Impact of GEOV1 NRT LAI and albedo on NWP within the ECMWF system

Souhail Boussetta, Gianpaolo Balsamo, Emanuel Dutra, Anton Beljaars, Alessio Bozzo, Robin Hogan

Why?

- Vegetation was shown to be of critical importance under the NWP framework:
  - Evapotranspiration
  - Boundary layer developement
  - Cloud and precipitation ...

- Vegetation directly affect the global carbon cycle

- LSM has evolved to better represent vegetation and its dynamics

- Satellite observation are becoming more and more available with higher resolution

- ➔ Assimilation of vegetation related observations would allow:

  - to seek eventual improvement in the near surface atmosphere.
  - to understand and adjust process developement within LSM
  - to better monitor the actual vegetation status and its dynamics
  - To better represent land biogenic fluxes

The data:

The GEOV1 LAI/albedo product is based on observations from the VEGETATION sensor on board of SPOT satellite. ➔ Global coverage with 1km resolution and 10 day temporal resolution

Produced in the framework of the Copernicus Initial Operation and ***Freely available***.

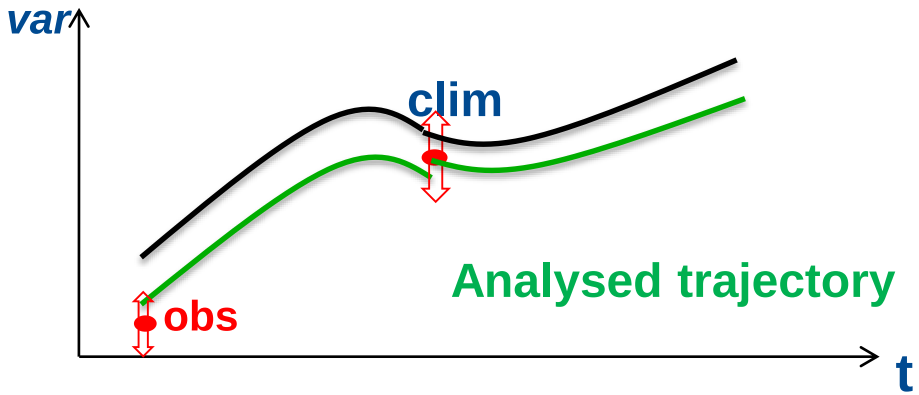
The model:

The ECMWF LSM (CTESSEL) coupled within the Integrated Forecasting system IFS

The analysis system:

The analysis procedure is an optimal combination of the satellite observations and derived climatology, depending on their associated errors σo and σc.

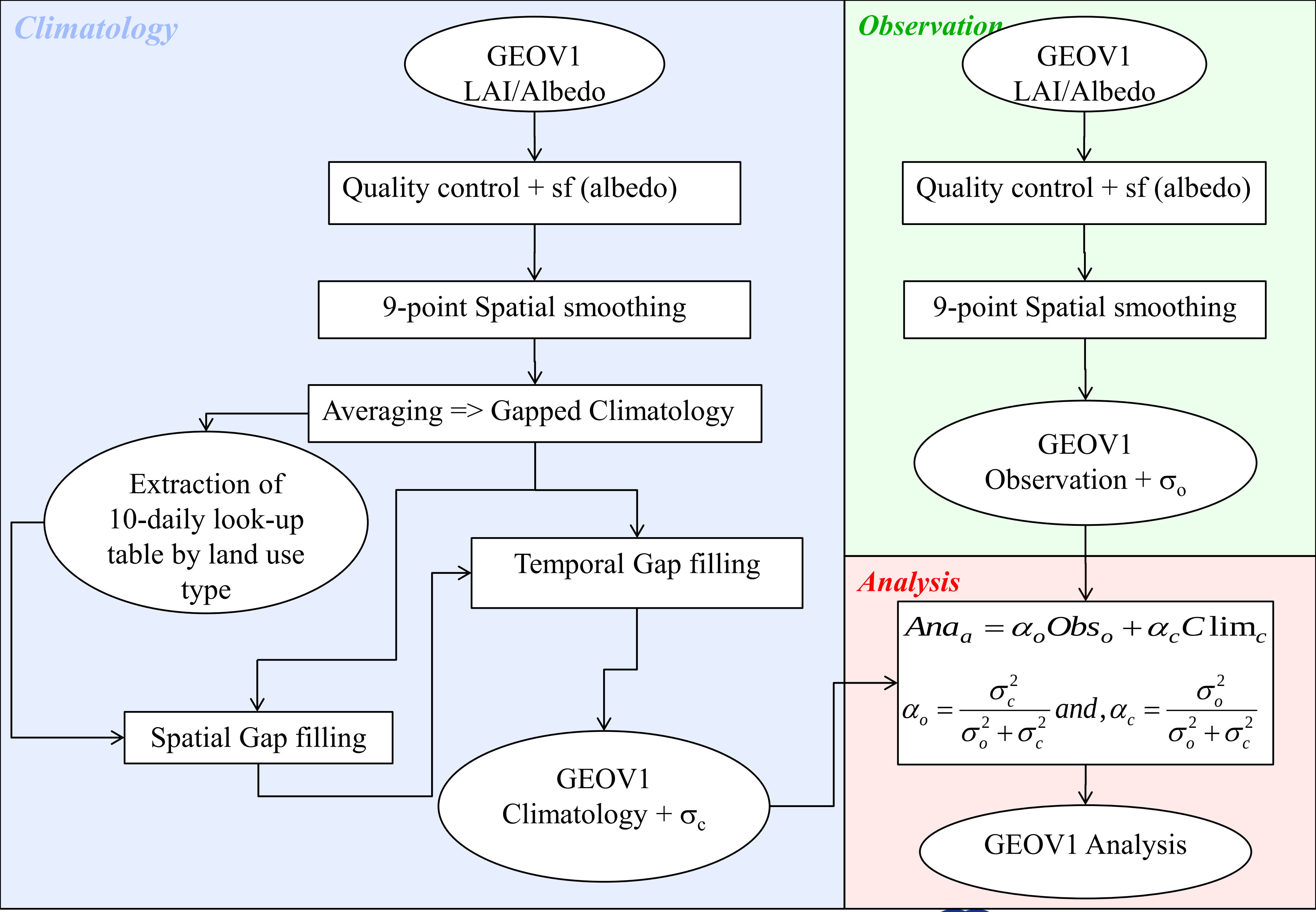
➔ Suitable for NWP framework and consistent with actual method used for slow evolving variables.



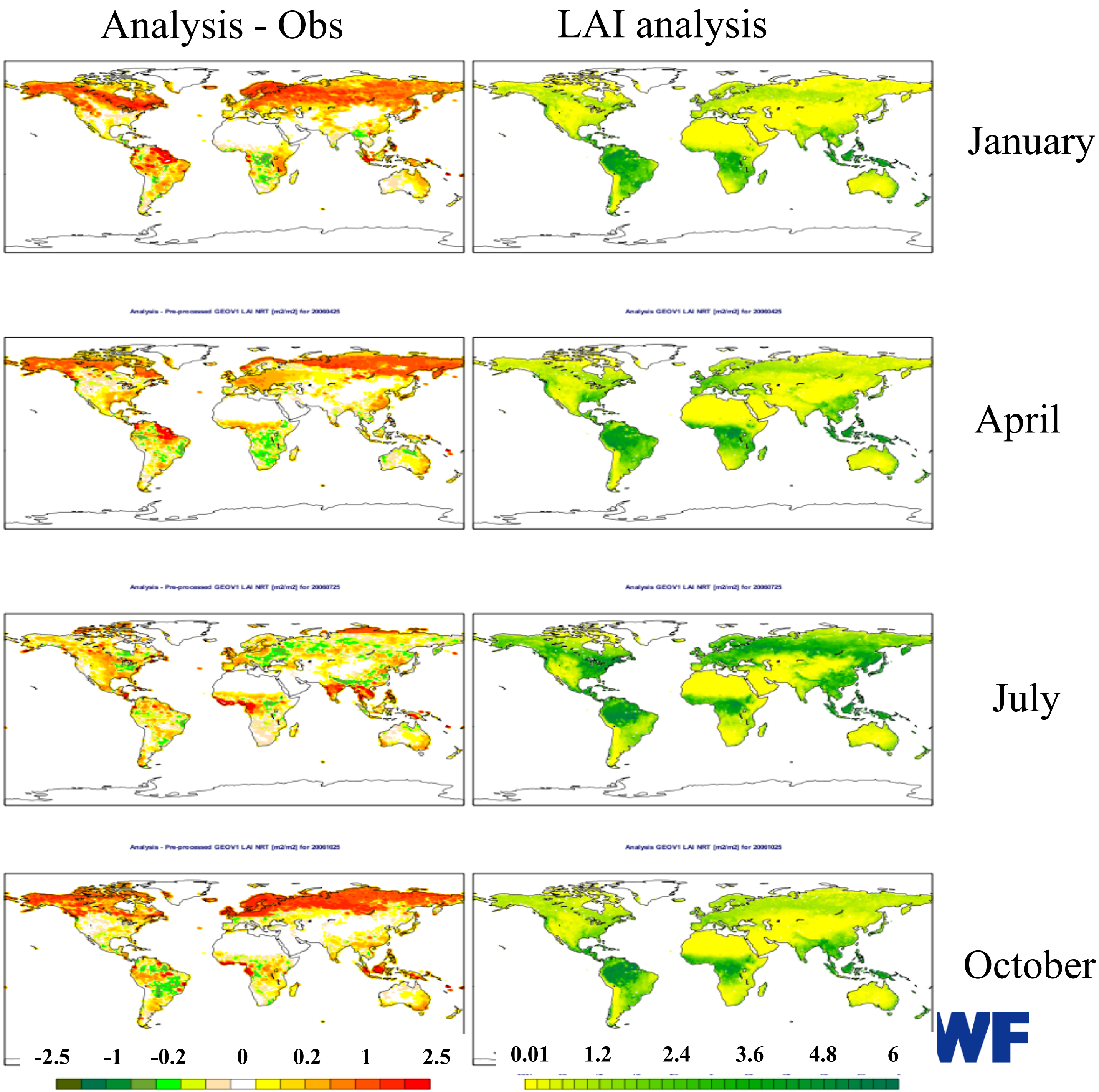
$$\mathrm{var}_a = \alpha_o \, \mathrm{var}_o + \alpha_c \, \mathrm{var}_c$$

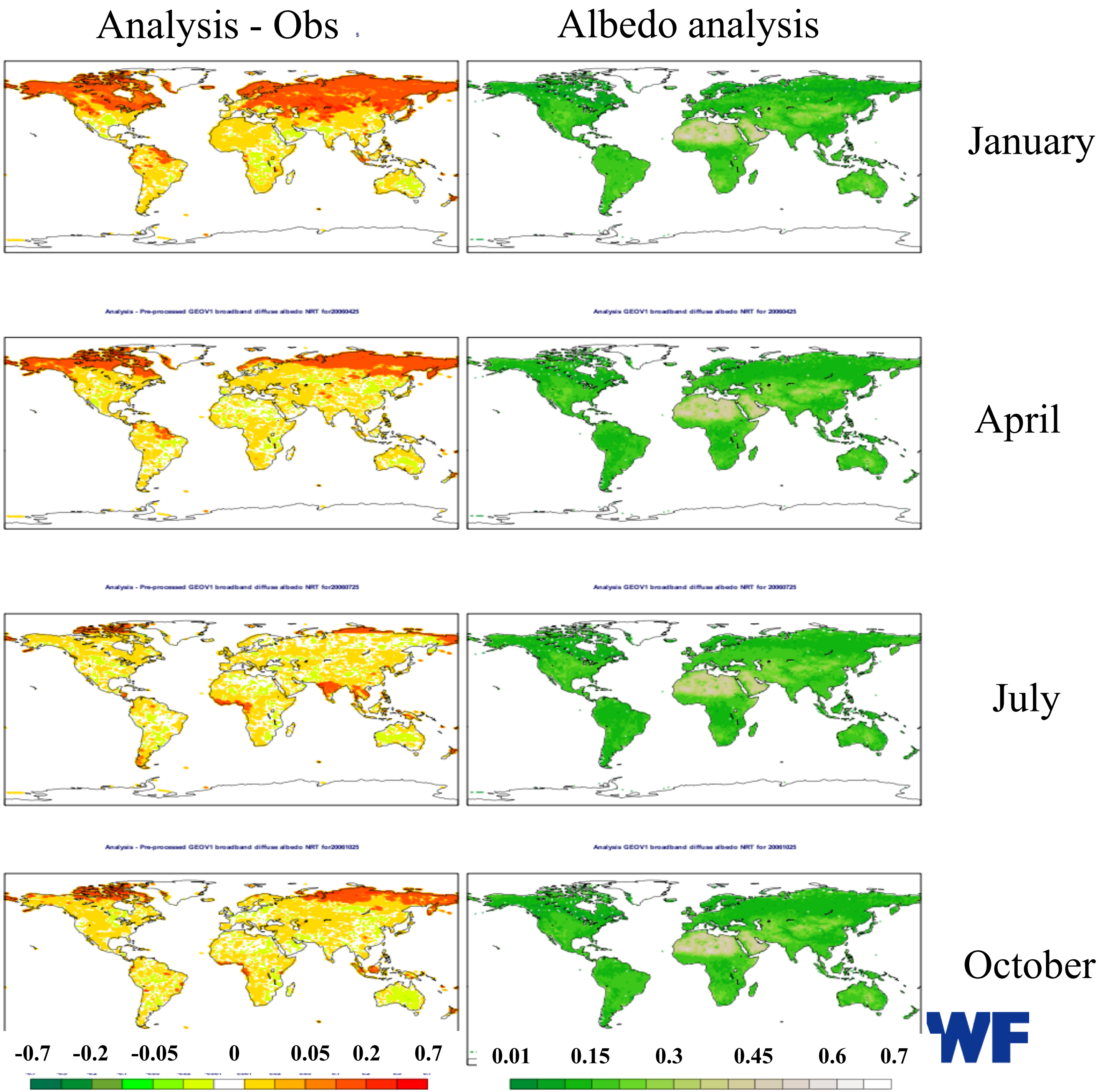
where

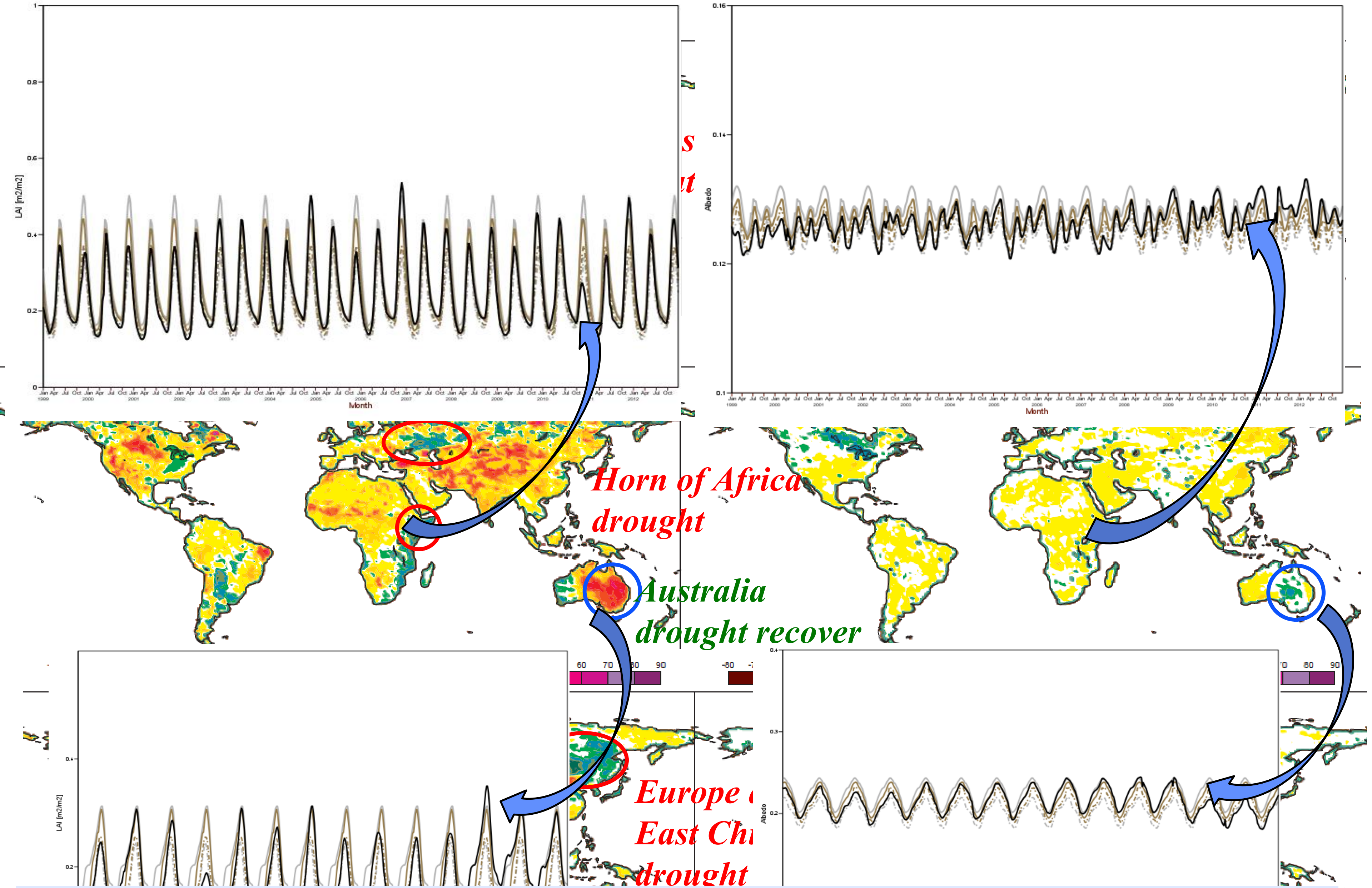
$$\alpha_o = \frac{\sigma_c^2}{\sigma_o^2 + \sigma_c^2} \; and, \alpha_c = \frac{\sigma_o^2}{\sigma_o^2 + \sigma_c^2}$$


