Monitoring and Forecasting the Impact of the 2018 Summer Heatwave on Vegetation using a Land Data Assimilation System

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Study the vegetation and terrestrial water cycles

- **Current fleet of Earth Satellite missions holds an unprecedent potential to quantify Land Surface Variables (LSVs)**
  [Lettenmaier et al., 2015, Balsamo et al., 2018]

➔ Spatial and temporal gaps & cannot observe all key LSVs (e.g. RZSM)

- **Land Surface Models (LSMs)** provide LSV estimates at all time/location

➔ LSMs have uncertainties

- Through a weighted combination of both, LSVs can be better estimated than by either source of information alone *[Reichle et al., 2007]*

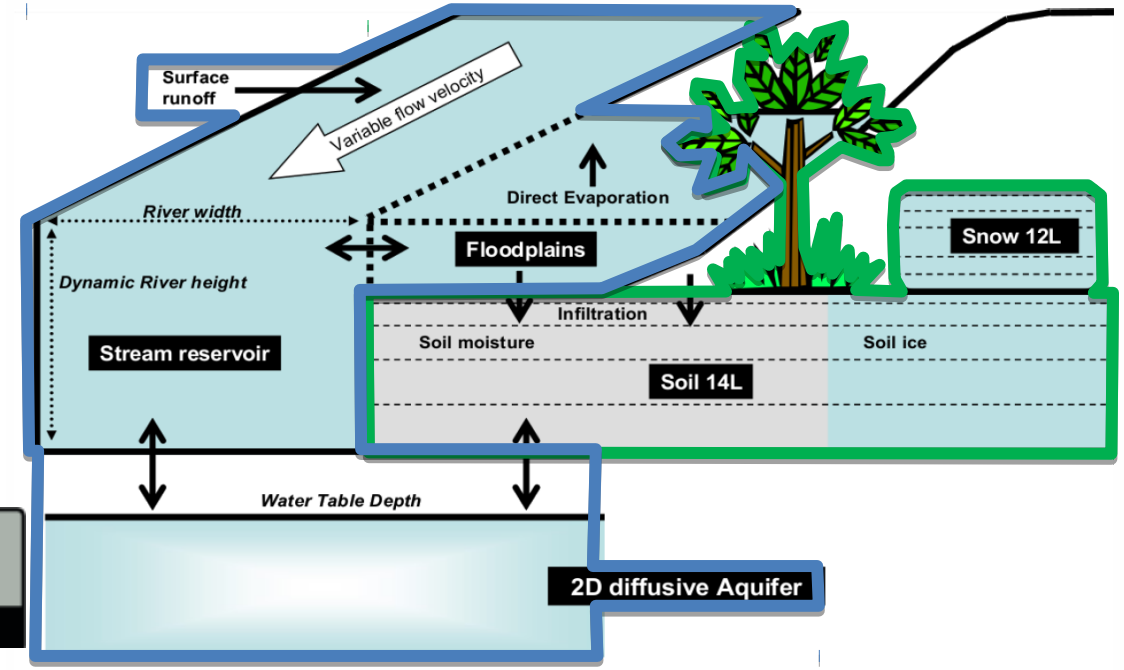
➔ **Data assimilation**
Spatially and temporally integrates the observed information into LSMs in a consistent way to unobserved locations, time steps and variables

Study the vegetation and terrestrial water cycles

LDAS-Monde: global capacity offline integration of satellite observations into a land surface model fully coupled to hydrology

LDAS-Monde involves

- **Land surface model: ISBA-A-gs**, simulates the diurnal cycle of water and carbon fluxes, plant growth and key vegetation variables
- **River routing system: CTRIP** (CNRM version of Total Runoff Integrating Pathways)
- **Data assimilation routines** (SEKF, EnSRF*, PF)



*Bonan et al., EGU2019-14804

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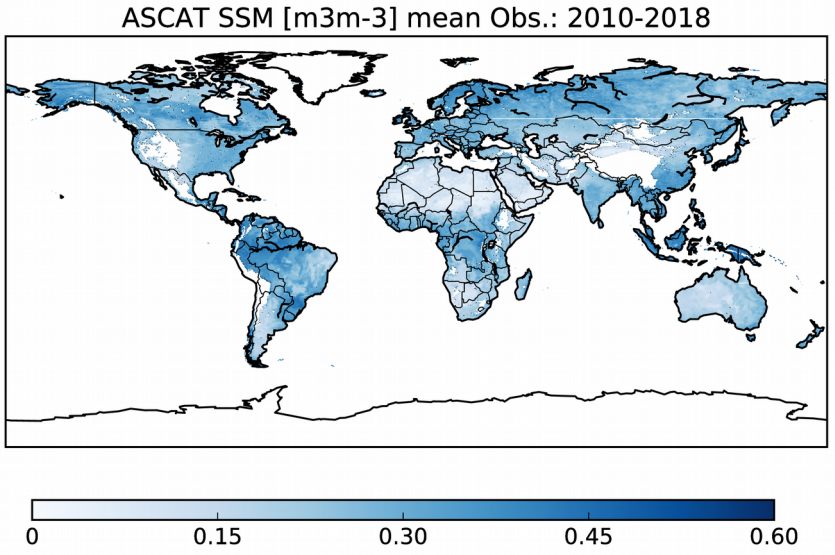
LDAS-Monde successfully validated

