Sea level changes in the Arctic Ocean (1954-2016)

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Summary: Sea level time series from coastal stations in the Siberian Seas (Kara, Laptev, East Siberian and Chukchi) for the period of 1954 – 2016 are analyzed to investigate the major features of Arctic sea level variability at decadal time scales. The estimated rate of sea level rise for these stations over the 1954 – 2016 is 2.82 ± 0.35 mm per year (after correction for glacial isostatic adjustment, GIA). Until the late 1990s, the sea level time series correlate relatively well with the AO index and with the inverse of the sea level atmospheric pressure at the North Pole, but then due to sea ice melt, warming of surface layers and persistent anticyclonic winds, the sea level regime changed. Consistent with these influences, sea level dropped significantly after 1990 and reached a minimum in 1996 – 1997 when the circulation regime changed from cyclonic to anticyclonic. In contrast, from 1997 to 2016 the mean sea level has generally increased while the AO and sea level pressure remained more or less stable. After 2008, sea level has had a decreasing tendency, showing no apparent correlation with the AO or sea level pressure at the North Pole. Since 2009, the sea level change exhibits large interannual variability and is the net result of many individual effects of environmental forcing, it is difficult to evaluate the significance of the change in relative terms. Although not statistically robust, the changing tendency toward decreasing sea level rise may be due to steric effects associated with some stabilization of surface ocean warming and its freshwater content.

Factors influencing sea level variability
- Geological effects
- Local effects such as:
  - Changes in sea level atmospheric pressure
  - Winds
  - Precipitation and evaporation
  - River runoff
  - Steric effects (changes in the water temperature and salinity)

Global sea level rise

What is the rate of sea level change in the Arctic Ocean?
What is the role of the individual contributing factors to observed Arctic Ocean sea level change?

Above: Five-year running mean time series of: annual mean sea level (SL) at nine tide gauge stations located along the coasts of the Kara, Laptev, East Siberian and Chukchi seas (black line; the light blue line shows the annual average); anomalies of the annual mean Arctic Oscillation index (AO, Thompson and Wallace, 1998) multiplied by 3 for easier comparison with other factors (red line); sea surface atmospheric pressure (sea level pressure, SLP) at the North Pole (from NCAR-NCEP reanalysis data) multiplied by -1 to show the inverse barometer effect (dark blue line). Dotted lines depict trends for SL (black), AO (red) and SLP (blue). Before 1997, there is a good correlation between external forcing and SL after 1997 there is no correlation with SLP or AO but an excellent correlation with AOO (left bottom figure.)

Above: Arctic circulation regimes. Top panels: SLP (black lines), hPa with 2 hPa isoline interval) and wind (blue arrows) typical for CCRs (left) and ACCRs (right). Red arrows show prevailing storm tracks. Middle panel: Bars show annual AOO index (Proshutinsky and Johnson, 1997, updated); black line depicts 5-year running mean AOO index. AOO alternates between ACCRs (blue bars) and CCRs, (red bars) with a period of 10-14 years while during the last 17 years a strong ACCR has dominated over the Arctic Ocean. Vertical colored lines show beginning of GSAs of the 1970s, 1980s, and 1990s from Belkin et al. [1998].

Sea Level data sources

Monthly mean relative sea levels were provided by the Arctic and Antarctic Research Institute for 71 stations (see station numbers) located in the Barents and Siberian Seas. The time series of sea level variability generally cover the period between 1948 and 2000 but temporal coverage differs significantly from station to station. Red dots stations with the most complete datasets.