An analysis of soil moisture retrieval from SMOS and ASCAT over arid regions

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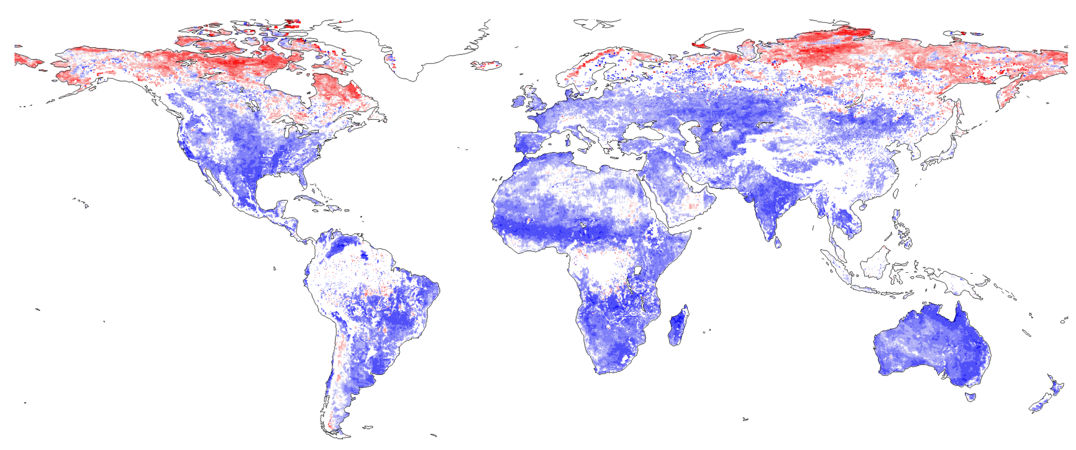
1) MOTIVATION

In arid regions soil moisture is normally low and rather stable. Nevertheless, sporadic rainfall events are extremely important for the flora and fauna in these dry environments. This makes it important to have sensitive instruments in space to measure even these small changes in the soil.

The first satellite dedicated to soil moisture, called Soil Moisture and Ocean Salinity (SMOS), has been launched on 2 November 2009 and is using a passive interferometry approach (L-band) for the retrieval of soil moisture. Since then several updates in the calibration and ground processing occurred and comparisons of longer time series were impossible. A reprocessing in February 2011 of the SMOS Level 2 soil moisture product should provide a consistent dataset (JAN-2010 to DEC-2010) for the first year of the mission. A global correlation test between this dataset and other soil moisture products, such as the Level 2 soil moisture product from the Advanced Scatterometer (ASCAT) onboard METOP-A and modelled soil moisture from the Noah model of the Global Land Data Assimilation System (GLDAS) showed good results for several different climate regions in the world. However, in arid regions a negative correlation between ASCAT and SMOS, as well as between ASCAT and GLDAS (Figure 1b) has been observed. This unusual situation has been investigated within this study by looking into soil moisture time series and backscatter characteristics.

1a) SMOS – GLDAS correlation (JAN 2010 – DEC 2010)



1b) ASCAT – GLDAS correlation (JAN 2007 – DEC 2010)

