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The Contribution of Atmospheric Circulation and Coverage Bias to the Warming Hiatus

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The global warming trend appears to have slackened or even halted since about 1998, in clear contrast with the strong warming signal projected by the CMIP5 multi-model mean for recent years. This warming hiatus shows a strong seasonal and geographical asymmetry, with cooling in the Northern Hemisphere winter, especially over land, and warming elsewhere and in the other seasons.
Many factors have been suggested to contribute to the warming hiatus, including changes in solar radiative forcing, tropospheric and stratospheric aerosols, internal variability in the Atlantic and the Equatorial Pacific, wind stress variability or a combination of those. In addition, deficiencies due to the incomplete observational coverage have led to an underestimation of recent temperature trends. Although the above factors can account for the reduced warming trends, it is not clear whether they can also explain the spatial and temporal characteristics of the current slow-down in the rate of global warming.

Working on five different reanalyses and on the HadCRUT4 temperature records, we quantify how internal atmospheric variability in the extratropical Northern Hemisphere (20-90°N) contributed to the spatial and seasonal asymmetry of the hiatus in the period 1998-2012 and how temperature trends were impacted by the incomplete observational coverage.
In order to determine the circulation-induced contribution to temperature trends we apply a dynamical adjustment technique by sampling atmospheric variability through empirical orthogonal functions.
We further test how missing observations influenced the observed warming by introducing the HadCRUT4 coverage bias in reanalysis temperatures.

We find that the temperature trends in 1998-2012 can be reconciled with the long-term trends in the period 1960-2012 when accounting for the effects of natural variability and coverage bias.
The contributions of atmospheric dynamics and incomplete coverage to the Northern Hemispheric and global DJF trends in the hiatus period are of similar magnitude. The winter cooling over Northern Hemispheric land is primarily due to anomalous circulation trends.
Trends in other seasons and for annual data were predominantly impacted by coverage bias. This has been exceptionally pronounced during recent years as an area of strong warming has been missed due to the declining observational coverage since the early nineties and, to a lesser extent, due to anomalous circulation.
Analogous results were found for global temperature trends.

An analysis on CMIP5 climate models suggests that the recent trends in the modes of atmospheric circulation accounted for in our work are likely due to unforced natural variability and not a result of a long-term circulation response to anthropogenic forcing.