ERA5 reanalysis cold bias of maximum land surface temperature in Iberia: The role of vegetation

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Overview

- Evaluation o ECMWF ERA-Interim and ERA5 Land surface temperature (LST) with LSA-SAF satellite:
  - Focus over Iberia and summer
- Use land-surface model offline simulations to understanding the potential sources of the biases:
  - Role of vegetation
- Impact of changing vegetation cover: Ongoing work
  - Changing vegetation cover in HTESSEL (ECOCLIMAP & ESA-CCI)
  - Comparing with SURFEX simulations

Land surface temperature

- Key variable in the surface-atmosphere exchanges (LW emission, turbulent fluxes, ground heat flux);
- Good quality and resolution (temporal (15 min) & spatial (3km)) and long record (2004-present) remote sensing observations, LSA-SAF.
- However the use of this remote sensing data has been very limited:
  - Restricted to cloud-free;
  - High temporal variability (no memory);
  - Large biases between models and remote sensing;

Data and Methods

ERA variables:

1. SKin Temperature (**SKT**)
2. Total Cloud Cover (**TCC**)

Offline Simulations (with the ECMWF HTESSEL scheme & SURFEX)

- both forced by ERA-5

Reference Product: **LSA-SAF LST**

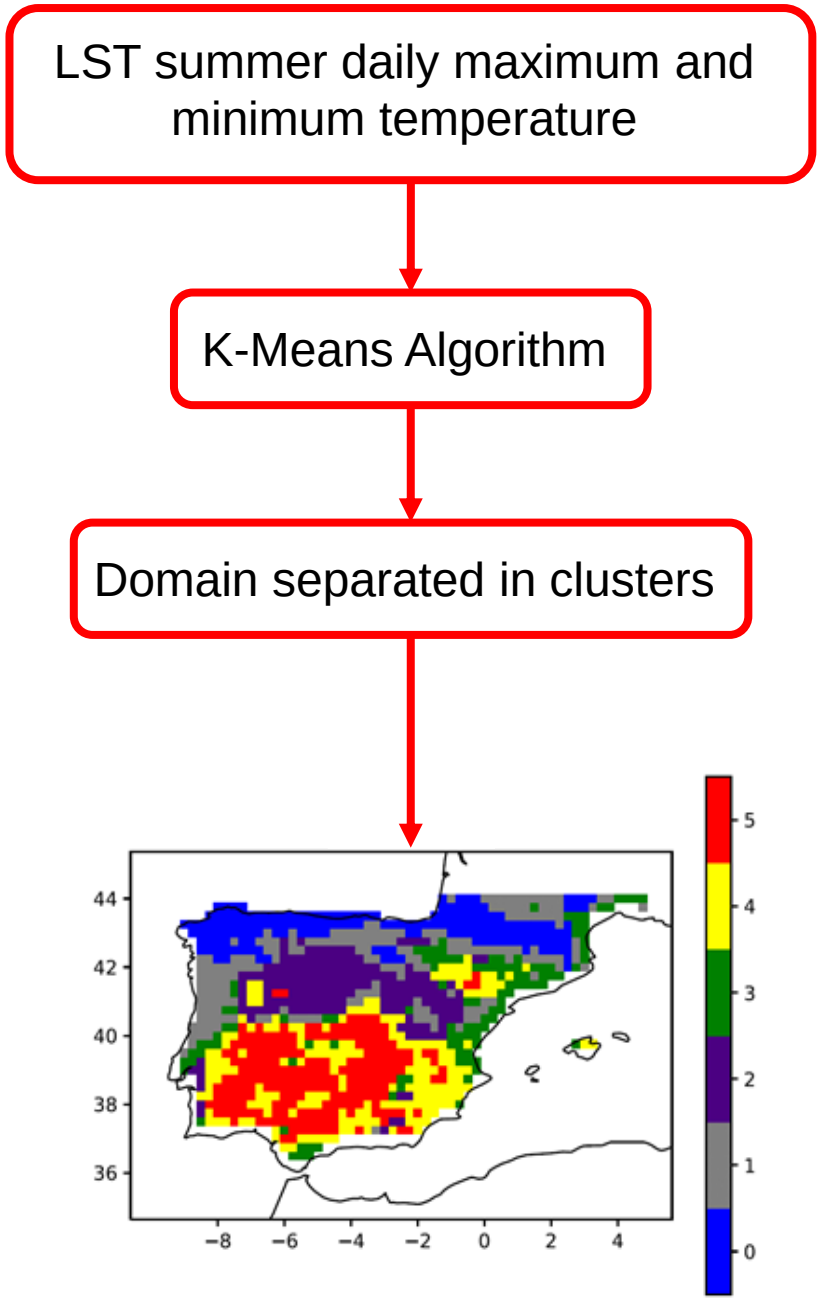
Period in Study: **2004–2015** (June-July-August, **JJA** only)

Area of Study: Iberian Peninsula in a 0.25° × 0.25° resolution

LST-SAF original resolution (in Iberia): ~5 km ➜ Upscaling

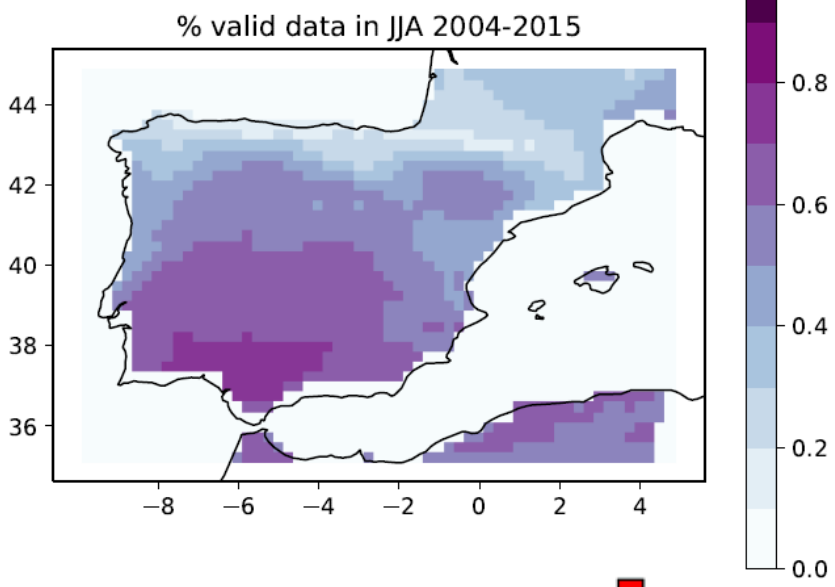
Clear-sky threshold:

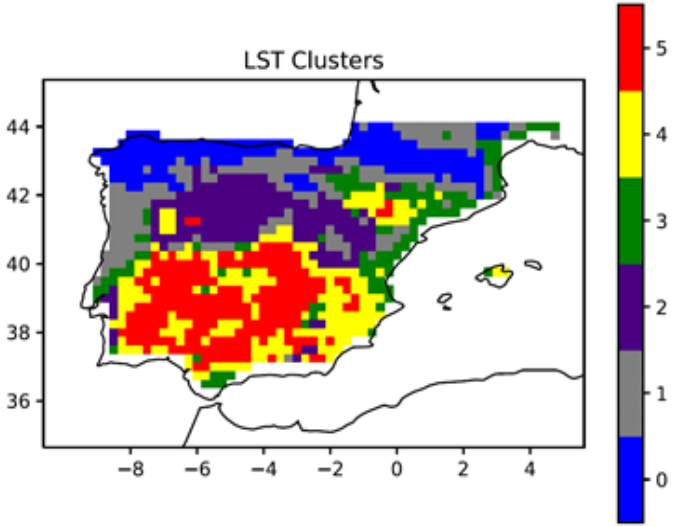
- The reanalysis's TCC < 0.3
- % of valid LST original data in each 0.25° grid cell > 0.7



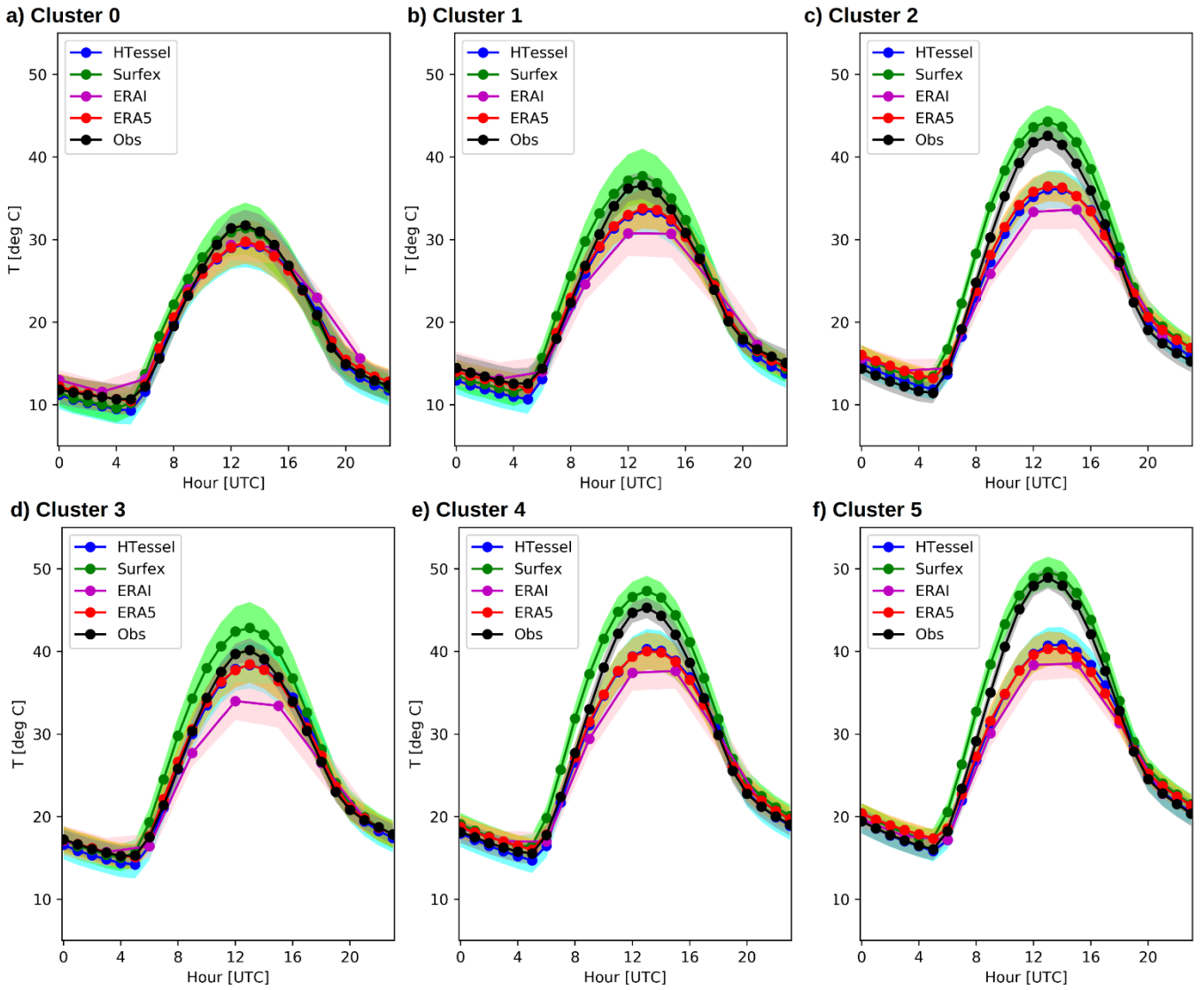
Evaluation

Percentage of valid data in the summer between 2004 and 2015 (SAF).

