

Interactive comment on “Nonlinear response of tropical lower stratospheric temperature and water vapor to ENSO” by Chaim I. Garfinkel et al.

Anonymous Referee #1

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General comments: This paper discusses the impact of ENSO on the tropical lower-stratospheric (LS) temperature and water vapor by analyzing datasets composed of numerical simulations and reanalyses. The authors found that both La Nina (LN) and strong El Nino (EN) lead to wet stratosphere while moderate EN leads to dry stratosphere even though the strength of stratospheric Brewer-Dobson circulation responds linearly to EN. The nonlinearity, i.e., the increase of ST water under strong EN condition is interpreted as the tropospheric warming extending up to the cold point that regulates the water entry to the stratosphere. The strong EN in 1997/98 and the following LN are attributed to the cause of the drop of ST water vapor in early 2001.

1. The analyses are limited to the temperature response and there found no argument on the modulation of pathways for the air entering the stratosphere. The coldness of

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the tropopause region does not necessarily result in the stratospheric dryness; as was pointed out by Bonazzola and Haynes (2004), “the sampling effect” as well as “the temperature effect” must be considered.

2. As for the millennial ST water drop, Fueglistaler (2012) and Hasebe and Noguchi (2016, ACP) identified its occurrence as October 2000 and September 2000, respectively. The current authors’ mentioning of the year 2001 is different from these studies. Some arguments are required on the difference in the occurrence time and, most importantly, the driving mechanism.

3. It is not clear how “anomalies” and means are defined in many variables such as LS temperature, SST, heating rate etc. “Anomalous” labeled for vertical axes is not appropriate.

4. The authors’ notion of nonlinearity is evident only in those shown in cyan with the Nino3.4 index greater than 2 (Figs. 1, 2, 9, and 10). Those points having the index > 2 will correspond to 1997/98 EP EN (p.6, l.30). In this context, it is important to study the features for this specific event in Section 5. The suggestion on the impact in the Indian Ocean is interesting, but there is no conclusive evidence having been shown.

5. The argument in Section 6 is not convincing. The time series of H₂O and cold point temperature show large negative anomalies in 1997 followed by large positive anomalies in 1998. The H₂O drop is more pronounced (anomalies are larger in magnitude of negative values) in 1997 than in 2001, but there found no discussion on the cause of large drop in 1997. I don’t find any logical consequence in the statements given in page 9, lines 13 to 16.

6. Appendix: I don’t understand why the mean age is discussed in the context of this paper. In addition, there found no explanation on how the mean age is estimated.

The bottom line will be that the LS water vapor tends to decrease in response to El Nino quantified by Nino 3.4 index but that the strong 1997/98 El Nino was exceptional

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in that it caused LS water increase. It is not clear if it is due to the warming in the TTL or it is related to the “flavor” (or type) of EP category it was classified. The mechanism has not been made clear by this analysis; it remains in the level of speculation. The terminology of “nonlinear response” may not be wrong, but it does not help understand the nature of LS water response to EN. The authors have interesting dataset obtained from ensemble runs, but it has not been analyzed satisfactorily. I recommend total rewrite of the manuscript after conducting analyses focusing on the specific features on 1997/98 EP EN. Considering the time necessary for the analysis, I suggest withdrawal of the present manuscript to consider re-submission.

Specific comments:

p.6, l.14-15: “EN leads to strong cooling” will be OK, but “LN leads to warming” is not obvious since the vertical axis is anomalies.

p.6, l.29: “This is especially evident in Figure 1ii”: In Figure 1i, the negative value of slope appears statistically significant, which may be interpreted as a linear response.

Figure 4. The choice of green (+) and red (-) in color scale is confusing; the choice of the same color as in other figures (Figs. 5, 6 and so on) is recommended.

Figures 5 and 6: The distribution of cold region is only one aspect of TTL dehydration. There is no information on the location of the dehydration that is taking place for the air entering the stratosphere. The distribution of Lagrangian cold point was reported to have changed dramatically during 1997/98 El Nino (Fig. 8 of Hasebe and Noguchi, 2016).

p.10, l.5-6: “regardless of their type”: It seems the nonlinearity appears only in EP type El Nino (2015/16 is also categorized as EP EN).

Technical corrections are omitted because a whole rewrite is suggested.

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