Climatology
Observation
Analysis
GEOV1 LAI/Albedo
Quality control + sf (albedo)
9-point Spatial smoothing
Averaging => Gapped Climatology
Extraction of 10-daily look-up table by land use type
Temporal Gap filling
Spatial Gap filling
GEOV1 Climatology + σ_c
GEOV1 LAI/Albedo
Quality control + sf (albedo)
9-point Spatial smoothing
GEOV1 Observation + σ_o
$Ana_a = \alpha_o Obs_o + \alpha_c Clim_c$
$\alpha_o = \frac{\sigma_c^2}{\sigma_o^2 + \sigma_c^2} and, \alpha_c = \frac{\sigma_o^2}{\sigma_o^2 + \sigma_c^2}$
GEOV1 Analysis

ECMWF


Analysis - Obs
LAI analysis
January
Analysis - Pre-processed GEOV1 LAI NRT [m2/m2] for 20060425
Analysis GEOV1 LAI NRT [m2/m2] for 20060425
April
Analysis - Pre-processed GEOV1 LAI NRT [m2/m2] for 20060725
Analysis GEOV1 LAI NRT [m2/m2] for 20060725
July
Analysis - Pre-processed GEOV1 LAI NRT [m2/m2] for 20061025
Analysis GEOV1 LAI NRT [m2/m2] for 20061025
October
-2.5 -1 -0.2 0 0.2 1 2.5
0.01 1.2 2.4 3.6 4.8 6

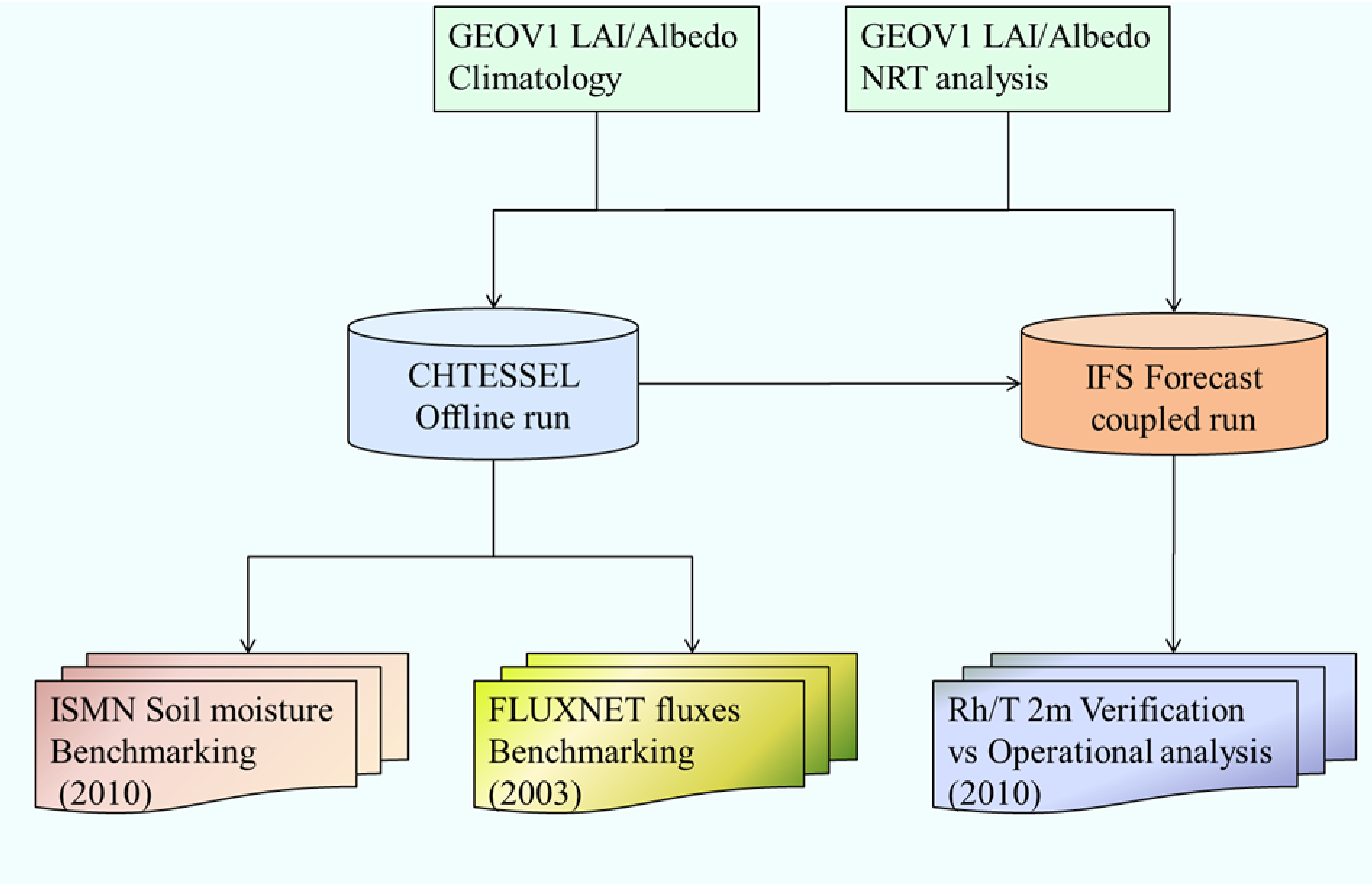

Analysis - Obs
Albedo analysis
January
Analysis - Pre-processed GEOV1 broadband diffuse albedo NRT for20060425
Analysis GEOV1 broadband diffuse albedo NRT for 20060425
April
Analysis - Pre-processed GEOV1 broadband diffuse albedo NRT for20060725
Analysis GEOV1 broadband diffuse albedo NRT for 20060725
July
Analysis - Pre-processed GEOV1 broadband diffuse albedo NRT for20061025
Analysis GEOV1 broadband diffuse albedo NRT for 20061025
October
-0.7 -0.2 -0.05 0 0.05 0.2 0.7
0.01 0.15 0.3 0.45 0.6 0.7



➔ NRT analysed LAI is able to fairly detect/monitor anomalous year

➔ The analysed LAI and albedo signal can be covariant mainly during wet year.

Impact evaluation procedure



The offline surface simulation setup:

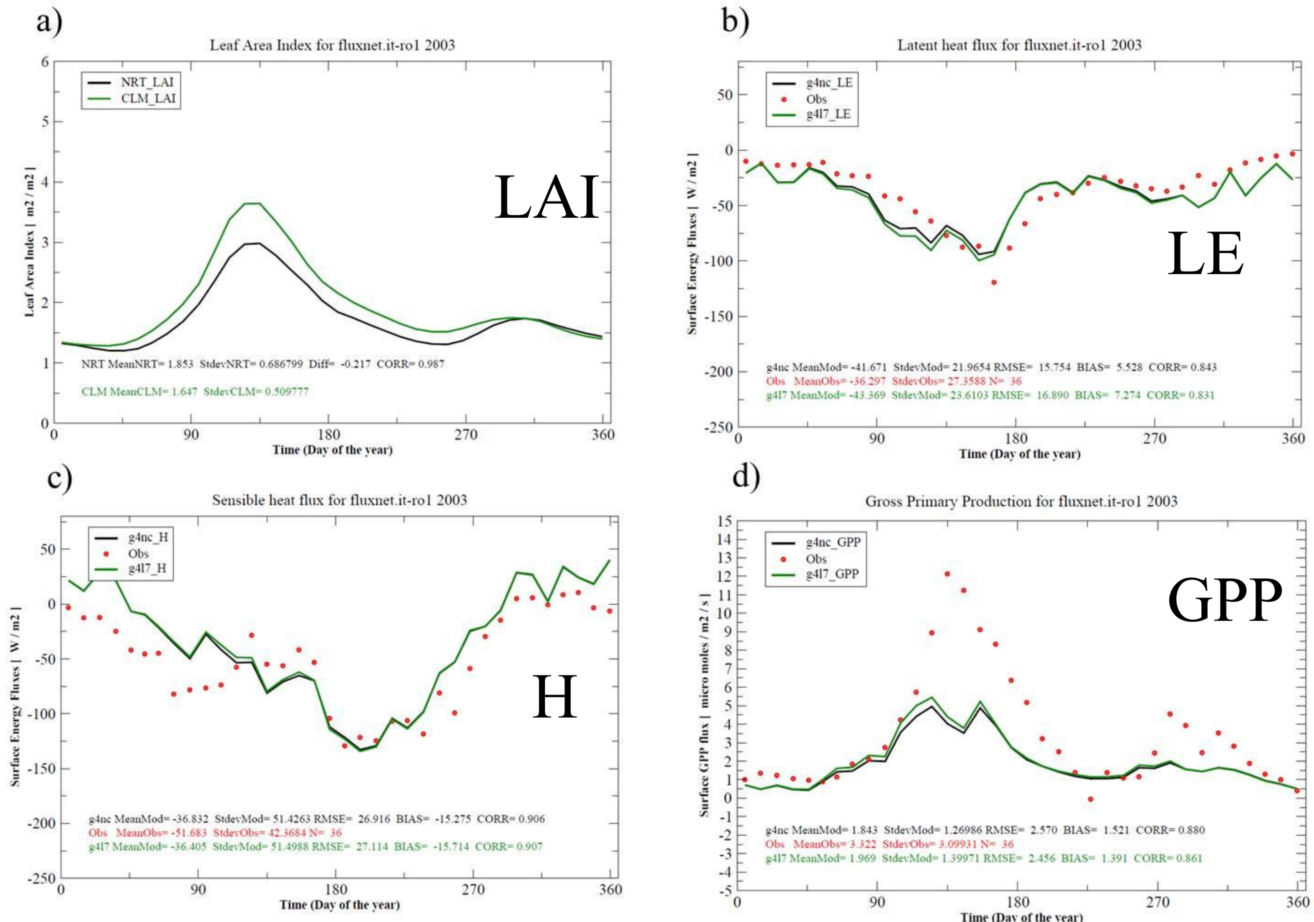
To seek the impact of the NRT analysed data four experiments are performed

Period: 1999 – 2012
Coverage: Global
Spatial resolution: T511 (~40km)

- Control: LAI+albedo climatology are used
- NRT_ALB_LAI: LAI nrt data + albedo nrt
- NRT_LAI: LAI nrt data + albedo climatology
- NRT_ALB: LAI climatology + albedo nrt

ECMWF

Flux Benchmarking



Fluxes evaluation against FLUXNET network (55 sites) for 2003

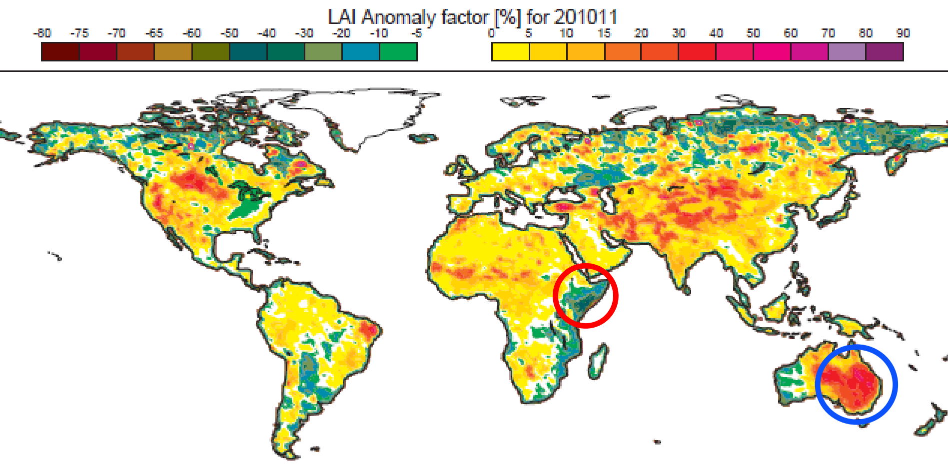
Flux	SCLIM			SLAINRT			SNRT		
	RMS	Bias	R	RMS	Bias	R	RMS	Bias	R
LE [W/m²]	20.958	10.403	0.850	20.648	9.583	0.850	20.680	9.626	0.849
H [W/m²]	20.323	-1.641	0.743	20.396	-1.771	0.739	20.506	-1.259	0.741
GPP [µml/m²/s]	2.065	0.797	0.818	2.117	0.879	0.824	2.119	0.880	0.824

Soil moisture Benchmarking

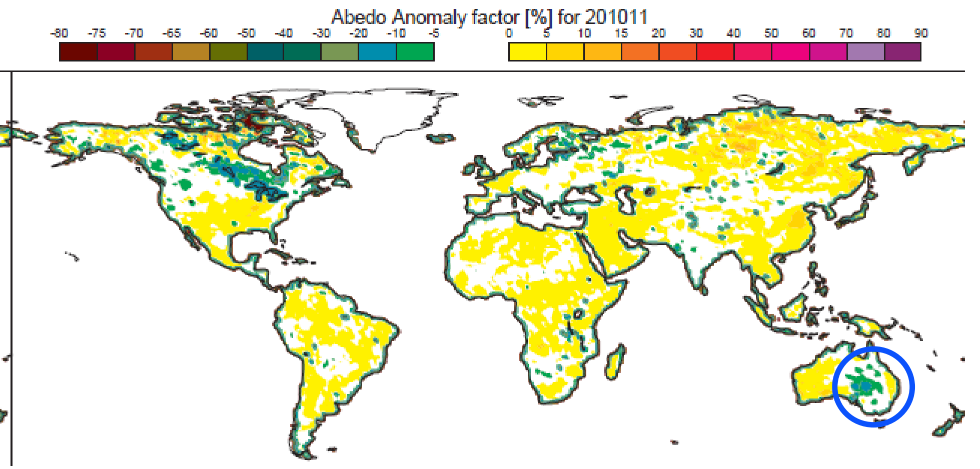
Network/Exp	SCLIM			SLAINRT			SNRT		
	R	RMS	Bias	R	RMS	Bias	R	RMS	Bias
AMMA	0.638	0.072	-0.056	0.642	0.073	-0.057	0.643	0.074	-0.057
SNOTEL	0.475	0.145	-0.076	0.479	0.145	-0.076	0.480	0.145	-0.076
SCAN	0.596	0.144	-0.079	0.599	0.143	-0.080	0.599	0.143	-0.080
Rhemedus	0.690	0.190	-0.170	0.690	0.190	-0.170	0.690	0.190	-0.170
Smosmania	0.840	0.093	-0.050	0.839	0.093	-0.050	0.839	0.094	-0.050
Oznet	0.774	0.146	-0.130	0.768	0.146	-0.130	0.768	0.146	-0.130
Umbria	0.799	0.137	-0.131	0.803	0.136	-0.131	0.803	0.136	-0.131
Vas	0.694	0.175	-0.168	0.703	0.171	-0.164	0.704	0.171	-0.164
Average	**0.688**	**0.138**	**-0.108**	**0.690**	**0.137**	**-0.107**	**0.691**	**0.137**	**-0.107**