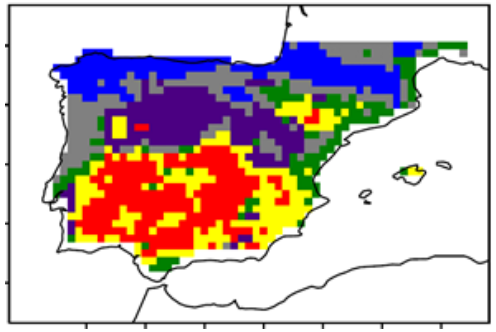


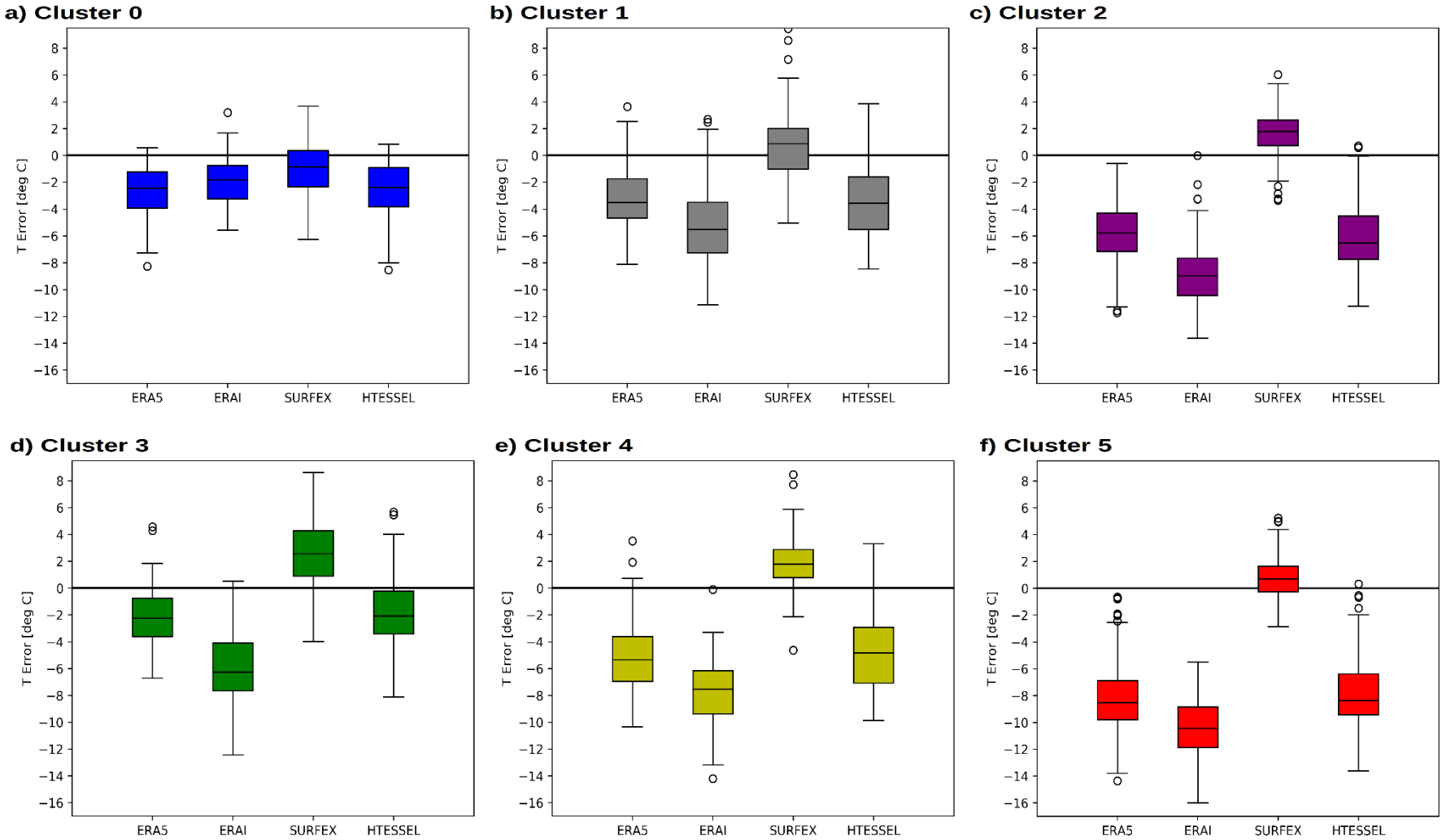


Overall: SURFEX > ERA5 and HTESSEL (offline) > ERA-Interim



Tmax Bias

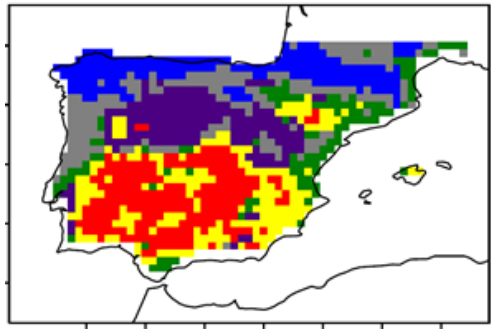


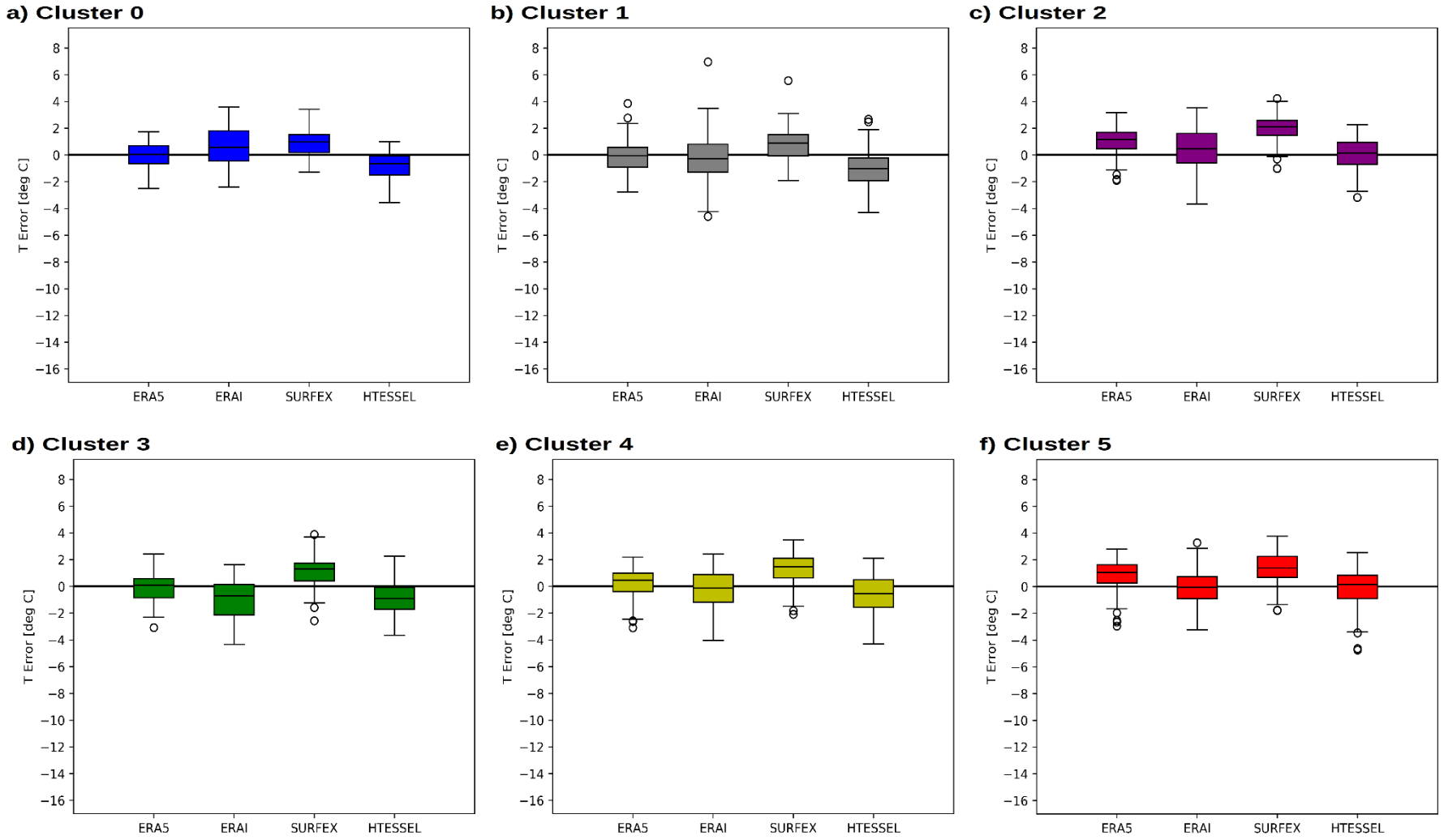


- ERA-Interim & ERA5 & HTESSEL → large cold bias
- **SURFEX** → small warm bias (**large cold bias is gone**)
