TOWARDS A HIGH-DENSITY SOIL MOISTURE NETWORK FOR THE VALIDATION OF SMAP IN PETZENKIRCHEN, AUSTRIA.

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ABSTRACT

This paper describes the design and characteristics of a new in situ soil moisture network in Austria, developed for the validation of spaceborne and modeled soil moisture products. The carefully chosen design of the network enables upscaling of the point measurements to the scale of a satellite footprint. As a first assessment soil moisture time series from an existing station are compared to both ASCAT and GLDAS surface soil moisture data. Results of this comparison show that both modeled and remotely sensed soil moisture corresponds with the in situ measurements. However, the overall higher soil moisture values for the in situ station, which are represented in the bias, emphasize the need for a carefully designed and calibrated soil moisture network.

Index Terms— *SMAP, validation, in situ*

1. INTRODUCTION

Soil moisture is a pivotal variable in land surface – atmosphere, hydrological and climate models [1]. Moreover, with the changing climate there is a need for long term spatially distributed soil moisture data [2]. Spaceborne microwave remote sensing has proven to be a valuable tool to fulfil those needs by quantitatively measuring soil moisture on a global scale under a variety of conditions. It monitors soil moisture on a spatial and temporal scale which cannot be achieved with in situ sampling. However, soil moisture is highly variable in both space and time as a result of heterogeneity in vegetation, soil properties, topography and climatic drivers [3-5]. As a consequence, in situ soil moisture measurements play an important role in the calibration and validation of land-surface models and satellite-based soil moisture retrievals. However, in most cases soil moisture networks provide one single observation within a satellite footprint, which impedes the upscaling of in situ soil moisture to the footprint level. With the (upcoming) launch of several new satellites, AMSR 2, MetOp B and SMAP, validation of these satellite-based soil moisture products with in situ observations will be essential. Here we present a new high-density soil moisture network located in Petzenkirchen, Austria. One of the goals of this network is to serve as a site for satellite validation, making careful design of the network imperative. Furthermore, as a first assessment, in situ soil moisture observations from an already installed station are compared to soil moisture retrieved from ASCAT observations and modeled soil moisture.

2. SITE DESCRIPTION

The Hydrological Open Air Laboratory (HOAL) in the Seitengraben catchment was established in 2009 through funding by the Austrian Science Foundation (FWF) to be used for multidisciplinary hydrologic research in order to understand hydrological processes. The HOAL is located in the western part of Lower Austria approximately 100 km west of Vienna and has a size of 64 ha [6]. Currently there is one in situ soil moisture (SSM) station, managed by the Federal Agency for Water Management (IKT), located close to the HOAL, which measures SSM at 0.10 cm using a TDR (Trace System-2) (Figure 1).

3. NETWORK SET-UP

The soil moisture network is currently being set up according to a novel soil monitoring concept developed by the Forschungszentrum Juelich [7]. Approximately 36 automated stations will be installed within the HOAL, which will measure soil moisture and temperature at depths of 0.05, 0.10, 0.20 and 0.50 m. 21 stations will be installed permanently and another 15 will be temporarily installed in cropland (Figure 1) for hydrologic modelling purposes. The stations located in the croplands will be removed once or twice a year during cultivation practices. Soil moisture and soil temperature will be measured using low-cost and low-current soil water capacitance probes SPADE. Additionally, evapotranspiration, air temperature and precipitation are measured at various locations within the catchment. Site-specific calibration will be done for each station at each depth using gravimetric soil samples in order to convert

