Progress on the CTB project "Enhancing Operational Drought Monitoring and Prediction Products through Synthesis of NLDAS and CPPA Research Results"

Eric F. Wood[1], Dennis P. Lettenmaier[2], Xing Yuan[1], Lifeng Luo[3], YouLong Xia[4], Michael Ek[4], Kingtse Mo[5]

[1]Department of Civil and Environmental Engineering, Princeton University

[2]Department of Civil and Environmental Engineering, University of Washington

[3]Department of Geography, Michigan State University

[4]Environmental Modeling Center, NCEP/NWS/NOAA

[5]Climate Prediction Center, NCEP/NWS/NOAA

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Summary of Project Tasks

Task 1

- Transition of the objective drought prediction system to NCEP EMC.
- Upgrade the drought prediction system with the new CFSv2-based forecasts.

Task 2

- Integration of forecast systems to provide objective drought indices.

Task 3

- Data set unification.

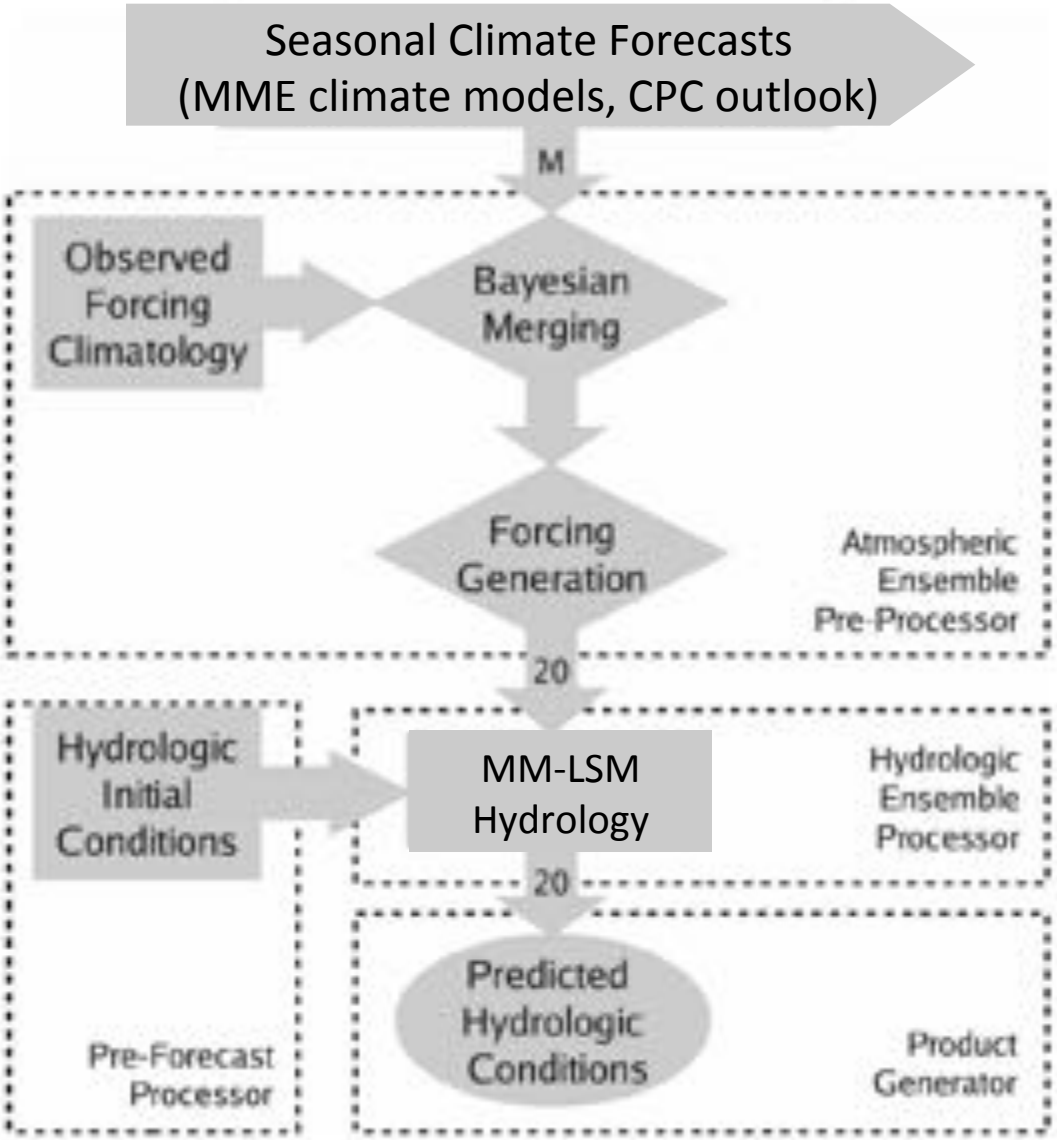
Task 4

- Generation of drought index hindcasts and forecasts.

Task 5

- Assessment and verification studies.

Schematic illustration of the project's seasonal hydrologic ensemble prediction system being transferred to the CTB

