Influence of Irrigation On Surface - Atmosphere Interactions: Insights from simulations with irrigation

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LIAISE Working Group 2

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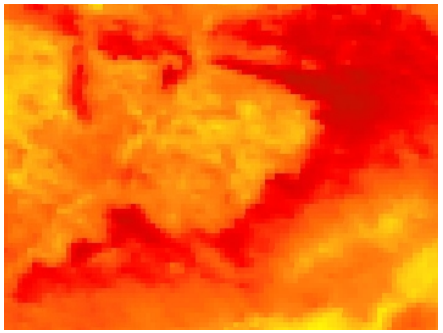
Plan

- Introduction & Context
- Methodology: Models and observation data
- Results
  - At the surface
  - Circulations & ABL
- Conclusions and prospects

Context

- Irrigation in surface – atmosphere coupled models nowadays:
  - Rare, approximative
    - Difficulties: where, when and how irrigation is performed?

Lleida region
seen by Sentinel 2
on 2021-07-22



Land Surface Temperature
seen by MODIS
on 2021-07-22

T2M forecasted by AROME
on Lleida region
For 2021-07-22T12

- Scientific questions:
  - What is the impact of irrigation on surface and atmospheric boundary layer (ABL)?
  - How important is it to consider irrigation in models? And how to represent it?

Models: standard configuration

General:

- From 2021/07/14 to 30 at 2km

Atmospheric model: *Meso-NH*

- Version 5-5-0
- Forced by ECMWF
- No deep convection parameterization
- Shallow convection parameterization
- Turbulence representation:
  - 1D (*L:* Bougeault & Lacarrère 1989)

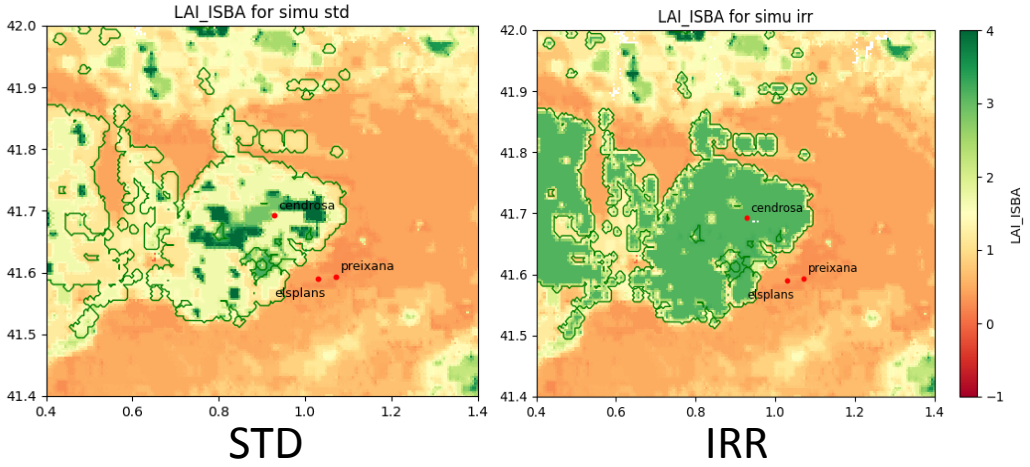
Surface model: *Surfex*

- Photosynthesis – Evapotranspiration scheme adapted to dry conditions (Calvet et al. - 2004)
- Diffusive scheme for heat and water with 14 layers in the soil
- No irrigation

Models: irrigation parameterization

Main modifications:

- Land cover database Ecoclimap-II (1999-2005): research and modification of irrigation related covers into a « pure » irrigation cover.
  - Main changes: LAI, C3 → C4, etc



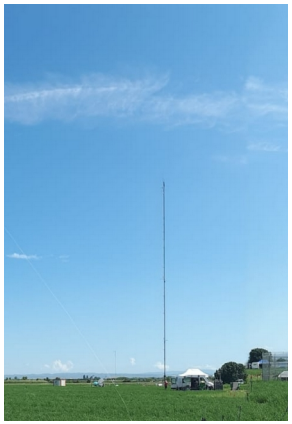
Sentinel-2 image on 2021-07-22

- Surfex: 1st parameterization of irrigation - simplistic vision (overestimation)
  - All irrigated zones start at field capacity
  - Water continuously added (0,36mm/h)

N.B.: Standard case still can see some features of irrigated areas

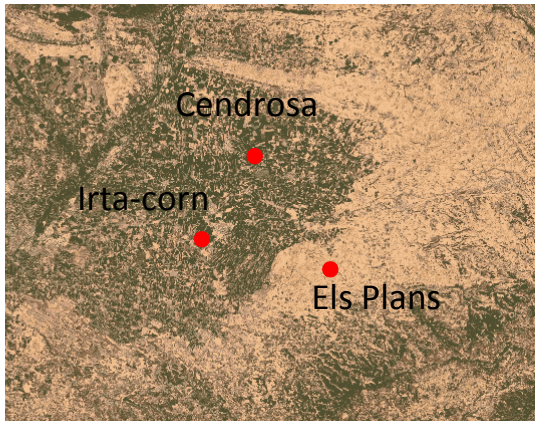
Observation data

- In irrigated zone
  - La Cendrosa: 50m mast + Radiosoundings – CNRM
  - Irta-corn: Surface Energy Budget station - UIB
- In rainfed/semi-arid zone
  - Els Plans: 50m mast + Radiosoundings - UKMO



La Cendrosa

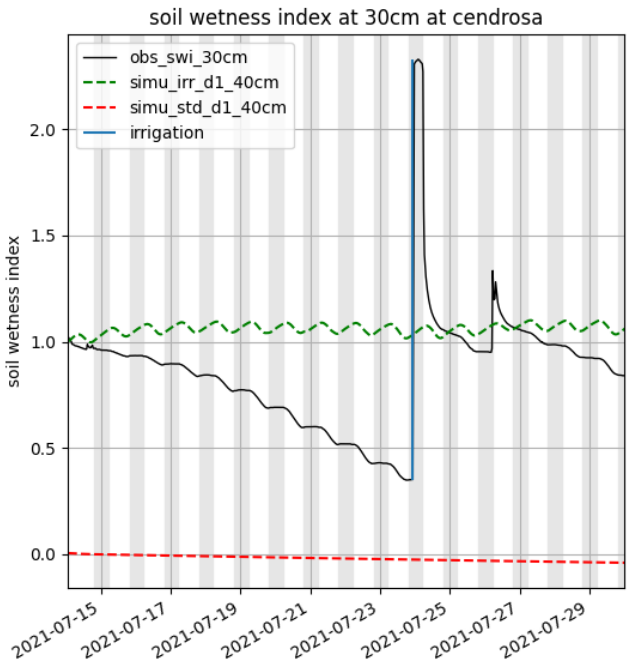
Irta-corn



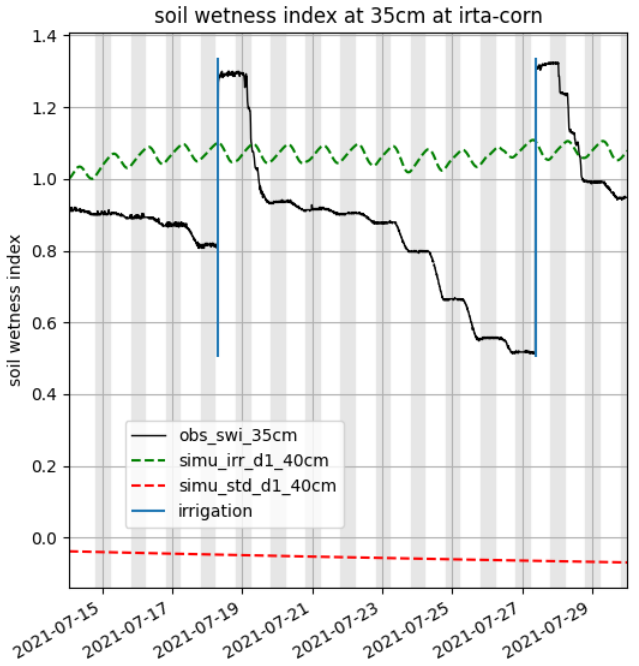
Els Plans

Results: Surface

Irrigation characteristics



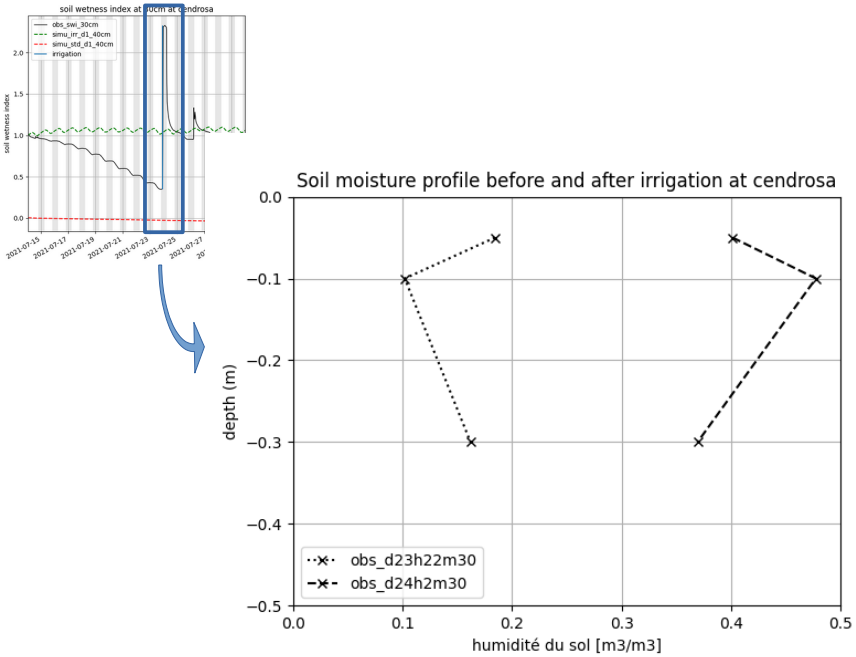
Cendrosa: irrigation events every 13 – 20 days

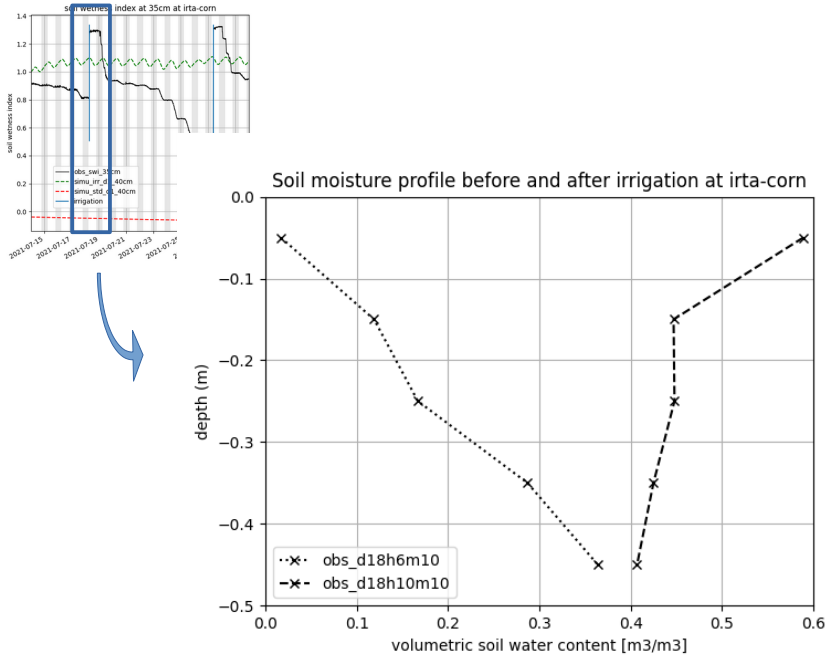


Irta-corn: irrigation events every 8 - 9 days

- Irrigated model at field capacity
- Standard model at wilting point or lower (negative SWI)

