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User's Manual for the Global Ocean Forecast System (GOFS) Version 2.6

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14. ABSTRACT

The purpose of this User's Manual (UM) is to describe the components, order of execution, setup and operational run of the Global Ocean Forecast System (GOFS) version 2.6. The emphasis of the document is on the additions to the system, mainly Naval Coupled Data Assimilation System (NCODA), and the coupling with PIPS 3.0. Flowcharts are included to describe the global NCOM inputs, execution, outputs, and the launch of the PIPS 3.0 system. Information on obtaining the GOFS through a Subversion repository is also included.

15. SUBJECT TERMS

Global ocean modeling	NCOM	MODAS	SVN
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1.0 Introduction

The Global Ocean Forecast System (GOFS) Version 2.6 (V2.6) combines the global coverage and relatively high vertical resolution of the Navy Coastal Ocean Model (NCOM), along with the Navy Layered Ocean Model (NLOM; Shriver et al., 2007), the Modular Ocean Data Assimilation System (MODAS; Fox et al., 2002), and *in situ* profile data assimilation via the Navy Coupled Ocean Data Assimilation (NCODA; Cummings, 2005) system to best represent the evolution of deep water fronts and eddies. The GOFS is commonly referred to as "global NCOM" within the operational community, given that the widely used global NCOM boundary conditions launch several other systems in the daily operational runstream. GOFS provides enhanced skill in the nowcasting and forecasting of global ocean environmental conditions, including surface and, where applicable, three-dimensional (3D) predictions of:

- Temperature
- Salinity
- Surface elevation
- Ocean velocity (current speed/direction or velocity components)
- Volume transport
- Eddy kinetic energy
- Sound speed
- Additional derived ocean properties

1.1 NLOM in GOFS

Global NLOM has coarse vertical resolution and excludes the Arctic Ocean and regions shallower than 200m. However, its horizontal resolution is very high at 1/32°, giving it excellent skill in representing deep water fronts and eddy locations. The sacrifices in vertical resolution and area coverage enable NLOM to be operational at very high resolutions. NLOM directly assimilates track-by-track altimeter data and MODAS 2D sea surface temperature (SST) analyses. The 1/32° NLOM was used exclusively in the GOFS V2.6 beginning in the fall of 2005 and was declared operational in March 2006. Shriver et al., (2007) discussed the analyses performed to declare the 1/32° NLOM superior to the 1/16° NLOM and Barron et al., (2007) compared differing versions of NLOM in a GOFS.

1.2 NOGAPS in GOFS

GOFS V2.6 uses atmospheric forcing from the Navy Operational Global Atmospheric Prediction System (NOGAPS). The 0.5° version of NOGAPS has been the atmospheric component since January 2005. Atmospheric forcing files are created using time varying *u* and *v* component surface wind stresses, air temperature, air mixing ratio, and net solar radiation. NOGAPS contributes these parameters, where available, as this is important for the ocean mixed layer where inertial oscillations are excited by transient forcing from surface winds (Rosmond et al., 2002). Operational runs use three-hourly forcing. Sensible and latent heat fluxes are strongly dependent on SST, so these are calculated every time step using the model SST in bulk formulations that include the effects of air-sea stability

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through the exchange coefficients (Kara et al., 2002). The annual climatological SST cycle is built into the model to a limited extent via the atmospheric air temperature. Including air temperature in the formulations for latent and sensible heat flux along with model SST in the bulk formulation automatically provides a physically realistic tendency towards the correct SST (Kara et al., 2003b). Although radiation fluxes also depend on SST to some extent, these fluxes are obtained directly from NOGAPS in order to utilize the atmospheric cloud mask.

1.3 MODAS in GOFS

Global NCOM assimilates temperature (T) and salinity (S) fields generated by MODAS. MODAS is a global statistical model containing a bimonthly climatology that records correlations at each location between surface temperature, surface steric height anomaly, and temperature deviation as a function of depth. Salinity is derived from temperature by climatological correlations between T and S and also as a function of depth (Fox et al., 2002a). In GOFS V2.6, MODAS is used to translate NLOM sea surface height (SSH) into 3D temperature and salinity fields suitable for assimilation into global NCOM. The altimetry information is introduced to NCOM by this transference. GOFS takes advantage of the relatively deep water skill and data assimilation of the sub-polar global ocean NLOM through MODAS' statistical ocean model. Temperature is taken from the MODAS 2D SST analysis, and SSH anomaly is estimated as the deviation of baroclinic NLOM SSH from its multi-year mean. It can then be optionally corrected for the difference between the mean MODAS and mean NLOM SSH. The synthetics use NLOM SSH only in deep water within the NLOM domain. Other areas use synthetic profiles based solely on MODAS 2D SST.

1.4 *In situ* Observations

In situ observations may also be assimilated into the 3D analyses. Data assimilation used in NCOM is performed using two mechanisms: 1) adjustment of surface heat and salinity fluxes, and 2) insertion of subsurface T and S profiles. In both cases, the strength of assimilation is controlled by a gridded weighting function that reflects the relative confidence between the model and the data. Preparation of the data fields is independent of the NCOM assimilation itself, allowing the model to accommodate many approaches to preparing observational analyses.

In the most recent upgrade to GOFS V2.6, the mixed layer depth (MLD) of the synthetic profiles is adjusted to that of an input MLD, such as from NLOM. Below the new MLD, blending with the original synthetic profile is accomplished via exponential weighting (Barron et al., 2008). The resulting global 3D fields comprised of the MLD-modified MODAS synthetic profiles are then used as the background or first guess field for a standalone NCODA analysis. The 3D T and S fields that have been updated with *in situ* profile data are then assimilated into GOFS V2.6 by depth and geographically dependent relaxation scales.

1.5 PIPS in GOFS

The GOFS V2.6 also has been coupled to the Polar Ice Prediction System (PIPS) Version 3.0, a dynamic sea-ice model that forecasts conditions in all sea-ice covered areas in the northern hemisphere (down to 30° North in latitude). PIPS has a horizontal resolution of approximately 9 km and a vertical resolution of 45 levels so that Arctic shelves, continental slopes and submarine ridges are accurately represented. In PIPS 3.0, the Los Alamos Sea Ice Model (CICE) (Hunke and Dukowicz, 1997) model is coupled to NCOM to predict multi-category ice thickness, concentration, and drift in the Arctic Ocean (Posey et al., 2008b). Coupling is accomplished via exchange of regridded fields. CICE receives global NCOM SST and surface velocities over the CICE model domain. NCOM receives ice concentration, SST, heat flux and ice-ocean stress the day following the daily PIPS run. These PIPS fields will replace climatological fields of SST, heat flux, and wind stress in the Arctic regions to produce a more realistic representation of the Arctic.

GOFS V2.6 typically runs a three-day hindcast and three- to- five day forecast in operational mode. Atmospheric forcing comes through winds and heat fluxes from NOGAPS. A database of almost 1000 rivers from around the world feeds into the river input of GOFS V2.6 (Barron and Smedstad, 2002).

1.6 Advantages of GOFS V2.6

GOFS V2.6 provides a resource allocation choice that combines multiple sub-optimal models to achieve a superior system to that of any one of its component models run individually. It is a global mesoscale ocean model extending from Antarctica to a full Arctic domain, including deep and coastal regions and global river inflows. It also assimilates synthetic T and S profiles derived from global SST analyses and SSH from a higher horizontal resolution deep-water global ocean model (via MODAS). The following advantages exist from the series of GOFS developments:

- Full global ocean coverage within the main model.
- Nominal coverage of 1/8° latitude (about 14 km) at 45°S.
- A global curvilinear horizontal grid that balances preservation of grid cell aspect ratios near 1, efficient distribution of grid points, and maintenance of a logically rectangular grid with singularities sufficiently removed from ocean portions of the domain.
- Coverage of global coastal regions through inclusion of both deep and shallow water to a minimum nominal depth of 5 m.
- Sigma-z vertical coordinate incorporation to allow for improved vertical resolution and to avoid problems of sigma coordinates over continental slopes and *z*-coordinates in models over regions where both deep and shallow areas must be resolved.
- High vertical resolution for a global model, with maximum rest spacing of 1 m for the surface material level. This will improve SST and mixed-layer depth capabilities.
- Global coupling of a high horizontal resolution deep water model to an accurate, deep and shallow water thermodynamic model at high vertical resolution.

- Inclusion of fresh water inflow from the major rivers of the world with development of a global database of monthly river climatology (Barron and Smedstad, 2002).
- The ability to host higher-resolution nested models.
- Optimal scalability and portability for efficient use of high-performance computing resources.
- Generic global regridding for scalar and vector quantities from the global model to arbitrary output points, profiles or grids.

