NOAA MAPP CMIP5 Task Force Overview

IGIM CMIP5 Workshop
4 October 2012

Jim Kinter
COLA & GMU

CMIP5 Task Force

- **Period: November 2011 – October 2014**
- **Funded by NOAA Climate Program Office Modeling, Analysis, Predictions and Projections program**
- **Mission**
  - Bring together scientists whose MAPP-funded research in the framework of CMIP5 aims at evaluating simulations of the 20th century climate and the uncertainties in long-term predictions and projection of 21st century climate over North America
  - Advance knowledge of the long-term climate outlooks for North America, relevant to the preparation of IPCC AR5.
  - Coordinate with other relevant national and international efforts (e.g. WCRP Panels such as WGCM and WGNE).
- **Leadership**
  Lead, ad-interim**:** Jim Kinter, COLA, George Mason University
  Co-Lead: Justin Sheffield, Princeton University
  Co-lead: Eric Maloney, Colorado State University

CMIP5 Task Force

- **MAPP Program Task Force Concept**
  - Target high-priority research areas where rapid progress is needed to advance MAPP objectives.
  - Provide a working-level opportunity for MAPP-funded PIs already engaged in research projects with synergetic objectives, to communicate and coordinate.
  - Target well-defined yet broad research objectives requiring a community approach, beyond the scope of an individual research project.
  - Define objectives considering programmatic, scientific and operational drivers of relevance to the Task Force research area, and the likelihood of success
- **Terms of Reference**
  - MAPP Program Management will initiate Task Forces in strategic areas, as needed.
  - The Task Forces will be led by scientists, selected by MAPP Program Management.
  - MAPP Program management will oversee Task Force activities working with the Leads.
  - Participation in the Task Force is by invitation, with the core of the Task Force constituted by MAPP-funded PIs.
  - Task Forces will typically be in place for 2-3 years, with a mid-term review of accomplishments and an opportunity for leadership rotation (as needed).
  - Most of the work will be done remotely via telecons, virtual meetings or leveraging on meetings of opportunity.

CMIP5 Task Force Participants

Member	Affiliation	Member	Affiliation
Jim Kinter (Lead Scientist)	Center for Ocean-Land-Atmosphere Studies (COLA) and George Mason University	Kingtse Mo	NOAA/Climate Prediction Center (CPC)
Eric Maloney (Co-Lead Scientist)	Colorado State University	J. David Neelin	University of California, Los Angeles
Justin Sheffield (Co-Lead Scientist)	Princeton University	Sumant Nigam	University of Maryland
Melissa Bukovsky	National Center for Atmospheric Research (NCAR)	Zaitao Pan	Saint Louis University
Suzana Camargo	Lamont-Doherty Earth Observatory (LDEO)	Alfredo Ruiz-Barradas	University of Maryland
Leila Carvalho	University of California, Santa Barbara	Richard Seager	Lamont-Doherty Earth Observatory (LDEO) of Columbia University
Edmund Chang	Stony Brook University	Yolande Serra	University of Arizona
Brian Colle	Stony Brook University	Anji Seth	University of Connecticut
Paul Dirmeyer	Center for Ocean-Land-Atmosphere Studies (COLA)	Julienne Stroeve	National Snow and Ice Data Center (NSIDC)
Rong Fu	University of Texas at Austin	De-Zheng Sun	NOAA/Earth System Research Laboratory (ESRL)
Lisa Goddard	International Research Institute for Climate and Society (IRI)	Gabriel Vecchi	NOAA/Geophysical Fluid Dynamics Laboratory (GFDL)
Qi Hu	University of Nebraska - Lincoln	Chunzai Wang	NOAA/Atlantic Oceanographic and Meteorological Laboratory (AOML)
Xianan Jiang	University of California, Los Angeles	Shang-Ping Xie	University of Hawaii
Charles Jones	University of California, Santa Barbara	Jin-Yi Yu	University of California, Irvine
Kristopher Karnauskas	Woods Hole Oceanographic Institution (WHOI)	Tao Zhang	NOAA/Earth System Research Laboratory (ESRL)
Ben Kirtman	University of Miami	Ming Zhao	NOAA/Geophysical Fluid Dynamics Laboratory (GFDL)
Arun Kumar	NOAA/Climate Prediction Center (CPC)		
Sanjiv Kumar	Center for Ocean-Land-Atmosphere Studies (COLA)	Annarita Mariotti (Lead Program Mgr)	NOAA/Climate Program Office (CPO)
Jialin Lin	Ohio State University	Dan Barrie	NOAA/Climate Program Office (CPO)
Lindsey Long	NOAA/Climate Prediction Center (CPC)	Will Chong	NOAA/Climate Program Office (CPO)

Year-1 Summary

Positives:

- Overall a very successful project so far
- Gathered and engaged, through monthly telecons and a wiki, many PIs who "rolled up their sleeves" and accomplished a lot of good scientific research
- Organized and executed 3 excellent many-author papers summarizing the CMIP5 20C simulations and 21C projections under the leadership of Task Force co-chairs
- Organized special collection in J. Climate with 20+ papers submitted
- Made a substantial contribution to IPCC AR5, expected to inform the WG1 report

Negatives:

- The (externally determined) deadline for submitting results was too soon after data became available relative to the time required to obtain data for the more data-intensive investigations – possibly due to shortcomings in CMIP5/AR5 planning and data distribution execution
- Failed to complete analysis of decadal predictions - partially due to inadequate scientific content of data set (sampling sparsity and poor prediction quality) and partially due to insufficient enthusiasm by Task Force

Overview Papers Prepared

- North American Climate in CMIP5 Experiments - Part I: Evaluation of 20th Century Continental and Regional Climatology. Justin Sheffield et al.
- North American Climate in CMIP5 Experiments - Part II: Evaluation of 20th Century Intra-Seasonal to Decadal Variability. Justin Sheffield et al.
- North American Climate in CMIP5 Experiments - Part III: Assessment of 21st Century Projections. Eric Maloney et al.

Individual Papers Prepared

1. **Drought and Persistent Wet Events Projected in the CMIP5 Experiments**. Lindsey N. Long et al.
2. **Simulation of Eastern Pacific Intraseasonal Variability in CMIP5 GCMs** Xianan Jiang and Eric D. Maloney
3. **CMIP5 simulations of low-level tropospheric temperature, moisture and trade winds over tropical Americas**. Leila M. V. Carvalho and Charles Jones
4. **MJO and convectively coupled equatorial waves simulated by IPCC AR5 climate models**. Meng-Pai Hung et al.
5. **Tropical East Pacific Storm Track Statistics in Select IPCC AR5 Models: Historical and RCP 4.5 Projections**. Yolande Serra and Kerrie Geil
6. Precipitation Patterns in the Inter-Americas Sea and North American Monsoon Regions on Seasonal to Interannual Time Scales in Select IPCC AR5 Models: Historical and RCP 4.5 Projections. Kerrie Geil and Yolande Serra
7. **Variability of the Atlantic Warm Pool in CMIP5 GCMs**: H. Liu et al.
8. **Inter-model variability and mechanism attribution of central and southeastern U.S. anomalous cooling in the 20th century as simulated by CMIP5 models** . Zaitao Pan and Xiaodong Liu
9. CMIP5 North Atlantic and eastern North Pacific tropical cyclone-like storms in present and future climates: Suzana J. Camargo
10. **Historical and future predictions of eastern North America and western Atlantic extratropical cyclones in CMIP5 during the cool season**. Brian A. Colle et al.
11. CMIP5 simulations of the impacts of the two types of ENSO on North America winter climate.Jin-Yi Yu and co-authors.
12. **Evolving land-atmosphere interactions over North America from CMIP5 simulations**. Paul A. Dirmeyer et al.
13. **Low-level Jets and Precipitation Variation in the U.S. Great Plains Simulated in the CMIP5 Models**. Qi Hu and S. Feng
14. **Simulated and projected drought, flood and extreme summer surface temperatures over US Southern Plains in CMIP5 models**, Rong Fu, Nelun Fernando et al.
15. **Global and regional aspects of tropical cyclone activity in the CMIP5 models**. Suzanna Camargo
16. **Multi-decadal climate variability and the "warming hole" in North America - results from CMIP5 climate simulations**. Sanjiv Kumar et al.
17. Representation of Arctic sea ice in CMIP5: Historical and Future Projections, J. Stroeve et al.
18. Annual Cycle of Monsoon Precipitation in CMIP5 Projections, A. Seth et al.
19. Process Evaluation of Northeast U.S. Warm Season Precipitation in CMIP5 Projections. J. Thibeault and A. Seth
20. **Detection and attribution of observed changes in Northern Hemisphere spring snow cover**. David Rupp
21. ENSO Asymmetry in CMIP5 Models. T. Zhang and D.-Z. Sun
22. **California winter precipitation change under global warming in the Coupled Model Intercomparison Project 5 ensemble**. David Neelin et al.
23. The Western Pacific Warm-pool in CMIP5 Models. Y. Sun and D.-Z. Sun
24. **Cloud and Water Vapor Feedbacks to the El Niño Warming: Are They Still Biased in CMIP5 Models?** Lin Chen
25. **Analyzing ENSO teleconnections in CMIP models as a measure of model fidelity in simulating precipitation**. B. Langenbrunner and J.D. Neelin
26. **Multi-year Predictions of North Atlantic Hurricane Frequency: Promise and limitations**. Gabe Vecchi et al.

