HyMeX

Human Impact on Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (HILIAISE)

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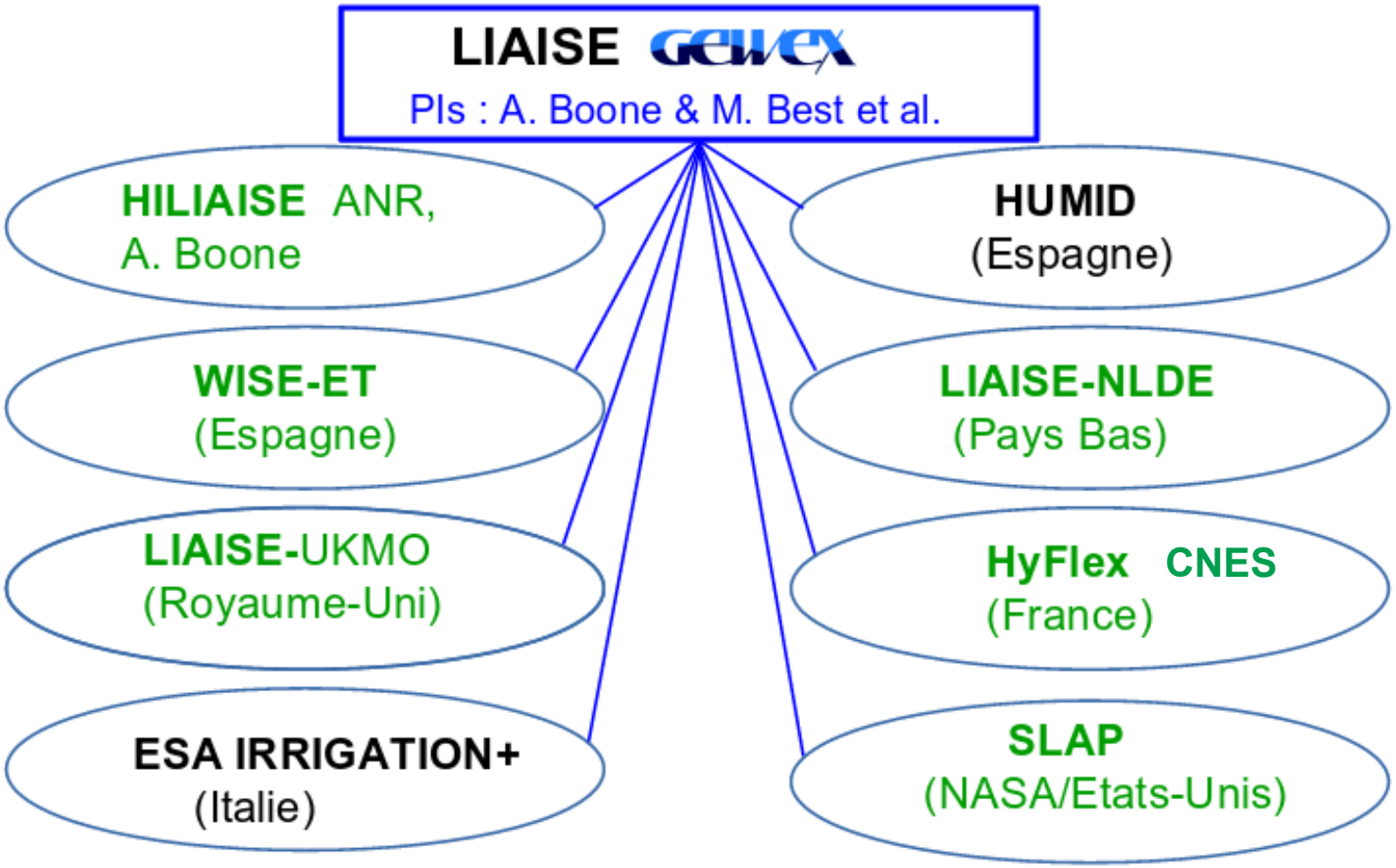
Overview



MISTRALS (HyMeX) : A. Boone
Météo-France, local support→ IRTA, SMC
EU-PRIMA IDEWA (France), SICMED
TRISHNA (franco-indienne), LST (ESA)

Overview

Context :

- Climate projections from the CMIP5 predict that the Mediterranean region will be a **climate change "hot-spot"** during 21st century, **BUT** semi-arid regions are **hot-spots for model biases**

- Semi-arid regions where the **coupling between soil moisture and precipitation** is greatest

- **Irrigation can impact local atmospheric boundary layer (ABL)** growth, meso scale meteorology, low level atmospheric conditions, possibly clouds-convection : **generally simple or not in LSMs** !

- **Water resources are limited**, depend to a certain extent on water natural *water towers,* **reservoir functioning**, and impact on discharge

- Mediterranean basin has **highly heterogeneous land cover** - driven by the limited availability of soil moisture and the nature of precipitation, **BUT LSMs have difficulties to capture** this

- **Human activities must be accounted for in climate projections** (WCRP)→land cover/irrigation

Overview

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?

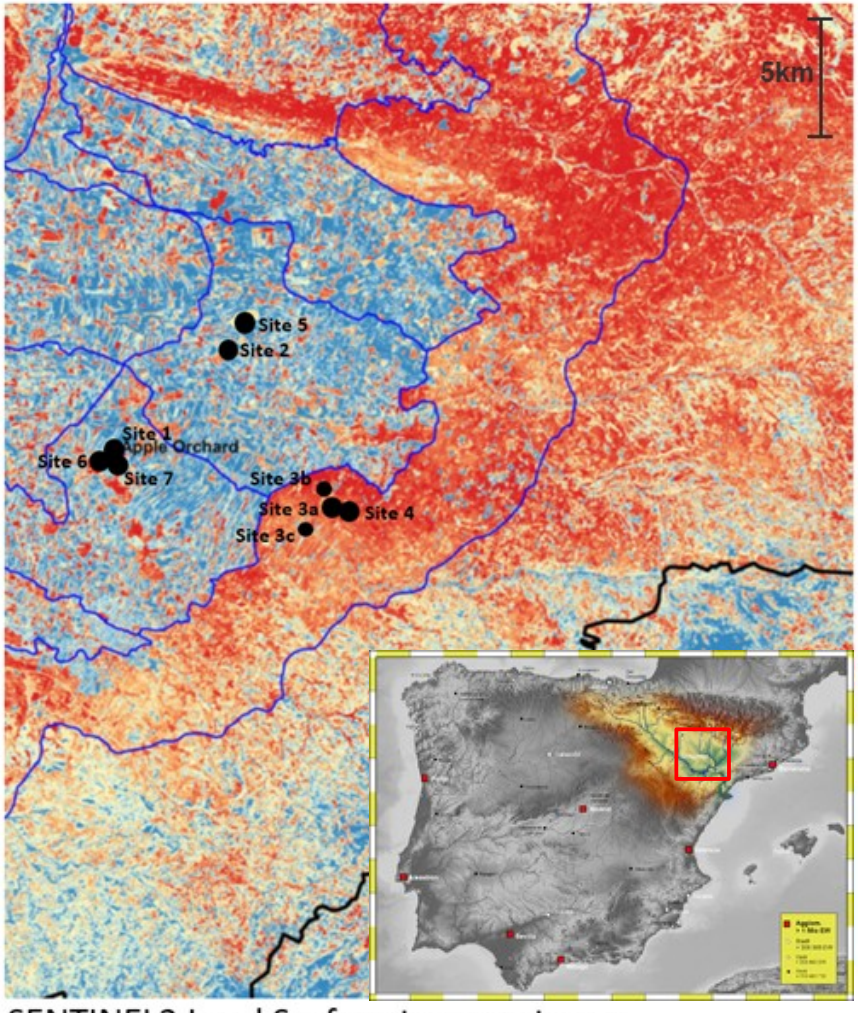
3. What is the sustainability of ground water and reservoirs in the face of expanding agricultural and farming activities, especially in light of projected future warming and drying over this region?

