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Investigating the influence of sea level oscillations in the Danish Straits on the Baltic Sea dynamics

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In this research, we study the influence of dynamic processes in the Danish Straits on the sea surface height (SSH) oscillations in the Baltic Sea. For this purpose, we use the model of marine and oceanic circulation INMOM (Institute of Numerical Mathematics Ocean Model).

The simulations were carried out for the period 2009-2010, and the coastal station data were used for verification of SSH modelling quality. Comparison of the simulated data with the ones measured in the coastal points showed us that the model does not describe SSH variability in different areas of the Baltic Sea well enough, so in the following simulation series the in situ SSH data of the coastal measurements were assimilated at the open boundary in the Danish Straits. The results of the new simulation showed us that this approach significantly increases the SSH simulation quality in all areas of the sea, where the comparison was made. In particular, the correlation coefficients between the simulated and measured SSH data increased from 0.21-0.73 to 0.81-0.90. On the basis of these results, it has been suggested that the Baltic Sea SSH variability is largely determined by the influence of the dynamic processes in the Danish Straits, which can be represented as a superposition of oscillations of different space-time scales. These oscillations can either be generated in the straits themselves, or propagate from the North Sea.

For verification of this hypothesis and assessment of the oscillation propagation distance in the Baltic Sea, the following experiment was performed. At the open boundary in the Danish Straits, the six harmonics were set with the following parameters: the periods are 1.5, 3.0, 6.0, 13.5, 40.5, and 121.5 days, and the amplitude for all the harmonics is 50 cm. The results showed us that the prescribed harmonic oscillations at the open boundary propagate into all areas of the sea without changing the frequency, but with decreasing amplitude. The decrease in amplitude is not related to the distance between the measurement point and open boundary. For example, in the Gulfs of Finland and Riga, the 36hr harmonic has an amplitude substantially higher than in the open sea, and in the Stockholm area, this harmonic is at the noise level. The 40dy and 121dy harmonics have slightly lower amplitudes than the original prescribed signal, but they are almost unchanged while propagating further into the sea, and in all the investigated locations have almost identical peaks of spectral density. The 3dy and 6dy harmonics significantly lost their amplitude in all parts of the sea, and spectral density peaks are at the noise level.

The simulation results showed us that the Danish straits do not filter 121dy and 40dy oscillations, and their amplitude does not decrease much. The 13dy, 6dy and 3dy oscillations significantly lose in amplitude and have no significant peaks of the spectral density. The 1.5dy harmonic propagates to the Gulfs of Finland and Riga, and increases in amplitude due to resonance at the natural frequency of the basin. It is suggested that, while Danish straits do not filter or transform frequency characteristics of oscillations propagated from the North Sea, but the Baltic Sea configuration may affect the magnitude and propagation extent of these oscillations.

Thus, the fluctuations in the North Sea and the Danish Straits can significantly contribute to the Baltic Sea dynamics in the low-frequency range of the spectrum, and the periods of natural oscillations of the basin.

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