P 1. 13

Synthesis of Issues from CTB-COLA Joint Seminar Summaries

" CFS as a Prediction System and Research Tool "

Jiayu Zhou, S&TI Climate Mission

Office of Science and Technology, NOAA/NWS

Introduction

To accelerate improvement of short-term climate prediction skill, NWS management advocates Science and Technology Infusion (S&TI) from research to operation (R2O) and operation to research (O2R). The CTB-COLA Joint Seminar Series "CFS as a Forecast System and Research Tool" emerged as the times require and was successfully rounded off after presenting 17 high quality assessment works from both operation and research perspectives. This presentation is a synthesis of outstanding R&D needs in view of seamless prediction.

1. As a Prediction System

Overarching View on Seamless Prediction with a Coupled System

- Seamless prediction emphasizes the importance of natural links of processes on all spatial and temporal scales.
- The strength of the climate system chain depends on the weakest link.

Focuses of Prediction with a Coupled Model

i. Initial condition – Predictability of the 1st kind

Climate predictability depends on slowly varying lower boundary forcings, which become internal exchange processes in a coupled model.

- Providing the land surface model with compatible and self-consistent land states is important to seasonal predictions. (Mitchell, EMC)
- Forecasts for MJO need to be initialized with atmospheric and oceanic initial conditions that contain intraseasonal variability and are in balance with each other. (Pegion, COLA; Vintzileos, EMC)
- Tremendous bias is found in Chi200 in day 1 forecast, pointing serious problems in R2 (used as ICs) and "consistency". (van den Dool, CPC)

Challenges:

The same model system should be used to create initial conditions (ICs) and make forecasts. The ICs need to be consistent in 4D within and between systems.
The development of coupled data assimilation with 4D constraint is much needed.

ii. Model trustfulness

a) Systematic Biases in Climatology

✓ SE Pacific and Atlantic Warm SST Bias

SE Atlantic SST warm mean bias (Hu, COLA)

- Too few low-level clouds, too many high-level clouds and shift of the center of the low-level clouds.
- Result in excessive short-wave radiation, causing the warm bias.
- In return, the warm SST bias does not favor an inversion layer hence the low-level cloud formation.

Similar situation is found in the SE Pacific (Manganello, COLA)
- Study reveals the warm SST bias is independent of resolution

Challenges:

According to research consensus, this tropical warm bias is a major factor that limits the interannual variability and predictability, which points to the importance of improving simulation of mean clouds over these areas.

Making empirical corrections exposes and amplifies other systematic errors that originate from the model atmospheric component and appear to be related to an overly active ITCZ.

Multi-scale modeling framework (MMF) development could be promising and needs to be tested.

✓ Bias in Air-Sea Coupling (Wu, COLA)

- LHF is higher than satellite estimates in the tropical Indo-western Pacific, tropical Atlantic, eastern tropical Pacific, and Kuroshio and Gulf Stream regions due to larger sea-air humidity difference.
- The CFS simulation fails to capture the LHF-SST relationship in the eastern equatorial Indian Ocean, showing an excessive SST dependence on the sea-air humidity difference anomalies.

Challenges:

The model underestimates atmospheric forcing of SST and overestimates the SST forcing of the atmosphere, which points to the importance of improving PBL physics for better simulation of mean moisture fields.

✓ Stratospheric Bias (C. Long, CPC)

- Distinct height bias begins above 200 hPa and continues to grow upward.
- For longer time-lead, the forecast shows no transition from winter to summer circulation in SH – consistent with strong height bias there.
- Too little SH poleward heat flux
- Suspect insufficient vertical wave propagation.

b) Variability Deficiencies

✓ Difficulties in prediction of ENSO phase change – model tends to persist anomaly events longer than observed. Multi-model ensemble shows improvement. (Kirtman, COLA)

