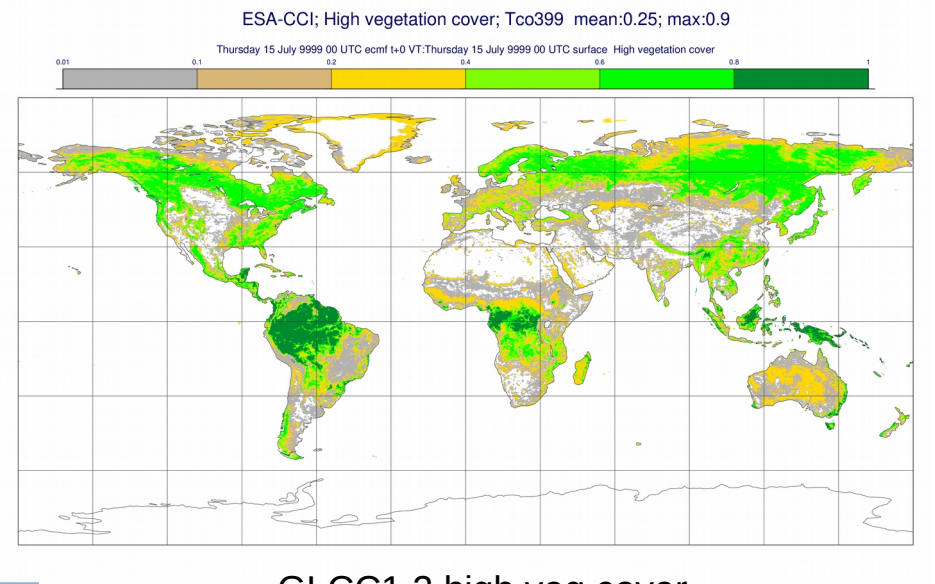
Sensitivity of the ECMWF Land surface model to vegetation and LU/LC maps

Souhail Boussetta, Gianpaolo Balsamo, Emanuel Dutra, Miguel Nogueira, Gabriele Arduini, Margarita Choulga, Nils Wedi, Joaquin Munoz Sabater

