CWRF Downscaling Enhancement on Seasonal-Interannual Climate Prediction

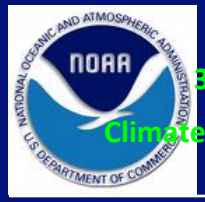
Xin-Zhong Liang

Department of Atmosphere & Ocean Science

Earth System Science Interdisciplinary Center

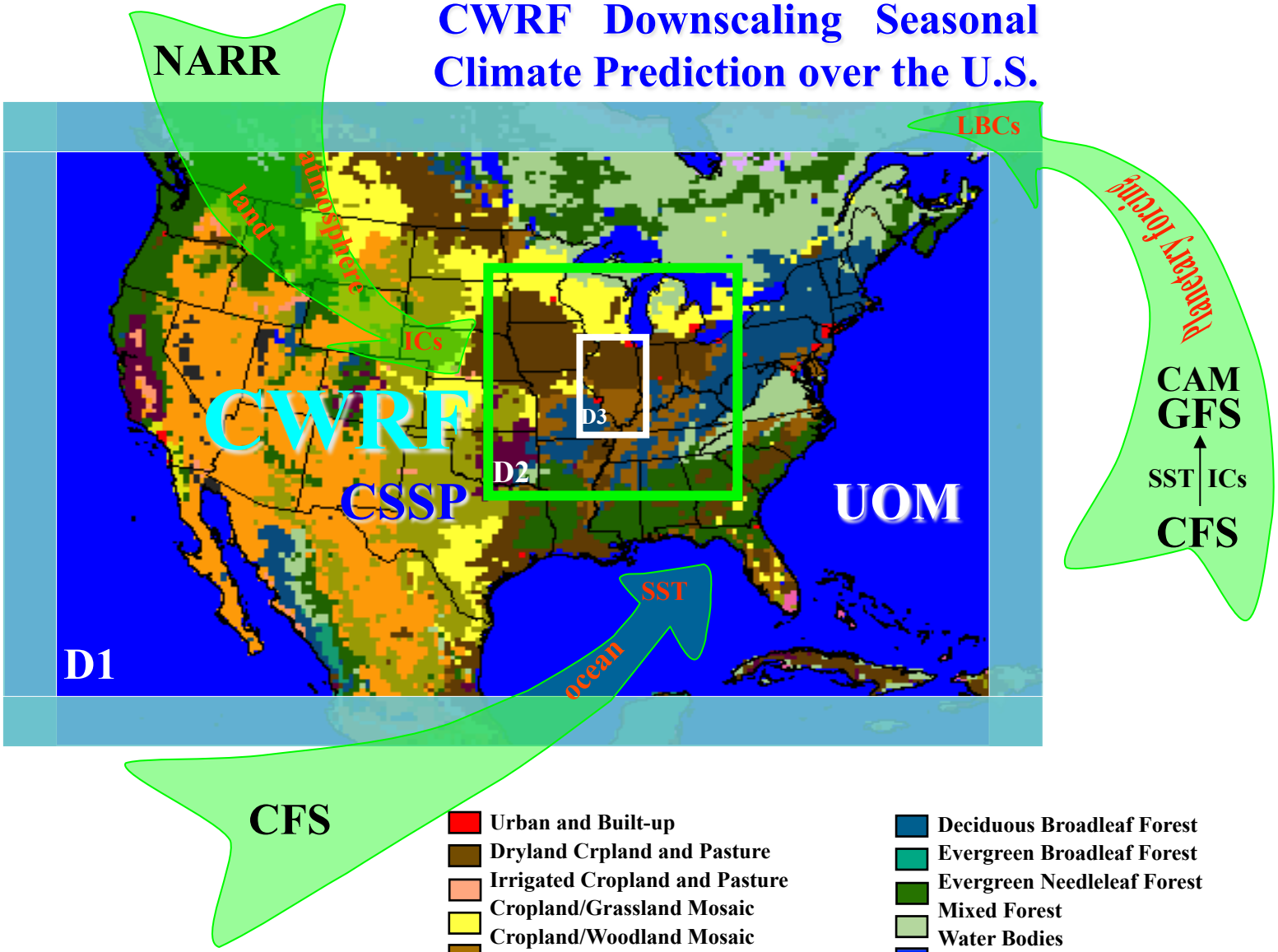
University of Maryland, College Park

2011 Oct 4



36th Annual Workshop for Climate Diagnostics & Prediction

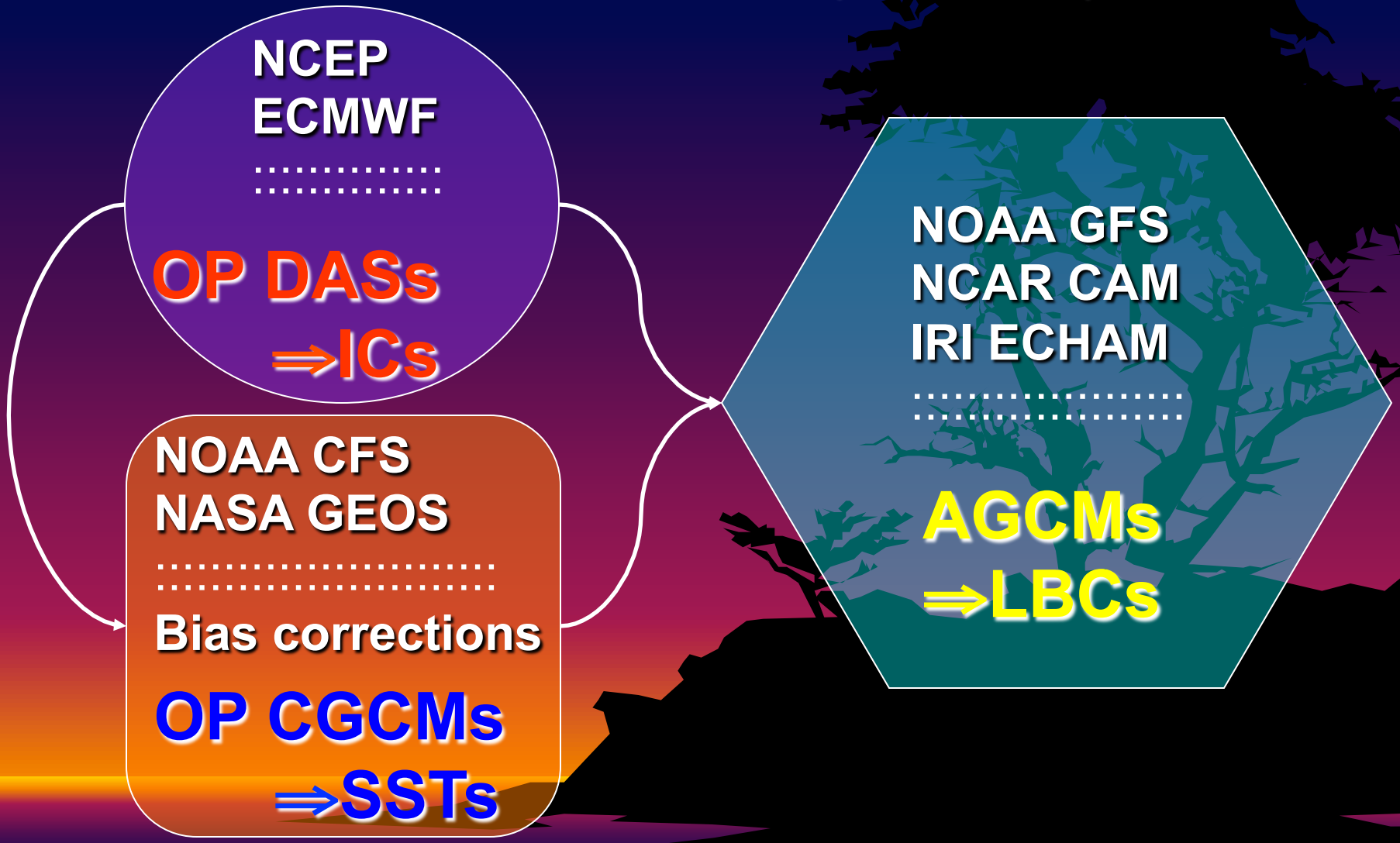
CWRF Downscaling Seasonal Climate Prediction over the U.S.

