Monitoring and Forecasting the Impact of the 2018 Summer Heatwave on Vegetation

Albergel C.[1], E. Dutra[2], B. Bonan[1], Y. Zheng[1], S. Munier[1], G. Balsamo[3], P. de Rosnay[3], J. Muñoz-Sabater[3] and J.-C. Calvet[1]

1 CNRM - Université de Toulouse, Météo-France, CNRS, Toulouse, France
2 Instituto Dom Luiz, IDL, Faculty of Sciences, University of Lisbon, Portugal
3 ECMWF, Reading, UK

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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

- 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

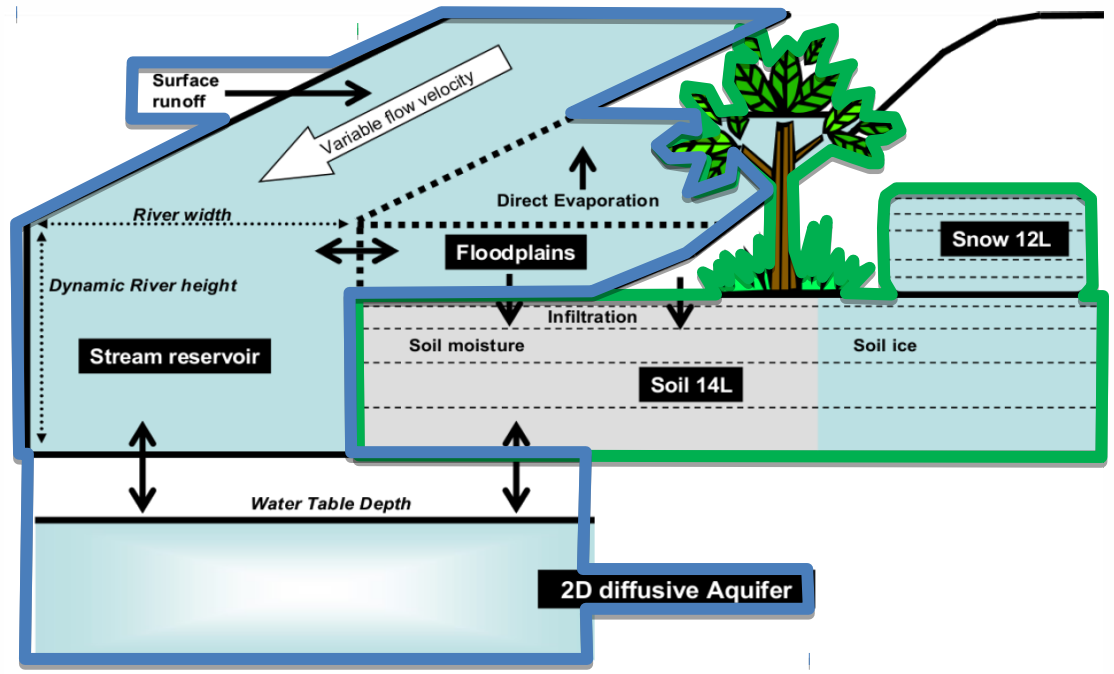
LDAS-Monde: Global capacity offline integration of satellite observations into a land surface model fully coupled to hydrology

LDAS-Monde involves:

- Land surface model : **ISBA-A-gs** (Interaction Sol-Biosphere-Atmosphere)
- River routing system: **CTRIP** (CNRM version of Total Runoff Integrating Pathways)
- Data assimilation routines (SEKF, EnSRF*, PF)

