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Interactive comment on "NO_y production, ozone loss and changes in net radiative heating due to energetic particle precipitation in 2002–2010" *by* Miriam Sinnhuber et al.

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*The paper states that "Analysis of several decades of re-analysis data show a warming of the mid-to late winter upper stratosphere related to high geomagnetic activity (*Lu et al.*, 2008; *Seppälä et al.*, 2013*). These have been interpreted as a result of coupling between the vortex strength and wave propagation and reflection, an assumption strengthened by the apparent relation to the phase of the stratospheric quasi-biennal oscillation and the solar cycle (*Lu et al.*, 2008; *Seppälä et al.*, 2013*). However, our results suggest that the direct radiative impact plays a role as well."*

*As we write (about the upper stratospheric warming signal) in (*Seppälä et al.*, 2013*),*

the paper referenced here: "Based on earlier work by others, Baumgaertner et al. *(2011) suggested that the warming signal would be a result in decrease in ozone radiative cooling as a response to ozone depletion, and the cooling signal might arise from dynamical heating due to slowing down of the meridional Brewer-Dobson circulation. Such a reduction would be associated with less upward EP flux and more waves reflecting toward the equator [see (*Lu et al.*, 2008b), and references therein]. As discussed above, this is now confirmed by our EP flux results." (Discussion, last paragraph)*

*"These results confirm the previous hypothesis of (*Lu et al.*, 2008b) regarding the role of dynamics in coupling geomagnetic activity levels and stratospheric changes and supports the suggestion of (*Baumgaertner et al.*, 2011) about the dynamical coupling mechanism connecting EPP-NOx induced ozone loss, polar stratospheric temperatures, and the modulation of the Northern Annular Mode." (Conclusions, last paragraph)*

*This clearly shows that the role of the direct radiative impact in the upper stratosphere suggested here is in no disagreement by the works cited. Results of (*Lu et al.*, 2008) and (*Seppälä et al.*, 2013) both support the suggestion of (*Baumgaertner et al.*, 2011) (which is unfortunately not cited in the current paper in this context) that the upper stratosphere warming signal is related to the radiative changes arising from changes in ozone, exactly as proposed again here.*

*In summary, the results of the modelling work done here regarding the role of direct radiative impact do, in fact, strongly support the results of (*Lu et al.*, 2008; *Baumgaertner et al.*, 2011; *Seppälä et al.*, 2013). This agreement between the independent studies is important, and I would be grateful if the authors would correct their statement concerning this in the current paper.*

Thanks for pointing this out. We have included a reference to Baumgaertner et al. (2011) in the Conclusions and in the Introduction. The text in the Conclusions has been changed to

Analysis of several decades of re-analysis data show a warming of the mid-to late winter upper stratosphere related to high geomagnetic activity (Lu et al., 2008; Seppälä et al., 2013) which is also reproduced in model experiments using free-running chemistry-climate models (Semeniuk et al., 2011; Baumgaertner et al., 2011). Based on older model experiments by (Langematz et al., 2005), Baumgaertner et al. (2011) and Seppälä et al. (2013) argue that the warming in the upper stratosphere and lower mesosphere is consistent with a direct radiative impact, while a cooling of the middle and lower stratosphere observed at the same time, during mid-winter (DJF in the Northern hemisphere), is more likely the result of coupling between the vortex strength and wave propagation and reflection, an assumption strengthened by the apparent relation to the phase of the stratospheric quasi-biennal oscillation and the solar cycle (Lu et al., 2008; Seppälä et al., 2013). Our results are consistent with these earlier studies, and strengthen the assumption that the mid-winter warming is due at least partly to a direct radiative impact.

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