TU WIEN
DEPARTMENT OF GEODESY
AND GEOINFORMATION
RESEARCH DIVISION
REMOTE SENSING

Subsurface scattering effects in the ASCAT soil moisture product

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Sebastian Hahn, Wolfgang Wagner, Raphael Quast and Andreas Salentinig

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Department of Geodesy and Geoinformation (GEO)
Technische Universität Wien (TU Wien)
http://www.geo.tuwien.ac.at/
sebastian.hahn@geo.tuwien.ac.at

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What is subsurface scattering?

Subsurface scattering, penetration depth, soil moisture content

- Subsurface scattering: penetration and scattering by subsurface objects, voids, or interfaces (e.g. bedrock or rocky layer covered by shallow soil)
- Radar penetration depth depends on moisture content
- Under dry soil conditions reflecting subsurface features can become visible
- The signal strength is typically much lower compared to surface scattering
- However, dry sandy soils have shown that a subsurface signal can be much stronger compared to a (wet) surface signal, which has been investigated in laboratory tests [1]

Where can we find (ASCAT) subsurface scattering?

Subsurface scattering areas

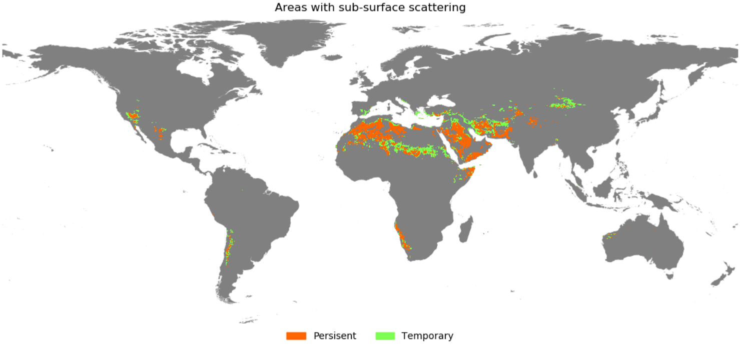

Figure 1: Areas showing persistent and temporary subsurface effects (from [1]).

What is the impact of subsurface scattering on the ASCAT backscatter signal?

Time series example: ASCAT backscatter vs. in-situ soil moisture

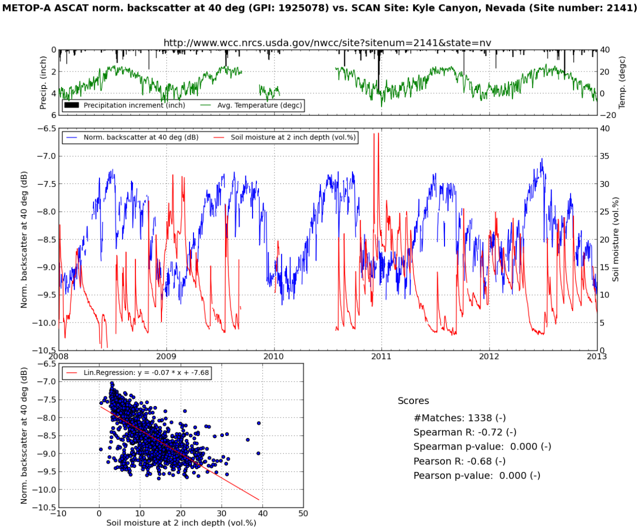

Figure 2: A strong negative correlation between ASCAT backscatter and in-situ soil moisture.