WCRP World Climate Research Programme

Grand Challenges

Field Campaign

What is the impact of land cover on the grid-scale area fluxes and subsequent PBL dynamics and regional scale circulation?



SENTINEL2 Land Surface temperature -
Courtesy : H. Nieto, IRTA

Field Campaign

Field Campaign (last of HyMeX) :

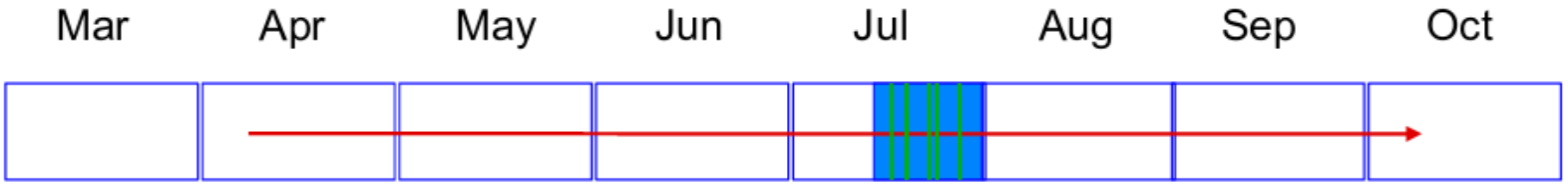
LOP : **April-October, 2021**→ surface flux stations, sfc satellite products, operational NWP (AROME from Météo-France and WRF from SMC), lysemeters, soil moisture...

SOP Summer/July 15-30 → Lower atmosphere, surface, 5 **IOP**s (ATR42)

Strategy →

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

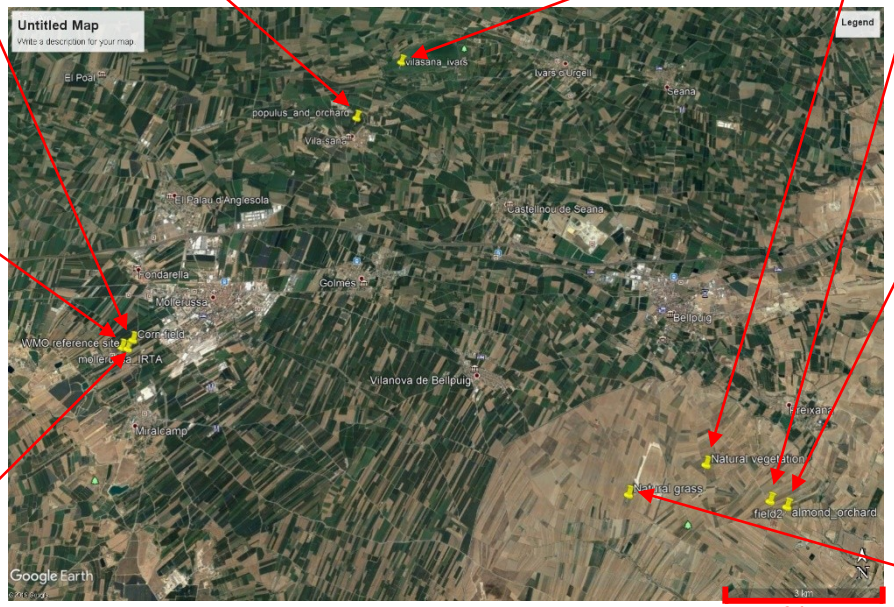
- Strategy to monitor the atmosphere : surface fluxes, surface layer, tethered balloons, wind profilers, lidar, freq. Radiosonde release, ATR42 (sfc to 3 or 4 km)



* Originally planned for 2020….

