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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

Anonymous Referee #2

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General comments:

A least square fitting procedure for ground based GPS zenith/slant water vapour observations to retrieve the three dimensional water vapour field is described. Experiments with simulated and real data are performed. The difference in the impact of assimilating zenith and slant integrated water vapour measurements is discussed. The use of ground based GPS measurements for numerical weather prediction is within the scope of ACP. However, I recommend some major changes before the manuscript can be published.
The most important issues are:

-It is concluded that the used network was too sparse to detect water vapour inversion correctly. In the manuscript I do not find a justification for this statement. If this hypothesis is left in the manuscript it must be substained by a simulation.

-The model resolution in the experiments is quite coarse to draw a significant conclusion regarding the difference in the impact of IWV and SWV assimilation. I recommend to perform additional experiments (for example the two days discussed in the manuscript 2003/05/03 and 2003/05/22) with a horizontal resolution in the order of < 20km to assess impact.

Specific comments:

p17194 line22: In the abstract it is mentioned that the used network was too sparse to detect water vapour inversion correctly. However, it will depend on horizontal and vertical resolution, the background error covariances, etc too. Did you make additional experiments with a more dense network, where inversions were introduced at correct locations? The statement must be substained in the manuscript by an experiment or simply removed.

p17196 line 15: You mention that fine scale structure (inversion?) can be generated by background error covariances. This is correct. In this context I do not understand the following statement:'The data used here are not able to detect such fine scale structure and therefore flow-dependency of the error structure will have a minor effect in the results presented here.' This statement in this context is confusing.

p17196 line 18: 'Ha et al. (2003) performed experiments in a convectively unstable region' (not stable). At his point you should point out what makes your study special (as compared to Ha et al. for example) a.) you use real GPS SWV data and b.) you make statistics (a long time series). To my knowledge, it is the first time that real SWV

ACPD

8, S7539–S7542, 2008

data are assimilated on a (more or less) statistical significant basis. This should be highlighted.

p17197 line 15: You mention that the effect of bending can be neglected for elevation higher than 10°. Please provide a reference.

line 13: I do not understand Eq. 1. Isn't it: $STD = \int (n-1)ds + \int ds - \int dg$ with s the actual signal path and g the geometric ray path form the receiver to the satellite (see e.g. Hoffmann-Wellenhof et al. 2001).I guess you neglect $\int ds$-$\int dg$ and assume $s = g$? The SWV computation in model grid point space is not clearly described. Please provide some additional information. (see also the comment on p17201 line12)

line 23: The same symbol STD is used for Eq.4 and Eq.6 but the equations obviously differ. I propose to skip Eq.4 since at this point it does not bring anything.

p17198 line 15: Please provide a reference for the Niell mapping functions.

p17199 line 13: Please specify the 'estimated parameters' (at least the most important ones). Are xs and xr position errors, and tr and ts clock errors? What is A?

p17200 line 12: The conversion factor k appearing in Eq. 8 (slant case) is the same as in Eq. 5 (zenith case)? I am not familiar with the conversion factor in the slant case. Please provide a reference.

p17201 line 12: The elevation angle you use depends on location. Do you account for both, curvature of earth and bending of the signal path?

p17203 line 23: As you mention, an exponential decay is not uncommon. Please provide some reference (e.g. Daley).

p17206 line 20: Please specify the month.

line 24: What are realistic errors? Please specify.

p17207 line 23: A horizontal resolution of 110km is quite coarse to study the difference

ACPD

8, S7539–S7542, 2008

between the zenith and the slant case. With a resolution of 110km the signal path is more or less in the same vertical column, especially close to the ground. The azimuthally asymmetric features of atmospheric water vapour which might be present in the SWV data is difficult to extract with such coarse resolution. It should be mentioned in the manuscript at some point. What do you mean by 'solitary'?

p17208 line 23: The standard deviation of the SWV experiment is indeed smaller than in the IWV experiment. You mention that this shows the potential of SWV observations. How many IWV and SWV observations do you use? Is the weighting (and therefore the forcing towards the observations) in the SWV experiment larger due to more observations?

p17210 line 13: The biases might exist due to differences between actual and modelled orography. Some GPS receivers in your study seem to be located in more or less complex terrain. Do you observe biases at these locations?

p17216 line 27: As you mention, the assimilation of slant measurements might profit from a more dense network. However, it is important to note that the background errors as well as the ability of the model to generate an inversion at correct location is of particular importance. It is not only a matter of the network design. Some more comments in this context are necessary.

Technical comments:

p17197 line 17: Please specify the constants in the equation, i.e. Rd and Rv.

p17202 line 10: Change Hx to H[x]

line 13: Explain abbreviations, i.e. 4DVAR and ECMWF.

p17203 line 6: 'course'?

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