Atmos. Chem. Phys. Discuss., 11, C11094–C11097, 2011
www.atmos-chem-phys-discuss.net/11/C11094/2011/


Atmospheric Chemistry and Physics Discussions

# *Interactive comment on* "The Arctic vortex in March 2011: a dynamical perspective" *by* M. M. Hurwitz et al.

**M. M. Hurwitz et al.**

margaret.hurwitz@cantab.net

Received and published: 31 October 2011

We kindly thank this referee for his/her comments. Our responses directly follow each comment:

> The main limitation I see in this paper is in that "as far as it goes", i.e., it doesn't go very far. Why only examine March, when the 2010/2011 winter really appears much more anomalous when you consider the entire winter? Why examine only an average over a calendar month in which the temperatures were changing rapidly – what makes that an appropriate averaging period? And isn't the state of the lower stratosphere (vortex strength/structure, temperatures) earlier in the winter relevant to how the other processes examined may affect it by March? How well does classifying whole winters as QBO-easterly or westerly, or as having or not having a La Nina condition really



characterize the potential influence of those phenonena on a single month? I'm not suggesting that the authors need to address all of these questions in a major revision, but it would be good to at least acknowledge the scope of the study and put it in the context of the larger picture.

> Page 22115, lines 14-21: This would be a good place to give some of the context mentioned in the general comment above.

We have chosen to focus on March 2011, and the dynamical forcings leading the conditions in March 2011, because of the unprecedented ozone depletion observed during that month. As we state in the revised manuscript: "While the Arctic vortex was relatively strong throughout the Arctic winter, Manney et al. (2011) showed that the exceptional nature of 2010–2011 was not apparent until late February and March".

While we agree that temperatures and ozone chemistry changed rapidly in March 2011 (Manney et al., 2011), it is the cumulative planetary wave driving over many weeks that led to the anomalous conditions in March. The dynamical forcings that modulate planetary wave driving in winter (principally SSTs and the phase of the QBO) are slowly varying. Thus, we have chosen to examine these forcings and their stratospheric responses on monthly and seasonal (rather than submonthly) timescales.

February wave driving and March vortex strength are well correlated (with correlation coefficient of 0.75, as stated in the revised manuscript). Considering the planetary wave driving earlier in the winter does not improve the predictability of March conditions in the Arctic lower stratosphere.

> Page 22114, line 19 to Page 22115, line 2: The authors couldn't have known this before, but now that it is out, Manney et al, 2011, Nature would be an excellent reference for the unprecedented Arctic ozone loss in 2011.

We agree. In the revised manuscript, we defer to the detailed ozone analysis by Manney et al. (2011).

> Page 22115, lines 6-13: I think it would be useful in this paragraph to note explicitly that these are statistical relationships, that is, they don't imply that, eg, a cold vortex will *always* be associated with a westerly QBO phase or an El Nino condition.

We agree and have softened the wording of the relationships between ENSO, the QBO and Arctic vortex strength.

> Page 22115, line 27– 22116, line 12: The NCEP-2 reanalysis has been shown to a poor choice for studies of the polar lower stratosphere (for any stratospheric studies for that matter). The NCEP-1 and NCEP-CPC are also analyses that have been shown to have serious deficiencies for stratospheric studies. (E.g., Manney et al, 2005, JGR; 2005, MWR; several others both before and since these). Why weren't more "modern" reanalyses used (e.g., the MERRA reanalysis using GEOS-5.2.0, or the ECMWF's ERA-Interim reanalysis)?

March 2011 MERRA fields were not available when the original analysis was performed. In the revised manuscript, we have replaced NCEP-2 with MERRA (with the exception of the Arctic vortex breakup dates). The change in reanalysis datasets has a negligible impact on our results.

> Page 22116, line 22, "In March...more persistent" sounds a bit odd, since more persistent applies to time evolution rather than a particular time period.

We agree. In the revised manuscript, this sentence reads: "In 2011, the Arctic vortex was colder, stronger and more persistent than usual."

> Page 22117, line 5, The breakup dates we are discussing are most commonly in late March or April, which is "spring", not "late winter".

Thank you for this suggestion. We have changed the wording accordingly.

> Page 22119, lines 2-3: Please explain (and give references for) why "March lower stratospheric temperature and February planetary waving driving should be most influenced by SST variability in mid- to late winter".



We have removed this statement and improved the definition of the subarctic SST index.

> Page 22119, lines 15-18: Please explain how this relates to the results of, e.g., Orsolini et al, 2009, QJRMS; Nishii et al, 2010, GRL.

We have added material on the links between tropospheric circulation anomalies (i.e., blocking on the Far East and North Pacific, as discussed by Orsolini et al., 2009) to the Introduction. Also, we have expanded our discussion on the influence of North Pacific SSTs on tropospheric circulation in the North Pacific sector.

> Page 22120, lines 5-7: Do you come to the same conclusion about the heat fluxes in 1997 vs 2011 if you look at different time periods or levels above or below 100hPa? Likewise, were the March 1997 polar cap temperatures lower than those in 2011 at levels throughout the lower stratosphere (results in of Manney et al, 2011, Nature suggest this might not be the case)?

Figures 3a and 3b show that the zonal and monthly mean polar cap temperature in March was lower in 1997 than in 2011, throughout the lower and middle stratosphere. However, the results of Manney et al. (2011) suggest that the fraction of "low temperature air" (i.e., the capacity for Arctic ozone depletion) was higher in March 2011 than in March 1997, likely because the Arctic vortex was more isolated (i.e., higher PV gradient) in 2011 than in 1997.

---

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 22113, 2011.