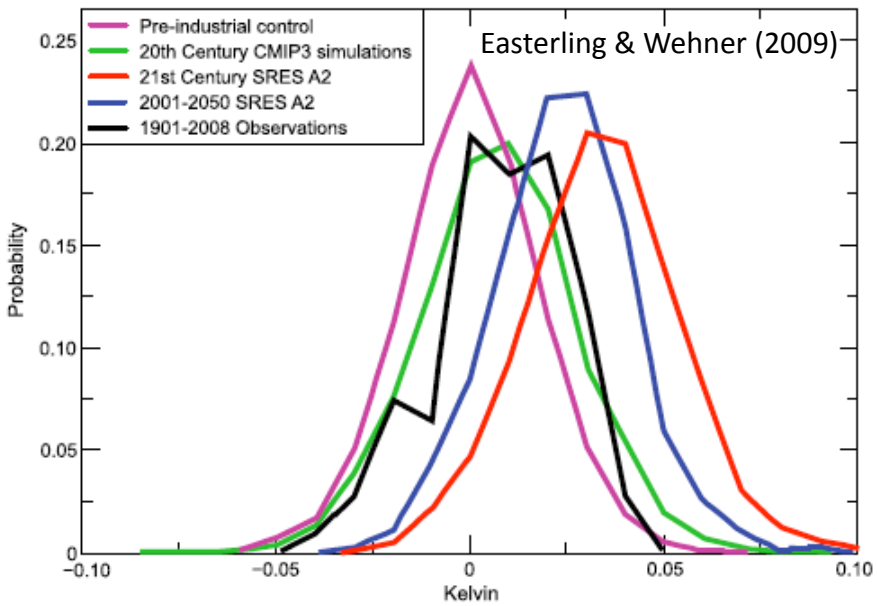
Session B7
WCRP 2011

Scale Dependency of the 20th Century Experiments by CMIP5 and CMIP3 Models: Do Reliable Scales Become Smaller?

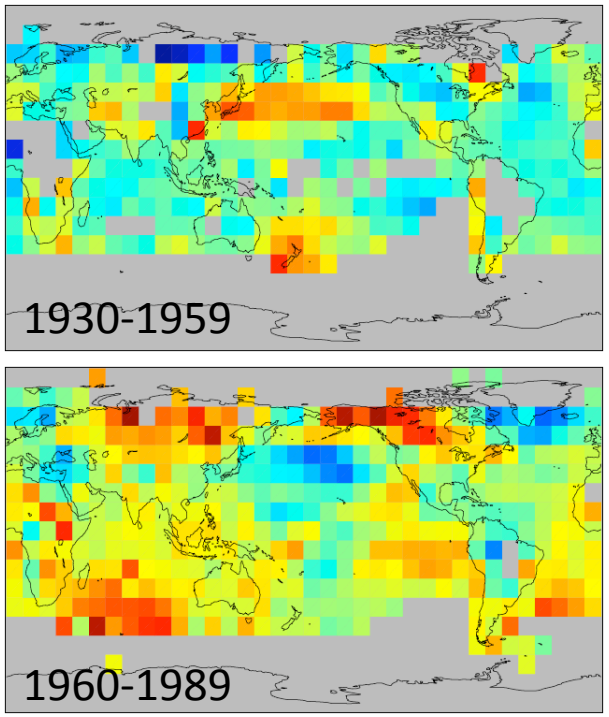
Koichi Sakaguchi, Xubin Zeng and Michael Brunke
Department of Atmospheric Sciences
The University of Arizona

ksa@email.arizona.edu

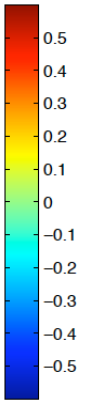
Questions



Probability distribution for decadal trends over running 10-yr periods (°C yr^{-1}).



30-year trends over 10°x10° grid



(C°/decade)

”How well are the coupled global climate models in predicting the surface air temperature **trend varying over space and time**?"

”How do their performance (errors) **change with temporal and spatial scales**?"

”How much progress have we made from **CMIP3 to CMIP5**?"

