

Wave climate in the Baltic Sea 2013

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Key message

The wave climate in 2013 showed regional differences between the northern and southern parts of the Baltic Sea. For example, March was rougher than usual in the Western Baltic Proper, while it was a little calmer than usual in the northern parts of the Baltic Proper. December, however, was clearly rougher than average at all the stations, and higher than ever values for the mean December significant wave heights were measured at several stations. A new record for the significant wave height was measured at station Arkona (6.2 metres) and a new December maximum was reached at station Finngrundet (4.5 metres). In the other stations where the measurements were available, the highest significant wave heights for the measuring season were between 4.0 - 6.8 metres, measured in November-December.

Results and assessment

In 2013 waves were measured in ten 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 are plotted in Figures 6 and 7, and the highest values of significant wave height are shown in Figures 8 and 9.

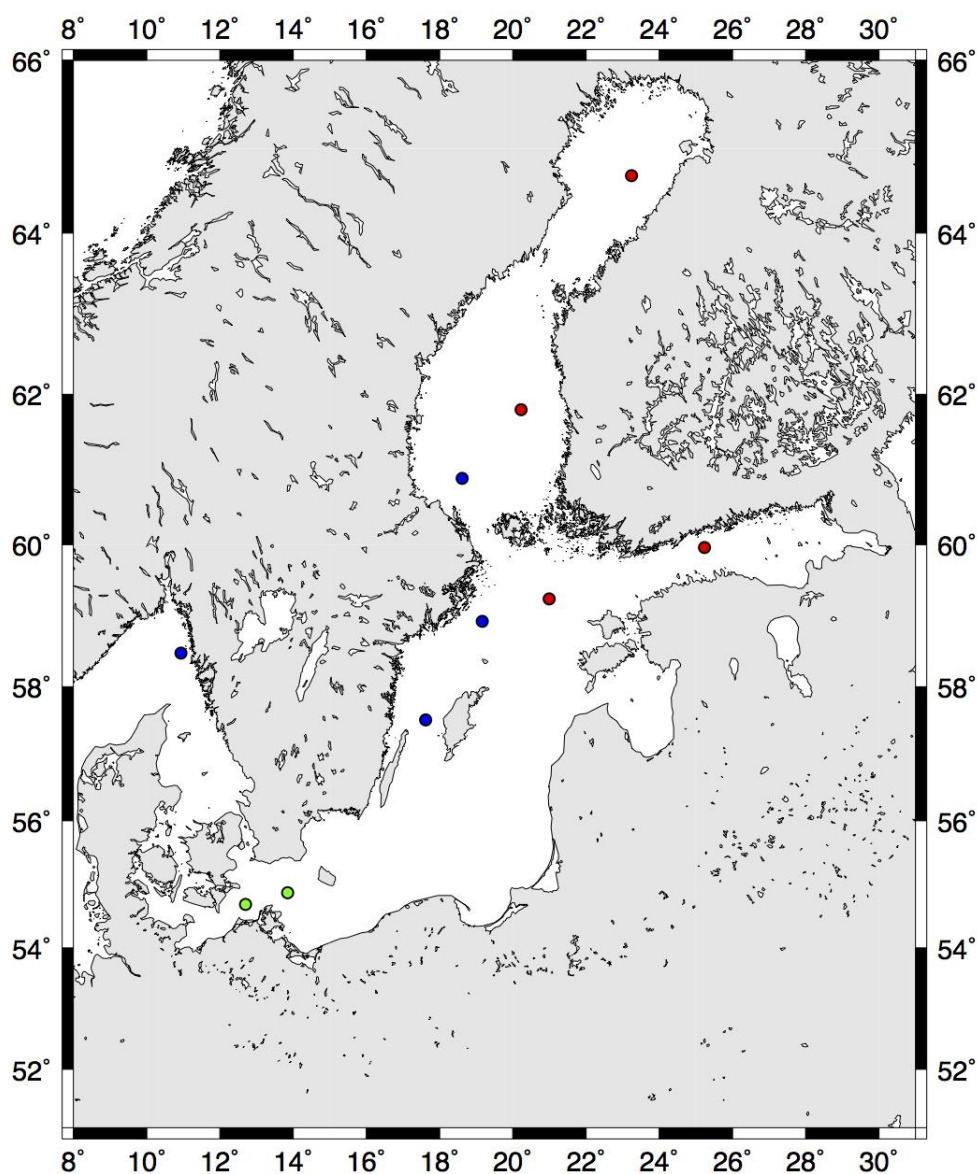


Figure 1. The positions of wave buoys in 2013. Red dots indicate FMI buoys in the Bay of Bothnia, in the Bothnian Sea, in the Northern Baltic Proper and in the Gulf of Finland (station Helsinki), blue dots SMHI buoys in the Southern Bothnian Sea (station Finngrundet), in the Baltic Proper (stations Huvudskär Ost and Knolls Grund) and in Skagerrak (station Väderöarna) and green dots the BSH and HZG buoys 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 measurements in the Bay of Bothnia were restarted in 2012. The previous measurements from this sea area are from 1980-81. The period for risk of ice in the Bay of Bothnia is naturally the longest for the present Baltic Sea wave stations: the measuring period will be typically from May-June to November-December. In 2013 the buoy was deployed 11th June and recovered 27th December.

The highest measured significant wave height in the 1980's was 3.1 metres. At the present location further out to the open sea, three metres were exceeded three times in 2012. In 2013 four metres were exceeded three times, 17th and 28th November (4.4 and 4.1 metres) and 13th December (4.2 metres), which are now the highest measured sea states in the Bay of Bothnia. Three metres were also exceeded once in September, 3.4 metres on 26th September and in October, 3.9 metres on 5th October. Of the summer months July was the roughest and the significant wave height exceeded two metres three times, 2nd (2.3 m), 17th (2.6 m) and 22nd (2.2 m). Two metres were exceeded once in August (2.4 metres on 15th), while in June the significant wave height reached one metre only four times, being 1.2 metres at highest on 27th June.

The Central Bothnian Sea

The buoy in the Central Bothnian Sea was recovered mid-January and redeployed in the end of May. The buoy was operational to the end of the year.

