

Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

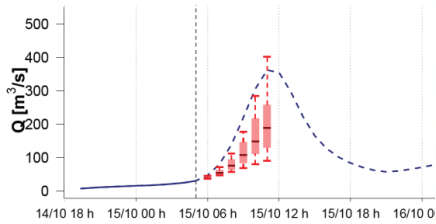
M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

1

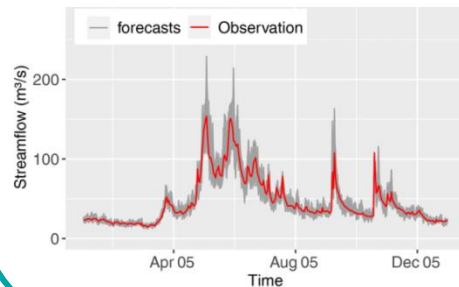
Quality

Forecast

Value



This picture by journalist P. Conte from France 3 shows what a "cellule de crise" looks like. Source: France 3



Loire River @ Grangent
November 2008
Photo: EDF

Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

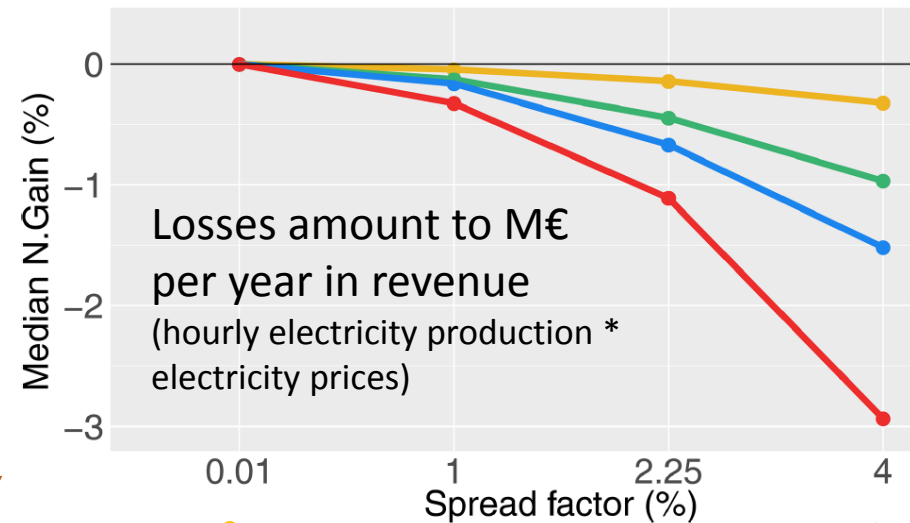
Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

SUMMARY

Conceptual approach: actual river flows, synthetic inflow forecasts, conceptually parameterized reservoirs, LP optimization model

2

Loss in value



Forecasts:

Unbiased

Underdispersive

Underestimation

Overestimation

+ Quality -

Loss in accuracy (ensemble mean)

Losses amount to M€
per year in revenue
(hourly electricity production *
electricity prices)

Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

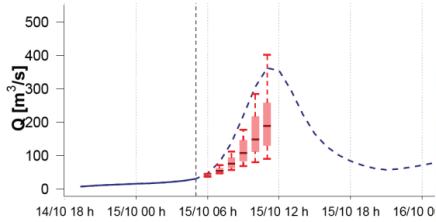
EGU21-14532

1

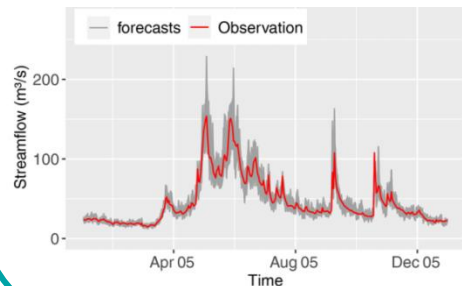
Quality

Forecast

Value



© Pascale Conte / France 3 Midi-Pyrénées - La cellule de crise de la préfecture de la Haute-Garonne
This picture by journalist P. Conte from France 3 shows what a "cellule de crise" looks like. Source: France 3



Loire River @ Grangent
November 2008
Photo: EDF

Context:

- The improvement of a forecasting system and the continuous evaluation of its quality are recurrent steps in operational practice.
 - ✓ Forecast quality is often characterized by attributes, such as reliability, sharpness, bias and accuracy.
 - ✓ It is often assessed with numeric or graphic scores and independently of forecast value.

