ON THE ADDED VALUE OF IMPROVING THE SPATIAL REPRESENTATION AND SEASONAL VARIATIONS OF VEGETATION COVER IN LAND SURFACE MODELS FOR SIMULATED LAND SURFACE TEMPERATURE

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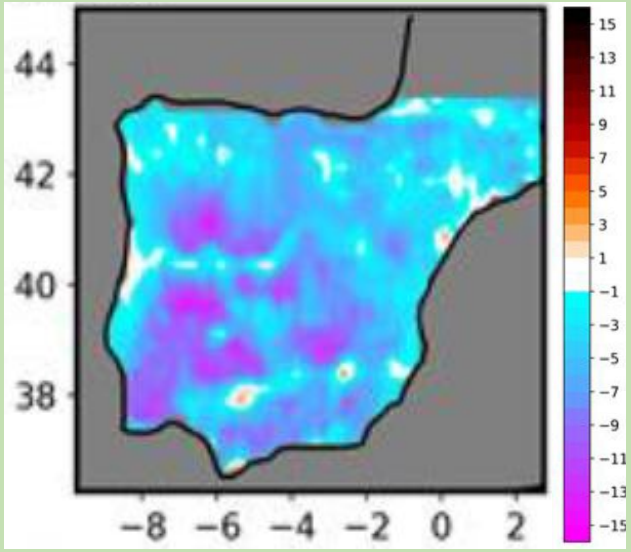
CONSTRAINING SUMMER (JJA) DAILY MAXIMUM LAND SURFACE TEMPERATURE (LST)

ERA5 JJA daily maximum LST over Iberia has large cold bias compared to satellite estimates (Johannsen et al., 2019; Nogueira et al. 2020)

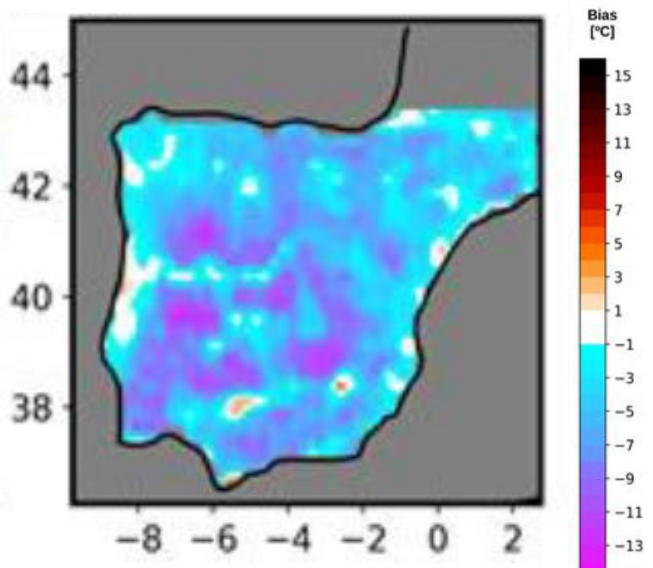
ERA5 (ECMWF reanalysis)



ERA5 JJA LSTmax Bias [ºC]

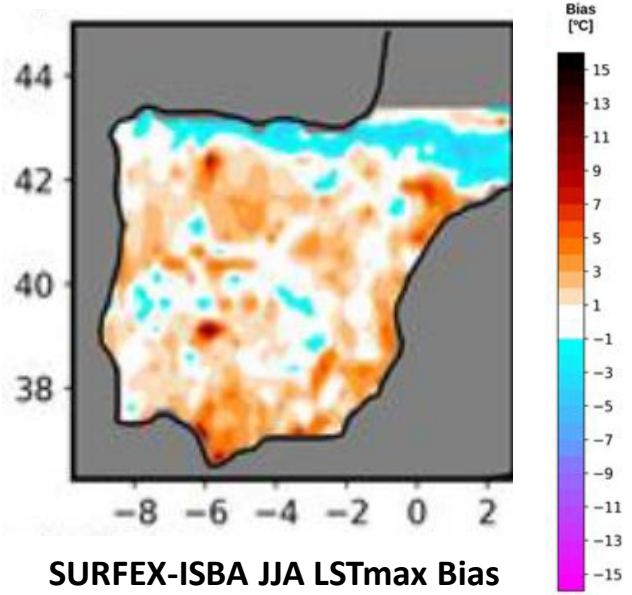
*Using LSA-SAF (satellite) LST as reference
* Only clear sky (limitation of LSA-SAF product)
*ERA5 uses CHTESSEL land-surface model
*Problem was already present in ERA-Interim (Johannsen et al., 2019)