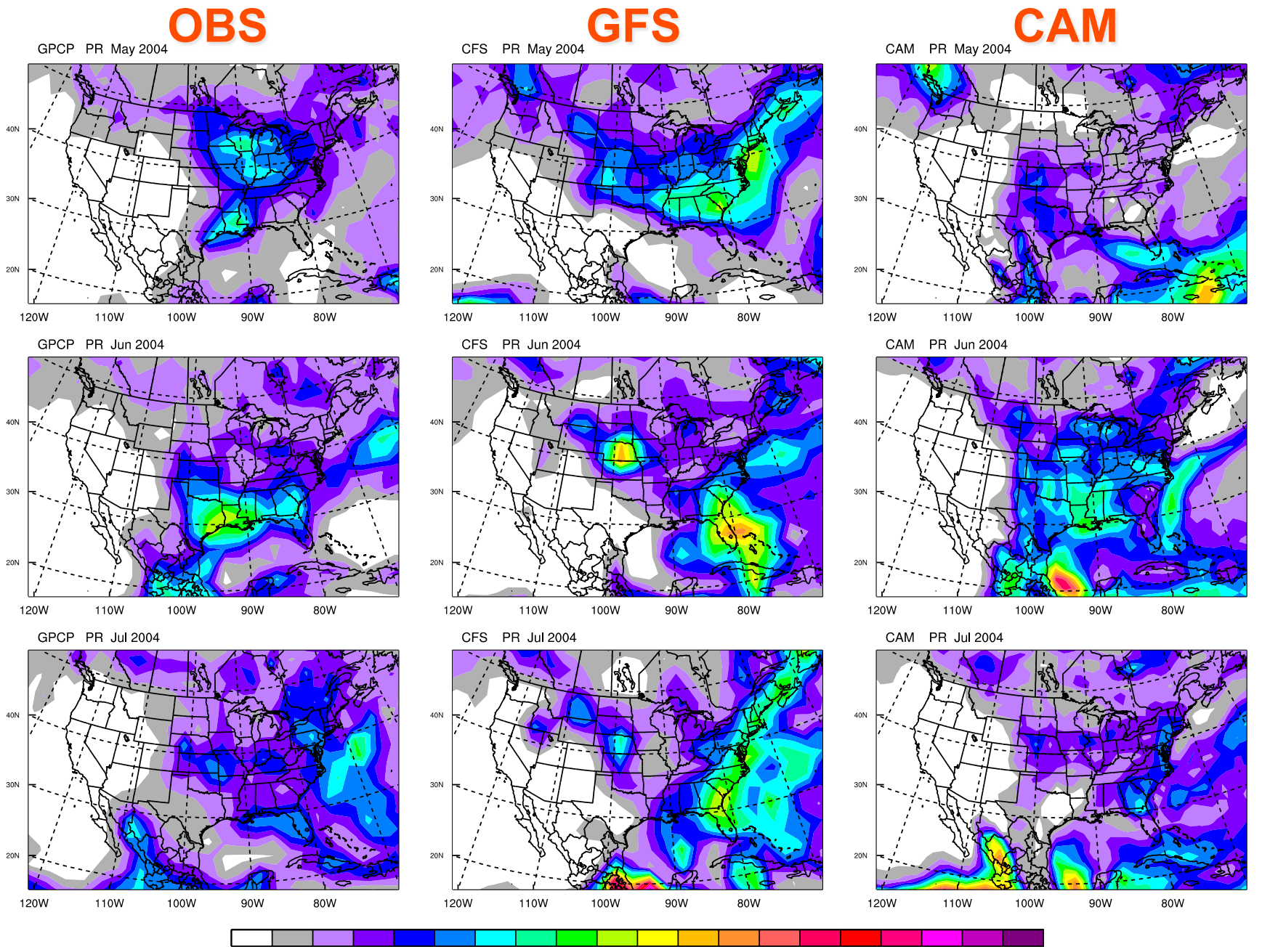


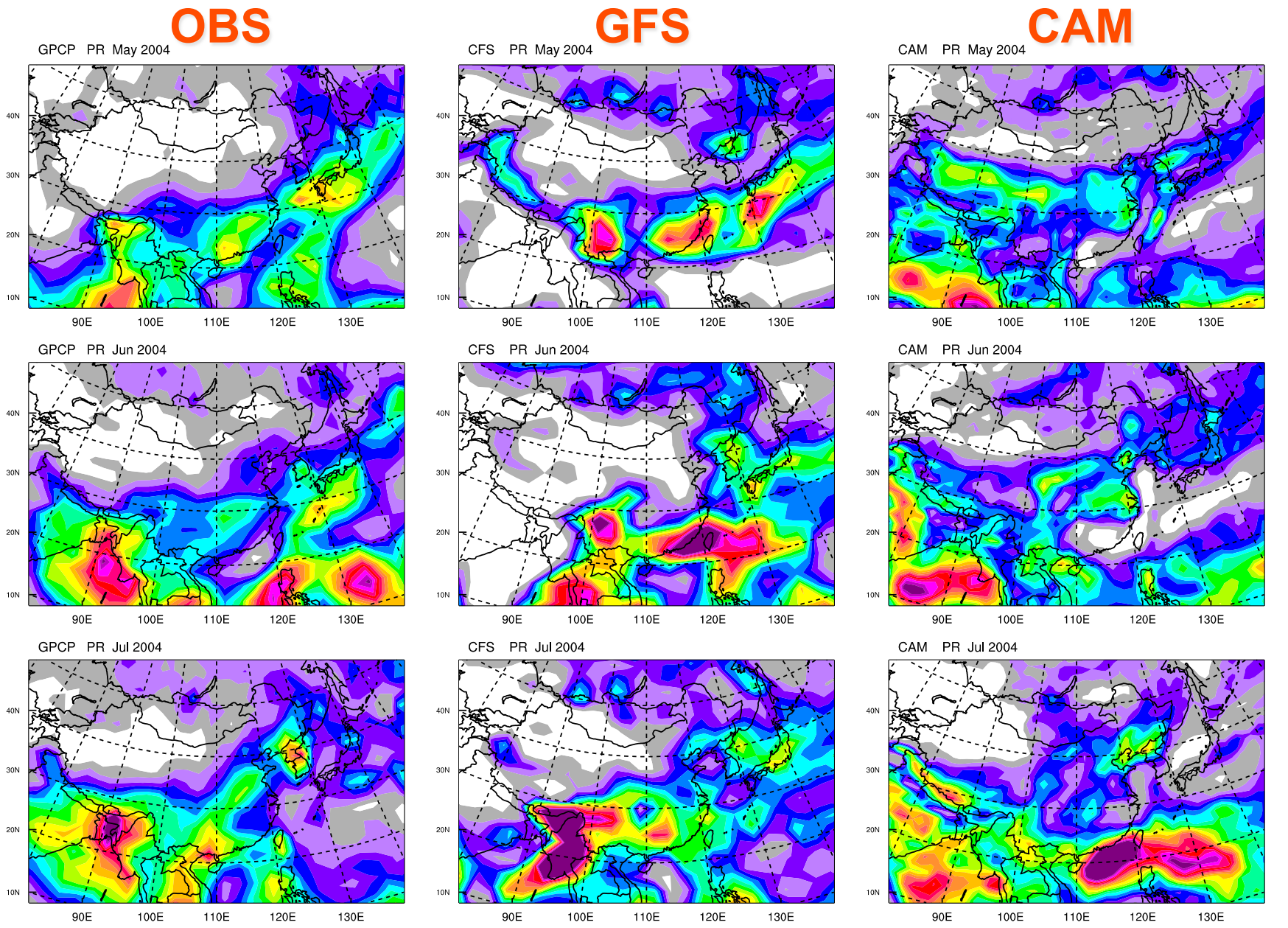
NOAA

2008-2011

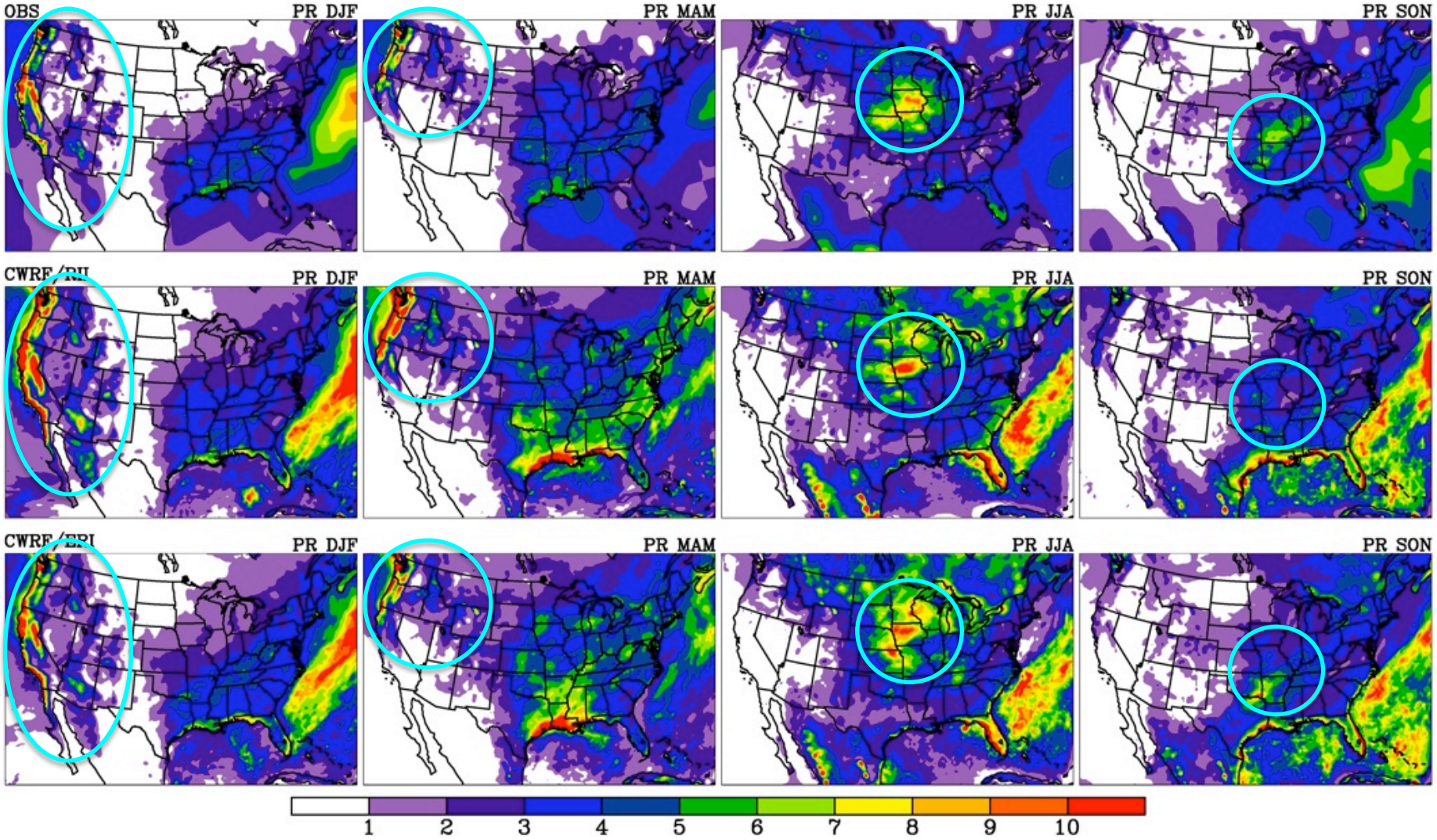
Ensemble Global Forecast System
⇒ICs, SSTs, LBCs




OBS
GFS
CAM
GPCP PR May 2004
CFS PR May 2004
CAM PR May 2004
GPCP PR Jun 2004
CFS PR Jun 2004
CAM PR Jun 2004
GPCP PR Jul 2004
CFS PR Jul 2004
CAM PR Jul 2004
40N
30N
20N
120W
110W
100W
90W
80W
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


OBS
GFS
CAM
GPCP PR May 2004
CFS PR May 2004
CAM PR May 2004
GPCP PR Jun 2004
CFS PR Jun 2004
CAM PR Jun 2004
GPCP PR Jul 2004
CFS PR Jul 2004
CAM PR Jul 2004
40N
30N
20N
10N
