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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Middle atmosphere response to the solar cycle in irradiance and ionizing particle precipitation" *by* K. Semeniuk et al.

Anonymous Referee #3

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General comments:

This study investigates the effects of energetic particle precipitation due to aurora, solar proton events, and galactic cosmic rays in the chemistry climate model CMAM. Additionally the effect of the solar cycle with and without the particle events is studied and it is concluded that the particle effect modulates the solar cycle effect such that the temperature and ozone variations are closer to observations. At the end implications for surface temperature variations due to water vapour changes and hence radiative forcing with the solar cycle are discussed.

The paper presents a very nice and comprehensive overview of the three particle ef-

fects in addition to solar cycle effects. This is original and has not been done before with any other chemistry climate model. However, I have a few concerns (outlined in my specific comments below) that need to be taken into account before I can recommend publication. The presentation of the results is lengthy and makes it difficult for the reader to follow the main points. Additionally, at many places speculations are presented that are not proven by the paper results and a number of recent publications that deal with some aspects of this study are not cited.

Specific comments:

Page24855_Line1-11(P24855-L1-11): a recent review on solar influence on climate is presented in Gray et al. (2010), Rev. Geophys., 48, RG4001, doi:10.1029/2009RG000282

P24855-L16: The influence of the EPP component of the solar cycle on the troposphere is not as solid as you state here. As an example, a quote from the Gray et al. (2010) paper:

"Similarly, there is currently little clear evidence that EPPâĂŘNOx can significantly perturb the stratosphere outside of the polar vortices, except perhaps during the very largest events [Thomas et al., 2007; Damiani et al., 2006; Ganguly, 2010]. Some sensitivity studies using CCMs suggest that EPPâĂŘNOx effects on ozone at low latitudes may be comparable to the effects of solar UV radiation [Callis et al., 2000, 2001; Langematz et al., 2005; Rozanov et al., 2005]. However, analysis of UARS Halogen Occultation Experiment (HALOE) NOx data over a 12 year period indicates no decadal NOx variations at low latitudes that could significantly affect the solar cycle variation of global ozone, and this conclusion is consistent with a more recent CCM simulation by Marsh et al. [2007]. In summary, there is currently little evidence that the EPPâĂŘNOx mechanism has a sufficient influence on stratospheric ozone and circulation that could significantly perturb tropospheric climate."

Can you please comment and explain this precisely in your text. Especially, the work

of Callis et al. is quite controversial. Please comment.

P24856_L13/14: the study of Langematz et al. (2005) also discussed this, see paragraph above.

P24857_L5: You refer to the paper by Austin et al. (2008) throughout your study. There is an update on some of the work presented in Austin et al. (2008) with the CCMVal-1 model runs now with the CCMVal-2 model runs in the SPARC CCMVal report (2010): http://www.atmosp.physics.utoronto.ca/SPARC. Please include this.

P24857_L11ff: There are a few papers by the EMAC/Mainz people on single EPP effects that have to be mentioned here:

A. J. G. Baumgaertner, P. Jöckel, M. Dameris, and P. J. Crutzen, 2010: Will climate change increase ozone depletion from low-energy-electron precipitation? Atmos. Chem. Phys., 10, 9647-9656.

A. J. G. Baumgaertner, P. Jöckel, H. Riede, G. Stiller, and B. Funke, 2010: Energetic particle precipitation in ECHAM5/MESSy – Part 2: Solar proton events, Atmos. Chem. Phys., 10, 7285-7302.

A. J. G. Baumgaertner, P. Jöckel, and C. Brühl, 2009: Energetic particle precipitation in ECHAM5/MESSy1 – Part 1: Downward transport of upper atmospheric NOx produced by low energy electrons, Atmos. Chem. Phys., 9, 2729-2740.

Are you aware of the comprehensive paper on model intercomparison with respect to a strong SPE event, the Halloween storm in 2003, in preparation within the HEPPA initiative (Funke et al., 2010)? Although it is only one of the particle effects that you investigate it gives an idea about the performance of other models in comparison to observations and therefore about the reliability of the modeling results.