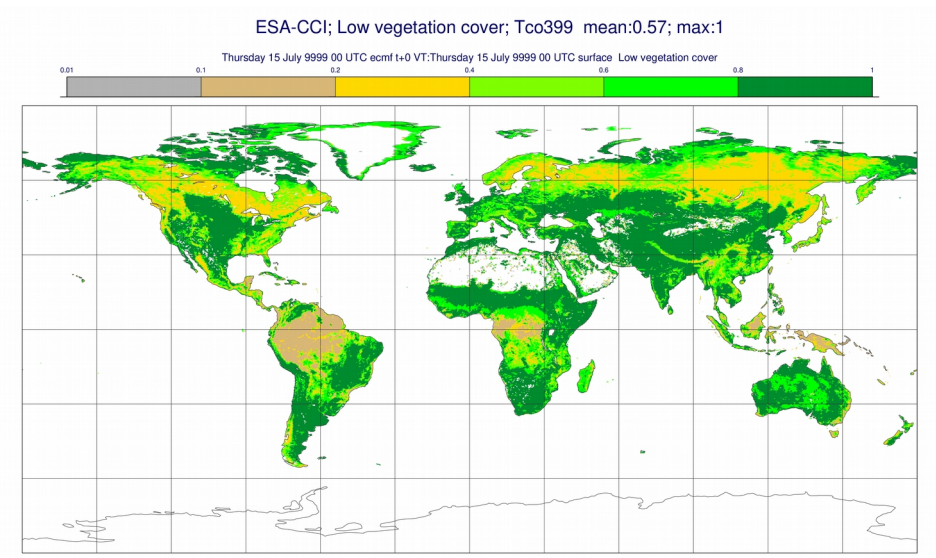
ECMWF

Vegetation cover

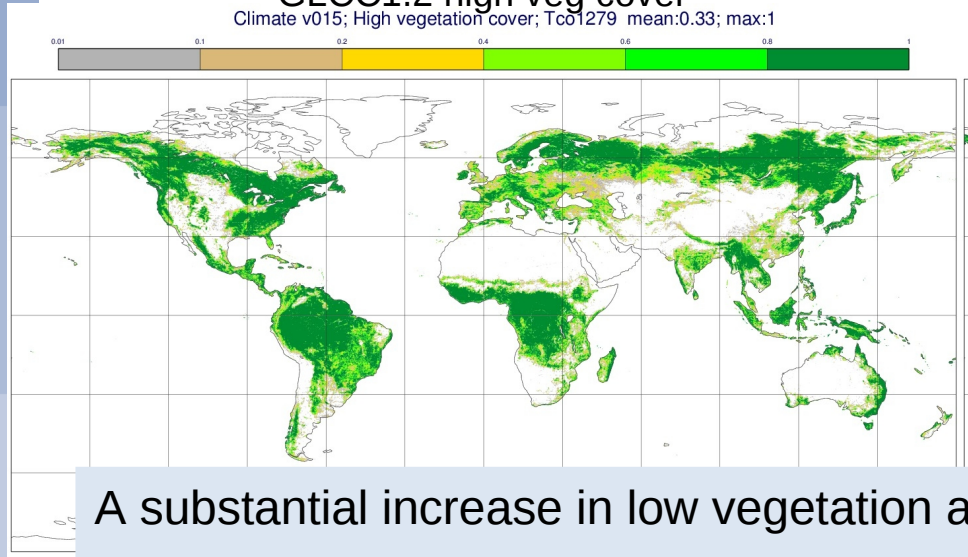
ESA-CCI high veg cover



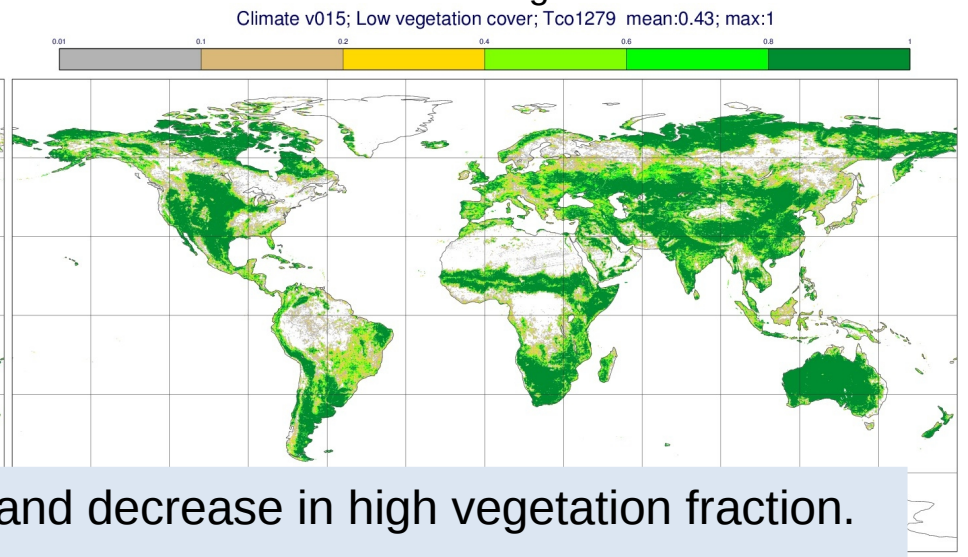
ESA-CCI low veg cover



GLCC1.2 high veg cover



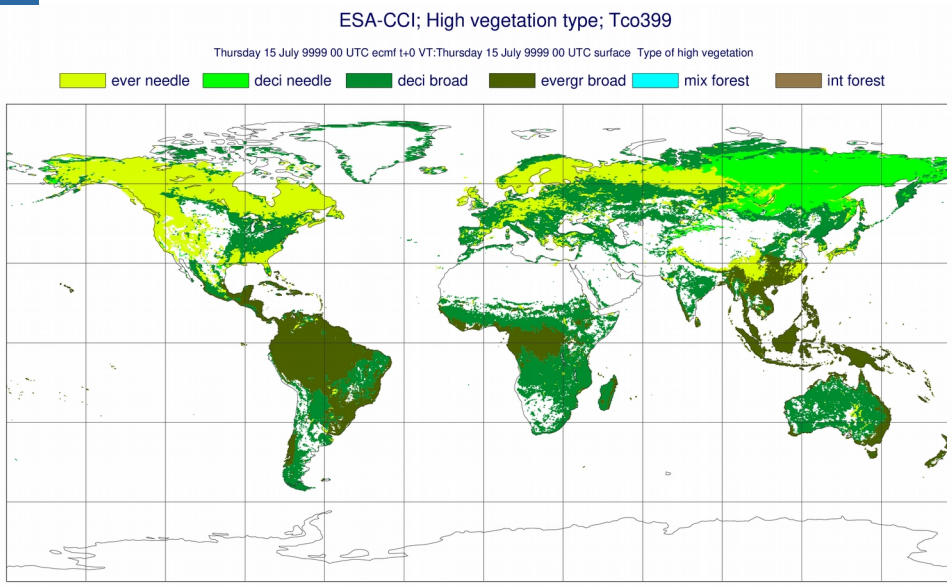
GLCC1.2 low veg cover



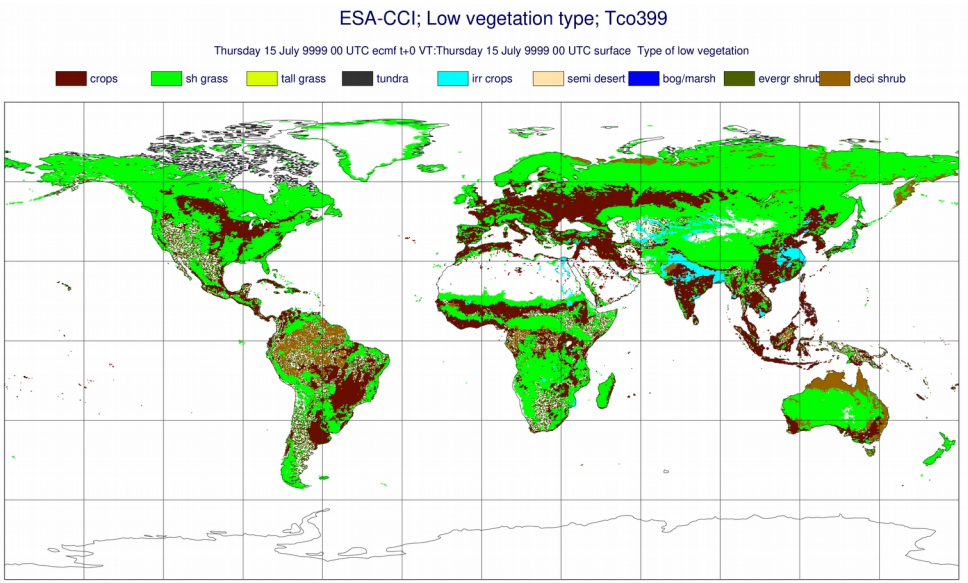
A substantial increase in low vegetation and decrease in high vegetation fraction.

