Simulation of historical and projected climate change in arid and semiarid areas by CMIP5 models

Tianbao Zhao

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Key Laboratory of Regional Climate-Environment Research for East Asia, Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS)

Introduction

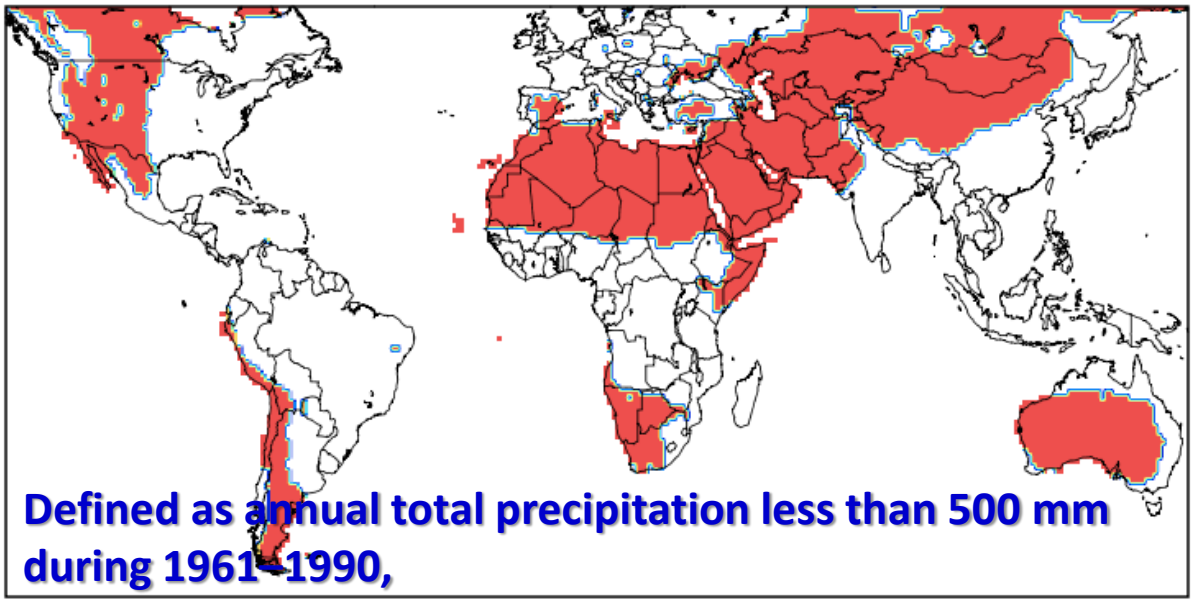
- recent decades, a distinct aridity has been found in the arid and semiarid regions, which has led to a lack of water resources, degradation of ecosystems, and desertification, which in turn have had significant impacts on the health of local residents.
- Therefore, further studies of climate change over arid and semiarid areas are of great scientific and practical significance.
- Climate models are undoubtedly crucial tools for assessing anthropogenic impacts on climate changes and for predicting future climate over arid and semiarid areas.
- In this study, the simulation for historical and future climate changes over arid and semiarid areas by CMIP5 models will be evaluated, which will facilitate further assessment of the influences of anthropogenic activity on climate change.

Data and method

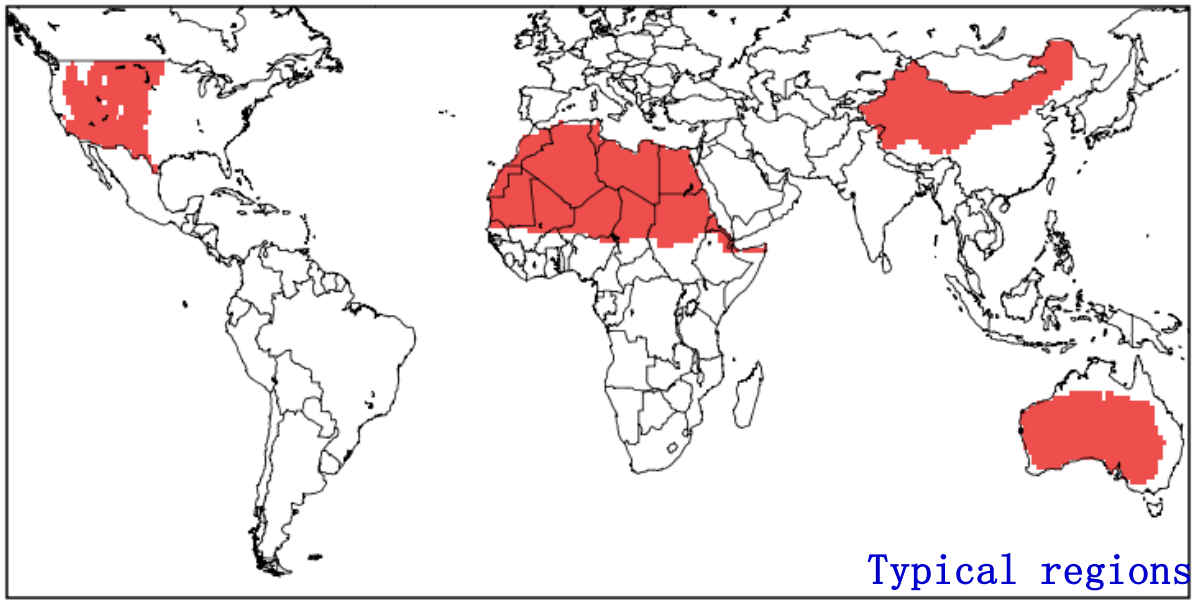
- **Observations:** CRU3.1 temperature and GPCC V6 precipitation
- **CMIP5 simulations:** Historical experiments and future projection under different Representative Concentration Pathways (RCPs)
- **Method:** 1) both the simulation and Obs. were re-gridded at the same resolution of 2.5 degree data; 2) To eliminate fluctuations among the different ensemble runs, each model's ensemble mean was first estimated as an equally-weighted average from the multi-runs and the multi-model ensemble mean was then derived from the each model's ensemble mean.

- bcc-csm1-1
- CanESM2
- CCSM4
- CESM1-CAM5-1-FV2
- CNRM-CM5
- CSIRO-Mk3-6-0
- **FGOALS-g2**
- GFDL-ESM2M
- GISS-E2-H
- GISS-E2-R
- HadGEM2-ES
- IPSL-CM5A-LR
- IPSL-CM5A-MR
- MIROC-ESM-CHEM
- MIROC-ESM
- MRI-CGCM3
- NorESM1-M
- **Ensemble**