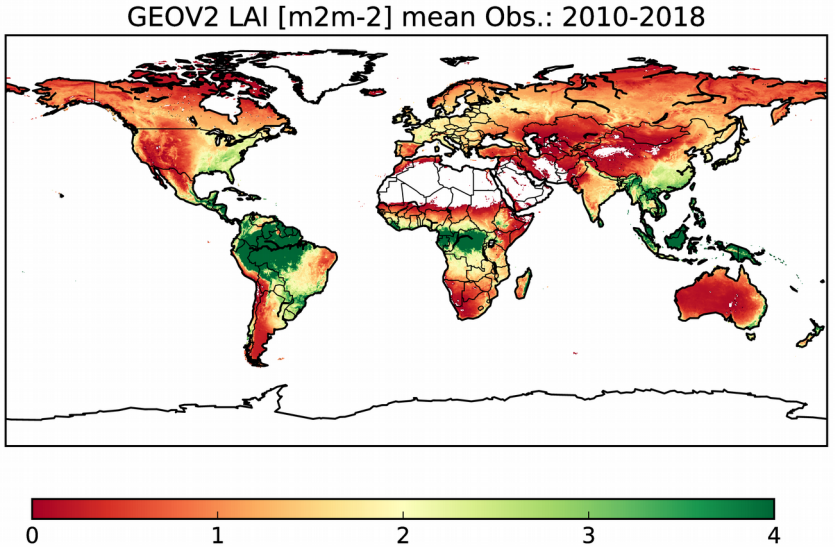
- Agricultural statistics (e.g. Dewaele et al., 2018, HESS)
- River discharge (e.g. Albergel et al., 2017, GMD, 2018, RS)
- In situ measurements of soil moisture (e.g. Albergel et al., 2018, *RS*)
- Evapotranspiration from GLEAM, Fluxnet2015 (e.g. Albergel et al., 2018, *RS*)
- Gross Primary Production from FLUXCOM (e.g. Tall et al., 2019)
- Sun-Induced Fluorescence (e.g. Leroux et al., 2018, *RS*, Tall et al., 2019, *RS*)

*Bonan et al., EGU2019-14804

LDAS-Monde experimental set up

Model	Domain	Atm. Forcing	DA Method	Assimilated Obs.	Observation Operator	Control Variables	Additional Option
ISBA Multi-layer soil model CO_2-responsive version (Interactive vegetation)	**Global (2010 – 2018)**	**ERA-5 Res.: 0.25°x0.25°**	**SEKF**	**SSM** (CGLS ASCAT SWI + cdf matching) **LAI** (CGLS GEOV2)	**Second layer of soil (1-4cm) LAI**	**Layers of soil 2 to 8 (1-100cm) LAI**	**Coupling with CTRIP (0.5°)**





- Control variables (CVs) are directly updated thanks to their sensitivity to the observed variables
- Other variables are indirectly modified through biophysical processes and feedbacks in the model

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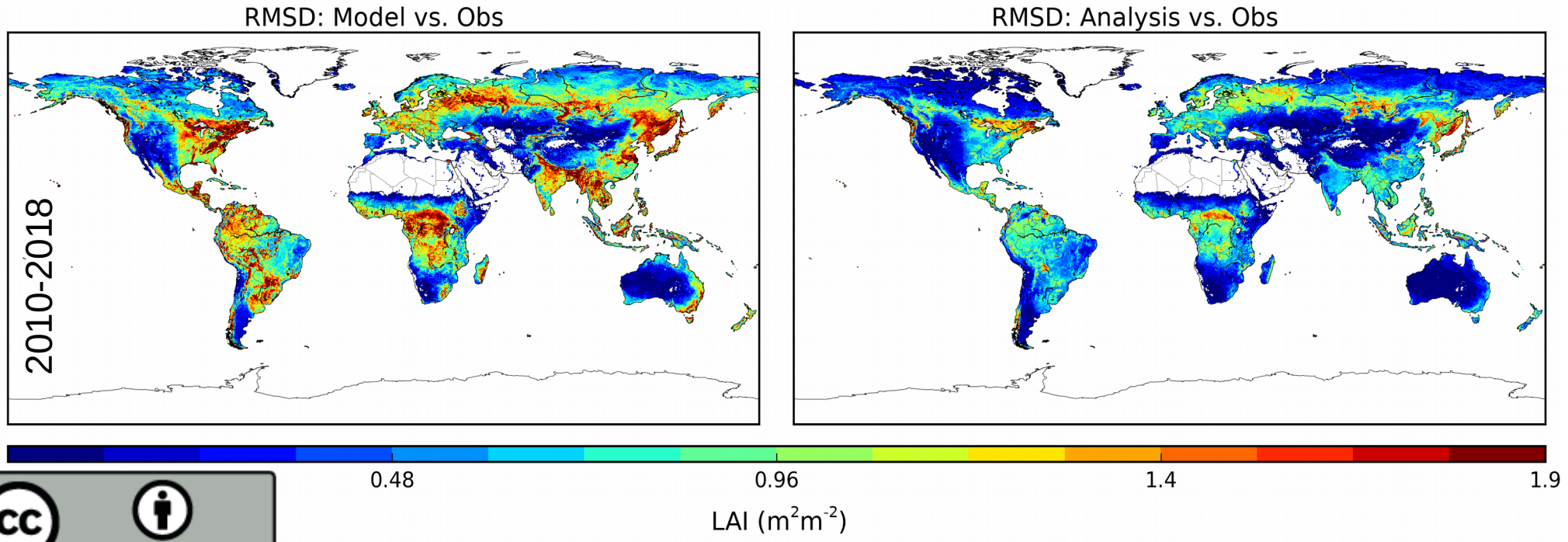
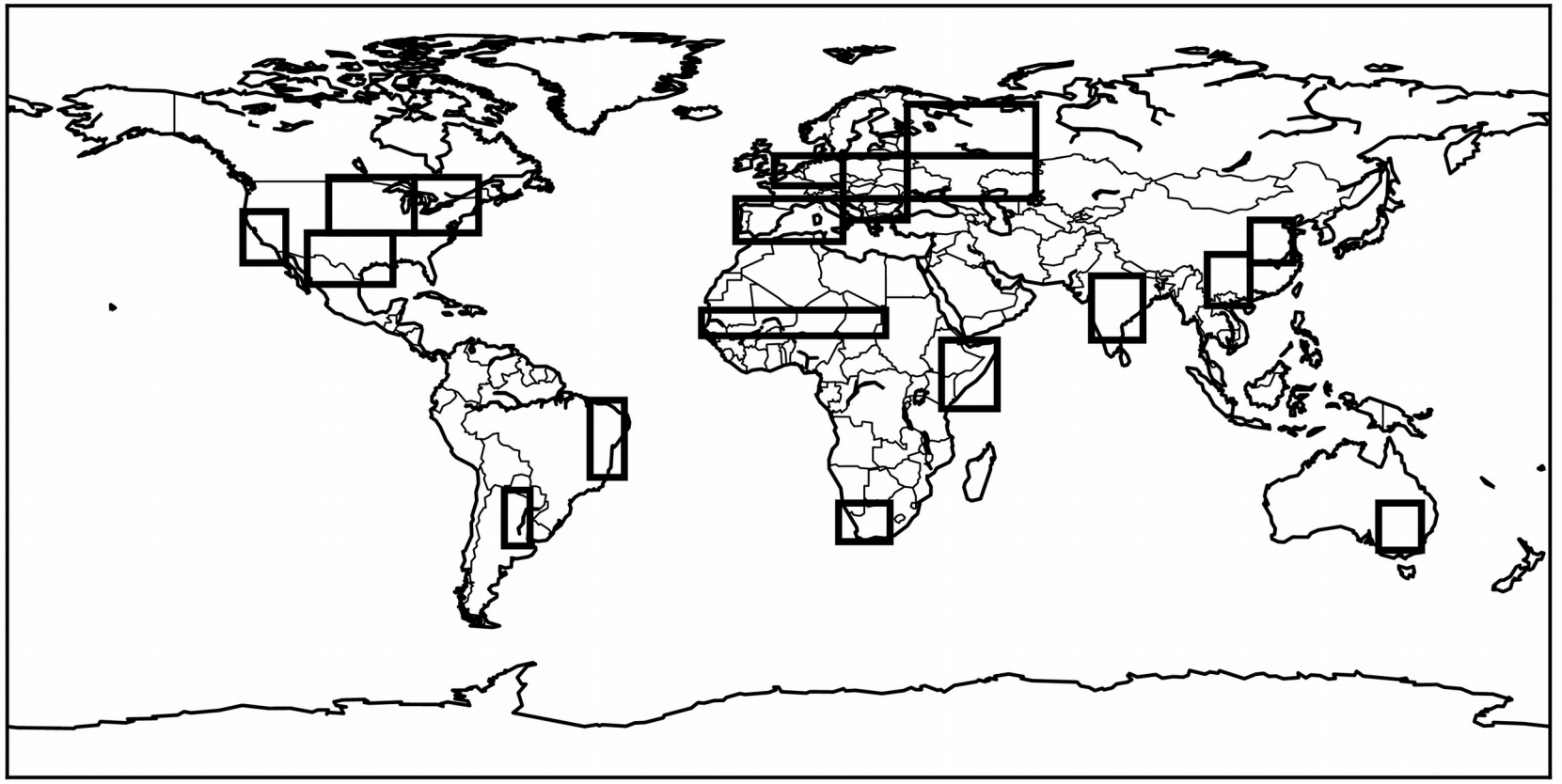
2 LDAS-ERA5 experiments : Model (no assimilation) and Analysis (assimilation)



