Cross-cutting validation of satellite products over France through their integration into a land surface model

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METEO FRANCE

Context

Heritage: geoland and geoland2 FP7 project (2004-2012)

ImagineS FP7 project (2013-2016)

- From biophysical variables to agricultural indicators.
- Performs the research needed in support to Copernicus GLS.
- Use of European space-borne instruments (SPOT-VGT, PROBA-V, METOP-ASCAT, … future Copernicus Sentinel missions) and of geostationary satellites for LST

Copernicus Global Land service (http://land.copernicus.eu/global/)

Started 1 January 2013.

Near-real-time production of satellite-derived LAI, FAPAR, surface albedo (SA), land surface temperature (LST), and surface soil moisture (SSM) products at a global scale, together with other vegetation indices, burnt areas, water bodies.

Copernicus Climate Change service (2015-2020, in preparation)

From historical satellite-derived products to validated Climate Data Records.

Validation of Earth observation data

Validation: independent assessment of the quality

Direct validation: based on independent (e.g. in situ) data

- Limited in space and time

Indirect validation: comparison with other pre-existing products

- Product intercomparison
- Comparison with models
- Integration into models (data assimilation / reanalyses)

Implementation of cross-cutting (multi-product) validation using a Land Data Assimilation System (LDAS)

ISBA-A-gs in SURFEX

SURFEX modeling platform of Meteo-France

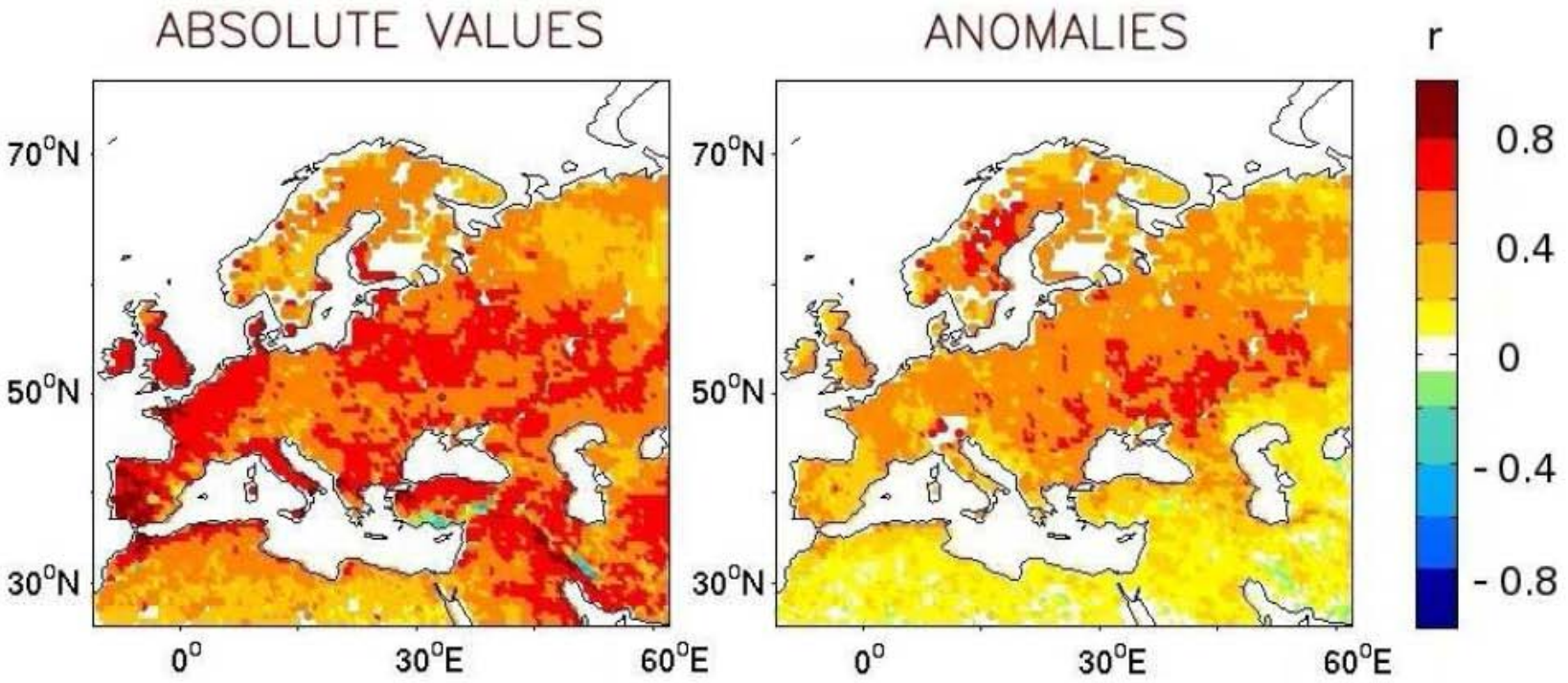
- Interoperable with operational real-time applications: weather forecast, hydrology, atmospheric CO_2 inversions
- Shared by many meteorological services in Europe and North Africa
- Used in CNRM-ARPEGE climate model (IPCC simulations)
- Version 8 will be open-source (end 2014)

ISBA-A-gs land surface model

- LAI, FAPAR, SA, LST, SSM are modeled
- LAI is flexible and can be analyzed at a given time
  - Photosynthesis-driven phenology (no growing degree-days)
  - All the atmospheric variables impact phenology
  - Interannual variability of LAImax is modeled
- Simulates the impact of long-term changes of atmospheric CO_2