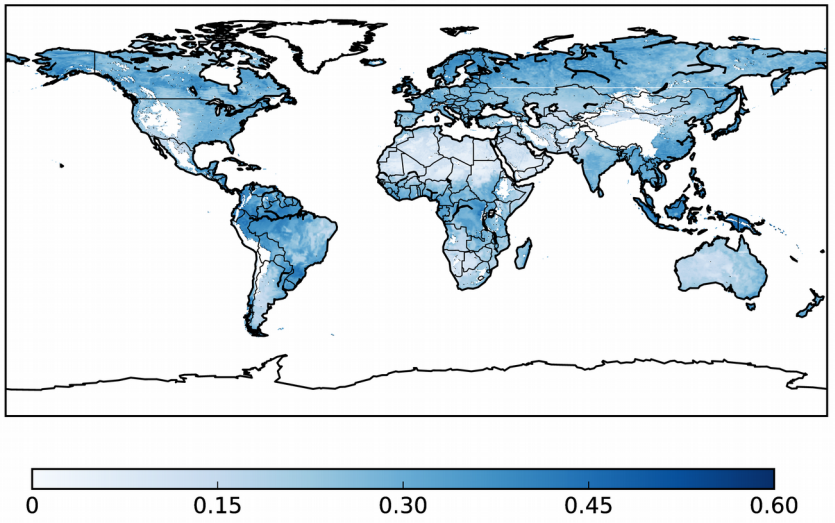
LDAS-Monde is open-source

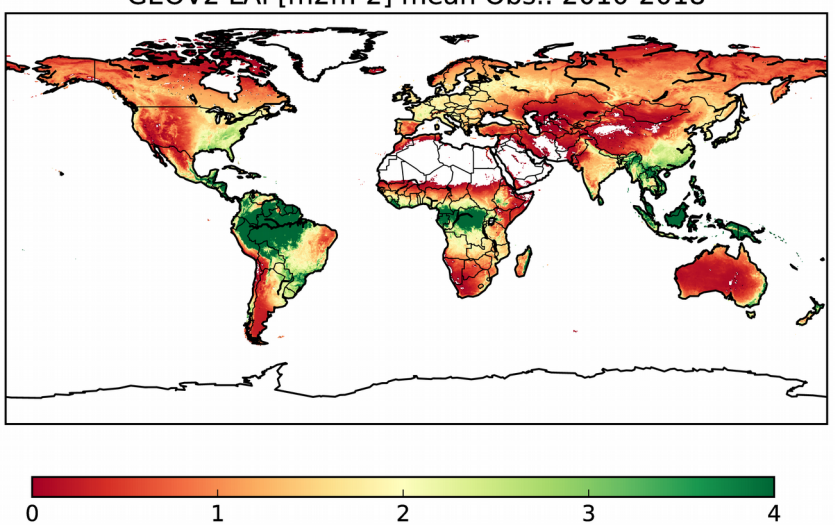
*Bonan et al., EGU2019-14804



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 SWI + cdf matching) **LAI** (CGLS)	**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 *[expressed by the SEKF Jacobians]*
