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Understanding the 11-year Solar Cycle Signal in Stratospheric Ozone using a 3D CTM

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The exact structure of the 11-year solar cycle signal in stratospheric ozone is still an open scientific question. Long-term satellite data such as Stratospheric Aerosol and Gas Experiment (SAGE) and Solar Backscatter UltraViolet (SBUV) show a positive solar response in the tropical lower stratosphere and upper stratosphere/lower mesosphere (US/LM), but a negligible signal in the tropical middle stratosphere. On the other hand, Halogen Occultation Experiment (HALOE) measurements show a positive signal in the lower and middle stratosphere and smaller solar signal in the tropical US/LM. Currently most chemical models are able to simulate a "double-peak"-structured solar signal but the model simulated solar signals tend to show better agreement with the HALOE-derived solar signal than those from SBUV or SAGE measurements. Also, some recent studies argue that due to the significantly different solar variability during the recent solar cycle (23), the solar signal in the US/LM ozone is negative (out of phase with total solar irradiance changes) for this later period compared to previous solar cycles.

We have used 3-D chemical transport model (CTM) simulations to better understand the possible mechanisms responsible for this discrepancy. Various model simulations have been performed for 1979-2012 time period using ERA-Interim meteorological fields as a dynamical forcing. Model output is sampled at collocated measurement points for three satellite instruments performing stratospheric ozone measurements using the solar occultation technique: SAGE II (1984-2005), HALOE (1992-2005) and Atmospheric Chemistry Experiment (ACE, 2003-present). Overall the modelled ozone shows good agreement with all the data sets. However, in the US/LM, modelled ozone anomalies are better correlated with HALOE and ACE than SAGE II measurements. Hence the modelled solar signal in the stratospheric and lower mesospheric ozone also shows better agreement with the solar signal derived using HALOE and ACE data. Our simulations do not show statistically significant differences in the tropical solar signal in the US/LM ozone compared to previous solar cycles. However, we diagnose a significantly different solar signal in the tropical middle stratospheric ozone both in observations as well as model simulations which could be linked to changes in stratospheric circulation.