- Bias in ERA5 < ERA-Interim (mostly)
- Bias in SURFEX<ERA5 (mostly)

*spread between grid points of each cluster

Tmin Bias

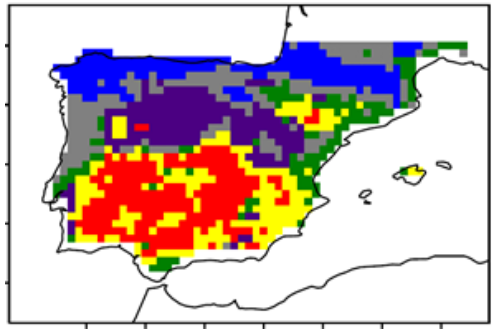


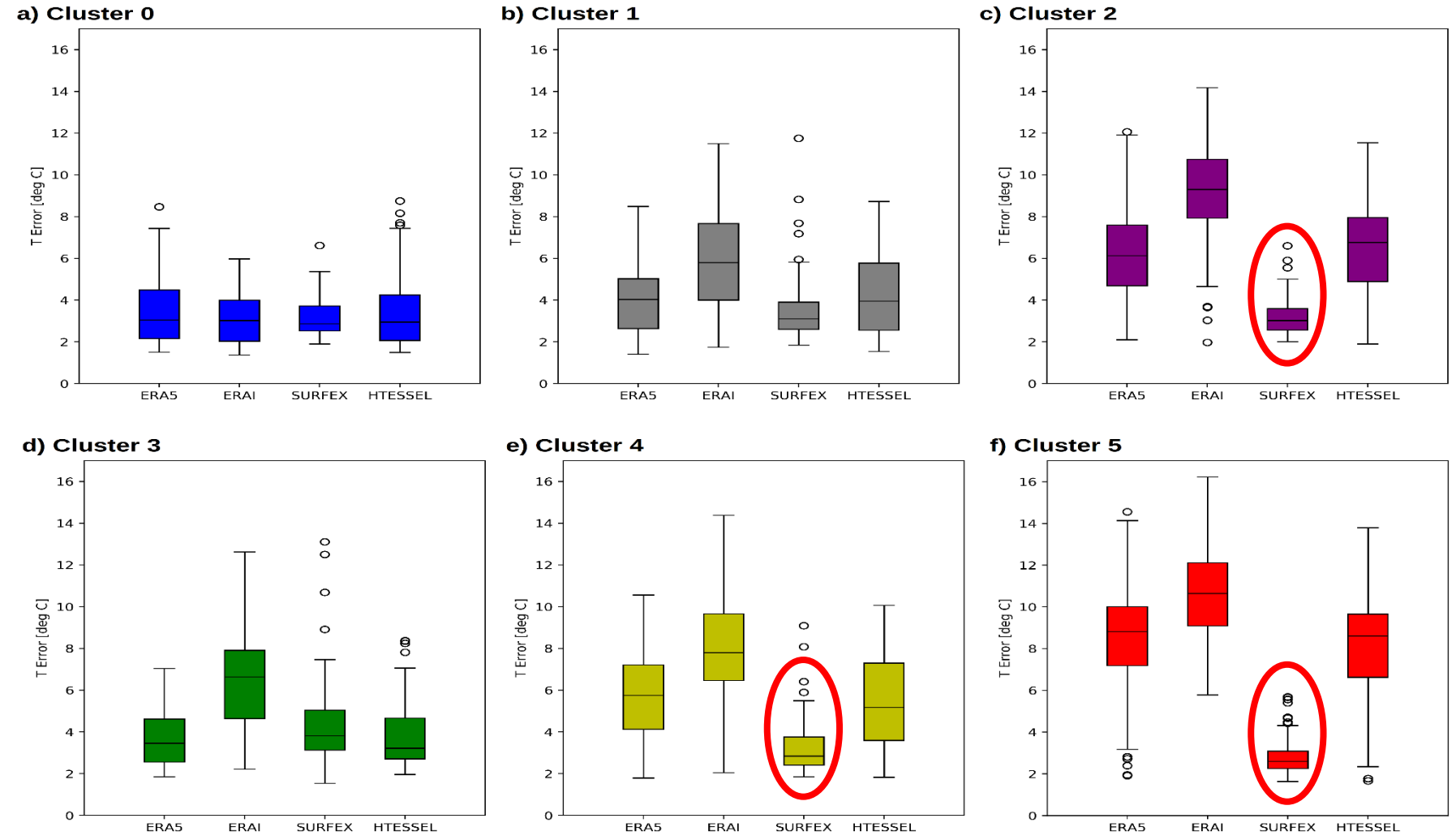


*spread between grid points of each cluster

- SURFEX → slightly warmer
- But small changes in Tmin Bias throughout all datasets (within satellite observation uncertainty)

