Data assimilation for continuous global assessment of severe conditions over terrestrial surfaces

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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

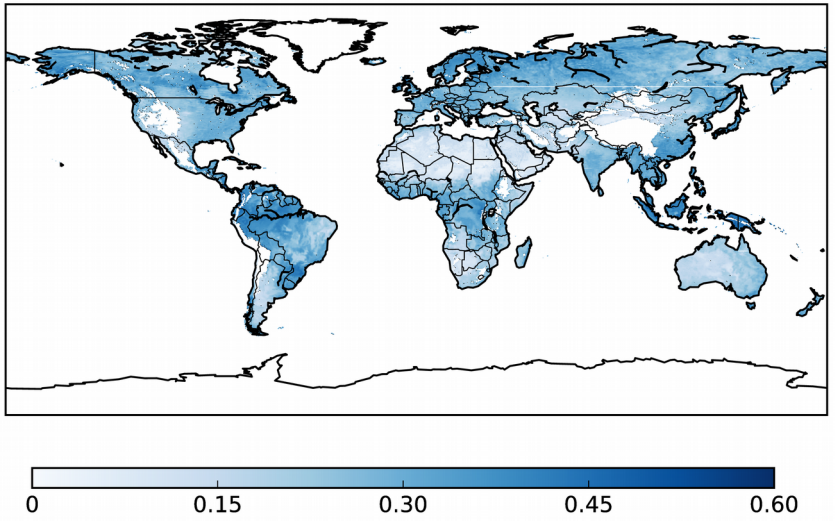
- **Land surface model: ISBA-A-gs**, simulates the diurnal cycle of water and carbon fluxes, plant growth and key vegetation variables
- **River routing system: CTRIP** (CNRM version of Total Runoff Integrating Pathways)
- **Data assimilation routines** (SEKF, EnSRF, PF)

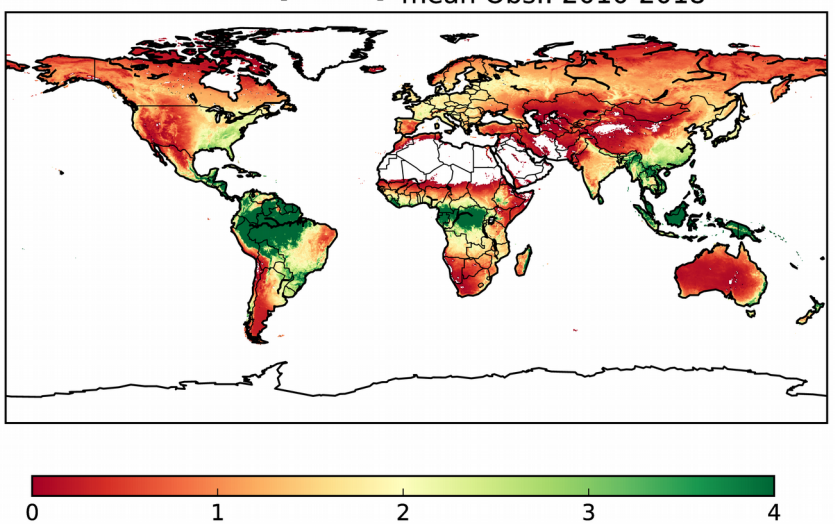
LDAS-Monde successfully validated at regional/continental scale

- 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, *RS*)
- Sun-Induced Fluorescence (vs. GPP, e.g. Leroux et al., 2018, *RS*, Tall et al., 2019, *RS*)

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° (LDAS-ERA5)**	**SEKF**	**SSM** (CGLS ASCAT SWI* + cdf matching) **LAI** (CGLS GEOV1*)	**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

*https://land.copernicus.eu/global/

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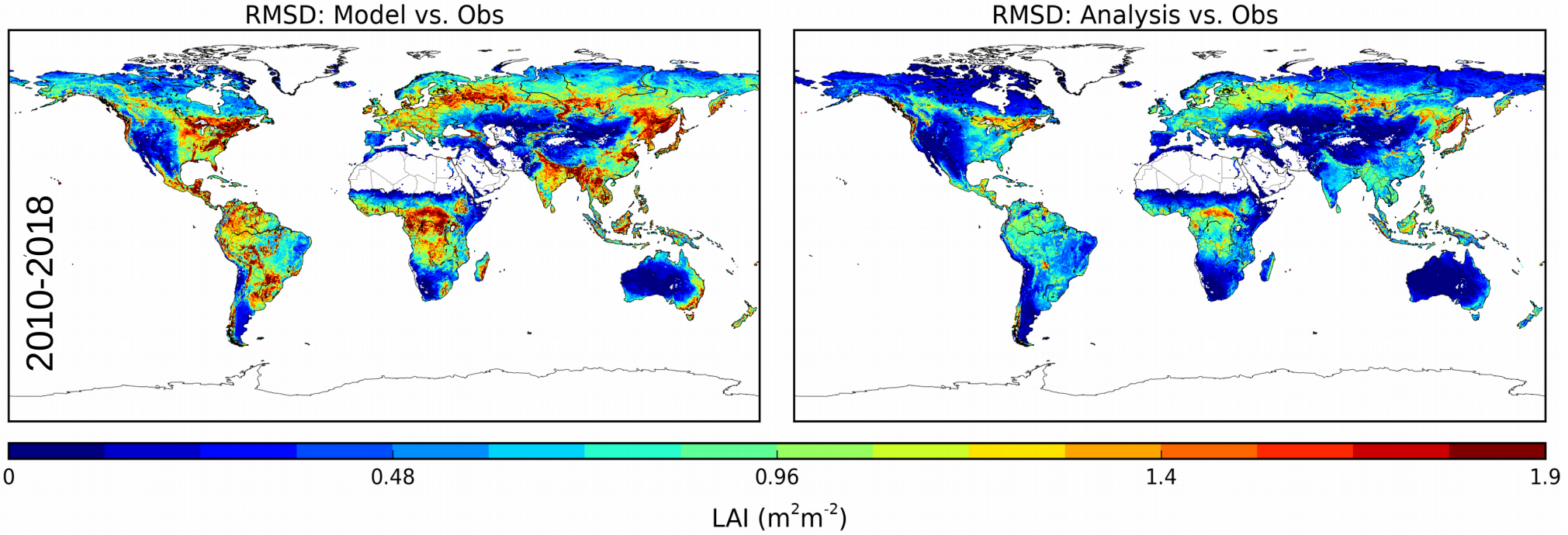
2 LDAS-ERA5 experiments : Model/Open-loop (no assimilation) and Analysis (assimilation)



