OS4.1 X4.80 5634: Providing Ocean Forecasts During Unmanned Warrior 2016

Richard Allard[1], Chery Ann Blain[1],Timothy Campbell[1], Anna Crawford[2], Kacey Edwards[1], Paul Martin[1], Michael Phelps[3], and Travis Smith[1]
[1]Naval Research Laboratory, Stennis Space Center, MS, USA
[2]Defence Research and Development Canada, Halifax, Nova Scotia, Canada
[3]Jacobs Engineering, Stennis Space Center, MS USA

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A coupled nested ocean-wave modeling system supported the Unmanned Warrior 2016 Exercise in Loch Alsh, Scotland for the period of September 10 – October 16, 2016. Utilizing available bathymetry from the UK Hydrographic Office and shallow-water bathymetry collected in April 2016, a 250 m host and 46 m inner nest of the Navy Coastal Ocean Model (NCOM) and the Simulating Waves Nearshore (SWAN) model were run twice daily with atmospheric forcing from a nested 3/1 km Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS). The coupled system produced 72-hr forecasts of ocean currents and wave heights for the exercise operating areas. The model forecasts were used to provide guidance in mission planning for the use of unmanned underwater vehicles in the Kyle of Loch Alsh. We show comparison of the NCOM's tidal prediction versus tide gauge data and modeled currents versus ADCP data collected during the exercise.

Overview of Modeling Sequence

NAVO RELO giuk (kilrain)
0.025° x 0.025° resolution
00Z 96 hour forecast completed by 1306 UTC (0806 CDT)

NAVGEM (FNMOC)
00Z forecast fields ready by 0700 UTC (0200 CDT)
12Z forecast fields ready by 1900 UTC (1400 CDT)

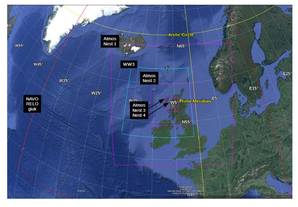
NCOM Nest 1 OBC Setup (kilrain)
Job queues at 1310 UTC (0810 CDT)
Completed by 1316 UTC (0816 CDT)
OBC files tarred and ftp'd to ftp7320

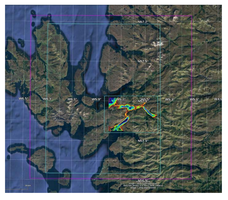
Atmosphere (hatm) (NRL)
27km, 9km, 3km, 1km nests
Running on 64 processors (12-core nodes)
Cron submits 00Z job at 0700 UTC (0200 CDT)
Cron submits 12Z job at 1900 UTC (1400 CDT)
00Z 12 hour forecast completed by 0720 UTC (0220 CDT)
12Z 72 hour forecast completed by 2100 UTC (1600 CDT)

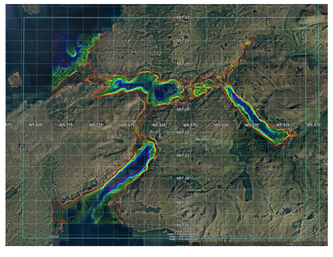
WW3 (hwav) (NRL)
0.1° x 0.05° resolution (~5.5km)
Running on 100 processors (20-core nodes)
Cron submits job at 2100 UTC (1600 CDT)
Prep checks for hatm completion
12Z 72 hour forecast completed by 2110 UTC (1610 CDT)
Submits Nest 1 job

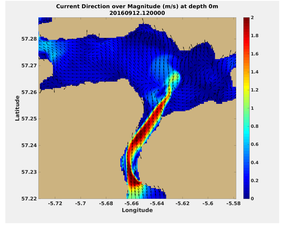
NCOM+SWAN Nest 1 (nst1) (NRL)
0.004° x 0.002° resolution (~230m)
Running on 98 processors (20-core nodes)
Prep checks for hatm & hwav completion & untars OBC files
12Z 72 hour forecast completed by 2140 UTC (1640 CDT)
Submits Nest 2 job

NCOM+SWAN Nest 2 (nst2) (NRL)
0.0008° x 0.0004° resolution (~46m)
Running on 288 processors (24-core nodes)
Prep checks for hatm & nst1 completion
12Z 72 hour forecast completed by 0040 UTC (1940 CDT)

