Quantifying Future Climate Change Impact on Crop Yield in the Americas: Assessing a new ensemble modeling approach to regional climate downscaling

Guiling Wang & Amir Erfanian

Hydroclimatology & Biosphere-Atmosphere Interactions Lab

Department of Civil and Environmental Engineering

University of Connecticut

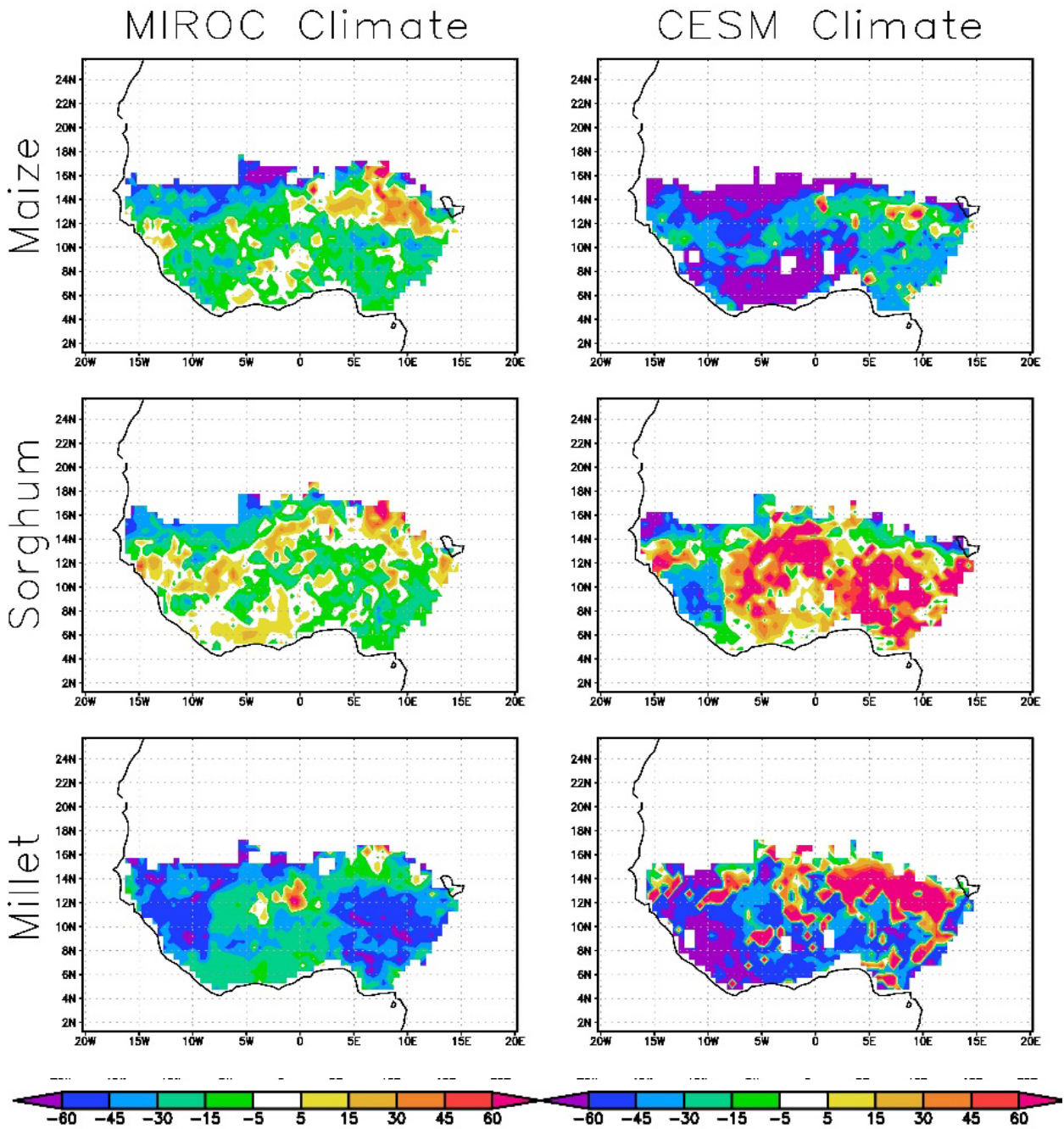
Storrs, CT 06269

guiling.wang@uconn.edu

http://hydroclimatology.uconn.edu/

Climate Model Dependence of Regional Agricultural Projections: West Africa as an example