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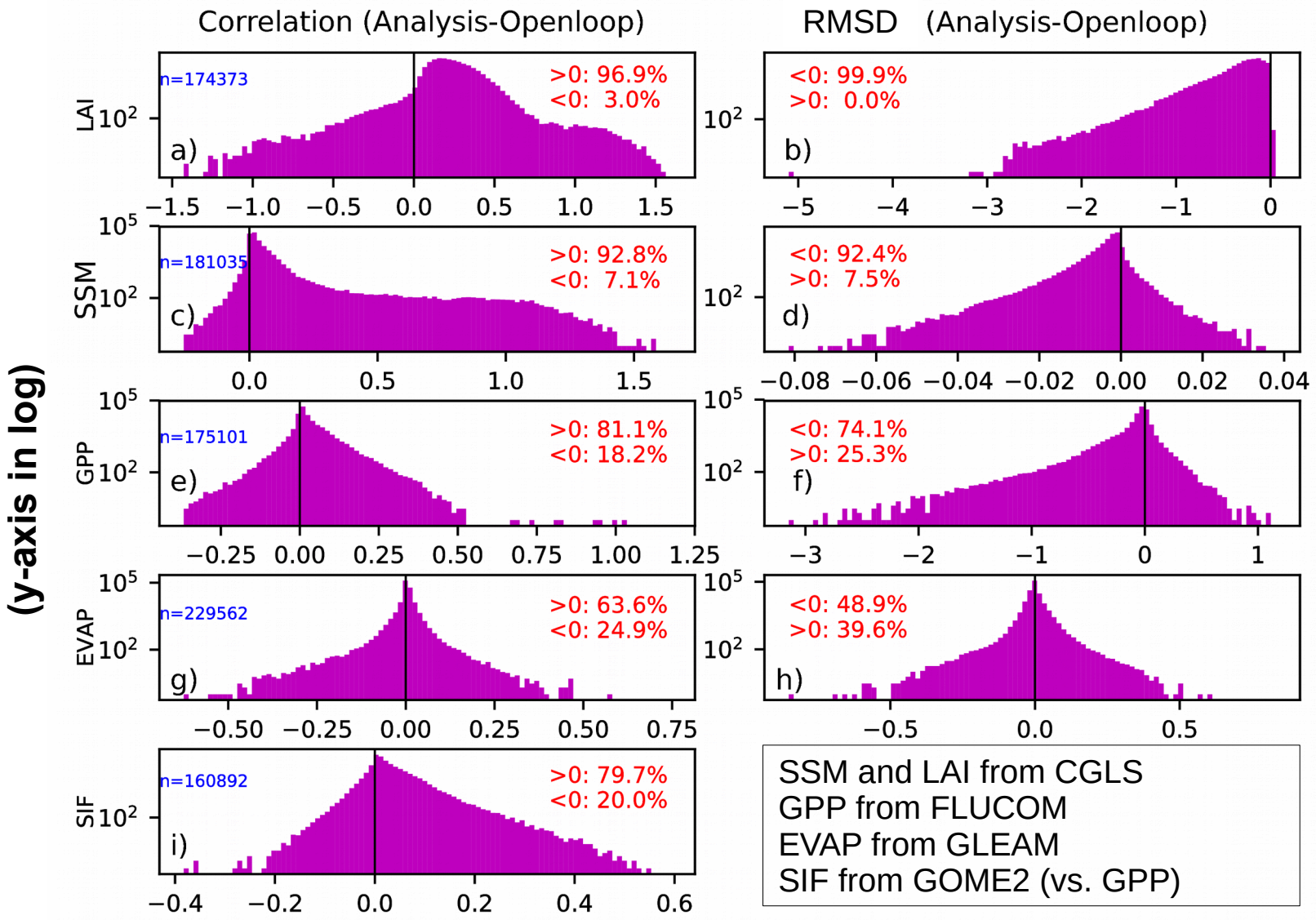
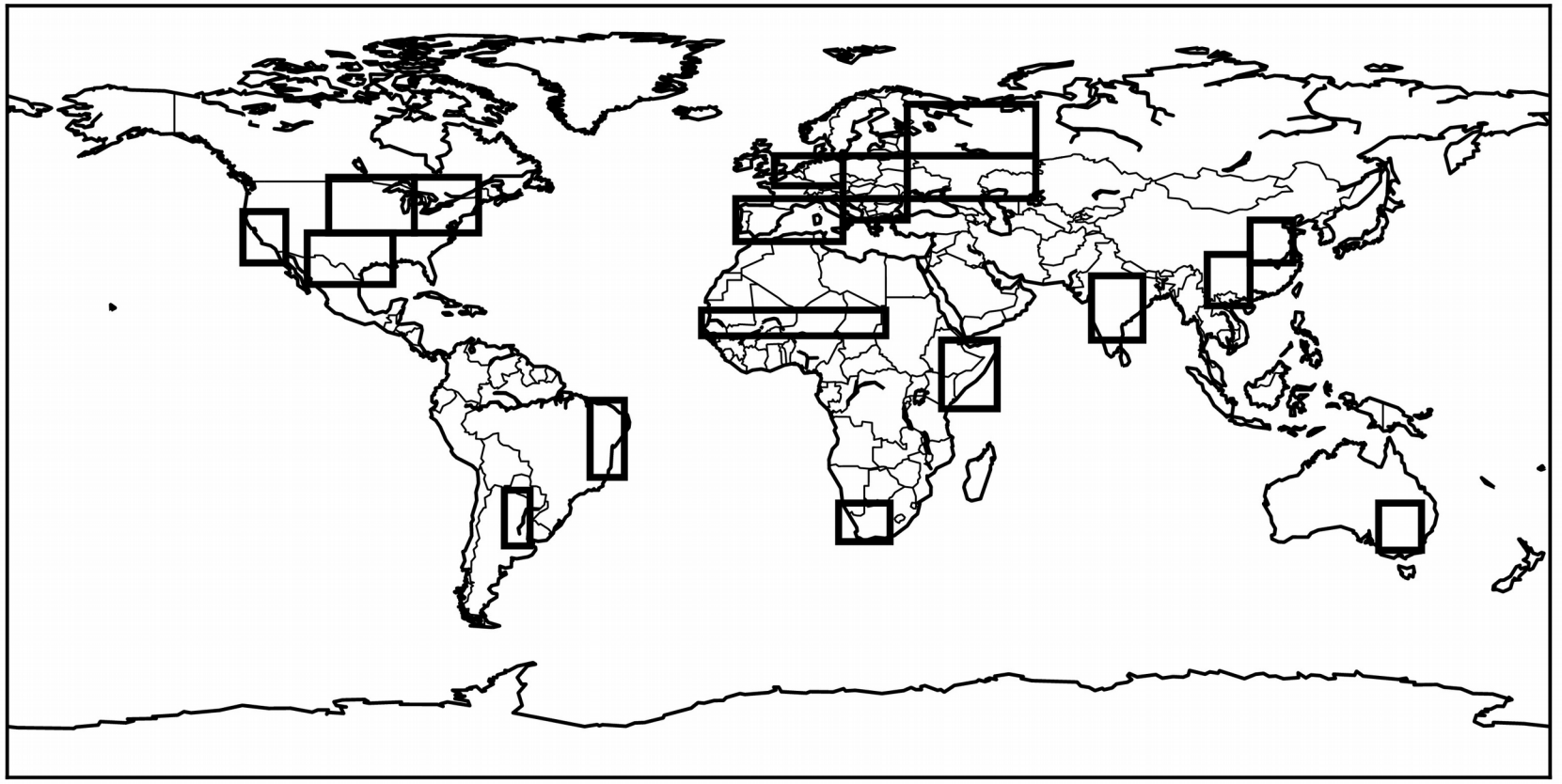
LDAS-Monde global evaluation (in a nutshell!)

Histograms of score differences: Analysis – Openloop (Correlation, RMSD)



