Developing Operational MME Forecasts for Subseasonal Timescales

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Acknowledgements:

Stephen Baxter and Augustin Vintzileos (CPC and UMD)

Outline

I. Operational multi-model ensemble for subseasonal forecasts

I. Sources of predictability

I. Skill of forecasts for week 3 and week 4 lead times

I. Challenges

To Add

I. Images of R in CFS and ECMWF (seminar)
II. Real-time verif (Both)

I. Description of 5 category system (Plans)

I. Statistical tools: CA and LIM (Plans)

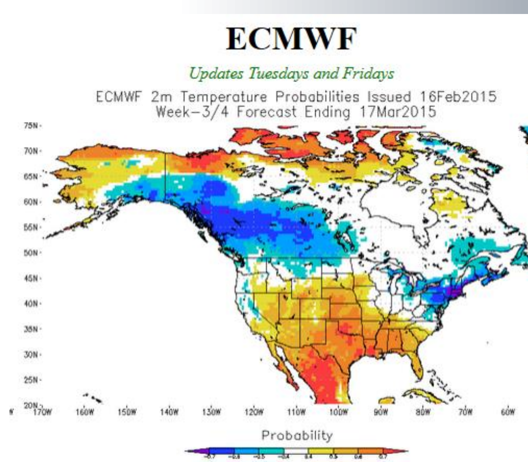
I. Reanalysis challenges (Plans, Describe proposal)

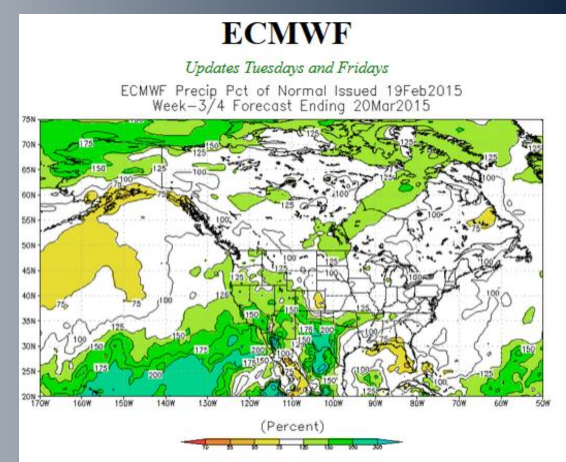
CPC will release experimental Week 3-4 outlooks in September 2015

- Experimental products to be probabilistic temperature and precipitation outlooks released **once per week**

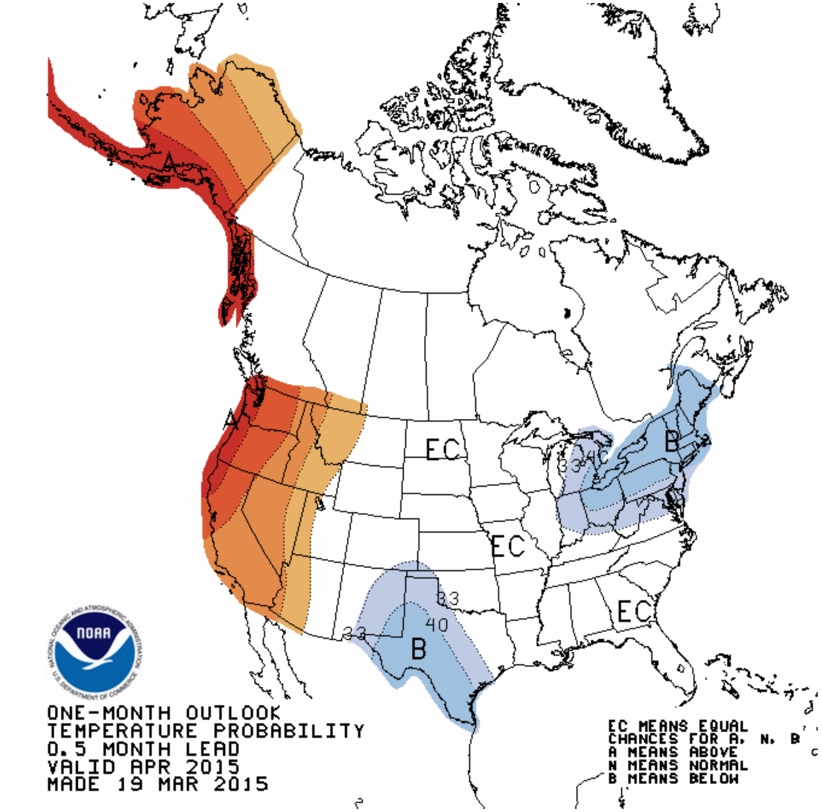
- We are evaluating dynamical model guidance from the CFS, ECMWF, and JMA, and will evaluate Environment Canada and NCEP Global Ensemble Forecast system.

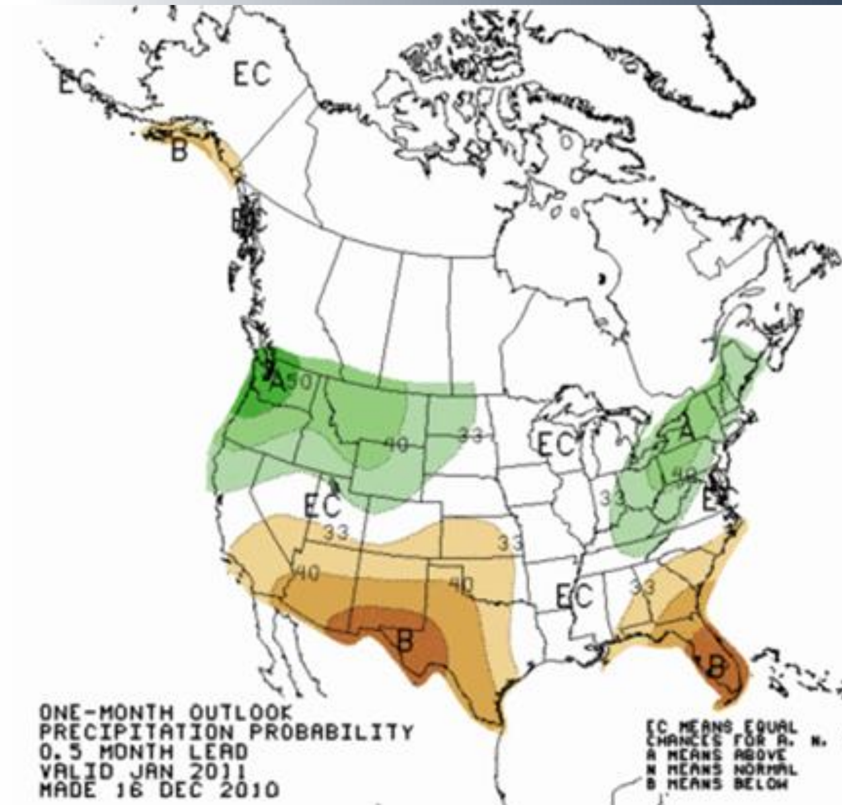
- Subseasonal NMME models may provide additional information, dependent on availability





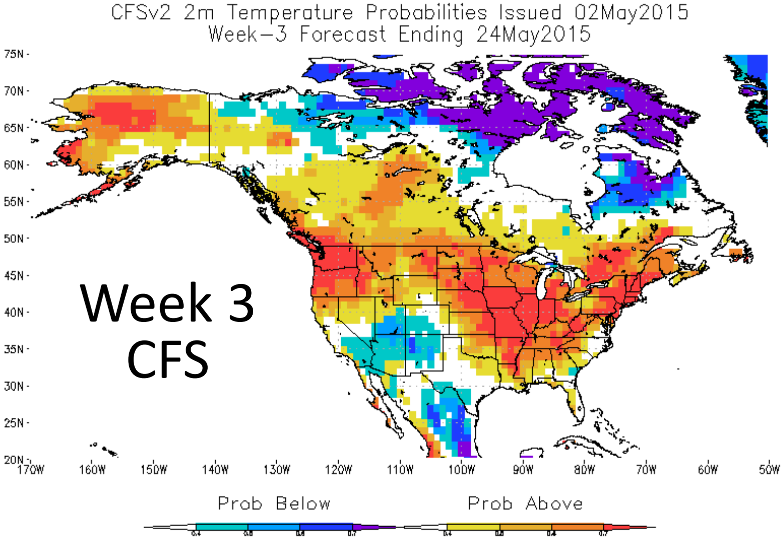
CPC Subseasonal Outlooks will likely be of similar format to other CPC products, BUT alternative formats are being considered

