GNSS-based remote sensing: Innovative observation of key hydrological parameters in the central Andes

N. Antonoglou[1,2], B. Bookhagen[1], F. Hongn[3], A. Güntner[1,2], M. Ramatschi[2], T. Symeonov[3,4], A. de la Torre[5], J. Wickert[2,6]

M. Asgarimehr[2,3]

[1]Institute of Geosciences, University of Potsdam, Germany, [2]German Research Centre for Geosciences GFZ, Germany, [3]Universidad Nacionale de Salta, Argentina, [4]Deutscher Wetterdienst,German, [5]Ingeniería, Universidad Austral, Argentina, [6]Technische Universität Berlin, German

antonogl@gfz-potsdam.de

Outline

- Motivation
- Objectives
- GNSS remote sensing advantages
- Estimation of integrated water vapour
- Estimation of soil moisture
- Pilot stations in Germany
- Current work
- Conclusion

Motivation

- Landscape diversity
- Transition from tropical climate to desert climate
- Large spatial and temporal climate variations
- Integrated water vapour and soil moisture are the most important parameters

Credits: Google Earth

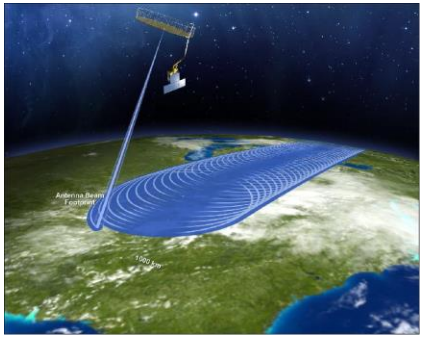
Objectives

- Installation of GNSS stations and in-situ soil moisture sensors
- Test of low-cost GNSS receivers along with commercial ones
- Use of data from pilot stations in Germany for testing
- Provision of independent solutions using GNSS data
- Integration with SAR images in the solution
- Comparison with global climate models
- Interpretation of the impact of the results in the environment

Why GNSS?

- **Classical methods:**
- Robust results
- High temporal resolution (in some cases)
- Very low spatial represantibility
- Pricey

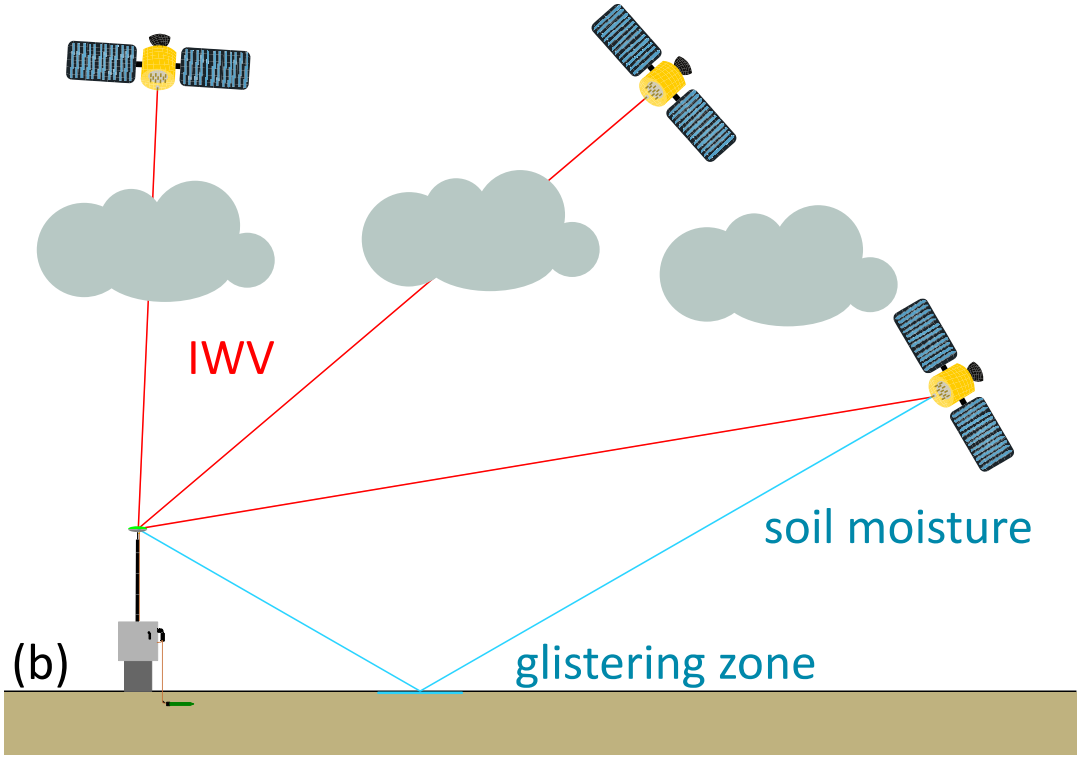
- **Satellite methods:**
- Lower accuracy
- Low temporal resolution
- Very high spatial represantibility



