The WCRP Grand Challenge on Water Availability

Water for the Food Baskets of the World

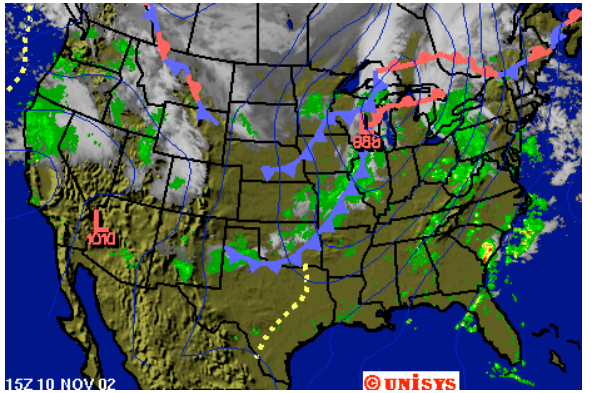
- Water Cycle the Main Driver of Food Production (~70% of water usage worldwide)
- A Warmer Climate Pushes the Water Cycle into Unknown Territory
- The Terrestrial Water Cycle is not Natural Anymore
- Urgency to Understand the New State of the Water Cycle and Food Production in which Natural and Anthropogenic Processes Interact

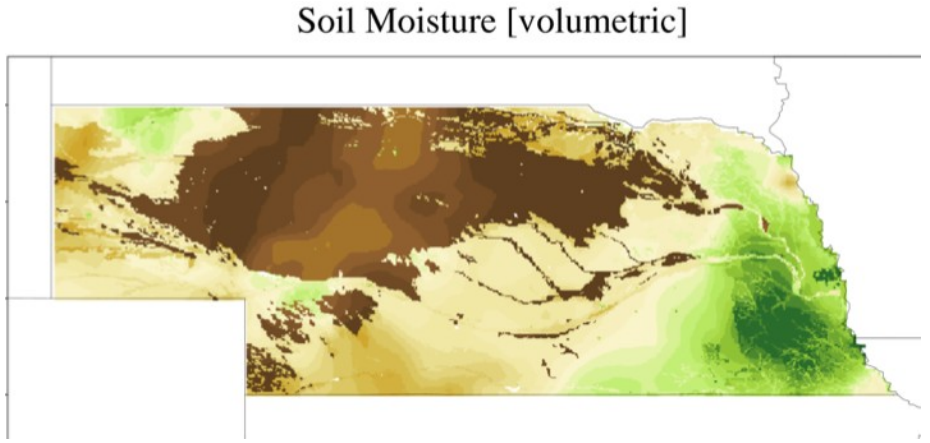
GEWEX

WCRP World Climate Research Programme

NCAR/RAL Ag related projects

- NSF/USDA EaSM (collaboration with ASU): couple urbanization and agriculture models to WRF.
- NSF INFEWS (collaboration with GMU): irrigation forecast to save 10% irrigation water in Nebraska.
- NOAA JTTI (collaboration with ISU): implement crop/irrigation/tile drainage in operational National Water Model.
- NCAR Reinvestment: modeling human impacts in the new Community Terrestrial System Model (CTSM).
- NCAR Water System: crop-atmosphere interactions in WRF 4-km regional climate simulations.





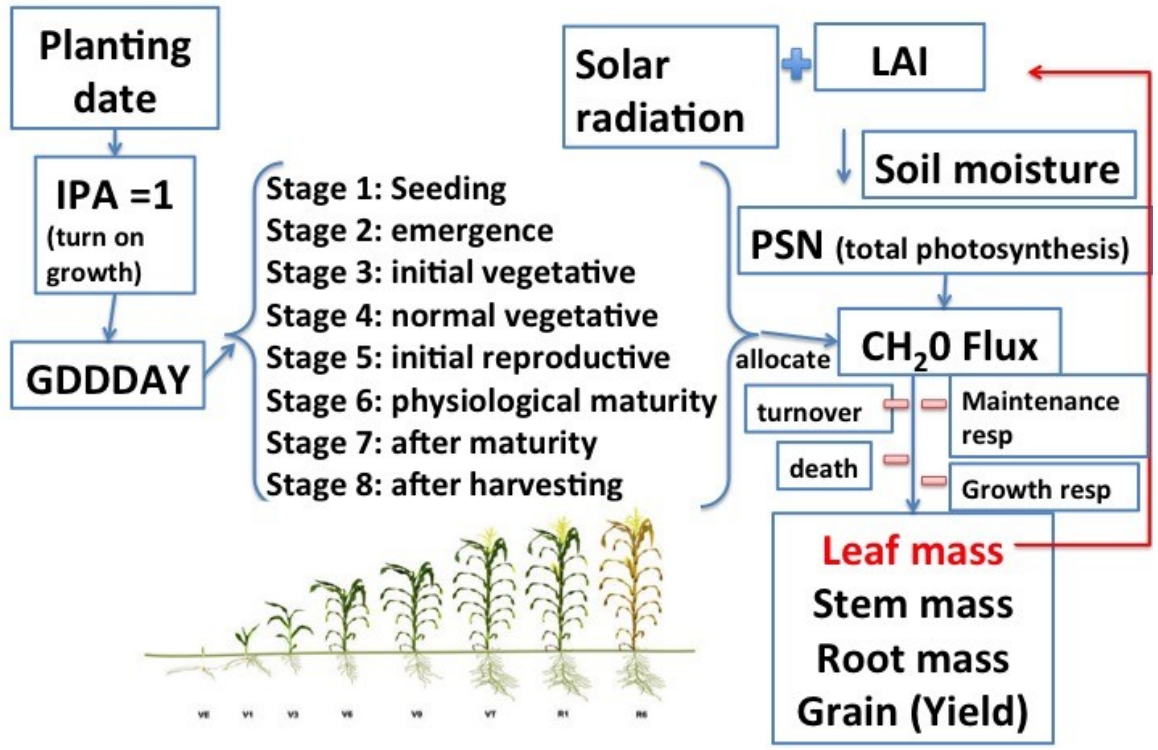
Main challenges in modeling agriculture in ESMs

