Wave climate in the Baltic Sea 2017

Authors:

Heidi Pettersson, Marine Research, Finnish Meteorological Institute
Ola Kalén, Swedish Meteorological and Hydrological Institute
Thorger Brüning, Bundesamt für Seeschifffahrt und Hydrographie

Key message

Although no all time record significant wave heights were observed during the measuring periods in 2017, several monthly records were recorded, especially in the Baltic Proper and the Western Baltic Sea. On average, the wave climate in the southern half of the Baltic Sea was rougher that usual, while in the northern half the monthly means were closer to long term values. The highest significant wave height for the measuring periods, 8.0 m, was observed in the Northern Baltic Proper in January 2017: significant wave heights this high have been observed before only once in the Baltic Proper (8.2 m), and twice in the Skagerrak (8.0 m and 8.1 m).

Results and assessment

In 2017 waves were measured in 11 locations in the Baltic Sea and Skagerrak (Figure 1). These buoys provide real time information of the wave climate for professional and free time navigation. The wave measurements are also important for wave related research and wave model development. As waves contribute to the mixing of the surface layer and their influence can extend to the bottom (resuspension) the information about the yearly wave activity adds to the understanding of the physical environment of the Baltic Sea.

The monthly mean values of significant wave height (see the definition of significant wave height in section Metadata) are plotted in Figures 2 and 3, and the highest values of significant wave height are shown in Figures 4 and 5. Figures 6 and 7 show the year-to-year variation of the mean significant wave height in June-July and October-November.

