

# Școala de vară privind evenimentele extreme de temperatură și precipitații

## Sesiunea 3: Inundațiile

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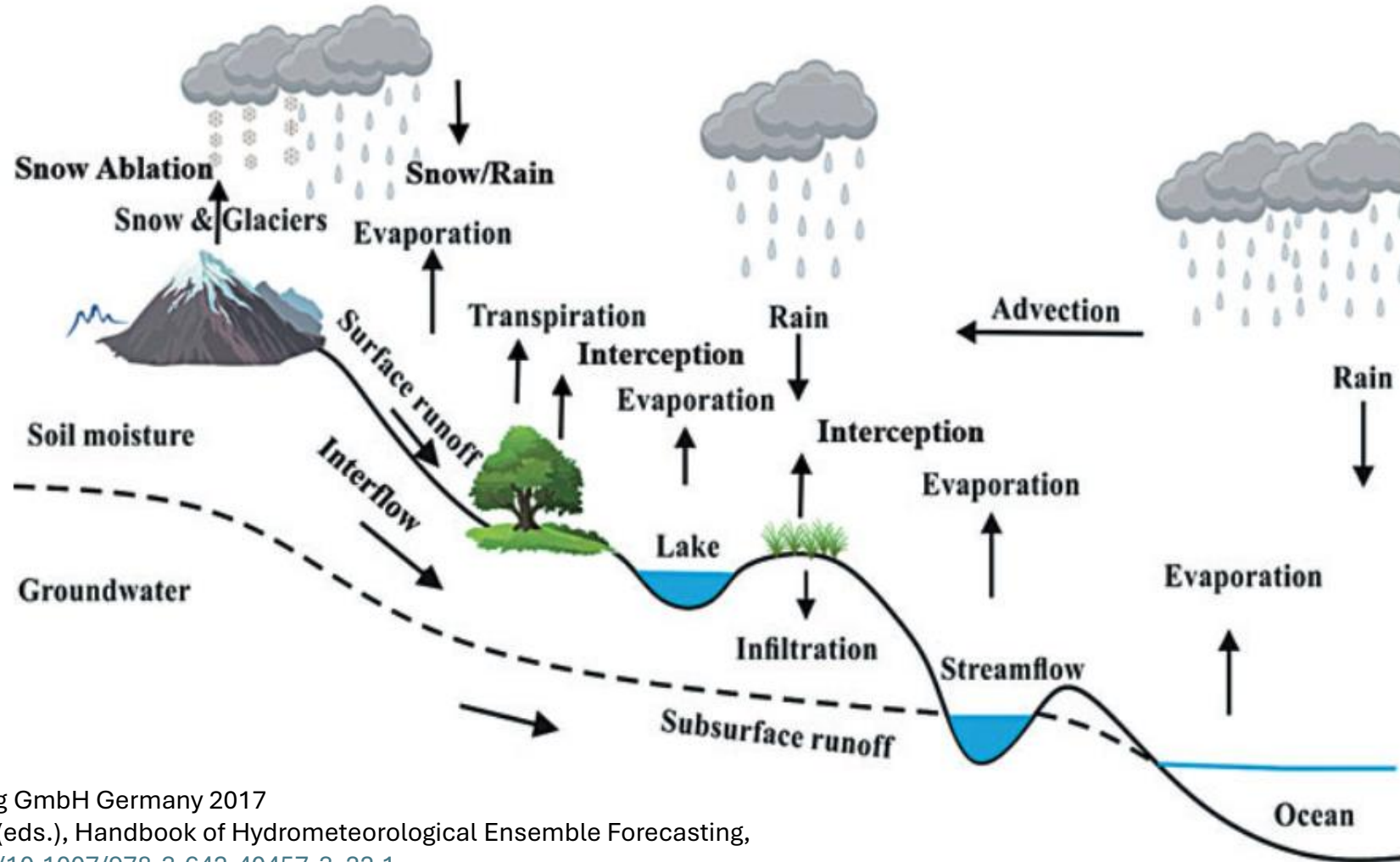
Organizație: Justus Liebig University Giessen - JLU

Cluj-Napoca, Romania

10 Septembrie 2025



# 1. Ciclul apei



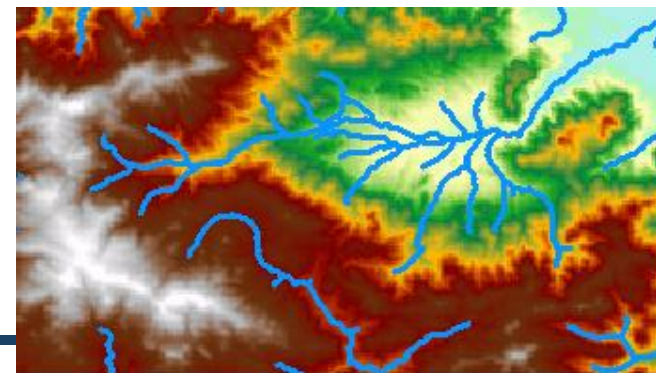
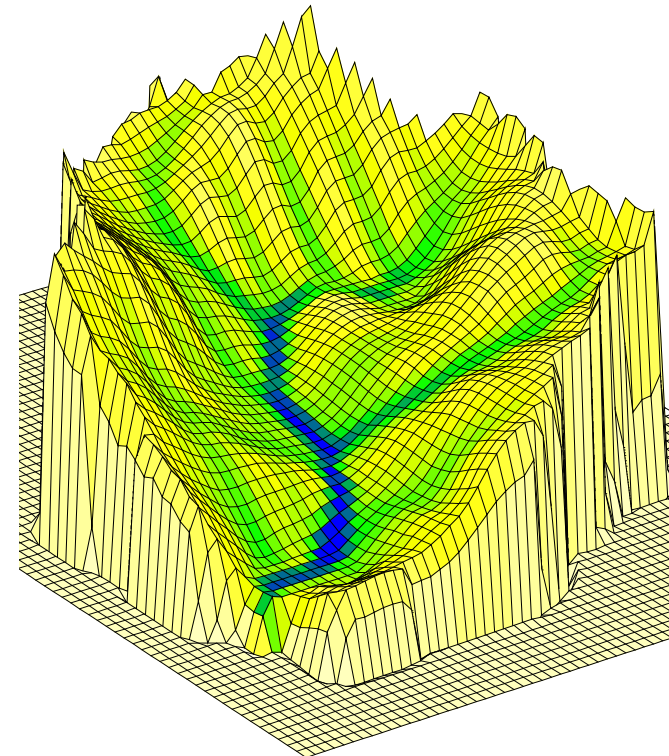
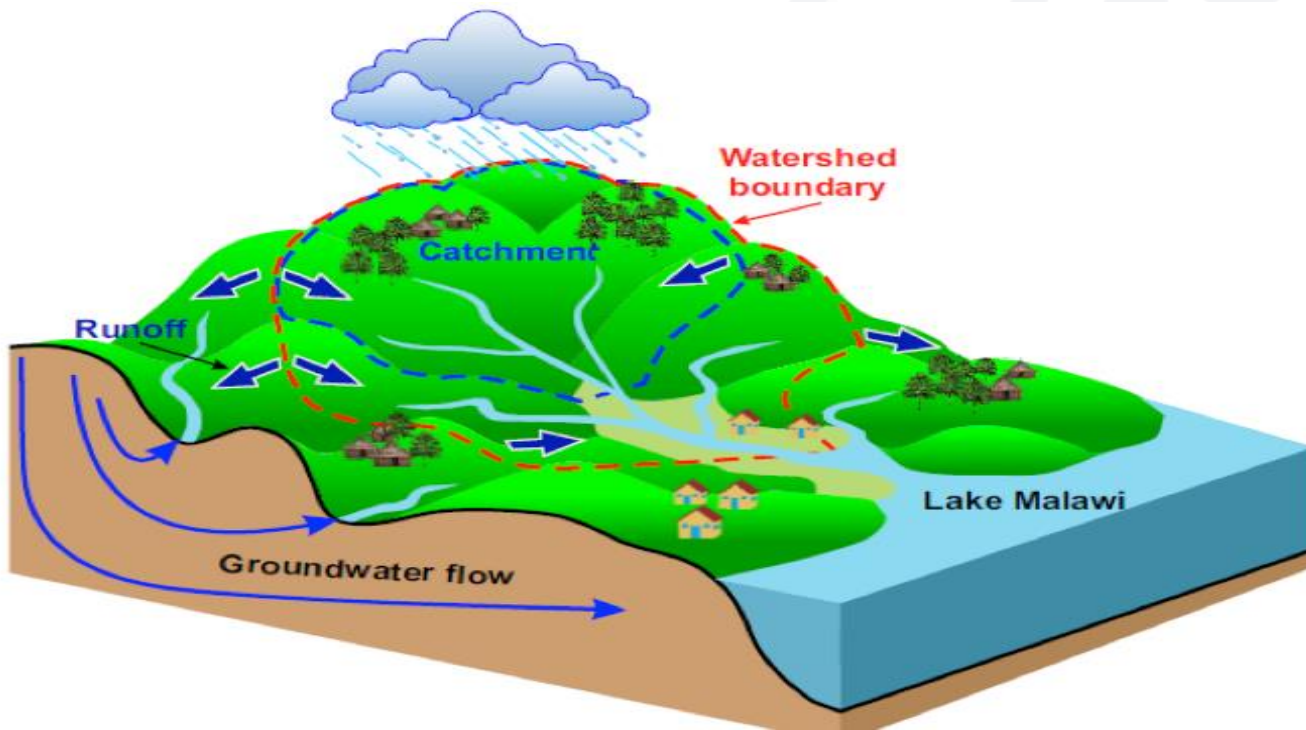
Springer-Verlag GmbH Germany 2017  
 Q. Duan et al. (eds.), Handbook of Hydrometeorological Ensemble Forecasting,  
[https://doi.org/10.1007/978-3-642-40457-3\\_22-1](https://doi.org/10.1007/978-3-642-40457-3_22-1)





## Bazin hidrografic (Catchment)

Un bazin hidrografic este o zonă în care toate apele se scurg către același punct de vărsare.

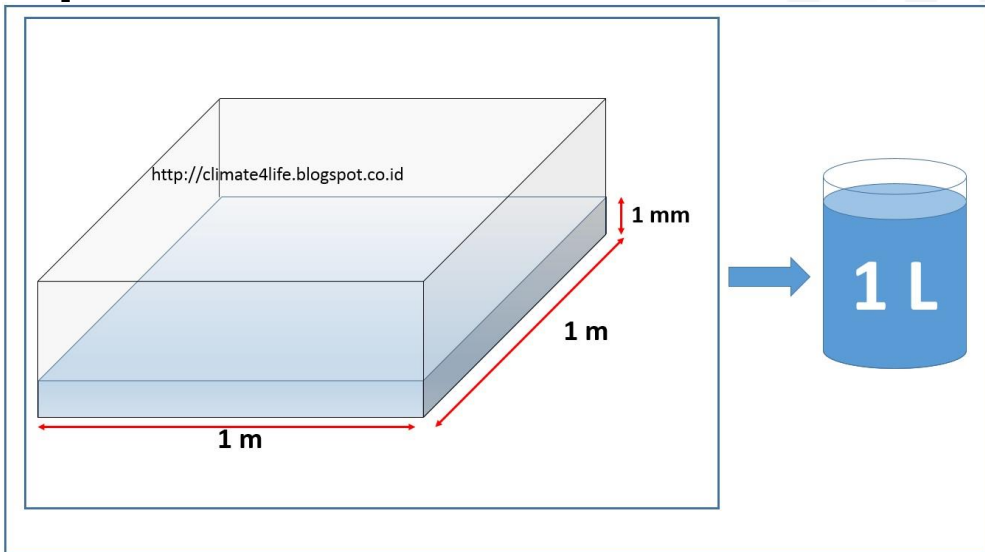




## Precipitațiile

Măsurarea **precipitațiilor** ca și adâncime este un standard internațional, în principal pentru că este foarte ușor de convertit adâncimea în volum.

Factorul de conversie este: **1 mm precipitație = 1 litru de apă/m<sup>2</sup>**



1 mm -> 1 mm/zi

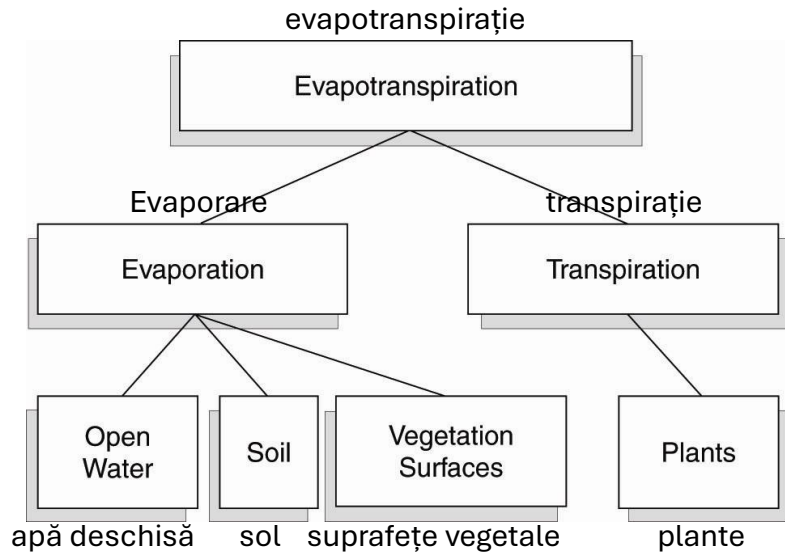
$$i = \frac{\Delta P}{\Delta t} \left[ \frac{mm}{or\acute{a}} \right]$$

$$i = \frac{5 \text{ mm}}{1 \text{ zi}} = 0.208 \frac{mm}{or\acute{a}}$$

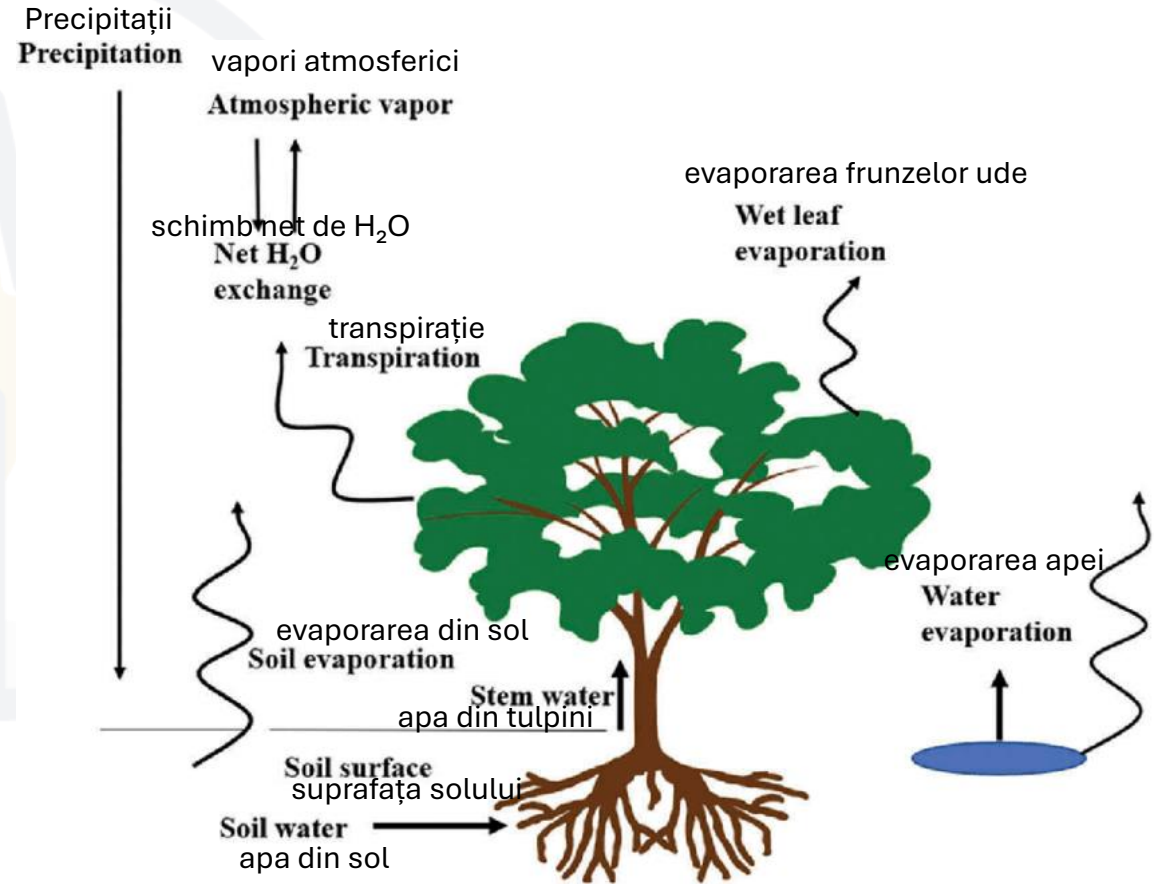




## Evaporare, transpirație și evapotranspirație

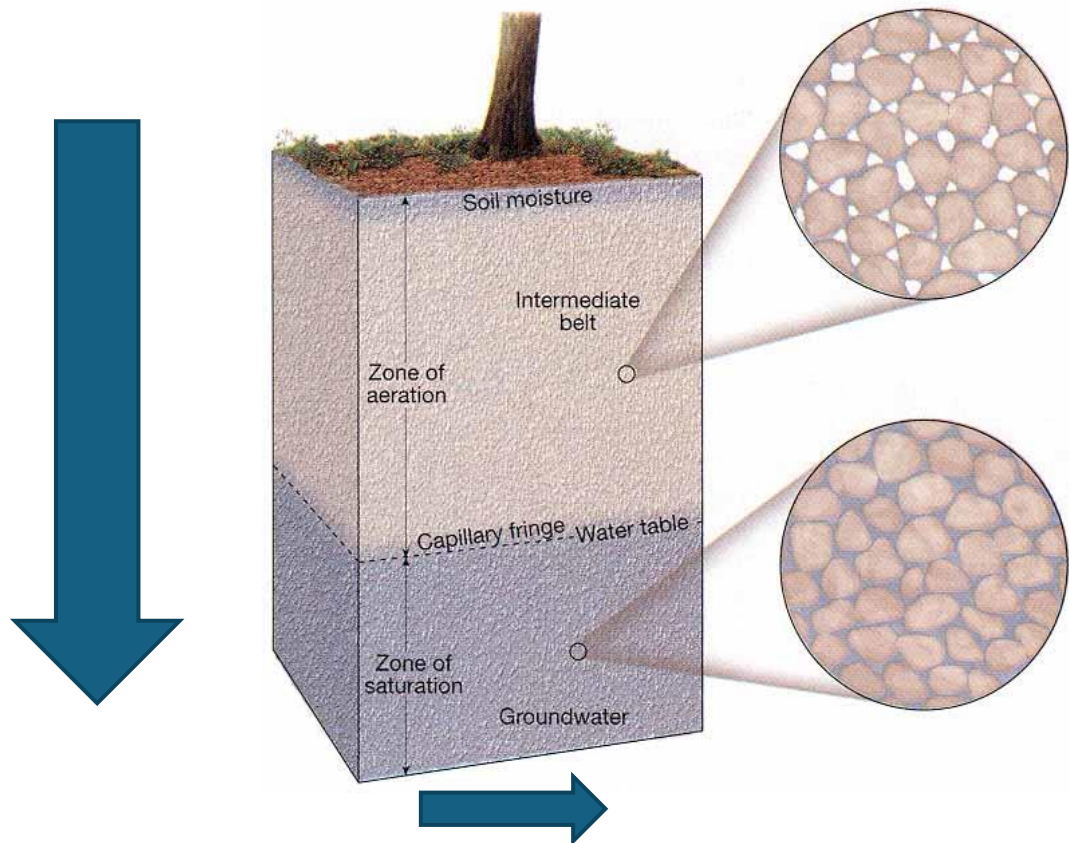


26.07.2010 03:10





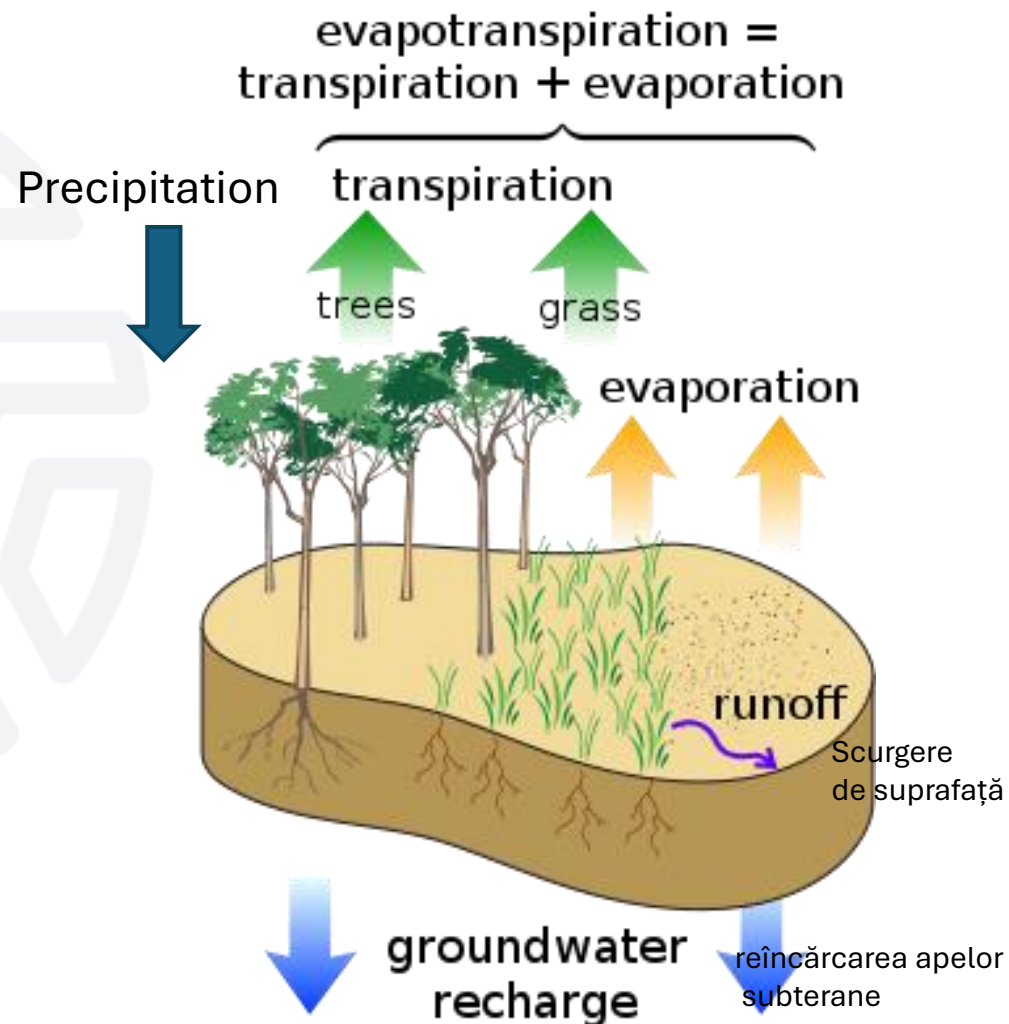
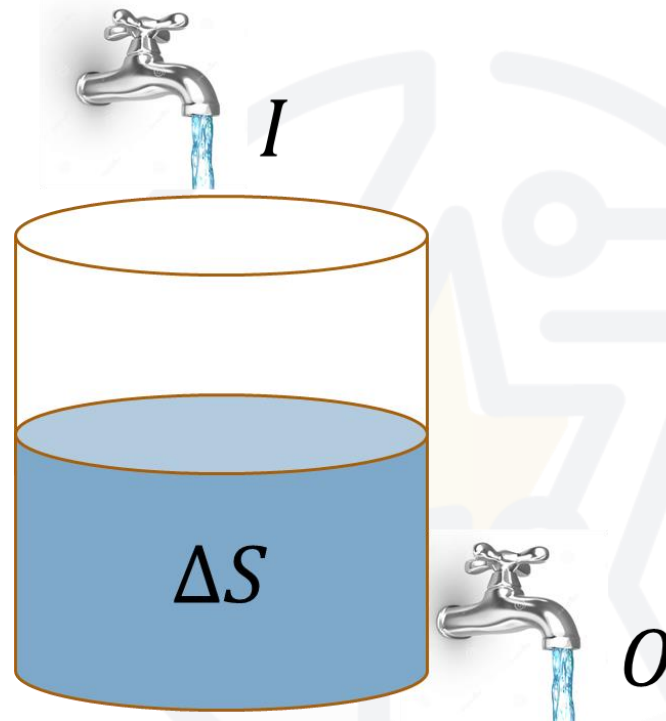
## Infiltrația





## Bilanțul apei

$$I - O = \Delta S$$



Pe baza teoremei transportului Reynolds  
 (Legea conservării masei, legea conservării  
 impulsului liniar, legea conservării energiei)

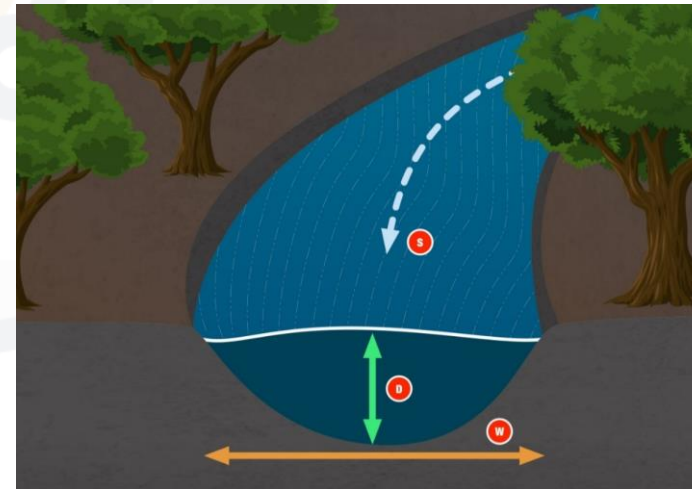
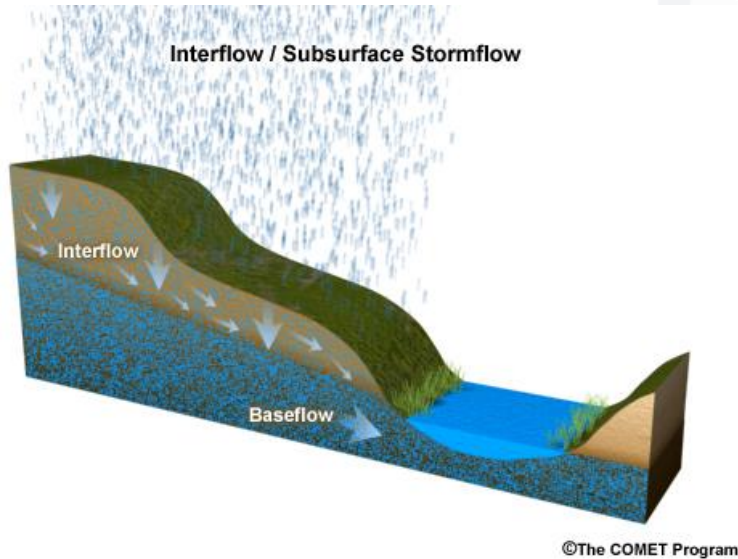


## Debitul (Streamflow)

Debitul, scurgerea sau scurgerea de suprafață reprezintă partea din precipitații, topirea zăpezii sau apa de irigație care curge pe suprafața solului către albia unui curs de apă.

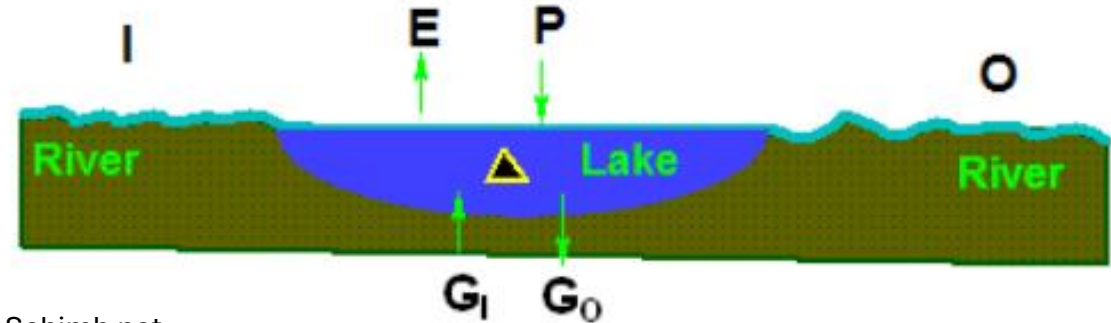
$$Q = A \bar{u}$$

- **Q** – debitul ( $[L^3T^{-1}]$ ;  $m^3/s$  sau  $ft^3/s$ )
- **A** – aria secțiunii transversale ocupată de curgere ( $[L^2]$ ;  $m^2$  sau  $ft^2$ )
- **u** – viteza medie a curgerii ( $[LT^{-1}]$ ;  $m/s$  sau  $ft/s$ )





## Bilanțul apei



Schimb net în stocare

$$\Delta \text{net change in storage} = I + P + G_1 - E + G_0 + O$$

I: stream inflow to lake / aport fluvial într-un lac  
 P: precipitation / precipitații  
 G<sub>1</sub>: groundwater inflow / aport de apă subterană  
 E: evaporation / evaporare  
 G<sub>0</sub>: groundwater outflow / ieșire a apelor subterane  
 O: stream water / apă fluvială



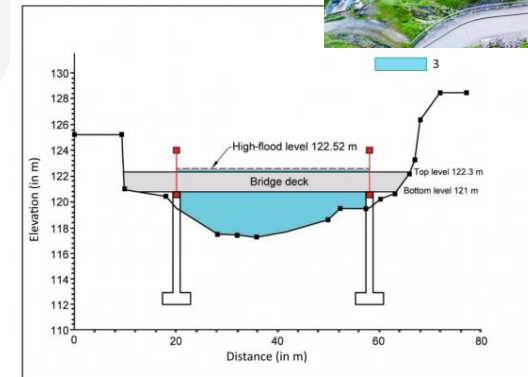
## De ce modelarea?

Utilizarea modelelor permite factorilor de decizie și părților interesate să ia decizii pe baza măsurătorilor limitate și a predicțiilor calitative în spațiu și timp ale proceselor hidrologice.

Modelarea reprezintă o modalitate fundamentală și cantitativă de a înțelege și analiza sisteme și fenomene complexe.

Modelarea este un complement al teoriei și experimentului.

