LSA SAF Land Surface Products and their use in Assessing Model Realism

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Thanks
Souhail Boussetta, Xabier Pedruzo-Bagazgoitia, João Martins (ECMWF)
Isabel Trigo, Sofia Ermida, Luis Fróis,(IPMA, IDL, FCUL)

Workshop on ancillary data for land surface and Earth system modelling 9 April 2025, Bonn

- **Can we enhance the use of Earth Observations (EO) in land surface model development ?**

- Routine use of **LST** for **model** and **ancillaries** evaluation ? Can it guide model development ?

- **When** and **where** do we observe a strong relationship between **inter-annual** variability of **soil moisture, vegetation state and LST**?
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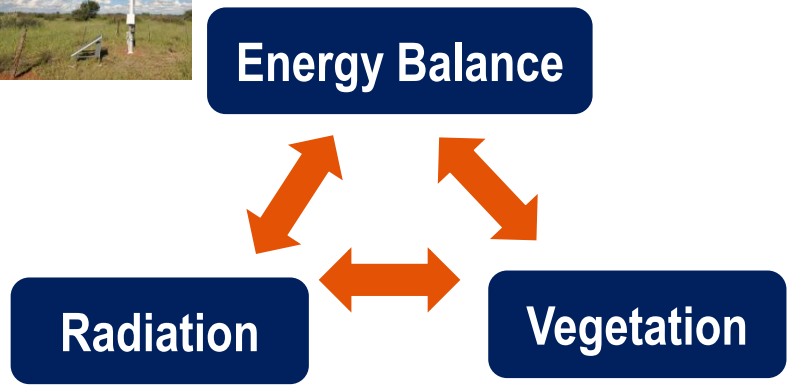
- Use **satellite LST** to assess the impact of the revised land information in the **ECMWF IFS** and **ICON** in NextGEMS simulations and assess the realism of the nextGEMS storm resolving simulations from a land surface perspective.

EUMETSAT
LSA SAF
LAND SURFACE ANALYSIS

SAF on Land Surface Analysis



Explore **Earth Observations [EUM Satellites]** to monitor and characterize

- Land Surfaces
- Land – Atmosphere Interactions

Why?

- ✓ "Land" as a component of the Earth System
- ✓ Land Heterogeneity leads to high uncertainty in land surface modelling (implications on, e.g., energy, water, carbon cycles) – *Independent obs. Needed!*
- ✓ Where we Live!

EUMETSAT LSA SAF LAND SURFACE ANALYSIS

Applications & Users

Vegetation, Water and Heat Stress Monitoring, including “Agro-Met applications”

- NMSs – e.g., Portugal, Slovenia, Bulgaria, Belgium, Poland, ...
- Private sector (e.g., Tecnalia, Biofuturo Lab, Assimila-Prise)
- Copernicus Global Land - CGLS

Hydrology/ Convective Precipitation

- CEH Nowcasting Portal (https://africa-hydrology.ceh.ac.uk/)

Wild Fires - Risk Assessment, Fire Management, Fire Emissions

- NMSs; Civil Protection (PT); NASA FIRMS
- CAMS
- Private sector (e.g., Forest Management Navigator, ZEBRIS, CIMA-Foundation)

Supporting the Energy Sector, Energy Transition

- ARSO (NMS)
- Private /Innovation (SunReport, Deltares)

- Heldpesk queries
- Training / Workshops
- Interaction with “Applications Groups” (e.g., SALGEE)
- Joint Activities (e.g., projects)
- Show Cases at lsa-saf.eumetsat.int