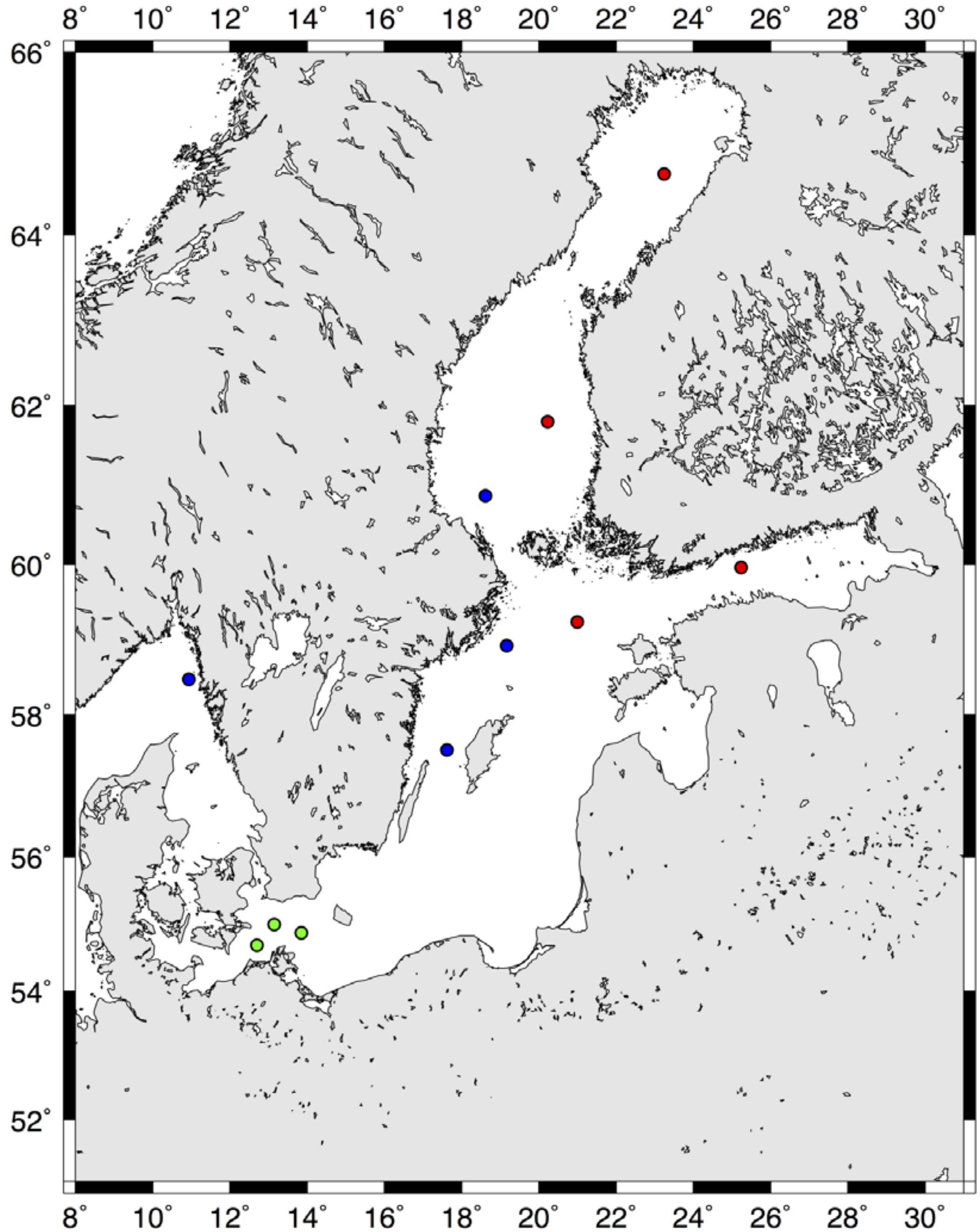

Figure 1. The positions of the wave buoys in 2017. Red dots indicate FMI buoys in the Bay of Bothnia, in the Bothnian Sea, in the Northern Baltic Proper and in the Gulf of Finland (station Helsinki), blue dots SMHI buoys in the Southern Bothnian Sea (station Finngrundet), in the Baltic Proper (stations Huvudskär Ost and Knolls Grund) and in Skagerrak (station Väderöarna) and green dots the BSH and HZG buoys in the Western Baltic Proper: Fino2, off Cape Arkona and on the Darss Sill. See section Metadata for the exact coordinates of the buoys.

The Gulf of Bothnia

The Bay of Bothnia

The wave buoy in the Bay of Bothnia was operational from the beginning of June to the end of November 2017.

June and July were typical for the season. August was clearly rougher, and the mean significant wave height was 0.9 m. On average September was calmer than usual followed by an October and November typical for the season. The monthly maxima remained under the long-term (four years) values. In June the significant wave height exceeded 1 m only twice, 1.3 m on the 21st and 1.2 on the 22nd. On 5-6 July the significant wave height was 2.0-2.3 m for 24 hours, which is a rather long period for the summer season. The highest significant wave height in August, 3.0 m, was measured on the 20th. In September the significant wave height reach 2.1 m only once, on 15 September. The significant wave height exceeded 3 m twice in October and November, 3.3 m on 16 October, 3.0 m on 29 October and 3.2 m on 23 November. The highest significant wave height for the measuring period was 3.7 m, measured on 9 November during southwestern winds.

The Central Bothnian Sea

In the beginning of 2017 the wave buoy in the Central Bothnian Sea was operational to the end of March. The buoy was redeployed in the beginning May and was operational the rest of the year.

In average January was typical for the season: the highest significant wave heights were 5 m on 7 January and 5.3 m on 12 January. The latter date is connected to a southwestern storm in the area of the Baltic Proper and it is the highest value of the measuring period in 2017. The highest significant wave height in February was 3.9 m (22 February) and in March 2.8 m (17 March). A significant wave height of 2 m was measured on 15 May and 2.2 m on 29 May. June and July were typical for the season: the significant wave height remained under 2.7 m (2 June) and 2.3 m (19 July). Like in the Bay of Bothnia, August was rougher and September calmer than usual. The highest measured values were 2.6 m (20 August and 1 September). A significant wave height of 4.9 m was measured on 29 October that was slightly higher than the previous October record (4.8 m in October 2014). October was followed by November and December typical for the season. The highest values for these months were 5.1 m on 23 November and 3.9 m on 23 December.

The Southern Bothnian Sea, station Finngrundet

The heavy ice winter caused the buoy at station Finngrundet to be out of operation until May.

On 29 October a low pressure system was situated east of Sweden. Over the Bothnian Sea there was a northerly wind of 26 m/s and the significant wave height at Finngrundet rose to 5.0 m. This is the second highest October observation on the site since the measurements started in 2006. The record October observation of 5.6 m was noted on the 31th in 2006. The day after, on 1 November 2006, the maximum significant wave height observed so far at this site, 6.4 m, was recorded. The monthly averages of significant wave height were around the long-term averages, except for October, when a new record for the month, 1.3 m, was noted.

The Gulf of Finland

The middle parts of the Gulf of Finland, station Helsinki

Due to the ice conditions the wave buoy off Helsinki was recovered mid-January 2017 and redeployed mid-April.

The wave climate in May was slightly calmer and in June slightly rougher than usual. In May the significant wave height remained under 1.5 m. In June the significant wave height reached 2.2 m on the 30th. The rest of the year was typical for the respective months: the mean significant wave heights were nearly exactly the same than long-term (16 years) averages. The monthly maxima remained under the monthly record values. The significant wave height reached 3 m three times, on 12 January, on 17 November and on 3 December. The highest significant wave height for the measuring period was 3.3 m, observed on 4 September.

The Baltic Proper

The Northern Baltic Proper, stations Northern Baltic Proper and Huvudskär Ost

The wave buoy at station Northern Baltic Proper was operational through 2017.

The monthly means of significant wave height were close to the long-term averages, the slightly calmer months alternated with the slightly rougher months. Two monthly records were observed. During a southwesterly storm in January the significant wave height reached 8.0 m on 11 January. 8.0 m has been exceeded only once before at this station: on 22 December 2004 a significant wave height of 8.2 m was observed. So far these are the highest values ever measured in the Baltic Sea. During the January 2017 storm, a significant wave height of 5.3 m was observed in the Central Bothnian Sea. At station Helsinki the significant wave height remained under 3 m due to the southern wind direction. Another monthly record was observed on 30 June, 4.4 m during high easterly winds. It was 0.3 m higher than the previous record from 2011. The significant wave height reached five metres on 4 September (5.0 m) and on 25 October (5.3 m). Four meters (4.2 - 4.9 m) were exceeded one to three times in all other months except April (3.5 m on the 24th), May (2.5 m on the 8th), July (3.0 m on the 1st) and August (3.1 m on the 29th).