Credits: GFZ, Trübner, NASA, ESA

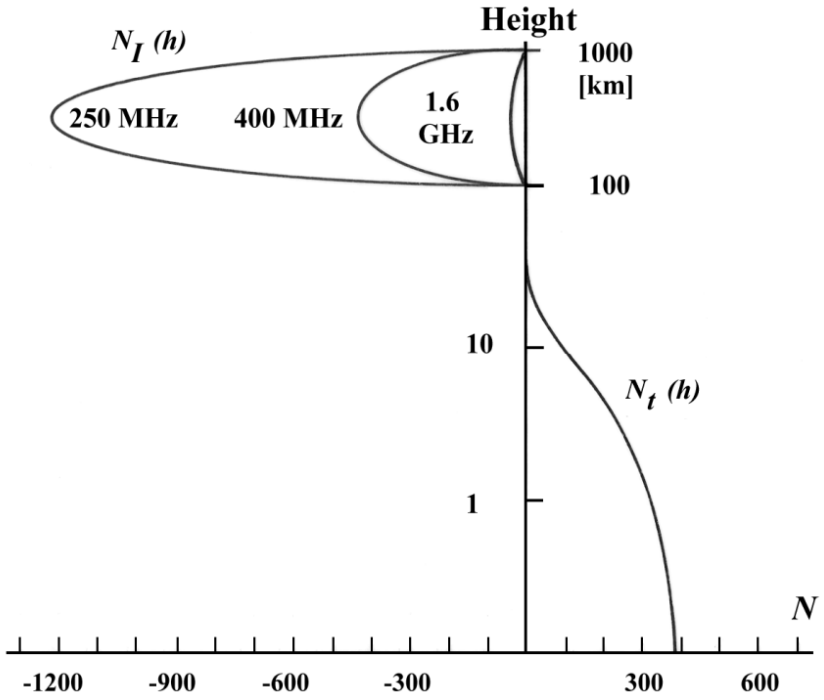
Why GNSS?

- **GNSS remote sensing:**
- High temporal resolution
- Optimal spatial represantibility for agriculture
- Cost-effective
- Big room for improvement



Integrated Water Vapour

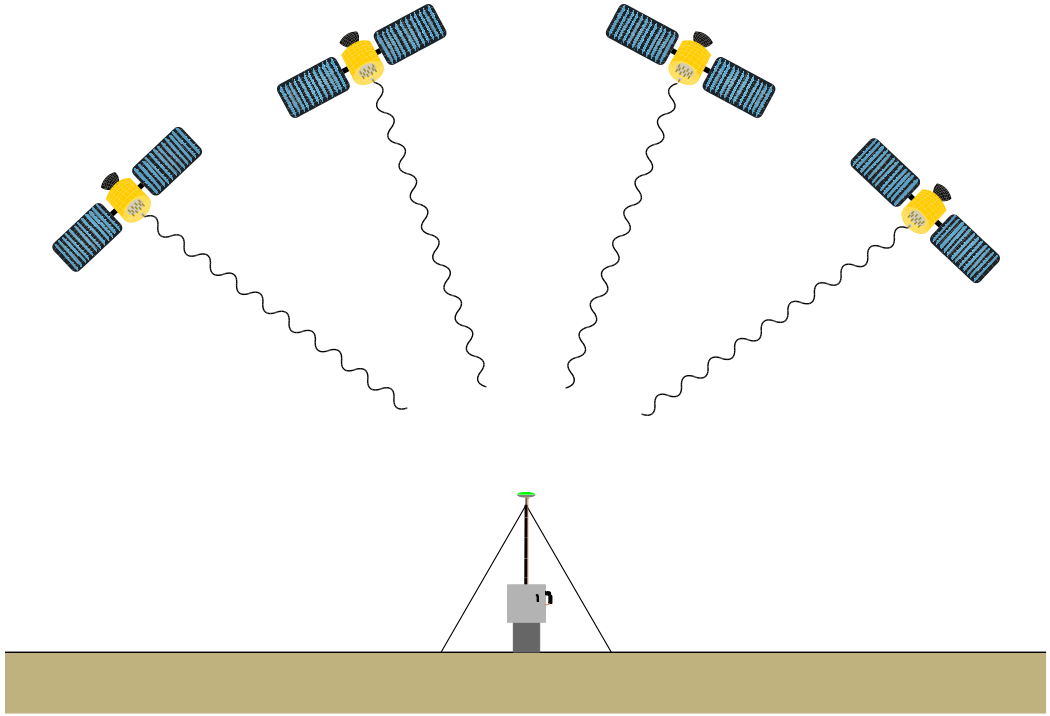
- Electromagnetic wave propagating through Ionosphere and Troposphere
- The ionospheric delay is dependent on the frequency
- The tropospheric delay gives information about the water vapour



Credits: J. Wickert

Integrated Water Vapour

- Isolation of the tropospheric delay
- Separation into dry and wet component
- Calculation of water vapour from the wet counterpart