Like in the Bay of Bothnia, in average July was the roughest of the summer months, and the significant wave height exceeded two metres at seven occasions. The highest value for the month was measured on 16th July, 2.7 metres. In June and August the significant wave height exceeded two metres once per month, 2.3 metres on 5th June and 17th August. After a rather calm first half of the month, a significant wave height of 3.8 metres was measured on 23rd September. In average October was rougher than September, but the highest significant wave height remained 3.7 metres, measured on 23rd October.

Measurements at this location started in 2011 and compared to the two previous years, November and December were rougher. In November four metres were exceeded twice, 4.5 metres on 17th and 4.1 metres on 28th November, corresponding to the high sea states measured in the Bay of Bothnia. The significant wave height exceeded four metres four times and five metres twice in December: 5.2 metres on 1st and 6.3 on 13th December. The latter is the highest significant wave height during the measuring season in 2013 and it is close to the highest significant wave height measured in the Bothnian Sea so far: 6.5 metres in December 2011.

The Southern Bothnian Sea, station Finngrundet

In 2013 no buoy was deployed at Finngrundet between January 23rd and May 27th. Around December 15th 2013 the buoy started drifting. The Finnish Coast Guard recovered it on December 27th.

Measurements for the winter season 2012/13 showed a calmer than usual January resulting in mean significant wave heights (H_s) approximately 0.3 metres below the climatological mean over three years data. As in the Bay of Bothnia and the central Bothnian Sea July was unusually windy. The mean significant wave height rose to 0.9 metres, the highest value for July at this position so far (measurements started 2006). A significant wave height of more than two metres was observed six times during this month. The highest H_s during July were registered on the 23rd at 2.9 metres.

October was unusually calm with a mean significant wave height around 0.9 metres. This is the first time the mean significant wave height in October at this position was below one metre. On October 18th the significant wave height exceeded three metres for the first time during the measuring period in 2013 reaching 3.1 metres. On November 28th the first of a series of storms arrived at Finngrundet. Winds from the northwest resulted in a maximum significant wave height of 3.2 metres. On December 1st the mean wind velocity was recorded at 28 m/s from NNW (at the close by coastal station Örskär) and significant wave height rose to 4.5 metres. Between December 5th and 7th an extended period with strong winds resulted in significant wave heights of over three metres for about 24 hours consecutively, the highest significant wave height at this occasion being 4.2 metres. During the night from December 12th to 13th significant wave height rose to 3.2 metres. Even on December 17th and 22nd low pressure systems passed the location of the Finngrundet buoy. Unfortunately the buoy had started drifting so no measurements are available on these occasions. Nonetheless the highest significant wave height was the highest ever for December and the mean significant wave height for the first half of the month was 1.6 metres which is about half a metre higher than the climatological mean for December (comprised of seven years of data).

