SURFEX Users Workshop

CIC meetings

Centre International de Conférences - Météo-France - Toulouse - France   February 27th - March 1st 2017

Integration of satellite data into SURFEX for better monitoring agricultural droughts

Calvet J.-C, Albergel C., Barbu A., Carrer D., Dewaele H., Fairbairn D., Leroux D., Mahfouf J.-F., Munier S.

CNRM, Toulouse, France

LDAS-Monde

Heritage

- 1990's: Meteo-France implements sequential assimilation of in situ T2m, HU2m observations to analyze soil moisture in weather forecast models
- 2000's: SMOSREX field experiment (L-band radiometry, sequential assimilation of surface soil moisture and LAI)
- 2010's: Land Data Assimilation System contributing to Copernicus Global Land Service (cross-cutting monitoring)

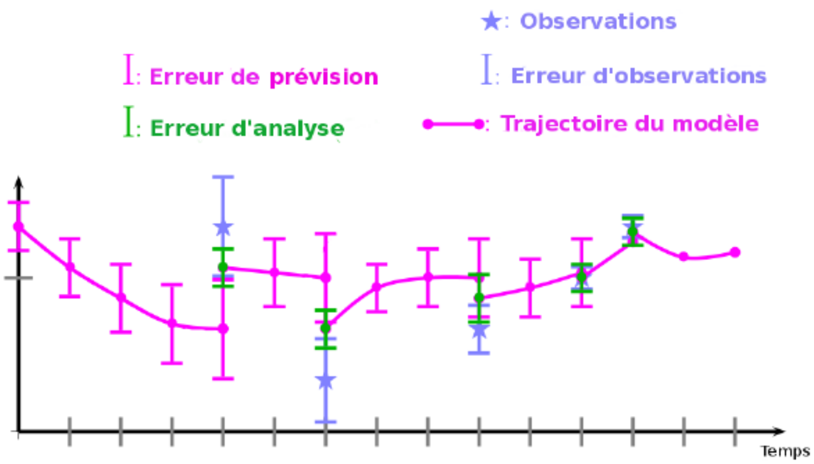
Sequential assimilation

- Model trajectory is driven by observations
- Better than model calibration:

  - all kinds of errors can be accounted for

  - near real-time operation is possible

  - key parameters can be efficiently tuned minimizing analysis increments



LDAS-Monde

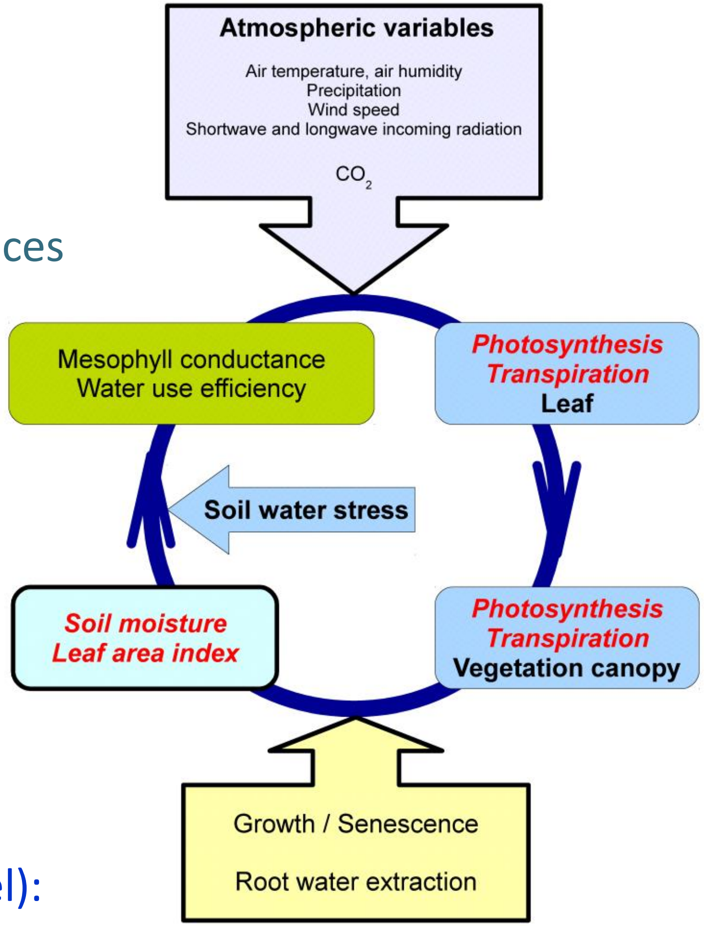
SURFEX modeling platform of Meteo-France

- Operational applications: weather forecast, hydrology, IPCC simulations (CNRM-ARPEGE)
- Open-source. Used by many meteorological services in Europe and North Africa

ISBA land surface model

- LAI, FAPAR, SA, LST, SSM are modeled
- Evapotranspiration, CO_2 fluxes
- Implicit representation of N cycle
- Simulates the impact on vegetation of long-term changes of atmospheric CO_2
- A-gs approach (not the Farquhar model)
- Photosynthesis-driven phenology (no GDD model):

  LAI is flexible and can be analyzed at a given time



LDAS-Monde

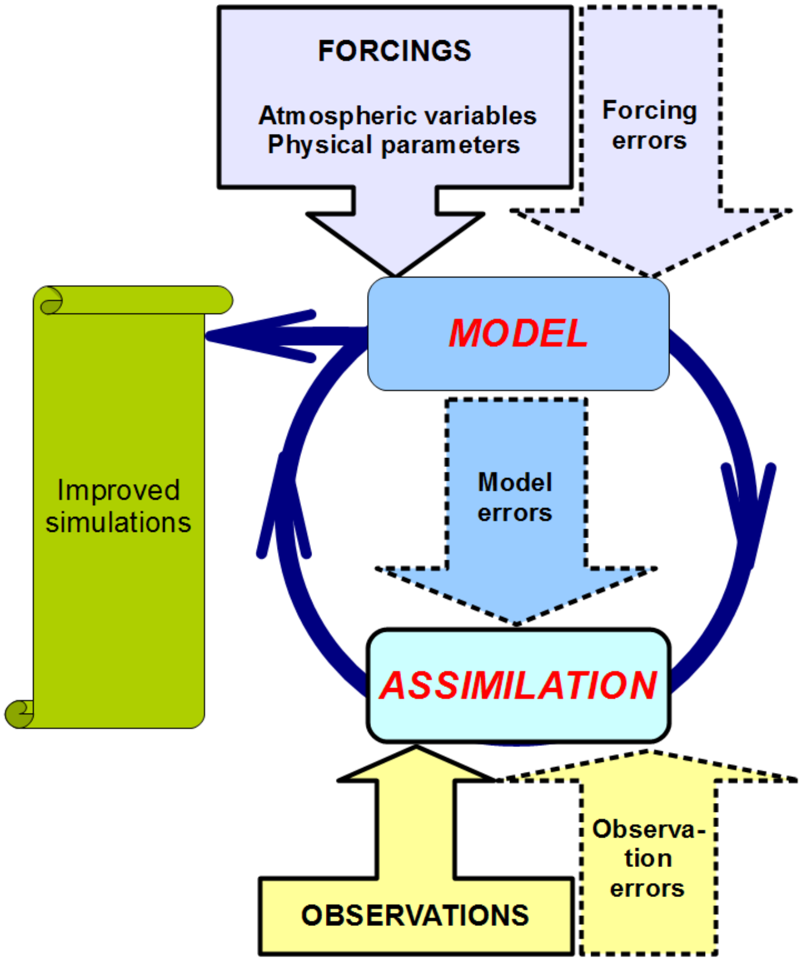
Data assimilation in SURFEX

LDAS-France (Barbu et al. HESS 2014)
- ISBA model forced by SAFRAN
- 8 km x 8 km

LDAS-Monde
- ISBA model forced by ERA-Interim
- 0.5° x 0.5°

Assimilation (active monitoring) of
- Copernicus GLS LAI
- Copernicus GLS surface soil moisture