Tmax RMSE

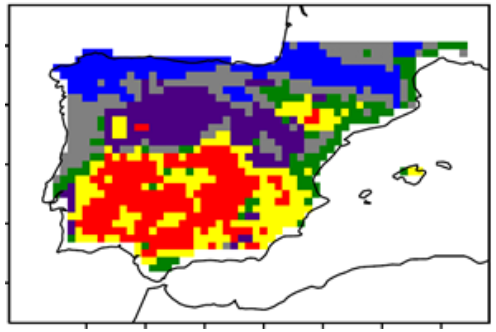


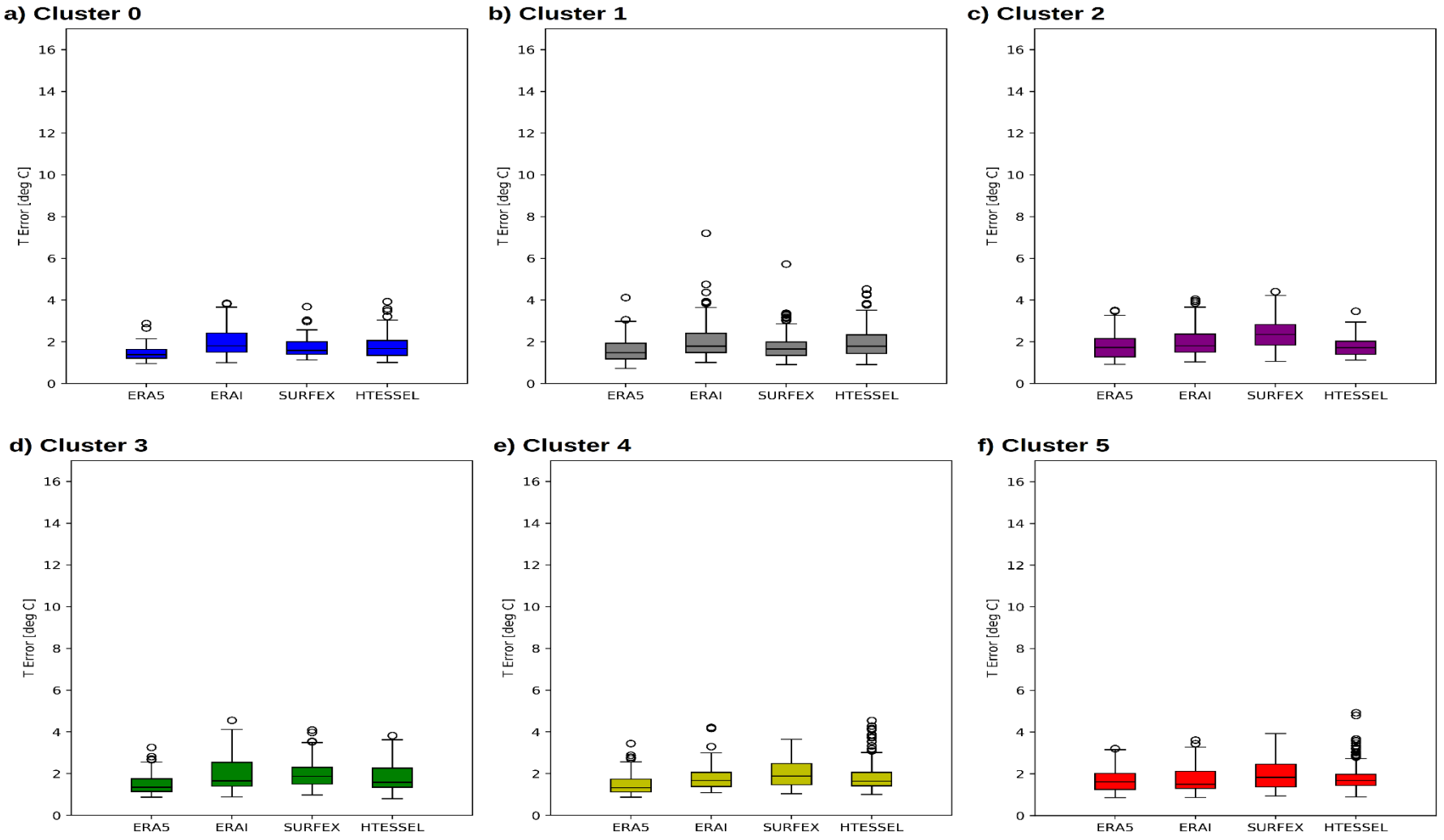


*spread between grid points of each cluster

- ERA5 better than ERA-Interim
- Large RMSE reduction in SURFEX (particularly warmer clusters 2, 4 & 5)
- RMSE largely driven by bias reduction