the arid and semiarid regions

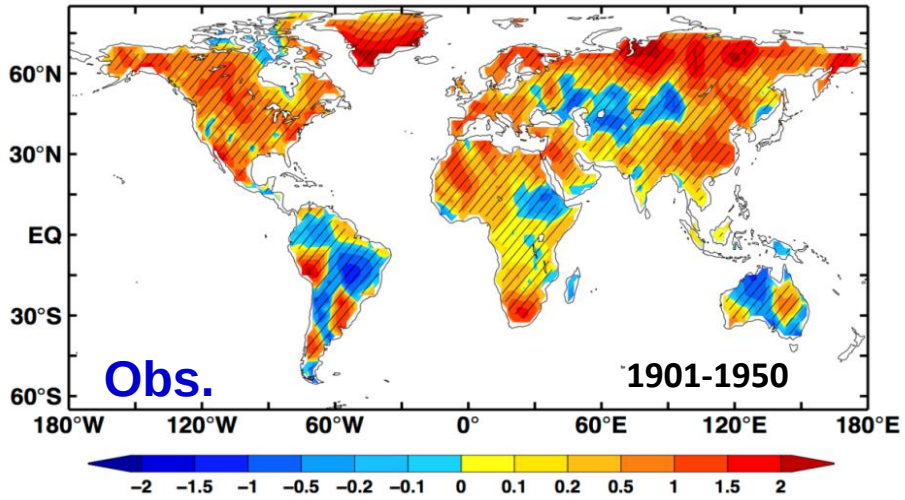


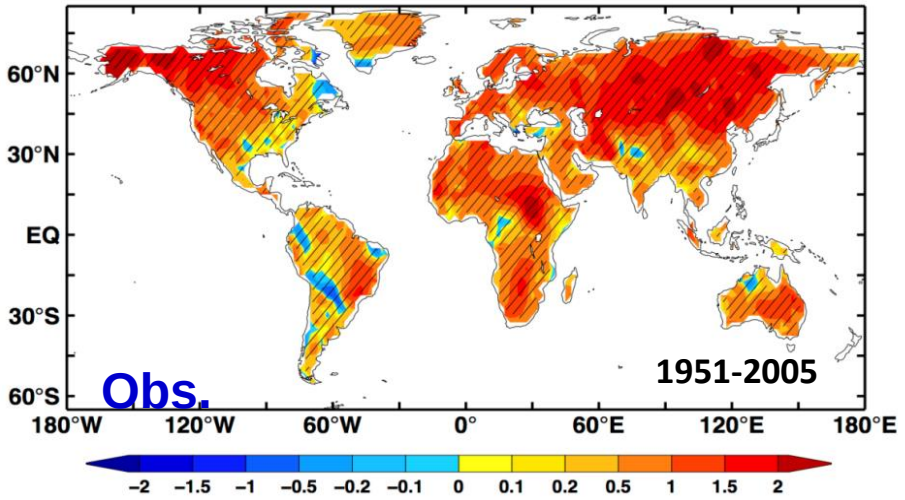
Defined as annual total precipitation less than 500 mm during 1961–1990,

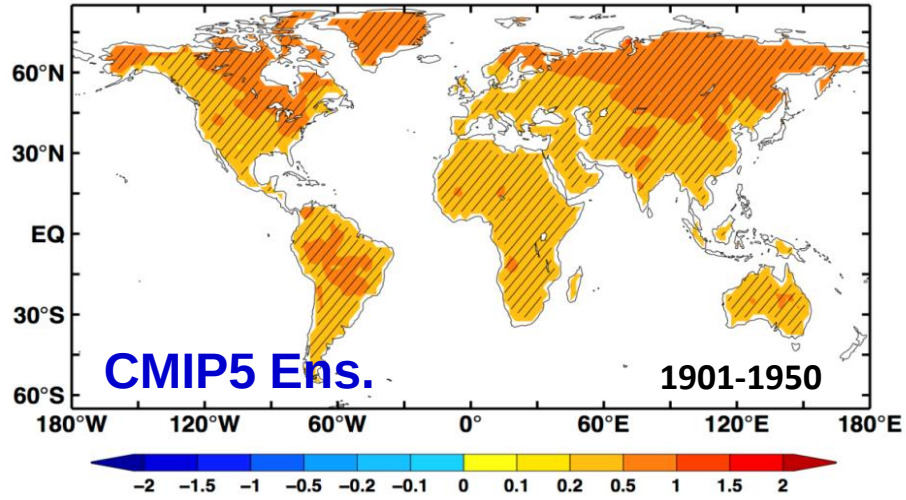


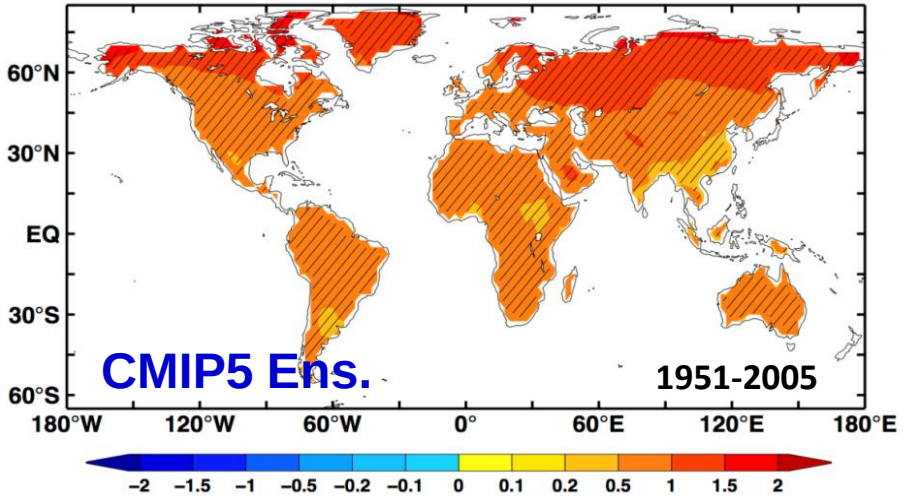
Typical regions

Long-term trends of temperature (°C/50a)



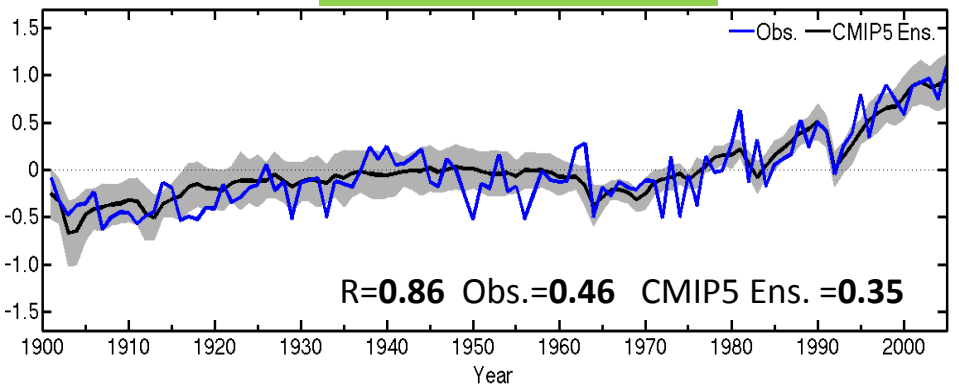




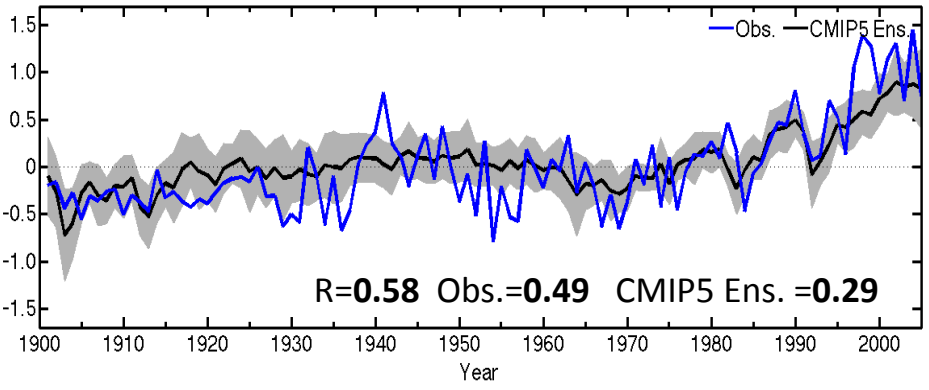


Time series of annual temperature anomalies over typical arid and semi-arid regions

