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SMART ANALYSIS OF WATER LEVEL EXTREMES REVEALS HIDDEN FEATURES OF CLIMATE CHANGE

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One of the largest concerns of coastal communities is the gradually increasing risk of extensive coastal flooding. Extreme water levels increase much faster (5–10 mm/yr) than the average water level in the Baltic Sea [1]. This risk is commonly quantified using classic extreme value distributions. The relevant approaches often fail for the coasts of the Baltic Sea where statistically almost impossible water level may occur [1]. The problem here is the presence of aperiodic large-amplitude subtidal (with time scales from a day up to a few weeks) variations in the water volume of the entire sea that are occasionally created by series of storms travelling over the Danish straits.

The paper describes several new options to analyse and forecast possible changes in extreme water levels at the Baltic Sea coasts where weekly-scale variations in the average water level of the entire sea are comparable with the magnitude of local storm surges. The local water level time series is split into slowly and rapidly changing components using a simple averaging procedure. For a certain averaging interval (about 8 days) there exists a natural separation of the total water level into components representing the basin-scale and local phenomena [2]. The frequency of occurrence of basin-scale (weekly average) water levels matches a Gaussian distribution whereas the similar frequency of the residual almost exactly follows an exponential distribution. Consequently, the residual (that characterises the impact of local storms) reflects an underlying Poisson process.

This simple separation makes it possible to quantify the contribution of each of the two major components of the water level (or its physical driver) into the increase in the extreme water levels. The contribution of the basin-scale phenomena is almost constant (about 4 mm/yr) for the entire north-eastern Baltic Sea. The contribution of single storms is almost zero at the coasts open to predominant storm directions but is substantial (up to 7 mm/yr) in the eastern bayheads of elongated sub-basins of the Baltic Sea. This pattern signals that (i) wind speed in strong storms has not increased over the last half-century but (ii) the series of autumn-winter storms have become longer and, most importantly, (iii) wind direction in the strongest storms have rotated [3].

The spatially varying contribution of various drivers to the water level and the frequent presence of outliers lead to large uncertainties in the projections of future extreme water levels. A natural way forward is the use of an ensemble of projections that involves different sets of block maxima (e.g., annual and stormy season water level maxima) to initialise extreme value distributions.

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