National Aeronautics and Space Administration

Advances on Polarimetric Bistatic Radar and Atmospheric sounding

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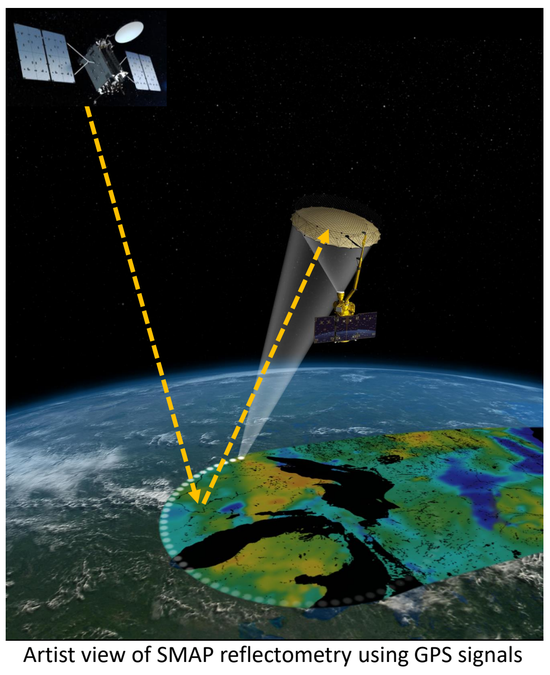
Soil Moisture Active Passive - Reflectometry

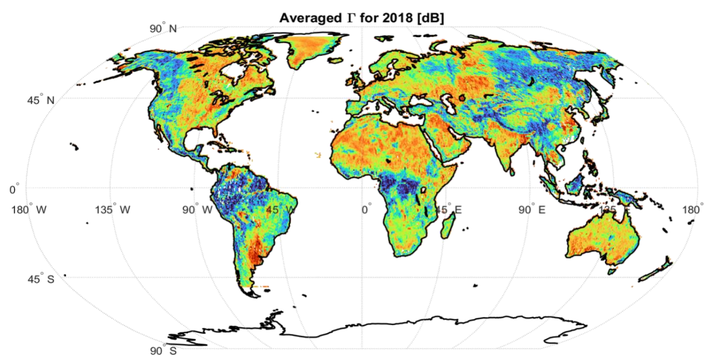


Artist view of SMAP reflectometry using GPS signals

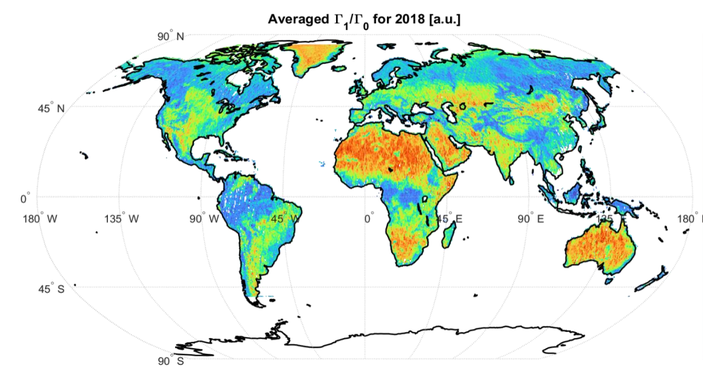
Global Navigation Satellite System - Reflectometry (GNSS-R) was conceived several years ago to overcome current problems in P-band and L-band **radar** systems:

1. Huge antennas are required (**6-meter** antenna at L-band for a 3 km radar resolution)
2. Backscatter radar contains a **large vegetation trunk component** that is hard to calibrate
3. Instrument high power consumption makes it **impossible to fit in small platforms**
4. Increased temporal resolution given by constellations is **economically not feasible**

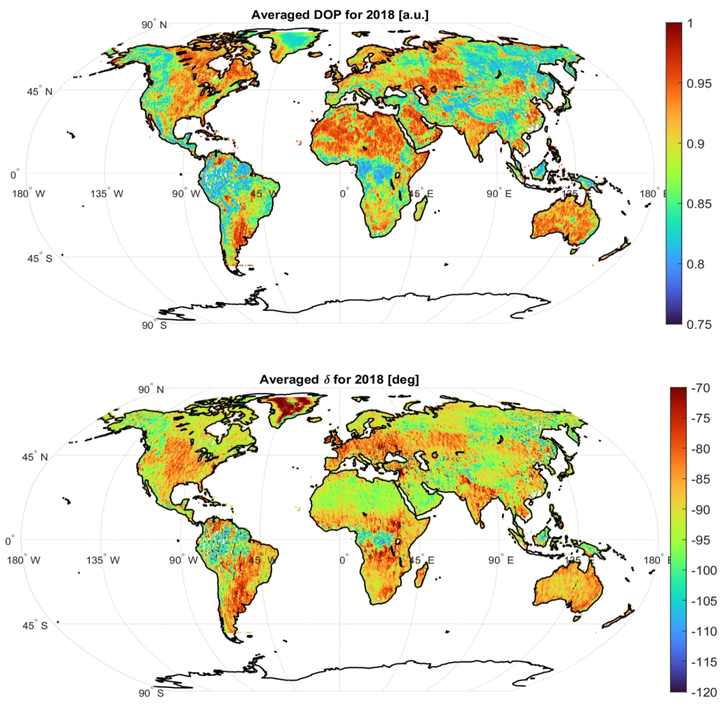
- Forward-scatter (e.g., GNSS-R) has the inverse behavior of back-scatter (e.g., normal radar): double bounce reflections are not produced in forward-scatter, vegetation generates volume scattering only, e.g., reflection contains a larger "**soil**" component
- **Hybrid Compact Polarimetric GNSS-R** (HCP GNSS-R) has been tested for the first time using **SMAP radar receiver** data tuned at the GPS L2C band: known as SMAP-Reflectometry.
- Polarimetric GNSS-R via Stokes parameters as a low-cost substitute of polarimetric radar. **Shorter revisit** times are feasible with this technique thanks to its **much lower cost**



