Use of SURFEX for large scale hydrology and drought monitoring

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SURFEX modeling platform

- a global modeling platform
  - shared by many national hydro-meteorological services in Europe and in North Africa

- designed for operational applications: weather forecast, hydrology, IPCC simulations
  - SAFRAN-ISBA-MODCOU (over France)
  - SURFEX-TRIP (global)
    - ***Many developments are first tested over France (validation is easier)***

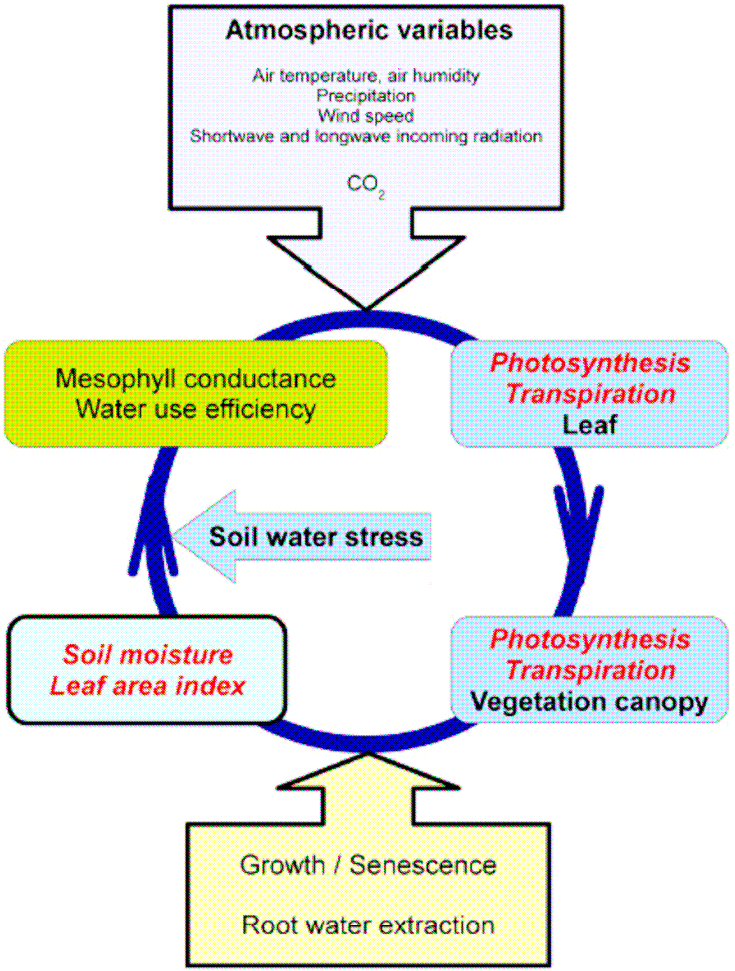
- Version 8 will be open-source (July 2016)

ISBA in SURFEX

The ISBA land surface model simulates:

- multilayer soil hydrology
- evapotranspiration, CO_2 fluxes, …
- carbon stocks
- the impact of the long term evolution of the CO_2 atmospheric concentration (can be used for climate change impact studies)

-variables observables from space: LAI, FAPAR, SA, LST, SSM
-a “flexible” LAI which can be analyzed at a given time

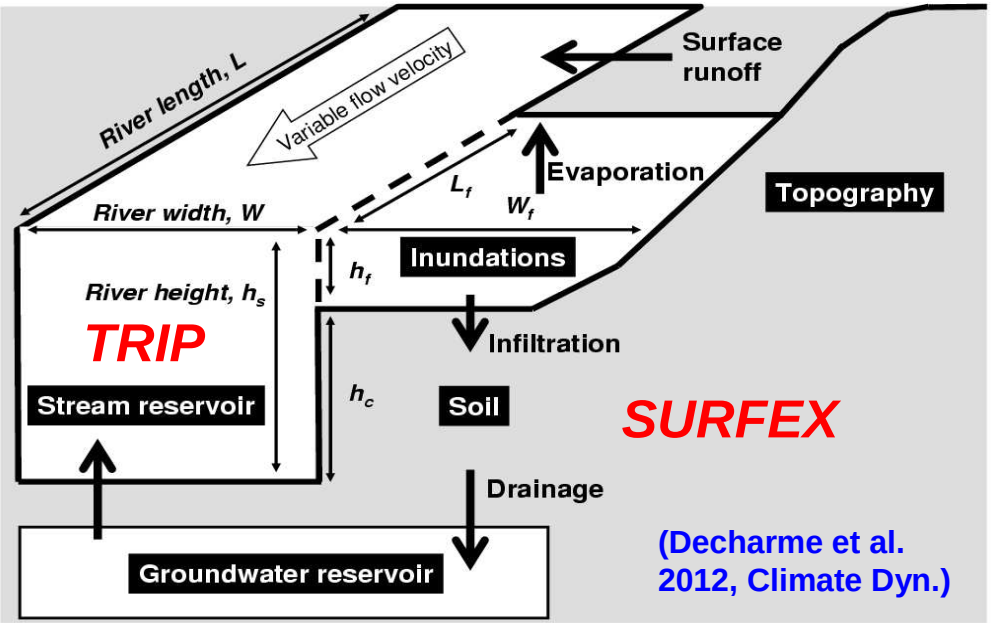


… assimilates:

- LAI
- surface soil moisture

TRIP

- Coupled to SURFEX
  - OASIS-MCT
- Groundwaters
- Inundations



Data assimilation

LDAS-France (Barbu et al. HESS 2014)

- ISBA-A-gs forced by SAFRAN
- 8 km x 8 km

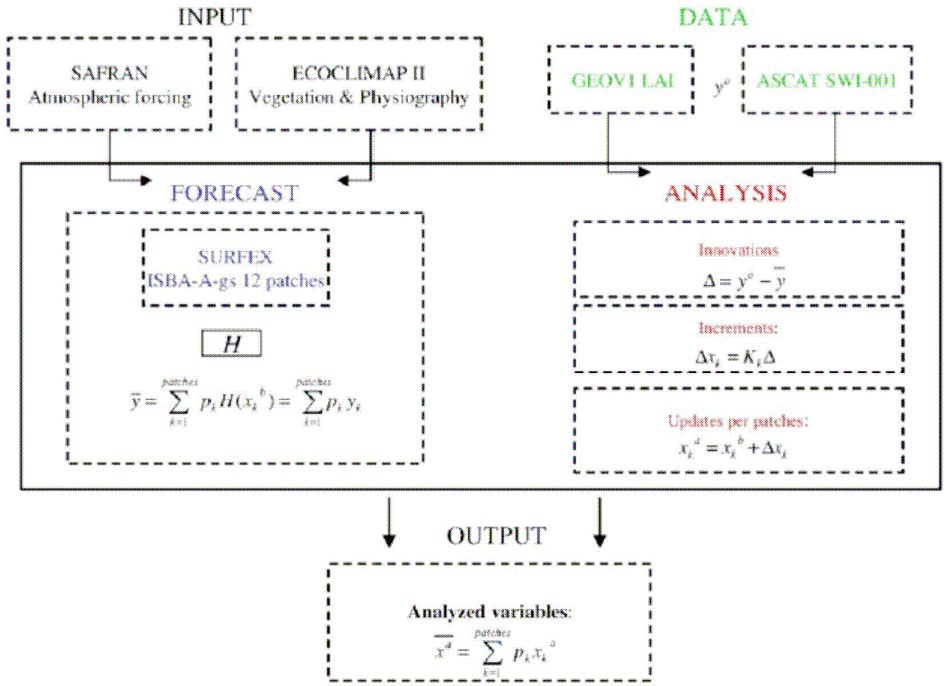
Sequential assimilation (SEKF)

