Seasonal Forecast Verification
User oriented verification

JP. Céron
and contribution from S. Mason (IRI)
jpceron.wmo@gmail.com

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

lectures

1 **Introduction**

2 *Forecast Attributes*

3 *ROC & Reliability - Exercise*

4 *Significance & Robustness*

5

User Oriented Verification

Why Verification ?

- **For Modelers**
  - Detection of problems and discrepancies
  - Validation and evaluation of models,
  - Improvement of models
  - Comparison of models

- **For Users** :
  - Better knowledge of model performance over the region of interest
  - Better use of the information
  - **Assessment of contribution of the forecast as additional information to the user's activity**
  - **Assessment of the « value » of the forecasting information**

User Oriented Verification

To answer to which question ?

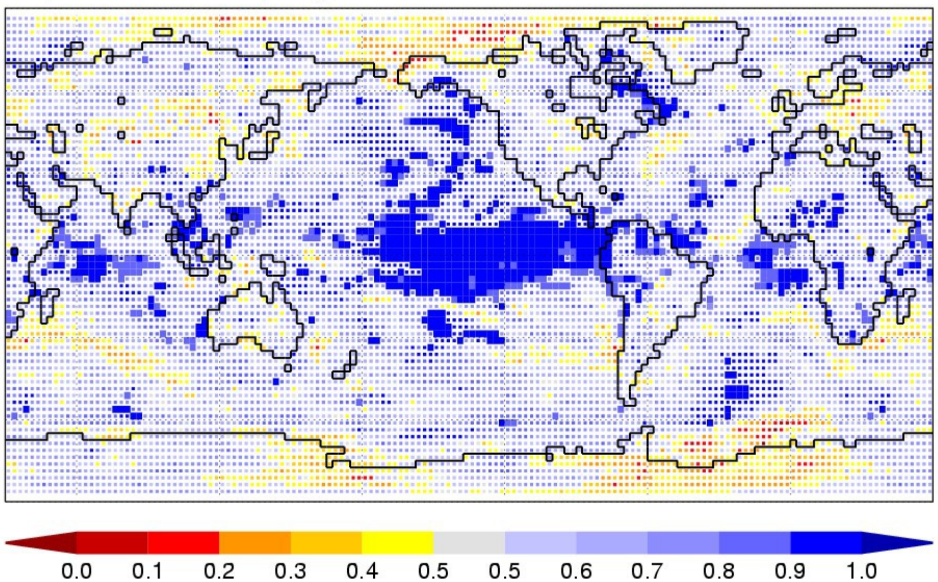
- **Different aspects for Modelers**
  - Is the model Good ? Skilful ?
  - Is the uncertainty estimate correct ?
  - Is the model perform better than another existing model ?

- **Different aspects for Users**
  - Is the information useful (including for Decision) ?
  - Is the information bring added value ?
  - Has the information some value ?
  - *Has the use of the information some impact on the user's activity?*

Score / Skill and Value

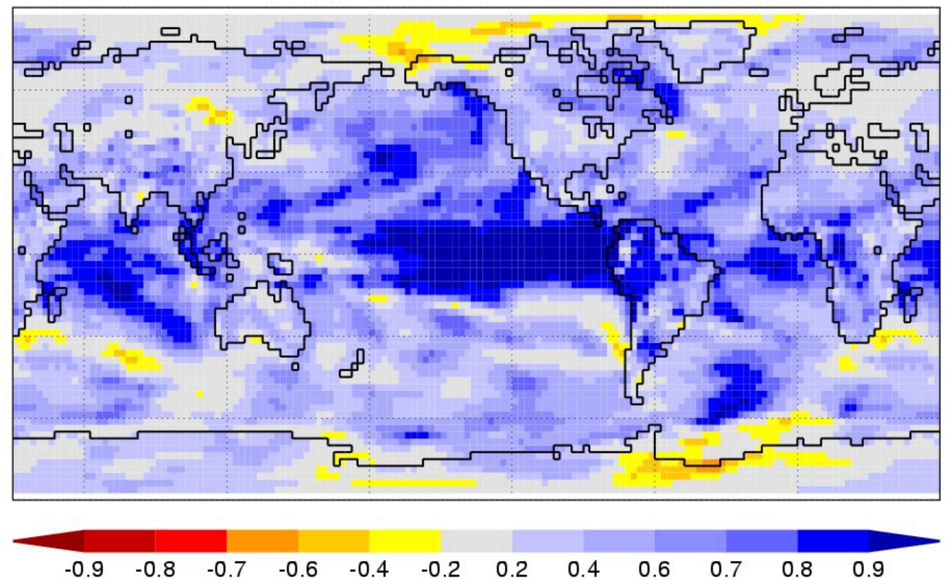
- Score and Skill : 2 different viewpoint (absolute and relative)

ROC Score: EXP(DEMETER II) regarding ERA-40 reanalysis
Event: 2m-Temperature Anomaly < -0.43 Standard Deviation
Forecast start month and years: November / 1987-1999
FC period: months 2-4 (DJF), ens: 0-62



October-November-December

2m-Temperature
Anomaly Correlation Coefficient: EXP(DEMETER II) regarding ERA-40 reanalysis
Forecast start month and years: November / 1987-1999
FC period: months 2-4 (DJF), ens: 0-62

