Development of CWRF for Regional Weather and Climate Prediction: Model Description and Performance over North America

Xin-Zhong Liang

Department of Atmosphere & Ocean Science
Earth System Science Interdisciplinary Center
University of Maryland, College Park

Julian X.L. Wang, NOAA/ARL

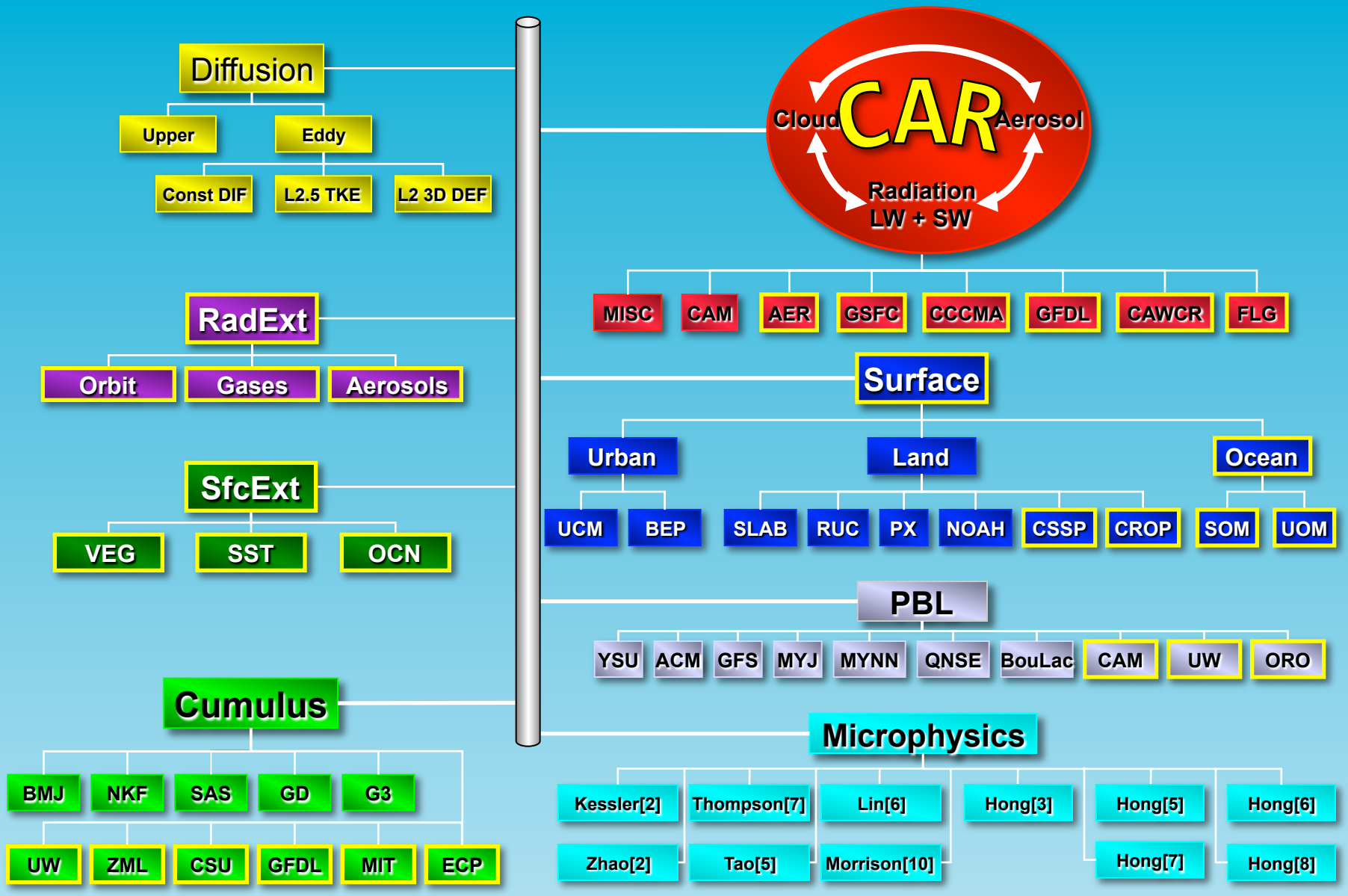
2011 March 23

RCM Downscaling is Science + Art

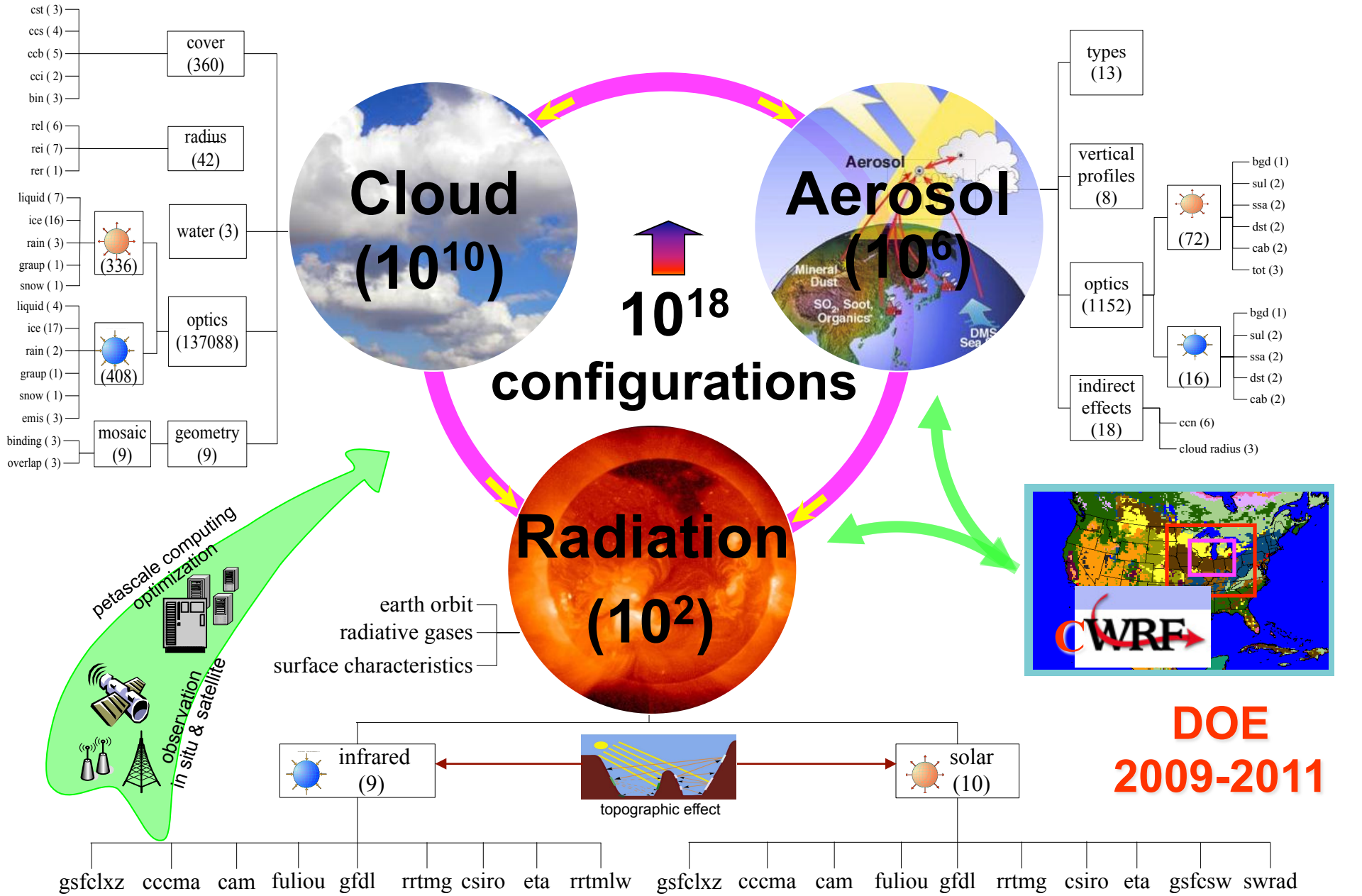
- Do NOT take an RCM off the shelf (localization)
- Domain Design (integrating planetary forcing)
- Physics Configuration (regime & scale dependence)
- Verification or Evaluation (obs. data & added values)
- Ensemble Approach (prediction skill & uncertainty)

Doing details is the key to success!

