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Software Design Description for the Simulating WAves Nearshore Model (SWAN)

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14. ABSTRACT

Simulating WAves Nearshore (SWAN) is a third-generation numerical wave model developed for wave computations in coastal regions and inland waters. The model is based on an Eulerian formulation of the discrete spectral balance of action density that accounts for refractive propagation over arbitrary bathymetry and current fields. SWAN is driven by boundary conditions and local winds. The processes of wind generation, whitecapping, quadruplet wave-wave interactions, bottom dissipation, triad wave-wave interactions, and depth-induced wave breaking are represented explicitly, though SWAN does not account for diffraction. SWAN's numerical propagation scheme is implicit; thus the model is most efficient (relative to other models) when applied to cases with relatively high geographic resolution (i.e., cases of smaller scale). SWAN has been validated by comparisons with analytical solutions, and laboratory and field observations.

SWAN is the state-of-the art phase-averaged coastal wave model (at the time of this writing). As a third-generation model, SWAN models propagation and dissipation explicitly. It also allows for simple integration of future developments in formulations for the physical processes mentioned above, as SWAN is a strictly and logically modular program.

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for the

Simulating WAves Nearshore Model (SWAN)

Cycle III Version 40.11

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1.0 SCOPE

1.1 INTRODUCTION

Simulating WAves Nearshore (SWAN) is a third-generation numerical wave model developed for wave computations in coastal regions and inland waters. The model is based on an Eulerian formulation of the discrete spectral balance of action density that accounts for refractive propagation over arbitrary bathymetry and current fields. SWAN is driven by boundary conditions and local winds. The processes of wind generation, whitecapping, quadruplet wave-wave interactions, bottom dissipation, triad wave-wave interactions and depth-induced wave breaking are represented explicitly, though SWAN does not account for diffraction. SWAN's numerical propagation scheme is implicit; thus the model is most efficient (relative to other models) when applied to cases with relatively high geographic resolution (i.e. cases of smaller scale). SWAN has been validated by comparisons with analytical solutions and laboratory and field observations.

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1.2 DOCUMENT OVERVIEW

The purpose of this Software Design Description (SDD) is to describe the software design and code of the Simulating WAves Nearshore model (SWAN). The SDD gives a summary of model operations, physics and basic equations and a description of source code components. Most importantly, the SDD gives a detailed description of the source code components, such as subroutines and common blocks, which make up the SWAN model.

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2.0 REFERENCE DOCUMENTS

2.1 SWAN SOFTWARE DOCUMENTATION

Carroll, S., Kelly, K. (2002). "User's Manual for the Simulating WAves Nearshore Model (SWAN) Cycle III Version 40.11." PSI Technical Report SSC-001-02.

Holthuijsen, L. H., Booij, N., Ris, R. C., Haagsma, IJ. G., Kieftenburg, A. T. M. M., and Kriezi, E. (2000). "SWAN Cycle III Version 40.11 User Manual, Electronic Version." Delft University of Technology, the Netherlands.

2.2 SWAN SOFTWARE RELEASE

Booij, N., Haagsma, IJ. G., Kieftenburg, A. T. M. M., and Holthuijsen, L. H. (2000). "SWAN Cycle II Version 40.11 Implementation Manual, Unauthorized Electronic Version." Delft University of Technology, the Netherlands.

Holthuijsen, L. H., Booij, N., Ris, R. C., Haagsma, IJ. G., Kieftenburg, A. T. M. M., and Kriezi, E. (2000). "SWAN Cycle III Version 40.11 User Manual, Unauthorized Electronic Version." Delft University of Technology, the Netherlands.

2.3 GENERAL TECHNICAL DOCUMENTATION

Abbott, M. B. and Basco, D. R., (1989). Computational Fluid Dynamics. John Wiley and Sons Inc., New York, p. 425.

Abreu, M., Larraza, A., and Thornton, E., (1992). Nonlinear transformation of directional wave spectra in shallow water. *J. Geophys. Res.*, 97: 15579-15589.

Arcilla, A. S., Roelvink, J. A., O'Connor, B. A., Reniers, A. J. H. M., and Jimenez, J. A., (1994). The Delta flume '93 experiment. *In the Proc. of the Coastal Dynamics Conf.*, 488-502.

Arcilla, A. S. and Lemos, C. M., (1990). Surf-zone Hydrodynamics. *Centro Internacional de Métodos Numéricos en Ingenieria*, Barcelona, Spain, 310 pp.

Banner, M. L. and Young, I. R., (1994). Modeling spectral dissipation in the evolution of wind waves, Part I: Assessment of existing model performance. *J. Phys. Oceanogr.*, 24(7): 1550-1571.

Battjes, J. A. and Beji, S., (1992). Breaking waves propagating over a shoal. *Proc. of 23rd Int. Conf. Coastal Engineering*, ASCE, 42-50.

Battjes, J. A. and Stive, M. J. F., (1985). Calibration and verification of dissipation model for random breaking waves. *J. Geophys. Res.*, 90(C5): 9159-9167.

Battjes, J. A. and Janssen, J. P. F. M., (1978). Energy loss and set-up due to breaking of random waves. *Proc. of 16th Int. Conf. on Coastal Eng.*, ASCE, New York, 569-587.

Beji, S. and Battjes, J. A., (1993). Experimental investigation of wave propagation over a bar. *Coastal Eng.*, 19: 151-162.

Bertotti, L. and Cavaleri, L., (1994). Accuracy of wind and wave evaluation in coastal regions. *Proc. of 24th Int. Conf. Coastal Eng.*, ASCE, 57-67.

Booij, N., Ris, R. C., and Holthuijsen, L. H., (1999). A third-generation wave model for coastal region, Part I: Model description and validation. *J. Geophys. Res.*, 104(C4): 7649-7666.

Booij, N., Ris, R. C., and Holthuijsen, L. H., (1999). A third-generation wave model for coastal region, Part II: Verification. *J. Geophys. Res.*, 104(C4): 7667-7681.

Booij, N., Holthuijsen, L. H., and Ris, R. C., (1993). A spectral wave model for the coastal zone. In: *Proc. of the 2nd Int. Symp. on Ocean Wave Meas. and Analysis*, New Orleans, LA, New York pp. 630-641.

Booij, N. and Holthuijsen, L. H., (1987). Propagation of ocean waves in discrete spectral wave models. *J. of Comp. Phys.*, 68: 307-326.

Bouws, E. and Komen, G. J., (1983). On the balance between growth and dissipation in an extreme, depth-limited wind-sea in the southern North Sea. *J. Phys. Oceanogr.*, 13: 1653-1658.

Cavaleri, L. and Malanotte-Rizzoli, P., (1981). Wind wave prediction in shallow water: Theory and applications. *J. Geophys. Res.*, 86(C11): 10961-10973.

Chen, Y. and Guza, R. T., (1997). Modeling of breaking surface waves in shallow water, *J. Geophys. Res.*, 102(C11): 25035-25046.

Collins, J. I., (1972). Prediction of shallow water spectra. *J. Geophys. Res.*, 77(15): 2693-2707.

Dingemans, M. W., (1997). Water wave propagation over uneven bottoms, Part 1: Linear wave propagation. *Adv. Ser. on Ocean Eng.*, 13, World Scientific, 471 pp.

Dingemans, M. W., Radder, A. C. and DeVriend, H. H., (1987). Computation of the driving forces of the wave-induced currents. *Coastal Eng.* 11: 539-563.

Eldeberky, Y., (1996). Nonlinear transformation of wave spectra in the nearshore zone, *Ph.D. thesis*. Delft University of Technology, Department of Civil Engineering, Delft, Netherlands.

Eldeberky, Y. and Battjes, J. A., (1996). Spectral modeling of wave breaking: Application to Boussinesq equations. *J. Geophys. Res.*, 101(C1): 1253-1264.

Eldeberky, Y. and Battjes, J. A., (1995). Parameterization of triad interactions in wave energy models. *Proc. Coastal Dynamics Conf.*, Gdansk, Poland, 140-148.

Elgar, S., Guza, R. T., Raubenheimer, B., Herbers, T. H. C., and Gallagher, E. L., (1997). Spectral evolution of shoaling and breaking waves on a barred beach. *J. Geophys. Res.*, 102(C7): 15797-15805.

Fletcher, C. A. J., (1988). Computational Techniques for Fluid Dynamics, Parts I and II, Springer-Verlag, Berlin; New York, pp. 409-484.

Galvin, C. J., (1972). Wave Breaking in Shallow Water, Waves on Beaches and Resulting Sediment Transport, Academic Press Inc., San Diego, California, pp. 413-455.

Goda, Y., Takeda, H., and Moriya, Y., (1967). Laboratory investigation of wave transmission over breakwaters. *Rep. Port and Harbour Res. Inst.*, 13 (from Seelig, 1979).

Golub, G. H. and Van Loan, C. F., (1986). Matrix Computations. Academic Press, London, p. 476.

Günther, H., Hasselmann, S., and Janssen, P. A. E. M., (1992). "The WAM model Cycle 4 (Revised Version)." Deutsch. Klim. Rechenzentrum, Technical Report No. 4, Hamburg, Germany.

Hasselmann, S. and Hasselmann, K., (1985). Computations and parameterizations of the nonlinear energy transfer in a gravity wave spectrum. Part I: A new method for efficient computations of the exact nonlinear transfer integral. *J. Phys. Oceanogr.* 15: 1369-1377.

Hasselmann, S., Hasselmann, K., Allender, J. H., and Barnett, T. P., (1985). Computations and parameterizations of the nonlinear energy transfer in a gravity wave spectrum, Part II: Parameterizations of the nonlinear transfer for application in wave models. *J. Phys. Oceanogr.*, 15(11): 1378-1391.

Hasselmann, S. and Hasselmann, K., (1981). A symmetrical method of computing the non-linear transfer in a gravity-wave spectrum. *Geophys. Einzelschr., Ser. A.,* Geophys. Inst., Univ. of Hamburg, Hamburg, Germany, 52(8).

Hasselmann, K., (1974). On the spectral dissipation of ocean waves due to whitecapping. *Boundary-layer Meteor.*, 6: 1-2, 107-127.

Hasselmann, K., Barnett, T. P., Bouws, E., Carlson, H., Cartwright, D. E., Enke, K., Ewing, J. A., Gienapp, H., Hasselmann, D. E., Kruseman, P., Meerbrug, A., Muller, P., Olbers, D. J., Richter, K., Sell, W., and Walden, H., (1973). Measurements of wind-wave growth and swell decay during the JOint North Sea WAve Project (JONSWAP). *Dtsch. Hydrogr. Z.*, 12(A80): 95.

Hasselmann, K. and Collins, J. I., (1968). Spectral dissipation of finite-depth gravity waves due to turbulent bottom friction. *J. Mar. Res.,* 29: 1-12.

Holthuijsen, L. H., Booij, N., and Herbers, T. H. C., (1989). A prediction model for stationary, short-crested waves in shallow water with ambient currents. *Coastal Eng.*, 13: 23-54.

Holthuijsen, L. H. and De Boer, S., (1988). "Wave forecasting for moving and stationary targets." Computer Modeling in Ocean Engineering. B.Y. Schrefler and O.C. Zienkiewicz, eds., Balkema Publishing Co., Rotterdam, Netherlands, pp. 231-234.

Janssen, P. A. E. M., (1992). Experimental evidence of the effect of surface waves on the airflow. *J. Phys. Oceanogr.* 22:1600-1604.

Janssen, P. A. E. M., (1991a). Quasi-linear theory of wind-wave generation applied to wave forecasting. *J. Phys. Oceanogr.*, 21: 1631-1642.

Janssen, P. A. E. M., (1991b). Consequences of the effect of surface gravity waves on the mean air flow, paper presented at the *Breaking Waves Int. Union of Theor. And Appl. Mech. (IUTAM)*, Sydney Australia, 193-198.

Janssen, P. A. E. M., (1989). Wave induced stress and the drag of air flow over sea waves. *J. Phys. Oceanogr.*, 19: 745-754.

Jonsson, I. G., (1980). A new approach to rough turbulent boundary layers. *Ocean Eng.*, 7: 109-152.

Jonsson, I. G. and Carlsen, N. A., (1976). Experimental and theoretical investigations in an oscillatory turbulent boundary layer. *J. Hydraulic Res.*, 14: 45-60.

Jonsson, I. G., (1966). Wave boundary layers and friction factors. *Proc. of 10th Int. Conf. Coastal Eng.*, ASCE, 127-148.

Kaminsky, G. M. and Kraus, N. C., (1993). Evaluation of depth-limited wave breaking criteria. *Proc. of 2nd Int. Sym. on Ocean Wave Meas. and Analysis*, New Orleans, Louisiana, 180-193.

Komen, G. J., Cavaleri, L., Donelan, M., Hasselmann, K., Hasselmann, S., and Janssen, P. A. E. M., (1994). Dynamics and Modeling of Ocean Waves. Cambridge Univ. Press, New York, p. 532.

Komen, G. J., Hasselmann, S., and Hasselmann, K., (1984). On the existence of a fully developed wind-sea spectrum. *J. Phys. Oceanogr.*, 14: 1271-1285.

Longuet-Higgins, M. S., (1969). On wave breaking and the equilibrium spectrum of wind-generated waves. *Proc. of Roy. Soc. A.* 310: 151-159.

Luo, W. and Monbaliu, J., (1994). Effects of the bottom friction formulation on the energy balance for gravity waves in shallow water. *J. Geophys. Res.*, 99(C9): 18501-18511.

Madsen, P. A. and Sørensen, O. R., (1993). Bound waves and triad interactions in shallow water. *Ocean Eng.,* 20(4): 359-388.

Madsen, O. S., Poon, Y. K., and Graber, H. C., (1988). Spectral wave attenuation by bottom friction: Theory. *Proc. of 21st Int. Conf. Coastal Eng.*, ASCE, Malaga, Spain, 492-504.

Mase, H. and Kirby, J. T., (1992). Hybrid frequency-domain KdV equation for random wave transformation. *Proc. of 23rd Int. Conf. Coastal Eng.*, ASCE, 474-487.

Mastenbroek, C., Burgers, G., and Janssen, P. A. E. M., (1993). The dynamical coupling of a wave model in a storm surge model through the atmospheric boundary layer. *J. Phys. Oceanogr.*, 23: 1856-1866.

Mei, C. C., (1983). The Applied Dynamics of Ocean Surface Waves. John Wiley and Sons Inc., New York, p. 740.

Miles, J. W., (1957). On the generation of surface waves by shear flows. *J. Fluid Mech.*, 3: 185-204.

Nelson, R. C., (1994). Depth limited wave heights in very flat regions. *Coastal Eng.*, 23: 43-59.

Nelson, R. C., (1987). Design Wave Heights on Very Mild Slopes: An Experimental Study. *Civil. Eng. Trans.,* 29: 157-161.

Padilla-Hernandez, R. and Monbaliu, J., (2001). Energy balance of wind waves as a function of the bottom friction formulation. *Coastal Eng.*, 43: 131-148.

Phillips, O. M., (1957). On the generation of waves by turbulent wind. *J. Fluid Mech.*, 2: 417-445.

Pierson, W. J. and Moskowitz, L., (1964). A proposed spectral form for fully developed wind seas based on the similarity theory of S.A. Kitaigorodskii. *J. Geophys. Res.*, 69(24): 5181-5190.

Plant, W. J., (1982). A relationship between stress and wave slope. *J. Geophys. Res.* 87(C#): 1961-1967.

Putnam, J. A. and Johnson, J. W., (1949). The dissipation of wave energy by bottom friction. *Trans. Am. Geoph. Union*, 30: 67-74.

Rogers, W. E., Kaihatu, J. M., Petit, H. A. H., Booij, N., and Holthuijsen, L. H., (2000). Arbitrary-Scale Propagation in a Third Generation Wind Wave Model, manuscript.

Seelig, W. N., (1979). Effects of breakwaters on waves: Laboratory tests of wave transmission by overtopping. *Proc. Conf. Coastal Structures*, 79(2): 941-961.

Shemdin, P., Hasselmann, K., Hsiao, S. V., and Herterich, K., (1978). Non-linear and linear bottom interaction effects in shallow water, in: Turbulent fluxes through the sea surface, *Wave Dynamics and Prediction, NATO Conf. Ser.*, V(1), 347-372 pp.

Snyder, R. L., Dobson, F. W., Elliott, J. A., and Long, R. B., (1981). Array measurement of atmospheric pressure fluctuations above surface gravity waves. *J. Fluid Mech.*, 102: 1-59.

Stelling, G. S. and Leendertse, J. J., (1992). Approximation of convective processes by cyclic AOI methods. *In the Proc. of the 2nd Int. Conf. on Estuarine and Coastal Modeling*, ASCE, Tampa, Florida, 771-782.

Thornton, E. B. and Guza, R. T., (1983). Transformation of wave height distribution. *J. Geophys. Res.*, 88(C10): 5925-5938.

Tolman, H. L., (1995). "On the selection of propagation schemes for a spectral wind-wave model." *NWS/NCEP Office Note 411*, 30 pp. + figures.

Tolman, H. L., (1992a). Effects of numerics on the physics in a third-generation wind-wave model. *J. Phys. Oceanogr.*, 22: 1095-1111.

Tolman, H. L., (1992b). An evaluation of expressions for the wave energy dissipation due to bottom friction in the presence of currents. *Coastal Eng.*, 16: 165-179.

Tolman, H. L., (1990). Wind wave propagation in tidal seas, *Ph.D. thesis*. Delft University of Technology, Department of Civil Engineering, the Netherlands.

Van der Vorst, H. A., (1992). Bi-CGSTAB: A fast and smoothly converging variant of Bi-CG for solution of non-symmetric linear systems. *SIAM J. Sci. Statistical Computing*, 13: 631-644.

Vincent, C. L., Smith, J. M., and Davis, J., (1994). Parameterization of wave breaking in models. M. Isaacson and M. Quick, eds., *Proc. of Int. Symp.: Waves - Physical and Numerical Modeling*, University of British Columbia, Vancouver, Canada, Vol. II, pp.753-762.

Vuik, C., (1993). Solution of the discretized incompressible Navier-Stokes equations with the GMRES method. *Int. J. for Num. Meth. in Fluids*, 16: 507-523.

WAMDI Group, (1988). The WAM model-A third generation ocean wave prediction model. *J. Phys. Oceanogr.*, 18: 1775-1810.

Weber, S. L., (1991a). Bottom friction for wind sea and swell in extreme depth-limited situations. *J. Phys. Oceanogr.*, 21: 149-172.

Weber, S. L., (1991b). Eddy-viscosity and drag-law models for random ocean wave dissipation. *J. Fluid Mech.*, 232: 73-98.

Weber, S. L., (1989). Surface gravity waves and turbulent bottom friction, *Ph.D. thesis*. University of Utrecht, the Netherlands.

Whitham, G. B., (1974). Linear and Nonlinear Waves. John Wiley and Sons Inc., New York, p. 636.

Wu, J., (1982). Wind-stress coefficients over sea surface from breeze to hurricane. *J. Geophys. Res.*, 87(C12): 9704-9706.

Yan, L., (1987). An improved wind input source term for third generation ocean wave Modeling. *Sci. Rep.*, WR 87-8, R. Neth. Meteorol. Inst., De Bilt, the Netherlands.

Young, I. R. and Van Vledder, G. P., (1993). A review of the central role of nonlinear interactions in wind-wave evolution. *Philos. Trans. R. Soc. London, Ser. A.*, 342: 505-524.

Young, I. R. and Banner, M. L., (1992). Numerical Experiments on the evolution of fetch limited waves, paper presented at *Int. Union of Theor. and Appl. Mech. (IUTAM)*, Sydney, Australia, 267-275.

Yuan, Yeli, Tung, C. C. and Huang N. E., (1986). "Statistical Characteristics of breaking waves" Wave Dynamics and Radio Probing of the Ocean Surface. O.M. Phillips and K. Hasselmann, eds., Plenum, New York, p. 265-272.

3.0 MODEL DESIGN DECISION

SWAN Version 40.01 has been modified to become Version 40.11. This section will discuss the additions, changes, compatibility, bug fixes and implementation of SWAN Version 40.11.

3.1 ADDITIONS TO SWAN

The first addition made to SWAN Version 40.11 allows for nesting in WAVEWATCH III. SWAN can now compute on spherical coordinates (latitude and longitude), allowing for calculations in laboratory situations, coastal regions, shelf seas and oceans. The new version also allows the user to define obstacles at which waves are reflected, such as coastlines or breakwaters, as opposed to just transmitting waves through obstacles. Lastly, a higher order propagation scheme was introduced for both the stationary and nonstationary modes.

3.2 CHANGES TO SWAN

The changes made to SWAN begin with the improvement of approximating the bathymetry in refraction computations. In order to give robust (but not necessarily accurate) results in cases of poor resolutions in bathymetry, currents or wave field, the user can now activate a limiter to avoid waves turning over more than 90 degrees in one spatial grid step. The limiter on the refraction is switched off on default. In Version 40.01 the Backward Space, Backward Time (BSBT) numerical propagation scheme was the only scheme available. Now, using Version 40.11 in stationary mode the Second ORDer UPwind (SORDUP) scheme is chosen as default, while in non-stationary mode the Stelling-scheme is default. The BSBT is still optionally available.

3.3 COMPATIBILITY OF SWAN

SWAN Version 40.11 is fully downward compatible with Version 40.01. Due to the changes in SWAN, a comparison of test results between Versions 40.01 and 40.11 may show differences in the results.

3.4 BUG FIXES

The purpose of describing the bug fixes, is to allow the user to identify previous SWAN runs that may have encountered these problems (either at runtime or in hindsight). The following are five bugs that were fixed in Version 40.11:

1. The output in the form of starplots on a rotated output frame;
2. The implementation of the QUANTITY command;
3. Spectral output of source terms on land points;
4. The output of 2-D spectra in combination with rotated grids or a directional sector;
5. The interpolation for test points too close to land points.

3.5 IMPLEMENTATION

SWAN (40.11) has been implemented so that all (except for one) obsolete FORTRAN 95 features have been removed to avoid compiler warnings. The implementation of allocatable arrays was done to avoid the use of the *pool* array for newly introduced arrays. Also implemented were modules to avoid lengthy argument lists of subroutines. The implementation of FORTRAN 90 implies that SWAN Version 40.11 will not compile under FORTRAN 77.

4.0 MODEL ARCHITECTURAL DESIGN

4.1 MODEL COMPONENTS

SWAN is a single computer program that is separated into three main files consisting of an executable file, a command file, and a run file.

a. Executable File- The name of the executable file is "a.out" for the versions running under Unix and "swanmain.exe" for the PC version generated with the Lahey Fortran90 compiler (in case swanmain.for is first on the list). Remove the "a.out" and replace with "swan.x" or "swan.exe".

b. Command File- The command file contains the user's input and selected instructions to run SWAN. The command file, which has the extension .swn must be presented to SWAN is American Standard Code for Information Interchange (ASCII) format.

c. Run File- Depending on which system is being used, either swan.bat (for MS-DOS systems) or swan.unix (for Unix systems) is the name of the run file. MS-DOS is not case-sensitive; however, Unix systems are.

4.2 System Requirements

The core memory for SWAN is determined at the installation of SWAN on the user's computer system. The required storage capacity in SWAN depends on the number of grid points in x- and y-direction (mxc*myc) and the number of points in frequency and directional space (msc*mdc). Calculating nonlinear four wave-wave interactions per sweep, instead of per iteration, decreases the amount of required memory by a factor of 2/3 (see Section 5.0 in the User's Manual-Carroll and Kelly, 2002). Other storage restrictions with calculating nonlinear four wave-wave interactions are summarized in Table 4.11-1 and 4.11-2 in the User's Manual (Carroll and Kelly, 2002).

To run the SWAN program for **test_cases**, 55 Mb of free internal memory is recommended. SWAN requires 100 to 500 Mb of memory for realistic cases, whereas for more stationary or 1-D cases significantly less memory is needed. The number of files addressable by the DOS system is at least twenty therefore the command line FILES=20 (or some higher number if necessary) should be included in the file config.sys of the DOS operating system.

4.3 Concept of Execution

SWAN is a single program, consisting of an executable file with extension *.exe*, a command file with extension *.swn*, and a run file with either extension *.bat* or *.unix*, depending on whether or not MS-DOS or Unix is being used. The execution of SWAN consists of three steps 1) implementing SWAN on the user's computer, 2) editing the command file for a particular model run, and 3) running SWAN.

The first step, implementing SWAN, can be done in the following manner:

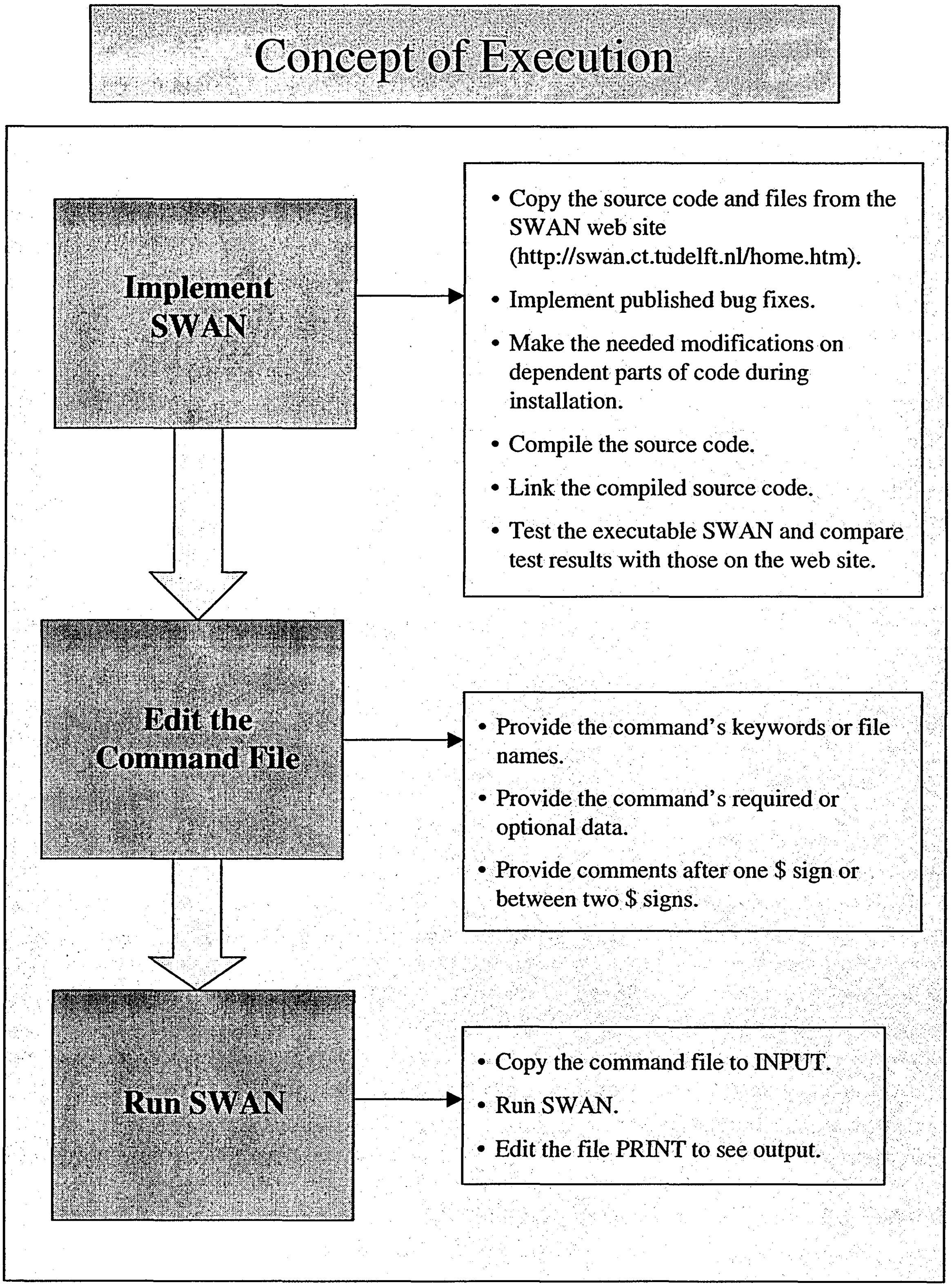
- Copy the source code and files from the SWAN web site (http://swan.ct.tudelft.nl/home.htm).
- Implement published bug fixes.
- Make the necessary modifications on dependent parts of code during installation.
- Compile the source code.
- Link the compiled source code.
- Test the executable SWAN and compare test results with those on the web site.

See the SWAN User's Manual for detailed information on implementation (Carroll and Kelly, 2002).

Next, the command file must be located and edited. The name of the command file from the source code will have the extension *.swn*. The user must present SWAN with one file (in ASCII) containing all of the actual commands. Within the command file the user should give the command's keyword, required or optional data, and comments. The keyword, which is usually the name of the command, indicates the primary function of that command and should comply with the rules of file identification of the computer system on which SWAN is run. To help with editing the input files for SWAN, the SWAN web site contains a template command file called *swan.edt*. The SWAN User's Manual provides a complete description of the commands available for selection in SWAN. Details of the command's keyword, data and comments and the way in which the user must enter them may be found in Appendix A of the User's Manual (Carroll and Kelly, 2002).

The final step is to run SWAN. Running SWAN requires three actions. First the user must copy the command file to INPUT (assuming INPUT is the standard filename for command input). Next, the user will run SWAN and view the output by copying the PRINT file (assuming PRINT is the standard filename for output). See **Section 4.4.1** for a description of the types of output files that are generated by SWAN.

A flow diagram illustrating the basic steps for the operation of SWAN is shown in **Figure 4.3-1**.



- Copy the source code and files from the SWAN web site (http://swan.ct.tudelft.nl/home.htm).
- Implement published bug fixes.
- Make the needed modifications on dependent parts of code during installation.
- Compile the source code.
- Link the compiled source code.
- Test the executable SWAN and compare test results with those on the web site.

- Provide the command's keywords or file names.
- Provide the command's required or optional data.
- Provide comments after one $ sign or between two $ signs.

- Copy the command file to INPUT.
- Run SWAN.
- Edit the file PRINT to see output.

Figure 4.3-1 Flow diagram summarizing the SWAN Version 40.11 execution steps.

4.4 Interface Design

4.4.1 Interface Identification and Diagrams

The user must provide the following input files to SWAN:

- A command file containing the user selected instructions to run SWAN.
- File(s) containing the bottom current, friction, and wind (if relevant).
- File(s) containing the wave field at the model boundaries (if relevant).

SWAN produces output only at the user's request. The output is available for many different wave and wave-related parameters. The types of files generated by the output are given below:

- Print Files- Error messages appear in a PRINT file, which can be renamed by the user with a batch (DOS) or script (Unix) command. In the DOS and Unix systems the file PRINT is renamed to the name of the command file (examples are on the SWAN web site), with the extension *.swn* replaced by *.prt.* All files with extension *.prt* are referred to as print files.

- Numerical Output Files- Output from commands such as BLOCK or TABLE appears in files with user provided names.

- Plot Files- One or more plot files are generated by the PLOT command. If the user does not specify a filename the plot file has the name PLF... where the run number as defined in the command PROJECT as nr appears on the dots.

- Error Files- A file called ERRFILE, which contains the error messages, is created only when SWAN produces error messages. Existence of this file is an indication that results must be carefully examined.

- Grid Point Error Files- A file called ERRPTS contains the grid points where specific errors occurred during the calculation, such as non-convergence of the iterative matrix-solver. Existence of this file is an indication to study the grid point spectrum more carefully.

5.0 SWAN DETAILED DESIGN

5.1 CONSTRAINTS AND LIMITATIONS

Despite the improvements of Version 40.11, a few limitations still remain:

1. Diffraction is not modeled in SWAN, so SWAN should not be used in areas where variations in wave height are large within a horizontal scale of a few wavelengths. Because of this, the wave field computed by SWAN will generally not be accurate in the immediate vicinity of obstacles, and certainly not in harbors.

2. SWAN does not calculate wave-induced currents. If relevant, such currents should be provided as input to SWAN (e.g. from a hydrodynamical model, which can be driven by waves from SWAN in an iteration procedure). As an option SWAN computes wave induced set-up.

3. The Lumped Triad Approximation (LTA) used in triad wave-wave interactions seems to depend on the width of the directional distribution of the wave spectrum. The present tuning in SWAN works reasonably well in most cases. It was obtained from observations in a narrow wave flume (long-crested waves).

4. The Discrete Interaction Approximation (DIA) used in quadruplet wave-wave interactions depends on the width of the directional distribution of the wave spectrum. DIA works reasonably well in many cases but gives a poor approximation for long-crested waves (narrow directional distribution) that depend on the frequency resolution. The DIA has also proven to be a poor approximator of frequency resolutions very different from 10%. SWAN shares this fundamental limitation with other third-generation wave models such as WAM and WAVEWATCH III.

5. This version of SWAN (40.11) may be used on any scale relevant for wind generated surface gravity waves (high-quality propagation (third order diffusion) and Cartesian or spherical coordinates). The background for providing SWAN with such flexibility is to:

   - Allow SWAN to be used from laboratory conditions to shelf seas (but not harbors, see above) and
   - Nest SWAN in the WAM or WAVEWATCH III models, which are formulated in terms of spherical coordinates.

   These facilities are not meant to support the use of SWAN on oceanic scales. SWAN has not been extensively tested and is less efficient on oceanic scales than WAVEWATCH III and probably less efficient than WAM (SWAN does not parallelize or vectorize well). SWAN developers have no plans to apply SWAN to blue water.

There are a few constraints that the user might encounter:

1. Sometimes the user input to SWAN is such that SWAN produces unreliable and possibly even unrealistic results. This may be the case if the bathymetry or the wave field is not well resolved. Be aware that the grid on which the computations are performed interpolates from the grids on which the input is provided; different resolutions for these grids (which are allowed) can therefore create unexpected interpolation patterns on the computational grid.

2. Other problems are due to more fundamental shortcomings of SWAN (which may or may not be typical for third-generation wave models) and unintentional coding bugs such as:

   - The user can request that refraction over one spatial grid step is limited to 90°.
   - SWAN cannot handle wave propagation on super-critical current flow. If such flow is encountered during SWAN computations, the current is locally reduced to sub-critical flow.
   - If the water depth is less than some user-provided limit, the depth is set at that limit (default is 0.05 m).
   - SWAN may not reproduce the user-imposed wave boundary conditions as SWAN replaces the *imposed* waves that move out of the computational area at the boundaries with the *computed* waves that move out of the computational area at the boundaries.
   - SWAN may have convergence problems.

Because of such scenarios, limiters, shortcomings and bugs, the results may look realistic but they may (locally) not be accurate. Any change in these limitations or problems (in particular newly discovered coding bugs and their fixes) are published on the SWAN web site (http://swan.ct.tudelft.nl) and implemented in new releases of SWAN.

5.2 LOGIC AND BASIC EQUATIONS

5.2.1 General Formulation

The waves in SWAN are described with the two-dimensional wave action density spectrum, even when nonlinear phenomena dominate (e.g., in the surf zone). The rationale for using the spectrum in such highly nonlinear conditions is that even in these conditions it seems possible to predict with reasonable accuracy spectral distribution of the second order moment of the waves (although it may not be sufficient to fully describe the waves statistically). The spectrum that is considered in SWAN is the action density spectrum rather than the energy density spectrum since in the presence of currents, action density is conserved whereas energy density is not (Whitham, 1974). The independent variables are the relative frequency (as observed in a frame of reference moving with the action propagation velocity) and the wave direction (the direction normal to the wave crest of each spectral component). The action density is equal to the energy density divided by the relative frequency. In SWAN, this spectrum may vary in time and space.

5.2.1.1 Action Balance Equation

The evolution of the wave spectrum in SWAN is described by the spectral action balance equation, which for Cartesian coordinates is (e.g., Hasselmann et al., 1973):

$$\frac{\partial}{\partial t}N+\frac{\partial}{\partial x}c_xN+\frac{\partial}{\partial y}c_yN+\frac{\partial}{\partial \sigma}c_\sigma N+\frac{\partial}{\partial \theta}c_\theta N=\frac{S}{\sigma} \qquad (1a)$$

The first term in the left-hand side of this equation represents the local rate of change of action density in time, the second and third term represent propagation of action in geographical space (with propagation velocities c_x and c_y in x- and y-space, respectively). The fourth term represents shifting of the relative frequency due to variations in depths and currents (with propagation velocity c_σ in σ-space). The fifth term represents depth-induced and current-induced refraction (with propagation velocity c_θ in θ -space). The expressions for these propagation speeds are taken from linear wave theory (e.g., Whitham, 1974; Mei, 1983; and Dingemans, 1997). The term S (= $S(\sigma,\theta)$) at the right hand side of the action balance equation is the source term in terms of energy density representing the effects of generation, dissipation and nonlinear wave-wave interactions. A brief summary of the formulations that are used for the various source terms in SWAN is given next.

In view of the use of SWAN at shelf, sea or oceanic scales the user can choose to express the basic equation in spherical coordinates:

$$\frac{\partial}{\partial t}N+\frac{\partial}{\partial \lambda}c_\lambda N+(\cos\varphi)^{-1}\frac{\partial}{\partial \varphi}c_\varphi \cos\varphi N+\frac{\partial}{\partial \sigma}c_\sigma N+\frac{\partial}{\partial \theta}c_\theta N=\frac{S}{\sigma} \qquad (1b)$$

with longitude, λ and latitude, φ.

5.2.1.2 Wind Input

Transfer of wind energy to the waves is described in SWAN with a resonance mechanism (Phillips, 1957) and a feedback mechanism (Miles, 1957). The corresponding source term for these mechanisms is commonly described as the sum of linear and exponential growth:

$$S_{in}(\sigma,\theta) = A + BE(\sigma,\theta) \tag{2}$$

in which A and B depend on wave frequency and direction, and wind speed and direction. The effects of currents are accounted for in SWAN by using the apparent local wind speed and direction. The expression for term A is due to Cavaleri and Malanotte-Rizzoli (1981) with a filter to avoid growth at frequencies lower than the Pierson-Moskowitz frequency (Tolman, 1992a). Two optional expressions for coefficient B are used in the model. The first is taken from an early version of the WAM model (known as WAM Cycle 3, the WAMDI group, 1988). This is due to Snyder et al. (1981), rescaled in terms of friction velocity U by Komen et al. (1984). The drag coefficient to relate U to the driving wind speed at 10m elevation U_{10} is taken from Wu (1982). The second expression for B is taken from the most recent version of the WAM model (known as WAM Cycle 4, Komen et al., 1994). It is due to Janssen (1991a) and accounts explicitly for the interaction between the wind and the waves by considering atmospheric boundary layer effects and the roughness length of the sea surface. The corresponding set of equations is solved (as in the WAM model) with the iterative procedure of Mastenbroek et al. (1993).

5.2.1.3 Dissipation

The dissipation term of wave energy is represented by the summation of three different contributions: whitecapping, $s_{ds,w}(\sigma, \theta)$, bottom friction, $s_{ds,b}(\sigma, \theta)$, and depth-induced breaking, $s_{ds,br}(\sigma, \theta)$.

Whitecapping is primarily controlled by the steepness of the waves. In presently operating third-generation wave models (including SWAN) the whitecapping formulations are based on a pulse-based model (Hasselmann, 1974) as adapted by the WAMDI group (1988):

$$s_{ds,w}(\sigma,\theta) = -\Gamma\tilde{\sigma}\frac{k}{\tilde{k}}E(\sigma,\theta) \tag{3}$$

where Γ is a steepness dependent coefficient, k is wave number and $\tilde{\sigma}$ and $\tilde{k}$ denotes a mean frequency and a mean wave number, respectively (cf. the WAMDI group, 1988). Komen et al. (1984) estimated the value of Γ by closing the energy balance of the waves in fully developed conditions. This implies that this value depends on the wind-input formulation that is used. Since two expressions are used for the wind input in SWAN, two values for Γ are also used. The first is due to Komen et al. (1984), as in Cycle 3 of the WAM model. It is used in SWAN when the wind input coefficient B of Komen et al. (1984) is used. The second expression is an adaptation of this expression based on Janssen (1991a); as in Cycle 4 of the WAM model (see Janssen, 1991b and Günther et al., 1992). It is used when the wind input term B of Janssen (1991a) is used. Young and Banner (1992) and Banner and Young (1994) have shown that the results of closing the energy balance in this manner depend critically on the choice of a high-frequency cut-off frequency above which a diagnostic spectral tail is used. In SWAN, this cut-off frequency is different from the one used in the WAM model. Differences in the growth rates between the WAM model and SWAN are therefore to be expected.

Depth-induced dissipation may be caused by bottom friction, by bottom motion, by percolation or by back scattering on bottom irregularities (Shemdin et al., 1978). For continental shelf seas with sandy bottoms, the dominant mechanism appears to be bottom friction (e.g., Bertotti and Cavaleri, 1994) which can be represented as:

$$S_{ds,b}(\sigma,\theta) = -C_{bottom}\frac{\sigma^2}{g^2\sinh^2(kd)}E(\sigma,\theta) \qquad (4)$$

in which C_{bottom} is a bottom friction coefficient. A large number of models have been proposed since the pioneering paper of Putnam and Johnson (1949). Hasselmann et al., (1973) suggested using an empirically obtained constant. It seems to perform well in many different conditions as long as a suitable value is chosen (typically different for swell and wind sea; (Bouws and Komen, 1983)). Hasselmann and Collins (1968) which was later simplified by Collins (1972) have proposed a nonlinear formulation based on drag. More complicated, eddy viscosity models have been developed by Madsen et al. (1988) and by Weber (1989, 1991a, 1991b). Considering the large variations in bottom conditions in coastal areas (bottom material, bottom roughness length, ripple height etc.), there is no field data evidence to give preference to a particular friction model (Luo and Monbaliu, 1994). For this reason, the simplest of each of these types of friction models has been implemented in SWAN: the empirical JONSWAP model of Hasselmann et al. (1973), the drag law model of Collins (1972) and the eddy-viscosity model of Madsen et al. (1988). The effect of a mean current on the wave energy dissipation due to bottom friction is not taken into account in SWAN. The reasons for this are given by Tolman (1992b) who argues that state-of-the-art expressions vary too widely in their effects to be acceptable. He found that the error in finding a correct estimate of the bottom roughness length scale has a much larger impact on the energy dissipation rate than the effect of a mean current.

The process of depth-induced wave breaking is still poorly understood and little is known about its spectral modeling. In contrast to this, the total dissipation (i.e., integrated over the spectrum) due to this type of wave breaking can be well modeled with the dissipation of a bore applied to the breaking waves in a random field (Battjes and Janssen, 1978 and Thornton and Guza, 1983). Laboratory observations (Battjes and Beji, 1992, Vincent et al. 1994; Arcilla et al., 1994 and Eldeberky and Battjes, 1996) show that the shape of initially uni-modal spectra propagating across simple (barred) beach profiles, is fairly insensitive to depth-induced breaking. This has led Eldeberky and Battjes (1995) to formulate a spectral version of the bore model of Battjes and Janssen (1978) which conserves the spectral shape. Expanding their expression to include directions, the expression that is used in SWAN is:

$$S_{ds,br}(\sigma,\theta)=\frac{D_{tot}}{E_{tot}}E(\sigma,\theta) \qquad (5)$$

in which E_{tot} is the total wave energy and D_{tot}(which is negative) is the rate of dissipation of the total energy due to wave breaking according to Battjes and Janssen (1978). Adding a quadratic dependency on frequency as suggested by Mase and Kirby (1992) supported by Elgar et al. (1997) seems to have no noticeable effect on the SWAN results. Chen and Guza (1997) inferred from observations and simulations with a Boussinesq model that the high-frequency levels are insensitive to such frequency dependency because an increased dissipation at high frequencies is compensated approximately by increased nonlinear energy transfer (but they did find the frequency dependency to be relevant in time domain). The value of D_{tot} depends critically on the breaking parameter $\gamma = H_{max}/d$ (in which H_{max} is the maximum possible individual wave height in the local water depth). In SWAN, a constant value and a variable value are available. The constant value is $\gamma =$ 0.73 (the mean value of the data set of Battjes and Stive (1985)).