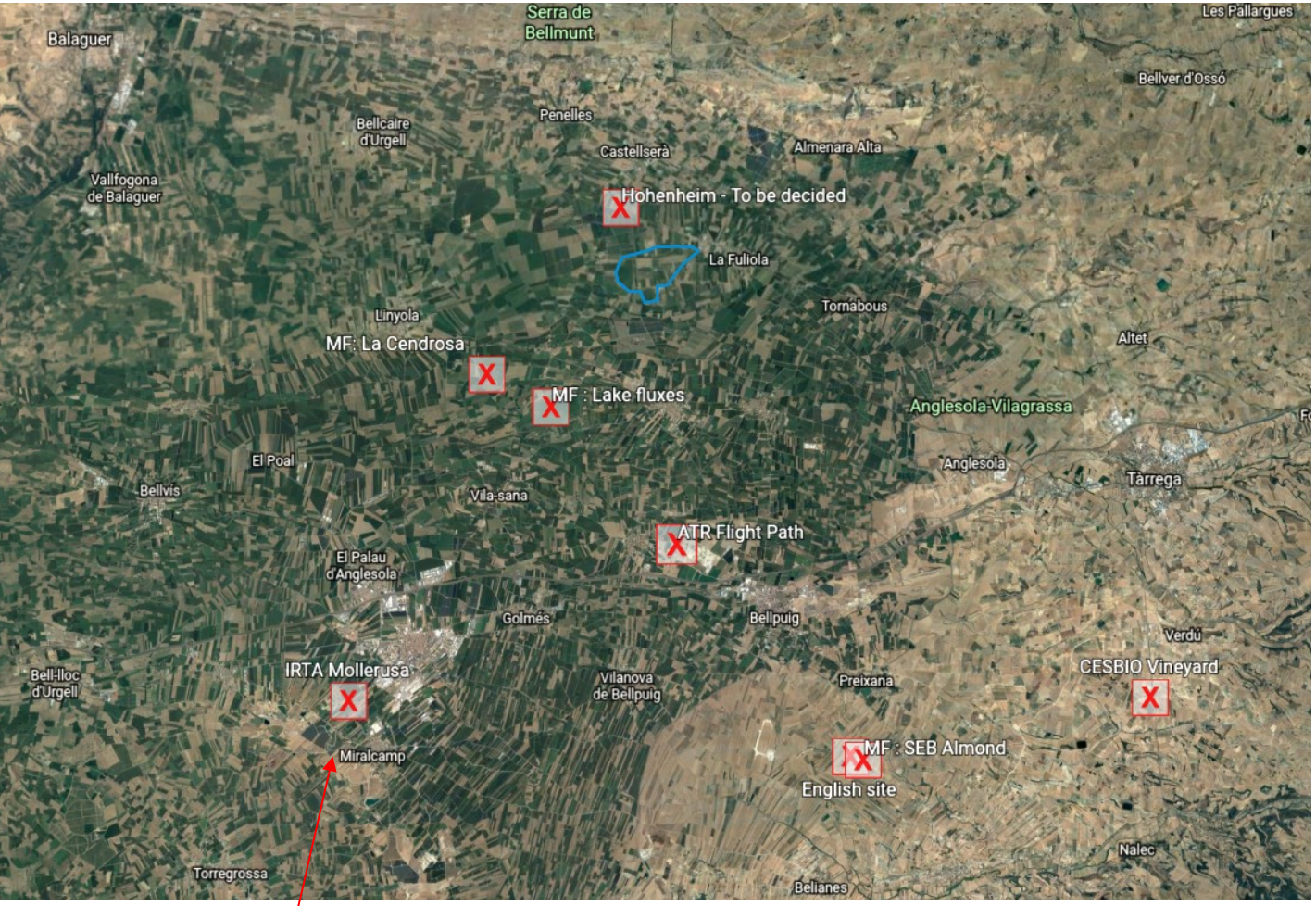
Field Campaign

Heterogeneity of land cover



Field Campaign

Surface Energy Budget (SEB) Stations



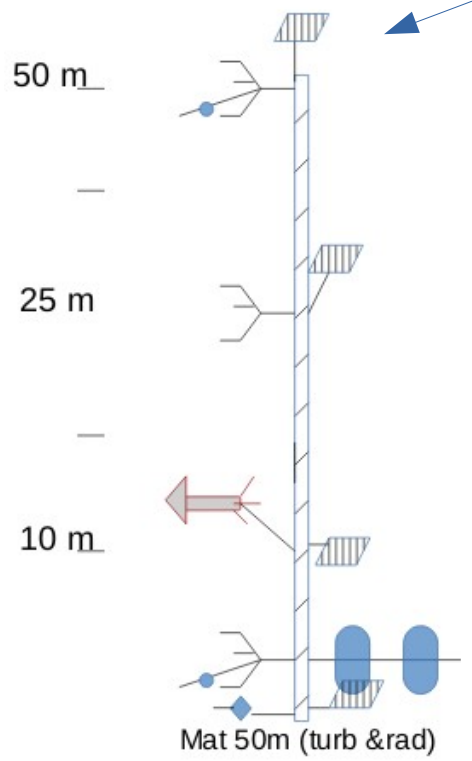
4 SEBs

10 SEB stations: Land cover

- Irrigated alfalfa**
- Irrigated fruit trees
- Irrigated in proximity to fruit trees
- Irrigated cut grass (ET0)
- Irrigated corn
- Irrigated low crop (TBD)
- Irrigated vineyard
- Natural grass/bare soil **
- Rain-fed fruit trees
- Lake

** Including 50m tower

Field Campaign



Turbulence

Vertical:

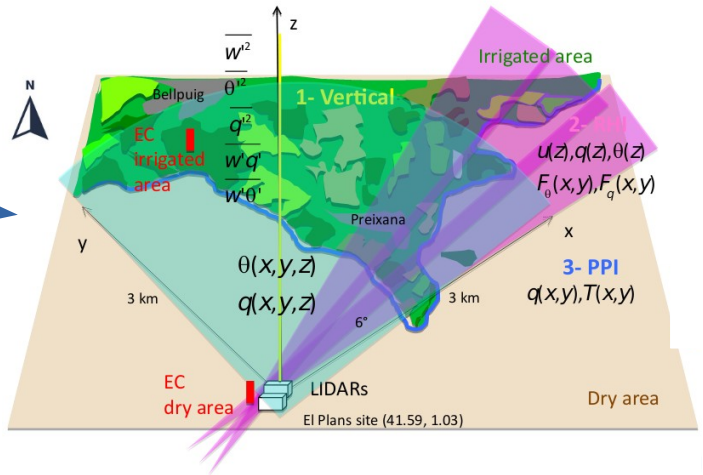
- 9 SEB stations → 2x50 m towers (rainfed & irrigated)
  → **ET** (processes: biophysics, lysimeters)
- Tethered balloons
- ATR42 measurements

Horizontal:

- 3 scintillometer configurations (LE, H)
- Lidar (u*, L)
- Spatially distributed remote sensed measures of SIF (HyFLEX), soil moisture (GLORI, SLAP), and surface IRT (HyTES, IRTA) → derive spatially dist. ET
- Satellite+model derived hi-res ET maps (S2, S3)

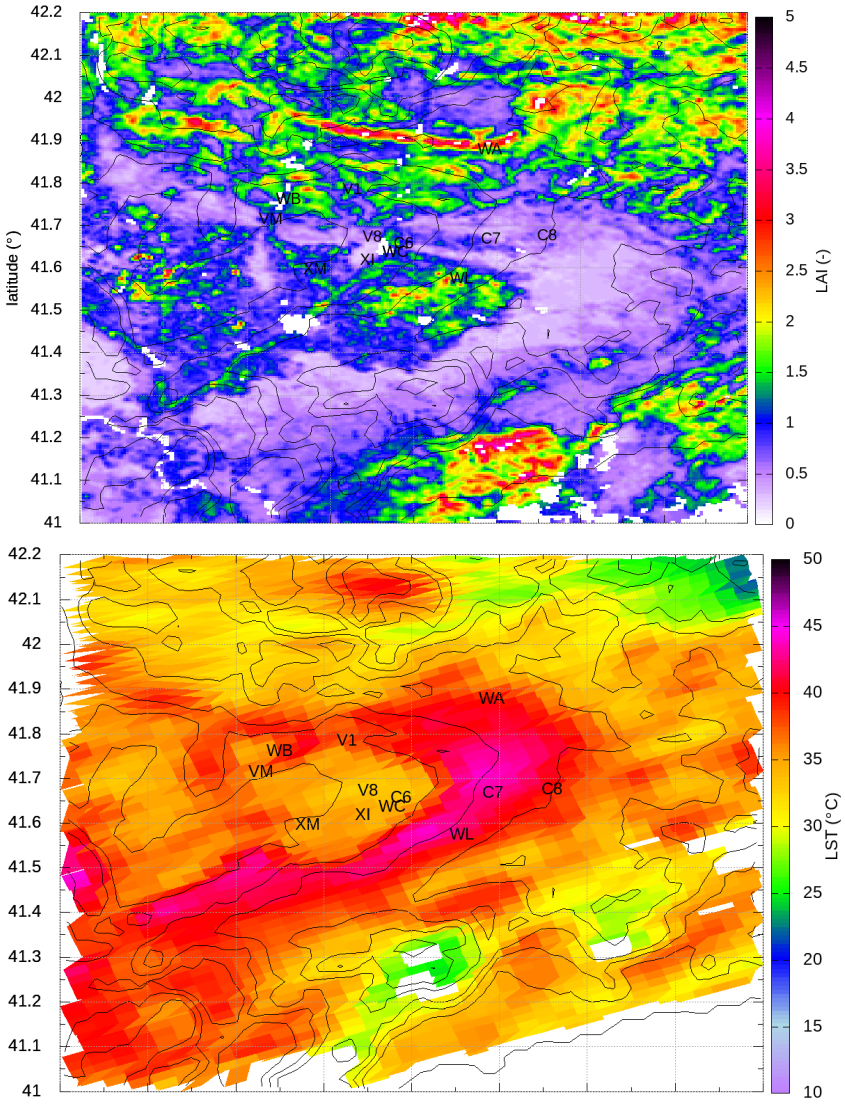
Thermodynamics:

- UHF
- Lidar (V, T, q)
- Drones (T, RH, p, IR)
- Wind Cube
- WindRASS
- Frequent RS releases
- DTS on 50m towers