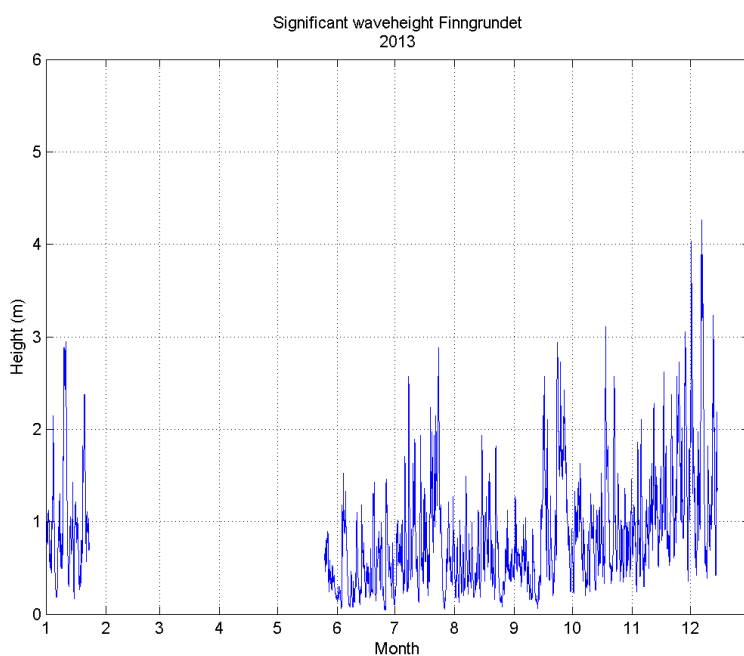
SMHI


Figure 2. Time series of significant wave height at station Finngrundet.

The Gulf of Finland

The middle parts of the Gulf of Finland, station Helsinki

The period for risk of ice damage in the middle parts of the Gulf of Finland is typically from January to May. In 2013 the buoy was deployed in the end of April and the measurements could be carried on to the end of the year.

From May to September, the wave climate was in average calmer than the long-term averages. In May the highest significant wave height was 1.8 metres (5th May). In June the significant wave height remained under 1.5 metres most of the time except on June 15th when the significant wave height reached 2.1 metres. In average, July was rougher than June, but the significant wave height did not exceed 1.6 metres (17th July). August and September were somewhat calmer than usually, the highest significant wave heights were 2.2 metres on August 15th and 1.8 metres on September 23rd.

The mean significant wave heights in October and November were typical for the season. The highest significant wave height in October was 2.8 metres (October 29th). It exceeded twice three metres in November: 3.1 metres on 10th and 3.3 metres on 27th. In average December was rougher than usual, the highest value for the month and for the whole measuring period was 4.0 metres, measured December 13th, on the same day than the high significant wave heights were measured in the Gulf of Bothnia.

The Baltic Proper

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

The extent of the ice cover in winter 2012-2013 did not reach the position of the wave buoy in the Northern Baltic Proper and measurements could be carried out through the winter.

The beginning of the year was clearly calmer than usual, especially February, when the average significant wave height was 0.6 metres smaller than the long-term average for the month. In January a significant wave height of 3.9 metres was measured twice, on 11th and 28th. In February the significant wave height reached 2.9 metres once, on February 4th. In March significant wave heights of 3.4 - 3.5 metres were measured during high wind events on 2nd - 3rd and 19th-20th. April, May and June were typical for the season; the highest values were 2.8 metres (April 19th), 1.8 metres (May 26th) and 2.3 metres (June 14th). Like in the Gulf of Bothnia, July was the roughest of the summer months and the significant wave height reached three metres on July 22nd. Like in the Gulf of Finland, August and September were calmer than usual. The highest measured significant wave heights were 2.3 metres on August 12th and 3.6 metres on September 23rd.