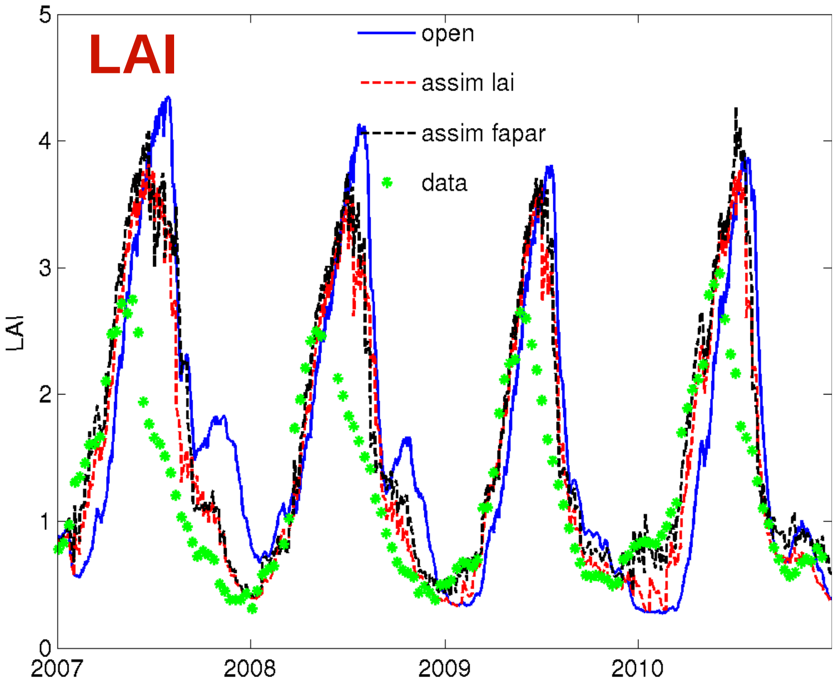
Passive monitoring of
- FAPAR
- SA
- LST

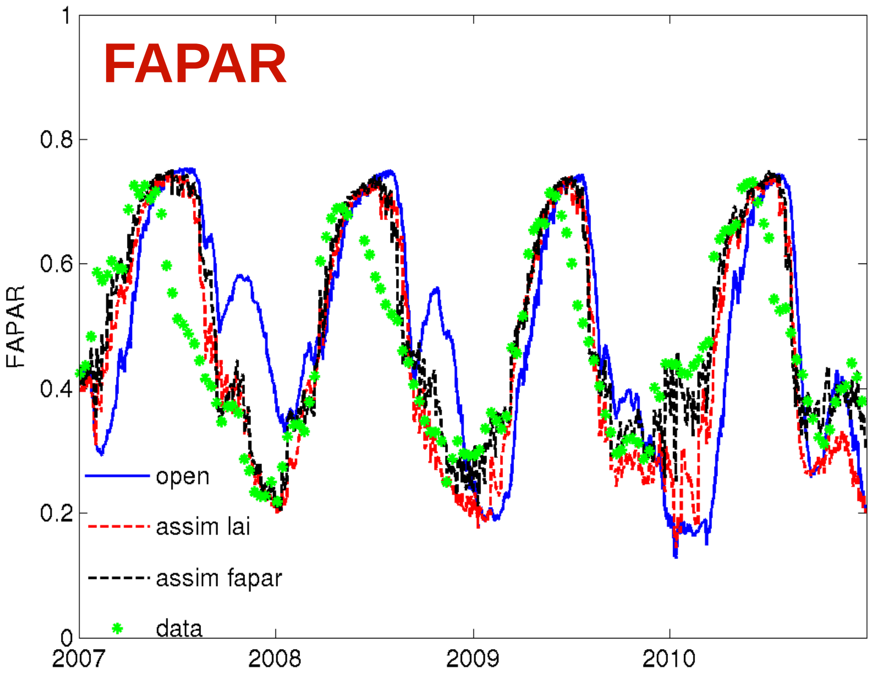


LDAS-Monde

Assimilating LAI or FAPAR ?

$$\sigma_{LAI}^{b} = 0.2, \sigma_{LAI}{}^{o} = 0.2, \sigma_{FAPAR}{}^{o} = 0.02$$

