Coupled Regional Weather Modeling Using UD HPC Resources

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Outline

- Model description

- Computing needs

- Coupled modeling
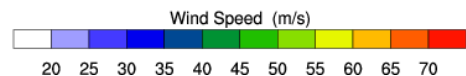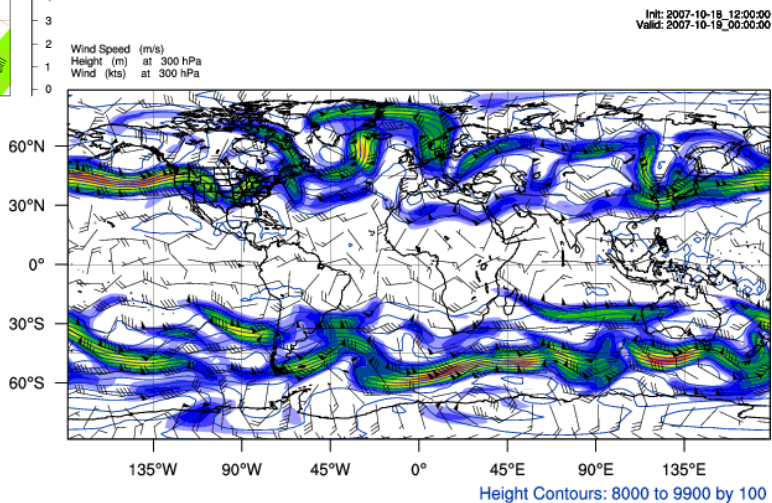
- Sample results

Weather Research and Forecasting – WRF
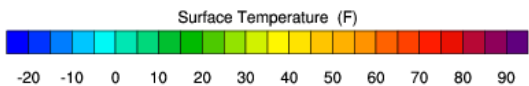
- State-of-the-art regional (mesoscale) atmospheric model
- Managed by the National Center for Atmospheric Research (NCAR)
- Modules contributed by scientists around the world
- Used for both research and operational weather forecasting
- Predominantly written in Fortran, with C wrappers
- Comprehensive variable registry
- Automated code development during initial compilation

Surface Temperature (F)
Sea Level Pressure (hPa)
Wind (kts)

Cape Hatteras (NC,USA) at 2000-01-24_12:00:00

Init: 2007-10-18_12:00:00
Valid: 2007-10-19_00:00:00

Wind Speed (m/s)
Height (m) at 300 hPa
Wind (kts) at 300 hPa

Sea Level Pressure Contours: 900 to 1100 by 4

Height Contours: 8000 to 9900 by 100

Surface Temperature (F)

-20 -10 0 10 20 30 40 50 60 70 80 90

http://www2.mmm.ucar.edu/wrf/users/

Wind Speed (m/s)

20 25 30 35 40 45 50 55 60 65 70

Model Computing Configuration

- Model can be run in a simple configuration on a single compute core
- Almost all modules compatible with MPI for complex model configurations and large, finely gridded domains
- Originally developed by NCAR with PGI compilers and AMD processors in mind
- Model consists of 2 primary components
  - WRF itself and all of its associated physics modules (wrf.exe, real.exe)
  - WPS: WRF Preprocessing System to prepare all of the input streams (geogrid, ungrib, metgrid)

Coupled Modeling

- Earth system is highly complex, so adding more components can improve results

- COAWST – Coupled Ocean-Atmosphere-Wave-Sediment Transport Model
  - WRF
  - SWAN (Simulating Waves Nearshore)
  - ROMS (Regional Ocean Modeling System)
  - Also includes sediment transport and sea ice model components
  - Coupled using the Model Coupling Toolkit (MCT)

http://woodshole.er.usgs.gov/operations/modeling/COAWST/
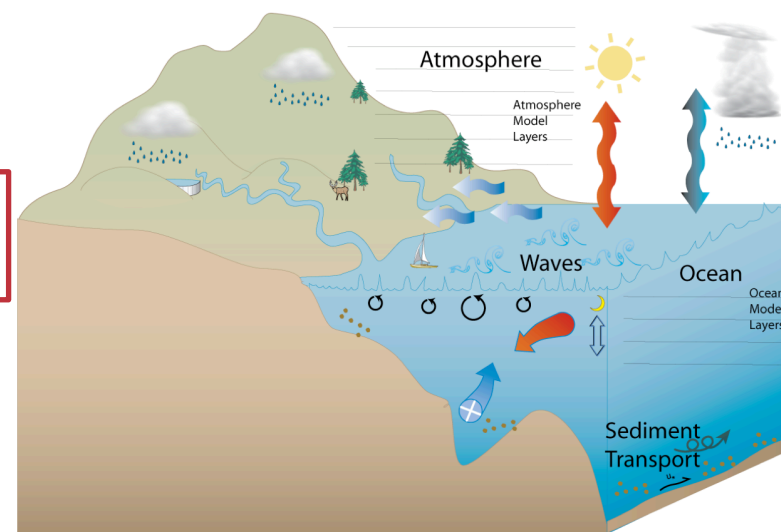
Mills Configuration

- VALET packages
  - NetCDF
  - PGI
  - OpenMPI
  - MCT (for coupled model)
- Compilation of WRF takes about 20-25 minutes
- Compilation of WPS takes less than 5 minutes
- Adding SWAN with COAWST only adds several minutes to the WRF compilation

Challenges

- Compiler flags
    - `DM_CC = mpicc –DMPI2_SUPPORT –DMPI2_THREAD_SUPPORT`
- Package locations
    - COAWST uses some unique environment variables
    - `MCT_INCDIR=/opt/shared/MCT/2.8.3/include` (for example)
- COAWST initialization issue with 3 WRF grids
- MPI knowledge
- Tutorial assembly!