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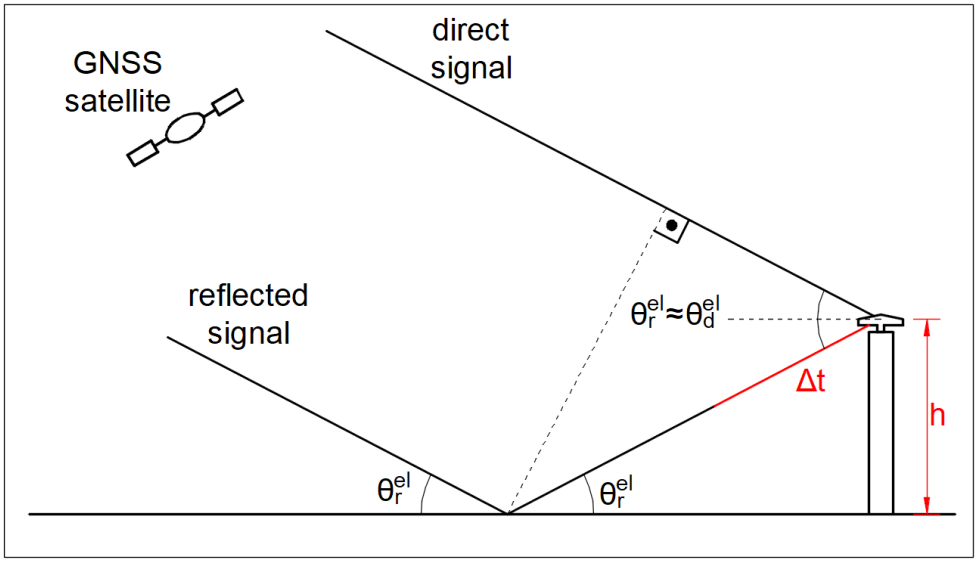
$$L_r^s = \rho_r^s + (u_r - u^s)c - I_r^s + Z_r^s + \lambda(\alpha_r - \alpha^s + N_r^s) + \epsilon_\Phi$$

$$Z_r^s \rightarrow Z_{rD}^s(p,h,T) \quad Z_{rW}^s \Rightarrow IWV = \Pi(T) Z_{rW}^s$$

Soil Moisture

- The antenna receives the direct and the reflected signal
- The interference creates specific patterns in the SNR observations
- The patterns are modeled into a sinusoidal function
- The initial phase is dependent on the penetration of the reflected signal
- The penetration is related with the dielectric properties of the soil → soil moisture estimation