Issue is reproduced by CHTESSEL offline



CHTESSEL JJA LSTmax Bias

But not in SURFEX-ISBA offline



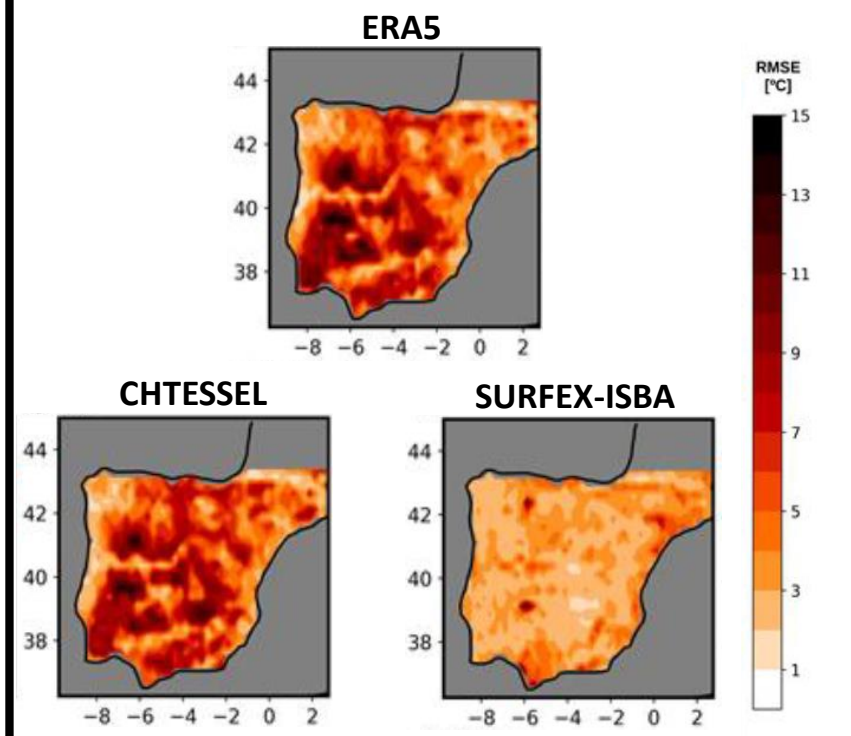
SURFEX-ISBA JJA LSTmax Bias

*Both forced by the same ERA5 atmospheric and radiative fields
*Both using LSA-SAF (satellite) LST as reference (clear-sky only)
* Offline CHTESSEL with original model setup (CTR) reproduces problem

Nogueira, M., Albergel, C., Boussetta, S., Johannsen, F., Trigo, I. F., Ermida, S. L., Martins, J. P. A., and Dutra, E., 2020, Geosci. Model Dev. Discuss.

CONSTRAINING SUMMER (JJA) DAILY MAXIMUM LAND SURFACE TEMPERATURE (LST)

JJA LSTmax error magnitude (RMSE):



*Using LSA-SAF (satellite) LST as reference
* Clear-sky only

CHTESSEL offline reproduces problem in ERA5 → use this fact to analyze problem

+

SURFEX-ISBA has much lower errors → Why?

+

JJA LSTmax issues related to Iberia vegetation cover in ERA5 (Johannsen et al., 2019)

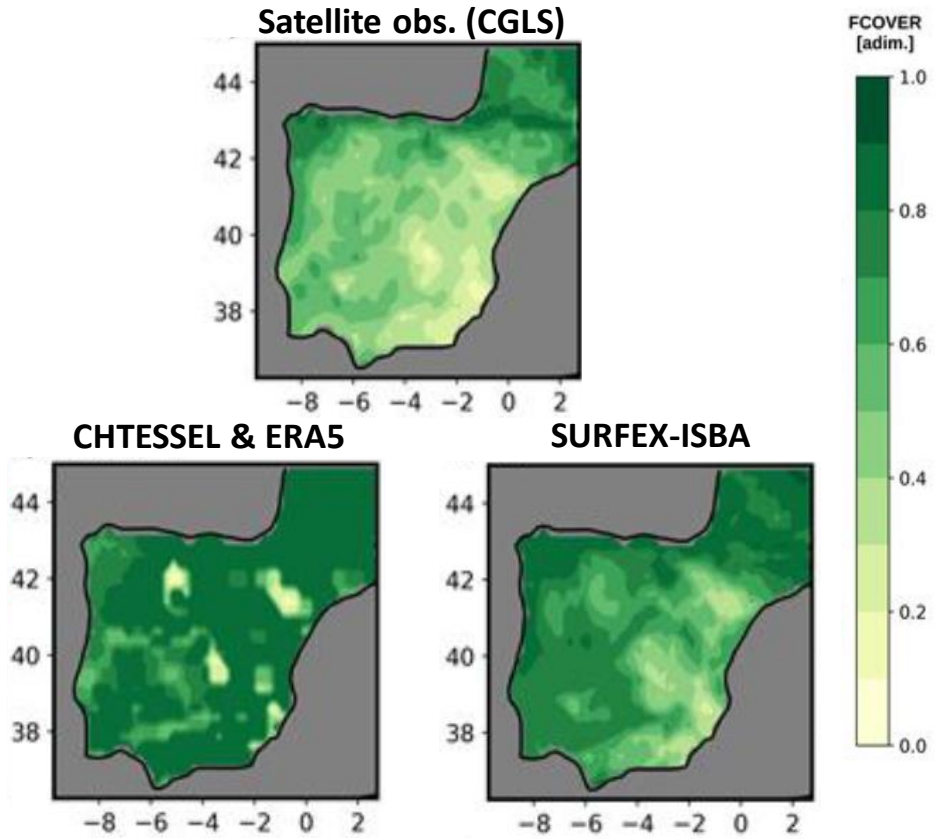
=

SOLUTION TO PROBLEM IN CHETESSEL (THUS IN ERA5) ?