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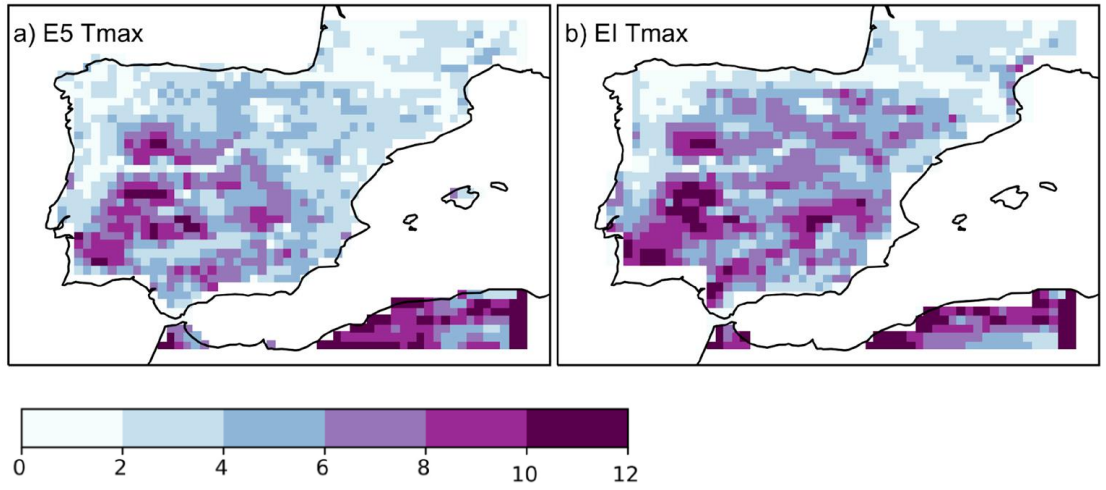
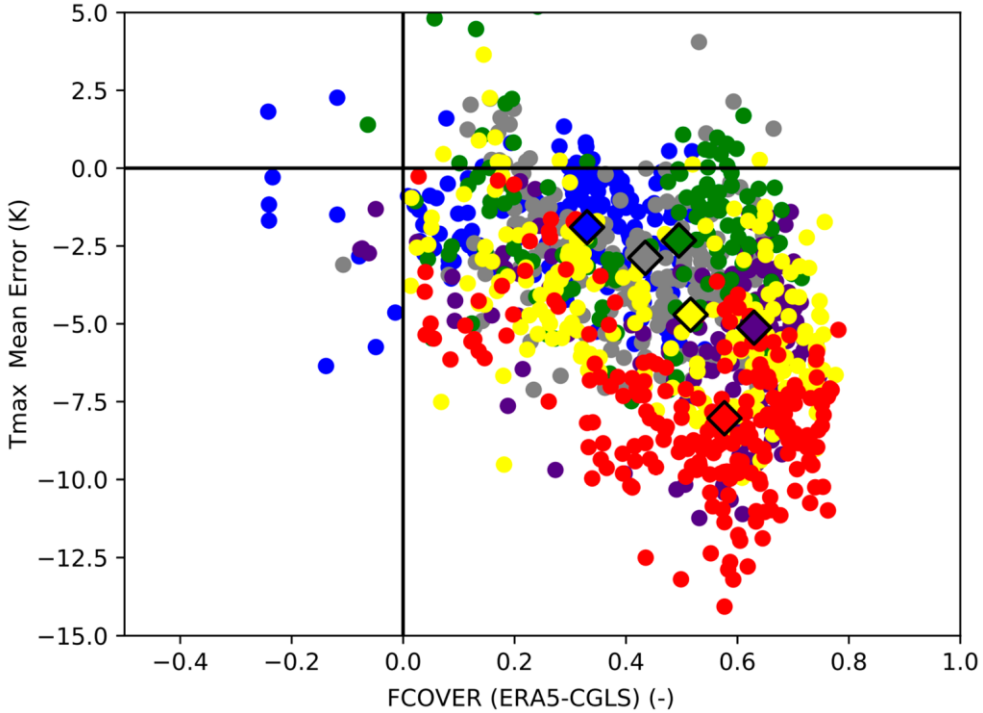
ERAI/ERA5 LST vs LSA SAF

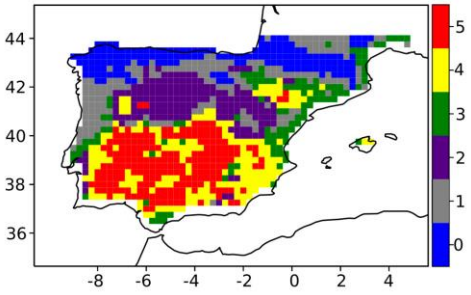
ERA5/ERAI LST maximum temperature RMSE JJA (K)





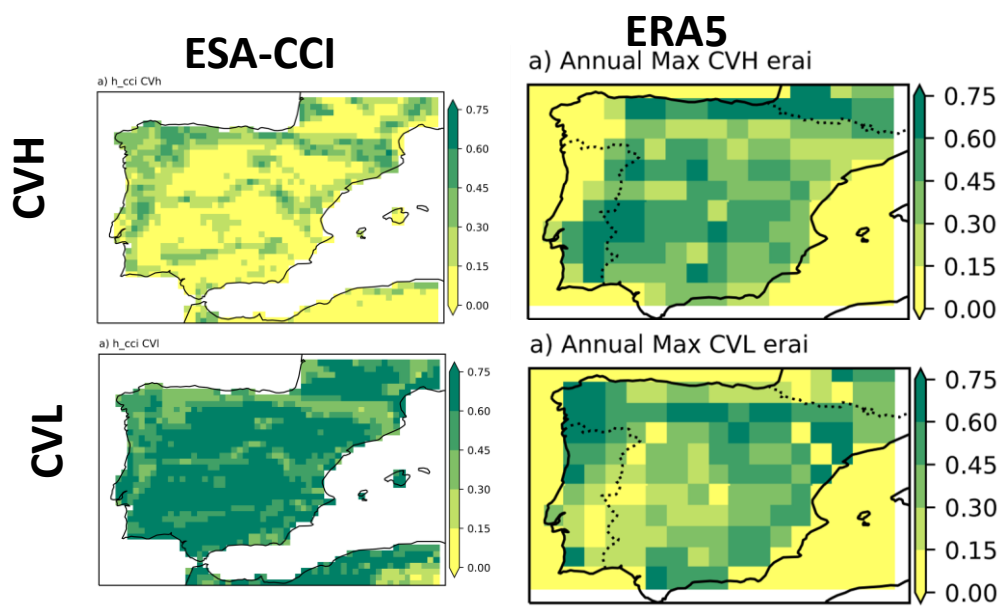
LST Tmax error (Yaxis) versus CGLS green vegetation cover difference between ERA5 & CGLS) (Xaxis). Colors different regions in Iberia.

Large daytime errors associated with vegetation cover and seasonality.



