HyMeX

LIAISE

# Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) : Field Campaign at a glance

A. Boone[1], M. Best[8], J. Cuxart[7], J. Polcher[2], P. Quintana-Segui[4], J. Bellevert[3], J. Brooke[6], G. Canut-Rocafort[1], J. Price[6], O. Hartogensis[7], J. R. Miro[8], P. LeMoigne[1]

1 CNRM Météo-France/CNRS, Toulouse, France
2 LMD, IPSL, Paris, France
3 IRTA, Lleida, Spain
4 Observatori de l'Ebre, Roquetes, Spain
5 UIB, Balearic Islands, Spain
6 UKMO, Exeter, UK
7 U. Wageningen, Netherlands
8 SMC, Barcelona

**Context :**

- Semi-arid regions are hot spots for model bias.

- The coupling between soil moisture and precipitation is most important in semi-arid regions.

- Irrigation can impact local atmospheric boundary layer growth, mesoscale meteorology, low-level atmospheric conditions, possibly moist convection

- Human activities must be considered in climate projections
  → land cover/irrigation.

Campaign Objective: Combine ground and airborne measurements with modeling studies to improve our understanding of key natural and anthropogenic surface processes and resulting feedbacks with the Mediterranean boundary layer and basin-wide hydrological cycle.

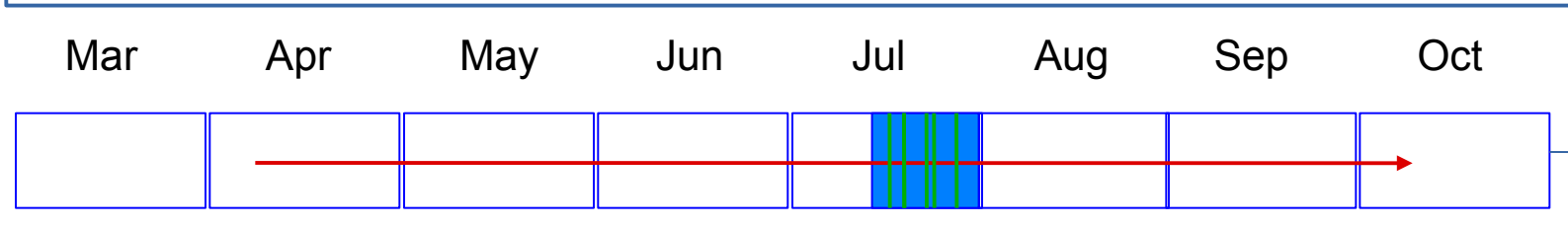
* Close ties with the GEWEX-ET initiative

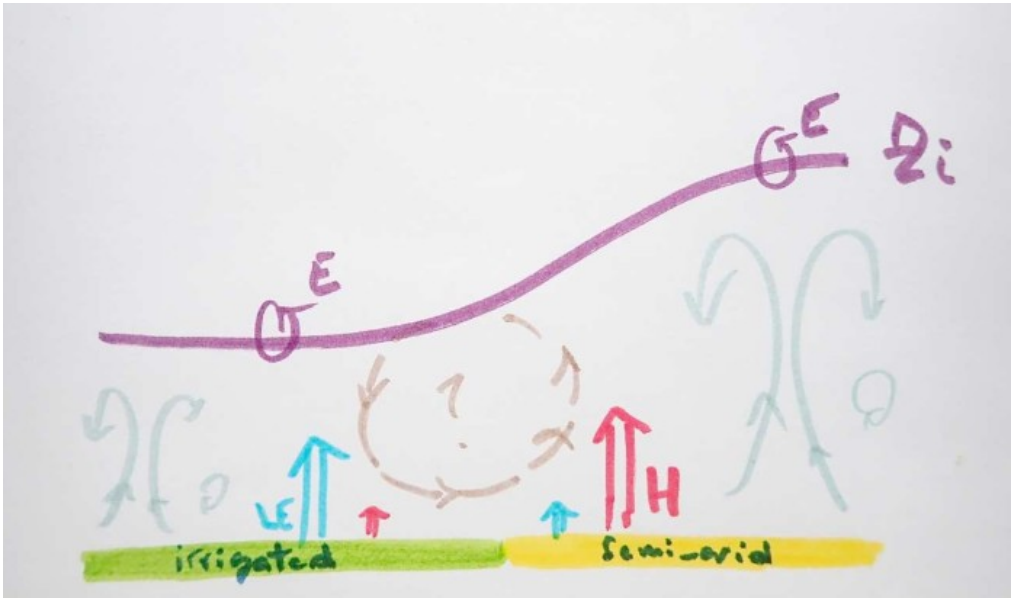
# HyMeX → Last field campaign

**Strategy** → Intense observations of surface and ABL when contrasts between anthropized (irrigated) and natural surfaces are a MAXIMUM and water needs LARGEST

**LOP** : **April-October, 2021** → surface flux stations, sfc satellite products, lysemeters, soil moisture & T… → **SEB, ET & partitioning**

**SOP Summer/**July 15-29 → Lower atmosphere, spatially distributed surface hi-res (SIF, LST, SM) 11 **IOP**s (ATR42, RS, tethered balloons, biophysical sfc...)

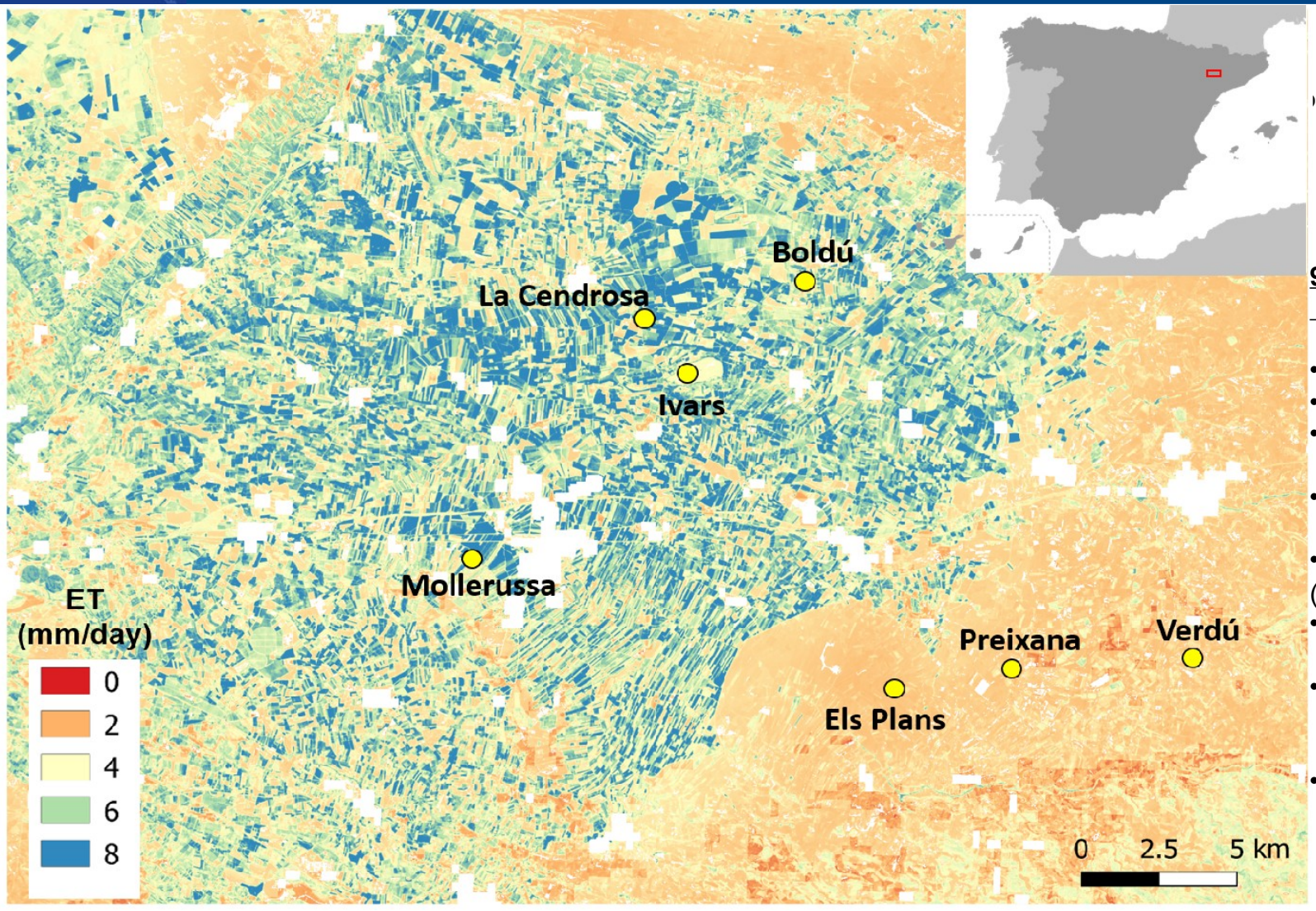



Dynamics :
-Wind profilers
-hourly RS

Turbulence :
-50m mast,
- tethered balloon,
- ATR42 aircraft
+SEB

+ numerical simulations
LES and sensitivity tests




**9 SEB stations:**
**Land cover, 7 sites**

- Irrigated alfalfa
- Irrigated apple trees
- Irrigated cut grass (ET0)
- Irrigated corn

