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

Albert Olioso[1 (2*)], Aubin Allies[3 (4*)], Hugo Desrutin[2], Simon Carrière[5(2*)],

Nesrine Farhani[4 (7*)], José Sobrino[6], Dražen Skoković[6], Jérôme Demarty[4], Jordi Etchanchu[4],

Gilles Boulet[7], Samuel Buis[2], Marie Weiss[2]

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 Sorbone 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

Context

❑ **ET is a major component of the hydrological cycle, but**

→ **in many situations, ET and its evolution are not well known**

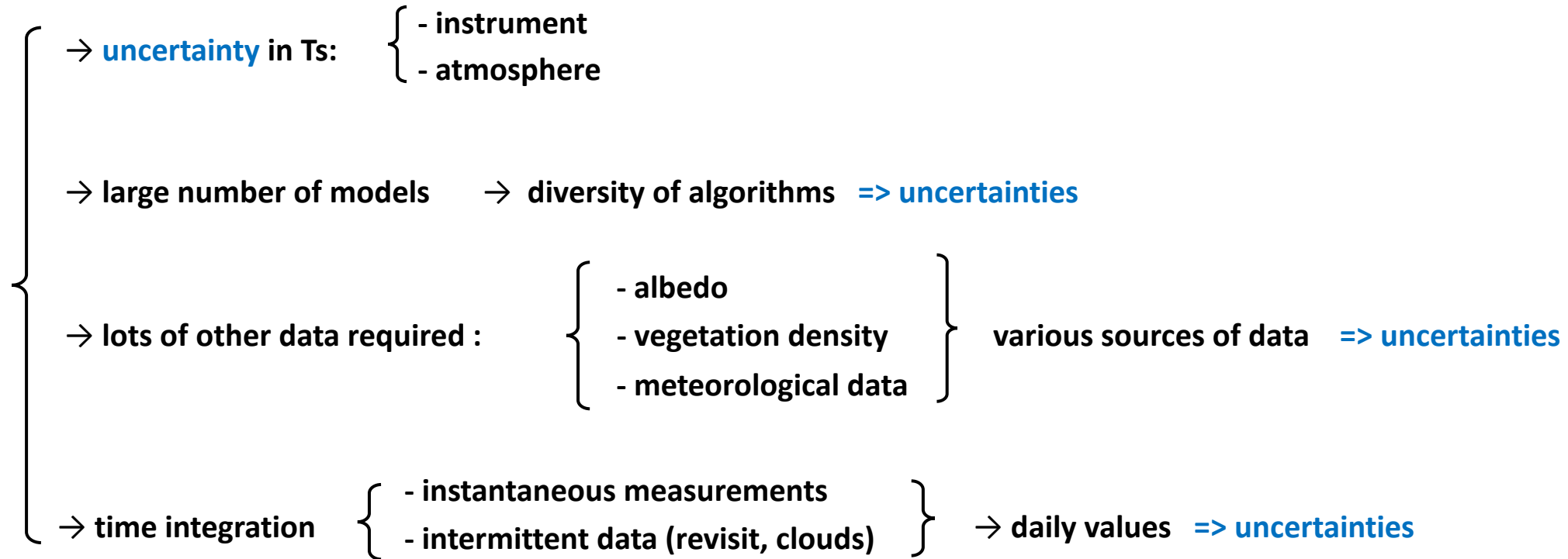→ **there is a lot of uncertainties in ET monitoring**

❑ **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   **various sources of data** **=> uncertainties**
                                       - meteorological data

→ **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 ~ EF x (Rn – G)*

with *EF* = **BC** / **BA**

EF = evaporative fraction <- *Ts* vs. *albedo or NDVI or fraction cover*

Rn = net radiation <-
- albedo, emissivity, Ts,
- solar irradiance
- atmospheric irradiance

G = ground heat flux <- *Rn, NDVI, fCOVER*

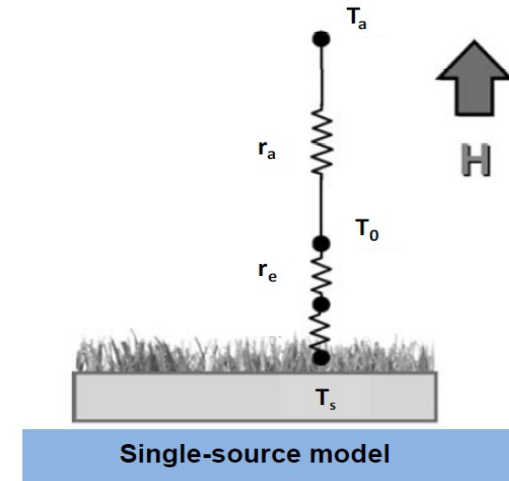ex: S-SEBI (Roerink et al. 2000)
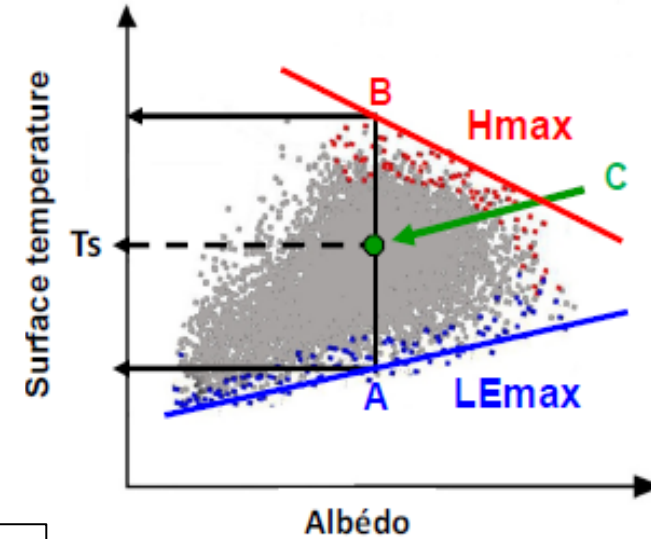
Upscalling to daily level based on