- Projected cereal crop yield changes (in %, by mid-century), simulated by the DSSAT crop models forced with output from a regional model (RegCM-CLM4.5) driven by initial and boundary conditions (IBCs) from MIROC-ESM & CCSM4, differ significantly depending on which GCM is used as the RCM IBCs
- An ensemble modeling approach is desirable to account for the uncertainties associated to the choice of climate models.



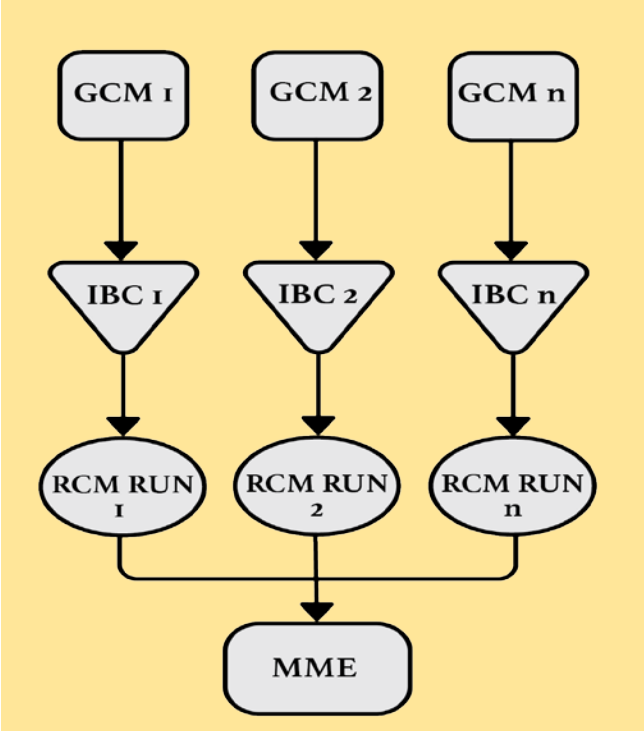
(Figure from Wang GL et al. 2017, *Journal of Advances in Modeling Earth Systems,* doi:10.1002/2016MS000712)

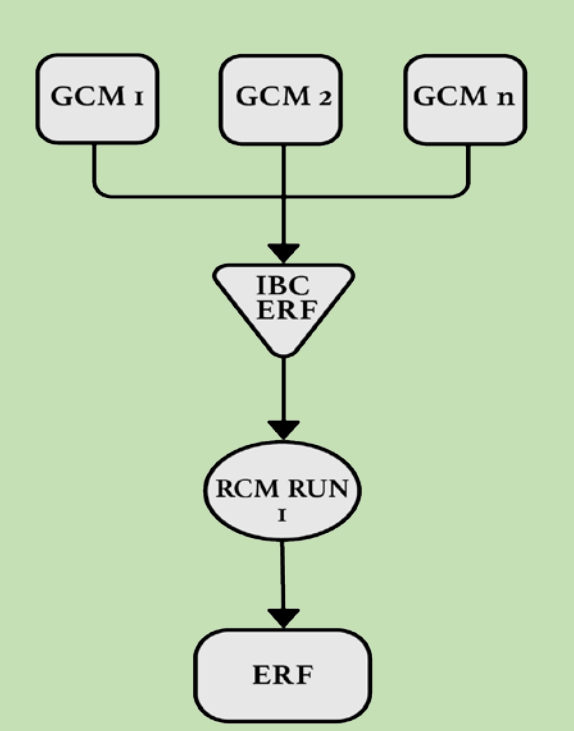
Ensemble Modeling Approaches to Regional Climate Downscaling

Conventional Approach
Multi-Model Ensemble (MME) Average

vs.

