SEASONAL FORECASTING FOR WATER RESOURCE MANAGEMENT
The example of CNR Genissiat dam on the Rhone River in France

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Why seasonal forecasts ? – the objectives

The convergence of public and private interests around optimizing the management of water resources throughout the French Rhone valley led Compagnie Nationale du Rhône (CNR) to develop hydrological models dedicated to **seasonal discharge forecasting**. Indeed, seasonal forecasting is a major issue for CNR and **water resource management**, in order to optimize long-term investments of the produced electricity, plan dam maintenance operations and anticipate low water period.

With an installed capacity of 420MW, Genissiat dam is the most upstream of the 19 CNR's hydropower plants. Discharge forecasting at Genissiat dam is strategic since its inflows contributes to 20% of the total Rhone average discharge and consequently to 40% of the total Rhone hydropower production.

CNR context

In 1934, the French government entrusted the Compagnie Nationale du Rhône (CNR) with the concession to develop and operate the Rhone river through **three community missions**:
- hydropower production,
- improving navigation,
- providing water for irrigation and other agricultural uses.

In this framework CNR has built hydropower plants, dams, locks and pumping stations; opened up a river-maritime corridor between Lyon and the Mediterranean Sea; and has built infrastructures for pleasure boating and leisure activities.

A major player in the energy market since its deregulation in 2001, the Compagnie Nationale du Rhône's production sources are now undergoing significant expansion.

Today, CNR relies on a mix of **exclusively renewable energy** generated by hydropower, wind power and solar energy, and it is an acknowledged actor on wholesale markets and European energy exchanges.

Input data

- **Hydro-meteorological data**

  Snow Water Equivalent (SWE) maps from
  - Crocus (Météo France) for French Alps
  - SLF's model for Swiss Alps

  MÉTÉO FRANCE — Toujours un temps d'avance

- **Seasonal precipitation trends**

  CNR hydro-meteorological forecasters assess meteorological trends regarding precipitations for the next coming months.
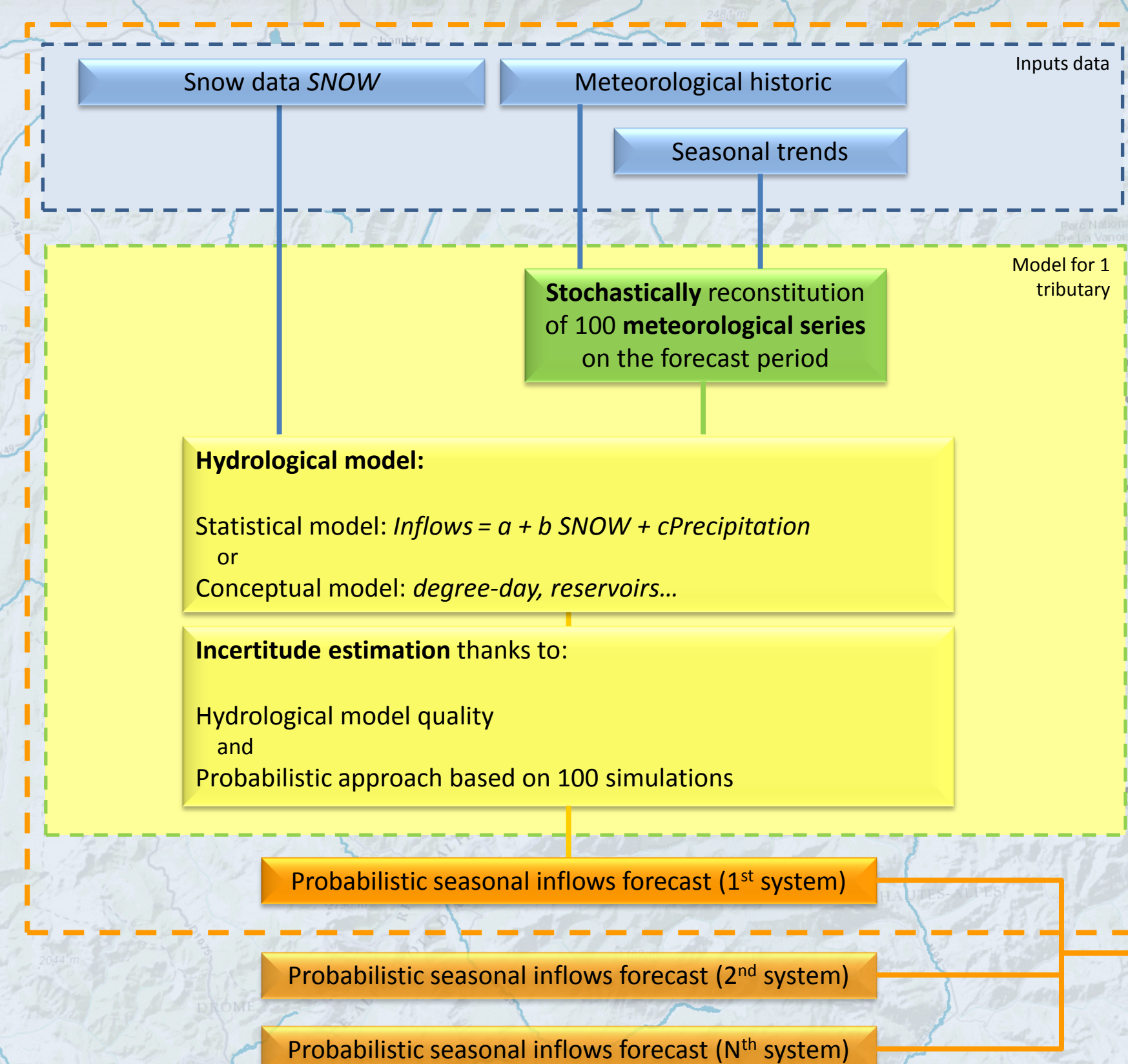
| Very humid |
| Humid |
| Normal |
| Dry |
| Very dry |