CONSTRAINING VEGETATION COVER

Fraction of green vegetation cover:

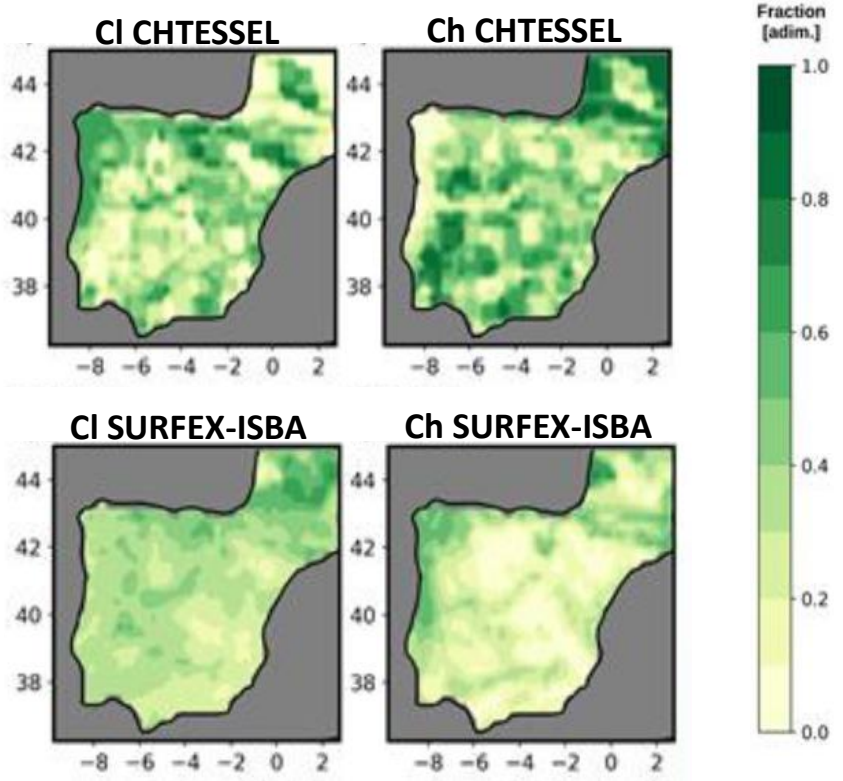
- Large differences between CHTESSEL (& ERA5) and satellite
- Better in original SURFEX-ISBA (SFX)



*Yearly maximum of monthly average fraction of green vegetation cover (FCOVER)
* Observations from Copernicus Global Land Service (CGLS)

JJA fractions of high (Ch) and low (Cl) vegetation cover:

- Large differences between CHTESSEL & SURFEX-ISBA
- CHTESSEL Cl and Ch seem “reversed” compared to reality
- SURFEX-ISBA closer to reality



*Here SURFEX-ISBA is used as reference (grounded by better LST & FCOVER
* Cl = grid point fraction of low vegetation x vegetation density parameter
* Ch = grid point fraction of high vegetation x vegetation density parameter

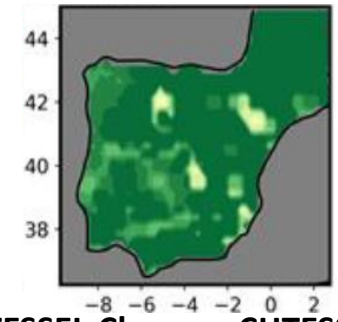
IMPROVING VEGETATION COVER IN CHTESSEL: STEP 1/3

ORIGINAL CHTESSEL

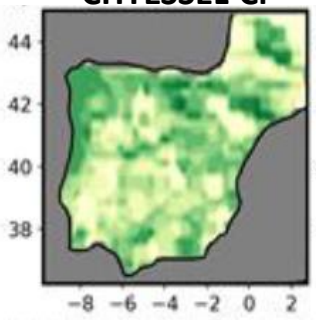
Use ESA-CCI dataset to update CHTESSEL:

- Grid point vegetation fraction maps
- Vegetation type maps

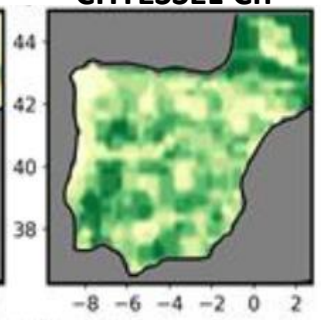
H_CCI FCOVER



CHTESSEL Cl



CHTESSEL Ch



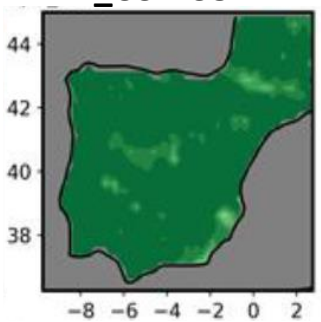
*Starting point from which to improve

STEP I (H_CCI)

