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Weather patterns associated with storm surges at Mariupol, Ukraine

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Any rise in sea level will have adverse impacts depending on the time scale and the magnitude of the rise and the human response to it. When each sea surge is considered, the primary forcing is associated with the passage of extra-tropical storms. In semi-enclosed basins, the most important meteorological factors are the associated winds. In the present study, sea level data observed at the Port of Mariupol, Ukraine are used. The port is located at north-western part of Taganrog Bay of the Azov Sea (14 miles from the entry into the Bay). Long-term mean of sea level is 471 cm, and we consider all sea levels exceeding dangerous elevated one (531 cm established by national regulations) as a storm surge. For the present investigation the 21-year hourly sea level data from 1985 to 2005 are used. During this period, the 84 storm surges were observed, i.e. 4 surges per year on average. The growing trend becomes apparent; the maxima of elevated sea level events (11 occurrences) were registered in 2000 and 2004, but during 2003 the storm surges were not observed. Three fourth of storm surges occurred from February to June. High-lever water persists generally a few hours, but there are events of prolonged persistent surge, e.g. one observed during 33 hours form 5 to 6 June, 2001.

The object of this study is to determine typical weather patterns associated with storm surges, which was achieved in three ways. First, we analysed synoptic charts for events of storm surges at the Mariupol. It was found that the dangerous elevated levels were mostly (∼60%) registered at southern or south-western peripheries of deep cyclones. It is noteworthy than most heavy storms in the Azov Sea occurs at northern part of cyclones, i.e. offshore storm wind is no dominant cause for storm surges at northern coast of Azov Sea. Further, we applied the principal component analysis (PCA) technique to sea level pressure for the dates with storm surges at the Mariupol. The first EOF explains 43% of the total variance and is characterised by the presence of strong negative centre in Scandinavia. The second EOF is a quasi-meridional dipole, which is characterized by large-scale structures with their main centres of action over Ural and Norwegian Sea. It accounts for 19% of the explained variance. Thus the PCA technique provides results similar to the analysis of synoptic charts. Finally, we utilized the continuous wavelet transform to reveal possible connection between variations of Mariupol's sea level and daily North Atlantic Oscillation index. As an example, consider the period from 1 February to 31 July of 2004, when 11 storm surges were registered. The continuous wavelet transform shows that the significant wavelet powers can be obtained at near-synoptic time scales for these time series during the periods with dangerous elevated sea levels. Moreover, the cross-wavelet transform (XWT) confirms such a result, and the XWT phase angle within significant region at near-synoptic time scales has the mean phase about 0, i.e. these variations are in phase.