90E
100E
110E
120E
130E
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

NCEP/AMIP II vs ECMWF-Interim Reanalysis



Recent Advances

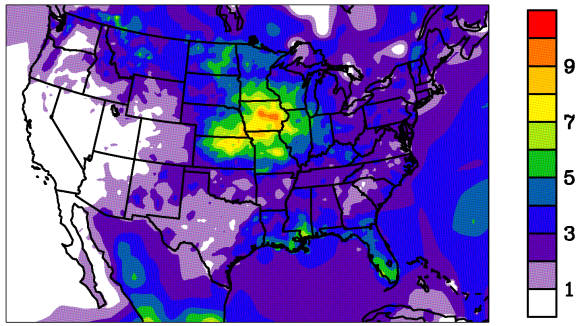
Comparing with Other RCMs

Ability to reproduce observations

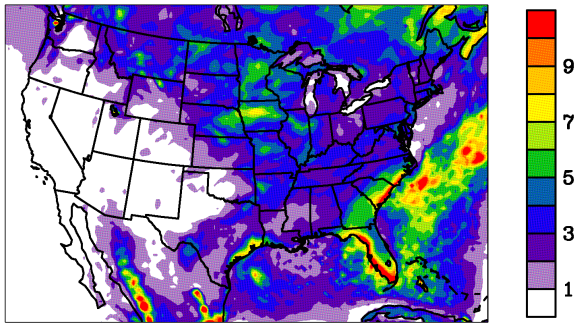
- All driven by the same reanalysis
- Result comparison on
  - Seasonal variations
  - Interannual anomalies
  - Extreme events

Rainfall (summer 1993)

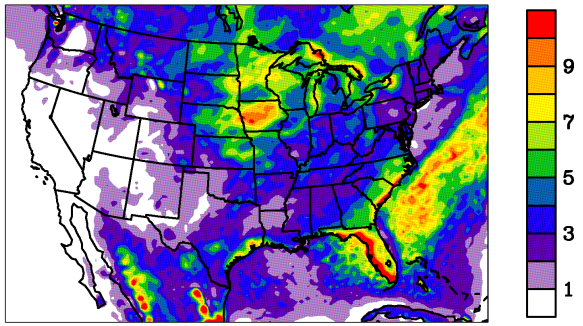
OBS



NOAH

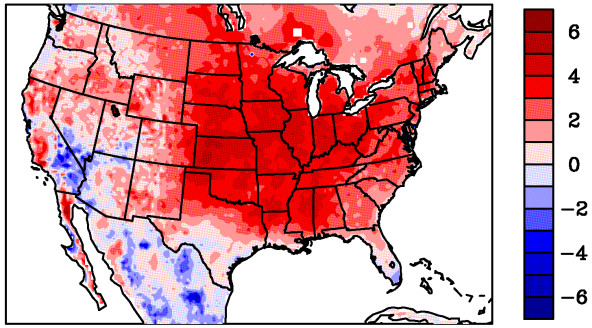


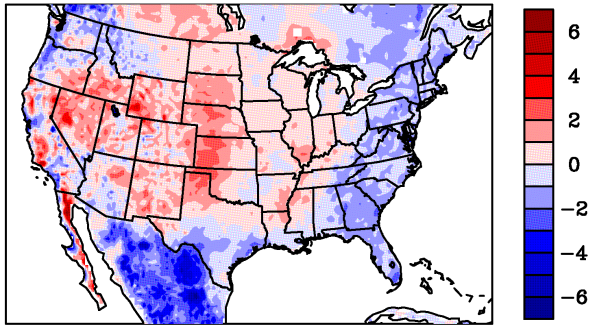
CSSP



CWRF has made significant improvements.