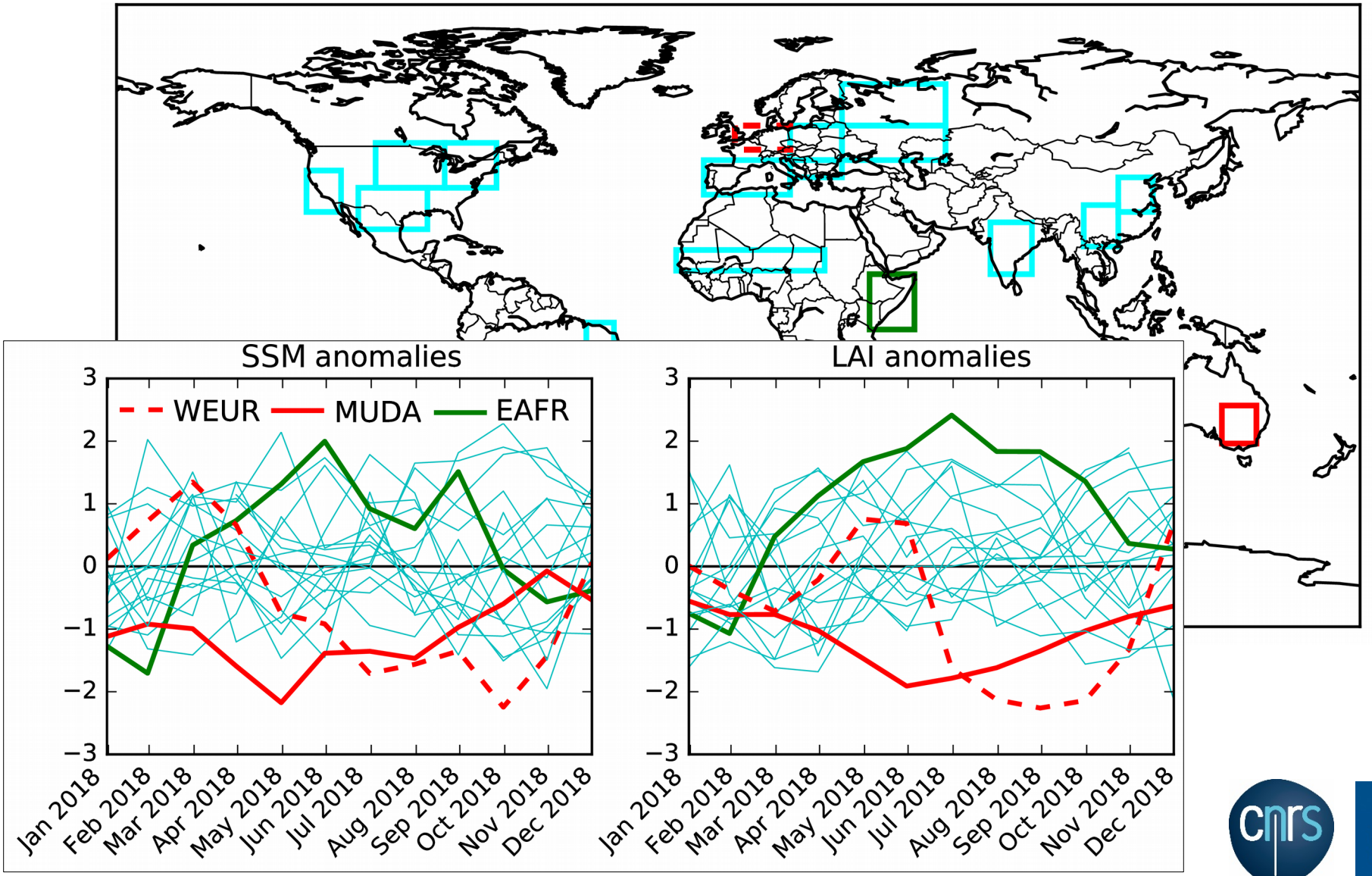
LDAS-Monde goes global

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



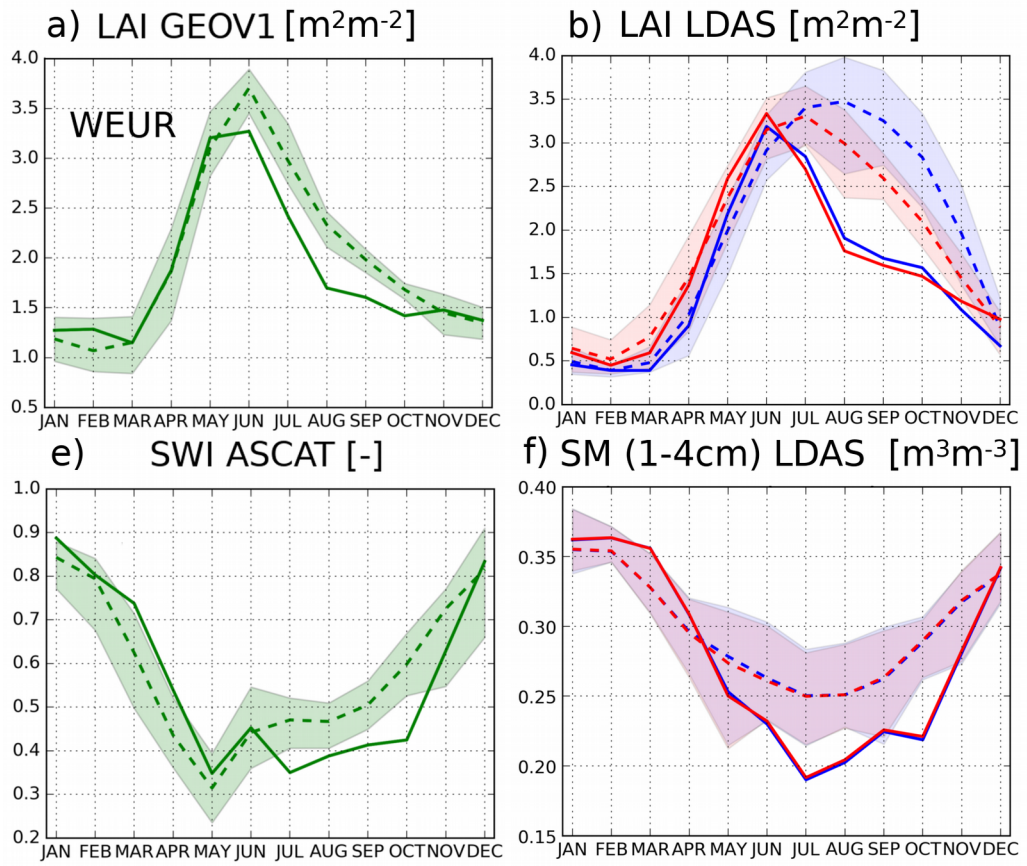
LDAS-Monde goes global

Monthly anomalies for 2018 with respect to 2010-2018



Impact of the 2018 heatwave on LSVs : WEUR

LDAS-Monde : Leaf Area Index (top) and soil Moisture (bottom)



Seasonal cycles:

- Obs., Model, Analysis : 2018 quite different from 2010-2017
- smaller differences between Model and Analysis for 2018 than for 2010-2017

min/max Obs. 2010-01-01 - 2017-12-31
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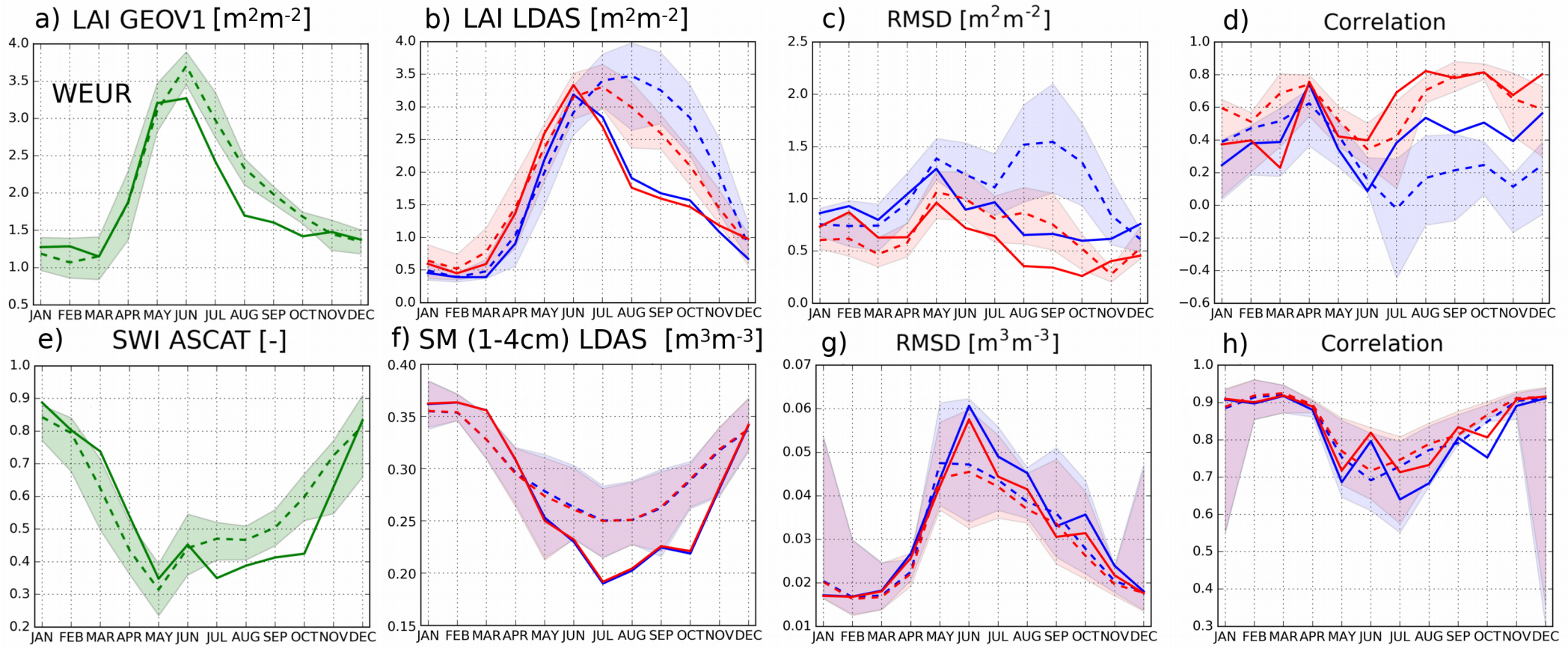
Analysis improvements over Model simulation