Tmin RMSE

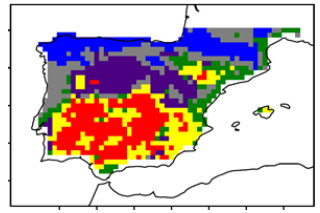


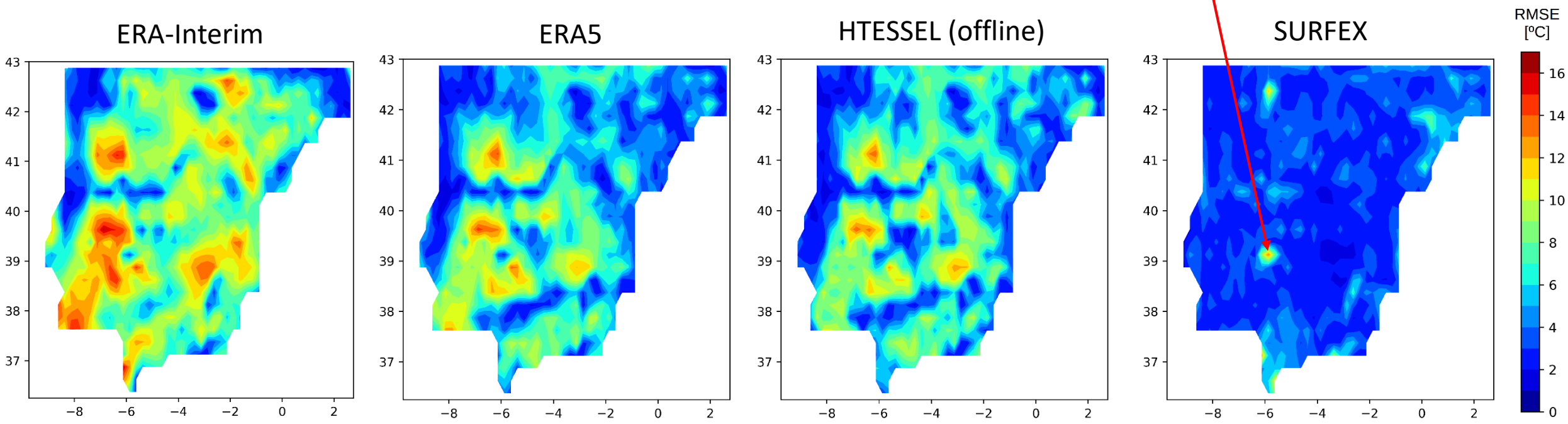


*spread between grid points of each cluster

- Essentially no change (improve or degradation) in Tmin amongst all datasets (within satellite uncertainty)

Tmax RMSE spatial pattern

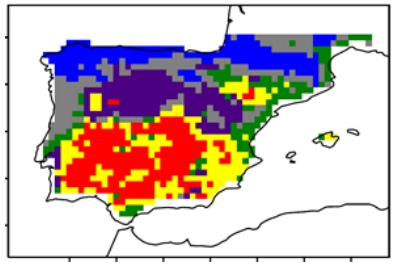




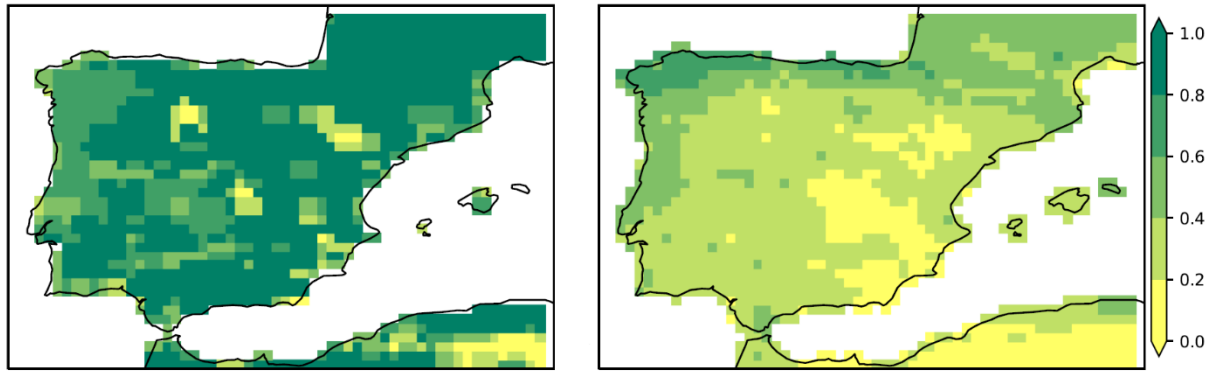
- **Very similar error spatial patterns in ERA-Interim & ERA5 & HTESSEL offline but not SURFEX. WHY?**

- **If both HTESSEL and SURFEX had the same forcing why are the LST simulation so different and SURFEX much better ?**

Link with vegetation cover



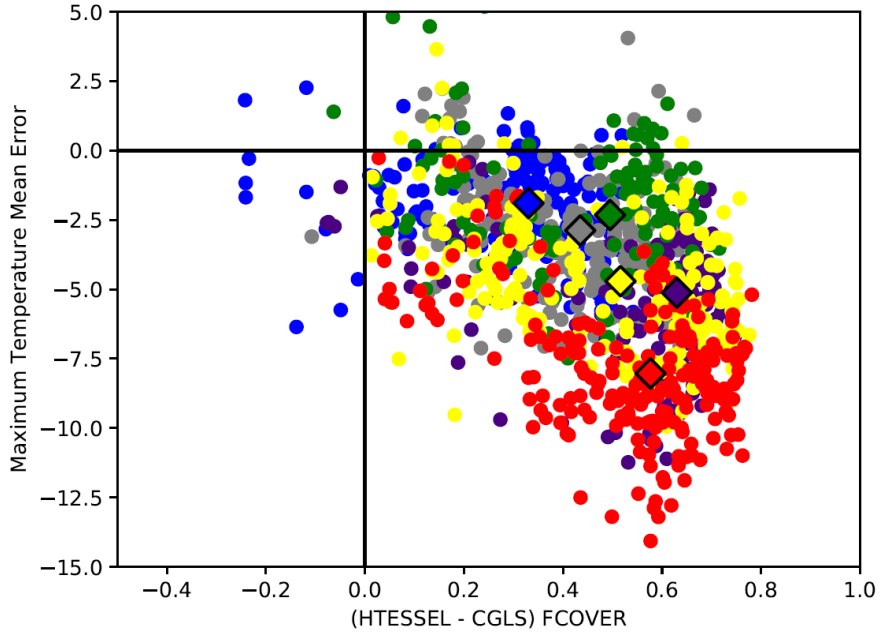
Correlation between Tmax bias and FCover error: 0.45



HTESSEL FCover (left) and Copernicus Global Land Service (CGLS) 1999-2018 Mean FCover (right) in Iberia.

