Supplemantary Material

Table S1: Available satellite data sets and reduction due to temperature and synchronization effects. The temporal interval of synchronized data is three days of consecutive data followed by three days without data.

Days	SMAP	Sentinel-1
original	881	428
Without data	24 → 857	
Low T	77 → 780	
Lost during synchronization	403→377	51 → 377
Final data set	377	377



Figure S1: Time series of soil moisture measured by capacitance probes at a depth of 0-5 cm (blue) and at a depth of 20-25 cm (red). R² is the coefficient of determination based on the linear regression between the soil moisture measured at the two different depth. Those sensors used for the analysis are highlighted in green.



Figure S2: Scatterplot of VV and VH backscatter vs. CRN soil moisture at the three CRN station sites and six different resolutions (20 m - 1000 m). Black dotted line indicates the linear regression line.

Table S2: Statistics of θ (SMAP) versus VH at spatial resolutions of 20 m, 100 m and 1000 m, shown invariant in space (entire area) or variant in space according to the three clusters.

θ vs VH	20 m		100 m		1000 m	
	slope	R ²	slope	R ²	slope	R ²
Entire area	0.036	0.293	0.037	0.293	0.037	0.293
Agriculture	0.018	0.239	0.020	0.249	0.028	0.296
Heathland	0.048	0.378	0.047	0.374	0.042	0.314
Forest	0.082	0.253	0.074	0.226	0.054	0.175



Figure S3: β estimation (θ SMAP vs. VV) for the three individual clusters and the entire area.



Figure S4: Scatter plots of SMAP estimated soil moisture vs. Sentinel-1 VH backscatter for the different clusters and the entire area.

Table S4: Example of Γ (δ (VV/VH)) estimation results for time-constant and space-independent (entire area) and space-dependent (based on the mean of Clusters) Γ .

Γ estimation	20 m		100 m		1000 m	
	Г	R ²	Γ	R ²	Г	R ²
Entire area	0.622	0.719	0.623	0.718	0.625	0.718
Agriculture	0.610	0.660	0.622	0.662	0.628	0.681
Heathland	0.635	0.719	0.634	0.724	0.6230	0.729
Forest	0.630	0.784	0.627	0.776	0.629	0.799



Figure S5: Downscaled soil moisture (mean and std) at a spatial resolution of 100 m shown for all 8 types.



Figure S6: Downscaled soil moisture (mean and std) at a spatial resolution of 1000 m shown for all 8 types.



Figure S7: Sentinel-1 backscatter in VV and VH polarization and their cross-ratio at a spatial resolution of 20 m at a zoom into the agricultural field at Voulund for four single dates representing different seasons.