Seasonal Prediction in France : Application to Hydrology

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WGSIP/WCRP workshop

on Seasonal to Decadal prediction

13-16/06/2013 - Toulouse

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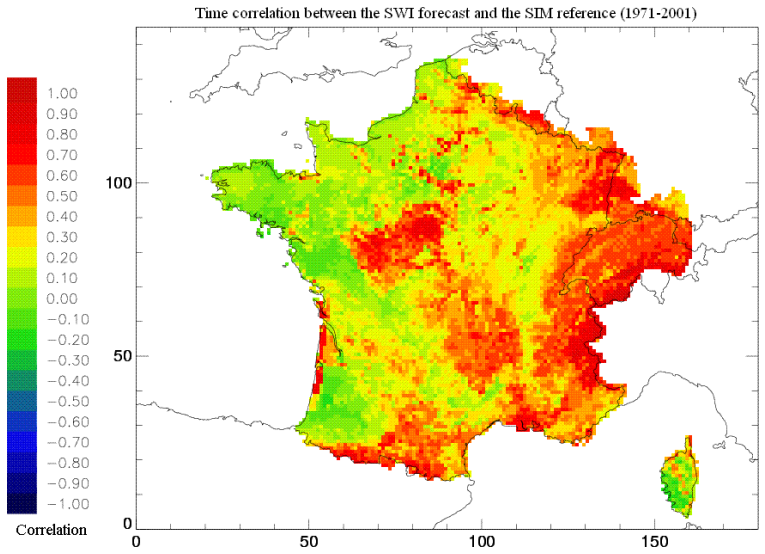
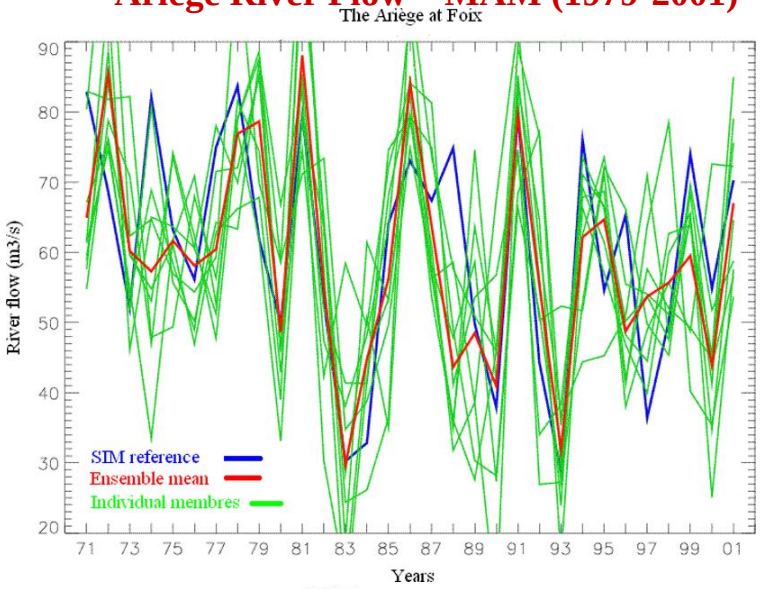
Introduction

- A first study showed the feasibility of hydrological seasonal forecasts over France (Tanguy, 2009 ; Céron *et al.*, 2010 - based on Demeter)
  - temperature better than precipitation ;
  - scores on hydrological variables better than for atmospheric variables.
- Spring period : March-April-May Lead time : one month

Correlation SWI – MAM (1979-2001)



Ariège River Flow – MAM (1979-2001)



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Introduction

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  - temperature better than precipitation ;
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- Spring period : March-April-May and Lead time : one month

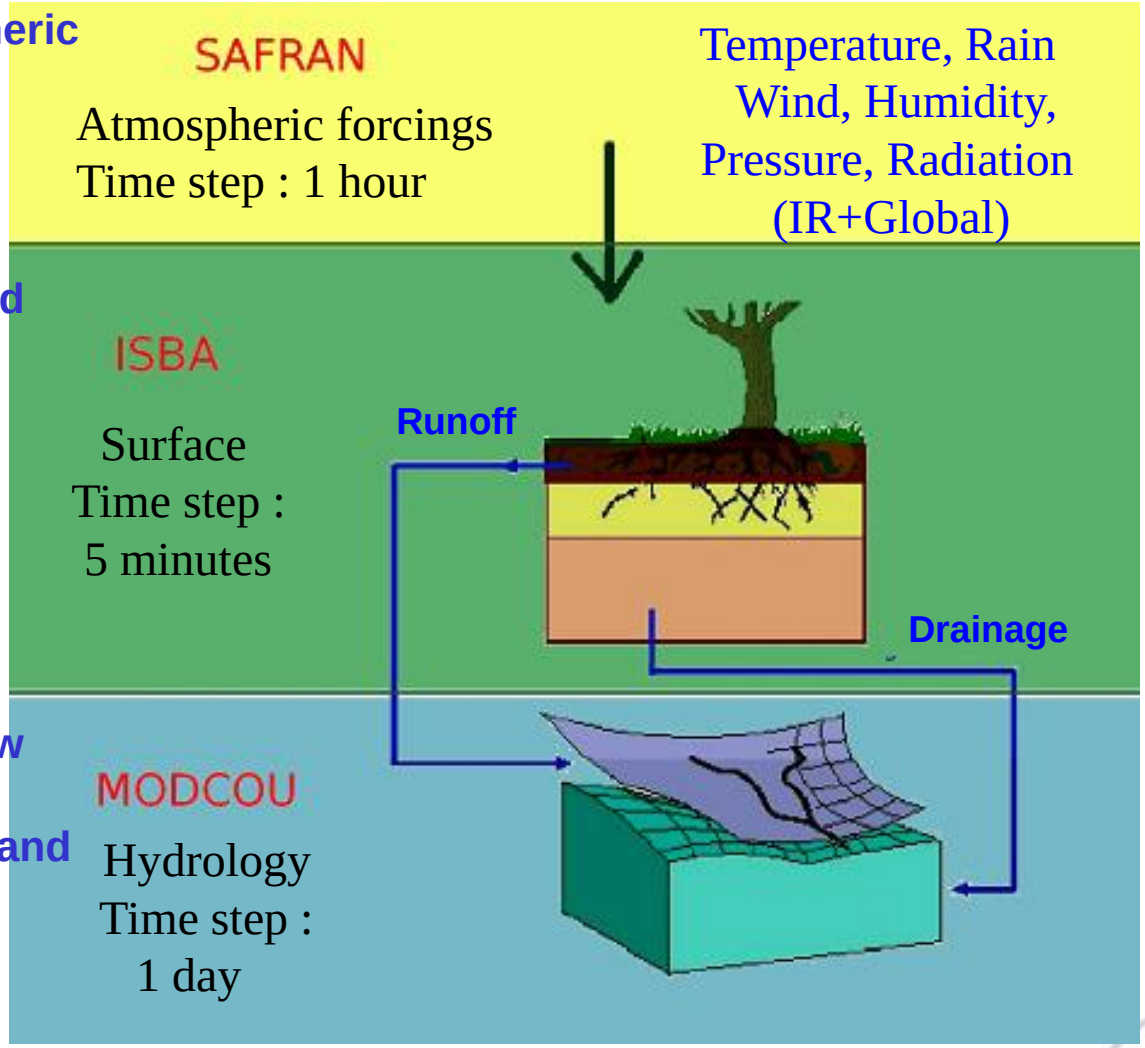
- **Main objectives**

1) **For Spring** : assess the sources of predictability of the hydrometeorological system in France and the potential additional information brought by the use of the seasonal forecast vs climatology (see RAF experiment hereafter)
2) **For Summer** : have some insight into the potential of anticipation brought by this system with respect of the critical low flow period

Outline

- **Methodology**
  - Hydrometeorological forecasting suite and experiments
  - Evaluation and comparison of experiments
- **Results for Spring (MAM)**
  - RAF results
  - RIS results
  - Comparison between Hydro-SF and RAF
- **Results for Summer (JJA)**
  - Lead-Time results (from February to May IC)
  - Comparison Hydro-SF and RAF for April IC
- **Conclusion & Perspectives**

