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A Consortium for COnvection-scale modelling Research and Development

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The surface energy balance in models and at observatories

- *ideas of process-oriented verification*

Carl Fortelius, 46th EWGLAM and 31th SRNWP Meeting, Prague 30 September 2024

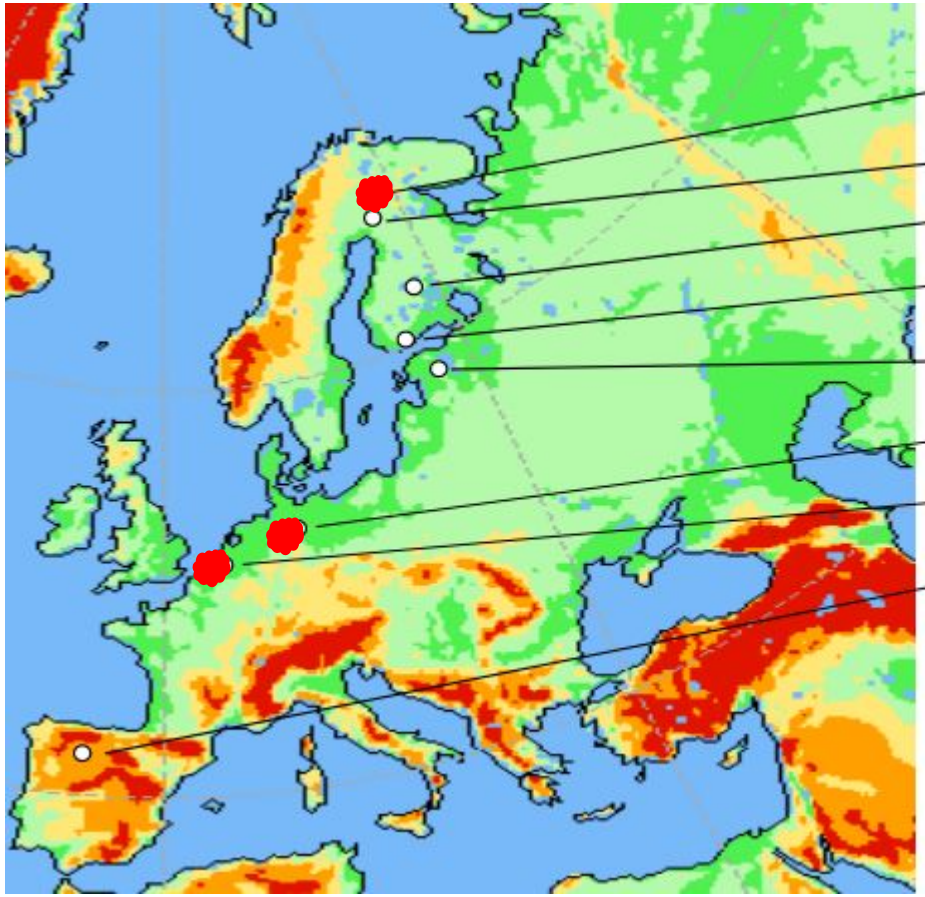
Outline

- The FMI Hirlam NRT model intercomparison enterprise (“mastverification”)
- Use of the data archive for assessing surface interactions in NWP forecasts: can it be done?
- Conclusion: yes, but

The model intercomparison enterprise

- **NRT** comparison of surface fluxes and near-surface variables from **operational** NWP forecasts and **observatories**
- On display at https://fminwp.fmi.fi/mastverif/ (currently halted)
- Data are uploaded by the producers; simple csv tables and hardly any meta data
- Seasonal summaries since 2010 on display at https://fminwp.fmi.fi/mastverif_stats/index.html
- Sites and models have changed over time
- Hosted by FMI and Hirlam

Sites and models (operational forecasts*)



Sodankylä
Rovaniemi
Kuopio
Kivenlahti
Valgjärve
Lindenberg
Cabauw
Valladolid

IFS (EC01)
ARPEGE (FRAR)
Harmonie-arome (MEP0)

IFS (EC01)
ARPEGE (FRAR)
Arome (FARO)

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Harmonie-arome (MEP0)

data received summer of 2023

*24-hour forecasts initiated at 00Z

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Available parameters

VARIABLES

- **Temperature 1** near 2 m, TT
- **Temperature 2** near 10 m/lowest mod. level, TL
- **Temperature diff (1-2)** DT
- **Relative humidity** near 2 m, RH
- **Wind speed** near 10 m, FF

TURBULENT FLUXES

- **Sensible heat flux** SSH
- **Latent heat flux** SLH
- **Evaporation** EVAP
- **Momentum flux** MOMF

RADIATIVE FLUXES

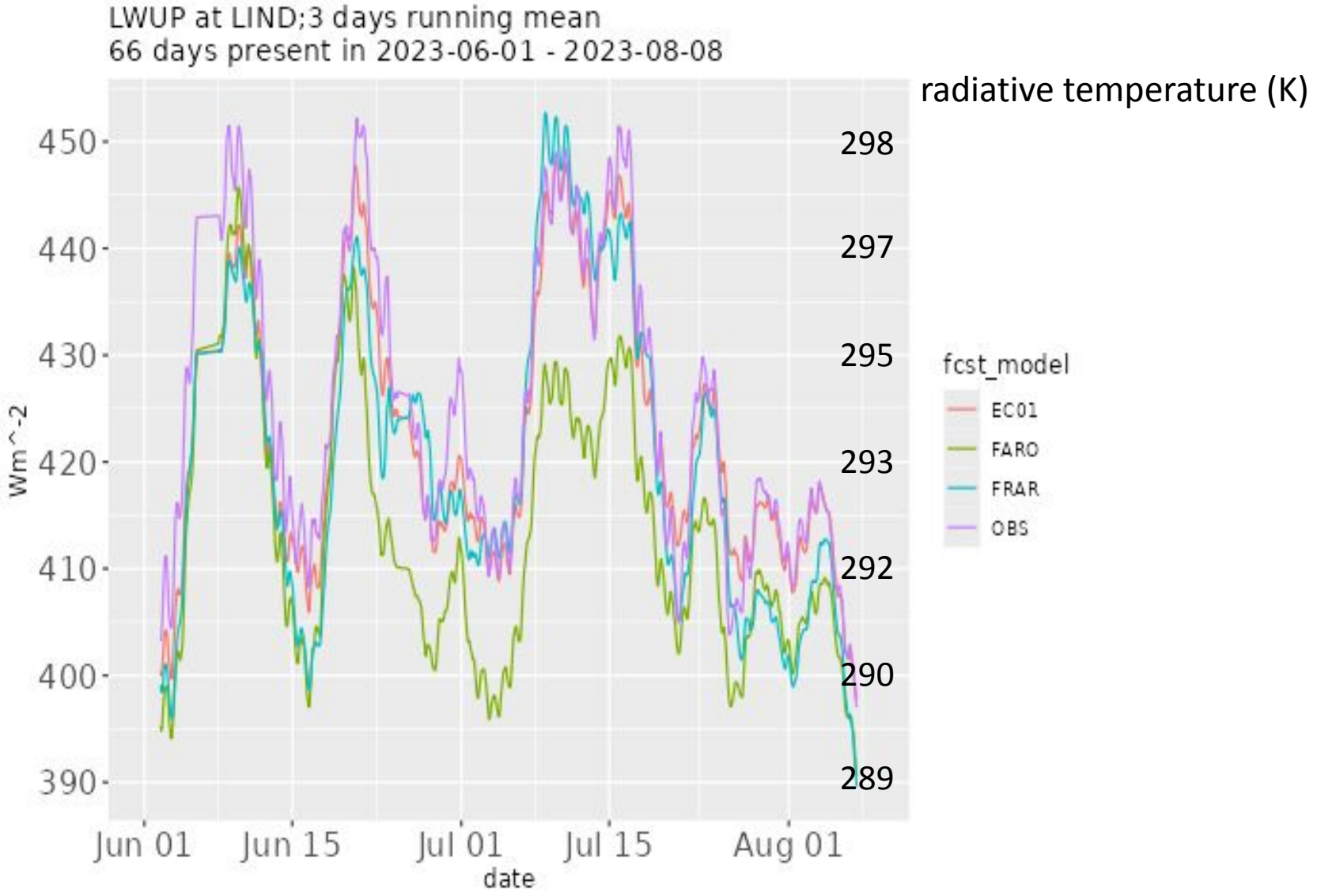
- **SW radiation down** SWDN
- **SW diffuse radiation** SWDIFF*
- **SW direct normal irradiance** DNI*
- **SW radiation up** SWUP
- **LW radiation down** LWDN*
- **LW radiation up** LWUP

