IMPACT OF LOW FLOWS ON THE ENERGY SECTOR

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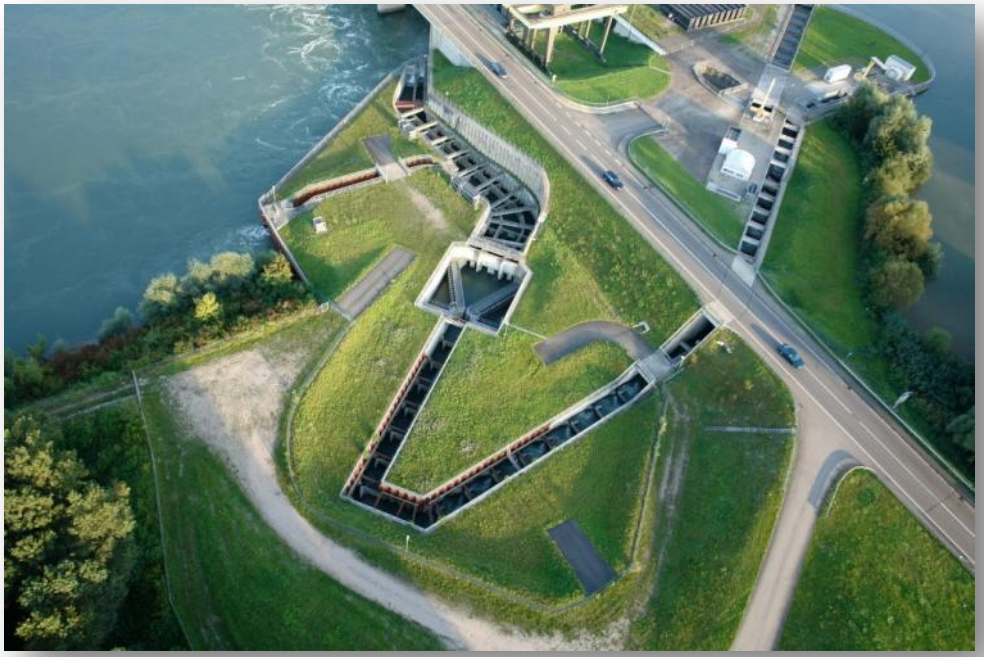
CHR Symposium
Low Flows in the Rhine Catchment

September 21st 2017

OUTLINE

- GENERAL CONTEXT
- MANAGEMENT OF LOW FLOWS AT EDF
- CASE STUDY : RHINE AND MOSELLE RIVERS
- CONCLUSIONS



EDF: A WEATHER SENSITIVE COMPANY

NATURAL HAZARDS

Flooding (Loire at Grangent, November 2008)

Severe drought

Snow and ice storms

Natural Hazards (flooding, drought, storms, …) affect our installations

EDF: A WEATHER SENSITIVE COMPANY
HYDROMETEOROLOGICAL FORECASTS

- **Water is for EDF:**
  - A **free renewable energy** for hydraulic production
  - A **cold source** for the classic nuclear and thermal productions
  - A **threat** for the installations
  - A **resource shared** with other users (agriculture, tourism, environment)

- **Hydrometeorological forecasts are necessary to:**
  - Ensure **safety** & **security** of installations
  - Meet **environmental standards**
  - Improve water **resource management**
  - **Optimize** powerplant production

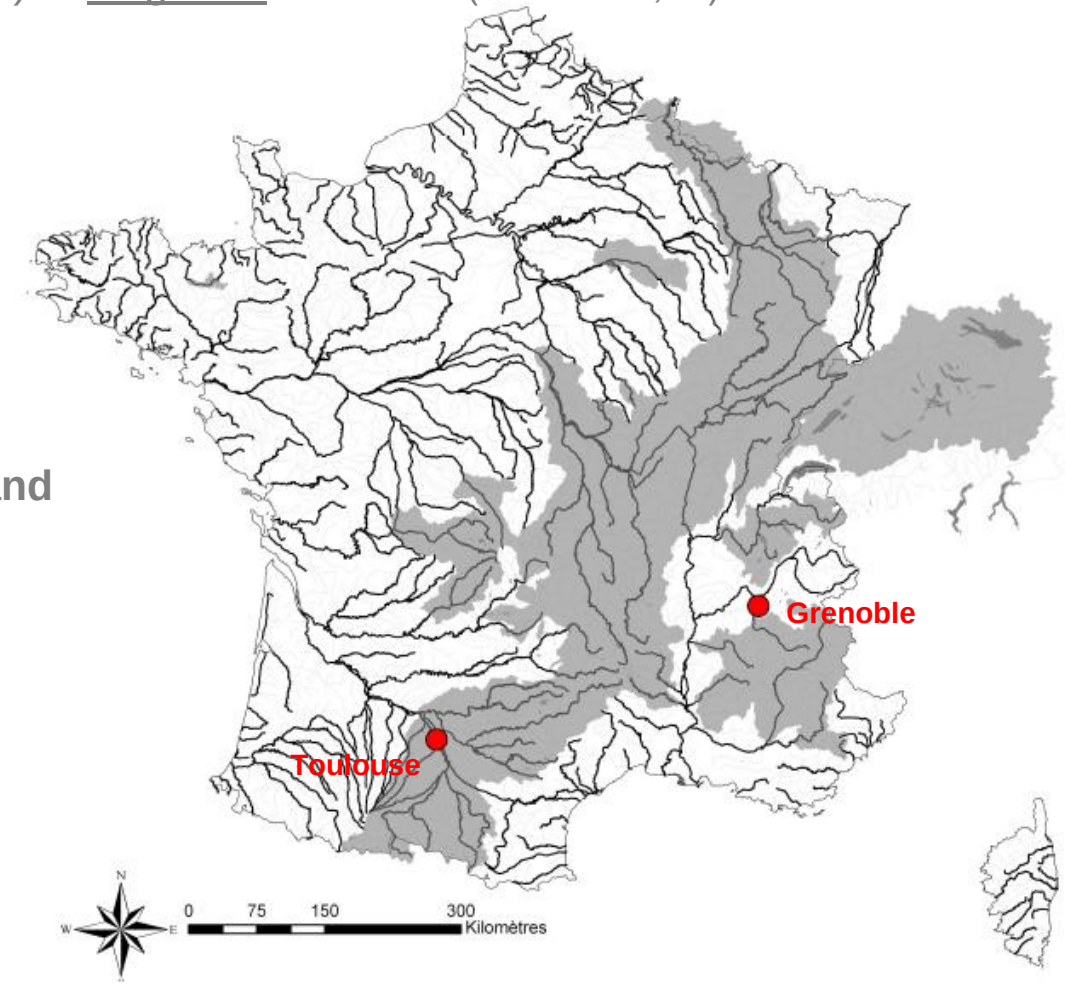
➡ **High importance of hydrometeorological forecasts**

HYDROMETEOROLOGICAL FORECASTS AT EDF

ORGANIZATION

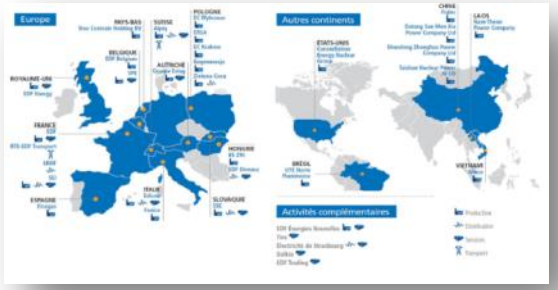
- **Inflow forecasts**
  - A long tradition since 1950 : from simple statistical models to ensemble forecasting and a probabilistic approach to hydrology
  - Daily short-term (monitoring, floods) to long-term forecasts (low flows,…)
  - ~ 150 watersheds (~10 to 50 000 km²), mainly in mountainous areas
  - Total covered area ~ 250 000 km²
  - Designed for safety and optimization of EDF powerplants

- **2 forecasting centers: Grenoble and Toulouse**
  - ~ 20 forecasters
  - 24h/24 monitoring
  - Support and development team



HYDROMETEOROLOGICAL FORECASTS AT EDF

WHERE ARE WE IN THE COMPANY?



EDF

160 000 persons






Nuclear | Hydro | Thermal | Wind and solar | Optimizer

Production | Engineering

Forecasting centers *20 p.*

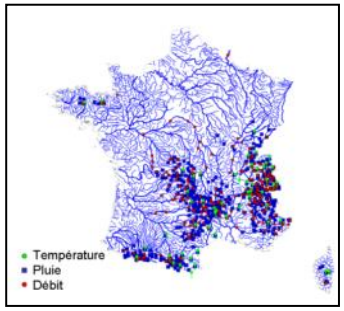
Forecasts

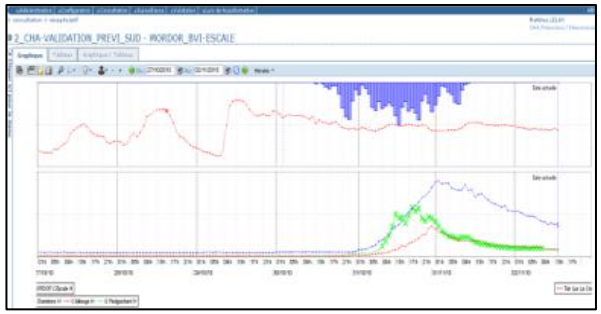
HYDROMETEOROLOGICAL FORECASTS AT EDF

NETWORK AND MONITORING

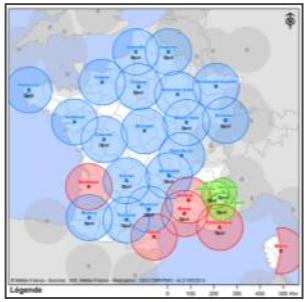
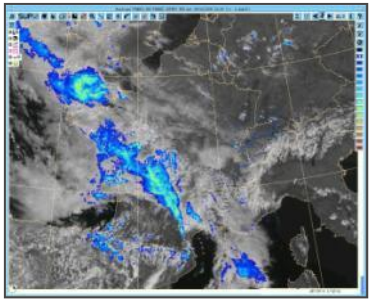
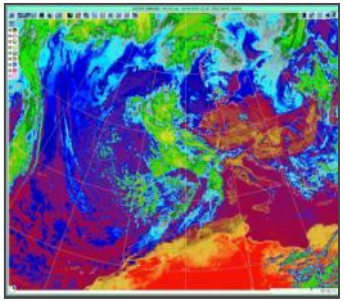
- **EDF Hydrometeorological network**
  - ~ 1200 stations (precipitation, streamflow, air and water temperature, snowpack, sediment,…), ~700 real-time directly available on our shared database.
  - Long chronological series (since the 1950's)
- **Partners : Météo-France, Météo-Suisse, OFEV,…**