1.7 New Features

The most observable improvements are *in situ* observations (via NCODA using the MLD-modified MODAS synthetics as the first guess). GOFS V2.6 has the following combined value added over existing global ocean modeling capabilities:

- Assimilation via relaxation to an analysis of observed T and S and synthetic profiles. The synthetics are generated by MODAS using SST from MODAS 2D and SSH from NLOM. NLOM operates solely in subpolar deep water with coarse vertical resolution, but its higher horizontal resolution makes it a good dynamic interpolator of altimetry data, as well as an excellent predictor of front and eddy location in deep water. After modifying the synthetic profile MLD using an input MLD from NLOM, observed T and S profiles from NAVOCEANO OCNQC are assimilated via NCODA using the T and S synthetics as the first guess (Cummings, 2005). OCNQC is an ocean data quality control program that works in conjunction with NCODA to perform automated quality control measures on all operationally relevant ocean data streams.
- Two-way coupling (via file transfer) with the Polar Ice Prediction System (PIPS) 3.0, containing a sea ice model (CICE) running operationally after the global NCOM daily run with an Arctic grid spacing of approximately 9 km.
- Suitability for feedback into a data analysis system using the model forecasts as a first-guess field for subsequent analyses.
- Compatibility as the ocean component of a coupled ocean-atmospheric model prediction system.

2.0 Application

2.1 Description of GOFS V2.6 Usage

This manual describes the procedures for running the Global Ocean Forecast System (GOFS) Version 2.6. Because GOFS V2.6 delivers outputs from the global version of the NCOM 4.0 model, all general NCOM operational instructions and details may be found in the User's Manual for the Navy Coastal Ocean Model (NCOM) Version 4.0 (Martin et al., 2008a). The user may also refer to the NCOM Software Design Description (SDD), which describes the model code (Martin et al., 2008b), an article by Barron et al., (2006), which discusses NCOM physics and basic equations, and two Validation Test Reports (Barron et al., 2007a, 2008) for additional insight into the NCOM system. Only instructions specific to operating the model globally will be discussed here.

2.2 Model Code Directory Structure

The directory structure for operational use of the GOFS V2.6 system is identical to the NCOM 4.0 directory structure except for the */misc_global* subdirectory, found within the */src* file folder. Refer to (Martin et al., 2008b) for the complete model code directory structure.

src/-
- misc_global/- Pre- and post-processing programs for GOFS.
  - Makefile- Builds miscellaneous programs.
  - addndays.F- Adds offset to DTG.
  - daysdiff.F- Computes difference in days b/w two date groups.
  - idaysdiff.F- Computes diff. in integer days b/w two date groups.
  - ihrsdiff.F- Computes diff. in hours between two date groups.
  - ncom_atm_prep_puvhs.5.F- Reads NOGAPS 0.5° files and uses pressure, wind stresses, longwave components of surface heat fluxes, and solar radiation fields.
  - ncom_atm_prep_puvhtms.5.F- Reads NOGAPS 0.5° files and uses pressure, wind stresses, longwave components of surface heat fluxes, dewpoint depression, and air temperature fields.
  - ncom_atm_prep_uvhtms.5.pf.F- Reads NOGAPS 0.5° files and applies a pole filter in the longwave radiation field using wind stresses, longwave components of surface heat fluxes, air temperature, dewpoint depression, and air temperature fields.
  - ncom_fixrst.F90 – Takes in restart file with values outside of limits and clamps to allowed values.

ncom_sstsss.F- Gets SST and S from binary files and stores on the GOFS grid.

ncom_tsnc.F- Gets 3D T and S from binary files and stores them on the GOFS grid.

extend_dcwinds.F90- Fills time gaps in grid files for model input.

extractfrompips.F90- Writes a MODAS-style netCDF file for each extracted field.

extractfrompips_f90.F90- Reads a set of two-dimensional (2D) and 3D netCDF files.

ncom_atmuvhtms_icemask3.F90- Reads 2D atm forcing and ice mask fields of the same dimension in direct access binary files. It replaces wind fluxes with ocean fluxes. It uses PIPS total heat flux where PIPS output ice concentration is >15%.

ncom_atmuvhtms_icemask3.01.F90- Performs the same functions as the above file, with a PIPS output ice conc. of >1%.

ncom_nc2atmice.F90- Reads 2D and 3D netCDF files. Writes in direct output format.

ncom_out2ncplus.F90- Converts direct access 2D or 3D output files to netCDF format.

ncpack2nc.F90- Converts compressed netCDF to uncompressed for easier input into packages such as MATLAB.

2.3 Memory and Processor Allocation

In order to successfully execute global 1/8° NCOM, there must be at least 50 GB of RAM distributed among the parallel processors. Thus, 256 processors with 256 MB each will suffice, as will 64 processors with 1 GB each. The binaries and source code require at least 30 MB of disk space, with a need for at least 100 GB of scratch space for I/O of restart, forcing, assimilation, and output files.

2.4 NCOM Subversion Repository

NCOM developers at NRL routinely make improvements, changes and bug fixes to the model, often simultaneously. Therefore, they have created an NCOM/GOFS Subversion Repository (http://subversion.tigris.org/; Collins-Sussman et al., 2007), whereby different editions of NCOM and GOFS V2.6 are stored and available for user access. These repositories also serve as backup in the event of a loss of operational system files. The internet address for the repository is https://www7320.nrlssc.navy.mil/svn/repos/NCOM for the NCOM code or https://www7320.nrlssc.navy.mil/svn/repos/GOFS for the system scripts and MODAS scripts. For web browser (read-only) viewing, via WebSVN, the repository is available at https://www7320.nrlssc.navy.mil/svn/websvn.

The Global NCOM code is embedded in the trunk of the NCOM repository. It is compiled as described in Section 2.4.1 below, with GLOBAL C pre-processor flags turning on the necessary routines and array sizes for a global model, including an Arctic domain.

The repository is accessible to Naval Research Laboratory- Stennis Space Center (NRL-SSC) personnel as well as to select Department of Defense (DoD) internet protocol (IP) addresses outside the NRL-SSC system, such as the High Performance Computing Modernization Program's (HPCMP) DoD Supercomputing Resource Center (DSRC) platforms. A user account must be requested from and created by Tim Campbell (tim.campbell@nrlssc.navy.mil). Send Dr. Campbell a digitally signed email request and he will reply with an encrypted email containing a username and initial password. After receiving the initial password, go to https://www7320.nrlssc.navy.mil/svn/websvn and click on the "Change Your SVN Password" link to change the password.

2.4.1 Global NCOM Build Information

README.make contains essential GOFS V2.6 build information. GNUmake is required for the GOFS build. Note that on some platforms GNUmake is referred to as "gmake". Compiling for a global simulation requires the following commands:

```
setenv NCOM_ARCH "ibm_sp"
setenv NCOM_COMP "default"
gmake ncom NCOM_USER=global
cd src/misc
gmake NCOM_USER=global
```

For compiling simulations, NCOM_ARCH is set to the appropriate machine type, NCOM_COMP (the compiler). The NCOM_USER variable refers to user-specific compile settings that are available in the appropriate **config/$(NCOM_ARCH).$(NCOM_COMP).$(NCOM_USER).mk** makefile fragment. Settings specific for compiling global NCOM on IBM with the AIX (default) compiler are in **config/ibm_sp.default.global.mk** (See Table 2.5-1). These are enabled by setting NCOM_USER=global in the user environment or on the make command line, as shown above. **NOTE:** Do not use libsetup, as it is not needed. The file **ncom_setup_plib.F** conflicts with `strlen` in the netCDF library as well. See Martin et al., (2008a) for a complete discussion of required and optional build variables.

Table 2.5-1: Global makefile settings.

Setting Type	Description	Default Setting
Machine/Hardware		IBM SP series
Compiler Set		Native (xlf/xlc)
Communication		Native MPI
CPPFLAGS	CPP flag for global domain.	+=-DGLOBAL_DOMAIN
INTLIB_SRC	User contributed internal library for NCOM_SETUP only.	+=-cdf += misc += modas

FC_PATHS	NetCDF paths for NCOM_SETUP only.	+= -I/site/netcdf64/include
CC_PATHS	NetCDF paths for NCOM_SETUP only.	+= -I/site/netcdf64/include
LD_PATHS	NetCDF paths for NCOM_SETUP only.	+= -L/site/netcdf64/lib
LD_LIBS	NetCDF paths for NCOM_SETUP only.	+= -lnetcdf

2.4.2 Accessing the GOFS V2.6 Scripts

The GOFS V2.6 is executed through a series of run scripts for global NCOM and its associated programs. These are located in the https://www7320.nrlssc.navy.mil/svn/repos/GOFS repository. Stepwise instructions for operating the system can be found in Section 3.3.

- **glb8_3b/** subdirectory- Contains the daily scripts needed to run the global model.
- **scripts/** subdirectory- Contains the post-pro cessing routines and a link to netCDF versions of global domain grid files found in **glb8_2a/nc**.
- **NCODA** di rectory- Contains scripts re quired to run the global NCODA pre-processing.
- **modas/syn/glb8_v3b** directory- Contains scripts required to run the MODAS pre-processing. This, in turn, generates input s ynthetic files in a separate parallel pre-process.
- **PIPS** directory- Contains the following:
    1. PIPS code found in **rundir.pips.v3.1**, **bld**, and **source** (see Posey et al., 2008a).
    2. PIPS domain grid files, found in **ncdirmaster** (see Posey et al., 2008b)**.**
    3. NOGAPS and NCOM input pre-processing, found in **data_in.**
    4. PIPS3 directory containing the scripts that send data between the models.