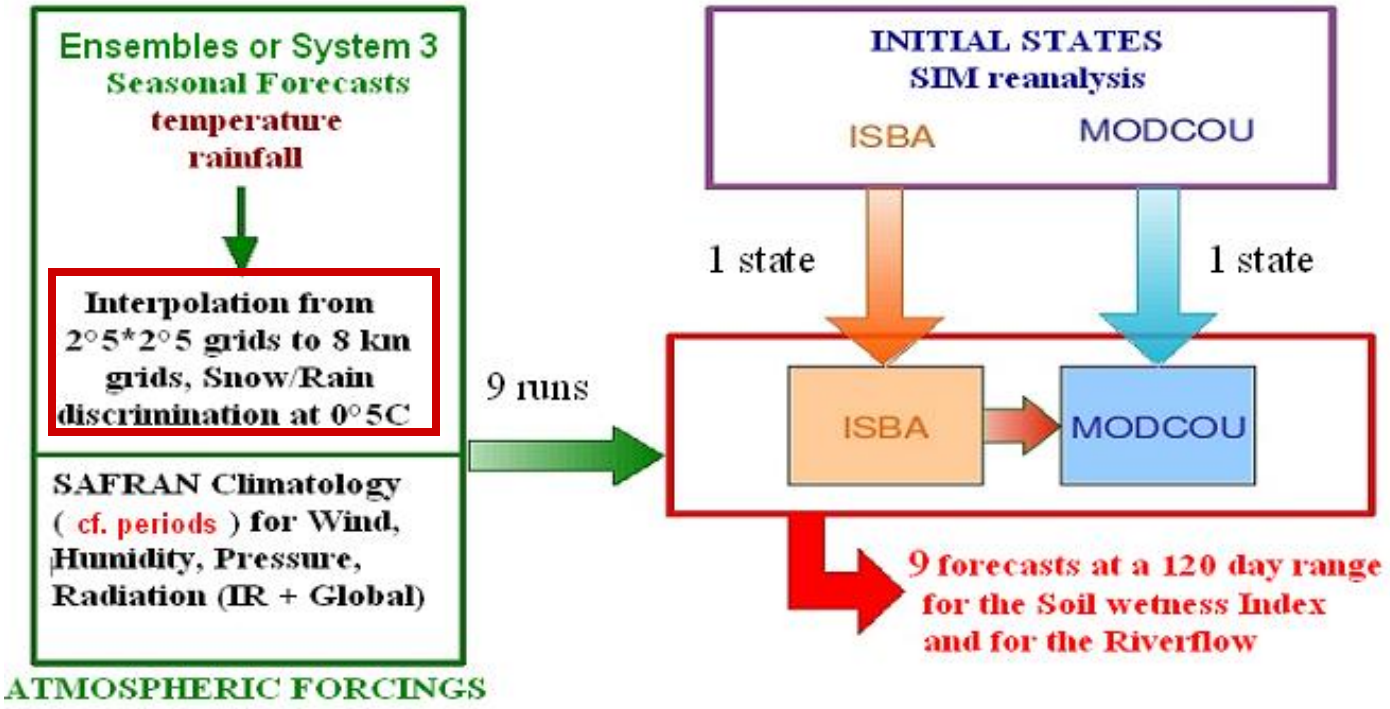
The hydrometeorological suite



- **SAFRAN-ISBA-MODCOU (SIM)** validated over all France (Habets *et al*, 2008) and operational since 2004.
- **SIM reanalysis** available over the 1958-2010 period (Vidal *et al*, 2010)

The forecasting suite

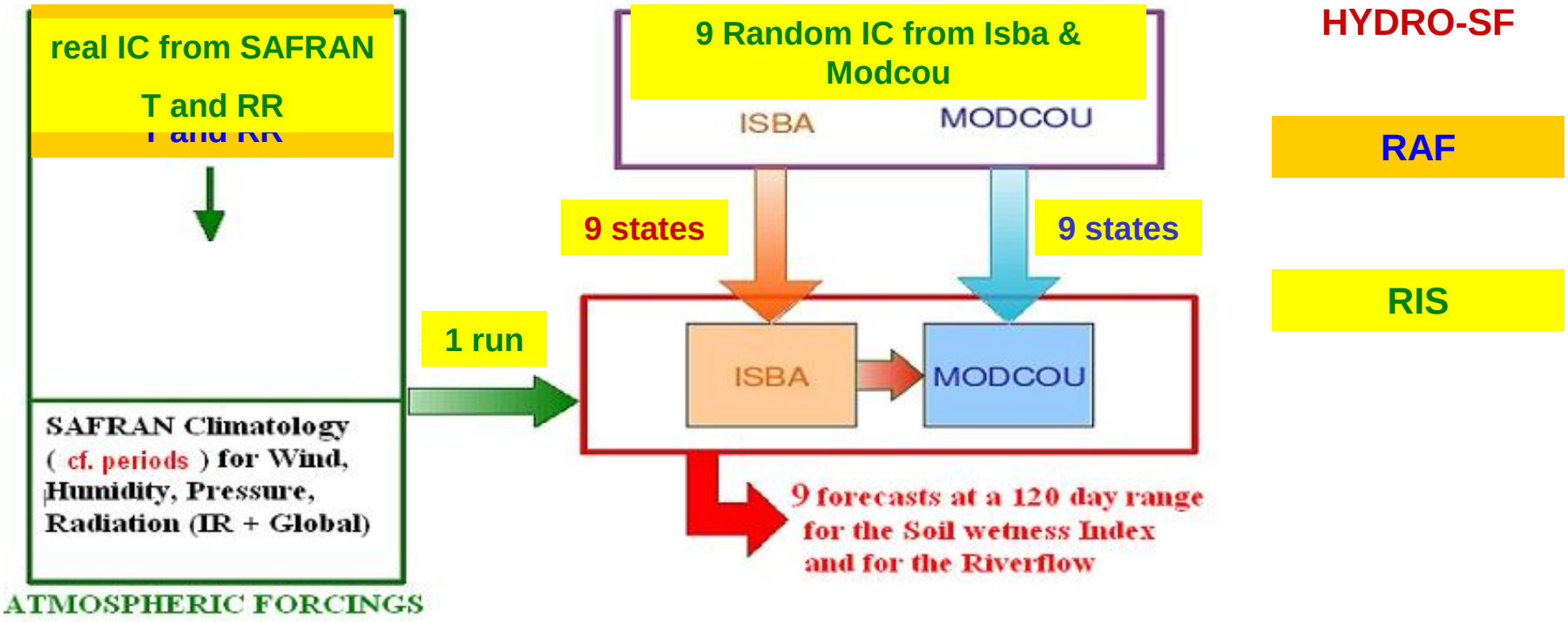
- Method adapted from the medium range ensemble riverflow forecast (Tanguy - 2009, Céron *et al.* - 2010)



- Period from 1960 to 2005 (ENSEMBLES) – 9 members
- Period from 1979 to 2007 (System3) – 9 or 11 members

The hydrometeorological suite

- Method adapted from the medium range ensemble riverflow forecast (Céron *et al.*, 2010) - **Additional experiments**



- Period from 1960 to 2005 (ENSEMBLES) – 9 members
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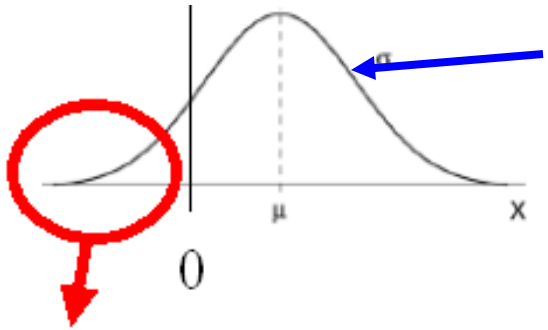
The evaluation of experiments

- Scores to evaluate the different experiments
  - Correlations, RMSE, Nash Score
  - Brier Score, Reliability and Resolution, ROC score,
  - SIM reanalysis reference dataset
- Comparison between different experiments
  - Skill Scores (BSS, …)
  - Bootstrap procedure
  - Frequency of negative skill scores



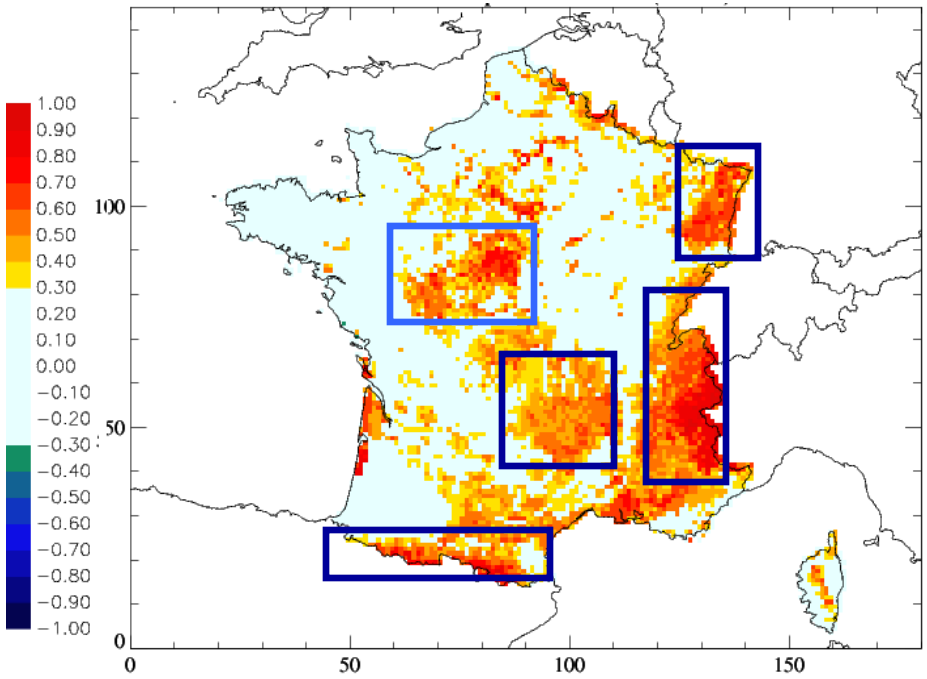
Bootstraped distribution of Skill-Scores

