Responses of East Asian summer monsoon to historical SST and atmospheric forcing during 1950–2000

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Introduction, Data, and Methods

East Asian summer monsoon (**EASM**) has experienced a significant decadal shift around the late 1970s. This shift is characterized by a weakening summer monsoon circulation and a change in rainfall patterns over East China that is often referred to as the "southern flooding and northern drought" (**SFND**). Using simulations by the NCAR CAM3 and GFDL AM2.1 models forced with different historical forcing (SSTs, greenhouse gases, aerosols), we have examined the relative role of these individual forcings in causing the observed monsoon and rainfall changes over East Asia. **GOGA** runs were forced by global SST, **TOGA** Same as GOGA but forced only by tropical (20S-20N) SSTs with extratropical SSTs fixed to climatological monthly SSTs, **GOGAI** runs were forced by global SST plus IPCC 20th century atmospheric forcings, and **RADATM** runs were forced by climatological monthly SST plus the IPCC 20th century atmospheric forcings.

The EASM index (EASMI) is defined as the normalized zonal wind (u) shear (or difference) between 850hPa and 200hPa averaged over 20˚-40˚N and 110˚-140˚E. We focused on the composite difference between 1977-1999 and 1954-1976, although time series were also examined for some of the variables. Only June-July-August (JJA) results are shown below.

SST forcing

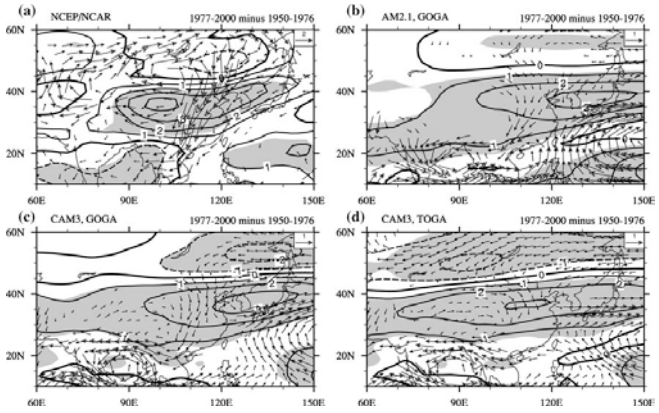

Figure 1. The 1977-2000 minus 1950-1976 difference of JJA mean 850hPa winds (vectors, m/s, only values that are statistically significant at the 5% level are shown) and 200hPa zonal wind (contours, m/s, interval=1m/s, dashed lines are for negative values, shading indicates statistically significant at the 5% level) from (**a**) NCEP/NCAR reanalysis, (**b**) AM2.1 GOGA runs, (**c**) CAM3 GOGA runs, and (**d**) CAM3 TOGA runs.

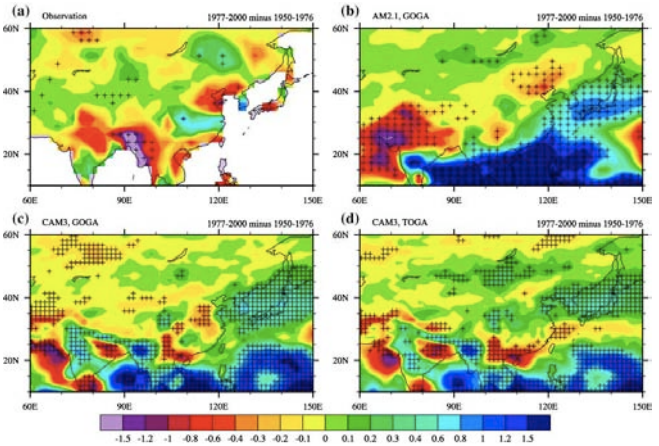

Figure 2. The 1977–2000 minus 1950–1976 difference of JJA mean precipitation (color) from (a) observations, (b) AM2.1 GOGA runs, (c) CAM3 GOGA runs, and (d) CAM3 TOGA runs. The pluses indicate where the precipitation change is statistically significant at the 5% level.