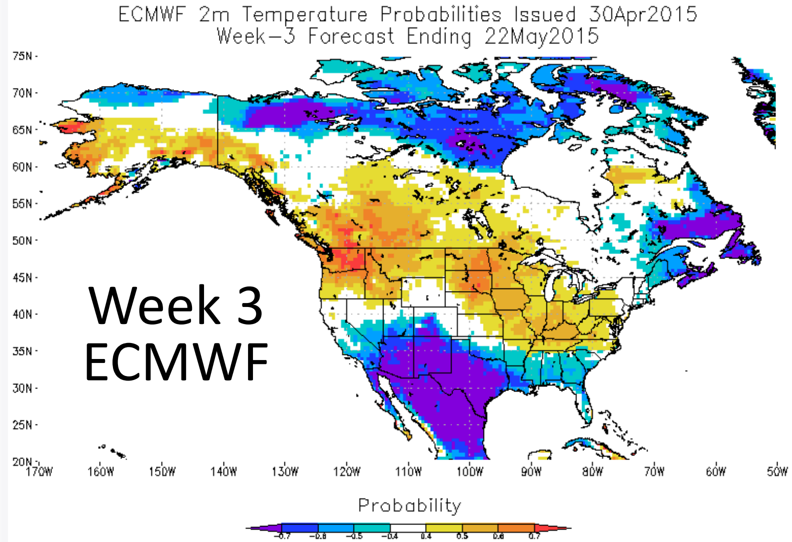


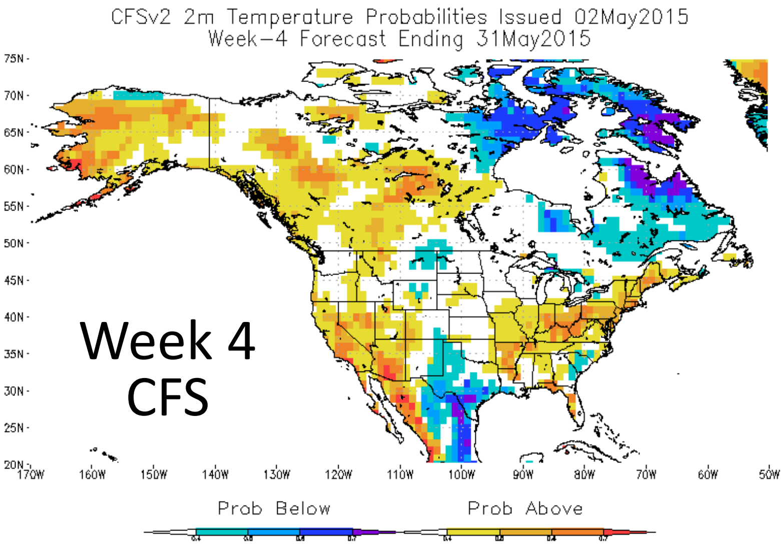


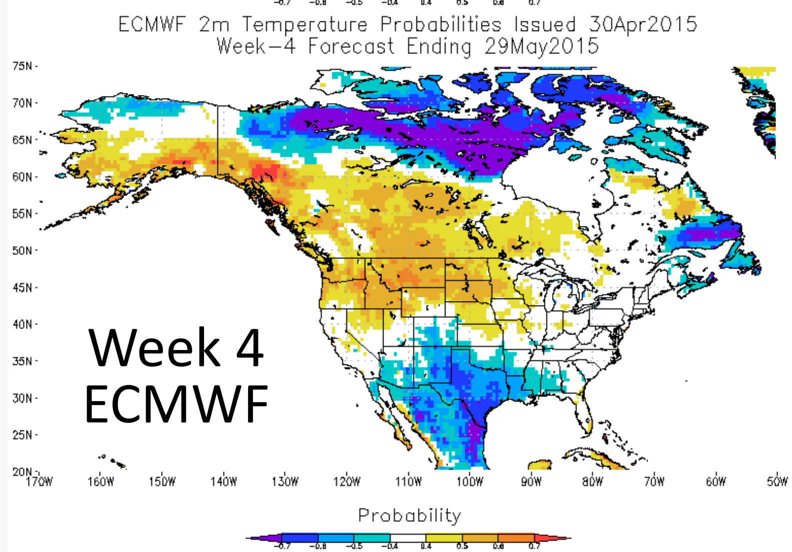
- Monthly T and P probability of Above and Below Normal Tercile shown
- Probabilistic temperature and precipitation
- Subseasonal dynamical model guidance will play an important role

Dynamical model anomaly and probability forecasts generated in ***real time*** for 3 and 4 weeks lead time



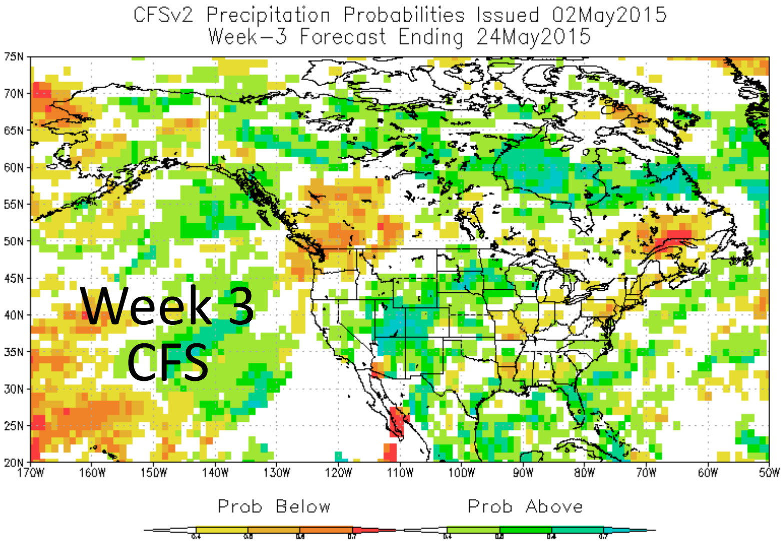


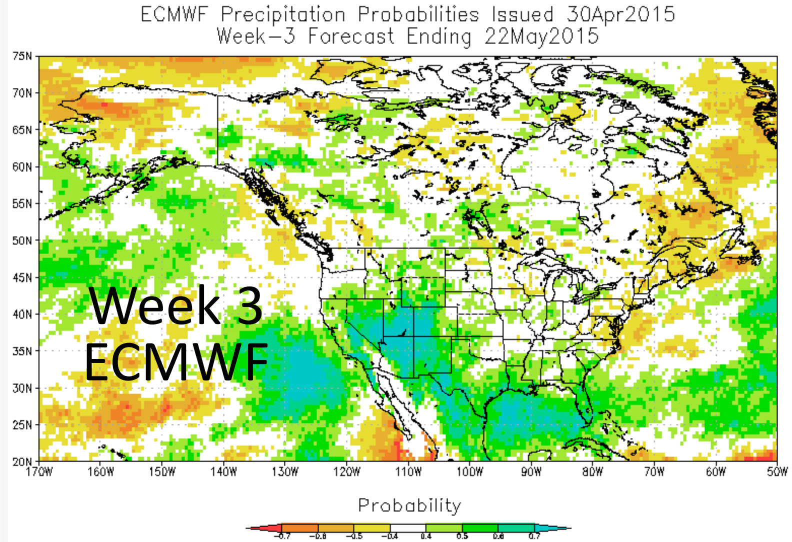


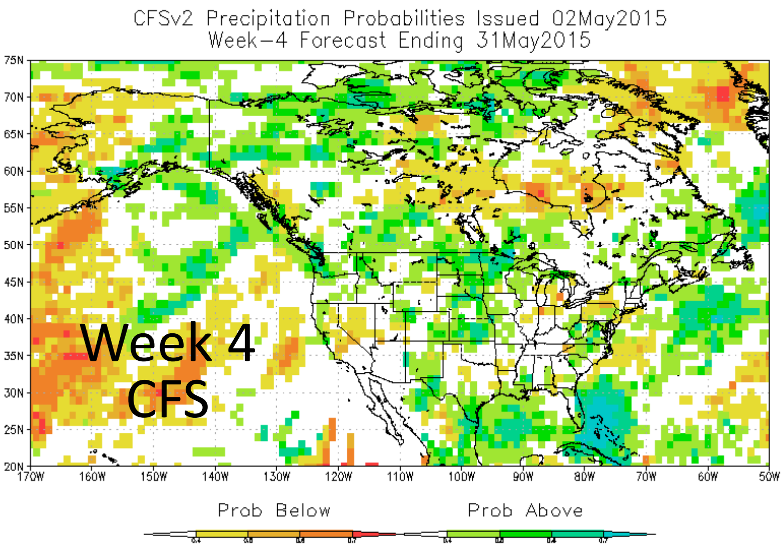


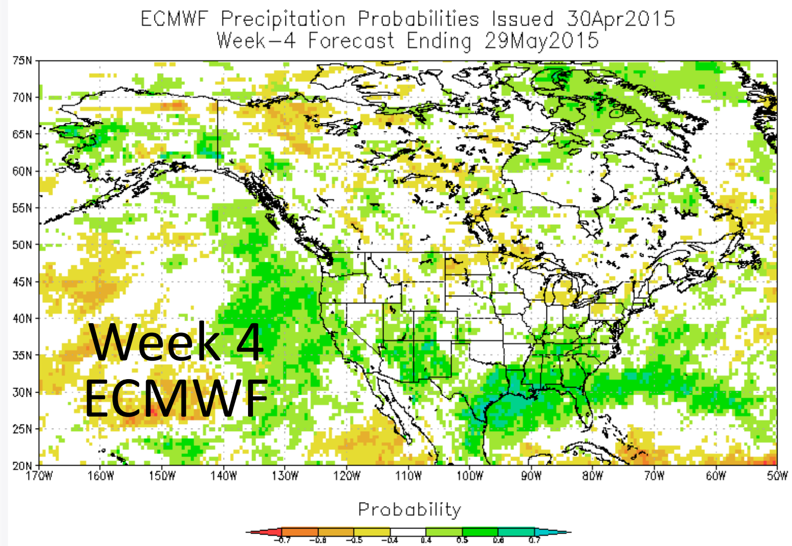
- **2-meter temperature Probability of above and below**

Dynamical model anomaly and probability forecasts generated in ***real time*** for 3 and 4 weeks lead time