Johannsen, F.; et. al, Cold Bias of ERA5 Summertime Daily Maximum Land Surface Temperature over Iberian Peninsula. *Remote Sensing* 2019, *11*, 2570, https://doi.org/10.3390/rs11212570

Role of land-cover in IFS CHTESSEL (&SURFEX)



Offline simulations 2004-2015 driven by ERA5 meteorology

CTR : reproduces the bias of ERA5

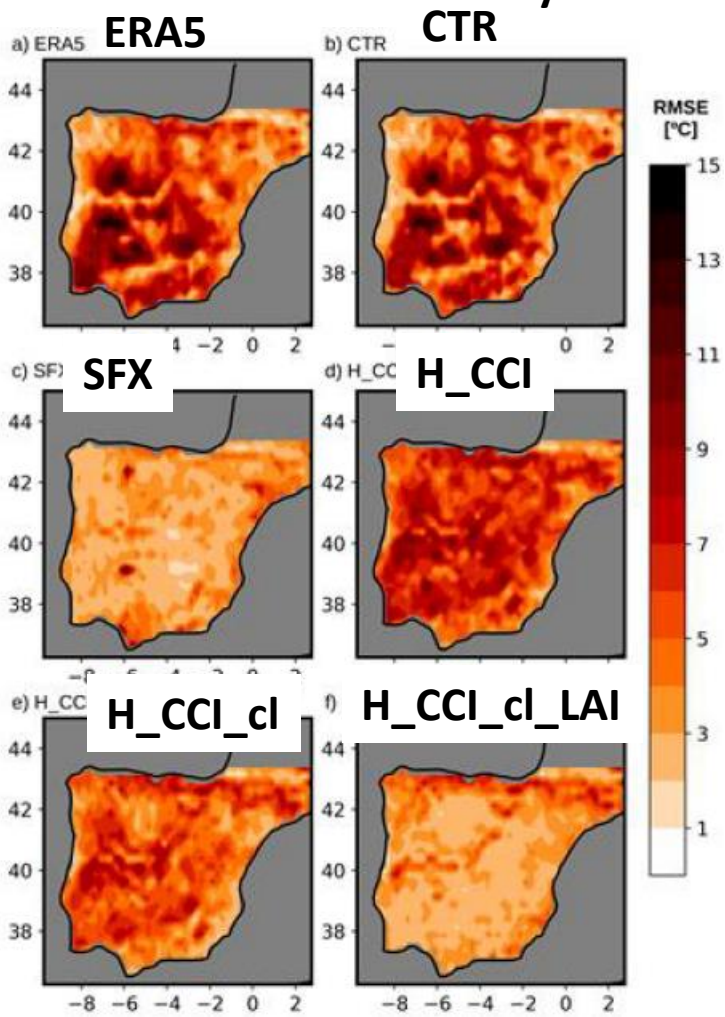
SFX (SURFEX): Much smaller biases ;

H_CCI : replacing land cover by ESA-CCI

H_CCI_cl : H_CCI + Vegetation seasonality (clumping)

H_CCI_cl_LAI : H_CCI_cl + CGLS LAI

RMSE of JJA daily maximum LST



Clear-sky only: ERA5 TCC < 0.3 & LST > 0.7, Synchronous in Time

Max LST between 11-15h

Combined effect of land-cover & vegetation seasonality (via clumping using LAI) reduces the daytime LST errors in offline experiments

Clumping has a large detrimental impact on global coupled simulations !

Nogueira, M., et al: Role of vegetation in representing land surface temperature in the CHTESSEL (CY45R1) and SURFEX-ISBA (v8.1) land surface models: a case study over Iberia, Geosci. Model Dev., 13, 3975–3993, https://doi.org/10.5194/gmd-13-3975-2020 , 2020.

Nogueira, M., et al. (2021). Upgrading land-cover and vegetation seasonality in the ECMWF coupled system: Verification with FLUXNET sites, METEOSAT satellite land surface temperatures, and ERA5 atmospheric reanalysis. *Journal of Geophysical Research: Atmospheres*, 126, e2020JD034163. https://doi.org/10.1029/2020JD034163

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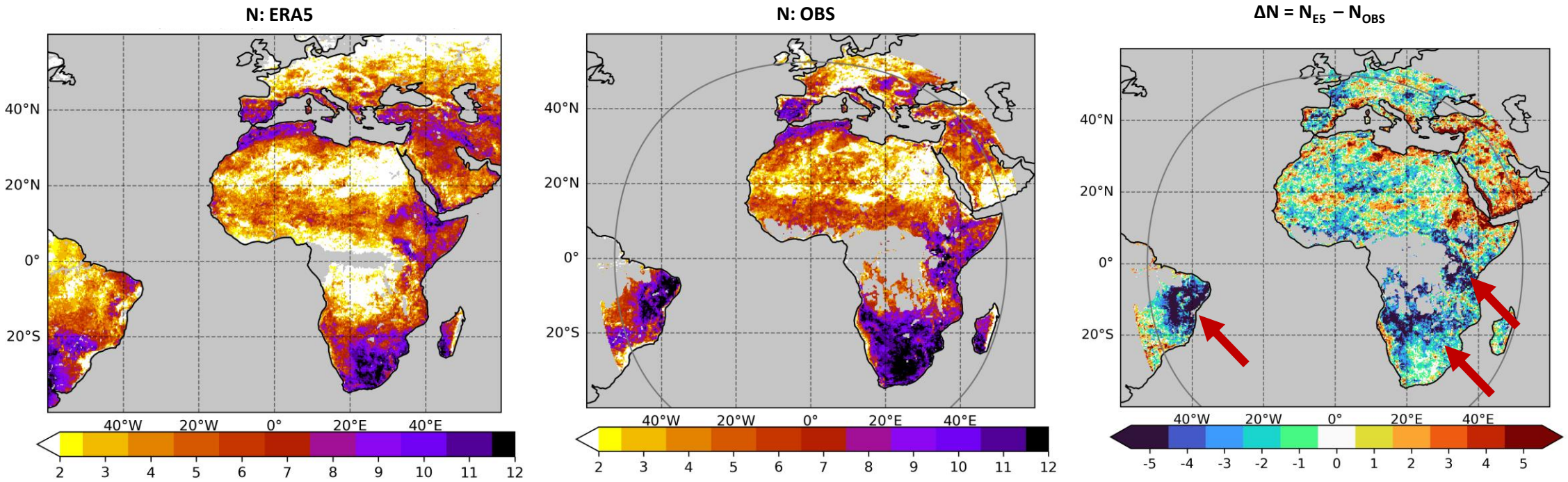
Measuring Soil moisture -LST interannual co-variability

