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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Equatorial middle atmospheric chemical composition changes during sudden stratospheric warming events" *by* O. Nath and S. Sridharan

Anonymous Referee #2

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This paper discusses the response of trace constituents to three major SSWs in the past 12 years. They show changes in ozone, H2O, CH4 and OH They attempt to relate CH4 and H2O changes to chemical changes related to OH. Unfortunately their arguments are superficial and most likely are simply wrong. Without more substantive analysis to back up their arguments, I regretfully cannot recommend this paper for publication.

The most likely explanation for the observed change in the CH4/H2O ratio in the tropical upper stratosphere is variations in transport. As discussed by Wrotny et al (JGR, February, 2010), the sum of H2O + 2xCH4 is conserved to within several percent.

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Indeed, in their Figure 2, they show this to be true for 2004, one of the periods discussed in the present paper. With faster upwelling, more CH4 is transported upwards (i.e. younger air) and less can be oxidized to form H2O. The present authors already show colder temperatures over the tropical upper stratosphere, this is consistent with increased upwelling. They correctly identify the increased ozone which responds to the lower temperatures. But their arguments about CH4 oxidation are “hand waving” at best and most likely wrong given that transport is the underlying explanation. There were a pair of papers by Nedoluha et al [1998, both GRL and JGR] which showed the link between decreasing CH4 and increasing H2O in the few years of the UARS mission. There is also a substantial body of work by authors such as WJ Randel on the relationship of tracers and transport in the tropical stratosphere, none of which is discussed in this paper.

Regarding the authors’ speculations about chemistry, they admit that they find no change in OH and thus have to rely on the O(1D) oxidation mechanism. This is too slow. For a rate coefficient of 1e-10 cm3/sec and a typical order of magnitude abundance of O(1D) of 1e3 cm-3, the time constant for this reaction is found to be many months. Thus we can completely rule out the authors’ mechanism and indeed, there is no requirement for it given the well known relationship between tropical CH4 and transport.

Once the authors speculations on chemistry are removed from the paper, there is little left. If we accept that the decrease in temperature is due to upwelling which is based upon their earlier work (Nath et al., 2015) and which is quite plausible, the response of O3 which is anticorrelated with temperature and which is also covered in their 2015 paper, the CH4, and H2O follow straightforwardly. The details of the CH4 and H2O response due also depend upon altitude dependent vertical gradients- to simulate that they would require a model. In the absence of either that or any other quantitative analysis, in my opinion, this paper does not offer sufficient correct new science to merit publication..

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