CFSv2 → CFSv3

2011 … 201x

Strategy Discussion

1 May 2012

Happy May Day!

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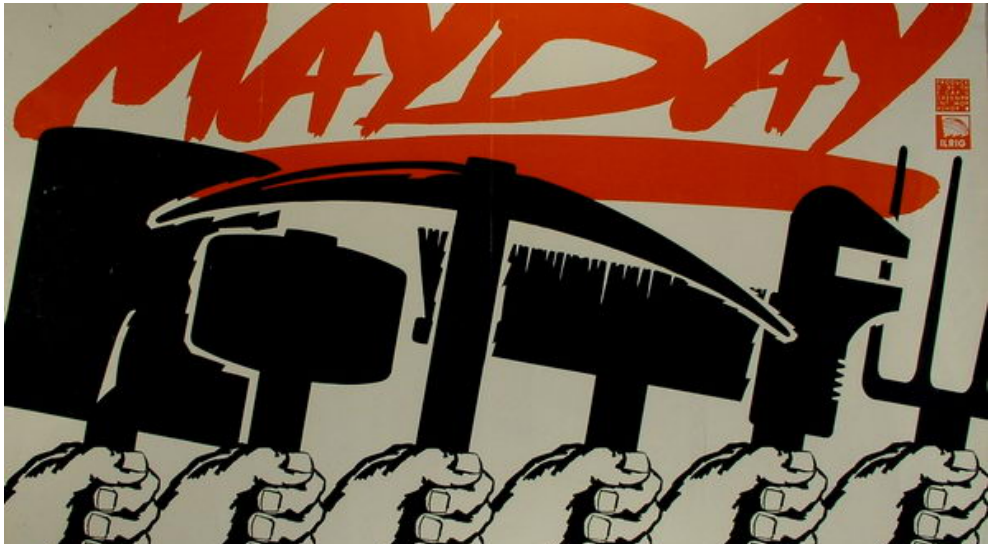

CFSv3 Planning Meeting – Aug. 2011

- Planning for the next generation of CFS should:
  - Be a **sustainable end-to-end effort** with a **bold and far-reaching vision** that addresses the broad range of user requirements, especially addressing regional scales and extreme events.
  - Take into account the **end-to-end requirements of users** in the research community and in the private sector, including the multiple purposes of reanalysis and reforecasts.
  - **Involve the research community** at the earliest possible stage. For example, further research and development is needed to go beyond the current level of accuracy and provide reliable regional climate predictions at ISI time scales, through increasing model resolution, including additional climate-relevant processes in the prediction model, and improving data assimilation.

NCEP Vision for CFSv3

- **Embrace a unified weather-climate modeling strategy**
  - Currently CFS is the dynamical model (coupling GFS with ocean and sea ice models) for **operational ISI prediction**
  - A unified weather-climate model requires model upgrades **to meet both weather and climate requirements**

- **Develop and sustain the CFS as the operational climate forecast system for the nation by combining forces from the research community including other NOAA labs/centers**

Courtesy of L. Uccellini

NOAA Commitment
for CFS Applications and Future Development

- **NOAA Grants Programs**
  - Create funding opportunities to bring NOAA labs/centers and the external community on key model challenges

- **NCEP FTE Support**
  - **Internal development**
    - Dedicated Climate Modeling Team from EMC and CPC
  - NCEP-External **Joint Projects**
    - CTB grants projects
  - **User Support**
    - User-friendly model codes and scripts; documentation

- **NOAA Computer Resources for Climate Studies**
  - GAEA – Oak Ridge, TN
  - ZEUS – Fairmont, WV
  - Operational WCOSS

Courtesy of L. Uccellini

Formulating a Plan

- Plans for future CFS development should **consider broad-NOAA climate modeling needs and resources**, and be specific on:
  - role of CFS, to justify the need
  - targets for next development cycle
  - resources needed/available

- Given the current budget environment, **synergies with other modeling efforts** need to be a critical element of any development plan

Courtesy of A. Mariotti

Role of Collaborative Modeling

- Strategic use of programmatic funds to **leverage collaborative model development** works IF:
  - there is a **critical internal R&D investment**
  - there is an **infrastructure/environment** that supports collaborative work

- An effective process is needed to:
  - **identify** "most appealing" test/evaluation research targets to complement internal development
  - **evaluate** research outcomes for operations
  - **systematically implement** those deemed as "advances"

Courtesy of A. Mariotti

Requirements for the NOAA Climate Forecast System

- **Service and Societal:**
  - Directly supports the US Seasonal Temperature GPRA Goal
  - Support climate monitoring, predictions and projections globally and regionally
  - Inform adaptation planning and decision making

- **Scientific Understanding:**
  - Advance understanding of climate variability and change and their impact on the Earth system
  - Facilitate research on the interplay between climate and weather (including high-impact weather events)
  - Develop process-level understanding of climate forcing mechanisms and interactions in a variable and changing climate system

Courtesy of W. Lapenta

Questionnaire

A. CFSv2 Evaluations

- Do the CFSv2 evaluations included in submitted abstracts and done elsewhere **sufficiently document the model's current status** as a climate forecast and research tool and the improvements from CFSv1 to CFSv2?
- What **additional diagnostics and experiments**, especially process-oriented model diagnosis, do you suggest to further understand the model biases in CFSv2?
- Does the **current data archive** support process-oriented diagnosis of CFSv2? Have we sufficiently capitalized on the data collected from process studies, field campaigns and satellite measurements for CFSv2 model evaluations and improvements?
- What **standard evaluation metrics** for CFS should be generated routinely by NCEP?

