



Challenges to Improving the Skill of Weekly to Seasonal Climate Predictions

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Outline



- CPC Background
 - Prediction, monitoring, diagnostics, and climate services
- Key challenges to improving forecast skill
 - Skill improvement of tools/weaknesses of current tools
 - Investigating new sources of predictability beyond ENSO and then modeling those with fidelity
- Thoughts on effective collaboration
- Summary



CPC Mission



Deliver real-time products and information that predict and describe climate variations on timescales from weeks to year(s) thereby promoting effective management of climate risk and a climate-resilient society.

- Focus: weeks, months, seasons, out to 1 year (i.e. short term climate)
- Integral to NWS Seamless Suite of Products
- Valuable resource for NOAA's efforts to deliver climate services
- Provides strong name recognition in international efforts

Temperature Outlook





Climate Prediction Products



- [±] 6-10 Day & 8-14 Day Precipitation & Temperature Outlooks
- [±] Day 3-14 Hazards Outlooks (US, Global Tropics)
- Monthly & Seasonal Precipitation & Temperature Outlooks
- $^{\pm}$ Monthly and Seasonal Drought Outlook
- [±] Seasonal Hurricane Outlooks (Atlantic and Eastern Pacific)
- $^{\pm}$ Monthly ENSO Prediction





Climate Monitoring Products

- Daily and monthly data, time series, and maps for various climate parameters and compilation of data on historical and current atmospheric and oceanic conditions
 - Primary modes of climate variability (ENSO, MJO, NAO, PNA, AO,...)
 - Atmospheric Circulation (global troposphere and stratosphere)
 - Storm Tracks and Blocking
 - Monsoons
 - Oceanic Conditions (global and coastal)
 - Precipitation and Surface Temperature (global and US)
 - Drought (US, North America; NIDIS)
 - Climate Reanalysis











Climate Diagnostic Products



- Synthesis of current weather and climate information and forecasts; issued on a routine basis
 - Climate Diagnostics Bulletin
 - ENSO Diagnostics Discussion
 - Weekly ENSO / MJO / Monsoon / Ocean updates
 - Seasonal Climate Summaries
 - Special Climate Diagnoses
 - Annual Climate Assessment (contributor)



Selected Other Climate Services at CP

Joint Agriculture Weather Facility

- USDA DOC partnership
- Weekly Weather and Crop Bulletin
- Briefings & Weather Summaries on global weather and crop conditions

CPC International Desks

- African Desk
- Monsoon Forecaster Training Desk
- Activities

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- Training and Education
- Partnerships
- Products

Famine Early Warning System Hazards Assessments (Africa, global tropics) Tropical Cyclone Monitoring





CPC Near-Term Focus within NOAA Seamless Suite of Forecast Products





Near-Term Focus for New Products and Improvement of Existing Products Will have Emphasis from Week 2 to Seasonal

Years

That is where the funding and demand are and will likely be for foreseeable future.

Longer timescale is important but is handled by other parts of NOAA.

Generation of Weekly to Seasonal Forecasts at CPC

Human Forecasters Use Various Tools To Develop Seasonal Predictions:

- Dynamical Models
- ^並 Statistical Models
- ^主 Historical Analogs
- ^主 Historical Composites

Goal is to leverage complementary skill

between the tools.

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Ultimately, skill of seasonal forecast depends on skill of tools made available to the forecaster.

Need to improve skill of forecast tools.

Need to invest in development of statistical tools.





Disclaimer: Adequacy of State of the Art Dynamical Tools (NNME in this case)



NMME:

- Example of effective collaboration between research and operations.
- Represents state of the art in seasonal forecast skill for dynamical models
 - Room for improvement in skill (at least we hope). Some examples.
 - From my perspective this motivates need to invest in improving the models not adding more similarly skilled models.



Multi-Model Ensembles and the North-American Multi-Model Ensemble (NMME) Project



Why do use multi-model ensembles (MME) for forecasts?:

- Allows representation of model uncertainty.
- Possibility of complementary skill between models.
- Skill of MME is frequently higher than that from the most skillful member in the ensemble (though if one model is dominantly better this is not always true).

NMME is frequently our most skillful tool but there is still room for improvement.

Models/Groups Participating in NMME

| Organizations | Models |
|--------------------|---------------------|
| NOAA/NCEP | CFSv2 |
| NOAA/GFDL | CM2.1 |
| | FLOR (March 2014) |
| NASA/GMAO | GEOS5 |
| Environment Canada | CMC1-CanCM3 |
| | CMC2-CanCM4 |
| NCAR | CCSM3.0 |
| | CCSM4.0 (July 2014) |
| NCAR | CESM1.0 (Mar. 2015) |



1 month lead NMME forecast calls for moderate cannonical El-Nino while observed anomalies were confined to western Pacific. Indicates gap in understanding of air-sea coupling processes.

60N

40 N

20N



JAN 2015 SST Anomaly (°C) (1981–2010 Climatology)







State of the Art MME Dynamical Forecast System has Low Skill in Predicting Near-Equatorial Western Pacific SST. If SST in this region drove the large-scale pattern past two years there is an issue.



Target Period Slippage of El-Nino Forecasts

- When predictions that correspond best with observations occur earlier than the intended target season. AKA. when the model forecasts lag or persist beyond the observations.
- Example from the IRI/CPC plume-- see Barnston et al., 2012; Tippett et al., 2012.



ENSO forecasts compared to observations: dynamic models

Climate.gov ENSO Blog

Increase Understanding of Sources of Predictability Beyond ENSO and Then Mode this with Fidelity!



Stratosphere – Troposphere Interactions







Ocean-Atmosphere Interactions; Role of sea-surface temperature



Land -Atmosphere Interactions; Role of soil moisture & land processes



Long-term Trends and **Climate Variability**

THE NATIONAL ACADEMIES: http://www.nap.edu/catalog/12878.html

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Thoughts on effective collaboration between research and operations as applied to CPC circa November 2015



Need to have focused product development and supporting research. (Working on everything diminishes our ability to work on highest priorities).

- Sweet spot these days in terms of resourcing and user requests is week 2 out to first season (including week 3-4, months 1, 2, 3). Next priority is going out to season 2, 3.
 - Climate forecasts longer than 1 year are important but are being addressed by bright people in other parts of NOAA.
- Need to balance requests for new products with current state of the science. Educate customers about skill profile of products and potential products.
 - Need to maintain our status as authoritative source of credible short-term climate information.



Thoughts on effective collaboration between research and operations as applied to CPC circa November 2015



Need vigorous targeted collaboration with partners:

- Short-term climate forecasting and monitoring is a difficult problem and we need to engage the whole community to be successful.
- Engage in <u>co-development (sooner in the process the better)</u> but we can't be dogmatic.

Need to candid about strengths, weaknesses and potential of products and tools (existing and new):

- Guard against overselling to enable effective management of expectations.
- Overselling leads to disappointed funders and customers and eventually to reduced funding.



Personal Perspective on Improving Weekly to Seasonal Forecasting Skill (Gaps)



Need to focus on and invest in:

- Updating current and exploring new statistical and hybridstatistical dynamical tools (including ensemble postprocessing and multi-model combination techniques).
- Improving representation of key processes in current generation of coupled models, especially atmospheric convection and PBL, and oceanic PBL.
- Improved understanding (and eventually modeling) of sources of predictability beyond ENSO

<u>Need vigorous targeted collaboration with partners to co-develop</u> products and services and conduct mission-oriented research.