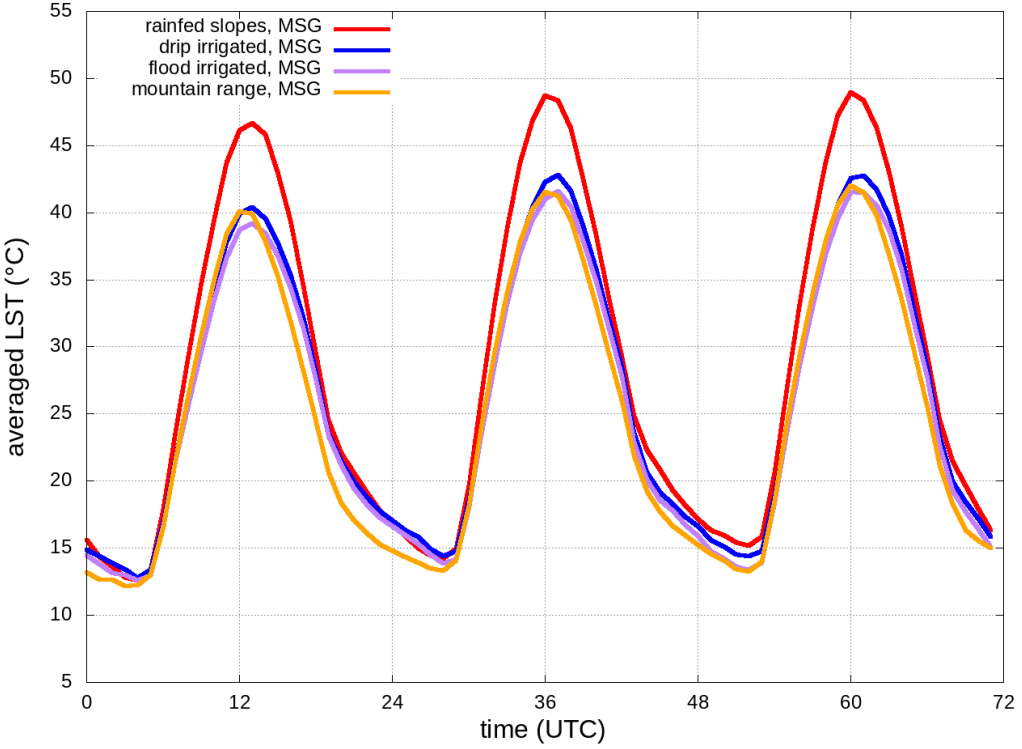


Field Campaign

LAI MSG (15-18/07/16)



MODIS LST 16/07/16-12:10 UTC



Field Campaign

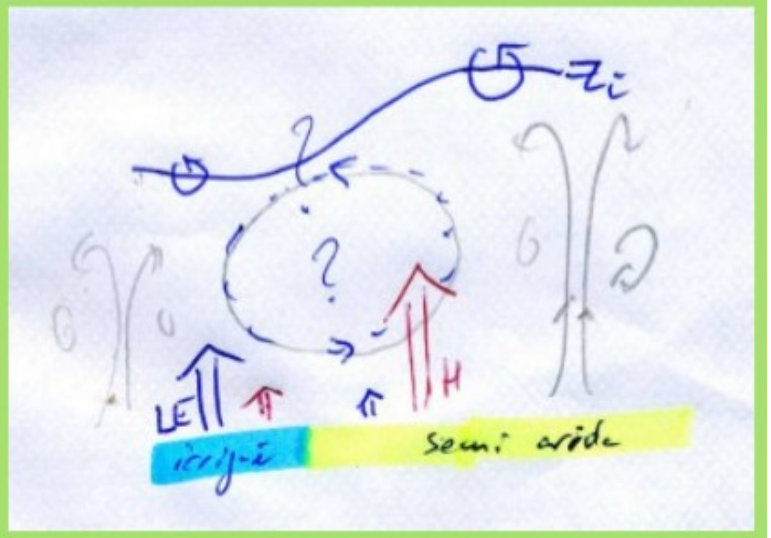
Thermodynamics and Turbulence from the ATR42 (M. Lothon, G. Canut, F. Lohou)

Observing the average theromodynamic structure and turbulence within the lower atmosphere to order to study:

- The impact of irrigation on sub-mesoscale circulations and the characteristics of the convective atmospheric layer (CAL)

- The role of turbulence in modulating the redistribution of heat and humidity within the CAL

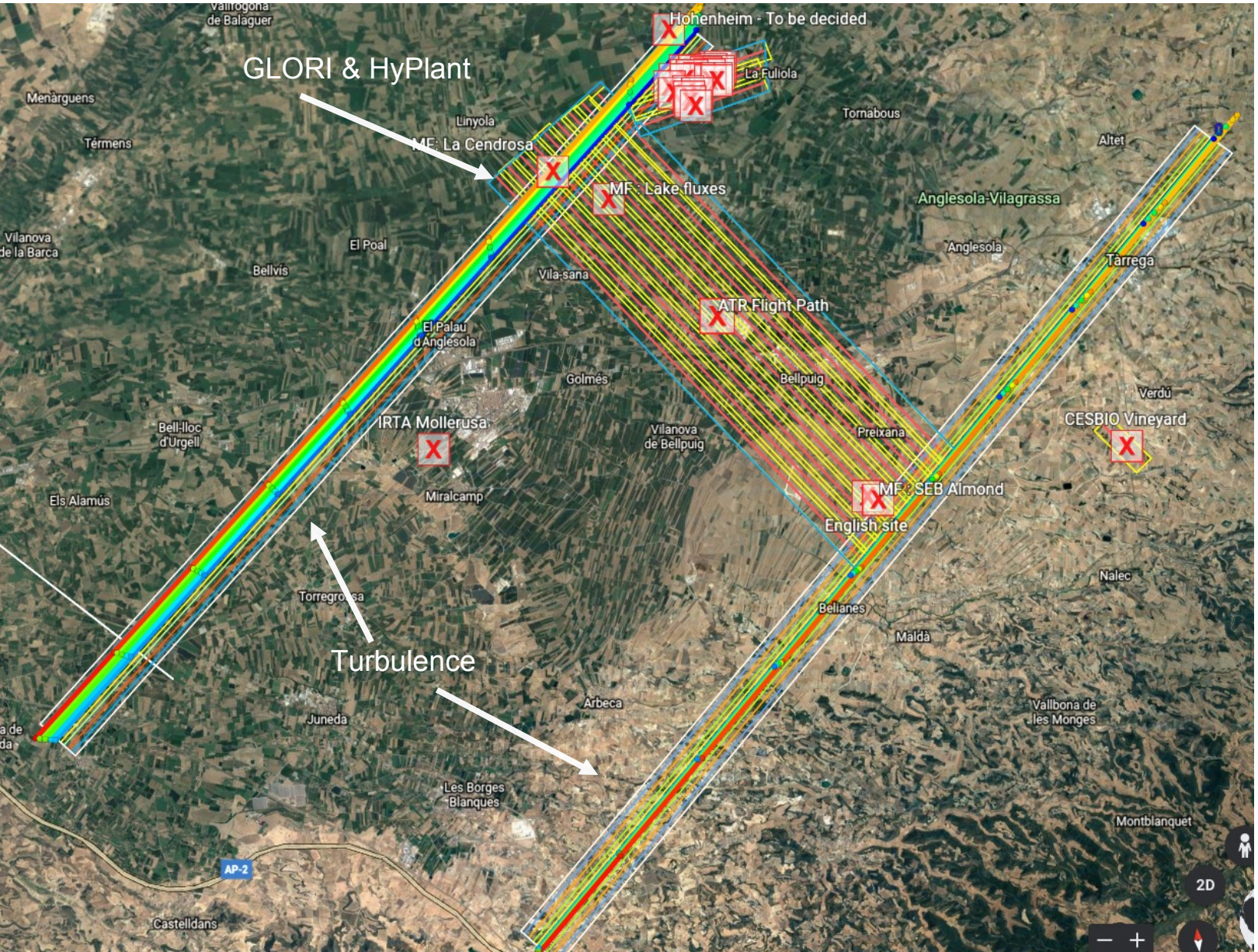
- The fine scale exchanges between the sfc and the free troposphere



Using the quantification of heat flux → **characterization of coherent turbuent structures, estimates of entrainment, identification of circulations...etc.**

- Complementary vertical obs over the SEB stations, radar wind profilers, lidar, and turbulence estimates from captive balloons

