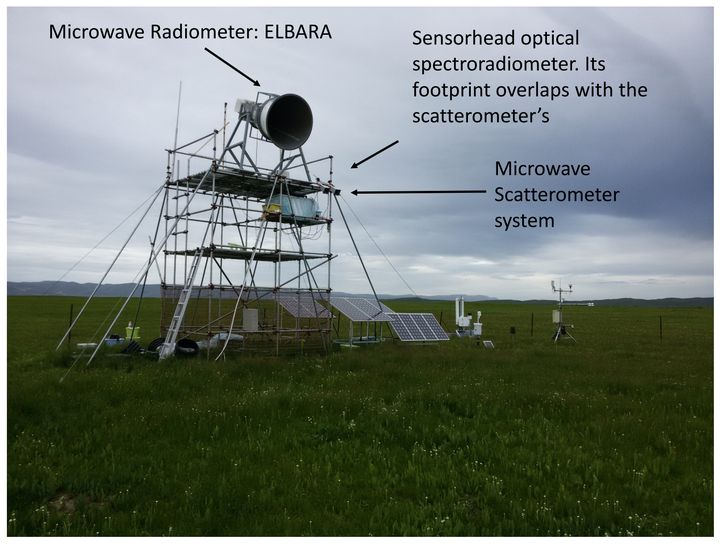
Long-Term Backscattering Observations over and Alpine Meadow with a ground-based Broadband full polarimetric Scatterometer

Jan Hofste, Rogier van der Velde, Xin Wang, Zuolang Wang, Donghai Zheng, Jun Wen, and Zhongbo Su. email: j.g.hofste@utwente.nl

[1] Introduction and objective:

To improve climate modelling over the Tibetan plateau it is necessary to understand its (local) dynamics of ground temperature, soil moisture, and vegetation. These dynamics can be studied by Remote sensing.

Our methodology involves combined ground-based observations in the microwave- (both active and passive) and optical spectrum over a full year period with high sampling frequency (every hour).



At the Maqu site (Tibetan Plateau, China) long-term measurements were performed with an ELBARA radiometer [1] (spring 2016 – now), a microwave scatterometer (Aug. 2017 – June 2019) and an optical spectroradiometer (summer & autumn 2018). The Maqu site is part of regional scale soil moisture monitoring network [2].

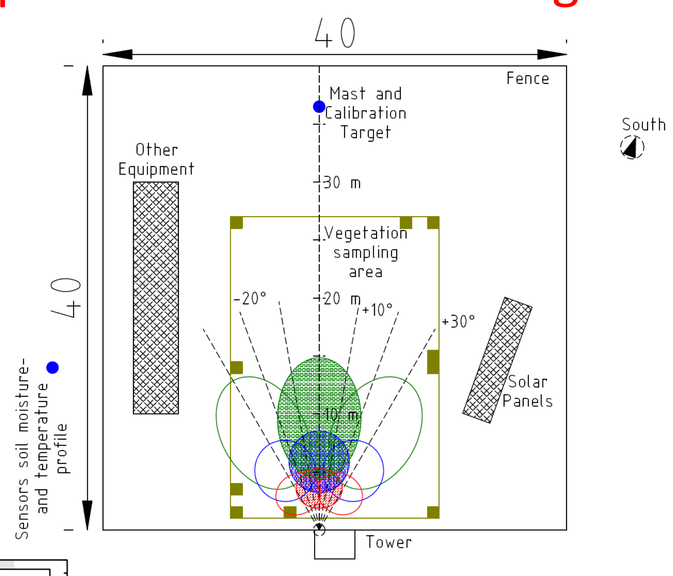
This poster: Scatterometer specifications and experimental setup, measurement results of backscattering coefficient σ^0.