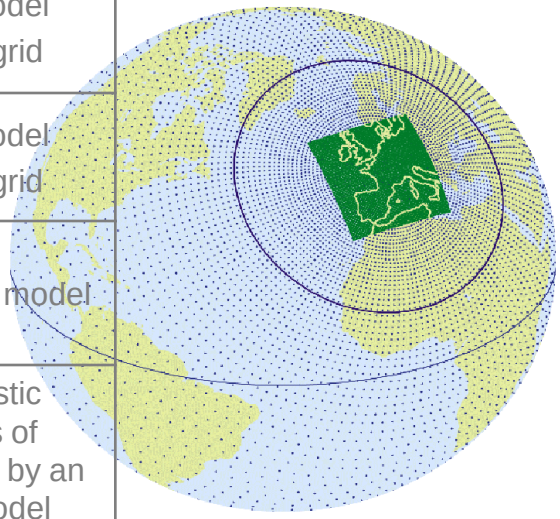
- **Large use of detection products for atmospheric observations**
  - Satellite products (IR, visible, water vapor)
  - RADAR (Météo-France RADAR reflectivity and radar/pluviometers mix)

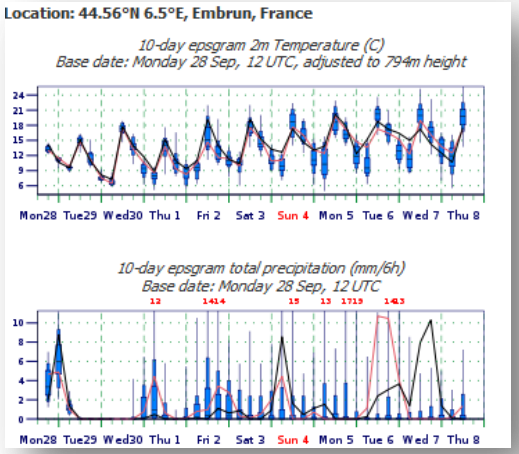
HYDROMETEOROLOGICAL FORECASTS AT EDF

METEOROLOGICAL MODELS

Model	Origin	Spatial resolution	Lead-time	Frequency	Characteristics
ARPEGE	Météo-France	7.5 (to 70)km	114h	2 runs/day	Global model Variable grid
CEP	ECMWF	16km	240h	2 runs/day	Global model Variable grid
AROME	Météo-France	1.3km	42h	4 runs/day	Limited area model
ANALOGUES	EDF-DTG	-	8 days	1 run/day	Probabilistic forecasts of precipitation by an analog model



+ other models, ensemble forecasts, etc.

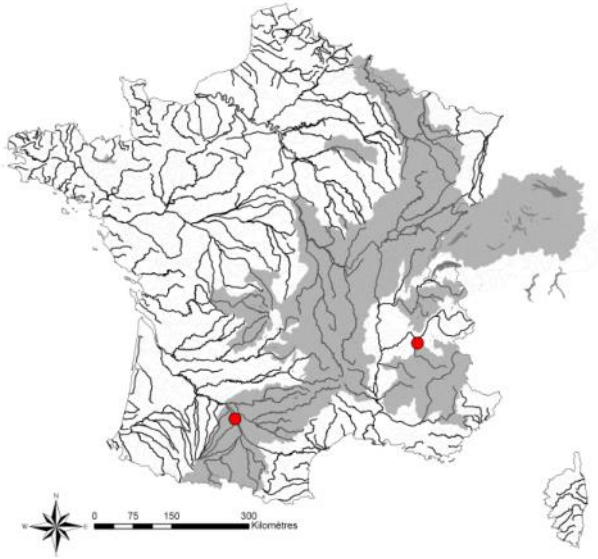


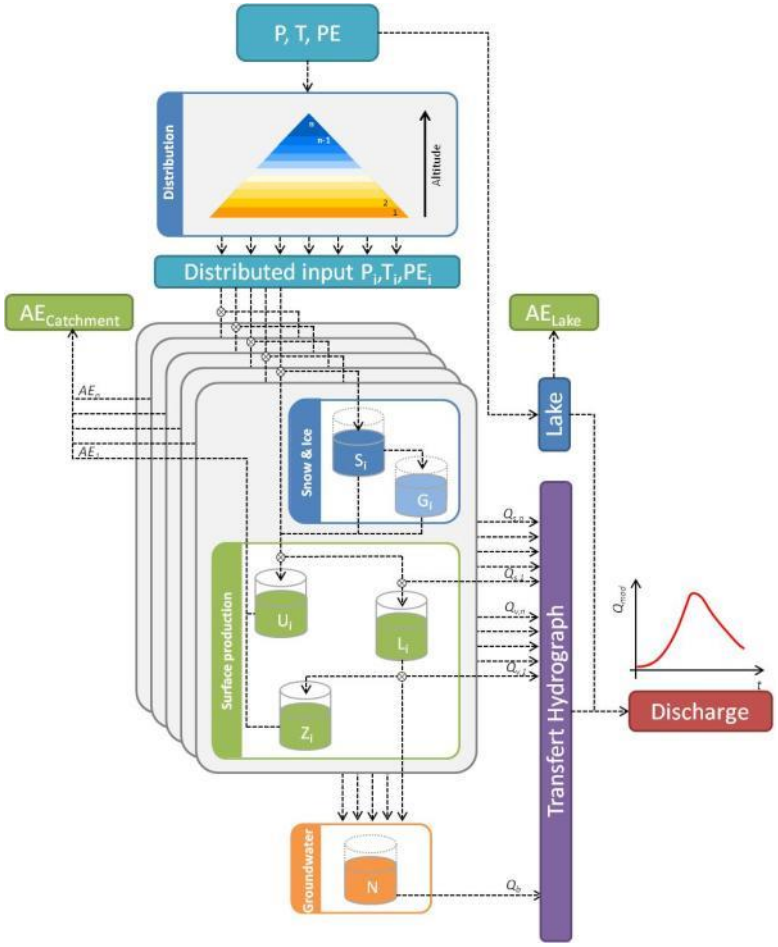
HYDROMETEOROLOGICAL FORECASTS AT EDF

HYDROLOGICAL MODEL

- **Hydrological model MORDOR (DTG)**
  - Conceptual
  - Semi-distributed
  - Continuous
  - Inputs: Spatial Precipitation & Air Temperature

➡ **More than150 models MORDOR for forecasts in 2017**





HYDROMETEOROLOGICAL FORECASTS AT EDF

TIME HORIZONS AND PHENOMENA

Data validation (precipitations, air temperature, flow)

Short-term forecasts

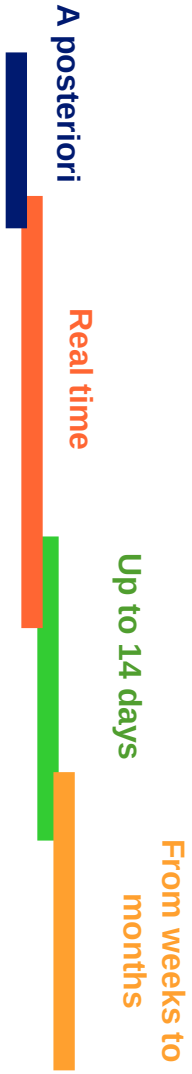
- Real time (24h/24) monitoring
- Thunderstorms, violent winds, sticky snow forecasts
- Deterministic hourly forecasts

Mid-term forecasts

- Probabilistic streamflow (Day 13+)
- Suspension materials (Day 6+)
- Water temperatures (Day 8+)
- Water conductivity (Day 8+)
- Dissolved oxygen (Day 8+)
- Cold source agressors (Day 6+)

Long-term forecasts

- Dam inflows forecasts
- Low flows forecasts



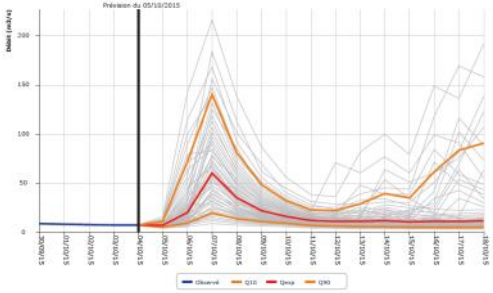
EDF IN THE RHINE CATCHMENT

PRODUCTION FACILITIES

- **Some figures:**
  - Hydraulic
    - **Hydropower plants: 12**
    - Installed capacity: 1 400 MW
    - Dams: 7
    - Mean production/year: 8 TWh
    - Number of locks (2 sluice-gates): 8
    - Design flows: 1100-1450m^3/s
    - Mean flow at Basel: approx. 1060m^3/s
  - Nuclear
    - **Nuclear plant: 1**
    - Installed capacity : 1 800 MW

