Evapotranspiration mapping from remote sensing data: uncertainties and ensemble estimates based on multimodel – multidata simulations

Albert Olioso, Aubin Allies, Hugo Desrutins, Simon Carrière, Nesrine Farhani, José Sobrino, Drazen Skoković, Jérôme Demarty, Jordi Etchanchu, Gilles Boulet, et al.

► To cite this version:

Albert Olioso, Aubin Allies, Hugo Desrutins, Simon Carrière, Nesrine Farhani, et al.. Evapotranspiration mapping from remote sensing data: uncertainties and ensemble estimates based on multimodel – multidata simulations. International Workshop on High-Resolution Thermal EO, ESA (European Space Agency), May 2023, ESRIN, Frascati, Italy. hal-04153021

HAL Id: hal-04153021

https://hal.inrae.fr/hal-04153021

Submitted on 6 Jul 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Evapotranspiration mapping from remote sensing data: uncertainties and ensemble estimates based on multimodel-multidata simulations

Albert Olioso¹ (2*), Aubin Allies³ (4*), Hugo Desrutin², Simon Carrière⁵ (2*),
Nesrine Farhani⁴ (7*), José Sobrino⁶, Dražen Skoković⁶, Jérôme Demarty⁴, Jordi Etchanchu⁴,
Gilles Boulet⁷, Samuel Buis², Marie Weiss²

1 INRAE (Mediterranean Forest Ecology Lab, URFM), Avignon, France
2 INRAE – Avignon Université (Mediterranean Agroecosystem Modeling Lab, EMMAH), Avignon, France
3 EarthDaily Agro, Balma, France
4 IRD (HydroScience Lab, HSM), Montpellier, France
5 Sorbonne University (METIS), Paris, France
6 University of Valencia (Global Change Unit), Burjassot, Spain
7 IRD (CESBIO), Toulouse, France
(* Previous affectation)

Preparation of the future missions

LSTM @ 🇪🇸esa

[Image of a satellite]
Context

- ET is a major component of the hydrological cycle, but
  
  → in many situations, ET and its evolution are not well known
  
  → there is a lot of uncertainties in ET monitoring

- Many models exist, but none looks satisfactory in every situations (season, type of climate, type of surfaces...)
  
  → ensemble modelling
  
  Ensemble modelling approaches were developed in various field of research (ex. Climate, hydrology, agronomy...) assuming they are providing an optimal or suboptimal solution

- Work done in the frame of TRISHNA and LSTM mission preparations
Evapotranspiration (ET) can be derived using various models based on thermal infrared data.

- **Uncertainty** in Ts: 
  - instrument
  - atmosphere

- Large number of models → diversity of algorithms ⇒ uncertainties

- Lots of other data required: 
  - albedo
  - vegetation density
  - meteorological data
  - various sources of data ⇒ uncertainties

- Time integration 
  - instantaneous measurements
  - intermittent data (revisit, clouds)
  ⇒ daily values ⇒ uncertainties

No consensus on a best model ⇒ ensemble averaging considering both models and data sources

Many unknowns remain concerning the uncertainties in the derivation of ET in particular for discriminating uncertainties from input data and models.

**ET estimate** = average of ensemble members

**Uncertainty** = standard deviation of ensemble members
Models of Latent Heat Flux ($LE$) [see Lagouarde and Boulet 2016]

- Evaporative fraction (EF) model:
  \[ LE \sim EF \times (Rn - G) \]
  with \( EF = \frac{BC}{BA} \)

  - \( EF \) = evaporative fraction <- \( Ts \) vs. albedo or NDVI or fraction cover
  - \( Rn \) = net radiation <- solar irradiance
  - \( G \) = ground heat flux <- \( Rn, NDVI, fCOVER \)

- Residual aerodynamic equation: \( LE = Rn - H - G \)
  - \( H \) = sensible heat flux <- \( Ts, Ta \) (air temperature), \( ua \) (wind speed)
  - \( zom, zoh \) (roughness)

Upscaling to daily level based on
\[ ET \sim LE \times \frac{Rgd}{Rgi} \]

- Residual aerodynamic equation: \( LE = Rn - H - G \)

ex: SSEBE (Olioso et al. 2006)
Application:

ESA experiment in Grosseto (Italy) in support of the LSTM program: July 2018

Airborne images in the solar and the thermal domains on two different days

Various sources for input data:

- incident radiations,
- LAI,
- fCOVER,
- surface temperature...

Various « models » for

- Ground heat flux
- Evaporative fraction EF
- albedo

Agricultural area (~10 X 10 km)
Example of variations (=> uncertainties) in data sources and models

**Uncertainty**

**Novice case** -> all available data or models are used

**Expert case** -> previous knowledge => some of the data sources and algorithms are dropped

**Global uncertainty** -> standard deviation of ET (pixel basis)
all together, ~400 000 cases ($ET$)

**Factor uncertainty** -> standard deviation of ET
for variations of one factor only
Uncertainty in Ts:

several processings were performed mainly differing in the atmospheric profiles used for the atmospheric corrections
Evapotranspiration map

Average of all the calculations for Day 2

Novice case – average ET = 3.4 mm d\(^{-1}\)

Expert case - average ET = 2.8 mm d\(^{-1}\)
Uncertainty in ET (standard deviation mm d\(^{-1}\))

Day 2 case

**Expert case**

**Novice case**
Uncertainty in ET (mm d\(^{-1}\)) Day 2 case

Expert case

Novice case

Uncertainty related to Ts:
ET uncertainty break-down.

Cumulated standard deviation (mm d^{-1})

- **Aerodynamic models**
  - Novice range
  - Expert range

- **Evaporative fraction models**
  - Novice range
  - Expert range

Legend:
- Surface Temperature
- Incoming solar radiation
- Incoming longwave radiation
- Albedo
- G/Rn ratio
- Evaporative fraction (EF)
- Wind speed
- Air temperature
- Aerodynamic roughness
- Thermal roughness

Ts
Applications of EVASPA to the Crau area

EVASPA is an implementation of the method that will be used for the level 2 ET product for TRISHNA (together with the STIC model (Mallick et al.))

Monthly ET obtained over the Crau aquifer (600 km²) with the evaporative fraction models for MODIS TERRA and AQUA data:
Summary

Ensemble modelling applied to multi-data source – multi-model (or algorithm) may be used for:

- monitoring ET
- providing uncertainty in the estimates
  (however this uncertainty is only epistemic and does not include estimation errors)
- providing information on the main uncertainty factors:
  - in all analysed cases, surface temperature was not the main limitation in ET estimations
  - for contextual models, the main sources of uncertainty concern algorithm (EF and ground heat flux)
  - for other models, including aerodynamic equations, meteorological forcing of wind speed and air temperature have also a strong impact

The EVASPA algorithm is a simple algorithm that will be the basis for implementing ET products in the frame of the TRISHNA program.