Met Office

Demonstrating the impact of coupled irrigation over the Iberian semi-arid environment

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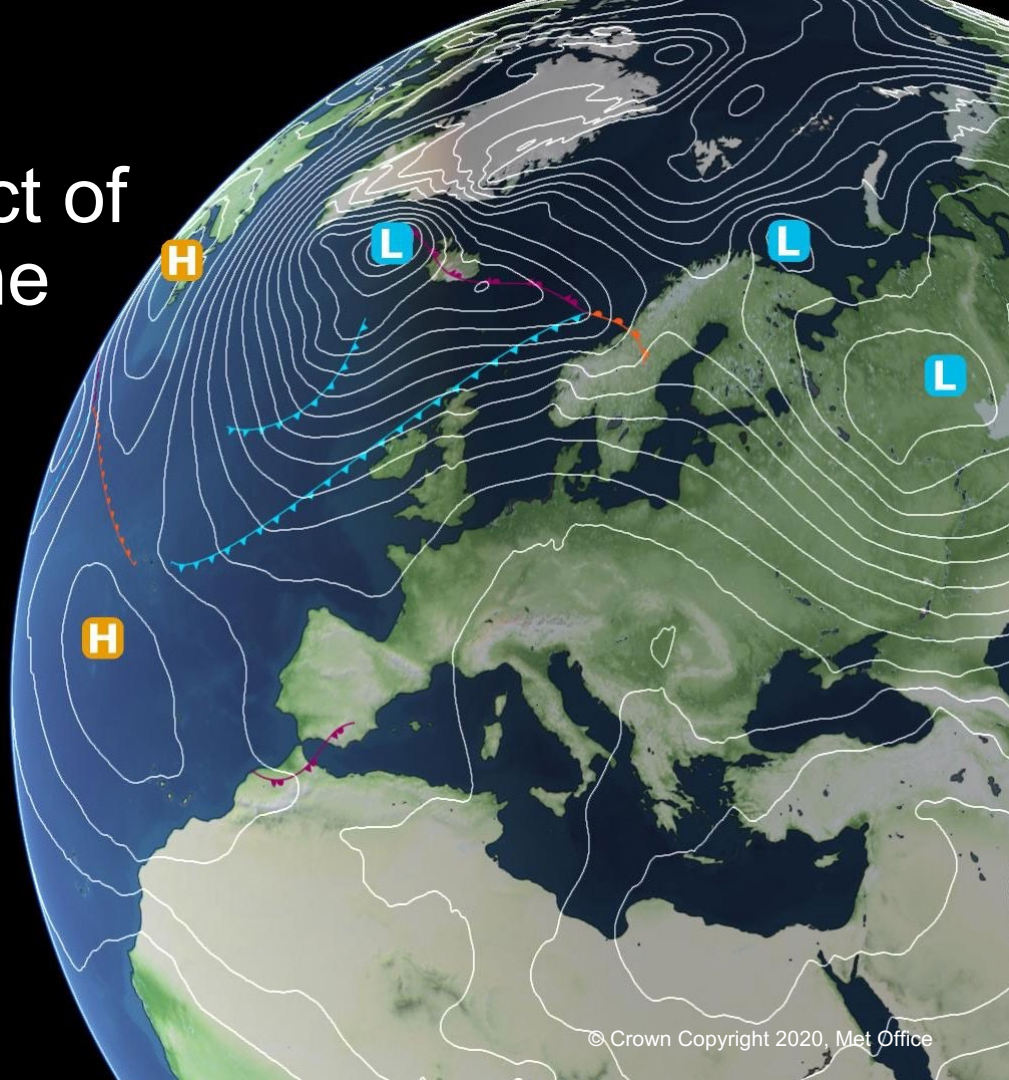

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Irrigation

- Huge spatial and temporal variability in application of irrigation
- Many different methods used in practise:
  - Bringing in water via pipes from rivers, canals and reservoirs
  - Flood irrigation systems
  - Sprinklers systems
  - Drip irrigation


(Credit: Jeff Vanuga, USDA Natural Resources Conservation Service)


https://phys.org/news/2014-01-effects-earth.html

- How can we represent this heterogeneity in our land surface models?

JULES Irrigation Code

Irrigation demand:

- Adds water to the top two soil layers up to the critical point for that surface tile - removing moisture deficit for the vegetation.

Irrigation limitation:

- Water is extracted from the groundwater, and then rivers in order to constrain irrigation demand according to available water (standalone JULES only).

