



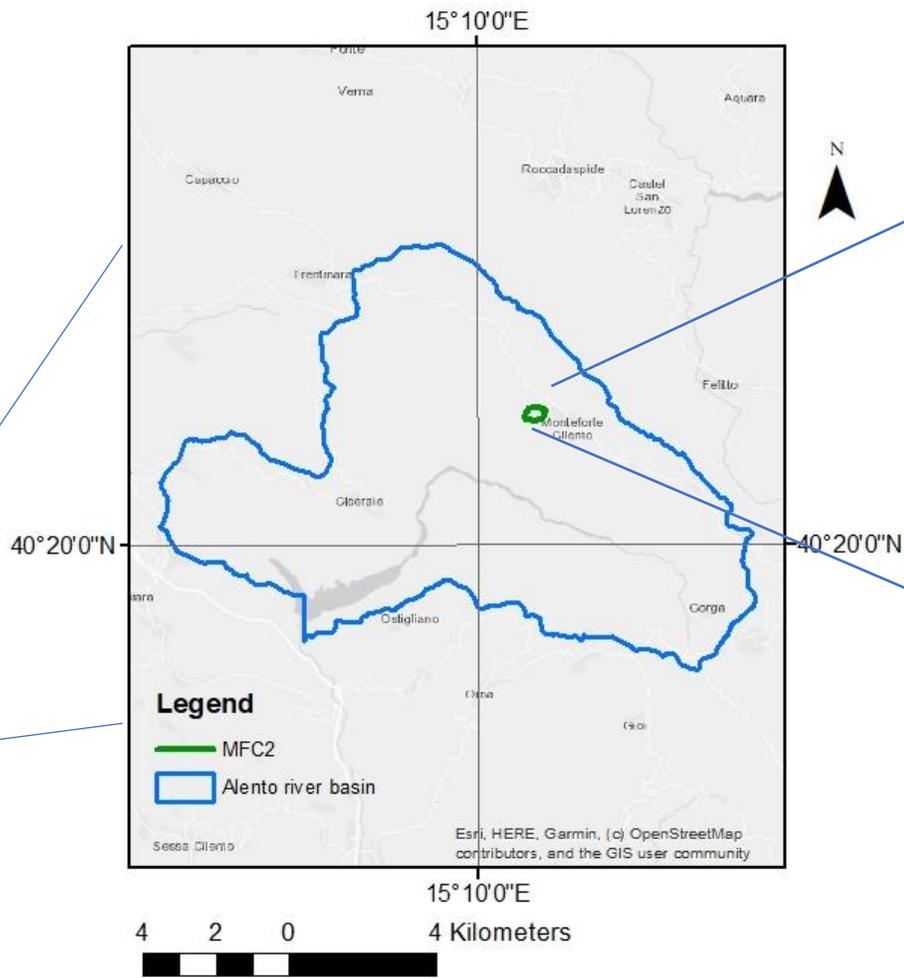
Soil Moisture Retrievals from Unmanned Aerial Systems (UAS)