Test on the frequency of negative Skill-Scores

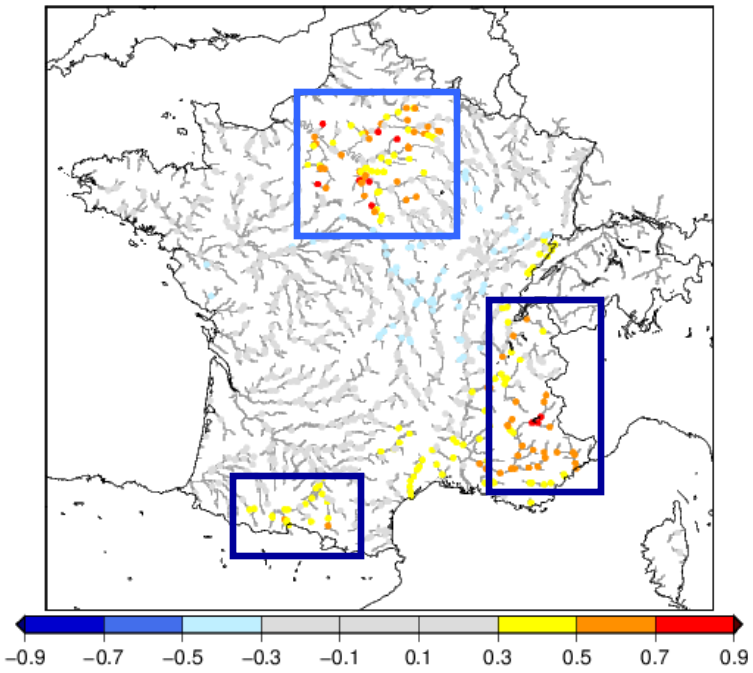
Results for Spring (MAM)

- RAF results (Singla *et al.*, 2012)
  - Correlations over 1960-2005 – IC 1st of February

Spatial representation of time correlation for SWI (left) and river flow (right) over France for the Spring period



SWI



River Flow

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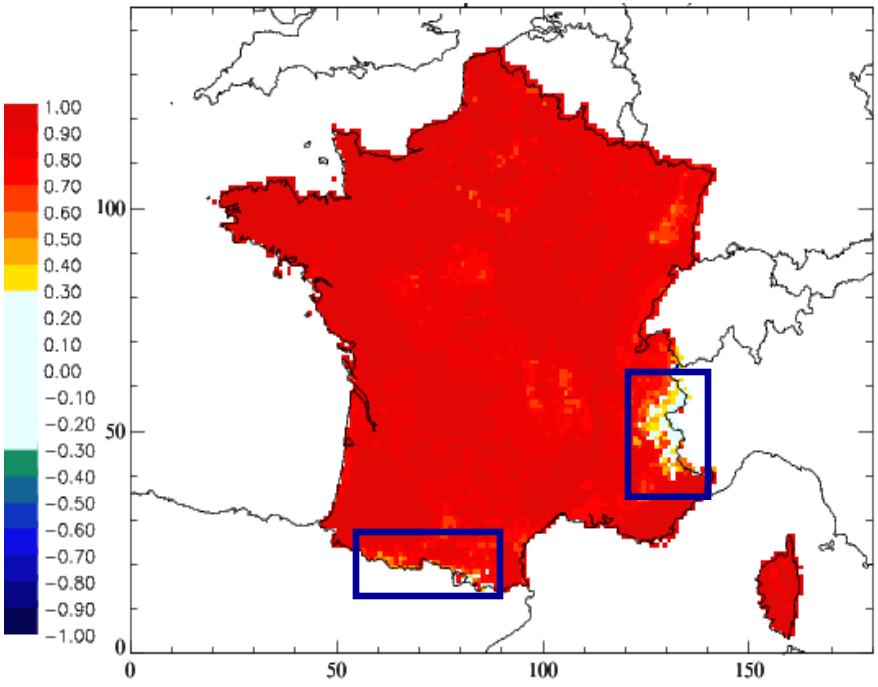
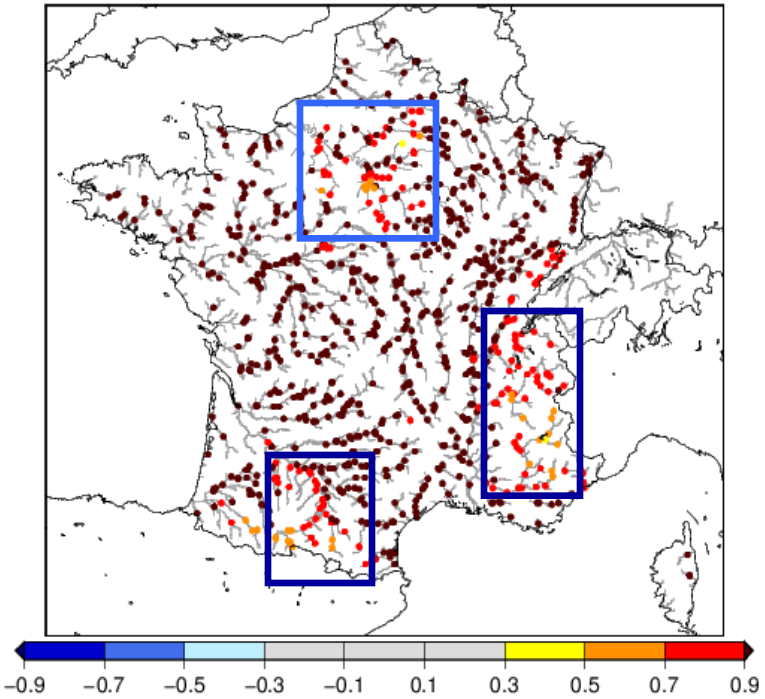


SWI



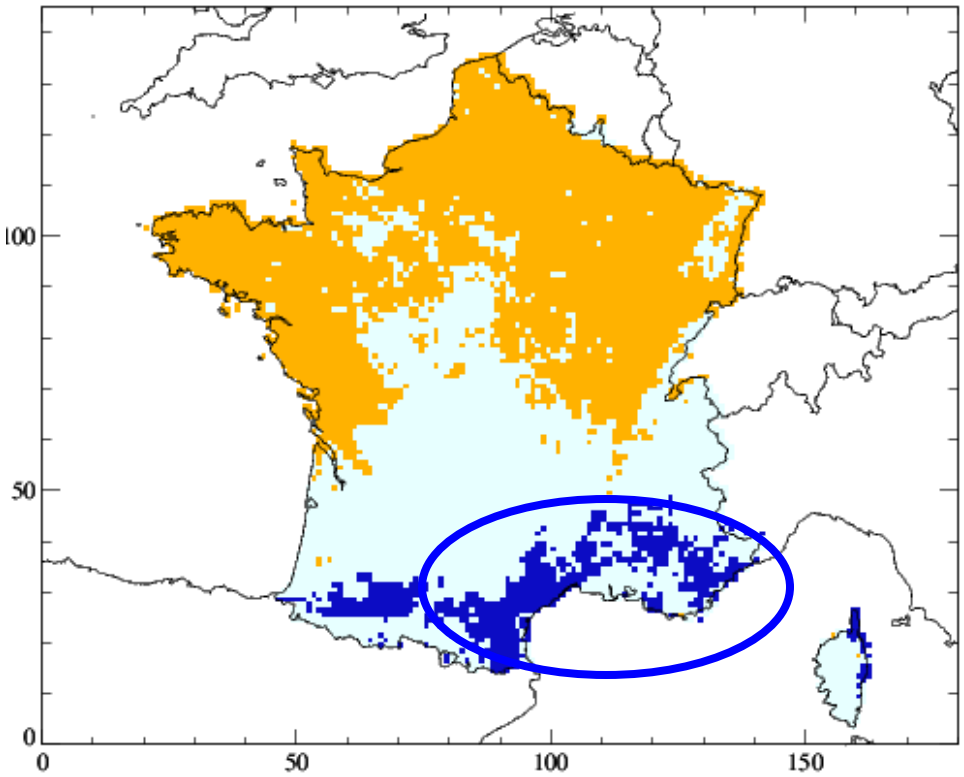
River Flow

Results for Spring (MAM)