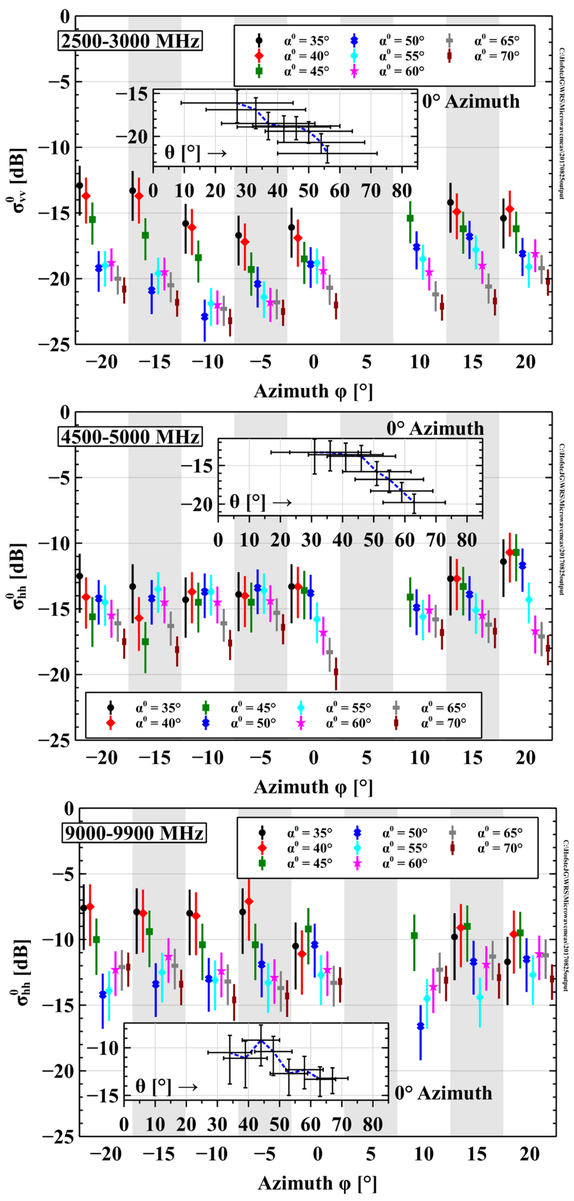
[3] Variation σ^0 over position & incidence angle:

Performed experiments to investigate behaviour backscattering over angle of incidence $\sigma^0(\theta)$ and variation of σ_0 over position. Shown are results for:

Band:	Used Bandwidth:	Pol. :
S-band	2.5 – 3.0 GHz	VV, HH
C-band	4.5 – 5.0 GHz	VV, HH
X-band	9.0 – 10.0 GHz	VV, HH

Left figure shows top view of Maqu site. Footprints for C-band indicated for α_0 = 35, 55, and 70°.





Left figures show measured $\sigma^0(\alpha_0,\phi)$ for all bands. Vertical bars represent 66% confidence intervals for σ^0. Insets shows $\sigma^0(\alpha^0)$ for azimuth ϕ = 0° . Horizontal bars depict range of actual angle of incidence θ.

Measured $\sigma^0(\alpha^0)$ were fitted with function $\sigma^0(\theta) = A\cos(\theta)^B$,with either B = 1 (σ^0 isotropic) or B = 2 (σ^0 Lambertian), to quantitively analyze behavior $\sigma^0(\alpha_0,\phi)$ for different frequency bands and polarizations.

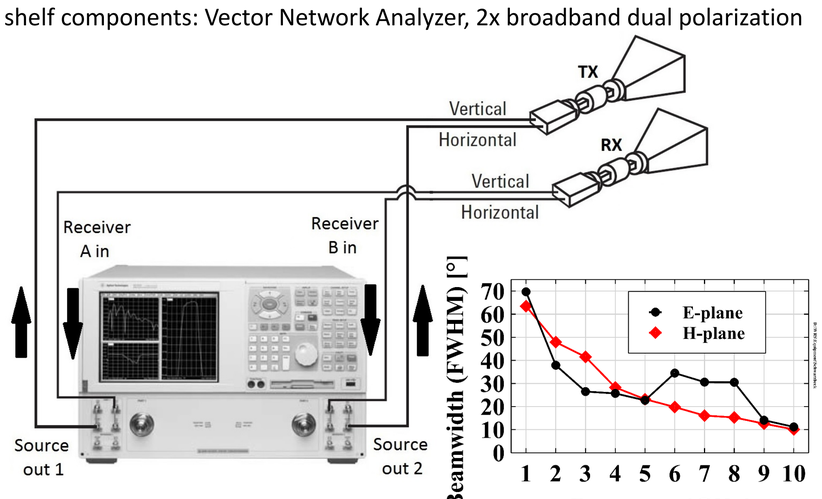
Results:

- A is largest for X-band, smallest for S-band. Indicates backscattering strongest for shortest wavelengths.
- B =2 fits best for S-band, C-band VV-pol. B = 1 fits best for C-band HH-pol and X-band. Consistent with theory and other experiments on influence of surface roughness on backscattering.
- Vegetation denser on left side of Maqu site (ϕ < 0°). Especially for X-band the backscattering for HH polarization was stronger with left-side than with right side.

[2] Equipment and Experimental setup:

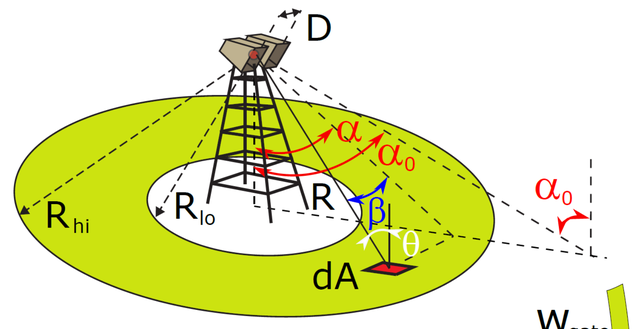
Scatterometer build with of the shelf components: Vector Network Analyzer, 2x broadband dual polarization horn antennas.

- Full frequency band: 0.75 – 10.25 GHz. Resolution 3 MHz (3201 points)
- Measurement of all polarization channels; VV, HH, VH, HV

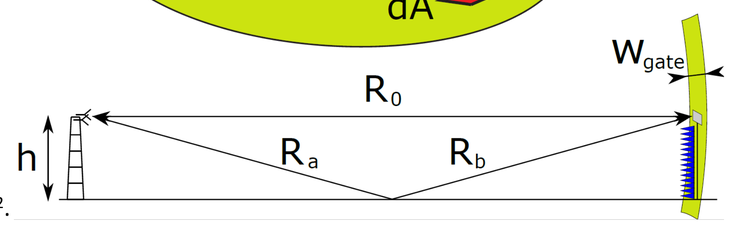


$$P_{pq}^{RX} = P_{pq}^{ref}\frac{(R_0)^4}{\sigma_{pq}^{ref}}\int\frac{G^2}{R^4}\sigma_{pq}^0(\theta).dA$$

Geometry of experimental setup. Scatterometer antennas 5 m above ground surface. For σ^0 timeseries measurements antenna boresight at α_0 = 55° angle with respect to ground surface.