- Other variables are indirectly modified through biophysical processes and feedbacks in the model

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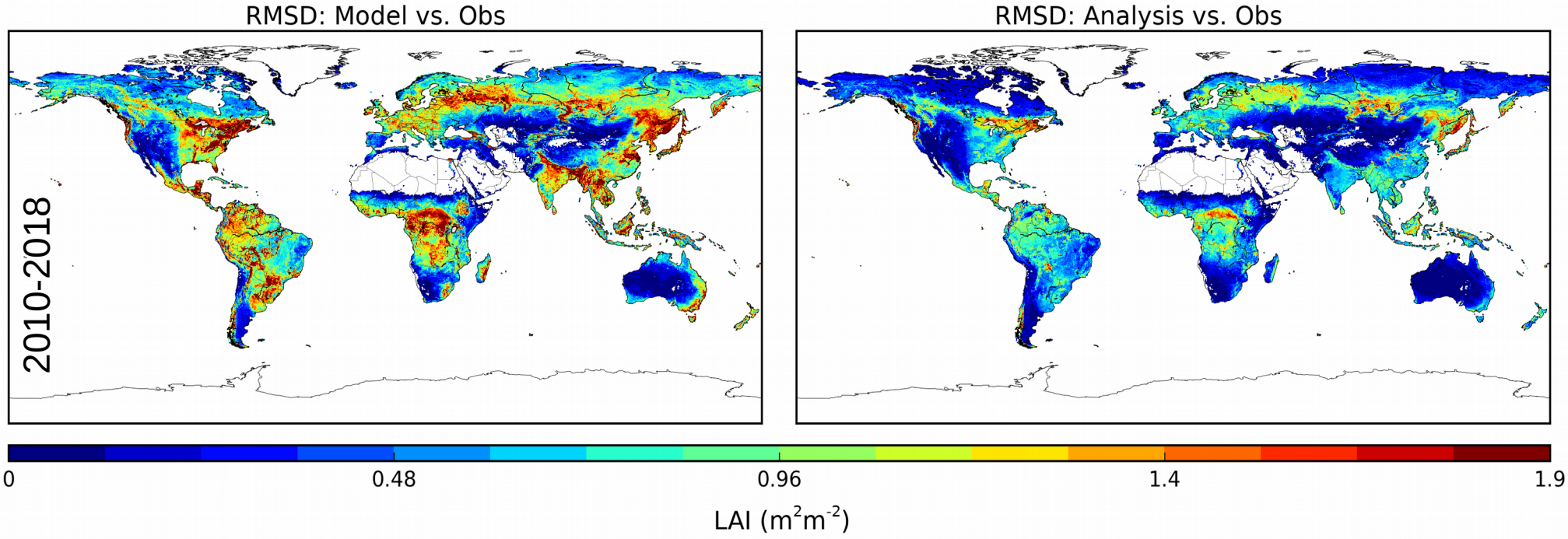
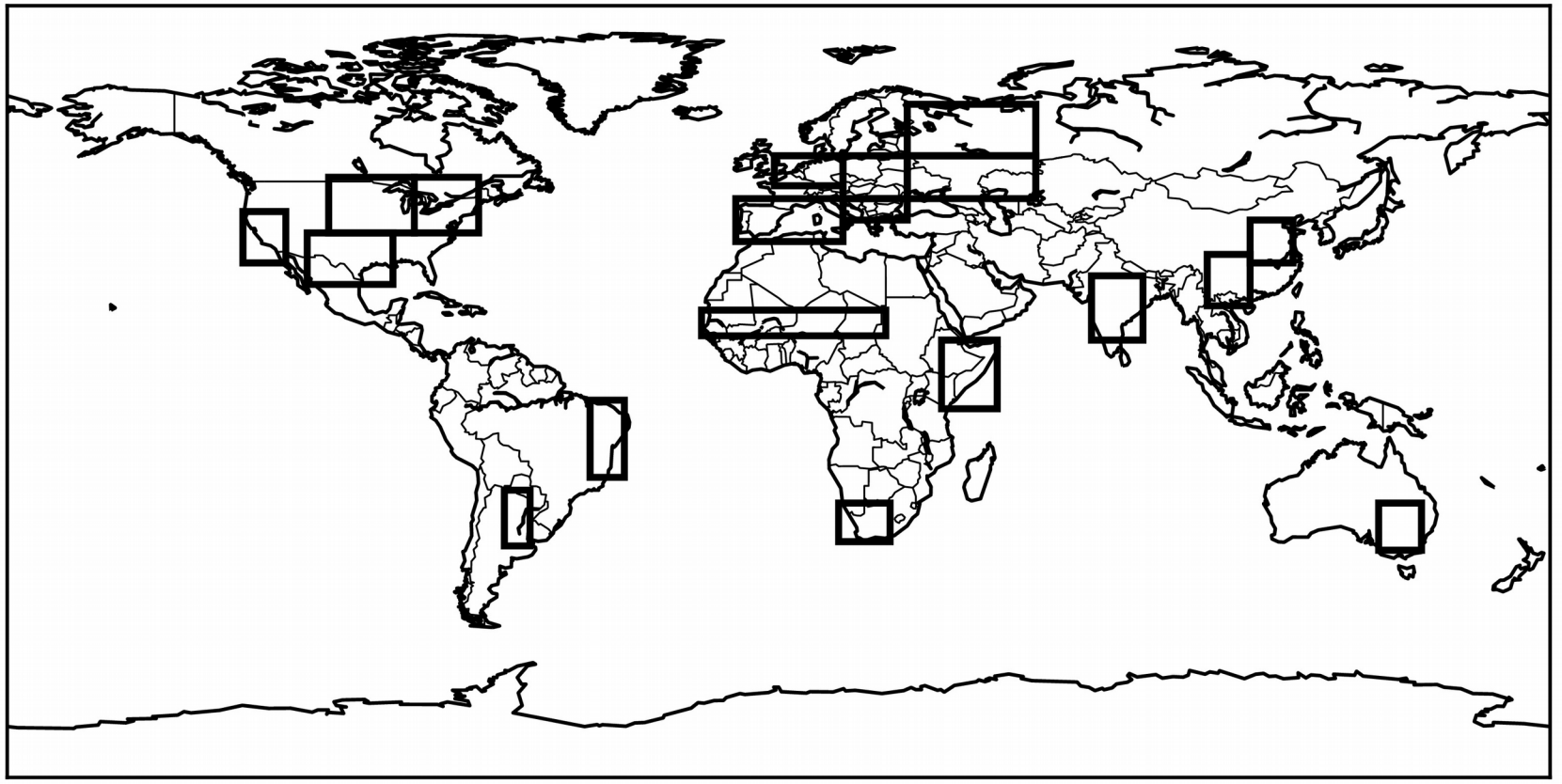
2 LDAS-ERA5 experiments : Model (no assimilation) and Analysis (assimilation)