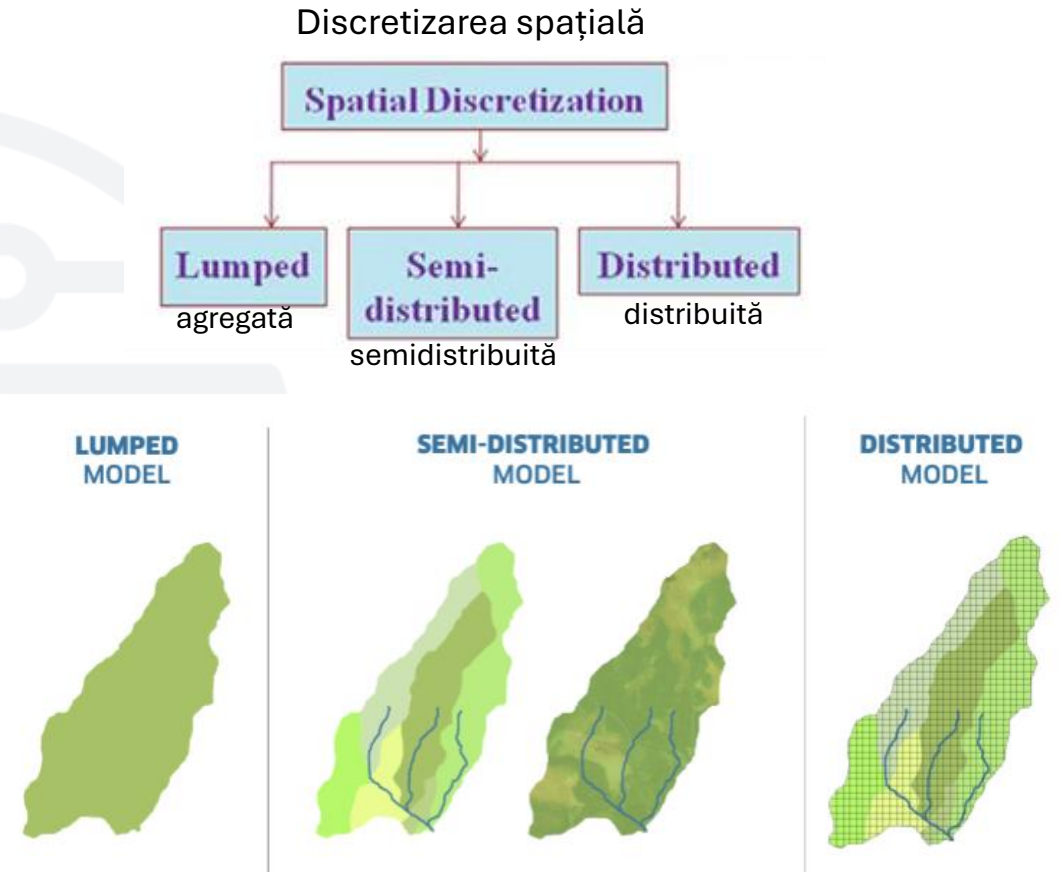
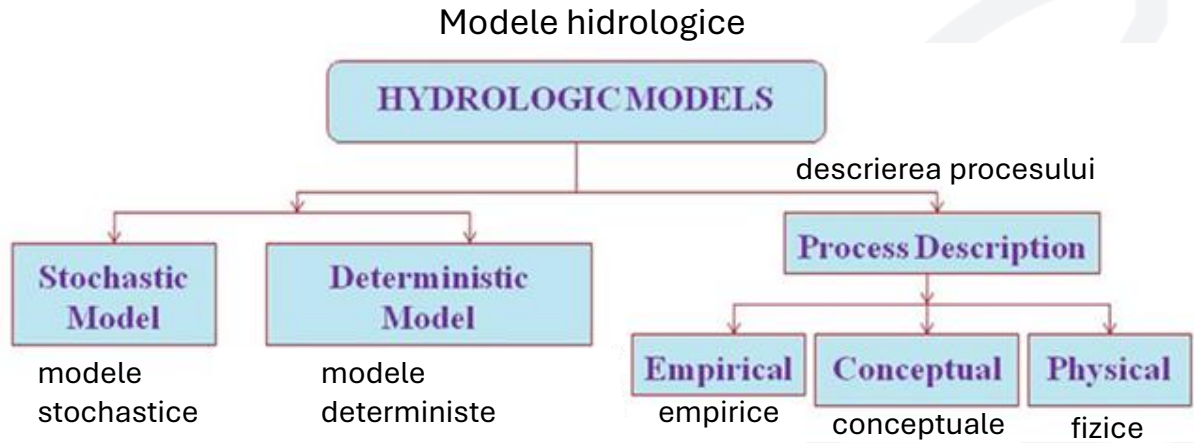
Exemplu: evaluarea disponibilității apei pentru consum uman, inundații, secete, irigații, contaminarea apei și altele.



https://www.hydrotech-group.com/blog/the-10-most-beautiful-water-dams-from-around-the-world



## Tipuri de modele



Ochoa-Tocachi, Cuadros-Adriazola, Arapa, Aste, Ochoa-Tocachi, & Bonnesoeur. (2022). *Guide to Hydrologic Modeling*. Forest Trends Association. [chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf](https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf)



## Modelul hidrologic GR4J

Si  $P_k \geq E$ , alors  $P_n = P_k - E$  et  $E_n = 0$ ,  
Si  $P_k < E$ , alors  $P_n = 0$  et  $E_n = E - P_k$

$$Ps = \frac{x1 \cdot (1 - (\frac{S_k}{x1})^2) \cdot \tanh(\frac{Pn}{x1})}{1 + \frac{S_k}{x1} \cdot \tanh(\frac{Pn}{x1})} \text{ et } Es = \frac{S_k \cdot (2 - \frac{S_k}{x1}) \cdot \tanh(\frac{Pn}{x1})}{1 + (1 - \frac{S_k}{x1}) \cdot \tanh(\frac{Pn}{x1})}$$

$$S' = S_k + Ps - Es,$$

$$Perc = S' \cdot \left\{ 1 - \left[ 1 + \left( \frac{4}{9} \cdot \frac{S'}{x1} \right)^4 \right]^{-1} \right\}, S_{k+1} = S' - Perc$$

$$Perc + (Pn - Ps)$$

$$\text{Si } 0 \leq j \leq X_4, SH1(j) = \left(\frac{j}{X_4}\right)^{\frac{1}{2}}; \text{ Si } j > X_4, SH1(j) = 1$$

$$\text{Si } 0 \leq j \leq X_4, SH2(j) = \frac{1}{2} \left(\frac{j}{X_4}\right)^{\frac{1}{2}};$$

$$\text{Si } X_4 \leq j \leq 2X_4, SH2(j) = 1 - \frac{1}{2} \left(2 - \frac{j}{X_4}\right)^{\frac{1}{2}};$$

$$\text{Si } j > 2X_4, SH2(j) = 1$$

$$UH1(j) = SH1(j) - SH1(j-1)$$

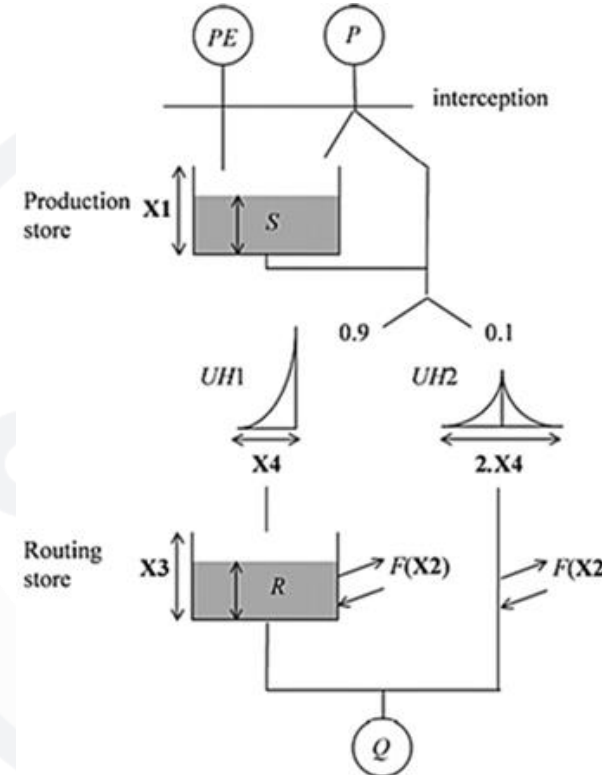
$$UH2(j) = SH2(j) - SH2(j-1)$$

$$Q9(k) = 0.9 \cdot \sum_{j=1}^k UH1(j) \cdot Pr(k-j+1),$$

$$Q1(k) = 0.1 \cdot \sum_{j=1}^m UH2(j) \cdot Pr(k-j+1)$$

$$F = X2 \cdot \left(\frac{R_k}{X3}\right)^{\frac{2}{3}}; R' = \max(0; R_k + Q9(k) + F)$$

$$(DP) \begin{cases} Qr = R' \cdot \left\{ 1 - \left[ 1 + \left( \frac{R'}{X3} \right)^4 \right]^{-1} \right\}; R_{k+1} = R' - Qr \\ Qd = \max(0; Q1(k) + F); \\ Q(k) = Qr + Qd \end{cases}$$



- X1 Capacity of the production store (mm)
- X2 Water exchange coefficient (mm)
- X3 Capacity of the nonlinear routing store (mm)
- X4 Unit hydrograph time base (day)

- $x_1$  – Capacitatea rezervorului de producție (mm)
- $x_2$  – Coeficientul de schimb de apă (mm)
- $x_3$  – Capacitatea rezervorului neliniar de rutare (mm)
- $x_4$  – Baza temporală a hidrografului unitar (zile)

Perrin, C., Michel, C., & Andréassian, V. (2003). Improvement of a parsimonious model for streamflow simulation. *Journal of Hydrology*, 279(1–4), 275–289. [https://doi.org/10.1016/S0022-1694\(03\)00225-7](https://doi.org/10.1016/S0022-1694(03)00225-7)



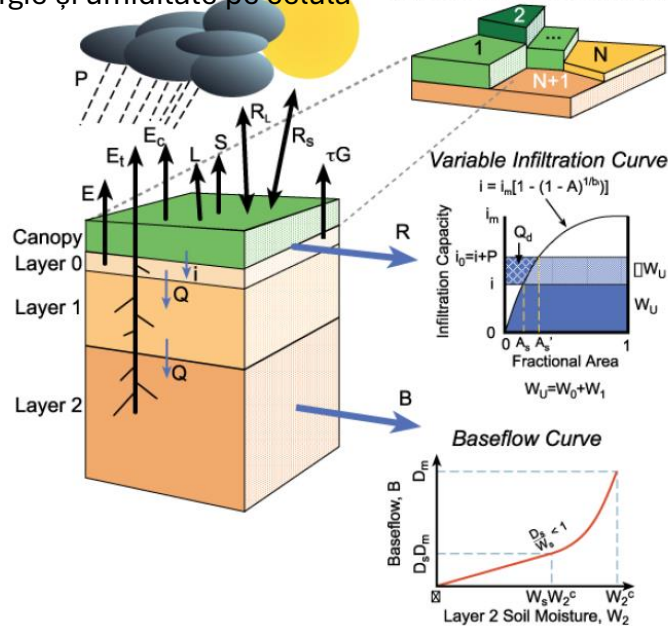
## VIC-WUR

[https://vicwur.readthedocs.io/en/latest/index\\_vicwur/](https://vicwur.readthedocs.io/en/latest/index_vicwur/)

**Variable Infiltration Capacity (VIC)** Capacitatea de infiltrație variabilă (VIC)  
**Macroscale Hydrologic Model** Model hidrologic la scară mare (macrosală)

Fluxuri de energie și umiditate pe celulă  
Cell Energy and Moisture Fluxes

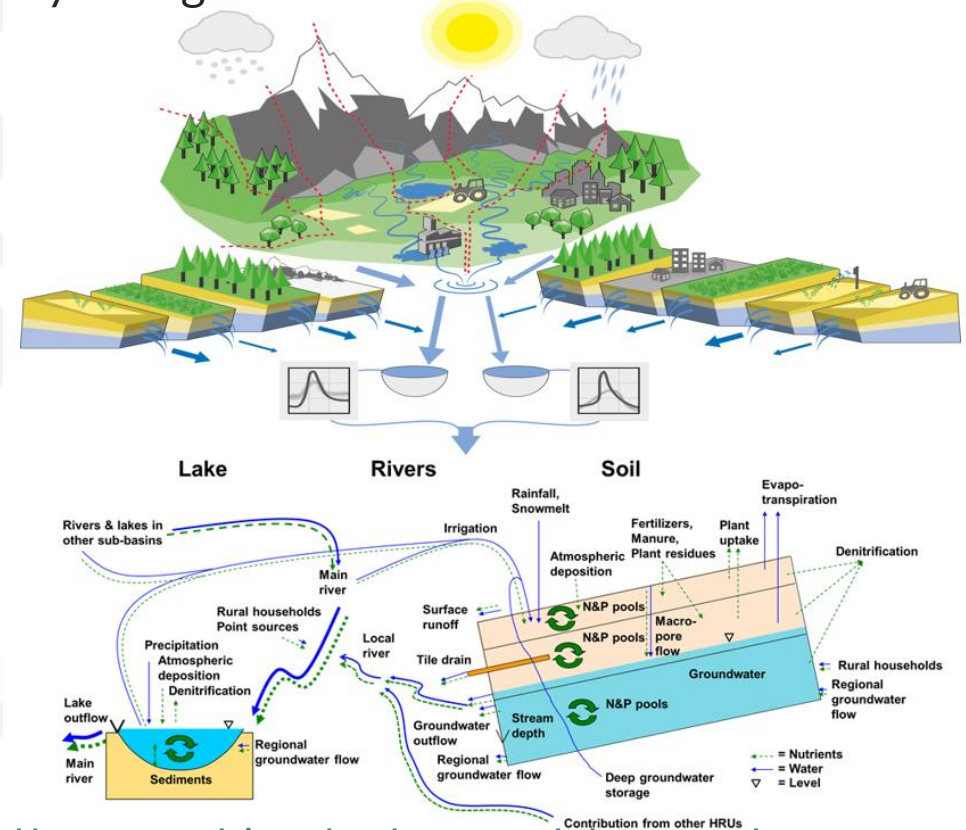
Acoperirea vegetației pe celulă de grilă  
Grid Cell Vegetation Coverage



<https://www.wur.nl/en/research-results/chair-groups/environmental-sciences/earth-systems-and-global-change-group/research/water-climate-food/vic-wur.htm>

## HYPE = Predicții Hidrologice pentru Mediu

### The Hydrological Predictions for the Environment (HYPE)



<https://www.smhi.se/en/research/research-units/hydrology/hype---our-hydrological-model>



## LISFLOOD

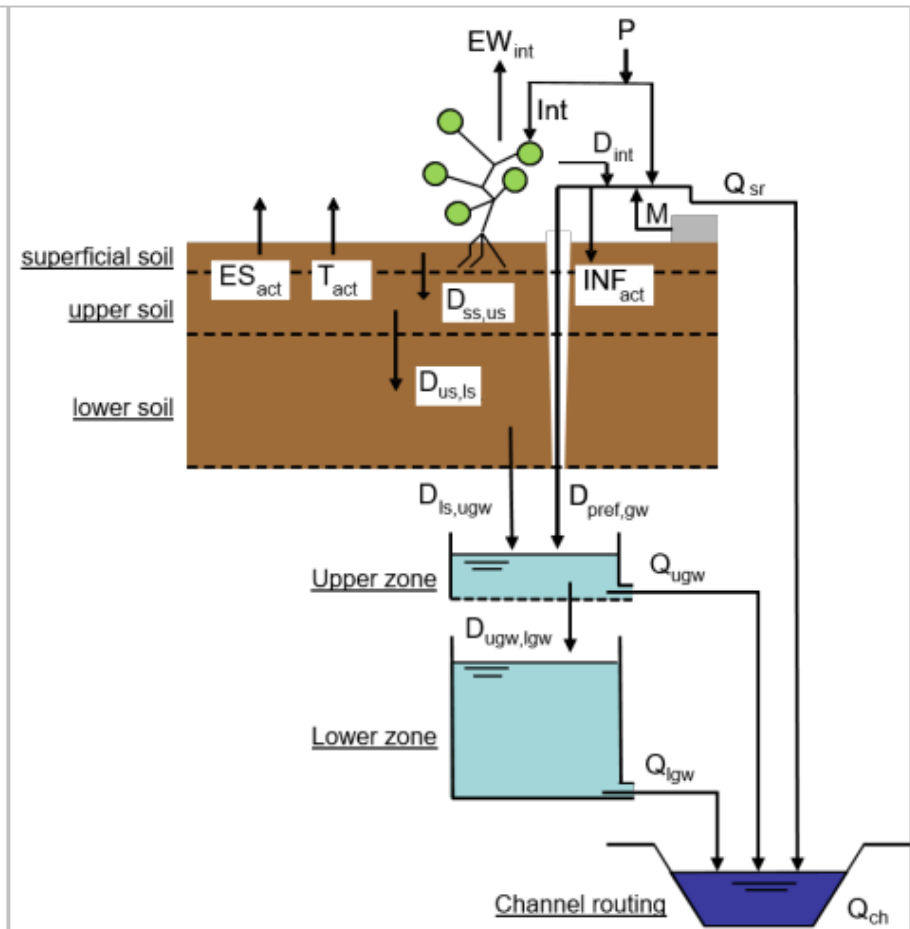
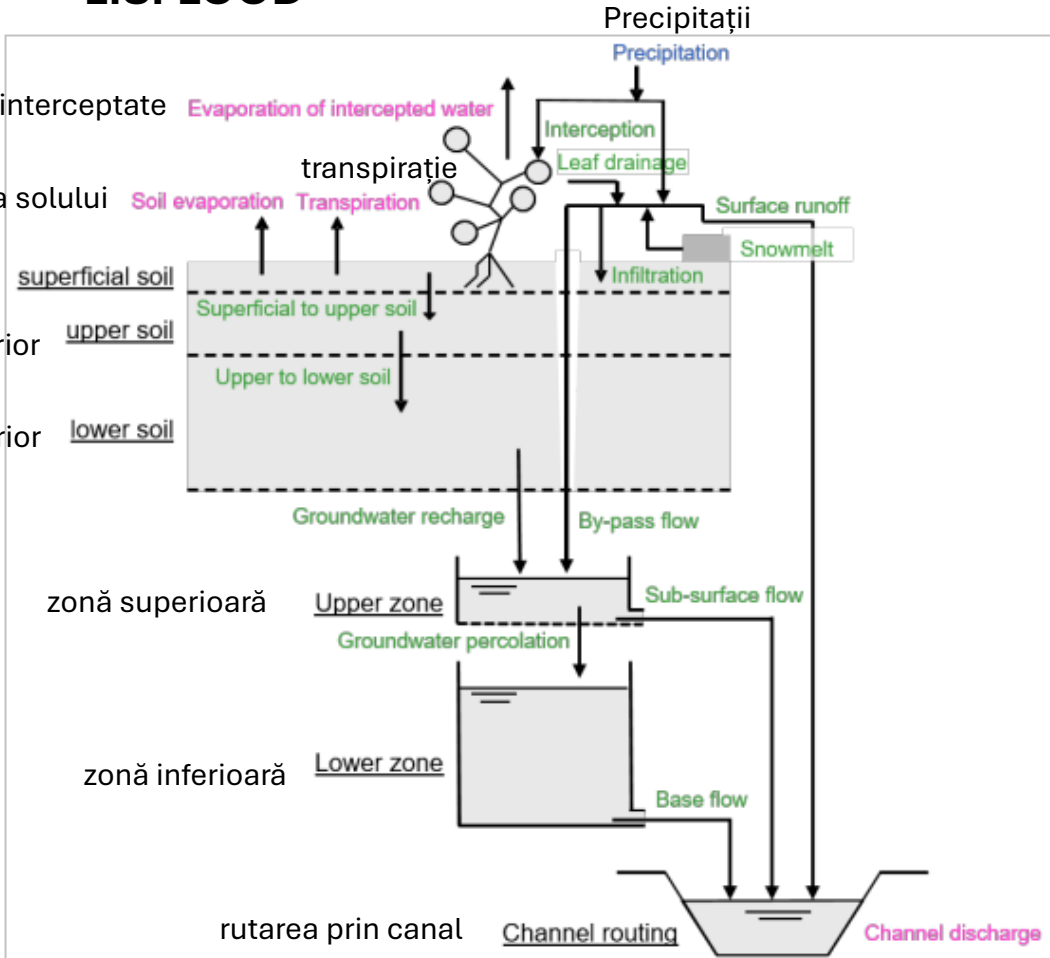
evaporarea apei interceptate Evaporation of intercepted water

evaporarea solului Soil evaporation

strat superficial al solului superficial soil

strat superior upper soil

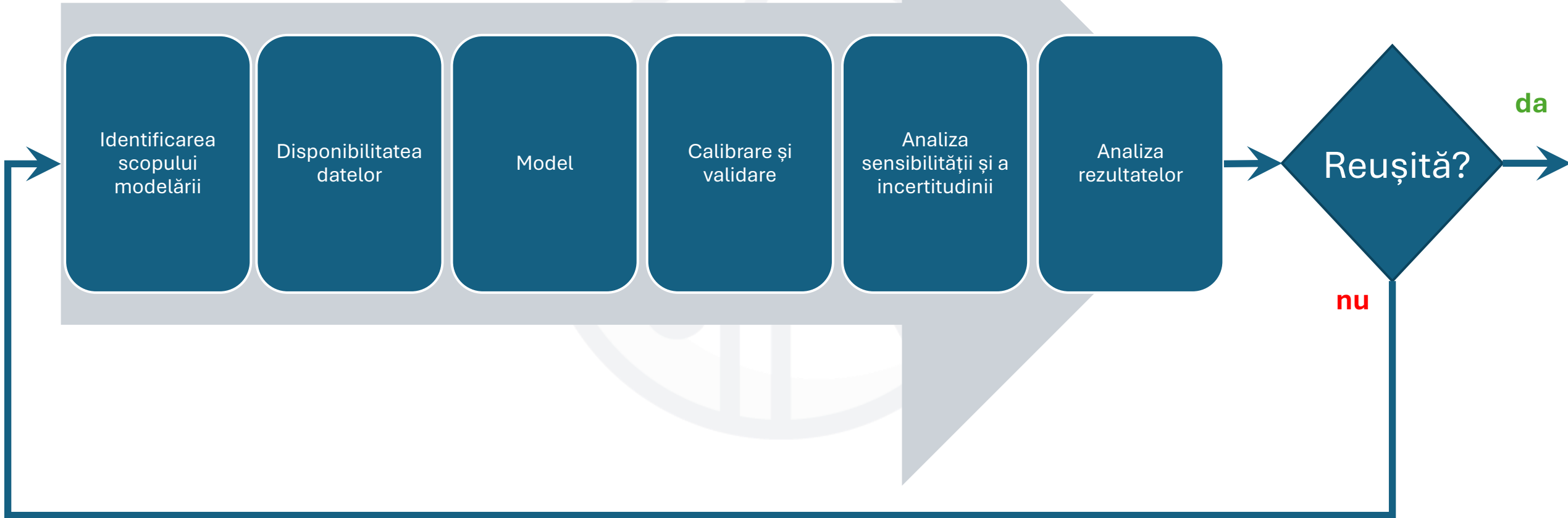
strat inferior lower soil



[https://ec-jrc.github.io/lisflood-model/2\\_01\\_stdLISFLOOD\\_overview/](https://ec-jrc.github.io/lisflood-model/2_01_stdLISFLOOD_overview/)

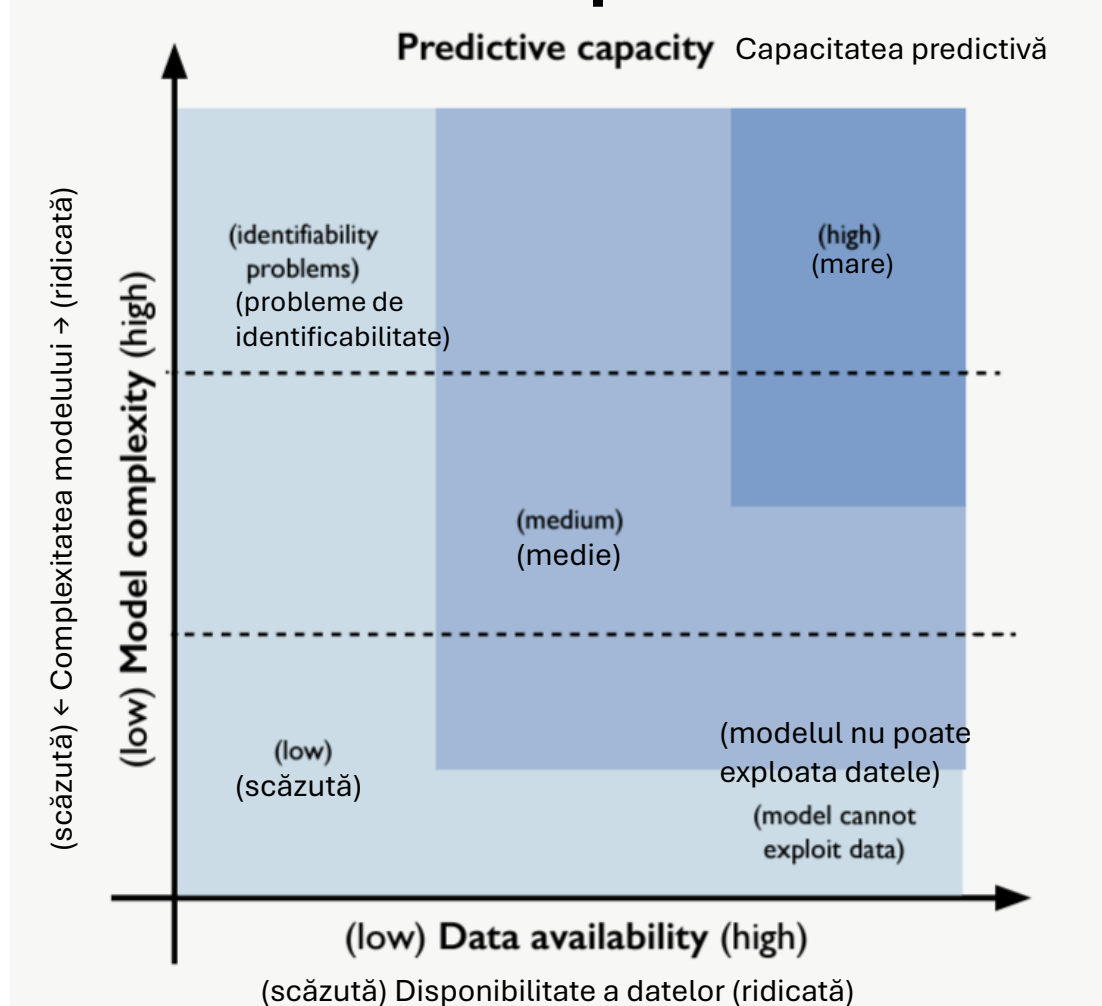


## Protocol





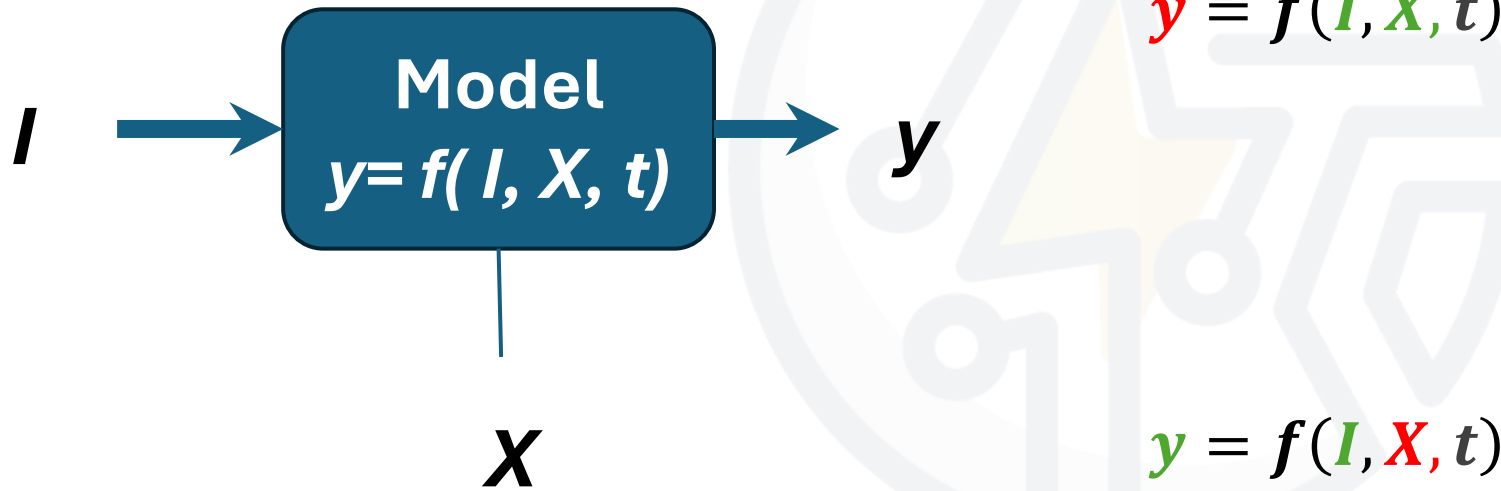
## Disponibilitatea datelor vs. complexitatea modelului



Ochoa-Tocachi, Cuadros-Adriazola, Arapa, Aste, Ochoa-Tocachi, & Bonnesoeur. (2022). *Guide to Hydrologic Modeling*. Forest Trends Association. [chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf](https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf)



## Problema inversă



Cunoaștem X și intrările, deci suntem interesați de rezultate

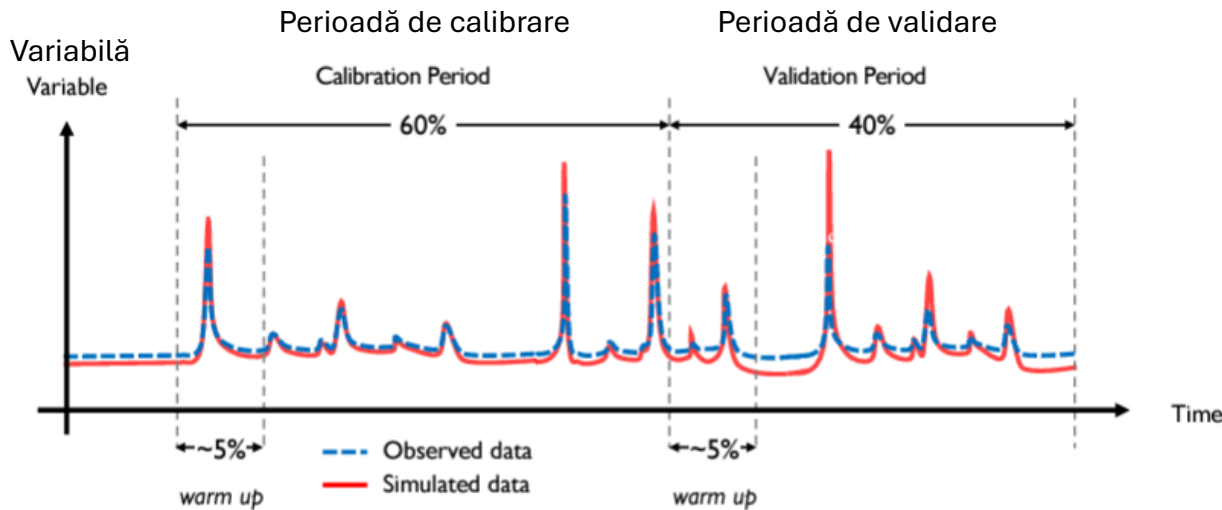
$$y = x_1 I + x_2$$

Cunoaștem intrările (I) și rezultatele (y), deci suntem interesați de parametri.

$$y = x_1 I + x_2$$



## Calibrare, validare și evaluarea performanței



Ochoa-Tocachi, Cuadros-Adriazola, Arapa, Aste, Ochoa-Tocachi, & Bonnesoeur. (2022). *Guide to Hydrologic Modeling*. Forest Trends Association. [chrome-extension://efaidnbmninnibpcapjpcglclefindmkaj/https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf](https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf)