Research on Hydroclimate Variability over North America:
AMO and its impact in CMIP3 and CMIP5 Historical Simulations of the 20th Century Climate.

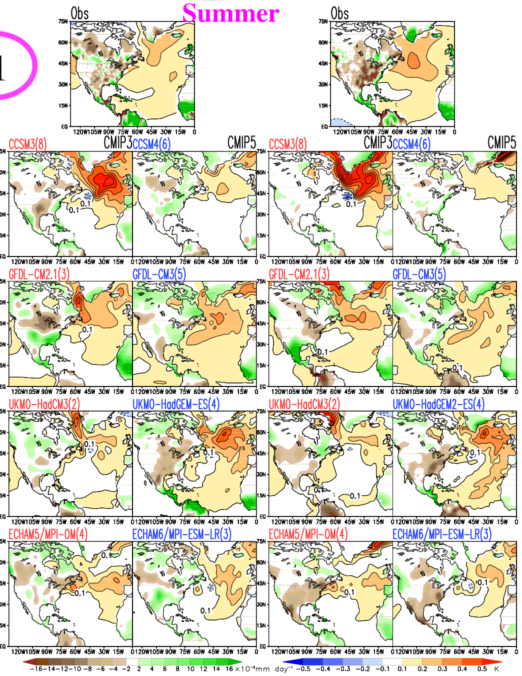
Alfredo Ruiz-Barradas and Sumant Nigam
University of Maryland

1

AMO regressions on SST and Precipitation Anomalies

Summer

Fall



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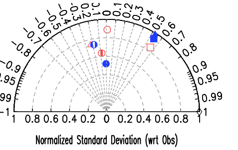
Taylor Diagrams of AMO Indices and SST/Precipitation AMO Regressions

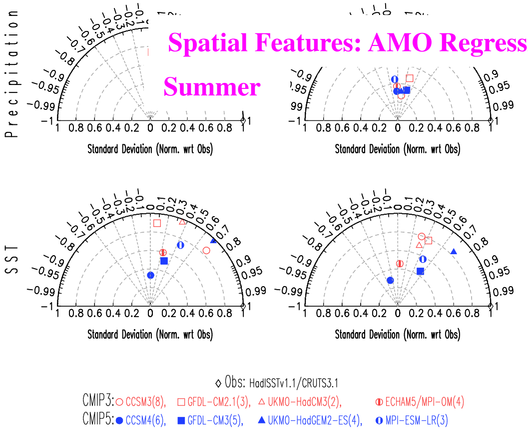
Temporal Features: AMO Indices



Spatial Features: AMO Regressions

Summer

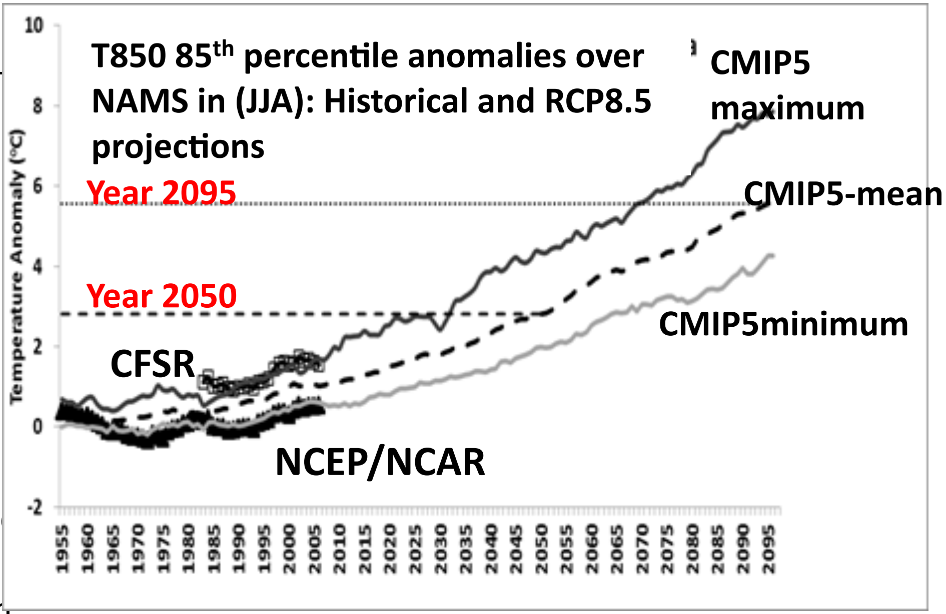
Fall

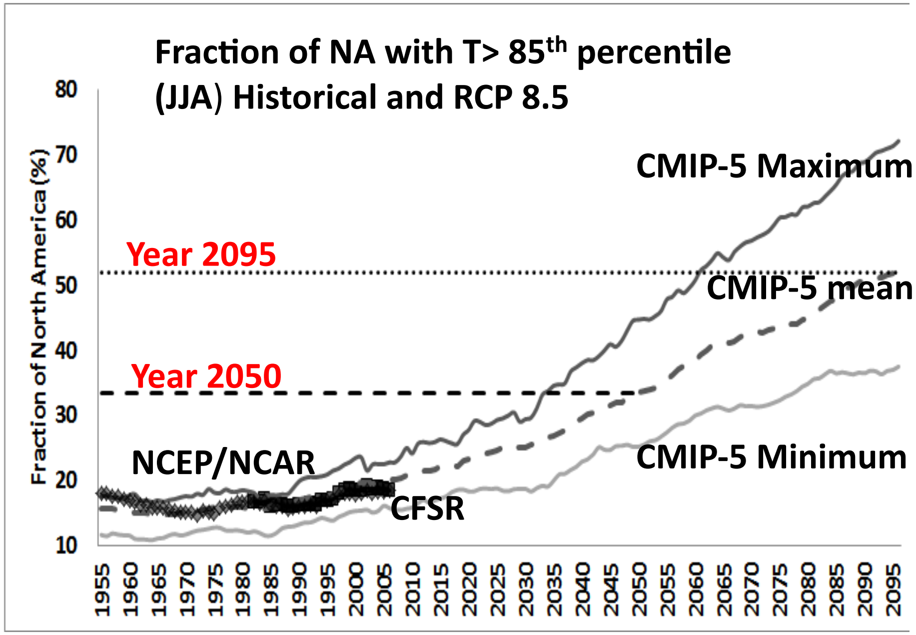


The decadal modulation of SST in the Atlantic Ocean, via the AMO, has been shown to have an important impact on extreme droughts and wet episodes over the central US (*Nigam et al. 2011*). The ability of the models to capture the AMO and its hydroclimate impact over North America in summer and fall are explored. **1)** The SST signature of the AMO is stronger in fall than in summer and this is reflected in a stronger impact in fall on central US precipitation in observations, highlighting the importance of the AMO seasonality. In general models do not capture well the SST seasonality of the AMO or the buildup of the drying conditions over the central US and wet conditions along the coastal south Atlantic US states from summer to fall *(J. Climate, 2012, CMIP5 Task Force submitted)*. **2)** Taylor diagrams of both the AMO indices and the regional anomalies associated with the AMO compact the struggles of the models. AMO indices from the CMIP5 versions of the GFDL and UKMO models have comparable temporal variability to observations, and are mildly correlated with the observed index. Models are not up to the task of simulating the AMO impact on hydroclimate over the neighboring continents. This is in spite that the spatial variability and correlations in the SST anomalies improve from CMIP3 to CMIP5 versions of the MPI and UKMO models; the most successful is the CMIP5 version of the UKMO model in both seasons *(Climate Dynamics, 2012, submitted)*. *In short, progress is uneven from CMIP3 to CMIP5 models in the capture of the observed spatio-temporal features of the AMO and its regional impact.*

