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Modelling the effects of future changes in short-term precipitation intensities on flooding in small catchments

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Projected changes in precipitation under a future climate suggest larger increases in short-term precipitation intensities than in daily. In small, rapidly responding catchments, this will lead to increases in instantaneous discharges that are larger than changes hereto estimated from daily data. In Norway, climate change factors for adapting to future flood hazard come from models and data with a daily time step, and future impacts on the instantaneous flood are unquantified. Three alternative climate data 'sources' have, therefore, been used to assess whether such effects can be assessed from higher temporal resolution simulations and data: 1) 3-hourly bias-adjusted EUROCORDEX RCM precipitation and temperature time series for reference (1970-2000) and future (2070-2100) periods (ECX BC); 2) control and perturbed simulations of observed extreme precipitation events using the WRF model and a perturbation representing a +2C increase in temperature (WRF PT); and 3) observed and perturbed 3-hourly time series for reference and future time periods constructed using change factors for individual quantiles estimated from uncorrected EUROCORDEX RCM data (ECX QP). Although not all aspects of the three approaches are directly comparable, they each highlight relevant factors for interpreting hydrological projections for changes in flood hazard in small catchments.

Three-hourly precipitation and temperature series from 5 SMHI-RCA4 runs (EUR11), representing 5 GCMs, were used to develop bias corrected (ECX BC) and perturbed (ECX QP) input series for hydrological modelling for 65 small catchments (< 160 km2) distributed across Norway. The WRF atmospheric model was also run for a domain covering the southern half of Norway with three grid resolutions (2 km, 4 km, and 12 km) and a 1-h time step. These runs simulated 28 observed extreme precipitation events during the period 2005-2014 with durations of 30 to 174 hours for today's climate and with a +2[U+F0B0] perturbed temperature. An ensemble of precipitation values for each event were extracted and merged with the full continuous time series for each of 48 catchments (WRF PT). Time series from all three methods, as well as corresponding 24-h aggregated series, were used as input to the DDD hydrological model for each catchment.

Hydrological simulations using ECX BC data produce an increase in the average annual maximum flood that is on average 20-25% higher for 3-h relative to 24-h simulations for the catchments. The ECX QP simulations further suggest that both precipitation increases and temperature changes contribute to the increased flood hazard due to changes in seasonal snow cover. In some cases, the increases in peak discharge are higher than estimated from increases in precipitation intensity alone. No effect of catchment size was seen in ECX results, possibly due to the EUR11 grid resolution (∼12 km2). The WRF simulations support this in that the 2 km grid produces the largest changes in the maximum discharge (up to a 60% increase), and this effect is most evident in the smallest catchments.