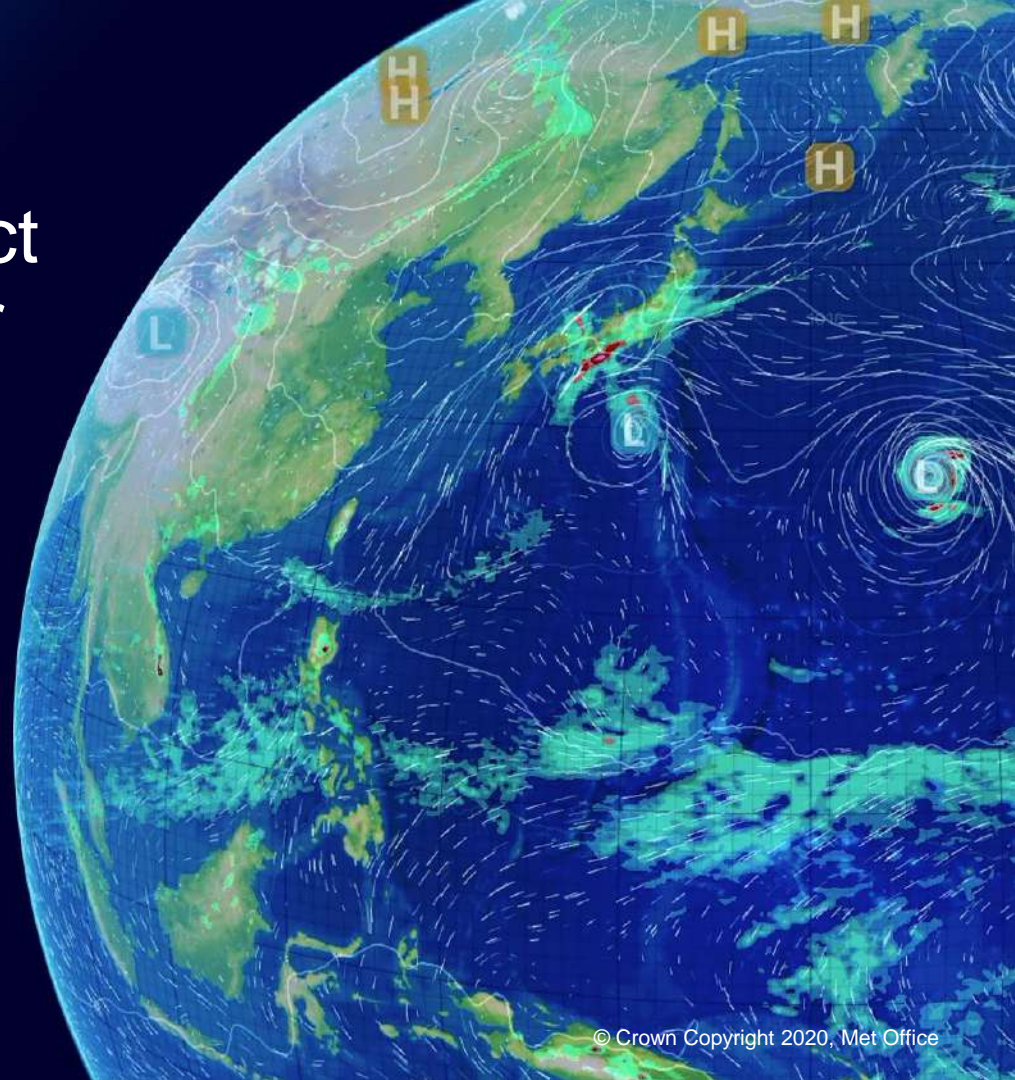


# Demonstrating the impact of coupled irrigation over the Iberian semi-arid environment

Heather Rumbold, Jennifer Brooke,  
Martin Best, Adrian Lock, Maggie  
Hendry



# Met Office Irrigation

- Application of water to the land with the aim to maintain plant productivity
- Many different methods used in practise:
  - Bringing in water via pipes from rivers, canals and reservoirs
  - Sprinklers systems
  - Drip irrigation
  - Flood irrigation systems



- Huge spatial and temporal variability in application of irrigation

# Met Office The Semi-arid Environment

- Semi-arid regions are hot spots for biases in climate model variables.
- In addition, climate projections from CMIP5 predict that the Mediterranean region will be a climate change “hot spot”.