N = # months with significant interannual correlation (α>0.05 with a membership function)



LSA SAF LST 2004-2023 daily max – daily mean (~diurnal amplitude)
C3S Surface soil moisture

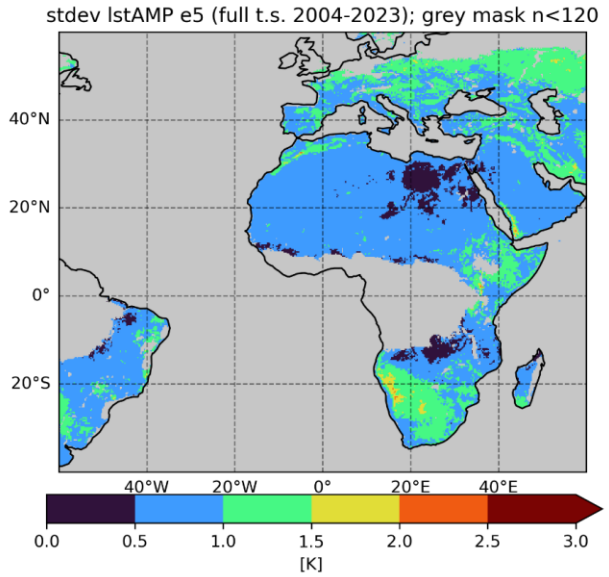
Good agreement between ERA5 and satellite products estimates, but some regions with an underestimation in ERA5, why ?

How relevant is the representation of Vegetation Interannual Variability in Reanalyses?

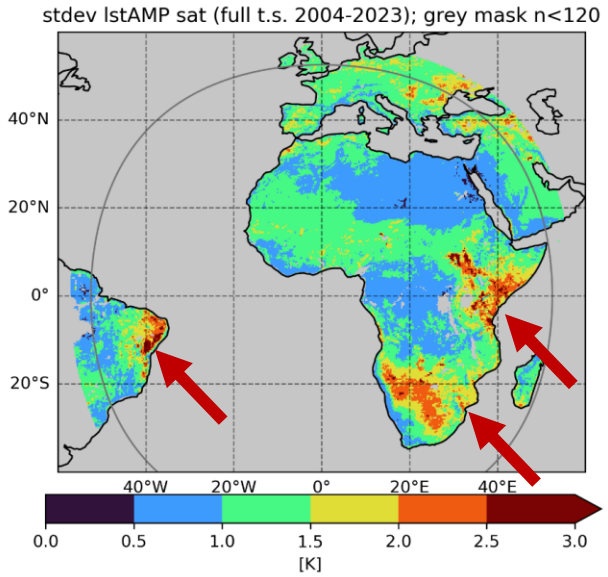
Standard Deviation of de-seasonalized Time-series

Land Surface Temperature - Amplitude of Daily Cycle

ERA5

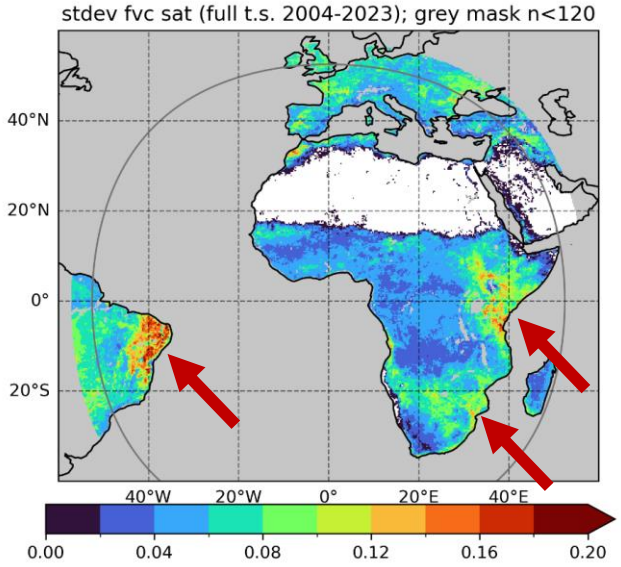


MSG/LSA SAF



Fraction Green Veg Cover

MSG/LSA SAF



- ERA-5 underestimates variability in SKT daily amplitude compared with satellite
- Larger diferences over areas where variability in Vegetation Cover is high

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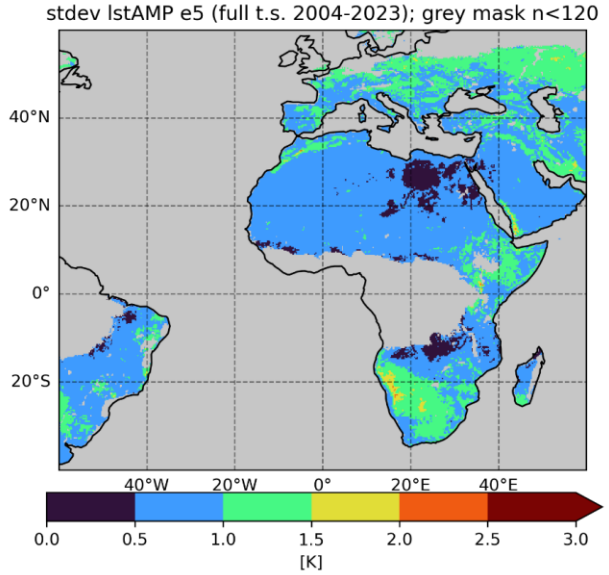