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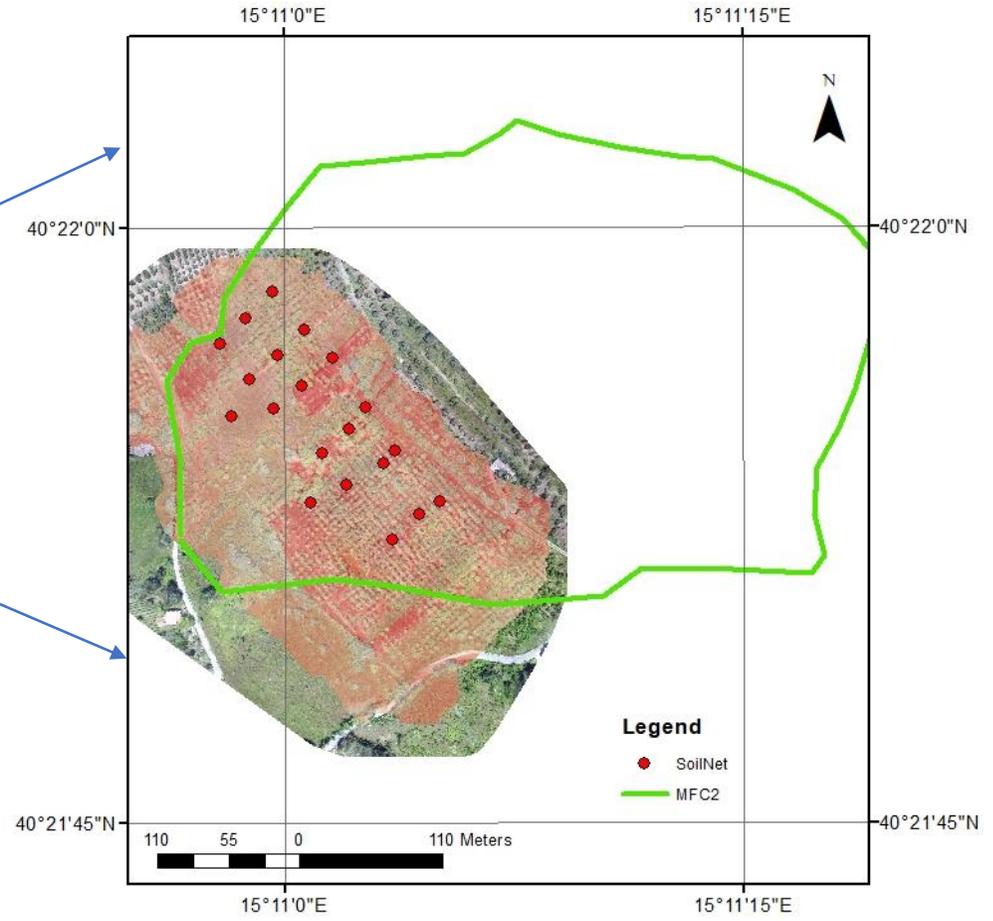
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Study Area