The buoy at station Huvudskär was recovered in the beginning of the year and was redeployed on 8 March.

Record significant wave heights for a month since the start of measurements in 2001 were observed in June, July and September. On 30 June there was a low pressure over the southern parts of the Baltic Sea. On the northern part there was a north-easterly wind of 14 m/s. The significant wave height at Huvudskär rose to 3.9 m. The same low pressure was present but weakened on 1 July when a significant wave height of 3.4 m was recorded. On 4 September there was a low pressure system southeast of the Baltic Sea. The north-eastern parts of the Baltic Proper had easterly winds of 20 m/s and the Huvudskär buoy registered a significant wave height of 4.4 m. The highest significant wave height so far recorded here, 5.7 m, was noted on 9 November 2010. The monthly averages were around normal except for the months April and June, which both had record values for the month, 0.9 and 0.8 m, respectively.

Central Baltic Proper, station Knolls Grund

The wave buoy at station Knolls Grund was in position during all of 2017, with full data availability except for a gap in February. On 11 January a deep low pressure system moved towards southern Scandinavia. Over the Baltic proper there was a southerly wind of 19 m/s and at Knolls Grund a significant wave height of 5.6 m was observed. This was a new January record since the start of the measurements in 2011. Later in the year, a record for the month of October was noted on the 29th, when the significant wave height was 5.1 m. The monthly average significant wave heights were above the long-term average for several months, and record averages for the month since the start of measurements were noted in March (1.0 m) and June (0.8 m).

Western Baltic Proper, stations Darss Sill, Arkona and Fino2

Unfortunately, none of the three stations in the Western Baltic Proper have a complete dataset for 2017. While Arkona data is missing in January, Darss Sill sent no data in February and March. For Fino2 only 5 months of data are available (January/February and August to October), while the buoy was out of operation for the rest of the year.

Where data were available, all three stations were in good agreement with each other throughout 2017. Compared to long-term mean, wave conditions at Arkona and Darss Sill were somewhat calmer from January to March, while from July to September and in November they were in good agreement with long term statistics. In the months April to June, October and December significantly rougher wave conditions were recorded. At Fino2 a comparison with the long-term mean is still not possible, because Fino2 started operating in October 2014, so that up to now only three years of data are available.

Two strong wind events in 2017 deserve special mention: From 3 to 5 January, high winds from at first west-north-west, then north-west and later north-north-east caused a severe storm surge on the German and Danish Baltic Sea coasts. Nevertheless, no particularly high waves were measured during this event. While Arkona unfortunately did not provide any data, a maximum significant wave height of 2.4 m was measured at Darss Sill, which is clearly below the long-term maximum of 4.2 m. For Fino2, the maximum value was 2.8 m, which is also clearly below the long-term maximum of 3.9 m. The reason for this is certainly the relatively short fetch from the observed wind directions at Darss Sill and Fino2. The highest significant wave height measured in 2017 was 4.2 m at Arkona during a storm from west-south-west associated with a much longer fetch on 13 September, which is also a new September record for Arkona. During this event 3.3 m was measured at Darss Sill, which is also very high, but just below the long-term maximum of 3.5 m. Unfortunately Fino2 did not provide any data during this event.

Skagerrak

Skagerrak, station Väderöarna

The buoy at station Väderöarna was operational and delivered data continuously during 2017.

A deep low pressure with accompanying southerly winds of 25 m/s led to the highest significant wave height of the year, 6.5 m on 11 January. This is slightly less than 2 m below the record value of 8.1 m, which was observed on 10 January 2015. A record high significant wave height of 4.6 m occurred for the month of June when a low pressure over northern Scandinavia induced southerly winds of 20 m/s over Skagerrak on 25 June. The monthly mean significant wave heights both had unusually high (April and October) and low values (May and September).