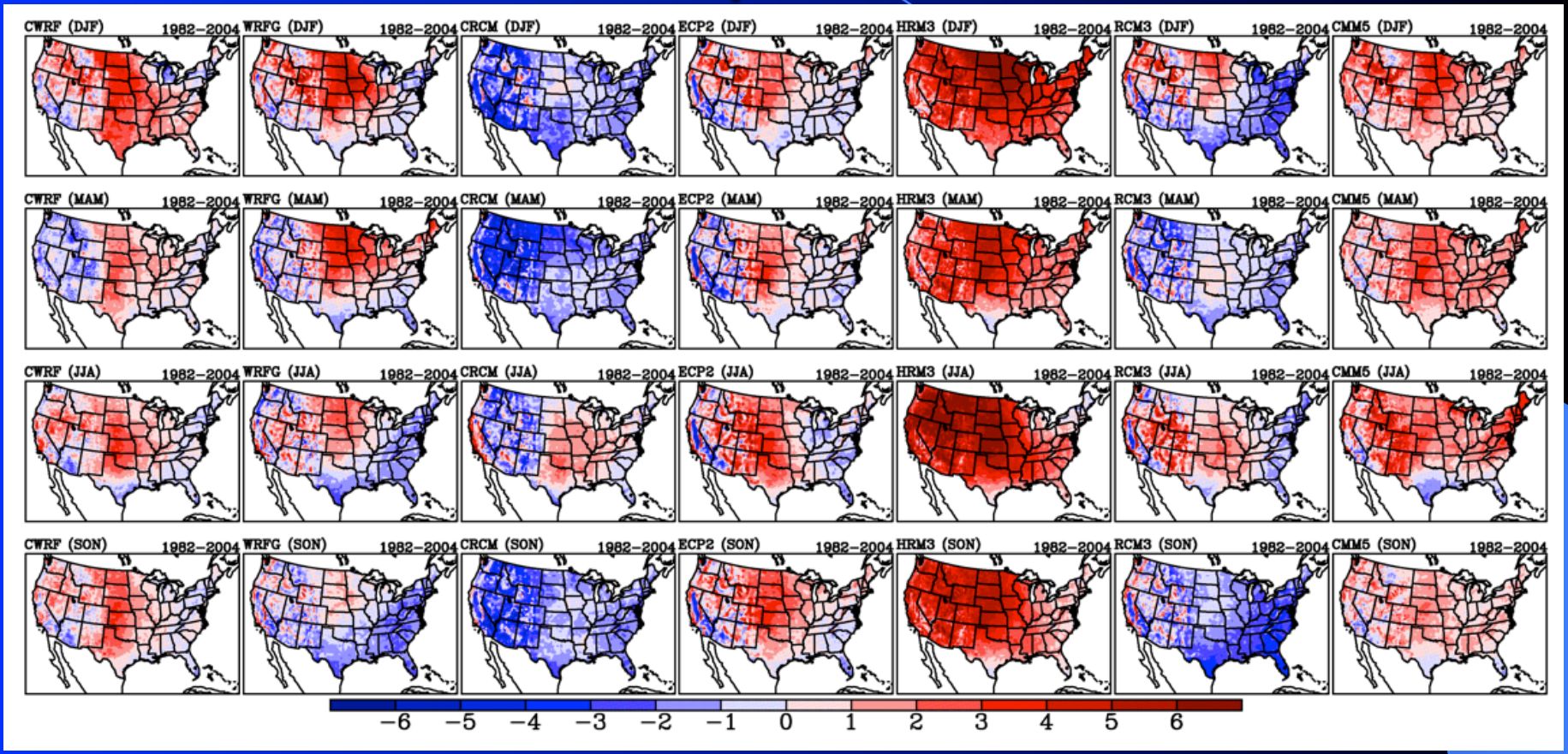
T2m Bias (summer 1993)





NARCCAP

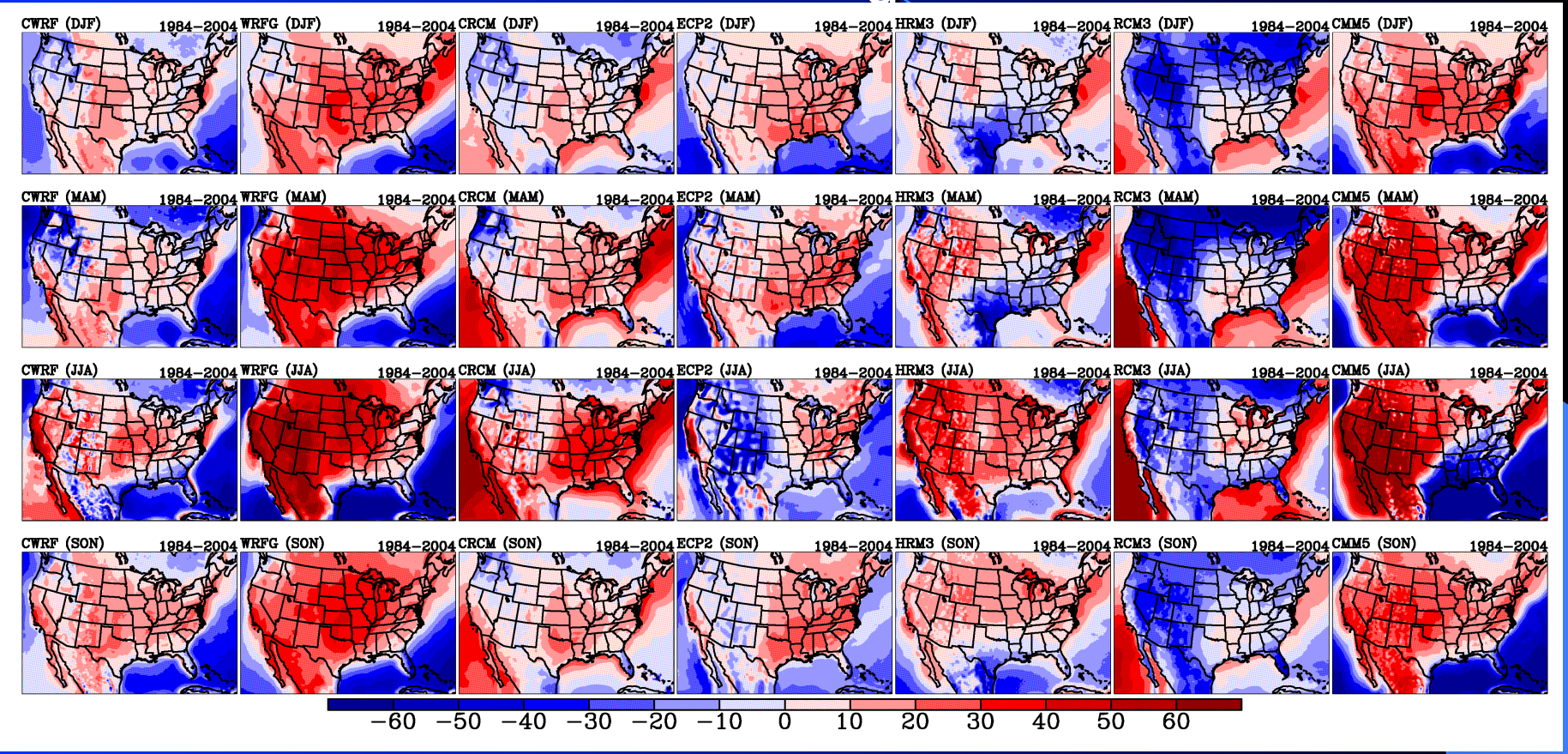
Surface Temperature Biases



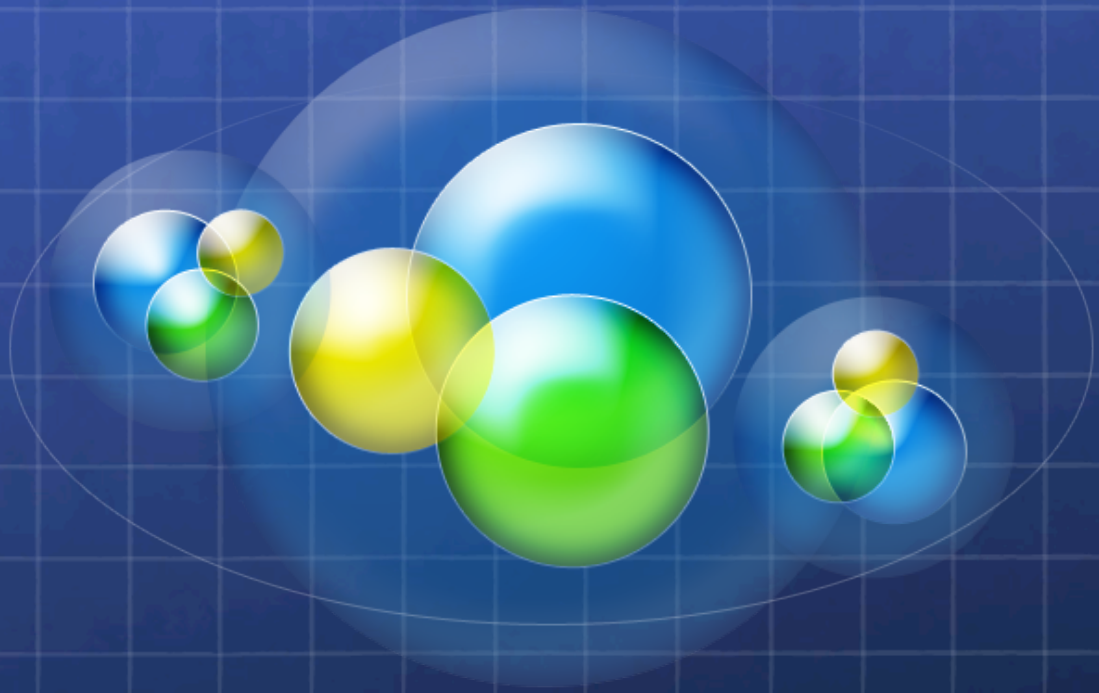
All driven by NCEP/DOE AMIP II Reanalysis

