Swiss Federal Institute for Forest, Snow and Landscape Research WSL

Schweizerische Gesellschaft für Hydrologie und Limnologie
Société suisse d'hydrologie et de limnologie
Società svizzera di idrologia e limnologia
Societad svizra d'idrologia e da limnologia

MACHINE LEARNING AIDED FORECASTING OF SUB-SEASONAL DROUGHT INDICATORS IN THE EUROPEAN ALPS

Annie Y.-Y. Chang[1,2], Simone Jola[1] , Daniela I.V. Domeisen[1], Konrad Bogner[2], Massimiliano Zappa[2]

[1] Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

[2] Swiss Federal Institute for Forest, Snow and Landscape Research, WSL, Birmensdorf, Switzerland

1 Introduction

- There is a need for decision makers to have early warnings of drought as many sectors in Central Europe depend heavily on its water resources, e.g. agriculture, hydropower production and transportation.
- ”Hybrid forecasts" combining traditional models and machine learning techniques have shown potential for improved skills and they are recommended for sub-seasonal to seasonal forecasts.
- “Weather pattern approach” has shown promising results for meteorological forecasts, but there has been less effort on applying such approach directly to hydrological forecast.

Research Questions:

1. Can machine learning model be used to perform hydrological routing and generate streamflow forecasts at monthly timescale?
2. Can large scale weather patterns help improve the predictability of local drought indicators?
3. Can low flow forecasts be combined with forest fire algorithms to explore the potential of early prediction of forest fire?

Keywords: Drought, Machine Learning, Weather Regimes, Forest Fire, Hybrid Forecasting

2 Work Packages

- **WP1:** Predicting low flows and lake levels in Swiss rivers and lakes using machine learning on sub-seasonal timescales.
  - Data: PREVAH [1] monthly runoff forecast data, BAFU streamflow and lake level observation data, weather regime (WR) forecast data provided by Karlsruhe Institute of Technology (KIT).
  - Study Period: March 2018 – September 2020
  - ML Algorithms: Multivariate Adaptive Regression Spline (MARS), Gaussian Process (GP), Quantile Random Forest (QRF), Gradient Boosting Machine (GBM)
- **WP2**: Predicting low flows and lake levels in large rivers and lakes in the European Alps on sub-seasonal scales.
  - Data: Alpine Drought Observatory (ADO) observation data, European Flood Awareness System (EFAS) forecast data, KIT WR forecast data
- **WP3:** Linking hydrological drought to forest fires in the Swiss Alps
  - Data: PREVAH [1] monthly runoff and soil moisture forecasts, KIT WR forecast data, historical fire data from database “Swissfire” [2].

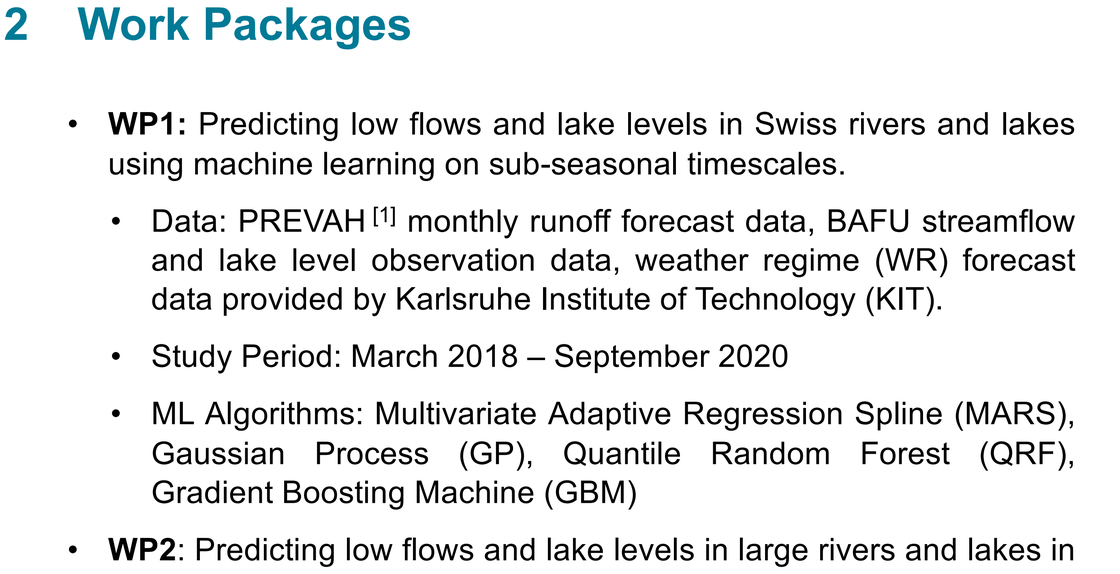

Fig. 1. Simplified workflow of WP1.

