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# COMPARISON OF SMAP-DERIVED SOIL MOISTURE PRODUCTS FOR NEAR REAL-TIME ROOT-ZONE SOIL MOISTURE ESTIMATION



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- New end-level L4 products for hydrological and agricultural applications are being developed from recent missions devoted to soil moisture, e.g. **SMOS** and **SMAP**.
- The soil moisture observation by remote sensing is made in the first few centimeters, but the root-zone soil moisture estimation is challenging because this soil layer is the reservoir of the plant available water.
- The Soil Water Index (SWI) was successfully used as a proxy of the root-zone soil moisture in several applications.

**The objective of this research is to compare the LEVEL 4 Root Zone Soil Moisture product with a proposed, new product using the Level 2 Surface Soil Moisture from SMAP and the Soil Water Index (SWI) as a surrogate of the root-zone soil moisture. The study period spans from March, 31 to December, 31 2015.**



- **SMAP L2\_SM\_P** is soil moisture derived from the radiometer brightness temperature measurements (Table 1).

Product	Description	Gridding (Resolution)	Latency**	
L1A_Radiometer	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_Radar	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer $T_b$ in Time-Order	(36×47 km)	12 hrs	
L1B_S0_LoRes	Low-Resolution Radar $\sigma_0$ in Time-Order	(5×30 km)	12 hrs	
L1C_S0_HiRes	High-Resolution Radar $\sigma_0$ in Half-Orbits	1 km (1-3 km) <sup>a</sup>	12 hrs	
L1C_TB	Radiometer $T_b$ in Half-Orbits	36 km	12 hrs	
L2_SM_A	Soil Moisture (Radar)	3 km	24 hrs	Science Data (Half-Orbit)
L2_SM_P*	Soil Moisture (Radiometer)	36 km	24 hrs	
L2_SM_AP*	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	Science Data (Daily Composite)
L3_FT_A*	Freeze/Thaw State (Radar)	3 km	50 hrs	
L3_SM_A	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P*	Soil Moisture (Radiometer)	36 km	50 hrs	
L3_SM_AP*	Soil Moisture (Radar + Radiometer)	9 km	50 hrs	
L4_SM	Soil Moisture (Surface and Root Zone)	9 km	7 days	Science Value-Added
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	14 days	

- **SMAP L4\_SM** (root zone) product merges surface observations with estimates from a land surface model in a data assimilation system, including precipitation and a soil moisture vertical transfer model between the surface and root zone reservoirs (Table 1). 8 estimations per day are provided.

Table 1. SMAP Products and characteristics.

- Using the L2\_SM to estimate root zone soil moisture **the latency can be improved from 7 days to 24 hours!**

- The Soil Moisture Measurement Stations Network of the University of Salamanca (**REMEDHUS**) is a permanent ground network covering a 1300 km<sup>2</sup> region in the Northwest of Spain with soil moisture stations measuring at different soil depths (Figure 1).

- L2\_SM and L4\_SM surface was firstly compared to the ground-measured surface soil moisture (Table 2).

	R	RMSD (m <sup>3</sup> m <sup>-3</sup> )	cRMSD (m <sup>3</sup> m <sup>-3</sup> )	BIAS	N
L2 Surface SM	0.69	0.064	0.043	0.047	152
L4 Surface SM	0.54	0.109	0.038	-0.085	2159

Table 2. Results of the comparison between L2 and L4 surface SM (area-averaged) with *in situ* surface measurements

- L4\_SM root zone was compared to the ground-measured soil moisture at different depths (Table 3).

	R	RMSD (m <sup>3</sup> m <sup>-3</sup> )	cRMSD (m <sup>3</sup> m <sup>-3</sup> )	BIAS	N
25 cm	0.44	0.087	0.035	-0.068	2156
50 cm	0.21	0.076	0.035	-0.037	2156
100 cm	-0.22	0.069	0.029	-0.030	2123
0-100 cm	0.43	0.062	0.023	-0.048	2123

Table 3. Results of the comparison between L4 root-zone SM (area-averaged) with *in situ* measurements at different depths