- Crop species evolve and crop growth models are not static
- Complex agriculture management/practice
  - Rotation and double crops
  - Fertilization
  - Irrigation
  - Tile drainage
- From field scales to regional scales
- Impact of various irrigation techniques on soil moisture are very different.

WRF-Crop model development

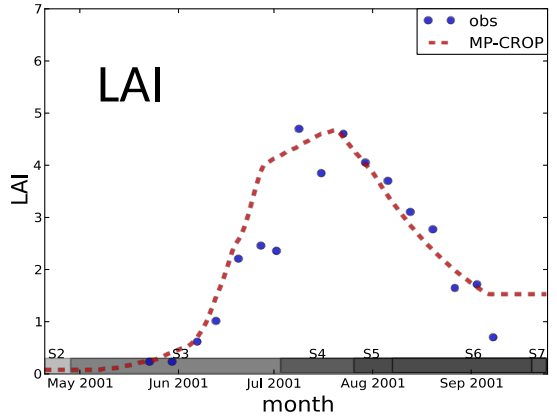
- Noah-MP-Crop (corn and soybean growth) models released in WRF 3.8 (2016)
- Implemented auxiliary crop data sets in WRF 3.9 (2017)

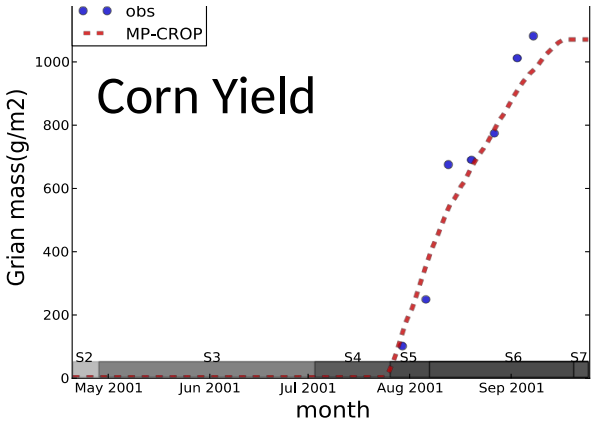
Noah-MP-Crop model



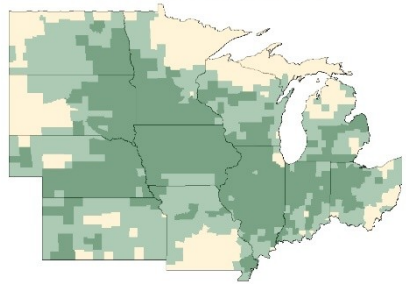
Liu et al., 2016, *JGR-Atmosphere*

Evaluated against field data, this model captured well the seasonal and annual variability of crop phenology and yield