Vegetation types

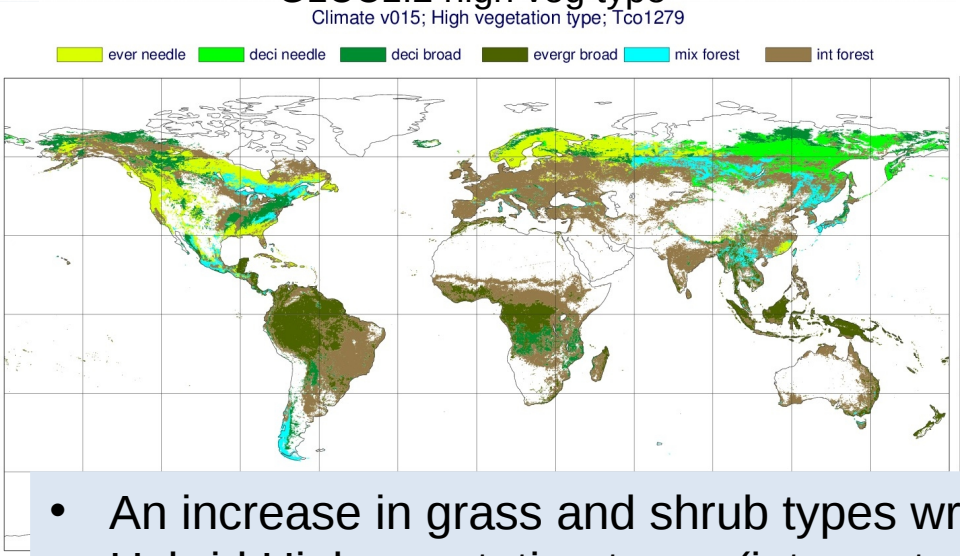
ESA-CCI high veg type



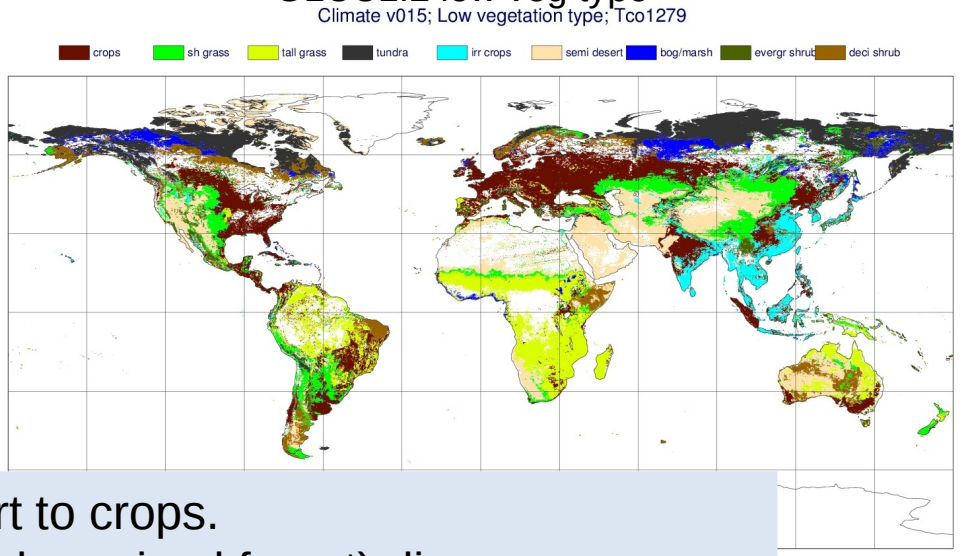
ESA-CCI low veg type



GLCC1.2 high veg type



GLCC1.2 low veg type



- An increase in grass and shrub types wrt to crops.
- Hybrid High vegetation types (interrupted or mixed forest) disappear.

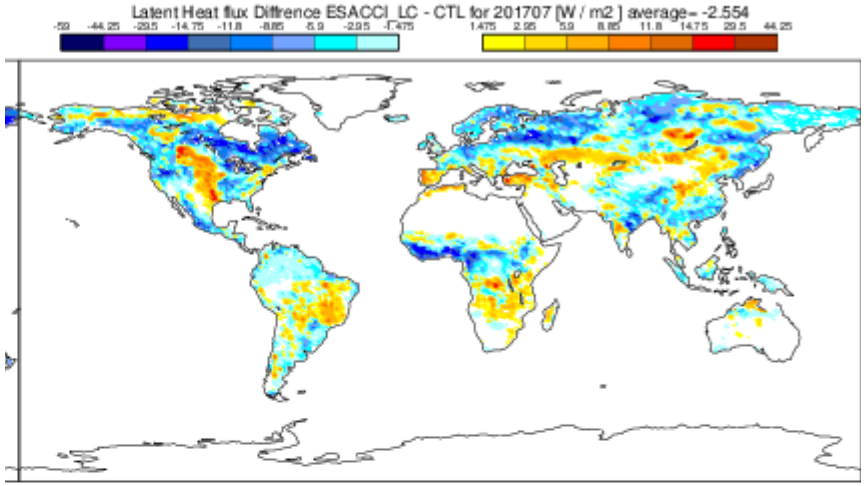
==> expected substantial impact via (roughness, albedo, canopy resistance..)

Percentage of vegetated points at Tco399

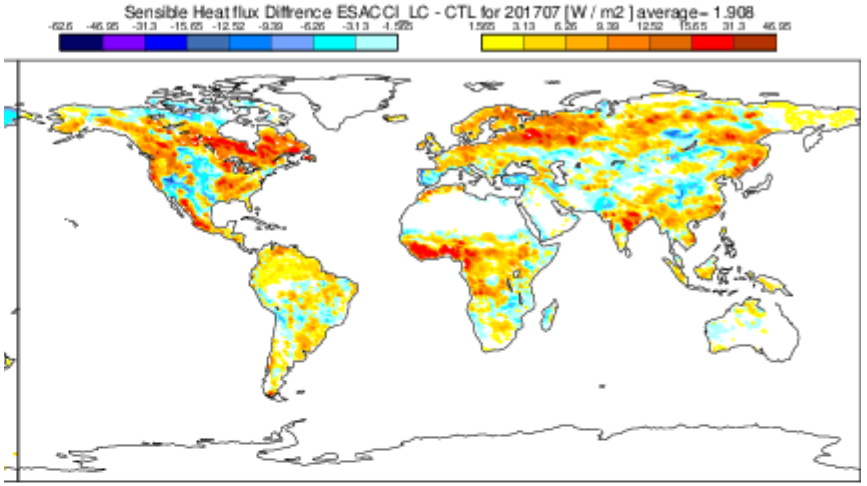
Index	Vegetation type	Percentage of land points	
		ESA-CCI	GLCC1.2
	Low vegetation		
1	crops	23.50%	18.00%
2	sh grass	38.70%	9.00%
7	ta grass	0.00%	12.80%
9	tundra	0.70%	6.00%
10	irr crops	1.90%	3.90%
11	semidesert	0.00%	11.60%
13	bog/marsh	0.00%	1.50%
16	ever shrub	5.10%	1.20%
17	deci shrub	4.70%	3.90%
	Remaining points	25.00%	31.40%
	High Vegetation		
3	ever needle	11.70%	5.40%
4	deci needle	4.70%	2.50%
5	deci broad	29.50%	5.60%
6	ever broad	18.20%	12.90%
18	mix forest	0.00%	3.00%
19	int forest	0.00%	24.70%
	Remaining points	35.60%	45.50%

Impact in Surface offline simulations (ESA-CCI)