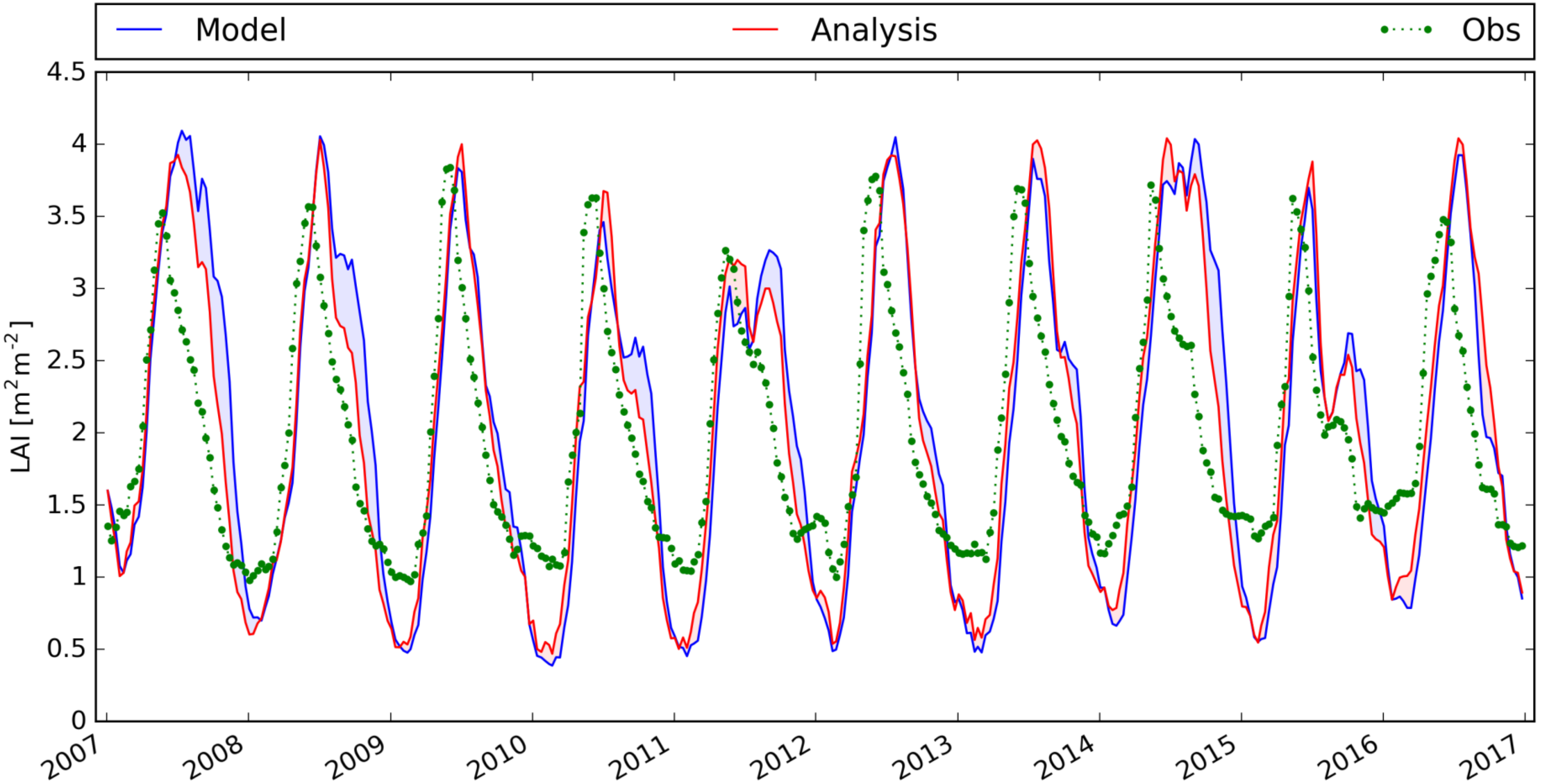




Explicit FAPAR (Carrer et al. 2013, JGR-B)

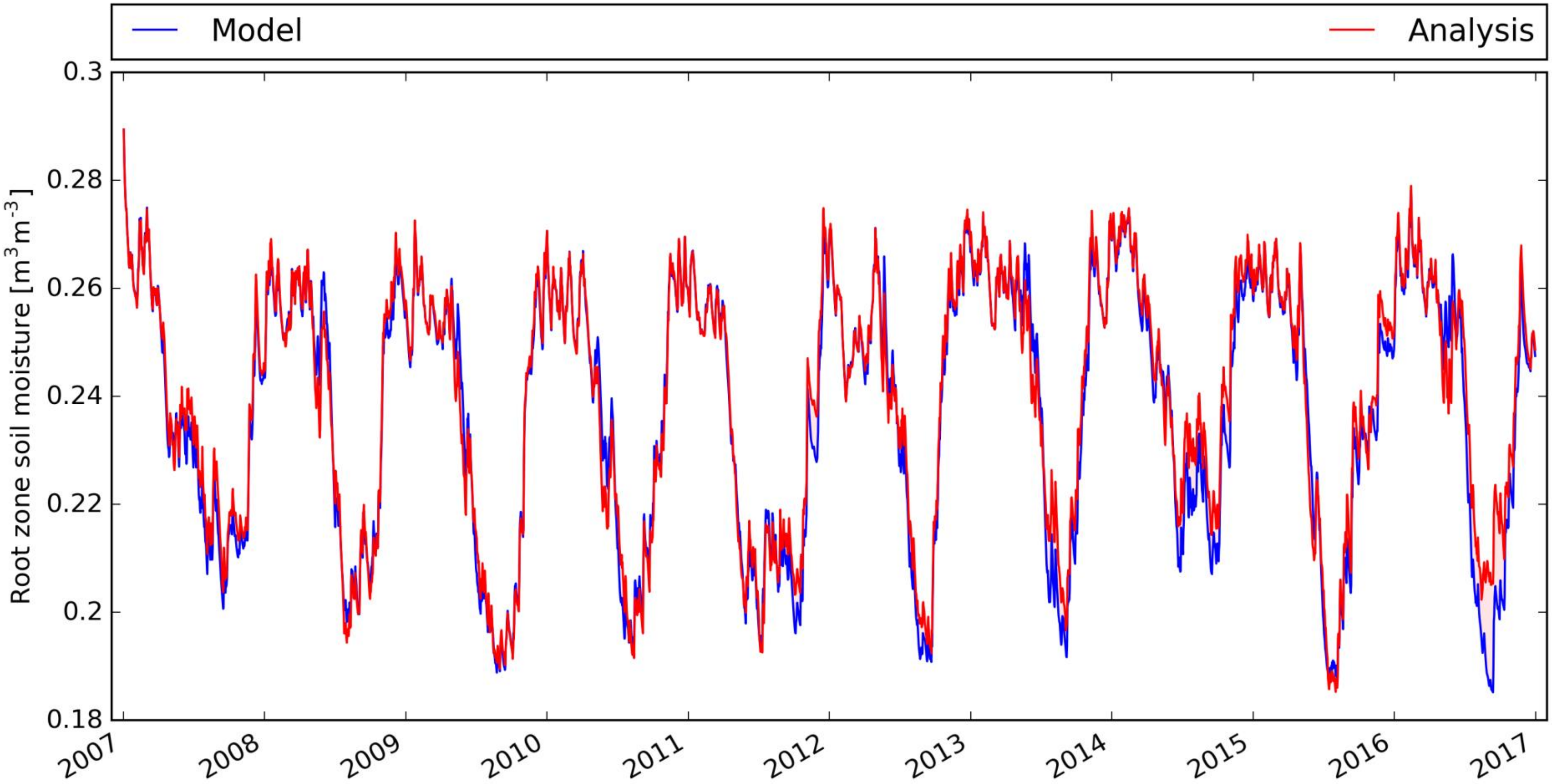
LDAS-Monde

LAI (mean monthly values for France)