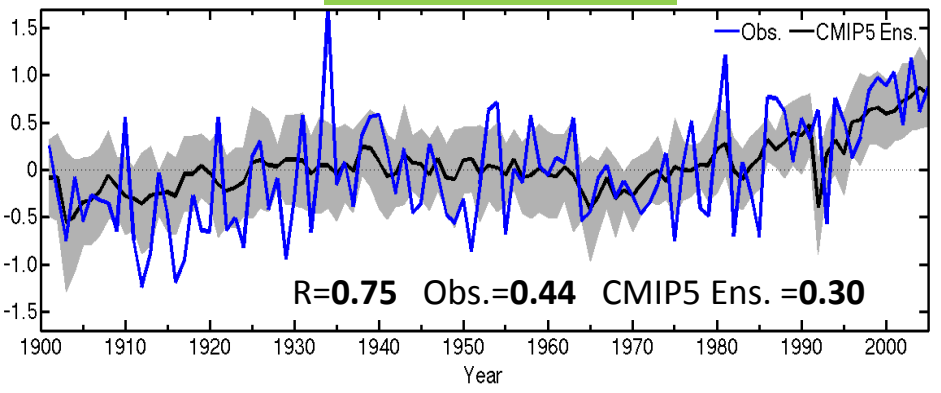
Global



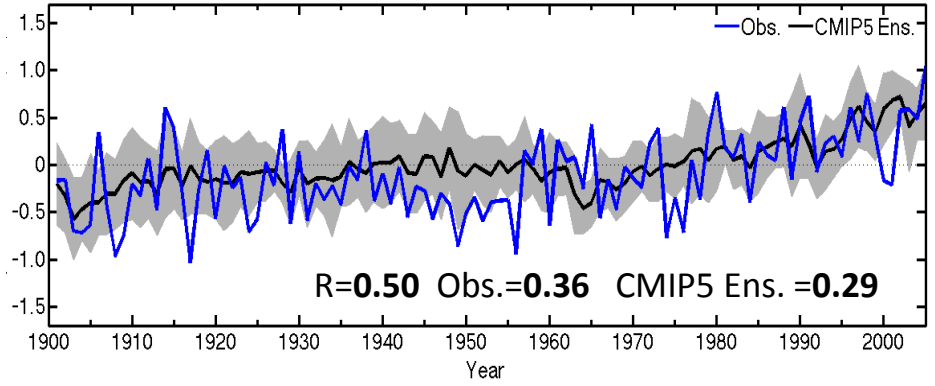
North China



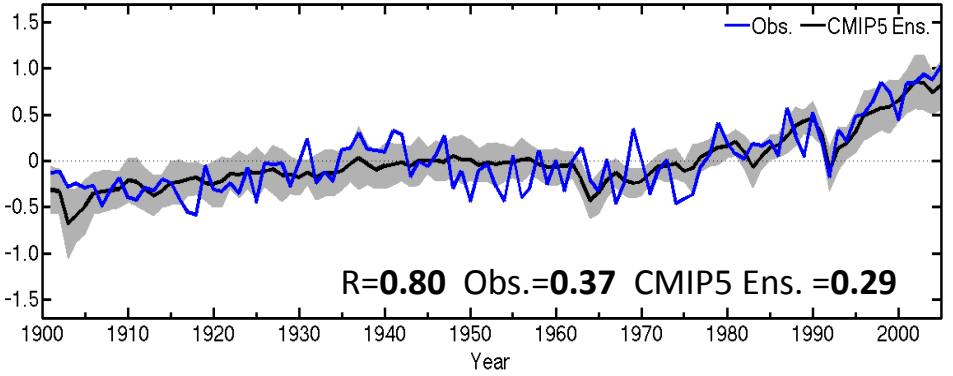
North US



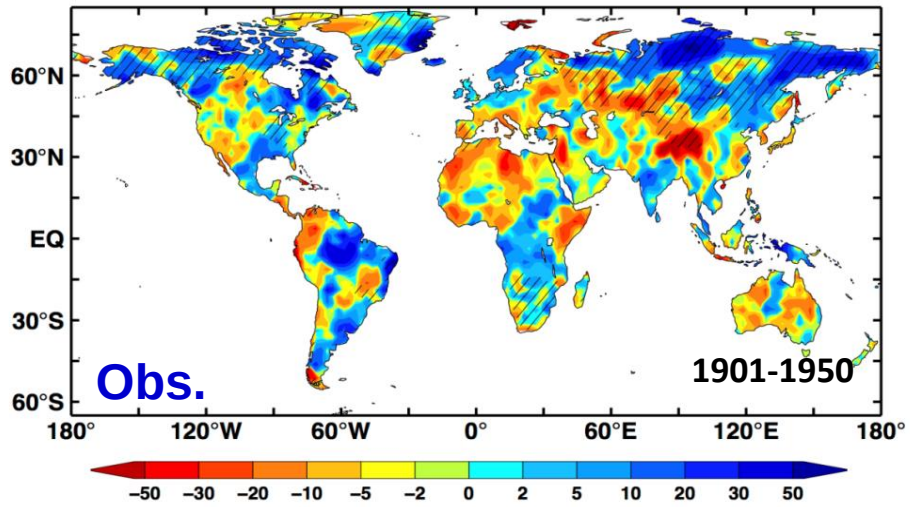
Australia

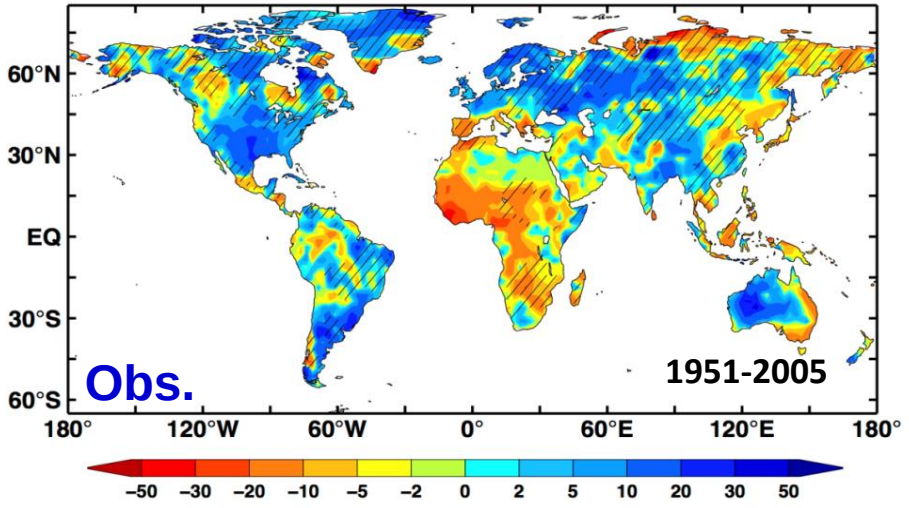


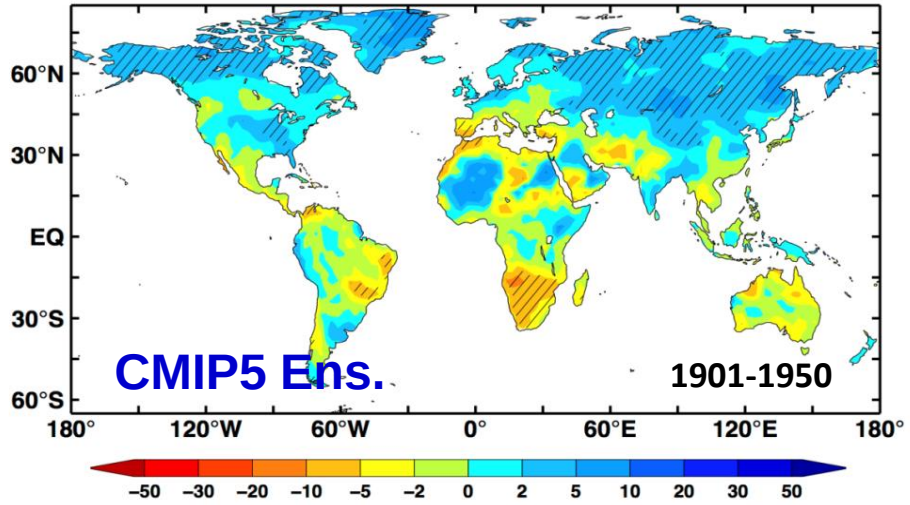
North Africa

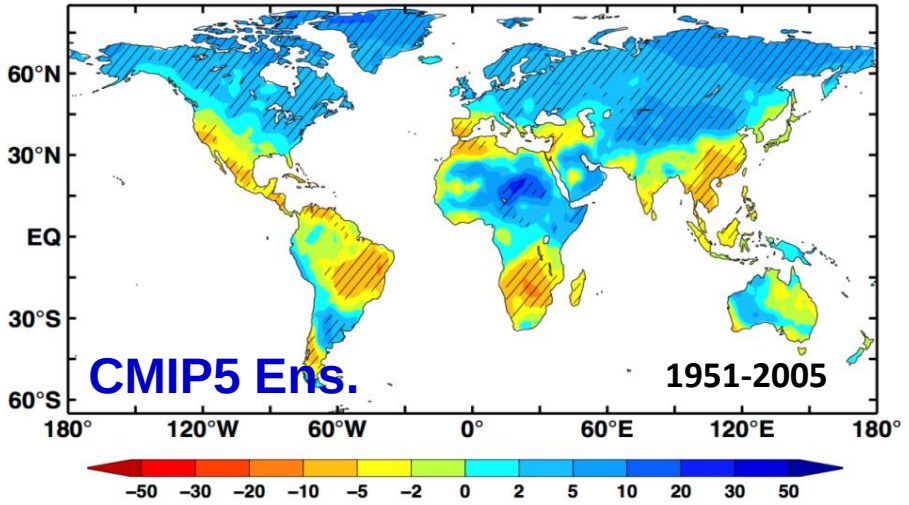


Long-term trends of Precipitation (%/50a)



