Comparing ASTER and Landsat 7 ETM+ imagery to estimate daily evapotranspiration within Mediterranean environment

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1 Context and objective

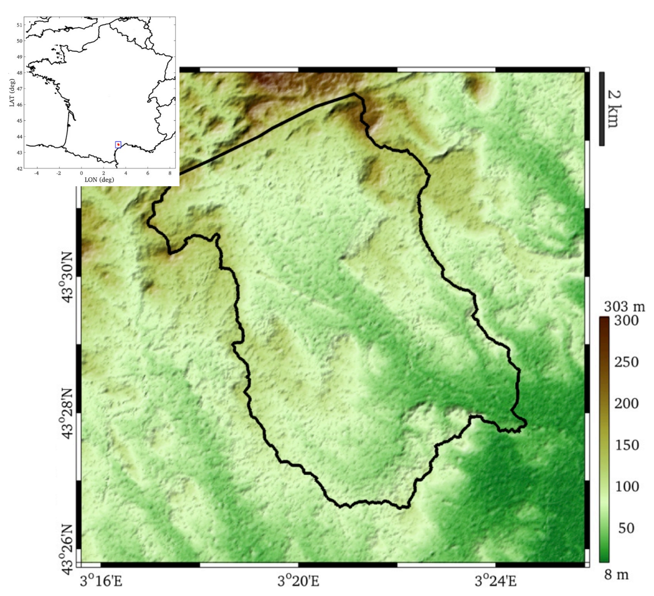
Estimation of evapotranspiration (ET) within heterogeneous watersheds requires accounting for spatiotemporal variability in relation to water fluxes and vegetation dynamics. This can be achieved by using solar and thermal infrared (TIR) remotely sensed data with high spatial resolution, where time series are valuable for understanding past trends and achieving short- and long-term prognostics. Hectometric resolution TIR data have been collected from ASTER and Landsat sensors over the last decades, with specific issues for each sensor:

ASTER:
Good radiometric quality
Collected punctually according to mission priorities

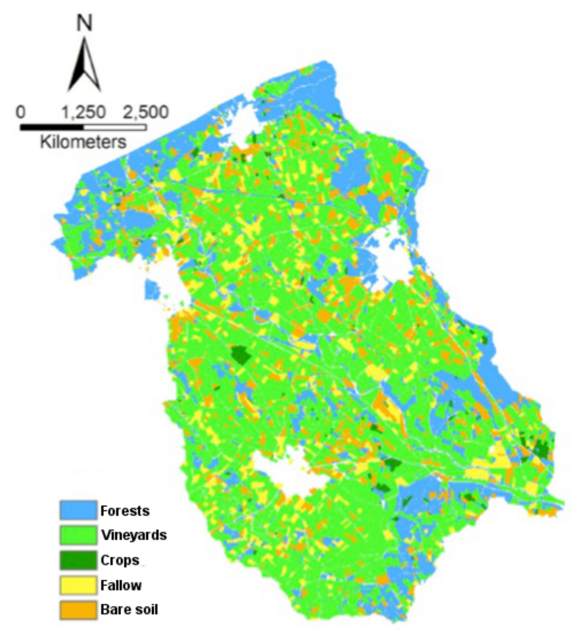
Landsat:
Difficulties in radiometric accuracy
Continuous monitoring ~30 years

With the ultimate goal of obtaining spatialized time series of ET, the objective of this work was to asses the performance of Landsat 7 ETM+ to estimate ET in a Mediterranean vineyard watershed by comparing with previously ground-validated ASTER estimations.

2 Study site



La Peyne watershed (65 km^2)
Département de l'Hérault
Southern France
Gentle slopes terrain (4.5%)
Subhumid Mediterranean climate
720 mm y^{-1} annual rainfall
1270 mm y^{-1} potential ET