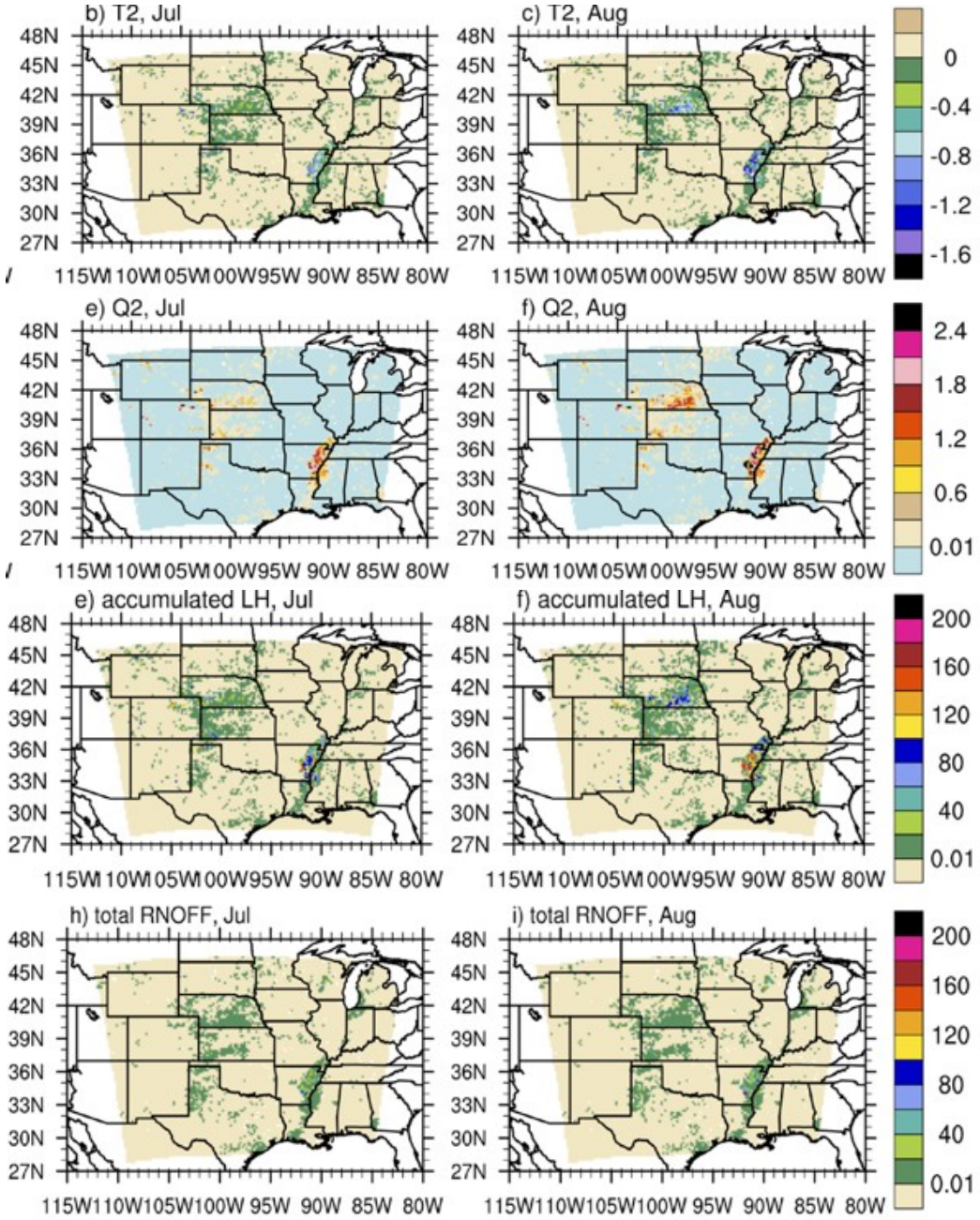




U.S. Corn Belt



Modeling hydrometeorological effects of irrigation



Reduce monthly temperature by 0.8~1.2 K in southeastern NE and by up to ~1.4 K in eastern AR

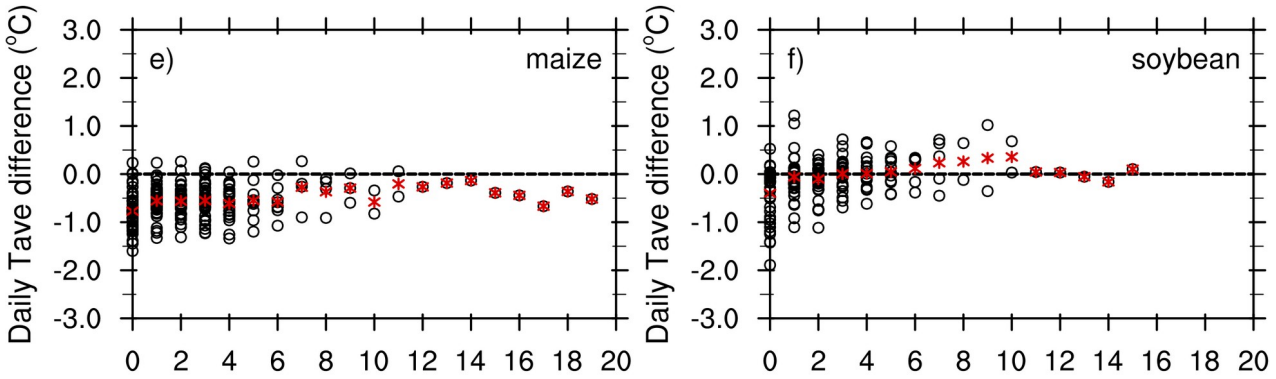
Increase air humidity by ~1.2~1.8 g kg^{-1} INE) and 2.4 g kg^{-1} (AR)

most of irrigation water are used to increase soil moisture and evaporation, rather than runoff.