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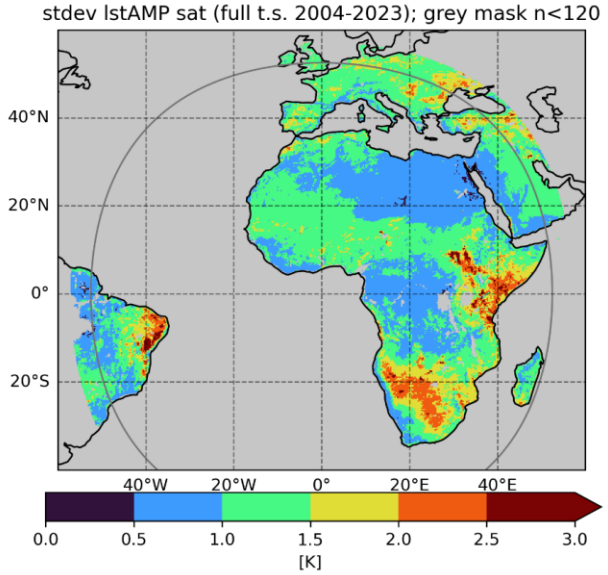

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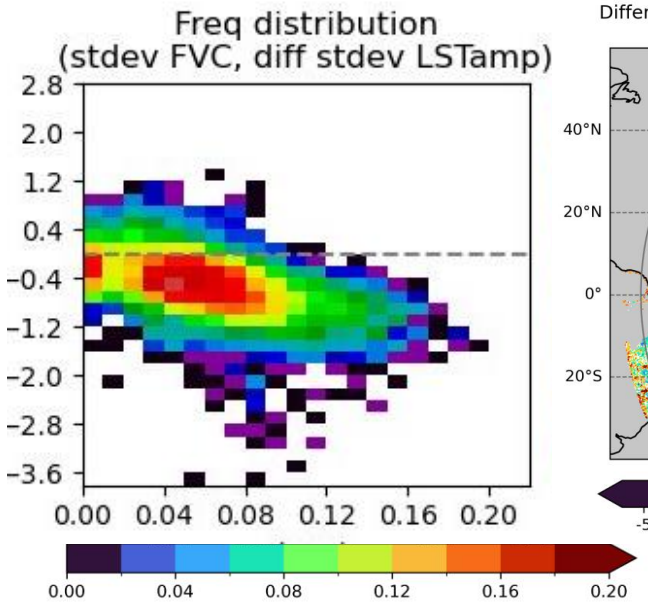

