Comments on ANGEO manuscript 2021-50

By Ellis Remsberg

I have several concerns and suggestions for the manuscript version under review, and I have already passed them along to the authors privately. Their reply to me indicates that accounting for anomalous HALOE profiles makes a quantitative difference for their findings, but does not change their conclusion that there may be some effect on temperature in late 1991 from the Pinatubo eruption. However, I do not think that the Pinatubo effects extend to 1993. The following paragraphs give my comments on the version of the manuscript that is currently under review. I am sure that the authors will make appropriate revisions based on their updated findings.

My past work on analyzing HALOE temperatures was exploratory, initially, because I was looking also for the Pinatubo effect that was alluded to by She et al. (1998). I was concerned about decadal-scale, dynamical influences, so I decided not to regress against a solar flux proxy, but to fit temperature series with an 11-yr sinusoid and check about its phasing with that of a solar cycle proxy. Subsequent to Remsberg and Deaver (2005), I discovered that I had not accounted properly for autoregressive effects. I reported on that realization and then updated my analyses in Remsberg (2007). I also used that revised approach in the analyses of Remsberg (2008; 2009). Most recently, I reported on analyses of HALOE water vapor in the mesosphere, and I included further updates about HALOE temperature, as well (Remsberg et al., 2018). For that study, I included a regression term for a solar proxy (Lyman-alpha flux) and a dynamical term related to an ENSO proxy (MEI index), and I obtained a good fit to the H2O time series and an improved fit to the temperature time series. However, I did not include a volcanic aerosol proxy term because I did not see that one was indicated from the time series of the model/data residuals.

After reading your manuscript, I re-analyzed HALOE temperature time series at 0.03 hPa in the manner of Remsberg et al. (2018), see Figure 1 below. In that paper I noted that there are so-called 'trip angle' biases in many of the SR profiles of November 1991 and April 1992; that problem is described in more detail on the GATS, Inc., HALOE Website homepage, including which profiles are not trustworthy. The regression analysis for Fig. 1 begins in October 1991 and includes SR and SS profiles at 37N +/- 7.5 degrees of latitude, which overlaps the sodium lidar station at Fort Collins (41N); you can compare them with that of Remsberg and Deaver (2005, Fig. 6). The response in Fig. 1 of HALOE T(p) to the Lyman-alpha flux proxy (max-min) is +1.8 K, and the analyzed linear trend for T(p) is -2.4 K/decade.

Figure 2 is my analysis for T(p) at 0.01 hPa or nearer to the sodium layer viewed by She et al. The response of T(p) to Lyman-alpha flux is +3.3 K, but the linear trend is now weakly positive (+0.46 K/decade) although it is not significant. In addition, my analyzed coefficient for the ENSO index is 0.86 K/MEI index, and it is highly significant. This pressure altitude of 0.01 hPa is where the dissipation of

gravity waves (and the phase of ENSO) may be affecting temperature. Again, my regression model fits the data well, even during the year or so following the Pinatubo eruption.

Finally, Figure 3 is an "image" of the longitude/pressure cross section for SS profiles on 15 December 1991 at 38N latitude. Note that HALOE viewed this latitude only about once every month or so. You may access and view similar images at the HALOE Website by clicking on 'Browse images' on the left menu of the homepage, and then selecting from the next pop-up page, a longitude/pressure plot, the parameter of interest (temperature), the months of a given year, and whether you wish to look at SS and/or SR scans. When you make your request at the bottom of that Webpage, the list of days that you asked for appears along with their mean latitude; clicking on one particular day then allows you to view more images. I show Fig. 3, so that you will see that there was a region of warm temperatures (225 K) near 0.01 hPa and about 270 E longitude (~Ft. Collins). There is also a pronounced zonal wave-1 in T(p) at this pressure level (see the cold values of ~200K near 60E). To my mind, this longitudinal variation in T(p) indicates effects from the interaction of planetary waves with gravity waves in the upper mesosphere. It may be that there is an indirect connection with the Pinatubo event, too, wherein its aerosol layers have altered slightly the meridional T(p) gradient of the lower stratosphere and allowed for a redirection of the transmission of gravity waves to the mesosphere. On the other hand, transport times and radiative relaxation rates are short in the upper mesosphere, such that any temperature anomalies decay quickly. A sustained transmission of gravity waves would be necessary to maintain those anomalies, in my opinion.

Additional references:

Remsberg, E. E., A re-analysis for the seasonal and longer-period cycles and the trends in middle atmosphere temperature from HALOE, J. Geophys. Res.—Atmospheres, vol. 112, D09118, doi:10.1029/2006JD007489, 2007.

Remsberg, E. E., On the response of Halogen Occultation Experiment (HALOE) stratospheric ozone and temperature to the 11-yr solar cycle forcing, J. Geophys. Res.-Atmospheres, 113, D22304, doi:10.1029/2008JD010189, 2008.

Remsberg, E., Damadeo, R., Natarajan, M., and Bhatt, P.: Observed responses of mesospheric water vapor to solar cycle and dynamical forcings, J. Geophys. Res., 123, 3830-3843, https://doi.org/10.1002/2017JD028029, 2018.