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- Irrigated vineyard (dry zone)
- Natural grass/bare soil
- Rain-fed Almond trees

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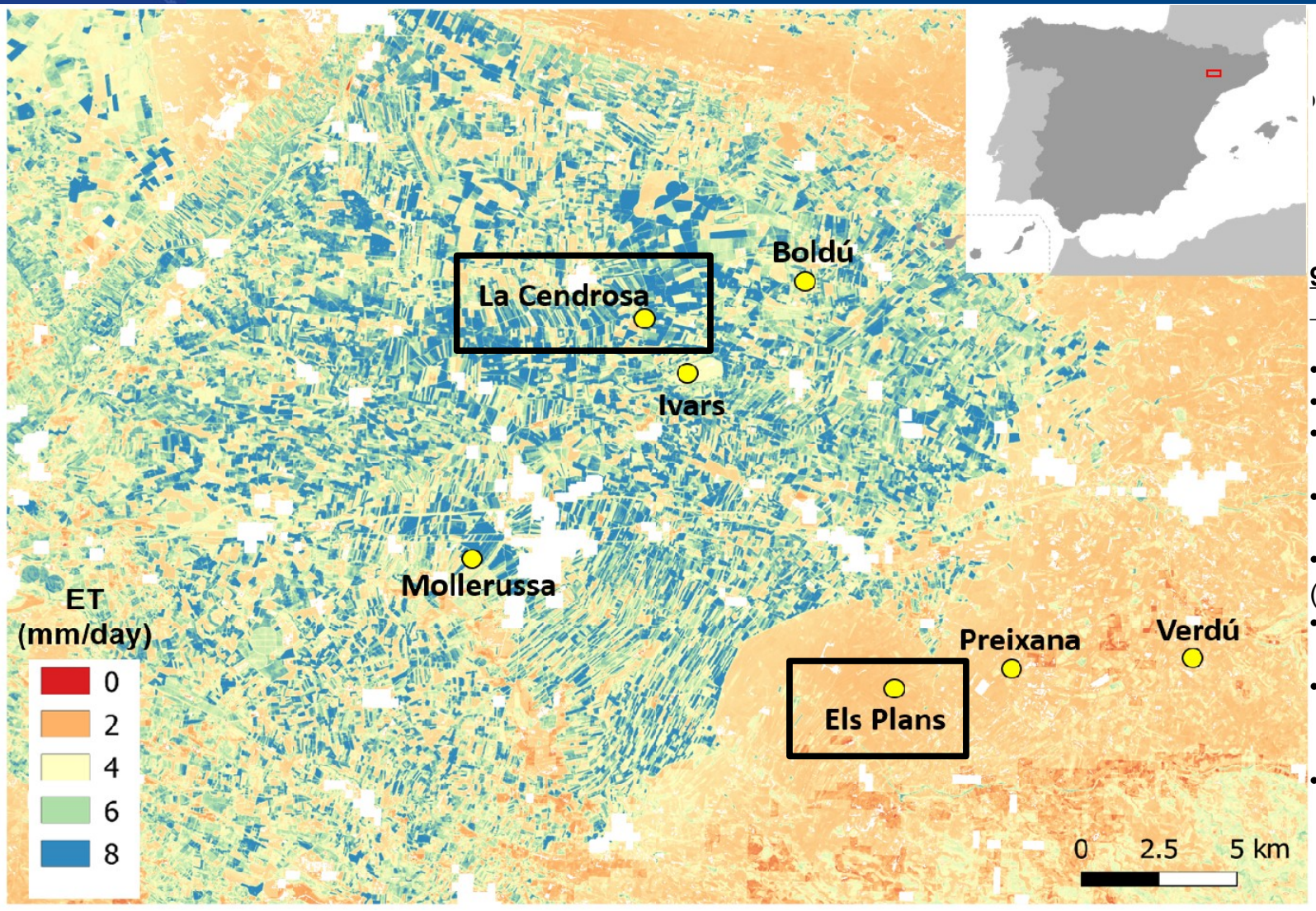
- Lake

The LIAISE study zone in NE Spain (Catalonia) with surface site locations plotted over a map of crop evapotranspiration corresponding to 17th July 2021 obtained through a Two-Source Energy Balance (TSEB) model using images from Sentinel-2 and Sentinel-3. Prepared by IRTA (J. Bellvert)

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# 2 well instrumented sites → similar setups



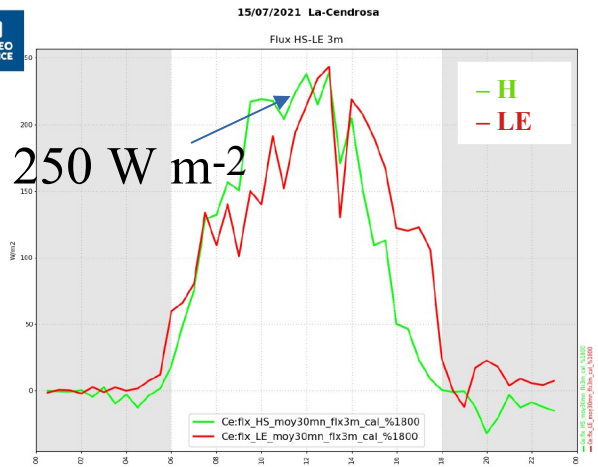
**Common Observations:**

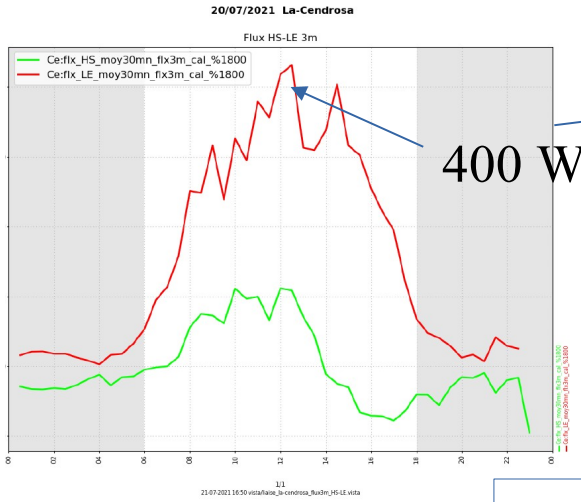
- 50m mast: turb. & rad Fluxes, soil T, w
- veg (LAI...) measures
- wind profilers (UHF)
- radiosoundings (hourly)
- airborne (atmos & sfc)

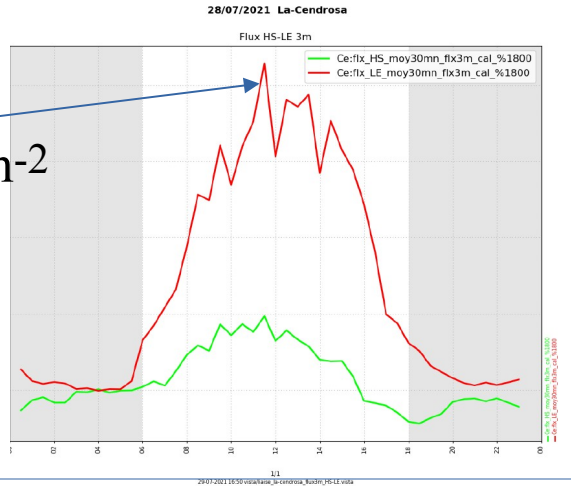
**Other observations:**

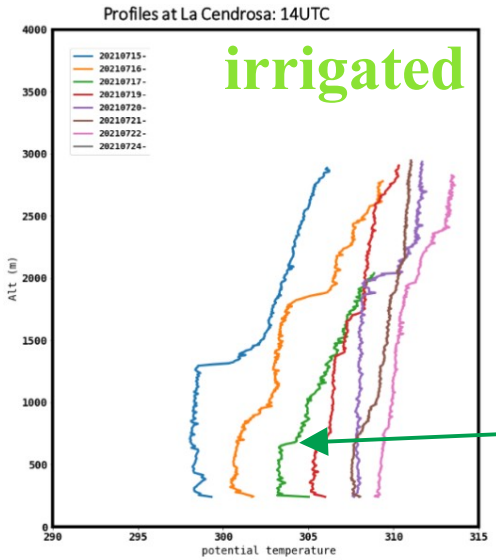
- Lidar: water vapor, temperature
- Turb. Fluxes → tethered balloon
- Temperature profile (vertical et horizontal) by DTS (distributed temperature sensing)