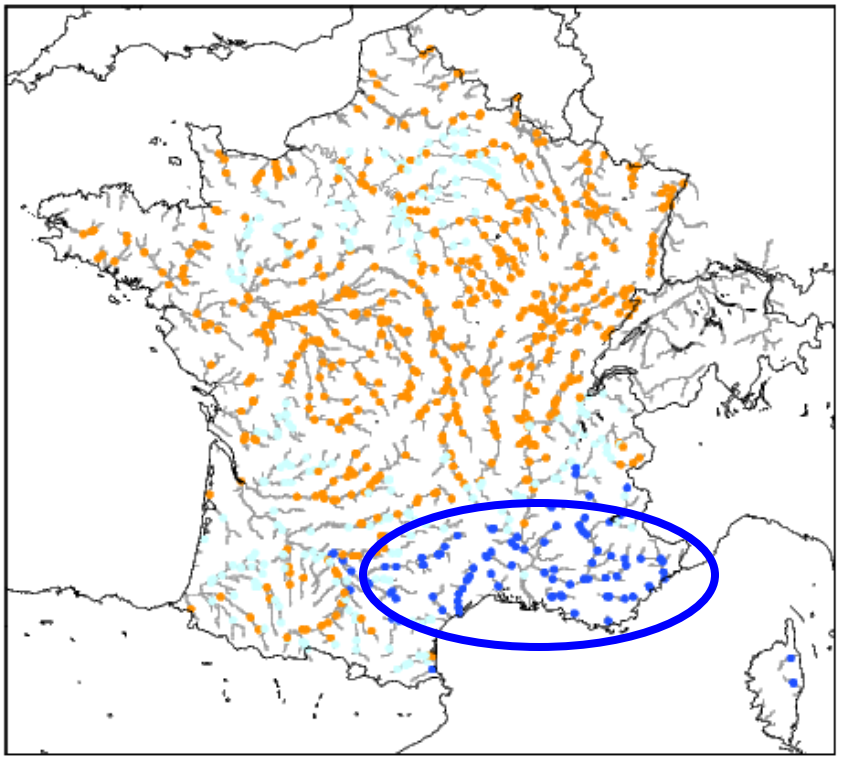
Comparison of correlations between Hydro-SF and RAF – IC 1st of February

(Singla *et al.*, 2012)

SWI



River Flow



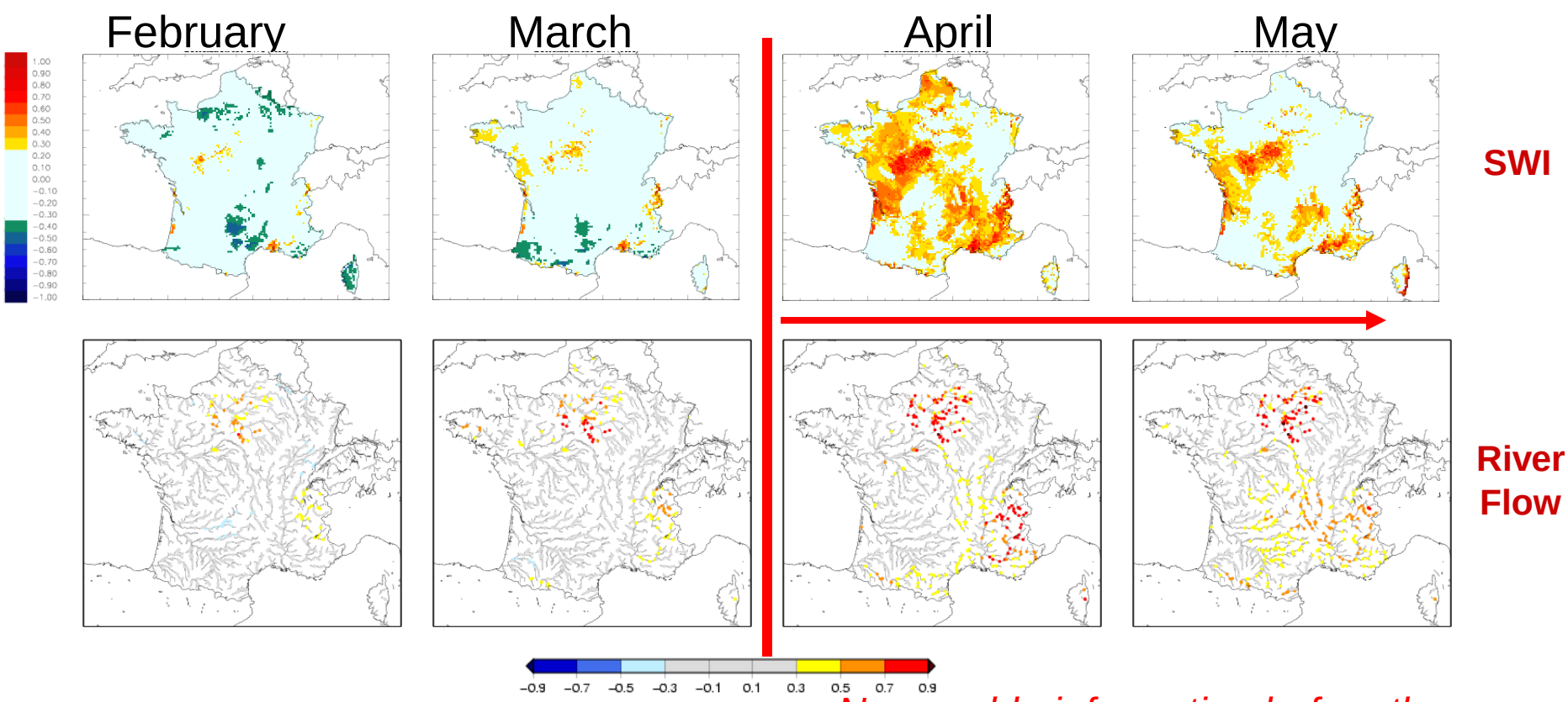
Regions where Hydro-SF is significantly better than RAF

Regions where Hydro-SF is equivalent to RAF

Regions where RAF is significantly better than Hydro-SF

Results for Summer (JJA)

- Correlation for SWI and River Flows over the 1979-2007 period (HYDRO-SF / ARPEGE-S3) for different IC for the summer forecast (JJA)

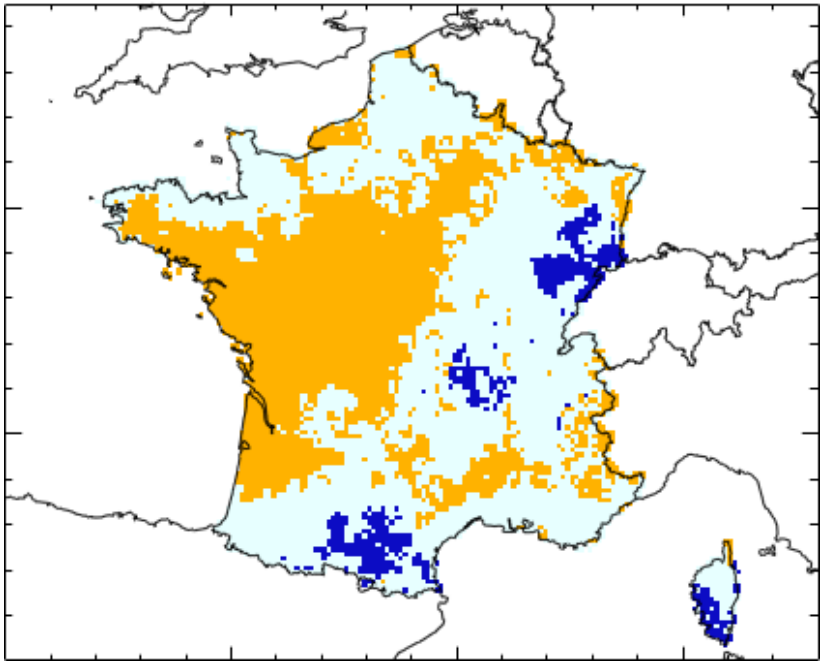


Correlations > 0.3 significant.
Clear improvement between March and April

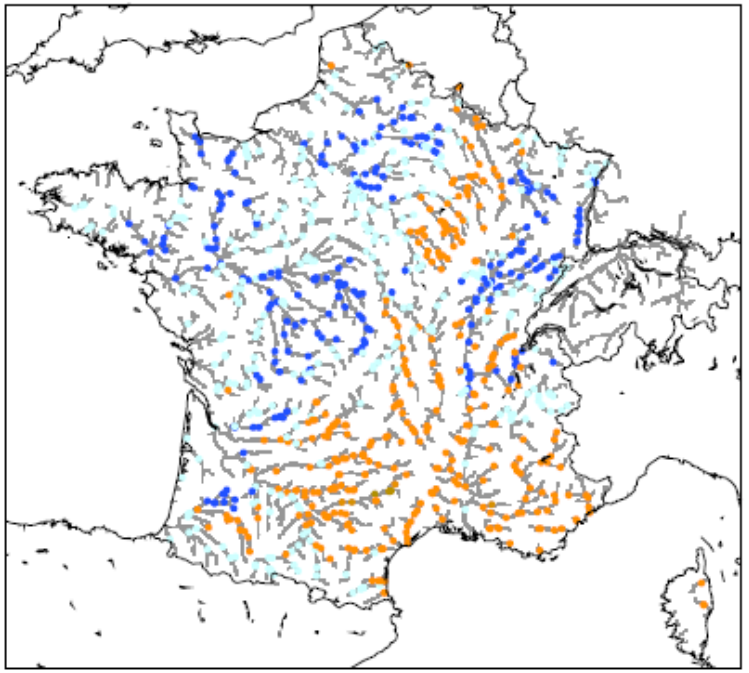
No useable information before the beginning of April