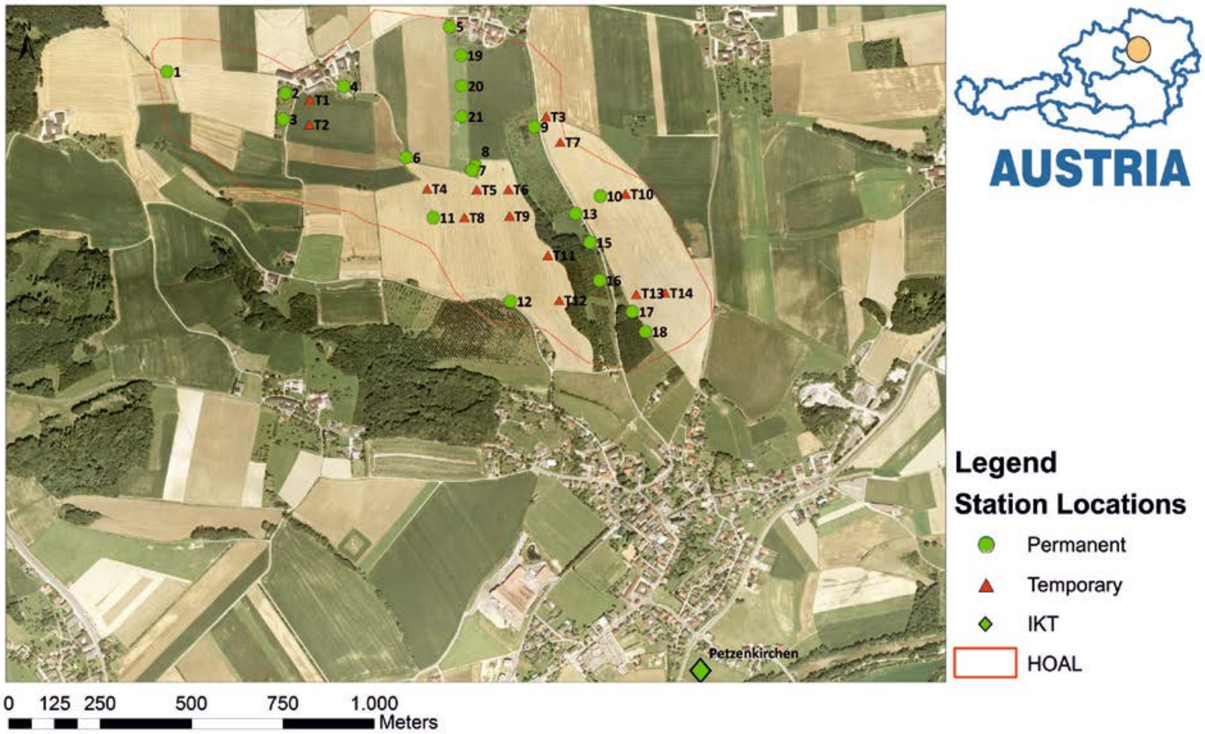

Figure 1: The HOAL with the locations of the permanent stations (green dots) and temporarily installed stations (red triangles) and the existing station (green diamond).

the sensor output to volumetric soil moisture content. The selection of station locations is done with a similar method as employed by [4] with the design and installation of the HOBE soil moisture network in the Skjern River Catchment, Denmark. The stations are located in a way that they cover the prevailing environmental conditions in the area according to their respective fractions. This method ensures statistically reliable validation via the reduction of the footprint variance and reduces the chance of sample bias [4]. This analysis has been done for a pixel, which includes the HOAL, approximately the size of a SMAP radiometer footprint (Figure 2). A composite class map is developed by summing up reclassified values of land cover, soil data and terrain data. This revealed 6 classes which individually cover >5% and together cover 58% of the pixel (Figure 2a).

The analysis based on environmental conditions shows that there is a distinct partitioning in two areas within the pixel (Figure 2). The HOAL is located in the low lying area in the centre of the pixel (Fig. 2d), where land use is mainly agriculture (Fig. 2b) and soils have a low permittivity due to a high percentage of clay in the soil (Fig. 2c). The northern part of the pixel is higher elevated, dominated by forests and permittivity is high due to high percentage of sand in the soil. It is expected that the behaviour of SSM will be very different in the northern area. Therefore, an additional cluster of stations will be installed outside of the HOAL, in the northern part of the pixel in order to cover all major environmental conditions.