3.0 Operating Guidelines

The following operational guidelines are solely for instructions unique to the operation of GOFS V2.6. The user should refer to the NCOM 4.0 User's Manual (Martin et al., 2008a) for all other stepwise directions for running this model.

3.1 Initialization and Execution

The GOFS V2.6 consists of several UNIX C shell scripts, with each script initializing the next. The scripts begin by creating input file formats required by global NCOM 4.0 and ending with regional extractions of the outputs. All scripts in the pre-processing, model run, and post-processing phases of the daily system use the file ***NCOM.env*** to set most of the needed environmental variables.

Three environmental variables are commonly used throughout the scripts. The starting date, *idtg1start*, is set via the ***NCOM.env*** file. It is the beginning of the hindcast, generally set three days prior to the model analysis. The analysis date, *idtg1analysis*, is usually today's date. The forecast date, *idtg1end*, is typically set to four days, or 96 hours, after the analysis date.

3.1.1 Set Macro Values

Set MACRO values in the file *ncom_4.0/include/**MACROS.h***. Macros are defined in Table 3.1-1.

Table 3.1-1: User-defined macros of *MACROS.h*.

Parameter	Description
MXPROC	Maximum number of processors (<= MX1PRC**2; default = 256).
MX1PRC	Maximum number of processors in either direction (x or y; default = 16).
MN1PRC	Minimum number of processors in either direction (x or y; default = 2).
NMXA	Maximum whole array dimension in either direction (x or y; default = 2048).
LMX	Maximum vertical array dimension (max number of layers + 1; default = 61).
ARCTIC	Used for a global domain that includes the Arctic Ocean.
GLOBAL	Implements code for running in a global operational environment.
GLOBAL_DOMAIN	Sets the GLOBAL macro and controls compiling with global domain array settings.
MYL2P5	Implements code for running Mellor-Yamada Level 2.5 mixing.
COAMPS	Implements code for running in a Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS) environment.

Parameter	Description
SYM4	Provides check for 4-fold symmetry in domain. It is used for testing only.
SYM8	Provides check for 8-fold symmetry in domain. It is used for testing only.

3.1.2 Set Maximum Dimensions

Maximum allowed dimensions are set in the file *ncom_4.0/include/**PARAM.h***. These will be 2048 x1280. The ***PARAM.h*** variables are used to dimension some scratch arrays in the model code. The only variable that changes for GOFS usage is:

nrivmx- maximum allowed number of (horizontal) river inflow points, set to 2000.

Note: See file *ncom_4.0/doc/READMEs/README.include* for more discussion.

3.1.3 Updating the Rivers File

The global rivers database is maintained in the Subversion repository at https://www7320.nrlssc.navy.mil/svn/repos/RIVERS. This database is contained in the ***rivers.dat*** text file. Its README file explains how the database was built and contains a list of edits made, such as river additions and corrections to mouth locations. The file ***README.read.rivers.dat*** gives instructions on Fortran direct reads of the text file. The ***README.make.model.input*** contains the run command

```
ncom_setup_rivers.exe rivers.dat sstscl_gdem3vs.A
sstscl_gdem3vs.B orivs_1.D ohgrd_1.A ovgrd_1.D odimens.D,
```

which takes the ***rivers.dat*** flow levels, inputs an SST and sea surface salinity (SSS) climatology from GDEM, and outputs the ***orivs_1.D*** file.

3.2 Setting up a GOFS V2.6 Simulation

Global NCOM (ncom1) runs are usually only changed by copying an entire global directory and changing the OPARM file or some other input. Preprocessing is conducted in the top level NCOM directory, /u/home/ooc/models/ncom1/$runname. To start the preprocessing sequence, type `csh dailyncom.com` or `csh dailyncom.com` (date) to redo a processing sequence. These scripts run **ncom_prep.com** with appropriate arguments. The script **ncom_prep.com** gets the SST and SSH data from mass storage as well as other necessary files. It then starts preparing synthetics using **syn_prep_poe.com**, which queues one **dosyn.com** for each date (all running in parallel). The script **ncom_prep.com** grabs NOGAPS atmospheric forcing fields and starts their preparation using **atmstartprep.com**, which, in turn, queues one **master_prep.com** for each date (all running in parallel). Once synthetics are prepared, **ncom_prep.com** begins preparation of T/S assimilation data using **tsstartprep.com**. The script **tsstartprep.com** queues one **master_prep.com**, which calls **ncom_sstsss_setup.com** and **ncom_ts_setup.com**. Once all preparations have finished,

ncom_prep.com copies data to operational NAVOCEANO DSRC compute platform and mass storage and queues the model run on the IBM SP4, at */u/home/ooc/models/ncom1/$runname/***startrun.com**. The model is then run on *HABU* (if the preparation worked correctly, the model should be automatically queued and no human intervention is required).

The script **startrun.com** creates a run script for the model named **ncom_$(runname) _ $(idtg1analysis)).com,** which is based on **master_script.com** and **master.awk**. The model setup is controlled by parameters set in **OPARM_1_initial.D** or **OPARM_1_restart.D**. Once the model has finished its run, the output is copied to mass storage. Model post-processing is conducted on the IBM SP4, which includes copying data to mass storage, making 2D and 3D netCDF files, 2D RGB files, and computing transports. The interfacing and operational environment for the global NCOM nowcast/forecast system, which demonstrates the relationship between the components of the system and associated files, is illustrated in Section 4.0.

3.3 Executing Pre-processing Scripts

- The **dailyncom.com** script is initialized via a crontab that calls **ncom_prep.com**.
- The script **ncom_prep.com** is the longest running component of the system. It launches jobs on the operational NAVOCEANO DSRC compute platform to create surface forcing fields from NOGAPS products, jobs to create the blended synthetics, and resulting assimilative data inputs. Specifically, **ncom_prep.com** calls **syn_prep.com**, **ncoda_syn_prep.com**, **atmstartprep.com**, and **tsstartprep.com** and then waits for up to 16 hours, testing every 10 minutes for the files needed to place the model script in the operational queues. Once these files are found, **startrun.com** is called, generating the specific script needed for the current day's model run. This is done by incorporating **master_script.com** via **master.awk**. Once the model run enters the queue, **ncom_prep.com** is complete.
- The **atmstartprep.com** script takes in **buildgrids_winds.com**, which reads the NOGAPS file formats as transferred to NAVO. The script calls **ncom_atm_prep_uvhtms.5.pf.exe** which runs on one processor to create surface forcing in the *osflx* file form that is read by NCOM 4.0.
- The script **syn_prep.com** builds a script that runs **dosyn_poe.com**, which incorporates **dosyn.com** to run one job per day of the model run (plus an additional start –1 and end +1 day) and creates MODAS synthetics for each day of the model run. The resulting 2D SSS and SST and 3D synthetic potential T and S files are output in netCDF file format.
- The script **ncoda_syn_prep.com** generates and submits a date-specific version of **ncoda_prep.com**, which runs **transfer_input_data.s** and **loop_analyses.s**. The former retrieves the needed NAVO OCNQC profile data and MODAS synthetic T and S files that will comprise the NCODA first guess. The latter builds and submits **ncoda_analysis.com** for each hindcast date. In the operational queue, these multiple NCODA analyses run concurrently. At the end of each NCODA hindcast analysis,

ncoda_post.com first runs **synthetics_post.s**, which updates the first guess field with the analyzed increments, then runs **transfer_output_data.s**. Output includes netCDF files of the T and S NCODA analyses as well as netCDF and binary files of SST and SSS that have been extracted from the 3D T and S files.

- The script **tsstartprep.com** sources **ncom_sstsss_setup_source.com** and **ncom_tsnc_setup_source.com,** which run **ncom_sstsss.exe** and **ncom_ts.exe,** respectively. Each runs on one processor and reads in binary SST and SSS files or netCDF synthetic T and S files and creates surface or 3D files in the *osstf* and *otsf* file forms read by NCOM 4.0.

3.4 Executing Model Run Scripts

- **Master_script.com** is used as a template for a specific script submitted to run NCOM 4.0 every day. **Startrun.com** creates the daily script. The model executable, **ncom.exe**, runs on 256 processors.
- The model script calls **fixname.com** to rename the model outputs into hindcast and forecast specific filenames. It calls **postproc_script.com** to begin the post-processing, as well as **transfer_output_script.com** and **transfer_restart_script.com**.
- With the exception of **transfer_output_script.com** and **transfer_restart_script.com,** which run on designated nodes to send data to mass storage, the 256 processor reservation left over from the model run is retained to parallelize post-processing tasks.

3.5 Post-processing Scripts

- The **postproc_script.com** script runs **out2ncplus_sf_script.com** and **out2ncplus_3d_script.com**, creating separate scripts for each model day for the surface and 3D fields, respectively. Each of these calls the script **ncom_out2ncplus_all.com** to run **ncom_out2ncplus.exe,** which performs all of the reformatting to generate netCDF and transport files from the model's binary outputs.
- The **out2ncplus** scripts launch the transfer of all netCDF and transport files to mass storage. They incorporate the following three modules into jobs that run in the transfer queue: **transfer_nc_3d.module**, **transfer_nc_sf.module**, and **transfer_transport.module**.
- The **out2ncplus** scripts launch the standard regional extraction routines using **regional_tasks.com**, which reads a list of regions from **regional_tasks.lis**. Each regional extraction routine is very specific and must be hand-edited to specify the coordinates of the sub-region and the type of field to be extracted.