Model Setup

- 3 WRF domains at 36, 12, 3 km grid resolution

- 2 SWAN domains at 6, 2 km grid resolution

- Fully coupled, with information passing between models every 9 minutes of model time

- 30 hour model run time

- Initial/boundary conditions provided by North American Regional Reanalysis (NARR) data

- Run using 88 cores (64 WRF, 24 SWAN), taking ~6 hours
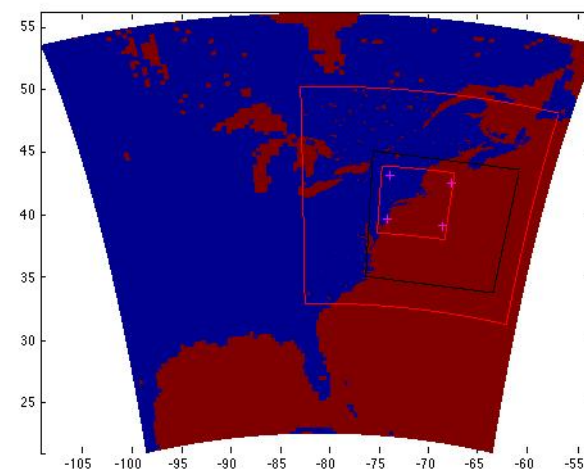
Some Results – 18 Jan 2011
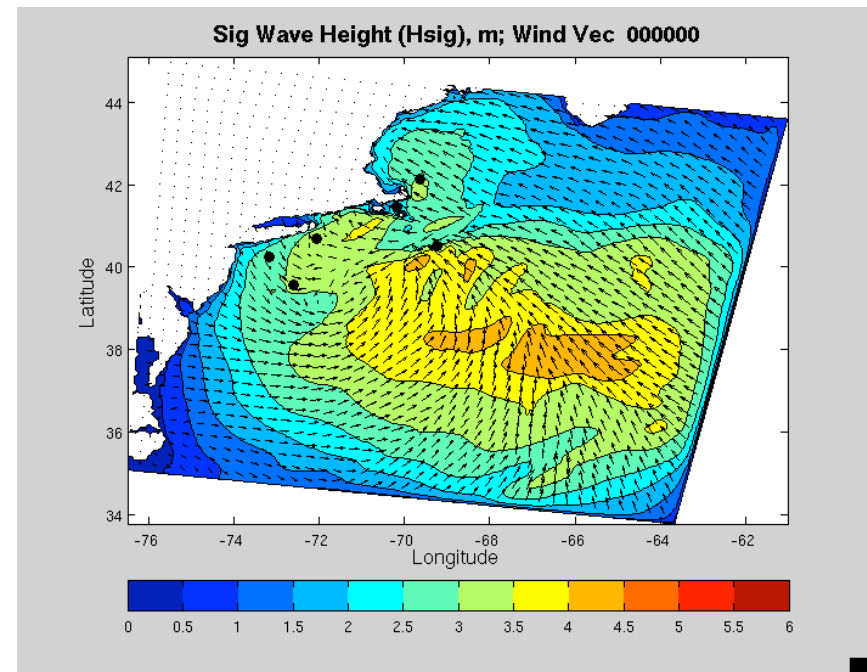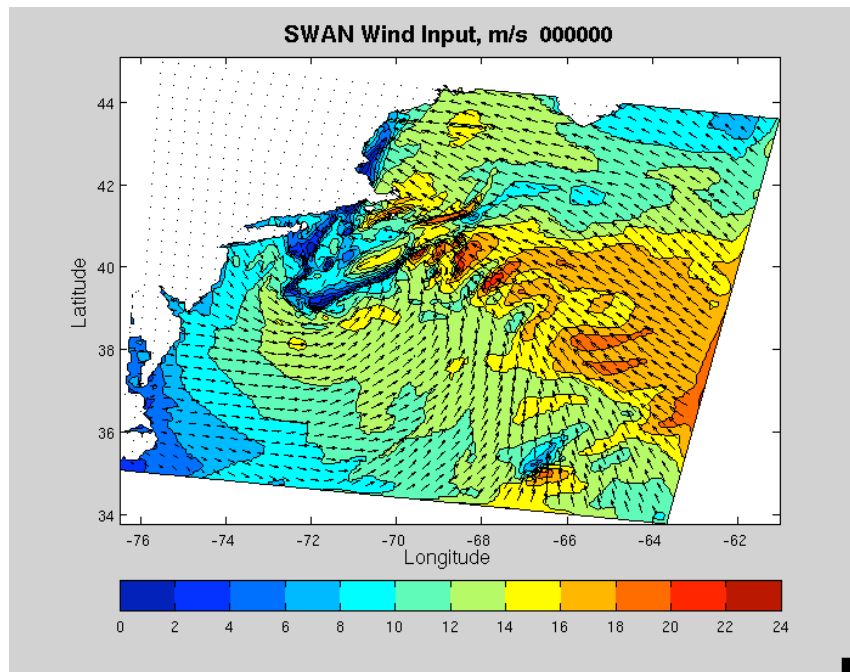
Conclusions & Discussion Points

- Compute time at national labs or other universities can be expensive and/or difficult to gain access to

- Complex Earth system modeling requires significant computing resources

- HPC at UD allows for immediate access to powerful resources

- Next Steps:
  - Dissertation work: modeling offshore wind farms in WRF
  - Operational weather model forecasting (Farber)