Another paper that needs some attention is the following:

Seppälä, A., C. E. Randall, M. A. Clilverd, E. Rozanov, and C. J. Rodger, Geomagnetic

activity and polar surface air temperature variability, J. Geophys. Res., 114, A10312, doi:10.1029/2008JA014029, 2009.

P24858: It would be very helpful to include a table with all the different model experiments, their settings and length as well as the number of ensembles. Also, if you would give names to the different experiments it would be easier to follow the description of the different experiments throughout the paper.

P24862_L10ff: Please include a little bit more on galactic cosmic rays and their potential impact on the atmosphere. This is highly discussed and speculative at the moment and needs therefore more attention.

P24862_L17ff: How reliable are these observations?

P24865_L116ff: too many abbreviations, please explain or remove

P24865_L26ff: You could mention explicitly that you use two orthogonal QBO terms.

P24866_L2: Why do you use the MEI index and not the Nino3.4? Does this make a difference?

P24866_L7ff: Did you test whether the Ap index gives a better fit for the auroral component?

P24866_L25: Why is the maximum temperature increase at 40km?

P24867_L4: To understand and judge the anomalies it would be extremely helpful to see the absolute pictures for the streamfunction but also for other dynamical and chemical species.

P24867_L9: I was confused by the order of the figures: Fig 4: JJA T, u, streamfunction Fig5: DJF Noy, Hox, O3 Fig6: JJA Noy, Hox, O3

After the dynamical impacts in JJA I would expect the chemical impacts in JJA first. Also, since you describe only one part of the figure per section (1. Aurora, 2. SPE, 3.

GCR) it would be more logically to group the figures together the way the text describes them. Alternatively, some of the text description can be shortened and a comparison of the three different particle events could be started.

P24867_L26: please rephrase “cannibalistic”, and spell out/explain “viz.”

P24868_L3: Why is this feature a remnant from the previous winter? Can you proof this? The next few sentences include a lot of speculation and should be carefully revised and rewritten.

P24869_R12ff: Do you have a reference for survival from the previous winter?

P24870_L1: “. . . below 20km”, what about anomalies above?

. . ._L3: Doesn’t figure 6 shows the chemical response?

. . ._L6: What does this mean? Latitudinally equal and vertically different?

. . ._L8ff: “This is consistent with. . ..” I do not understand this sentence, can you please rephrase.

. . ._L13ff: “In the NH winter...” Can you please indicate in brackets the respective Figure number (Fig. 5 or 6?) that you are talking about. This is just an example and applies to the whole text. Sometimes it is very difficult to follow the descriptions as you jump e.g. between Figs. 4, 5, and 6. Shortening of the Figure descriptions or indication of Figure numbers helps the reader to get through it.

. . ._L20ff: repetition from above

. . ._L25ff: again a lot of speculation! Also note, that the absolute ozone concentration in the troposphere is low and therefore percentage changes might be unusually large.

P24871_L8: “There is also a non-significant warming in the tropics. . ..”

. . ._L11ff: The warming at high latitudes around 40km doesn’t seem to be corresponding to changes in the Brewer Dobson circulation, please comment.

. . .L23: . . .” peaks around 60km. . .”, it is 50km according to Figure 3.

P24872_L4/5: Dynamical processes during SH summer? Please comment.

. . ._L7/8: “. . . in contrast to the case. . .” I don’t understand this.

. . ._L8ff: Please indicate where exactly the anomalies take place (height/latitude) here and anywhere else.

. . ._L10: “. . .large correlation. . .” positive or negative?

. . ._L13/14: “. . . but the difference is not so large. . .” to auroral effects, please add!

. . ._L17/18: “. . . so this feature is not simply a . . .” but what is it?

P24873_L2: “Vortex variability. . ..” Isn’t this a contradiction to the statement on page 24872 that SPEs are sporadic events?