Impact of the 2018 heatwave on LSVs : MUDA

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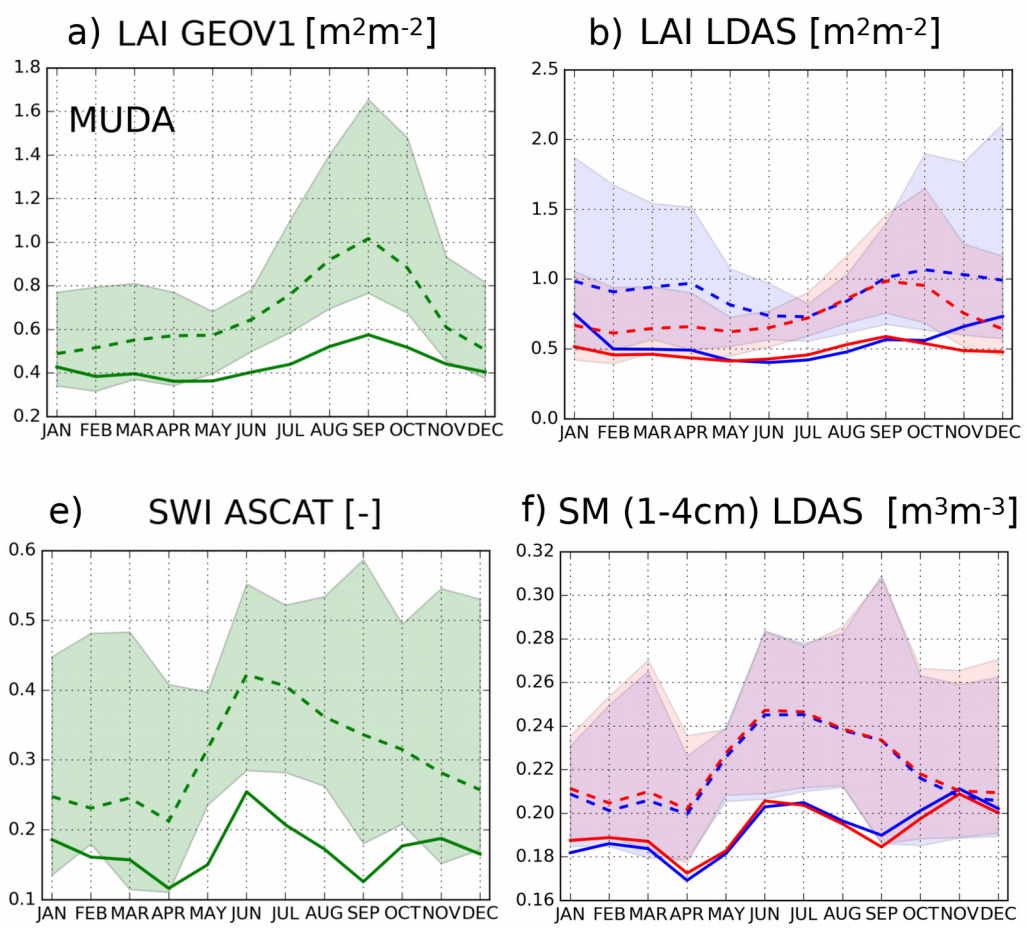

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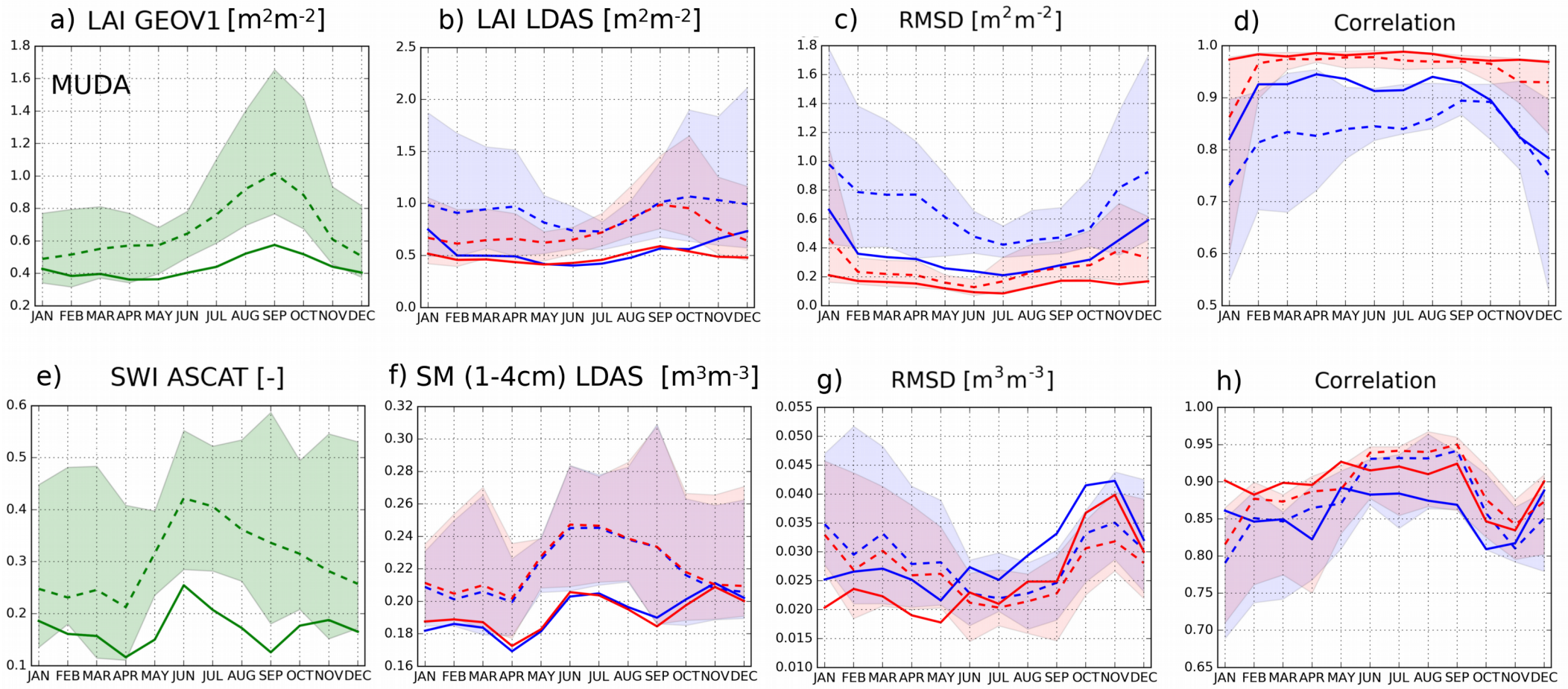
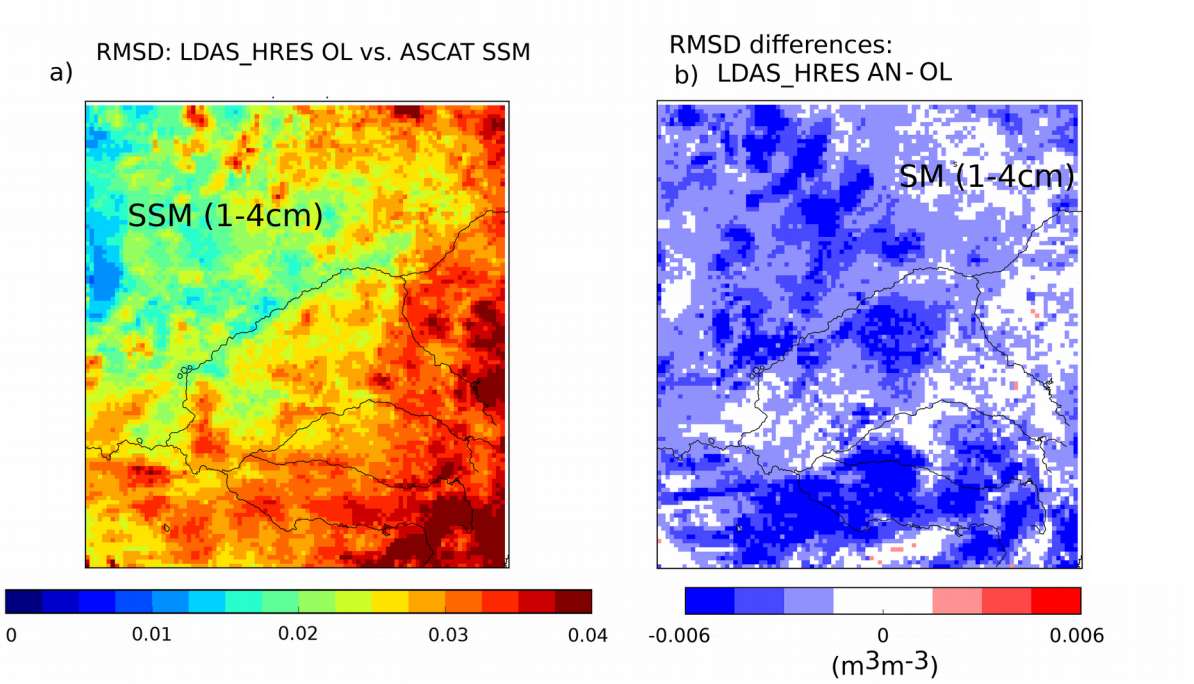