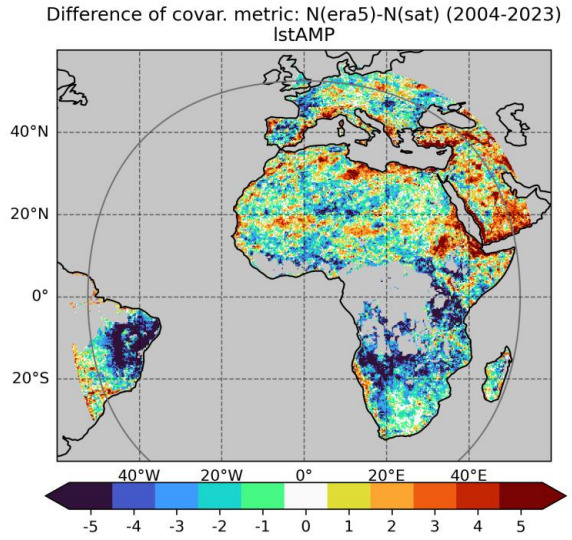

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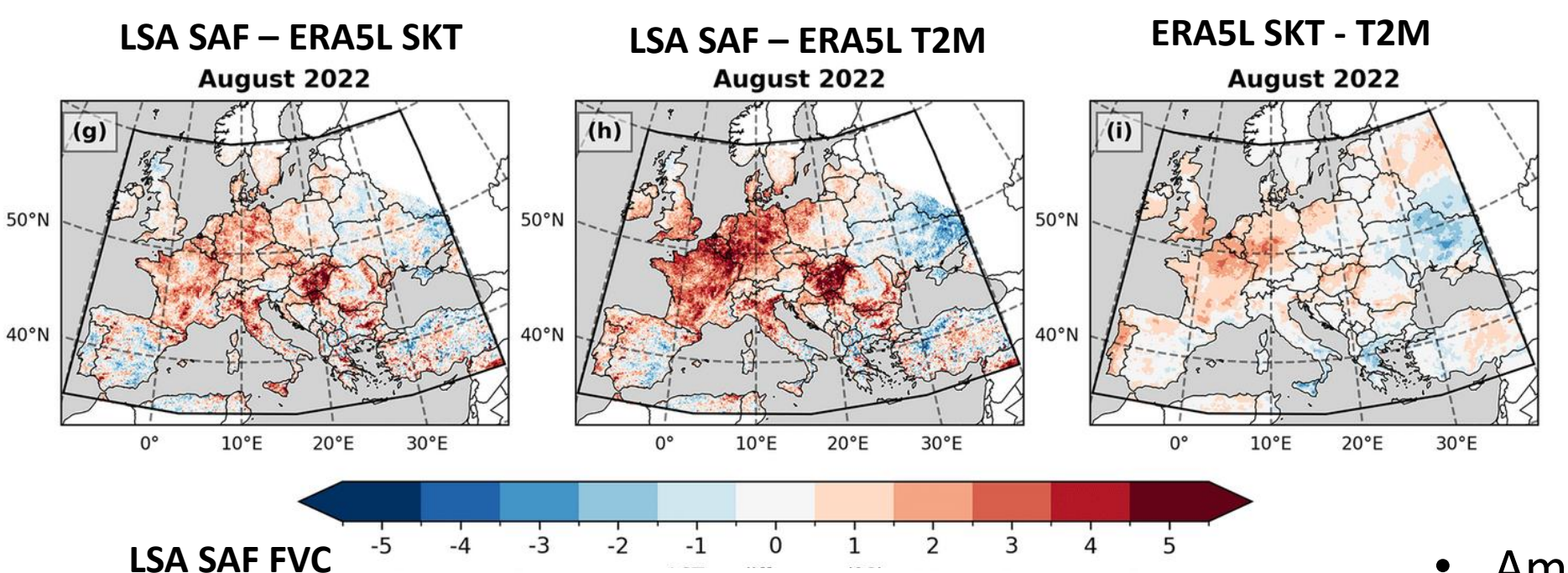

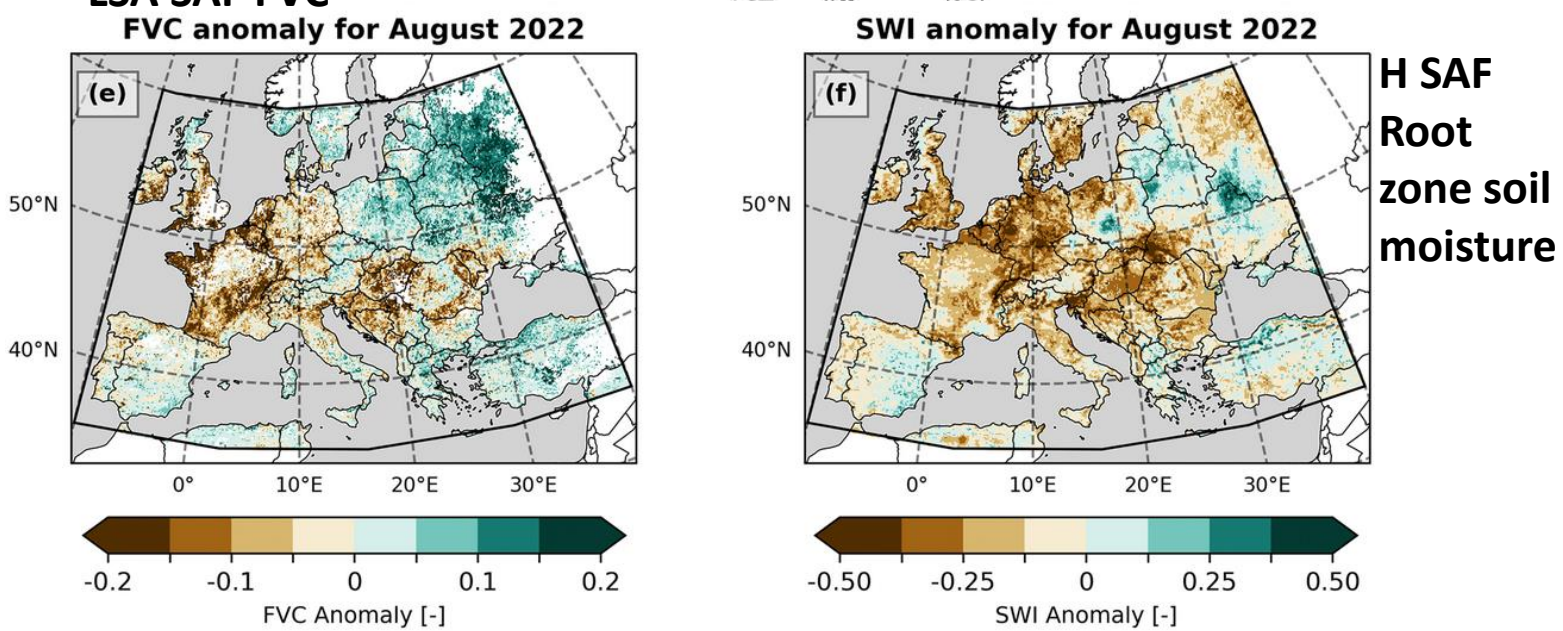

H SAF Root zone soil moisture

- Amplification of LST anomalies linked with vegetation anomalies
- ERA5 Land under-estimates the amplitude of the signal

Martins, J. P. A., Caetano, S., Pereira, C., Dutra, E., and Cardoso, R. M.: A satellite view of the exceptionally warm summer of 2022 over Europe, Nat. Hazards Earth Syst. Sci., 24, 1501–1520, https://doi.org/10.5194/nhess-24-1501-2024, 2024.

