

## ***Interactive comment on “Stratospheric and tropospheric SSU/MSU temperature trends and compared to reanalyses and IPCC CMIP5 simulations in 1979–2005” by A. M. Powell Jr. et al.***

**A. M. Powell Jr. et al.**

jianjun.xu@noaa.gov

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### Response to Referee #1

Interactive comment on “Stratospheric and tropospheric SSU/MSU temperature trends and compared to reanalyses and IPCC CMIP5 simulations in 1979–2005” by A. M. Powell Jr. et al. Anonymous Referee #1 Received and published: 13 February 2013  
General comments: This paper shows that the selected CMIP5 models consistently capture such important climate features as the stratospheric cooling trend due to anthropogenic emissions, the stratospheric warming episodes due to volcanic eruptions, etc. However, authors have misused the CMIP5 data in sections 3.1, 3.2 and 5a as far

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as the El Niño/La Niña signals are concerned. Thus, the manuscript requires a major revision before publication.

Specific comments: 1. Authors seem not to take account of “unforced variability” in CMIP5 models, which was expounded in Taylor et al. (2012) as follows. “In addition to responding to “external” forcing (attributable both to natural causes, such as volcanic eruptions, and to anthropogenic activities, such as fossil fuel burning), climate exhibits variations solely due to internal interactions within the complex nonlinear climate system. These unforced variations must be taken into account to sensibly analyze the CMIP5 output. Examples of quasi-regular internal climate variations of this sort are the El Niño events, the North Atlantic Oscillation (NAO), and, on shorter timescales, the Madden–Julian oscillation (MJO). There are, however, other variations occurring on a variety of time scales that may be much less regular (e.g., a record cold December). A realistic climate model should exhibit internal variability with spatial and temporal structure like the observed. In the long-term simulations, however, the timing of individual unforced climate events will only by coincidence match observations. For example, the El Niño years in a “historical” climate simulation will rarely (and only by chance) coincide with years when El Niños have actually occurred. This is because the historical runs are initiated from an arbitrary point of a quasi-equilibrium control run, so internal variations (even if they were perfectly predictable) would not be expected to occur at the same time as those found in the observational record. Analysts comparing model simulations with observations should take this expected discrepancy into account and not naively attribute it to model errors. In contrast, in the AMIP simulations, sea surface temperatures are specified, based on observations, which guarantees that the occurrences of simulated historical El Niño events coincide with observations. In these runs it is possible to directly compare with observations a model’s atmospheric manifestations of El Niño conditions, but agreement will still be limited by atmospheric variability not tightly coupled to SSTs.”

response:

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Yes, I agree with the comments. But I didn't take out internal variability from the CMIP5 output. The purpose in this study is to evaluate the capability of CMIP5 model in the "historical" climate simulation through comparison with the "historical" observation and reanalysis data. I accept the comments for the limitation of Climate model simulation in the El Niño events. We removed the discussion related to El Niño events in the revised manuscripts in section 3.1 and 5.1

2. The interpretation of Table 3 in section 3.2 was misleading. High correlations between SSU/MSU and CMIP5 climate models are related with the cooling trends, i.e., positive anomalies in the earlier half/part of times series and negative anomalies in the later half/part of time series. What do authors mean by "It is clear that the selected seven CMIP5 climate models effectively reproduced the time variation of the global mean stratospheric temperature in the upper stratosphere"? Trend in the raw (non-stationary) time series or variability in the detrended time series?

Response: The correlation is based on the raw time series, the high correlation is dominated by the same temperature cooling trend. So we change the "It is clear that the selected seven CMIP5 climate models effectively reproduced the time variation of the global mean stratospheric temperature in the upper stratosphere" into "It is clear that the selected seven CMIP5 climate models effectively reproduced the trends of the global mean stratospheric temperature in the upper stratosphere"

Technical corrections: P3957: "and compared to" : "in comparison with" Modified

P3959, L2: Delete "in the middle-upper atmosphere" In 1987, Andrews, D. G., J. R. Holton, and C. B. Leovy clarified the distinction between the middle and upper atmospheres as follows. "The atmosphere is conventionally divided into layers based on the vertical structure of the temperature field. These layers, the troposphere, stratosphere, mesosphere, and thermosphere, are separated by the tropopause, the stratopause, and the mesopause. In the past, meteorologists often designated the entire region above the tropopause as the 'upper atmosphere'. Only fairly recently has the term

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'middle atmosphere' become popular in referring to the region from the tropopause to the homopause (at approximately 110 km). In this part of the atmosphere, eddy processes keep the constituents well mixed and ionization plays only a minor role. It is this region of the atmosphere that is the concern of this volume. The upper atmosphere will here be defined as the region above the homopause, where molecular diffusion begins to dominate over eddy mixing so that constituents become separated vertically according to their molecular masses, and increased ionization makes electromagnetic forces significant in the dynamics. This distinction between the middle and upper atmospheres is now widely accepted, although the term 'upper atmosphere' still appears fairly frequently in reference to the stratosphere and mesosphere. Thus, the 'Upper Atmosphere Research Satellite (UARS)' is actually designed primarily for observation of the middle atmosphere. However, there can be little doubt that the name 'middle atmosphere' will eventually become the standard term for describing the layers of the atmosphere between about 10 and 100 km." This reviewer would like authors to follow the well-accepted terminology.