Impact of the 2018 heatwave on LSVs : MUDA

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°)



- SSM: strong positive impact from the analysis

Impact of the 2018 heatwave on LSVs : MUDA

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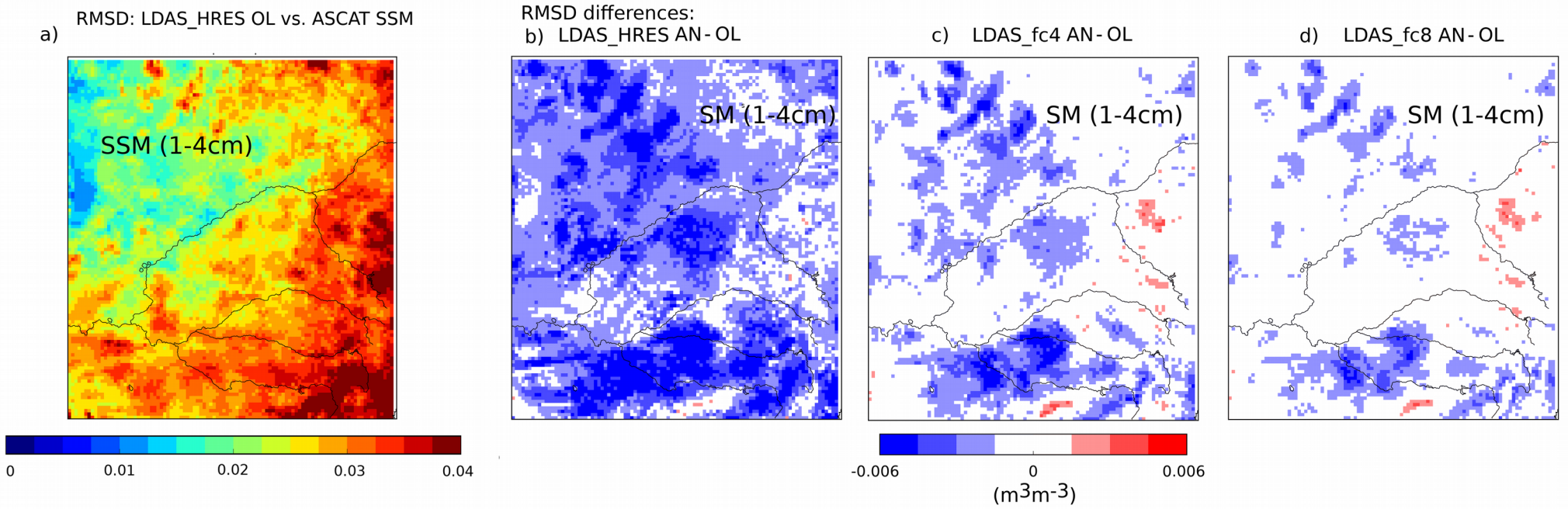

- SSM: strong positive impact from the analysis, impact of initialisation seems to vanish quickly

Impact of the 2018 heatwave on LSVs : MUDA

Such an extreme event needs more attention!