SWAN can estimate wave transmission through a (line-) structure such as a breakwater (dam). Such an obstacle will affect the wave field in two ways, first it will reduce the wave height locally all along its length, and second it will cause diffraction (which the model does not account for) around its end(s). In irregular, short-crested wave fields, however; it seems that the effect of diffraction is small, except in a region less than one or two wavelengths away from the tip of the obstacle (Booij et al., 1993). Therefore the model can reasonably account for waves around an obstacle if the directional spectrum of incoming waves is not too narrow. Since obstacles usually have a transversal area that is too small to be resolved by the bottom grid in SWAN, an obstacle is modeled as a line. If the crest of the breakwater is at a level where (at least part of the) waves can pass over, the transmission coefficient K_t (defined as the ratio of the (significant) wave height at the downwave side of the dam over the (significant) wave height at the upwave side) is a function of wave height and the difference in crest level and water level. The expression is taken from Goda et al. (1967):

$$K_t = 0.5\left[1-\sin\left(\frac{\pi}{2\alpha}\left(\frac{F}{H_i}+\beta\right)\right)\right] \quad \text{for } -\beta-\alpha<\frac{F}{H_i}<\alpha-\beta \qquad (6)$$

where $F = h\text{-}d$ is the freeboard of the dam and where H_i is the incident (significant) wave height at the upwave side of the obstacle (dam), h is the crest level of the dam above the reference level same as reference level of the bottom), d the mean water level relative to the reference level, and the coefficients α, β depend on the shape of the dam. Table 5.2-1 provides the coefficients for some of the more common cases encountered.

Table 5.2-1. Coefficients α, β determined by the shape of the dam (Seelig, 1979).

Case	α	β
vertical thin wall	1.8	0.1
caisson	2.2	0.4
dam with slope 1:3/2	2.6	0.15

Equation 6 is based on experiments in a wave flume, so strictly speaking it is only valid for normal incidence waves. Since there are no data available on oblique waves it is assumed that the transmission coefficient does not depend on direction. Another phenomenon that is to be expected is a change in wave frequency since often the process above the dam is highly nonlinear. Again there is little information available, so in SWAN it is assumed that the frequencies remain unchanged over an obstacle (only the energy scale of the spectrum is affected and not the spectral shape).

5.2.1.4 Nonlinear Wave-wave Interactions

In deep water, quadruplet wave-wave interactions dominate the evolution of the spectrum. These interactions transfer wave energy from the spectral peak to lower frequencies (thus moving the peak frequency to lower values) and to higher frequencies (where the energy is dissipated by whitecapping). In very shallow water, triad wave-wave interactions transfer energy from lower to higher frequencies often resulting in higher harmonics (Beji and Battjes, 1993); low-frequency energy generation by triad wave-wave interactions is not considered here.

A full computation of the quadruplet wave-wave interactions is extremely time consuming and not convenient in any operational wave model. A number of techniques, based on parametric methods or other types of approximations have been proposed to improve computational speed (see Young and Van Vledder, 1993 for a review). In SWAN the computations are carried out with the DIA of Hasselmann et al. (1985). This DIA has been found quite successful in describing the essential features of a developing wave spectrum (Komen et al., 1994). For uni-directional waves, this approximation is not valid. In fact, the quadruplet interaction coefficient for these waves is nearly zero (G. P. van Vledder, personal communication, 1996). For finite-depth applications, Hasselmann and Hasselmann (1981) have shown that for a JONSWAP-type spectrum the quadruplet wave-wave interactions can be scaled with a simple expression (it is used in SWAN).

A first attempt to describe triad wave-wave interactions in terms of a spectral energy source term was made by Abreu et al. (1992). However, their expression is restricted to non-dispersive shallow water waves and is therefore not suitable in many practical applications of wind waves. The breakthrough in the development came with the work of Eldeberky and Battjes (1995), which transformed the amplitude part of the Boussinesq model of Madsen and Sørensen (1993) into an energy density formulation and parameterized the biphase of the waves on the basis of laboratory observations (Battjes and Beji, 1992 and Arcilla et al., 1994). A Discrete Triad Approximation (DTA) for co-linear waves was subsequently obtained by considering only the dominant self-self interactions. The Boussinesq model has been verified with flume observations of long-crested, random waves breaking over a submerged bar (Beji and Battjes, 1993) and over a barred beach (Arcilla et al., 1994). The model appeared to be fairly successful in describing the essential features of the energy transfer from the primary peak of the spectrum to the super harmonics. The LTA, a slightly different version derived by Eldeberky (1996) is used in SWAN.

5.2.2 First-, Second- and Third-generation Mode

SWAN can operate in first-, second- and third-generation mode. The first- and second-generation modes are essentially those of Holthuijsen and De Boer (1988) as indicated above (first-generation with a constant Phillips constant of 0.0081; second-generation with a variable Phillips constant). An overview of the options is given in **Table 5.2-2.**

Table 5.2-2: Summary of options available for SWAN operation modes.

Option	**Source**	**Generation mode of SWAN**		
		1st	2nd	3rd
Linear wind growth:	Cavaleri and Malanotte-Rizzoli (1981) [modified]	x	x	
	Cavaleri and Malanotte-Rizzoli (1981)			x
Exponential wind growth:	Snyder et al. (1981) [modified]	x	x	
	Snyder et al. (1981)			x[1]
	Janssen (1989, 1991)			x[2]
Whitecapping:	Holthuijsen and De Boer (1988)	x[3]	x[4]	
	Komen et al. (1984)			x[1]
	Janssen (1991), Komen et al. (1994)			x[2]
Quadruplet interaction:	Hasselmann et al. (1985)			x
Triad interactions:	Eldeberky (1996)	x	x	x
Depth-induced breaking:	Battjes and Janssen (1978)	x	x	x
Bottom friction:	Hasselmann et al. (1973)	x	x	x
	Collins (1972)	x	x	x
	Madsen et al. (1988)	x	x	x
Obstacle transmission:	Seelig (1979)	x	x	x

For SWAN running in a third generation mode, the following combinations of the input and whitecapping parameterizations are used (indicated with 1 and 2, see command GEN3):

1. Gives the wind input and whitecapping formulations as used in WAM Cycle 3.
2. Gives the wind input and whitecapping formulations as used in WAM Cycle 4.
3. Pierson-Moskowitz spectrum as an upper limit.

4. Scaled Pierson-Moskowitz spectrum as upper limit.

5.2.3 Wave-induced Set-up

In a (geographic) 1-D case the computation of the wave-induced set-up is based on the vertically integrated momentum balance equation which reduces to a balance between the gradient of the wave radiation stress and the hydrodynamic pressure gradient (no wave-induced currents exist). In a 2-D case the computation of the wave-induced set-up is based on the divergence of the vertically integrated momentum balance equation equaling zero.

5.2.4 Detailed Formulation

The complete expressions for the physical processes of generation, dissipation and nonlinear wave-wave interactions that are available in the SWAN model are given here.

5.2.4.1 Input by Wind (S_{in})

Wave growth by wind is described by:

$$S_{in}(\sigma,\theta)=A+BE(\sigma,\theta) \tag{7}$$

in which A describes linear growth and BE exponential growth. It should be noted that the SWAN model is driven by the wind speed at 10m elevation U_{10} whereas the computations use the friction velocity U_*. For the WAM Cycle 3 formulation the transformation from U_{10} to U_* is obtained with

$$U_*^2=C_D U_{10}^2 \quad , \tag{8}$$

in which C_D is the drag coefficient from Wu (1982):

$$C_D(U_{10})=\begin{cases} 1.2875\times10^{-3} & \text{for}\,U_{10}<7.5\,\text{m/s} \\ (0.8+0.065\,\text{s/m}\times U_{10})\times10^{-3} & \text{for}\,U_{10}\geq 7.5\,\text{m/s} \end{cases} \tag{9}$$

For the WAM Cycle 4 formulations, the computation of U_* is an integral part of the source term.

5.2.4.2 Linear Growth by Wind

For the linear growth term A, the expression due to Cavaleri and Malanotte-Rizzoli (1981) is used with a filter to eliminate wave growth at frequencies lower than the

Pierson-Moskowitz frequency (Tolman, 1992a) (note that in his Eq. 10 the power of 10^{-5} should be 10^{-3}, H. Tolman, personal communication, 1995):

$$A = \frac{1{,}5 \times 10^{-3}}{g^2 2\pi} [U_* \max[0, \cos(\theta - \theta_w)]\,]^4 H \quad ,$$
$$H = \exp(-(\sigma / \sigma^*_{PM})^{-4}) \quad \text{with} \quad \sigma^*_{PM} = \frac{0.13 g}{28 U_*} 2\pi \quad , \tag{10}$$

in which θ_w is the wind direction, H is the filter and $\theta_{PM}{}^*$ is the peak frequency of the fully developed sea state according to Pierson and Moskowitz (1964; reformulated in terms of friction velocity).

5.2.4.3 Exponential Growth by Wind

Two expressions for exponential growth by wind are optionally available in the SWAN model. The first expression is due to Komen et al. (1984). Their expression is a function of $\frac{U_*}{C_{ph}}$:

$$B = \max\left[0, 0.25 \frac{\rho_a}{\rho_w} \left[28 \frac{U_*}{C_{ph}} \cos(\theta - \theta_w) - 1\right]\right] \sigma \quad , \tag{11}$$

in which c_{ph} is the phase speed and ρ_a and ρ_w are the density of air and water, respectively. This expression is also used in WAM Cycle 3 (WAMDI group, 1988). The second expression, which is based on a quasi-linear wind-wave theory, is due to Janssen (1989, 1991) and is given by:

$$B = \beta \frac{\rho_a}{\rho_w} \left(\frac{U_*}{c_{ph}}\right)^2 \max[0, \cos(\theta - \theta_w)]^2 \sigma \tag{12}$$

where β is the Miles constant. In the theory of Janssen (1991), this Miles constant is estimated from the non-dimensional critical height λ:

$$\begin{cases} \beta = \frac{1.2}{\kappa^2} \lambda \ln^4 \lambda \ , & \lambda \le 1 \\ \lambda = \frac{g z_e}{c_{ph}^2} e^r , & r = \kappa c / \left| U_* \cos(\theta - \theta_w) \right| \end{cases} \tag{13}$$

where κ is the Von Karman constant, equal to 0.41 and z_e is the effective surface roughness. If the non-dimensional critical height $\lambda > 1$, the Miles constant β is set equal to zero. Janssen (1991) assumes that the wind profile is given by:

$$U(z) = \frac{U_*}{\kappa} \ln\left(\frac{z + z_e - z_o}{z_e}\right) \quad , \tag{14}$$

in which $U(z)$ is the wind speed at height z (10m in the SWAN model) above the mean water level, z_o is the roughness length. The effective roughness length z_e depends on the roughness length z_o and the sea state through the wave induced stress τ_w and the total surface stress τ:

$$z_e = \frac{z_o}{\sqrt{1 - \tau_w / \tau}} \quad \text{and} \quad z_o = \hat{\alpha} \frac{U_*^2}{g} \quad , \tag{15}$$

The second of these two equations is a Charnock-like relation in which $\hat{\alpha}$ is a constant equal to 0.01. The wave stress $\underline{\tau}_w$ vector is given by:

$$\underline{\tau}_w = \rho_w \int_0^{2\pi} \int_0^{\infty} \sigma B \, E(\sigma, \theta) \frac{\underline{k}}{k} \mathrm{d}\sigma \, \mathrm{d}\theta \quad . \tag{16}$$

The value of U_* can be determined for a given wind speed U_{10} and a given wave spectrum $E(\sigma, \theta)$ from the above set of equations. In the SWAN model the iterative procedure of Mastenbroek et al. (1993) is used. This set of expressions (Eq. 12 - 16) is also used in WAM Cycle 4 (Komen et al., 1994).

5.2.4.4 Dissipation of Wave Energy (S_{ds})

5.2.4.4.1 Whitecapping

The pulse-based model of Hasselmann (1974) represents the processes of whitecapping in the SWAN model. Reformulated in terms of wave number (rather than frequency) so as to be applicable in finite water depth (cf. WAMDI group, 1988), this expression is:

$$S_{ds,w}(\sigma, \theta) = -\Gamma \tilde{\sigma} \frac{k}{\tilde{k}} E(\sigma, \theta) \quad , \tag{17}$$

where $\tilde{\sigma}$ and $\tilde{k}$ denote the mean frequency and the mean wave number (for expressions see below) respectively, and the coefficient Γ depends on the overall wave steepness. This steepness dependent coefficient, as given by the WAMDI group (1988), has been adapted by Günther et al. (1992) based on Janssen (1991a, 1991b):

$$\Gamma = \Gamma_{KJ} = C_{ds}\left((1-\delta)+\delta\frac{k}{\tilde{k}}\right)\left(\frac{\tilde{s}}{\tilde{s}_{PM}}\right)^{p} \quad . \tag{18}$$

For $\delta = 0$ the expression of Γ reduces to the expression as used by the WAMDI group (1988). The coefficients C_{ds}, δ and m are tunable coefficients, $\tilde{s}$ is the overall wave steepness (defined below), $\tilde{s}_{PM}$ is the value of $\tilde{s}$ for the Pierson-Moskowitz spectrum (1964; $\tilde{s}_{PM} = (3.02 \times 10^{-3})^{½}$). This overall wave steepness $\tilde{s}$ is defined as:

$$\tilde{s} = \tilde{k}\sqrt{E_{tot}} \quad . \tag{19}$$

The mean frequency $\tilde{\sigma}$, the mean wave number $\tilde{k}$, and the total wave energy E_{tot} are defined as (cf. WAMDI group, 1988):

$$\begin{aligned}\tilde{\sigma} &= \left(E_{tot}^{-1}\int_0^{2\pi}\int_0^{\infty}\frac{1}{\sigma}E(\sigma,\theta)\,d\sigma\,d\theta\right)^{-1} \\ \tilde{k} &= \left(E_{tot}^{-1}\int_0^{2\pi}\int_0^{\infty}\frac{1}{\sqrt{k}}E(\sigma,\theta)\,d\sigma\,d\theta\right)^{-2}\end{aligned} \quad , \tag{20}$$

$$E_{tot} = \int_0^{2\pi}\int_0^{\infty}E(\sigma,\theta)\,d\sigma\,d\theta \quad . \tag{21}$$

The values of the tunable coefficients C_{ds} and δ and exponent p in this model have been obtained by Komen et al., (1984) and Janssen (1992) by closing the energy balance of the waves in idealized wave growth conditions (both for growing and fully developed wind seas) for deep water. This implies that coefficients in the steepness dependent coefficient Γ depend on the wind-input formulation that is used. Since two different wind input formulations are used in the SWAN model, two sets of coefficients are used. For the wind input of Komen et al. (1984; corresponding to WAM Cycle 3; the WAMDI group, 1988): $C_{ds} = 2.36\text{x}10^{-5}$, $\delta = 0$ and $p = 4$. Janssen (1992) and Günther (1992) obtained (assuming $p = 4$) $C_{ds} = 4.10\text{x}10^{-5}$ and $\delta = 0.5$ (as used in the WAM Cycle 4; Komen et al., 1994).

5.2.4.4.2 Bottom Friction

The bottom friction models that have been selected for SWAN are the empirical model of JONSWAP (Hasselmann et al., 1973), the drag law model of Collins (1972) and the eddy-viscosity model of Madsen et al. (1988). The formulations for these bottom friction models can all be expressed in the following form:

$$S_{ds,b}(\sigma,\theta) = -C_{bottom} \frac{\sigma^2}{g^2 \sinh^2(kd)} E(\sigma,\theta) \quad , \qquad (22)$$

in which C_{bottom} is a bottom friction coefficient that generally depends on the bottom orbital motion represented by U_{rms}:

$$U_{rms}^2 = \int_0^{2\pi}\int_0^{\infty} \frac{\sigma^2}{\sinh^2(kd)} E(\sigma,\theta)\, d\sigma\, d\theta \quad . \qquad (23)$$

Hasselmann et al. (1973) found from the results of the JONSWAP experiment $C_{bottom} = C_{JON} = 0.038$ m^{2}s^{-3} for swell conditions. Bouws and Komen (1983) selected a bottom friction coefficient of $C_{JON} = 0.067$ m^{2}s^{-3} for fully developed wave conditions in shallow water. Both values are available in SWAN.

The expression of Collins (1972) is based on a conventional formulation for periodic waves with the appropriate parameters adapted to suit a random wave field. The dissipation rate is calculated with the conventional bottom friction formulation of Eq. 7 in which the bottom friction coefficient is $C_{bottom} = C_f g U_{rms}$ with $C_f = 0.015$ (Collins, 1972). (Note that Collins (1972) contains an error in the expression due to an erroneous Jacobean transformation; see page A-16 of Tolman, 1990).

Madsen et al. (1988) derived a formulation similar to that of Hasselmann and Collins (1968), but in their model the bottom friction factor is a function of the bottom roughness height and the actual wave conditions. Their bottom friction coefficient is given by:

$$C_{bottom} = f_w \frac{g}{\sqrt{2}} U_{rms} \quad , \qquad (24)$$

in which f_w is a non-dimensional friction factor estimated by using the formulation of Jonsson (1966; cf. Madsen et al., 1988):

$$\frac{1}{4\sqrt{f_w}} + \log_{10}\left[\frac{1}{4\sqrt{f_w}}\right] = m_f + \log_{10}\left[\frac{a_b}{K_N}\right] \quad , \qquad (25)$$

in which $m_f = -0.08$ (Jonsson and Carlsen, 1976) and a_b is a representative near-bottom excursion amplitude:

$$a_b^2 = 2\int_0^{2\pi}\int_0^{\infty} \frac{1}{\sinh^2(kd)} E(\sigma,\theta)\, d\sigma\, d\theta \quad , \qquad (26)$$

and K_N is the bottom roughness length scale. For values of a_b / K_N smaller than 1.57 the friction factor f_w is 0.30 (Jonsson, 1980).

5.2.4.4.3 Depth-induced Wave Breaking

To model the energy dissipation in random waves due to depth-induced breaking, the bore-based model of Battjes and Janssen (1978) is used in SWAN. The mean rate of energy dissipation per unit horizontal area due to wave breaking D_{tot} is expressed as:

$$D_{tot} = -\frac{1}{4}\alpha_{BJ} Q_b \left(\frac{\bar{\sigma}}{2\pi}\right) H_m^2 \quad , \tag{27}$$

in which $\alpha_{BJ} = 1$ in SWAN, Q_b is the fraction of breaking waves determined by:

$$\frac{1-Q_b}{\ln Q_b} = -8\frac{E_{tot}}{H_m^2} \quad , \tag{28}$$

in which H_m is the maximum wave height that can exist at the given depth and $\bar{\sigma}$ is a mean frequency defined as:

$$\bar{\sigma} = E_{tot}^{-1} \int_0^{2\pi}\int_0^{\infty} \sigma E(\sigma,\theta) \mathrm{d}\sigma \mathrm{d}\theta \quad . \tag{29}$$

Extending the expression of Eldeberky and Battjes (1995) to include the spectral directions, the dissipation for a spectral component per unit time is calculated in SWAN with:

$$S_{ds,br}(\sigma,\theta) = D_{tot}\frac{E(\sigma,\theta)}{E_{tot}} \quad , \tag{30}$$

The maximum wave height, H_m, is determined in SWAN with $H_m = \gamma d$, in which γ is the breaker parameter and d is the total water depth (including the wave-induced set-up if computed by SWAN). In the literature, this breaker parameter γ is often a constant or it is expressed as a function of bottom slope or incident wave steepness (see e.g., Galvin, 1972; Battjes and Janssen, 1978; Battjes and Stive, 1985; Arcilla and Lemos, 1990; Kaminsky and Kraus, 1993; and Nelson, 1987, 1994). Since SWAN is locally defined, the dependency on incident wave steepness cannot be used. Instead, the other two options (constant value or bottom-slope dependent) were used in SWAN Version 40.01 and older to determine the value of the breaker parameter. In SWAN III Version 40.11 the option of Nelson has been removed as the results of SWAN were better with the option of a constant value.

In the publication of Battjes and Janssen (1978) in which the dissipation model is described, a constant breaker parameter of $\gamma = 0.8$ was used based on Miche's criterion. Battjes and Stive (1985) re-analyzed wave data of a number of laboratory and field experiments and found values for the breaker parameter varying between 0.6 and 0.83 for different types of bathymetry (plane, bar-trough and bar) with an average of 0.73. From a compilation of a large number of experiments Kaminsky and Kraus (1993) have found breaker parameters in the range of 0.6 to 1.59 with an average of 0.79.

5.2.4.5 Nonlinear Wave-wave Interactions (S_{nl})

5.2.4.5.1 Quadruplet Wave-wave Interactions

The quadruplet wave-wave interactions are computed with the DIA as proposed by Hasselmann et al. (1985). Their source code (slightly adapted by Tolman, personal communication, 1993) has been used in the SWAN model. In the DIA two quadruplets of wave numbers are considered, both with frequencies:

$$\begin{aligned} \sigma_1 &= \sigma_2 = \sigma \\ \sigma_3 &= \sigma(1+\lambda) = \sigma^+ \quad , \\ \sigma_4 &= \sigma(1-\lambda) = \sigma^- \end{aligned} \tag{31}$$

where λ is a constant coefficient set equal to 0.25. To satisfy the resonance conditions for the first quadruplet, the wave number vectors with frequency σ_3 and σ_4 lie at an angle of $\theta_1 = -11.5°$ and $\theta_2 = 33.6°$ to the two identical wave number vectors with frequencies σ_1 and σ_2. The second quadruplet is the mirror of this first quadruplet (the wave number vectors with frequency σ_3 and σ_4 lie at mirror angles of $\theta_3 = 11.5°$ and $\theta_4 = -33.6°$).

Within this discrete interaction approximation, the source term $S_{nl4}(\sigma, \theta)$ is given by:

$$S_{nl4}(\sigma,\theta) = S^{*}_{nl4}(\sigma,\theta) + S^{**}_{nl4}(\sigma,\theta) \quad , \tag{32}$$

where S^{*}_{nl4} refers to the first quadruplet and S^{**}_{nl4} to the second quadruplet (the expressions for S^{**}_{nl4} are identical to those for S^{*}_{nl4} for the mirror directions) and:

$$S^{*}_{nl4}(\sigma,\theta) = 2\delta S_{nl4}(\alpha_1\sigma,\theta) - \delta S_{nl4}(\alpha_2\sigma,\theta) - \delta S_{nl4}(\alpha_3\sigma,\theta) \quad , \tag{33}$$

in which $\alpha_1 = 1$, $\alpha_2 = (1+\lambda)$ and $\alpha_3 = (1-\lambda)$. Each of the contributions ($i = 1, 2, 3$) is:

$$\delta S_{nl4}(\alpha_i\sigma,\theta) = C_{nl4}(2\pi)^2 g^{-4}\left(\frac{\sigma}{2\pi}\right)^{11}\left[E^2(\alpha_i\sigma,\theta)\left(\frac{E(\alpha_i\sigma^+,\theta)}{(1+\lambda)^4}+\frac{E(\alpha_i\sigma^-,\theta)}{(1-\lambda)^4}\right) - 2\frac{E(\alpha_i\sigma,\theta)E(\alpha_i\sigma^+,\theta)E(\alpha_i\sigma^-,\theta)}{(1-\lambda^2)^4}\right] \quad (34)$$

The constant $C_{nl4} = 3\times10^7$. Following Hasselmann and Hasselmann (1981), the quadruplet interaction in finite water depth is taken identical to the quadruplet transfer in deep water multiplied with a scaling factor R:

$$S_{nl4,\,finitedepth} = R(k_p d)\, S_{nl4,infinitedepth} \quad , \qquad (35)$$

where R is given by:

$$R(k_p d) = 1 + \frac{C_{sh1}}{k_p d}\left(1 - C_{sh2}\cdot k_p d\right)\exp\left(C_{sh3}\cdot k_p d\right) \quad , \qquad (36)$$

in which k_p is the peak wave number of the JONSWAP spectrum for which the original computations were carried out. The values of the coefficients are: $C_{sh1} = 5.5$, $C_{sh2} = 6/7$ and $C_{sh3} = -1.25$. In the shallow water limit, i.e., $k_p d \rightarrow 0$ the nonlinear transfer tends to infinity. Therefore a lower limit of $k_p d = 0.5$ is applied (cf. WAM Cycle 4; Komen et al., 1994), resulting in a maximum value of $R(k_p d) = 4.43$. To increase the model robustness in case of arbitrarily shaped spectra, the peak wave number k_p is replaced by $k_p = 0.75\tilde{k}$ (Komen et al., 1994).

5.2.4.5.2 *Triad Wave-wave Interactions*

The LTA of Eldeberky (1996), which is a slightly adapted version of the Discrete Triad Approximation (DTA) of Eldeberky and Battjes (1995), is used in SWAN in each spectral direction:

$$S_{nl3}(\sigma,\theta) = S^-_{nl3}(\sigma,\theta) + S^+_{nl3}(\sigma,\theta) \quad , \qquad (37)$$

with

$$S^+_{nl3}(\sigma,\theta) = \max\left\{0, \alpha_{EB} 2\pi c c_g J^2 |\sin(\beta)| \left\{E^2(\sigma/2,\theta) - 2E(\sigma/2,\theta)\,E(\sigma,\theta)\right\}\right\} \quad , \qquad (38)$$

and

$$S_{nl3}^{-}(\sigma,\theta) = -2S_{nl3}^{+}(2\sigma,\theta) \quad , \tag{39}$$

in which α_{EB} is a tunable proportionality coefficient. The biphase β is approximated with

$$\beta = -\frac{\pi}{2} + \frac{\pi}{2}\tanh\left(\frac{0.2}{Ur}\right) \quad , \tag{40}$$

with *ursell* number Ur

$$Ur = \frac{g}{8\sqrt{2}\pi^2}\frac{H_s\overline{T}^2}{d^2} \quad , \tag{41}$$

where $\overline{T} = 2\pi/\overline{\sigma}$. The triad wave-wave interactions are calculated only for $10 > Ur > 0.1$. The interaction coefficient J is taken from Madsen and Sørensen (1993):

$$J = \frac{k_{\sigma/2}^2(g\,d + 2c_{\sigma/2}^2)}{k_\sigma d(g\,d + \frac{2}{15}g\,d^3k_\sigma^2 - \frac{2}{5}\sigma^2 d^2} \quad . \tag{42}$$

5.2.4.5.3 *Wave-induced Set-up*

In a (geographic) 1-D case the computation of the wave induced set-up is based on the vertically integrated momentum balance equation which is a balance between the wave force (gradient of the wave radiation stress normal to the coast) and the hydrodynamic pressure gradient (note that the component parallel to the coast causes wave-induced currents but no setup).

$$F_x + g\,d\frac{\partial\overline{\eta}}{\partial x} = 0 \tag{43}$$

where d is the total water depth (including the wave-induced set-up) and η is the mean surface elevation (including the wave-induced set-up).

Observation and computations based on the vertically integrated momentum balance equation of Dingemans et al. (1987) show that the wave-induced currents are mainly driven by the divergence-free part of the wave forces, whereas the set-up is mainly due to the rotation-free part of these forces. To compute the set-up, it would then be sufficient to consider the divergence of the momentum balance equation. If the divergence of the acceleration in the resulting equation is ignored, the result is:

$$\frac{\partial F_x}{\partial x}+\frac{\partial F_y}{\partial y}+\frac{\partial}{\partial x}\left(g\,d\frac{\partial \zeta}{\partial x}\right)+\frac{\partial}{\partial y}\left(g\,d\frac{\partial \zeta}{\partial y}\right)=0 \quad . \tag{44}$$

5.2.5 Numerical Implementation

The integration of the action balance equation has been implemented in SWAN with finite difference schemes in all five dimensions, including time, geographic space and spectral space, etc. These are first described for the propagation of the waves without the source terms for generation, dissipation and wave-wave interactions. Then the implementation of these source terms is described.

Time is discretized with a simple constant timestep, Δt, for the simultaneous integration of the propagation and the source terms. This is different from how time was discretized in the WAM model or the WAVEWATCH III model where the timestep for propagation is different from the timestep for the source terms. Geographic space is discretized with a rectangular grid with constant resolutions Δx and Δy in x- and y-direction respectively (in fact, this rectangular grid is a special case of the curvilinear grid that has been programmed in SWAN). The spectrum in the model is discretized with a constant directional resolution $\Delta\theta$ and a constant relative frequency resolution $\Delta\sigma/\sigma$ (logarithmic frequency distribution). For reasons of economy, an option is available to compute only wave components traveling in a pre-defined directional sector ($\theta_{\min} < \theta < \theta_{\max}$; e.g., those components that travel shoreward within a limited directional sector). The discrete frequencies are defined between a fixed low-frequency cut-off and a fixed high-frequency cut-off (the prognostic part of the spectrum). For these frequencies the spectral density is unconstrained. Below the low-frequency cut-off (typically f_{min} = 0.04 Hz for field conditions) the spectral densities are assumed to be zero. Above the high-frequency cut-off (typically 1 Hz for field conditions) a diagnostic tail f^{-m} is added (this tail is used to compute nonlinear wave-wave interactions at the high frequencies and to compute integral wave parameters). The reason for using a fixed high-frequency cut-off rather than a dynamic cut-off frequency that depends on the wind speed or on the mean frequency, as in WAM and WAVEWATCH III, is that in coastal regions mixed sea states with rather different characteristic frequencies may occur. For instance, a local wind may generate a very young sea behind an island, totally unrelated to (but superimposed on) a simultaneously occurring swell. In such cases a dynamic cut-off frequency may be too low to properly account for the locally generated sea state. Based on physical arguments the value of m (the power in the above expression of the spectral tail) should be between four and five (e.g., Phillips, 1985). In SWAN, m = 4 if the wind input formulation of Komen et al. (1984) is used (cf. WAM Cycle 3), and m = 5 if the wind input formulation of Janssen (1991a) is used (WAM Cycle 4).

5.2.5.1 Propagation

The numerical schemes in SWAN have been chosen on the basis of robustness, accuracy and economy. Since the nature of the basic equation is such that the state in a grid point is determined by the state in the upwave grid points, the most robust scheme would be an implicit upwind scheme (in both geographic and spectral space). The adjective "implicit" is used here to indicate that all derivatives of action density (in t, x or y) are formulated at one computational level (i_t, i_x or i_y) except the derivative in the integration dimension for which also the previous or upwave level is used (time in non-stationary mode and x or y in stationary mode). For such a scheme the values of the time and space steps Δt, Δx, and Δy would be mutually independent. An implicit scheme would also be economical in the sense that such a scheme is unconditionally stable. It permits relatively large timesteps in the computations (much larger than for explicit schemes in shallow water). Several years of experience in using the second-generation HISWA shallow water wave model (Holthuijsen et al., 1989) has shown that for coastal regions a first-order upwind difference scheme in geographic space is usually accurate enough. This experience, together with test computations with SWAN has also shown that in spectral space a higher accuracy than that of a first-order upwind scheme is required. This can be achieved by supplementing such a scheme with a second-order central approximation (more economic than a second-order upwind scheme). For SWAN therefore, implicit upwind schemes in both geographic and spectral space have been chosen, supplemented with a central approximation in spectral space.

The fact that in geographic space, the state in a grid point is determined by the state in the upwave grid points (as defined by the direction of propagation), permits a decomposition of the spectral space into four quadrants (eight octants would be an alternative). In each of the quadrants the computations can be carried out independently from the other quadrants except for the interactions between them due to refraction and nonlinear wave-wave interactions (formulated in corresponding boundary conditions between the quadrants). The wave components in SWAN are correspondingly propagated in geographic space with an upwind scheme (upwind is the common term in numerical analysis, but up-wave would be more appropriate in the case of SWAN). SWAN contains three such schemes:

a. First-order (stationary and non-stationary cases) backward space-backward time (BSBT) scheme,
b. Second-order (non-stationary cases) with third-order diffusion: the S&L scheme (Stelling and Leedertse, 1992),
c. Second-order (stationary cases) with second-order diffusion (SORDUP) scheme.

The BSBT scheme (not default in SWAN) will be discussed first and then the extension to the higher order schemes that are default in SWAN. The first-order upwind scheme (BSBT) is a sequence of four forward-marching sweeps (one per quadrant). To properly account for the boundary conditions between the four quadrants, the computations are carried out iteratively at each timestep. The integration in time is a simple backward finite difference, so that the discretization of the action balance equation is (for positive propagation speeds; including the computation of the source terms but ignoring their discretization):

$$\left[\frac{N^{i_t,n}-N^{i_t-1}}{\Delta t}\right]_{i_x,i_y,i_\sigma,i_\theta} + \left[\frac{[c_xN]_{i_x} - [c_xN]_{i_x-1}}{\Delta x}\right]^{i_t,n}_{i_y,i_\sigma,i_\theta} + \left[\frac{[c_yN]_{i_y} - [c_yN]_{i_y-1}}{\Delta y}\right]^{i_t,n}_{i_x,i_\sigma,i_\theta}$$

$$+\left[\frac{(1-\nu)[c_\sigma N]_{i_\sigma+1} + 2\nu[c_\sigma N]_{i_\sigma} - (1+\nu)[c_\sigma N]_{i_\sigma-1}}{2\Delta\sigma}\right]^{i_t,n}_{i_x,i_y,i_\theta} +$$

$$\left[\frac{(1-\eta)[c_\theta N]_{i_\theta+1} + 2\eta[c_\theta N]_{i_\theta} - (1+\eta)[c_\theta N]_{i_\theta-1}}{2\Delta\theta}\right]^{i_t,n}_{i_x,i_y,i_\sigma} = \left[\frac{S}{\sigma}\right]^{i_t,n^*}_{i_x,i_y,i_\sigma,i_\theta} \quad (45)$$

where i_t is the time-level index and i_x, i_y, i_σ and i_θ are grid counters and Δt, Δx, Δy, $\Delta\sigma$, and $\Delta\theta$ are the increments in time, geographic space and spectral space respectively. The iterative nature of the computation is indicated with the iteration index n (the iteration index for the source terms n^* is equal to n or n-1, depending on the source term, see below). Because of these iterations, the scheme is also approximately implicit for the source terms. For negative propagation speeds, appropriate + and - signs are required in Eq. 45.

The coefficients ν and η determine the degree to which the scheme in spectral space is upwind or central. They control the numerical diffusion in frequency and directional space, respectively. A value of $\nu = 0$ or $\eta = 0$ corresponds to central schemes which have the largest accuracy (numerical diffusion ≈ 0). Value of $\nu = 1$ or $\eta = 1$ correspond to upwind schemes which are somewhat more diffusive and therefore less accurate but more robust. If large gradients of the action density in frequency space or directional space are present, numerical oscillations can arise (especially with the central difference schemes) resulting in negative values of the action density. In each sweep such negative values are removed from the two-dimensional spectrum by setting these values equal to zero and rescaling the remaining positive values such that the frequency-integrated action density per spectral direction is conserved. The depth derivatives and current derivatives in the expressions of c_σ and c_θ are calculated with a first-order upwind scheme. For very strong refraction the value of c_θ is reduced in each grid point and for each wave component individually with the square of the fraction of the grid spacing over which $kd < 3.0$.

For stationary conditions SWAN can be run in stationary mode. Time is then removed as a variable but the integration (in geographic space) is still carried out iteratively. The propagation scheme is still implicit as the derivatives of action density (in x or y) at the computational level (i_x or i_y, respectively) are formulated at that level except in the integration dimension (x or y; depending on the direction of propagation) where the upwave level is used. The values of Δx and Δy are therefore still mutually independent.

For the stationary second-order upwind scheme (Rogers et al., 2000; SORDUP) which is the default scheme for stationary computations, the two terms in Eq. 45 representing x- and y-derivatives are replaced by:

$$\left[\frac{1.5[c_xN]_{i_x} - 2[c_xN]_{i_x-1} + 0.5[c_xN]_{i_x-2}}{\Delta x}\right]_{i_y,i_\sigma,i_\theta}^{i_t,n} + \left[\frac{1.5[c_yN]_{i_y} - 2[c_yN]_{i_y-1} + 0.5[c_yN]_{i_y-2}}{\Delta y}\right]_{i_x,i_\sigma,i_\theta}^{i_t,n} \quad (45a)$$

For the non-stationary second-order upwind scheme (Rogers et al., 2000; S&L), which is the default scheme for non-stationary computations, the two terms in Eq. 45 representing x- and y-derivatives are replaced by:

$$\left[\frac{\frac{5}{6}[c_xN]_{i_x} - \frac{5}{4}[c_xN]_{i_x-1} + \frac{1}{2}[c_xN]_{i_x-2} - \frac{1}{12}[c_xN]_{i_x-3}}{\Delta x}\right]_{i_y,i_\sigma,i_\theta}^{i_t,n} + \left[\frac{\frac{5}{6}[c_yN]_{i_y} - \frac{5}{4}[c_yN]_{i_y-1} + \frac{1}{2}[c_yN]_{i_y-2} - \frac{1}{12}[c_yN]_{i_y-3}}{\Delta y}\right]_{i_x,i_\sigma,i_\theta}^{i_t,n} +$$
$$\left[\frac{\frac{1}{4}[c_xN]_{i_x+1} - \frac{1}{4}[c_xN]_{i_x-1}}{\Delta x}\right]_{i_y,i_\sigma,i_\theta}^{i_t-1} + \left[\frac{\frac{1}{4}[c_yN]_{i_y+1} - \frac{1}{4}[c_yN]_{i_y-1}}{\Delta y}\right]_{i_x,i_\sigma,i_\theta}^{i_t-1} \quad (45b)$$

To explain the above numierical solution technique in terms of matrix solutions, first ignore the decomposition in quadrants. The propagation of the waves in both geographic and spectral space would then be described with one large basic matrix that can be solved in several ways. Removing refraction, frequency shifting and nonlinear source terms from this basic matrix permits a matrix solution with a Gauss-Seidel technique (e.g., Golub and van Loan, 1986) in which the matrix is decomposed in four sections (the above four directional quadrants) which are each solved in one step (super-convergence). Restoring refraction and frequency shifting to the matrix requires the solution of a submatrix for each geographic grid point. If no currents are present and the depth is stationary, this is readily done with a Thomas algorithm (e.g., Abbott and Basco, 1989; $c_\sigma = 0$ and the sub-matrix is a simple tri-diagonal matrix). If currents are present or the depth is not stationary, the sub-matrix is a band matrix. It is solved with an iterative ILU-CGSTAB method (Vuik, 1993; Van der Vorst, 1992). Restoring refraction and frequency-shifting also introduces coefficients in each matrix section (directional quadrant) that cause dependency between the matrix sections. The same happens when nonlinear source terms are added to the matrix. The basic matrix as a whole therefore needs to be solved iteratively until some break-off criteria are met. To reduce the number of iterations in stationary mode with wind generation, SWAN starts with a reasonable first-guess of the wave field (a "quickstart" based on the second-generation source terms of Holthuijsen and De Boer, (1988) adapted for shallow water). It reduces the number of iterations typically by a factor two. In non-stationary mode, a very reasonable first-guess per timestep is available from the previous timestep and the number of iterations is expected to be small. If no iterations are used in non-stationary mode (as in most phase averaged wave models), the computations of propagation are still implicit and therefore still unconditionally stable.

In the neighborhood of grid points which represent open boundaries, land boundaries and obstacles (i.e., the last two grids adjoining such grid points for the SORDUP scheme and the last three grids adjoining such grid points for the S&L scheme), SWAN will revert to the first-order BSBT scheme. This scheme has a larger numerical diffusion but that is usually acceptable over the small distances involved.

The numerical diffusion of the S&L scheme is so small that the so-called garden-sprinkler effect (GSE) may show up if propagation over very large distances is considered. This effect is due to the spectral resolution (Booij and Holthuijsen, 1987). It can be counteracted by a diffusion term that has been explicitly added to the numerical scheme (not default in SWAN). Its value depends on the spectral resolution and the propagation time of the waves (see the input variable [wave age] in the SCHEME command).

The diffusion applied in the propagation direction is:

$$D_{ss} = \Delta c^2 T / 12 \quad , \tag{46}$$

where T is the wave age.

The diffusion normal to the propagation direction is:

$$D_{ss} = c^2 \Delta\theta^2 T / 12 \quad . \tag{47}$$

From these diffusion coefficients (in terms of x and y) are calculated:

$$D_{xx} = D_{ss}\cos^2\theta + D_{nn}\sin^2\theta;$$
$$D_{yy} = D_{ss}\sin^2\theta + D_{nn}\cos^2\theta; \qquad (48)$$
$$D_{xy} = (D_{ss} - D_{nn})\cos\theta\sin\theta\,.$$

The diffusion terms are computed at the time level $i_t - 1$. The diffusion terms are computed as follows:

$$D_{xx}\left[\frac{[N]_{i_x+1} - 2[N]_{i_x} + [N]_{i_x-1}}{\Delta x^2}\right]_{i_y,i_\sigma,i_\theta}^{i_t-1}$$
$$D_{yy}\left[\frac{[N]_{i_y+1} - 2[N]_{i_y} + [N]_{i_y-1}}{\Delta y^2}\right]_{i_x,i_\sigma,i_\theta}^{i_t-1} \qquad . \qquad (49)$$
$$D_{xy}\left[\frac{[N]_{i_x,i_y} - [N]_{i_x-1,i_y} - [N]_{i_x,i_y-1} + [N]_{i_x-1,i_y-1}}{\Delta x \Delta y}\right]_{i_\sigma,i_\theta}^{i_t-1}$$

This explicit finite differentiation is fast (having little impact on computation time) but only conditionally stable. Through mathematical analysis (not shown) it can be shown that a likely stability condition for the one-dimensional S&L scheme with this GSE correction is $D\Delta t/(\Delta x^2) \leq 0.5$ which corresponds to the two-dimensional stability criterion of Tolman (1995); (based on Fletcher, 1988):

$$Q = \frac{\max(D_{xx}, D_{yy}, D_{xy})\Delta t}{\min(\Delta x \Delta y)^2} \leq 0.5 \qquad . \qquad (50)$$

Thus it is credible that Eq. 50 holds true for the two-dimensional S&L scheme with this GSE correction. In experiments, it was found that for all experiments which satisfy the slightly more restrictive $Q \leq 0.48$ instability was observed. In short, by adding the GSE correction, the unconditionally stable advection scheme of SWAN becomes a (likely) conditionally stable advection diffusion scheme. It is readily shown that for typical ocean applications D_{nn} dominates the diffusion and can be written as:

$$Q = \overline{C}T/\Delta x.\overline{C}\Delta t/\Delta x.\Delta\theta^2/12 \qquad . \qquad (51)$$

The variable wave age $\overline{T}$ could be computed during the computations of SWAN (Booij and Holthuijsen, 1987) but it requires the same order of magnitude of computer memory as integrating the action balance equation. Instead a constant wave age $\overline{T}$ can be used as an approximation, so that Eq. 51 becomes

$$Q = \overline{L}/\Delta x.\mu.\Delta\theta/12 \qquad , \qquad (52)$$

where the characteristic travel distance of the waves is $\overline{L} = \overline{C}\overline{T}$ (e.g., the dimension of the ocean basin). For oceanic applications the Courant number is typically $\mu \approx ½$ so that $Q \leq 0.25$ for typical values of $\Delta\theta$ and $\overline{L} / \Delta x$ (the number of grid point in one direction of the grid). This implies that the S&L scheme with this GSE correction is stable for typical ocean cases. For shelf sea (regional) applications the value of $\mu = O(1)$ but the garden-sprinkler effect tends to be small on these scales and the diffusion can and should not be used to avoid the stability problem. For small-scale (local) applications typically $\mu = O(10\text{-}100)$. But such cases are usually treated as stationary and the SORDUP scheme should be used (no GSE correction is included in this scheme).