Comparison with models: ESA-CCI SM

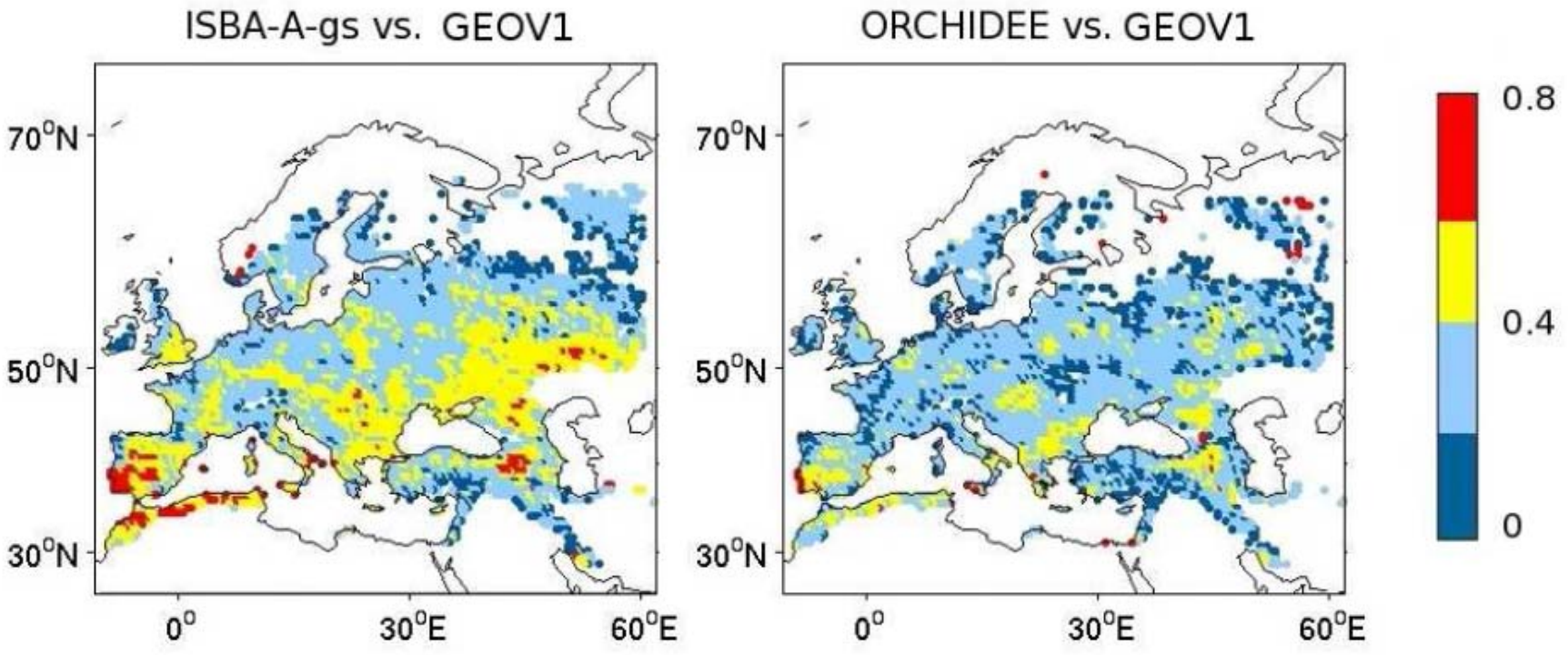
Surface soil moisture (ESA-CCI microwave-derived product)
Correlations (1991-2008 day-to-day variability)



Szczypta et al. 2014, GMD

Comparison with models: GEOV1

Leaf Area Index (GEOV1 Copernicus Global Land product)
Correlations (1991-2008 10-daily interannual variability)

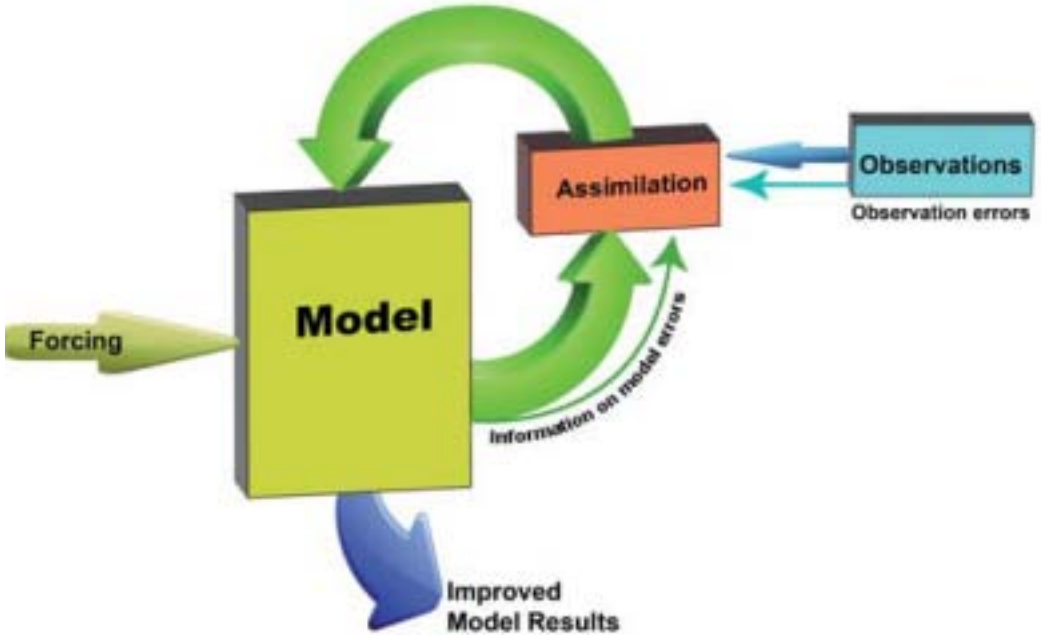


Szczypta et al. 2014, GMD

Data assimilation

Numerical models contain errors that increase with time due to model imperfections and uncertainties in initial and boundary conditions. Data assimilation minimizes these errors by correcting the model stats using new observations.

Paul R. Houser, Figure from http://www.hzg.de/institute/coastal_research/cosyna



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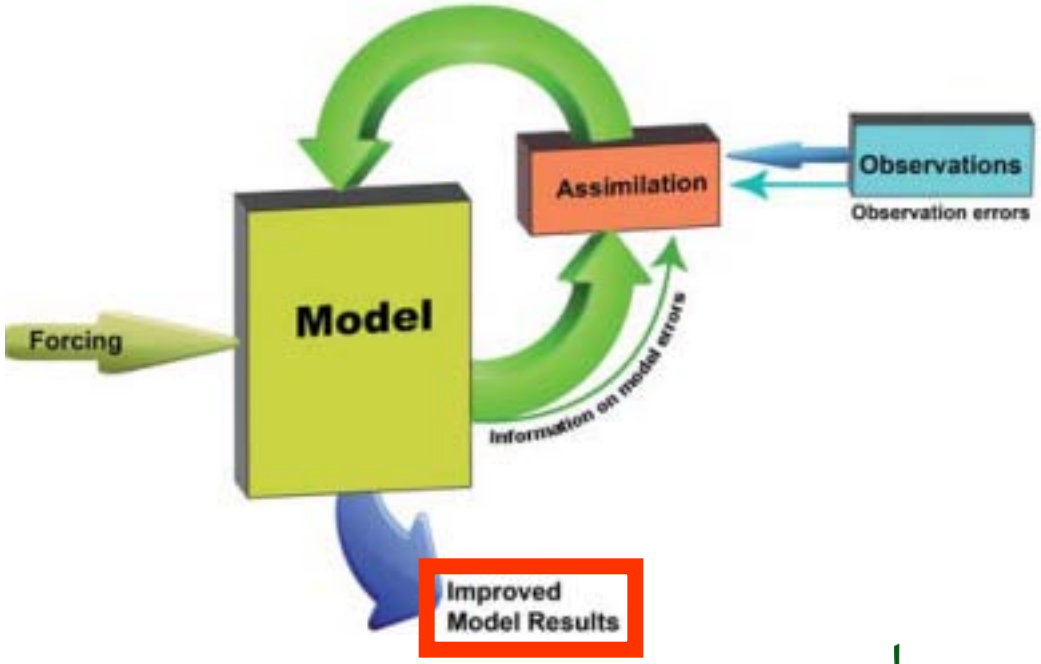