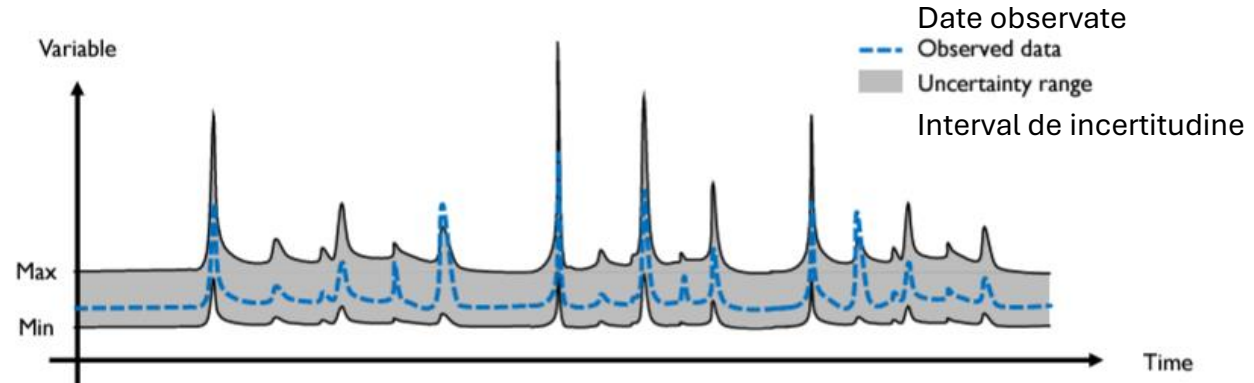
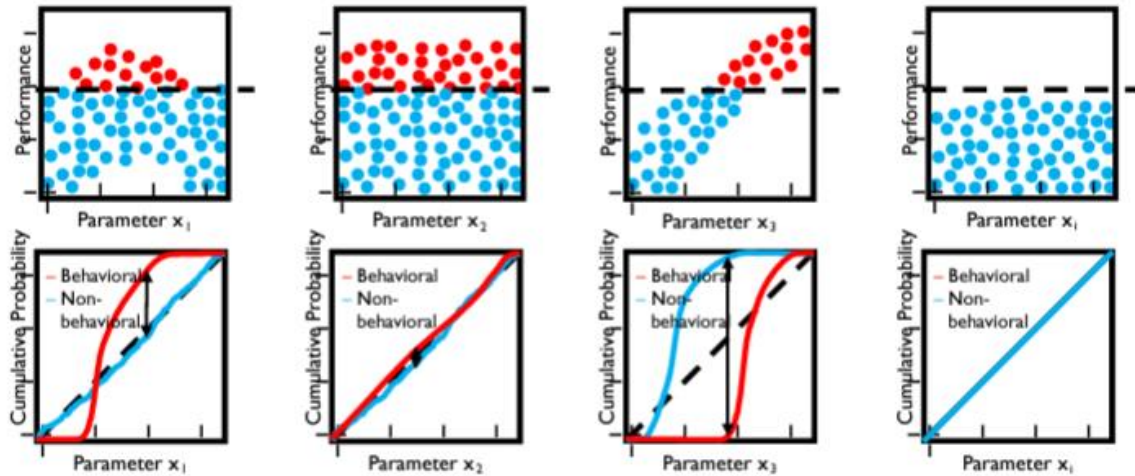
| Performance metric                          | Expression   |
|---|--|
| Mean Absolute Error (MAE)                   | $F_1 = \frac{1}{N} \sum_{t=1}^N  y_{s,t} - y_{o,t} $   |
| Mean Square Error (MSE)                     | $F_2 = \frac{1}{N} \sum_{t=1}^N  y_{s,t} - y_{o,t} ^2$   |
| Root Mean Square Error (RMSE)               | $F_3 = \left[ \frac{1}{N} \sum_{t=1}^N  y_{s,t} - y_{o,t} ^2 \right]^{1/2}$  |
| Minimax objective function                  | $F_4 = \frac{1}{N} \max  y_{s,t} - y_{o,t} $   |
| Average Absolute Percentage Error (AAPE)    | $F_5 = 100 \frac{1}{N} \sum_{t=1}^N \left  \frac{y_{s,t} - y_{o,t}}{y_{o,t}} \right $  |
| Mean Square Relative Error (MSRE)           | $F_6 = 100 \frac{1}{N} \sum_{t=1}^N \left  \frac{y_{s,t} - y_{o,t}}{y_{o,t}} \right ^2$  |
| Coefficient of determination ( $R^2$ )      | $F_7 = \left\{ \frac{\sum_{t=1}^N (y_{o,t} - \bar{y}_o)(y_{s,t} - \bar{y}_s)}{\left[ \sum_{t=1}^N (y_{o,t} - \bar{y}_o)^2 \right]^{0.5} \left[ \sum_{t=1}^N (y_{s,t} - \bar{y}_s)^2 \right]^{0.5}} \right\}^2$ |
| Index of agreement ( $D$ )                  | $F_8 = 1 - \frac{\sum_{t=1}^N (y_{s,t} - y_{o,t})^2}{\sum_{t=1}^N ( y_{s,t} - \bar{y}_o  +  y_{o,t} - \bar{y}_o )^2}$  |
| Nash–Sutcliffe Efficiency coefficient (NSE) | $F_9 = 1 - \frac{\sum_{t=1}^N (y_{s,t} - y_{o,t})^2}{\sum_{t=1}^N (y_{o,t} - \bar{y}_o)^2}$  |

Biondi, D., Freni, G., Iacobellis, V., Mascaro, G., & Montanari, A. (2012). Validation of hydrological models: Conceptual basis, methodological approaches and a proposal for a code of practice. *Physics and Chemistry of the Earth, Parts A/B/C*, 42–44, 70–76. <https://doi.org/10.1016/j.pce.2011.07.037>

Modified Kling–Gupta efficiency  $KGE' = 1 - \sqrt{(\gamma - 1)^2 + (\beta - 1)^2 + (r - 1)^2}$



## Analiza sensibilității și a incertitudinii



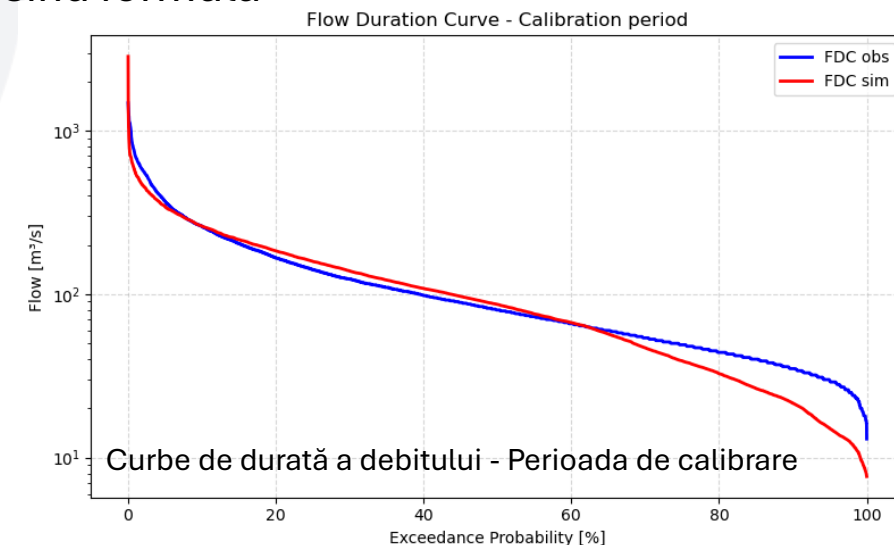
Ochoa-Tocachi, Cuadros-Adriazola, Arapa, Aste, Ochoa-Tocachi, & Bonnesoeur. (2022). *Guide to Hydrologic Modeling*. Forest Trends Association. [chrome-extension://efaidnbmnnnibpcajpcglclefndmkaj/https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf](https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf)



## Curbele de durată a debitului

O curbă de frecvență cumulată care arată procentul de timp în care anumite debite sunt egale sau depășite

- Aranjează debitele în ordine cronologică
- Determină numărul de înregistrări (N)
- Sortează datele de la cea mai mare la cea mai mică valoare
- Atribuie ranguri ( $m = 1$  pentru valoarea cea mai mare și  $m = N$  pentru cea mai mică)
- Calculează probabilitatea de depășire pentru fiecare valoare folosind formula corespunzătoare
- Reprezintă  $p$  pe axa x și  $Q$  (ordonat) pe axa y





## Ajustarea funcției PDF: Gumbel

- **Extreme Value Distribution:** Extreme value distributions are widely used in hydrology. Storm rainfalls are most commonly modeled by the **Extreme Value Type I distribution**. Below is the “cumulative” probability distribution version of the function.

$$F(x) = e^{-e^{-\frac{x-u}{\alpha}}} \quad -\infty \leq x \leq \infty$$

$$\alpha = \frac{\sqrt{6}s_x}{\pi}$$

$$u = \bar{x} - 0.5772\alpha$$

$$\text{Let } y = \frac{x-u}{\alpha}$$

**Distribuția valorilor extreme:** Distribuțiile valorilor extreme sunt utilizate pe scară largă în hidrologie. Precipitațiile de furtună sunt cel mai frecvent modelate prin distribuția de **tipul I a valorilor extreme**. Mai jos este versiunea „cumulativă” a funcției de distribuție a probabilității.

- Correlating “y” with Return Period (T), the Extreme Value Distribution can be simplified to:

$$x_T = u + \alpha y_T$$

$$y_T = -\ln \left[ \ln \left( \frac{T}{T-1} \right) \right]$$

$$(x-u) / \alpha = -\ln (-\ln (F(x)))$$

$$x = -\ln (-\ln (F(x))) \cdot \alpha + u$$

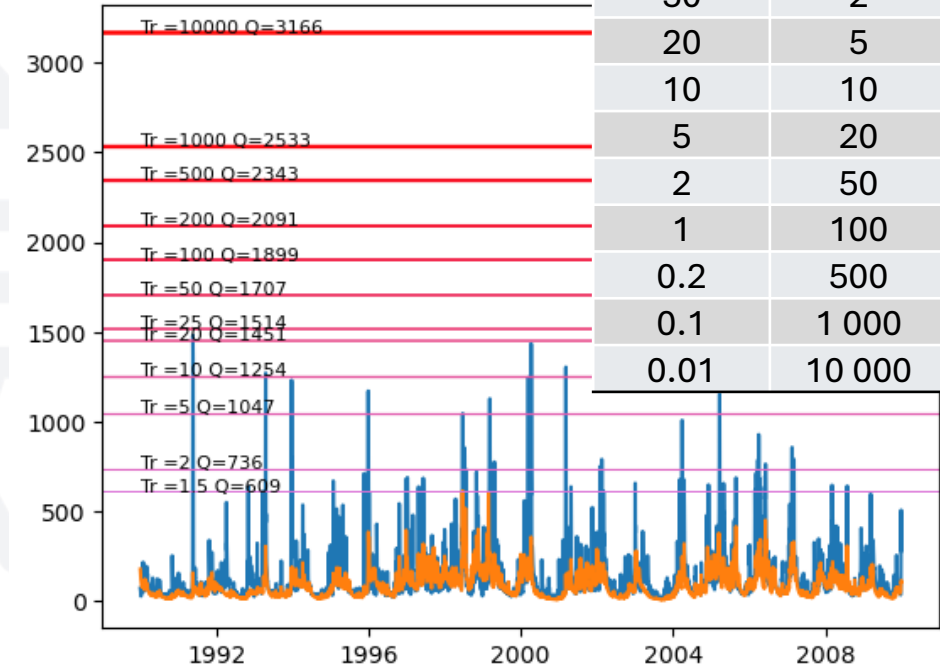
$$\mu_y = 0,5772; \sigma_y = 1,2825$$

$$\alpha = s_x / \sigma_y$$

$$u = \bar{x} - \mu_y \cdot \alpha$$

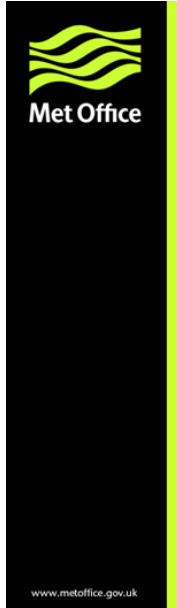
$$Pr = 1/Tr$$

| Pr    | Tr      |
|-------|---------|
| [%]   | [Years] |
| 66.67 | 1.5     |
| 50    | 2       |
| 20    | 5       |
| 10    | 10      |
| 5     | 20      |
| 2     | 50      |
| 1     | 100     |
| 0.2   | 500     |
| 0.1   | 1 000   |
| 0.01  | 10 000  |





## Prognoză prin ansamblu (Ensemble forecasting)



### Ensembles

Incertitudinea condițiilor inițiale

prognoză deterministă

Deterministic forecast

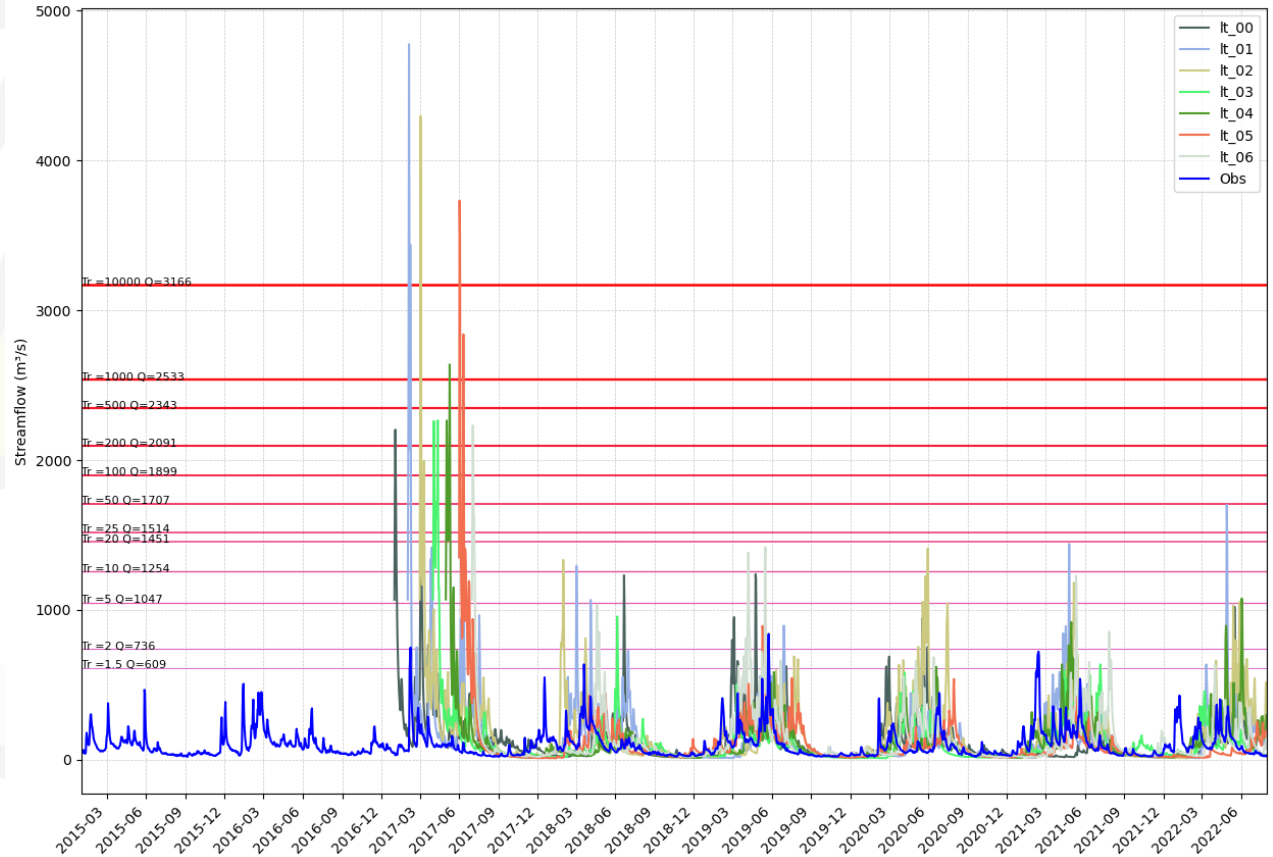
Initial condition uncertainty

Analysis analiză

Time

climatology  
Climatology

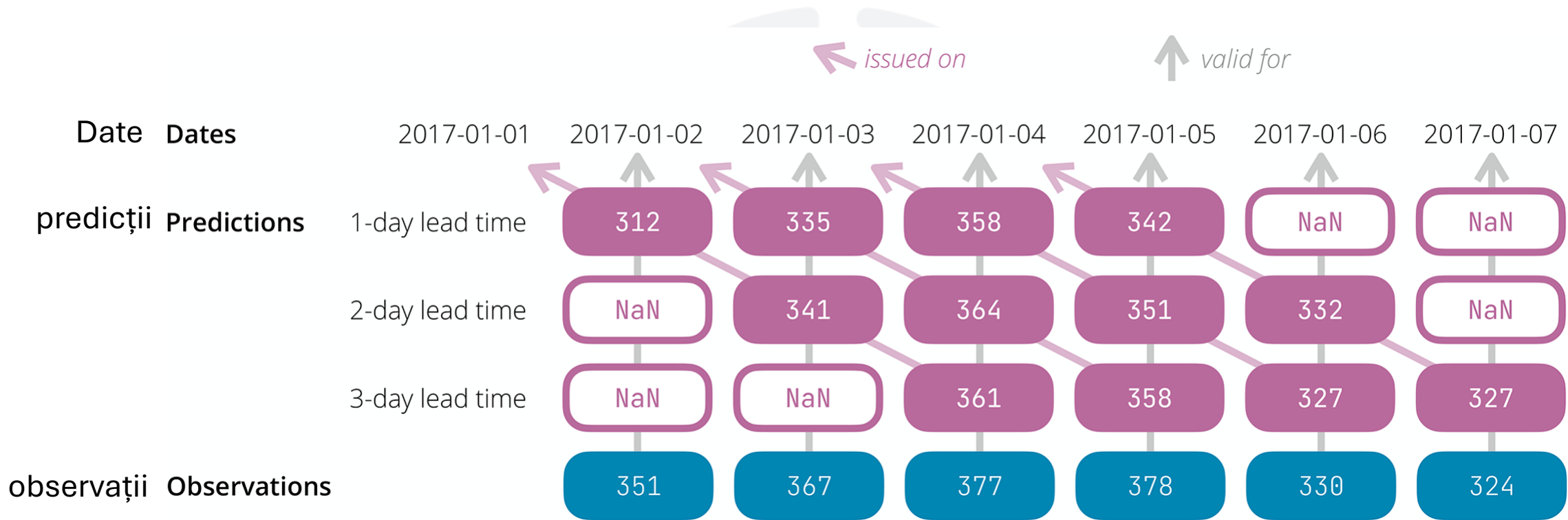
incertitudinea prognozei  
Forecast uncertainty



<https://www.rmets.org/metmatters/ensembles-how-forecast-comes-together>



## Înțelegerea timpului de anticipație (lead time)



Hallouin, T., Bourgin, F., Perrin, C., Ramos, M.-H., & Andréassian, V. (2024). EvalHyd v0.1.2: A polyglot tool for the evaluation of deterministic and probabilistic streamflow predictions. *Geoscientific Model Development*, 17(11), 4561–4578. <https://doi.org/10.5194/gmd-17-4561-2024>

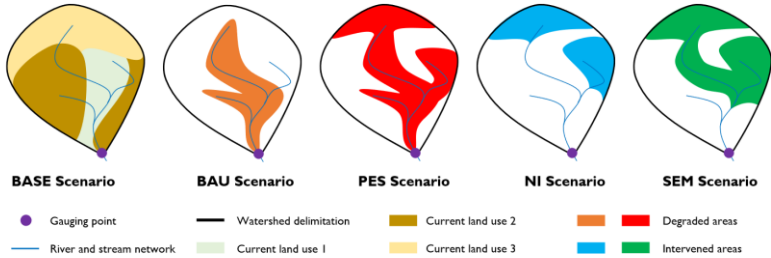
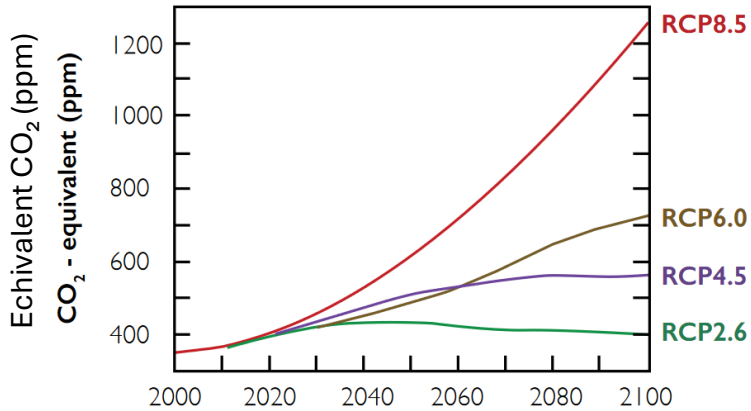




## Analiza rezultatelor

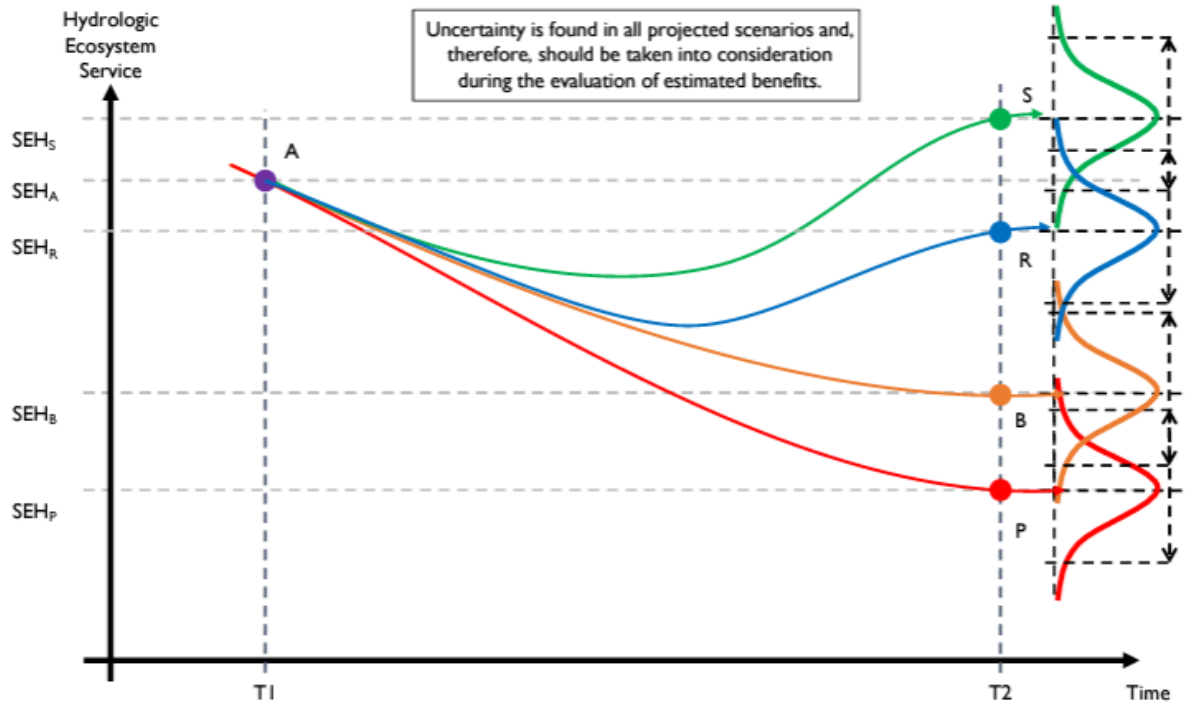
### Ce se întâmplă dacă...

Căile reprezentative de concentrare IPCC  
IPCC Representative Concentration Pathways



Serviciu ecosistemic hidrologic

Incertitudinea este prezentă în toate scenariile proiectate și, prin urmare, trebuie luată în considerare în timpul evaluării beneficiilor estimate.



Ochoa-Tocachi, Cuadros-Adriazola, Arapa, Aste, Ochoa-Tocachi, & Bonnesoeur. (2022). *Guide to Hydrologic Modeling*. Forest Trends Association. [chrome-extension://efaidnbmninnibpcapjpcglclefindmkaj/https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf](https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf)



## Indicatori de performanță pentru prognoza prin ansamblu

Brier Score (BS) → Scorul Brier

$$BS = \overline{(p - o)^2}$$

Brier Skill Score (BSS) → Scorul de abilitate Brier

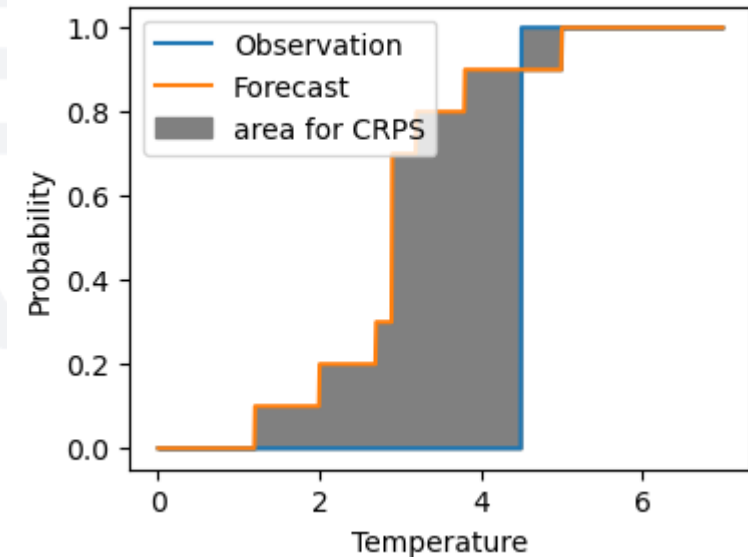
Rank Probability Scores (RPS) → Scorul probabilității ordonate

Continuous Ranked Probability Scores (CRPS) → Scorul continuu al probabilității ordonate

Continuous Ranked Probability Skill Score (CRPSS) → Scorul de abilitate al probabilității ordonate continue

Funcția de distribuție cumulativă empirică (CDF) bazată pe ansamblu

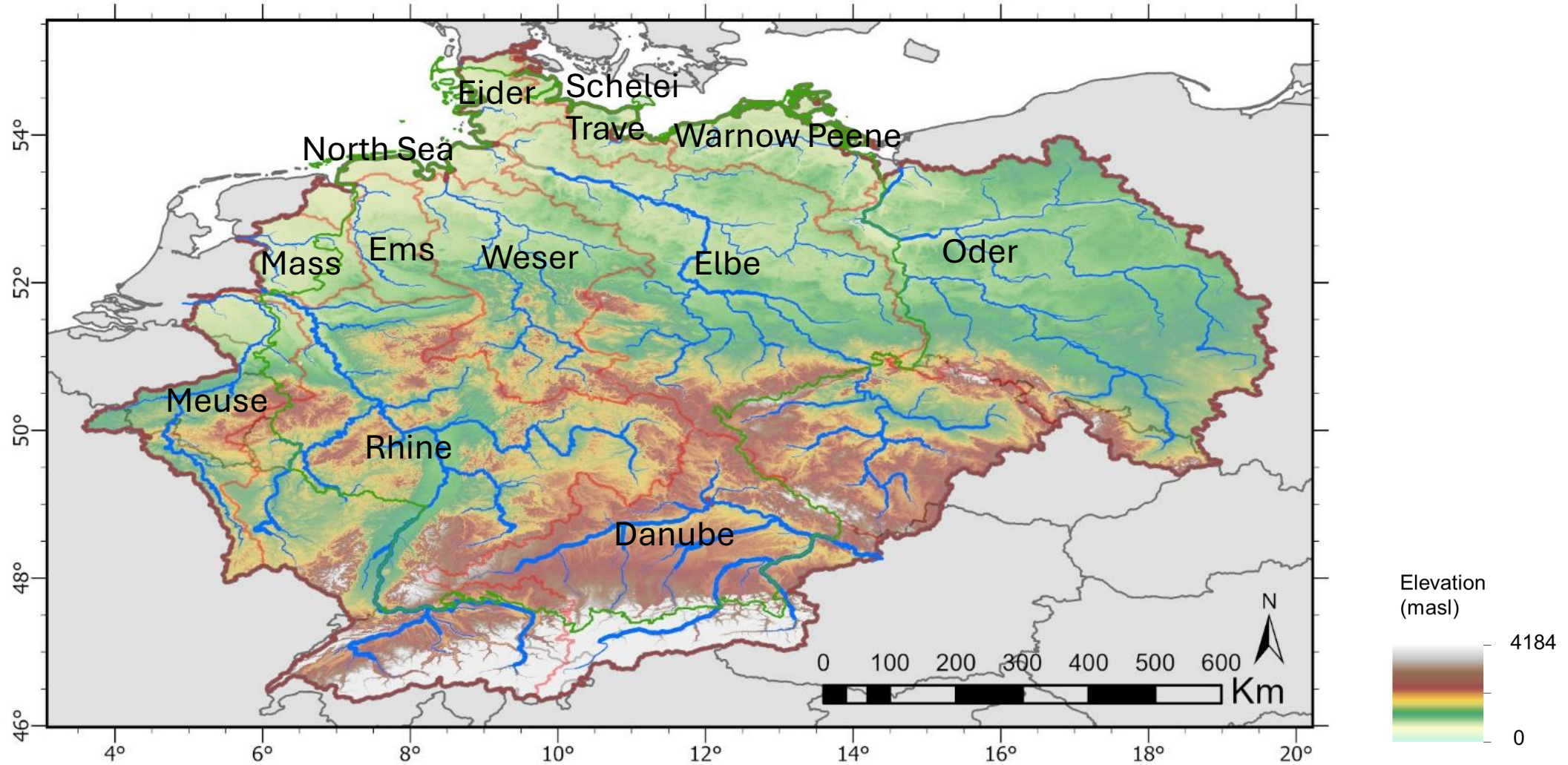
Empirical CDF based on Ensemble



<https://confluence.ecmwf.int/display/FUG/Section+12.B+Statistical+Concepts+-+Probabilistic+Data>



# 3. Exemplu – DAKI-FWS



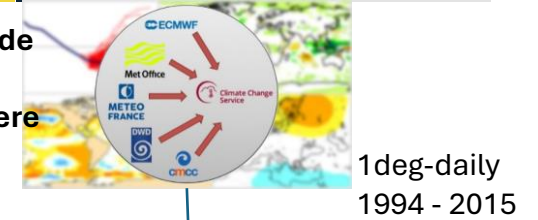
## Methodology

1 Pregătirea datelor de intrare:  
Forțări meteorologice:  
pd, rgd, tn, tx, ws, ta

1 Pregătirea datelor de intrare:  
Hărți statice

1 Pregătirea datelor de intrare:  
Observații hidrologice:  
Debite (streamflow)  
Informații despre stații

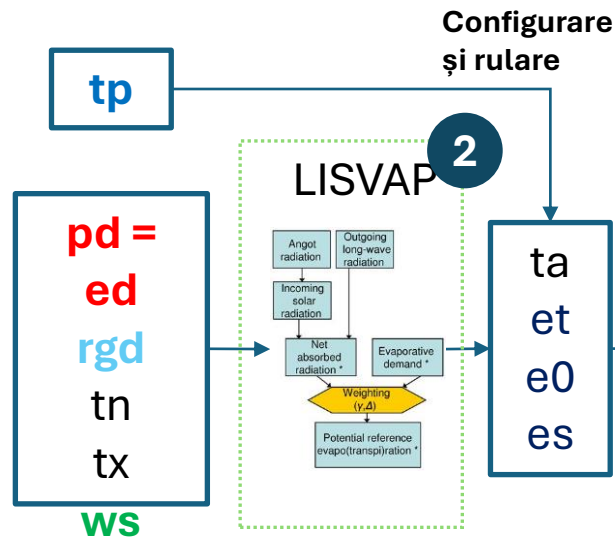
1 Pregătirea datelor de intrare:  
Prognoze sezoniere reforecast