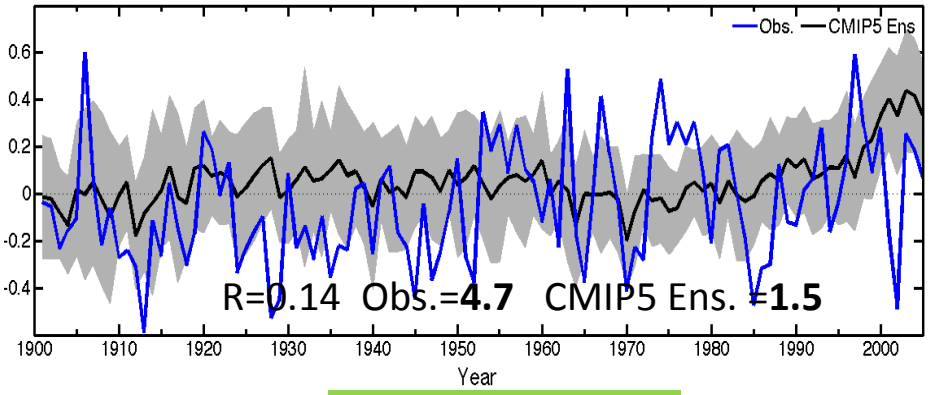




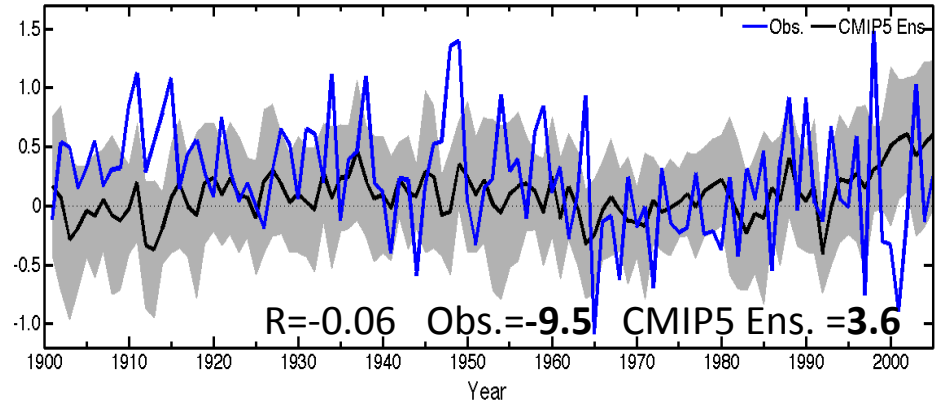


Time series of annual precipitation anomalies (0.1mm/day)

