Zackenberg Valley seen by TerraSAR-X – Land cover and moisture conditions

Jennifer Sobiech-Wolf[1], Tobias Ullmann[2], Achim Roth[3], Wolfgang Dierking[1]

1 Alfred-Wegener-Institut, Helmholtz Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany
2 Universität Würzburg, Germany
3 DLR Oberpfaffenhofen, Germany

Motivation

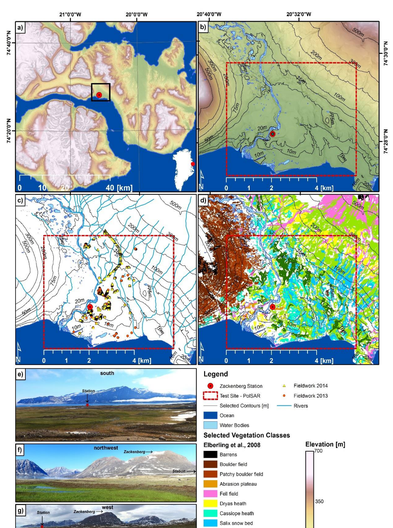
- **Soil moisture** is an important variable in the hydrological cycle, as evapotranspiration is highly dependent on the availability of water stored in the soil just beneath the surface.
- **Radar remote sensing** has been identified as a suitable tool for the detection of spatial and temporal soil moisture variability.
- **Ground measurements** are difficult to obtain and thus sparse in arctic regions.

Land Cover classes

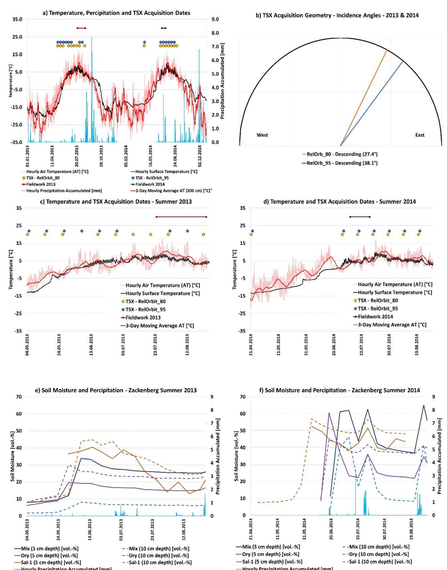
Barrens	BAR
Boulder Field	BFL
Abrasian plateau	APL
Fell field	FFL
Dryas heath	DYH
Cassiope heath	CAH
Salix snow bed	SSB
Grassland	GRL
Fen	FAN
Water	WAT

Zackenberg Valley

North-East Greenland

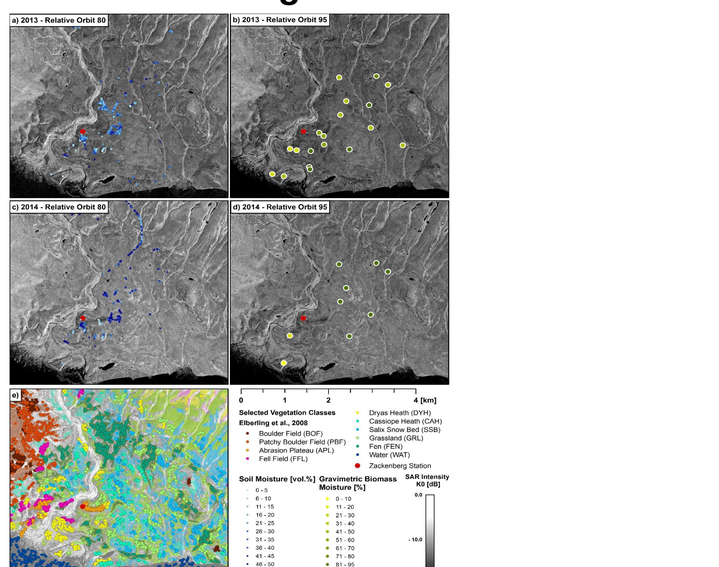


Climate Conditions and TerraSAR-X data

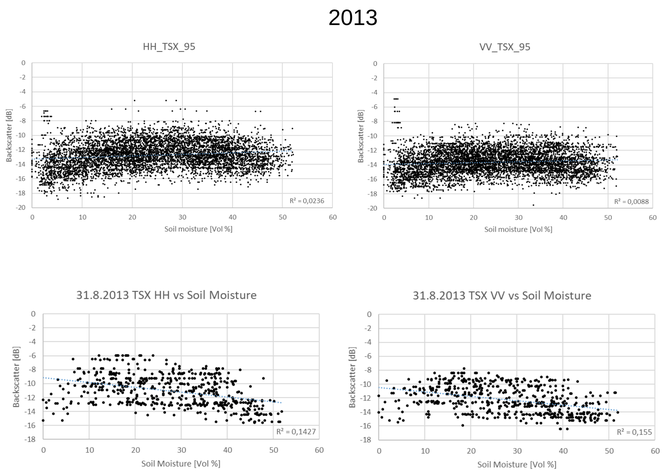


- Data stacks from Mai – August 2013 (17 images) and April – August 2014 (13 images)
- Spotlight dual-pol HH/VV
- Orbits 80 = 27.4° and Orbit 95 = 38,1°, both descending
- Spatial resolution after data processing including geocoding and terrain correction: 3.4m in ground and azimuth direction
- Multi-looking and a 3x3 Lee filter were applied.