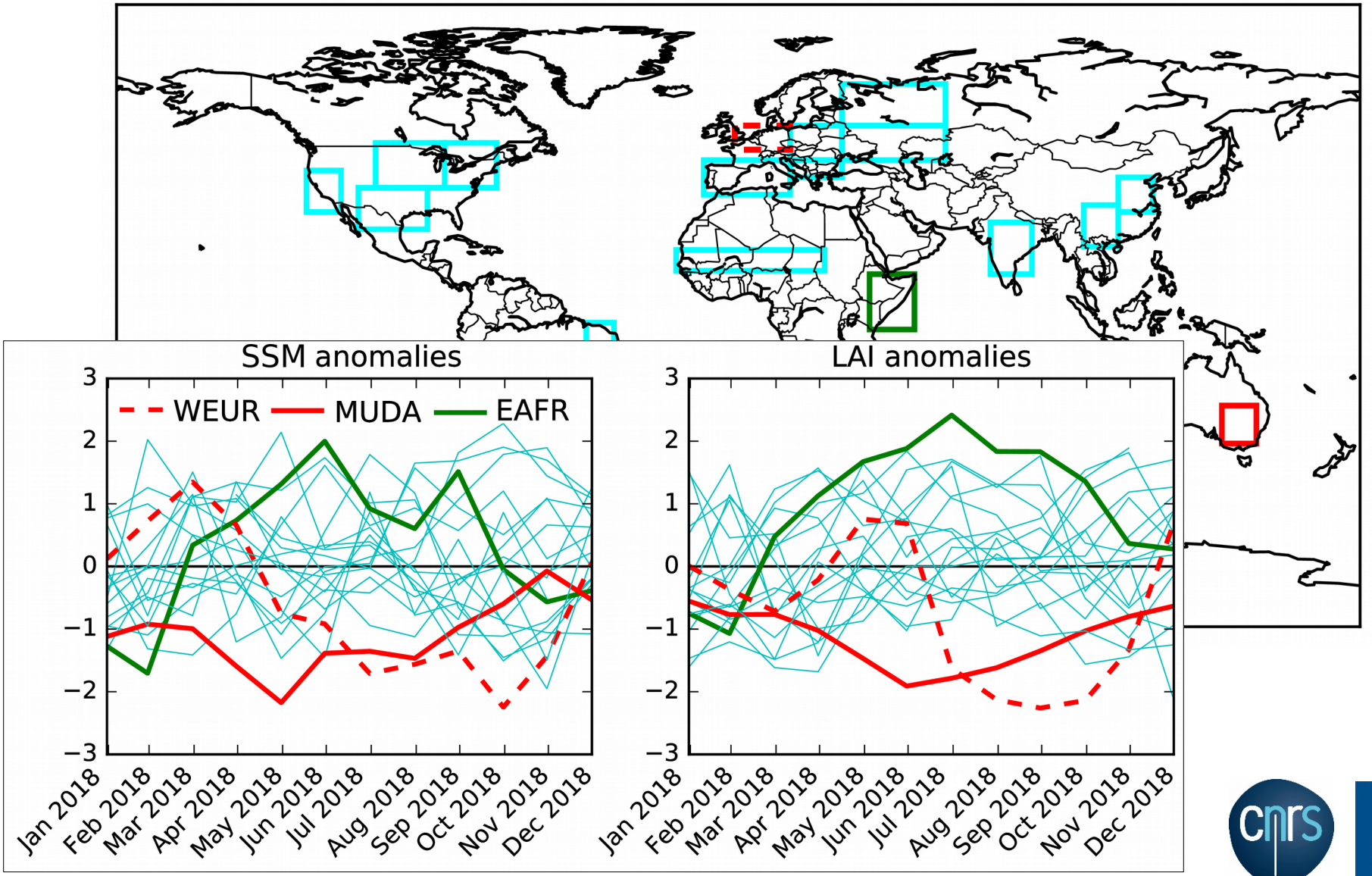
LDAS-Monde goes global

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



LDAS-Monde goes global

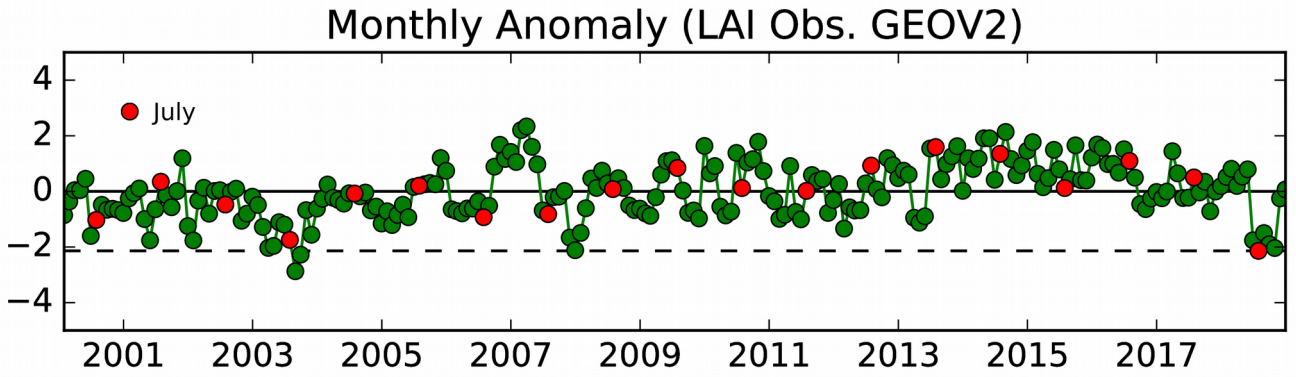
Monthly anomalies for 2018 with respect to 2010-2018

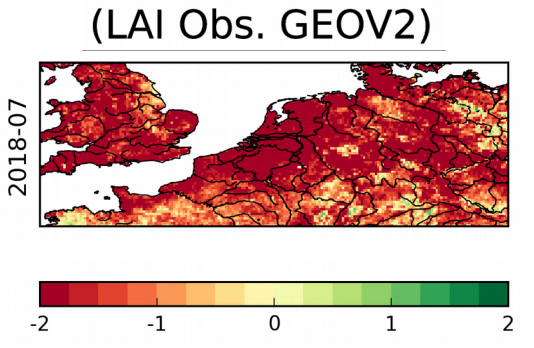


Impact of the Summer 2018 heatwave on LSVs

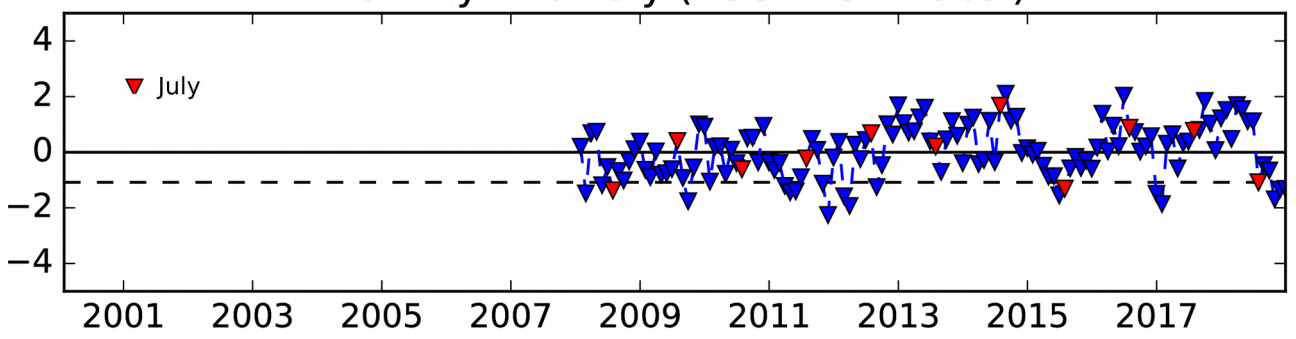
The Earth Observations point of view: *CGLS GEOV2 and SWI*
Monthly anomaly (scaled by stdv)

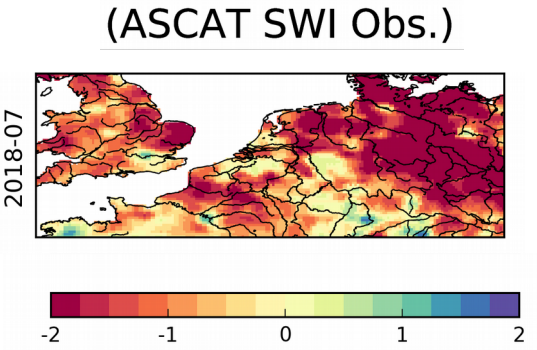
a)





b)

