



The EUMETSAT  
Network of  
Satellite Application  
Facilities



**H SAF**

Support to Operational  
Hydrology and Water  
Management



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

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**METEO FRANCE**

# Context

## H-SAF

- Develops and issues surface soil moisture (SSM) products.
- Provision by MF of in situ soil moisture observations for the validation.
- Production of scores.

**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 soil moisture products at a global scale, together with other vegetation indices, burnt areas, water bodies.
- Cross-cutting validation operated by MF.

# Validation of Earth observation data

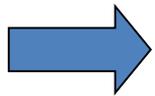
**Validation:** independent assessment of the quality

**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)**

# SMOSMANIA

21 stations in southern France

Automatic weather stations of Meteo-France

4 depths: 5, 10, 20, 30 cm

Soil moisture (ThetaProbe) since 2007 (west)  
Soil temperature (PT100) since 2009

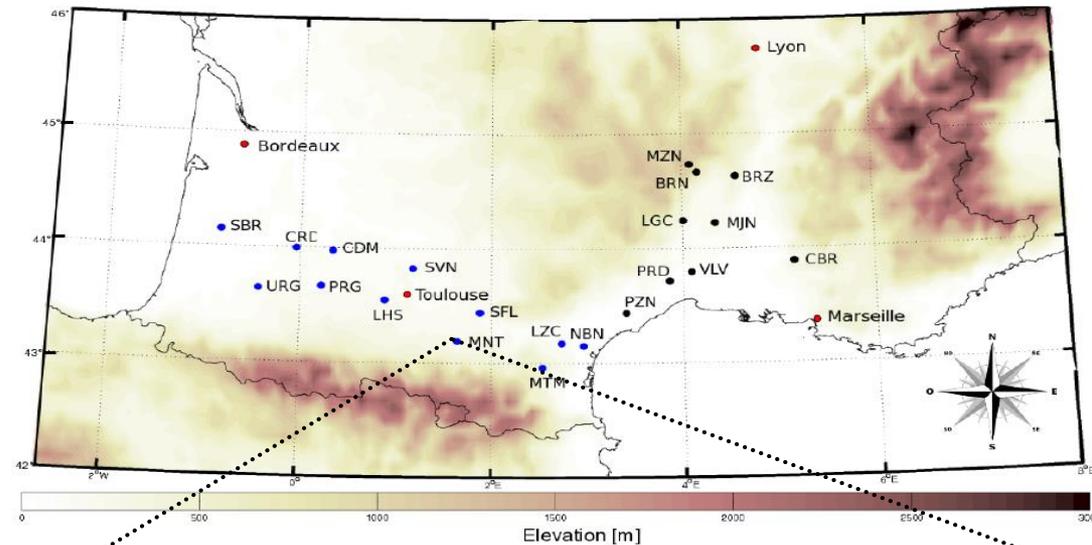
Fully operational maintenance since 04/2014