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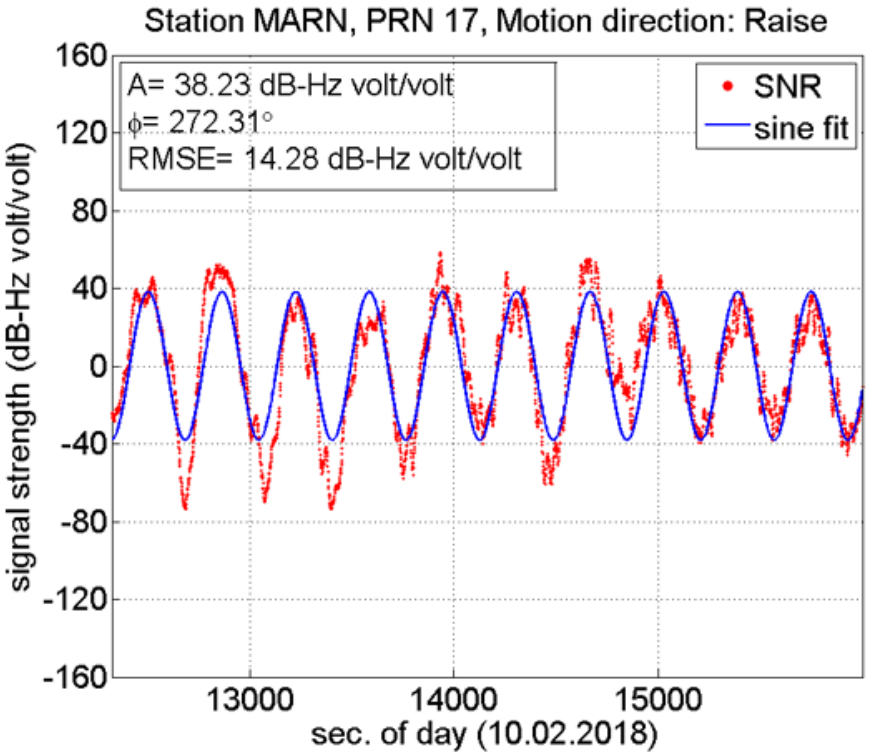
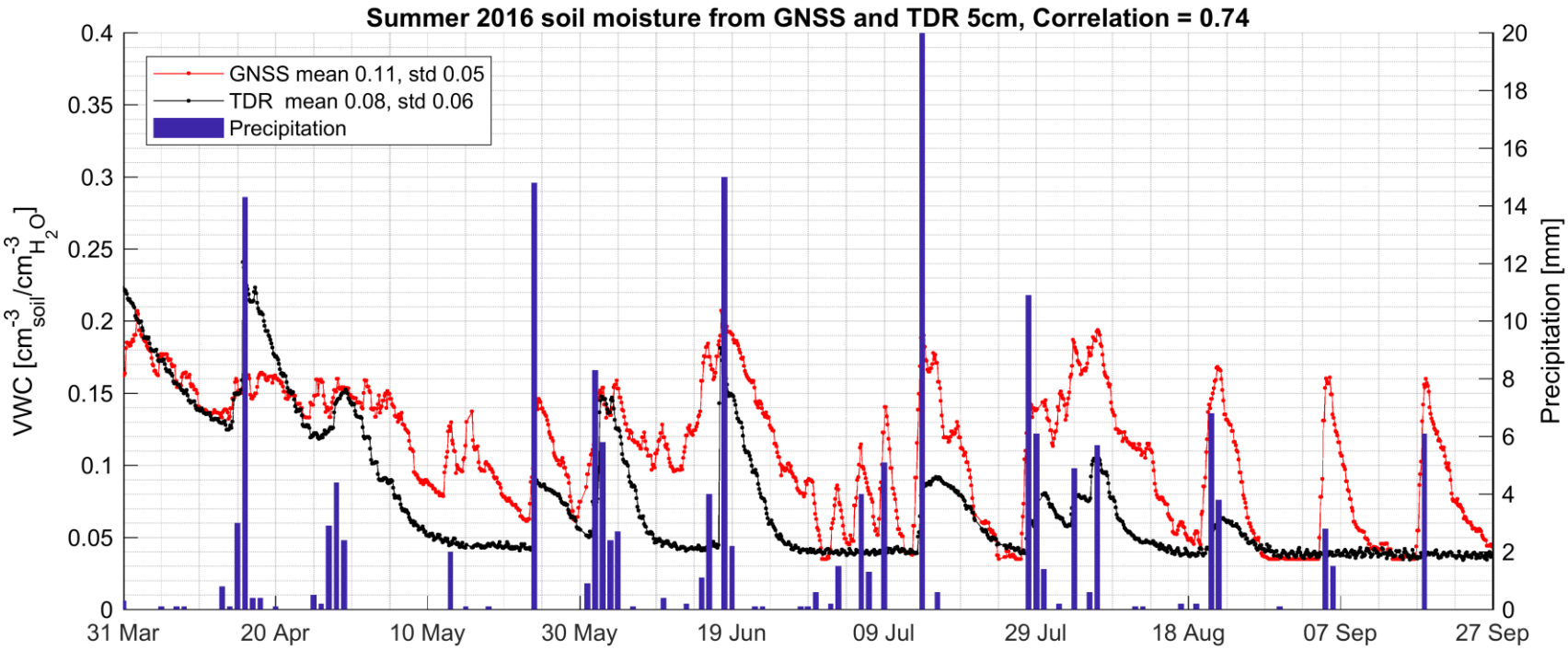


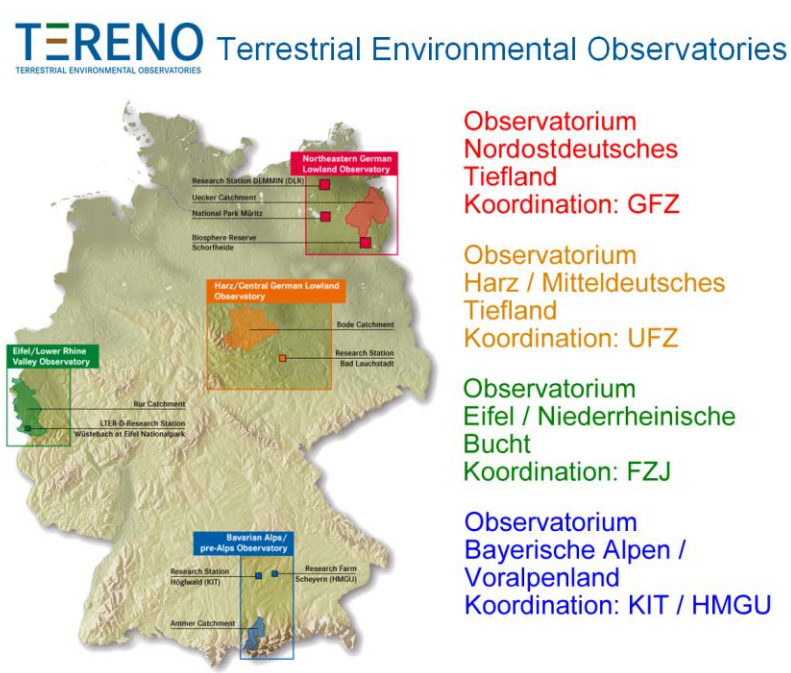
Pilot Stations - Marquardt

- Sensors installed in Marquardt Research Site, Brandenburg
- Focuses on research related to resource conservation, sustainability and environmental protection
- Precipitation events are measured with a meteorological station
- Equipped with various types of GNSS receivers
- In-situ soil moisture data are used for calibration/evaluation