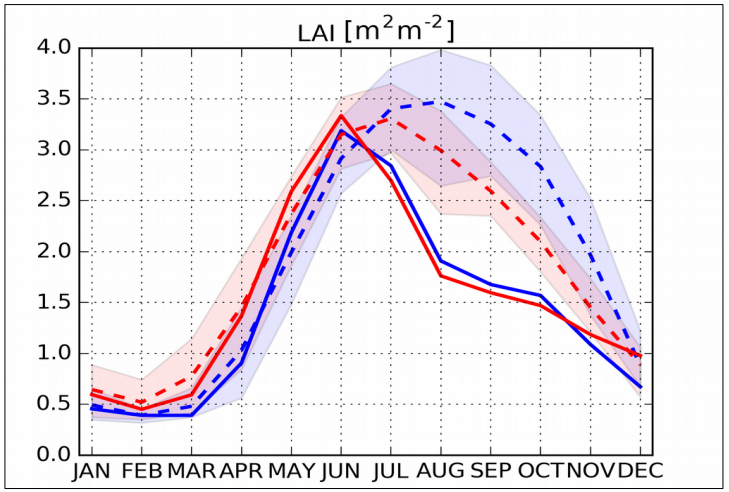


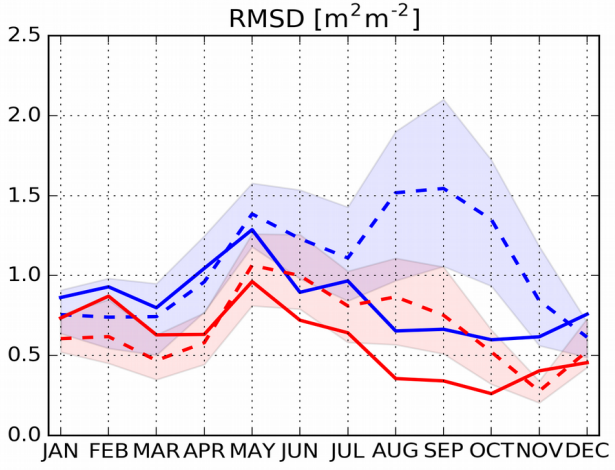


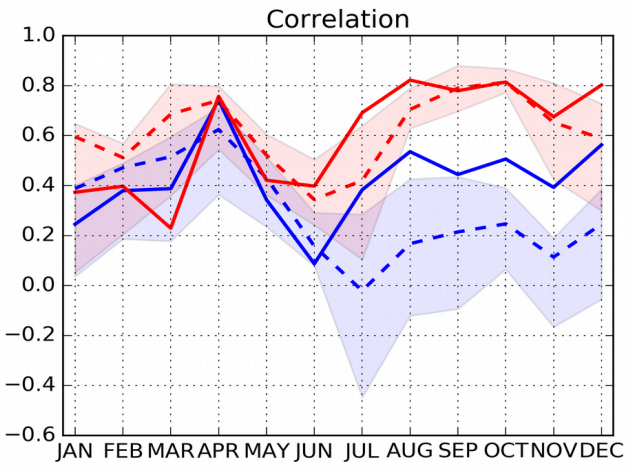
Impact of the Summer 2018 heatwave on LSVs

LDAS-Monde : Leaf Area Index

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







- Seasonal cycles:

➔ 2018 quite different from 2010-2017

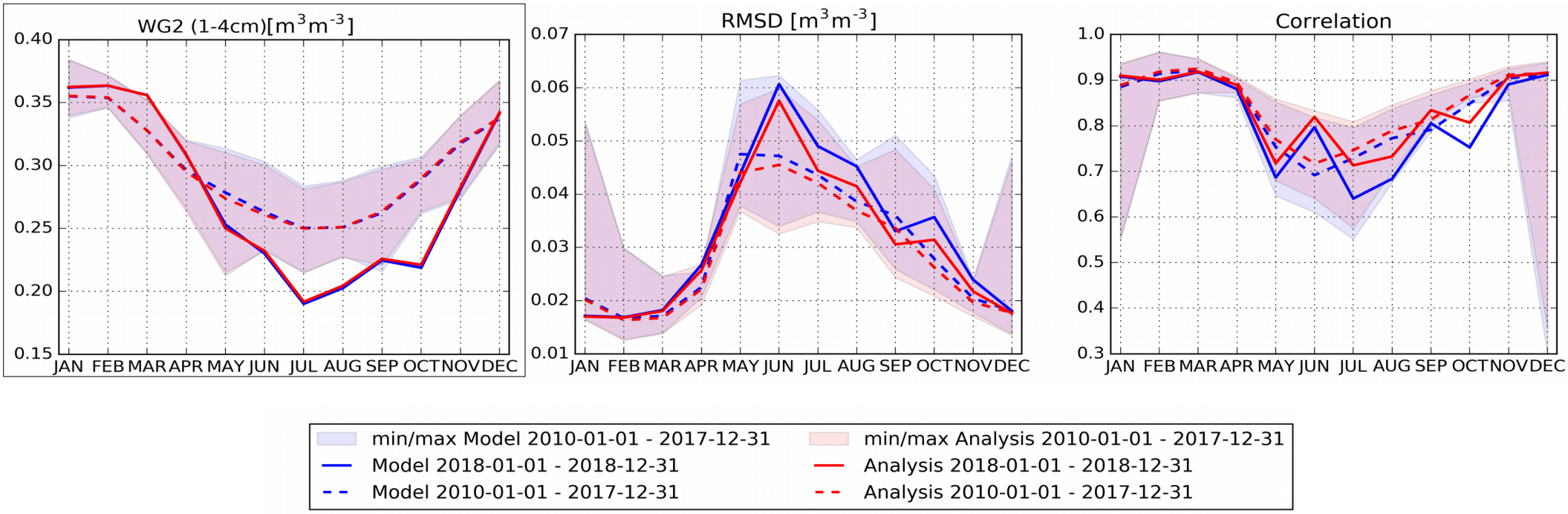
➔ smaller differences between Model and Analysis for 2018 than for 2010-2017 (True for RMSD and R values as well)