Soil moisture evaluation against ISMN networks (523 sites) for 2010

Horn of Africa drought & Australia drought recover

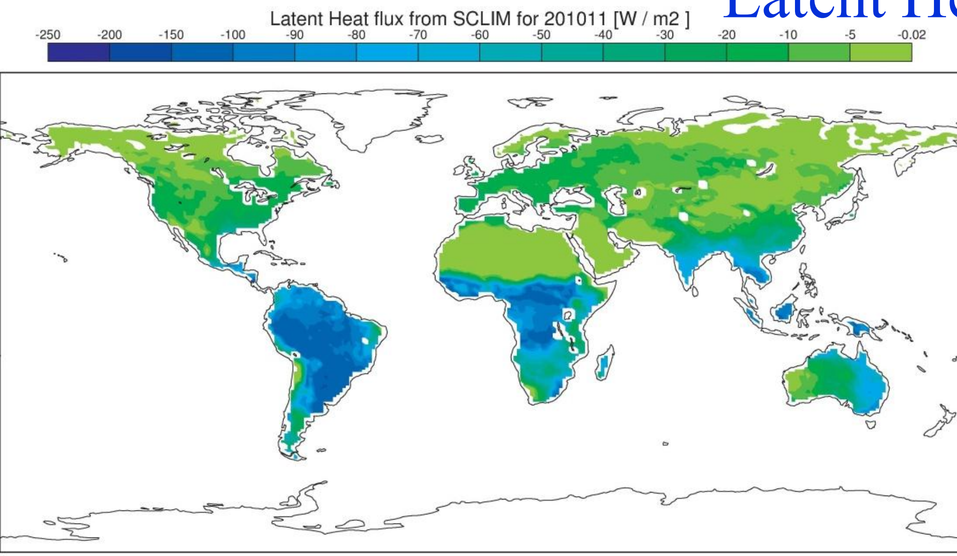


LAI anomaly

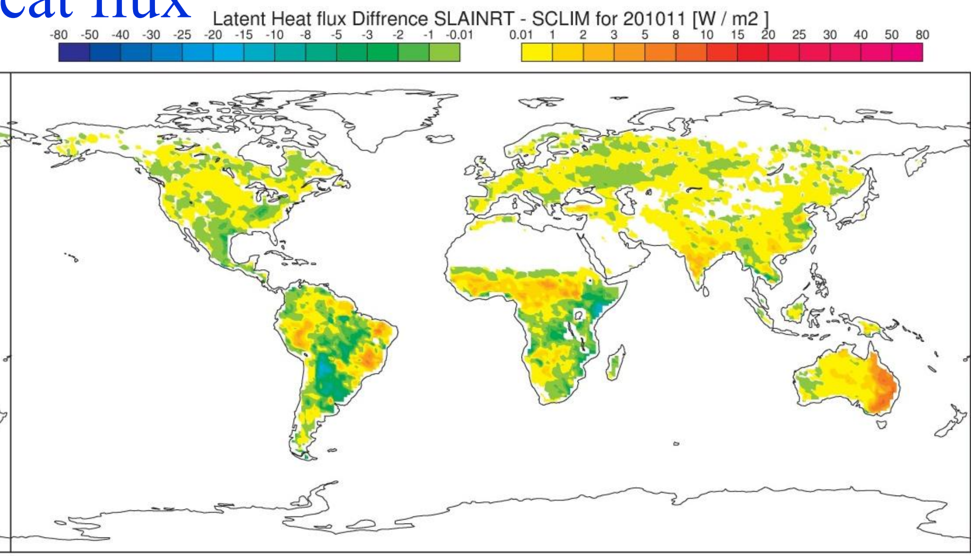


Albedo anomaly

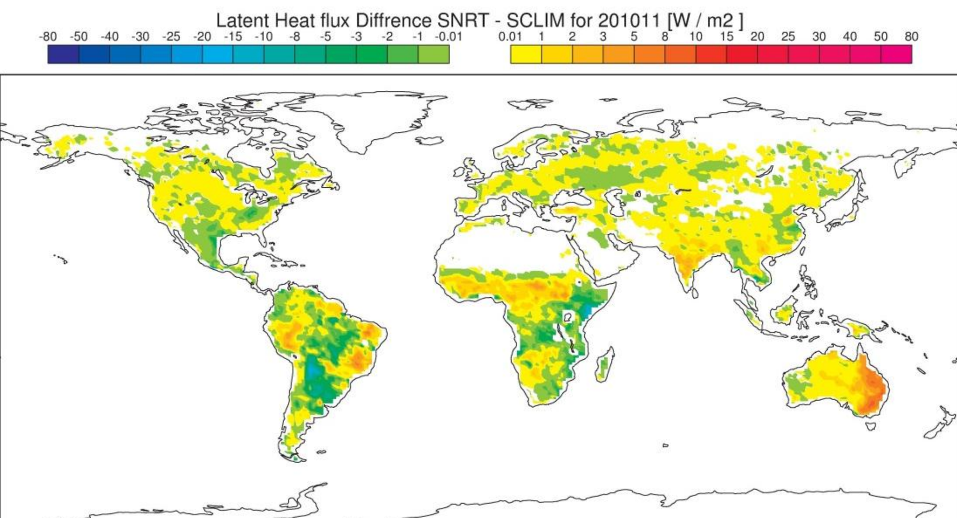
Latent Heat flux



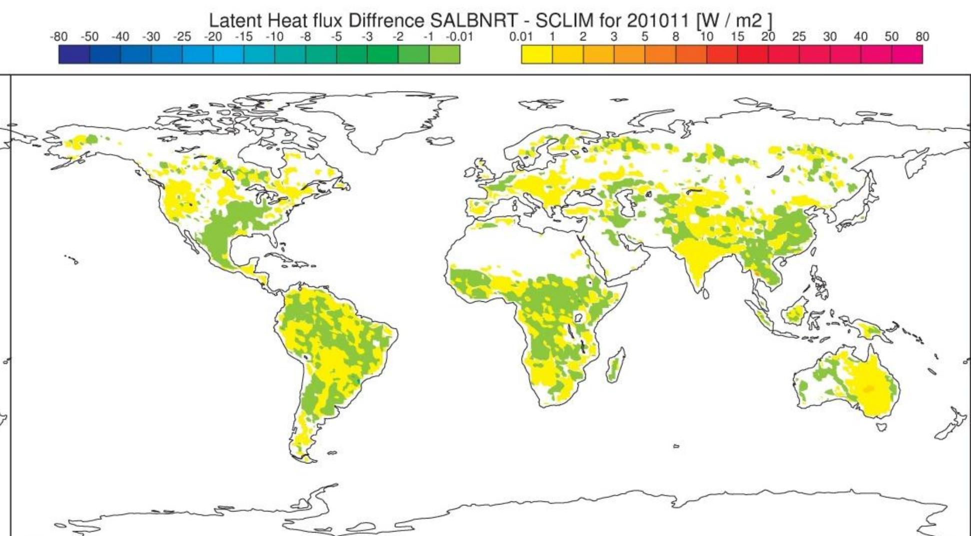
Clim



NRT_LAI - Clim



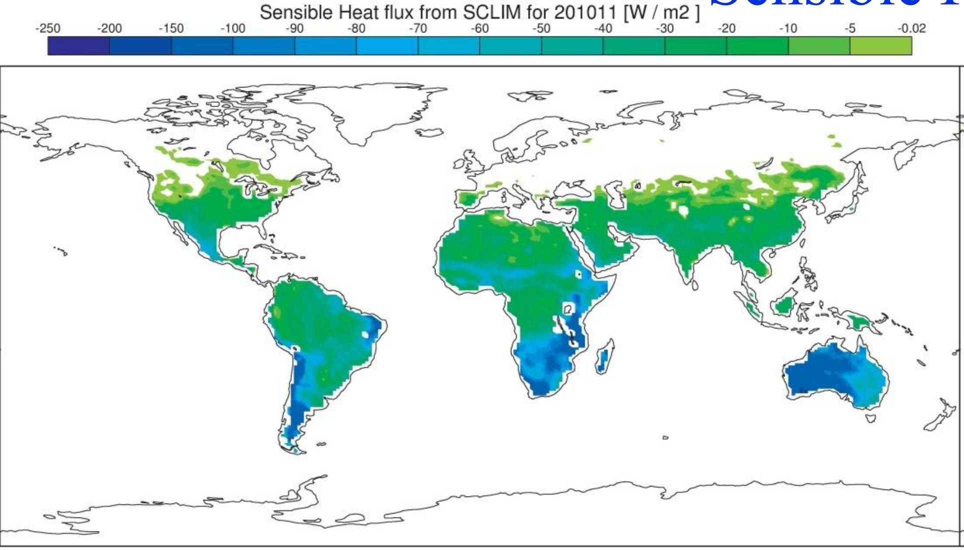
NRT_ALB_LAI - Clim



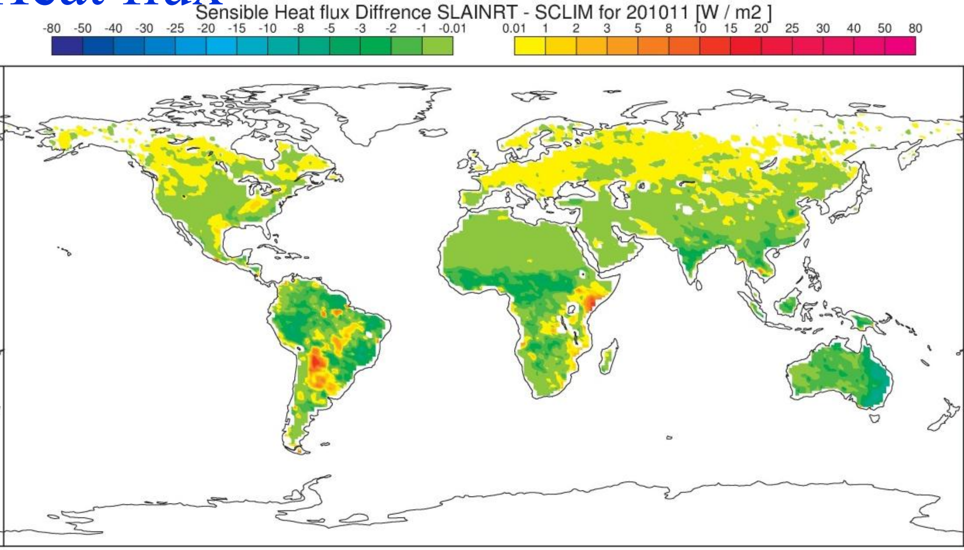
NRT_ALB - Clim

ECMWF

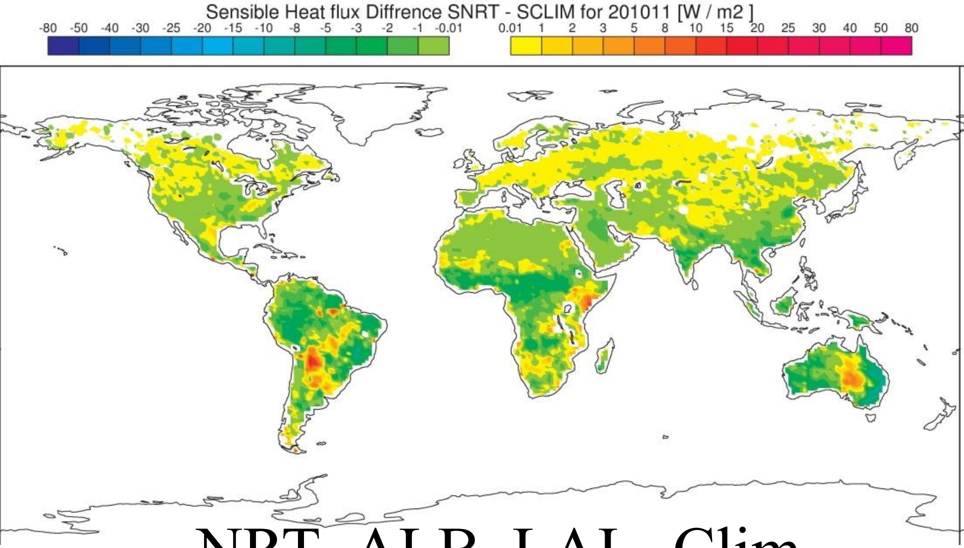
Sensible Heat flux



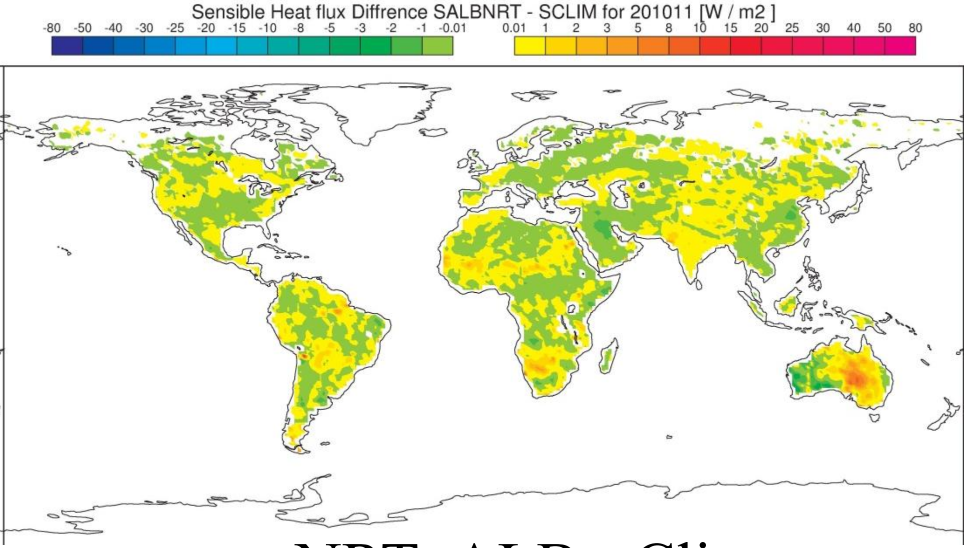
Clim



NRT_LAI - Clim



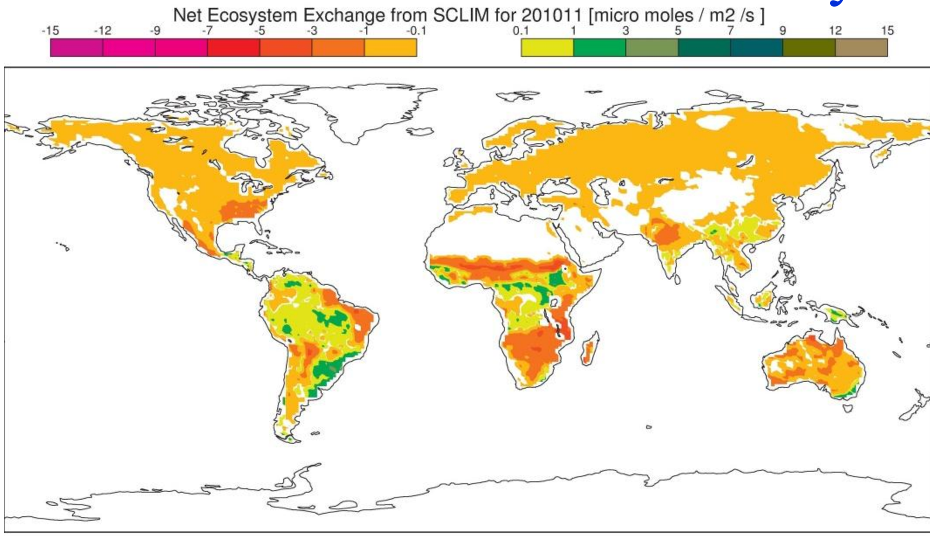
NRT_ALB_LAI - Clim



NRT_ALB - Clim

ECMWF

Net Ecosystem Exchange



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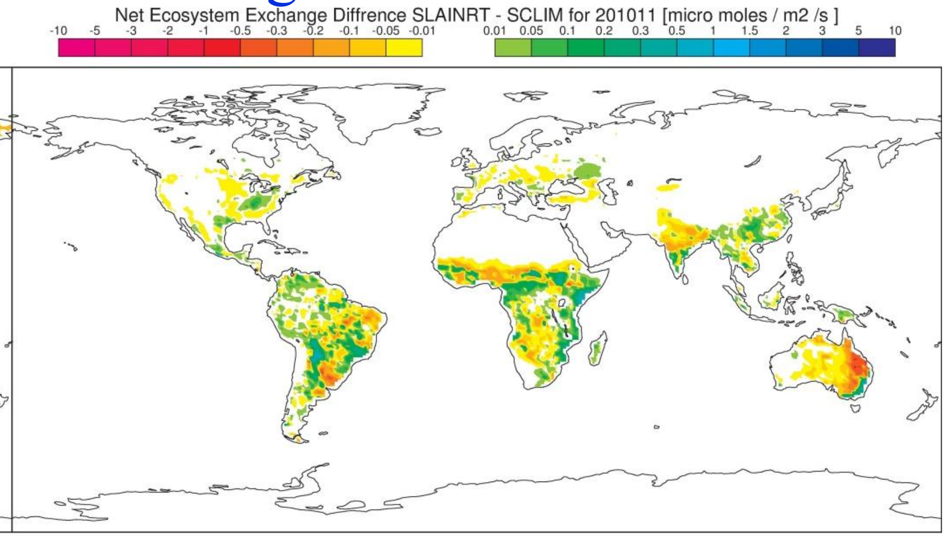
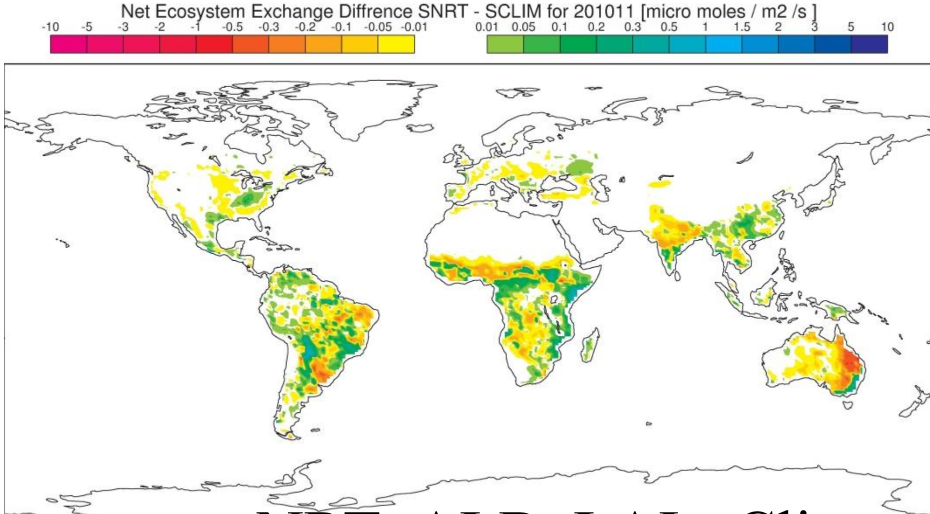
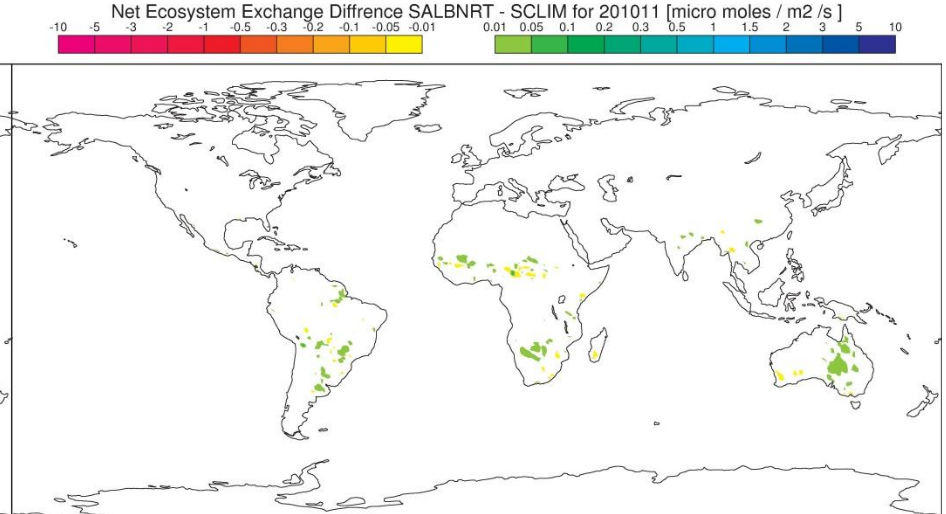


