Downscaling LST data to estimate field-scale evapotranspiration using images from the SPOT-5 Take-5 experiment

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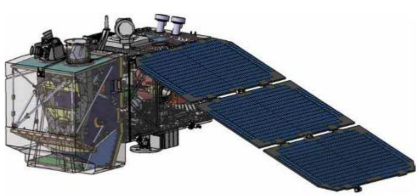

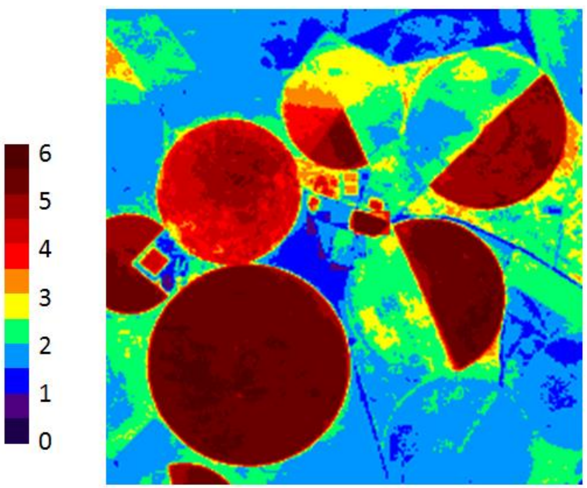

living planet symposium 2016

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9-13 May 2016

Scheme

- Introduction
  - ✓ Motivation
  - ✓ Necessity
  - ✓ Objective
- Methods
  - ✓ Study Area
  - ✓ Disaggregation techniques
  - ✓ Surface energy fluxes
- Results
  - ✓ Field scale assessment
    - Disaggregated LST
    - Surface energy fluxes
  - ✓ Image scale assessment
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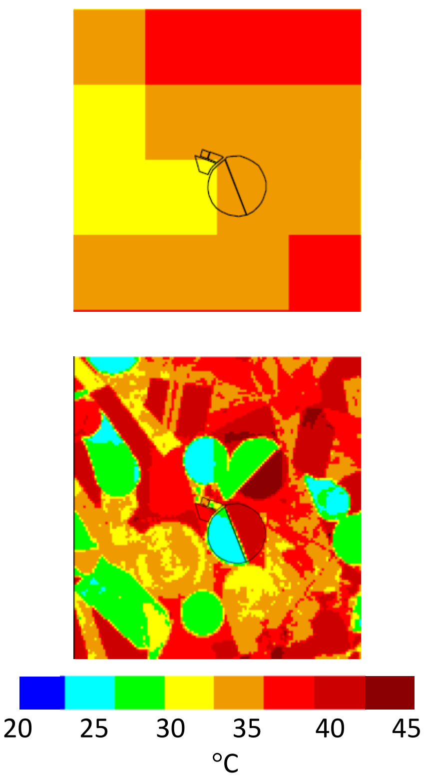
I. Introduction (motivation)

Time series of high spatial and temporal resolution images are key inputs in numerous studies, e.g water resources management .

There is a limitation in the existing satellites since those with high revisit cycles do not offer high spatial resolution (HR), and those offering HR have low temporal resolution.

This is especially remarkable when using thermal infrared (TIR) bands because they have lower spatial resolution than the visible and near infrared (VNIR) bands onboard the same sensor

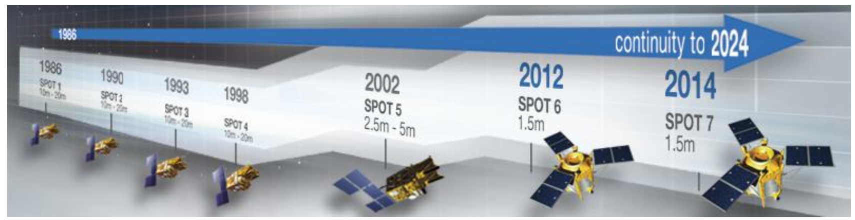


MODIS 250 m (VNIR) - 1 km (TIR)
Every day

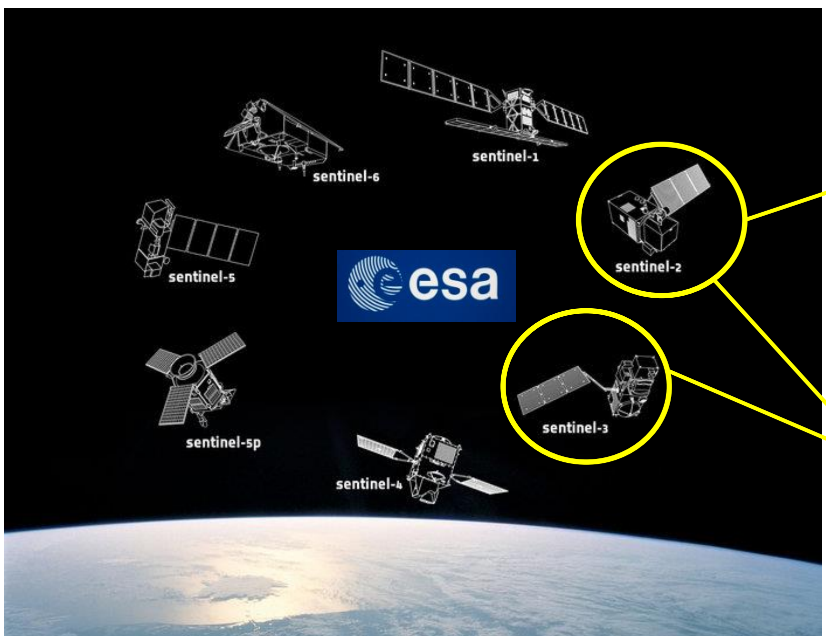
Landsat 7,8 30 m (VNIR) -60-100 m (TIR)
Every 2 weeks

I. Introduction <u>(necessity)</u>

There are HR sensors provided with VNIR bands (no TIR band) that might be helpful at this point. SPOT series is an example.



