Evaluation of EVASPA, a tool for mapping evapotranspiration from space

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Evaluation of EVASPA, a tool for mapping evapotranspiration (ET) from space

Objective: provide evapotranspiration maps at relevant spatial and time scales for agronomical and hydrological purposes

Supports

⇒ CNES in the frame of the thermal infrared satellite mission project **MISTIGRI**

(and NASA-CNES joint project **THIRSTY**)

⇒ Application to water balance of irrigated Mediterranean catchments in the frame of the SIRRIMED FP7 project and SICMED

⇒ Fundacion Ramon Areces (Spanish program for post-doc fellowships)

MISTRALS

Mediterranean I
at Regional A

SIRRIMED

SUSTAINABLE USE OF IRRIGATION WATER IN THE MEDITERRANEAN REGION

Objectives

- Provide evapotranspiration (ET) maps at relevant spatial and time scales for agronomical and hydrological purposes
  - → watershed hydrological balance
  - → water stress and drought monitoring
  - → crop water requirements and irrigation management

- Account of the improvements in algorithms for mapping <u>evapotranspiration</u>

  and land surface variables since the 90's
  - → LAI
  - → albedo
  - → vegetation fraction cover
  - → emissivity
  - → surface temperature
  - → incident radiation

NB: Operational Evapotranspiration products are only few and have strong limitations (validity, temporal and spatial resolution)

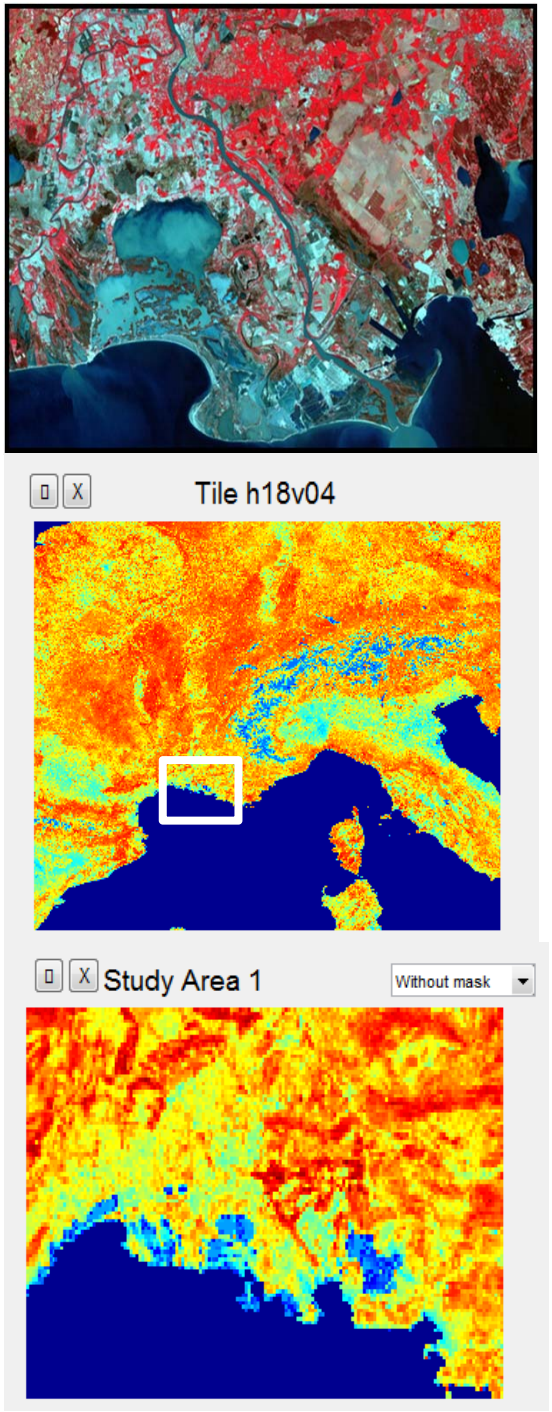
Main features of EVASPA

- ❑ **Combination of Evapotranspiration models (ensemble calculation):**
  => estimation of uncertainties

- ❑ **Integrate data from various remote sensing sensors (Integration of new sensors is easy)**

- ❑ **Continuous daily ET maps (interpolation methods)**

- ❑ **Graphical User Interface (GUI) (MATLAB)**



EVASPA first operational version

- **MODIS data (TERRA and AQUA) :**

  Continuous daily ET maps at kilometric spatial resolution

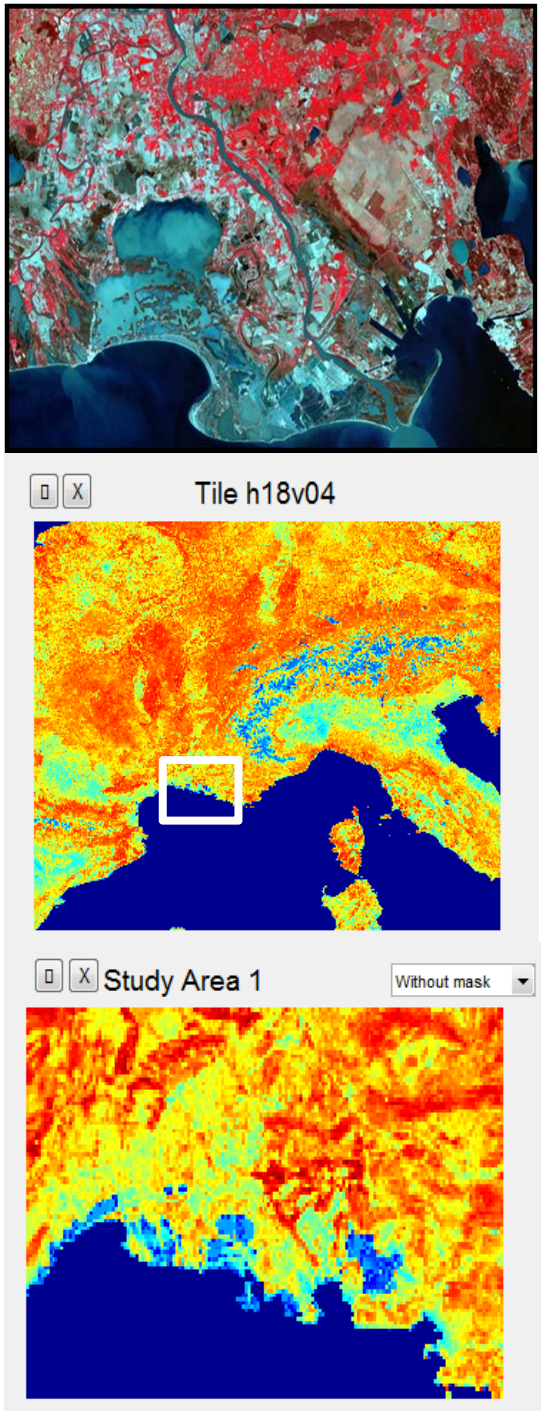
- **Landsat 5 and 7**

  High resolution ET maps (~hectometric)

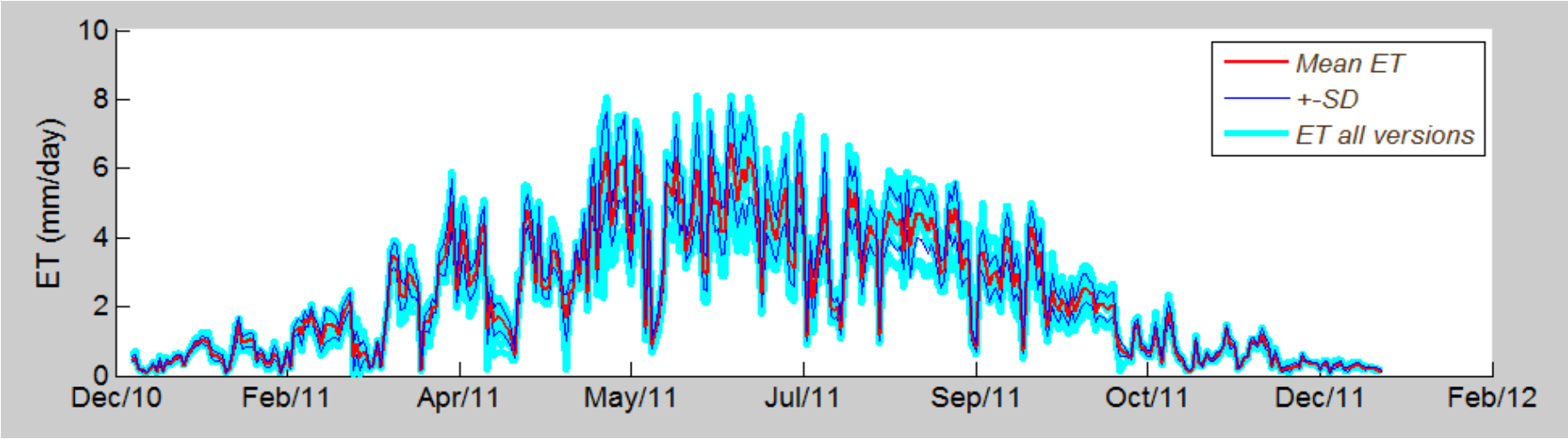
  when images of the study area are available

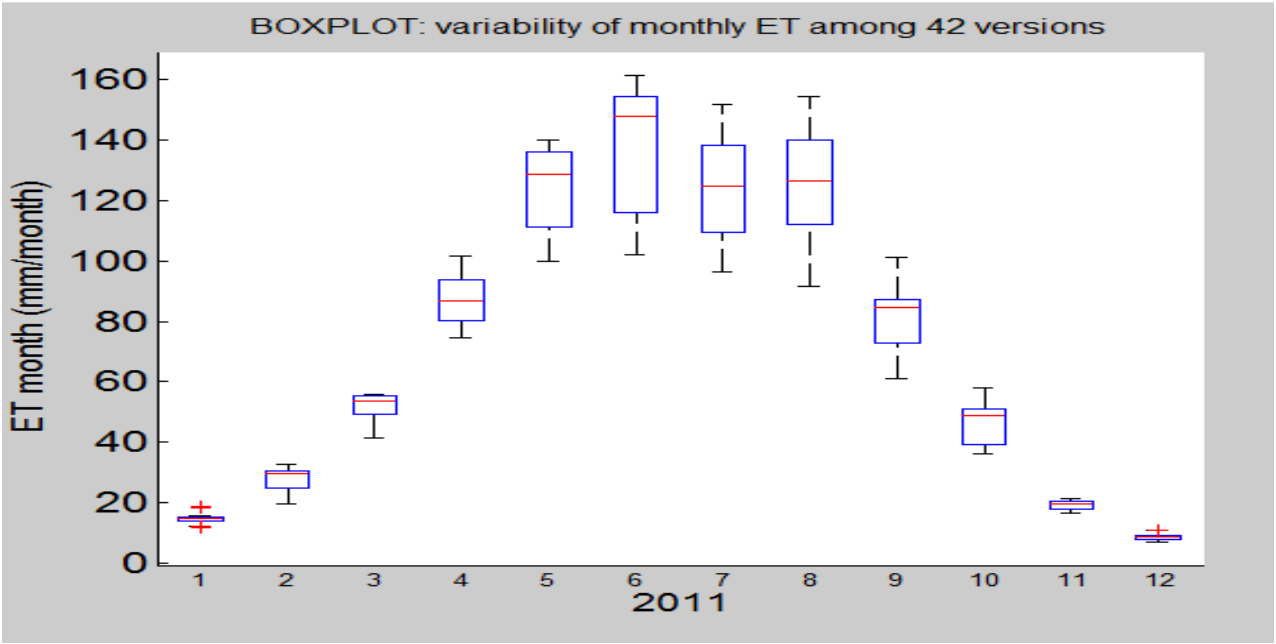
- **Mapping algorithms based on**
  - **→ S-SEBI (Roerink 2000)**
  - **→ Triangle approach (Jiang and Islam 1999)**

- **Several algorithms and hypotheses for the calculations of**
  - **→ albedo**
  - **→ emissivity**
  - **→ ground heat flux**
  - **→ evaporative fraction**
  - **→ time interpolation**



