Revising ECMWF land cover and vegetation: impact in offline and coupled atmosphere simulations

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Data & Methods

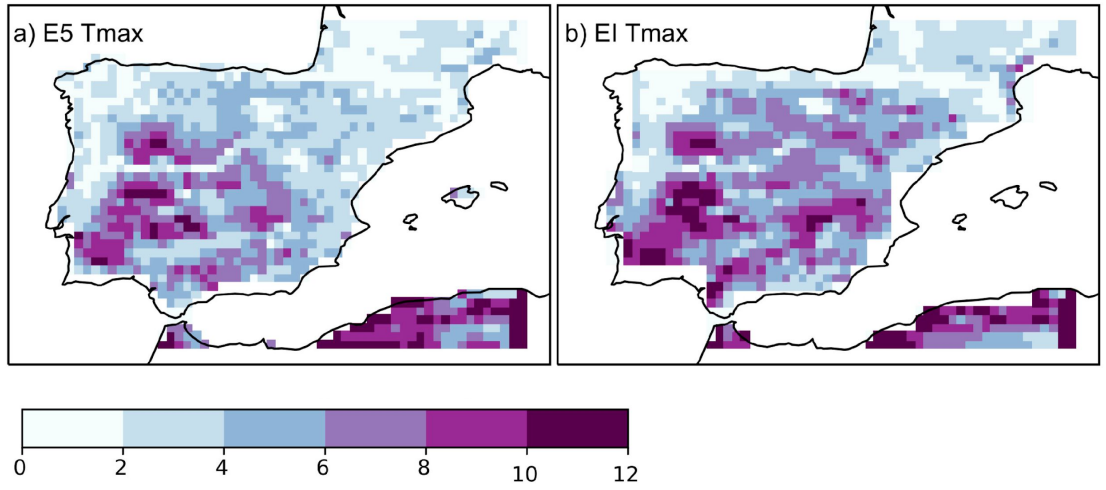
- **Can we enhance the use of Earth Observations (EO) in model development ?**
- **Routine use of LST for model evaluation ? Can it guide model development ?**
- **What's the impact of revising land-cover and vegetation in the ECMWF model ?**

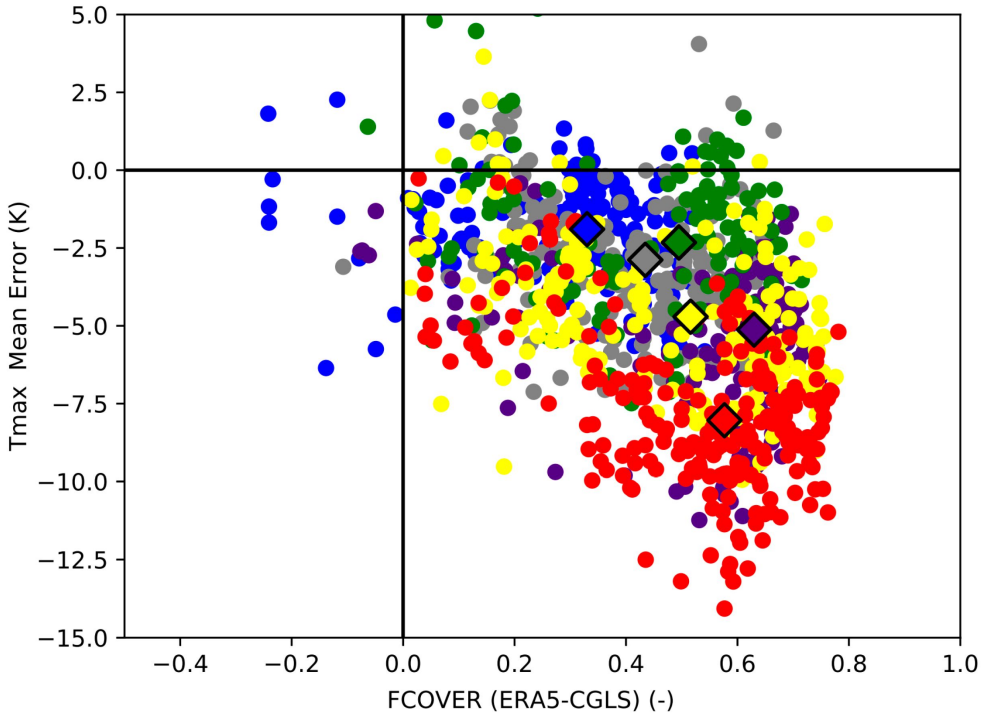
- Models:
  - **IFS & CHTESSEL**: ECMWF current model cycle, atmosphere and land-surface;
    - Offline simulations driven by ERA5, 1-year atmospheric nudged simulations and short-range weather forecasts;
  - ERA5 reanalysis, SURFEX;