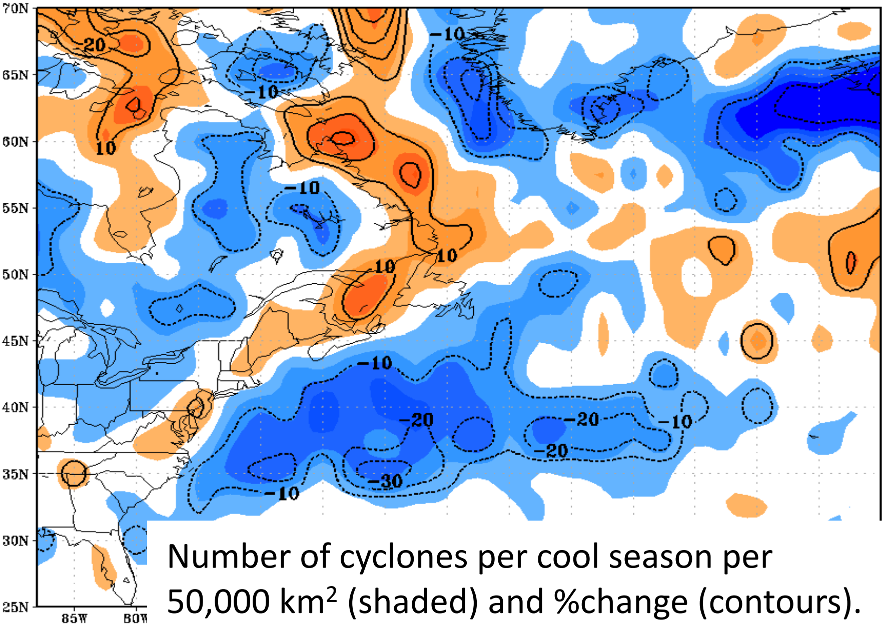
CMIP5 Simulations of Low-Level Tropospheric Temperature and Moisture over Tropical Americas. (Carvalho, L. M. V. and C. Jones)

- Interannual-to-decadal variations and changes in the low-troposphere (850hPa) temperature (T850) and specific humidity (Q850) over the North American Monsoon (NAMS) and South American Monsoon (SAMS) Systems using the NCEP/NCAR and CFSR reanalyses and CMIP5 simulations for two scenarios: “historical” (1951-2005) and “RCP8.5” (2006-2095).
- Trends in the magnitude and area of the 85th percentiles were distinctly examined over SAMS and NAMS regions during the peak of the respective monsoon seasons. The historic simulations and the two reanalyses agree well an indicate that significant warming has already occurred over tropical South America with a remarkable increase in the area and magnitude of the 85th percentile in the last decade (1996-2005) – 10% of the area according to the CFSR reanalysis.
- A more modest increase in T850 and Q850 have occurred over NAMS in the same period.
- The RCP8.5 ensemble mean projects an increase in the T850 85th percentile of about 2.5°C (2.8°C) by 2050 and 4.8°C (5.5°C) over South America (North America) by 2095 relative to 1955. The area of South America (North America) with T850 ≥ the 85th percentile is projected to increase from ~10% (15%) in 1955 to ~58% (~33%) by 2050 and ~80% (~50%) by 2095. This progressive warming is associated with an increase in the 85th percentile of Q850 of about 3g kg^{-1} over SAMS and NAMS by 2095.

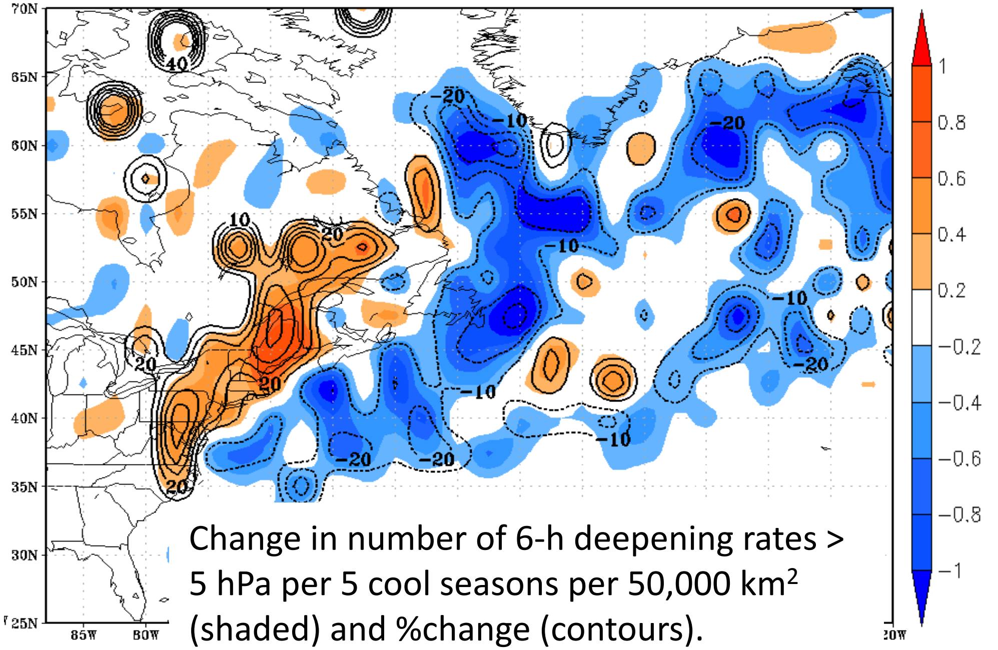




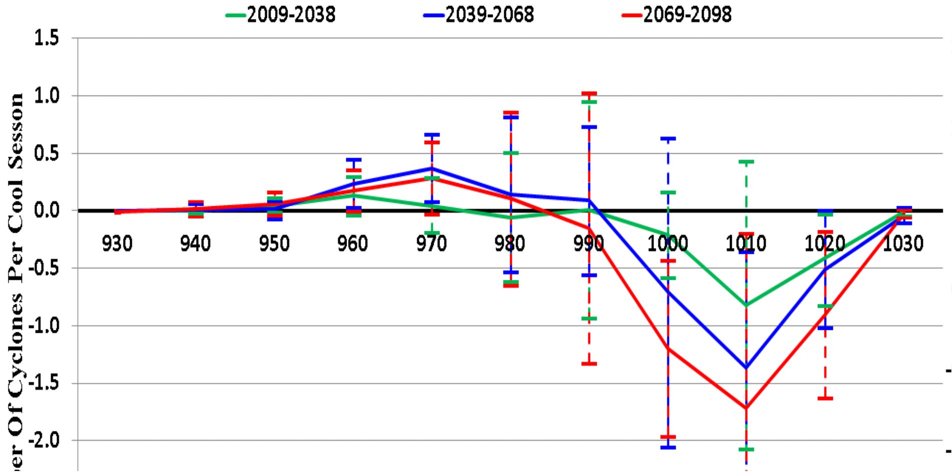
Difference in Cyclone Track Density, Max Intensity, and 6-h Deepening Rates Between 2039-2068 and 1979-2004 for 7 “Best” CMIP5 Models (Colle et al. 2012)



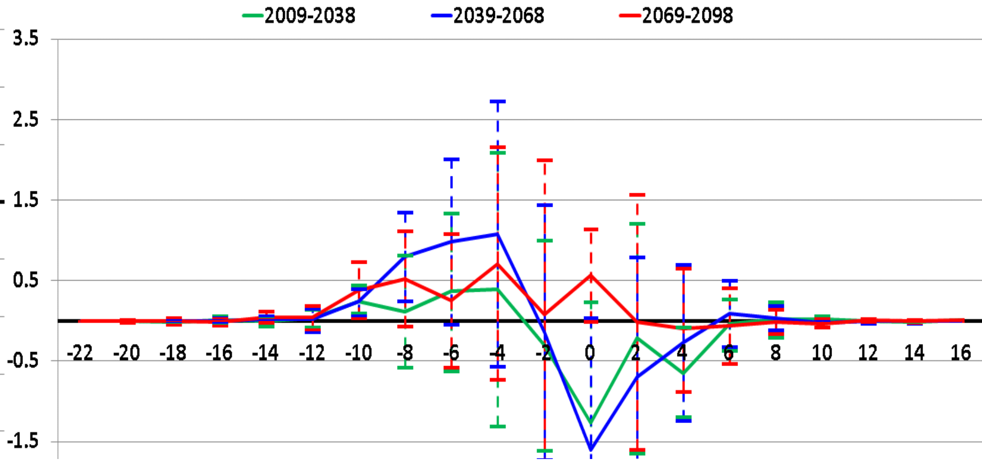
Number of cyclones per cool season per 50,000 km^2 (shaded) and %change (contours).



