Streamflow forecast for Icelandic catchments using an analogue sorting prediction method

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Introduction

Floods in Iceland have led to significant material destruction and disruption in the past. With increasing tourism, it is expected that floods will create further risks.

Weather-related floods are responsible for localised damage in most parts of the country. The forecasting of these floods at the Icelandic Met Office (IMO) has historically relied on daily monitoring of water levels alongside meteorological forecasts.

Analogue sorting methods are traditionally used for meteorological forecasts, but similar methods, often named "k-nearest-neighbor" methods, have been successfully tested for streamflow forecasts (Karlsson & Yakowitz, 1987; Akbari et al., 2011; Oyebode et al., 2014). In 2013, Crochet (2013) researched successfully the use of these methods at IMO.

The numerical weather prediction model Harmonie has been in use at IMO since 2011, with forecasts available for the next 72 hours. Hindcasting of previous weather conditions has resulted in a 30-year record of gridded, 2.5 by 2.5 km forecast data for the whole of Iceland. This dataset offers new opportunities for streamflow forecasting with weather variables readily available everyday for the three next days.

In this poster, results of this forecasting method are presented along with the setup of an operational flood forecasting system for catchments in Iceland.

Study area

Thirteen catchments, located throughout the country, were investigated (Fig.1). Their characteristics are diverse: from simple direct run-off catchments to catchments fed by groundwaters, glaciers or lakes, their size varying from 1132 km^2 for the largest (vhm200) to 38 km^2 for the smallest (vhm19).