- Data
  - LST satellite data from LSA-SAF MSG SEVIRI 1 or 3-hourly: clear sky only.
  - ESA-CCI land cover transformed to IFS land-cover types;
  - Copernicus Global Land Service (CGLS) Leaf Area Index ;

ERAI/ERA5 LST vs LSA-SAF

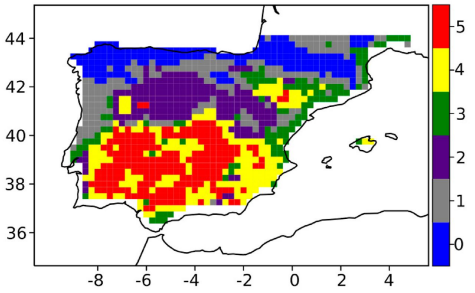
ERA5/ERAI LST maximum temperature RMSE JJA (K)





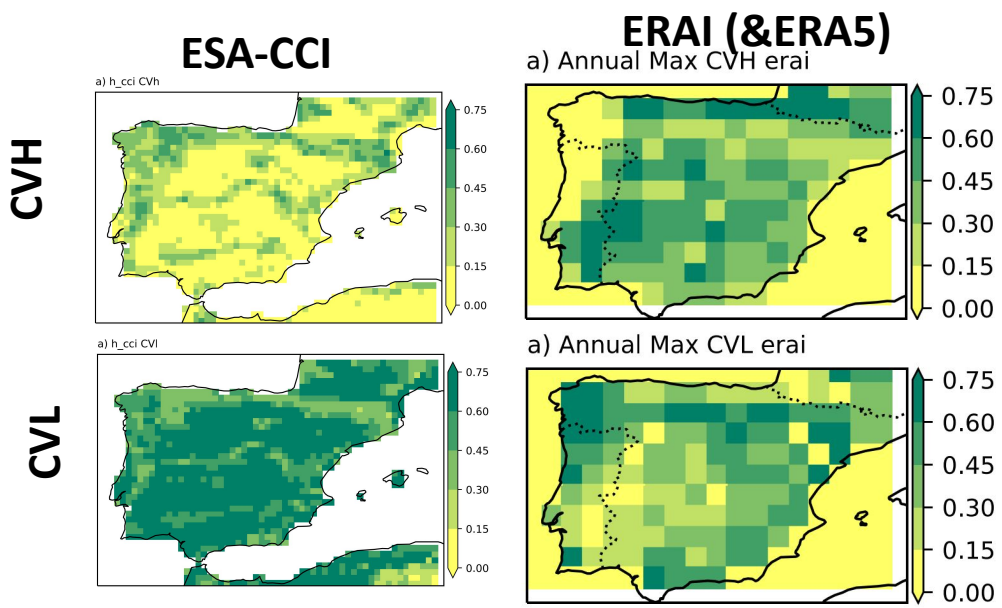
LST Tmax error (Yaxis) versus CGLS green vegetation cover difference between ERA5 & CGLS) (Xaxis). Colors different regions in Iberia.

Large daytime errors associated with vegetation cover and seasonality.



