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Atmospheric Measurement Techniques Discussions

Interactive comment on "On the accuracy of integrated water vapor observations and the potential for mitigating electromagnetic path delay error in InSAR" *by* D. Cimini et al.

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Below, reviewer comments are reported in black while our replies in red.

The manuscript provides a detailed comparison of different measurements and models of the atmospheric integrated water vapor (IWV). This inter-comparison is particularly rich (data from four different sources and two types of meteorological models), all performed in a restricted area (Roma, Italy) and during a restricted period of time, which allow the authors to perform a triple collocation analysis between the various IWV sets and thus analyse relative scaling factors and variances. Assessment of the accuracy on IWV sets is of primary importance for using them in DInSAR applications, and for

other measurements based on the electromagnetic wave delay trough the troposphere. The paper is well written and informative. As such, this work appears rather unique and worth being published with minor revisions.

We thank the reviewer for his/her positive feedback.

Dry delay: the delay versus elevation due to variation of T stratification (Temperature lapse rate) induces non negligible phase delay patterns in interferograms (Doin et al., 2009). The term d(dry delay)/dz can be related to P0,T0 and dT/dz through the hydrostatic equation, but dT/dz is not so "easily predicted". The related paragraph in introduction could be changed accordingly, and values for typical variability of d(dry delay)/dz in Roma area should be given (possibly negligible there if dT/dz and T0 variations are small).

The reviewer is correct. We have inserted these information in the introduction, better specifying the difference between the so-called "dry" component and the "hydrostatic" component related to the surface pressure, which was not very clear. However, though we concur that the hydrostatic (and/or dry) component is an important issue to be faced for correcting InSAR, especially for compensating the height dependent path delay due to stratification, this paper focuses on the wet delay component and in particular on the related variable IWV, whose importance is not limited to InSAR applications.

Data set: Please only cite the data acquisition from the metawave project used in the paper. It will be easier to follow.

Agreed. We removed PTU, LIDAR and CMR from Table 1 and from the list in Section 2. We just mention the CMR network within the text and refer to the companion paper Sahoo et al., 2011 for further details.

GPS: How are the ZTD, ZWD, ZDD computed? Different methods are cited in the literature with different claimed accuracies. Are the Vienna Mapping function used for example?

ZTD were computed using the Bernese software package. The main processing steps implemented in the Bernese Processing Engine (BPE) script were:
- Code processing for clocks estimation (station by station)
- Network graph definition using a minimum distance algorithm by single difference setting up
- Single difference cycle slips identification and estimation
- First baselines estimation in a ambiguities float, ionospheric free estimation
- Ambiguities fixing with QIF (Quasi Ionospheric Free) strategy
- Final multibase estimation in a ambiguities fixed, ionospheric free solution
- ZTD estimation station by station (also considering horizontal gradient modelling) every 30 minutes.

Concerning the mapping functions, the dry-Niell in conjunction with the wet-Niell mapping function implemented in the BPE were applied. From ZTD estimated by GPS, the ZWD component was obtained by subtracting the zenith hydrostatic delay (ZHD). ZHD was predicted using time and spatial co-located measurements of surface pressure. IWV values were then obtained from ZWD using the relationship IWV = P x ZWD. The factor P was estimated by a regression analysis using a large set (more than 6000 samples) of ZWD and IWV data from the ECMWF analysis around the area of Rome during the period September-October 2008, introducing an error within 1% in IWV.
We have added information on the processing software and mapping functions in Section 3.

Figure 1: Replace with two dedicated subfigures (not google earth), with scales indicated, and with all labels used in text (PDM, DIESAP for example).

Agreed. We replaced Figure 1 with one panel indicating the scale and with all the labels used within the text. Since we have now removed CMR from the instruments' list (see above), the second panel, showing the urban scale of Rome, is not longer useful.

Map comparison of IWV for MM5 and ECMWF: Using ECMWF, due to the knowledge of vertical stratification, one can compute the IWV as a function of elevation at a

much finer spacing than the coarse ECMWF grid. Of course this vertical stratification varies laterally with the 25km grid ECMWF resolution. Could you please change Fig 5a with a figure where elevation is taken into account to compute IWV. The patterns then may appear much closer to MM5 and MERIS. Comments on text could then be added/changed.