NRT_LAI - Clim



NRT_ALB_LAI - Clim



NRT_ALB - Clim

ECMWF

Coupled experiments

Setup:

- Daily 3 days forecasts in 2010

- 4 experiments with T511 spatial resolution and initialised from the corresponding offline run (to avoid spin-up issues)

* Control	CLIM
* NRT LAI	NRT_LAI
* NRT albedo	NRT_ALB
* NRT LAI+albedo	NRT_ALB_LAI

➔Check the T 2m and RH on short term forecast fc+36 valid 12 UTC

Sensitivity = (exp –ctl),

if >0 => warming/adding moisture,

if <0 => cooling/removing moisture

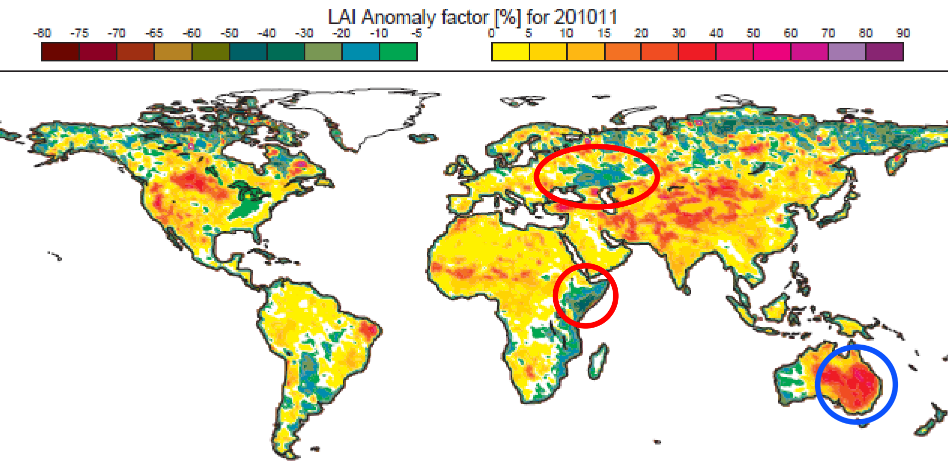
And

Impact = |ctl – analysis| - |exp – analysis| ,

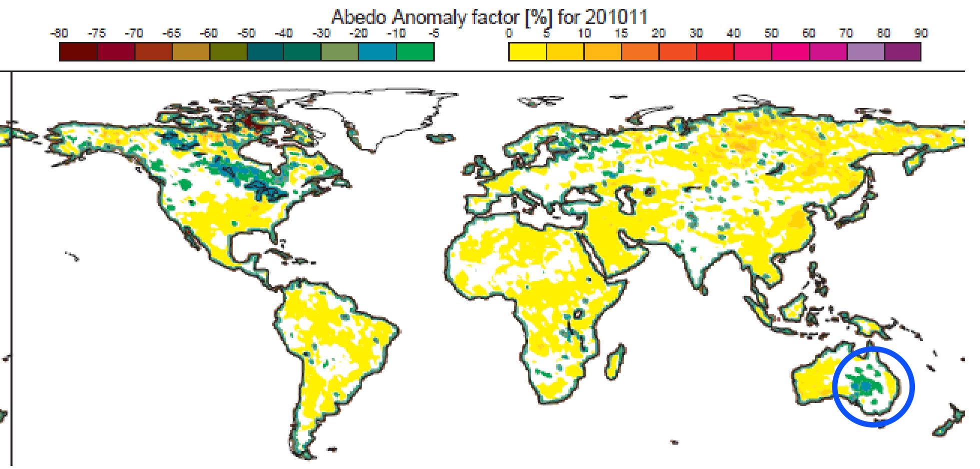
if >0 => relative error reduction from the analysis (positive impact)

if <0 => relative error increase from the analysis (negative impact)

Horn of Africa drought & Australia drought recover

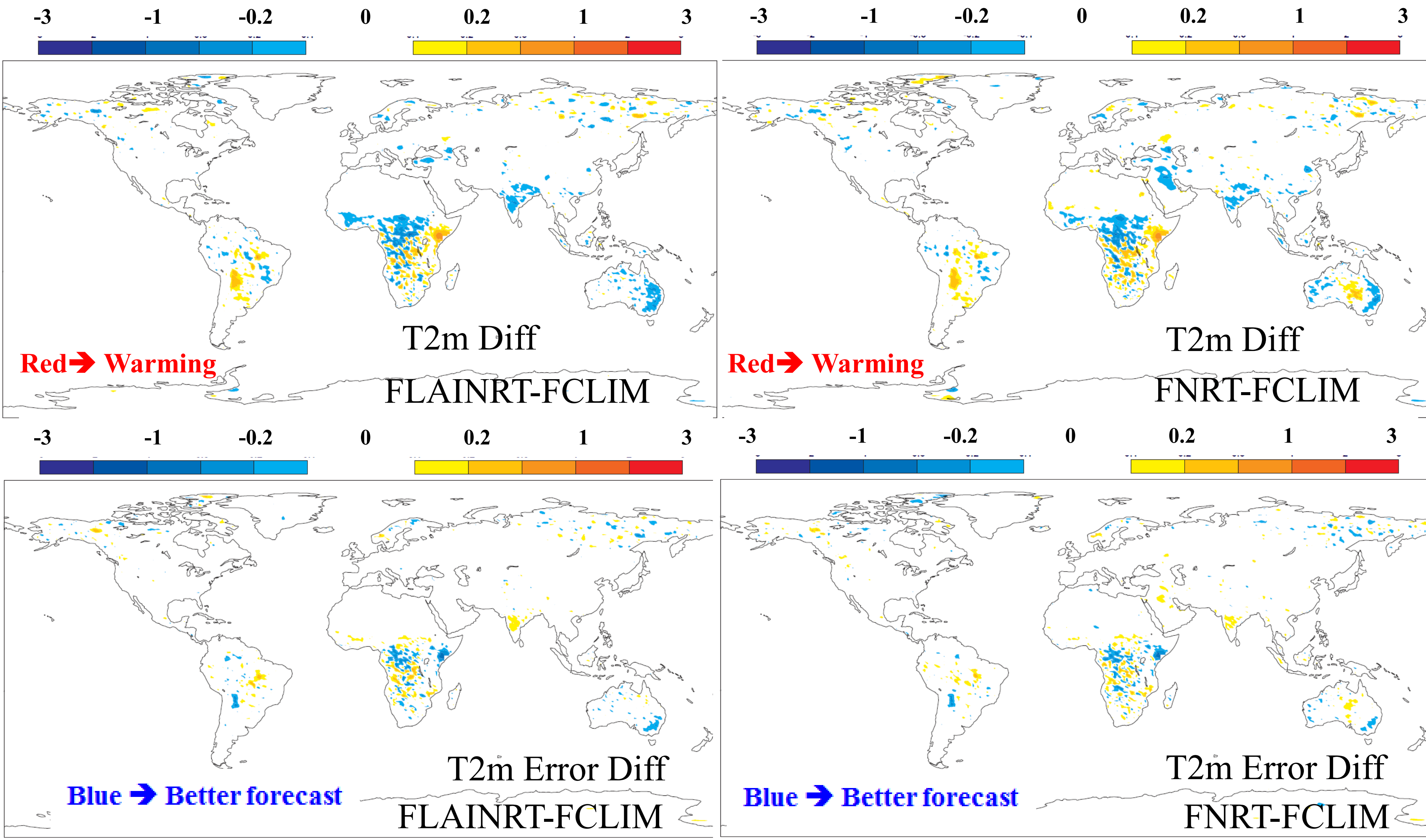


LAI anomaly

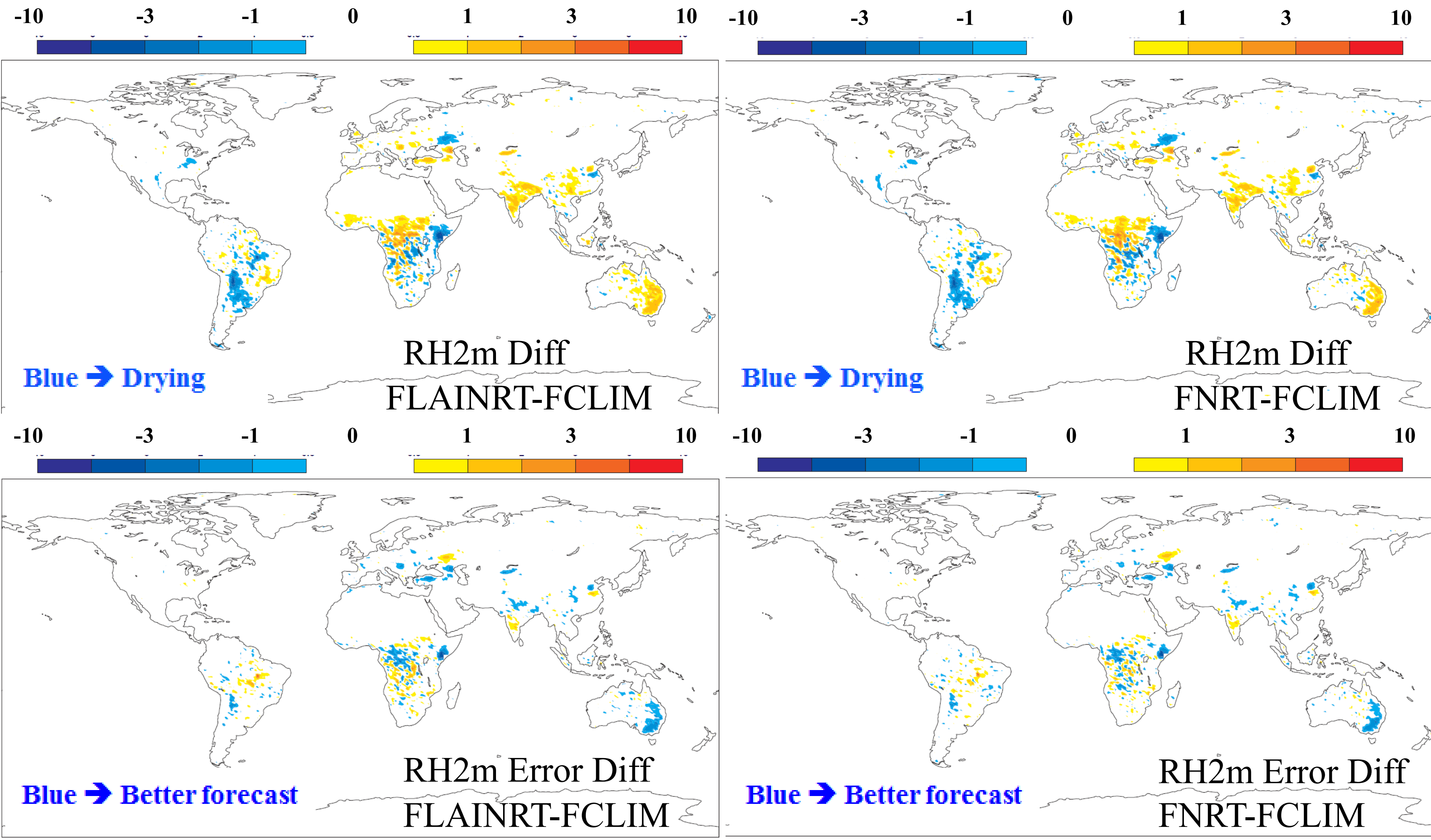


Albedo anomaly

2m temperature sensitivity (coupled)



2m humidity sensitivity (coupled)



ECMWF

Conclusions

- The analysis process resulted in products with smooth temporal evolution, which makes them more appropriate for environmental prediction than the original data.

The impact of assimilating LAI/Albedo products within the ECMWF system shows that:

- The NRT assimilation enables to detect/monitor extreme climate conditions where LAI anomaly could reach more than 50% and albedo anomaly of 10% (e.g. in wet years).
- The analysed NRT albedo signal can be covariant with the NRT LAI mainly during wet year despite the compensation effect that may occur between vegetation and bare-ground albedo.

- Extreme NRT LAI anomalies have a strong impact on the surface fluxes, larger than the albedo anomalies. Neutral to slightly better agreement with in-situ surface soil moisture (from ISMN) and surface energy and CO_2 fluxes (from FLUXNET) is obtained.

- In forecast coupled run, the assimilation of NRT LAI is shown to reduce the near-surface air temperature and humidity errors both in wet and dry cases while NRT albedo has a reduced impact and mainly in wet cases (when albedo anomalies are more pronounced).

Acknowledgements to:

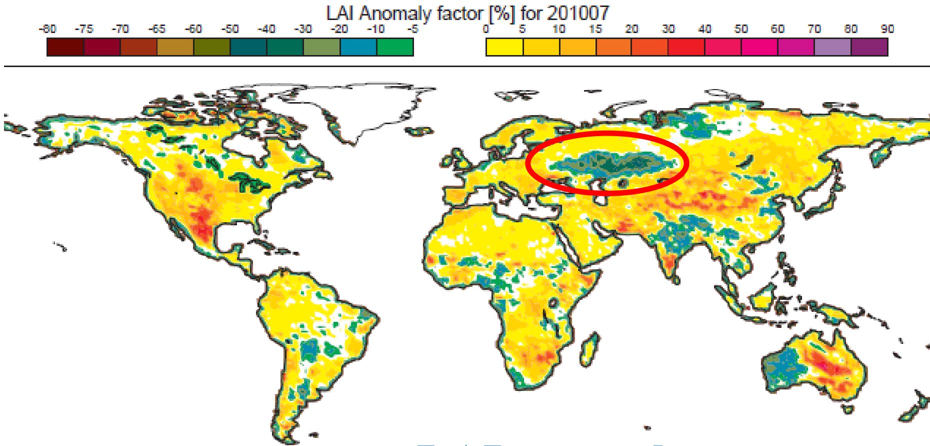
Clement Albergel, Patricia de Rosnay, Roselyne Lacaze, Fred Baret, J. J. Calvet and all the data providers from FLUXNET, and the ISMN

