Quality of regional coupled system against Cardington long-term observational dataset

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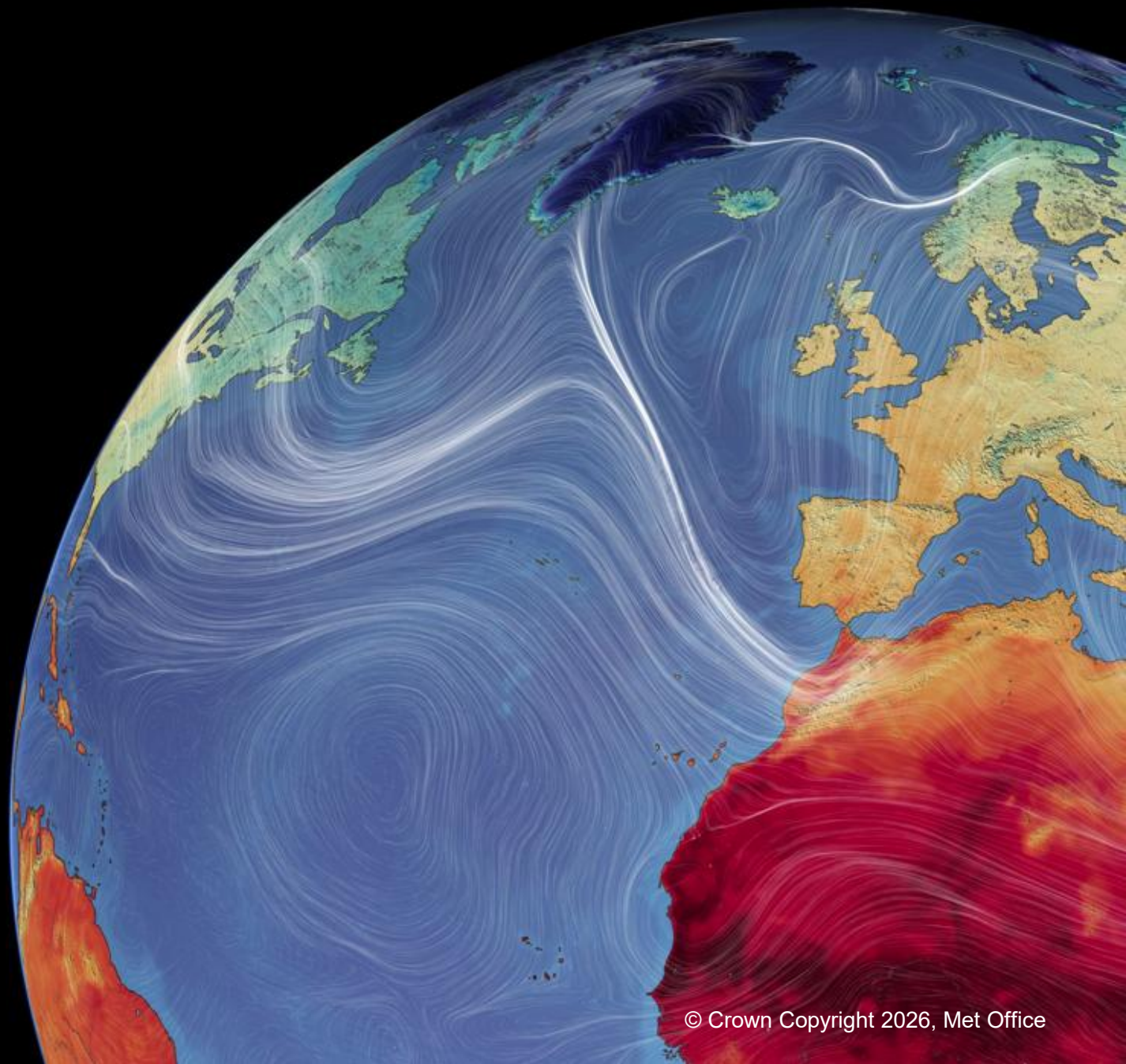

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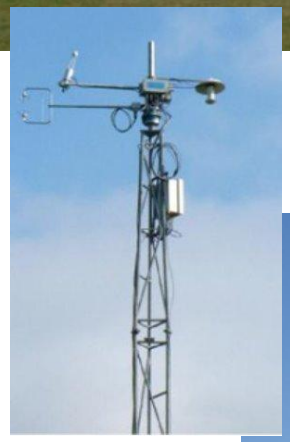
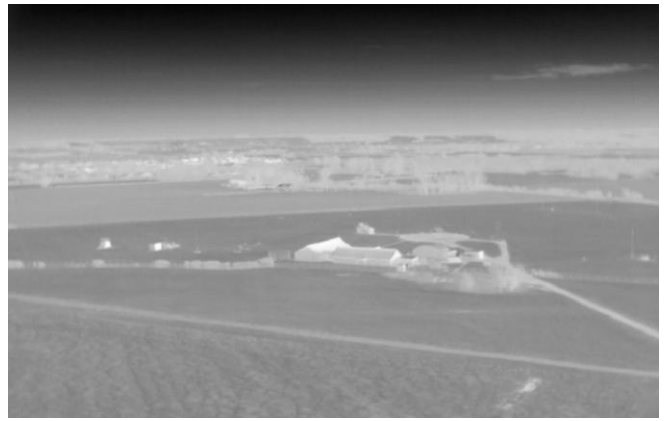
Observations from the Cardington field site

2004 to 2024
(resampled to one-hourly data; or daily for soil moisture)

Data from subsoil to 50 m (plus additional levels from remote-sensing instruments and radiosonde launches)





Model data from UKC4 (regional-coupled system)