Fully operational acquisition and QC in 2015

*Data available for non-commercial use from the ISMN*



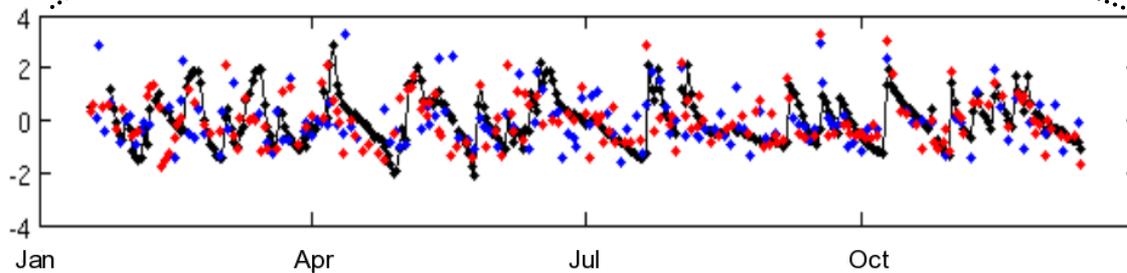
# SMOSMANIA



**Anomalies:**

$$\Theta = \frac{SSM(i) - \overline{SSM(F)}}{Stdev(SSM(F))}$$

F: 5 week window

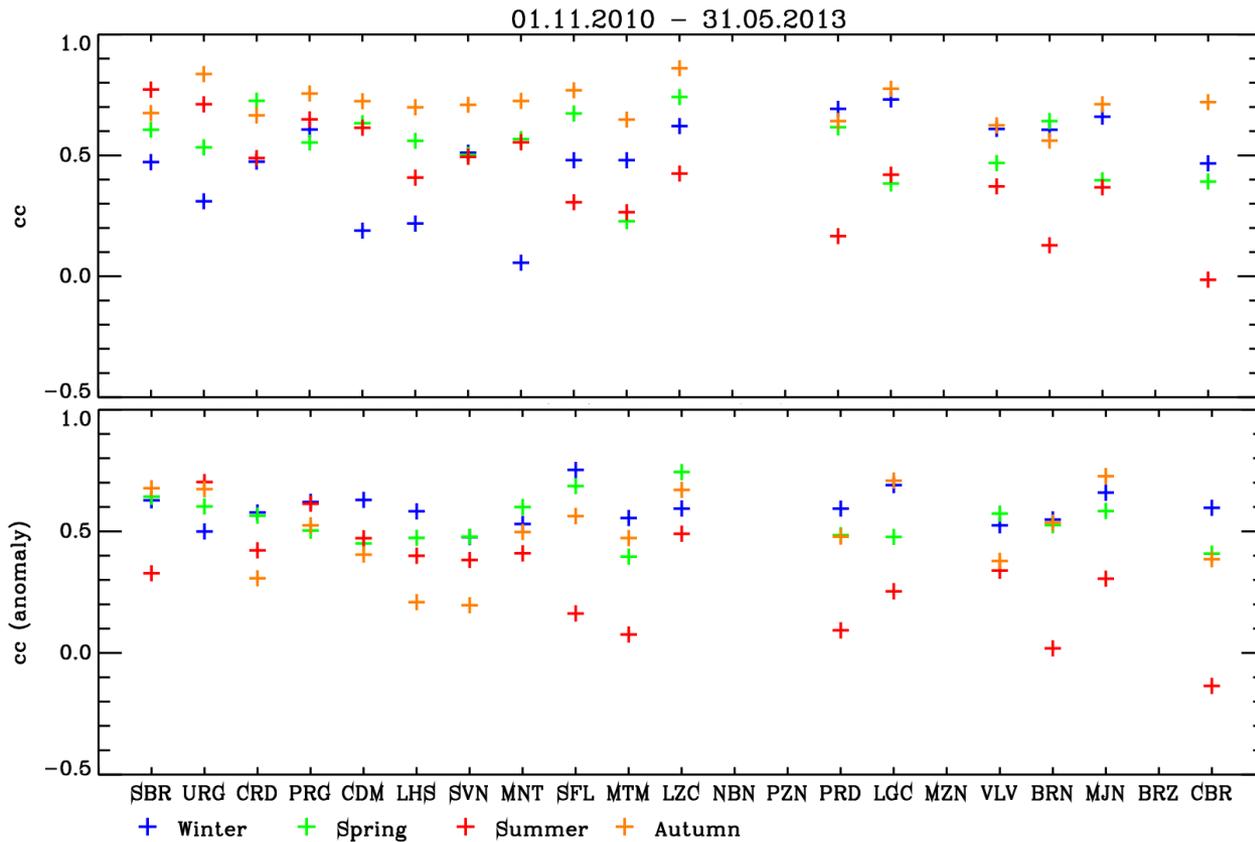


- ◆ In-situ
- ◆ SMOS SSM
- ◆ ASCAT

Parrens et al. 2012, HESS

# SMOSMANIA

Absolute correlations



Anomaly correlations

# ISBA-A-gs in SURFEX

## **SURFEX modeling platform of Meteo-France**

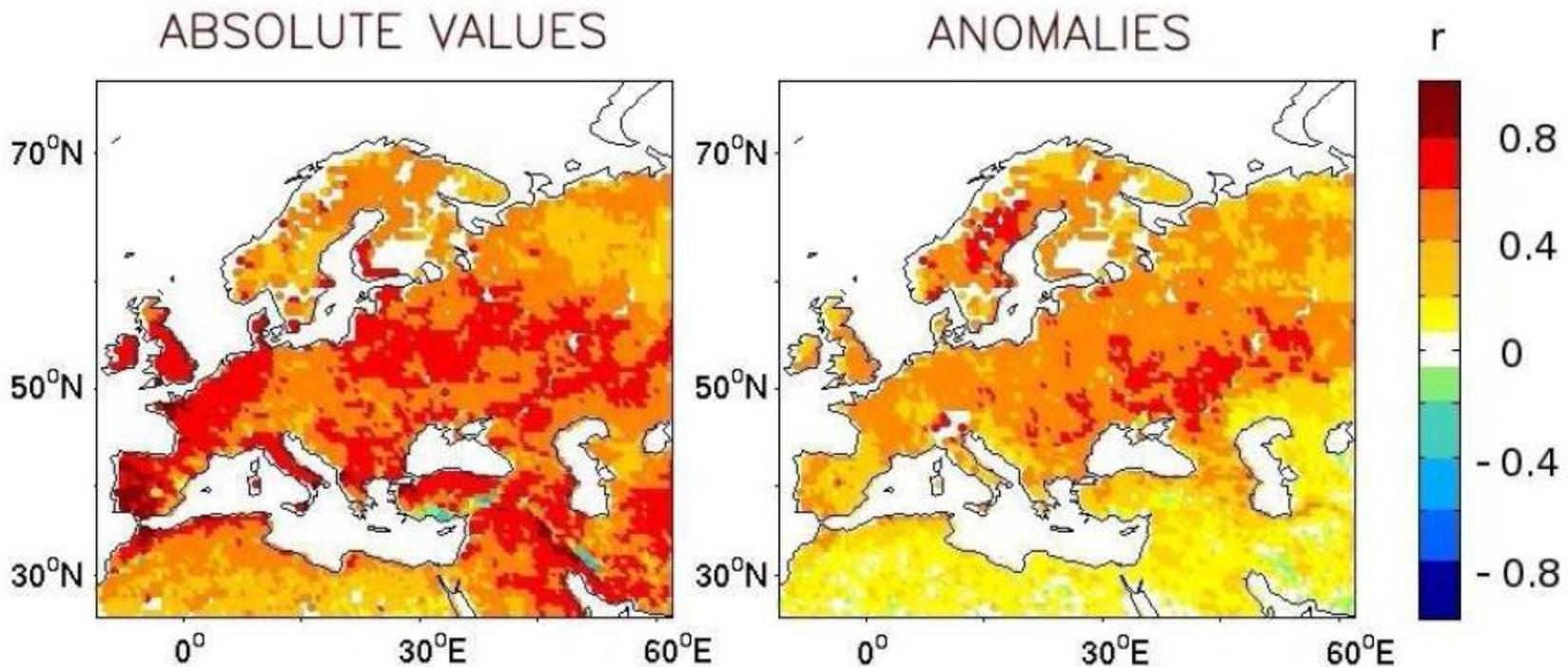
- Interoperable with operational real-time applications: weather forecast, hydrology, atmospheric CO<sub>2</sub> inversions
- Shared by many meteorological services in Europe and North Africa
- Used in CNRM-ARPEGE climate model (IPCC simulations)
- Version 8 will be open-source (end 2014)

## **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 on vegetation of long-term changes of atmospheric CO<sub>2</sub>

# Comparison with models: ESA-CCI SM

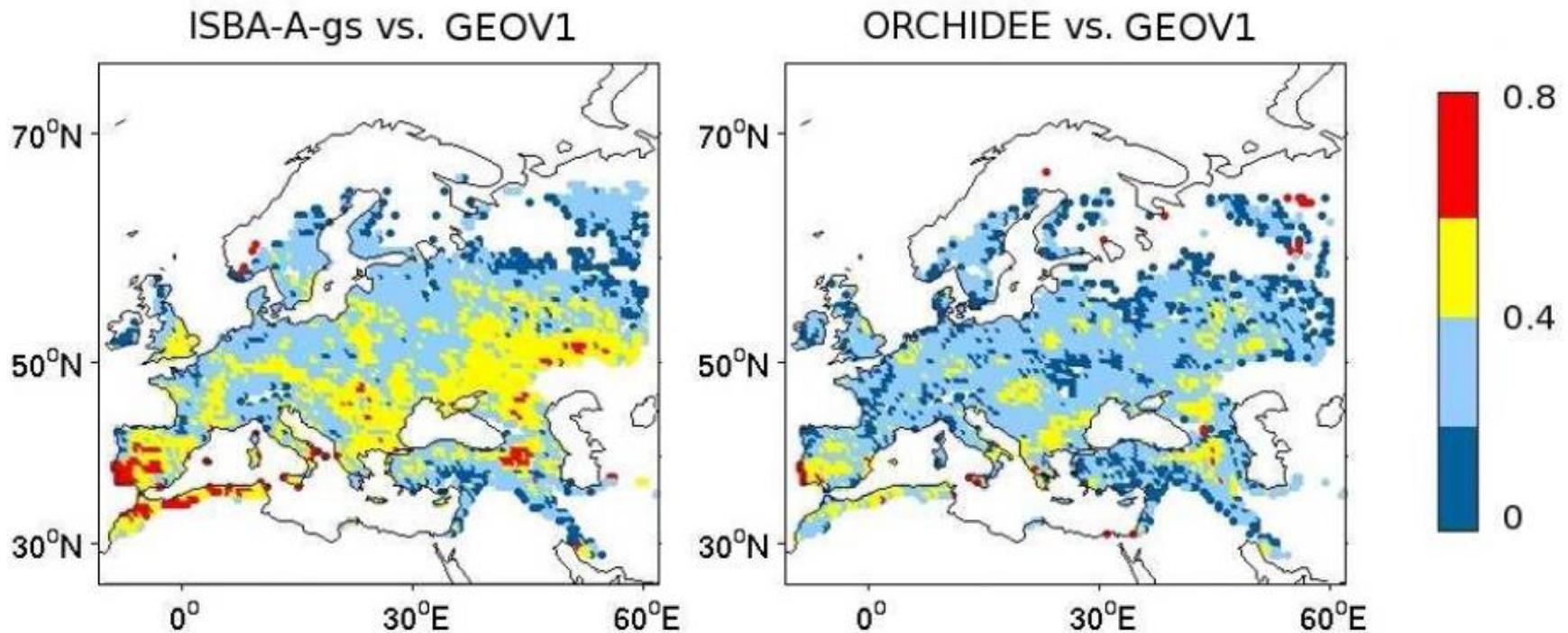
Surface soil moisture (ESA-CCI microwave-derived product)  
Correlations (1991-2008 day-to-day variability)