ET ~ LE X Rgd / Rgi

-> **Residual aerodynamic equation:** *LE = Rn – H – G*

H = sensible heat flux <-
- Ts, Ta (air temperature),
- ua (wind speed)
- zom, zoh (roughness)

Single-source model

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

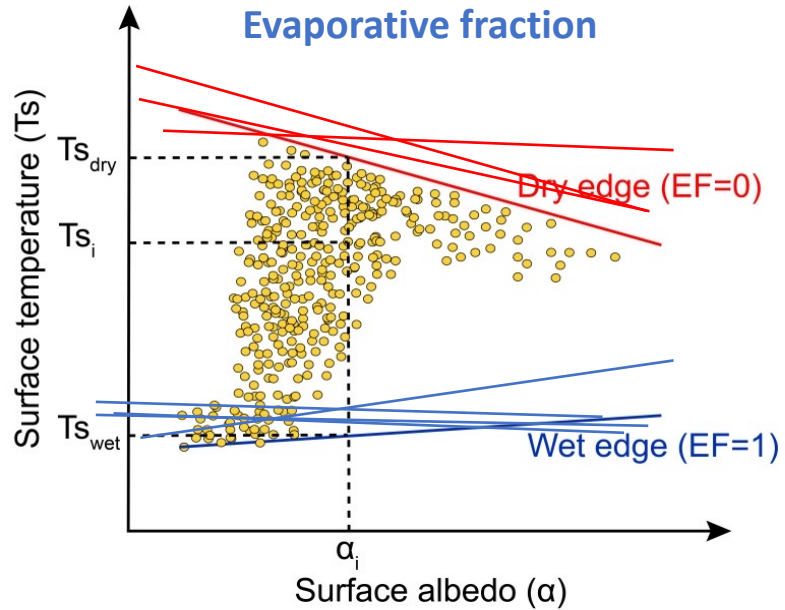**Various sources for input data :**
- incident radiations,
- LAI,
- fCOVER,
- surface temperature...

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

Evaporative fraction

Ground heat flux ratio to Rn
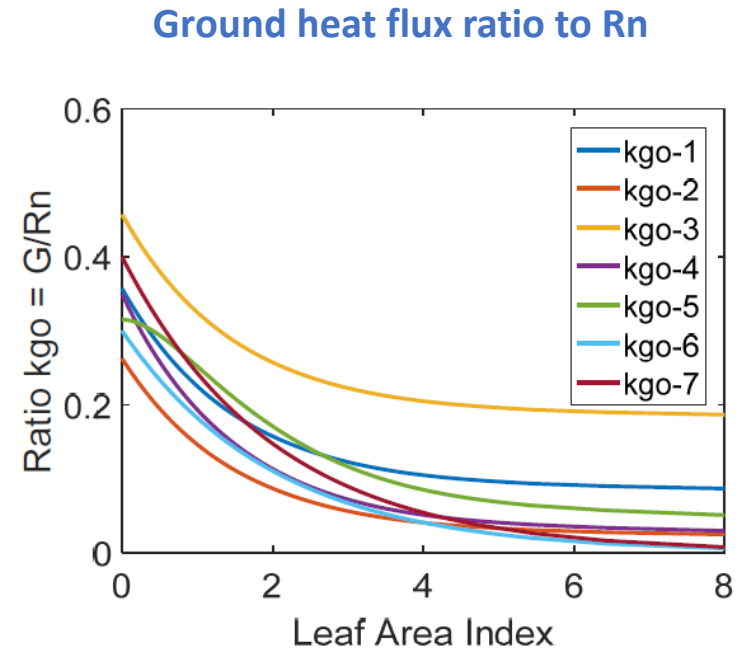
Uncertainty

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
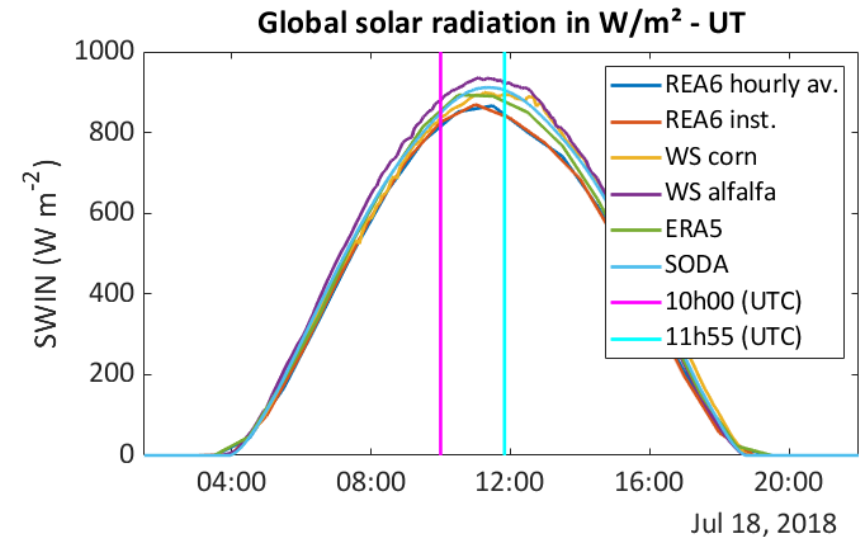
Uncertainty in Ts:

several processings were performed mainly differing in the atmospheric profiles used for the atmospheric corrections
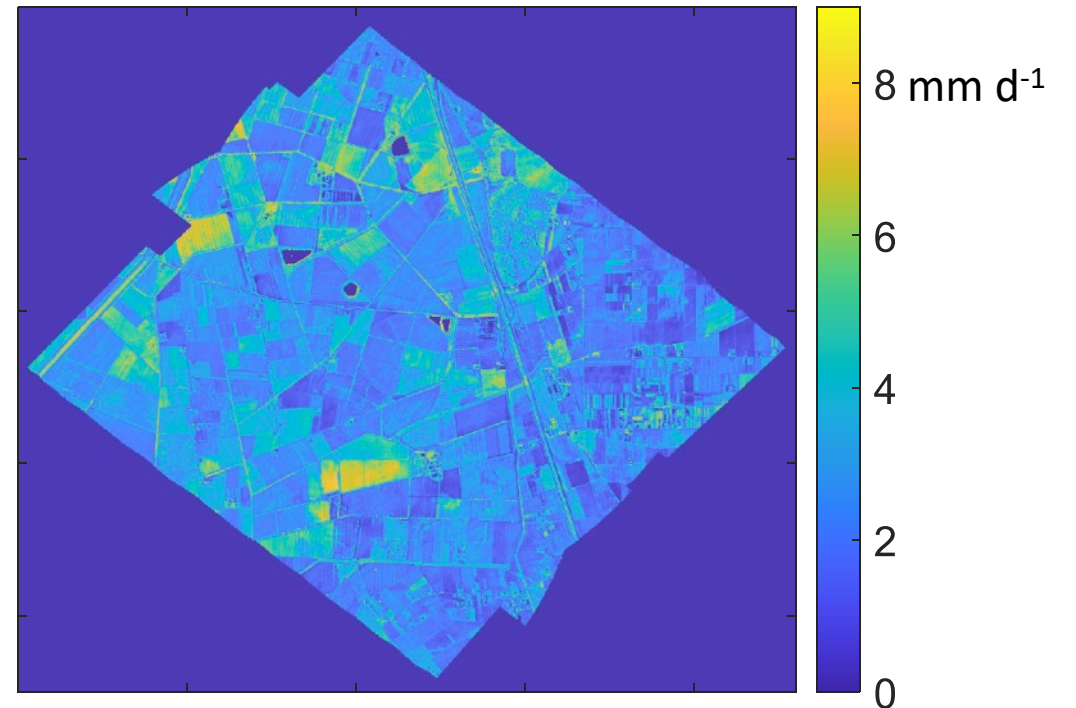
Standard deviation of the 4 Ts maps (at pixel level)

mean std = 0.6 K

mean std = 1.4 K

Day 1

Day 2

Standard deviation Ts (K)

Ts standard deviation map Day 2 (K)
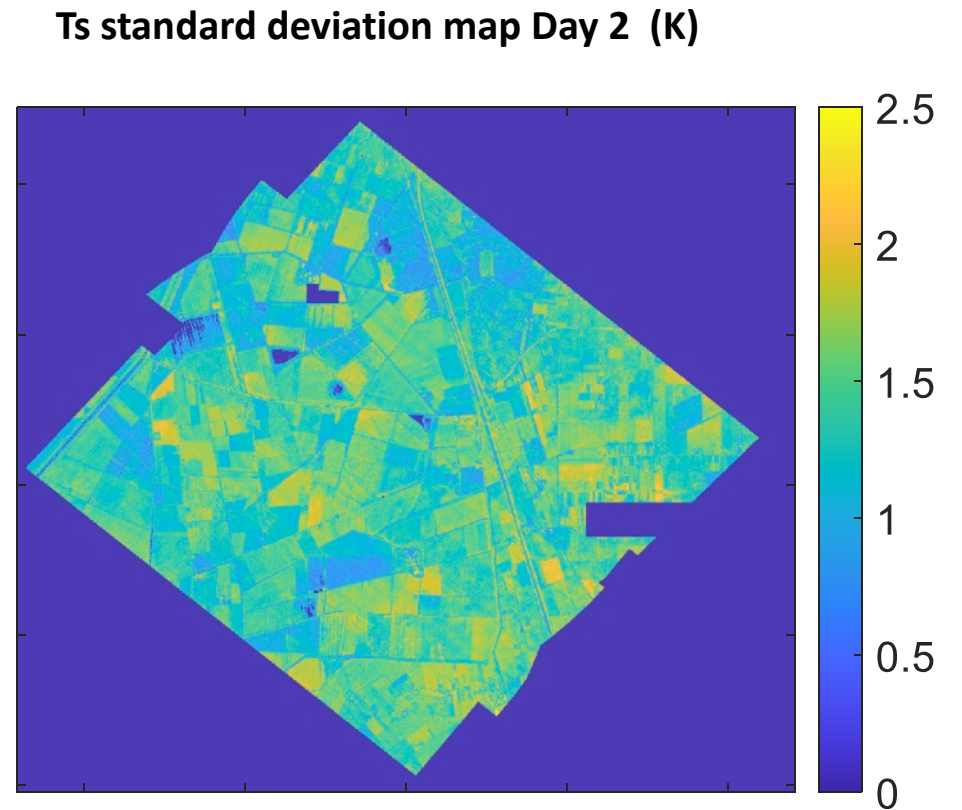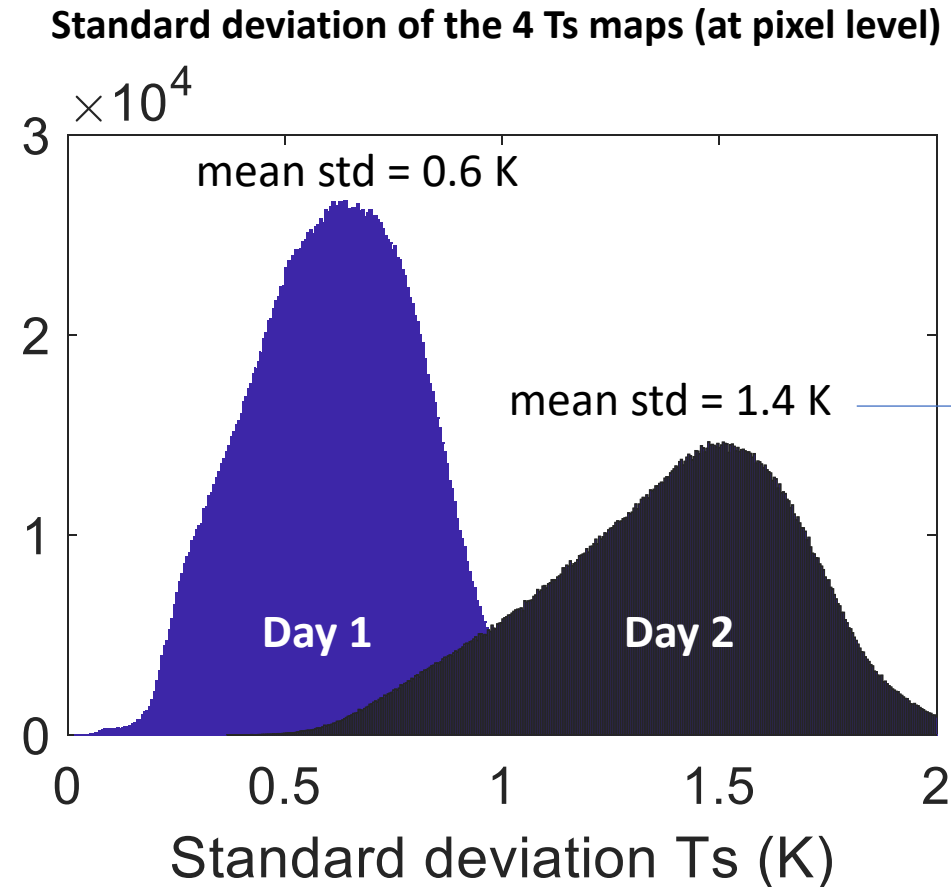
Evapotranspiration map

