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The Baltic Sea Level Variability and Floods in the Gulf of Finland

Igor Medvedev and Evgueni Kulikov
P.P. Shirshov Institute of Oceanology, Moscow, Russian Federation (patamates007@yandex.ru)

Floods in the Gulf of Finland are the most dangerous extreme events in the Baltic Sea. Catastrophic sea-level rises here are mainly related to cyclones passing over the Baltic Sea. Strong cyclone-associated west winds produce storm surges in the gulf. At the same time, an important factor amplifying this effect is the resonant response of the gulf basin to the wind. Statistical analysis of long-term sea-level observations in the Baltic Sea demonstrated that the wave field in this basin is constructed by a complex superposition of standing wave modes. In the Gulf of Finland, sea level spectral energy for the broad band of periods from 0.5 to 10 days increase with the distance from the entrance to the head of the gulf. Prominent peak with a period of about 27 hrs has been detected in the spectra of tide gauge records located in the Gulf of Finland and found to be related to the fundamental gulf mode. Cross-spectral analysis of simultaneous sea-level time series indicated the existence of nodal lines of standing longitudinal modes in the gulf. The main feature of the frequency response function estimated between two stations located in the gulf entrance (Hanko) and the gulf head (Saint Petersburg), is a major resonant peak with a period of 27 hrs. The quality factor of the respective oscillations is Q = 3.3. The cross-spectral characteristics between the atmospheric forcing (wind velocity and atmospheric pressure) and sea level oscillations indicate the dominant role of the zonal wind in the generation of floods in the Gulf of Finland. Moreover, the frequency response function calculated between atmospheric pressure/wind components taken as an input and sea level as an output, shows evident resonance response at the same period of 27 hrs. In general, the results of numerical computations and time series analysis validate that the most probable cause of extreme floods in St. Petersburg is the resonant "swinging" of the fundamental 27-hour mode in the Gulf of Finland generated by strong atmospheric disturbances.