Szczypta et al. 2014, GMD

# Comparison with models: GEOV1

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

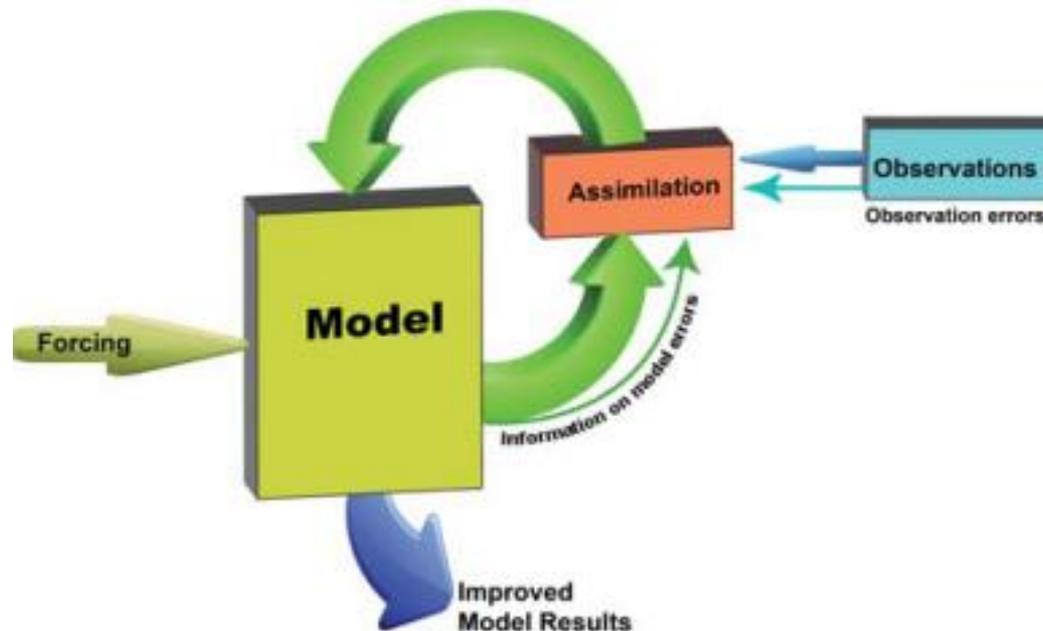


Szczypta et al. 2014, GMD

# 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.

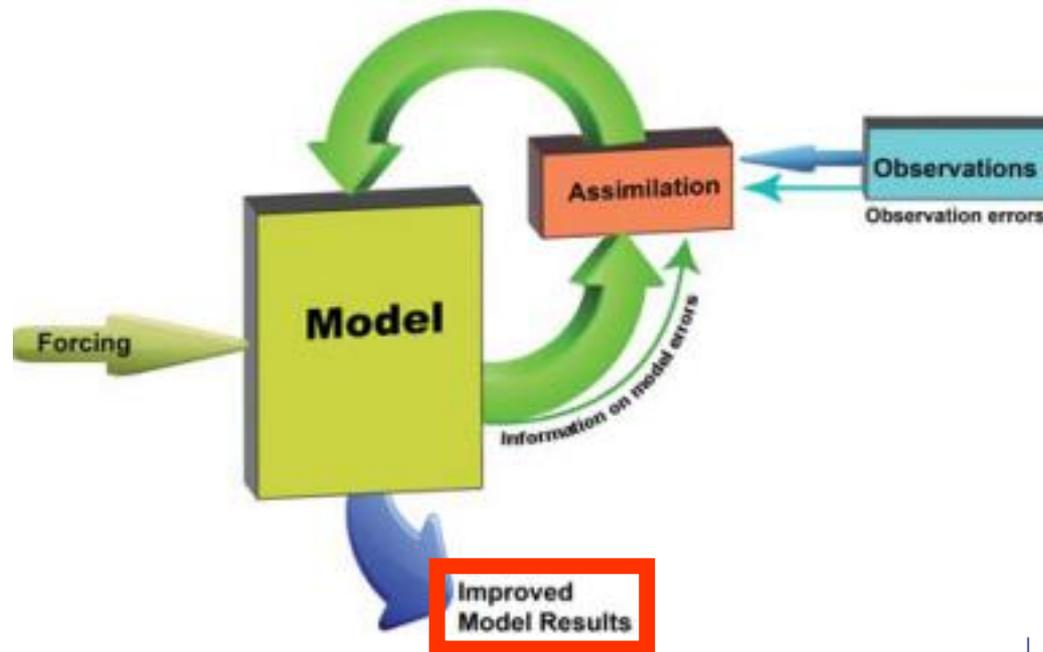
*Paul R. Houser, Figure from [http://www.hzg.de/institute/coastal\\_research/cosyna](http://www.hzg.de/institute/coastal_research/cosyna)*



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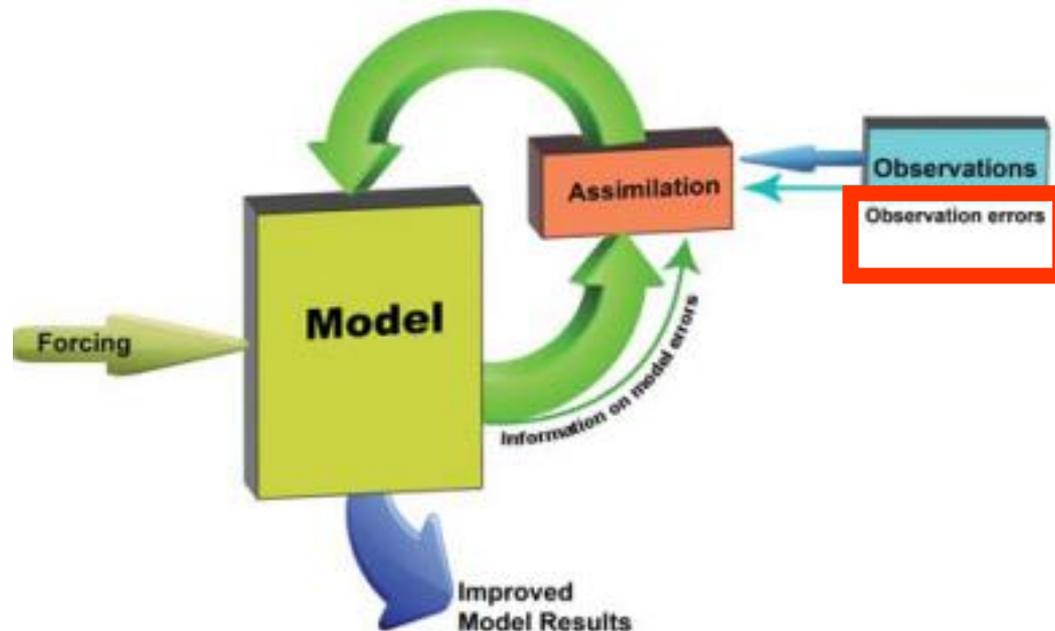
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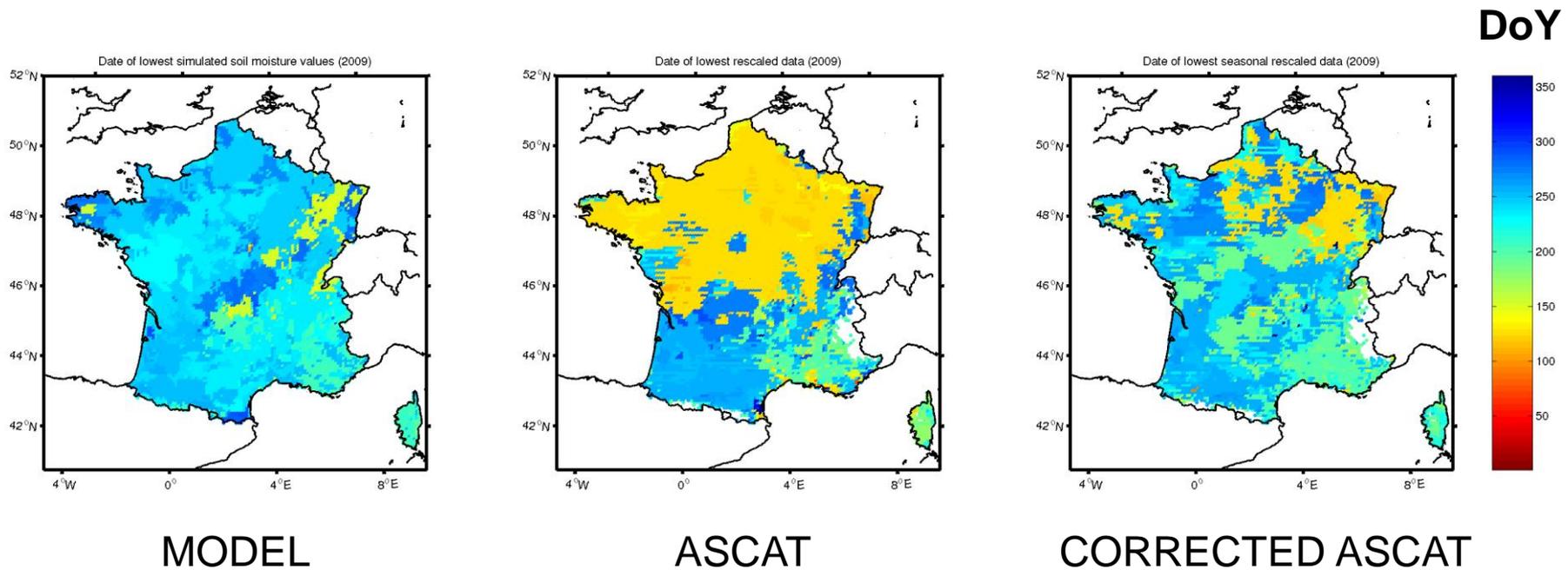
# Some issues/problems