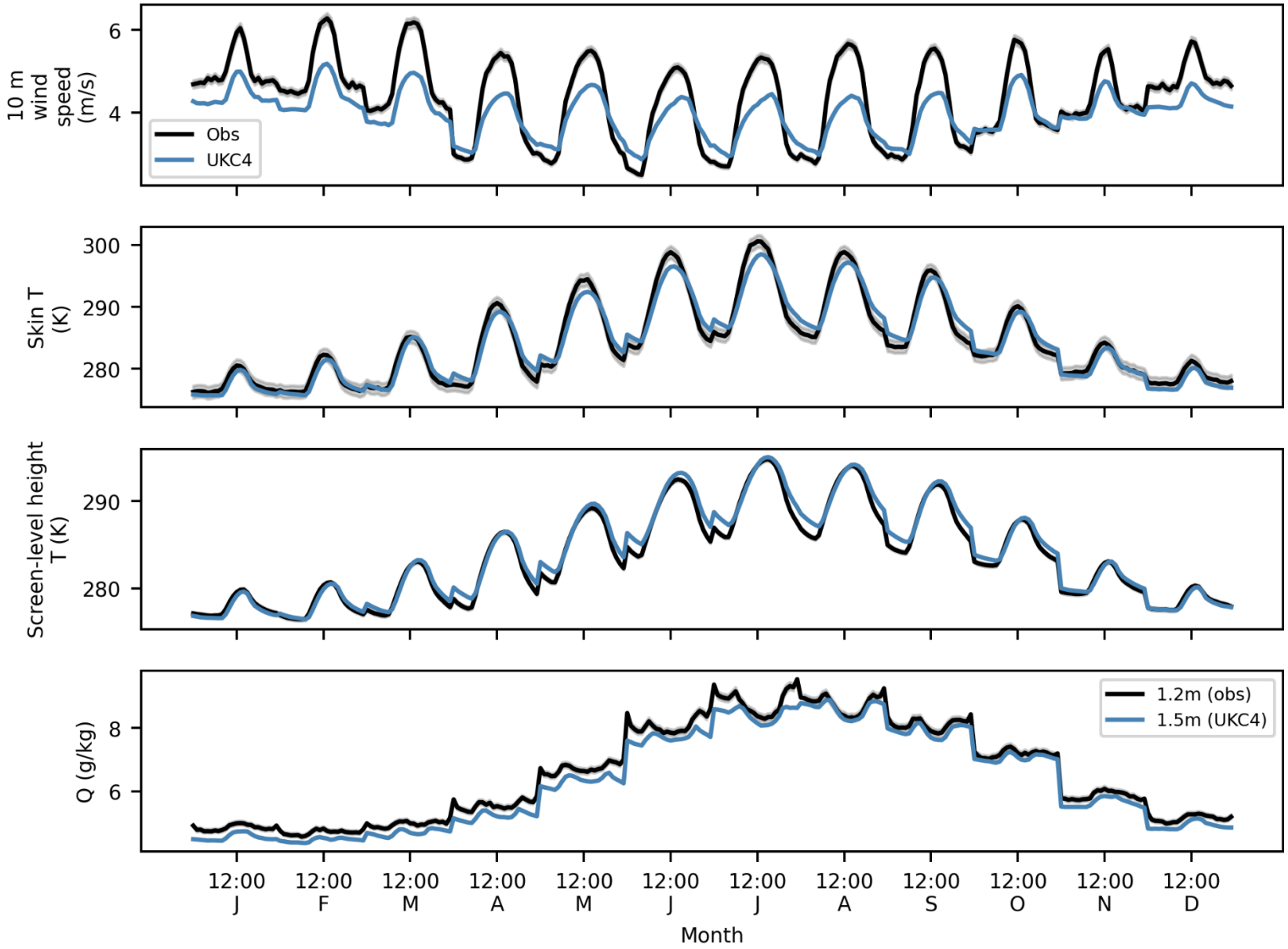
ERA5/GloSea-5-driven hindcast model runs (coupled atmosphere-land-ocean-waves)

1999 to 2023
(Hourly, 3-hourly, and daily data used here.)

Resolution:
Atmosphere/land (UM/JULES - RAL 3.3): 4.4km to 2.2km
Ocean (NEMO): 1.5km
Waves (WaveWatchIII): 3km to 1.5km

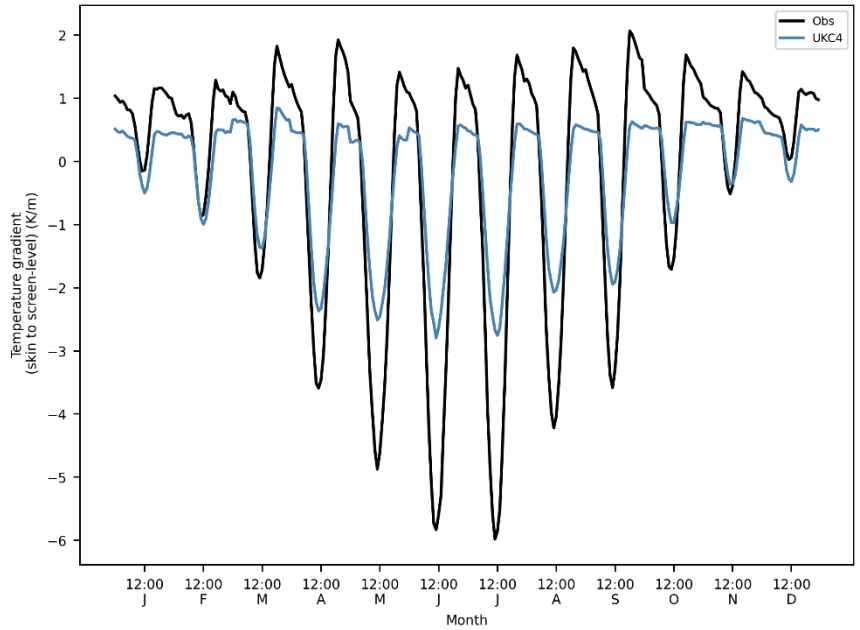
Data

CEDA Archive - Cardington dataset



Diurnal cycle doesn't have as large a range in model as obs (Skin T, 1.5m T, u10)
Maximum daytime skin T, 1.5m q, and u10 higher in obs