Thank you for your attention

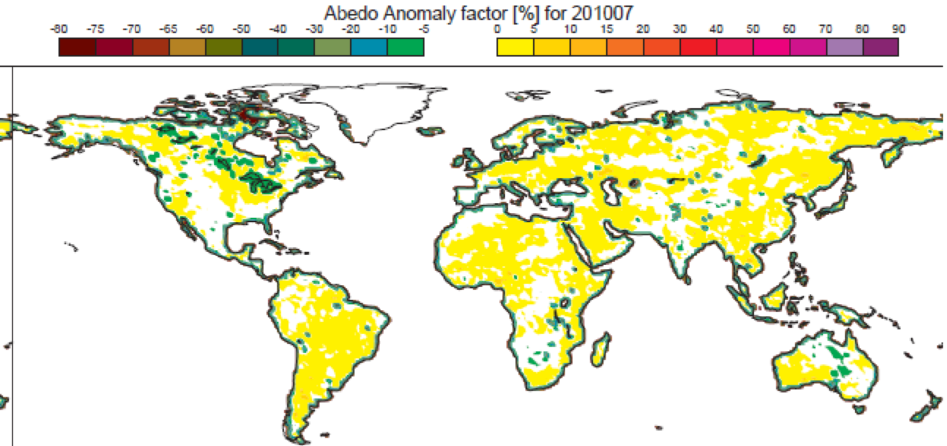
http://fp7-imagines.eu/

Contact: souhail.boussetta@ecmwf.int

2010 Russian Heat wave

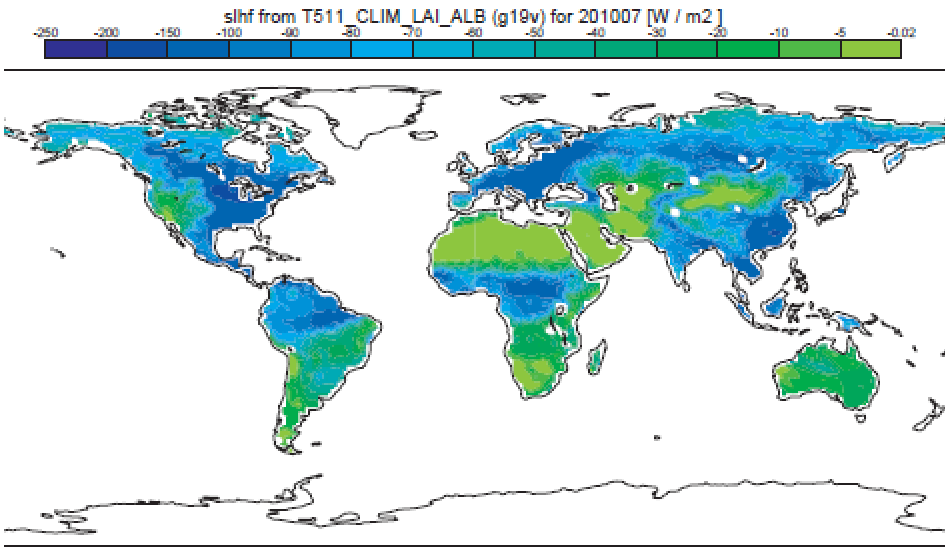


LAI anomaly

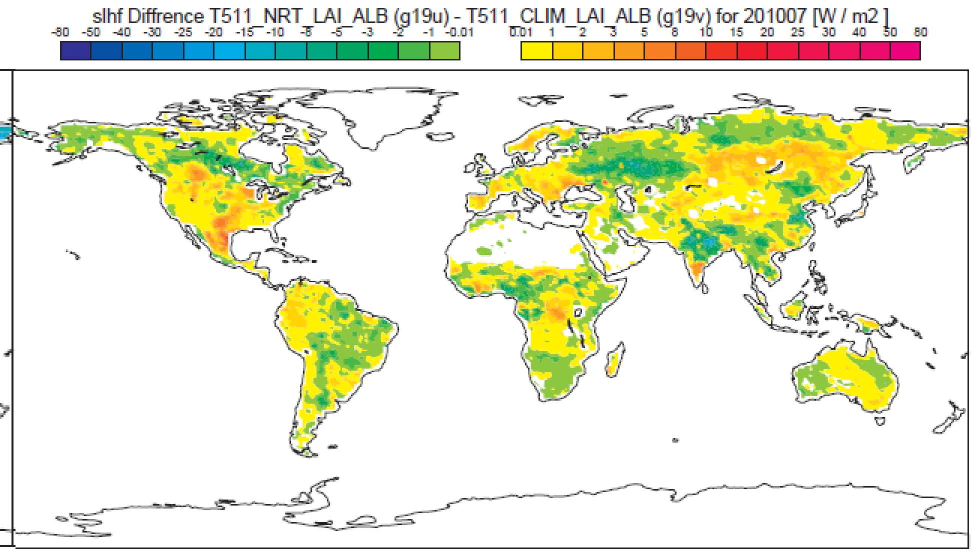


Albedo anomaly

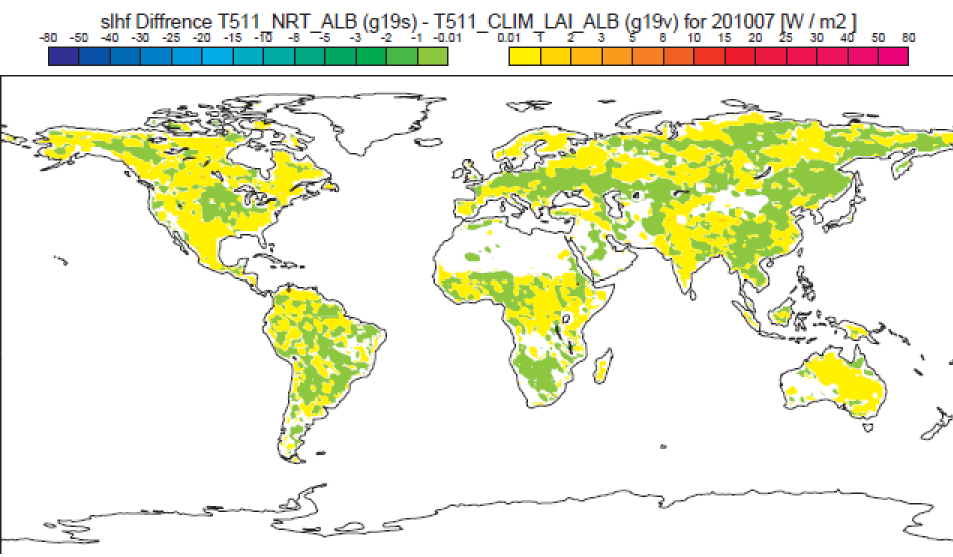
Latent Heat flux



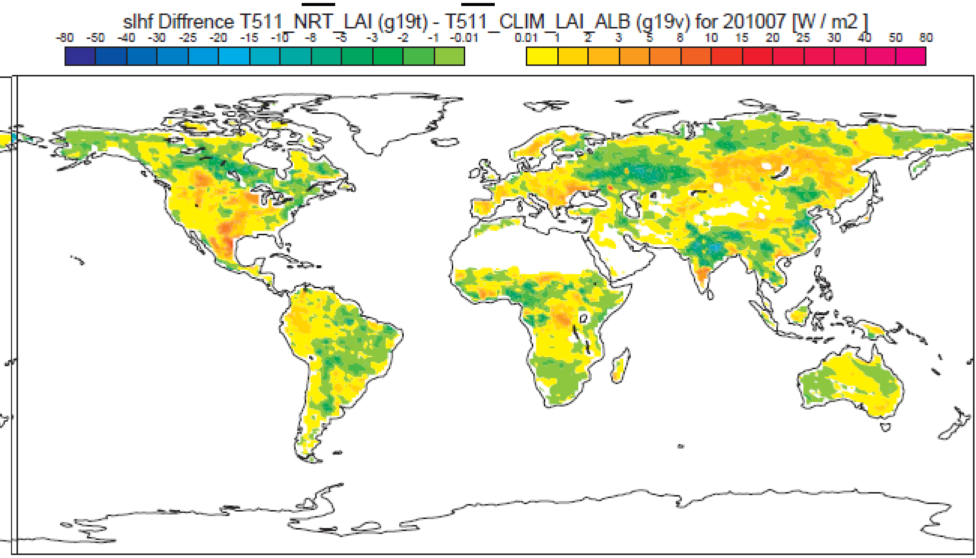
Clim



NRT_ALB_LAI - Clim

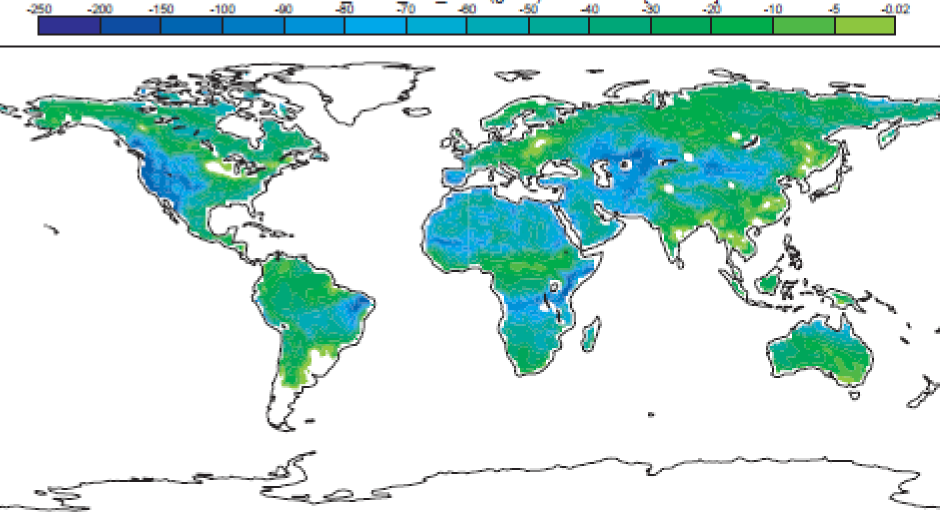


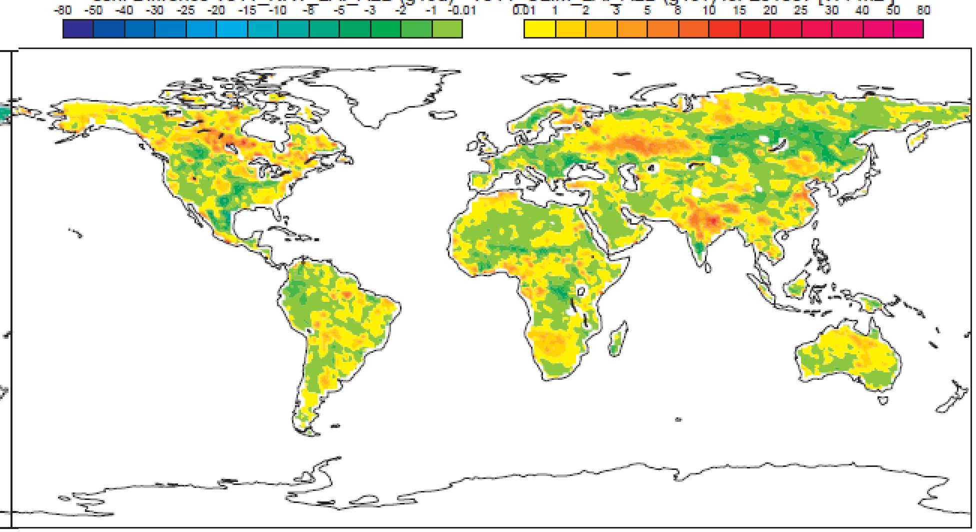
NRT_ALB - Clim



NRT_LAI - Clim

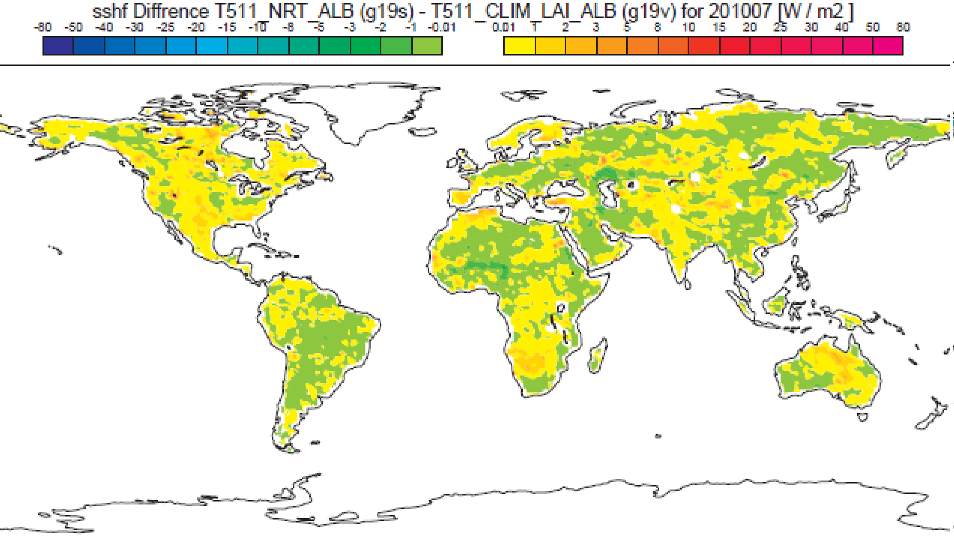
Sensible Heat flux

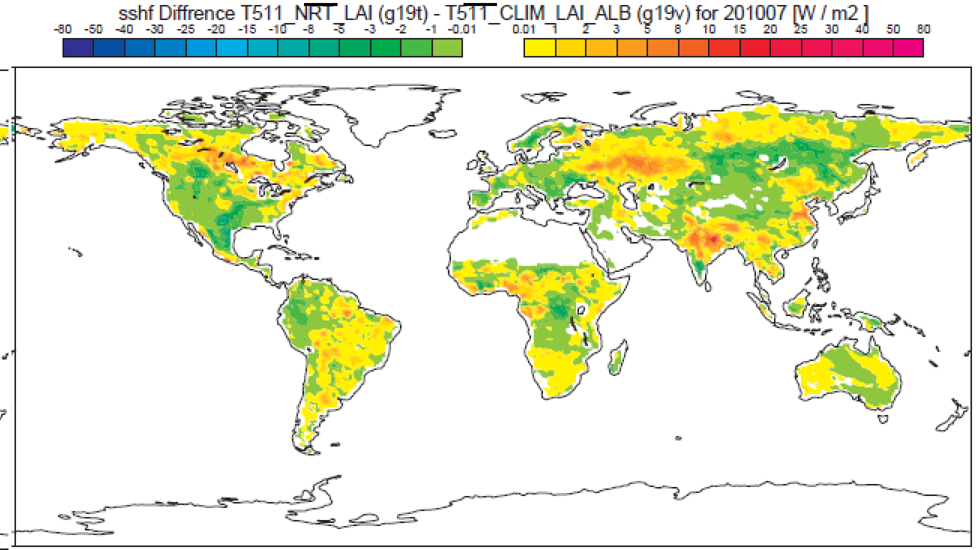




Clim

NRT_ALB_LAI - Clim



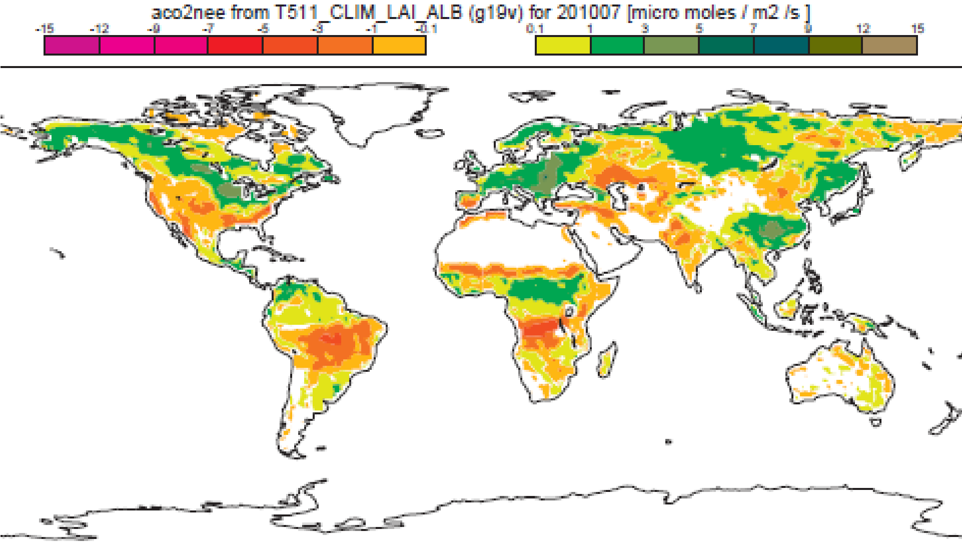


NRT_ALB - Clim

NRT_LAI - Clim

ECMWF

Net Ecosystem Exchange



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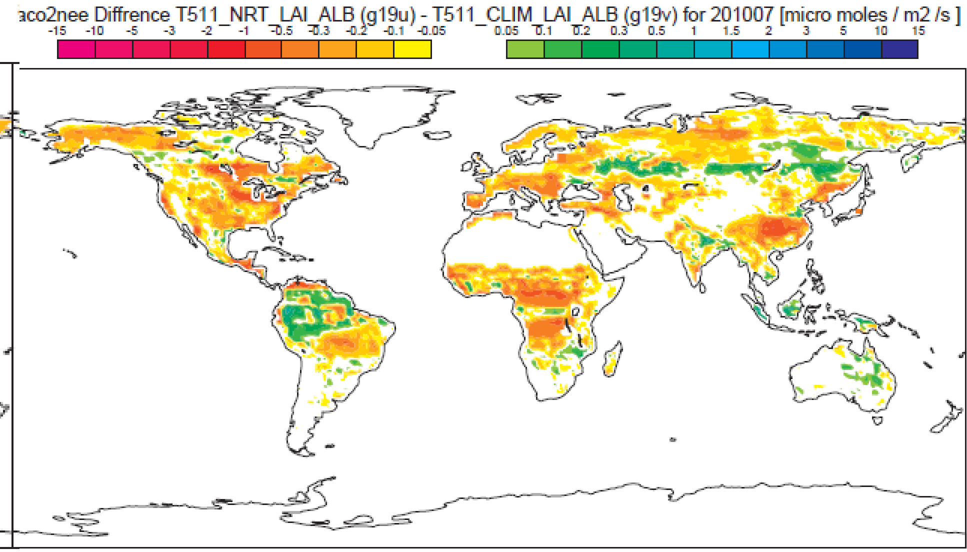
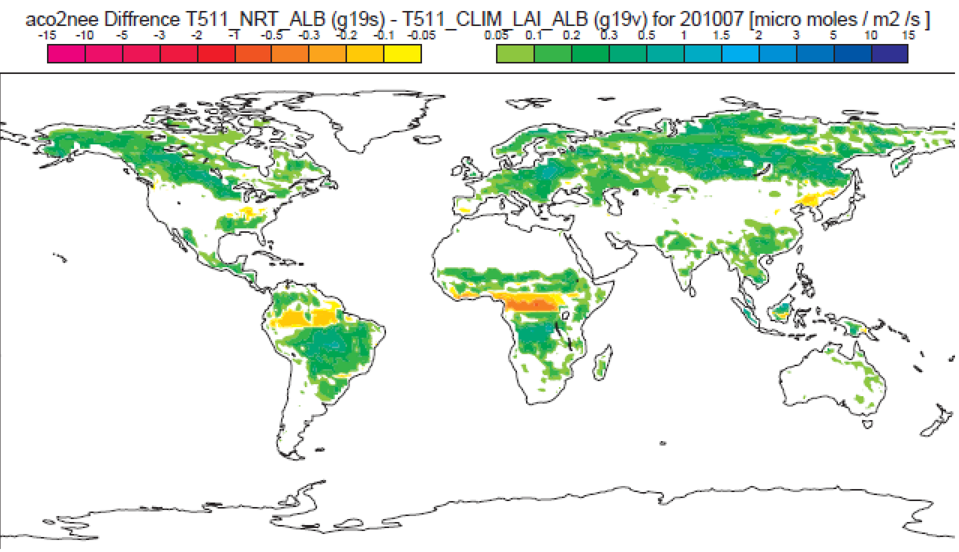
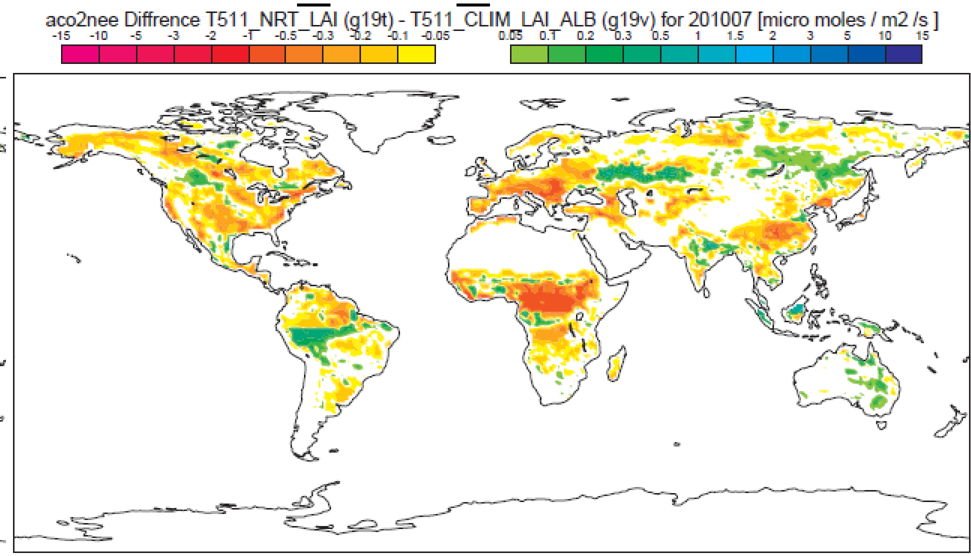