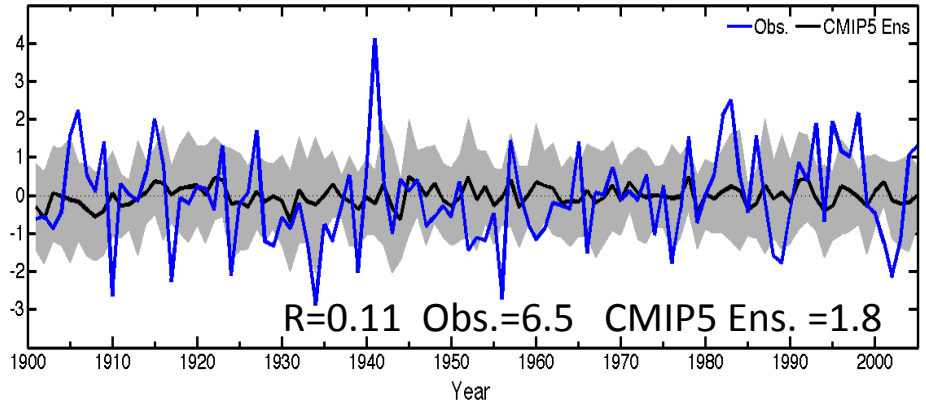
Global



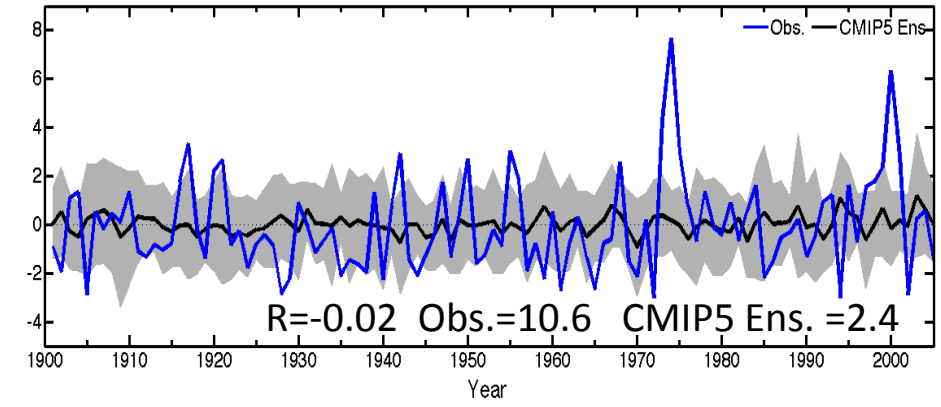
North China



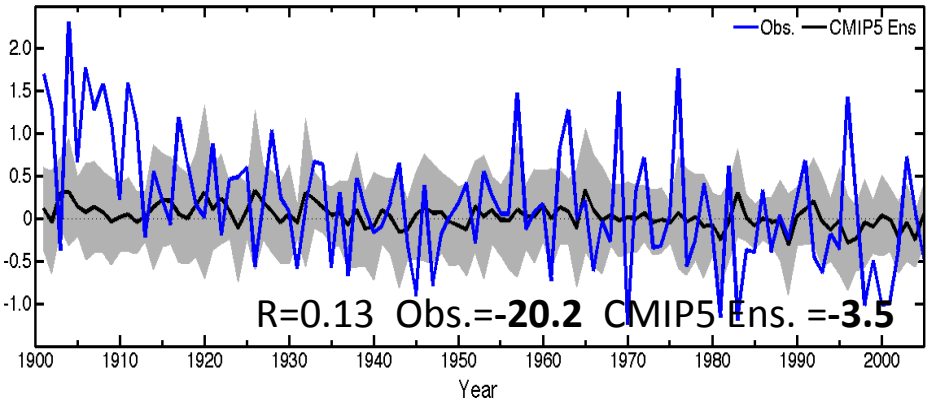
North US



Australia

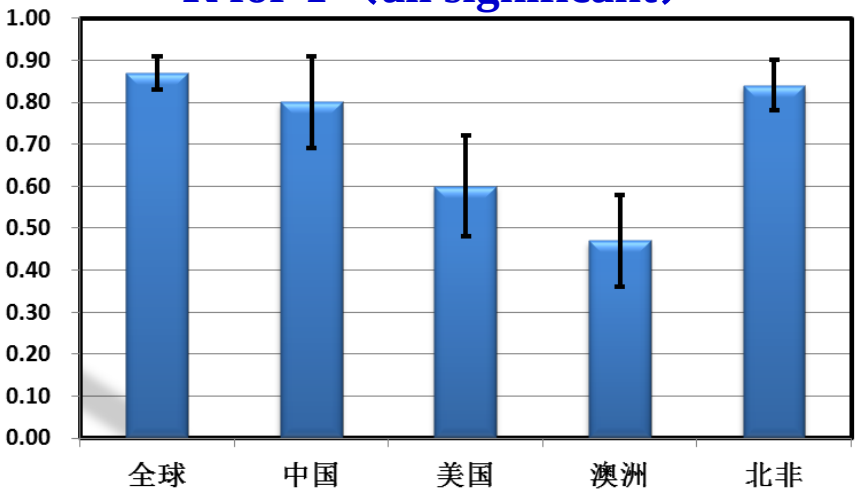


North Africa

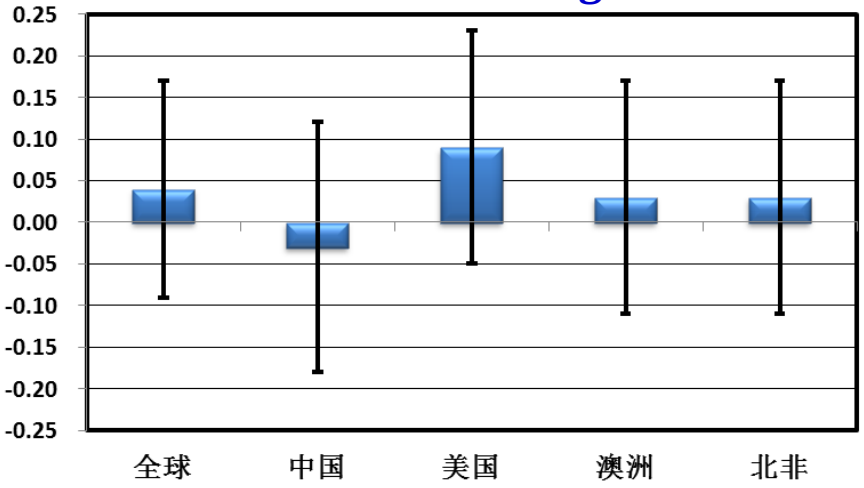


Correlations of Obs. with simulation ant their long-term trends（1951-2005年）

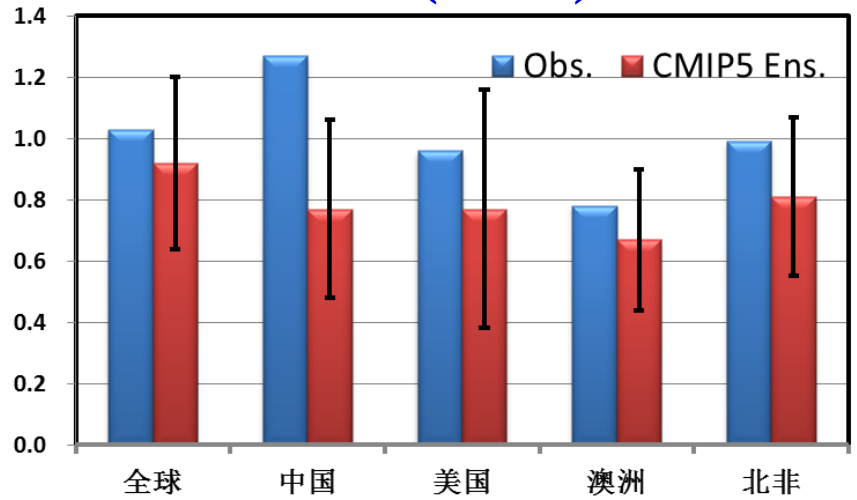
R for T（all significant）



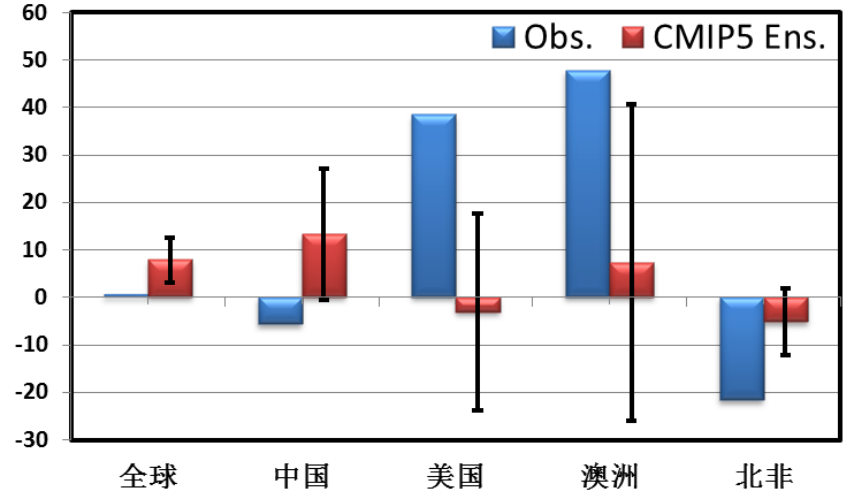
R for P（all are not significant）



T trend (ºC/50a)



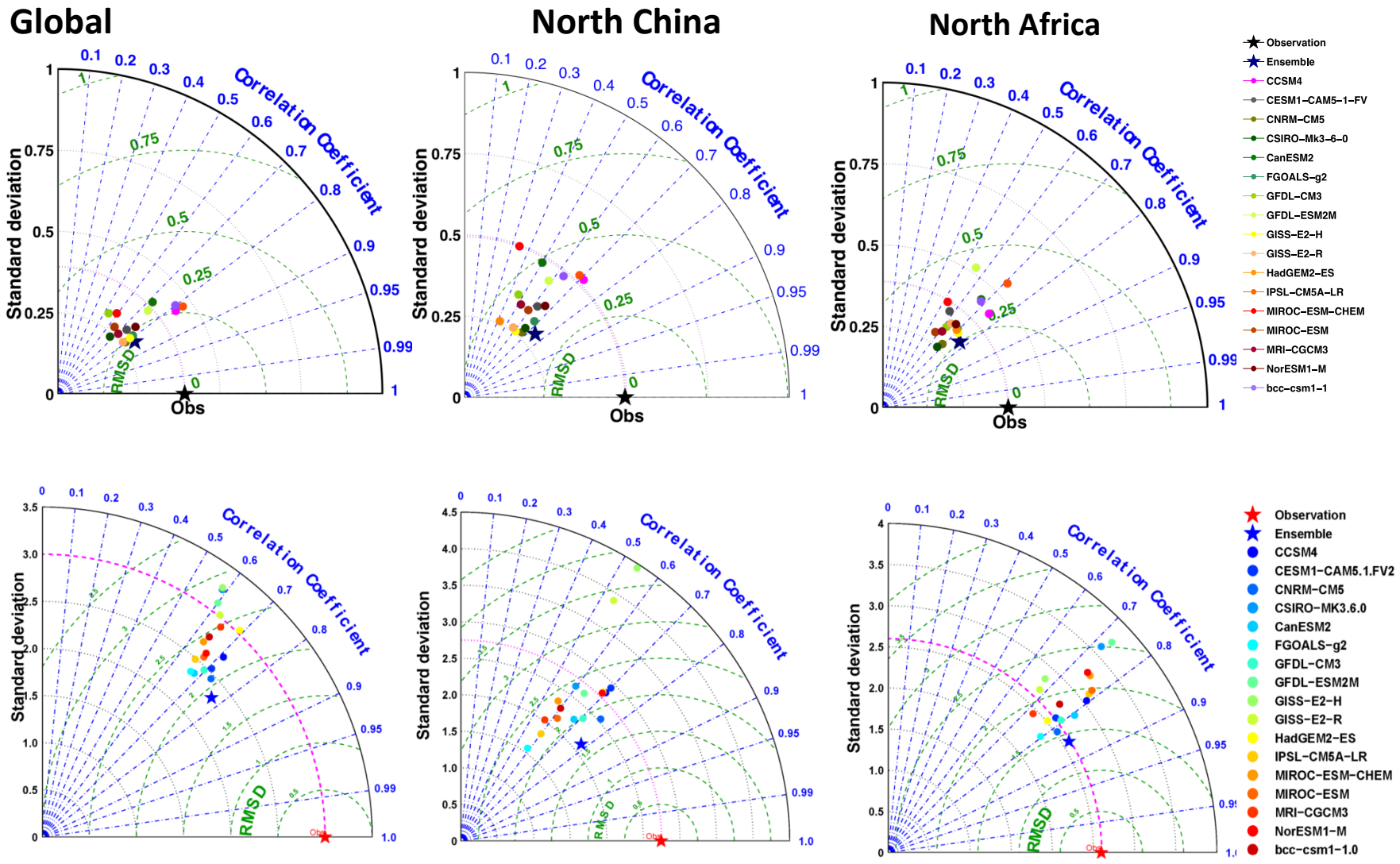
P trend (mm/50a)



