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How the 11-year solar signal in the upper troposphere forces the stratosphere

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The observed pattern of stratospheric variability over the 11-year solar irradiance cycle [Kodera, 2002] is modeled in a middle atmospheric model using only a wave forcing from the high troposphere for the period 1963-1999. The study concists of two parts:

First, the difference between years of maximum and minimum solar irradiance over the 11-year cycle is calculated for the 300 hPa geopotential height of the NCEP/NCAR reanalysis data. In boreal winter the signal consists primarily of higher geopotential heights in the North Pacific ocean, and significant changes are also seen in the first three planetary waves.

Second, a three-dimensional middle atmosphere model is used with the NCEP/NCAR 300 hPa geopotential height as a lower boundary to study how the stratosphere responds to the above described tropospheric solar signal. The model is forced only by the geopotential heights, i.e. there are no changes in the solar irradiance, ozone etc. One long model run is performed and the difference between solar maximum and minimum solar activity is calculated. We find a pattern of downward and poleward propagating zonal means of the temperature and zonal wind, much like that found in observations [Kodera, 2002]. The pattern is weaker in the model in early winter but increases in strenght and is comparable to the observations in February.

We conclude that the stratospheric winter response to the decadal solar cycle is dominated by planetary wave forcing from the troposphere.

Reference Kodera, K., and Y. Kuroda (2002), Dynamical response to the solar cycle, J. Geophys. Res., 107, D24, doi:10.1029/2002JD002224.