*optional

Process-oriented verification

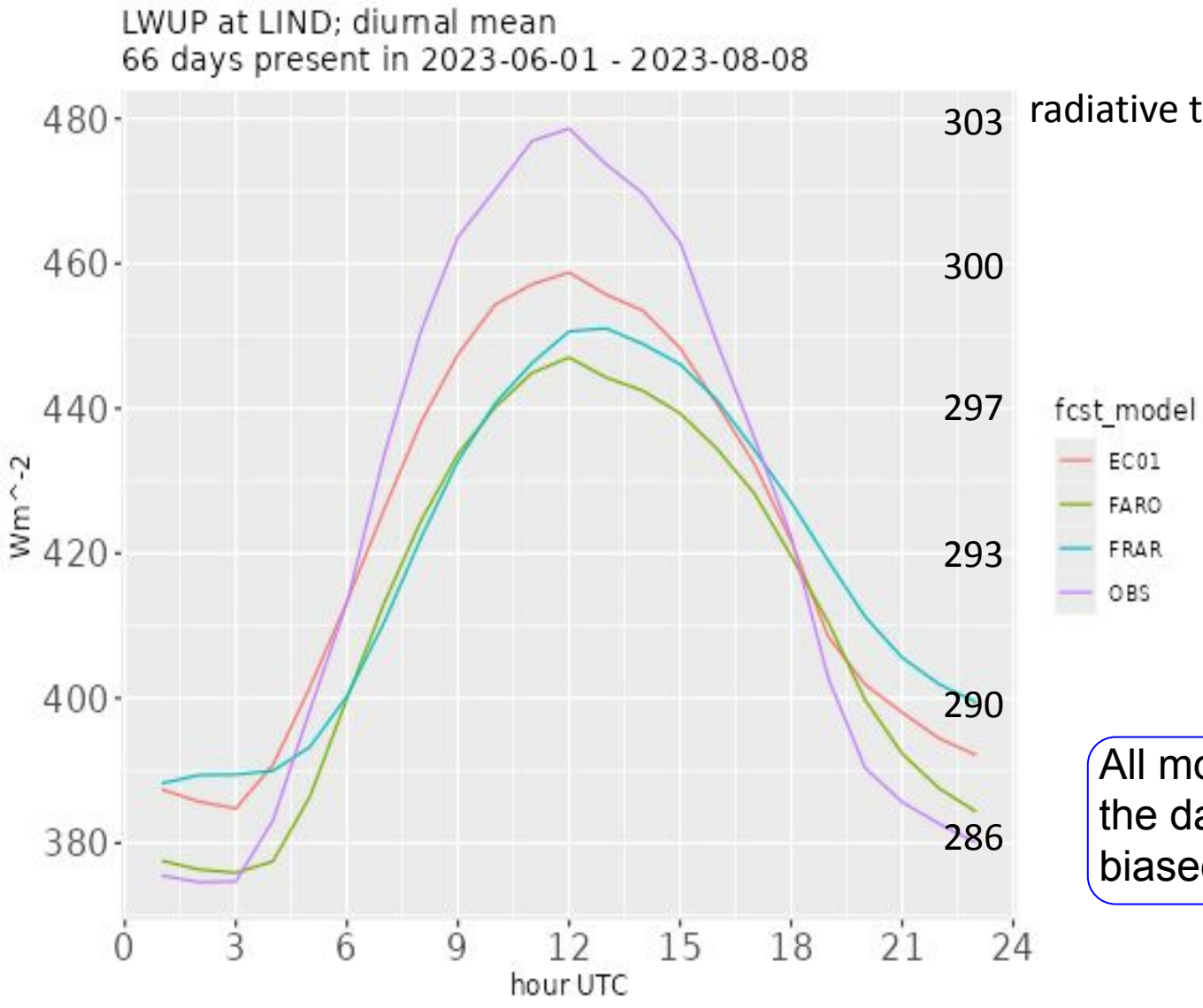
- With these data we can apply a multivariate approach, trying to assess how conditions evolve in response to active processes and their interactions
- But we will be constrained to very few localities that may or may not be well represented, in the models we wish to evaluate
- As an example, we shall examine the summertime surface temperature at Lindenberg Observatory in the framework of the surface energy budget equation