CWRF Physics Options

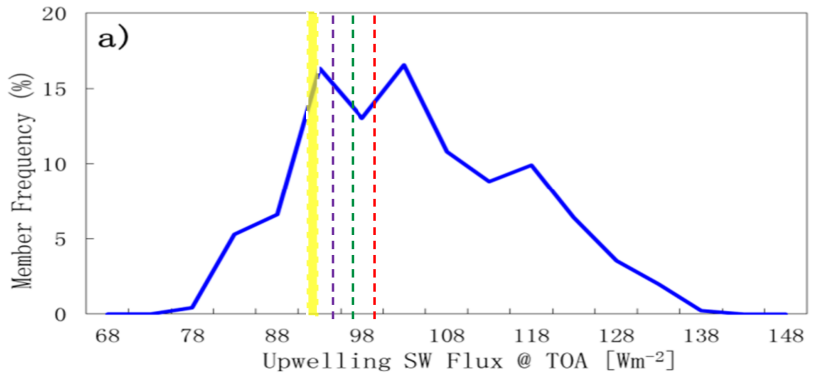


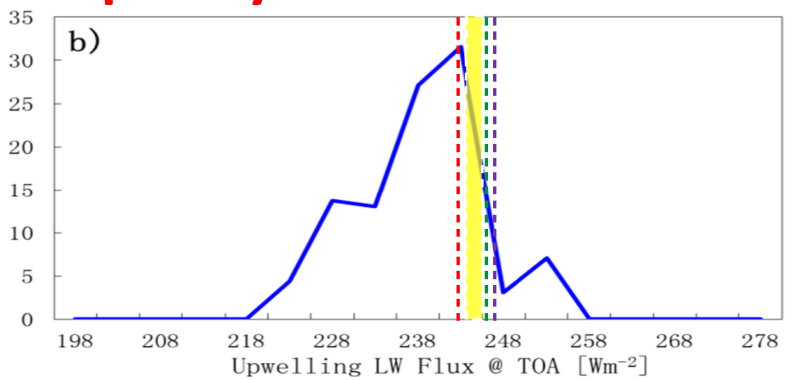
Cloud-Aerosol-Radiation Ensemble Model

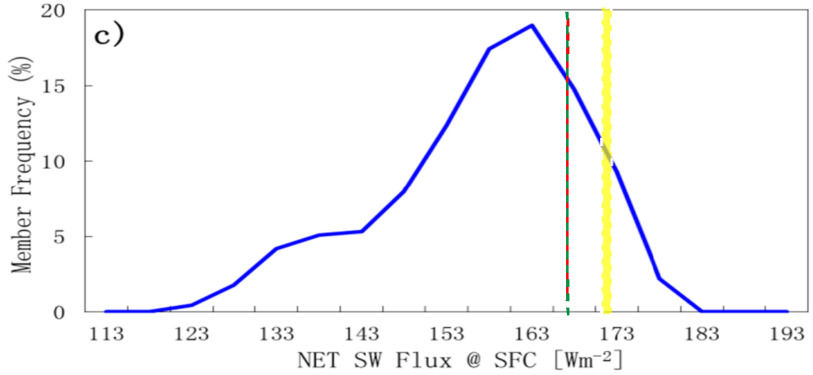


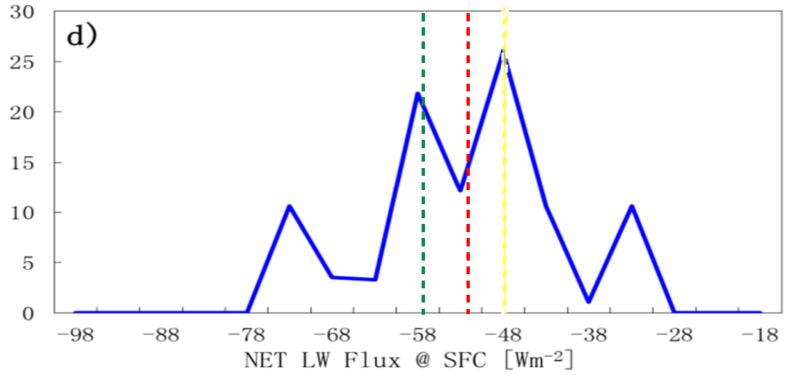
DOE 2009-2011

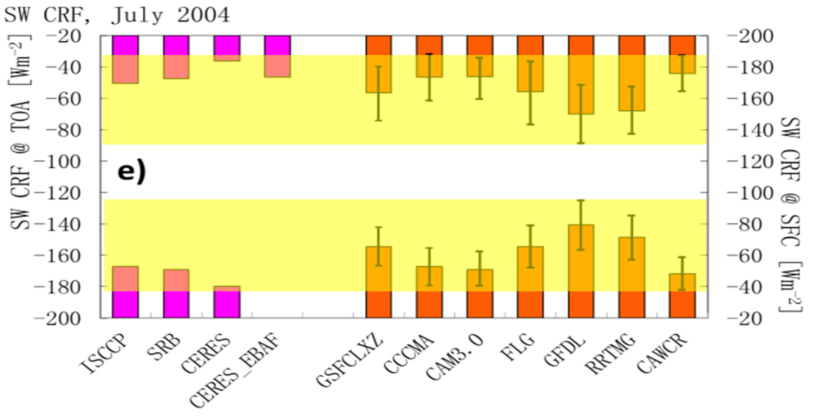
CAR Ensemble Flux Frequency Distribution