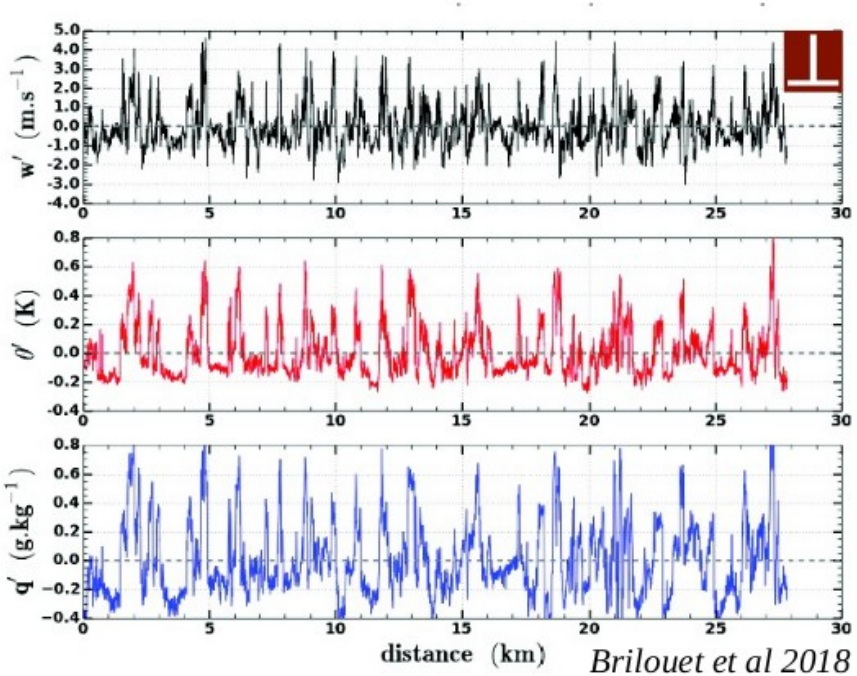
- Combined use of LES simulations, model validation and sensitivity tests



Flight Path:
GLORI & HyPlant
Turbulence

Field Campaign

Measure → temperature, water vapor mixing ratio, and 3 wind components:



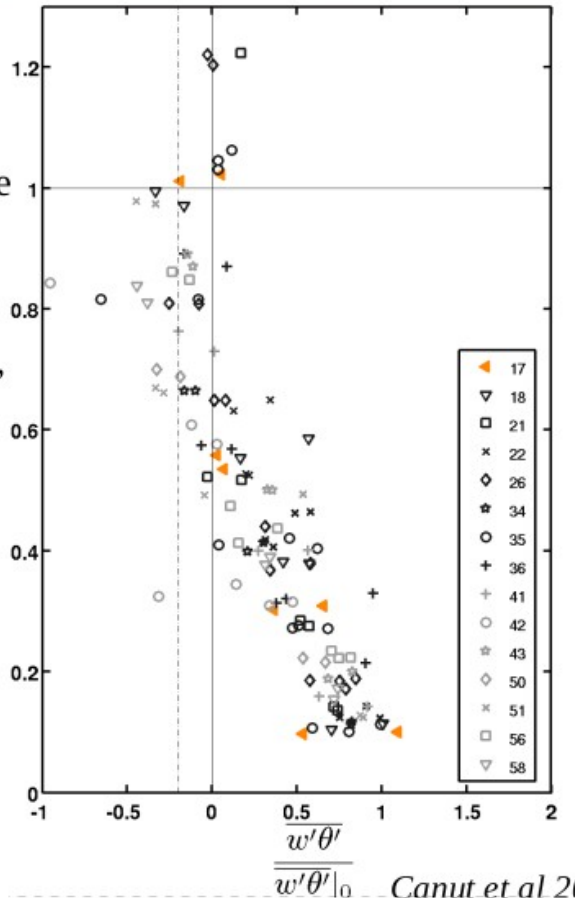
Brilouet et al 2018

25 pt/s → spatial resolution - 4m

+ Other measurements : radiative fluxes

Estimation at different heights in the CLA:

- 2nd order turbulence moments (variance, heat flux, TKE)
- 3rd order moments (skewness)
- Others : characteristic length scales, TKE dissipation,...



Canut et al 2010

SURFEX Land Surface Model setup

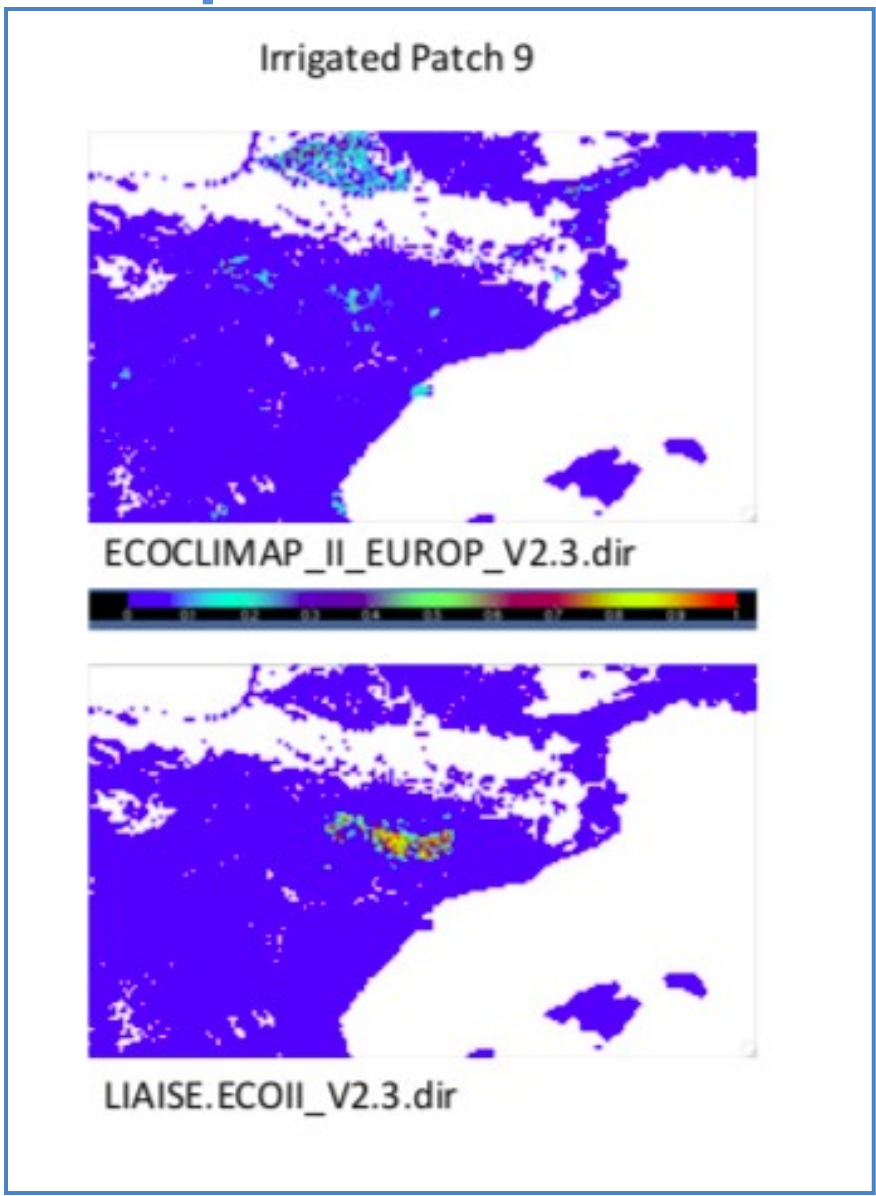
- SURFEX coupled to Meso-NH
- ISBA model for natural surfaces (DIF)
- Representation of land covers is based on 1km

ECOCLIMAP global database, representative of vegetation types in the period 1999-2006