LDAS-Monde

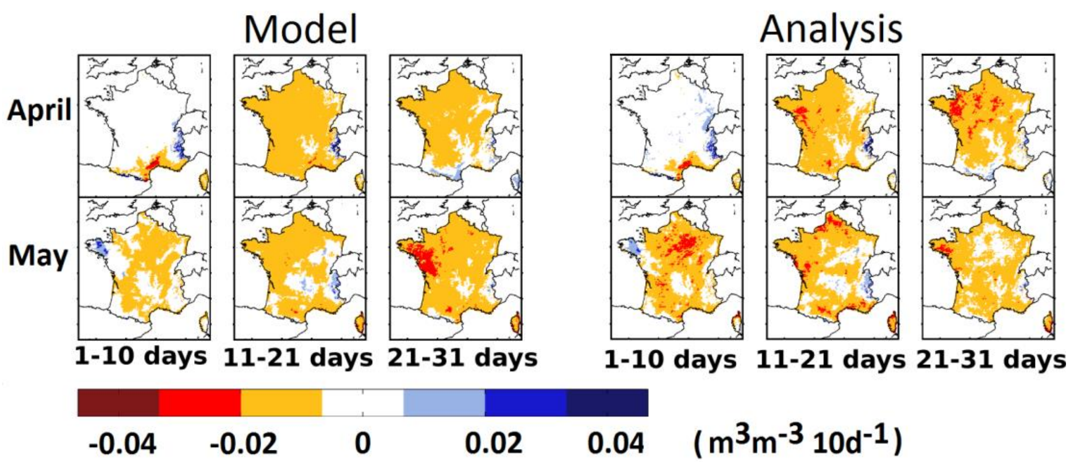
Surface soil moisture (mean monthly values for France)



LDAS-Monde

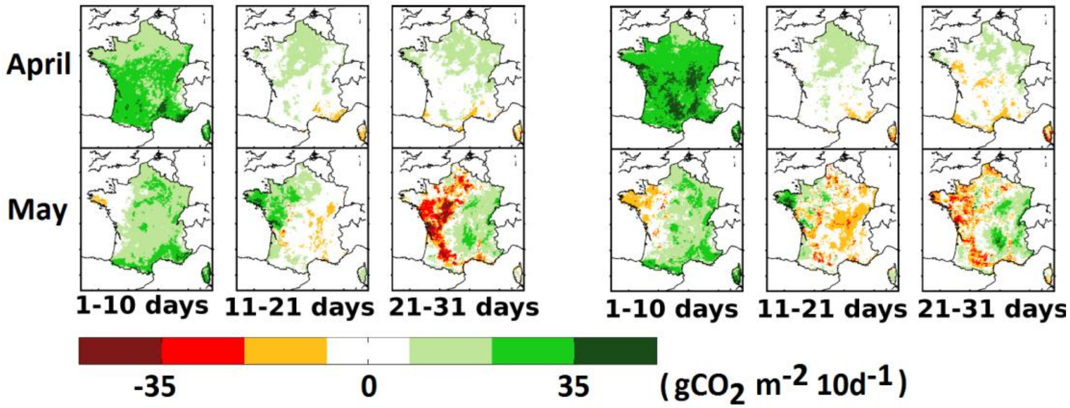
Enhanced representation of agricultural droughts: spring 2011

Soil moisture and photosynthesis: 10-day changes in 2011 (spring drought)



SOIL MOISTURE

Assimilation reinforces the drought signal



GPP

Barbu et al. 2014, HESS

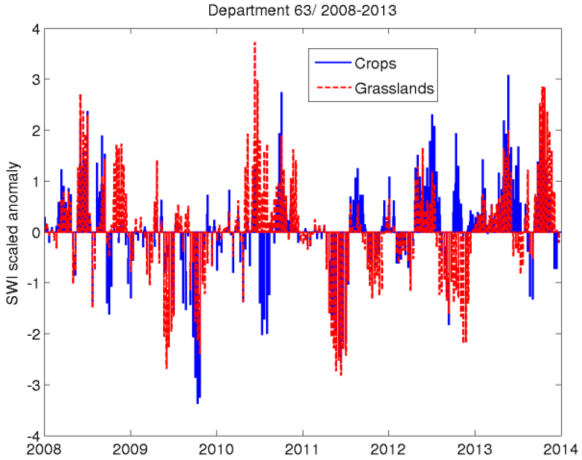
LDAS-Monde

Enhanced representation of agricultural droughts: spring 2011
Agricultural drought indicators, example of Puy de Dôme (France)

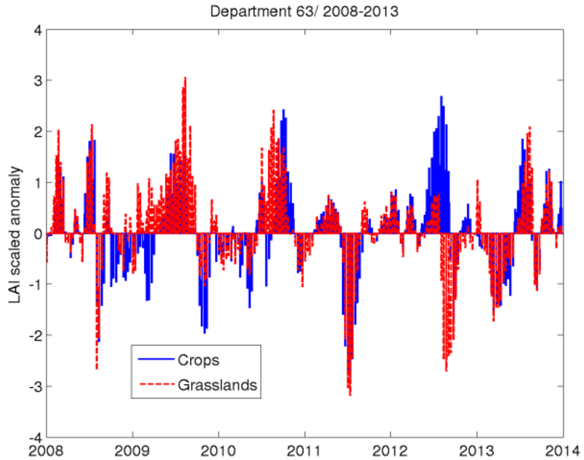
LAI and biomass anomalies are less erratic than SWI anomalies
Complementary information content

10-day scaled anomalies:

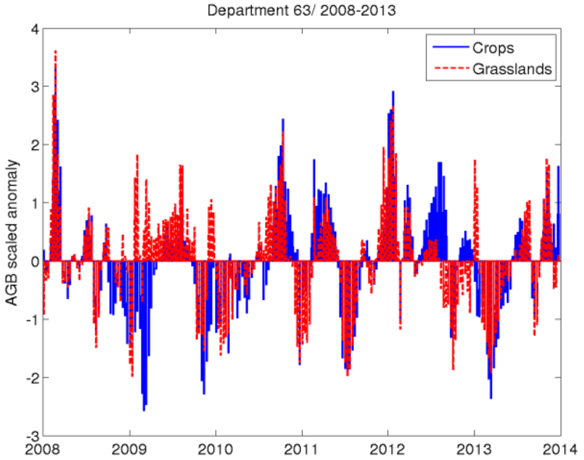
SWI



LAI

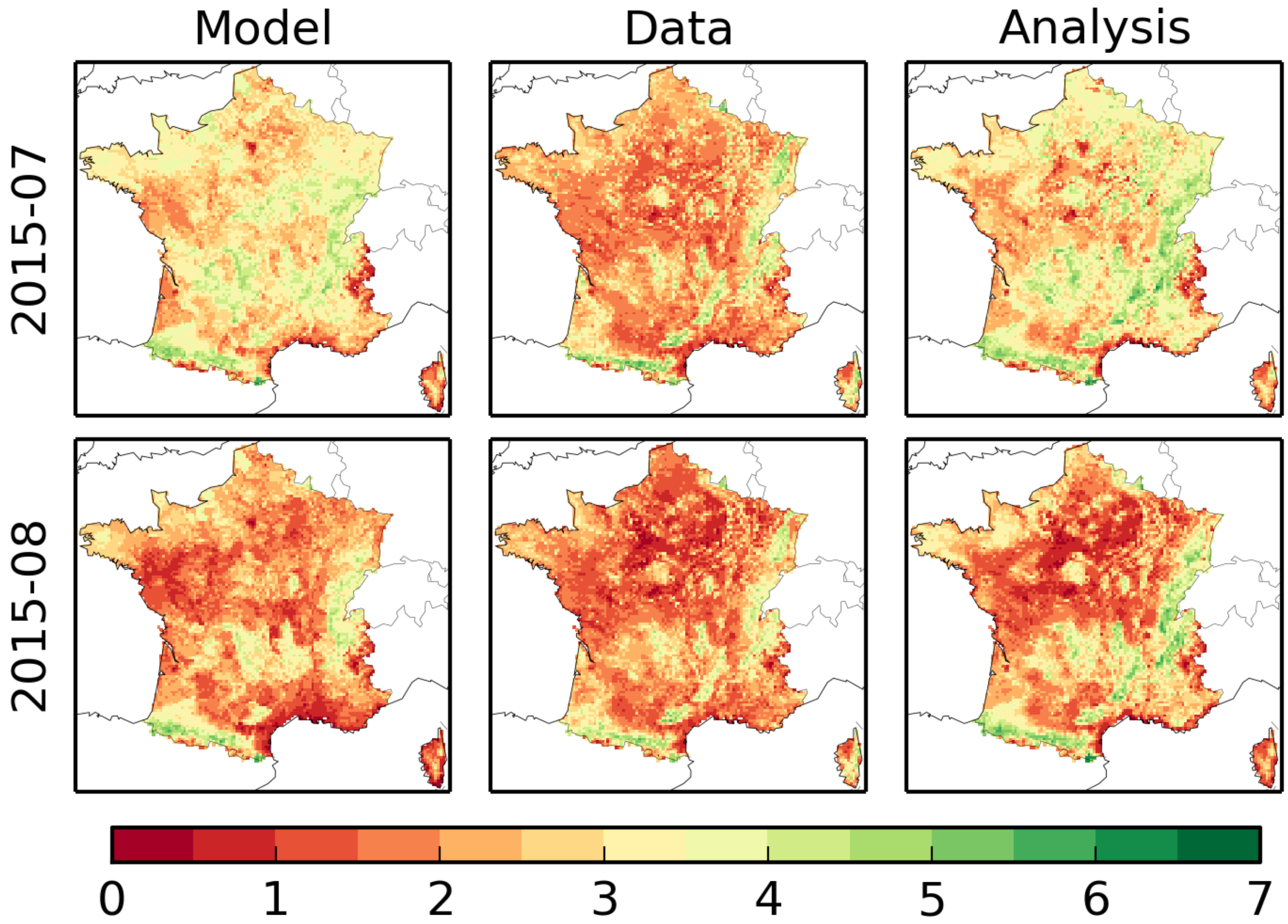


Above-ground biomass



LDAS-Monde

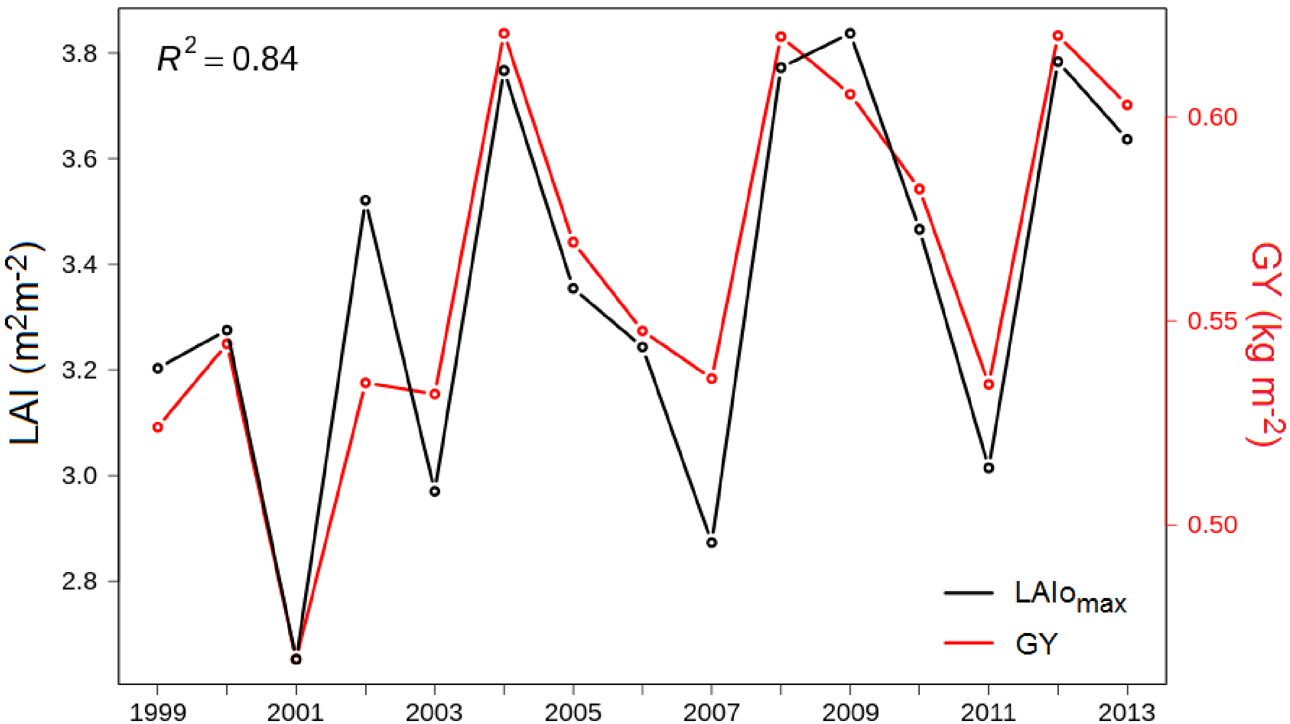
Enhanced representation of agricultural droughts: summer 2015