Method & Data

Variable: temperature trends calculated over:

- moving time windows (e.g., 1880-1889, 1881-1890, 1882-1891,…)
- 5 different temporal scales (10, 20, 30, 40, and 50 years)
- 8 different spatial scales (5°x5°, 10°x10°, 15°x15°, ... global mean)

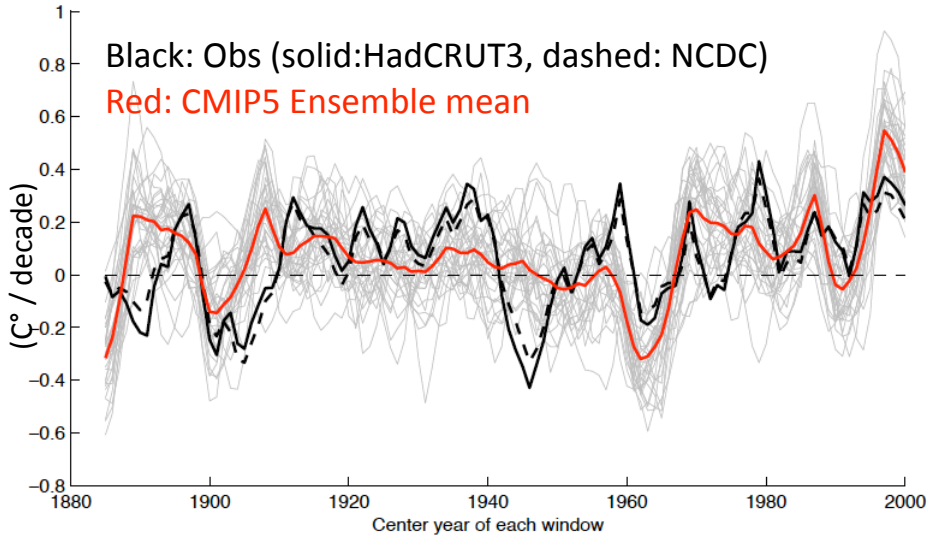
Observation: HadCRUT3 (Brohan et al., 2006) and NOAA NCDC (Smith et al., 2008) surface air temperature anomaly

Climate models:

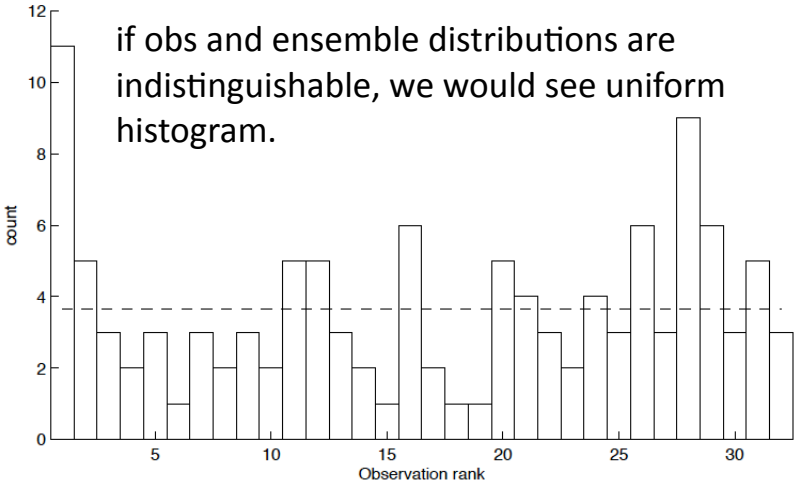
CMIP3	CMIP5
CCCMA CGCM3.1 T47 (5)	CCCMA CanESM2 (5)
GFDL CM2.0 (3)	CSIRO Mk3.6.0 (5 out of 10)
GISS E-H (5)	GISS E2-H (5)
MIUB ECHO-G(5)	IPSL CM5a-LR (4)
MPI ECHAM5 (4)	MOHC HadGEM2-ES(4)
MRI CGCM2.3.2 (5)	MRI CGCM3 (5)
NCAR CCSM3.0 (5)	NCC NorESM1-M (3)
20c3m: 32 ensemble members	historical: 31 ensemble members