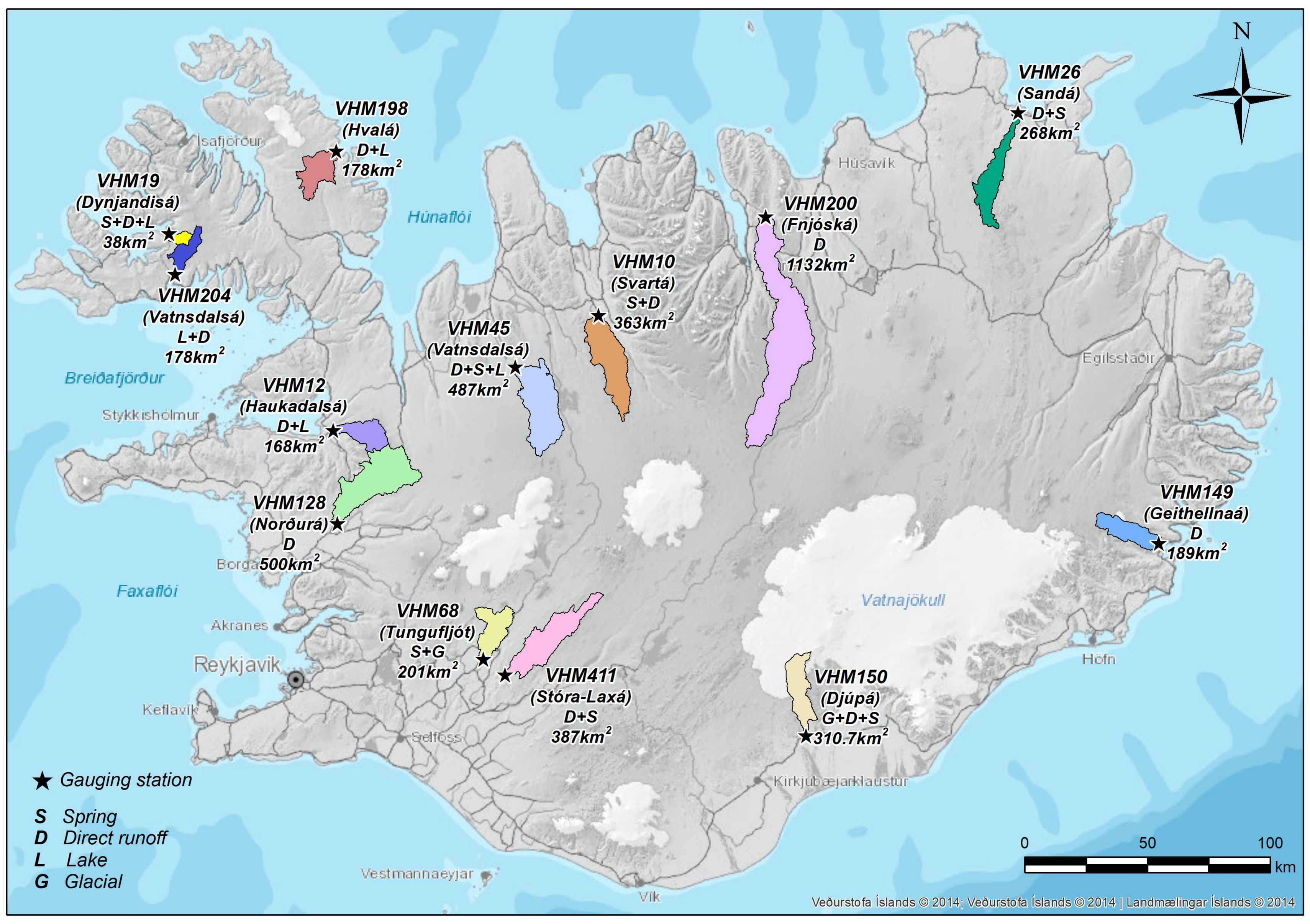

Figure 1: Map of the catchments used to test the analogue sorting methods.

Methodology

Discharge and meteorological history of the catchments are combined into predictor-sets. Four meteorological variables, computed by Harmonie, have been selected to start evaluating this method: precipitation, air temperature, melt and snow-water equivalent (SWE).

