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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Observing three dimensional water vapour using a surface network of GPS receivers" *by* S. de Haan and H. van der Marel

**S. de Haan and H. van der Marel**

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We thank the anonymous referee for his/her carefully reading the manuscript and thorough comments. We have considered all comments as valid and useful to improve the manuscript.

1) General comment: horizontal grids of 10-15 km:

With the data set at hand and used in this study the optimal (in accuracy and computation time) resolution of the 3DVAR system is 30 km. We agree with the referee that mesoscale analysis would be a major goal of a tomographic analysis system of GPS SWV. With the current density in the Netherlands (of around 50 km, with some close sites) a step in this direction could be made.

2) General comment: On the use of ECMWF+24 in the background characteristics

We calculated also the background error characteristics based on HIRLAM+06 based on the same 18 months period. The results are included in the revised manuscript and show no difference with the previous found background error characteristics. In the appendix of the revised manuscript a graph is shown with the values.

3) General comment: Manuscript style

We have updated the manuscript with the helpful "specific comments" of all referees.

Specific comments:

We have adapted comments: 2-13,18-25,27-35,37,38,46-55,57-71 by changing the text accordingly or adding some extra words.

Special attention was made to comments:

14: The quality of the GPS_ZTD estimate is indeed influenced by the type of orbit. The current processing scheme uses double differences which eliminates both the clock and receiver error. Our experience is that the quality of the GPS-ZTD estimate is practically the same for final and rapid orbits, and slightly reduced when the first 9 hours of the predicted orbits are used, but the quality will still be satisfactory.

15: We added a reference for more information (van der Marel, 2002) Proper modelling of covariances means taking into account the mathematical correlations due to the double differencing. The elevation dependent weighting is 1/cos(z)2. This weighting scheme has been verified using the least squares residuals. See also http://gnss1.lr.tudelft.nl/tough/datasets/2000_297-311/sres.html

16: Niell mapping functions are widely used and at the time of processing a very good choice. We acknowledge that better alternatives are available nowadays, e.g. the Vienna Mapping Functions (VMF).

17: We believe that these time scales are small because we have removed long pe-



**ACPD**

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riodic effects caused by carrier phase multipath and antenna phase center variations in the multipath mapping. So what remains is mainly carrier phase noise and high frequency multipath, which will be reduced by averaging over 5 minute intervals. However, due to the differencing process, or estimation of clock offsets for that matter, correlations between stations will remain and continue to have an effect. This is inherent to the GPS technique.

26: We removed the words concerning this point.

36: Systematic errors are independent of site, site separation etc. These errors could be originating from erroneous satellites, ocean loading satellite positions etc. and would show up as a offset at large distances. This is not observed in the figures.

39: The quality control is based on the requirement that the standard deviation in 5 minutes of ZTD mapped to the zenith is smaller than 12 mm.

41: We changed the phrase "realistic error" into "Gaussian noise"

42: We added some words on this; it could be useful to include artificial errors on the lateral boundaries.

45: We believe the thruth is "wetter" than the analysis could be due to the difference in orography of the ECMWF nature run and the HIRLAM analysis.

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Interactive comment on Atmos. Chem. Phys. Discuss., 8, 17193, 2008.