EDF IN THE RHINE CATCHMENT

NETWORK AND MODELS



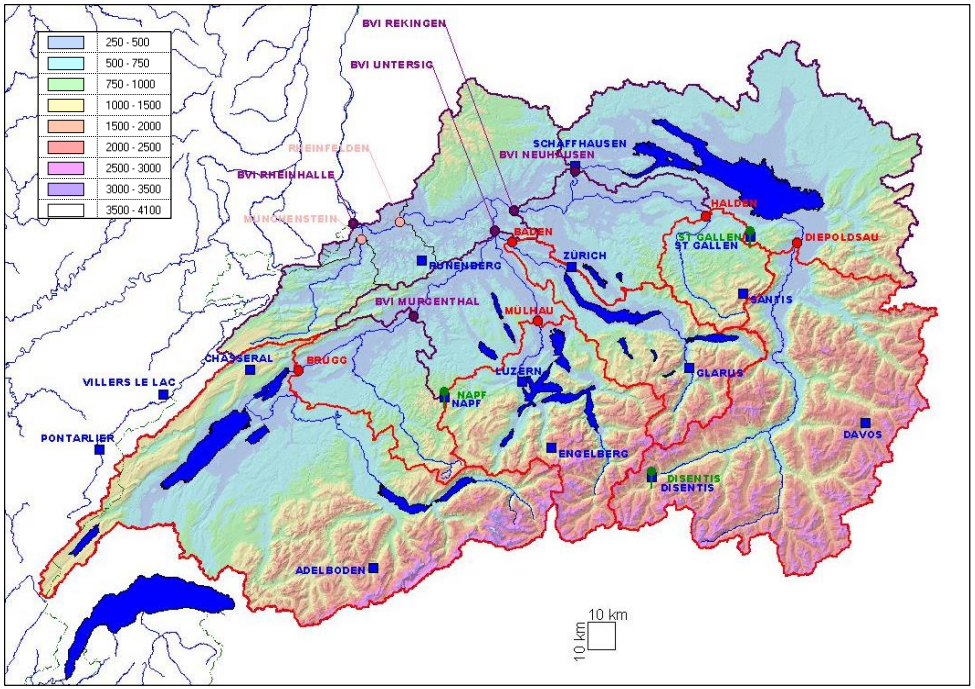
- **Contracts with OFEV and Météo-Suisse** : real-time collect of hourly data
  - OFEV : 12 hydrometric stations
  - Météo-Suisse : 12 pluviometric and 3 air temperature stations

- **Hydrological models**
  - 10 successive models
  - Outlet: Rhine river at Rheinhalle

➔ **Probabilistic forecasts**

Lead-time: 14 days

At least 2/week



LOW FLOWS MANAGEMENT AT EDF

MULTIPLE USERS – MULTIPLE ISSUES

EDF: multi-park energy producer and user of the shared water resources needs to cope with several major issues

Nuclear safety

- To ensure minimum water level which maintains cooling system when powerplant is off (water level), which corresponds to a few m^3/s

Power production

- To adapt and manage production when renewable energy is lowered (hydro)
- To comply with functioning specifications of safety heat exchangers (water temperature) (nuclear)
- To optimize energy power production

Environment

- To monitor and ensure the combination of flow & water temperature as an indicator of water quality (Maximum authorized water heating)
- To monitor and manage effluent releases

Drinking Water

- To ensure minimum flow dedicated for drinking water (Durance)

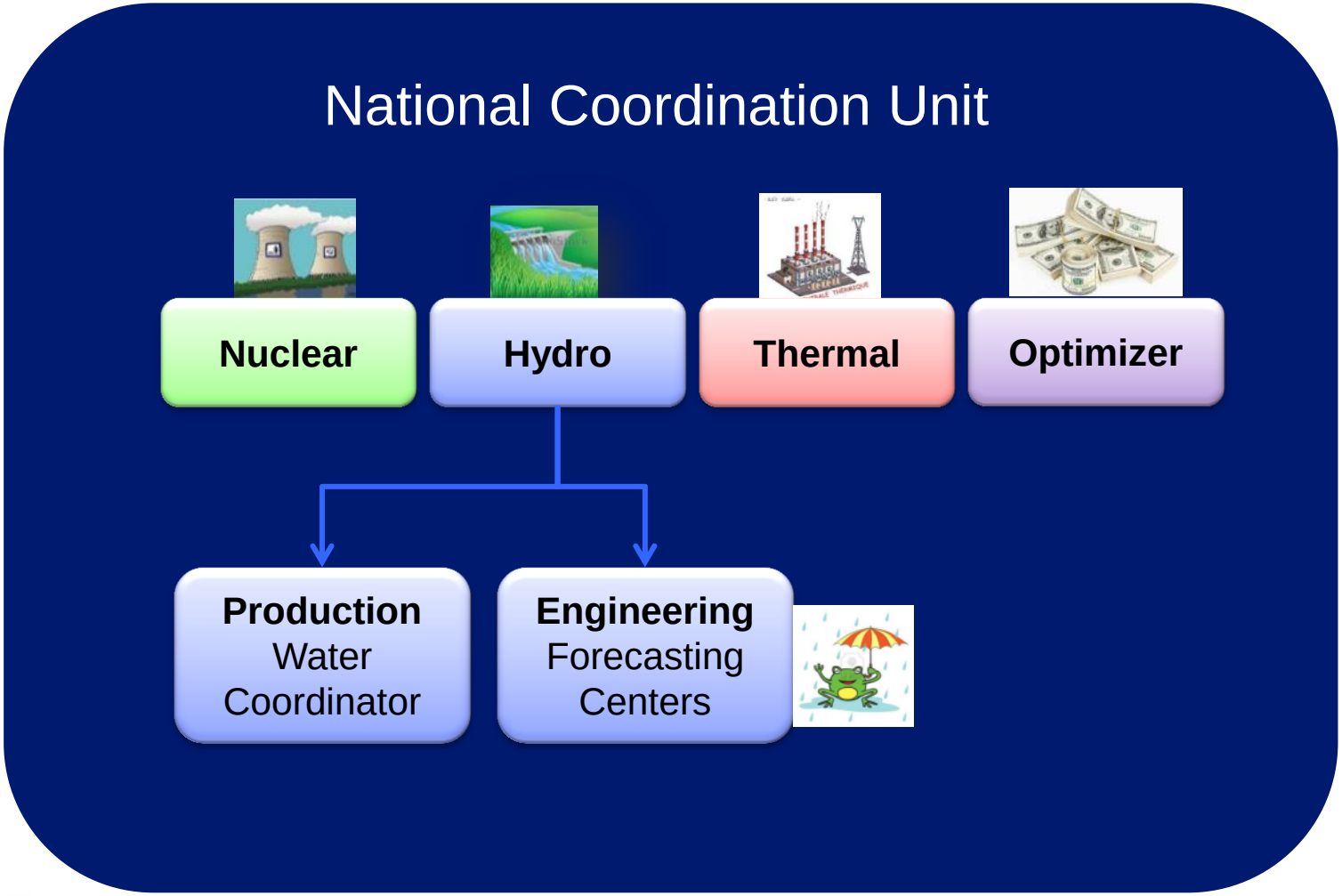
Navigation

- To ensure the minimum water level for navigation.
- To better estimate external actors influence on streamflows (VNF, CNR…)

LOW FLOWS MANAGEMENT AT EDF

NATIONAL COORDINATION

- **A national organization set up after the heat wave of 2003, gathering all the different actors.**



LOW FLOWS MANAGEMENT AT EDF

LOCAL COORDINATION

- **Local version of the national organization**
  - From surveillance to alert
  - Strong relationship between the 2 organizations
  - Perimeter based on governmental catchments (“Agence de l’eau”)

- **Local coordination unit “Rhine/Meuse rivers”**
  - Headquarter at Mulhouse

Input Data

Hydrometeo Forecasts

Hydrologic Data
Streamflow
Water level in reservoirs

Production Data

Local Coordination Unit

National Coordination Unit

Nuclear | Hydro | Thermal | Optimizer

Production Water Coordinator | Engineering Forecasting Centers

Decision - Levers

Water support

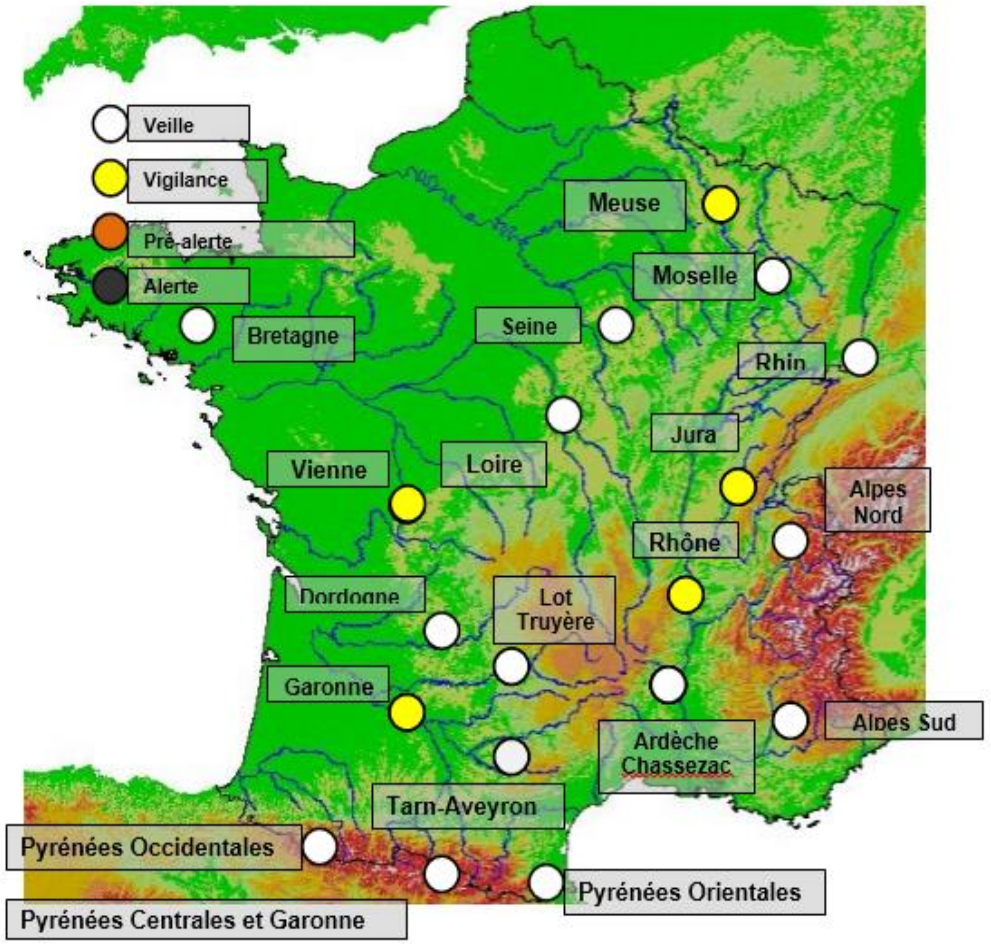
Coordination with external actors
VNF, CNR…