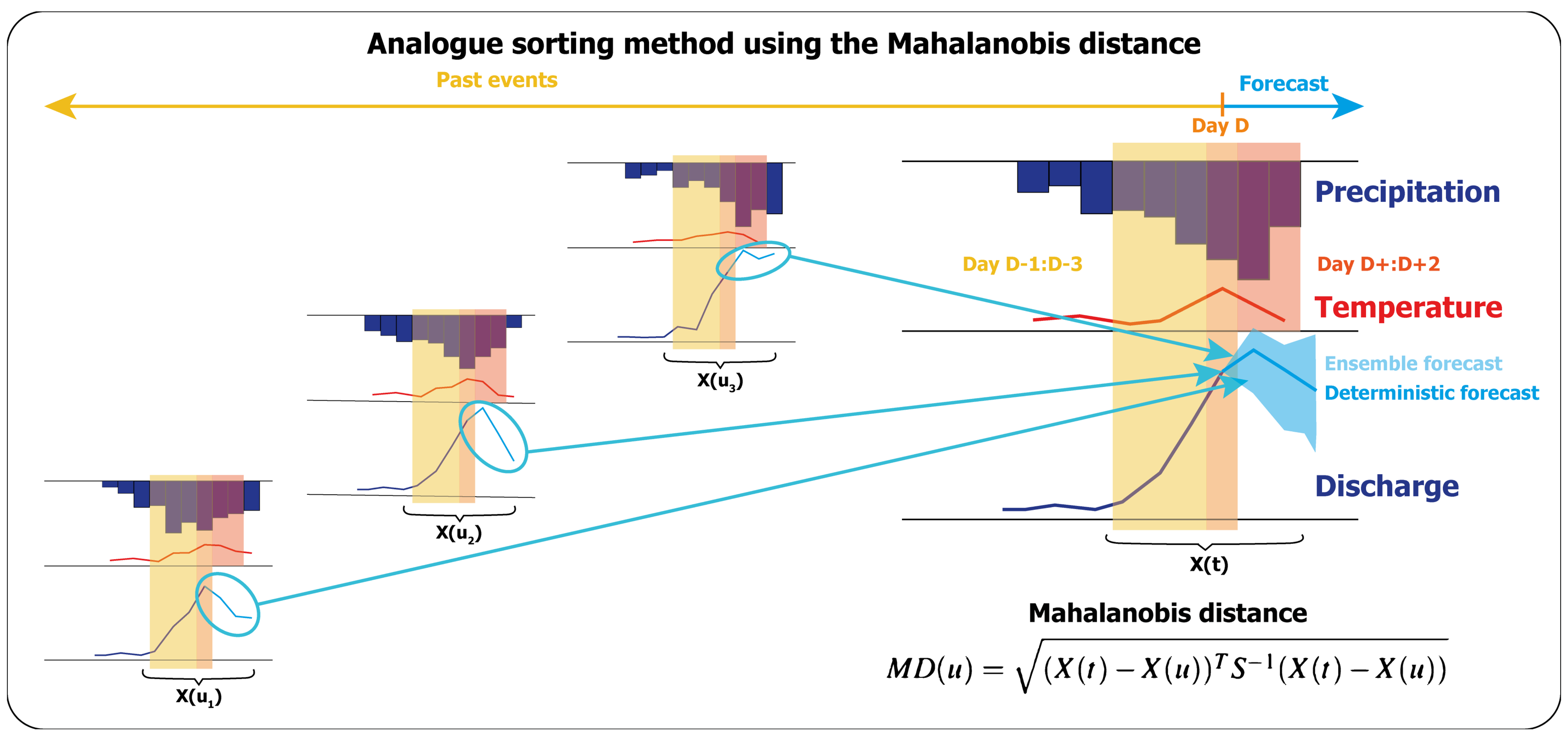

Figure 2: Analogue sorting method.

For the purpose of this study, tests are run on past years in order to assess over longer periods the performance of different predictor combinations.

The Mahalanobis distance is used to determined which past events x(u) are most alike the present event (x(t)) (Fig. 2). The events are sorted and k events are retained to compute the deterministic and ensemble forecasts.

Twenty combinations of predictors and 8 sizes (k) of ensemble were tested. Five day forecasts are computed over a period of 365 days. The benefits of rescaling are also considered.

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Statistical calibration

Test runs show very good results for the first day of the forecast D+1 , with Nash-Sutcliffe coefficient varying from 0.68 to 0.97. These values drop with each additional day of forecast and lower to the range 0.12-0.83 for D+5.

Looking at the predictor-sets, it is apparent that some variables appear to have more influence than others. If we focus on the D+1 results, for snow-mitigated direct-runoff catchments (vhm 204, 198, 200 and 19) the predictors-sets including the temperature, melt or SWE variables are the most efficient while for catchments with storage -groundwater, wetland, lake- (vhm 128, 411, 12, 54, 10 and 26), the predictors-sets including the previous days discharges improve the forecast. For catchments with glacial influences (vhm 68, 150 and 149) better results are found when the weather forecasts are used in the predictors-sets. Regarding the D+2 – D+5 forecasts, the inclusion of weather forecasts in the predictors-sets gives better results.