New Approach of Erfanian et al. 2017
Ensemble Reconstructured Forcing (ERF)

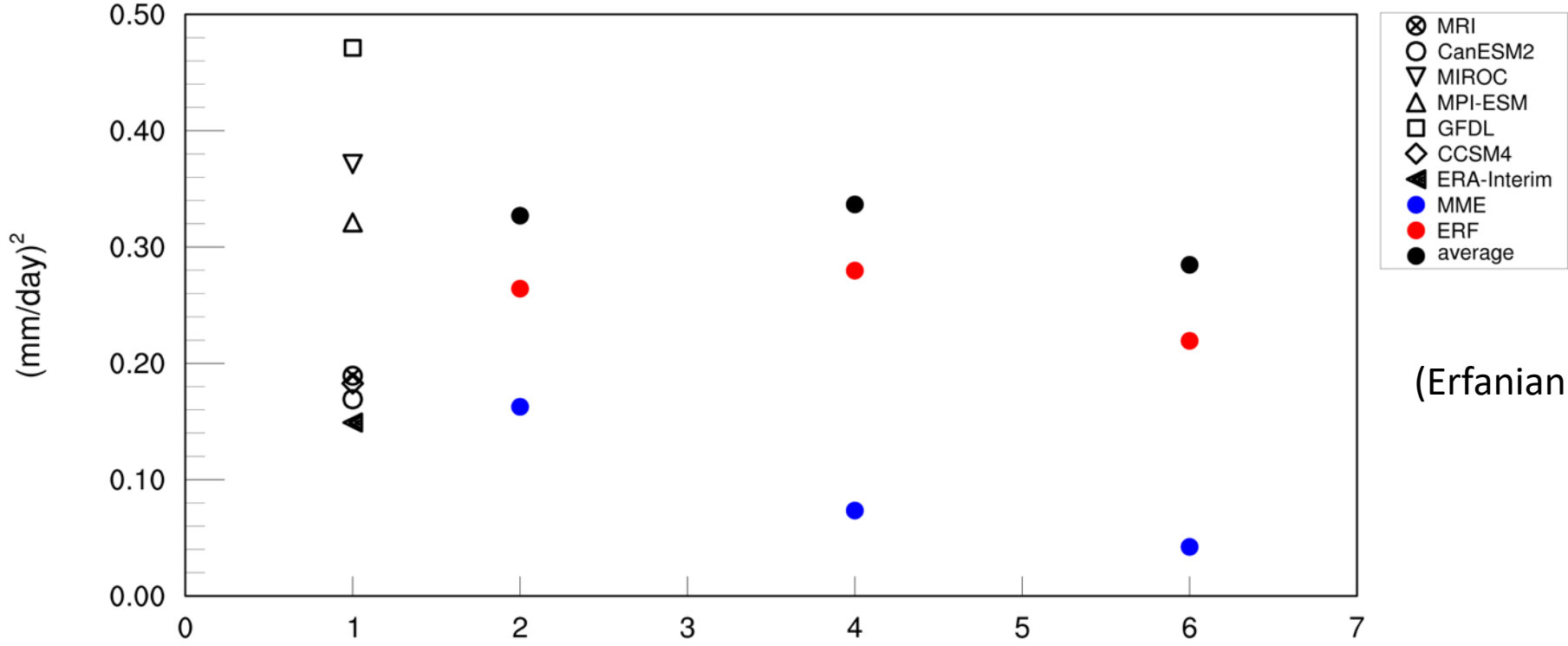




- The ERF method is not prone to the physical inconsistencies in the MME mean climate resulting from averaging multiple solutions.
- For *n* driving GCMs, MME requires *n* RCM simulations, and ERF requires only 1.
- ERF performs similarly to MME in capturing the mean climate, and better than MME in retaining the temporal variability.