Taylor diagrams for temperature precipitation

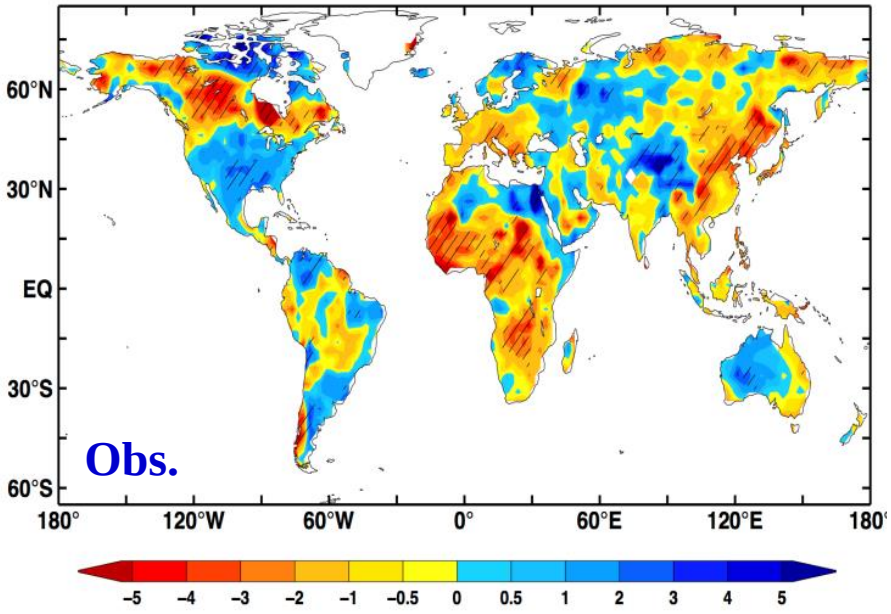
T

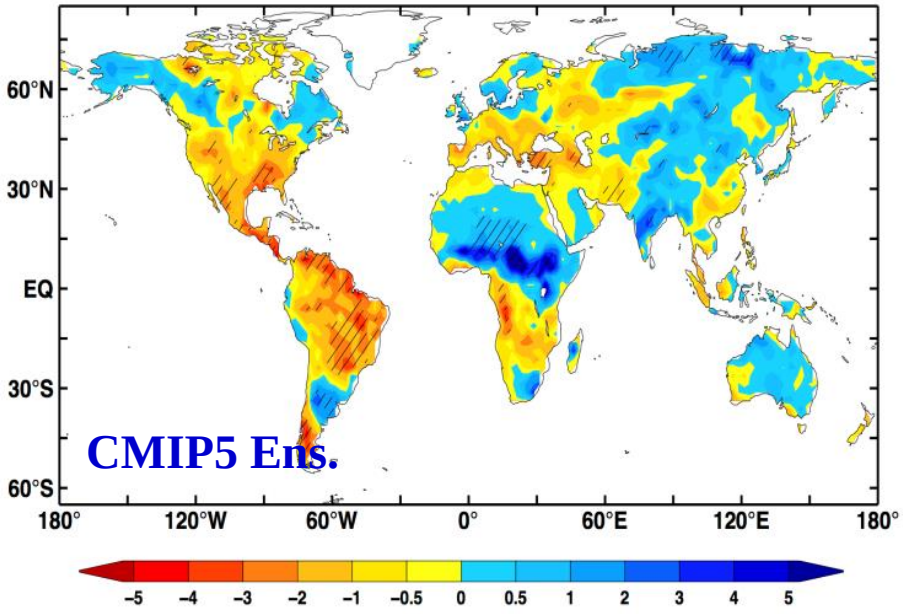
P



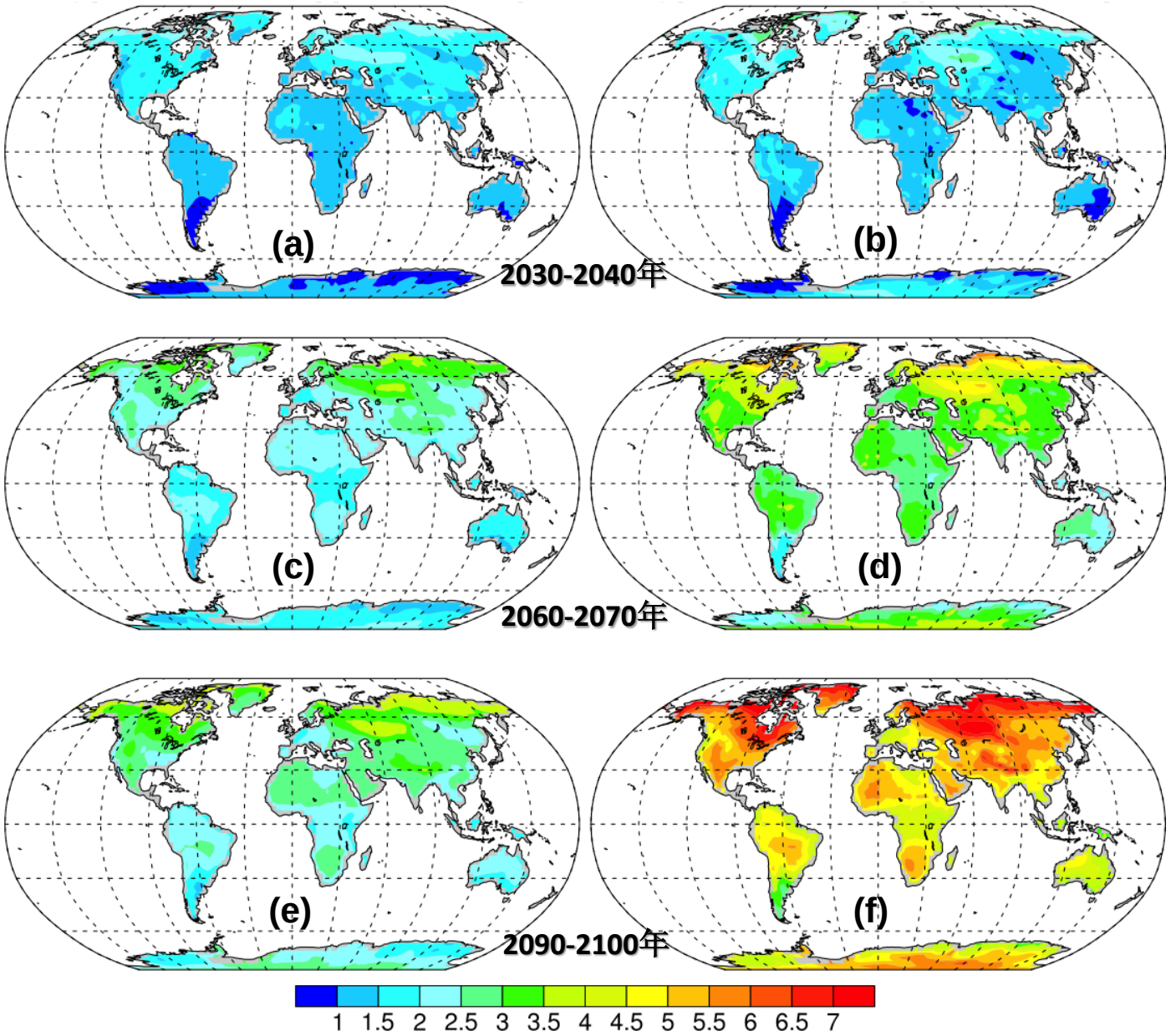
Long-term trends for PDSI duing1951-2005