Questionnaire

B. Model improvements towards CFSv3

- How can the **model evaluation/diagnosis** process for CFSv2 be **integrated into the CFSv3 development** process?
- Do you agree with the **recommendations made in the CFSv3 Planning Meeting in August 2011**, for how to improve the model development process and planning for the next generation of CFS?
- What are the **potential synergies** among climate modeling efforts at NCEP, at other NOAA labs/centers, and in the external community? How can NOAA take best advantage of these synergies?
- What are the specific **requirements for NCEP infrastructure** to support for CFSv3 development by NCEP and its external collaborators?
-

Standard Metrics

- **Deterministic**
  - Temporal anomaly correlation
  - Mean bias
  - Standard deviation ratio
  - RMSE, using standardized anomalies
- **Probabilistic**
  - Ranked probability skill score
  - Reliability analysis
- **Seamless**
  - Weather: standard NWP metrics
  - Climate: week-2 to year-2 skill (see above)
  - Long-term: 100-year free run (drifts; bias)

Additional Metrics (examples)

- **General**
  - Lead-time dependence of bias
  - Trends in forecasts, reanalyses and observations
  - Coupling strength among component models
- **Atmosphere**
  - Moist static energy budget in the tropics
  - Skill in prediction of AO
  - Stratospheric circulation and troposphere-stratosphere interactions
  - Teleconnections to Atlantic (e.g. AMV) and Indian Ocean (e.g. IOD)
- **Ocean** - biases
- **Sea ice** - trends and variability
- **Applications**
  - Wind and moisture for fire weather

Issues

- **Discontinuities in reanalysis**
  - Do we need a reanalysis with every new model version?
- **No improvement in precip forecast**
- **Lack of closure in budgets** - inherent in the procedures based on analysis increments for state variables
- **Data archive**:
  - A lot of variables, but not all variables are there
  - Difficulties accessing/using the data and metadata in the form produced operationally by NCEP
- **Code/script redundancy and confusion**
- **Inadequate documentation**

Evaluation → Development

- **Findings (random research results)**
  - CFSv2 outperforms CFSv1 in many metrics and in many places, particularly in the tropics, esp. MJO
  - Expansion to include ocean and sea ice provides new opportunities and new challenges
  - To form ensemble, need to include uncertainty in ocean initial state and multiple ODA products can help
  - Longer time scales, e.g., AMOC and sea ice trend are serious issues
  - New diagnostics being developed to entrain diagnostic results into development
  - New or more in-depth analysis of phenomena or system components in CFSv2 are being explored with mixed results (e.g. soil moisture ☹, drought, stratosphere ☺, indifferent troposphere ☹, hurricanes ☺, tornadoes ☺, AMOC ☹)

Evaluation → Development

- **Unified development**
  - Changes in atmospheric component of CFS reflected in changes to GFS
- **Systematic reanalysis for research**
  - Beyond initial states for calibrating real-time forecasts
  - Report increments along with state variables and fluxes
  - Reduce magnitude of increments and imbalances
  - Attribution of increments to specific flux errors or errors in other terms in the prediction equations
- **Simplified workflow** to run entire prediction system in research mode

Strategy Suggestions

- **Define clear CFS mission** with strong support of NCEP leadership and stakeholders
  - ISI? Unified weather-climate modeling? Cutting-edge reanalysis?
- **Develop and maintain significant sustained funding**
- **Bring different NOAA model development groups together**
  - "… a team composed of NOAA and some outside experts has all the necessary expertise to be able to develop the best global weather-seasonal-climate prediction system in the world."
  - "Only by combining forces with GFDL will NCEP really be able to achieve the critical mass needed to dramatically improve CFS as a short-range climate prediction model."
- **Infrastructure**
  - Adequate **computing power** for research
  - **Balance** of CPU, disk, network and archive resources
  - Better **documentation**, user-friendly **scripts**, open code repository with **source code control**
  - **Data repository** for CFSv2 prediction data (with corresponding observations) for all variables needed by research and stakeholder communities
- **Forum** for people to exchange their experience/information
- Attract more **top-notch scientific talent into NCEP**
- **Working with selected external collaborators** on model development should be part of job description and reward system of NCEP scientists

Bold and Far-Reaching?

How will NOAA work with community* to determine the basic structure of CFSv3?

*** including India (others?)**

- Consider **alternative full coupled models**?
  - GFDL CMx in place of NCEP model? NCAR CESM? GMAO?
- **Alternative system components**?
  - Does GFS change too fast for research & climate purposes?
  - AGCM from Lab-1 + OGCM from Lab-2 + LSM from Lab-3 etc.?
- **Alternative sub-component modules**?
  - AGCM dynamical core (e.g. isentropic coordinates; vertical resolution; non-hydrostatic)
  - AGCM physics (Multi-Physics, Super-Parameterization, Stochastic SGS)
  - OGCM dynamical core (e.g. isopycnal coordinates)
  - OGCM physics (e.g., eddy-resolving vs. parameterized eddies)
  - LSM choices (e.g., mosaic, catchment; VIC)
- **Data assimilation**
  - Method developed in-house or elsewhere? Atm? Ocn? LS? Sea-ice?
- **Reanalysis**
  - Do we need it for every new model implementation?
  - Data base of climate states produced in-house (consistency) vs. "best" state estimate (may be from somewhere else)
- **Initialization strategy** (role of reanalysis)
- **Ensemble strategy** (e.g., perturbed vs. lagged ensemble)

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NOTE: Each of these would require a different set of processes and metrics to couple into implementation process and would have different implications, e.g., in terms of unified weather/climate prediction

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