Change in number of 6-h deepening rates > 5 hPa per 5 cool seasons per 50,000 km^2 (shaded) and %change (contours).

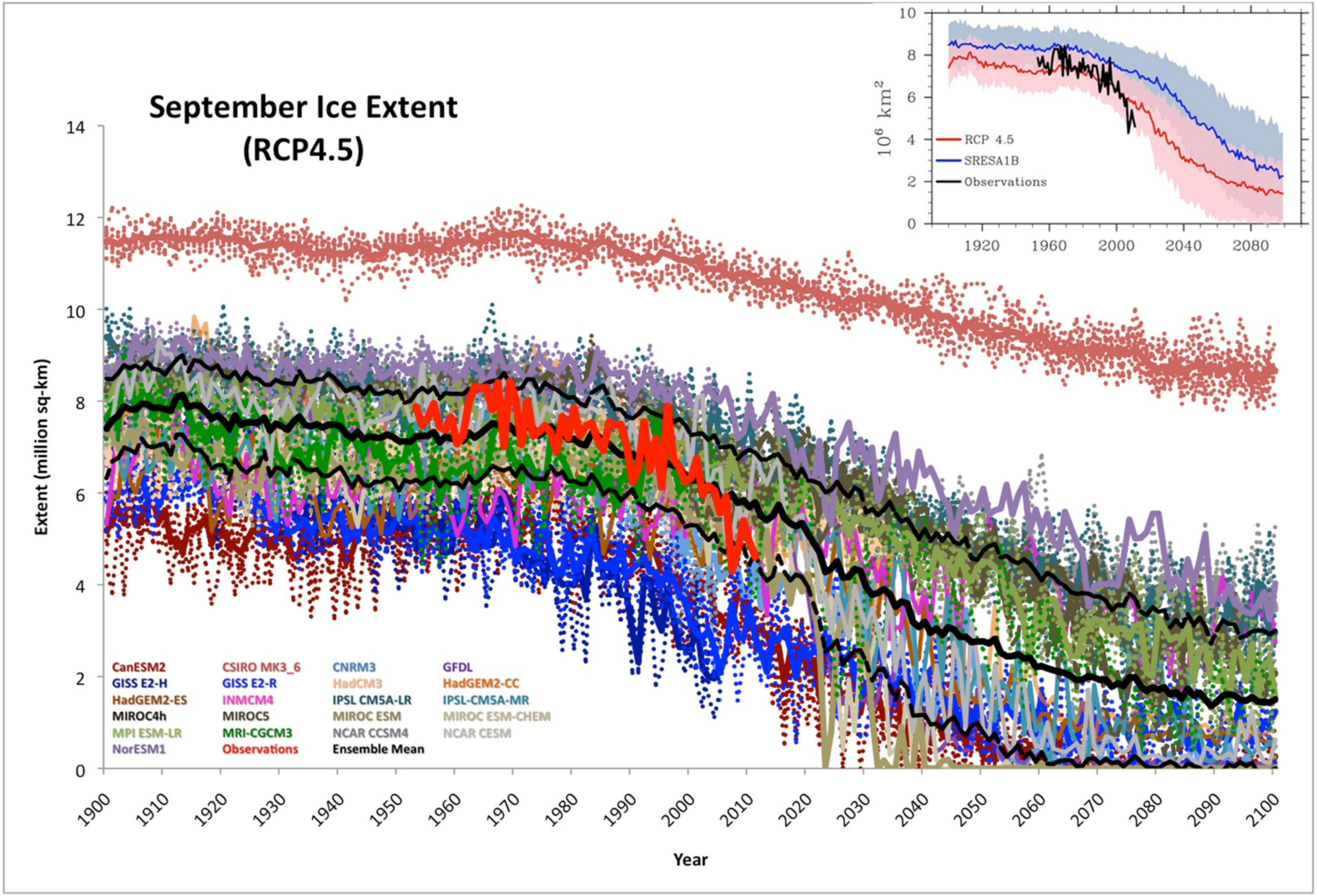


Difference in number of cyclones per cool season reaching maximum intensity for each 10 hPa bin between 3 future periods and 1979-2004 for U.S. East coast



Difference in number of 6-h pressure change per cool season for each 2 hPa pressure change bin between 3 future periods and 1979-2004 for U.S. East coast

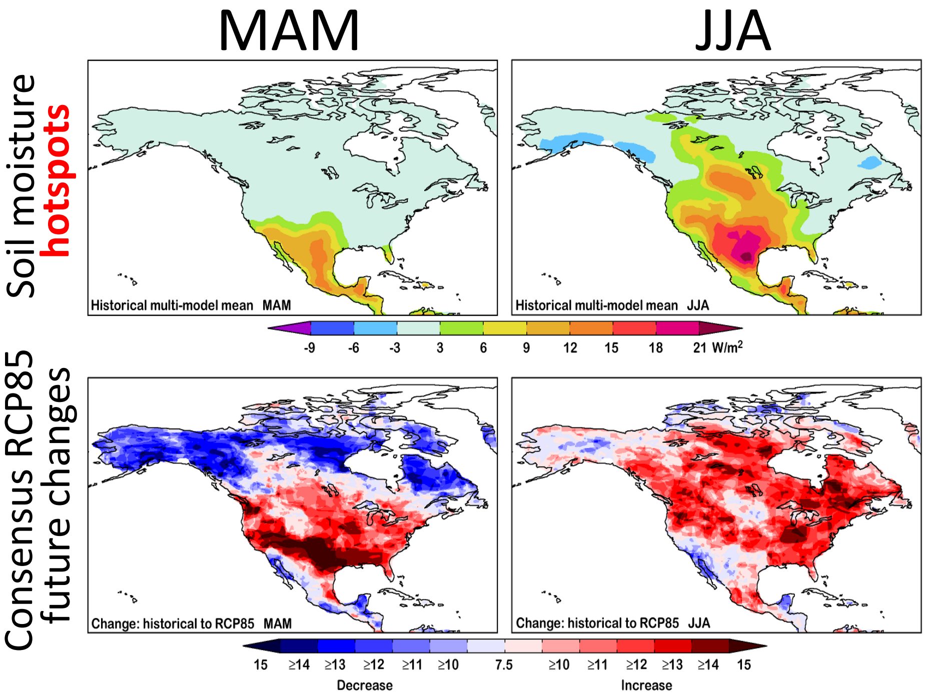
Evolution of September ice extent



From Stroeve et al., 2012, GRL

Changing Land-Atmosphere Interactions

- **Today**: strong L-A coupling spreads north from Mexico to central Canada from spring to summer (top).
- **Future changes**: earlier onset, greater extent poleward and into current humid climates (bottom).
- Warming also leads to deeper, drier daytime boundary layer, weaker gradients across BL top, less effect of free atmosphere on BL (not shown).

