Flood frequency analysis in a changing climate - Climate change impact on design flood

(Greining á flóðatíðni vegna loftslagsbreytinga og áhrif á hönnunarflóð)

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The aim of this study was to evaluate the impact of climate change on flood characteristics in Icelandic rivers. Daily streamflow discharge series were simulated for three river catchments over the 1981-2100 period with the HYPE hydrological model forced with an ensemble of bias-corrected CORDEX climate projections under two emission scenarios. The catchments are located in the south-east, south-west and north of the country and their drainage area is ranging from 115 to 5700 km^2. The hydrological response of these catchments was analysed, considering moving 30-year time-windows and compared to the situation in the 1981-2010 reference period.

A significant temperature warming was projected in all seasons and all studied catchments, along the projection horizon, more or less pronounced according to the emission scenario, the season and the catchment location (0.29 °C/decade on average for the lowest emission scenario and 0.45 °C/decade on average for the highest emission scenario). Precipitation did not exhibit any significant temporal linear trend in a large majority of cases. Instead, decadal to multi-decadal oscillations were observed in the precipitation time-series, especially in autumn-winter, corresponding to a succession of wet and dry periods. However, the wet and dry periods of the different projection scenarios were sometimes found not to be in phase with each other, complicating the interpretation of results in some cases.

The hydrological response of the studied river basins was found to depend on the physiographic characteristics of the catchments. The projected temperature warming was found to gradually alter snow conditions and lead to a shorter snow season combined with less snow accumulation and a shift toward an earlier and lower peak of snowmelt. A gradual change with increasing projection horizon toward an increase of streamflow discharge in autumn-winter, an earlier and lower spring streamflow peak and a reduction of summer streamflow discharge were also projected except for a partly glaciated catchment where summer streamflow was projected to remain mainly unchanged.

Projected climate change was observed to have an impact on flood characteristics and the results of this study suggest that if projected climate scenarios realise, the frequency of extreme floods is likely to change. However, the uncertainty of the projected changes is considerable. The changes were found to be specific to each catchment in relation to its physiographic properties and dominating flood-generating mechanisms (rain-fed, snowmelt-fed, interplay of rain and snowmelt). Under the lowest emission scenario, both an increase and decrease of extreme flood quantiles are projected in a recent future (until circa 2031-2060), depending on the catchment under consideration, while an increase of flood quantiles dominates in a more distant future (2041-2070 and thereafter). Under the highest emission scenario, a shift toward larger extreme flood quantiles dominates along most of the 21st century. The projected changes in flood quantiles are moderate (less than 20% increase, on average) but translate into larger changes in terms of return period (up to 50% reduction, on average). Concerning flood occurrence dates, a larger number of annual maximum flood events are projected to occur in autumn-winter and fewer in spring-summer, relative to 1981-2010, under both emission scenarios.