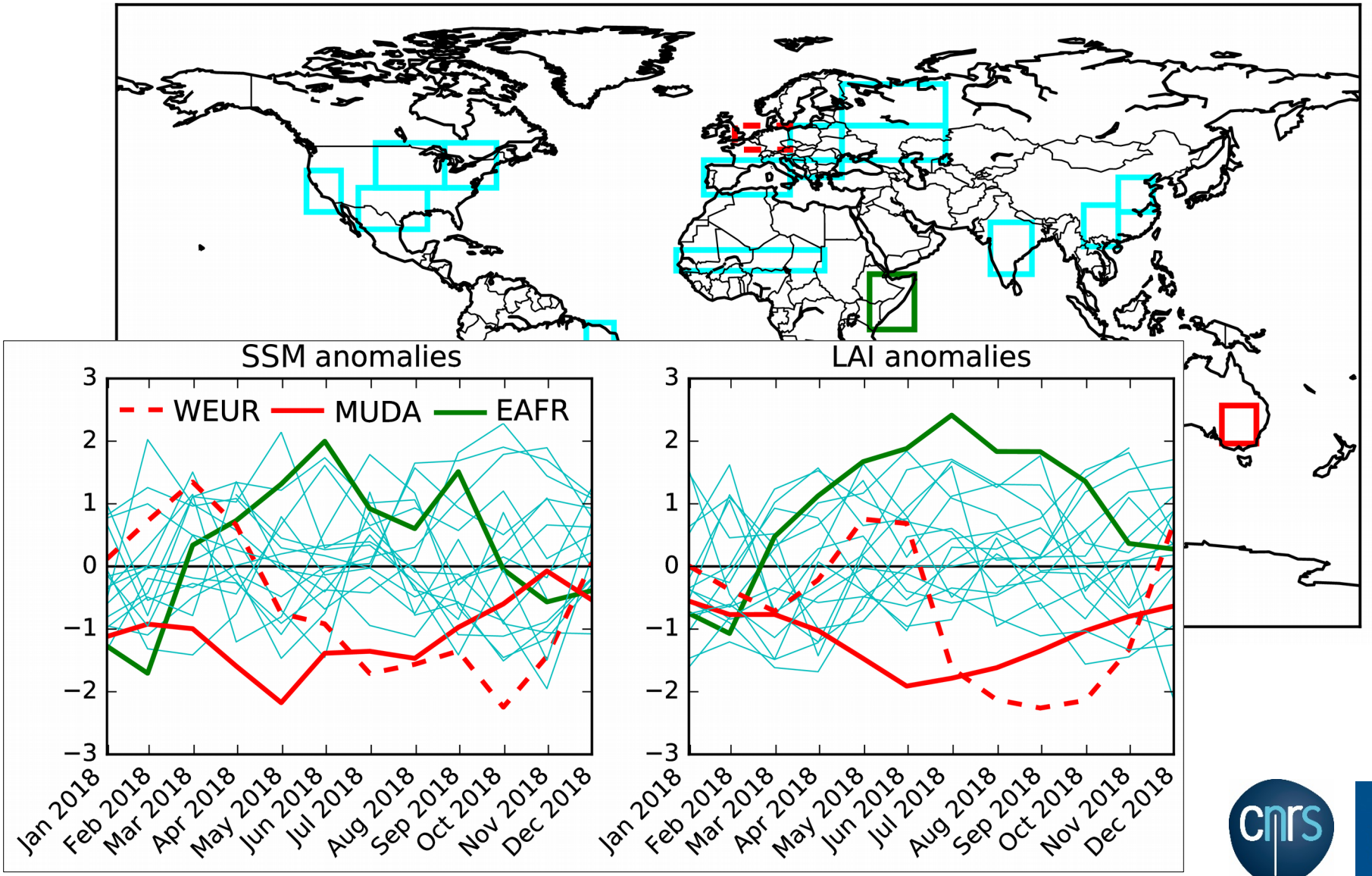
LDAS-Monde goes global

Selection of 19 regions known for being potential hot spots for droughts and heat waves