3.6 Executing Regional Post-processing Scripts- NCOM coupling with PIPS 3.0

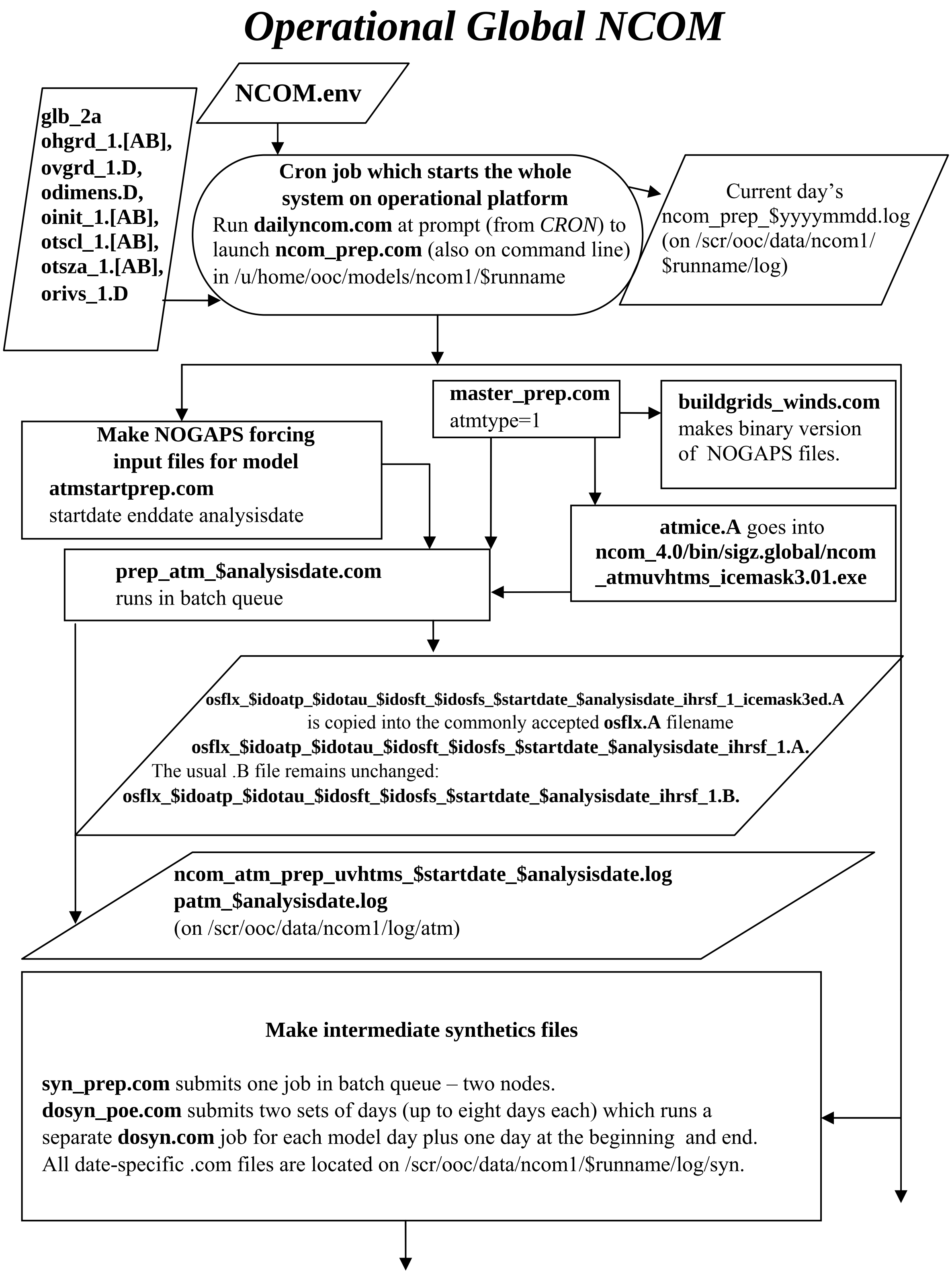
- After NCOM runs each day, it calls the regional post-process script **launch_pips.com,** which runs **ncom2pips.com** for that day.

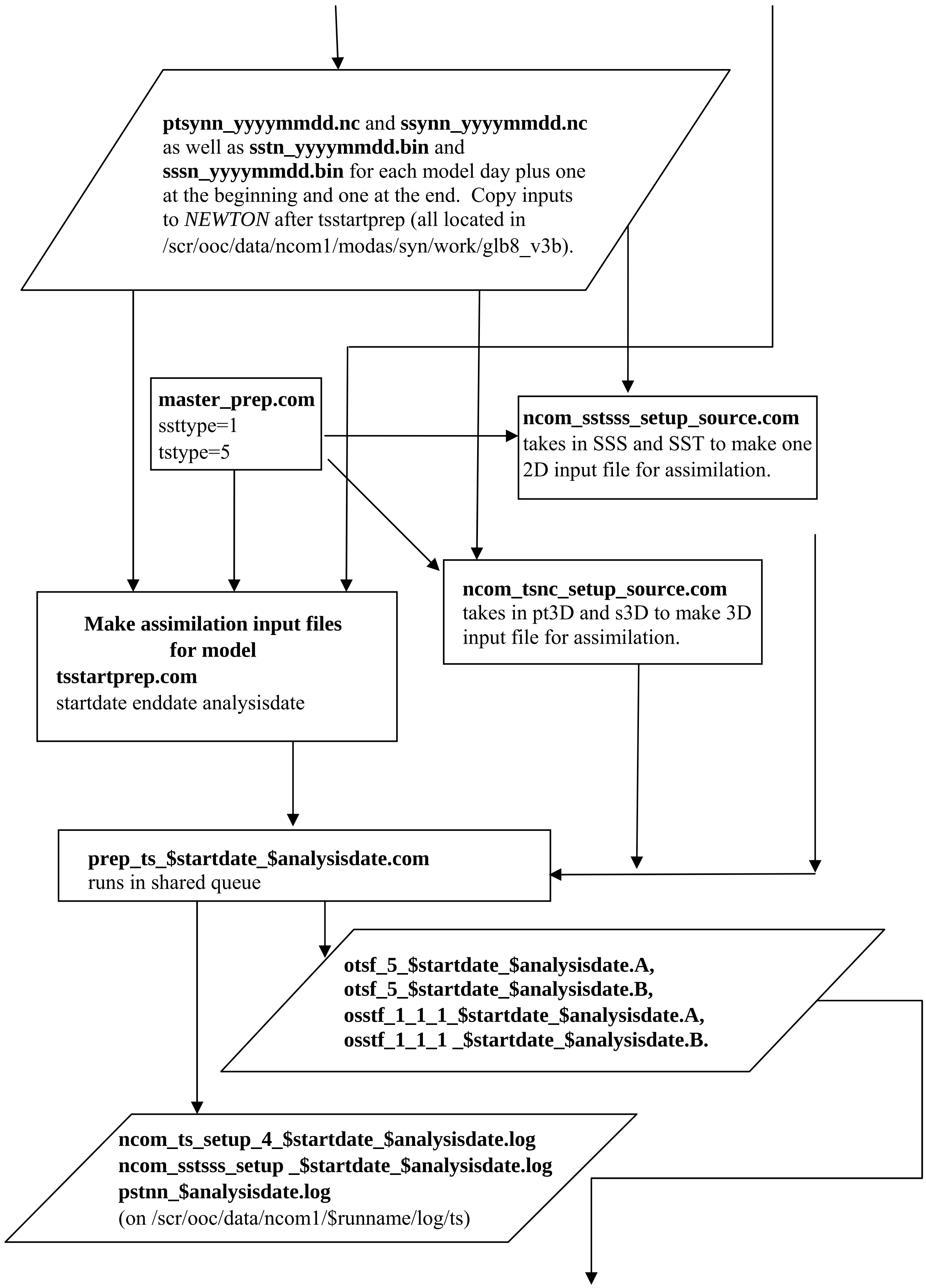
The **ncom2pips.com** script uses MODAS regridding routines to regrid the NCOM surface temperature and velocities onto the PIPS grid in netCDF format. PIPS then extracts the data from the netCDF files into a text file and runs **average_file_realtime.x** to make a daily mean for input.

