The WCRP Grand Challenge on Water Availability

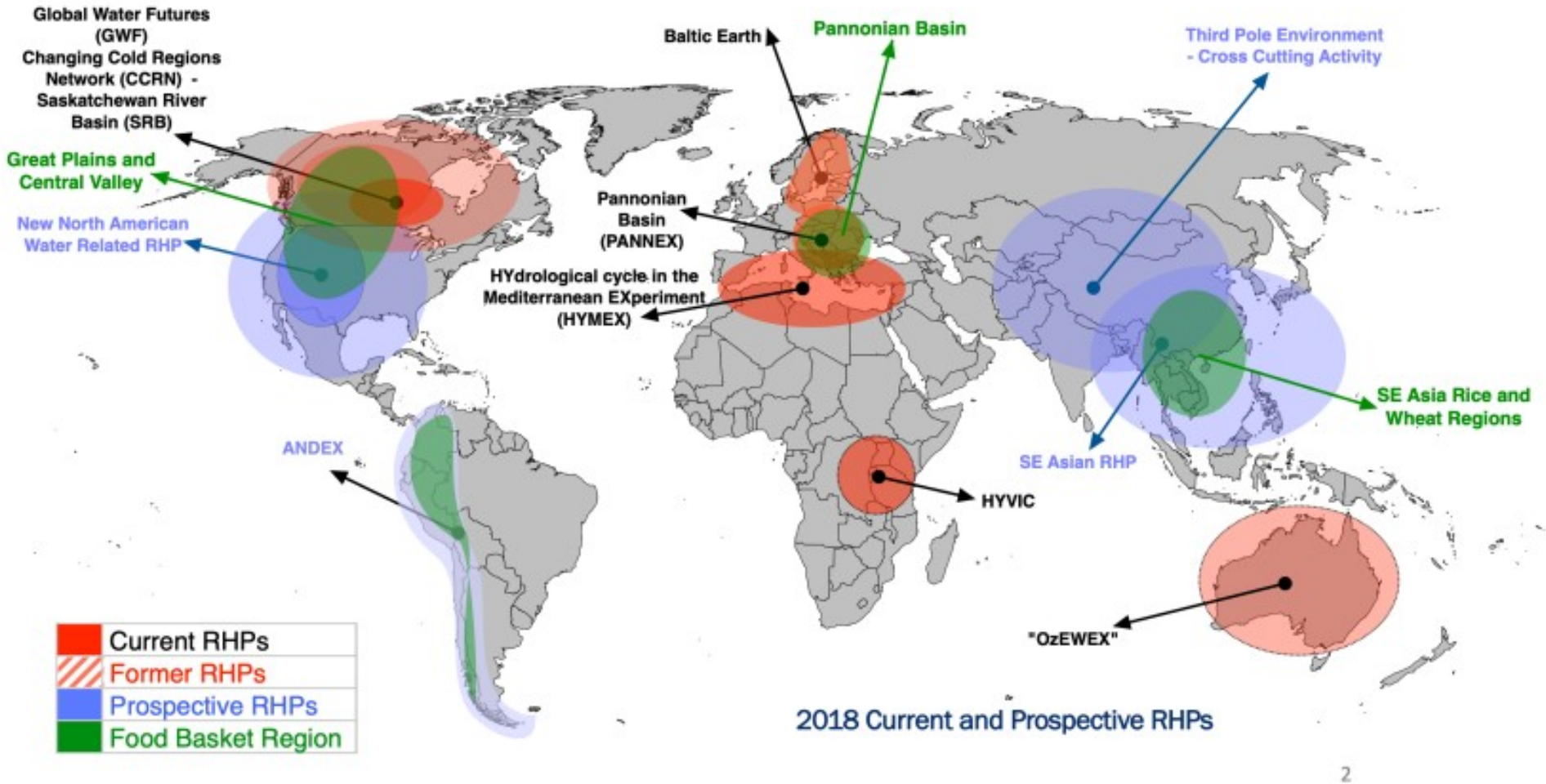
Water for the Food Baskets of the World

- 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

Regional Hydroclimate Projects



2018 Current and Prospective RHPs

Proposed Effort: Conduct Convective Permitting Simulations over the central U.S. foodbasket for 50 years at 4 km grid spacing with and without agriculture

Motivation :

- Understand the interactions between water management and climate variability and change.
- Improve our modeling capabilities of human water management.
- Regional re-analysis that includes the evolution of water usage and land use ... thus reproducing the real water cycle.

Why the central U.S. foodbasket?

- High importance to the U.S. and global food supply
- Availability of data and models to verify and run the model

Methodology :

- Dynamical downscaling with convection permitting models driven by re-analysis
- Include crop model with a dynamic irrigation module calibrated with irrigation data collected over the central U.S. from 1950 to present.
- Encourage multiple groups to perform the same simulation and inter-compare at workshops and on web sites
- Re-visit the last 50 years over a region with a large expansion of irrigated crops.