LDAS-Monde goes global

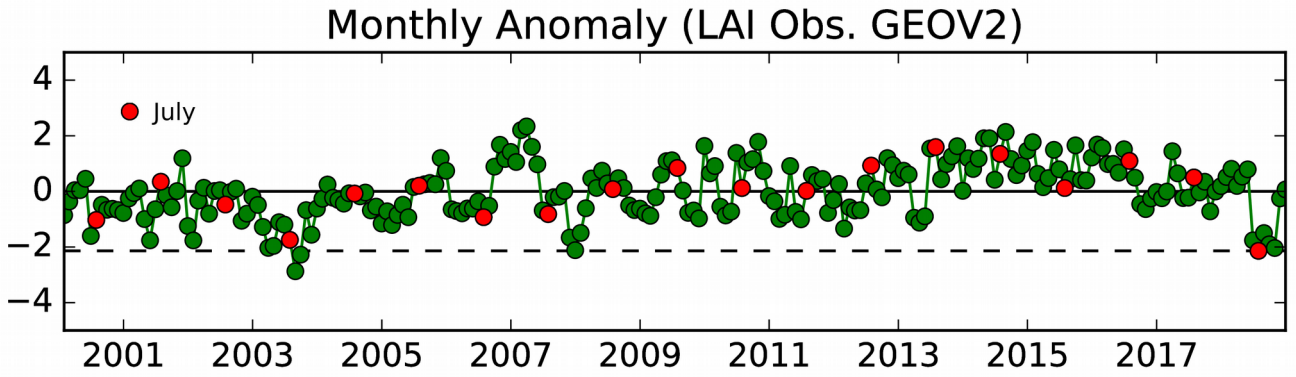
Monthly anomalies for 2018 with respect to 2010-2018

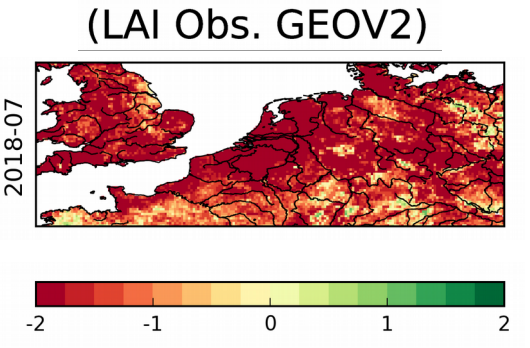


Impact of the Summer 2018 heatwave on LSVs

The Earth Observations point of view: *CGLS GEOV2 and SWI*
Monthly anomaly (scaled by stdv)

a)





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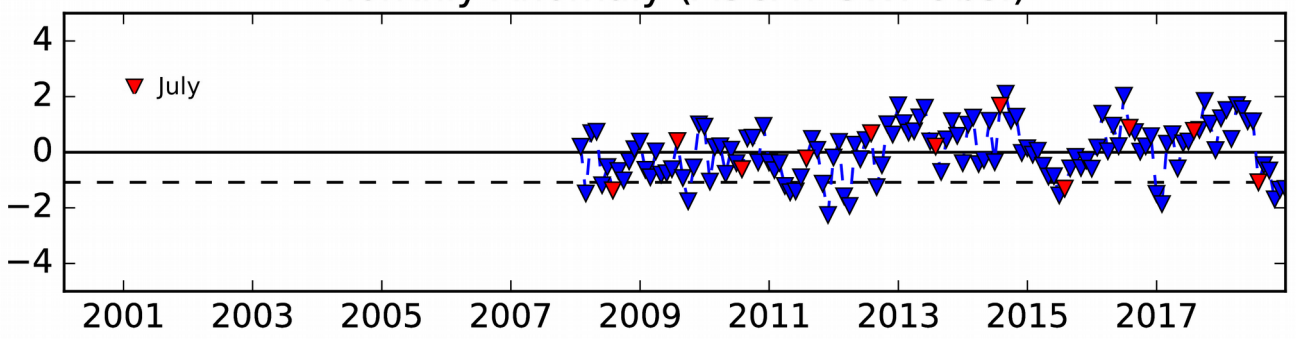
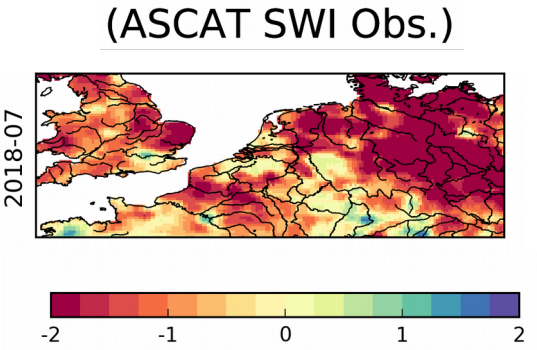
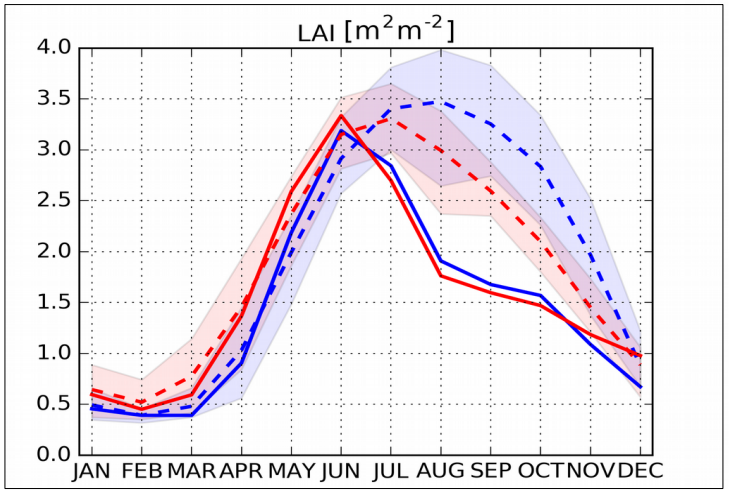