NARCCAP

Surface SW_d Biases



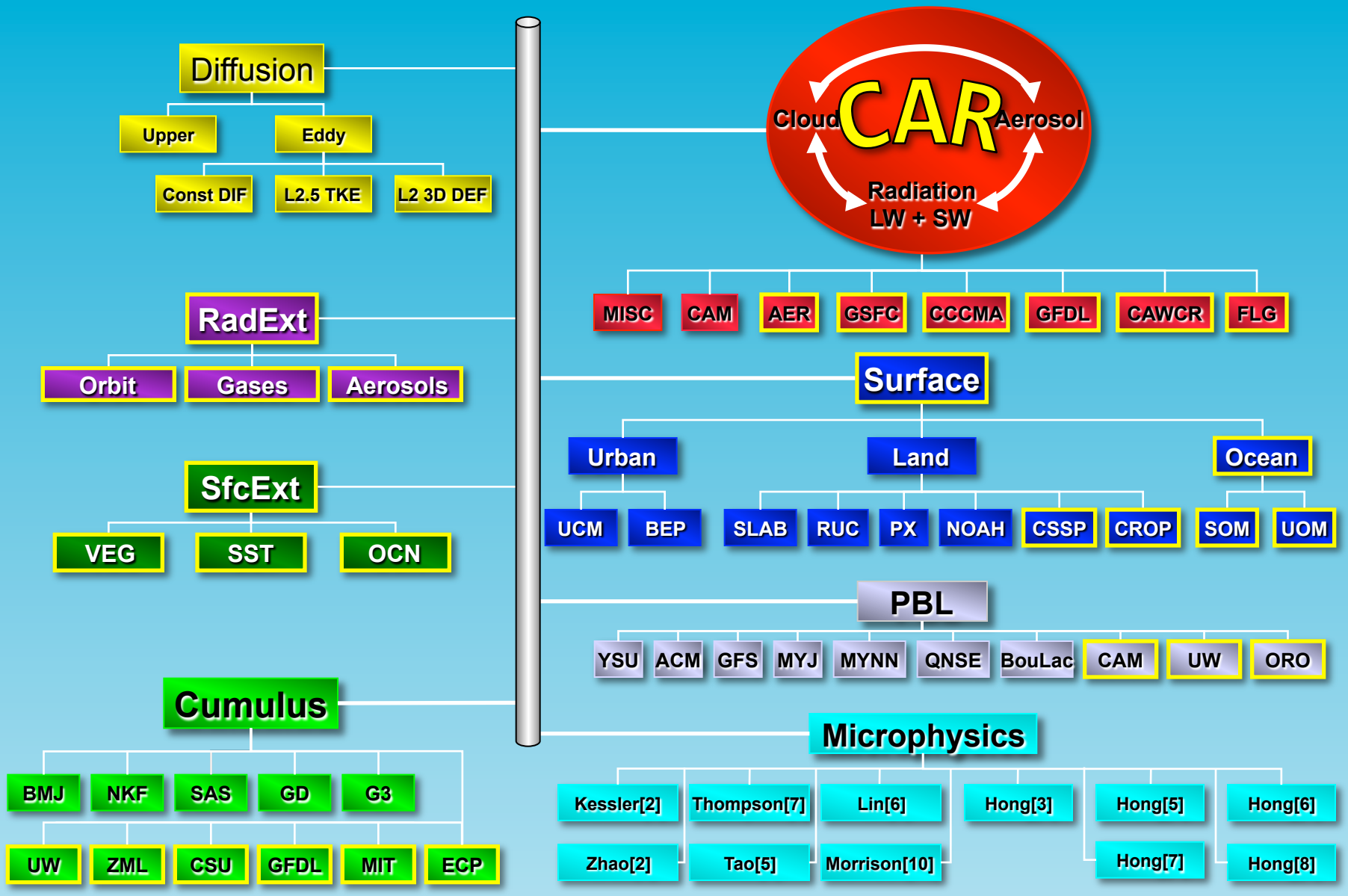
All driven by NCEP/DOE AMIP II Reanalysis



Physics Representation

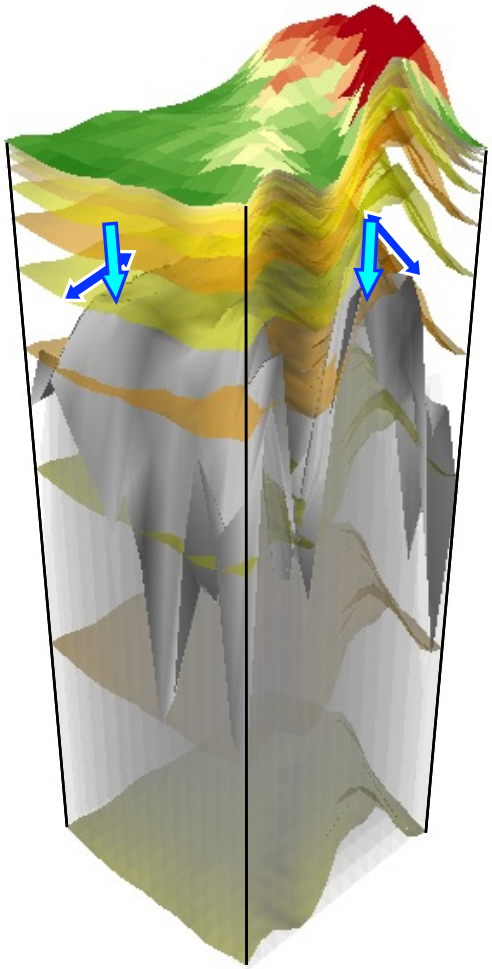
Evaluating Skill under Correct Forcing Conditions