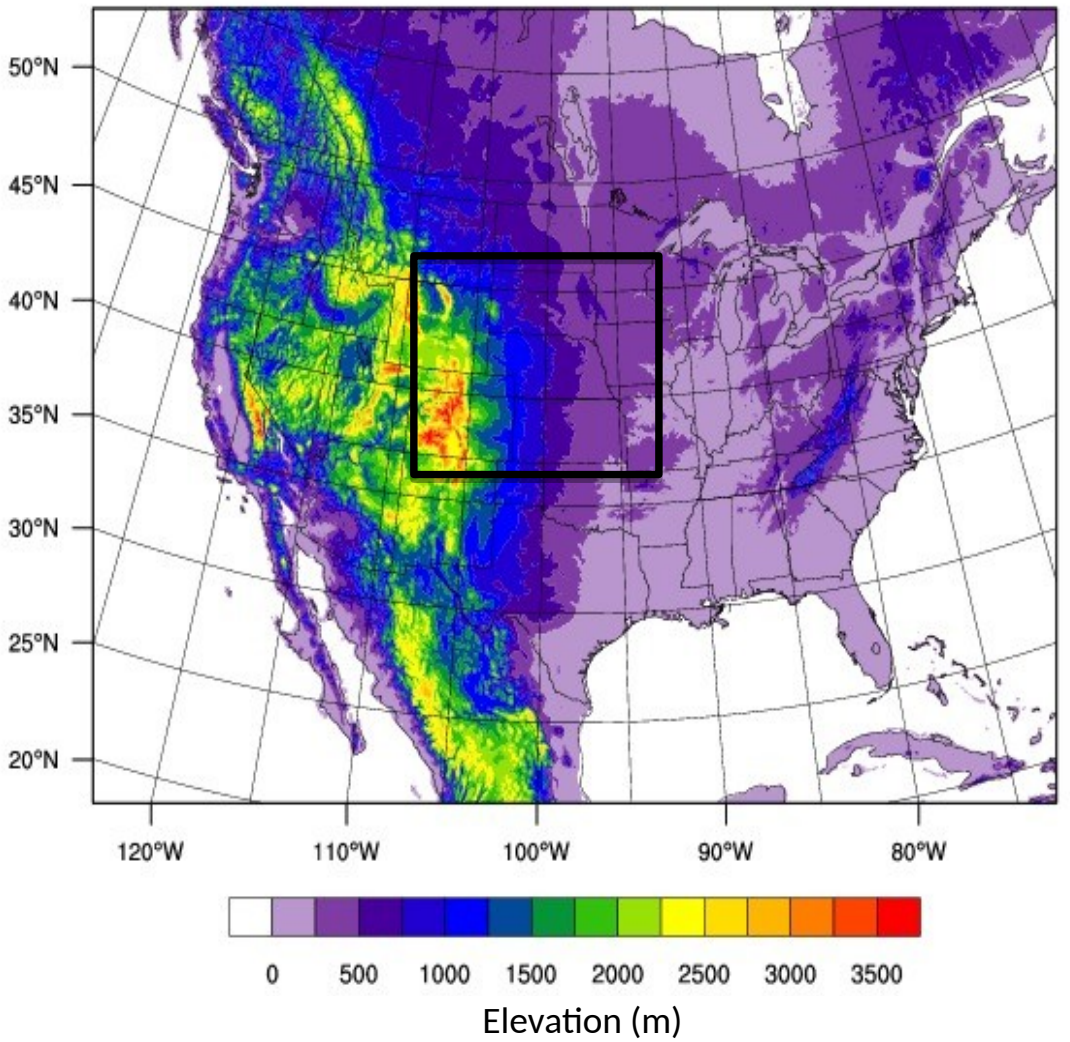
Prospectus:

Effort just starting. If interested in participating please contact:

Roy Rasmussen (rasmus@ucar.edu), Andreas Prein (prein@ucar.edu), Fei Chen (feichen@ucar.edu), Peter VanOevelen (gewex@gewex.org or pvanoevelen.gewex.org) or Jan Polcher (jan.polcher@lmd.jussieu.fr)

Website: http://www.gewex.org

Black Outline Indicated Domain for 50 year simulations



Activities related to Water for Foodbaskets

- Monthly telcons of interested participants starting in 2019 (started in February 2019, monthly thereafter)
- Townhall at GEWEX International Conference in Canmore
- Presentation and discussion at Convective Permitting Climate Modeling workshop in Sept. 2018, Boulder
- Held side meeting at AGU (25 participants)
- White paper completed.
- Creating a powerpoint deck that can share with participants
- Presented concept to NASA and NOAA agency leads during AGU 2018. Need to continue to pursue agency involvement.
- Engaged crop modelers with the effort (AGMIP workshop in 2018, AGU session 2018, Alex Ruane (NASA GISS) and Fei Chen (NCAR))
- Engaged with David Lawrence (NCAR) on the Land Use Model Intercomparison Project (LUMIP)
- Presented the Water for Foodbaskets effort at the January 2019 NCAR Water Systems retreat
- NCAR developing implementation plan for initial 50 year simulations

Activities 2019

- ANDEX, PANNEX and SE Asian RHP's in active development with focus on foodbaskets
  - Writing workshop ANDEX (finalize white book)
  - Workshops for PANNEX and SE Asia
- Development of the website: waterforthefoodbaskets.org
- Townhalls at EGU, AGU (proposed)
- Sessions on Conv. Permitting Modeling: AGU, EGU and AOGS
- Workshop CPM Zurich (Aug 2019)
- Further strengthening links to AgriMIP

Challenges in Representing Hydroclimatic Effects of Agriculture Management in Earth System Models

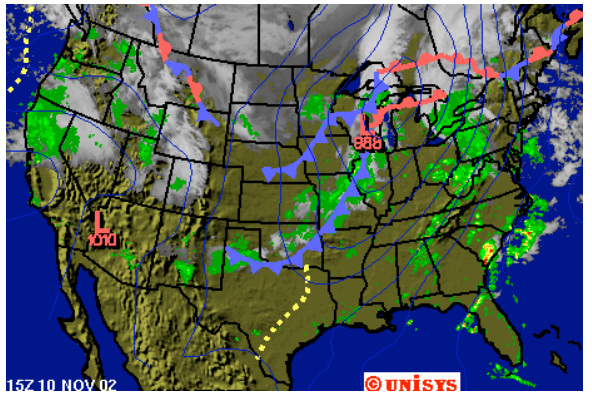
Fei Chen[1], Xiaoyu Xu[2], Michael Barlage[1], David Gochis[1], Xing Liu[3], Dev Niyogi[3], Alex Mahalov[4], Liping Di[5]