- However, the systematic evaluation of forecast value or usefulness for better decision-making is less frequent, even if it is also essential to guide strategic planning and investments.
 - ✓ The value of a forecast represents the benefits realized through the use of the forecast in decision-making.
 - ✓ It is therefore necessary to acquire knowledge on how decisions are made when informed by forecasts.

Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

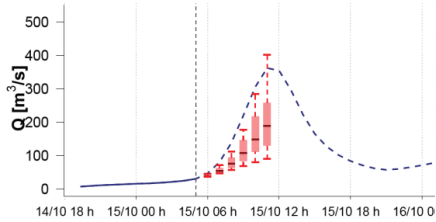
M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

1

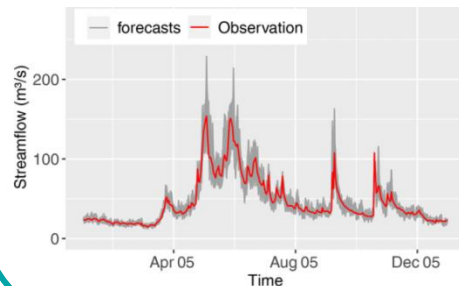
Quality

Forecast

Value



This picture by journalist P. Conte from France 3 shows what a "cellule de crise" looks like. Source: France 3



Loire River @ Grangent
November 2008
Photo: EDF

- In hydroelectric reservoir management, the value of a forecast is often assessed by the performance and benefits obtained from optimal management. It can be expressed in terms of economic revenues, often associated with a monetary unit, and in terms of utility, often associated with a production unit.
- To better understand the relationship between the quality of hydrometeorological forecasts and their value through the management of hydroelectric reservoirs, some studies have created synthetic, quality-controlled hydrological forecasts.

OUR AIM:

- to assess how much improving the quality of hydrometeorological forecasts will improve their economic value,
- to understand how the system and its optimization model are sensitive to sequences of input forecasts of different quality.

Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

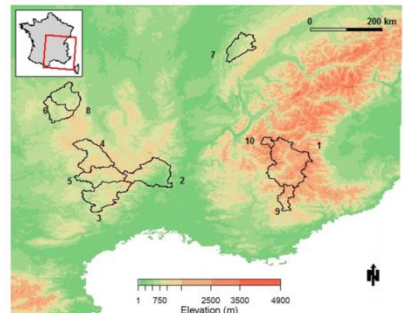
M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

Quality

Forecast

Value

Conceptual approach: actual river flows, synthetic inflow forecasts, conceptually parameterized reservoirs, LP optimization model

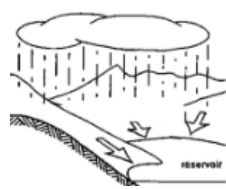


10 catchments
in France

7-day weather
forecasts



Hydrological
model



Synthetic
forecasts
(controlled
quality)

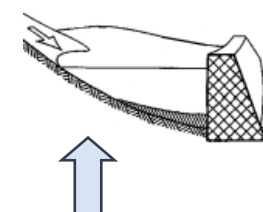


Q observations

7-day reservoir
inflow forecasts
of different quality



LP optimization model of
the management of a
hydroelectric reservoir



Electricity price (€/MWh)