Debite observate ale cursurilor de apă  
• GRCD  
• <https://www.pegelportal.de/>

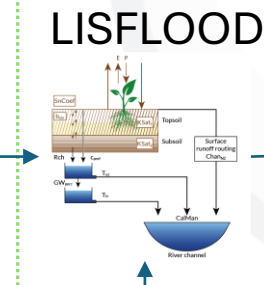
Prognoză sezonieră + Inteligență Artificială (AI) Downscaling Corecția erorilor (bias correction)

1 arc-daily 1994 - 2015



1 arcmin-daily 1990 - 2021

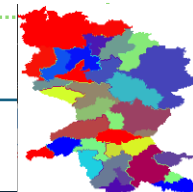
3 Configurare și rulare



Qsim

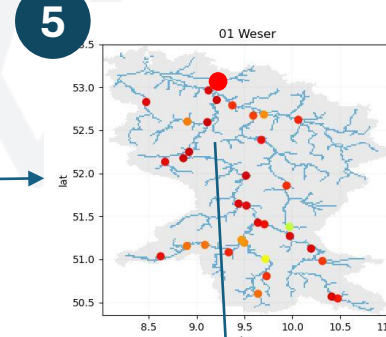
4 Calibrare

Parametri calibrații (x14)



Qobs

5 Calculul „pseudo-observațiilor”



1 arcmin-daily 1990 - 2021

6 Prognoză hidrologică sezonieră

7 Evaluarea performanței

8 Cartografiere



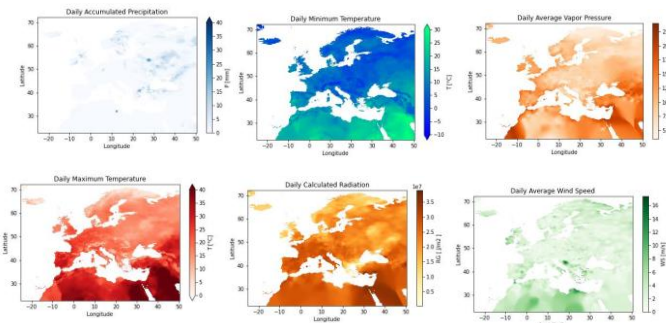
## Forțările meteorologice

## Hidrologie

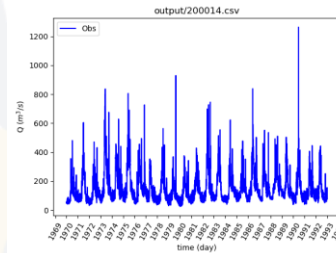
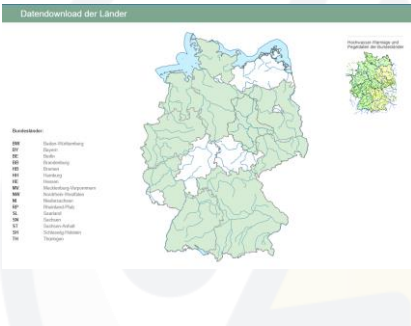
## Proprietăți morfologice, fizice, de sol și de utilizare a terenurilor

### Observații:

### EFAS

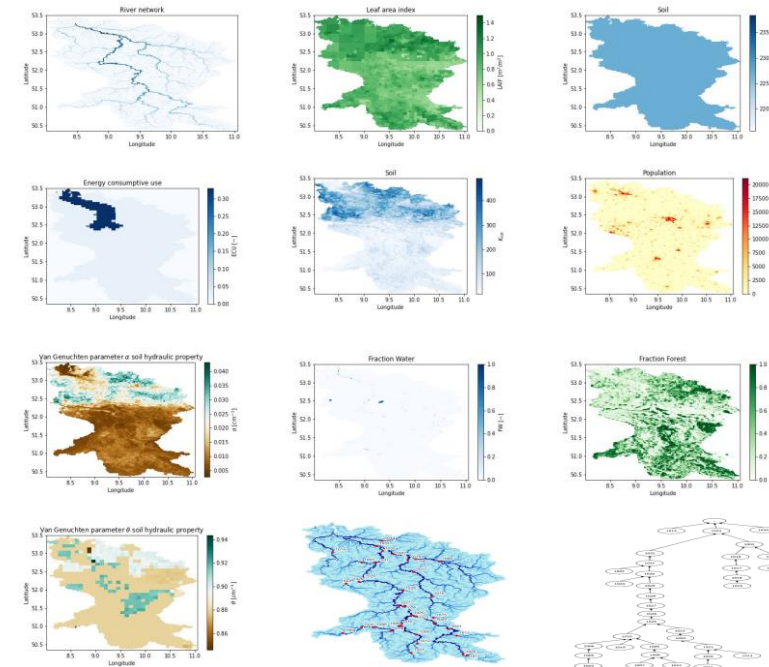
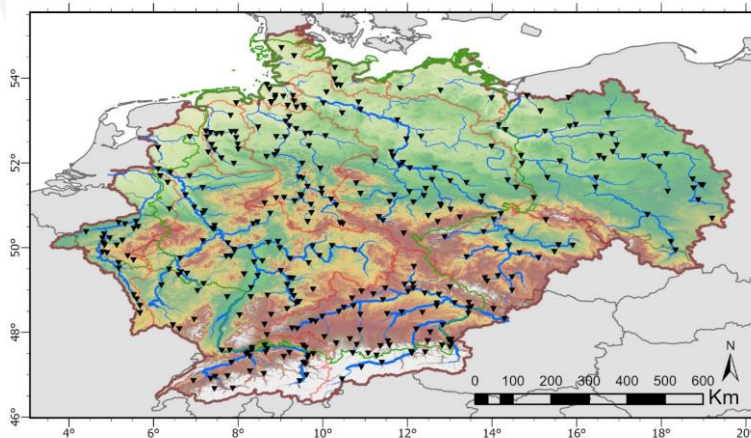
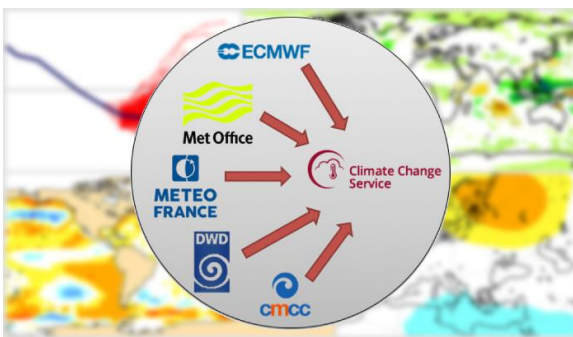


### Pegelportal



EMO – 1  
 Rezoluție spațială: 1 arcmin  
 Rezoluție temporală: zilnică  
 Perioadă: 1990–2021

### Prognoză sezonieră Re-forecast



### EFAS

Francesca Moschini; Margarita Choulga; Cinzia Mazzetti; Disperati, Juliana; Grimaldi, Stefania; Salamon, Peter; Prudhomme, Christel (2023): LISFLOOD static and parameter maps for Europe. European Commission, Joint Research Centre (JRC) [Dataset] PID: <http://data.europa.eu/89h/f572c443-7466-4adf-87aa-c0847a169f23>



## Pre-processor LISVAL

LISVAP instalat și testat pe sistemul HPC Levante

1. Installing/initializing git for large file Instalarea/inițializarea Git pentru fișiere mari

```
git lfs install
```

2. clone LISVAP from the repository Clonarea LISVAP din depozit (repository)

```
git clone https://github.com/ec-jrc/lisflood-lisvap.git
```

```
cd lisflood-lisvap
```

3. Creating a conda environment for lisvap Crearea unui mediu Conda pentru LISVAP

```
conda create --name lisvap python=3.8 --no-default-packages
```

```
source activate lisvap
```

4. Installing and checking lisvap Instalarea și verificarea LISVAP

```
pip install -r requirements.txt
```

5. Installing and checking pcraster Instalarea și verificarea PCRaster

```
conda install -c conda-forge pcraster
```

6. Running LISVAP from scr folder Rularea LISVAP din folderul scr

```
python lisvap1.py /my_system/lisflood-lisvap/tests/data/tests_efas.xml -v -t
```

```
#####
##      ##### ##      #####
##      ## ## ##      ## ## ##
##      ## ## ##      ## ## ##
##      ## ## ##      ## ## ##
##      ## ## ##      ## ## ##
#####

#####

TIP:
You can use $(ProjectDir) or $(ProjectPath) as built-in variable to use in this XML settings, to refer Lisvap project folder (in cas
You can use $(SettingsDir) or $(SettingsPath) to refer directory containing the XML settings.
-->

<lfsettings>
  <lfuser>
    <group>
      <comment>
        *****
        TIME-RELATED CONSTANTS
        *****
      </comment>
      <textvar name="CalendarDayStart" value="01/01/1995 00:00">
        <comment>
          calendar day number of 1st day in model run
          e.g. 1st of January: 1; 1st of June: 151 (or 152 in leap year)
        </comment>
      </textvar>
      <textvar name="DtSec" value="86400">
        <comment>
          time step [seconds] ALWAYS USE 86400!!
        </comment>
      </textvar>
      <textvar name="StepStart" value="01/01/1995 06:00">
        <comment>
          Number of first time step in simulation
        </comment>
      </textvar>
      <textvar name="StepEnd" value="31/12/1995 06:00">
        <comment>
          Number of last time step
        </comment>
      </textvar>
      <textvar name="ReportSteps" value="1..14">
        <comment>
          *****
        </comment>
      </textvar>
    </group>
  </lfuser>
</lfsettings>
```



## Modelul hidrologic LISFLOOD

LISFLOOD, LISFLOOD-Utilities și instrumentele de calibrare LISFLOOD instalate și testate pe sistemul HPC Levante.

(Funcționează în serie și în paralel.)

```
# 2023-05-05 Installing Lisflood Calibration tool
# installation for solving the multiprocessing problems attemp 1

module load python3
module load git

conda create --name lisflood_calibration_2 python=3.7 -c conda-forge

git clone --single-branch https://github.com/ec-jrc/lisflood-calibration.git

source activate lisflood_calibration_2
conda install -c conda-forge pcraster gdal
pip install lisflood-model==4.1.2

# pip show lisflood-model # allows you to know where is the source code of lisflo
# /work/bb1245/hydromodelling/conda_venvs/lisflood_calibration_2/lib/python3.7/si
# After installing lisflood compile the cython module kinematic_wave_parallel_to
# To compile this Cython module to enable OpenMP multithreading (parallel kinemat
# Delete the files *.so (if any) in directory hydrological-modules
# Inside the hydrological_modules folder, execute "python compile_kinematic_wave_

# For get rid of the errors in related with hdf5
conda remove hdf5
conda install -c conda-forge hdf5==1.12.1

# other tools
pip install pandas
pip install numpy
pip install matplotlib
pip install netCDF4
pip install deap
conda install -c conda-forge deap

pip install -r requirements.txt # run it in the lisflood_code folder
pip install . # run it in the lisflood_calibration folder

pip install tbb # For parallelization
```

```
#####
##      ##      ##      ##      ##      ##      ##      ##
##      ##      ##      ##      ##      ##      ##      ##
##      ##      ##      ##      ##      ##      ##      ##
##      ##      ##      ##      ##      ##      ##      ##
#####

<lfsettings>

<lfoptions>
#-----
# modelling and reporting options
#-----
<setoption choice="0" name="TemperatureInKelvin"/>
<setoption choice="1" name="gridSizeUserDefined"/>

# options to turn hydrological modules on/off
<setoption choice="0" name="cropsEPIC"/>

<setoption choice="1" name="wateruse"/>
<setoption choice="1" name="TransientWaterDemandChange"/>
<setoption choice="0" name="useWaterDemandAveYear"/>
<setoption choice="1" name="wateruseRegion"/>

<setoption choice="0" name="groundwaterSmooth"/>
<setoption choice="1" name="wateruseRegion"/>
<setoption choice="1" name="drainedIrrigation"/>
<setoption choice="1" name="riceIrrigation"/>
<setoption choice="0" name="indicator"/>

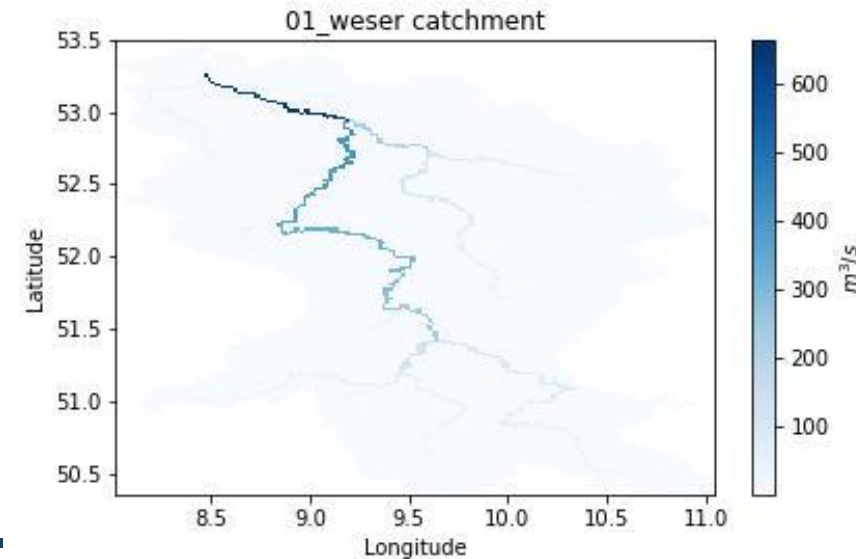
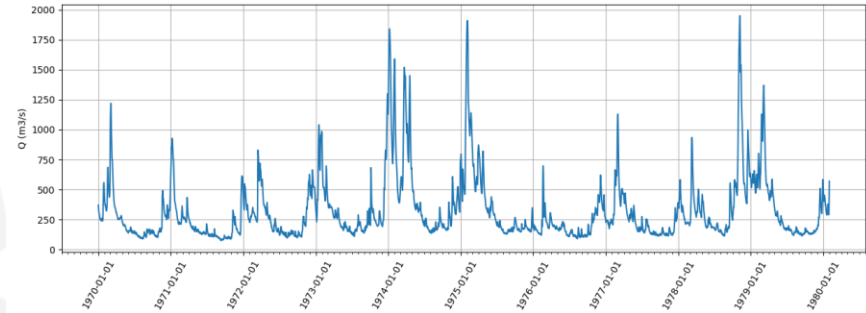
<setoption choice="1" name="openwaterevapo"/>
<setoption choice="0" name="simulateLakes"/>
<setoption choice="0" name="simulateReservoirs"/>

<setoption choice="0" name="simulateReservoirs"/>

<setoption choice="1" name="SplitRouting"/>

# use inflow data
<setoption choice="0" name="inflow"/>

# option to initialize Lisflood
<setoption choice="0" name="InitLisflood"/>
```





## Calibrare – Validare

### Algoritmul Genetic cu Sortare Nedominată – II (NSGA-II)

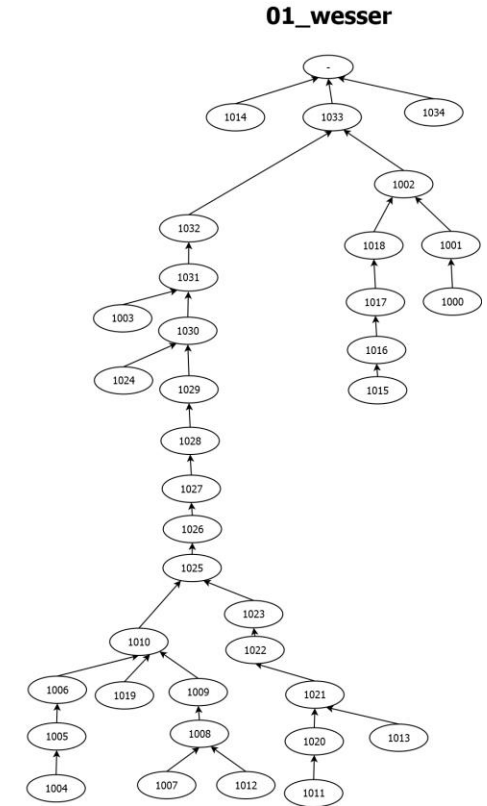
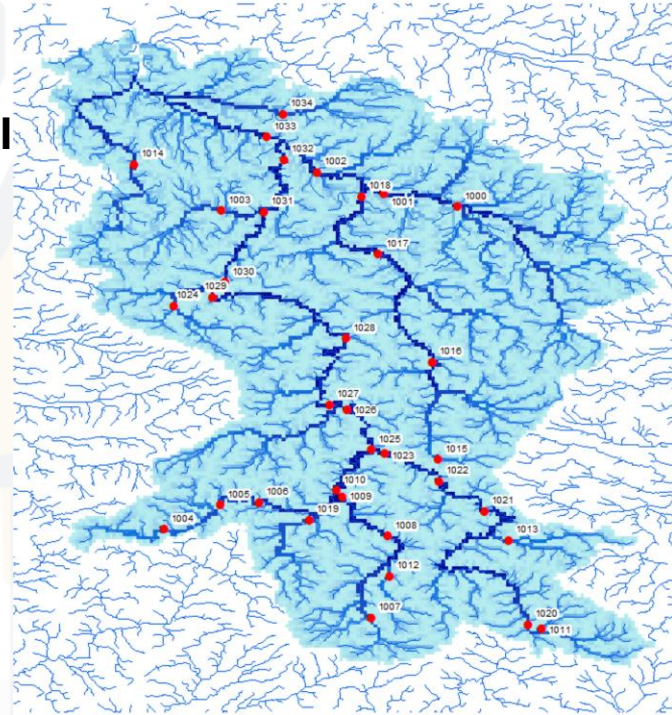
### Eficiența modificată Kling-Gupta (KGE)

$$KGE' = 1 - \sqrt{(r - 1)^2 + (\beta - 1)^2 + (\gamma - 1)^2}$$

$$r_{xy} = \frac{\sum_i x_i y_i - n \bar{x} \bar{y}}{\sqrt{\sum_i x_i^2 - n \bar{x}^2} \sqrt{\sum_i y_i^2 - n \bar{y}^2}}$$

$$\beta = \frac{\mu_s}{\mu_o} \quad \gamma = \frac{\sigma_s / \mu_s}{\sigma_o / \mu_o}$$

| KGE'      | Description          |
|-----------|----------------------|
| 1.0 - 0.8 | Very good Foarte bun |
| 0.8 - 0.6 | Good Bun             |
| 0.6 - 0.4 | Medium Mediu         |
| 0.4 - 0.2 | Poor Slab            |
| < 0.2     | Bad Foarte slab      |





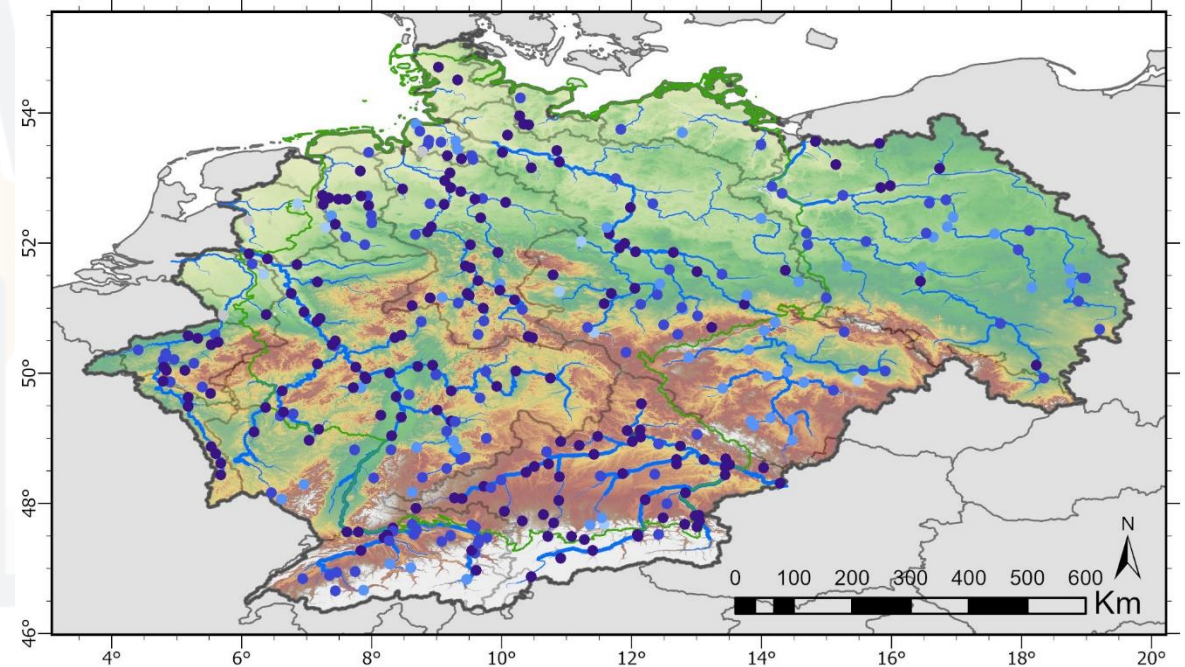
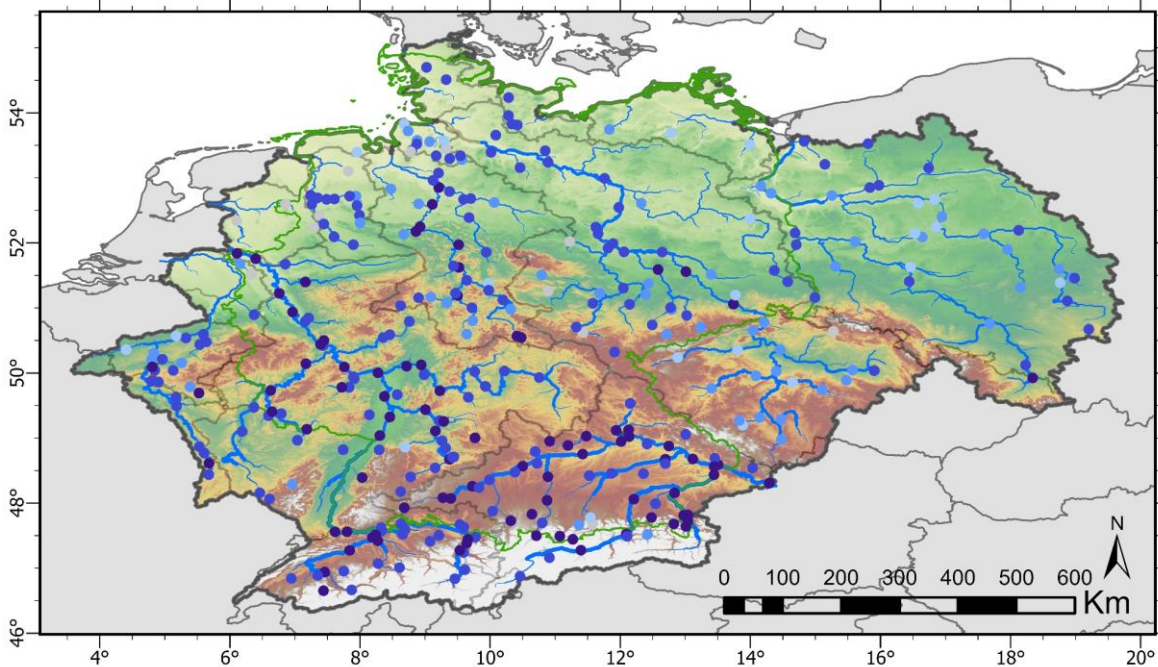
## Calibrare – Validare

### Calibrare

### Validare

- Excelent
- Bun
- Acceptabil
- Scăzut
- Foarte Scăzut

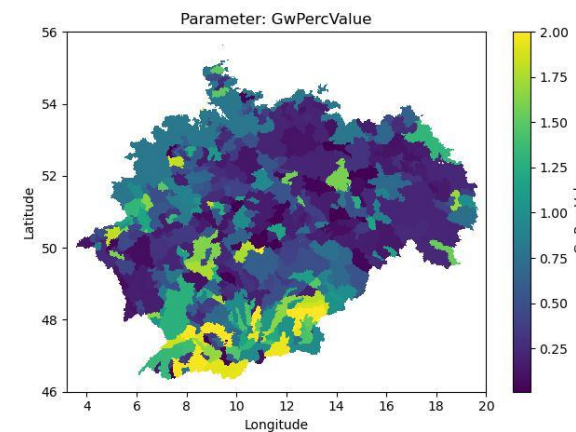
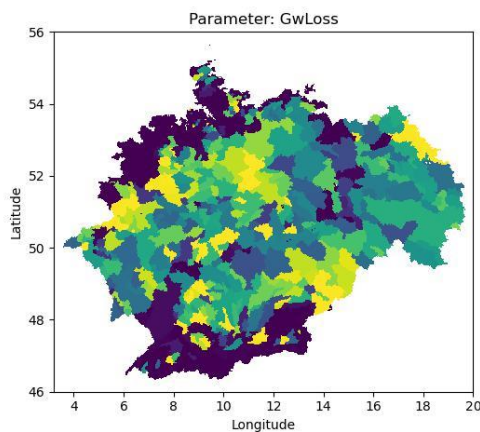
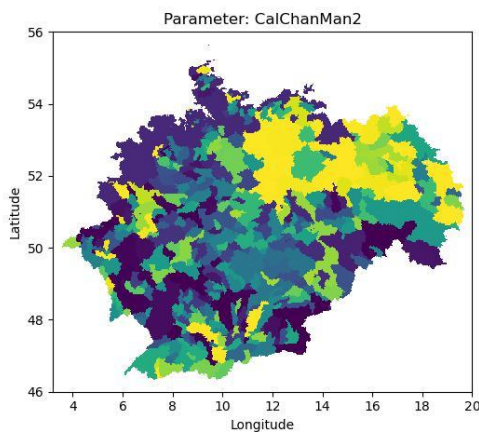
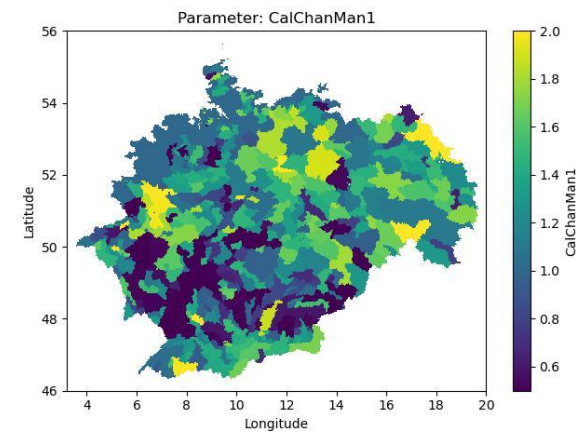
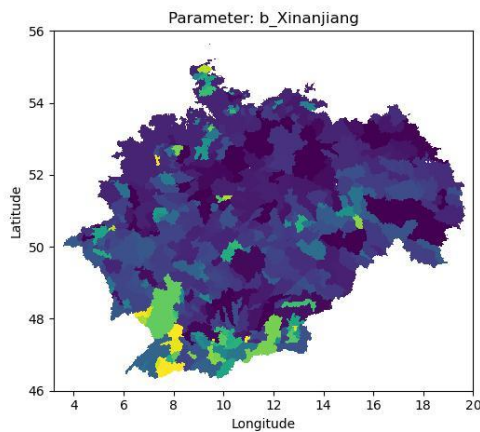
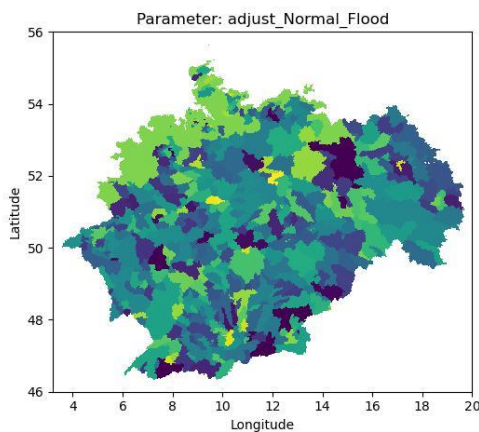
| KGE'      | Description |
|-----------|-------------|
| 1.0 - 0.8 | Excellent   |
| 0.8 - 0.6 | Good        |
| 0.6 - 0.4 | Acceptable  |
| 0.4 - 0.2 | Low         |
| < 0.2     | very low    |