## **Ebro basin, north-eastern Spain**

- Semi-arid area where human activity has altered the hydrological cycle through intense agricultural activity.
- Rainfall is limited to the winter and mountainous areas, irrigation is required to provide water for crops.
- Delivered through dams and canals and applied using drip irrigation, sprinklers and controlled floods.

➤ Important to understand the physical processes



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



11+ international partners from across Europe and America

<https://liaise.aeris-data.fr/>



# JULES Irrigation (the technical bits...)

- JULES irrigation code has been coupled to the Unified Model (UM) at vn12.0 (JULES vn6.1) (tickets #6099/#838).
- New namelist parameter: `nstep_irrig` – irrigation frequency (tickets #6139/#1146)
- Coupled simulations evaluated using 1 configuration so far:

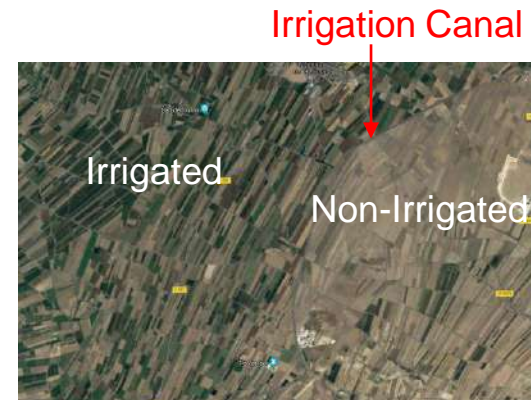
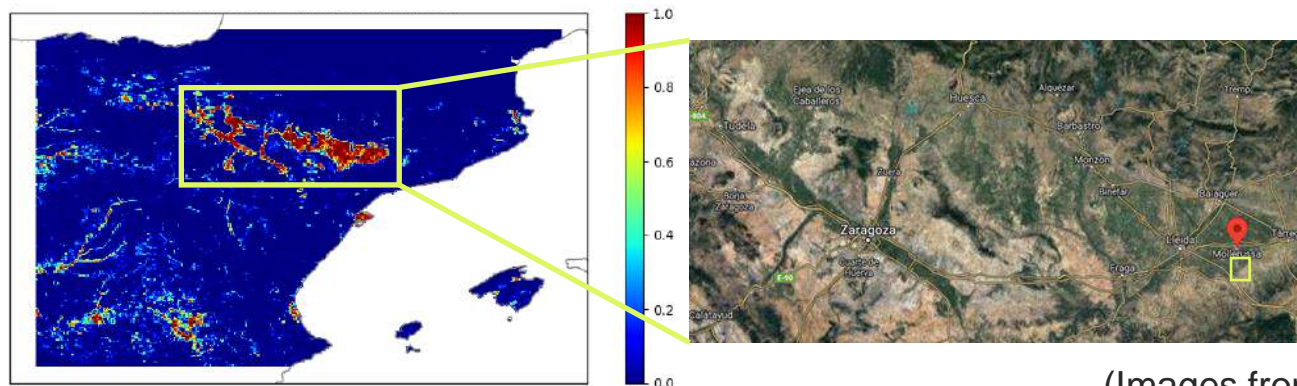
```
[namelist:jules_irrig]
frac_irrig_all_tiles=.false.
irr_crop=0
irrigtiles=3,4
l_irrig_dmd=.true.
l_irrig_limit=.false.
nirrtiler=2
nstep_irrig=1
set_irrfrac_on_irrtiles=.false.
```

- UM rose stem test added
- Code added to reconfiguration to initialise 'sth\_urr' to 'sth' in UM start dump file.
- 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.