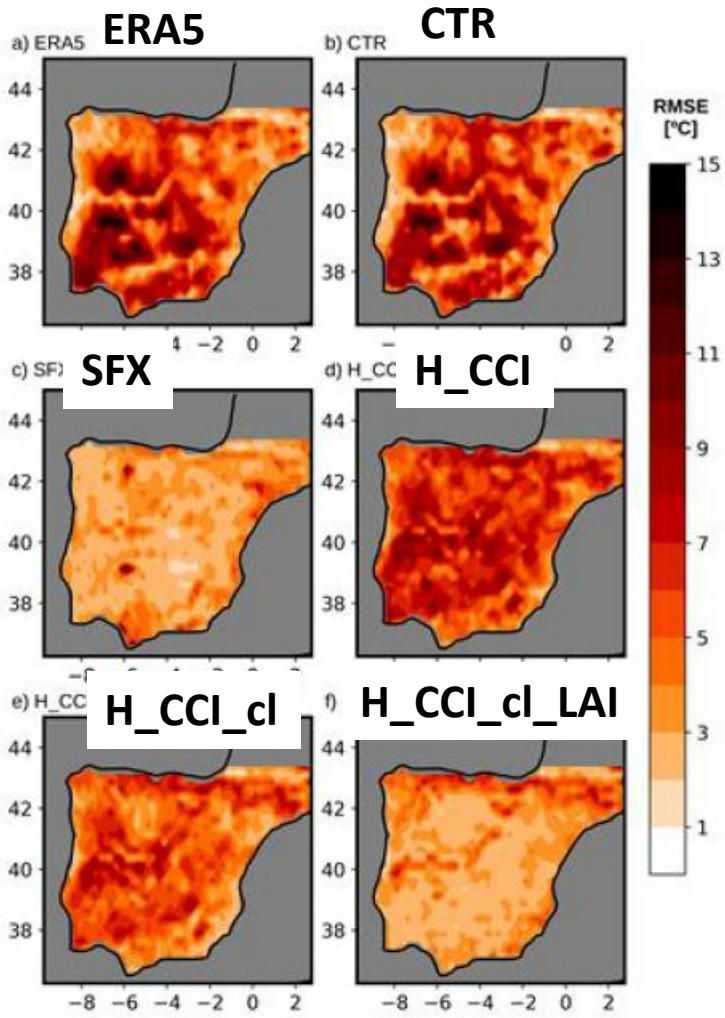
Johannsen, F.; et. al, Cold Bias of ERA5 Summertime Daily Maximum Land Surface Temperature over Iberian Peninsula. *Remote Sensing* 2019, *11*, 2570, https://doi.org/10.3390/rs11212570

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

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.