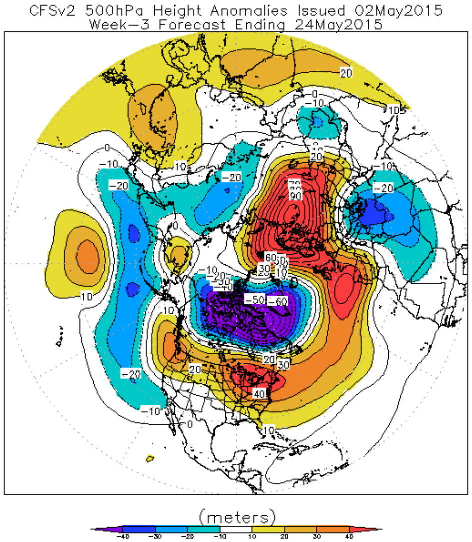




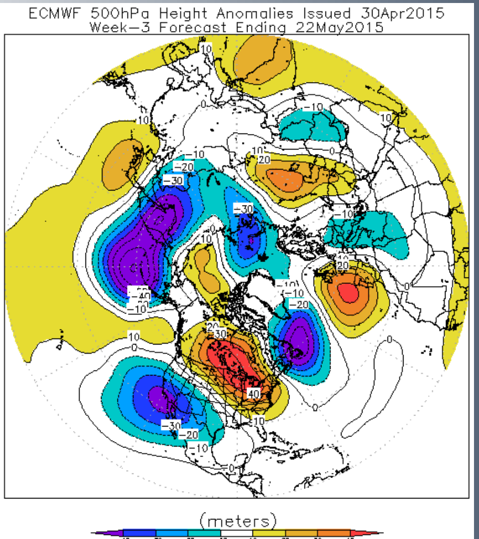
- **2-meter precipitation Probability of above and below**

Dynamical model height anomaly forecasts to support forecast interpretation

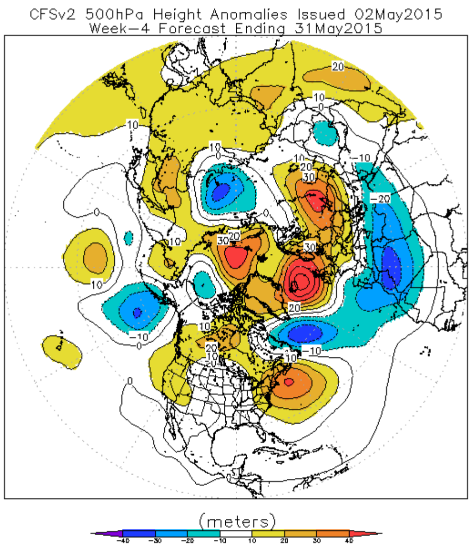
Week 3
CFS



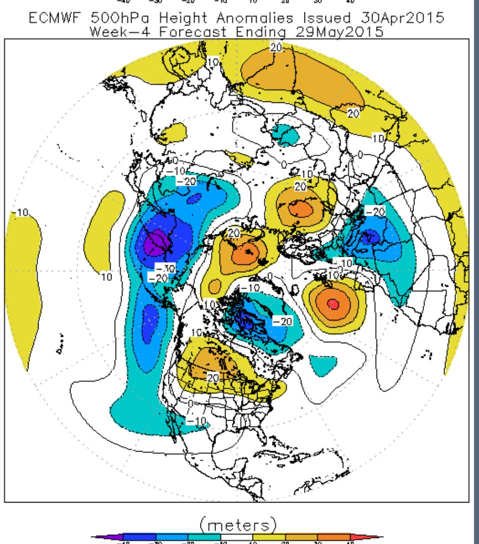
Week 3
ECMWF



Week 4
CFS



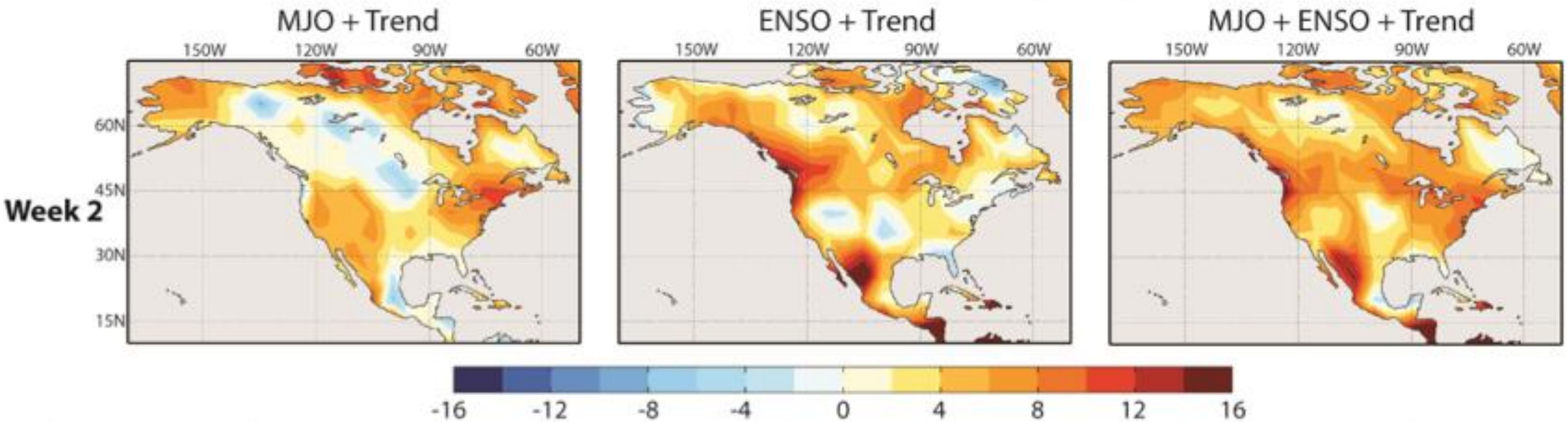
Week 4
ECMWF



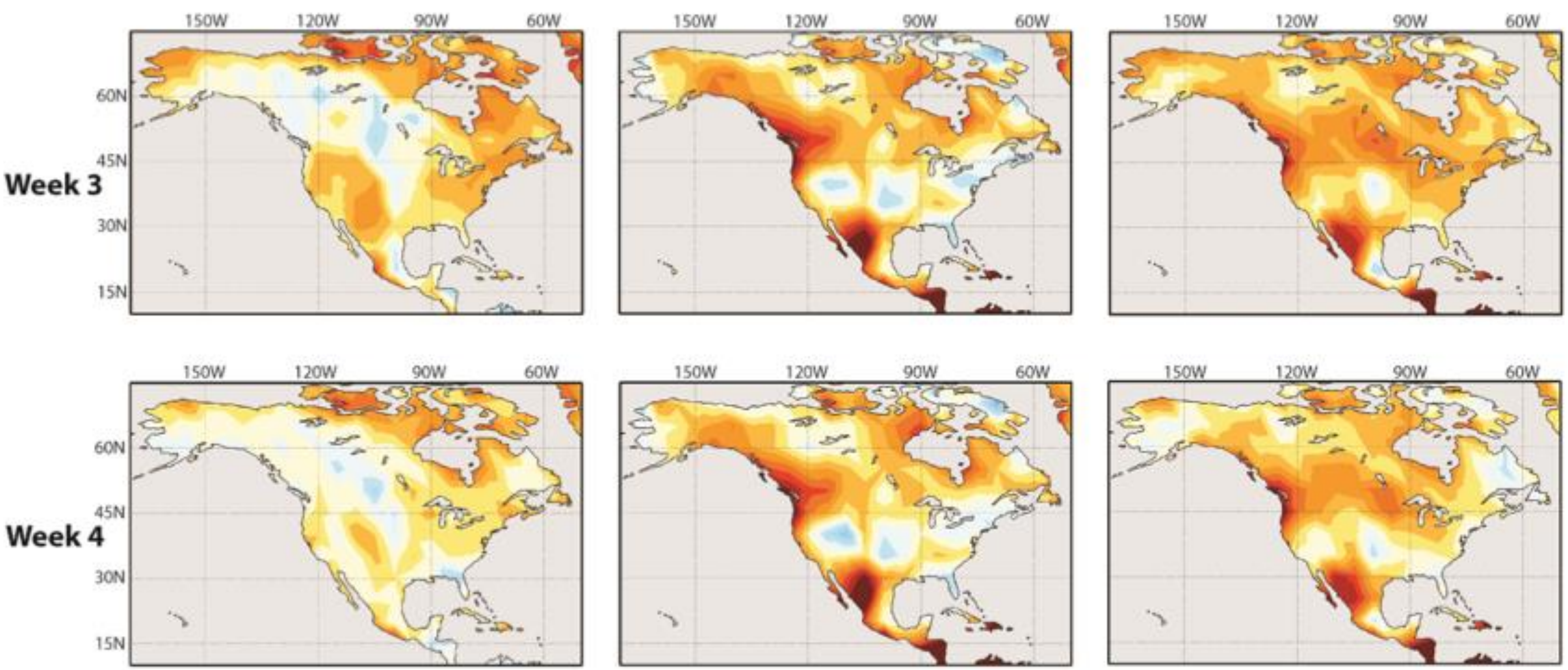
- **500-hPa height anomalies relative to model climatology**

The MJO and ENSO primarily impact different regions of North America.

Mean Heidke Skill Scores (HSS)



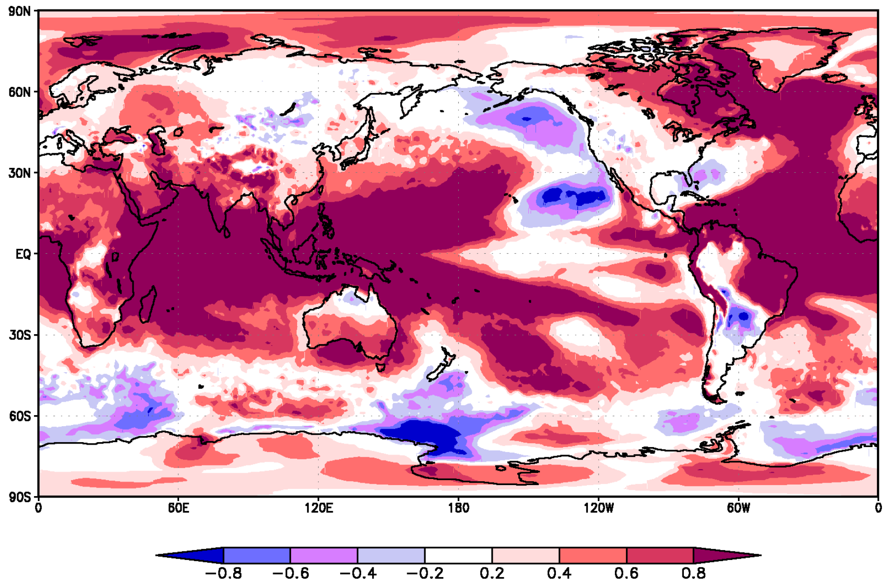
The MJO influence decays between weeks 2 and 4, whereas the ENSO influence remains nearly constant at these timescales.