# Met Office 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



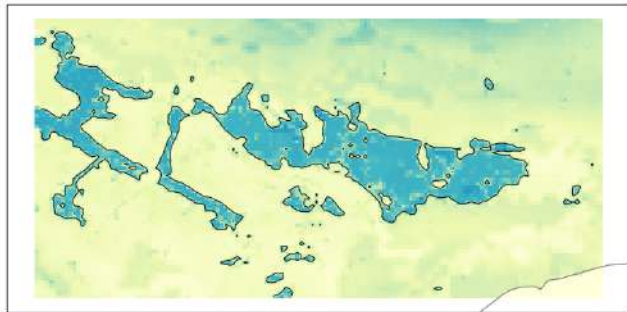
(Images from Google maps)

# Met Office Soil Moisture

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



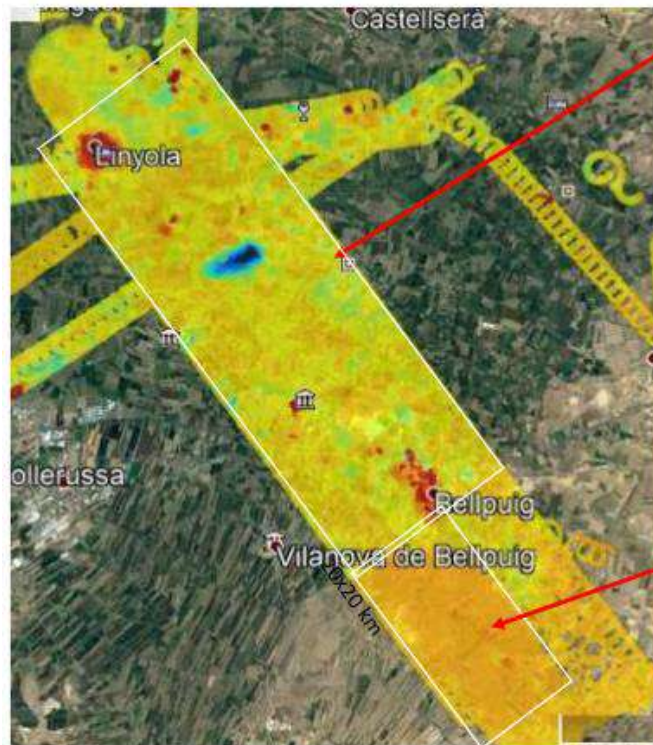
Soil Moisture, fraction of saturation in Layer 1 -  
RA2M with irrigation from 20210716 00Z,  
20210717 12Z T+36



Contours – irrigated fraction >0.5

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



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

17 July 2021

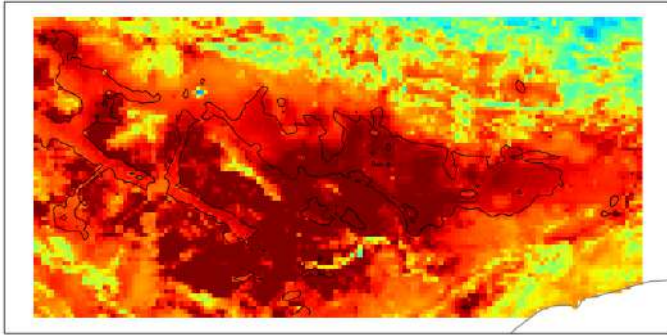
Diagnosed uniform dry/warmer area over non irrigated land

Note: Colour scale is not calibrated yet!

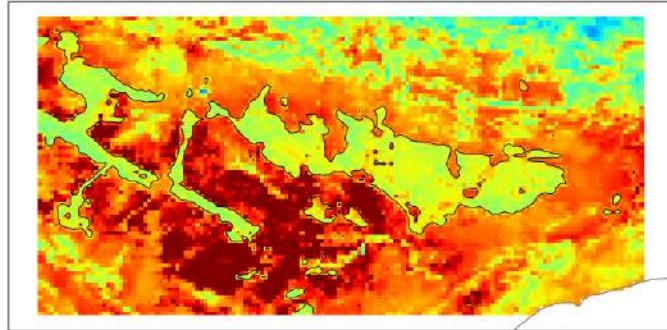
Image from Ed Kim and Albert Wu (NASA)