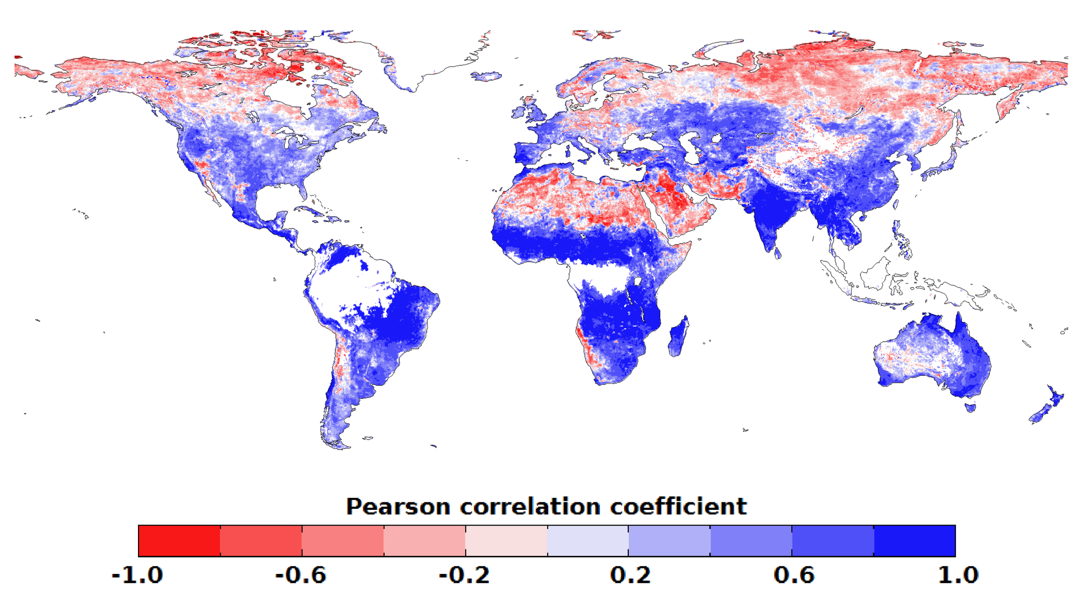


Figure 1: A correlation analysis for three different soil moisture products (SMOS, ASCAT, GLDAS) can be seen in Figure 1. Negative correlations in both images (see Figure 1a and 1b) are visible in northern regions. This result might be related to freeze-thaw events, which have not filtered out before the analysis. However, in addition some striking negative patterns can also be found for GLDAS and ASCAT (see Figure 1b). It seems that mostly arid regions are effected (compare Figure 2) and the ASCAT soil moisture product is not reliable in those regions.

2)