In our research we are interested in providing LST at high spatial and temporal resolutions to fulfill the requirements in the estimation of surface energy fluxes and evapotranspiration



Sentinel-2 will be offering 5-day temporal resolution and 10-20 m spatial resolution in the VNIR bands, whereas no TIR information is provided.

The combination of Sentinel-2 and Sentinel-3 could offer the desired solution of spatial and temporal resolution. The relationship between TIR and VNIR bands could be extracted from Sentinel-3 and then applied to Sentinel-2.

I. Introduction (Objective)

SPOT-5 Take 5 ESA experiment:

- Place Spot-5 in a 5-day orbit
- Support the preparation for the Sentinel-2 mission

Comparison between SPOT and Sentinel-2, VNIR band features

	SPOT 5	Sentinel-2
Launch Date – End mission	05/04/2002 – 03/31/2015*	06/23/2015 - ...
Revisit time (days)	1-3	5
Swath (km)	60	290
Multispectral bands	4	10
Spatial Resolution	10 m	4(10m) 4(20m) 2(60m)

The aim of this work is to the use disaggregated temperatures from two different satellites, in order to obtain surface energy fluxes from sensors without thermal bands (e.g. Sentinel 2) in agricultural areas.

Spot-5 and MODIS imagery are used in this work because they have similar characteristics to Sentinel 2 and 3, respectively.

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- <u>Results</u>
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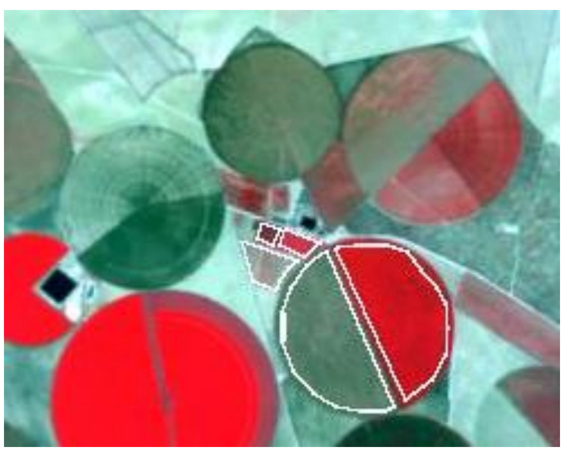
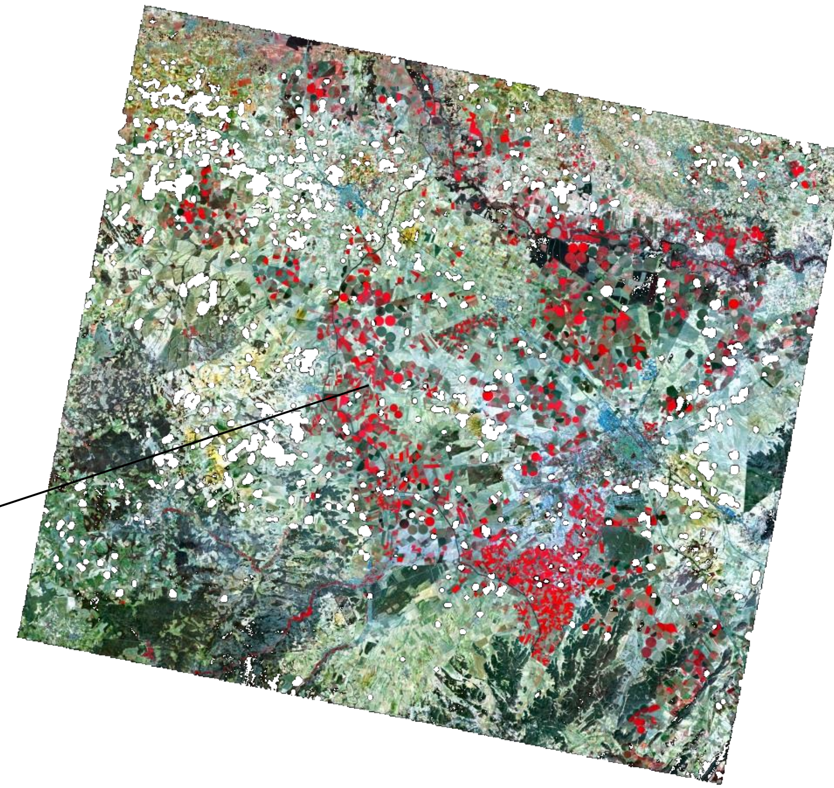
        - Surface energy fluxes

- <u>Conclusions</u>

II. Methods (Study site)

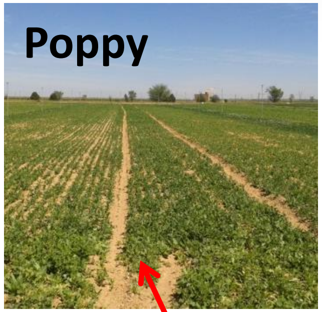
- Barrax, Central Spain (39° 03’ 35’’ N, 2° 06’ W)
- Flat area, average altitude 700 m
- ESA test site
- Variety of land uses and croplands