# Irrigated Alfalfa growth → ~3-4 cm/day



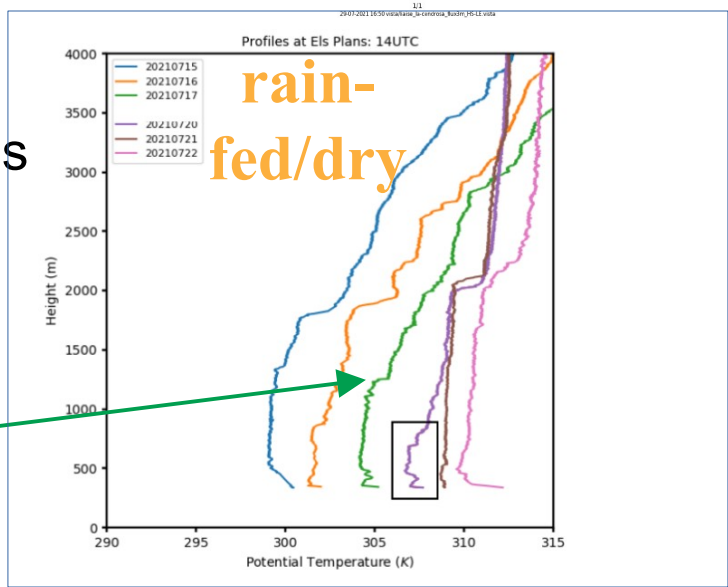




Temperature profiles (theta) from RS

*Zi*



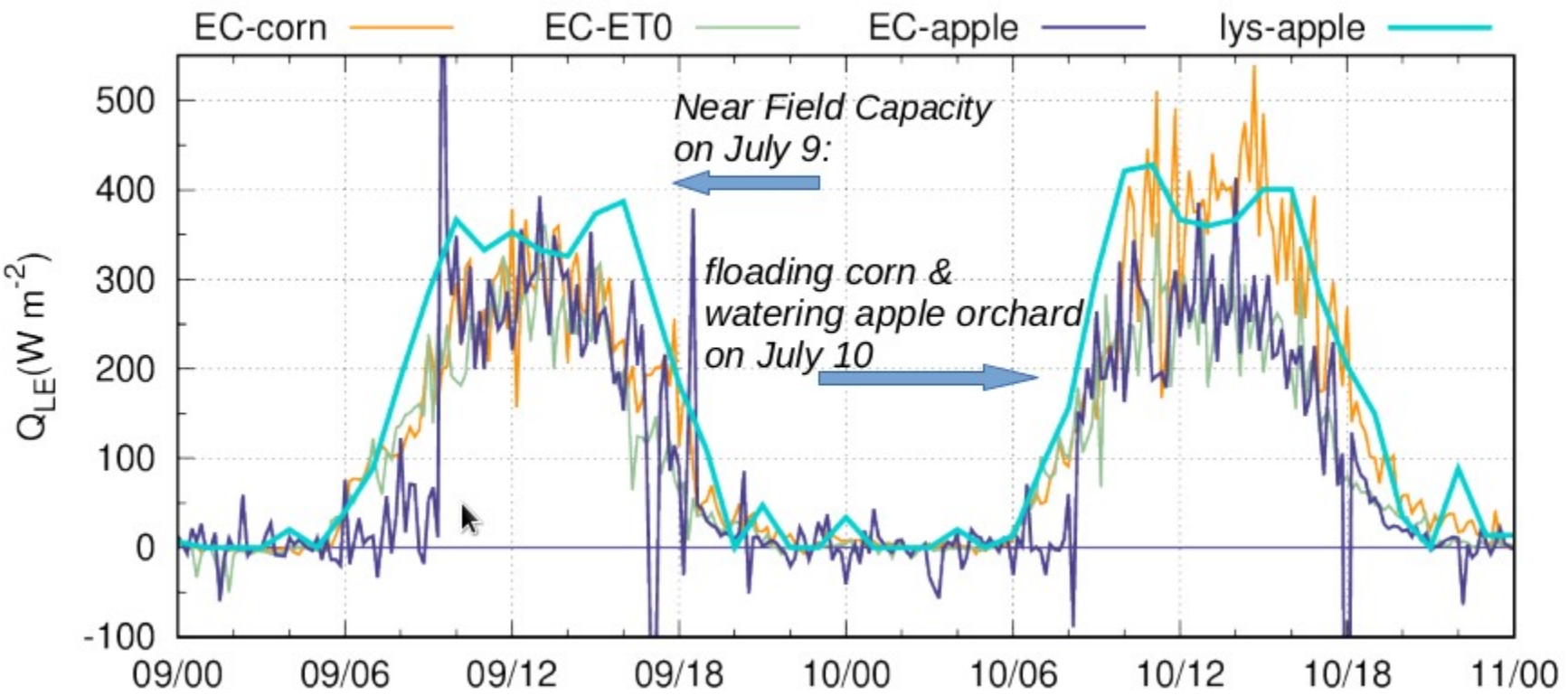
## Central site: IRTA (Mollerussa)

- 3 independent ET estimates (IRTA, UIB, SMC) → SEB stations (irrigated apple orchard, corn, grass-ET0)

- Satellite/remote sensing: LST-based ET & model derived (data assimilation in LSMs, merged products…)

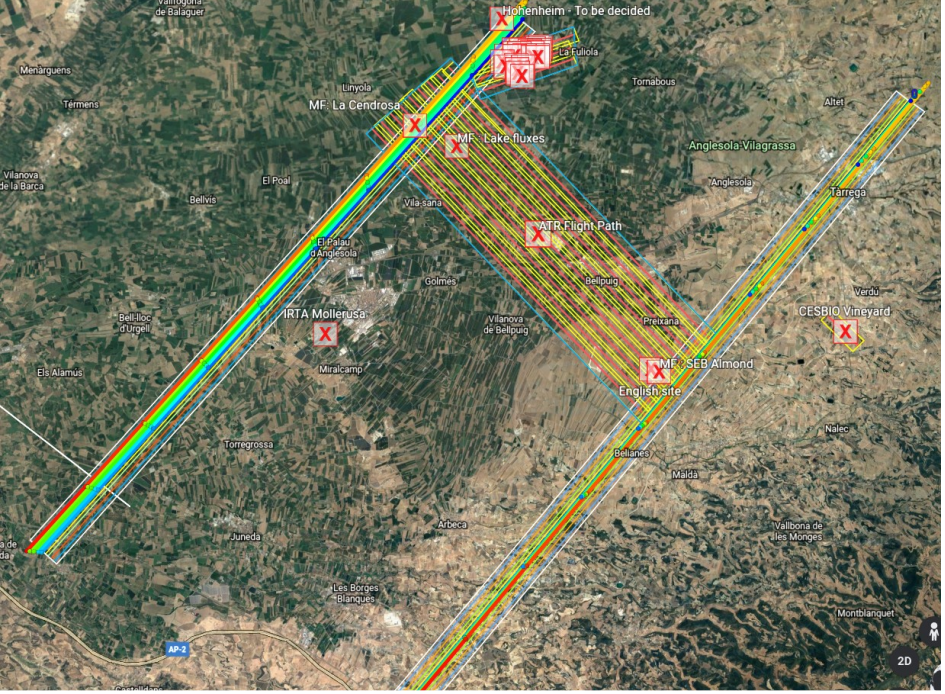
- Lysemeters (2 fixed, + 1 mobile → corn site)

- Long path Scintillometer (WUR)




On July 10 corn is flooded.
The apple orchard is irrigated more than usual.
The lysimeter reacts stronger than the EC system

(J. Cuxart, UIB)





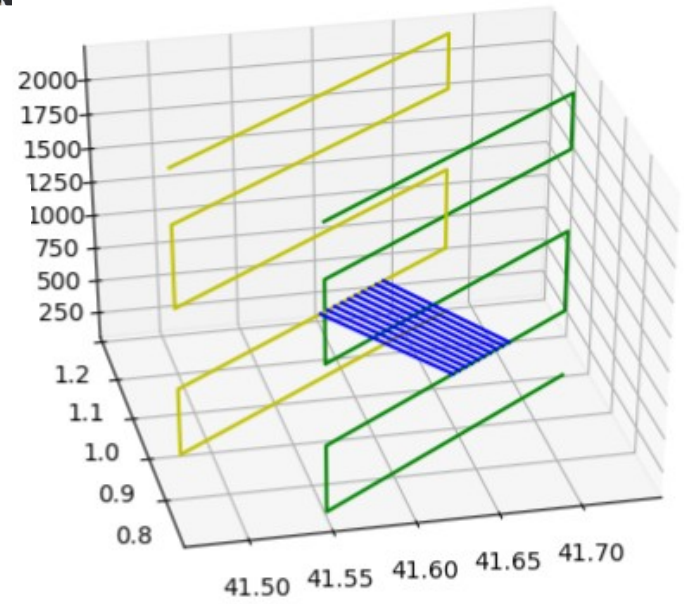
SAFIRE

- 4-5 flight hours from Toulouse →8 flights
- Stacked 30-km-long legs within the CBL
- 2 vertical plans, above irrigated and semi-arid areas
- 1 sounding at start of each plan
- Hyperspectral horizontal scanning in between

**Surface (airborne remote sensing) →**
- SM from GLORI (CESBIO)
- SIF from HyPlant (JFZ, CNRM, CNES)

ALSO…2 additional planes:

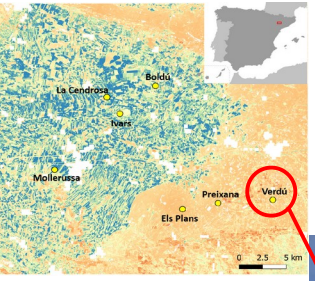
- SM from SLAP (NASA SMAP simulator)
- LST (CzechGlobe, ESA)