Lindenberg, JJA 2023: LWUP



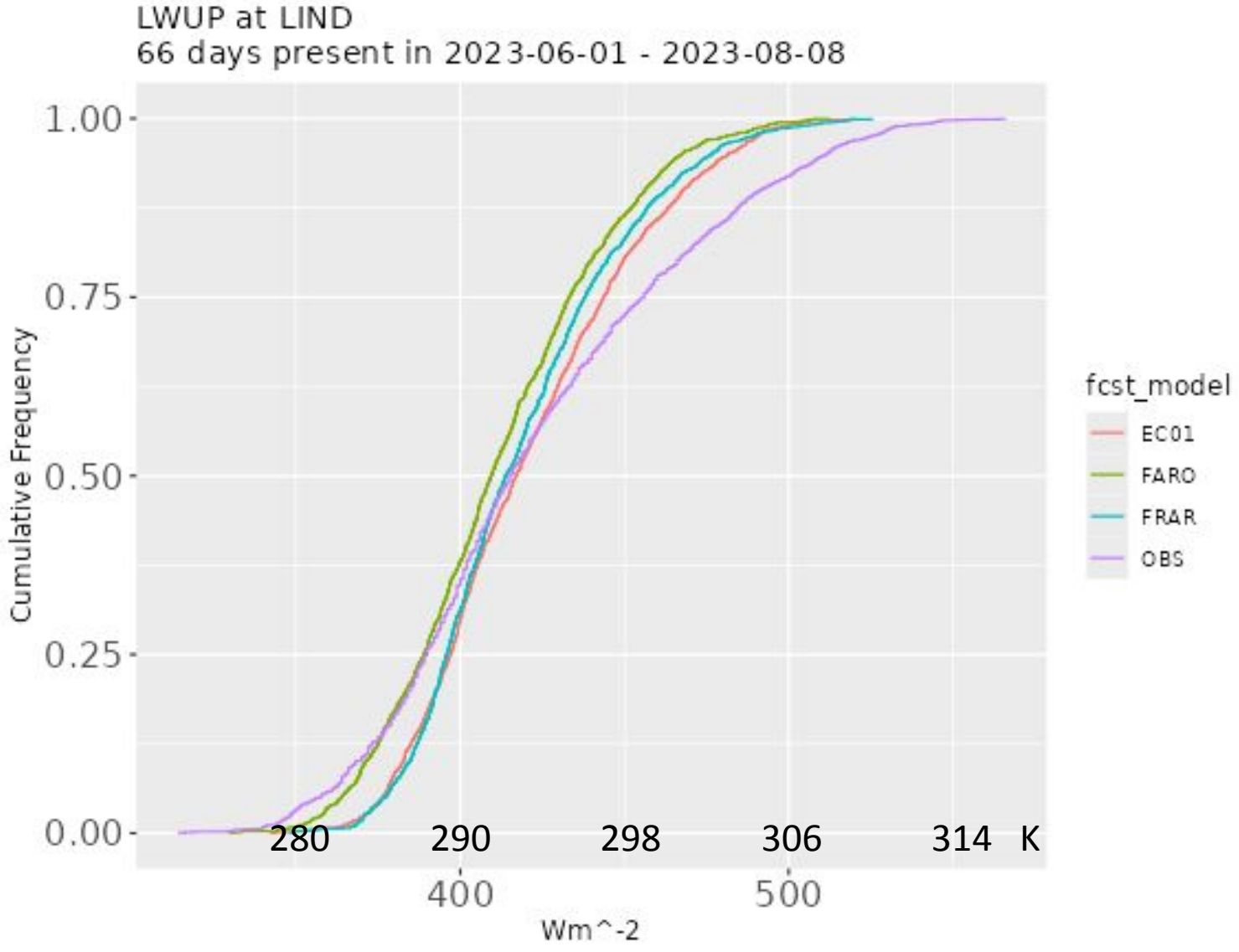
radiative temperature (K)

