NOAA Update

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SPARC DA and S-RIP Workshop – October 17-21, 2016 – Victoria, BC
Topics

- Recent Upgrades
- NCEP Production Suite
- Model Advisory Committee Recommendations
- NEMS
- NGGPS
- FV3 Dynamic Core
- Conventional Observation Reanalysis (CORe)
Recent Global Implementations

- GFS T1534 (~13 km) Semi-Lagrangian 2015
- GSI (4D hybrid en var) 2016
- GEFS (higher resolution: T574L64, 20 member)
- CFS V2.2.0 (data assimilation upgrade)
- NEMS GFS Aerosol Component - NGAC
  - all aerosol types: dust, sea salt, carbonaceous aerosols, and sulfate
- *Future*: L128, raise top to 0.01hPa
## 2016 GFS Implementation Score Card

### Anomaly Correlation

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*SPARC DA and S-RIP Workshop – October 17-21, 2016 – Victoria, BC*
Temperature RMS error is better in troposphere but is worse in Stratosphere in NH and Tropics
Seamless Suite: Spanning Weather and Climate

Forecast Lead Time

- Outlook
- Guidance
- Threats
- Assessments
- Forecasts
- Watches
- Warnings & Alert Coordination

Forecast Uncertainty

- Seasons
- Months
- 2 Week
- 1 Week
- Days
- Hours
- Minutes

Benefits

- Life & Property
- Aviation
- Maritime
- Space Operations
- Fire Weather
- Emergency Mgmt
- Commerce
- Energy Planning
- Hydropower
- Reservoir Control
- Agriculture
- Recreation
- Ecosystem
- Health
- Environment

- Climate Forecast System
- North American Ensemble Forecast System
- Global Ensemble Forecast System
- Global Forecast System
- Global Dust
- Short-Range Ensemble Forecast
- Wave Ensemble
- North American Mesoscale
- Waves
- Global Ocean
- Bays
- Fire Wx
- Regional Hurricane
- Space Weather
- Storm Surge
- Rapid Refresh (HWRF & GFDL)
- Dispersion (smoke)
- Air Quality
- Tsunami
- Whole Atmosphere
- HRRR
- NMME
- NLDAS

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Production suite ca. January 2014

- **Climate Forecast System (CFS)**
  - GFS, MOM4, NOAH, Sea Ice

- **Regional Hurricane**
  - GFDL WRF-NMM

- **Regional NAM**
  - NMMB
  - NOAH

- **Short-Range Ensemble Forecast**
  - WRF(ARW, NMM) NMMB

- **High Res Windows**
  - WRF(ARW, NMM) & NMMB

- **Regional Bays**
  - Great Lakes (POM)
  - N Gulf of Mexico (FVCOM)
  - Columbia R. (SELF)
  - Chesapeake (ROMS)
  - Tampa (ROMS)
  - Delaware (ROMS)

- **Air Quality**
  - CMAQ

- **Rapid Refresh**
  - WRF ARW

- **Space Weather**
  - ENLIL

- **Dispersion**
  - HYSPLIT

- **Ecosystem**
  - EwE

- **North American Land Surface Data Assimilation System**
  - NOAH Land Surface Model

- **Global Ensemble Forecast System (GEFS)**
  - 21 GFS Members

- **North American Ensemble Forecast System**
  - GEFS, Canadian Global Model

- **Global Forecast System (GFS)**
  - Global Spectral NOAH

- **3D-Var DA**

- **3D-En-Var DA**

- **Production suite ca. January 2014**

- **SPARC DA and S-RIP Workshop – October 17-21, 2016 – Victoria, BC**

**Additional References**
- SPARC DA and S-RIP Workshop – October 17-21, 2016 – Victoria, BC
- SPARC DA and S-RIP Workshop – October 17-21, 2016 – Victoria, BC
Complex Array of Models

- Been aware that NCEP runs too many models of different cores, physics, etc
- Burden on computing system
- UCAR review of modeling system
UMAC Overarching Recommendations

- Reduce complexity of the NCEP Production Suite.
- A unified, collaborative strategy for model development across NOAA is needed.
- Leverage the capabilities of the external community.
- Continue to enhance High Performance Computing capabilities.
- Execute strategic and implementation plans based on stakeholder requirements.

University Corporation for Atmospheric Research (UCAR)
UCAR Community Advisory Committee for NCEP (UCACN)
UCACN Model Advisory Committee (UMAC)
• **ESMF** (Earth Systems Modeling Framework)
  – national effort to build a software infrastructure that enables different weather, climate, and data-assimilation components to operate together on a variety of platforms
  – allows scientists to build models quickly, reuse existing software rather than reinventing it, and exchange modeling components in a systematic way.
  – to increase scientific productivity and to promote new scientific opportunities.

• **NEMS** (NOAA Environmental Modeling System) infrastructure.
  – to streamline the interaction of analysis, forecast, and post-processing systems within NCEP
  – is a shared, portable, high performance software superstructure and infrastructure for use in operational prediction models at the NCEP.