Results: example

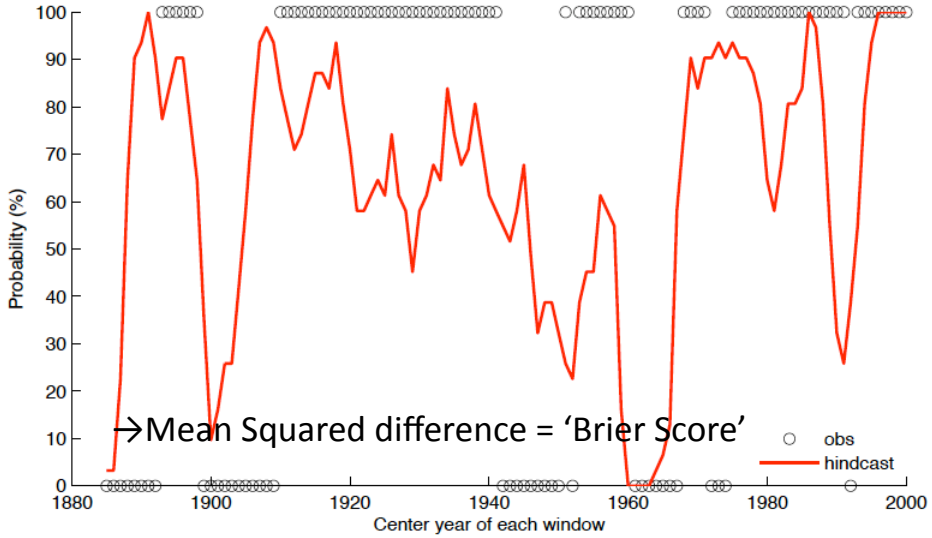
Global mean, 10-year trend time series



Rank Histogram



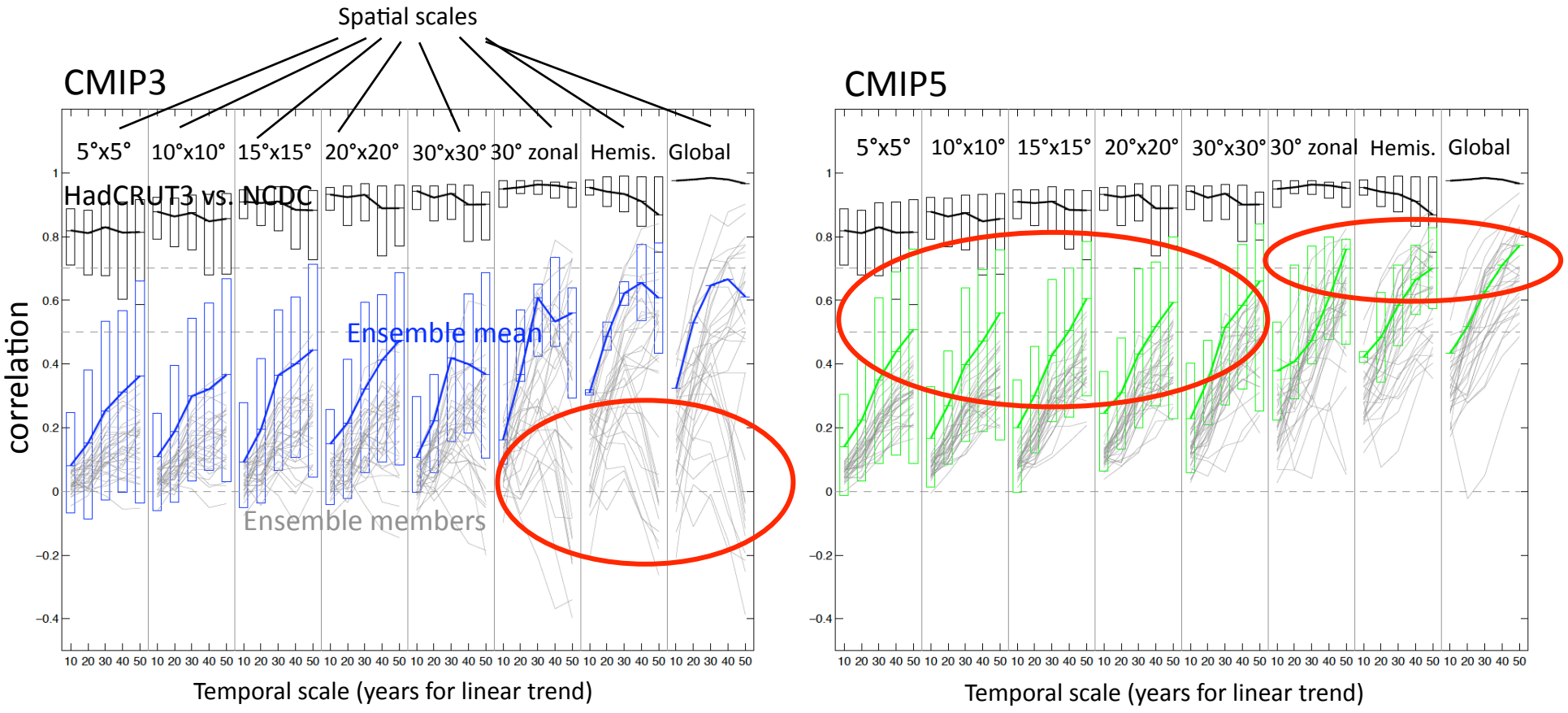
Time series of probability for positive trend



	CMIP5	CMIP3
correlation	**0.43**	0.32
RMSE(°C/decade)	0.18	0.17
Brier Score	0.20	0.20
χ^2 for uniformity	43.0	42.7

