Development of a machine learning hydrological forecast model using in-situ and remote sensing data

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1. Context and goals

- Process-based hydrological models requires a deep expertise to be implemented and used in an operational context.
- Machine learning based models such as Neural Network (NN) can be an efficient alternative, however, their fidelity is highly affected by quality and quantity of the input data i.e., in-situ measurements and Remote Sensing (RS).
- In-situ measurements are available at daily time scale or less, but are limited in coverage area.
- RS images cover wide ranges of area, and are valuable for ungagged river basins.

General objectives of the project:

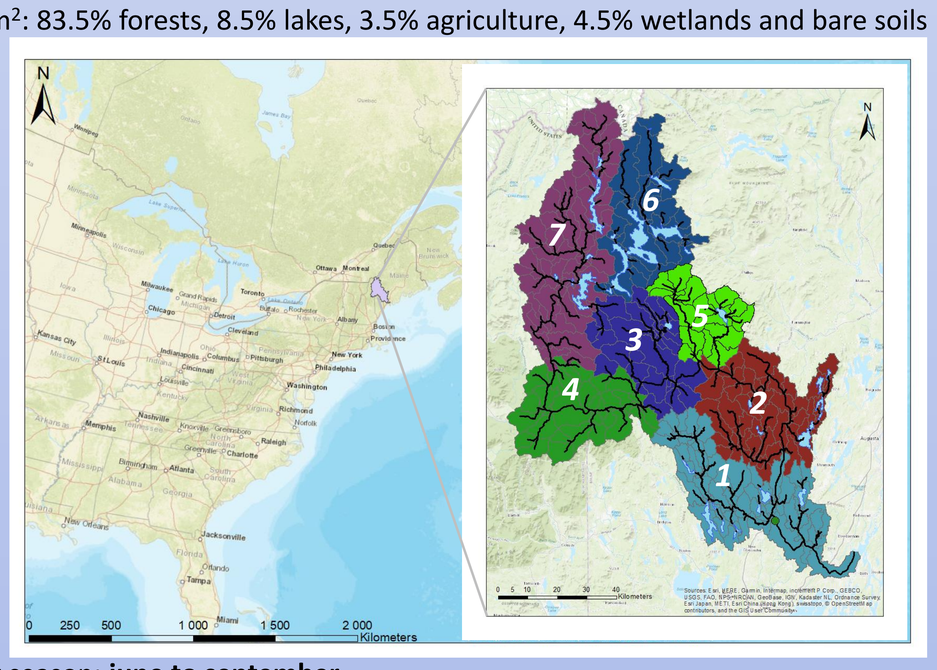
- To develop a neural network-based model with dynamic set of variables according to seasons and forecasting time.
- To introduce remote sensing and in-situ data to improve the hydrological model in different watersheds, seasons and forecasting time.

Specific objectives of the present work in progress:

- To calibrate HYDROTEL model on Androscoggin watershed located in North-east USA.
- *To evaluate the potential of hydro-meteorological variables using outputs of HYDROTEL as inputs of an NN hydrological model.*

2. Study case

- **Androscoggin watershed** (ME), USA
- 8 935 km^2: 83.5% forests, 8.5% lakes, 3.5% agriculture, 4.5% wetlands and bare soils



- Summer season: **june to september**
- Forecasting delay: **1 to 20 days**
- Physically based model: **HYDROTEL,** 403 HHU clustered in 7 groups
- Computation of correlation between runoff and precipitation, evapotranspiration and soil moisture

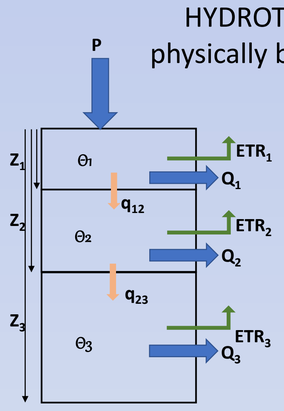
3. Methodology

General methodology

Development of hydrometeorological indices including RS data → NN hydrological model → Evaluation of NN models by comparison against HYDROTEL under seasonality and forecasting delay

1st step: determination of the most important inputs for NN model based on outputs from HYDROTEL model

