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Signatures of naturally induced variability in the atmosphere using multiple reanalysis datasets

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A multiple linear regression analysis of nine different reanalysis datasets has been performed to test the robustness of variability associated with volcanic eruptions, the El Niño Southern Oscillation, the Quasi-Biennial Oscillation and with a specific focus on the 11-year solar cycle. The analysis covers both the stratosphere and troposphere and extends over the period 1979–2009.

The characteristic signals of all four sources of variability are remarkably consistent between the datasets and confirm the responses seen in previous analyses. In general, the solar signatures reported are primarily due to the assimilation of observations, rather than the underlying forecast model used in the reanalysis system. Analysis of the 11-year solar response in the lower stratosphere confirms the existence of the equatorial temperature maximum, although there is less consistency in the upper stratosphere, probably reflecting the reduced level of assimilated data there. The solar modulation of the polar jet oscillation is also evident, but only significant during February. In the troposphere, vertically banded anomalies in zonal mean zonal winds are seen in all the reanalyses, with easterly anomalies at 30°N and 30°S suggesting a weaker and possibly broader Hadley circulation under solar maximum conditions. This structure is present in the annual signal and is particularly evident in NH wintertime. As well as the 'top-down' solar contribution to Northern Annular Mode variability, we show the potential contribution from the surface conditions allowing for a 'bottom-up' pathway.

Finally, the reanalyses are compared with both observed global-mean temperatures from the Stratospheric Sounding Unit (SSU) and from the latest general circulation models from CMIP-5. The SSU samples the stratosphere over three different altitudes, and the 11-year solar cycle fingerprint is identified in these observations using detection and attribution techniques.