Interhemispheric coupling of the atmosphere-ocean system and circulation in the response to greenhouse gas and aerosol radiative forcings

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Major changes have occurred in the radiative drive of the atmosphere and surface since preindustrial times owing to anthropogenic emissions, which includes well-mixed greenhouse gases and tropospheric aerosols. In particular, while the well-mixed greenhouse gases exert a forcing that is pervasive throughout the globe, the manmade aerosol forcing is predominantly in the Northern Hemisphere. This contrast is emblematic of a general climate science problem that seeks to understand the consequence due to an asymmetry in forcings between the Northern and Southern Hemispheres. How do the atmosphere-ocean system and interhemispheric circulation respond? Using the NOAA/GFDL global climate model and observations, we discuss how the hemispheric top-of-the-atmosphere and surface energy balance have evolved in the 20th Century under the action of the different forcings. The interhemispheric asymmetry in the forcings affects the coupling across the hemispheres, and this is discernible in the hydrologic cycle. There is a particularly interesting change in the tropical circulation yielding changes of opposite sign in the precipitation across the equator. We diagnose the physical factors that are responsible, including an accounting of the effects on the poleward transport of heat in the atmosphere and oceans in the two hemispheres. The asymmetric nature of the anthropogenic aerosol forcing and the resulting pattern of the climate response in the two hemispheres has a similarity to other climate forcing problems e.g., land surface changes induced in a hemisphere, presence of ice sheets in the Northern Hemisphere, stratospheric aerosols after a volcanic eruption.

Keywords: Interhemispheric asymmetry in climate forcings, Interhemispheric coupling of circulation and climate change, Hemispheric poleward heat transport, Interhemispheric coupling of hydrologic cycle