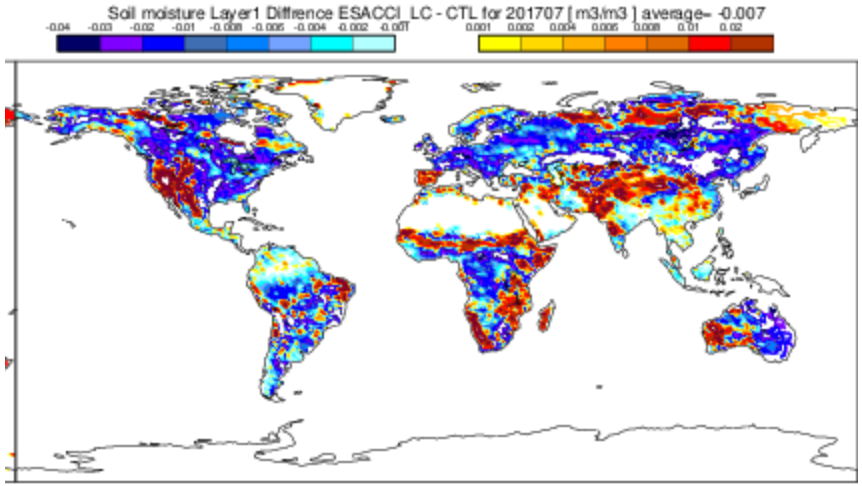
Difference w.r.t control experiment (all simulations forced with ERA5)



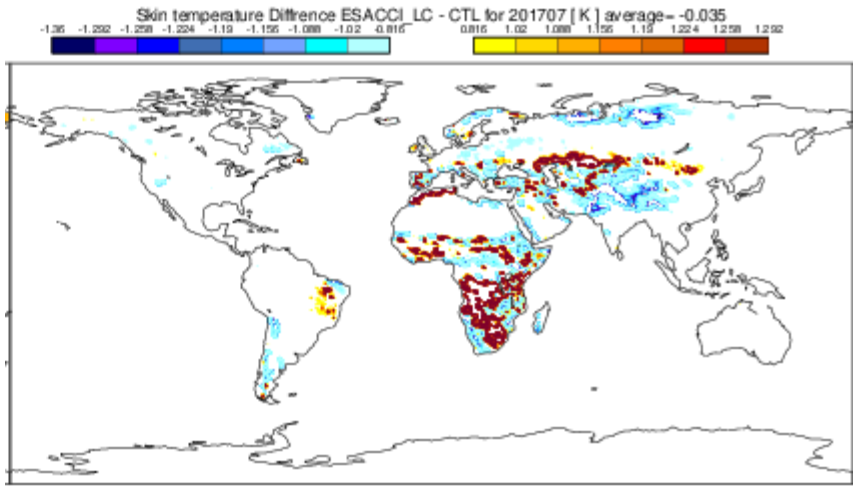
Latent heat flux



Sensible heat flux



Surface soil moisture layer

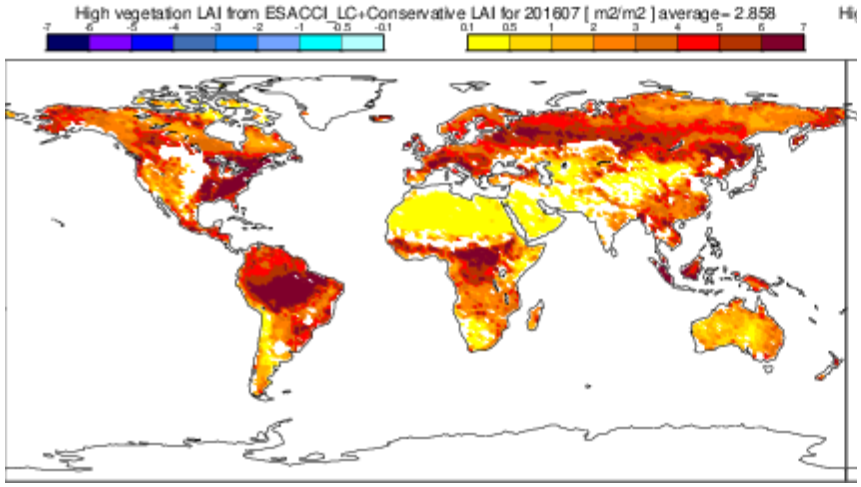


Skin Temperature

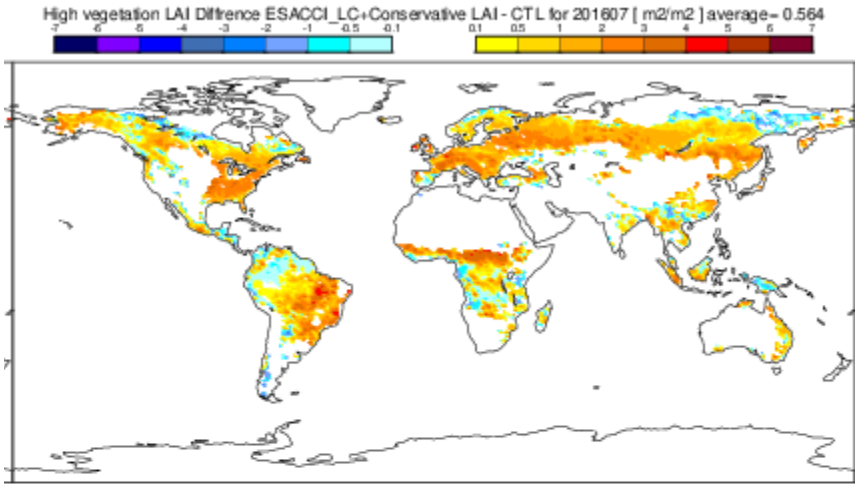
- An increase of latent heat flux with a decrease in sensible heat flux especially in forest areas associated with a decrease in the surface soil moisture. And the opposite is seen in arid/semi-arid regions like Iberia and central Asia