Land cover – Global

Current IFS

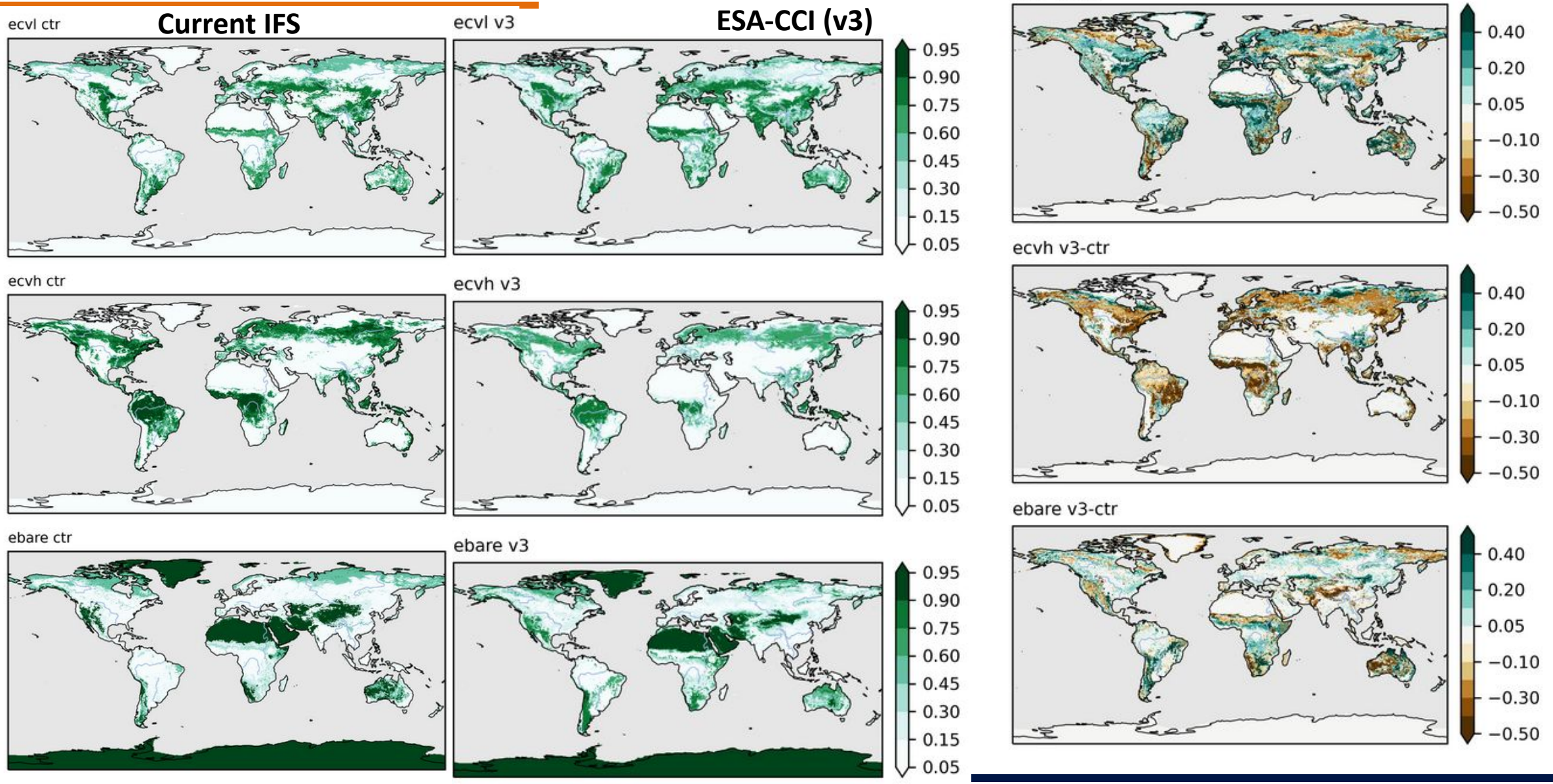
ESA-CCI (v3)