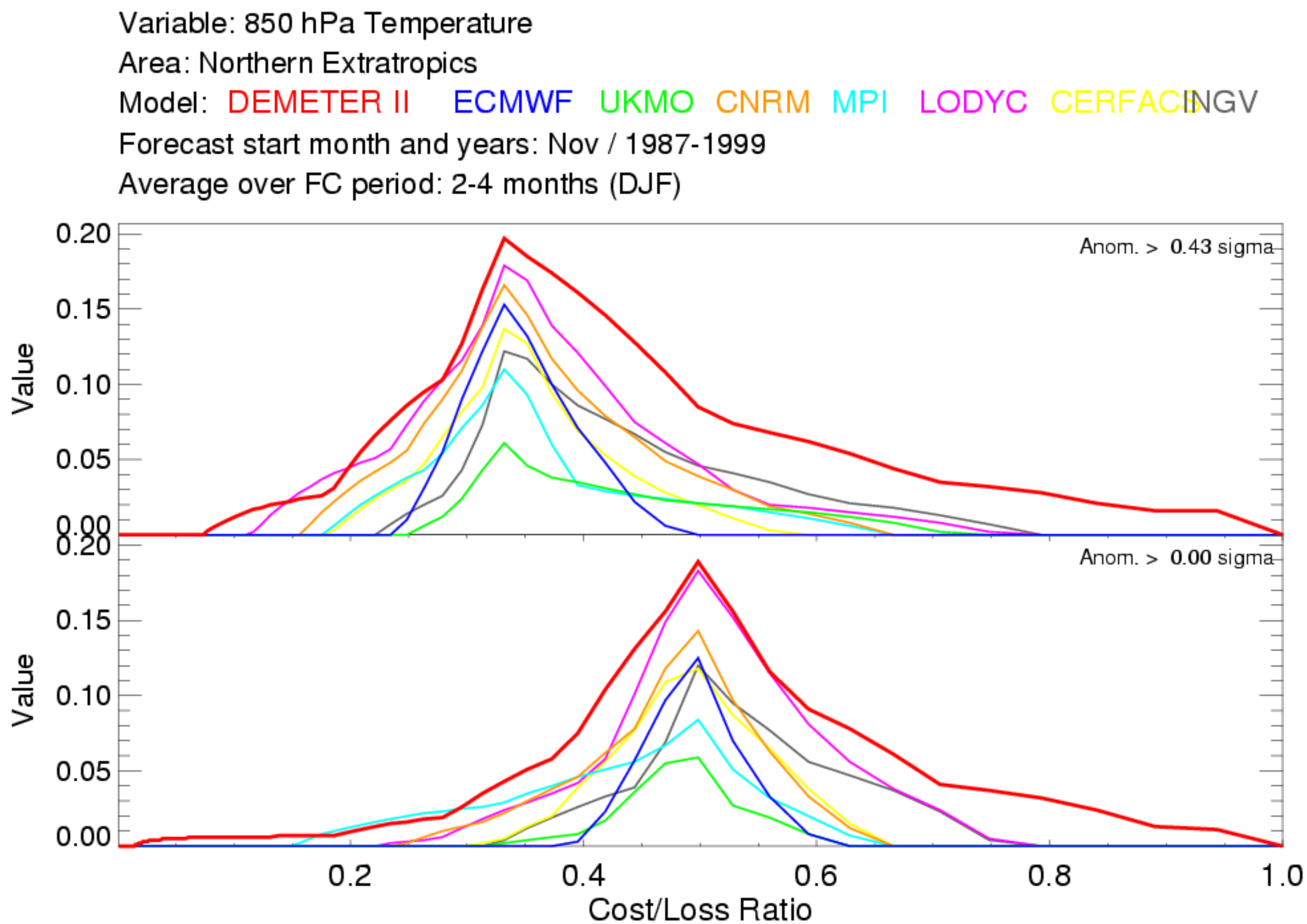


August-September-October

Score / Skill and Value

- **Value : a third vay**

Cost / Lost model



User Oriented Verification

Cost / Lost model

- **2 categories and economical consideration**
  - Categories e.g. Dry or Wet or ….
  - Cost/Lost ratio C/L (depends on the user)

Event	Obs	Non Obs
Forec.	C	C
Non Forec.	L	0

Event	Obs	Non Obs
Forec.	a	b
Non Forec.	c	d

f = frequency of the forecasted event
C1= mean cost using the climatology forecast
C2 = mean cost using a perfect forecast
C3= mea, cost using the real forecast

$$V = 100\,\frac{C1 - C3}{C1 - C2}$$

User Oriented Verification

Value of a probabilistic forecast

- **For a deterministic forecast**
  - If the event of interest for the user is forecasted one can take an action (prepardness, prevention, …),
  - If the forecast is No Occurrence of the event, one can do Nothing !

- **For a probabilistic forecast** :
  - How to decide whan the forecast is provided as probabilities for the different categories
  - One must convert the probabilities in term of Action or No Action
  - Choice of a probabilistic threshold Pa
    - When $p > Pa$ take decision of action
    - When $p < Pa$ take decision of No Action

User Oriented Verification

How to choose the probablistic threshold ?

- **With the Cost/Lost model**

Event	Obs	Non Obs
Forec.	C	C
Non Forec.	L	0

Event	Obs	Non Obs
Forec.	a	b
Non Forec.	c	d

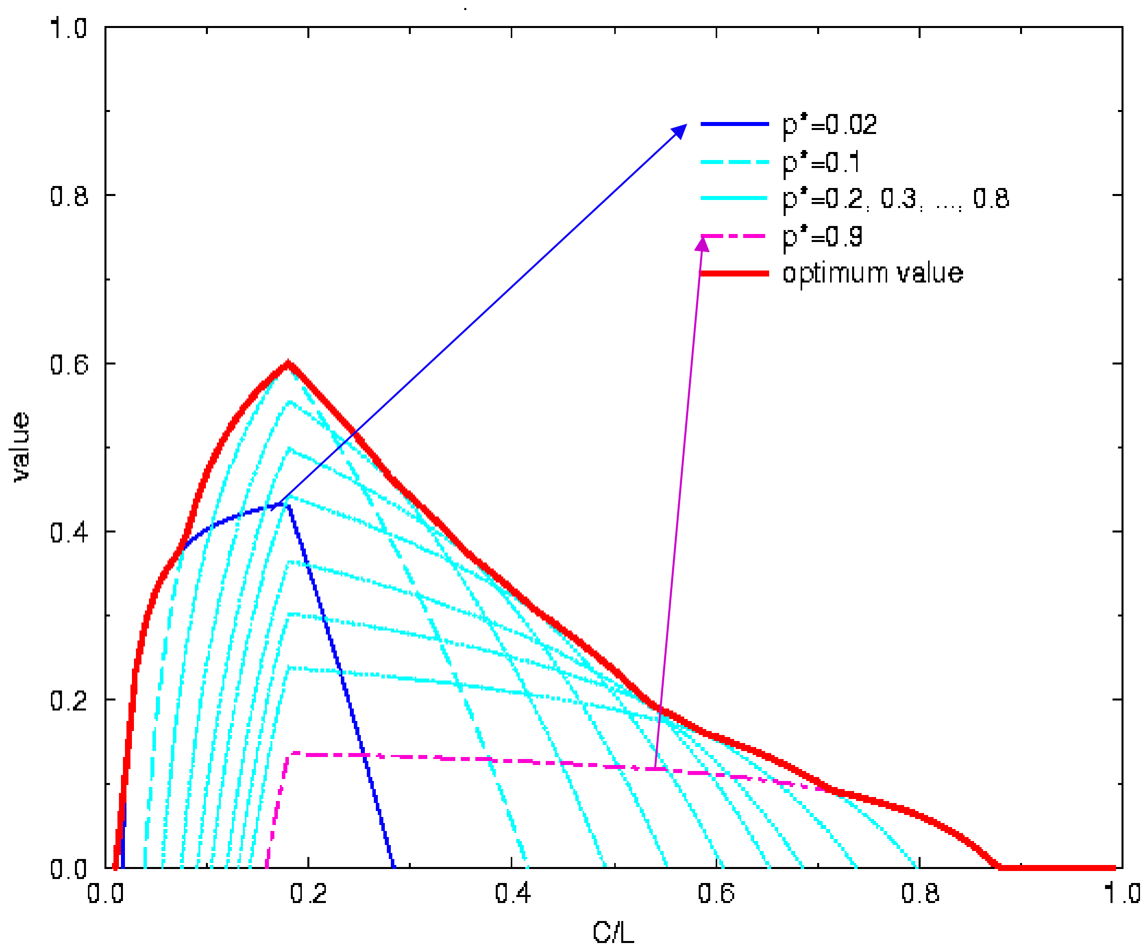
Assuming that the probability is p

- Cost of Permanent action : $E_A(cu) = C$
- Cost of No Action $E_N(cu) = pL$
- Best solution for users ; decide Action if C/L<p