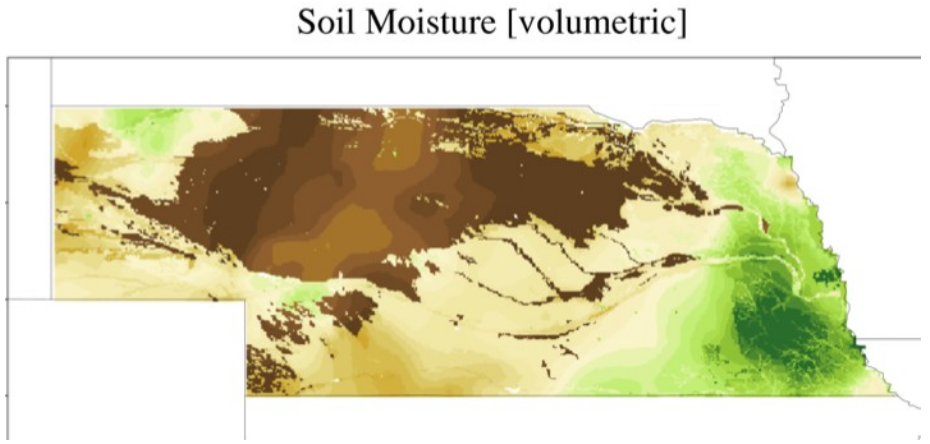
[1] National Center for Atmospheric Research
[2] Nanjing University of Information Science & Technology,
[3] Purdue University
[4] Arizona State University
[5] George Mason University

AMS 33rd Conference on Hydrology
8 January 2019, Phoenix, AZ

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.





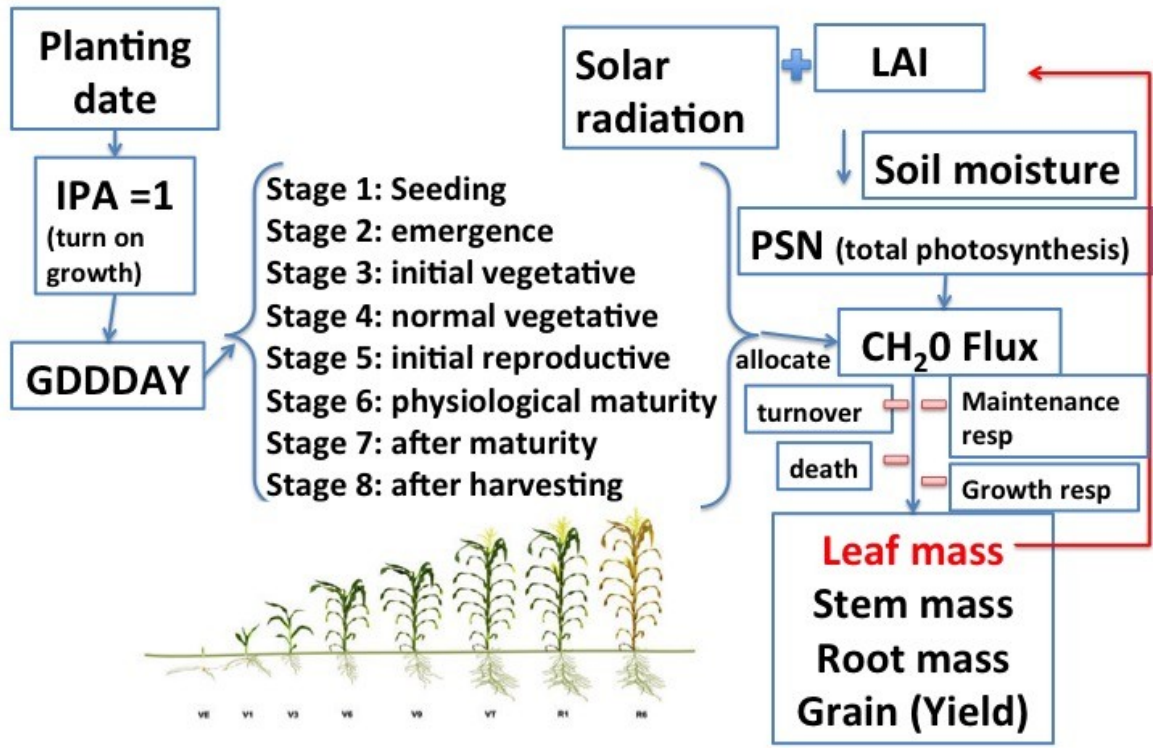
Main challenges in modeling agriculture in ESMs

- 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
-

WRF-Crop model development

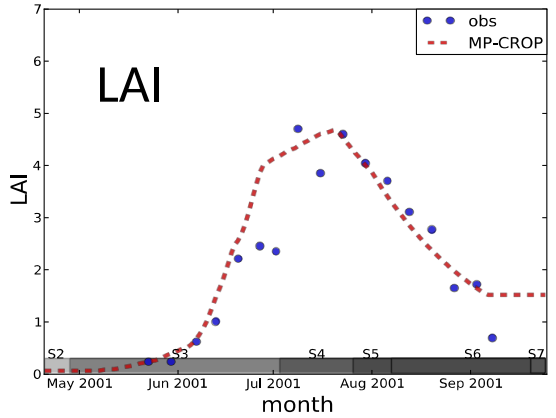
- Noah-MP-Crop (corn and soybean growth) models released in WRF 3.8 (2016)
- Implemented auxiliary crop data sets in WRF 3.9 (2017)