## Assimilation of surface soil moisture

- Soil moisture is model-dependent
- Decoupling of soil moisture content between surface and deep soil layers in dry conditions
- ASCAT product has seasonal and interannual issues
  - Vegetation correction is empirical
  - Fixed seasonal parameters
  - Discontinuities in the parameter values (ERS-derived, then 2-yr ASCAT, ...)

# Model/observation mismatch: SSM

## Date of lowest ASCAT SSM value in 2009

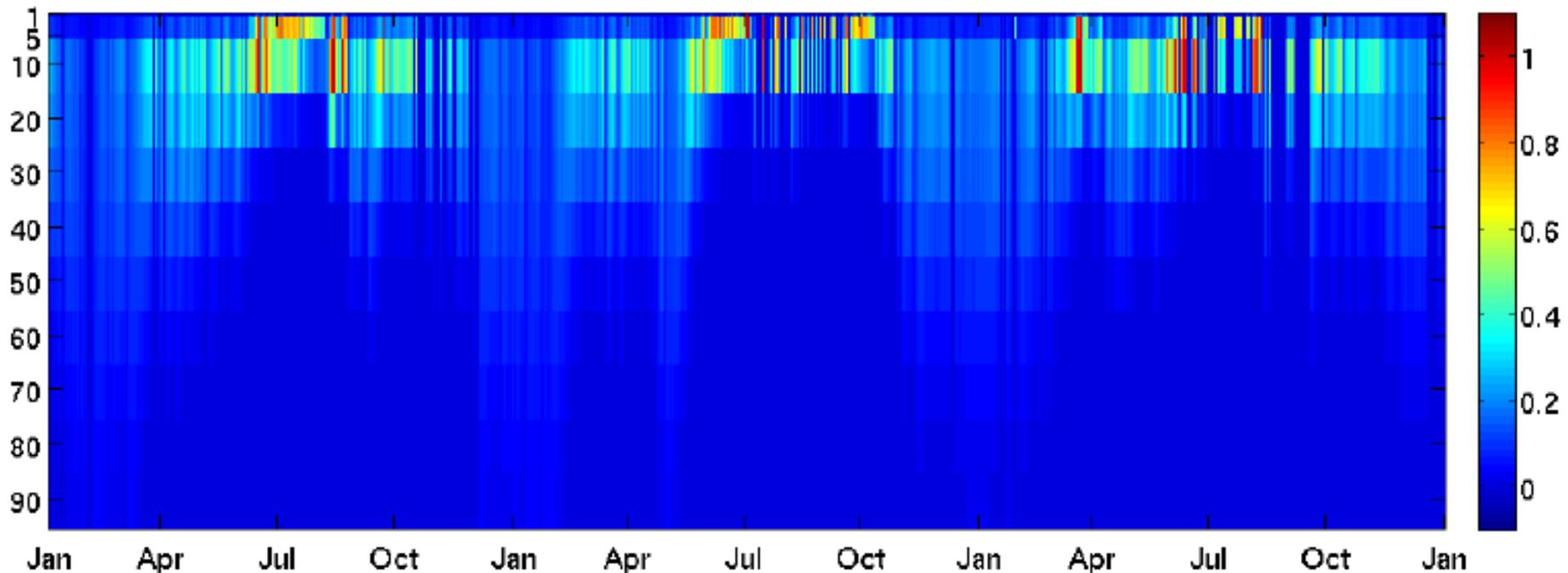


Barbu et al. 2014, HESS

# Seasonal change in sensitivity: SSM

## Assimilation of SSM in a multilayer soil hydrology model

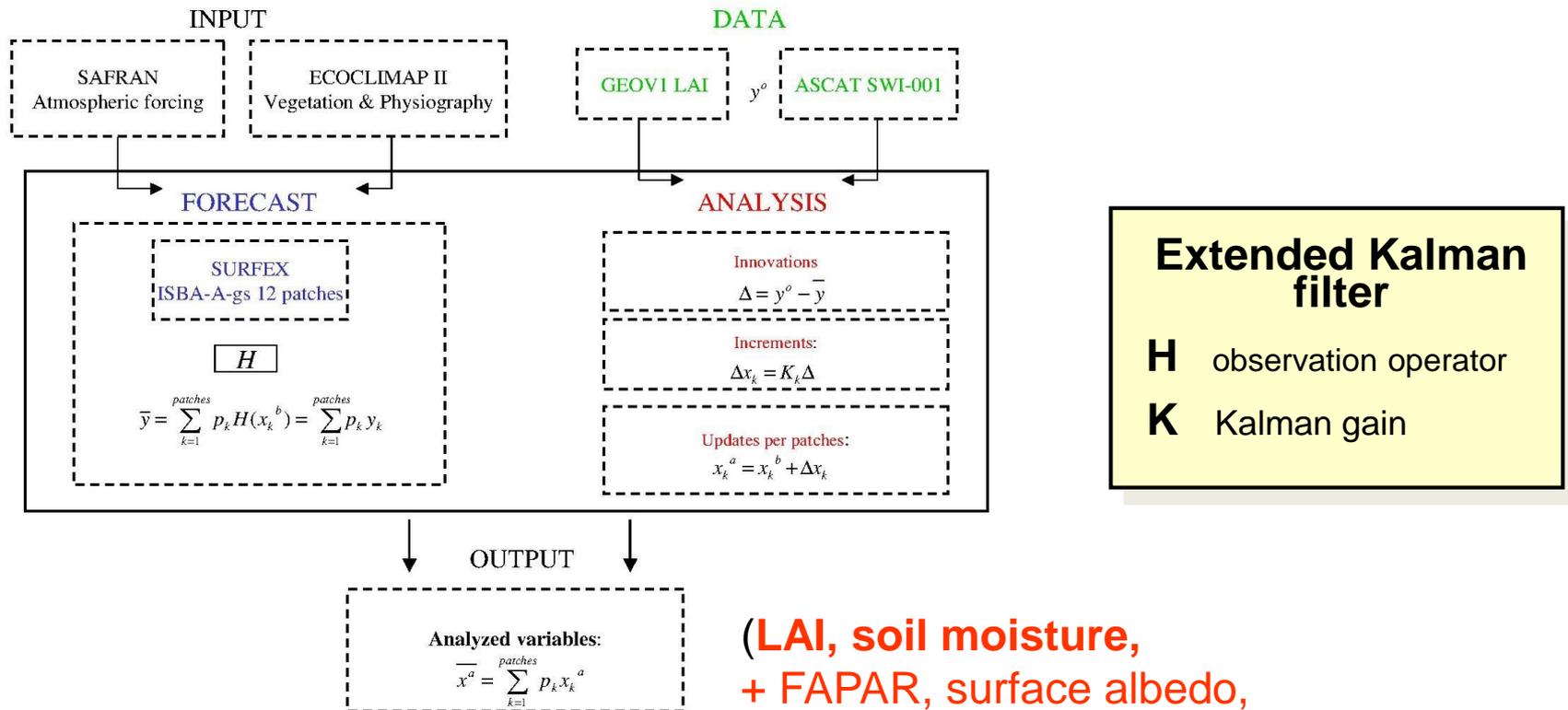
*Jacobian profiles (sensitivity of SSM to perturbations of deep layers)*