# Met Office Land Surface (Skin) temperatures

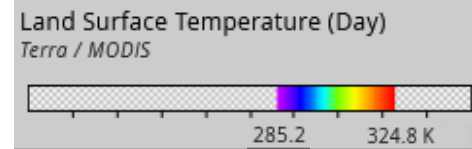
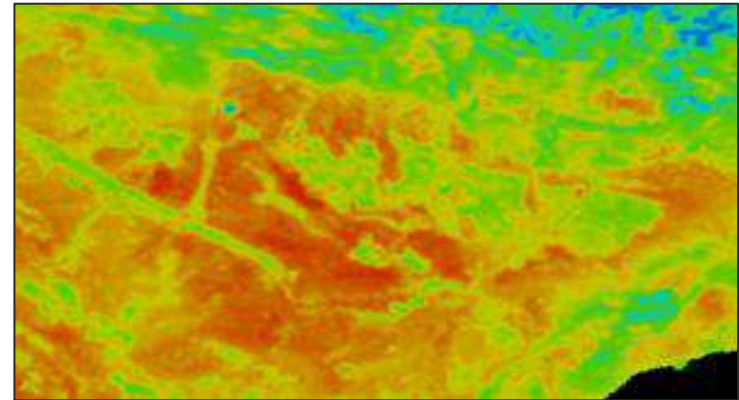
GBM Skin Temperature - RA2M  
from 20210716 00Z, 20210717 12Z T+36



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



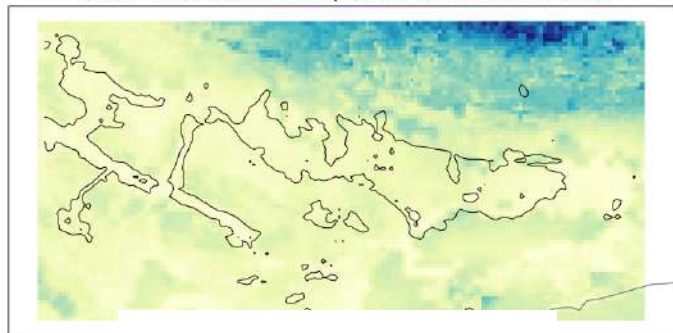
Observed daytime LST from Terra/Modis (20210717)



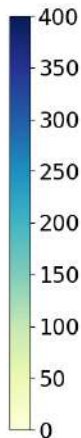


# Met Office Surface Fluxes

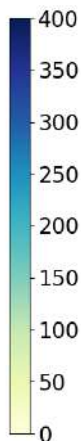
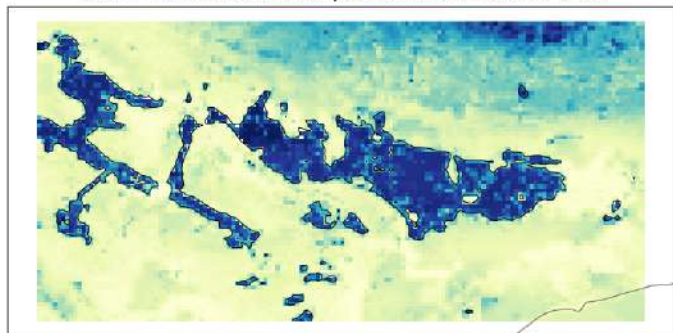
latent - RA2M  
from 20210716 00Z, 20210717 12Z T+36