LDAS-Monde

Validation: wheat yields in France

Disaggregated Copernicus GLS LAI correlates with wheat yield



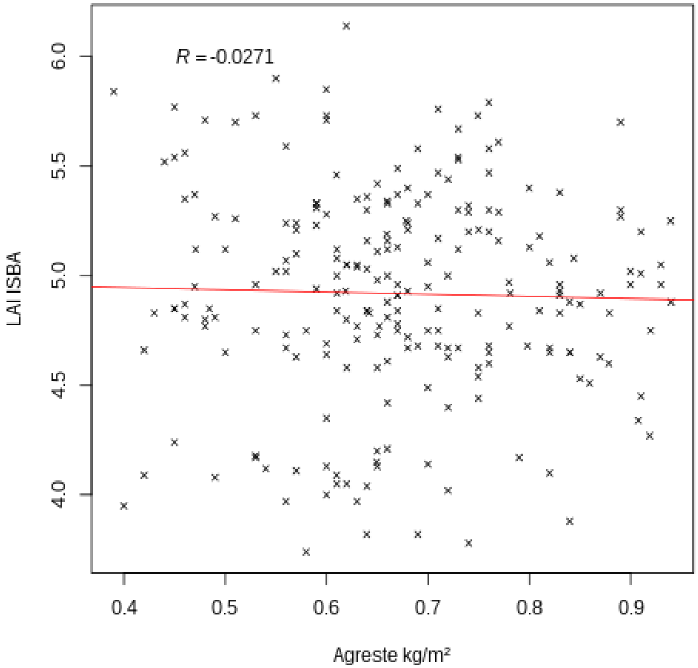
Dewaele et al. 2017

LDAS-Monde

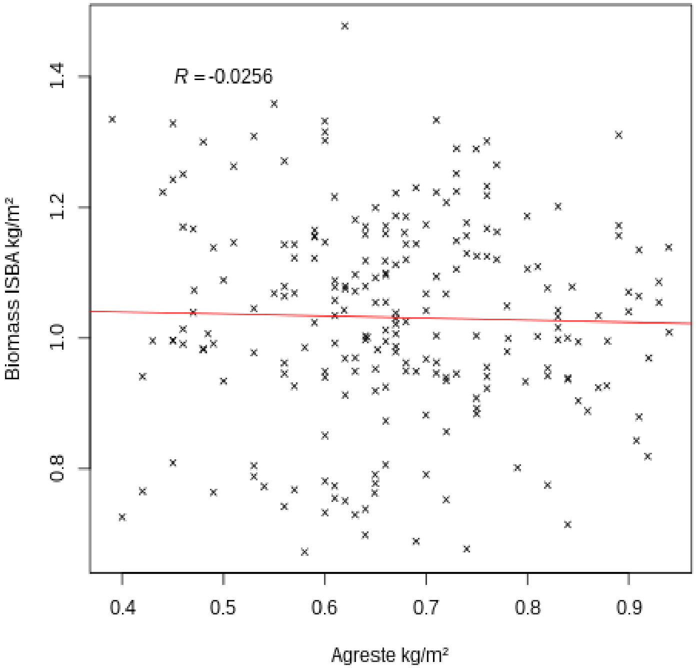
Validation: wheat yields in France

WITHOUT ASSIMILATION OF LAI

LAI



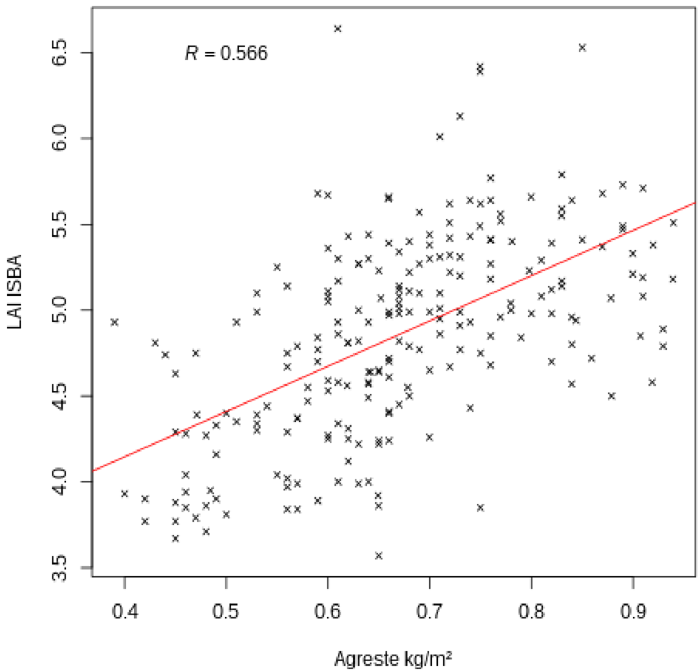
Above-ground biomass



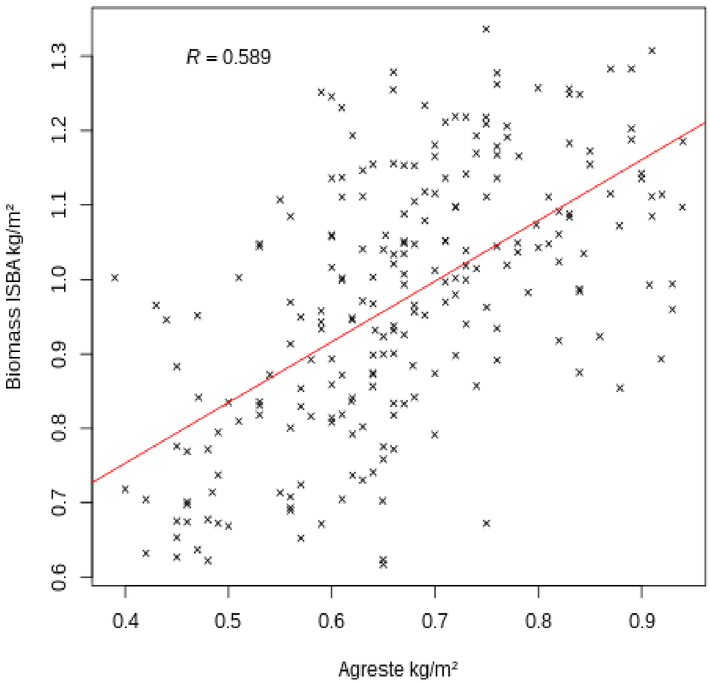
Validation: wheat yields in France

WITH ASSIMILATION OF LAI

LAI

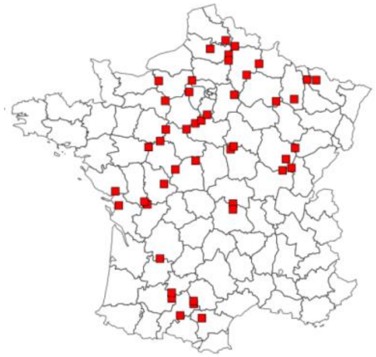


Above-ground biomass



LDAS-Monde

Validation: wheat yields in France



Consistency can be improved further tuning
a key model parameter: MaxAWC

(maximum available soil water content for plant transpiration)

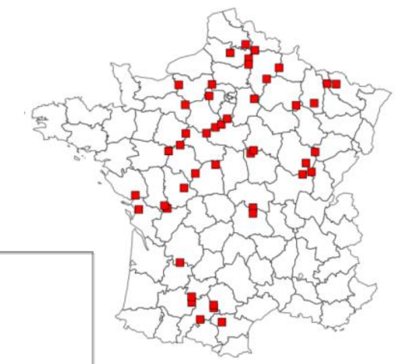
Two methods:

- Inverse modeling (parameter tuning minimizing RMSE)
- LDAS tuning (minimizing LAI increments in sequential assimilation)