Results: Linear Correlation

Boxes: 25th-75th range
Lines: Median

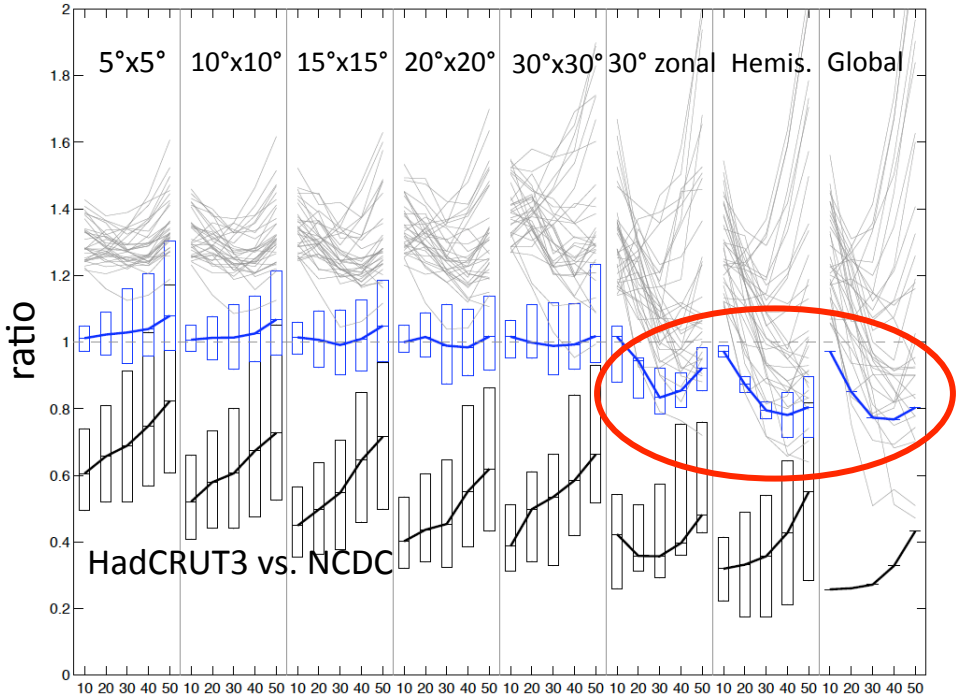


- CMIP5 generally shows better *r* with the observed trends than CMIP3.
- $r > 0.7$ ($r^2 \approx 0.5$) is reached more often by CMIP5 simulations at 40 or longer years, over hemispherical and global averages
- CMIP5 also has smaller inter-member differences in *r*.

