Comparison of tropospheric delays from Raman lidar, radiosondes, GPS and DORIS during the MANITOU experiment

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Abstract

Water vapor measurements from a Raman lidar (RAMEAU) developed con-
jointly by IGN and LATMOS/CNRS are used for documenting water vapor heterogeneities in the lower troposphere and correcting geodetic radio-signal propagation delays in clear sky conditions. This instrument has both capabilities for realizing zenith pointing and slant pointing measurements.

During fall 2009, the system was deployed in Toulouse (France) in collaboration with Météo-France, IPGP and CNRS for an experiment devoted to investigate the impact of water vapor heterogeneities on the propagation of DORIS and GPS signals and subsequent position estimates.

The Manuscript experiment

We focus on observations retrieved by the following instruments:

- Lidar : We only interest in lidar measurements realized in zenith pointing mode. Measurements are done during 9 nights from 23 Sept. to 15 Oct.
- Radiosoundings : 4 kinds of radiosoundings are used during the experiment:
  - Vaisala RS92 sondes (3 per lidar sessions)
  - Modern M2K2 sondes (2 soundings : 28 & 29 Sept.)
  - Modern M2K2-DC sondes (2 soundings : 28 & 29 Sept.)
  - Meteorlabor Snow-white sondes (SW ; 1 sounding ; 29 Sept.)
- GPS : Analysis is done in PPP mode using Gipsy-Oasis II 5.0 and a standard
  estimator minimizing biases due to low photocounts in the nitrogen channel [Bos-
  ser et al., 2007].

Calibration is provided by different means: fit to radiosonde data or ground-
based sensor, or estimated during GPS data reduction [Bosser et al., 2009].

The agreement between WVMR profiles retrieved by lidar and collocated radio-
soundings RS92 and Snow-white are rather good up to maximum range with a very
similar sensing of the different inversion layers. M2K2 and M2K2-DC sondes are
shown to strongly overestimate humidity in the upper layers.

Lidar water vapor mixing ratio profiles

The RAMEAU lidar collects Raman-shifted backscattered signals in a water vapor channel (408 nm) and a nitrogen channel (387 nm). The Water Vapor Mixing Ratio (WVMR) is derived from the ratio of these signals using a special estimator minimizing biases due to low photocounts in the nitrogen channel [Bosser et al., 2007].

FIG. 1 : Data availability during the Manitol campaign.

FIG. 2 : WVMR profile retrieved during the 26 Sept. lidar session: comparison of profile from lidar, and the different available radiosoundings: RS92, Snow-white, M2K2 and M2K2-DC.

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Zenith Wet Delay retrieval

FIG. 4 : Evolution of ZWD from the different techniques during the whole experiment: GPS (TLMF & 24 h analysis), DORIS, lidar and Radiosoundings (RS92, M2K2, M2K2-DC and SW sondes).

Lidar and GPS ZWD agree at the mm-level. A strong bias between lidar and radiosoundings is observed, maybe due to bias affecting this kind of sondes. Differences between lidar and DORIS show pretty good agreement despite of higher fluctuations.

FIG. 5 : Comparison of ZWD from the different techniques with respect to lidar Radiosoundings (RS92 sondes), GPS (TLMF & TLMF-6th analysis on lidar sessions) and DORIS. Error bars represent variations at the one-

level. The number of data pairs is indicated in brackets.

FIG. 6 : Height repeatability for the stations TLMF and TLMF computed using the 2 analysis strategies on the nine 8-h sessions.

Impact of lidar measurements on GPS analysis

FIG. 3 : Lidar WVMR profiles evolution during the 26 Sept. - session

The evolution of the mixing ratio profiles observed by lidar gives an interesting view into the evolution of the nocturnal atmospheric boundary layer. This product can be an important additional information source for wet delay evolution investi-
gation.