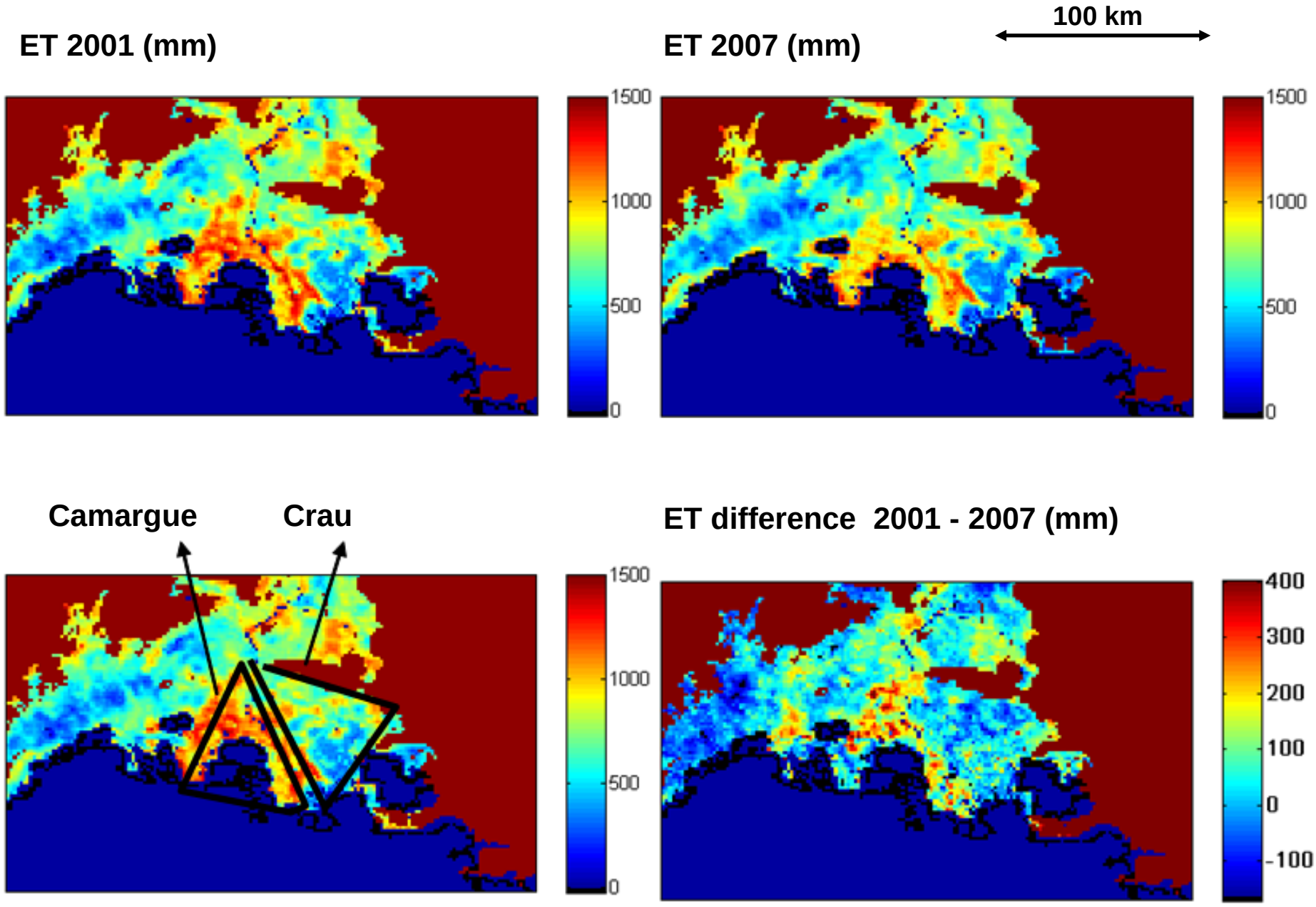
Example : continuous daily evapotranspiration from MODIS (irrigated grassland area - South East France)





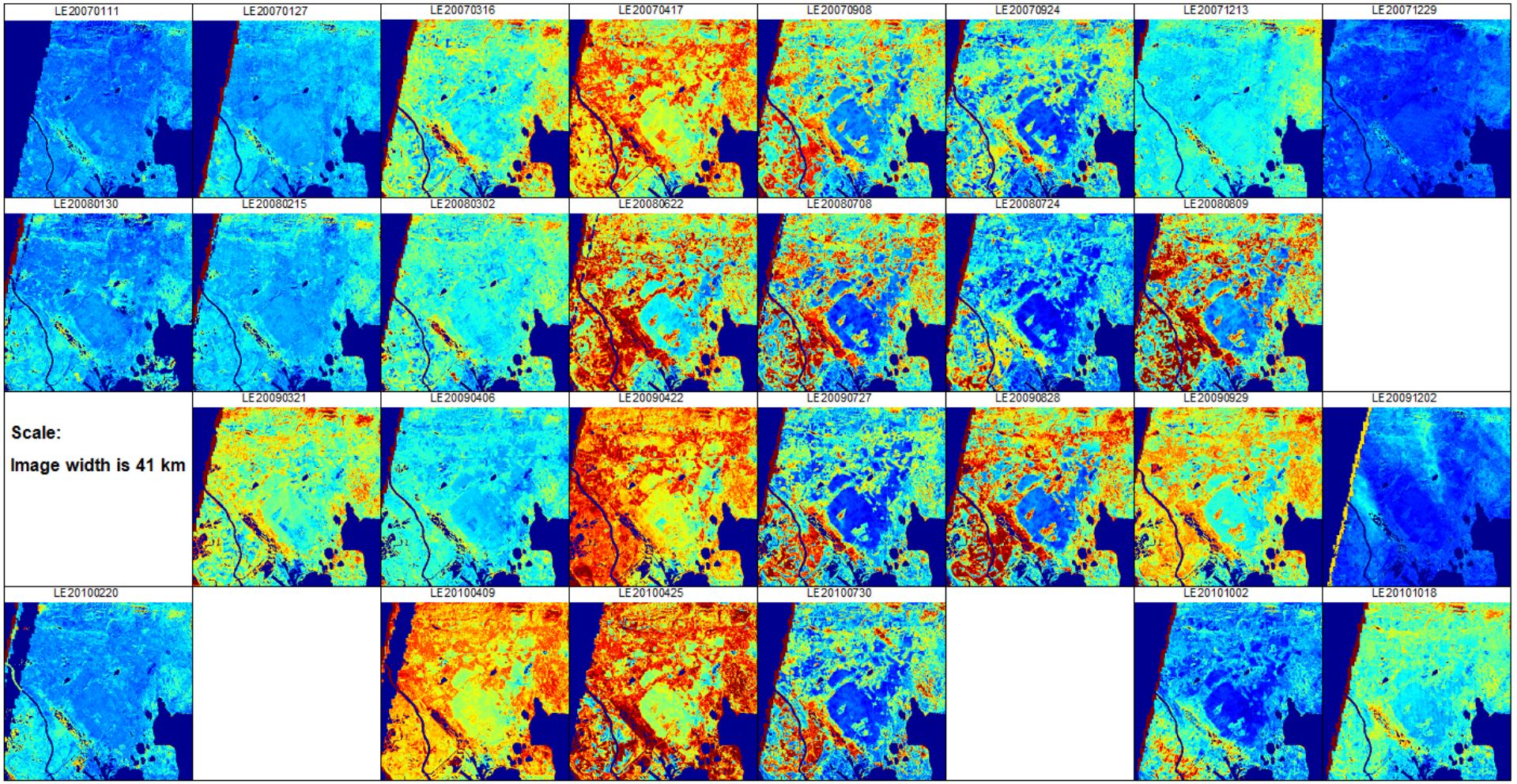
Example: annual evapotranspiration maps integrated from MODIS

[South East France, comparison of a normal year (2001) to a dry year (2007)]



Example: Latent heat flux maps from LANDSAT-7 data
[Crau area – South East France - from 2007 to 2010]

Spatial range = 40 km; Flux range: 0 Wm^{-2} (dark blue) to 500 Wm^{-2} (dark red); images at 10:30 LST



Evaluation of EVASPA

- Evaluation against flux tower measurements:

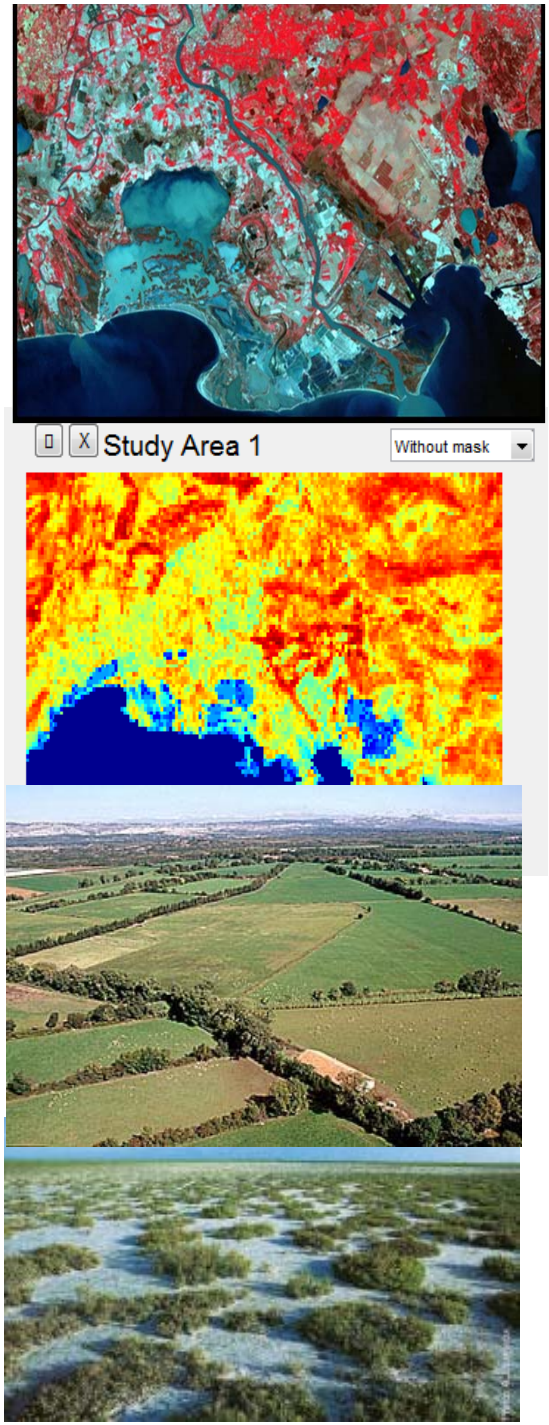
  error and uncertainty assessment

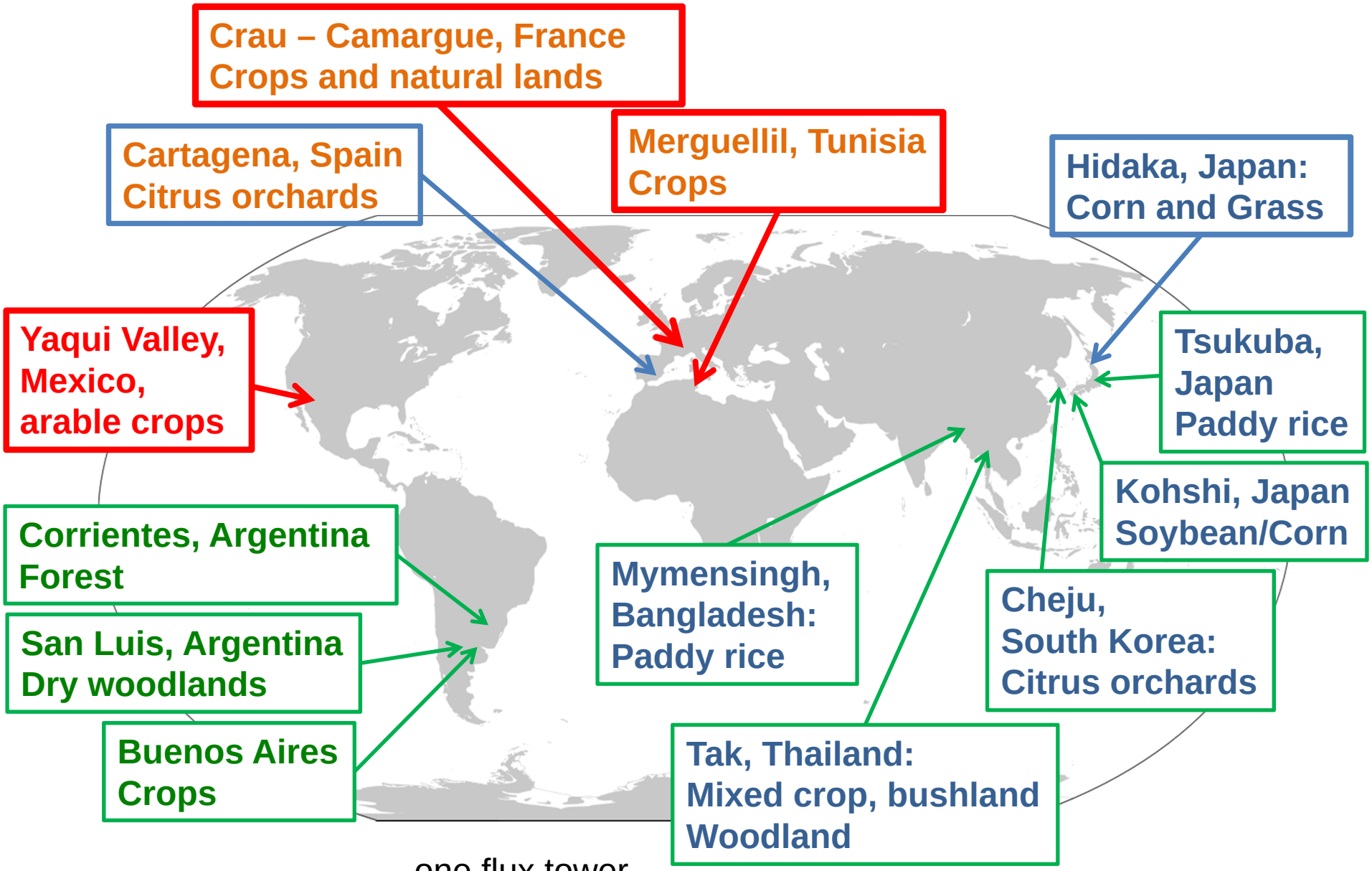
  - → Mediterranean program
  - → South American program
  - → Monsoon Asian program

- Evaluation against ground station (flux tower)

  and higher resolution ET images

- Derivation of long term ET series by training on ground ET measurements for specific ecosystems and comparison to hydrological features