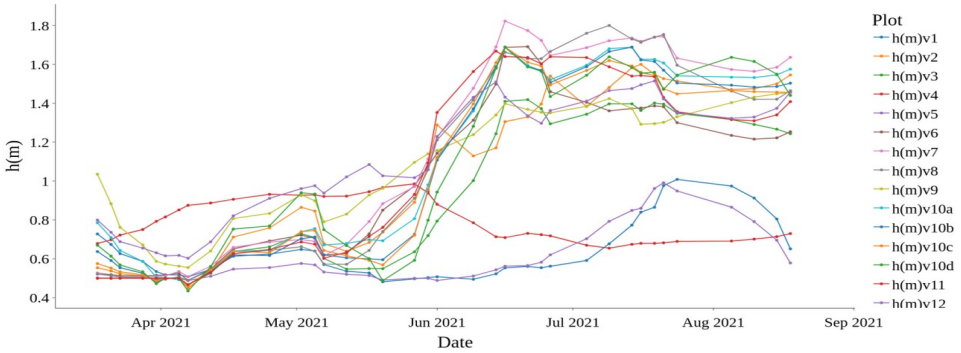

Approx. heights of legs:

-300m
-600m
-1200m
-1800m
-2500m

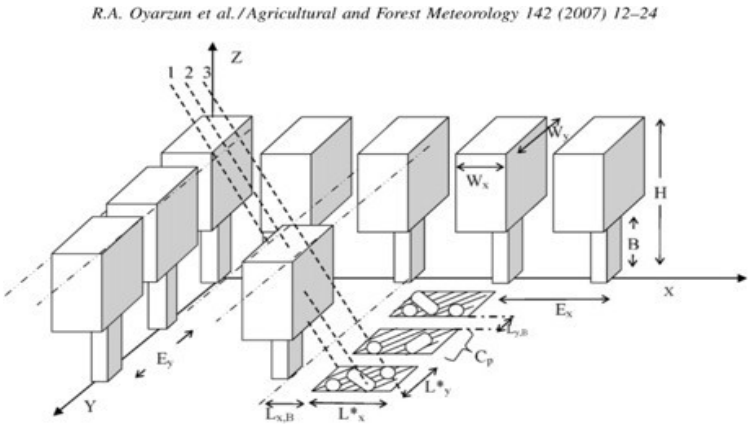
# Verdu drip-irrigated vineyard. Mixing satellite observations and a 3D model to estimate ET



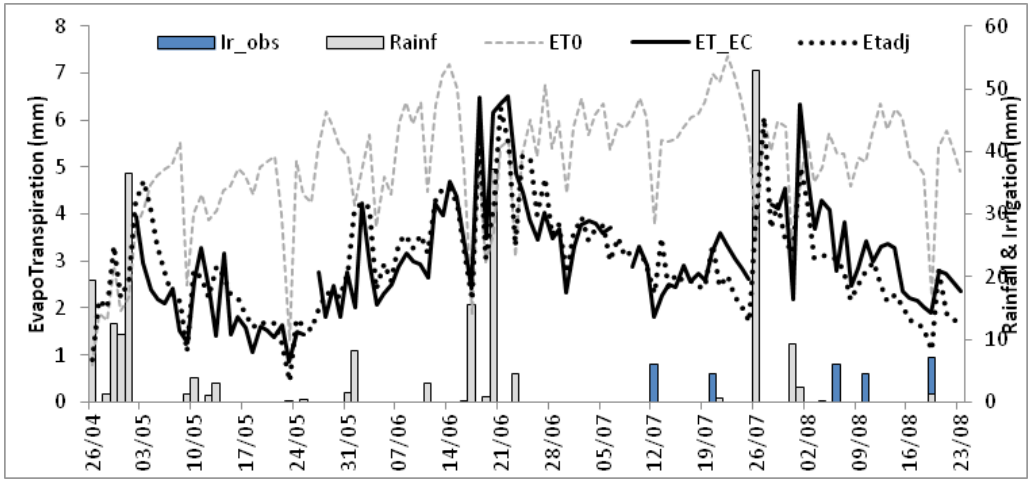

Measurement of λE from March to Sep. 2021




Estimation of Height=f(NDVI), Width=f'(NDVI) on 12 different plots




Estimation of fiPAR




Estimation of ET. RMSE=0.62 mm/day, $R^2$=0.54

## Summary:

- A successful campaign (weather was nearly perfect!) despite Covid, complexities to prepare….

- 11 IOPs out of 15 SOP days (originally hoped for 10!)

- Fights by ATR42, *also* NASA-SLAP, Czechglobe (Tsfc)

- +150 RS by CNRM, 116 by UKMO, 100 hours of tethered balloon flights (with turb. measures), growing season by SEB stations (UKMO will continue through spring 2022, SMC will maintain ET0 station….)

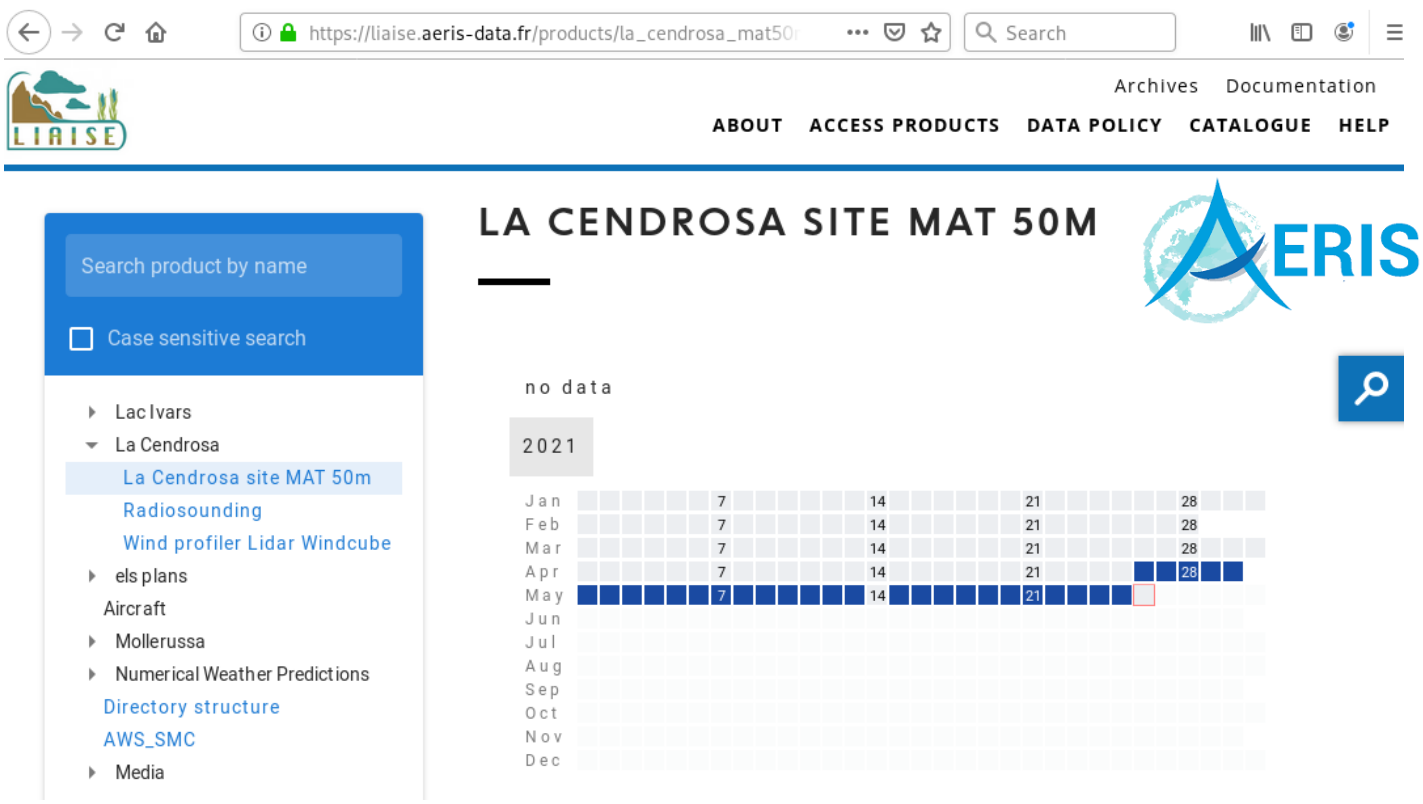
- very strong sfc contrasts found → big ABL contrasts obs'd → circulations?

- Multitude of in-situ (leaf→ plant → field) biophysical measures! (see LIAISE web site & GEWEX News)

Data processing starting (DB → *https://liaise.aeris.fr)*→ GEWEX-ET & Eventual GEWEX projects (Best & Brooke at AMS 2021) See *https://www.hymex.fr/liaise*

Fin...