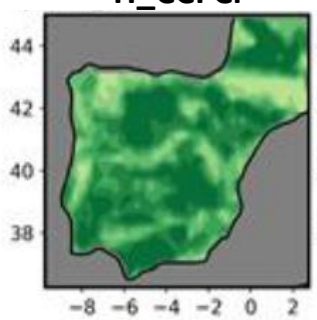
Use ESA-CCI dataset to update CHTESSEL:

- Grid point vegetation fraction maps
- Vegetation type maps

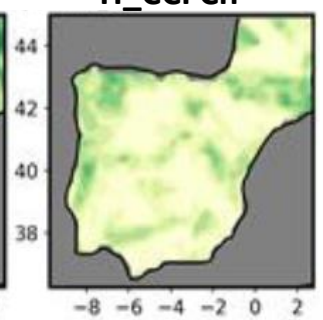
H_CCI FCOVER



H_CCI Cl



H_CCI Ch

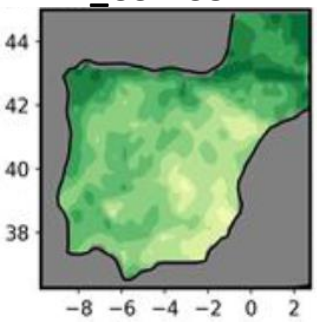


JJA high veg. fraction clearly improved
Overestimation of Cl & FCOVER remain

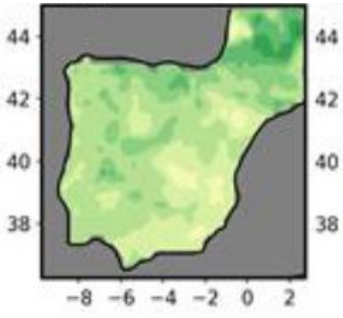
REFERENCE (TARGET) FIELDS

CGLS FCOVER
SURFEX-ISBA Ch & Cl

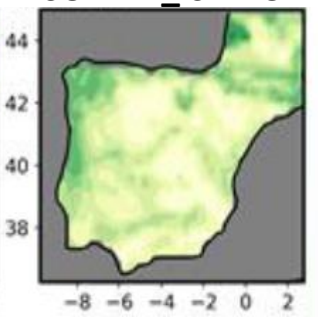
H_CCI FCOVER



SURFEX-ISBA Cl



SURFEX_ISBA Ch



*Reference maps for validation
* SURFEX-ISBA is used as reference given its better simulated LST and more realistic FCOVER, but care must be taken

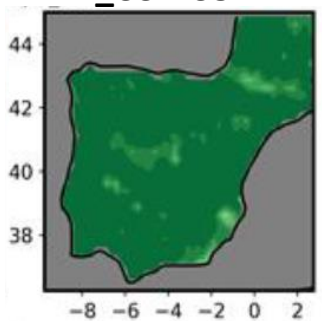
IMPROVING VEGETATION COVER IN CHTESSEL: STEP 2/3

STEP I (H_CCI)

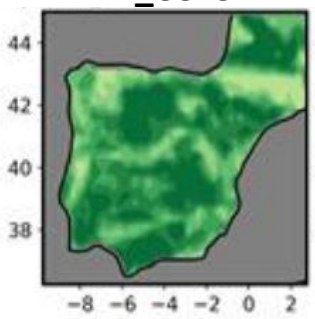
Use ESA-CCI dataset to update CHTESSEL:

- Grid point vegetation fraction maps
- Vegetation type maps

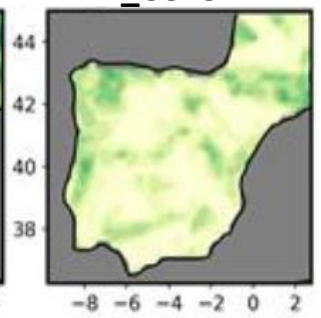
H_CCI FCOVER



H_CCI Cl



H_CCI Ch



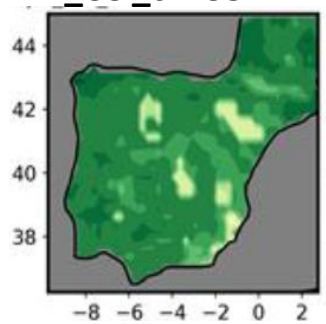
*Now Step I is starting point from which to improve
* Step I improved initial setup but further changes are required

STEP II (H_CCI_cl)

