Attributing changes of global stratospheric temperatures to natural and anthropogenic forcings

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Satellite instruments have provided observations of global stratospheric temperatures since 1979, showing a cooling at all stratospheric altitudes. The satellite data record is now long enough to include two whole decades characterized by the absence of major volcanic eruptions and by decreasing concentrations of ozone depleting substance (ODS). This allows us to estimate the solar component of stratospheric temperature changes as well as to calculate temperature trends over a period with decreasing ODS concentrations. In order to attribute the features of the global stratospheric temperature time series to the main forcing agents, we performed a set of simulations using the NASA Goddard Earth Observing System Chemistry-Climate Model (GEOSCCM). The model simulations show that the cooling of the stratosphere from 1979 to present has been mostly driven by changes in concentrations of greenhouse gases (GHG) in the middle and upper stratosphere and of GHG and ODS in the lower stratosphere. While the cooling trend caused by increasing GHG is roughly constant over the whole analyzed time period, changing ODS concentrations cause a significant stratospheric cooling only up to the mid-1990s, when they started to decrease thanks to the implementation of the Montreal protocol. Even though sporadic volcanic events and the solar cycle have a distinct signature in the time series of stratospheric temperature anomalies, these forcing mechanisms did not play a statistically significant role in the long-term trends over the 1979-present period. Several factors combined to produce the step-like behavior in the stratospheric temperatures: the decrease in ozone depleting substances mainly caused the flattening of lower stratospheric temperature anomalies since the mid 1990s, and changes in solar irradiance are largely responsible for the step-like behavior of global temperatures anomalies in the middle and upper stratosphere, together with volcanically induced ozone depletion and water vapor increases in the post-Pinatubo years.