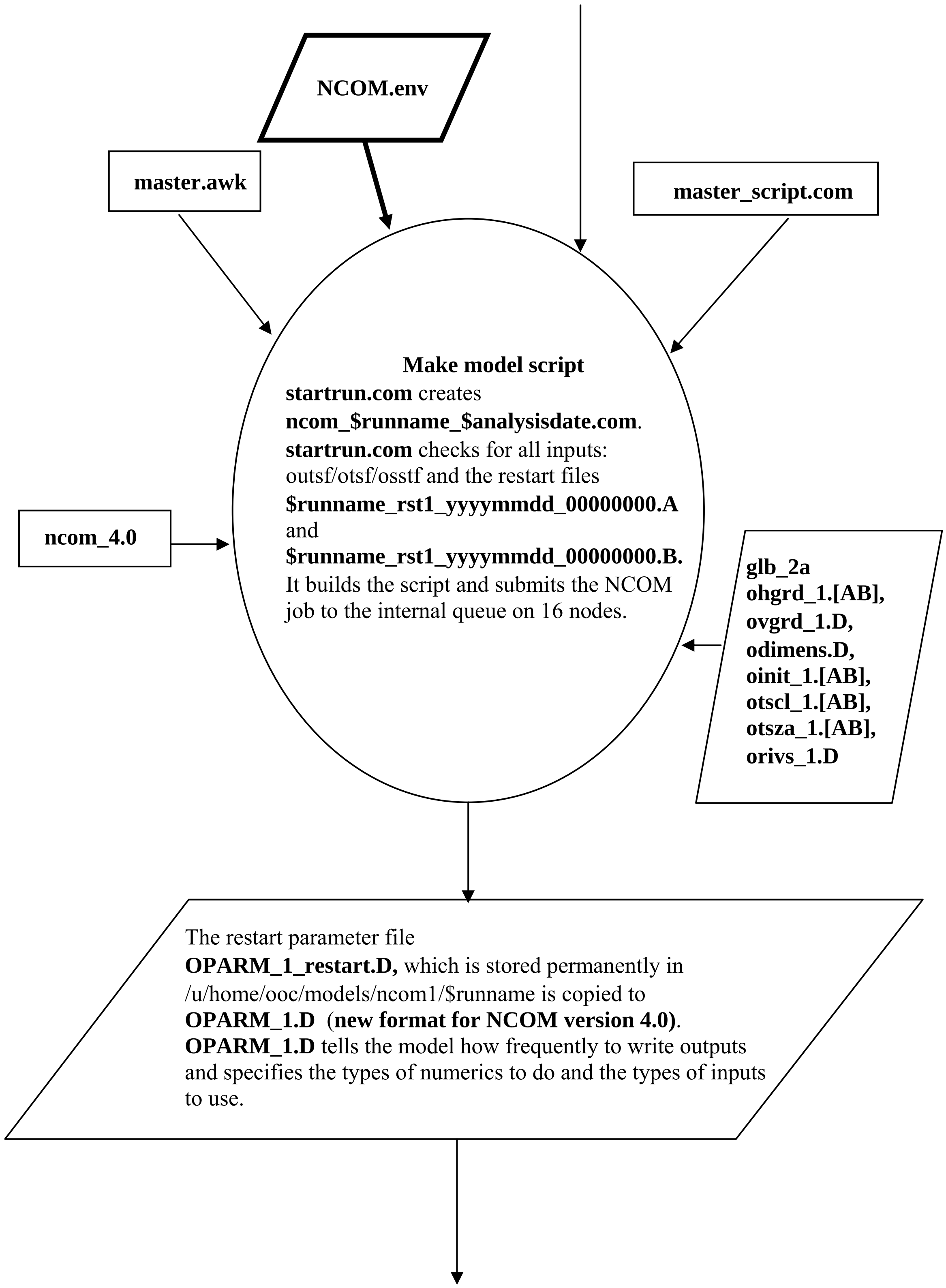
- After PIPS 3.0 has run, **launch_ncom.com** is called. This runs **ncom2pips.com**, which, in turn, starts the parallel process **regrid_pips_poe.com** of serial jobs. Following these script runs, **regrid_pips.com** will regrid the PIPS output every three hours onto the NCOM grid, including the ice concentration, heat flux, and ice-ocean stresses. Sea surface temperature files are only regridded at the 00 hour. The **fill4.com** routine masks noise at the land-sea boundaries, and the **landmask.com** script places the NCOM landmask onto the newly gridded fields.
- Ice-ocean stresses, heat fluxes, and ice concentrations are brought into **ncom_4.0/bin/sigz.global/ncom_nc2atmice.exe**, thus creating an **atmice.A** file. PIPS 3.0 is run for 96 hours and files are persisted for an additional 24 hours. The **atmice.A** file is saved for the following day.
- The executable **ncom_4.0/bin/sigz.global/ncom_atmuvhtms_icemask3.01.exe** is run the next day, after the NOGAPS forcing **OSFLX_1.A** file is made. This uses ice concentration to determine where ice is present (at a concentration of 1% or higher) and replaces wind stresses with ice ocean stresses and heat fluxes over the NCOM bulk-formulae heat fluxes.
- The SST outputs are blended into the MODAS 2D synthetics by using ice concentration to determine where ice is present. The ice concentration file, **aice,** is used to assess three types of areas: those with significant ice, those near ice areas, and those in open water. A minima of ice areas with a value of at least 0.0001 creates a lesser ice mask and is used to make a mask of 1's and 0's. A creep fill is used to expand the mask to areas near ice. In near-ice areas and in regions with high ice concentration 1's are used and for open water 0's are used. For in-between areas, a blend zone filled with special values has been created.
- An ice mask (*blendmask*) of 1's and 0's is generated as well as an inverse ice mask (*blendmaski*) of 0's and 1's. The *blendmaski* will be multiplied by the MODAS SST output the following day. The *blendmask* is multiplied by the PIPS SST netCDF output.
- By running **grdmath.com,** the PIPS and MODAS blended files, with their inverse masks, are added together in the NCOM synthetic pre-processing for the following day. Persisted files are used to make up for the last record.

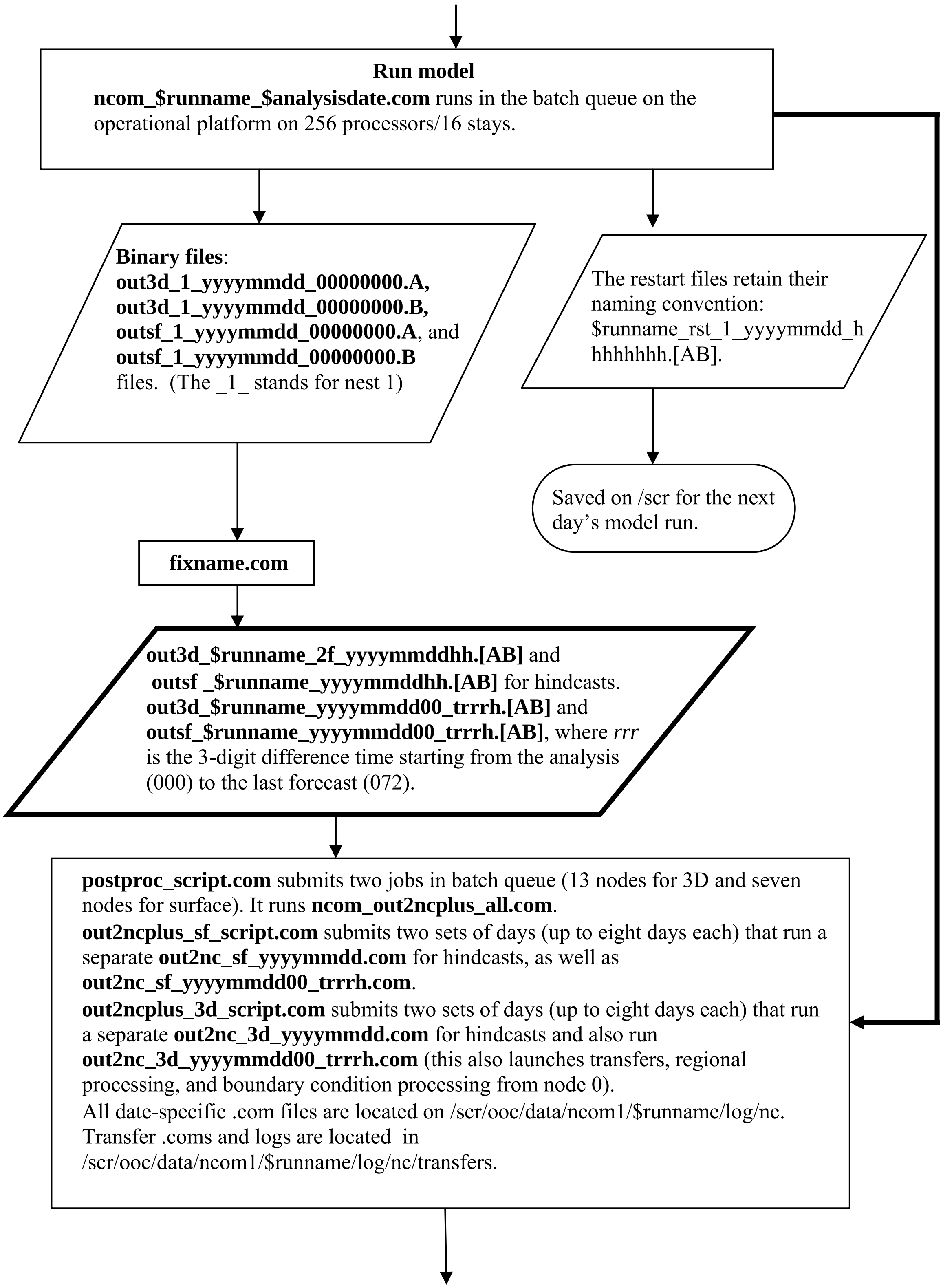
4.0 GLOBAL OCEAN FORECAST SYSTEM V2.6 FLOWCHARTS