topography

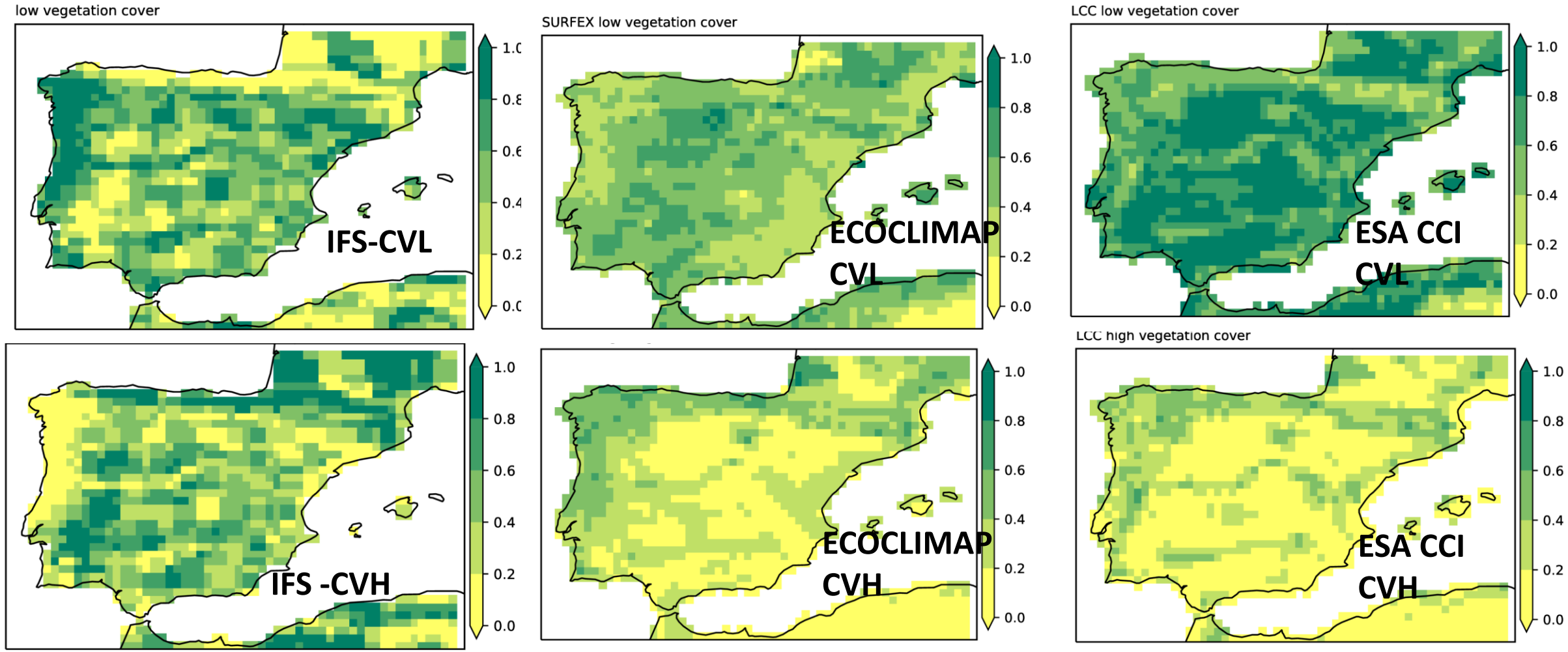
IFS almost does not have bare-ground in Iberia plateaus:
Most of SKT Tmax error in ERA5 / HTESSEL in areas with large differences between CVEG & CGLS FCOVER



Tmax Mean Error (K) in ERA5 vs CGLS-FCover error in the HTESSEL (Colors=Clusters)

Vegetation cover is a good candidate to explain the large biases

IFS/ECOCLIMAP/ESA CCI vegetation cover



- Some agreement between ECOCLIMAP & ESA CCI CVL/CVH distribution, and very different from IFS.
- IFS vegetation distribution does not look realistic !
- ESA-CCI CVL higher than ECOCLIMAP: ESA CCI bare ground is very small, mainly deserts

TOWARDS A SOLUTION

- **IFS vegetation cover not realistic.**

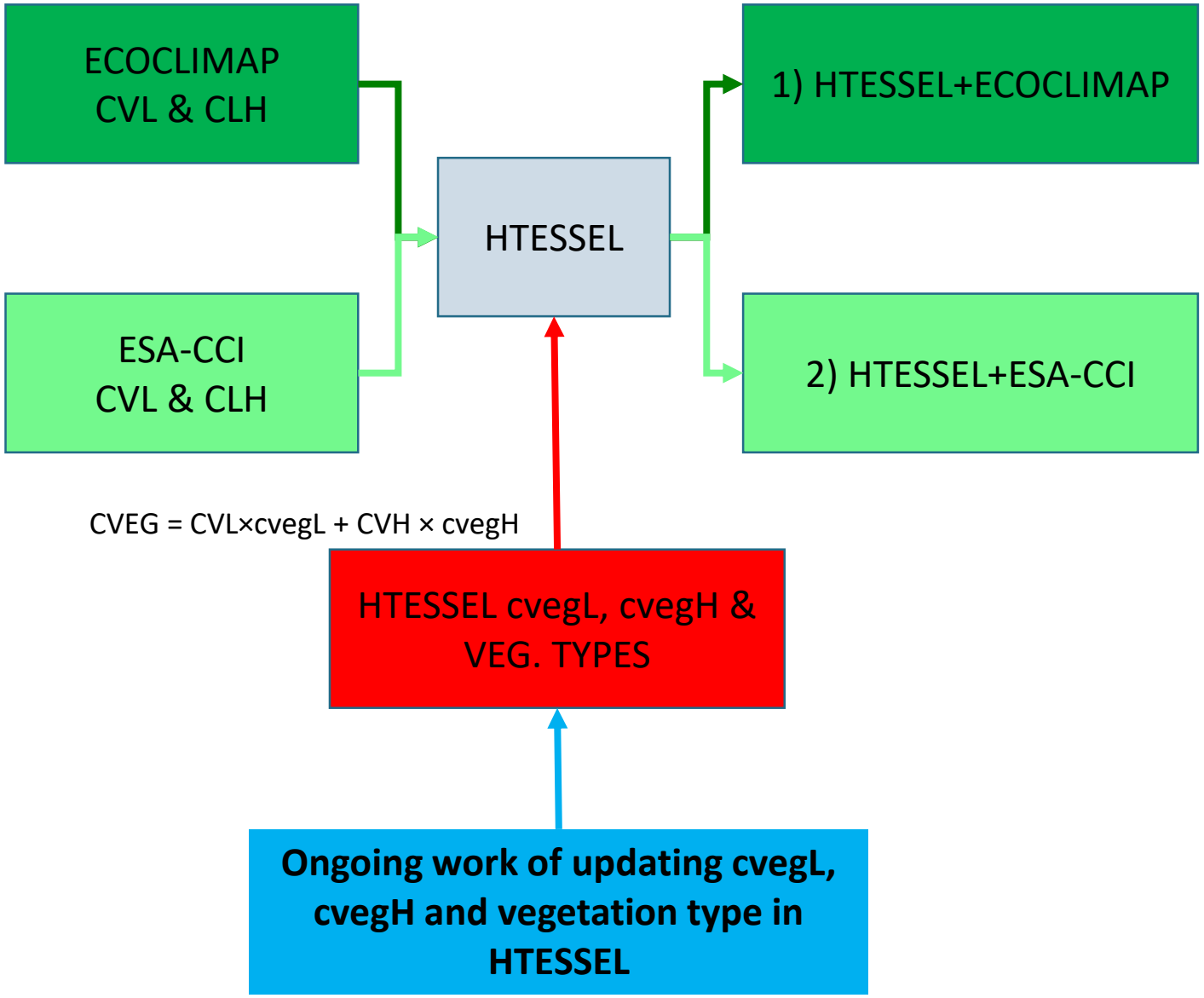
- **2 new HTESSEL simulations**

Corrected low & high vegetation cover:

