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Sensitivity of tropical stratospheric and mesospheric ozone to short-term solar variability: observations vs chemistry climate model simulations

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The response of stratospheric and mesospheric ozone in the tropics to short-term solar ultraviolet variations (i.e. 27-day solar rotational cycle) over the descending phases of two consecutive solar cycles (solar cycles 22 and 23) is investigated using daily ozone measurements (MLS on UARS and AURA, GOMOS on ENVISAT), reconstructed solar spectra variations and stratospheric chemistry-climate model calculations. Daily solar spectra are taken from the NRL-SSI solar reconstruction model. The chemistry-climate model is forced at the top by the reconstructed solar spectra, and at the surface by analyzed sea-surface temperatures and sea-ice. The solar variable for regression analysis is the UV flux at 205nm, within an atmospheric window region that is crucial for the ozone photochemistry. The same spectral analysis (cross-correlation, wavelet and fourier transform, coherence,. . .) is carried out on all the observations and model simulations, and for both periods. In the stratosphere, statistically significant correlation is found between around 1 and 10 hPa with a peak at about 4 hPa ($\sim$36 km) for both periods. However the ozone sensitivity to solar variations (defined as the percentage change in ozone for 1% change in solar 205nm flux) is two times weaker during the solar cycle 23 (0.2) than during the solar cycle 22 (0.4%/%). Moreover, wavelet transforms show that the magnitude and occurrence of the solar signal in ozone data is highly variable temporally and vanishes during several solar rotations. This intermittence is much more pronounced during the solar cycle 23 than during the solar cycle 22. The chemistry-climate model calculations are able to reproduce most of the features of the solar signal in tropical stratospheric ozone including the differences between the solar cycle 22 and 23. In the mesosphere, the analysis of the GOMOS data reveals a clear 27-day solar signal in ozone. The results have implications for the impact of solar variability on ozone and ultimately on climate on longer-time scales.