Operational hydrological ensemble forecasts in France.

Recent development of the French Hydropower Company (EDF), taking into account rainfall and hydrological model uncertainties.

Thibault Mathevet [thibault.mathevet@edf.fr], F. Garavaglia, J. Gailhard, R. Garçon, L. Dubus

EDF – DTG, 21 avenue de l'Europe, BP 41, 38040 Grenoble Cedex 9, France

HEPEX Hydrologic Ensemble Prediction EXperiment

1 EDF Context & Hydrological ensemble

Context :

Water resources management is a central concern for EDF, both in the fields of safety, regulation and energy production. In order to ensure an efficient water resources management EDF performs hydro-meteorological forecasts on more than 100 watersheds in France. In the field of probabilistic forecasts, EDF-DTG has a long experience based on 60 years of probabilistic forecasts.

In operational conditions, the current quality of meteorological and hydrological forecasts do not allow decision-making in a certain future. In this context, meteorological and hydrological ensemble forecasts allow a better representation of forecasts uncertainties. Compared to classical deterministic forecasts, ensemble forecasts improve the human expertise of hydrological forecasts, which is essential to synthesize available information, coming from different meteorological and hydrological models and human experience.

To improve the quality of our hydro-meteorological forecasts, an operational hydrological ensemble forecasts system is currently under development at EDF. The aim of such a system is to both take into account future rainfall uncertainty and Rainfall-Runoff transformation uncertainty (Pappenberger et al., 2005).

2 Rainfall uncertainty

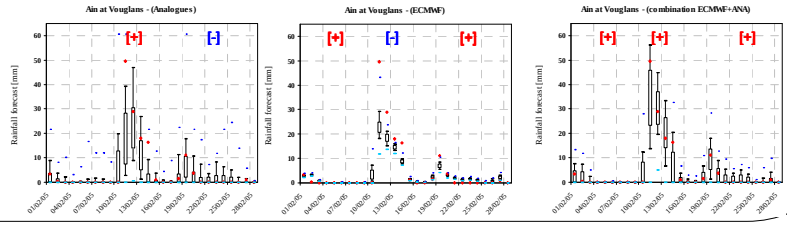
Three sources of future rainfall uncertainty :

In order to improve the estimation of future rainfall uncertainty, we use two sources of rainfall forecasts from J+0 to J+6:

- **ECMWF** : 50 rainfall forecasts from J to J+6 ;
- **Analogues** rainfall forecasts [Obled et al., 2002] : rainfall analogues forecasts based on ECMWF atmospheric pressure fields forecasts (750 & 1000 hpa) ;
- **Combination of ECMWF and Analogues** rainfall forecasts (OPT): weighted combination of ECMWF and Analogues rainfall forecatst ;

Analysis of rainfall forecasts characteristics :

- **ECMWF :**
  - + : good distinction of no rain / rain events ;
  - - : underestimation of high rain events ;
- **Analogues :**
  - + : good estimation of high rain events ;
  - - : bad distinction of no rain / rain events ;
- **Combination of ECMWF and Analogues rainfall forecasts :**
  - + : good distinction of no rain / rain events ;
  - + : better estimation of high rain events ;



3 RR model uncertainty

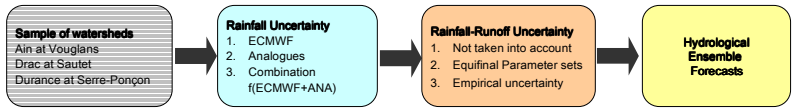
Rainfall-Runoff modelisation :

The hydrological model used for hydrological ensemble forecasts is the **MORDOR model**. This model has been developed by EDF-DTG [Garçon, 1996]. This model has a conceptual structure, represents the **snowpack accumulation/ablation** processes and the **rainfall – runoff transformation**. The daily use of the MORDOR model in operational conditions and the tests on large sample of watersheds [Mathevet, 2005; **MOPEX 2004** : Chahinian et al, 2006; Andreassian et al., 2006], have shown its reliablility and robustness within a wide range of hydrological applications.