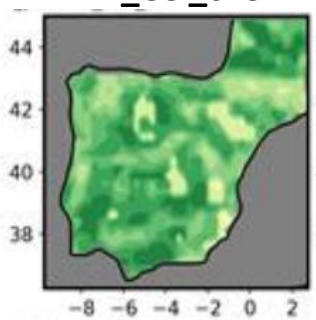
Implemented clumping parameterization:

- Improve vegetation density parameter
- Introduce vegetation cover seasonality

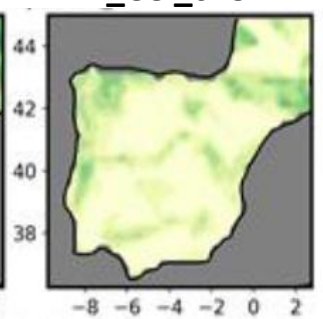
H_CCI_cl FCOVER



H_CCI_cl Cl



H_CCI_cl Ch

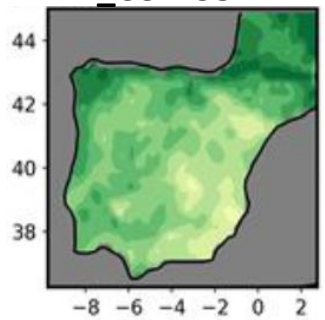


FCOVER & JJA Cl improved
Overestimation of Cl & FCOVER remain

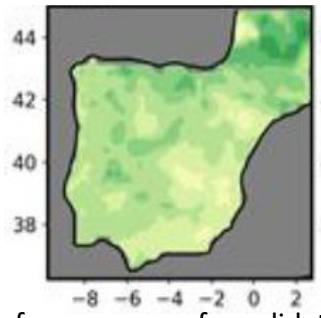
REFERENCE (TARGET) FIELDS

CGLS FCOVER
SURFEX-ISBA Ch & Cl

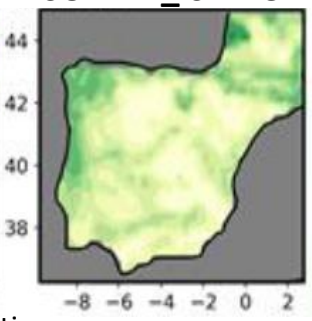
H_CCI FCOVER



SURFEX-ISBA Cl



SURFEX_ISBA Ch



*Reference maps for validation
* SURFEX-ISBA also uses clumping parameterization for vegetation density parameter (cveg):

$$cveg = 1 - \exp(-k \times LAI)$$

LAI = Leaf Area Index and k = 0.6

IMPROVING VEGETATION COVER IN CHTESSEL: STEP 3/3

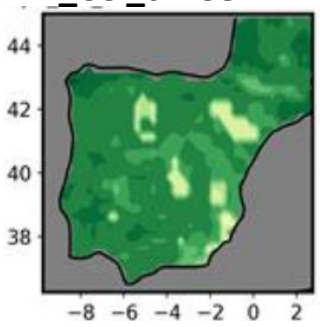
STEP II (H_CCI_cl)

Clumping parameterization:

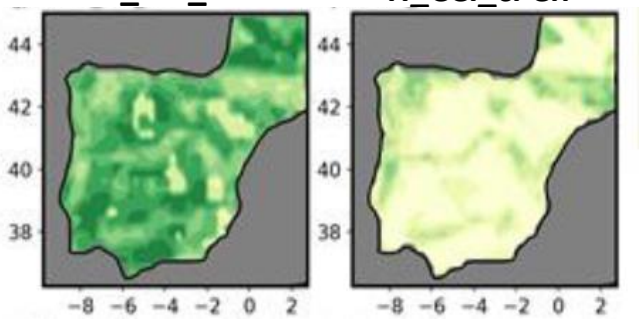
$$cveg = 1 - \exp(-k \times LAI)$$

Introduced large sensitivity to LAI

H_CCI_cl FCOVER



H_CCI_cl CI **H_CCI_cl Ch**



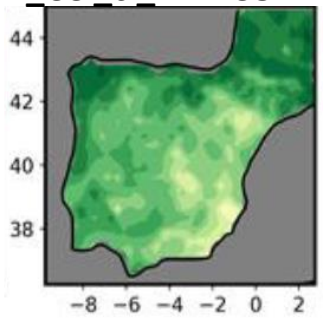
*Now Step II is starting point from which to improve

* Step II further improved initial setup but further changes are still required

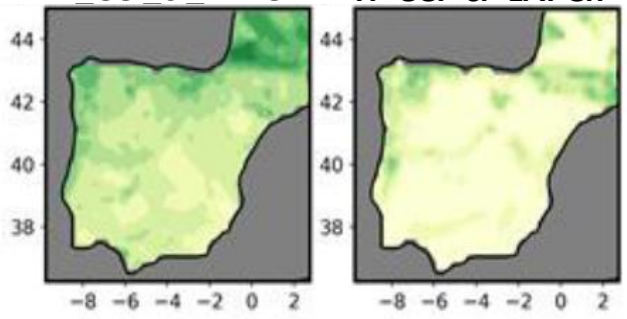
STEP III (H_CCI_cl)

Update LAI in CHTESSEL from CGLS satellite-based product.