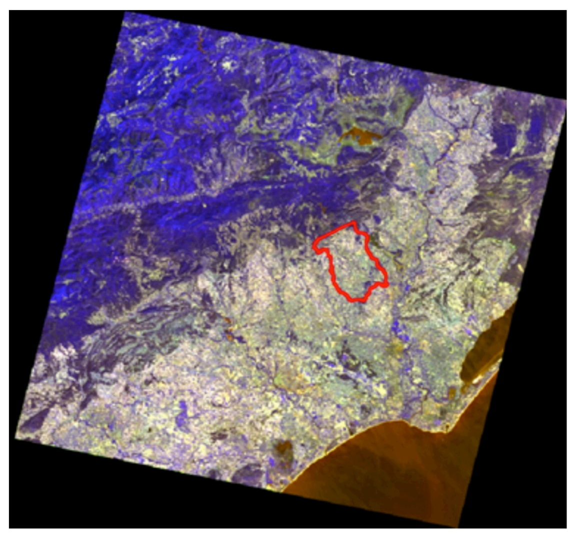


Land use:
70% cultivated with vineyards
90% of rainfed vineyards
Strong plot fragmentation (1 km)

3 Satellite data

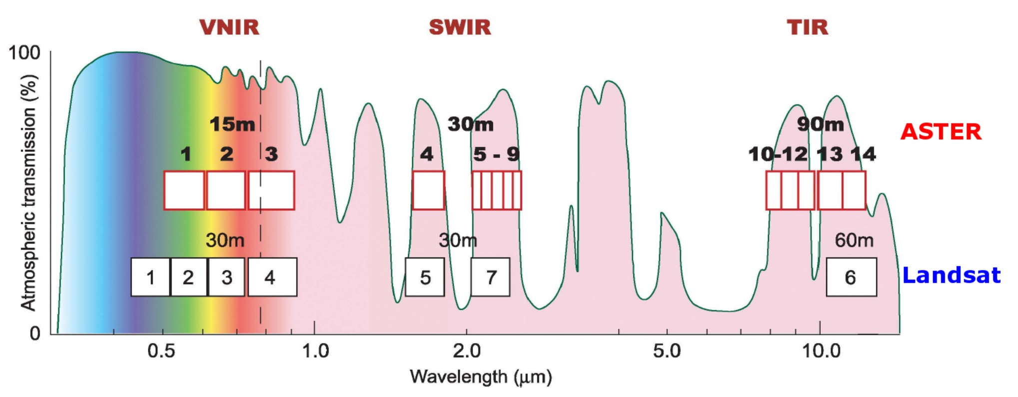
The comparison exercise was carried out using ASTER and Landsat imagery collected for 2 dates:

Mai-3-2007 (date 1)
July-15-2008 (date 2)



ASTER
Spatial resolution:
15m (VIS-NIR), 30m (SWIR), 90 m (TIR)
> TIR spectral resolution

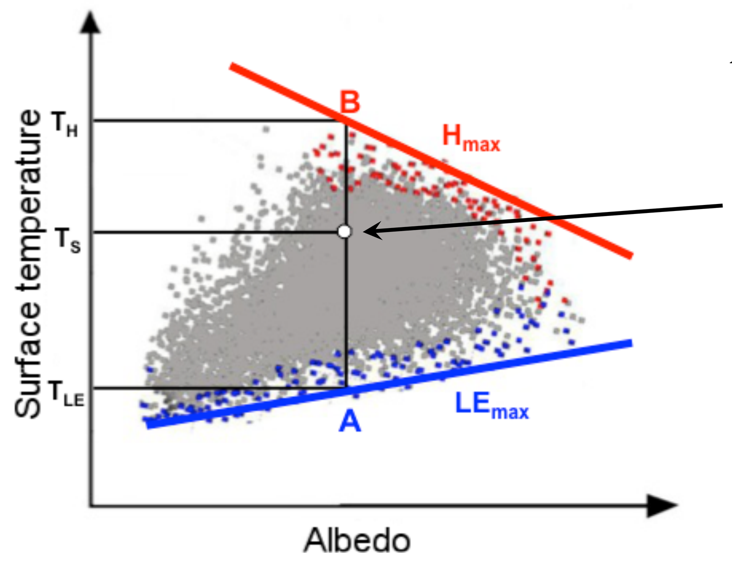
Landsat 7 ETM+
Spatial resolution
30m (VIS-NIR-MIR), 60 m (TIR)
< TIR spectral resolution



4 Evapotranspiration method

S-SEBI: Simplified Surface Energy Balance Index (Roerink et al., 2000)