## Hărțile parametrilor pentru regiunea de studiu

... un total de 14 hărți

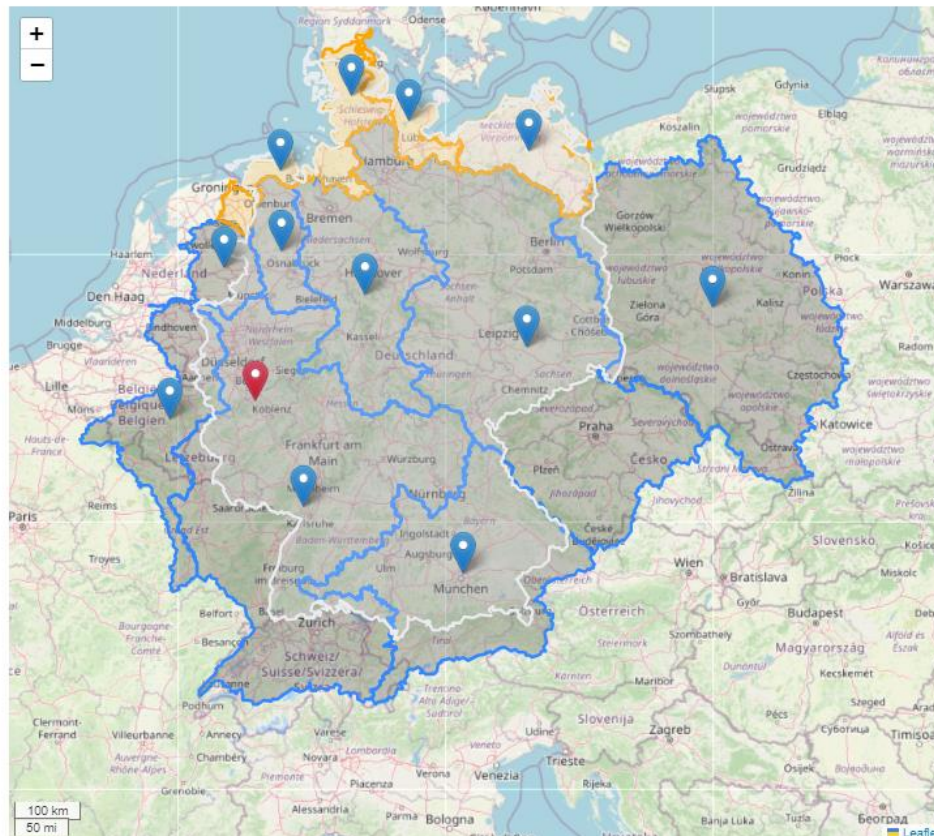




## Dashboard

### Bazine hidrografice de interes Catchments of interest

List of catchments Listă de bazine



Clicked Point 7.184211526660529, 50.54654466503386

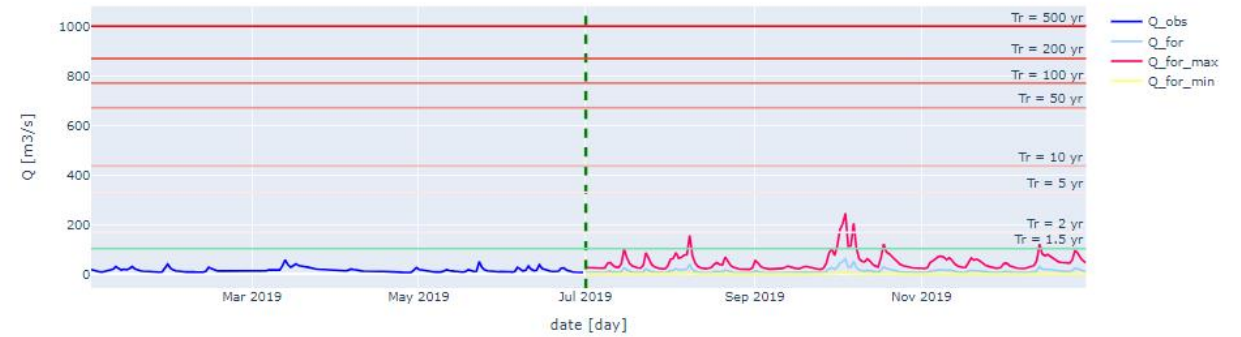
Selected catchment: None

Information about the calibration

## Prognoză hidrologică sezonieră Hydrological seasonal forecast

DAKI-FWS

Hidrograf  
Hydrograph

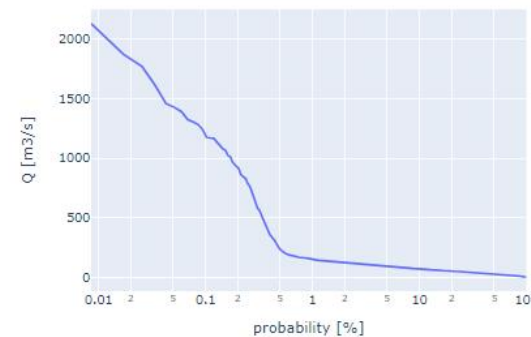


### Curba duratei debitului

Flow duration curve

Observed period

### Perioadă observată



(12.47, 65.30) means  $pr(Q > 65.30 \text{ m}^3/\text{s}) = 12.78 \%$

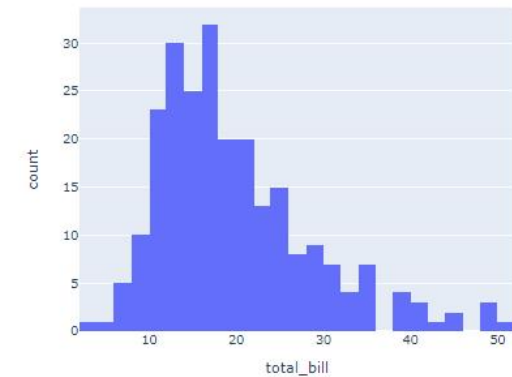
(p, q) means  $pr(Q > q) = p$

### Probabilitate de depășire

Probability of exceedence

Forecast period

### Perioadă de prognoză



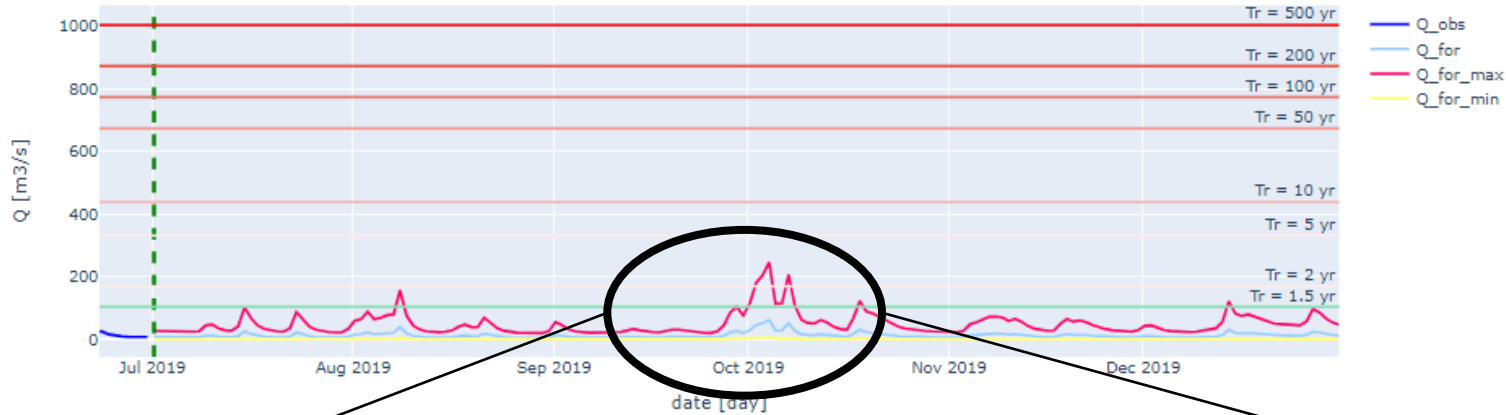


SCEWERO

# 3. Exemplu – DAKI-FWS

Lon = 10.063°

Lat = 52.622°



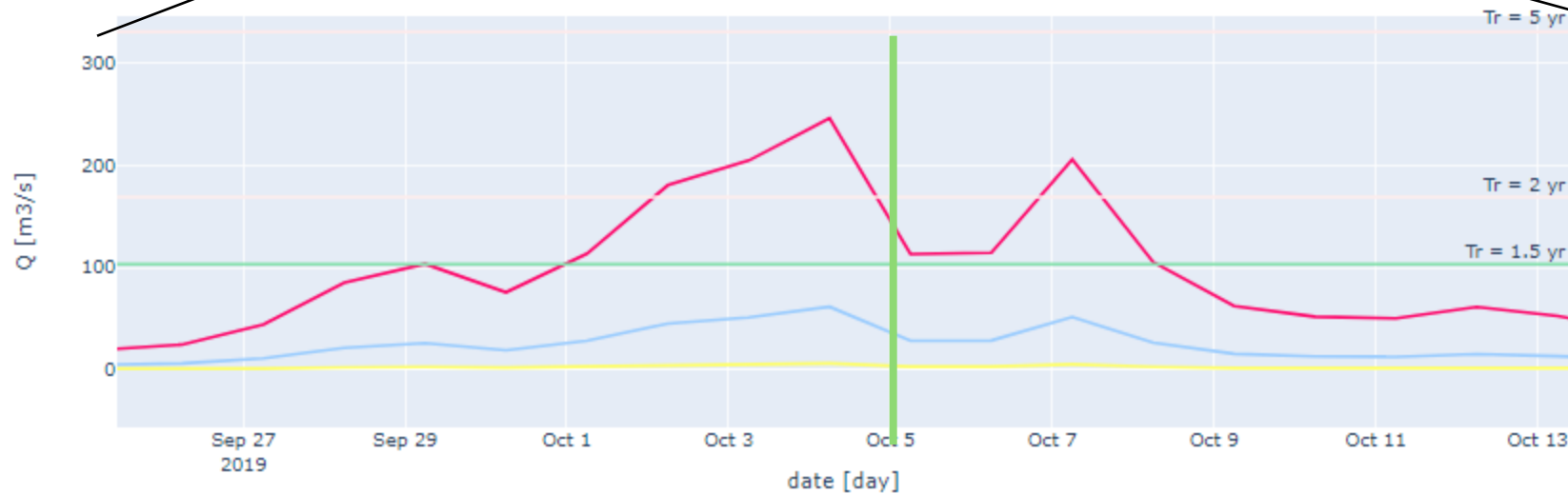
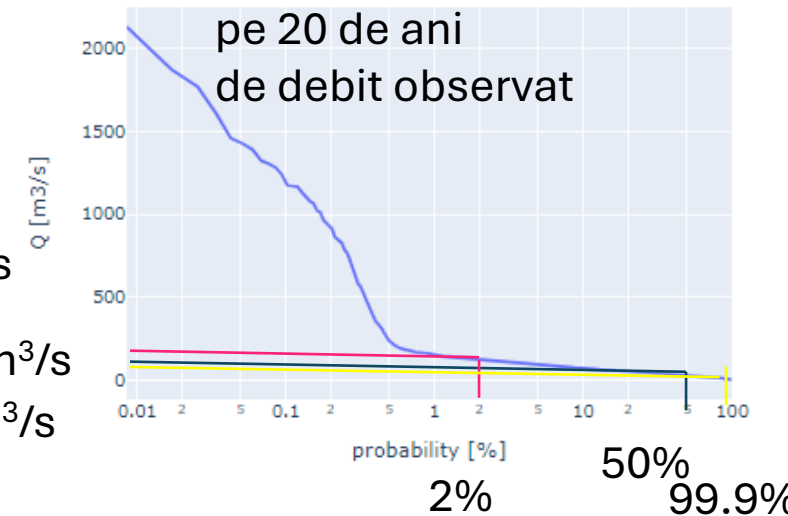
113m<sup>3</sup>/s

28.31 m<sup>3</sup>/s

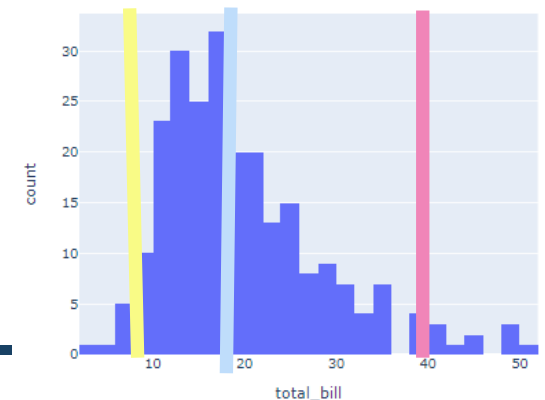
2.8 m<sup>3</sup>/s

STRENGTHENING THE RESEARCH CAPACITIES FOR EXTREME WEATHER EVENTS IN ROMANIA

Probabilitate bazată pe 20 de ani de debit observat



- Q<sub>max</sub> = 113m<sup>3</sup>/s
- Q<sub>mean</sub> = 28.31 m<sup>3</sup>/s
- Q<sub>min</sub> = 2.83 m<sup>3</sup>/s



UNIVERSITATEA BABEȘ-BOLYAI

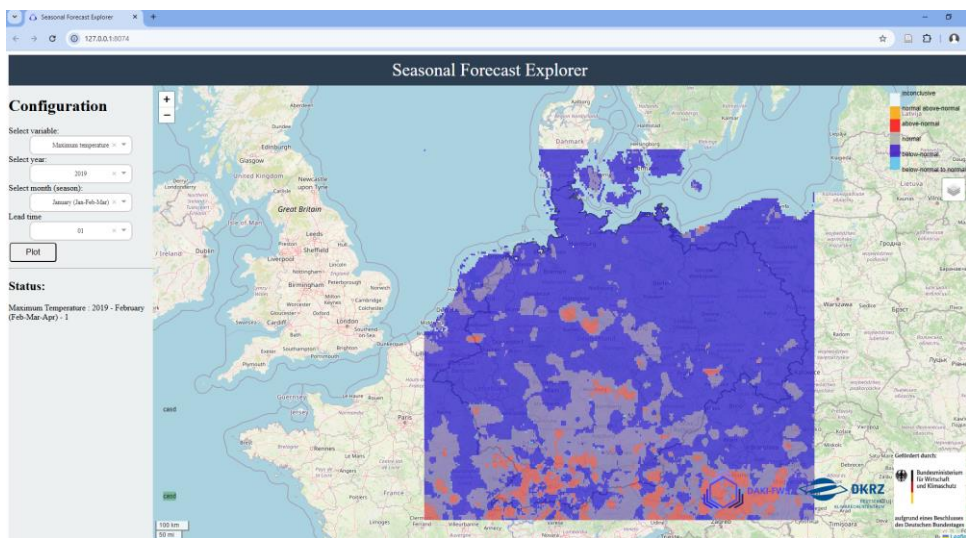


Universiteit Antwerpen

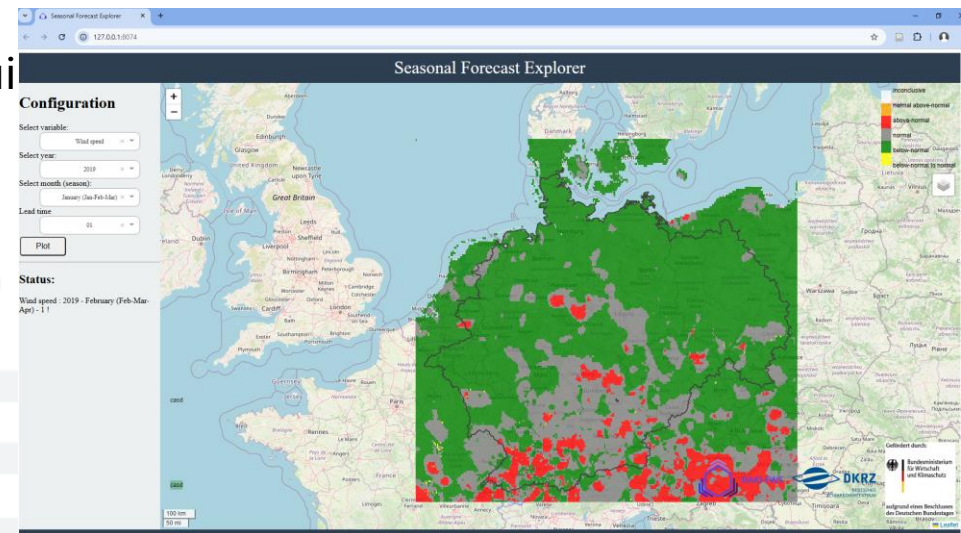




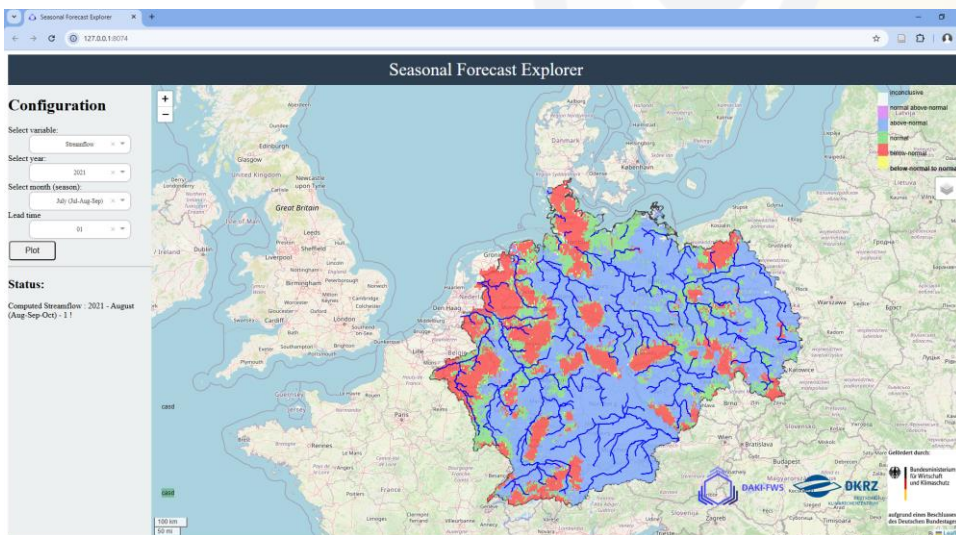
Temperatură



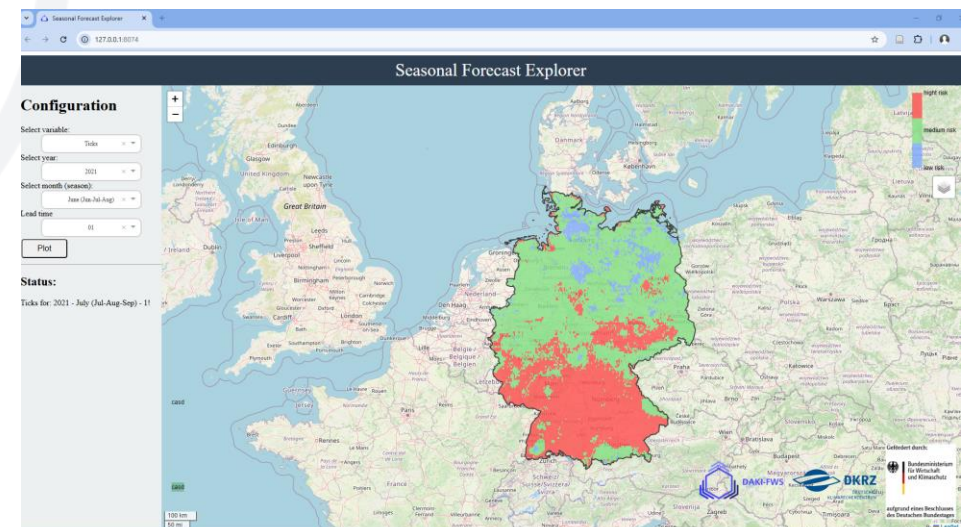
Viteza vântului



Debite



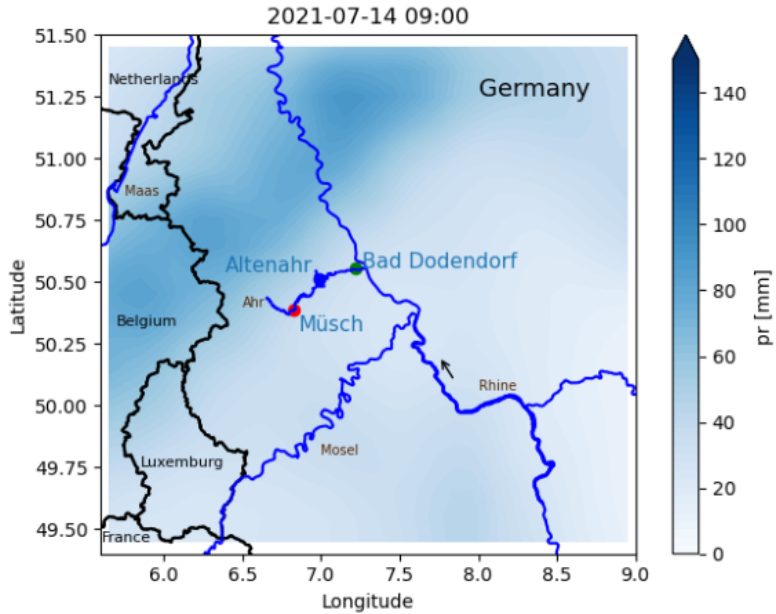
Ticks



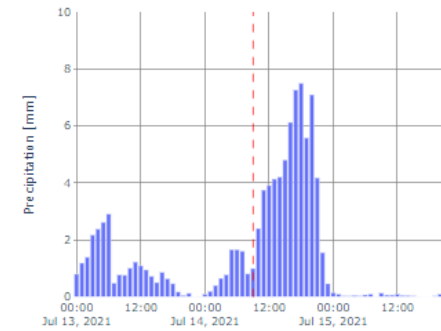


## Propagation of the Ahrtal flood in 2021 Propagarea inundației din Ahrtal, 2021

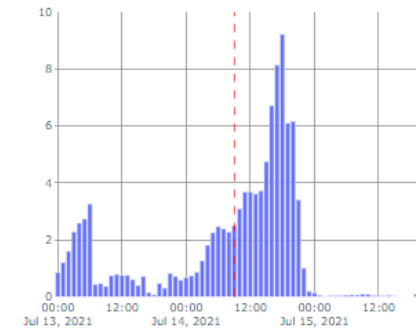
Cumulative rainfall in the region:  
Precipitații cumulate în regiune:



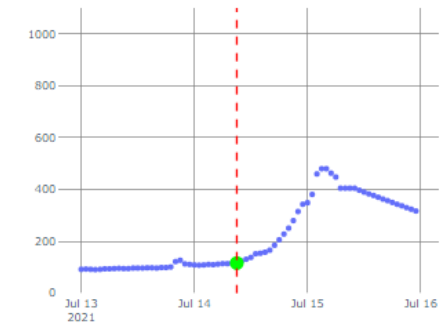
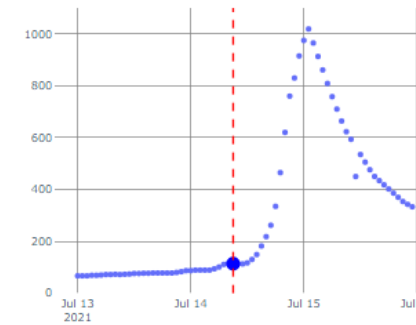
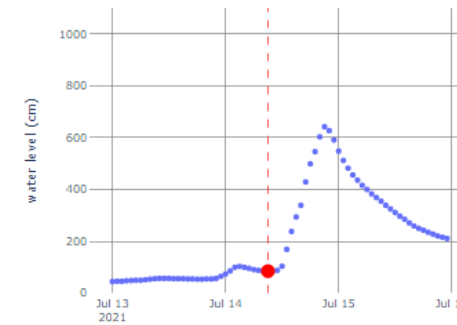
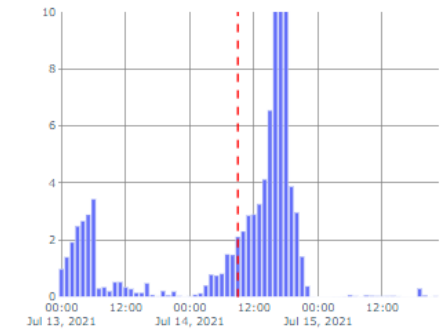
Müsch



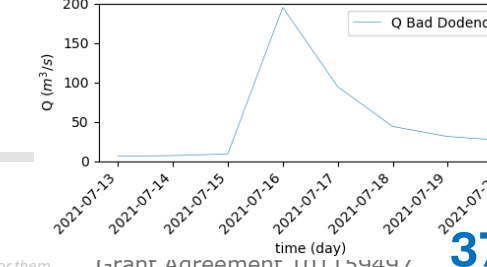
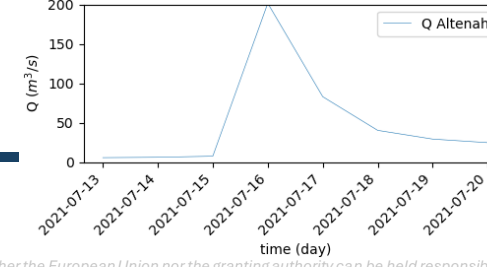
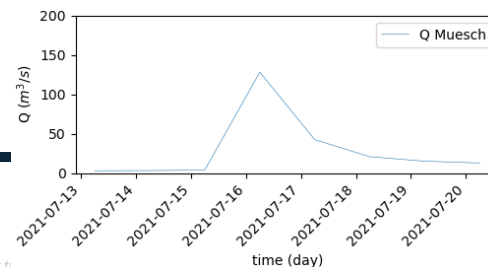
Altenahr



Bad Dodendorf



## Precipitații și nivelul apei observate



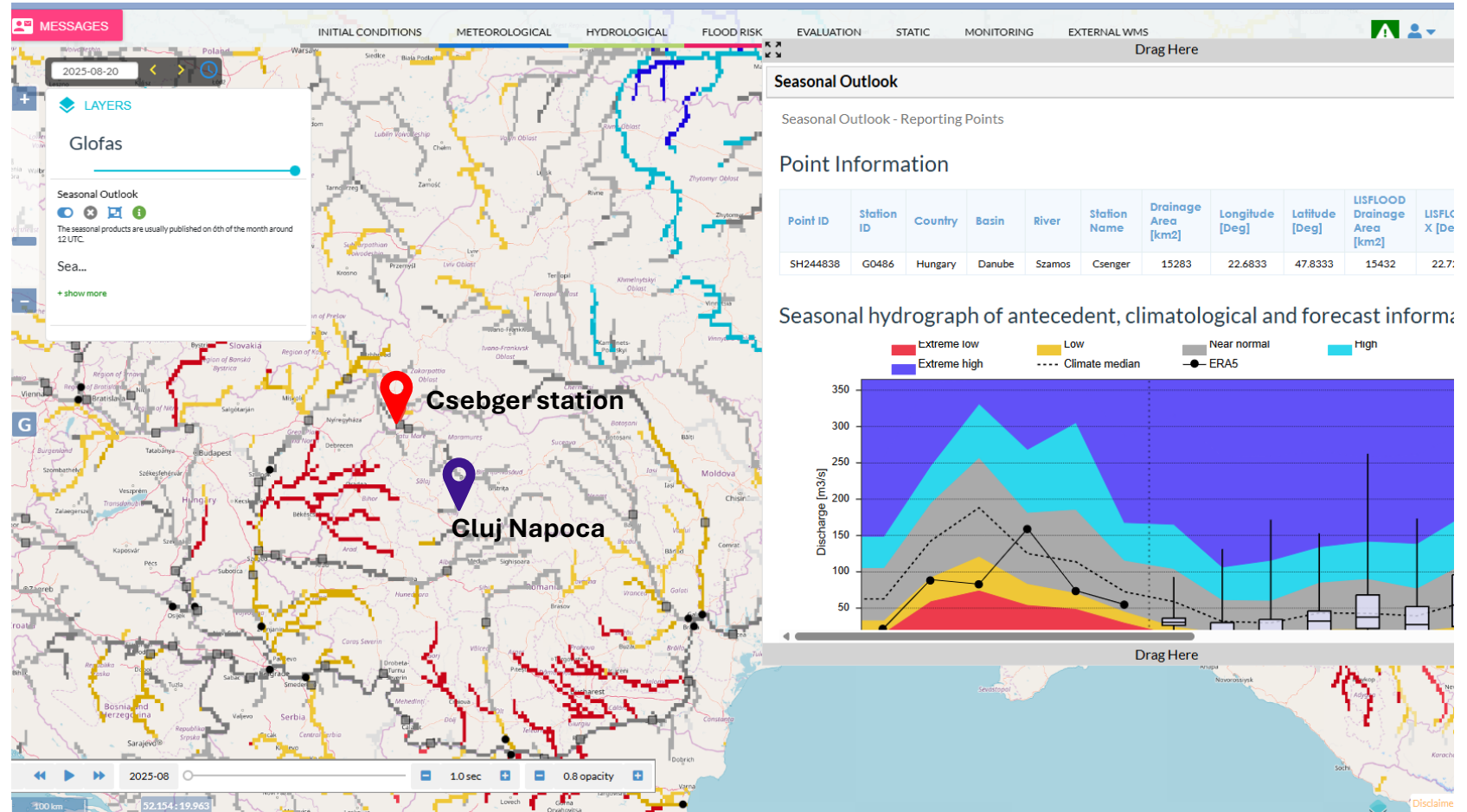


## Global Flood Awareness System - GLOFAS

<https://global-flood.emergency.copernicus.eu/>

## European Flood Awareness System - EFAS

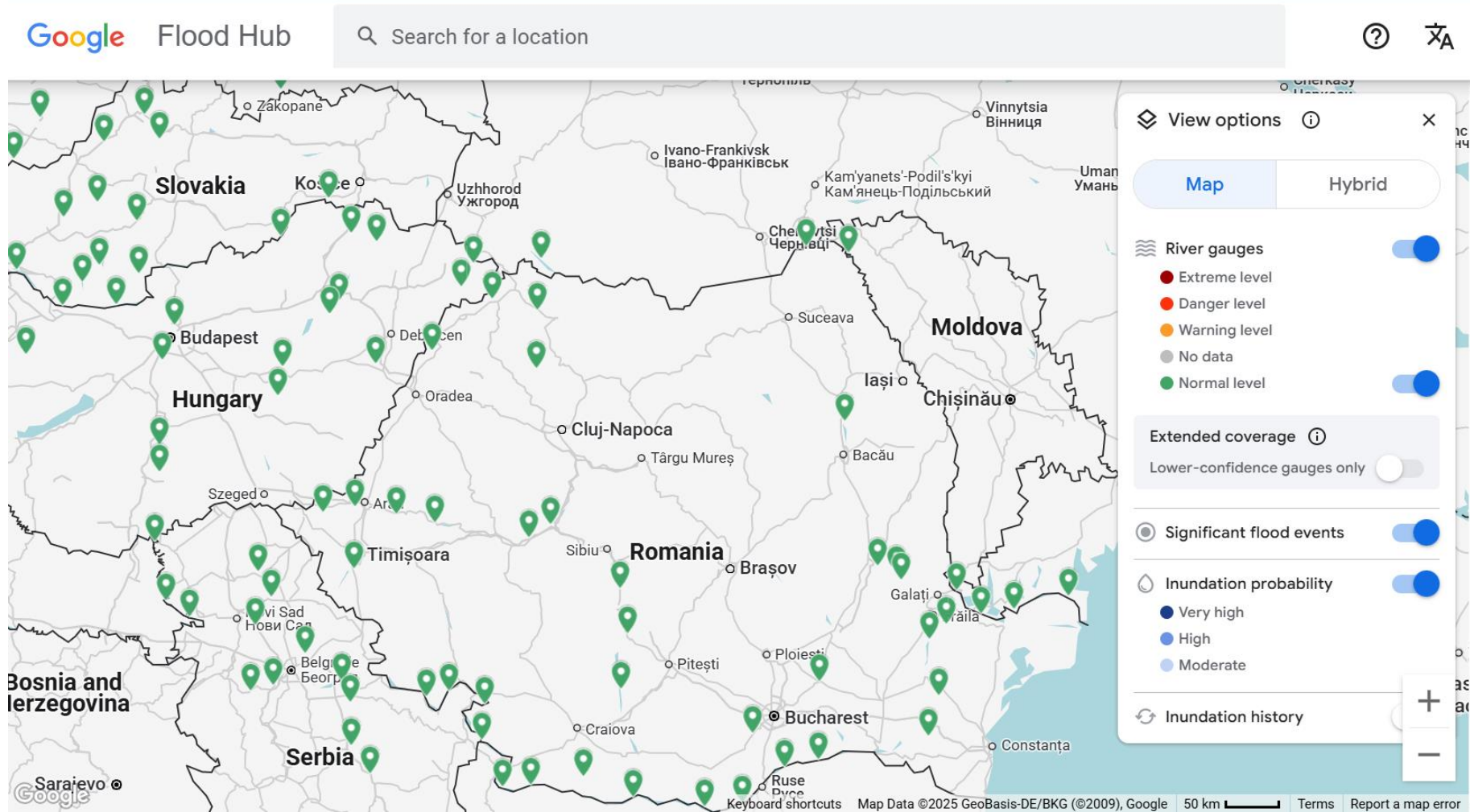
<https://european-flood.emergency.copernicus.eu/en>





## AI – Google Flood Hub

<https://g.co/floodhub>



Nearing, G., Cohen, D., Dube, V. *et al.* Global prediction of extreme floods in ungauged watersheds. *Nature* **627**, 559–563 (2024).  
<https://doi.org/10.1038/s41586-024-07145-1>





Ciclul hidrologic

Modelarea hidrologică

Modele

Protocol

Aplicație



Mulțumesc!

Întrebări?