Pilot Stations - Marquardt



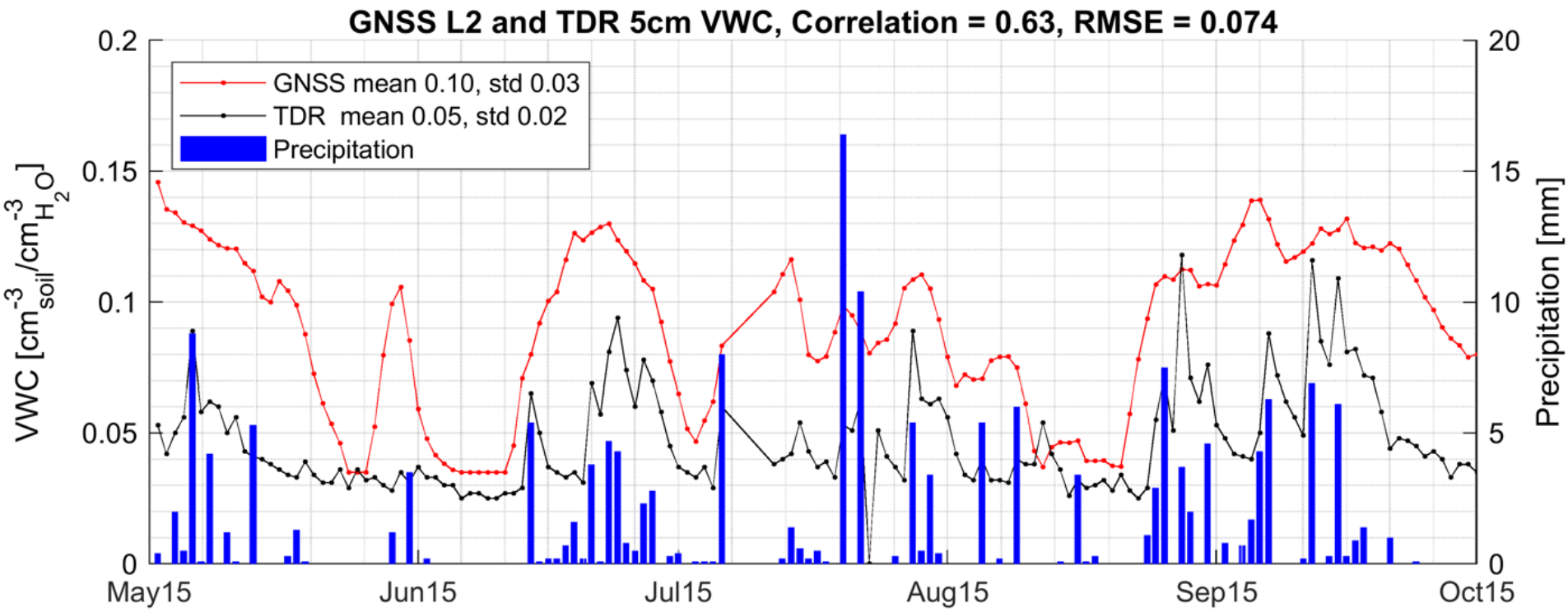
Pilot Stations - Fürstensee



- Station part of Terrestrial Environmental Observatories (TERENO) Project
- Aims at monitoring the long-term ecological, social and economic impact of global change at regional level
- Located in Fürstensee, Mecklenburg Vorpommern
- Equipped with meteorological station, GNSS receiver and in-situ soil moisture sensors