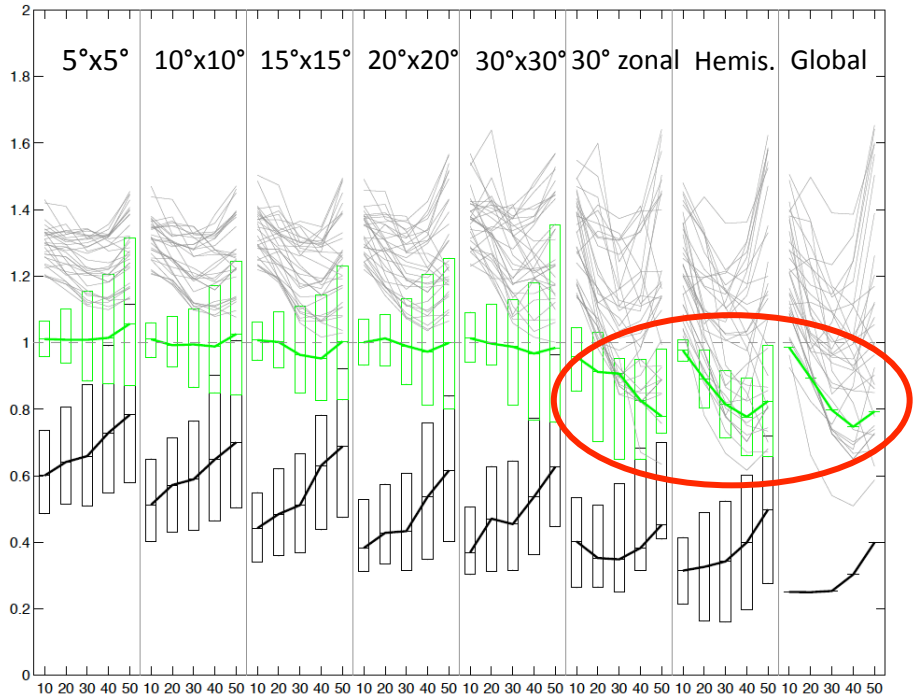
Results: RMSE / s_{Obs}

Boxes: 25th-75th range
Lines: Median

CMIP3

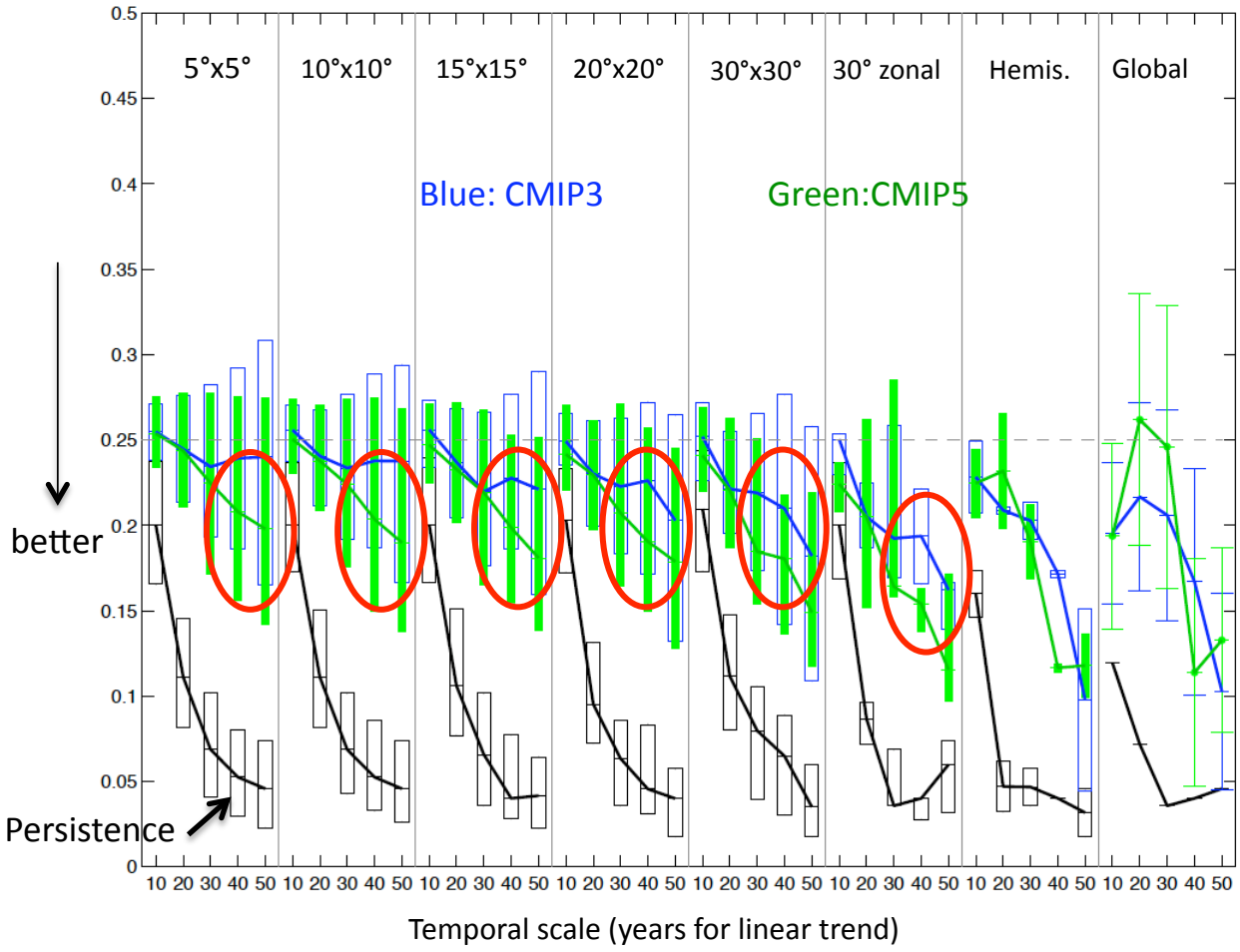


CMIP5



- Similar performance by CMIP3 and CMIP5
- Ensemble mean has RMSE smaller than the observed variability at 30° zonal mean or larger scales