NRT_ALB_LAI - Clim



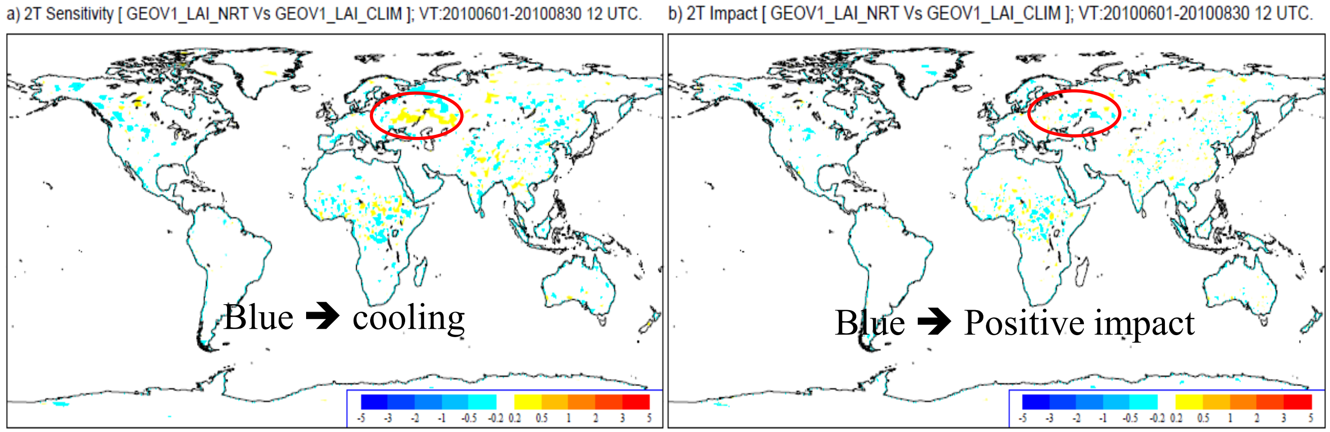
NRT_ALB - Clim



NRT_LAI - Clim

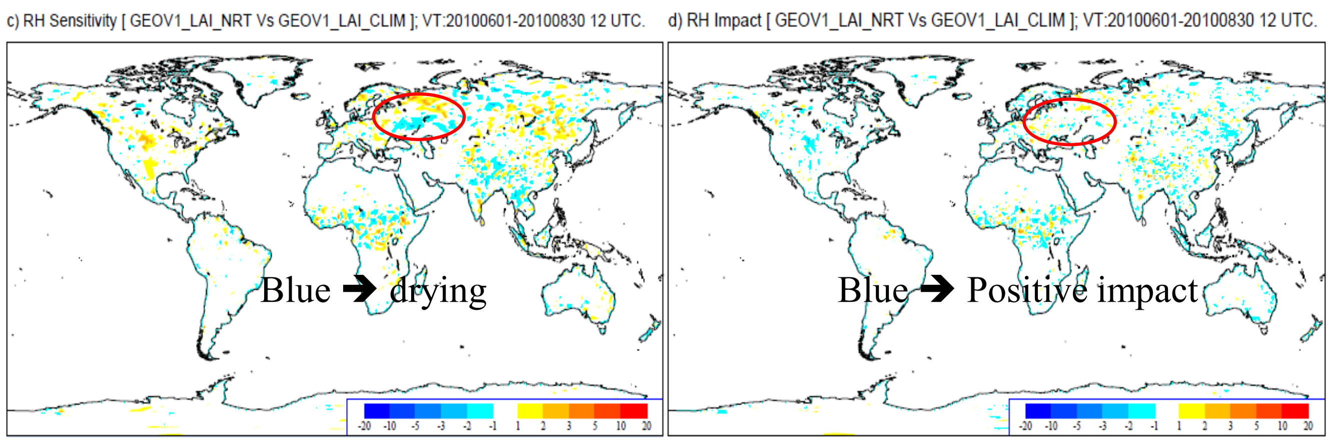
Assimilation of GEOV1 NRT LAI and its potential value (coupled runs)

T_{2m}



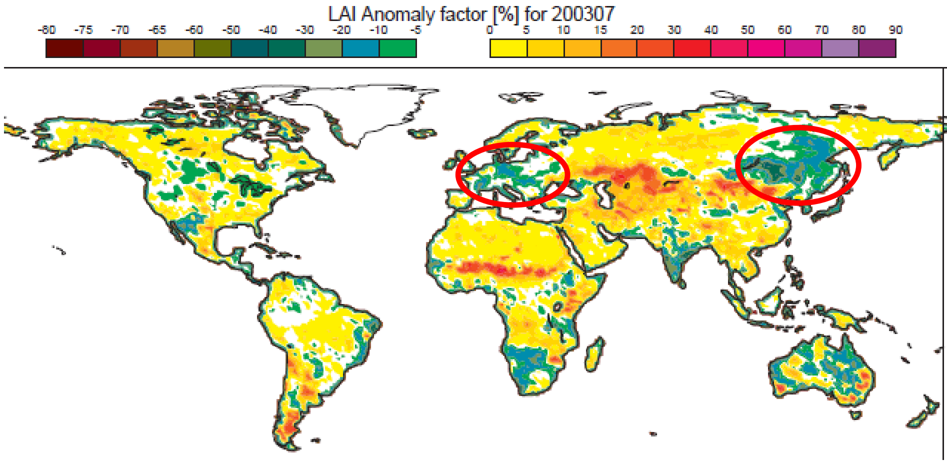
$$sensitivity(X) = X_{LAI\_exp} - X_{LAI\_ctl} \qquad impact(X) = |X_{LAI\_ctl} - X_{an}| - |X_{LAI\_exp} - X_{an}|$$

RH

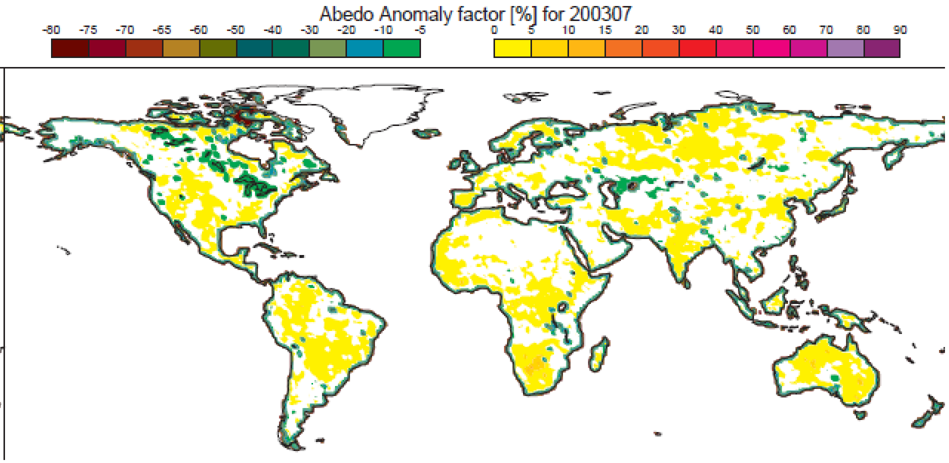


Scores of GEOV1 LAI NRT against GEOV1 LAI climatology for JJA: a) 2m temperature sensitivity [K], b) 2m temperature impact, c) 2m relative humidity sensitivity [%], d) 2m relative humidity impact. ➔ An overall neutral to positive impact.