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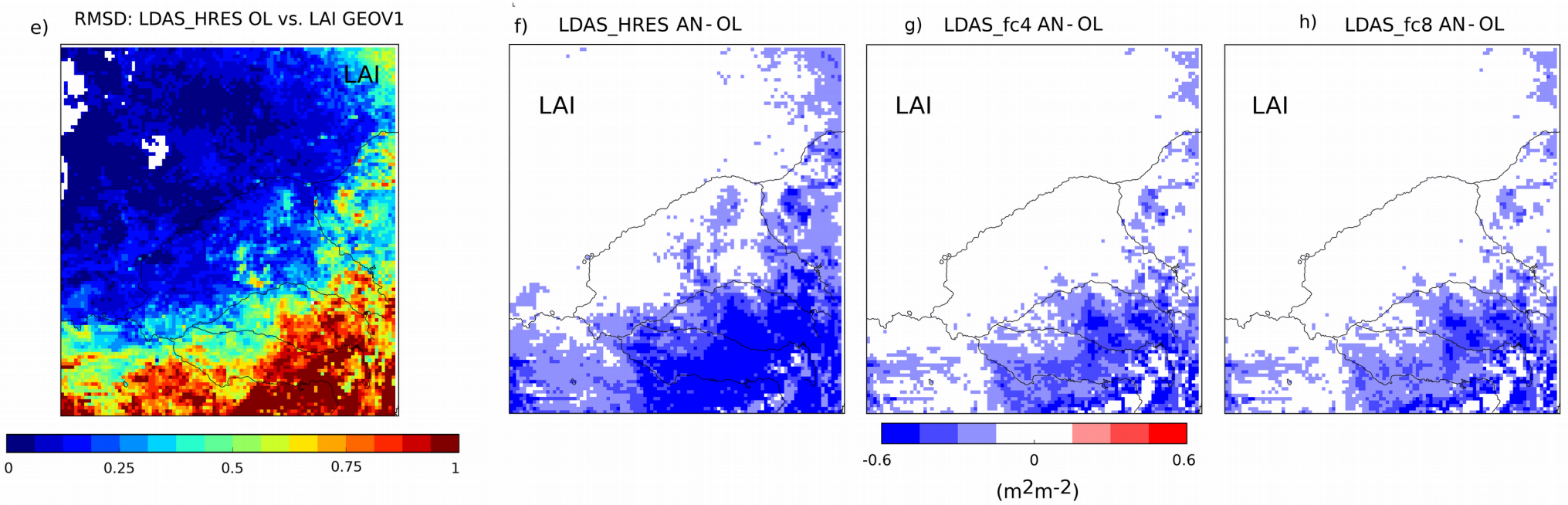
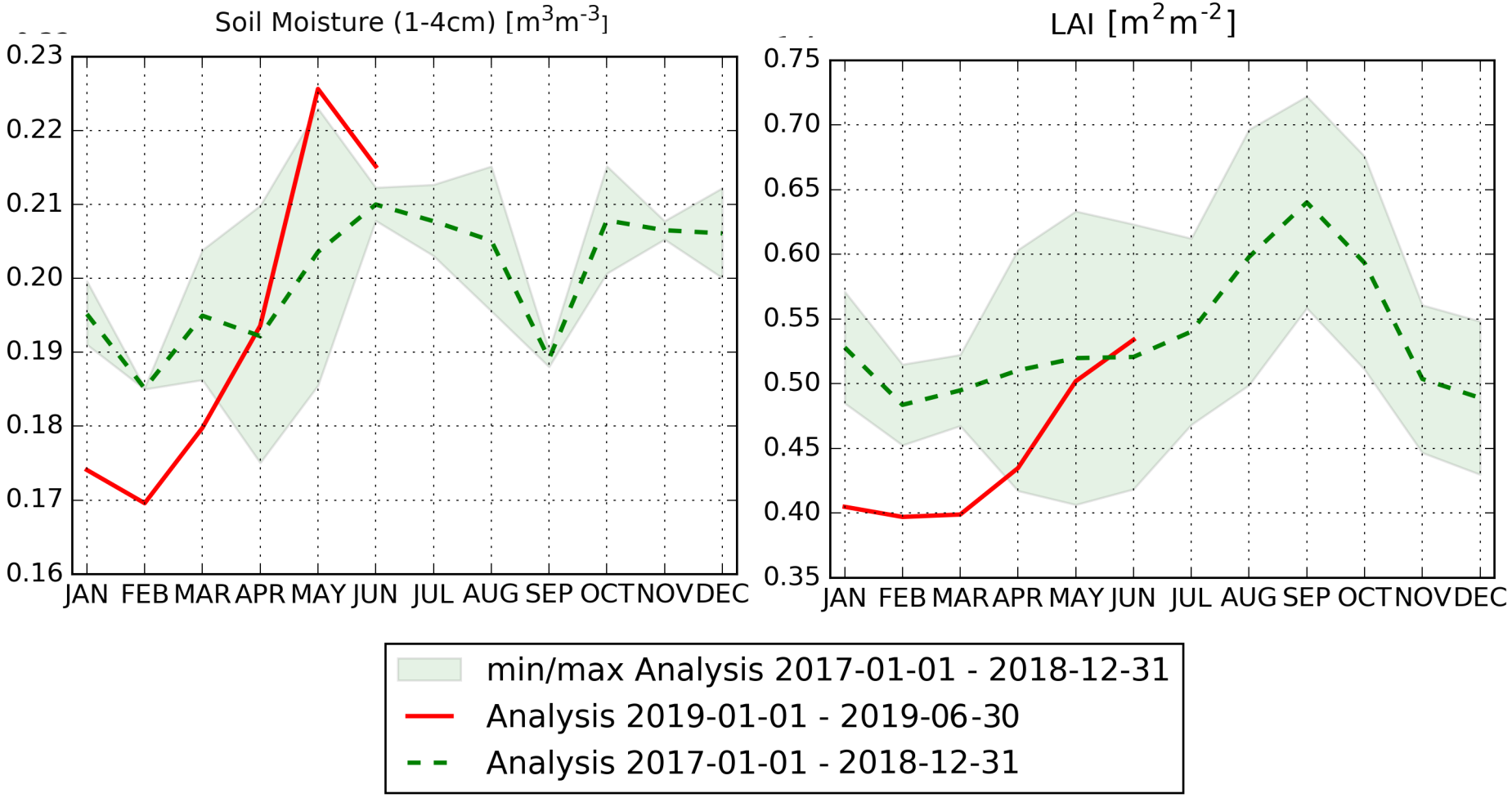


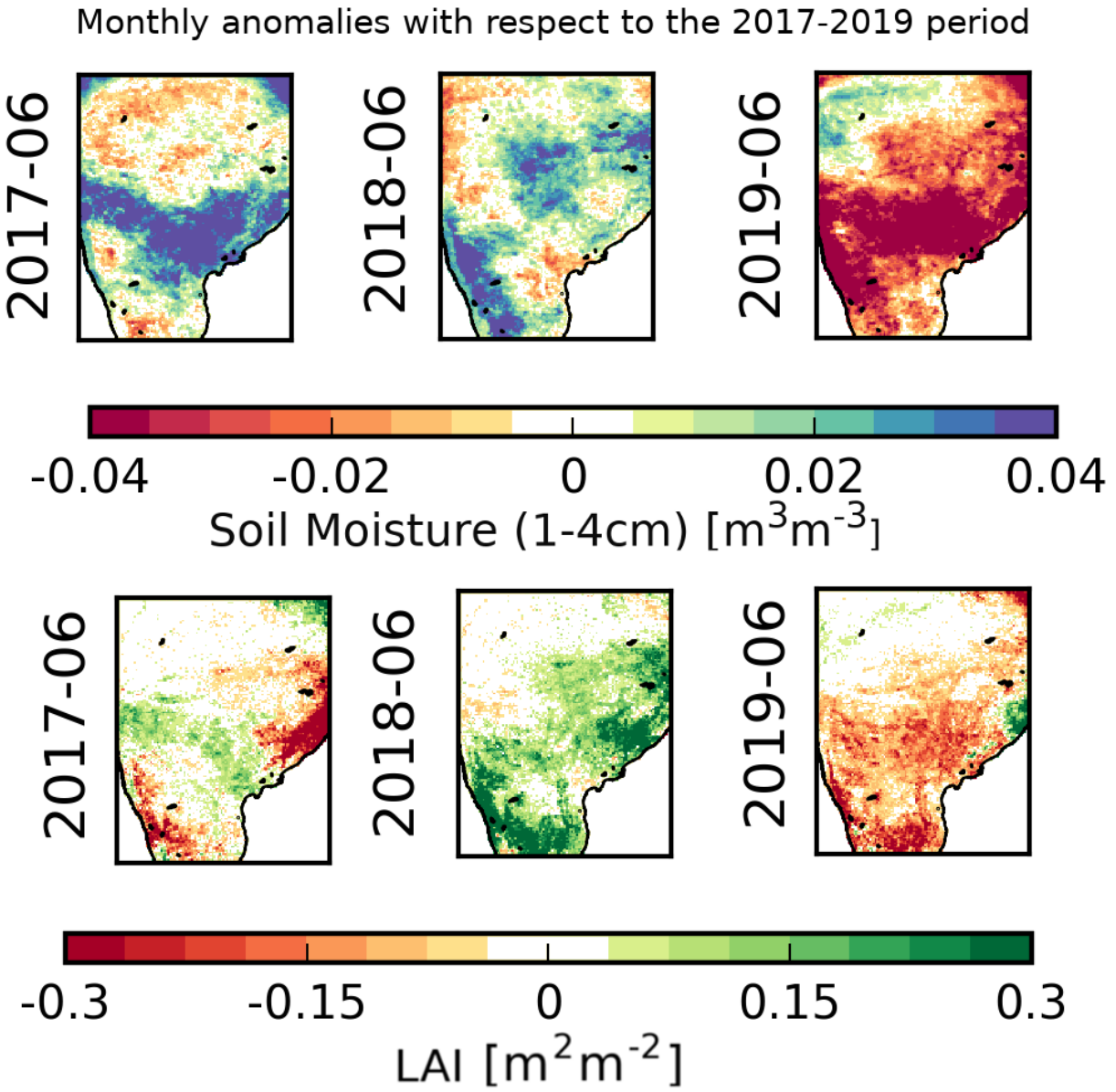
- LAI: strong positive impact from the analysis, strong positive impact from the initialisation

