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Towards the best L-band soil moisture representation – Comparing SMOS satellite pixel with ELBARA footprints

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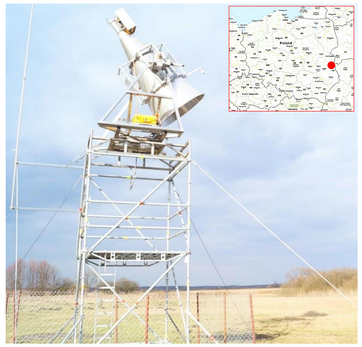
Introduction

Continuous and long-lasting measurements of soil moisture provide relevant data about changes in water content and contribute to better understanding of local and global water cycle. In this study we use the ESA L-band Radiometer (ELBARA III), mounted on a tower situated between fallow, meadow, cultivated field and Bubnow wetland, for continuous observations of different land-covers, in natural seasonal cycle over the year. Owing to the azimuth tracking capabilities, the ELBARA III maps the brightness temperatures around the tower within the full circle of azimuths. To evaluate the brightness temperature changes measured over the year we have analysed the Hovmöller diagrams. They were compared with time-courses of surface soil moisture and precipitation measured by the nearby agrometeorological station. With the aim of check if any part of Bubnow may be treated as "representative" for the entire area, we compared the brightness temperatures measured by ELBARA radiometer and Soil Moisture and Ocean Salinity (SMOS) satellite. Despite the huge scale difference between ELBARA footprint and SMOS DGG pixel, the comparison of the time-series shown some important relations.



Bubnow test site is placed in Poland, at the border of different vegetation and soil types: cultivated field, meadow, fallow and marsh (peat-bog with seasonally standing water). The soil moisture may vary from 0 % for mineral soil up to 95% for peat. Test site is 200×200 m. **ELBARA III**, the 1.4 GHz ESA passive radiometer, is placed in the centre, on 6 m tower, near agrometeorological stations (that provide soil moisture, weather and other data for reference). Radiometer trackers enables to observe high number of quasi-simultaneous footprints by rotating antenna in horizontal (azimuth range 0-350°) and vertical plane (incidence angle range 30-85°). There are 4 measuring sessions per day: at midnight (00:00 AM), in the morning (6:00 AM), noon (12:00 PM) and in the evening (6 PM) and sky calibration near midnight.

Fig 1. Photo of the ELBARA and test-site localization on Poland map

Materials and methods

Fig 2. Aerial photo of test-site

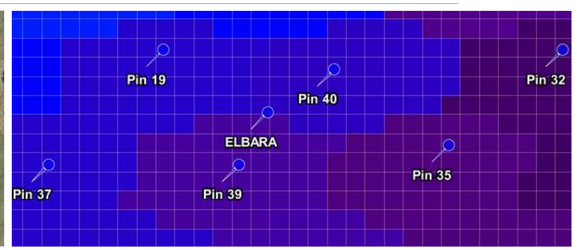


Fig 3. Representation of SMOS pixels near test-site

To assess brightness temperature variations of the studied area within 2 years, we have used the Hovmöller diagrams (Fig. 4). These diagrams were compared with both the time series of surface moisture and rainfall, measured by a nearby agro-meteorological station. The goal was to assess the response of specific footprints in the wetting/drying cycle. Subsequently we analysed the brightness temperature for three characteristic sub-areas: meadow, wetland and cultivated field. ELBARA elevation (incidence) angle was chosen 40° because it is close to the measurement angle of SMOS. ELBARA data was collected in the morning scan (starting at 04:20 UTC), which is almost the same time when SMOS passing over Bubnow Wetland region (ascending scan). Radiometric data was calculated with dedicated script wrote by Ingo Voelksch and Andreas Wiesmann. Satellite data was processed using BEAM Visat software. The results were averaged every 7 days for 4 nearest pixels around the radiometer location (marked as pin 19, 35, 39 and 40). Similar procedure was applied for results from characteristic places (meadow, wetland, cultivated field) that were measured by ELBARA. Then data was analysed using standard statistical methods (Pearson correlation).

Results

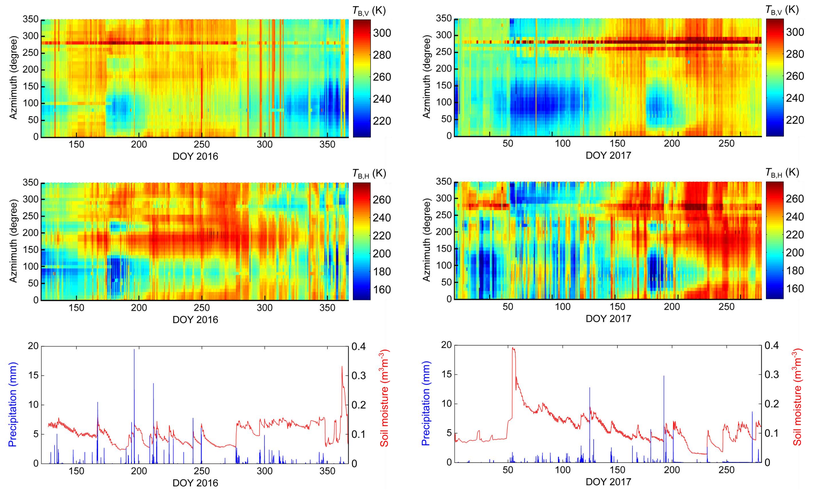


Fig 4. Hovmöller diagrams of brightness temperatures (elevation = 60°) measured by ELBARA, compared to *in–situ* soil moisture and precipitation.