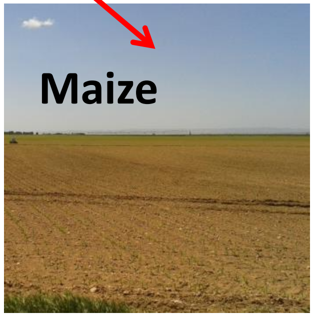


False color Spot-5 image
(R: NIR, G: red, B: green)
for date 06/29/2015

II. Methods (Study site)



- ➢Since early May 2015, ground temperatures have been measured in 5 different fields.
- ➢A variety of crops and vegetation fraction: poppy, grass, vineyard, corn and barley.
- ➢LST transects concurrent with MODIS overpasses.
- ➢The temperatures were measured using hand-held infrared radiometers (IRTs) Apogee MI-210
- ➢10 min averages around MODIS overpass time



3 Apogee MI-210

- Thermal Infrared Radiometers
- 8-14 µm spectral window
- FOV 22º
- Sensitivity 0.1ºC
- Accuracy 0.3ºC
- Working range -40 to 60ºC

II. Methods (Study site)

Two agricultural fields with ground data (LST and surface energy fluxes):

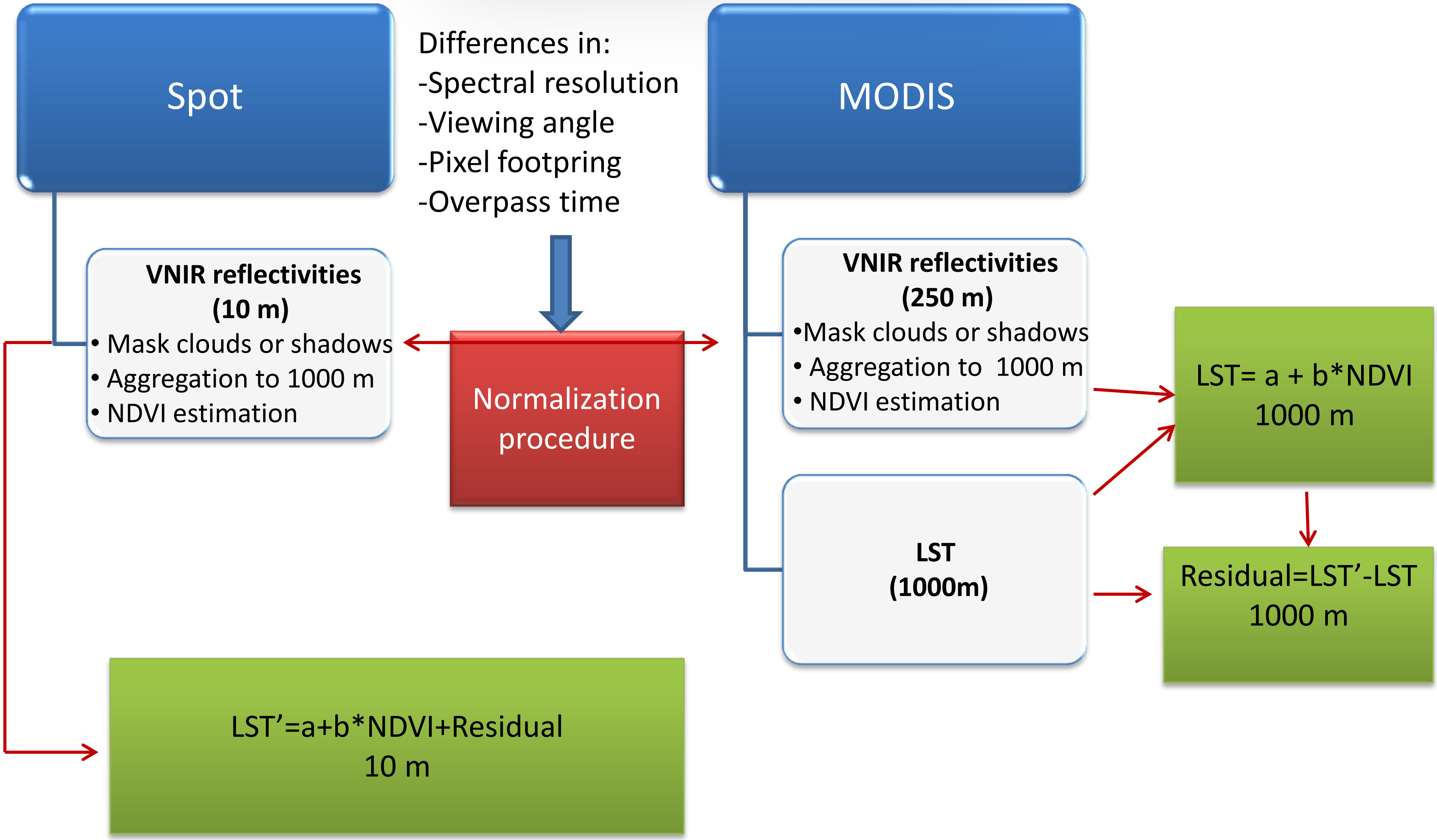
- Vineyard: Eddy-covariance with sensible heat flux and evapotranspiration, net radiometer, and ground heat flux plates

- Grass field: lysimeter (evapotranspiration) and net radiometer.