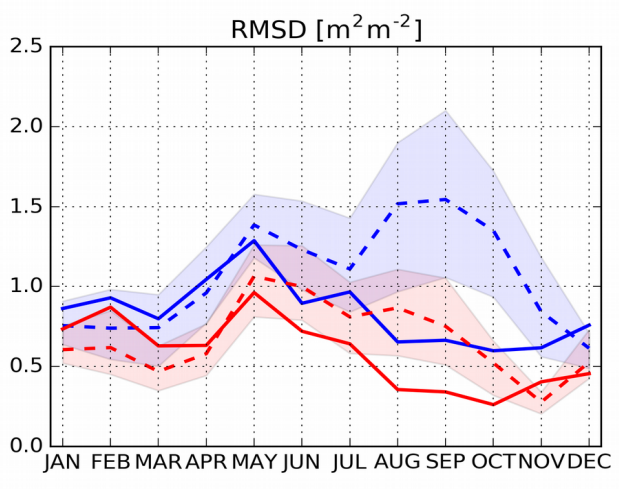


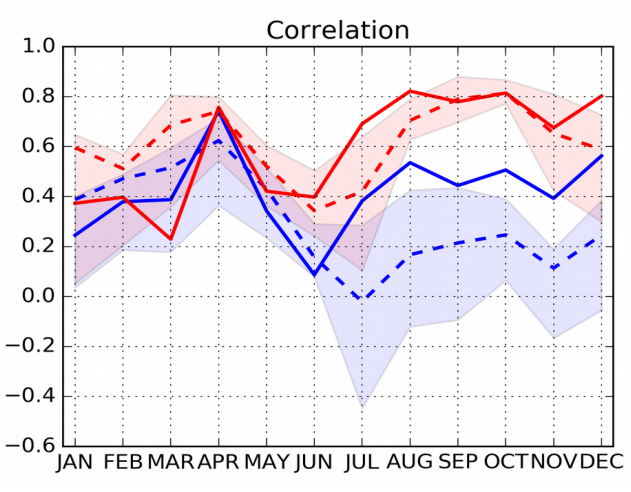
Impact of the Summer 2018 heatwave on LSVs

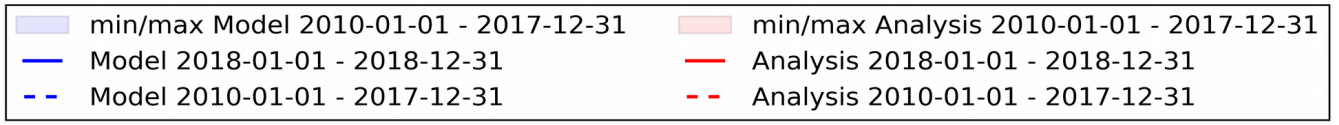
LDAS-Monde : Leaf Area Index

- Seasonal cycles, RMSD and Correlations values (Model, Analysis)









- Seasonal cycles:

➔ 2018 quite different from 2010-2017

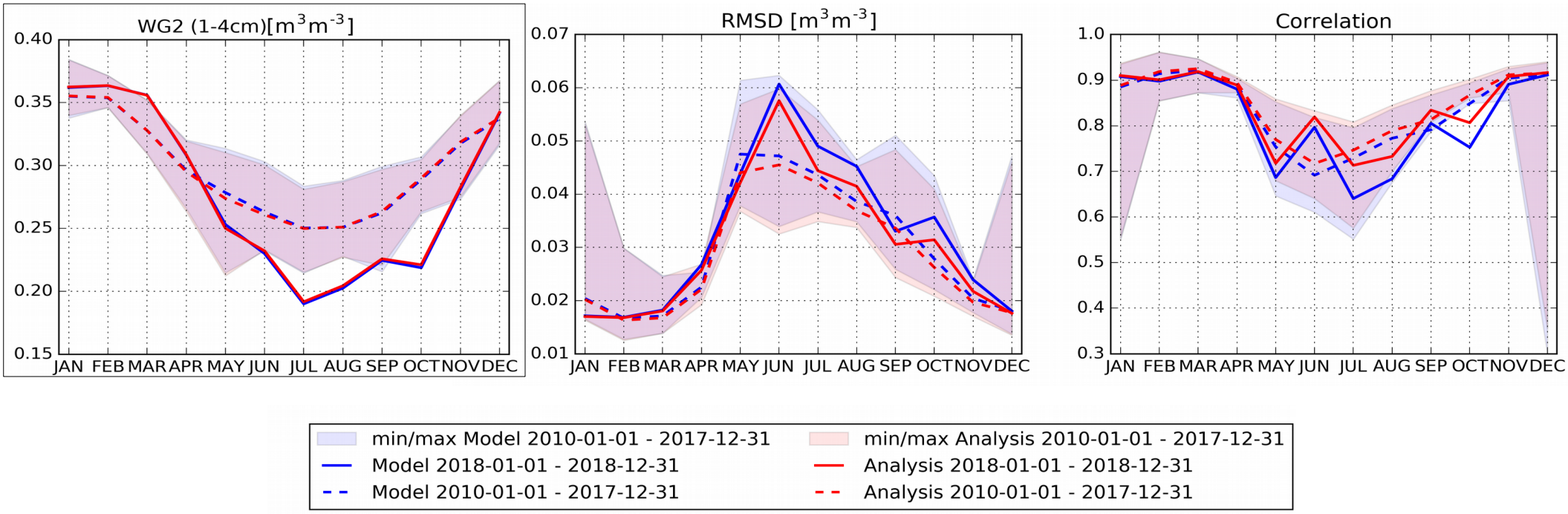
➔ smaller differences between Model and Analysis for 2018 than for 2010-2017 (True for RMSD and R values as well)

- Analysis improvements over Model simulation

Impact of the Summer 2018 heatwave on LSVs

LDAS-Monde : surface soil moisture

- Seasonal cycles, RMSD and Correlations values (Model, Analysis)