- Contextual method: ET from the information of the single image
- Basic principle: the scatter plot between surface temperature and albedo is bounded by two theoretical lines corresponding to extreme soil moisture conditions
- Evaporative fraction is obtained (Λ)



$$\Lambda_i = \frac{LE_i}{H_i + LE_i} = \frac{LE_i}{Rn_i - G_i}$$

$$\Lambda_i = \frac{T_H - T_S}{T_H - T_{LE}}$$

$$LE_i = \Lambda_i (Rn_i - G_i)$$

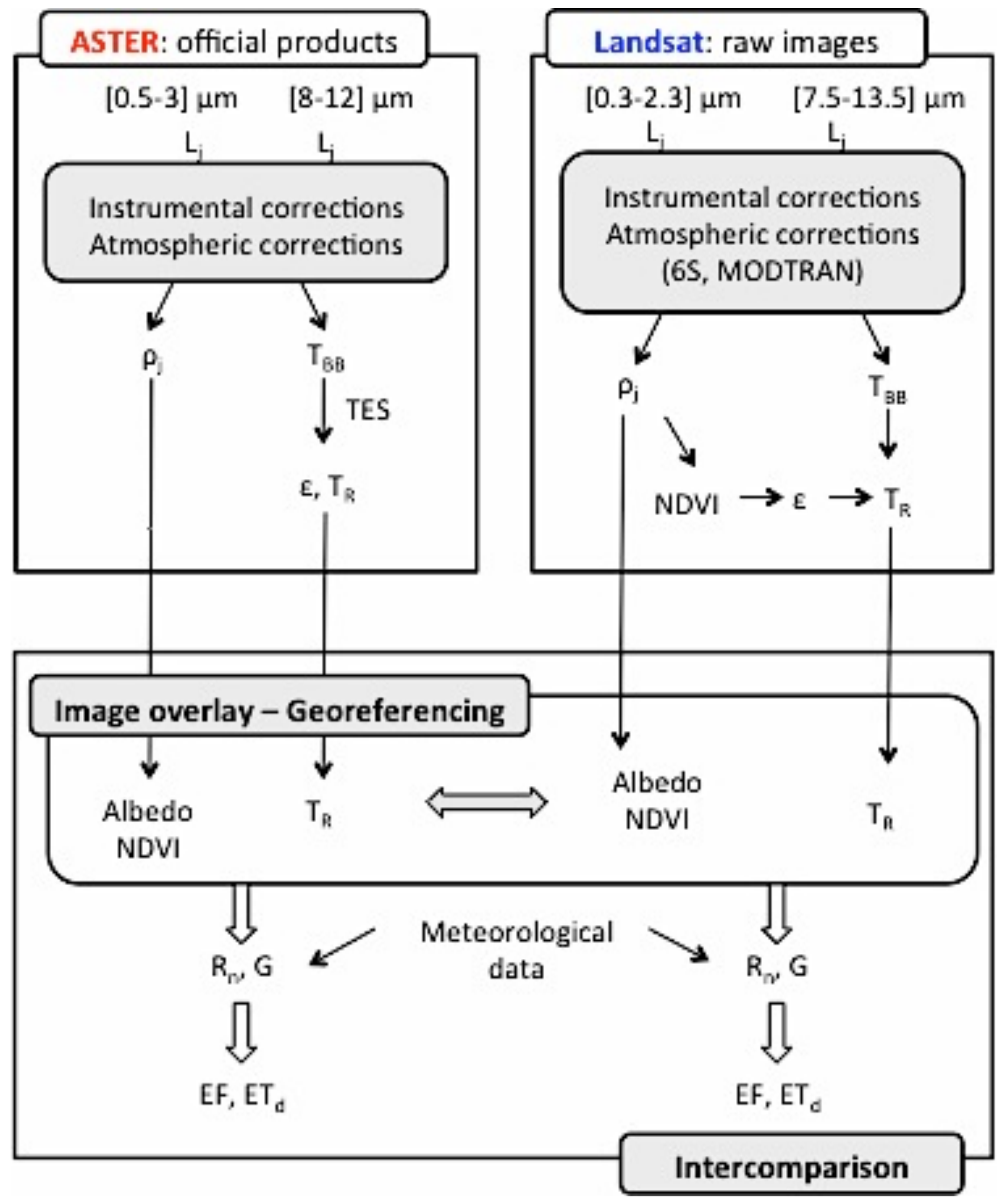
LE: latent heat; H: sensible heat; R_n: net radiation; G: soil heat flux

Subject to the actual contrast in water conditions within the image

5 Approach

ASTER ET estimations were previously validated with in situ measurements: 0.8 mm d^{-1} accuracy (Galleguillos et al., 2011).
While ASTER corrections are made by the providing institution, Landsat 7 ETM + are raw data that have to be pretreated prior to the implementation of the S-SEBI method. This includes several steps:

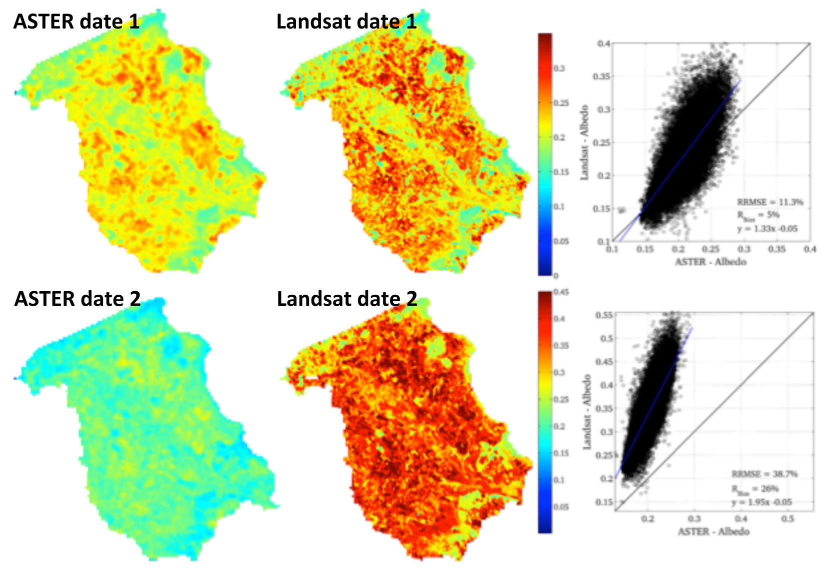
- Atmospheric corrections
- Radiometric corrections
- Geometric corrections
- Estimating surface temperature, emissivity, and biophysical variables (albedo, NDVI, R_n, G)
- Estimating evaporative fraction (EF) and daily evapotranspiration (ET_d)



L_j and ρ_j: radiance and reflectance of the spectral band j; 6S and MODTRAN: radiative transfer models for the solar and thermal infrared domain, respectively; T_{BB}: brightness temperature; T_R radiometric temperature; ε surface emissivity; TES: Temperature Emissivity Separation model.