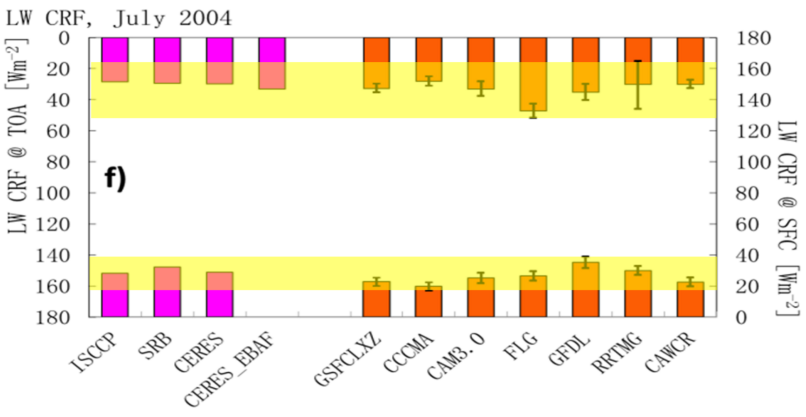




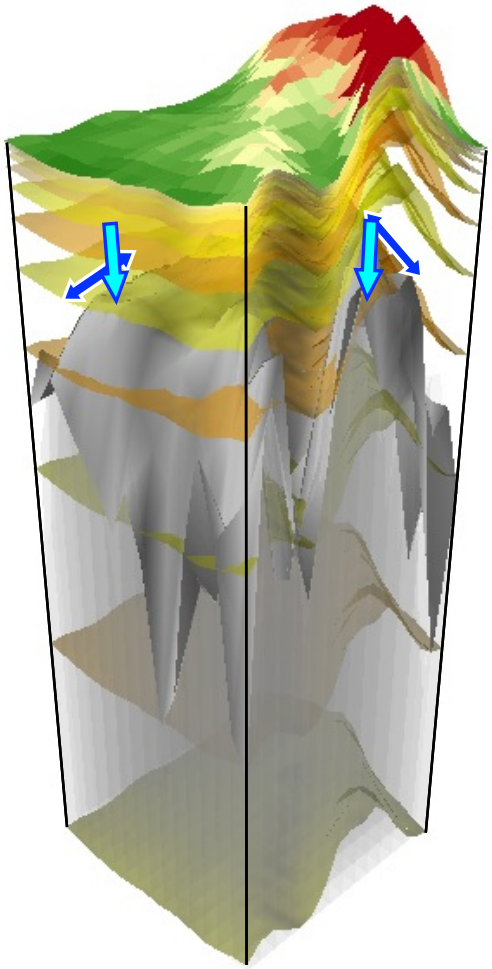


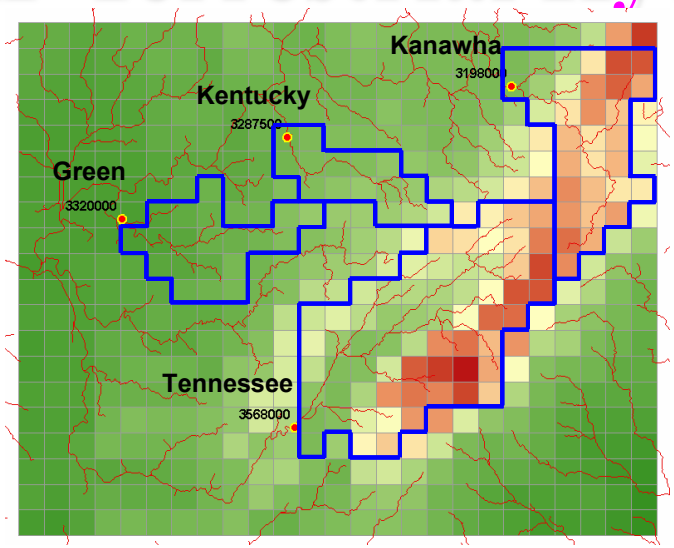


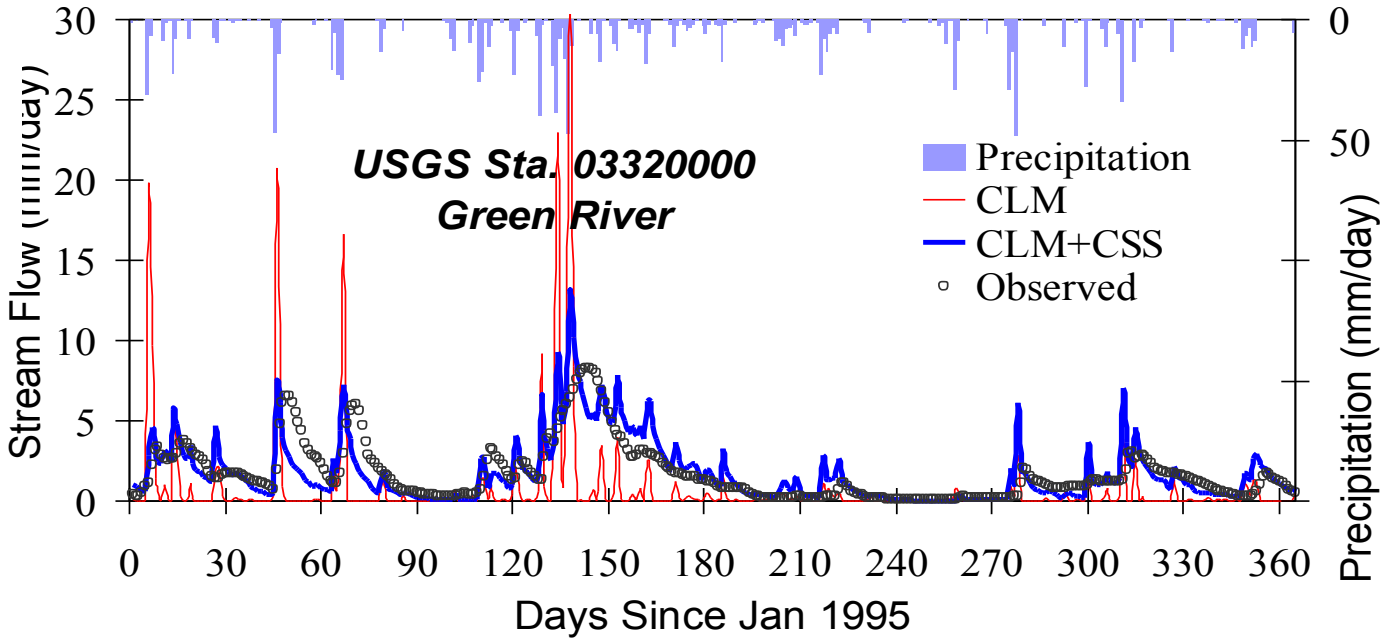