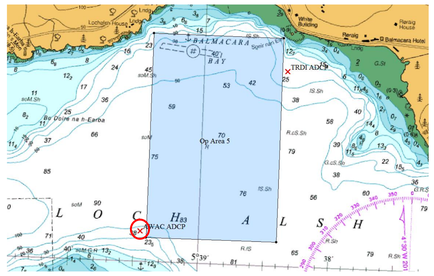


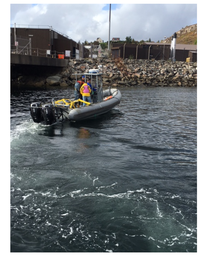




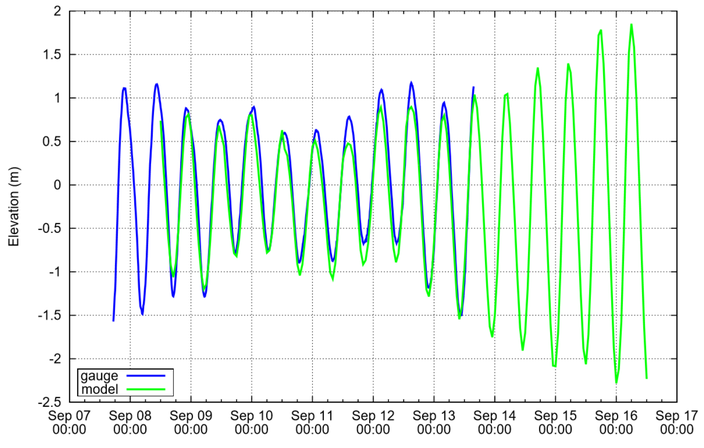


Nested modeling configuration. Figure on bottom left depicts 46m coupled ocean-wave domain. Lower right figure depicts typical forecast product of current vectors overlaid on magnitude.



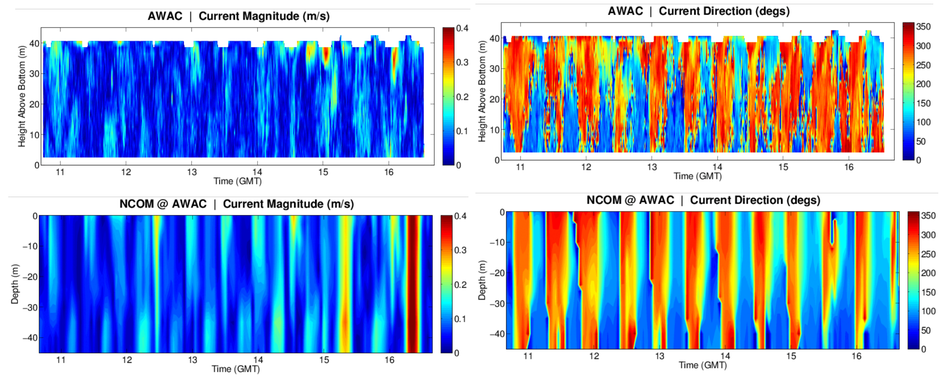


A Nortek AWAC ADCP was deployed near the Southwest corner of Op Area 5 in 45 m of water, shown above, at 57° 16.82622' N, 5° 39.4470' W. It was programmed to measure currents and surface waves with separate sets of profiling transmissions. The averaged currents output is every 10 minutes, skipping the times when waves profiling was underway, i.e. at 0, 20, 30, 40 and 50 minutes each hour.

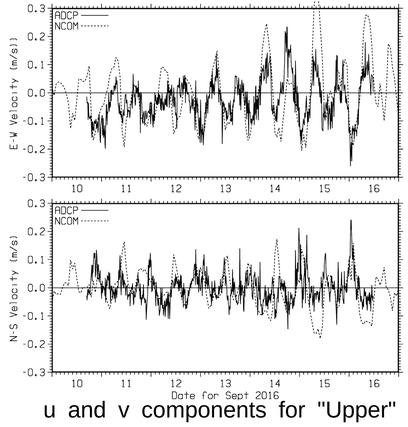


Tide gauge data (blue line) deployed by the UK Royal Navy at the Loch Alsh pier (57.279° N, -5.707 ° W) versus tides predicted (green line) by the U.S. Navy's Navy Coastal Ocean Model (NCOM) which is forced with modeled winds. Overall, the model agrees well with phase, with maximum amplitude differences on the order of 25-30 cm. Note that the Oregon State University tidal database used in NCOM does not resolve the tides in Loch Alsh, but gives an idea of the overall tidal amplitude. The tides are strongly semi-diurnal and increase steadily starting at 0Z on Sep 12 up to 0Z Sep 17 - the sea surface height amplitude more than triples over this 5-d period from 65-75 cm to 225 cm. Discrepancies could be due to errors in tidal constituents we are using, missing tidal constituents, and errors in non-tidal forcing, e.g., wind effects, etc.

ADCP Comparison



Top left) Observed ADCP current magnitude for the period of Sept 10-16, 2017; right) ADCP current direction; Bottom: NCOM currents (left) and direction (right)



u and v components for "Upper" ADCP current versus NCOM current at 5m depth.

Left) looking west toward Skye bridge
Right) looking east toward Loch Alsh

Discussion

Both the NCOM and ADCP currents show a strong, semi-diurnal, tidal signal, with a flood tide to the WNW at 12-2a and at 12-2p, and an ebb tide to the ESE between the flood tides. The ebb tide to the ESE is stronger than the flood tide to the WNW, and the tides are much stronger towards the latter part of the 7-day period. The tidal signal is modulated by wind events, and these are probably less well-simulated than the tides. The observed currents are much noisier than the model currents, and there seems to be more noise during the peak tidal currents, but this could be attributed to the change in the tidal current at peak tide which is small, so the noise is more apparent. The atmospheric forcing is too coarse to respond to the local orography in this area. This is evident in animations (not shown) of COAMPS surface winds that indicate little to the land areas. Waves were not prominent in this region during the period of September 9-17. A moored wave gauge recorded a maximum of 35cm on Sept 12, while SWAN indicated a 20cm wave height. The AWAC surface wave measurements were excessively noisy due to the small wave heights and water depth at the deployment location.