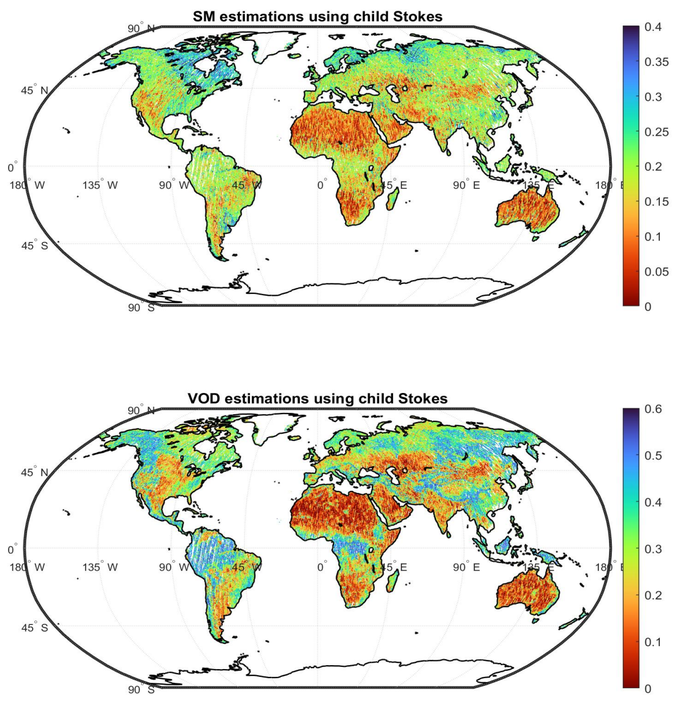
Total intensity calibrated reflectivity (Γ_0) over the Earth's surface. Γ_0 shows a large correlation to roughness and vegetation, but not to soil moisture.



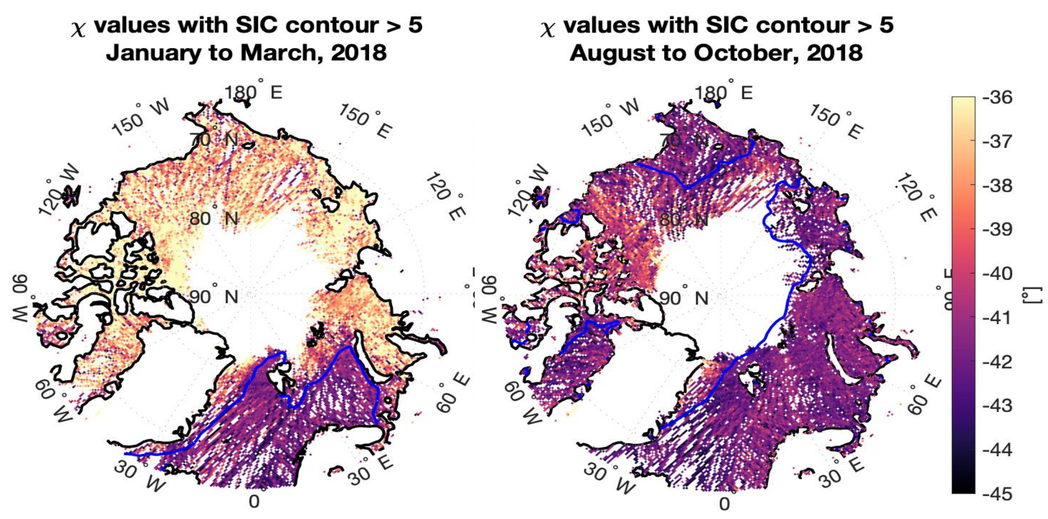
The ratio between the linear components (H and V) of the reflected signal (Γ_1) is highly sensitive to soil water content



Advanced signal processing schemes can be derived using Stokes parameters, as the degree of polarization (top), which is highly sensitive to vegetation content and roughness. The angle between the linear components (bottom) also shows significant correlation to dense vegetation (Rainforest).