Crau – Camargue, France
Crops and natural lands
Cartagena, Spain
Citrus orchards
Merguellil, Tunisia
Crops
Hidaka, Japan:
Corn and Grass
Yaqui Valley,
Mexico,
arable crops
Tsukuba,
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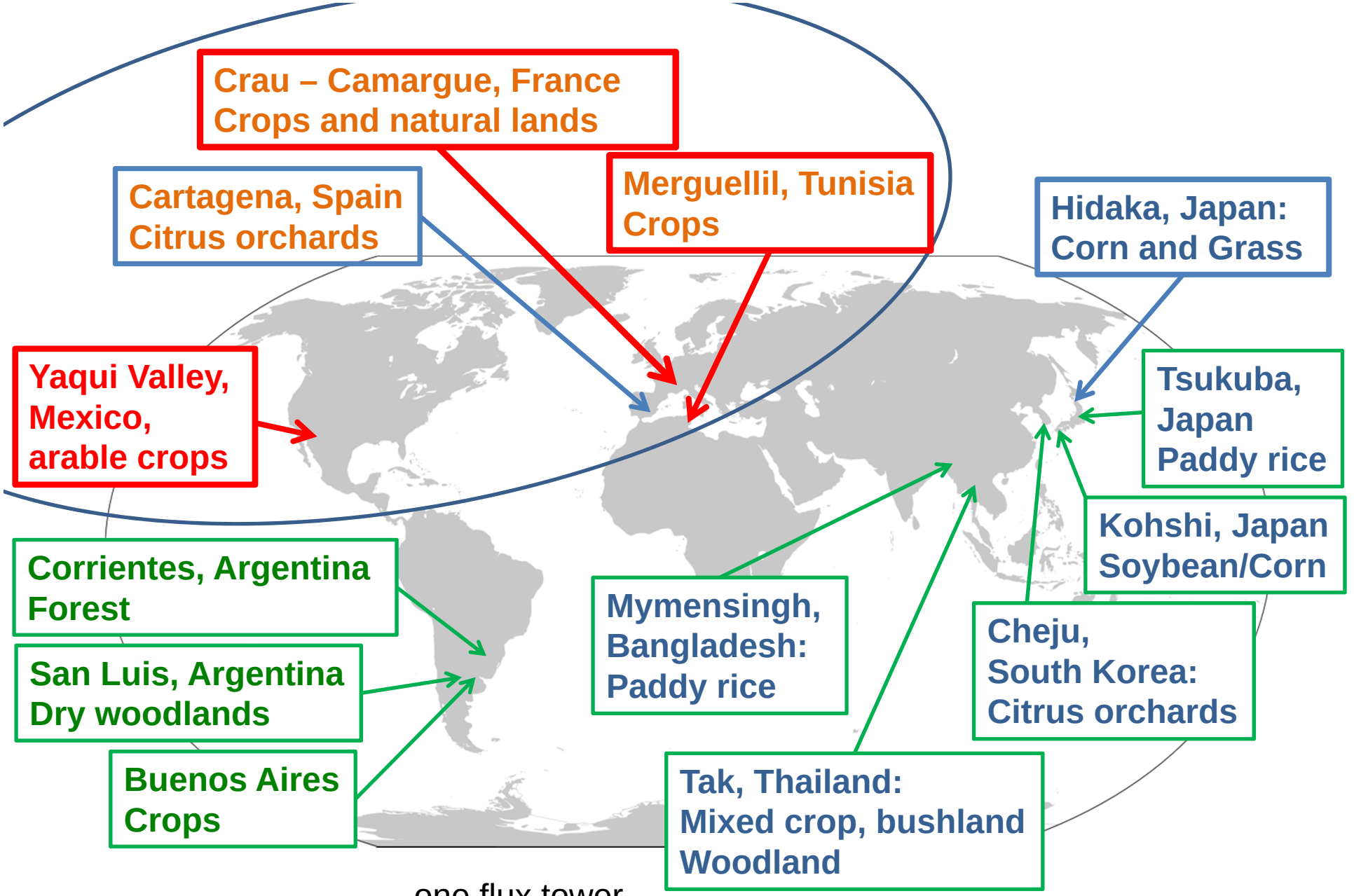
Paddy rice
Kohshi, Japan
Soybean/Corn
Corrientes, Argentina
Forest
San Luis, Argentina
Dry woodlands
Buenos Aires
Crops
Mymensingh,
Bangladesh:
Paddy rice
Cheju,
South Korea:
Citrus orchards
Tak, Thailand:
Mixed crop, bushland
Woodland
one flux tower
two flux towers
more flux towers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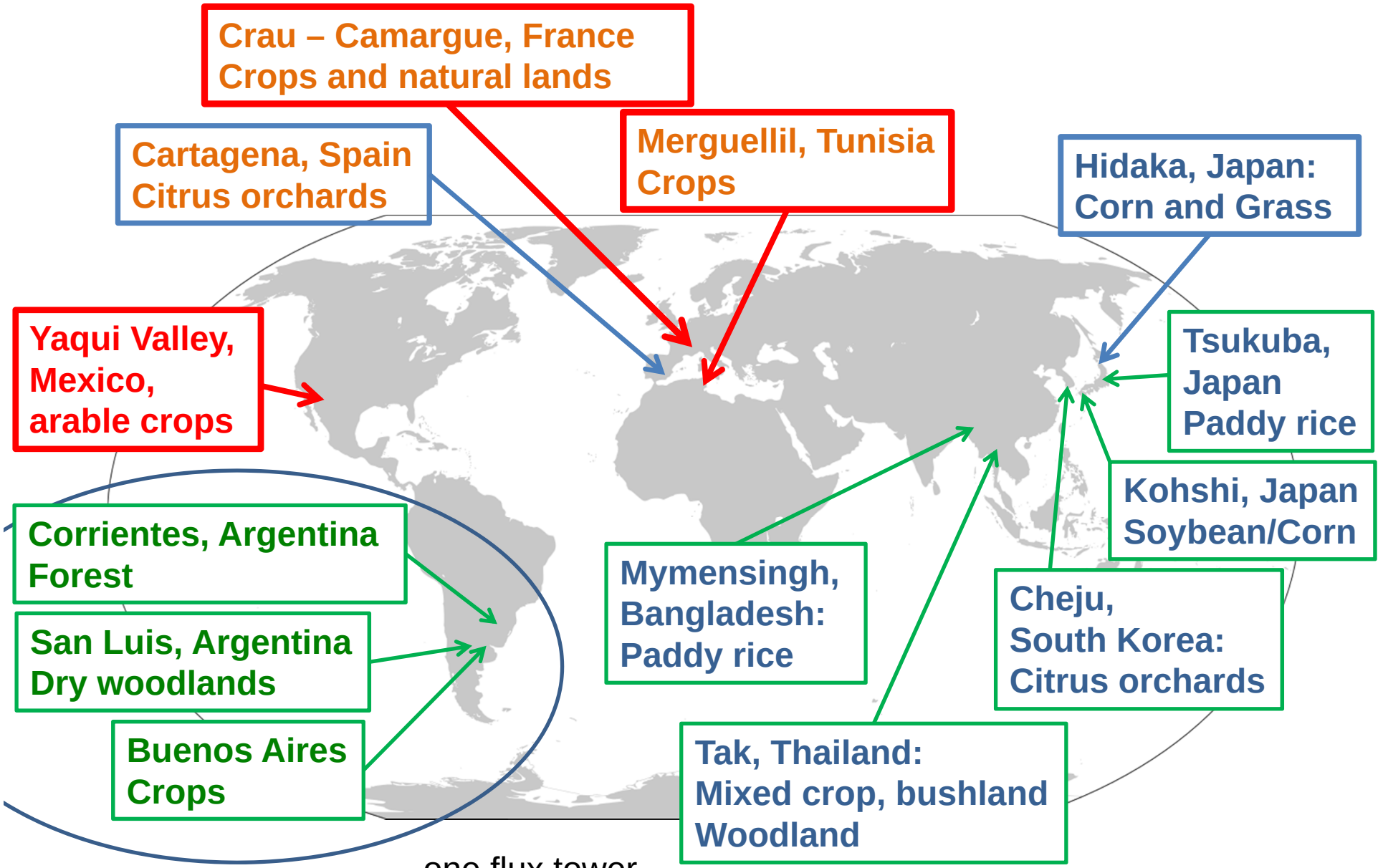
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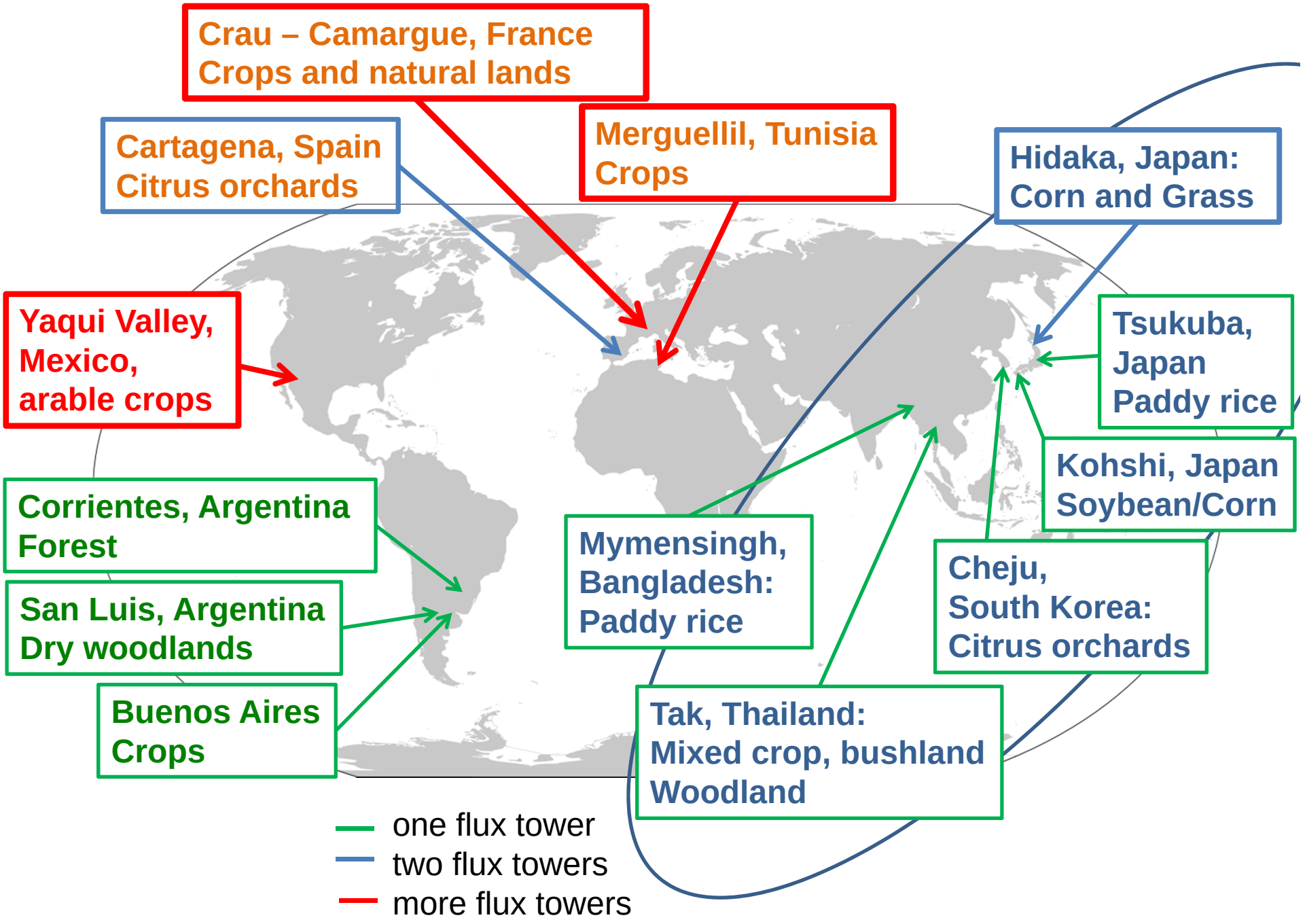
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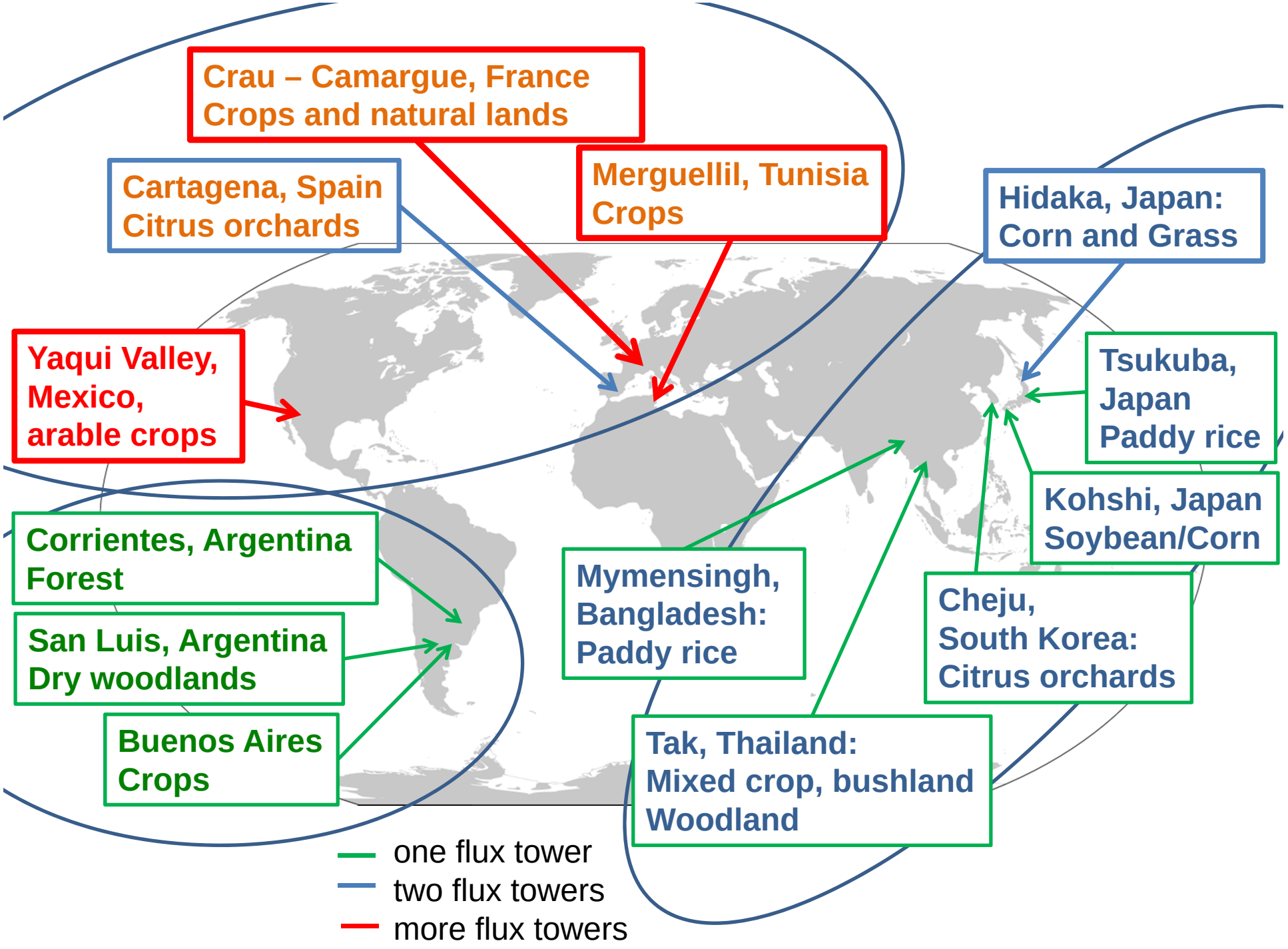
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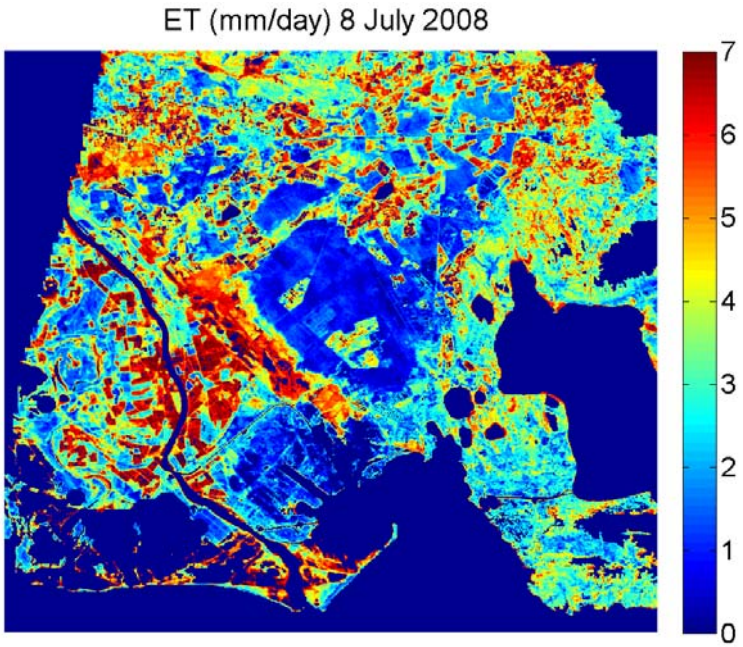
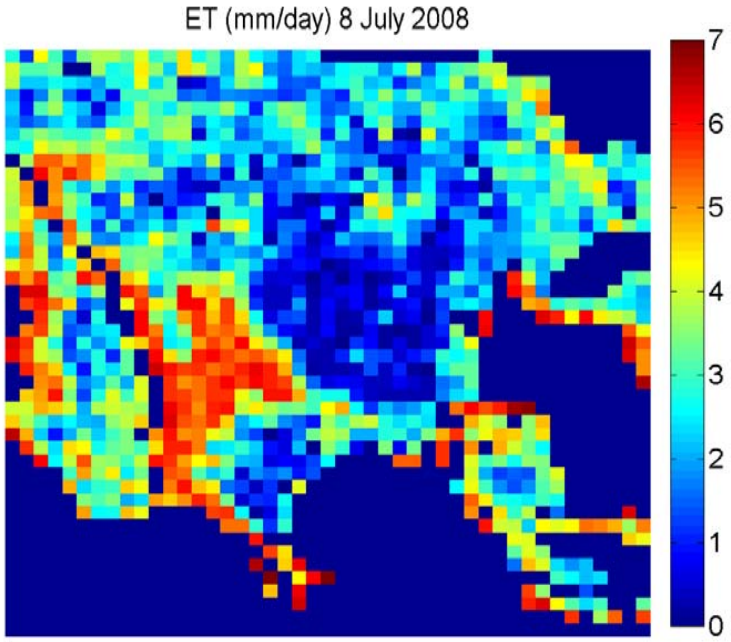
Evaluation of EVASPA maps