Parrens et al. 2014, HESS

# LDAS-France

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



**Extended Kalman filter**

**H** observation operator

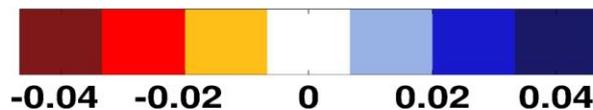
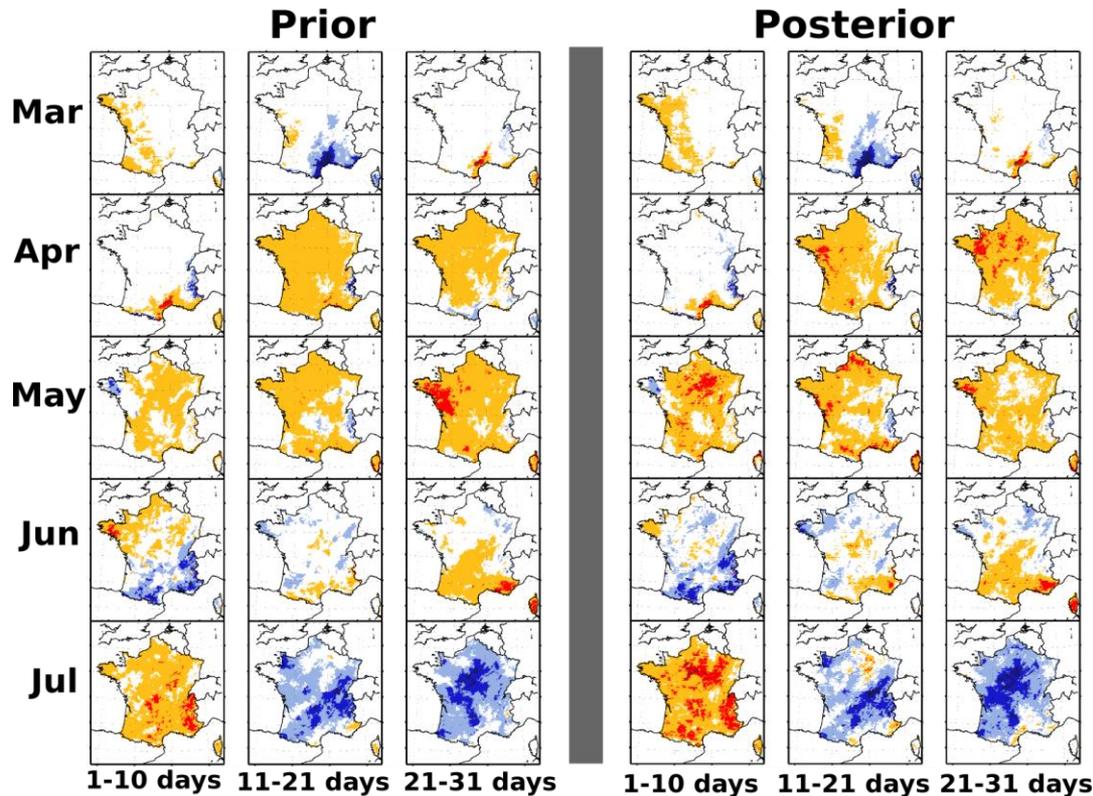
**K** Kalman gain

Barbu et al. 2014, HESS

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

# Application to drought monitoring

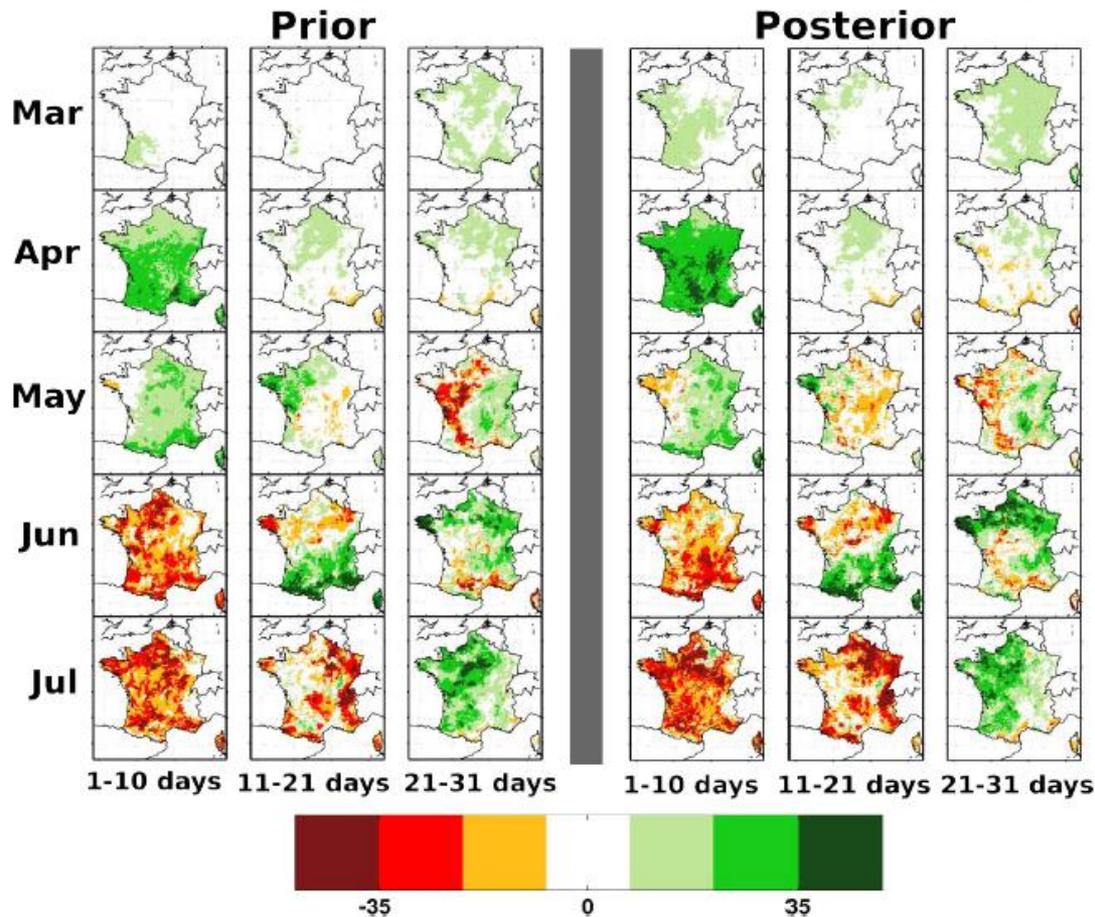
## Soil moisture change rate in 2011 (extreme spring drought)