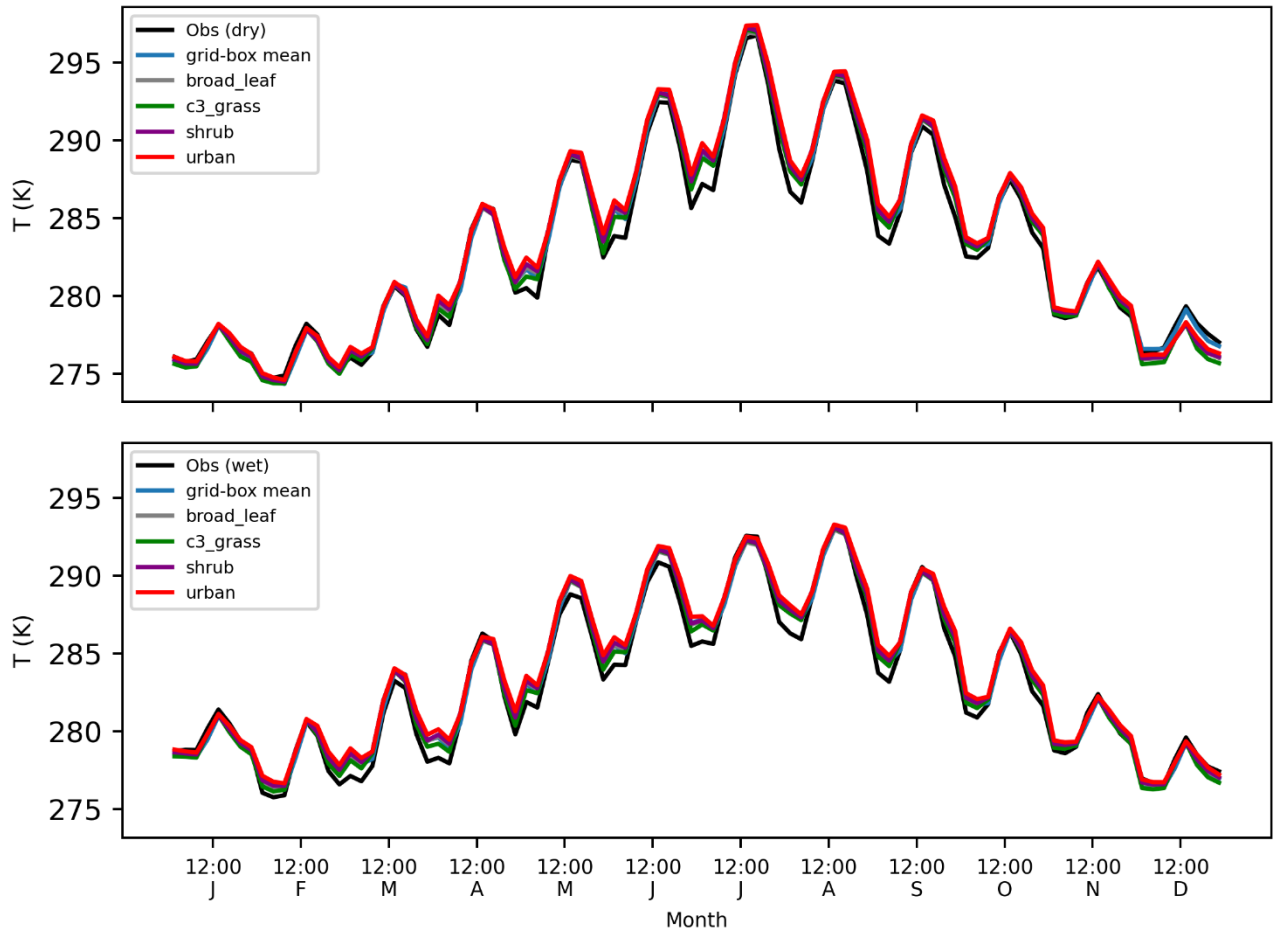
Stronger observed Temperature gradient during daytime and nighttime (obs more stable during the night)