- SURFEX → 19 classes, 1 for irrigation
- **Modified land cover map:**
  - irrigate only the Ebro basin on C3 crops
  - increase the irrigated fraction

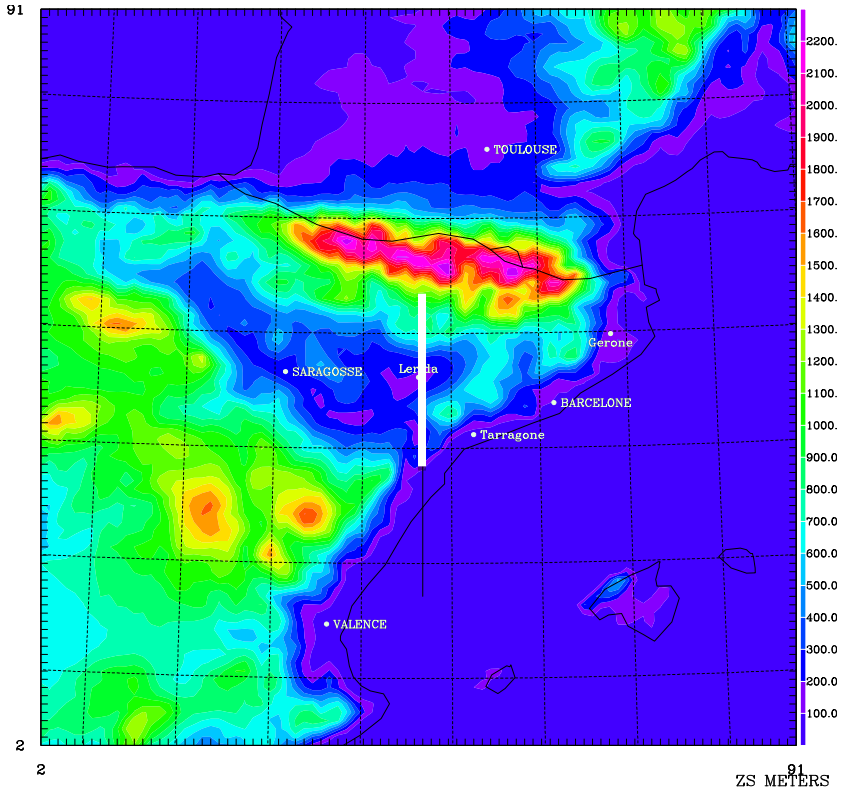
Sensitivity experiments:

ARO without irrigation
IRR with irrigation

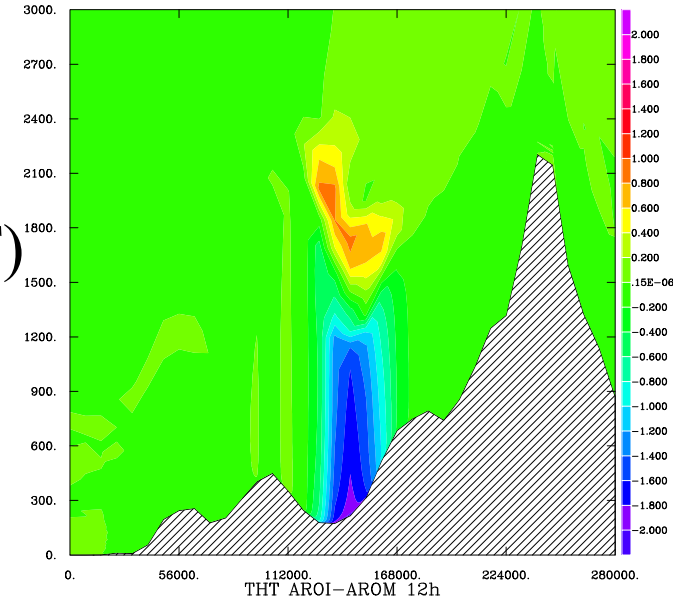


Modeling

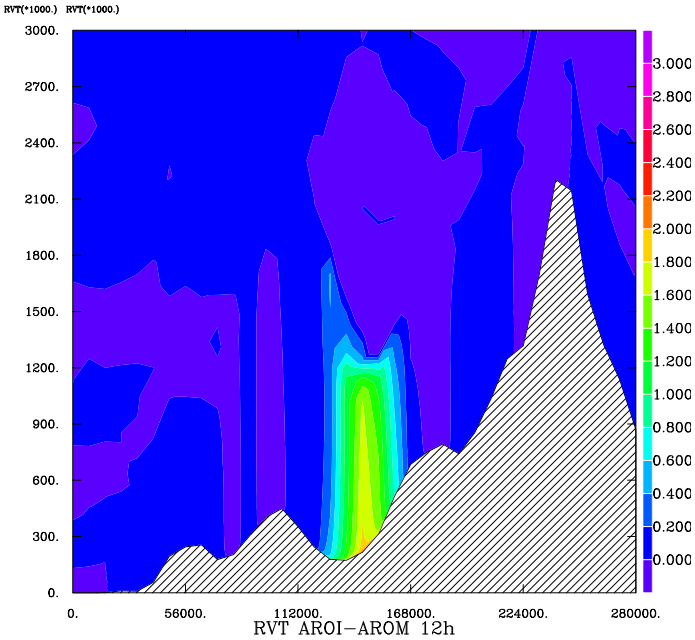
4 km runs with MesoNH
16-17/07/16



d(Pot. T)



$d(r_v)$

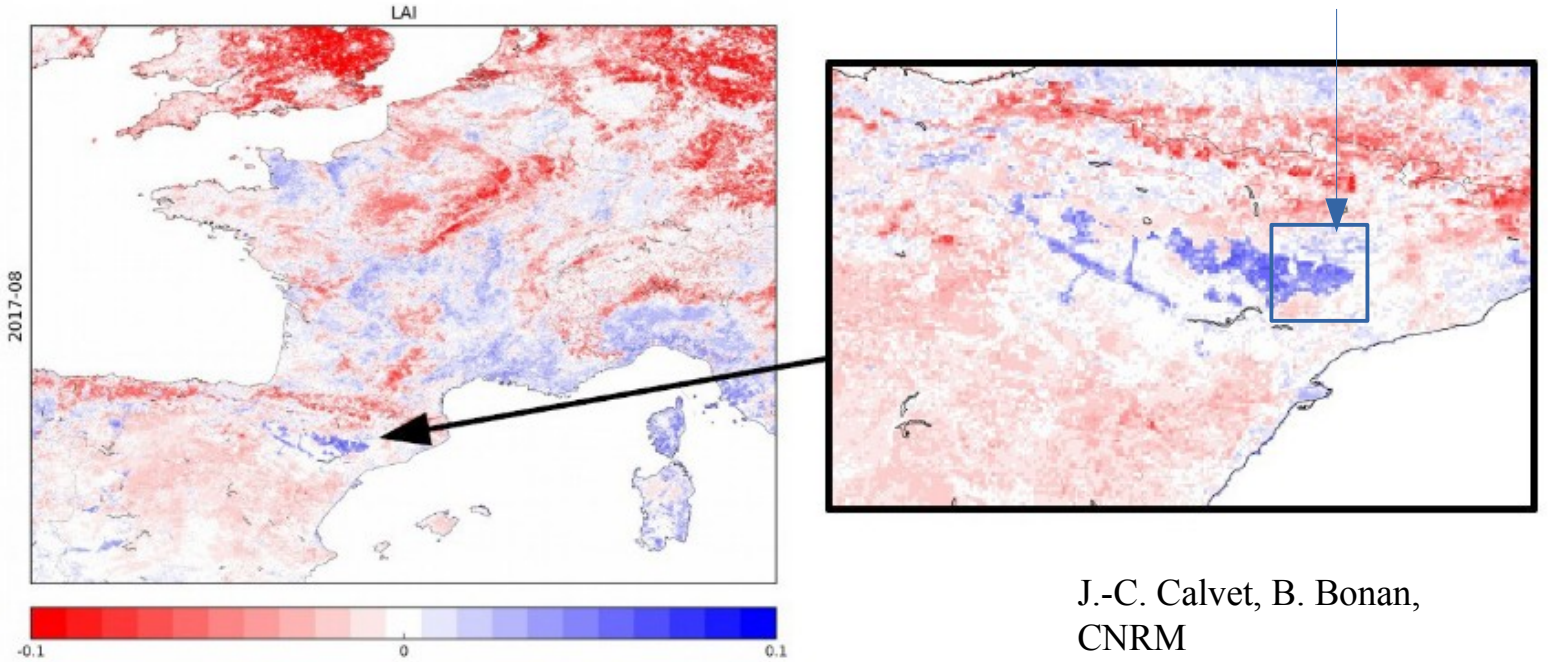


A water supply of 8.6mm/d has a large impact on surface and boundary layer variables

