Monsoon Region Expands

Monsoonal Thunderstorm over Arizona: Credit NOAA

Measuring the impacts of a warming climate on monsoon rainfall is not a straightforward task and depends, among other things, on the definition of the term "monsoon domain" and on the rainfall products used for analysis. In past studies, the global monsoon domain was viewed as a fixed geographical area and was defined based on long-term climatology. The monsoon system may have changed in recent decades as land surfaces have warmed more than the ocean, especially in the Northern Hemisphere. The geographical boundaries of the regions dominated by a monsoon climate may have changed as well.

With this possibility in mind, **Pang-chi Hsu**, **Tim Li**, and **Bin Wang** at the IPRC decided to look at the global monsoon domain not as a fixed region, but defined each year as the area in which the year's rainfall range exceeds 2 mm/day and the local summer precipitation exceeds 55% of the annual rainfall. They used the Global Precipitation Climatology Project (GPCP) and the Climate Prediction Center Merged Analysis of Precipitation (CMAP) products for their 30-year (1979–2008) analysis

Despite rather large year-to-year fluctuations, the global monsoon area shows a clear trend growing from 1979 through 2008. Over the 29 years, the global monsoon area expanded by 6.3 x 10^6 km^2 in GCPC data and by 3.39 x 10^6 km^2 in CMAP data (see Figure 1), and the spatial distributions of the expansion are quite similar in the two rainfall products. The monsoon climate tends to expand at the poleward edges of the tropical monsoon region near 15°–30° N and S. Charting the rainfall in the expanding monsoon regions in the Northern and Southern Hemispheres shows that these regions have shifted toward more summer rainfall and less winter rainfall. This poleward expansion of the global monsoon area could result from a widening tropical circulation over recent decades that is associated with the poleward expansion of the Hadley cell during summer.

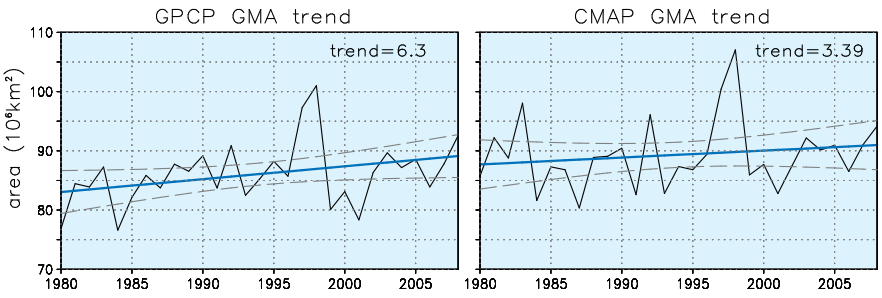


Figure 1. Time series of the global monsoon area (GMA) based on the GPCP (left) and CMAP (right) datasets for the period 1979–2008. Thick blue lines represent the linear trend of each time series (10^6 km^2/29 years) shown in each panel. Dashed lines represent 95% confidence intervals for the GMA trends.

To show the effects of the fixed and variable global-monsoon-area definitions on amount of rainfall, Hsu calculated the global monsoon rainfall for both a fixed area derived from the 30-year climatological rainfall field and for the interannually varying area as defined earlier. In the fixed global-monsoon area, the monsoon rainfall

increases 10.6 x 10^9 m^3/day (Figure 2, upper left panel) in the GPCP, but decreases 7.19 x 10^9 m^3/day in the CMAP data (Figure 2, upper right panel) over the period. In the monsoon area defined each year, rainfall increases significantly in both data sets, though the increase is much greater in GPCP (42.5 x 10^9 m^3/day) than in CMAP (2.57 x $10^9 m^3$/day).

That monsoon rainfall has increased globally should not surprise given that the area over which monsoon rainfall was computed has expanded. What counts for people living in the region, though, is the intensity of rainfall. To quantify the change in the global monsoon strength, Hsu computed a global monsoon intensity index, defined as the global monsoon rainfall amount divided by the area of the global monsoon domain. The GPCP and the CMAP products both show slightly less intense monsoon rainfall over the past 30 years: in GPCP this change is –0.03 and in CMAP it is –0.24 mm/day (Figure 3).

