Atmos. Chem. Phys. Discuss., 8, S7740–S7744, 2008
www.atmos-chem-phys-discuss.net/8/S7740/2008/

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

Anonymous Referee #3

Received and published: 1 October 2008

General comments

A system for 3-dimensional assimilation of ground based Slant Water Vapour (SWV) and Zenith Water Vapour (IWV) GPS measurements is presented. Simulated and real data are assimilated and the impact of using SWV observations is discussed. The assimilation of ground based GPS measurements for nowcasting and short-term prediction is within the scope of ACP. However, there are some major issues that should be fixed before the manuscript can be published in ACP:

Background error covariances: Background error covariances for operational ECMWF 24-hour forecasts are constructed by means of the well established method of

Hollingsworth and Lonneberg, using radiosonde observations from a time-span of 18 month. However, these forecasts are used as a background only in one part at the beginning of the study, while there are three different additional background fields employed later on:

- 6-hour forecasts from nested HIRLAM model integrations
- previous 3D-Var analyses based on GPS IWV observations
- previous 3D-Var analyses based on GPS IWV and SWV observations

Generally, it might be acceptable to use an approximation of background error covariances as a start, but the assumptions and approximations made should be discussed and justified. Especially, the case where only GPS IWV observations are assimilated is problematic because here, the true background error might be expected to grow substantially larger than the background error actually used. Preferably, I recommend to estimate separate background error covariances for the various background fields used within this study.

Spatial resolution: Two referees already commented on the issue of spatial resolution. I agree with their conclusions. Especially the assimilation of simulated observations has been conducted with a spatial resolution that is by far to coarse to draw any conclusion on the additional benefit of GPS SWV observations. I recommend to conduct additional simulations with increased resolution of the analysis grid.

Manuscript style: The manuscript should be revised in order to improve understandability and clarity of the text. Please, see the list of specific comments below.

Specific comments

1. Page 17194, line 18: The notation “with persistence as background” is (to my knowledge) not an established term in data assimilation literature. Please consider using something like “with the previous analysis as background”.

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2. Page 17196, line 15-17: It is not only the data itself that determines the detectability of small scale structures, but in the first place, the spatial resolution of the analysis grid together with a realistic specification of background error covariances. Hence, this statement should be justified somehow or deleted from the manuscript.

3. Page 17200, lines 18-19: Should it read “the vertical coordinate is in metres”?

4. Page 17201, line 14: The definition of p_n is not very precise. What does “position at the middle of level n” mean?

5. Page 17202, line 13: What do you mean by “at least 24h ECMWF forecasts”? In order to derive valid background error covariance statistics for 24h forecasts, it is necessary to use 24h forecast only.

6. Page 17202, line 15-16: I do not understand the meaning of “significant levels”? What are “vertical levels” in connection with radiosondes?

7. Page 17202, line 24-26: The first sentence is a repetition (see line 14). The other information from this paragraph belongs to the description given just a few lines above (lines 14-16).

8. Page 17204, Subsection 3.2: The purpose of this section remains somewhat vague to me. Is it to demonstrate that the observation minus background differences show a normal distribution? Are the extreme outliers excluded from further processing? What is the reason for mapping the differences to the zenith? The section title “Slant observation error covariances” does not seem to be appropriate, as the section does not deal with SWV error covariances. You state that the mapped differences have a normal distribution. This should be demonstrated by fitting a normal distribution and displaying it together with the original distribution in Figure 5.

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9. Page 17204-17205, Subsection 3.3: I do not understand the logic behind the argumentation that systematic GPS ZTD errors are small. Could you please explain this point more extensively? You assume an observation error variance of 2.5 kg m^{-2} at zenith elevation based on the distributions between GPS SWV and NWP SWV mapped to the zenith. The statistics of these differences is determined by both, background and observation errors. How do you justify to take the variance of the distribution of these differences as the observation error variance?

10. Page 17206, Section 4.1: The background for the SIM-GPS experiment is a nested HIRLAM run. Is the nesting sequence the one that is shown in Figure 1? In Figure 1 the area of the smallest nest does not coincide with any of the two analysis grids. Can you, please, briefly describe how the background values for the analysis grid are derived from background (interpolation, averaging,...) for the two different analysis grids?

11. Page 17224 and 17226, Figures 4 and 6: Obviously, you use different networks of GPS stations and radiosondes to generate these figures, but this is not mentioned anywhere.

Technical corrections

1. Page 17202, line 10: replace Hx with $H(x)$

2. Page 17213, line 3 and page 17232, Figure 12: The symbols in the figure are triangles, but are said to be stars in the text and the figure caption.

3. Page 17223, Figure 3: The figure caption says that ECMWF 12h forecasts have been used, while in the text it is stated that ECMWF 24h forecast have been used to generate background error covariances.

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4. Page 17226, Figure 6: The figure caption refers to (a) and (b), but in the figure itself there are no such labels.

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