The role of internal variability in multi-decadal trends of summer rainfall over East Asia-Northwest Pacific

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Background

- In the monsoon region of East Asia, where more than 100 million people live, the summer rainfall has experienced a prominent change in recent decades.
- Both external forcing and internal variability likely contribute to the multi-decadal trends of summer rainfall in East Asia. However, the relative contribution of each has not yet been known.
- It is often difficult to distinguish the internal-generated low-frequency variability and human-induced climate change by analyzing observations.
- Using a large ensemble of climate change simulations is proved to be effective to separate the role of the forced climate change and internal variability.

Objectives

- Investigate the effect of internal variability on summer precipitation trends in East Asia on the multidecadal time scale.

Materials and Methods

- Large ensemble of climate change simulations from CCSM4, CESM and MPI-ESM : 1970-2005
- GPCPv2.3 reanalysis from ECMWF: monthly, 2.5°*2.5°

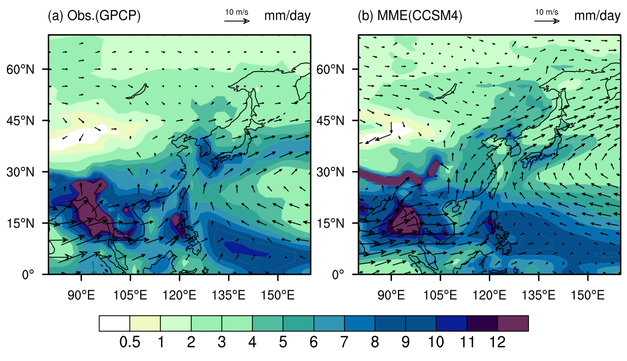


Fig.1The climatological mean for JJA rainfall (mm day^{-1}; shading) and 850hPa winds (m s^{-1}; vectors). The climatology is derived from the period of 1979-2005. (a) Observation (b) in the ensemble mean of the 30-member CCSM4 simulations.

Internal and external parts of total trends

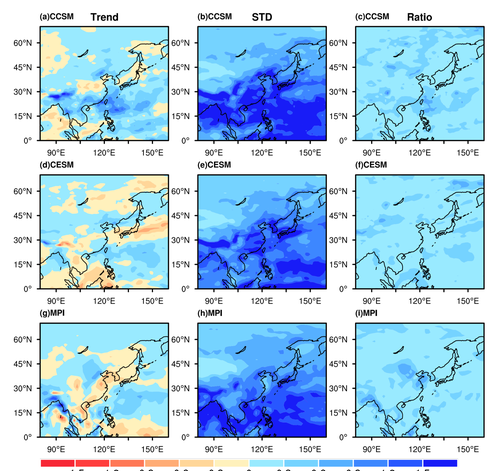
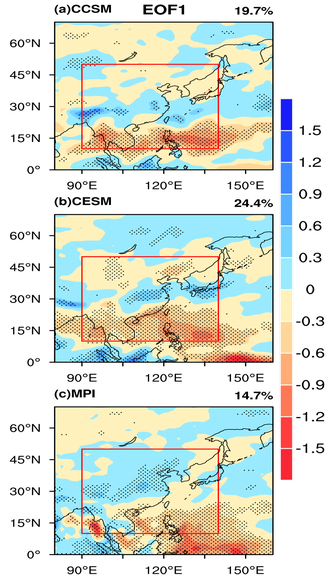


Fig.2 The ensemble-mean rainfall trends during 1979–2005 (mm day^{-1} 27^{-1} year^{-1}) in (a) CCSM, (b)The standard deviation of the rainfall trends and (c) The ratio of the ensemble mean to the standard deviation of rainfall trends among the 30 CCSM4 ensemble members. (d-f) in CESM and (g-i) in MPI

- The ratio is lower than 1 over the EANWP in all the simulations.
- It suggested that internally-generated variations may be larger than external forced rainfall changes there during this interval.

Leading mode of internal variability



- The internally-generated low frequency variability in all the three simulations all features a meridional dipole pattern
- With wetting trends in Mei-yu region (20°-35°N) and drying trends in the tropical Northwest Pacific.

Fig.3 Regressions of summer rainfall trends (1970–2005; shading; mm day^{-1} 36^{-1} year^{-1} among the ensemble members upon the normalized PC1 of EOF modes of rainfall trends in the domain of East Asia-Northwest Pacific (10º–50ºN, 90º–145ºE) in (a) CCSM, (b) CESM and (c) MPI respectively..

Corresponding circulations & SST

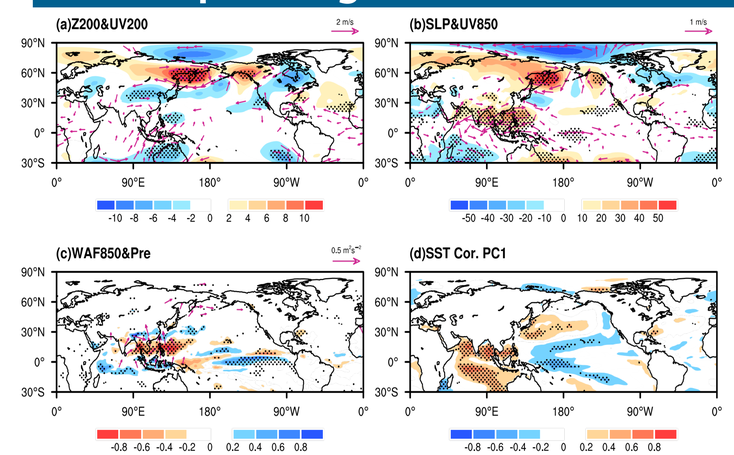


Fig.4 Regression of JJA geopotential height trends (shading) and winds trends (vectors) at 200hPa (a) and SLP trends (shading) and winds trends (vectors) at 850 hPa (b) on the normalized PC1 in CCSM. The wave activity flux at 850hPa (vectors) and rainfall trends (shading) associated with the EOF1 mode (c) with the PC1 in CCSM. Correlation of JJA SST trends (d) with the PC1 in CCSM.

- The leading mode is correlated with a warming trend in the North Indian Ocean(NIO) warming and a cooling trend in the tropical western Pacific (WP) ,which can lead to a low-level anomalous anticyclone over the tropical NIO-WP region and cause dipole rainfall anomalies over the EANWP.

Conclusions

- Internal variability plays a large role in recent EANWP summer rainfall. The leading mode of internally-generated rainfall trends over EANWP shows drying trends over the subtropical NWP and wetting trends in the Mei-yu Front rainfall belt
- The leading mode in turn is likely caused by a gradient between a warming trend in the North Indian Ocean (NIO) warming and a cooling trend in the tropical western Pacific (WP), which can lead to a low-level anomalous anticyclone over the tropical NIO-WP region and cause dipole rainfall anomalies over the EANWP.
- The linkage between the NIO-WP SST gradient and the anticyclonic circulation over the NWP on the multidecadal time scales also exists in other two large ensemble of climate change simulations and models in CMIP5 simulations.