Thank you very much, please check the fixed parts in the revision

P3959, LL2-6: "defined by the layers from the middle troposphere to the upper stratosphere. These layers receive a great deal of attention in the climate change community, because these trends, anomalies, and variations provide evidence of natural and anthropogenic climate change mechanisms" : "characterized by the layered structure from the middle troposphere to the upper stratosphere, which has received a great deal of attention in the climate research community. These trends and variations provide an insight into natural and anthropogenic climate change mechanisms (Eichelberger and Hartmann 2005; Ueyama and Wallace 2010; Young et al. 2011; Young et al. 2012)" Eichelberger, S. J., and D. L. Hartmann, 2005: Changes in the strength of the Brewer–Dobson circulation in a simple AGCM. *Geophys. Res. Lett.*, 32, L15807, doi:10.1029/2005GL022924. Ueyama, R., and J. M. Wallace, 2010: To what extent does high-latitude wave forcing drive tropical upwelling in the Brewer–Dobson circula-

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tion? J. Atmos. Sci., 67, 1232–1246. Young, P. J., D. W. J. Thompson, K. H. Rosenlof, S. Solomon, J. Lamarque, 2011: The Seasonal Cycle and Interannual Variability in Stratospheric Temperatures and Links to the Brewer–Dobson Circulation: An Analysis of MSU and SSU Data. J. Climate, 24, 6243–6258. Young, P. J., K. H. Rosenlof, S. Solomon, S. C. Sherwood, Q. Fu, J. Lamarque, 2012: Changes in Stratospheric Temperatures and Their Implications for Changes in the Brewer–Dobson Circulation, 1979–2005. J. Climate, 25, 1759–1772.

Modified

P3959, L6: “the variation in the upper atmosphere”: “the variations in the stratosphere”

Modified

P3959, L8: Please list “Amplifying the Pacific Climate System Response to a Small 11-Year Solar Cycle Forcing” by Meehl et al (2009) in the reference.

Modified

P3959, LL10-11: “The largest climate change program, the Intergovernmental Panel on Climate Change (IPCC)”: “The World Climate Research Program (WCRP)” Please refer to Fig. 1 in Taylor et al (2012) and <http://www.sparc-climate.org>

Modified

P3959, L12: “in the upper atmosphere”: “in the stratosphere” Modified

P3959, L16: “Charlton-Perez et al., 2012”: The title of their paper has been changed into “On the lack of stratospheric dynamical variability in low-top versions of the CMIP5 models”. Authors should correct it accordingly in P3974, LL22-23.

Modified

P3959, L18: “in the upper atmosphere”: “in the upper stratosphere”

Modified

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P3959, L24: “understanding”: either delete “understanding” or change it into “to understand”

Modified

P3959, L26: “the set”: “a set”

Modified

P3960, L17: “application”: “quality”

Modified

P3960, L22: delete “for”

Modified

P3960, L25: “popularly”: “widely”

Modified

P3961, LL12-15: “an investigation of the temperature trends in the middle-upper atmosphere from the middle troposphere to the upper stratosphere using satellite observations, reanalyses and the CMIP5 simulations was undertaken using the same way for analyses”: “a comparative study on the temperature trends from the middle troposphere to the upper stratosphere among satellite observations, reanalyses and the CMIP5 simulations was undertaken methodically”

Modified

P3961, L21: “To assess the middle-upper atmospheric temperature trends”: “To assess the temperature trends from the middle troposphere to the upper stratosphere”

Modified

P3963, L20: “(1860–2005)”: “(1850–2005)”

Modified

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P3963, LL21-24: "The CMIP5 models chosen for this analysis were those where the model tops were 10 hPa or higher and provided sufficient height in the stratosphere to test the value of the data from the SSU.": "The tops of the CMIP5 models selected in this study are located at 10 hPa or higher, enabling the comparisons of the model results with the SSU data". By the way, are you sure that 10 hPa or higher is sufficiently high when you compare the model results with SSU3?

Modified

No, I don't think the 10 hPa or higher can sufficiently describe the SSU3, but it can be partially used to represent the SSU1.

P3964, LL3-5: "To facilitate intercomparison of the same type of data, the pressurelevel CMIP5 model simulation and reanalysis data are converted to layer temperatures based on. . .": "To facilitate the intercomparison study, the pressure-level CMIP5 model results and reanalysis data are converted to the equivalent brightness temperatures based on. . ."

Modified

P3964, L16: Delete "on the time variation" Modified

P3964, L22: ", the data changes with each different vertical layer": "for six different vertical layers" Modified

P3964, L25: "trend rate": "trend at a rate" Modified

P3965, LL20-23: "For the CMIP5 simulations, all seven of the selected climate models reproduced the temperature variability in the stratosphere (Fig. 3a-d) except the MRI-CGCM3 overestimated the temperature response to the Mt. Pinatubo volcano in 1991-1992." Those models can indeed capture the temperature variations in the stratosphere due to the external forcings. Do you also imply that the selected climate models reproduced the INTERNAL temperature variability in the stratosphere? If yes, why?

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We didn't do any analysis for the internal variability in these selected CMIP5 models, in which the "historical" simulation included all external forcings. But it is good suggestion to go back to discuss the internal variability in these climate models for the next work.

P3965, LL23-25: The interpretation/method is problematic (see general and specific comments).

Modified

P3965, L25: "El Niño/El Niña": "El Niño/La Niña": Modified

P3968, L26: "contrained to": "confined in" or "constrained to" Modified

P3969, L2: "Arctic": "Antarctic" Modified

P3974, L2: "out of phase or opposes": "opposite to" Modified

P3978: "MERR": "MERRA" Modified

P3979, L2: "mode": "model" Modified

P3979, L6,L9, L14: "lan": "land" Modified

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 3957, 2013.

Revised manuscript was attached here

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/13/C208/2013/acpd-13-C208-2013-supplement.pdf>

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 3957, 2013.

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