Irrigation crop mode:

- 0 - adds water to the soil throughout the year, 1 – adds water during a particular growing season, 2 – Adds water according to the development stage of the plant or crop (1 & 2 require a dynamic crop model, available in standalone JULES only).

Select surface tiles to be irrigated:

- Either irrigated all surface tiles or select certain tiles to be irrigated (e.g. grass tiles)

Coupled JULES Irrigation

- JULES irrigation code has been coupled to the Unified Model (UM) at vn12.0 (JULES vn6.1).
- Added irrigation frequency as an input (nstep_irrig)
- Coupled simulations evaluated using 1 configuration so far:

```
[namelist:jules_irrig]
frac_irrig_all_tiles=.false.
irr_crop=0
irrigtiles=3,4
l_irrig_dmd=.true.
l_irrig_limit=.false.
nirrtile=2
nstep_irrig=1
set_irrfrac_on_irrtiles=.false.
```

- Irrigation demand only (limitation not available in UM yet)
- Irrigating all year round on every UM timestep
- Irrigating C3 and C4 grass only

- Code developed in the new ancillary generation system (ANTS) to generate maps of global irrigated fraction based on land cover classes from the CCI* dataset.

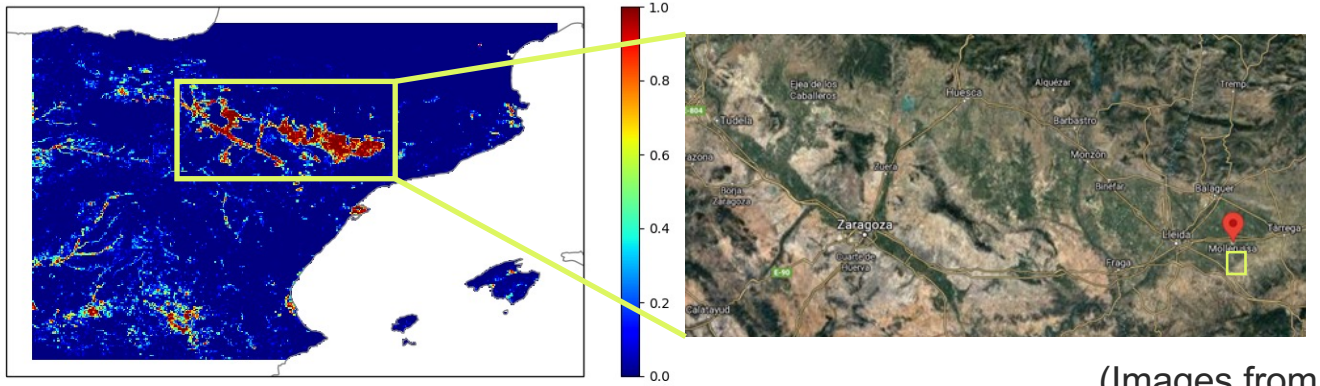
*ESA Climate Change Initiative

Impacts of irrigation in UM Simulations

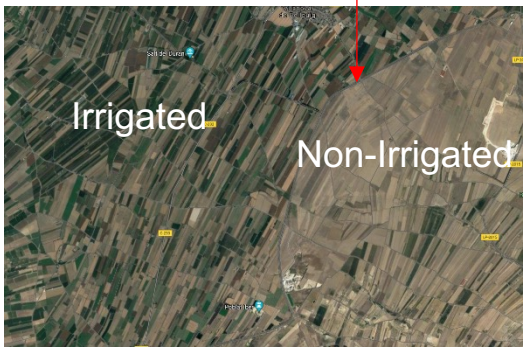
Aim - Improve our ability to model a heterogenous irrigated land surface and understand how the land and atmosphere interact in these conditions.

- Testing code using the UM Regional Nesting Suite over a 2.2km domain centred around the LIAISE field campaign area of north-eastern Spain

Irrigated Fraction Ancillary



Irrigation Canal



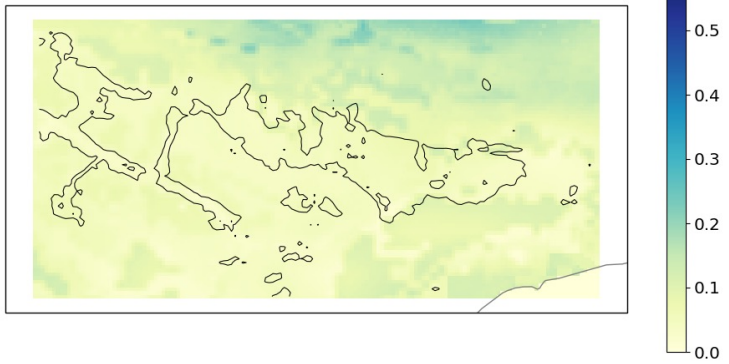
(Images from Google maps)