Average of all the calculations for Day 2

Novice case – average ET =3.4 mm d^{-1}
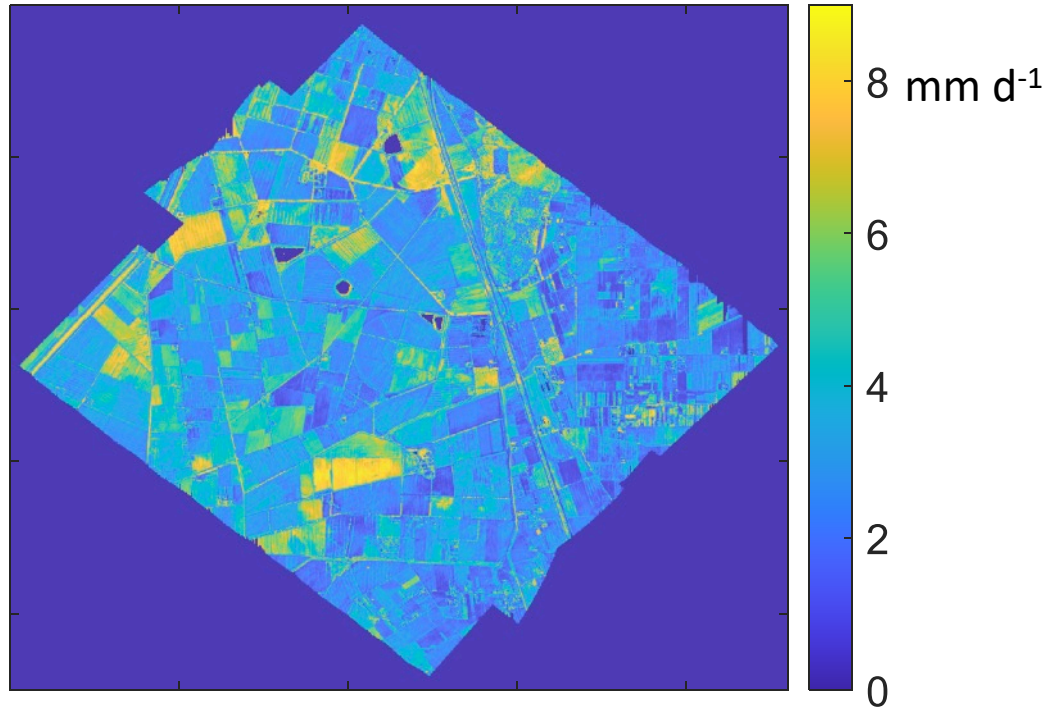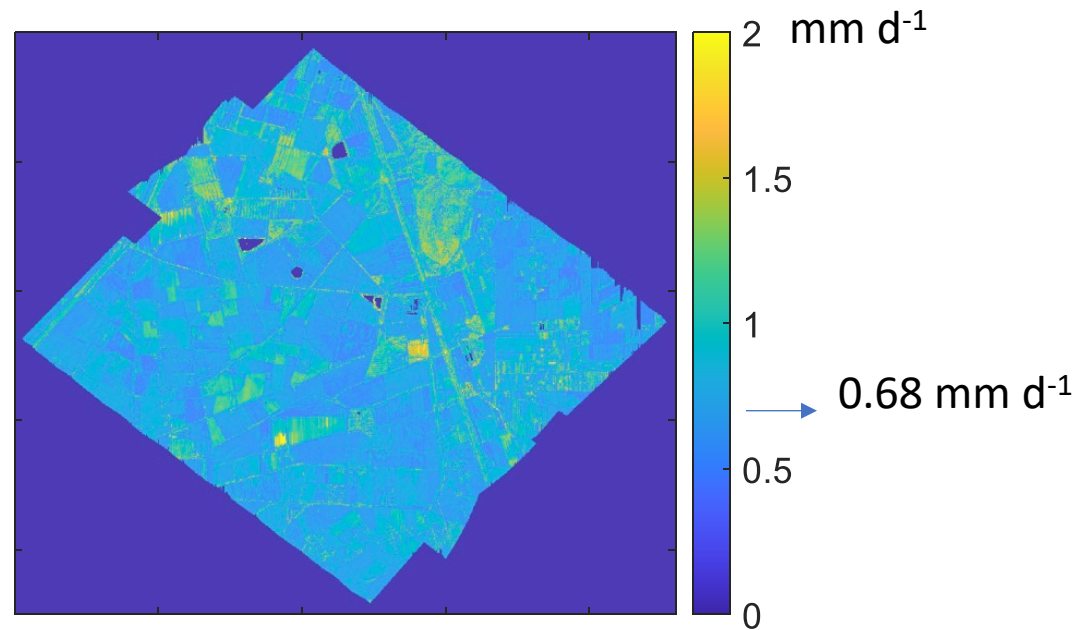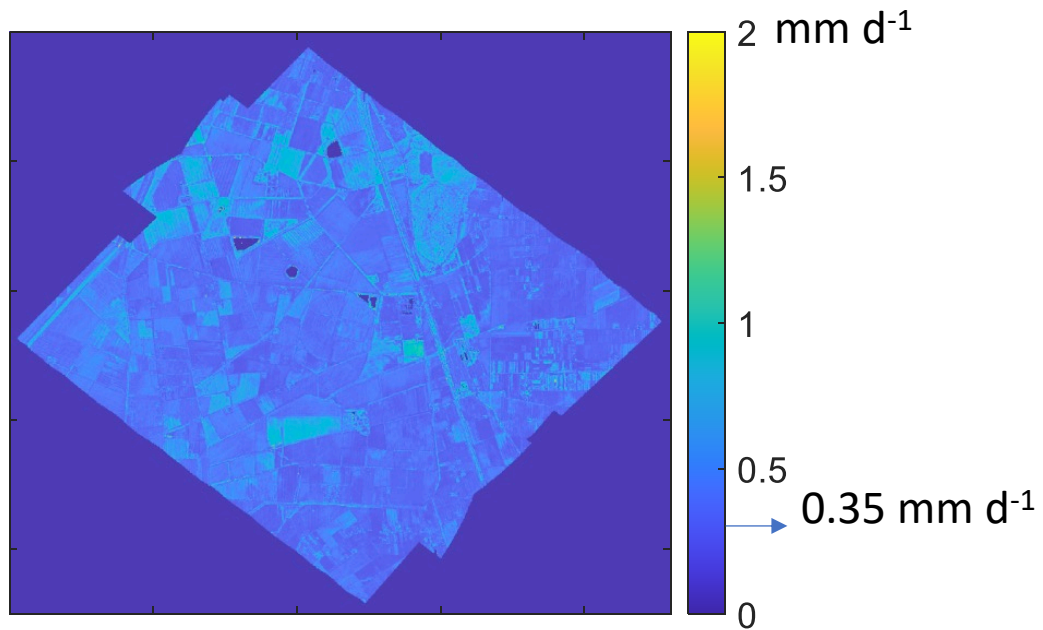
Expert case - average ET =2.8 mm d^{-1}