Time series example: ASCAT backscatter signal inverted

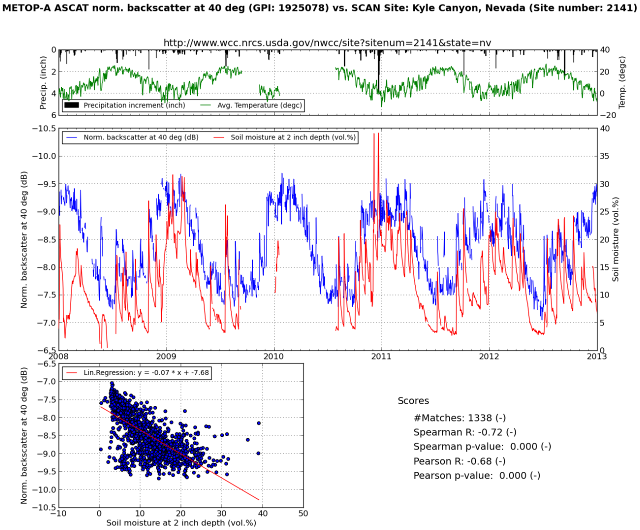

Figure 3: An inverted ASCAT backscatter time series shows a good agreement.

Relationship between ASCAT backscatter and ERA5 soil moisture

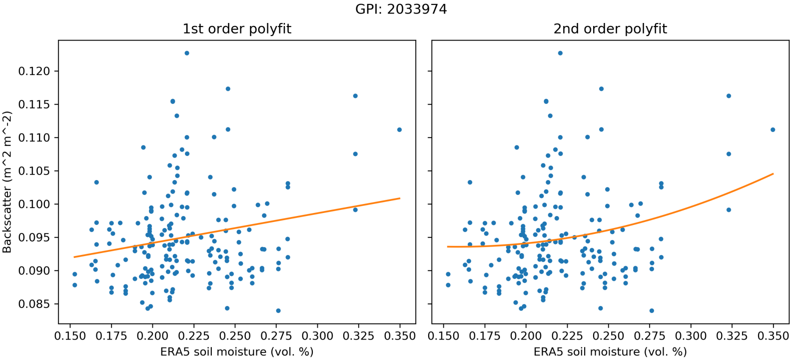

Figure 4: Positive (=normal) relationship between backscatter and soil moisture.

Relationship between ASCAT backscatter and ERA5 soil moisture

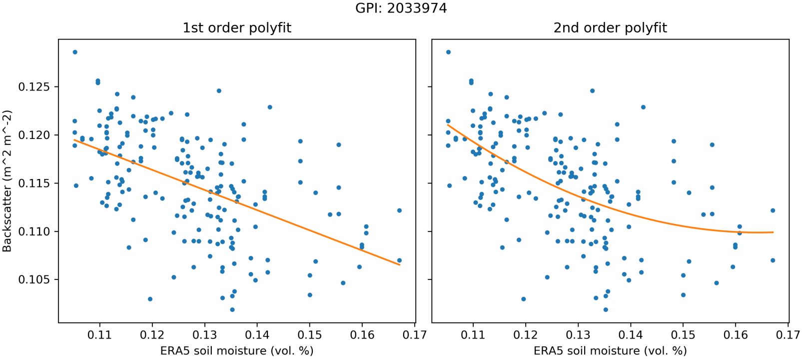

Figure 5: Negative (=anomaly) relationship between backscatter and soil moisture.

Relationship between ASCAT backscatter and ERA5 soil moisture

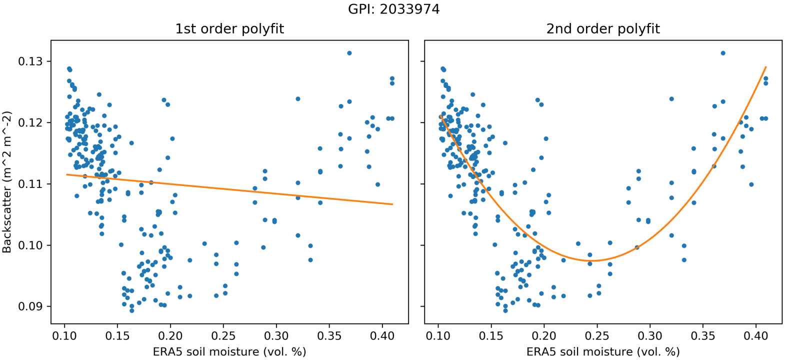

Figure 6: Transition between subsurface and surface scattering.

How to control subsurface scattering effects in case of ASCAT soil moisture retrieval?