Lindenberg, JJA 2023: LWUP



All models biased during the day, two models biased during the night

Lindenberg, JJA 2023: LWUP



The surface energy balance

$\varepsilon\sigma T_s^4$

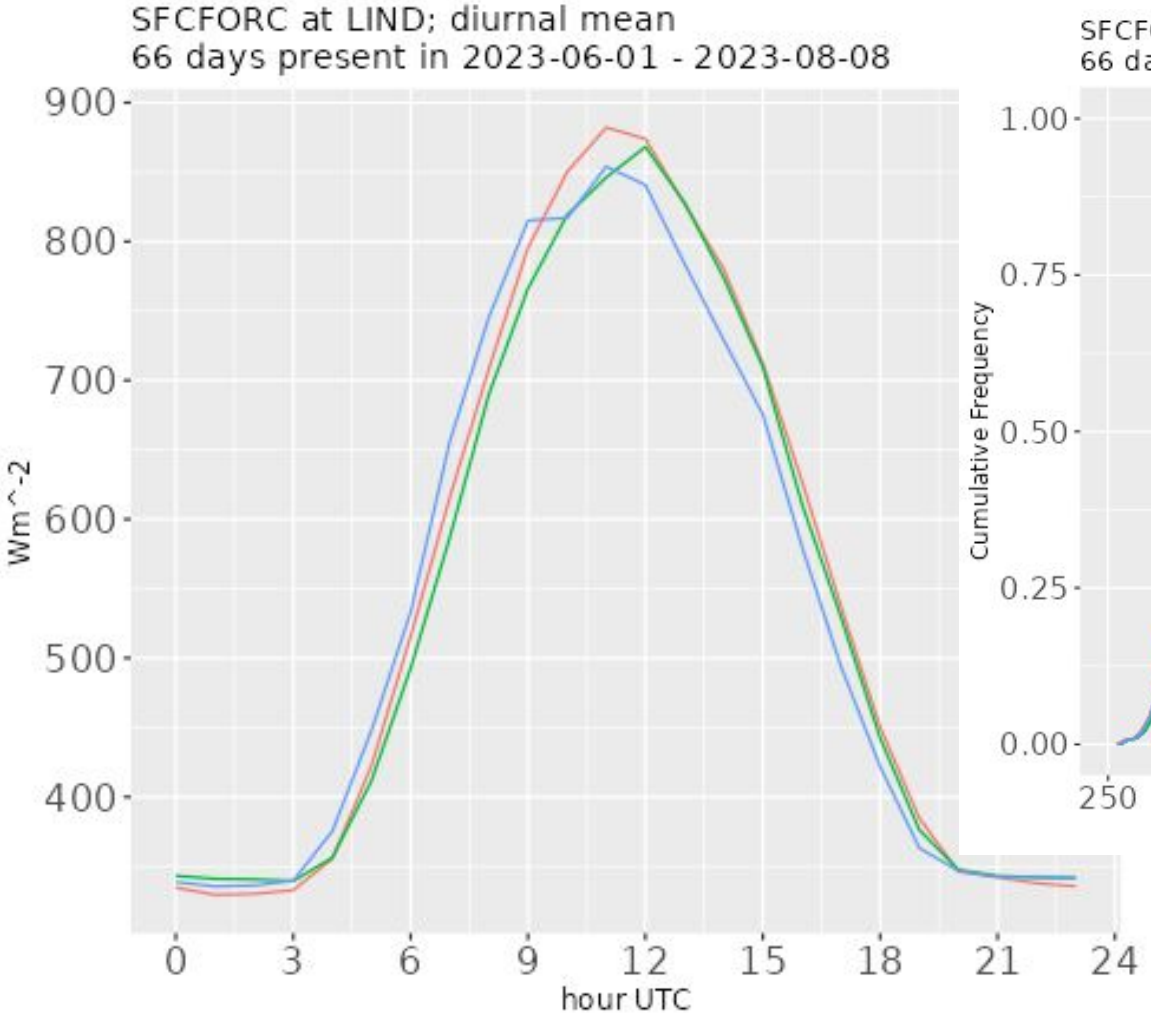
turbulent fluxes

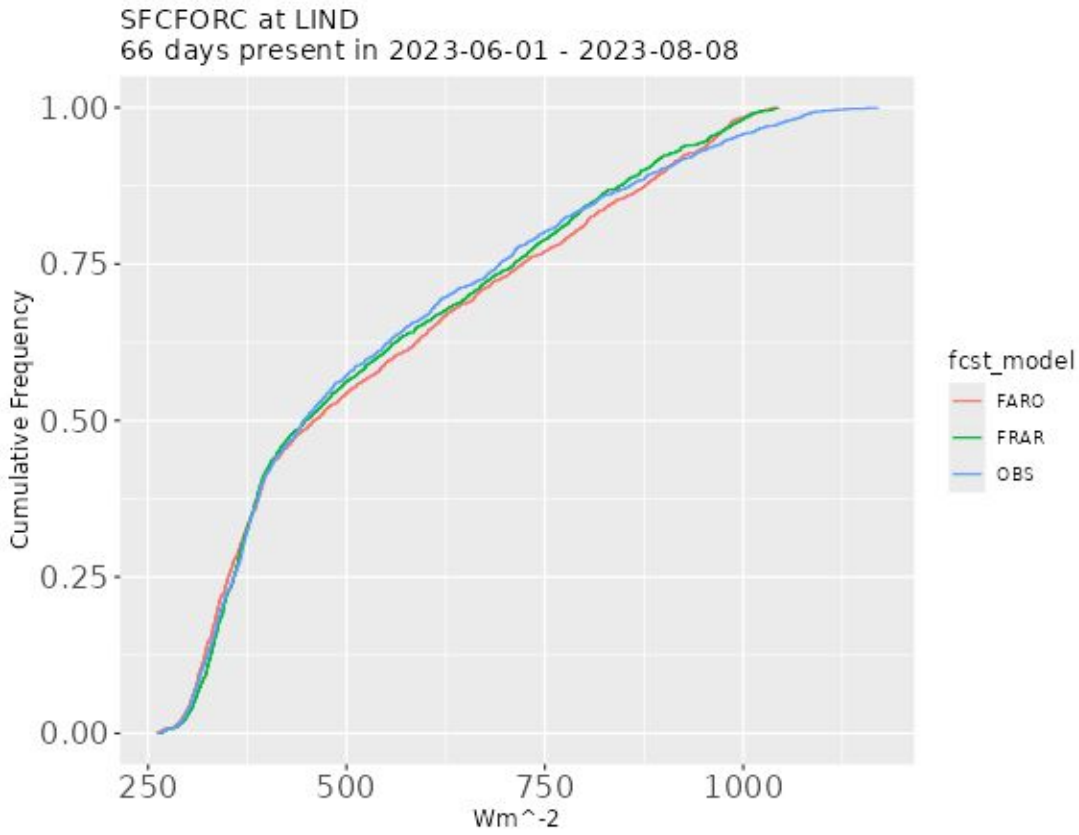
SWDN - SWUP + LWDN = LWUP + SSH + SLH + G

quasi external radiative forcing “SFCFORC”

heat flux into the soil “RESID”

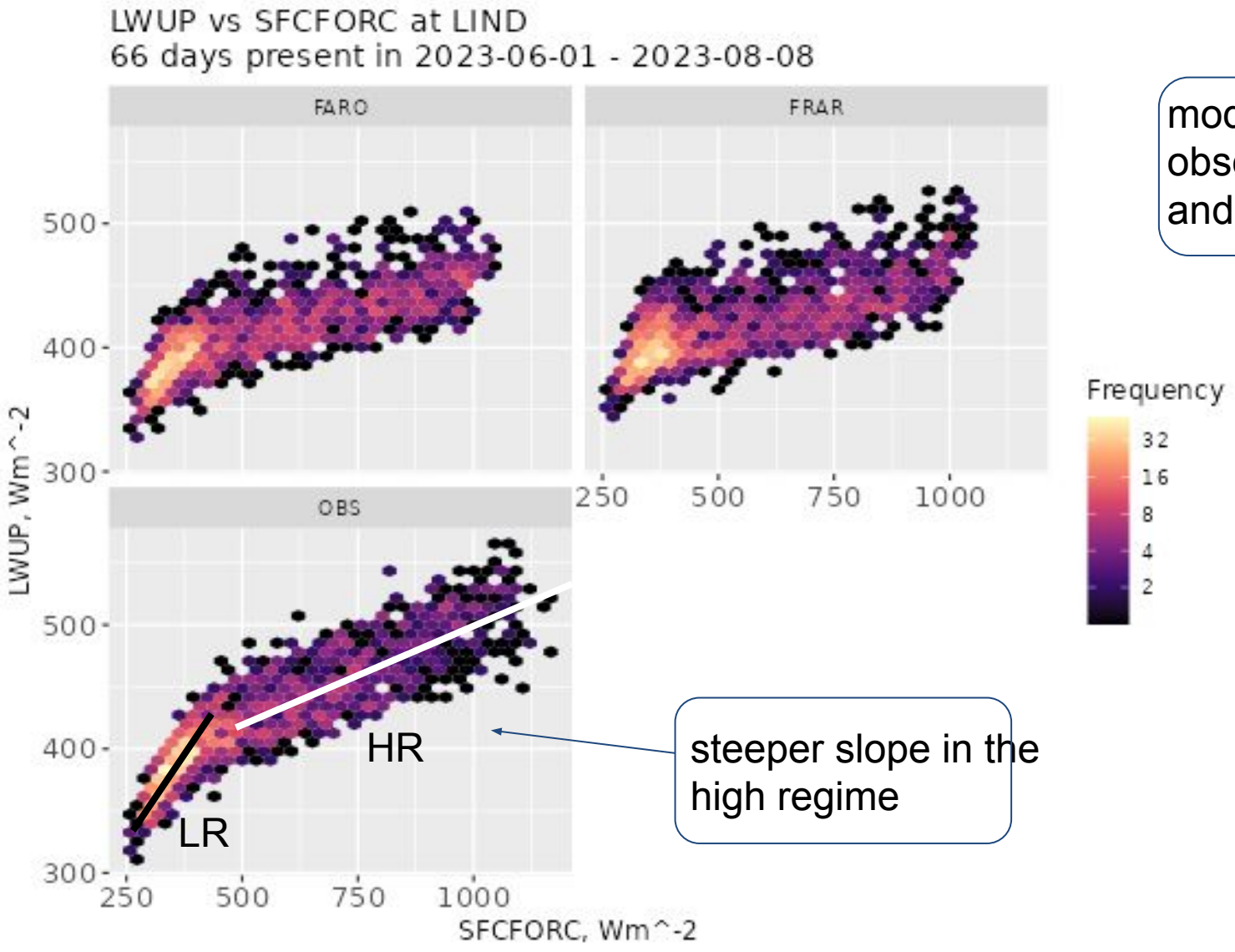
Lindenberg, JJA 2023: *SFCFORC*





on average, there is less forcing observed than forecasted by the two models

Lindenberg, JJA 2023: *LWUP vs SFCFORC*



models reproduce observed “low regime” and “high regime”