Uncertainty in ET
(standard deviation mm d⁻¹)

Day 2 case

Expert case

Novice case

2 mm d⁻¹

2 mm d⁻¹

ET standard deviation (mm/d)

0.35 mm d⁻¹

0.68 mm d⁻¹
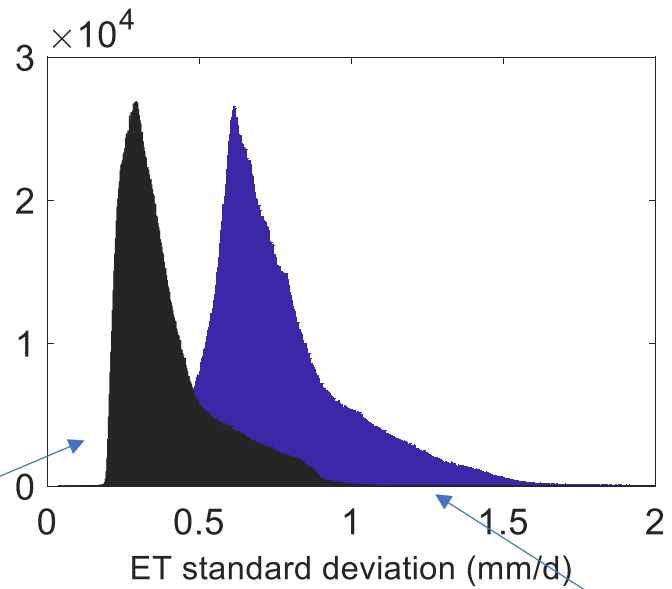
Uncertainty in ET (mm d⁻¹) Day 2 case

Expert case

(mm d⁻¹)

→ 0.35 mm d⁻¹

Novice case

(mm d⁻¹)