Backscatter scaled between dry and wet backscatter reference

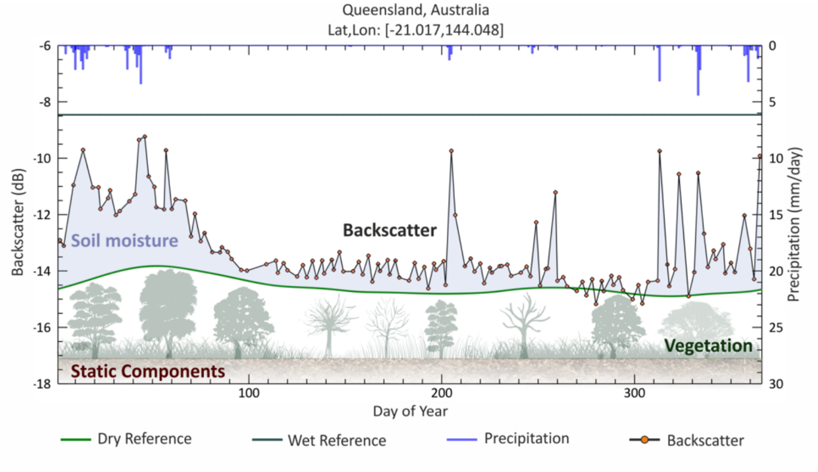

Figure 7: TU Wien change detection method (from [2]).

Practical solution: switching dry and wet backscatter reference

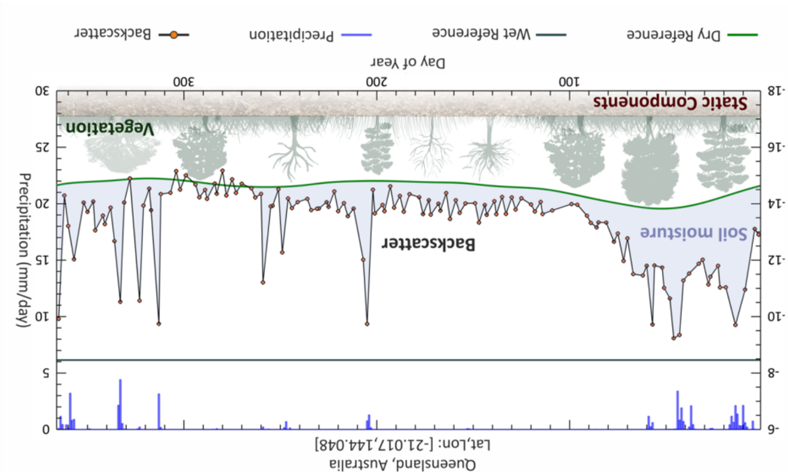

Figure 8: Wet reference = lowest backscatter, dry reference = highest backscatter.

Validation between H SAF ASCAT SM and Noah GLDAS SM

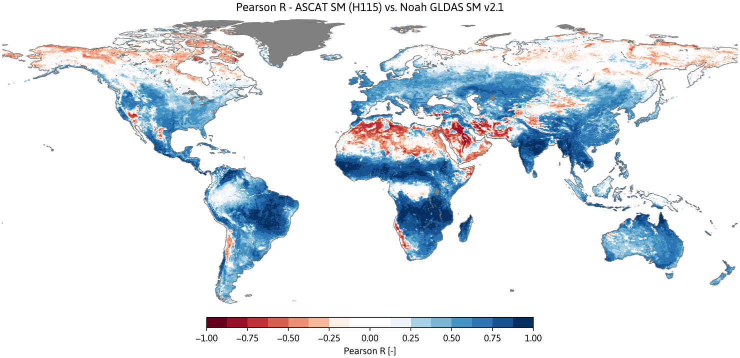

Figure 9: H SAF ASCAT SSM CDR v5 [3] vs Noah GLDAS SM.