Barbu et al. 2014, HESS

# Application to drought monitoring

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



$$\text{g CO}_2 \text{ m}^{-2} \times 10 \text{ days}^{-1}$$

# Copernicus GLS products in 2014

## Model / Observations / Analysis

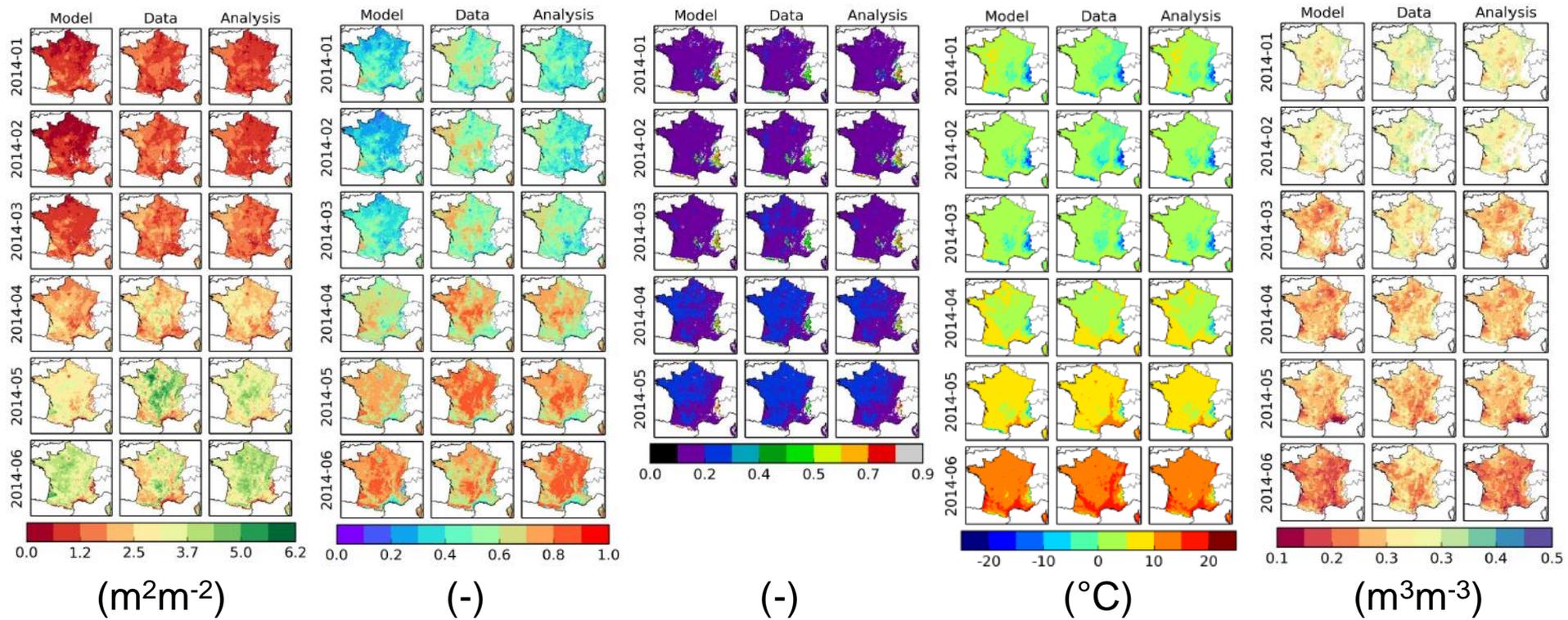
LAI

FAPAR

SA

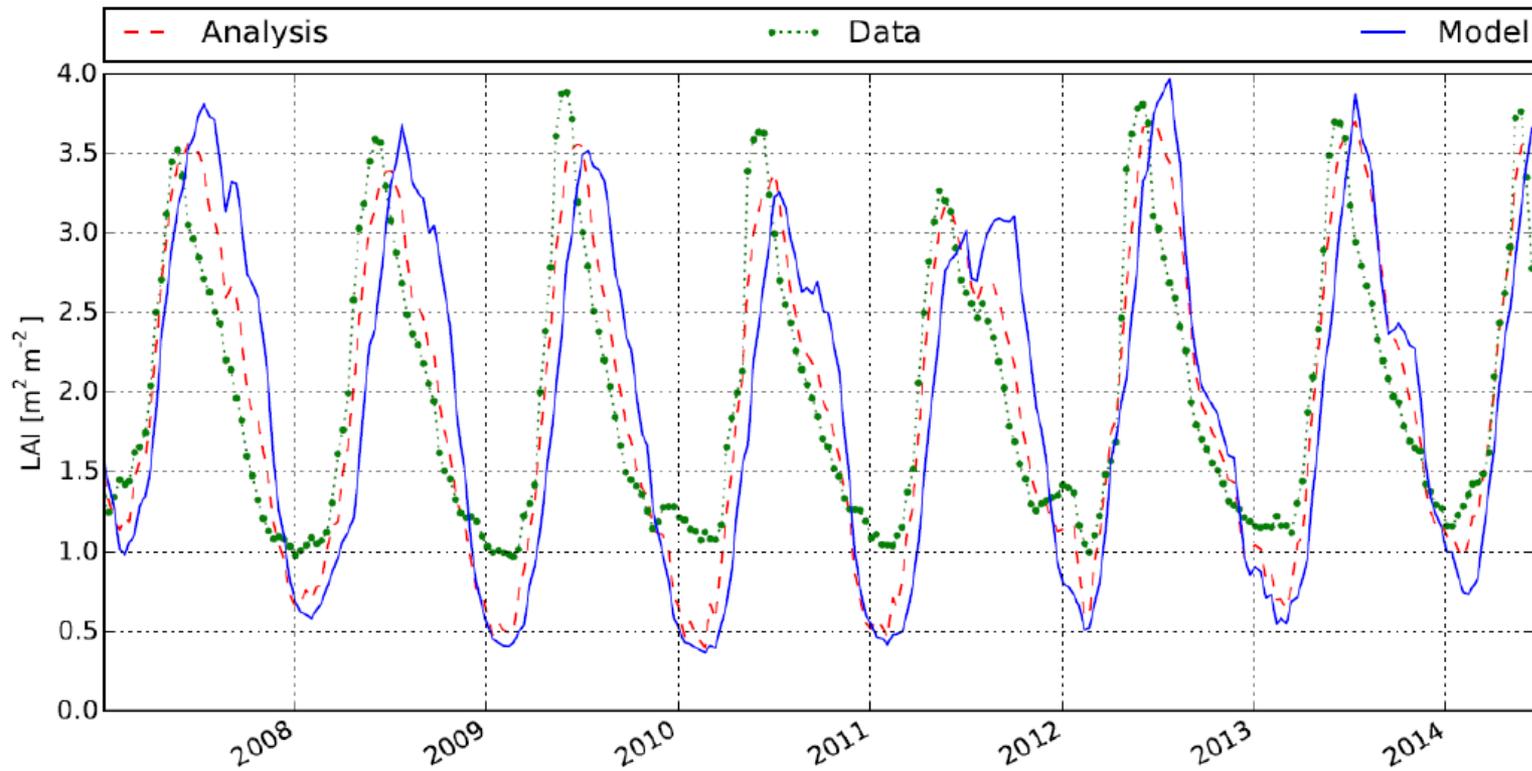
LST

SSM



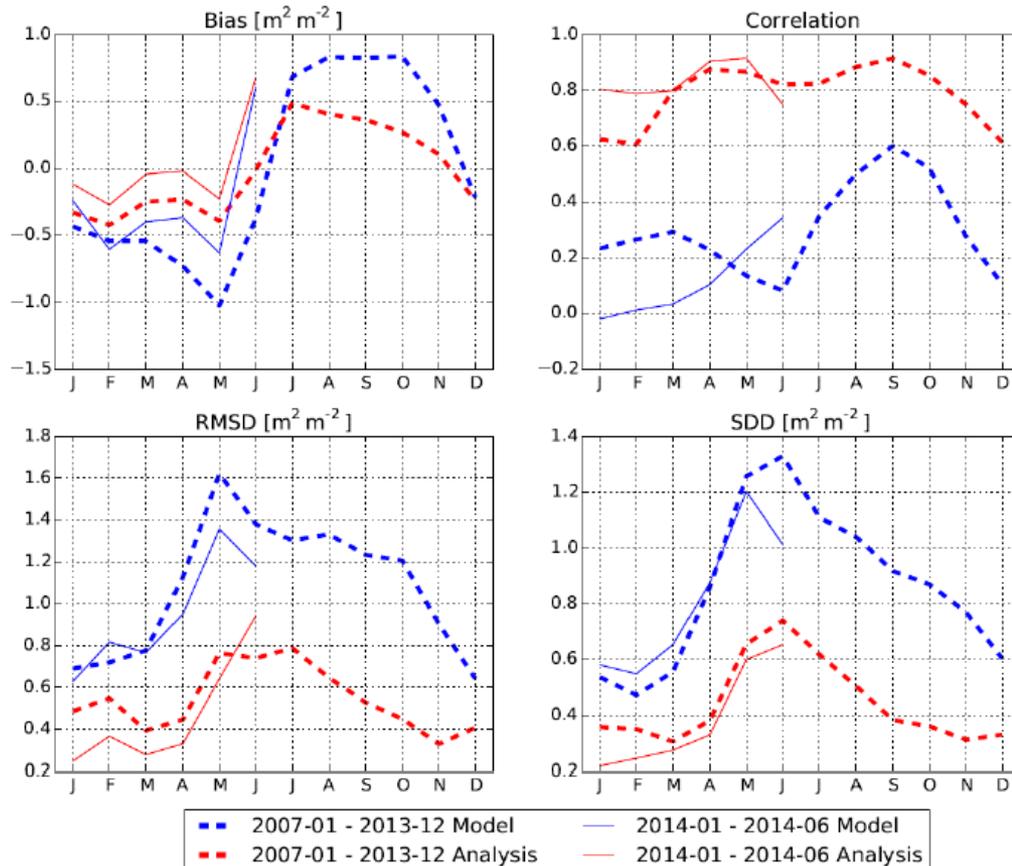