→ 0.68 mm d⁻¹
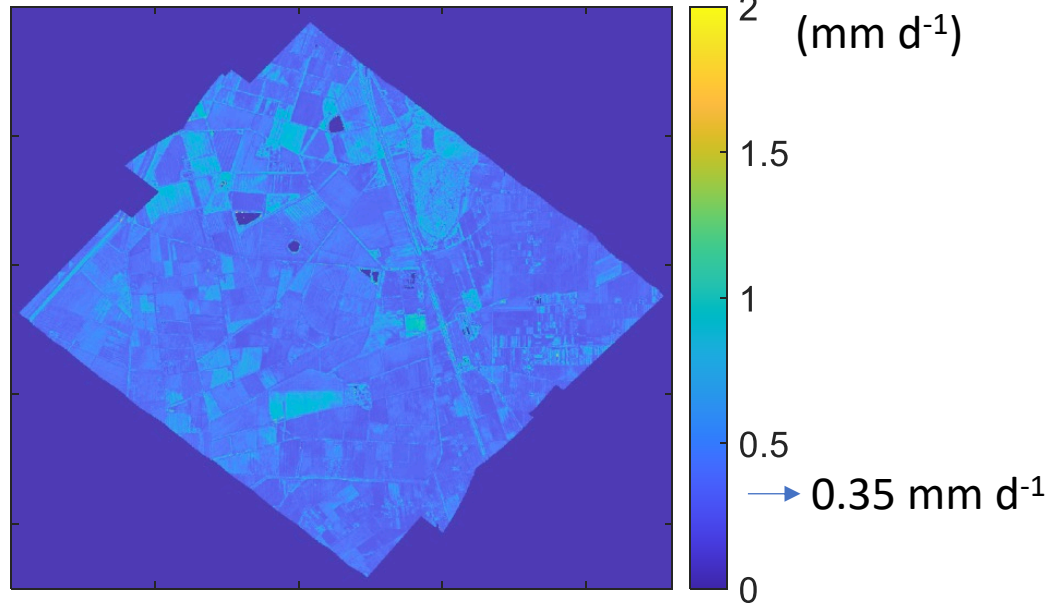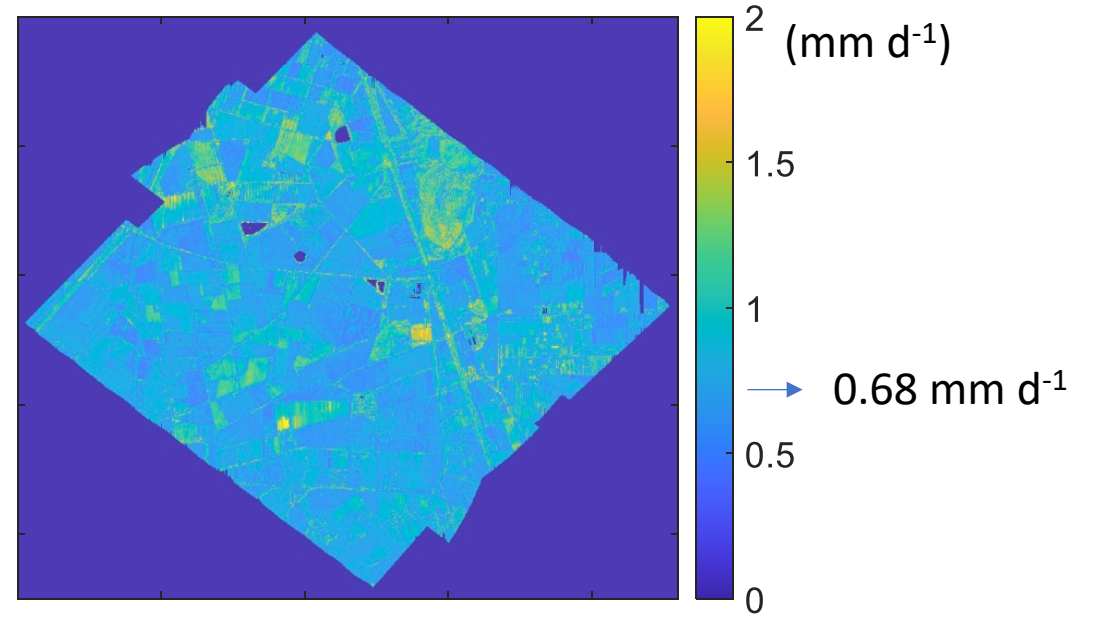