



Operational hydro-meteorological monitoring and forecasts over France using the SAFRAN-SURFEX-MODCOU model chain

François Besson¹, Fabienne Regimbeau¹, Christian Viel¹, Pierre Etchevers¹, Mathieu Papazzoni¹, Anne-Lise Beaulant¹, Patrick Le Moigne², Eric Martin^{2,3}, and Florence Habets⁴

¹ : Climate Services and Climatology Departement, METEO FRANCE, Toulouse, France

² : CNRM, METEO FRANCE, Toulouse, France

³ : UR RECOVER, IRSTEA, Aix-en-Provence, France

⁴ : UMR 7619 METIS, CNRS, UPMC, Paris, France

Context

- Hydrometeorological model chain operational at Météo-France since 2003 :
 - First version SAFRAN – ISBA (3L) – MODCOU had been used for 13 years
 - ▶ Underestimation of the incident IR radiation from SAFRAN
 - ▶ Hydrology : spatial resolution (64 km²) unsuitable in mountainous area + use of a constant subgrid drainage
 - ▶ Surface scheme : Force-Restore approach prevent us to study soil's thermal conditions
 - New version since September 2016 SAFRAN – SURFEX – MODCOU

Plan

- Presentation of the model chain
- Evaluation
- Applications

Model chain

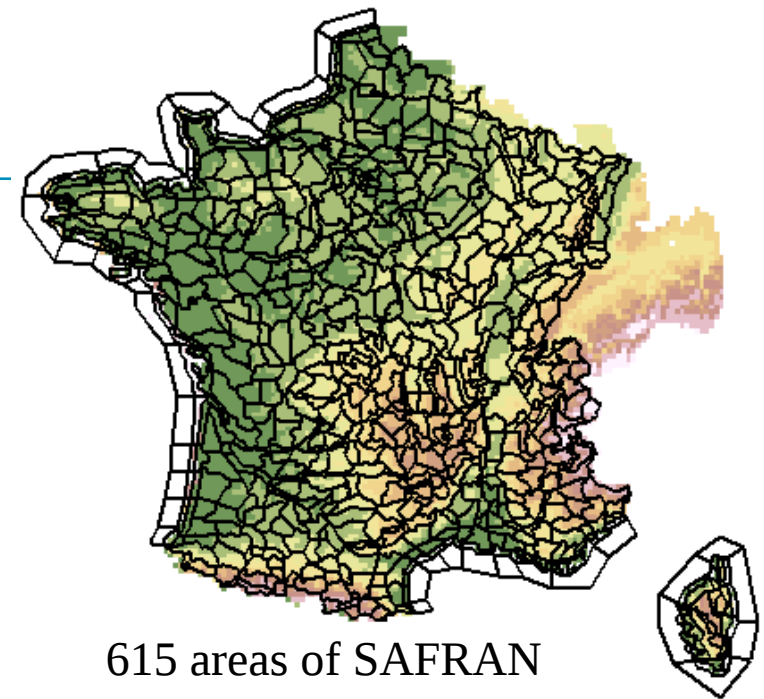
SAFRAN

Input : Guess + Observations

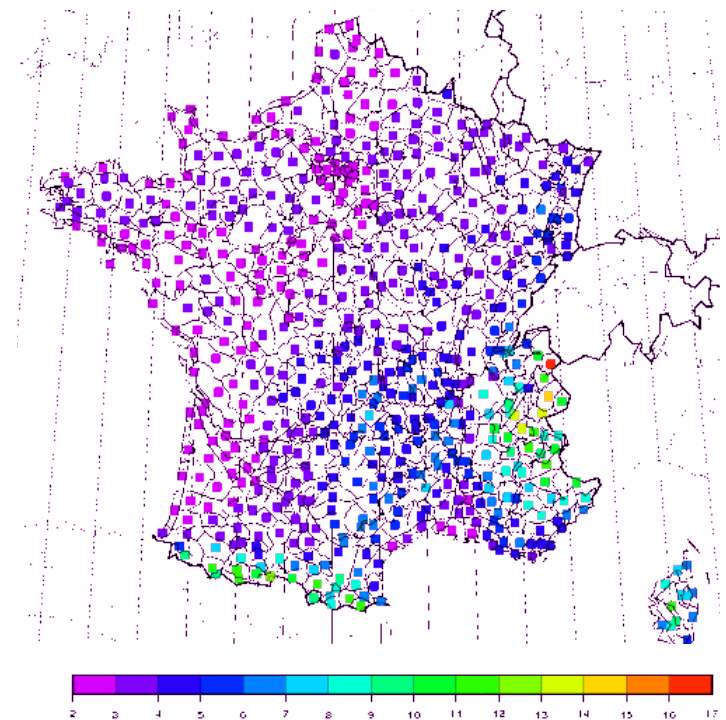
Output : Atmospheric forcing

■ SAFRAN

- Analysis over climatologically homogeneous areas (615), one analysis by 300m elevation steps (2452 analysis points) => possibility to interpolate on a grid
- Outputs at hourly time step :
 - ▶ Temperature and relative humidity (2m)
 - ▶ Wind speed (10m)
 - ▶ Liquid and solid precipitation
 - ▶ Cloudiness
 - ▶ Solar radiation
 - ▶ Corrected IR radiation

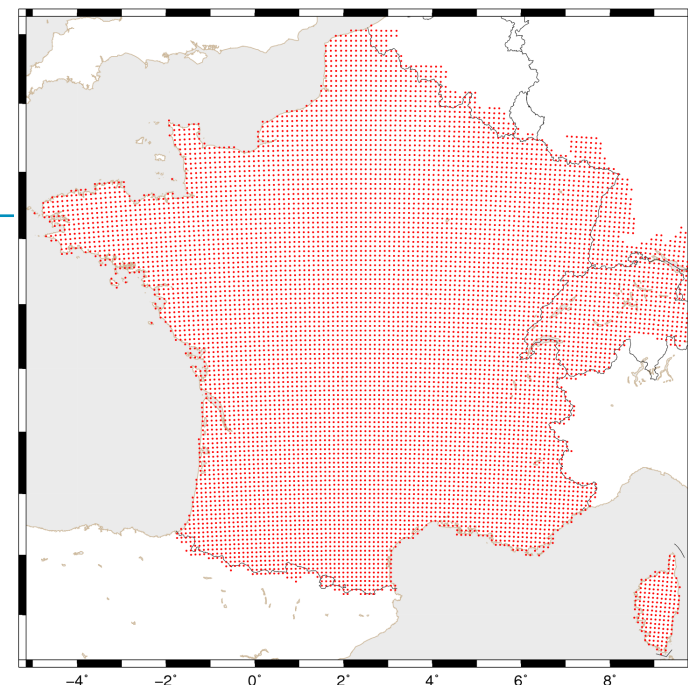
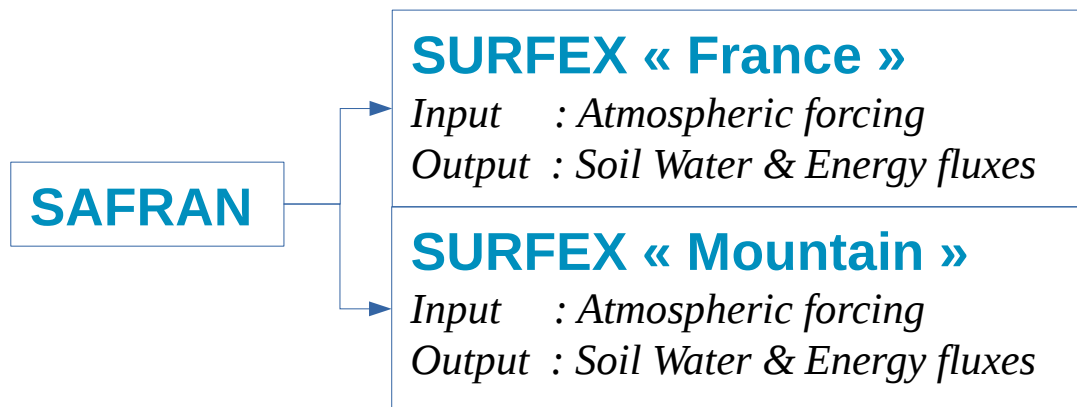