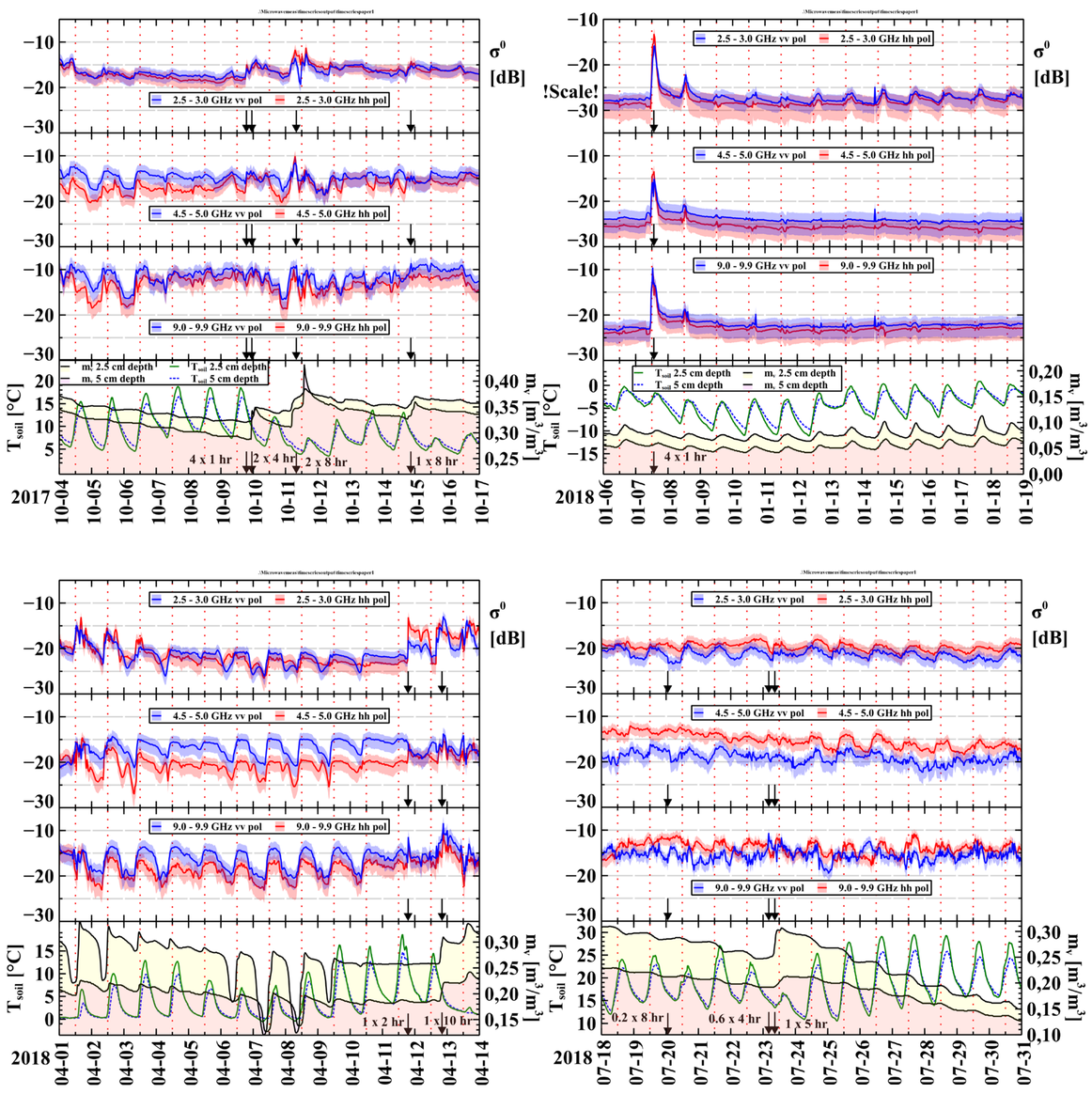
Time-domain gating applied to filter antenna-to-antenna coupling and scattering outside footprint. Green ring depicts 'gated' ground surface.



Calibration of scatterometer by normalization to measured RCS of a rectangular metal plate of 0.85 x 0.65 m². Green ring depicts 'gated' range during RCS measurement.

[4] Full year time series of σ^0:

σ^0 for three sub bandwidths is shown for four 13-day periods during 2017 – 2018. Angle α_0 fixed at 55°, range θ between 30 – 65°. Shaded regions represent 66% confidence intervals for σ^0. Lower graphs show measured volumetric soil moisture content m_v and soil temperature T_{soil} at 2.5 and 5 cm depth. Black arrows indicate rain events, quantified by two numbers as rate [mm m^{-2} hr^{-1}] x duration [hours].



[5] Conclusion & Outlook:

- Installed cost-effective scatterometer system using commercial of the shelf components
- Behaviour σ^0 over θ according to commonly accepted behaviour in terms of wavelength and polarization.
- Collected dataset of σ^0 over 1 – 10 GHz bandwidth for all four polarization channels over a one year – period. (1 -2 measurements per hour).
- Vegetation complicates interpretation of measured σ^0 (scatterometer) and brightness temperature (radiometer). Improve interpretation of microwave signals by using optical spectroscopy observations to quantify vegetation amount.

[1] Zheng D., Wang X., et al., 2017, IEEE Trans. on Geo-Sc. and Rem. Sens.
[2] Su Z., Wen J., et al., 2011, Hydr. and Earth Syst. Science.

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