Alento River Basin



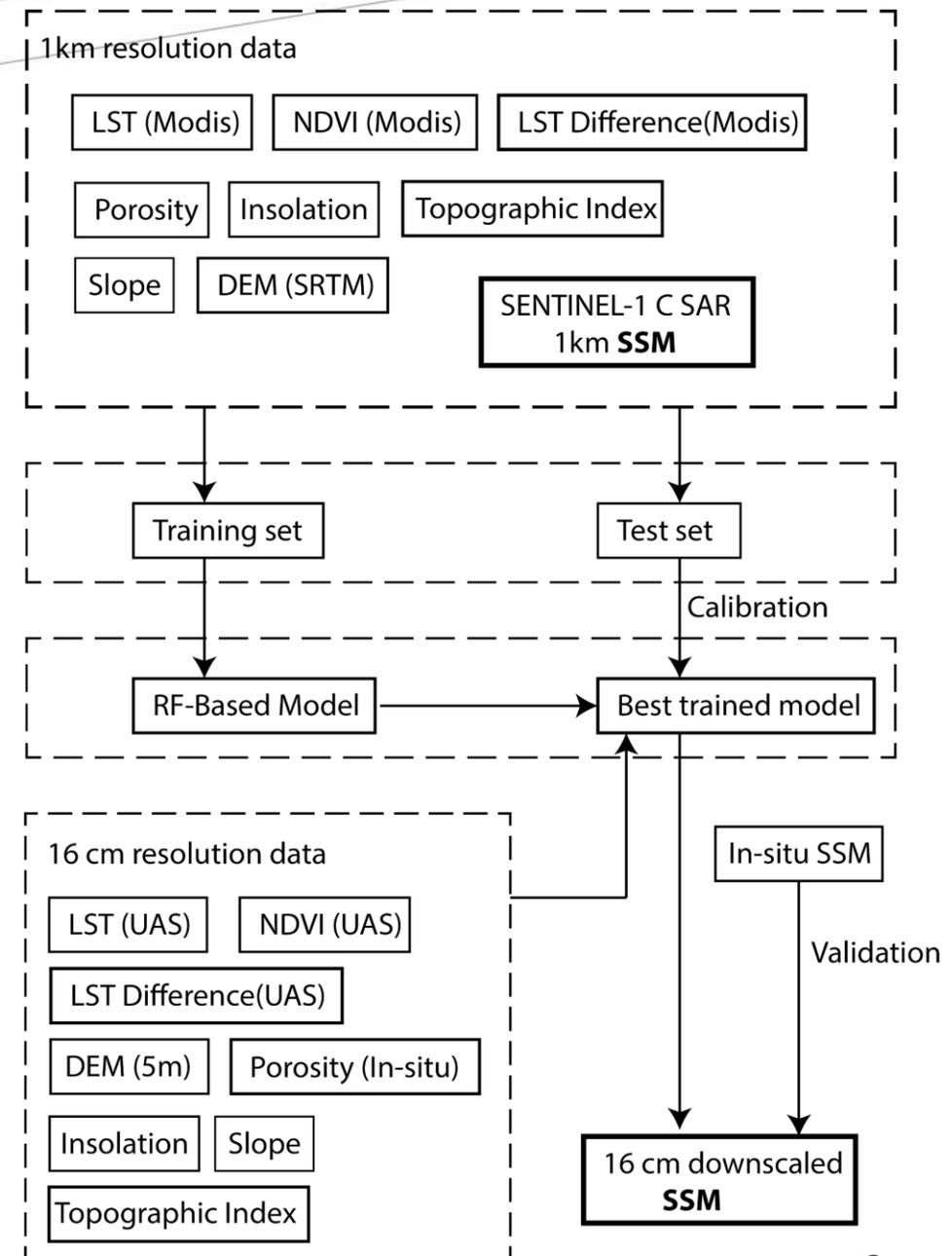
Monte Forte Cilento

SM Retrieval: Random Forest Regression Model

Eight Features:

1. Land surface temperature (LST, 1yr)
2. NDVI (1yr)
3. LST differences (LST day – LST night, 1yr)
4. Porosity
5. Insolation (monthly solar radiation distribution)
6. Topographic Index
7. DEM
8. Slope