615 areas of SAFRAN

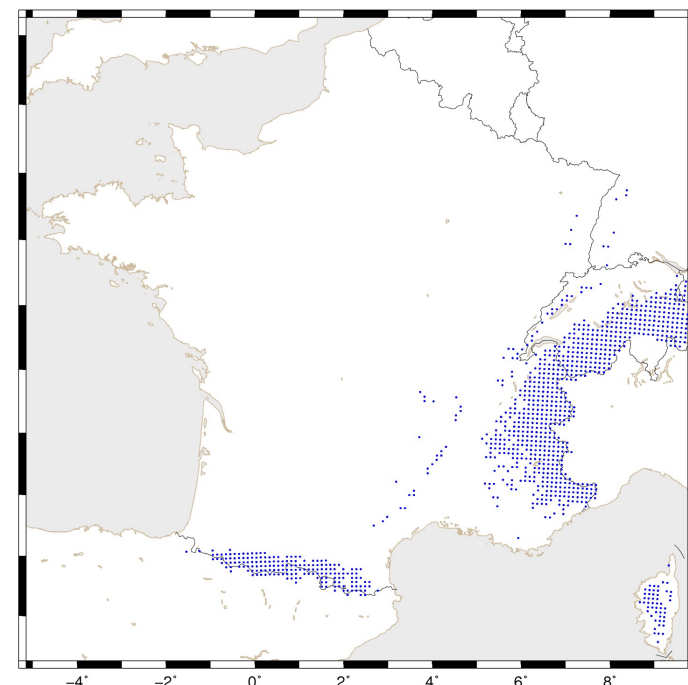


Number of elevation steps per area

Model chain



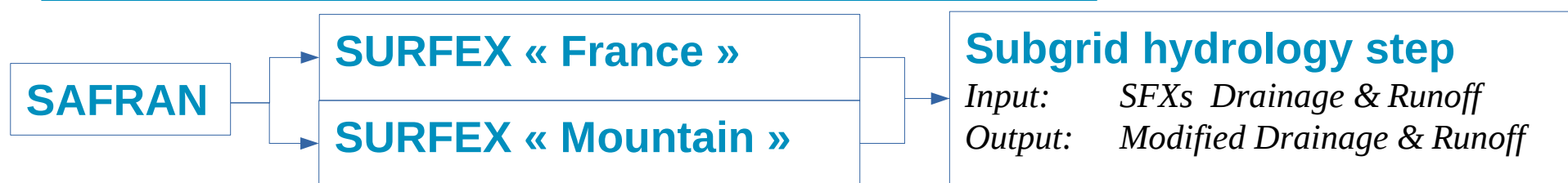
SURFEX « France » domain



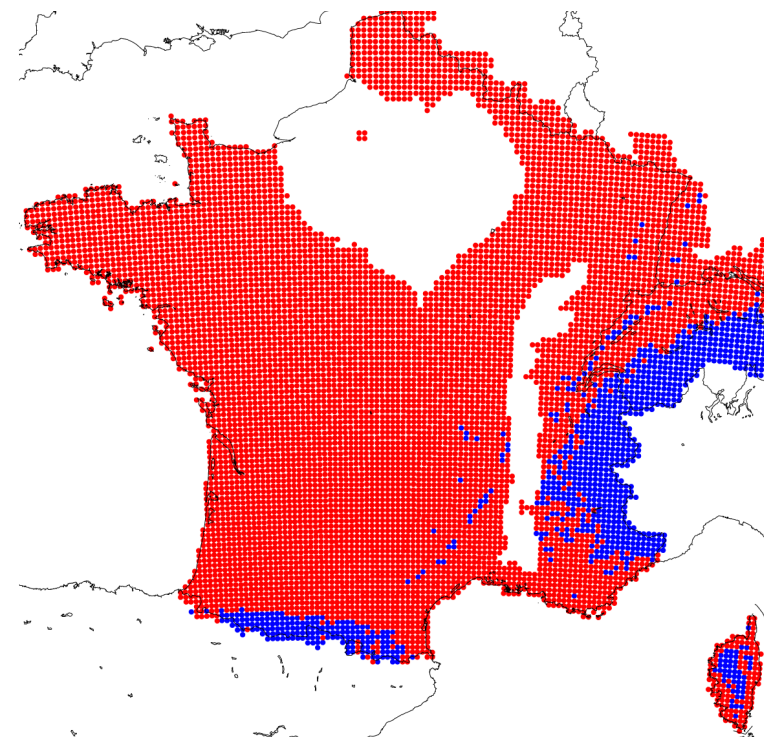
SURFEX «Mountain» domain

- Domains :
 - SURFEX « France » : 2D grid, resolution 8km (9892 points)
 - SURFEX « Mountain » : 1044 grid meshes from « France » domain, simulation at several elevations => 3878 points
- SURFEX V8 :
 - Diffusive scheme : 14 layers (12m depth)
 - Databases : srtm90m for elevation, HWSD soil database
 - 12 vegetation patches in each grid cell (ECOCLIMAP-II)
 - Photosynthesis : AST
 - Snowpack model : ES 12 layers