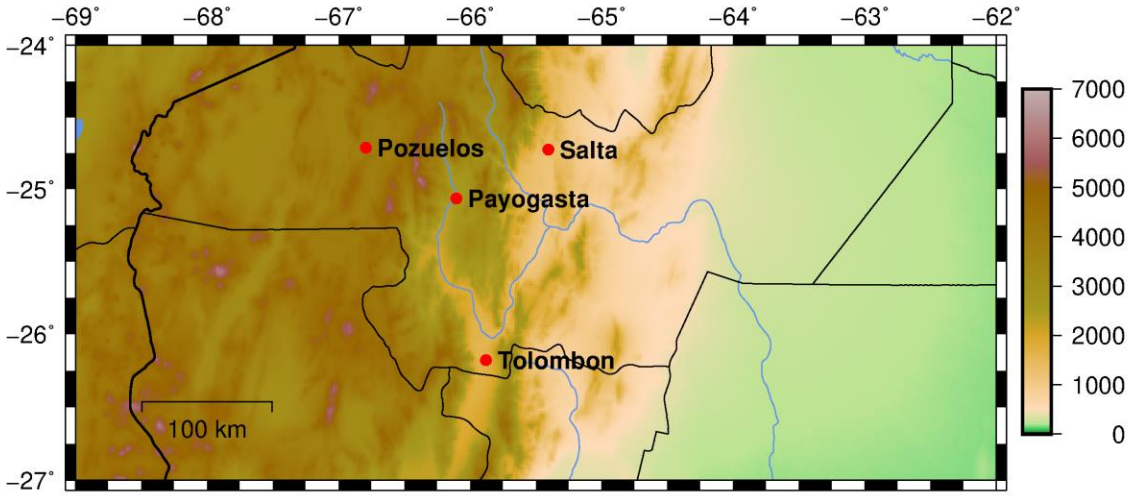
Credits: Tereno

Pilot Stations - Fürstensee



Current Work

- 4 stations installed along the climatic gradient
- Various types of GNSS receivers in each station
- In-situ soil moisture sensors installed additionally for comparison and calibration