EVASPA LANDSAT MAP



EVASPA MODIS MAP

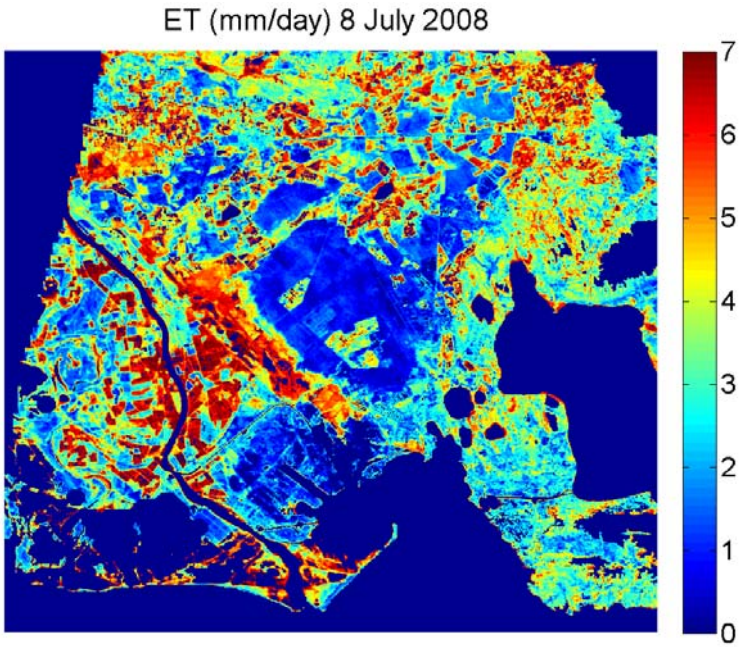


ENERGY BALANCE FLUX STATIONS

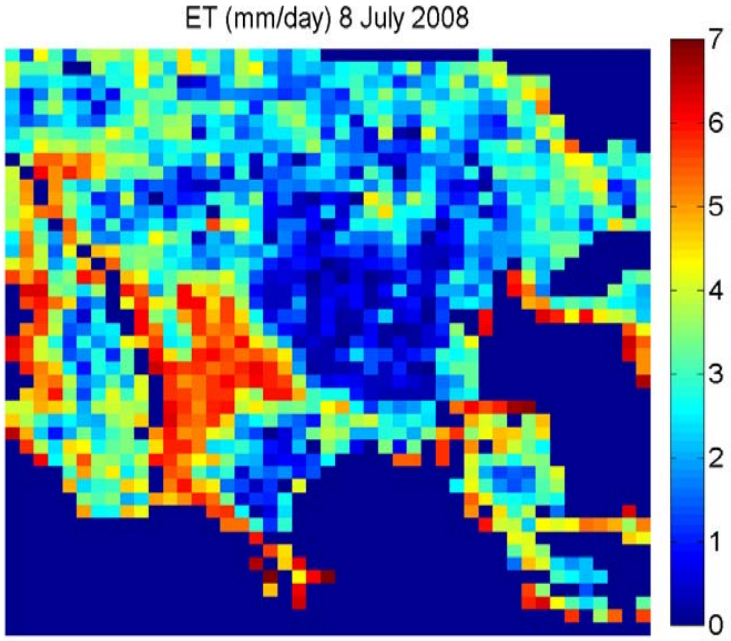
FLUX STATIONS IN LARGE HOMOGENEOUS AREAS

Evaluation of EVASPA maps

EVASPA LANDSAT MAP (OR OTHER MODELS MAPS)