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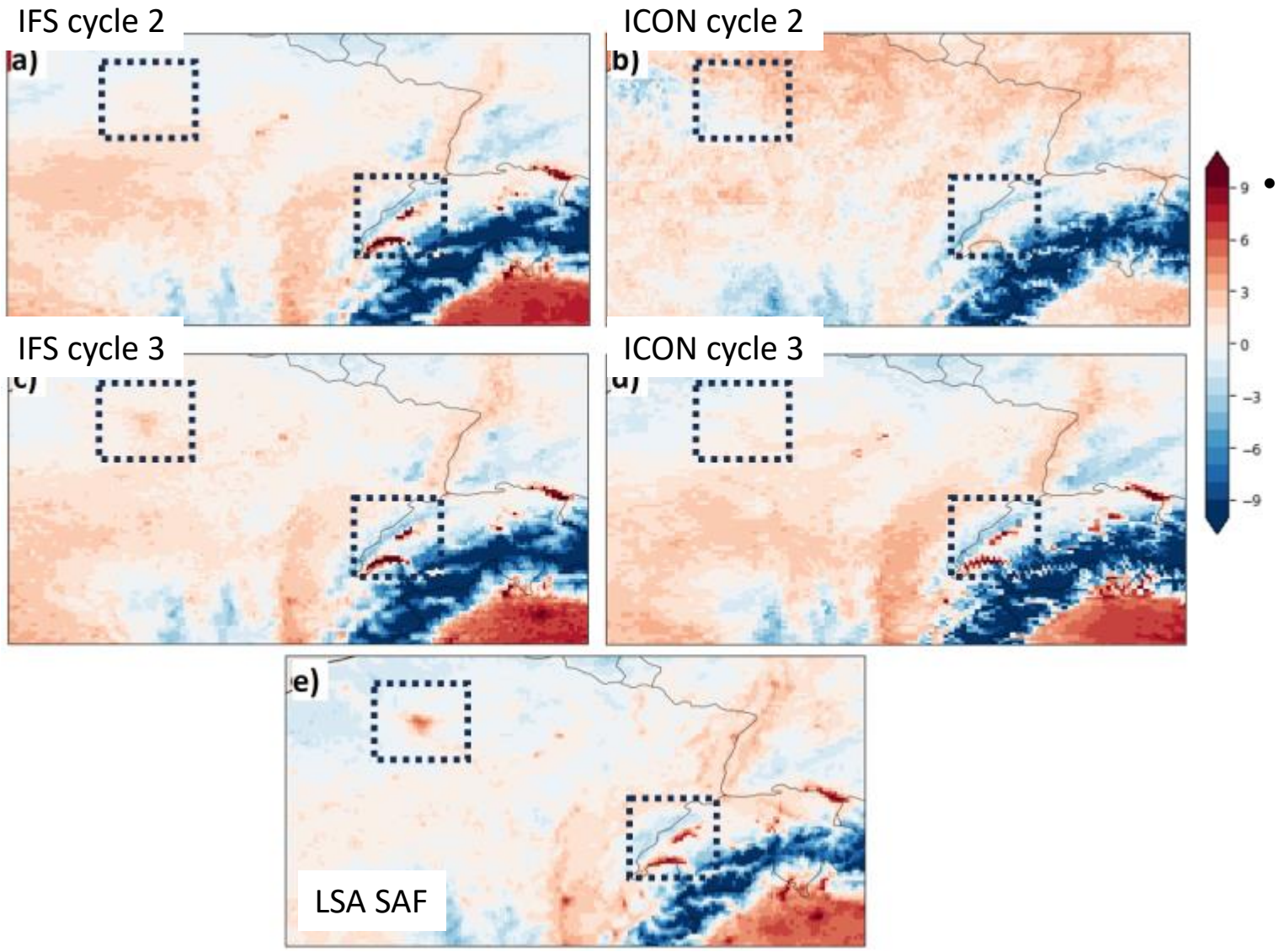
Cycle 2 to 3 (IFS & ICON)

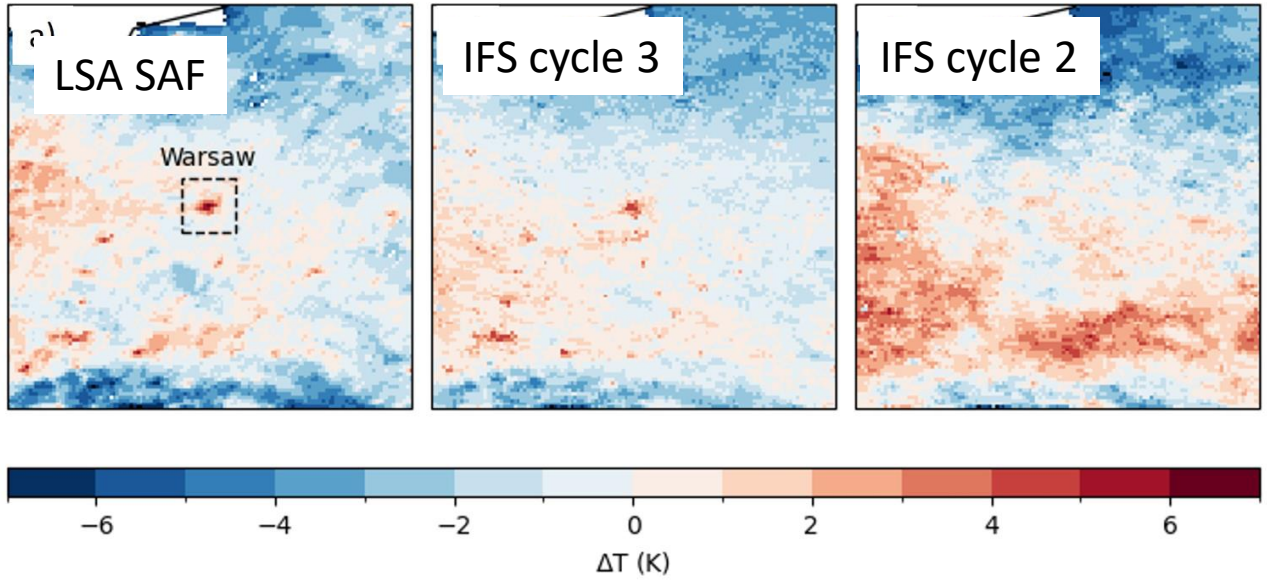
Spatial anomaly of LST diurnal minimum JJA



