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Discussions

Interactive comment on "Impact of the 2009 major stratospheric sudden warming on the composition of the stratosphere" *by* M. Tao et al.

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This paper describes the NH major sudden warming event of 2009 from a modeling and satellite observation perspective. The CLaMS model provides explicit information about the effects of sub-grid scale mixing and this is used to explain features in the trace gas correlations related to the MW seen in MLS measurements and CLaMS output. The description of the dynamical evolution of the NH stratosphere from the tropics to the pole before and after the MW is interesting and well done. The description of the evolution of the N2O-O3 correlations related to this dynamical evolution is important but unfortunately is not described or shown well enough.

I have used tracer correlations extensively and appreciate their value but it took me

several readings to understand all of the features described in Section 5. This was due to a combination of not describing all of the features well, not showing the changes in the correlations clearly enough and not giving the reader enough motivation up front to make the effort to follow the description. Tracer correlations are not widely used and understood, even though they are powerful indicators of transport features. Extra help in guiding readers through this section is necessary if you want them to understand what you've done and how useful it is. Consistent translation between physical space and tracer correlation space is required throughout this section.

There are many grammatical errors and I have attempted to list the most obvious ones below. This made the paper difficult to understand in sections. I would suggest the authors perform a detailed grammar review before the paper is resubmitted.

Overall the paper describes interesting work and I suggest it is published after revision of Section 5 and grammatical improvements are made.

Specific comments:

Pg. 4384, line 8: using tracer-tracer correlations isn't really a "technique". I would remove that word and just say "tracer-tracer correlations and by..."

Pg. 4385, line 26: insert "the" before "Pacific"

Pg. 4386, line 2: remove "the" before "recent" and "10" after "recent"

Pg. 4386, line 8: change to ", which describes" after "advection"

Pg. 4386, line 9: "along a 3D", insert commas after "trajectory" and after "mixing". Add "which parameterizes"

Pg. 4386, line 10: remove "the" before "air"

Pg. 4386, line 21: remove "the" before "models"

Pg. 4388, line 9: change "at" to "on"

Pg. 4388, line 14: add "the" before "generation"

Pg. 4388, line 16: add "the" before "disturbance"

Pg. 4388, line 22: change "during" to "over"

Pg. 4388, line 25: change "at the end" to "in turn"

Pg. 4391, line 12: change "on" to "in"

Pg. 4393, line 22: change "altitudes" to "altitude"

Pg. 4393, line 23: add "mid-latitude" before "surf zone"

Pg. 4394, line 7: add comma after "easterlies"

Pg. 4394, line 27: Remove "Complementary," and change "illustrate" to "illustrates"

Pg. 4395, line 1: change "vertex" to "vortex"

Pg. 4395, lines 2 and 3: change "days" to "day"

Pg. 4395, line 24: remove "and" before "after"

Pg. 4396, line 3: add "shown" before "although"

Pg. 4396, line 24: add "of" before "picture", remove "does" and change "respond" to "responds"

Pg. 4396, line 29: change "Another important point is" to "This would help provide"

Pg. 4397, line 1: add "of" before "how" and remove "itself"

Pg. 4397, line 5: change "much" to "even" and add "so" after "more"

Pg. 4397, line 9: I'd suggest removing "technique" and just saying "correlations"

Pg. 4397, line 12: remove "the" after "shows", change "correlation" to "correlations", remove "the" before "MLS" and remove "a" before "probability"

Pg. 4397, line 14: change to "data cover the NH eq. latitudes..."

Pg. 4397, lines 20-21: change to something like "two stronger branches and one weaker branch of N2O-O3 correlations..."

Pg. 4397, lines 22-23: end sentence after "Fig. 7a". New sentence starts "These branches describe...", change to "...within the polar vortex, the surf zone and the tropics..."

Pg. 4397, line 25: remove "the" before "tracer-tracer"

Pg. 4398, line 1: remove "the" before "tracer-tracer"

Pg. 4398, line 2: change "Reversely" to "Conversely"

Pg. 4398, line 3: change "at the same time" to "following the MW"

Pg. 4398, line 5: change "will be" to "is"

Pg. 4398, line 13: change "Reversely" to "Conversely"

Pg. 4398, lines 20-25: This paragraph should be rewritten or at least another sentence or two added to make it more clear what you are describing. In line 20 I would change to "...range of potential temperatures are considered,..."

