

A pause in Southern Hemisphere circulation trends due to the Montreal Protocol

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Observations show robust near-surface trends in the Southern Hemisphere tropospheric circulation towards the end of the 20th century, including a poleward shift in the midlatitude jet, a positive trend in the Southern Annular Mode, and an expansion of the Hadley cell. It is established that these trends have been driven by ozone depletion in the Antarctic stratosphere due to emissions of ozone-depleting substances. Here we show that these widely reported circulation trends have, in fact, paused, or slightly reversed, around the year 2000. Using a pattern-based detection and attribution analysis of atmospheric zonal wind, we show that the pause in circulation trends is forced by human activities, and has not occurred simply due to internal or natural variability of the climate system. Further, we demonstrate the essential role of stratospheric ozone recovery as a result of the Montreal Protocol in driving the pause through stratosphere-troposphere coupling. Since the pre-2000 circulation trends have impacted precipitation, and potentially, the ocean circulation and salinity, we anticipate that a pause in these trends will have wider impacts on the Earth system. Signatures of the Montreal Protocol and the associated stratospheric ozone recovery might therefore manifest, or might have already manifested, in other aspects of the Earth system.

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