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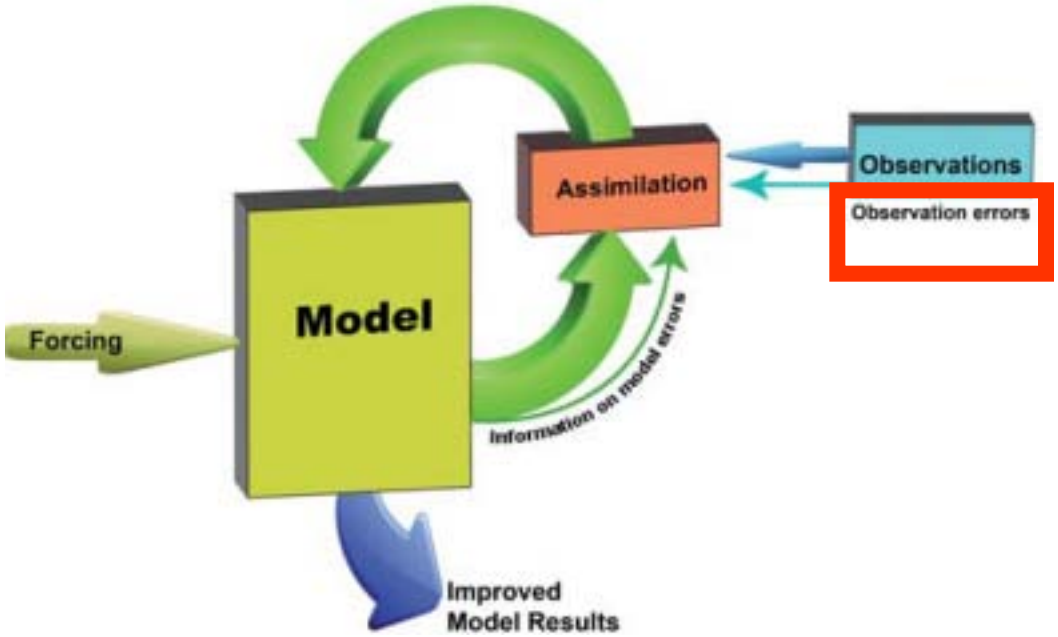


Some issues/problems

Assimilation of vegetation products: LAI or FAPAR ?

- FAPAR has very little sensitivity to LAI changes for LAI > 2
- FAPAR is a radiative product (has a diurnal cycle, depends on atmospheric variables)
- New LAI products are designed to limit the saturation effect (ex. GEOV1, Baret et al. 2013)
- However, FAPAR is highly informative at wintertime

Assimilation of surface soil moisture

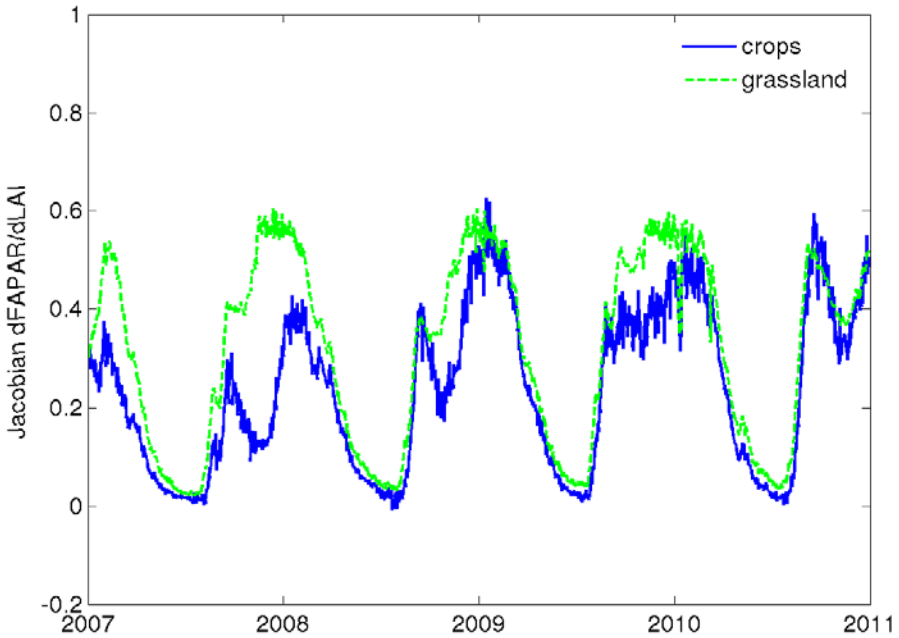
- ASCAT product has seasonal and interannual issues (vegetation impact on the C-band signal should be better described)
- Decoupling in dry conditions: couple with assimilation of surface temperature (more sensitive to soil water content in dry conditions) ?

Seasonal change in sensitivity: FAPAR

Assimilation of FAPAR

Jacobians (sensitivity of FAPAR to LAI perturbations)

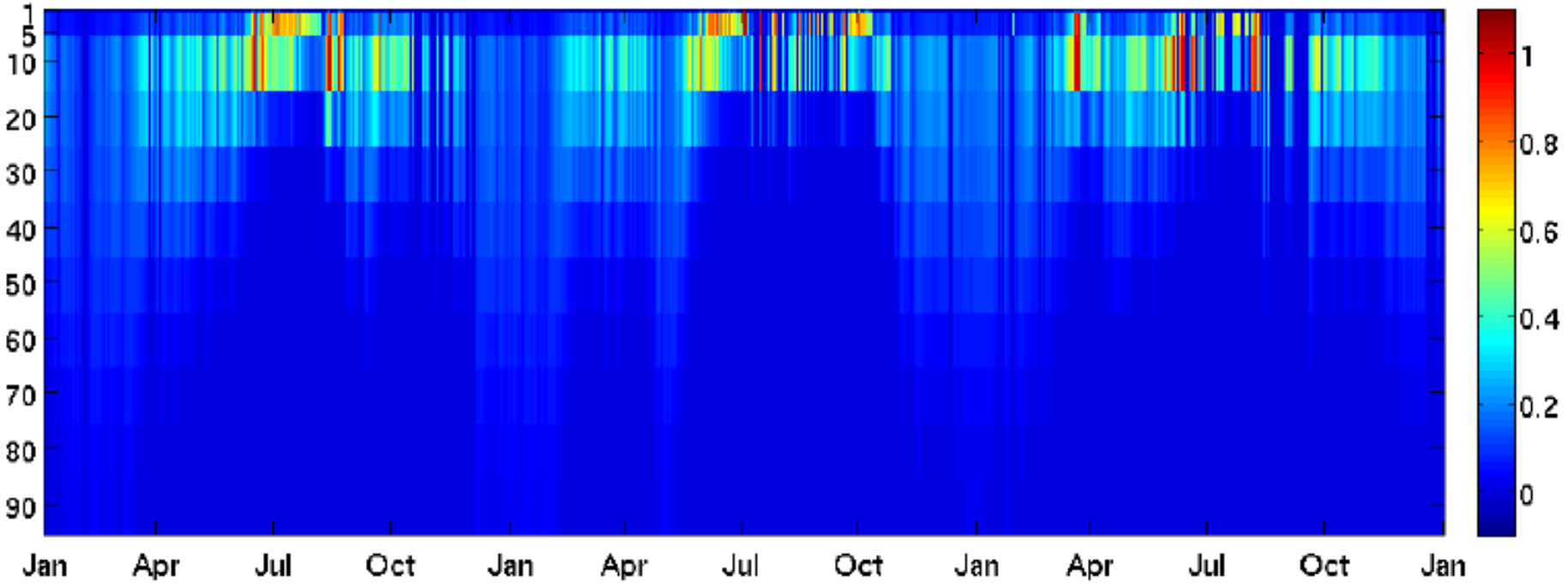
Grid cell near Toulouse (8km x 8km)



