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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Differences between the QBO in the first and in the second half of the ERA-40 reanalysis" *by* H. J. Punge and M. A. Giorgetta

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We thank the reviewer for his helpful comments and suggestions. Based on the suggestions of both reviewers, we decided to extend our analysis of the ERA-40 data using 7-year running means of annual and seasonal means and QBO amplitude in order to resolve the timing of the observed change in the composites. Relevant findings will be included in the final version to be submitted to ACP.

Reply to General Comments:

We can say that according to the new tests most of the difference between the two halves of ERA-40 is due to changes that occurred in the mid-1980s or thereafter. For this reason, consideration of rocketsonde data, available only until 1983, does not help

much with the interpretation of our findings. However, as Baldwin and Gray (2005) showed, ERA-40 data in the earlier years is generally consistent with Rocketsonde winds from Ascension and Kwajalein up to 2-3 hPa. Unfortunately, analysis of long term evolution is also inhibited by gaps in the record.

The referee also pointed on the SAO as a potential source for the observed changes. Indeed, we find that seasonal mean winds vary considerably and nonuniformly. Most prominently, in the solsticial seasonal (7-year running) mean zonal wind switched from easterlies to westerlies around 1985 for boreal summer and 1980 for boreal winter. The transition occured earlier between 10 and 5 hPa and is delayed above. These changes account for much of the change observed in the annual mean. They translate to a decrease in the SAO amplitude in the second half of the record.

We thank the author for drawing our attention to a study with similar findings for the NCEP reanalysis (Huesmann and Hitchman, 2003).

Reply to Specific Comments:

1. Similarly to Huesmann and Hitchman (2003), we find major changes in reanalyzed atmospheric conditions around 1980. No abrupt change is however found, and it is not straightforward to link our findings to the availability of satellite data from 1979 on. Further, we find a strong increase in the annual cycle strength of temperature in the early 1970s which corresponds to the start of VTPR temperature data assimilation from the NOAA-4 satellite. This may actually indicate the positive effect of enhanced data availability in the satellite era. Also, a decrease in lower stratospheric temperature in the mid 1980s towards the end of the record is found, in agreement with the findings of Huesmann and Hitchman.

2. We checked the validity of the thermal wind equation at the equator, and found a deviation between 5 and 2 hPa especially during 1982-1989 (which roughly corresponds to the time of assimilation of METEOSAT cloud motion winds) and a

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general increase of the deviation for the second half of the record for the equatorial upper stratosphere. In fact, this may be due to the mechanism proposed by the reviewer and Huesmann and Hitchmann (2003).

3. The computed running 7-year averages of both annual mean and QBO amplitude of the zonal wind show that much of the difference found in the composites is due to more westerly winds above 10 hPa during the second half of the 1980s and much of the 1990s. Regarding the SAO we wish to stress that the climatological mean SAO is removed before composite construction by subtracting the climatological monthly means. Therefore, only the interannual variation of the SAO is left in the composites. We do find a trend for the SAO amplitude to decrease after 1982, but since the climatologies were computed separately for the 1960-1980 and 1980-2000 periods, the effect should not be too large. On the other hand, for the separate seasons, there are considerable variations over the course of the record.

   The SAO is expected to play a major role with the explanation of our findings. Generally, longer data records would be required to study the interaction of QBO and SAO in more detail. Timing of the QBO onset of e.g. westerlies varies among time slices. For example, at 10 hPa, onset of westerlies occurs often in spring for 1980-1999 while it spreads over summer and fall in the earlier period. This explains the 6-month signal in the composite of Figure 1c.

4. As mentioned above, we found no evidence for a change in circulation precisely in 1978 but mostly later, particularly in the 1980s.

Reply to Technical corrections:

We thank the reviewer for careful reading and will correct these errors before submission of the final version of the article.

References:

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