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Application of a large climate model ensemble to study compound flood events: four case studies for regional water systems in the Netherlands.

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In this contribution four case studies in the Netherlands are discussed, investigating the role of atmospheric drivers, the probability of occurrence of compound flood events and their impact on regional water systems, and the potential changes therein in a warming climate. Observations of extreme compound events are rare by definition and observational datasets are often too short to look far in the tail of the probability distribution of the relevant variables. Here we use a 16-member initial-condition ensemble generated with the global climate model EC-EARTH and further downscaled with the regional climate model KNMI-RACMO$_2$ over Western Europe at 12 km spatial resolution for the period 1950-2100, forced with historical emissions until 2005, and the RCP8.5 emission scenario thereafter. Model time series are used to drive a North Sea surge model. The periods 1951-2000 and 2026-2075 were selected to study 16 x 50 years of current and future climate, respectively.

Two of the case studies concern water systems in the north of the Netherlands for which discharge to sea under gravity is blocked when sea levels are too high. Historical data suggest a correlation between storm surges and precipitation. The RACMO EC-EARTH simulations are used to investigate this relation for the present-day and future climate. The relation found in the current climate simulations is similar to the relation in the observations, with the exception of the far tails of the probability distribution. We currently investigate whether the climate model is realistically capturing the synoptic-scale patterns associated to the most extreme observed events. Hydrological and hydraulic models are used to study the impact of compound flood events on the regional water systems and the effect of potential measures against flood risks.

The third case study considers the Dommel and Aa rivers, which both discharge under gravity to the river Meuse. In 1993 and 1995 high discharges from these rivers occurred simultaneously with high Meuse water levels, which resulted in large inundations around the city of Den Bosch. Correlations between precipitation in the three river basins and the timing of peak discharges in RACMO EC-EARTH correspond to historical observations. The effect of joint occurrence of high discharges in the three rivers on water level statistics in the city is assessed using hydraulic models.

The final case study considers the area of Brabantse Delta. In case of extreme storm surge at the North Sea, the coastal flood defense structures are closed and Rhine and Meuse rivers cannot discharge to the sea. When this jointly occurs with extreme discharges, the Rhine and Meuse are forced to discharge into lake Volkerak. Discharge of smaller local rivers into this lake is blocked when lake water levels rise too high, posing flood risk in the area. Hydrological, hydrologic and hydrodynamic models are used to investigated the joint occurrence of high sea water levels, high Rhine river discharges and high local river discharges.