CWRF Terrestrial Hydrology

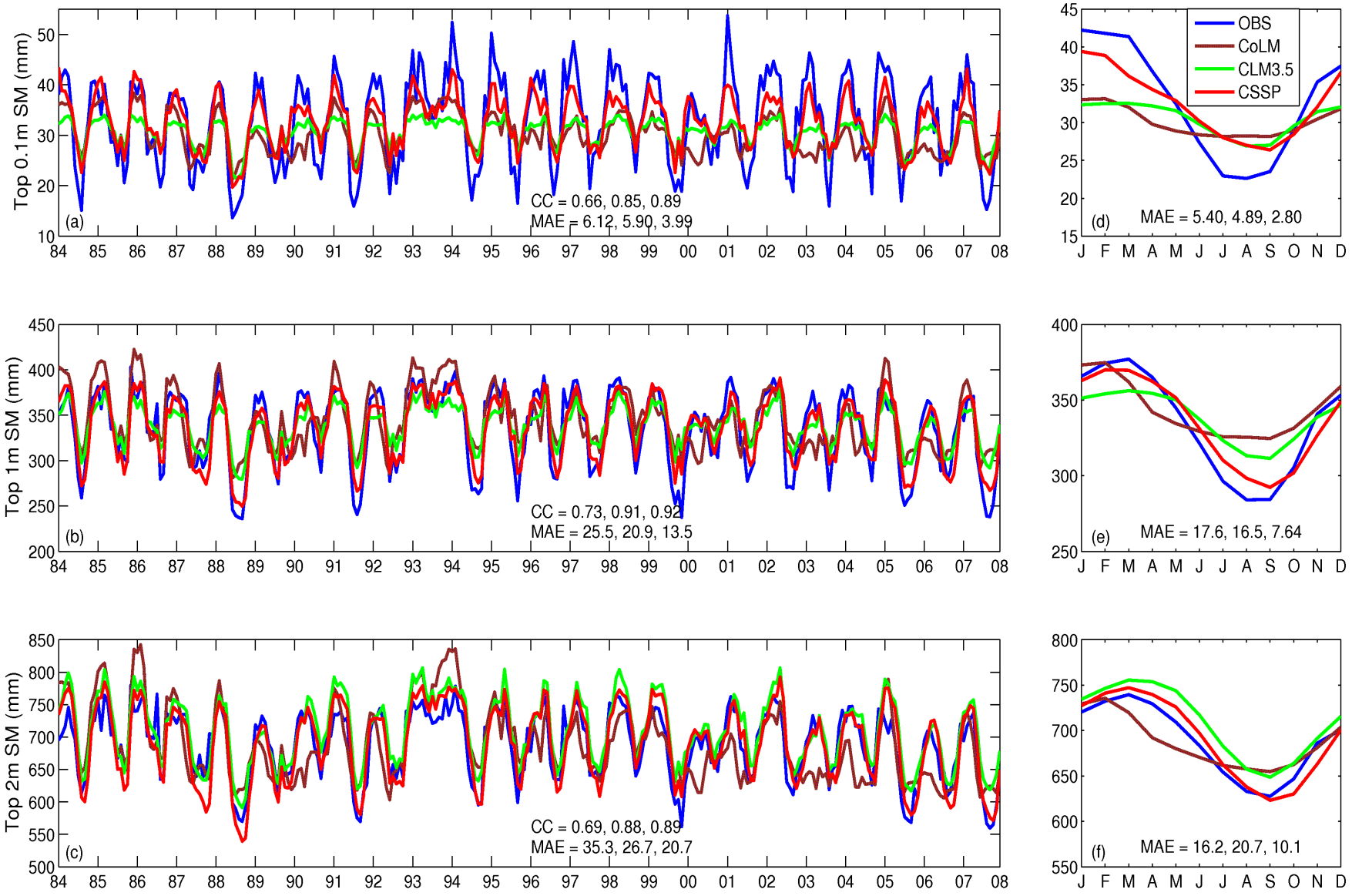






Choi 2006; Choi et al. 2007; Choi and Liang 2010; Yuan and Liang 2010; Liang et al. 2011

