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A proxy analysis of urban air quality hazards in Bergen, Norway under a changing climate.

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The urban air quality in Bergen, Norway is characterized by clean air throughout most of the year interrupted by short episodes of hazardous pollution levels especially in close proximity to major road-emission sources. These pollution episodes are linked to winter time anti-cyclonic weather conditions with persistent stable temperature stratification (inversions) in the Atmospheric Boundary Layer. Although the pollution episodes are local events, the high pollution episodes are linked to large-scale persistent blockings in the atmospheric circulation.

Here we present an atmospheric circulation proxy for the pollution episodes based on the ECMWF ERA-Interim reanalysis. The proxy is based on local 3-hourly instantaneous wind-speeds and directions at the 1000 hPa pressure level, and 1-day running mean temperature deviations at 2 m above ground from the 1-day running mean temperatures averaged over the full ERA-Interim record length. We tuned the thresholds for each quantity to the occurrence of events with an hourly mean NO_2 concentration > 150 μg/m^3 at a high pollution reference station. A condition on cloud cover had only little effect, sea-level pressure was not applicable. High pollution episodes predicted during typical low traffic days (Sundays, Christmas, New Year) were removed.

The final proxy had a detection rate of 82 %, a false alarm rate of 77 % and a correct null prediction rate of 96 %. The high false alarm rate was expected because of the relaxed thresholds chosen in order to include a large fraction of possible states of atmospheric circulation that lead to hazardous air quality. Additionally, the false alarm rate was high because no constraint on the persistence of adverse meteorological conditions was set and because of the high variability of traffic, not always leading to hazardous pollution levels, even if the atmospheric circulation would allow for it.

The Scandinavian index, an often used proxy for the occurrence of atmospheric circulation allowing for high pollution events, showed only limited agreement with both the local proxy developed herein and the actual number of pollution events both on a monthly and on a seasonal basis. The NAO index showed an anti-correlation to the local proxy and the observations at least on a seasonal basis, the picture of the monthly basis was more unclear.

Finally, the proxy was applied to NORESM CMIP 5 simulations to find the long term trend of the occurrence of adverse meteorological conditions for air quality in Bergen between 1950 and 2050. For this, the thresholds for the proxy had to be modified because the necessary NORESM data were only available as daily means. The prediction rates in ERA-Interim then changed to 77 % (detection rate), 61 % (false alarm rate) and 95 % (correct null prediction rate), respectively.