The finding that the monsoon climate, with wetter summers and drier winters, is expanding poleward will have agricultural and other economic consequences for these regions. The slightly weaker global monsoon intensity seems not too worrisome, but, as the previous story on the drying trend in South Asia showed, consequential local changes in rainfall intensity have been observed in some places.

This story is based on
Hsu, P.-c., T. Li, and B. Wang, 2011: Trends in global monsoon area and precipitation over the past 30 years. *GRL*, **38**, L08701, doi:10.1029/2011GL046893.

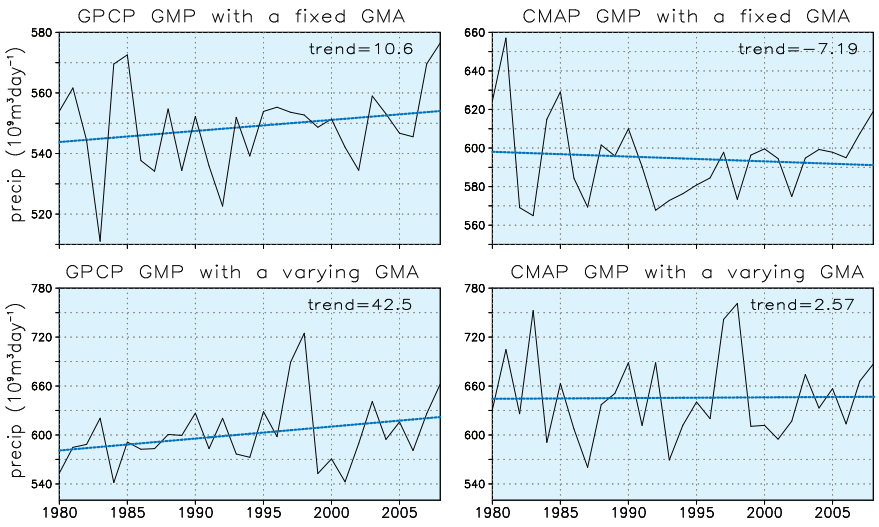


Figure 2. Time series of the global monsoon precipitation (GMP, unit:10^9 m^3/day) based on a fixed (top panels) and varying (bottom panels) global monsoon domain using the GPCP (left) and CMAP (right) datasets for the period of 1979-2008. The linear trend of each time series is shown by a blue line (unit: $10^9 m^3$/day over 29 years) in each panel.

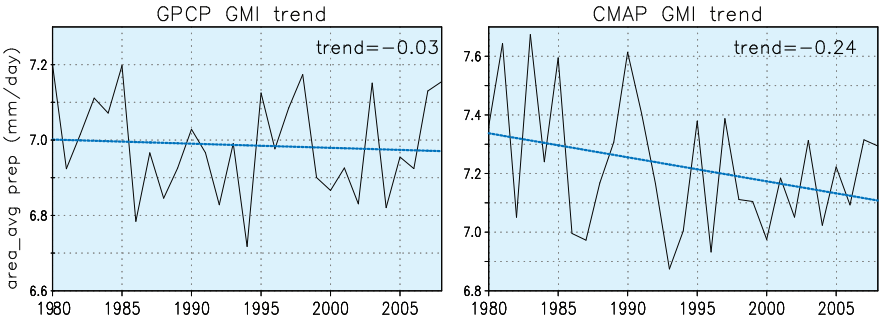
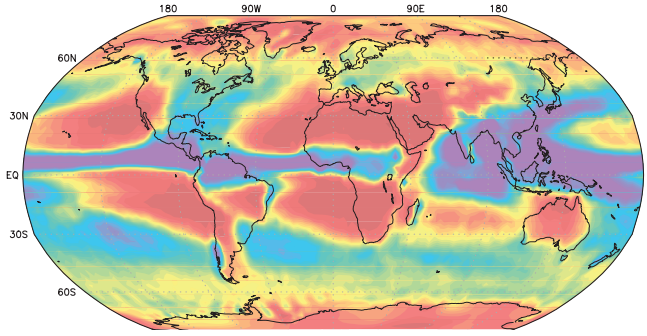


Figure 3. Time series of the global monsoon intensity (GMI, unit: mm/day) based on the GPCP (left) and CMAP (right) datasets for the period of 1979-2008. The linear trend in each time series is shown by a blue line (unit: mm/day) in each panel.



CMAP Precipitation Climatology: Credit APDRC