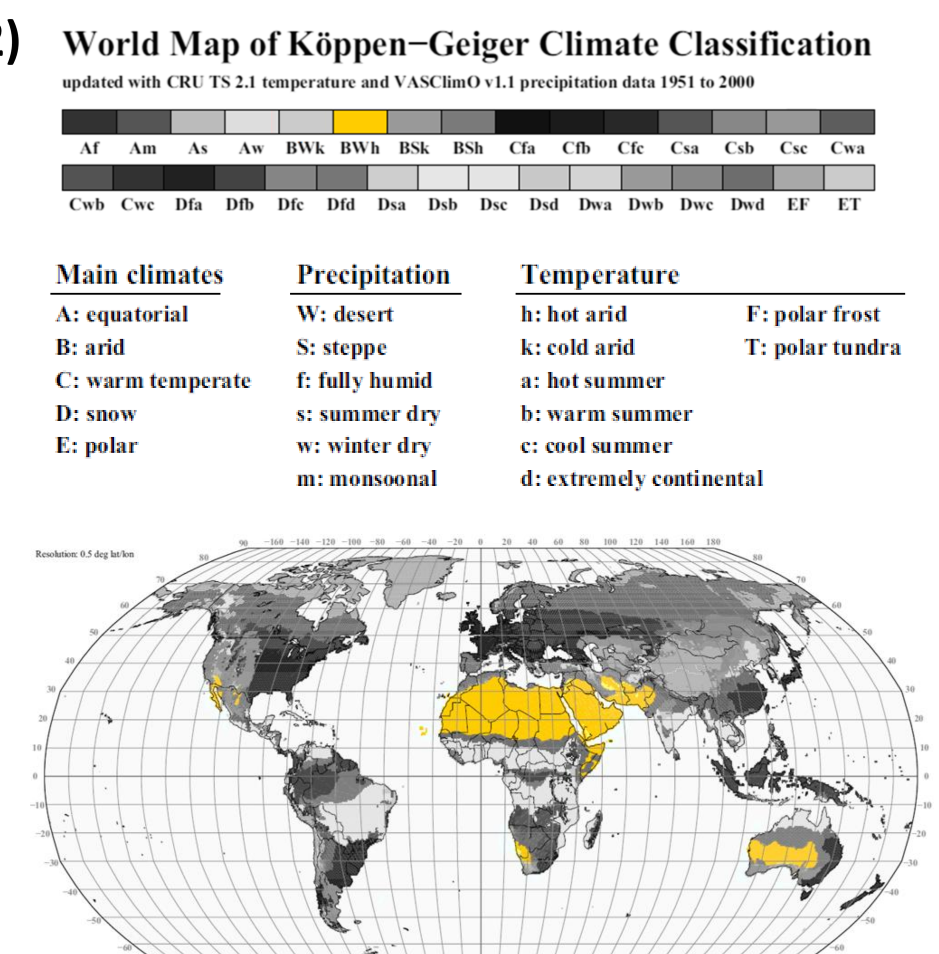
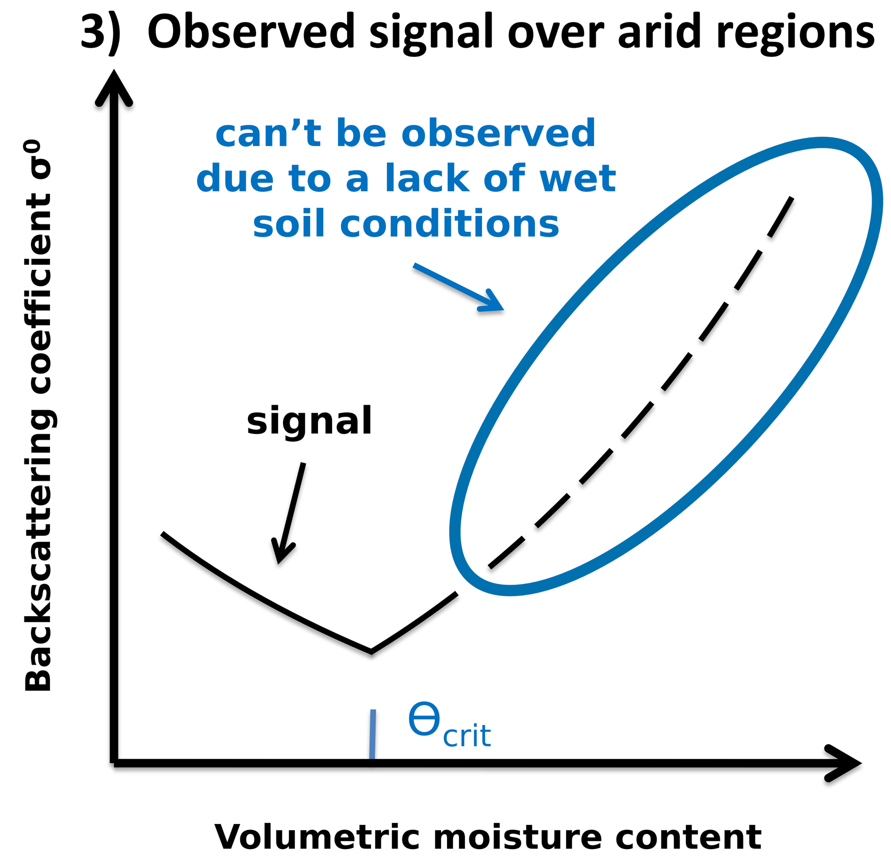


Figure 2: A world map of Köppen-Geiger climate classification [1]. All classes, except BWh, have been converted to grey scale.