Illinois Soil Moisture Simulations Driven by NARR

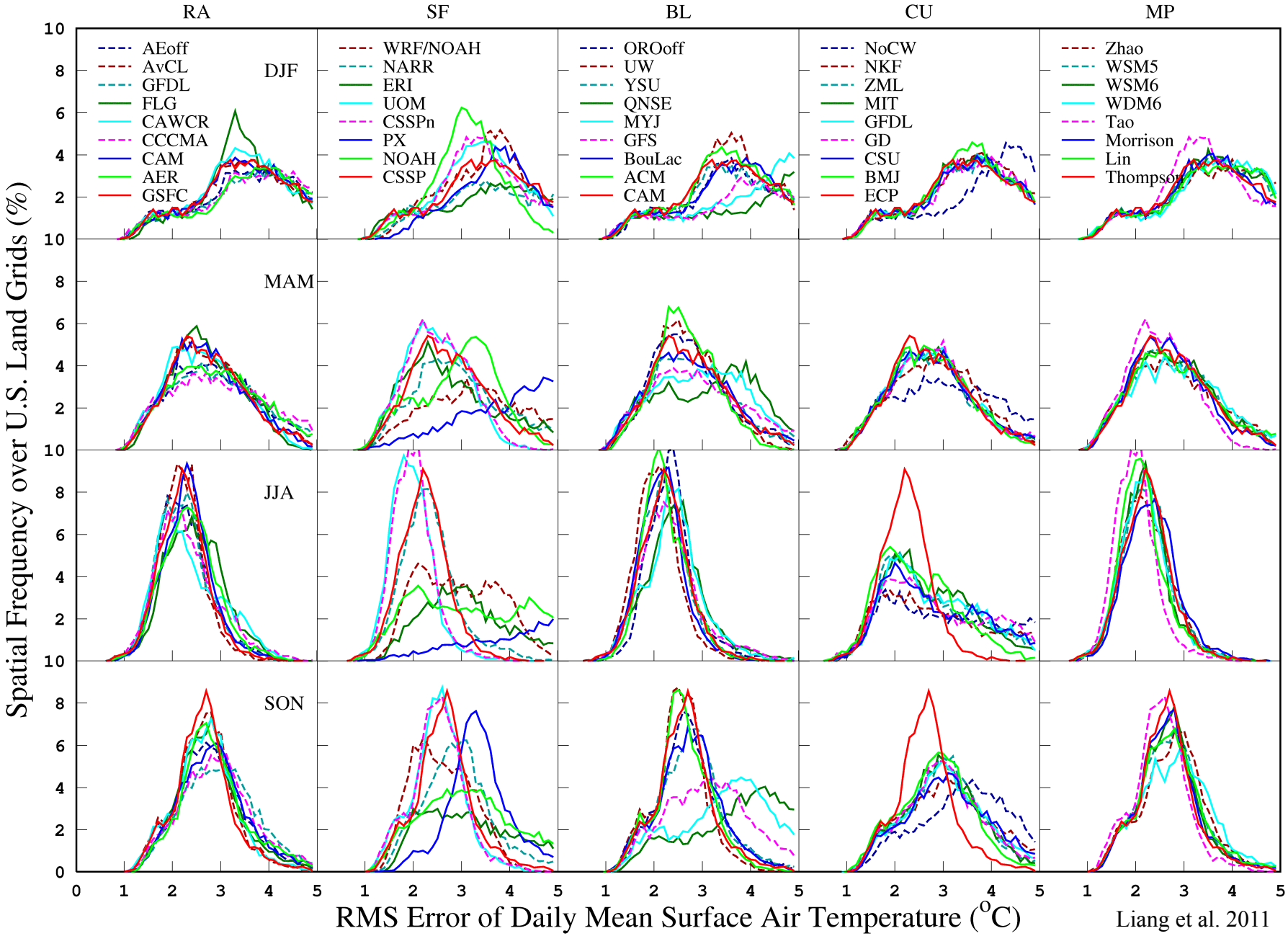


Yuan and Liang 2010

PHYSICS CONFIGURATION

SELECTING OPTIMAL PARAMETERIZATION SCHEMES

CWRF Daily 2m Temperature (1993) Skill Sensitivity to Physics



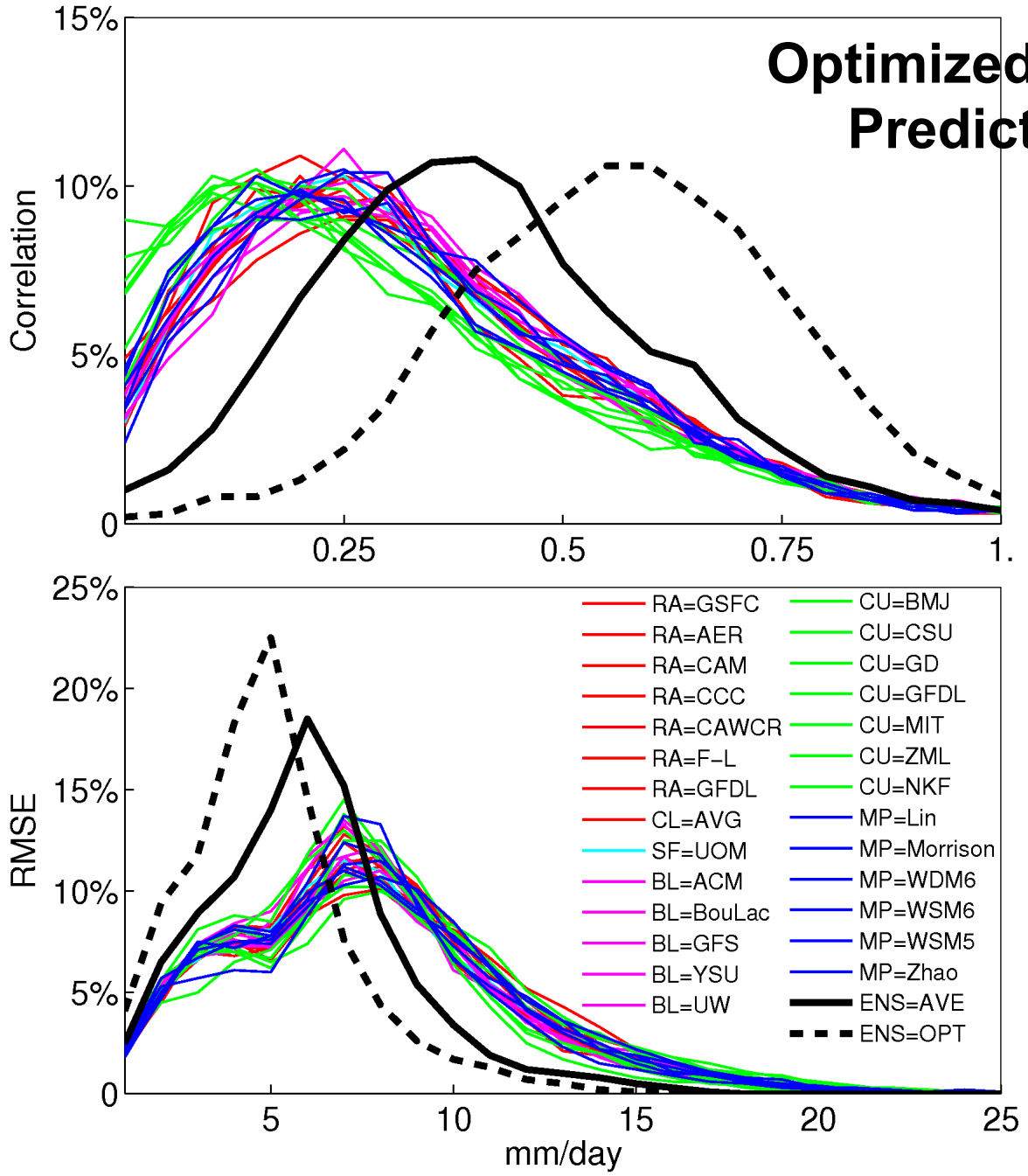
Liang et al. 2011

Optimized Physics Ensemble

Increasing predictive skill

Quantifying uncertainty

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.