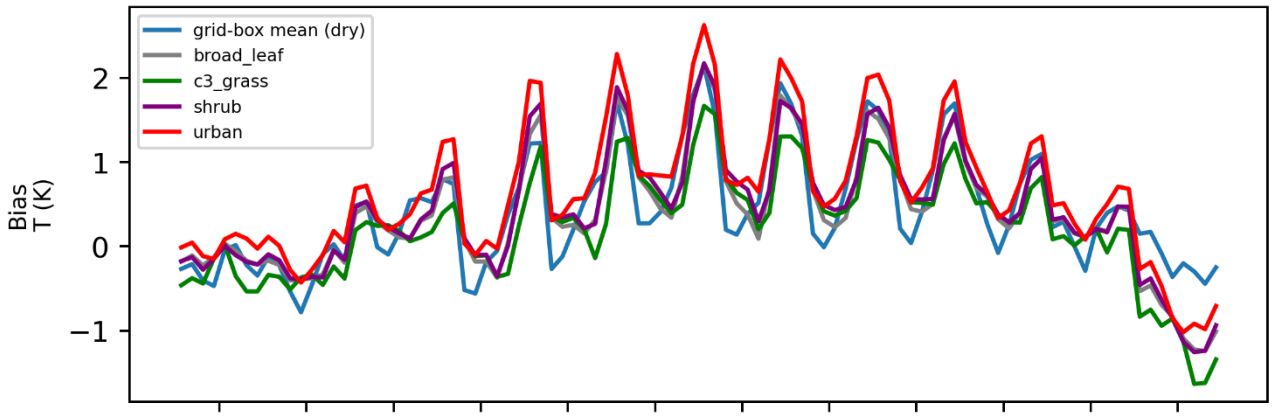


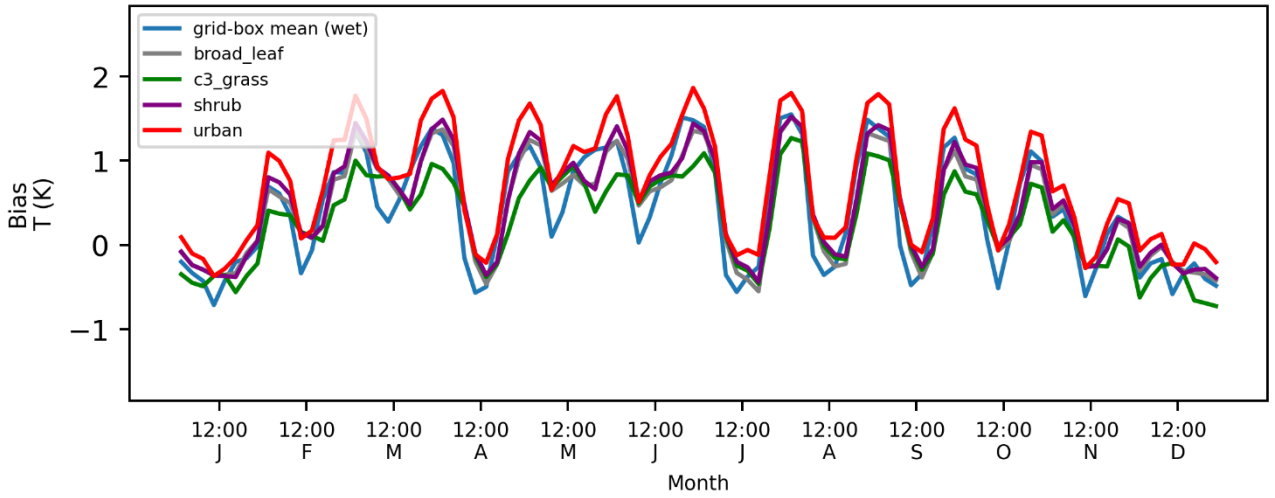
Temperature, specific humidity, wind speed

1.5 m temperature on tiles (not grid-box mean)

Generally, the same ‘story’ as with the grid-box mean, i.e. too warm overnight at screen-level height for all tiles – therefore acceptable to use the grid-box mean to represent conditions at Cardington
(same for other relevant variables)







Temperature on tiles

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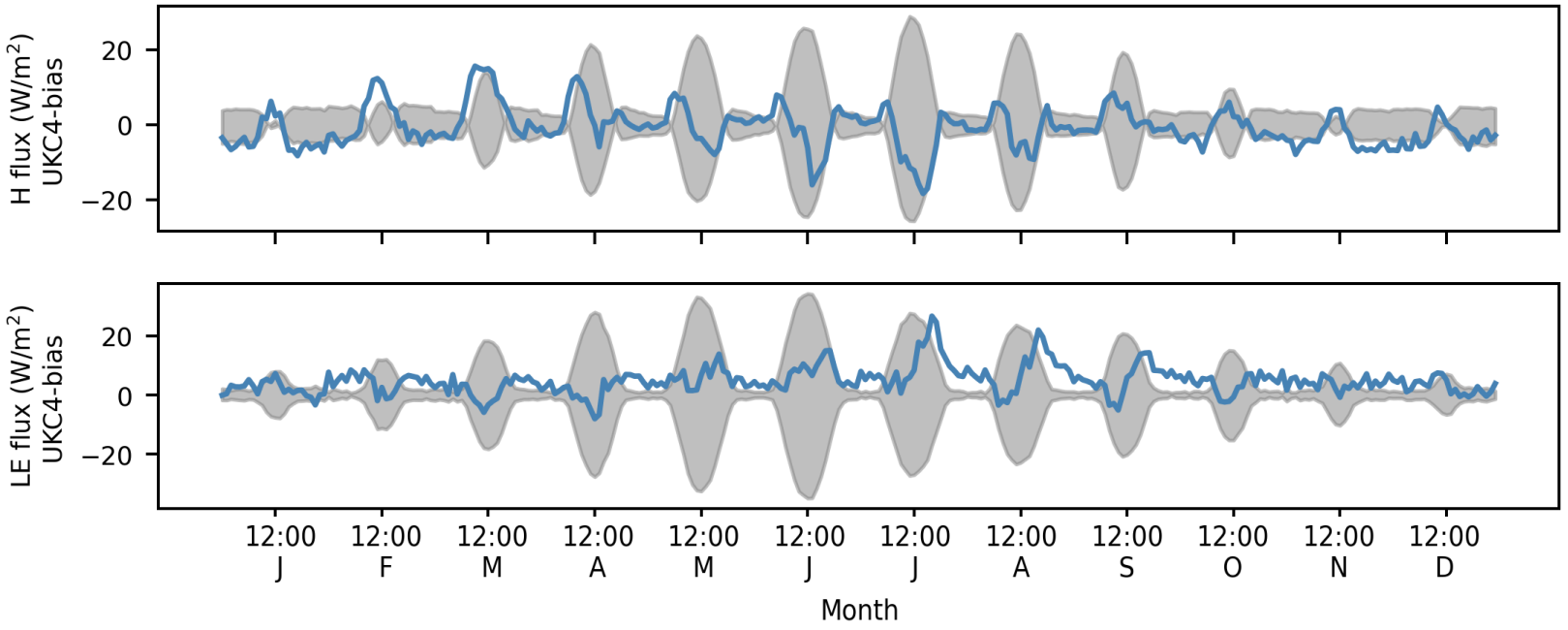
H flux

- Daytime peaks higher in October-March and too low May to August (‘turning points’ in April and September)

