Hot temperatures and storm surges: Modelling the change of climate extremes

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Due to the anthropogenic increase of greenhouse gases global-mean temperature will rise by 2-4 K during the 21st century, and this temperature rise will be accompanied by changes in other climate variables.

Weather-related threads come from extremes (storms, heat waves, heavy precipitation) rather than from the mean weather ("climate"). Therefore, the socio-economic impacts of a changing climate are not so much determined by the change of the means, but by the accompanying change of the extremes. The central question arising in this respect is whether the extremes change in proportion to the change in the mean, or whether they are larger (or smaller). Mathematically , the question is whether the probability density function (PDF) of the variable in question is just shifting or also changing its shape.

To address this question, KNMI, as part of the Dutch Center for Climate Research (CKO), has conducted a project called ESSENCE (http://www.knmi.nl/~sterl/Essence), in which a stat-of-the-art climate model has been integrated for the period 1950-2100. 17 integrations, starting from slightly different initial conditions, have been performed. This gives enough data to reliably asses (changes of) extreme events. Two examples are presented.

The first example is the 100-year-return value of temperature (T_{100}). In some areas T_{100} rises up to three times faster than the mean temperature. The cause is an increase of the scale parameter of a GEV distribution fitted to the annual-maxima of temperature. In other words: Extreme temperatures become more extreme. Physically, this is caused by a drying of the soil, which in the future, warmer, climate occurs more often. Even after correcting for a possible model bias, expected values of T_{100} at the end of this century far exceed 40°C in many densely-populated regions.

The second example is the hight of storm surges along the Dutch coast, which have been modelled by forcing a surge model with the winds from ESSENCE. The large model ensemble makes it possible to reliably assess the 10,000-year return surge height, which by law is relevant for the coastal defence system. Winds tend to increase slightly in the southern North Sea. However, this increase is due to southwesterly winds which do not lead to high surges along the Dutch coast. Within the model uncertainty, no changes of the 10,000-year return height are found.