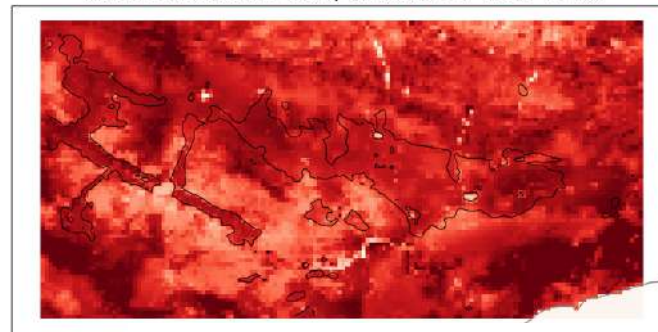
## Latent Heat Flux



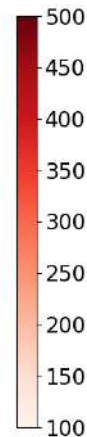
latent - RA2M with irrigation  
from 20210716 00Z, 20210717 12Z T+36



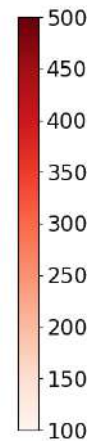
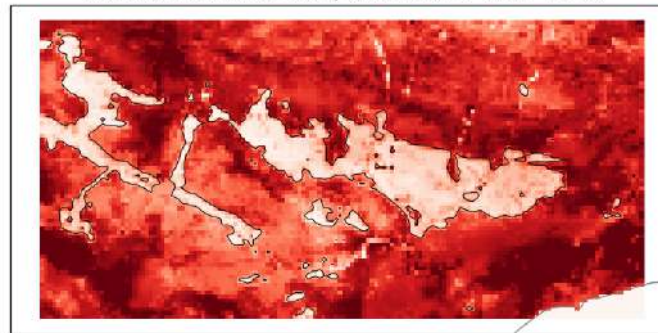
sensible - RA2M  
from 20210716 00Z, 20210717 12Z T+36



## Sensible Heat Flux

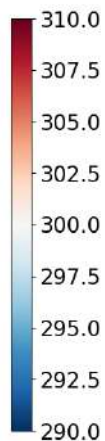
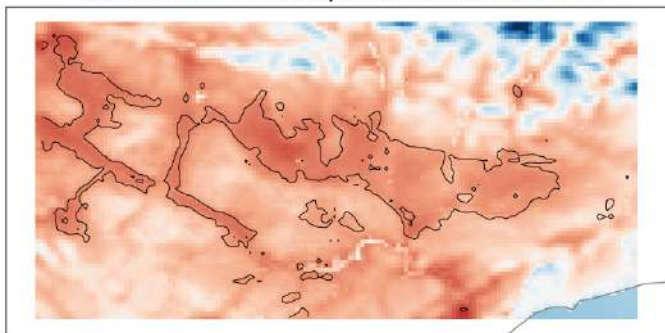


sensible - RA2M with irrigation  
from 20210716 00Z, 20210717 12Z T+36

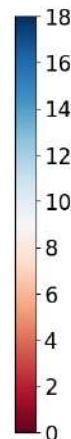
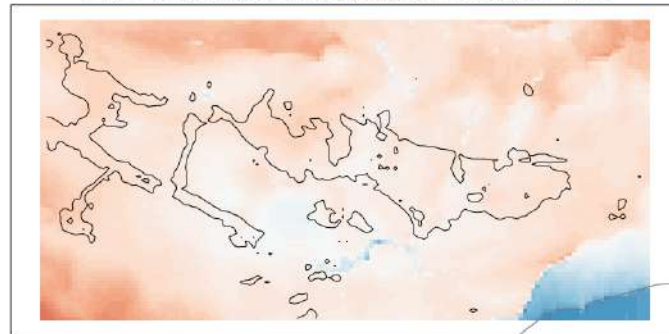


# Met office Screen level temperature and humidity

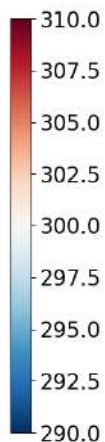
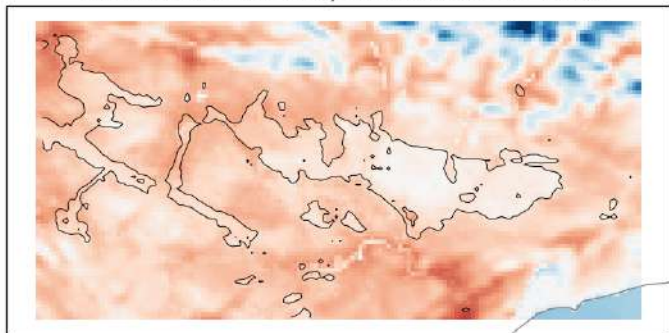
1.5m Temperature [K] RA2M  
from 20210715 00Z, 20210716 12Z T+36