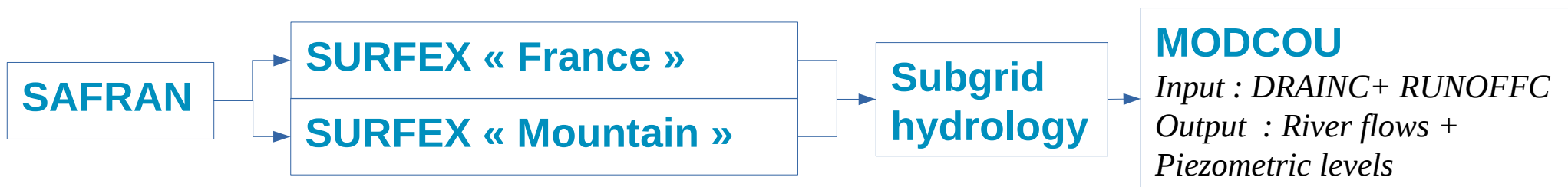
Model chain



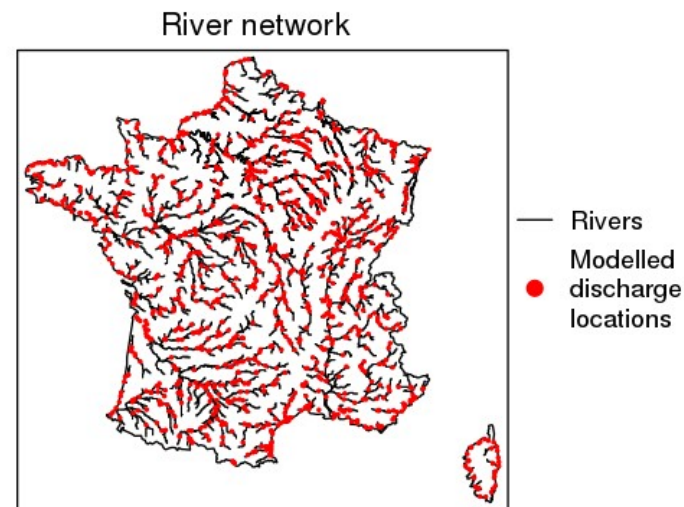
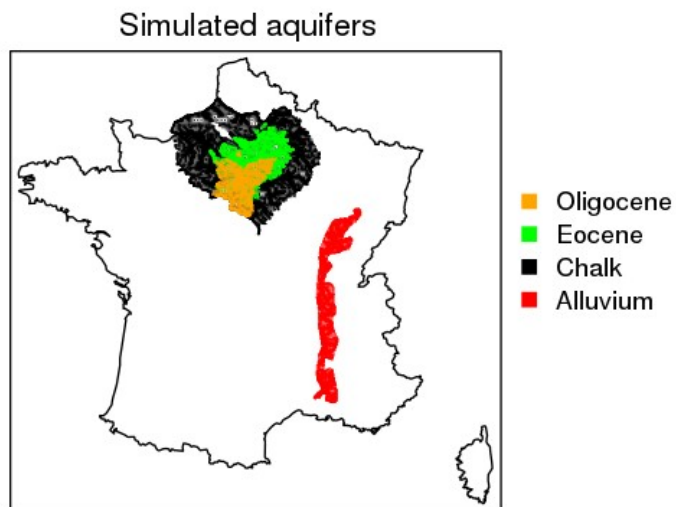
- Subgrid hydrology aims :
 - Simulate aquifers where they are not explicitly represented in the model chain
 - Improve hydrology in mountainous areas
- How it works :
 - White grid meshes : no modification (aquifers explicitly simulated in MODCOU)
 - Red grid meshes
 - ▶ Drainage : use of reservoir with finite capacity (Artinyan et al. 2006)
 - ▶ Runoff : no modification
 - Blue grid meshes
 - ▶ Drainage : use of reservoir with infinite capacity (Lafaysse et al. 2011)
 - ▶ Drainage & Runoff : mix of data coming from simulations at different elevations to get values on a 2D grid



Model chain



- MODCOU
 - Routing water into rivers ($\Delta t=3h$)
 - Evolution of the Aquifers ($\Delta t=1day$)



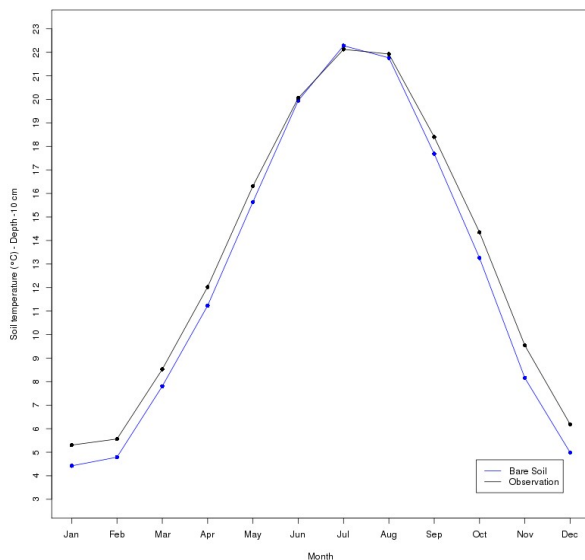
Plan

- Presentation the model chain
- **Evaluation**
- Applications

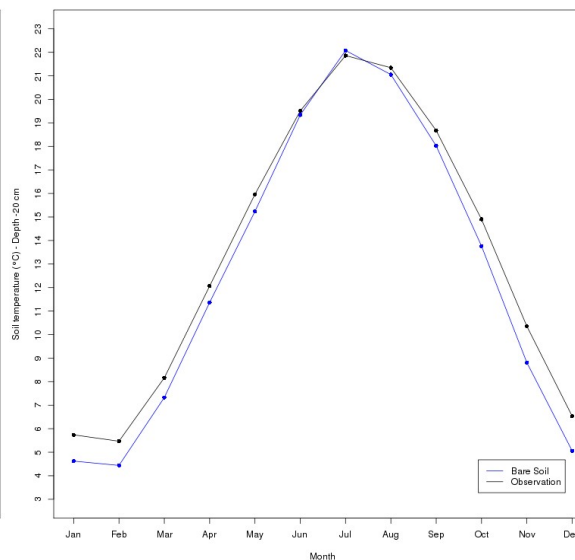
Evaluation

- Soil temperature validation ; Period 1985-2014 ; 112 stations with measurement at 10, 20, 50 and 100cm ; 3H time step