The decisional threshold Pa depends on the user

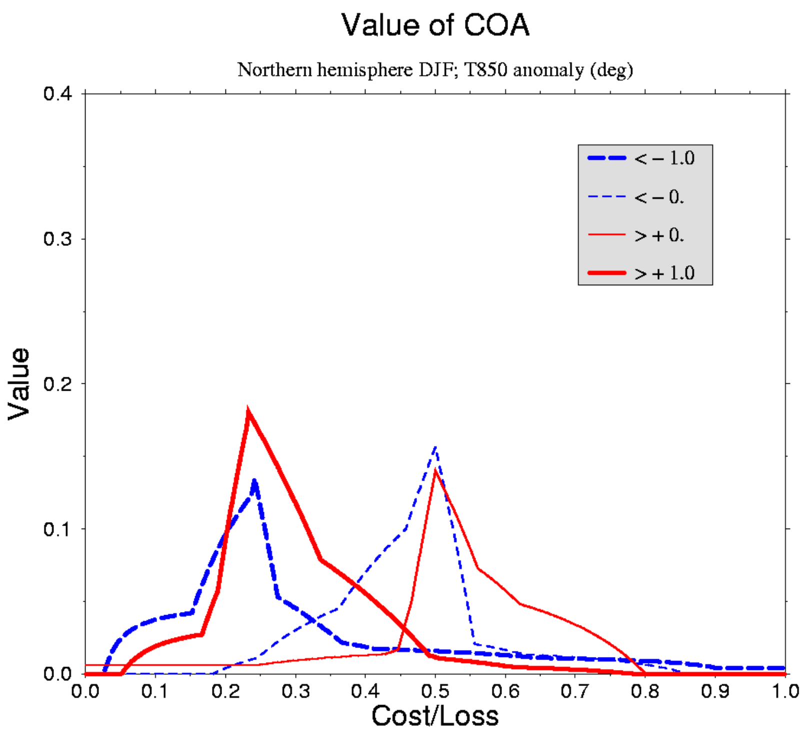
User Oriented Verification

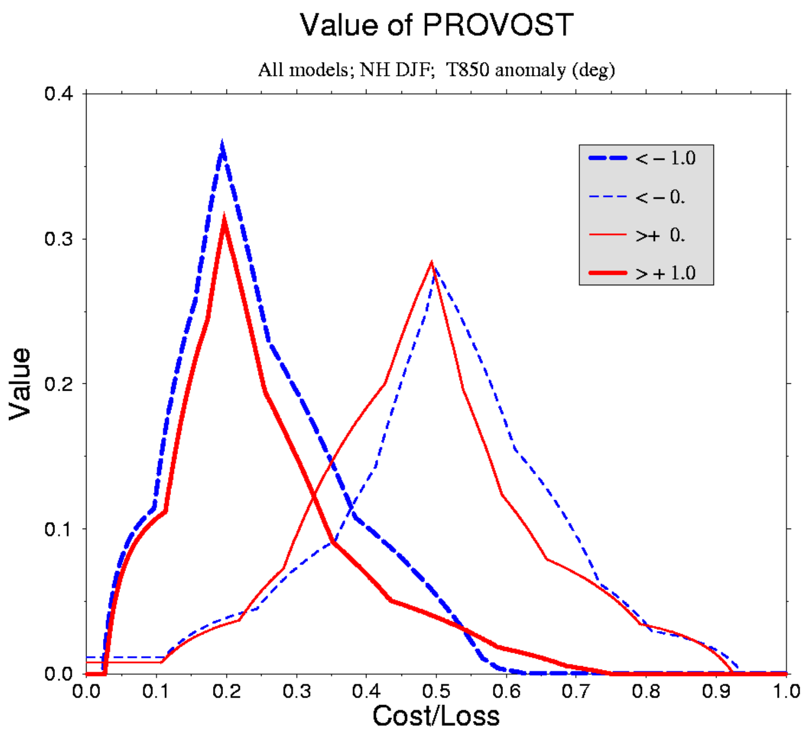
- Value for different users



User Oriented Verification

- Value for different users



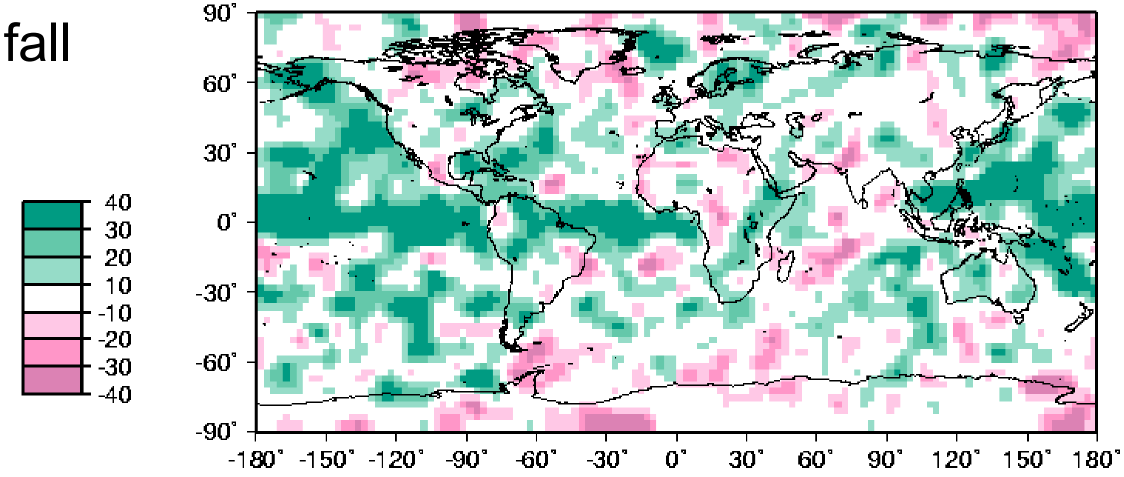


User Oriented Verification

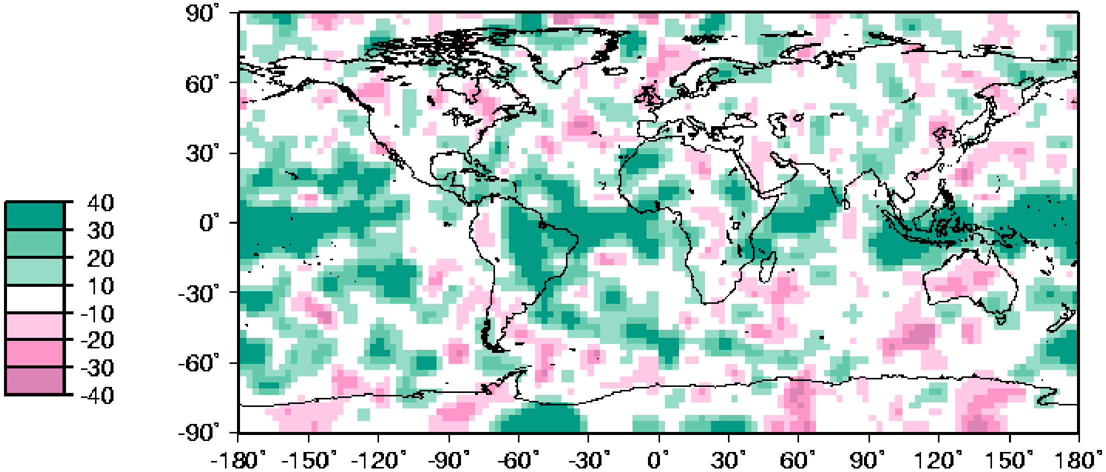
- Value of a probabilistic rainfall forecast