Monitoring of the LSVs : MUDA

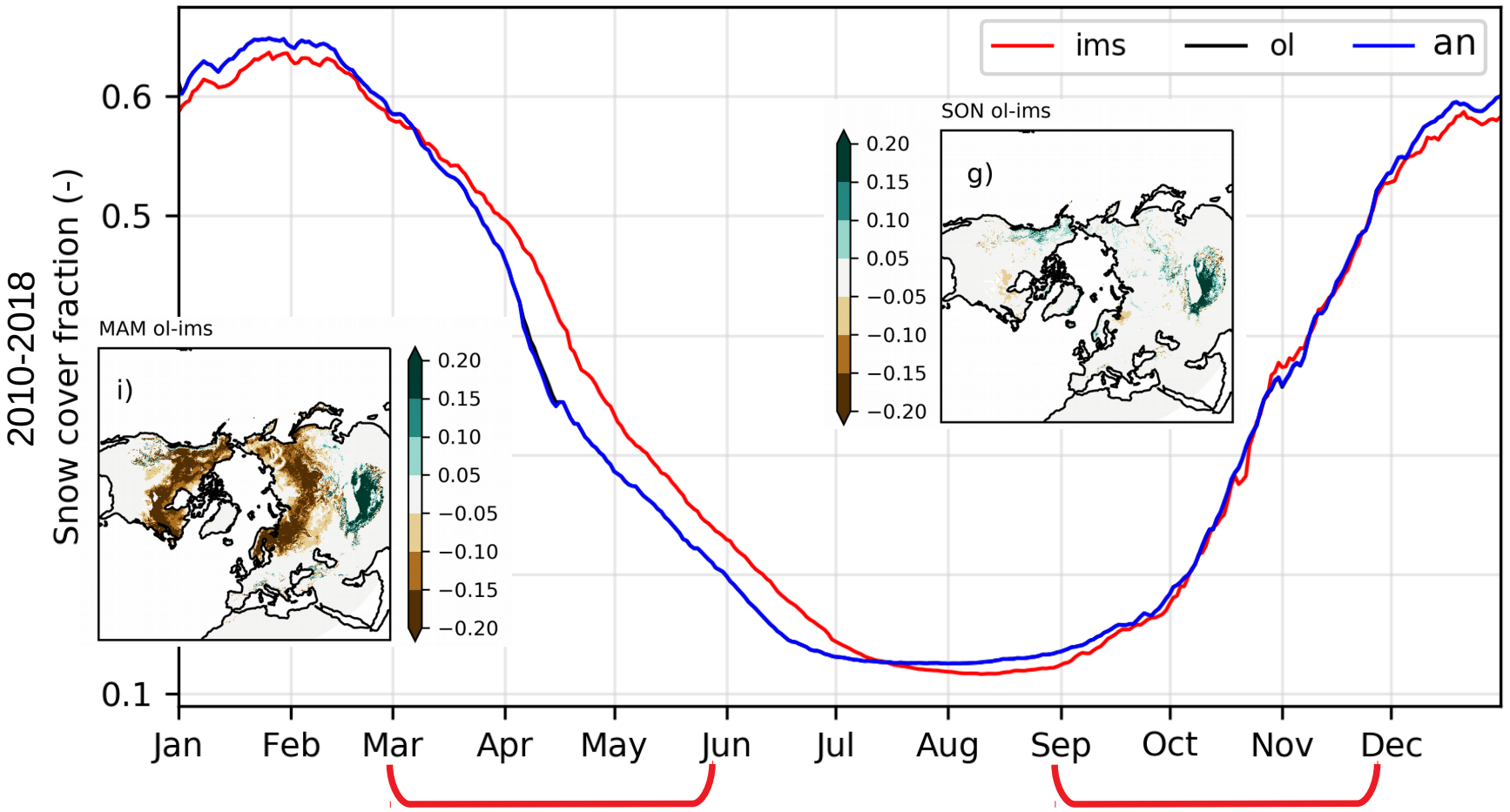
- Information exchanged with the Bureau of Meteorology



Monitoring of the LSVs : India



LDAS-Monde: towards snow cover DA



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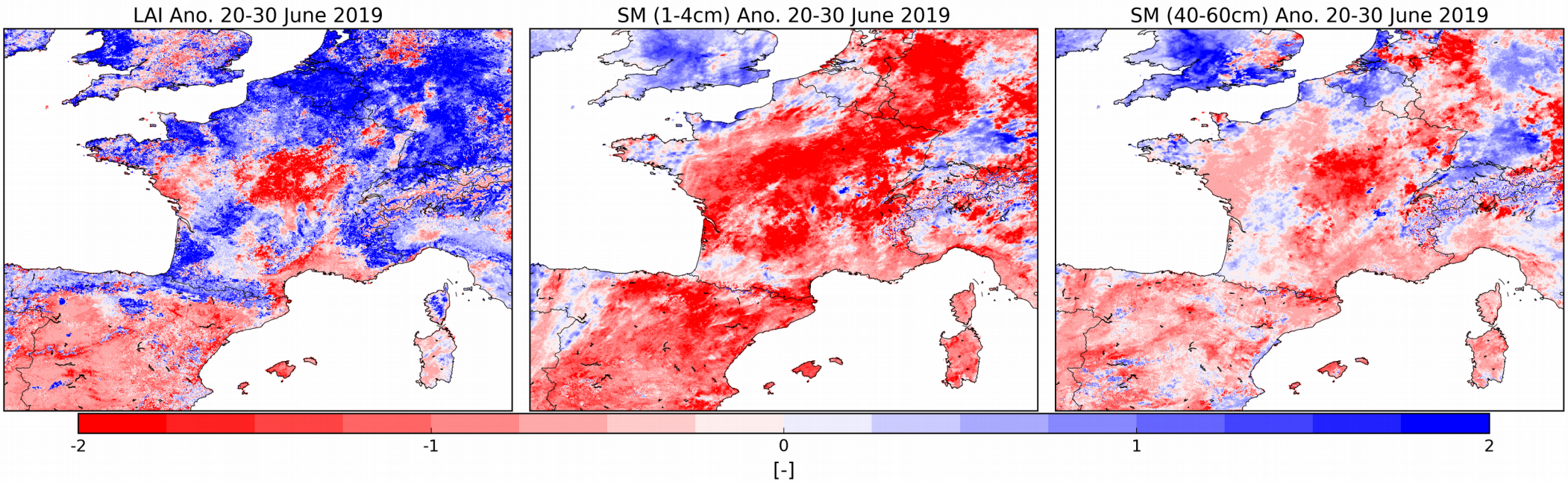
In a first stage, snow cover data from the Interactive Multi-sensor Snow and Ice Mapping System (or IMS) will be assimilated in LDAS-Monde

Towards '*higher*' spatial resolution

- **LDAS-Monde** forced by **AROME** atmospheric fields from Météo-France at 2.5km x 2.5km spatial resolution (aggregated from 1.3km x 1.3km spatial resolution)

➔ Impact of the June 2019 heatwave



Monthly anomalies in units of standard deviation

Conclusions

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

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

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

➔ Significant anomalies trigger more detailed monitoring and forecasting activities at higher spatial resolution