Active monitoring (assimilation) of

- Copernicus GLS LAI
- Copernicus GLS surface soil moisture

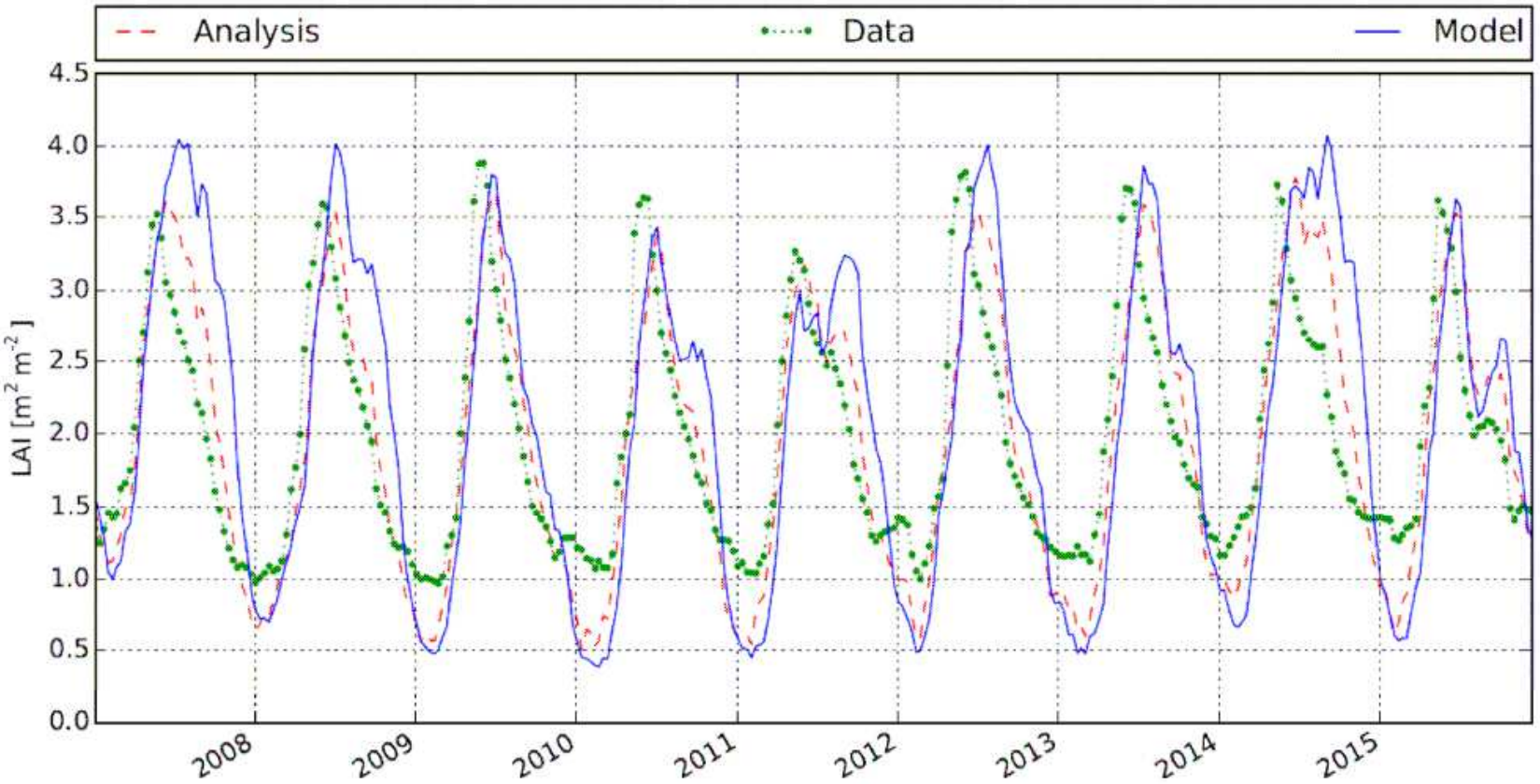
Passive monitoring of

- FAPAR
- SA
- LST



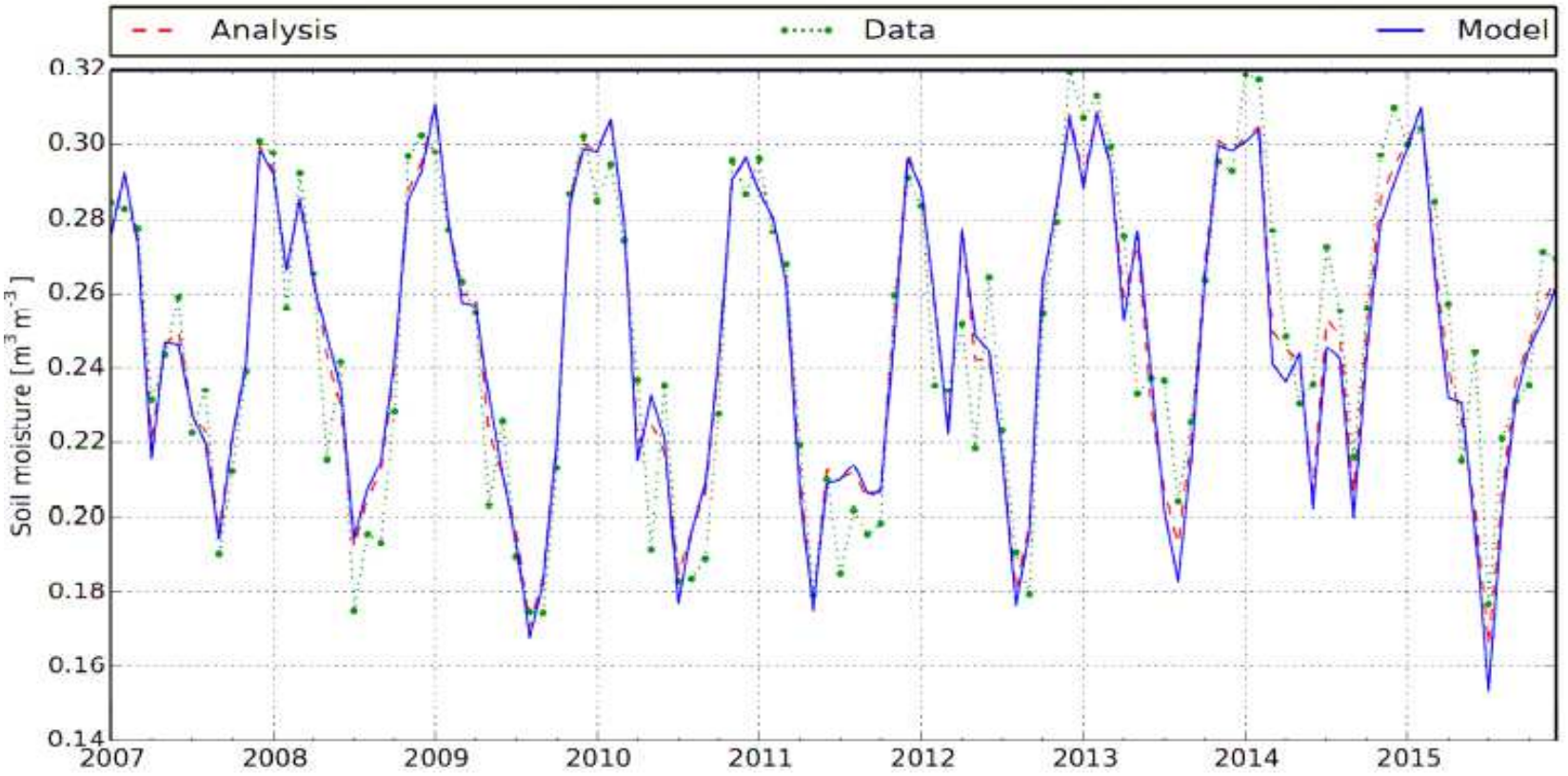
Data assimilation

LAI (mean monthly values over France)