Soil Moisture

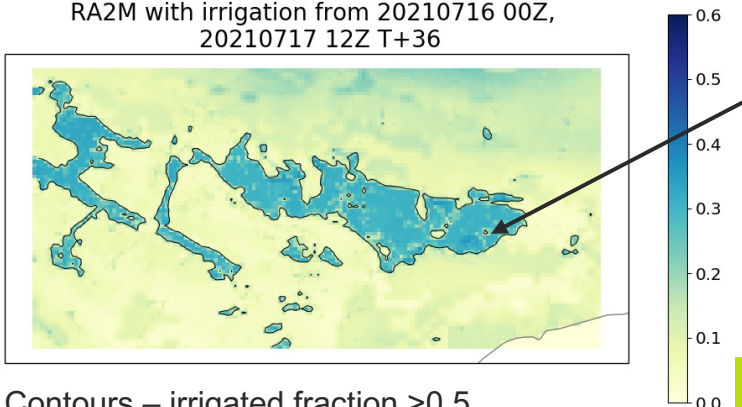
Soil Moisture observations from SLAP:

- An airborne simulator of NASA's SMAP soil moisture satellite on the NASA King Air aircraft
- Measures soil moisture using passive microwaves at 1.4 GHz

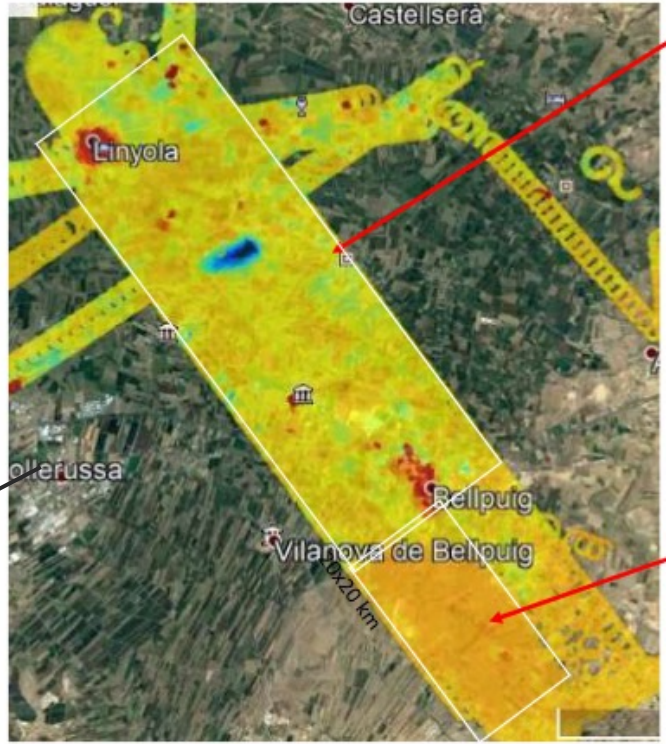
Soil Moisture, fraction of saturation in Layer 1 - RA2M from 20210716 00Z, 20210717 12Z T+36



Soil Moisture, fraction of saturation in Layer 1 - RA2M with irrigation from 20210716 00Z, 20210717 12Z T+36



Contours – irrigated fraction >0.5



Area diagnosed with heterogeneous wetter/cooler and drier/warmer conditions over irrigated land

17 July 2021

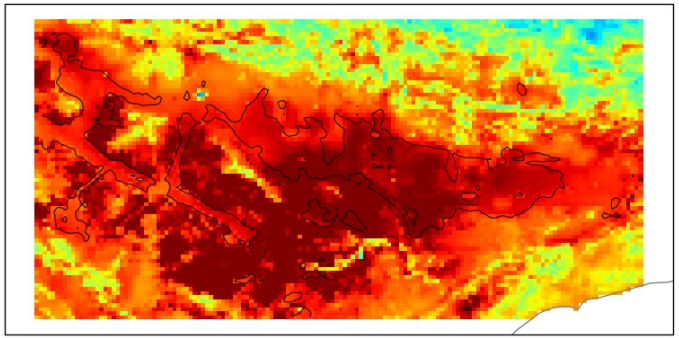
Diagnosed uniform dry/warmer area over non irrigated land

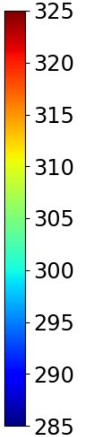
Note: Colour scale is not calibrated yet!