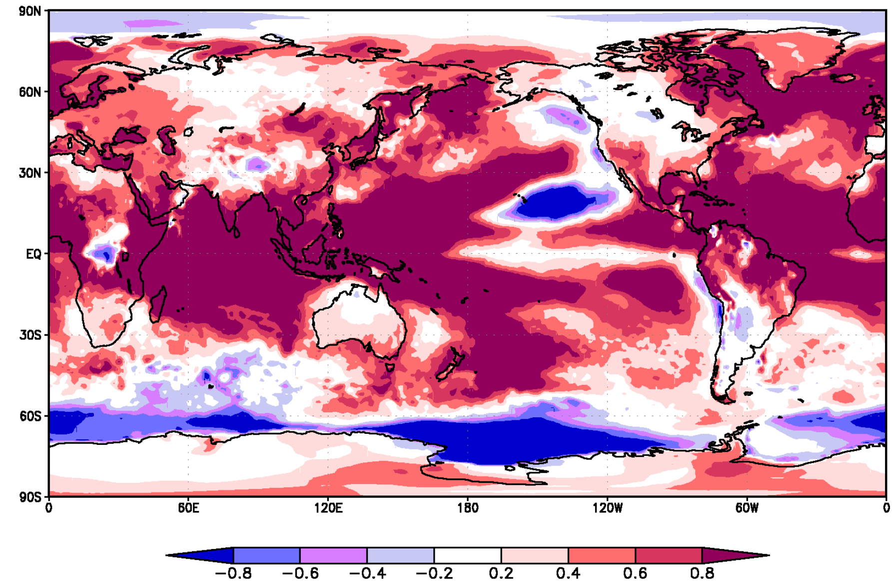
Temperature trend for 1985 to 2010

<u>Standardized</u> by weekly temperature variability

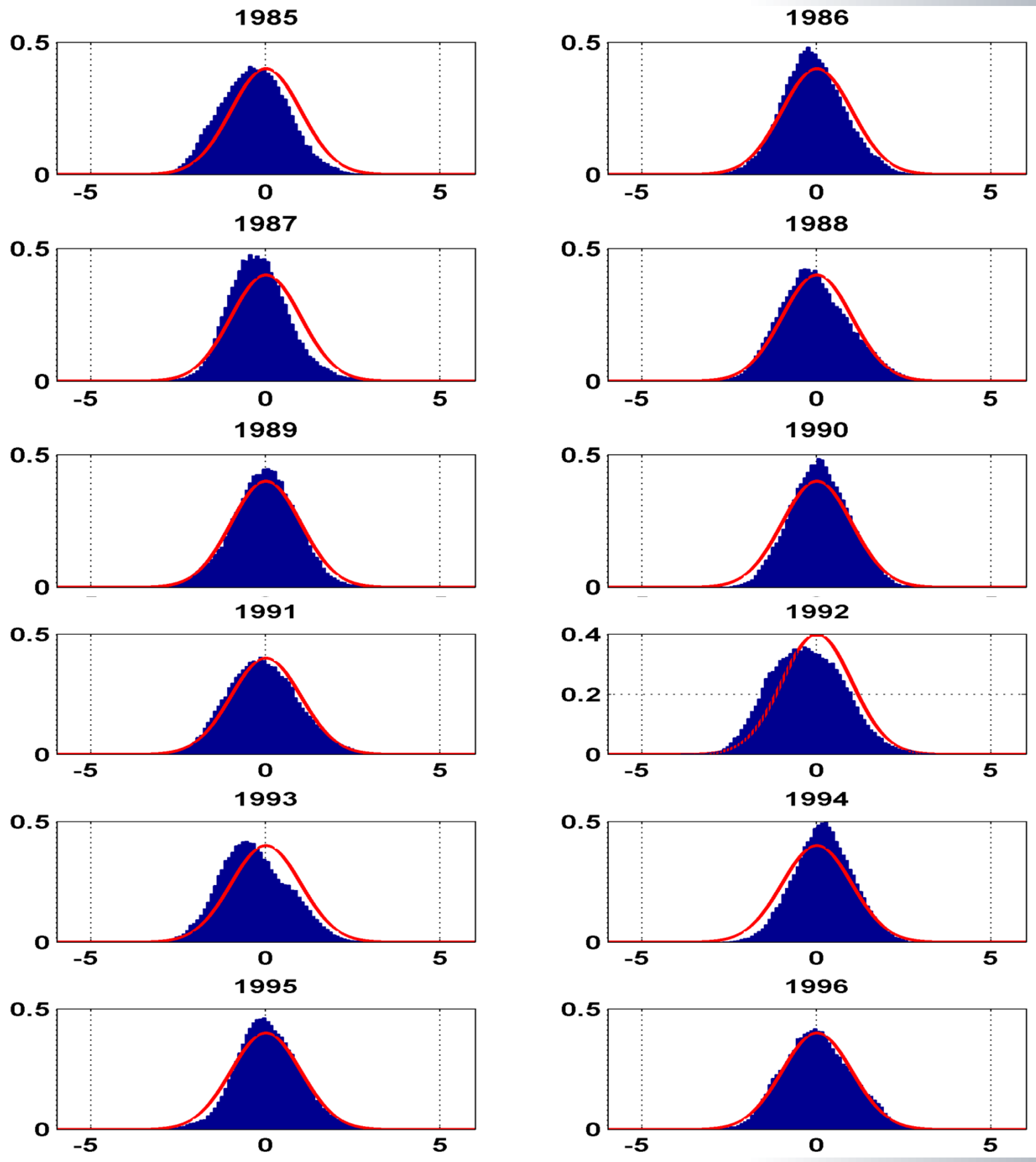
November to March



May to September



- Temperature trends are significant fraction of weekly timescale variability
- Large areas of 0.5 to 1 standard deviations



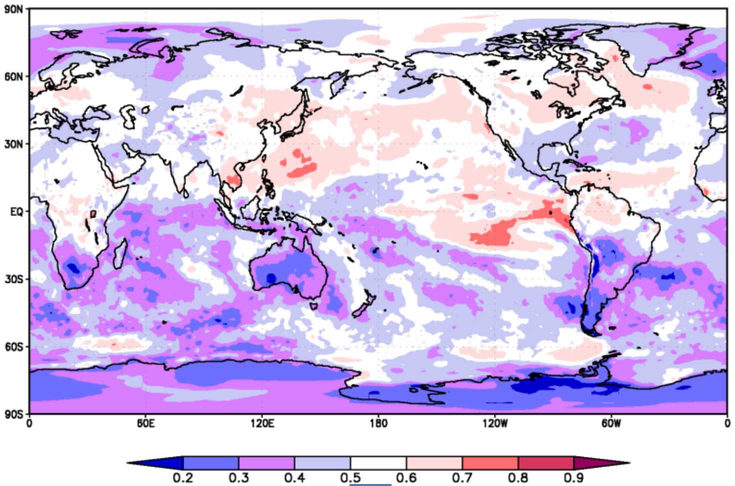
- Weekly mean forecast temperatures over the U.S. by year
- 25-year climatology in red
- PDF shifting each year

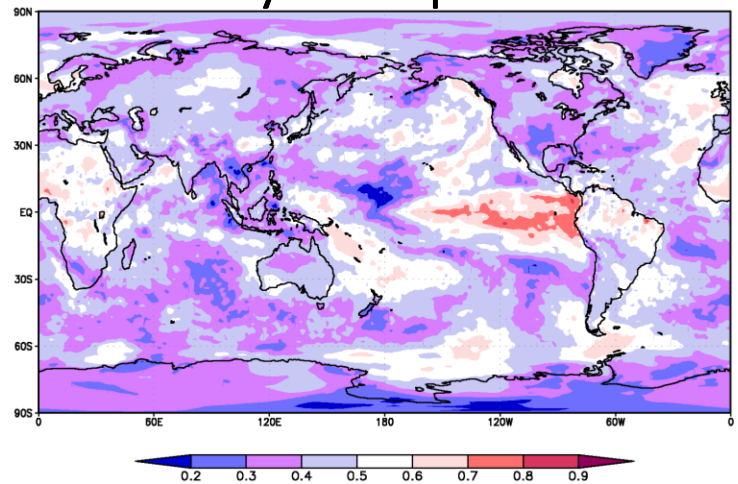
Calculating linear trend in correlation skill
of (two-week) forecast to analysis from 1985 to 2010