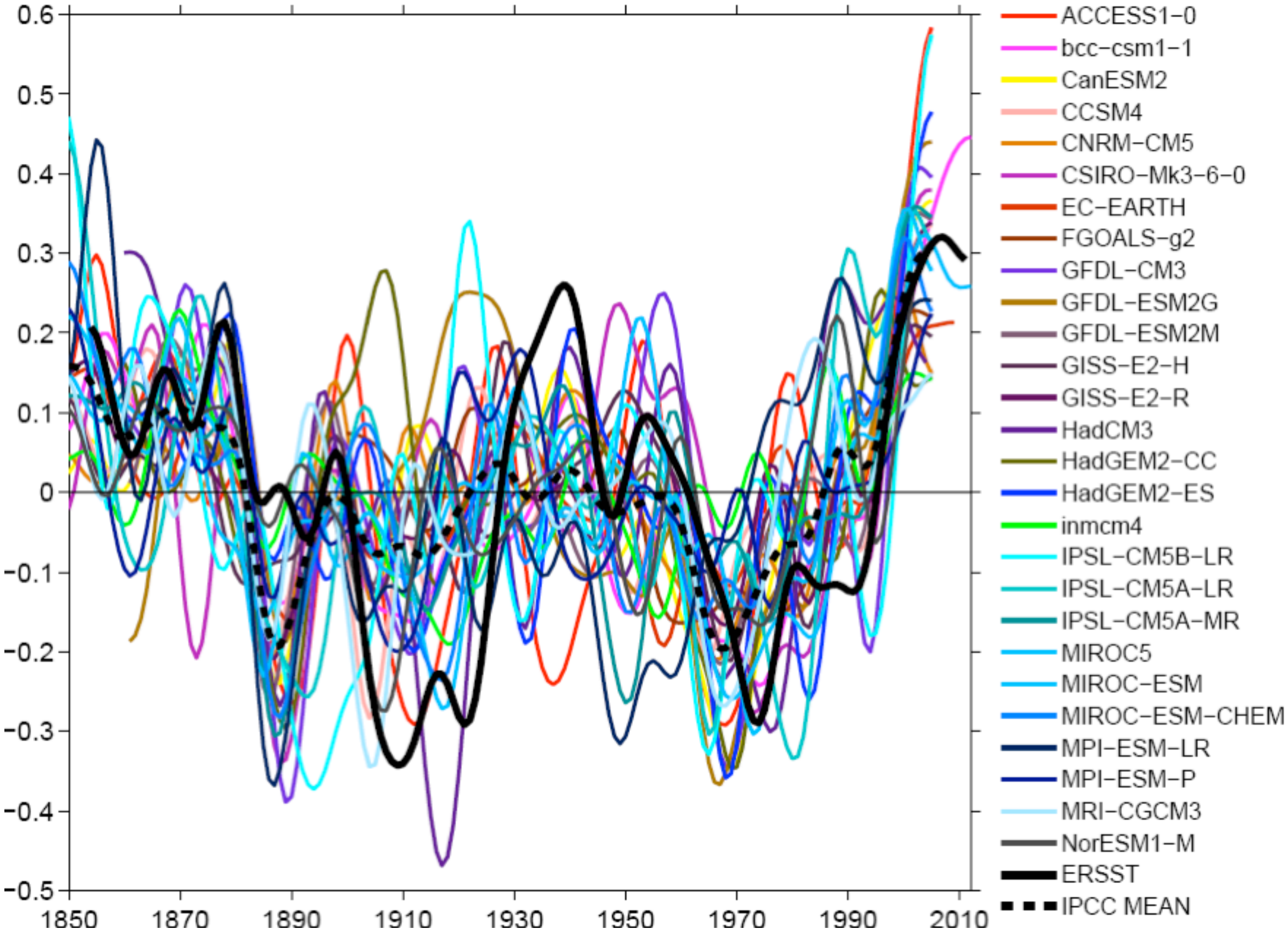


- **Net effect**: Land surface controls on atmosphere become stronger over much of North America in both absolute and relative sense.

Droughts are projected to be more common and severe in CMIP5 simulations – is this due in part to stronger positive feedbacks SM?

Dirmeyer et al., 2012: *J Climate*, (submitted).

The AMO Simulated from 27 CMIP5 Models (Wang - AOML)

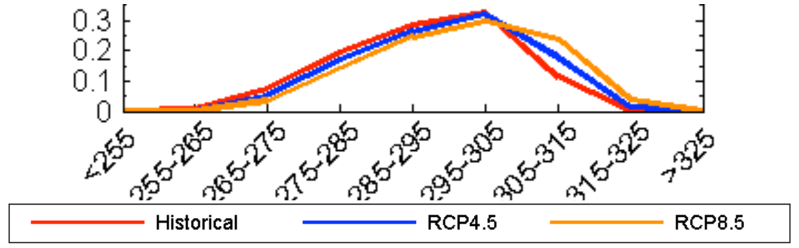


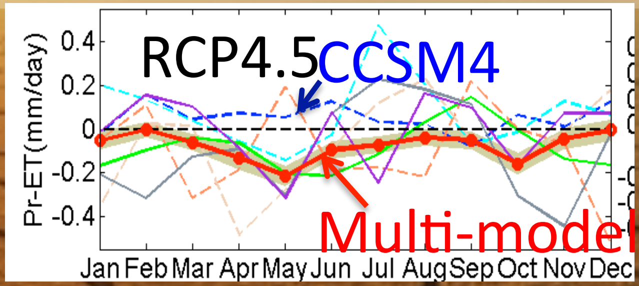
- Models show a large spread of uncertainty, but better than CMIP3 simulations.
- All models display a warming in the last two decades.
- Models underestimate the cooling (1900-25) and the subsequent warming (1926-65).

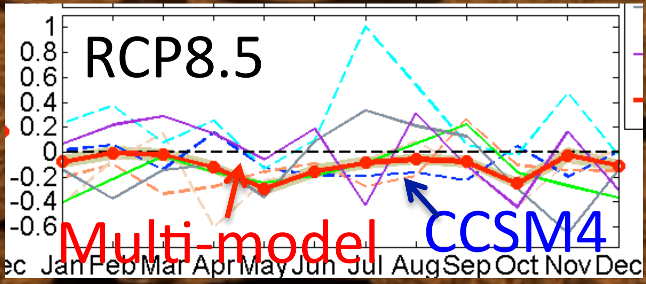
Assessing Future Changes of Climate and Drought over the South-Central United States Projected by the CMIP5 Models

- Models consistently project an increase of occurrence of daily maximum temperature (Tmax) warmer than 90F by 25-50% under the RCP4.5 scenario, and by 50-100% under the RCP8.5 scenario during 2071-2100 relative to 1979-2005;
- Whether the SC US will become drier under is ambiguous under the RCP4.5 scenario due to disagreement between multi-model ensemble mean and “best performing” model projections. But under the RCP8.5 scenario, the projected drying is robust.

Relative occurrences of Tmax:







