Subseasonal to Seasonal (S2S) Overview

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• Motivation/need for improved S2S model forecasts, especially for precipitation.
• Drivers:
  • CPC S2S prediction products that use ensembles with focus on first month.
  • CPC technical requirements for ensemble forecast systems.
• Success stories for S2S model predictions:
  • EMC improved MJO forecast skill
  • Science challenges limiting S2S forecast skill
• Conclusions/Thoughts
Why we need to keep pushing the skill envelope for improved S2S (precipitation) forecast skill

S2S predictions are characterized by a small signal and large noise. Hence they are inherently probabilistic.

The key tool for informing forecasts are ensembles of dynamical models.
Forecast Uncertainty Narrows as Time to event decreases. But it never becomes deterministic on these timescales.

Hazards are forecasts of opportunity when we anticipate a period of increased predictability.
Global Tropics Hazards and Benefits Outlook

Forecasts of likelihood of:

- Above or below average rainfall
- Above or below average temperature
- Tropical cyclone development

Product is updated once per week, except from 6/1 - 11/30 for the region from 120E to 0, 0 to 40N. The product targets broad scale conditions integrated over a 7-day period for US interests only. Consult your local responsible forecast agency.
Week Two Probabilistic Hazards Outlook
Designed to Forecast Probability of Extreme Events

Slight (20-40%), Moderate (40-60%), Or High (GT 60%)
Probability of:

Much below minimum or much above maximum temperature

Heavy Precipitation

High Winds

CPC GEFS-Based Probabilities of Extremes Tool

GEFS-based daily
day 8 to 14 global probabilities of:

Temperature:
- Upper or lower 15%
- Over 90 or 100F
- Less than 28, 32, or 40 F

Precipitation:
- Upper 15%
- Over 1, 2, or 4 inches

Winds:
Upper 15%
Over 25, 40, 50 MPH
CPC Week Two Temperature and Precipitation Outlooks

Tercile Class Probabilities of Above, Near, or Below Normal

For temperature and precipitation

Issued daily.
CPC Week Three-Four
Temperature and Precipitation Outlooks

Two Class Probabilities of Above or Below Normal

For temperature and precipitation

Issued Once per Week on Fridays
CPC GEFS-Based Week-2 Precipitation Forecasts
Probability of Exceedance of 50 mm Rainfall
• Consistent reforecasts with each real-time upgrade: Length: At least 20 years, and 5 members.
• Equilibrated boundary conditions in reforecasts and real-time, i.e. no discontinuities or non-physical trends (soil moisture, upper ocean temperature, and sea ice).
• Metrics for evaluation of upgrades (including but not necessarily limited to):
  • Temperature and precipitation skill over same domain as CPC Outlooks.
  • Global skill for relevant fields for Global Tropics Hazards Outlook and International Desk products.
  • Fidelity of simulation of major modes of S2S variability and associated teleconnections: ENSO, MJO, AO, NAO, PNA, and SSW.
CPC Wish List for Day 6 to ~ Day 35 Ensemble Forecast System

- Reliable predictions of periods of enhanced versus suppressed predictability.
- Improved precipitation forecasts on all timescales.
- Reduction of persistent systematic errors in CGCMs.
Dramatically increased skill of MJO from improved physics! Need to continue to improve teleconnections from MJO, i.e. precipitation forecast skill over western US.
Major Systematic Errors Limiting S2S Forecast Skill: El Nino False Alarms

Figure shows forecasts for Nino3.4 SST at 3 month and 6 month lead from CFSV2. This demonstrates that current generation coupled models have large errors in timing and amplitude of S2S equatorial Pacific SST anomalies.
State of the Art S2S Coupled Models Have Major Systematic Errors Forecasting Magnitude and Distribution of Average Precipitation in the Tropics (Even at First Month Lead)

Figure compares standard deviation of precipitation from one month lead precipitation forecasts from 3 state of the art S2S models and observations. It demonstrates that models have errors of 100% or more in predicting mean statistics of tropical precipitation. Result is even worse if an ENSO event.
Rapid onset of the 2017 Northern Plains occurred over a 2 to 3 month period. All models failed to predict the onset of this drought beyond about two weeks lead. The inability to predict the onset of this drought highlights several science challenges for improving spring and summer drought prediction skill:
- Is there predictability for precipitation beyond week two for the Spring and Summer seasons when variability is controlled by convective as opposed to advective processes?
- Can land surface models accurately simulate the onset of flash drought conditions, which are at least partly due to enhanced evaporation?
Figure shows that CMIP5 models have major errors in distribution of mean precipitation including the development of erroneous double ITCZ, that is not found in nature. Coupled models used for S2S
Conclusions/Thoughts

• Societal demand for S2S forecasts continues to grow.
• S2S models are just starting to be run at resolutions where transient eddies are resolved. Hopefully, this leads to improvements in representation of their statistics from a forecasting perspective.
• Persistent systematic errors in S2S (and climate change) models likely limit forecast skill. Reducing these errors should be a priority for the global S2S enterprise in order to meet societal demand for improved S2S forecast skill.
Ability to Accurately Model Storms (and Hence Their Mean Statistics) is a Function of Resolution. Seasonal Forecast Models Currently use Resolution of 50 to 100 KM. Can We Expect Improved Forecast Skill As Seasonal Forecast Model Resolution Increases?

GFS Skill Improvement in 5-Day ACC Greater Than 0.9 Due to Increased Resolution, Data Assimilation and Physics Upgrades

- Hybrid 4D En-VAR Data Assimilation
- Eulerian to Semi-Lag; Hybrid EDMF PBL
- Hybrid-Ensemble 3D-VAR Data Assimilation
- 55km to 38km
- 38km to 27km
- 27km to 13km
- New shallow convection; updated SAS and PBL; positive-definite tracer
- Flow-dependent error covariance; Variational QC

AMSU-A & HIRS-3 data