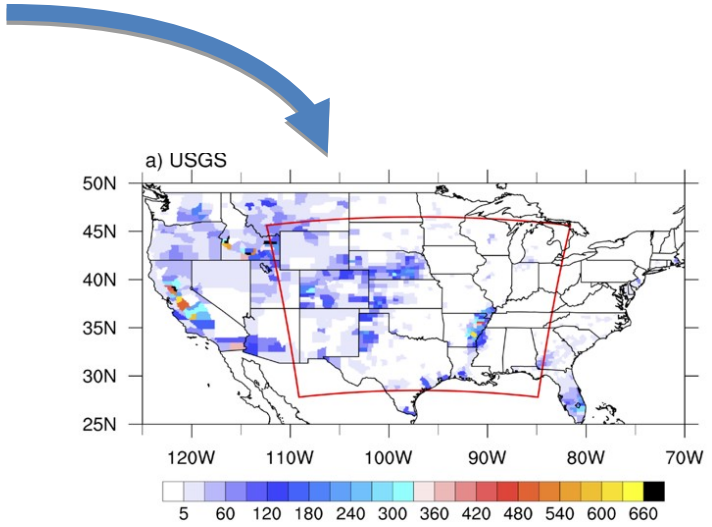
- increase monthly evaporation by up to 80 mm in NE and ~120 mm in AR
- increase monthly total runoff by ~ 20 mm

Lessons Learned

- Irrigation amount and timing, and their hydroclimatic impacts depend on crop species and growing season progression



- It's challenging to transition crop and irrigation modeling from field scale to regional scale
  -

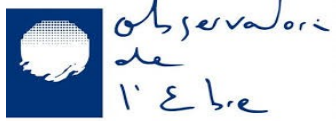


Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE)

A. Boone[1], J. Polcher[2], J. Cuxart[7], M. Best[8], P. Quintana-Segui[6], M. Zribi[3], Y. Tramblay[5], F. Lohou[9], C. Albergel[1], S. Bastin[2], J. Brooke[8], J.-C. Calvet[2], G. Canut-Rocafort[1], S. Donier[1], P. Fanise[3], S. Garrigues[4], M. Haeffelin[2], L. Jarlan[3], M. Lothon[9], O. Merlin[3], P. LeMoigne[1], M. LePage[3], J. Price[8], H. Nieto[4]

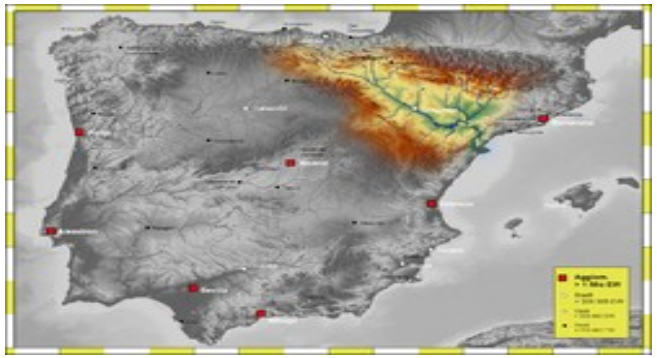
1 CNRM Météo-France/CNRS, Toulouse, France
2 LMD, IPSL, Paris, France
3 CESBIO, Toulouse, France
4 IRTA, Lleida, Spain
5 MSE, Montpellier, France
6 Observatori de l'Ebre, Roquetes, Spain
7 UIB, Balearic Islands, Spain
8 UKMO, Exeter, UK
9 LA, Lannemezan, France

Funding sources :
- French Research Agency
- UKMO
- Spanish Government
- HyMeX/MISTRAL
- ESA
- CNES



Field Campaign

Observational campaign will bring together ground-based and airborne measurements
with modeling studies including data assimilation of remotely sensed data