Irrigation characteristics





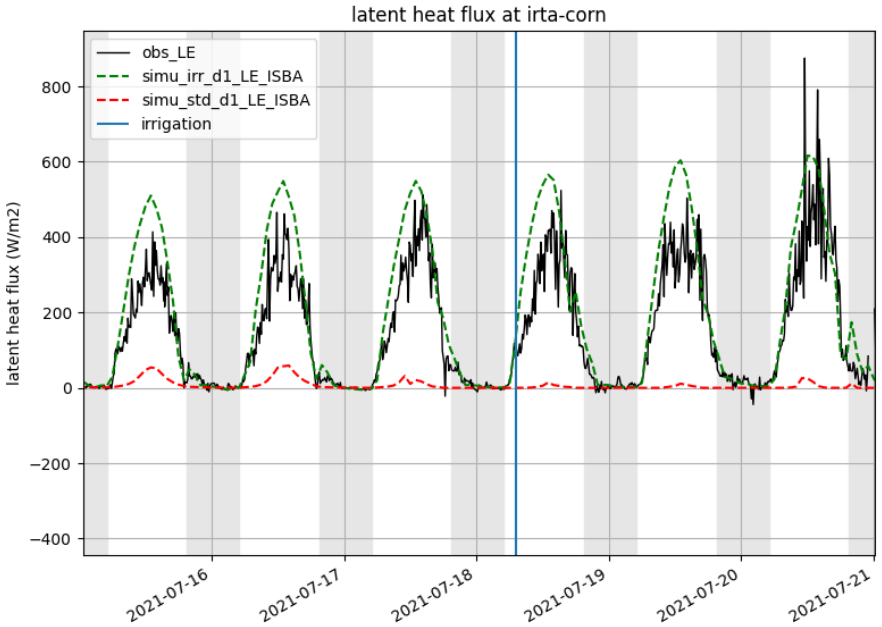
Cendrosa: irrigation events every 13 – 20 days

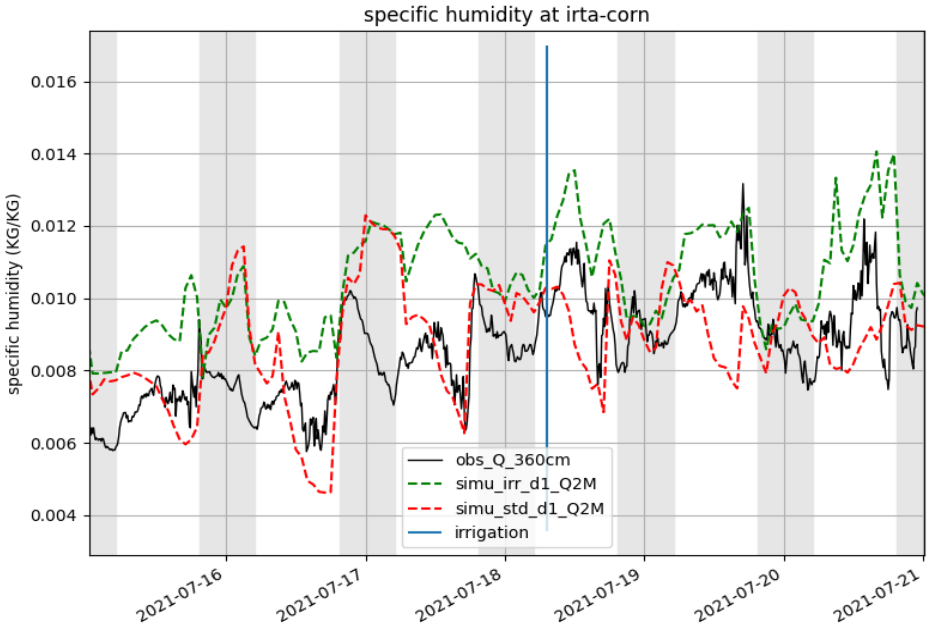
- 71mm added in first 30cm (underestimated)
  - Eq. ~9 days of continuous irrigation in the model

Irta-corn: irrigation events every 8 - 9 days

- 107mm added in first 45cm
  - Eq. ~16 days of continuous irrigation in the model

Irta-corn



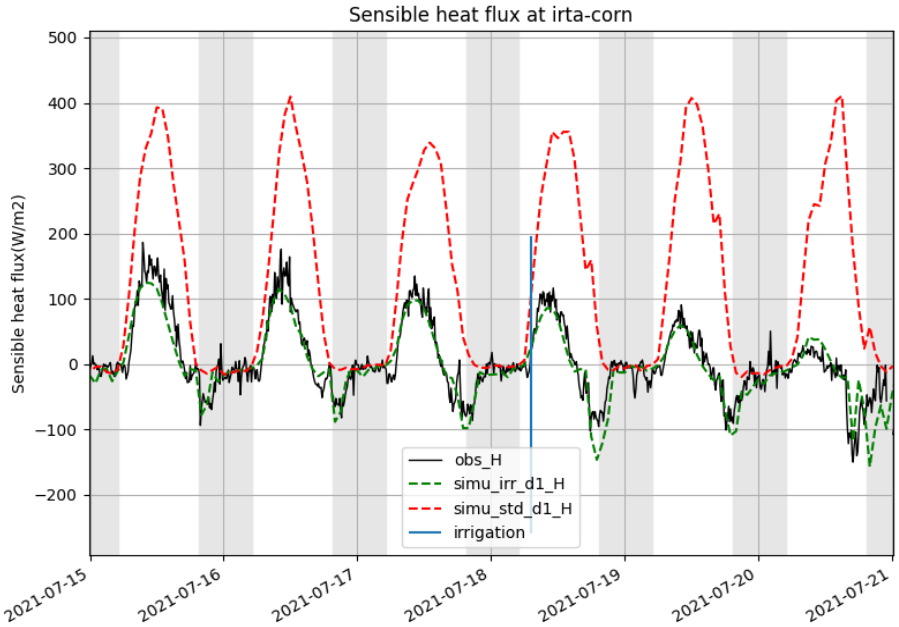


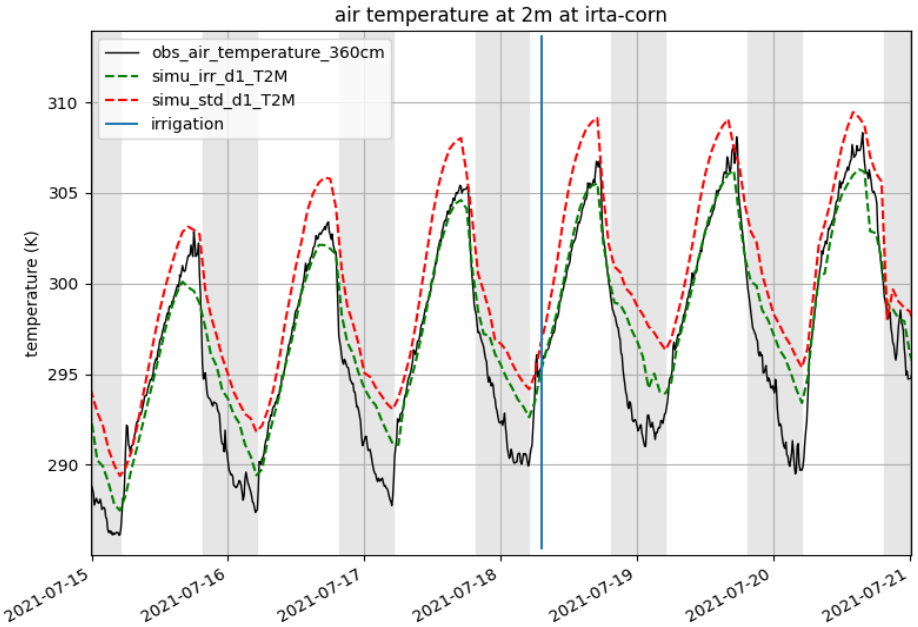
Biases:	irr = + 65 W/m²	std = -141 W/m2
RMSE:	irr = 118 W/m²	std = 210 W/m²

Biases:	irr = + 1,5 g/kg	std = - 0,2 g/kg
RMSE:	irr = 2,0 g/kg	std = 1,7 g/kg

- General overestimation of LE with irrigation model
- Overestimation of specific humidity during daytime
- No clear impact of local irrigation events on daily fluxes

Irta-corn





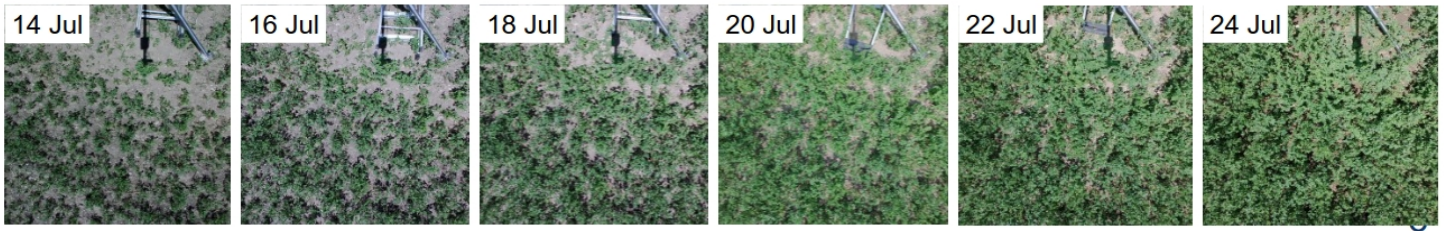
Biases:	irr = -7 W/m²	std = +134 W/m²
RMSE:	irr = 30 W/m²	std = 192 W/m²

Biases:	irr = + 0.96 K	std: + 3.28 K
RMSE:	irr = 2.0 K	std: 3.68 K

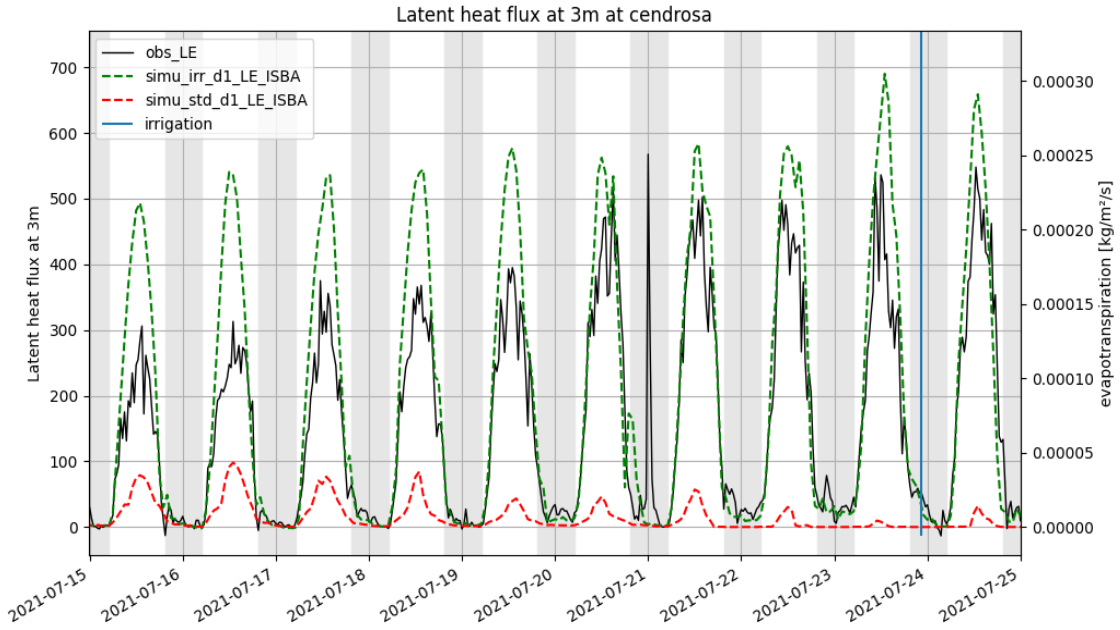
- Sensible heat flux drastically improved with irrigation model
- Warm bias during nighttime
- No clear impact of local irrigation events on daily fluxes