Production
and revenue
from optimal
reservoir
management

Forecast quality

Forecast value

Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

EGU21-14532

Quality

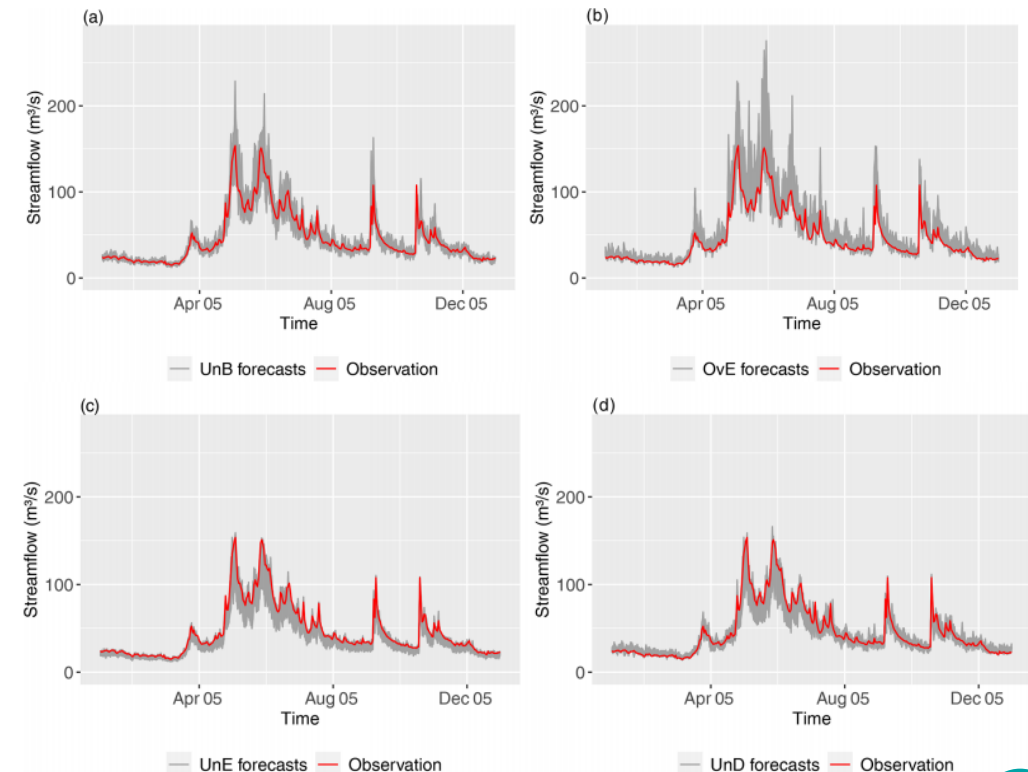
Forecast

Value

Conceptual approach: actual river flows, synthetic inflow forecasts, conceptually parameterized reservoirs, LP optimization model

- For each catchment and over the 4- year study period, we generated 16 synthetic ensemble forecasting systems (4 types of biases * 4 spread factors):

- UnB (reliable and unbiased): forecasts uniformly distributed around the observed flows
- OvE (overestimation): systematic positive biases towards forecasts that overestimate the observed flows
- UnE (underestimation): systematic negative biases towards forecasts that underestimate the observed flows
- UnD (underdispersed): flows greater than the historic 75th percentile are underestimated and flows lower than the historic 25th percentile are overestimated



Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

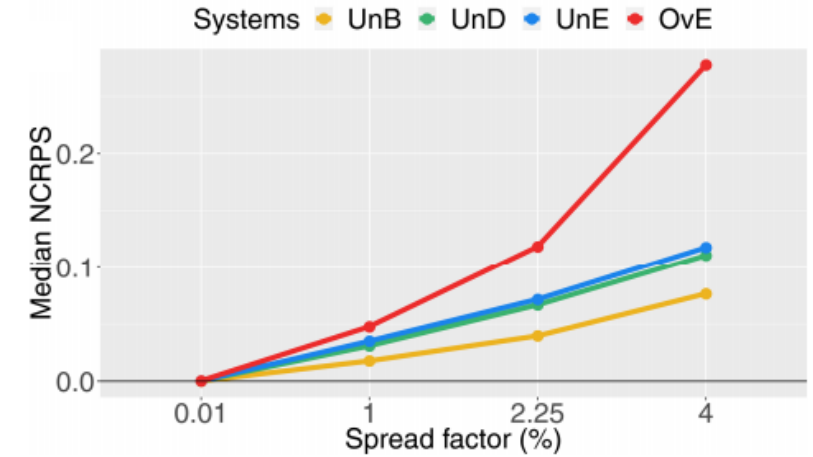
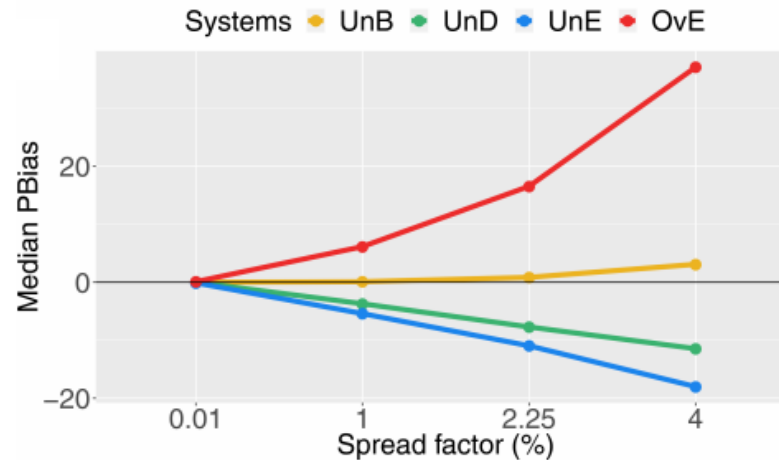
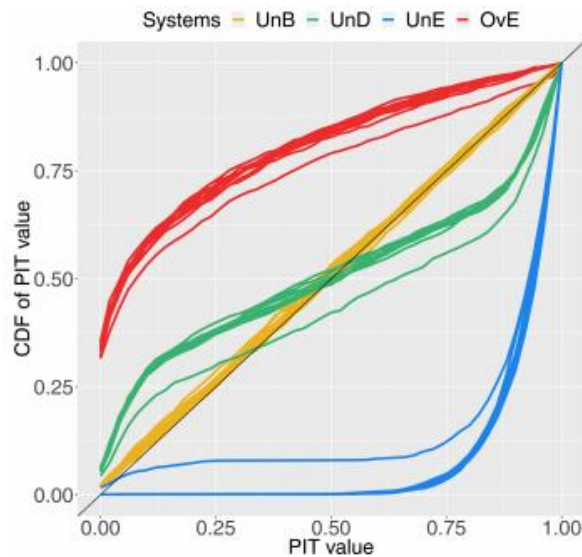
Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

EGU21-14532

Quality of the forecasts

Reliability (PIT), Bias (Pbias) and overall performance (normalized CRPS)



Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

#vEGU21 – Session HS5.2.1 – Contact: maria-helena.ramos@inrae.fr

Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

Value of the forecasts

- Normalized gain: reference system is given by a “perfect forecasting system”, where the forecasts are identical to the observed inflows: here, percentage of loss wrt the reference.
 - ✓ The difference in economic value between the synthetic forecast systems widens with the increase in the spread factor.
 - ✓ The forecasting system displaying the worst scores in terms of forecast quality is also the one that displays the lowest economic value.