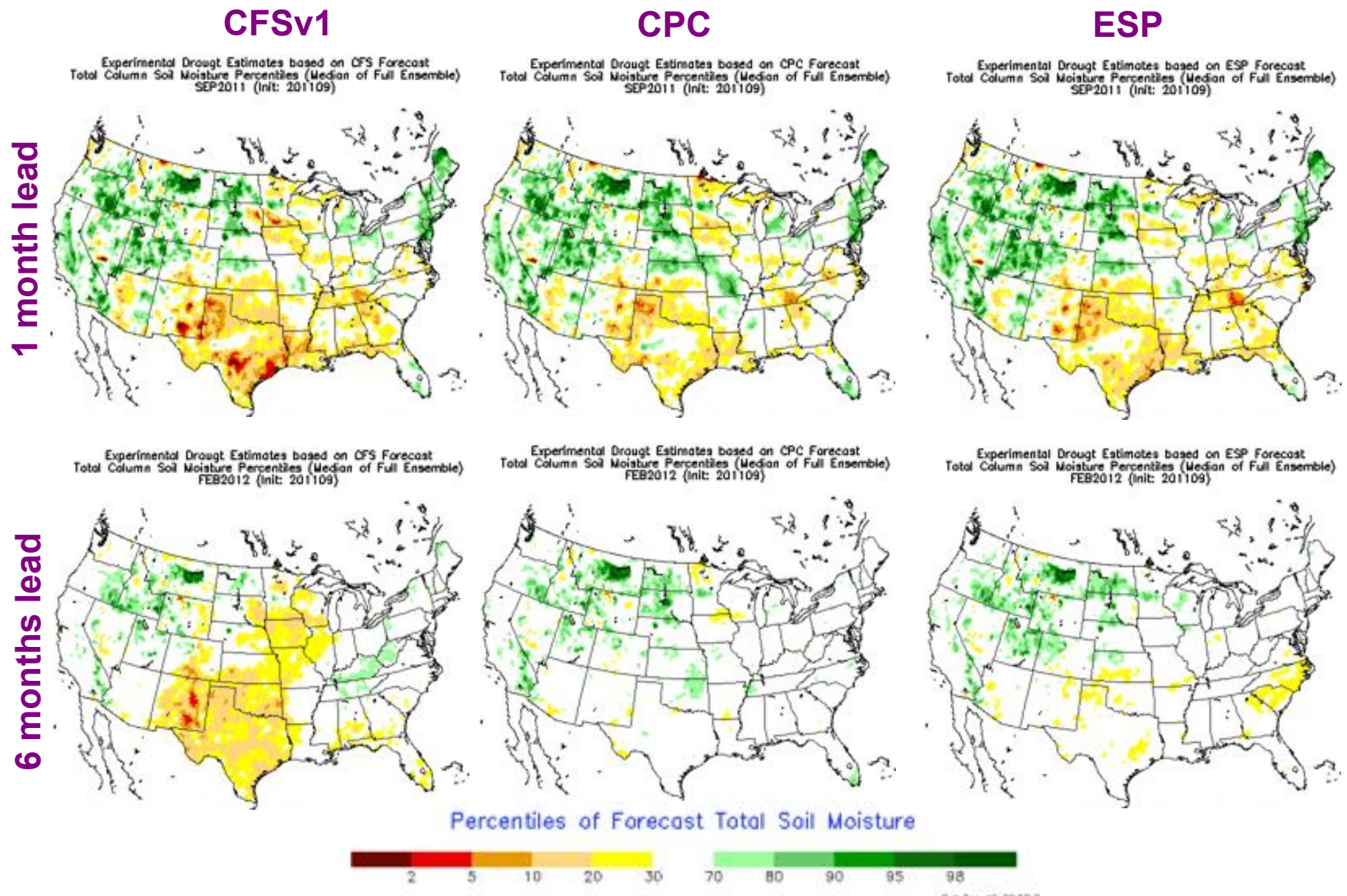


NLDAS Drought Monitoring Component

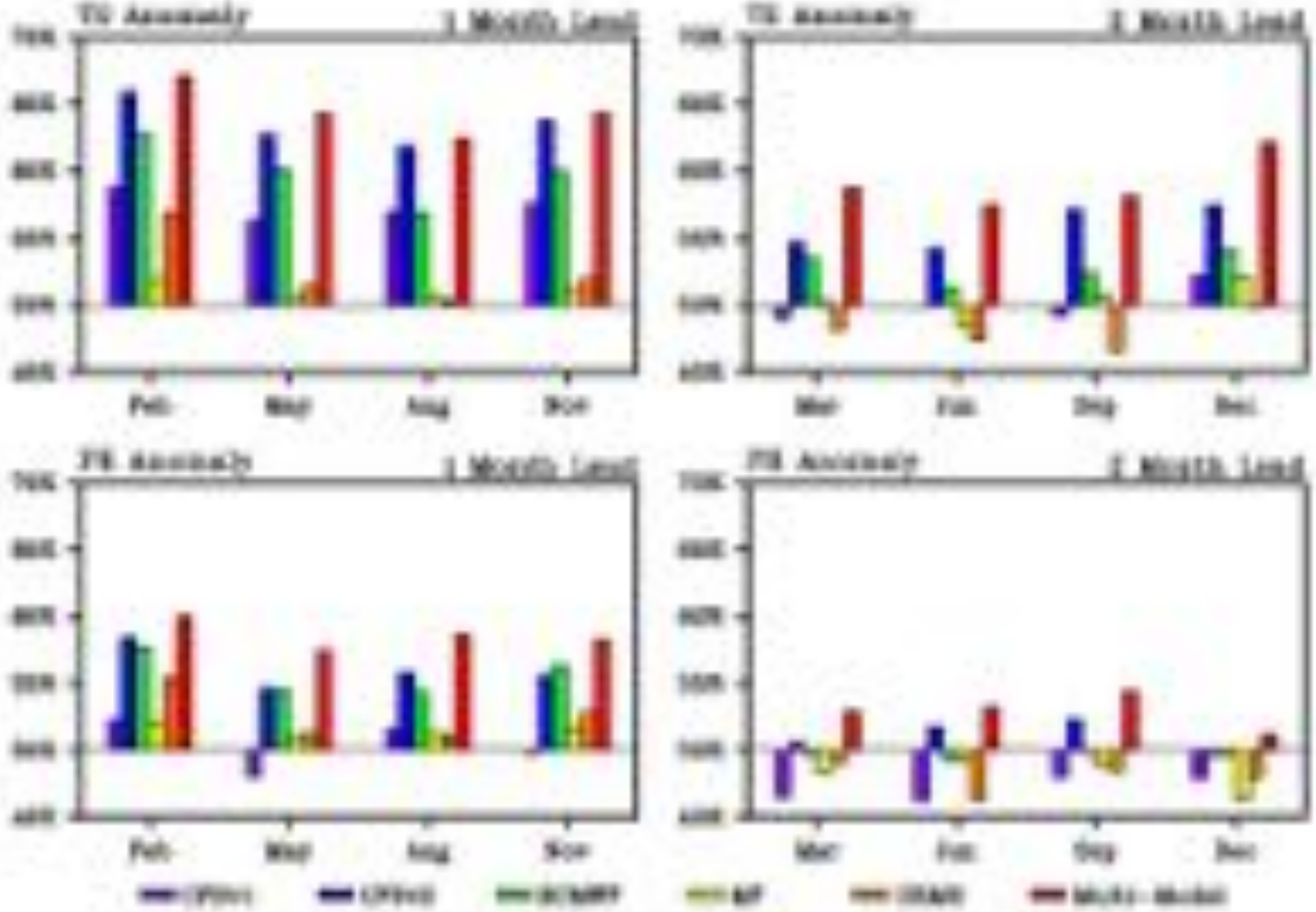
Task 1: Transition of the objective drought monitoring and

- **Work Done**:
  - The prediction component of the PU/UW, Drought Monitor and Prediction System (DMAPS) was transferred to NCEP/EMC at the beginning of the project, and has been running in a quasi-operational setting since.
  - The three prediction methods (CFS-based, CPC-based and ESP-based) are implemented on EMC's TEMPEST computer system.
- **Ongoing/Future Work:**
  - Evaluation and integration of CFSv2 into the system.
  - Integration of all three drought prediction systems (i.e. PU, UW, EMC) and its implementation on CTB system.

NLDAS Drought Forecast Analysis (Sept 2011) http://www.emc.ncep.noaa.gov/mmb/nldas/forecast/TSM/perc/

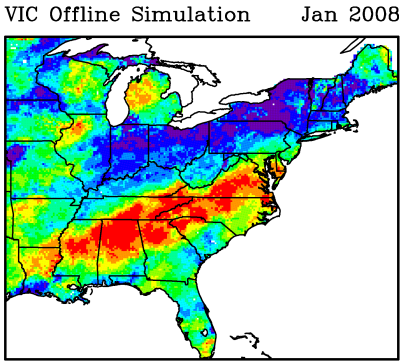


Task 1+:



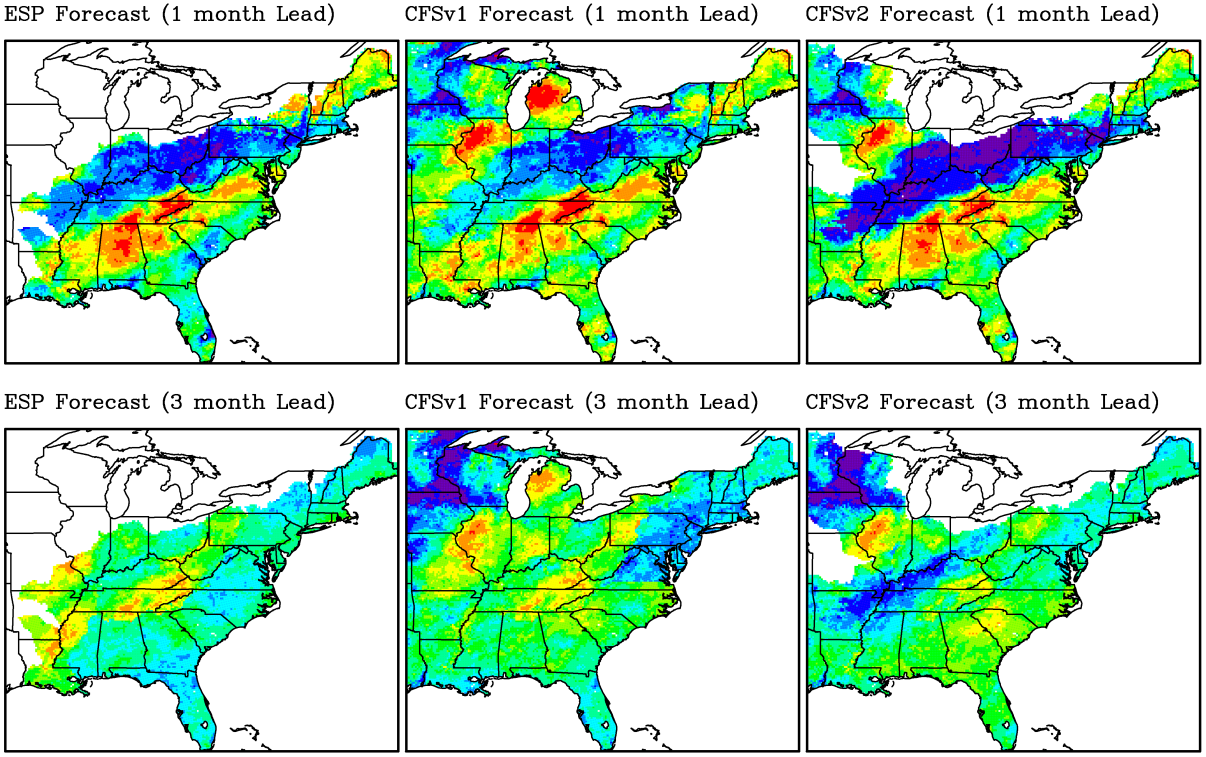
Percentage of positive RPSS for global monthly temperature and precipitation anomaly