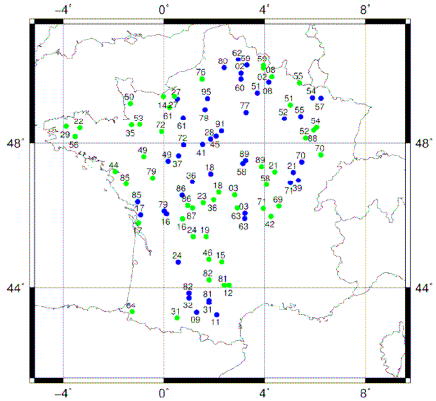
Data assimilation

SSM (mean monthly values over France)



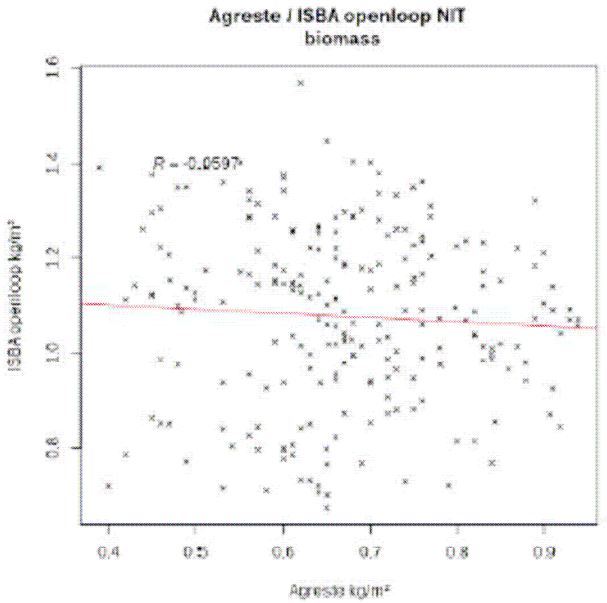
Data assimilation

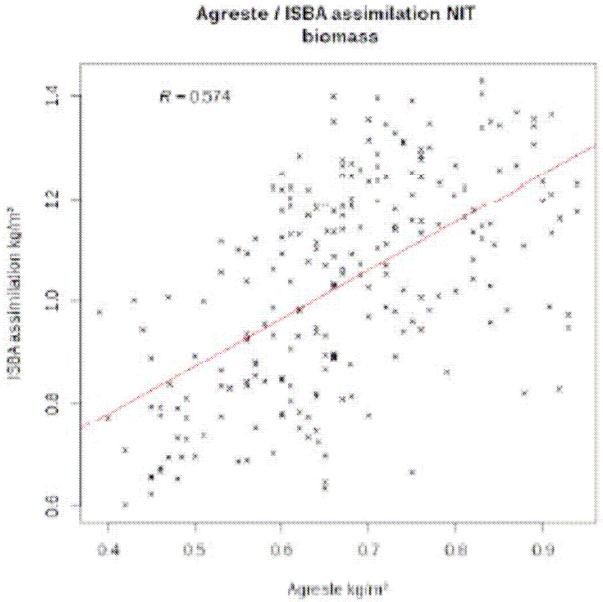
LDAS-France vs. crop yield observations vs. WOFOST (JRC)

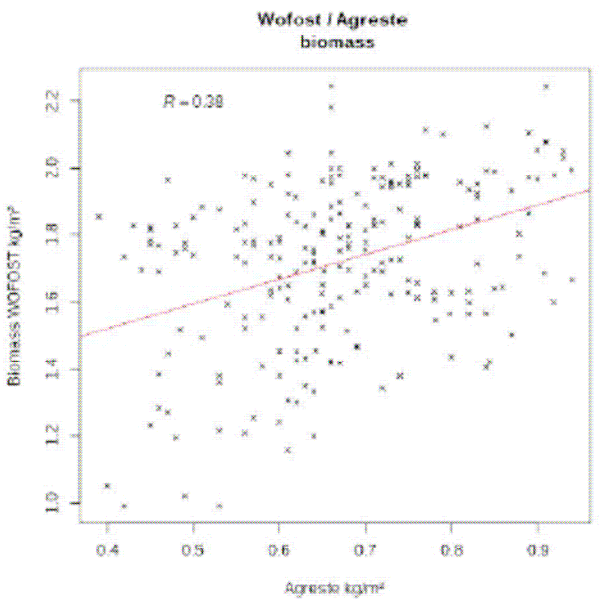


Assimilation turns biomass simulations consistent with agricultural in situ observations

Above-ground biomass:

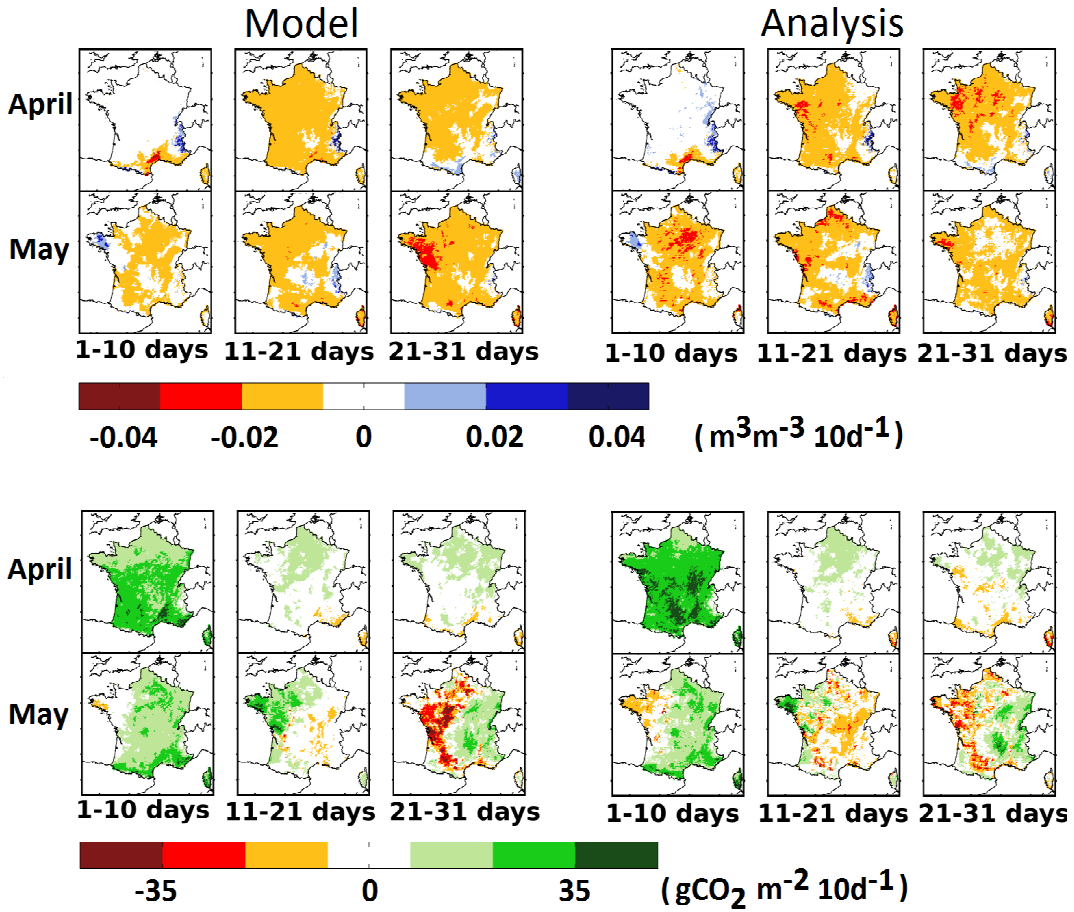






Data assimilation

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



Assimilation reinforces the drought signal

Barbu et al. 2014, HESS

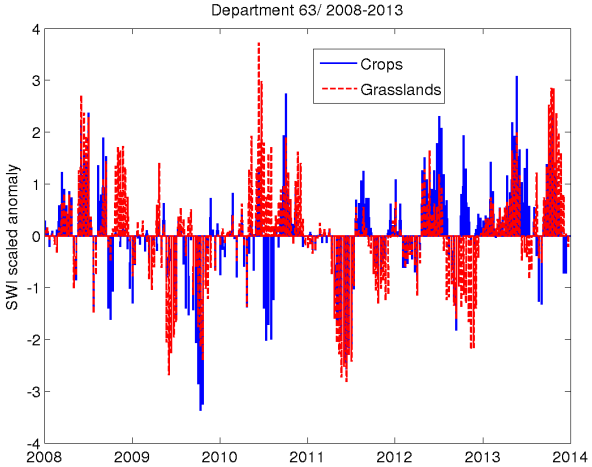
Data assimilation

LDAS-France: agricultural drought indicators, example of Puy de Dôme

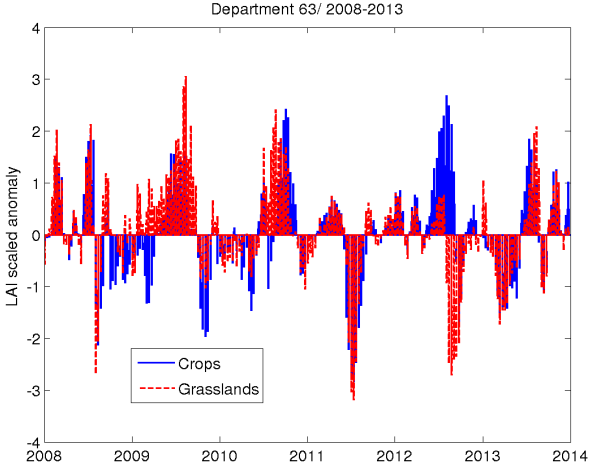
LAI and biomass anomalies are less erratic than SWI anomalies
Complementary information content

10-day scaled anomalies:

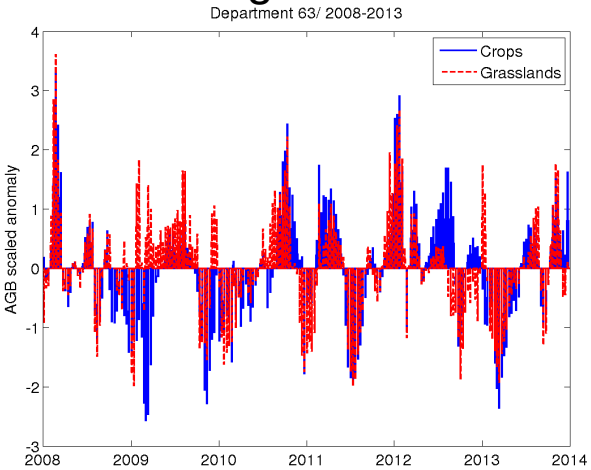
SWI



LAI

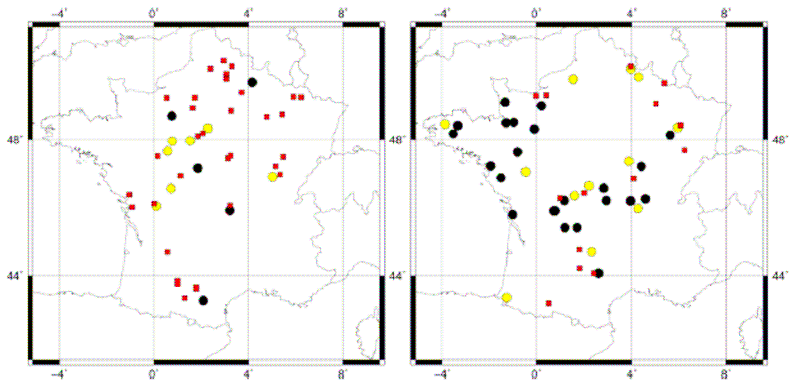


Above-ground biomass



[Another type of] data assimilation

- Key parameter retrieval from agricultural in situ observations
  - **Canal et al., HESS, 2014**
    - Mesophyll conductance
    - Soil depth



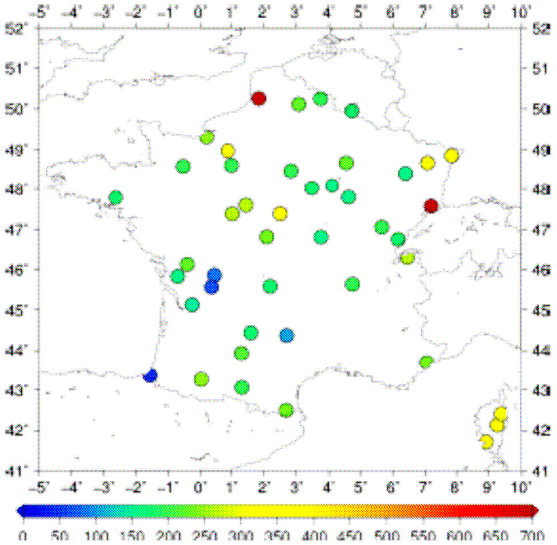
Plant type	C3 crops					Grasslands				
Experiment	FR-2L	DIF1	DIF2	DIF3	DIF1-NRT	FR-2L	DIF1	DIF2	DIF3	DIF1-NRT
Median and standard deviation of optimal g_m ($mm\ s^{-1}$)	**1.75** 0.40	**1.75** 0.53	**1.75** 0.51	**1.75** 0.53	**1.75** 0.56	**1.38** 0.48	**1.38** 0.49	**1.50** 0.47	**1.25** 0.49	**1.25** 0.42
Median and standard deviation of optimal MaxAWC (mm)	**125** 54.0	**112.5** 61.3	**81.3** 84.0	**93.8** 63.0	**100** 64	**81.3** 55.0	**68.8** 54.0	**75.0** 55.0	**75.0** 58.0	**75.0** 58.0

[Another type of] data assimilation

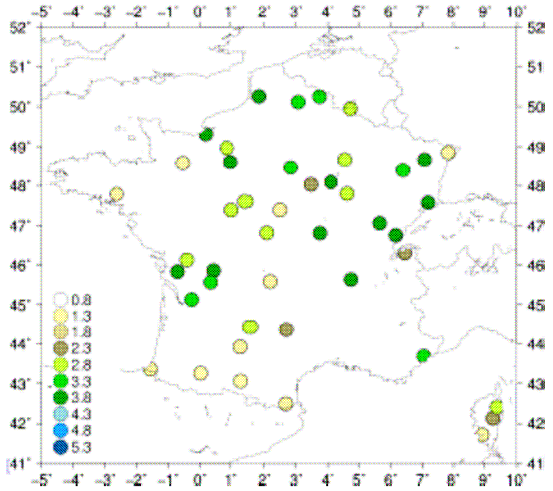
- Key parameter retrieval from forest inventory data
  - **Equilibrium climax biomass from IFN data** (JD Bontemps, INRA Nancy)