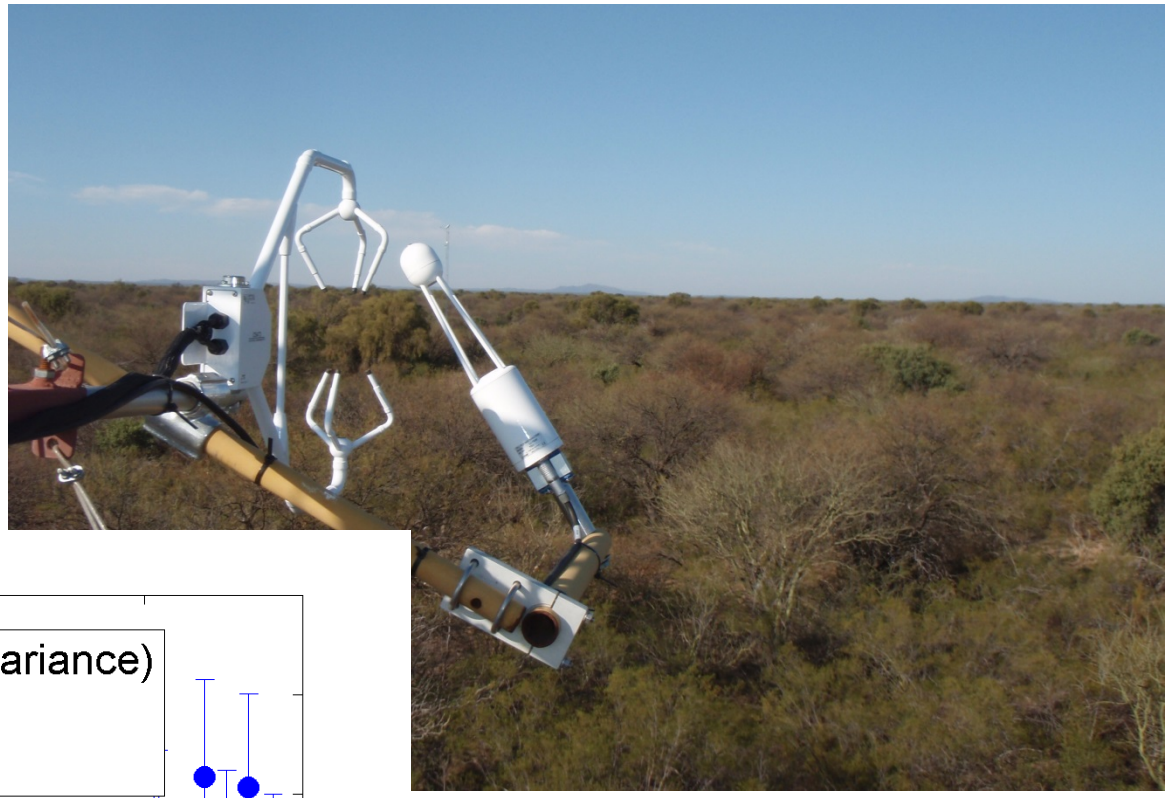
EVASPA MODIS MAP

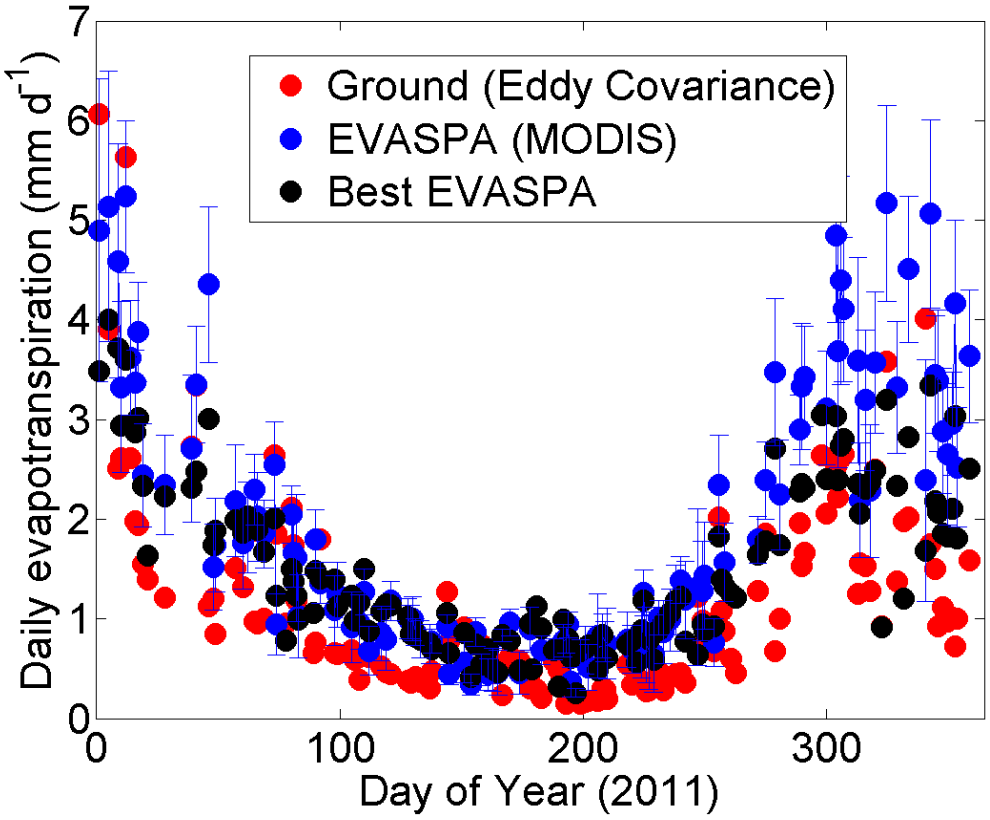


ENERGY BALANCE FLUX STATIONS

San Luis – East Argentina

- Evaluation of MODIS estimates against flux tower
- Dry woodlands

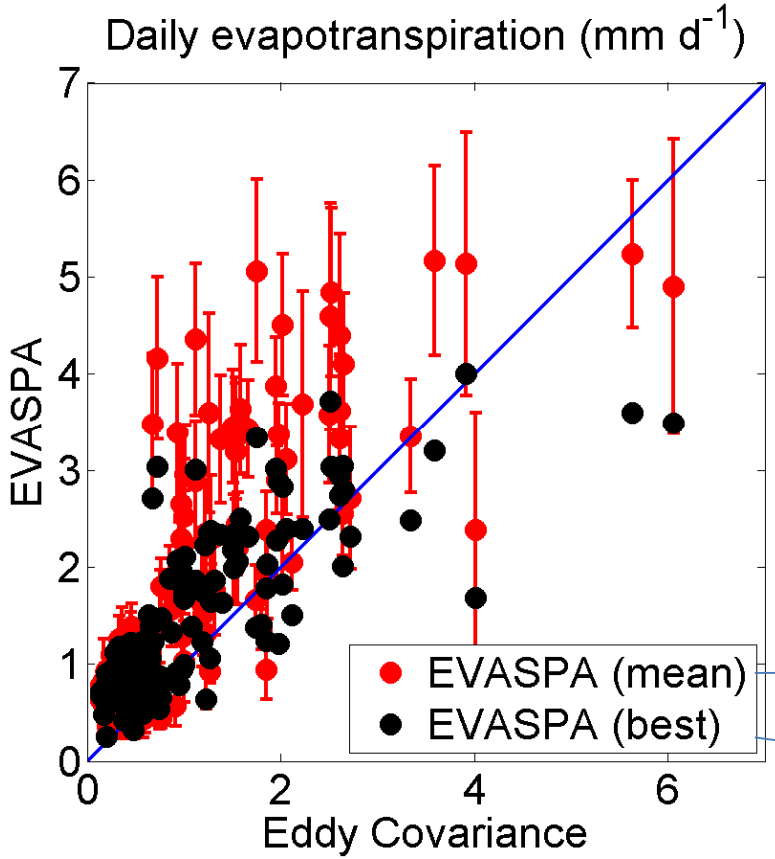




- General overestimation
- Large uncertainties:
  standard deviation:
  - → 0.2 mm d^{-1} in winter
  - → 0.6 – 1.2 mm d^{-1} in summer

San Luis – East Argentina

- Evaluation of MODIS estimates against flux tower
- Dry woodlands



RMSE = 1.23 mm d^{-1} **Bias = 0.7 mm d^{-1}**

RMSE = 0.74 mm d^{-1} **Bias = 0.4 mm d^{-1}**

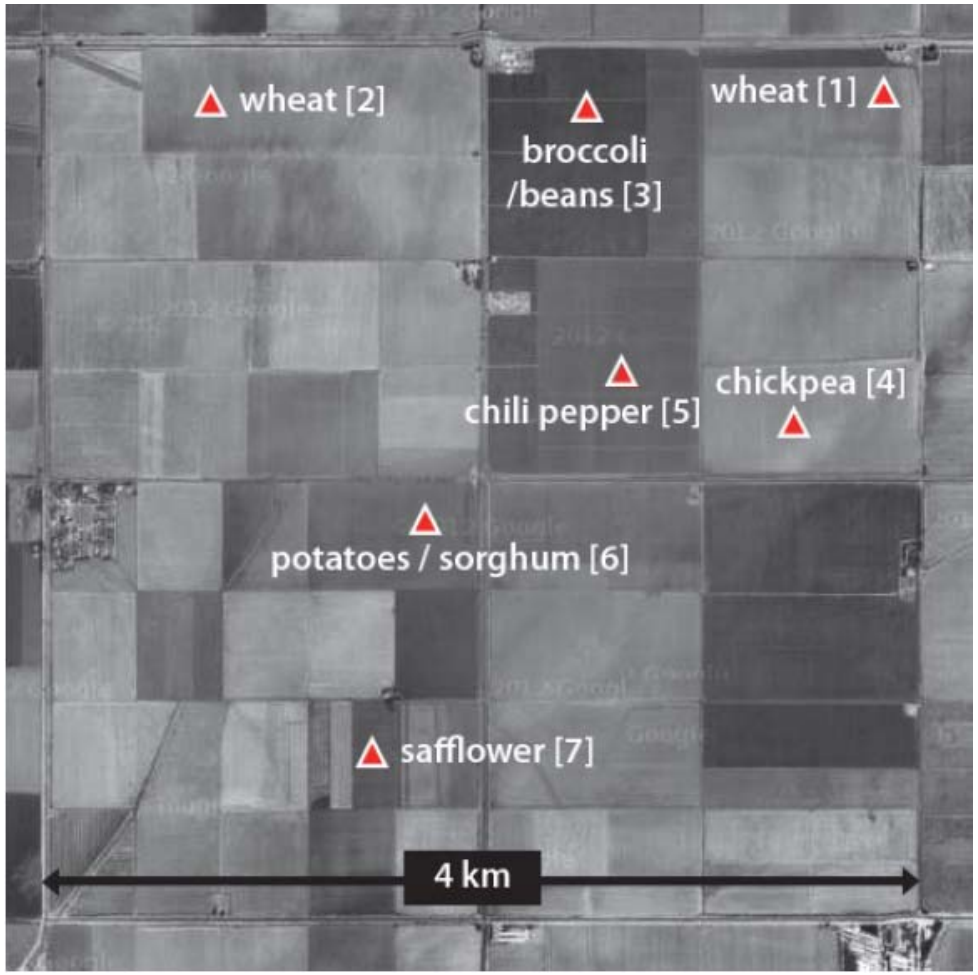
Yaqui Valley – Sonora - Mexico - Agricultural area

- Evaluation of EVASPA MODIS maps (1 km resol.)
  against ASTER maps (90 m resolution) using the SEBS model (Su 2002)

- ASTER maps were previously evaluated
  against flux tower network
  over a 4 km X 4 km area
  (7 images for 6 months)

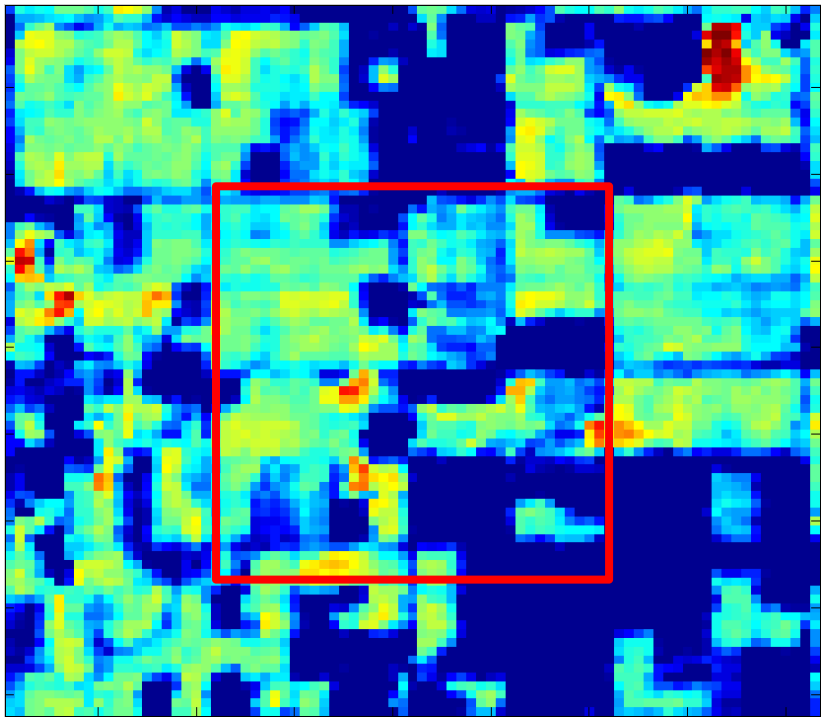
  Chirouze et al., HESS, 2014

- Poster P3.03 by Bahir et al.
  Wednesday poster session

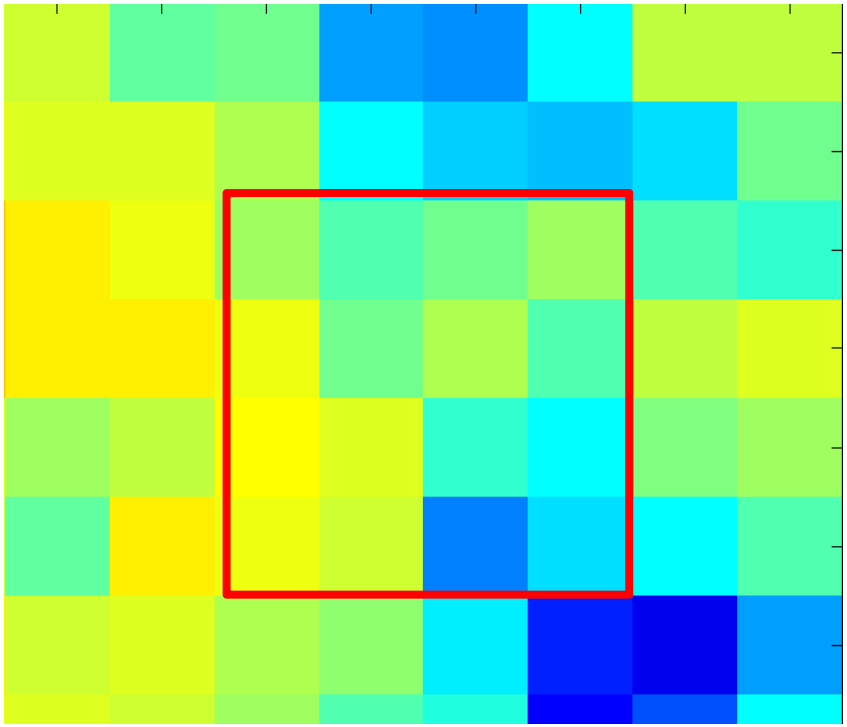


Latent heat flux maps from ASTER using the SEBS model and MODIS (TERRA) using EVASPA

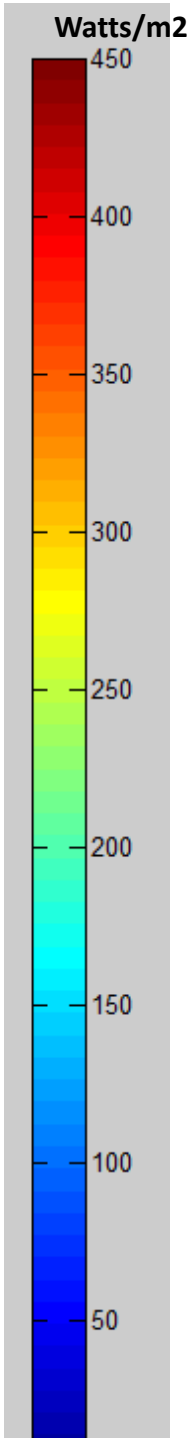
06 May 2008
4km by 4km area in the Yaqui valley, Sonora, Mexique.



