Operational Ocean Forecasts at NWS/NCEP: Current Status and Future plans

Avichal Mehra¹
Modeling and Data Assimilation Branch

¹NOAA/NWS/EMC, MD, USA

OceanPredict ’19 - GODAE OceanView Symposium 2019
May 7, 2019, Halifax, NS
Outline

- **Current Operational Systems**
  - Global
  - Regional/Hurricane

- **Future Operational Systems**
  - Global
  - Regional/Hurricane

- Operational Users

- Operational/Transition Challenges
Current: Climate Forecast System (CFS v2) at NCEP

- **Ocean Model**: MOMv4, fully global, 1/2°x1/2° (1/4° in tropics), 40 levels
- **Atmospheric Model**: GFS (2007), T382, 64 levels
- **Land Model**: Ice Mdl SIS
- **Ice Ext**: 6hr
- **GODAS 3DVAR**: 6hr

[http://cfs.ncep.noaa.gov/cfsr](http://cfs.ncep.noaa.gov/cfsr)
Current: Real Time Ocean Forecast System (RTOFS v1.2) at NWS/NCEP

- Eddy Resolving Ocean Modeling and Initialization
- Coupled Modeling for Hurricanes (Air-Sea-Wave flux interactions, mixing)
- Coupled Modeling for Weather and S2S scales (Air-Ocean-Sea Ice-Wave flux interactions, ensembles)
- Coupled Ecosystem Forecasting (Biogeochemical, NPZD, tracers)
- RTOFS presently based on HYCOM

Strong collaboration with US Navy, leveraging core HYCOM and ocean data assimilation developments at NRL.
Current: Operational HWRF (Hurricane Weather Research and Forecast) System

- HWRF continuously improved in the past six years through support from HFIP
- Successful community modeling approach for accelerated transition of research to operations
  - Three nested domains at a horizontal resolution of 13.5/4.5/1.5 kms
  - Formal vortex initialization and GSI-based data assimilation
  - Actively coupled to Ocean models in all global basins
  - Actively coupled to Wave model (WW3) in NHC basins
  - Inner-core DA including real-time data from recon missions (TDR, dropsondes, SFMR etc.)

Results from annual retrospectives

Expanded international partnerships & collaborations

2017 HWRF
**Current: Operational HMON at NWS/NCEP**

**HMON: Hurricanes in a Multi-scale Ocean coupled Non-hydrostatic model**

**HMON:** Implements a long-term strategy at NCEP/EMC for multiple static and moving nests globally, with one- and two-way interaction and coupled to other (ocean, wave, land, surge, inundation, etc.) models using NEMS-NUOPC infrastructure. Precursor to FV3-based systems.
Future Operations at NWS/NCEP: Simplify Production Suite

... we will move to a product based system that covers all present elements of the productions suite in a more systematic and efficient way.

Starting from the quilt of models and products created by the implementing solutions rather than addressing requirements ....
• NOAA GFDL FV3 selected for dynamic core component of NGGPs
  – Using Non-hydrostatic option
  – GFS v15 (based on FV3) becomes operational in 2019
  – Initial configuration uses C768 (~13km); L64 (55km top)
  – Adaptation of current hybrid 4DEnVar scheme
  – Regridding to accommodate current DA infrastructure
Future: FV3-based Unified Forecast System

- NWS UFS system consists of the following components (at the moment)
  - NEMS for infrastructure
  - FV3 dycore with Physics driver (IPD)
  - MOM6 ocean model (S2S scales)
  - HYCOM ocean model (weather scales)
  - WW3 wave model
  - CICE5 ice model
  - GOCART aerosol model
  - Noah MP land model
- Each component has its own authoritative repository. NEMS infrastructure allows flexibility to connect instantiations of the repositories together to create a coupled model.
Future: Unified DA Effort - JEDI