Adapt Production Stopping or Lowering

LOW FLOWS MANAGEMENT AT EDF

AREAS AND MOBILISATION LEVELS

- **19 areas** including Rhine, Meuse and Moselle catchments.
- **4 different mobilization levels**
  - From surveillance to alert
- **Levels depend on different parameters**
  - Different criteria for each site
  - Based on:
    - Air temperature
    - Water temperature
    - Water flow

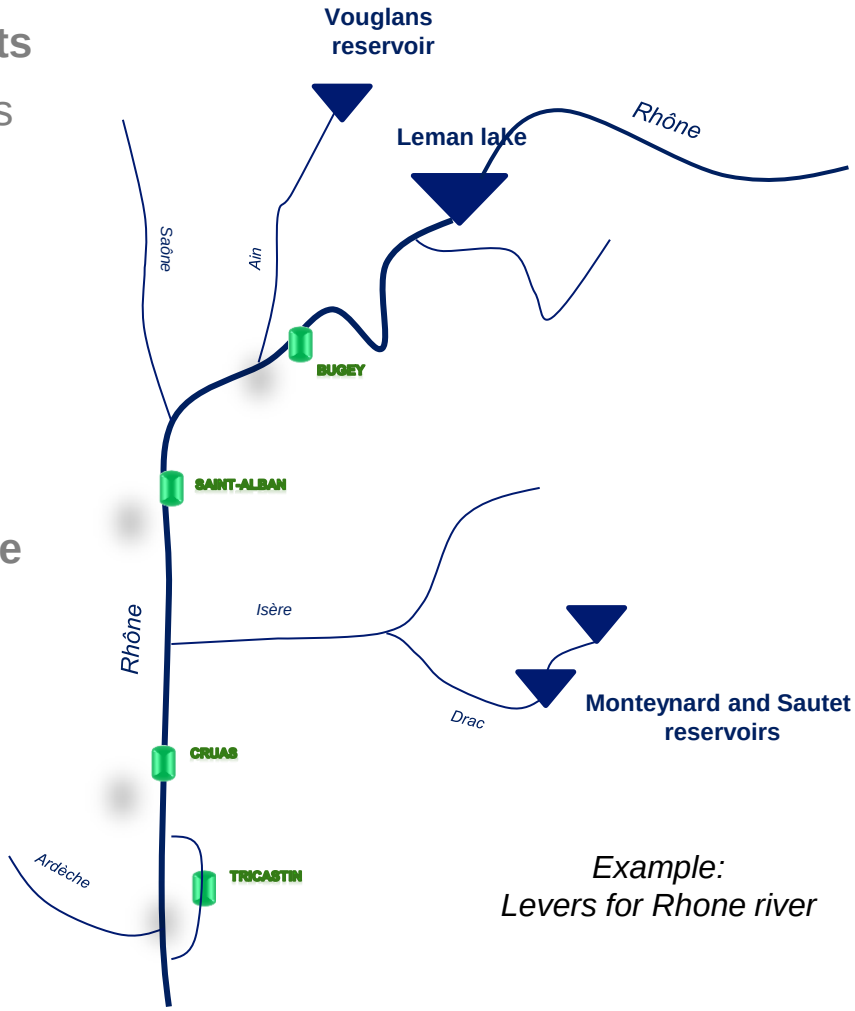


Situation in June 2017

LOW FLOWS MANAGEMENT AT EDF

LEVERS

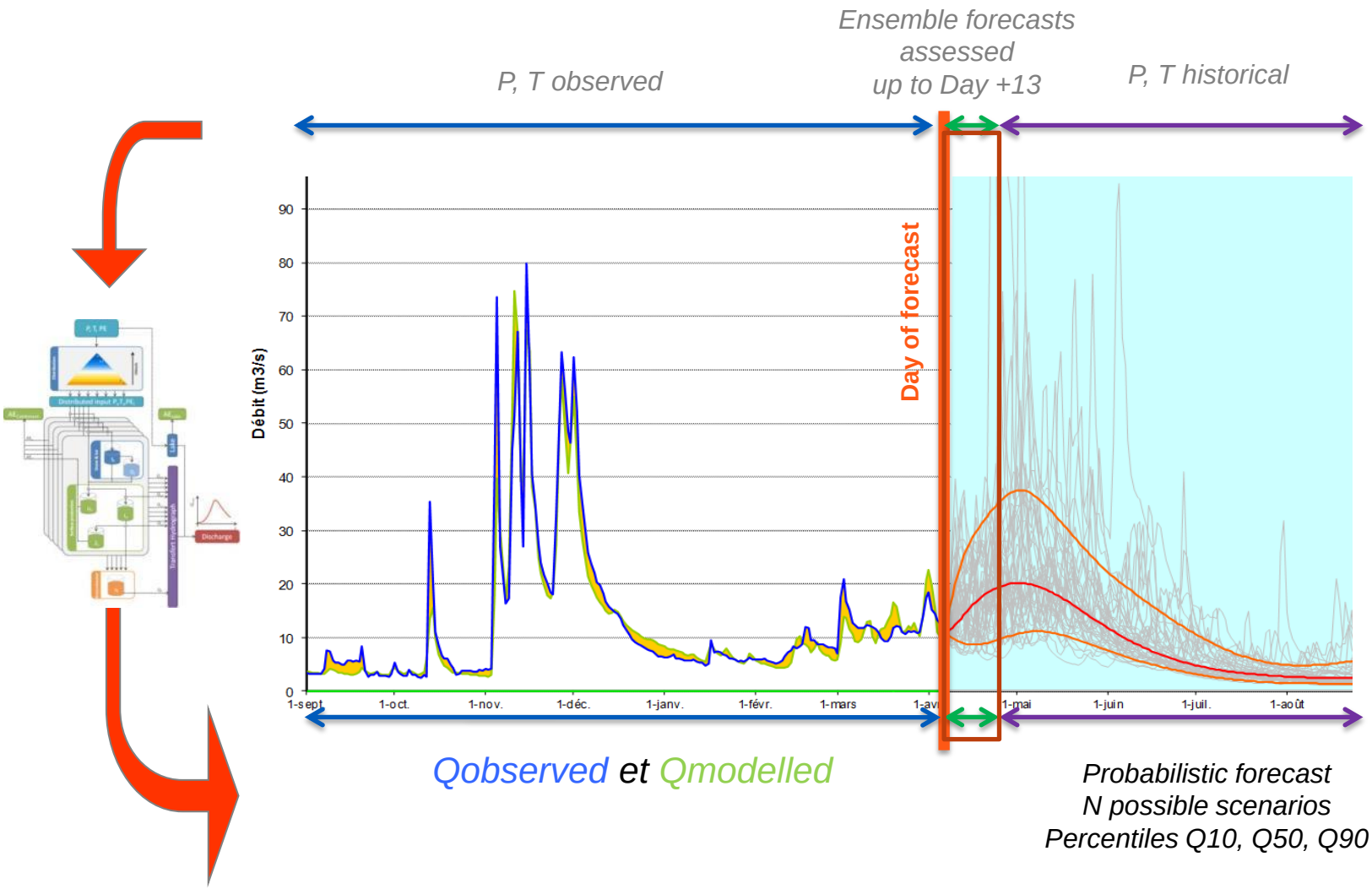
- **Water support for nuclear powerplants**
  - Rhône river: reservoirs of the tributaries and water agreement with Switzerland on Leman lake
  - Meuse river: Vieilles Forges and Revin reservoirs
  - Moselle river: Vieux-Pré reservoir
- **Best anticipation of powerplants functioning (stops), in order to reduce the risk of warming rivers**
- **Optimization of the management of discharge effluents**



Example:
Levers for Rhone river

LOW FLOWS FORECASTS AT EDF

STREAMFLOW FORECASTS - METHODOLOGY

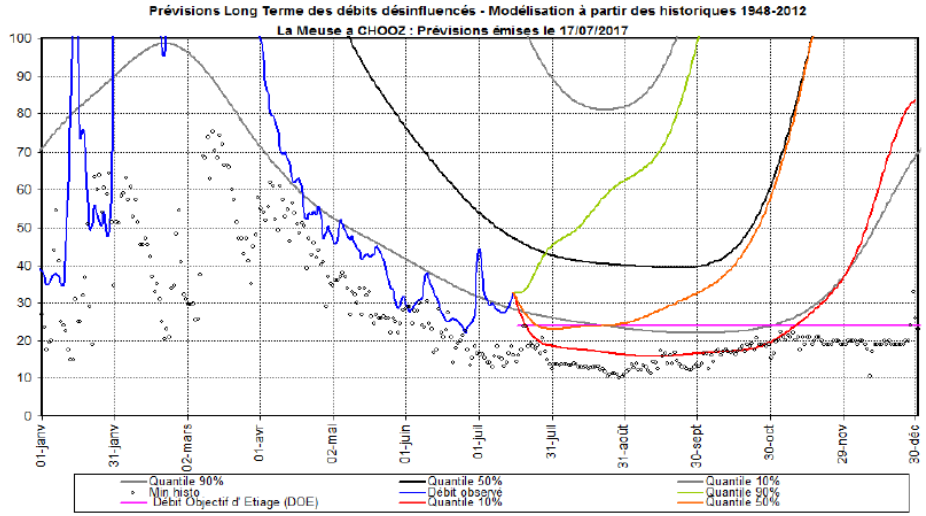


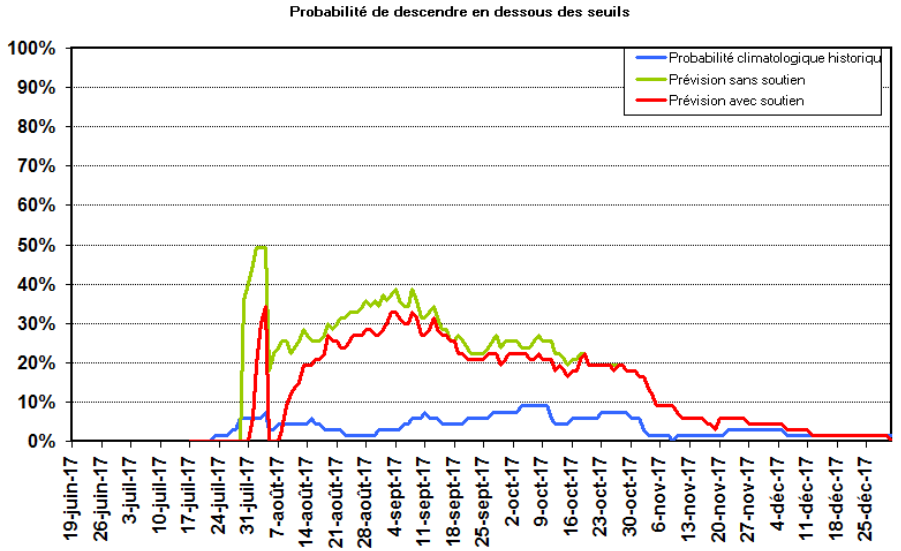
LOW FLOWS FORECASTS AT EDF

STREAMFLOW FORECASTS - USE

Streamflow forecasts give a probability of low flow evolution up to 2 months (default risk)

