

Review of “On the value of reanalyses prior to 1979 for dynamical studies” by Peter Hitchcock

This paper presents an interesting and carefully presented study of the value of reanalyses covering years before 1979 for use in certain dynamical studies. It merits publication, but would benefit from minor revision to take the following comments into account.

(1) Title. As the study deals mainly with stratospheric dynamics, and stratospheric sudden warmings in particular, the author should consider changing the title so that “dynamical studies” becomes “studies of stratospheric dynamics” or “studies of the dynamics of sudden stratospheric warmings”. The study does not present much evidence concerning tropospheric dynamics, nor does it reference results on tropospheric dynamics from other studies

(2) Page 1, line 3. The word “satellite” is rightly in inverted commas in the abstract. But it needs to be made clear in the body of the paper that the satellite era begins before 1979, and that it is a simplification, albeit a reasonable one, to refer to the period up to 1978 as the radiosonde era, and the period from 1979 as the satellite era. In practice (and as discussed by Uppala et al. (2005) for those observations used in ERA-40):

(i) The MSU and SSU sounding data that characterise the start of the “satellite” era are available from November 1978.

(ii) ERA-40 and JRA-55 assimilated radiances from the VTPR instrument available from late 1972 until early 1979.

(iii) ERA5 is currently assimilating BUV ozone data available from 1970. Ozone analyses provide implicit information on stratospheric dynamics.

(iv) Some cloud-tracked wind data from satellites are available and used prior to 1979.

(v) Satellite imagery was used by the Australian Bureau of Meteorology to generate pseudo surface-pressure observations that were assimilated in ERA-40 from 1972 to 1978, although these are not being used now in ERA5 to the best of my knowledge.

In addition, there are improvements over time to the observing system, as indeed discussed in the paper under review. It is perhaps worth noting in the paper that in the “radiosonde” era, and back to the late 1940s, soundings over the North Atlantic and (to a lesser extent) the North Pacific Ocean were provided from fixed-position weather ships that were retired once satellite soundings were shown to provide a sufficient alternative. This in part compensates for lack of satellite data in the earlier years for the northern hemisphere.

(3) Page 1, line 5. The word “could” should be avoided here. The paper demonstrates that the radiosonde era does extend the useful period of record back beyond 1979, so this should be made clear in the abstract. The sentence as it stands leaves the question still open.

(4) Page 1, Line 10. It is inappropriate to issue a blanket call for reanalysis centres to consider generating products prior to 1979. ECMWF did this for ERA-40, and is currently producing analyses from 1950 onwards for ERA5. ECMWF has also studied use of radiosonde and other upper-air data for the period 1939-1967 as reported in a paper by Hersbach et al. (2017, doi: 10.1002/qj.3040) that rather surprisingly is not referenced in the paper under review. JMA ran JRA-55 from 1958 onwards, and will soon start production of JRA-3Q, for which the plan is to start in the late 1940s. So these two major producers appear already to appreciate the value of products prior to 1979 – though further evidence as provided by the paper under review is always welcome.

(5) Page 2, line 8. It would be appropriate here to record that ECMWF is currently producing ERA5 reanalyses from 1950 onwards and that analyses from the late 1940s onwards are expected from JRA-3Q.

(6) Page 2, line 18. A reference to Hersbach et al. (2017) could be introduced here.

(7) Page 2, line 22. It could be referenced here that Simmons et al. (2005, J.Atmos. Sci, March) demonstrated that the ERA-40 reanalysis was of sufficient quality in January 1958 to produce a good five-day forecast of the split-vortex sudden warming that occurred during that month. Caveats were issued in this paper about the quality of the stratospheric analyses over the southern hemisphere prior to 1979, but these analyses nevertheless gave no indication of a major split-vortex event between 1957 and 1978 of the type observed in September 2002, a result consistent with analysis of the sparse radiosonde data available for the period.

(8) Page 5, lines 12 to 14. The text here needs revising. It refers to “uncertainties” in observations but “errors” in forecast models and the assimilation process. In reality there are errors in observations, and uncertainties in modelling and assimilation due to the stochastic nature of some of the processes being dealt with. So one should not use one word for observations and another for models/assimilation.

(9) Page 5, equation (2). The upper limit of the second sum on the left-hand side of the equation should be N_r not N_s .

(10) Page 6, lines 21 and 22. Same comment as (8) regarding the use of the words “observational uncertainty” and “errors in the forecast model and the assimilation process”.

(11) Page 7, line 6. The text on Fig5 refers to σ_{sat} and σ_{rad} , whereas Fig 7 and the text refer to σ_s and σ_r . This should be rectified.

(12) Page 7, line 16. The lack of a strong balance constraint is a reasonable explanation for the reanalysis uncertainty in the tropical upper stratosphere. But reanalysis uncertainty is much lower than dynamical variability at 10hPa and below. This is presumably because radiosonde data alone are quite effective in constraining the QBO in the lower and middle stratosphere in reanalyses. A comment could be added to this effect.

(13) Page 7, lines 17 and 18. Manney et al. (2005) is the reference the author chooses to use here. But the deficiency of ERA-40 under discussion was first identified in preparing a SPARC Report on stratospheric climatology, and this was published in a subsequent peer-reviewed paper by Randel et al. (2004), i.e. earlier than the Manney et al. paper. So Randel’s paper would probably be a fairer reference. The problem was also acknowledged in Uppala et al.’s (2005) write-up of ERA-40.

(14) Page 10, line 26. Delete the word “at”.

(15) Page 10, line 34. This is another place where a reference to Hersbach et al. (2017) could be added, as that paper discusses, *inter alia*, the utility of 1950s radiosonde data for analysing the QBO.

(16) Page 11, line 23. “following 1979” should at least be changed to “following 1978” and more precisely could be written “from late 1978 onwards”. The subsequent reference to radiosondes being remarkably effective in constraining the boreal stratosphere from 1958 to 1978 perhaps can remain as is, in view of the results of JRA-55C, even though VTPR data provide an additional constraint from late 1972. It perhaps should be recognised however that radiosonde observations continue to provide a constraint on the stratosphere from 1979 onwards. Satellite radiances (particularly from the TOVS instruments flown from 1978 until phased out between 1998 and 2006)

have significant biases, and radiosondes play an important role in the bias-correction schemes for radiance data used by reanalysis centres, at least prior to the availability of substantial amounts of GPS radio occultation data from 2006 onwards. The better-quality reanalyses produced for the period from 1979 onwards is due to the combined use of radiosonde and satellite data, notwithstanding the labelling of the period as the “satellite era”.

(17) Page 12, line 15. “be” should be “been”.

(18) Page 12, line 21. Some rewording is required here, as it is a bit misleading to categorize the sudden warmings in full-data reanalyses as a “result of assimilated observations”. They are a result of assimilating observations making use of a forecast model, and as such are a result of both forecast-model dynamics and assimilated observations. The reanalyses that assimilate only surface observations demonstrate that assimilating upper-air observations is important, but does not show that the forecast model is unimportant.

(19) Page 12, lines 22 to 25. Newer reanalyses apply bias corrections to radiosonde data (generally following the work of Haimberger), and assimilating the bias-corrected radiosonde data tends to control the biases of the reanalyses, at least in places and at levels radiosonde data are reasonably plentiful. No bias-correction of pre-1979 radiosonde data was applied in ERA-40, but the radiosonde data would nevertheless have limited systematic error in ERA-40 to some extent. A change is not called for at this point in the paper, but consideration could be given to writing something earlier in the paper on this point.

(20) Page 12, lines 29 and 30. Comment (4) above, concerning the final sentence of the abstract, applies equally to this final sentence of section 6.