Seasonal change in sensitivity: SSM

Assimilation of SSM in a multilayer soil hydrology model

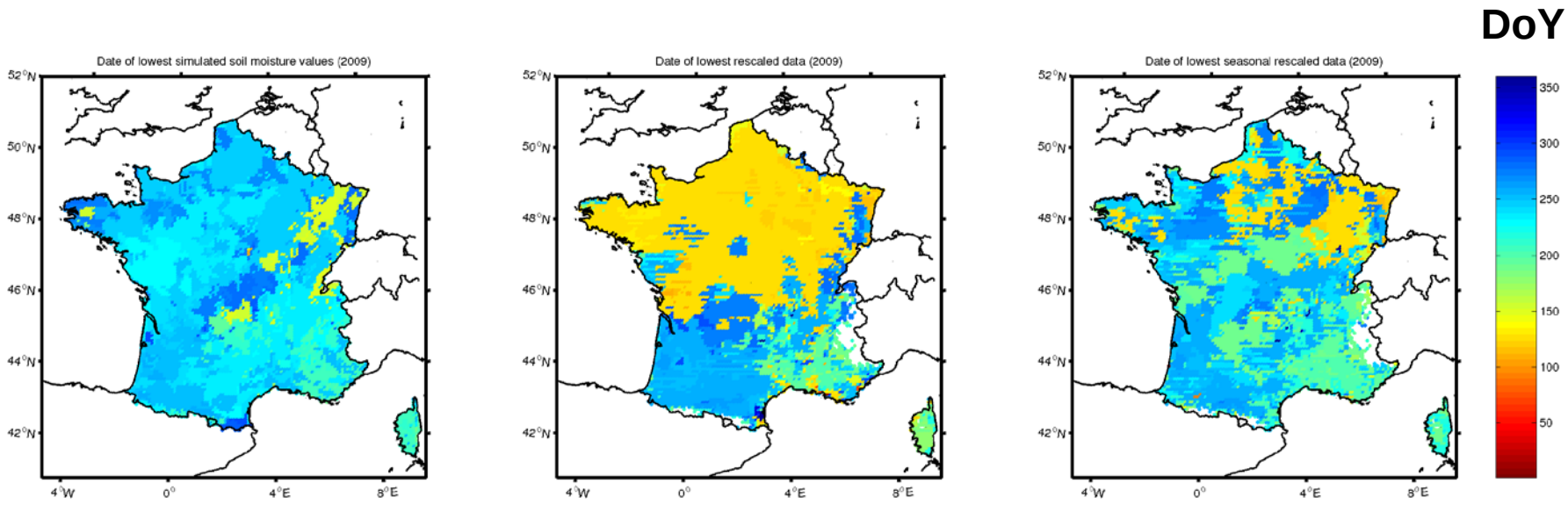
Jacobian profiles (sensitivity of SSM to perturbations of deep layers)



Parrens et al. 2014, HESS

Model/observation mismatch: SSM

Date of lowest ASCAT SSM value in 2009

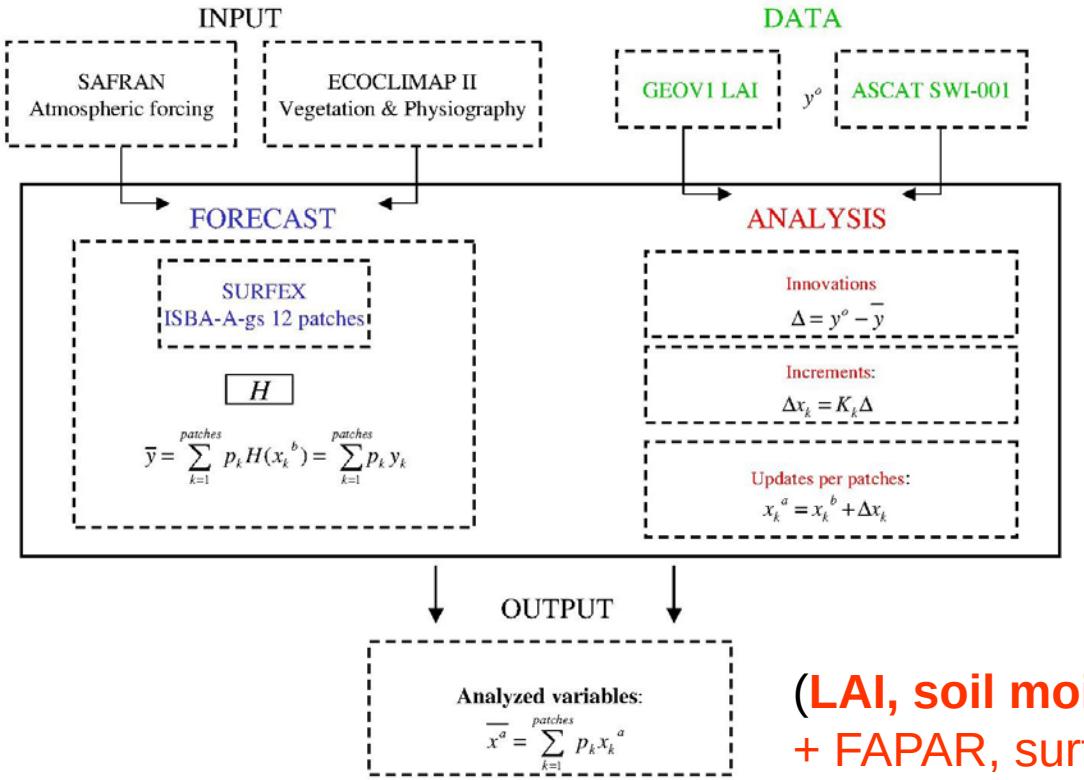


MODEL ASCAT CORRECTED ASCAT

Barbu et al. 2014, HESS

LDAS-France

Joint assimilation of LAI and surface soil moisture (8km x 8km)