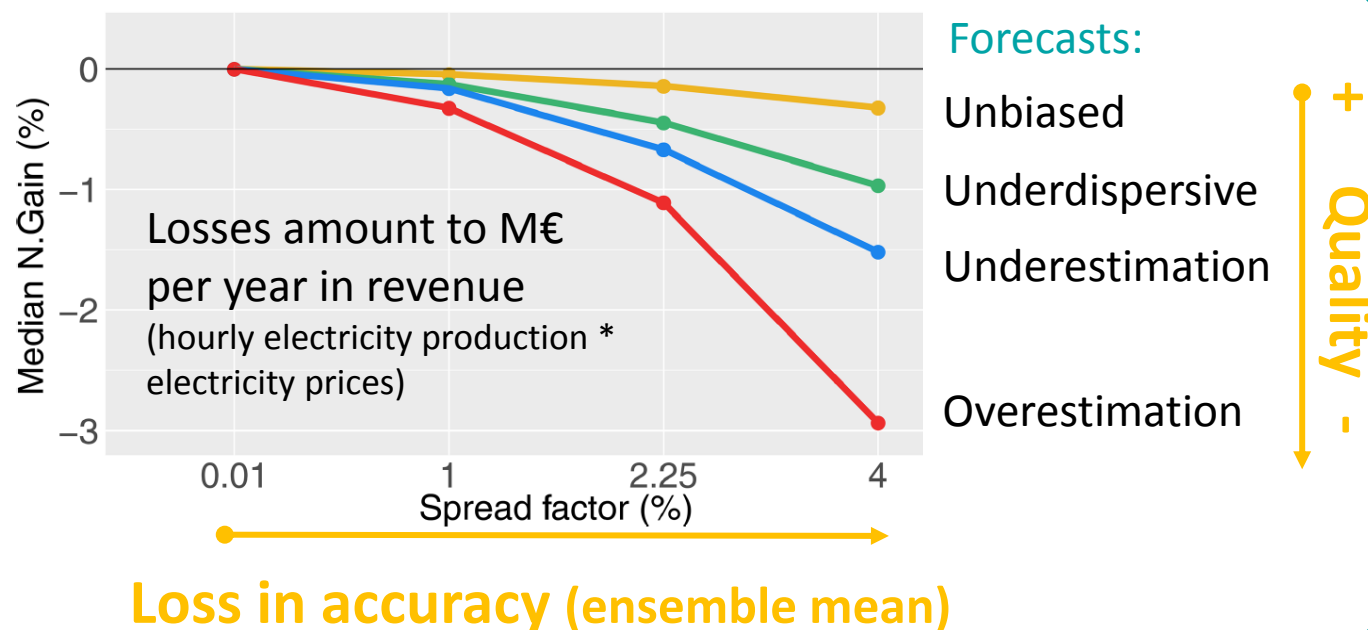
Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

Total economic revenue from the hydropower reservoir operation when using, on a daily basis, each system’s 7-day forecasts as input to the reservoir management model (LP optimization) over 2005– 2008