Eddy-covariance

Lysimeter

II. Methods (Disaggregation techniques)

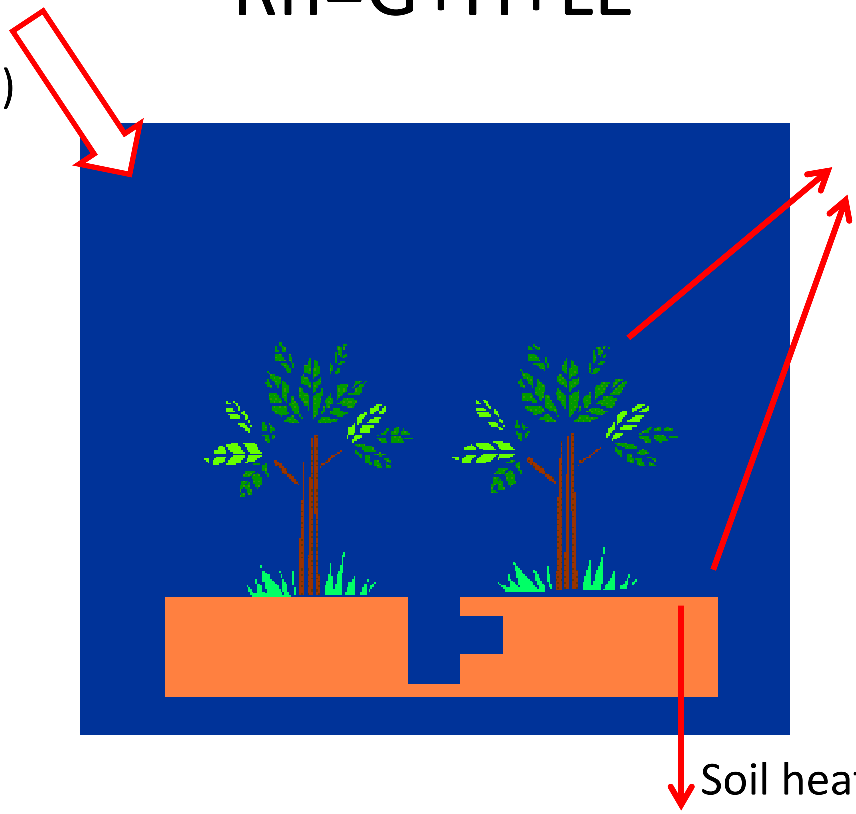


Bisquert, M.; Sánchez, J. M.; Caselles, V. (2016). Evaluation of Disaggregation Methods for Downscaling Modis Land Surface Temperature to Landsat Spatial Resolution in Barrax Test Site. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* , 9(4), 1430-1438.

II. Methods (Evapotranspiration)

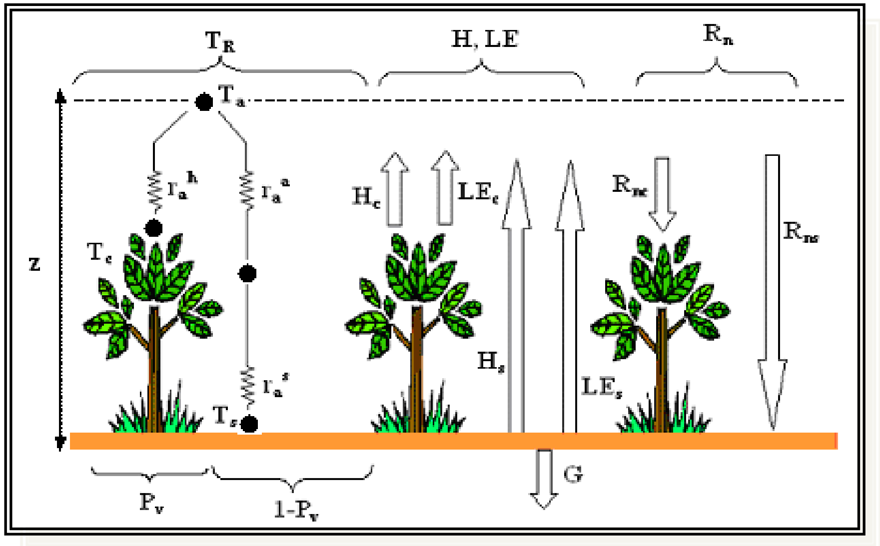
- Evapotranspiration estimation from remote sensing based on the energy balance equation (EBE)

$$Rn=G+H+LE$$



II. Methods (STSEB)

Simplified two-source energy balance model



Sensible heat flux

$$H = (1-P_v)H_s + P_v H_c$$

$$H_c = \rho C_p \frac{T_c - T_a}{r_a^h}$$

$$H_s = \rho C_p \frac{T_s - T_a}{r_a^a + r_a^s}$$

Net radiation

$$R_n = (1-\alpha)S + \varepsilon L_{sky} - \varepsilon \sigma T^4$$

Soil heat flux

$$G = C_G(1-P_v)R_n$$

C_G constant (0,15-0,40) (Choudhury et al., 1987)

Latent heat flux

$$LE = R_n - H - G$$

Sánchez, J. M.; Kustas, W.P.; Caselles, V; Anderson, M.C. Modelling surface energy fluxes over maize using a two-source patch model and radiometric soil and canopy temperature observations. ***Remote Sensing of Environment, 2008***, 112, 1130-1143.

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III. Results (LST disaggregation assessment)

May

July

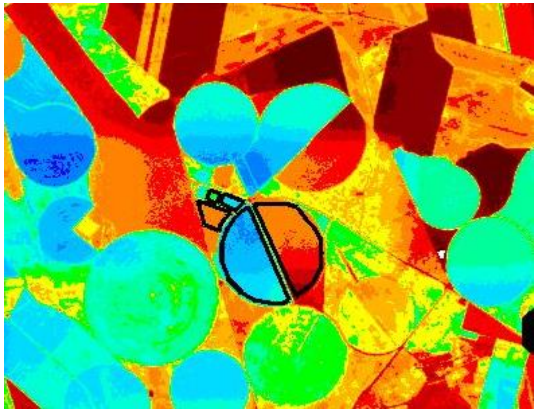




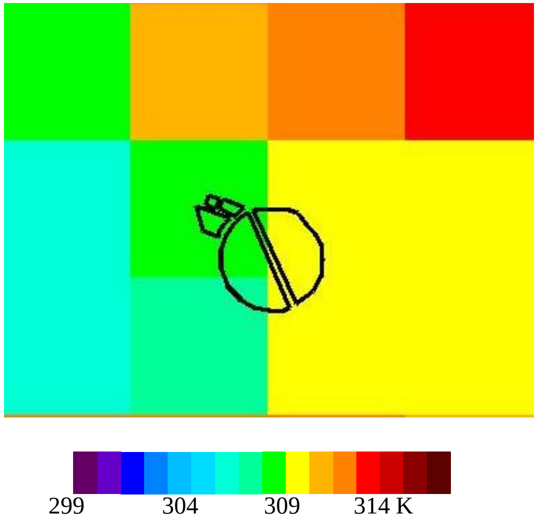
III. Results (LST disaggregation assessment)