Correlation scores for rainfall

Winter rainfall



Summer rainfall

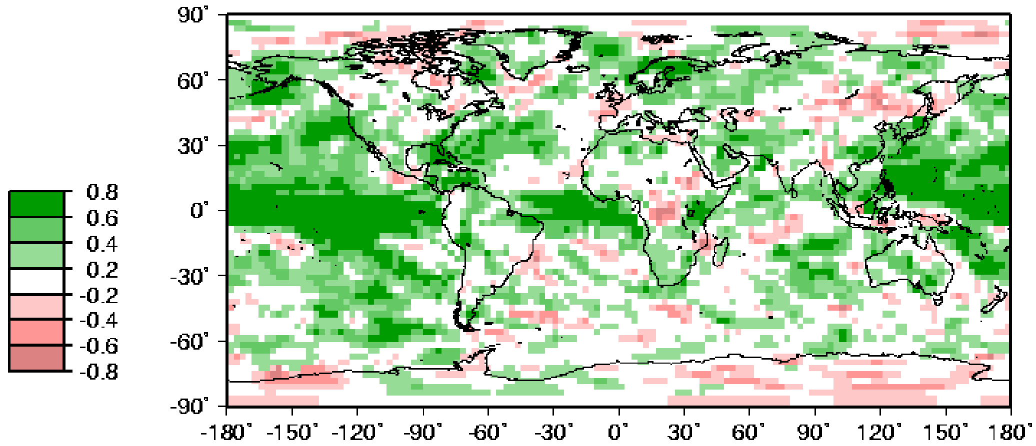


User Oriented Verification

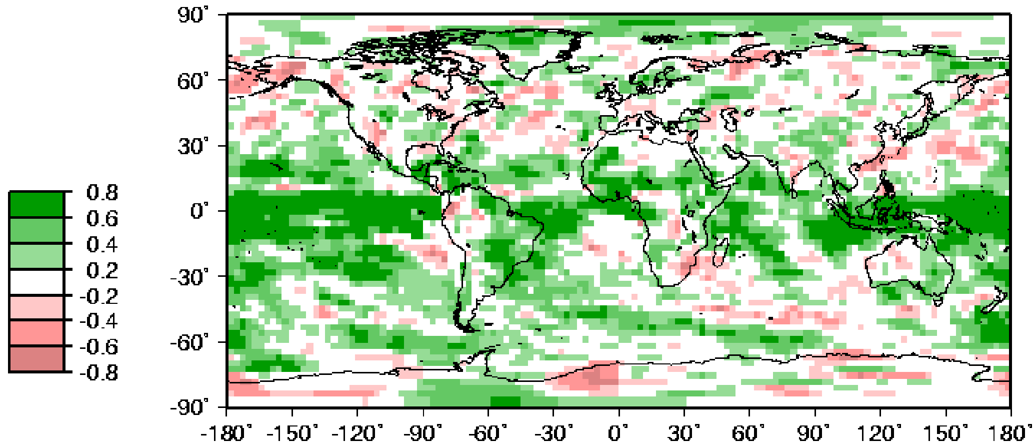
- Linkage Score and Value for different users

2 categories Dry /Wet
Cost/Lost ratio 0.5

Winter rainfall



Summer rainfall



User Oriented Verification

Linkage between Score and Value

- **Introducing the Hit Rate (H), the False Alarm rate (F) and the Cost/Lost ratio (C/L) :**

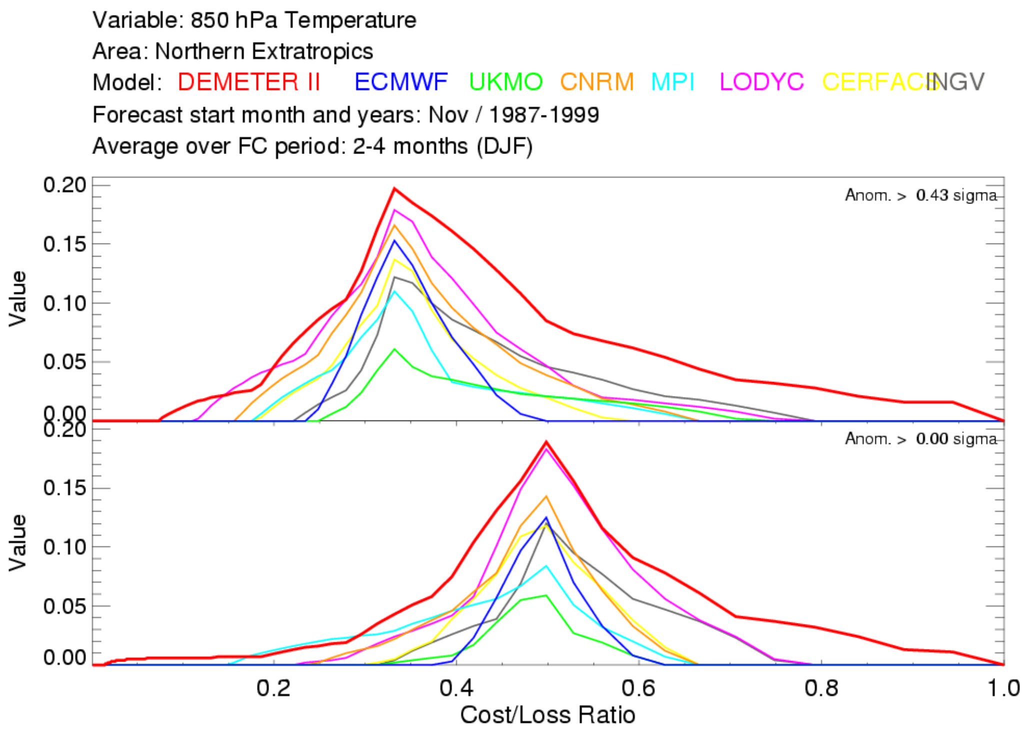
$$V = (1-F) - \left(\frac{1-C/L}{C/L}\right)\left(\frac{f}{1-f}\right)(1-H) \quad \text{si} \quad C/L < f$$

$$V = H - \left(\frac{C/L}{1-C/L}\right)\left(\frac{1-f}{f}\right) F \quad \text{si} \quad C/L > f$$

- The value depends on the Quality of the forecasts (H and F)
- The Value depends of the economical model of the user (C/L)
- The value depends on the observed frequency f of the event

User Oriented Verification

- Multimodel issues



User Oriented Verification

- Use of other economical models
  - Exmple of Insurance domain : Benefit/Lost mode and open marketl

Forecast / Obs	E_-	E_0	E_+	
E_-	a	b	c	O_-
E_0	d	e	f	O_0
E_+	g	h	i	O_+
	Pr_-	Pr_0	Pr_+	

User Oriented Verification

- Use of other economical models
  - Exmple of Insurance domain : Benefit/Lost mode and open marketl

Forecast / Obs	E_-	E_0	E_+	
E_-	G_-	$-G_-$	$G_+ - G_-$	O_-
E_0	G_-	0	G_+	O_0
E_+	$G_- - G_+$	$-G_+$	G_+	O_+
	Pr_-	Pr_0	Pr_+	

User Oriented Verification

- Use of other economical models
  - Exmple of Insurance domain : Benefit/Lost mode and open marketl