Pg. 4399, lines 14 and 15: remove "Similar", remove "same", add comma after "before"

Pg. 4399, lines 16-22: Need to more clearly explain why the tropical latitudes are excluded in the correlation plots. Also, should explain more clearly that the tropical correlation is seen in the non-mixing run because of the tropical air that has physically moved into the mid-latitudes and not been mixed. It helps to relate physical space to tracer correlation space as clearly as possible so readers can translate between the two more easily.

Pg. 4400, lines 1-2: This is really for the whole paragraph but you need to more clearly show in Figure 9 how the non-mixing correlations cannot be reconciled with

observations. I have more suggestions on how to change the figures below.

Pg. 4400, line 3: change "trajactories" to "trajectories"

Pg. 4400, lines 8-10: The isentropes move upward in tracer space but not in physical space. This is another place where you should be clear so that it is easier to translate between what is happening in physical vs. tracer correlation space.

Pg. 4400, lines 16-28: This discussion of Figure 10 and how descent affects the tracer correlations should be moved after the discussion of Figure 9a1-c1 on Pg. 4401. The best flow of the discussion would be to first compare Figure 7 to Figure 9a1-c1 since those correlations should be the most similar. I would also strongly suggest that you combine Figure 7 with Figure 9 so that it is easier to compare the MLS correlations with the CLaMS correlations.

Pg. 4401, line 1: What does "very similar" refer to here? Similar to what?

Pg. 4401, lines 7-8: Not sure what is meant by the mid-latitudes "do not undergo further descent". There is descent in the mid-latitudes all winter isn't there?

Pg. 4401, lines 11-12: The effects mentioned here aren't well discerned in Fig. 9. The changes in the correlations are subtle on plots of this size so lines need to be added to better compare between them. You could add the three main branches in Fig. 9a1-c1 onto 9a2-c2. You could add the main branches in MLS onto Fig. 9a1-c1. Something like this needs to be done to make the subtle shifts in the correlations more obvious.

Pg. 4401, line 14: change "(by far more)" to "mostly", "mid-latitude" is misspelled, add "some" before "tropical"

Pg. 4401, lines 19-21: Again, this slight shift is too hard to see in the figure. Need to add some lines to help guide the reader.

Pg. 4401, lines 2-5: This sentence is too long, needs to be broken up. Also, what are the "highest values" that are referred to here?

C771

Pg. 4401, line 6: change to "warm winter in 2008/09, few PSCs. . .", remove "subsequent,"

Pg. 4401, line 21: change "the" to "a", change "latitude" to "location"

Pg. 4401, line 25: change to "detail similar to Crutzen. . ."

Pg. 4403, line 1: remove "other"

Pg. 4403, line 3: change "Contrary" to "In contrast

Pg. 4403, line 4: change to "a most probable location of"

Pg. 4403, line 8: change "here" to "in this part of the tropics"

Pg. 4403, line 9: change to "investigated whether the", change "has" to "had"

Pg. 4403, line 23-24: change to "which resulted", "upwelling through late March"

Pg. 4404, lines 8-9: change to "MW, triggered by"

Pg. 4404, line 10: add "been" after "have"

Pg. 4404, line 20: change "the order of" to "a"

Pg. 4404, line 24: add "us" after "allow"

Pg. 4404, lines 26-27: remove "a" before "significant", add comma after "loss"

Pg. 4405, line 12: remove "exemplary"

Pg. 4405, line 15: change to "correlation, which disappears. . ."

Pg. 4405, lines 21-22: change to "is it the N2O or the. . .", "an impression of how. . ."

Pg. 4406, lines 1-4: remove "Complementary," end first sentence with "are also used." Then start with "An ACE profile crossed the potential temperature surfaces. . .on this day (red circles are the profile. . .". Remove "as well as the corresponding CLaMS profiles before and after applying the averaging kernel"

C772

Figures 7 and 9 should be combined so that the MLS correlations are on the top row and it is easy to compare among all the correlation plots. Clearly label on the left side of each row that it is MLS, CLaMS with mixing and CLaMS without mixing. Add correlation lines from similar plots such as was done in Fig. 11 for easier comparison.

Figure 12: Why is the bottom right plot so different from Fig. 9c1 or 9b1? Those plots are all from a similar time period and the plots in Fig. 9 do have a polar correlation.

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