- 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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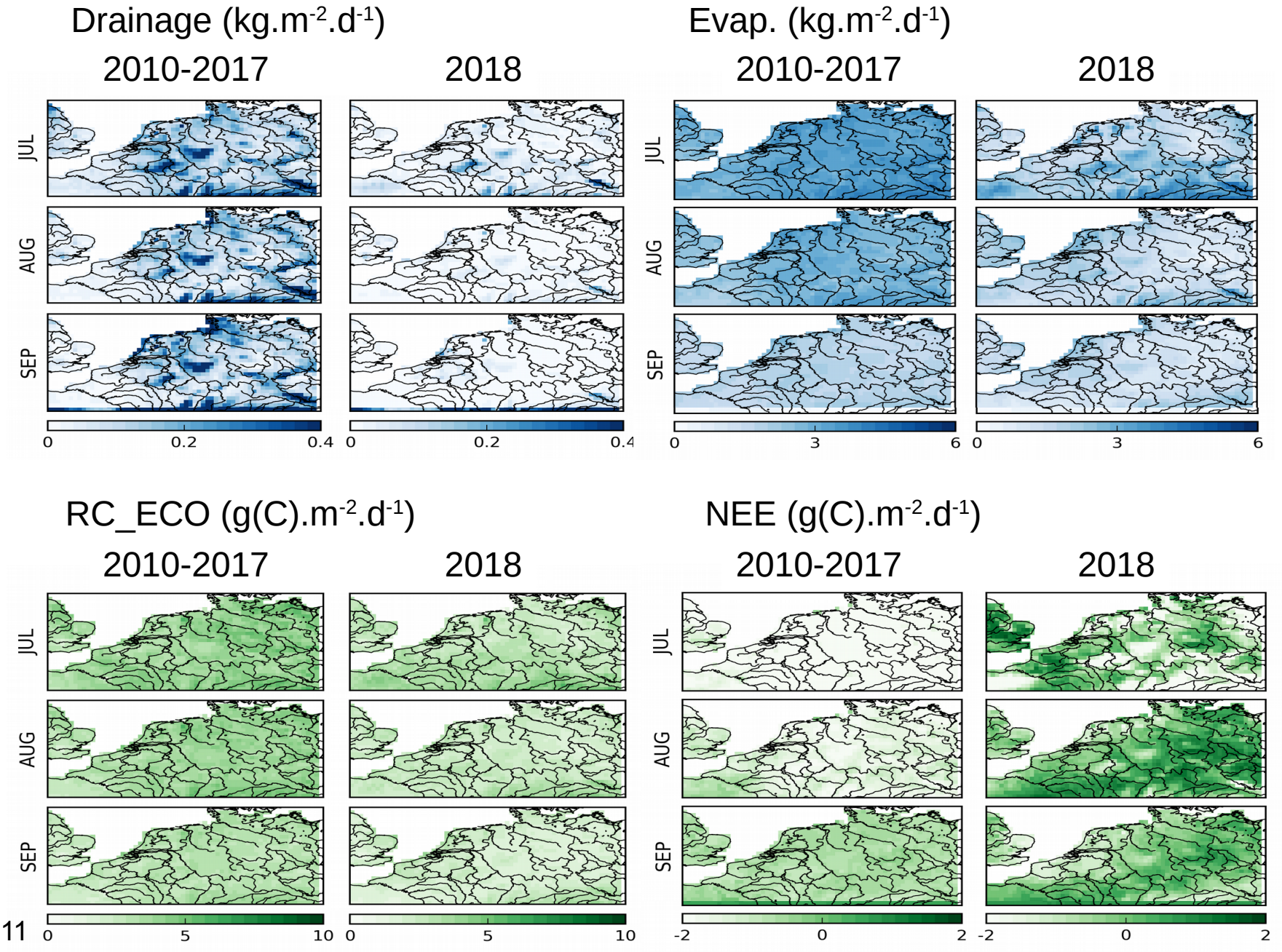
Impact of the Summer 2018 heatwave on LSVs