The boundary conditions in SWAN, both in geographic space and spectral space are fully absorbing for wave energy that is leaving the computational domain or crossing a coastline. The incoming wave energy along open geographic boundaries needs to be prescribed by the user. For coastal regions such incoming energy is usually provided only along the deep-water boundary and not along the lateral geographic boundaries (i.e., the spectral densities are assumed to be zero). This implies that such erroneous lateral boundary conditions are propagated into the computational area. The affected areas are typically triangular regions with the apex at the corners, between the deep-water and lateral boundaries, spreading towards shore at an angle of 30° to 45° (for wind sea conditions) on either side of the deep-water mean wave direction (less for swell conditions; this angle is essentially equal to the one-sided width of the directional distribution of the incoming wave spectrum). For this reason the lateral boundaries should be sufficiently far away from the area of interest to avoid the propagation of this error into the area.

5.2.5.1.1 Generation, Wave-wave Interactions and Dissipation

The numerical estimations of the source terms in SWAN are essentially implicit. This is achieved with explicit or implicit approximations of the source terms which in the limit of a large number of iterations, always result in an implicit estimation. In actual computations final convergence is obviously never achieved and the estimations of the source terms are therefore strictly speaking only approximately implicit. In the following, "explicit" and "implicit" refer to the approximations of the source terms within each iteration.

The linear growth term A is independent of integral wave parameters and of the energy density and can therefore be readily computed. All other source terms depend on energy density and they can be described as a (quasi-) linear term: $S = \phi E$, in which ϕ is a coefficient that depends on (integral) wave parameters (e.g., E_{tot}, $\tilde{\sigma}$, $\tilde{k}$, σ, k, etc.) and action densities of other spectral components. Since these are only known at the previous iteration level n-1, the coefficient is determined at that iteration level: $\phi = \phi^{n-1}$.

For positive source terms (wind input and the triad wave-wave interactions if positive) the integration is generally more stable if an explicit formulation is used (i.e., the source term depends on E^{n-1} and not on E^n) rather than an implicit formulation (i.e., the source term also depends on E^n). The explicit formulation for these source terms in SWAN is therefore:

$$S^n \approx \phi^{n-1} E^{n-1} \quad . \tag{53}$$

For reasons of economy this explicit approximation is also used for the formulation of the quadruplet wave-wave interactions (for both the positive and negative contributions). This is considered reasonable since Tolman (1992a) has shown that using an explicit formulation in combination with a limiter (see below) gives similar results as the use of a more expensive implicit scheme (this implicit formulation is optionally available in SWAN; in the WAM model it is indicated as the semi-implicit scheme, (the WAMDI group, (1988); Komen et al, (1994))).

For negative source terms the integration is generally more stable if an implicit scheme is used. The strongly nonlinear, negative source term of depth-induced wave breaking at iteration level n is accordingly estimated with a linear approximation:

$$S^n \cong \phi^{n-1} E^{n-1} + \left(\frac{\partial S}{\partial E}\right)^{n-1} (E^n - E^{n-1}) \quad . \tag{54}$$

However, to achieve even more stable computations for this source term, the term $\phi^{n-1}E^{n-1}$ in this formulation has been replaced by $\phi^{n-1}E^n$ (making the formulation somewhat more implicit and thus more robust; note that in the limit the solution is the same). Since this process of depth-induced wave breaking has been formulated such that $S = aS_{tot}$ and $E = aE_{tot}$, the derivative is $\partial S / \partial E$ analytically determined as $\partial S_{tot} / \partial E_{tot}$ (where is a identical in both expressions and the total energy E_{tot} and the total source S_{tot} are the integrals over all frequencies and directions of $E(\sigma, \theta)$ and $S_{ds,br}(\sigma, \theta)$, respectively). For the other negative (mildly nonlinear) source terms, i.e., whitecapping, bottom friction and negative triad wave-wave interactions, a similar accuracy of estimating S^n can be achieved with the following simpler, and therefore more economical approximation in which $(\partial S / \partial E)^{n-1}$ of Eq. 14 has been replaced by $(S/E)^{n-1}$

$$S^n \cong \phi^{n-1} E^{n-1} + \left(\frac{S}{E}\right)^{n-1} (E^n - E^{n-1}) \quad . \tag{55}$$

With $S = \phi E$, this reduces to:

$$S^n \cong \phi^{n-1} E^n \quad . \tag{56}$$

These approximations for the source terms are added to the elements of the matrix for the propagation. To suppress the development of numerical instabilities, the maximum total change of action density per iteration at each discrete wave component is limited to a fraction of 10% of the Phillips (1957) equilibrium level (reformulated in terms of action density and wave number to be applicable in shallow water; as in the WAM model and in the WAVEWATCH III model (Tolman, 1992a)):

$$\left|\Delta N(\sigma,\theta)\right|_{\max} = \frac{0.1}{2\pi\sigma}\frac{\alpha_{PM}\pi}{k^3 c} \quad , \qquad (57)$$

where $\alpha_{PM} = 0.0081$ is the Phillips' "constant" of the Pierson-Moskowitz (1964) spectrum. To retain the very rapid but realistic decrease of wave energy near the shore due to depth-induced wave breaking, this limiter is not applied if the waves actually break (in SWAN: $H_{rms}/H_{\max} < 0.2$ with $H_{rms} = \sqrt{8E_{tot}}$ which implies a fraction of breakers $Q_b >$ 0.00001).

The fraction of depth-induced breakers (Q_b) is determined in SWAN with

$$Q_b = 0 \qquad \text{for} \quad \beta \le 0.2$$

$$Q_b = Q_0 - \beta^2 \frac{Q_0 - \exp((Q_0 - 1)/\beta^2)}{\beta^2 - \exp((Q_0 - 1)/\beta^2)} \qquad \text{for} \quad 0.2 < \beta < 1 \qquad (58)$$

$$Q_b = 1 \qquad \text{for} \quad \beta \ge 1$$

where $\beta = H_{rms}/H_{\max}$. For $\beta \le 0.5$, $Q_0 = 1$, and for $0.5 < \beta \le 1$, $Q_0 = (2\beta - 1)^2$.

5.2.5.1.2 Wave-induced Set-up

In 1-D cases the wave-induced set-up is calculated in SWAN with a simple trapezoidal rule.

In 2-D cases the Poisson equation of the divergence-free force field is solved in SWAN with the same solver that is used for wave propagation with ambient currents. The boundary conditions for this elliptical partial differential equation are:

Non-nested computations:

- At open boundaries, the equilibrium between wave force and hydrodynamic pressure gradient is normal to the model boundary,
- At last grid points before shoreline, the equilibrium between wave force and hydrodynamic pressure gradient is normal to the model boundary,
- At deepest boundary point, the set-up is zero.

Nested computations:

- At open boundaries, the set-up is taken from the larger computation,
- At last grid points before shoreline, the equilibrium between wave force and hydrodynamic pressure gradient is normal to the model boundary.

The shoreline in SWAN moves as dictated by the wave-induced set-up. The set-up computations are available on both the rectilinear and curvilinear grids.

5.2.5.1.3 Curvilinear Grid

The propagation scheme in SWAN for geographic space is formulated on a curvilinear geographic grid (irregular, quadrangular, and not necessarily orthogonal) rather than the rectilinear grid of SWAN Cycle I. This modification is based on approximating the geographic distribution of the energy (action) density between each three neighboring grid points with a flat triangle. The gradient in each grid point at location (x_i, y_j) is then readily approximated from the up-wind grid points. For the x-direction this approximation is for grid point i, j (the grid points are ordered in x, y-space with labels i and j respectively):

$$\frac{\partial C_x N}{\partial x} \cong \left[\frac{[c_x N]_{i,j} - [c_x N]_{i-1,j}}{\Delta\tilde{x}_1}\right] + \left[\frac{[c_x N]_{i,j} - [c_x N]_{i,j-1}}{\Delta\tilde{x}_2}\right] \quad , \qquad (59)$$

where $\Delta\tilde{x}_1 = \Delta x_1 - (\Delta y_1 / \Delta y_2)\Delta x_2$, $\Delta\tilde{x}_2 = \Delta x_2 - (\Delta y_2 / \Delta y_1)\Delta x_1$. The increments are $\Delta x_1 = x_{i,j} - x_{i-1,j}$, $\Delta x_2 = x_{i,j} - x_{i,j-1}$, $\Delta y_1 = y_{i,j} - y_{i-1,j}$ and $\Delta y_2 = y_{i,j} - y_{i,j-1}$. The gradient in y-direction is similarly estimated.

5.2.6 SWAN Physics

SWAN accounts for the following Physics:

- wave propagation in time and space, shoaling, refraction due to current and depth, frequency shifting due to currents and non-stationary depth;
- wave generation by wind;
- three- and four-wave interactions;
- whitecapping, bottom friction, and depth-induced breaking;
- wave induced setup;
- propagation from laboratory up to global scales;
- transmission through and reflection from obstacles.

5.3 SWAN Routines

5.3.1 Command Reading Routines (ocpcre FOR File)

5.3.1.1 Logical Function EQCSTR

Function EQCSTR is assigned the value True if the two strings are the same (case-insensitive).

Calling Sequence:	eqcstr (str1, str2)	
Data Declaration:	Character	str1, str2
Arguments:	str1, str2	Two character strings to be compared.

5.3.1.2 Subroutine GETKAR

Subroutine GETKAR reads the next character (KAR) from the string KAART. The position of this character in KAART is indicated by KARNR. If needed, a new input line is read. At the end of the input file, ELTYPE is made EOF.

5.3.1.3 Subroutine IGNORE

Subroutine IGNORE calls subroutine INKEYW to read a keyword. If this keyword is equal to *string*, ELTYPE is made USED. It is used if a keyword can occur in the input, which does not lead to any action.

Calling Sequence:	ignore (string)	
Data Declaration:	Character	string
Arguments:	string	Keyword (if appearing in the input file) that can be ignored.

5.3.1.4 Subroutine INCSTR

Subroutine INCSTR reads a string in free format.

Calling Sequence:	incstr (naam, c, kont, csta)	
Data Declaration:	Character	naam, c, kont, csta

Arguments:	naam	Name of the variable according to the User's Manual.
	kont	Variable options: = req Error message if no value is found in the input file; = unc If no value, then variable will not be changed; = sta If no value, then variable will get default value; = rqi Variable may not have the value of *csta*; = rep Repeat; = nskp No skip. If data item is of different type, value is left unchanged.
	c	String to be read from the input file.
	csta	Default value of the string.

5.3.1.5 Subroutine INCTIM

Subroutine INCTIM reads and interprets a time string.

Calling Sequence: inctim (ioptim, naam, rv, kont, rsta)

Data Declaration:	Integer	ioptim
	Real	rv, rsta
	Character	naam, kont

Arguments:	ioptim	Time reading option (see subroutine DTSTTI).
	rv	Variable that is to be assigned a value.
	rsta	Default value.
	naam	Name of the variable according to the User's Manual.
	kint	Variable options: = req Error message if no value is found in the input file; = unc If no value, then variable will not be changed; = sta If no value, then variable will get default value; = rqi Variable may not have the value of *rsta*; = rep Repeat; = nskp No skip. If data item is of different type, value is left unchanged.

5.3.1.6 Subroutine INDBLE

Subroutine INDBLE reads a double precision number in free format.

Calling Sequence: indble (naam, r, kont, rsta)

Data Declaration:

Real	r, rsta
Character	naam, kont

Arguments:

r	The value of the variable that is to be read.
rsta	Reference value needed for *kont* = sta or rqi
kont	Variable options: = req Variable is required; = unc If no variable, then variable will not be changed; = sta If no variable, then variable will get value of *rsta*; = rqi Variable may not have the value of *rsta*; = rep Repeat; = nskp No skip. If the data item is of a different type then the value is left unchanged.
naam	Name of the variable according to the User's Manual.

5.3.1.7 Subroutine ININTG

Subroutine ININTG reads an integer number in free format.

Calling Sequence: inintg (naam, iv, kont, ista)

Data Declaration:

Integer	iv, ista
Character	kont, naam

Arguments:

iv	Integer variable that is to be assigned a value.
ista	Default value.
naam	Name of the variable according to the User's Manual.
kont	Variable options: = req Error message if no value is found in the input file; = unc If no value, then variable will not be changed; = sta If no value, then variable will get default value;

= rqi	Variable may not have the value of *rsta*;
= rep	Repeat;
= nskp	No skip. If the data item is of a different type, then the value is left unchanged.

5.3.1.8 Subroutine ININTV

Subroutine ININTV reads a time interval in the form: number day/hr/min/sec.

Calling Sequence: inintv (naam, rvar, kont, rsta)

Data Declaration:

Character	kont, naam
Real	rvar, rsta

Arguments:

naam	Name of the variable according to the User's Manual.
kont	Variable options: = req Error message if no value is found in the input file; = unc If no value, then variable will not be changed; = sta If no value, then variable will get default value; = rqi Variable may not have the value of *rsta*; = rep Repeat; = nskp No skip. If data item is of a different type, value is left unchanged.
rsta	Default value.
rvar	Variable that is to be assigned a value.

5.3.1.9 Subroutine INKEYW

Subroutine INKEYW reads a keyword.

Calling Sequence: inkeyw (kont, csta)

Data Declaration:

Character	kont, csta

Arguments:

kont	Action to be taken if no keyword is found in input: = req Required. Error message; = sta Standard. The value of *csta* is assigned to keyword.
csta	Default value of the string.

5.3.1.10 Subroutine INREAL

Subroutine INREAL reads a real number in free format.

Calling Sequence: inreal (naam, r, kont, rsta)

Data Declaration:

Real	r, rsta
Character	naam, kont

Arguments:

r	The value of the variable that is to be read.
rsta	Reference value needed for *kont* = sta or rqi.
kont	Variable options: = req Variable is required; = unc If no variable, then variable will not be changed; = sta If no variable, then variable will get value of *rsta*; = rqi Variable may not have the value of *rsta*; = rep Repeat; = nskp No skip. If data item is of different type, then the value is left unchanged.
naam	Name of the variable according to the User's Manual.

5.3.1.11 Subroutine KEYWIS

Function KEYWIS tests whether or not a keyword given by the user coincides with a keyword known in the program (i.e. *string*). If so, KEYWIS is made True, otherwise it is False. ELTYPE is made USED, so that the next element can be read.

Calling Sequence: keywis (string)

Data Declaration: Character string

Arguments:

string	A keyword, which is compared with another keyword found in the input file.

5.3.1.12 Subroutine LEESEL

Subroutine LEESEL reads a new data item from the string KAART. The type of the item is determined, and the contents appear in ELTEXT, ELINT, or ELREAL, as the case may be.

The following types are distinguished:

KEY	Keyword.
INT	Integer or real number.
REAL	Real number.
CHAR	Character string enclosed in quotes.
EMPT	Empty data field.
OTHR	Non-empty data item not recognized as real, integer or character. Possibly a time string.
EOF	End of input file.
EOR	End of repeat or end of record.
ERR	Error.
USED	Used, item last read is processed already.

5.3.1.13 Subroutine NWLINE

Subroutine NWLINE jumps to the reading of the next input line if the end of the previous one is reached.

5.3.1.14 Subroutine PUTKAR

Subroutine PUTKAR inserts a character (*karr*), usually read by subroutine GETKAR, into the string *ltext*, which is equal to ELTEXT, in the place *jkar*. After this, *jkar* is increased by one.

Calling Sequence: putkar (ltext, karr, jkar)

Data Declaration:	Integer	jkar
	Character	karr, ltext

Arguments:	jkar	Counts the number of characters in a data field.
	ltext	Character string. After a number of calls it will contain the character representation of a data field.
	karr	Character to be inserted into *ltext*.

5.3.1.15 Subroutine RDINT

Subroutine RDINT initializes the command reading system.

5.3.1.16 Subroutine UPCASE

Subroutine UPCASE changes all characters of the string *charst* from lower to uppercase.

Calling Sequence:	upcase (charst)	
Data Declaration:	Character	charst
Arguments:	charst	A character string.

5.3.1.17 Subroutine WRNKEY

Subroutine WRNKEY produces an error message. It is called if an illegal keyword is found in the user's input. It makes ELTYPE = USED.

5.3.2 Dynamic Data Pool Routines (ocpdpn FOR Files)

5.3.2.1 Subroutine COPYCH

Subroutine COPYCH copies a string into an integer array or vice-versa. The variable *move* (TO_ or FROM_) indicates the copying direction.

Calling Sequence:	copych (string, move, iarray, lenarr, ierr)	
Data Declaration:	Integer	iarray, lenarr, ierr
	Character	string, move
Arguments:	iarray	An integer *array*.
	lenarr	Length of *iarray*.
	ierr	Error status: = 0 No error; = 9 End-of-file.
	string	A character string.
	move	If *move* = to_, *string* is copied to *iarray*; If *move* = from_, *string* is copied from *iarray*.

5.3.2.2 Subroutine DPADDP

Subroutine DPADDP adds a new pointer. If the name of the pointer is not yet present, all of the data in *array* after the names and pointers of the existing point-sets are moved *lenpnt* places. The free places are then filled with the new name, which is the pointer to the start of the record and the record length.

Calling Sequence: dpaddp (array, pname, pindex, ptype, padres, ierr)

Data Declaration:	Integer	array, pindex, ptype, padres, ierr
	Character	pname
Arguments:	array	Array in which the pointer structure exists.
	ierr	Error status: = 0 No error; = 9 End-of-file.
	padres	Location in *array* of first data.
	pindex	Index of the new pointer.
	ptype	Type of data referenced by the new pointer: S = Single precision data; P = Pointers of the record referenced by the pointer.
	pname	Name of the new pointer.

5.3.2.3 Subroutine DPBLDP

Subroutine DPBLDP builds a *pool* structure into *array*.

Calling Sequence: dpbldp (array, lenarr, lenpnm, lenadt, ierr)

Data Declaration:	Integer	array, lenarr, lenpnm, lenadt, ierr
Arguments:	array	Array into which the pointer structure is to be built.
	lenarr	Length of *array*. If the input value is negative, it is assumed that the array already contains the proper length.
	lenpnm	Length provided for the names of the pointers.
	lenadt	Length provided for additional data in the pointer.
	ierr	Input: If = 0 Standard message; If = -1 No message; If < -1 More complete message. Output: = 0 No errors, otherwise: > 0; = 9 End-of-file.

5.3.2.4 Subroutine DPCHEK

Subroutine DPCHEK checks the data integrity in the *pool* and displays the *pool* structure. *pool* cycles have to remain intact. Pointer index $\longrightarrow$ record address $\longrightarrow$ record length $\longrightarrow$ end of the record. At the end of the record the pointer index must be found.

Calling Sequence:	dpchek (array, ierr)	
Data Declaration:	Integer	array, ierr
Arguments:	array	Array in which the pointer structure exists.
	ierr	Error status: = 0 No error; = 9 End-of-file.

5.3.2.6 Subroutine DPEXPR

Subroutine DPEXPR makes record number *pindex* the length *newsiz*. If the data type is real/integer then the return record address is *padres*. If the record data type is pointer, the *pool* structure is possibly destroyed if the record is reduced in length.

Calling Sequence:	dpexpr (array, pindex, newsiz, padres, ierr)	
Data Declaration:	Integer	array, pindex, newsiz, padres, ierr
Arguments:	array	Array in which the pointer structure exists.
	ierr	Error status: = 0 No error; = 9 End-of-file.
	newsiz	New size of the record referenced by the pointer.
	padres	Location in *array* of the first data of the record referenced by the pointer.
	pindex	Index of a pointer.

5.3.2.7 Integer Function DPGETI

Function DPGETI gives the integer value of element *pplace* of record number *pindex* in *array*.

Calling Sequence: dpgeti (array, pindex, pplace, ierr, move)

Data Declaration:	Integer	array, pindex, pplace, ierr
	Character	move

Arguments:	array	Array in which the pointer structure exists.
	pindex	Index of the pointer.
	pplace	Number of elements in the record.
	ierr	Error status: = 0 No error; = 9 End-of-file.
	move	If *move* = up, *pplace* is increased by one.

5.3.2.9 Subroutine DPINQA

Subroutine DPINQA provides information about the base pointer of an array.

Calling Sequence: dpinqa (array, lenarr, lenocp, numpns, lenpnm, lenadt, ierr)

Data Declaration:	Integer	array, lenarr, lenocp, numpns, lenpnm, lenadt, ierr

Arguments:	array	Array in which the pointer structure exists.
	lenarr	Length of *array*.
	lenocp	Number of occupied places in the array.
	numpns	Number of pointers in the array.
	lenpnm	Length provided for the names of the pointers.
	lenadt	Length provided for additional data in the pointer.
	ierr	Error status: = 0 No error; = 9 End-of-file.

5.3.2.10 Subroutine DPINQP

Subroutine DPINAP provides the index of a pointer given by name, as well as the address and length of the associated record. If the name of the pointer is not yet present, the index and address will both be made zero.

Calling Sequence: dpinqp (array, pname, pindex, ptype, padres, lenrec, ierr)

Data Declaration:	Integer	array, pindex, padres, lenrec, ierr
	Character	pname, ptype

Arguments:	array	Array in which the pointer structure exists.
	pindex	Index of a pointer given by its name.
	padres	Location in *array* of the first data of the

	record referenced by the pointer.
lenrec	Length of the record referenced by the pointer.
ierr	Error status: = 0 No error; = 9 End-of-file.
pname	Name of a pointer.
ptype	Type of data in record referenced by the pointer.

5.3.2.11 Subroutine DPMAXR

Subroutine DPMINR makes record number *pindex* as long as possible. The length of the record is returned in *newsiz*. If the data type is real/integer the record address *padres* is returned.

Calling Sequence: dpmaxr (array, pindex, newsiz, padres, ierr)

Data Declaration: Integer array, pindex, newsiz, padres, ierr

Arguments:

array	Array in which the pointer structure exists.
pindex	Index of a pointer.
newsiz	New size of the record referenced by the pointer.
padres	Location in *array* of the first data of the record referenced by the pointer.
ierr	Error status: = 0 No error; = 9 End-of-file.

5.3.2.12 Subroutine DPMINR

Subroutine DPSHFT makes record number *pindex* the length *newsiz*. If data type is real/integer then record address *padres* is returned. If the record data type is *pointer*, the *pool* structure is possibly destroyed if the record is reduced in length.

Calling Sequence: dpminr (array, pindex, newsiz, padres, ierr)

Data Declaration: Integer array, pindex, newsiz, padres, ierr

Arguments:

array	Array in which the pointer structure exists.
ierr	Error status: = 0 No error; = 9 End-of-file.
newsiz	New size of the record referenced by the pointer.

padres	Location in *array* of the first data.
pindex	Index of a pointer of the record referenced by the pointer.

5.3.2.13 Subroutine DPPUTR

Subroutine DPPUTR puts a real value into an integer *array*. *Array* is declared here as real, but it is integer in the calling program.

Calling Sequence: dpputr (array, pplace, rv)

Data Declaration:	Integer	pplace
	Real	array, rv

Arguments:	pplace	Number of elements in *array.*
	array	Array in which the pointer structure exists.
	rv	Real variable to be put into *array.*

5.3.2.14 Subroutine DPSHFT

Subroutine DPEXPR adds *mshif* to empty places (*mshif* > 0) or deletes -*mshif* places (*mshif* < 0) after ILOX in array IOUTD.

Calling Sequence: dpshft (array, linsrt, mshif, ierr)

Data Declaration:	Integer	array, linsrt, mshif, ierr

Arguments:	array	Array in which the pointer structure exists.
	ierr	Error status: = 0 No error; = 9 End-of-file.
	linsrt	First element that is moved.
	mshif	Number of places to be added after *linsrt.*

5.3.2.15 Character Function DPTYPE

Function DPTYPE provides the type of data in the record with *pindex.*

Calling Sequence: dptype (array, pindex)

Data Declaration:	Integer	array, pindex

Arguments:	array	Array in which the pointer structure exists.
	pindex	Index of the new pointer.

5.3.2.16 Integer Function IADRS

Function IADRS provides the address of a record in a pool. If the name of the pointer is not yet present, the index and the address will both be made zero.

Calling Sequence: iadrs (array, pindex)

Data Declaration: Integer array, pindex

Arguments:	array	Array in which pointer structure exists.
	pindex	Index of a point.

5.3.2.17 Integer Function OCINTG

Function OCINTG delivers an integer value stored as a real array.

Calling Sequence: ocintg (rvalue)

Data Declaration: Integer rvalue

Arguments: rvalue An integer value.

5.3.2.18 Real Function OCREAL

Function OCREAL delivers a real value stored in an integer array.

Calling Sequence: ocreal (ivalue)

Data Declaration: Integer ivalue

Arguments: ivalue An integer value.

5.3.3 Installation Dependent Subroutines (ocpids FOR Files)

5.3.3.1 Subroutine CMTOPL

Subroutine CMTOPL converts paper coordinates (*xp*, *yp* in cm) to (HP) plot units.

Calling Sequence:	cmtopl (xp, yp, ix, iy)	
Data Declaration:	Integer	lnt, ix, iy
	Real	dashl, xp, yp
Arguments:	lnt	Line type: 1-6: Dashed, 10: Continuous.
	dashl	Dash length.
	xp, yp	Paper coordinates.
	ix, iy	Integer numbers.
Common Blocks:	PLPARM(3)	
	PLPARM(4)	
	PLPARM(5)	
	PLPARM(6)	

5.3.3.2 Subroutine DTSTTI

Subroutine DTSTTI transforms time strings into integer time arrays.

Calling Sequence:	dtstti (iopt, timstr, dttime)	
Data Declaration:	Integer	iopt, dttime
	Character	timstr
Arguments:	iopt	Option number.
	timstr	Time string.
	dttime	Time array elements: year, month, day, hour, minute and second.

5.3.3.3 Subroutine DTTIST

Subroutine DTTIST transforms integer time arrays into time strings.

Calling Sequence:	dttist (iopt, timstr, dttime)	
Data Declaration:	Integer	iopt, dttime
	Character	timstr
Arguments:	iopt	Option number.
	timstr	Time string.

	dttime	Time array elements: year, month, day, hour, minute and second.

5.3.3.4 Subroutine OCDTIM

Using processor dependent routines, subroutine OCDTIM gets the time of processing.

Calling Sequence: ocdtim (prctim)

Data Declaration:	Integer	prctim
Arguments:	prctim	Time array elements: year, month, day, hour, minute and second.

5.3.3.5 Subroutine OCPINI

Subroutine OCPINI initializes a number of common variables and opens standard input and output files if necessary.

Calling Sequence: ocpini (inifil, lread, inerr)

Data Declaration:	Integer	inerr
	Logical	lread
	Character	inifil
Arguments:	inerr	Number of the initialization error.
	inifil	Name of the initialization file.
	lread	If true, command input file must be opened and command reading must be initialized.

5.3.3.6 Subroutine OPENDF

Subroutine OPENDF terminates a picture.

5.3.3.8 Subroutine OPFRAM

Subroutine OPFRAM plots the edge of the figure and the captions.

Calling Sequence: opfram (fropt, ptitl)

Data Declaration:	Integer	fropt

	Character	ptitl
Arguments:	fropt	Frame option: = 0 No frame, = 1 Simple frame, = 2 DUT frame.
	ptitl	Figure title.
Common Blocks:	FILENM XASL YASL SYMSIZ XPLO XPHI YPLO YPHI SUBLNS XPSUB YPSUB	

5.3.3.9 Subroutine OPINIT

Subroutine OPINIT starts the plotting of a figure and opens the plot file if necessary.

Calling Sequence:	opinit (xflen, yflen)	
Data Declaration:	Real	xflen, yflen
Arguments:	xflen	Length of figure in x-direction.
	yflen	Length of figure in y-direction.
Common Blocks:	FILENM	

5.3.3.10 Subroutine OPMARK

Subroutine OPMARK plots a single (centered) symbol.

Calling Sequence:	opmark (xt, yt, syms, isym, updown)	
Data Declaration:	Integer	isym
	Real	xt, yt, syms
	Character	updown

Arguments:	xt, yt	Place where the first character is plotted.
	syms	Size of the symbols on the plot.
	isym	Indicator of the symbol to be plotted. Symbol is centered at (*xt, yt*).
	updown	= up Pen moves to (*xt, yt*) with pen up;
		= down Pen moves to (*xt, yt*) with pen down.

5.3.3.11 Subroutine OPNPEN

Subroutine OPNPEN puts on a new plotting pen (with different color).

Calling Sequence: opnpen (ipen)

Data Declaration:	Integer	ipen

Arguments:	ipen	Number of the new pen.

5.3.3.12 Subroutine OPPLOT

Subroutine OPPLOT moves the pen to the location (*xt, yt*).

Calling Sequence: opplot (xt, yt, updown)

Data Declaration:	Real	xt, yt
	Character	updown

Arguments:	xt, yt	Place where the first character is plotted.
	updown	= up Pen moves to (*xt, yt*) with pen up;
		= down Pen moves to (*xt, yt*) with pen down.

5.3.3.13 Subroutine OPTEXT

Subroutine OPTEXT plots a string.

Calling Sequence: optext (xt, yt, syms, string, angl, nc)

Data Declaration:	Integer	nc
	Real	xt, yt, syms, angl
	Character	string

Arguments:	xt, yt	Place where the first character is plotted.
	syms	Size of symbols on plot.

strng	Character string to be plotted.
angl	Angle under which the string is plotted.
nc	Number of characters in the string.

5.3.3.14 Subroutine OPTYPE

Subroutine OPTYPE plots a new line type.

Calling Sequence: optype (lnt, dashl)

Data Declaration:	Integer	lnt
	Real	dashl

Arguments:	lnt	Line type: 1-6: Dashed; 10: Continuous.
	dashl	Dash length.

5.3.4 Plot Routines (ocplot FOR File)

5.3.4.1 Subroutine ISOLIN

Subroutine ISOLIN computes one contour line, starting from a given point in a given mesh. Modify *idir* (contour direction) if necessary by determining the line on which the next contour point is searched and then determining the first guess of the new point. Call search after the two steps above to determine a new contour point, if a new point is on the edge of the mesh, move to new the mesh.

Calling Sequence: isolin (f, cval, fstep, cf, bpost, idir0, ix0, iy0, srx0, sry0, start, pstat, ibx, iby, errc)

Data Declaration:	Integer	ibx, iby, idir0, ix0, iy0, pstat, start
	Real	cf, cval, f, fstep, srx0, sry0
	Logical	bpost
	Character	errc

Arguments:	ibx	Test for x-connection between neighboring points; *ibx* = 0: no test.
	iby	Test for y-connection between neighboring points; *iby* = 0: no test.
	idir0	Initial direction of contour line *idir0* = 1: -45 <= direction <= 45 degrees;

	= 2: 45 <= direction <= 135 degrees;
	= 3: 135 <= direction <= 215 degrees;
	= 4: 215 <= direction <= 305 degrees.
ix0	X-coordinate of starting mesh.
iy0	Y-coordinate of starting mesh.
pstat	Status in points of grid.
start	Indicates whether a new contour line may start in given mesh.
cf	Function values are divided by *cf*.
cval	Value of function on contour line.
f	Values of function to be contoured.
fstep	Contour line interval.
srx0	Start point in the mesh, 0 <= *srx0* <= 1.
sry0	Start point in the mesh, 0 <= *sry0* <= 1.
bpost	Indicates whether posting of the function value is to be done.
errc	Error condition code.

5.3.4.2 Subroutine OCPISO

Subroutine OCPISO organizes the plotting of contour lines. The procedure consists of the following steps:

1) Determine gradients in points where F > 0.
2) Extrapolate where F = 0 (if *cpos* = pos).
3) Start contour lines from boundary points.
4) Start contour lines from interior points.

Calling Sequence: ocpiso (cpos, ibx, iby, pstat, f, fmin, fstep, fmax, cf, start)

Data Declaration:	Integer	ibx, iby, pstat, start
	Real	cf, f, fmin, fmax, fstep
	Character	cpos

Arguments:	ibx	Test for x-connection between neighboring points; *ibx* = 0: no test.
	iby	Test for y-connection between neighboring points; *iby* = 0: no test.
	pstat	Status in points of the grid. Point status is encoded in array *pstat* as follows: Index im = ixq + (iyq-1)*mxq denotes point (ixq, iyq); If *ibx* and *iby* are zero, it is assumed that all connections exist. Otherwise:

		If iand(*pstat*(im), *ibx*) = 0, then connection between points (ixq, iyq) and (ixq+1, iyq) is absent. If iand(*pstat*(im), *iby*) = 0, then connection between points (ixq, iyq) and (ixq, iyq+1) is absent.
	start	For each mesh indicates: = 0 Contour line went through this mesh; = 1 New contour line can start in this mesh.
	cf	Function values appearing on plot are divided by *cf.*
	f	Values of function to be contoured.
	fmax	Highest contour value.
	fmin	Lowest contour value.
	fstep	Contour function interval.
	cpos	When equal to pos, it means that *f* >= 0.
Common Blocks:	MXQ	
	MYQ	
	DXQ	
	DYQ	

5.3.4.3 Subroutine OCPSCH

Subroutine OCPSCH determines a scale factor for a plot. The resulting scale *rsc* must be smaller than *slm*, and it must be a number of the form 10**N, 2*10**N, or 5*10**N.

Calling Sequence: ocpsch (slm, rsc)

Data Declaration:	Real	slm, rsc
Arguments:	slm	Maximum size of the scale factor.
	rsc	Chosen scale factor.

5.3.4.4 Subroutine OCPSUB

Subroutine OCPSUB plots part of the legend under a figure.

Calling Sequence: ocpsub (cquan, qsca, qr, qunit)

Data Declaration:	Real	qr, qsca
	Character	cquan, qunit
Arguments:	cquan	One of several cases: = delt Function increment is plotted;

		= lens A length scale is plotted;
		= arow A vector scale is plotted;
		= other The text *cquan* is plotted.
	qsca	Length or vector scale: Input if *cquan* = lens or arow; Output if *cquan* = delt.
	qr	Number to be plotted: Output if *cquan* = lens or arow; Input if *cquan* = delt.
	qunit	Unit of the plotted quantity.

Common Blocks: XASL
YASL
PMR
SYMSIZ

5.3.4.5 Subroutine OCPVEC

Subroutine OCPVEC plots a vector field.

Calling Sequence: ocpvec (vsca, vvx, vvy, stag, ibd, pstat, idist)

Data Declaration:	Integer	ibd, idist, pstat
	Real	vsca, vvx, vvy
	Logical	pstag, pms
	Character	stag

Arguments:	ibd	If non-zero: tests with *pstat* whether depth is positive or not.
	pstat	Encodes the status in points of the grid.
	idist	Number of meshes between vector origins.
	vsca	Vector scale.
	vvx	Array containing x-components of vector.
	vvy	Array containing y-components of vector.
	pstag	True if staggered grid.
	pms	Test for positive depth.
	stag	Staggered grid, Other: non-staggered grid.

5.3.4.6 Subroutine OPNUMB

Subroutine OPNUMB plots a real number. The number is converted to a string and then written to a file using subroutine OPTEXT.

Calling Sequence: opnumb (xt, yt, syms, reval, angl, ndec)

Data Declaration:

Integer	ndec
Real	xt, yt, syms, angl, reval

Arguments:

xt, yt	Place where the first character is plotted.
syms	Size of the symbols on the plot.
reval	Real number to be plotted.
angl	Angle under which the number is plotted.
ndec	Number of decimals.

5.3.4.7 Subroutine OPSYMB

Subroutine OPSYMB plots a single (centered and oriented) symbol.

Calling Sequence: opsymb (xt, yt, syms, isym, angle, updown)

Data Declaration:

Integer	isym
Real	xt, yt, syms, angle
Character	updown

Arguments:

isym	Indicator of the symbol to be plotted. Symbol is centered at (*xt, yt*).
syms	Size of the symbols on the plot.
xt, yt	Place where the first character is plotted.
angle	Angle under which the symbol must be plotted.
updown	= up Pen moves to (*xt, yt*) with pen up; = down Pen moves to (*xt, yt*) with pen down.

5.3.4.8 Subroutine PLOTF

Subroutine PLOTF plots a point given in window (physical) coordinates.

Calling Sequence: plotf (xf, yf, updown)

Data Declaration:

Real	xf, yf
Character	updown

Arguments:

xf, yf	Window coordinates.
updown	Pen up or down when moving to the point.

5.3.4.9 Subroutine PSYM

Calling Sequence: psym (xf, yf, syms, isym, updown)

Data Declaration:	Real	xf, yf, syms
	Character	updown
	Integer	isym

Arguments:	xf, yf	Place whereto the pen must move and where the symbol must appear in paper coordinates (cm).
	syms	Size of symbols on plot (cm).
	isym	Symbol indicator.
	updown	Pen up or down when moving to the point.

5.3.4.10 Subroutine SNYPT1

Subroutine SNYPT1 determines the crossing point of a line segment with the edge of the frame; (*xs, ys*) is the crossing point in paper coordinate (cm). The end points of the line segment are (*x1, y1*) and (*x2, y2*). It is assumed that (*x1, y1*) is inside the frame, and (*x2, y2*) outside.

Calling Sequence: snypt1 (x1, y1, x2, y2, xs, ys)

Data Declaration:	Real	x1, y1, x2, y2, xs, ys

Arguments:	x1	X of the begin point.
	y1	Y of the begin point.
	x2	X of the end point.
	y2	Y of the end point.
	xs	X of the crossing.
	ys	Y of the crossing.

5.3.4.11 Subroutine SNYPT2

Subroutine SNYPT2 determines the number of crossing points and their coordinates of a line segment with the plotting frame. Both ends of the line segment should be outside the plotting frame. First check whether the line segment lies fully right, left, top or bottom of the plotting frame. When this is not the case it looks for possible cross-sections with all four sides of the plotting frame.

Calling Sequence: snypt2 (x1, y1, x2, y2, xs1, ys1, xs2, ys2, nsnypt)

Data Declaration:	Integer	nsnypt
	Real	s1, y1, x2, y2, xs1, ys1, xs2, ys2
Arguments:	nsnypt	Total number of crossing points.
	xs1	X-coordinate of the first cross-section.
	xs2	X-coordinate of the second cross-section.
	x1	X-coordinate of the begin line segment.
	x2	X-coordinate of the end line segment.
	ys1	Y-coordinate of the first cross-section.
	ys2	Y-coordinate of the second cross-section.
	y1	Y-coordinate of the begin line segment.
	y2	Y-coordinate of the end line segment.
Common Blocks:	OUTPDA	

5.3.5 Miscellaneous Routines (ocpmix FOR Files)

5.3.5.1 Subroutine BUGFIX

Subroutine BUGFIX adds one character to the version character string.

Calling Sequence:	bugfix (fixabc)	
Data Declaration:	Character	fixabc
Arguments:	fixabc	Character indicating a bugfix.

5.3.5.2 Subroutine DTINTI

Subroutine DTINTI calculates integer time array *inttim* from time in seconds for a given reference day *refday*. Every fourth year is a leap year except century-years. Leap years also include year 0, 1000, 2000 etc. The first day of January of year zero is day number one.

Calling Sequence:	dtinti (timesc, inttim)	
Data Declaration:	Integer	inttim
	Real	timesc

Arguments:	inttim	(1) Year;
		(2) Month;
		(3) Day;

	(4) Hour;
	(5) Minute;
	(6) Second.
timesc	Time in seconds from given reference day refday.

5.3.5.3 Subroutine DTRETI

Calling Sequence: dtreti (tstrng, iopt, timesc)

Data Declaration:		
	Integer	iopt
	Real	timesc
	Character	tstrng

Arguments:		
	iopt	Option number.
	timesc	Time in seconds from given reference day refday.
	tstrng	Time string.

5.3.5.4 Real Function DTTIME

Function DTTIME gives the time in seconds from a reference day. It also initializes the reference day. Every fourth year is a leap year except century-years. Leap years also include year 0, 1000, 2000 etc. The first of January of year zero is day number one.

Calling Sequence: dttime (inttim)

Data Declaration: Integer inttim

Arguments:		
	inttim	(1) Year;
		(2) Month;
		(3) Day;
		(4) Hour;
		(5) Minute;
		(6) Second.

Common Blocks: REFDAY

5.3.5.5 Character Function DTTIWR

Calling Sequence: dttiwr (iopt, timesc)

Data Declaration:		
	Integer	iopt
	Real	timesc

	Character	tstrng
Arguments:	iopt	Time coding option number.
	timesc	Time in seconds from given reference day refday.
	tstrng	Time string.

5.3.5.6 Logical Function EQREAL

Function EQREAL determines whether a value (usually a value read from file) is an exception value or not. Function EQREAL is later used to make comparisons of floating points within reasonable bounds.

Calling Sequence:	eqreal (real1, real2)	
Data Declaration:	Real	real1, real2
Arguments:	real1	Value that is to be tested.
	real2	The given exception value.

5.3.5.7 Subroutine FOR

Subroutine FOR is a general open file routine.

Calling Sequence:	for (iunit, ddname, sf, iostat)	
Data Declaration:	Integer	iunit, iostat
	Character	ddname, sf
Arguments:	iunit	= 0 Get free unit number; > 0 Fixed unit number; Output: allocated unit number.
	ddname	Filename string (empty if *iunit* > 0).
	sf	File qualifiers: 1st character: O(ld), N(ew), S(cratch), U(nknown); 2nd character: F(ormatted), U(nformatted).

	iostat	= 0 Full messages printed;
		= -1 Only error messages printed;
		= -2 No messages printed;
		Output: error indicator.

5.3.5.8 Subroutine INAR2D

Subroutine INAR2D reads a 2-D array from a data set and is used to read bathymetry, one component of wind velocity.

Calling Sequence: inar2d (arr, mxa, mya, ndsl, ndsd, idfm, rform, idla, vfac, nhed, nhedf)

Data Declaration:

	Integer	idfm, idla, mxa, mya, ndsd, ndsl, nhed, nhedf
	Real	arr, vfac
	Character	rform

Arguments:

	idfm	Format index.
	idla	Layout indicator.
	mxa	Number of points along x-side of grid.
	mya	Number of points along y-side of grid.
	ndsd	Unit number of the file from which to read the data set.
	ndsl	Unit number of the file containing the list of filenames.
	nhedf	Number of heading lines in the file (first lines).
	nhedl	Number of heading lines in the file before each array.
	arr	Results appear in this array.
	rform	Format used in reading data (character string).
	vfac	Factor by which data must be multiplied.

5.3.5.9 Subroutine LSPLIT

Subroutine LSPLIT separates a line read from a file into single data items. Each data item is found in a string *datitm.*

Calling Sequence: lsplit (reline, datitm, numitm)

Data Declaration:

	Integer	numitm
	Character	reline, datitm

Arguments:

	numitm	Maximum number of data items in the array.
	datitm	Array of data items.
	reline	String (read from an input file).

5.3.5.10 Subroutine MSGERR

Subroutine MSGERR produces error messages. If necessary, the value of leverr is increased. In case of a high error level an error message file is opened.

Calling Sequence: msgerr (lev, string)

Data Declaration:	Integer	lev
	Character	string
Arguments:	lev	Indicates how severe the present error is.
	string	Contents of the present error message.

5.3.5.11 Subroutine REPARM

Subroutine REPARM reads parameters used for reading an array from user input.