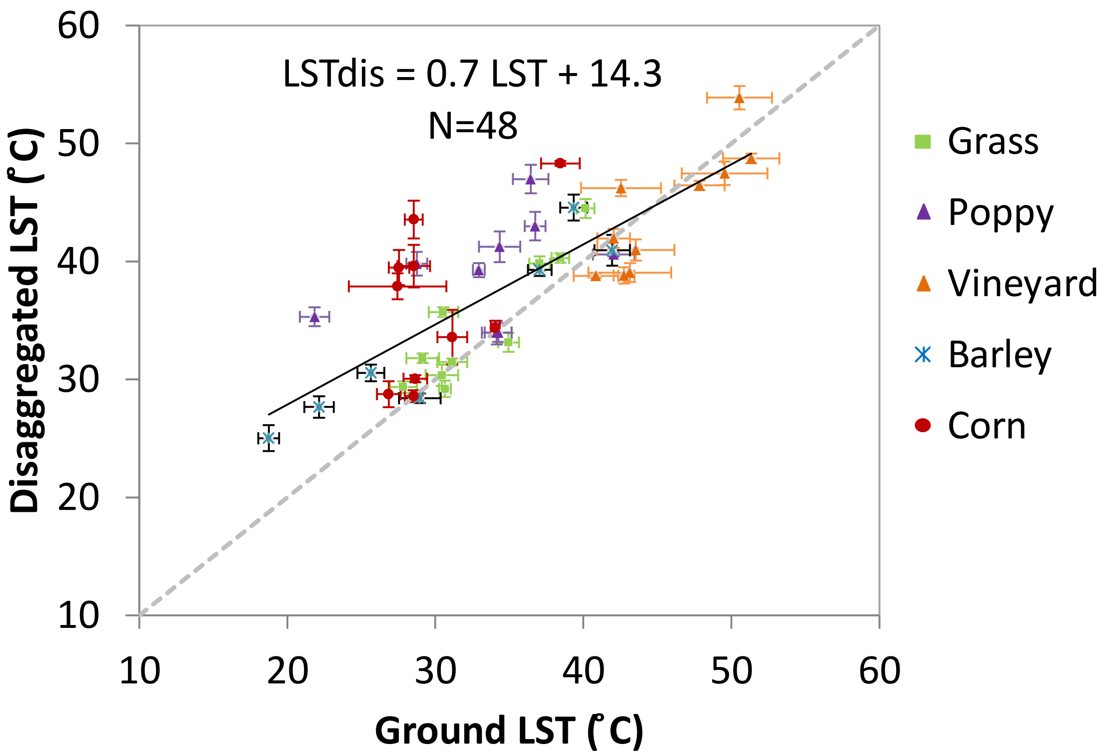
MODIS – Spot disaggregation

Disaggregated LST (10 m)



MODIS LST (1 km)

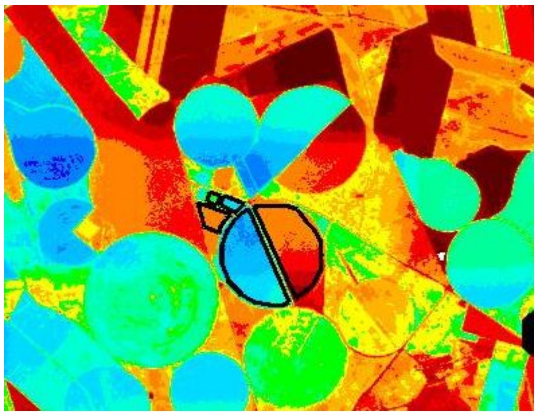




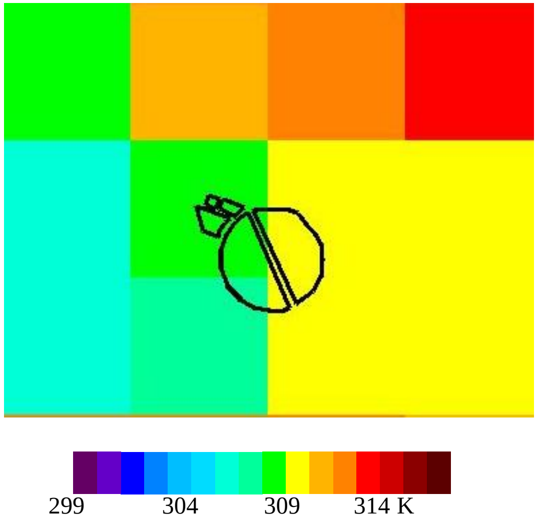
III. Results (LST disaggregation assessment)

