Inversion Methods for Tropospheric Water Vapor Retrieval by means of a Constellation of LEO Satellites: the SATCROSS Contribution

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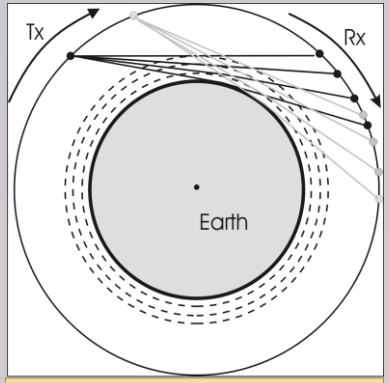
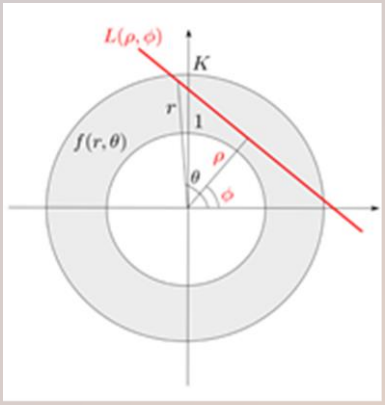
- Normalized Differential Spectral Absorption (NDSA): active measurement method that estimates the integral Water Vapor (IWV) along a microwave link propagation path
- Necessity of (tomographic) inversion methods to achieve the water vapor (WV) spatial distribution
- The SATCROSS project (funded by Italian Space Agency, ASI) investigates on an acquisition system composed of a constellation of Low Earth Orbit (LEO) satellites with transmitters-receivers (Tx-Rx) operating in the K and Ku bands
- The specific geometry of the system fits the so-called *external reconstruction* problem, proposed for the inversion of the Radon transform (represented here by the IWV measurements) when it is available only in the external part of a body
- In this study, we investigate on the application of the External Reconstruction Tomographic Algorithm (ERTA) to the IWV inversion problem and compare its performance with that of already proposed methods based on Least Squares with Tikhonov Regularization (LSATR)



Co-rotating LEO satellites



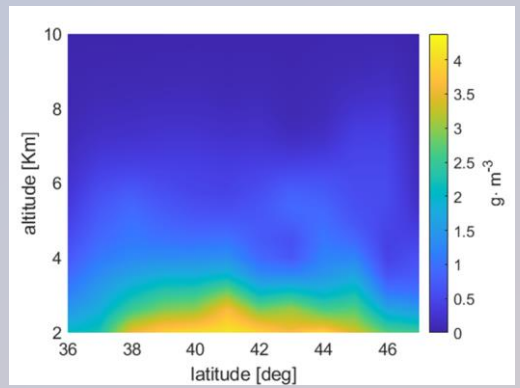
The geometry of ERTA (normalized with respect to Earth radius)

Reconstruction example

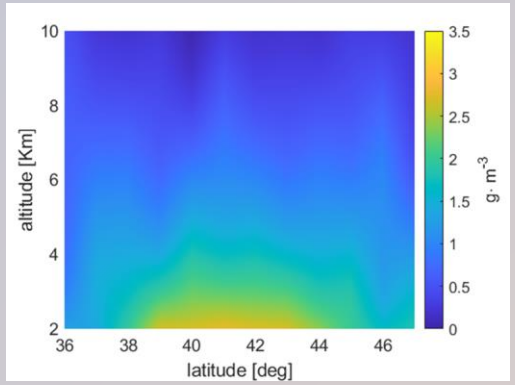
Analysis of 27 July 2020 03:00pm

- We used ‘true maps’ generated through the WRF (Weather Research and Forecasting) numerical weather prediction model, initialized with the IFS (Integrated Forecasting System) model of the ECMWF, with a vertical sampling interval of 125 m and a horizontal sampling of 3 km

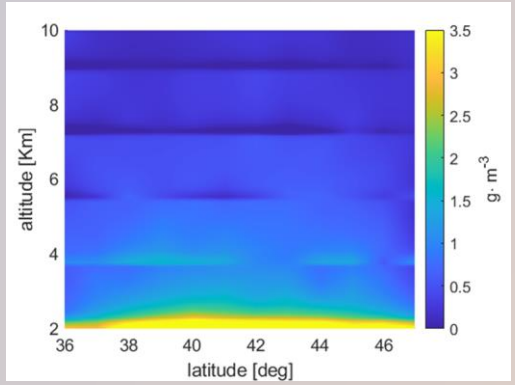
- Acquisition system parameters:
  - 1 Tx satellite and 5 Rx satellites;
  - Satellite altitude equal to 273 km;
  - Constant angular speed with a revolution period of 90 min;
  - Integration time at the receiver: T_s = 1 s.
  - Transmitted power: 3 dBW for each of the two NDSA tones;
  - Tx and Rx antenna gain: 26.4 dB
  - System temperature: 25.3 dBK
  - Scintillation amplitude (on each NDSA Rx tone): 0.3 dB
  - Scintillation correlation coefficient (between the two tones): 0.85
  - Scintillation bandwidth: 0.1 Hz



True map



ERTA



LSATR