*https://liaise.aeris.fr*

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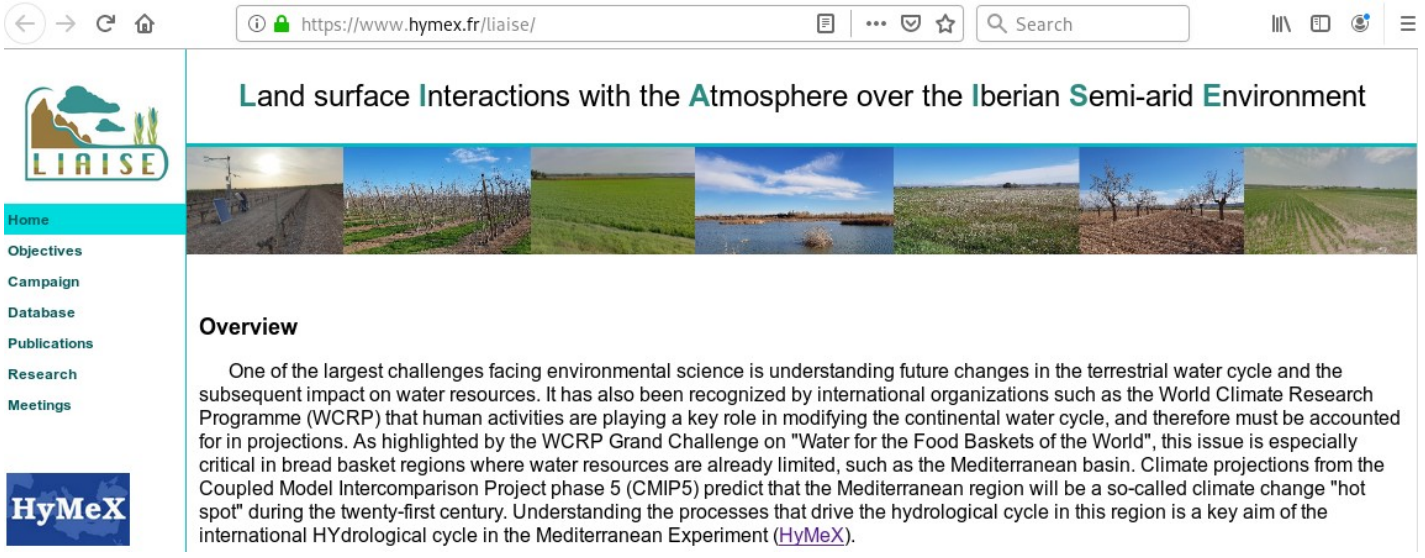
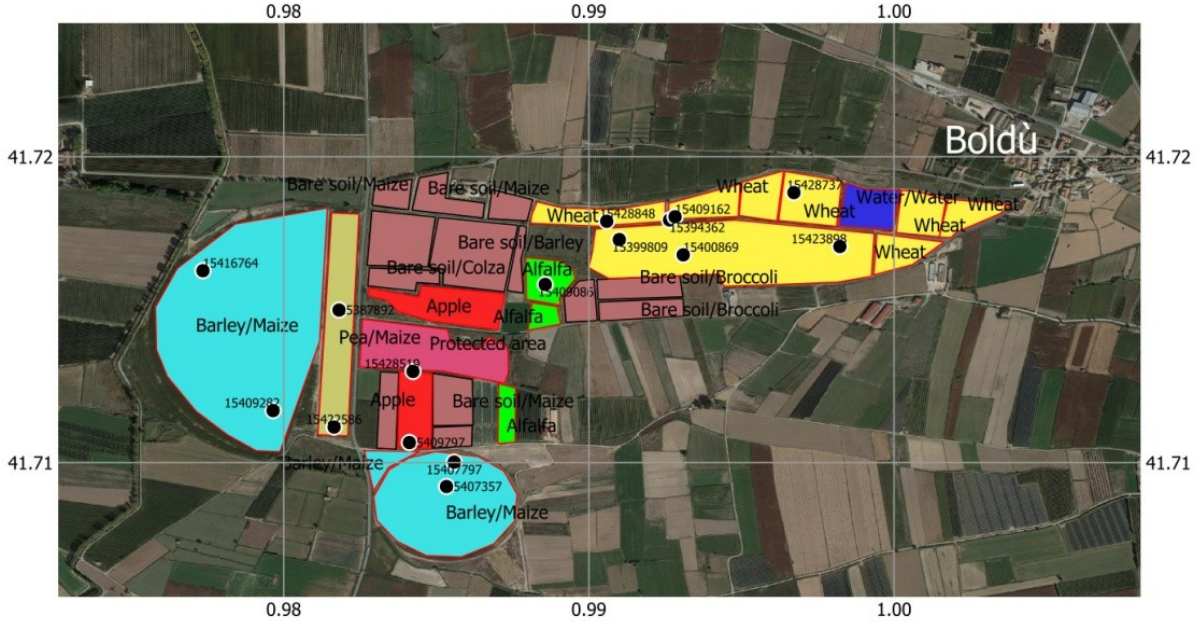
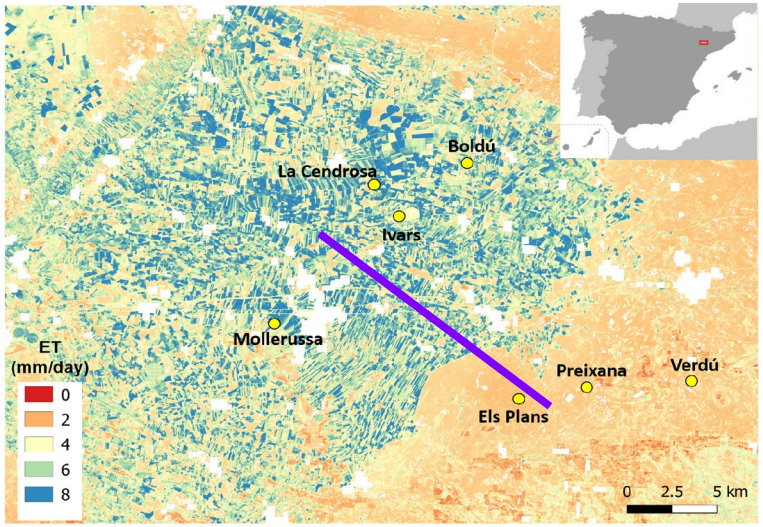


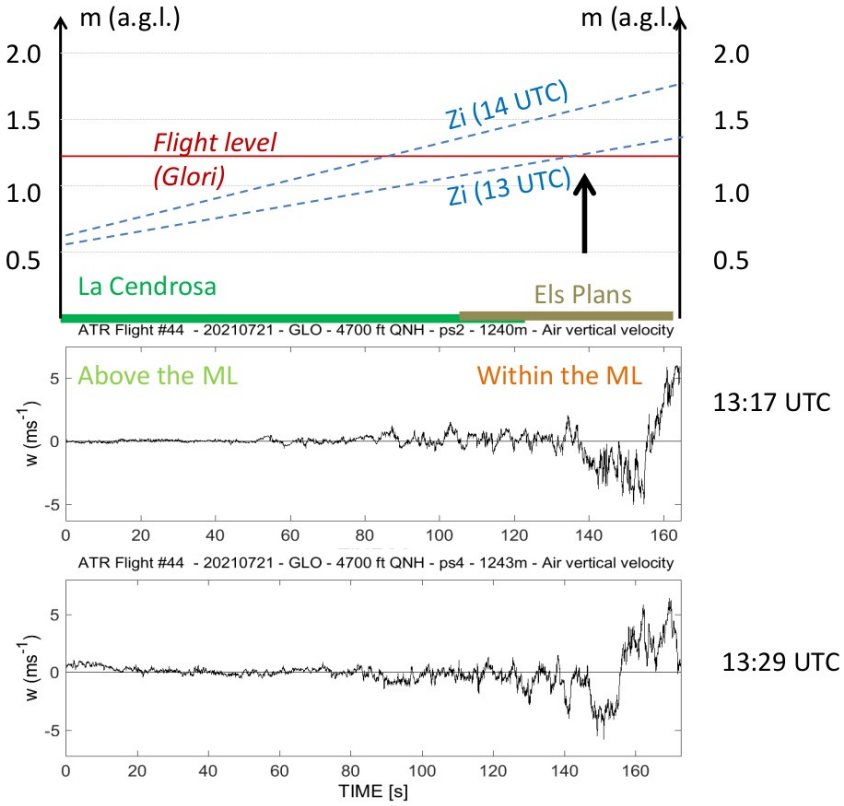
# Soil Moisture/Irrigation Monitoring Network