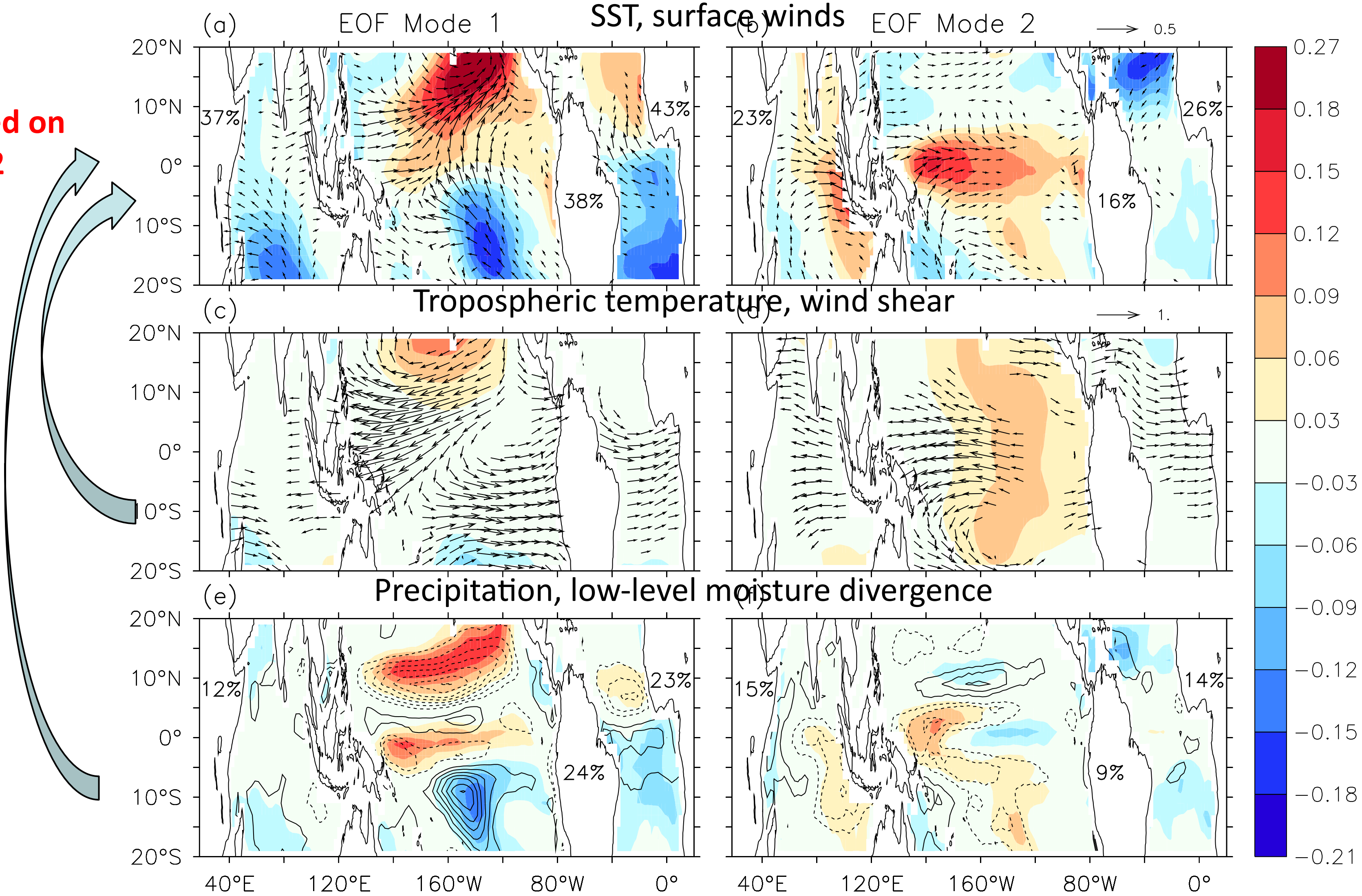
Fu et al. 2012

Inter-Model Variability in CMIP3

J. Ma & S.-P. Xie (2012, JC)

A considerable fraction of inter-model differences in rainfall projection is due to those in SST warming pattern

Regressed on SST EOF2



Simulations of the Eastern North Pacific Intraseasonal Variability in CMIP5 GCMs

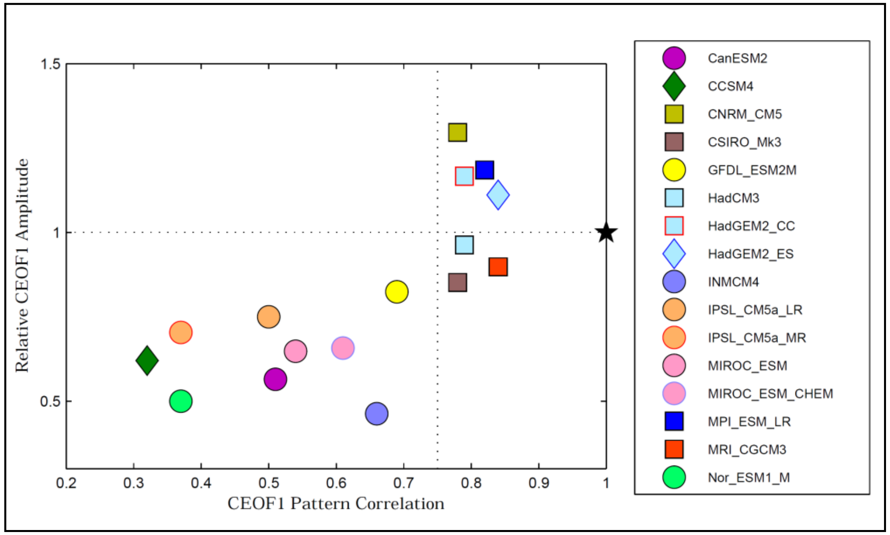


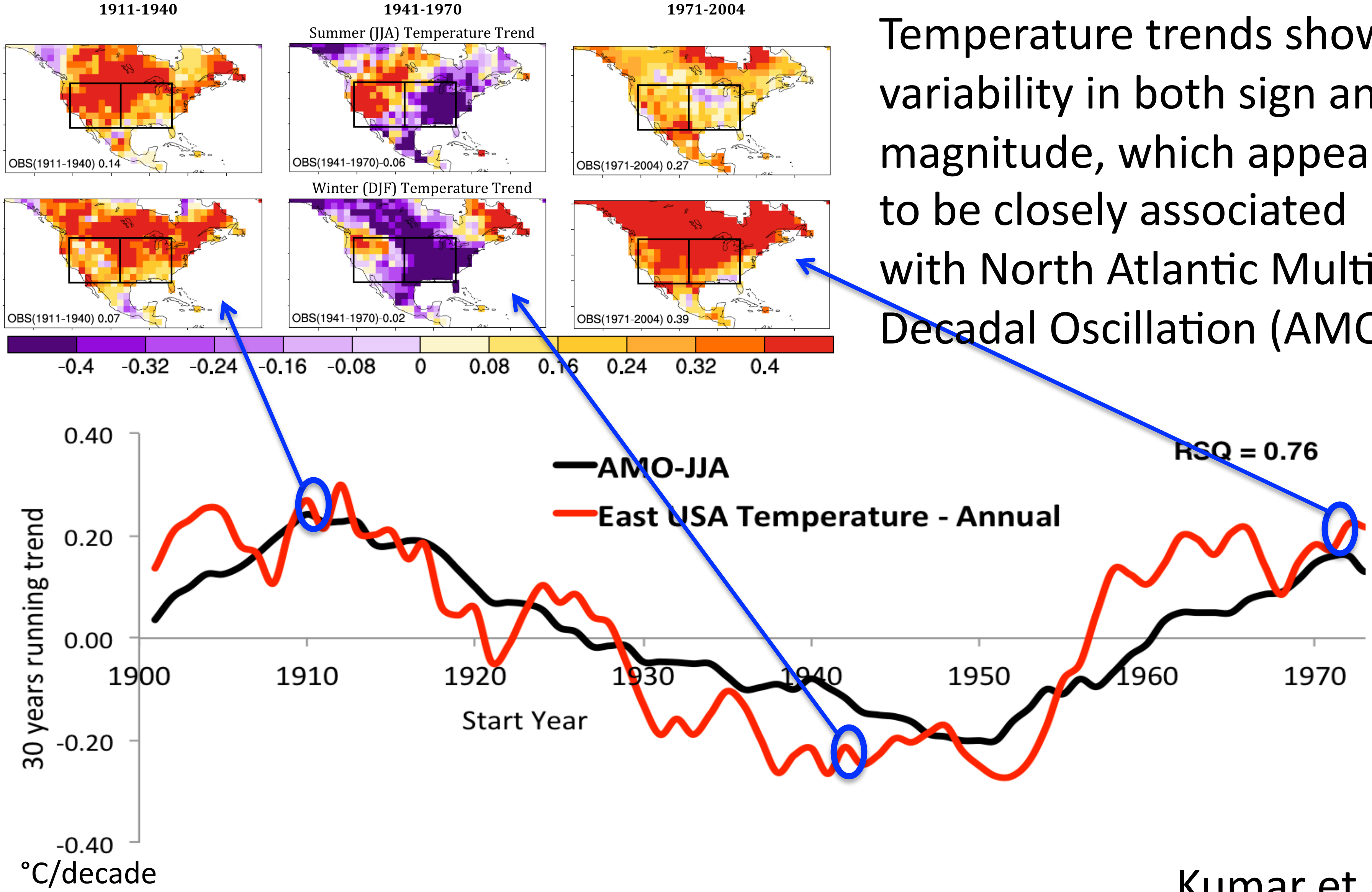
Fig. 1 *(X-axis)* Pattern correlation coefficients of the 1st Complex Empirical Orthogonal Function mode (CEOF1) between TRMM observations and CMIP5 GCM simulations.
(Y-axis) Relative amplitudes of CEOF1 in model simulations to the observed counterpart. Both pattern correlations and amplitudes are derived by averaging over the ENP domain (5°N-25°N, 140°W-80°W) where the active ISV is observed during boreal summer. The black "star" mark represents the TRMM observations. Models with "square" marks display westerly or weak easterly (<1.5 m s^{-1}) summer mean wind at 850hPa, while strong easterly winds (> 4 m s^{-1}) are noted in models with "circle" marks. Wind fields are not available in the data portal at the time of this analysis from the two GCMs with "diamond" marks.

Problem: As the intraseasonal variability (ISV) over the eastern north Pacific (ENP) exerts pronounced influences on regional weather and climate. While GCMs are essential tools for prediction and projection of future climate, current model deficiencies in representing this important variability leave us greatly disadvantaged in studies and prediction of climate change. In this study, model fidelity in representing ENP ISV is examined by analyzing 16 CMIP5 GCMs.