Atmospheric forcing

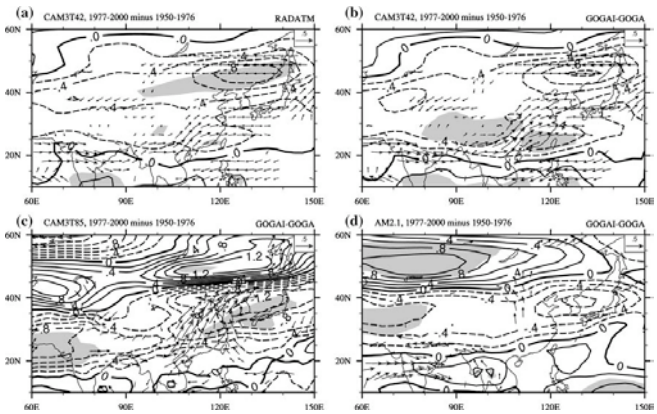

Figure 3. The 1977–2000 minus 1950–1976 difference of JJA mean 850 hPa winds (vectors, m/s, only values that are statistically significant at the 5% level are shown) and 200 hPa zonal wind (contours, interval is 0.2 m/s, dashed lines for negative values, the shaded areas are statistically significant at the 5% level) from (a) CAM3 T42 RADATM runs, (b) CAM3 T42 GOGAI minus GOGA runs, (c) CAM3 T85 GOGAI minus GOGA runs, and (d) AM2.1 GOGAI minus GOGA runs.

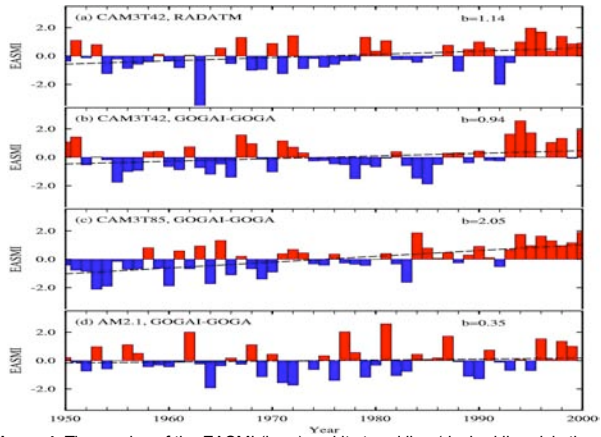

Figure 4. Time series of the EASMI (bars) and its trend line (dashed line, *b* is the slope in changes per 50 years) from (**a**) CAM3 T42 RADATM runs, (**b**) CAM3 T42 GOGAI minus GOGA runs, (**c**) CAM3 T85 GOGAI minus GOGA runs, and (**d**) AM2.1 GOGAI minus GOGA runs.

Summary

We have analyzed EASM's response to different forcings using NCAR CAM3 and GFDL AM2.1 models. We found that:

1)The simulations from both models show that the observed SST forcing, primarily from the Tropics, is able to induce most of the observed circulation changes associated with the weakening of the EASM since the 1970s.

2)The atmospheric forcings (primarily greenhouse gases plus the direct effect of aerosols) during 1950–2000 increase the summer land-ocean temperature contrast and thus enhance the EASM.

3)A realistic simulation of the relatively small-scale rainfall change pattern over East China remains a challenge for the global models.

Referece: Li, H., A. Dai, T. Zhou, and J. Lu, 2008: Responses of East Asian Summer Monsoon to Historical SST and Atmospheric Forcing during 1950-2000. *Climate Dynamics, in press. doi:10.1007/s00382-008-0482-7*

We thank Adam Phillips for making the CAM3 simulations available. We acknowledge Fangrong Zhang and Tom Delwoth for conducting the experiments with AM2.1.