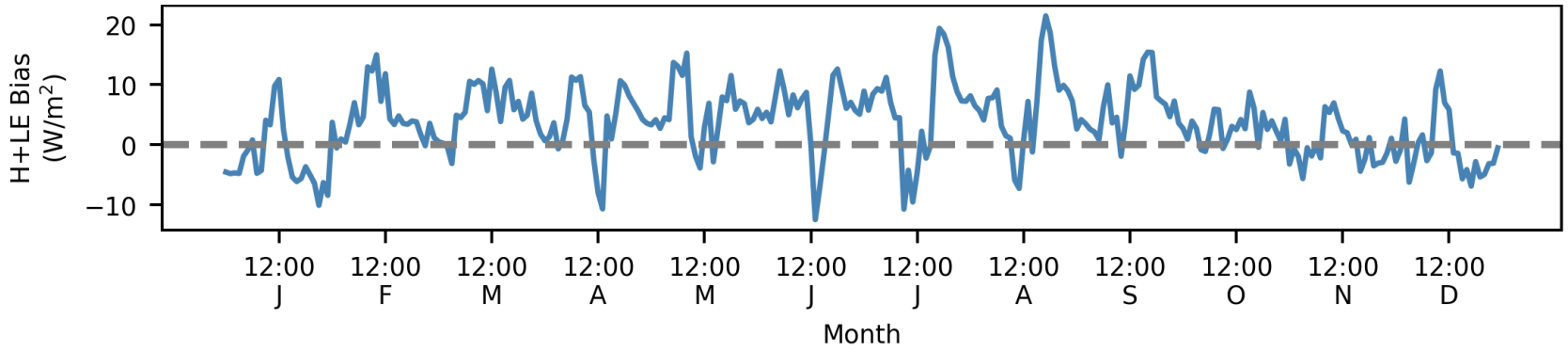
LE flux

- Too high during May to September – mostly in the afternoon through to the following morning



Total turbulent fluxes (LE + H)

Tendency to be higher in model outside of winter months – but daytime peaks too low from April to August (where H flux bias is strongest)



Sensible heat flux, latent heat flux

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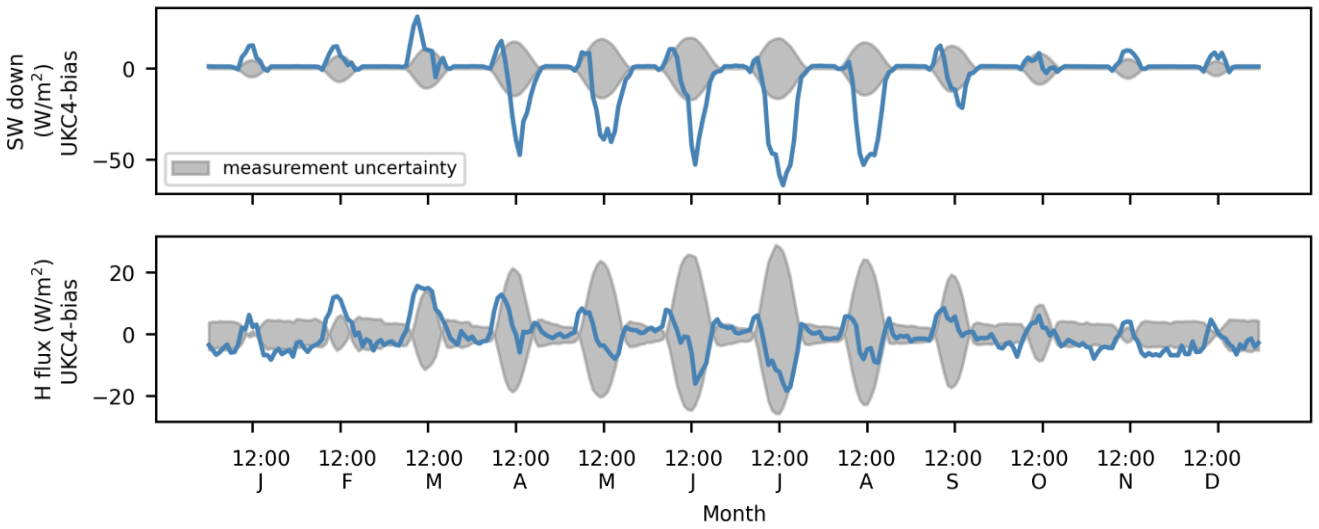
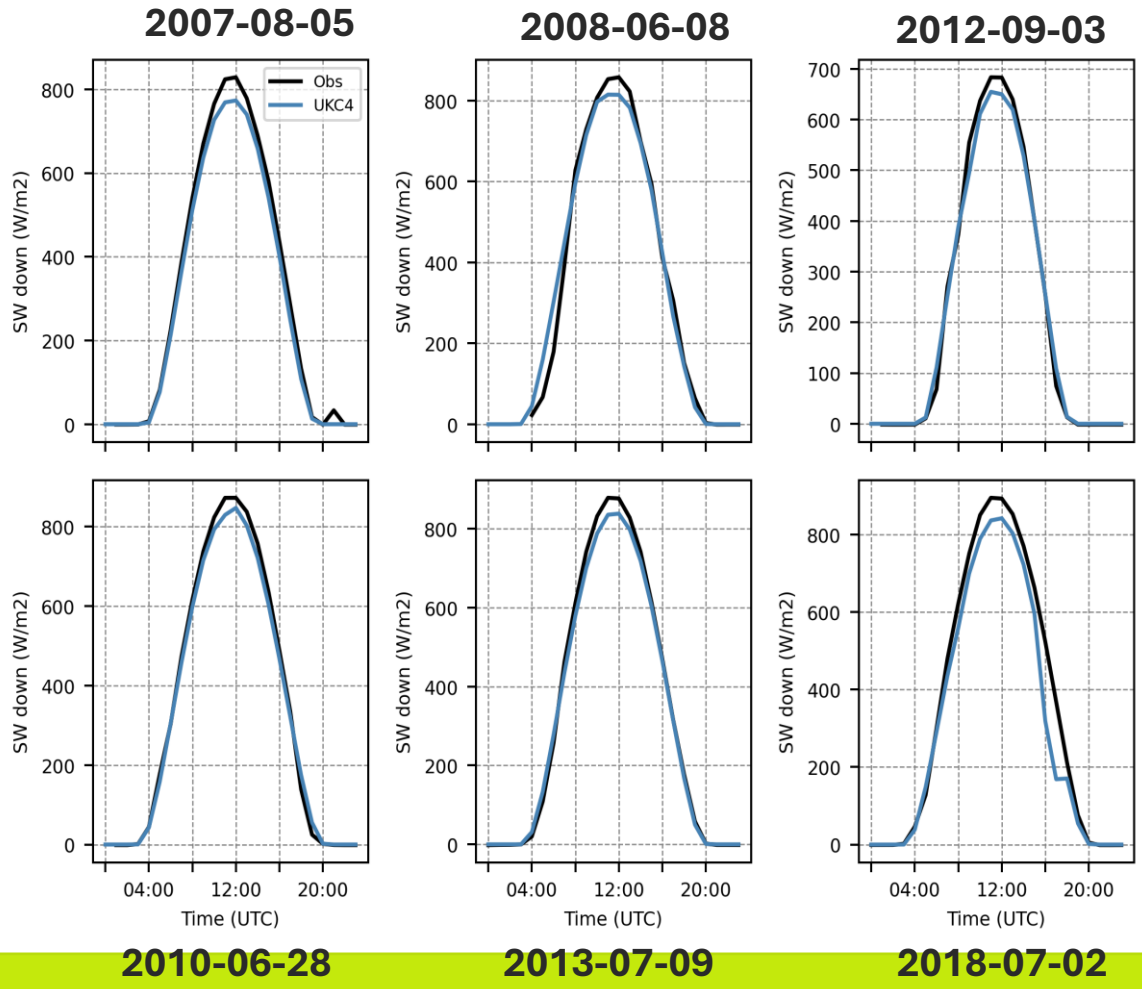