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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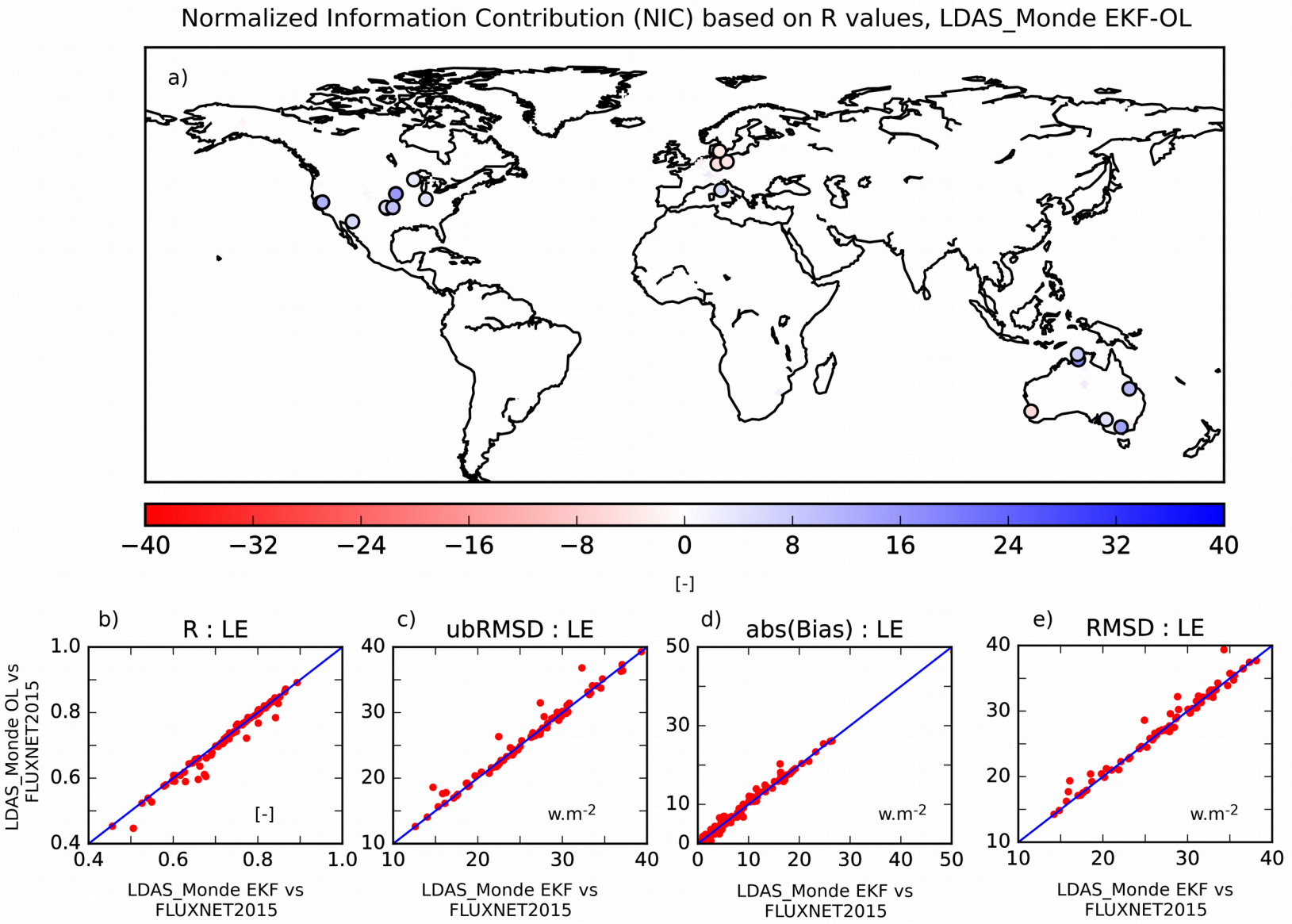
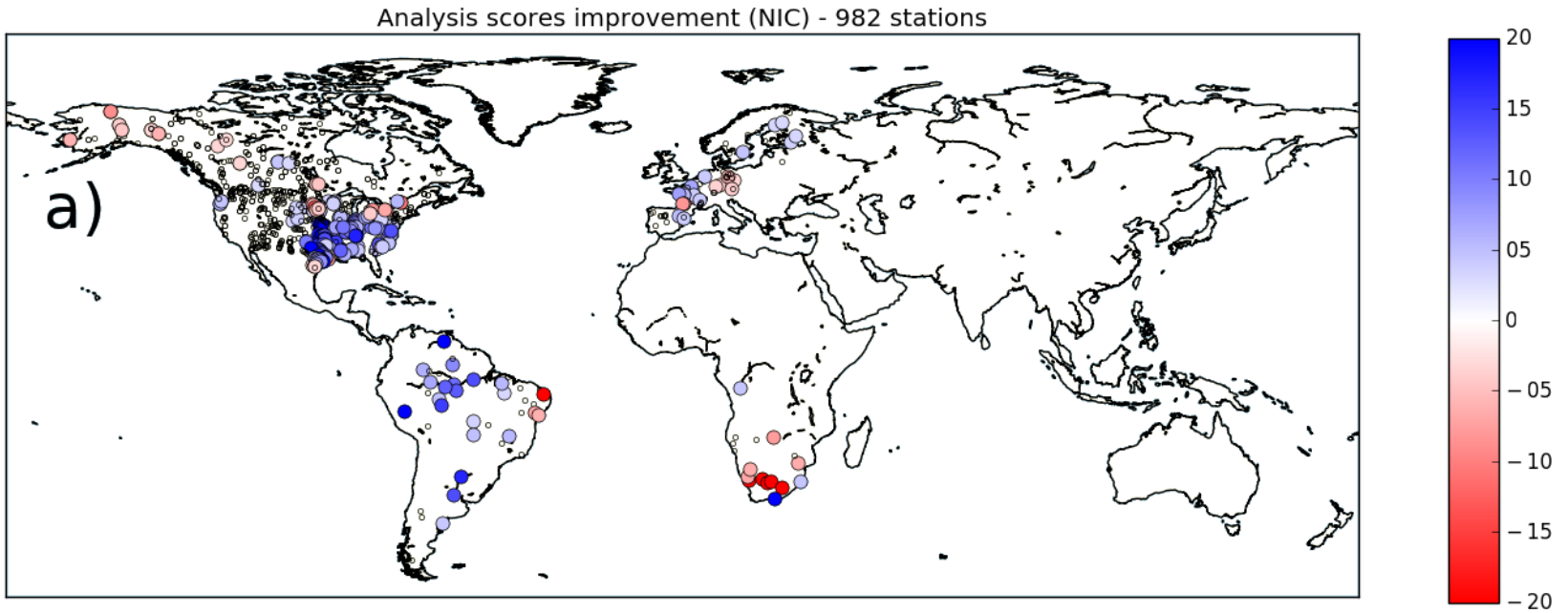
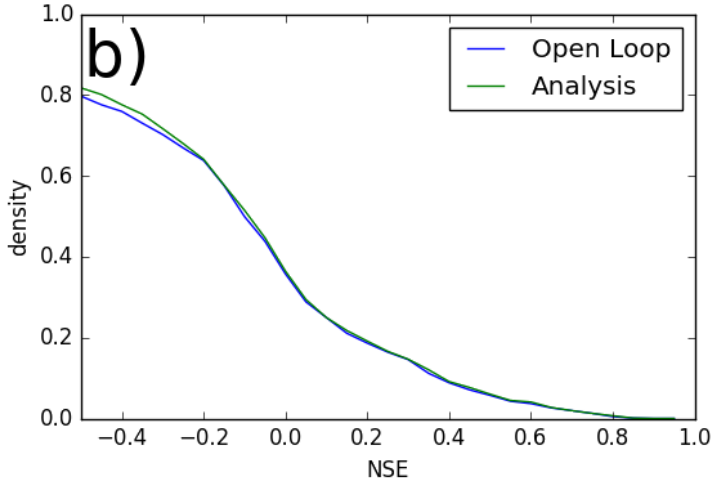
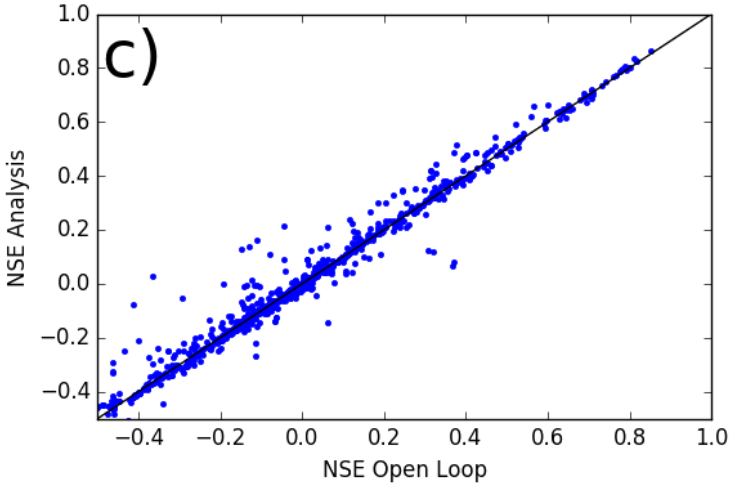
Evaluation against Fluxnet2015 (evap)



Evaluation against river discharge







Evaluation against in situ SSM