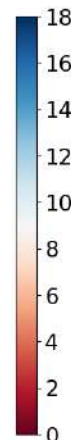
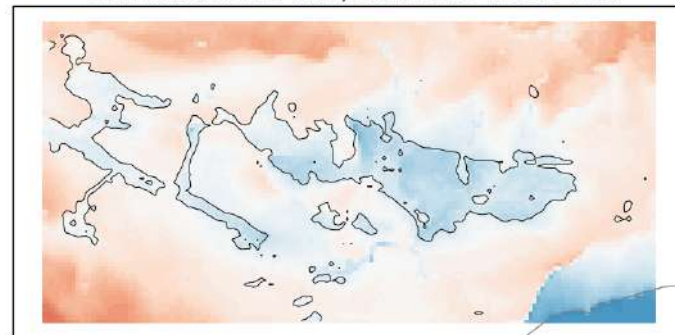
q1p5m - RA2M, g/kg  
from 20210716 00Z, 20210717 12Z T+36



1.5m Temperature [K] RA2M with irrigation  
from 20210715 00Z, 20210716 12Z T+36

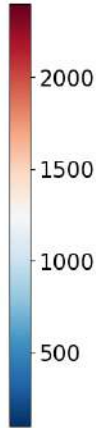
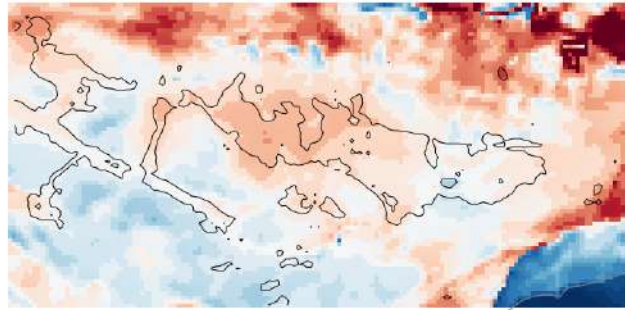


q1p5m - RA2M with irrigation, g/kg  
from 20210716 00Z, 20210717 12Z T+36

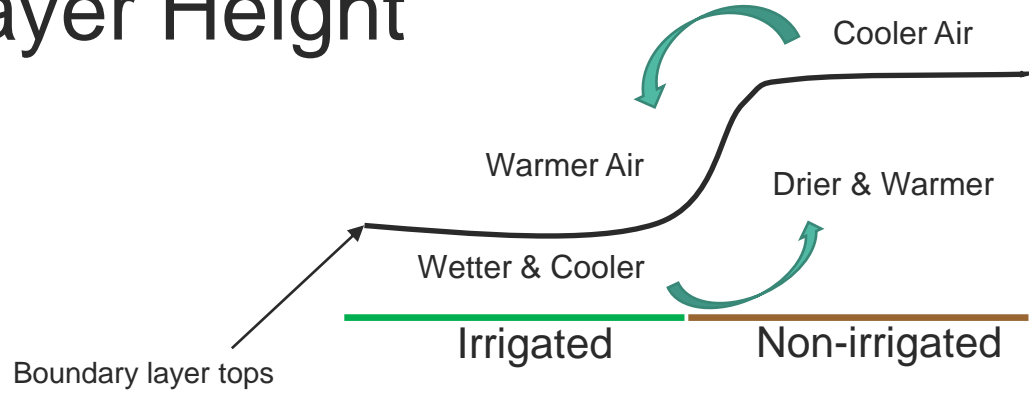
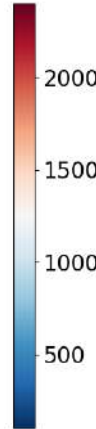
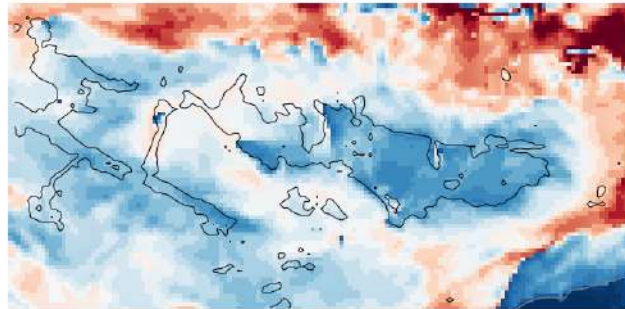