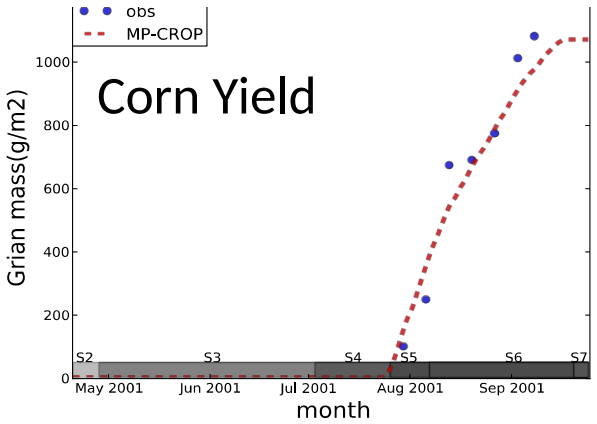
Noah-MP-Crop model



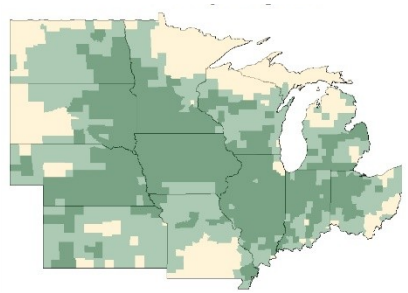
Liu et al., 2016, *JGR-Atmosphere*

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

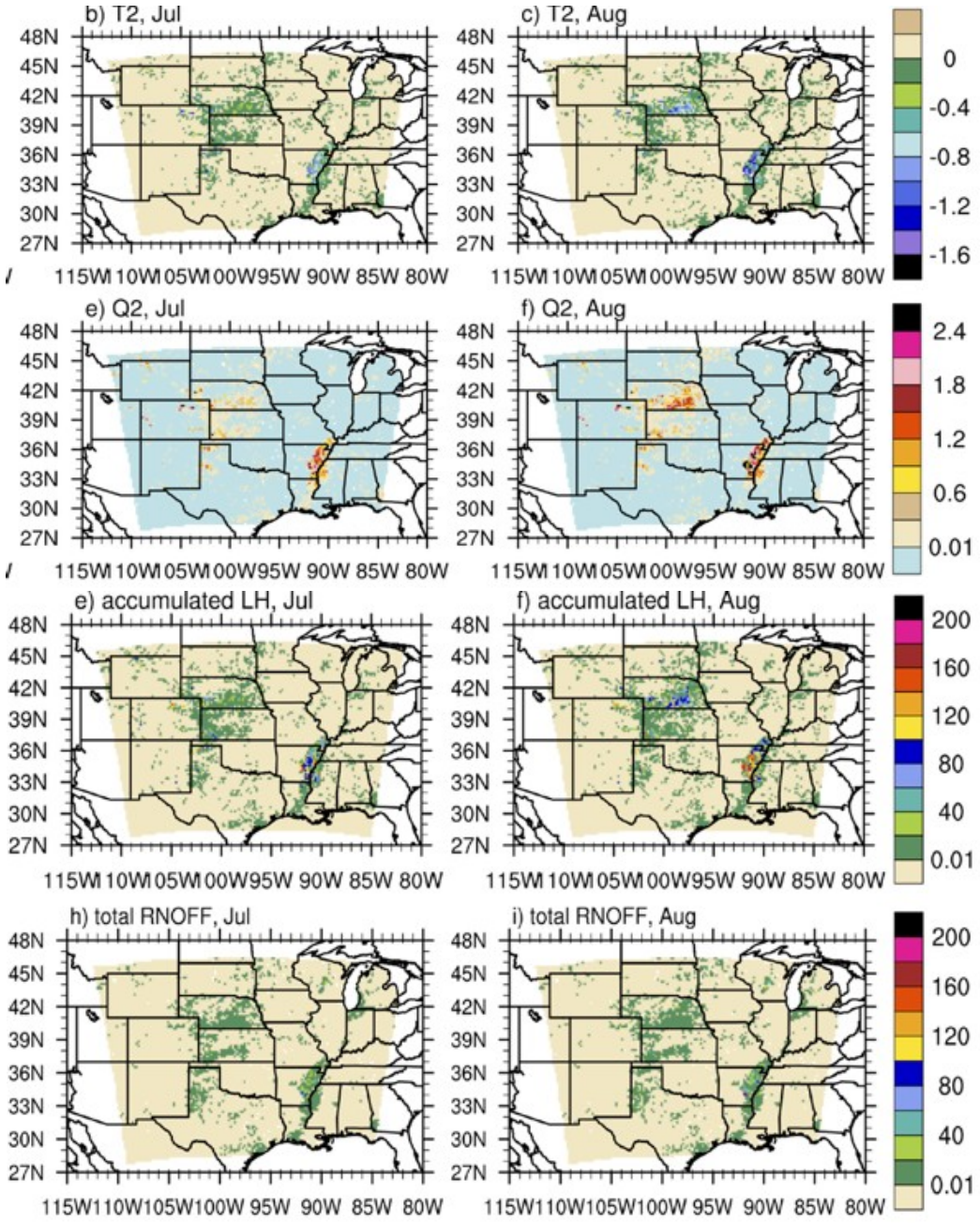




U.S. Corn Belt



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

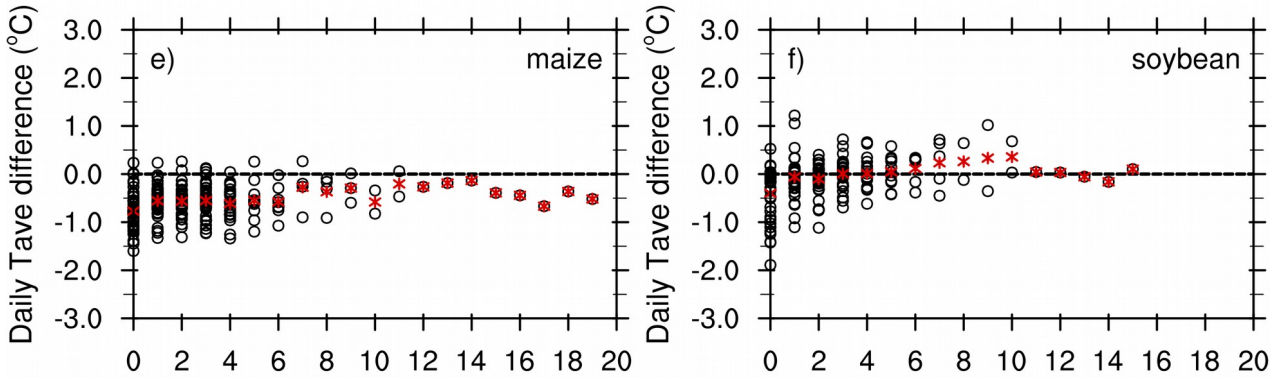
Increase air humidity by ~1.2~1.8 g kg^{-1} INE) and 2.4 g kg^{-1} (AR)

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