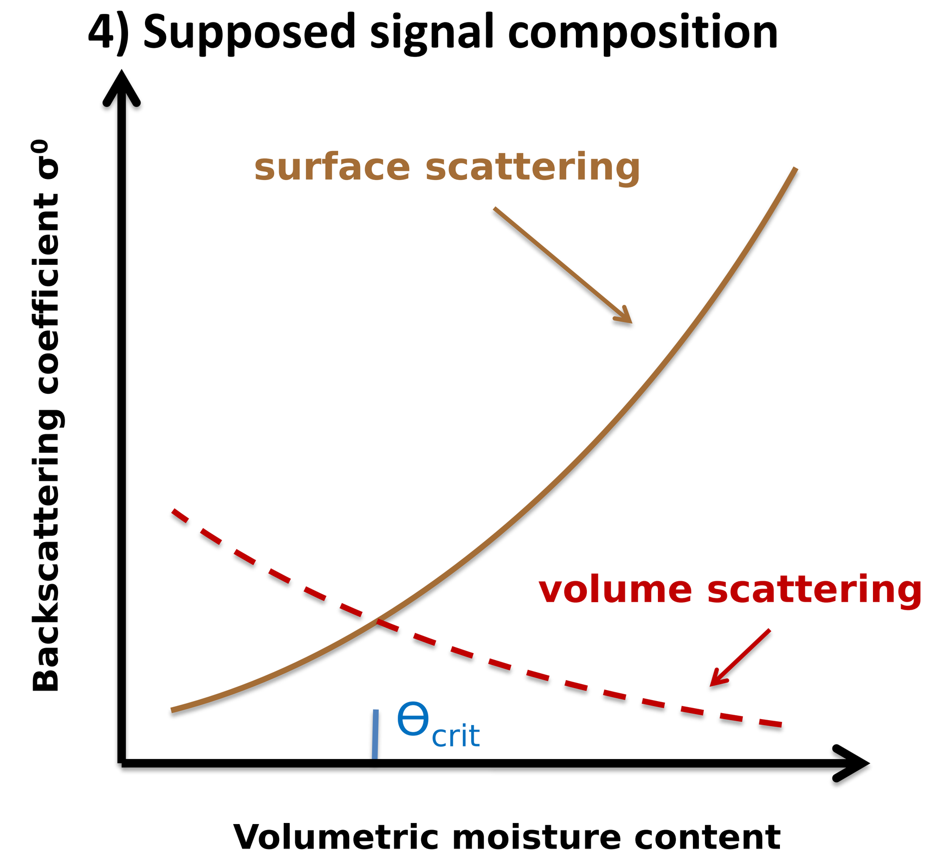
2) HYPOTHESIS

The radar backscatter coefficient σ^0 of a soil surface is primarily governed by the surface roughness and soil moisture content and, to a lesser extent, by soil type and volume scattering in the soil medium. It is usually assumed that because the penetration depth in wet soil is so small, the inhomogeneities within the soil medium cause negligible amounts of volume scattering in comparison to scattering from the air-soil surface [2]. However, if the soil profile dries out completely the volume scattering contribution from deeper soil layers may not be negligible any longer. We hypothesise that the observed increase of backscatter with decreasing soil moisture in very dry soil moisture regimes is due to this effect (see Figure 3 and Figure 4).