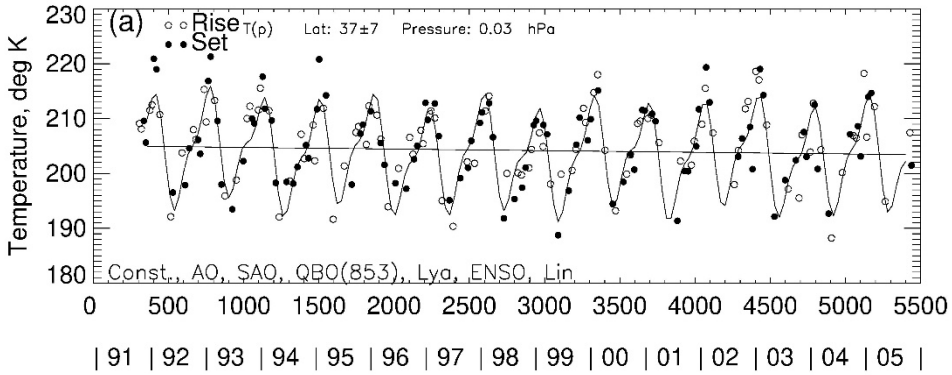

Figure 1—HALOE temperature time series at 0.03 hPa and 37N +/- 7°. Regression model terms are listed at lower left; x-axis is days since 1 January 1991.

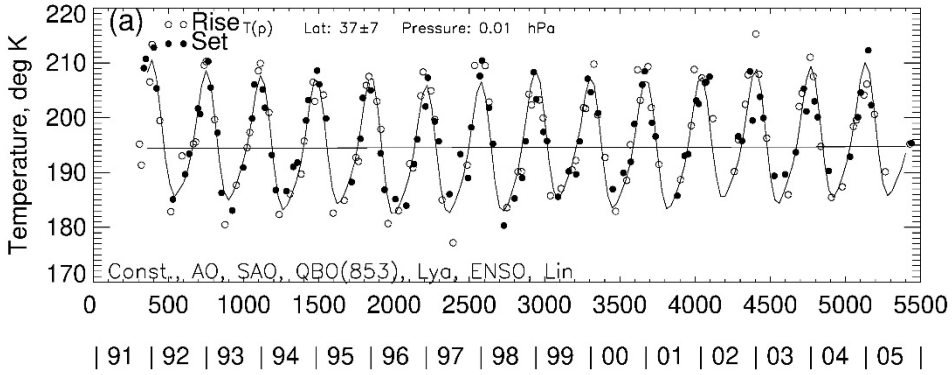

Figure 2—As in Fig. 1, but for 0.01 hPa.

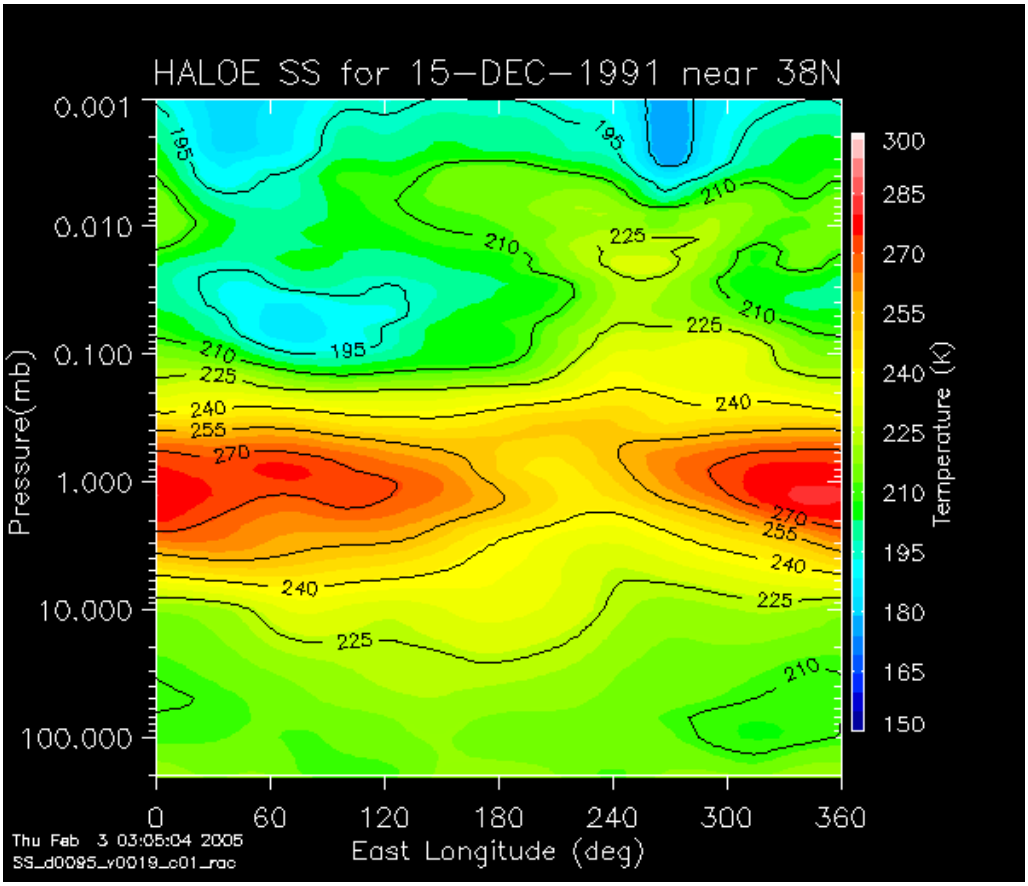

Figure 3—Image of longitude-pressure cross section for HALOE T(p) at SS for 15 December 1991.