- Deb, K., Pratap, A., Agarwal, S., & Meyarivan, T. A. M. T. (2002). A fast and elitist multiobjective genetic algorithm: NSGA-II. *IEEE transactions on evolutionary computation*, 6(2), 182-197.
- Kratzert, Frederik, Daniel Klotz, Sepp Hochreiter, and Grey S. Nearing. “A Note on Leveraging Synergy in Multiple Meteorological Data Sets with Deep Learning for Rainfall–Runoff Modeling.” *Hydrology and Earth System Sciences* 25, no. 5 (May 20, 2021): 2685–2703. <https://doi.org/10.5194/hess-25-2685-2021>.
- Yang, Shuyu, Dawen Yang, Jinsong Chen, Jerasorn Santisirisomboon, Weiwei Lu, and Baoxu Zhao. “A Physical Process and Machine Learning Combined Hydrological Model for Daily Streamflow Simulations of Large Watersheds with Limited Observation Data.” *Journal of Hydrology* 590 (November 2020): 125206. <https://doi.org/10.1016/j.jhydrol.2020.125206>.
- Besaw, Lance E., Donna M. Rizzo, Paul R. Bierman, and William R. Hackett. “Advances in Ungauged Streamflow Prediction Using Artificial Neural Networks.” *Journal of Hydrology* 386, no. 1–4 (May 2010): 27–37. <https://doi.org/10.1016/j.jhydrol.2010.02.037>.
- Lees, Thomas, Marcus Buechel, Bailey Anderson, Louise Slater, Steven Reece, Gemma Coxon, and Simon J. Dadson. “Benchmarking Data-Driven Rainfall–Runoff Models in Great Britain: A Comparison of Long Short-Term Memory (LSTM)-Based Models with Four Lumped Conceptual Models.” *Hydrology and Earth System Sciences* 25, no. 10 (October 21, 2021): 5517–34. <https://doi.org/10.5194/hess-25-5517-2021>.
- Kratzert, Frederik, Daniel Klotz, Claire Brenner, Karsten Schulz, and Mathew Herrnegger. “Rainfall–Runoff Modelling Using Long Short-Term Memory (LSTM) Networks.” *Hydrology and Earth System Sciences* 22, no. 11 (November 22, 2018): 6005–22. <https://doi.org/10.5194/hess-22-6005-2018>.
- Hu, Youchuan, Le Yan, Tingting Hang, and Jun Feng. “Stream-Flow Forecasting of Small Rivers Based on LSTM,” 2020. <https://doi.org/10.48550/ARXIV.2001.05681>.
- Ochoa-Tocachi, Cuadros-Adriazola, Arapa, Aste, Ochoa-Tocachi, & Bonnesoeur. (2022). Guide to Hydrologic Modeling. Forest Trends Association. <https://www.forest-trends.org/wp-content/uploads/2022/08/Guide-to-Hydrologic-Modeling-of-NI.pdf>
- Biondi, D., Freni, G., Iacobellis, V., Mascaro, G., & Montanari, A. (2012). Validation of hydrological models: Conceptual basis, methodological approaches and a proposal for a code of practice. *Physics and Chemistry of the Earth, Parts A/B/C*, 42–44, 70–76. <https://doi.org/10.1016/j.pce.2011.07.037>



# Exercițiu practic: Modelarea hidrologică

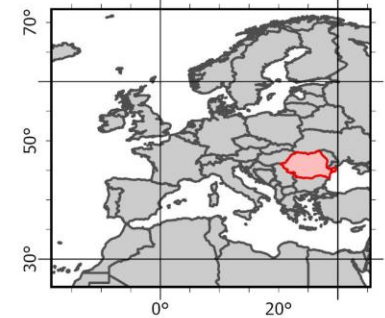
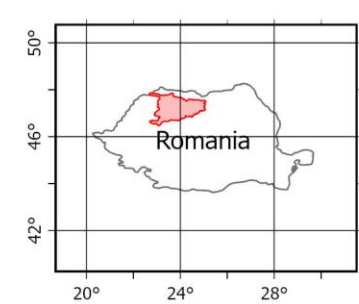
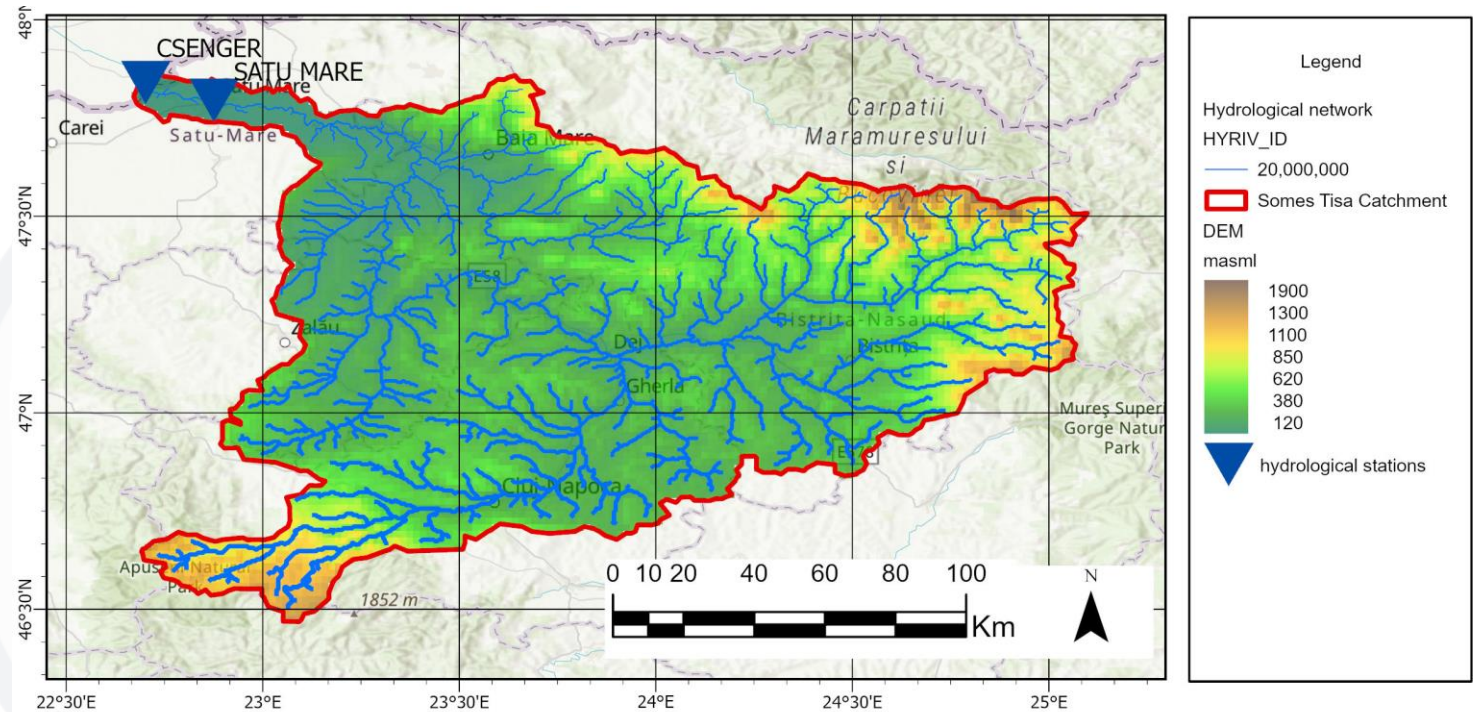




## Bazinul hidrografic Someș-Tisa

Bazinul hidrografic Someș-Tisa este situat în partea de nord și nord-vest a țării, fiind delimitat la nord de frontiera naturală, râul Tisa, care constituie granița cu Ucraina pe o lungime de 61 km, la vest de frontiera cu Republica Ungară, iar pe teritoriul național se învecinează cu bazinul Siret la est, bazinul Mureș la sud și bazinul Crișuri la sud-vest.

<https://inundatii.ro/en/river-basins/somes-tisa-watershed-area/>





## Evidențe privind inundațiile

Cantitățile maxime de precipitații sunt înregistrate în timpul primăverii și verii, în special în perioada martie–iunie și în august. Se pot menționa mai multe valori istorice maxime de precipitații asociate cu inundații severe în întregul bazin hidrografic, cum au fost cele din mai 1970 (peste 150 mm/24 h și chiar 200 mm/24 h în Baia Sprie).

Inundațiile severe, cu debite maxime semnificative, provin din ploi abundente pe suprafețe mari ale bazinului sau din surse mixte (topirea zăpezii și ploi). Cea mai mare inundație istorică din ultimele 50–60 de ani a avut loc în 1970, având o sursă mixtă. Analiza seriilor de inundații din ultimii circa 50 de ani arată că cele mai importante inundații au avut loc în anii: 1970, 1974, 1975, 1978, 1979, 1980, 1981, 1989, 1993, 1995, 1998, 2000, 2001, 2005 și 2008.

Prima jumătate a anului 1970 a fost caracterizată

<https://inundatii.ro/en/river-basins/somes-tisa-watershed-area/>

de inundații catastrofale. Cele mai grave au avut loc pe râurile Someș, Tisa, Tur, Vișeu, Iza, Lăpuș, Șieu, Crasna, Almaș, Someșul Mic și afluenții lor. Debite care depășesc probabilitatea de asigurare de 1% au fost înregistrate pe râurile Someș (aval de Dej) și Vișeu, iar pe alte cursuri de apă debitele au avut probabilități de 5–10%. Ruperea digurilor pe râurile Someș și Tur (județul Satu Mare) a provocat inundarea multor localități urbane și rurale. Inundațiile au fost cauzate de ploi abundente și de lungă durată, combinate cu topirea zăpezii, ceea ce a dus la depășirea cotelor de inundație pe majoritatea râurilor din bazinul Someș–Tisa.

Au fost afectate localități urbane importante precum Năsăud, Beclean, Gherla, Dej, Zalău, Jibou, Șimleu, Satu Mare, precum și peste 200 de localități rurale.

### Inundații

Forțări meteorologice

[https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/CEMS-EFAS/meteorological\\_forcings/EMO-1arcmin/](https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/CEMS-EFAS/meteorological_forcings/EMO-1arcmin/)

Debite

<https://portal.grdc.bafg.de/applications/public.html?publicuser=PublicUser#dataDownload/Stations>

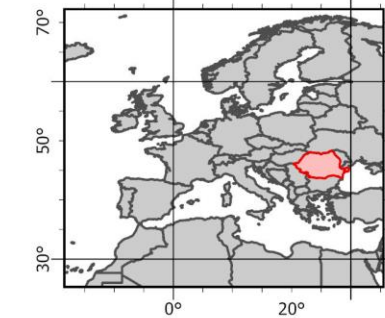
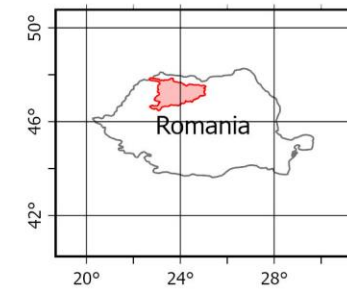
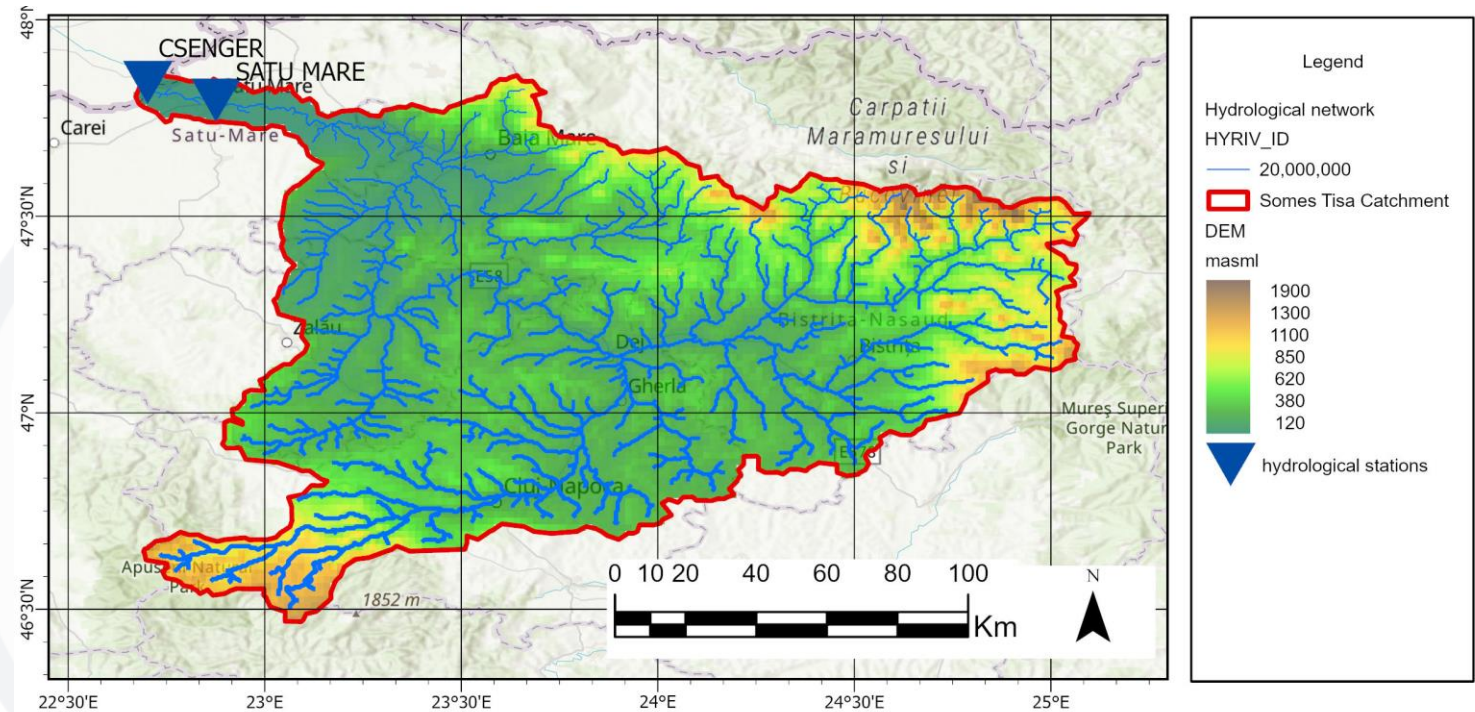
Informații geografice

DEM – rezoluție 30 m

EFAS – 1 arcmin

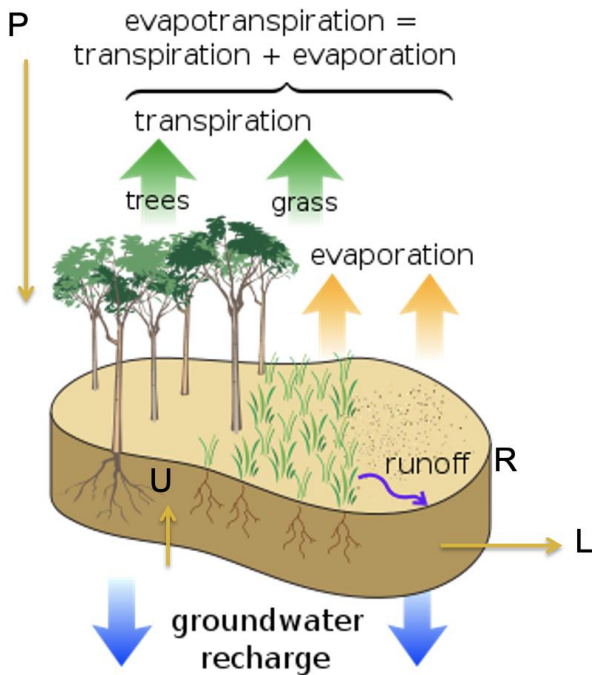
[https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/CEMS-EFAS/LISFLOOD\\_static\\_and\\_parameter\\_maps\\_for\\_EFAS/](https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/CEMS-EFAS/LISFLOOD_static_and_parameter_maps_for_EFAS/)

<https://inundatii.ro/en/river-basins/somes-tisa-watershed-a>

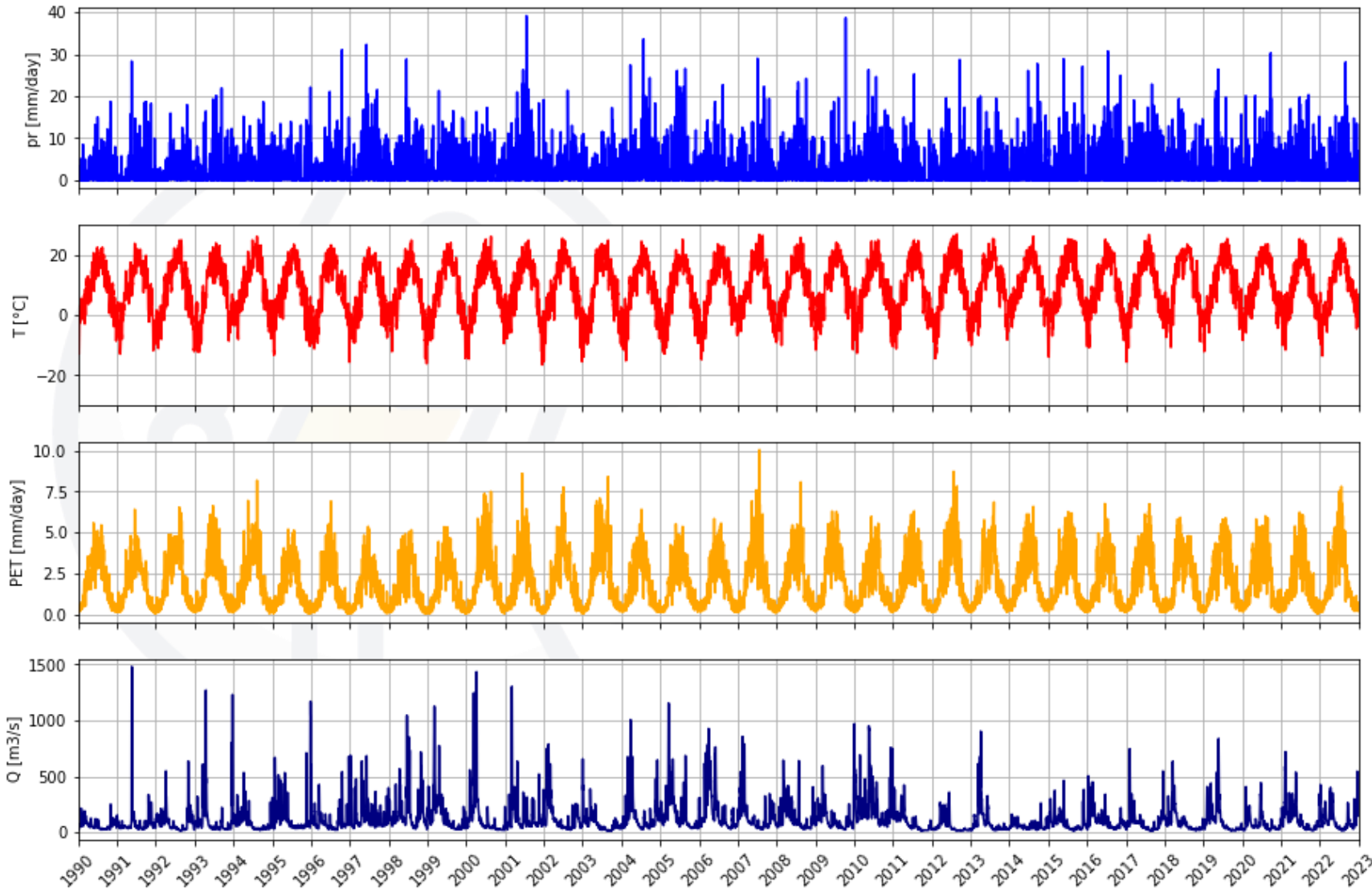




## 01\_data\_preparation\_example



<https://aquaticiceodynamics.github.io/hydrology-workbook/E5.html>

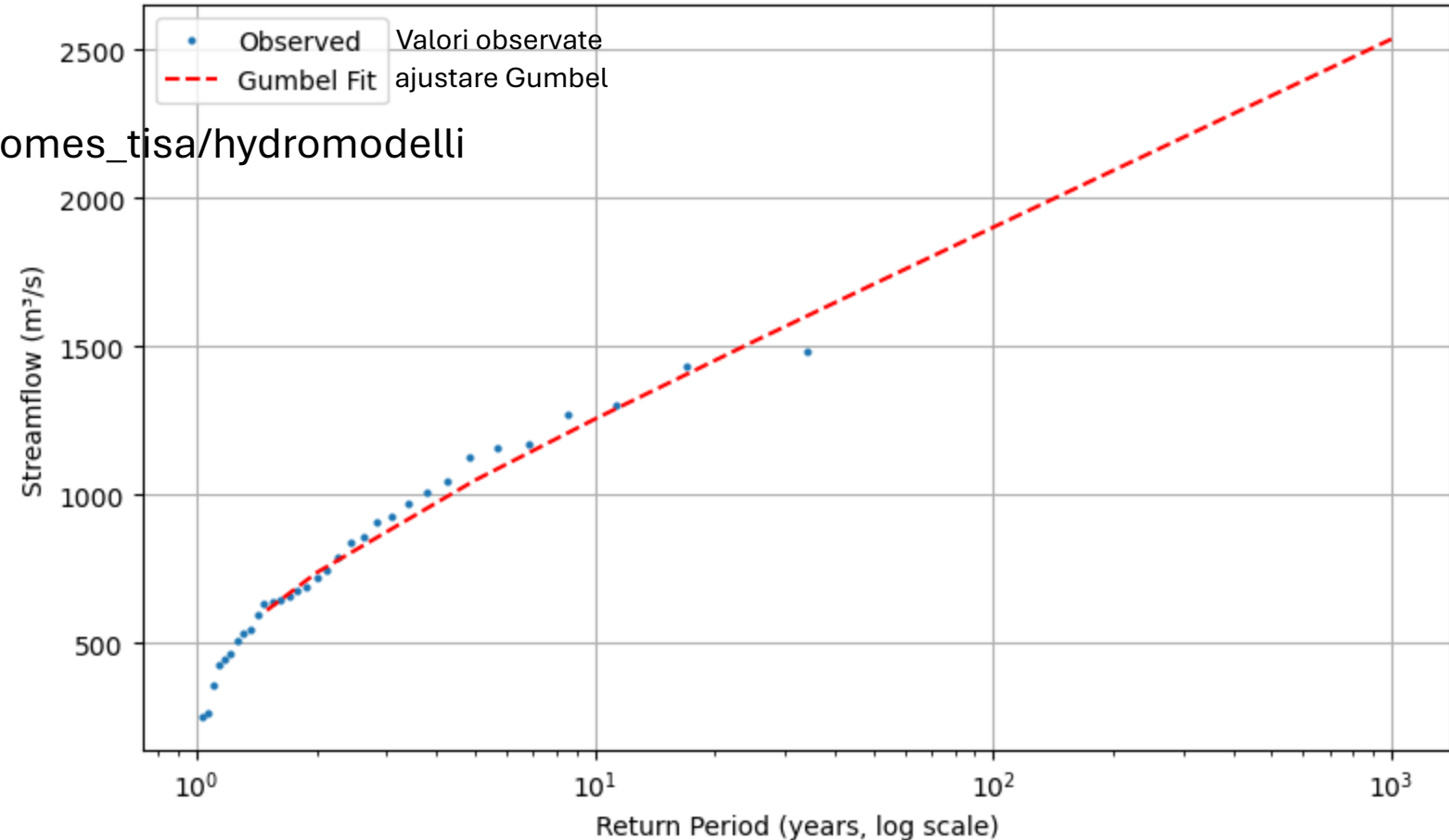


# Evenimente extreme

/work/bb1480/b381840/scewero/somes\_tisa/hydromodelli  
ng/somes\_tisa\_extrems.ipynb

Analiza perioadei de revenire utilizând distribuția Gumbel

Return Period Analysis using Gumbel Distribution



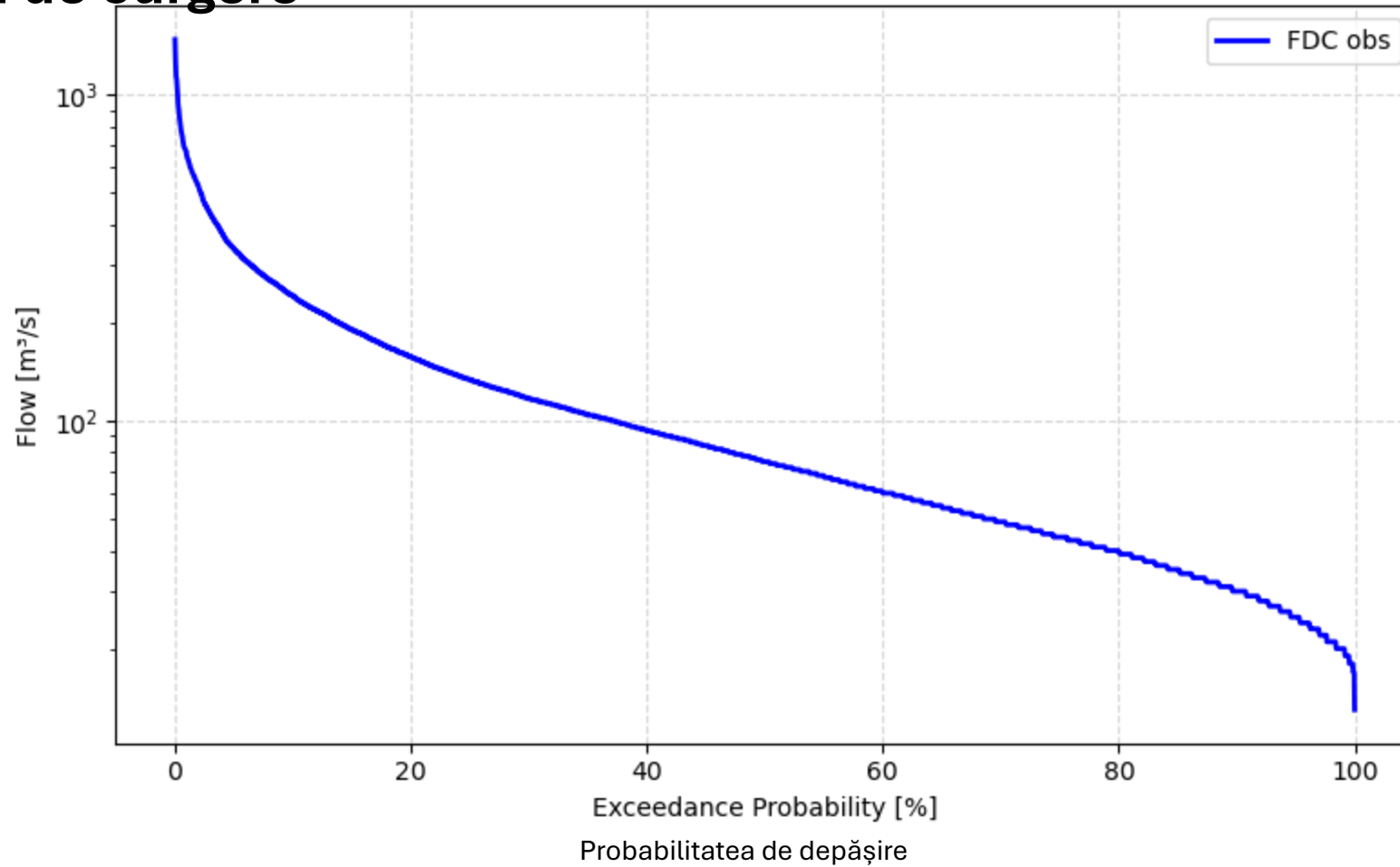
## Distribuția Gumbel

| Perioada de revenire<br>Tr<br>[Years] | Debit<br>Q<br>[m <sup>3</sup> /s] |
|---------------------------------------|-----------------------------------|
| 1.5                                   | 610                               |
| 2                                     | 736                               |
| 5                                     | 1048                              |
| 10                                    | 1254                              |
| 25                                    | 1515                              |
| 50                                    | 1708                              |
| 100                                   | 1900                              |
| 200                                   | 2091                              |
| 500                                   | 2343                              |
| 1000                                  | 2534                              |

Perioada de revenire (ani, scară logaritmică)

# Curbele duratei de curgere

Flow Duration Curve - All data set



# Model hidrolologic

## GR4J

Si  $P_k \geq E$ , alors  $P_n = P_k - E$  et  $E_n = 0$ ,  
 Si  $P_k < E$ , alors  $P_n = 0$  et  $E_n = E - P_k$

$$P_s = \frac{x_1 \left(1 - \left(\frac{S_k}{x_1}\right)^2\right) \tanh\left(\frac{P_n}{x_1}\right)}{1 + \frac{S_k}{x_1} \tanh\left(\frac{P_n}{x_1}\right)} \text{ et } E_s = \frac{S_k \left(2 - \frac{S_k}{x_1}\right) \tanh\left(\frac{P_n}{x_1}\right)}{1 + \left(1 - \frac{S_k}{x_1}\right) \tanh\left(\frac{P_n}{x_1}\right)}$$

$$S' = S_k + P_s - E_s$$

$$Perc = S' \left\{ 1 - \left[ 1 + \left( \frac{4}{9} \cdot \frac{S'}{x_1} \right)^4 \right]^{-1} \right\}, S_{k+1} = S' - Perc$$

$$Perc + (P_n - P_s)$$

$$\text{Si } 0 \leq j \leq X_4, SH1(j) = \left(\frac{j}{X_4}\right)^{\frac{1}{2}}; \text{ Si } j > X_4, SH1(j) = 1$$

$$\text{Si } 0 \leq j \leq X_4, SH2(j) = \frac{1}{2} \left(\frac{j}{X_4}\right)^{\frac{1}{2}};$$

$$\text{Si } X_4 \leq j \leq 2X_4, SH2(j) = 1 - \frac{1}{2} \left(2 - \frac{j}{X_4}\right)^{\frac{1}{2}};$$

$$\text{Si } j > 2X_4, SH2(j) = 1$$

$$UH1(j) = SH1(j) - SH1(j-1)$$

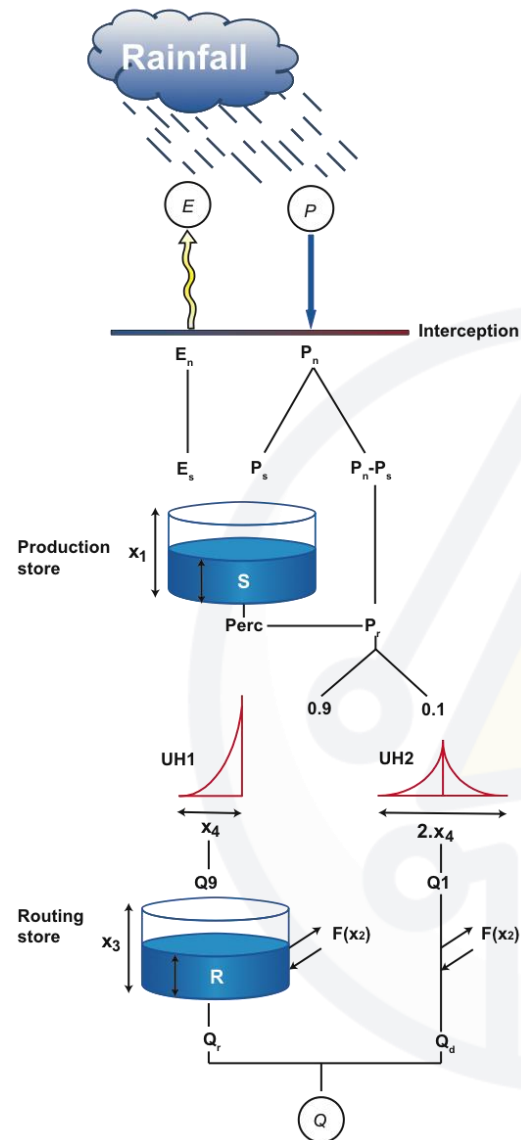
$$UH2(j) = SH2(j) - SH2(j-1)$$

$$Q9(k) = 0.9 \cdot \sum_{j=1}^k UH1(j) \cdot Pr(k-j+1),$$

$$Q1(k) = 0.1 \cdot \sum_{j=1}^m UH2(j) \cdot Pr(k-j+1)$$

$$F = X_2 \cdot \left(\frac{R_k}{X_3}\right)^{\frac{1}{2}}; R' = \max(0; R_k + Q9(k) + F)$$

$$(DP) \begin{cases} Q_r = R' \cdot \left\{ 1 - \left[ 1 + \left( \frac{R'}{X_3} \right)^4 \right]^{-1} \right\}; R_{k+1} = R' - Q_r \\ Q_d = \max(0; Q1(k) + F); \\ Q(k) = Q_r + Q_d \end{cases}$$