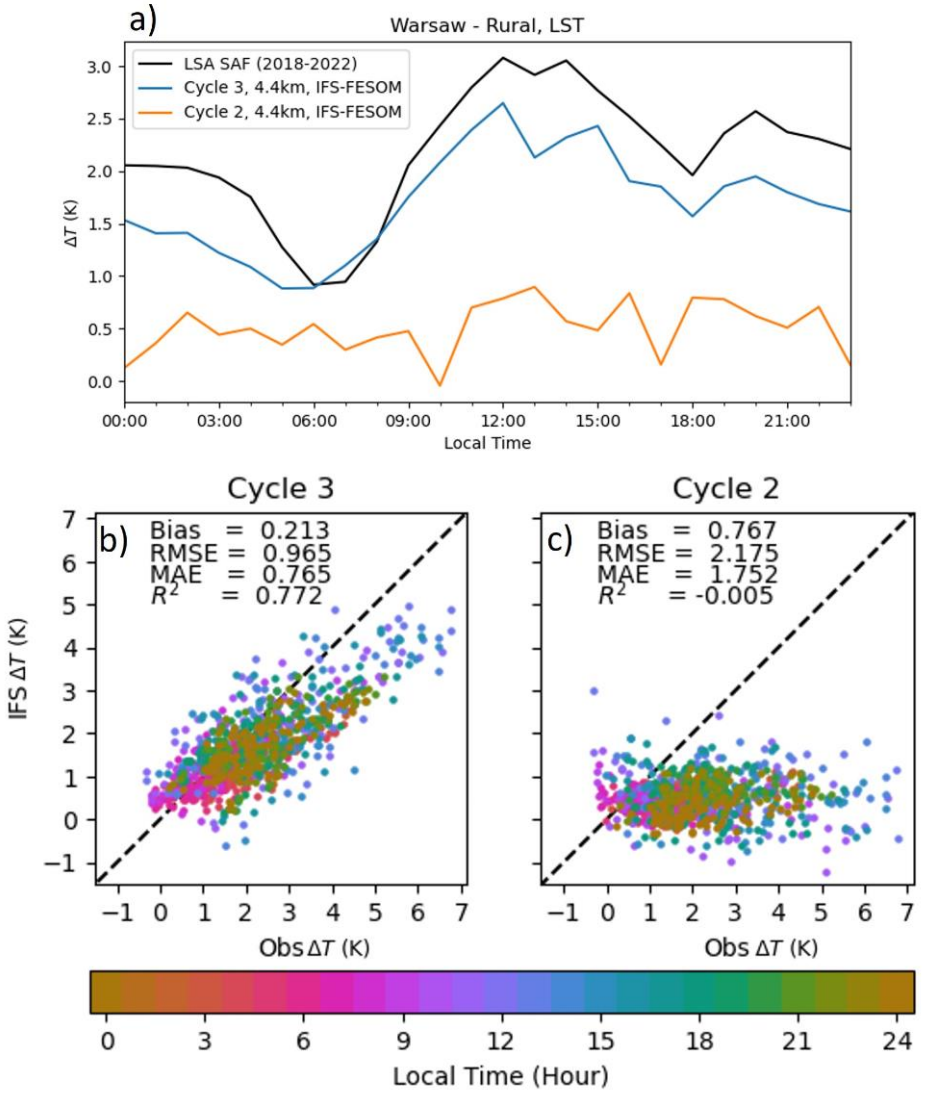
- NextGEMS is building prototypes for a new generation of storm-resolving earth system models'
- IFS Ecland model upgrade Cycle 2- > Cycle 3
  - Urban scheme
  - Updated high-res LU/LC

"Blueprint" of Swiss Lakes and Paris in the Satellite products and Cycle 3 simulations

Cycle 2 to 3 (IFS)



Maps of Land Surface Temperature difference with respect to the rural reference at 12 00 Local Time. The displayed values are a 5-year summer clear-sky average



Mean diurnal cycle Warsaw-rural

Clear added value of updated land-cover & urban scheme in cycle 3 vs cycle 2

Idealized ifs 9 km experiment with coarse land/veg. cover: **Land cover and vegetation spatial variability explain part of the LST daily maximum sub-grid variability**. ->>> check the Poster ☺

Can we enhance the use of Earth Observations in land surface model development ?

1. **Globally consistent** EO **data records, +15 years**, of **LST, vegetation state, soil moisture, etc** are paramount to identify process oriented constrains for model's evaluation – **EO** medium resolution is ok **~25km**; High resolution **~1-5km** EO also very important, with at least a few years (**~5**)

2. Use of Earth Observations products is not simply "**plug and play**" - the model needs to be "**ready**" for that data.

3. Going from static/climatological to **interannual** varying land&vegetation conditions ?
    1. Are the models ready ?
    2. EO products temporal consistency ? Availability in near-real time ?