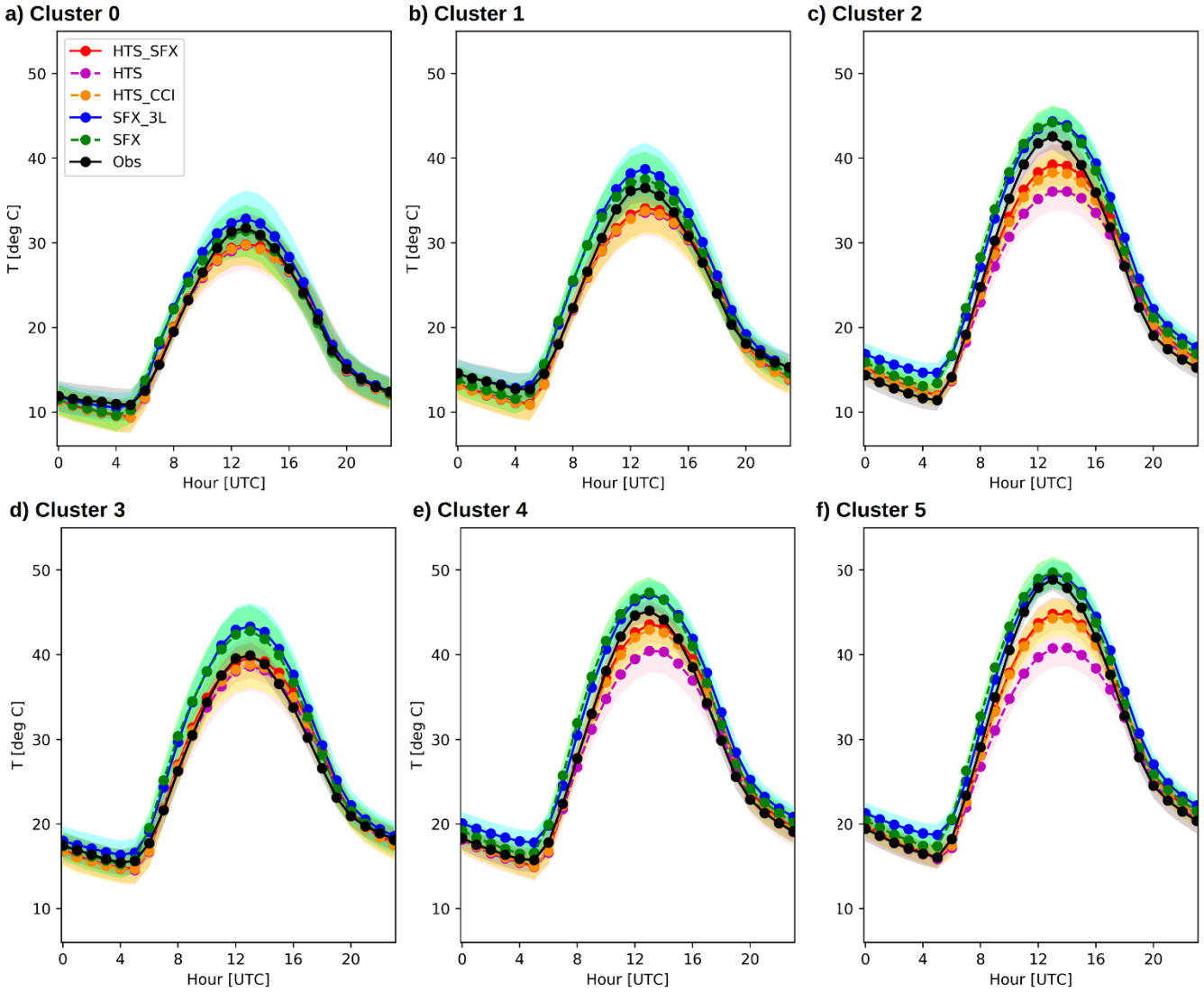
1) **CVL & CVH derived from ECOCLIMAP**
2) **CVL & CVH derived from ESA-CCI**

- **ECOCLIMAP correction becomes more consistent with CGLS FCOVER**

- **Same is true for ESA-CCI correction**



Changing vegetation cover in Iberia



HTESSEL

HTESSEL + ECOCLIMAP

HTESSEL + ESA-CCI

SURFEX (14 soil layers+explicit soil diffusion)

SURFEX simplified physics
(3 layers+force-restore method)

- Corrected vegetation → Error reduction
- Degraded physics small → change to Tmax
  - SURFEX vegetation correction (ECOCLIMAP) dominates over improved physics
- Sensitivity tests showed little improvement in HTESSEL by improving physics
- cvegL, cvegH and veg. type not corrected yet → Further improvement?? (ONGOING!)

Final remarks

- ERA5 presents an overall higher quality product in relation to ERA-Interim; However the large cold bias of maximum temperature did not change from ERAI to ERA5
- HTESSEL offline reproduces the ERA5 LST errors, but SURFEX does not;
  - Clear link between vegetation cover in ECMWF products and LST biases
  - SURFEX ECOCLIMAP very similar to ESA-CCI vegetation cover and patterns, but very different from those used by ECMWF
- Ongoing work changing vegetation cover in HTESSEL to ECOCLIMAP/ESA-CCI shows potential to reduce the large biases, but still work need to be done to address vegetation types and related parameters
- We only focus in Iberia and Summer and clear-sky
  - What's the impact on other seasons ?
  - Other regions of the world with similar issues LST and vegetation ?
  - Impact on these changes in coupled atmosphere simulations ?