steeper slope in the high regime

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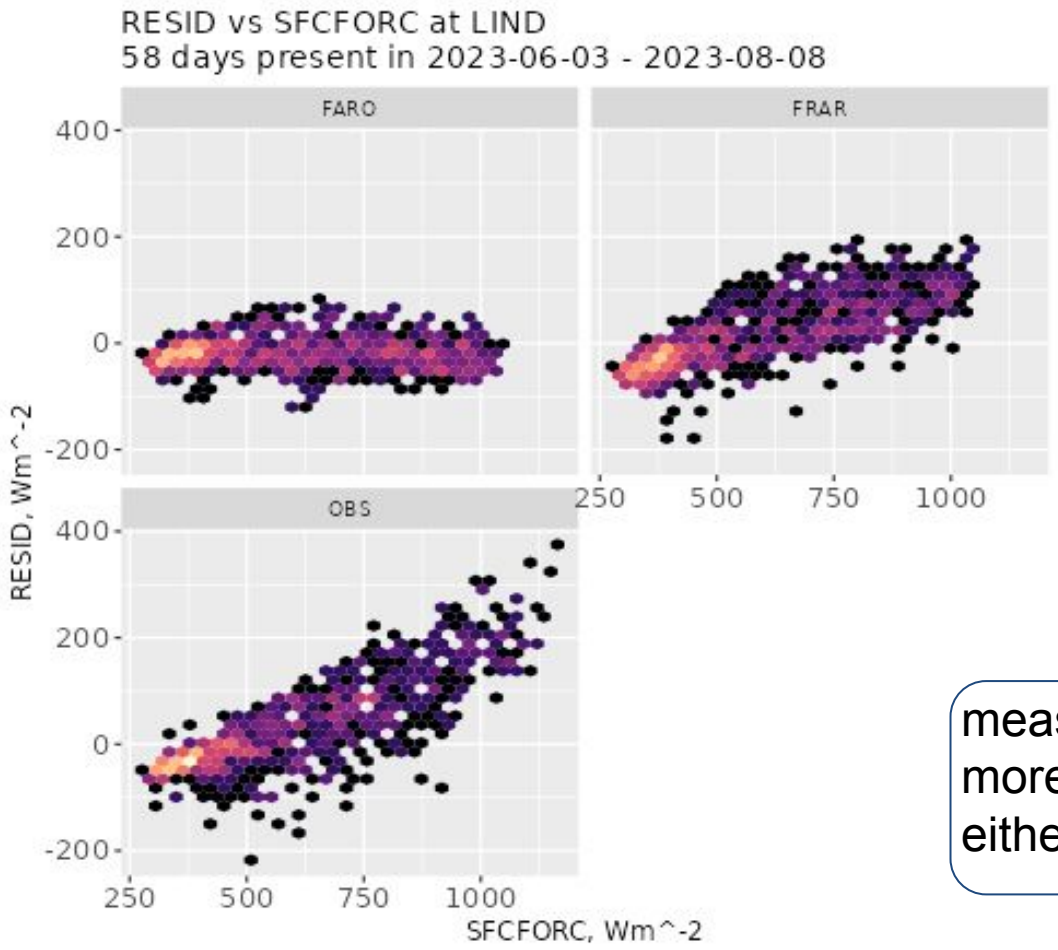
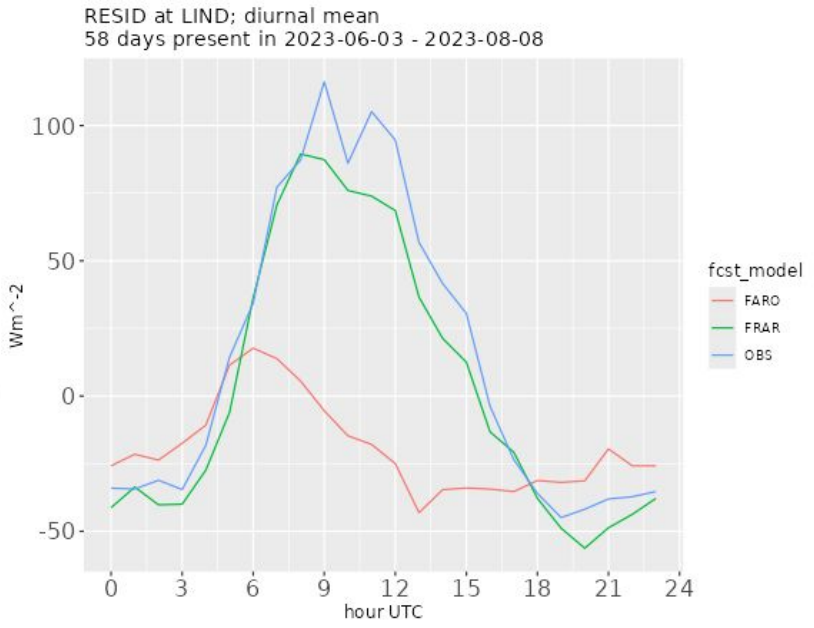
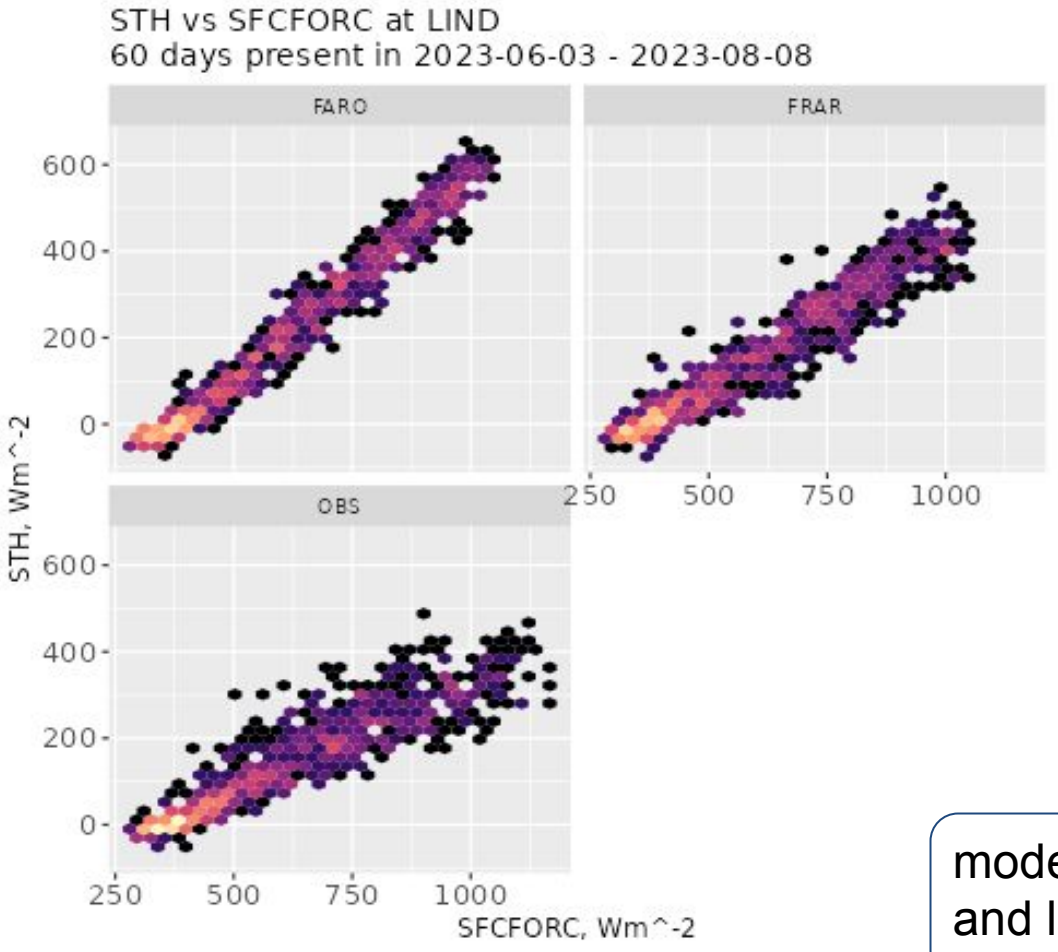
Lindenberg, JJA 2023: *RESID vs SFCFORC*