Data

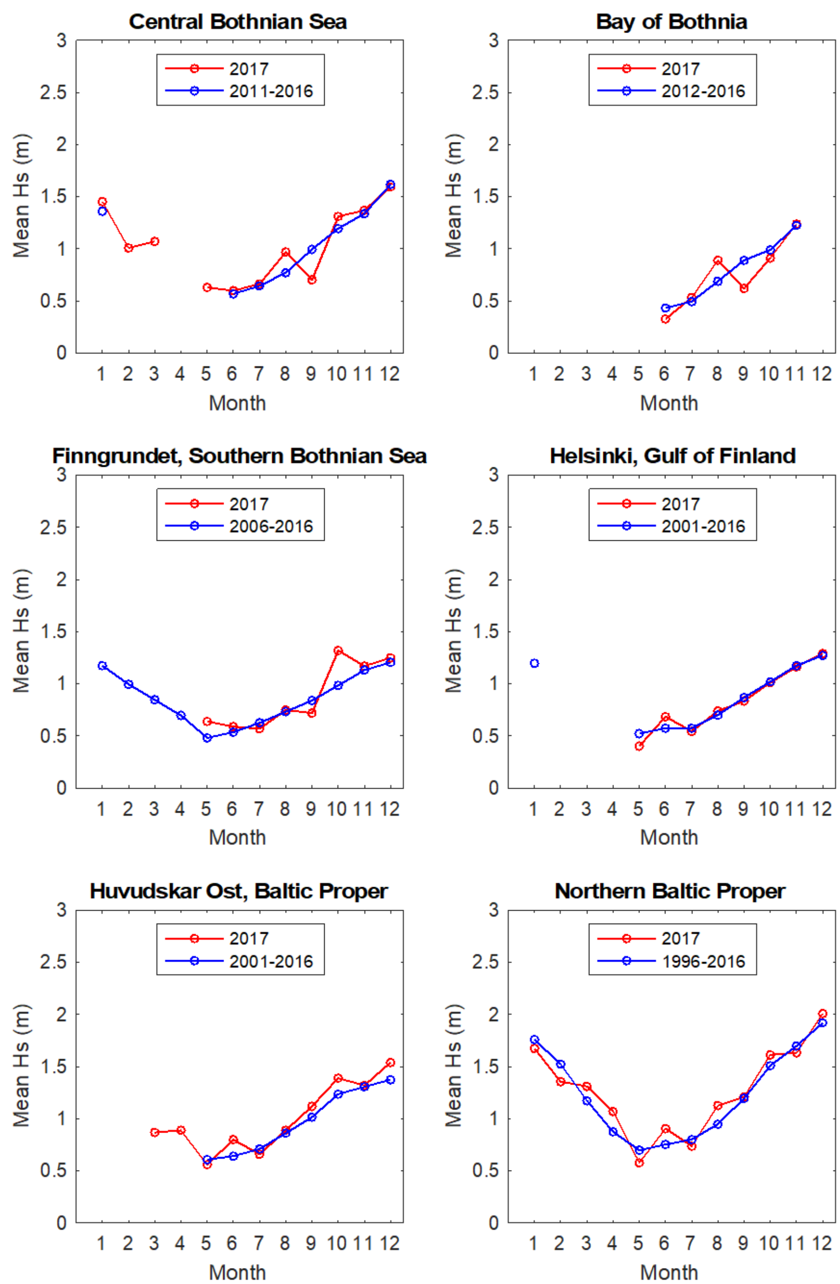

Figure 2. The monthly means of significant wave heights in the Bothnian Sea, the Gulf of Finland and the Northern and Central Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