. . ._L12: “The polar vortex weakens statistically significant. . ..”

. . ._L23: What does this imply?

. . ._L27: “. . . there is upwards. . ..” above 13km?

P24874_L6: How does the SH summer polar region exhibit dynamical variability? See also comment above.

P24875_L6: This is very weak and insignificant for SPEs.

. . ._L23: “. . .similar dynamical impact. . .” most pronounced for GCR (Fig.4).

. . ._L28: How long is the ozone memory?

P24876_L6/7: I don’t understand “left” and “right hand panels” for this plot.

. . ._L14/15: But the dynamical response is very different! Can you please comment.

. . ._L18: What do you mean with low amplitude regime? Please define.

P24877_L1: ".. individuell EPP types", this could and should be highlighted well before as stated in my comments above.

. . ._L15: the main results could be made clearer.

. . .L18: "A comparison of two of the combined EPP ensemble members. . .." Can you please highlight clearly what is shown here. The experiment table would help too.

. . ._28: change "left" to "upper" panel, and vise versa L29 (right->lower)

I find it surprising that there is practically no difference in the ozone response, although the dynamical response is quite different. Could you please comment.

P24878_L3: I don't understand this explanation

. . ._L15: highlight once more the solar cycle

. . ._L25: Is this plot necessary?

P24879_L13/14: "The solar cycle variation. . ...", this sentence is unclear to me

. . .L19: Wouldn't it be interesting to show the tropical increase?

P24880_L1: I assume that the regression is for annual means? If so, please add in the text and in the Figure caption.

. . ._L10: The pos. and neg. anomalies are not very clear.

. . ._L13: Why don't you use the solar max definition as before?

P24881_L16: ". . .during solar max years is not associated. . ." This is a very strong statement, shouldn't it be explained/motivated more?

. . ._L23: Please compare Fig 20 to observations (SPARC CCMVal report 2010)

. . ._L24: "It appears that. . ..." Not so clear to me. Shouldn't it be similar in 2000? Apparantly it is not similar.

P24882_L4: please refer to SPARC CCMVal report (2010)

. . ._L8ff: Please add more discussion on this (SPARC CCMVal, 2010) to make clear which factors are important, e.g. variable SSTs, QBO, time-varying vs. time slice

P24883_L2: ". . .did reach about 1.5% per. . .." Of H2O or what?

. . ._L4ff: This paragraph is unclear, please revisit other available literature

. . ._L24ff: "These chemical effects of EPP. . .." Not so clear from the results presented here.

P24884_L18: Do you talk about annual mean features?

. . ._L19: ". . . idealized picture of. . .." This sounds very negative, can you please find another explanation/wording.

P24885_L6ff: "The H2O variation . . ..." this is just a side note but should be highlighted more detailed.

. . ._L10ff: Which mechanisms are you talking about?

. . ._L13/14: "A significant feature. . ..." It is not new that changes at high stratospheric latitudes also impact tropospheric tropical circulation. See e.g., Kodera (2006), Influence of stratospheric sudden warming on the equatorial troposphere, GRL, 33, L086804, doi:10.1029/2005GL024510

. . ._22ff: Why don't you analyse this in more detail to test you mechanism?

Technical comments:

Figure 4: The contour range is strange and different for every plot, please adapt. The figure caption is confusing "Run mean, June-August mean differences. . .", could you please rephrase here and in all the other captions. Something like "Long-term June-August mean differences between aurora (left), . . . and the reference run . . .. You can again refer to the experiment table, so it gets clearer how many years, how many

ensembles of each run went into the differences. Of course this comment applies to all figure captions that have this formulation in it.

Figure 5: Again it is confusing that the range is different for each row. For GCR the scale goes from -100% to 1900 (???)%? Similar comments apply to all other figures that show these anomalies.

Figure 7: Why is this not in percent as all the other plots before?

Figure 17: "...between the two ensembles..." Can you please highlight again what is shown here, again you could refer to the experiment table and things are easier to understand.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 24853, 2010.