Task 1+:



VIC Off-line (Control)

Soil moisture percentile in Jan 2008



1 Month Lead

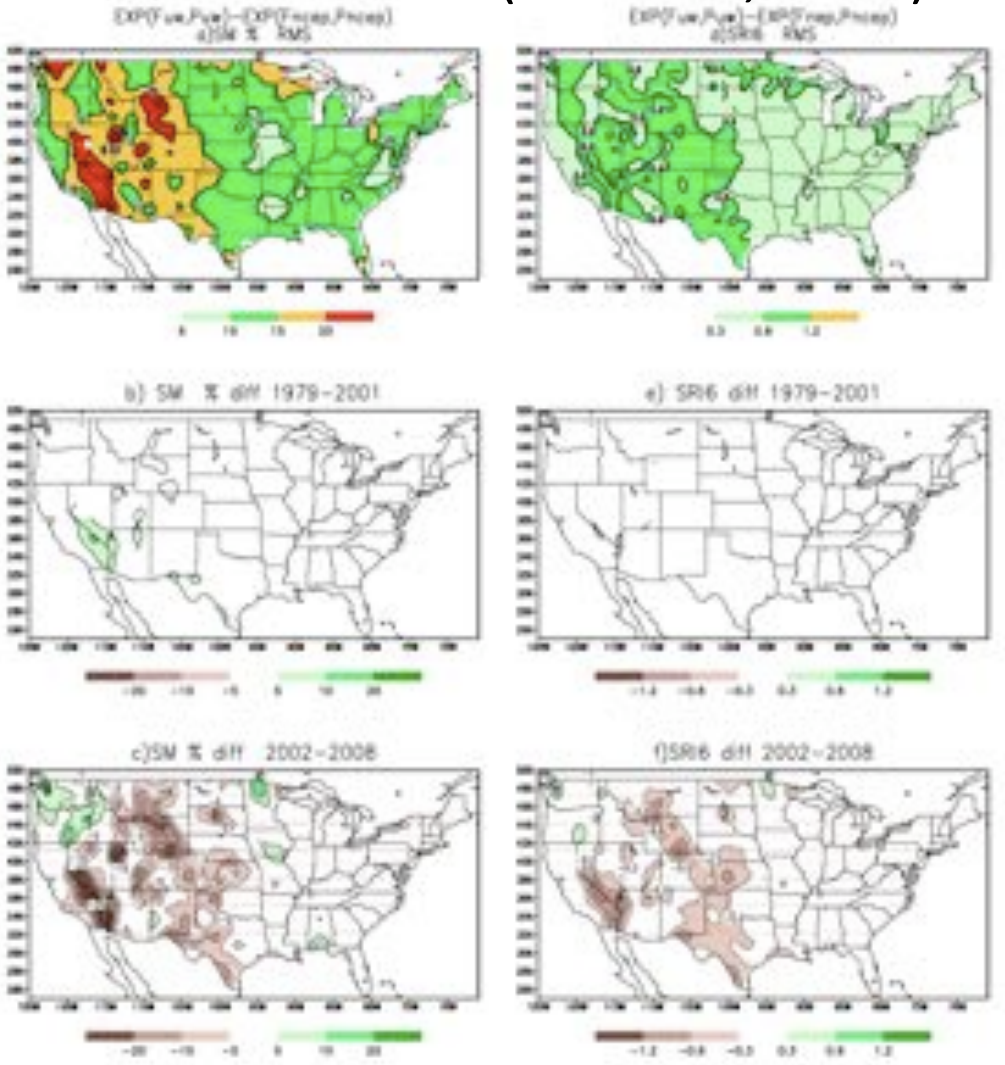
3 Month Lead

Task 2: Integration of systems to provide objective drought indices (Lead PU)

- **Issue:**
  - Real-time hydrological runs (needed for drought statistics and the drought index) are based on different data sets, which has a discernable impact on the drought assessment (risk).
- **Work Done**:
  - The uncertainties/differences among the three drought monitoring systems (PU, UW and EMC) have been analyzed in conjunction with Dr. Kingtse Mo (CPC).
- **Ongoing/Future Work:**
  - Integration/unification of all three drought monitoring systems (i.e. UW, EMC, PU) and its implementation on CTB system with the assistance of EMC (YouLong Xia).

Uncertainties in North American Land Data Assimilation Systems over the Contiguous United States. (*Mo et al., 2011*)

Uncertainties in SM percentile and SRI-6

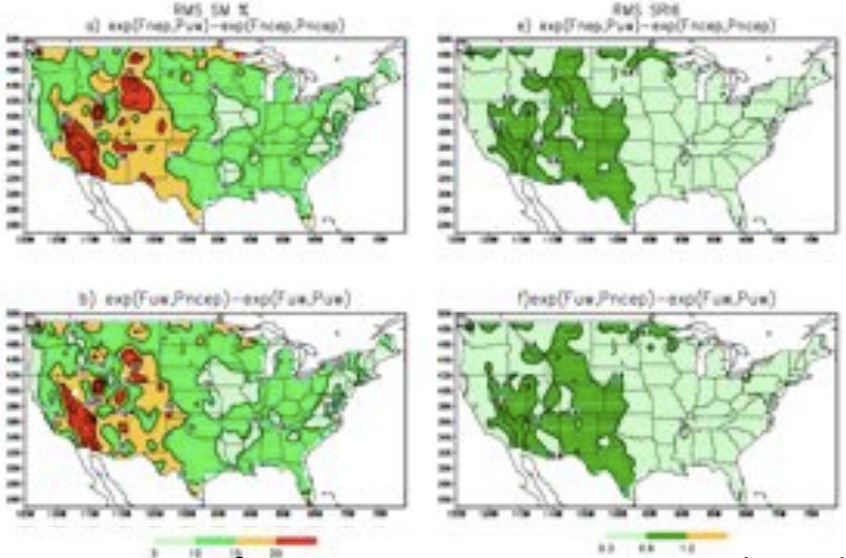


- ✓ **The ensemble mean differences between the two systems are large over the western United States – in some cases exceeding 20% for SM and runoff percentile differences.**
- ✓ **These differences are too large for drought classification.**

Uncertainties mainly prominent over 2002-08

Fig. 1: (a) RMS difference of SM percentiles for the experimental period (1979-2008) between the control UW experiment, Exp(F_{uw}, P_{uw}), and the control NCEP experiment, Exp(F_{ncep}, P_{ncep}). (b) Difference of SM (c) same as (b), but for the real-time period (2002-2008); and (d)-(f) same as (a)-(c), but for SRI6. Contour interval is 0.3.

(a) Uncertainties due to difference in Precipitation forcings



(b) Uncertainties due to difference in Temperature forcings

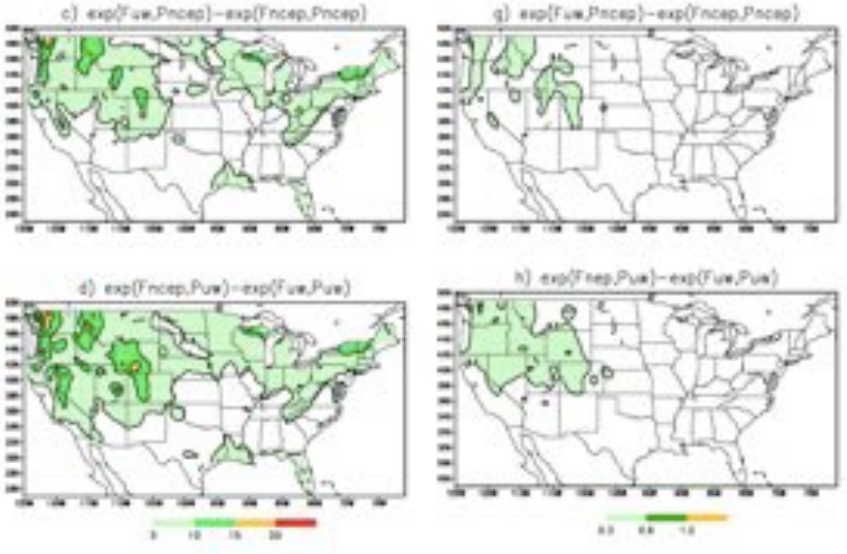
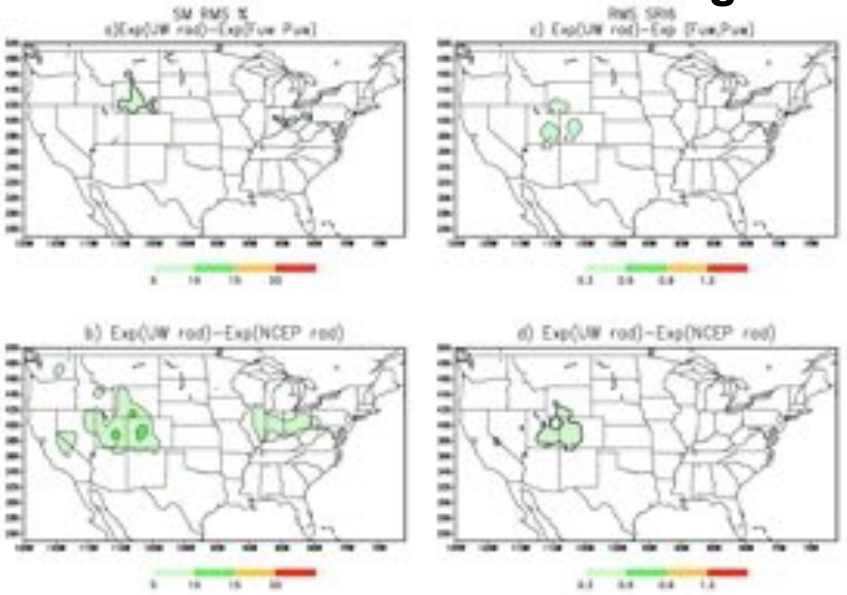