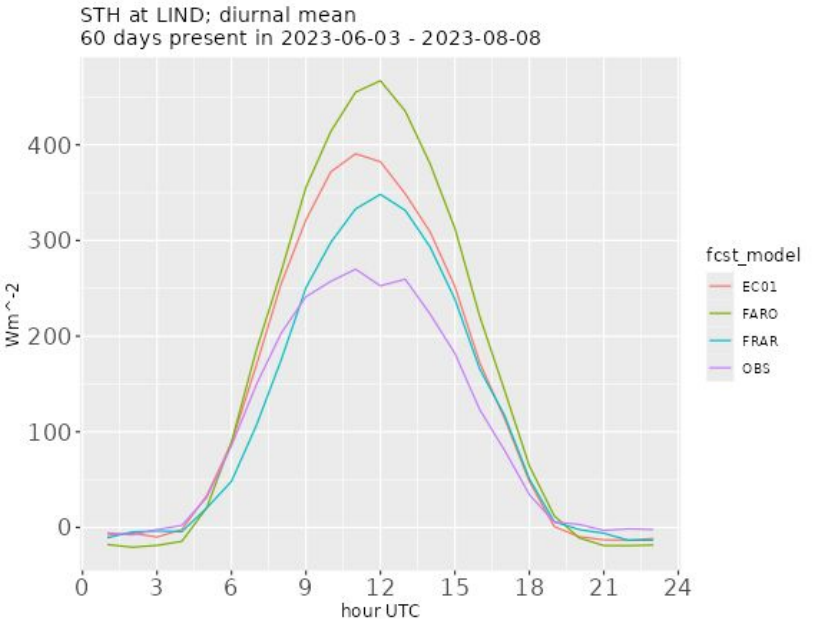




measurements indicate more flux into the soil than either model, not less

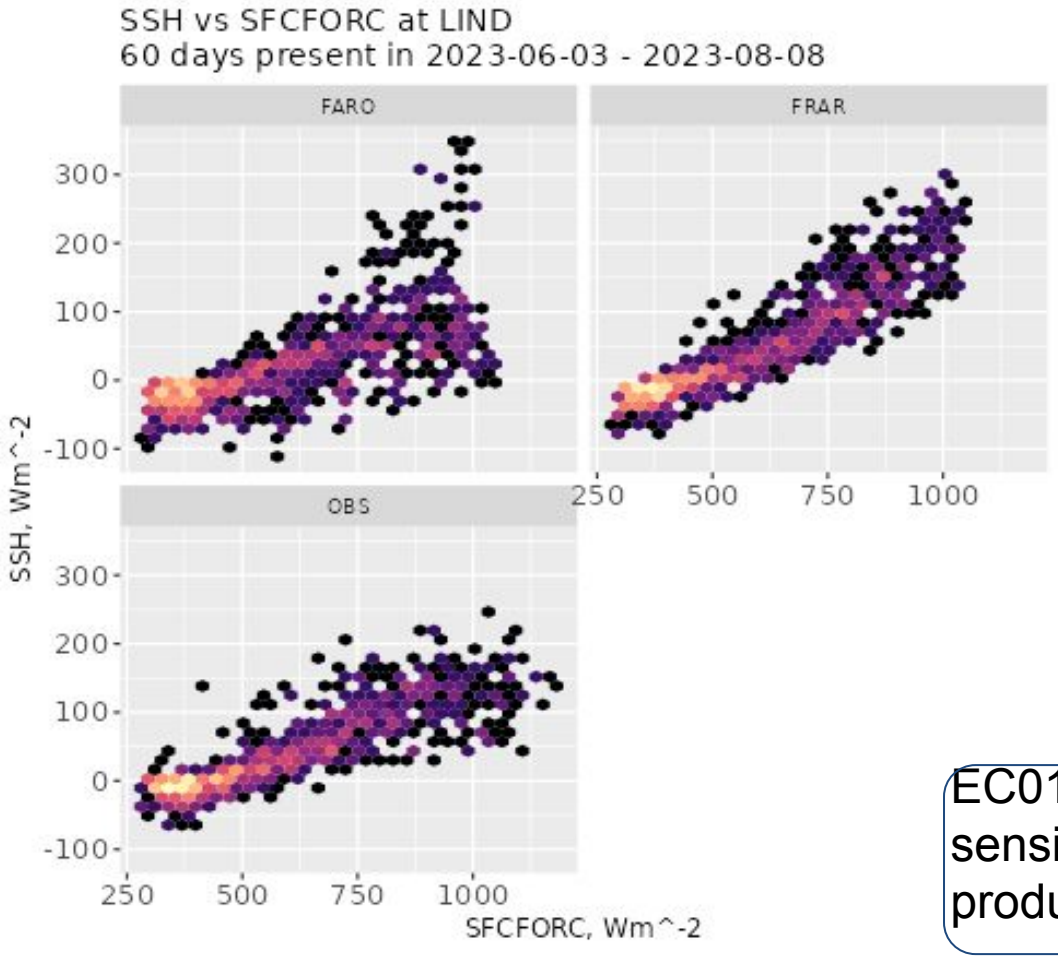
Lindenberg, JJA 2023: *SSH + SLH vs SFCFORC*

