Application of ECOSTRESS multispectral LWIR images to assess topsoil properties: preliminary results on agricultural test sites in Central Italy

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INTRODUCTION

- ECOSTRESS (Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station) was built at NASA-JPL and launched to the ISS on June 29, 2018. It has a viewing swath width of around 384 km, has a variable revisit times, dependent on the orbit of ISS.

- ECOSTRESS uses a multispectral thermal infrared radiometer to capture radiance of the Earth's surface in 5 spectral bands in the thermal infrared (8-12 micron) and one shortwave infrared band. It acquires data at ~ 70 m spatial resolution. Emissivity and T data set were downloaded from the web site.

- Multispectral data in the LWIR region allows to retrieve quantitative information on top soil properties, such as texture, carbon and nitrogen content. Literature reports the use of multivariate statistical models.

- This study intends to verify the potential of night and day ECOSTRESS images for topsoil properties estimation.

STUDY AREA

- On this fields ECOSTRESS images were explored (compared with the Sentinel 2 images) to identify the images in which the sample fields are ploughed (i.e., bare soil conditions)

ECOSTRESS	
29 JANUARY 2019	
3 JUNE 2019	

Channel	CW [μm]
1	8.29
2	8.78
3	9.20
4	10.49
5	12.09

ECOSTRESS

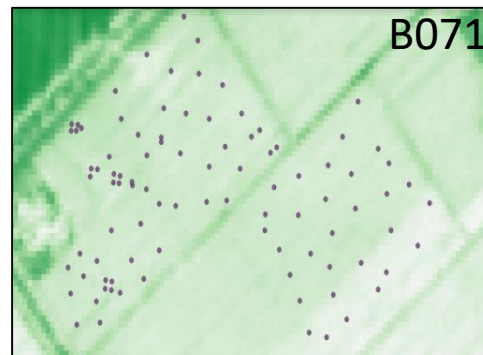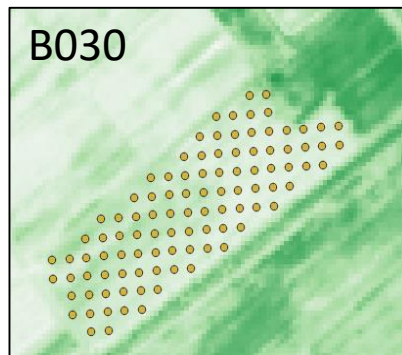**T image**

Emissivity, bands 3,4,5
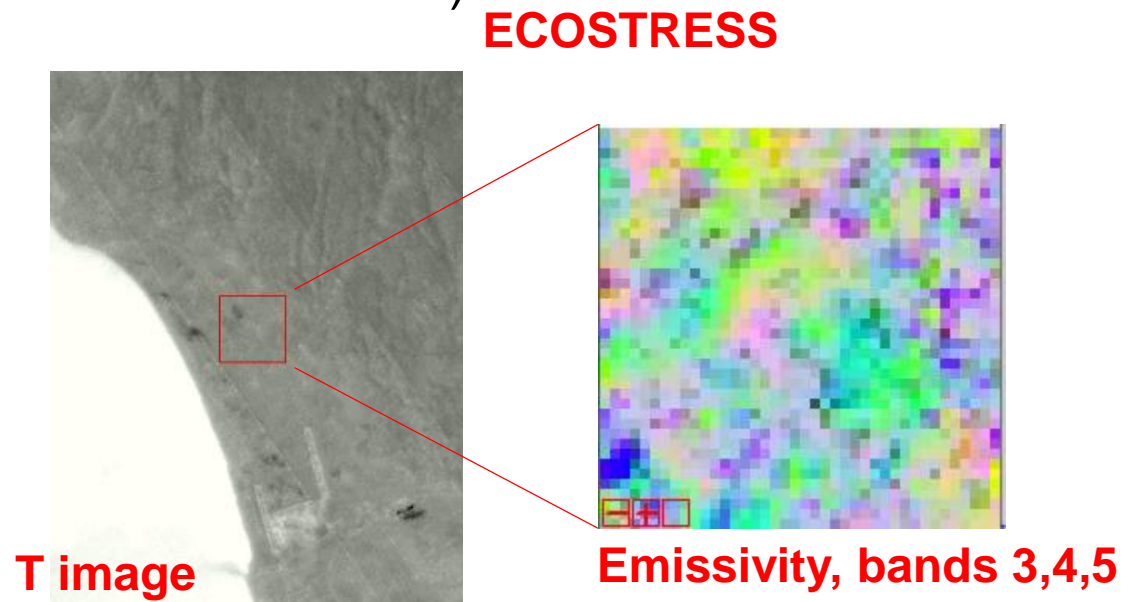
- Soil sampling campaigns have been conducted to assess the topsoil properties like soil texture (clay, silt, sand) and soil organic carbon (SOC) on specific experimental fields in the Maccarese farm (Central Italy).