Results: Brier Score

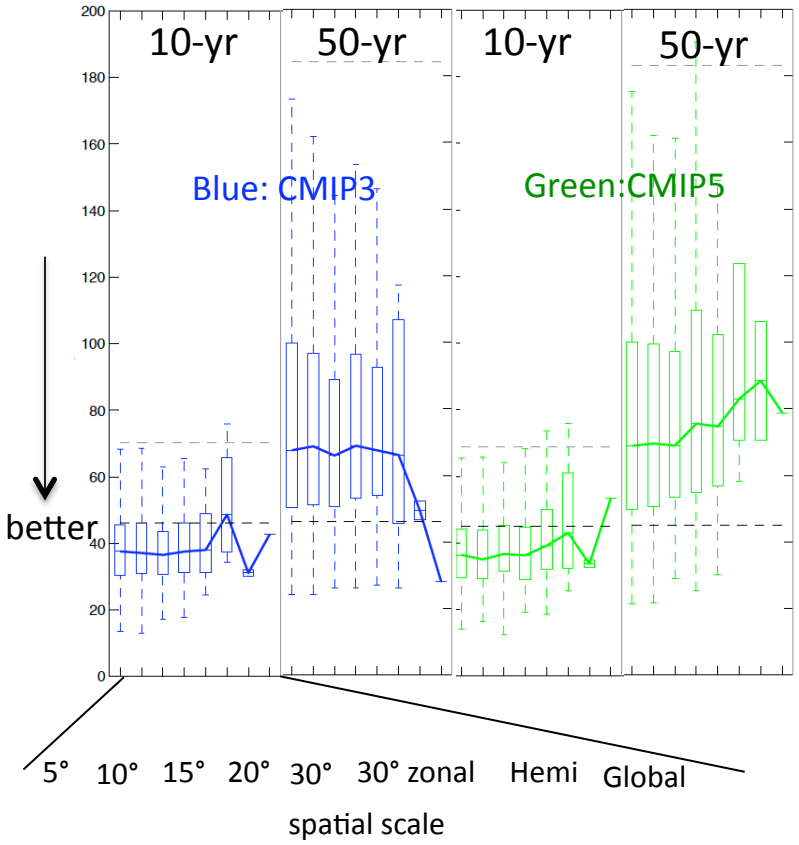


Boxes: 25th-75th range
Thick Lines: Median

- Improvement with longer temporal scales
- CMIP5 shows better score for 30-year or longer scales

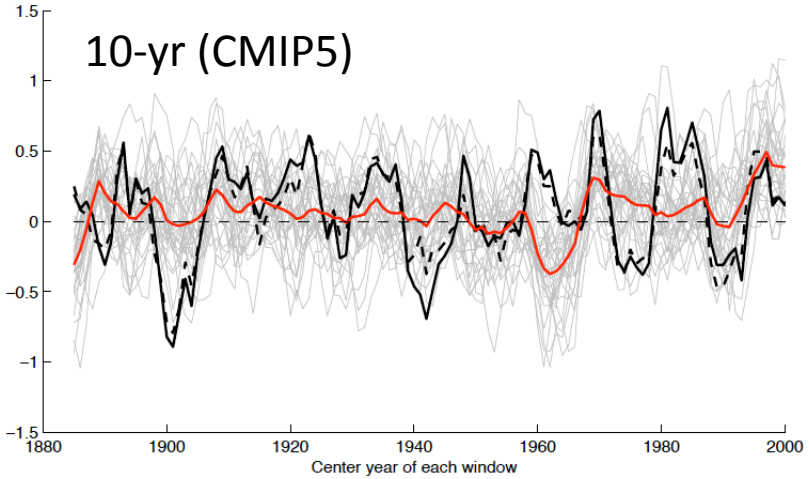
Results: Rank Histogram

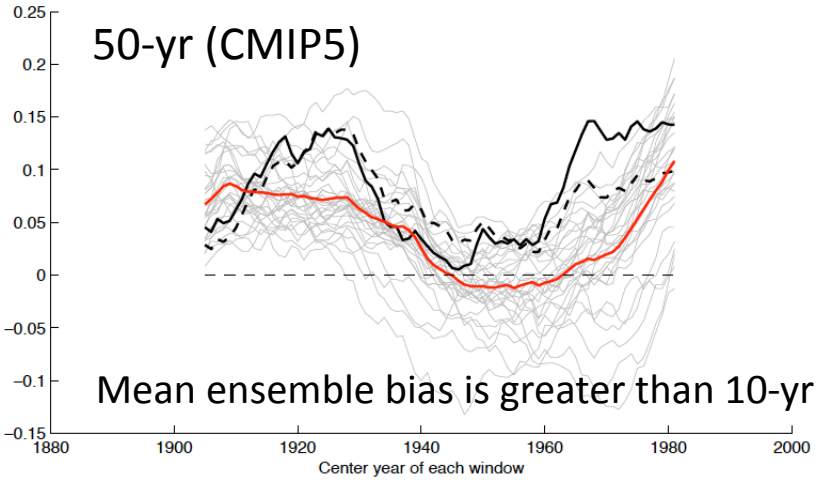
Chi-square value for Rank Histogram



- Ensemble consistency is not necessarily improved with longer temporal scales?