Current Work

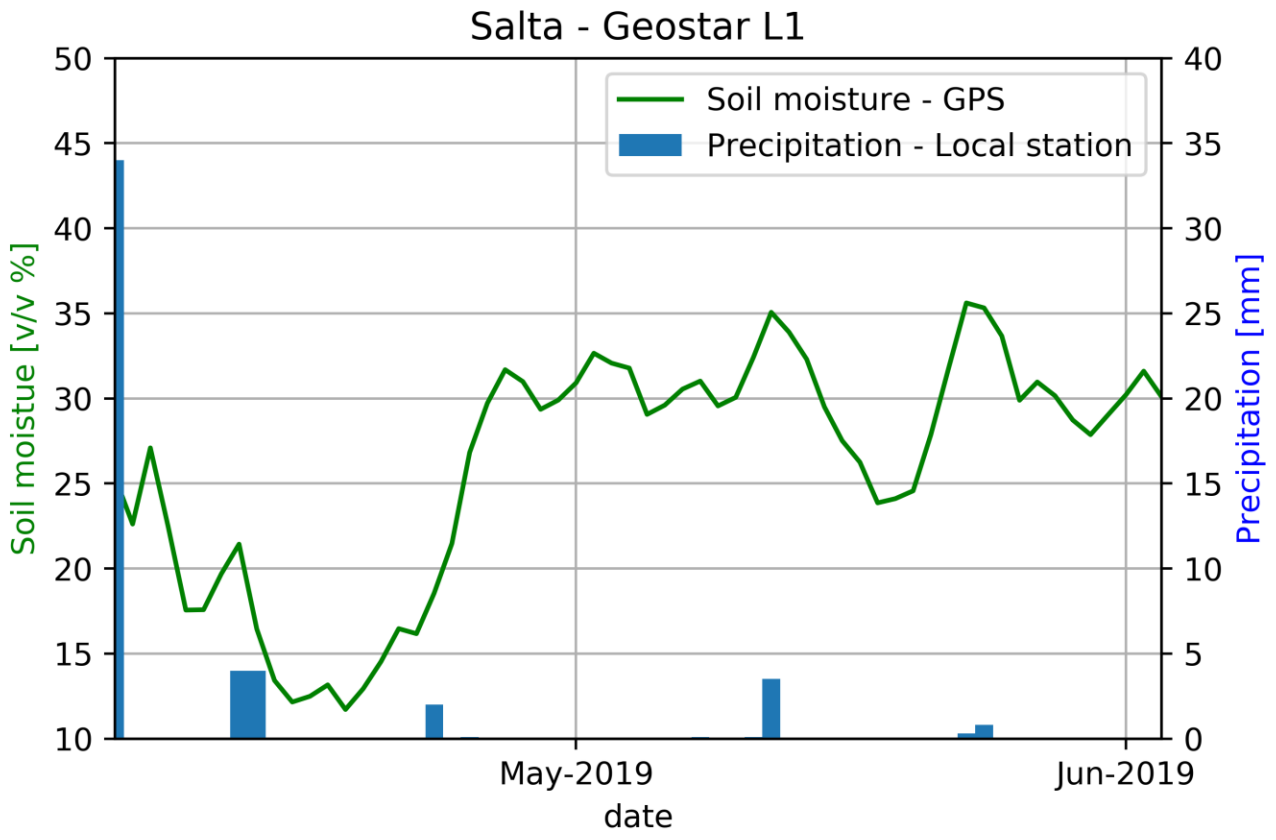
Salta

Tolombon

Payogasta

Pozuelos

Initial Results



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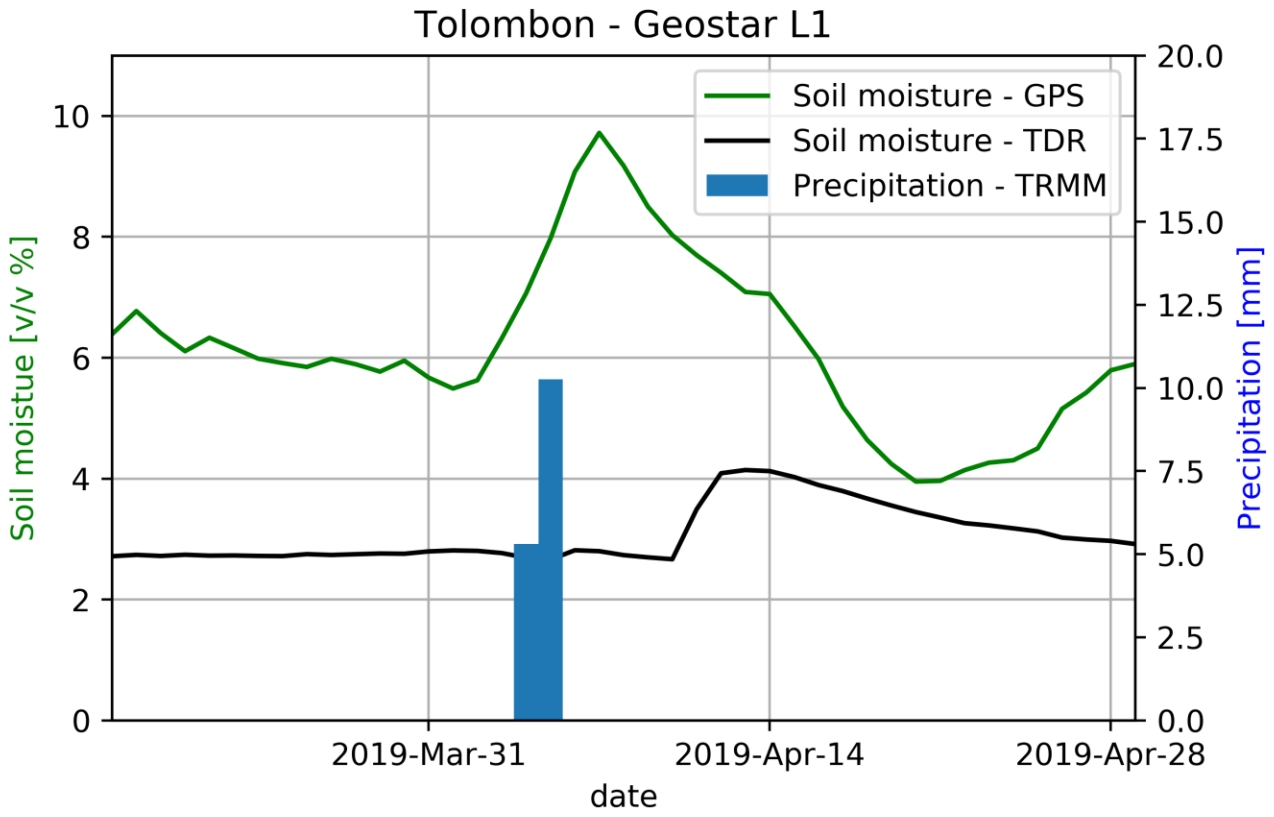

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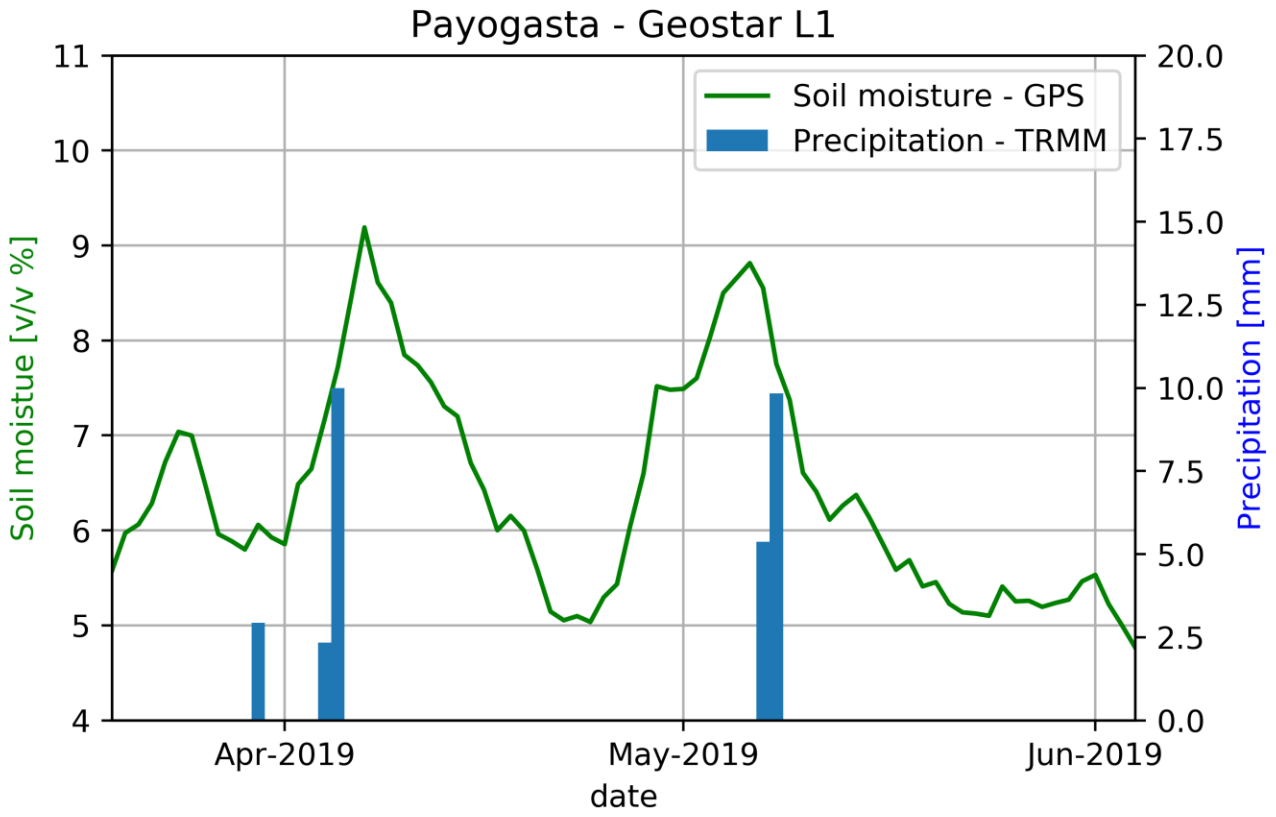