November to March

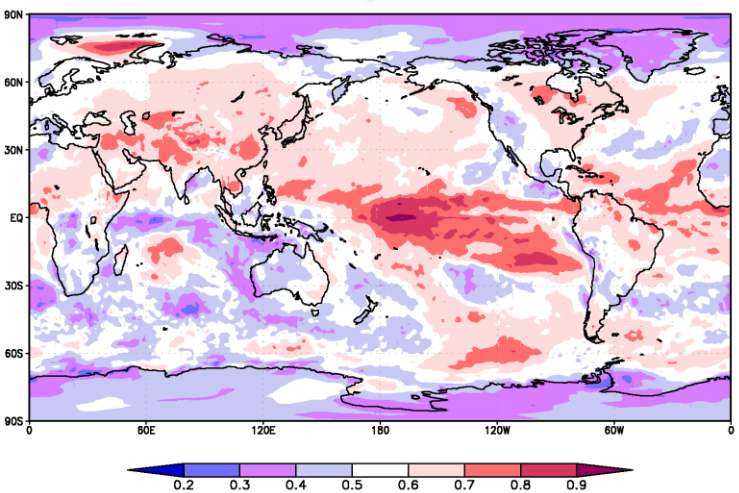
May to September

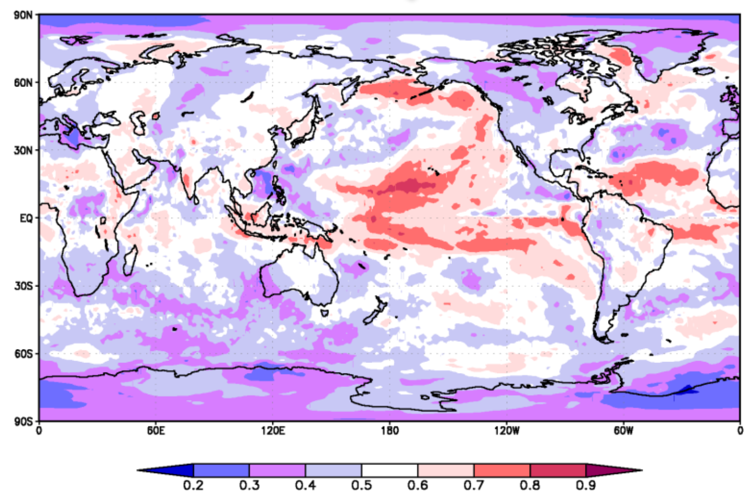
1985





2011

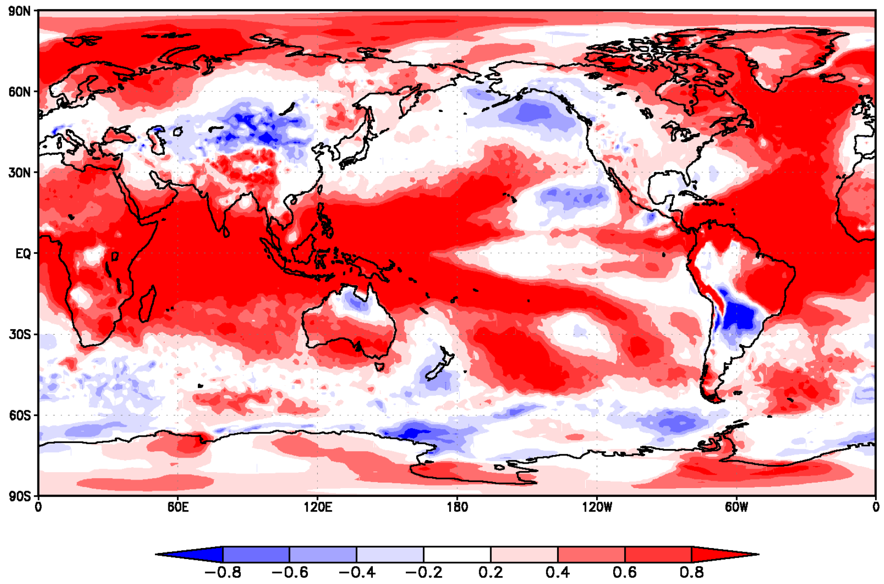




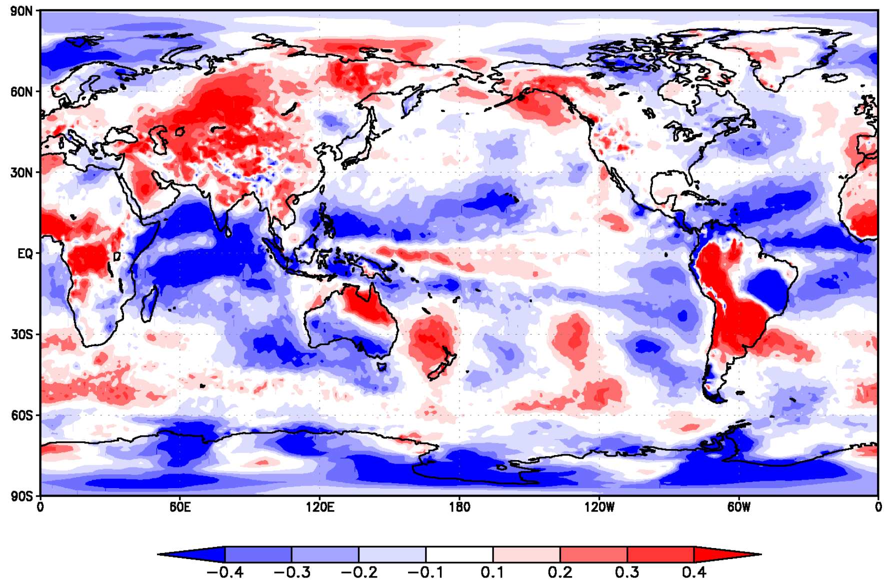
- Is this what an improving observation network does to forecast skill?

Looking a little more precisely at winter (Dec-Jan) bias and trends

Standardized linear Temperature trend



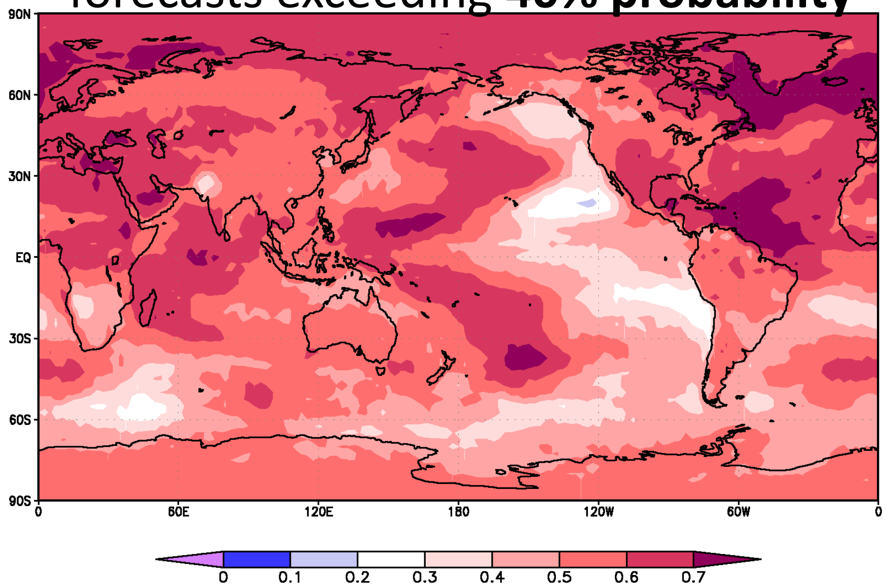
Standardized linear trend of Ensemble mean bias



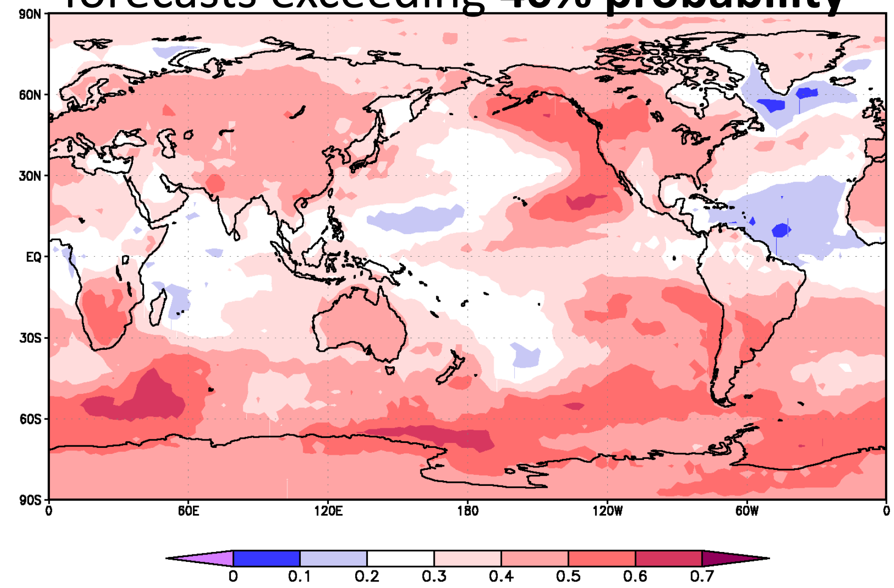
- Growing cold bias where trend is greatest?
- Does **climate change** alter bias-correction of subseasonal forecasts?

What is the frequency of significant subseasonal climate signals?
Forecasts of opportunity

Fraction of <u>week 3</u> above normal T forecasts exceeding **40% probability**



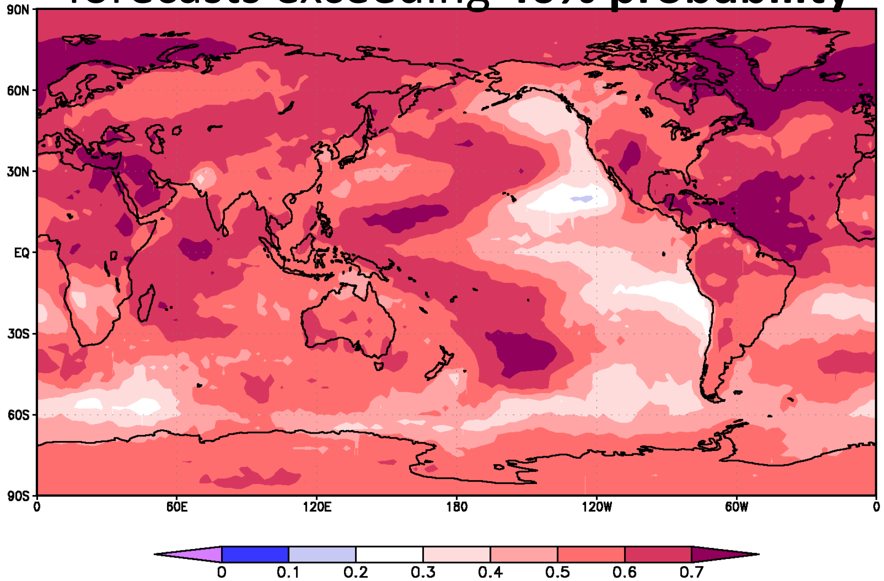
Fraction of <u>week 3</u> below normal T forecasts exceeding **40% probability**



