High resolution GPS tomography during COPS: Overview and perspectives

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Why GPS water vapour measurements?

1- Additional all weather capable dataset with good temporal sampling for CI case studies (Samiro Khodayar Poster).

2- Impact of GPS data assimilation in numerical modeling: need to determine the best GPS network configuration for future operational QPF (Olivier Caumont presentation).

3- Synergy between the GPS tomography and the profiling instruments (RS, LIDAR, IASI)
The COPS GPS Network

Things done:
- 25 GPS (20 Fr. et 5 All.) installed during COPS
- ~80 GPS on a large COPS area
- A regional network (50 km)
- A E-W dense profil (10 km)
- 3 months of continuous measurements
- About 15 people participated to the field experiment
- All the ZTD data processed and available
- IWV, SWV and tomography available: please ask for
Bias GPS / Radiometer: 0.56 kg/m² at supersite M (AMF)
RMSE GPS / Radiometer: 1.14 kg/m² at supersite M (AMF)
Bias GPS / RS: 1.35 kg/m² at supersite V (Poster of P. Bosser)
RMSE GPS / RS: 1.24 kg/m² at supersite V (Poster of P. Bosser)
In fact, additional \textit{vertically resolved} measurements needed (RS)

\[ \Delta L_{ij} \]

\[ \rho_i \]

\[ SWV_j \]

\[ \text{Satellites GPS} \]

\[ \text{Stations GPS} \]

\[ \text{Gradient humide} \]

\[ \text{Integrated Water Vapor} \]

\[ \text{Slant Integrated Water Vapor} \]

\[ \text{mI} \]

\[ \text{Résidus} \]

\[ \text{Récepteur GPS} \]

\[ \text{Satellite GPS} \]

-> Tomography is the combination of all water vapor measurements to retrieve the 4D water vapor field
Previous tomography studies

First attempt of GPS tomography during ESCOMPTE in south France (Marseille):
- very dense GPS network (5 km) but small extend (25km²) and no CI case

Second attempt during IHOP:
- Very good CI cases, mesoscale GPS network but sparse (40 km)
Champollion et al., QJRMS, 2008, accepted.

And COPS ?
- Both mesoscale (40 km) and local (10km) GPS Network
- Good CI cases
- Ground-based and airborne LIDAR data for validation

The main questions:
- What kind of water vapour heterogeneities GPS tomography can retrieve ?
- As radiosoundings measurements must be used in the GPS tomography, When and Where?
Tomography setting

- 3D water vapour field retrieved each hour.
- Vertical resolution of 250 to 500 m in the lowest levels
- Horizontal resolution of 10 km between the supersites (EW profile), 50 km in the whole COPS domain
Horizontal and vertical water vapour heterogeneities: Mountain slopes winds (1)

Airborne LIDAR measurements over the Vosges mountains (15/07:1300UTC)
Horizontal and vertical water vapour heterogeneities: Mountain slopes winds (2)

Very similar pattern in tomography and lidar: both east-west and vertical water vapour variations

![Airborne LIDAR](image1)

![Tomography](image2)

\[\text{Rapport de mélange (g/kg)} B2007703151300. 2\]

\[\text{vertical lat: 48.6}\]

\[\text{g/m}^3\]
Horizontal and vertical water vapour heterogeneities: Mountain slopes winds (3)

At 0600 UTC the 15 June,
Start of slopes winds in the Vosges

At 1300 UTC the 15 June,
- Slopes winds still more active in the Vosges
- No more water vapour in the Rhine Valley
Vertical heterogeneities only: dry layer (lids)

Airborne LIDAR measurements over the Vosges mountains and the Black forest
(26/07:0800UTC)
Vertical heterogeneities only: dry layer (lids)

! Different units!

similar pattern in tomography and lidar:
but only one dry layer retrieved by the tomography
Conclusion and future work

**Processing**
- Process the all COPS period (three months)

**Quantitative Validation**
- Extensive validation of the GPS data processing (all radiometers and RS available, GFZ processing)
- Statistical GPS tomography validation: Ground-based LIDAR
- Cases validation: airborne LIDAR

**Cases studies**
- Mountain slopes dynamic -> influence on the water vapour field and CI (both Vosges Mountain and Black Forest)
- Dry layer dynamic during COPS: impact on CI
- Convergence lines -> influence on the water vapour field and CI

**Methodology studies**
- Best GPS / RS network for tomography and assimilation -> towards HYMEX SOP
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- Secretaries of SA and IPGS
- Field participants (Diana, Sophie, Myrto, Phillipe, Joel, Pascal, Cécile, Caroline, Bernard, ...).
- GPS data providers: Orphéon, RGP, GFZ, Engref Nancy, SwissTopo
- Meteorological surface data providers: Météo-France, SwissMeteo, DWD
- GM and GA for free GPS rent, IPGS for technical help.