Ebro basin

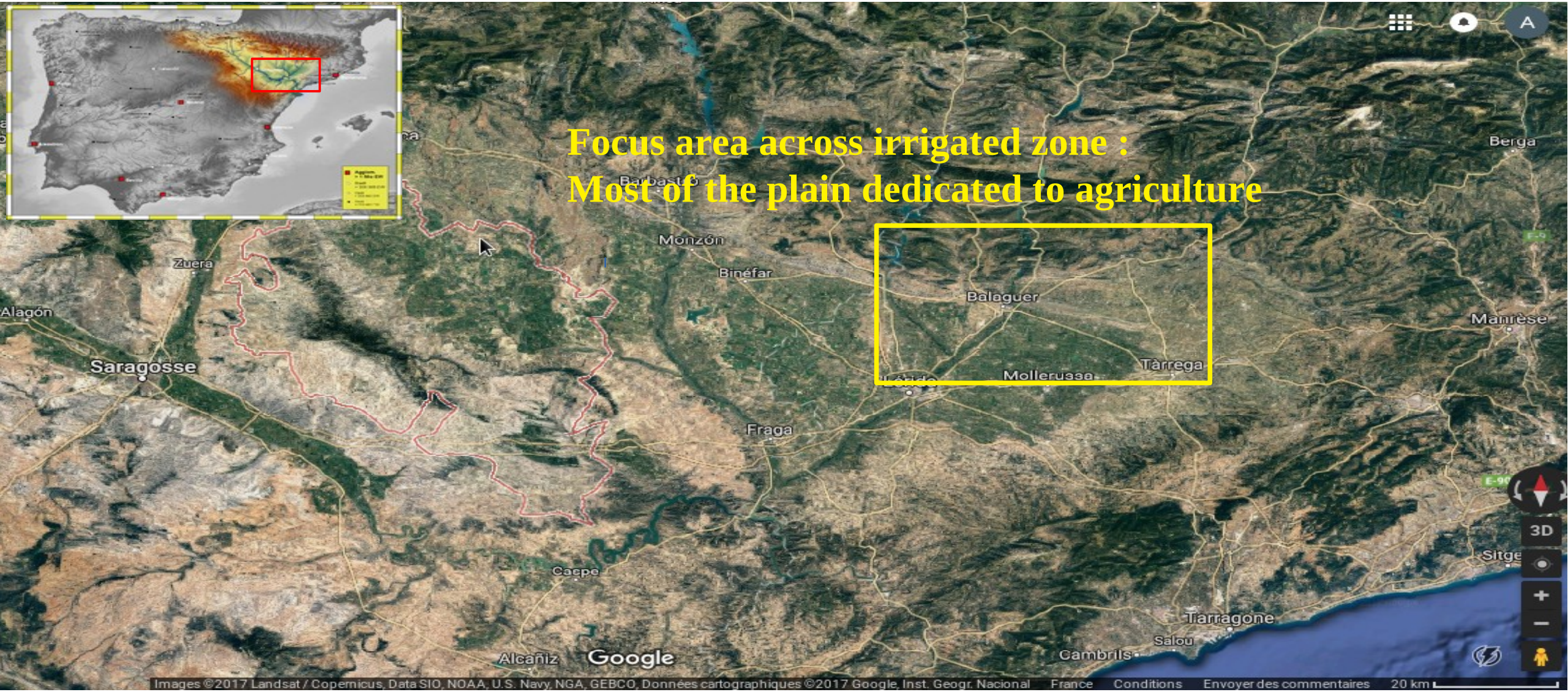
Surface-based deployment:

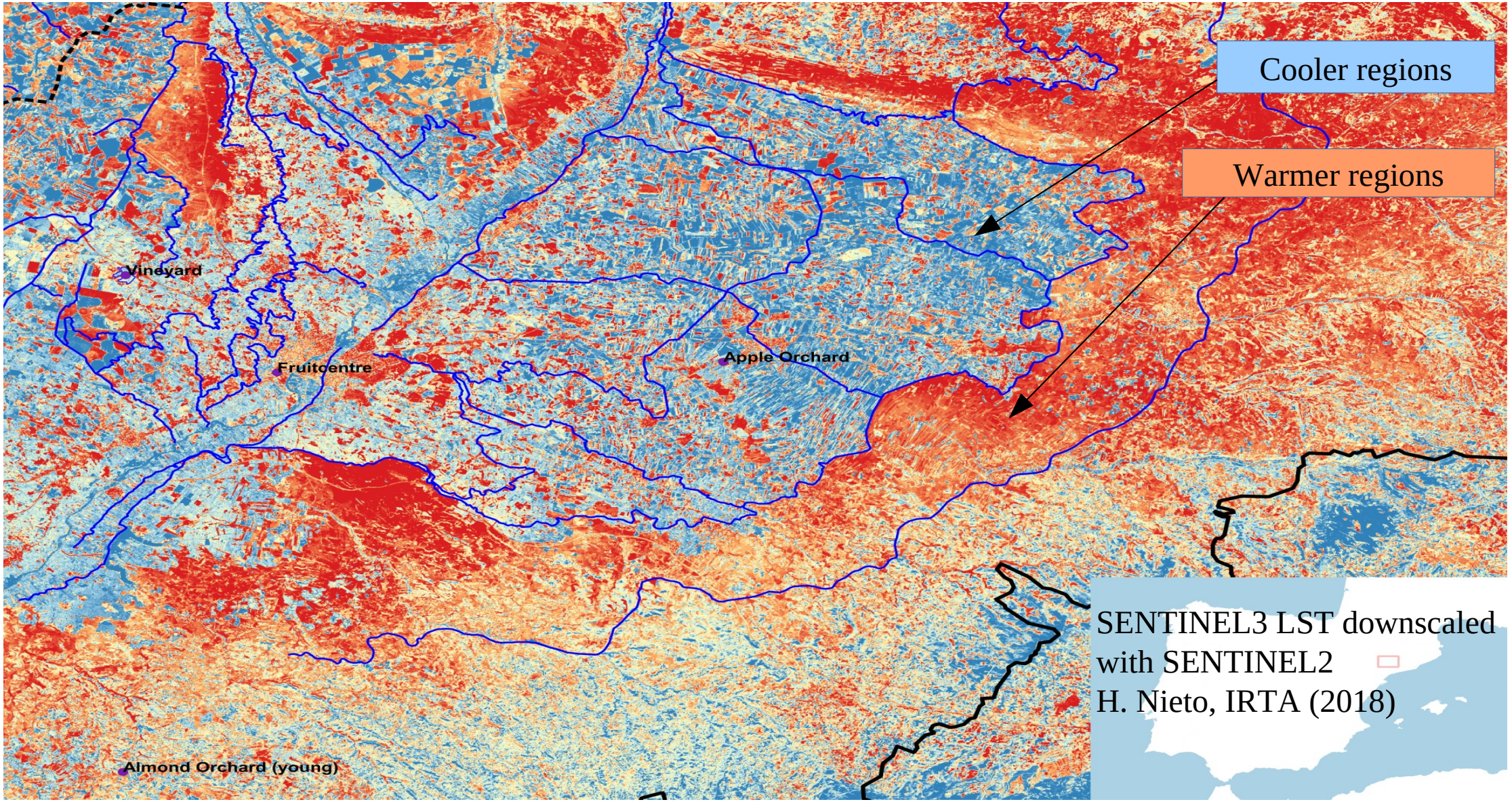
(i) obtain continuous monitoring of physical processes and their evolution