ESA-CCI (v3) -CTR

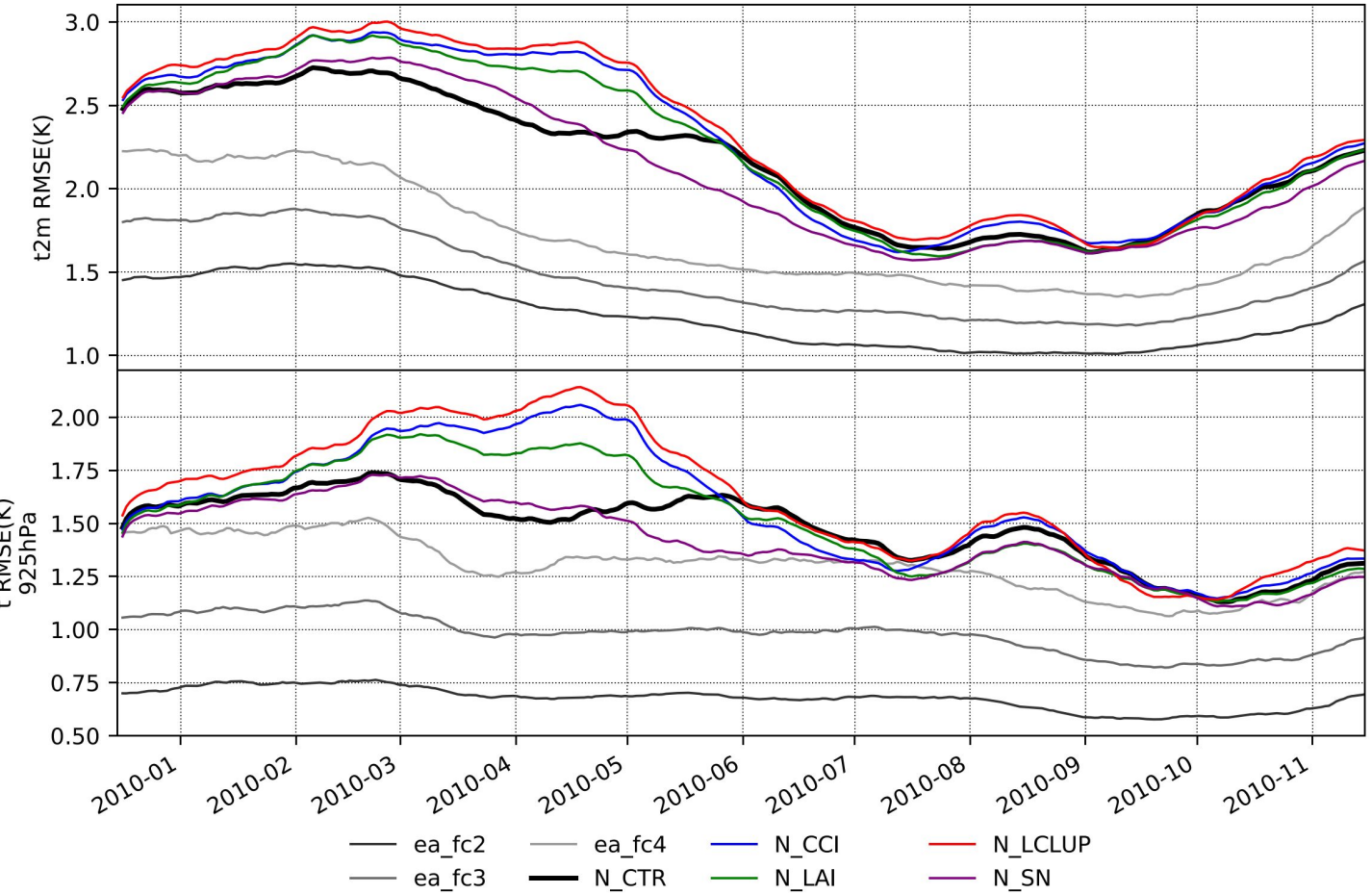
ECVL

ECVH

EBARE



Global IFS nudged simulations



Mean RMSE land points poleward 20N against ERA5
2-meter temperature top
Temperature @925hPa

Nudging configuration with temperature errors > day 4 forecasts (worst for T2m – no data assimilation…)