HYDROTEL model
physically based model



$$Q = Q_1 + Q_2 + Q_3$$

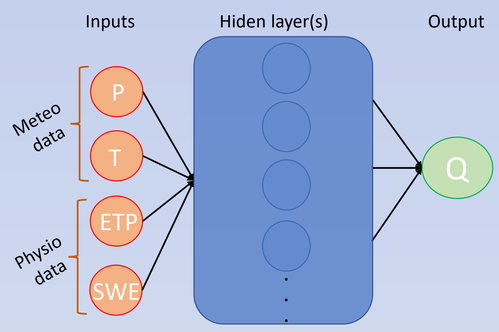
$$(Z_2 - Z_1).\frac{\partial \Theta_2}{\partial t} = q_{1,2} - q_{2,3} - T_{r,2} - Q_2$$

$$Z_1.\frac{\partial \Theta_1}{\partial t} = P_i - q_{1,2} - E - T_{r,1}$$

$$Q_2 = K(\Theta_2).\sin(\arctan(S_n))(Z_2 - Z_1)$$

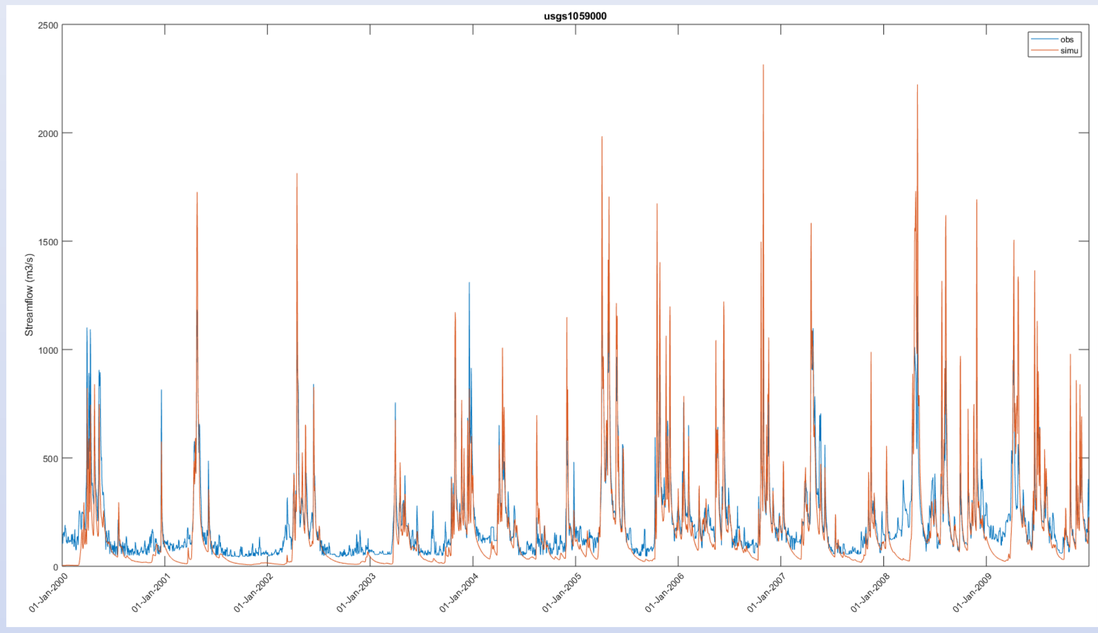
$$Q_3 = k_r(Z_3 - Z_2)\Theta_3$$

NN model
statistically based model



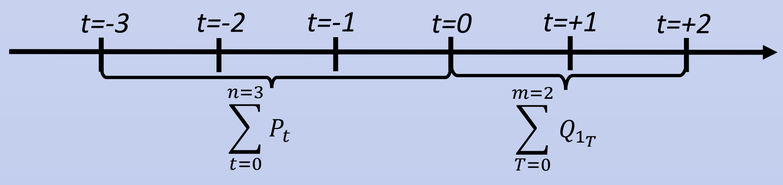
4. Preliminary results

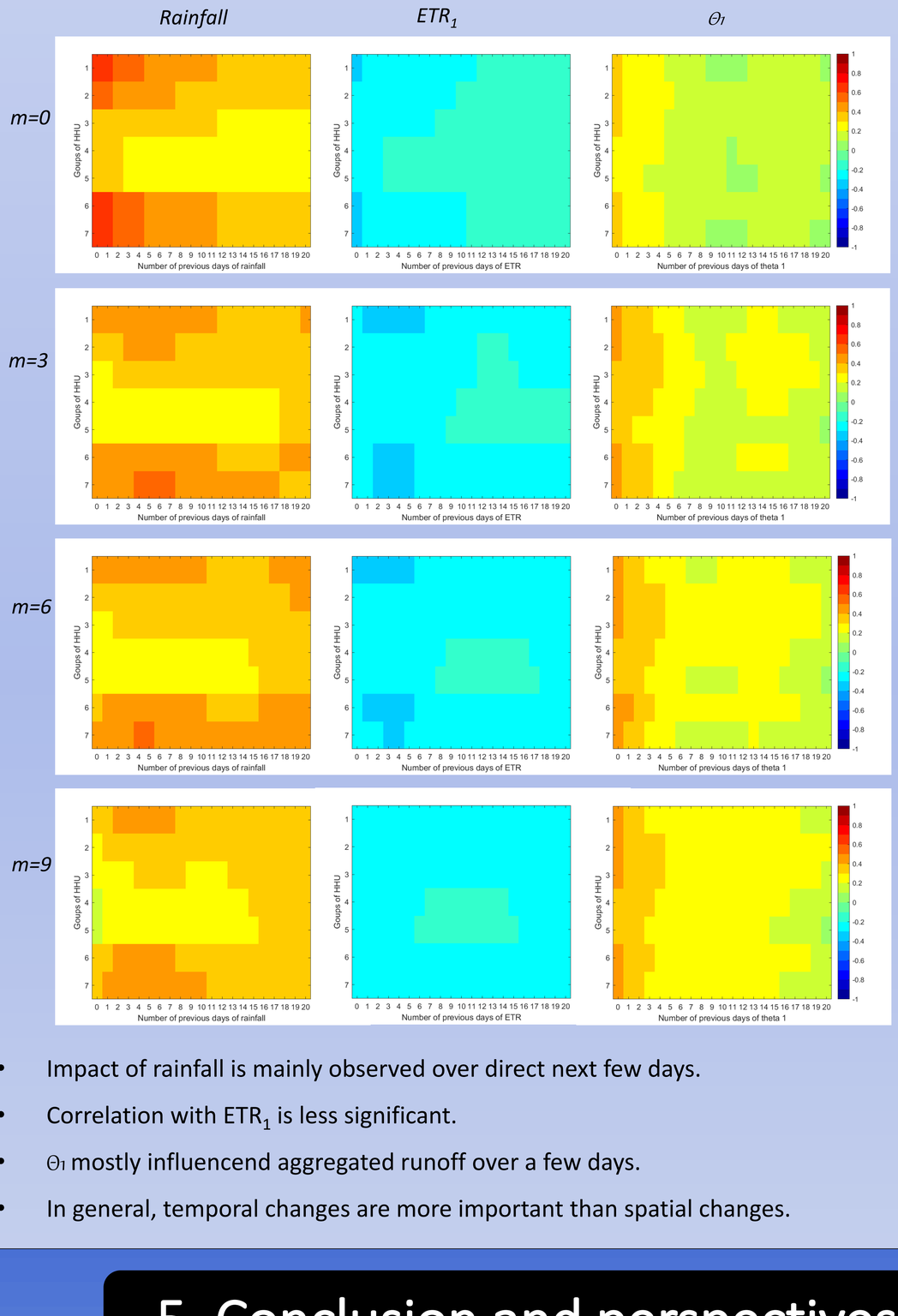
1. HYDROTEL calibration



- NS = 0.61
- Small underestimation of low flows
- Generally good estimation of peak flows

2. Correlation computation





- Impact of rainfall is mainly observed over direct next few days.
- Correlation with ETR_1 is less significant.
- Θ_1 mostly influencend aggregated runoff over a few days.
- In general, temporal changes are more important than spatial changes.

5. Conclusion and perspectives

- Correlations obtained are encouraging.
- In the future, it could be interesting to look at variables such as Antecedent Precipitation Index and Soil Moisture Index.
- To test the more sensitive variables as inputs of NN model.

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