3 Preliminary Results

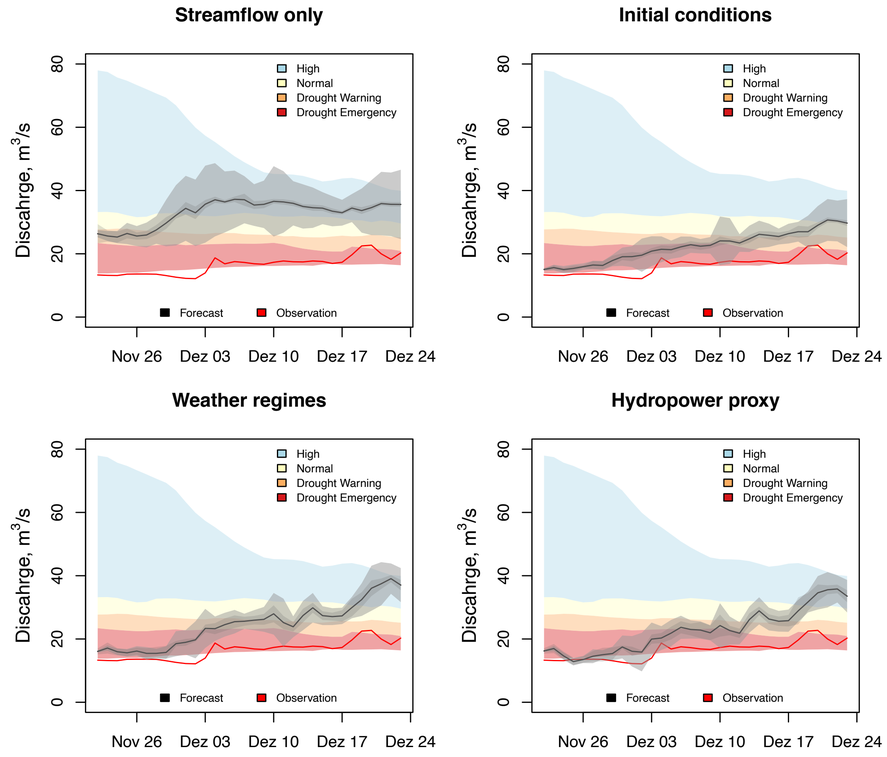

Fig. 2. Discharge forecast from 22.11.2018 to 23.12.2018 at Lake Brienz outlet. The classes of drought emergency, drought warning, normal and high correspond respectively to 1-10, 33-10, 66-33 and 99-66 percentiles of climatology from 1991-2000. The solid black line represents the multi-model mean with uncertainty derived from the 51 ensemble members. Upper left panel: with PREVAH outputs only. Upper right panel: with added observed initial conditions. Bottom left: with added weather regime indices. Bottom right: with added Julian days as hydropower proxy. Model runs are with pre-processed forecasts.

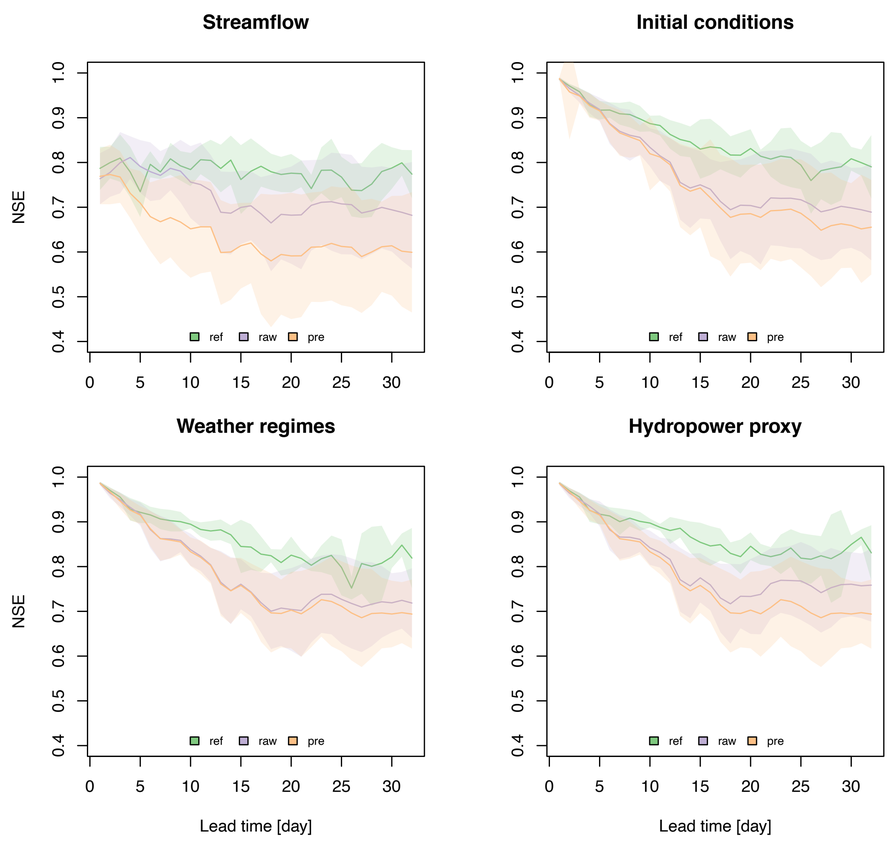

Fig. 3. NSE of lake level forecast for Lake Brienz with 32-day lead time. Upper left panel: with PREVAH outputs only. Upper right panel: with added observed initial conditions. Bottom left: with added weather regime indices. Bottom right: with added Julian days as hydropower proxy. Model runs are with raw, pre-processed or reference PREVAH simulations.

4 Risk Assessment

- Sufficient data quantity needed for machine learning model training
- Interpretability of machine learning outputs to understand the driving forces of hydrological drought events.

5 References

1. Viviroli, D., Zappa, M., Gurtz, J., and Weingartner, R. (2009). An introduction to the hydrological modelling system PREVAH and its pre- and post-processing-tools. Environmental Modelling and Software, 24(10):1209–1222.

2. Pezzatti, G., Reinhard, M. and Conedera, M. (2010), ‘Swissfire: die neue schweizerische Waldbranddatenbank’, *Schweizerische Zeitschrift für Forstwesen* **161**, 465–469.

Partners

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Karlsruher Institut für Technologie

Interreg Alpine Space
Alpine Drought Observatory