Forecast / Obs	E_-	E_0	E_+	
E_-	0	L-	L_-	O_-
E_0	0	0	0	O_0
E_+	L_+	L_+	0	O_+
	Pr_-	Pr_0	Pr_+	

User Oriented Verification

- Use of other economical models
  - Exmple of Insurance domain : Benefit/Lost mode and open marketl

Forecast / Obs	E_-	E_0	E_+	
E_-	G_-	$-G_- -L_-$	$G_+ -G_- -L_+$	O_-
E_0	G_-	0	G_+	O_0
E_+	$G_- -G_+ -L_+$	$-G_+ -L_+$	G_+	O_+
	Pr_-	Pr_0	Pr_+	

User Oriented Verification

- Use of other economical models
  - Exmple of Insurance domain : Benefit/Lost mode and open marketl

Forecast / Obs	E_-	E_0	E_+	
E_-	G	-G-L	-L	O_-
E_0	G	0	G	O_0
E_+	-L	-G-L	G	O_+
	Pr_-	Pr_0	Pr_+	

User Oriented Verification

- Use of other economical models
  - Exmple of Insurance domain : Benefit/Lost mode and open marketl

Prévi / Obs	E_-	E_0	E_+	
E_-	a	b	c	O_-
E_0	d	e	f	O_0
E_+	g	h	i	O_+
	Pr_-	Pr_0	Pr_+	

User Oriented Verification

- Use of other economical models
  - Exmple of Insurance domain : Benefit/Lost mode and dedicated market (E+)

Prévi / Obs	E_-	E_0	E_+	
E_-	a	b	c	O_-
E_0	d	e	f	O_0
E_+	g	h	i	O_+
	Pr_-	Pr_0	Pr_+	

User Oriented Verification

- Use of other economical models
  - Indices associated to the insurance domain

$$V_{SPS}=\frac{1}{N}\left[\left(a+d+i+f-b-h\right)-\left(b+c+g+h\right)R\right] \qquad R=\frac{Lost}{Gain}$$

$$V_{Cli}=\frac{2}{9}\left(1-2R\right) \qquad V_{Max}=\frac{2}{3} \qquad VSS_{SPS}=\frac{V_{SPS}-V_{Cli}}{V_{MAX}-V_{Cli}}$$

$$V_{SPS-}=\frac{1}{N}\left[\left(i+f+c-g-h\right)-cR\right] \qquad V_{SPS+}=\frac{1}{N}\left[\left(a+d+g-b-c\right)-gR\right]$$

$$V_{Cli+}=V_{Cli-}=\frac{1}{9}\left(1-R\right) \qquad V_{Max+}=V_{Max-}=\frac{1}{3}$$

User Oriented Verification

- **How do we know that a forecast is « good » ?**
  - **In case of Impact Forecast** (tailored e.g. for DMP)
    - **Verification ?**
    - Depends on the usefulness for the user
    - Needs of reference dataset from the user side (Impacts, Decisions, …)
    - Verification of the use and better decision still to be developped (e.g. Placebo protocol). **The problem is more complex !**

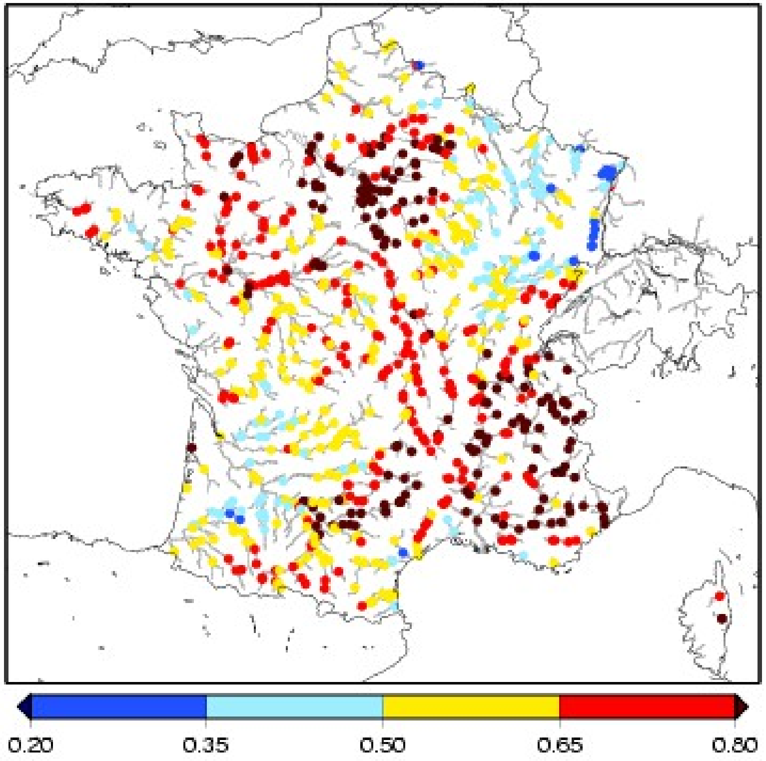
User Orientd Verification

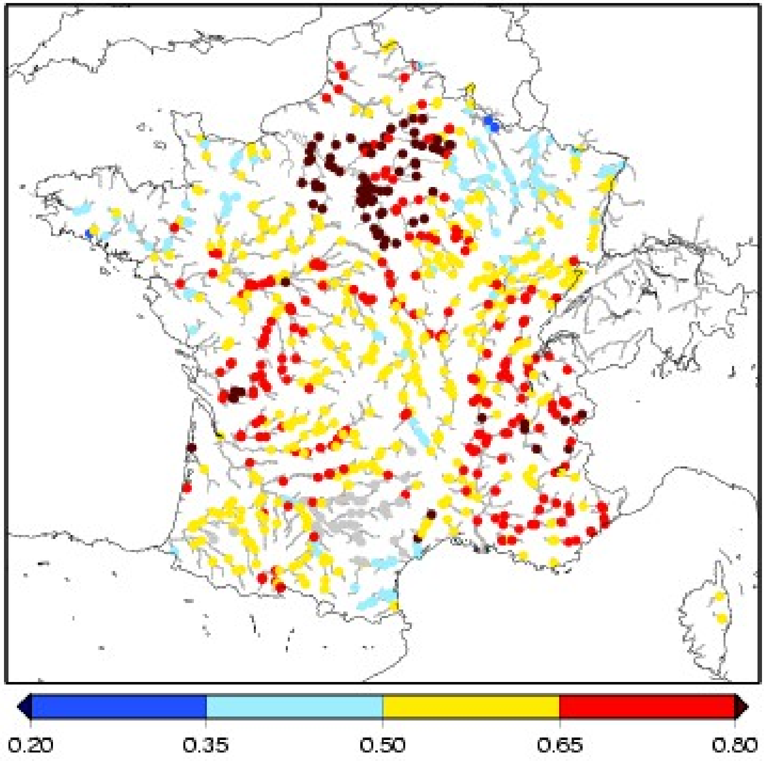
Evaluation of Impact Forecasts

- Evaluation of the impact probabilistic forecast
  - Reference data (impact variables, …)
  - Reference strategy (climatology, random atmospheric forcing, …)
- Evaluation of the impact of the use of the information
  - Demonstration of the impact of the use of the information onto the DMP : based on Placebo concept
    - ✓ Extension of the Placebo concept to the evaluation of the quality of the decisions made using DMPs : provision of 2 set of forecasts
    - ✓ Set 1 : impact forecast using Atmospheric Seasonal Forecast forcing
    - ✓ Set 2 : impact forecast using Random Atmospheric Forcing (“Placebo” like set of climate information) presented in the same fashion than the one used for impact seasonal forecast
  - Stakeholders “replaying” (if possible) 30 years of decisions (blind method),
  - Issuing a comprehensive analysis of the Decision made,
    - ✓ Set 1 , Set 2 and Past decisions
    - ✓ Note the need to define what is a “good” decision, a ”bad” decision and likely an “acceptable” decision