ASTER image – resolution ~100m

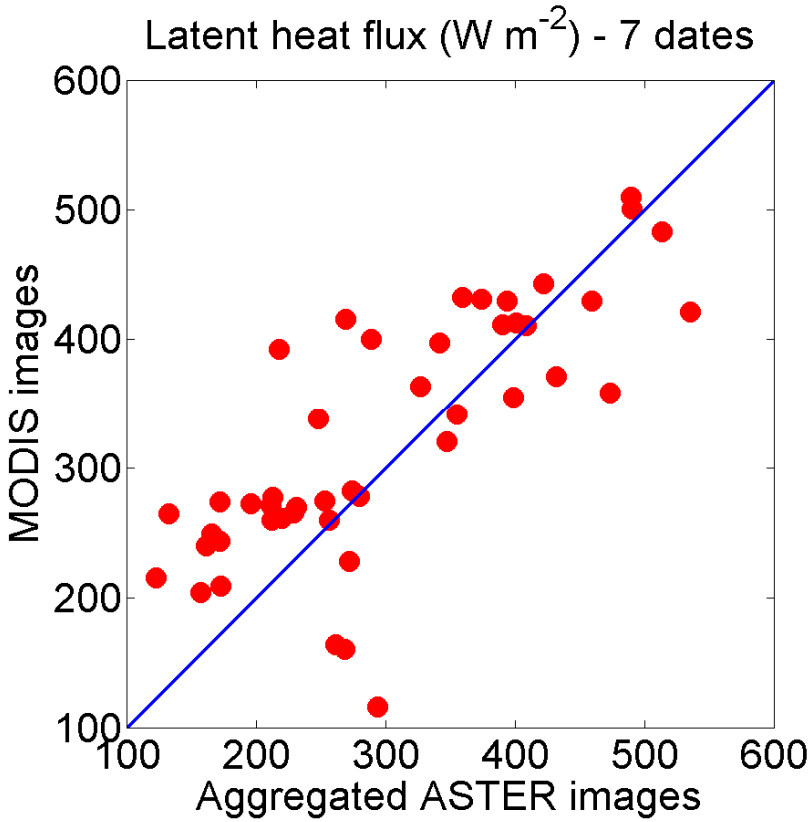


MODIS image – resolution 1 km



Yaqui Valley – Sonora - Mexico - Agricultural area

- **MODIS maps / aggregated ASTER maps**
  - → **RMSE = 75 Wm^{-2} (> 1 mm d^{-1})**
  - → **Bias = 22 Wm^{-2}**



- **ASTER estimates / flux tower: RMSE = 138 Wm^{-2}**

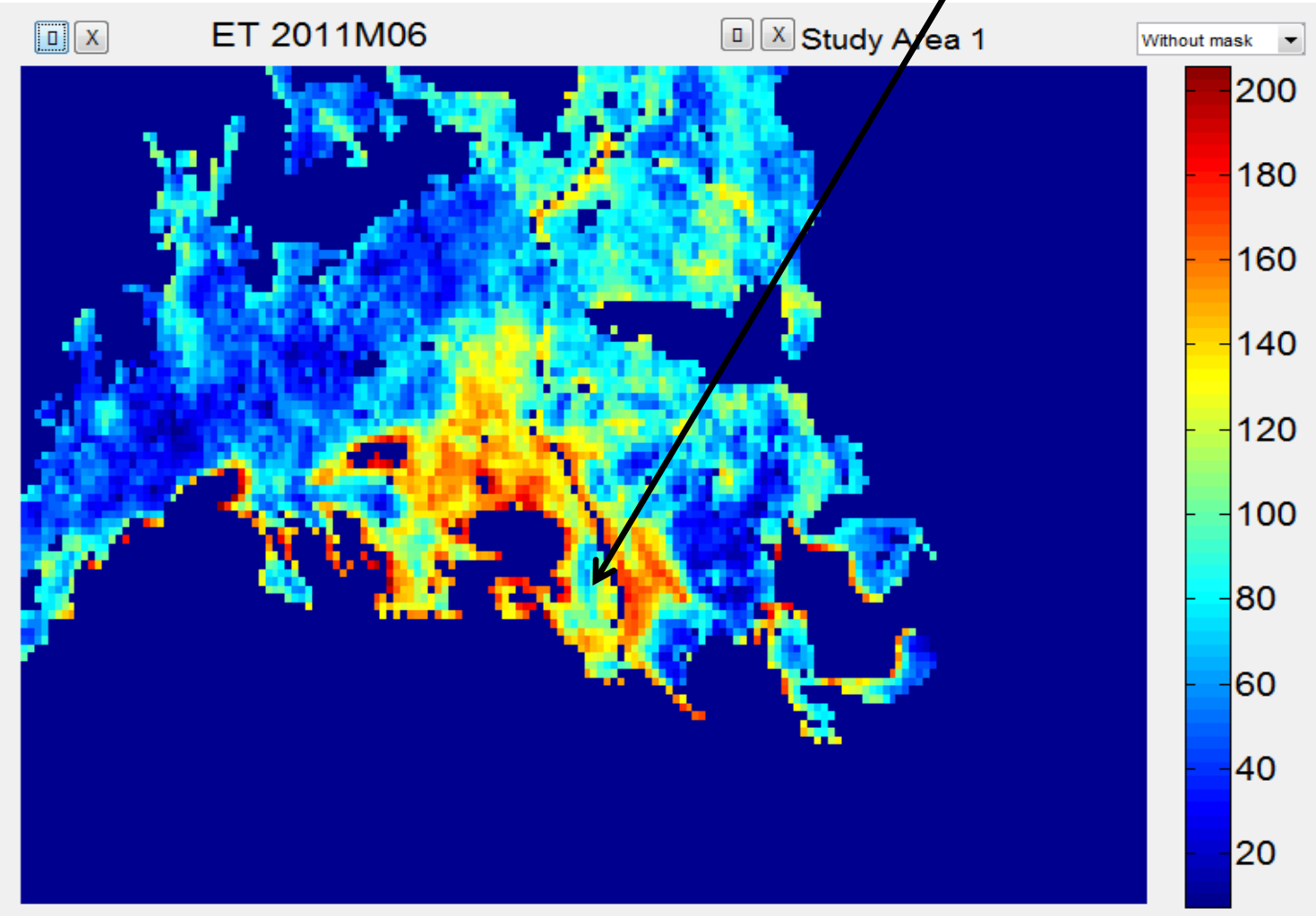
- Errors from albedo derived over ASTER images

- SEBS is very sensitive to metorological forcing (air temperature) and vegetation height

- Sensors Point Spread Function (PSF) not accounted and impact of reprojection of MODIS images

Tour du Valat – Camargue – France

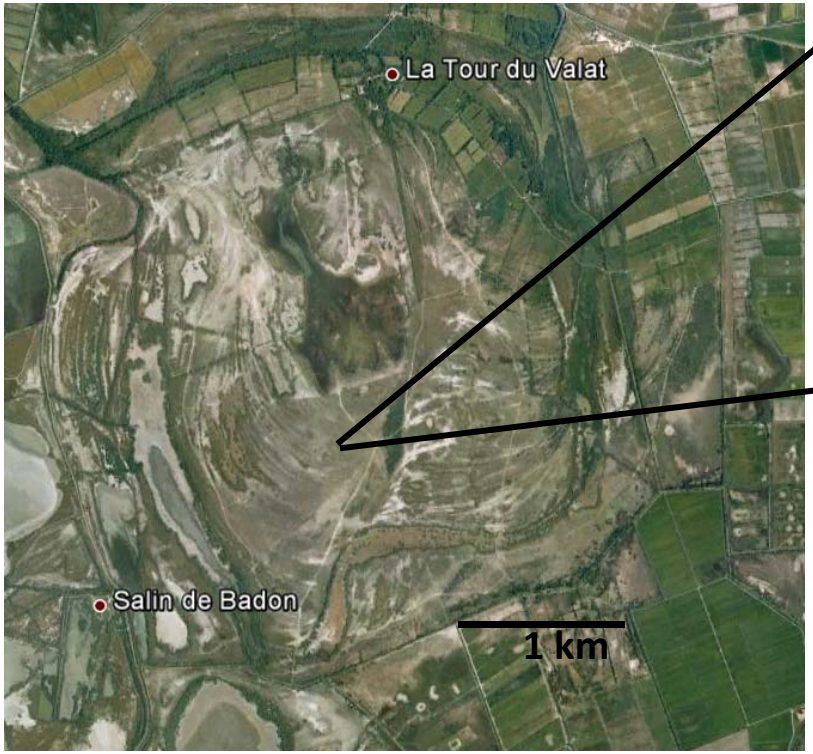
- MODIS data against ground station and water table fluctuations



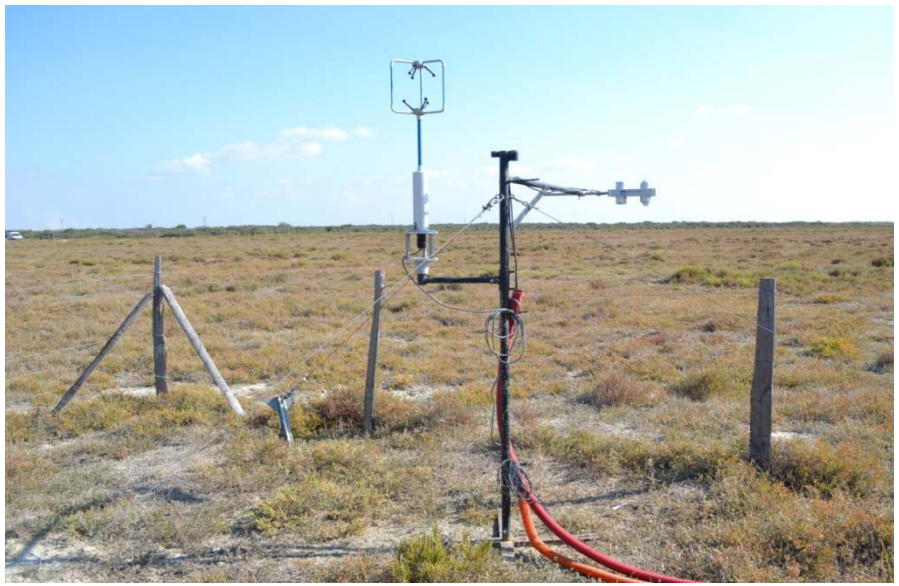
Tour du Valat – Camargue – France

- **Tour du Valat wetland conservation area:**

  - → large saltmarsh scrubs area
  - → endoreic behaviour
  - → Shallow water table (0 to 2.5 m)

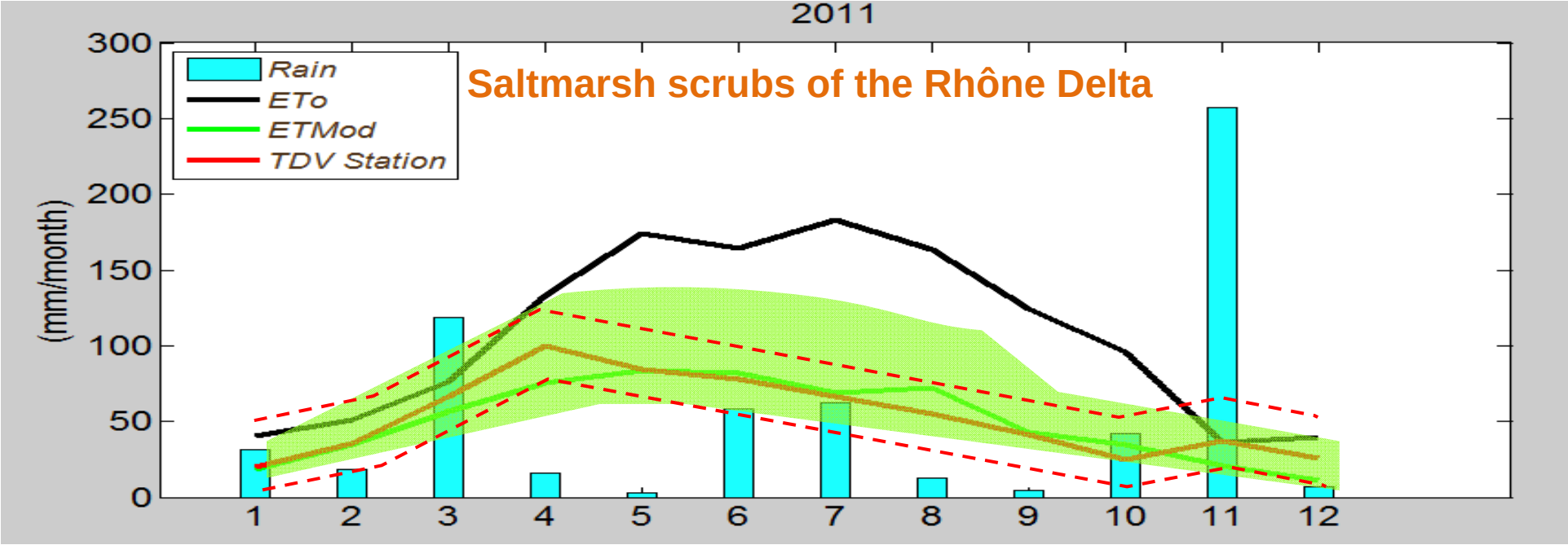


piezometer – rain gauge - evaporation pan



energy balance station

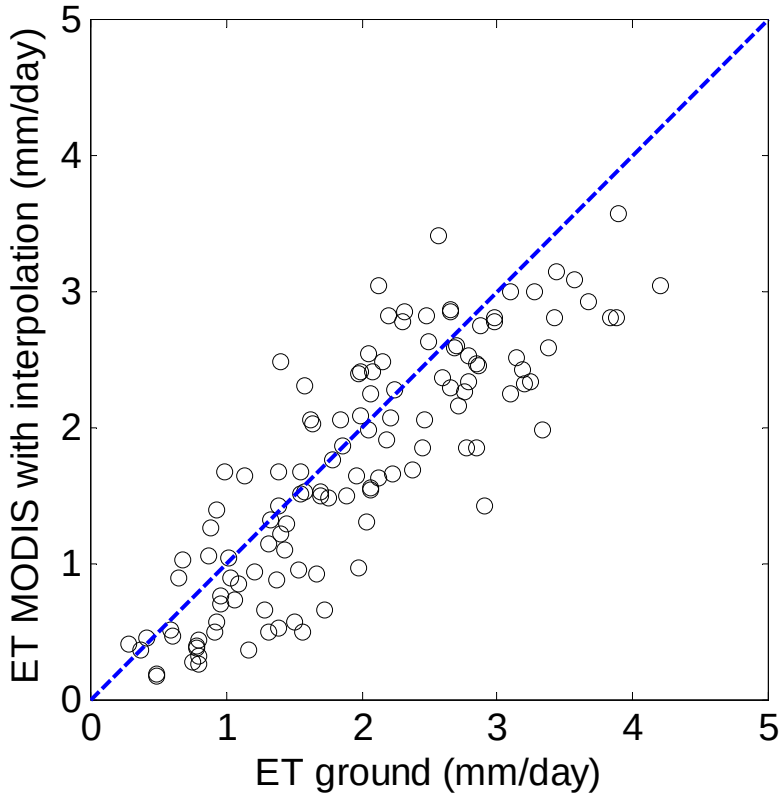
EVASPA ET estimations vs. ground stations