Similarly to the wave climate in the Gulf of Finland, the wave climate in October and November was typical for the season and clearly rougher in December. The significant wave height reached 5.3 metres on October 29th but remained otherwise under four metres. In November four metres were exceeded twice, reaching 5.9 metres on November 10th, which is the highest significant wave height measured at this location in 2013. Although the average significant wave height was higher than usual in December

and the significant wave height was less than half a metre only twice, the significant wave height remained under five metres, being 4.9 metres at highest, on December 1st.

In 2013 the buoy at Huvudskär Ost was not in its position before May 4th. The buoy started drifting during the storm on October 4th. It was recovered some days later.

The buoy at Huvudskär was only deployed during summer and autumn. From May to July the mean significant wave height was typical for the season. In August and September the mean significant wave heights were less than the climatological mean, corresponding to the wave climate in nearby station Northern Baltic Proper. Although periods of higher significant wave heights are in accordance with wave measurements at Knolls Grund and occasionally Finngrundet, the highest significant wave height exceeded only thrice two metres during the measurement period, in July (2.3 m), September (2.4 m) and October (2.7 m).

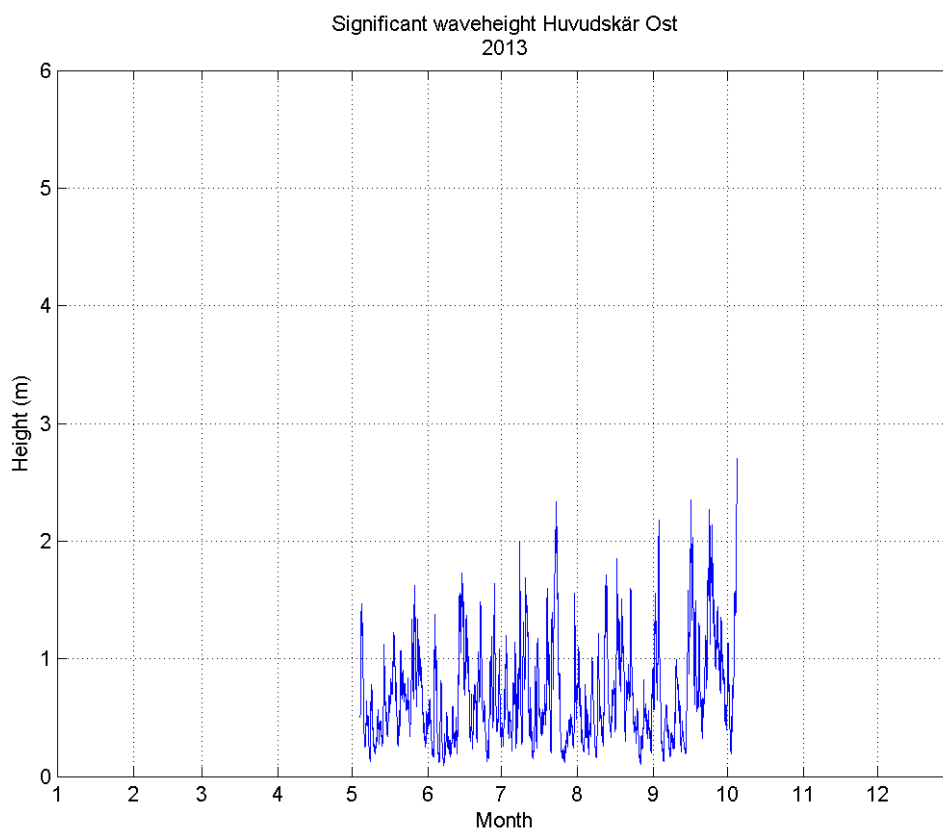
SMHI


Figure 3. Time series of significant wave height at the station Huvudskär Ost.

Central Baltic Proper, station Knolls Grund

On February 24th 2013 the buoy at Knolls Grund was cut loose from its mooring by a passing trawler. On April 27th another buoy was deployed in its place.

2013 being the second year wave measurements were conducted at Knolls Grund makes it difficult to achieve statistically sound conclusions. Compared to 2012 mean significant wave heights for all months from January to September were below the previous year's values. Nevertheless even at Knolls Grund the effects of an unusually windy July were apparent as the highest significant wave height of the month on the 10th rose to 3.2 metres.