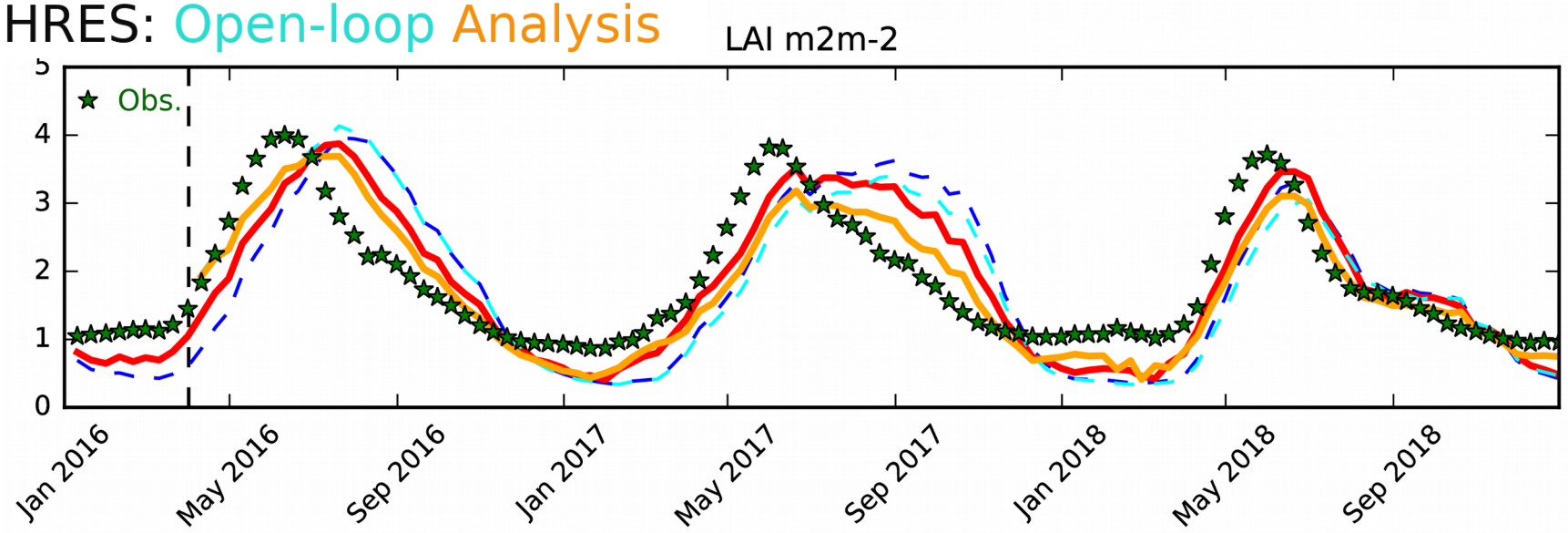


Impact of the Summer 2018 heatwave on LSVs

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

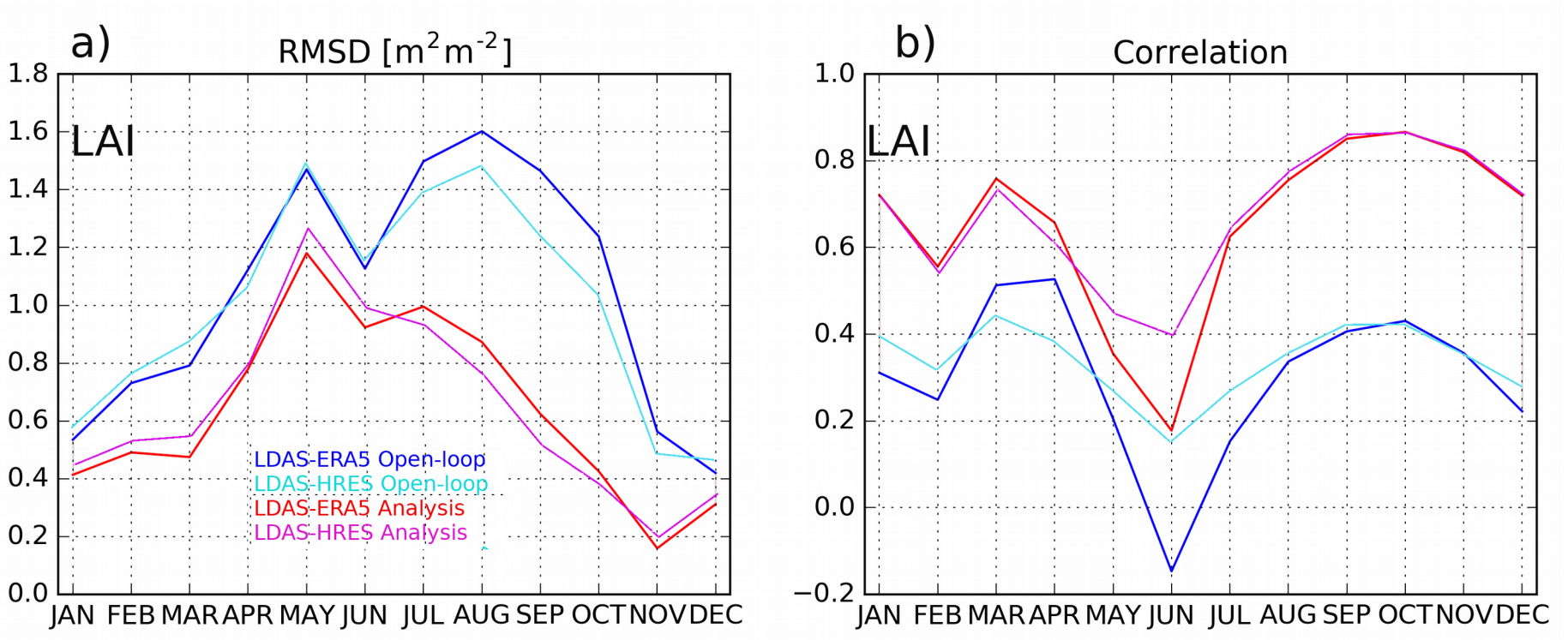


➔ Despite the spatial resolution, ERA5 production cycle (IFS Cycle 41r2) is still close to that of the HRES (IFS Cycle 41r2 to 43r3 from 2016 and 45r1 from June 2018)

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.