2003 Europe and East China drought



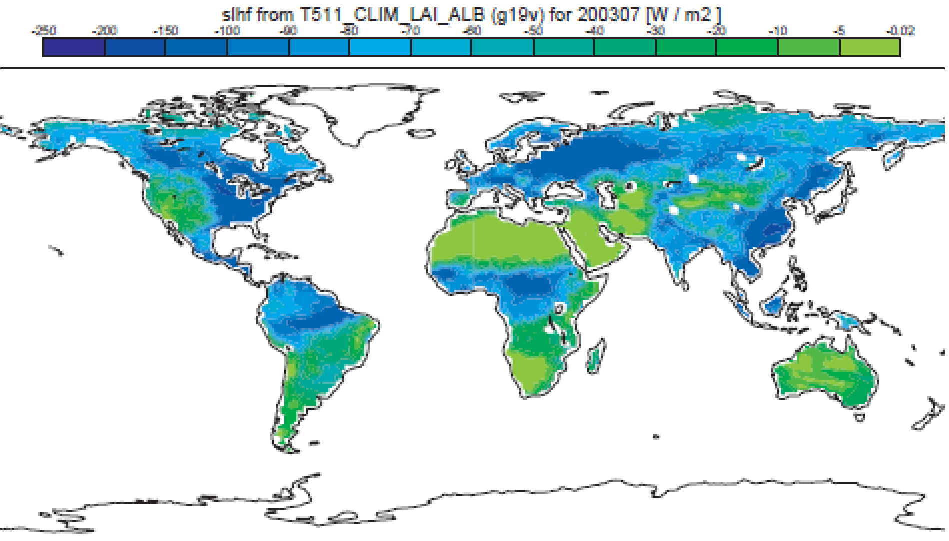
LAI anomaly



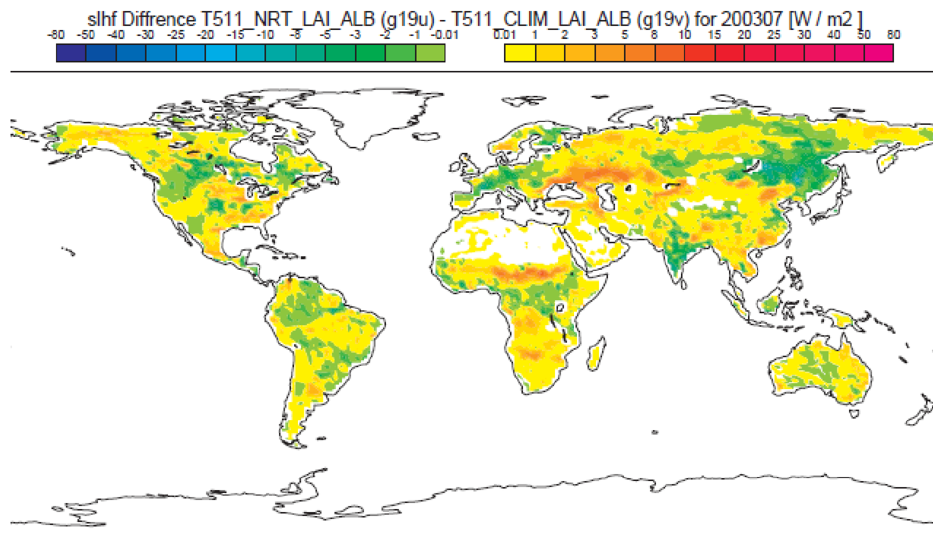
Albedo anomaly

ECMWF

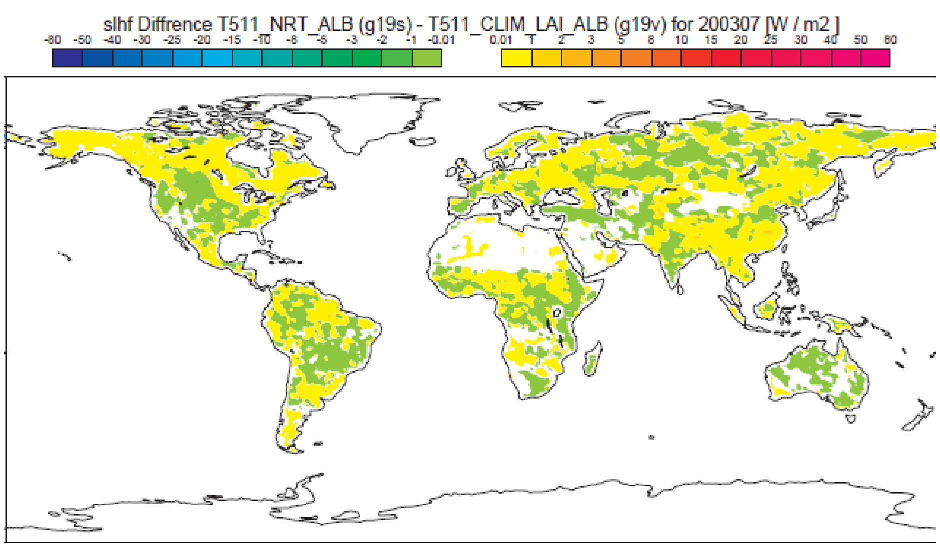
Latent Heat flux



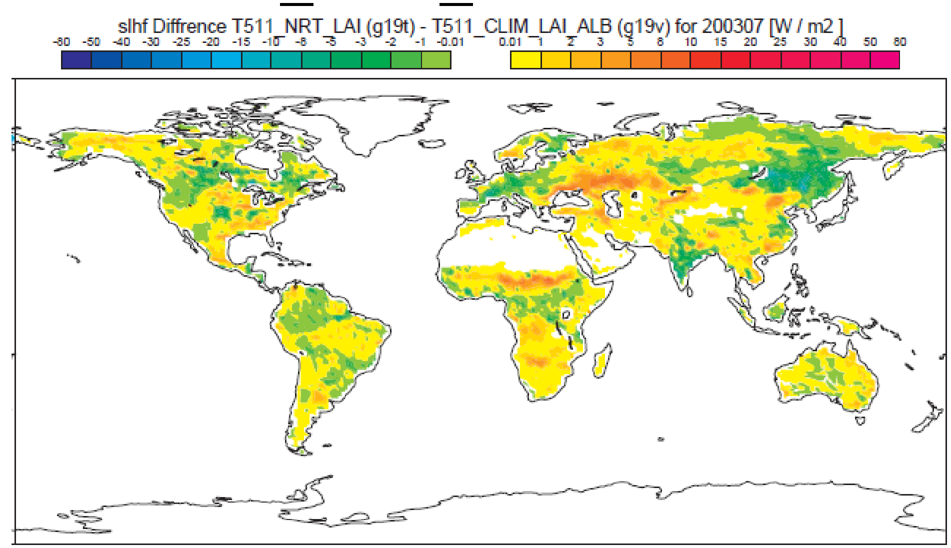
Clim



NRT_ALB_LAI - Clim

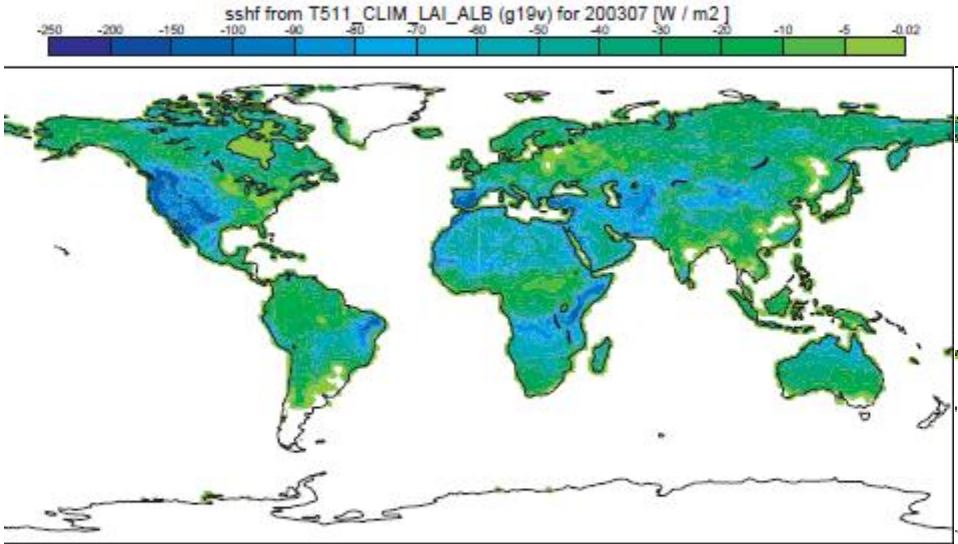


NRT_ALB - Clim

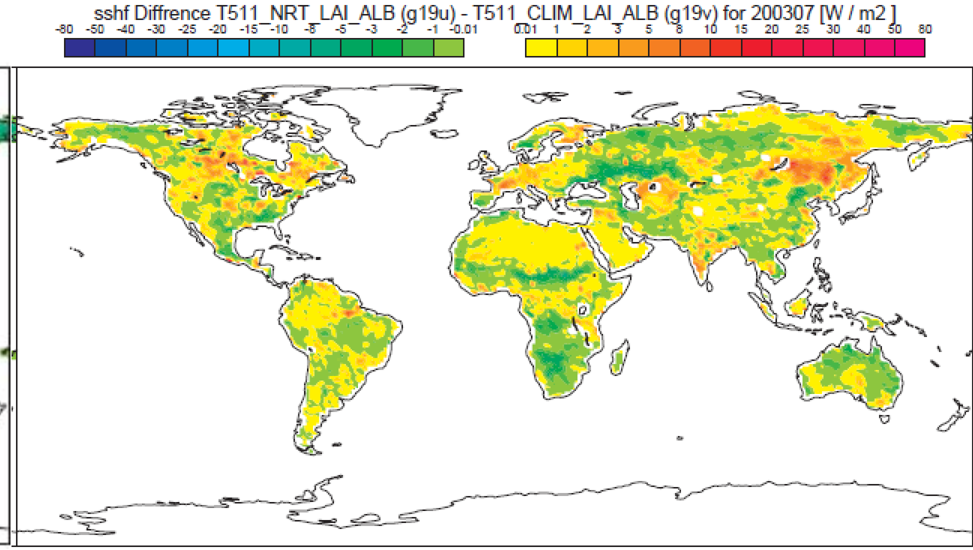


NRT_LAI - Clim

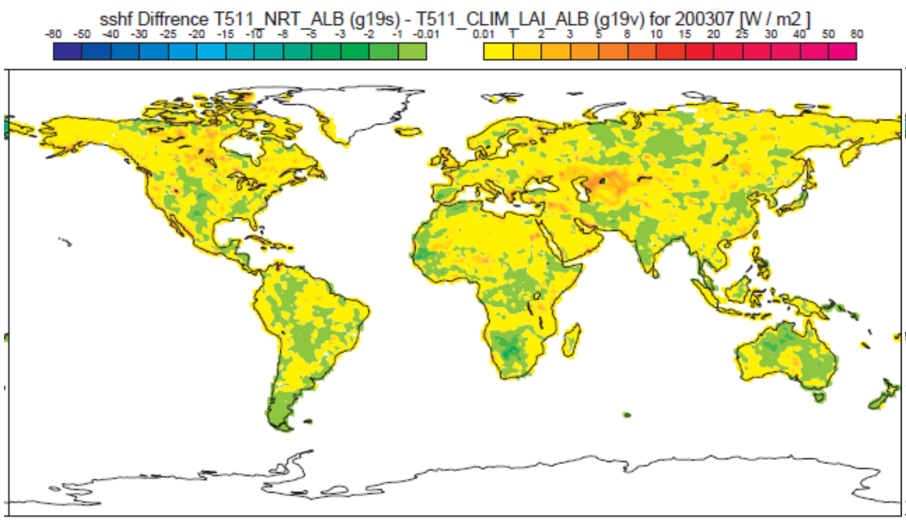
Sensible Heat flux



Clim



NRT_ALB_LAI - Clim



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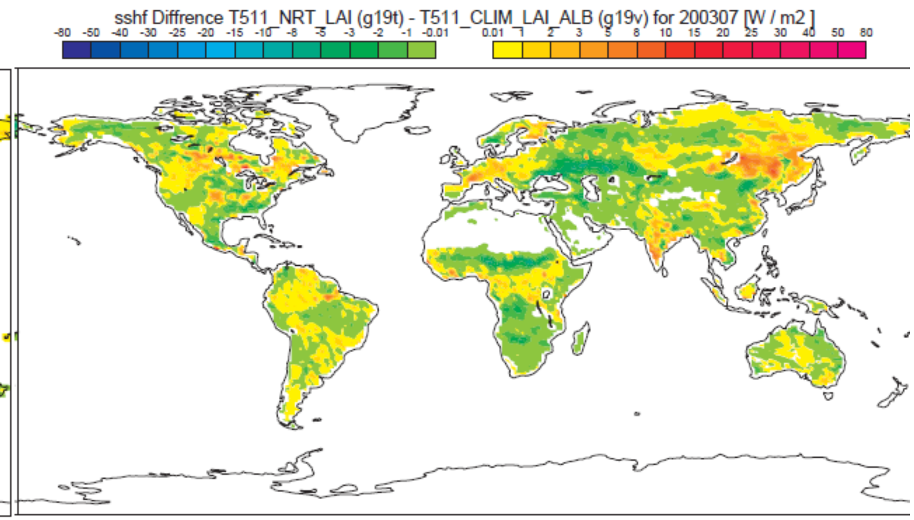
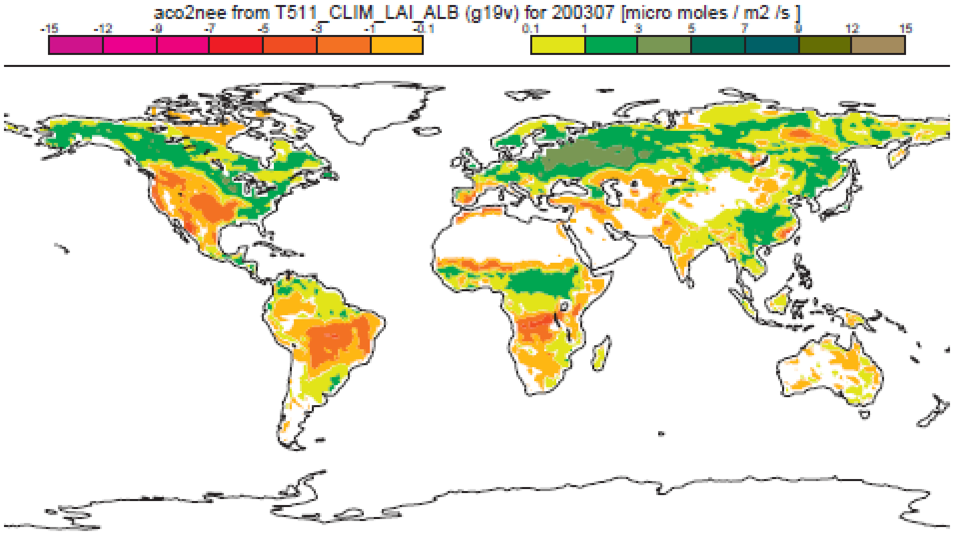


NRT_LAI - Clim

ECMWF

Net Ecosystem Exchange



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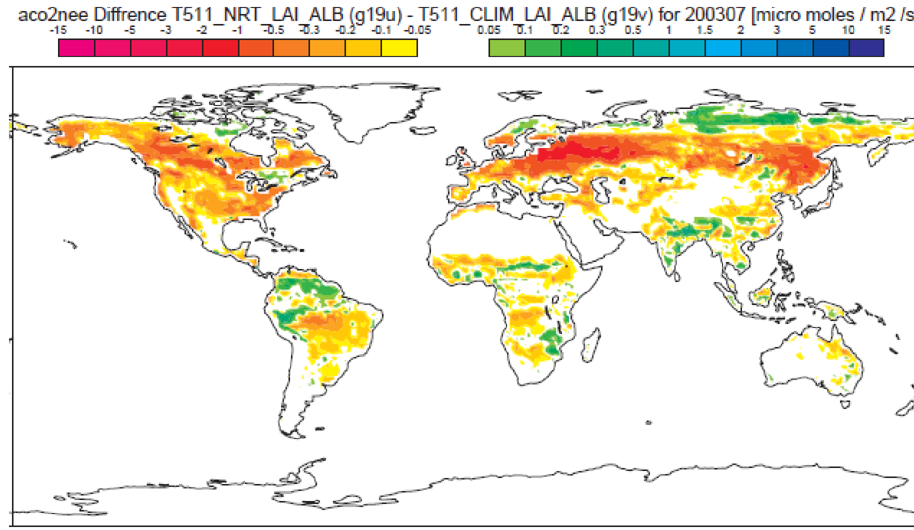

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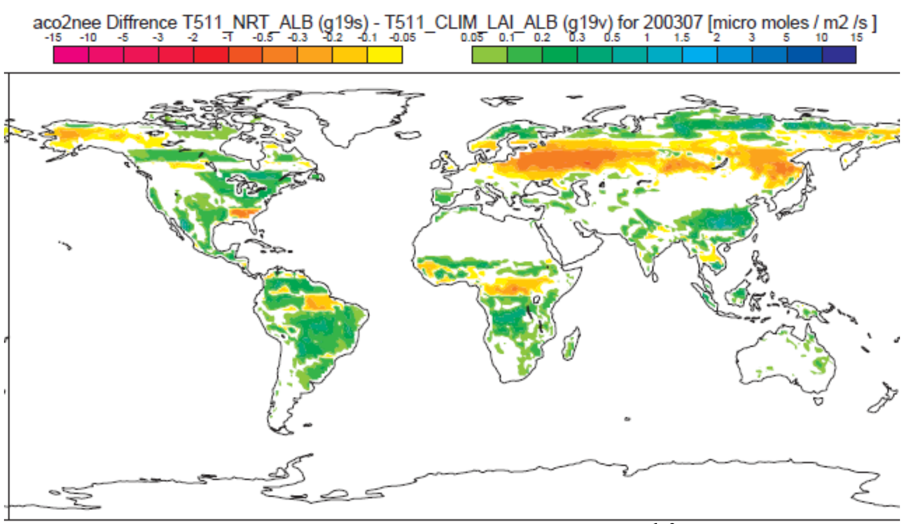

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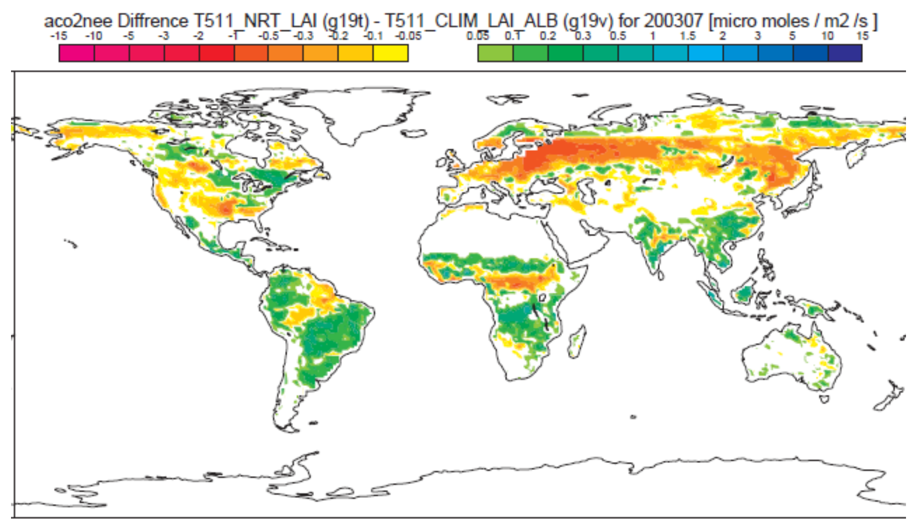
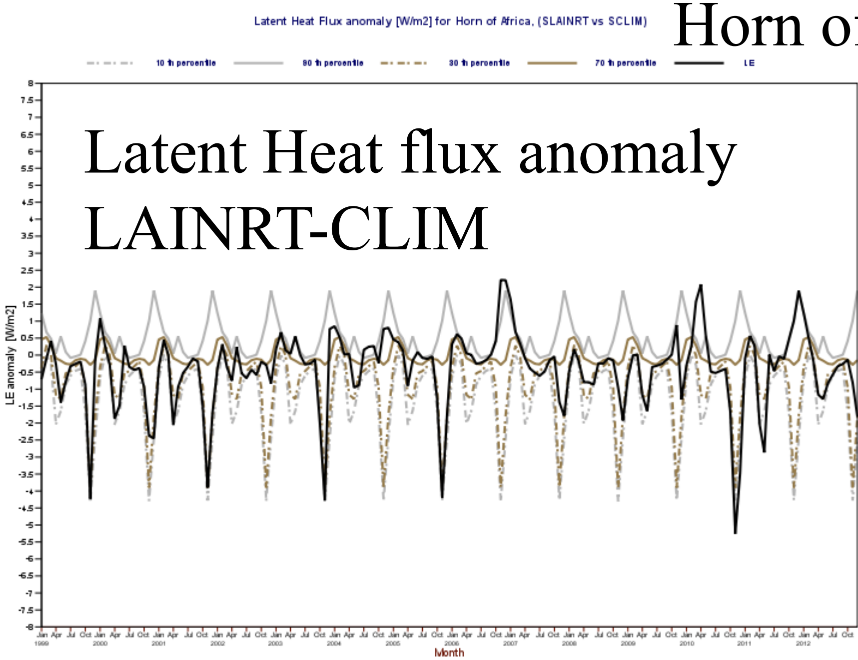
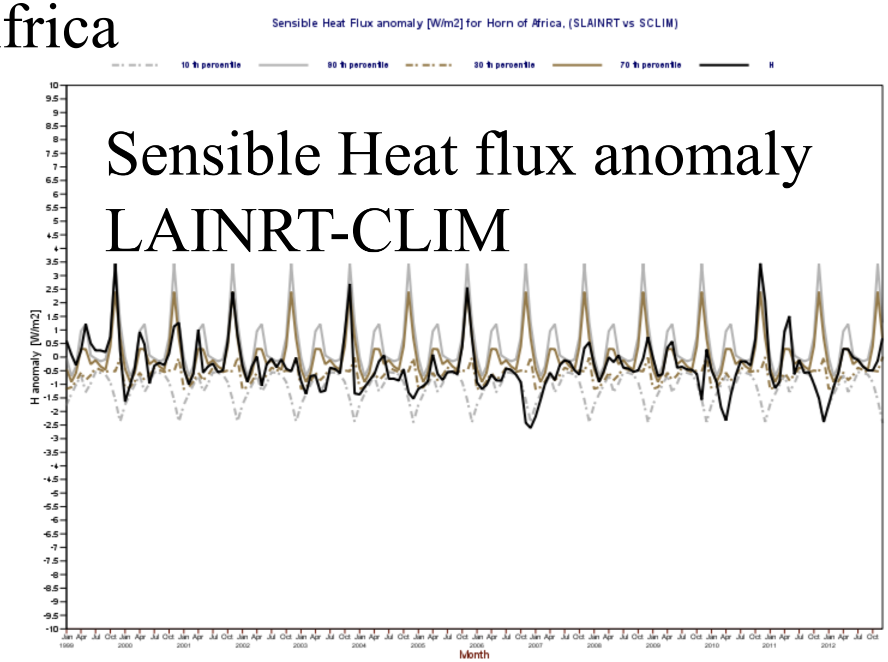