The highest significant wave height during 2013 (and the 2nd highest so far at this location) was registered on October 28th at 4.6 metres. In December the mean significant wave height reached 1.5 metres, so far the highest monthly mean value measured at this location. The significant wave height once more exceeded four metres when 4.5 metres was registered during the storm during the night from December 5th to 6th.

SMHI

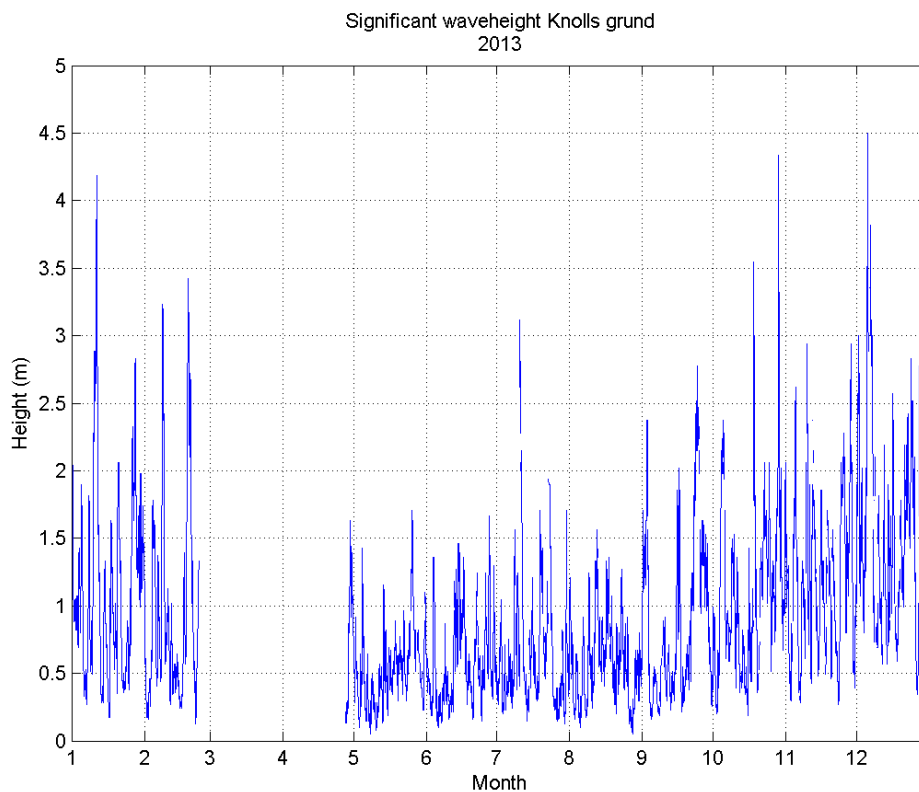


Figure 4. Time series of significant wave height at the station Knolls Grund.

Western Baltic Proper, stations Darss Sill and Arkona

Mean significant wave heights in the area of Darss Sill typically are 0.6 metres in summer and 0.9 metres in winter; the annual mean is 0.8 metres. Wave heights at the Arkona station are slightly higher, ranging from about 0.6 to 1.2 metres, with an annual mean of 0.9 metres. The larger distance from the coast (i.e. a longer wind fetch) and deeper water at the Arkona station are important factors contributing to higher wave heights.

In the Arkona basin the wave conditions in the months March, October and December were significantly rougher, whereas the February was calmer than usual. The other months correspond very well to the long-term mean. Especially in March the mean significant wave height was with 1.35 meters nearly half a meter higher than usual. In particular there were three storms in 2013, which caused very high significant wave heights in Arkona basin: On March 7th 4.5 metres, on October 28th 4.1 metres and on December 6th 6.2 metres were measured. Corresponding to the wind directions during the storms the waves came from easterly directions on March 7th and from westerly directions on October 28th and on December 6th. For March and December these are new monthly records, the December value of 6.2 metres is even the new historical total maximum value at this station. One reason for this extraordinary high value was the long period of very high wind speeds (two days almost constantly more than 15 m/s and gales up to more than 25 m/s were measured during the Santa Clause storm on the 5th and 6th of December). In addition to that a relatively long period of 9 seconds during the storm could mean that the waves already felt the bottom, so that the resultant increasing steepness of the waves might have contributed to the high value of significant wave height too.