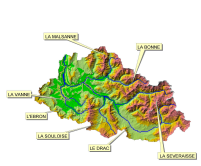
Rainfall-Runoff model uncertainty estimation :

Two methods of hydrological model forecasts uncertainty estimation were used : one is based on the use of **equifinal parameter sets** (Beven & Binley, 1992), the other is based on the **statistical modelisation** of the hydrological **forecast empirical uncertainty** (Montanari et al., 2004 ; Schaefli et al., 2007; Todini, 2008).

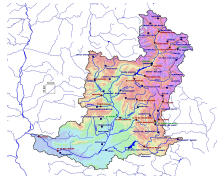
4 Results



Ain at Vouglans
1125 km²



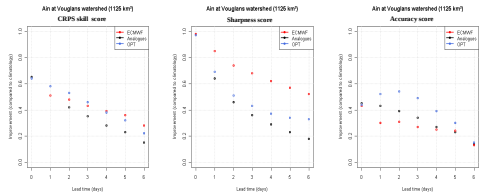
Drac at Sautet
1018 km²



Durance at Serre-Ponçon
3727 km²

CRPS score :

Streamflow forecasts



The CRPS skill score was used to assess streamflow forecasts performances, in comparison to the streamflow regime, which is the basic available information.

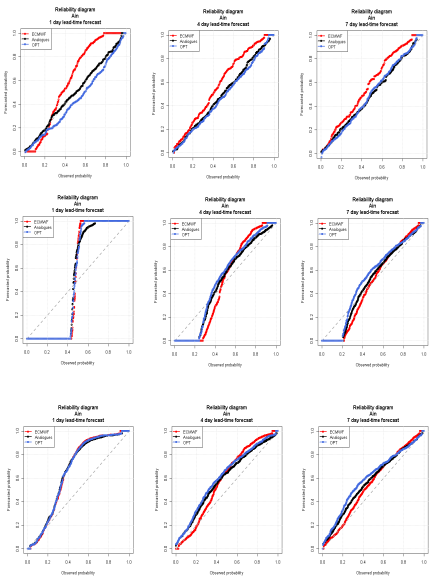
Globally, CRPS skill scores shows that the **combination of ECMWF and Analogues rainfall forecasts** (OPT) **is better** than ECMWF or Analogues alone. The sharpness of OPT is intermediate between ECMWF and Analogues forecasts, but the accuracy is better.

Reliability diagrams :

Rainfall forecasts {non null observed}

Streamflow forecasts {Rainfall}

Streamflow forecasts {Rainfall + Model U}



The reliability diagrams are shown for (1) the rainfall forecasts, (2) streamflow forecasts, using rainfall forecasts only, and (3) streamflow forecasts, using rainfall forecasts and empirical RR model uncertainty.

The reliability diagrams are also shown for 0, 3 and 6 days lead-time.

Rainfall forecasts :

- the spread of rainfall forecasts is globally and slightly underestimated.
- from J to J+3, OPT and Analogues is closer to x=y theoretical perfect forecast line and ECMWF underestimates high quantiles ;
- from J to J+3, from J+3 to J+6, ECMWF is closer to x=y theoretical perfect forecast line ;
- for high quantiles (>= 0.7) Analogues and OPT quite well calibrated ;

Streamflow forecasts :

- the spread of rainfall forecasts is underestimated at short-term and slightly underestimated at long-term.
- from J to J+3, it is necessary to take into account model uncertainty to get a better spread of ensembles ;
- from J+3 to J+6, it is necessary to take into account future rainfall and model uncertainty to get a better spread of ensembles
- the spread of streamflow ensembles is slightly sensitive to the source of rainfall.

5 Conclusions

This poster presents preliminary results of operationnal streamflow ensemble forecasts. Depending on watershed properties, rainfall forecasts and RR model performances, our main conclusions are the followings :

- from J to J+3 : the main part of forecasts uncertainty is supported by RR model uncertainty ;
- from J+3 to J+6 : the main part of forecasts uncertainty is supported by rainfall forecasts ;
- **the combination of ECMWF+Analogues rainfall forecasts and RR model uncertainty allow a good statistical calibration of probabilistic streamflow forecasts ;**

Further work is needed to use different assessment criteria, to increase the length of ECMWF rainfall forecasts records and to generalize our conclusions on a wider sample watersheds.

Acknowledgements : « EDF and the authors acknowledge ECMWF for providing the data and forecasts used in this study »