Depth 10cm
Bias : $-0,7^{\circ}\text{C}$
RMSE : 2.7°C

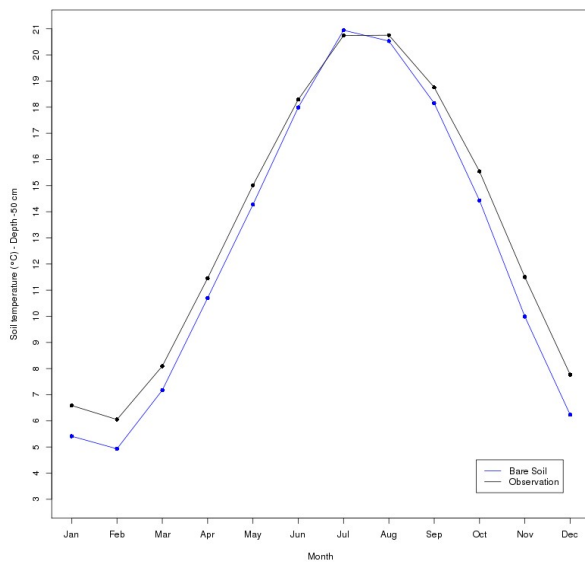


Depth 20cm
Bias : -0.8°C
RMSE : 2.2°C

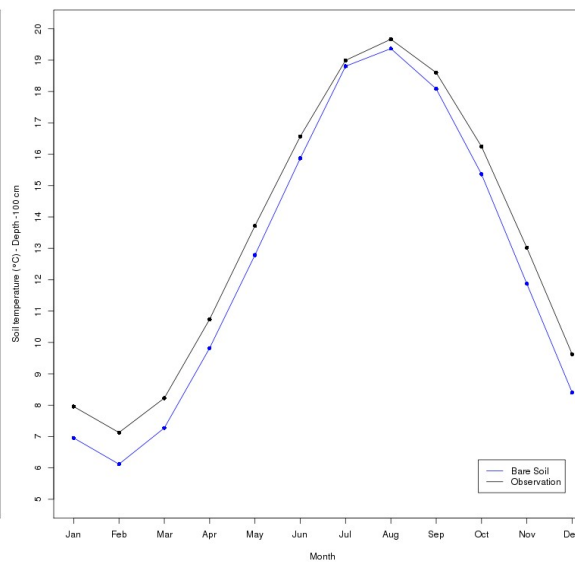


Monthly mean annual cycle

Depth 50cm
Bias : -0.8°C
RMSE : 1.7°C

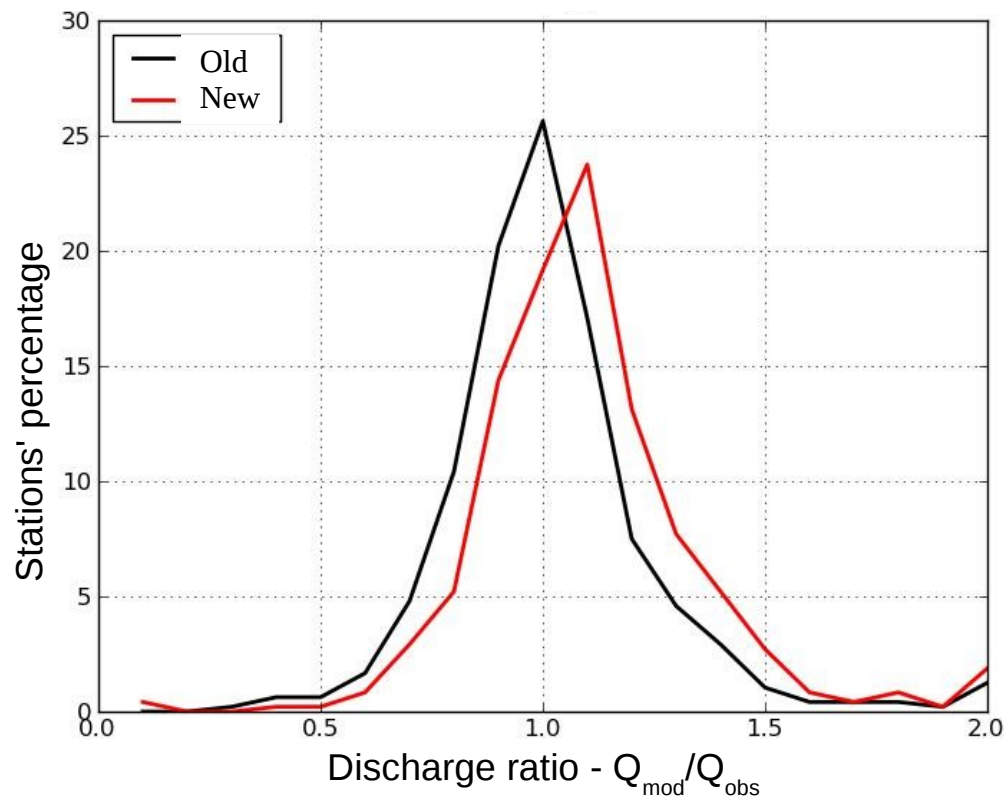
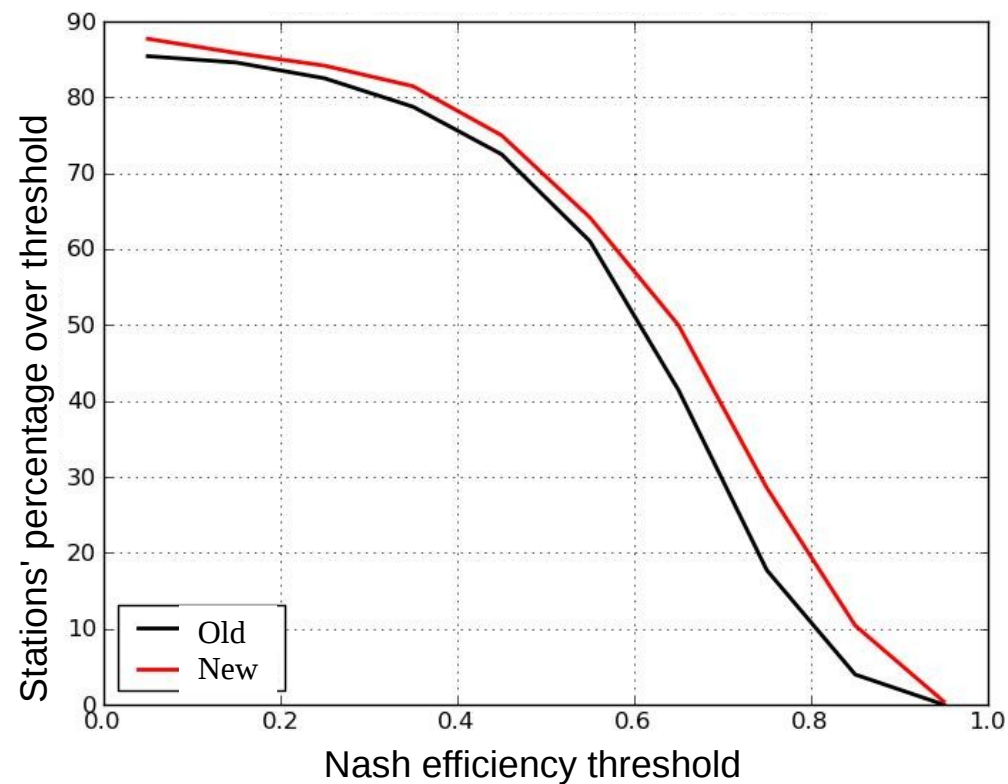