Perrin, C., Michel, C., & Andréassian, V. (2003). Improvement of a parsimonious model for streamflow simulation. *Journal of Hydrology*, 279(1-4), 275-289. [https://doi.org/10.1016/S0022-1694\(03\)00225-7](https://doi.org/10.1016/S0022-1694(03)00225-7)

## Implementare în Python

```
import numpy as np
...
This class modelate a process rainfall-runoff
Perrin, C., C. Michel, et al. (2003). "Improvement of a parsimonious model for streamflow simul
http://www.cemagref.fr/webgr/Modelesgb/gr4j/fonctionnement_gr4jgb.htm
...

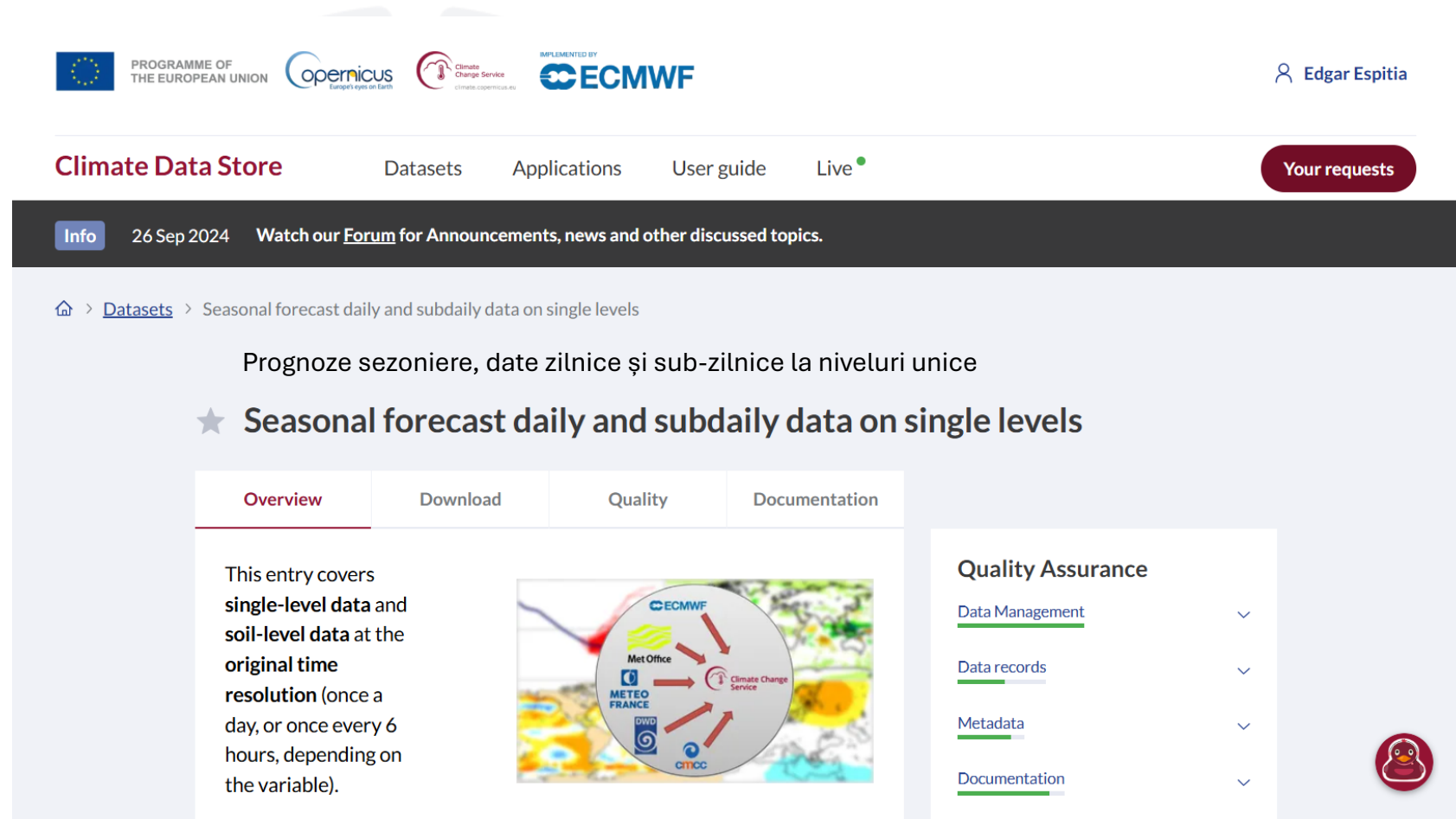
class GR4J:
    'Class hydrological model GR4J'

    def __init__(self, PEQ, A, X, S0, R0):
        self.set_PEQ(PEQ)
        self.a = np.copy(A) # Area of basin in km2
        n = PEQ.shape[0] # Get the lenght of data series
        self.X = np.copy(X) # Parameters of model
        self.Pn = np.zeros((n))
        self.En = np.zeros((n))
        self.R_ = np.copy(R0)
        self.S_ = np.copy(S0)

    # Define the inputs
    def set_PEQ(self, PEQ):
        self.P = np.copy(PEQ[:,1])
        self.E = np.copy(PEQ[:,2])
        self.Q = np.copy(PEQ[:,3])
```

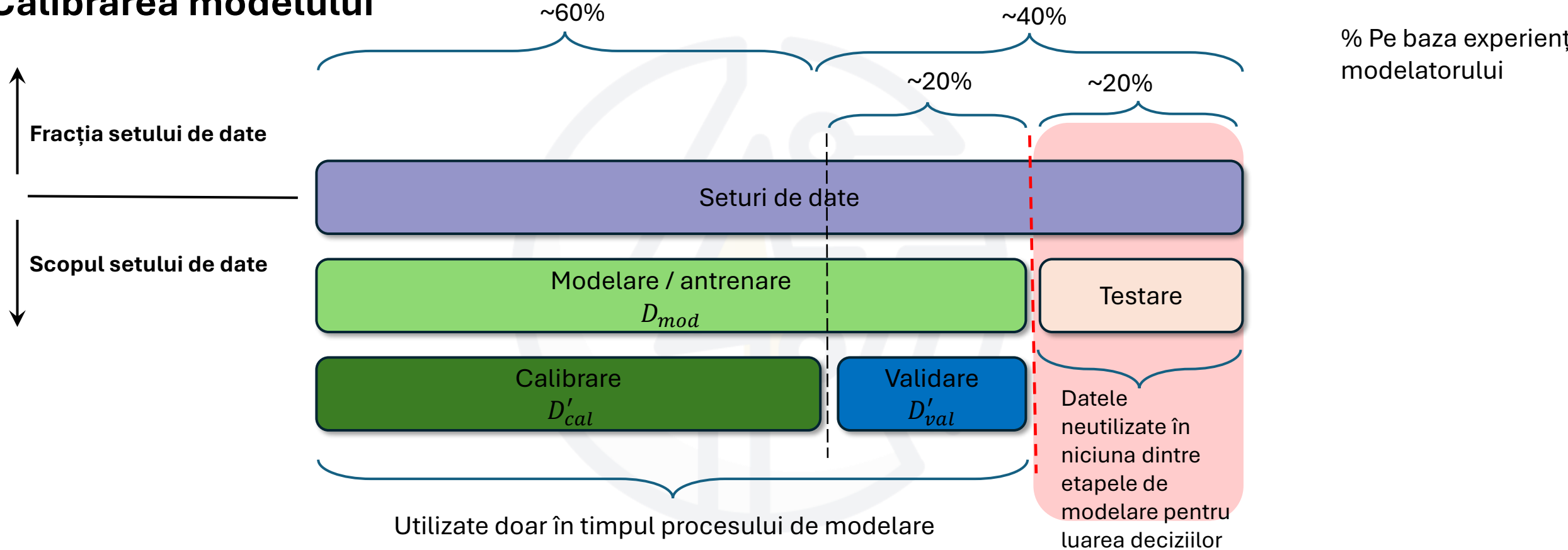
<https://cds.climate.copernicus.eu/datasets/seasonal-original-single-levels?tab=overview>

## Forțări meteorologice



The screenshot shows the Copernicus Climate Data Store interface. At the top, there are logos for the European Union, Copernicus, and ECMWF. The main navigation bar includes 'Climate Data Store', 'Datasets', 'Applications', 'User guide', 'Live', and a 'Your requests' button. A dark banner below the navigation bar contains an 'Info' icon, the date '26 Sep 2024', and the text 'Watch our Forum for Announcements, news and other discussed topics.' The breadcrumb trail shows 'Home > Datasets > Seasonal forecast daily and subdaily data on single levels'. The main heading is 'Prognoze sezoniere, date zilnice și sub-zilnice la niveluri unice' followed by a star icon and 'Seasonal forecast daily and subdaily data on single levels'. Below this is a tabbed interface with 'Overview', 'Download', 'Quality', and 'Documentation' tabs. The 'Overview' tab is active, displaying a text description: 'This entry covers single-level data and soil-level data at the original time resolution (once a day, or once every 6 hours, depending on the variable).' To the right of the text is a circular diagram showing data sources: ECMWF, Met Office, METEO FRANCE, DWD, and CMCC, all pointing to the 'Climate Change Service'. On the far right, there is a 'Quality Assurance' section with a dropdown menu containing 'Data Management', 'Data records', 'Metadata', and 'Documentation'. A small red circular icon is visible at the bottom right of the page.

## Calibrarea modelului



Based on: Shen, H., Tolson, B. A., & Mai, J. (2022). Time to Update the Split-Sample Approach in Hydrological Model Calibration. *Water Resources Research*, 58(3), e2021WR031523. <https://doi.org/10.1029/2021WR031523>

# Calibrarea modelului

$$KGE^c = 1 - \sqrt{(r - 1)^2 + (\beta - 1)^2 + (\gamma - 1)^2}$$

$$r_{OS} = \frac{\sum_{i=1}^n (O_i - \bar{O}) (S_i - \bar{S})}{\sqrt{\sum_{i=1}^n (O_i - \bar{O})^2} \sqrt{\sum_{i=1}^n (S_i - \bar{S})^2}}$$

Raport de bias  $\beta = \frac{\mu_s}{\mu_o}$

Raport de variabilitate  $\gamma = \frac{\sigma_s / \mu_s}{\sigma_o / \mu_o}$

|  | KGE'      | Description            |
|--|-----------|------------------------|
|  | 0.8 - 1.0 | Excellent Excelent     |
|  | 0.6 - 0.8 | Good Bun               |
|  | 0.4 - 0.6 | Acceptable Acceptabil  |
|  | 0.2 - 0.4 | Low Scăzut             |
|  | < 0.2     | Very low Foarte scăzut |

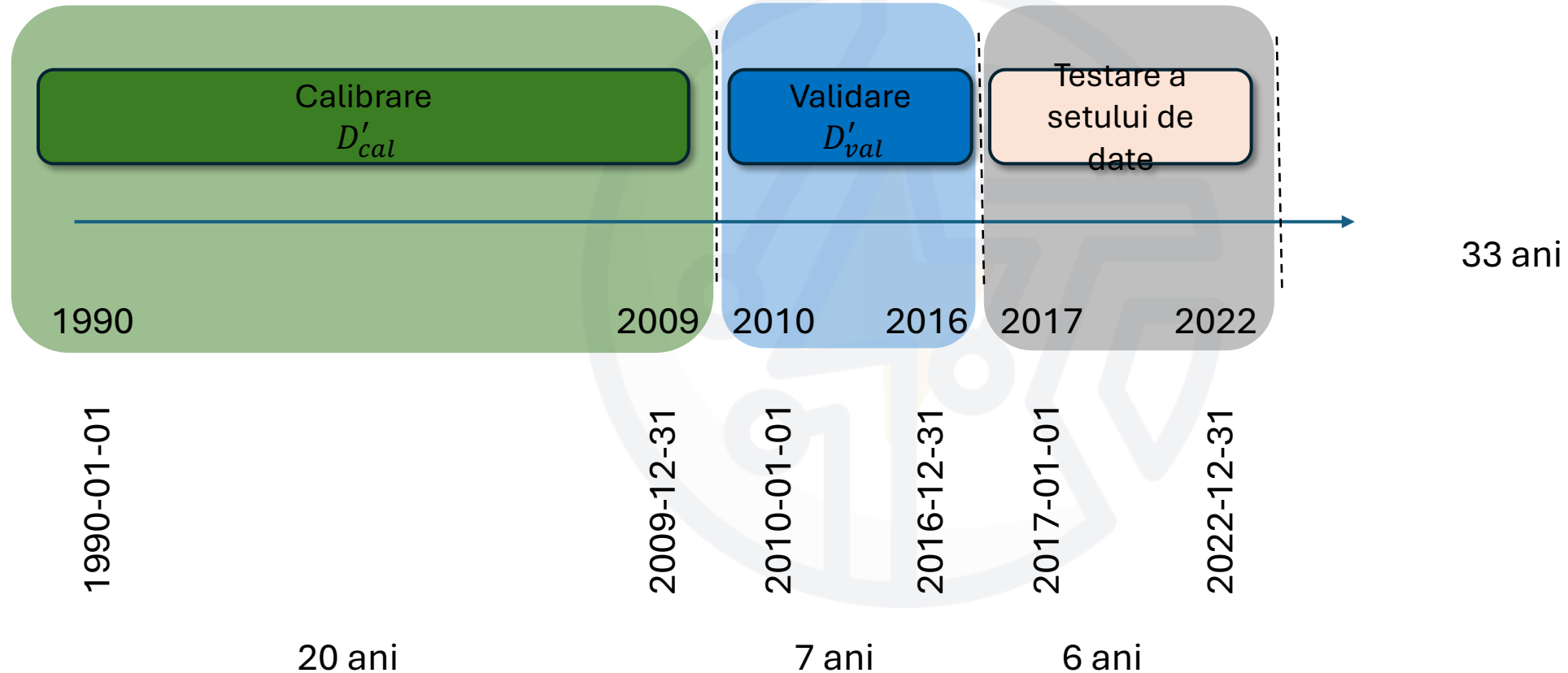
|  | r         |
|--|-----------|
|  | 0.8 - 1.0 |
|  | 0.6 - 0.8 |
|  | 0.4 - 0.6 |
|  | 0.2 - 0.4 |
|  | < 0.2     |

|  | bias ratio β |
|--|--------------|
|  | > 1.5        |
|  | 1.3 - 1.5    |
|  | 1.1 - 1.3    |
|  | 0.9 - 1.1    |
|  | 0.7 - 0.9    |
|  | 0.5 - 0.7    |
|  | < 0.5        |

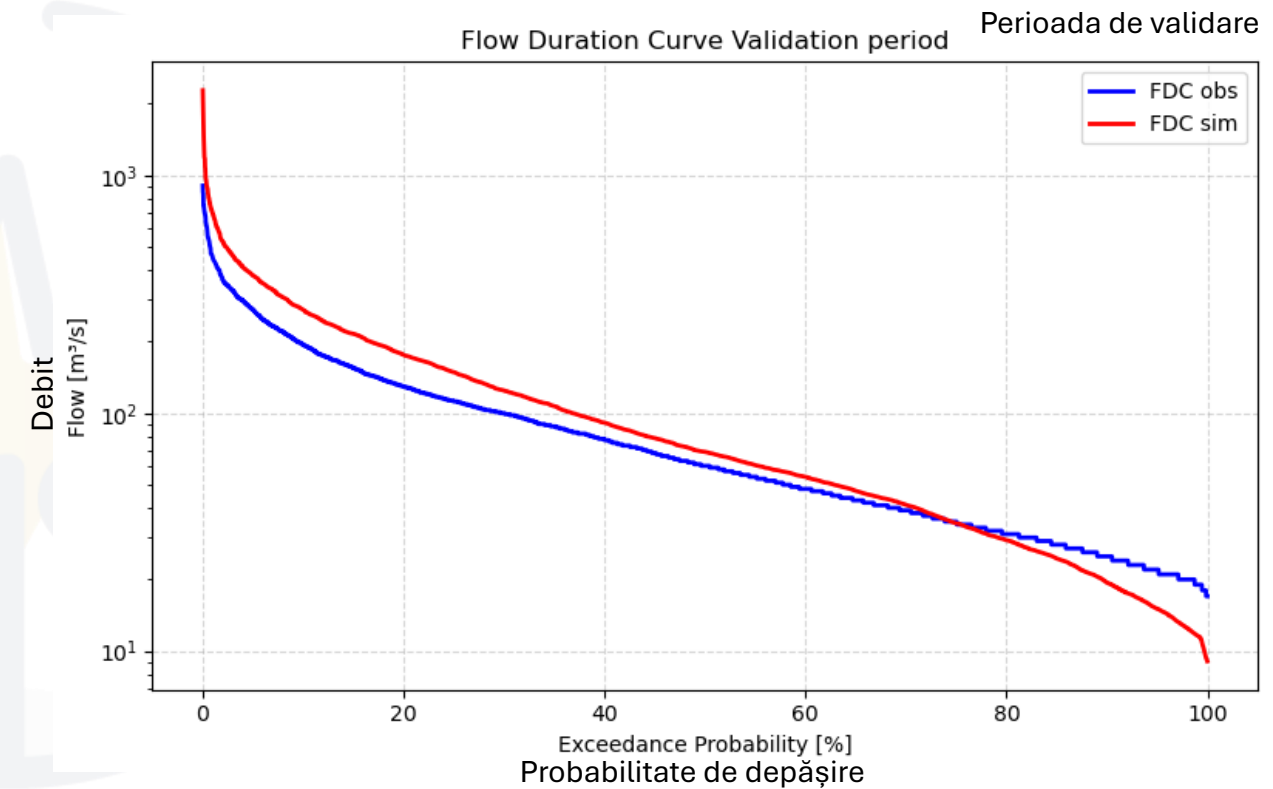
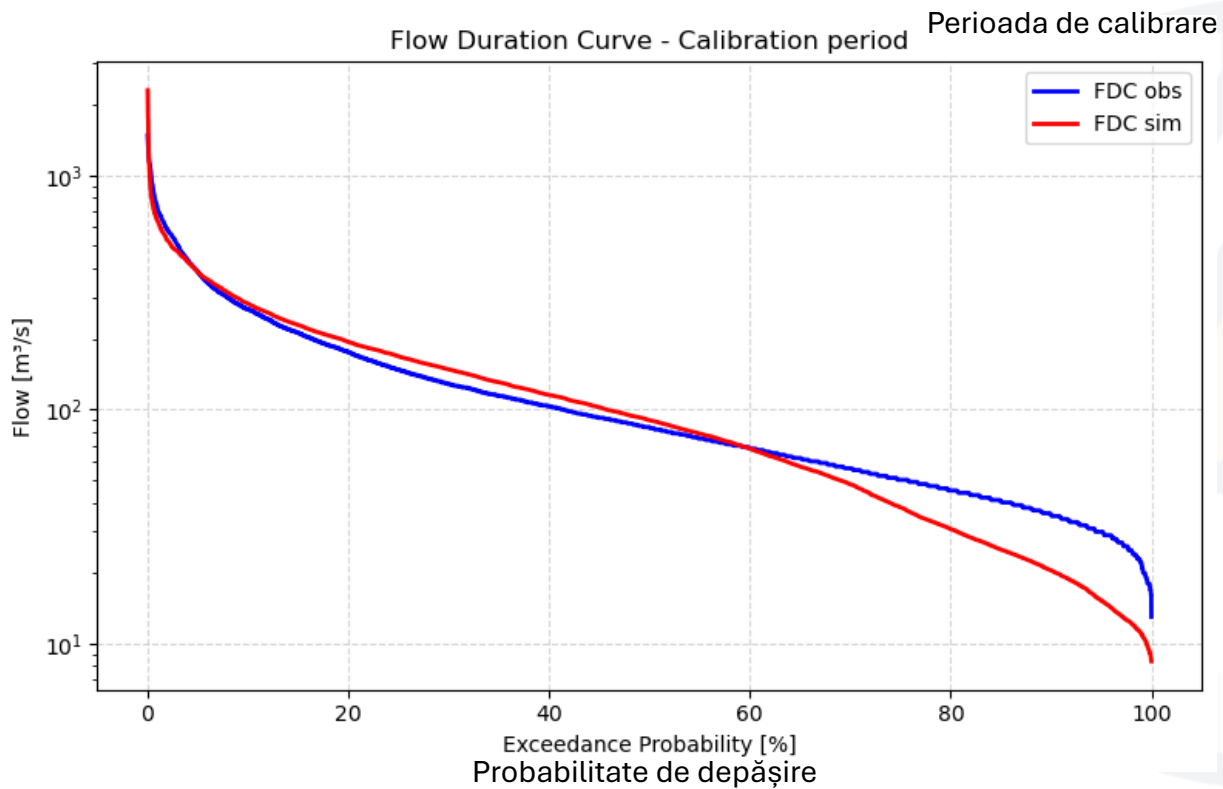
|  | variability ratio γ |
|--|---------------------|
|  | > 1.5               |
|  | 1.3 - 1.5           |
|  | 1.1 - 1.3           |
|  | 0.9 - 1.1           |
|  | 0.7 - 0.9           |
|  | 0.5 - 0.7           |
|  | < 0.5               |

## Calibrarea modelului

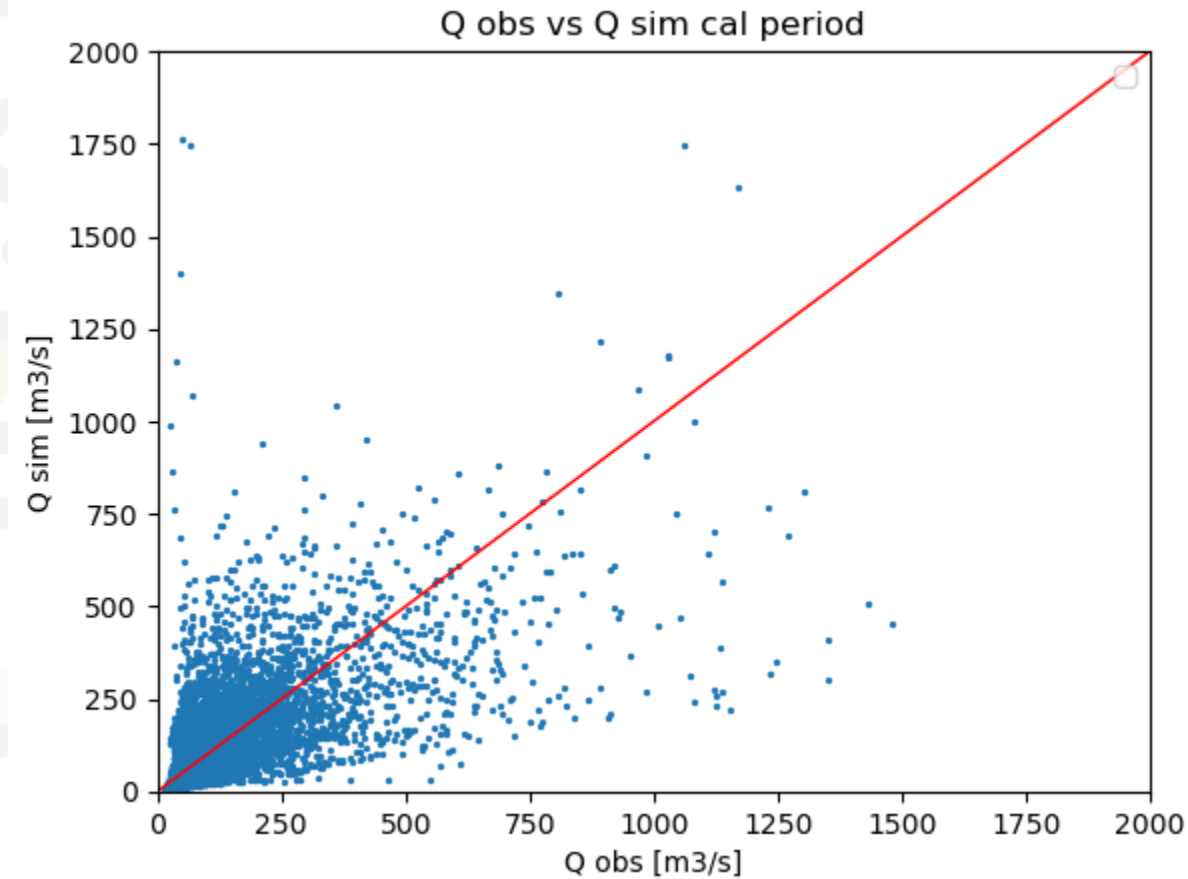
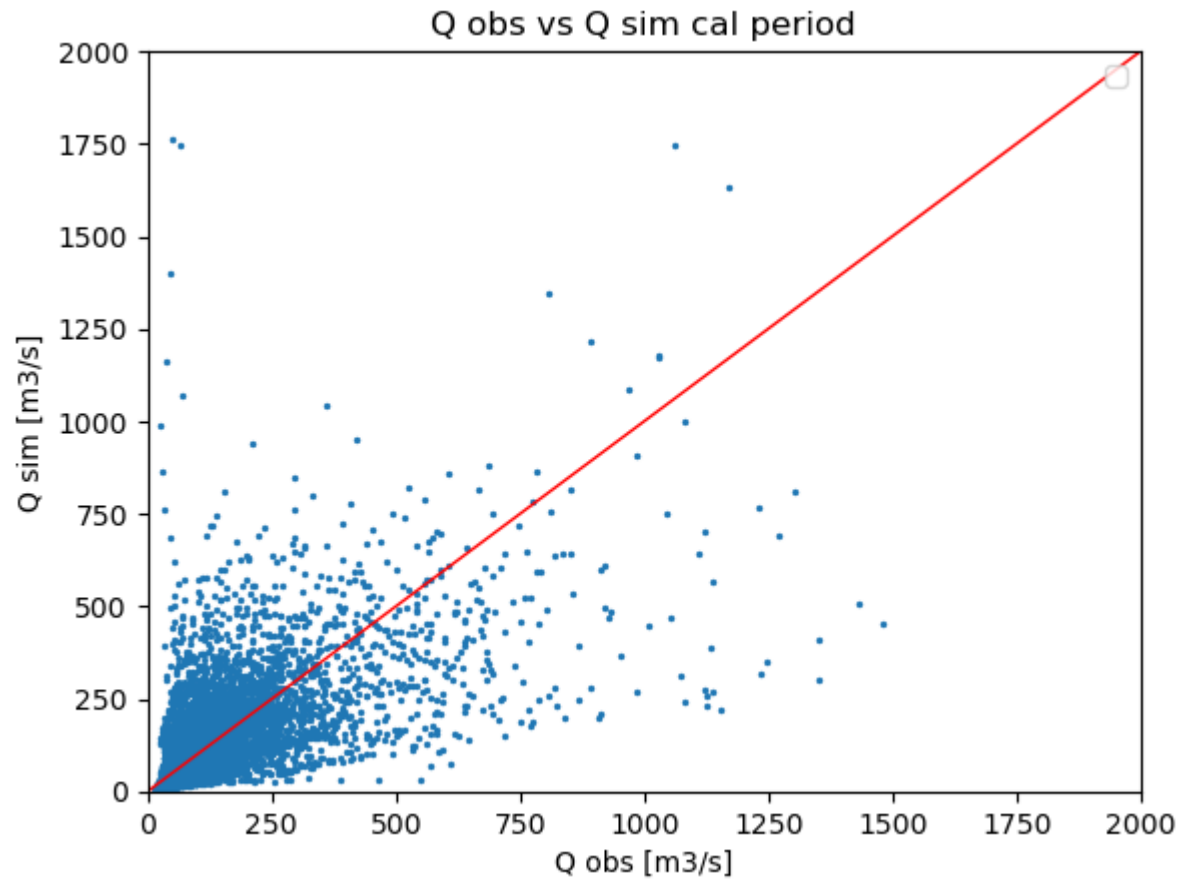
[/work/bb1480/b381840/scewero/somes\\_tisa/hydromodelling/somes\\_tisa\\_hydromodelling.ipynb](/work/bb1480/b381840/scewero/somes_tisa/hydromodelling/somes_tisa_hydromodelling.ipynb)



# Curbele duratei de curgere



## Diagrame de dispersie (Scatter plots)

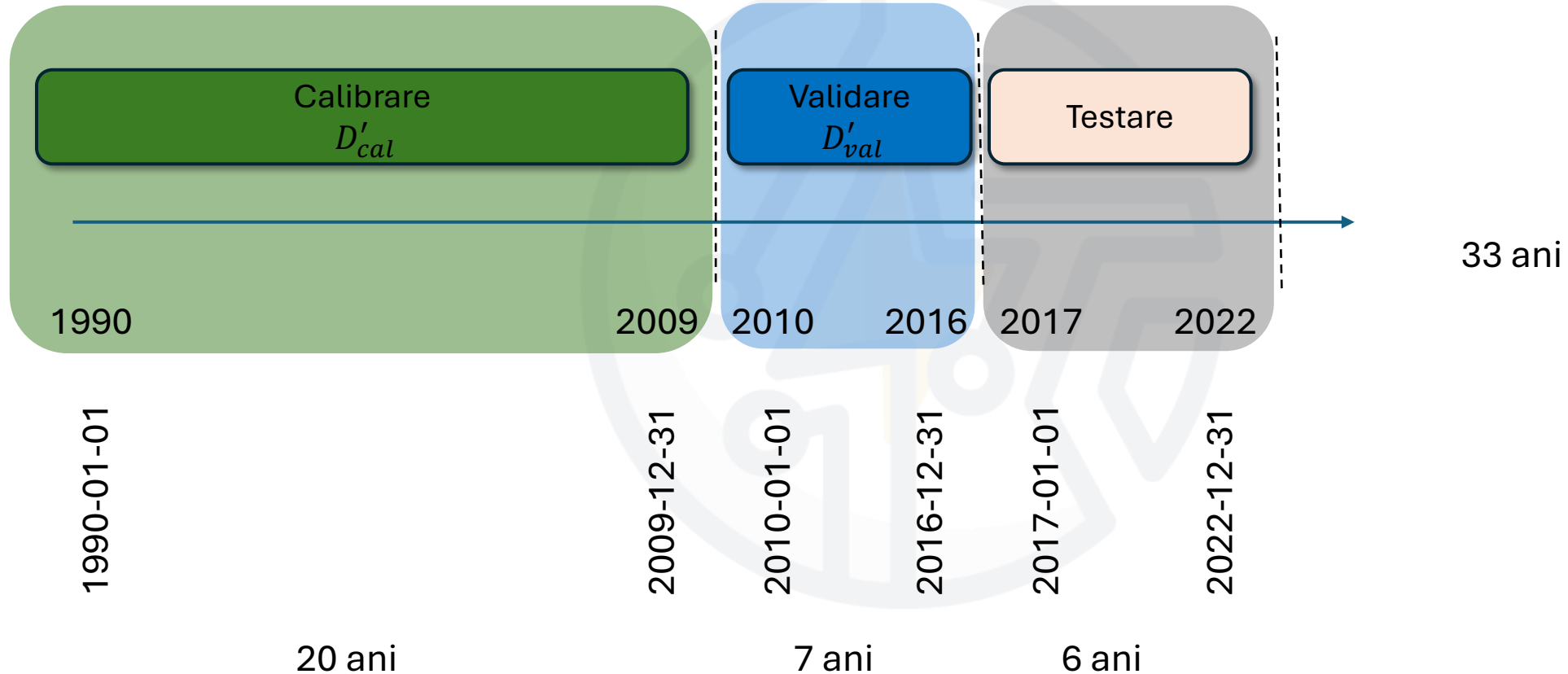
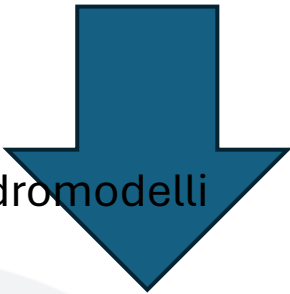




