Anthropogenic forcing on the Hadley circulation in CMIP5 Simulations

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Poleward expansion of the Hadley circulation has been an important topic in climate change studies in the past few years, and one of the critically important issues is how it is related to anthropogenic forcings. Using simulations from the coupled model intercomparison projection phase 5 (CMIP5), we study influences of anthropogenic forcings on the width and strength of the Hadley circulation. It is found that significant poleward expansion of the Hadley circulation can be reproduced in CMIP5 historical all-forcing simulations although the magnitude of trends is much weaker than observations. Simulations with individual forcings demonstrate that among three major types of anthropogenic forcings, increasing greenhouse gases (GHGs) and stratospheric ozone depletion all cause poleward expansion of the Hadley circulation, whereas anthropogenic aerosols do not have significant influences on the Hadley circulation. Increasing GHGs cause significant poleward expansion in both hemispheres, with the largest widening of the northern cell in boreal autumn. Stratospheric ozone depletion forces significant poleward expansion of the Hadley circulation for the southern cell in austral spring and summer and for the northern cell in boreal spring. In CMIP5 projection simulations for the twenty-first century, the magnitude of poleward expansion of the Hadley circulation increases with GHG forcing. On the other hand, ozone recovery competes with increasing GHGs in determining the width of the Hadley circulation, especially in austral summer. In both historical and projection simulations, the strength of the Hadley circulation shows significant weakening in winter in both hemispheres.

Key words: Hadley circulation, Subtropical dry zone, Increasing greenhouse gases, Ozone depletion and recovery, Anthropogenic aerosols

References

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