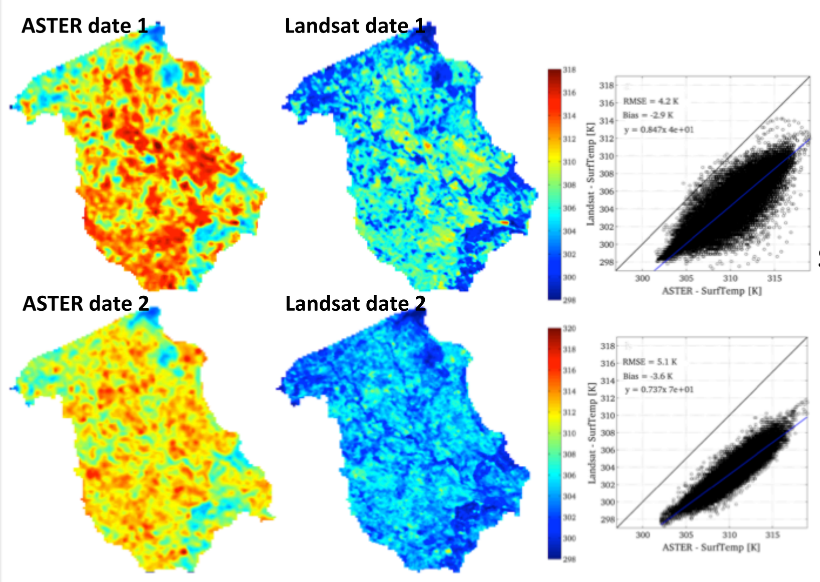
6 Results: S-SEBI input variables

1) Surface albedo: Liang (2000) method



Strong dispersion
Landsat: higher albedo

2) Surface temperature

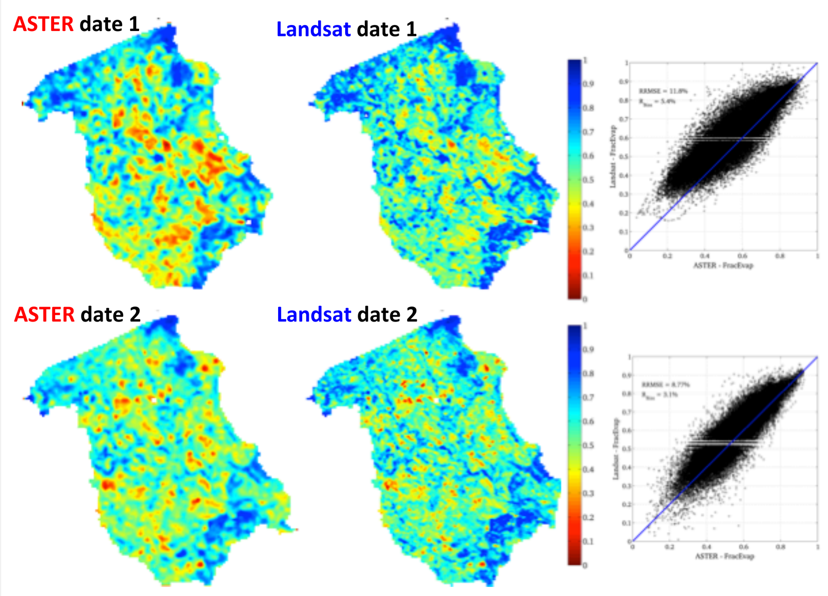


Landsat: systematically lower surface temperature

7 Results: S-SEBI outputs

Despite strong differences in S-SEBI input variables, good results for EF and ET were obtained:

1) Evaporative fraction



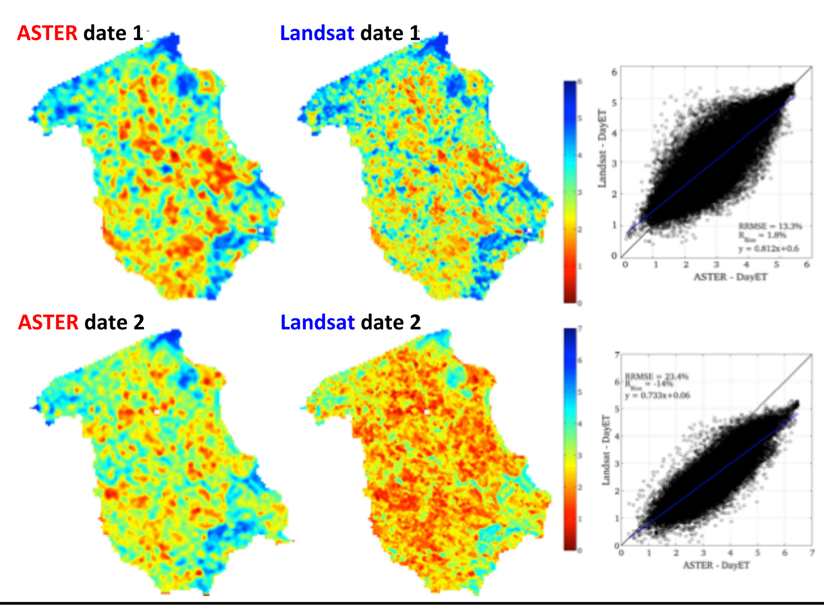
Similar spatial structure for both EF and ET$_d$

High dispersion in temperature

Method based on temperature difference within the image

Low dispersion in evaporative fraction and evapotranspiration

2) Daily evapotranspiration



8 Concluding remarks

- Despite differences in radiometric quality, spectral configuration, and image pre-processing, Landsat 7 ETM+ appears as a useful tool to estimate evapotranspiration as compared with ASTER
- Differences obtained for intermediate variables were attenuated by the temperature differencing S-SEBI method
- Similar results with an operational satellite (Landsat) makes possible to consider its long-term use for evapotranspiration estimations

Galleguillos, M., F. Jacob, L. Prévot, P. Lagacherie and S. Liang. 2011. Mapping daily evapotranspiration over a Mediterranean vineyard watershed. *IEEE T. Geosci. Remote.* 8, 168-172.
Liang, S. 2000. Narrowband to broadband conversions of land surface albedo. I Algorithms. *Remote Sens. Environ.* 76, 213-238.
Roerink, G.J., Z. Su and M. Menenti. 2000. S-SEBI: a simple remote sensing algorithm to estimate the surface energy balance. *Phys. Chem. Earth Pt. B.* 25, 147–157.