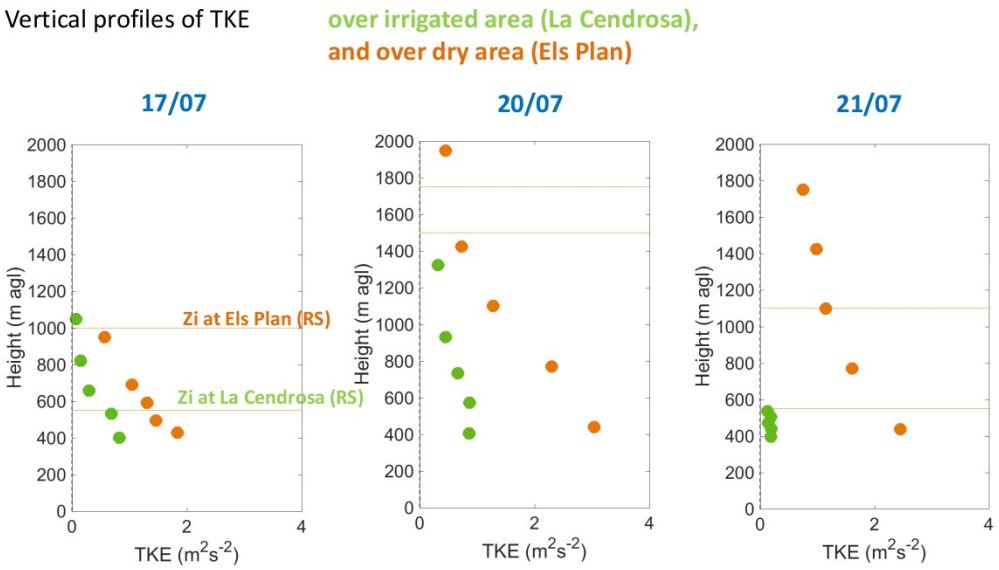



- The map of crops and the soil moisture network deployed in late March 2021 (M. Le Page, CESBIO and D. Tous de Moner, SAF-Samping) → Irrigation+ project (ESA & HILIAISE)

- SEB station from Univ. Hohenheim → irrigated corn



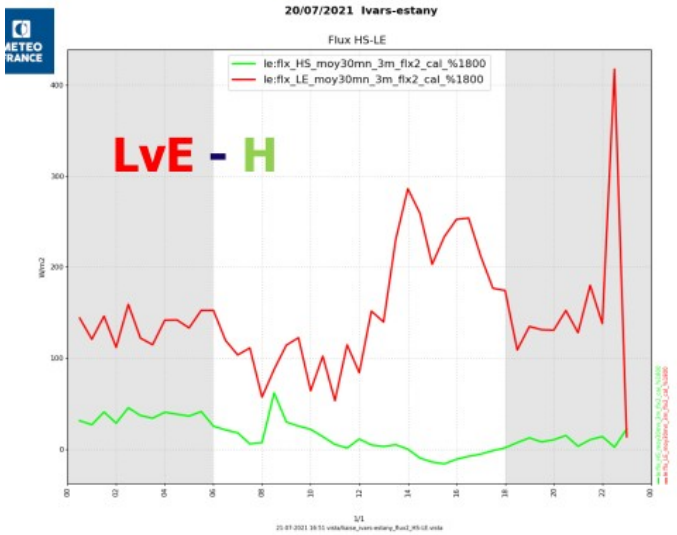



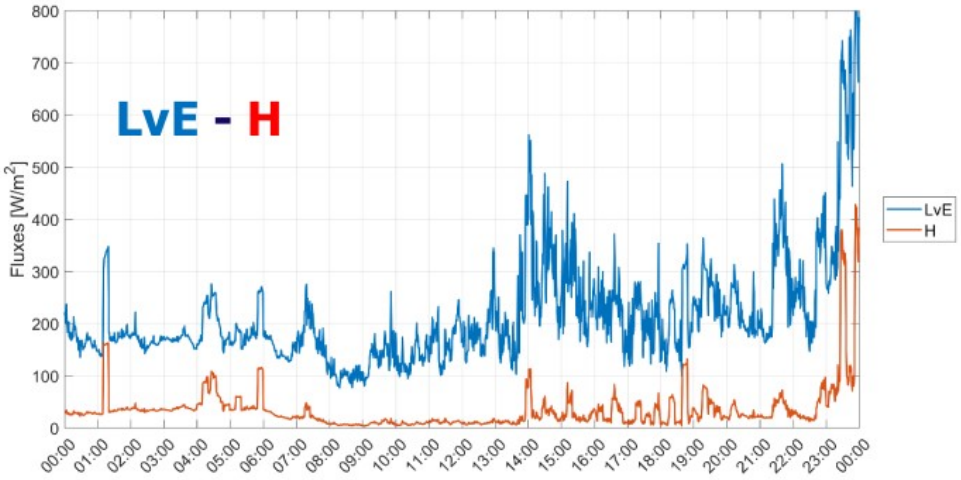

From M.Lothon &
F.Lohou, LA

# SEB: eddy covariance & scintillometry

Jul 7 14 21 28

## Ivars – Flux regime – 2021-07-21

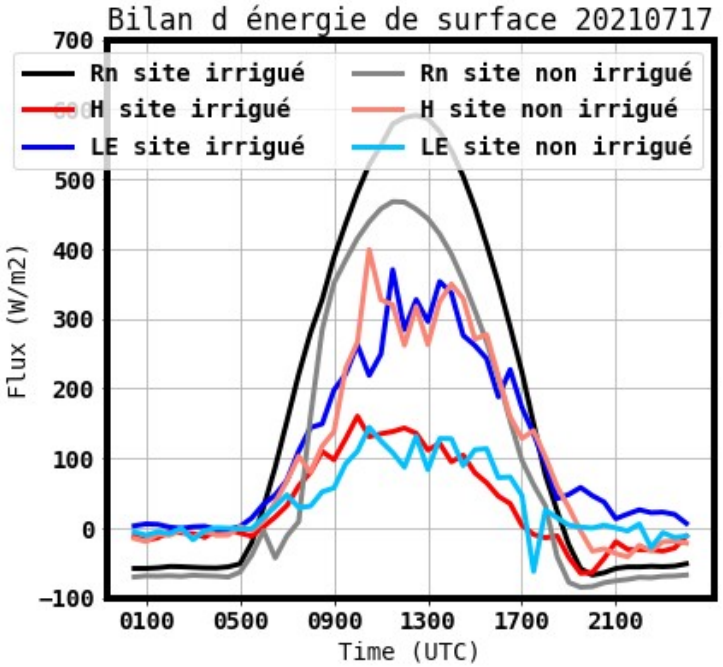



CNRM/
GMEI/4M

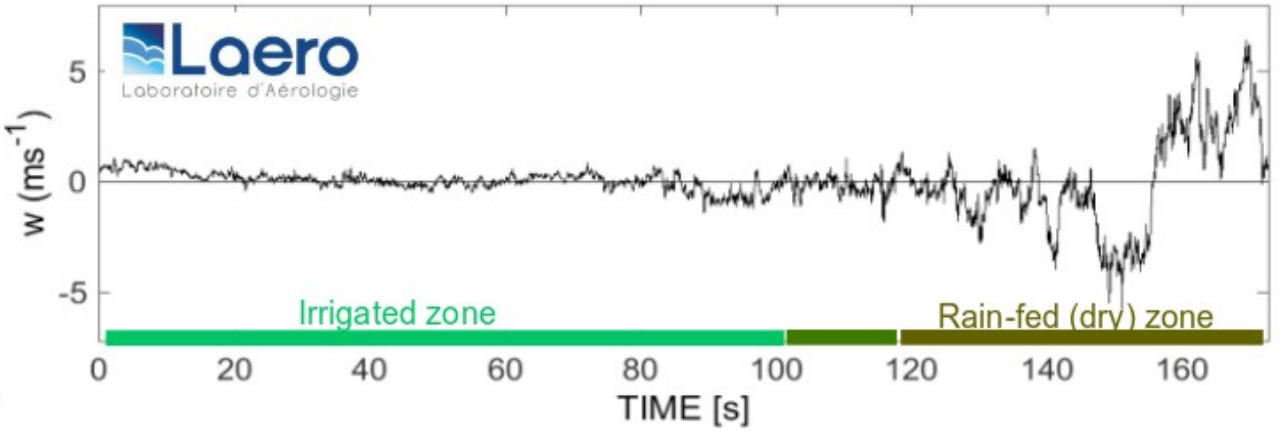
Wageningen
Univ.

Photo aérienne à bord de l'avion ATR42 (SAFIRE) au cours de la campagne en juillet. Région de Lleida dans le nord-est de l'Espagne (bassin de l'Èbre)




Evolution journalière du bilan d'énergie de surface sur un site irrigué (CNRM) et non irrigué (UKMO). Les paramètres représentés sont le rayonnement net (Rn), le flux de chaleur sensible (H) et le flux d'évapotranspiration (LE).

Le 21 juillet, à partir de 13:47 UTC à une hauteur de 1240 m de NE à SO. Vélocité verticale de l'air (w).