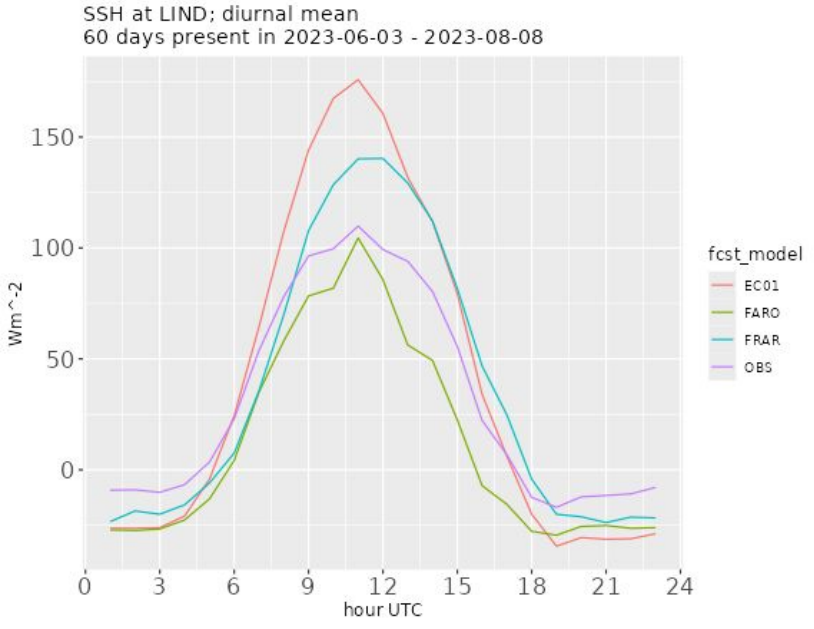




models show steeper slope and larger day-time flux

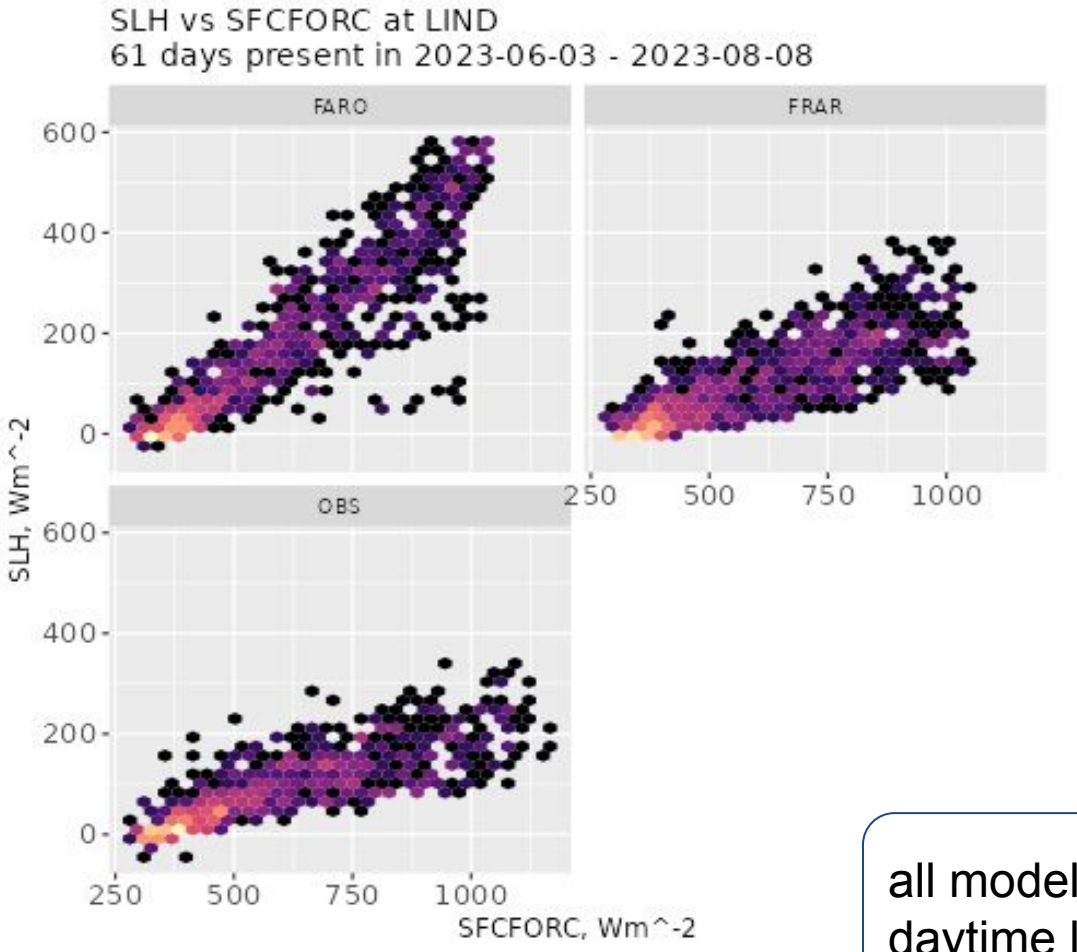
Lindenberg, JJA 2023: *SSH vs SFCFORC*

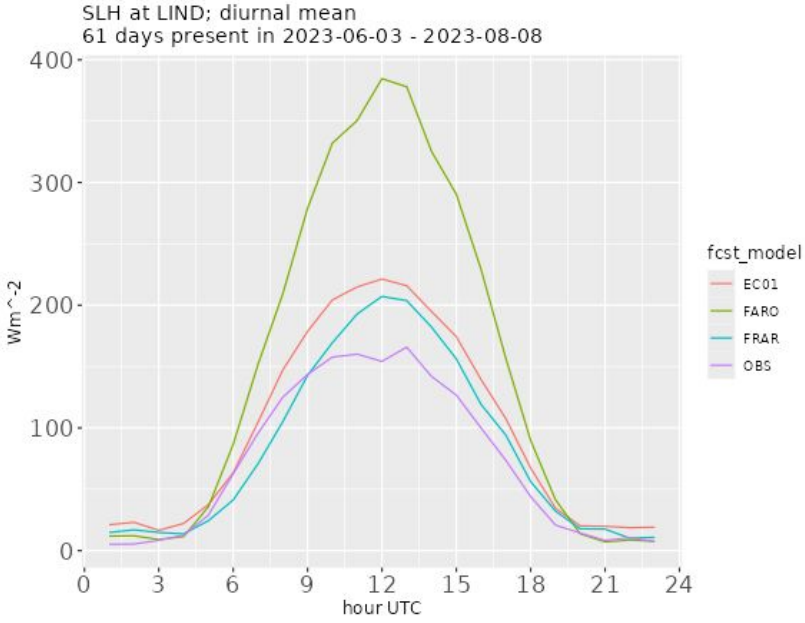




EC01 and FRAR produce more daytime sensible heat flux than observed, FARO produces less