$$C_8^3 + C_8^4 + C_8^5 + C_8^6 + C_8^7 + C_8^8 = 217 \text{ combinations}$$

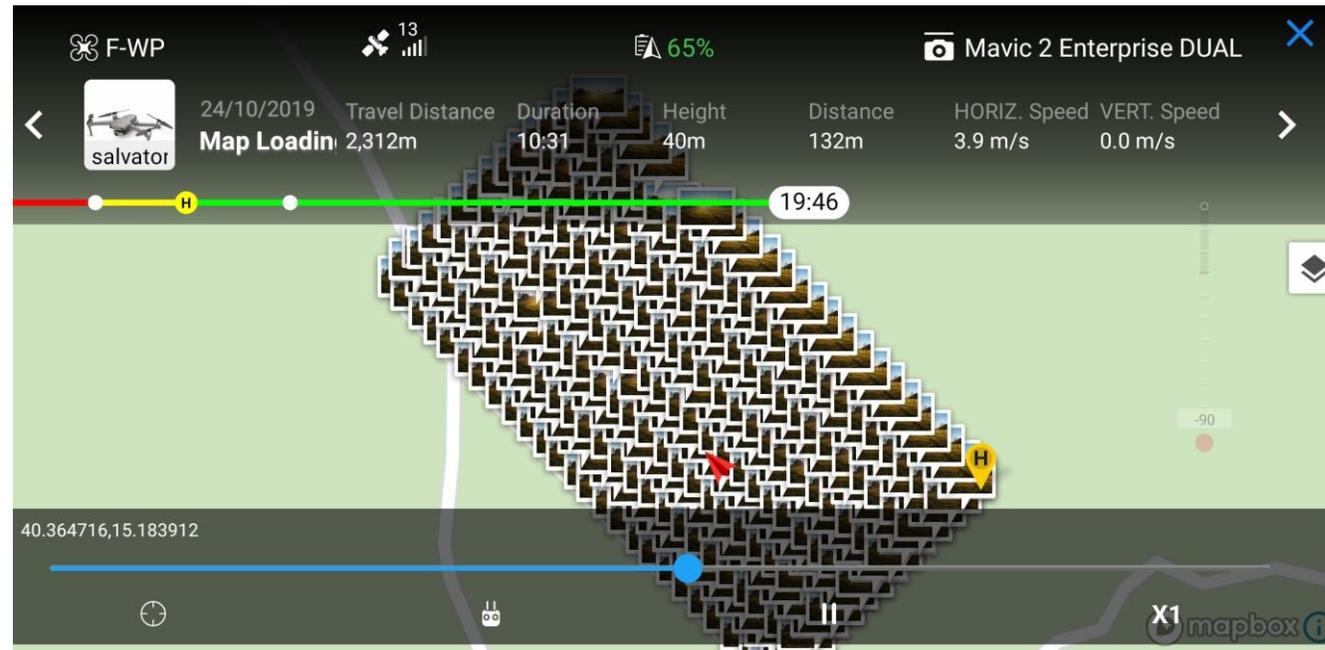


Coarse Resolution (1km) Data



Datasets (Sensor)	Variables	Spatial resolution	Temporal resolution	Source	Duration
Sentinel-1 C-SAR	Surface soil moisture (SSM)	1km	Daily	https://land.copernicus.eu/global/	<u>One-year 2015</u>
MODI11AI	Land surface temperature (LST)	1km	Daily	https://lpdaac.usgs.gov/products	One-year 2015
MODI11AI	LST difference	1km	Daily	https://lpdaac.usgs.gov/products	
MODIS	Normalized difference vegetation (NDVI)	1km	10 days	https://lpdaac.usgs.gov/products/mod13a2v006/	One-year 2015
SRTM30+	Digital Elevation Model (DEM)	1km	/	https://land.copernicus.eu/global/	/
LUCAS	Porosity	1km	/	https://esdac.jrc.ec.europa.eu/content/topsoil-physical-properties-europe-based-lucas-topsoil-data#tabs-0-description=0	/
	Slope	1km	/	DEM	/
	Insolation	1km	/	Slope	/
	Topographic Index	1km	/	DEM	/