Extended Kalman filter

H observation operator

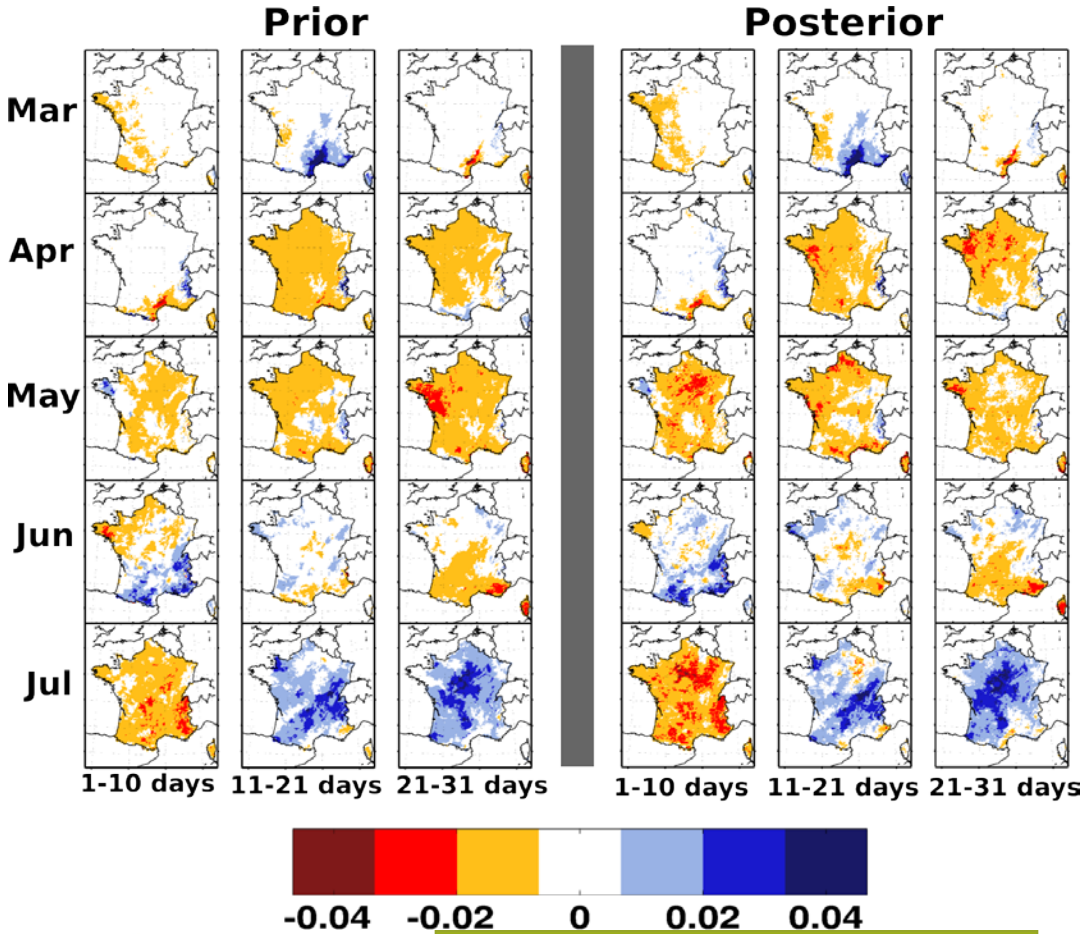
K Kalman gain

(**LAI, soil moisture,**
+ FAPAR, surface albedo,
land surface temperature)

Barbu et al. 2014, HESS

Application to drought monitoring

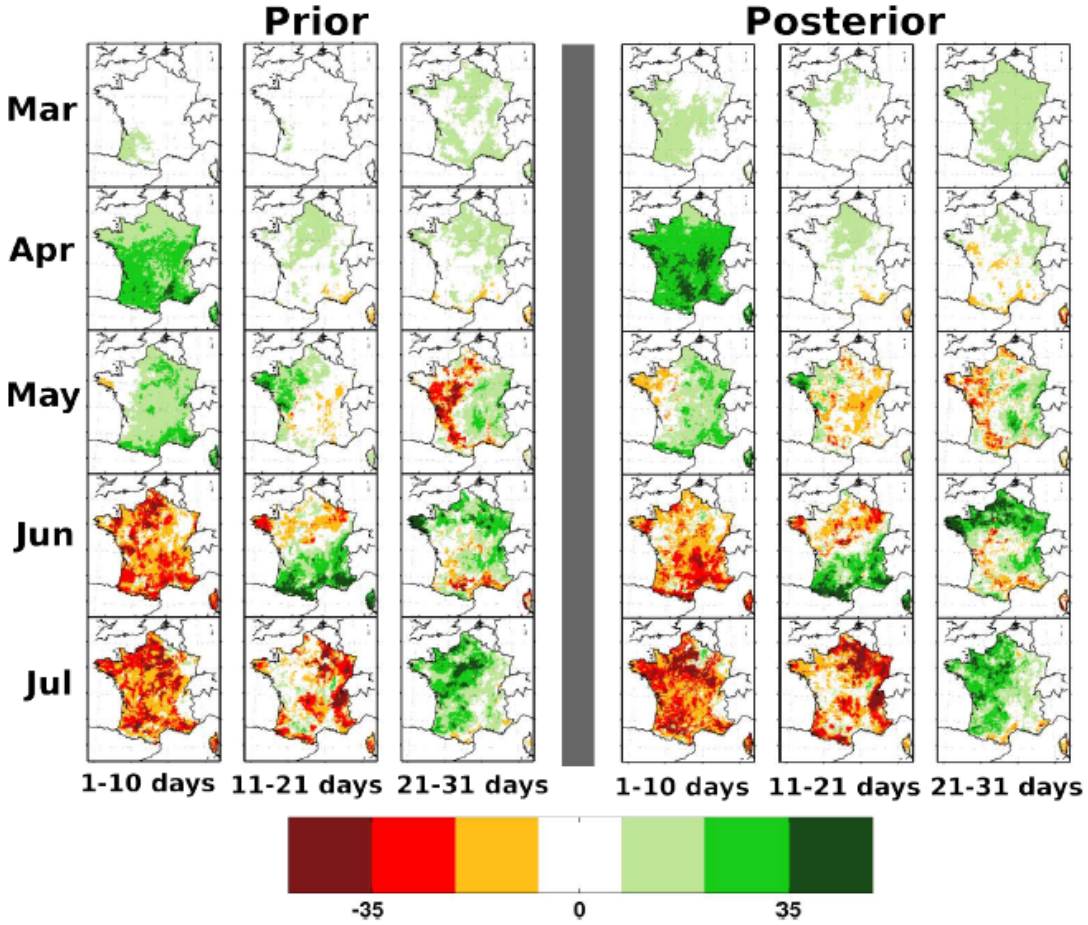
Soil moisture change rate in 2011 (extreme spring drought)