New land cover with large impact in Spring – snow albedo

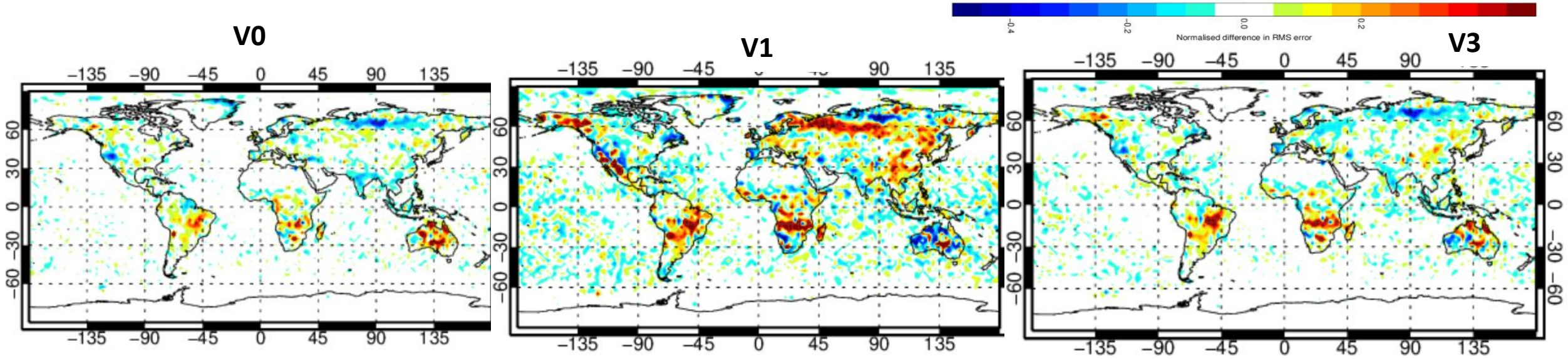
Including shaded snow improves CTR from May-June

Nogueira, 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*(15), e2020JD034163. https://doi.org/10.1029/2020JD034163

The “details” of the cross-walking table and meteorological impact

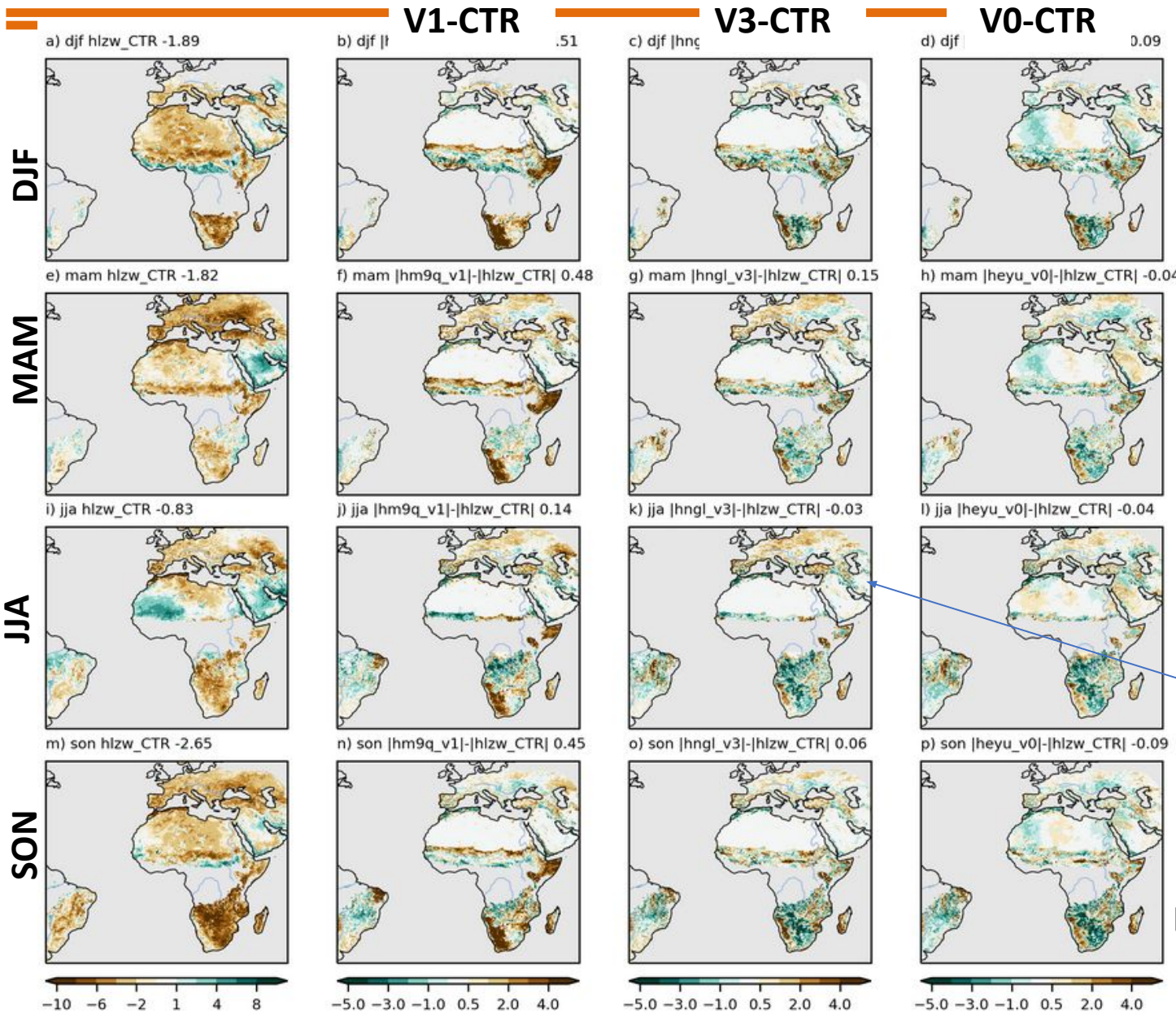
CCI_IND	CCI_NAME	IFS_VNAME	crops	short grass	everg needle	deci needle	deci broad	ever broa
		IFS_INDEX	1	2	3	4	5	6
		IFS_VTYPE	L	L	H	H	H	H
0.0	no_data							
10.0	cropland_rainfed		100 90	0 10				
11.0	cropland_rainfed_herbaceous_cover		100 90	0 10				
12.0	cropland_rainfed_tree_or_shrub_cover		50 30					