Leaf Area Index disaggregation operator

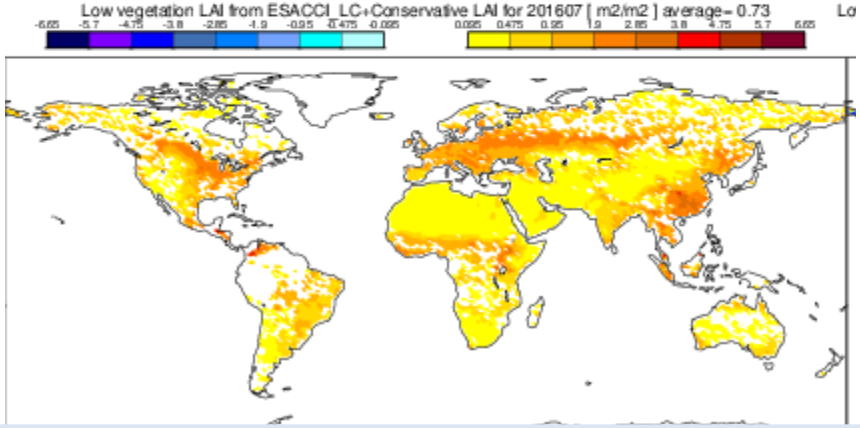
High veg LAI conservative



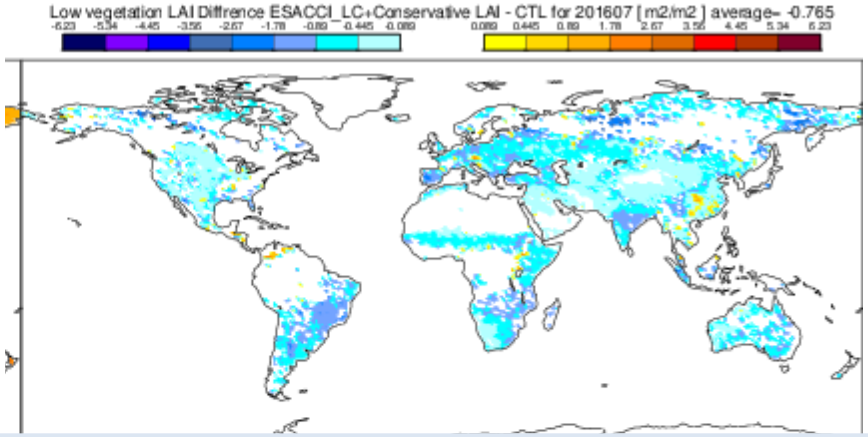
High veg LAI conservative - ctl



Low veg LAI conservative



Low veg LAI conservative - ctl

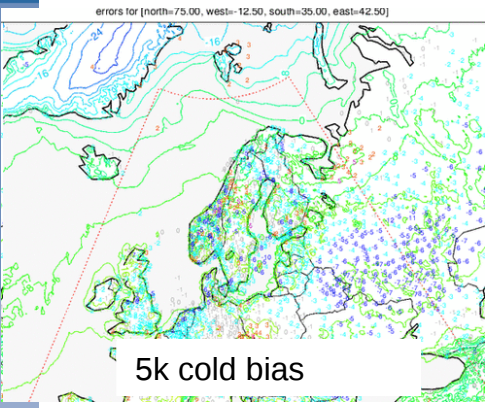


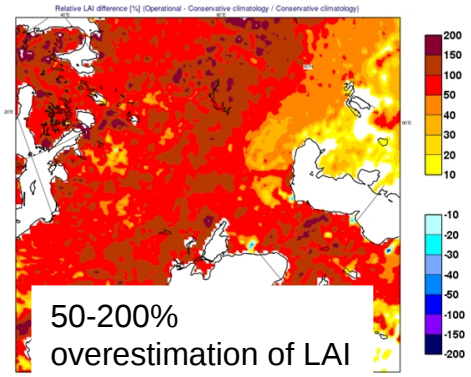
An update of the LAI disaggregation operator ➔

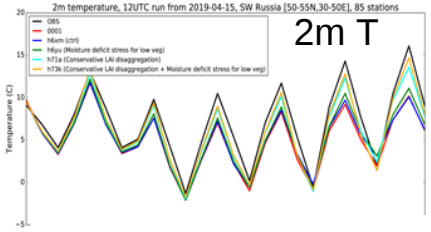
- More consistent and coservative of the observed total LAI.
- Increase of the high vegetation LAI and an decrease of the low vegetation LAI when using the ESA-CCI land cover