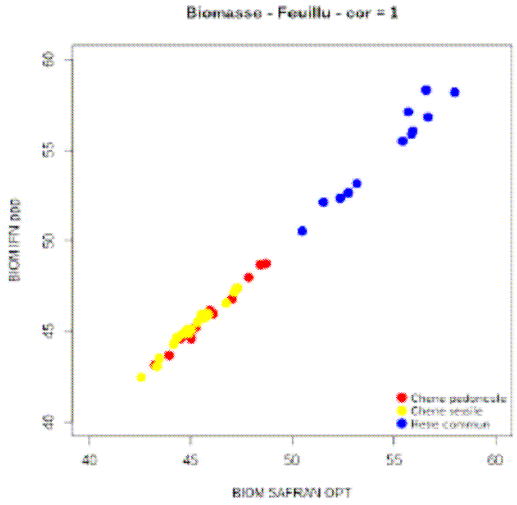
Broadleaf

MaxAWC (mm)



Leaf mass-based nitrogen content (%)





[Another type of] data assimilation

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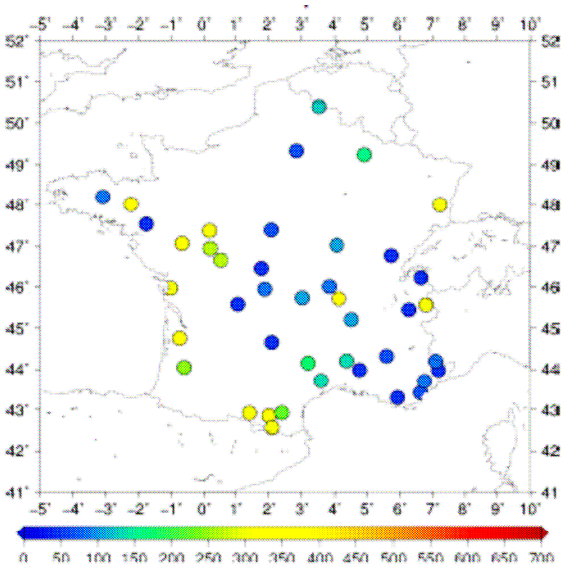
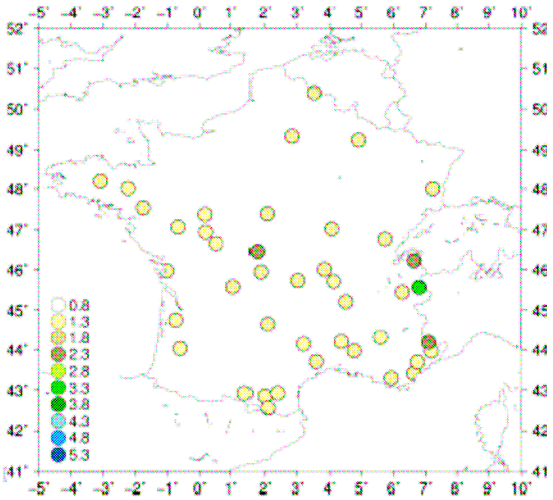
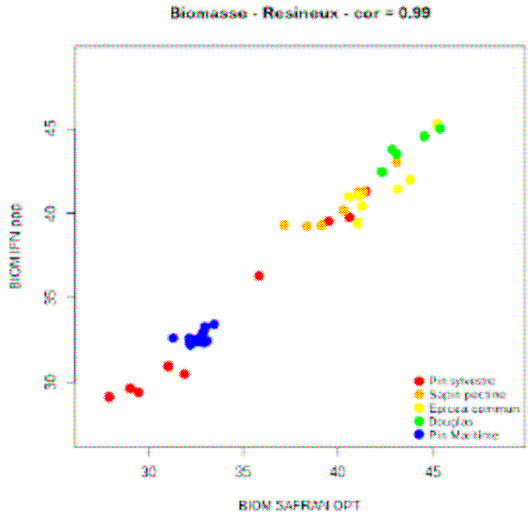
Conifers

MaxAWC (mm)