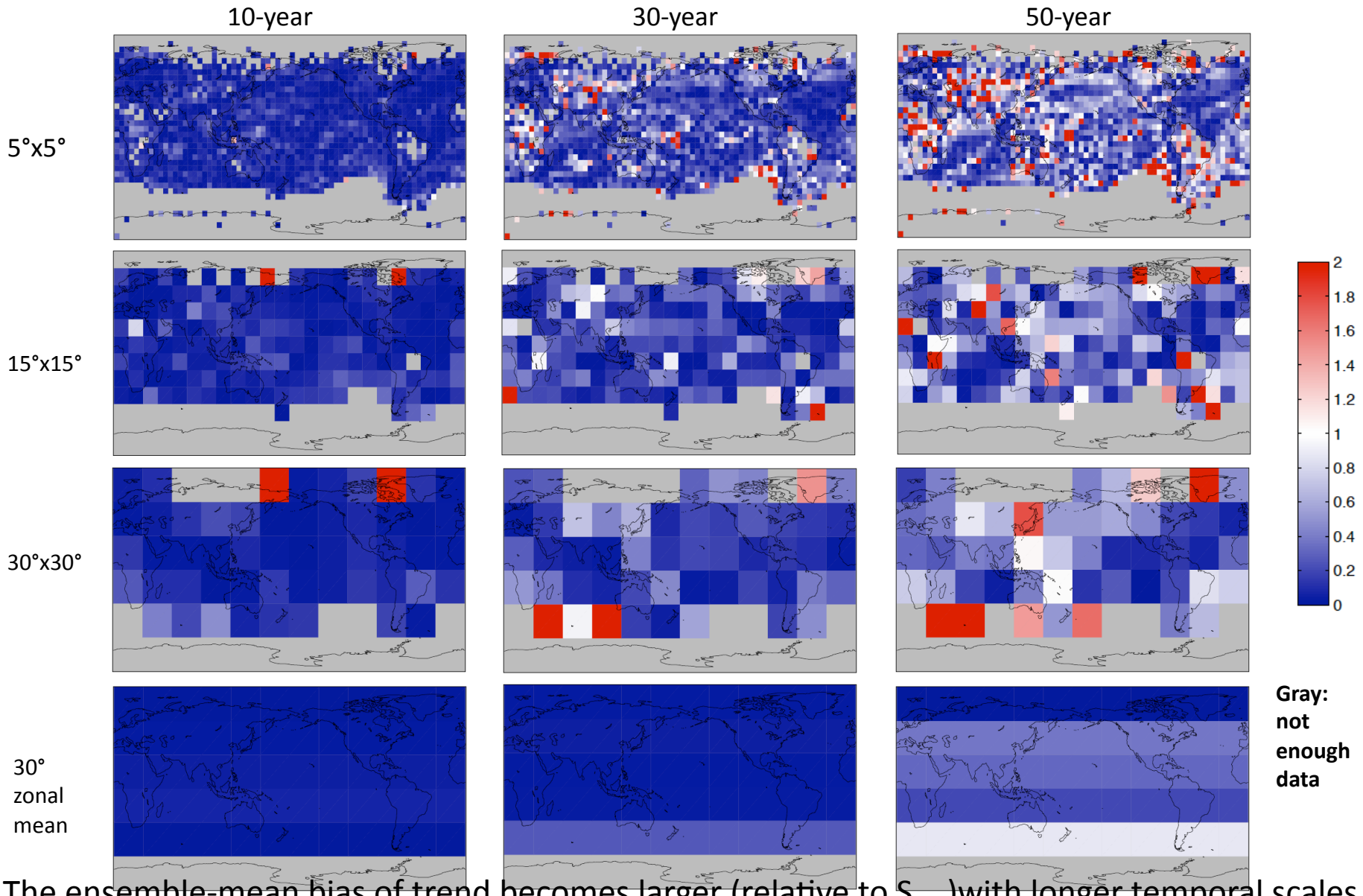
5°x5° grid (2.5°S, 27.5°W), Tropical Atlantic Ocean