3) Observed signal over arid regions



4) Supposed signal composition



3) FIRST ANALYSIS

5) Example in Namib Desert: 24.40° S, 15.65° E

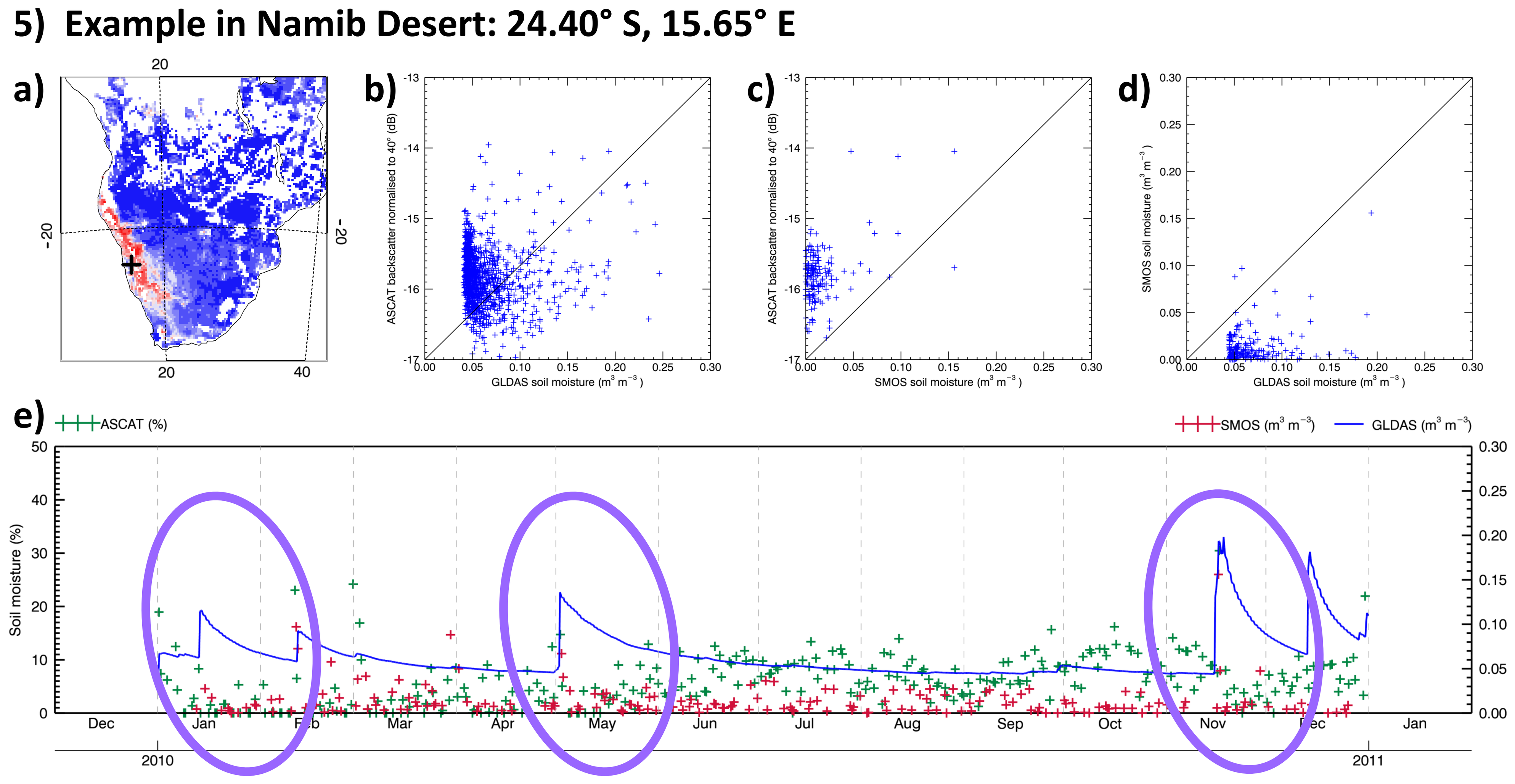


Figure 5: An example for one grid point in the Namib desert is shown in this graphic. A map (a) indicates the point of interest, the upper scatterplots provides the distribution between σ^0 and soil moisture for GLDAS/ASCAT (b) and SMOS/ASCAT (c), as well as soil moisture between GLDAS/SMOS (d) and a time series for all three products in 2010 is also shown below (e).

The volume scattering anomaly (see Figure 3) has been found for many grid points in arid regions. One example is given in Figure 5. In this example we see that the backscatter responds correctly to increasing soil moisture, but when the surface dries we see an extreme decrease with backscatter returning below the "normal dry level" (see Figure 5e). At this point (Θ_{crit}) we assume that surface and volume scattering are both present, but in total are very low. In some areas with very limited wetness events it is likely that the critical saturation point (Θ_{crit}) is never reached and so only volume scattering can be observed or the dynamic range of the backscatter signal is so narrow that no clear conclusion can be drawn.

Further detailed analyses are planned with other datasets as well (AMSR-E, ERA-INTERIM, in-situ), in order to expand the study of the backscatter characteristics and to enable an assessment of different soil moisture products across arid regions.

REFERENCES

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[2] F. T. Ulaby, R. K. Moore, and A. K. Fung, *Microwave Remote Sensing: Active and Passive. Vol. II – Radar Remote Sensing and Surface Scattering and Emission Theory*. Reading, MA, USA: Addison-Wesley, Advanced Book Program, 1982.

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