Fine Resolution (16cm) data



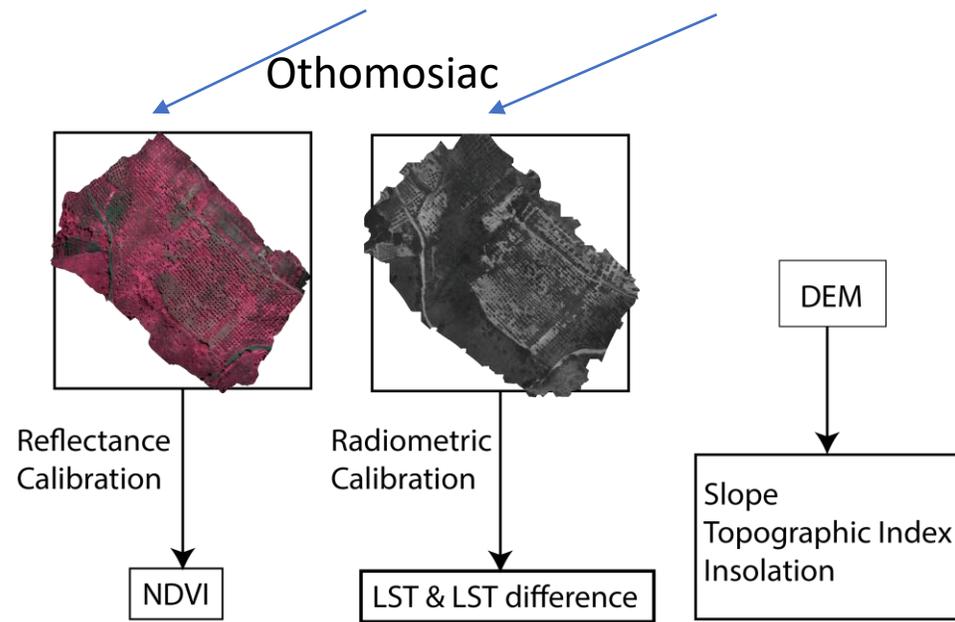
UAS Photos



RGB

Multispectral

Thermal



In-situ SM data

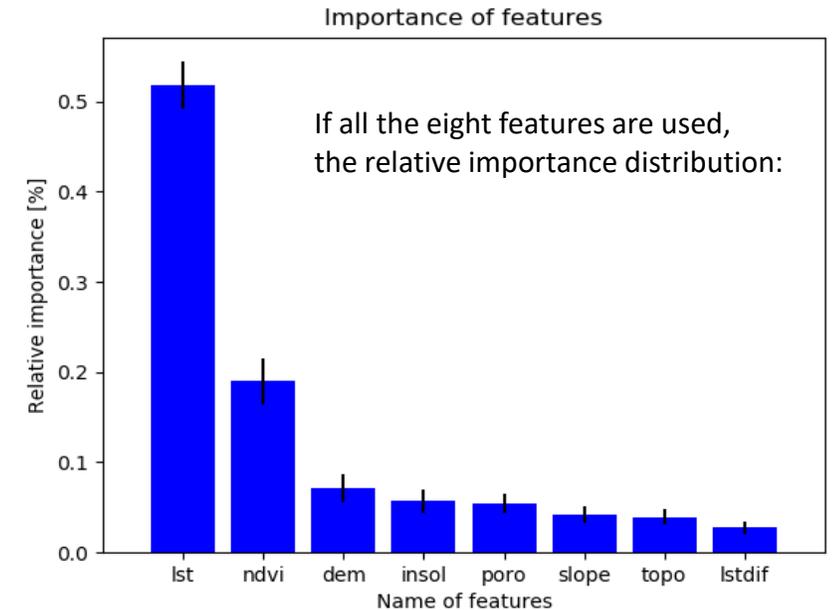
SoilNet	Porosity	SM (m3/m3) June 2019	SM (m3/m3) Oct 2018
1	0.522	0.223064	/
2	0.496	0.234558	0.239153
3	0.54	0.309555	0.259954
4	0.497	0.273765	0.20804
5	0.614	0.293384	0.248602
6	0.636	0.440813	0.35132
7	0.569	0.300506	0.207614
8	0.612	0.225775	/
9	0.526	0.294847	0.310054
10	0.524	/	/
11	0.601	0.503583	0.324233
12	0.6	0.372757	0.301017
13	0.523	0.227575	0.221581
14	0.546	0.254018	/
15	0.609	0.386679	0.293193
16	0.581	0.337154	0.302652
17	0.57	0.303795	0.275138
18	0.467	0.238331	0.227784
19	0.563	0.376328	0.296456
20	0.596	0.287435	0.244967