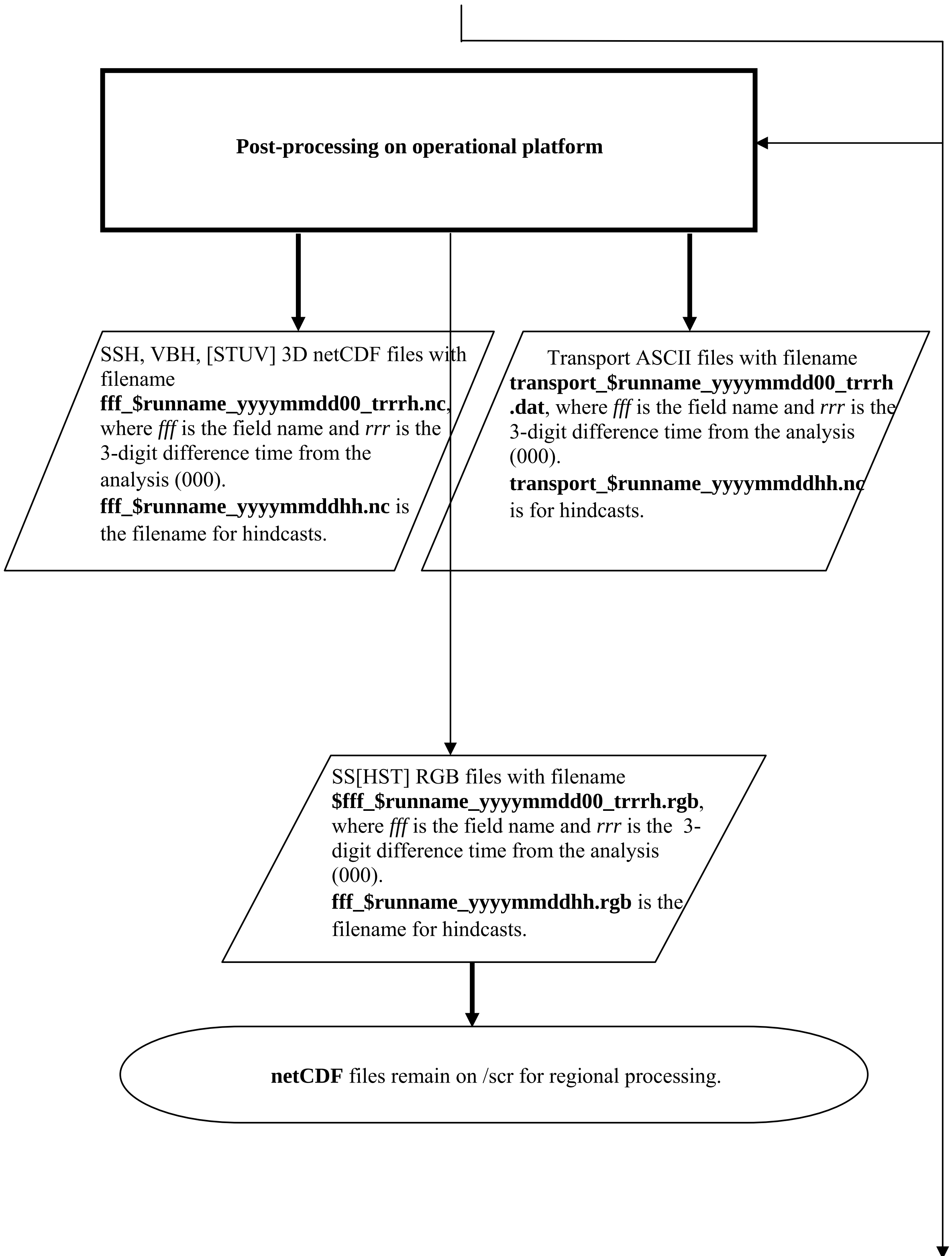
4.1 Operational GOFS V2.6 Flowchart

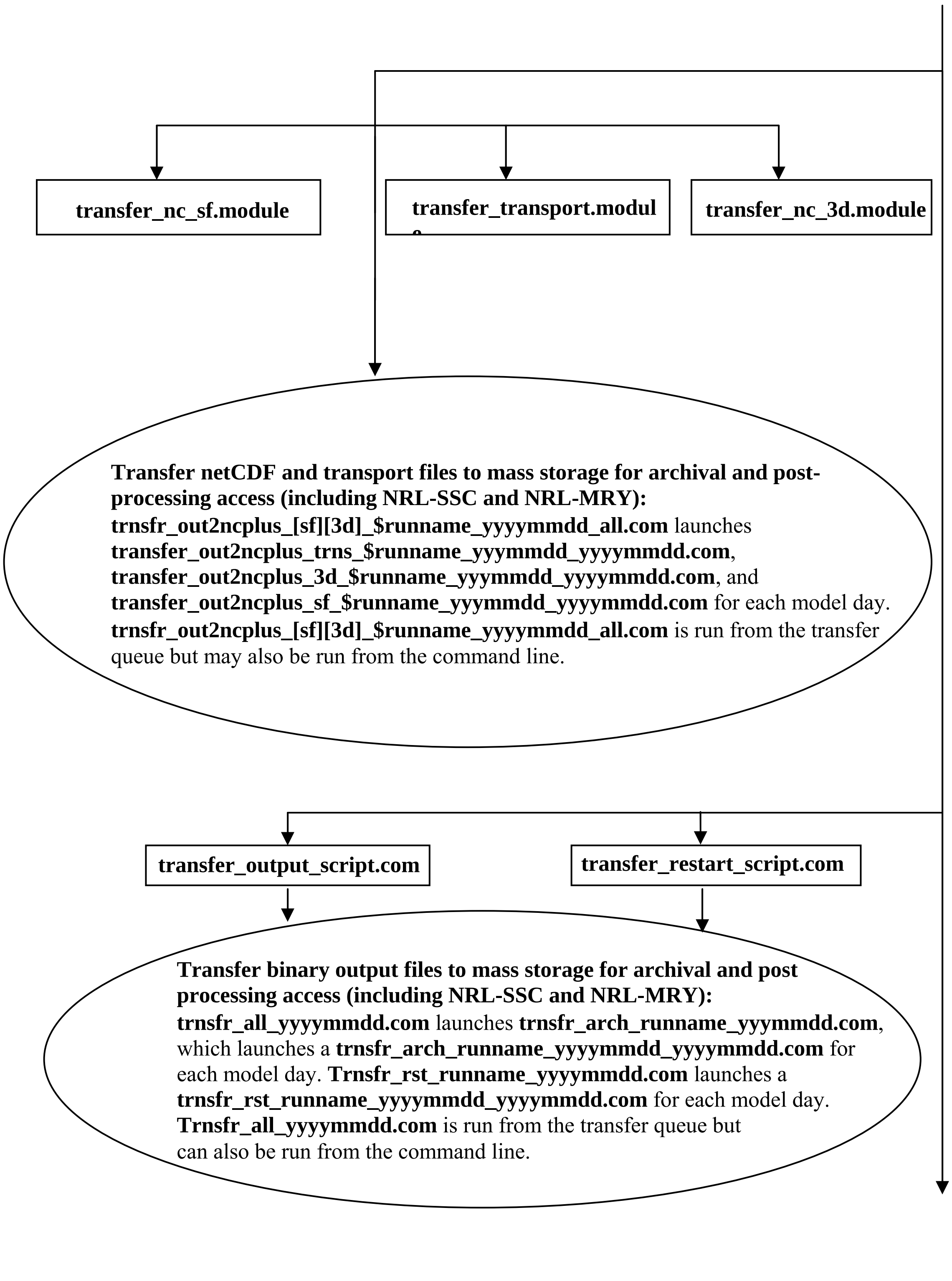


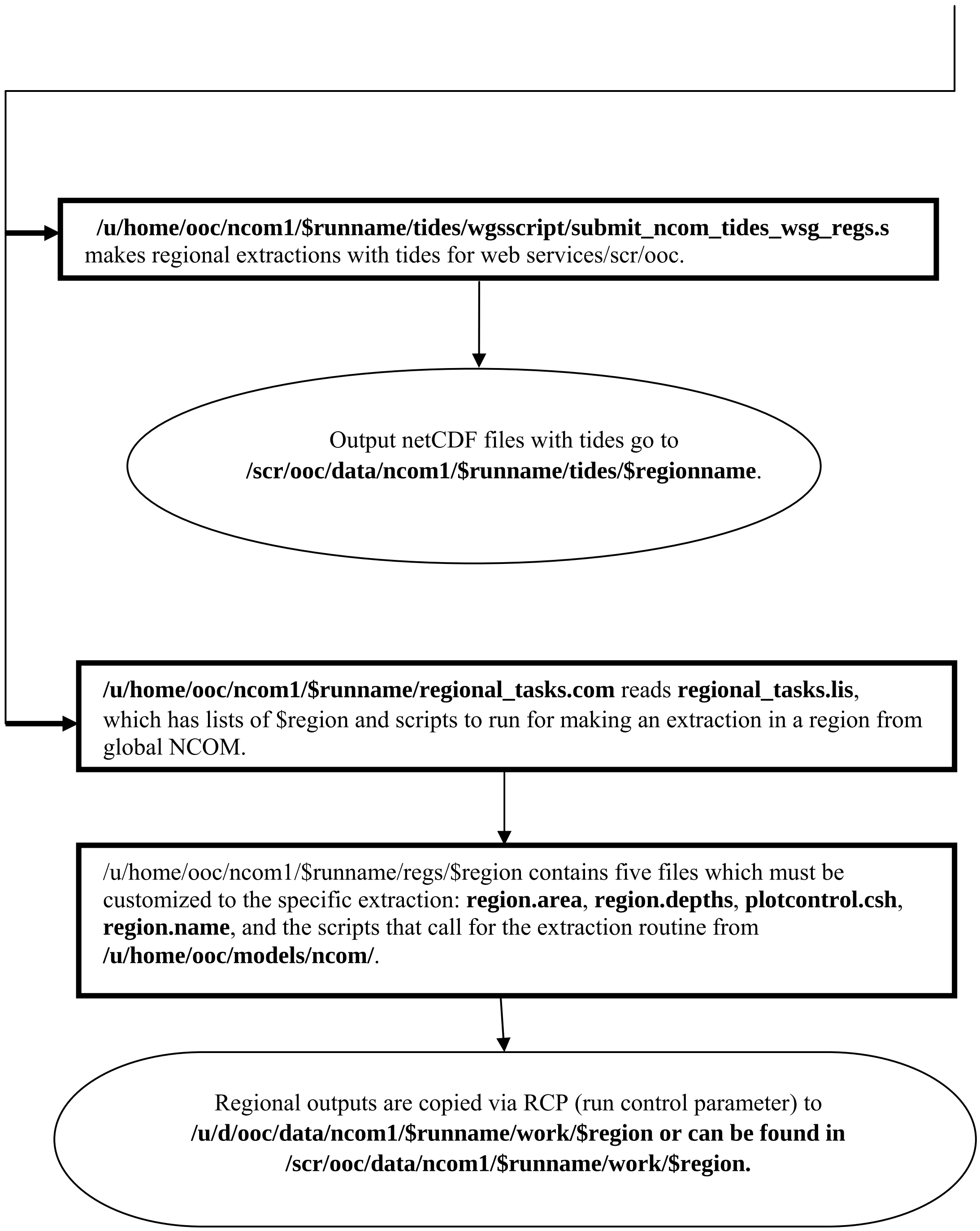

ptsynn_yyyymmdd.nc and ssynn_yyyymmdd.nc as well as sstn_yyyymmdd.bin and sssn_yyyymmdd.bin for each model day plus one at the beginning and one at the end. Copy inputs to NEWTON after tsstartprep (all located in /scr/ooc/data/ncom1/modas/syn/work/glb8_v3b).
master_prep.com
ssttype=1
tstype=5
ncom_sstsss_setup_source.com takes in SSS and SST to make one 2D input file for assimilation.
ncom_tsnc_setup_source.com takes in pt3D and s3D to make 3D input file for assimilation.
Make assimilation input files for model
tsstartprep.com
startdate enddate analysisdate
prep_ts_$startdate_$analysisdate.com
runs in shared queue
otsf_5_$startdate_$analysisdate.A,
otsf_5_$startdate_$analysisdate.B,
osstf_1_1_1_$startdate_$analysisdate.A,
osstf_1_1_1 _$startdate_$analysisdate.B.
ncom_ts_setup_4_$startdate_$analysisdate.log
ncom_sstsss_setup _$startdate_$analysisdate.log
pstnn_$analysisdate.log
(on /scr/ooc/data/ncom1/$runname/log/ts)


NCOM.env
master.awk
master_script.com
Make model script
startrun.com creates
ncom_$runname_$analysisdate.com.
startrun.com checks for all inputs:
outsf/otsf/osstf and the restart files
$runname_rst1_yyyymmdd_00000000.A
and
$runname_rst1_yyyymmdd_00000000.B.
It builds the script and submits the NCOM job to the internal queue on 16 nodes.
ncom_4.0
glb_2a
ohgrd_1.[AB],
ovgrd_1.D,
odimens.D,
oinit_1.[AB],
otscl_1.[AB],
otsza_1.[AB],
orivs_1.D
The restart parameter file
OPARM_1_restart.D, which is stored permanently in
/u/home/ooc/models/ncom1/$runname is copied to