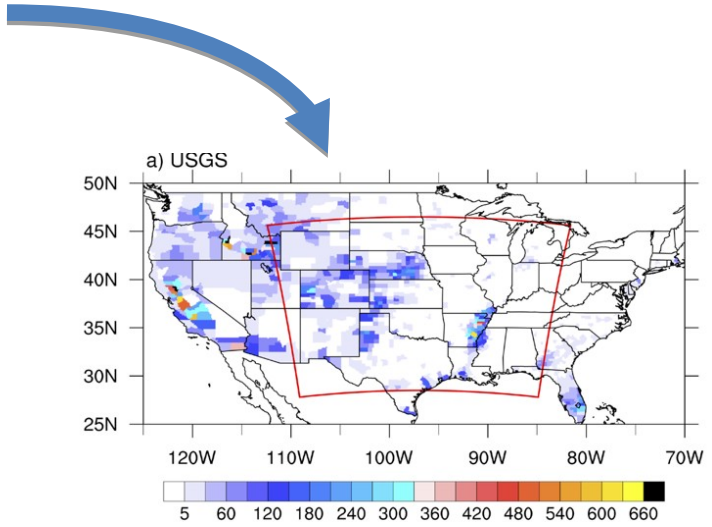
- increase monthly evaporation by up to 80 mm in NE and ~120 mm in AR
- increase monthly total runoff by ~ 20 mm

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

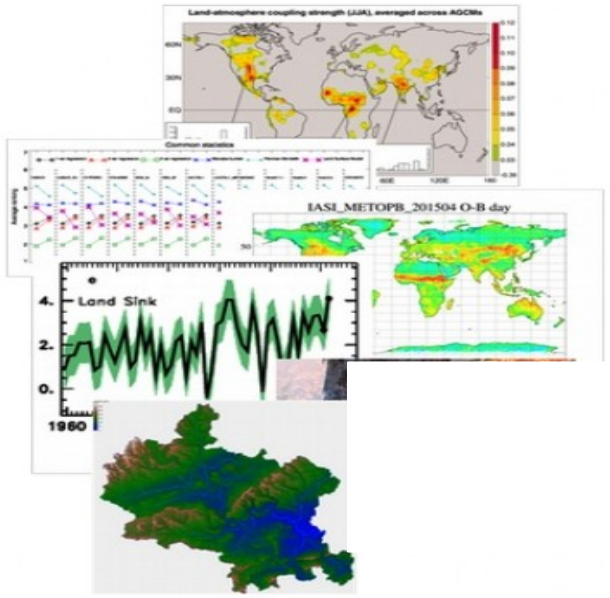
Objectives of HLIAISE :

The overall objective of HILIAISE is to better understand and model the **human imprint on the semi-arid energy and water cycle** over a region which has significant anthropization.
Project is part of HyMeX.