Barbu et al. 2014, HESS

Application to drought monitoring

10-daily GPP change rate in 2011 (extreme spring drought)

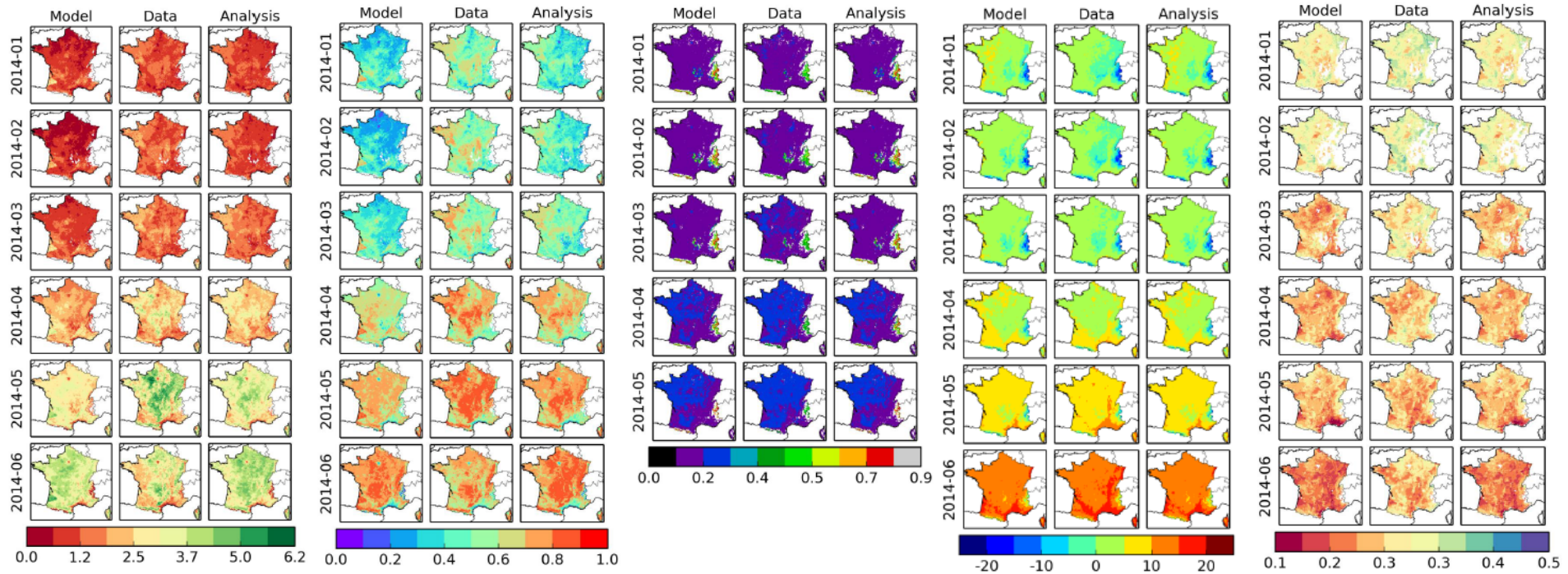


$$\mathrm{g\,CO_2\,m^{-2} \times 10\,days^{-1}}$$

Barbu et al. 2014, HESS

CGLS LAI, FAPAR, SA, LST, SSM

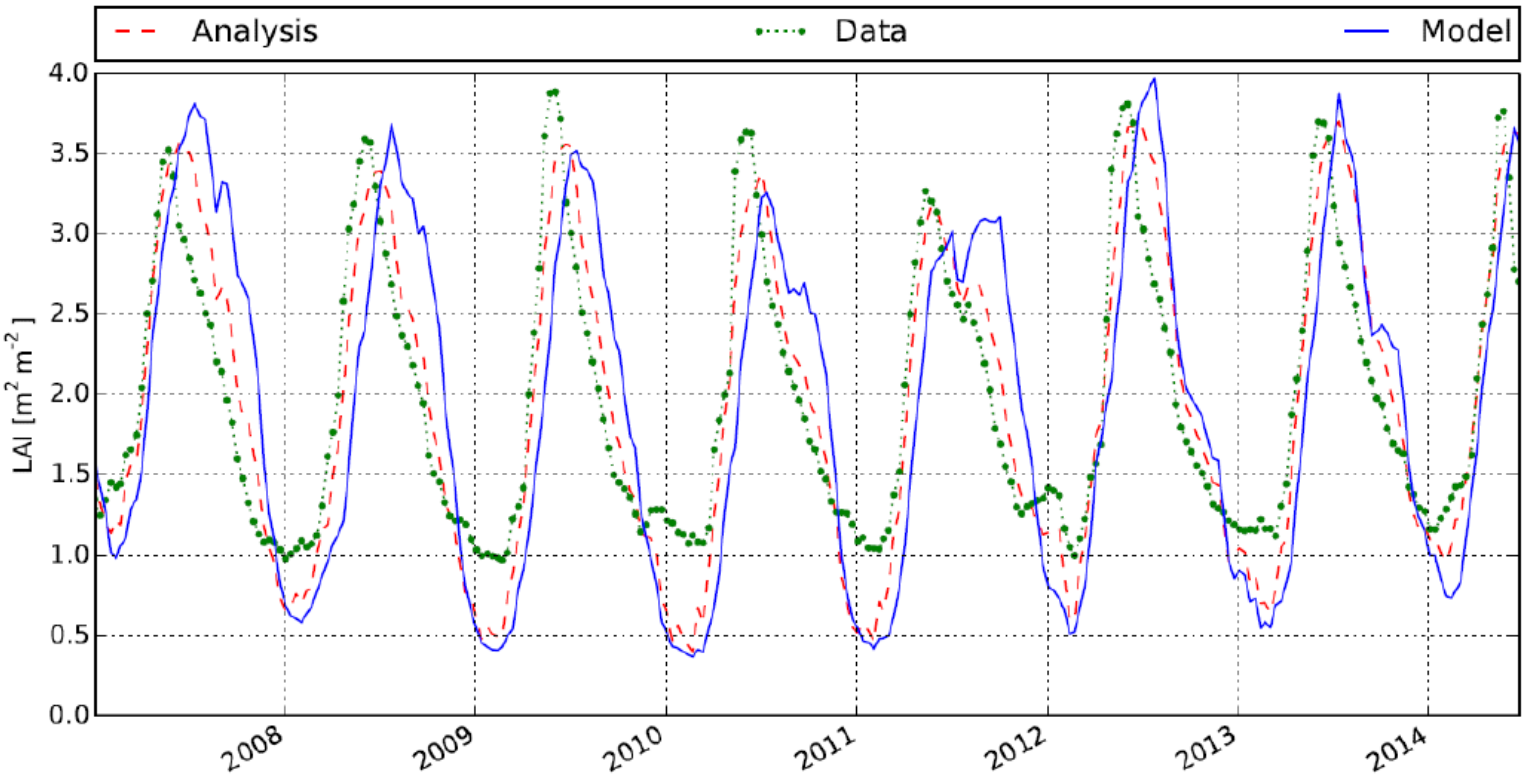
2014 S1 report: Model / Observations / Analysis