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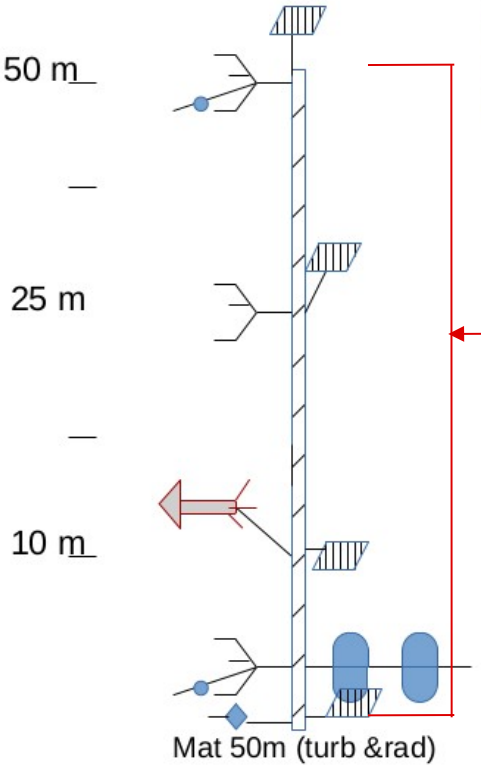
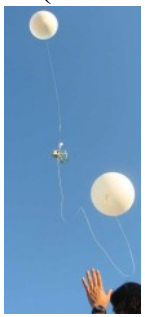
# Turbulence on the 50m mast- 3 levels






DTS cable (TUD)

RS (3+ km)



Turb. (T,q,V)

UHF: V→ 500-3000m

## Results/Outcome : Scientific, Socio-Economic impact

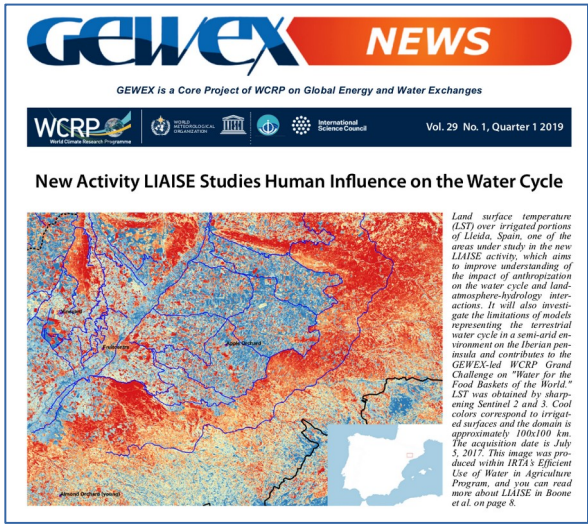
• A **comprehensive database** : surface-based and aircraft measurements of surface and hydrological fluxes and states, and properties of the PBL - **MISTRALS/HyMeX database → projects GEWEX**

• Better representation of **semi-arid surface processes** : LST, Evap (soil & veg), sfc hydrology... **hydrological monitoring, weather forecasting and climate studies**

• Improved understanding and representation of **anthropogenic processes** in LSMs used for **hydrological monitoring, weather forecasting and climate studies**

• Improved anthropization - for **water resource** impact studies under **future climate change**-communicated to water management services within the Ebro basin.

→ *https://www.hymex.fr/liaise*


GEWEX NEWS

GEWEX is a Core Project of WCRP on Global Energy and Water Exchanges

WCRP World Climate Research Programme | World Meteorological Organization | International Science Council | Vol. 29 No. 1, Quarter 1 2019

New Activity LIAISE Studies Human Influence on the Water Cycle

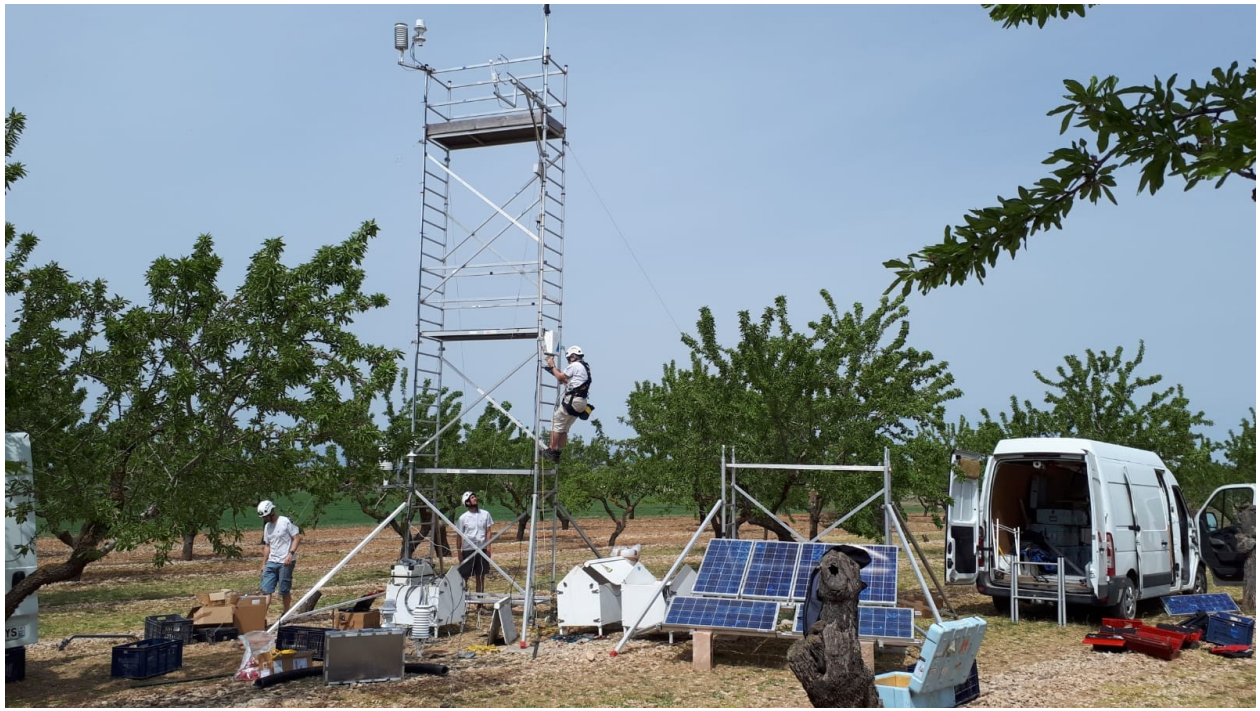
Land surface temperature (LST) over irrigated portions of Lleida, Spain, one of the areas under study in the new LIAISE activity, which aims to improve understanding of the impact of anthropization on the water cycle and land-atmosphere-hydrology interactions. It will also investigate the limitations of models representing the terrestrial water cycle in a semi-arid environment on the Iberian peninsula and contributes to the GEWEX-led WCRP Grand Challenge on "Water for the Food Baskets of the World." LST was obtained by sharpening Sentinel 2 and 3. Cool colors correspond to irrigated surfaces and the domain is approximately 100x100 km. The acquisition date is July 5, 2017. This image was produced within IRTA's Efficient Use of Water in Agriculture Program, and you can read more about LIAISE in Boone et al. on page 8.

AGENCE NATIONALE DE LA RECHERCHE ANR

HI LIAISE



METEO FRANCE



## Drip-Irrigated Almond Grove

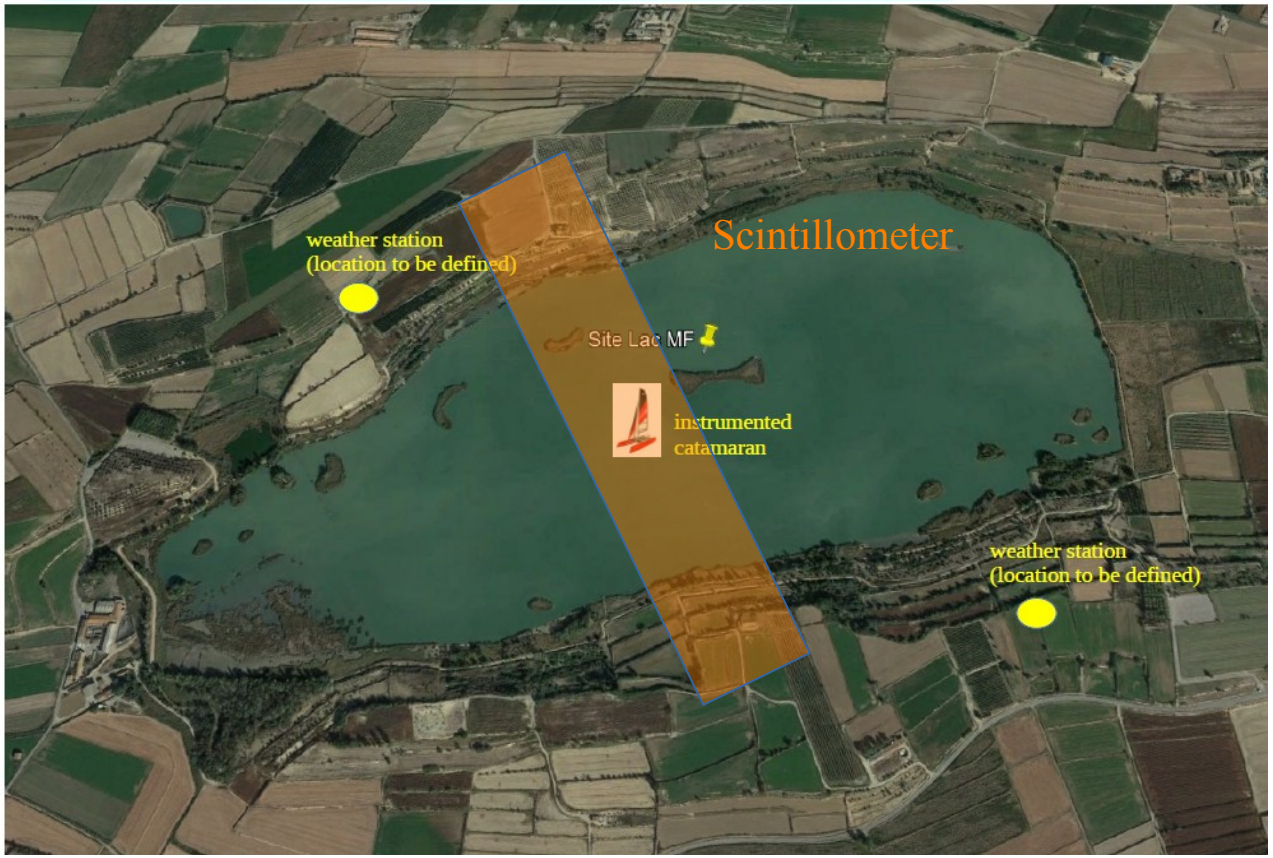
- Near Preixana (dry zone)
- 10m winds, radiation components, eddy-cov
- soil moisture, T
- 2 source-energy budget (LSM) modeling
- CNRM