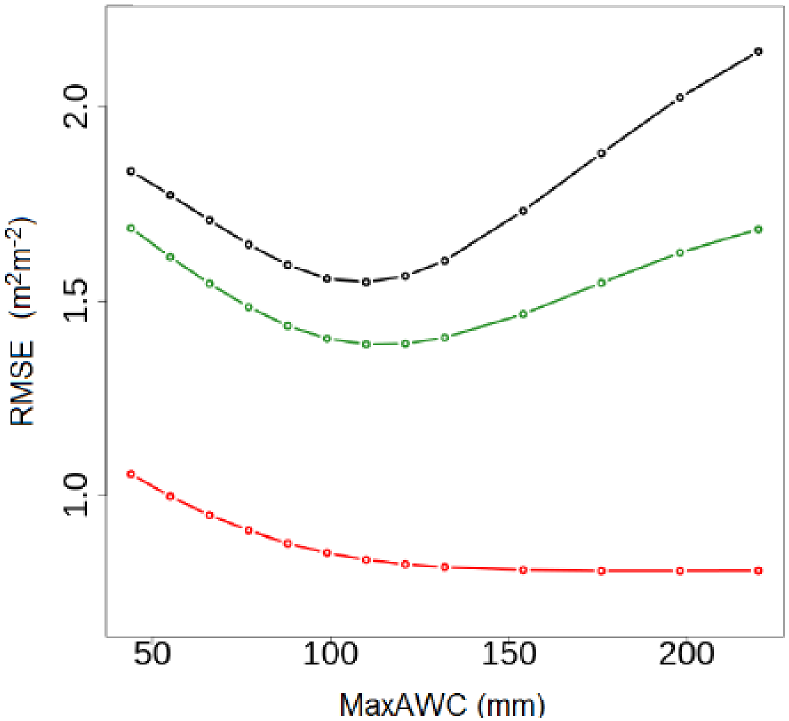
LDAS-Monde

Validation: wheat yields in France

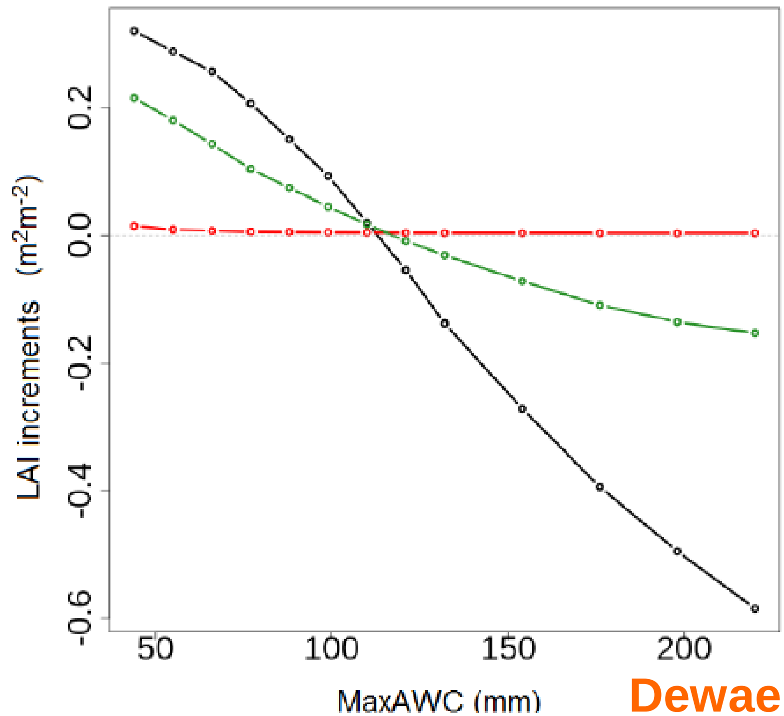
MaxAWC retrieval: LDAS tuning (minimize LAI increments) is better than inverse modeling (minimize LAI RMSE)



Inverse modeling



LDAS tuning



Growth

Peak

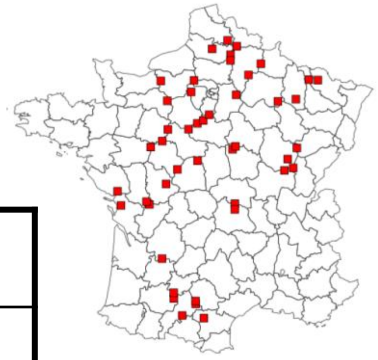
Senescence

Dewaele et al. 2017

LDAS-Monde

Validation: wheat yields in France

MaxAWC retrieval: LDAS tuning (minimize LAI increments) is better than inverse modeling (minimize LAI RMSE)



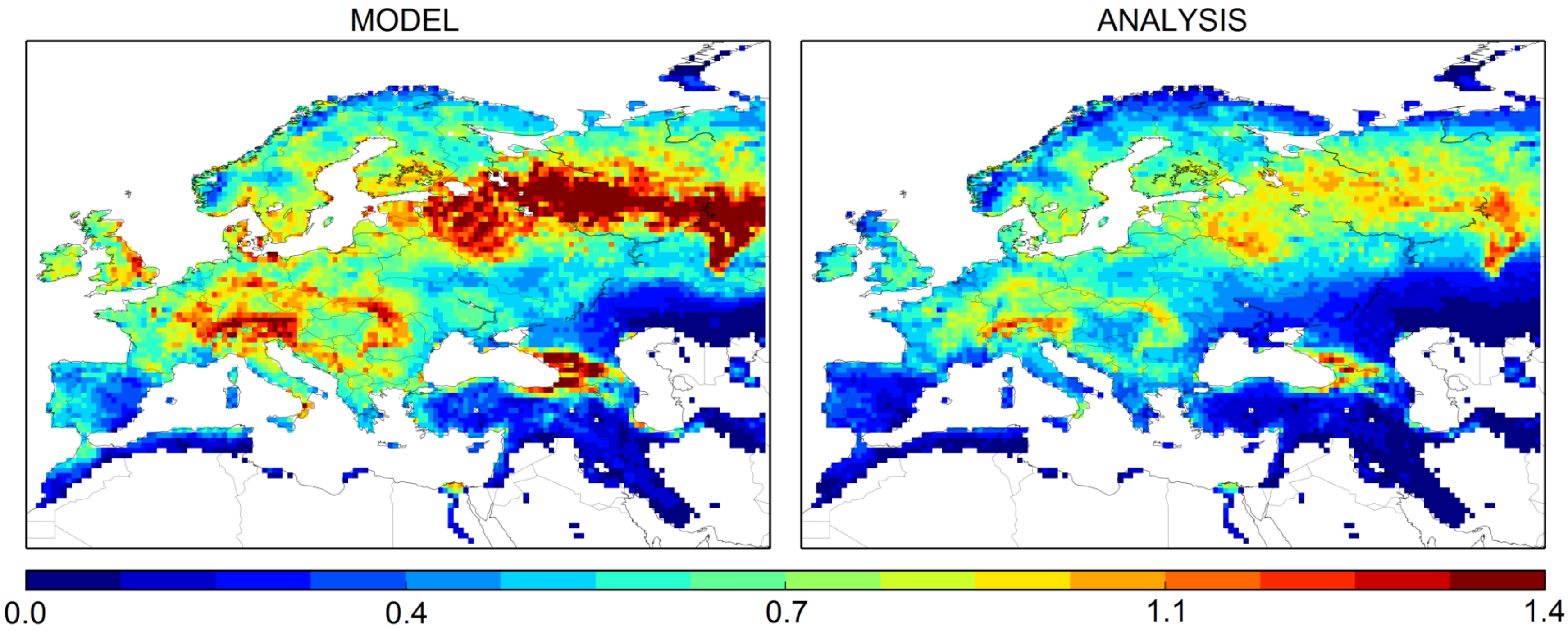
	Inverse modeling	LDAS tuning
Fraction of administrative units with significant correlation (p-value < 0.01)	36 %	**53 %**
LAI RMSE	1.2 m^2m^{-2}	**1.1 m^2m^{-2}**
Median MawAWC	111 mm	**129 mm**

More realistic !