Image from Ed Kim and Albert Wu (NASA)

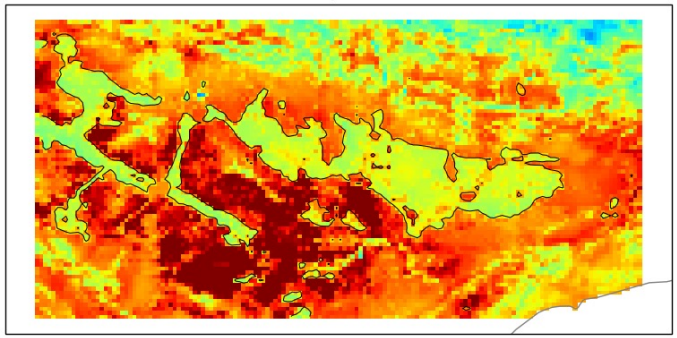
Land Surface (Skin) temperatures

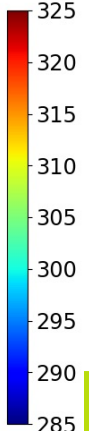
GBM Skin Temperature - RA2M
from 20210716 00Z, 20210717 12Z T+36



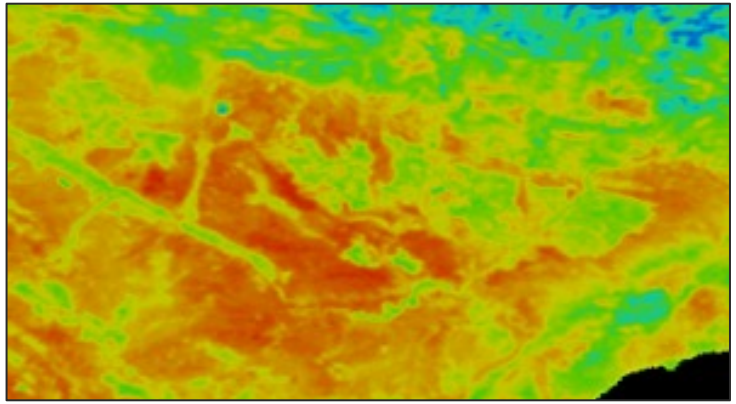


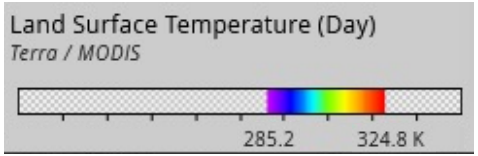
GBM Skin Temperature - RA2M with irrigation
from 20210716 00Z, 20210717 12Z T+36





Observed daytime LST from Terra/Modis (20210717)

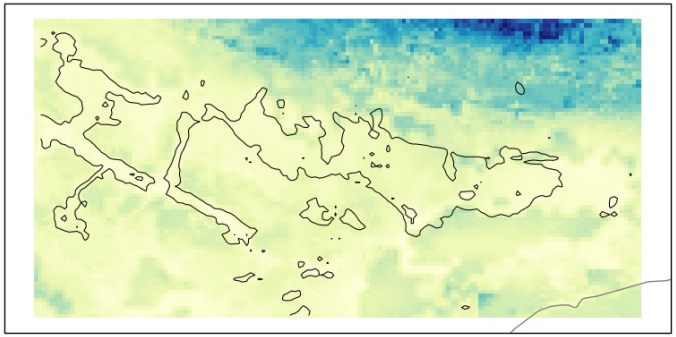


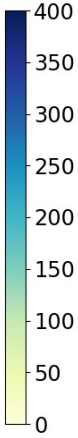


Observations from https://worldview.earthdata.nasa.gov

Surface Fluxes

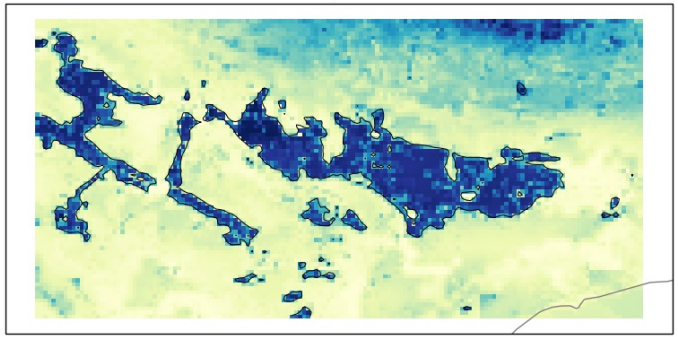
latent - RA2M
from 20210716 00Z, 20210717 12Z T+36