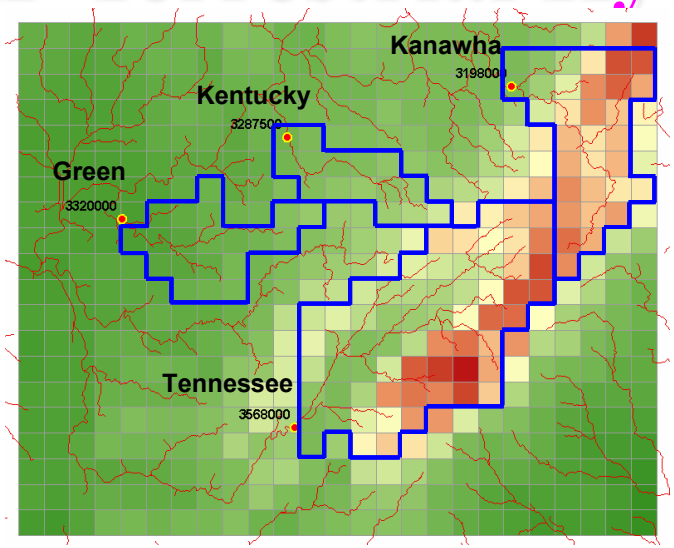
CWRF Physics Options

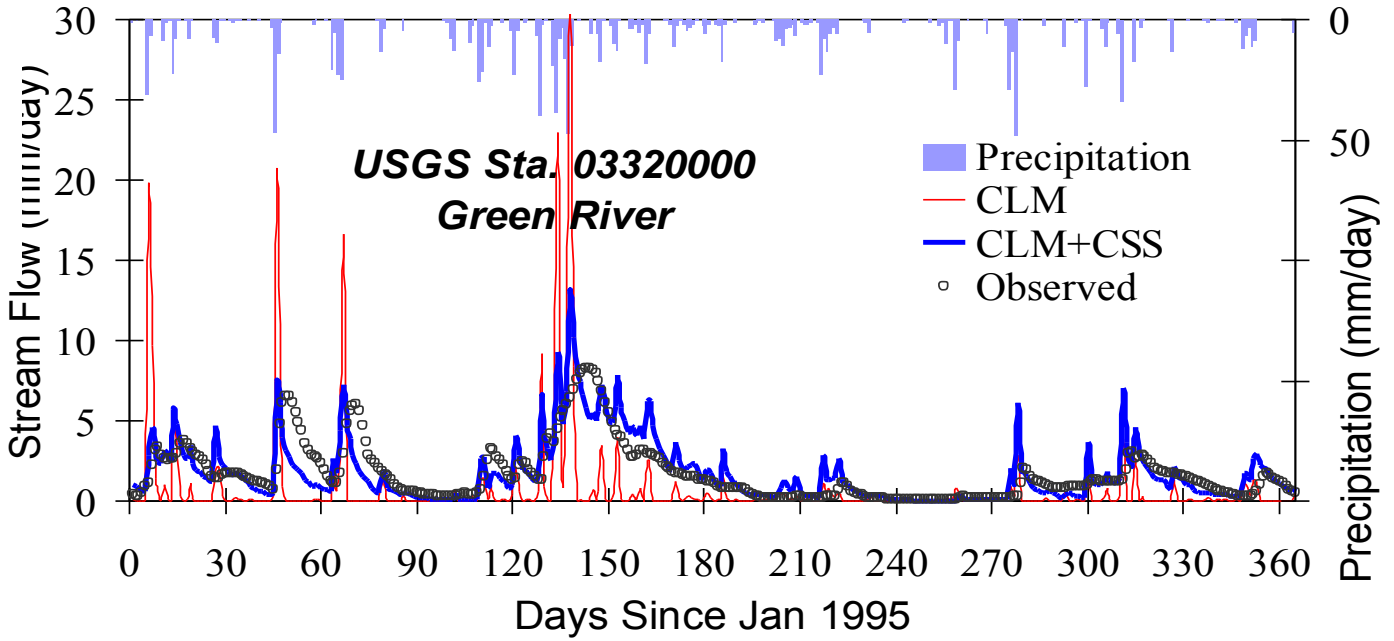


http://cwrf.umd.edu

CWRF Terrestrial Hydrology

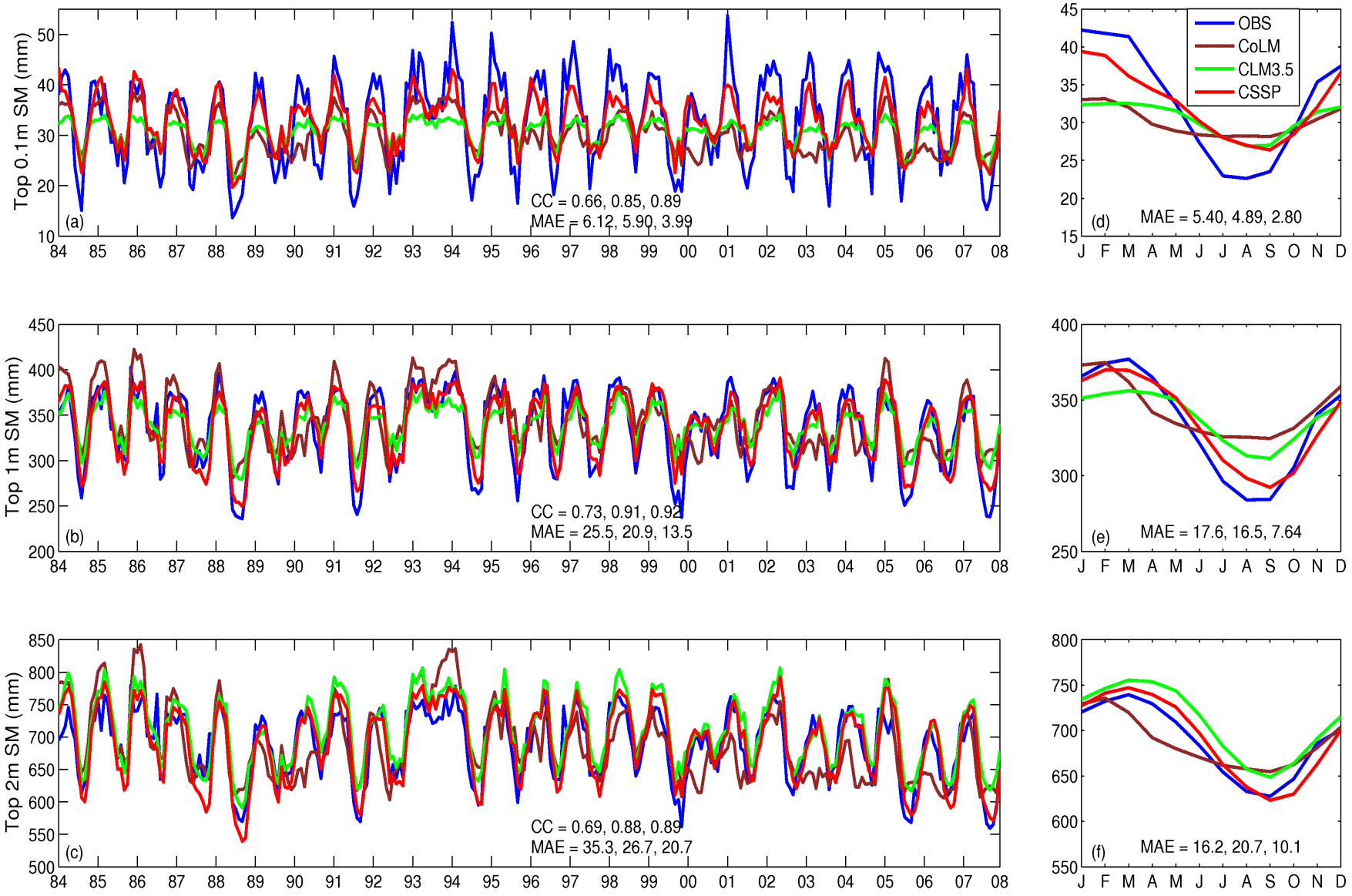






Choi 2006; Choi et al. 2007, 2011; Choi and Liang 2010; Yuan and Liang 2010; Liang et al. 2010d

Illinois Soil Moisture Simulations Driven by NARR



Yuan and Liang 2011 (J. Hydrometeorology)