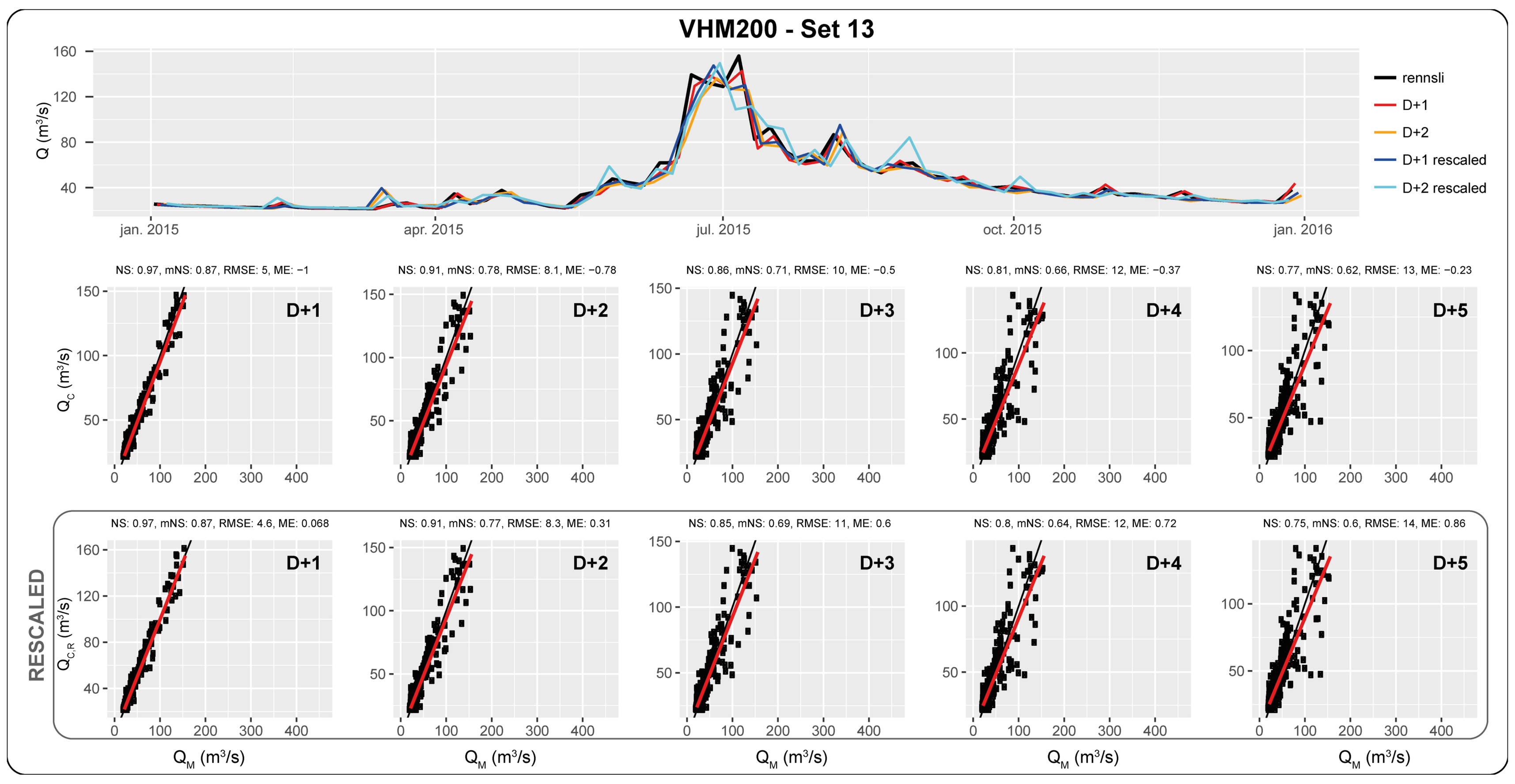

Figure 3: Results for vhm 200 with predictor set 13 (Q, Q_{D-1}, Q_{D-2})

K's from 10 to 100 were tested and it was estimated to be most efficient between 40 and 50, after which it simply decreases the computing efficiency with no significant improvement of the results.

Rescaling often improves the result of the first 2 days of forecast, but the improvements are often less visible for the 3 last days (Fig. 3).

Operational setup

Results of the analogue forecast will be displayed on a webpage similar to Figure 4. All catchments are shown on a map of Iceland (Fig. 4, left). The bottom subplot (Fig. 4, right) shows the measured discharge over the last 30 days (black lines) along with the analogue forecast for the next five days (each color corresponds to a different predictors-set) while the grey shading shows the minimum and maximum values of the past forecasts. The upper graph shows the WaSiM simulated temperature (purple line) and precipitations (grey bars) over the last 30 days.

In addition, the colors of the catchments (Fig. 4, left) are updated hourly depending on the latest measured discharges. A green catchment indicates a discharge value under the 2-year return period. As this first threshold is reached, the catchment will change color to become yellow and so on.