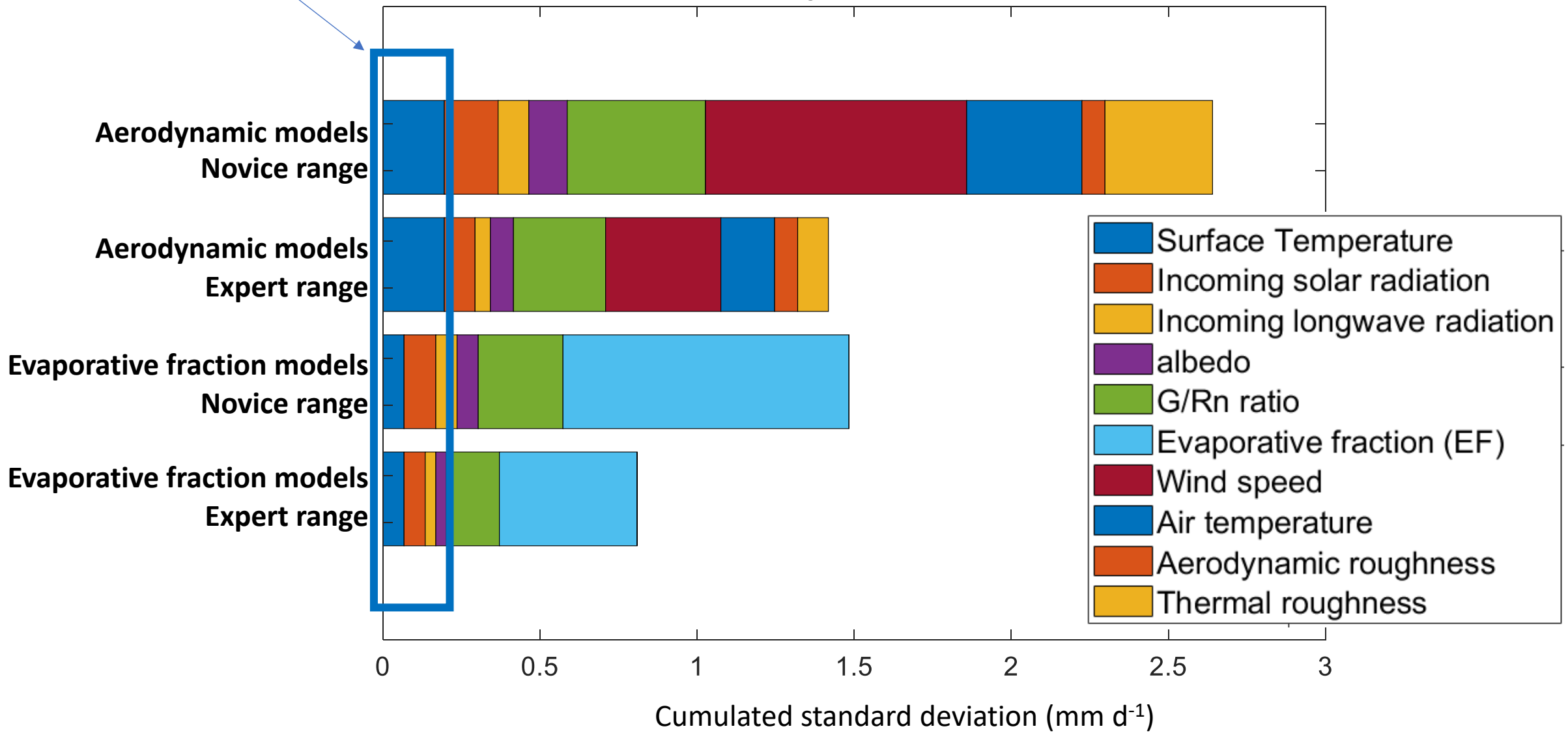
Uncertainty related to Ts:
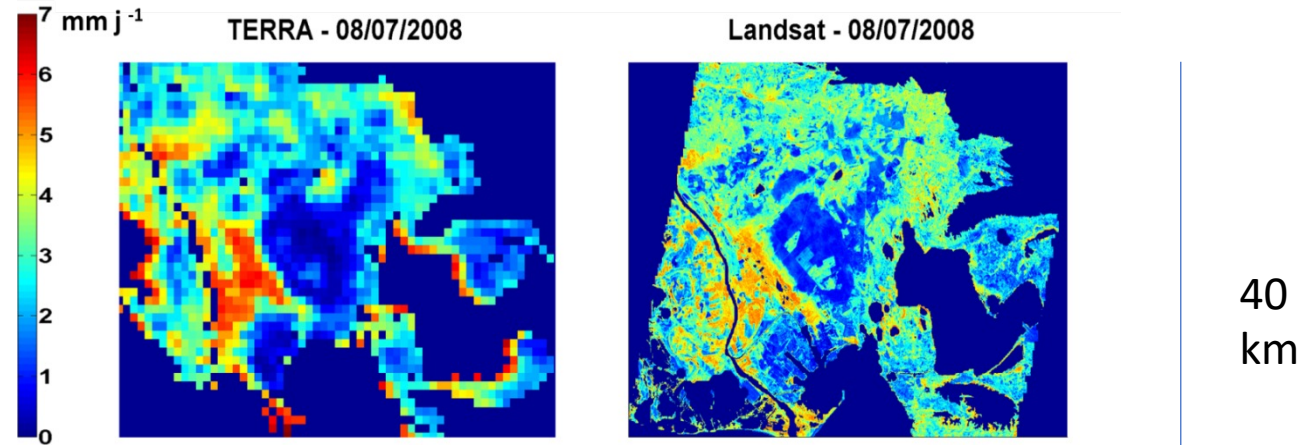

