



## Attribution of the local Hadley cell widening in the Southern Hemisphere

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The Hadley cell (HC), the thermally direct overturning circulation in the tropics, is closely related to the hydroclimate of the subtropics and mid-latitudes. In particular, understanding the local HC changes is important due to its significant influence on regional climate, but there have been no attribution studies of local HC changes. This study conducts an attribution analysis of long-term changes in the southern edge of the local Hadley cell during austral summer for the past three decades (1979–2009). The southern edges of the local HC are defined as the latitudes of maximum sea level pressure in the Southern Hemisphere subtropics, and the long-term variations of local HC edges from multireanalyses are compared with those from Coupled Model Intercomparison Project Phase 5 (CMIP5) multimodel simulations by using the optimal fingerprinting technique. The observed local HC exhibits a poleward expansion in the Atlantic and Indian Ocean regions, which is successfully reproduced by the CMIP5 models including anthropogenic forcing (ANT) but with weaker amplitude. The optimal detection analyses further show that ANT signals are detected robustly in both Atlantic and Indian HC trends. More importantly, anthropogenic forcings other than greenhouse gas forcing are found to be clearly detected in separation, indicating a possible attribution of the observed local HC widening over these regions to stratospheric ozone depletion. Further studies are needed to identify physical mechanisms for the observed local HC expansions as well as the causes of the observation-model discrepancy in tropical widening, including influences of decadal climate variability.