➔ **Objective: anticipate critical situations**





LOW FLOWS FORECASTS AT EDF

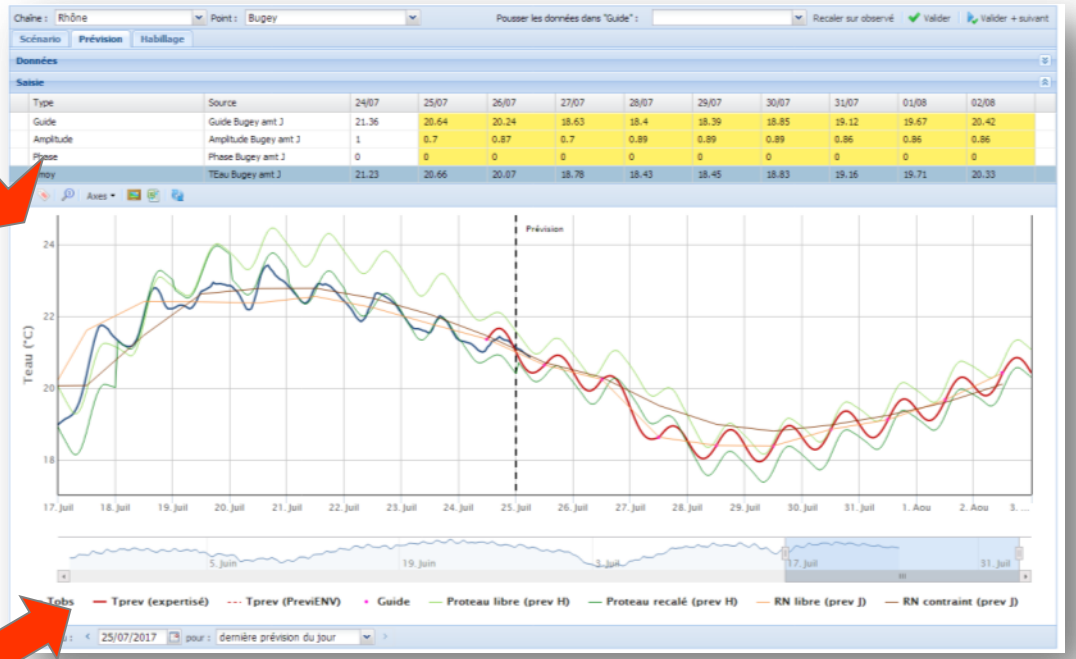
WATER TEMPERATURE FORECASTS - METHODOLOGY

Input data:

Forecasts
- Precip
- Air temp

Streamflow forecasts

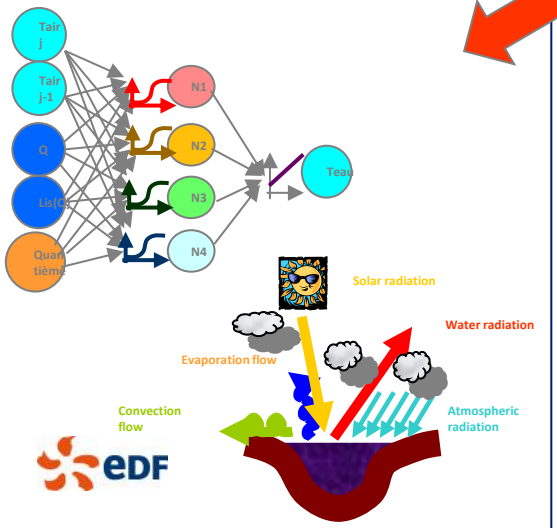
Forecasts
- Nebulosity
- Winfd and humidity
- Air temp



Models:

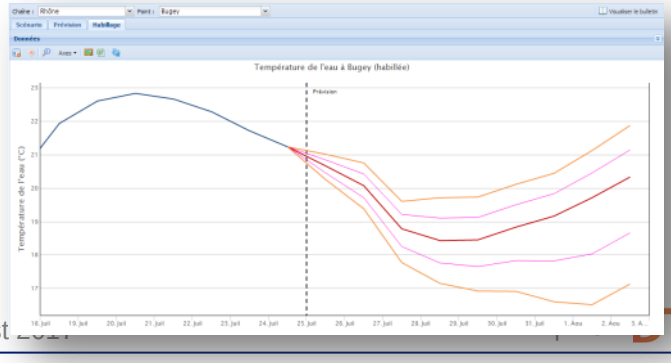
-Neural network

-physical model (radiation – flow)



Output data:

- Probabilistic forecasts (percentile)

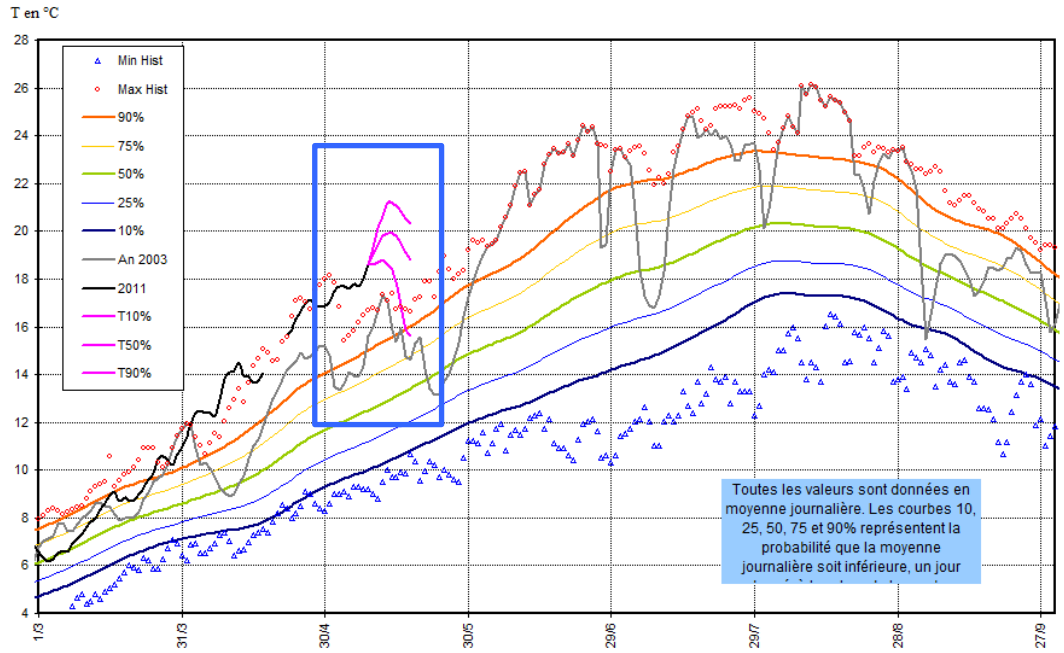


LOW FLOWS FORECASTS AT EDF

WATER TEMPERATURE FORECASTS - USE

Water temperature forecasts give a probability of water temperature evolution up to 9 days

➔ **Objective: anticipate potential decreases of production**



LOW FLOWS MANAGEMENT AT EDF

EXAMPLE - MOSELLE RIVER – SUMMER 2017 (1/2)

- **Context and requirements**
  - Minimum regulatory flow at Cattenom (nuclear powerplant) : 29 m^3/s
  - Water support when minimum flow is reached (including other conditions): Vieux-Pré (40 hm^3) to compensate air coolers evaporation