Depth 100cm
Bias : -0.8°C
RMSE : 1.5°C



Evaluation

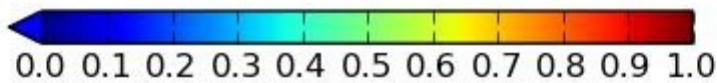
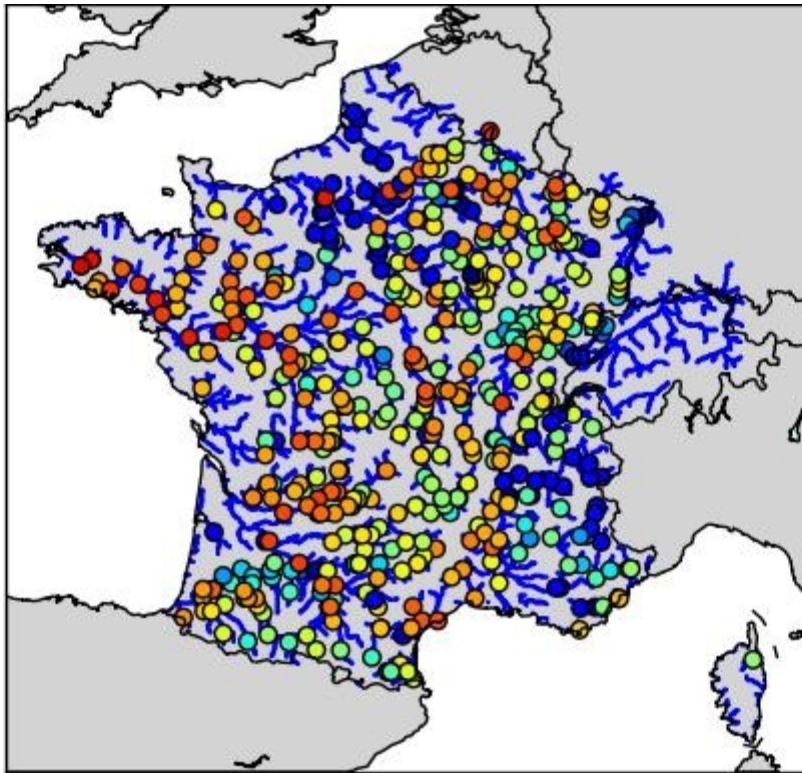
- Daily river discharge scores ; Period August 1958 – July 2015
- 480 stations with at least 50 % of available observations



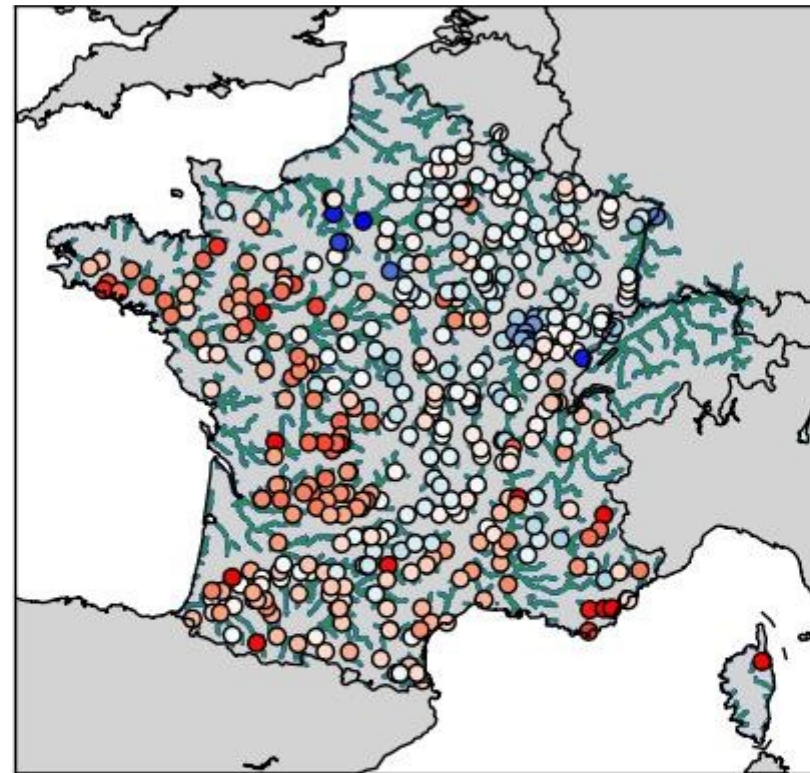
- Improvement for Nash efficiency
- Distributions of discharge ratio quite similar, slightly shifted to higher values in the new version

Evaluation

- Improvement over a large number of station (west/south/mountainous part mainly)
- Deterioration over the Seine bassin and North-east



Nash Efficiency of the new version



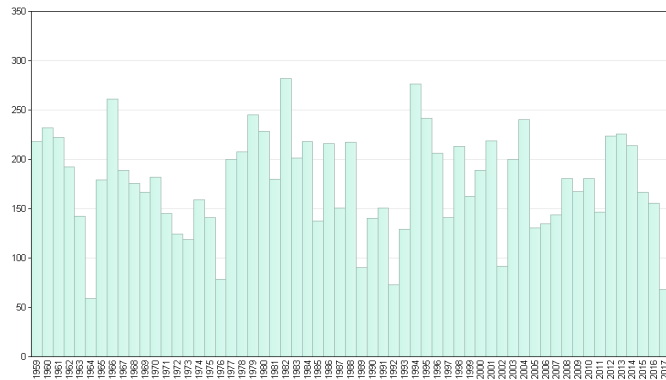
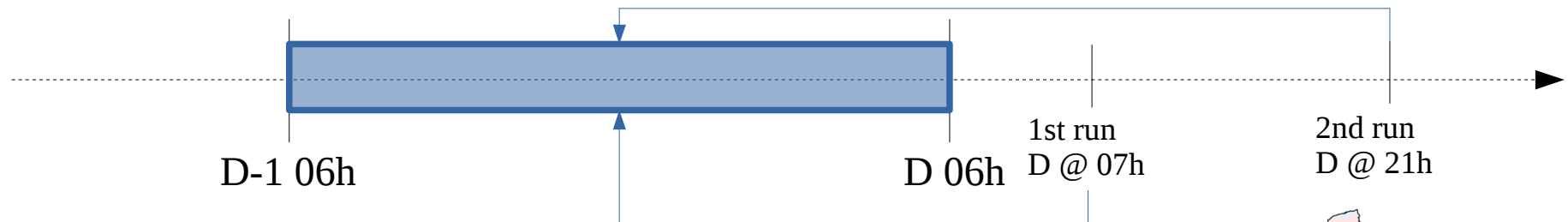
Comparison of the Nash Efficiency (New - Old)

Plan

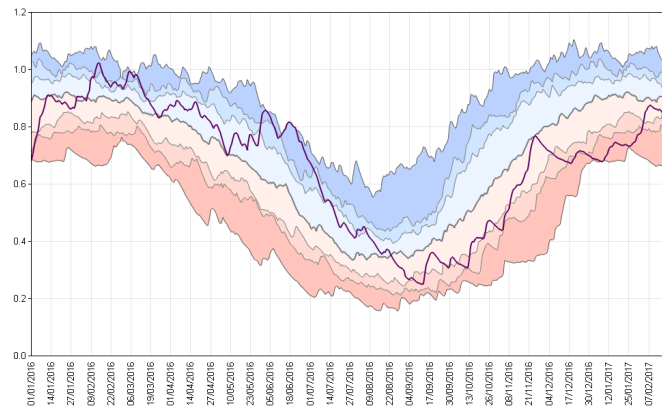
- Presentation the model chain
- Evaluation
- Applications