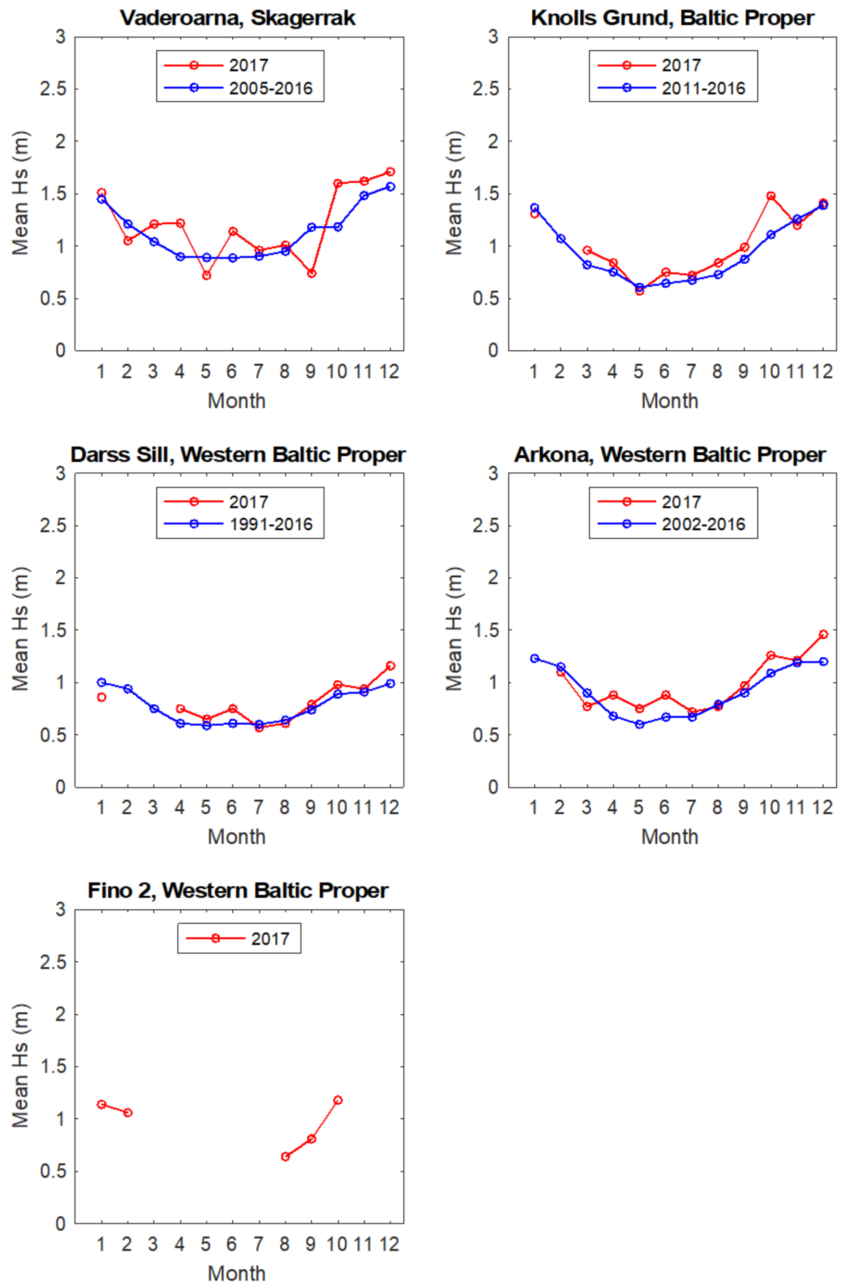

Figure 3. The monthly means of significant wave heights in Skagerrak, Central and Western Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

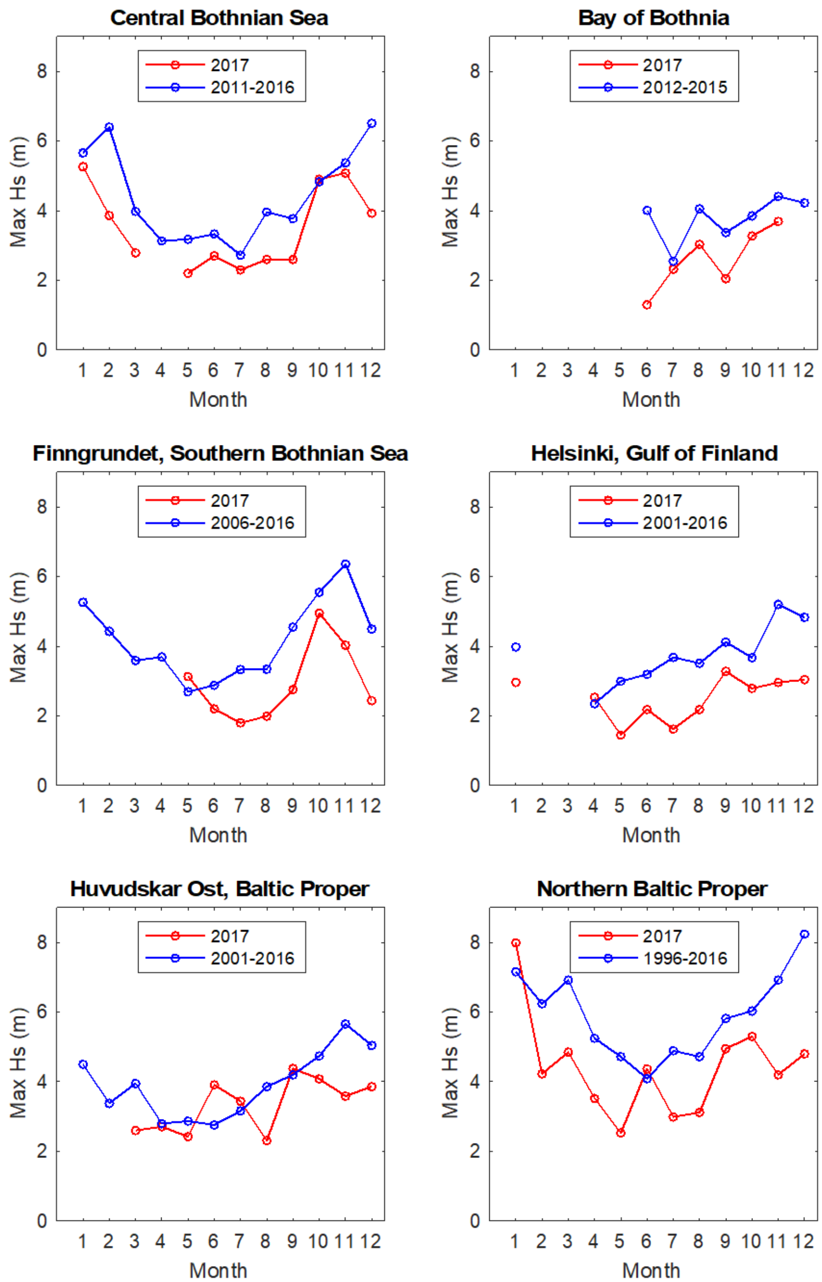

Figure 4. The monthly maxima of significant wave heights in the Gulf of Bothnia, the Gulf of Finland and the Northern Baltic Proper. Data gaps occur in some of the months.