STUDY AREA

- On this fields ECOSTRESS images were explored (compared with the Sentinel 2 images) to identify the images in which the sample fields are ploughed (i.e., bare soil conditions or with some residues)

SENTINEL 2	ECOSTRESS
31 JANUARY 2019	29 JANUARY 2019

Maccarese fields with sampling points

- The emissivity images were used to define a prediction model (calibration and validation) by using multivariate statistical models.

PLSR (Partial Least Square Regression)

- It is a statistical method that bears some relation to principal components regression. Principal component regression (PCR) is a regression technique based on Principal component analysis (PCA).

- PCA is a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components.

The data were used with :
- Random hold back (70% calibration, 30% validation)
- Leave-one-out-cross-validation (LOCV)

METHODOLOGY

Whenever we train or calibrate a model, we can generate predictions.

Prediction were assessed using statistical metric like:

RMSE (Root Mean Square Error)

RPD (Residual Prediction deviation)

RPIQ   (Ratio of performance to interquartile range)

R^2 (Coefficient of Determination)

Development of a prototype algorithm aiming to retrieve from spectroscopic data, soil top properties using PLSR (Partial Least Square Regression) technique using the software R.
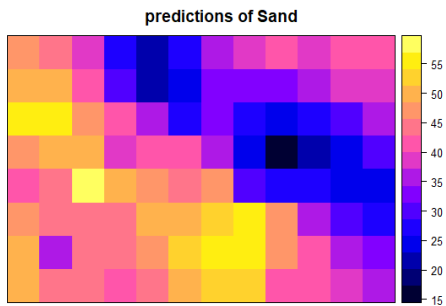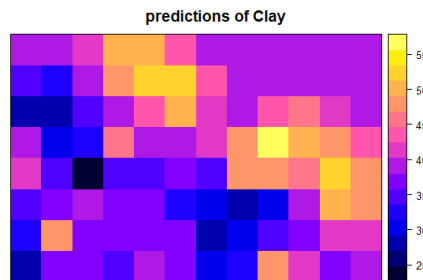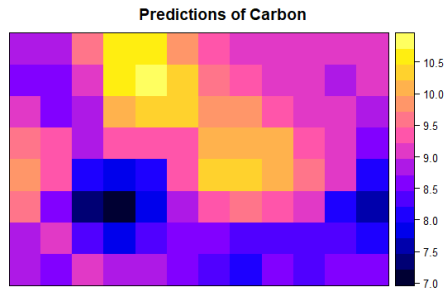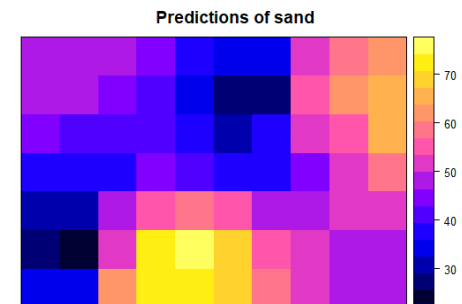
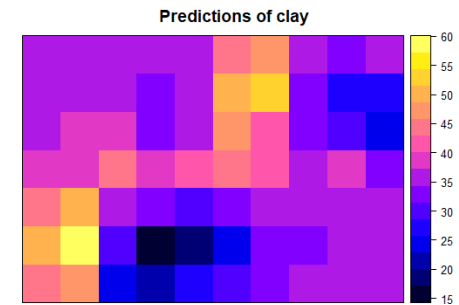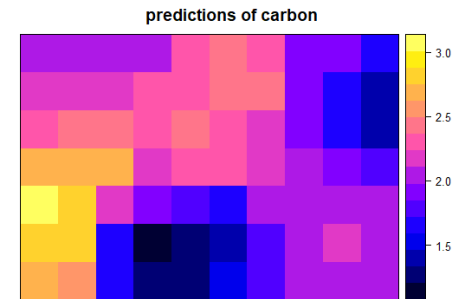For the PLSR two cases are taken into account.