At Darss Sill unfortunately we have reliable data only from August till November. Whereas August and September were typical, October and November were rougher than usual and in October a mentionable maximum was measured: A significant wave height of 3.52 metres on 28th October during the storm, which also caused high waves at Arkona. This value describes a new monthly record for October at this station. However during the storms in March and December unfortunately no measurements at Darss Sill were available - most probably very high waves could be observed also at Darss Sill at that time.

Kattegat and Skagerrak*Kattegat*

No wave measurements were conducted in the Kattegat.

Skagerrak, station Väderöarna

The wave buoy at Väderöarna was recovered on January 17th 2013 as a precaution to prevent damage during the ice season. On April 24th the buoy was redeployed. On October 12th the wave buoy was replaced by a buoy that even measures other than wave parameters. This buoy failed delivering data on November 6th. It was replaced by a spare wave buoy on November 10th thus resulting in a near continuous data record for the ice-free season of 2013.

In January 2013 the highest significant wave height was registered in the aftermath of the stormy weather in the last days of 2012. At 1 am on January 1st the significant wave height was still 3.3 metres. After the redeployment in the end of April a low pressure system passing over Sweden with high wind velocities from the southwest resulted in a significant wave height of 3.6 metres on the 29th. It was not until September 16th that the significant wave height again rose above 3.5 metres to 3.9 metres. On October 24th, a low pressure system over the North Atlantic resulted in high significant wave heights, at most reaching 4.2 metres. On November 4th, the significant wave height reached 4.1 m and on November 16th the significant wave height once again exceeded 3.5 metres. On December 5th the highest significant wave height for 2013 was measured, 6.8 metres. A significant wave height of above 3.5 m was even registered on December 16th (3.9 m), 22nd (5.8 m) and on the 27th/28th (4.2 m). The mean significant wave height was typically close to or below the climatological mean with the sole exception of December. In December the highest mean significant wave height, 2.4 metres, at this location was registered, which was about one metre above the climatological mean.

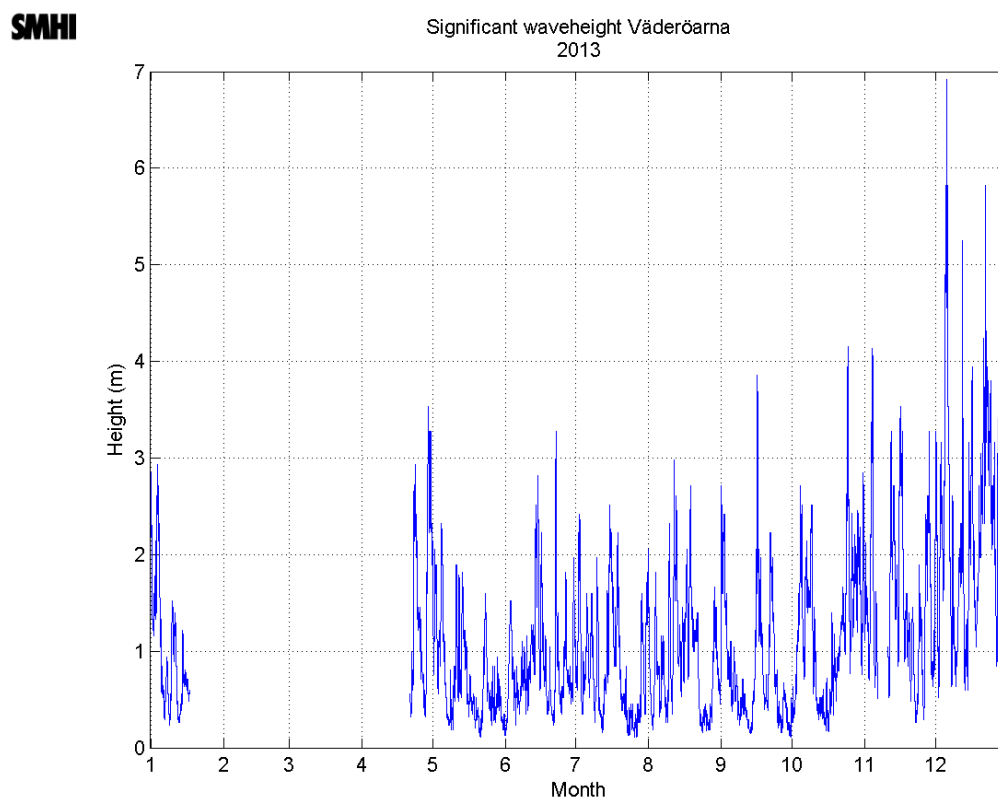


Figure 5. Time series of the significant wave height at the station Väderöarna.