MODIS – Spot disaggregation

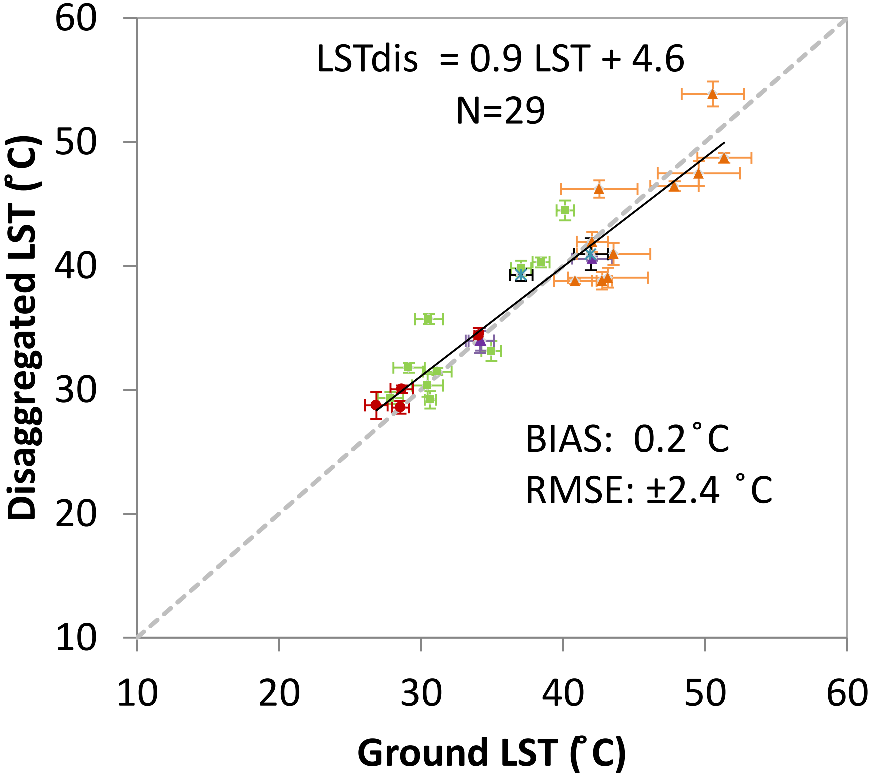
Disaggregated LST (10 m)



MODIS LST (1 km)



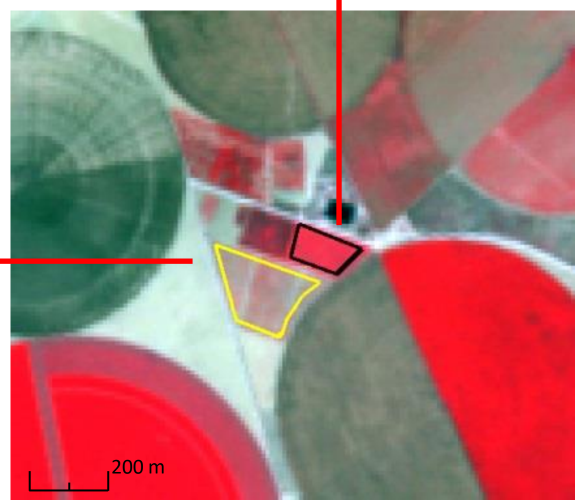
Excluding irrigated fields



III. Results (Surface energy fluxes assessment)

Grass

Vineyard

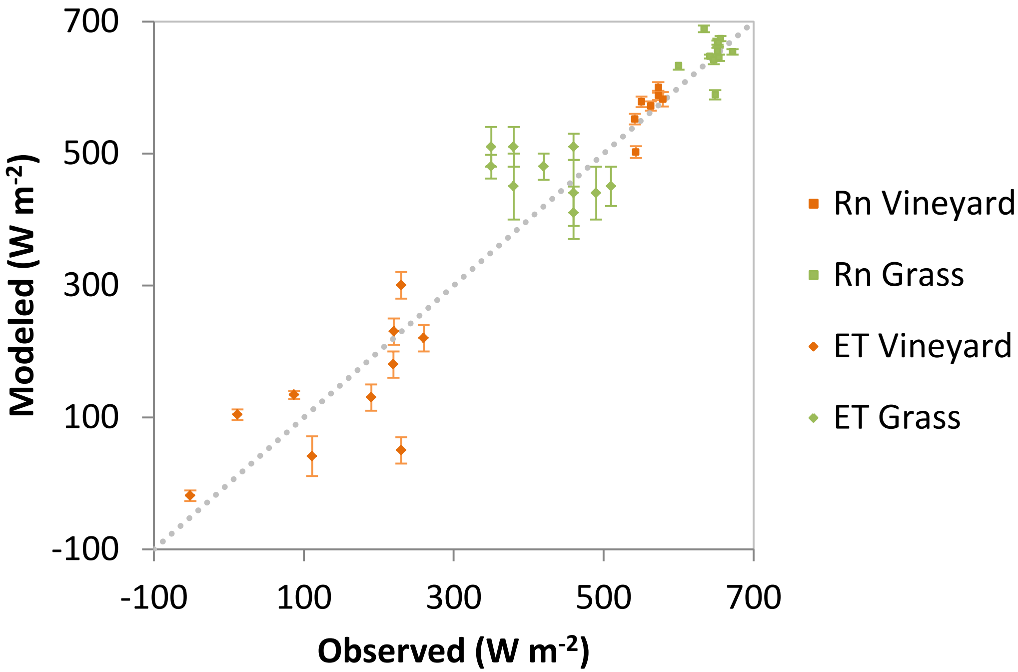


- Grass:
  - ❑ Weighting lysimeter (evapotranspiration)
  - ❑ Net radiometer
- Vineyard
  - ❑ Eddy-covariance system : sensible heat flux and evapotranspiration (installed in June),
  - ❑ Net radiometer
  - ❑ Soil heat flux plates