Cendrosa

- Major bias in la Cendrosa during the SOP is the LAI:
  - Alfalfa cut on july 5

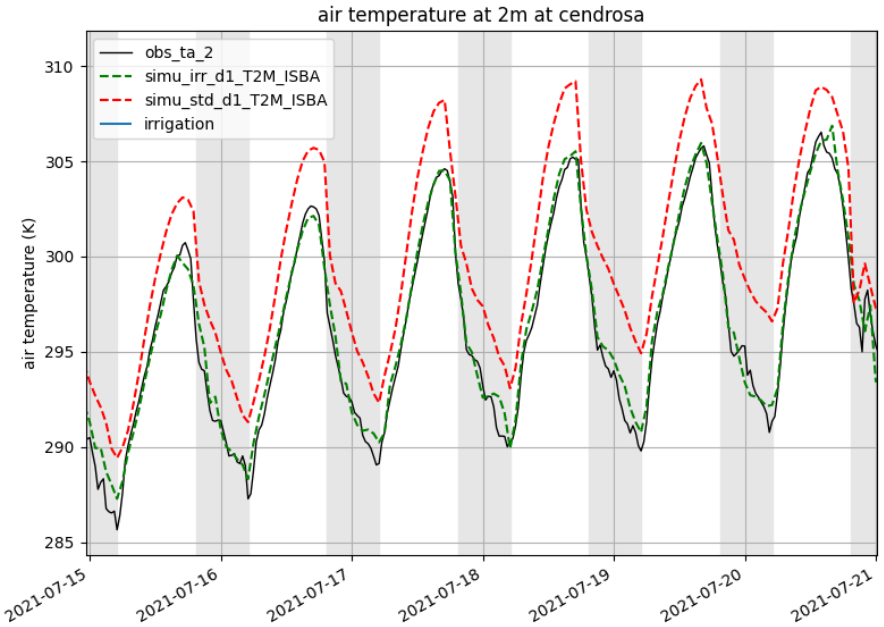


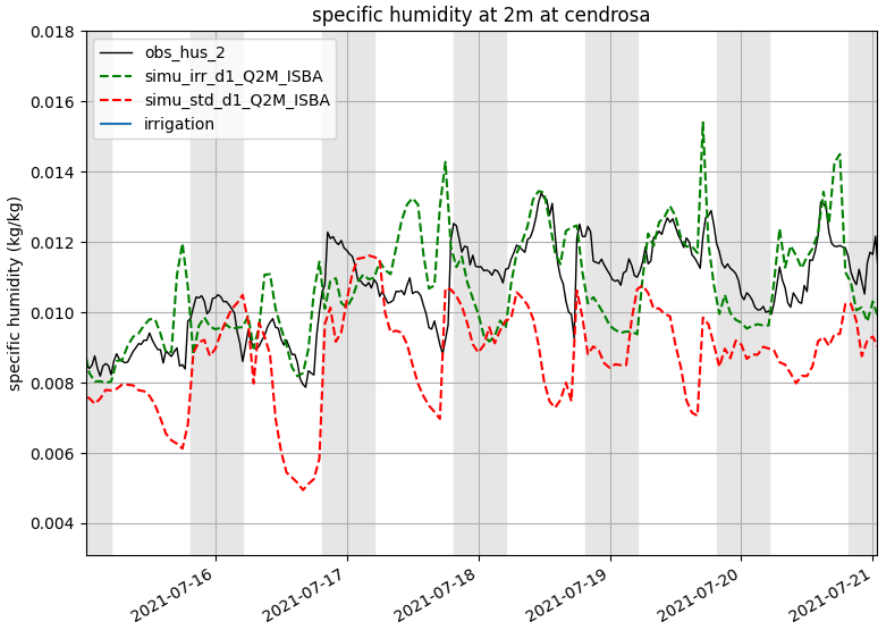
From Bastian Siegmann presentation (LIAISE WG1 2022-11-24)



- Nominal fluxes reached around july 20
- No clear impact of local irrigation events on daily fluxes

Cendrosa





Biases:	irr = 0.63 K	std = 4.09 K
RMSE:	irr = 1.34 K	std = 4.29 K

Biases:	irr = - 0,21 g/kg	std = -2,3 g/kg
RMSE:	irr = 1,4 g/kg	std = 2,7 g/kg

- Temperature and humidity at 2m are okay even before july 20

Conclusions on surface modelling

- Adding simplistic irrigation parameterization can improve modelled fluxes and temperatures.
- Temperature and humidity at 2m are more influenced by neighbourhood than by direct surface.
- Irrigation events do not result in noticeable changes in heat fluxes the days after.

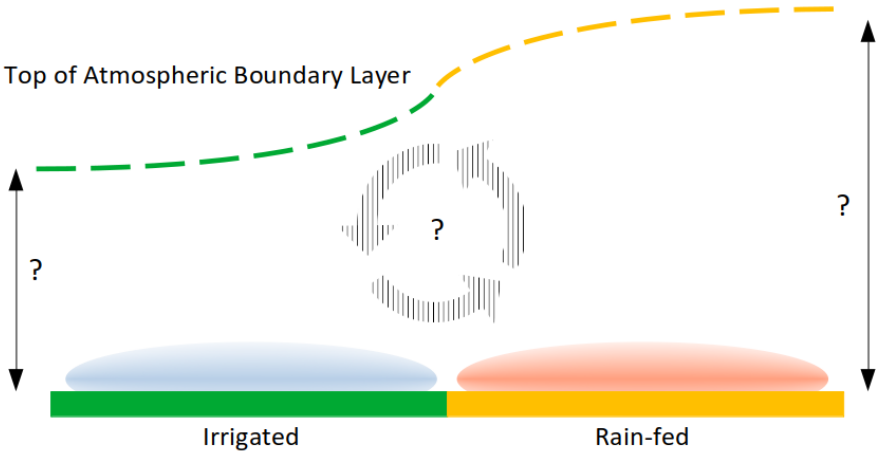
→ Representing regional irrigation in models is important.

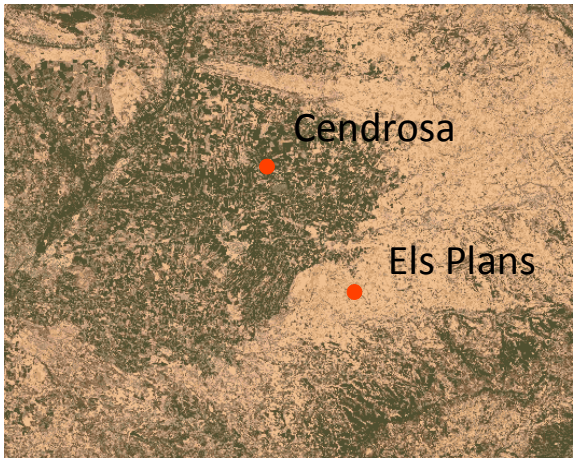
→ But representing time and precise location of each irrigation event is not important.

Results: Circulations in the ABL

Circulations

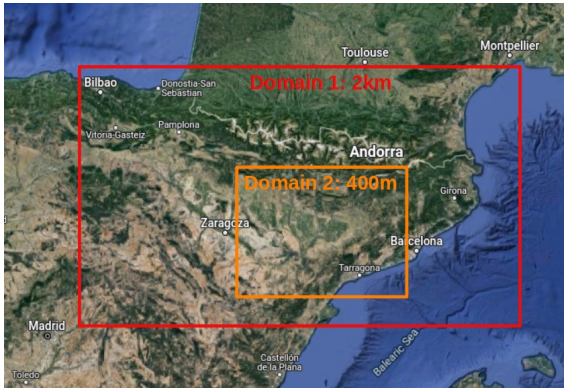
- Circulations in the Atmospheric Boundary Layer
  - Influence of irrigation on height of ABL?
  - Irrigation breeze?
  - Stability and humidity in ABL?
- Surface sites and radiosoundings: Cendrosa and Els Plans

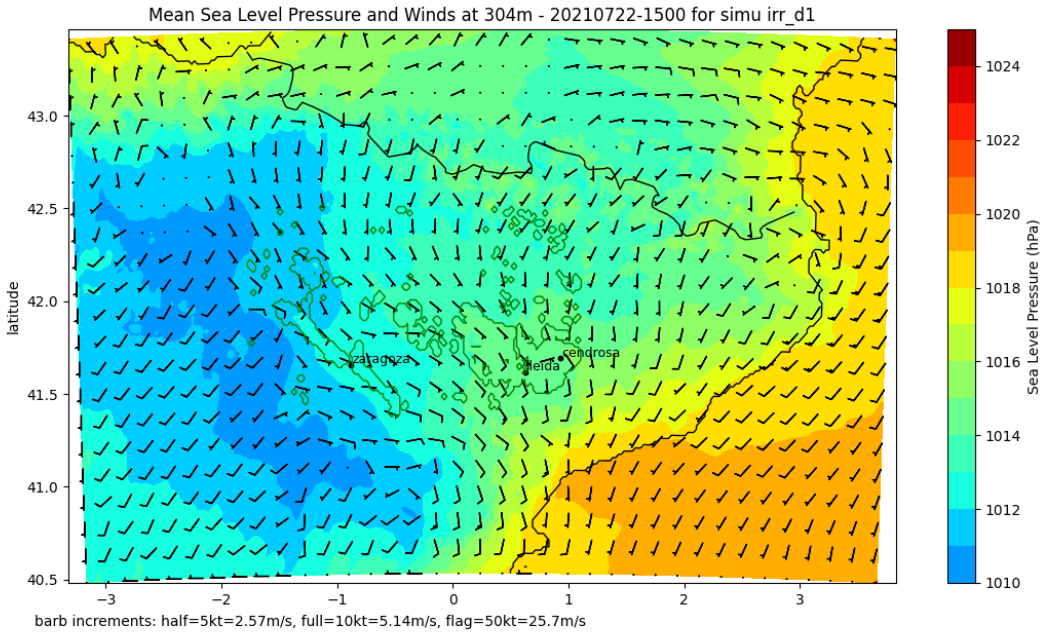


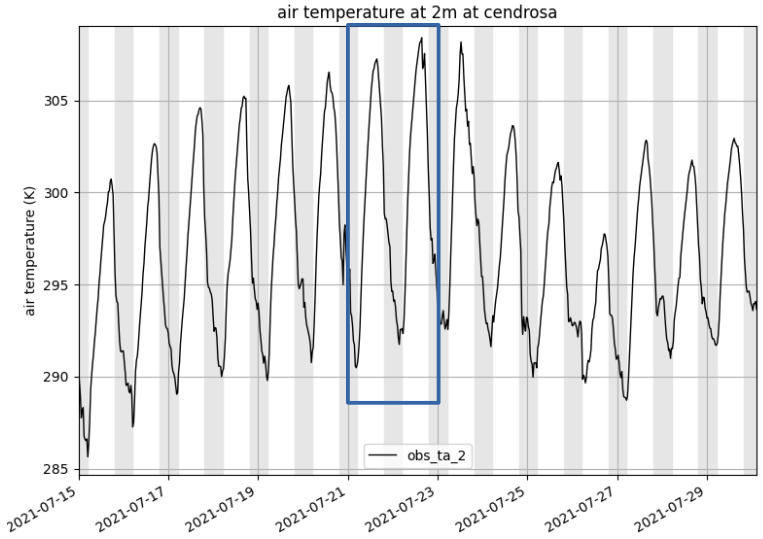


Circulations

- Zoom on July 21-22
  - Thermal low
  - South-East wind near the surface
  - The hottest clear days
- Nested simulation with horizontal resolution of 400m
  - No shallow convection / 3D turbulence / adaptive mixing length for grey zone of turbulence