2

Loss in value



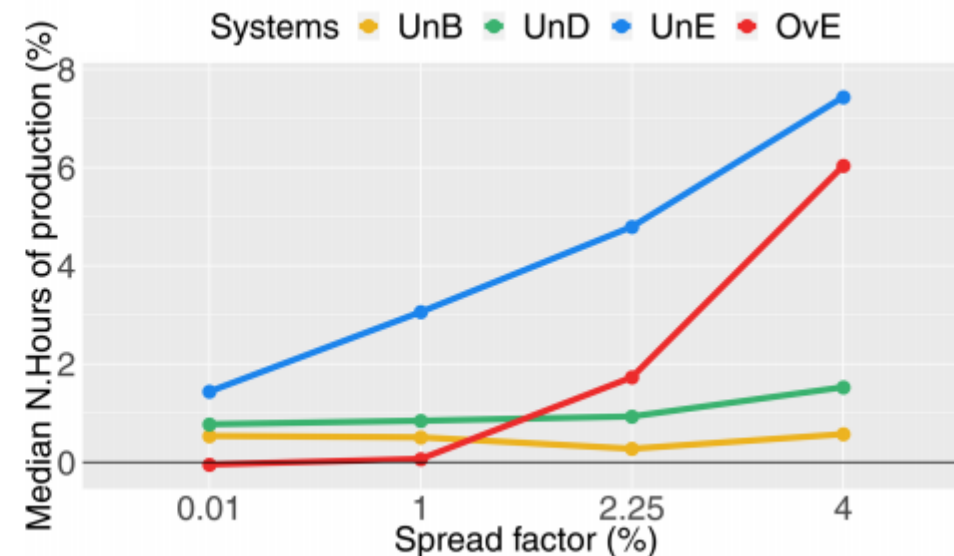
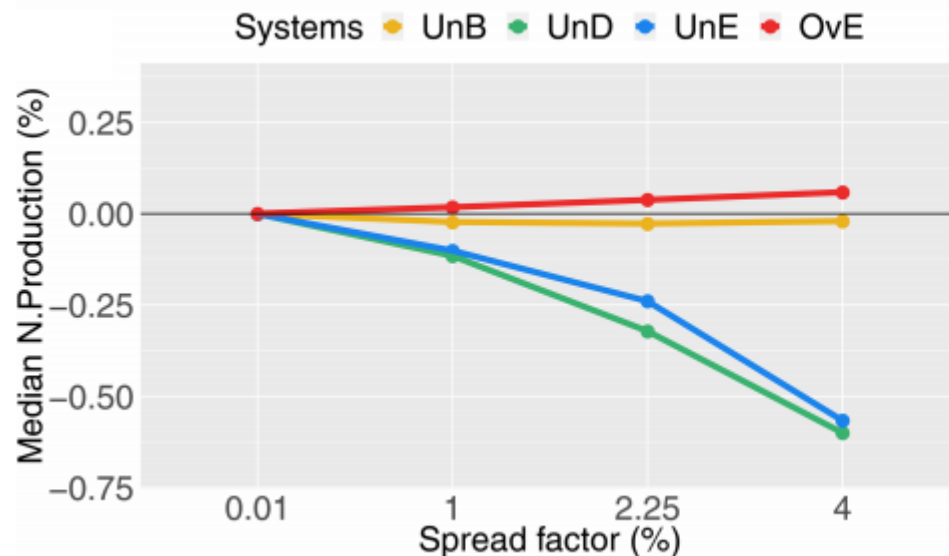
Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

EGU21-14532

Value of the forecasts

Total production (left) and hours of production (right) of the synthetic ensemble forecasting systems as a percentage of the total (production or hours of production, respectively) of the reference system



Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

EGU21-14532



MAIN CONCLUSION: The worst (best) scores in forecast quality are associated with forecasting systems that display the lowest (higher) economic value

- The quality of forecasts has an impact on management revenues due to several factors:
 - ✓ Biased forecasting systems may result in more frequent hydroelectric production (i.e., more production hours) but the production is less often operated at higher capacities.
 - ✓ Forecasting systems that present a positive bias result in a tendency of operations to keep the storage at lower levels so that the reservoir can be able to handle the high volumes expected. This impacts the optimal placement of production at the best hours (i.e., when prices are higher) and the opportunity to produce electricity at higher production rates.
 - ✓ When using biased forecasting systems in hydropower reservoir management, production is not only planned during more hours at lower production rates but also at hours with lower median prices of electricity.

Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

Understanding how hydrological forecast quality impacts the management of hydroelectric reservoirs

M. Cassagnole, M-H Ramos, I. Zalachori, G. Thirel, R. Garçon, J. Gailhard, T. Ouillon

EGU21-14532

Quality

Forecast

Value

Thank you for your attention!

Conceptual approach versus complexity of real-life systems:

The proof-of-concept that the conceptual approach provides is a step forward towards refined studies which, following a more detailed, long-term approach, may address the future challenges of the multiuse management of water resources

Cassagnole et al., HESS, 25, 1033–1052,
doi.org/10.5194/hess-25-1033-2021

Impact of the quality of hydrological forecasts on the management and revenue of hydroelectric reservoirs – a conceptual approach

#vEGU21 – Session HS5.2.1 – Contact: maria-helena.ramos@inrae.fr