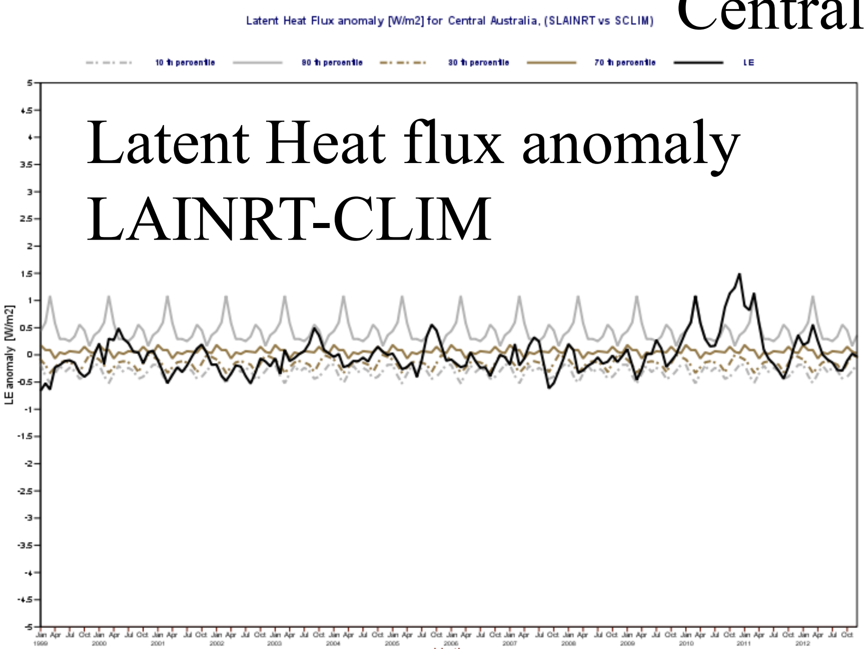
NRT_LAI - Clim

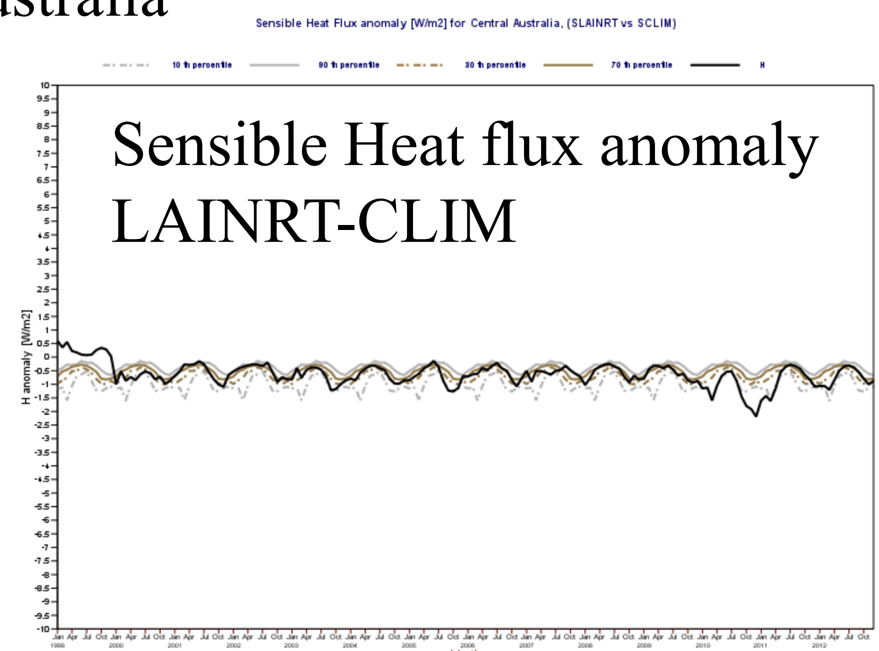
Horn of Africa



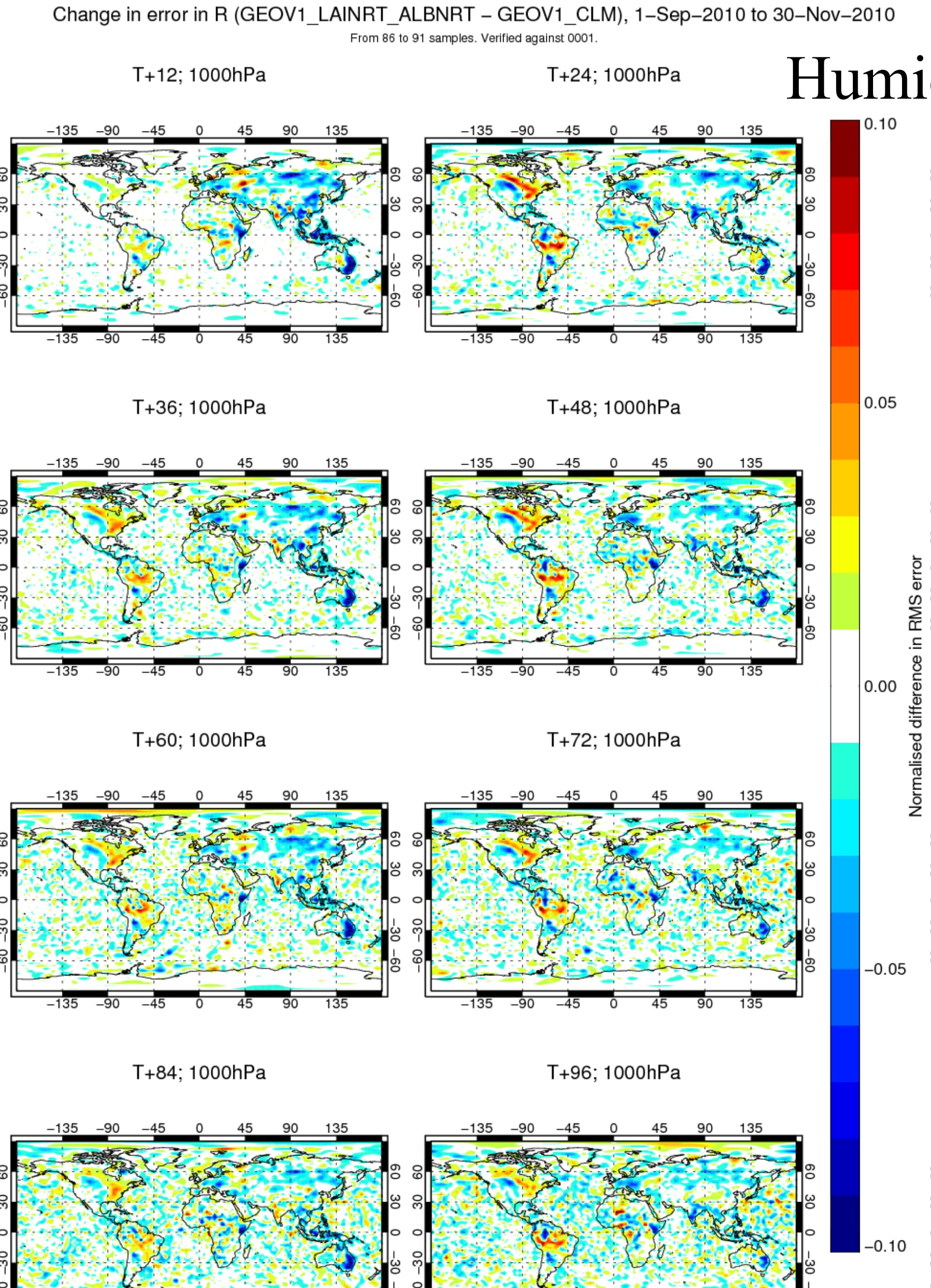


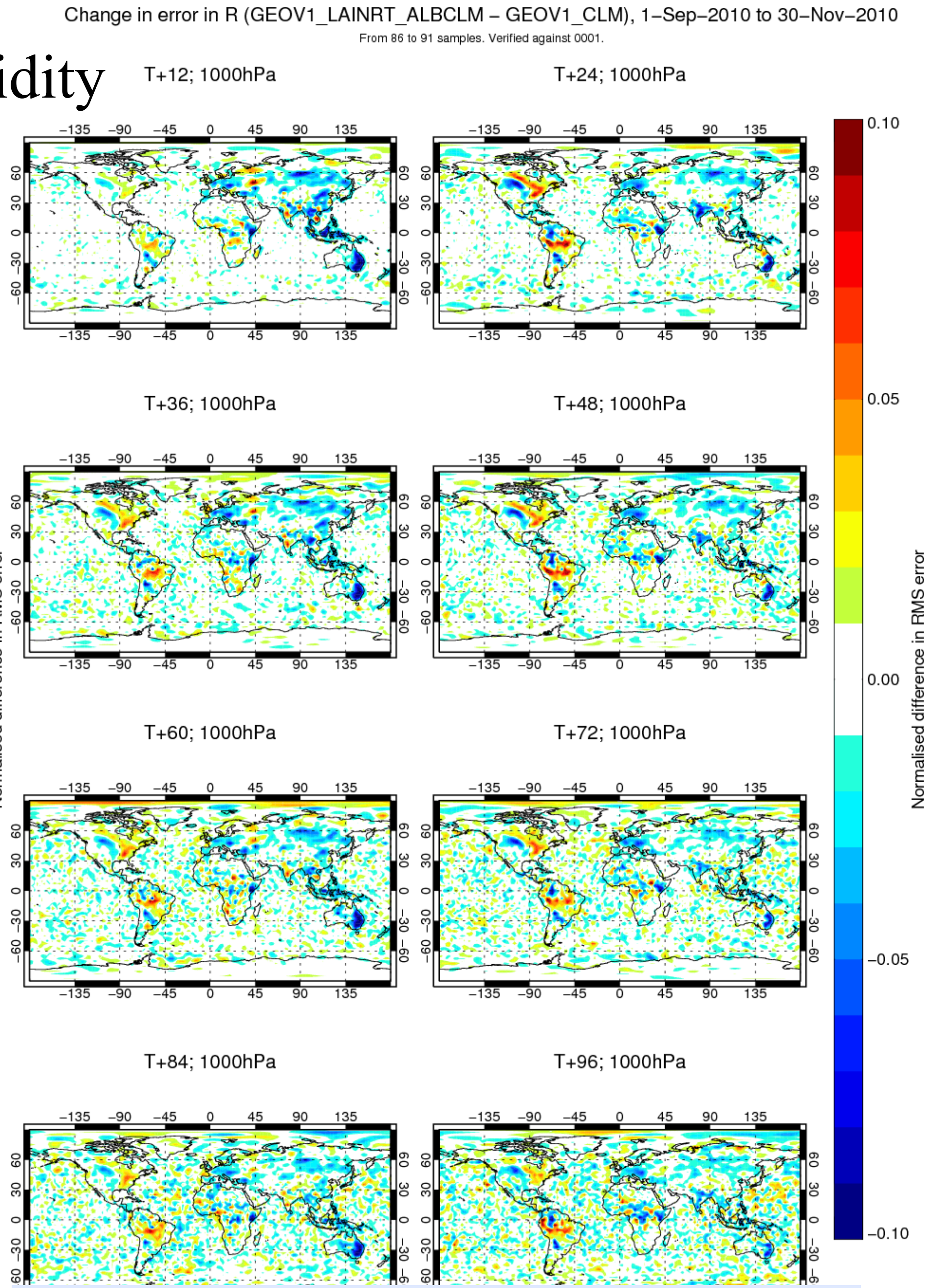
Central Australia





Humidity

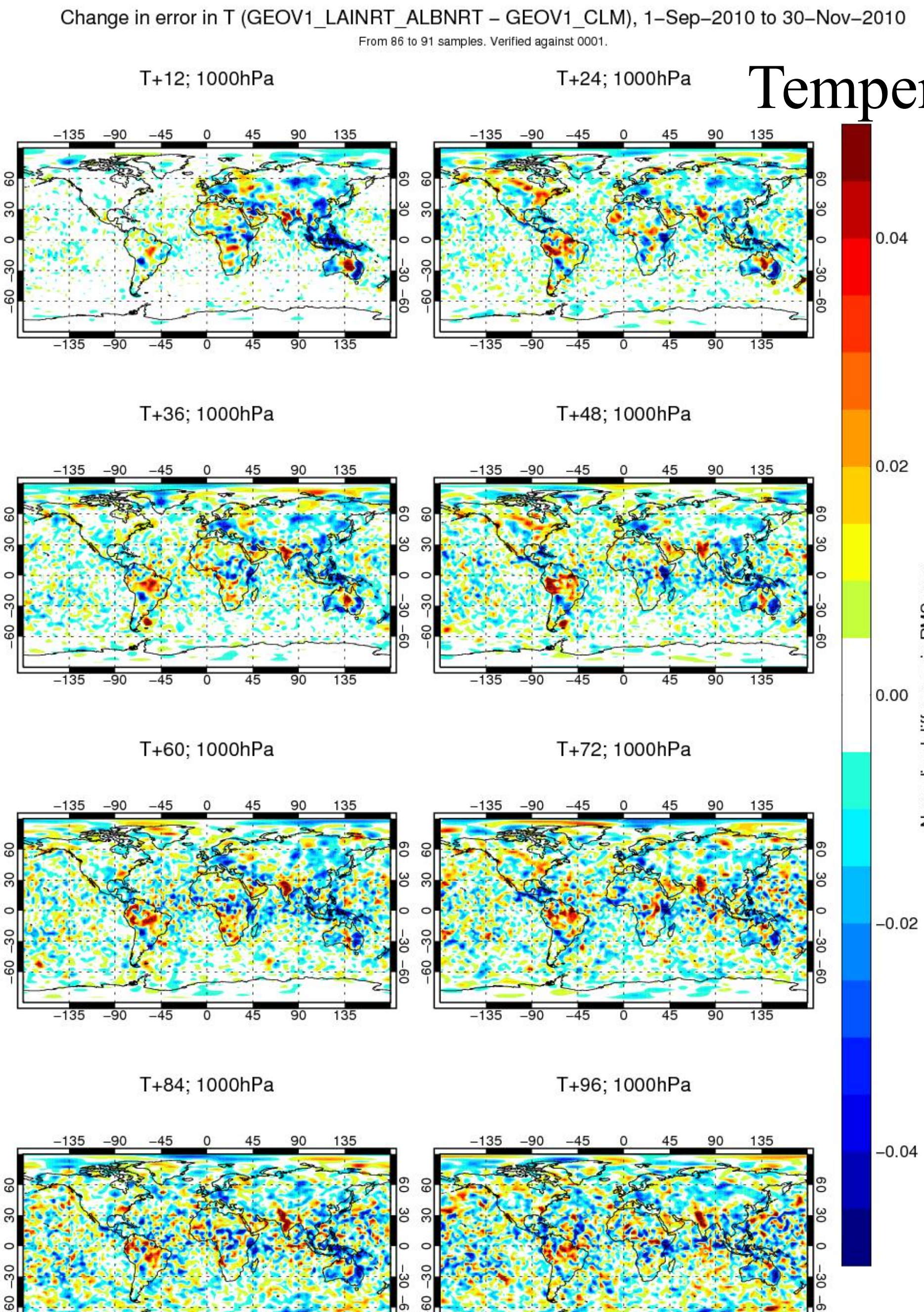




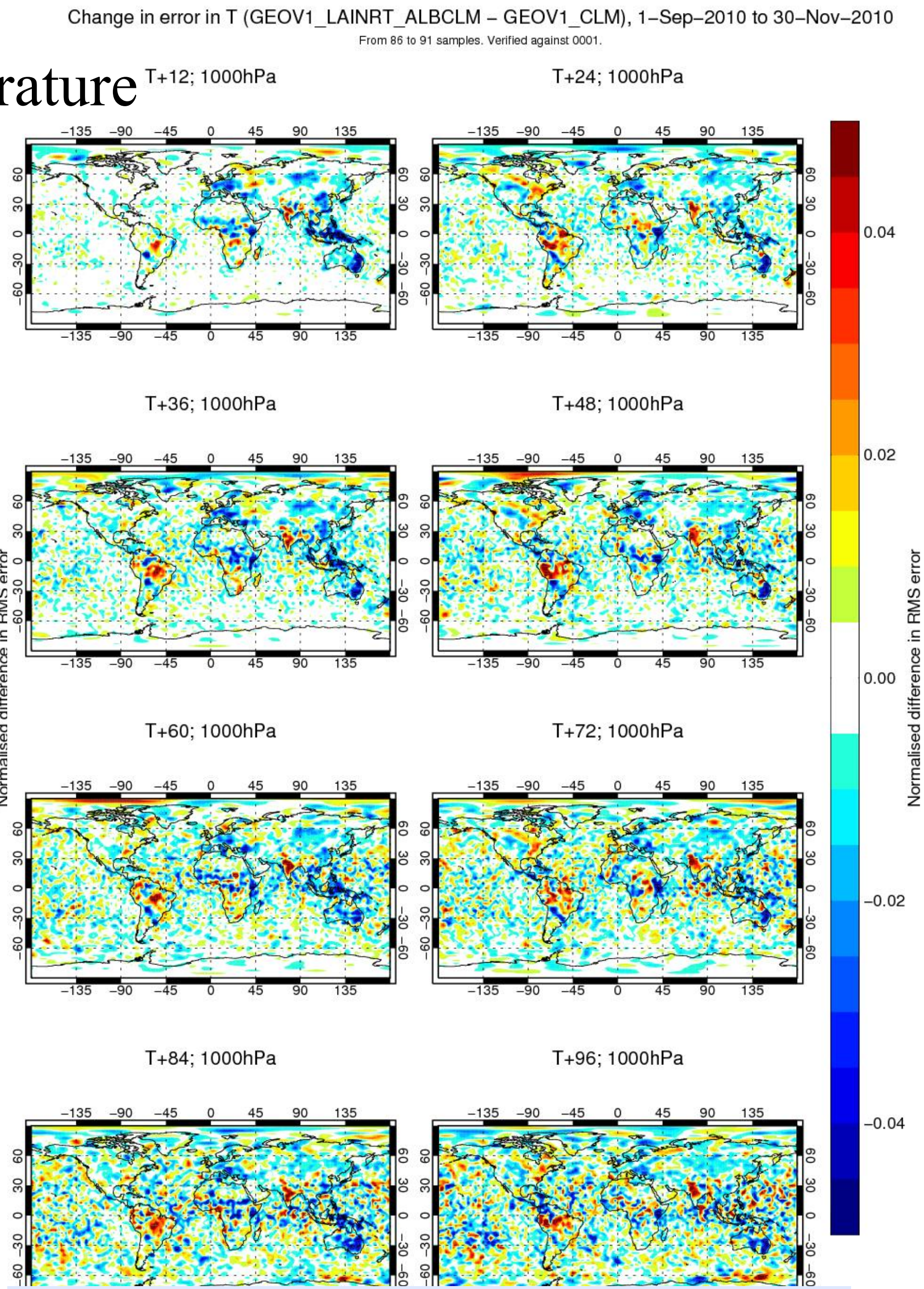
LAI_NRT ALB_NRT - CLIM

LAI_NRT ALB_CLIM - CLIM

Temperature



LAI_NRT ALB_NRT - CLIM



LAI_NRT ALB_CLIM - CLIM