Liang et al. 2011

Verification
on climate scale

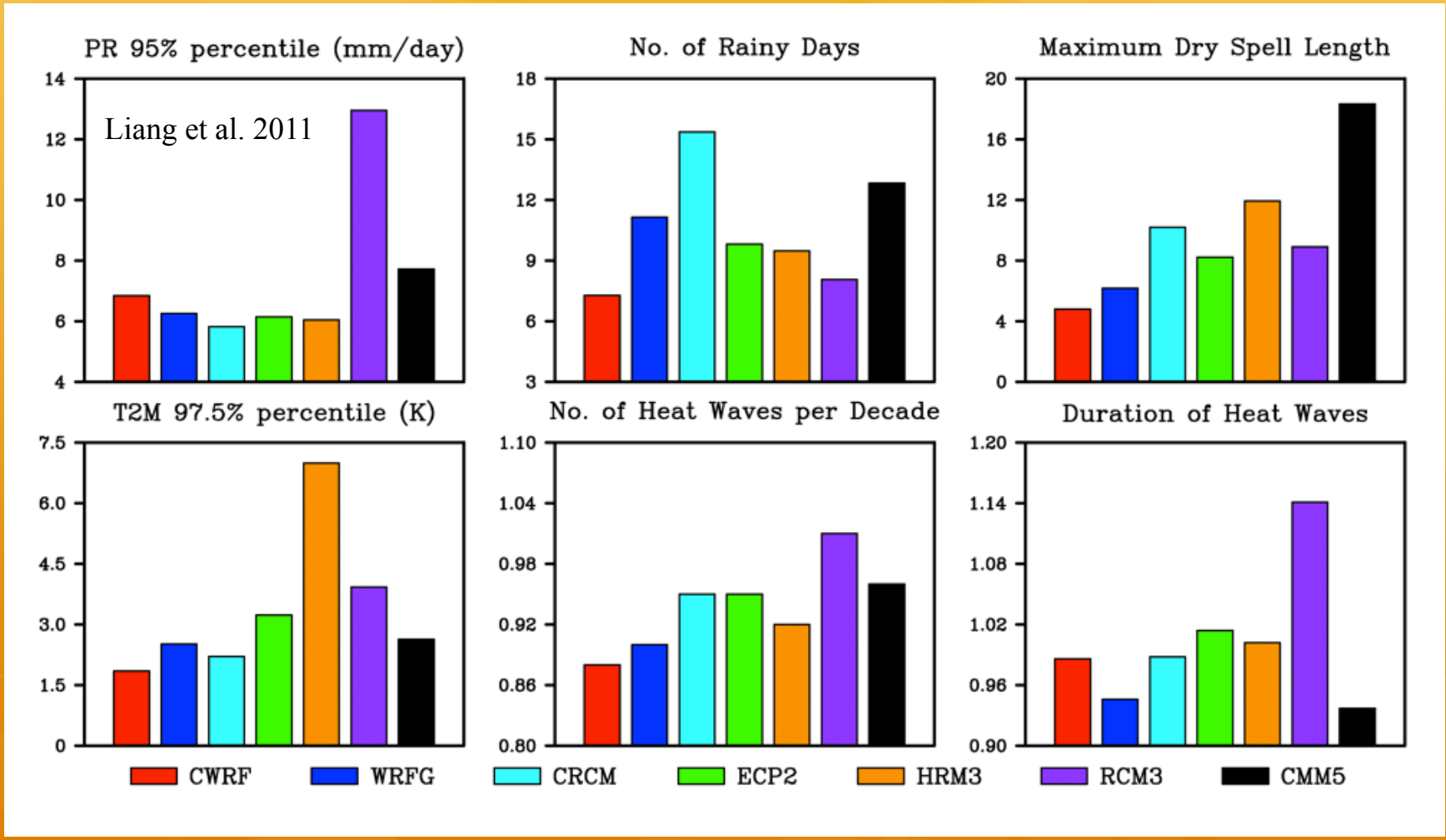
Ability to reproduce observations

- Reanalyses – temporal evolution
- GCM Present – climate statistics

