The Climate of Asia and Tibet – Not Just a Simple Monsoon

Gerard H. Roe[1]

[1] Department of Earth and Space Sciences, University of Washington, Seattle, WA 98195, USA, gerard@ess.washington.edu

Asia, the largest continuous landmass, experiences the greatest seasonality and climate gradients on Earth, and induces an atmospheric circulation that each year draws more than half the air mass of a hemisphere across the equator. Tibet, the largest topographic feature outside of the poles, sits square in the middle of the jet stream and induces atmospheric circulation patterns that affect climate around the globe.

Within Earth Sciences, and also many textbooks, the climate of Asia is often deconstructed into two semi-annual components: a wintertime, dry cold monsoon, associated with the Siberian high-pressure system; and a summertime, warm wet monsoon associated with a thermal low-pressure system over the continent. In the extreme of this cartoon, the whole Indian-Asian monsoon system is depicted as a single dynamical system, driven by the thermal contrast between land and ocean.

In actuality, this vast tract of real estate experiences a rich spatial structure of atmospheric circulation and related weather. In many cases these varied phenomena have largely independent causes. Moreover some of the most interesting features of the climate dynamics defy a simple deconstruction into two monsoonal seasons.

Some examples of this: in fall, northern Asia experiences the greatest circulation variability anywhere in the hemisphere; year-round coastal and orographic precipitation dominates in the maritime climates of southeast China; the greatest concentration of storm development anywhere on Earth happens during springtime in the lee of the Mongolian Altai - these storms loft dust into the atmosphere and create the loess plateau and the associated environmental records; temperatures fall in India when the monsoon intensifies, breaking the link between precipitation and land-sea temperature contrasts; a springtime maximum in precipitation in western Asia occurs due to a storm track emanating from the Mediterranean; precipitation across central China maximizes in late summer due to a circulation feature known as the Meiyu front.

Recent studies of the dynamics of the monsoon have focussed on the moist entropy as the key driver of the south Asian monsoon, and have distinguished between the relative roles of the Himalaya and the plateau proper. While these advances have helped improved theoretical understanding of monsoon dynamics, complex land-atmosphere interactions and strong climate gradients means there remains great uncertainty over future regional climate changes.

Asia is also an important repository of paleoclimate information: striking connections are apparent between abrupt climate changes in the North Atlantic and isotopes in speleothems across China. However the dynamical connections remain elusive. Our confidence in the reconstruction and understanding of past climate variations rests on our accounting for, and understanding the cause of, modern variability. Toward that end, the recent incorporation of isotopes into global climate models represents an exciting development. Initial results from several groups suggest that the climatic controls on isotopic variations vary in different parts of Asia, with some places following the clear and theoretically predicted relationship between isotopic fractionation and precipitation intensity, whereas other regions appear to be controlled by variations in moisture source.

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