Calling Sequence: reparm (ndsl, ndsd, idla, idfm, rform, nhedf, logt, nhedt, logc, nhedc)

Data Declaration:	Integer	idfm, idla, ndsl, ndsd, nhedf, nhedt, nhedc
	Logical	logt, logc
	Character	rform
Arguments:	idfm	Format index.
	idla	Layout indicator.
	ndsd	Unit number of the file from which to read the data set.
	ndsl	Unit number of the file containing the list of filenames.
	nhedf	Number of heading lines in the file (once in each file).
	nhedt	Number of heading lines in the file before reading each time level.
	nhedc	Number of heading lines in the file before each array or vector component.
	logt	If true, then the field is time-dependent.
	logc	If true, then more than one component is read from the file.
	rform	Reading format.

5.3.5.12 Logical Function STPNOW

Function STPNOW determines whether the SWAN program should be stopped due to a terminating error. STPNOW compares two common variables. The maximum allowable error-level, maxerr, and the actual error-level, leverr.

5.3.5.13 Subroutine STRACE

Subroutine STRACE produces, depending on the value of itrace, a message containing the name *subnam*. The purpose of this action is to detect the entry of a subroutine. The first executable statement of subroutine AAA (which is a name for any subroutine) must be: CALL STRACE(IENT, AAA). Further if necessary: DATA IENT/0/ If ITRACE = 0, no message. If ITRACE > 0, a message is printed up to itrace times.

Calling Sequence:	strace (ient, subnam)	
Data Declaration:	Integer	ient
	Character	subnam
Arguments:	ient	Number of entries into the calling subroutine.
	subnam	Name of the calling subroutine.

5.3.5.14 Subroutine TABHED

Subroutine TABHED prints the table heading that contains the run description, three lines, name of institute, program name, project name, and run ID.

Calling Sequence:	tabhed (prognm, lpr)	
Data Declaration:	Integer	lpr
	Character	prognm
Arguments:	lpr	Unit reference number.
	prognm	Program name.

5.3.6 *Computation Subroutines (swancom1 FOR File)*

5.3.6.1 Subroutine ACTION

Subroutine ACTION determines the transportation, refraction and source terms of the ACTION balance equation.

Calling Sequence: action (idcmin, idcmax, spcsig, ac2, cax, cay, cas, cad, imatla, imatda, imatua, imatra, warea, sector, imat5l, imat6u, iscmin, iscmax, iddlow, iddtop, isstop, anyblk, anybin, leakc1, ac1, dyndep, rdx, rdy, swpdir, ix, iy, ksx, ksy, obsta, xcgrid, ycgrid, cross, iter, kgrpnt, dep2, chs, obredf, wlev2, cax1, cay1, spcdir, cgo)

Data Declaration:	Real	spcsig, xcgrid, ycgrid, ac2, cax, cay, cax1, cay2, cgo, cas, cad, imatla, imatda, imatua, imatra, imat5l, imat6u, leakc1, rdx, rdy, dep2, obredf, wlev2, chs, spcdir, ksx, ksy
	Integer	warea, idcmin, idcmax, iscmin, iscmax, sector, obsta, kgrpnt, cross, iddlow, iddtop, isstop, swpdir, iter, ix, iy, supdir
	Logical	anyblk, anybin, dyndep

Arguments:	spcsig	Relative frequencies in computational domain in sigma space.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	idcmin	Integer array containing minimum counter.
	idcmax	Integer array containing maximum counter.
	ac2	Action density as function of D, S, X, Y at time T.
	cax	Wave transport velocity in x-direction as function of (*id, is, ic*).
	cay	Wave transport velocity in y-direction as function of (*id, is, ic*).
	cas	Wave transport velocity in frequency-direction as function of (*id, is, ic*).
	cad	Wave transport velocity in spectral direction as function of (*id, is, ic*).
	imatla	Coefficients of lower diagonal of matrix.
	imatda	Coefficients of diagonal of matrix.
	imatua	Coefficients of upper diagonal of matrix.
	imatra	Coefficients of right-hand side of matrix.
	warea	The big array used in data pool scheme, to contain many variables.

sector	Indicates which configuration is present.
imat5l	Coefficient of lower diagonal in the presence of a current.
imat6u	Coefficient of upper diagonal in the presence of a current.
iscmin	Frequency dependent counter in frequency space.
iscmax	Frequency dependent counter in frequency space.
iddlow	Minimum counter per sweep taken over all frequencies.
iddtop	Maximum counter per sweep taken over all frequencies.
isstop	Maximum frequency counter for wave components that are propagated within a sweep.
anyblk	2D Determines if a bin is BLOCKED by a counter current based on a CFL criterion.
anybin	= True, if a certain bin is enclosed in a sweep.
leakc1	Leak coefficient.
ac1	Action density as function of D, S, X, Y at time T.
dyndep	If true, depths vary with time.
rdx, rdy	Array containing spatial derivative coefficient.
swpdir	Current sweep direction.
ix	Counter of grid points in x-direction.
iy	Counter of grid points in y-direction.
ksx	Dummy variable to get the right sign in the numerical difference scheme in x-direction depending on the sweep direction, KSX = ñ1.
ksy	Dummy variable to get the right sign in the numerical difference scheme in y-direction depending on the sweep direction, KSY = ñ1.
obsta	Array of obstacle parameters.
xcgrid	X-coordinate of computational grid in x-direction.
ycgrid	Y-coordinate of computational grid in y-direction.
cross	Array which contains 0's if there is no obstacle crossing if an obstacle is crossing between the central point and its neighbor *cross* is equal to the number of the obstacle.
iter	Iteration counter for SWAN.
kgrpnt	Grid point addresses.
dep2	Depth.
chs	Sign. wave height in whole computational grid.
obredf	Array of action density reduction coefficients.
wlev2	Water level in grid points.
cax1	Propagation velocity in x old time level.
cay1	Propagation velocity in y old time level.

spcdir	(*,1) Spectral directions (radians);
	(*,2) Cosine of spectral directions;
	(*,3) Sine of spectral directions;
	(*,4) Cosine^2 of spectral directions;
	(*,5) Cosine*sine of spectral directions;
	(*,6) Sine^2 of spectral directions.
cgo	Group velocity.

5.3.6.2 Subroutine INSAC

Subroutine INSAC checks the accuracy of the final computation. If a certain accuracy has been reached it stops the iteration.

Calling Sequence: insac (ac2, spcsig, dep2, hsacc2, sacc2)

Data Declaration:	Real	spcsig, ac2, dep2, hsacc2, sacc2
Arguments:	spcsig	Relative frequencies in computational domain in sigma space.
	dep2	Depth.
	ac2	Action density as function of D, S, X, Y at time T.
	hsacc2	Dummy array for the significant wave height (old value).
	sacc2	Dummy array for the mean frequency (old value).

5.3.6.3 Subroutine PHILIM

Subroutine PHILIM limits the change in action density between two iterations to a certain percentage of the Phillips equilibrium level.

Calling Sequence: philim (ac2, ac2old, cgo, kwave, spcsig, anybin, qb_loc)

Data Declaration:	Logical	anybin
	Real	ac2, ac2old, cgo, kwave, spcsib, qb_lo
Arguments:	qb_loc	Local value of *qb* (fraction of breaking waves).
	ac2	(Non-stationary case) action density as function of D, S, X, Y at time T + DT.
	ac2old	Values of action density stored for limiter.
	cgo	Group velocity.
	kwave	Wave number as function of the relative frequency S and position ic (*ix, iy*).
	spcsig	Relative frequencies in computational domain in

	sigma space.
anybin	= True if a certain bin is enclosed in a sweep. Array is used to determine whether or not some coefficients in the array have to be changed.

5.3.6.4 Subroutine RESCALE

Subroutine RESCALE removes negative values from a computed action density spectrum.

Calling Sequence: rescale (ac2, isstop, idcmin, idcmax)

Data Declaration:	Real	ac2
	Integer	idcmin, idcmax, isstop

Arguments:	ac2	Action densities.
	isstop	Maximum frequency counter in this sweep.
	idcmin	Integer array containing minimum counter of directions.
	idcmax	Integer array containing maximum counter.

5.3.6.5 Subroutine SACCUR

Subroutine SACCUR checks the accuracy of the final computation. If a particular accuracy has been reached then the iteration process terminates.

Calling Sequence: saccur (dep2, ac2, spcsig, accur, hsacc1, hsacc2, sacc1, sacc2, delhs, deltm)

Data Declaration:	Real	spcsig, ac2, dep2, hsacc1, hsacc2, sacc1, sacc2, delhs, deltm, accur

Arguments:	spcsig	Relative frequencies in computational domain in sigma space.
	dep2	Depth.
	ac2	Action density as function of D, S, X, Y at time T.
	accur	User specified option used to influence the criterion for terminating the iterative procedure in the SWAN computations.
	hsacc1	Dummy array for the significant wave height (new value).
	hsacc2	Dummy array for the significant wave height (old value).

sacc1	Dummy array for the mean frequency (new value).
sacc2	Dummy array for the mean frequency (old value).
delhs	Difference in Hs between last two iterations.
deltm	Difference in Tm between last two iterations.

5.3.6.6 Subroutine SCOMPU

Subroutine SCOMPU is the main subroutine of the computational part.

5.3.6.7 Subroutine SINTGRL

Subroutine SINTGRL computes several integrals used in SWAN and some general parameters.

Calling Sequence: sintgrl (spcdir, kwave, ac2, dep2, qb_loc, ursell, rdx, rdy, ac2tot, etot, abrbot, ubot, hs, qb, hm, kmespc, smebrk)

Data Declaration: Real dep2, kwave, rdx, rdy, spcdir, ac2, qb, ubot, ursell, abrbot, etot, hm, hs, qb_loc, ac2tot, kmespc, smebrk, ac2tot

Arguments:

abrbot	Near bottom excursion.
ac2	Action density as a function of *id, is, ix* and *iy.*
ac2tot	Total action density per grid point.
dep2	Water depth.
etot	Total wave energy density.
hm	Maximum wave height.
hs	Significant wave height.
kmespc	Mean average wave number according to the WAM formulation.
kwave	Wave number function of frequency and ic.
qb	Fraction of breaking waves.
qb_loc	Fraction of breaking waves at current grid point.
smebrk	Mean frequency according to first order moment.
ubot	Near bottom velocity as function of *ix* and *iy.*
ursell	*Ursell* number as function of *ix* and *iy.*
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
rdx, rdy	Array containing spatial derivative coefficient.

5.3.6.8 Subroutine SOLBAND

Subroutine SOLBAND solves the array in the case of a current. A fully implicit scheme in frequency and directional space is used. Dr. C. Vuik, from Delft University of Technology in the Netherlands, has provided the subroutines that solve this matrix.

Calling Sequence: solband (band, exact, rhv, rinsol, solut, work, precon, upperi, loperi, anybin, infmat, iinsol, imatra, imatla, imatda, imatua, imat5l, imat6u, ac2old, cgo, kwave, spcsig, idcmin, idcmax, ac2, sector, iter, idtot, istot, iddlow, iddtop, isstop, inocnv, qbloc, errpts, ix, iy, itsw)

Data Declaration:

Integer	iter, itsw, iddlow, inocnv, iddtop, idtot, istot, isstop, errpts, infmat, iinsol, idcmin, idcmax, sector
Real	spcsig, exact, rhv, solut, work, precon, imatra, imatla, imatda, imatua, imat5l, imat6u, ac2old, cgo, idcmin, idcmax, ac2, qbloc, rinsol, upperi, loperi, kwave
Logical	anybin

Arguments:

iter	Iteration counter for SWAN.
itsw	Timestep counter for SWAN.
spcsig	Relative frequencies in computational domain in sigmaspace.
ix	Counter of grid points in x-direction.
iy	Counter of grid points in y-direction.
idtot, istot	Maximum range between the minimum and maximum counter in directional and frequency space, respectively.
band	Matrix from the equations to be solved.
exact	Exact Solution.
rhv	Right-hand side.
rinsol	Real information for the solver.
solut	Iterative solution.
work	Work space.
precon	Preconditioner.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.
anybin	= True if a certain bin is enclosed in a sweep.
infmat	Integer information for the matrix.
iinsol	Integer information for the solver.
imatda	Coefficients of diagonal of the matrix.
imatla	Coefficients of lower diagonal of the matrix.

imatua	Coefficients of upper diagonal of the matrix.
imatra	Coefficients of right-hand side of the matrix.
imat5l	Coefficients for implicit calculation in frequency space (lower diagonal).
imat6u	Coefficients for implicit calculation in frequency space (upper diagonal).
ac2old	Values of action density stored for limiter.
cgo	Group velocity.
kwave	Wave number as function of the relative frequency S and position ic (*ix, iy*).
idcmin	Integer array containing minimum counter.
idcmax	Integer array containing maximum counter.
ac2	Action density as function of D, S, X, Y and T.
sector	Indicates which configuration is present.
iddlow	Minimum counter per sweep taken over all frequencies.
iddtop	Maximum counter per sweep taken over all frequencies.
isstop	Maximum frequency counter for wave components that are propagated within a sweep.
inocnv	Counts occurrence of nonconvergence in solver.
qbloc	Fraction of breaking waves at current grid point.
errpts	Info for SWAN to keep track of grid points (x,y) at which errors occur.

5.3.6.9 Subroutine SOLMAT

Subroutine SOLMAT solves the matrix that is filled in subroutine ACTION. The solutions give the values for the wave action for every frequency and every direction. Only the Thomas Sweep Algorithm in the spectral direction solves the matrices.

Calling Sequence: solmat (idcmin, idcmax, ac2, imatra, imatda, imatua, imatla, ac2old, kwave, cgo, spcsig, qbloc)

Data Declaration:	Real	spcsig, qbloc, ac2, imatda, imatla, imatua, imatra, ac2old, kwave
	Integer	idcmin, idcmax

Arguments:	spcsig	Relative frequencies in computational domain in sigma space.
	idcmin	Integer array containing minimum counter.
	idcmax	Integer array containing maximum counter.
	ac2	Action density as a function of D, S, X, Y and T.
	imatda	Coefficients of a diagonal of matrix.

imatla	Coefficients of lower diagonal of matrix.
imatua	Coefficients of upper diagonal of matrix.
imatra	Coefficients of right-hand side of matrix.
ac2old	Values of action density stored for limiter.
kwave	Wave number as function of the relative frequency S and position ic (*ix, iy*).
cgo	Group velocity.
qbloc	Fraction of breaking waves at current grid point.

5.3.6.10 Subroutine SOLMT1

Subroutine SOLMT1 solves the matrix that is filled in subroutine ACTION. The solutions give the values for the wave action for every frequency and direction. Only the Thomas Sweep Algorithm in the spectral direction solves the matrices.

Calling Sequence: solmt1 (idcmin, idcmax, ac2, imatra, imatda, imatua, imatla, ac2old, kwave, cgo, spcsig, sector, icolu2, anybin, qbloc, isstop, anyblk, iddlow, iddtop

Data Declaration:

Real	ac2, imatra, imatda, imatua, imatla, ac2old, kwave, cgo, spcsig, qbloc, icolu2
Integer	idcmin, idcmax, sector, isstop, iddtop, iddlow
Logical	anybin, anyblk

Arguments:

spcsig	Relative frequencies in computational domain in sigma space.
ac2	Action density as function of D, S, X, Y and T.
imatda	Coefficients of the diagonal of the matrix.
imatla	Coefficients of the lower diagonal of the matrix.
imatua	Coefficients of the upper diagonal of the matrix.
imatra	Coefficients of the right-hand side of the matrix.
cgo	Group velocity.
idcmin	Integer array containing minimum counter.
idcmax	Integer array containing maximum counter.
sector	Sectors enclosed in a sweep.
anybin	= True if a certain bin is enclosed in a sweep. The array is used to determine whether some coefficients in the array must be changed.
icolu2	Auxiliary array for storing the coefficients in the last column.
kwave	Wave number as a function of the relative frequency S and position ic (*ix, iy*).
qbloc	Fraction of breaking waves at current grid point.
isstop	Maximum frequency counter for wave components

	that are propagated within a sweep.
anyblk	Determines if a bin is BLOCKED by a counter current based on a CFL criterion.
iddlow	Minimum counter per sweep taken over all frequencies.
iddtop	Maximum counter per sweep taken over all frequencies.

5.3.6.11 Subroutine SOLPRE

Subroutine SOLPRE copies local spectrum to array *ac2old*, and writes the test output fill array for non-active bins.

Calling Sequence: solpre (ac2, ac2old, imatra, imatla, imatda, imatua, imat5l, imat6u, idcmin, idcmax, sector, anybin, idtot, istot, iddlow, iddtop, isstop, inocnv)

Data Declaration:	Real	ac2, ac2old, imatda, imatla, imatua, imatra, imat5l, imat6u
	Integer	idcmin, idcmax, iddlow, inocnv, iddtop, idtot, istot, isstop, sector
	Logical	anybin

Arguments:	ac2	Action density as function of D, S, X, Y and T.
	ac2old	Values of action density stored for limiter.
	imatda	Coefficients of diagonal of the matrix.
	imatla	Coefficients of lower diagonal of the matrix.
	imatua	Coefficients of upper diagonal of the matrix.
	imatra	Coefficients of right-hand side of the matrix.
	imat5l	Coefficients for implicit calculation in frequency space (lower diagonal).
	imat6u	Coefficients for implicit calculation in frequency space (upper diagonal).
	idcmin	Integer array containing minimum counter.
	idcmax	Integer array containing maximum counter.
	sector	Indicates which configuration is present.
	anybin	= True if a certain bin is enclosed in a sweep.
	idtot, istot	Maximum range between the minimum and maximum counter in directional and frequency space, respectively.
	iddlow	Minimum counter per sweep taken over all frequencies.
	iddtop	Maximum counter per sweep taken over all frequencies.

isstop	Maximum frequency counter for wave components that are propagated within a sweep.
inocnv	Counts occurrence of nonconvergence in solver.

5.3.6.12 Subroutine SOURCE

Subroutine SOURCE computes the source terms, i.e., bottom friction, wave breaking, wind input, whitecapping and non-linear wave-wave interactions.

Calling Sequence: source (iter, ix, iy, swpdir, kwave, spcsig, ecos, esin, ac2, dep2, imatda, imatra, abrbot, kmespc, smespc, ubot, ufric, ux2, uy2, idcmin, idcmax, iddlow, iddtop, idwmin, idwmax, isstop, plwnda, plwndb, plwcap plbtfr, plwbrk, plnl4s, plnl4d, pltri, warea, hs, etot, qbloc, thetaw, hm, fpm, wind10, etotw, groww, alimw, smebrk, snlc1, fachfr, dal1, dal2, dal3, af11, ue, sa1, sa2, da1c, da1p, da1m, da2c, da2p, da2m, sfnl, dsnl, memnl4, wwint, wwawg, wwswg, cgo, ustar, zelen, spcdir, anywnd, dissc0, dissc1, szeroc, eps2wc, diswcp, wcpsme, wcpkme, wcpqb, wcphm, xis, frcoef, it, precor, ursell)

Data Declaration:	Real	ecos, esin, spcdir, spcsig, abrbot, etot, hm, qbloc, etotw, fpm, wind10, thetaw, smespc, kmespc, snlc1, fachfr, dal1, dal2, dal3, ufric, smebrk, hs, szeroc, eps2wc, diswcp, wcpqb, wcphm, wcpsme, wcpkme, xis, ac2, dep2, alimw, imatda, imatra, kwave, ubot, ux2, uy2, af11, ue, sa1, sa2, da1c, da1p, da1m, da2c, da2p, da2m, sfnl, dsnl, memnl4, plwnda, plwndb, plwcap, plbtfr, plwbrk, plnl4s, plnl4d, pltri, wwawg, wwswg, cgo, ustar, zelen, dissc0, dissc1, ursell, frcoef, etotw, swpdir
	Integer	iter, idwmin, idwmax, isstop, iddtop, iddlow, ix, iy, warea, idcmin, idcmax, wwint, it
	Logical	precor, groww, anywnd

Arguments:	ecos	= *spcdir*(*,2) Cosine of spectral directions.
	esin	= *spcdir*(*,3) Sine of spectral directions.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	spcsig	Relative frequencies in computational domain in sigma space.

iter	Iteration counter for SWAN.
ix	Counter of grid points in x-direction.
iy	Counter of grid points in y-direction.
swpdir	Current sweep direction.
kwave	Wave number as function of the relative frequency S and position ic (*ix, iy*).
ac2	(Non-stationary case) action density as function of D, S, X, Y at time T + DT.
dep2	(Non-stationary case) depth as a function of X and Y at time T + DIT.
imatda	Coefficients of diagonal of matrix.
imatra	Coefficients of right-hand side of matrix.
abrbot	Near bottom excursion.
kmespc	Mean average wave number according to the WAM formulation.
smespc	Mean average frequency over full spectrum.
ubot	Absolute orbital velocity in a grid point (*ix, iy*).
ufric	Wind friction velocity.
ux2	(Non-stationary case) X-component of current velocity in (X, Y) at time T + DIT.
uy2	(Non-stationary case) Y-component of current velocity in (X, Y) at time T + DIT.
idcmin	Minimum frequency dependent counter in directional space.
idcmax	Maximum frequency dependent counter in directional space.
iddlow	Minimum counter per sweep taken over all frequencies.
iddtop	Maximum counter per sweep taken over all frequencies.
idwmin	Minimum counter for spectral wind direction.
idwmax	Maximum counter for spectral wind direction.
isstop	Maximum frequency that is propagated within a sweep.
plwnda	Values of source term for test point.
plwndb	Values of source term for test point.
plwcap	Array containing the whitecapping source term for test output.
plbtfr	Bottom friction source term array for outputting on one of the source terms at a particular grid point.
plwbrk	Surf breaking source term array for outputting on one of the source terms at a particular grid point .
plnl4s	Nonlinear source term array (rhs part) for outputting on one of the source terms at a particular grid point.
plnl4d	Nonlinear source term array (diagonal part) for

	outputting on one of the source terms at a particular grid point.
pltri	Values of the triad source terms in test points.
warea	The big array used in data pool scheme, to contain many variables.
hs	Significant wave height.
etot	Total energy density per grid point.
qbloc	Fraction of breaking waves.
thetaw	Mean direction of the relative wind vector.
hm	Maximum wave height.
fpm	PM frequency.
wind10	Velocity of the relative wind vector.
etotw	Total energy of the wind sea spectrum.
groww	Check for a certain frequency if the waves are growing or not in a spectral direction.
alimw	Maximum energy by wind growth.
smebrk	Mean frequency according to first order moment.
snlc1	Coefficient for the subroutines SWSNLN.
fachfr	Contribution of high frequency tail to wave stress.
dal1, dal2, dal3	Lambda dependent weight factors
af11	Scaling frequency.
ue	"Unfolded" spectrum.
sa1, sa2	Interaction contribution of first and second quadrants, respectively (unfolded space).
da1c, da1p, da1m, da2c, da2p, da2m	Items for diagonal matrix.
sfnl	Source term Snl, rhs part.
dsnl	Source term Snl, diag part.
memnl4	Saves sfnl at every x, y point in memory.
wwint	Counters for four wave-wave interactions.
wwawg	Weight coefficients for the four wave-wave interactions.
wwswg	Weights coefficients for the four wave-wave interactions for the semi-implicit computation.
cgo	Group velocity.
ustar	Friction velocity at previous iteration for Janssen (1989, 1991) wind input formulation.
zelen	Roughness length at previous iteration for Janssen (1989, 1991) wind input formulation.

spcdir	(*,1) Spectral directions (radians);
	(*,2) Cosine of spectral directions;
	(*,3) Sine of spectral directions;
	(*,4) Cosine^2 of spectral directions;

	(*,5) Cosine*sine of spectral directions;
	(*,6) Sine^2 of spectral directions.
anywnd	Indicator if wind input has to be taken into account for a bin.
dissc0	(Not used); Stores the dissipation distributed over spectral space in one point of the computational grid (old value).
dissc1	(Not used); Dissipation coefficient, function of sigma and theta.
szeroc	Not used.
eps2wc	Not used.
diswcp	Not used.
wcpsme	Not used.
wcpkme	Not used.
wcpqb	Not used.
wcphm	Not used.
xis	Difference between succeeding frequencies.
frcoef	Spatially variable friction coefficient.
it	Timestep counter for SWAN.
precor	Determines whether first guess estimate for stationary mode is calculated.
ursell	*Ursell* number as function of *ix* and *iy*.

5.3.6.13 Subroutine SWCOMP

Subroutine SWCOMP is the main subroutine for the computational module. In subroutine SCOMPU the main processes taking place in the shallow water zone are determined in several subroutines. The input for this subroutine comes from SWANPRE1, SWANPRE2 and SWANPRE3. The output is sent to the subroutines SWANOUT1, SWANOUT2 and SWANOUT3. The output consists of some characteristic wave parameters and the wave action density. The equations are all based on the action density N, which is a function of the spatial position (x, y), the relative frequency(s) and the spectral direction(d).

Calling Sequence: swcomp (warea, rwarea, lwarea, ac1, ac2, compda, spcdir, spcsig, swtsda, xytst, it, kgrpnt, xcgrid, ycgrid, obsta, cross)

Data Declaration:	Real	rwarea, spcdir, spcsig, xcgrid, ycgrid, ac2, ac1, compda, swtsda
	Logical	lwarea
	Integer	it, warea, xytst, kgrpnt, obsta, cross

Arguments:	rwarea	Real equivalence of *warea.*
	spcdir	(*,1) Spectral directions (radians);
		(*,2) Cosine of spectral directions;

	(*,3) Sine of spectral directions;
	(*,4) Cosine^2 of spectral directions;
	(*,5) Cosine*sine of spectral directions;
	(*,6) Sine^2 of spectral directions.
spcsig	Relative frequencies in the computational domain in sigma space.
xcgrid	X-coordinate of computational grid in x-direction.
ycgrid	Y-coordinate of computational grid in y-direction.
ac1	Action density as function of D, S, X, Y at time T.
ac2	(Non-stationary case) action density as function of D, S, X, Y at time T + DT.
warea	The big array, used in data pool scheme, to contain many variables.
lwarea	*Warea* for logical variable storage.
compda	Array containing depth and other arrays of (*ix, iy*).
swtsda	Intermediate data computed for the test points.
xytst	Test points.
it	Timestep counter for SWAN.
kgrpnt	Grid point addresses.
obsta	Array of obstacle parameters.
cross	Array which contains 0's if there is no obstacle crossing if an obstacle is crossing between the central point and its neighbor *cross* is equal to the number of the obstacle.

5.3.6.14 Subroutine SWOMPU

Subroutine SWOMPU computes the wave spectrum for one sweep direction and is called four times per iteration.

Calling Sequence: swompu (swpdir, ksx, ksy, ix, iy, ddx, ddy, dt, snlc1, dal1, dal2, dal3, xis, swtsda, inocnv, ac2, compda, spcdir, spcsig, xytst, iter, warea, cgo, cg, cax, cay, cas, cad, swmatr, lswmat, kwave, alimw, groww, af11, ue, sa1, sa2, da1c, da1p, da1m, da2c, da2p, da2m, sfnl, dsnl, memnl4, idcmin, idcmax, sector, wwint, wwawg, wwswg, icolu2, diflow, difdig, difupp, difrhv, band, exact, rhv, rinsol, solut, work, precon, upperi, loperi, infmat, iinsol, iscmin, iscmax, anywnd, ac1, it, precor, xcgrid, ycgrid, kgrpnt, cross, obsta, obredf, cax1, cay1)

Data Declaration:	Integer	iter, it, ix, iy, swpdir, ksx, ksy, inocnv, xytst, warea, idcmin, idcmax, iscmin, iscmax, sector, wwint, infmat, iinsol, kgrpnt, obsta, cross
	Real	spcdir, spcsig, xcgrid, ycgrid, ddx, ddy, dt, dal1,

		dal2, dal3, xis, ac2, ac1, compda, cgo, cg, cax, cay, cax1, cay1, cas, cad, alimw, swmatr, kwave, af11, ue, sa1, sa2, da1c, da1p, da1m, da2c, da2p, da2m, sfnl, dsnl, memnl4, swtsda, wwawg, wwswg, icolu2, diflow, difdig, difupp, difrhv, band, exact, rhv, rinsol, solut, work, precon, upperi, loperi, obredf
	Logical	lswmat, groww, anywnd, precor
Arguments:	iter	Iteration counter for SWAN.
	it	Timestep counter for SWAN.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	spcsig	Relative frequencies in computational domain in sigma space.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	lswmat	Logical equivalence of *swmatr.*
	swpdir	Current sweep direction.
	ksx	Dummy variable to get the right sign in the numerical difference scheme in x-direction.
	ksy	Dummy variable to get the right sign in the numerical difference scheme in y-direction.
	ix	Counter of grid points in x-direction.
	iy	Counter of grid points in y-direction.
	ddx	Length of spatial cell in x-direction, but with correct sign depending of the direction of the sweep (+1 or -1).
	ddy	Length of spatial cell in y-direction, but with the correct sign depending of the direction of the sweep (+1 or -1).
	dt	Timestep.
	snlc1	Coefficient for the subroutine SWSNLN.
	dal1, dal2, dal3	Lambda dependent weight factors.
	xis	Difference between succeeding frequencies.
	swtsda	Intermediate data computed for the test points.
	inocnv	Counts occurrence of nonconvergence in solver.
	ac2	(Non-stationary case) action density as function of D, S, X, Y at time T + DT.
	compda	Array containing depth and other arrays of (*ix, iy*).

xytst	Test points.
warea	The big array, used in data pool scheme, to contain many variables.
cgo	Group velocity as function of *ic* and *is* in the direction of wave propagation in absence of currents.
cg	Group velocity as function of *ic, is* and *id* in the direction of wave propagation in presence of currents.
cax	Wave transport velocity in x-direction, function of (*id, is, ic*).
cay	Wave transport velocity in y-direction, function of (*id, is, ic*).
cas	Wave transport velocity in s-direction, function of (*id, is, ic*).
cad	Wave transport velocity in d-direction, function of (*id, is, ic*).
swmatr	An array containing several variables (for data pool).
kwave	Wave number as function of the relative frequency S and position *ic (ix, iy*).
alimw	Maximum energy by wind growth. This dummy array is used because the maximum value has to be checked directly after the solver of the tri-diagonal matrix.
groww	Check for a certain frequency if the waves are growing or not in a spectral direction.
af11	Scaling frequency.
ue	"Unfolded" spectrum.
sa1, sa2	Interaction contribution of first and second quadrants, respectively (unfolded space).
da1c, da1p, da1m, da2c, da2p, da2m	Items for diagonal matrix.
sfnl	Source term Snl, RHS part.
dsnl	Source term Snl, DIAG part.
memnl4	Saves sfnl at every x,y point in memory.
idcmin	Frequency dependent counter in directional space.
idcmax	Frequency dependent counter in directional space.
sector	Indicates which configuration is present.
wwint	Counters for four wave-wave interactions.
wwawg	Weight coefficients for the four wave-wave interactions.
wwswg	Weights coefficients for the four wave-wave interactions for the semi-implicit computation.

icolu2	Auxiliary array for storing the coefficients in the last column.
diflow	Lower diagonal in solver for diffusion.
difdig	Diagonal in solver for diffusion.
difupp	Upper diagonal in solver for diffusion.
difrhv	Right-hand vector.
band	Matrix from the equations to be solved.
exact	Exact solution.
rhv	Right-hand side.
rinsol	Real information for the solver.
solut	Iterative solution.
work	Work space.
precon	Preconditioner.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.
infmat	Integer information for the matrix.
iinsol	Integer information for the solver.
iscmin	Frequency dependent counter in frequency space.
iscmax	Frequency dependent counter in frequency space.
anywnd	Indicator if wind input has to be taken into account for a bin.
ac1	Action density as function of D, S, X, Y at time T.
precor	Determines whether first guess estimate for stationary mode is calculated.
kgrpnt	Grid point addresses.
cross	Array which contains 0's if there is no obstacle crossing if an obstacle is crossing between the central point and its neighbor *cross* is equal to the number of the obstacle.
obsta	Array of obstacle parameters.
obredf	Array of action density reduction coefficients.
cax1	Propagation velocity in x old time level.
cay1	Propagation velocity in y old time level.

5.3.7 Source Terms and Dissipation Subroutines (swancom2 FOR File)

5.3.7.1 Subroutine BRKPAR

Subroutine BRKPAR determines the bottom slope in upwave direction and calculates the slope dependent breaking parameter according to Nelson (1987). It is used here because Nelson (1994) has an error present in the equation.

Calling Sequence: brkpar (mdc, msc, ecos, esin, pi, ac2, spcsig, dep2, psurf, msurf, icmax, etot, kcgrd, mcgrd, rdx, rdy)

Data Declaration:	Real	ac2, ecos, esin, dep2, psurf, rdx, rdy, etot, spcsig, pi
	Integer	msc, mdc, msurf, kcgrd, mcgrd, icmax

Arguments:	mdc	Maximum counter of directional distribution.
	msc	Maximum counter of relative frequency.
	ecos	Cosine of angle.
	esin	Sine of angle.
	pi	3.14.
	ac2	Action density.
	spcsig	Relative frequencies in computational domain in sigma space.
	dep2	Depth.
	psurf	Coefficients for breaking module.
	msurf	Dimensioning size for *psurf.*
	icmax	Maximum number of elements in *kcgrd.*
	etot	Total wave energy density in a particular direction.
	kcgrd	Grid counter in central grid point.
	mcgrd	Maximum counter in geographical space.
	rdx, rdy	Array containing spatial derivative coefficient.

5.3.7.2 Subroutine FRABRE

Subroutine FRABRE computes the fraction of breaking waves in point (*ix, iy*) of the computational grid.

Calling Sequence: frabre (hm, etot, qbloc)

Data Declaration: Real hm, etot, qbloc

Arguments:	etot	Total energy per spatial grid point.
	qbloc	Second iteration of the fraction of breaking waves.
	hm	Maximum wave height.

5.3.7.3 Subroutine FRABRE2

Subroutine FRABRE2 computes the fraction of breaking waves in point (*ix, iy*) of the computational grid.

Calling Sequence: frabre2 (hm, etot, qbloc)

Data Declaration: Real hm, etot, qbloc

Arguments:	etot	Total energy per spatial grid point.
	qbloc	Second iteration of the fraction of breaking waves.
	hm	Maximum wave height.

5.3.7.4 Subroutine PLTSRC

Subroutine PLTSRC stores the source terms for the TESTFL grid point in a file.

Calling Sequence: pltsrc (plwnda, plwndb, plwcap, plbtfr, plwbrk, plnl4s, plnl4d, pltri, ac2, spcsig, dep2, xytst, kgrpnt)

Data Declaration:	Real	ac2, spcsig, plwnda, plwndb, plwcap, plbtfr, plwbrk, plnl4s, plnl4d, pltri, dep2
	Integer	xytst, kgrpnt

Arguments:	plwnda	Value of source term for test point.
	plwndb	Value of source term for test point.
	plwcap	Array containing the whitecapping source term for test output.
	plbtfr	For outputting on of the source terms at a particular grid point.
	plwbrk	For outputting on of the source terms at a particular grid point.
	plnl4s	For outputting on of the source terms at a particular grid point.
	plnl4d	For outputting on of the source terms at a particular grid point.
	pltri	Value of the triad source terms in test points.
	ac2	Action density.
	spcsig	Relative frequencies in the computational domain in sigma space.
	dep2	Depth.
	xytst	Test points.
	kgrpnt	Grid point addresses.

5.3.7.5 Subroutine SBOT

Subroutine SBOT provides computation of the source terms due to bottom friction.

Calling Sequence: sbot (mdc, msc, icmax, icur, ibot, grav, abrbot, dep2, ecos, esin, imatda, kwave, spcsig, ubot, ux2, uy2, pbot, mbot, idcmin, idcmax, plbtfr, isstop, dissc1, varfr, frcoef, kcgrd, mcgrd)

Data Declaration:	Real	spcsig, grav, abrbot, dep2, ecos, esin, imatda, kwave, pbot, plbtfr, ubot, ux2, uy2, disscl, frcoef
	Integer	icur, ibot, mdc, msc, icmax, mbot, isstop, mcgrd, kcgrd, idcmin, idcmax
	Logical	varfr

Arguments:	spcsig	Relative frequencies in the computational domain in sigma space.
	mdc	Maximum counter of directional distribution.
	msc	Maximum counter of relative frequency.
	icmax	Maximum counter for the points of the molecule.
	icur	Indicator if a current is present.
	ibot	Indicator if bottom friction is on.
	grav	Gravitational acceleration.
	abrbot	Near bottom excursion amplitude.
	dep2	Depth.
	ecos	Cosine per spectral direction (id).
	esin	Sine per spectral direction (id).
	imatda	Coefficients of diagonal of matrix.
	kwave	Wave number function of frequency and *ic.*
	ubot	Near bottom velocity as function of X, Y.
	ux2	Current velocity in x direction as function of X, Y.
	uy2	Current velocity in y direction as function of X, Y.
	pbot	Coefficient for bottom friction models.
	mbot	Maximum array size for the array *pbot.*
	idcmin	Minimum number for counter *iddum.*
	idcmax	Maximum number for counter *iddum.*
	plbtfr	For outputting on of the source terms at a particular grid point.
	isstop	Maximum counter of wave component in frequency space that is propagated.
	disscl	Dissipation coefficient, function of sigma and theta.
	varfr	Friction is spatially varying.
	frcoef	Spatially variable friction coefficient.
	kcgrd	Grid counter in central grid point.
	mcgrd	Maximum counter in geographical space.

5.3.7.6 Subroutine SSURF

Subroutine SSURF provides computation of the source term due to wave breaking. Whitecapping is not taken into account.

Calling Sequence: ssurf (etot, hm, qb, smebrk, ac2, imatra, imatda, idcmin, idcmax, plwbrk, isstop, dissc0, dissc1)

Data Declaration:	Real	ac2, dissc0, dissc1, imatda, imatra, plwbrk, etot, hm, qb, smebrk
	Integer	isstop, idcmin, idcmax

Arguments:	ac2	Action density array.
	dissc0	(Not used); Stores the dissipation distributed over spectral space in one point of the computational grid (old value).
	dissc1	(Not used); Dissipation coefficient, function of sigma and theta.
	etot	Total energy per spatial grid point.
	hm	Maximum wave height.
	idcmin	Minimum number for counter *iddum.*
	idcmax	Maximum number for counter *iddum.*
	imatda	Coefficient of diagonal matrix.
	imatra	Coefficient of the right-hand side of the matrix.
	isstop	Maximum for counter *is.*
	plwbrk	For outputting on of the source terms at a particular grid point.
	qb	Fraction of breaking waves.
	smebrk	Mean frequency according to first order moment.

5.3.7.7 Subroutine SWCAP

Subroutine SWCAP calculates the dissipation due to whitecapping.

Calling Sequence: swcap (spcdir, spcsig, kwave, ac2, idcmin, idcmax, isstop, etot, imatda, imatra, plwcap, dep2)

Data Declaration:	Real	ac2, dep2, etot, kwave, spcdir, spcsig, plwcap, imatda, imatra
	Integer	isstop, idcmin, idcmax

Arguments:	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	spcsig	Relative frequencies in computational domain in sigma space.
	kwave	Wave number.

ac2	Action density array.
idcmin	Minimum number for counter *iddum.*
idcmax	Maximum number for counter *iddum.*
isstop	Maximum for counter *is.*
etot	Total energy per spatial grid point.
imatda	Coefficient of diagonal matrix.
imatra	Coefficient of right-hand side of matrix.
plwcap	Array containing the whitecapping source term for test output.
dep2	Array containing water depth.

5.3.8 Source Terms for Generation of Wave Energy Subroutines (swancom3 FOR File)

5.3.8.1 Subroutine SWIND0

Subroutine SWIND0 provides computation of the source term for the wind input for a third generation wind growth model: Linear wind input term according to Cavaleri and Malanotte-Rizzoli (1981).

Calling Sequence: swind0 (mdc, msc, idcmin, idcmax, isstop, spcsig, thetaw, grav, pi, anywnd, ufric, fpm, plwnda, imatra, spcdir, kcgrd, icmax, pwind)

Data Declaration:	Real	fpm, grav, ufric, thetaw, pi, imatra, plwnda, pwind, spcdir, spcsig
	Integer	mdc, msc, idcmin, idcmax, isstop, kcgrd
	Logical	anywnd

Arguments:	mdc, msc	Counters in spectral space.
	idcmin	Frequency dependent minimum counter.
	idcmax	Frequency dependent maximum counter.
	isstop	Maximum frequency that fall within a sweep.
	spcsig	Relative frequencies in computational domain in sigma space.
	thetaw	Mean direction of the relative wind vector.
	grav	Gravitational acceleration.
	pi	3.14.
	anywnd	Indicator if wind input has to be taken into account for a bin.
	ufric	Wind friction velocity.
	fpm	PM frequency.
	plwnda	Values of source term for test point.
	imatra	Coefficients of right-hand side of vector.

spcdir	(*,1) Spectral directions (radians);
	(*,2) Cosine of spectral directions;
	(*,3) Sine of spectral directions;
	(*,4) Cosine^2 of spectral directions;
	(*,5) Cosine*sine of spectral directions;
	(*,6) Sine^2 of spectral directions.
kcgrd	Grid counter in central grid point.
icmax	Maximum counter for the points of the molecule.
pwind	Coefficient for the wind growth model.

5.3.8.2 Subroutine SWIND3

Subroutine SWIND3 provides computation of the source term for the wind input for a third generation wind growth model:

> Exponential input term, (Snyder et al. 1981, which expression has been modified by Komen et al. 1984). This input term should be combined with the dissipation term of Komen et al. (1984).

Calling Sequence: swind3 (mdc, msc, spcsig, thetaw, imatda, pwind, mwind, kwave, imatra, pi, idcmin, idcmax, ac2, icmax, ufric, fpm, plwndb, isstop, spcdir, anywnd, kcgrd, mcgrd)

Data Declaration:

Real	spcsig, spcdir, fpm, ufric, thetaw, pi, ac2, imatda, kwave, pwind, plwndb
Integer	mdc, msc, icmax, mwind, isstop, mcgrd, kcgrd, idcmin, idcmax
Logical	anywnd

Arguments:

mdc, msc	Counters in spectral space.
spcsig	Relative frequencies in computational domain in sigma space.
thetaw	Mean direction of the relative wind vector.
imatda	Coefficients of the diagonal.
pwind	Coefficient for thw wind growth model.
mwind	Maximum array size for *pwind.*
kwave	Wave number.
imatra	Coefficients of right-hand side of matrix.
pi	3.14.
idcmin	Frequency dependent minimum counter.
idcmax	Frequency dependent maximum counter.
ac2	Action density as function of X, Y, S, and T.
icmax	Maximum counter for the points of the molecule.
ufric	Wind friction velocity.

fpm	PM frequency.
plwndb	Values of source term for test point.
isstop	Maximum frequency that fall within a sweep.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
anywnd	Indicator if wind input has to be taken into account for a bin.
kcgrd	Grid counter in central grid point.
mcgrd	Maximum counter in geographical space.

5.3.8.3 Subroutine SWIND4

Subroutine SWIND4 provides computation of the source term for the wind input for a third generation wind growth model:

> Computation of the exponential input term based on a quasi-linear theory developed by Janssen (1989, 1991a). This formulation should be used in combination with the whitecapping dissipation source term according to Janssen (1991a and b) and Mastenbroek et al. (1993).