LAI high/low vegetation disaggregation operator

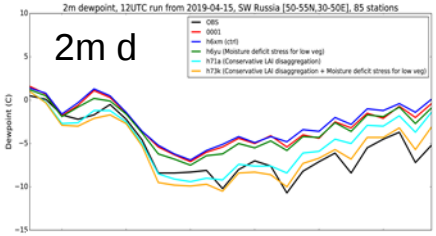
April 2019 SW Russia case



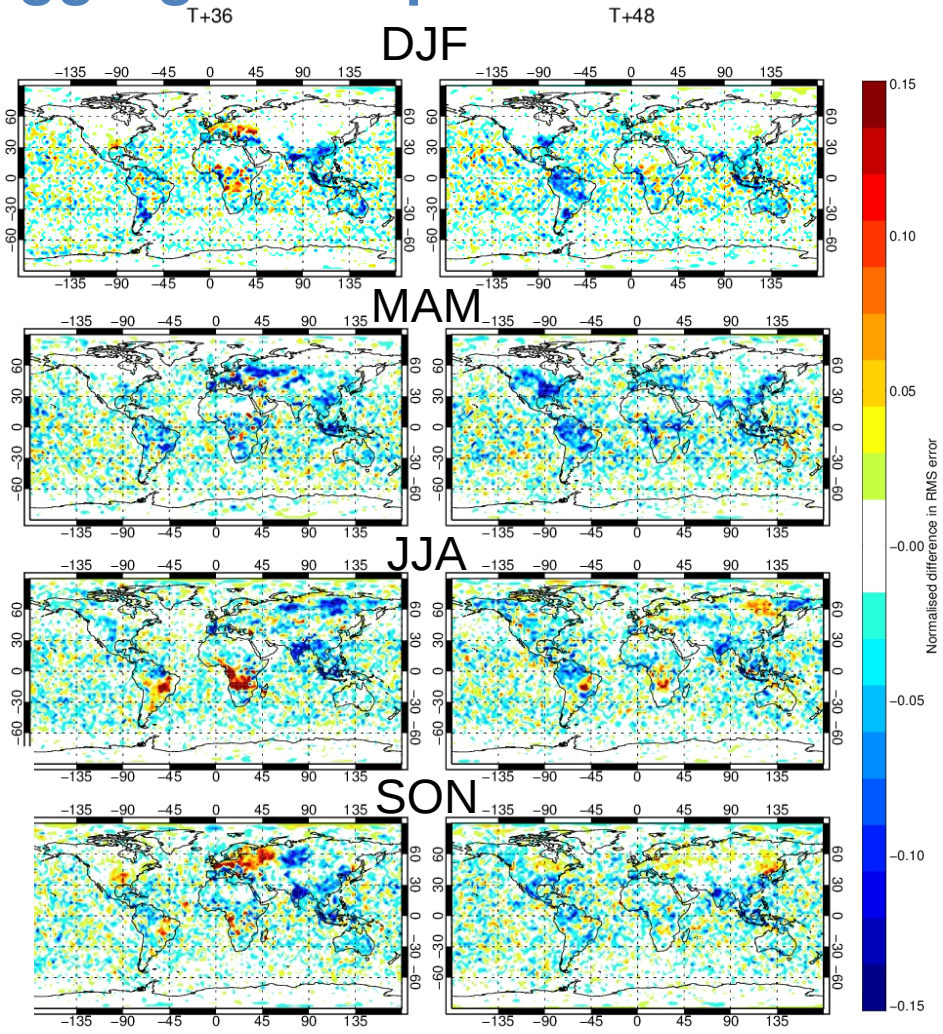




__Obs __Oper __newLAI



__Obs __Oper __newLAI

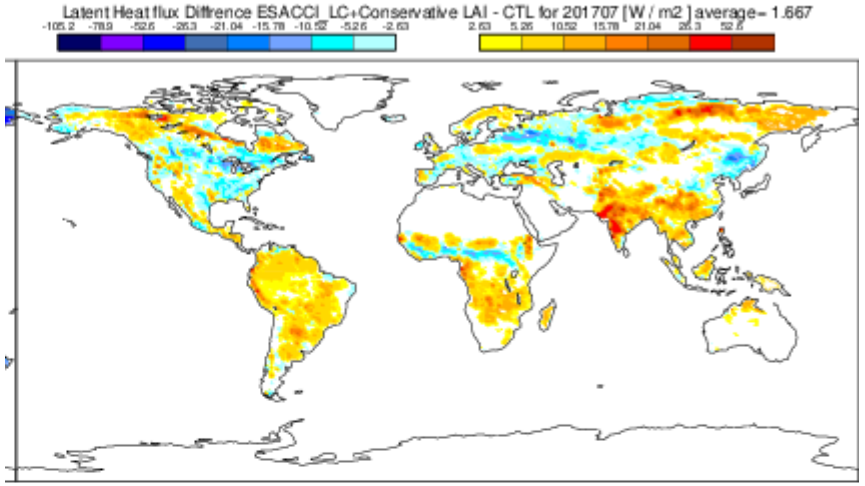


Change in RMSE error of the 2m temperature

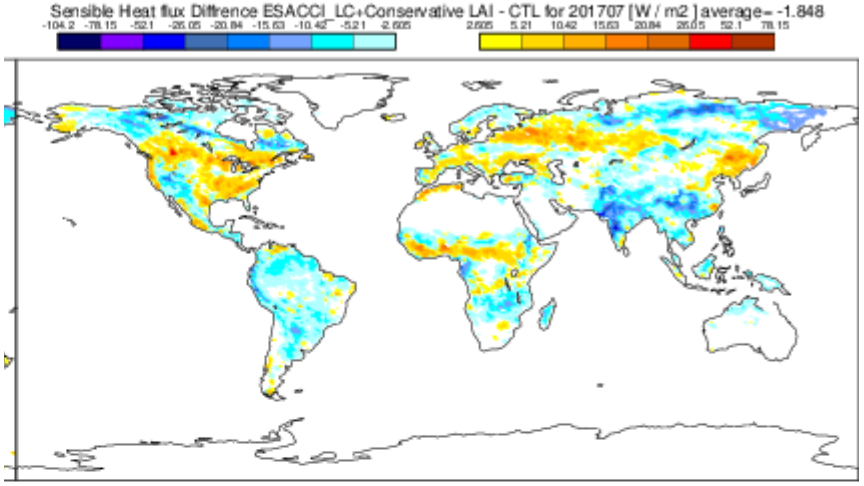
- SW Russia case shows that using new LAI disaggregation correct for an overestimation of the LAI that lead to a cold/wet bias.
- Overall beneficial for the scores of near surface atmosphere (although some adjustment of the vegetation parameters might be necessary to overcome the autumn bad scores over Eur

Impact in Surface offline simulations (ESA-CCI + conservative LAI)

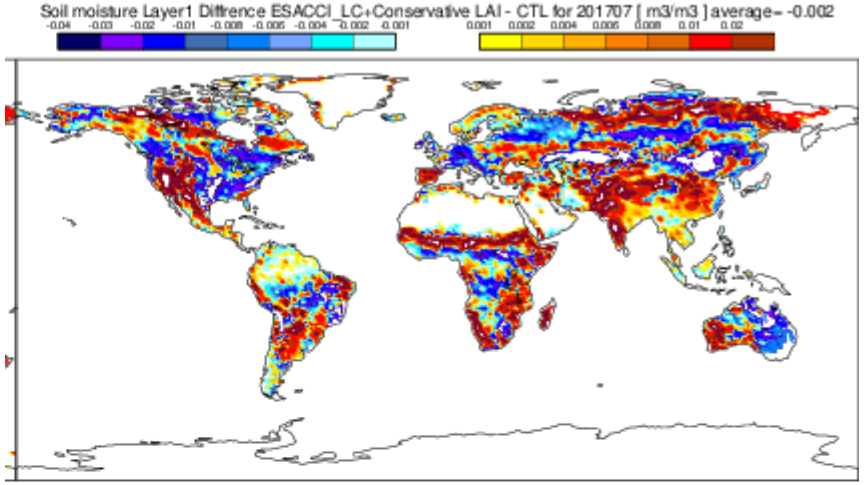
Difference w.r.t control experiment (all simulations forced with ERA5)