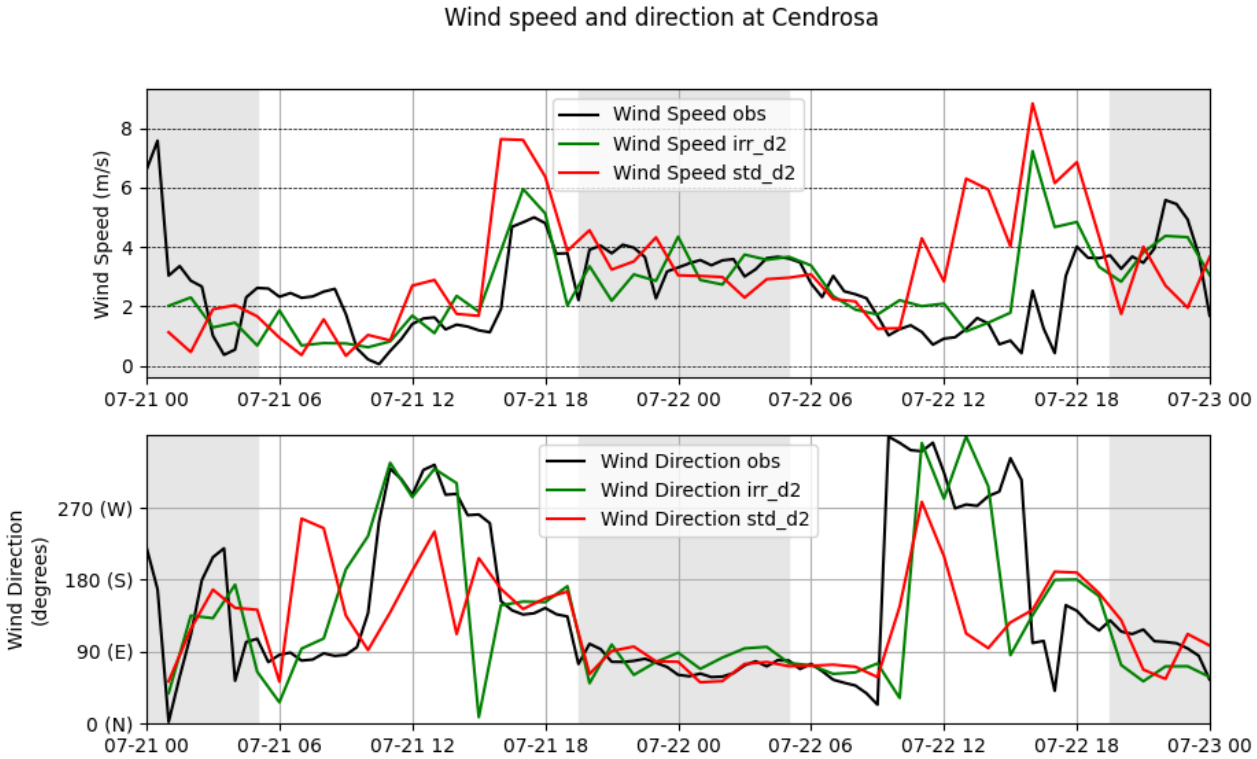




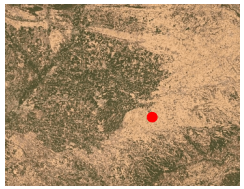


Surface winds: Cendrosa

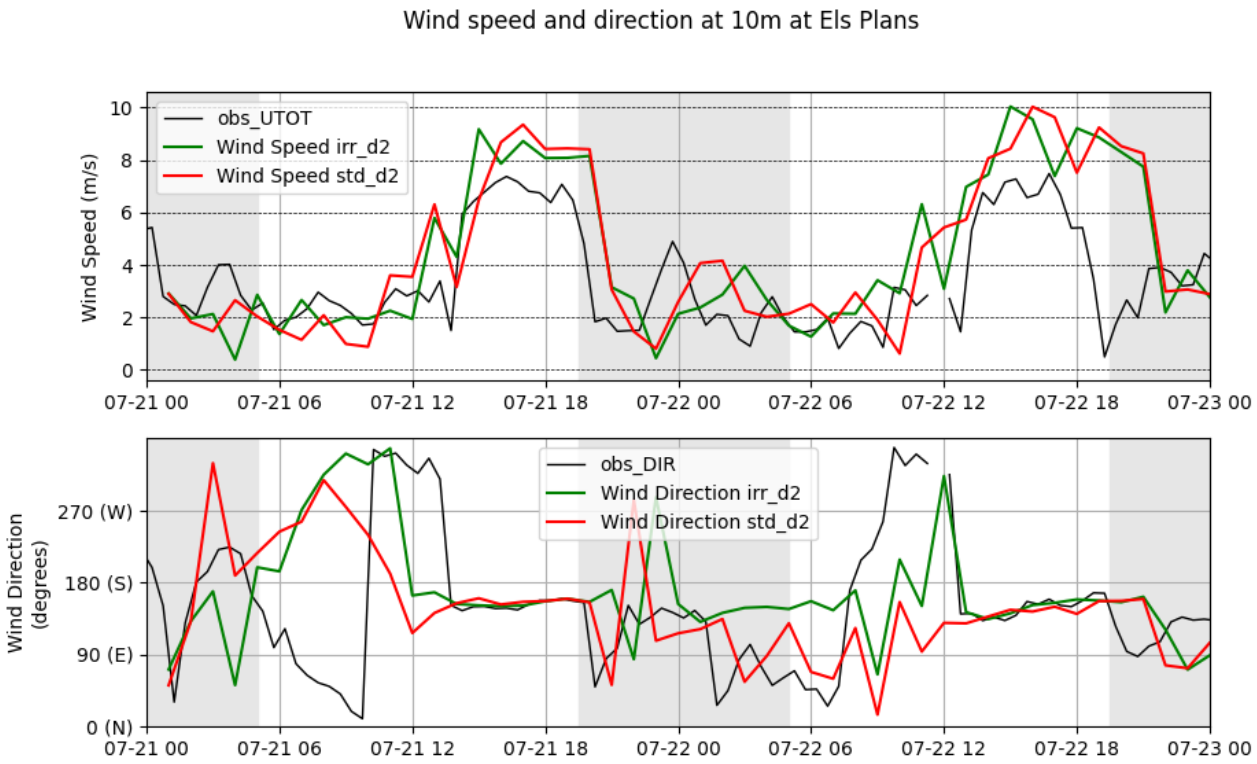
- Wind speed slightly better with irrigation model
- Wind direction changed around noon: irrigation breeze



Surface winds: Els Plans



- Wind direction changed around noon: irrigation breeze



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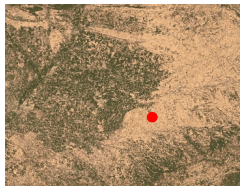

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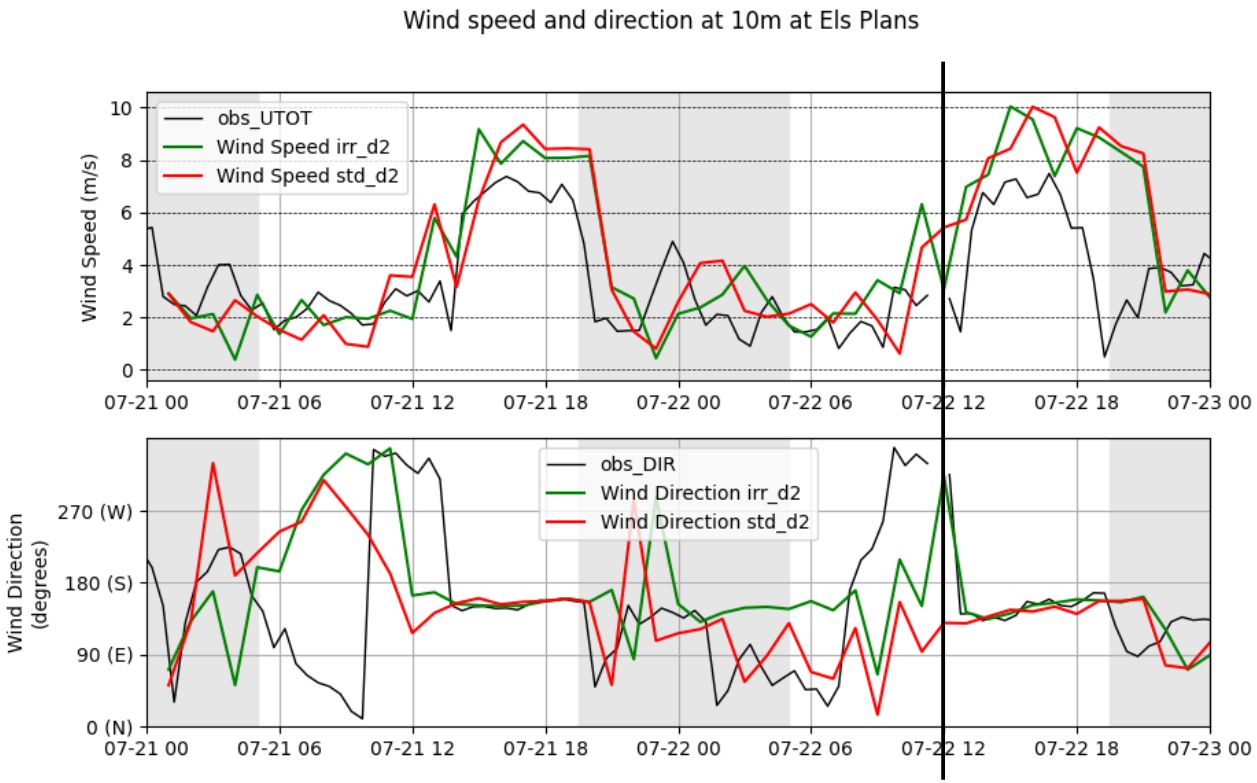
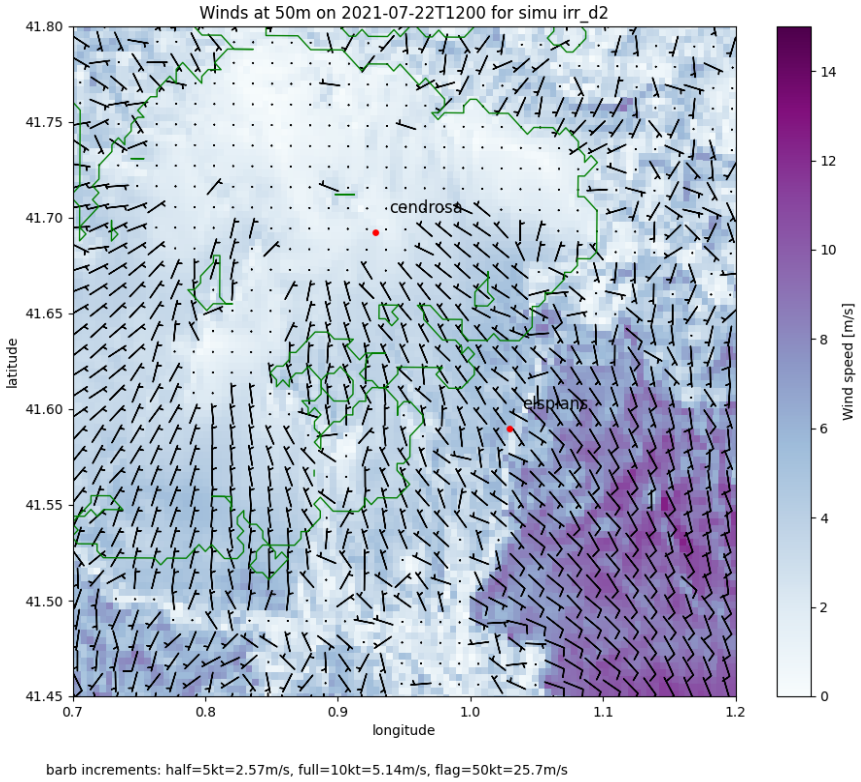