CWRF

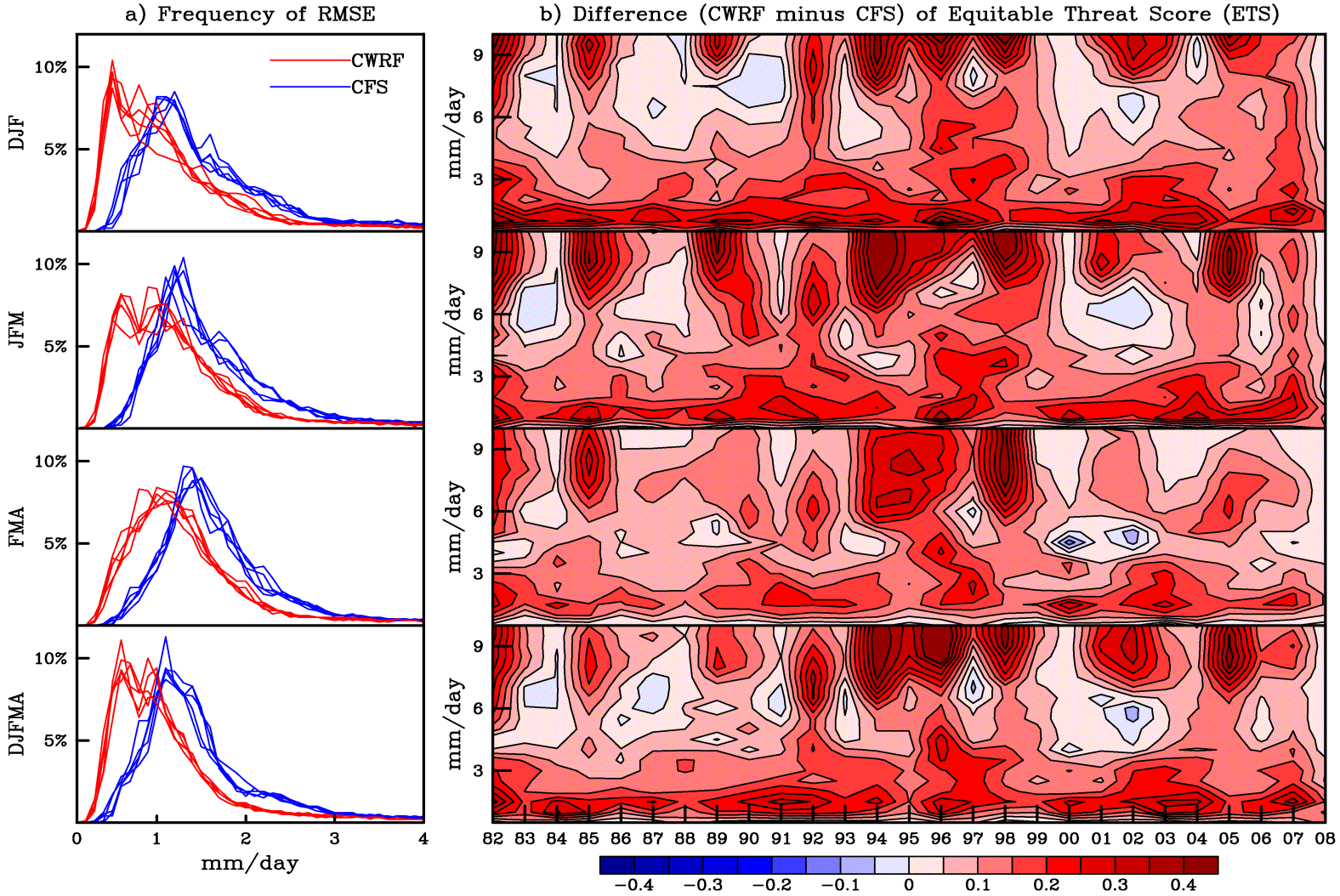
Seasonal-Interannual Climate Prediction

Nested with NOAA Operational

CFS

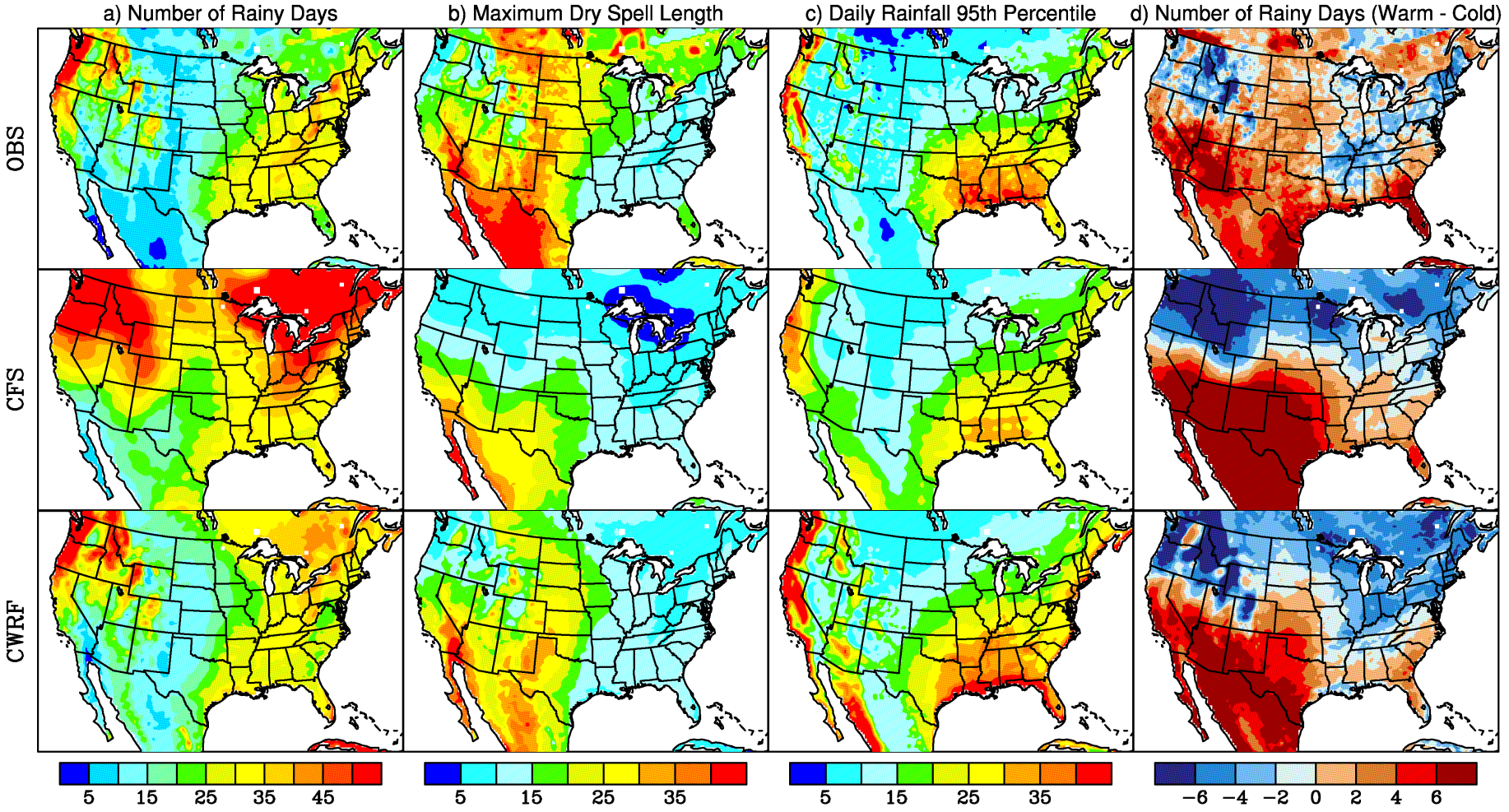
Yuan, X., and X.-Z. Liang, 2011: Improving cold season precipitation prediction by the nested CWRF-CFS system. *Geophys. Res. Lett.,* **38**, L02706, doi:10.1029/2010GL046104 .

CWRF Improves Seasonal Climate Prediction



a) Spatial frequency distributions of root mean square errors (*RMSE*, mm/day) predicted by the CFS and downscaled by the CWRF and **b)** CWRF minus CFS differences in the equitable threat score (*ETS*) for seasonal mean precipitation interannual variations. The statistics are based on all land grids over the entire inner domain for DJF, JFM, FMA, and DJFMA from the 5 realizations during 1982-2008. *From* Yuan and Liang 2011 (GRL).

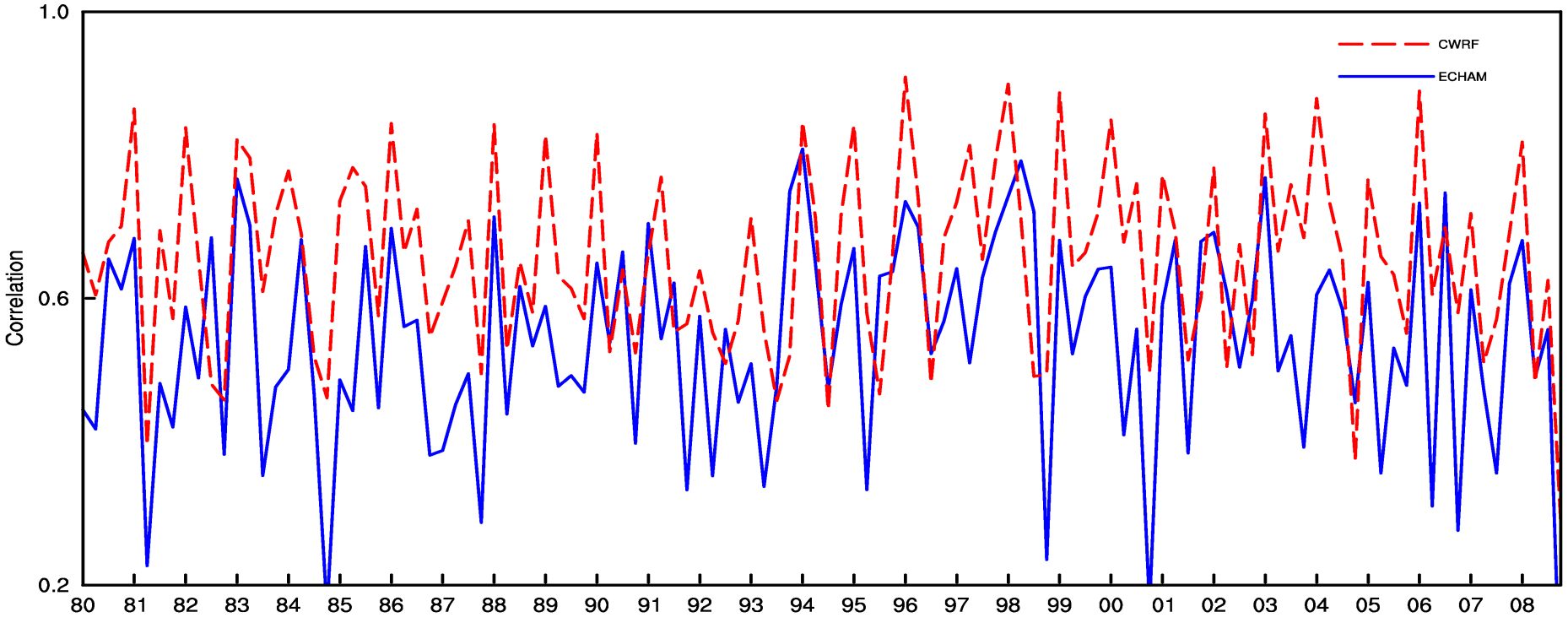
CWRF Downscaling Seasonal Climate Prediction: Extreme Events



Observed (OBS), CFS-predicted, and CWRF-downscaled: **a)** number of rainy days, **b)** maximum dry spell length (day), **c)** daily rainfall 95th percentile (mm/day), and **d)** difference in number of rainy days averaged between the El Niño (warm) and La Niña (cold) events for JFM during 1983-2008.