sc_PDSI-pm

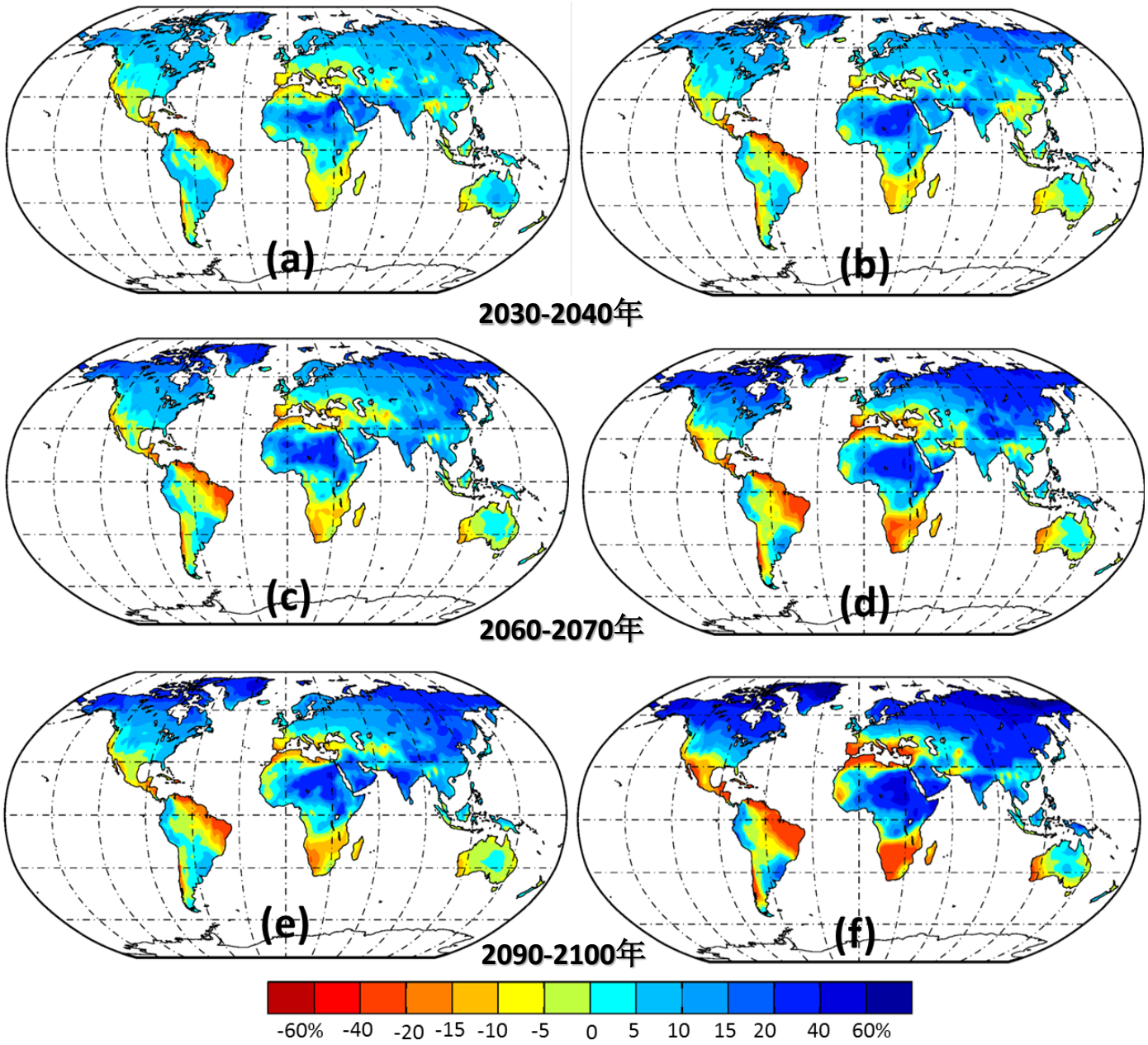




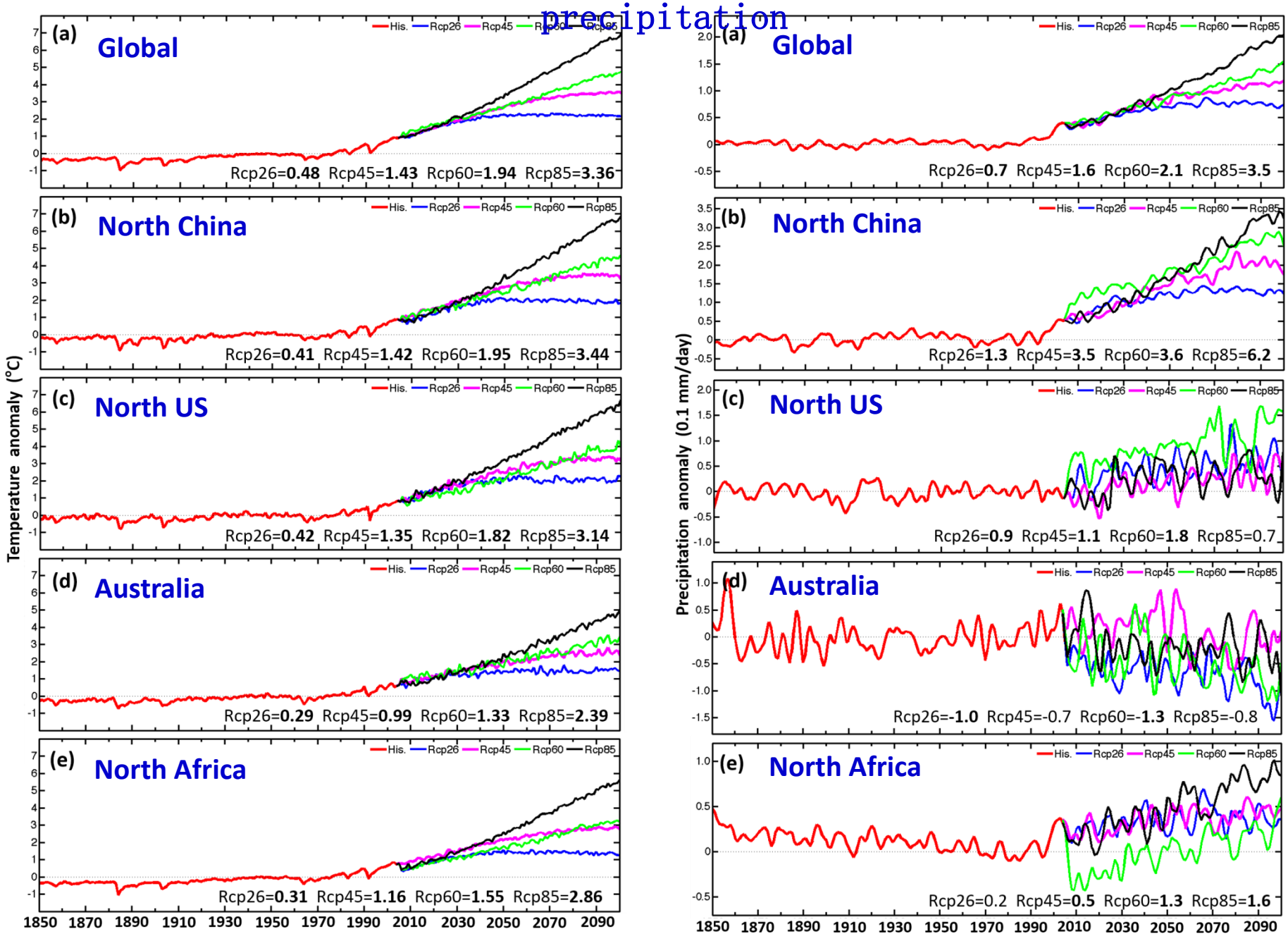
Future temperature changes under RCP45 (left) and RCP8.5 (right