Case 1: Emissivity

Case 2: Absorbance

Block kriging of sampled soil points to:
ECOSTRESS 70 pixels grid

Field B071

Predictions of Carbon

predictions of Clay

predictions of Sand

Field B030

predictions of carbon

Predictions of clay

Predictions of sand

Results:

Field - B030 field bulked data

	Variable	pretratment	n. comp	Bias	rBias	R2	r	signif	RMSE	rRMSE	MAE	RPD	RPIQ
1	carbon	reflectance	5	0.06	3.04	0.55	0.74	**	0.30	0.26	15.44	1.49	1.97
2	carbon	absorbance	5	0.06	3.04	0.55	0.74	**	0.30	0.26	15.44	1.49	1.97
3	clay	reflectance	4	-0.42	-1.14	0.45	0.67	**	7.33	5.64	19.97	1.37	1.47
4	clay	absorbance	4	-0.42	-1.14	0.45	0.67	**	7.35	5.66	20.01	1.37	1.47
5	sand	reflectance	4	0.67	1.41	0.43	0.66	**	10.49	8.38	22.32	1.35	1.84
6	sand	absorbance	4	0.67	1.42	0.43	0.65	**	10.52	8.41	22.38	1.34	1.84
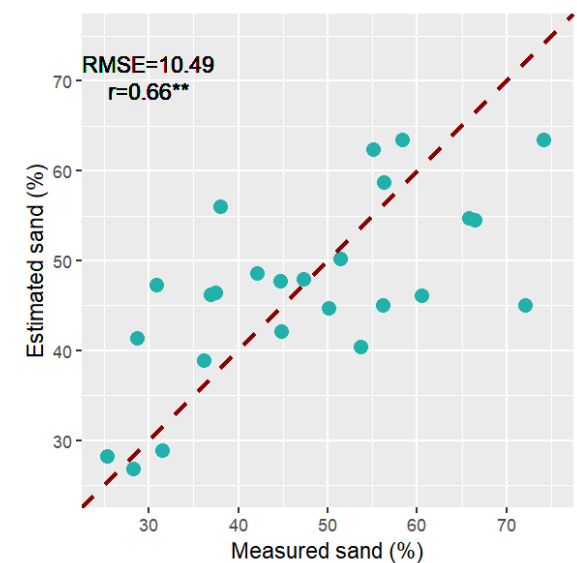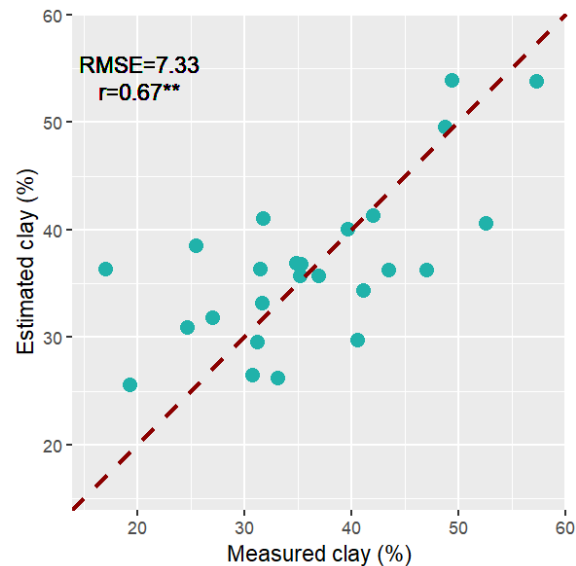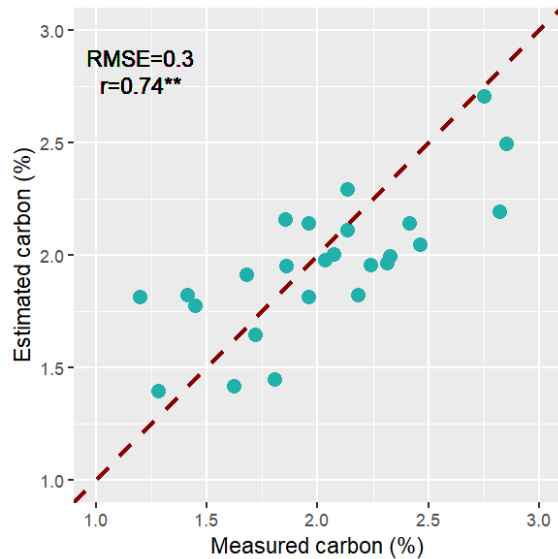
Field - B071 field bulked data