H_CCI_cl_LAI FCOVER



H_CCI_cl_LAI CI **H_CCI_cl_LAI Ch**



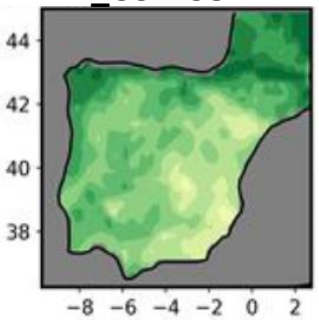
FCOVER & JJA CI greatly improved

REFERENCE (TARGET) FIELDS

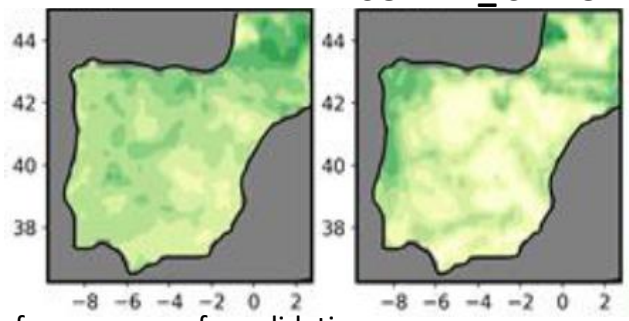
CGLS FCOVER

SURFEX-ISBA Ch & CI

H_CCI FCOVER



SURFEX-ISBA CI **SURFEX_ISBA Ch**



*Reference maps for validation

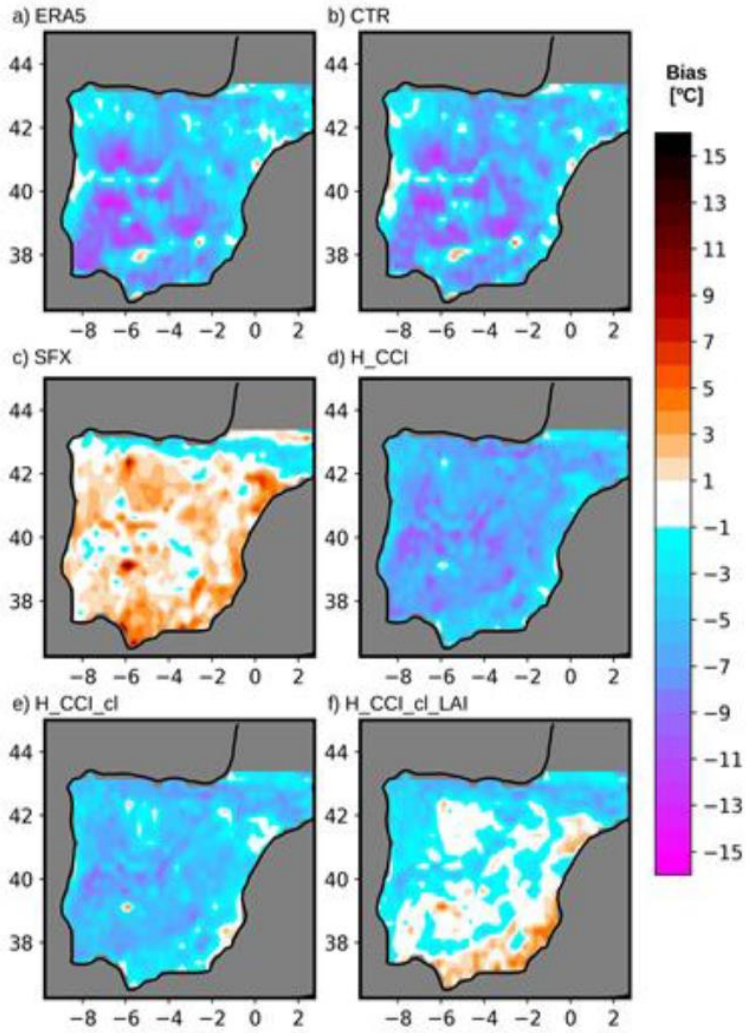
* SURFEX-ISBA also uses clumping parameterization for vegetation density parameter (cveg):