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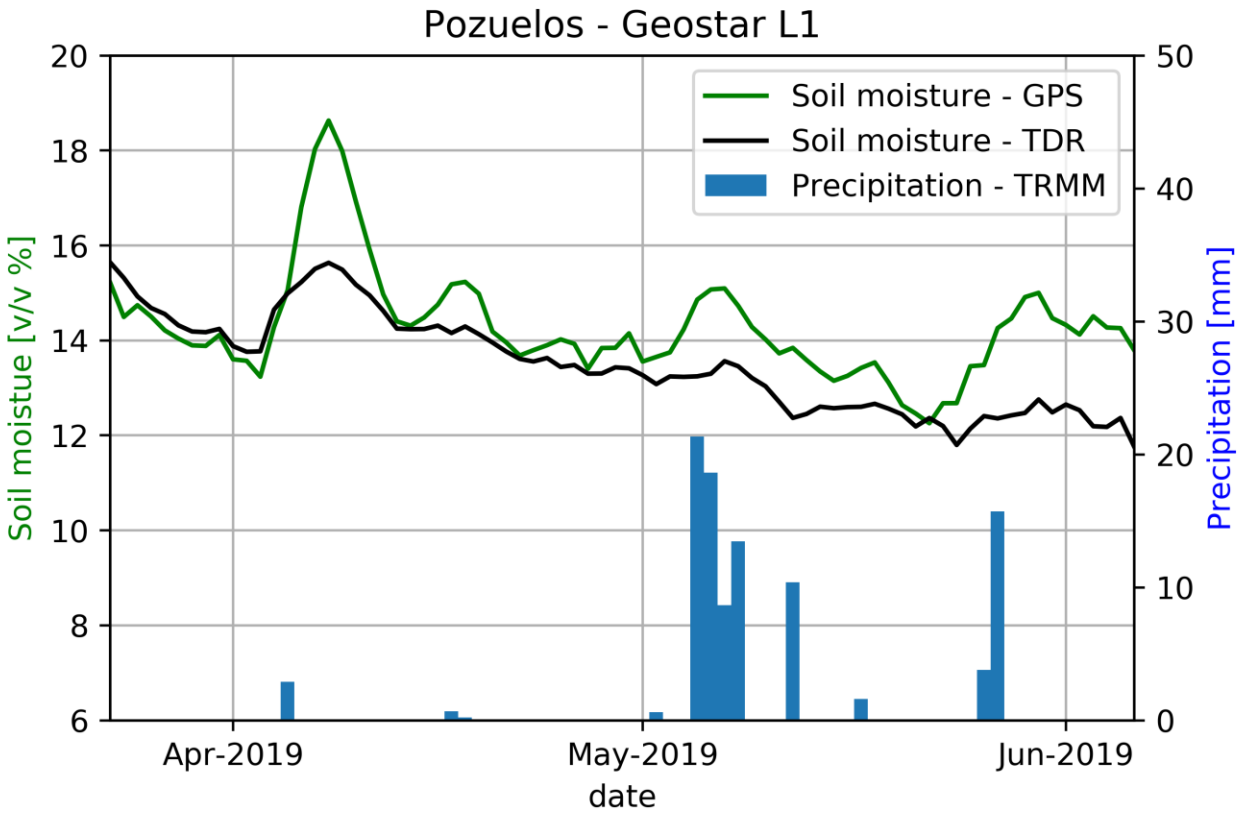

Conclusion

- The initial results are very promissing
- The soil type plays a very important role
- The dynamics between soil and lower atmosphere have to be understood better
- It is optimal to have measurements over a complete seasonal cycle