	Variable	pretratment	n. comp.	Bias	rBias	R2	r	signif	RMSE	rRMSE	MAE	RPD	RPIQ
1	Carbon	reflectance	2	-0.20	-2.21	0.19	0.44	*	0.79	0.65	8.62	1.04	1.29
2	Carbon	absorbance	2	-0.20	-2.19	0.19	0.44	*	0.80	0.65	8.63	1.04	1.28
3	Clay	reflectance	1	-0.28	-0.71	0.03	0.17	n.s.	7.78	6.78	19.69	1.04	1.79
4	Clay	reflectance	1	-0.28	-0.71	0.03	0.17	n.s.	7.78	6.78	19.69	1.04	1.79
5	Clay	absorbance	1	-0.28	-0.71	0.03	0.17	n.s.	7.78	6.78	19.68	1.04	1.79
6	Sand	reflectance	1	0.89	2.17	0.06	0.24	n.s.	9.96	8.79	24.44	1.05	1.37
7	Sand	absorbance	1	0.89	2.17	0.06	0.24	n.s.	9.96	8.78	24.43	1.05	1.37
8	silt	reflectance	2	0.77	4.17	0.34	0.59	**	2.60	1.87	14.01	1.20	1.76
9	silt	absorbance	2	0.78	4.19	0.34	0.59	**	2.61	1.87	14.05	1.19	1.76
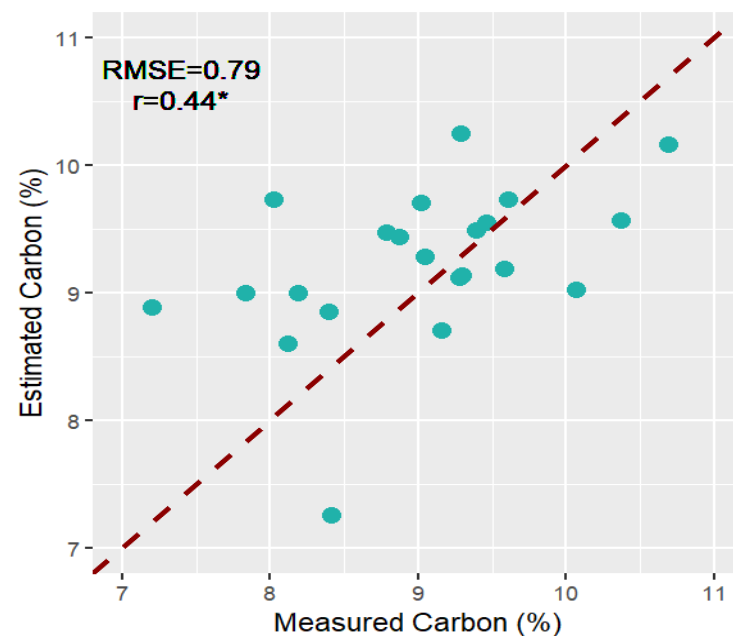
Conclusions

On the basis of the preliminary assessment of ECOSTRESS data for topsoil mapping:

1. ECOSTRESS emissivity were downloaded by the web

2. Images were compared to contemporary S2 images to identify bare soil fields

3. Soil texture and SOC data were kriged to have a spatial continuity to reduce the impact of he Ecostress GSD:

4. PLSR analysis produced:

   a. better results for Carbon and clay on Field B030

   b. retrievals on B071 gave not satisfactory results for sand e clay, while carbon still have a low RMSE

Further analysis will be performed to understand the different RMSE retrieved for the two fields (030 and 071) and including soil texture data of other central Italy sites to confirm the retrieval results obtained on Maccarese