By placing the stations in a way that they cover these major environmental conditions according to their respective fractions, the average SSM over all stations should represent the average SSM of the area. In addition, the most representative station will be identified by using the widely used temporal stability analysis [8]. Although, the temporarily installed stations are not very valuable for satellite validation because of discontinuous data, they are very valuable for the temporal stability analysis, since they increase the spatial coverage of the area.

4. ASCAT AND GLDAS COMPARISON

A first assessment of satellite retrieval of SSM in the area has been done by comparing ASCAT and GLDAS SSM with existing in situ observations from the IKT Petzenkirchen station. Since soil moisture retrieved from ASCAT observations with the TU Wien detection model is a relative soil moisture product (between 0 and 100%) the data is converted to volumetric soil moisture by estimating porosity with data from the Harmonized World Soil Database [9].

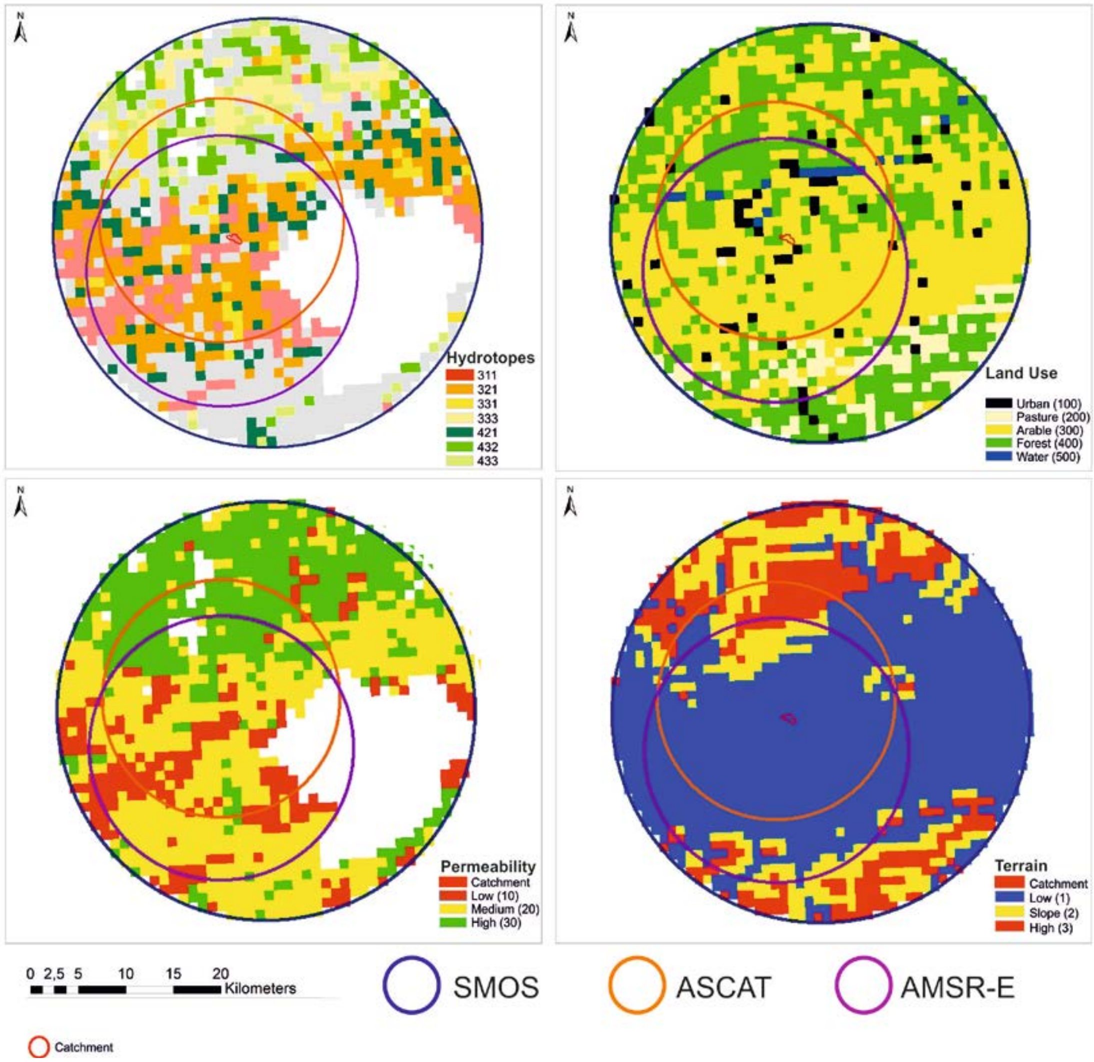

Figure 2: Composite Class Map where the number represent the 6 composite classes (a), Landuse (b), Soil Permittivity (c) and Terrain (d) for SMOS and SMAP pixel around Petzenkirchen.

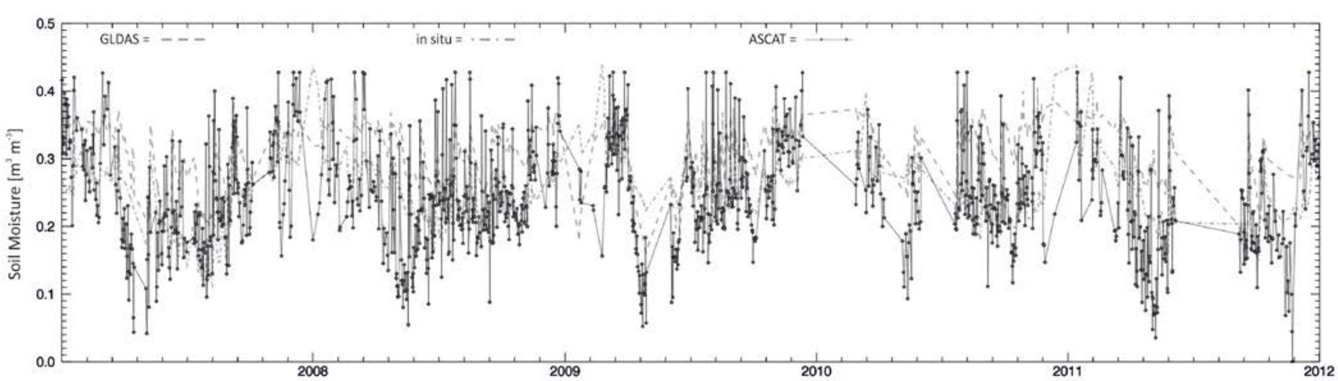

Figure 3: Time series of in situ soil moisture from the IKT in situ soil moisture station in Petzenkirchen and ASCAT and GLDAS over that area.