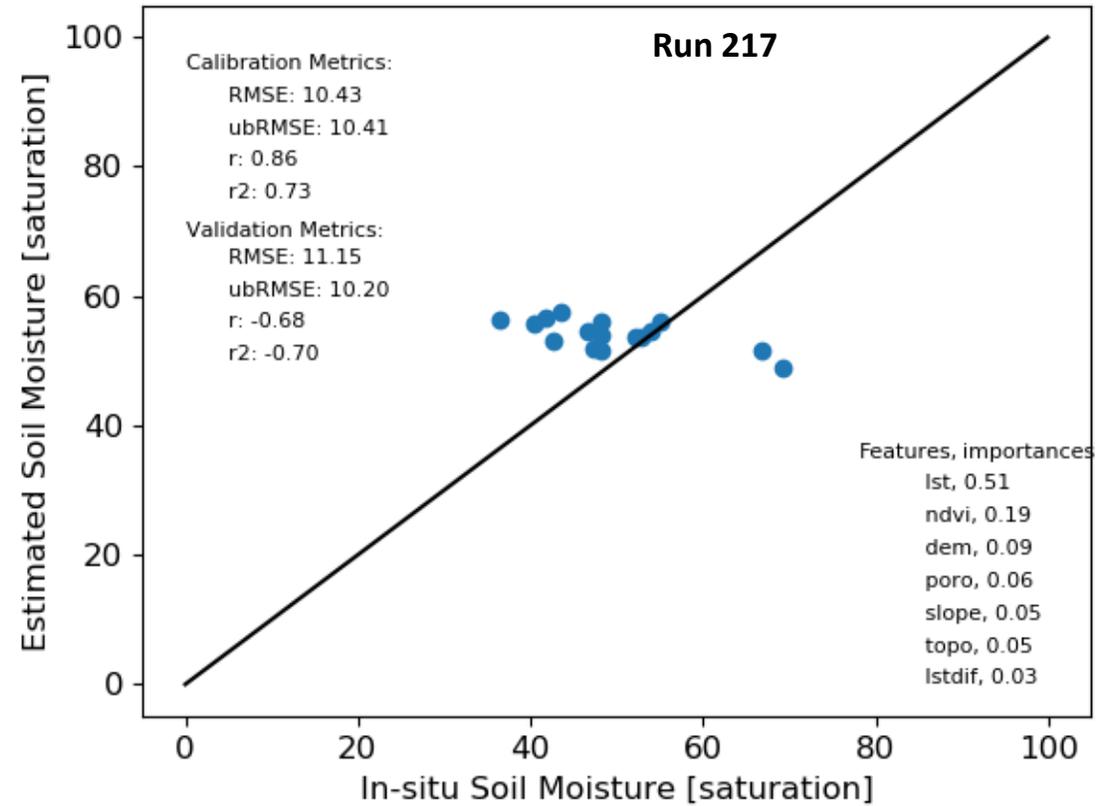
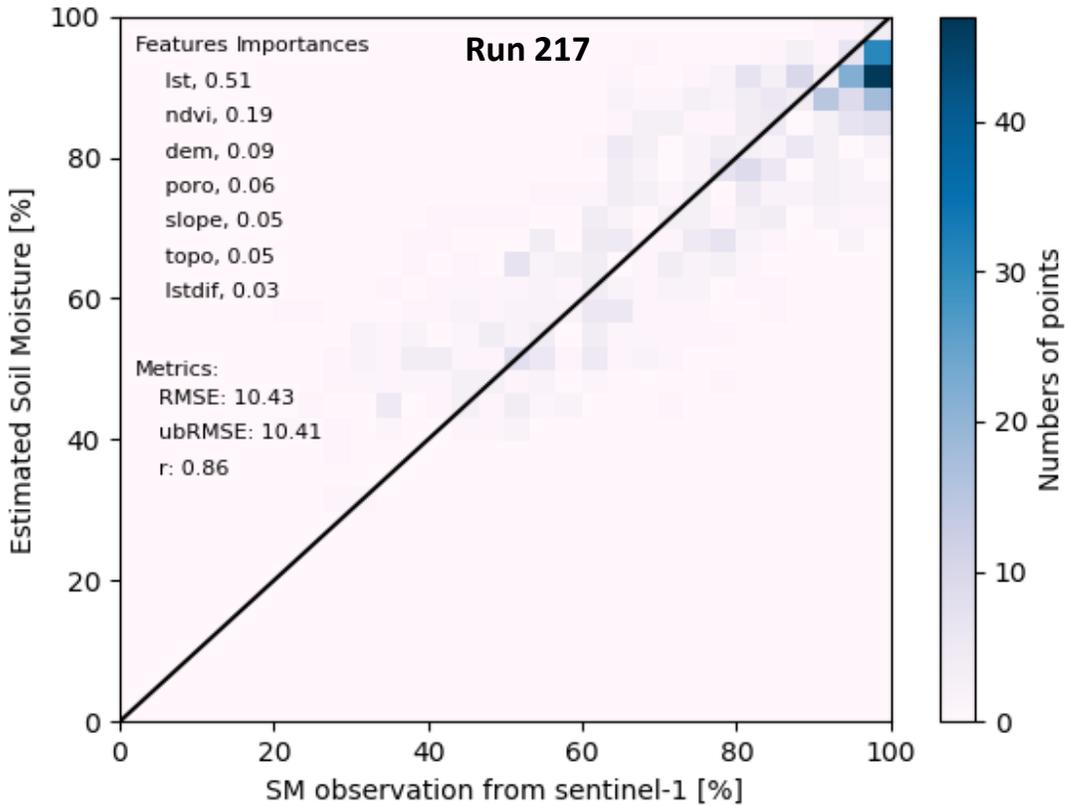
Calibration results