User Oriented Verification

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





Upper Tercile

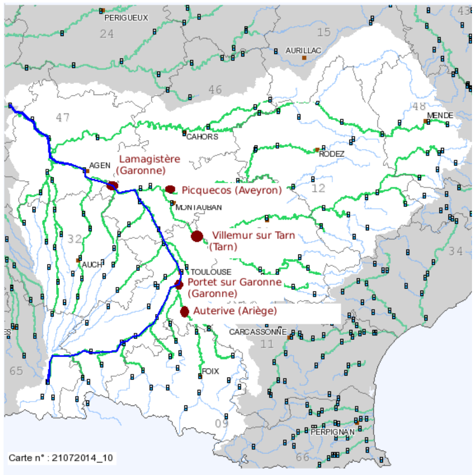
Lower Tercile

Skills can significantly better for River Flow and SWI than for Temperature and Rainfall

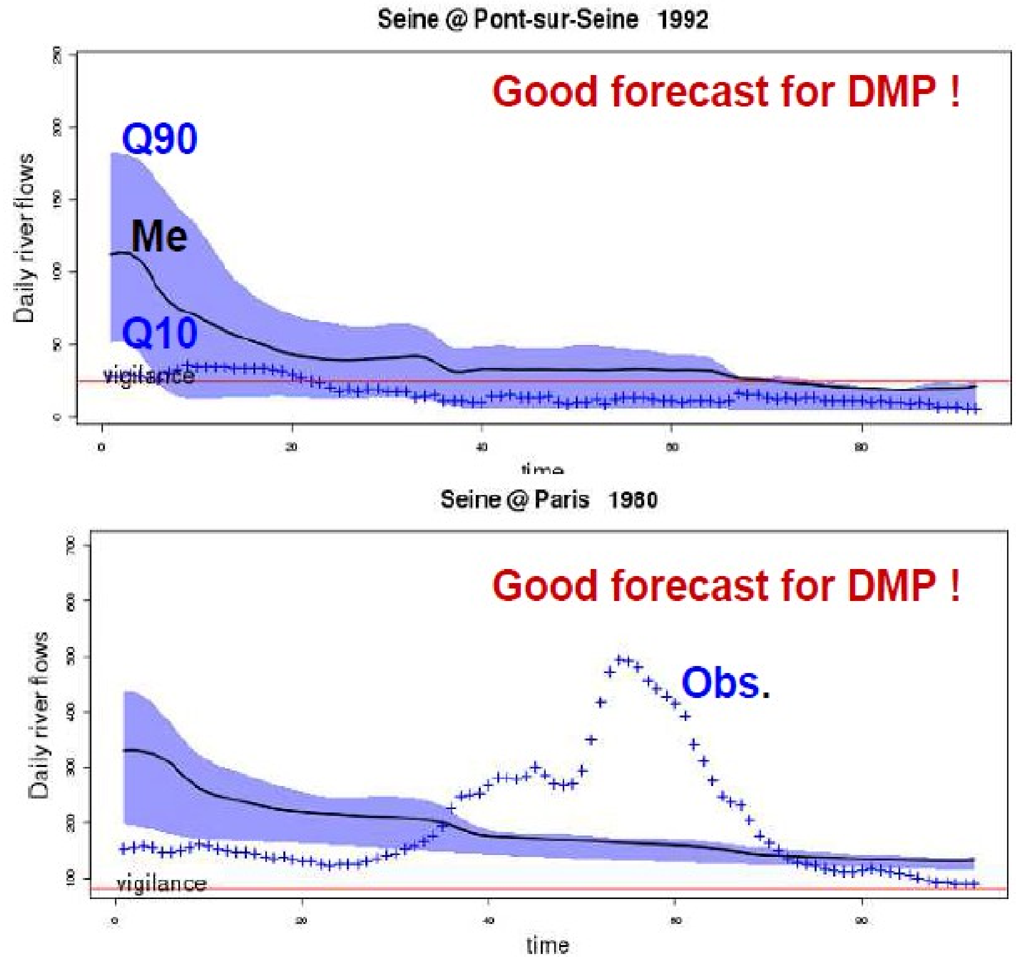
(Ref : Singla et al. 2012)