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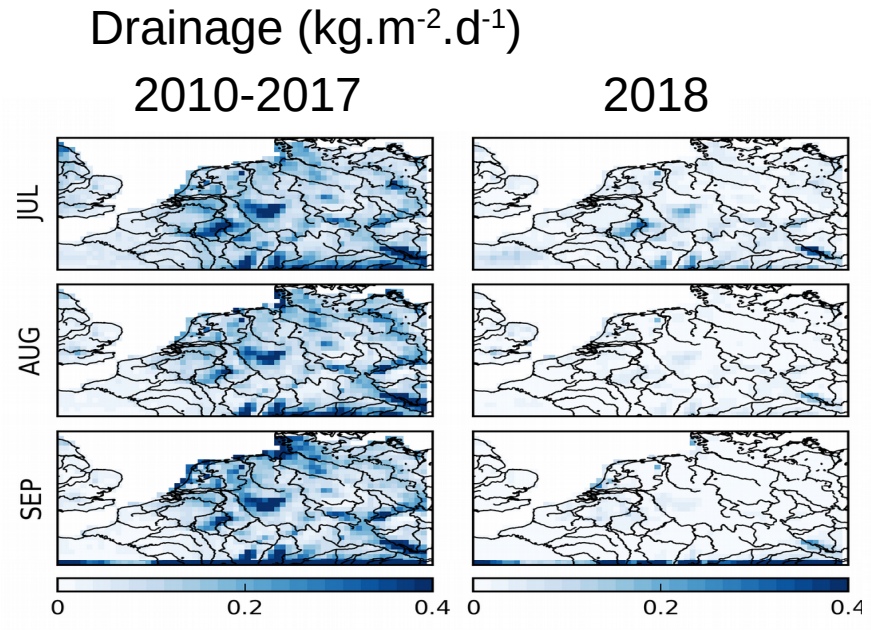
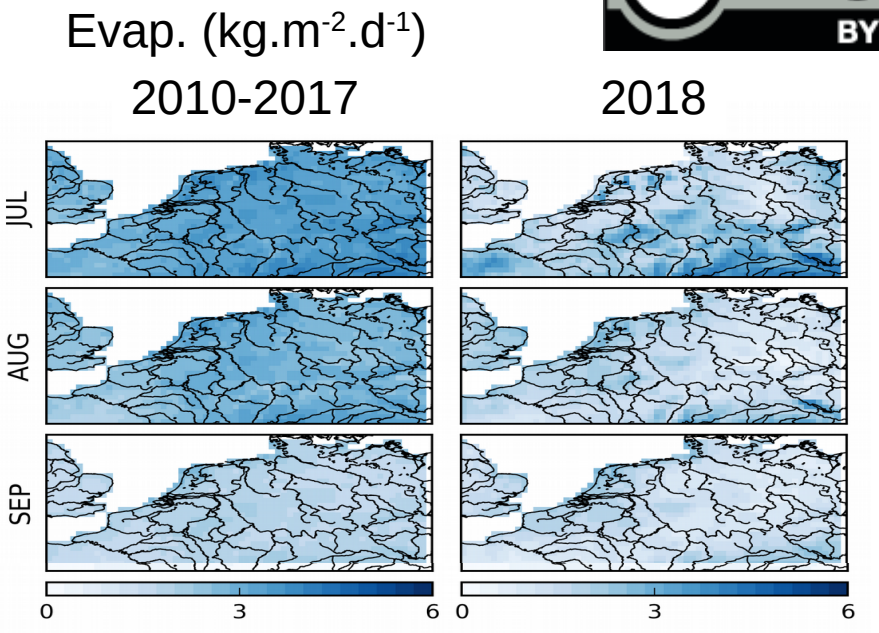
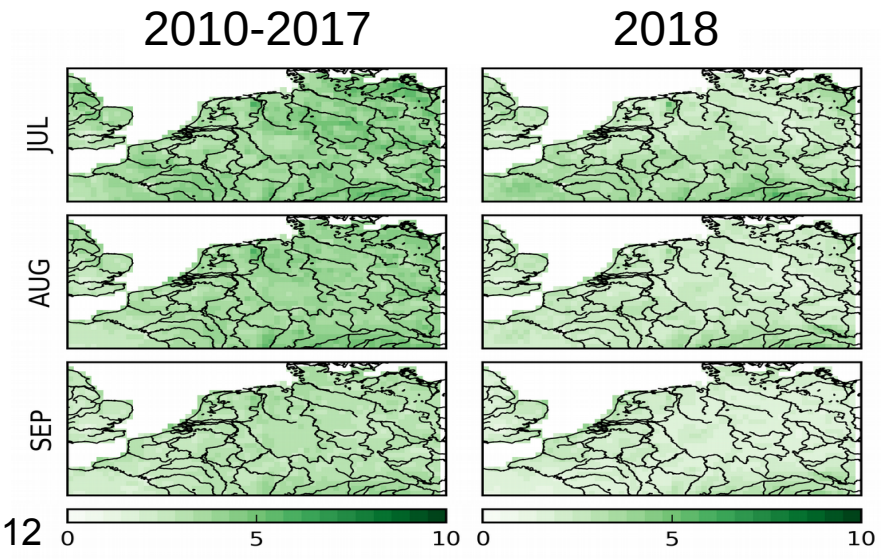
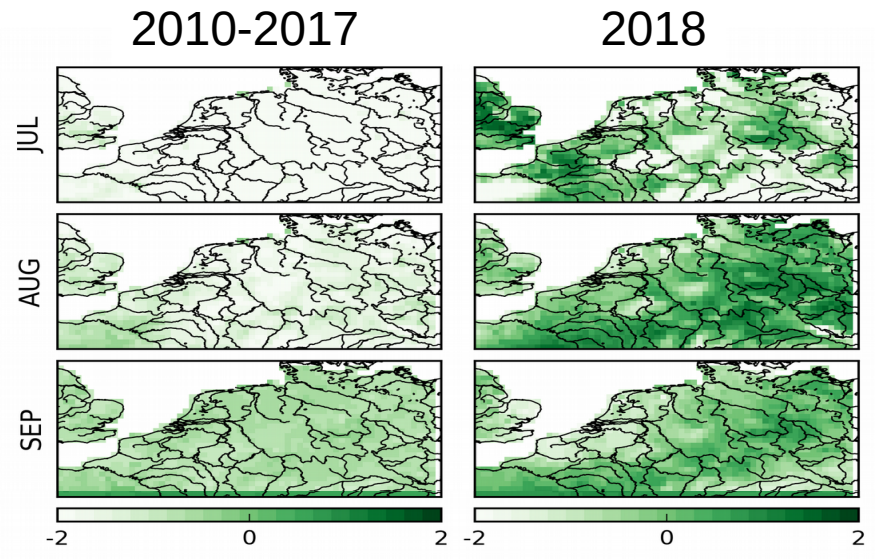