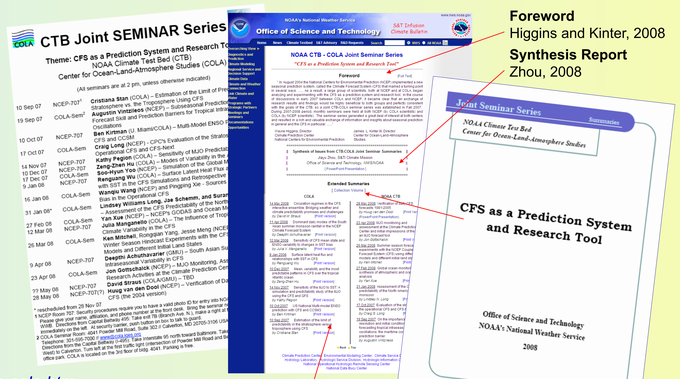
✓ Failure to capture the correct sign of the ENSO-monsoon correlation, though coupling found is crucial for ENSO-monsoon teleconnection. (Achuthavarier, COLA)

✓ MJO maritime continent prediction barrier - skill drops when enhanced convection over the Indian Ocean enters the Maritime Continent. (Vintzileos, EMC)

✓ Indian Monsoon intraseasonal oscillations are considerably slower and extended well beyond the JJAS summer season. (Achuthavarier, COLA)

Review of Works Have Been Done

- Theme: CFS as a prediction system and research tool
- Period: 9/10/07 – 5/28/08
- Locations: Held at NCEP and COLA alternately
- Speakers: 9 from NCEP and 8 from COLA
- Extended summaries: Collected
- Seminar web site: Complete information & timely posted
- Collection volume: Available online with Foreword co-authored by two directors
- S&TI synthesis report: What has been learned? – Issues and R&D needs