Validation between H SAF ASCAT SM and Noah GLDAS SM

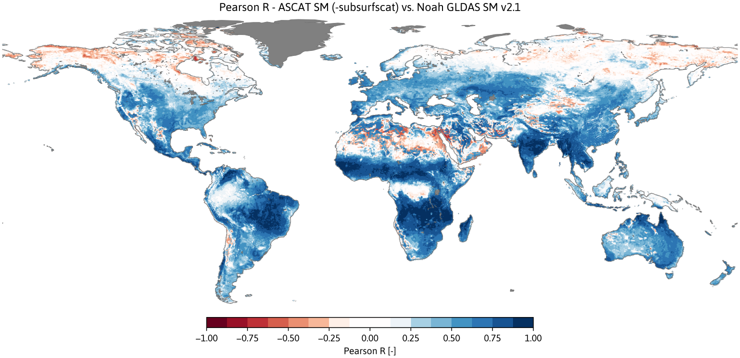

Figure 10: H SAF ASCAT SSM CDR v5 (+dry/wet switch) vs Noah GLDAS SM v2.1.

Validation between H SAF ASCAT SM and ESA CCI Passive SM

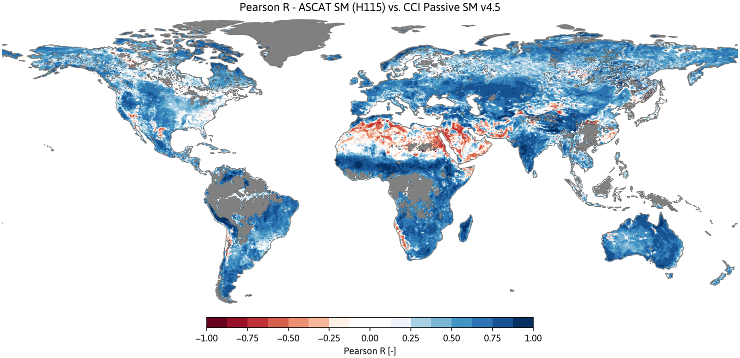

Figure 11: H SAF ASCAT SSM CDR v5 [3] vs ESA CCI Passive SM v4.5.

Validation between H SAF ASCAT SM and ESA CCI Passive SM

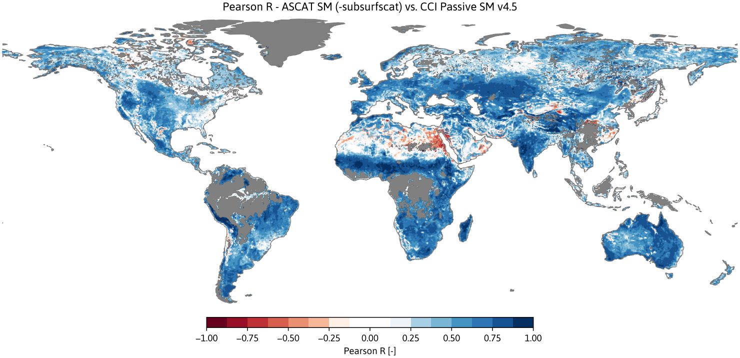

Figure 12: H SAF ASCAT SSM CDR v5 (+dry/wet switch) vs ESA CCI Passive SM v4.5.

Summary

Subsurface scattering effects in the ASCAT soil moisture product

- Dry sandy soils are able to show a stronger subsurface signal compared to a (wet) surface signal, which results in a negative relationship between ASCAT backscatter and soil moisture. Both, persistent and temporary subsurface scattering can be observed.

- H SAF ASCAT soil moisture product
  - Switch between dry and wet reference: simple and effective for areas with a persistent subsurface scattering.
  - However, temporary subsurface scattering (only during dry periods) is much more complex (especially during transition periods). A switch between dry and wet reference is too simple and not effective.
  - A backscatter model needs to be developed describing the relation of subsurface and surface scattering depending on soil type and moisture conditions accurately.

Acknowledgments and references

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[1] Keith Morrison and Wolfgang Wagner.
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[3] H SAF.
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[1] http://h-saf.eumetsat.int/