SCEWERO

Testare

/work/bb1480/b381840/scewero/somes\_tisa/hydrmodell  
ng/somes\_tisa\_generate\_Q.ipynb



UNIVERSITATEA BABEŞ-BOLYAI



Universiteit Antwerpen

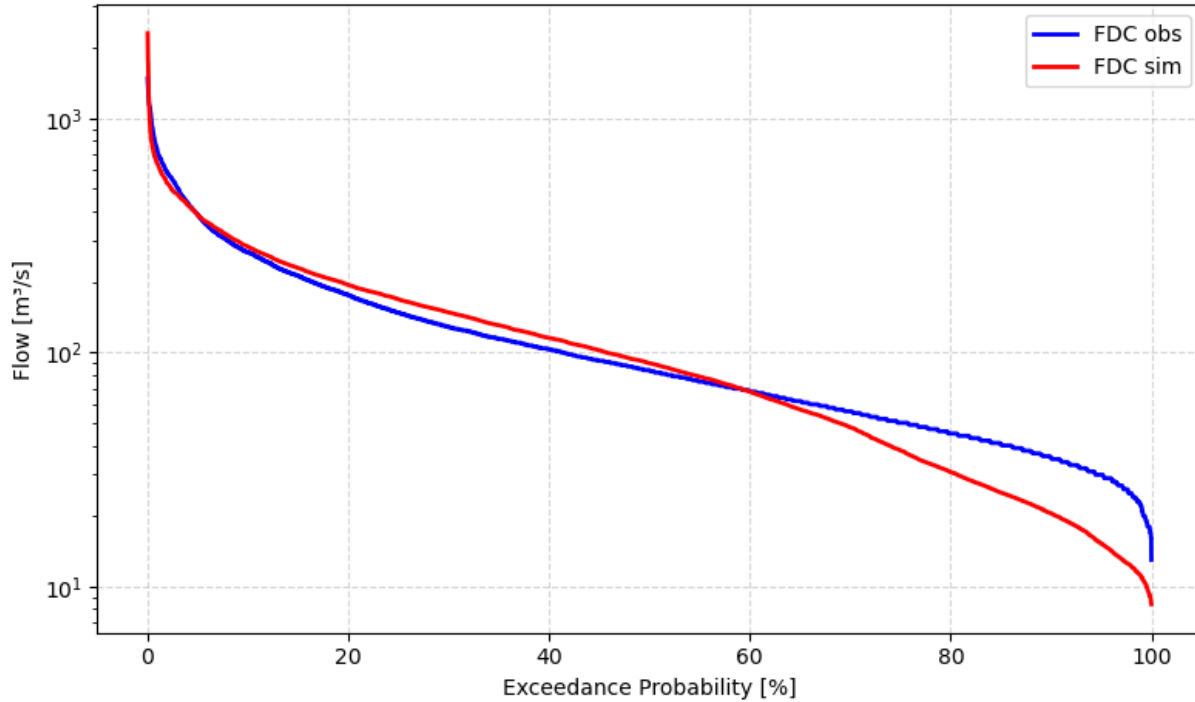


Co-funded by the European Union

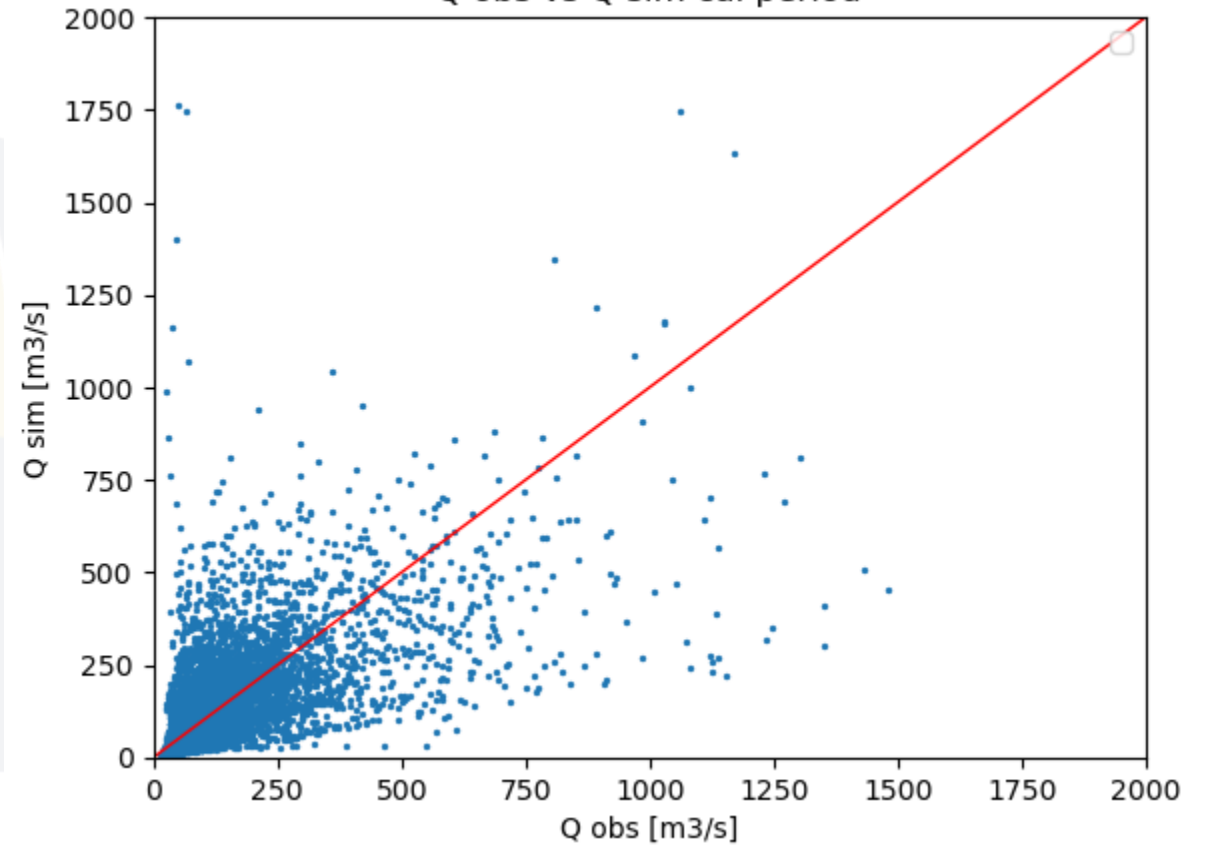
Grant Agreement 101159497

## Testare

Flow Duration Curve - Calibration period

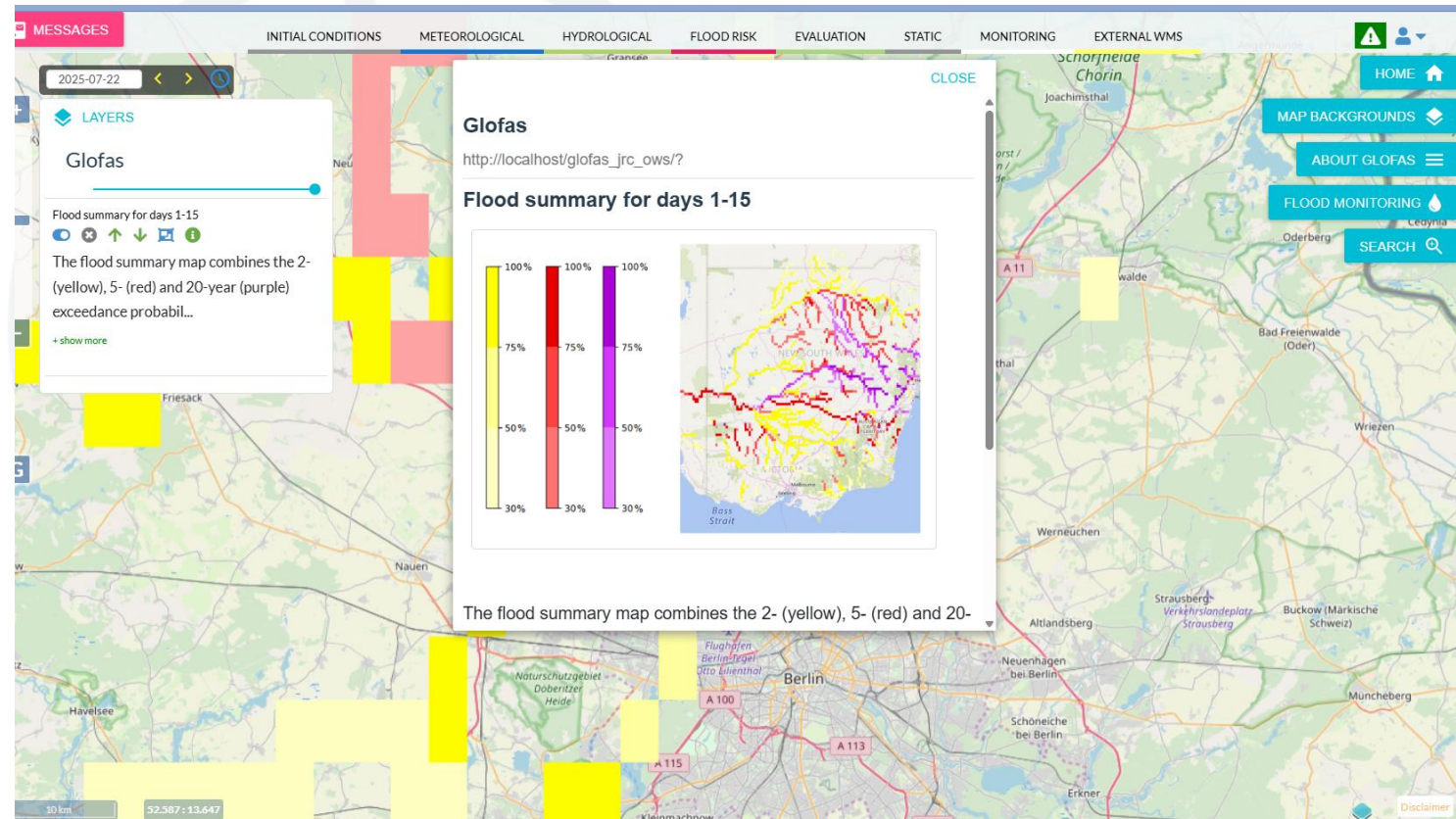


Q obs vs Q sim cal period

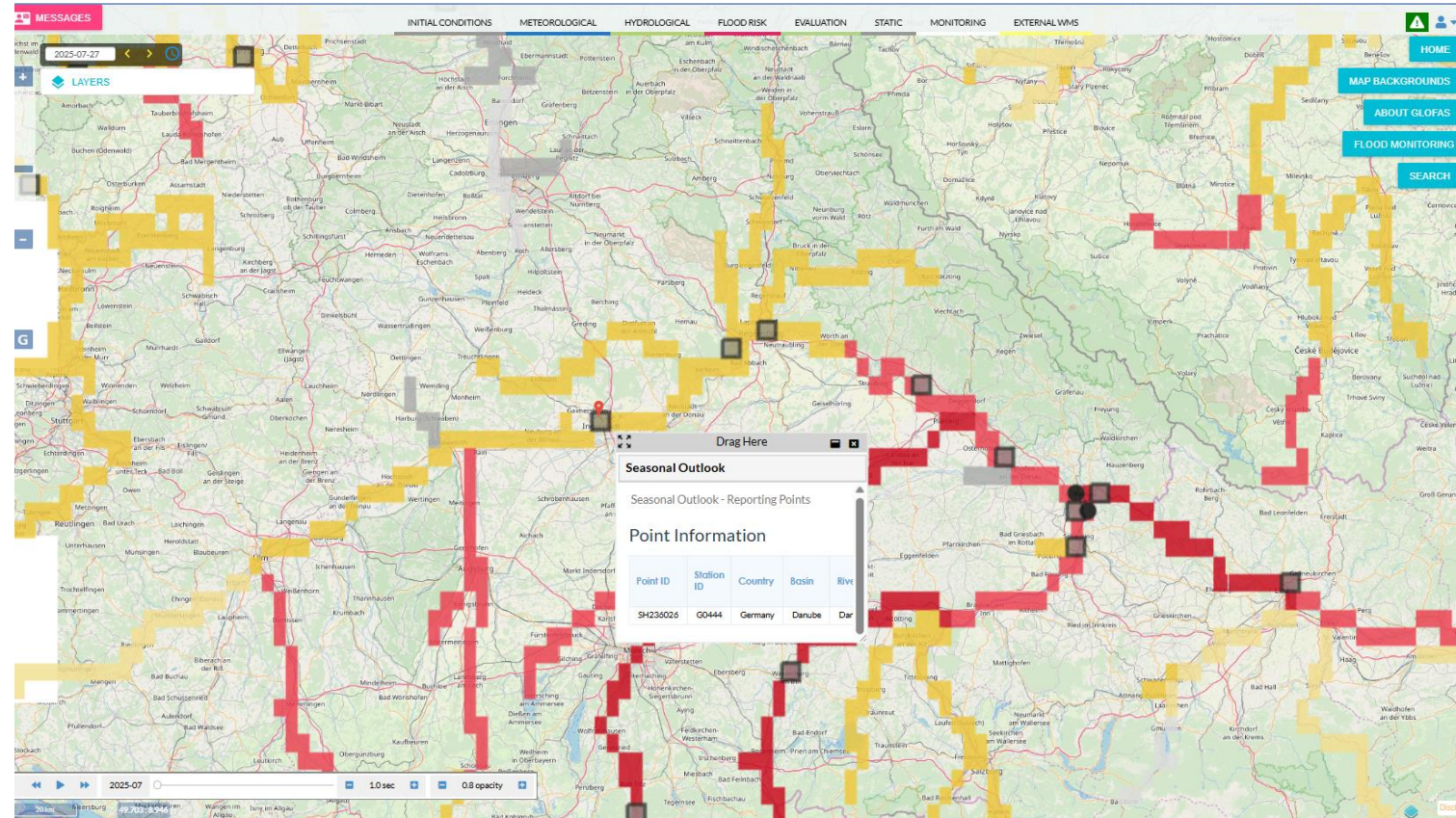


## Rezumat pe termen scurt al inundațiilor

<https://global-flood.emergency.copernicus.eu/>



# Prognoze sezoniere



# Prognoze sezoniere

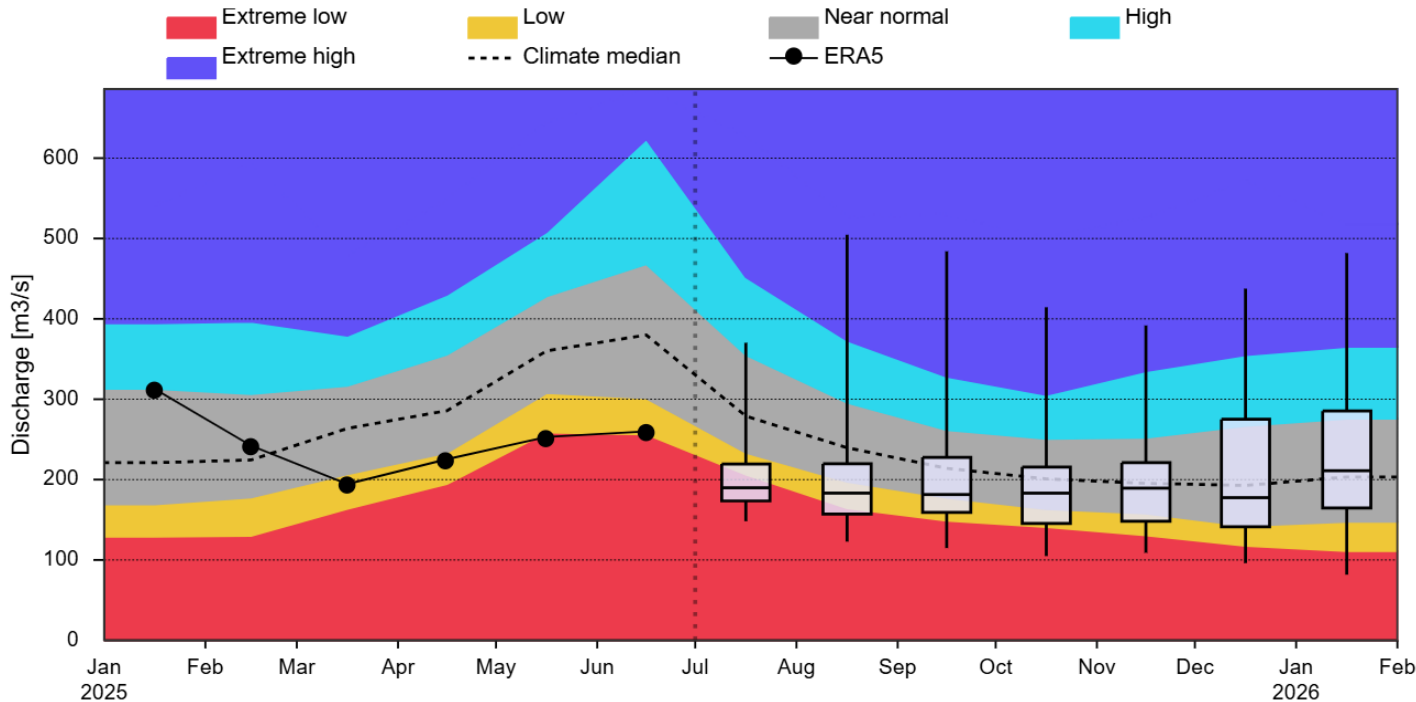
Seasonal Outlook - Reporting Points

Point Information

| Point ID | Station ID | Country | Basin  | River  | Station Name | Drainage Area [km <sup>2</sup> ] | Longitude [Deg] | Latitude [Deg] | USFLOOD Drainage Area [km <sup>2</sup> ] | USFLOOD X [Deg] | USFLOOD Y [Deg] |
|----------|------------|---------|--------|--------|--------------|----------------------------------|-----------------|----------------|--|-----------------|-----------------|
| SH236026 | G0444      | Germany | Danube | Danube | Ingolstadt   | 20001                            | 11.4220         | 48.7540        | 20419                                    | 11.4250         | 48.7750         |

## Hidrograful sezonier cu informații anterioare, climatologice și de prognoză

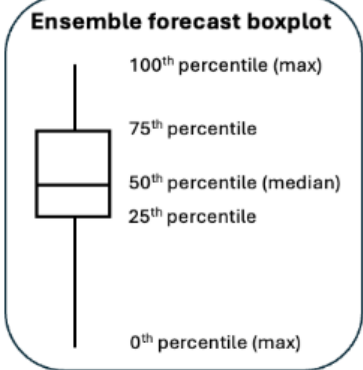
Seasonal hydrograph of antecedent, climatological and forecast information



Praguri climatologice, de la extrem de scăzut la extrem de ridicat (roșu-albastru), derivate din climatologiile modelului dependente de interval

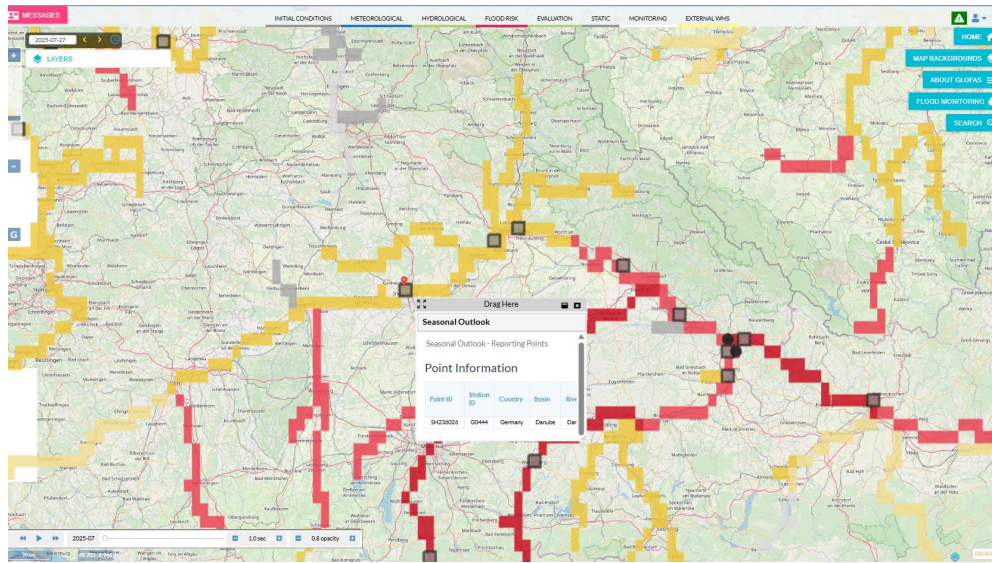
**Climatological thresholds**  
From extreme low to extreme high (red to blue), derived from range-dependent model climatologies

Reprezentare tip boxplot pentru ansamblu de prognoză



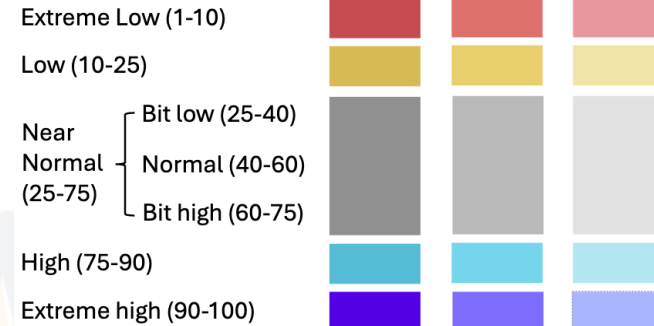
| Anomaly category | Rank                | Description   |   |
|------------------|---------------------|---|---|
| Extreme low      | 1-10                | Bottom 10% of the climatological distribution                       |   |
| Low              | 10-25               | 15% from the 1 <sup>st</sup> decile to the 1 <sup>st</sup> quartile |   |
| Bit low          | Near normal (25-75) | 25-40   | 15% from the 1 <sup>st</sup> quartile to the 2 <sup>nd</sup> quintile |
| Normal           |                     | 40-60   | 20% from the 2 <sup>nd</sup> quintile to the 3 <sup>rd</sup> quintile |
| Bit high         |                     | 60-75   | 15% from the 3 <sup>rd</sup> quintile to the 3 <sup>rd</sup> quartile |
| High             | 75-90               | 15% from the 3 <sup>rd</sup> quartile to the 9 <sup>th</sup> decile |   |
| Extreme high     | 90-100              | Top 10% of the climatological distribution                          |   |

# Prognoze sezoniere



**Anomaly category (rank-mean)**

**Uncertainty category (rank-std)**  
Low (0-10) Medium (10-20) High (20<)



| Uncertainty category | Rank STD | Description  |
|----------------------|----------|--|
| Low uncertainty      | <10      | The standard deviation of the ensemble member ranks is less than 10      |
| Medium uncertainty   | 10-20    | The standard deviation of the ensemble member ranks is between 10 and 20 |
| High uncertainty     | 20<      | The standard deviation of the ensemble member ranks is higher than 20    |

Seasonal forecast probability (numbers) and expected anomaly category (coloured cells) [2025-07-01]

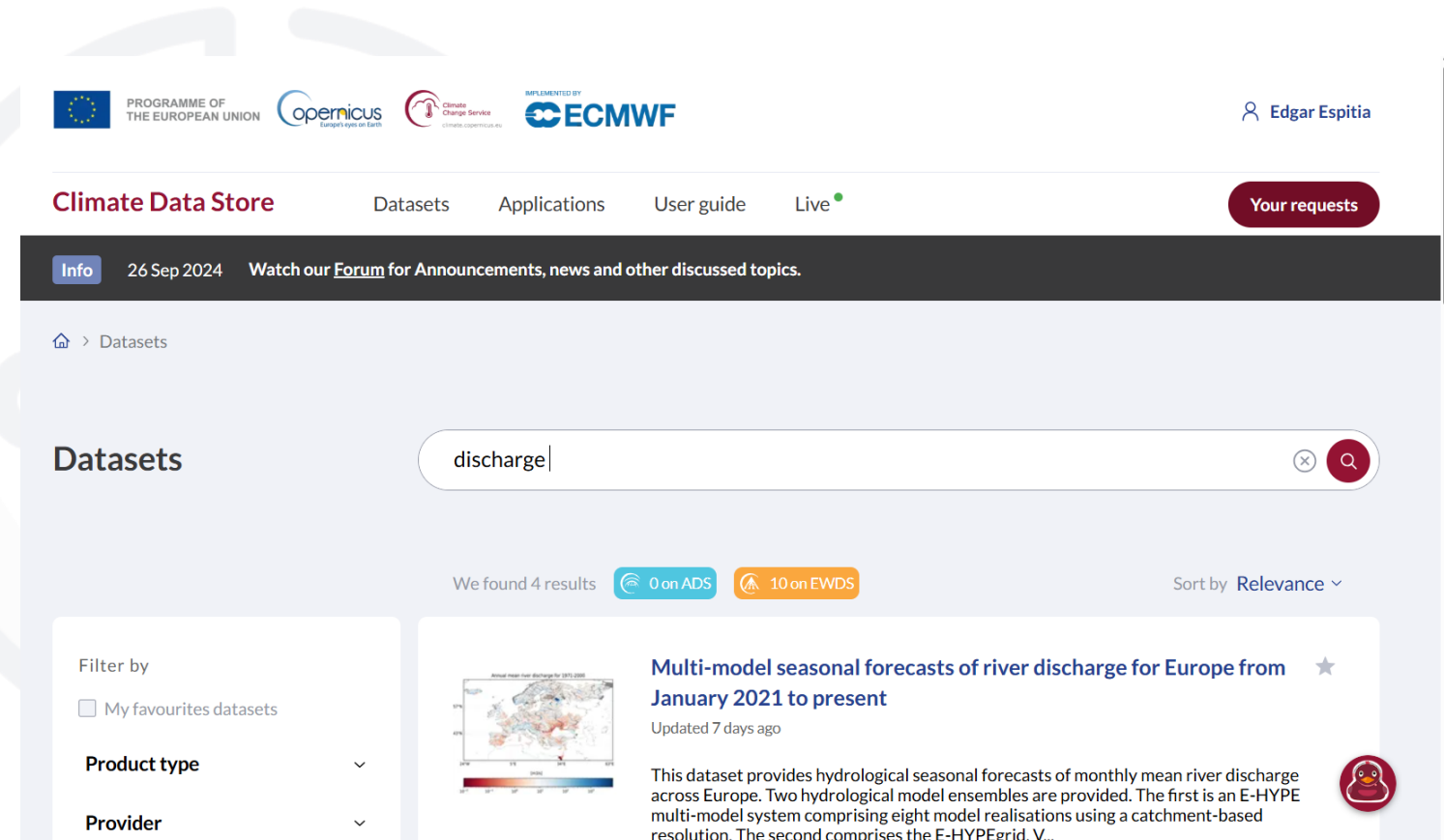
|               | July 2025 |    |    |    |    |    | August 2025 |    |    |    |    |    | September 2025 |    |    |    |    |    | October 2025 |    |    |    |    |    | November 2025 |    |    |    |    |    | December 2025 |    |    |    |    |    | January 2026 |    |    |    |    |    |    |    |    |    |    |    |    |
|---------------|-----------|----|----|----|----|----|-------------|----|----|----|----|----|----------------|----|----|----|----|----|--------------|----|----|----|----|----|---------------|----|----|----|----|----|---------------|----|----|----|----|----|--------------|----|----|----|----|----|----|----|----|----|----|----|----|
|               | EL        | L  | BL | N  | BH | H  | EH          | EL | L  | BL | N  | BH | H              | EH | EL | L  | BL | N  | BH           | H  | EH | EL | L  | BL | N             | BH | H  | EH | EL | L  | BL            | N  | BH | H  | EH | EL | L            | BL | N  | BH | H  | EH | EL | L  | BL | N  | BH | H  | EH |
| July 2025     | 65        | 27 | 4  | 0  | 2  | 2  | 0           | 33 | 31 | 12 | 10 | 8  | 4              | 2  | 16 | 29 | 16 | 15 | 8            | 8  | 8  | 23 | 10 | 18 | 23            | 12 | 12 | 2  | 10 | 19 | 16            | 27 | 12 | 14 | 2  | 14 | 16           | 17 | 12 | 10 | 23 | 8  | 12 | 10 | 16 | 21 | 12 | 23 | 6  |
| June 2025     | 22        | 21 | 14 | 21 | 14 | 2  | 6           | 14 | 31 | 19 | 16 | 10 | 6              | 4  | 12 | 14 | 18 | 17 | 16           | 17 | 6  | 17 | 14 | 14 | 19            | 14 | 12 | 10 | 16 | 17 | 12            | 23 | 14 | 6  | 12 | 8  | 19           | 12 | 19 | 20 | 14 | 8  | 8  | 19 | 12 | 19 | 20 | 14 | 8  |
| May 2025      | 12        | 23 | 16 | 21 | 20 | 8  | 0           | 12 | 21 | 14 | 21 | 10 | 16             | 6  | 14 | 14 | 33 | 17 | 10           | 6  | 18 | 16 | 17 | 21 | 14            | 8  | 6  | 16 | 14 | 14 | 10            | 19 | 25 | 2  |    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |
| April 2025    | 12        | 12 | 19 | 14 | 21 | 12 | 10          | 8  | 12 | 16 | 14 | 21 | 19             | 10 | 6  | 19 | 18 | 23 | 8            | 10 | 16 | 12 | 15 | 21 | 14            | 12 | 14 | 12 |    |    |               |    |    |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |
| March 2025    | 6         | 21 | 14 | 12 | 19 | 20 | 8           | 6  | 14 | 21 | 20 | 16 | 19             | 4  | 4  | 21 | 16 | 27 | 12           | 16 | 4  |    |    |    |               |    |    |    |    |    |               |    |    |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |
| February 2025 | 10        | 15 | 14 | 25 | 14 | 16 | 6           | 6  | 12 | 14 | 27 | 19 | 6              | 16 |    |    |    |    |              |    |    |    |    |    |               |    |    |    |    |    |               |    |    |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |
| January 2025  | 8         | 12 | 18 | 14 | 25 | 17 | 6           |    |    |    |    |    |                |    |    |    |    |    |              |    |    |    |    |    |               |    |    |    |    |    |               |    |    |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |

Deviația standard a rangurilor membrilor ansamblului:

- Incertitudine scăzută • < 10 → scăzută
- Incertitudine medie • 10–20 → medie
- Incertitudine ridicată • 20 → ridicată

## Descărcarea prognozelor sezoniere

<https://cds.climate.copernicus.eu/datasets>



The screenshot shows the Copernicus Climate Data Store (ADS) interface. At the top, there are logos for the European Union, Copernicus, Climate Change Service, and ECMWF. The user 'Edgar Espitia' is logged in. The main navigation includes 'Climate Data Store', 'Datasets', 'Applications', 'User guide', and 'Live'. A 'Your requests' button is also present. Below the navigation, there is an 'Info' section dated 26 Sep 2024, with a link to watch the forum for announcements. The main content area is titled 'Datasets' and features a search bar with the query 'discharge'. Below the search bar, it indicates 'We found 4 results' with '0 on ADS' and '10 on EWDS'. A filter sidebar on the left allows filtering by 'My favourites datasets', 'Product type', and 'Provider'. The first search result is 'Multi-model seasonal forecasts of river discharge for Europe from January 2021 to present', updated 7 days ago. The description states: 'This dataset provides hydrological seasonal forecasts of monthly mean river discharge across Europe. Two hydrological model ensembles are provided. The first is an E-HYPE multi-model system comprising eight model realisations using a catchment-based resolution. The second comprises the E-HYPEgrid, V...'. A small map of Europe is shown next to the title.

Mulțumesc!

Întrebări ?