Identification of best performance methods for different surfaces and water stress conditions

Results

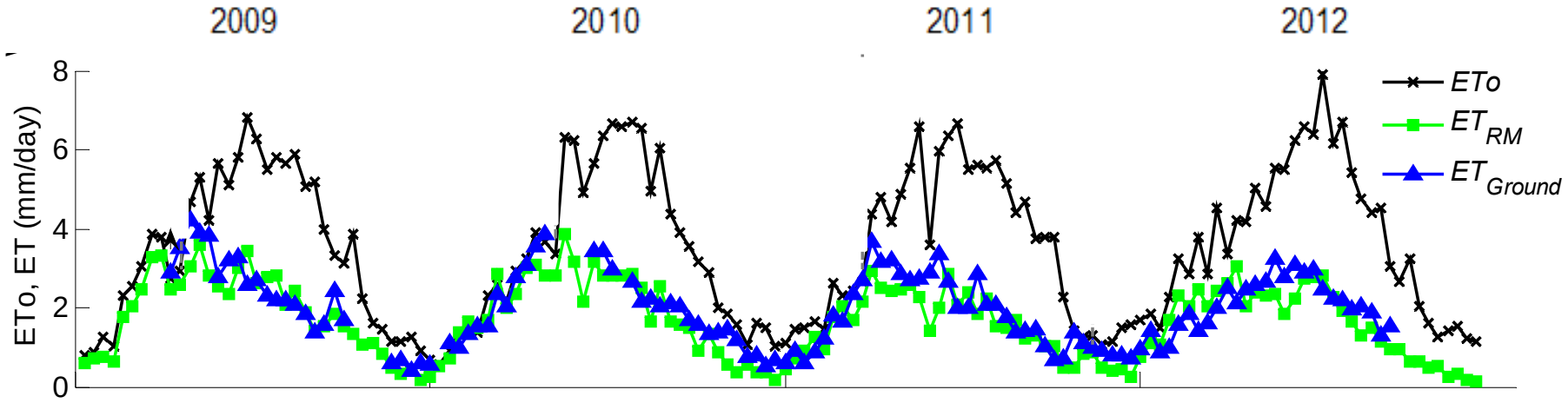
Calibration on one year, evaluation on the 3 others
(almost similar whatever the chosen calibration year)



RMSE	**0.78 mm d^{-1}**
MBE	**-0.12 mm d^{-1}**
R^2	**0.76**

Results

➢ Evapotranspiration over 4 years (10 day integration time)



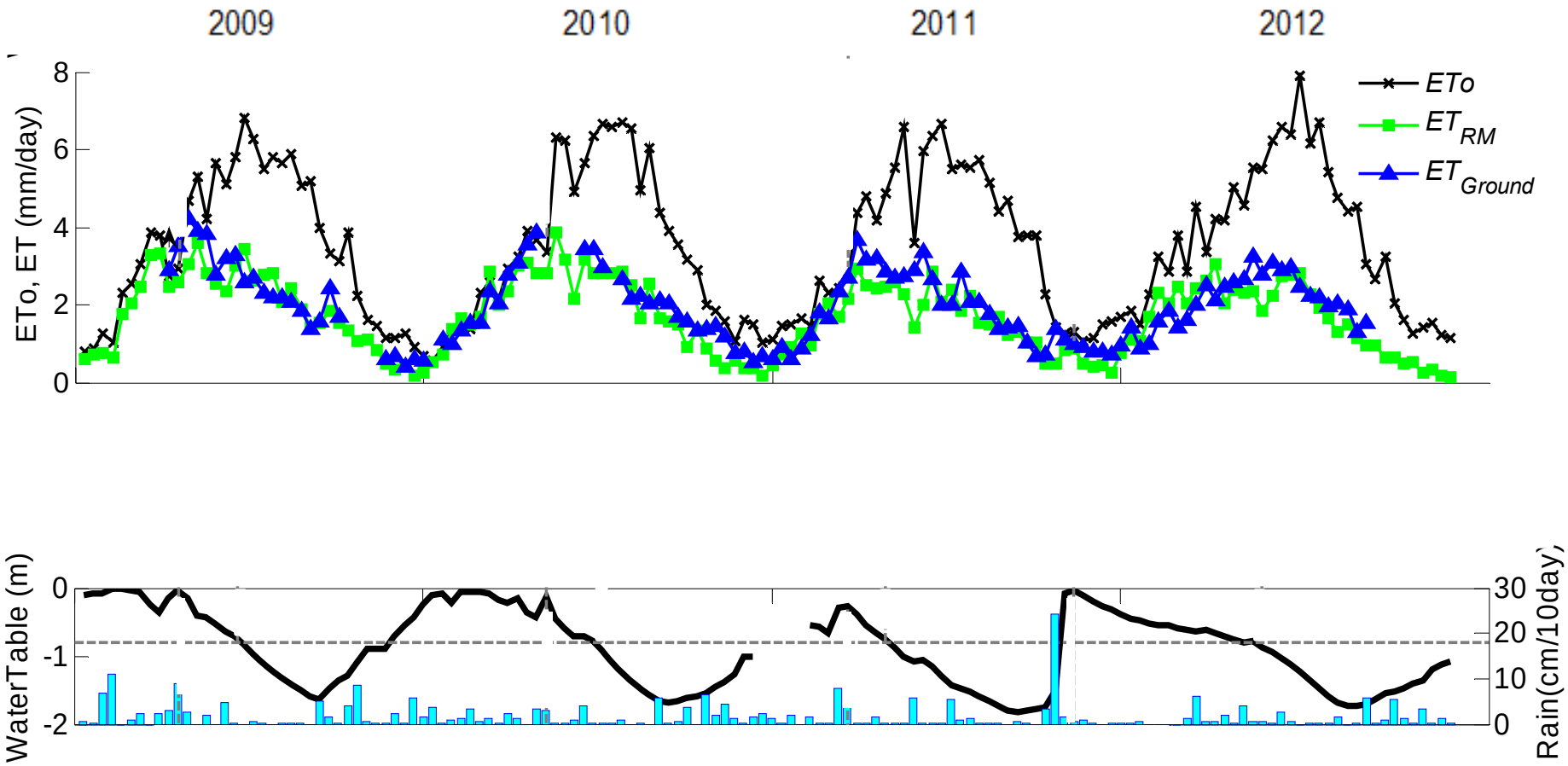
ET_{Ground} : daily evapotranspiration derived from latent heat flux measurements (*LE*) [mm d^{-1}]

ET_{RM} : daily evapotranspiration derived from remote sensing and used for gap filling [mm d^{-1}]

ETo : reference evapotranspiration (FAO 56, Allen et al. 1998) [mm d^{-1}]

Results

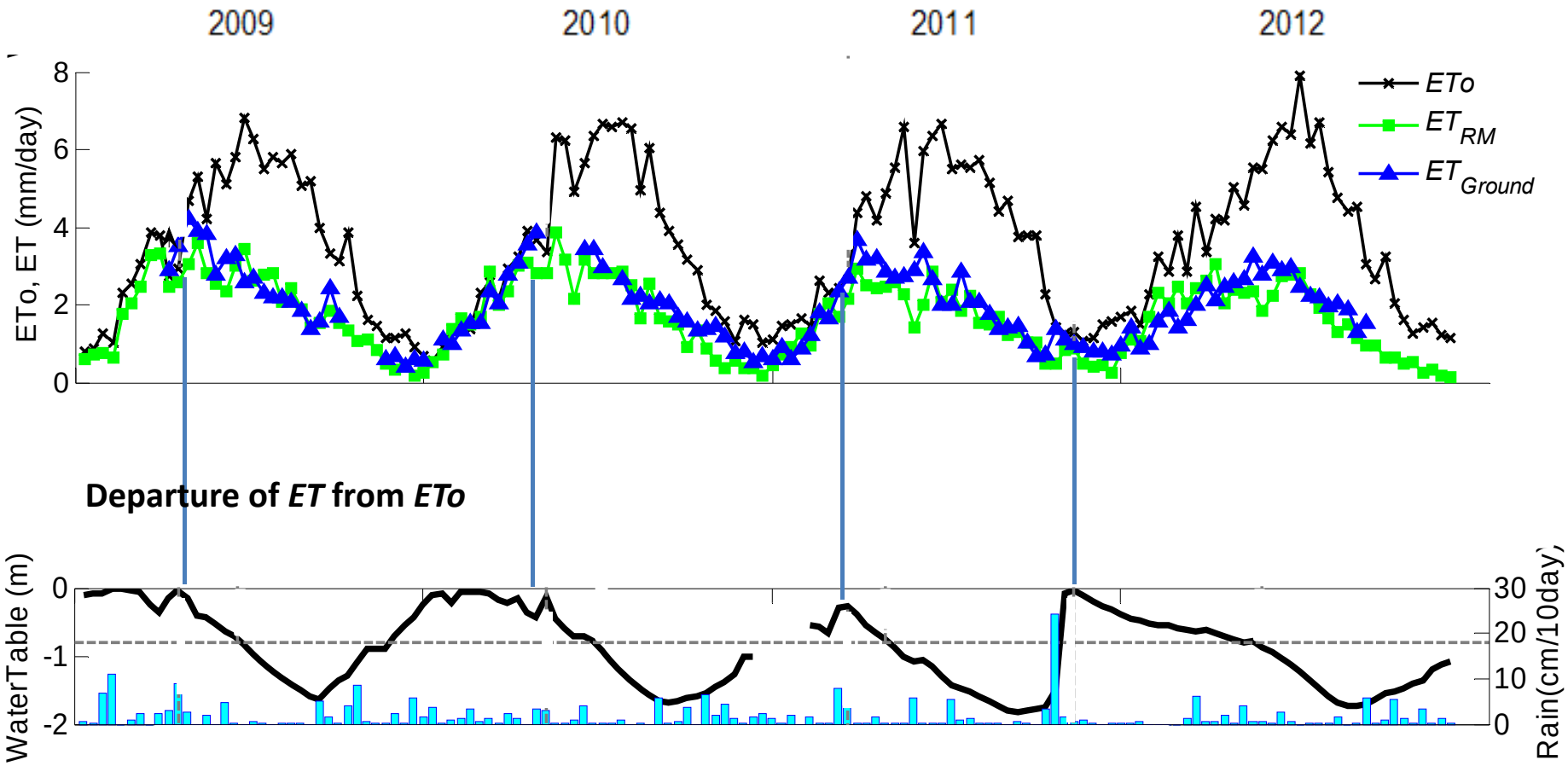
➢ Evapotranspiration over 4 years : relation to the water table



Evolution of the water table

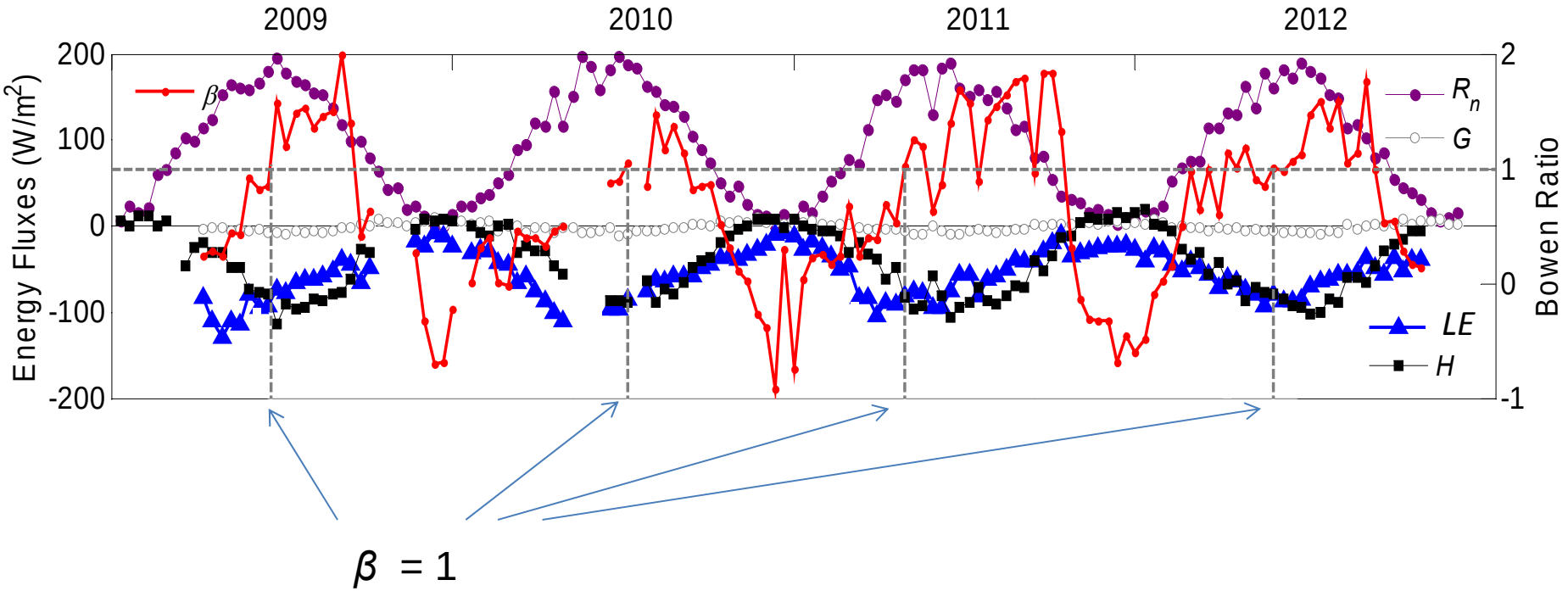
Results

➢ Evapotranspiration over 4 years : relation to the water table



Results

➢ Energy balance and Bowen ratio (β) over 4 years (10 day integration time)