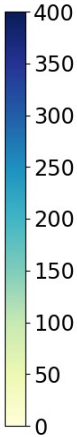




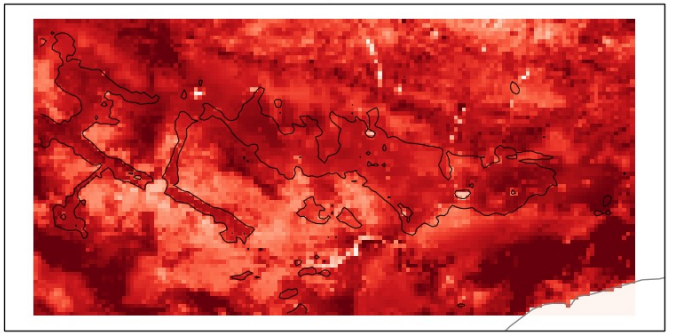
Latent Heat Flux

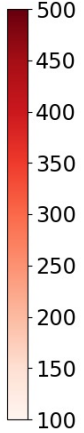
latent - RA2M with irrigation
from 20210716 00Z, 20210717 12Z T+36





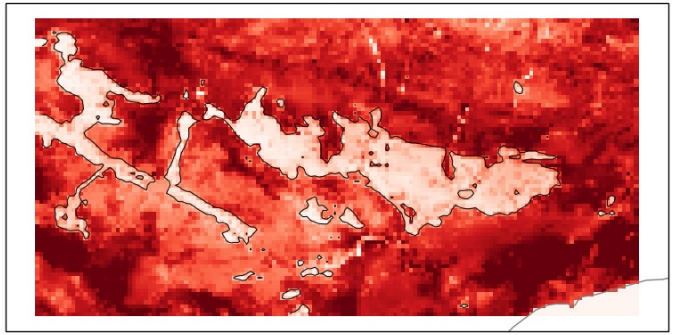
sensible - RA2M
from 20210716 00Z, 20210717 12Z T+36