OPARM_1.D (new format for NCOM version 4.0).
OPARM_1.D tells the model how frequently to write outputs
and specifies the types of numerics to do and the types of inputs
to use.

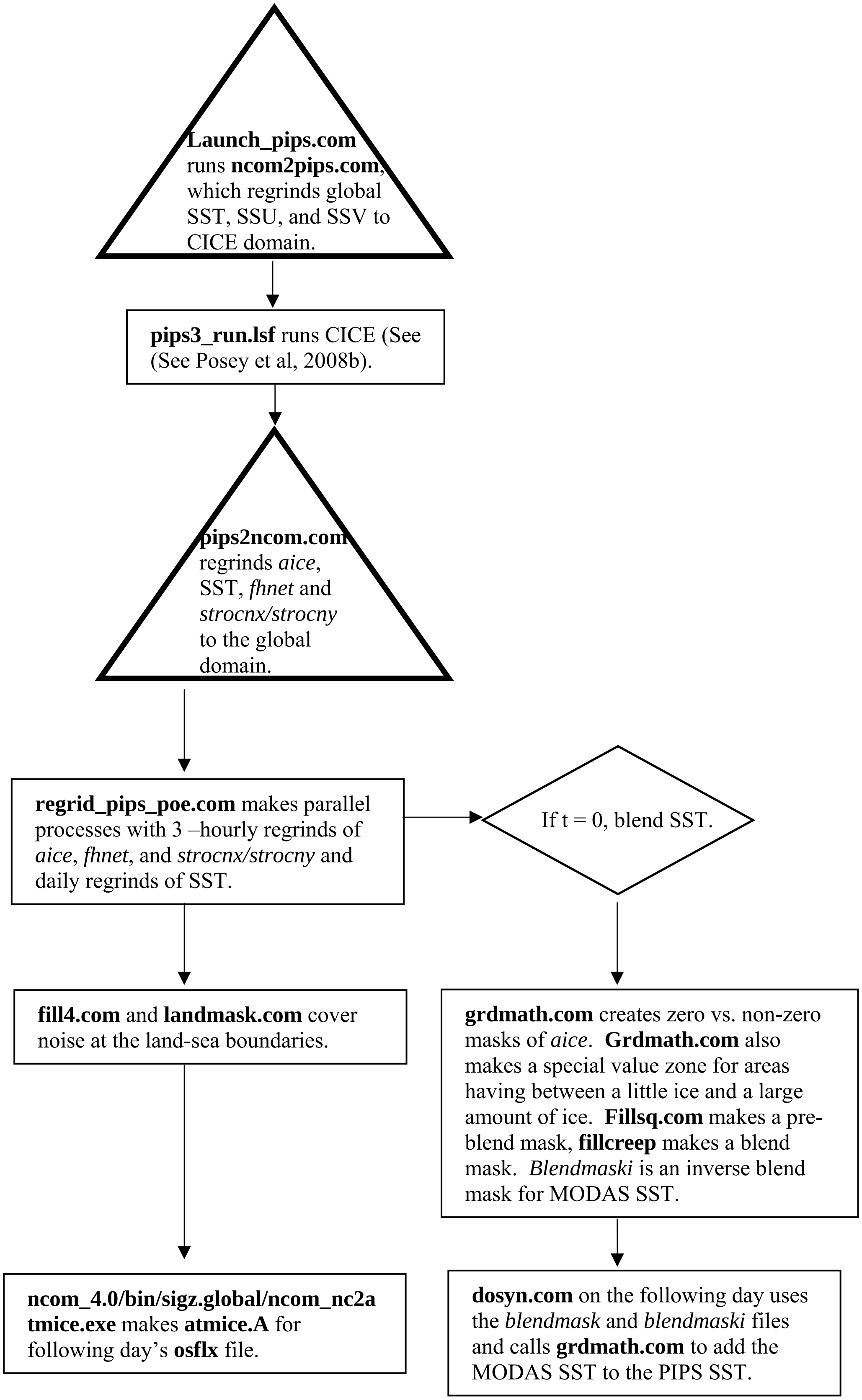

Run model
ncom_$runname_$analysisdate.com runs in the batch queue on the operational platform on 256 processors/16 stays.
Binary files:
out3d_1_yyyymmdd_00000000.A,
out3d_1_yyyymmdd_00000000.B,
outsf_1_yyyymmdd_00000000.A, and
outsf_1_yyyymmdd_00000000.B
files. (The _1_ stands for nest 1)
The restart files retain their naming convention: $runname_rst_1_yyyymmdd_hhhhhhhh.[AB].
Saved on /scr for the next day's model run.
fixname.com
out3d_$runname_2f_yyyymmddhh.[AB] and
outsf _$runname_yyyymmddhh.[AB] for hindcasts.
out3d_$runname_yyyymmdd00_trrrh.[AB] and
outsf_$runname_yyyymmdd00_trrrh.[AB], where rrr is the 3-digit difference time starting from the analysis (000) to the last forecast (072).
postproc_script.com submits two jobs in batch queue (13 nodes for 3D and seven nodes for surface). It runs ncom_out2ncplus_all.com.
out2ncplus_sf_script.com submits two sets of days (up to eight days each) that run a separate out2nc_sf_yyyymmdd.com for hindcasts, as well as out2nc_sf_yyyymmdd00_trrrh.com.
out2ncplus_3d_script.com submits two sets of days (up to eight days each) that run a separate out2nc_3d_yyyymmdd.com for hindcasts and also run out2nc_3d_yyyymmdd00_trrrh.com (this also launches transfers, regional processing, and boundary condition processing from node 0).
All date-specific .com files are located on /scr/ooc/data/ncom1/$runname/log/nc.
Transfer .coms and logs are located in /scr/ooc/data/ncom1/$runname/log/nc/transfers.