Integration of geographical info into SURFEX

- **ECOCLIMAP** (using satellite-derived land cover info)
- **LDAS-Monde**
  - Another way of integrating satellite data in ISBA
  - e.g. LAI increments highlighting irrigated areas in Spain (August 2017)

LIAISE measurements



J.-C. Calvet, B. Bonan, CNRM

Summary

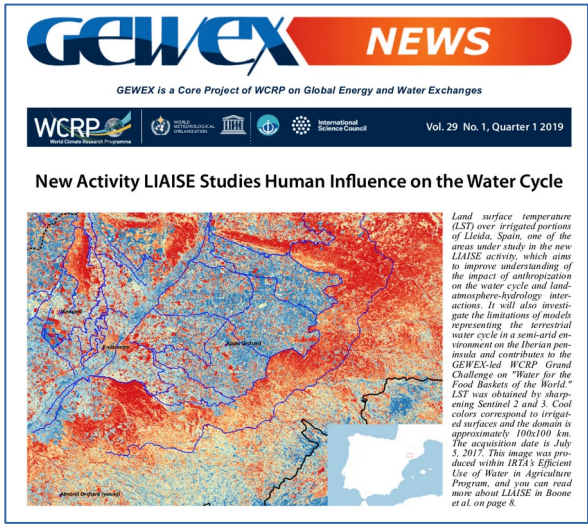
Results/Outcome : Scientific, Socio-Economic impact

• 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.


GEWEX NEWS

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

WCRP World Climate Research Programme

Vol. 29 No. 1, Quarter 1 2019

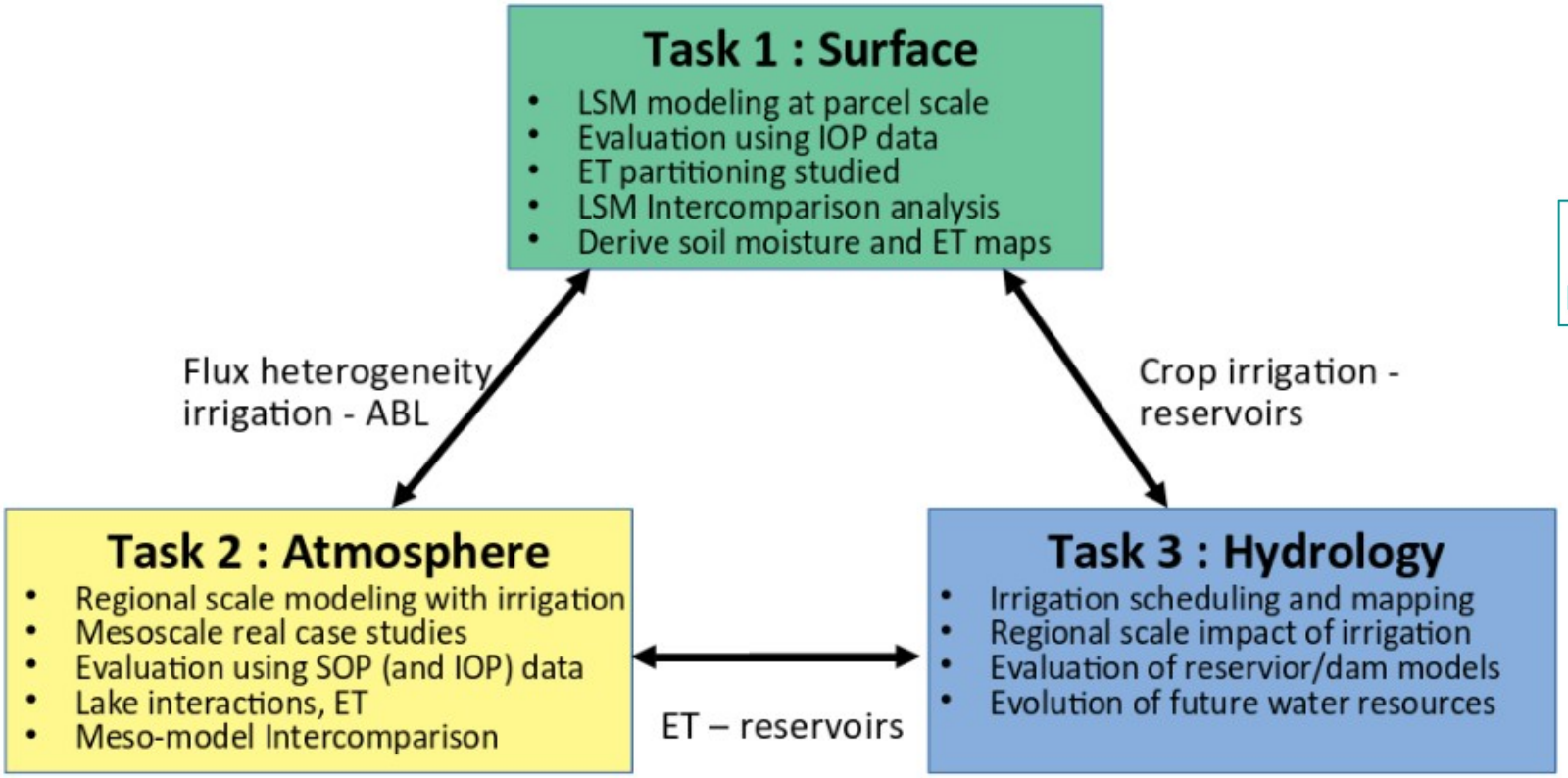
New Activity LIAISE Studies Human Influence on the Water Cycle

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.

* French activities supported by : ANR-HILIAISE (2019-2023), MISTRALS, CNES-TOSCA (2020-21), Météo-France

Fin...

Integrated view of the regional hydrological and energy cycles:



Field Campaign

A 15-day SOP is planned for mid July 2020, when contrasts between irrigated and natural surfaces are maximum.