Three components :

Science

Questions

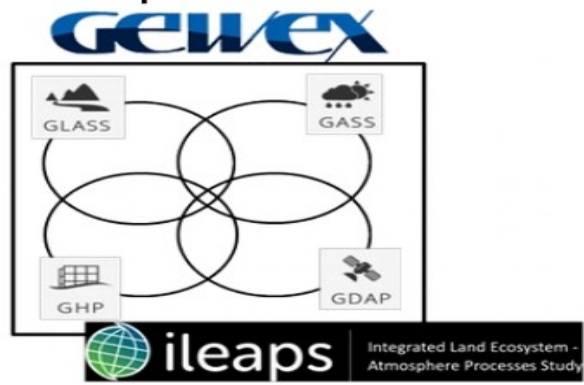


Observational

Capabilities

Community

Experiments



Science Questions

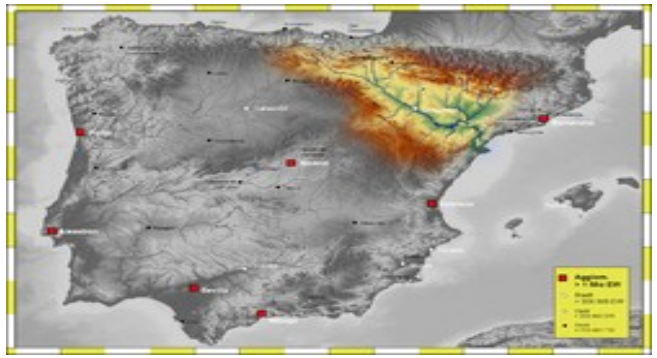
1) How does the anthropization (LULCC, irrigation...) impact the boundary layer development, mesoscale circulations and potentially precipitation recycling over this region via feed-backs with the atmosphere?

2) What are the key natural semi-arid processes and how does their spatial heterogeneity impact the planetary boundary layer growth and structure?