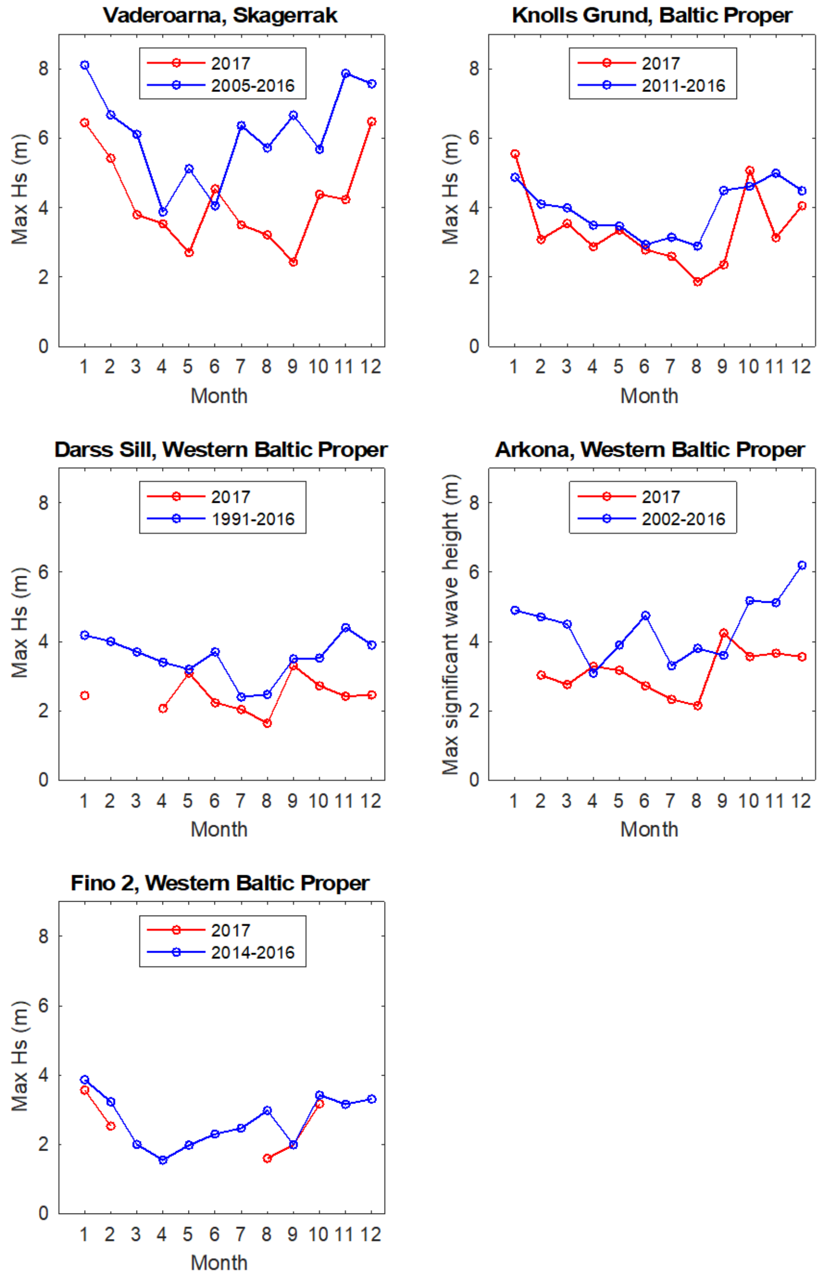

Figure 5. The monthly maxima of significant wave heights in Skagerrak, the Central and the Western Baltic Proper. Data gaps occur in some of the months.

