MULTI-CONSTELLATION GNSS TOMOGRAPHY FOR ACCURATE IONOSPHERIC IMAGING

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Motivation: Why use multi GNSS?

• Number of satellites in view is a limiting factor for the spatial resolution of your image.

• Combining multiple constellations will increase the number of satellites.

• Goal: to demonstrate the improvement from GPS-only to GPS+GLONASS+Galileo tomography.
Ionospheric tomography

• Total Electron Content (TEC) measurements as line-integral data.

• By inversion, 3 or 4 dimensional ionospheric maps are obtained.

• Data coverage is essential.

MIDAS

Multi Instrument Data Analysis Software: Software suite that uses available GNSS data to image the ionosphere.

Simulation
Simulation method

- 60 simulated receivers. Emulated STEC measurements obtained by integrating satellite-to-receiver paths through known ionosphere (IRI).
- Measurements used as input in MIDAS. 3-D electron density images are obtained.
- Vertical TEC from the reconstructed images are compared to the vertical TEC from the known ionosphere (IRI).

- Different resolutions and number of constellations.
- **Aim**: Test if the addition of GLONASS and Galileo brings any improvement to images in terms of:
  - Accuracy
  - Resolution.
Real observations
Multi GNSS measurement coverage

- 20 + 7 multi GNSS receivers, all of them tracking the 3 constellations.
- Observations from 1-5 January 2019.
- More measurements available, why not use them?
Multi GNSS tomography: Experiment

- MIDAS electron density videos with:
  - GPS-only/Multi constellation in a **low resolution** grid (4 by 4 degrees resolution)
  - GPS-only/Multi constellation in a **high resolution** grid (0.5 by 0.5 degree resolution)
- Vertical TEC and Slant TEC are analysed.
Multi GNSS tomography: VTEC Results

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GPS-only

Low res.

Multi-GNSS

High res.
Multi GNSS tomography: STEC Results

- 7 receivers left out of the inversion process and used as validation.
- Daily DCBs were calculated from MIDAS, and applied to calibrate the STEC measurements of these receivers.
- Calibrated TEC were compared to STEC integrated through the reconstructed images.
Conclusions

• **Multi-GNSS integration** for ionospheric tomography has been demonstrated.

• **Multi constellation tomography can significantly improve** the accuracy of high-resolution electron density images compared to GPS-only tomography.
Future work

• Case-study with denser receiver network.
• Image MSTID in the ionosphere.
• Add more constellations (e.g. BeiDou).