User Oriented Verification

- Some examples



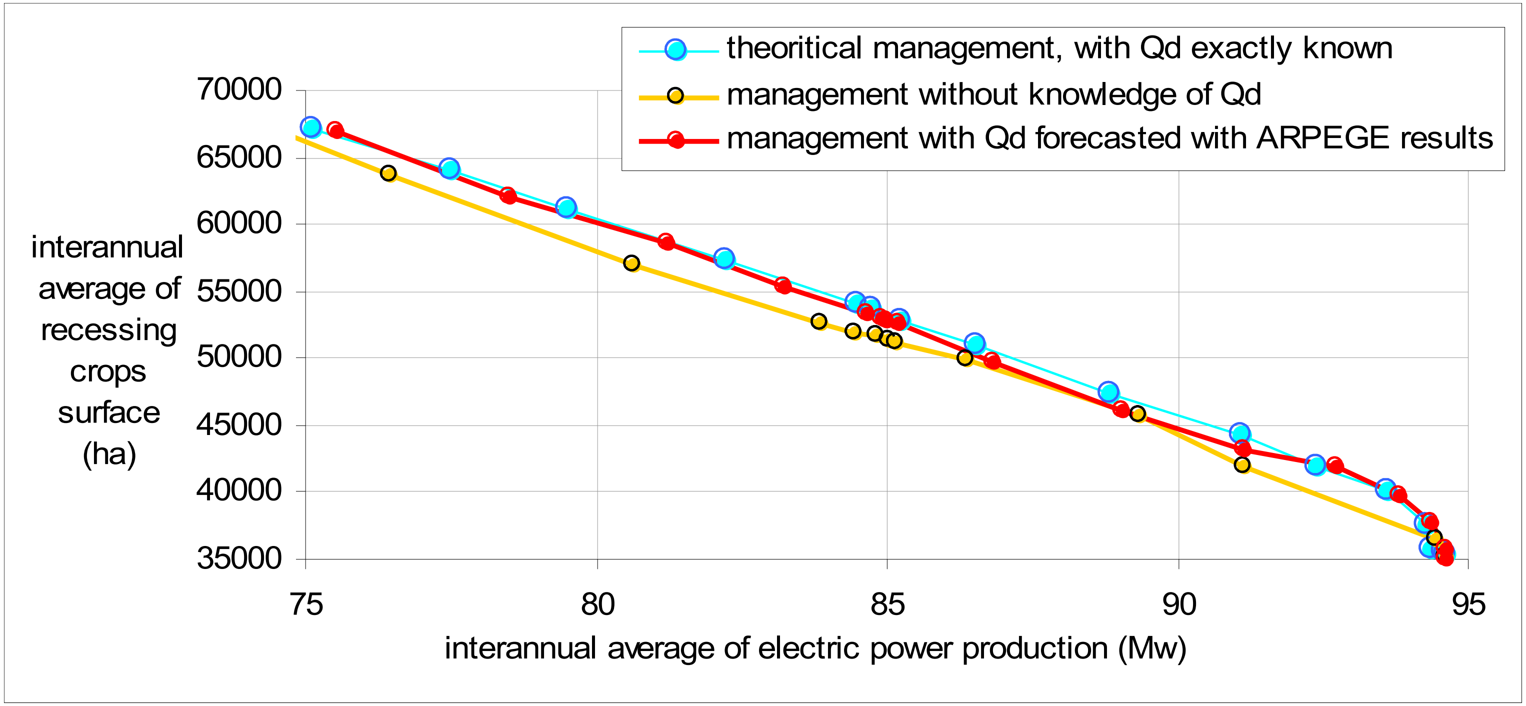
Key Stations used by the SMEAG



Forecast - Daily Time Series of ensemble Median, Q10 and Q90

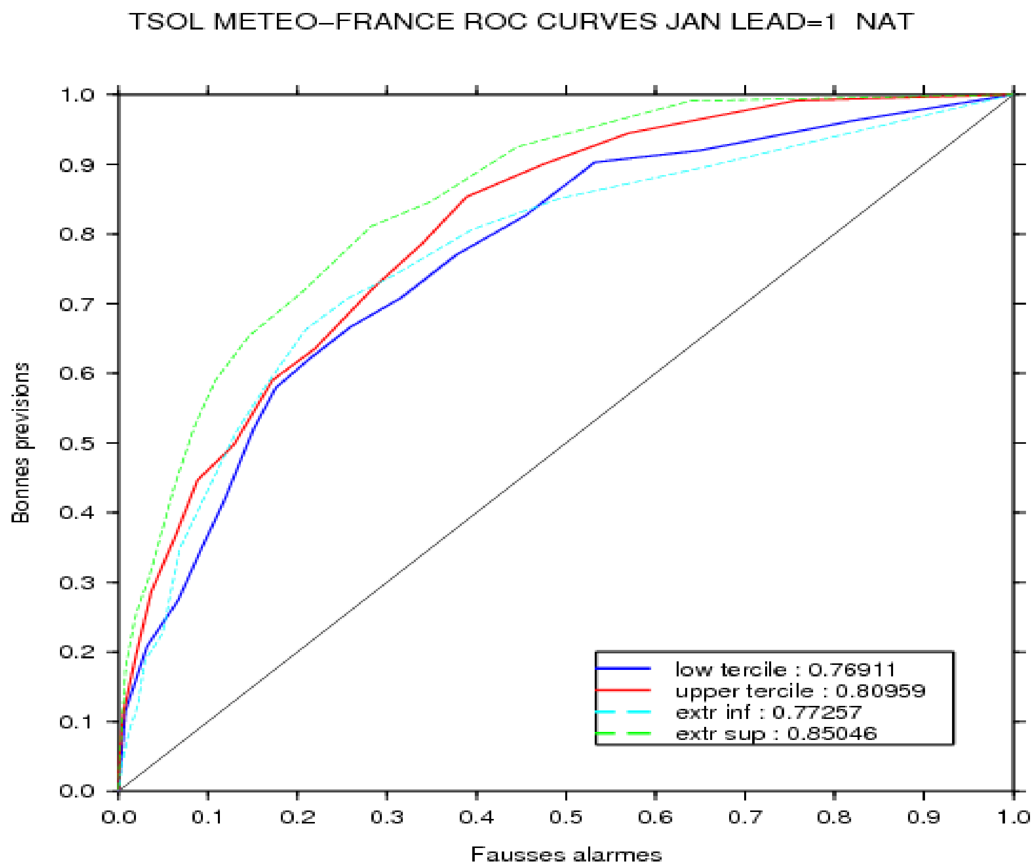
Use of the Seasonal Forecasting Information

- Additional value brought by the system,



<u>13. Benefits obtained with a basic use of the forecasts</u> :
The simulations were made for different values of Hf, with different hypothesis concerning the natural discharge of September-October : 1- exactly known (theoritical); 2- unknown; 3 - forecasted with the ARPEGE results.

Use of ROC curve



ROC curves (period 1981 – 2010)

TNA SST

WMO OMM

Butterfly Effect …

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

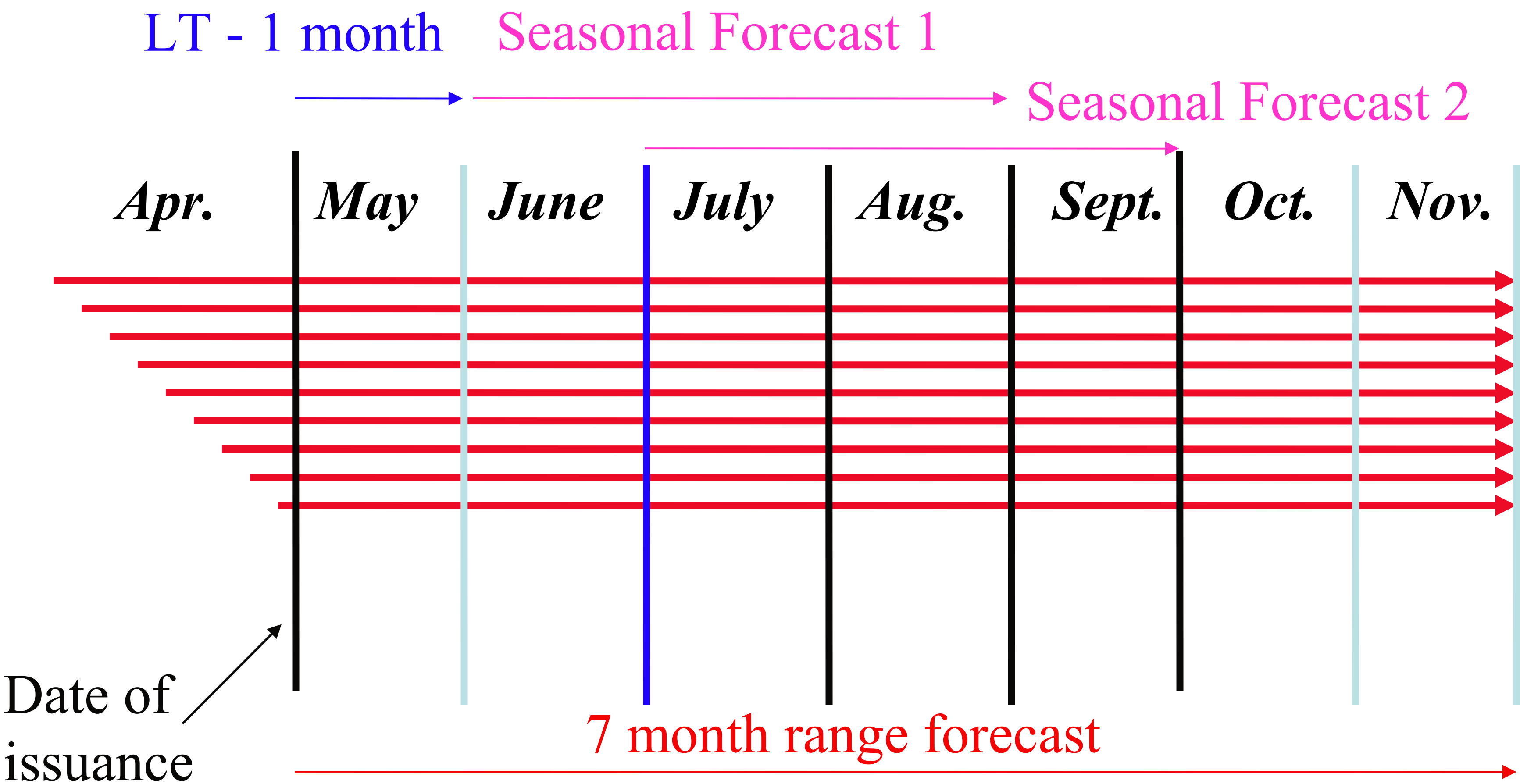
WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