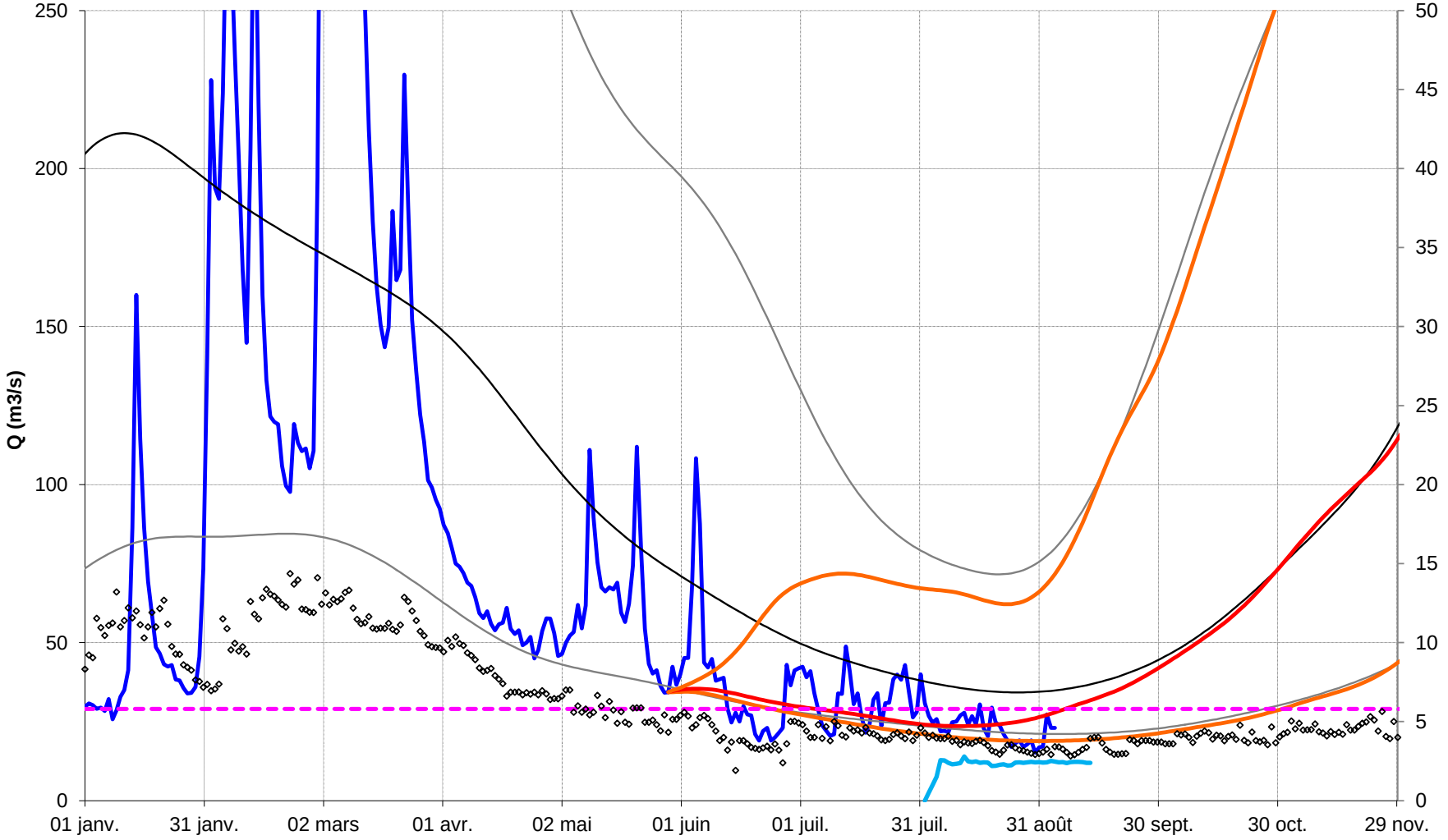
- **Since June 2017 :**
  - Coordination meetings twice a week
  - Compensation since August 5th (around 2.7 m^3/s)

  - The long-term forecasts allowed to :
    - Evaluate the probability to stay below 29 m^3/s.
    - Estimate the water volume required at Vieux-Pré.

Modelling of the various scenarios based on the probability of overtaking of the threshold help the coordination with hydro power plant.

LOW FLOWS MANAGEMENT AT EDF

EXAMPLE - MOSELLE RIVER – SUMMER 2017 (2/2)



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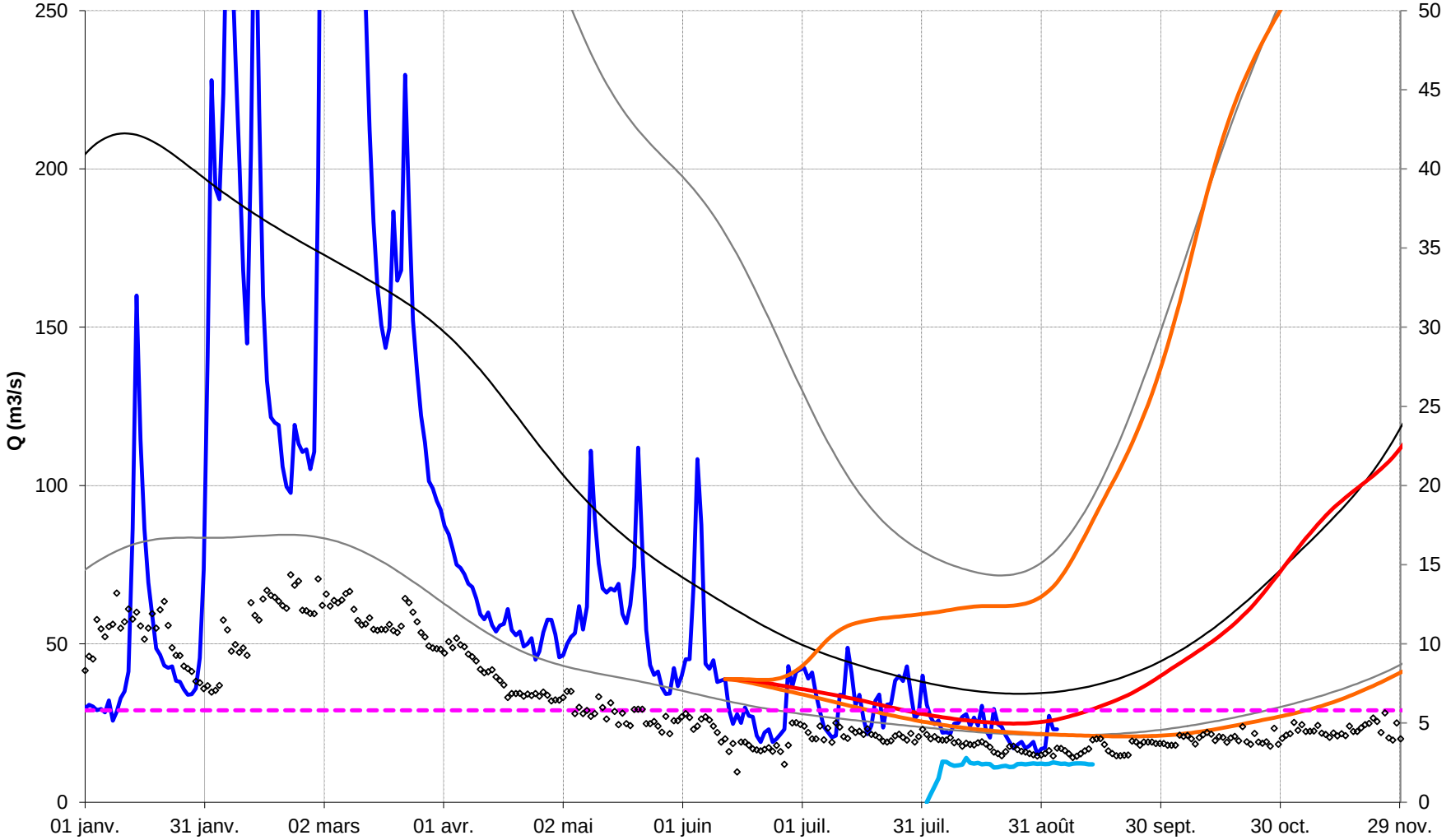

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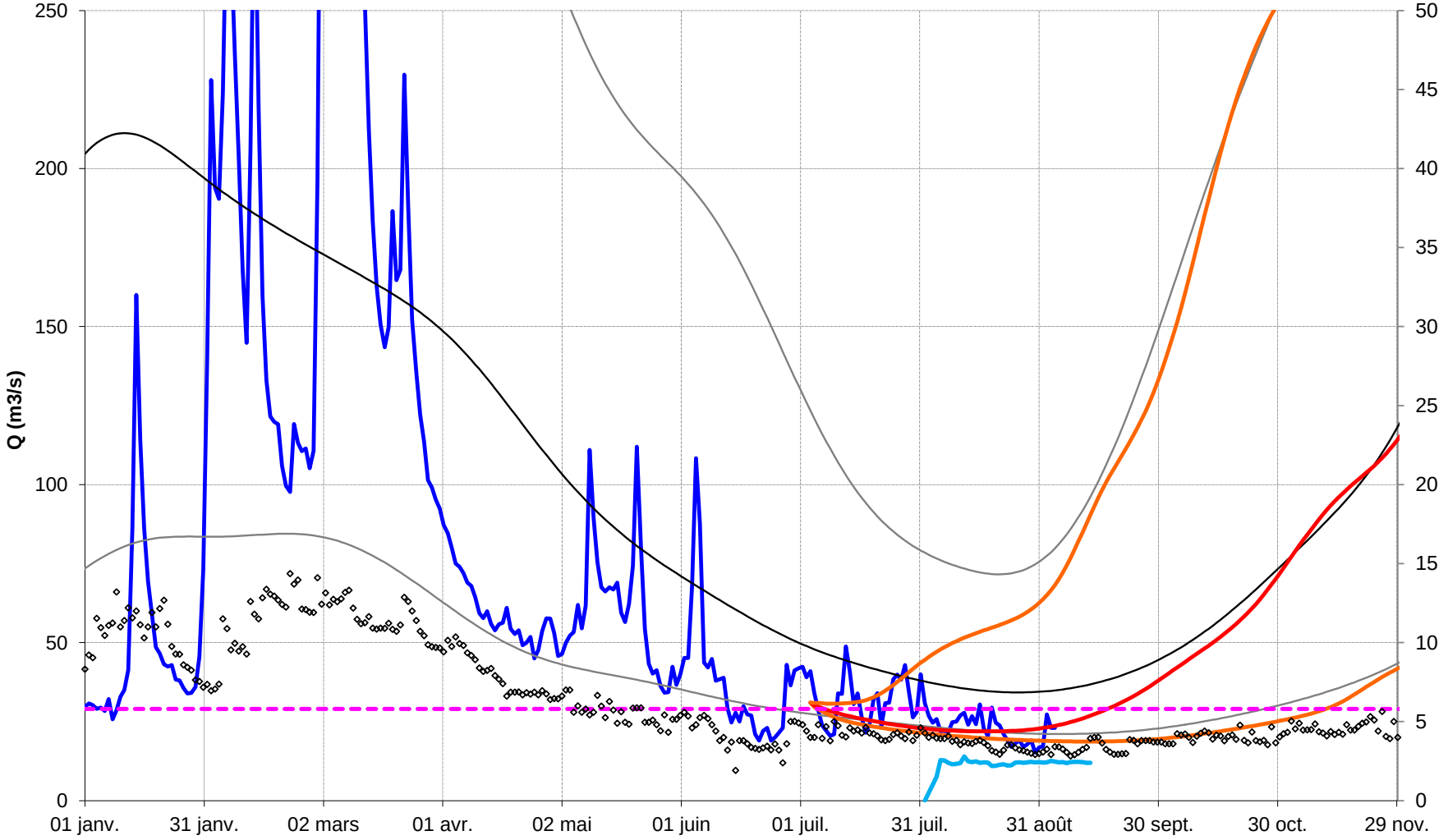