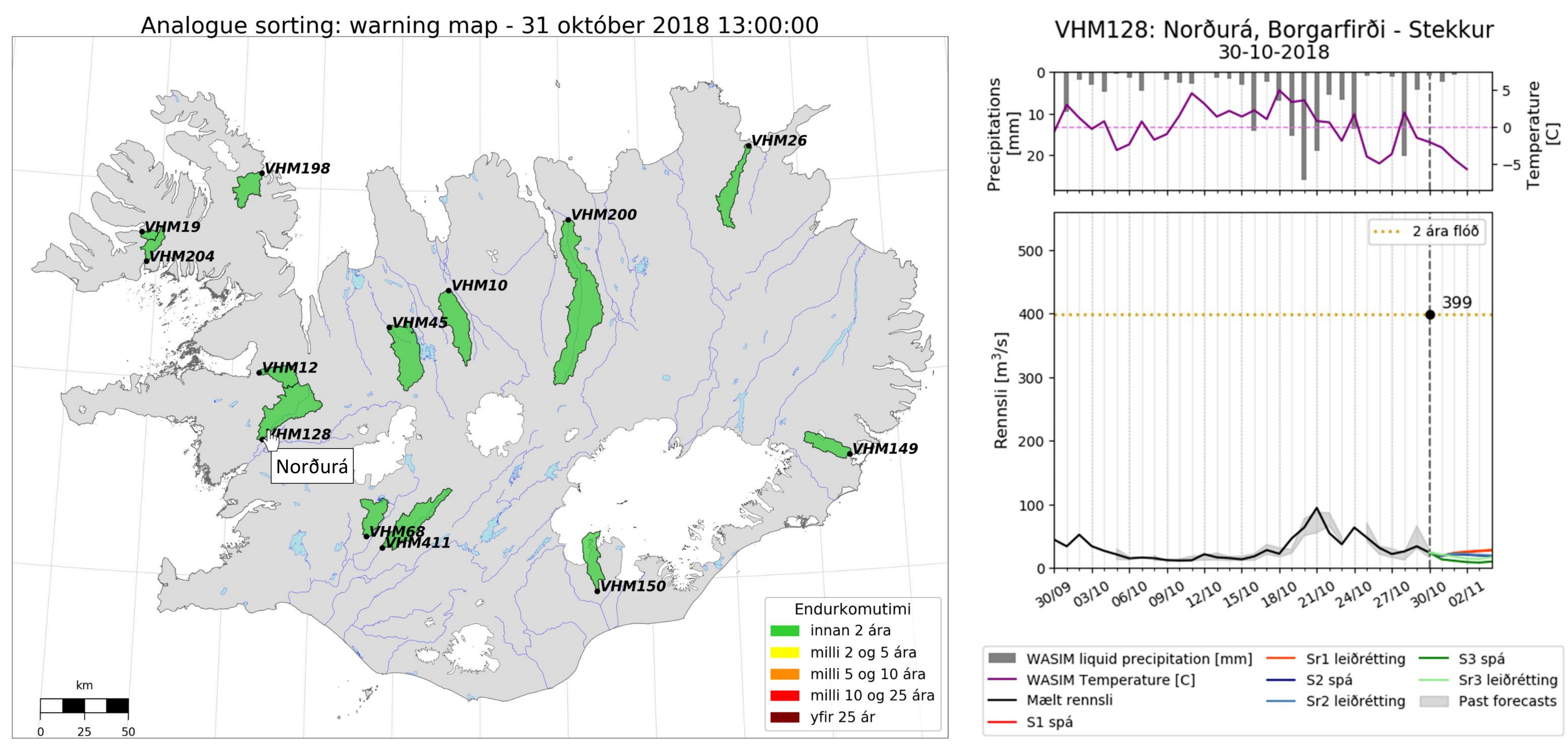

Figure 4: Snapshot of the operational forecast system website with mouse hovering over vhm128 (Norðurá).

Conclusions and next steps

Streamflow forecasting based on analogue sorting methods requires little to no pre-processing and it is not as compute-intensive as the forecasting system already in place. It also enables longer forecast periods, going from 2 to 5 days forecasts.

This method gives promising results for a large variety of catchments. A selection of predictors based on the type of catchment improves the quality of the results. Further improvements of the forecasts will be investigated using post-processing methods.

References

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