http://www.weather.gov/ost/climate/STIP/jsctb-cola.htm

Foreword
Higgins and Kinter, 2008

Synthesis Report
Zhou, 2008

Extended summary
Web & Print Versions

~~~~~~~~~~~~~~~~ ~~~~~~~~~~~~~~~~ ~~~~~~~~~~~~~~~~

✓ CFS has problems in simulating the GoC LLJ, the Mexican High and the interannual variability of NAM. Capturing the NAM seasonal cycle, including magnitude and onset of precipitation, seems to be for wrong reasons. (L.W. Long, CPC)

✓ Too little interannual variability in stratospheric temperature, height and wind; decreasing dramatically as the forecast lead time increases.

QBO is weakened and changes to semiannual variation with increasing forecast time. (C. Long, CPC)

The ensemble prediction has no skill for the stratospheric sudden warming events (Stan, COLA)

✓ Loses 5-20% in terms of SD and eDOF in the first few days, showing overconfidence in prediction. (van den Dool, CPC)

Challenges:

The causes of coupled model variability deficiencies and their impact on reanalysis need to be identified.

c) Dynamical Issues

✓ Impact of increased horizontal resolution

– MJO forecast skill does not show any significant dependence on model resolution. (Vintzileos, EMC)
– Helps to reduce errors in Indian Ocean but not in Pacific. (Manganello)
– Does not seem to make improvement in simulation of stratospheric circulation. (C. Long. CPC)
– Simulation using a grid scale as fine as 15 km still fails to capture the GoC LLJ. (L.W. Long, CPC)
– There is no noticeable differences found between T62 and T126 as far as Indian monsoon rainfall climatology and variability are considered. (Achuthavarier, COLA)

✓ Stratosperic dynamics

– Dynamics plays a critical role in representing stratosphere processes.
– The vertical fluxes of wave propagation involve derivatives of second-order quantities, which are more sensitive to small errors. (Stan, COLA)

Challenges:

Develop next generation dynamical core – beyond sigma-p hybrid
Need vertical resolution compatible with physics (We still need to understand the causes of improvement from L28 to L64.)
Suggest to raise the model top.

Products and O2R

✓ Introduction of global ocean monitoring – A synthesis of atmospheric and oceanic analysis (Xue, CPC)

– GODAS web site *http://www.cpc.ncep.noaa.gov/products/GODAS/*
– Monthly and annual ocean briefing
– Future additions

✓ R&D needs for MJO prediction (Gottschalck, CPC)

– What role do extratropical-tropical exchanges play?
– How important are scale interactions (i.e., diurnal convection, mesoscale regional convection)?
– Is pre-conditioning of atmospheric moisture the primary player in regenerating the MJO evolution?

Challenges:

Customer-oriented products development and operation-benefited research advancement are very much needed.

2. As a Research Tool

Sensitivity of MJO to SST Variability and Air-Sea Coupling (Pegion, COLA)

- There is potential to improve forecasts of the MJO by using ensembles and a coupled model for week-2 and beyond. The loss of potential skill by not using a coupled model is approximately 18 days.
- There is potential skill for lead times of up to 4-weeks even without intraseasonal filtering. This skill comes from both ENSO and the MJO.

Challenges: Develop multi-model ensemble.

Circulation Regimes – Bridging Weather and Climate Predictability (Straus)

- Large ensembles of model simulations are very helpful in providing estimates of sampling statistics for regime properties.
- Regimes respond to changes in SST forcing both by changes in the structure of the regimes themselves, and in their population of occurrence.
- Preliminary results indicate that the regimes obtained from the CFS Interactive Ensemble forecasts are likely to be truly preferred states

Limitation of Predictability in the Stratosphere vs. Troposphere (Stan)

- The systematic decrease in variability towards the end of boreal winter seen at upper levels.
- The shorter time of predictability in the stratosphere when compared to the troposphere.
- The predictability of sudden stratospheric events is low.

Most Predictable Pattern in the Atlantic (Hu)

- The predictable patterns are identified by applying an empirical orthogonal function analysis with maximized signal-to-noise ratio (MSN EOF) to the predicted time series of 1981-2003 with given lead-time of the hindcasts. (Figure Right)
- The time series of the most predictable pattern of SST is highly correlated with the SST in the eastern tropical Pacific, implying that the predictable signals mainly result from the ENSO influence.

3. Concluding Remarks

How did we learn? ("Not too much" vs. "A lot")

✓ Outstanding modeling R&D needs for seamless prediction

– Coupled data assimilation with 4D constraint
– Multi-scale modeling framework (MMF)
– Advanced dynamical core
– Improved PBL physics
– Multi-Model Ensembles (MME)

✓ Reliability needs to be assessed and explored.

✓ COLA scientists need O2R support from NCEP

– CFS and supporting datasets
– Documentation
– Helpdesk facilities
– Participation in ongoing discussion on model improvements
– Joint proposals

✓ Research and Operations have different perspectives:

– Research (Univ. & Labs) ~ more science oriented
– Operations (NCEP) ~ more engineering focused

✓ Even within operations, climate model development and climate services have different perspectives

– EMC ~ Improve simulations of Weather & Climate as observed in nature.
– CPC ~ Improve the skill of climate outlooks (GPRA) to deliver reliable climate information to users.

✓ NWS/NCEP Strategic Priorities

– O2R is needed to accelerate R2O — essential to advancing ISI prediction.
– Maintain a balance between innovation and operations through transition activities.

Resources are Needed to Meet the Challenges !

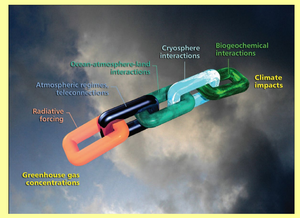
~~~~~~~~~~~~~~~~ ~~~~~~~~~~~~~~~~ ~~~~~~~~~~~~~~~~

Acknowledgements.

This presentation is based on the extended summaries contributed by the speakers of the 1st NOAA CTB-COLA Joint Seminar Series and supported by CPC Director Dr. Wayne Higgins and COLA Director Dr. James L. Kinter III.

COLA Contributors:
Cristiana Stan, Ben Kirtman, Kathy Pegion, Zeng-Zhen Hu, Renguang Wu, Julia Manganello, David Straus, Deepthi Achuthavarier

CTB Contributors:
Augustin Vintzileos, Craig Long, Lindsey Williams Long, Yan Xue, Ken Mitchell, Jon Gottschalck, Huug van den Dool



From Palmer et al. 2008