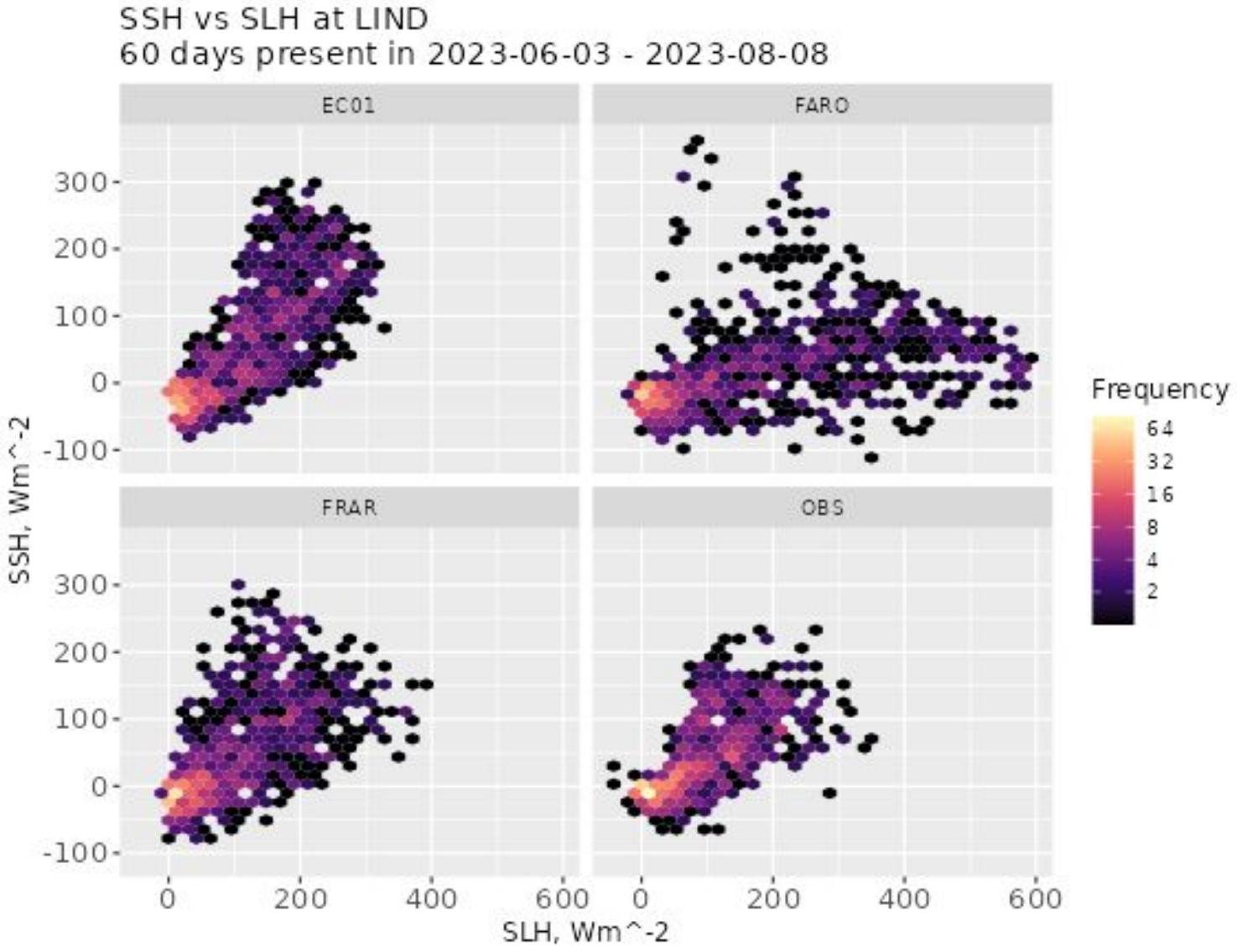
Lindenberg, JJA 2023: *SLH vs SFCFORC*





all models generate more than observed daytime latent heat flux; FARO much more

Lindenberg, JJA 2023: *SSH vs SLH*



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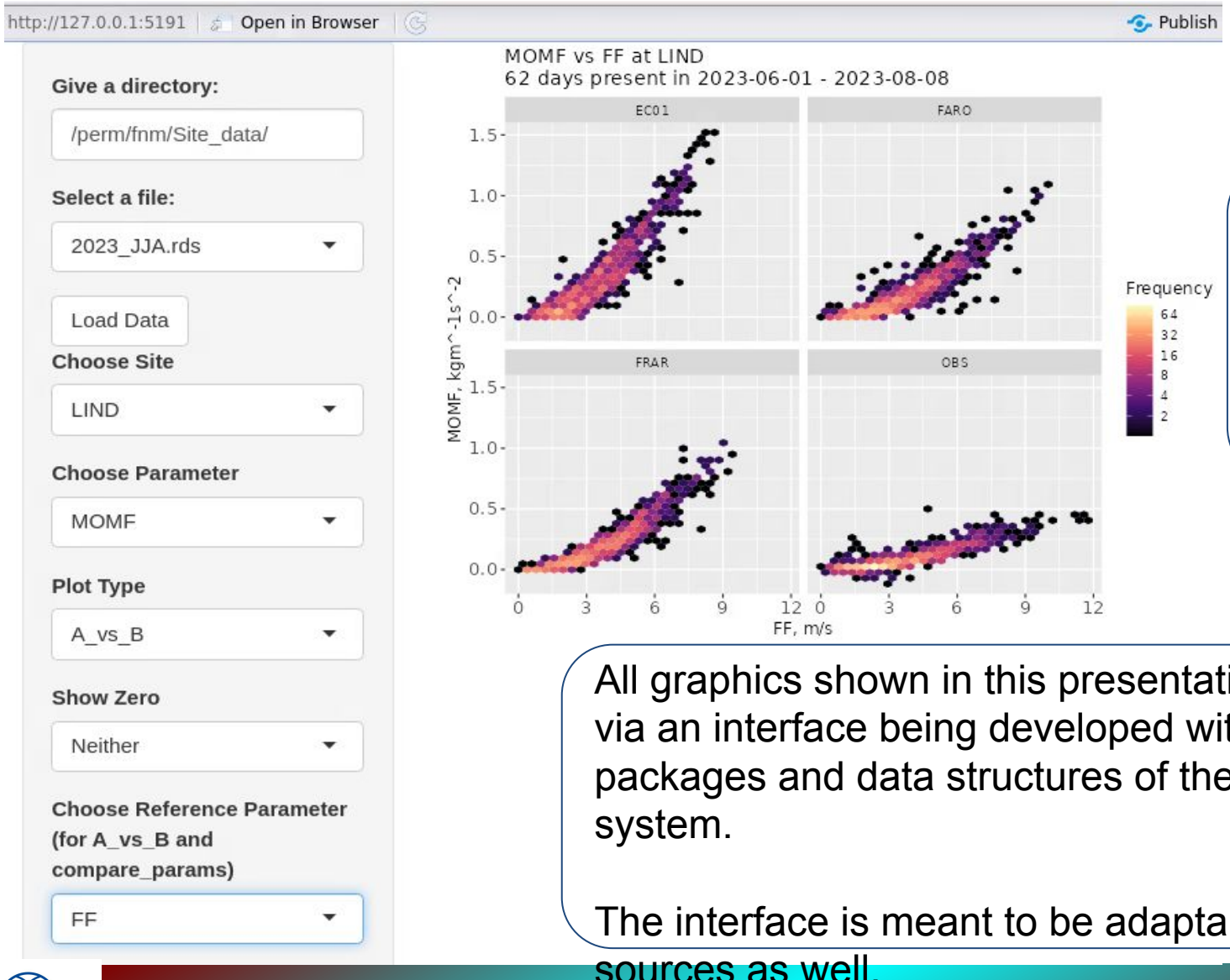
Physics or physiography?

- Many inter parameter relationships look remarkably similar in models and data
- On average, the models produce less than observed upward longwave radiation at daytime, more at nighttime
- On average, the models tend to generate more than observed daytime (and night time) turbulent heat flux
- There are differences in how the heat flux is partitioned into sensible and latent heat
- How are the latent heat flux and the upward ground heat flux produced by model FARO sustained? By analysis increments?
- Can the differences be due to different surface characteristics, e.g., roughness, in each model and at the site? I believe for at least some of them, they can
- Surface characteristics are not stored with the data, which hinders the interpretation of results

Interface to archived data based on harp



This example showing momentum flux vs wind speed at Lindenberg suggests that different surface roughness is present in models nature

All graphics shown in this presentation were produced via an interface being developed within ACCORD using packages and data structures of the harp verification system.

The interface is meant to be adaptable to other data sources as well.

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Conclusions

- The data archive from the model intercomparison enterprise is potentially useful for process-oriented verification such as evaluating surface interactions. (Lack of) quality control is an issue.
- It is necessary to take into account the differences in surface characteristics between the sites and the model being evaluated. Ideally, a match of characteristics should be ensured
- When a model is operated in data assimilation mode, the analysis increments need to be included in the analysis
- An efficient and flexible interface to the data is essential