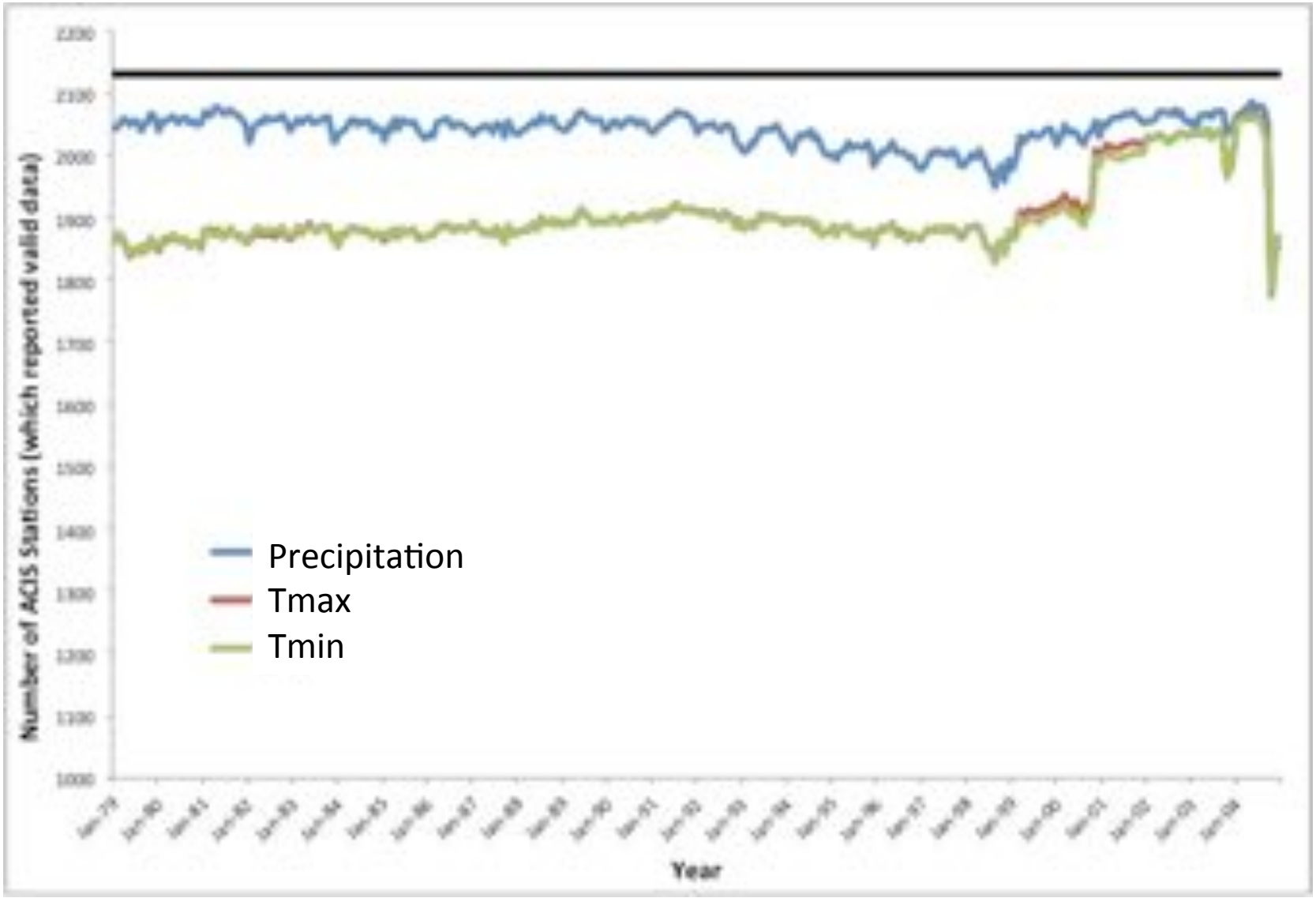
Fig. 2: Sources of uncertainties in SM percentile and SRI-6.

(c) Uncertainties due to difference in Rad. and Humid. forcings

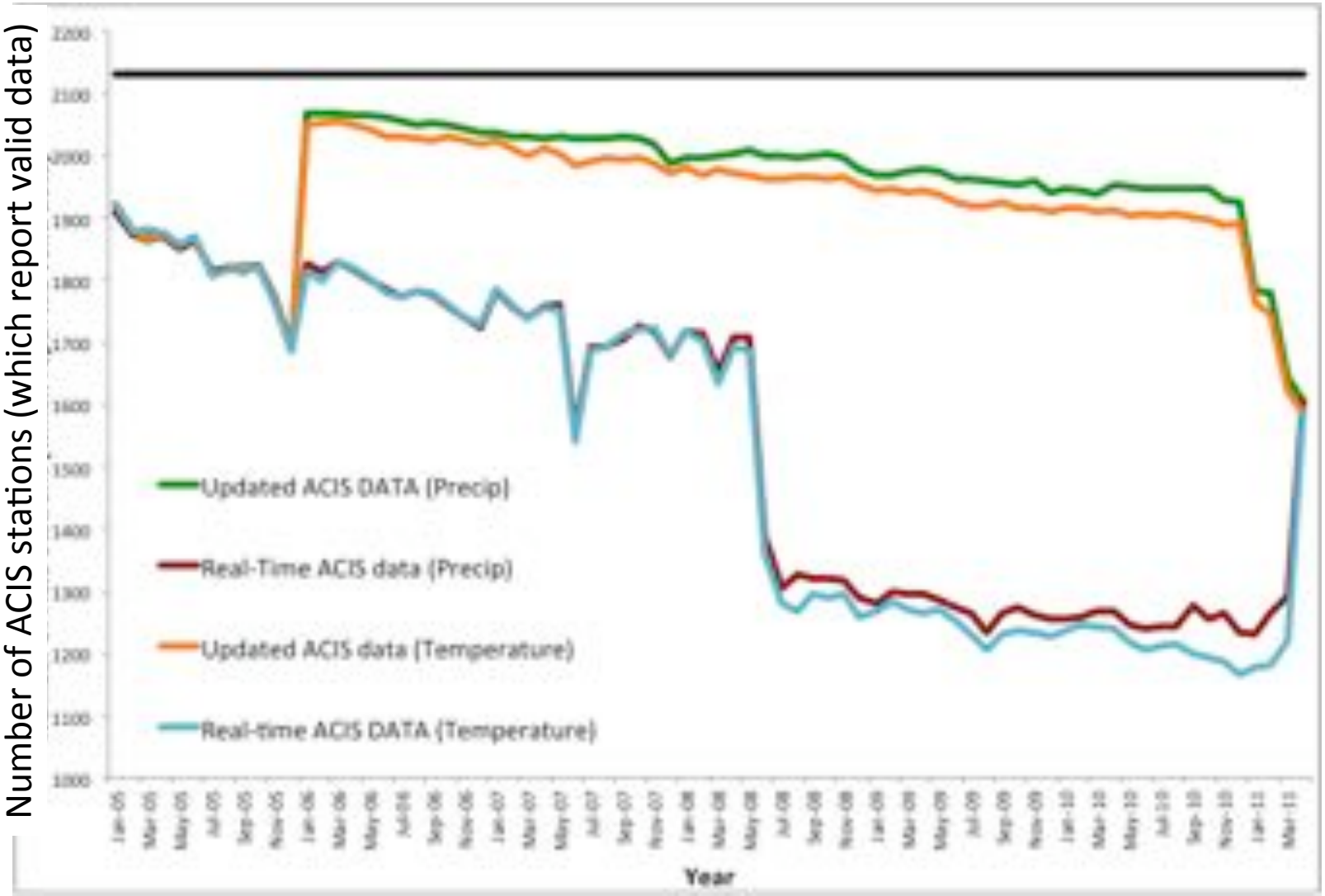


- ✓ Uncertainties are mainly due to difference in precipitation forcings.
- ✓ Post 2004 the number of stations reporting data dropped.
- ✓ Although the NCEP uses all available station reports each day (about 6000-8000), the UW system relies on a smaller number of stations (about 2400), which however have a more consistent climatology, and are more likely to report on most days.