(mm d⁻¹)

→ 0.07 mm d⁻¹
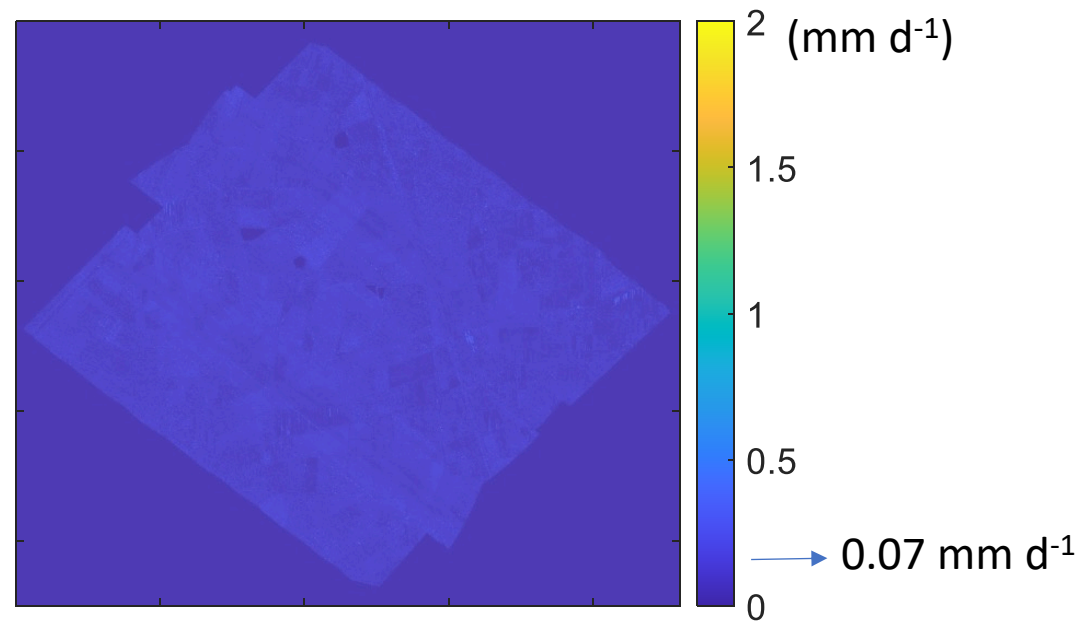
ET uncertainty break-down
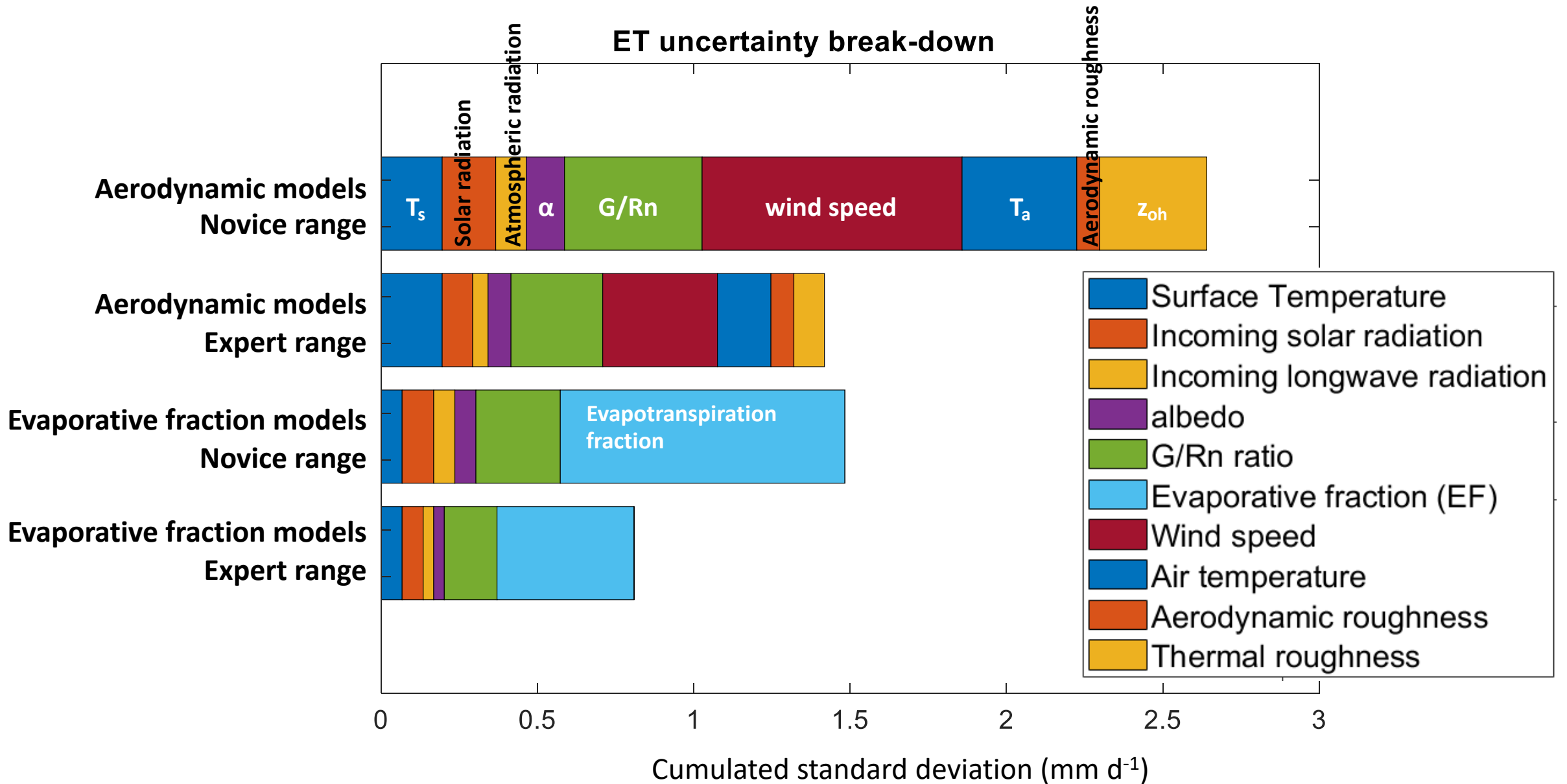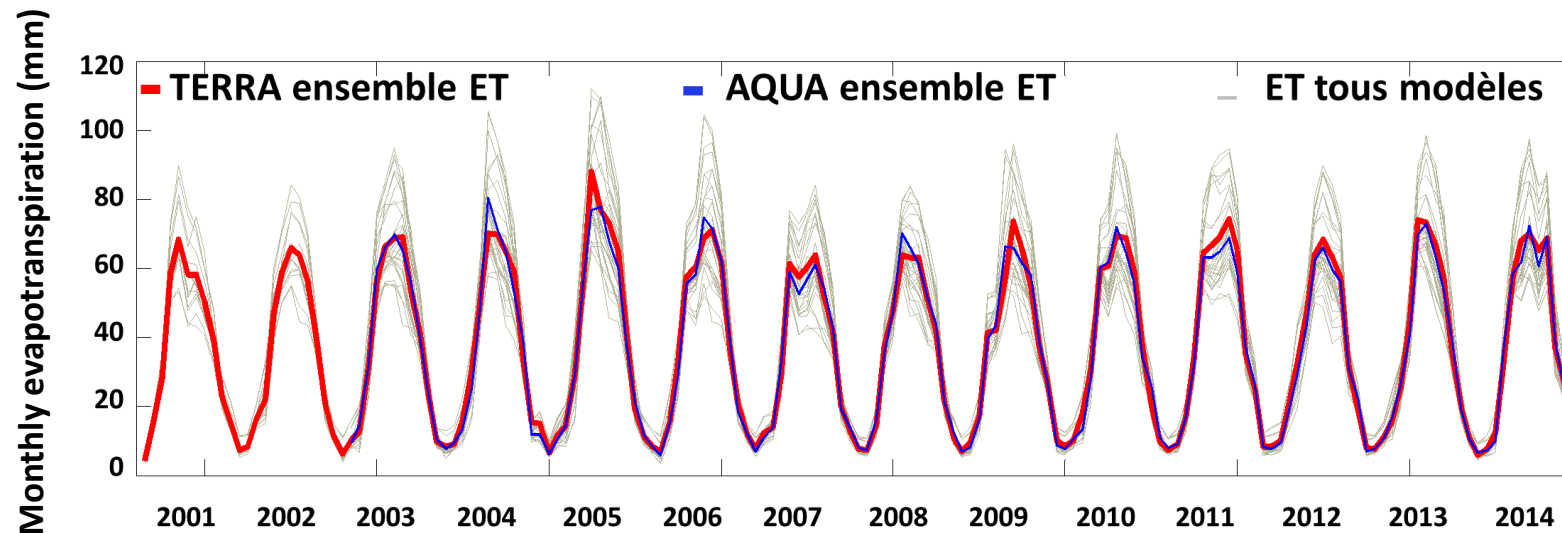
ET uncertainty break-down

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.))

40 km

Monthly ET obtained over the Crau aquifer (600 km^2) 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