Table: top 20 combinations based on ubRMSE

run	features	RMSE(%)	ubRMSE(%)	p_r
217	['lst', 'ndvi', 'lstdif', 'dem', 'slope', 'topo', 'poro']	10.4313	10.4126	0.8580
216	['lst', 'ndvi', 'lstdif', 'dem', 'slope', 'insol', 'poro']	10.4967	10.4921	0.8495
218	['lst', 'ndvi', 'lstdif', 'dem', 'slope', 'topo', 'insol']	10.8831	10.8019	0.8285
168	['lst', 'ndvi', 'dem', 'topo', 'poro']	10.9099	10.8613	0.8383
179	['lst', 'ndvi', 'lstdif', 'dem', 'poro']	10.9237	10.8940	0.8301
201	['lst', 'ndvi', 'lstdif', 'topo', 'insol', 'poro']	10.9321	10.8852	0.8324
205	['lst', 'ndvi', 'lstdif', 'dem', 'insol', 'poro']	11.1430	11.1403	0.8308
166	['lst', 'ndvi', 'slope', 'topo', 'insol']	11.2449	11.2005	0.8171
206	['lst', 'ndvi', 'lstdif', 'dem', 'topo', 'poro']	11.2927	11.2914	0.8228
113	['lst', 'ndvi', 'topo', 'poro']	11.3042	11.2870	0.8231
208	['lst', 'ndvi', 'lstdif', 'dem', 'slope', 'poro']	11.3130	11.3099	0.8161
213	['lst', 'ndvi', 'dem', 'slope', 'topo', 'insol', 'poro']	11.3174	11.3100	0.8381
173	['lst', 'ndvi', 'lstdif', 'insol', 'poro']	11.4308	11.4264	0.8320
209	['lst', 'ndvi', 'lstdif', 'dem', 'slope', 'insol']	11.4547	11.4258	0.8403
210	['lst', 'ndvi', 'lstdif', 'dem', 'slope', 'topo']	11.4600	11.4585	0.8268
215	['lst', 'ndvi', 'lstdif', 'dem', 'topo', 'insol', 'poro']	11.4734	11.4685	0.8307
207	['lst', 'ndvi', 'lstdif', 'dem', 'topo', 'insol']	11.4897	11.4897	0.8215
204	['lst', 'ndvi', 'lstdif', 'slope', 'topo', 'insol']	11.4931	11.4929	0.8090
177	['lst', 'ndvi', 'lstdif', 'slope', 'insol']	11.5101	11.4242	0.8042
219	['lst', 'ndvi', 'lstdif', 'dem', 'slope', 'topo', 'insol', 'poro']	11.5613	11.5564	0.8215



Calibration Results vs Validation Results



The combinations work well in calibration at large scale (30km*30km, 1km resolution)
 could give a bad results at small scale (200m*300m, 16cm resolution)

Calibration Results vs Validation Results

Table: top 5 combinations based on RMSE

run	features	rmse	ubrmse	p_r
48	['lst', 'lstdif', 'topo']	8.3438	8.1064	0.3327
103	['lst', 'lstdif', 'topo', 'poro']	8.4527	8.4073	0.2375
156	['lst', 'lstdif', 'slope', 'topo', 'insol']	8.5652	8.5199	0.1173
105	['lst', 'lstdif', 'slope', 'poro']	8.6973	8.6750	0.2099
155	['lst', 'lstdif', 'slope', 'topo', 'poro']	8.7052	8.0827	0.3283