Applications

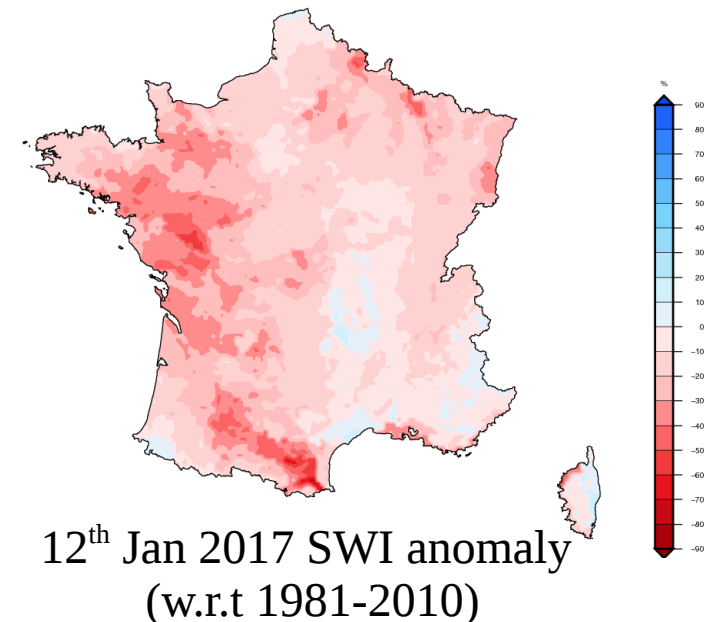
- Reanalysis from August 1958 to July 2016
- Daily operational analysis to monitor hydrometeorological situation :
 - Period [D-1 06h UTC ; D-day 06hUTC] ; 2 runs/day
 - Surface observations and guess coming from ARPEGE
 - SURFEX initial state from the last run of the previous day + update 1st day of each month from a monthly reanalysis



Precipitation (mm) - France
Dec-Jan Period 1959 – 2017



Soil Wetness Index
France



12th Jan 2017 SWI anomaly
(w.r.t 1981-2010)

Applications

- Ensemble/Seasonal forecast up to 10-days/7months, using ECMWF's EPS/ARPEGE System5 downscaled
- Both use the real-time analysis to get SURFEX-MODCOU initial states

Atmospheric Forecast

Input :

N-runs from ECMWF's EPS (D+10)

N-runs ARPEGE System5 (M+7)

Output :

N-Downscaled Atmospheric forcing

SURFEXs + Subgrid Step

Input :

N-Downscaled Atmospheric forcing

Initial State from real-time analysis

Output :

N-Soil Water & Energy fluxes

MODCOU

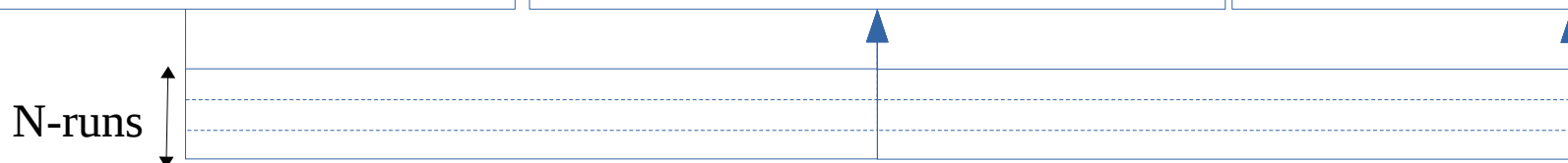
Input :

N-Drainage and Runoff

Initial State from real-time analysis

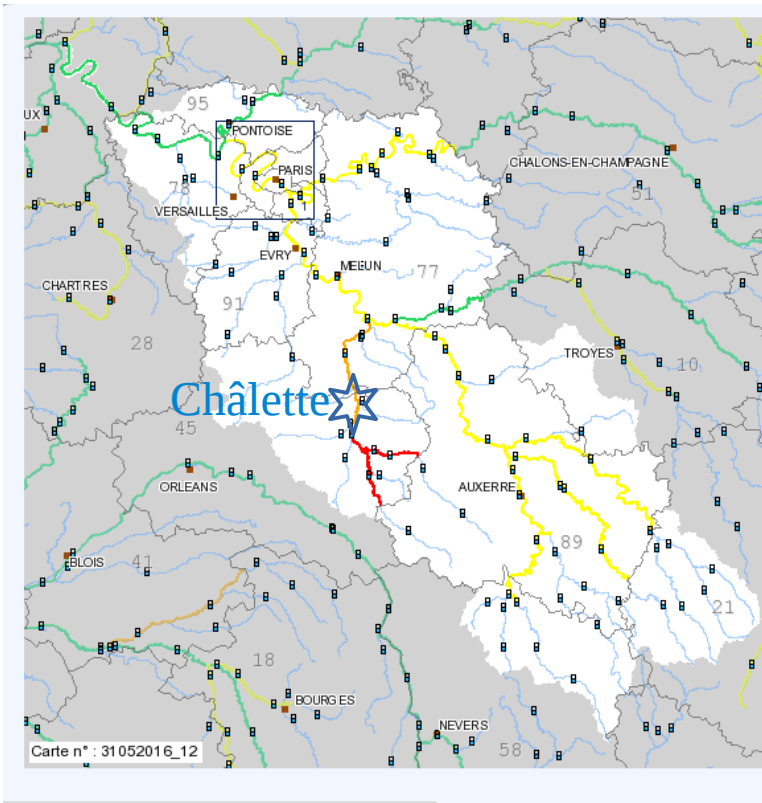
Output :