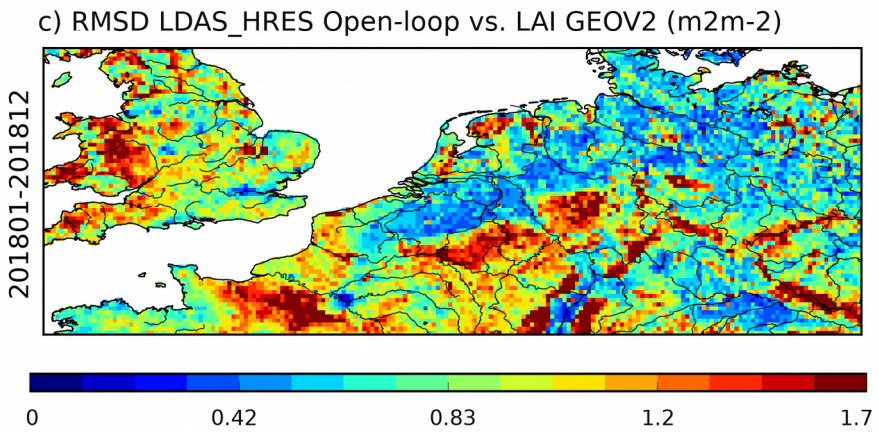


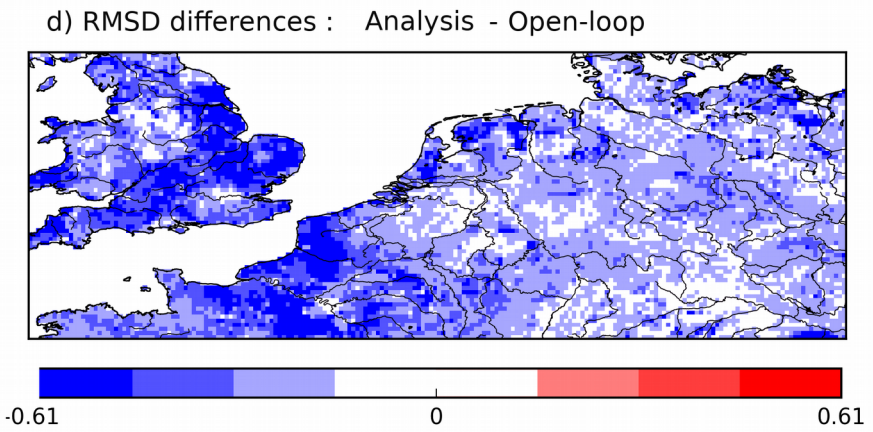
- ERA5 (blue) and HRES (cyan) driven open loop are comparable, HRES being better
- Analysis (red and pink) add skill to both which is indication of healthy behaviour

Impact of the Summer 2018 heatwave on LSVs

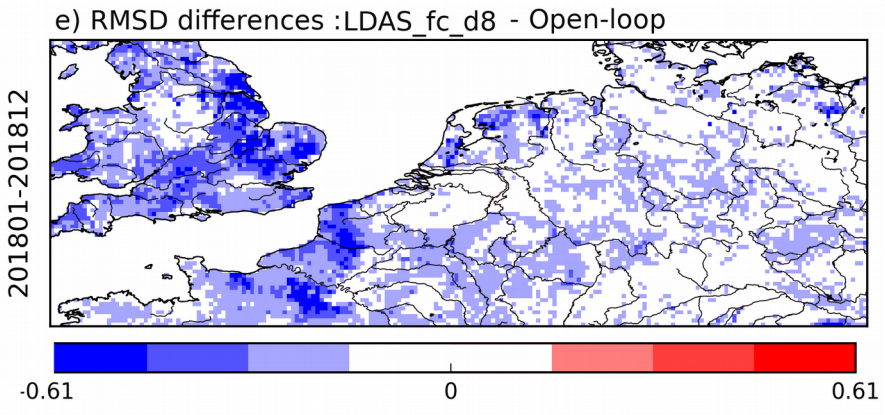
From monitoring to forecasting using LDAS-HRES (0.1°x0.1°):

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





82 % of the domain presents lower RMSD values



49 % of the domain presents lower RMSD values

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

➔ Forecast of LSVs is also a matter of initial conditions

Conclusions

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

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

Global long term 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

➔ Initialisation of the forecast of land surface variables

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

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Guest Editor

Dr. Clement Albergel

Météo-France/CNRS, 42, Av. G. Coriolis31057 Toulouse Cedex 1, France

Website 1 | Website 2 | E-Mail

Interests: land surface modelling; remote sensing; data assimilation

Guest Editor

Dr. Emanuel Dutra

Instituto Dom Luiz, IDL, Faculty of Sciences, University of Lisbon, FCUL, Campo Grande, Lisbon, Portugal

Website | E-Mail

Interests: meteorology; hydrology; numerical weather prediction; climate modeling

Guest Editor

Dr. Sujay Kumar

Hydrological Sciences Lab, NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD, 21042, USA

Website | E-Mail

Interests: land surface modeling, data assimilation, remote sensing, high-performance computing, machine learning

Guest Editor

Dr. Christoph Rüdiger

Department of Civil Engineering, Faculty of Engineering, 23 College Walk, Monash University, VIC 3800, Australia (Clayton campus)

Website | E-Mail

Interests: soil moisture; remote sensing; hydrology; climate change

Guest Editor

Dr. Dongryeol Ryu

Department of Infrastructure Engineering, Melbourne School of Engineering, The University of Melbourne, Victoria 3010, Austrilia

Website | E-Mail

Phone: +61-3-8344-7115

Interests: remote sensing; hydrological modelling; land surface processes; environmental data analysis; scientific data visualisation; woodwork

Guest Editor

Dr. Nemesio Rodriguez-Fernandez

Centre d'Etudes Spatiales de la Biosphère (CESBIO), Centre National de la Recherche Scientifique (CNRS), 18 avenue. Edouard Belin, bpi 2801, 31401 Toulouse cedex 9, France

Website | E-Mail

Phone: +33 561 55 8577

Interests: microwave remote sensing; soil moisture; biomass; interferometry; neural networks; data assimilation