Methodology

Rhone at Genissiat watershed is split into several sub-systems, considering available hydro-meteorological data and hydrological specificities.
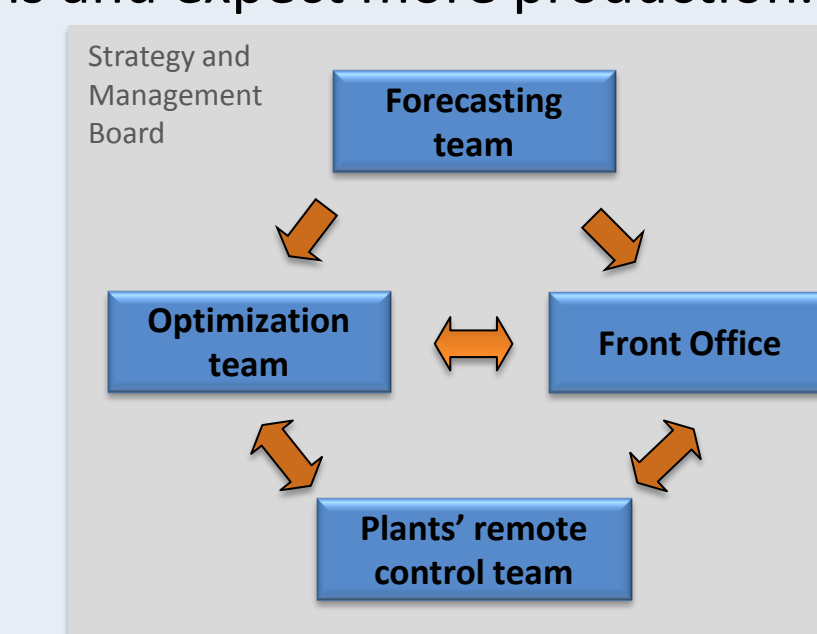
For each sub-system, probabilistic seasonal forecasts are provided thanks to statistical models, using seasonal trends and snow data as inputs.

Genissiat inflows are issued from stochastic sums of the previous sub-system streamflow forecasts. A medium value and its confidence interval are assessed to complete this decision-making support tool.