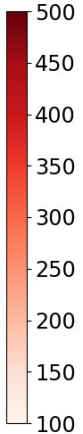




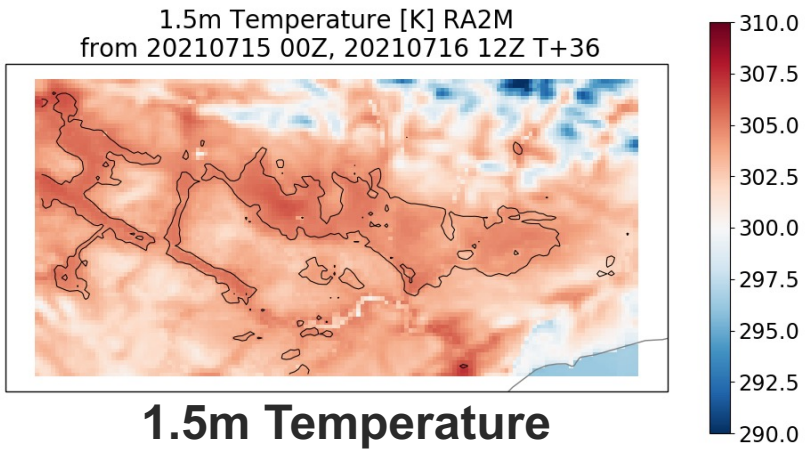
Sensible Heat Flux

sensible - RA2M with irrigation
from 20210716 00Z, 20210717 12Z T+36

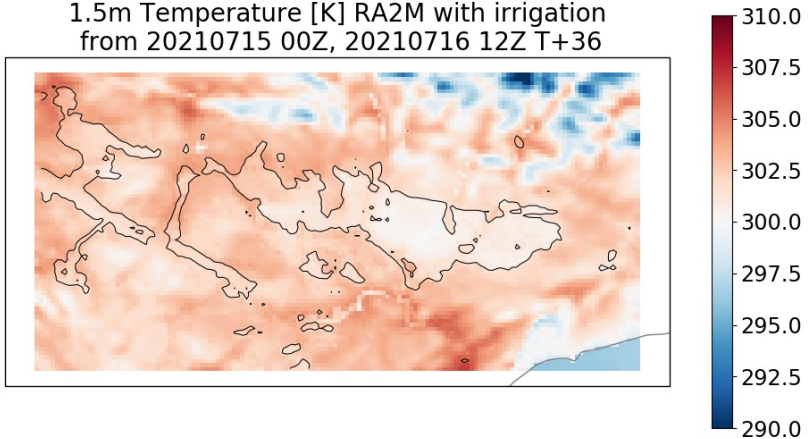


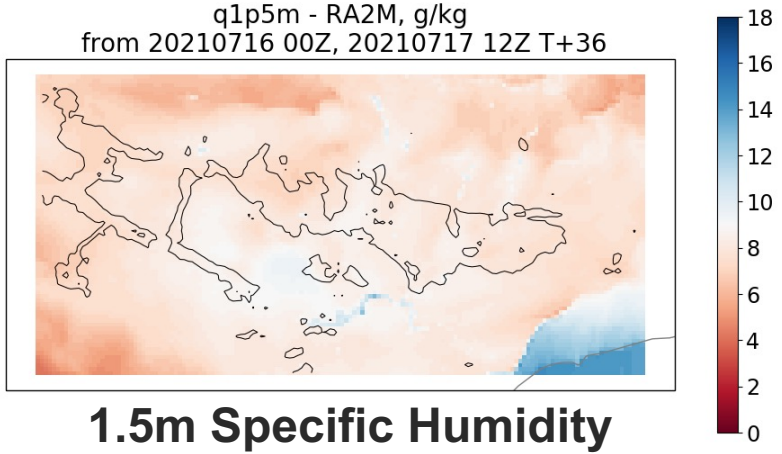


Met Office Screen level temperature and humidity

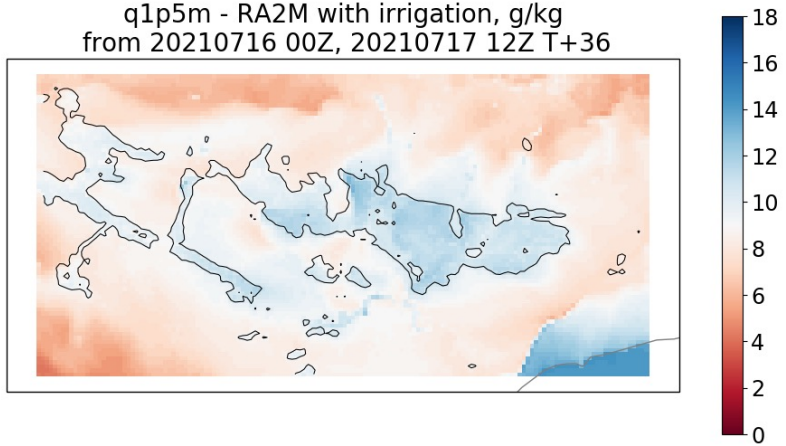


1.5m Temperature

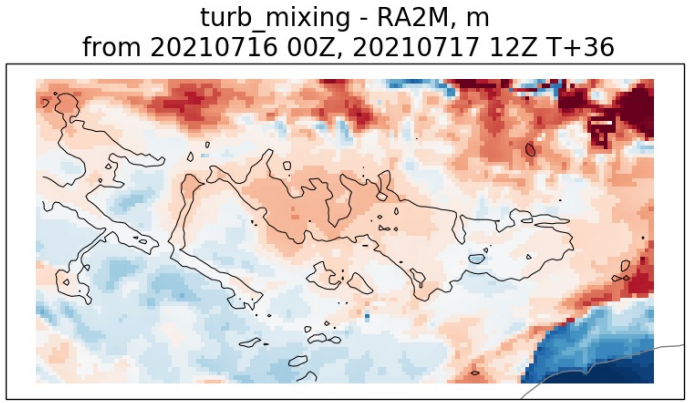


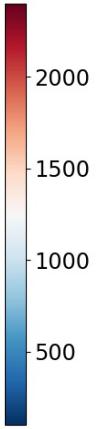


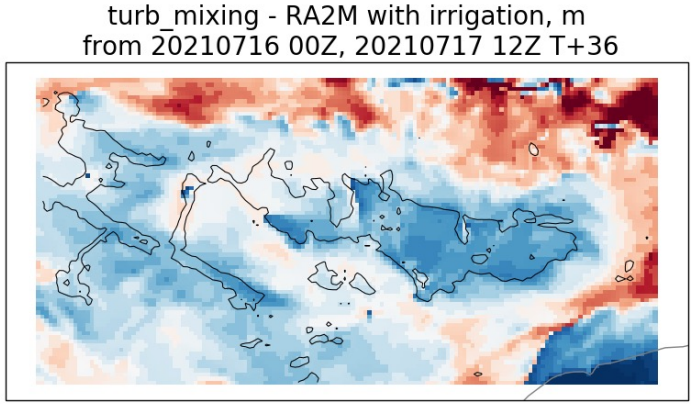
1.5m Specific Humidity

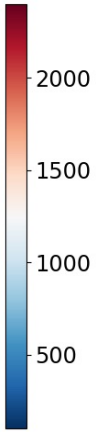


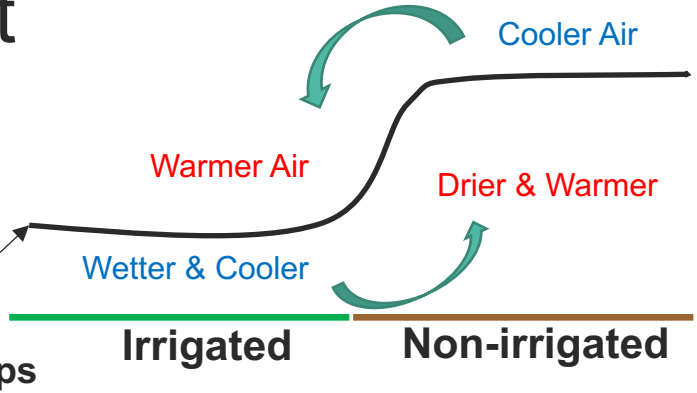
Boundary Layer Height





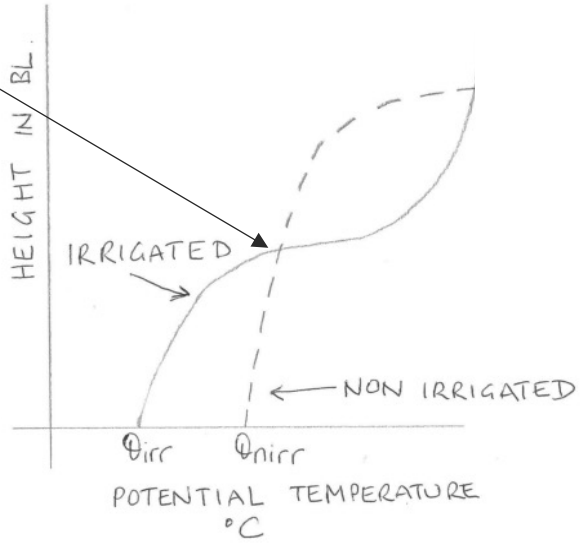




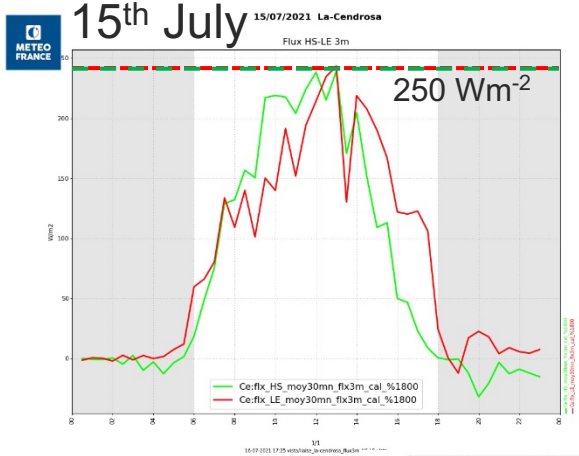


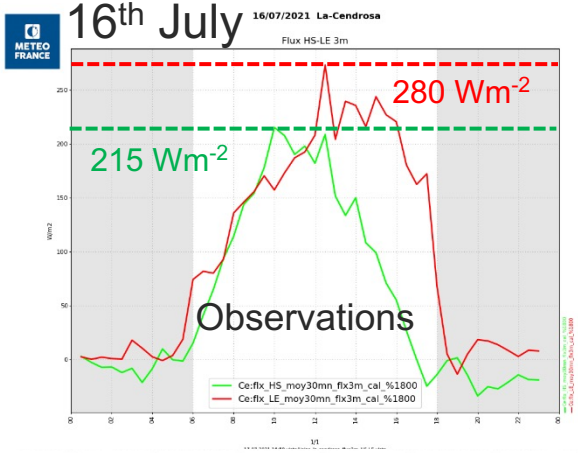
Boundary layer tops

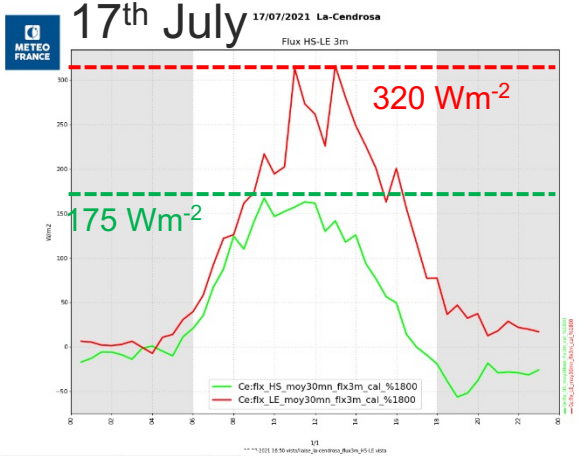