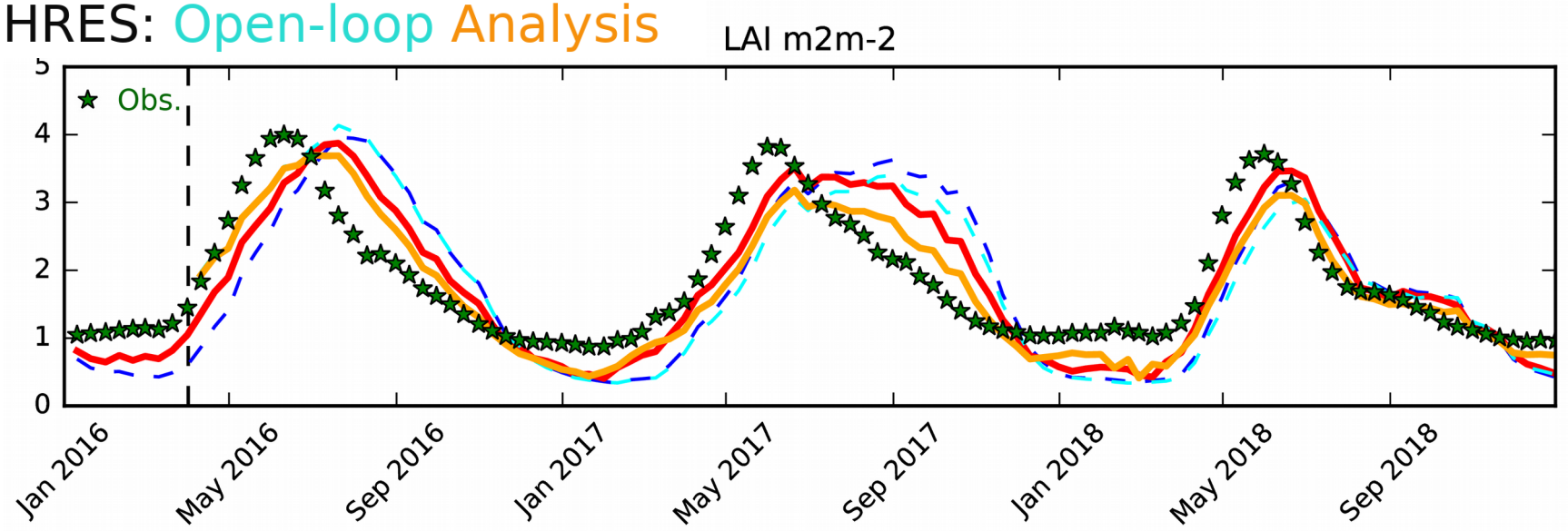


Impact of the Summer 2018 heatwave on LSVs

Such an extreme event needs more attention!

- Using ECMWF high resolution operational analysis to force LDAS-Monde (LDAS-HRES, 0.10°x0.10°) and complement the use of ERA5 (LDAS-ERA5, 0.25°x0.25°)

LDAS-ERA5: Open-loop Analysis
LDAS-HRES: Open-loop Analysis

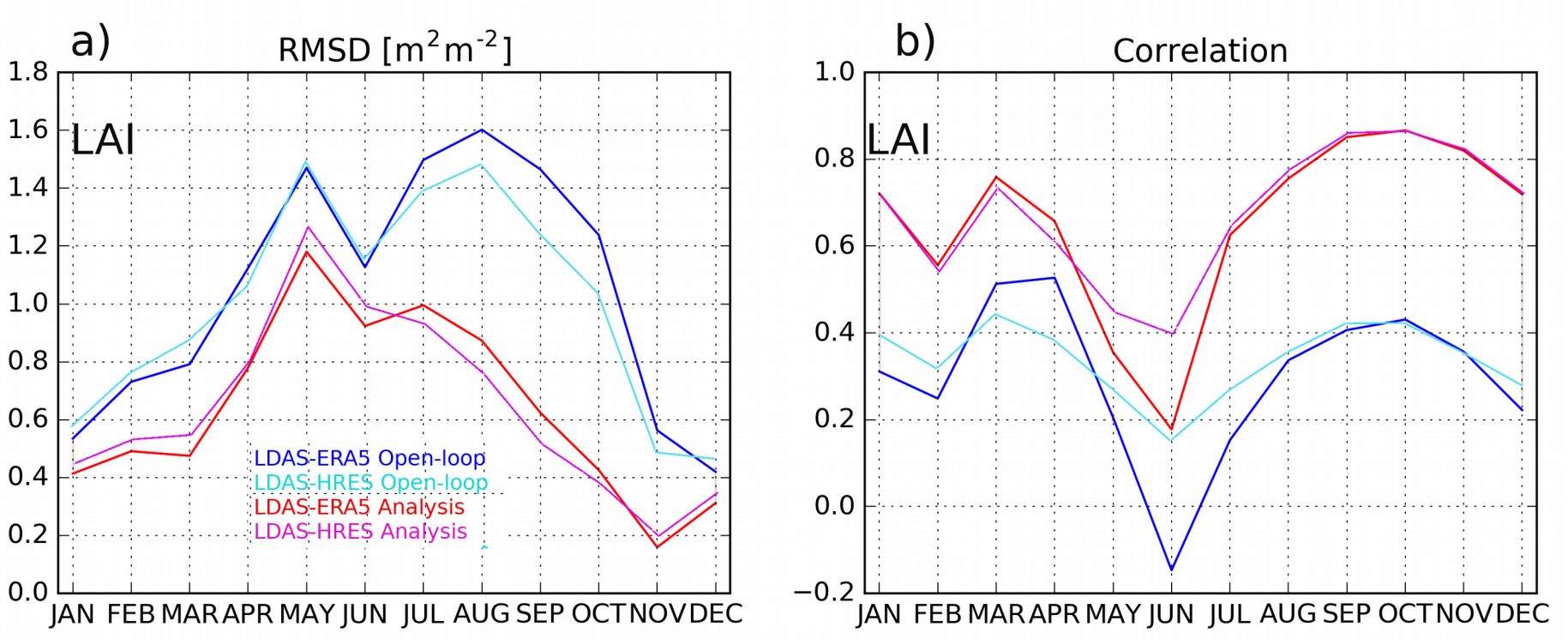


➔ Despite the spatial resolution, ERA5 production cycle (IFS Cycle 41r2) is still close to that of the HRES (IFS Cycle 41r2 to 43r3 from 2016 and 45r1 from June 2018)