Not enough SW down during spring/summer
Sensible heat flux too low at midday peaks during much of this period

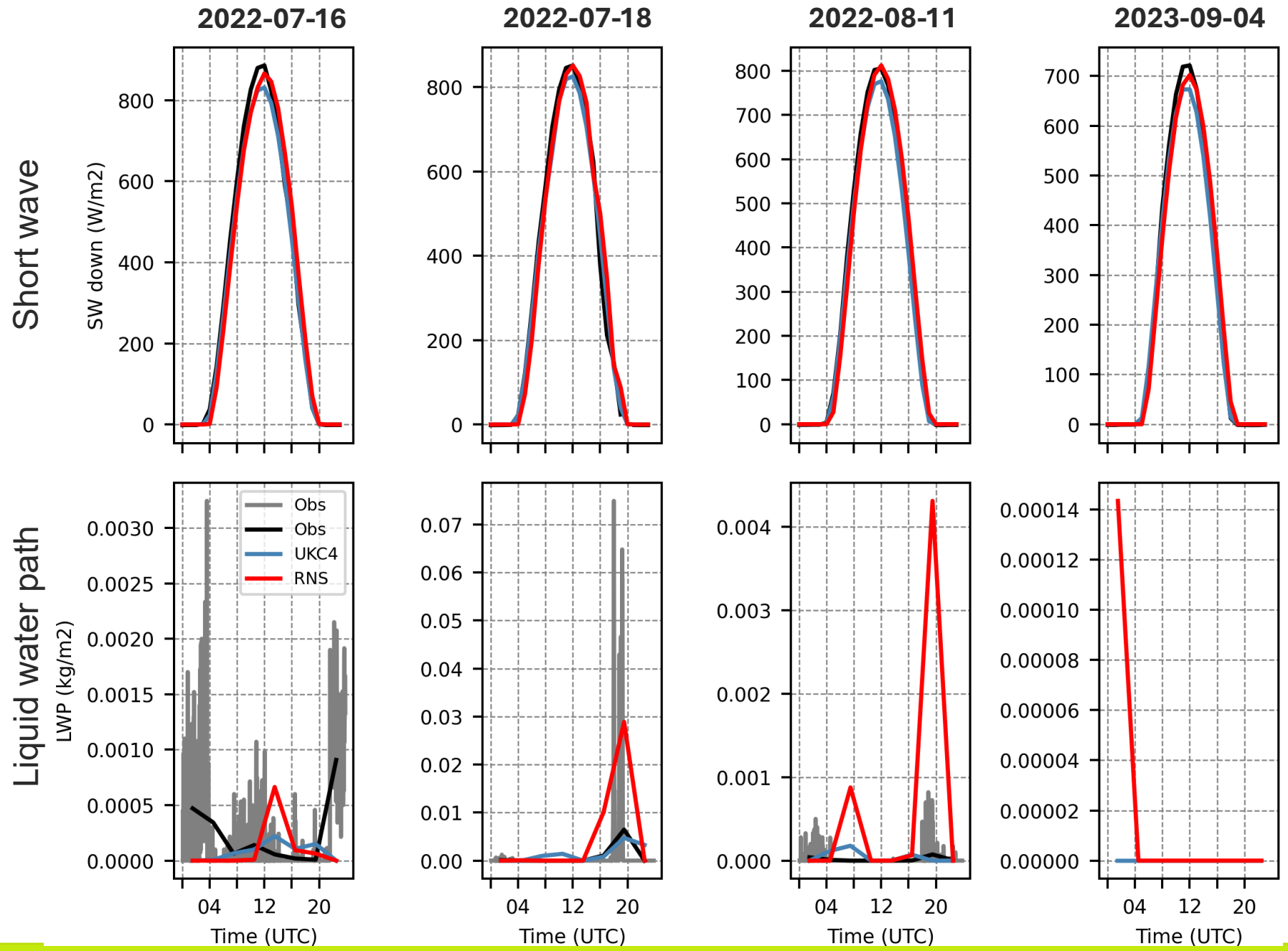
Clear-Sky cases

Daytime peaks consistently higher in obs (approx. by 50Wm2 on average)

Is the discrepancy due to **aerosol** representation?