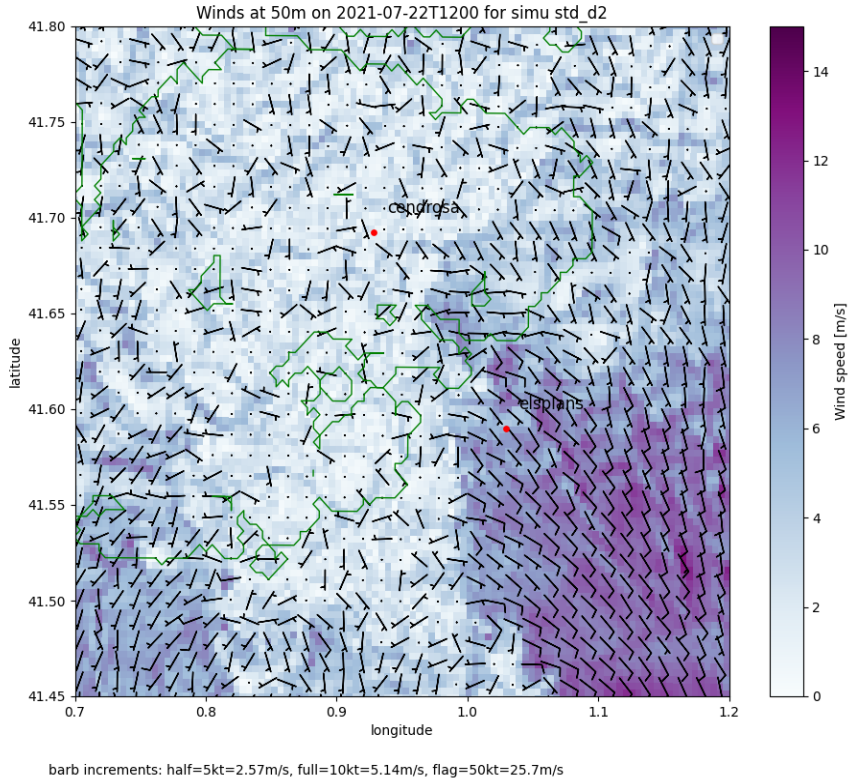
Surface winds

- Horizontal winds on july 22 at 12pm: irrigation breeze confirmed in the model

IRR



STD



Surface winds

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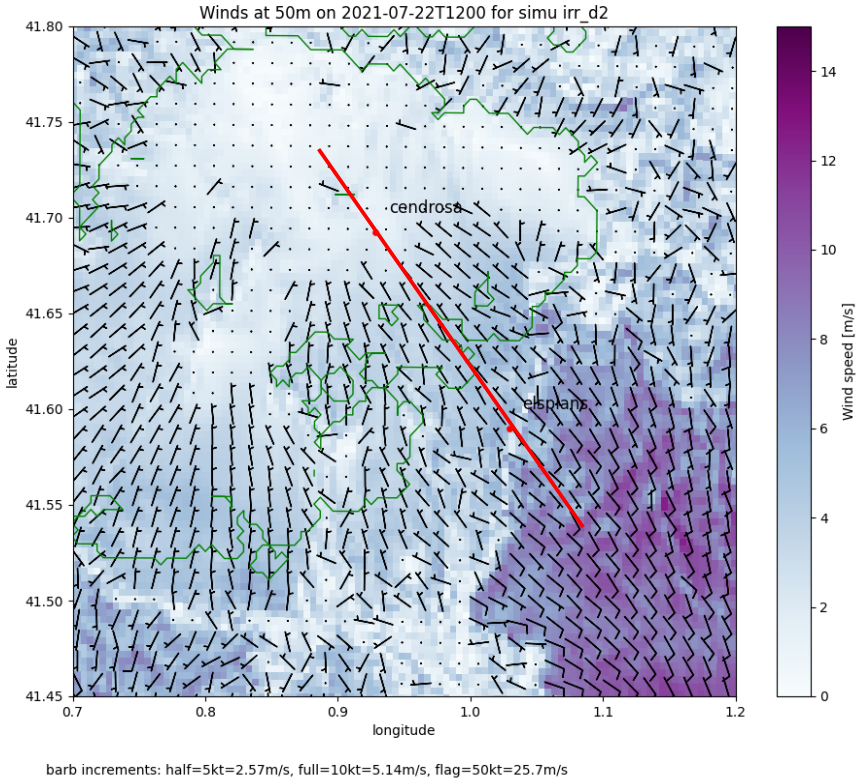

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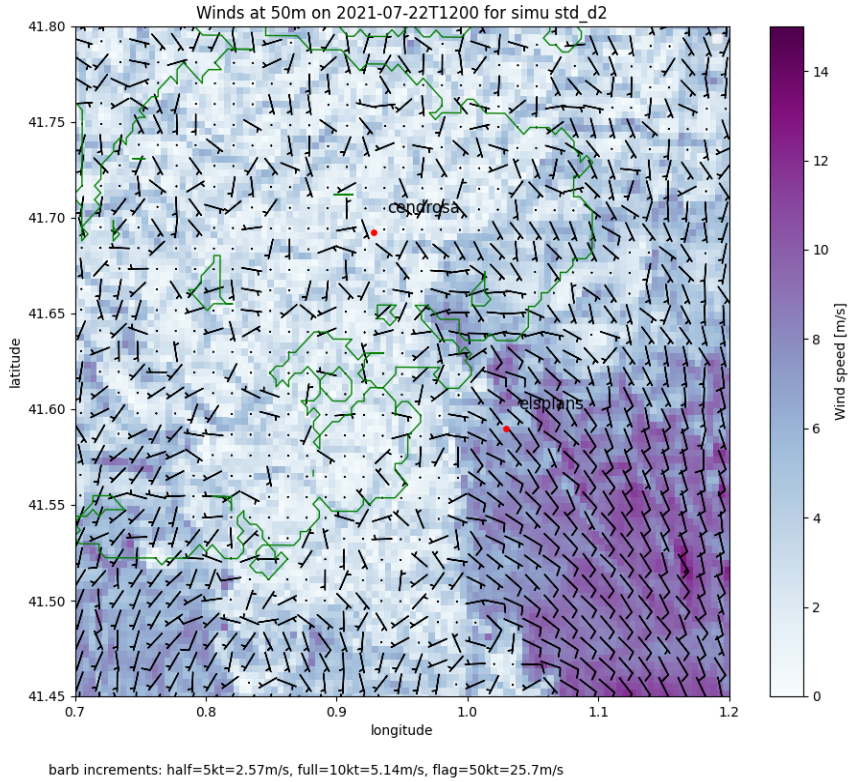
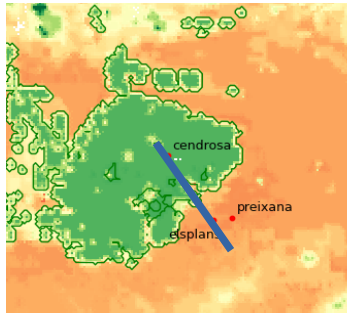
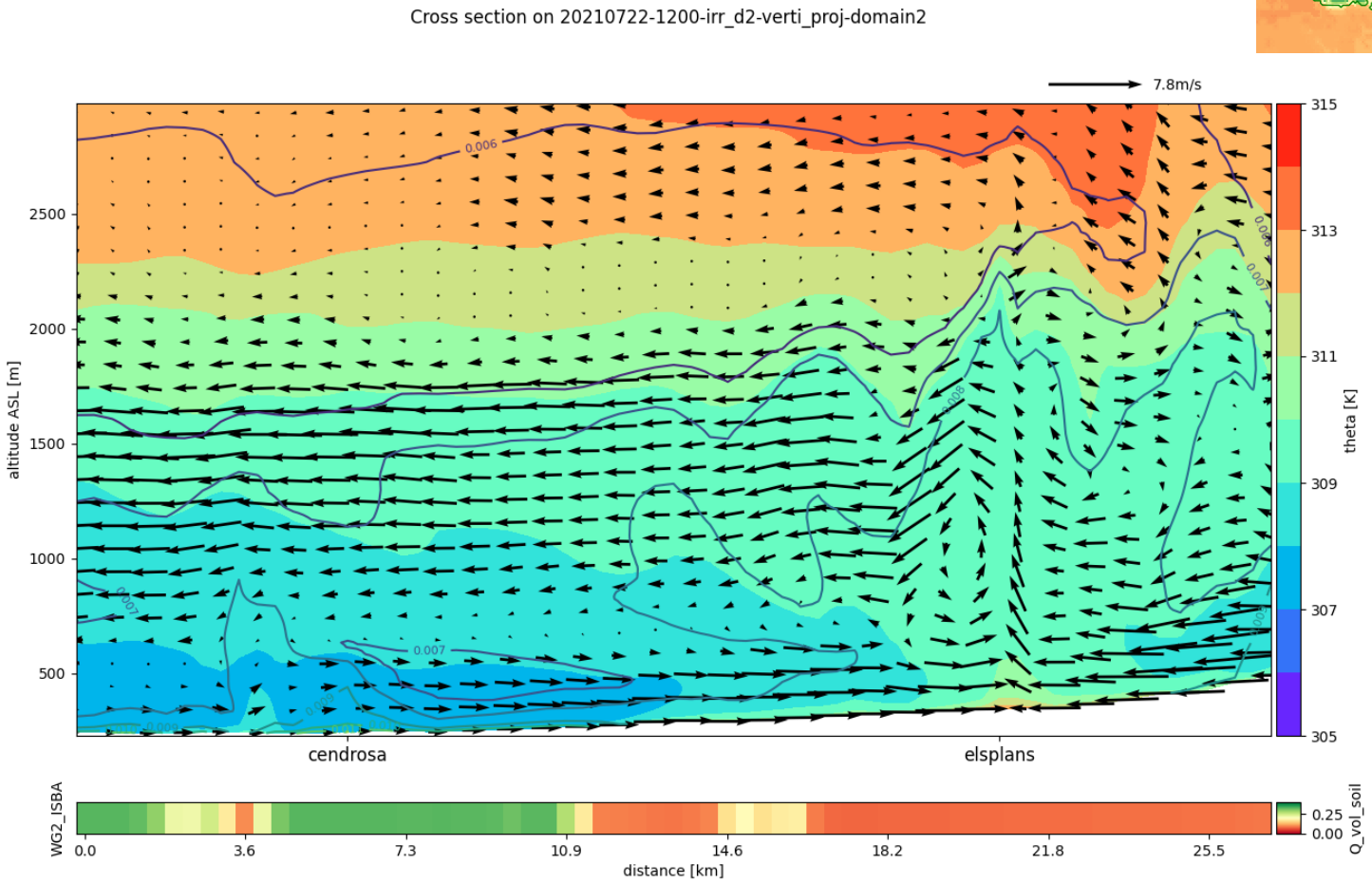


Circulations

- Clear irrigation breeze:





Circulations

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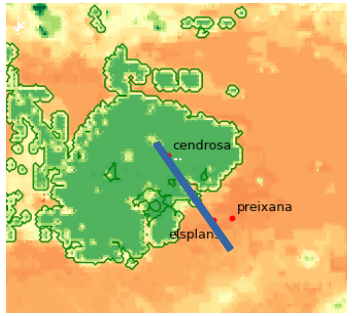
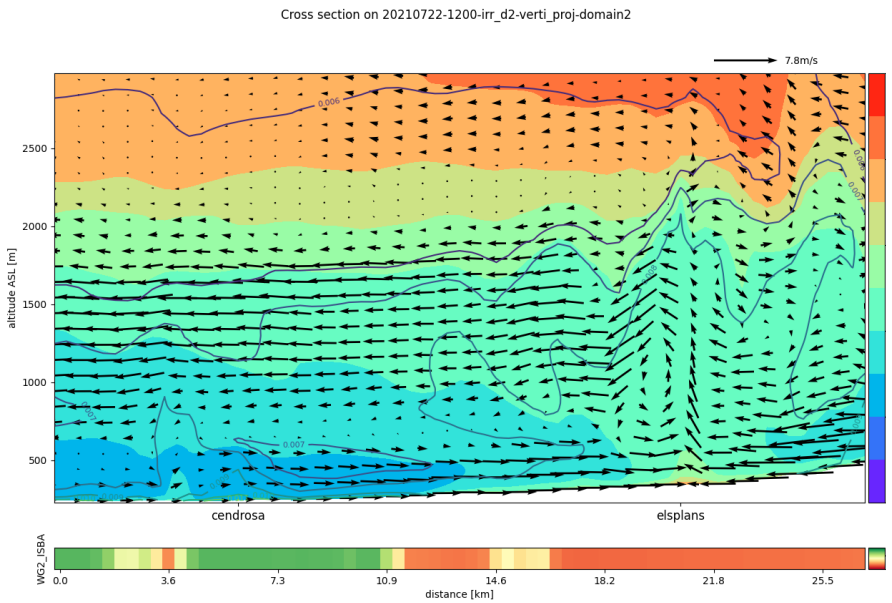


IRR



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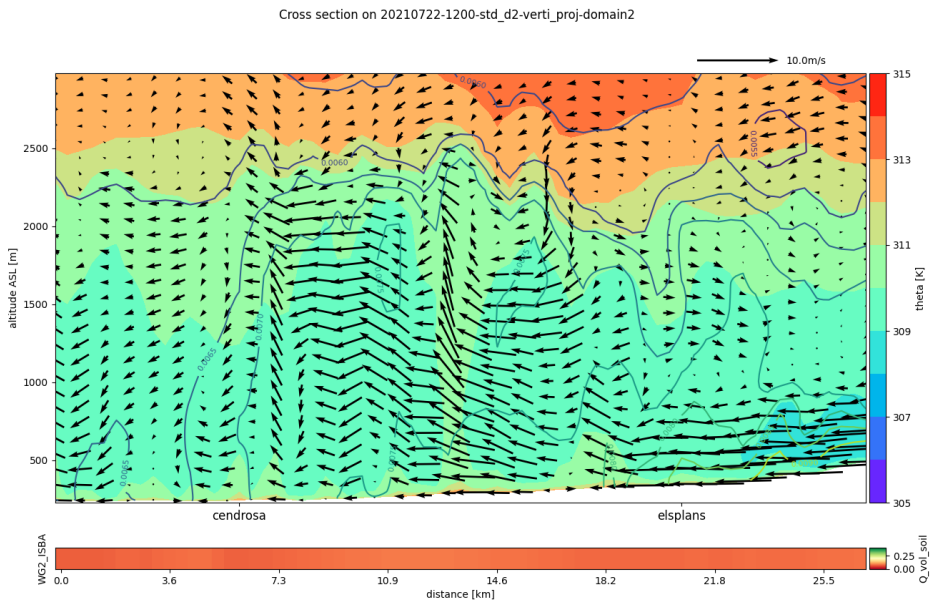
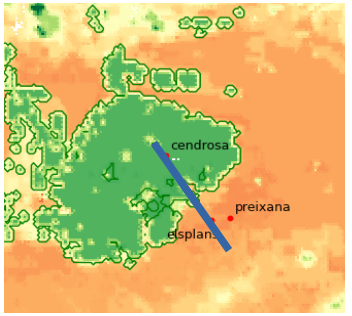


Circulations

- Clear irrigation breeze : transition zone elsplans



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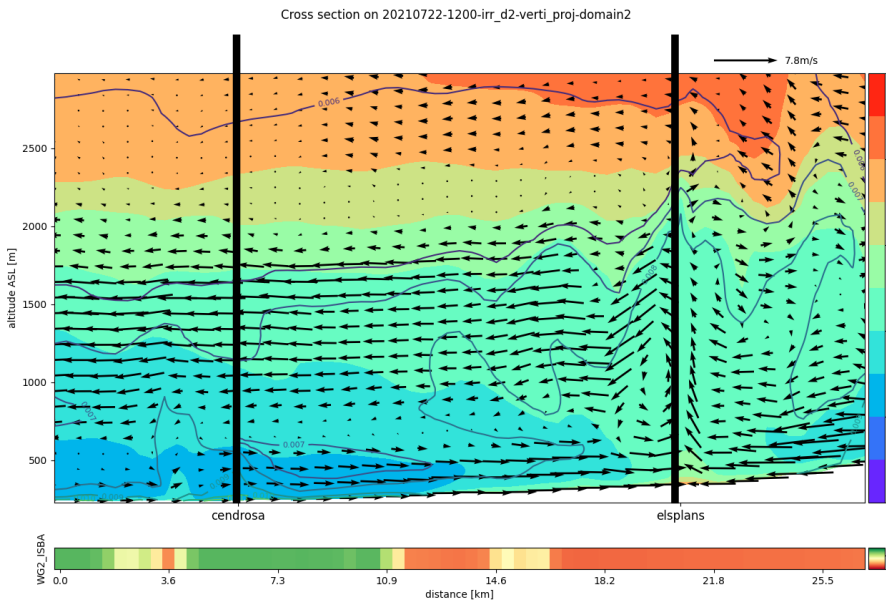
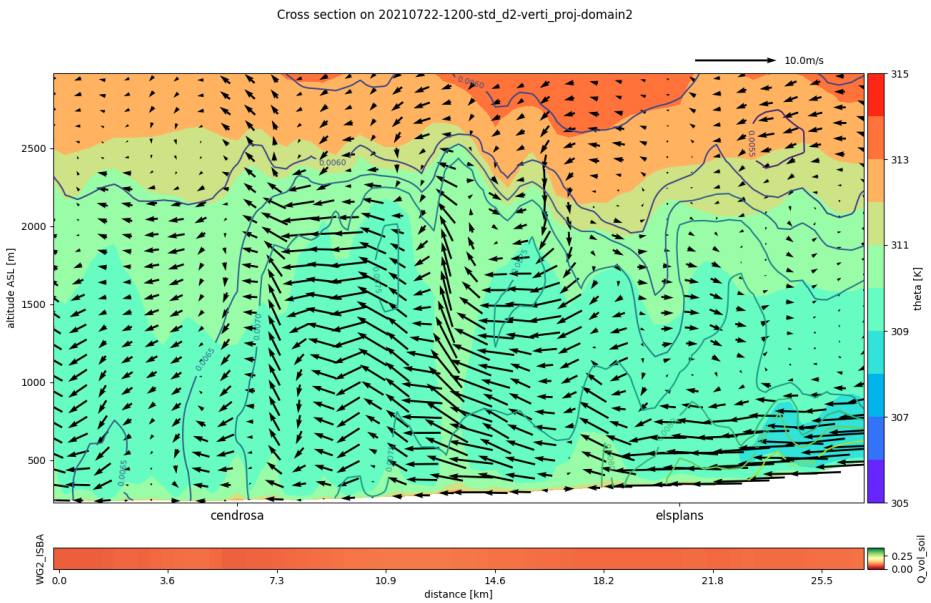
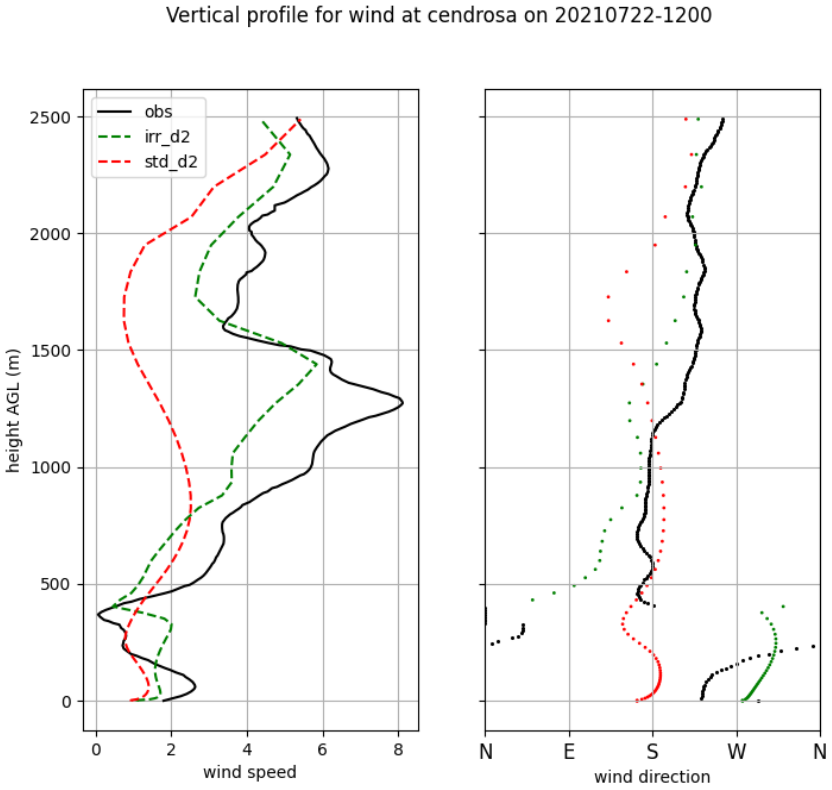
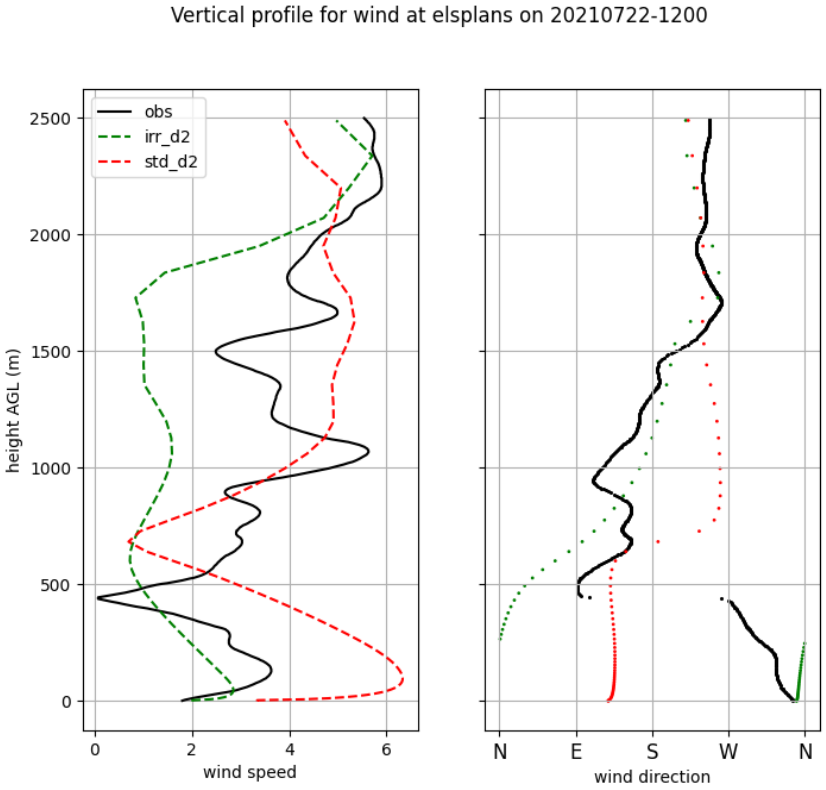