Number of ACIS stations reported valid data during 1979-2004



Issues with stations data download in real-time (post-2004)



Task 3: Data set unification (Lead UW)

- **Issue:**
  - Real-time hydrological runs (needed for initial conditions) are based on different data sets, which has a discernable impact on the hydrologic forecasts.
- **Work Done**:
  - Maurer et al., (2002) data set has been developed for the period of 1915-2010 (August) at 1/16 degree resolution for the CONUS. The data set has been tested against the previous version (i.e. Maurer et al., 2002).
- **Ongoing/Future Work:**
  - Development of 1915-present data set at 1/8 deg, using index station method for CONUS domain is underway.
  - Extension of NARR data set (possibly to as early as 1915) that adjusts station-based methods to be consistent with NARR in the overlap period, and to use the extended data set for purposes of estimating the probabilities associated with drought indices. This work will be undertaken in collaboration with Dr Kingste Mo (CPC).

Extension and Spatial Refinement of a Long-Term Hydrologically Based Dataset of Land Surface Fluxes and States for CONUS (*Livneh et al., 2011*)

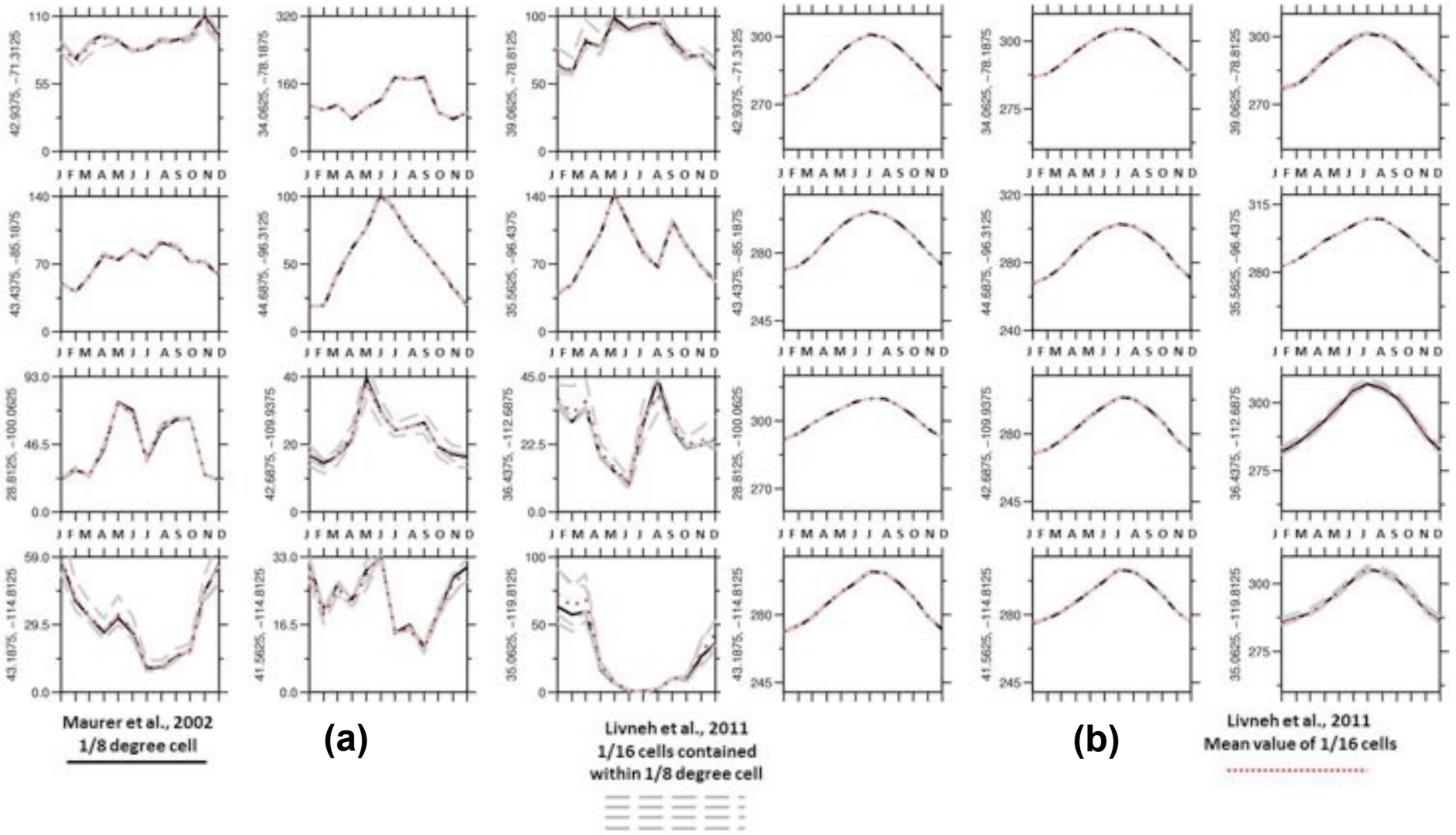


Fig. 3: (a) Precipitation (b) Tmax comparison between Livneh et al., (2011) and Maurer et al. (2002) data set for the selected grid cells.