Impact of the Summer 2018 heatwave on LSVs

LDAS-ERA5, LDAS-HRES

- 4 experiments: 2 analyses and their 2 openloops
- Seasonal scores over April 2016 to December 2018 : each experiments vs. LAI obs.

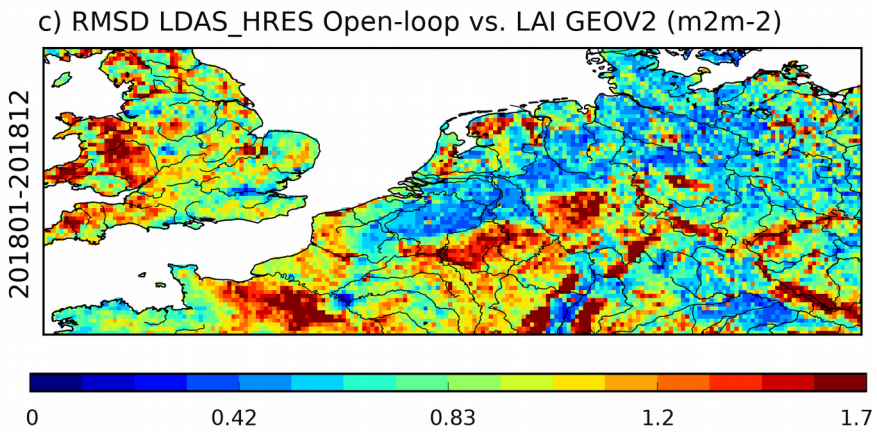


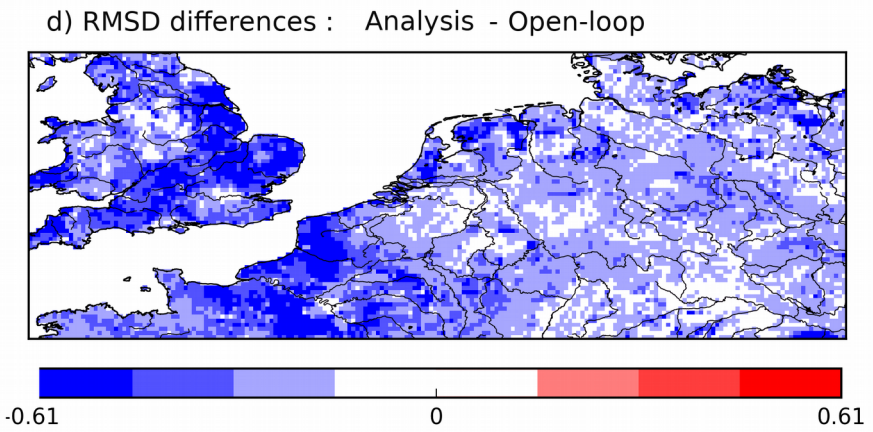
- ERA5 (blue) and HRES (cyan) driven open loop are comparable, HRES being better
- Analysis (red and pink) add skill to both which is indication of healthy behaviour

Impact of the Summer 2018 heatwave on LSVs

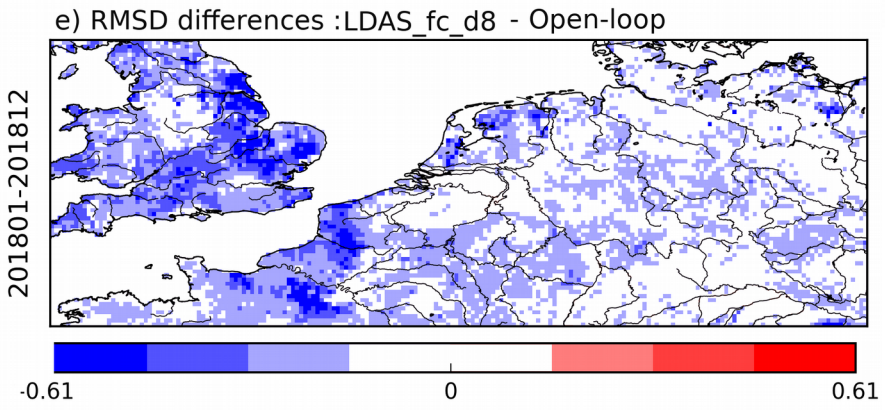
From monitoring to forecasting using LDAS-HRES (0.1°x0.1°):

- LAI forecast up to 8-days ahead (initialised by LDAS-Monde) vs. Openloop





82 % of the domain improved by the analysis



49 % of the domain improved by the forecast initialised by an analysis

➔Forecast experiment with up to 8-day lead time, initialised by the analysis, better than an open-loop!

➔Forecast of LSVs is also a matter of initial conditions!

Conclusions

LDAS-Monde: combining LSM, satellite EOs and atmospheric forcing

➔ Great potential to monitor and forecast the impact of extreme weather on LSVs

➔ Global LDAS-Monde provides a model climate as reference for anomalies of LSVs

➔ Significant anomalies trigger more detailed monitoring and forecasting activities

LDAS-Monde ready for use in various applications

➔ Reanalyses of land ECVs

➔ Water resource / drought / vegetation monitoring

➔ Detection of severe conditions over land and initialisation of LSVs forecast

Open LDAS-Monde freely available:
https://opensource.umr-cnrm.fr/projects/openldasmonde
contact: clement.albergel@meteo.fr @CAlbergel

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