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Local and Global Influences on the Asian Monsoon

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Localised tropical/subtropical surface heating has long been known to be able to generate a stationary wave circulation with characteristics similar to the Asian monsoons. In addition, more recent work suggests that increasing the amplitude of such a heating pattern may capture some of the time dependent characteristics of the monsoon, e.g. fast onset. Here we investigate whether this stationary wave perspective of the monsoon circulation may also aid in understanding the interactions between the South and East Asian monsoons, and teleconnections of the Asian monsoons to other parts of the world. These questions are motivated by two observations. Firstly, while the South and East Asian monsoons have distinct behaviours, their circulations are generated by the same low pressure system located over the Asian continent. Secondly, the northern hemisphere summer stationary wave pattern is dominated by a wavenumber-2 signal, with a second region of low pressure sitting over Central/North America. To explore these possible interactions, we have run simulations using an idealised model, in which simplified continents resembling those of Earth are progressively removed.

Results when all continents are included are roughly comparable with reanalysis, and suggest that the onsets of the East and South Asian monsoons may be connected via the development of the low pressure system over the Asian continent. This system drives geostrophic northward flow and ascent over East Asia. This off-equatorial ascent acts to lower the upper-level absolute vorticity, which we suggest may trigger a transition of the Hadley cell that extends west over the Asian continent, resulting in a sudden intensification of the overturning circulation and precipitation over South Asia. We test this hypothesis further by removing different regions of East and South Asia.

To investigate whether the wavenumber-2 structure of the stationary wave pattern has any significance, we compare an experiment including all continents with one in which North and South America are removed. We find that when the Americas are not present, a wavenumber-1 structure is instead dominant, and the JJA precipitation is reduced over Asia by up to 40%. While this is clearly an unrealistic scenario, it suggests climate on the two continents may be more connected than might be at first expected, and that changes in the surface energy balance on one continent, e.g. land use changes, could potentially have far reaching effects. The dynamical processes responsible are explored.

Implications of the results of our idealised simulations for the real world are then investigated by analysing inter-annual variability in the stationary wave patterns in ERA-Interim data.