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

Field Campaign

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



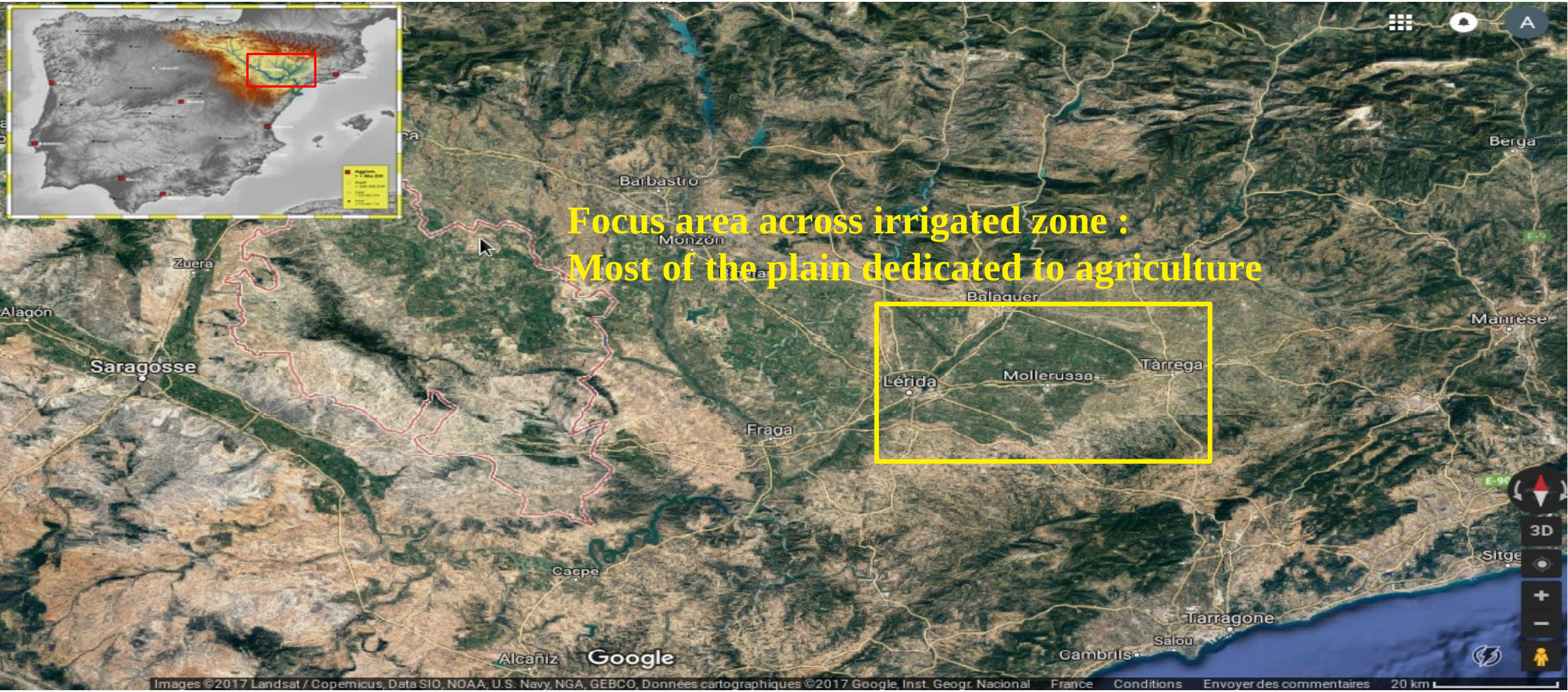
Ebro basin

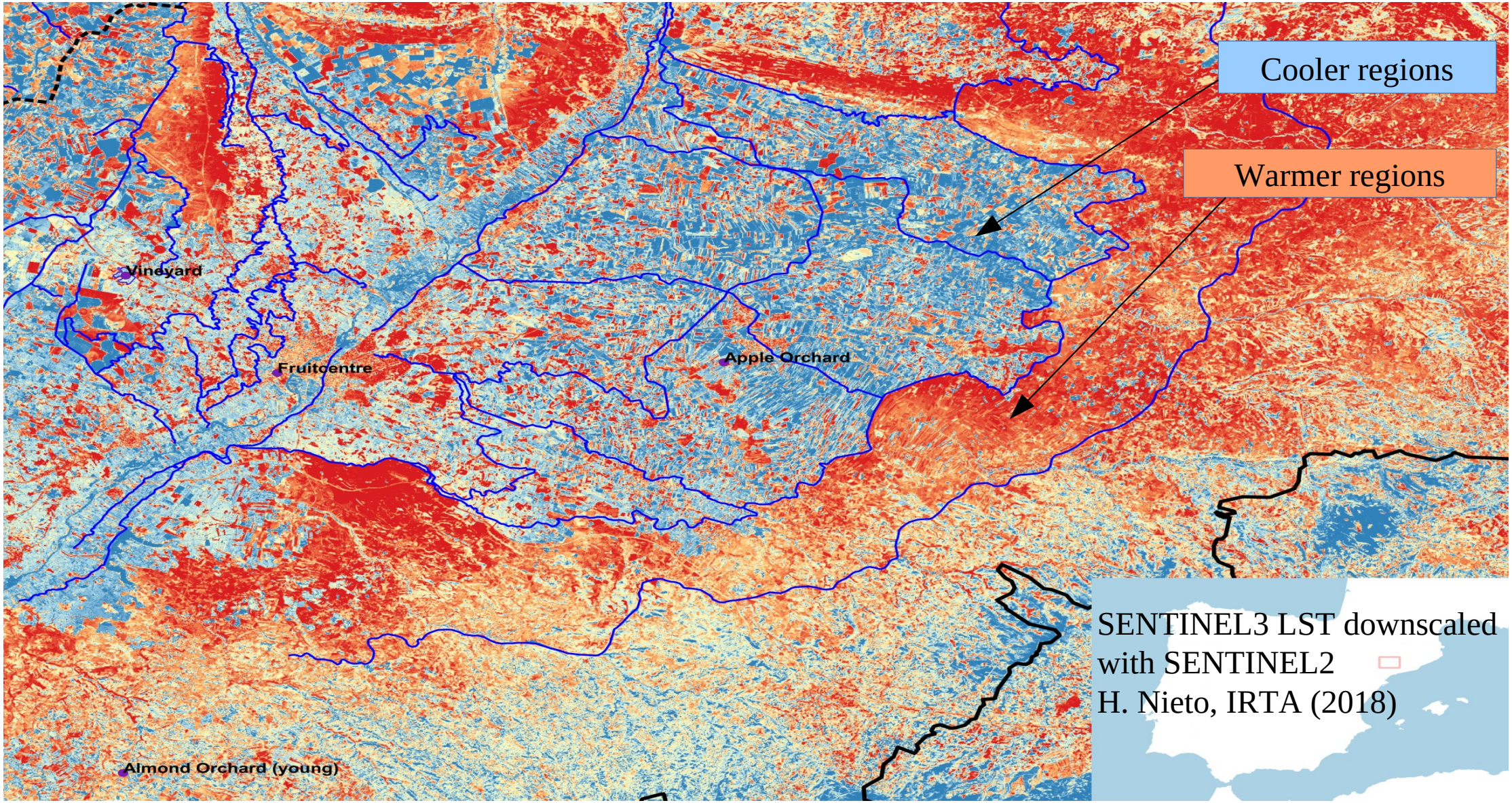
Surface-based deployment:

(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...)


Focus area across irrigated zone :
Most of the plain dedicated to agriculture
Barbastro
Monzón
Zuera
Alagón
Saragosse
Fraga
Caspe
Alcañiz
Balaguer
Lérida
Mollerussa
Tàrrega
Berga
Manresa
Sitges
Tarragone
Salou
Cambrils
Google
Images ©2017 Landsat / Copernicus, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, Données cartographiques ©2017 Google, Inst. Geogr. Nacional
France
Conditions
Envoyer des commentaires
20 km
3D


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

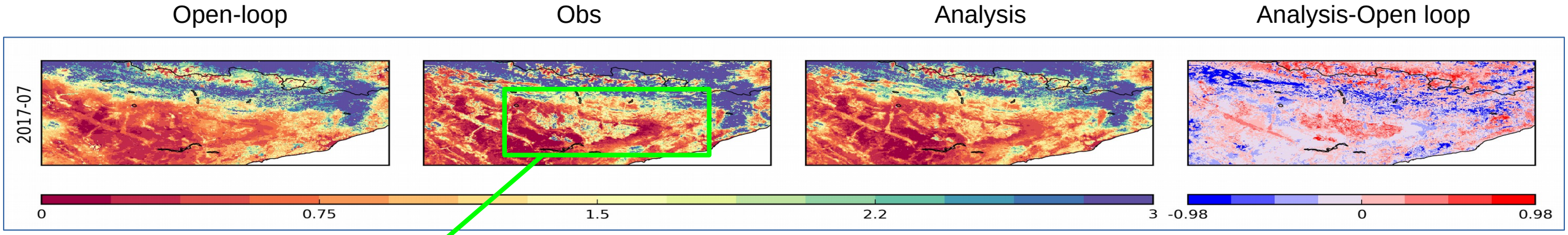
LIAISE case study

Zoom on the Ebro basin (July 2017)