- The Joint Effort for Data assimilation Integration (JEDI) is a collaborative development spearheaded by the JCSDA:
  - Next generation unified data assimilation system
    - For research and operations (including R2O/O2R)
    - For various components of the earth system, including coupled
    - Mutualize as much as possible without imposing single approach
      - Open-development software – model: in addition to supported releases, community, developers can obtain and collaborate on latest development branches
  - Collaborative teams – NOAA, NASA, US NAVY

- The Marine JEDI DA system for NOAA/NCEP is through SOCA (Sea-ice Ocean Coupled Assimilation)
Future: Hurricane Analysis and Forecast System (HAFS)

A collaborative effort within the Unified Forecast System (UFS) Framework.
HAFS Experimental Configurations

HAFS V0.A SAR domain

The NATL basin focused standalone regional domain configuration
- C768 with a refinement ratio of 4
- the regional domain size: 2880x1920 (~85x56deg)
- The blue box indicates the output grid

HAFS V0.B nest domain

The NATL basin focused global-nesting domain configuration
- C768 with a refinement ratio of 4
- the nested domain size of 2880x1536 (~85x45deg)
Operational Ocean Forecasts at NCEP: Users

**NOAA:**
- **NWS** (EMC, CPC, NHC, OWP);
- **NOS** (Coastal & Estuarine OFS; IOOS, WCOFS);
- **OAR** (PMEL, AOML, CPO, ESRL);
- **NESDIS** (Ocean Color, Sea Ice, SSS, ADT)

**Non-NOAA Federal:**
- US Coast Guard
- JCSDA,
- FDA, USGS, other federal agencies

**Others:**
- Universities
- International Projects
- Private Industry
Operational Ocean Forecasts at NCEP: Challenges

**Coupled Modeling:**
- Modern architectures for coupling
- Community Modeling; common code bases
- Unified systems for operational applications

**Coupled Data Assimilation:**
- Modern architectures for object oriented methods, community-based efforts (JEDI)
- Enable and explore coupled DA
- Modern cross-component databases
Operational Ocean Forecasts at NCEP: Challenges

Enhanced Probabilistic Guidance:

- Use of ensembles and super-ensembles
- Advanced post-processing for improved uncertainty measures
- Co-ordination amongst national and international efforts

Advanced Ocean Observation Systems:

- Adaptive in-situ systems for rapid response deployment (e.g. for Hurricanes)
- Use of forecast uncertainties for enhanced observation systems
- Use of advanced/improved sensors on future satellites
Operational Ocean Forecasts at NCEP: Challenges

Modern Computing Architectures/ Cloud Servers:

- Software Engineering practices
- Hybrid CPU/GPU platforms
- Cloud-based resources
Thank You!
Operational Ocean Forecasts at NCEP: Status

Global Models:

- **Current:**
  - Real Time Ocean Forecast System (RTOFS) based on HYCOM for weather scales at 1/12°
  - Climate Forecast System (CFS) based on MOM4 for sub-seasonal to seasonal scales at 1/2°

- **Future:**
  - Unified Forecast System (UFS) with MOM6 coupled to FV3 and CICE6, initially for sub-seasonal to seasonal applications

Regional (Hurricane) Models:

- **Current Status:**
  - HWRF coupled to MPIPOM and HYCOM at 1/12°
  - HMON coupled to HYCOM at 1/12°

- **Future:**
  - Hurricane Analysis and Forecast System (HAFS) with FV3 based Hurricane model coupled to HYCOM (initially) and MOM6 when available.
Current: NWS/NCEP Operational Hurricane Forecasting Models

- **HWRF/HYCOM**: North West Pacific, North Indian Ocean, Southern Hemisphere Basins. Initial Conditions (IC) come from Global RTOFS nowcast.
- **HMON/HYCOM**: North Atlantic, North East Pacific, Central Pacific Basins. IC come from climatology and SSH-based feature model.
- **HWRF/MPIPOM**: North Atlantic Basin. IC from Global RTOFS nowcast.
- **HWRF/MPIPOM**: North East Pacific, Central Pacific Basins. IC from Global RTOFS nowcast.