# Boundary Layer Height

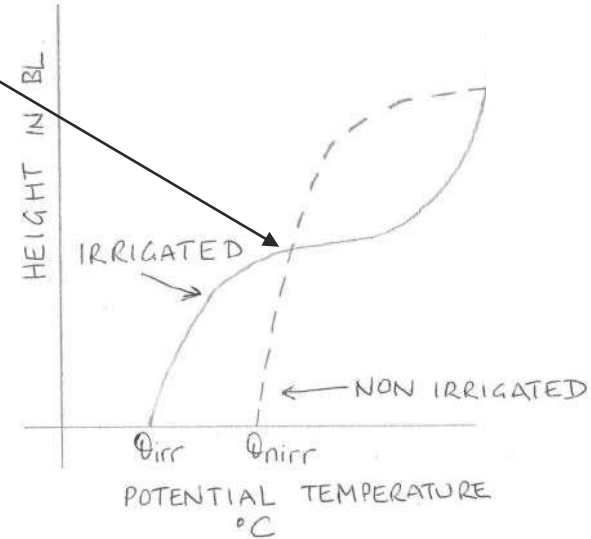
turb\_mixing - RA2M, m  
from 20210716 00Z, 20210717 12Z T+36



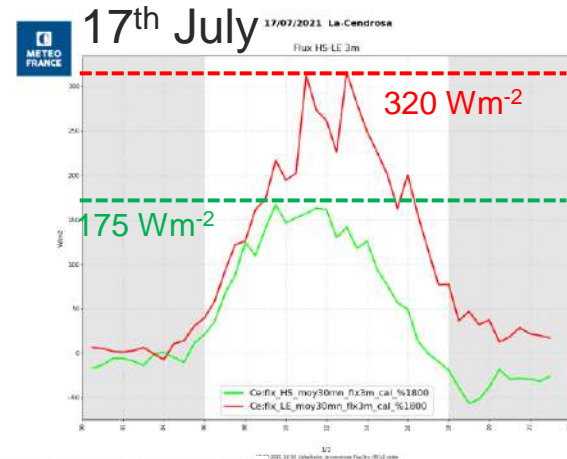
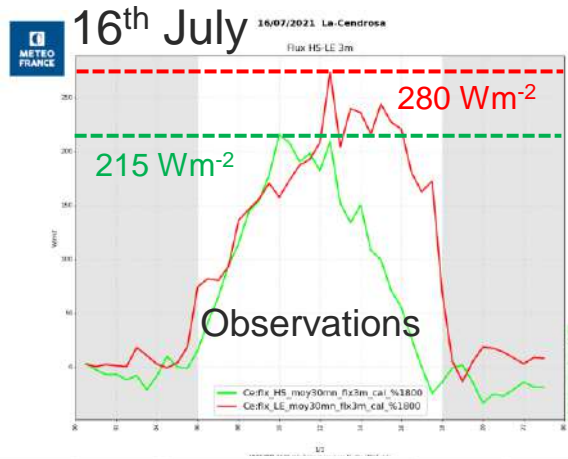
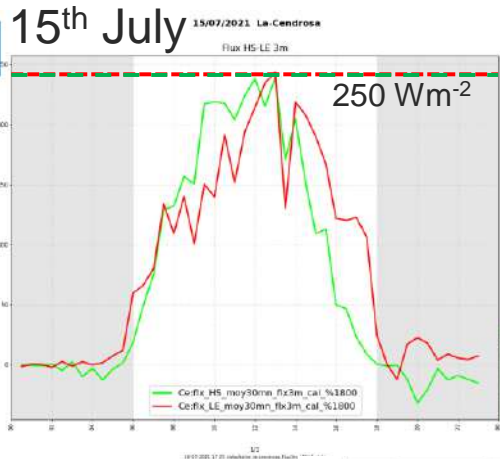
turb\_mixing - RA2M with irrigation, m  
from 20210716 00Z, 20210717 12Z T+36