Precipitation Variance (inter-annual time scale) vs. Ensemble Size, based on MME average and ERF

- As the ensemble size increases, the inter-annul variability is rapidly smoothened out in the MME average, but in ERF it remains close to the average level of individual models (with n ≤ 6 at least)



(Erfanian et al., 2017)

Erfanian et al., 2017: Ensemble Reconstructed Forcing (ERF) approach for regional climate modeling: Attaining performance at a fraction of cost. *Geophysical Research Letters*, in 2nd round of reviews

RCM-Produced Future Changes in West Africa

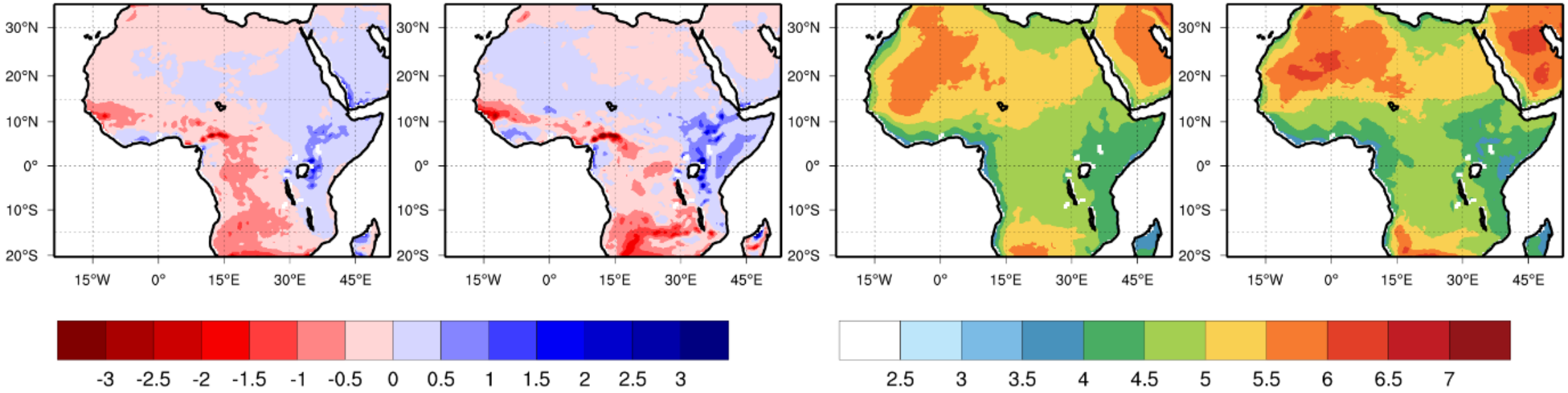
(based on MME and ERF, with the RCM LBCs derived from six global models including CCSM4, GFDL, MPI-ESM, MIROC-ESM, CanESM2, MRI)

Precipitation (mm/day)

MME6 ERF6

2-m Air Temperature (K)

MME6 ERF6



<u>Motivation for the computing project</u>: The ERF approach produced future climate changes projections that are similar to the MME approach but at a fraction of the MME CPU cost. Is the ERF approach useful in assessing climate change impact on the society (e.g., on agriculture)?

The SDWG Computing Project

Objective: To evaluate the performance of the ERF approach (against the MME approach) in quantifying climate change impact on agriculture and water resources.

Methodology: Output from the individual RCM runs for present and future climate (including 4-6 present-versus-future pairs driven by different GCMs and one pair driven by ERF LBCs) will be used as climate forcing for crop yield modeling. Crop yields from the ERF runs will be compared against crop yields averaged across the individual GCMs (i.e., MME approach).

CLM5 will be used to model crop yield and hydrological changes. Geographic focus will be on the Americas.