Results for Summer (JJA)

Comparison of correlations between Hydro-SF (April IC) and RAF



SWI



River Flow

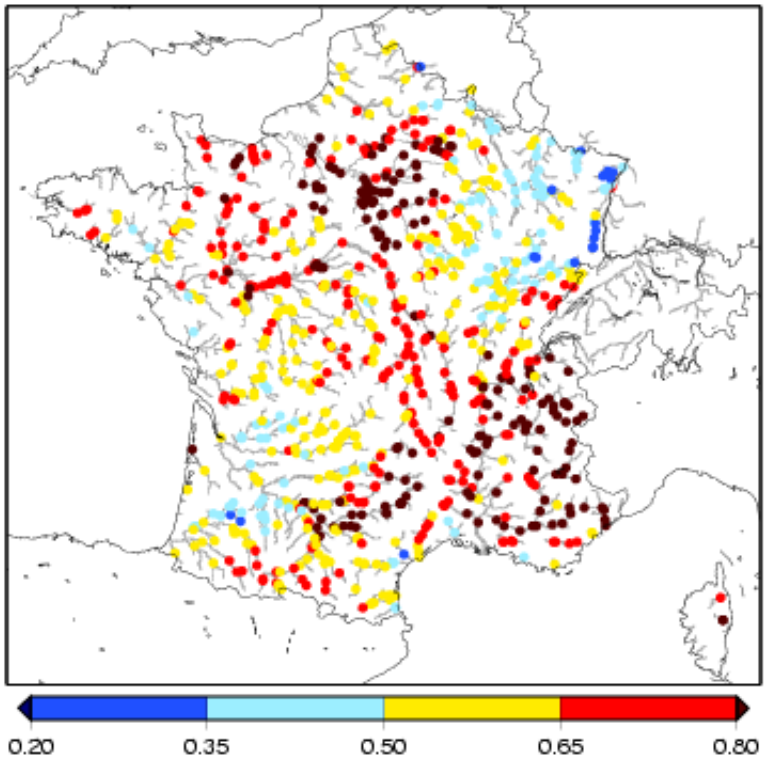
Regions where Hydro-SF is significantly better than RAF

Regions where Hydro-SF is equivalent to RAF

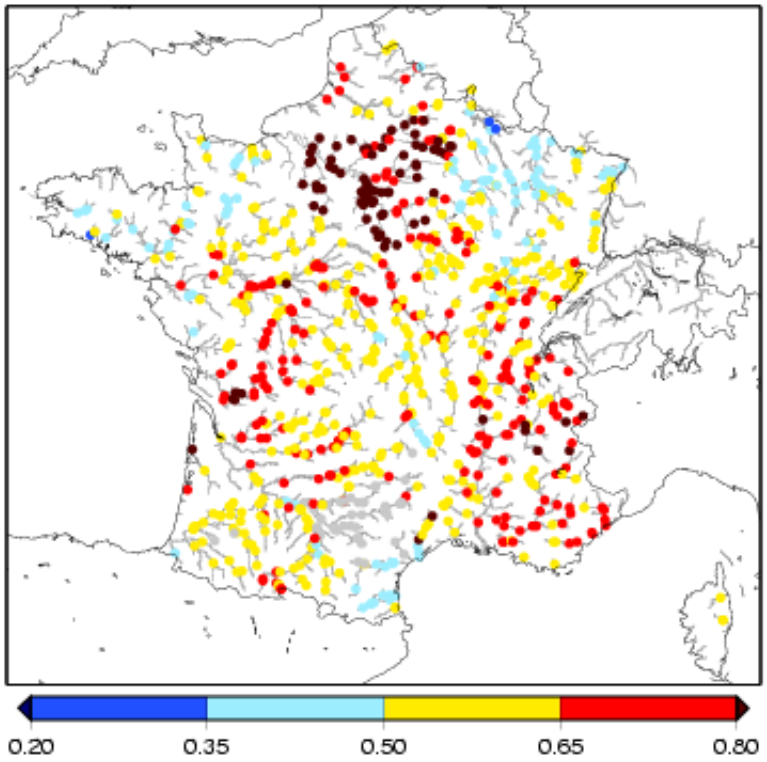
Regions where RAF is significantly better than Hydro-SF

Results for Summer (JJA)

ROC scores for Hydro-SF (1979-2007 – IC from 1st of April)



Upper Tercile



Lower Tercile

Conclusions & Perspectives

- Predictability sources for Spring (Singla *et al.*, 2012)
  - Snow in mountainous regions (Alps and Pyrenees)
  - Aquifer for the Seine river catchment
  - Atmosphere over plain regions (to the exception of specific regions) ; mostly T2m and total precipitation.

- Evaluation of Hydro-SF for Spring (Singla *et al.*, 2012)
  - For SWI : better performance (vs RAF) over the half North of France
  - For River Flow : better performance over a large portion of France
  - For both : Degradation over regions close to the Mediterranean basin

Conclusions & Perspectives

- Predictability for Summer
  - Predictability barrier between March and April
  - Aquifer for the Seine river catchment (stronger than for Spring)
  - Snow for Northern Alps river catchments

- Evaluation of Hydro-SF for Summer
  - For SWI : better performance (vs RAF) over the Western regions
  - For River Flow : better performance over Southern regions (and part of North-Eastern regions)

Conclusions & Perspectives

- Perspectives on the Hydro-SF suite
  - Improvement of the initial conditions (snow, river flow, aquifers …)
  - Improvement of the atmospheric forcing (seasonal forecast, downscaling …)
  - Models improvements
    - Arpège system 5
    - Isba (better snow representation, vegetation, …)
    - Modcou (implementation of other aquifers, presently in progress, …)
  - Multi model approaches
- Evaluation of the usefulness of the information
  - Comparison with observed river flows
  - Euporias project (FP7 EU funded project – coordination UK Met Office)
  - Stakeholders at the river catchment and national levels
    - Seine river basin agency and DRIIE (institutional)
    - Adour-Garonne river basin agency and DREAL (institutional)
    - National Drought committee

Thank you for attention

Résults - Snow

- Monthly river flows (m3/s) from SIM : Alps river flows

Durance at Embrun (South)		Arc at Bramans (North)		Isère at Moutiers (North)	
01	4.13	01	0.01	01	1.10
02	4.80	02	0.01	02	0.83
03	18.66	03	0.13	03	5.37
04	64.79	04	1.40	04	20.09
05	166.13	05	19.43	05	91.86
06	125.10	06	43.80	06	126.15
07	30.42	07	24.15	07	54.72
08	9.95	08	4.61	08	16.91
09	21.61	09	4.44	09	14.98
10	43.89	10	5.13	10	17.51
11	27.15	11	0.96	11	9.07
12	6.48	12	0.07	12	3.05

SIM

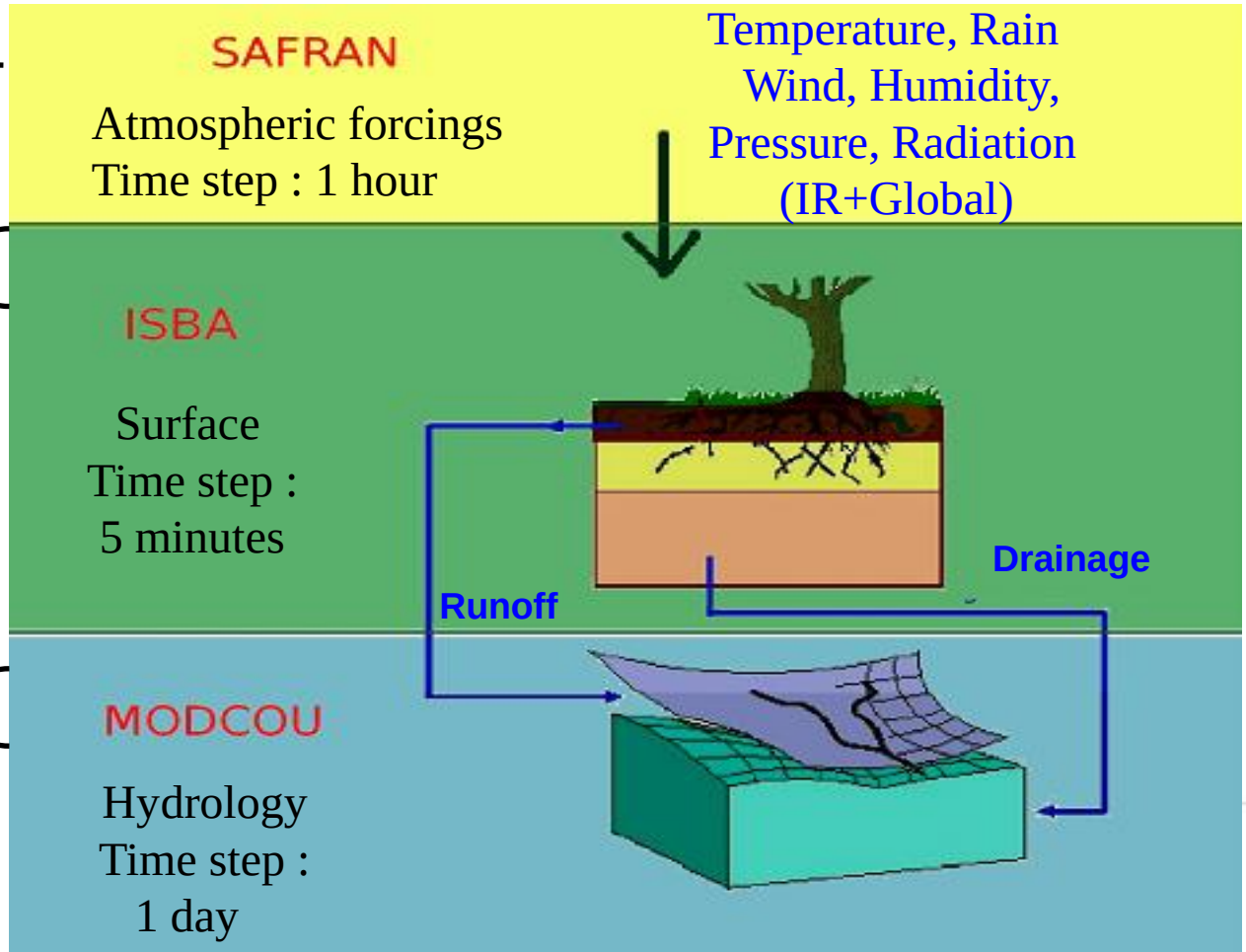
$$SWI = \frac{W - W_{wilt}}{W_{fc} - W_{wilt}}$$