Future precipitation changes (%) under RCP45 (left) and RCP8.5

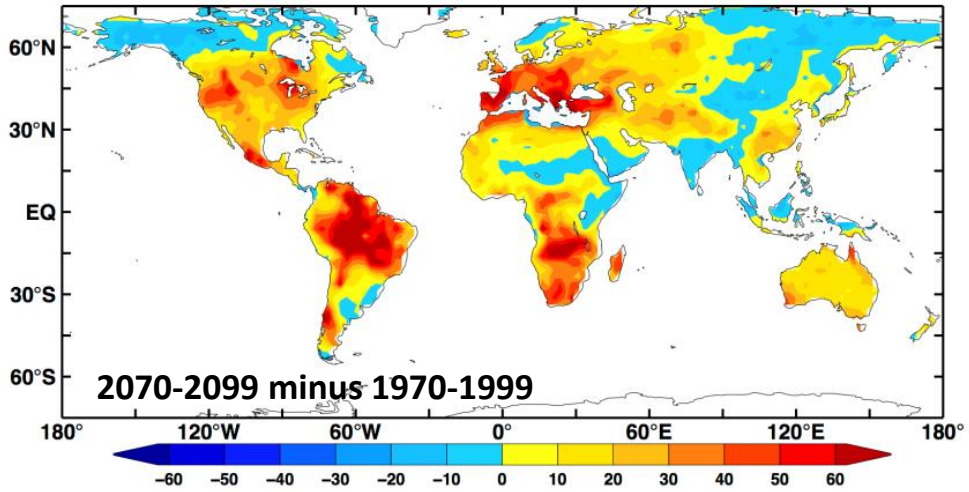


Historical and future variation for temperature and precipitation

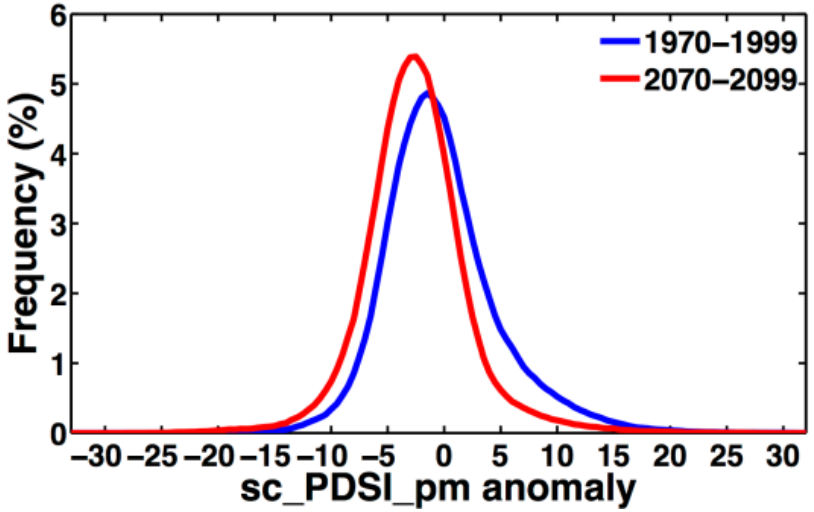


Magnitude and Cause of GHG Induced drying in the 21st Century

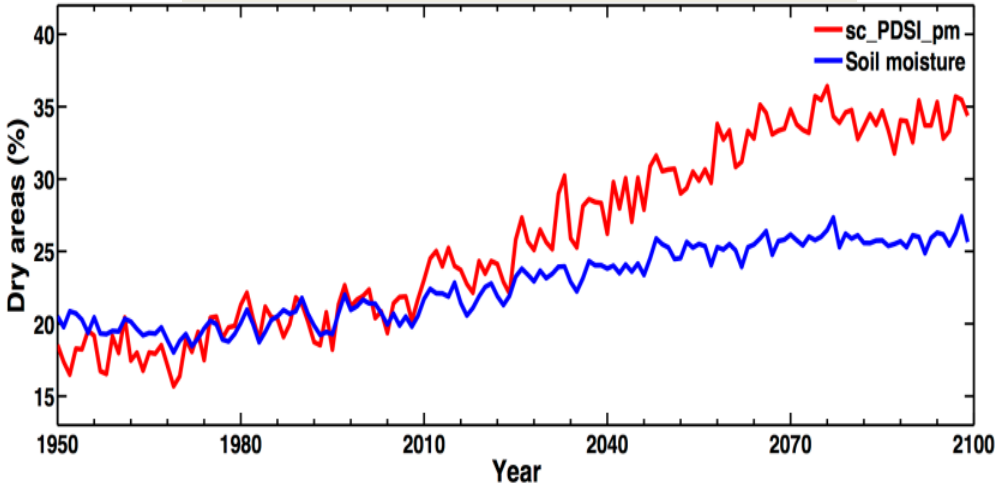
sc_PDSI_pm frequency change (%)

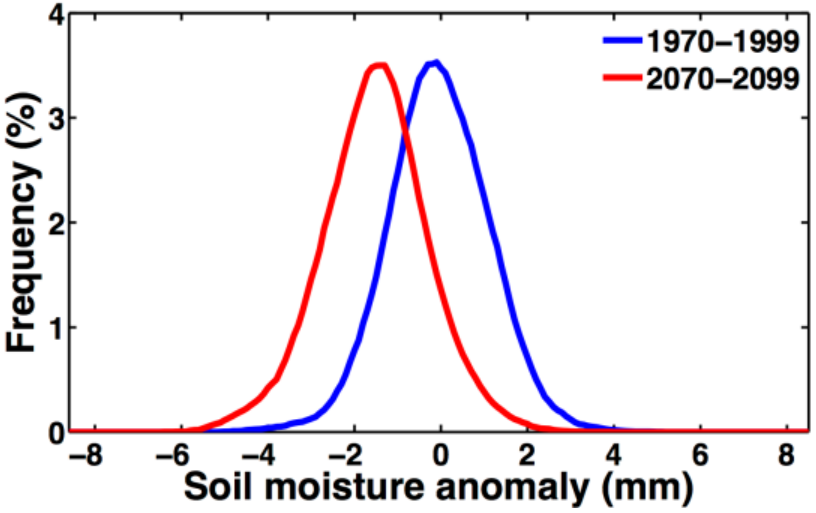


PDF of PDSI for Kansas of US (103.75~93°W, 36.25~41.25°N)



Drought areas of global land (%)





Summary

- Most of the models are able to capture the dominant features of the spatio-temporal changes in temperature, especially the geographic distribution, during the past 60 years, both globally as well as over arid and semiarid areas.
- The models can **reproduce the observed warming trends**, but with magnitudes generally **less than the observations** of around0.1–0.3^{o}C/50a.
- Compared to temperature, the models perform worse in simulating the annual evolution of observed precipitation, underestimating both the variability and tendency, and there is a huge spread among the model simulations.

Summary

- In terms of future climate change, an ongoing warming projected by the multi-model ensemble over arid and semiarid areas can clearly be seen under different RCPs, especially under the high emissions scenario (RCP8.5), which is twice that of the moderate scenario (RCP4.5).
- Unlike the increasing temperature, precipitation changes vary across areas and are more significant under high-emission RCPs with more precipitation over wet areas but less precipitation over dry areas.
- In particular, northern China is projected to be one of the typical areas experiencing significantly increased temperature and precipitation in the future.


Thank you for
your attention!