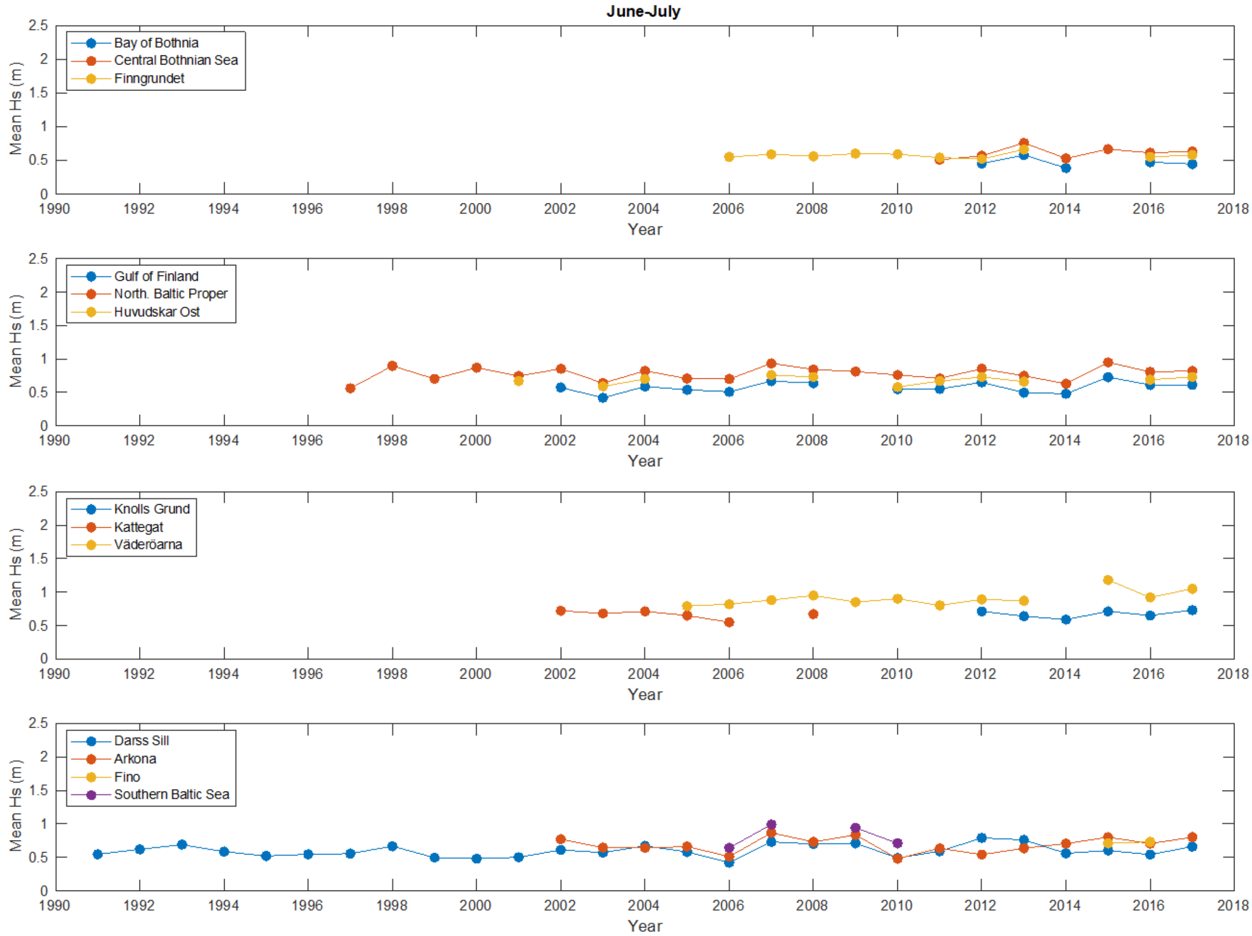

Figure 6. The yearly variation of the mean significant wave height Hs in the period of June-July. In some years the data does not fully cover the whole period.