Result: Only seven out of the 16 CMIP5 GCMs analyzed in this study capture the spatial pattern of the leading ENP ISV mode relatively well, although even these several GCMs exhibit biases in simulating ISV amplitude. It is indicated that model fidelity in representing ENP ISV is closely associated with ability to simulate a realistic summer mean low-level circulation. The presence of westerly or weak mean easterly winds over the ENP could be conducive for more realistic simulations of the ISV. Results also suggest that, in a future climate, the amplitude of ISV could be enhanced over the southern part of the ENP, while reduced over the northern ENP off the coast of Mexico/Central America and the Caribbean.

Jiang X., E. Maloney, F. Li, and D. Waliser, *J. Climate*, 2012, submitted.

The "warming hole": natural variability versus forced response

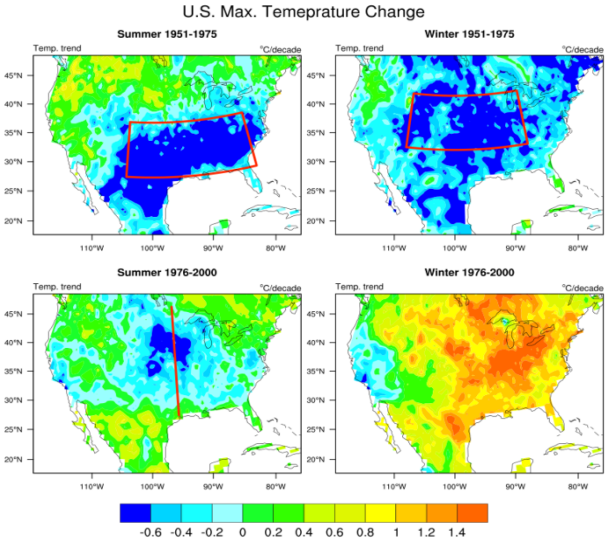


Temperature trends show variability in both sign and magnitude, which appears to be closely associated with North Atlantic Multi-Decadal Oscillation (AMO)

Kumar et al.

Anomalous cooling in the south-central U.S. while global warming accelerated during the second half of the 20th century

– Z. Pan (Saint Louis University), X. Liu, S. Kumar, Z. Gao, and J. Kinter



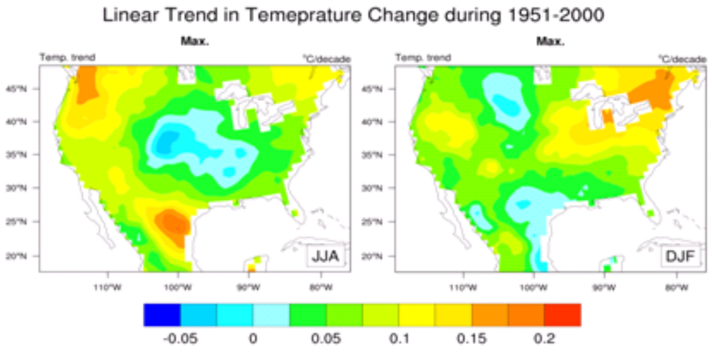


Figure 1. Top: Observed (CRU) daily maximum surface temperature (Tmax) trend over two periods of the 2nd half of the 20th century, corresponding to the slight cooling (1951-1975) and sharp warming (1976-2000) periods globally. Bottom: Modeled Tmax trends during 1951-2000 periods averaged among six models of higher resolutions (ACCESS, CanCSM, CCSM4, CNRMS, CSIRO, and MRI-CGCM3), totaling 28 members. It shows that these models together can capture the anomalous cooling, termed "warming hole", in the central U.S.

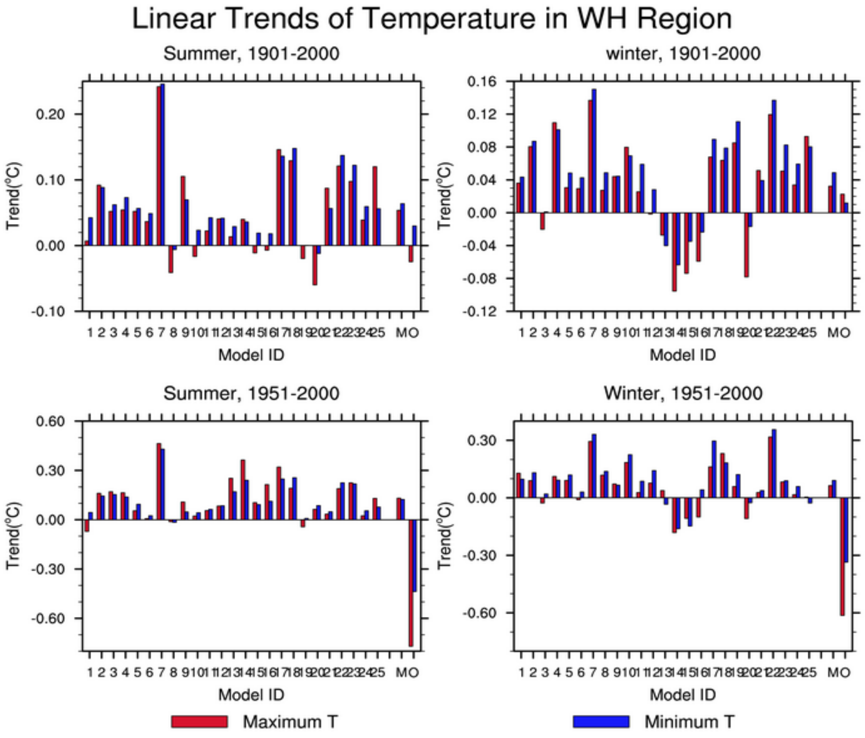
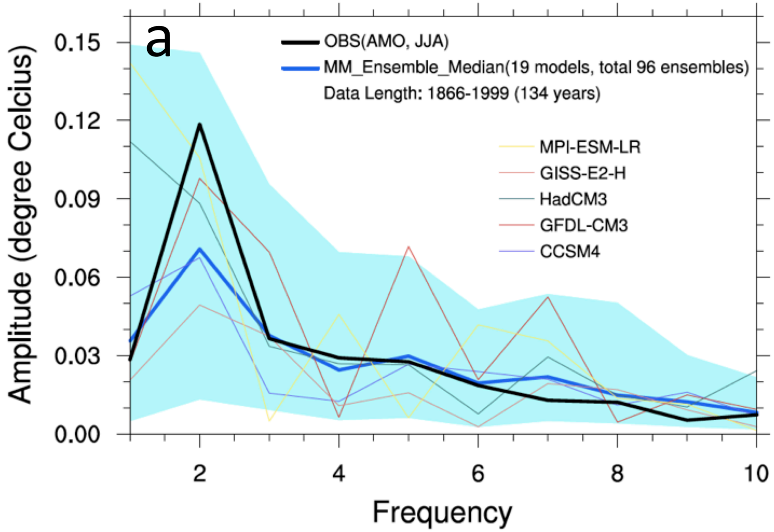
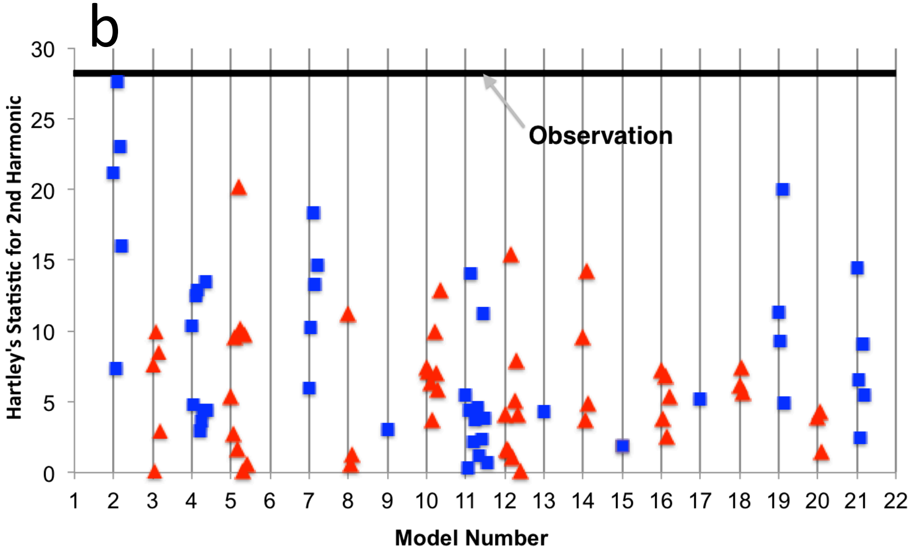
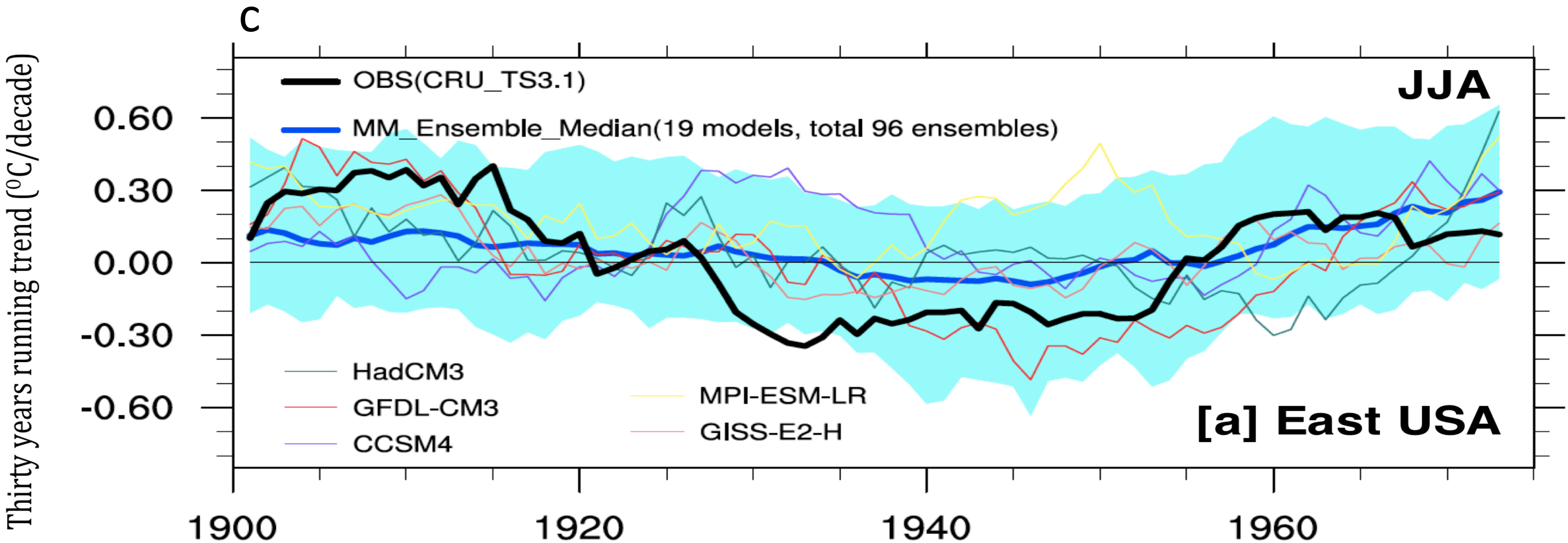