(m^2m^{-2}) (-) (-) (°C) (m^3m^{-3})

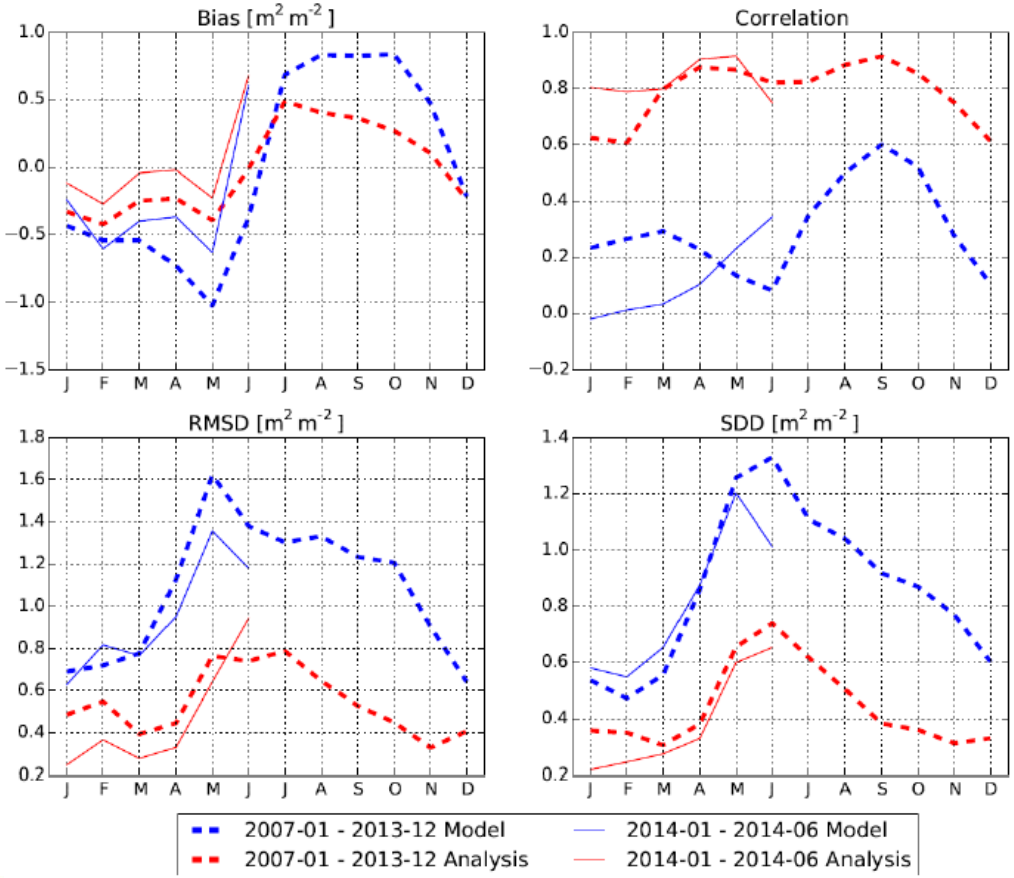
GEOV1 LAI

LAI analysis (mean value for France)



GEOV1 LAI

LAI analysis (France)



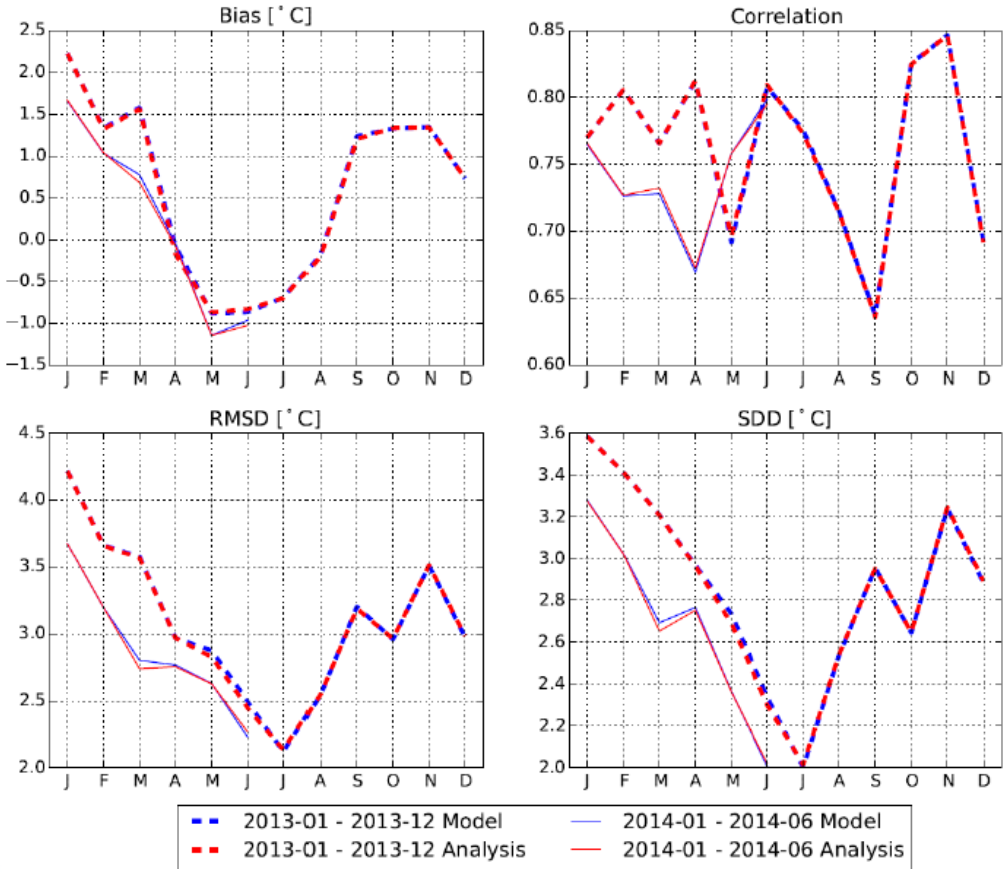
June 2014: from SPOT-VGT to PROBA-V data

The analysed LAI presents a positive bias (i.e. the simulated LAI is higher than the observations, by more than 0.5 m^2m^{-2} on average) while it is generally unbiased in June.