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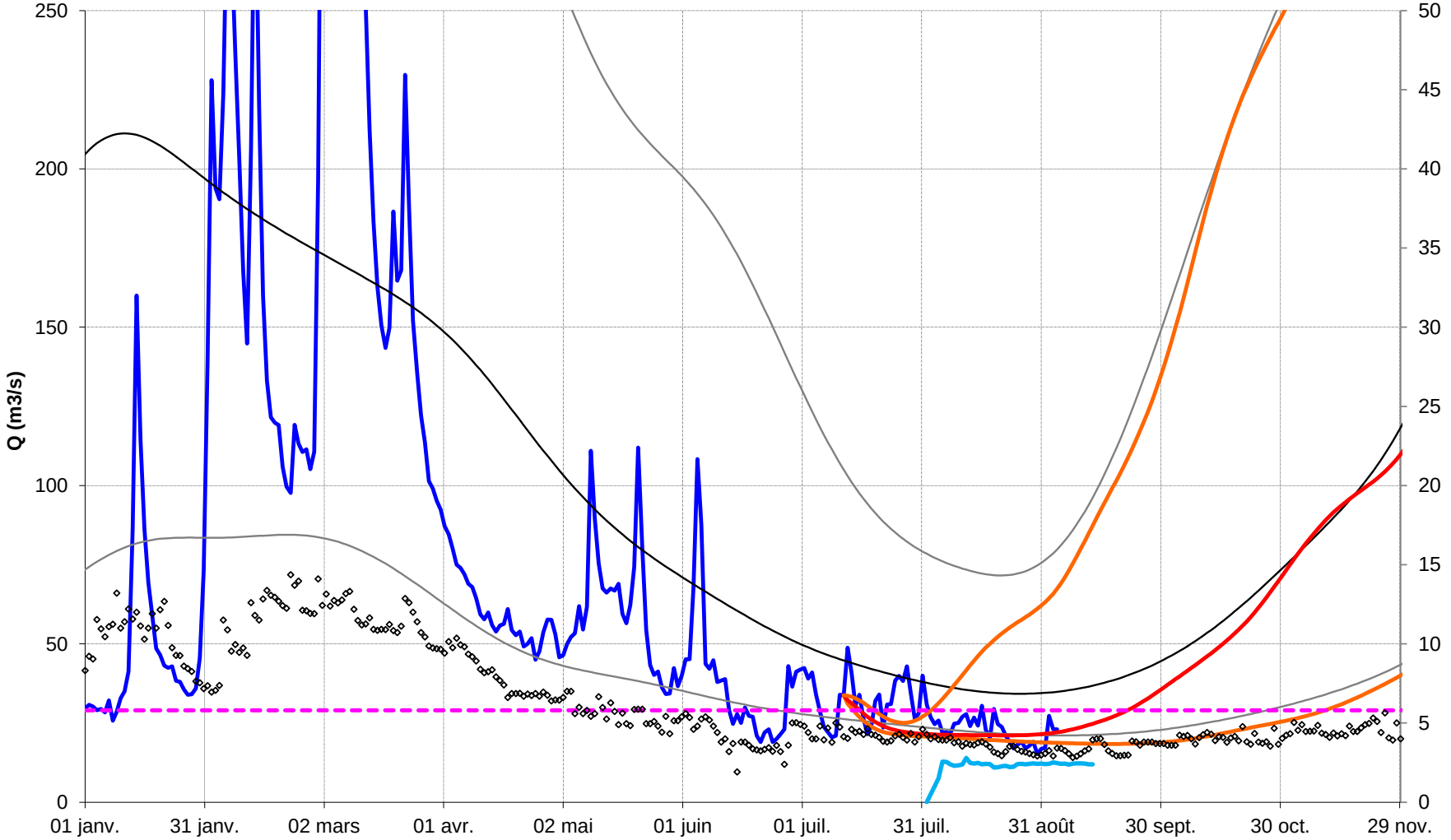

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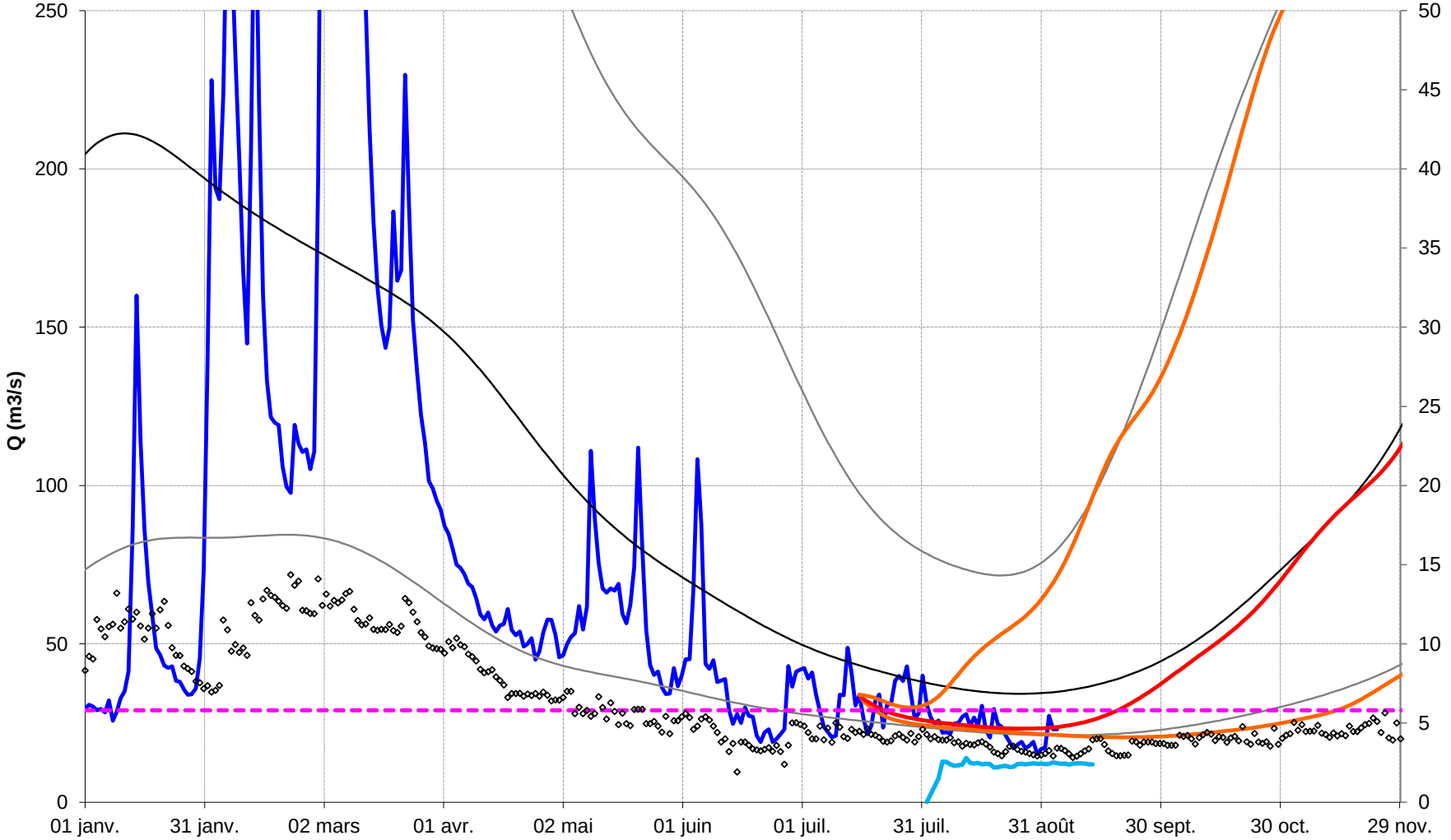

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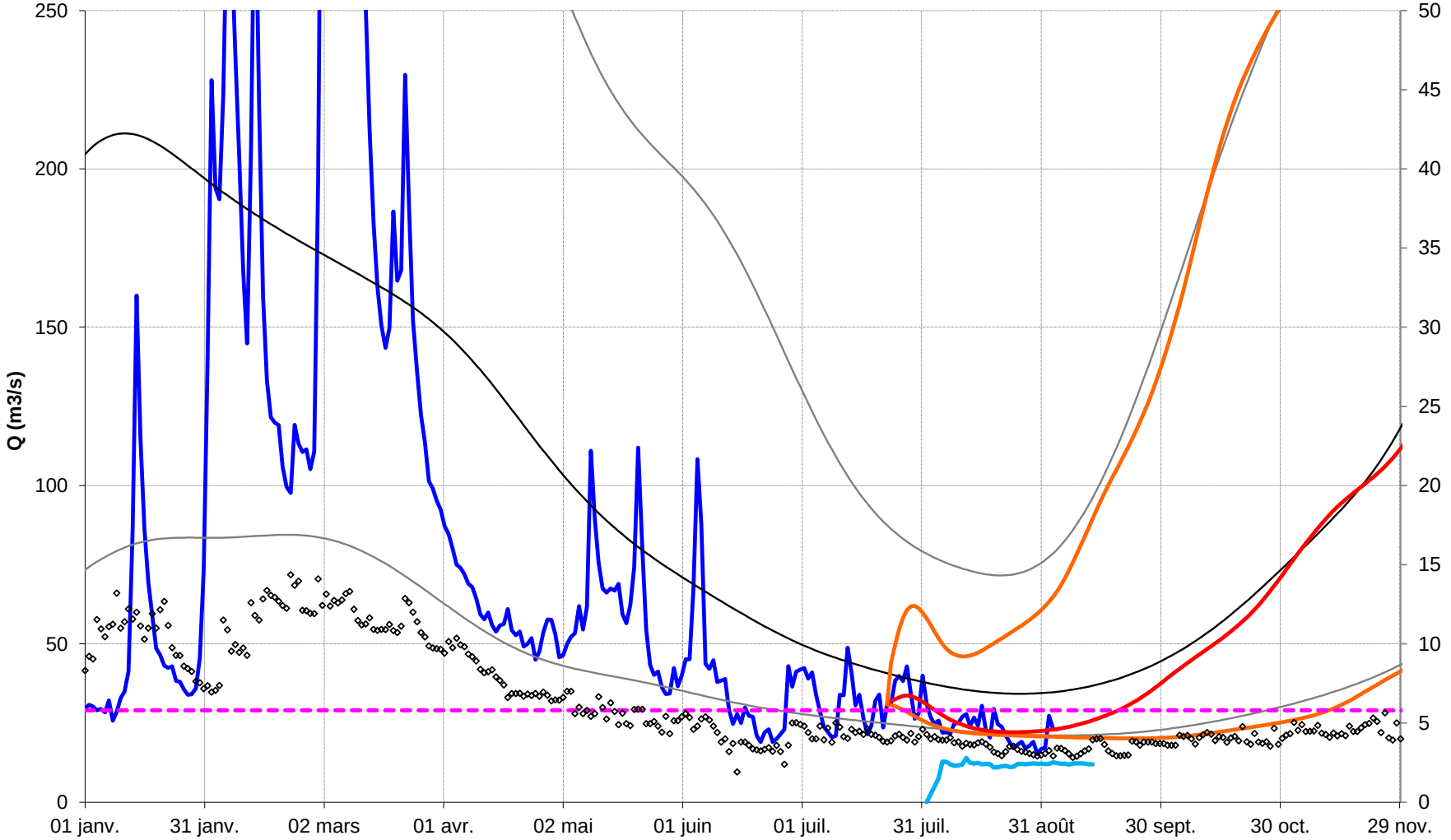