STD



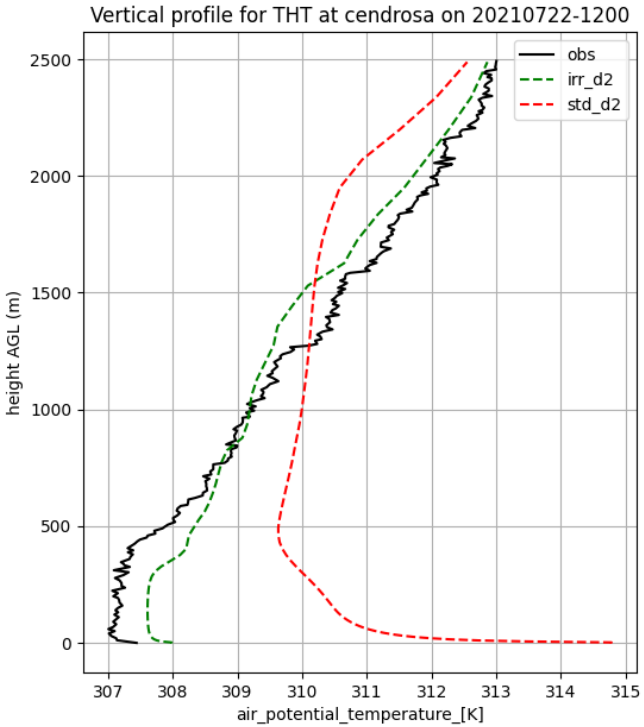
Radiosoundings: winds

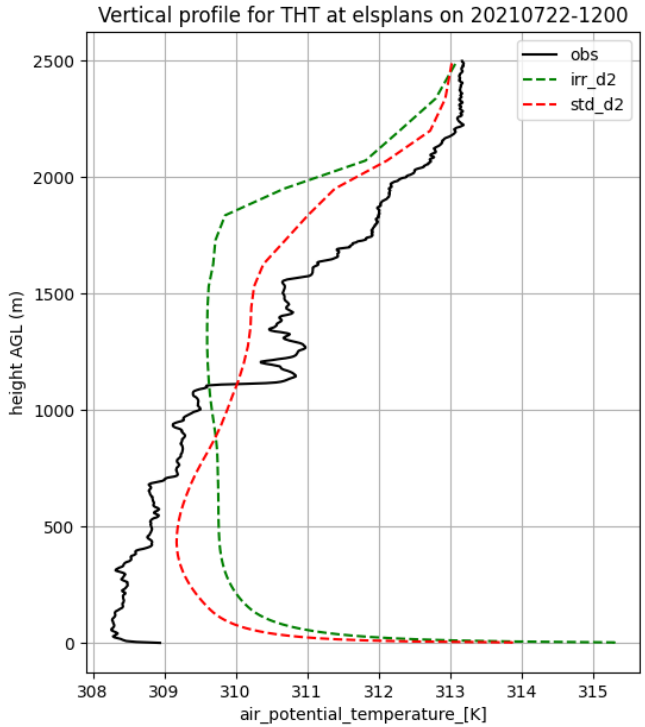




- Improvement in circulations as well

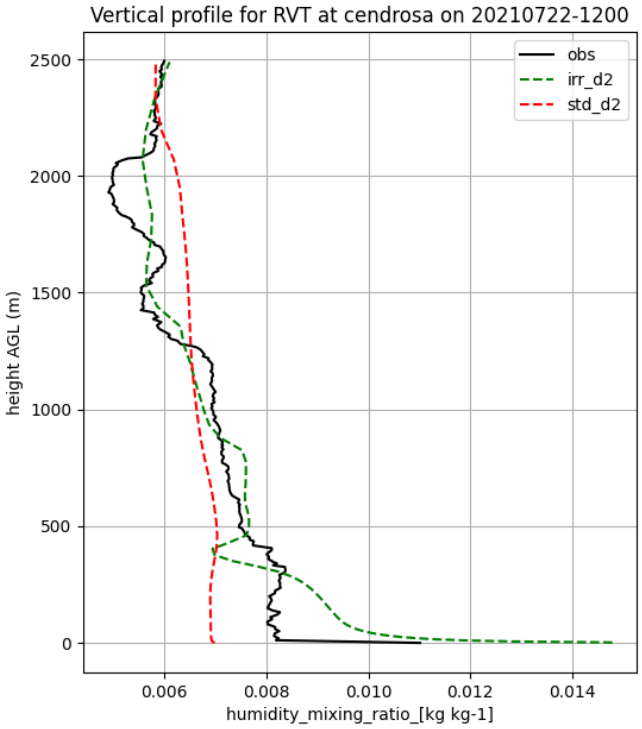
Radiosoundings: potential temperature

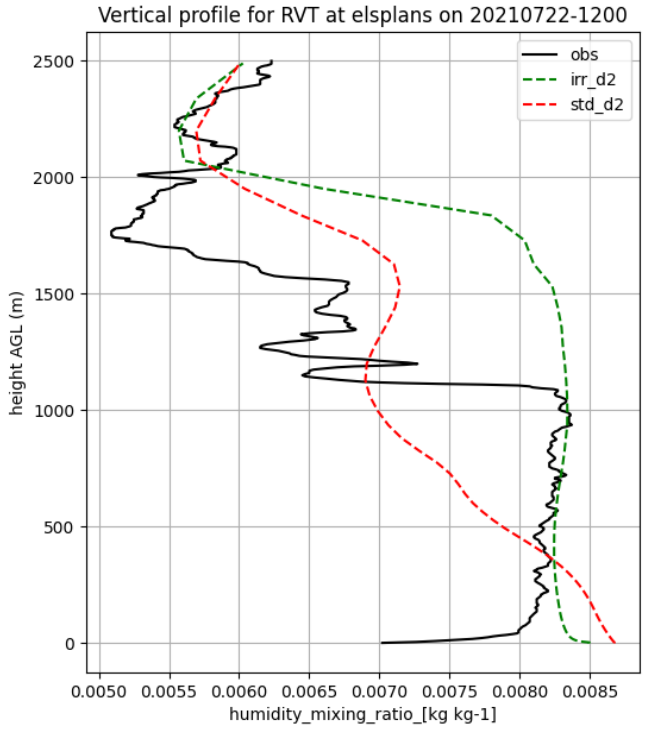




- Effect on ABL over irrigated area:
  - Stabilisation
- Effect on ABL over rain-fed area:
  - Strengthening of updraft

Radiosoundings: mixing ratio





- Effect on ABL over irrigated area:
  - Humidification

- Effect on ABL over rain-fed area:
  - Humidification

No clear improvement or deterioration over Els Plans:

- Transition zone in the model
- Overestimation of updraft and humidity

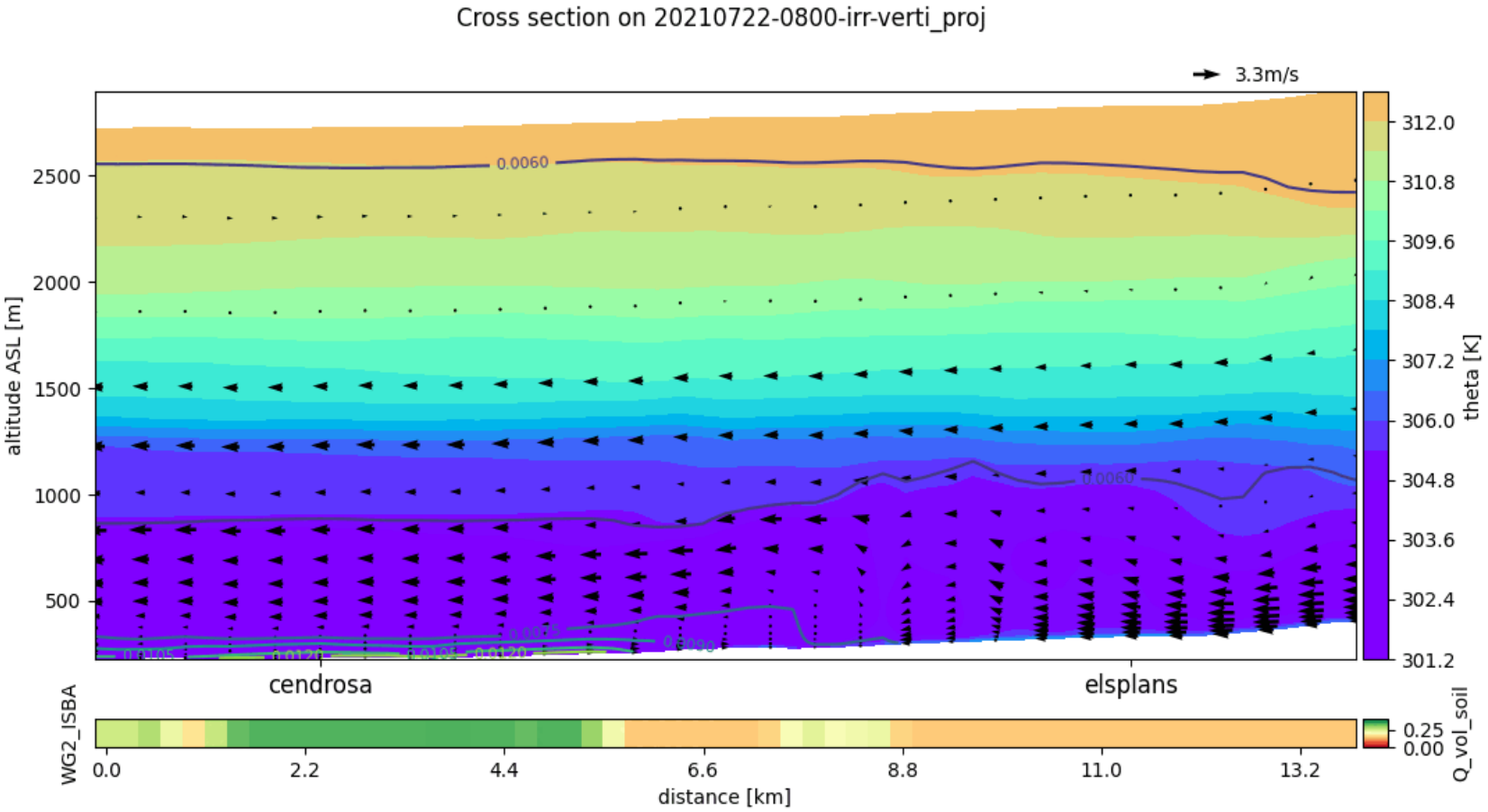
Conclusions and prospects

- Influence of irrigation in semi-arid environment is major, and affects surface conditions, fluxes and circulations in the ABL.
- Not considering it in models is a source of error.
- A simple parameterization of irrigation allows for improvement in representation of surface and ABL characteristics.
- More complex irrigation parameterization may improve simulated humidity.
- Representing time and precise location of each irrigation event is not important in our model.

- Prospects :
  - Irrigation parameterization
    - depending on SWI threshold (threshold at 0,5 SWI → 100mm)
    - with constant SWI = 0,8.
  - Processes studies (TKE, ...)