- W : soil water content
- W_{wilt} : soil water content at the wilting point
- W_{fc} : soil water content at the field capacity

Atmospheric Analyse

Water and Energy Budgets

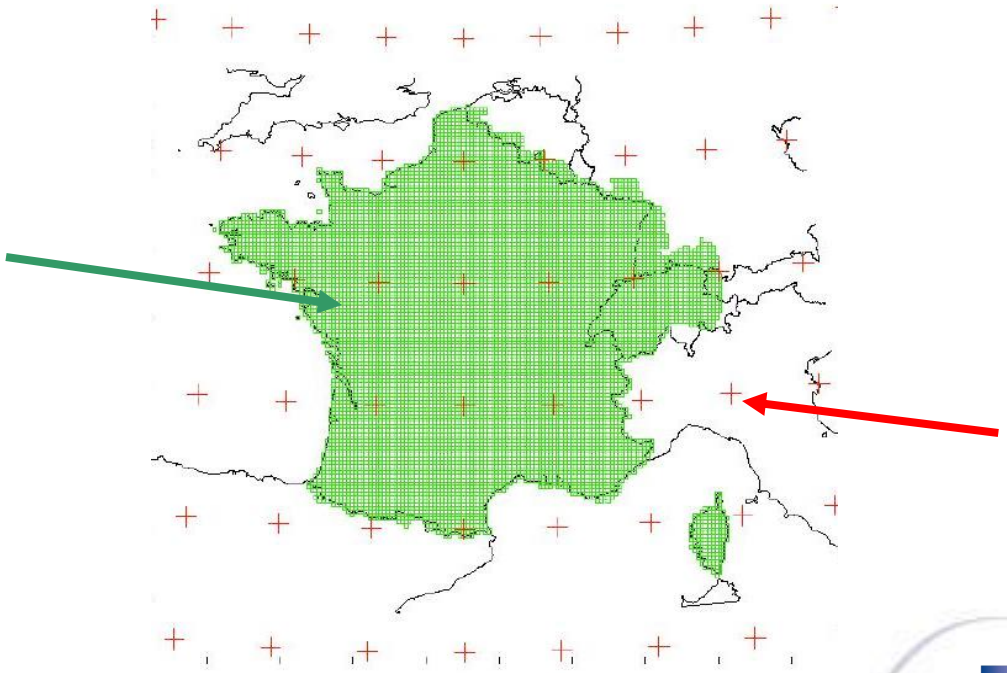
Riverflow for 907 stations and Aquifers



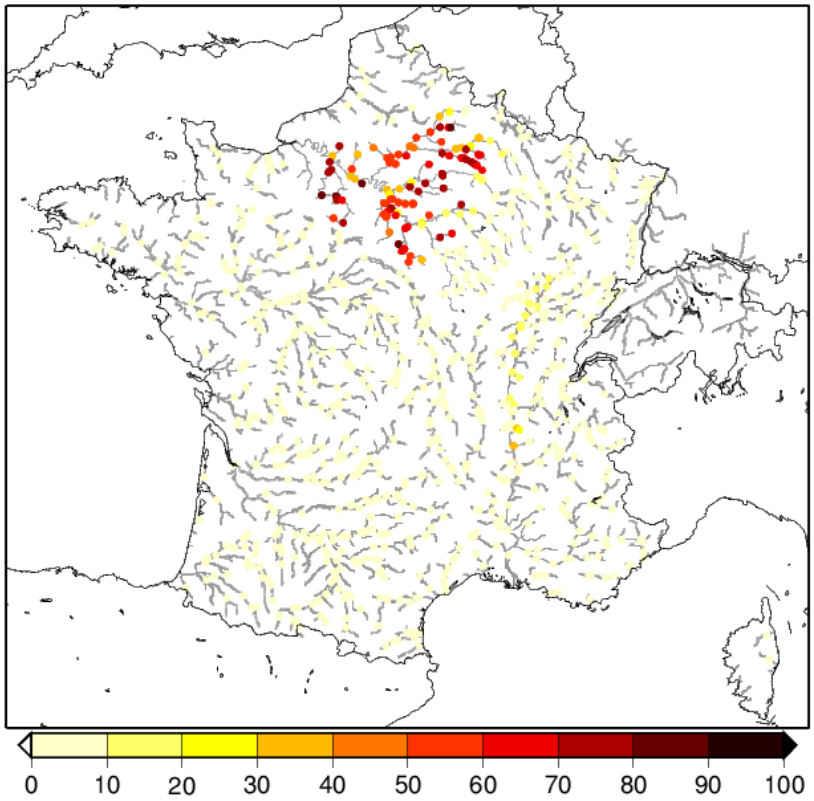
The downscaling

	DEMETER	ISBA
Precipitations	Total	Rain and Snow
	Daily	Hourly
Temperatures	4 values per day	Hourly
Resolution	2,5°	8 kilometers

ISBA mesh



Résults - Aquifers

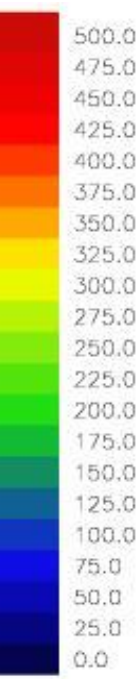


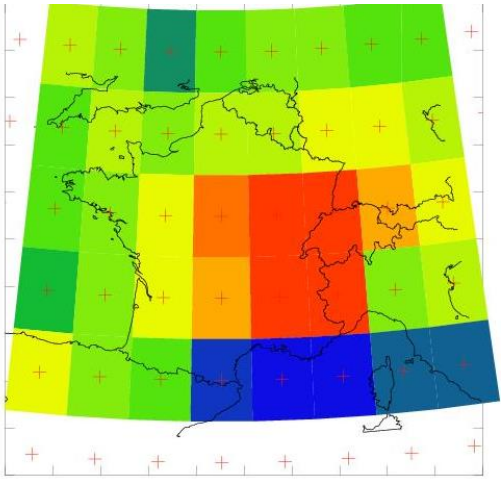
Ratio of the contribution of the Aquifer to the River Flow for MAM (SIM reanalysis) period 1960-2005

The spatial downscaling

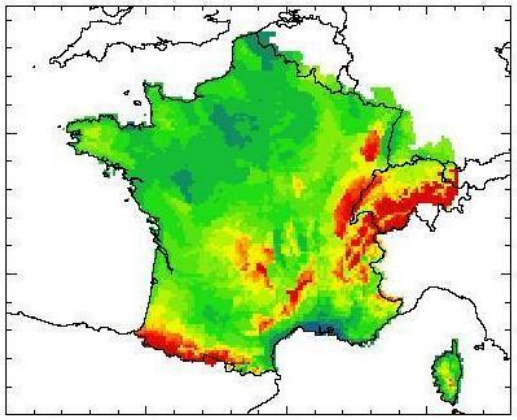
- Adaptation of the downscaling used for the medium range ensemble riverflow forecast (ROUSSET-REGIMBEAU,2007)