• **NGGPS** (Next Generation Global Prediction System)
Future of Global Modeling at NCEP: NGGPS and NEMS / ESMF

Modular modeling, using ESMF to modularize elements in fully coupled unified global model

( + ionosphere, ecosystems, ...... )
• Implement a weather-scale, fully-coupled NWP System
• Extend forecast skill beyond 8 to 10 days
• Improve hurricane track and intensity forecast
• Extend weather forecasting to 30 days
Implementation Structure

- Atmospheric Prediction - Dynamics
- Atmospheric Prediction - Physics
- Aerosols and Atmospheric Composition
- Atmospheric Data Assimilation
- Marine Prediction (*incl ocean, waves, sea ice, and marine data assimilation*)
- Land Surface Prediction and land data assimilation
- Nesting (*includes hurricanes and convective systems*)
- Post-Processing
- Ensemble Development
- Overarching System (*architecture/integration incl NEMS/ESMF*)
- Infrastructure
- Verification and Validation
- Testbeds
Dynamic Core: FV3

- The non-hydrostatic finite volume dynamical core (FV3) at the Geophysical Fluid Dynamics Laboratory (GFDL)
- Finite-volume cubed-sphere dycore is a scalable and flexible core capable of both hydrostatic and non-hydrostatic simulation
- Designed to be computationally efficient
- Capable of predicting high impact weather events from the smallest to the largest scales, a new breed of “seamless” weather-climate model.
How does NGGPS affect the CFSv3 Timeline?

- Prototype development
- Prototype ready
- Full system testing
- Reanalysis begins
- Production of reforecasts
- Evaluation Phase
- NCO Parallel testing
- Implementation

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How does NGGPS affect the CFSv3 Timeline?

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While we are waiting for CFSv3...
Atmospheric reanalyses can be optimized to produce the most accurate reanalysis by assimilating all observations including satellite observations.

However, this type of reanalysis often shows discontinuities in various time series with the introduction of new satellite systems.

The NCEP/Climate Prediction Center (CPC) would like to replace NCEP/NCAR Reanalysis (R1) with something newer / better.

The replacement reanalysis has to have accuracy of R1, eliminate the gross artifacts from the introduction of various satellites and span from the 1950's to the present.

Can a conventional observation reanalysis satisfy these requirements?
**Conventional Observations Reanalysis - CORe**

- CORe was recently completed for the period of 1950 to 2009.
- CORe is an atmospheric reanalysis based on the latest Semi-Lagrangian NCEP/GFS model using EnKF DAS.
  - 80 member ensemble
  - T254/L64 vs T62L28 for R1
- To test feasibility of the EnKF based analysis over periods with different density and time-varying quality of conventional observed data
- Conventional data + cloud track winds* + GPS-RO (COSMIC)* *(these satellite data are not sensitive to biases in sensors)*
- CORe was produced by running six simultaneous streams of analyses with one year overlap:
  - Stream 1: Jan1950 to Dec1960;
  - Stream 2: Jan1960 to Dec1970;
  - Stream 3: Jan1970 to Dec1981;
  - Stream 4: Jan1981 to Dec1990;
  - Stream 5: Jan1990 to Dec1998;
The first decade in the SH figure is unusual because R1 shows more skill than the following decade. We speculate it's artificial skill from a lack of SH obs. Forecast skill is influenced by the model. CORe is higher resolution (T254 vs T62, 64 vs 28 levels) and has much better physics. So the improved forecast skill may be from a better model rather than an improved analysis.
500 hPa Z Correlation with ERA-I

ERA-I vs CORe
ERA-I vs R1

Improvement r[CORe]-r[R1]
Evaluation of CORe in the Tropics

T500 - Tropics

U200 - Tropics

ERA-I vs CORe

ERA-I vs R1

Improvement

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Evaluation of CORe in the Stratosphere

U50 - Tropics

U50 – 60S-30S

ERA-I vs CORe
ERA-I vs R1

Improvement
R1 has major temp change after 1979. CORe and JRA55C agree post 1979 and are consistent with pre-1979 values.
R1 and CORe QBO winds differ substantially below 10 mb. Both have amplitude issues in 1950’s
JRA55C and CORe QBO winds have very good agreement at all QBO levels.
10 hPa Polar Winds

CORe, R1

CORe, JRA55C

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R1 and CORe temps agree below 10mb. Not many raobs reaching 10mb in SH. CORe has issues in 1950’s and seasonal amplitude before 1988 is smaller.
R1 and CORe temps agree below 10mb. Not many raobs reaching 10mb in SH. CORe has issues in 1950’s and seasonal amplitude before 1988 is smaller.
Summary

• NCEP is undergoing changes to model system
  – Unified
  – External community
  – Design models to meet users needs
• Delay increasing vertical resolution to L128 and top to 0.01 hPa
• Foresee a delay in next coupled reanalysis
• Climate Prediction Center generated a multi-decade reanalysis using just conventional observations
  – Hope to replace R1
  – Many improvements over R1, but some tuning still needs to be done