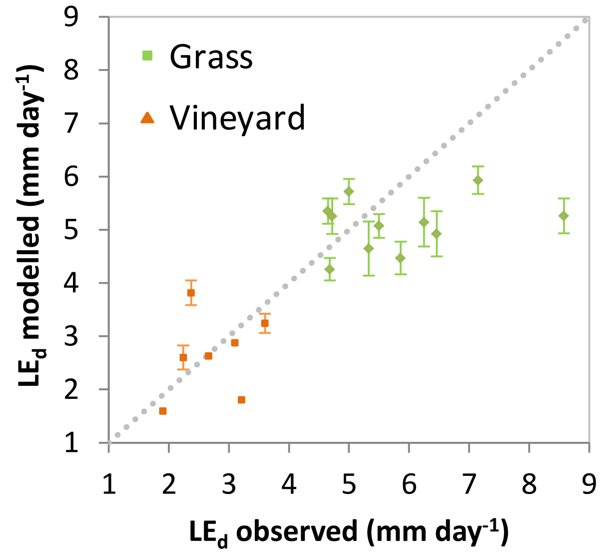
III. Results (Field scale assessment - Spot)

Grass

Vineyard



Daily assessment



Rn

BIAS: 6 Wm^2
RMSE: ±26 Wm^2
MADP: 3 %

LE

BIAS: 14 Wm^2
RMSE: ±80 Wm^2
MADP: 25%

LE_d

BIAS: -0.5 mm d^{-1}
RMSE: ± 1.2 mm d^{-1}
MADP: 19%

III. Results (Field scale assessment - Spot)

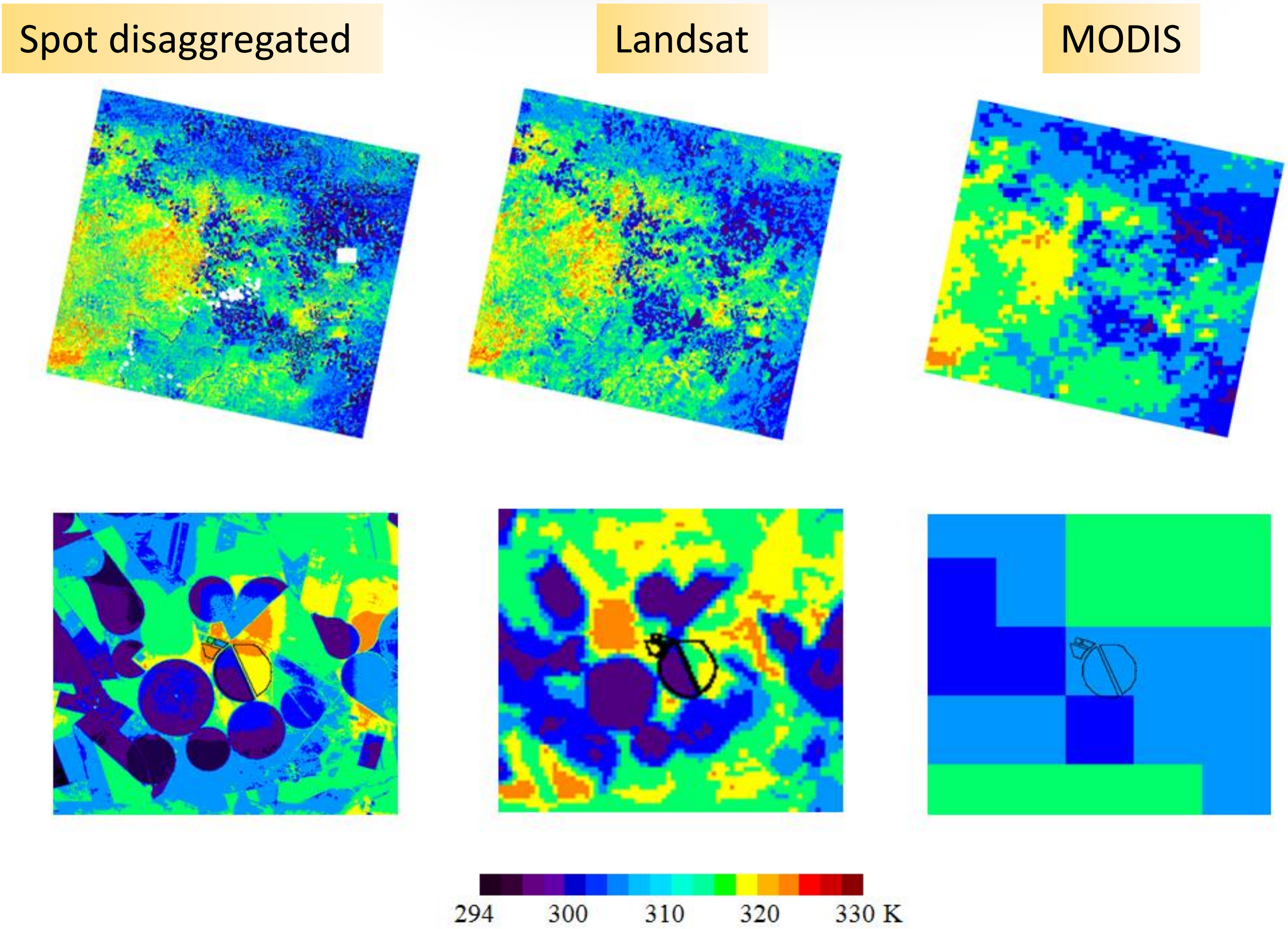
Grass

Vineyard

Instant.	BIAS	RMSE	MAD	MADP
LST (°C)	0.2	2.4	2.0	5 %
Rn (W/m^2)	6	26	21	3 %
LE (W/m^2)	14	80	70	25 %

Daily	BIAS	RMSE	MAD	MADP
Rn (W/m^2)	2	7	6	3 %
LE ($mm\ d^{-1}$)	**-0.5**	**1.2**	**0.9**	**19 %**