N-River discharges and Piezometric levels

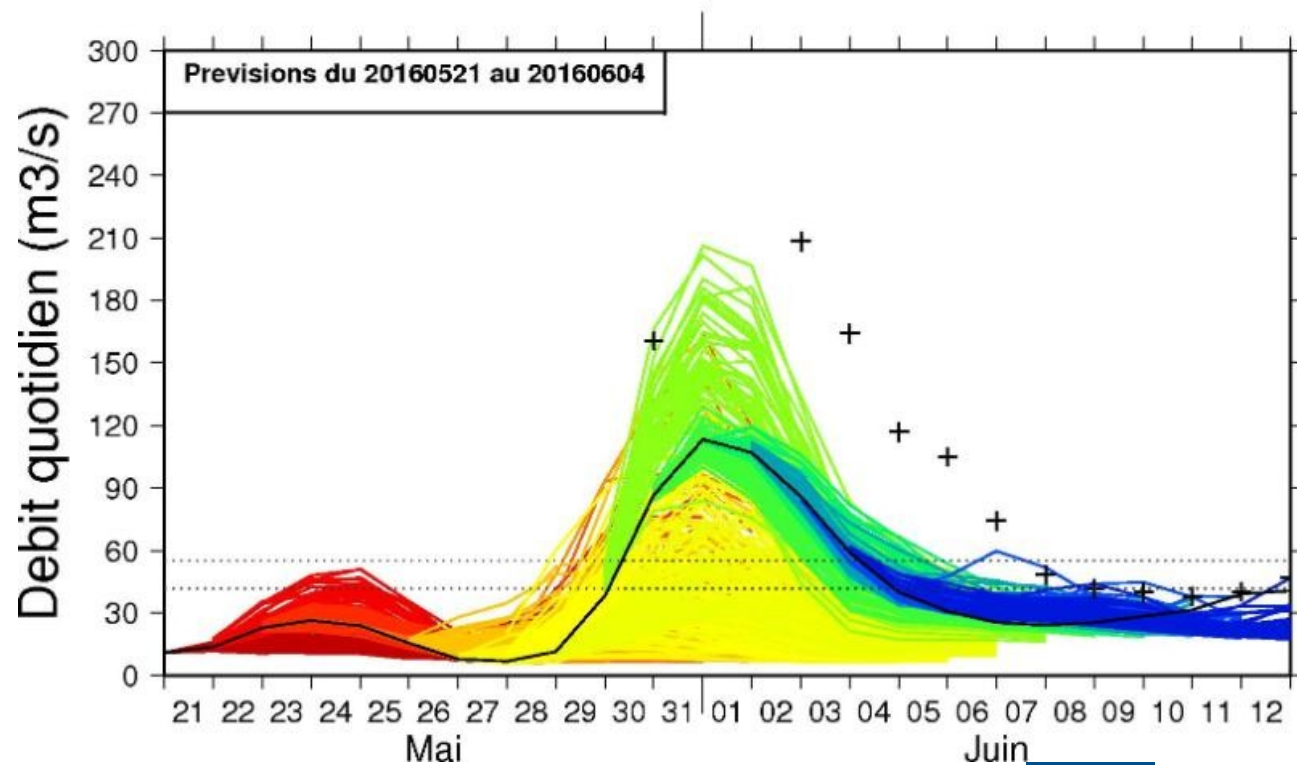


Applications

- Ensemble Forecast: flood over Seine bassin may-june 2016 (red flood warning) :
 - one colour per base time (from 20160521 to 20160604), 10days forecast
 - dotted line : thresholds provided by the operational flood forecasting service (SCHAPI)