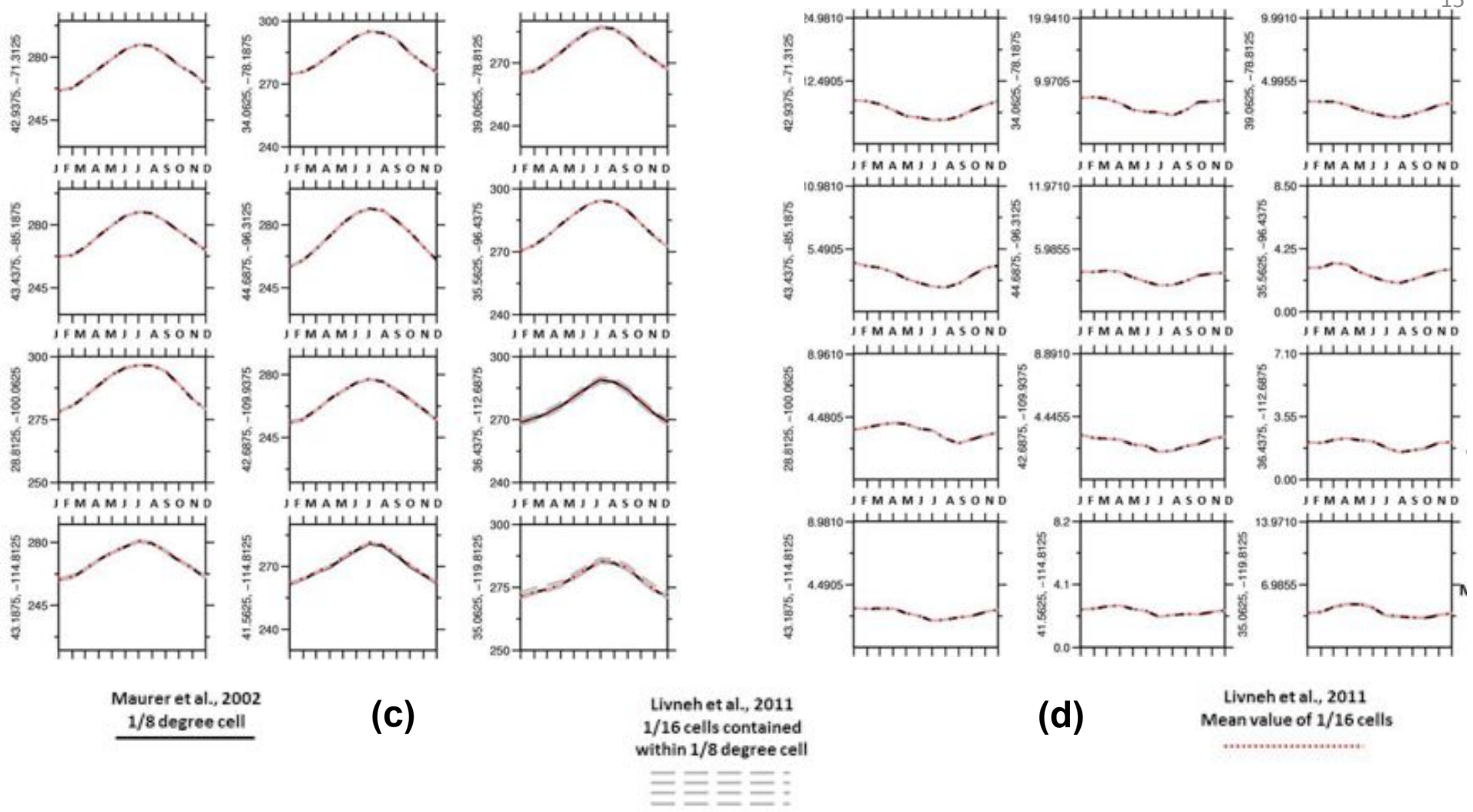


Fig. 3: (c) Tmin (d) Wind speed comparison between Livneh et al., (2011) and Maurer et al. (2002) data set for the selected grid cells.

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Task 5: Assessment and verification studies (Lead UW)

- **Work Done**:
  - The assessment of the relative controls of initial hydrologic conditions and atmospheric forcings on seasonal hydrologic and drought prediction skill (over the CONUS) has been performed.
  - Comparison of skill between CFSv1, CFSv2 and ESP for river discharge (eastern US, being extended to CONUS)
  - Assessment of skill in predicting on-set , continuation and recovery of drought over the SE NIDIS Testbed

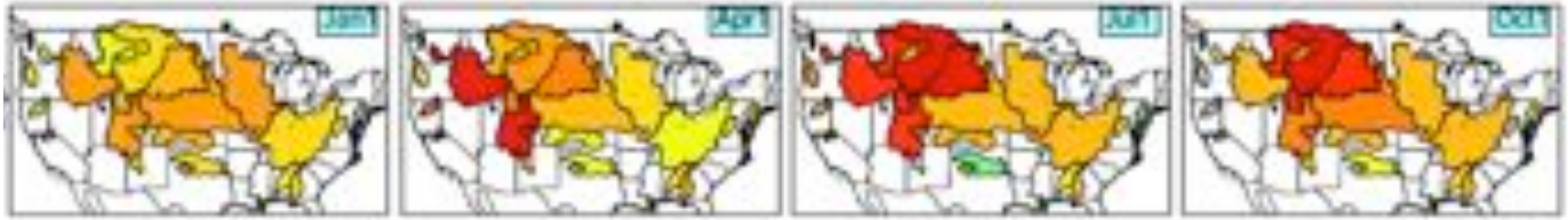
(cont)

Task 5: Assessment and verification studies (Lead UW)

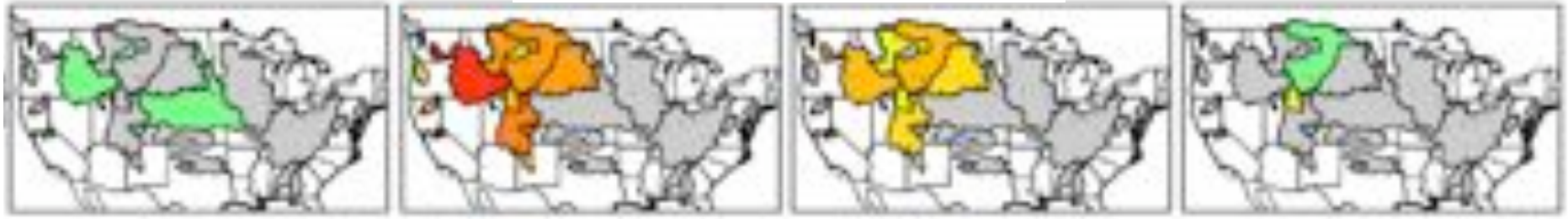
- **Ongoing/Future Work:**
  - The evaluation and verification of the forecast skill of the multi-model drought products in collaboration with our partners at EMC and CPC.
  - Metrics currently being used to assess the Princeton seasonal hydrologic forecast system include ranked probability scores, brier score and root mean square error, with a focus on drought over the NIDIS testbeds.

Soil Moisture, Snow, and Seasonal Streamflow Forecasts in the United States (*Mahanama et al., 2011*)

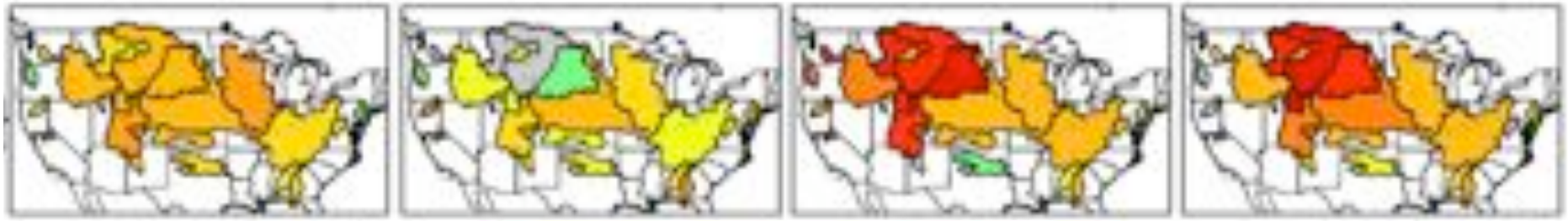
(a) EXP1: Initial SM and snow known



(b) EXP2: Only initial snow known



(c) EXP3: Only initial SM known



Skill (r^2) vs observations

Fig. 4: Skill (r^2) of multi-model ensemble 3-month streamflow forecasts at 0-month lead for four start dates (columns) and the three experiments (rows). Gray shading indicates that skill levels are not significant at the 95% level.

Seasonal hydrologic prediction in the United States: understanding the role of initial hydrologic conditions and seasonal climate forecast skill (*Shukla and Lettenmaier, 2011*)