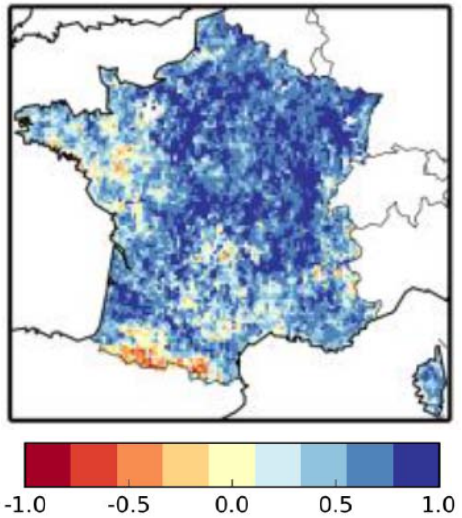
This denotes a problem caused by the transition from SPOT-VGT to PROBA-V.

MSG LST

Land Surface Temperature (France, 06:00 UTC)



April 2014: negative correlations

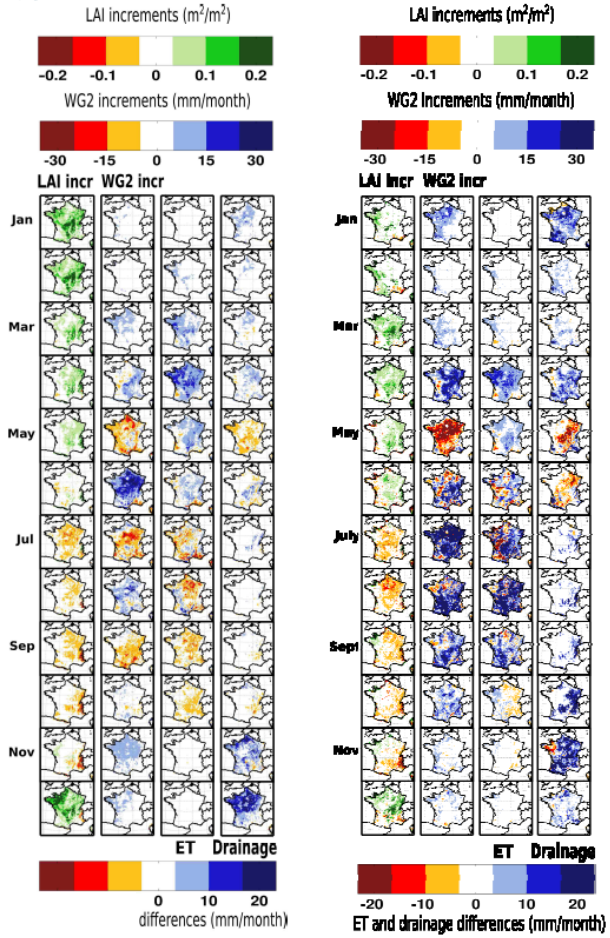


cloud screening at nighttime could probably be improved

ASCAT SSM

Increments

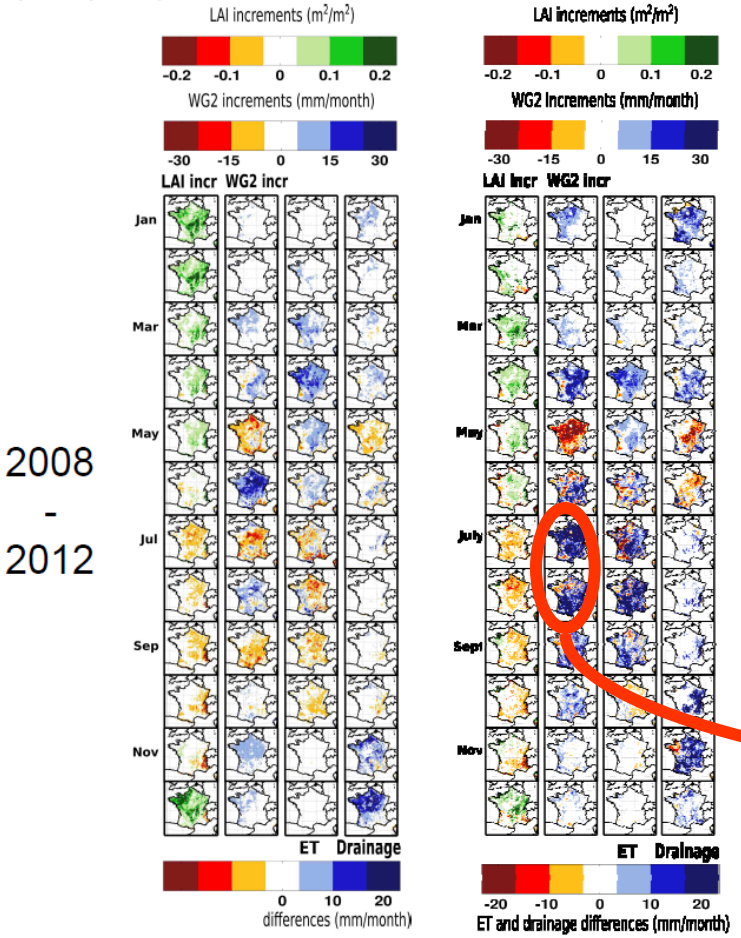
2008 - 2012



2013

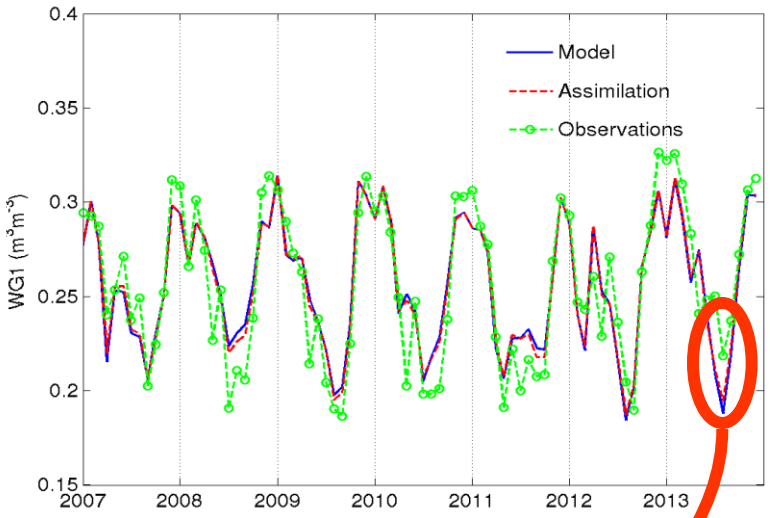
ASCAT SSM

Increments



2008 - 2012

2013



Too high SSM observations ?

Conclusions

Cross-cutting validation reports are generated every 6 months for the Copernicus Global Land service

Ongoing activities

Test the assimilation of FAPAR and other variables
Multi-layer soil hydrology
From EKF to EnKF
Link to hydrology (in situ river discharge observations used for validation)

Medium term objectives

Go global (LDAS-Monde)
Build a multi-decadal global land reanalysis integrating the existing vegetation and soil moisture satellite-derived ECV products
Intercomparison of global land reanalyses (eartH2Observe project)

Thank you for your attention

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