Accumulation (mm) on March-April-May 1998

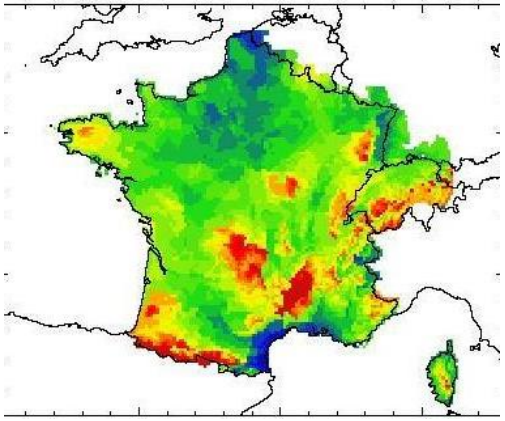




Seasonal forecast : precipitations

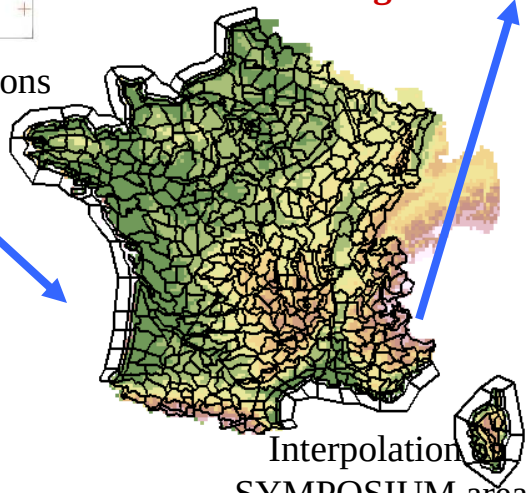


downscaling on ISBA mesh 8km



SAFRAN reference

Interpolation Distance $1/r^2$



Interpolation on SYMPOSIUM areas

Considering local properties by using the Safran Climatology for computing the local anomaly (and then the value)

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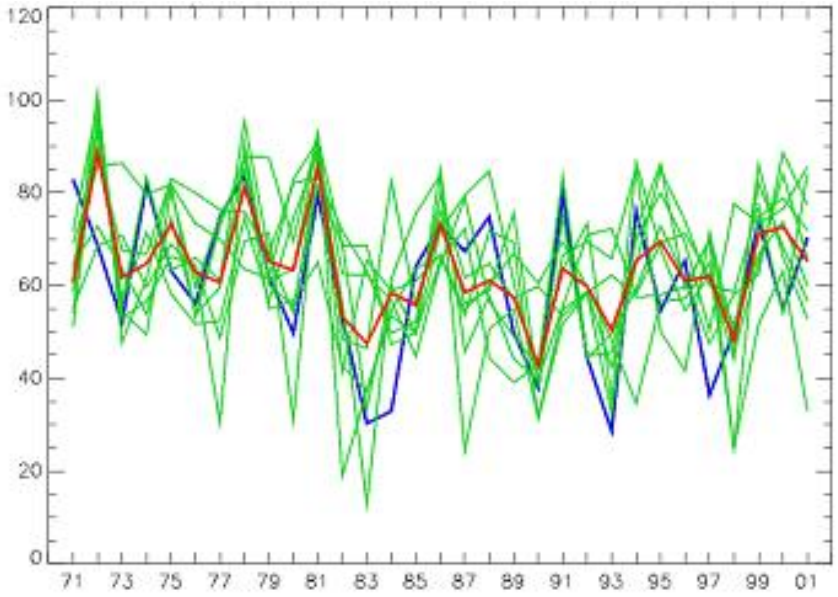
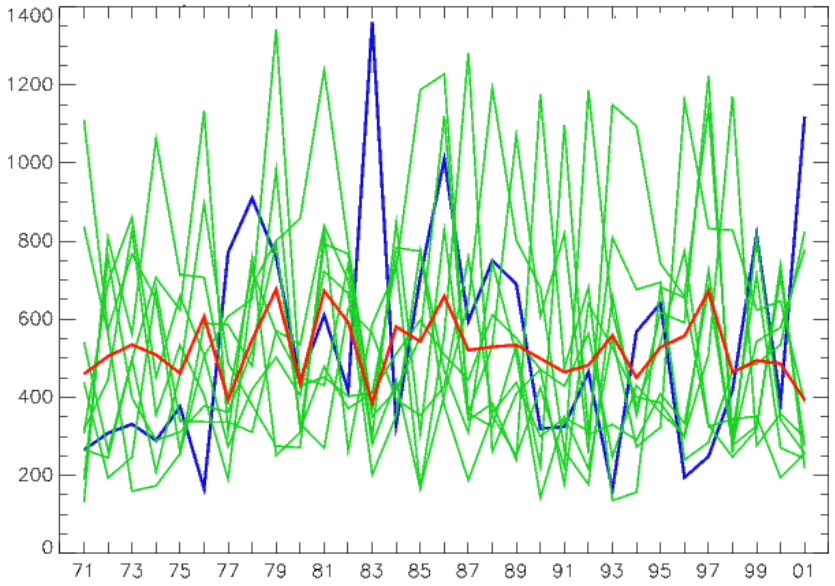
Randomly atmospheric forcing

Time series on mean river flow (m3/s) over two catchment for the spring period (March-April-May) from 1971 to 2001



Ariege at Foix (Mountain)

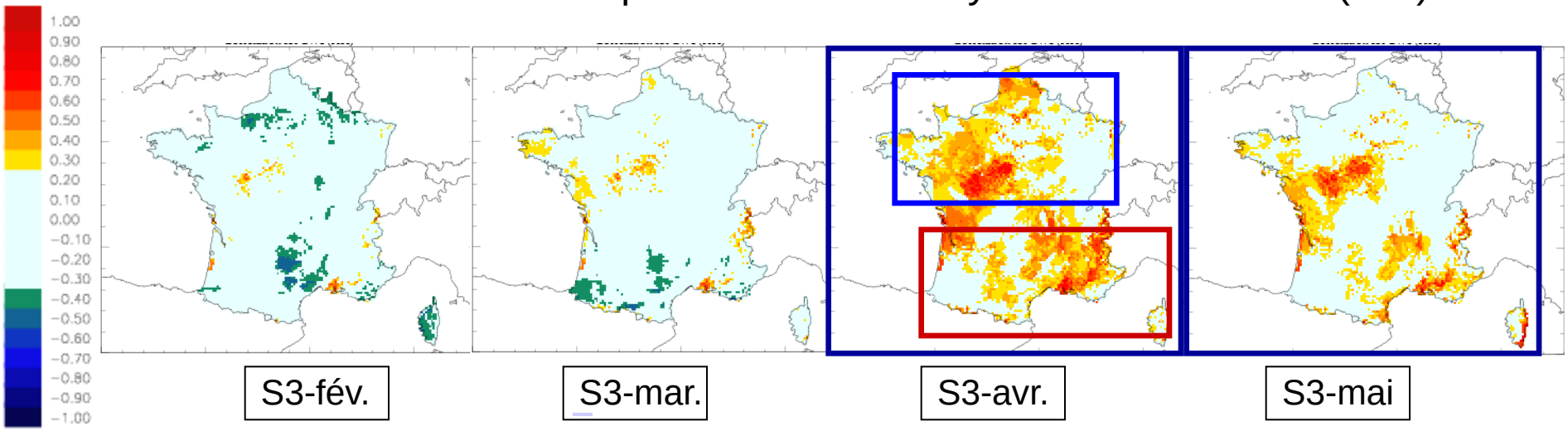


Saone at Trevoux (Plain)

Legend : Run -Mean ensemble –SIM reference-

Summer results (JJA) for Hydro-SF

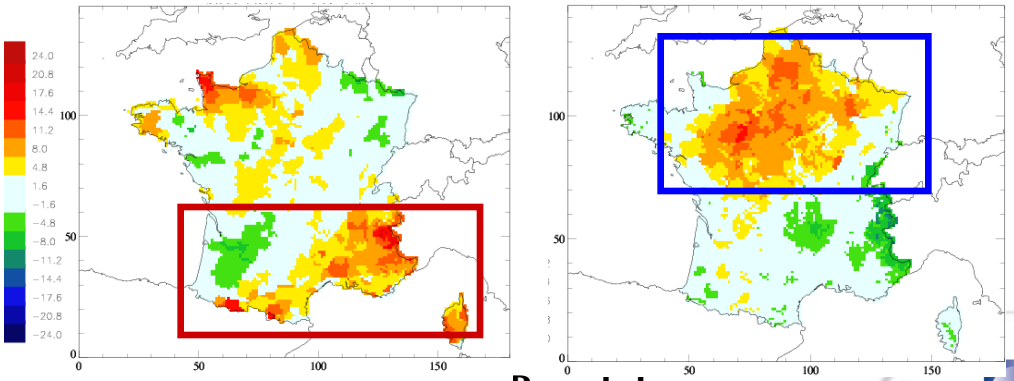
Carte des corrélations temporelles de SWI moyens sur le trimestre (JJA)



S3-fév. | S3-mar. | S3-avr. | S3-mai

Areas where the correlations between S3-April and S3-May for JJA are significantly different