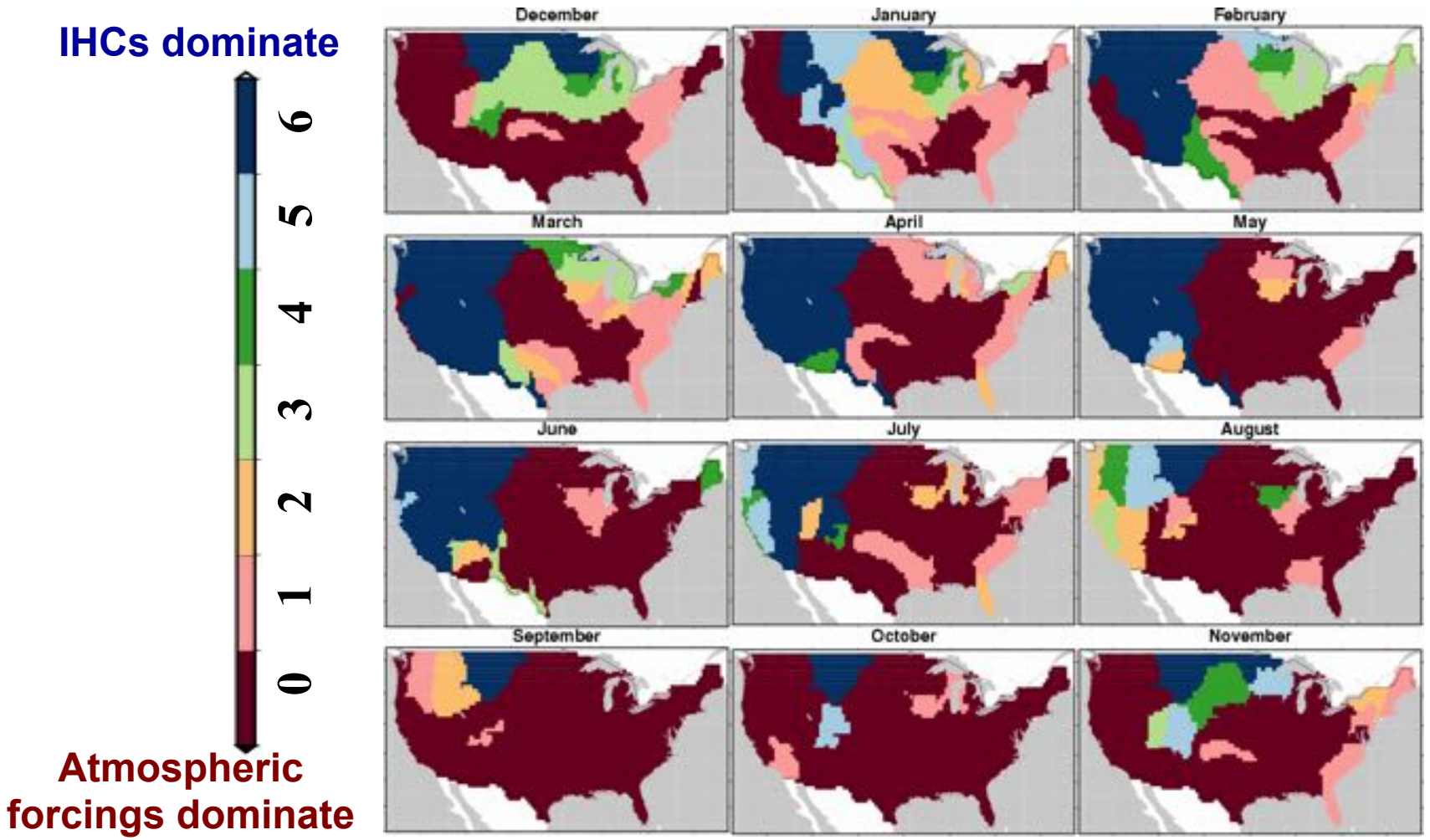
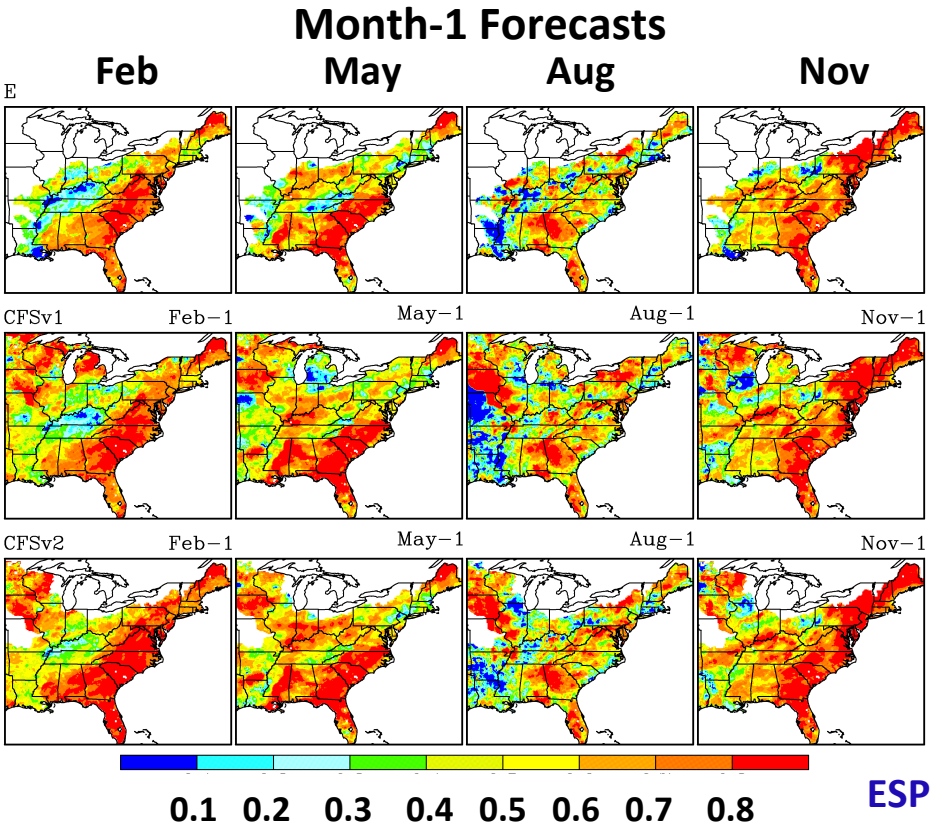
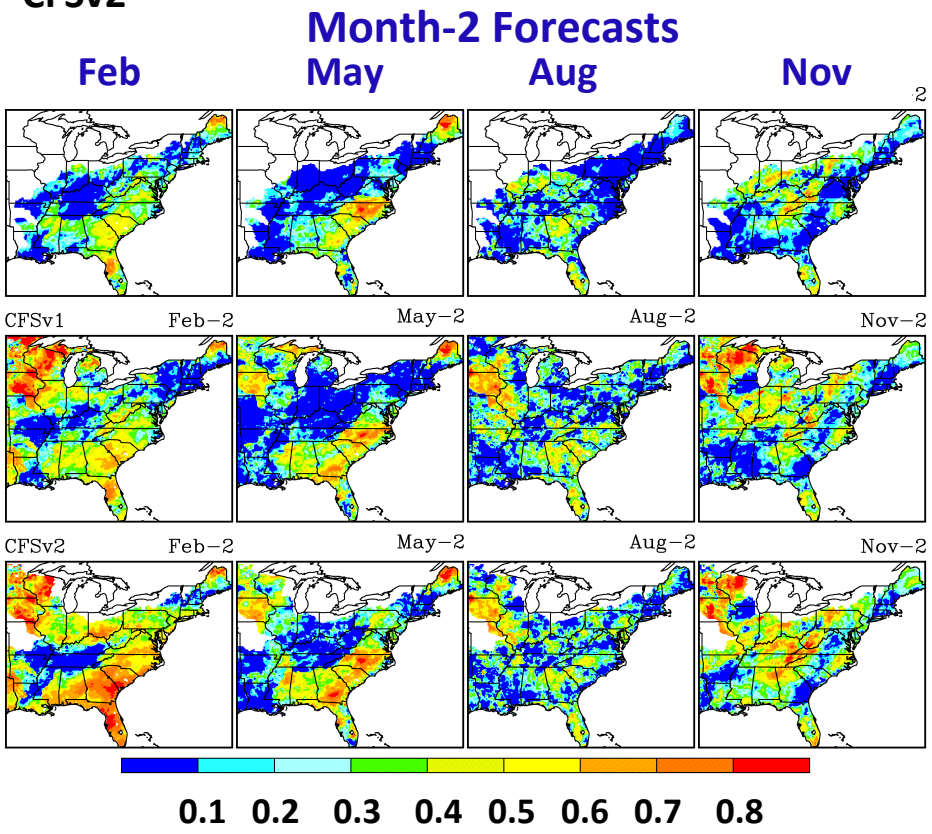


Fig. 5: Plot of the maximum lead (in months) where RMSE Ratio [RMSE(ESP)/RMSE(revESP)] is less than 1, for *cumulative runoff forecasts*, initialized on the beginning of each month.

