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Seasonal and long-term variability of the sea level in the coastal zone of the Norwegian and Barents seas

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One of the parameters useful for monitoring large-scale climate variability in the Arctic is sea level. It integrates virtually all static and dynamic processes in the hydrosphere and atmosphere. Increases in the World Ocean's sea level may indicate global warming. Rising sea level and increases storm activity will intensify coastal erosion and could cause coastal flooding.

Mean monthly sea level data from 17 Norwegian and 11 Russian stations in the Norwegian and Barents seas (NBS) were used to analyse seasonal and inter-annual variability and assess the role that different factors play in the processes of sea level change.

Sea level in these seas has a significant annual cycle with an average seasonal amplitude in the coastal zone on the order of 20-40 cm. At all the stations the minimum values were observed in April-May and maxima in October-December. The inverted barometer effect and local wind account for about 80% of the formation of the sea level annual cycle.

The magnitude of the linear trend in sea level change for the period 1950-2000 in the NBS, averaged for 28 stations, is equal to -0.035$\pm$0.005 cm per year. At 11 stations the trend has a positive sign and at 17 it is negative. Analysis of the linear trend at all stations shows that the average trend changes from decade to decade. In the 1950s the trend was substantially negative (-1.032 cm per year) but in the 1960s it was close to zero. The negative magnitude of the trend again increased in the 1970s (-0.5118 cm per year) but in the 1980s became substantially positive (0.780 cm per year). The average linear trend coefficient became negative again in the 1990s (-0.269 cm per year). We can therefore surmise that there is 20-year cycle. The predominantly negative trends

at most stations along the NBS coastal line allow us to suggest that long-term sea level oscillations occur against the background of the Earth's crust lifting in this area. Analysis of the trends of the inter-annual sea level variability in the different seasons shows that at all the stations maximal values of the linear trend appear in winter (December-February) and minima in June-October.

Statistical analysis and modelling results suggest three major causes of the long-term sea level variability in the NBS. The first is changes of the atmospheric pressure and reorganization of the atmospheric circulation. This effect is responsible for a contribution of approximately 70-75% to the sea level change at the annual time scale and about 10% at the decadal time scale. The second is associated with the steric ocean expansion and reorganization of the thermohaline water circulation in the NBS. This effect is responsible for a contribution of approximately 10-15 % to the sea level change at the annual time scale and more than 60% at the decadal time scale. Thus, cumulative atmospheric and oceanic effects can explain more than 80% of the long-term sea level variability in the coastal zone of the NBS during the last five decades.