LE : latent heat flux (W m^{-2})

H : sensible heat flux (W m^{-2})

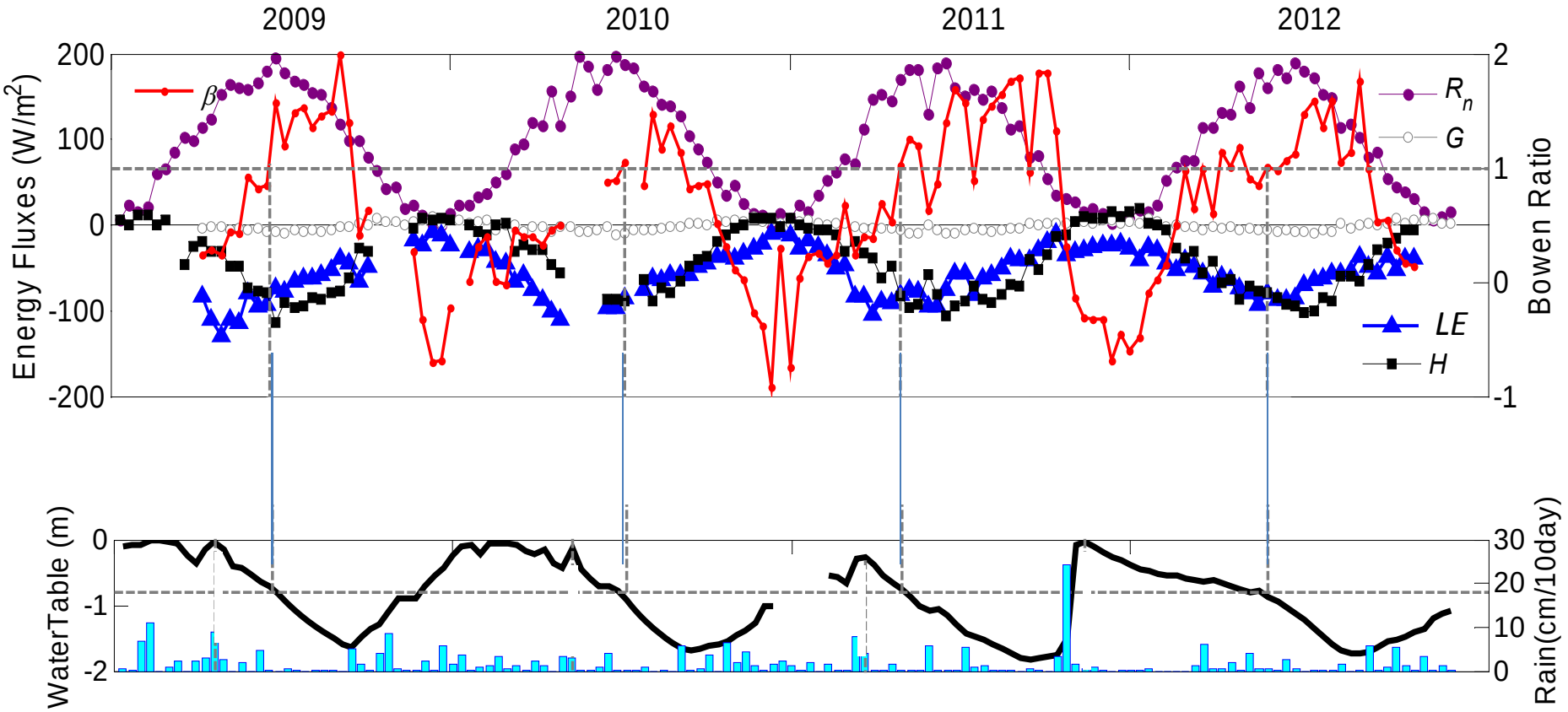
R_n : net radiation (W m^{-2})

G : ground heat flux (W m^{-2})

β Bowen ratio = *H* / *LE*

Results

➢ Energy balance and Bowen ratio (β) over 4 years (10 day integration time)



β around 1 <=> water table around - 70 cm

Results

➢ Water balance over 4 years (mm yr^{-1})

(mm yr^{-1})	2009	2010	2011	2012		4 year average
rain	710	730	610	**290**		590
ET	**710**	**710**	**630**	**640**		**670**
ETo	1260	1240	1280	1360		1280

ET is half of ETo

Equilibrium between rain and ET

very dry year but ET is almost unchanged

Results

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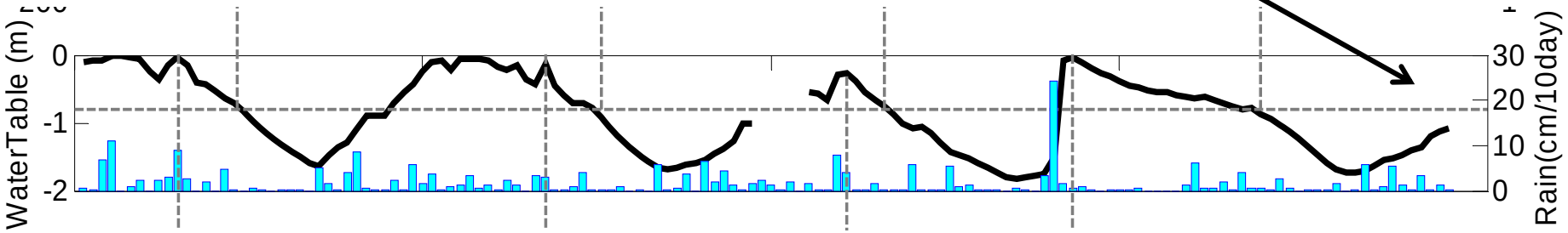
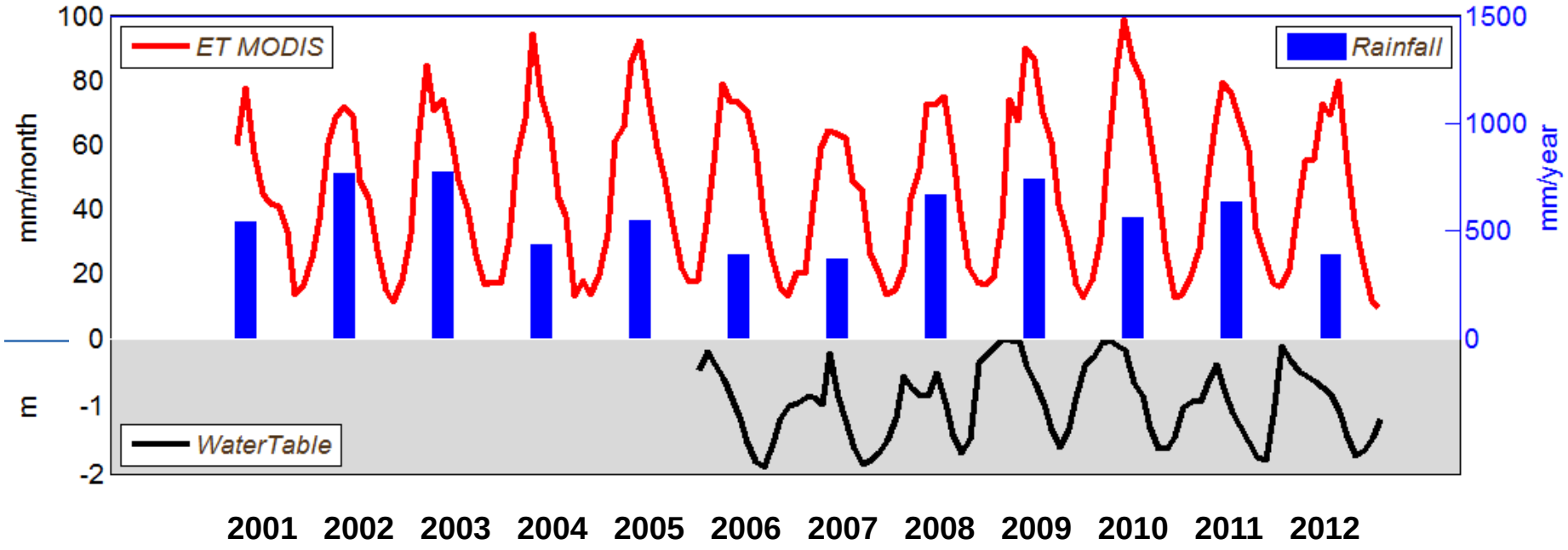


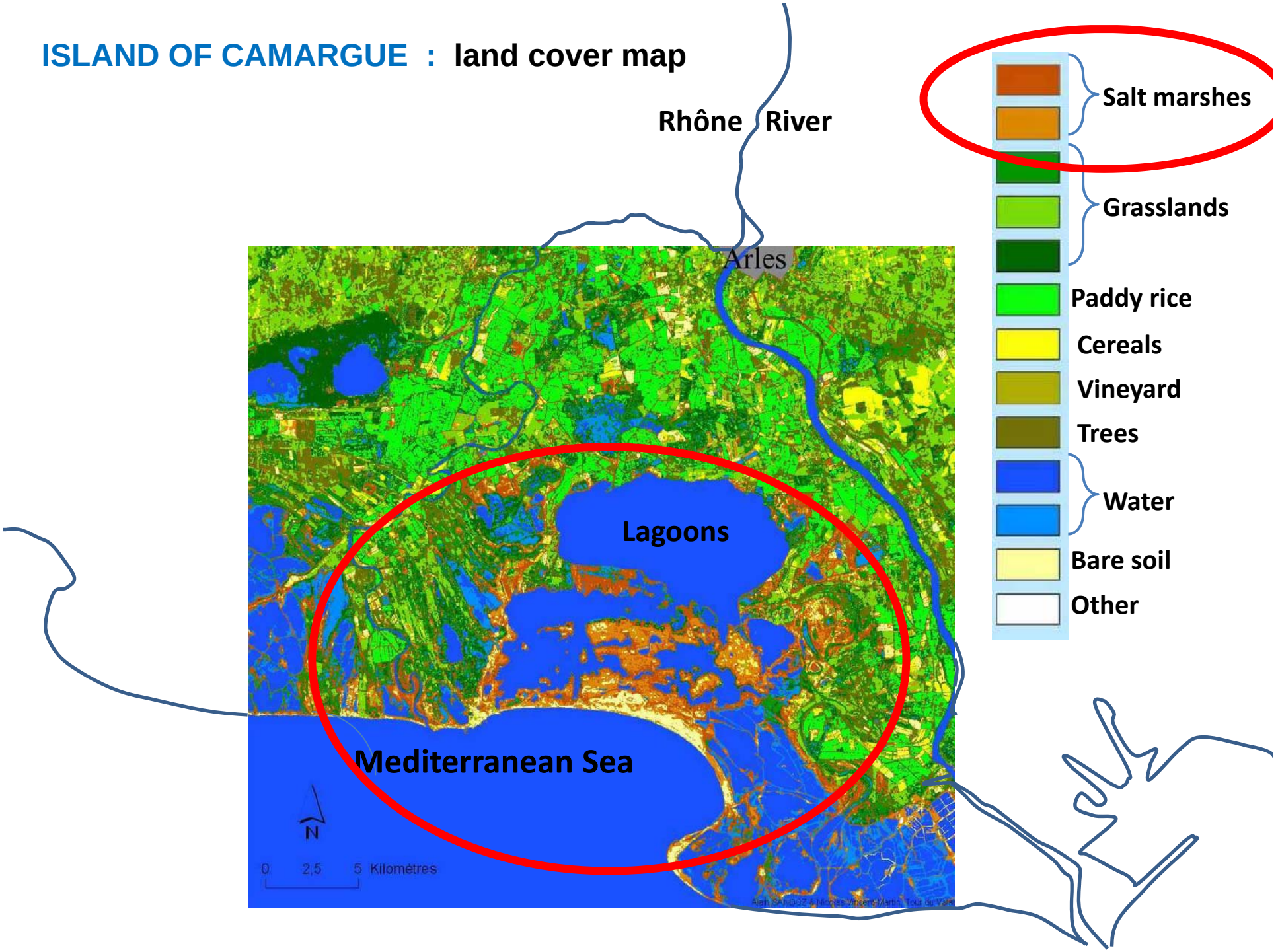
Evolution of evapotranspiration, rain and water table



Ground measurements period -> « training »

Application of EVASPA from MODIS data
-> extrapolation of evapotranspiration measurements

ISLAND OF CAMARGUE : land cover map



Final remarks

- EVASPA integrates:
  - → several methods to derive ET
  - → uncertainty assessment through ensemble methods
  - → data from several remote sensing sensors

- Work in progress
  - → performance assessment in several laboratories and over various types of landscapes
  - → identify the most suitable and reliable methods for different surfaces and water stress conditions
  - → uncertainty assessment
  - → inclusion of new sensors and new models

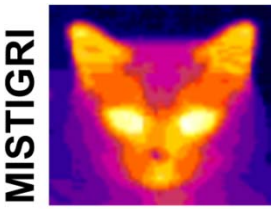
THANK YOU FOR YOUR ATTENTION

Supports

⇒ CNES in the frame of the preparation of

the thermal infrared satellite mission project **MISTIGRI**

(and now the NASA-CNES joint project **THIRSTY**)



⇒ Application to water balance of irrigated Mediterranean catchments in the frame of the SIRRIMED FP7 project and SICMED

⇒ Fundacion Ramon Areces (Spanish program for post-doc fellowships)

MISTRALS

Mediterranean I

at Regional A

SIRRIMED

SUSTAINABLE USE OF IRRIGATION WATER IN THE MEDITERRANEAN REGION