Ability to predict climate variations

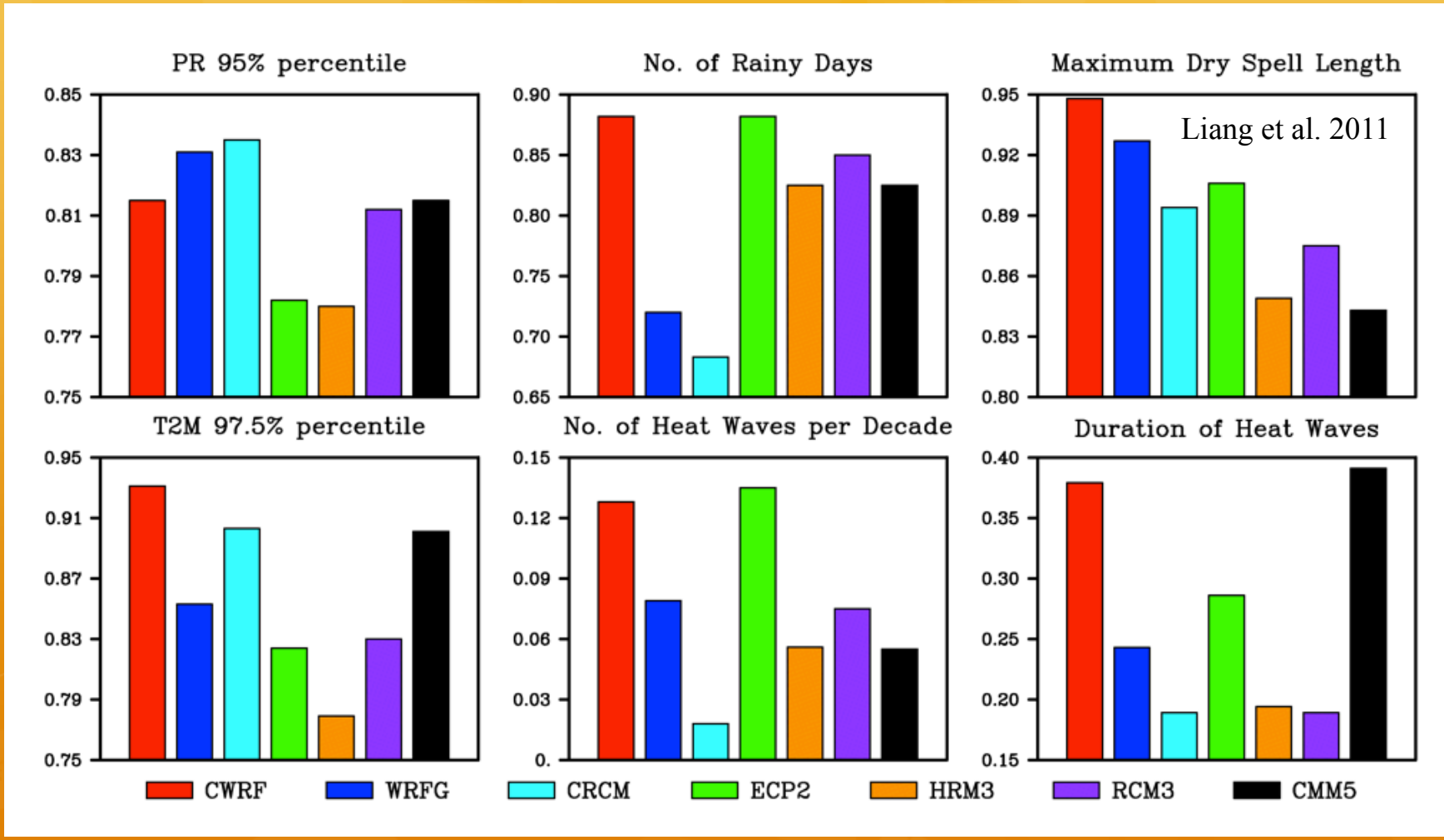
- GCM Prediction – climate statistics

Overall RMSE Score over USA



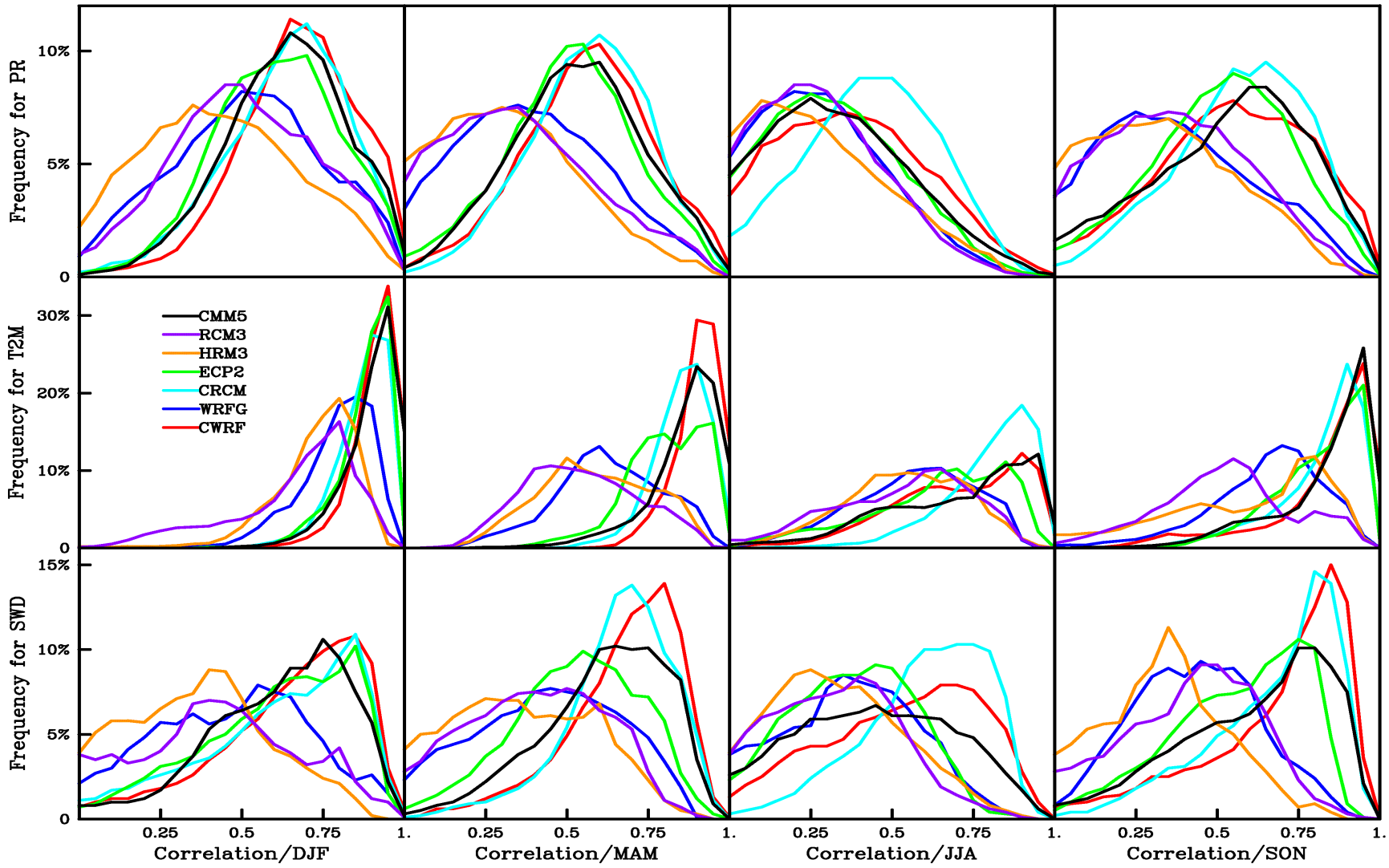
All driven by NCEP/DOE AMIP II Reanalysis