(ii) to provide complete and multidisciplinary data-sets for numerical modeling evaluation as well as satellite product validation.

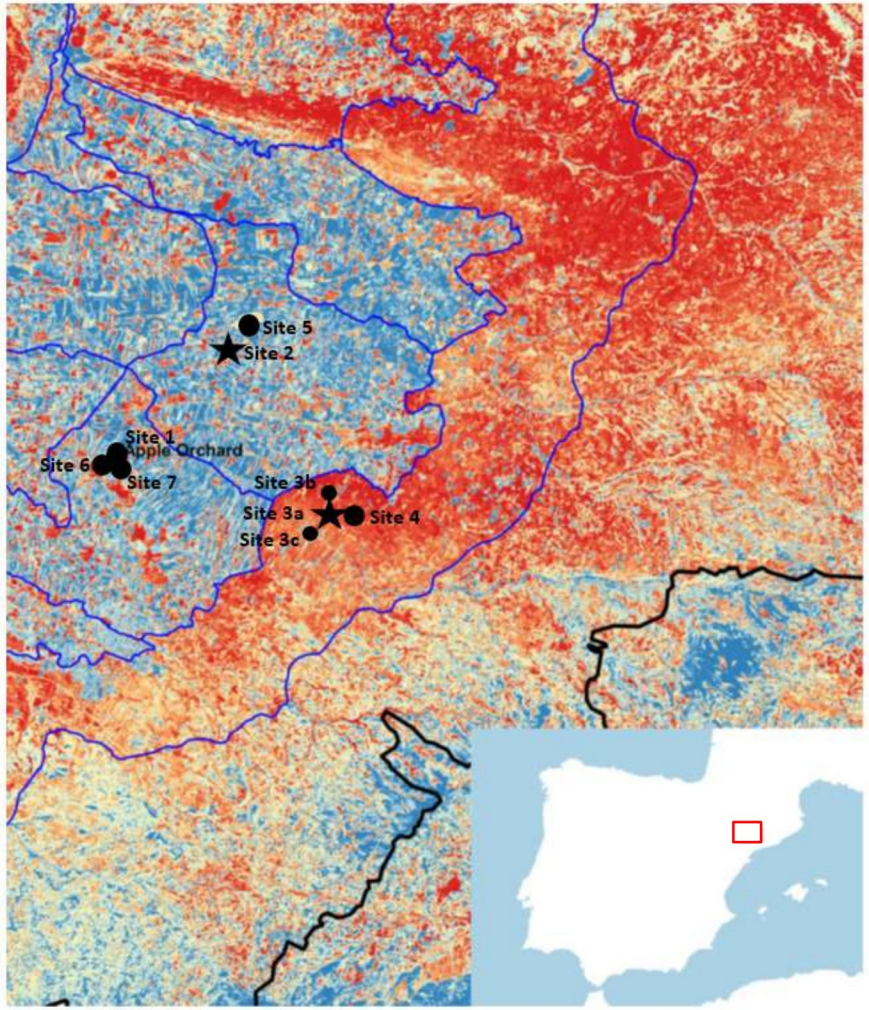
It will be implemented through the enhancement of existing measurements sites from **Spanish** research groups, the Spanish State Meteorological Agency (AEMET) and the Meteorological Service of Catalonia (SMC) , the Hydrographic Confederation of the Ebro, and private companies involved in irrigation monitoring such as Isardsat and Lab-Ferrer...
other potential partners (Germany, Morocco...)