Dewaele et al. 2017

LDAS-Monde

Can be applied to any region of the world. E.g. Euro-Mediterranean
LAI standard deviation of differences from 2007 to 2015



LDAS-Monde

Conclusion

- Integration of satellite observations into SURFEX
- Fully coupled to hydrology (CTRIP model)
- Now the only system able to sequentially assimilate vegetation products (together with soil moisture observations)
- A powerful tool to monitor droughts
- Validation
    - using agricultural yield statistics
    - using SIF data

Prospects

Observation operator for surface albedo, ASCAT sigma0, LST, … and SIF

Thank you for your attention !

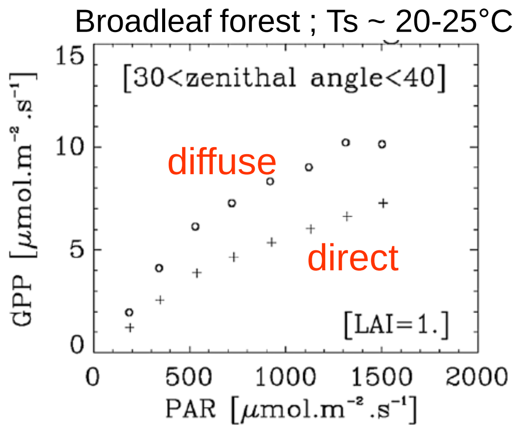
Contact:

jean-christophe.calvet@meteo.fr

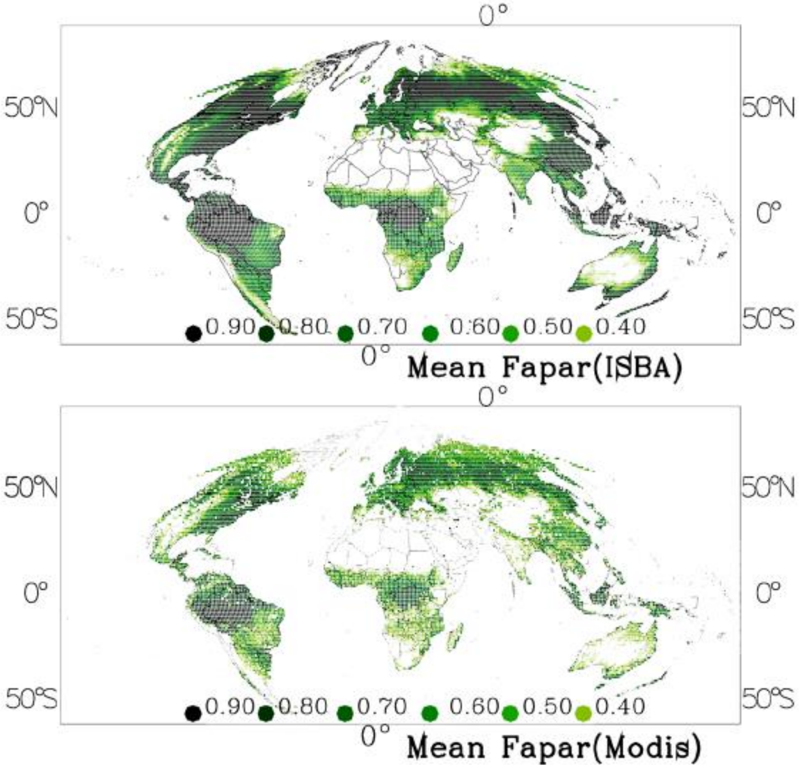
LDAS-Monde: Extra slides

Canopy scale: radiative transfer model (10 layers, sunlit/shaded leaves)

Multilayer photosynthesis model representing the absorption of direct/diffuse solar radiation



Prognostic FAPAR



Explicit FAPAR (Carrer et al. 2013, JGR-B)

LDAS-Monde: Extra slides

Enhanced representation of drought

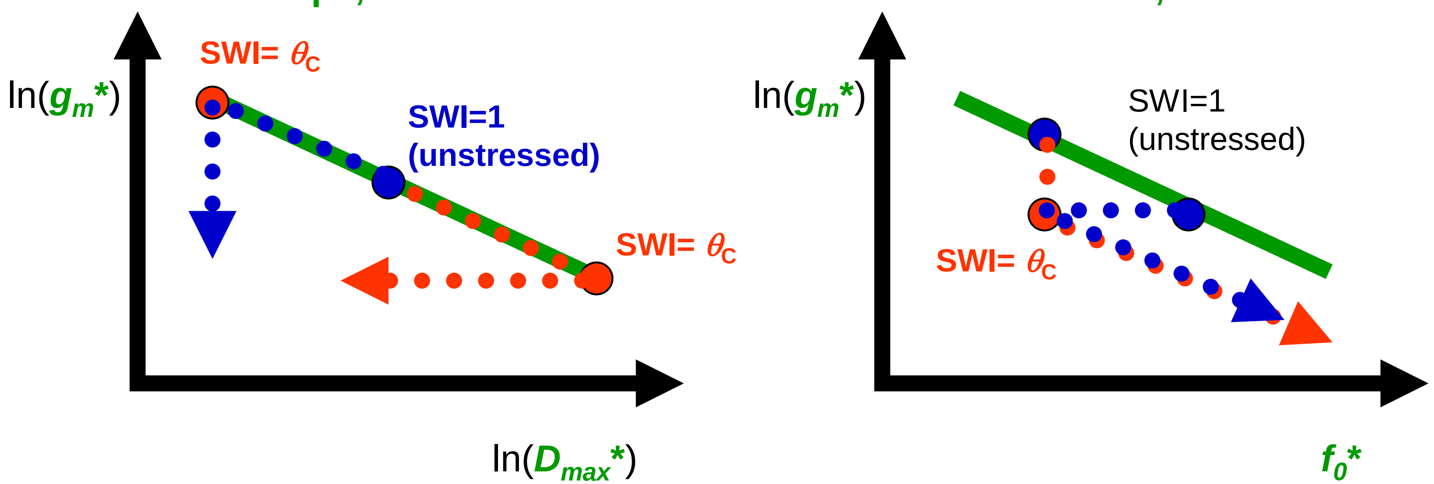
Key parameters of the photosynthesis model are affected by drought:

the well-watered value are adjusted by using the Soil Wetness Index (SWI)

Two possible strategies: drought-avoiding / drought-tolerant

Important parameter: θ_C critical extractable soil moisture content, below which severe soil moisture stress is observed

Crops, Grasslands **Trees, Shrubs**



Calvet 2000, Calvet et al. 2004