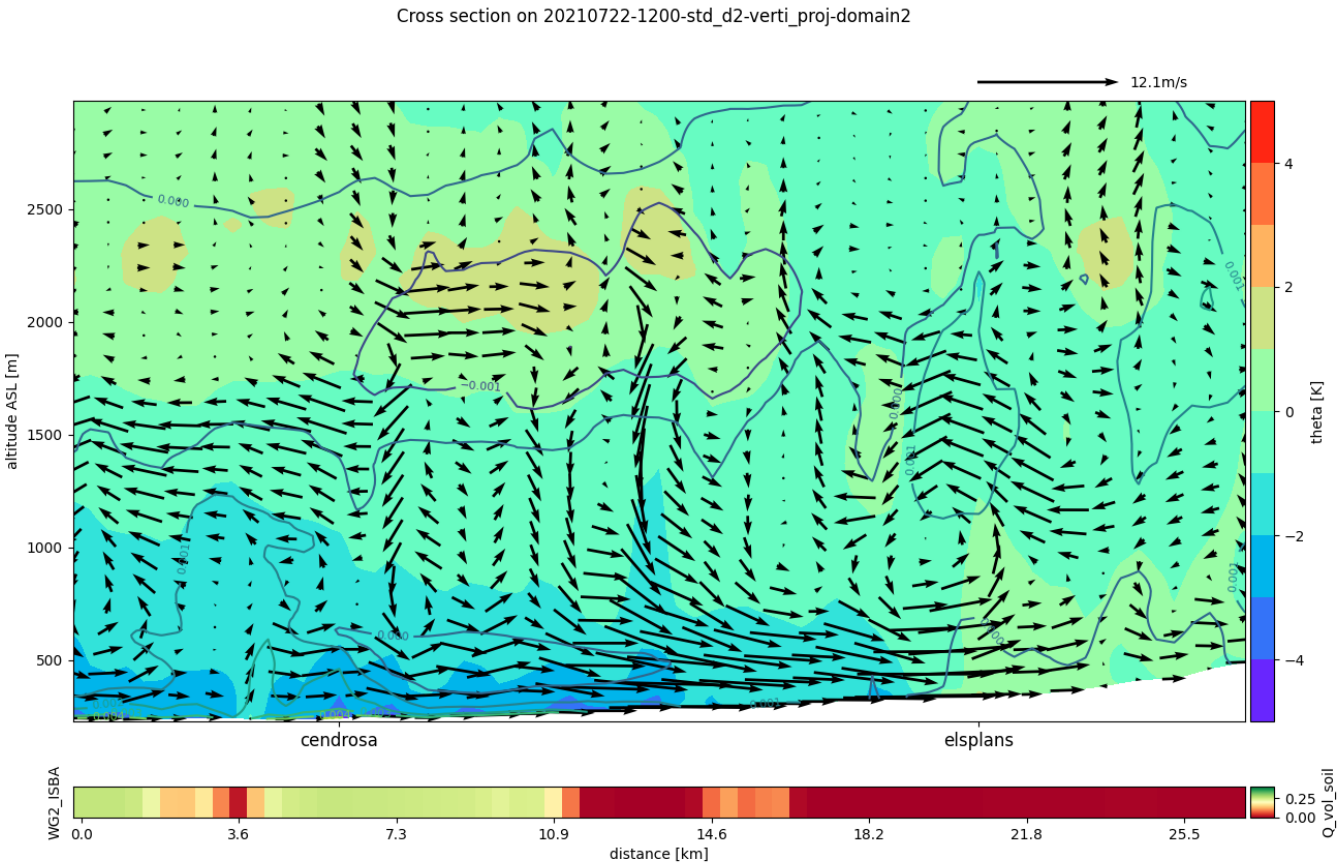
Thanks for you attention

Circulations

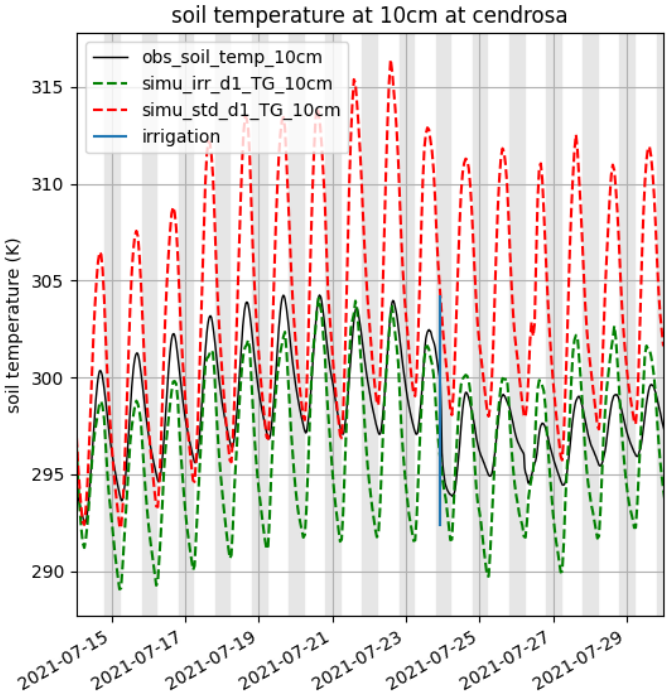


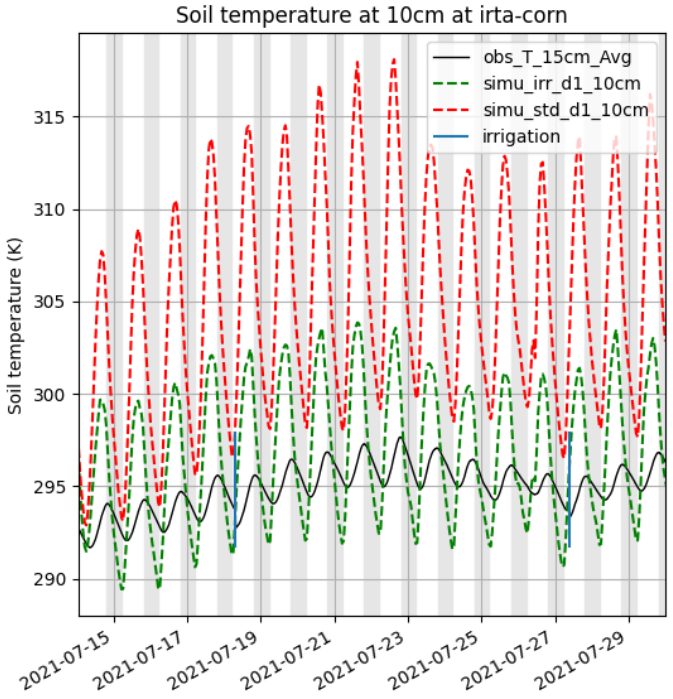
Winds

- IRR – STD:



Ground temperature



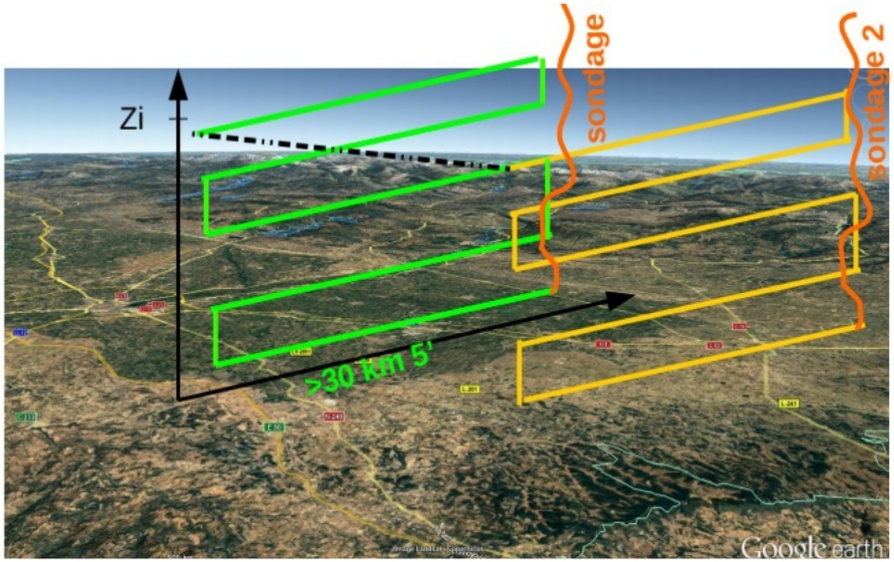


- Ground temperatures:
  - overestimated during daytime
  - underestimated during night

- Irrigation brings improvement
- Immediate effect of irrigation event is weak

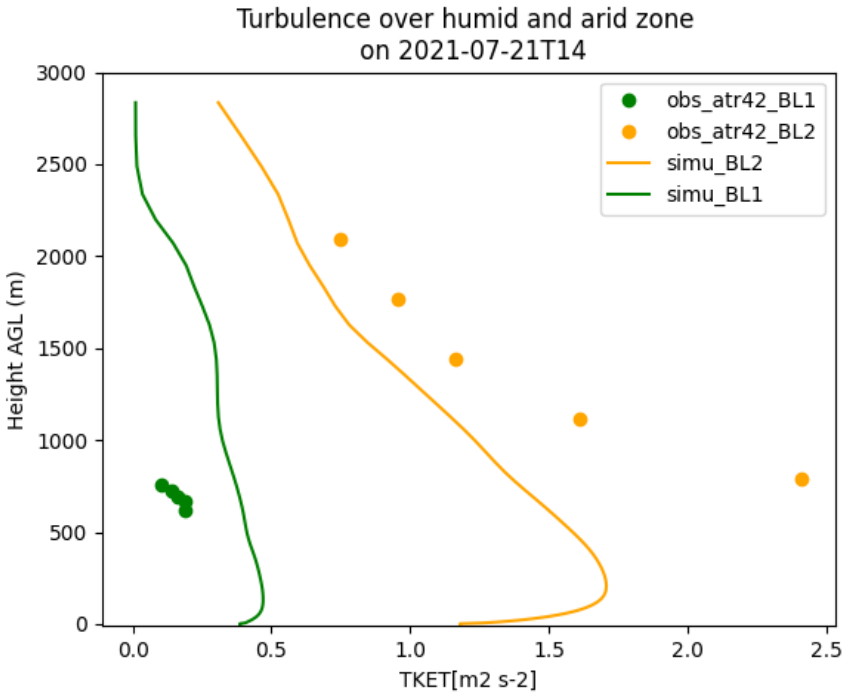
Flights ATR-42

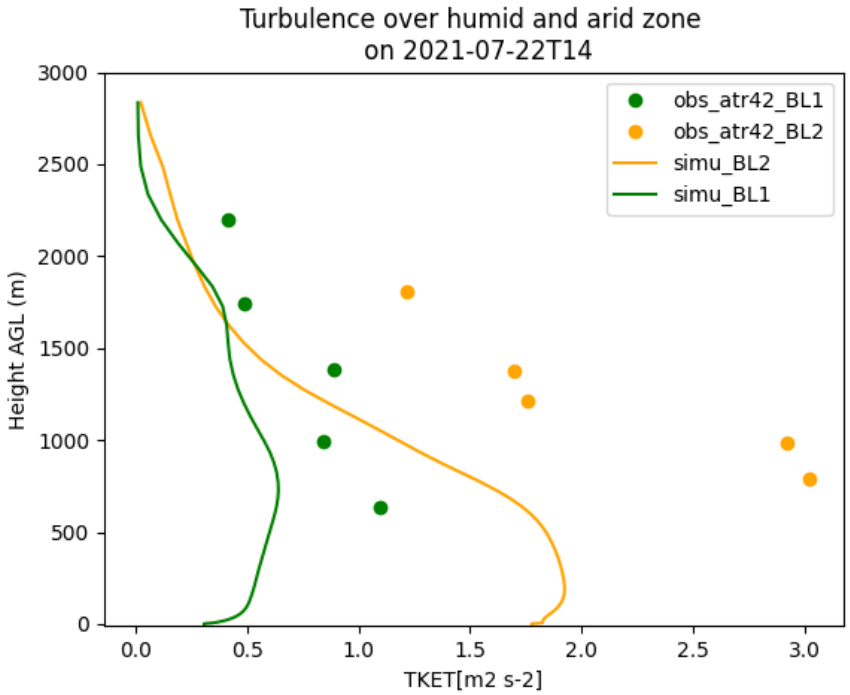
- Transects at different altitudes over irrigated and semi-arid zones

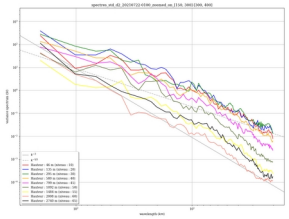


Flights ATR-42: Turbulences

- Global coherence of TKE evolution along ABL
- Not enough turbulence in models compared to observations over BL2







Weather patterns – West and thermal low