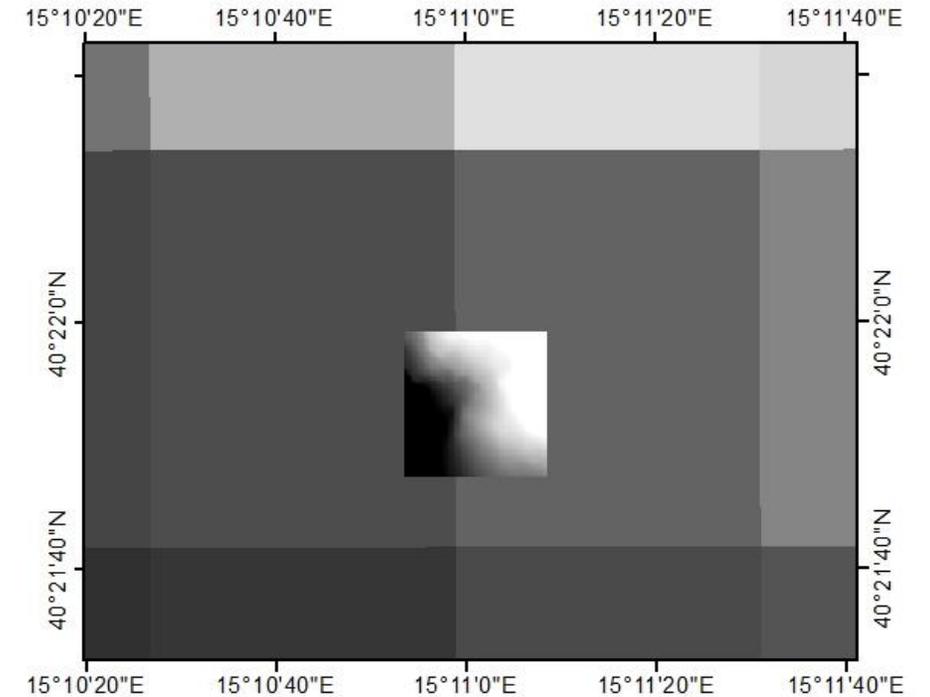
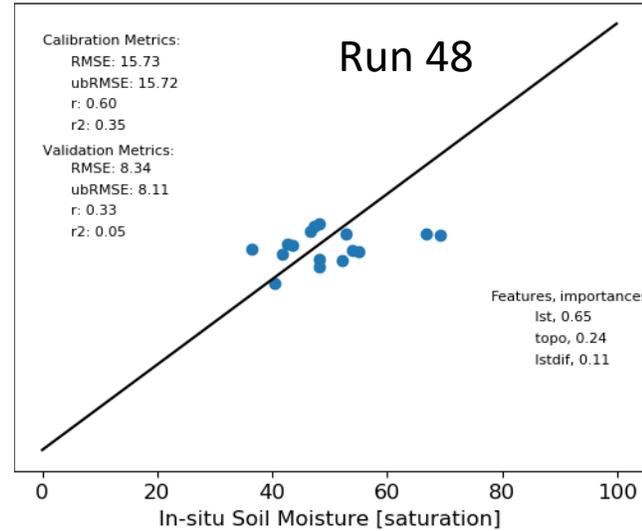
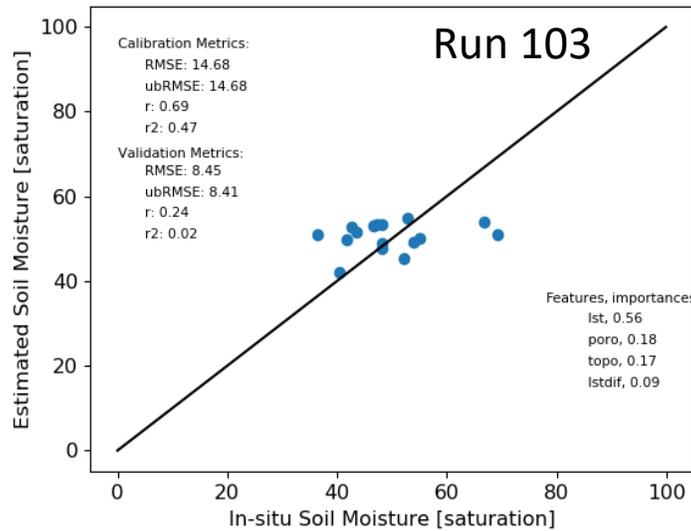


Fig. 16cm resolution and 1km resolution

Combinations work well at both large and small scale:

The feature combinations work well at small scale can also work well in large scale.

Thanks!