Field Campaign : **Observational campaign will bring together ground-based and airborne measurements with modeling studies including data assimilation of remotely sensed data.**




Cooler regions
Warmer regions
Vineyard
Fruitcentre
Apple Orchard
Almond Orchard (young)
SENTINEL3 LST downscaled
with SENTINEL2
H. Nieto, IRTA (2018)

LIAISE: Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment



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

LIAISE is an international observational field campaign commencing in April 2020 which will support a number of international modelling experiments.

Six-month field campaign located in the Lleida region of the Ebro basin (north-east Spain).

Co-located long term (six-month) surface observations.

★ Two super-sites with 50m masts

● Five additional SEB sites

- Heterogeneous land cover
- Irrigated and natural sites

Observation strategy for LIAISE

Each site will have multiple energy balance stations and dedicated flux measurements (Scintillometers).

Vertical profiling lidars.

Intense radiosounding program.

The irrigated site will have fluorescence measurements (active & passive) and lysimeters.

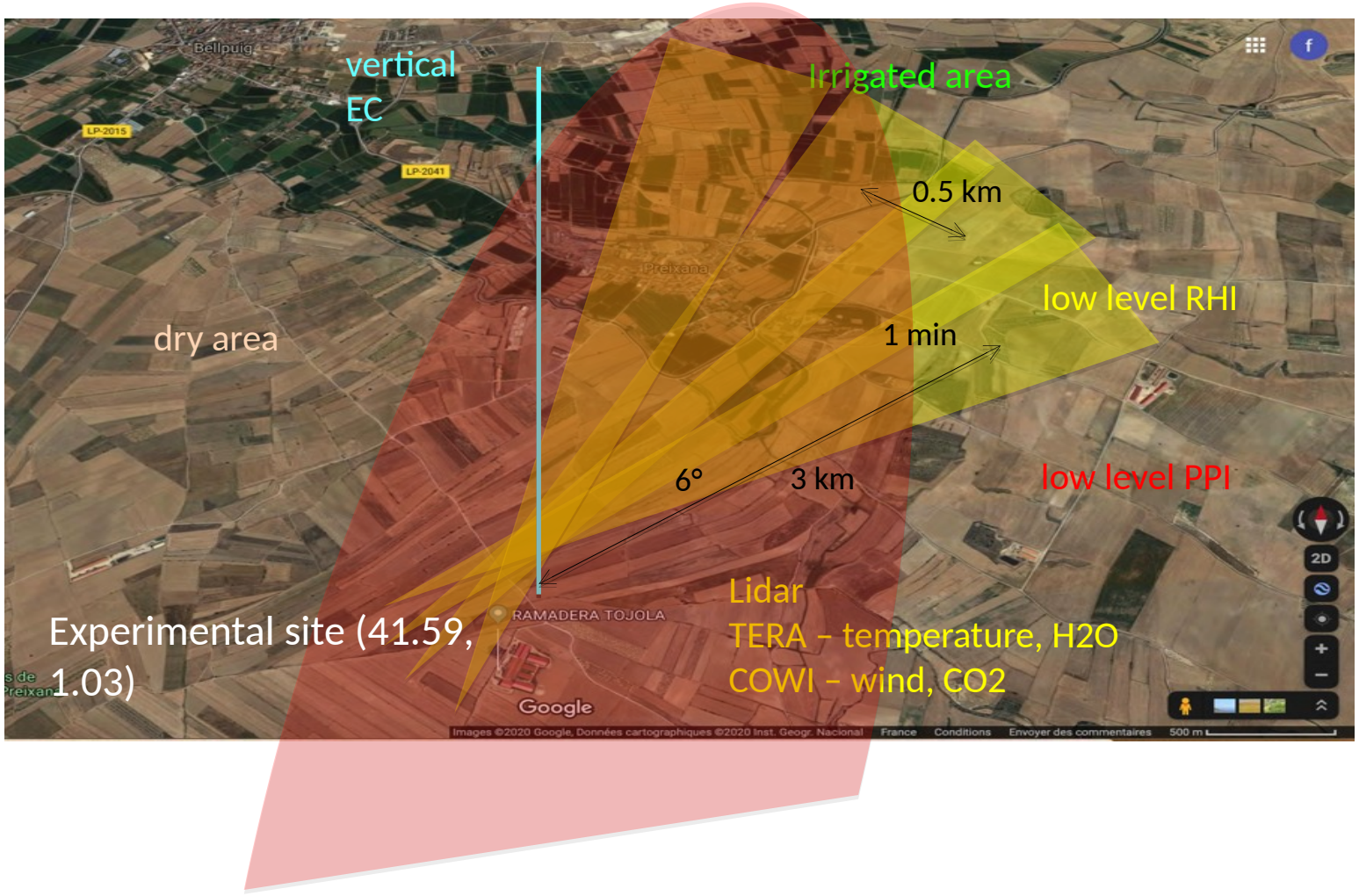
The dry side will have horizontal scanning lidars looking at the transition with irrigated areas.