T2m



RR

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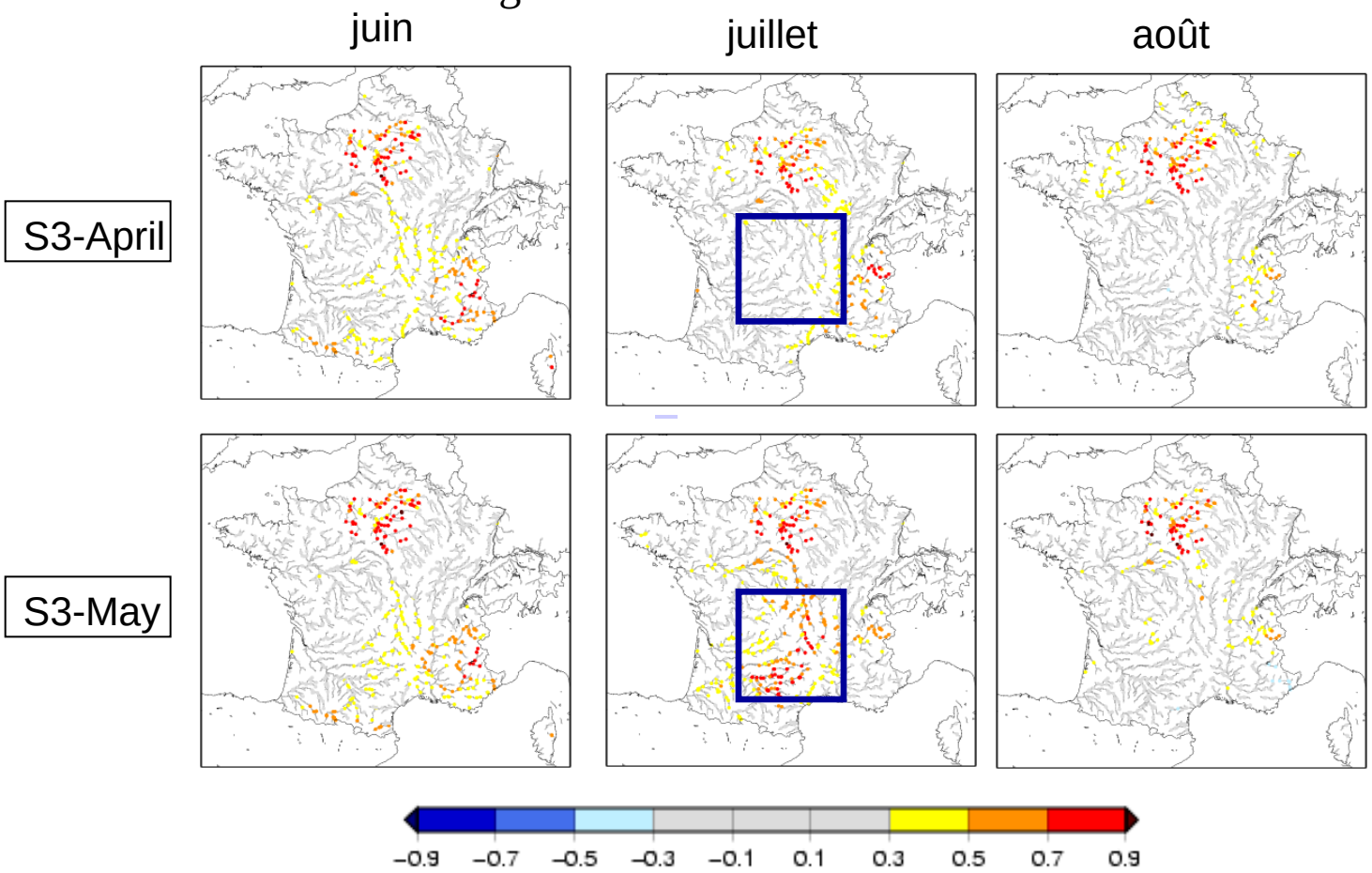
Summer results (JJA) for Hydro-SF

➢ Better river flows with May IC vs April IC : Better river flows in July over the Massif Central region

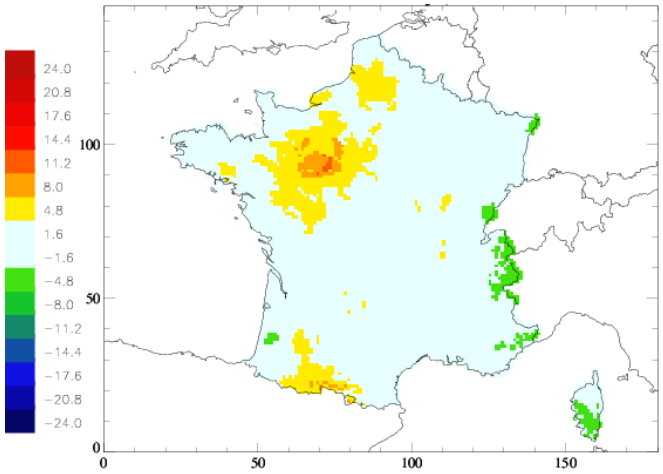


Correlation for monthly river flows

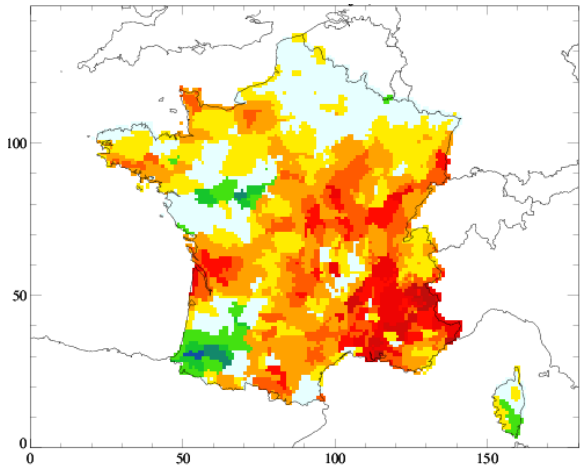
Expériences Hydro-SF avec différentes dates d'initialisation

➢River flows in July over the Massif Central region ?

T2m and Rainfall Correlations comparison between May IC and April IC)



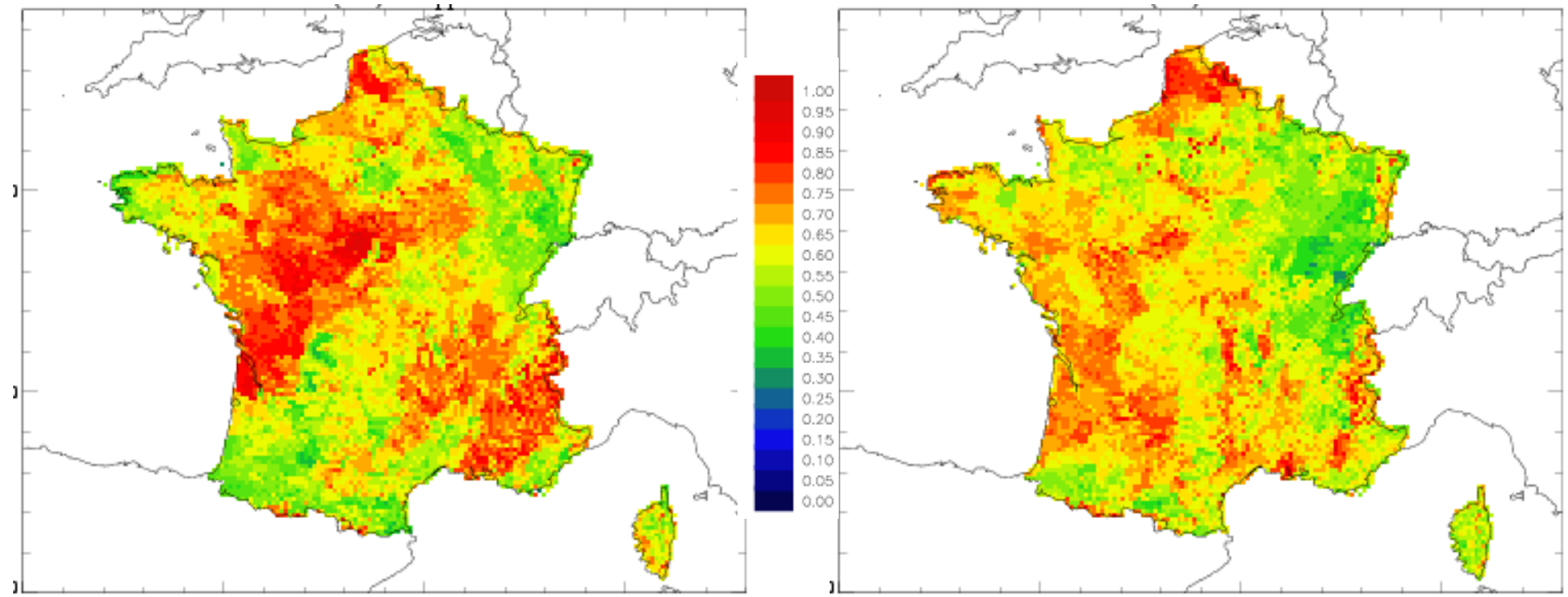
T2m



RR

Results for Summer (JJA)

ROC scores for Hydro-SF (1979-2007 – IC from 1st of April)



Upper Tercile **Lower Tercile**