## Drip-Irrigated vinyard

(ESA-WineEO project)

- Near Voldu (SE domain)
- remote sensing applications, ET estimation
- LSM modeling
- CESBIO

# Lac Estany d'Ivars
## 41,683412° 0,948339°




Optical Large Aperture Scintillometer
- Mm-wave scintillometer (2.8mm)
- Path length ~720m
- H + LvE

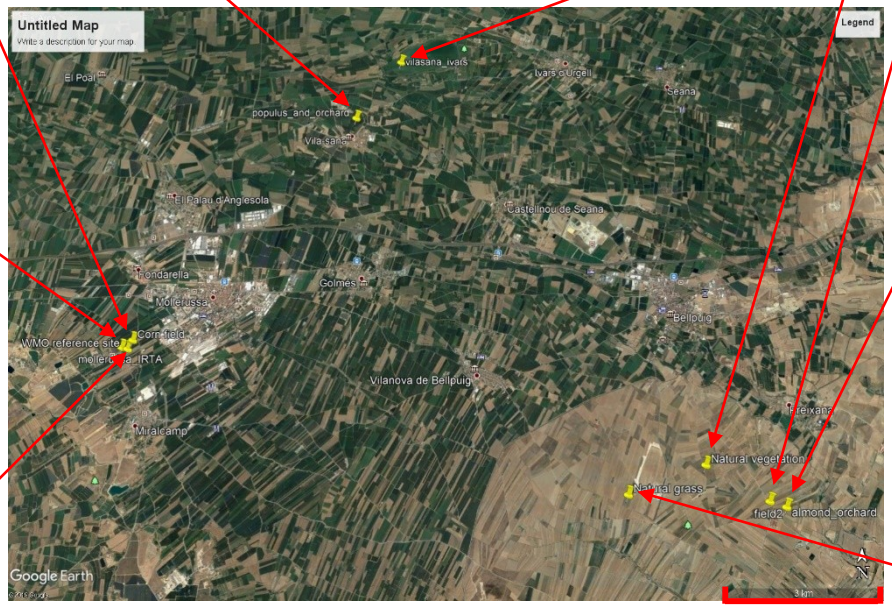
# Heterogeneity of land cover









## Science Questions

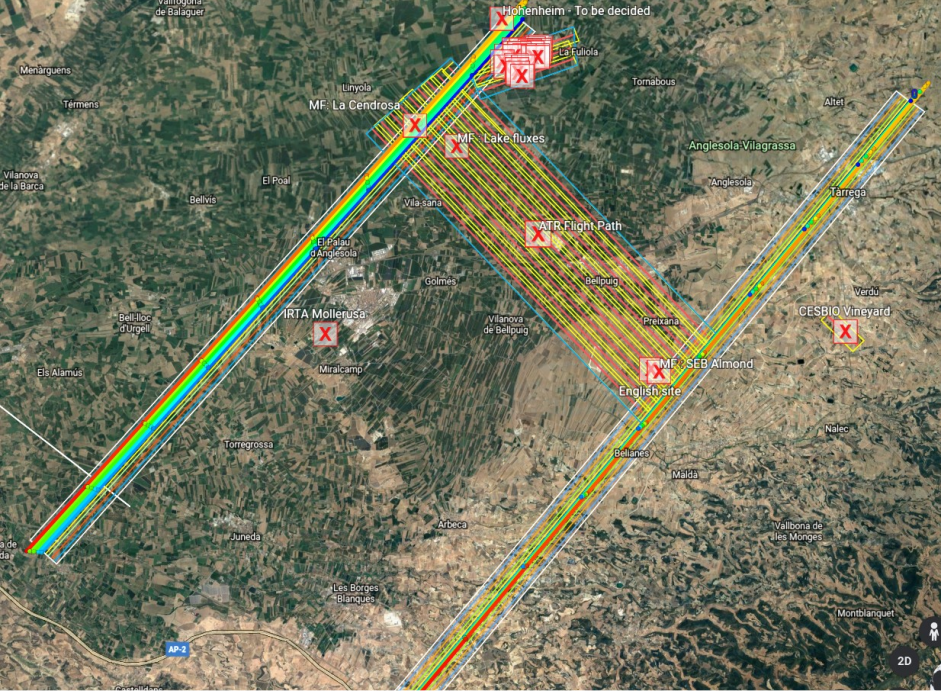
1) What are the key natural and anthropogenic semi-arid surface processes that modulate or control infiltration and runoff and govern turbulent fluxes and their spatial heterogeneity?

2. How does the highly heterogeneous (natural and anthropized) surface impact boundary layer development, mesoscale circulations and potentially precipitation recycling over this region via feedbacks with the atmosphere?

3. What is the sustainability of ground water and reservoirs in the face of expanding agricultural and farming activities, especially in light of projected future warming and drying over this region?

WCRP World Climate Research Programme

Grand Challenges





SAFIRE

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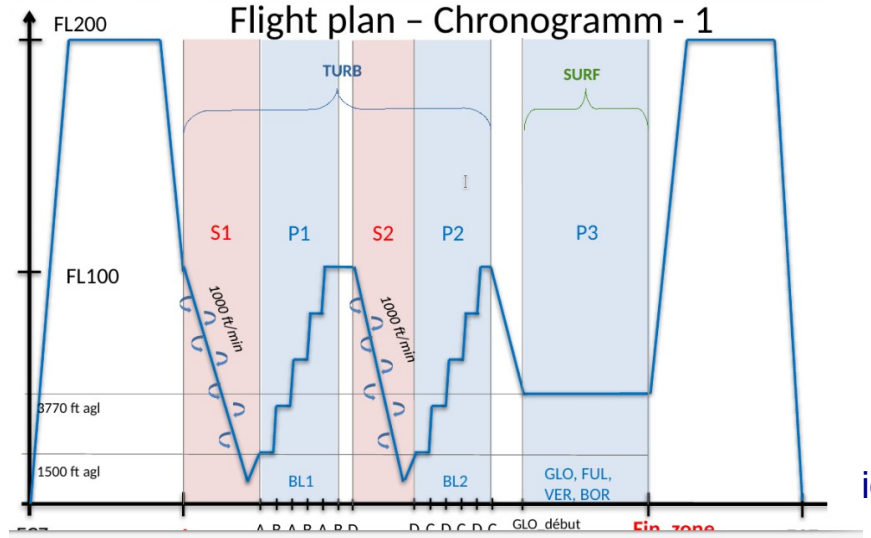
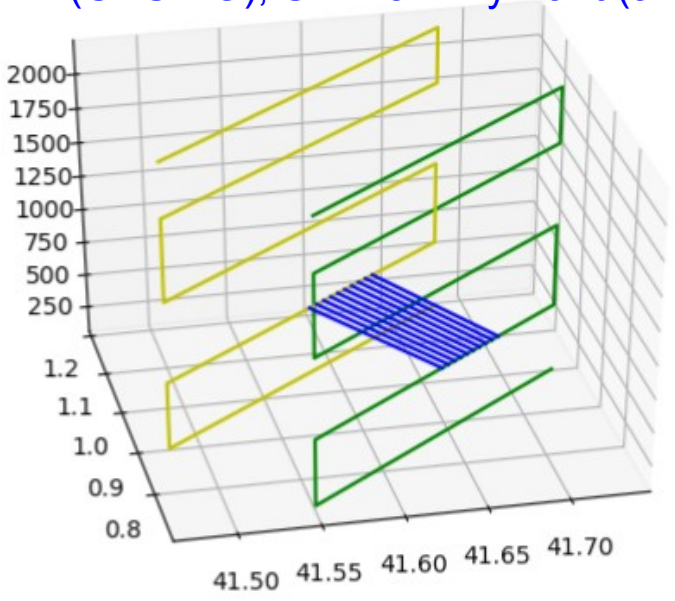
- Stacked 30-km-long legs within the CBL
- 2 vertical plans, above irrigated and semi-arid areas
- 1 sounding at start of each plan
- Hyperspectral horizontal scanning in between

Surface → SM from GLORI (CESBIO), SIF from HyPlant (JFZ)




Approx. heights of legs:

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-2500m

igation Initiative, Nov 4-5., 2021

METEO FRANCE