Shortwave downwelling



Aerosol represented differently in **weather (RNS)** to climate (UKC4) (both using RAL3.3)

RNS (weather) in better agreement with observed SW downwelling (not consistently too low as in UKC4)

Column liquid water path (lwp) in **RNS** often higher than that from UKC4 – supports idea that the SW discrepancy is due to aerosol representation and not UKC4 having too much cloud

Shortwave and Liquid Water Path – clear-sky cases

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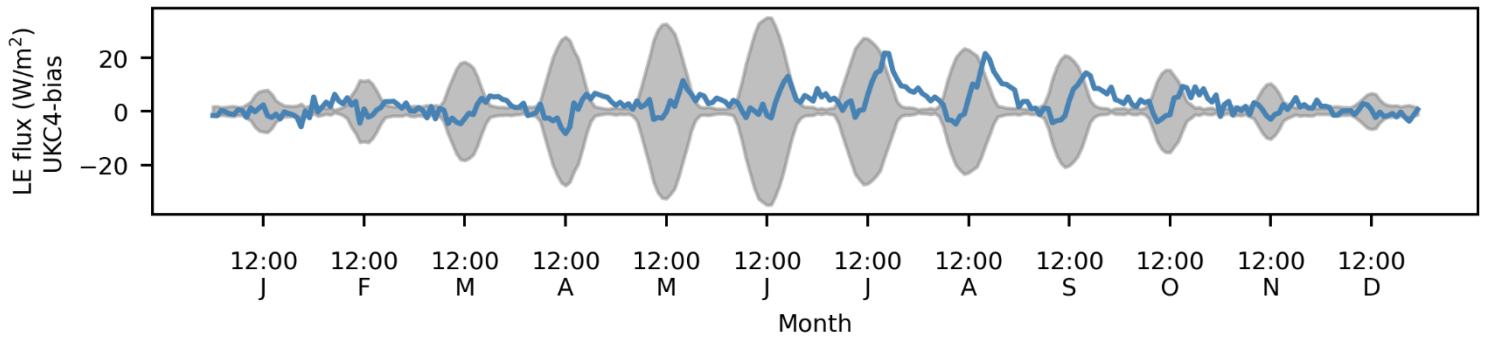
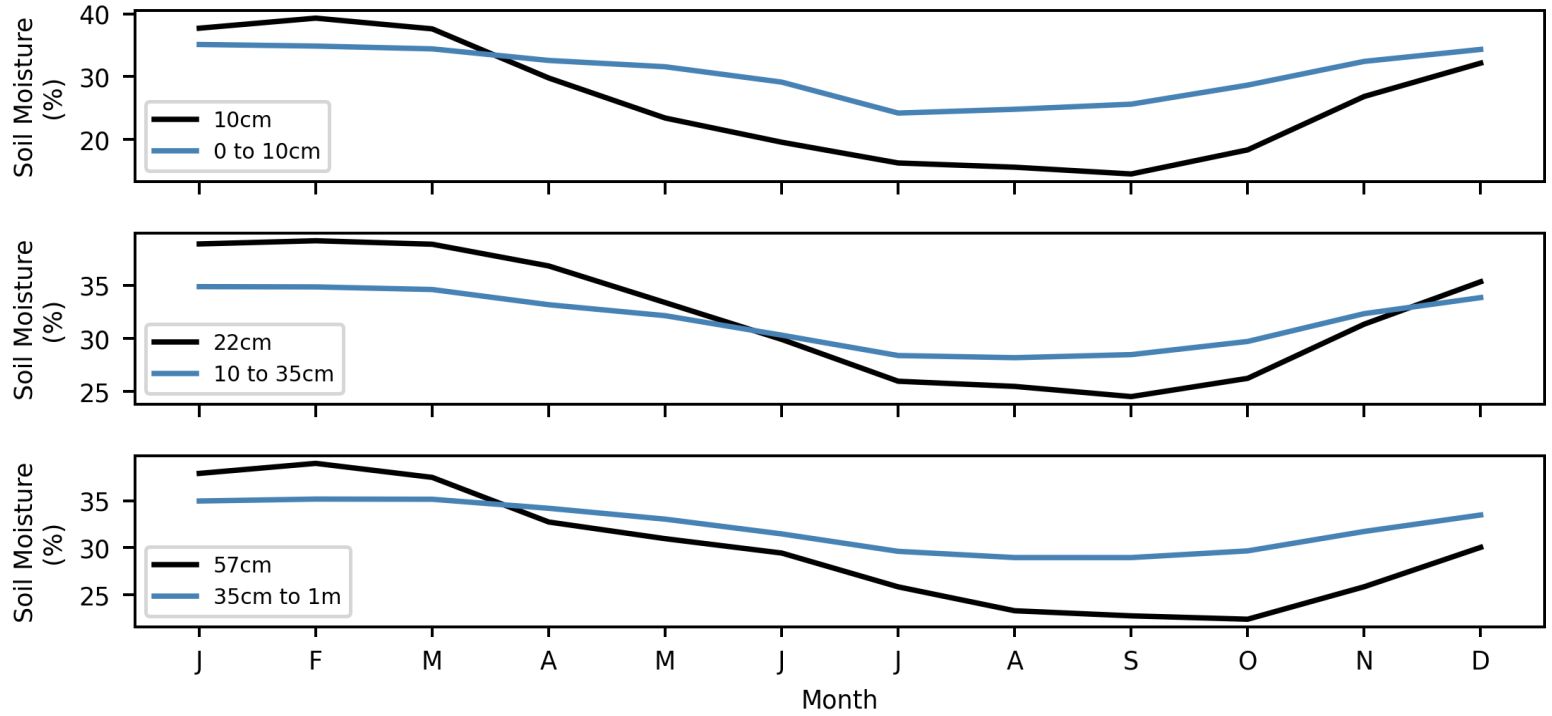
LE flux

- bias often within measurement uncertainty
- but when this isn't the case it tends to be positive and occur during the nighttime and/or evening

Is the LE flux affected by the **soil moisture** remaining too high over Spring/Summer/Autumn?