# GEOV1 LAI

## LAI analysis (mean value for France)



# GEOV1 LAI

## LAI analysis (France)



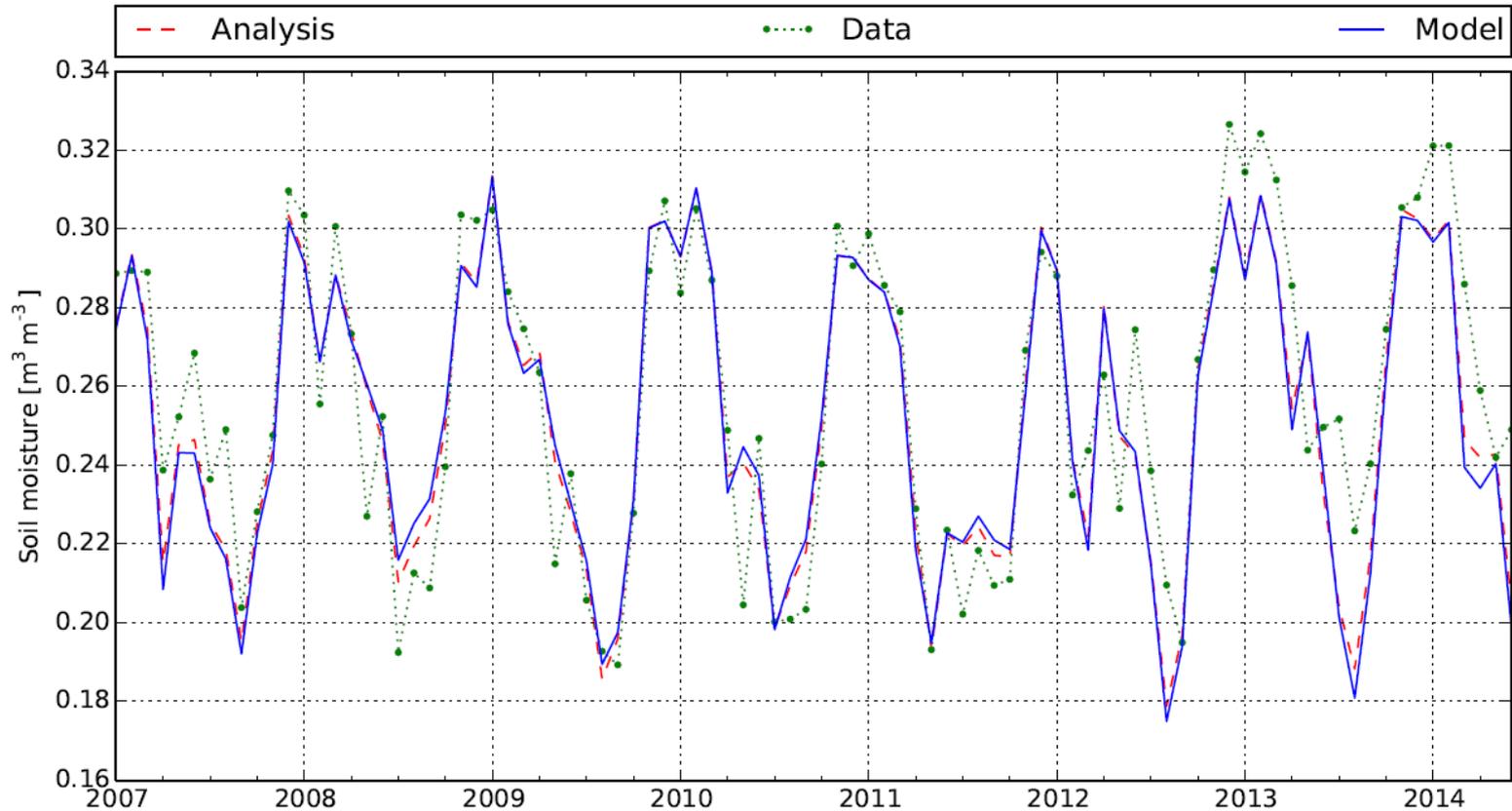
## June 2014: from SPOT-VGT to PROBA-V data

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

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

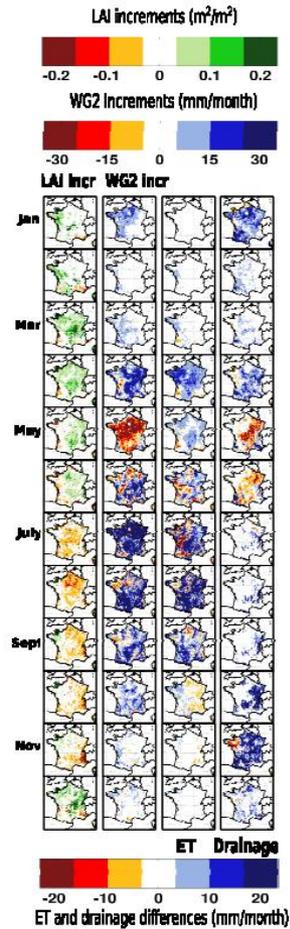
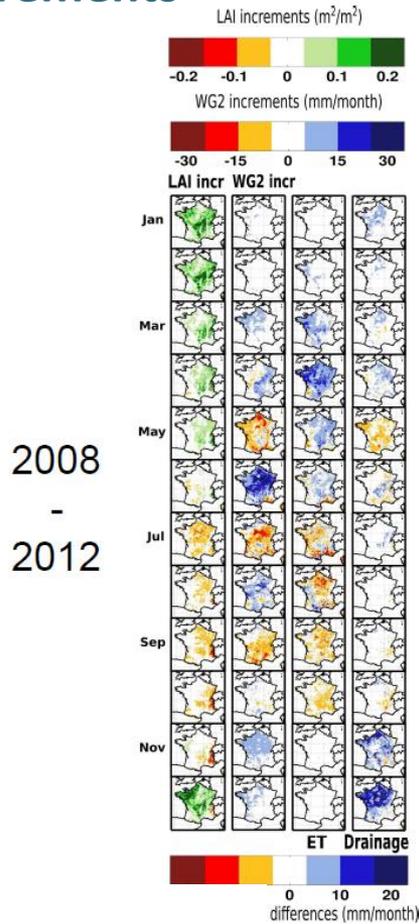
# ASCAT SSM