TerraSAR-X images



TerraSAR-X backscatter vs soil moisture



Soil Moisture / Land cover classes

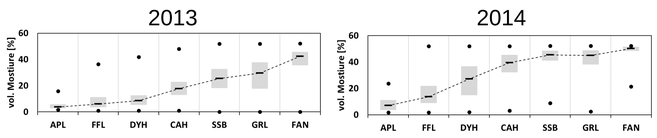


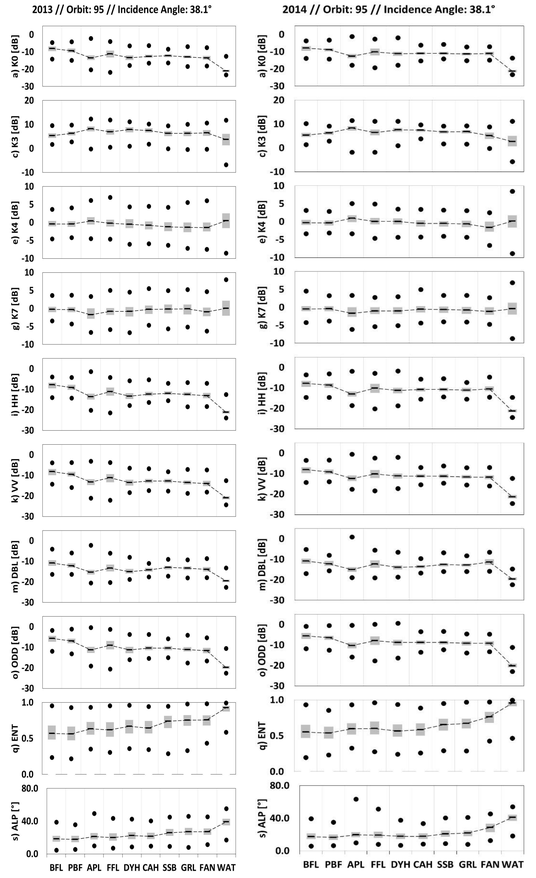
Table 1.
R² values TerraSAR-X Backscatter values vs soil moisture

Vegetation Class	HH Orbit 95 2013 / 2014	VV Orbit 95 2013 / 2014	HH Orbit 80 2013 / 2014	VV Orbit 80 2013 / 2014
APL	0.0093 / 0.0269	0.0292 / 0.0288	0.0287 / 0.0399	0.00001 / 0.0002
FFL	0.0039 / 0.4017	0.00003 / 0.2834	0.0058 / 0.2664	0.0393 / 0.2095
DYH	0.0271 / 0.0021	0.0017 / 0.001	0.001 / 0.0016	0.0003 / 0.00002
CAH	0.0058 / 0.0215	0.0035 / 0.0104	0.01 / 0.0228	0.0179 / 0.0335
SSB	0.0231 / 0.0082	0.0055 / 0.0129	0.0097 / 0.0011	0.0136 / 0.0033
GRL	0.0356 / 0.1489	0.0363 / 0.1012	0.0472 / 0.12	0.0352 / 0.1005
FAN	0.0363 / 0.0001	0.0041 / 0.0145	0.0017 / 0.0018	0.0023 / 0.017

- **Soil moisture** was measured manually in the field with a Hydrosense 2 device with 12 cm rods randomly or along 100m transects with one measurement each m.
- More than 5000 soil moisture measurements were performed in 2013 and 2014 each.
- The soil moisture values were than compared to the TerraSAR-X backscatter values.

→ **The results show no relation between the soil moisture and the backscatter values, independent of the land cover on top and the moisture regime on ground.**

Polarimetric decomposition - Land cover



Kennaugh matrix decomposition

- K0: Total intensity of HH and VV
- K3: Loss of polarization during the scattering process - real part of the conjugation of the complex signals of HH and VV
- K4: change of the relation between two amplitude values during reflection - difference of the HH and VV intensities
- K7: phase delay during scattering in a particular direction - imaginary part of the conjugation of the complex signals of HH and VV

Land cover classification

A Maximum Likelihood and a Random Forest classification showed similar classification results with low overall accuracy of about 44%.

→ Water bodies and fan areas could be separated best from their surroundings

→ lowest classification performance was found for heath and salix formations.

→ **TerraSAR-X is valuable to separate land, water, and fen areas in this high arctic tundra landscape, while soil moisture monitoring and further land cover analysis require data from radar sensors operating with longer wavelength.**