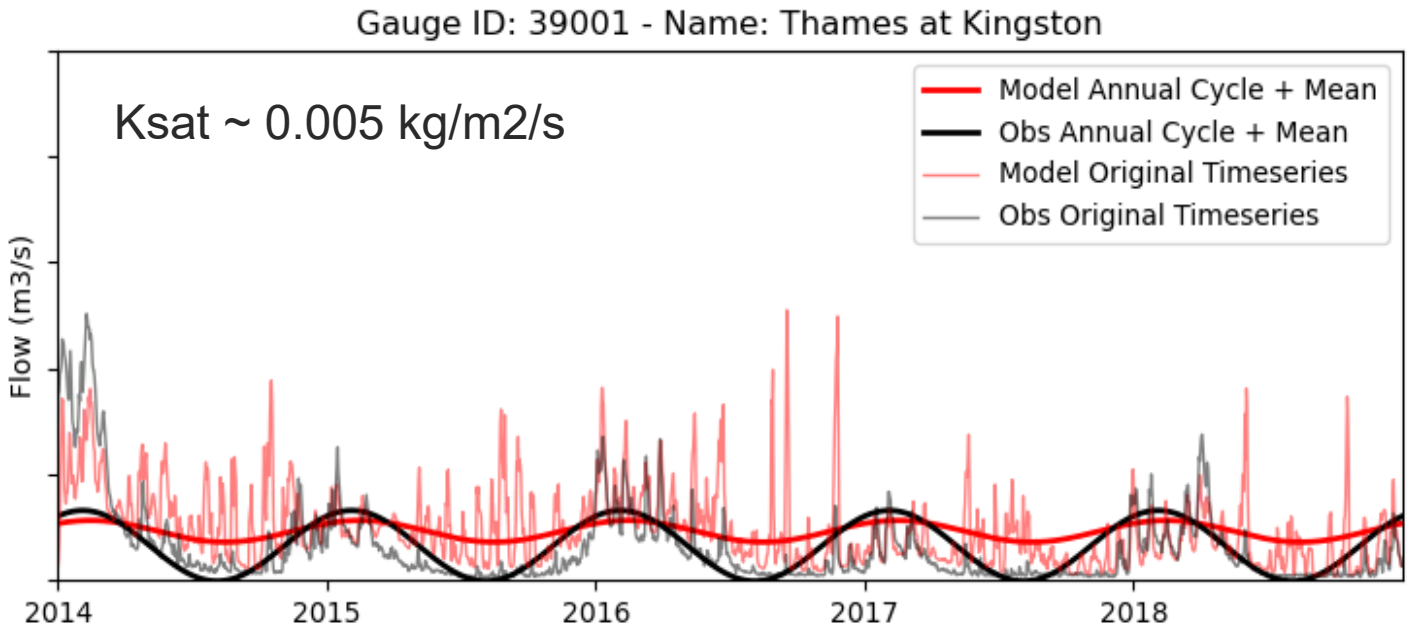


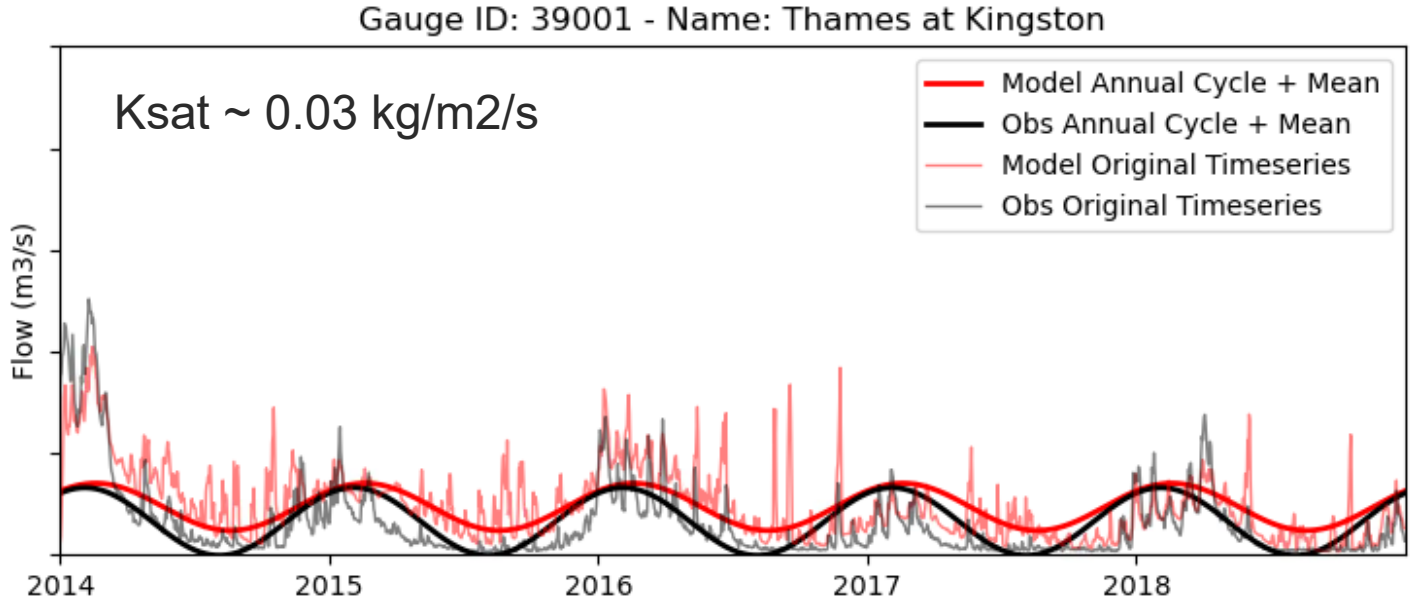


River flow cycles can also not have as varied a cycle as obs and can be too ‘flashy’ in the south-east of England

Sensitivity tests using offline JULES:

- Ksat changed to reflect bedrock values (chalk in SE)
- Increase in Ksat allowing more infiltration and less surface runoff – **drier soil** at upper layers – less ‘flashy’ rivers and therefore minimums in cycle become lower and more in-line with obs





Plots by Maisie Wright, data from Martin Best

Summary and Future Work

- Not enough variability in diurnal cycles
- Peak daytime SW downwelling too low (coinciding with too low H flux and daytime skin temperature) – suspected cause is the aerosol representation
- Rivers in south-east can be too “flashy” but are in better agreement with obs when bedrock Ksat is used

- Plans to carry out sensitivity tests to determine whether different aerosol representation improves the hindcast (UKC4) SW downwelling
- Repeat ‘river’ sensitivity test with the regional coupled model to assess affect on the fluxes and associated variables
- Carry out hindcast/Cardington analysis using a ML model that predicts fluxes from met conditions (model trained using COSMOS-UK network observations) – similar to **Zouzoua et al (2025)**

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