Post-processing on operational platform
SSH, VBH, [STUV] 3D netCDF files with filename **fff_$runname_yyyymmdd00_trrrh.nc**, where *fff* is the field name and *rrr* is the 3-digit difference time from the analysis (000). **fff_$runname_yyyymmddhh.nc** is the filename for hindcasts.
Transport ASCII files with filename **transport_$runname_yyyymmdd00_trrrh.dat**, where *fff* is the field name and *rrr* is the 3-digit difference time from the analysis (000). **transport_$runname_yyyymmddhh.nc** is for hindcasts.
SS[HST] RGB files with filename **$fff_$runname_yyyymmdd00_trrrh.rgb**, where *fff* is the field name and *rrr* is the 3-digit difference time from the analysis (000). **fff_$runname_yyyymmddhh.rgb** is the filename for hindcasts.
netCDF files remain on /scr for regional processing.


transfer_nc_sf.module
transfer_transport.modul
transfer_nc_3d.module
Transfer netCDF and transport files to mass storage for archival and post-processing access (including NRL-SSC and NRL-MRY):
trnsfr_out2ncplus_[sf][3d]_$runname_yyyymmdd_all.com launches transfer_out2ncplus_trns_$runname_yyymmdd_yyyymmdd.com, transfer_out2ncplus_3d_$runname_yyymmdd_yyyymmdd.com, and transfer_out2ncplus_sf_$runname_yyymmdd_yyyymmdd.com for each model day.
trnsfr_out2ncplus_[sf][3d]_$runname_yyyymmdd_all.com is run from the transfer queue but may also be run from the command line.
transfer_output_script.com
transfer_restart_script.com
Transfer binary output files to mass storage for archival and post processing access (including NRL-SSC and NRL-MRY):
trnsfr_all_yyyymmdd.com launches trnsfr_arch_runname_yyymmdd.com, which launches a trnsfr_arch_runname_yyyymmdd_yyyymmdd.com for each model day. Trnsfr_rst_runname_yyyymmdd.com launches a trnsfr_rst_runname_yyyymmdd_yyyymmdd.com for each model day.
Trnsfr_all_yyyymmdd.com is run from the transfer queue but can also be run from the command line.


/u/home/ooc/ncom1/$runname/tides/wgsscript/submit_ncom_tides_wsg_regs.s
makes regional extractions with tides for web services/scr/ooc.
Output netCDF files with tides go to
/scr/ooc/data/ncom1/$runname/tides/$regionname.
/u/home/ooc/ncom1/$runname/regional_tasks.com reads regional_tasks.lis, which has lists of $region and scripts to run for making an extraction in a region from global NCOM.
/u/home/ooc/ncom1/$runname/regs/$region contains five files which must be customized to the specific extraction: region.area, region.depths, plotcontrol.csh, region.name, and the scripts that call for the extraction routine from /u/home/ooc/models/ncom/.
Regional outputs are copied via RCP (run control parameter) to
/u/d/ooc/data/ncom1/$runname/work/$region or can be found in
/scr/ooc/data/ncom1/$runname/work/$region.

4.2 Polar Ice Prediction System (PIPS) 3.0 Flowchart



5.0 TROUBLESHOOTING GOFS V2.6

Problem	Solution
Model has not queued by three hours after initial sourcing of **dailyncom.com**.	Look in queues for any other OOC jobs with names containing *atm*, *ts*, or *syn*. If none are in the queue, backtrack to /scr/ooc/data/ncom1/$runname/input to look for inputs.
Osflx files do not exist in /scr/ooc/data/ncom1/$runname /input.	Go to /scr/ooc/data/ncom1/$runname/log/atm. A resubmission of **prep_atm_yyyymmdd.com** will probably catch any missing inputs due to late NOGAPS transfer.
Otsf files do not exist in /scr/ooc/data/ncom1/$runname /input.	Go to /scr/ooc/data/ncom1/$runname/log/syn. If one of the log files for a particular day is much smaller than the others, resubmit that one day by going to /home/ooc/models/ncom1/modas/syn/regs/glb8_v3b and manually typing `qdosyn.com yyyymmdd`. If all days have problems go back to /home/ooc/models/ncom1/$runname and type `syn_prep_poe.com –idtg1start yyyymmdd –idtg1end yyyymmdd -idtg1analysis yyyymmdd`.
Model is still not in queue. It is prior to the reservation time and all inputs exist and are standard size.	Check the log file in /scr/ooc/data/ncom1/$runname/log called **ncom_prep_yyyymmdd.log**. Do a tail, and if the end is still within the loop, look for the full size **otsf** file, wait ten minutes, and see if it queues.
Model did not queue before reservation time.	Edit /u/home/ooc/models/ncom1/$runname/ncom_$runname_yyyymmdd.com by taking out the *startdate* line at top and changing from internal to batch queue. The model has missed its reservation but can wait for an opening in the queues to run regularly.
Post-processing did not complete.	Go to /scr/ooc/data/ncom1/$runname/log/nc for log files. If a rerun is needed, go to /u/home/ooc/models/ncom1/$runname/ and run `csh postproc_script.com –idtg1start yyyymmdd –idtg1end yyyymmdd -idtg1analysis yyyymmdd.`
Files did not transfer.	Transfers can also be run interactively or resubmitted to the transfer queue. Go to /scr/ooc/data/ncom1/$runname/log/transfers for model output and to /scr/ooc/data/ncom1/$runname/log/nc/transfers for converted netCDF outputs. Look for .com files with *all* and the *analysis date* in the filenames. Resubmit the *all* .com files with `allsubmit` to the transfer queue or with the csh filename on the command line.

A regional extraction did not run in the regular pre-processing or it needs to be rerun or run for another date.	Go to /u/home/ooc/models/ncom1/$runname/regs/${regionname} Most regional extractions are set up with a README file, where a local script is run with an input of an analysis date. Ex: **ncom2points.com** –`idtg1analysis yyyymmdd`
CICE did not run.	The **/scr/ooc/data/ncom1/pips/pipsfrcst/atmice.A** file should exist from the previous day. If present, NCOM pre-processing will use it. The PIPS SST fields will be persisted in the MODAS pre-processing.
NCOM gives error at start of initial check stating T is below allowed value	Run /u/home/ooc/models/ncom1/ncom_4.0/bin/sigz.global/ncom_fixrst.exe on first hindcast day's restart file. Use restart file name, and (2048, 1280, 40) values as inputs.

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7.0 NOTES

7.1 Acronyms and Abbreviations

Acronym	Description
ASCII	American Standard Code for Information Interchange
CICE	Los Alamos Sea Ice Model
COAMPS	Coupled Ocean Atmosphere Mesoscale Prediction System
cpp	C compiler
DoD	Department of Defense
DTG	Date Time Group
ECMWF	European Center for Medium-range Weather Forecast
GB	GigaByte
GDEM	Global Digital Elevation Map
GOFS	Global Ocean Forecast System
HPCMP	High Performance Computing Modernization Program
IEEE	Institute of Electrical and Electronic Engineers
I/O	Input/Output
IP	Internet Protocol
MB	MegaByte
MLD	Mixed Layer Depth
MODAS	Modular Ocean Data Assimilation System
MPI	Message Passing Interface
DSRC	DoD Supercomputing Resource Center
NCODA	Navy Coupled Ocean Data Assimilation
NCOM	Navy Coastal Ocean Model
netCDF	Network Common Data Form
NLOM	Navy Layered Ocean Model
NOGAPS	Navy Operational Global Atmospheric Prediction
NRL-SSC	Naval Research Laboratory, Stennis Space Center
NRL-MRY	Naval Research Laboratory, Monterey
OCNQC	Quality Controlled Ocean Data
OOC	Optimizing Oberon-2 Compiler
PIPS	Polar Ice Prediction System
RCP	Run Control Parameter
S	Salinity
SDD	Software Design Description
SSC	Stennis Space Center
SSH	Sea Surface Height
SSS	Sea Surface Salinity

Acronym	Description
SST	Sea Surface Temperature
SVN	Subversion
T	Temperature