Calling Sequence: swind4 (mdc, msc, icmax, idwmin, idwmax, spcsig, wind10, thetaw, pwind, xis, mwind, dd, kwave, grav, imatra, pi, idcmin, idcmax, ac2, ufric, plwndb, isstop, iter, ustar, zelen, spcdir, anywnd, nstatc, it, precor, kcgrd, mcgrd)

Data Declaration:	Real	spcsig, spcdir, grav, thetaw, wind10, ufric, ac2, imatra, kwave, pwind, plwndb, ustar, zelen, pi, xis, dd
	Integer	idwmax, idwmin, mdc, msc, isstop, icmax, mwind, mcgrd, nstatc, kcgrd, idcmin, idcmax, it
	Logical	anywnd, precor

Arguments:	mdc, msc	Counters in spectral space.
	icmax	Maximum counter for the points of the molecule.
	idwmin	Minimum counter for spectral wind direction.
	idwmax	Maximum counter for spectral wind direction.
	spcsig	Relative frequencies in computational domain in sigma space.
	thetaw	Mean direction of the relative wind vector.
	wind10	Velocity of the relative wind vector.

pwind	Coefficient for the wind growth model.
xis	Difference between succeeding frequencies.
mwind	Maximum array size for *pwind*.
dd	Directional band width.
kwave	Wave number.
grav	Gravitational acceleration.
imatra	Coefficients of the right-hand side of matrix.
pi	3.14.
idcmin	Frequency dependent minimum counter.
idcmax	Frequency dependent maximum counter.
ac2	Action density as function of X, Y, S, and T.
ufric	Wind friction velocity.
plwndb	Values of source term for test point.
isstop	Maximum frequency that fall within a sweep.
iter	Iteration counter for SWAN.
ustar	Friction velocity at previous iteration level.
zelen	Roughness length at previous iteration level.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
anywnd	Indicator if wind input has to be taken into account for a bin.
nstatc	Indicator if computation is stationary.
it	Timestep counter for SWAN.
precor	Determines whether first guess estimate for stationary mode is calculated.
kcgrd	Grid counter in central grid point.
mcgrd	Maximum counter in geographical space.

5.3.8.4 Subroutine SWIND5

Subroutine SWIND5 provides computation of the source term for the wind input for a third generation wind growth model:

> The exponential input term is according to Yan (1987). This input term is valid for the higher frequency part of the spectrum (strongly forced wave components). The expression reduces to the Snyder (1981) expression form for spectral wave components with weak wind forcing and to the Plant (1982) form for more strongly forced wave components.

Calling Sequence: swind5 (mdc, msc, spcsig, thetaw, isstop, ufric, kwave, imatra, pi, idcmin, idcmax, ac2, icmax, anywnd, plwndb, spcdir, kcgrd, mcgrd)

Data Declaration:

Real	spcsig, spcdir, ac2, pi, ufric, thetaw, imatra, kwave, plwndb
Integer	kcgrd, mcgrd, idcmin, idcmax, icmax, isstop, mdc, msc
Logical	anywnd

Arguments:

mdc, msc	Counters in spectral space.
spcsig	Relative frequencies in computational domain in sigma space.
thetaw	Mean direction of the relative wind vector.
isstop	Maximum frequency that fall within a sweep.
ufric	Wind friction velocity.
kwave	Wave number.
imatra	Coefficients of right-hand side of matrix.
pi	3.14.
idcmin	Frequency dependent minimum counter.
idcmax	Frequency dependent maximum counter.
ac2	Action density as function of X, Y, S, and T.
icmax	Maximum counter for the points of the molecule.
anywnd	Indicator if wind input has to be taken into account for a bin.
plwndb	Values of source term for test point.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
kcgrd	Grid counter in central grid point.
mcgrd	Maximum counter in geographical space.

5.3.8.5 Subroutine WNDPAR

Subroutine WNDPAR provides computation of the wind input source term with formulations of a first-generation model (constant proportionality coefficient) and a second-generation model (proportionality coefficient depends on the energy in the wind sea part of the spectrum). The expressions are from Holthuijsen and De Boer (1988) and from the DOLPHIN-B model. During the implementation of the terms, modifications to the code have been made after personal communications with Holthuijsen and Booij.

Calling Sequence:	wndpar (isstop, idwmin, idwmax, idcmin, idcmax, dep2, wind10, thetaw, ac2, kwave, imatra, imatda, spcsig, cgo, alimw, groww, etotw, plwnda, plwndb, spcdir, iter)	
Data Declaration:	Real	spcdir, spcsig, wind10, thetaw, etotw, ac2, alimw, imatda, imatra, kwave, plwnda, plwndb, dep2, cgo
	Integer	iter, idwmin, idwmax, iddum, isstop, idcmin, idcmax
	Logical	groww
Arguments:	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	spcsig	Relative frequencies in computational domain in sigma space.
	isstop	Counter for the maximum frequency of all directions.
	idwmin	Minimum counter for spectral wind direction.
	idwmax	Maximum counter for spectral wind direction.
	idcmin	Minimum counter in directional space.
	idcmax	Maximum counter in directional space.
	dep2	Depth.
	wind10	Velocity of the relative wind vector.
	thetaw	Mean direction of the relative wind vector.
	ac2	Action density as function of D, S, X, Y and T.
	kwave	Wave number.
	imatra	Coefficient of right-hand side of vector.
	imatda	Coefficient of the diagonal.
	cgo	Group velocity.
	alimw	Limiting spectrum in terms of action density.
	groww	Array to determine whether there are wave generation conditions.
	etotw	Total energy of the wind sea part of the spectrum.
	plwnda	Value of source term for test point.
	plwndb	Value of source term for test point.
	iter	Iteration counter for SWAN.

5.3.8.6 Subroutine WINDP1

Subroutine WINDP1 provides computation of parameters derived from the wind for several subroutines such as SWIND1, SWIND2, SWIND3 and CUTOFF.

Calling Sequence:	windp1 (wind10, thetaw, idwmin, idwmax, fpm, ufric, wx2, wy2, anywnd, spcdir, ux2, uy2, spcsig	
Data Declaration:	Real	spcsig, spcdir, wind10, thetaw, ufric, fpm, wx2, wy2, ux2, uy2
	Integer	idwmin, idwmax
	Logical	anywnd
Arguments:	wind10	Velocity of the relative wind vector.
	thetaw	Mean direction of the relative wind vector.
	idwmin	Minimum counter for spectral wind direction.
	idwmax	Maximum counter for spectral wind direction.
	fpm	PM frequency.
	ufric	Wind friction velocity.
	wx2, wy2	Wind velocity array relative to a current.
	anywnd	Indicator if wind input has to be taken into account for a bin.
	ux2	(Non-stationary case) X-component of current velocity in (X, Y) at time T + DIT.
	uy2	(Non-stationary case) Y-component of current velocity in (X, Y) at time T + DIT.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	spcsig	Relative frequencies in computational domain in sigma space.

5.3.8.7 Subroutine WINDP2

Subroutine WINDP2 provides computation of the wind sea energy spectrum for the second-generation wind growth model.

Calling Sequence:	windp2 (idwmin, idwmax, sigpkd, fpm, etotw, ac2, spcsig, wind10)	
Data Declaration:	Integer	idwmin, idwmax
	Real	spcsig, etotw, fpm, ac2, sigpkd, wind10
Arguments:	idwmin	Minimum counter for spectral wind direction.
	idwmax	Maximum counter for spectral wind direction.

sigpkd	Adapted peak frequency for shallow water.
fpm	PM frequency.
etotw	Total energy of the wind sea part of the spectrum.
ac2	Action density as function of D, S, X, Y and T.
spcsig	Relative frequencies in computational domain in sigma space.
wind10	Velocity of the relative wind vector.

5.3.8.8 Subroutine WINDP3

Subroutine WINDP3 reduces the energy density in the spectral direction directly after solving the tri-diagonal matrix, if the energy density level is larger than the upper bound limit given by a Pierson Moskowitz spectrum. This is only carried out if a particular wave component is "growing". If the energy density in a bin is larger than the upper bound limit (for instance when crossing wind seas are present) then the energy density level is a lower limit.

Calling Sequence: windp3 (mdc, msc, isstop, alimw, ac2, groww, idcmin, idcmax, kcgrd, mcgrd, icmax)

Data Declaration:

Real	ac2, alimw
Integer	mdc, msc, mcgrd, icmax, idcmin, idcmax, kcgrd, isstop
Logical	groww

Arguments:

mdc, msc	Counters in spectral space.
isstop	Maximum frequency that falls within a sweep.
alimw	Contains the action density upper bound limit regarding spectral action density per spectral bin (A(s, t)).
ac2	Action density as function of X, Y, S, and T.
groww	Logical array which determines if there is a) generation (E < E_lim $\rightarrow$ True) or b) dissipation (E > E_lim $\rightarrow$ False).
idcmin	Frequency dependent minimum counter.
idcmax	Frequency dependent maximum counter.
kcgrd	Grid counter in central grid point.
mcgrd	Maximum counter in geographical space.
icmax	Maximum counter for the points of the molecule.

5.3.9 Nonlinear Four Wave-wave Interaction Subroutines (swancom4 FOR File)

5.3.9.1 Subroutine BND4WW

Subroutine BND4WW computes the array size for the nonlinear four-wave interactions in order to allocate some memory in the *warea.*

Calling Sequence: bnd4ww (mscmax, mdcmax, spcsig)

Data Declaration:	Real	spcsig
	Integer	mscmax, mdcmax
Arguments:	mscmax	Auxiliary variable for the 4-WAVE interactions to allocate required memory in the *warea.*
	mdcmax	Auxiliary variable for the 4-WAVE interactions to allocate required memory in the *warea.*
	spcsig	Relative frequencies in computational domain in sigma space.

5.3.9.2 Subroutine FAC4WW

Subroutine FAC4WW calculates interpolation constants for *snl.*

Calling Sequence: fac4ww (iter, xis, snlc1, dal1, dal2, dal3, spcsig, af11, wwint, wwawg, wwswg)

Data Declaration:	Real	spcsig, af11, xis, snlc1, wwawg, wwswg, dal1, dal2, dal3
	Integer	iter, wwint
Arguments:	iter	Iteration number.
	xis	Difference between succeeding frequencies.
	snlc1	Coefficient for the subroutines SWSNLN.
	dal1, dal2, dal3	Lambda dependent weight factors.
	spcsig	Relative frequencies in computational domain sigma space.
	af11	Scaling frequency.
	wwint	Counters for four-wave interactions.
	wwawg	Values for the interpolation.
	wwswg	Values for the interpolation.

5.3.9.3 Subroutine FILNL3

Subroutine FILNL3 fills the *imatra* array with the nonlinear wave-wave interaction source term for a grid point (*ix, iy*) per sweep direction.

Calling Sequence: filnl3 (mdc, msc, idcmin, idcmax, imatra, memnl4, plnl4s, isstop, kcgrd, mcgrd, icmax)

Data Declaration:	Real	imatra, memnl4, plnl4s
	Integer	mdc, msc, idcmin, idcmax, isstop, kcgrd, mcgrd, icmax

Arguments:	mdc	Grid points in theta-direction of computational grid.
	msc	Grid points in sigma-direction of computational grid.
	idcmin	Minimum frequency dependent counter in directional space.
	idcmax	Maximum frequency dependent counter in directional space.
	imatra	Coefficient of the right-hand side of the matrix.
	memnl4	Saves sfnl at every x,y point in memory.
	plnl4s	For outputting on of the source terms at a particular grid point.
	isstop	Maximum frequency that is propagated within a sweep.
	kcgrd	Grid address of points of computational stencil.
	mcgrd	Number of wet grid points of the computational grid.
	icmax	Number of points in computational stencil.

5.3.9.4 Subroutine RANGE4

Subroutine RANGE4 calculates the minimum and maximum counters in frequency and directional space that fall with the calculation for the nonlinear wave-wave interactions.

Calling Sequence: range4 (wwint, iddlow, iddtop)

Data Declaration:	Integer	wwint, iddlow, iddtop

Arguments:	wwint	Counters for four-wave interactions.
	iddlow	Minimum counter of the bin that is propagated within a sweep.
	iddtop	Maximum counter of the bin that is propagated within a sweep.

5.3.9.5 Subroutine STRIAD

Subroutine STRIAD models the triad self-interaction based on Boussinesq equation.

Calling Sequence: striad (ac2, dep2, cgo, imatra, kwave, hs, iddlow, iddtop, spcsig, smebrk, imatda, pltri, ursell)

Data Declaration:	Real	ac2, dep2, cgo, imatra, kwave, hs, spcsig, imatda, ursell, pltri
	Integer	iddlow, iddtop

Arguments:	ac2	Action density as function of D, S, X, Y at time T.
	dep2	Depth at (*ix, iy*).
	cgo	Group velocity.
	imatra	Right-hand vector.
	kwave	Wave number.
	hs	Significant wave height.
	iddlow	Minimum counter in directional space.
	iddtop	Maximum counter in directional space.
	spcsig	Relative frequencies in computational domain in sigma space.
	smebrk	Mean frequency according to first order moment.
	imatda	Coefficient of diagonal matrix.
	pltri	Values of the triad source terms in test points.
	ursell	*Ursell* number as function of *ix* and *iy*.

5.3.9.6 Subroutine STRIAN

Subroutine STRIAN calculates triad-wave interactions with the LTA of Eldeberky (1996). His expression that is based on a parameterization of the biphase (in terms of the *ursell* number) is directionally uncoupled and takes into account for self-self interactions only. For a full description of the equations reference is made to Eldeberky (1996). Only the main equations are given here.

Calling Sequence: strian (ac2, dep2, cgo, imatra, kwave, hs, iddlow, iddtop, spcsig, smebrk, imatda, pltri, ursell)

Data Declaration:	Real	ac2, dep2, cgo, imatra, kwave, hs, spcsig, smebrk, imatda, pltri, ursell
	Integer	iddlow, iddtop

Arguments:	ac2	Action density as function of D, S, X, Y at time T.
	dep2	Depth at grid point (*ix, iy*).
	cgo	Group velocity.
	imatra	Right-hand vector.
	kwave	Wave number.
	hs	Significant wave height.
	iddlow	Minimum counter in directional space.
	iddtop	Maximum counter in directional space.
	spcsig	Relative frequencies in computational domain in sigma space.
	smebrk	Mean frequency.
	imatda	Diagonal of matrix.
	pltri	Values of the triad source terms in test points.
	ursell	*Ursell* number as function of *ix* and *iy*.

5.3.9.7 Subroutine SWSNL1

Subroutine SWSNL1 calculates a non-linear interaction using the discrete interaction approximation (Hasselmann and Hasselmann 1985; WAMDI group, 1988), including the diagonal term for the implicit integration. The interactions are calculated for all bins that fall within a sweep. No additional auxiliary array is required.

Calling Sequence: swsnl1 (wwint, wwawg, wwswg, idcmin, idcmax, af11, ue, sa1, sa2, daic, da1p, da1m, da2c, da2p, da2m, spcsig, snlc1, kmespc, fachfr, isstop, dal1, dal2, dal3, sfnl, dsnl, dep2, ac2, imatda, imatra, plnl4s, plnl4d, iddlow, iddtop)

Data Declaration:	Real	wwawg, wwswg, spcsig, af11, da1c, da1p, da1m, da2c, da2p, da2m, sa1, sa2, ue, snlc1, dal1, dal2, dal3, sfnl, dsnl, dep2, ac2, imatda, imatra, plnl4s, plnl4d, fachfr, kmespc
	Integer	wwint, idcmin, idcmax, iddlow, iddtop, isstop

Arguments:	wwint	Counters for four-wave interactions.
	wwawg	Values for the interpolation.
	wwswg	Values for the interpolation.
	idcmin	Minimum frequency dependent counter in directional space.
	idcmax	Maximum frequency dependent counter in directional space.
	spcsig	Relative frequencies in computational domain sigma space.
	af11	Scaling frequency.
	ue	"Unfolded" spectrum.

sa1, sa2	(Array) Interaction contribution of first and second quadrants, respectively (unfolded space).
da1c, da1p, da1m, da2c, da2p, da2m	Items for diagonal matrix.
snlc1	Coefficient for the subroutines SWSNLN.
kmespc	Mean average wave number according to the WAM formulation.
fachfr	Contribution of high frequency tail to wave stress.
isstop	Maximum frequency that is propagated within a sweep.
dal1, dal2, dal3	Lambda dependent weight factors.
sfnl	Source term Snl, RHS part.
dsnl	Source term Snl, DIAG part.
dep2	Depth.
ac2	Action density as function of D, S, X, Y at time T.
imatda	Coefficient of the diagonal of the matrix.
imatra	Coefficient of the right-hand side of the matrix.
plnl4s	For outputting on of the source terms at a particular grid point.
plnl4d	For outputting on of the source terms at a particular grid point.
iddlow	Minimum counter of the bin that is propagated within a sweep.
iddtop	Maximum counter of the bin that is propagated within a sweep.

5.3.9.8 Subroutine SWSNL2

Subroutine SWSNL2 calculates non-linear interaction using the discrete interaction approximation (Hasselmann and Hasselmann 1985; WAMDI group, 1988).

Calling Sequence: swsnl2 (iddlow, iddtop, wwint, wwawg, af11, ue, sa1, isstop, sa2, spcsig, snlc1, dal1, dal2, dal3, sfnl, dep2, ac2, kmespc, imatra, fachfr, plnl4s, idcmin, idcmax)

Data Declaration:	Real	wwawg, af11, ue, sa1, sa1, spcsig, snlc1, dal1, dal2, dal3, sfnl, dep2, ac2, kmespc, imatra, fachfr, plnl4s
	Integer	iddlow, iddtop, wwint, isstop, idcmin, idcmax
Arguments:	iddlow	Minimum counter of the bin that is propagated within a sweep.

iddtop	Maximum counter of the bin that is propagated within a sweep.
wwint	Counters for four-wave interactions.
wwawg	Values for the interpolation.
af11	Scaling frequency.
ue	"Unfolded" spectrum.
sa1, sa2	Interaction contribution of first and second quadrants, respectively (unfolded space).
isstop	Maximum frequency that is propagated within a sweep.
spcsig	Relative frequencies in computational domain sigma space.
snlc1	Coefficient for the subroutines SWSNLN.
dal1, dal2, dal3	Lambda dependent weight factors.
sfnl	Source term Snl, RHS part.
dep2	Depth.
ac2	Action density as function of D, S, X, Y at time T.
kmespc	Mean average wave number according to the WAM formulation.
imatra	Coefficient of right-hand side of matrix.
fachfr	Contribution of high frequency tail to wave stress.
plnl4s	For outputting on of the source terms at a particular grid point.
idcmin	Minimum frequency dependent counter in directional space.
idcmax	Maximum frequency dependent counter in directional space.

5.3.9.9 Subroutine SWSNL3

Subroutine SWSNL3 calculates non-linear interaction using the discrete interaction approximation (Hasselmann and Hasselmann 1985; WAMDI group, 1988) for the full circle (option if a current is present). Using this subroutine requires an additional array with size (MXC*MYC*MDC*MSC). Although it requires more internal memory, if a current is present, it can speed up the computations significantly.

Calling Sequence: swsnl3 (mdc, msc, wwint, wwawg, af11, ue, sa1, sa2, spcsig, snlc1, dal1, dal2, dal3, sfnl, dep2, ac2, kmespc, memnl4, facher, pi, msc4mi, msc4ma, mdc4mi, mdc4ma, kcgrd, mcgrd, icmax

Data Declaration: Real wwawg, af11, ue, sa1, sa2, spcsig, snlc1, dal1, dal2, dal3, sfnl, dep2, ac2, kmespc, memnl4, facher, pi,

	Integer	wwint, msc4mi, msc4ma, mdc4mi, mdc4ma, kcgrd, mcgrd, icmax, mdc, msc
Arguments:	mdc	Grid points in theta-direction of computational grid.
	msc	Grid points in sigma-direction of computational grid.
	wwint	Counters for four-wave interactions.
	wwawg	Values for the interpolation.
	af11	Scaling frequency.
	ue	"Unfolded" spectrum.
	sa1, sa2	Interaction contribution of first and second quadrants, respectively (unfolded space).
	spcsig	Relative frequencies in computational domain sigma space.
	snlc1	Coefficient for the subroutine SWSNLN.
	dal1, dal2, dal3	Lambda dependent weight factors.
	sfnl	Source term Snl, RHS part.
	dep2	Depth.
	ac2	Action density as function of D, S, X, Y at time T.
	kmespc	Mean average wave number according to the WAM formulation.
	memnl4	Saves sfnl at every x,y point in memory.
	fachfr	Contribution of high frequency tail to wave stress.
	pi	3.14.
	msc4mi	Lowest array counter in frequency space.
	msc4ma	Highest array counter in frequency space.
	mdc4mi	Lowest array counter in directional space.
	mdc4ma	Highest array counter in directional space.
	kcgrd	Grid address of points of computational stencil.
	mcgrd	Number of wet grid points of the computational grid.
	icmax	Number of points in computational stencil.

5.3.10 Subroutines for the Propagation in X, Y, S, D Space and Parameters (swancom5 FOR File)

5.3.10.1 Subroutine ADDDIS

Subroutine ADDDIS adds dissipation and leak.

Calling Sequence: adddis (msc, mdc, ddir, frintf, dissxy, leakxy, ac2, anybin, disc0, disc1, leakc1, spcsig, kcgrd, mcgrd, icmax)

Data Declaration:	Real	ddir, frintf, dissxy, leakxy, ac2, disc0, disc1, leakc1, spcsig
	Integer	msc, mdc, mcgrd, kcgrd, icmax
	Logical	anybin

Arguments:	msc	Maximum counter of relative frequency.
	mdc	Maximum counter of directional distribution.
	ddir	Spectral direction band width.
	frintf	Frequency integration factor.
	dissxy	Dissipation integrated over the spectrum for each point in the computational grid.
	leakxy	Leak integrated over the spectrum for each point in the computation grid.
	ac2	Action density as function of D, S, X, Y and T.
	anybin	Determines if a bin falls within a sweep.
	dissc0	(Not used); Stores the dissipation distributed over spectral space in one point of the computational grid (old value).
	dissc1	(Not used); Stores the dissipation distributed over spectral space in one point of the computational grid (new value).
	leakc1	Leak coefficient.
	spcsig	Relative frequencies in the computational domain in sigma space.
	kcgrd	Grid counter in central grid point.
	mcgrd	Maximum counter in geographical space.
	icmax	Maximum array size for the points of the molecule.

5.3.10.2 Subroutine DSPHER

Subroutine DSPHER computes the propagation velocities of energy in theta-space, i.e., CAD, due to the use of spherical coordinates.

Calling Sequence: dspher (cad, cg, anybin, ycgrid, ecos)

Data Declaration:	Real	cad, cg, ecos, ycgrid
	Logical	anybin

Arguments:	cad	Wave transport velocity in D-direction, function (*id, is, ic*).
	cg	Group velocity as function of sigma and theta in the direction of wave propagation in absence of currents.

anybin	If true the spectral component (*id, is*) is to be computed.
ycgrid	Y-coordinate (latitude) for each geographic grid point.
ecos	Represent the values of cos(theta) of each spectral direction.

5.3.10.3 Subroutine SANDL

Subroutine SANDL computes the space derivative of action transport.

Calling Sequence: sandl (isstop, idcmin, idcmax, cgo, cax, cay, ac2, ac1, imatra, imatda, rdx, rdy, cax1, cay1, spcdir)

Data Declaration:

Real	cgo, cax, cay, ac2, ac1, imatra, imatda, rdx, rdy, cax1, cay2, spcdir
Integer	isstop, idcmin, idcmax

Arguments:

isstop	Highest spectral frequency counter in the sweep.
idcmin	Minimum value of direction counter in this sweep.
idcmax	Maximum value of direction counter in this sweep.
cgo	Group velocity.
cax	Propagation velocity in x new time level.
cay	Propagation velocity in y new time level.
ac2	Spectral action density, function of x, y, theta, and sigma.
ac1	Action density as function of D, S, X, Y at time T.
imatra	Coefficients of right-hand side of matrix.
imatda	Coefficients of diagonal of matrix.
rdx, rdy	Containing spatial derivative coefficient.
cax1	Propagation velocity in x old time level.
cay1	Propagation velocity in y old time level.
spcdir	Spectral directions.

5.3.10.5 Subroutine SORDUP

Subroutine SORDUP computes the space derivative of action transport using the SORDUP scheme. This is for stationary calculations only (no time derivative). Delft Hydraulics scientists suggest that the implementation of a modified form of the scheme, in which the model user has the option for using a non-zero value for THETAK, be used as a means to eliminate wiggles.

To summarize:

With THETAK = 0, the scheme is second order accurate.

With THETAK = 0, the scheme reduces to the "best" approximation of d/dx which can be determined using Taylor Series for the stencil (IX), (IX-1), (IX-2): 3/2*mu*phi(IX)-2*mu*phi(IX-1) + 1/2*mu*phi(IX-2).

With a non-zero THETAK, the scheme is only first order accurate, and is only approximately mass conserving (mass balance error is slight).

With a negative THETAK, the scheme has positive diffusion. This makes the scheme something of a hybrid between the BSBT scheme (of the original SWAN) and the second order scheme (THETAK = 0). The only reason to intentionally introduce diffusion is in case of wiggles. Wiggles will, for the most part, only occur when spatial gradients are very severe, so using a negative THETAK is generally not necessary. Using a THETAK of -0.1 for case-set of severe gradient, diffusion seems to be about midway between that of the BSBT scheme and that of the second order (THETAK = 0) scheme. For this case-set, wiggles are seen in the second order scheme solution, and are virtually eliminated with the (THETAK = -0.1) scheme. Henri has shown that the scheme with small negative THETAK is very likely to be unconditionally stable. Larger |THETAK| ==> more diffusion.

With a positive THETAK, the scheme is unconditionally unstable. This instability is generally not noticeable, but since there is not a good reason for using positive THETAK, if this option is chosen, a warning or error message will be given.

Calling Sequence: sordup (isstop, idcmin, idcmax, cax, cay, ac2, imatra, imatda, rdx, rdy)

Data Declaration:	Real	cax, cay, ac2, imatra, imatda, rdx, rdy
	Integer	isstop, idcmin, idcmax

Arguments:	isstop	Highest spectral frequency counter in the sweep.
	idcmin	Minimum value of direction counter in this sweep.
	idcmax	Maximum value of direction counter in this sweep.
	cax	Propagation velocity in x.
	cay	Propagation velocity in y.
	ac2	Spectral action density, function of x, y, theta, sigma.
	imatra	Coefficients of right-hand side of matrix.
	imatda	Coefficients of diagonal of matrix.
	rdx, rdy	Containing spatial derivative coefficient.

5.3.10.6 Subroutine SPREDT

Subroutine SPREDT predicts the action density depending on the sweep direction. A good prediction is necessary for a first accurate prediction of the action density to compute the dissipation of energy. To compute the energy dissipation a prediction is needed at time T.

Calling Sequence:	spredt (swpdir, ac2, cax, cay, idcmin, idcmax, isstop, anybin, rdx, rdy, obredf)	
Data Declaration:	Real	swpdir, ac2, cax, cay, rdx, rdy, obredf
	Integer	idcmin, idcmax, isstop
	Logical	anybin
Arguments:	swpdir	Sweep direction (identical as the description of the direction the wind is blowing).
	ac2	Action density as function of D, S, X, Y at time T.
	cax	Wave transport velocity in x-direction, function of (*id, is, ic*).
	cay	Wave transport velocity in y-direction, function of (*id, is, ic*).
	idcmin	Minimum frequency dependent counter in case of a current.
	idcmax	Maximum frequency dependent counter in case of a current.
	isstop	Maximum frequency counter for wave components that are propagated within a sweep.
	anybin	Determines if a bin falls within a sweep.
	rdx, rdy	Array containing spatial derivative coefficient.
	obredf	Action reduction factors, a function of frequency and direction.

5.3.10.7 Subroutine SPROSD

Subroutine SPROSD computes the propagation velocities of energy in S- and D-space, i.e., CAS, CAD, in the presence or absence of currents, for the action balance equation.

Calling Sequence:	sprosd (spcsig, kwave, cas, cad, cgo, dep2, dep1, ecos, esin, ux2, uy2, swpdir, idcmin, idcmax, coscos, sinsin, sincos, rdx, rdy, cax, cay, anybin, kgrpnt, xcgrid, ycgrid)	
Data Declaration:	Real	spcsig, kwave, cas, cad, cgo, dep2, dep1, ecos, esin, ux2, uy2, swpdir, rdx, rdy, cax, cay, xcgrid, ycgrid
	Integer	idcmin, idcmax, kgrpnt
	Logical	anybin
Arguments:	spcsig	Relative frequencies in the computational domain in sigma space.

kwave	Wave number as function of the relative frequency sigma.
cas	Wave transport velocity in S-direction, a function of (*id, is, ic*).
cad	Wave transport velocity in D-direction, a function of (*id, is, ic*).
cgo	Group velocity as function of X, Y and sigma in the direction of wave propagation in absence of currents.
dep2	Depth as function of (X, Y) at time T+1.
ux2	(Non-stationary case) X-component of current velocity in (X, Y) at time T + DIT.
uy2	(Non-stationary case) Y-component of current velocity in (X, Y) at time T + DIT.
dep1	Depth as function of X and Y at time T.
ecos	Represent the values of cos(d) of each spectral direction.
esin	Represent the values of sin(d) of each spectral direction.
swpdir	Current sweep direction.
idcmin	Lower theta boundary of current sweep.
idcmax	Upper theta boundary of current sweep.
coscos	Cosine^2 of spectral directions.
sinsin	Sine^2 of spectral directions.
sincos	Cosine*sine of spectral directions.
rdx, rdy	Array containing spatial derivative coefficient.
cax	Wave transport velocity in X-direction, a function of (*id, is, ic*).
cay	Wave transport velocity in Y-direction, a function of (*id, is, ic*).
anybin	= True if a certain bin is enclosed in a sweep.
kgrpnt	Grid point addresses.
xcgrid	X-coordinate of computational grid in x-direction.
ycgrid	Y-coordinate of computational grid in y-direction.

5.3.10.8 Subroutine SPROXY

Subroutine SPROXY computes the propagation velocities of energy in X-, Y-space, i.e., *cax*, *cay*, in the presence or absence of currents, for the action balance equation. The propagation velocities are computed for the full 360 degree sector.

Calling Sequence: sproxy (ic, icmax, msc, mdc, icur, cax, cay, cgo, ecos, esin, ux2, uy2, swpdir, kcgrd, mcgrd)

Data Declaration:	Real	cax, cay, cgo, ecos, esin, ux2, uy2, swpdir
	Integer	msc, mdc, icmax, ic, icur, kcgrd, mcgrd

Arguments:	ic	Dummy variable.
	icmax	Maximum array size for the points of the molecule.
	msc	Maximum counter of relative frequency.
	mdc	Maximum counter of spectral directions.
	icur	Indicator for current.
	cax	Wave transport velocity in x-direction, function of (*id, is, ic*).
	cay	Wave transport velocity in y-direction, function of (*id, is, ic*).
	cgo	Group velocity.
	ecos	Represent the values of cos(d) of each spectral direction.
	esin	Represent the values of sin(d) of each spectral direction.
	ux2	X-component of current velocity of X and Y at time T + 1.
	uy2	Y-component of current velocity of X and Y at time T + 1.
	swpdir	Current sweep direction.
	kcgrd	Grid counter in central grid point.
	mcgrd	Maximum counter in geographical space.

5.3.10.9 Subroutine STRSD

Subroutine STRSD computes ∂[CAD AC2]/∂D for the initial and boundary conditions.

Calling Sequence: strsd (msc, mdc, icmax, dd, idcmin, idcmax, cad, imatla, imatda, imatua, imatra, ac2, pnums, isstop, fulcir, anybin, leakc1, kcgrd, mcgrd)

Data Declaration:	Real	dd, cad, ac2, pnums, imatla, imatda, imatua, imatra, leakc1
	Integer	msc, mdc, icmax, idcmin, idcmax, isstop, kcgrd, mcgrd
	Logical	anybin, fulcir

Arguments:	msc	Maximum counter of relative frequency.
	mdc	Maximum counter of directional distribution.
	icmax	Maximum counter for the points of the molecule.
	dd	Width of spectral direction band.
	idcmin	Minimum value of direction counter in this sweep.

idcmax	Maximum value of direction counter in this sweep.
cad	Wave transport velocity in S-direction, function of (*id, is, ic*).
imatla	Coefficients of lower diagonal of matrix.
imatda	Coefficients of diagonal of matrix.
imatua	Coefficients of upper diagonal of matrix.
imatra	Coefficients of right-hand side of matrix.
ac2	Action density as function of D, S, X, Y at time T.
pnums	Array containing various coefficients/controls for the model.
isstop	Maximum frequency counter for wave components that are propagated within a sweep.
fulcir	If true, computation on a full circle.
anybin	= True if a certain bin is enclosed in a sweep.
leakc1	Leak coefficient.
kcgrd	Grid counter in central grid point.
mcgrd	Maximum counter in geographical space.

5.3.10.10 Subroutine STRSSB

Subroutine STRSSB computes ∂[CAS AC2]/∂S for the initial and boundary conditions with an explicit scheme. The energy near the blocking point is removed from the spectrum based on a CFL criterion.

Calling Sequence: strssb (mdc, msc, icmax, iddlow, iddtop, idcmin, idcmax, isstop, cax, cay, cas, ac2, spcsig, imatra, pnums, anyblk, kcgrd, mcgrd, rdx, rdy)

Data Declaration:

Real	cax, cay, cas, ac2, spcsig, imatra, pnums, rdx, rdy
Integer	mdc, msc, icmax, iddlow, iddtop, idcmin, idcmax, isstop, kcgrd, mcgrd
Logical	anyblk

Arguments:

msc	Maximum counter of relative frequency.
mdc	Maximum counter of directional distribution.
icmax	Maximum counter for the points of the molecule.
iddlow	Minimum direction that is propagated within a sweep.
iddtop	Idem maximum.
idcmin	Minimum value of direction counter in this sweep.
idcmax	Maximum value of direction counter in this sweep.
isstop	Maximum frequency counter for wave components that are propagated within a sweep.
cax, cay	Propagation velocities in x-y space.

cas	Wave transport velocity in S-direction, function of (*id, is, ic*).
ac2	Action density as function of D, S, X, Y at time T.
spcsig	Relative frequencies in computational domain in sigma space *imatra.*
pnums	Array containing various coefficients/controls for the model.
anyblk	Determines if a counter current blocks a bin based on a CFL criterion.
kcgrd	Grid counter in central grid point.
mcgrd	Maximum counter in geographical space.
rdx, rdy	Array containing spatial derivative coefficient.

5.3.10.11 Subroutine STRSSI

Subroutine STRSSI computes ∂[CAS AC2]/∂S for the initial and boundary conditions with an implicit scheme.

Calling Sequence: strssi (msc, mdc, icmax, pnums, spcsig, cas, imat5l, imatda, imat6u, anybin, imatra, ac2, iscmin, iscmax, iddlow, iddtop, kcgrd, mcgrd)

Data Declaration:

Real	pnums, spcsig, cas, ac2, imat5l, imatda, imat6u, imatra
Logical	anybin
Integer	msc, mdc, icmax, iscmin, iscmax, iddlow, iddtop, kcgrd, mcgrd

Arguments:

msc	Maximum counter of relative frequency.
mdc	Maximum counter of directional distribution one sweep.
icmax	Maximum counter for the points of the molecule.
pnums	Array containing various coefficients/controls for the model.
spcsig	Relative frequencies in computational domain in sigma space.
cas	Wave transport velocity in S-direction, function of (*id, is, ic*).
imat5l	Coefficients of lower diagonal of matrix.
imatda	Coefficients of diagonal of matrix.
imat6u	Coefficients of upper diagonal of matrix.
anybin	If true the spectral component (*id, is*) is to be computed.
imatra	Coefficients of right-hand side of matrix.

ac2	Spectral action density, function of x, y, theta, and sigma.
iscmin	Minimum counter in frequency space per direction.
iscmax	Maximum counter in frequency space per direction.
iddlow	Minimum counter per sweep taken over all frequencies.
iddtop	Maximum counter per sweep taken over all frequencies.
kcgrd	Grid counter in central grid point.
mcgrd	Maximum counter in geographical space.

5.3.10.13 Subroutine STRSXY

Subroutine STRSXY computes the space derivative of action transport.

Calling Sequence: strsxy (isstop, idcmin, idcmax, cax, cay, ac2, ac1, imatra, imatda, rdx, rdy, obredf)

Data Declaration:

Real	cax, cay, ac2, ac1, rdx, rdy, imatra, imatda, obredf
Integer	isstop, idcmin, idcmax

Arguments:

isstop	Highest spectral frequency counter in the sweep.
idcmin	Minimum value of direction counter in this sweep.
idcmax	Maximum value of direction counter in this sweep.
cax	Propagation velocity in x.
cay	Propagation velocity in y.
ac2	Spectral action density, function of x, y, theta and sigma.
ac1	Action density as function of D, S, X, Y at time T.
imatra	Coefficients of diagonal of matrix.
imatda	Coefficients of right-hand side of matrix.
rdx, rdy	Array containing spatial derivative coefficient.
obredf	Action reduction factors, function of frequency and direction.

5.3.10.14 Subroutine SWAPAR

Subroutine SWAPAR computes the wave parameters *k, cgo,* and *cg* in the nearby points, depending on the sweep direction. The nearby points are indicated with the index *ic.*

Calling Sequence: swapar (ic, msc, mdc, icmax, cg, icur, grav, dep2, kwave, cgo, ecos, esin, ux2, uy2, spcsig, kcgrd, mcgrd, depmin)

Data Declaration:

Real	cg, grav, dep2, kwave, cgo, ecos, esin, ux2, uy2, spcsig, depmin
Integer	ic, msc, mdc, icmax, icur, kcgrd, mcgrd

Arguments:

ic	Dummy variable.
msc	Maximum counter of relative frequency.
mdc	Maximum counter of directional distribution.
icmax	Maximum array size for the points of the molecule.
cg	Group velocity as function of X, Y and S and D in the direction of wave propagation in presence of currents.
icur	Indicator for current.
grav	Gravitational acceleration.
dep2	Depth as function of X and Y at time T+1.
kwave	Wave number as a function of the relative frequency S.
cgo	Group velocity as function of X, Y and S in the direction of wave propagation in the absence of currents.
ecos	Represent the values of cos(d) of each spectral direction.
esin	Represent the values of sin(d) of each spectral direction.
ux2	X-component of current velocity of X and Y at time T+1.
uy2	Y-component of current velocity of X and Y at time T+1.
spcsig	Relative frequencies in computational domain in sigma space.
kcgrd	Grid counter in central grid point.
mcgrd	Maximum counter in geographical space.
depmin	Threshold depth (m); in the computation any positive depth smaller than *depmin* is made equal to *depmin*. Default = 0.05.

5.3.10.15 Subroutine SWPSEL

Subroutine SWPSEL computes the frequency dependent counters in situations with and without a current. The counters are only computed for the grid point considered. This means *ic* = 1 (see loop with call for ICCODE function).

Calling Sequence: swpsel (swpdir, idcmin, idcmax, sector, cax, cay, anybin, iscmin, iscmax, idtot, istot, iddlow, iddtop, isstop, dep2, ux2, uy2, spcdir, xcgrid, ycgrid, rdx, rdy, ksx, ksy)

Data Declaration:	Real	swpdir, spcdir, xcgrid, ycgrid, sector, cax, cay, dep2, ux2, uy2, rdx, rdy, ksx, ksy
	Integer	idcmin, idcmax, iscmin, iscmax, idtot, istot, iddlow, iddtop, isstop
	Logical	anybin
Arguments:	swpdir	Current sweep direction.
	idcmin	Minimum frequency dependent counter.
	idcmax	Maximum frequency dependent counter.
	sector	Counter for number enclosed sectors.
	cax, cay	Propagation velocities.
	anybin	= True if a certain bin enclosed in a sweep.
	iscmin	Minimum counter in frequency space.
	iscmax	Maximum counter in frequency space.
	idtot	Maximum value between the lowest and highest counter in directional space.
	istot	Maximum value between the lowest and highest counter in frequency space.
	iddlow	Minimum counter per sweep taken over all frequencies.
	iddtop	Maximum counter per sweep taken over all frequencies.
	isstop	Maximum frequency counter for wave components that are propagated within a sweep.
	dep2	Depth.
	ux2	(Non-stationary case) X-component of current velocity in (X, Y) at time T + DIT.
	uy2	(Non-stationary case) Y-component of current velocity in (X, Y) at time T + DIT.
	spcdir	Spectral directions.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	rdx, rdy	Array containing spatial derivative coefficient.
	ksx	Dummy variable to get the correct sign in the numerical difference scheme in X-direction.
	ksy	Dummy variable to get the right sign in the numerical difference scheme in Y-direction.

5.3.11 Subroutines for Solving the Band Matrix (swancomi FOR File)

5.3.11.1 Subroutine CGSTAB

Subroutine CGSTAB solves an asymmetric system of linear equations by the Bi-CGSTAB method. The subroutine contains a number of preconditioners.

Calling Sequence: cgstab (n, amat, rhsd, usol, eps1, eps2, itmax, res, p, rbar, t, s, v, work, icontr, infmat, prec, nprec, ndim, nconct, upperi, loperi, nstatc, itsw, itersw)

Data Declaration:

Real	amat, rhsd, usol, eps1, eps2, res, p, rbar, t, s, v, prec, work, upperi, loperi
Integer	n, itmax, icontr, infmat, nprec, ndim, nconct, nstatc, itsw, itersw

Arguments:

n	The number of rows in the matrix A.
amat	Matrix from the equations to be solved.
rhsd	Vector containing the right-hand side vector of the system of equations.
usol	Solution vector of length n. On input the array contains a starting vector. At output the array contains the last iterate, which is an approximation to the solution of the system.
eps1, eps2	Determines the accuracy of the final approximation.
itmax	The maximum number of iterations to be performed.
res	Array containing the residual vector.
p	Work array to store the direction vector.
rbar	Work array to store the quasi-residual vector.
t, s	Work array to store an auxiliary vector.
v	Work array to store an auxiliary vector.
work	Work array to store an auxiliary vector. The array work(.,3) contains the update of the solution usol during an iteration. If post-conditioning is used, it is first adapted before it is added to *usol.*
icontr	Integer array in which information about the solution process must be given by the user.
infmat	Integer array with information of the matrix structure, to be used in matrix-vector multiplication subroutine.
prec	Array which contains part of the preconditioning matrix.

nprec	Number of diagonals which are used in the pre-conditioning.
ndim	Integer indicating the amount of unknowns in every grid point. In the momentum equations *ndim* = 2 or 3, whereas in the pressure and transport equations *ndim* = 1.
nconct	Maximal number of connections in one row of the matrix.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.
nstatc	Indicates stationary: = 0; stationary computation; = 1; non-stationary computation.
itsw	Timestep counter for SWAN
itersw	Iteration counter for SWAN.

5.3.11.2 Subroutine DAXPY

Subroutine DAXPY is a BLAS routine that overwrites double precision *dy* with double precision *da*dx + dy*. For i = 0 to n-1, replace *dy(ly + i*incy)* with *da*dx(lx + i*incx) + dy(ly + i*incy)*, where lx = 1 if *incx* >= 0, else lx = *(-incx)*n*, and *ly* is defined in a similar way using *incy*.

5.3.11.3 Subroutine DCOPY

Subroutine DCOPY is a BLAS routine that copies double precision *dx* to double precision *dy*. For i = 0 to n-1, copy *dx(lx + i*incx)* to *dy(ly + i*incy)*, where lx = 1 if *incx* > 0, else lx = *(-incx)*n*, and ly is defined in a similar way using *incy*.

5.3.11.4 Double Precision Function DDOT

Subroutine DDOT calculates the dot product of two vectors of equal length.