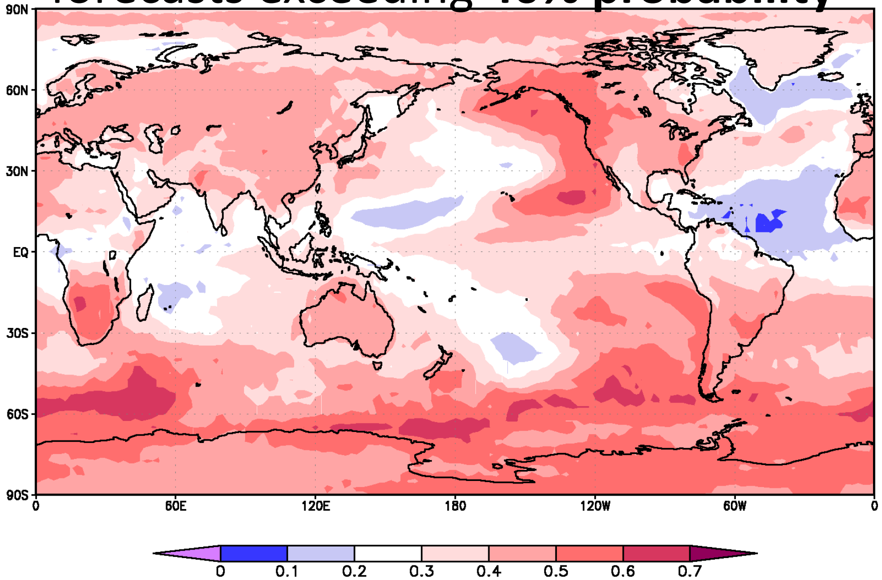
- In 2001 – 2010 **Above** normal probabilities *exceed 40%* in <u>40-50% </u>of week 3 forecasts for North America (based of JMA EPS forecasts)
- In 2001 – 2010 **Below** normal probabilities *exceed 40%* in <u>30-40% </u>of week 3 forecasts for North America

Higher probabilities occur about as frequently in week 4 forecasts as in week 3.
Under-dispersion of ensemble grows with lead

Fraction of week 4 above normal T forecasts exceeding **40% probability**



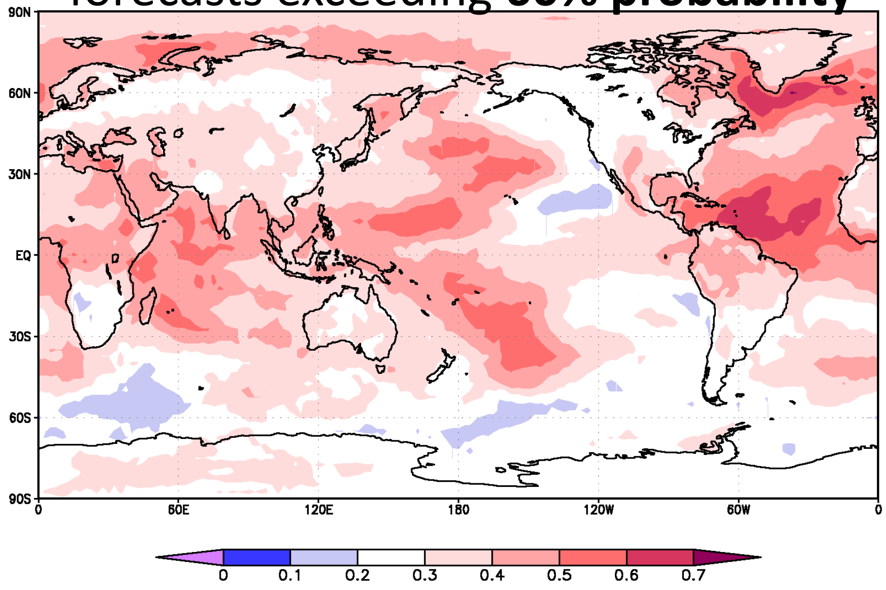
Fraction of week 4 below normal T forecasts exceeding **40% probability**



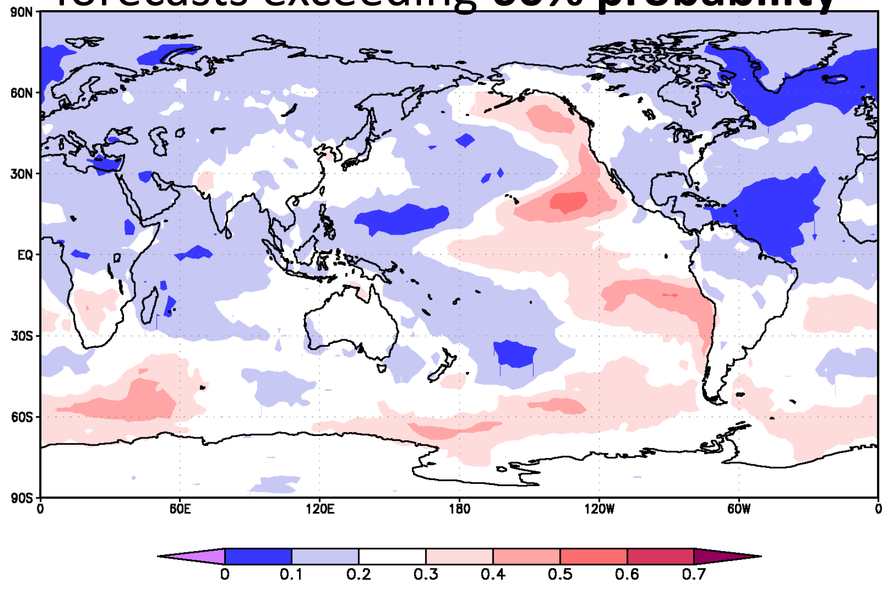
- In 2001 – 2010 **Above** normal probabilities *exceed 40%* in 40-50% of week 3 and week 4 forecasts for North America (based of JMA EPS forecasts)
- In 2001 – 2010 **Below** normal probabilities *exceed 40%* in 30-40% of week 3 and week 4 forecasts for North America

Forecasts with greater than 60% probability are rare
Forecasts of opportunity

Fraction of week 3 above normal T forecasts exceeding **60% probability**



Fraction of week 3 below normal T forecasts exceeding **60% probability**



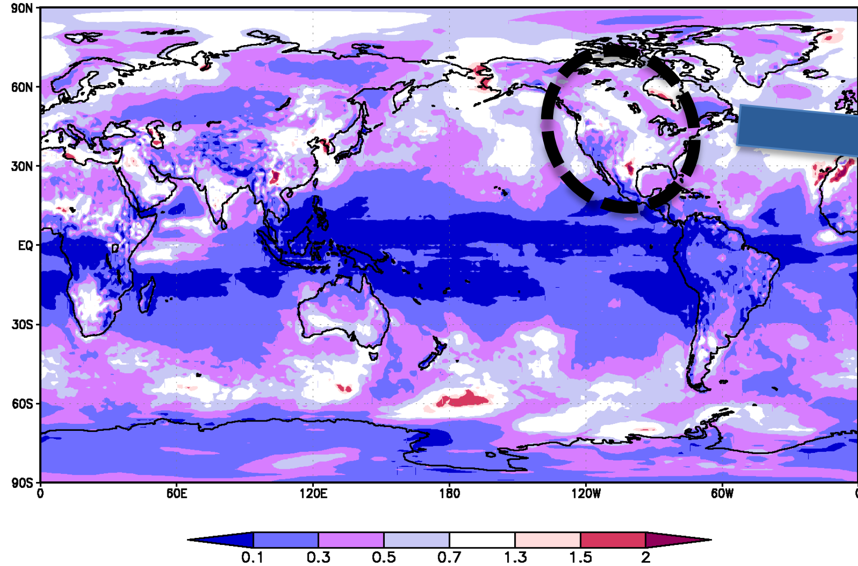
- In 2001 – 2010 **Above** normal probabilities *exceed 60%* in 20-30% of week 3 forecasts for North America (based of JMA EPS forecasts)
- In 2001 – 2010 **Below** normal probabilities *exceed 60%* in 10-20% of week 3 forecasts for North America

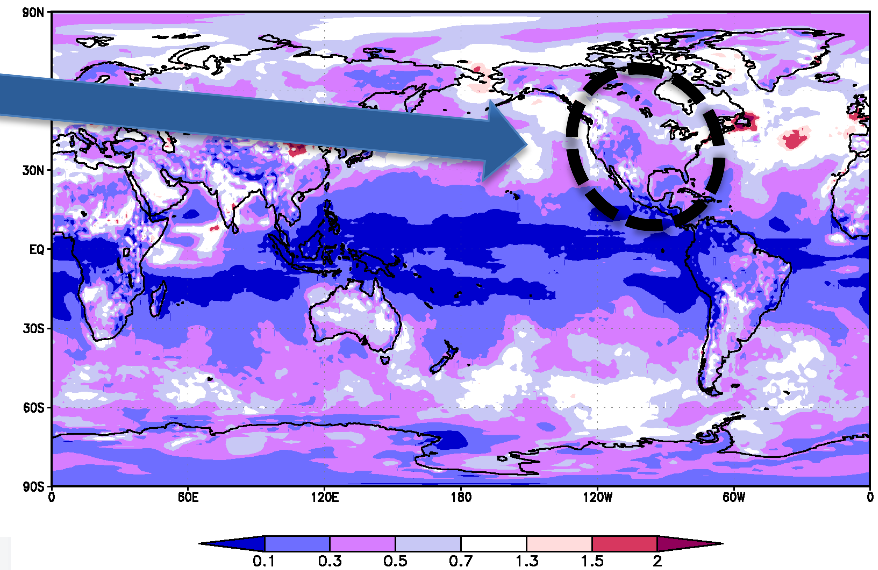
Ensemble is under-dispersive compared to mean square error of ensemble mean forecast