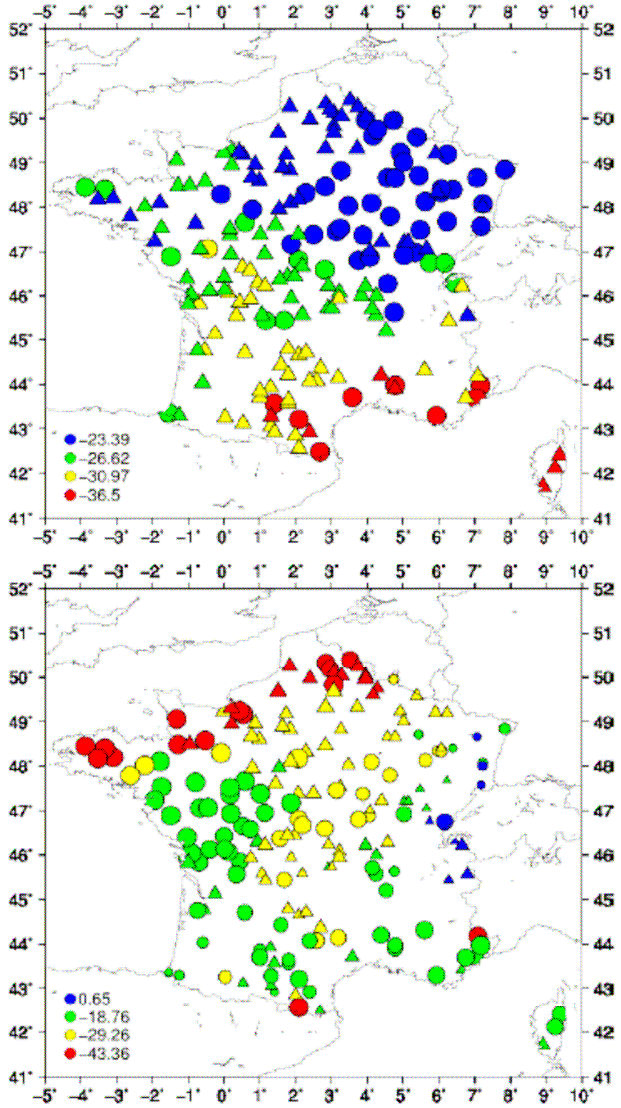


Leaf mass-based nitrogen content (%)





Impact of climate change on vegetation



Regional impact of climate change for distant future (2070-2099) on straw cereals (Laanaia et al., Climate Risk Management, 2016):

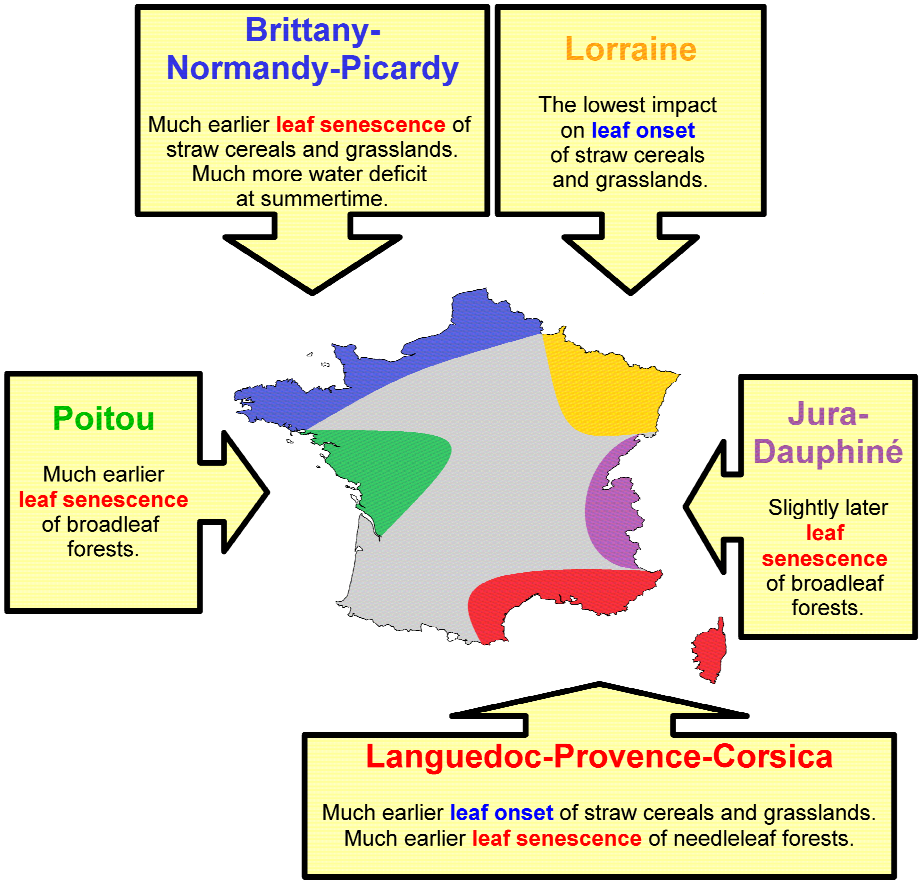
(top) leaf onset,
(bottom) leaf senescence.

Colors correspond to impact clusters (blue, green, yellow, and red, from low to high impact).

The size of the symbols is proportional to the number of climatic simulations (11 as a maximum) presenting a significant trend (Mann-Kendall test).

Circles denote consistent trends, triangles denote divergent trends (ANOVA test).

Impact of climate change on vegetation



Synthesis for straw cereals, grasslands, and forests

(Laanaia et al., Climate Risk Management, 2016):

Prospects

- **Data assimilation**
  - From LDAS-France to LDAS-Monde
  - Global reanalysis (0.25° x 0.25°)
  - Assimilation of albedo (observation operator)
  - Assimilation of ASCAT sigma0 (observation operator)
- **Impact of climate change on vegetation**
  - Over the Euro-Mediterranean area
- **SURFEX evolution**
  - **Improved parameter mapping**
    - ECOCLIMAP-SG (1km to 300m, more recent satellite observations)
    - Vegetation parameters (minimum LAI, SLA, …)
    - Soil parameters (quartz, soil depth)
  - **Enhanced representation of vegetation (critical for Mediterranean areas)**
    - Irrigation, summer crops
    - Forests: more explicit representation of branch/twig mortality, carbohydrate storage
- **TRIP evolution (critical for Mediterranean areas)**
    - Reservoirs, dams, …

Thank you for your attention !