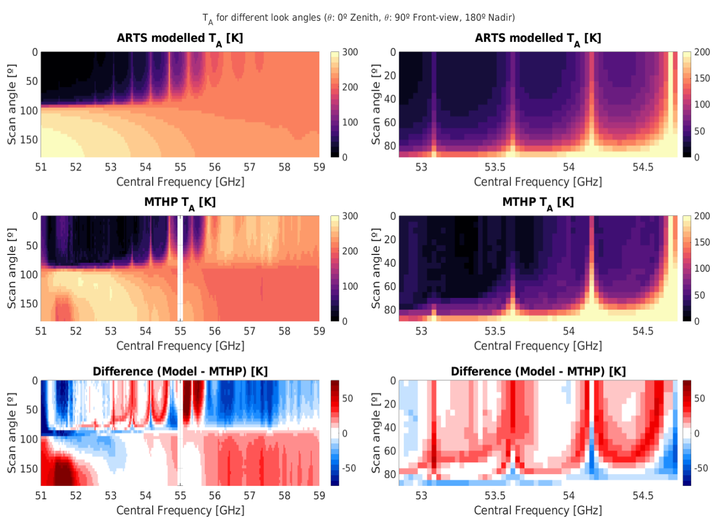


Linear regressions can be derived using SMAP-R data to produce soil moisture and vegetation optical depth estimations, with significant correlations (**0.74 and 0.6**) to actual SMAP soil moisture and vegetation optical depth products

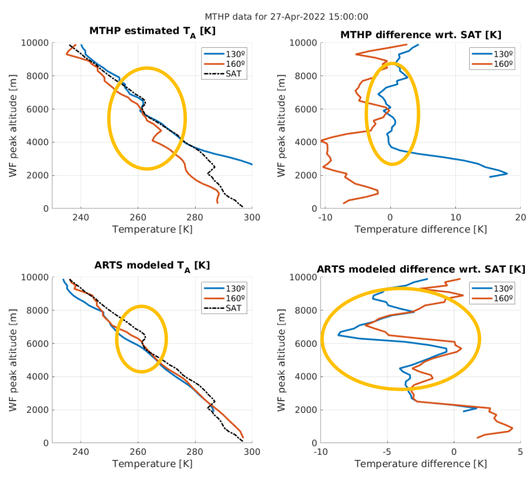


Reflectometry does not only has potential for land monitoring. Preliminary analysis show very high sensitivities to sea-ice using polarimetric component decompositions via Stokes parameters

Microwave Temperature Humidity Profiler (MTHP)



High resolution spectrometry is a novel technique that allows high vertical resolution temperature retrievals on the 60 GHz complex oxygen spectrum, but also high-resolution detection of absorption spectral lines



Detection of atmospheric **turbulence** in the high-resolution spectral data that models cannot even reproduce using the turbulent atmospheric profile

- Demonstrate capabilities of high-resolution spectrometry for atmospheric sounding
- Flew in NCAR TI3GER campaign from NSF
- Even though low-resolution sounding is an already proven technique, high-resolution would allow the detection of turbulent layers, as the **Planetary Boundary Layer (PBL)**, with significant implications in climate and weather modeling

Team award received from section 386 for the rapid implementation and airborne campaign for PBL estimations

Instrument P.I.: Javier Bosch-Lluis (332)

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Poster Number:

Publications:

J. F. Munoz-Martin, et. al., "Stokes Parameters Retrieval and Calibration of Hybrid Compact Polarimetric GNSS-R Signals," in IEEE Transactions on Geoscience and Remote Sensing, doi: 10.1109/TGRS.2022.3178578.
N. Rodriguez-Alvarez, J. S. Jao, **J.F. Munoz-Martin**, C. G. Lee, "Feed-forward Neural Network Denoising Applied to Goldstone Solar System Radar Images", Remote Sensing 2022, 14, 1643
J. F. Munoz-Martin, et. al., "A Pseudo-Polarimetric GNSS-R Analysis of the Earth's Land Surface," submitted to IEEE Transactions on Geoscience and Remote Sensing
J. F. Munoz-Martin, et. al., "Detection Probability of Polarimetric GNSS-R Signals," submitted to IEEE Geoscience and Remote Sensing Letters.
J. F. Munoz-Martin, et. al., "Effective Surface Roughness Impact in Polarimetric GNSS-R Soil Moisture Retrievals", submitted to IEEE Transactions on Geoscience and Remote Sensing
N. Rodriguez-Alvarez**, J. F. Munoz-Martin**, et. al., "A Hybrid Compact Polarimetry GNSS-R Analysis of the Earth's Cryosphere", submitted to IEEE Transactions on Geoscience and Remote Sensing
N. Rodriguez-Alvarez**, J. F. Munoz-Martin**, et. al., "Studying the Earth's Surface with the Recovered SMAP Radar Receiver Capability," in preparation for Nature SR
J. F. Munoz-Martin, et. al., "Vertical Oxygen Temperature Profile Estimations using High-Resolution Millimeter Wave Spectrometer," in preparation for Nature SR

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