Ensemble spread in **week 3** T forecasts as fraction of mean square error in DJF

Ensemble spread in **week 4** T forecasts standardized by mean square error

DJF

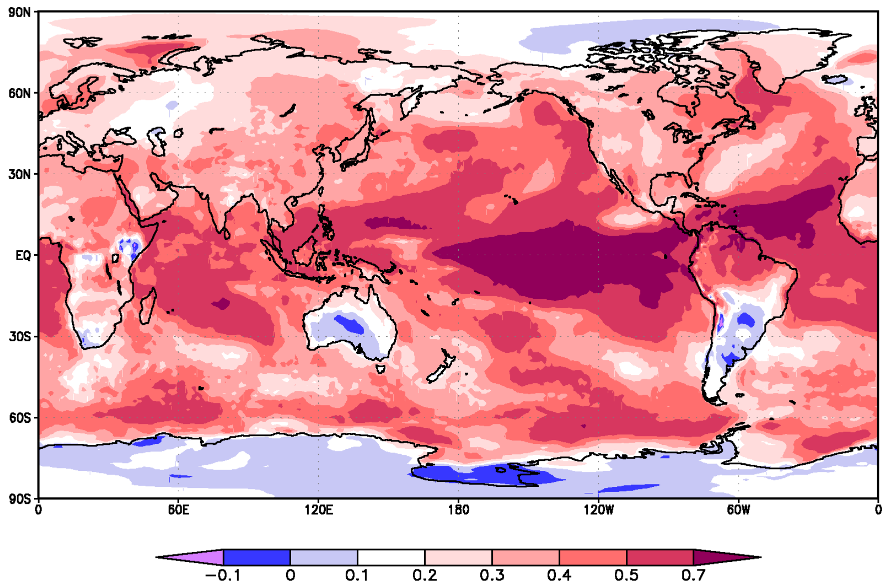




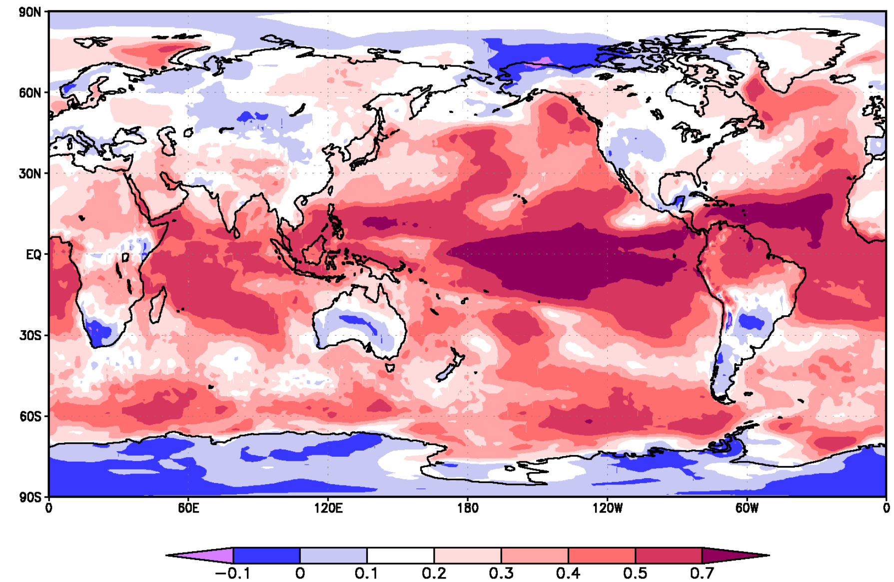
- *While the EPS has a good estimate of its own skill of some regions of central North America in week 3, ensemble is somewhat overconfident by week 4.*

What is the skill of subseasonal model forecasts?

Correlation of **<u>week 3</u>** T forecasts to observational analysis for DJF



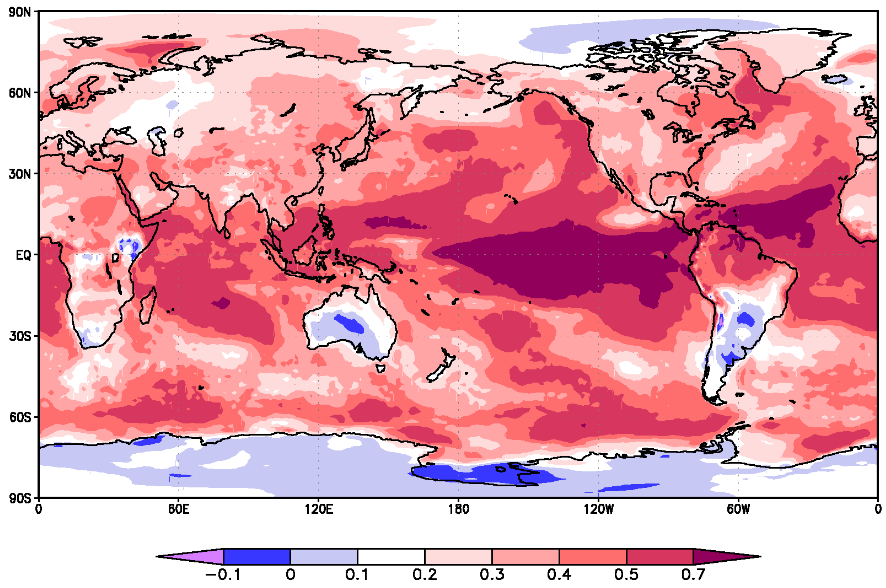
Correlation of **<u>week 4</u>** T forecasts to observational analysis for DJF



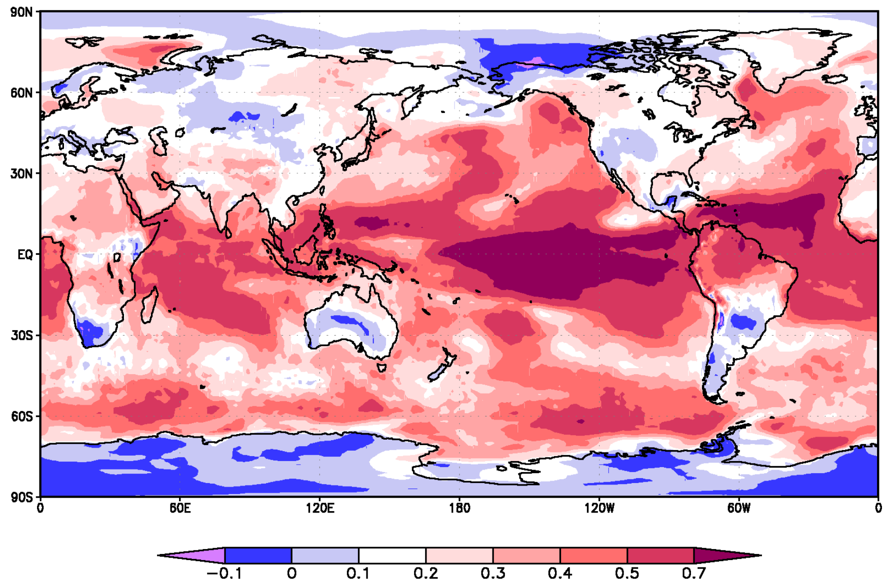
- In 1986 – 2010 **correlation is approximately 20-40% in week 3** for North America winter (DJF)
- In 1986 – 2010 **correlation is approximately 10-30% in week 4** for North America winter (DJF) *(based on JMA EPS forecasts)*

What is the skill of subseasonal model forecasts?

Correlation of **week 3** T forecasts to observational analysis for DJF



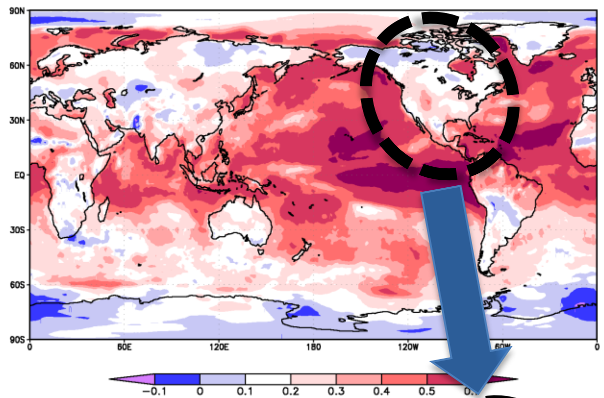
Correlation of **week 4** T forecasts to observational analysis for DJF



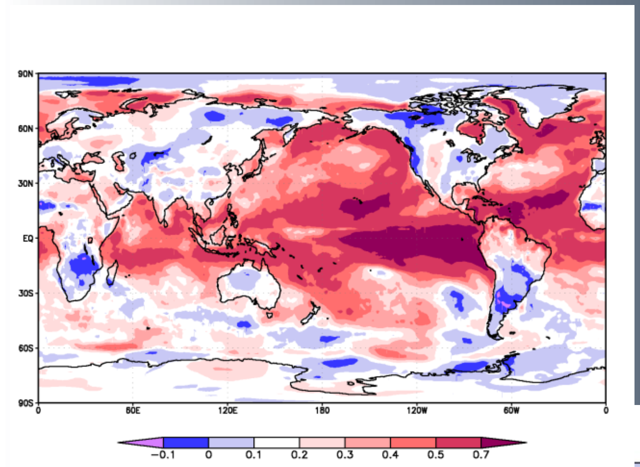
Dependency of skill of subseasonal model forecasts on season