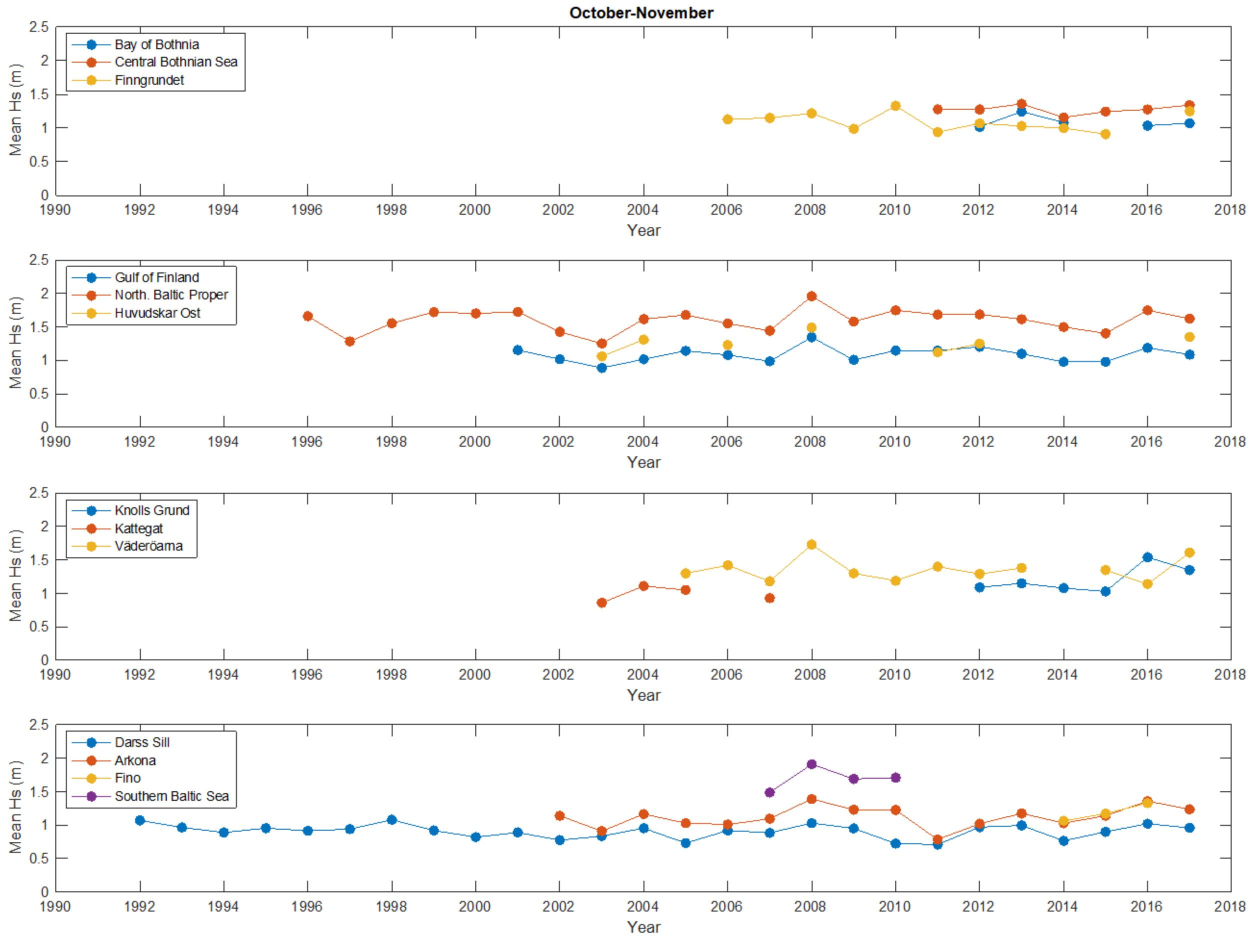

Figure 7. The yearly variation of the mean significant wave height Hs in the period of October-November. In some years the data does not fully cover the whole period. Especially at station Huvudskär Ost, the gaps in the data in years 2011 and 2012 might have left the mean value lower than it should be.

Metadata

In 2017 Finnish Meteorological Institute (FMI) made real time wave measurements at four locations in the Baltic Sea, in the Bay of Bothnia (station Bay of Bothnia, 64° 41.1' N, 23° 14.4' E), in the Central Bothnian Sea (station Bothnian Sea, 61° 48.0' N, 20° 14.0' E), in the Northern Baltic Proper (station Northern Baltic Proper, 59° 15.0' N, 21° 00.0' E) and in the Gulf of Finland (station Helsinki, 59° 57.9' N, 25° 14.1' E). The northern parts of the Baltic Sea freeze every year. The length of the measuring periods varies every year depending on the extent of the ice cover.

The Swedish Meteorological and Hydrological Institute (SMHI) made wave measurements at four locations, in the Southern Bothnian Sea (station Finngrundet, 60° 53' N, 18° 37' E), in the Northern Baltic Proper (station Huvudskär Ost, 58° 56' N, 19° 10' E), in the Central Baltic Proper (station Knolls Grund 57° 31' N, 17° 37' E) and in Skagerrak (station Väderöarna, 58° 29' N, 10° 56' E). To prevent the loss of both instruments and data due to trawling activities in the area the position of the buoy at Finngrundet has been adjusted twice since 2012. Today the position is still south of the eastern bank in waters of comparable depth but approximately 1 km further to the southwest of the previous position. The positions of the buoys operational in earlier years (shown in Figures 6 and 7) are: Kattegat 57° 11' N, 11° 32' E and Southern Baltic Proper 55° 55' N, 18° 47' E.

Since 1991, wave measurements in the western Baltic Sea have been carried out at a station located at 54° 41.9'N, 12° 42.0'E in the area of Darss Sill (with Helmholtz-Zentrum Geesthacht - Zentrum für Material und Küstenforschung GmbH (HZG) as the operator), since 2002 at a station northwest of Cape Arkona (54° 52.9'N, 13° 51.5'E) and since 2014 at the Fino2 research platform located at 55° 00.5'N, 13° 09.3'E, where measurements are performed by the Federal Maritime and Hydrographic Agency of Germany (BSH). Long-term climatological wave data are not yet available at the latter position. Up to now, measurement interruptions due to ice coverage or drift ice occurred only in the winter of 1995/1996 at the Darss Sill measuring station, and in February and March 2010 at the Arkona Basin station.

The significant wave height, usually denoted by H_s is, confusingly, defined in several ways. The most common way today is to calculate it from the variance of spectral density, also denoted by H_{m0}: $H_{m0} = 4\sqrt{\sigma^2}$, where $\sigma^2 = \int_0^\infty S(f)df$, $S(f)$ is the wave spectrum and f frequency. Another, older definition of H_s is the average height of the highest third of the waves, also denoted by $H_{1/3}$. In water that is deep for the waves (deeper than half of the wavelength) H_{m0} and $H_{1/3}$ are nearly equal. Both definitions are chosen to reflect how an experienced observer would visually estimate the sea state, which is the third, and probably the oldest definition of the significant wave height: a measure of the sea state that is significant to seafarers. The highest individual wave is approximately 1.6-2.0 times higher than the significant wave height.

The waves at each station are measured with surface following buoys, Seawatch, Watchmate (at Huvudskär Ost), Directional Waveriders, and Waveriders. Measurements were collected 0.5 - 1 hour via

Iridium, HF link, Argos-satellite, Orbcomm system and dataloggers. The significant wave height is calculated as H_{m0} on board the buoys over 1600 s or 1800 s time series of surface displacement and the quality of the measurements were checked according to the routines at each of the responsible Institutes. All measurement data referred to in the text are significant wave heights, namely monthly averages and maxima unless otherwise stated.

The lengths of the deployment periods in 2017 are indicated in the text. The length of the period at each station depends on the extent of the ice cover, maintenance and deployment logistics and possible instrument damages. As a consequence, measurements are not always available for 12 months per year for the long-term statistics. The years given in the Figures 2 - 4 indicate the start of the measurements: in some months the statistics are over fewer years but only statistics over at least four years are plotted in the Figures. The monthly means are given when there are measurements over half of the month. Because of data gaps, the maximum values do not necessarily constitute the true monthly maximum, whereas the mean values are largely reliable. Due to the variation of the lengths of the time series in the statistics they should be used with caution.

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