U.S. Land Seasonal Precipitation Spatial Pattern Correlation

CWRF downscaling is much more realistic than ECHAM



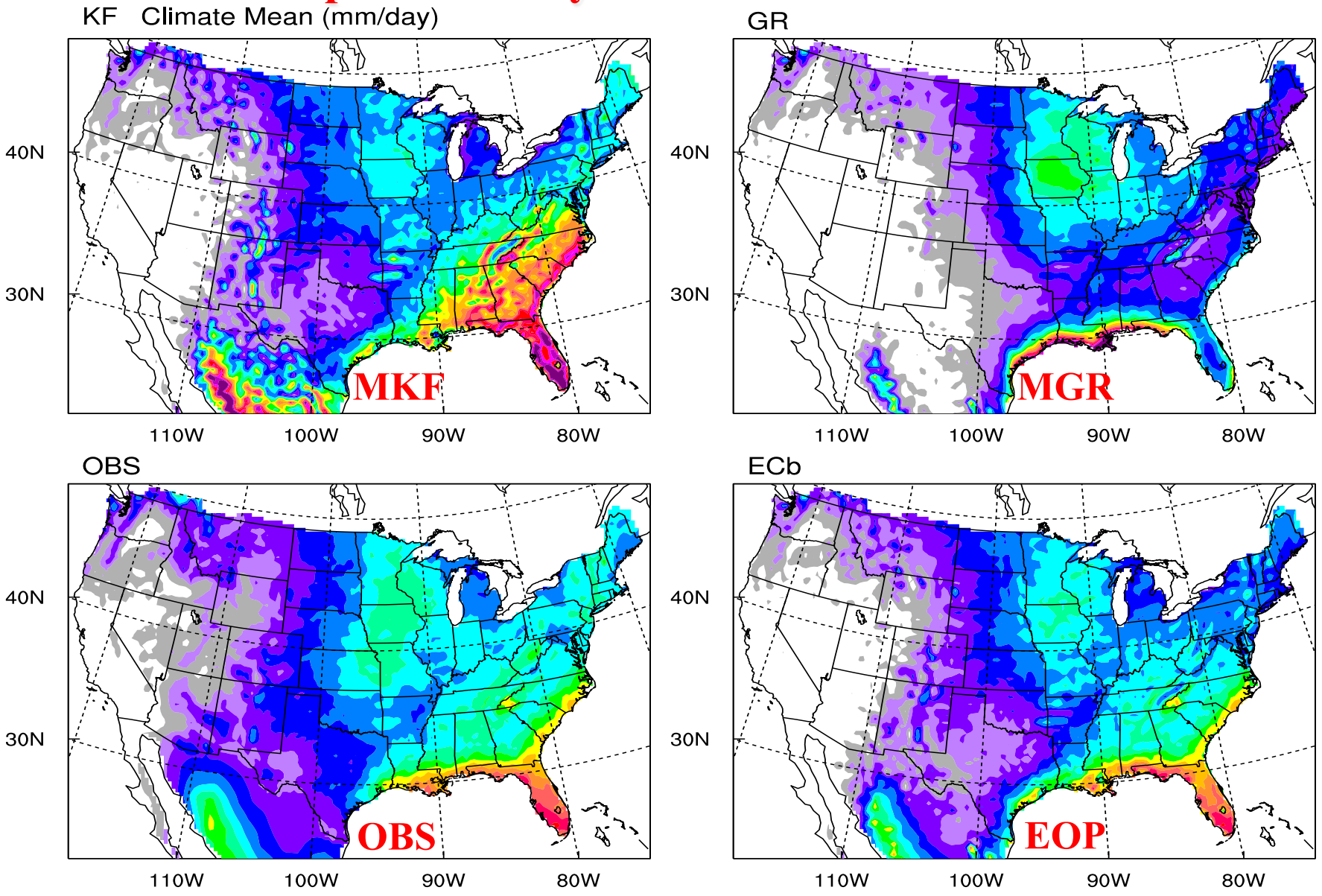
In collaboration with Dave DeWitt of IRI

Optimized Physics Ensemble

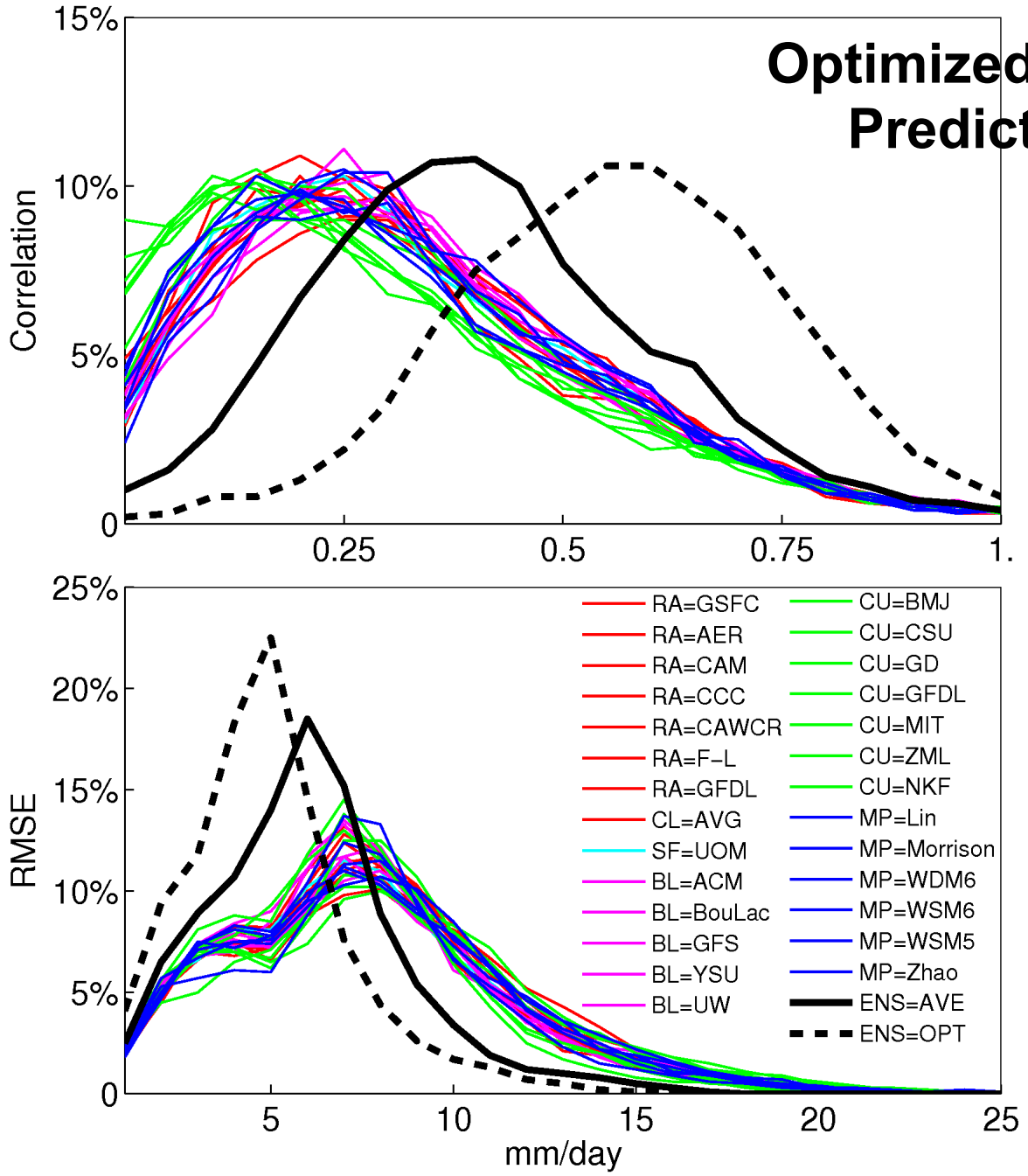
Increasing predictive skill

Quantifying uncertainty

Optimized Physics-Ensemble Prediction



Optimized Physics Ensemble Prediction of Precipitation In summer 1993



The physics ensemble mean substantially increases the skill score over individual configurations, and there exists a large room to further enhance that skill through intelligent optimization.

Spatial frequency distributions of correlations (*top*) and rms errors (*bottom*) between CWRF and observed daily mean rainfall variations in summer 1993. Each line depicts a specific configuration in group of the five key physical processes (*color*). The ensemble result (ENS) is the average of all runs with equal (Ave) or optimal (OPT) weights, shown as *black solid* or *dashed* line.

CWRF improves predictions at regional-local scales

- CWRF includes advanced physics schemes crucial to climate
- CWRF couples essential components directly linking to impacts
- CWRF builds upon a super ensemble of alternative physics schemes for skill optimization and uncertainty quantification
- CWRF has greater capability & better skill than CMM5, WRF…
- CWRF downscaling improves CFS precipitation predictions