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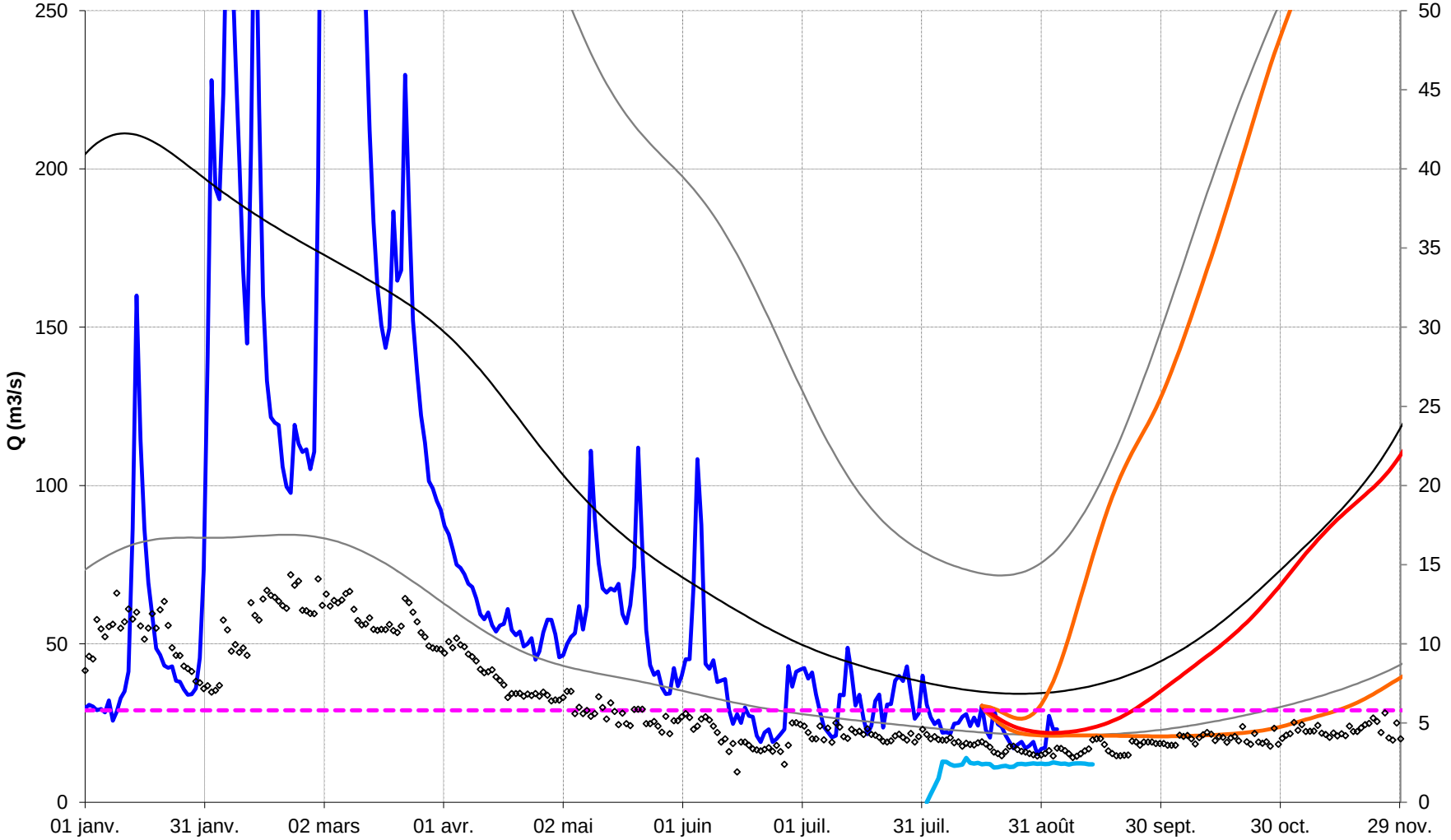

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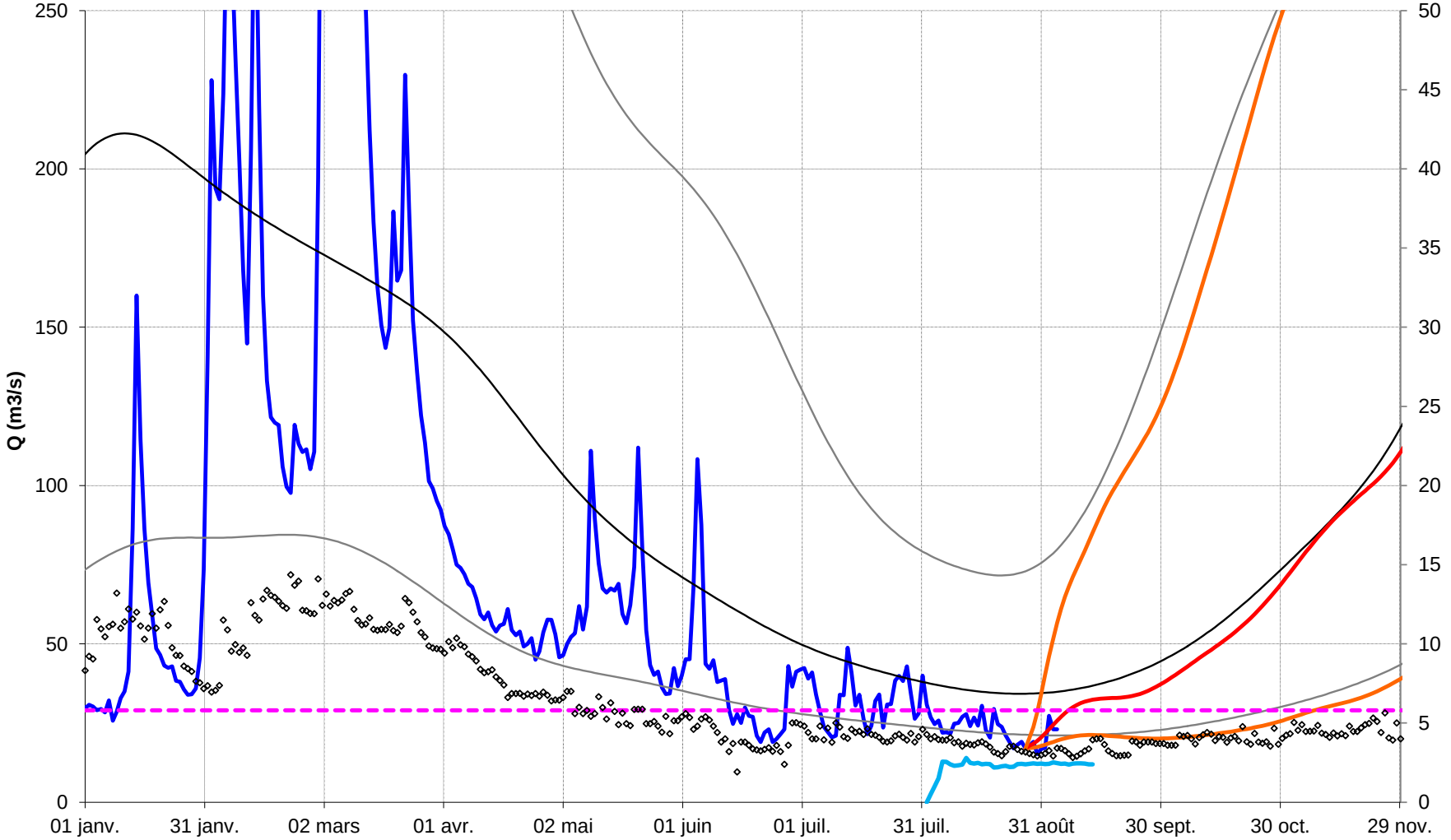
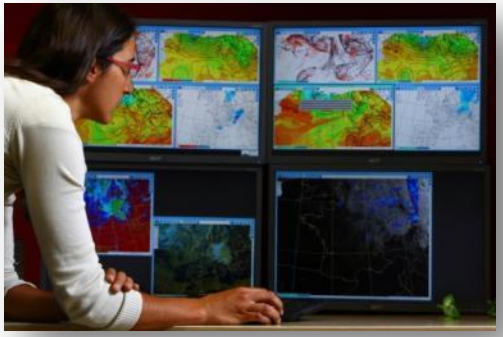


CONCLUSIONS

- **During low flows periods:**
  - Organization to anticipate (forecasts) and manage (coordination) evolution of low flows and their consequences
  - Optimization of the production with a priority given to safety
  - At the same time, consideration of other water uses
  - Valorization of more than 50 years of experience, of a global and integrated vision (hydro/nuclear power plants, from measurement to power plant operators)

- **Please note:**
  - Organizations, issues and levers are different from one basin to another

➔ **A company as EDF permanently adapts to the needs / constraints of each basin**



VIELEN DANK!

MERCI BEAUCOUP!