Comparison of the in situ station SSM to ASCAT SSM observations and GLDAS-Noah model data demonstrates that the soil moisture signature of the three products corresponds to each other (R=0.56 and 0.60). However ASCAT and GLDAS data indicate an overestimation of the existing in situ station, thus indicating wetter conditions (biases of 0.06 m^3 m^{-3} for both ASCAT and GLDAS), and a Root Mean Square Error (0.07/0.09 m^3 m^{-3}). One of the reasons for the bias between the in situ observations and the modelled and remotely sensed soil moisture could be that the in situ station is located in an area with a high percentage of clay in the topsoil. In contrast, the modelled product and remote sensing product cover a larger area, including areas with more permeable soils as pointed out in this paper. Correlation coefficients, RMSE and bias are in agreement with average worldwide validation results [4, 10, 11].

5. CONCLUSIONS

The extensive analysis for the selection of station locations demonstrated that stations need to be placed in two clusters. Hereby, most of the environmental conditions present within the pixel will be covered, which shall reduce the chance of sample bias and variance in the pixel. It is expected that the new, carefully designed, network will be more representative for the SSM signal within a pixel than the one point observation used in the comparison, because of better spatial coverage. Furthermore, the new network will measure SSM at a depth of 0.05 m, which is more consistent with the thin surface layer that is observed by both passive and active microwave remote sensing. The set up of the network, with its two separate clusters, enables a robust validation for both the high resolution (3 km) radar observations and the low resolution (40 km) radiometer observations, making it a valuable validation site for SMAP.

6. REFERENCES

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