- Irrigation reduces the boundary layer height
- Colder/wetter surface suppresses boundary layer growth and sets up circulation
- Potential for increasing convective activity and clouds downwind of irrigated areas



Met Office Surface Flux time series, La Cendrosa



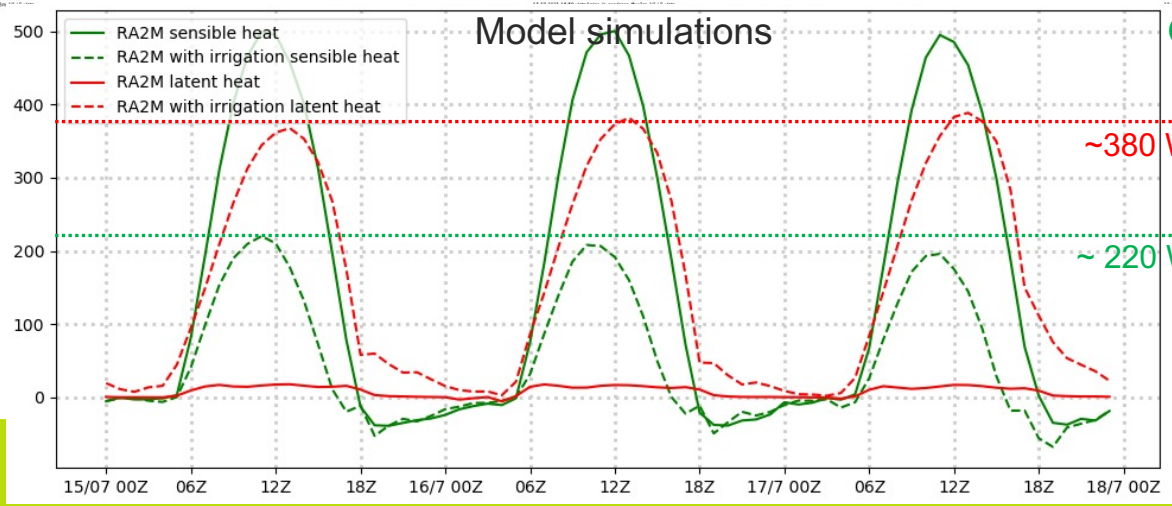




Irrigated site

Alfalfa crop is growing throughout

Flood irrigation times:
~10th, 23rd – 25th



Green = Sensible Heat
Red = Latent Heat

--- With irrigation
— Without irrigation

Met Office Conclusions & Future Plans

- Early results show that the impact of using a coupled irrigation scheme leads to an **increase in soil moisture** over the areas mapped by the ancillary. This has led to a **positive impact on land surface (skin) and screen temperature**, an **increase in screen humidity** and an **improvement to low level winds**.

- The colder/wetter surface **suppresses boundary layer growth** and sets up circulation, increasing the potential for convective activity and clouds downwind of irrigated areas.

- At the flux tower **latent and sensible heat fluxes are significantly improved** compared to non irrigated run, however are now **overestimated** compared to observations.

- Plan to **evaluate the land surface and boundary layer fully** using the ground-based and airborne observations collected during the LIAISE field campaign and use this to **improve simulations of irrigation in JULES** especially over regional and global domains

- Need to look to **how the parameterisation can be improved** further (e.g. implement irrigation limitation and parameter sensitivity studies)

Thank you for listening, email: heather.rumbold@metoffice.gov.uk