

Relative roles of ozone-depleting substances, greenhouse gases and internal variability on recent Southern Hemisphere stratosphere-troposphere coupled circulation trends

Observations show robust near-surface trends in Southern Hemisphere tropospheric circulation towards the end of the twentieth century, including a poleward shift in the mid-latitude jet, a positive trend in the Southern Annular Mode and an expansion of the Hadley cell. It has been established that these trends were driven by ozone depletion in the Antarctic stratosphere due to emissions of ozone-depleting substances. Here we show that these widely reported circulation trends paused, or slightly reversed, around the year 2000. Leveraging model ensembles, we use pattern-based detection and attribution to show that this pause on decadal timescales has been externally forced by stratospheric ozone recovery (resulting from the Montreal Protocol). We find these trends have not occurred owing only to internal or natural variability, and have rather been modulated by greenhouse gas forcing. We anticipate that the Montreal Protocol, through this pause in summertime circulation trends, may have wider impacts on the climate system. Conversely, in the winter-spring season, we show how internal variability, rather than external forcing, has played the major role in observed circulation trends, including an equatorward trend over the Pacific ocean basin.