Calling Sequence: ddot (dx, dy, n)

Data Declaration:	Real	dx, dy
	Integer	n

Arguments:	dx	First vector in dot product.
	dy	Second vector in dot product.
	n	Vector length.

5.3.11.5 Subroutine DIAG

Subroutine DIAG makes a diagonal scaling of the matrix for the momentum, transport, or pressure equations.

Calling Sequence: diag (amat, n, ndimso, nconct, prec, nprec, infmat)

Data Declaration:	Real	amat, prec
	Integer	n, ndimso, nconct, nprec, infmat

Arguments:	amat	The coefficient matrix for the momentum equations or an equation similar to the pressure equation.
	n	Number of unknowns in the solution vector.
	ndimso	Integer indicating the dimension of the space in which the problem must be solved (*ndimso* = 1 or *ndim*).
	nconct	Number of connections in one row of the matrix.
	prec	The preconditioning matrix.
	nprec	Number of diagonals, which are used in the pre-conditioning. In this subroutine *nprec* = 1.
	infmat	If *infmat* = 1 momentum equations are used, whereas if *infmat* >= 4 equations with a structure similar to the pressure equation are used.

5.3.11.6 Subroutine DIAGMU

Subroutine DIAGMU multiplies x with the diagonal matrix given in *prec*. The array *prec* should be filled by subroutine DIAGF.

Calling Sequence: diagmu (n, x, b, prec, nprec)

Data Declaration:	Real	x, b, prec
	Integer	n, nprec

Arguments:	n	Number of unknowns in the solution vector.
	x	The original vector.
	b	The resulting vector after multiplication.

prec	The diagonal preconditioning matrix.
nprec	Number of diagonals, which are used in the preconditioning. In this subroutine *nprec* = 1.

5.3.11.7 Subroutine DINVL3

Subroutine DINVL3 multiplies x by L, the preconditioning matrix given in *prec*. In this case we obtain:

$$b = L^{-1} x.$$

The array *prec* should be filled by dmlu3.f. This subroutine contains compiler directives to run in vector speed on the convex.

Calling Sequence: dinvl3 (x, b, matrix, n, ndim, nconct, prec, nprec, infmat)

Data Declaration:

Real	x, b, prec
Integer	matrix, n, ndim, nconct, nprec, infmat

Arguments:

x	The original vector.
b	The result vector, which contains: $b = L^{-1} x$.
matrix	The coefficient matrix for the momentum or an equation similar to the pressure equation.
n	Number of unknowns in the solution vector.
ndim	Integer indicating the dimension of the space in which the problem must be solved (*ndim* = 2 or 3).
nconct	Number of connections in one row of the matrix.
prec	The preconditioning matrix.
nprec	Number of diagonals, which are used in the preconditioning. In this subroutine *nprec* = *nconct*.
infmat	If *infmat* = 1 the momentum equations are used, whereas if *infmat* = 1 is larger than or equal to four equations with a structure similar to the pressure equations are used.

5.3.11.8 Subroutine DINVU3

Subroutine DINVU3 multiplies x by U, the preconditioning matrix given in *prec*. In this case we obtain:

$$b = U^{-1} x.$$

The array *prec* should be filled by dmlu3.f. This subroutine contains compiler directives to run in vector speed on the convex.

Calling Sequence:	dinvu3 (x, b, matrix, n, ndimso, nconct, prec, nprec, infmat)	
Data Declaration:	Real	x, b, prec, matrix
	Integer	n, ndimso, nconct, nprec, infmat
Arguments:	x	The original vector.
	b	The result vector, which contains: $b = U^{-1} x$.
	matrix	The coefficient matrix for the momentum or an equation similar to the pressure equation.
	n	Number of unknowns in the solution vector.
	ndimso	Integer indicating the dimension of the space in which the problem must be solved (*ndimso* = 1 or *ndim*).
	nconct	Number of connections in one row of the matrix.
	prec	The preconditioning matrix.
	nprec	Number of diagonals, which are used in the pre-conditioning. In this subroutine *nprec* = *nconct*.
	infmat	If *infmat*(1) is one the momentum equations are used, whereas if *infmat*(1) is larger than or equal to four equations with a structure similar to the pressure equation are used.

5.3.11.9 Subroutine DMLU3

Subroutine DMLU3 calculates an upper triangular matrix U and a lower triangular matrix L, which form an incomplete decomposition of A.

Calling Sequence:	dmlu3 (matrix, n, ndim, nconct, prec, nprec, infmat)	
Data Declaration:	Real	matrix, prec
	Integer	n, ndim, nconct, nprec, infmat
Arguments:	matrix	The coefficient matrix for the momentum equations or an equation similar to the pressure equation.
	n	Number of unknowns in the solution vector.
	ndim	Integer indicating the dimension of the space in which the problem must be solved (*ndim* = 2 or 3).
	nconct	Number of connections in one row of the matrix.
	prec	The preconditioning matrix.
	nprec	Number of diagonals, which are used in the pre-conditioning. In this subroutine *nprec* = *nconct*.

infmat	If *infmat*(1) is one the momentum equations are used, whereas if *infmat*(1) is larger than or equal to four, equations with a structure similar to the pressure equation are used. *Infmat*(2) is the number of discretization points in the x-direction.

5.3.11.10 Double Precision Function DNRM2

Subroutine DNRM2 calculates the Euclidean norm of a vector *dx*() of length *n*.

Calling Sequence: dnrm2 (n, dx, incx)

Data Declaration:

Real	dx
Integer	n, incx

Arguments:

n	Length of the vector in *dx*()
dx	Array containing the vector.
incx	Stride of the vector stored in *dx*().

5.3.11.11 Subroutine DRUMA1

Calling Sequence: druma1 (x, b, matrix, n, nconct, infmat, upperi, loperi)

Data Declaration:

Real	x, b, matrix, upperi, loperi
Integer	n, nconct, infmat

Arguments:

x	The original vector.
b	The result vector, which contains: -1 b = U x.
matrix	The coefficient matrix for the momentum or an equation similar to the pressure equation.
n	Number of unknowns in the solution vector.
nconct	Number of connections in one row of the matrix.
infmat	If *infmat*(1) is one the momentum equations are used, whereas if *infmat*(1) is larger than or equal to four, equations with a structure similar to the pressure equation are used. *Infmat*(2) is the number of discretization points in the x-direction.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.

5.3.11.12 Subroutine ISSOLV

Subroutine ISSOLV solves an asymmetric system of equations of the shape Ax = f.

Calling Sequence: issolv (iinsol, rinsol, matrix, rhside, solut, nusol, nconct, infmat, work, nwork, precon, nprec, upperi, loperi, inocnv, itsw, itersw)

Data Declaration:

Real	rinsol, matrix, work, rhside, solut, precon, upperi, loperi
Integer	iinsol, nusol, infmat, itsw, itersw, inocnv, nonct, nwork, nprec

Arguments:

iinsol	Integer information for the solver.
rinsol	Real information for the solver.
matrix	The banded matrix being solved (input).
rhside	Right hand side.
solut	Output solution.
nusol	Number of points in solution.
nconct	Number of connections in a row of the matrix.
infmat	Integer information for the matrix.
work	Work array.
nwork	Dimension for work array.
precon	Preconditioner.
nprec	Number of diagonals used in the preconditioner.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.
inocnv	Counts occurrence of nonconvergence in solver.
itsw	Timestep counter for SWAN.
itersw	Iteration counter for SWAN.

5.3.11.13 Subroutine MKPREC

Subroutine MKPREC is used to build a preconditioner.

Calling Sequence: mkprec (matrix, nusol, ndimso, nconct, precon, nprec, infmat, mkind)

Data Declaration:

Real	matrix, precon
Integer	nusol, ndimso, nconct, nprec, infmat, mkind

Arguments:

matrix	Double precision array in which the matrix of the linear system of equations is stored. In the case of *mkind* = 2 the matrix is scaled.

nusol	The length of the solution vector.
ndimso	The dimension of the space for the solver: (*ndimso* = 1 for non-coupled equations, *ndimso* > 1 for coupled equations).
nconct	The number of non-zero diagonals of *matrix.*
precon	Double precision array in which a preconditioning matrix might be stored, of length *nprec* * *nusol.* It is assumed that *precon* has a similar structure as *matrix.*
nprec	Maximum number of diagonals in *precon.*
infmat	Array which describes the structure of *matrix.*
mkind	The kind of the preconditioner required.

5.3.11.14 Subroutine PREVC

Subroutine PREVC multiplies the vector x with a preconditioner.

Calling Sequence: prevc (n, x, b, matrix, ndim, nconct, precon, nprec, infmat, mkind)

Data Declaration:

Real	x, b, matrix, precon
Integer	n, ndim, nconct, nprec, infmat, mkind

Arguments:

n	The length of the solution vector.
x	The input vector.
b	The output vector which is the preconditioner times the vector *x*.
matrix	Double precision array in which the matrix of the linear system of equations is stored.
ndim	The dimension of the space (*ndim* = 2 or 3).
nconct	The number of non-zero diagonals of *matrix.*
precon	Double precision array in which a preconditioning matrix might be stored, of length *nprec* * *nusol.* It is assumed that *precon* has a similar structure as *matrix.*
nprec	Maximum number of diagonals in *precon.*
infmat	Array which describes the structure of the matrix.
mkind	The kind of the preconditioner required.

5.3.11.15 Subroutine PRIRES

Subroutine PRIRES prints the norm of the residual.

Calling Sequence: prires (text, rnorm, icontr, final)

Data Declaration:	Real	text, rnorm, final
	Integer	icontr

Arguments:	text	Denotes output form subroutine TEXT.
	rnorm	2-norm of the initial residual.
	icontr	Integer array in which information about the solution process must be given by the user.
	final	Logical variable telling PRIRES whether this is final iteration or not.

5.3.11.16 Subroutine SWCOVA2D

Subroutine SWCOVA2D computes covariant base vectors in integration points two-dimensional case.

Calling Sequence: swcova2d (mxc, myc, xcg, ycg, cva)

Data Declaration:	Real	xcg, ycg, cva
	Integer	mxc, myc

Arguments:	mxc	Number of points in the x-direction.
	myc	Number of points in the y-direction.
	xcg	X-coordinates.
	ycg	Y-coordinates.
	cva	Array containing the covariant basis vectors.

5.3.11.17 Subroutine SWDISDT2

Subroutine SWDISDT2 distributes diffusion terms for transport equation in R2.

Calling Sequence: swdisdt2 (mxc, myc, depth, depmin, alphad, matrix, dtsum)

Data Declaration:	Real	depth, depmin, dtsum, matrix
	Integer	mxc, myc, alphad

Arguments:	mxc	Number of points in the x-direction.
	myc	Number of points in the y-direction.
	depth	Depth direct addressed.
	depmin	Minimum possible depth.
	alphad	Direction index of integration.
	matrix	Matrix.
	dtsum	Derivative contributions to the matrix.

5.3.11.18 Subroutine SWESSBC

Subroutine SWESSBC puts essential boundary conditions into the matrix.

Calling Sequence: swessbc (mxc, myc, matrix, rhside, setup)

Data Declaration:	Real	matrix, rhside, setup
	Integer	mxc, myc

Arguments:	mxc	Number of points in the x-direction.
	myc	Number of points in the y-direction.
	matrix	Matrix.
	rhside	Right-hand side.
	setup	Unknown to be computed direct addressed.

5.3.11.19 Subroutine SWJCTA2D

Subroutine SWJCTA2D computes sqrt(g) x contra-variant base vectors in integration point two-dimensional case.

Calling Sequence: swjcta2d (mxc, myc, cva, jcta)

Data Declaration:	Real	cva, jcta
	Integer	mxc, myc

Arguments:	mxc	Number of points in the x-direction.
	myc	Number of points in the y-direction.
	cva	Array containing the covariant basis vectors.
	jcta	Jacobian times contra-variant basis vectors: In point pnttyp = 1 base vector 1; In point pnttyp = 2 base vector 2.

5.3.11.20 Subroutine SWSOLV

Subroutine SSWSOLV prepares for ISSOLV.

Calling Sequence: swsolv (matrix, rhside, setup, npoint, work, nwork, itsw, iter, upperi, loperi)

Data Declaration:	Real	matrix, rhside, setup, work, upperi, loperi
	Integer	npoint, nwork, itsw, iter

Arguments:	matrix	Matrix.
	rhside	Right-hand side.
	setup	Unknown to be computed direct addressed.
	npoint	Number of points *mxc*myc*.
	work	Work array.
	nwork	Dimension for work array.
	itsw	Timestep number.
	iter	Iteration number for SWAN.
	upperi	Only relevant for computation in periodic domain.
	loperi	Only relevant for computation in periodic domain.

5.3.11.21 Subroutine SWTRAD2D

Subroutine SWTRAD2D computes the contribution of diffusion term in R2 for a transport equation per integration point.

Calling Sequence: swtrad2d (mxc, myc, wfrcx, wfrcy, depmin, alphad, depth, cva, jcta, cva, jcta, cvc, ctc, dtsum, rhside)

Data Declaration:	Real	wfrcx, wfrcy, depmin, depth, cva, jcta, cvc, ctc, dtsum, rhside
	Integer	mxc, myc, alphad

Arguments:	mxc	Number of points in the x-direction.
	myc	Number of points in the y-direction.
	wfrcx	Force x-component direct addressed.
	wfrcy	Force y-component direct addressed.
	depmin	Minimum depth.
	alphad	Direction index of integration.
	depth	Depth direct addressed.
	cva	Array containing the covariant basis vectors.
	jcta	Jacobian times contra-variant basis vectors In point pnttyp = 1 base vector 1; In point pnttyp = 2 base vector 2.
	cvc	Work array containing the covariant WESBEEK vectors.
	ctc	Work array containing the contra-variant WESBEEK vectors.
	dtsum	Derivative contributions to the matrix.
	rhside	Right-hand side.

5.3.11.22 Subroutine VULMAT

Calling Sequence: vulmat (n, nconct, a, infmat, upperi, loperi)

Data Declaration:

Real	a, upperi, loperi
Integer	n, nconct, infmat

Arguments:

n	The length of the solution vector.
nconct	The number of non-zero diagonals of *matrix.*
a	Banded matrix being tested.
infmat	Array which describes the structure of the matrix.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.

5.3.11.23 Subroutine VULMT1

Calling Sequence: vulmt1 (ntot, band, upperi, loperi, rhv, imatra, imatla, imatda, imatua, imat5l, imat6u, sector, mdc, msc, iddlow, iddtop, isstop, idcmin, idcmax, anybin, idtot, kcgrd, icmax)

Data Declaration:

Real	ban, upperi, loperi, rhv, imatra, imatla, imatda, imatua, imat5l, imat6u, sector
Integer	ntot, mdc, msc, iddlow, iddtop, isstop, idcmin, idcmax, idtot, dcgrd, icmax
Logical	anybin

Arguments:

ntot	Number of points in solution.
band	Banded matrix.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.
rhv	RHS of set of equations.
imatra	Coefficients of right hand side of matrix.
imatla	Coefficients of lower diagonal of matrix.
imatda	Coefficients of diagonal of matrix.
imatua	Coefficients of upper diagonal of matrix.
imat5l	Coefficient of lower diagonal in presence of a current.
imat6u	Coefficient of upper diagonal in presence of a current.
sector	The integer array SECTOR denotes which case is present for a certain frequency: = 0: No bins belongs to first sweep, no sector lies within the first sweep = 2: Circle has 2 intersections with sector boundary

	= 4: Circle has 4 intersections with sector boundary
	= 1: Full circle lies within the first quadrant, all directions have to taken into account
mdc	Maximum counter of directional distribution in computational model.
msc	Maximum counter of relative frequency in computational model.
iddlow	Minimum counter per sweep taken over all frequencies.
iddtop	Maximum counter per sweep taken over all frequencies.
isstop	Maximum frequency counter for wave components that are propagated within a sweep.
idcmin	Integer array containing minimum counter.
idcmax	Integer array containing maximum counter.
anybin	Set a particular bin True or False depending on *sector*.
idtot	Maximum range between the counters in directional space.
kcgrd	Grid address of points of computational stencil.
icmax	Maximum array size for the points of a molecule.

5.3.12 SWAN Main Program and Miscellaneous Routines (swanmain FOR File)

5.3.12.1 Subroutine ERRCHK

Subroutine ERRCHK checks all possible combinations of physical processes if they are being activated and it changes the value of settings if necessary.

Calling Sequence: errchk (pool)

Data Declaration: Integer pool

Arguments: pool Dynamic data pool.

5.3.12.2 Subroutine FLFILE

Subroutine FLFILE updates boundary conditions and non-stationary input fields.

Calling Sequence: flfile (icr1, icr2, vnam1, vnam2, jx1, jx2, jx3, jy1, jy2, jy3, cosfc, sinfc, pool, rpool, compda, xcgrid, ycgrid, kgrpnt, ierr)

Data Declaration:	Real	cosfc, sinfc, rpool, compda, xcgrid, ycgrid
	Integer	icr1, igr2, jx1, jx2, jx3, jy1, jy2, jy3, pool, kgrpnt, ierr
	Character	vnam1, vnam2

Arguments:	icr1	Location in array *compda* for interpolated input field data (x-comp).
	icr2	Location in array *compda* for interpolated input field data (y-comp) for a scalar field *igr2* = 0.
	vnam1	Pointer name of *pool* array holding values read from file (x-comp).
	vnam2	Pointer name of *pool* array holding values read from file (y-comp).
	jx1, jx2, jx3	Location in array *compda* for interpolated input field data (x-comp).
	jy1, jy2, jy3	Location in array *compda* for interpolated input field data (y-comp).
	cosfc	Cosine of the angle between the input and computational grids.
	sinfc	Sine of the angle between the input grid and computational grid.
	pool	Dynamic data pool.
	rpool	Real equivalence for integer *pool.*
	compda	Array holding values for computational grid points.
	xcgrid	X-coordinate of computational grid points.
	ycgrid	Y-coordinate of computational grid points.
	kgrpnt	Indirect addresses of computational grid points.
	ierr	Error status: = 0 No error; = 9 End-of-file.

5.3.12.3 Subroutine RBFILE

Subroutine RBFILE reads boundary spectra from one file and additional information of the heading lines.

Calling Sequence: rbfile (spcsig, spcdir, bfiled, bsploc, bspdir, rbsdir, bspfrq, rbsfrq, bspecs, bspaux, rbsaux, xytst)

Data Declaration:	Real	spcdir, spcsig, bspecs, rbsaux, rbsdir, rbsfrq
	Integer	bspaux, bspdir, bspfrq, bfiled, bsploc, xytst

Arguments:	spcsig	Relative frequencies in the computational domain in sigma space.

spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
bfiled	Data concerning boundary condition files.
bsploc	Place in array *bspecs* for storing interpolated spectra.
bspdir	Spectral directions of input spectrum.
rbsdir	Real equivalence of *bspdir.*
bspfrq	Spectral frequencies of input spectrum.
rbsfrq	Real equivalence of *bspfrq.*
bspecs	Boundary spectra.
bspaux	Auxiliary array used for interpolation.
rbsaux	Real equivalence of *bspaux.*
xytst	Test points.

5.3.12.4 Subroutine RESPEC

Subroutine RESPEC reads one 1-D or 2-D boundary spectrum from file, and transforms to internal SWAN spectral resolution.

Calling Sequence: respec (btype, ndsd, bfiled, unform, dorder, baux1, baux2, baux3, baux4, spcsig, spcdir, bspfrq, bspdir, lspec, ufac, ierr)

Data Declaration:

Real	spcsig, spcdir, baux1, baux2, baux3, baux4, bspfrq, bspdir, lspec, ufac
Integer	ndsd, bfiled, integer, ierr
Character	btype
Logical	unform

Arguments:

btype	Type of input.
ndsd	Unit reference number of input file.
bfiled	Options for reading boundary condition file.
unform	If true, unformatted reading is called.
dorder	If < 0, order of directions must be reversed.
baux1, baux2, baux3, baux4	Auxiliary array.
spcsig	Relative frequencies in computational domain in sigma space.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions;

	(*,4) Cosine^2 of spectral directions;
	(*,5) Cosine*sine of spectral directions;
	(*,6) Sine^2 of spectral directions.
bspfrq	Spectral frequencies of input spectrum.
bspdir	Spectral directions of input spectrum.
lspec	Interpolated spectrum.
ufac	Factor used to multiply data.
ierr	Error status:
	= 0 No error;
	= 9 End of file.

5.3.12.5 Subroutine SINARR

Subroutine SINARR calculates energy density at boundary point (x, y, sigma, theta).

Calling Sequence: sinarr (pool)

Data Declaration: Integer pool

Arguments: pool Dynamic data pool.

5.3.12.6 Logical Function SINBTG

Subroutine SINBTG checks whether a point given in problem coordinates is in the bottom grid (SINBTG = True) or not (SINBTG = False).

Calling Sequence: sinbtg (xp, yp)

Data Declaration: Real xp, yp

Arguments:	xp	X-coordinate (problem grid) of the point.
	yp	Y-coordinate (problem grid) of the point.

5.3.12.7 Logical Function SINCMP

Subroutine SINCMP checks whether a point given in problem coordinates is in the computational grid (SINCMP = True) or not (SINCMP = False).

Calling Sequence: sincmp (xp, yp, xcgrid, ycgrid, kgrpnt, kgrbnd)

Data Declaration:	Real	xp, yp, xcgrid, ycgrid
	Integer	kgrpnt, kgrbnd

Arguments:

xp	X-coordinate (problem grid) of the point.
yp	Y-coordinate (problem grid) of the point.
xcgrid	X-coordinate of computational grid in x-direction.
ycgrid	Y-coordinate of computational grid in y-direction.
kgrpnt	Grid point addresses.
kgrbnd	Describes computational grid boundary.

5.3.12.8 Subroutine SINUPT

Subroutine SINUPT checks whether the point *xp, yp* (given in problem coordinates) of the output point-set *sname* is located in the computational grid and bottom grid or not. If not, a warning is generated.

Calling Sequence: sinupt (psname, xp, yp, xcgrid, ycgrid, kgrpnt, kgrbnd)

Data Declaration:

Real	xp, yp, xcgrid, ycgrid
Integer	kgrpnt, kgrbnd
Character	psname

Arguments:

psname	Name of the output point-set (any type).
xp	X-coordinate of the point (problem coordinates).
yp	Y-coordinate of the point (problem coordinates).
xcgrid	X-coordinate of computational grid in x direction.
ycgrid	Y-coordinate of computational grid in y direction.
kgrpnt	Addresses of the computational grid points.
kgrbnd	Describes the computational grid boundary.

5.3.12.9 Subroutine SNEXTI

Calling Sequence: snexti (pool, rpool, bfiles, bsploc, bspdir, rbsdir, bspfrq, rbsfrq, bspaux, rbsaux, bspecs, bgridp, compda, ac1, ac2, spcsig, spcdir, xcgrid, ycgrid, kgrpnt, xytst)

Data Declaration:

Real	rpool, ac1, ac2, bspecs, compda, rbsaux, rbsdir, rbsfrq, spcdir, spcsig, xcgrid, ycgrid
Integer	pool, bfiles, bsploc, bspdir, bspfrq, bgridp, bspaux, xytst, kgrpnt

Arguments:

pool	Data pool.
rpool	Real equivalence of data *pool.*
bfiles	Parameters for reading boundary files.
bsploc	Location where to put boundary values.

bspdir	Spectral directions of boundary spectra.
rbsdir	Spectral directions of boundary spectra.
bspfrq	Spectral frequencies of boundary spectra.
rbsfrq	Spectral frequencies of boundary spectra.
bspaux	Auxiliary array used for interpolation.
rbsaux	Auxiliary data for interpolation of spectra.
bspecs	Boundary spectra.
bgridp	Data for interpolating to computational grid points.
compda	Values on computational grid.
ac1	Action density spectra on old time level.
ac2	Action density spectra on new time level.
spcsig	Relative frequencies in computational domain in sigma space.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
xcgrid	X-coordinate of computational grid in x-direction.
ycgrid	Y-coordinate of computational grid in y-direction.
kgrpnt	Computational grid point addresses.
xytst	Test points.

5.3.12.10 Subroutine SPRCON

Subroutine SPRCON executes some tests on the given model description.

Calling Sequence: sprcon (outps, xcgrid, ycgrid, kgrpnt, kgrbnd)

Data Declaration:	Real	xcgrid, ycgrid
	Integer	kgrpnt, kgrbnd, outps

Arguments:	outps	Contains information about output points.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.
	kgrpnt	Grid point addresses.
	kgrbnd	Describes the computational grid boundary.

5.3.12.11 Real Function SVALQI

Subroutine SVALQI determines the value of a quantity, such as depth, from an input grid and the current velocity components for point given in problem coordinates.

Calling Sequence:	svalqi (xp, yp, igrid, arrinp, zero, ixc, iyc)	
Data Declaration:	Real	xp, yp, arrinp
	Integer	igrid, ixc, iyc, zero
Arguments:	xp	X-coordinate in the computational grid point.
	yp	Y-coordinate in the computational grid point.
	igrid	Grid indicator.
	arrinp	Array holding the values at the input grid locations.
	zero	If *zero* = 0, then value outside the grid is zero, otherwise the value is extrapolated.
	ixc	Counter for X-coordinate in computational grid (used in curvilinear case).
	iyc	Counter for Y-coordinate in computational grid (used in curvilinear case).

5.3.12.12 Program SWAN

Subroutine SWAN is the main program that initializes data pool, and makes common areas empty.

Common Blocks: NAMES
TESTDA
OUTPDA
REFNRS
LEESDA
LEESDN
SWNAME
SWGRID
SWCOMG
SWNUMS
SWTEST
SWUITV
SWFYSP
COMPDA

5.3.12.14 Subroutine SWINCO

Subroutine SWINCO imposes wave initial conditions at a computational grid.

Calling Sequence: swinco (ac2, compda, xcgrid, ycgrid, kgrpnt, spcdir, spcsig, xytst)

Data Declaration:	Real	ac2, compda, xcgrid, ycgrid, spcdir, spcsig, kgrpnt
	Integer	xytst

Arguments:	ac2	Action density spectra.
	compda	Quantities in grid points.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	kgrpnt	Indirect addresses of grid points.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	spcsig	Relative frequencies in the computational domain in sigma space.
	xytst	Test points.

5.3.12.15 Subroutine SWINIT

Subroutine SWINIT initializes the dynamic data pool and assigns initial values to the variables in the common blocks.

Calling Sequence: swinit (pool, inerr)

Data Declaration:	Integer	pool, inerr

Arguments:	pool	Dynamic data pool.
	inerr	Number of the initialization error.

5.3.12.16 Subroutine SWMAIN

Subroutine SWMAIN calls subroutines SWINIT, SWREAD, SWCOMP and SWOUTP.

Calling Sequence: swmain (pool, rpool, lpool, inerr)

Data Declaration:	Real	rpool
	Integer	pool, inerr
	Logical	lpool

Arguments:	pool	Dynamic data pool.
	rpool	Real equivalence to *pool.*

lpool	Logical equivalence to *pool.*
inerr	Number of the initialization error.

5.3.12.17 Subroutine SWPREP

Subroutine SWPREP computes the transformation coefficients between the different grids.

Calling Sequence: swprep (outda, xcgrid, ycgrid, kgrpnt, obsta, cross, kgrbnd)

Data Declaration:	Real	xcgrid, ycgrid
	Integer	outda, kgrpnt, cross, obsta, kgrbnd

Arguments:	outda	Contains output data.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.
	kgrpnt	Grid point addresses.
	kgrbnd	Describes the computational grid boundary.
	obsta	Array of obstacle parameters.
	cross	Array which contains 0's if there is no obstacle crossing if an obstacle is crossing between the central point and its neighbor *cross* is equal to the number of the obstacle.

5.3.12.18 Subroutine SWRBC

Subroutine SWRBC determines and writes the depths and currents at a line in the computational grid to a file with reference number *nref.*

Calling Sequence: swrbc (pool, rpool, compda, kgrpnt, xcgrid, ycgrid)

Data Declaration:	Integer	kgrpnt, pool
	Real	rpool, compda, xcgrid, ycgrid

Arguments:	pool	Dynamic data pool.
	rpool	Real equivalence of *pool.*
	compda	Values on the computational grid.
	kgrpnt	Grid point addresses.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.

5.3.13 Main Output Routines (swanout1 FOR File)

5.3.13.1 Subroutine SWIPOL

Subroutine SWIPOL interpolates *finp* to the point given by the computational grid coordinates *xc* and *yc*. The result appears in array *foutp*.

Calling Sequence:	swipol (finp, excval, xc, yc, mip, foutp, kgrpnt, dep2)	
Data Declaration:	Real	finp, excval, xc, yc, foutp, dep2
	Integer	mip, kgrpnt
Arguments:	finp	Array of function values defined on the computational grid.
	excval	Exception value (assigned if point is outside the computational grid).
	xc, yc	Array containing the computational grid coordinates of output points.
	mip	Number of output points.
	foutp	Array of interpolated values for the output points.
	kgrpnt	Index for indirect addressing.
	dep2	Depth at the computational grid points.

5.3.13.2 Subroutine SWODDC

Subroutine SWODDC decodes output point set data.

Calling Sequence:	swoddc (outps, psname, pstype, mip, mxk, myk, xnlen, ynlen, mxn, myn, xpcn, ypcn, alpcn, xcgrid, ycgrid, rtype)	
Data Declaration:	Real	xcgrid, ycgrid, xnlen, ynlen, xpcn, ypcn, alpcn
	Integer	outps, mip, mxk, myk, mxn, myn
	Character	psname, pstype, rtype
Arguments:	outps	Array containing output data.
	psname	Name of output point set referred to.
	pstype	Type of output point set.
	mip	Number of output points.
	mxk	Number of output points in X-direction (Frame).
	myk	Number of output points in Y-direction (Frame).
	xnlen, ynlen	(X, Y) length of the nested grid.
	mxn, myn	Number of meshes in X, Y direction for the nested grid.
	xpcn, ypcn	Location of the origin of the nested grid.

alpcn	Angle of the nested grid with the positive x-axis, counter-clockwise measured.
xcgrid	X-coordinate of computational grid in x direction.
ycgrid	Y-coordinate of computational grid in y direction.
rtype	Indicates type of output; "PLOT" means that a spatial plot is made.

5.3.13.3 Subroutine SWOEXA

Subroutine SWOEXA calculates quantities for which the spectral action density is necessary.

Calling Sequence: swoexa (oqproc, bkc, mip, xc, yc, voqr, voq, ac2, acloc, spcsig, wk, cg, spcdir, ne, ned, kgrpnt, depxy)

Data Declaration:

Real	xc, yc, voq, ac2, spcsig, spcdir, wk, cg, ne, ned, depxy, acloc
Integer	mip, voqr, kgrpnt
Logical	oqproc

Arguments:

oqproc	Processing of output quantities.
bkc	Variable used to flag variables for calculation for purpose of writing to output.
mip	Number of output points.
xc, yc	Computational grid coordinates.
voqr	Location in *voq* of certain output quantities.
voq	Values of output quantities.
ac2	Action densities.
acloc	Local action density spectrum.
spcsig	Relative frequencies in the computational domain in sigma space.
wk	Wave number in output point.
cg	Group velocity in output point.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
ne	Ratio of group and phase velocity.
ned	Derivative of *ne* with respect to depth.
kgrpnt	Index for indirect addressing.
depxy	Depth in points of the computational grid.

5.3.13.4 Subroutine SWOEXC

Subroutine SWOEXC calculates the computational grid coordinates of the output points.

Calling Sequence: swoexc (outps, pstype, mip, xp, yp, xc, yc, kgrpnt, xcgrid, ycgrid, kgrbnd)

Data Declaration:	Real	xp, yp, xc, yc, xcgrid, ycgrid
	Integer	outps, mip, kgrpnt, kgrbnd
	Character	pstype

Arguments:	outps	Array containing output data.
	pstype	Type of output point set.
	mip	Number of output points.
	xp, yp	User coordinates of output point.
	xc, yc	Computational grid coordinates.
	kgrpnt	Index for indirect addressing.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.
	kgrbnd	Describes the computational grid boundary.

5.3.13.5 Subroutine SWOEXD

Subroutine SWOEXC calculates the distance, depth, Ux, Uy, etc.

Calling Sequence: swoexd (oqproc, mip, xc, yc, voqr, voq, compda, kgrpnt)

Data Declaration:	Real	xc, yc, compda, voq
	Integer	mip, kgrpnt, voqr
	Logical	oqproc

Arguments:	oqproc	Y/n process output quantities.
	mip	Number of output points.
	xc, yc	Computational grid coordinates.
	voqr	Location in *voq* of certain output quantities.
	voq	Values of output quantities.
	compda	Array holding values for computational grid points.
	kgrpnt	Index for indirect addressing.

5.3.13.6 Subroutine SWOEXF

Subroutine SWOEXF calculates wave-driven force (output quantity IVTYPE = 20).

Calling Sequence: swoexf (mip, xc, yc, voqr, voq, ac2, dep2, spcsig, wk, cg, spcdir, ne, ned, kgrpnt, xcgrid, ycgrid)

Data Declaration:

Real	xc, yc, voq, ac2, dep2, spcsig, wk, cg, spcdir, ne, ned, xcgrid, ycgrid
Integer	mip, voqr, kgrpnt

Arguments:

mip	Number of output points.
xc, yc	Computational grid coordinates of output point.
voqr	Location in *voq* of a certain output quantity.
voq	Values of output quantities.
ac2	Action density.
dep2	Depth at the computational grid points.
spcsig	Relative frequencies in the computational domain in sigma space.
wk	Wave number in output point.
cg	Group velocity in output point.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
ne	Ratio of group and phase velocity.
ned	Derivative of *ne* with respect to depth.
kgrpnt	Index for indirect addressing.
xcgrid	X-coordinate of computational grid in x direction.
ycgrid	Y-coordinate of computational grid in y direction.

5.3.13.7 Subroutine SWOINA

Subroutine SWOINA interpolates local action density *acloc* from array *ac2.*

Calling Sequence: swoina (xc, yc, ac2, acloc, kgrpnt, depxy)

Data Declaration:

Real	xc, yc, ac2, acloc, depxy
Integer	kgrpnt

Arguments:

xc, yc	Computational grid coordinates.
ac2	Action densities.
acloc	Local action density spectrum.
kgrpnt	Index for indirect addressing.
depxy	Depth in points of the computational grid.

5.3.13.8 Subroutine SWORDC

Subroutine SWORDC decodes output requests.

Calling Sequence: swordc (outi, outr, rtype, psname, nvoqp, oqproc, bkc, voqr, logact)

Data Declaration:

Integer	voqr, bkc, outi, nvoqp
Real	outr
Logical	oqproc, logact
Character	rtype, psname

Arguments:

outi	Array for storage of information regarding location, type of output.
outr	Code for one output request.
rtype	Type of output.
psname	Name of output point set referred to.
nvoqp	Number of data per output point.
oqproc	Whether or not an output quantity must be processed.
bkc	Variable used to flag variables for calculation for purpose of writing to output.
voqr	Place of each output quantity.
logact	Logical variable; TRUE enables output.

5.3.13.9 Subroutine SWOUTP

Subroutine SWOUTP processes the output requests.

Calling Sequence: swoutp (outda, routda, loutda, ac2, spcsig, spcdir, compda, xytst, kgrpnt, xcgrid, ycgrid, kgrbnd)

Data Declaration:

Real	routda, ac2, spcsig, spcdir, xcgrid, ycgrid, compda
Integer	outda, xytst, kgrpnt, kgrbnd
Logical	loutda

Arguments:

outda	Array containing output data, requests.
routda	Real equivalence of *outda.*
loutda	Logical equivalence of *outda.*
ac2	Action density in all computational points.
spcsig	Relative frequencies in the computational domain in sigma space.
spcdir	Spectral directions, cosines and sines.
compda	Array holding values for the computational grid points.

xytst	Test points.
kgrpnt	Index for indirect addressing.
xcgrid	X-coordinate of computational grid in x direction.
ycgrid	Y-coordinate of computational grid in y direction.
kgrbnd	Describes the computational grid boundary.

5.3.14 Output Routines (swanout2 FOR File)

5.3.14.1 Subroutine PLOTCG

Subroutine PLOTCG plots the computational grid.

Calling Sequence: plotcg (ixmax, iymax, ixmin, iymin, lincol, cx, cy, kgrpnt)

Data Declaration:	Integer	ixmax, iymax, ixmin, iymin, lincol, kgrpnt
	Real	cx, cy

Arguments:	ixmax	Maximum X for which computational grid is to be plotted.
	iymax	Maximum Y for which computational grid is to be plotted.
	ixmin	Minimum X for which computational grid is to be plotted.
	iymin	Minimum Y for which computational grid is to be plotted.
	lincol	Line color (pen number) used for plotting.
	cx, cy	Coordinates of computational grid points.
	kgrpnt	Array grid point indices.

5.3.14.2 Subroutine SBLKPT

Subroutine SBLKPT writes the block output either on paper or to data file.

Calling Sequence: sblkpt (ipd, nref, dfac, psname, qunit, mxk, myk, idla, string, oqvals)

Data Declaration:	Real	dfac, oqvals
	Integer	ipd, nref, mxk, myk, idla
	Character	psname, qunit, string

Arguments:	ipd	Switch for printing on paper (*ipd* = 1) or writing to data file (*ipd* = 2 or 3).

nref	Unit reference number of output file.
dfac	Multiplication factor of block output.
psname	Name of output point set (frame).
qunit	Physical unit (dimension) of variable.
mxk	Number of points in x-direction of frame.
myk	Number of points in y-direction of frame.
idla	Controls layout of output.
string	Description of output variable.
oqvals	Generic array containing variable which is being written.

5.3.14.3 Subroutine SPLOER

Subroutine SPLOER draws a plot with the locations of error points.

Calling Sequence: sploer (oreq, xcgrid, ycgrid)

Data Declaration:	Real	xcgrid, ycgrid
	Integer	oreq

Arguments:	oreq	Array containing output requests.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.

5.3.14.4 Character Function SUHEAD

Subroutine SUHEAD prepares a unit for the table print output in the form: [unit].

Calling Sequence: suhead (qunit)

Data Declaration:	Character	qunit

Arguments:	qunit	Unit of the variable to be printed in the table headings.

5.3.14.5 Subroutine SWBLOK

Subroutine SWBLOK prepares output in the form of a block that is printed by subroutine SBLKPT.

Calling Sequence: swblok (rtype, oreq, psname, mxk, myk, voqr, voq)

Data Declaration:	Real	voq
	Integer	voqr, oreq, mxk, myk
	Character	rtype, psname

Arguments:	rtype	Type of output request: BLKP for output on paper; BLKD and BLKL for output to data file.
	oreq	Array containing current output request.
	psname	Name of output frame.
	mxk	Number of grid points in x-direction.
	myk	Number of grid points in y-direction.
	voqr	Gives location in array *voq* where to find a variable.
	voq	Values of variables for all output points.

5.3.14.6 Subroutine SWCMSP

Subroutine SWCMSP computes energy density spectrum 1-D or 2-D.

Calling Sequence: swcmsp (otype, xc, yc, ac2, acloc, spcsig, dep, dep2, ux, uy, ecos, esin, ofac, kgrpnt, ierr)

Data Declaration:	Real	xc, yc, ac2, acloc, spcsig, dep, dep2, ux, uy, ecos, esin, ofac
	Integer	otype, kgrpnt, ierr

Arguments:	otype	Type of spectrum wanted: 2 or -2 for 2-D spectrum, 1 or -1 for 1-D frequency spectrum positive: relative frequency negative: absolute frequency.
	xc, yc	Coordinates of output location(s).
	ac2	Action densities.
	acloc	$\|otype\| = 2$: 2-D spectrum at one output location. $\|otype\| = 1$: 1-D spectra at output locations.
	spcsig	Relative frequencies in computational domain in sigma space.
	dep	Depths at output location.
	dep2	Depth.
	ux, uy	Current velocities at output location.
	ecos	Cosines of spectral directions.
	esin	Sines of spectral directions.
	ofac	Output factor (if *inrhog* = 1, equal to *rho*grav*).
	kgrpnt	Array grid point indices.

ierr	Error status: = 0 No error; = 9 End-of-file.

5.3.14.7 Subroutine SWPLOT

Subroutine SWPLOT prepares to plot contour lines and vector patterns.

Calling Sequence: swplot (oreq, mxk, myk, ppname, voqr, voq, orer, places, placer, clines, cliner, psdata, outpr, xcgrid, ycgrid, kgrpnt, kgrbnd, i_voq)

Data Declaration:

Real	cliner, outpr, placer, xcgrid, ycgrid, orer
Integer	i_voq, mxk, myk, voqr, clines, ppname, oreq, places, psdata, kgrpnt, kgrbnd

Arguments:

oreq	Array containing output requests.
mxk, myk	Number of grid points of output frame.
ppname	Output frame.
voqr	Gives location in array *voq* where to find a variable.
voq	Values of variables for all output points.
orer	Real equivalence of *oreq.*
places	Data on town and region names.
placer	Real equivalence of *places.*
clines	Data on coastlines.
cliner	Real equivalence of *clines.*
psdata	Data on output point sets.
outpr	Real equivalence of *psdata.*
xcgrid	X-coordinate of computational grid in x direction.
ycgrid	Y-coordinate of computational grid in y direction.
kgrpnt	Array grid point indices.
kgrbnd	Describes the computational grid boundary.
i_voq	Integer equivalence of *voq.*

5.3.14.8 Subroutine SWSPEC

Subroutine SWSPEC prints action density spectrum in the form of a table.

Calling Sequence: swspec (rtype, oreq, mip, voqr, voq, ac2, acloc, spcsig, spcdir, dep2, kgrpnt)

Data Declaration:

Real	voq, ac2, spcsig, spcdir, dep2
Integer	oreq, mip, voqr, kgrpnt

	Character	rtype

Arguments:	rtype	Type of output request: *spec* for 2-D spectral output; *spe1* for 1-D frequency spectrum.
	oreq	Array containing output request data of request currently being processed.
	mip	Number of output points in set *psname.*
	voqr	Gives location in array *voq* where to find a variable.
	voq	Values of variables for all output points.
	ac2	Action densities.
	acloc	Case *spec*: 2-D spectrum at one output location. Case *spe1*: 1-D spectra at output locations.
	spcsig	Relative frequencies in computational domain in sigma space.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	dep2	Depth.
	kgrpnt	Array grid point indices.

5.3.14.9 Subroutine SWSTAR

Subroutine SWSTAR plots directional distribution of action transport.

Calling Sequence: swstar (oreq, mxk, myk, voqr, voq, orer, kgrpnt, spcsig, spcdir, ac2, acloc, wavn, cg, ne, ned)

Data Declaration:	Real	voq, spcsig, spcdir, ac2, acloc, wavn, cg, ne, ned, orer
	Integer	oreq, mxk, myk, voqr, kgrpnt

Arguments:	oreq	Array containing output requests.
	mxk, myk	Number of grid points of output frame.
	voqr	Gives location in array *voq* where to find a variable.
	voq	Values of variables for all output points.
	orer	Real equivalence of *oreq*.
	kgrpnt	Array grid point indices.
	spcsig	Relative frequencies in computational domain in

	sigma space.
spcdir	(*,1) Spectral directions (radians);
	(*,2) Cosine of spectral directions;
	(*,3) Sine of spectral directions;
	(*,4) Cosine^2 of spectral directions;
	(*,5) Cosine*sine of spectral directions;
	(*,6) Sine^2 of spectral directions.
ac2	Action densities.
acloc	Spectral action densities in output point.
wavn	Wave numbers.
cg	Energy property velocity.
ne	Unused.
ned	Unused.