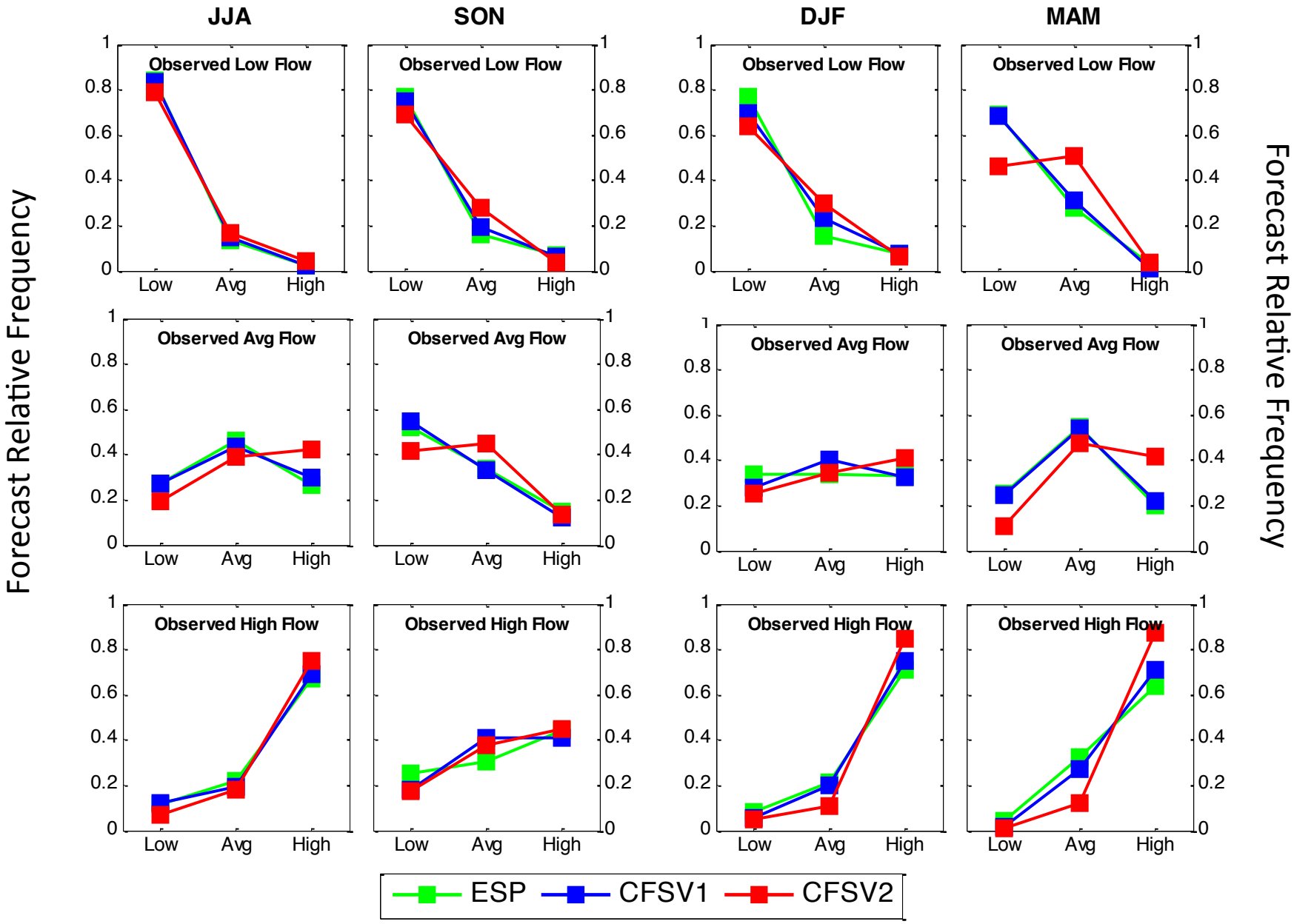
Correlation with Predicted Runoff for the first two months over Eastern US



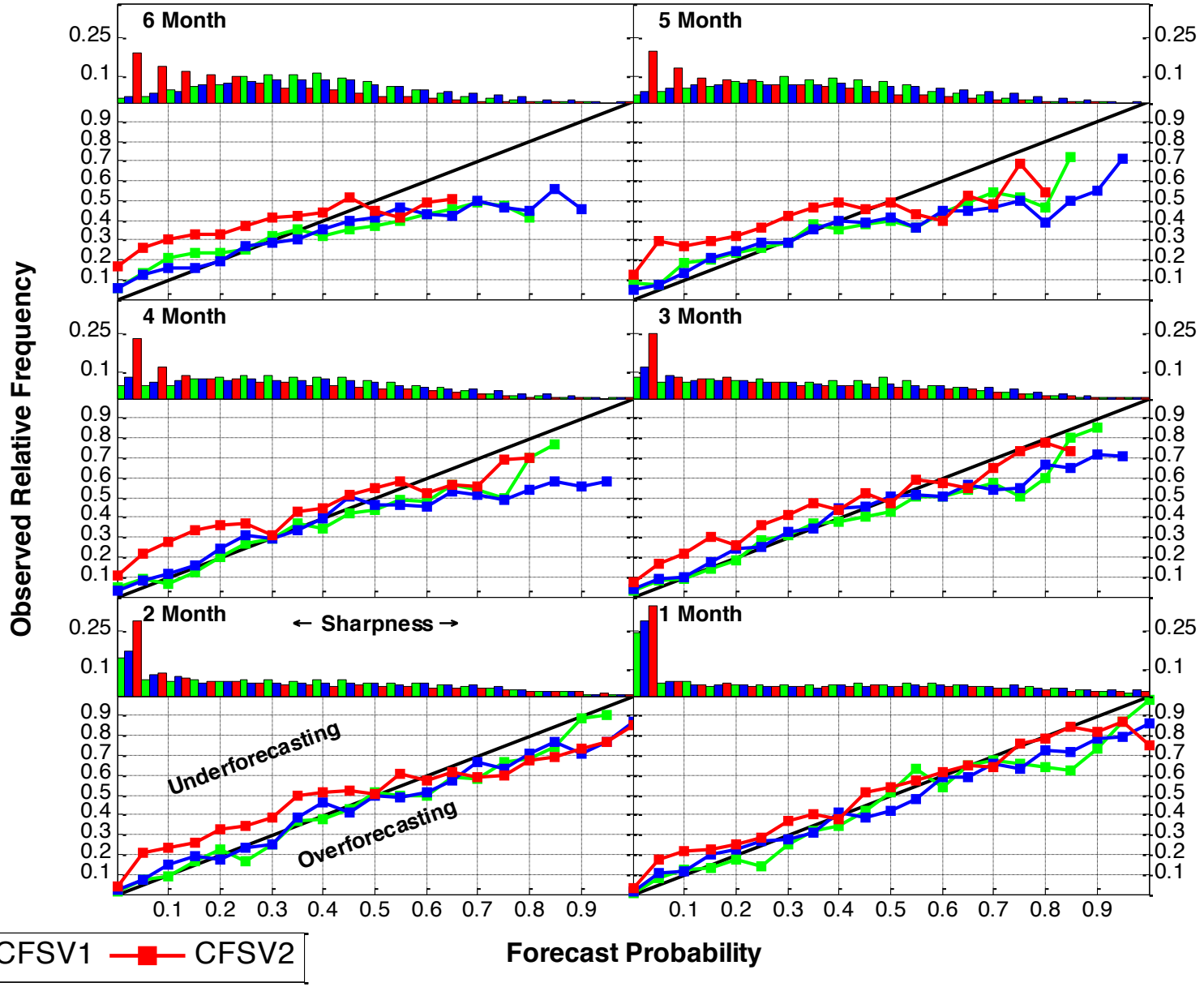


- Cold season is better than warm season.
- Skill decreases dramatically in the second month.
- Due to the effects of initial conditions, CFSv1 and CFSv2 have more obvious improvement for month-2.

SE NIDIS, Seasonal Forecast Discrimination (month 1)



- Reliability Diagram
  - Given a forecast of low flow, how reliable is it?



References and Project Publications

- Livneh B., E.A. Rosenberg, V. Mishra, K.M. Andreadis, and D.P. Lettenmaier, 2011: Extension and Spatial Refinement of a Long-Term Hydrologically Based Dataset of Land Surface Fluxes and States for the Conterminous United States, *J. Climate*, (in preparation).
- Maurer, E. P., A. W. Wood, J. C. Adam, D. P. Lettenmaier, and B. Nijssen, 2002: A long-term hydrologically based dataset of land surface fluxes and states for the conterminous United States. *J. Climate*, 15, 3237–3251.
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- Mahanama, S.P., B. Livneh, R.D. Koster, D.P. Lettenmaier, and R.H. Reichle, 2011: Soil Moisture, Snow, and Seasonal Streamflow Forecasts in the United States. J. Hydrometeorol. (in review).
- Shukla, S. and D. P. Lettenmaier, 2011: Seasonal hydrologic prediction in the United States: understanding the role of initial hydrologic conditions and seasonal climate forecast skill, *Hydrol. Earth Syst. Sci.* (in review).
- Yoon, J-H, K Mo and E F Wood, 2011 Meteorological Drought Prediction based on the Standardized Precipitation Index, *J Hydromet.* (in press).
- Yuan Xing; Wood Eric F.; Luo Lifeng; Ming Pan. 2011. A first look at Climate Forecast System version 2 (CFSv2) for hydrological seasonal prediction,*Geophys. Res. Letts.* 38, Art. No. L13402, doi: 10.1029/2011GL047792