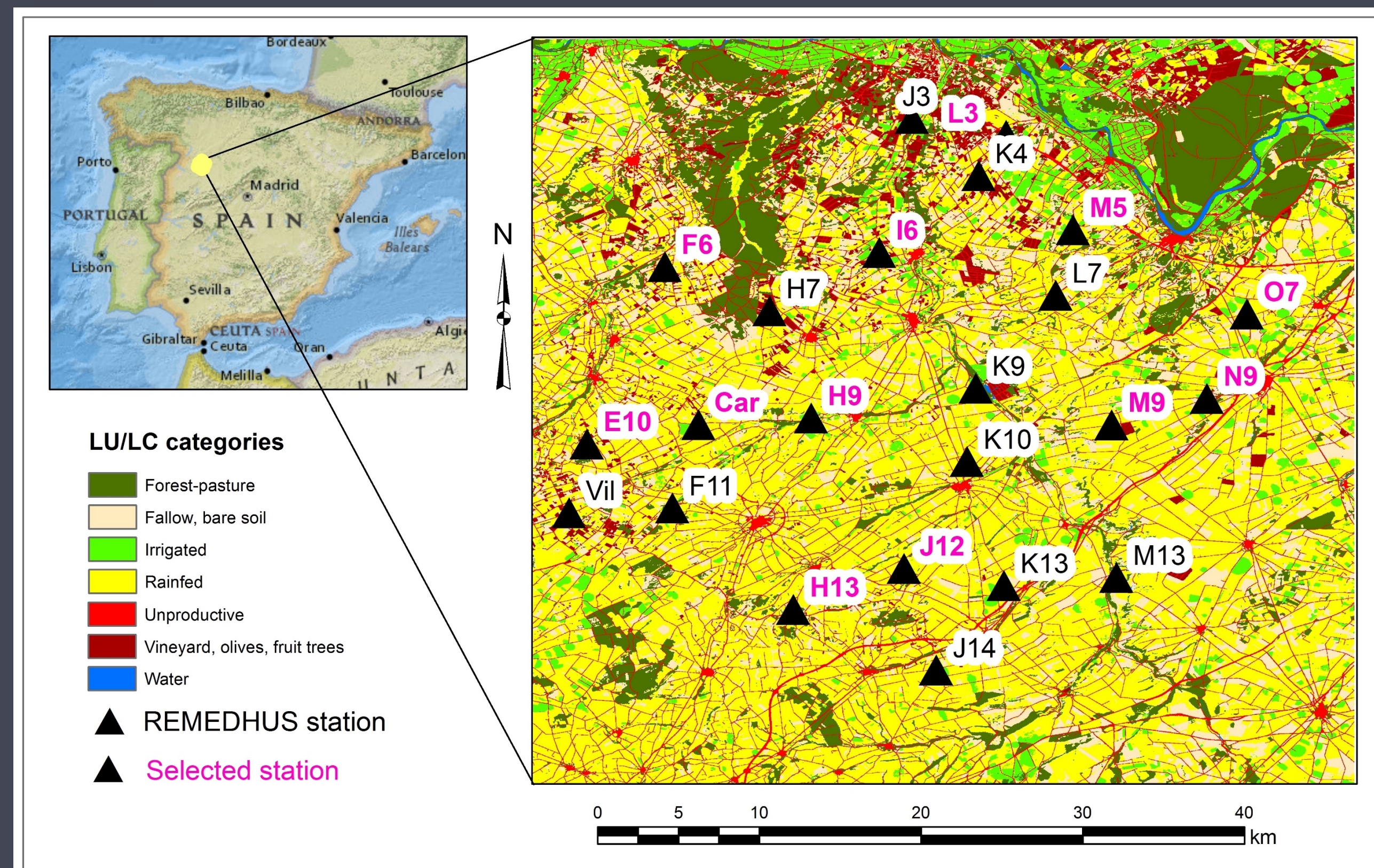


Figure 1. REMEDHUS stations over a Land Cover-Land Uses map.

The best correlation was found for the 25 cm top layer and the profile average. cRMSD is lower than 0.04 m<sup>3</sup>m<sup>-3</sup> and bias is negative, indicating overestimation.

The **proposed model** (Wagner et al., 1999; Albergel et al. 2008) relates the instantaneous value of surface moisture to the profile moisture using an exponential smoother filter instead of a linear relation, assuming that the soil moisture content integrated over deeper layers exhibits much smaller variations than in the topmost layer.

$$SWI_n = SWI_{(n-1)} + K_n(SM(t_n) - SWI_{(n-1)})$$

$$K_n = \frac{K_{n-1}}{K_{n-1} + e^{-\frac{t_n - t_{n-1}}{T}}}$$

T is an exponential smoother filter representing (in days) the characteristic time length for each type of soil, increasing with the depth of the reservoir and decreasing with the specific-soil diffusivity constant.

E10	r	p-value	RMSD	cRMSD	bias	N
25 cm	0.59	0.00	0.052	0.045	0.027	95
50 cm	0.43	0.00	0.252	0.035	0.250	95
100 cm	0.30	0.00	0.221	0.029	0.219	95
Area-Average						
25 cm	0.58	0.00	0.095	0.044	0.073	122
50 cm	0.27	0.00	0.107	0.033	0.088	119
100 cm	-0.34	0.00	0.135	0.032	0.128	121

Table 4. Results of the comparison between L2 SWI-derived with *in situ* measurements at different depths

The proposed root zone soil moisture product L2-based **improves the accuracy** of the original L4\_SM whilst diminishing the period of time between the observation acquisition and the possible deliver, owing to the **smaller latency** of the L2 product.

**24 h**

Albergel, C., Rüdiger, C., Pellarin, T., Calvet, J.-C., Fritz, N., Froissard, F., Suquia, D., Petitpa, A., Pignat, B., Martin, E., 2008. From near-surface to root-zone soil moisture using an exponential filter: an assessment of the method based on in-situ observations and model simulations. *Hydrology and Earth System Sciences*, 12: 1323-1337

Wagner, W., Lemoine, G., Rott, H., 1999. A Method for Estimating Soil Moisture from ERS Scatterometer and Soil Data. *Remote Sensing of Environment*, 70(2): 191-207

- Both L4 and L2-derived products have shown an acceptable relationship with ground measurements, but further research is needed when a longer period of data is available.
- The proposed experimental product is a potential root-zone product derived from the original L2\_SM as an input and a simple, easy-to-implement model. A challenging scenario of new products is opened from the SMAP family products and applications.

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