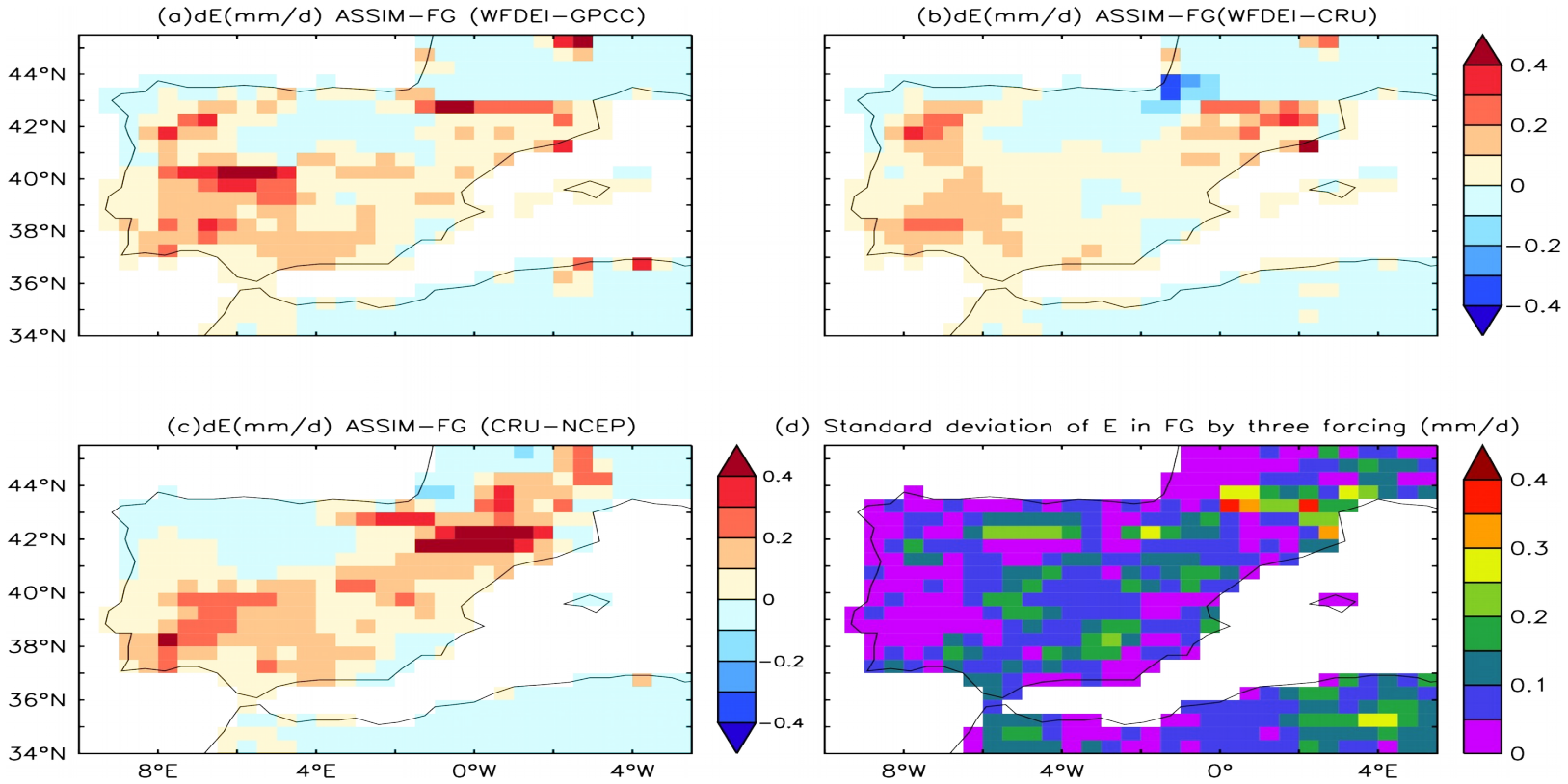
C. Albergel, CNRM

Experimental setup

Model	Domaine	Atm. Forcing	DA Method	AssimilatedObs.	Observation Operator	Control Variables	Additional Option
ISBA Multi-layer soil model CO_2-responsive version (Interactive veg.)	**Adour-Garonne & Ebro basins 2017**	**IFS dowscaled to 1km x 1km**	**SEKF**	**LAI** (GEOV1-300m)	**Second layer of soil (1-4cm) LAI**	**Layers of soil 2 to 8 (1-100cm) LAI**	**N/A**



- LAI Obs. (300m aggregated to 1km highlights areas with high LAI)
- Almost a perfect match with irrigated land presented on the left
- While the open-loop does not reflect these areas (no irrigation in SURFEX, yet [!]), this specific pattern is visible in analysis (i.e. after data assimilation)



- Assimilating observed river discharge allows to correct the water divergence over the continents.
- ORCHIDEE forced by classical forcing data.
- 27 stations from the GRDC database can be used on the peninsula.

The assimilation increases evaporation in areas known for intense agriculture.
The correction in E is larger than the variance of E estimates for all 3 forcing.

F. Wang, et al. 2018

Field Campaign : Last Campaign of HyMeX → Ebro Basin, NE Spain

Measurement strategy for 2020 :

Lower Atmospheric (3-4 km)

- Take observations within and outside of irrigated zone (UHF wind profilers, radiosounding releases and tethered balloons at 2 locations)...how is PBL conditioned over each of the regions and how does vapor and heat interact with non-irrigated atmosphere
- fluxes from aircraft (V, q, T) at multiple levels to sample convective PBL heterogenities

Surface

- 6 (or 7) SEB stations (surface flux, soil T and moisture profiles), each over a representative land cover :

1) Rain-fed fruit trees
2) Irrigated crops (alfalfa)
3) Natural grass+baresoil
4) Mixed holm oak/pine forest
5) Irrigated fruit trees

• Lake/reservoir (water stored/used for irrigation)

- Remote sensing products (irrigated surface, LST, superficial soil moisture)
- Aircraft measured LST and superficial soil moisture...how well do these measurements compare to satellite derived products ?

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
- Irrigation will either be imposed or simulated

Conclusion : Interactions with GEWEX panels

- 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.