Figure 2. Trends of Tmax and Tmin over the "warming hole" (delineated by the southeastern red box in Figure 1) in summer and winter during 1901-2000 and 1951-2000 periods. The numbers on X-axis are model IDs. The right most two dual-bars represent all model mean (M) and observation (O), respectively. On the century scale in summer (top left panel), the observed cooling occurred in summer during daytime (rightmost red bar denoted "O" on the X-axis). Six out of 25 models simulated a negative trend. On the 50-y scale (bottom panels), the observed cooling reached 0.4 (Tmin) – 0.6 (Tmax) ^{o}C dec^{-1} both in summer and winter, but majority of models simulated warming on both Tmax and Tmin in summer. In winter, only a couple of models simulated a negative trend.

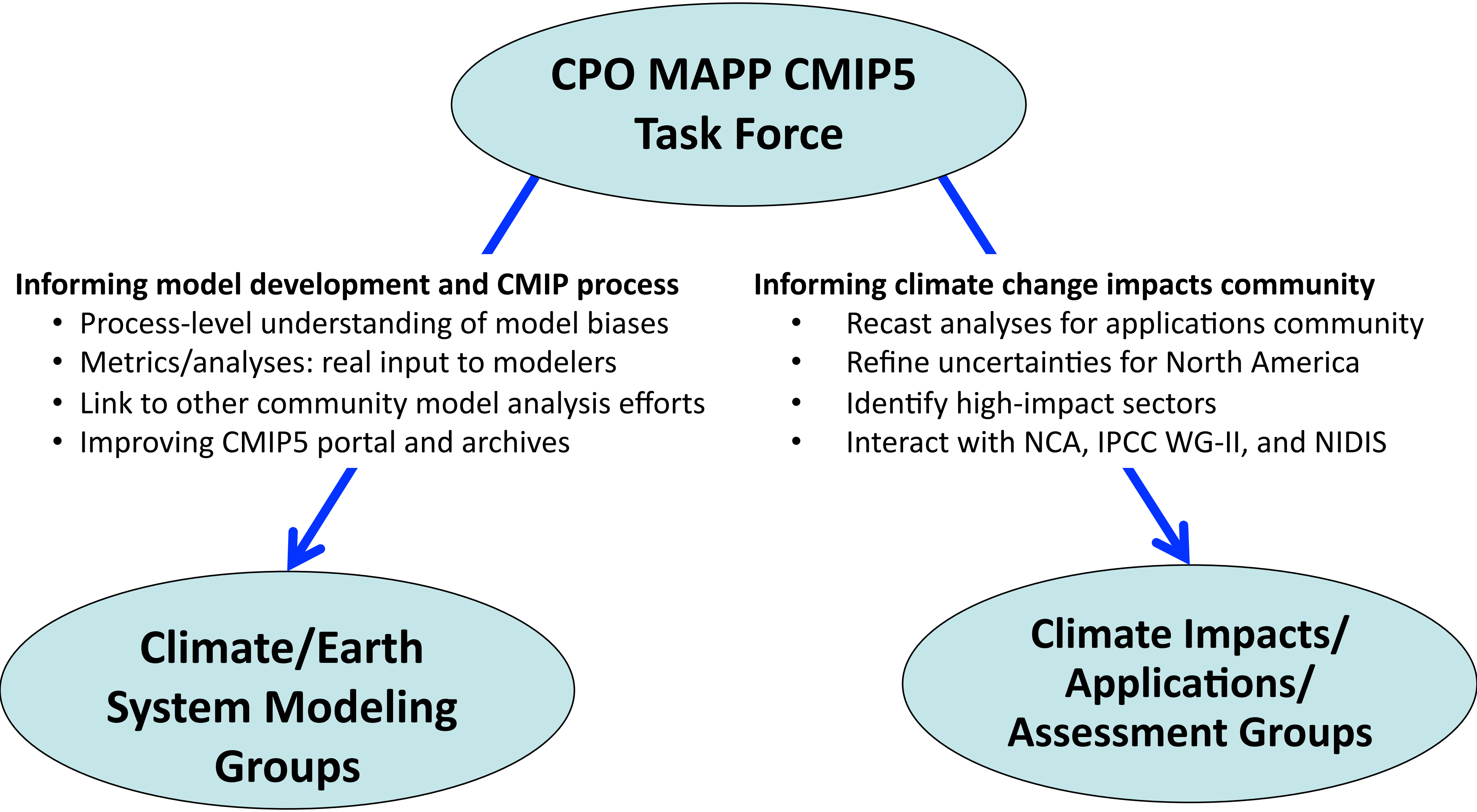
CMIP5 Evaluation: Majority of CMIP5 climate models underestimate AMO amplitude (Fig. a and b) – resulting into higher uncertainty in eastern USA temperature trend simulations (Fig. c)







Next Steps



CPO MAPP CMIP5 Task Force

Informing model development and CMIP process
- Process-level understanding of model biases
- Metrics/analyses: real input to modelers
- Link to other community model analysis efforts
- Improving CMIP5 portal and archives

Informing climate change impacts community
- Recast analyses for applications community
- Refine uncertainties for North America
- Identify high-impact sectors
- Interact with NCA, IPCC WG-II, and NIDIS

Climate/Earth System Modeling Groups

Climate Impacts/ Applications/ Assessment Groups