Overall CORR Score over USA



All driven by NCEP/DOE AMIP II Reanalysis

Interannual CORR over USA



Conclusions

- The CWRF has been developed on the basis of the Weather Research and Forecasting model by incorporating numerous improvements that are crucial to climate scales, including interactions between land–atmosphere–ocean, convection–microphysics and cloud–aerosol–radiation, and system consistency throughout all process modules.
- The CWRF improvements have been accomplished through iterative, extensive model refinements, sensitivity experiments, and rigorous evaluations over the past 8 years.
- As a result, the CWRF has demonstrated greater capability and better performance (with its designated physics configuration) in simulating the U.S. regional climate than the existing CMM5 and the original WRF. This justifies its initial release for the community use.

CWRF

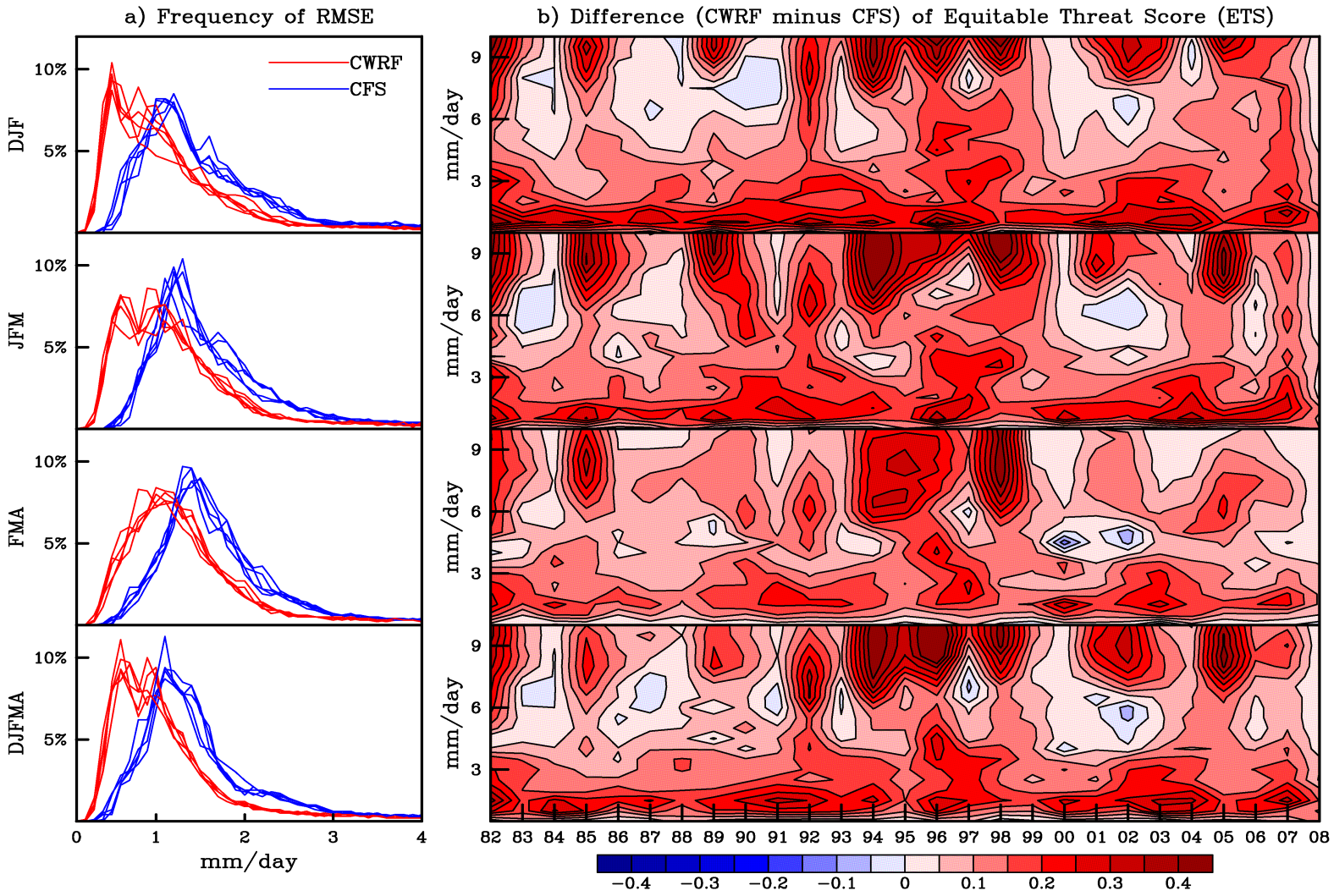
Seasonal-Interannual Climate Prediction

Nested with NOAA Operational

CFS

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

CWRF Downscaling Seasonal Climate Prediction: Equitable Threat Score



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.