The reviewer is right; coupling the information on vertical stratification at 25km from ECMWF with higher resolution DEM, IWV can be estimated at the DEM resolution. The so-obtained IWV shows patterns that are closer to MM5 and MERIS, especially where the orography is complex. This can be seen in the figure below, which could replace Fig.5a as the reviewer suggested, where we used ECMWF profiles at 25km and MM5 DEM at 1 km. However, this is not a product of ECMWF and it needed some post-processing; to avoid confusion, we prefer to show the ECMWF product (i.e. leave Fig. 5a as it is) and mention this possibility within the text.
Hopefully this satisfies the reviewer's comment.

Technical comments :

Abstract:

analised: ==> analysed

Agreed. We thank the reviewer for spotting this typo.

"the sensitivity to water vapour....": this sentence is not clear and should be re-written: It is not here a problem of "sensitivity" or accuracy of measurements of IWV with respect to InSAR, but on the stochastic nature of turbulent atmospheric contribution that would need a measure of IWV patterns at the same time and spatial spacing as InSAR (if I understand correctly).

Agreed. The sentence has been rewritten as follows: "The present analysis concludes that the requirements for mitigating the effects of turbulent water vapor component into InSAR are significantly higher than the accuracy of the instruments analyzed here."

This suggests that, even if one of these instruments would have the same time and spatial sampling as InSAR, its accuracy may not suffice to meet the requirements for direct InSAR water vapour effect mitigation.

Introduction:

sismic ==> seismic InSar ==> InSAR

Agreed. We thank the reviewer for these suggestions.

Methodology:

The paragraph "It must be considered ....soil moisture estimates" could, in my opinion, be reduced.

Agreed. Two full sentences have been removed (reducing the paragraph by 6 lines), without altering the meaning significantly.

Integrated water vapor:

"The two panels show..." ==> "the top panel shows.."

Agreed. We thank the reviewer for this suggestion.

I did not really understand the difference between IWVi and IWVm, may be reformulate? IWVm is an average stratification for a long period of time ?

Correct: IWVi is the “instantaneous” spatially averaged stratification, while IWVm is an average stratification for a longer period of time (i.e. 2 weeks). We have reformulated and added this information when dIWVi and dIWVm are introduced.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 839, 2012.

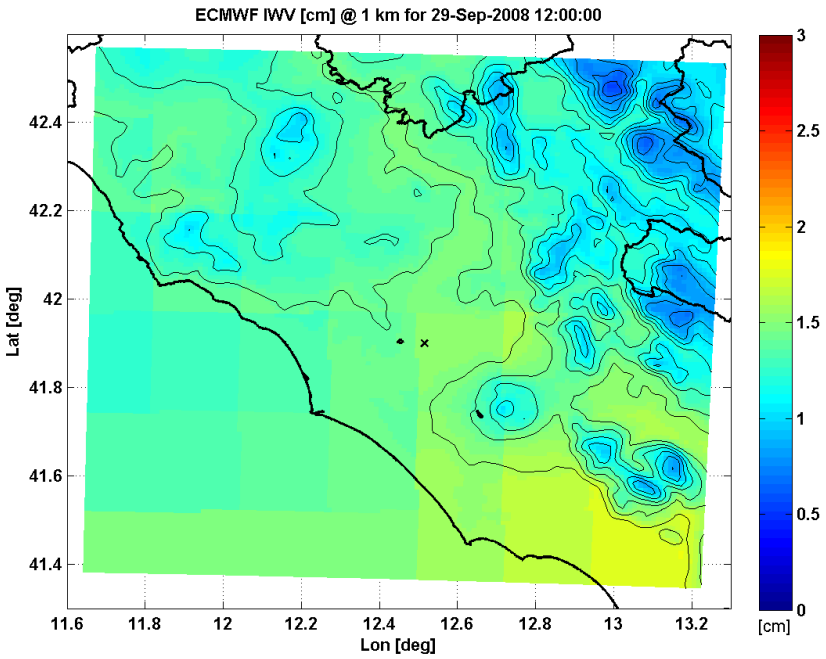

Fig. 1. IWV map estimated from ECMWF profiles at 25 km and DEM at 1 km resolution