III. Results <u>(Image scale assessment - Spot)</u>

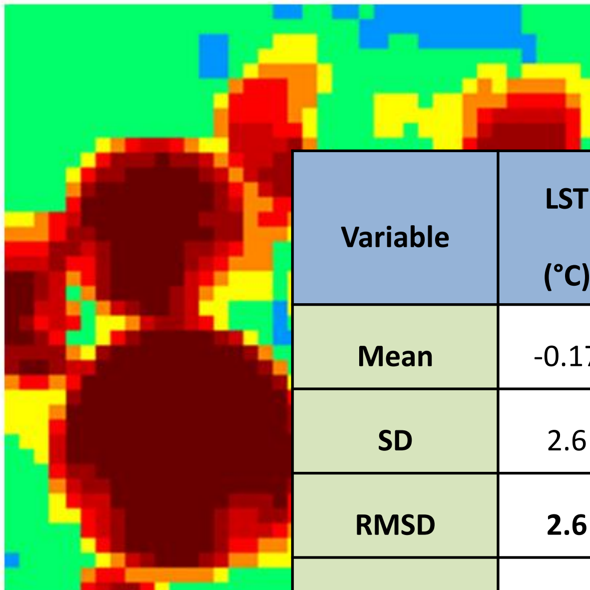


Example of LST images corresponding to DOY 141. A Spot image subset (upper row), and a zoom to the experimental area (bottom row) are shown.

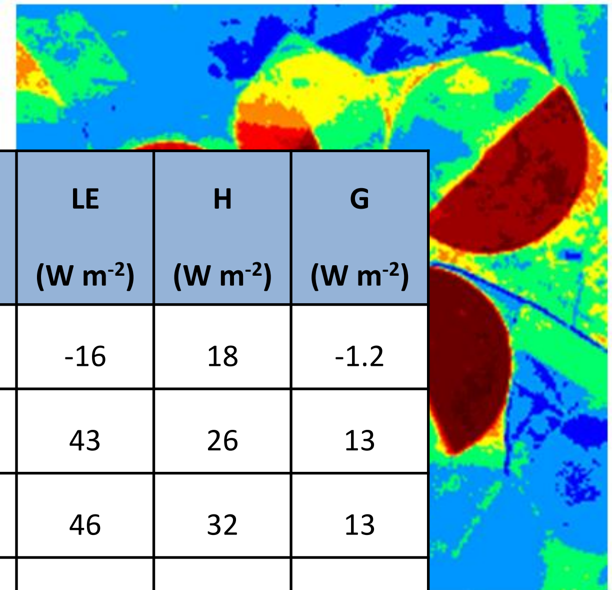
III. Results (Image scale assessment - Spot)

- Maps of daily ET (mm d^{-1}) corresponding to DOY 237 obtained from:

Landsat 60 m resolution image



Spot 10 m resolution image



Variable	LST (°C)	Rn ($W\ m^{-2}$)	LE ($W\ m^{-2}$)	H ($W\ m^{-2}$)	G ($W\ m^{-2}$)
Mean	-0.17	0.5	-16	18	-1.2
SD	2.6	26	43	26	13
RMSD	**2.6**	26	46	32	13
MAD	1.9	20	32	24	9
MADP	5 (%)	**3 (%)**	**14 (%)**	**10 (%)**	**8 (%)**
r^2	0.87	0.84	0.89	0.88	0.87

Statistics of the differences between the surface energy fluxes obtained from the Spot disaggregated and the Landsat 7 images

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IV. Conclusions

- ❑ A **disaggregation method** was applied to **MODIS and Spot-5** imagery in a heterogeneous area of central Spain.

- ❑ D**isaggregated LSTs at 10 m** spatial resolution were used, together with the Spot-5 VNIR bands, for the **evapotranspiration estimation** from the STSEB model.

- ❑Ground measurements of LST and surface energy fluxes in a variety of crops fields and from different dates were used in **a local assessment**.

- ❑ Results obtained are encouraging, showing **errors of ±2.4 °C in LST, and lower than 20% in terms of daily evapotranspiration**.

- ❑ These findings reinforce the application of disaggregation procedures to sensors provided with no thermal bands.

- ❑The **application to Sentinel-2, with a high revisit cycle, could provide the time series of disaggregated LSTs and surface energy fluxes at high temporal and spatial resolution** required for studies related to hydrology, climatology or agriculture.

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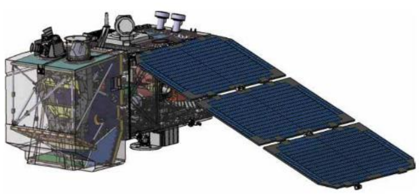
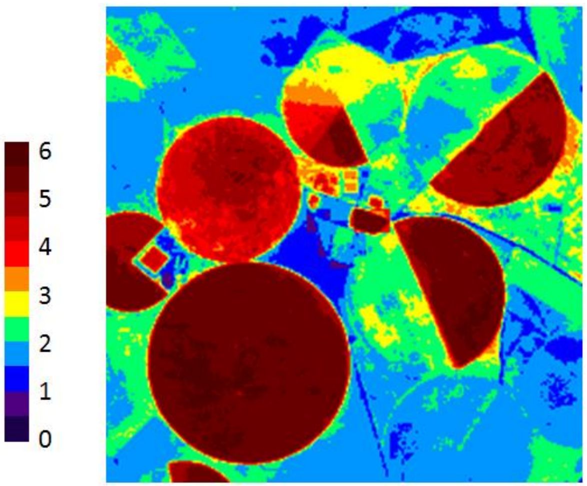
DIPUTACION DE ALBACETE

Thank you for your attention!





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