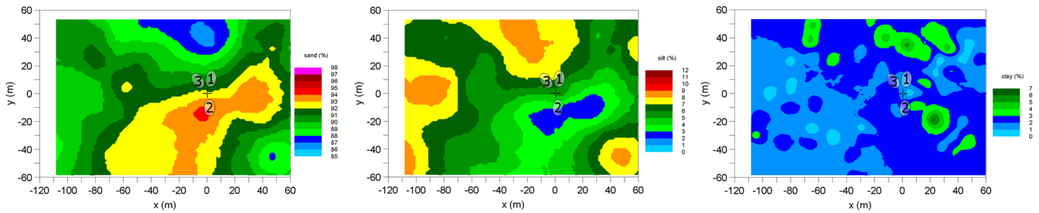


Fig 5. Sand, silt and clay contents around ELBARA (localized in (0,0) point). Marked places are study areas: 1 – meadow, 2 – wetland and 3 – cultivated field.

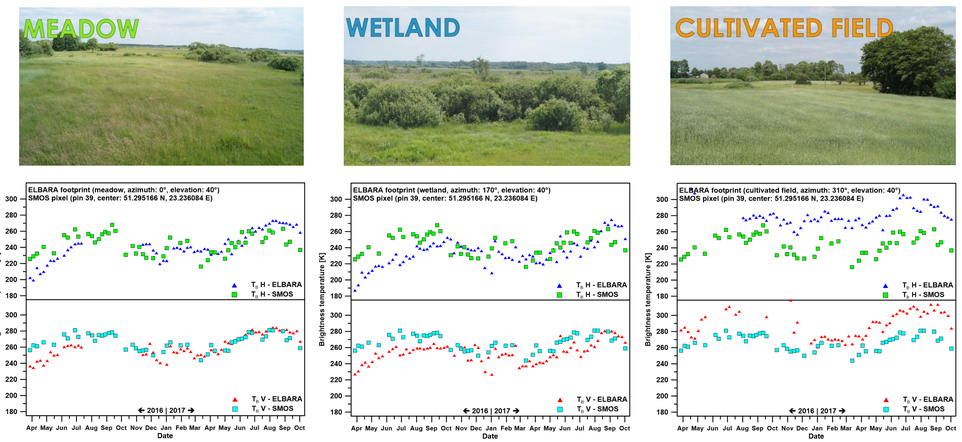


Fig 6. Photos of each study area (upper panel) and comparison of averaged measurements from ELBARA and SMOS (lower panel).

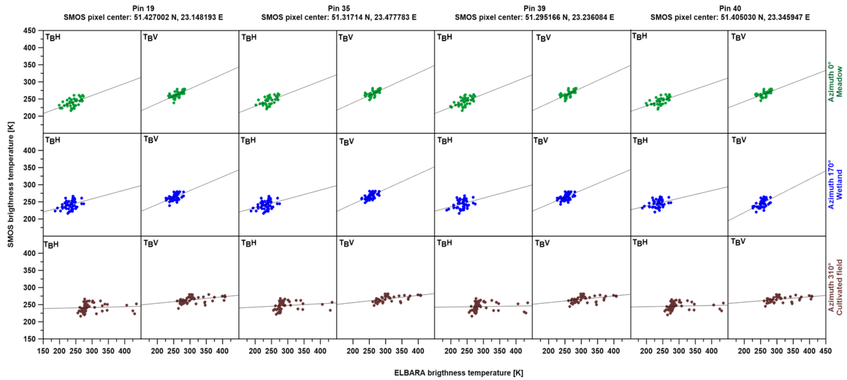


Fig 7. Comparison of ELBARA and SMOS brightness temperature results

Table 1. Summary of ELBARA vs. SMOS brightness temperatures coefficients of determination (R^2)

SMOS	Pin 19		Pin 35		Pin 39		Pin 40	
ELBARA	T_B H	T_B V	T_B H	T_B V	T_B H	T_B V	T_B H	T_B V
Meadow	0.310	0.387	0.276	0.425	0.324	0.422	0.322	0.368
Wetland	0.123	0.260	0.123	0.334	0.115	0.274	0.116	0.275
Cultivated field	0.076	0.159	0.023	0.213	0.002	0.167	0.005	0.151

Summary and Conclusions

In order to check if any examined experimental plot on Bubnow test-site is representative of the entire area seen from space, we compared the brightness temperatures measured by two L-band radiometers: ELBARA and SMOS satellite. Despite the huge scale difference (single ELBARA footprint covers about 25 m^2, whereas SMOS DGG pixel is approx. 200 km^2), the comparison of the time-series shown some weak and medium correlations. The coefficient of determination revealed that the lowest ELBARA-SMOS agreement was for the cultivated field, which may be caused by modification (thus diversification) of this area through plant cultivation, mowing and soil ploughing. Wetland, due to the high level of organic matter and lush vegetation cover, showed only a partial agreement. The meadow appears the best match with SMOS result, which is probably a consequence of meadow-agricultural land cover domination in the examined pixel. Also high sand content, low vegetation and thus reduced number of factors influencing thermal radiation may be the reasons for such fair agreement. Comparing the brightness temperature measured by ELBARA with *in-situ* agro-meteorological data we have noticed that only for a few footprints the brightness temperature decreases after rain events. For most of them increases, what is characteristic for strong rain interception effects. In general, for most antenna footprints, the measured brightness temperature is strongly dependent on the effect of vegetation, litter and interception, and only partly on the soil moisture. Despite that fact, it was possible to determine the footprint representative for the entire pixel area seen by SMOS satellite (at least in the 2 examined years).

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