Hydropower producible is deduced from the seasonal streamflow forecasts at Genissiat dam, with a probabilistic point of view

Methodology diagram:

- Snow data *SNOW*
- Meteorological historic
- Seasonal trends
- Inputs data

Stochastically reconstitution of 100 **meteorological series** on the forecast period — Model for 1 tributary

Hydrological model:
Statistical model: *Inflows = a + b SNOW + cPrecipitation*
or
Conceptual model: *degree-day, reservoirs…*

Incertitude estimation thanks to:
Hydrological model quality
and
Probabilistic approach based on 100 simulations

- Probabilistic seasonal inflows forecast (1st system)
- Probabilistic seasonal inflows forecast (2nd system)
- Probabilistic seasonal inflows forecast (Nth system)

Forecasts composition module — Σ Forecasts → Probabilistic seasonal inflows forecast at Genissiat dam

Decision-making support

Forecasts are updated every decades. CNR's stakeholders meet monthly, and can support their decisions thanks to those forecasts: e.g. if CNR's producible is expected to be greater than the historical medium value with 70% chance, then they may prefer to postpone maintenance operations and expect more production.

Strategy and Management Board → Forecasting team → Optimization team ⇄ Front Office → Plants' remote control team

Lyon Openspace

Results – 2011 and 2013 forecasts

2011 has been a particularly dry year. Snow cover in the Alps was the lowest for the past 25 years, and spring meteorology the hottest and driest over 50 years (source : Météo-France). **2013** has been on the contrary a very snowy year, the third year over the past 25 years.
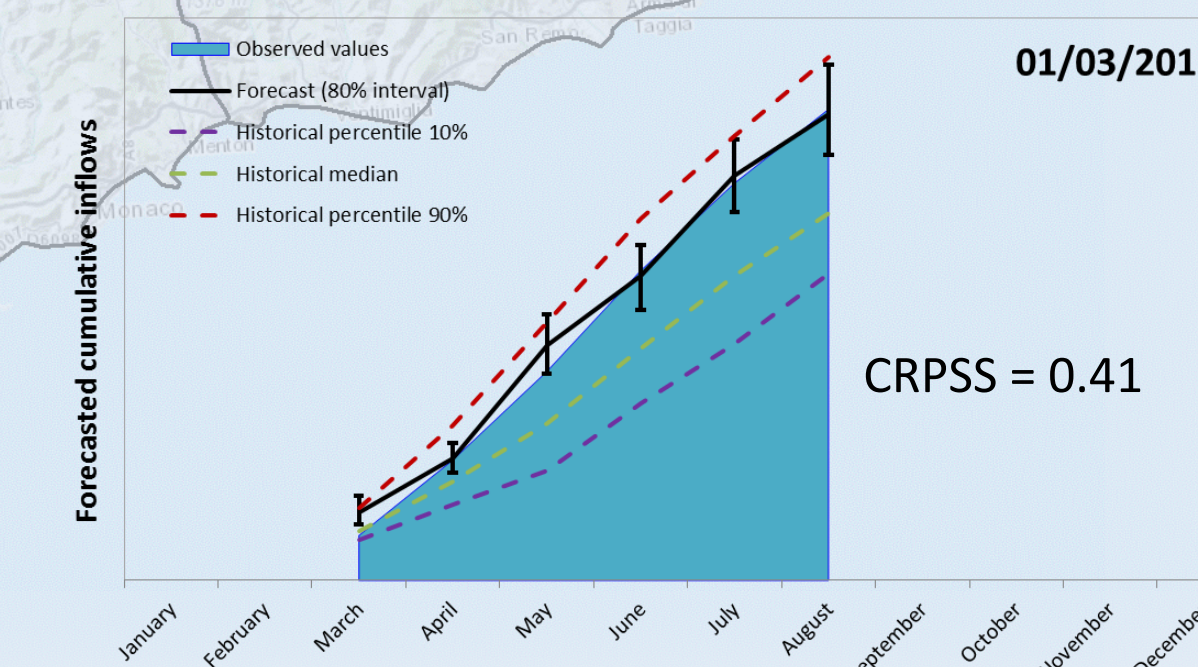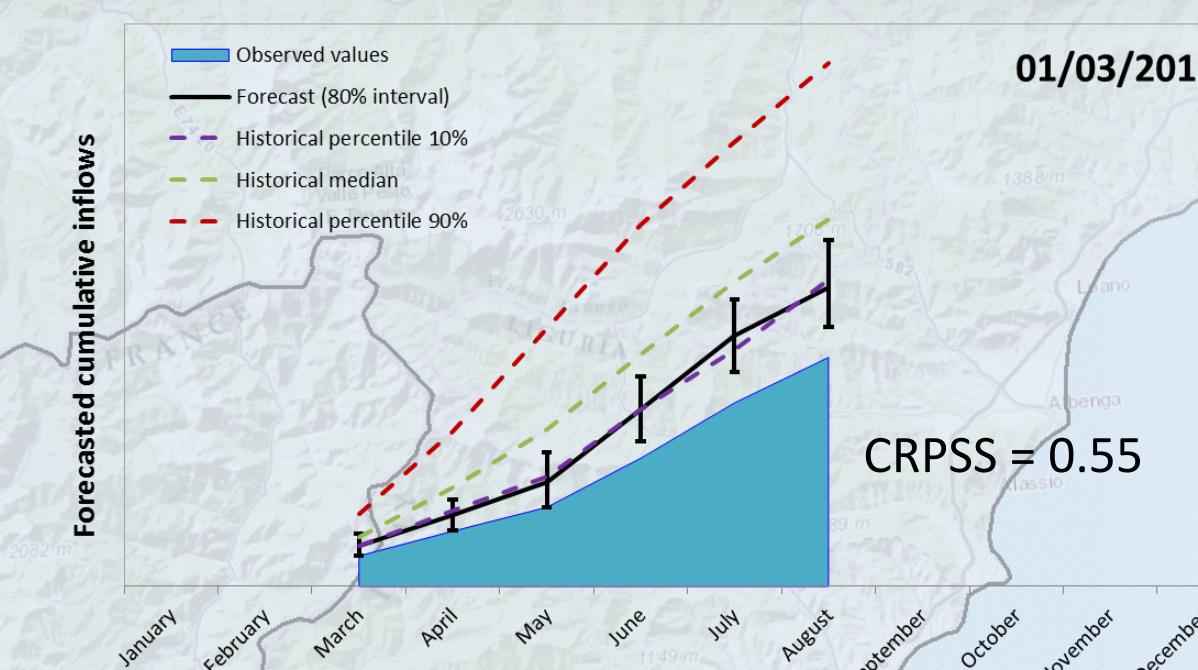
Water resource management of these two specific years was a challenge for CNR:

2011 : CNR had to face low flow, with difficulty to ensure operating constraints, regarding nuclear power plants water supply and long-planned hydropower production.

2013 : CNR had to deal with high flow during a long period of time, limiting water spillage, optimizing hydropower production and planning maintenance operations.

Seasonal forecasting models have **successfully anticipated** those flow rates:
Probabilistic forecasts are compared to reference historical climatology thanks to CRPS scores

$$CRPSS = \frac{CRPS - CRPS_{climatology}}{CRPS_{perfect} - CRPS_{climatology}}$$

01/03/2011 — CRPSS = 0.55

01/03/2013 — CRPSS = 0.41

Conclusion

Seasonal discharge forecasting is now available on the Rhone River at Genissiat dam. Forecasting models will be extended to the whole Rhone basin: tributaries as Saone, Isère or Ardèche have their importance in the total Rhone hydropower production.

Those tributaries have not necessarily an hydrological snow regime. Alternative input data to forecasting models will be used.

Acknowledgment

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Legend

- ⚡ Power plants
- Arve catchment
- Valserine catchment
- Reyvroz catchment
- Seujet catchment
- Swiss Rhone catchment
- Rhone river

Kilomètres 0 10 20 40 60

Map labels: usine de Seyssel, usine de Génissiat, usine de Porcieu-Amblagnieu, usine de Chautagne, Usine de Brens, usine de Pierre-Bénite, Usine de Brégnier-Cordon, usine de Vaugris, usine de Sablons, usine de Gervans, usine de Bourg-lès-Valence, usine de Beauchastel, usine de Logis Neuf, usine de Châteauneuf, usine de Bollène, usine de Caderousse, usine de Sauveterre, usine d'Avignon, usine de Beaucaire

Watershed map labels: Porte du Scex, Reyvroz, Barrage du Seujet, Lake Geneva regulation, Rhone at Porte-du-Scex, Valserine, Arve, Dranse, CROCUS snow data, SLF snow data, Seasonal trends, Génissiat Inflows, Transitional output, Output