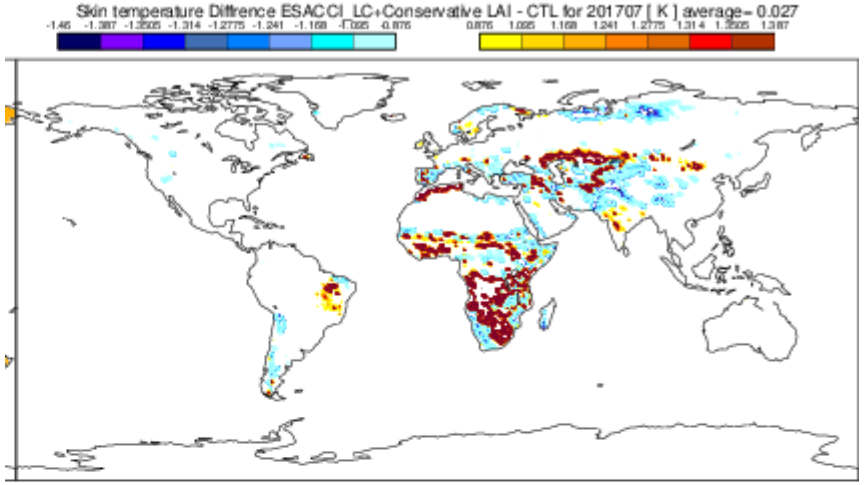
Latent heat flux



Sensible heat flux



Surface soil moisture layer



Skin Temperature

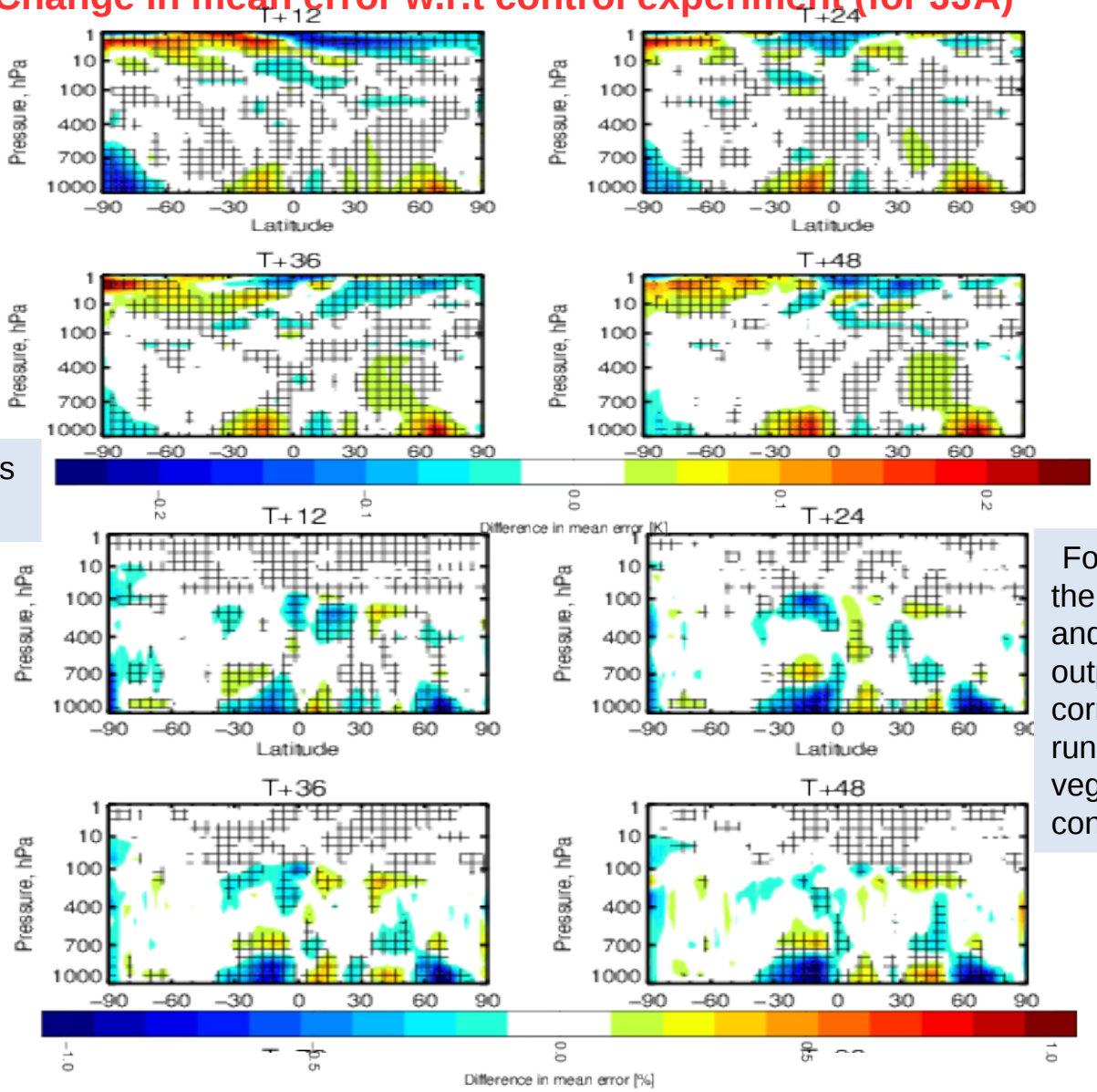
- Combining the ESA-CCI LC with the new LAI disaggregation results in overall dumping of the flux signal seen with the ESA-CCI only and different patterns appearing especially in SE Asia and south America

Impact in coupled forecast runs (ESA-CCI + conservative LAI)

Change in mean error w.r.t control experiment (for JJA)

Temperature

Humidity



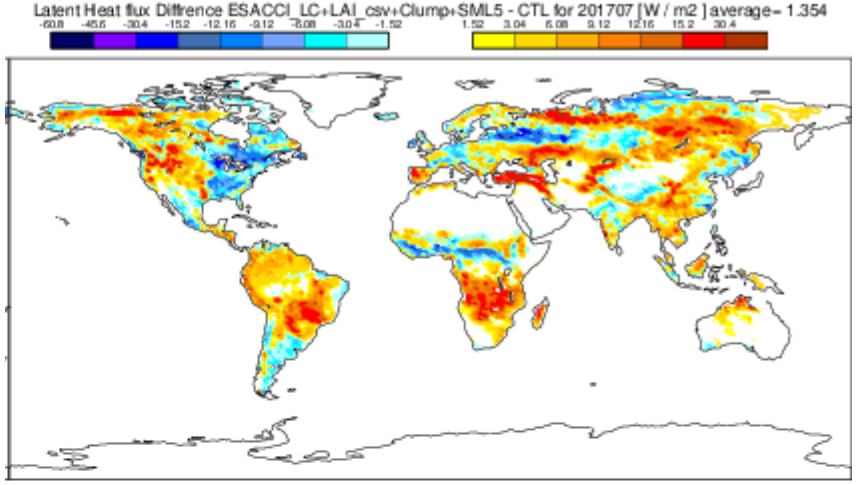
Blue => Reduction in bias
Red => Increase in bias