## Surface soil moisture (mean value for France)



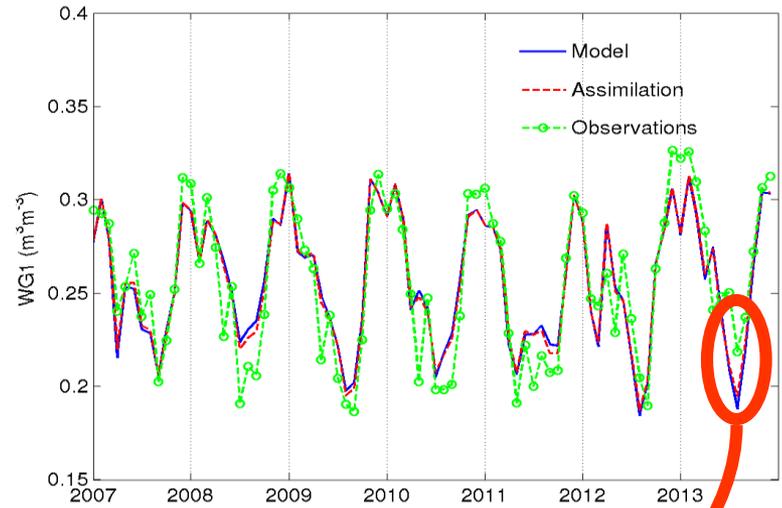
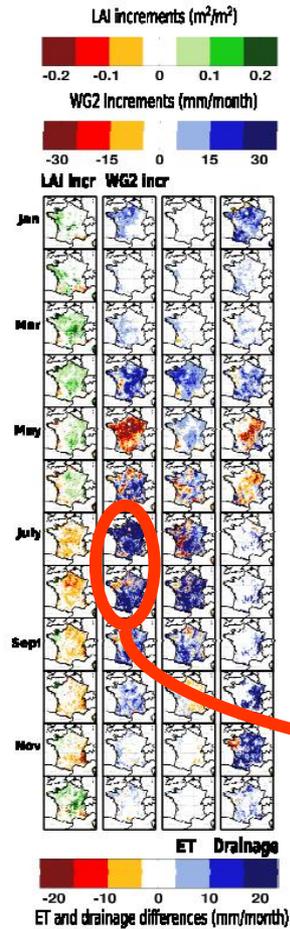
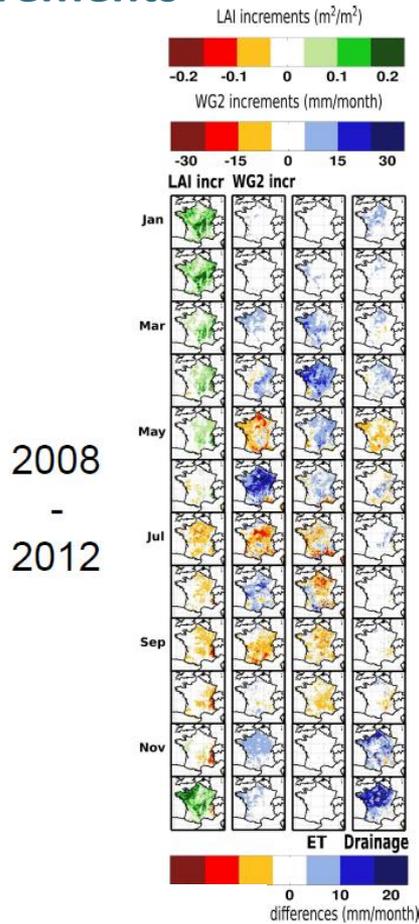
# ASCAT SSM

## Increments



# ASCAT SSM

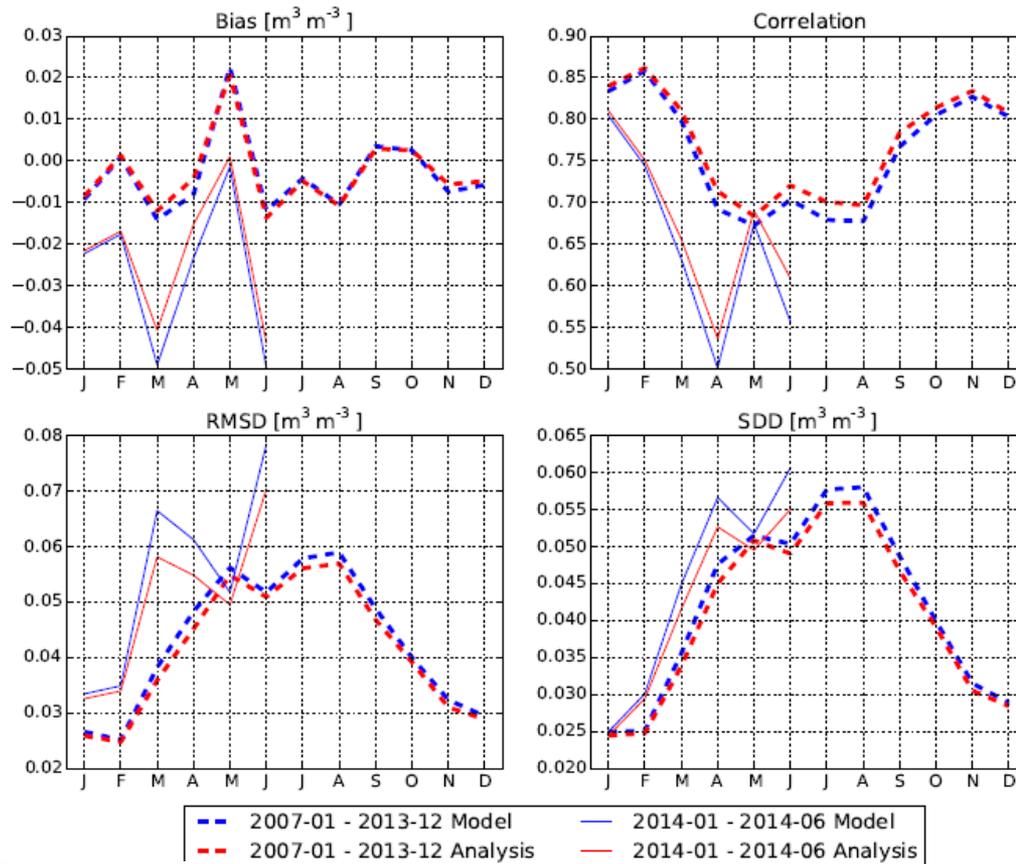
## Increments



Too high SSM observations ?

# ASCAT SSM

## Surface soil moisture



## Trend towards higher values and score degradation

The analysed SSM presents a negative bias (the simulated SSM is lower than the observations, down to  $-0.05 \text{ m}^3 \text{m}^{-3}$  on average) and correlation coefficient is lower than usual.

*This is caused by the transition from one vegetation parameter set to another in June 2012.*

# Conclusions

## Cross-cutting validation reports for the Copernicus Global Land Service

Active and passive monitoring across biophysical variables

ASCAT SSM: harmonization of NRT and past time series is needed

## Ongoing activities

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 (earthH2Observe project)



# Thank you for your attention

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