Correlation of **week 3** T for JJA   Correlation of **week 4** T for JJA

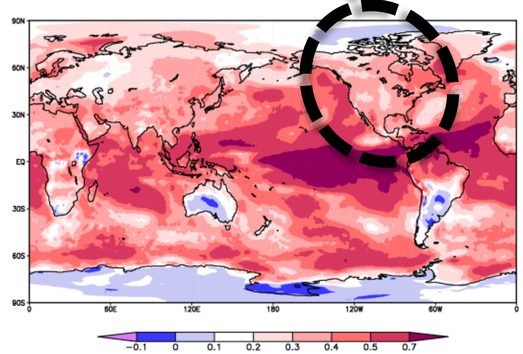
JJA



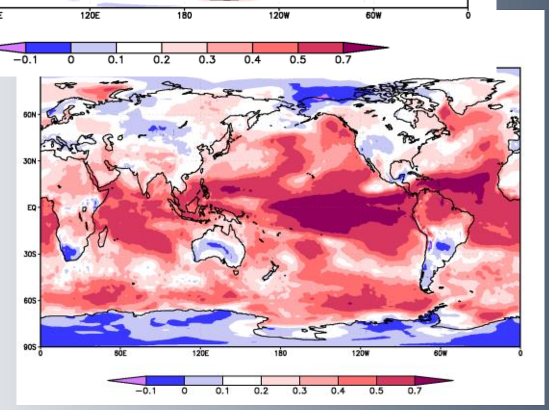
JJA



DJF



DJF

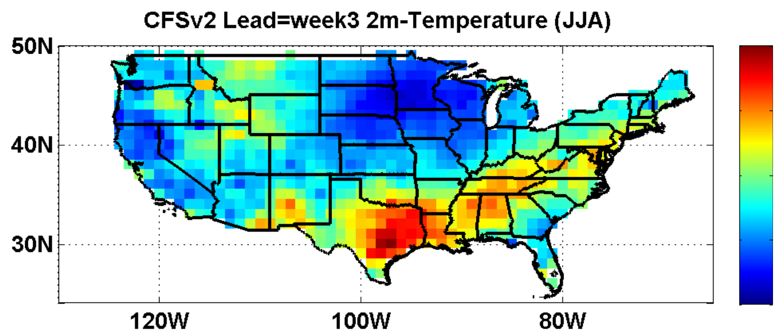


- **Correlation skill is greatest for North America winter** (DJF), *and drops to near zero* skill in summer (JJA) in some parts of North America
- Similar seasonal variation in skill of weather forecasts creates challenge for subseasonal

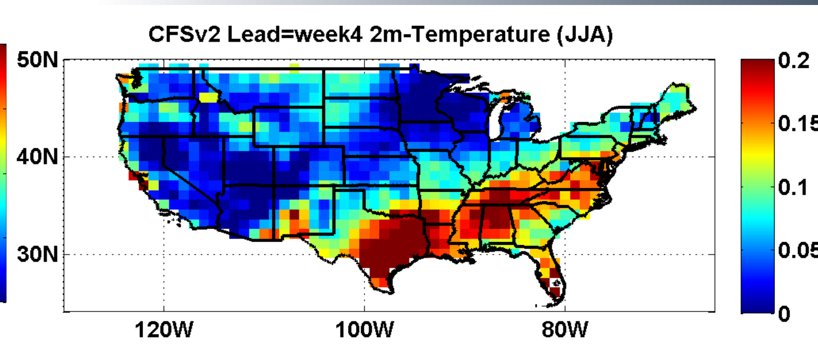
Dependency of skill of subseasonal model forecasts on season

Correlation of **week 3** T for JJA   Correlation of **week 4** T for JJA

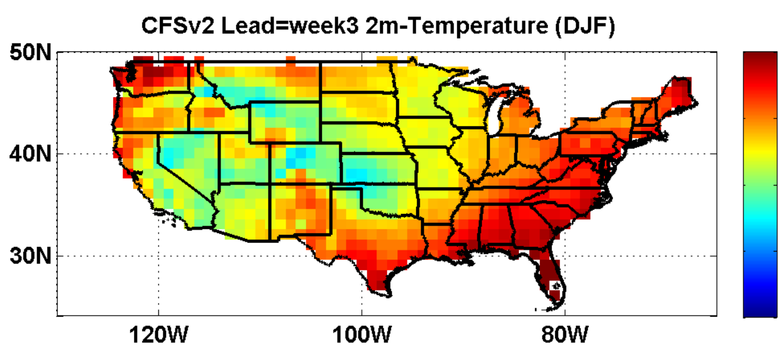
JJA

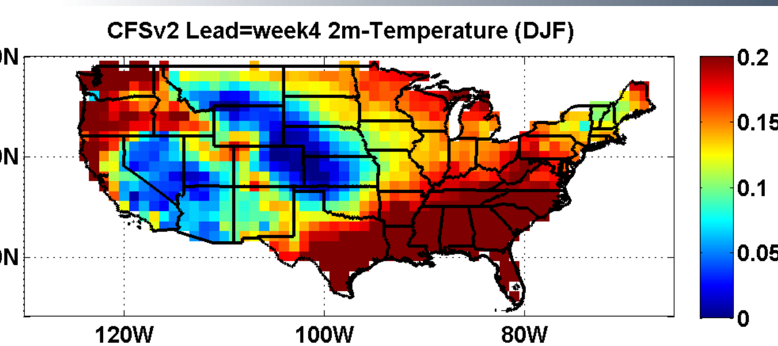


JJA



DJF

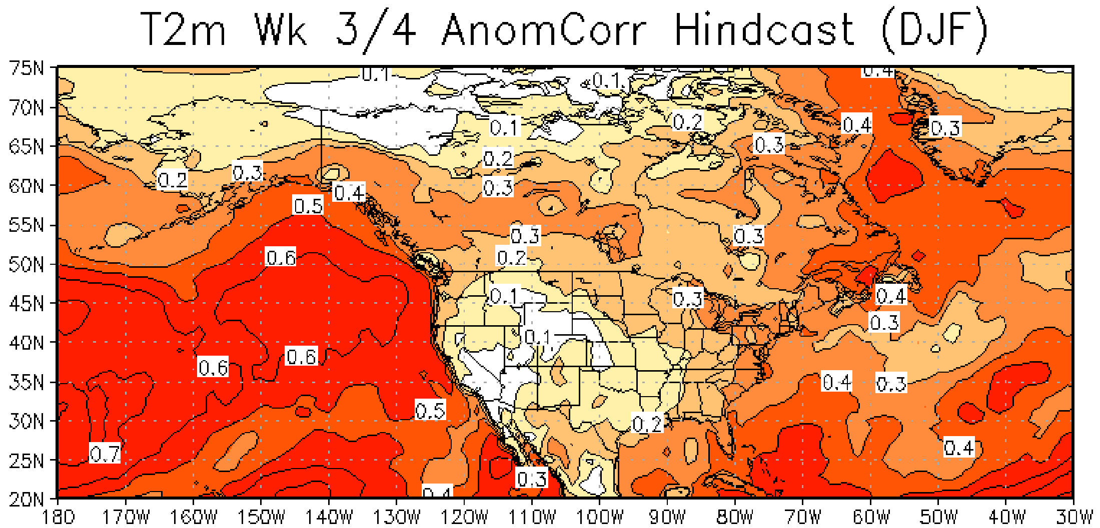




DJF

Examining combined week 3 and 4 forecasts versus separating week 3 and week 4

ECMWF



- **Correlation skill of combined week 3 and 4 is similar to week 3 alone for North America winter** (DJF)
- Increasing the strength of longer timescale signals while reducing impact of unpredictable shorter timescale variability beyond week 3

Conclusions

- Plan to generate an ***MME of opportunity*** to support operational subseasonal forecasts from a variety of ensemble prediction systems

- Dynamical subseasonal forecasts show drop in skill, from week-2 to week-4
  - Week 3 and 4 combined forecasts derive almost all skill from week 3
  - Calibration of ***under-dispersive, overconfident*** **model ensembles** likely should separate statistics by lead time

- Limited skill produces limited number of forecasts with greater confidence (higher probability) and ***Forecasts of opportunity***

- **Longer timescales** (seasonal and decadal climate change) impact the prediction of subseasonal timescales

- Further development is needed to better exploit *subseasonal predictability from climate change and interannual variability*

Abstract

A number of recent international research and operational prediction development projects have focused on bridging the gap between weather and climate forecasts; for example the WMO WCRP/WWRP Subseasonal to Seasonal Prediction Project (S2S). The NOAA Climate Prediction Center (CPC) has a milestone to provide operational subseasonal forecasts before the end of 2015. Environment Canada and U.S. National Centers for Environmental Prediction (NCEP) ensembles from the North American Ensemble Forecast System (NAEFS), currently used in weather forecasts out to two weeks lead time, have been extended to more than four weeks lead time. In addition to the NAEFS models, CPC is evaluating retrospective and real-time ensemble prediction system (EPS) subseasonal forecasts from the European Centre for Medium-range Weather Forecasts (ECMWF) and Japan Meteorological Agency (JMA). The ensemble models of the North American Multi-Model Ensemble (NMME) including the U.S. NCEP Climate Forecast System (CFS) and the Canadian Seasonal to Inter-annual Prediction System (CanSIPS), used in CPC operational seasonal forecasts with one to five months lead time, are now providing data at daily resolution for research on subseasonal prediction. The ensemble models available for subseasonal forecasts are varied in several respects. The NAEFS and JMA EPS are currently uncoupled atmosphere dynamical models, while the ECMWF EPS and NMME models are all coupled to ocean models. Extended weather models also differ from the seasonal forecast systems of the NMME in that they have generally higher spatial resolution and more advanced data assimilation and initialization schemes.

This talk will present preliminary evaluations of the multitude of ensemble model forecasts individually and combined as multi-model ensemble forecasts, compare subseasonal modeling systems, and discuss the prospects for provision of skillful subseasonal forecasts with three to four weeks lead time.