Ongoing efforts to “revise” cross-walking table to limit some negative meteorological impact on short-range forecasts; Crucial point is the split between High/Low vegetation and bare ground : cope with seasonality



JJA 2019 short-range forecasts +12h Normalized RMS of 2-m temperature (v0) left v1 (center) v3 (right)and v1 (right)

Impact of cross-walking table on LST evaluation

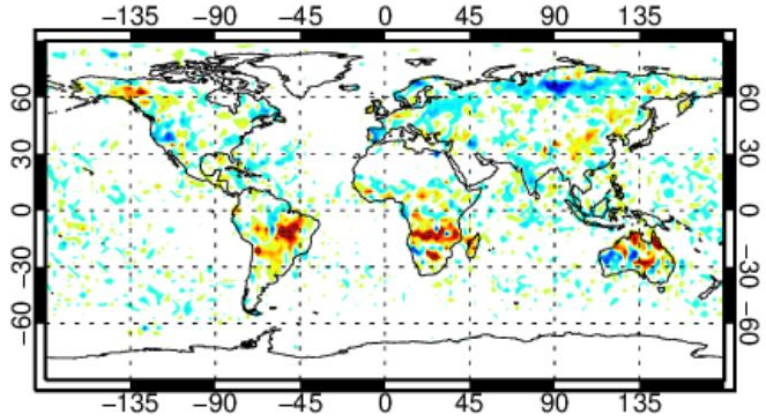


Daily maximum LST bias in CTR (left) and absolute bias difference in different experiments

v0 was +/- ok but using an “old” cross-walking table

v1 an attempt to use a cross-walking table “similar” to one used by ORCHIDEE – too much vegetation (or lack of seasonality) & correct unrealistic bare ground regions;

v3 getting better and closer to v0 ?? (we’re going in circles?)



LST & 2-m temperature impact are not identical !

Final Remarks

- This work was driven by EO data: LST / land-cover / LAI;
  - More effort required to use and prove the added value of these products in the context of Numerical Weather Prediction ;
  - Ongoing effort to “tune” cross-walking table and model parameters to limit negative meteorological impacts – Aim to update land cover in ECMWF operational model;

- Explore the impact of these land-cover and LAI changes on biogenic fluxes (H2020 CoCO2)

- Very high global resolution ~4km : What’s the role of representing surface heterogeneities? (H202 NextGEMS)