$$cveg = 1 - \exp(-k \times LAI)$$

LAI = Leaf Area Index and k = 0.6

IMPACT OF IMPROVED VEGETATION ON JJA DAILY MAXIMUM LST

JJA LSTmax Bias

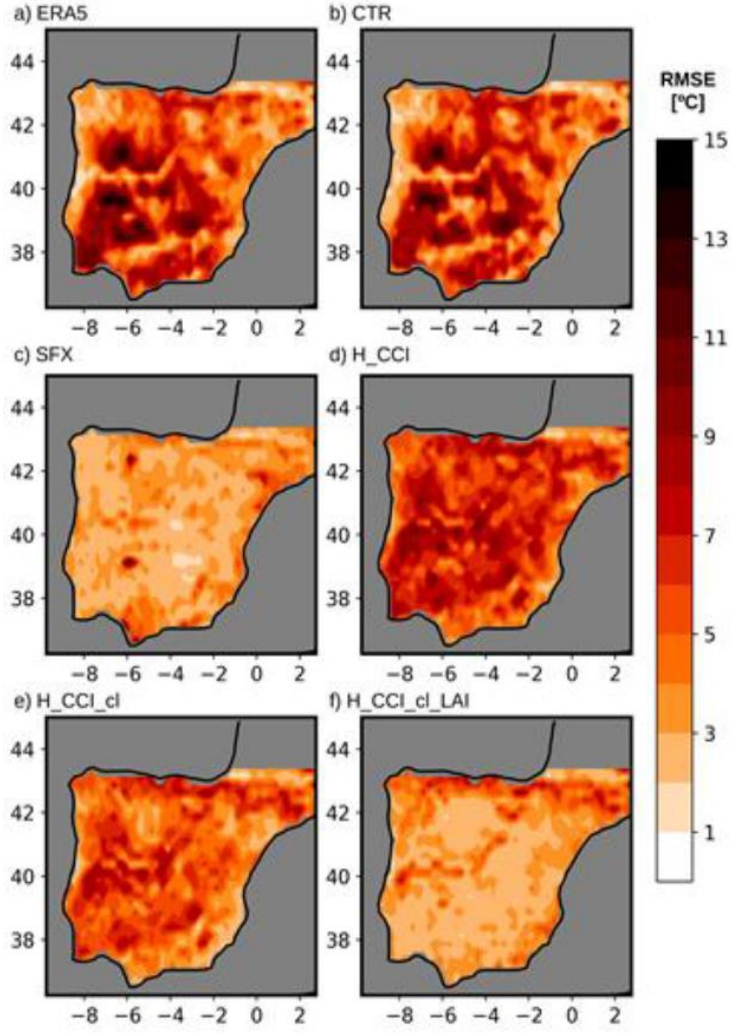


I) By itself, updating Veg. Types and Fractions from ESA-CCI does not improve LST errors significantly;

II) Adding clumping parameterization to updates in I results in slight LST error reduction;

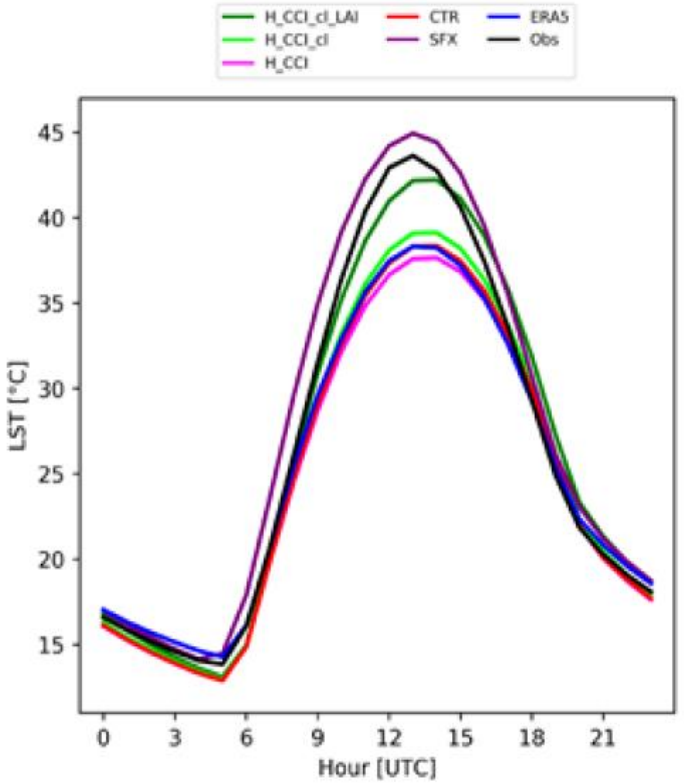
III) Further adding updated LAI to clumping and veg. fraction and types updates = Large error reduction!