Forecasts are run at the Tco399 resolution and initialised with the output of corresponding offline runs having the same vegetation configuration

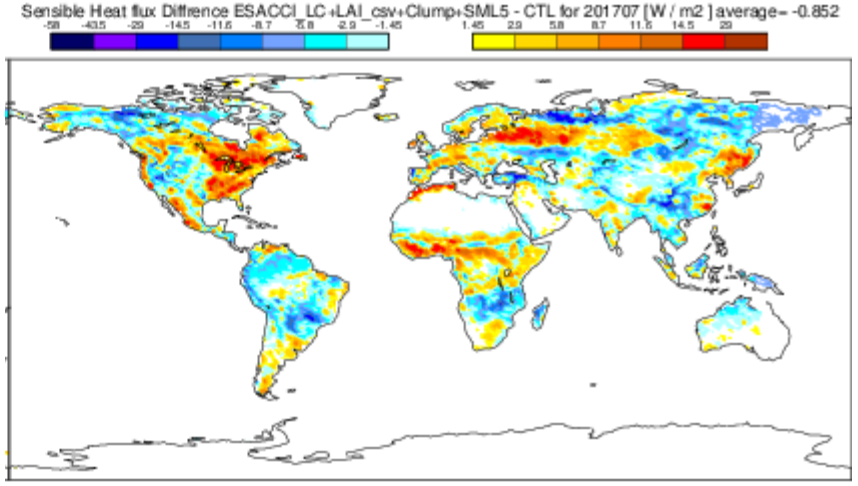
- Temperature bias increased around 10° south and 70° north while humidity bias has decreased => additional parameters optimisation is needed

Impact in Surface offline simulations (ESA-CCI + LAIcsv + Clumping)

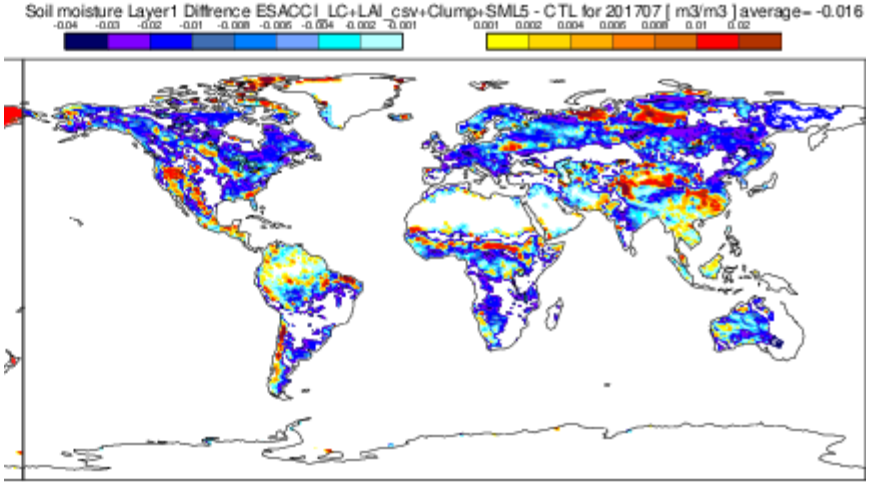
Difference w.r.t control experiment (all simulations forced with ERA5)



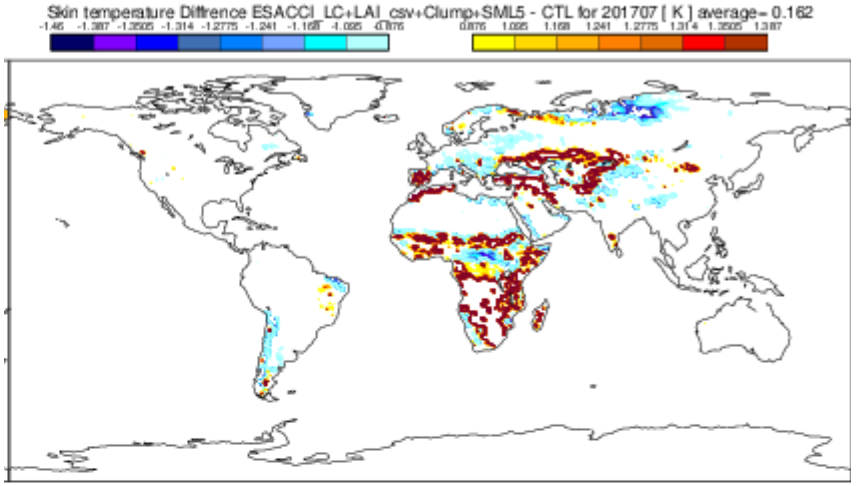
Latent heat flux



Sensible heat flux



Surface soil moisture layer



Skin Temperature

- Combining the ESA-CCI LC + new LAI disaggregation + Seasonal land cover variation based on the clumping results in overall increase of the flux signal as compared with the case without clumping

Summary

- An update of the vegetation status in the ECMWF model is being explored by introducing:
  - ESA-CCI/C3S LC/LU maps
  - Conservative disaggregation operator for the LAI
  - Vegetation cover seasonality based on clumping
- Introducing ESA-CCI LU/LC results in an increase in low vegetation cover at the expense of the high vegetation cover, and allow to get rid of “non pure” vegetation types.
- Combining the ESA-CCI LU/LC with the new LAI disaggregation results in substantial modification of the surface fluxes which is even strengthen when introducing the seasonal land cover variation.
- Initial results in forecast Coupled mode show mixed scores which suggests that model parameters related to the surface and its interaction with the atmosphere (roughness, stomatal resistance, skin conductivity..) would need optimisation/tuning.
- Additional validation is also performed using the satellite LST products (see M. Nogueira presentation in BG3.20)