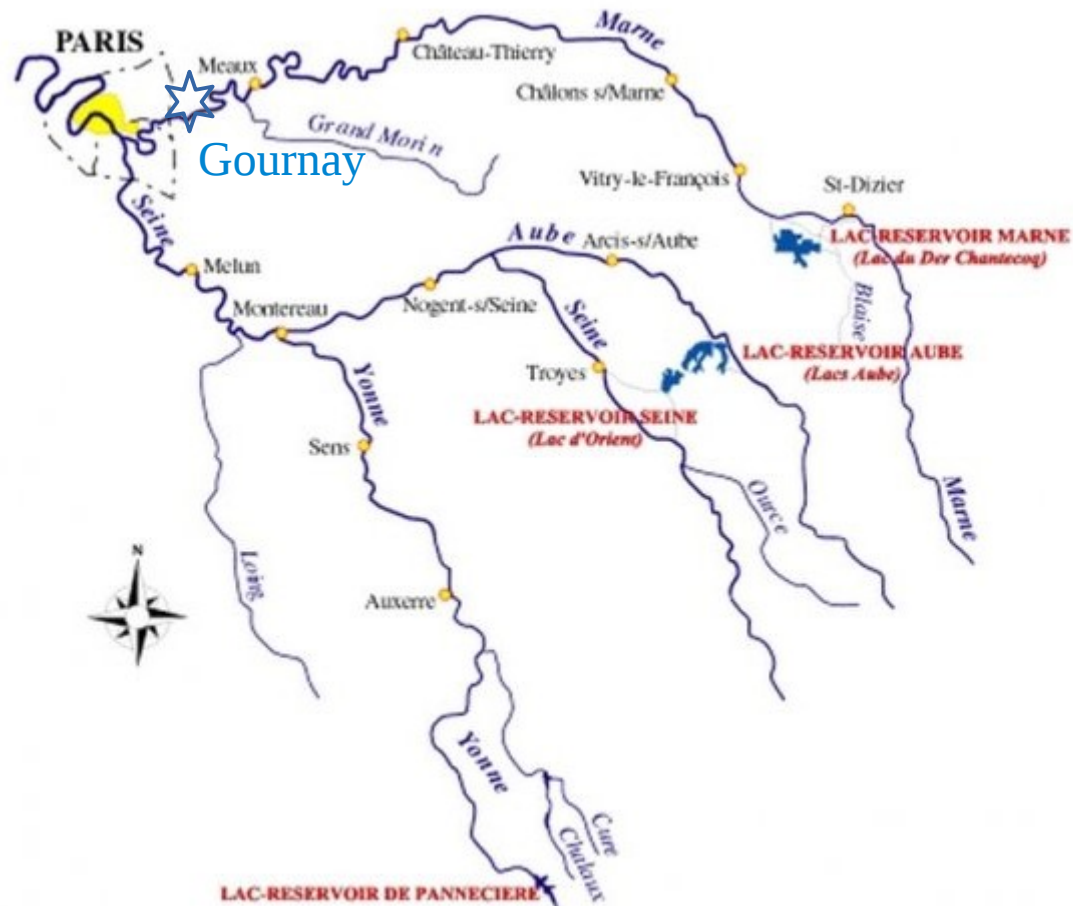


LE LOING A CHALETTE-SUR-LOING



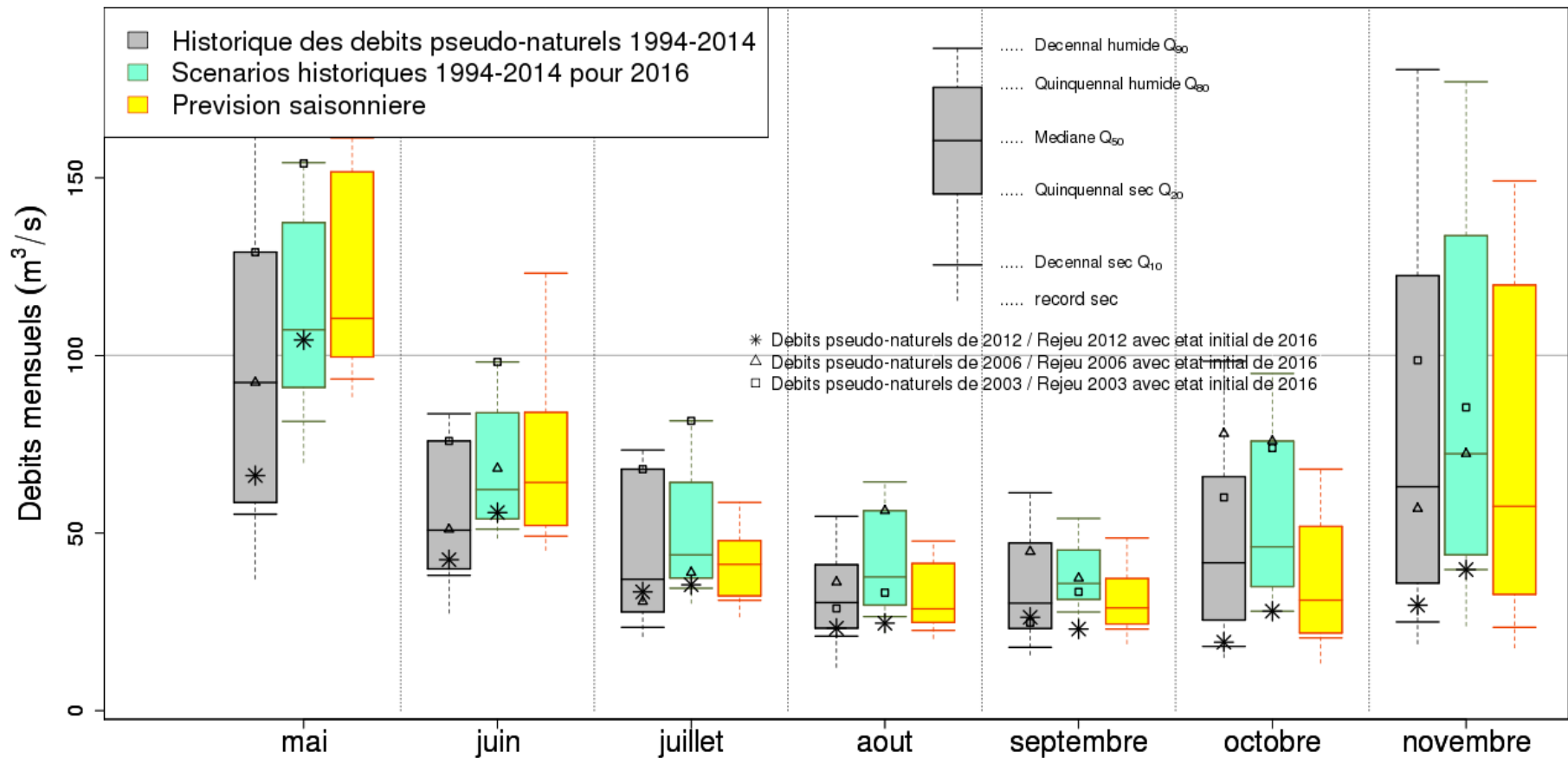
Applications

- Seasonal Forecast
 - Case study : management of water resources over the Seine basin during low flow period
 - Provide forecasts at several stations in particular at Gournay



Applications

- Seasonal Forecast from May 2016
 - Monthly river discharges
 - Boxplots to compare : past-observations, climatological forecast, seasonal forecast



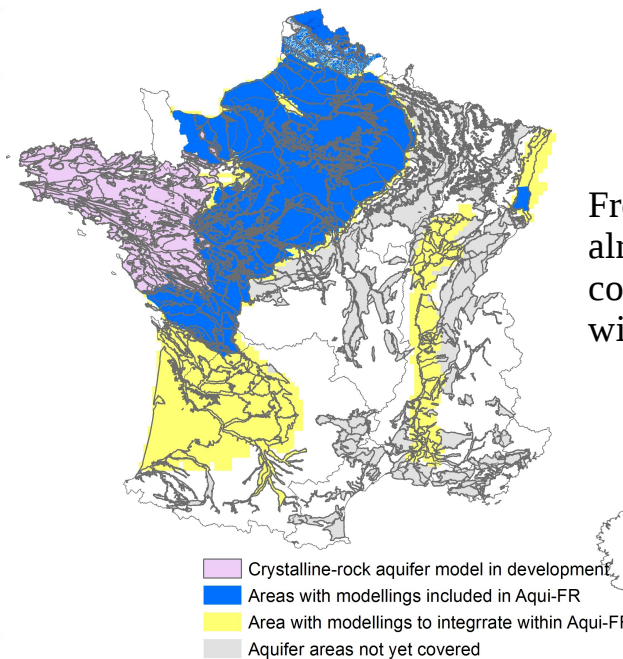
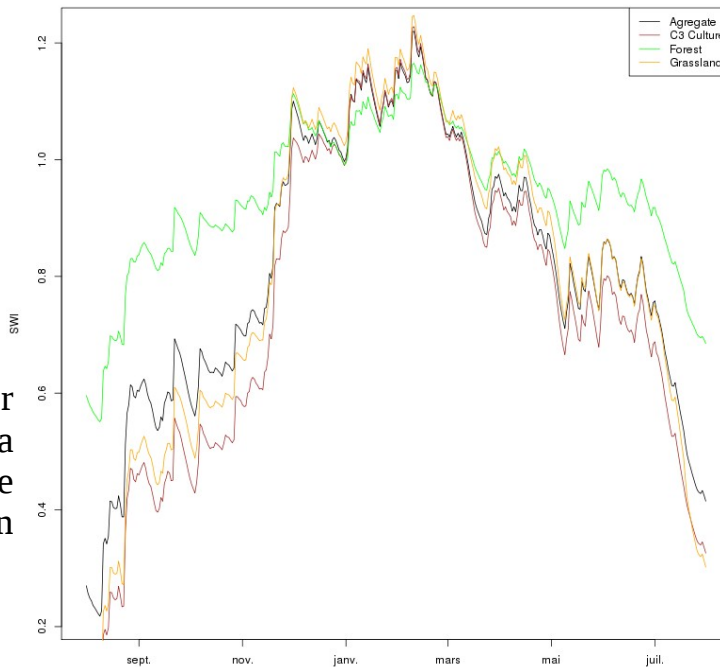
Grey : Monthly observations from 1994 to 2014

Green : SURFEX-MODCOU with 2016 initial state and forced by SAFRAN reanalysis (1994 to 2014)

Yellow : SURFEX-MODCOU with 2016 initial state and forced by ARPEGE System5 (51 members)

Conclusions & Perspectives

- Operationnal use of SURFEX forced by SAFRAN to monitor hydrometeorological situation & applications for ensemble/seasonnal forecasts
- To come
 - Develop new products to take benefit from other SURFEX outputs e.g. SWI per patch, soil temperature per layer etc.
 - Changes in the model chain : MESCAN (under development) to replace SAFRAN ; New hydrogeological component Aqui-Fr project
 - Climate change studies (using downscaling method from ADAMONT project – CEN) : CHIMERE21 (impact on Meuse river), EFFICACE (impact on forestry)
 - Use of PEARP for ensemble forecasts





Thank you for your attention