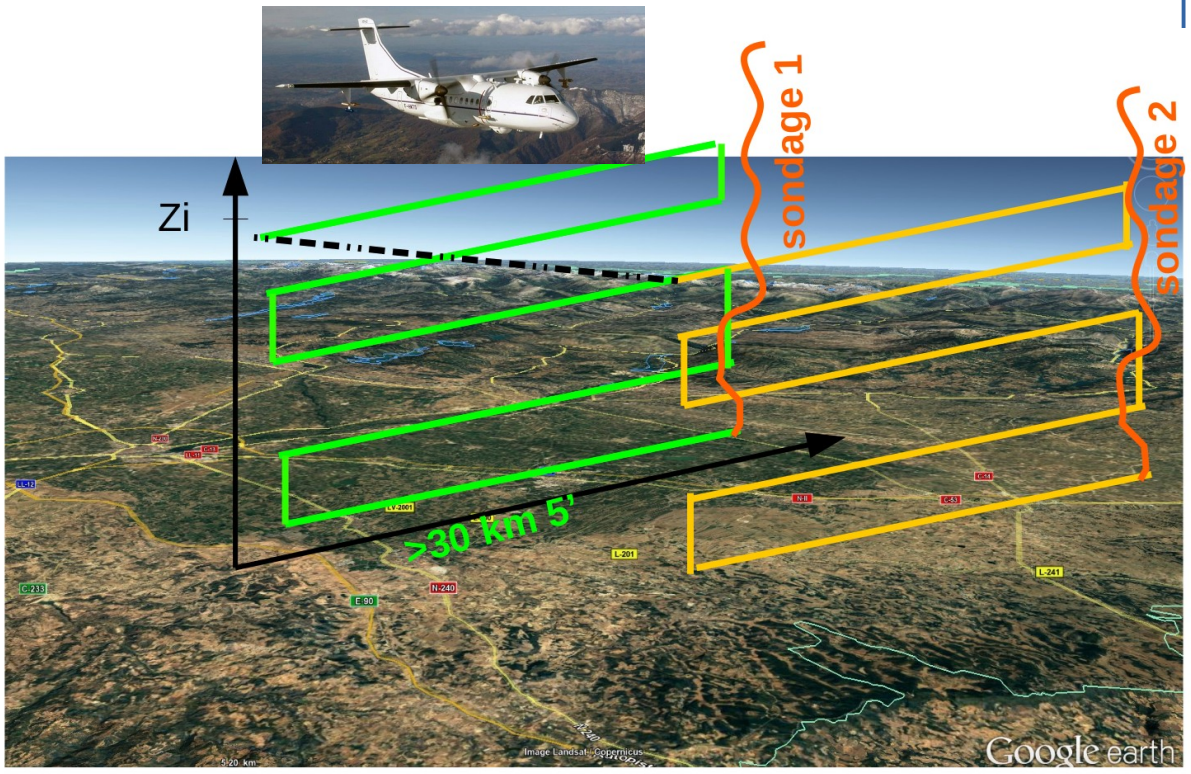
→ Characterize the impact of contrasting sfc fluxes on PBL, meso-circulation development

SAFIRE : ATR42

- 5 flights (days)...max 3.5h (total flight time 5h)
- 5 flight levels (up to 4 km), 2 X ~10km transects
- Turbulent fluxes of heat, moisture, momentum...
- Onboard instruments : GLORI (surface soil moisture : CESBIO), LST, SIF (CNES/FZ-Juelich)
- Fluorecence (CNRM, LMD, CESBIO)

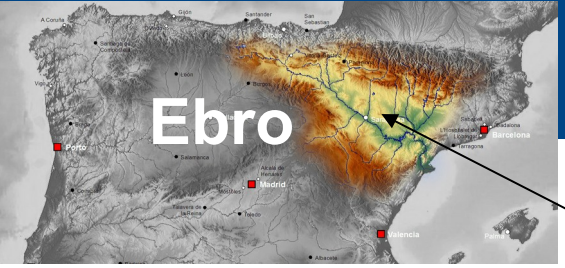
Sfc-based Lower Atmosphere

- 2 Tethered balloons : 10d (CNRM & UIB)
- Radiosoundings : 2 sites, up to 3 km, SOP (10/15d)
- 2 Wind profilers (UHF), WindCube, WindRASS
- Ceilometer
- Meteo obs and SMC radar
- Lidar (Raman/dial doppler)
- Microwave rain radar (CNRM), Parsivel disdrometer (UB)



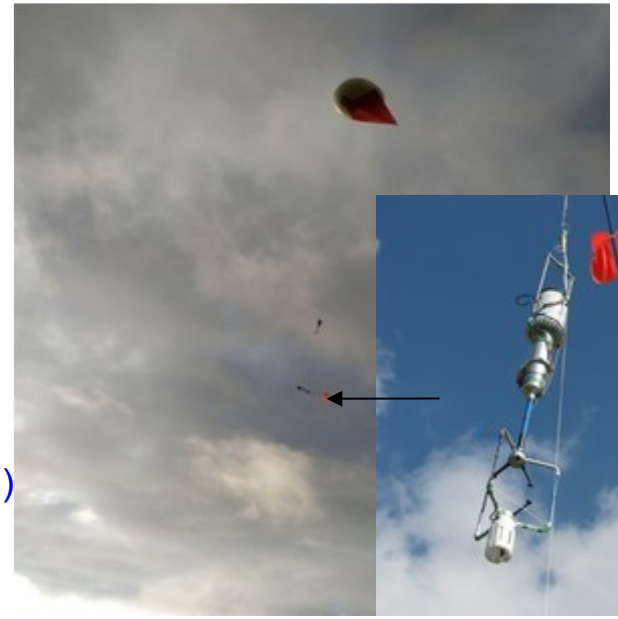
Field Campaign (2021)

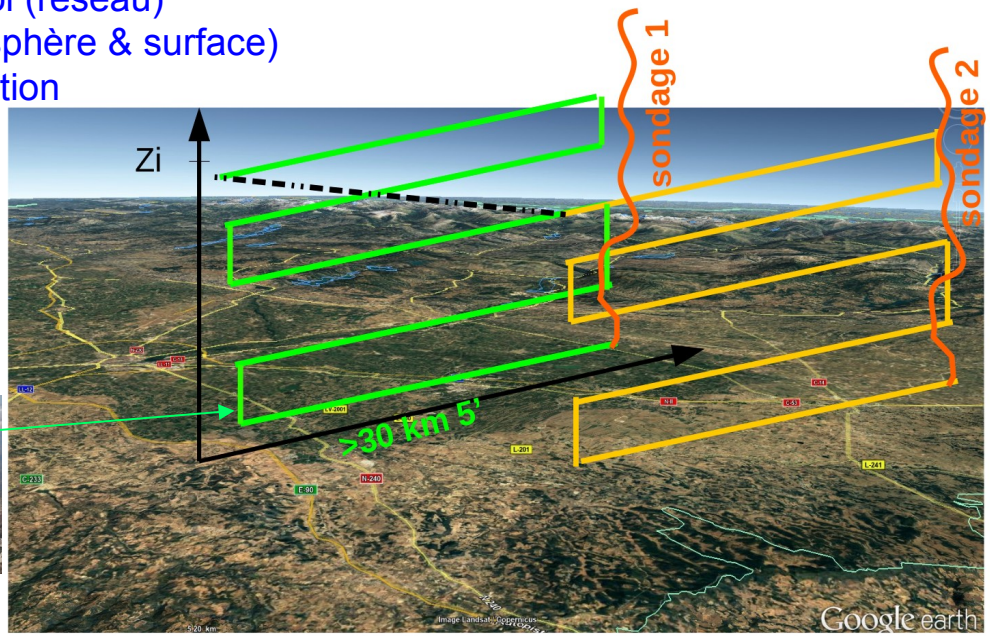
HyMeX



LOP : avril-oct
SOP : 15-30 juillet
IOP : 5j

- vols : ATR42 (SAFIRE)
- radiosondages (sfc à 4 km)
- lidar
- ballons captifs
- profileurs du vent UHF
- vols NASA et ESA (surface)
- 9 stations de flux (2 tours à 50m)
  → surfaces contrastées
- lysimètres
- humidité du sol (réseau)
- drones (atmosphère & surface)
- suivi de l'irrigation





ATR42 (SAFIRE)

cnrs

HI LIAISE

Field Campaign