User Oriented Verification

- Reliability depends on the year,
- Relaibility depends on the region and the parameter,
- Quality (scientific view) different than Usefulness (user view - economical value, added value for Decision Making),
- Useful in a decision making context and for climate risk management ; especially for activities (including economic) which are sensitive to climate when the range of the forecast is consistent with the decision calendar of the stakeholder.

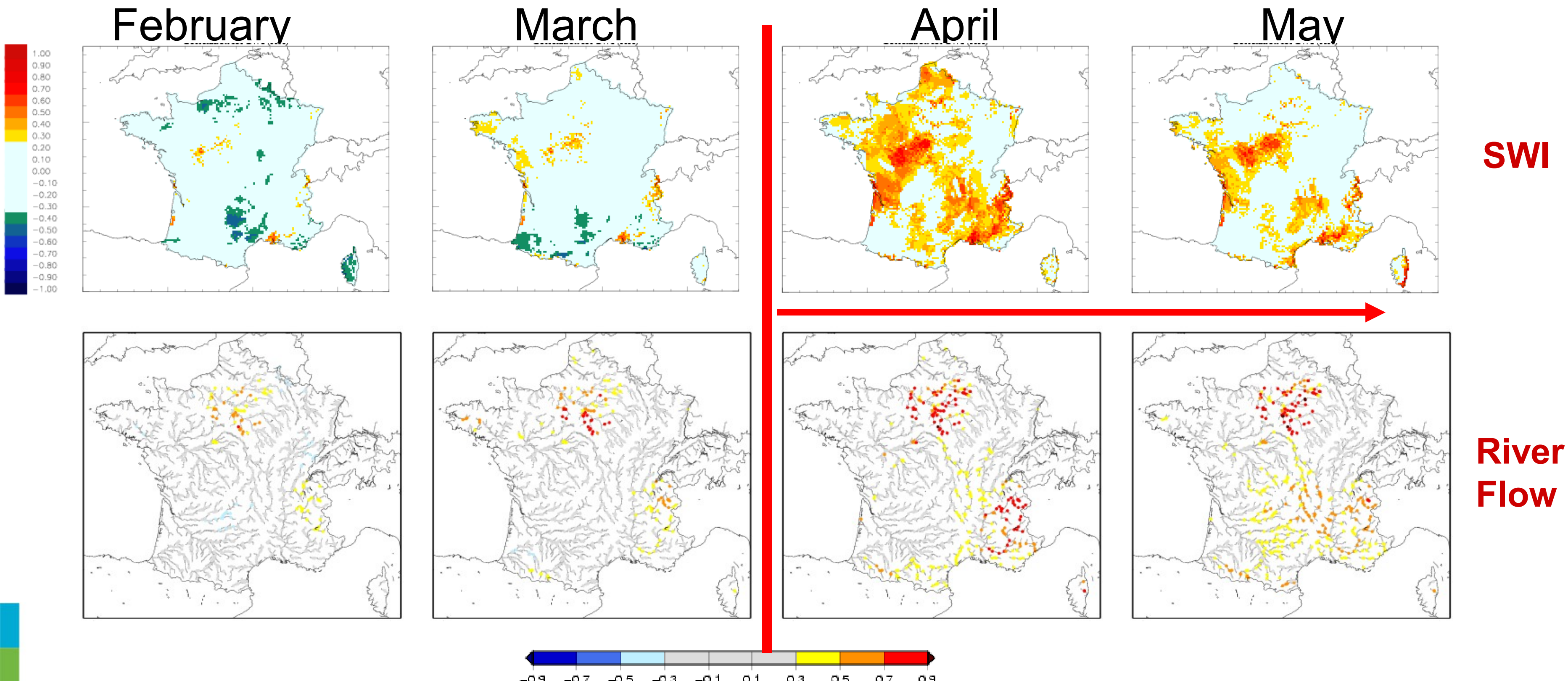
Use of Seasonal Forecasts



Beware of the predictability

Use of Seasonal Forecasts

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



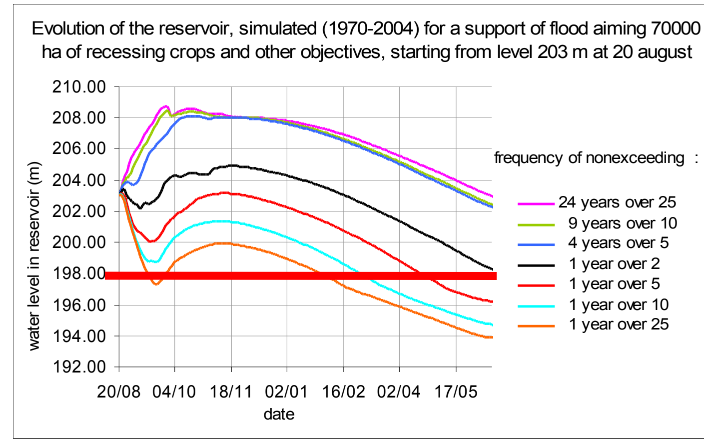
Correlations > 0.3 significant.
Clear improvement between March and April

No useable information before the beginning of April

Impact Forecasting suites

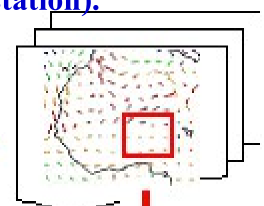
An example : from forecasting information to DMP

- The Manantali dam management



Atmospheric Forecast: beginning of August rain for SON

Post-processing/Dissemination : downscaling and tailoring the climate information in impact variable (river flow at a specific station).

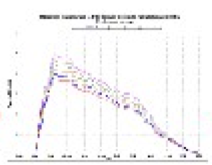


Impact assessment : merging the impact information with management rules and dam data to provide information relevant to the DMP

POGR

Schematic representation of the water management system

Real time management of the water release over the september and october period using the observed flows of the Bakoye and Famélé rivers



Water Permanent Commission 20 August

Decision Making Process : Choice of the best strategy with respect of concurrent use of water and the characteristics of the climate (dry season occuring end of October and forecast of the end of the rainy season)

- **Tailored Information**
  - River Flow forecast related to the DMP and management rules
  - Transformation of the impact forecast in risk assessment
  - Model simulation of water stock evolution into the dam
  - Critical threshold into the DMP
  - Critical date for Decision