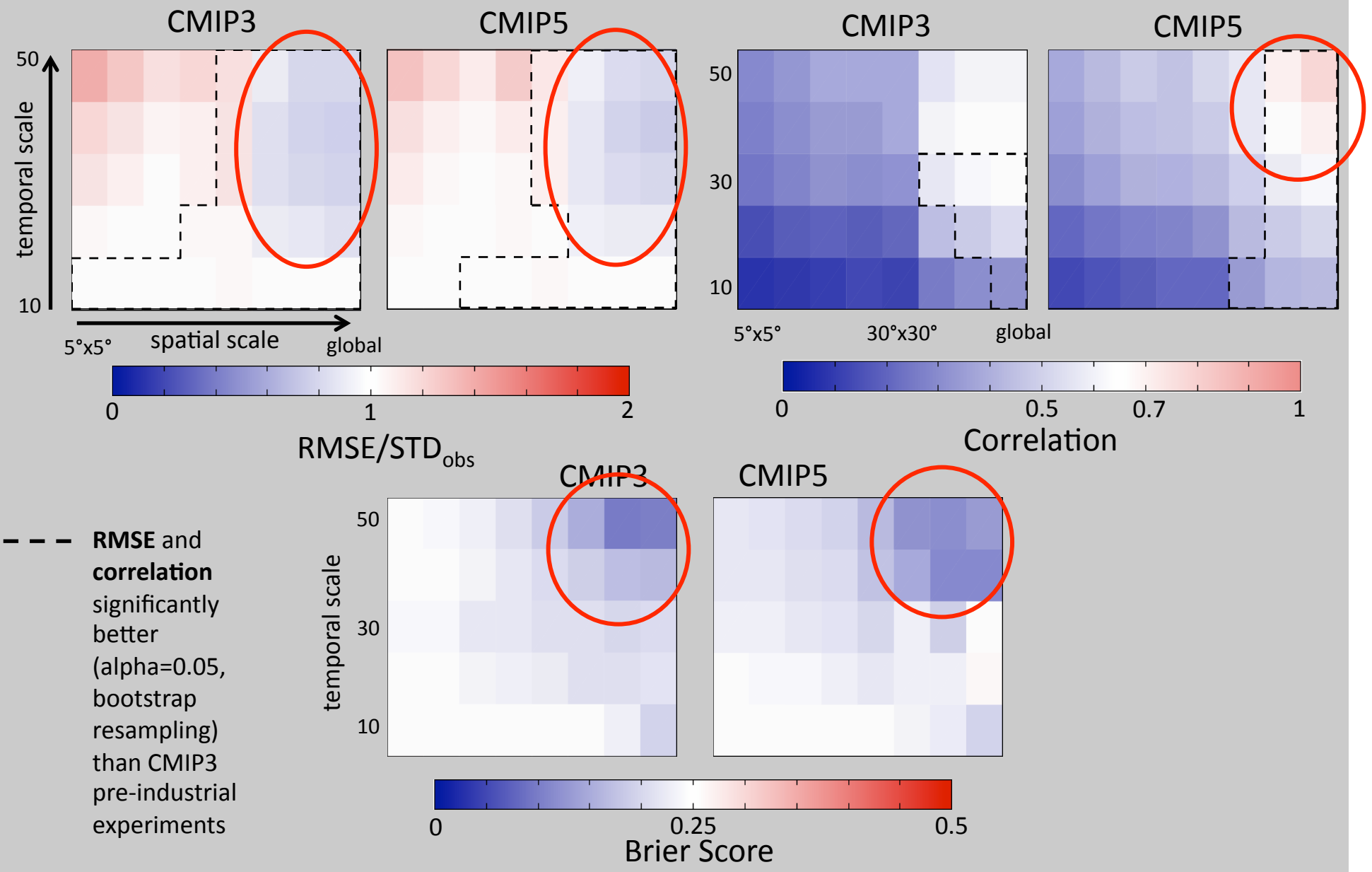
Mean ensemble bias is greater than 10-yr

Results: Ensemble mean bias ($bias_{mean}/s_{obs}$), CMIP5



The ensemble-mean bias of trend becomes larger (relative to S_{obs})with longer temporal scales

Summary



RMSE and **correlation** significantly better (alpha=0.05, bootstrap resampling) than CMIP3 pre-industrial experiments

Summary

ksa@email.arizona.edu

- Based on the simulated and observed running trends time series, we found

Linear Correlation (*r*): CMIP5 generally shows better *r* with the observed trends than CMIP3. CMIP5 also has smaller inter-member differences in *r*.
CMIP5 MME mean reach reasonable correlation (≈0.7, i.e., $r^2 \approx 0.5$) at hemispherical and global mean scales for 30-years or longer temporal scales.

RMSE: similar between CMIP3 and CMIP5 MME means. The error becomes smaller than observed variability at 30° zonal means or larger spatial scales.

Brier Score: CMIP3 & CMIP5 probabilistic predictions for 'positive' trend are usually better than coin-toss (50% each) at 30° zonal mean or larger spatial scales.
CMIP5 ensemble better than CMIP3 over smaller (≤ 30°) spatial scales for 30-year or longer trends

Rank Histogram: Possible mean bias for both ensembles, particularly with longer temporal scales.

- Systematic scale-dependent performance summary is more desirable under the increasing interests in regional and decadal predictions.