- 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



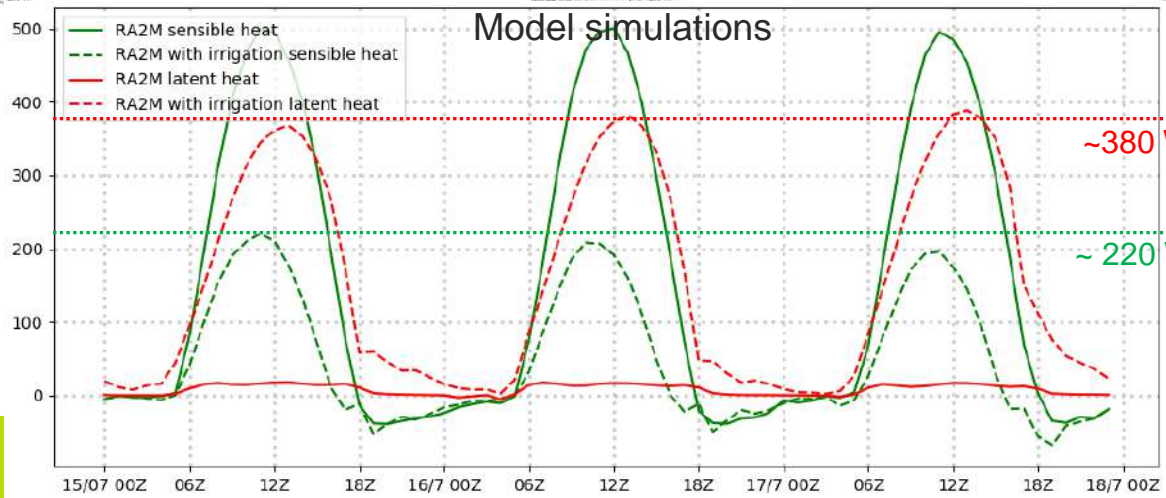
# Met Office Surface Flux time series, La Cendrosa



Irrigated site

Alfalfa crop is growing throughout

Flood irrigation times:  
~10<sup>th</sup>, 23<sup>rd</sup> – 25<sup>th</sup>



Green = Sensible Heat  
Red = Latent Heat

~380 Wm<sup>-2</sup>  
~220 Wm<sup>-2</sup>

--- With irrigation  
— Without irrigation

# Conclusions so far...

- Increase in soil moisture over the areas mapped by the ancillary.
- Decrease on land surface (skin) and screen temperature
- Increase in screen humidity
- Colder/wetter surface suppresses boundary layer growth and sets up circulations = potential for increase in convective activity and clouds downwind of irrigated areas
- At flux tower:
  - LE/H significantly improved compared to no irrigated run
  - But, now overestimate compared to observations.

# Further work

- Many more observations to come!
- Plan to evaluate the land surface and boundary layer fully using the ground-based and airborne observations collected during the LIAISE field campaign
- Use this to improve simulations of irrigation in JULES especially over regional and global domains
- Revisit the irrigation limitation scheme (UM rivers? UM Groundwater?)
- Test the remaining irrigation options (`frac_irrig_all_tiles` and `set_irrfrac_on_irrtiles`)
- Test the sensitivity of the `nstep_irrig` option.

Thank you for listening!  
[heather.rumbold@metoffice.gov.uk](mailto:heather.rumbold@metoffice.gov.uk)