5.3.14.10 Subroutine SWTABP

Subroutine SWTABP prints output in the form of a table for any type of output point set.

Calling Sequence: swtabp (rtype, oreq, psname, mip, voqr, voq)

Data Declaration:	Real	voq
	Integer	mip, voqr, oreq
	Character	rtype, psname

Arguments:	rtype	Type of output request.
	oreq	Array containing output requests.
	psname	Name of output point set (frame).
	mip	Number of output points in set *psname*.
	voqr	Gives location in array *voq* where to find a variable.
	voq	Values of variables for all output points.

5.3.15 Output routines (swanout3 FOR File)

5.3.15.1 Subroutine PLSPEC

Calling Sequence: plspec (oreq, orer, spcsig, logpl, acloc, ip, xc, yc, hsig, aper, pper, adir, dspr, wvx, wvy, spcdir)

Data Declaration:	Real	orer, spcsig, acloc, xc, yc, hsig, aper, pper, adir, dspr, wvx, wvy, spcdir
	Integer	oreq, ip

	Logical	logpl
Arguments:	oreq	Array containing output requests.
	orer	Real equivalence of *oreq*.
	spcsig	Relative frequencies in the computational domain in sigma space.
	logpl	Logical array used as working space with dimension (*nfreq, nangl*).
	acloc	|*otype*| = 2: 2-D spectrum at one output location. |*otype*| = 1: 1-D spectra at output locations.
	ip	Point to be plotted.
	xc, yc	Coordinates of output location(s).
	hsig	Significant wave height.
	aper	Average wave period.
	pper	Peak wave period.
	adir	Average (mean) wave direction.
	dspr	One-sided directional width of spectrum.
	wvx, wvy	X and y component, respectively, of wind velocity.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.

5.3.15.2 Subroutine PLTAR1

Subroutine PLTAR1 plots an arrow (centered).

Calling Sequence: pltar1 (x0, y0, arl, tha, th2, fac2, arlmin)

Data Declaration:	Real	x0, y0, arl, tha, th2, fac2, arlmin
Arguments:	x0, y0	Center coordinates of *array*.
	arl	Arrow length.
	tha	Direction of arrow.
	th2	Angle in head of arrow.
	fac2	Length factor head arrow.
	arlmin	Minimum arrow length.

5.3.15.3 Subroutine PLTAR2

Subroutine PLTR2 plots an arrow (centered).

Calling Sequence:	pltar2 (x0, y0, arl, tha, th2, fac2, arlmin)	
Data Declaration:	Real	x0, y0, arl, tha, th2, fac2, arlmin
Arguments:	x0, y0	Center coordinates of array.
	arl	Arrow length.
	tha	Direction of arrow.
	th2	Angle in head of arrow.
	fac2	Length factor head arrow.
	arlmin	Minimum arrow length.

5.3.15.4 Subroutine PLTCIR

Subroutine PLTCIR plots a circle with radius *r* around the origin.

Calling Sequence:	pltcir (r, dashln)	
Data Declaration:	Real	r, dashln
Arguments:	r	Radius of circle in plot units.
	dashln	Length of dashes.

5.3.15.5 Subroutine PLTISO

Subroutine PLTISO is a contour plot with isolines on a rectangular grid.

Calling Sequence:	pltiso (spcsig, chts, logpl, acloc, spcdir)	
Data Declaration:	Real	spcsig, chts, acloc, spcdir
	Logical	logpl
Arguments:	spcsig	Relative frequencies in the computational domain in sigma space.
	chts	Real array with dimension of at least *nhts*, containing contour heights.
	logpl	Logical array used as working space with dimension (*nfreq, nangl*).
	acloc	$\|otype\|$ = 2: 2-D spectrum at one output location. $\|otype\|$ = 1: 1-D spectra at output locations.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions;

(*,4)	Cosine^2 of spectral directions;
(*,5)	Cosine*sine of spectral directions;
(*,6)	Sine^2 of spectral directions.

Common Blocks: CPLT1

5.3.15.6 Subroutine PLTLN1

Subroutine PLTLN1 plots a (dashed) line.

Calling Sequence: pltln1 (x1, x2, y1, y2, dashln)

Data Declaration: Real x1, x2, y1, y2, dashln

Arguments:

x1	X-coordinate of starting point.
x2	X-coordinate of end point.
y1	Y-coordinate of starting point.
y2	Y-coordinate of end point.
dashln	Length of dashes.

5.3.15.7 Subroutine PLTSEG

Subroutine PLTSEG computes coordinates of the begin and end points of a line starting on a circle with radius *radc* with an end point on the side of a square box with size *psmax*. The direction of the line is *psi* degrees.

Calling Sequence: pltseg (radc, psmax, psi, x1, x2, y1, y2)

Data Declaration: Real radc, psmax, psi, x1, x2, y1, y2

Arguments:

radc	Radius of inner circle.
psmax	Size of outer box.
psi	Direction in degrees.
x1	X-coordinate of starting point.
x2	X-coordinate of end point.
y1	Y-coordinate of starting point.
y2	Y-coordinate of end point.

5.3.15.8 Subroutine PLT2DS

Subroutine PLT2DS is a polar contour plot of 2-D spectrum.

Calling Sequence: plt2ds (norms2, spcsig, rcir, logpl, acloc, nhts, chts, iln, spcdir)

Data Declaration:

Real	spcsig, spcdir, acloc, rcir, chts
Logical	logpl
Integer	norms2, nhts, iln

Arguments:

norms2	Parameter specifying normalization.
spcsig	Relative frequencies in computational domain in sigma space.
rcir	Radii of circles.
logpl	Logical array used as working space with dimension (*nfreq, nangl*).
acloc	|*otype*| = 2: 2-D spectrum at one output location. |*otype*| = 1: 1-D spectra at output locations.
nhts	Number of contour heights (maximum = 14).
chts	Real array with dimension of at least *nhts*, containing contour heights.
iln	Parameter specifying whether the lines and circles must be plotted: = 0 no lines and circles; = 1 lines are plotted; = 2 circles are plotted; = 3 lines and circles are plotted.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.

5.3.15.9 Subroutine PSIGMA

Subroutine PSIGMA draws a sigma.

Calling Sequence: psigma (x, y, dxout3, dyout3)

Data Declaration: Real x, y, dxout3, dyout3

Arguments:

x	X-coordinate of lower left corner.
y	Y-coordinate of lower left corner.
dxout3	Size in X-direction.
dyout3	Size in Y-direction.

5.3.15.10 Subroutine PTHETA

Subroutine PTHETA draws a theta.

Calling Sequence: ptheta (x, y, dxout3, dyout3)

Data Declaration:

Real	x, y, dxout3, dyout3

Arguments:

x	X-coordinate of lower left corner.
y	Y-coordinate of lower left corner.
dxout3	Size in X-direction.
dyout3	Size in Y-direction.

5.3.15.11 Subroutine SWPLSP

Calling Sequence: swplsp (rtype, oreq, orer, mip, ac2, acloc, aux, laux, voq, voqr, spcsig, spcdir, kgrpnt, dep2)

Data Declaration:

Integer	oreq, voqr, kgrpnt, mip
Real	orer, ac2, acloc, aux, voq, spcsig, spcdir, dep2
Logical	laux
Character	rtype

Arguments:

rtype	Type of output request: *spec* for 2-D spectral output; *spe1* for 1-D frequency spectrum.
oreq	Array containing output requests.
orer	Real equivalence of *oreq*.
mip	Number of output points in set *psname*.
ac2	Action densities.
acloc	|*otype*| = 2: 2-D spectrum at one output location; |*otype*| = 1: 1-D spectra at output locations.
aux	Action density at one location in space.
laux	Logical equivalence of *aux*.
voqr	Gives location in array *voq* where to find a variable.
voq	Values of variables for all output points.
spcsig	Relative frequencies in the computational domain in sigma space.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.

kgrpnt	Array grid point indices.
dep2	Depth.

5.3.15.12 Subroutine TRAFO

Subroutine TRAFO transforms polar coordinates to rectangular coordinates.

Calling Sequence: trafo (xin, yin, xout, yout, spcdir)

Data Declaration: Real xin, yin, xout, yout, spcdir

Arguments:

xin	(Normalized) frequency.
yin	Direction (number of direction steps).
xout	Output X.
yout	Output Y.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.

5.3.16 Preconditioning Subroutines (swanpre1 FOR File)

5.3.16.1 Subroutine BACKUP

Subroutine BACKUP is a backup current state of the wave field to a file.

Calling Sequence: backup (ac2, spcsig, spcdir, kgrpnt, xcgrid, ycgrid)

Data Declaration:

Real	ac2, spcsig, spcdir, xcgrid, ycgrid
Integer	kgrpnt

Arguments:

ac2	Action density as function of D, S, X, Y at time T.
spcsig	Relative frequencies in the computational domain in sigma space.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.

kgrpnt	Indirect addresses for grid points.
xcgrid	X-coordinate of computational grid in x direction.
ycgrid	Y-coordinate of computational grid in y direction.

5.3.16.2 Subroutine CGBOUN

Subroutine CGBOUN determines an array containing all points of (closed) boundary/boundaries within the computational grid.

Calling Sequence: cgboun (kgrpnt, kgrbnd)

Data Declaration: Integer kgrpnt, kgrbnd

Arguments:

kgrpnt	Indirect addresses for grid points.
kgrbnd	Array containing all boundary points (+ 2 extra zeros as area separators for all separated areas).

5.3.16.3 Subroutine CGINIT

Subroutine CGINIT initializes arrays for description of the computational grid.

Calling Sequence: cginit (pool, rpool, logcom)

Data Declaration:

Integer	pool
Real	rpool
Logical	logcom

Arguments:

pool	Dynamic data pool.
rpool	Real equivalence of *pool.*
logcom	The logical variable *logcom* has a record about which commands have been given to know if all the information for certain command is available.

5.3.16.4 Subroutine INITVA

Subroutine INITVA processes command INIT and computes the initial state of the wave field.

Calling Sequence: initva (ac2, spcsig, edirs, spcdir, kgrpnt, xcgrid, ycgrid, logcom, xytst)

Data Declaration: Real spcsig, spcdir, xcgrid, ycgrid, ac2, edirs

	Integer	kgrpnt, xytst
	Logical	logcom
Arguments:	ac2	Action density as function of D, S, X, Y at time T.
	spcsig	Relative frequencies in computational domain in sigma space.
	edirs	Not used.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	kgrpnt	Indirect addresses for grid points.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.
	logcom	The logical variable *logcom* has a record about which commands have been given to know if all the information for certain command is available.
	xytst	Test points.

5.3.16.5 Logical Function PVALID

Subroutine PVALID finds whether or not a couple (*ix, iy*) represents a valid grid point.

Calling Sequence: pvalid (ix, iy, kgrpnt)

Data Declaration: Integer ix, iy, kgrpnt

Arguments:	ix, iy	X- and y-indices of the point under consideration.
	kgrpnt	Indirect addresses for grid points.

5.1.16.6 Subroutine SEPARAREA

Subroutine SEPARAREA separates the areas that could be connected with a one cell connection.

Calling Sequence: separarea (ix, iy, kgrpnt, idir)

Data Declaration: Integer ix, iy, kgrpnt, idir

Arguments:	ix, iy	X- and y-indices of point under consideration.
	kgrpnt	Indirect addresses for grid points.
	idir	Index for direction.

5.3.16.7 Subroutine SINPGR

Subroutine SINPGR reads parameters of an input grid.

Calling Sequence: sinpgr (igrid1, igrid2, snameg, outps, xcgrid, ycgrid)

Data Declaration:	Real	xcgrid, ycgrid, outps
	Integer	igrid1, igrid2
	Character	snameg

Arguments:	igrid1	Grid number for which parameters are read.
	igrid2	Grid number for which parameters are read only relevant if > 0.
	snameg	Name of output frame corresponding to input grid.
	outps	Array storing output frame data.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.

Common Blocks: REFNRS
SWCOMG
SWFYSP
SWGRID
SWTEST
SWUITV
TESTDA
TIMFIL

5.3.16.8 Subroutine SREDEP

Subroutine SREDEP reads depths and/or currents.

Calling Sequence: sredep (pool, lwindr, lwindm, logcom, rpool)

Data Declaration:	Integer	pool, lwindr, lwindm
	Real	rpool
	Logical	logcom

Arguments:	pool	Output variable that is filled with computational data needed for the simulation by SWAN.

lwindr	Describes type of wind information being read.
lwindm	Describes wind input physics mode.
logcom	The logical variable *logcom* has a record about which commands have been given to know if all the information for certain command is available.
rpool	Real equivalence of *pool* array.

5.3.16.9 Subroutine SSFILL

Subroutine SSFILL discretizes in frequency (sigma) and direction (theta).

Calling Sequence: ssfill (spcsig, spcdir)

Data Declaration:	Real	spcsig, spcdir
Arguments:	spcsig	Relative frequencies in computational domain in sigma space.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.

5.3.16.10 Subroutine SWDIM

Subroutine SWDIM computes depths and currents by bilinear interpolation and usually writes to file INSTR.

Calling Sequence: swdim (kgrpnt, depth, xcgrid, ycgrid, xytst)

Data Declaration:	Real	xcgrid, ycgrid, depth
	Integer	kgrpnt, xytst
Arguments:	kgrpnt	Indirect addresses for grid points.
	depth	The water depth array.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.
	xytst	Test point.

5.3.16.11 Subroutine SWREAD

Subroutine SWREAD reads and processes the user commands describing the model.

Calling Sequence: swread (comput, pool, rpool)

Data Declaration:

Real	rpool
Integer	pool
Character	comput

Arguments:

comput	Output variable that determines the sort of computation to be performed by SWAN: = comp Computation requested; = noco No computation but output requested; = retr Retrieve data from previous computation; = stop Make computation, output and stop.
pool	Output variable that is filled with computational data needed for the simulation by SWAN.
rpool	Real equivalence for *pool.*

Common Blocks:

CBOUP
COMPDA
LEESDA
LEESDN
NAMES
OUTPDA
REFNRS
SWANWL
SWCOMG
SWFYSP
SWGRID
SWNAME
SWNUMS
SWUITV
SWTEST
TESTDA
TIMCOM
TIMRED
WAMBOU
WFILNM

5.3.16.12 Logical Function VALIDBP

Subroutine VALIDBP checks to see whether or not the point with index (*ix, iy*) can be a valid boundary point.

Calling Sequence: validbp (ix, iy, kgrpnt, wnp)

Data Declaration:	Integer	ix, iy, kgrpnt, wnp

Arguments:	ix, iy	X- and y-indices of point under consideration.
	kgrpnt	Indirect addresses for grid points.
	wnp	Number of wet neighboring points.

5.3.17 File Two of the Preconditioning Subroutines (swanpre2 FOR File)

5.3.17.1 Subroutine BCFILE

Subroutine BCFILE reads file data for boundary condition.

Calling Sequence: bcfile (fbcnam, bctype, bfiled, bsploc, bspdir, rbsdir, bspfrq, rbsfrq, bgridp, bspaux, xcgrid, ycgrid, kgrpnt, xytst, kgrbnd, donall)

Data Declaration:	Real	rbsdir, rbsfrq, xcgrid, ycgrid
	Integer	bspdir, bspfrq, bfiled, bspaux, kgrpnt, bgridp, bsploc, xytst, kgrbnd
	Character	fbcnam, bctype
	Logical	donall

Arguments:	fbcnam	Filename of boundary data file.
	bctype	If value is "NEST" $\rightarrow$ nesting b.c.
	bfiled	Data concerning boundary condition files.
	bsploc	Place in array *bspecs* where to store interpolated spectra.
	bspdir	Spectral directions of input spectrum.
	rbsdir	Real equivalence of *bspdir.*
	bspfrq	Spectral frequencies of input spectrum.
	rbsfrq	Real equivalence of *bspfrq.*
	bgridp	Data concerning boundary grid points.
	bspaux	Auxiliary array used for interpolation.
	xcgrid	X-coordinate of computational grid points.
	ycgrid	Y-coordinate of computational grid points.
	kgrpnt	Indirect addresses of grid points.
	xytst	*Ix, iy* of test points.

kgrbnd	Array of boundary grid points.
donall	Declares if the nesting boundary is open or closed. *Donall* is defined by the users.

5.3.17.2 Subroutine BC_POINTS

Subroutine BC_POINTS interpolates grid points to the SWAN computational grid.

Calling Sequence: bc_points (bsploc, bgridp, bspaux, xcgrid, ycgrid, kgrpnt, xytst, kgrbnd, xp2, yp2, boun_coun, nbounc, donall)

Data Declaration:

Real	xcgrid, ycgrid, xp2, yp2
Integer	bsploc, bgridp, bspaux, kgrpnt, xytst, kgrbnd, boun_coun, nbounc
Logical	donall

Arguments:

bsploc	Place in array *bspecs* for storing interpolated spectra.
bgridp	Data concerning boundary grid points.
bspaux	Auxiliary array used for interpolation.
xcgrid	X-coordinate of computational grid points.
ycgrid	Y-coordinate of computational grid points.
kgrpnt	Indirect addresses of computational grid points.
xytst	Array of (*ix, iy*) of test points.
kgrbnd	Array of boundary grid points.
xp2	Problem x-coordinate of a boundary location.
yp2	Problem y-coordinate of a boundary location.
boun_coun	Counter show of the existing boundary point.
nbounc	Maximum number of boundary points.
donall	Declares if the nesting boundary is open or closed. *Donall* is defined by the users.

5.3.17.3 Subroutine BCWAMN

Subroutine BCWAMN reads file data for WAM nesting boundary conditions.

Calling Sequence: bcwamn (fbcnam, bctype, bfiled, bsploc, bspdir, rbsdir, bspfrq, rbsfrq, bgridp, bspaux, rbsaux, xcgrid, ycgrid, kgrpnt, xytst)

Data Declaration:

Real	rbsaux, rbsdir, rbsfrq, xcgrid, ycgrid
Integer	bspaux, bspdir, bspfrq, bfiled, bgridp, kgrpnt, bsploc, xytst
Character	fbcnam, bctype

Arguments:	fbcnam	Filename of boundary data file.
	bctype	If value is "NEST" → nesting b.c.
	bfiled	Data concerning boundary condition files.
	bsploc	Place in array *bspecs* that stores interpolated spectra.
	bspdir	Spectral directions of input spectrum.
	rbsdir	Real equivalence of *bspdir.*
	bspfrq	Spectral frequencies of input spectrum.
	rbsfrq	Real equivalence of *bspfrq.*
	bgridp	Data concerning boundary grid points.
	bspaux	Auxiliary array used for interpolation.
	rbsaux	Real equivalence of *bspaux.*
	xcgrid	X-coordinate of computational grid points.
	ycgrid	Y-coordinate of computational grid points.
	kgrpnt	Indirect addresses of grid points.
	xytst	*Ix, iy* of test points.

5.3.17.4 Subroutine BCWW3N

Subroutine BCWW3N reads file data for WAVEWATCH III boundary conditions.

Calling Sequence: bcww3n (fbcnam, bctype, bfiled, bsploc, bspdir, rbsdir, bspfrq, rbsfrq, bgridp, bspaux, xcgrid, ycgrid, kgrpnt, xytst, kgrbnd, donall)

Data Declaration:	Real	xcgrid, ycgrid, rbsdir, rbsfrq
	Integer	bfiled, kgrbnd, xytst, kgrpnt, bgridp, bsploc, bspaux, bspdir, bspfrq
	Character	fbcnam, bctype
	Logical	donall

Arguments:	fbcnam	Filename of boundary data file.
	bctype	Boundary condition type, is "WW3N" in this case.
	bfiled	Data concerning boundary condition files.
	bsploc	Place in array *bspecs* where to store interpolated spectra.
	bspdir	Spectral directions of input spectrum.
	rbsdir	Real equivalence of *bspdir.*
	bspfrq	Spectral frequencies of input spectrum.
	rbsfrq	Real equivalence of *bspfrq.*
	bgridp	Data concerning boundary grid points.
	bspaux	Auxiliary array used for interpolation.
	xcgrid	X-coordinate of computational grid points.

ycgrid	Y-coordinate of computational grid points.
kgrpnt	Indirect addresses of computational grid points.
xytst	Array of (*ix, iy*) of test points.
kgrbnd	Array of boundary grid points.
donall	Declares if the boundary is open or closed.

5.3.17.5 Logical Function BOUNPT

Subroutine BOUNPT determines whether a grid point is a point where a boundary condition can be applied.

Calling Sequence: bounpt (ix, iy, kgrpnt)

Data Declaration:	Integer	ix, iy, kgrpnt

Arguments:	ix, iy	Grid point indices.
	kgrpnt	Indirect addresses of grid points.

5.3.17.6 Subroutine RETSTP

Subroutine RETSTP reads test points, generates output point set TESTPNTS, and reads source term filenames.

Calling Sequence: retstp (mptst, xytst, kgrpnt, kgrbnd, xcgrid, ycgrid, spcsig, spcdir, ioutda, routda)

Data Declaration:	Real	xcgrid, ycgrid, spcsig, spcdir, routda
	Integer	mptst, xytst, kgrpnt, kgrbnd, ioutda

Arguments:	mptst	Maximum number of test points.
	xytst	Grid point indices of test points.
	kgrpnt	Indirect addresses of grid points.
	kgrbnd	Array of boundary grid points.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	spcsig	Relative frequencies in the computational domain in sigma space.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.

ioutd	Integer equivalence of *outda.*
routda	Real equivalence of *outda.*

5.3.17.7 Function SIRAY

Subroutine SIRAY searches the first point on a ray where the depth is *dp.*

Calling Sequence: siray (dp, xp1, yp1, xp2, yp2, xx, yy, botdep, botlev, watlev)

Data Declaration:

Logical	botdep
Real	botlev, watlev, xp1, yp1, xp2, yp2, xx, yy, dp

Arguments:

dp	Depth.
xp1	X-coordinate start point of ray.
yp1	Y-coordinate start point of ray.
xp2	X-coordinate end point of ray.
yp2	Y-coordinate end point of ray.
xx	X-coordinate point with depth *dp.*
yy	Y-coordinate point with depth *dp.*
botdep	Indicates that bottom depth is being read.
botlev	Bottom levels.
watlev	Water levels.

5.3.17.8 Subroutine SPROUT

Subroutine SPROUT reads and processes the user output commands.

Calling Sequence: sprout (found, outda, routda, spcsig, xcgrid, ycgrid, kgrpnt, botlev, watlev)

Data Declaration:

Real	routda, spcsig, xcgrid, ycgrid, botlev, watlev
Integer	outda, kgrpnt
Logical	found

Arguments:

found	Parameter indicating whether command being processed is found (value True) or not (False).
outda	Array containing output data.
routda	Real equivalence of *outda.*
spcsig	Relative frequencies in computational domain in sigma space.
xcgrid	X-coordinate of computational grid in x direction.
ycgrid	Y-coordinate of computational grid in y direction.
kgrpnt	Indirect addresses of the computational grid points.

botlev	Bottom levels.
watlev	Water levels.

5.3.17.9 Subroutine SVARTP

Subroutine SVARTP converts keywords into an integer.

Calling Sequence: svartp (ivtype)

Data Declaration:	Integer	ivtype
Arguments:	ivtype	Type number output variable.

5.3.17.10 Subroutine SWBOUN

Subroutine SWBOUN reads and processes boundary commands.

Calling Sequence: swboun (bfiles, bsploc, rbsloc, bspdir, rbsdir, bspfrq, rbsfrq, bspecs, mxspec, bgridp, bspaux, rbsaux, xcgrid, ycgrid, kgrpnt, spcsig, spcdir, bcaux, xytst, kgrbnd)

Data Declaration:	Real	rbsloc, rbsdir, rbsfrq, rbsaux, xcgrid, ycgrid, spcsig, spcdir, bspecs
	Integer	bsploc, bspdir, bspfrq, bspaux, bfiles, mxspec, bcaux, bgridp, kgrpnt, xytst, kgrbnd

Arguments:	bfiles	Data concerning boundary condition files.
	bsploc	Place in array *bspecs* where to store interpolated spectra.
	rbsloc	Real equivalence of *bsploc.*
	bspdir	Integer equivalence of *rbsdir.*
	rbsdir	Spectral directions of input spectrum.
	bspfrq	Integer equivalence of *rbsfrq.*
	rbsfrq	Spectral frequencies of input spectrum.
	bspecs	Array containing boundary spectra.
	mxspec	Number of spectra that *bspecs* can contain.
	bgridp	Data concerning boundary grid points.
	bspaux	Auxiliary array used for interpolation.
	rbsaux	Real equivalence of *bspaux.*
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.
	kgrpnt	Indirect addresses of grid points.
	spcsig	Relative frequencies in the computational domain in

	sigma space.
spcdir	(*,1) Spectral directions (radians);
	(*,2) Cosine of spectral directions;
	(*,3) Sine of spectral directions;
	(*,4) Cosine^2 of spectral directions;
	(*,5) Cosine*sine of spectral directions;
	(*,6) Sine^2 of spectral directions.
bcaux	Auxiliary array used in this subroutine.
xytst	*Ix, iy* of test points.
kgrbnd	Array of boundary grid points.

5.3.17.11 Subroutine SWNMPS

Subroutine SWNMPS reads the name of the set of output points and gets the type and number of points in the set.

Calling Sequence: swnmps (outps, psname, pstype, mip, ierr)

Data Declaration:	Integer	outps, mip, ierr
	Character	psname, pstype

Arguments:	outps	Array containing data on output point sets.
	psname	Output name.
	pstype	Output type.
	mip	Number of points.
	ierr	Error status:
		= 0 No error;
		= 9 End-of-file.

5.3.17.12 Subroutine SWREOQ

Subroutine SWREOQ reads and processes the output requests.

Calling Sequence: swreoq (found, outoq, outor, outps, outpr, spcsig)

Data Declaration:	Real	spcsig, outor, outpr
	Integer	outoq, outps
	Logical	found

Arguments:	found	Parameter indicating whether the command being processed is found (value True) or not (False).
	outoq	Array containing various parameters related to output requests (plotting).

outor	Array containing various parameters related to output requests (plotting).
outps	Array containing data on output point sets.
outpr	Real equivalence of *outps*.
spcsig	Relative frequencies in the computational domain in sigma space.

5.3.17.13 Subroutine SWREPS

Subroutine SWREPS reads and processes the commands defining output points.

Calling Sequence: swreps (found, outps, outpr, xcgrid, ycgrid, botlev, watlev)

Data Declaration:	Real	xcgrid, ycgrid, botlev, watlev, outpr
	Integer	outps
	Logical	found

Arguments:	found	Parameter indicating whether command being processed is found (value True) or not (False).
	outps	Array containing data on output point sets.
	outpr	Real equivalence of *outps*.
	xcgrid	X-coordinate of computational grid in x direction.
	ycgrid	Y-coordinate of computational grid in y direction.
	botlev	Bottom levels.
	watlev	Water levels.

5.3.18 SWAN Service Routines (swanser FOR File)

5.3.18.1 Subroutine AC2TST

Calling Sequence: ac2tst (xytst, ac2, kgrpnt)

Data Declaration:	Integer	xytst, kgrpnt
	Real	ac2

Arguments:	xytst	Grid point indices of test points.
	ac2	Action density array.
	kgrpnt	Array of indirect addressing.

5.3.18.2 Real Function ANGDEG

Function ANGDEG transforms radians to degrees.

Calling Sequence:	angdeg (radian)	
Data Declaration:	Real	radian
Arguments:	radian	Radians.

5.3.18.3 Real Function ANGRAD

Function ANGRAD transforms degrees to radians.

Calling Sequence:	angrad (degree)	
Data Declaration:	Real	degree
Arguments:	degree	Degrees.

5.3.18.4 Subroutine CHGBAS

Subroutine CHGBAS changes the x-basis of a discretized y-function.

Calling Sequence: chgbas (x1, x2, period, y1, y2, n1, n2, itest, prtest)

Data Declaration:	Real	x1, x2, y1, y2, period
	Integer	n1, n2, itest, prtest
Arguments:	x1	X-coordinate of input grid.
	x2	X-coordinate of output grid.
	period	Period, i.e. x-axis is periodic if *period* > 0 e.g. spectral directions.
	y1	Function values of input grid.
	y2	Function values of output grid.
	n1	Number of x-values of input grid.
	n2	Number of x-values of output grid.
	itest	Integer variable which determines the level of test output.
	prtest	Unit number for output.

5.3.18.5 Subroutine CVCHEK

Subroutine CVCHEK checks whether or not the given curvilinear grid is correct. CVCHEK also sets the value of *cvleft*.

Calling Sequence: cvchek (kgrpnt, xcgrid, ycgrid)

Data Declaration:	Integer	kgrpnt
	Real	xcgrid, ycgrid
Arguments:	kgrpnt	Array of indirect addressing.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.

5.3.18.6 Subroutine CVMESH

Subroutine CVMESH finds location in a curvilinear grid for a point given in problem coordinates.

Calling Sequence: cvmesh (xp, yp, xc, yc, kgrpnt, xcgrid, ycgrid, kgrbnd)

Data Declaration:	Real	xcgrid, ycgrid, xp, yp, xc, yc
	Integer	kgrpnt, kgrbnd
Arguments:	xp, yp	A point given in problem coordinates.
	xc, yc	Same point in computational grid coordinates.
	kgrpnt	Array (*mxc, myc*) grid numbers if *kgrpnt* <= 1, the point is not in computational grid.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	kgrbnd	Lists all boundary grid points consecutively.

5.3.18.7 Real Function DEGCNV

Function DEGCNV transforms degrees from Nautical to Cartesian or vice versa.

Calling Sequence: degcnv (degree)

Data Declaration:	Real	degree
Arguments:	degree	Direction in Nautical or Cartesian degrees.

5.3.18.9 Subroutine EVALF

Subroutine EVALF evaluates the coordinates (in problem coordinates) of point (*xc, yc*) given in computational coordinates.

Calling Sequence:	evalf (xc, yc, xvc, yvc, xcgrid, ycgrid)	
Data Declaration:	Real	xc, yc, xvc, yvb, xcgrid, ycgrid
Arguments:	xc, yc	Point in computational grid coordinates.
	xvc, yvc	Same point but in problem coordinates.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.

5.3.18.10 Real Function GAMMA

Function GAMMA computes the transcendental function GAMMA.

Calling Sequence:	gamma (xx)	
Data Declaration:	Real	xx
Arguments:	xx	X-coordinate of the point.

5.3.18.11 Function GAMMLN

Calling Sequence:	gammln (xx)	
Data Declaration:	Real	xx
Arguments:	xx	X-coordinate of the point.

5.3.18.12 Subroutine HSOBND

Subroutine HSOBND compares computed significant wave height with the value of the significant wave height as described by the user. If the values differ more than, say, ten percent, an error message and the grid points where the error has been located are given.

Calling Sequence:	hsobnd (ac2, spcsig, hsibc, kgrpnt)	
Data Declaration:	Real	ac2, spcsig, hsibc
	Integer	kgrpnt

Arguments:	ac2	Action density.
	spcsig	Relative frequencies in computational domain in sigma space.
	hsibc	Significant wave height given as input on the boundary.
	kgrpnt	Values of grid indices.

5.3.18.13 Logical Function INFRAM

Subroutine INFRAM checks whether a point given in frame coordinates is located in the plotting frame (INFRAM = True) or not (INFRAM = False).

Calling Sequence: infram (xqq, yqq)

Data Declaration:	Real	xqq, yqq

Arguments:	xqq	X-coordinate (output grid) of the point.
	yqq	Y-coordinate (output grid) of the point.

5.3.18.14 Logical Function INMESH

Function INMESH finds whether or not a given location is in the (curvilinear) computational grid.

Calling Sequence: inmesh (xp, yp, xcgrid, ycgrid, kgrbnd)

Data Declaration:	Real	xp, yp, xcgrid, ycgrid
	Integer	kgrbnd

Arguments:	xp, yp	A point given in problem coordinates.
	xcgrid	Array (*ix, iy*) x-coordinate of a grid point.
	ycgrid	Array (*ix, iy*) y-coordinate of a grid point.
	kgrbnd	Array containing boundary grid points.

5.3.18.15 Subroutine KSCIP1

Subroutine KSCIP1 interpolates the wave number, group velocity and *n* from a table, and calculation of the derivative of *n* with respect to depth (= *nd*).

Calling Sequence: kscip1 (mmt, sig, d, k, cg, n, nd)

Data Declaration:	Integer	mmt
	Real	sig, d, k, cg, n, nd

Arguments:	mmt	Number of frequency-wise points in arrays.
	sig	Relative frequency for which wave parameters must be determined.
	d	Local depth.
	k	Wave number.
	cg	Group velocity.
	n	Ratio of group and phase velocity.
	nd	Derivative of *n* with respect to *d* computation must be done.

5.3.18.16 Subroutine NEWTON

Subroutine NEWTON solves equations and finds a point *(xc, yc)* in a curvilinear grid (computational grid) for a given point *(xp, yp)* in a Cartesian grid (problem coordinates).

Calling Sequence: newton (xp, yp, xcgrid, ycgrid, kgrpnt, mxitnr, xc, yc, find, kgrbnd)

Data Declaration:	Real	xp, yp, xcgrid, ycgrid, xc, yc
	Integer	kgrbnd
	Logical	find

Arguments:	xp	X-coordinate in problem coordinates.
	yp	Y-coordinate in problem coordinates.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	kgrpnt	Grid addresses.
	mxitnr	Maximum number of iterations.
	xc	X-coordinate in computational coordinates.
	yc	Y-coordinate in computational coordinates.
	find	Determines whether or not *xc* and *yc* are found.
	kgrbnd	Grid addresses of the boundary points.

5.3.18.17 Subroutine NEWT1D

Subroutine NEWT1D solves equations and finds a point *(xc, yc)* in a curvilinear 1-D grid (computational grid) for a given point *(xp, yp)* in a Cartesian grid (problem coordinates).

Calling Sequence: newt1d (xp, yp, xcgrid, ycgrid, kgrpnt, mxitnr, xc, yc, find)

Data Declaration:	Real	xp, yp, scgrid, ycgrid, xc, yc
	Integer	kgrpnt, mxitnr
	Logical	find

Arguments:	xp	X-coordinate in problem coordinates.
	yp	Y-coordinate in problem coordinates.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	kgrpnt	Grid addresses.
	mxitnr	Maximum number of iterations.
	xc	X-coordinate in computational coordinates.
	yc	Y-coordinate in computational coordinates.
	find	Whether or not *xc* and *yc* are found.

5.3.18.18 Subroutine OBSTLINE

Subroutine OBSTLINE finds out whether or not vector (*x1, y1*) lies above the line piece through (*x3, y3*) and (*x4, y4*).

Calling Sequence: obstline (x1, y1, x2, y2, x3, y3, x4, y4, xgtl, exc)

Data Declaration:	Real	x1, y1, x2, y2, x3, y3, x4, y4
	Logical	xgtl, exc

Arguments:	x1, y1	User coordinates of one end of the grid link.
	x2, y2	User coordinates of the other end of the grid link.
	x3, y3	User coordinates of one end of the obstacle side.
	x4, y4	User coordinates of the other end of the obstacle side.
	xgtl	Indicates whether (*x1, y1*) is situated above line piece (*x3, y3*) (*x4, y4*).
	exc	Indicates whether *x4* = *x3*, which results in exceptional situation (line parallel to y-axis).

5.3.18.19 Recursive Subroutine OBSTMOVE

Subroutine OBSTMOVE moves obstacle points (*x3, y3*) and (*x4, y4*) a bit if computational grid cell (*x1, y1*) is on the obstacle line piece.

Calling Sequence: obstmove (obsta, xcgrid, ycgrid, kgrpnt)

Data Declaration:	Real	xcgrid, ycgrid

	Integer	obsta, kgrpnt
Arguments:	obsta	Array of obstacle parameters.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	kgrpnt	Indirect addressing for computational grid points.

5.3.18.20 Subroutine PCOAST

Subroutine PCOAST plots lines defined by the command LINE.

Calling Sequence: pcoast (clines, cliner)

Data Declaration:	Real	cliner
	Integer	clines
Arguments:	clines	Line parameter.
	cliner	Real equivalence to *clines*.

5.3.18.21 Subroutine PLNAME

Subroutine PLNAME writes the name of a place or region in a plot.

Calling Sequence: plname (pname, nsym, xpp, ypp, isit, symsz)

Data Declaration:	Character	pname
	Real	xpp, ypp, symsz
	Integer	nsym, isit
Arguments:	pname	Name of town or region to be plotted.
	nsym	Number of characters of the name.
	xpp	X-coordinate of the reference point in the problem grid.
	ypp	Y-coordinate of the reference point in the problem grid.
	isit	Type of name (0 or 1: the name is plotted right of the reference point with (1) or without (0) a mark at the point, 2: the reference point is at the middle of the name (region)).
	symsz	Size of the characters in the plot (cm).

5.3.18.22 Subroutine PLOSIT

Subroutine PLOSIT draws a plot with the location of the output point sets.

Calling Sequence: plosit (outps, outpr, psname)

Data Declaration:

Character	psname
Real	outpr
Integer	outps

Arguments:

outps	Array containing data on output point sets.
outpr	Real equivalence of *outps*.
psname	Name of one output point set to be plotted if blank, all point sets will be plotted.

5.3.18.23 Subroutine PLOTU

Subroutine PLOTU moves the pen to a point given in problem coordinates with pen up (moving the pen) or with pen down (drawing a line segment).

Calling Sequence: plotu (xx, yy, updown)

Data Declaration:

Real	xx, yy
Character	updown

Arguments:

xx	X-coordinate of the point.
yy	Y-coordinate of the point.
updown	Indicating whether the pen must be up or down when moving to the point.

5.3.18.24 Subroutine PNAMES

Subroutine PNAMES plots the names of places and regions defined with the command PLACE.

Calling Sequence: pnames (places, placer)

Data Declaration:

Integer	places
Real	placer

Arguments:

places	Array containing places and their locations.
placer	Real equivalence of *places*.

5.3.18.25 Subroutine READXY

Subroutine READXY reads x and y and initializes offset values xoffs and yoffs.

Calling Sequence: readxy (namx, namy, xx, yy, kont, xsta, ysta)

Data Declaration:

	Real	xx, yy, xsta, ysta
	Character	namx, namy, kont

Arguments:

	namx, namy	Names of the two coordinates given in the user manual.
	xx, yy	Values of x and y, taking into account offset.
	kont	If values are missing see documentation of INDBLE (Ocean Pack documentation).
	xsta, ysta	Standard values of x and y.

5.3.18.26 Subroutine REFIXY

Subroutine REFIXY initializes offset values xoffs and yoffs, and shifts *xx* and *yy*.

Calling Sequence: refixy (nds, xx, yy, ierr)

Data Declaration:

	Real	xx, yy
	Integer	nds, ierr

Arguments:

	nds	File reference number.
	xx, yy	Values of x and y taking into account offset.

	ierr	Error indicator: When *ierr*:
		= 0 No error;
		= -1 End-of-file;
		= -2 Read error.

5.3.18.27 Subroutine REFLECT

Subroutine REFLECT computes reflections near obstacles.

Calling Sequence: reflect (ac2, ac2ref, imatra, x1, y1, x2, y2, x3, y3, x4, y4, xgtl, exc, cax, cay, rdx, rdy, loop, trcoef, ref0, anybin)

Data Declaration:

	Integer	loop
	Real	ac2, imatra, x1, y1, x2, y2, x3, y3, x4, y4, cax, cay, rdx, rdy, ac2ref, trcoef, ref0
	Logical	anybin, xgtl, exc

Arguments:	ac2	(Non-stationary case) action density as function of D, S, X, Y at time T + DT.
	ac2ref	(Non-stationary case) reflected action density as function of D, S, X, Y at time T + DT.
	imatra	Right-hand side of matrix equation.
	x1, y1	Coordinates of computational grid point under consideration.
	x2, y2	Coordinates of computational grid point neighbor.
	x3, y3	User coordinates of one end of obstacle side.
	x4, y4	User coordinates of the other end of the obstacle side.
	xgtl	Indicates whether *(x1, y1)* is situated above line piece *(x3, y3) (x4, y4)*.
	exc	Indicates whether *x4 = x3*, which results in an exception situation (line parallel to y-axis).
	cax, cay	Propagation velocity.
	rdx, rdy	Array containing spatial derivative coefficients.
	loop	Indicates which link is analyzed: 1 $\rightarrow$ neighbor in x; 2 $\rightarrow$ neighbor in y.
	trcoef	User defined transmission coefficient.
	ref0	User defined reflection coefficient (0 <= *ref0* <= 1).
	anybin	Set a particular bin True or False depending on *sector*.

5.3.18.28 Subroutine SETUPP

Subroutine SETUPP computes the forces/(*rho*grav*) responsible for the *setup* and adds the *setup* to the depth.

Calling Sequence: setupp (kgrpnt, mstpda, setpda, ac2, dep2, depsav, setup2, wforcx, wforcy, xcgrid, ycgrid, spcsig, spcdir, itsw, iter, upperi, loperi)

Data Declaration:	Real	setpda, ac2, dep2, depsav, setup2, wforcx, wforcy, xcgrid, ycgrid, spcsig, spcdir, upperi, loperi
	Integer	kgrpnt, mstpda, itsw, iter

Arguments:	kgrpnt	Indirect addresses for grid points.
	mstpda	Number of (aux.) data per grid point value is set at 10 in swancom1.ftn.
	setpda	Data for computation of Setup: = 1 Depth;

	= 2 Previous estimate of Setup;
	= 3 X-comp of force;
	= 4 Y-comp of force;
	= 5 Rad. stress computation RSxx;
	= 6 RSxy;
	= 7 RSyy.
	setpda(*, *, 5 *mstpda*) is used as a work array.

ac2	Action density as a function of D, S, X, Y at time T + DT.
dep2	Total depth, including Setup on entry: includes previous estimate of Setup on exit: includes new estimate of Setup.
depsav	Depth following from bottom and water levels.
setup2	Setup in grid points, using indirect addresses.
wforcx	Force x-component.
wforcy	Force y-component.
xcgrid	X-coordinate of computational grid in x-direction.
ycgrid	Y-coordinate of computational grid in y-direction.
spcsig	Relative frequencies in computational domain in sigma space.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
itsw	Time step counter for SWAN.
iter	Iteration counter.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.

5.3.18.29 Subroutine SETUP2D

Subroutine SETUP2D computes the *setup*, change of the water level by waves. A Poisson equation is solved in general coordinates.

Calling Sequence: setup2d (xcgrid, ycgrid, wfrcx, wfrcy, depth, setup, upperi, loperi, nwkarr, wkarr, itsw, iter)

Data Declaration:	Integer	itsw, ier, nwkarr
	Real	xcgrid, ycgrid, wfrcx, wfrcy, depth, setup, upperi, loperi, nwkarr, wkarr, itsw, iter

Arguments:	xcgrid	X-coordinates.

ycgrid	Y-coordinates.
wfrcx	Force x-component.
wfrcy	Force y-component.
depth	Depth.
setup	Unknown setup; to be computed indirect addressed.
upperi	Only relevant for computation in periodic domain.
loperi	Only relevant for computation in periodic domain.
nwkarr	Dimension for work array.
wkarr	Work array.
itsw	Time step counter for SWAN.
iter	Iteration number.

5.3.18.30 Subroutine SINTRP

Subroutine SINTRP interpolates spectra.

Calling Sequence: sintrp (w1, w2, fl1, fl2, fl, spcdir, spcsig)

Data Declaration: Real w1, w2, fl1, fl2, fl, spcdir, spcsig

Arguments:

w1	Weighting coefficient for spectrum one.
w2	Weighting coefficient for spectrum two.
fl1	Input spectrum one.
fl2	Input spectrum two.
fl	Interpolated spectrum.
spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
spcsig	Relative frequencies in computational domain in sigma space.