3 aircraft will be flown with the following objectives :

- Atmospheric turbulence
- GLORI soil moisture instrument
- FLEX simulator for fluorescence
- SLAP (SMAP simulator)
- LSTM instrument for Copernicus candidate mission.

LMD lidars contribution in HILIAISE

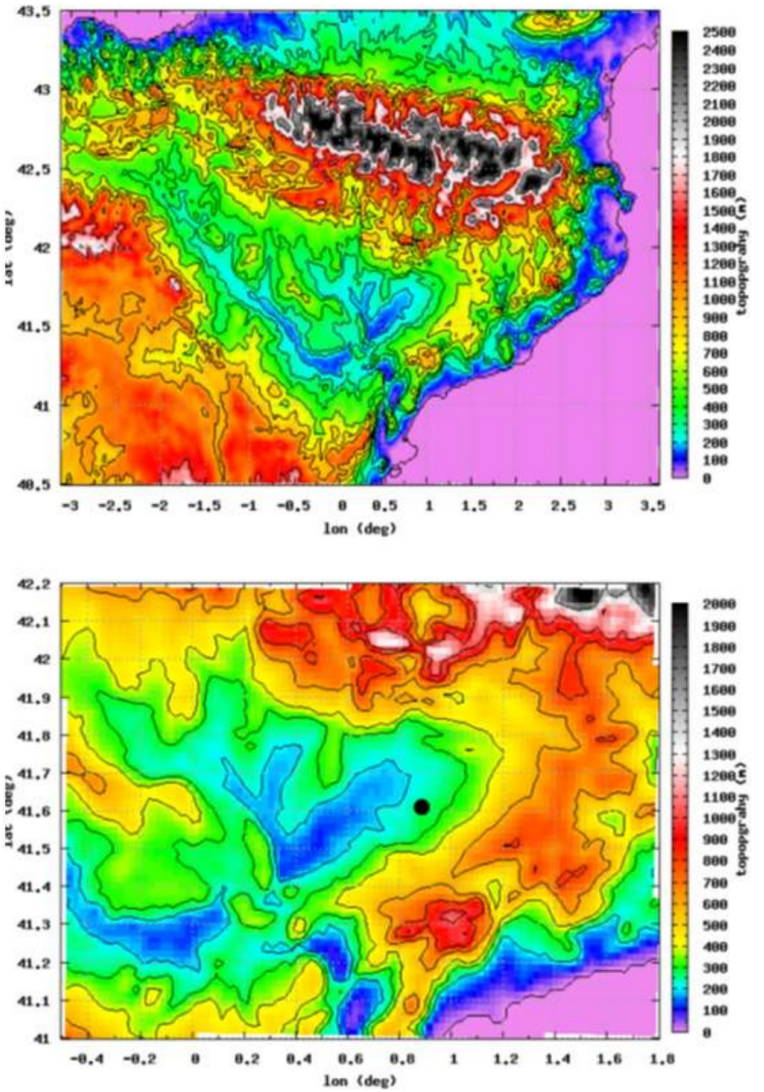
F. Gibert, D. Edouart, C. Cénac, P. Monnier, H. Salvador



Lidar operation mode	Scientific objectives
RHI: range height indicator	surface flux heterogeneity (from MOST)
PPI: plane polar indicator	scalar field heterogeneity
vertical, EC: eddy-covariance mode,	- boundary layer/ troposphere profiling - turbulent flux profiling (from EC)

Modeling strategy for LIAISE

- A diversity of CP regional models will be implemented :
  - AROME, MesoNH, UM-LAM, RegIPSL, WRF
  - All will have at least 3km resolution over the entire Iberian Peninsula
  - Cases will be simulated at 400m resolution.
- Irrigation will either be imposed or simulated



Outer (2km x 2km resolution) and inner (400m x 400m resolution) domains.

Irrigation Modeling in ESMs

- Sonali McDermid organized a AGU TownHall meeting on irrigation modelling in LSMs.
- It was attended by LSM, Agronomic and hydrology modelers.
- Different approaches are possible :
  - Invent the water provided to crops for evaporation
  - Determine from where the water is taken and how its availability determines irrigation.
  - What do we do with groundwater pumping ?
- A group is forming to try and coordinate the efforts underway in many Earth system modeling groups.

Next meeting : February 6th, from 10-11 AM (EST, New York time)

Conclusion : Engaging the community

- GLASS in order to coordinate crop and irrigation modeling in LSMs.
- GLASS/GASS : for coupling studies over managed land areas.
- GHP for interaction with regional climate research and the Evaporation CC.
- Interactions with CliC, CLIVAR & CORDEX?
- Proposal for a conference in 2021 : "Advancing our understanding of the role of irrigation and water management in the Earth system"