JJA LSTmax RMSE



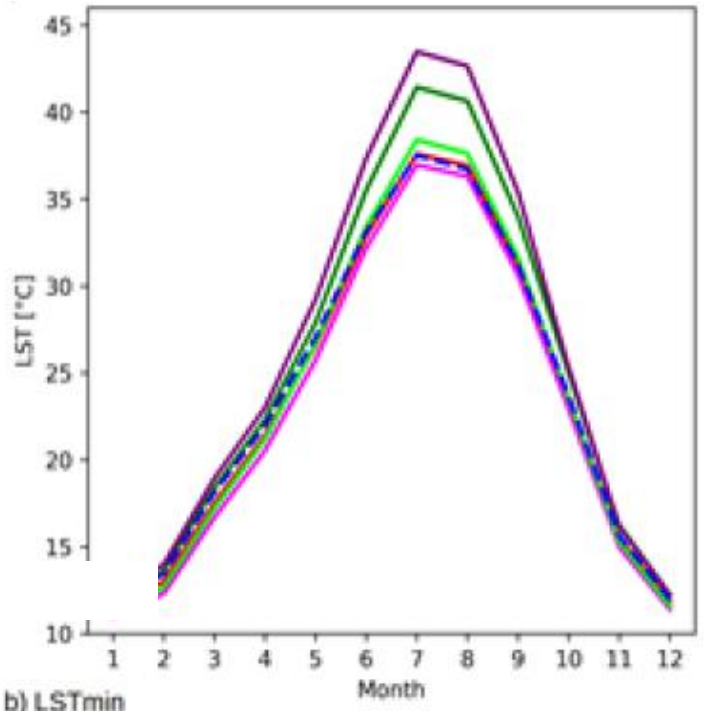
IMPACT OF IMPROVED VEGETATION ON LST DIURNAL & SEASONAL CYCLES

- H_CCI_cl_LAI improves daytime LST
- It has negligible impact during nighttime
- Here negligible = within (LSA-SAF) observational uncertainty (~2 K)

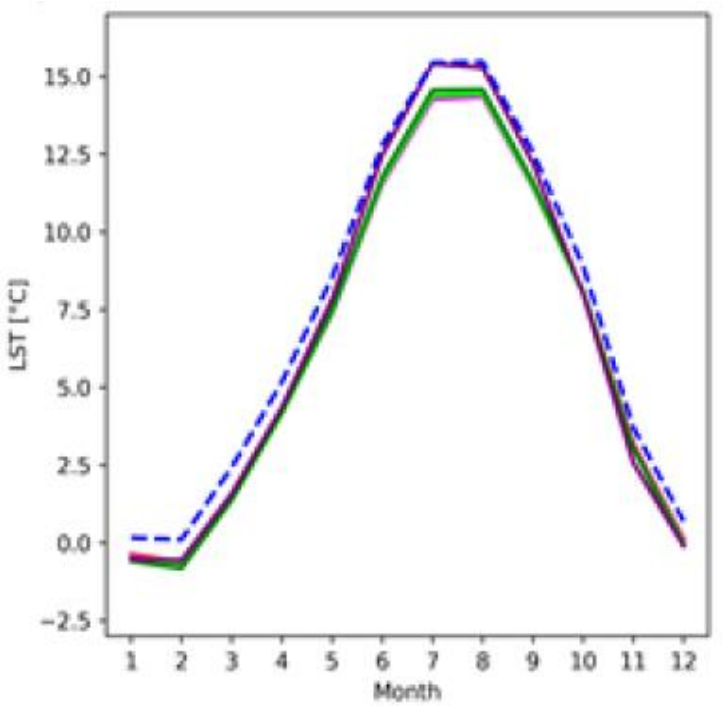


*JJA LST diurnal cycle averaged over Iberia

- H_CCI_cl_LAI increases daily max. LST during warm season
- This was previously shown to be error reduction
- H_CCI_cl_LAI has negligible impact during cold season
- All steps have negligible on daily min. LST during winter but cool during winter.
- However, daily min. LST change is within (LSA-SAF) observational uncertainty



*JJA daily maximum LST seasonal averaged over Iberia



*JJA daily minimum LST seasonal averaged over Iberia

SUMMARY

- ERA5 has large cold bias in summer daily maximum LST over Iberia compared to satellite observations;
- Cold bias reproduced by offline CHTESSEL simulations, but not offline SURFEX-ISBA simulations;
- CHTESSEL misrepresents vegetation cover fractions, types and seasonality over Iberia compared to satellite observations;
- In fact, Iberia JJA daily maximum LST error in CHTESSEL largely due to misrepresentation of vegetation
- Cold bias in CHTESSEL may be almost completely removed by:
  - Updating vegetation fractions and types in CHTESSEL from ESA-CCI observational product
  - Introducing a clumping parameterization for vegetation density parameters (also introduces seasonality)
  - Updating LAI in CHTESSEL from CGLS observational product
- Impact on other times of day and seasons are neutral (within observational uncertainty)!
- These 3 updates must be performed together to obtained improve results. Updates to one model property often require coherent updates to related parameters
- Satellite observations are essential to validate model results and constrain model development

- Future work: impact of CHTESSEL vegetation updates on global scale & in coupled simulations (using IFS)

THANK YOU

References

- Nogueira, M., Albergel, C., Boussetta, S., Johannsen, F., Trigo, I. F., Ermida, S. L., Martins, J. P. A., and Dutra, E., 2020, 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. Discuss. https://doi.org/10.5194/gmd-2020-49
- Johannsen, F.; Ermida, S.; Martins, J.P.A.; Trigo, I.F.; Nogueira, M.; Dutra, E. Cold Bias of ERA5 Summertime Daily Maximum Land Surface Temperature over Iberian Peninsula. Remote Sens. 2019, 11, 2570. https://doi.org/10.3390/rs11212570

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