5.3.18.31 Subroutine SSHAPE

Subroutine SSHAPE calculates energy density at boundary point (x, y, sigma, theta).

Calling Sequence: sshape (acloc, spcsig, spcdir, fshapl, dshapl)

Data Declaration:

Real	acloc, spcsig, spcdir
Integer	fshapl, dshapl

Arguments:	acloc	Energy density at a point in space.
	spcsig	Relative frequencies in computational domain in sigma space.
	spcdir	(*,1) Spectral directions (radians); (*,2) Cosine of spectral directions; (*,3) Sine of spectral directions; (*,4) Cosine^2 of spectral directions; (*,5) Cosine*sine of spectral directions; (*,6) Sine^2 of spectral directions.
	fshapl	Shape of spectrum: = 1 Pierson-Moskowitz spectrum; = 2 JONSWAP spectrum; = 3 bin; = 4 Gauss curve; If > 0 Period is interpreted as peak per; If < 0 Period is interpreted as mean per.
	dshapl	Directional distribution.

Common Blocks: PSHAPE
SPPARM

5.3.18.32 Subroutine SWOBST

Subroutine SWOBST reads from the *pool* array all the data required to find obstacles and uses subroutine TCROSS2 to find them.

Calling Sequence: swobst (obsta, xcgrid, ycgrid, kgrpnt, cross)

Data Declaration:	Real	xcgrid, ycgrid
	Integer	kgrpnt, obsta, cross

Arguments:	obsta	Array of obstacle parameters.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	kgrpnt	Indirect addressing for computational grid points.
	cross	Array that contains 0's if there is no obstacle crossing. If an obstacle is crossing between the central point and its neighbor, *cross* is equal to the number of the obstacles.

5.3.18.33 Subroutine SWTRCF

Subroutine SWTRCF takes the value of transmission coefficient from the pool given by the user for obstacle transmission or computes the transmission coefficient for obstacle DAM, based on Goda (1967) [from Seelig (1979)]. If reflections are turned on, the source term in subroutine REFLECT is calculated.

Calling Sequence: swtrcf (obsta, cross, wlev2, chs, link, obredf, ac2, imatra, kgrpnt, xcgrid, ycgrid, cax, cay, rdx, rdy, anybin)

Data Declaration:	Integer	cross, obsta, kgrpnt, link
	Real	chs, obredf, wlev2, ac2, xcgrid, ycgrid, cax, cay, imatra, rdx, rdy
	Logical	anybin

Arguments:	obsta	Array containing obstacle data.
	cross	Array that contains 0's if there is no obstacle crossing. If an obstacle is crossing between the central point and its neighbor; *cross* is equal to the number of the obstacle.
	wlev2	Water level in grid points.
	chs	Hs in all computational grid points.
	link	Indicates whether link in stencil crosses an obstacle.
	obredf	Array of action density reduction coefficients (reduction at the obstacle).
	ac2	Action density array.
	imatra	Coefficients of right-hand side of matrix equation.
	kgrpnt	Array of indirect addressing.
	xcgrid	X-coordinate of computational grid in x-direction.
	ycgrid	Y-coordinate of computational grid in y-direction.
	cax, cay	Propagation velocities.
	rdx, rdy	Array containing spatial derivative coefficients.
	anybin	Set a particular bin True or False depending on *sector*.

5.3.18.34 Logical Function TCROSS

Function TCROSS finds out if there is an obstacle crossing the stencil being used.

Calling Sequence: tcross (x1, x2, x3, x4, y1, y2, y3, y4)

Data Declaration: Real x1, x2, x3, x4, y1, y2, y3, y4

Arguments:	x1, y1	User coordinates of one end of grid link.
	x2, y2	User coordinates of the other end of grid link.
	x3, y3	User coordinates of one end of the obstacle side.
	x4, y4	User coordinates of the other end of the obstacle side.

5.3.18.35 Logical Function TCROSS2

Function TCROSS2 finds out if there is an obstacle crossing the stencil being used.

Calling Sequence: tcross2 (x1, x2, x3, x4, y1, y2, y3, y4, x1onobst)

Data Declaration:	Real	x1, x2, x3, x4, y1, y2, y3, y4
	Logical	x1onobst

Arguments:	x1, y1	User coordinates of one end of the grid link.
	x2, y2	User coordinates of the other end of the grid link.
	x3, y3	User coordinates of one end of the obstacle side.
	x4, y4	User coordinates of the other end of the obstacle side.
	x1onobst	Boolean which tells whether *(x1, y1)* is on obstacle.

5.3.18.36 Subroutine WRSPEC

Subroutine WRSPEC writes the action density spectrum in SWAN standard format.

Calling Sequence: wrspec (nref, acloc)

Data Declaration:	Real	acloc
	Integer	nref

Arguments:	nref	Unit reference number or output file.
	acloc	2-D spectrum or source term at one output location.

5.3.19 Module Containing Global Variables (swmodl FOR File)

This file is used to create global variables used in whitecapping and integral parameter subroutines. It contains no subroutines.

7.0 NOTES

7.1 ACRONYMS AND OTHER ABBREVIATIONS

ASCE	American Society of Civil Engineering
ASCII	American Standard Code for Information Interchange
BI-CGSTAB	Method to solve an asymmetric system of linear equations
BLAS	Basic Linear Algebra Subprograms
BSBT	Backward Space, Backward Time
CFL criterion	Courant-Friedrich-Levy condition for computational stability
DIA	Discrete Interaction Approximation
DTA	Discrete Triad Approximation
DUT frame	Delft University of Technology
EOF	End of File
GSE	Garden-Sprinkler Effect
HISWA	HIndcast Shallow Water wave model
ID	Identification
IUTAM	International Union of Theoretical and Applied Mechanics
JONSWAP	JOint North Sea WAve Project
LTA	Lumped Triad Approximation
Mb	Megabytes
OPPL	Ocean Pack PLot code
QB	Fraction of breaking waves
S&L	Stelling and Leendertse's second order with third-order diffusion scheme
SIAM	Society for Industrial and Applied Mathematics
SORDUP	Second ORDer Upwind scheme
SWAN	Simulating WAves Nearshore
WAM	WAve Model
WAMDI	WAM Development and Implementation group

TABLE OF COMMON BLOCKS

8.0 APPENDIX I.

8.1 (OCPIDS FOR FILE)

8.1.1 COMMON/ FILENM
Filename of plot file.

8.1.2 COMMON/ XASL
Size on paper of geographic area in x-direction.

8.1.3 COMMON/ YASL
Size on paper of geographic area in y-direction.

8.1.4 COMMON/ SYMSIZ
Size of symbols on plot.

8.1.5 COMMON/ XPLO
Lowest x on paper of geographic area.

8.1.6 COMMON/ XPHI
Highest x on paper of geographic area.

8.1.7 COMMON/ YPLO
Lowest y on paper of geographic area.

8.1.8 COMMON/ YPHI
Highest y on paper of geographic area.

8.1.9 COMMON/ SUBLNS
Number of lines in caption for scales etc.

8.1.10 COMMON/ XPSUB
Position of one line of caption.

8.1.11 COMMON/ YPSUB
Y position of one line of caption.

8.1.12 COMMON/ PLPARM(3)
Conversion factor; default 402.

8.1.13 COMMON/ PLPARM(4)
Plotting margin horizontal.

8.1.14 COMMON/ PLPARM(5)
Plotting margin vertical.

8.1.15 COMMON/ PLPARM(6)
Rotation.

8.2 (OCPLOT FOR FILE)

8.2.1 COMMON/ PMR
Plot margin.

8.2.2 COMMON/ MXQ
Number of grid points in x-direction.

8.2.3 COMMON/ MYQ
Number of grid points in y-direction.

8.2.4 COMMON/ DXQ
Mesh size in x-direction.

8.2.5 COMMON/ DYQ
Mesh size in y-direction.

8.3 (OCPMIX FOR FILE)

8.3.1 COMMON/ REFDAY
Day number of the reference day; the reference time is 0:00 of the reference day; the first day entered is used as reference day.

8.4 (SWANMAIN FOR FILE)

8.4.1 COMMON/ NAMES
Names and other character strings.

Variable	**Type**	**Description**
INST	Character	Name of the institute. It can be changed in the file SWANINIT.
PROJID	Character	Acronym of the project for which the computation is taking place.
PROJNR	Character	= BLANK; run number for the computation; = NR; set by command PROJ ... NR ...

PROJT1	Character	= BLANK; first line of the project title; = title1; set by command PROJ ... title1.
PROJT2	Character	= BLANK; second line of the project title; = title2; set by command PROJ ... title2.
PROJT3	Character	= BLANK; third line of the project title; = title3; set by command PROJ ... title3.
PTITLE	Character	Not used.
FILENM	Character	Filename of the file currently used for I/O.
FILEA	Character	Not used.
FILEB	Character	Not used.
DIRCH1	Character	Directory separation character as appears in input file.
DIRCH2	Character	Directory separation character replacing DIRCH1.
VERTXT	Character	Program version, character representation.
C4(LNAMS)	Character	Contains all the items in /NAMES/. C4 is used in a .for file; each item is listed individually in a .inc file.

8.4.2 COMMON/ TESTDA

Test parameter.

Variable	Type	Description
ITEST	Integer	Indicates the amount of test output requested.
ITRACE	Integer	Message is printed up to ITRACE times.
LTRACE	Logical	Indicates whether to call STRACE.
LEVERR	Integer	Severity of the errors encountered.

MAXERR	Integer	Maximum severity of errors allowed, if larger no computation:
		= 1 Warnings;
		= 2 Errors;
		= 3 Severe errors;
		= 4 Terminating errors;
		= MAXERR Set by command SET ... [MAXERR].

OTSTD(NTSTD)	Real	(Not used); Contains all of the items in /TESTDA/. OTSTD is used in a .for file; each item is listed individually in a .inc file.

8.4.3 COMMON/ OUTPDA

Data for output, mainly plotting.

Variable	Type	Description
LEFT	Logical	The coordinate system is left/right-oriented i.e. counterclockwise from X to Y/clockwise from Y to X.
PFROPT	Integer	Frame option in plot, read from SWANINIT.
VERNUM	Real	Version number of SWAN.

XASM	Real	Maximum size of area available for plotting isolines and vector fields in x-direction.
YASM	Real	Maximum size of area available for plotting isolines and vector fields in y-direction.
MXQ	Integer	Number of grid points of the output frame in X-direction.
MYQ	Integer	Number of grid points of the output frame in Y-direction.
DXQ	Real	Mesh size of the output frame in X-direction.
DYQ	Real	Mesh size of the output frame in Y-direction.
XASL	Real	Size on paper of geographic area in x-direction.
YASL	Real	Size on paper of geographic area in y-direction.
SYMSIZ	Real	Size of the symbols in the plot.
LSC	Real	Not used.
VSC	Real	Not used.
PENUP	Logical	Not used.
XPLO	Real	Lowest x on paper of geographic area.
XPHI	Real	Highest x on paper of geographic area.
YPLO	Real	Lowest y on paper of geographic area.
YPHI	Real	Highest y on paper of geographic area.
HORSC	Real	Horizontal scale.
VRTSC	Real	Vertical scale.
XFLO	Real	Lower limit of X in the physical plane.
XFHI	Real	Upper limit of X in the physical plane.
YFLO	Real	Lower limit of Y in the physical plane.
YFHI	Real	Upper limit of Y in the physical plane.
SUBLNS	Integer	Number of lines available in the plot legend = 3 If FROPT = 1 = 4 If FROPT = 2
XPSUB	Real	Place (X-coordinate) of the legends in the frame.
YPSUB	Real	Place (Y-coordinate) of the legends in the frame.
ODA(MCODA)	Real	(Not used); Contains all the items in /OUTPDA/. ODA is used in a .for file; each item is listed individually in a .inc file.

8.4.4 COMMON/ REFNRS

File unit reference numbers.

Variable	**Type**	**Description**
PRINTF	Integer	Unit number for the file with standard output (PRINT).
INPUTF	Integer	Unit number for the file with command input (INPUT).
IUNMIN	Integer	Minimum unit number.
IUNMAX	Integer	Maximum unit number.
FUNLO	Integer	Lowest free unit number.

FUNHI	Integer	Highest free unit number.
SCREEN	Integer	Unit number for the screen.
PRTEST	Integer	Unit number for the print file containing test output.
IMPORT	Integer	Not used.
EXPORT	Integer	Not used.
HIOPEN	Integer	Highest unit number of an open file.
ITMOPT	Integer	Time coding option.
IRFNS(NRFNS)	Integer	(Not used); Contains all of the items in /REFNRS/. IRFNS is used in a .for file; each item is listed individually in a .inc file.

8.4.5 COMMON/ LEESDA

Character data used by the command reading system.

Variable	**Type**	**Description**
ELTYPE	Character	Type of the element last read by reading system.
ELTEXT	Character	Contents of the last string read by reading system.
KAART	Character	Contents of the input line last read by the reading system.
KAR	Character	Character last read by the reading system.
KEYWRD	Character	Contents of the last keyword read by reading system.
BLANK	Character	Blank string.
TABC	Character	Tabular character.
COMID	Character	Character that distinguishes comments in the command input.
LSDA(NLSDA)	Character	Contains all of the items in /LEESDA/. LSDA is used in a .for file; each item is listed individually in a .inc file.

8.4.6 COMMON/ LEESDN

Number data used by the command reading system.

Variable	**Type**	**Description**
ELREAL	Double Precision	Last element read from user command, when real or double.
ELLINT	Integer	Last element read from user command, when integer.
KARNR	Integer	Position on the input line of character last processed by the reading system: = 0 No characters read yet; = 81 Next input line has to be read to the common KAART first.
CHGVAL	Logical	Whether or not the last read value is different from a given value for subroutines INREAL, ININTG, INCSTR and INCTIM.
LENCST	Integer	Length of the string stored in ELTEXT.

ILSDN(NLSDN)	Integer	(Not used); Contains all of the items in /LEESDN/. ILSDN is used in a .for file; each item is listed individually in a .inc file.

8.4.7 COMMON/ SWNAME

Names and other character data.

Variable	Type	Description
FNEST SNAME	Character Character	Name of nest file. Name of output point set.
OVKEYW	Character	Keyword identifying output quantity in a SWAN command.
OVSNAM	Character	Short name of output quantity.
OVLNAM	Character	Long name of output quantity.
OVUNIT	Character	Unit of output quantity.
UH	Character	Unit of vertical length (m).
UV	Character	Unit of velocity (m/s).
UT	Character	Unit of time (sec).
UL	Character	Unit of horizontal length (m).
UET	Character	Unit of energy transport, and wave force (m^3/s).
UDI	Character	Unit of direction (degrees).
UST	Character	Not used.
UF	Character	Unit of pressure or shear stress (force per area) (N/m^2).
UP	Character	Unit of energy flux density (W/m).
UAP	Character	Unit of dissipation (W/m^2).
UDL	Character	Unit of dissipation (m^2/s).
UD	Character	Not used.
FBCL	Character	Not used.
FBCR	Character	Not used.
CHTIME	Character	Character string representation of date-time of computation.
TIT(LHNAMS)	Character	Contains all of the items in /SWNAME/. TIT is used in a .for file; each item is listed individually in a .inc file.

8.4.8 COMMON/ SWGRID

Location and dimensions of input grids.

Variable	Type	Description
XPG	Real	X of origin.
YPG	Real	Y of origin.
ALPG	Real	Direction of the x-axis with respect to the user coordinates.
COSPG	Real	Cosine of ALPG.

SINPG	Real	Sine of ALPG.
DXG	Real	Mesh size of input grid in x-direction.
DYG	Real	Mesh size of input grid in y-direction.
MXG	Integer	Number of meshes in x-direction.
MYG	Integer	Number of meshes in y-direction.
LEDS	Integer	= 0 When values have not been read; = 1 If values were read.
IGTYPE	Integer	= 0 When grid has constant values; = 1 When grid is regular; = 2 When grid is curvilinear.
VARFR	Logical	Friction coefficient is or is not variable over space.
VARWI	Logical	Wind velocity is or is not variable over space.
COSVC	Real	Cosine of the angle of current input grid with respect to the computational grid.
SINVC	Real	Sine of the angle of current input grid with respect to the computational grid.
COSWC	Real	Cosine of the angle of wind input grid with respect to the computational grid.
SINWC	Real	Sine of the angle of wind input grid with respect to the computational grid.
XOFFS	Real	Offset value in x.
YOFFS	Real	Offset value in y.
LXOFFS	Logical	Offset values were or were not initialized already.
VARWLV	Logical	Water level is or is not variable over space.
DYNDEP	Logical	True if depth varies with time.
NESRUN	Integer	Indicator for a nested run.
NWAMN	Integer	Indicator for a WAM-nested run.
OPTG	Integer	Type of the computational grid: = 1 When regular; = 2 When irregular, but rectangular (not used); = 3 When curvilinear.
STAGX	Real	Staggering of the curvilinear input grid with respect to the computational grid in X.
STAGY	Real	Staggering of the curvilinear input grid with respect to the computational grid in Y.
CVLEFT	Logical	The curvilinear computational grid is left/right-oriented.
RDTIM	Real	= 0 When in stationary mode; = 1/DT When in non-stationary mode.
ICOND	Integer	Initial conditions: = 0 When mode stationary, or no initial conditions needed; = 1 When mode non-stationary and initial conditions should be calculated.
EXCFLD	Real	Exception values for input grids.

NBFILS	Integer	Number of boundary condition files.
NBSPEC	Integer	Number of boundary spectra.
NBGRPT	Integer	Number of computational grid points for which boundary.
VARAST	Logical	Air-sea temperature difference is or is not variable over space.
BOTG(MCINGR)	Real	(Not used); Contains all of the items in /SWGRID/. BOTG is used in a .for file; each item is listed individually in a .inc file.

8.4.9 COMMON/ SWCOMG

Location and dimensions of computational grid.

Variable	Type	Description
ICOMP	Integer	Unused.
XPC	Real	X coordinate of the origin of the computational grid.
YPC	Real	Y coordinate of the origin of the computational grid.
ALPC	Real	Direction of x-axis of computational grid with respect to the user coordinates.
COSPC	Real	Cosine of ALPC.
SINPC	Real	Sine of ALPC.
XCLEN	Real	Length of computational grid in x-direction.
YCLEN	Real	Length of computational grid in y-direction.
MTC	Integer	Computational timesteps.
MXC	Integer	Grid points in x-direction of computational grid.
MYC	Integer	Grid points in y-direction of computational grid.
MDC	Integer	Grid points in the theta-direction of the computational grid.
MSC	Integer	Points in the sigma-direction of the computational grid.
SLOW	Real	Lowest spectral value of sigma.
SHIG	Real	Highest spectral value of sigma.
DX	Real	Mesh size in x-direction of computational grid.
DY	Real	Mesh size in y-direction of computational grid.
DDIR	Real	Mesh size in theta-direction of computational grid.
NX	Integer	Only used locally. Equal to MXS.
NY	Integer	Only used locally. Equal to MYS.
XCP	Real	Origin of the user coordinates with respect to the computational coordinates.
YCP	Real	Origin of user coordinates with respect to the computational coordinates.
ALCP	Real	Direction of user coordinates with respect to the computational coordinates.
DXRP	Real	Not used.

DYRP	Real	Not used.
MSC4MI	Integer	Some counter for quadruplet interactions. Stored in WWINT(15).
MSC4MA	Integer	Some counter for quadruplet interactions. Stored in WWINT(16).
MDC4MI	Integer	Some counter for quadruplet interactions. Stored in WWINT(17).
MDC4MA	Integer	Some counter for quadruplet interactions. Stored in WWINT(18).
FRINTF	Real	Frequency integration factor (df/f).
FRINTH	Real	Frequency mesh boundary factor.
MMCGR	Integer	Grid points in computational grid.
FULCIR	Logical	Spectral directions cover full or part of circle.
SPDIR1	Real	Represents the first spectral direction.
JSPDIR	Integer	Array *spcdir* within *pool* array.
JSIGMA	Integer	Array *spcsig* within *pool* array.
MCGRD	Integer	Number of wet grid points of the computational grid.
SPDIR2	Real	Represents the second spectral direction.
IXCGRD	Integer	IX of the points of the computational stencil.
IYCGRD	Integer	IY of the points of the computational stencil.
KCGRD	Integer	Grid address of the points of the computational stencil.
XCGMIN	Real	Minimum x-coordinate of computational grid points.
XCGMAX	Real	Maximum x-coordinate of computational grid points.
YCGMIN	Real	Minimum y-coordinate of the computational grid points.
YCGMAX	Real	Maximum y-coordinate of the computational grid points.
NGRBND	Integer	Number of grid points on the computational grid boundary.
COMG (MCCOM)	Real	(Not used); Contains all of the items in /SWCOMG/. COM is used in a .for file; each item is listed individually in a .inc file.

8.4.10 COMMON/ SWNUMS

Information related to the numerical scheme.

Variable	**Type**	**Description**
NCOR	Integer	Not used.
IWCAP	Integer	Indicates whitecapping: = 0 For command GEN1...; = 0 For command GEN2...; = 0 For command OFF WCAP..., no whitecapping; = 1 For command GEN3 KOM...; = 1 For command WCAP KOM ..., not documented in manual, standard WAM formulation (Komen et al., 1984);

		= 2 For command GEN3 JANS...; = 2 For command WCAP JANS ..., not documented in manual, according to Janssen (1989, 1991); = 3 For command WCAP LHIG ..., not documented in manual, according to Longuet-Higgins (1969), Yuan et al. (1986); = 4 For command WCAP BJ ..., not documented in manual, according to Battjes and Janssen (1978); = 5 For command WCAP KBJ ..., not documented in manual, combined formulation of Komen et al. (1984) and Battjes and Janssen (1978).
IPRE	Integer	Not used.
ICOR	Integer	Not used.
IBOT	Integer	Indicator bottom friction: = 0 No bottom friction dissipation; = 1 Set by command FRIC JON ..., JONSWAP bottom friction model; = 2 For command FRIC COLL ..., Collins bottom friction model; = 3 For command FRIC MAD ..., Madsen bottom friction model.
ICUR	Integer	Indicates presence of currents: = 0 No currents; = 1 For command READ CUR ..., currents are present.
IDBR	Integer	Not used.
IDIF	Integer	Not used.
IINC	Integer	Not used.
ITRIAD	Integer	Indicates triad interaction term: = 0 Triads are inactive; = 1 For command TRI DTA IMP ..., not documented in manual; = 2 For command TRI DTA EXP ..., not documented in manual; = 3 For command TRI [trfac] [cutfr], as in manual; = 3 For command TRI LTA IMP ..., not documented in manual; = 4 For command TRI LTA EXP ..., not documented in manual.
IREFR	Integer	Indicates refraction effect: = 0 For command OFF REF, refraction is inactive; = 1 Refraction is active.
ISURF	Integer	Indicates surf breaking (shallow water) term: = 0 For command OFF BRE, surf breaking is inactive; = 1 For command BRE CON ..., surf breaking with constant parameter;

		= 2 For command BRE VAR ..., surf breaking.
ITRSY	Integer	Not used.
IWIND	Integer	Indicates presence of wind and type of source term used: = 0 No wind; = 1 For command GEN1 ..., if wind is made active; = 1 For command GROWTH G1 ..., not documented in manual, first generation source term; = 2 For command GEN2 ..., if wind is made active; = 2 For command GROWTH G2 ..., not documented in manual, second generation source term (as in Dolphin); = 3 For command WIND ..., if IWIND still was 0, else unchanged; = 3 For command GEN3 KOM ..., if wind is made active; = 3 For command GROWTH G3 KOM ..., not documented in manual, third generation source term (Snyder); = 4 For command GEN3 JANS ..., if wind is made active; = 4 For command GROWTH G3 JANS ..., not documented in manual, source term by P. Janssen (1989, 1991); = 5 For command GEN3 YAN ..., if wind is made active; = 5 For command GROWTH G3 YAN.

IQUAD	Integer	Indicates the quadruplet interaction term:
		= 0 For command OFF QUAD;
		= 0 For command GEN1;
		= 0 For command GEN2;
		= 0 For command GROWTH G1;
		= 0 For command GROWTH G2, quadruplets are inactive;
		= 1 Quadruplets are calculated semi-implicit per sweep direction;
		= 2 For command GEN3;
		= 2 For command QUAD;
		= 2 Set when *iwind* = 3 or 4 and *icur* = 0 in subroutine ERRCHK, quadruplets are calculated fully explicit per sweep direction;
		= 3 Set when *iwind* = 3 or 4 and *icur* = 1 in subroutine ERRCHK, quadruplets are calculated fully explicit per iteration;
		= iquad Set by command GEN3 ... QUAD [iquad].

ICMAX	Integer	Number of points in computational stencil.

ITERMX	Integer	Maximum number of iterations: Set equal to MXITST for stationary computations. Set equal to MXITNS for non-stationary computations.
NSTATC	Integer	Indicates stationary of computation: = 0 Stationary computation; = 1 Non-stationary computation.

NSTATM	Integer	= 0 Stationary mode;
		= 1 Non-stationary mode;
		= -1 Unknown.

U10	Real	Wind velocity.
WDIP	Real	Wind direction with respect to problem coordinates.
WDIC	Real	PI2*((WDIP/PI2-NINT(WDIP/PI2))
DEPMIN	Real	Threshold depth (to prevent zero divisions).
PWCAP	Real	Whitecapping coefficients.
PBOT	Real	Coefficients for the bottom friction models.
PTRIAD	Real	Controls the proportionality coefficient.
PNUMS	Real	Numerical coefficients.
PSURF	Real	Surf breaking coefficients.
PWIND	Real	Wind growth term coefficients.
SY0	Real	Peak enhancement parameter of the JONSWAP spectrum.
SIGMAG	Real	Width of the Gaussian frequency spectrum in Hz.
ITFRE	Integer	Indicator for transport of action in frequency space: = 0 For command OFF FSH, frequency shifting inactive; = 1 Frequency shifting active.
NUMOBS	Integer	Number of obstacles.
LSETUP	Integer	= 0 Setup is not calculated; = 1 Setup is calculated; = 2 Setup is calculated with the boundary conditions from a nest file.
BNDCHK	Logical	Indicates whether computed Hs on boundary must be compared with the value entered as boundary condition.
HSRERR	Real	The error margin allowed between pre-scribed and calculated Hs at the upwave boundary. If exceeded, then a warning is produced.
FSHAPE	Integer	Indicates option for computation of frequency distribution in the spectrum (boundary spectra etc.).
DSHAPE	Integer	Indicates option for computation of directional distribution in the spectrum (boundary spectra etc.).
PSHAPE	Real	Coefficients for calculation of spectrum from integral parameters.
SPPARM	Real	Integral parameters used for computation of incident spectrum.

BNAUT	Logical	Indicates whether Nautical or Cartesian directions are used.
ONED	Logical	Indicates whether the calculation should be performed in 1-D mode.
PQUAD	Real	Coefficients for quadruplet interaction.
BRESCL	Logical	Rescaling on/off.

IGEN	Integer	Indicates the generation mode:
		= 1 For command GEN1;
		= 2 For command GEN2;
		= 3 For command GEN3.

PSETUP	Real	User defined level for correction of the setup.
CSETUP	Logical	Indicates whether or not the solver for setup has converged.
ACUPDA	Logical	Indicates whether or not action densities are to be updated during computation.
MXITST	Integer	Maximum number of iterations in stationary computations.
MXITNS	Integer	Maximum number of iterations in non-stationary computations.
NMS(MCNMS)	Integer	(Not used); Contains all of the items in /SWNUMS/. NMS is used in a .for file; each item is listed individually in a .inc file.

8.4.11 COMMON/ SWTEST

Information for test output.

Variable	**Type**	**Description**
LXDMP	Integer	Grid counter for a test point in the x-direction.
LYDMP	Integer	Grid counter for a test point in the y-direction.
NEGMES	Integer	Not used.
MAXMES	Integer	Not used.
TESTFL	Logical	Test output must/must not be made, mainly for test points.
NPTST	Integer	Number of test points; set by command TEST.
IPTST	Integer	Sequence number of a test point.
NPTSTA	Integer	Number of test points, equal to MAX(1, NPTST).
INTES	Integer	Testing parameter.
ICOTES	Integer	Minimum value for ITEST.
IOUTES	Integer	Minimum value for ITEST.
UNDFLW	Real	Small number to prevent underflows.
IFPAR	Integer	Unit reference number for output of parameters in test points.
IFS1D	Integer	Unit reference number for output of 1-D spectra of source terms.

IFS2D	Integer	Unit reference number for output of 2-D spectra of source terms. If used, the value is made non-zero by subroutine FOR.
OUT(NKTST)	Real	(Not used); Contains all of the items in /SWTEST/. OUT is used in a .for file; each item is listed individually in a .inc file.

8.4.12 COMMON/ SWUITV

Information for output.

Variable	Type	Description
ALCQ	Real	Angle between x-axes of computational grid and output frame.
COSCQ	Real	Cosine of ALCQ.
SINCQ	Real	Sine of ALCQ.
IUBOTR	Integer	Set to one, when *ivtype* = 6 or 18.
INRHOG	Integer	Indicates the choice for output based on "variance" or "true energy". = 0 Output based on variance; = 1 Output based on "true energy".
ERRPTS	Integer	Unit reference number of file containing coordinates of "problem points".
DXK, DYK	Real	Mesh size of output frame.
ALPQ	Real	Angle between x-axes of user coordinate system and output frame.
COSPQ	Real	Cosine of ALPQ.
SINPQ	Real	Sine of ALPQ.
XQP	Real	X-coordinate (user coordinate) of origin of output frame.
YQP	Real	Y-coordinate (user coordinate) of origin of output frame.
XQLEN	Real	Length of x-side of output frame.
YQLEN	Real	Length of y-side of output frame.

OVSVTY	Integer	Type of the output variable:
		= 1 Scalar;
		= 2 Angle;
		= 3 Vector;
		= 4 Tensor;
		= 5 Fully spectral quantity;
		= 6 Directional spectral quantity.

OVLLIM	Real	Lower limit of validity of output quantity.
OVULIM	Real	Upper limit of validity.
OVLEXP	Real	Lower expected limit of output quantity.
OVHEXP	Real	Upper expected limit of output quantity.
OVEXCV	Real	Exception value for output quantity.

SPCPOW	Integer	Power in expression for computation of average frequency.
AKPOWR	Real	Power in expression for computation of average wave number.
MXOUTAR	Integer	Calculates maximum memory needed for the output routines.
XPQ	Real	X-origin of a frame.
YPQ	Real	Y-origin of a frame.
OUTPAR	Real	Array containing various parameters for computation of output quantities.
UDA(MCUDA)	Real	(Not used); Contains all of the items in /SWUITV/. UDA is used in a .for file; each item is listed individually in a .inc file.

8.4.13 COMMON/ SWFYSP

Physical parameters.

Variable	**Type**	**Description**
GRAV	Real	Acceleration due to gravity.
WLEV	Real	Water level.
PI	Real	Circular constant.
PI2	Real	2*PI
RHO	Real	Density of the water.
DEGRAD	Real	Constant to transform degrees to radians.
DNORTH	Real	Direction of North with respect to the x-axis of user coordinates.
PWTAIL	Real	Coefficients to calculate the tail of the spectrum.
CASTD	Real	Air-sea temperature difference.
FP(MCFP)	Real	(Not used); Contains all of the items in /SWFYSP/. FP is used in a .for file; each item is listed individually in a .inc file.

8.4.14 COMMON/ COMPDA

Pointers for data arrays on computational grid.

Arguments	**Type**	**Description**
JCMPDA	Integer	Array *compda* within *pool* array.
MCMVAR	Integer	Within array *compda.*
JHS	Integer	Significant wave height Hs within array *compda.*
JDISS	Integer	Dissipation within array *compda.*
JUBOT	Integer	Bottom orbital velocity within array *compda.*
JQB	Integer	Fraction of breaking waves within array *compda.*
JSTP	Integer	Steepness within array *compda.*
JDHS	Integer	Wave height correction within array *compda.*

JDP1	Integer	Old depth within array *compda.*
JVX1	Integer	X of old current velocity within array *compda.*
JVY1	Integer	Y of old current velocity within array *compda.*
JDP2	Integer	New depth within array *compda.*
JVX2	Integer	X of new current velocity within array *compda.*
JVY2	Integer	Y of new current velocity within array *compda.*
JFRC2	Integer	Friction coefficient within array *compda.*
JFRC3	Integer	Friction coefficient within array *compda.*
JWX2	Integer	X of new wind velocity within array *compda.*
JWY2	Integer	Y of new wind velocity within array *compda.*
JBOT	Integer	Bottom level within array *compda*, not used.
JWLV1	Integer	Old water level within array *compda.*
JWLV2	Integer	New water level within array *compda.*
JWAREA	Integer	Work area within *pool* array.
JAC1	Integer	Array *ac1* within *pool* array.
JAC2	Integer	Array *ac2* within *pool* array.
JOUTD	Integer	Array *outda* within *pool* array.
JXYTST	Integer	Test points within *pool* array.
JTSTDA	Integer	Array *testda* within *pool* array.
MTSVAR	Integer	Within array *testda.*
JPWNDA	Integer	Within array *swtsda*, wind source term part A.
JPWNDB	Integer	Within array *swtsda*, wind source term part B.
JPWCAP	Integer	Within array *swtsda*, whitecapping.
JPBTFR	Integer	Within array *swtsda*, bottom friction.
JPWBRK	Integer	Within array *swtsda*, surf breaking.
JP4S	Integer	Within array *swtsda*, quadruplet interactions.
JP4D	Integer	Within array *swtsda*, quadruplet interactions.
JPTRI	Integer	Within array *swtsda*, triad interactions.
JAUX	Integer	Auxiliary array within *pool* array.
JDTM	Integer	Wave period correction within array *compda.*
MSWMAT	Integer	Within array *swmatr.*
JMATD	Integer	Within array *swmatr.*
JMATR	Integer	Within array *swmatr.*
JMATL	Integer	Within array *swmatr.*
JMATU	Integer	Within array *swmatr.*
JMAT5	Integer	Within array *swmatr.*
JMAT6	Integer	Within array *swmatr.*
JABIN	Integer	Within array *swmatr.*
JABLK	Integer	Within array *swmatr.*
JDIS0	Integer	Within array *swmatr.*
JDIS1	Integer	Within array *swmatr.*
JLEK1	Integer	Within array *swmatr.*
JAOLD	Integer	Within array *swmatr.*

JLEAK	Integer	"Leak" within array *compda.*
JWLV3	Integer	Last read water level within array *compda.*
JVX3	Integer	X of last read current velocity within array *compda.*
JVY3	Integer	Y of last read current velocity within array *compda.*
JWX3	Integer	X of last read wind velocity within array *compda.*
JWY3	Integer	Y of last read wind velocity within array *compda.*
JDP3	Integer	Last read depth within array *compda.*
JFL1	Integer	Boundary spectra at time = T within *pool* array.
JFL2	Integer	Boundary spectra at time = T + DT within *pool* array.
JAUXW	Integer	Auxiliary array within *pool* array. Used for WAM.
JAUXW2	Integer	Auxiliary array within *pool* array. Used for WAM.
JAUXW3	Integer	Auxiliary array within *pool* array. Used for WAM.
JFRW	Integer	Computed spectral frequencies WAM within *pool* array.
JANGSW	Integer	Computed spectral directions WAM within *pool* array.
JCOOX	Integer	X coordinates computational grid within array *compda.*
JCOOY	Integer	Y coordinates computational grid within array *compda.*
JADDRS	Integer	Indirect addresses of the computational grid within *pool* array.
JSETUP	Integer	Setup values within array *compda.*
JDPSAV	Integer	Saved depth (for setup) within array *compda.*
JWFRCX	Integer	Within array *compda*: x-computation is wave induced force.
JWFRCY	Integer	Within array *compda*: y-computation is wave induced force.
JUSTAR	Integer	Friction velocity within array *compda.*
JZEL	Integer	Roughness within array *compda.*
JTAUW	Integer	TauW within array *compda.*
JCDRAG	Integer	Drag coefficient within array *compda.*
JBFILS	Integer	Sequence number for pool array *bfiles.*
JBSPEC	Integer	Sequence number for pool array *bspecs.*
JBGRID	Integer	Sequence number for pool array *bgridp.*
JBSLOC	Integer	Sequence number for pool array *bsploc.*
JBSDIR	Integer	Sequence number for pool array *bspdir.*
JBSFRQ	Integer	Sequence number for pool array *bspfrq.*
JBSAUX	Integer	Sequence number for pool array *bspaux.*
JHSIBC	Integer	Significant wave height from boundary condition in array *compda.*
JGRBND	Integer	Pointer to *pool* array holding boundary grid.
JURSEL	Integer	*Ursell* number as used in Triad computation.
JASTD1	Integer	Old air-sea temperature difference within array *compda.*
JASTD2	Integer	New air-sea temperature difference within array *compda.*
JBTIME	Integer	Not used.

JASTD3	Integer	Last read air-sea temperature difference within array *compda*.
CDA(MCDA)	Real	(Not used); Contains all of the items in /COMPDA/. CDA is used in a .for file; each item is listed individually in a .inc file.

8.5 (SWANOUT3 FOR FILE)

8.5.1 COMMON/ CPLT1(Not used)

Variable	**Type**	**Description**
IPLOT	Integer	Parameter specifying plot option IPLOT = 0 No plotting of lines; = 1 Plotting option on.
NN	Integer	Number of segments in which a basic line has to be divided.
LTEST	Integer	Parameter specifying quantity of test output of intermediate results.
IC1	Integer	Number of steps after which the first number is plotted on a contour line.
IC2	Integer	Number of steps between succeeding plot actions of a number on a contour line.

8.6 (SWANPRE1 FOR FILE)

8.6.1 COMMON/ TIMFIL(Not used)

Time related variables for the grids.

Variable	**Type**	**Description**
INTECU	Integer	Timestep between non-stationary input conditions for currents.
INTEFR	Integer	Timestep between non-stationary input conditions for bottom friction.
INTEWI	Integer	Timestep between non-stationary input conditions for wind.
INTEWL	Integer	Timestep between non-stationary input conditions for water levels.
TBEGCU	Real	Start time for the non-stationary input conditions for currents.
TBEGFR	Real	Start time for the non-stationary input conditions for bottom friction.
TBEGWI	Real	Start time for the non-stationary input conditions for wind.

TBEGWL	Real	Start time for the non-stationary input conditions for water levels.
TENDCU	Real	End time for the non-stationary input conditions for currents.
TENDFR	Real	End time for the non-stationary input conditions for bottom friction.
TENDWI	Real	End time for the non-stationary input conditions for wind.
TENDWL	Real	End time for the non-stationary input conditions for water levels.
TIMCU	Real	Last time that non-stationary input conditions has been read for currents.
TIMFR	Real	Last time that non-stationary input conditions has been read for bottom friction.
TIMWI	Real	Last time that non-stationary input conditions has been read for wind.
TIMWL	Real	Last time that non-stationary input conditions has been read for water levels.

8.6.2 COMMON/ CBOUP(Not used)

8.6.3 COMMON/ SWANWL

Variables for project h3268.

8.6.4 COMMON/ TIMCOM

Time related variables for the computation.

Variable	**Type**	**Description**
TINIC	Real	Start time and date of the computation.
DT	Real	Timestep of the computation.
TFINC	Real	End time and date of the computation.
TIMCO	Real	Time and date of the computation during the simulation.

8.6.5 COMMON/ TIMRED

Time related variables for nested runs.

Variable	**Type**	**Description**
BEGBOU	Real	Start time for the non-stationary boundary conditions.
TIMERB	Real	(Not used); Last time that non-stationary boundary conditions has been read in the case of nested runs.
IFACMX	Integer	Not used.
IFACMY	Integer	Not used.

TINTBO	Real	Timestep between non-stationary boundary conditions in the case of nested runs.

8.7 (SWANSER FOR FILE)

8.7.1 COMMON/ PSHAPE

Coefficients of spectral distribution.

Variable	**Type**	**Description**
PSHAPE(1)	Real	SY0, peak enhancement factor (gamma) in JONSWAP spectrum.
PSHAPE(2)	Real	Spectral width for Gauss spectrum in rad/s.

8.7.2 COMMON/ SPPARM

Array containing integral wave parameters.

Variable	**Type**	**Description**
SPPARM	Real	Incident wave Parameters (Hs, Period, direction, Ms).
SPPARM(1)	Real	Hs, significant wave height.
SSPARM(2)	Real	Wave period given by the user (either peak or mean).
SSPARM(3)	Real	Average direction.
SSPARM(4)	Real	Directional spread.

8.8 (OCPCOMM1 INC FILE)

8.8.1 COMMON/ REFTIM

Origin for day and time.

Variable	**Type**	**Description**
REFDAY	Integer	Day number of the reference day. The first day entered is used as reference day, the reference time is 0:00 of the reference day.

8.9 (OCPCOMM3 INC FILE)

8.9.1 COMMON/ PLDATA

Plotting related variables.

Variable	**Type**	**Description**
IPLOPT	Integer	Plotting option.
IUPLF	Integer	Unit reference number of the PLOT file.
PLFACT	Real	Not used.

PLPARM	Real	Plotting parameters.

8.9.2 COMMON/ BINARY

Common variables.

Variable	Type	Description
BIT	Integer	Not used.

8.10 (POOLCOMM INC FILE)

8.10.1 COMMON/ SWPOOL

Data Pool.

Variable	Type	Description
POOL	Integer	Dynamic data pool array.
RPOOL	Real	Real equivalence of *pool.*
LPOOL	Logical	Logical equivalence of *pool.*

8.11 (SWCOMM2 INC FILE)

8.11.1 COMMON/ INPGRS (Not used)

Variable	Type	Description
IFLIDL	Integer	Lay-out in input file.
IFLIFM	Integer	Format identifier.
IFLNHF	Integer	Number of heading lines per file.
IFLNHD	Integer	Number of heading lines per input field.
IFLFAC	Real	Multiplication factor.
IFLNDS	Integer	Unit reference number of data file.
IFLNDF	Integer	Unit reference number of name list file.

IFLDYN	Integer	If = 0, Data is stationary,
		If = 1, Non-stationary.

IFLTIM	Real	Time of last reading.
IFLBEG	Real	Begin time of data on file.
IFLINT	Real	Time interval of data on file.
IFLEND	Real	End time of data on file.
IFLFRM	Character	Format string.

8.12 (SWCOMM4 INC FILE)

8.12.1 COMMON/ SWROP

Higher order propagation and spherical coordinates.

Variable	Type	Description

PROPSC	Integer	Indicates which numerical scheme is to be used for spatial propagation:
		= 1 First order (BSBT);
		= 2 SORDUP;
		= 3 Third order (S&L).

PROPSL	Integer	Indicates which numerical scheme is used locally.
PROPSS	Integer	Indicates which numerical scheme is to be used in stationary computations: = 1 First order (BSBT); = 2 SORDUP.
PROPSN	Integer	Indicates which numerical scheme is to be used in non-stationary computations: = 1 First order (BSBT); = 3 Third order (S&L).
WAVAGE	Real	Indicates "wave age" parameter.
KSPHER	Integer	Indicates whether spherical coordinates are used, and which projection method: = 0 Cartesian coordinates; > 0 Spherical coordinates.
REARTH	Real	Radius of the earth.
LENDEG	Real	Length of a degree *ns*.
KREPTX	Integer	If > 0, the domain repeats itself in x-direction (primarily intended for propagation around the globe).
COSLAT	Real	Cosine of latitude; = 1 for Cartesian coordinates.
PROJ_METHOD	Integer	Projection method: = 0 (Quasi-)Cartesian; = 1 Uniform Mercator (only spherical coordinates).