Data

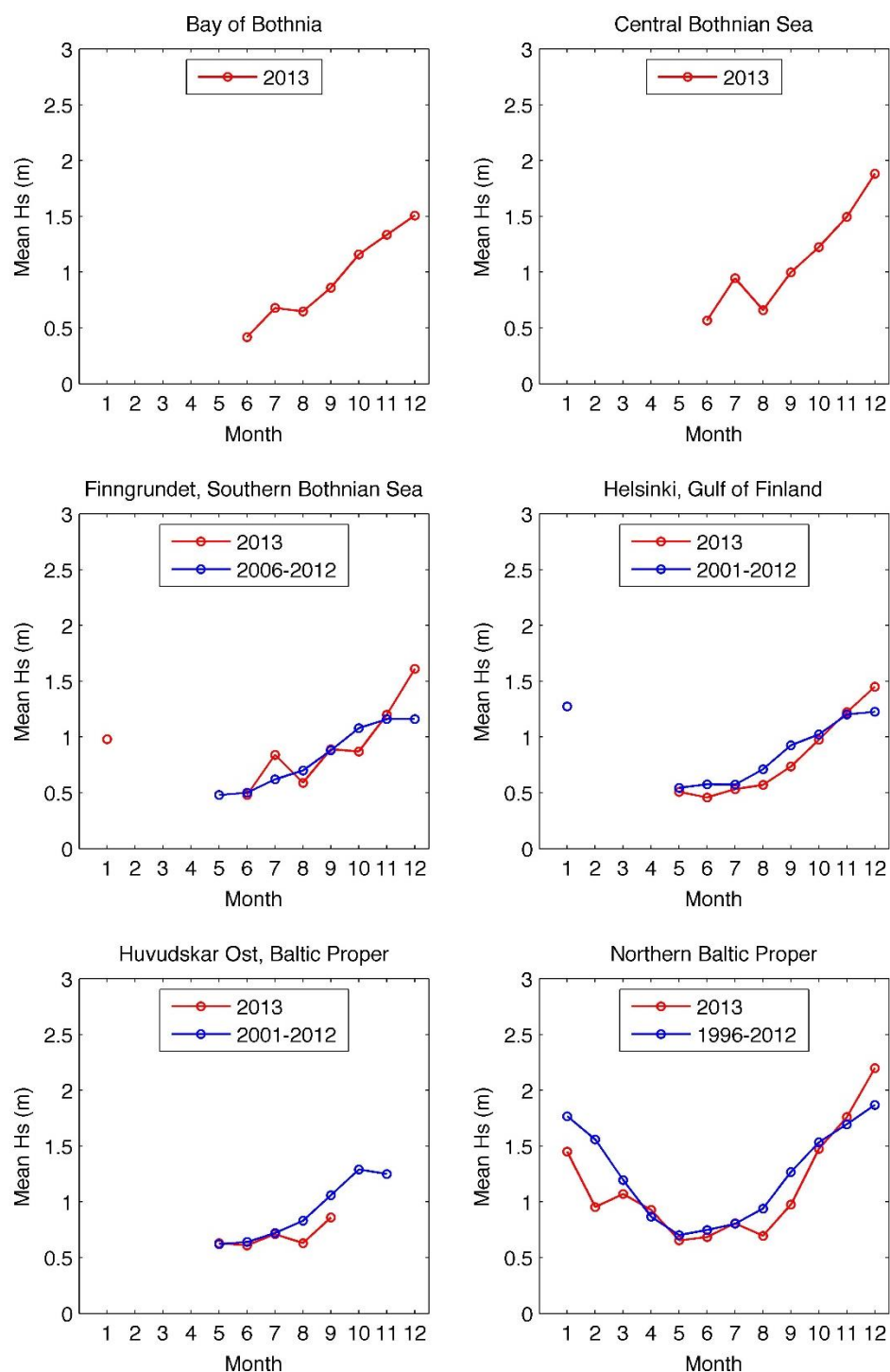


Figure 6. The monthly means of significant wave heights in the Bay of Bothnia, the Bothnian Sea, the Gulf of Finland and the Northern Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

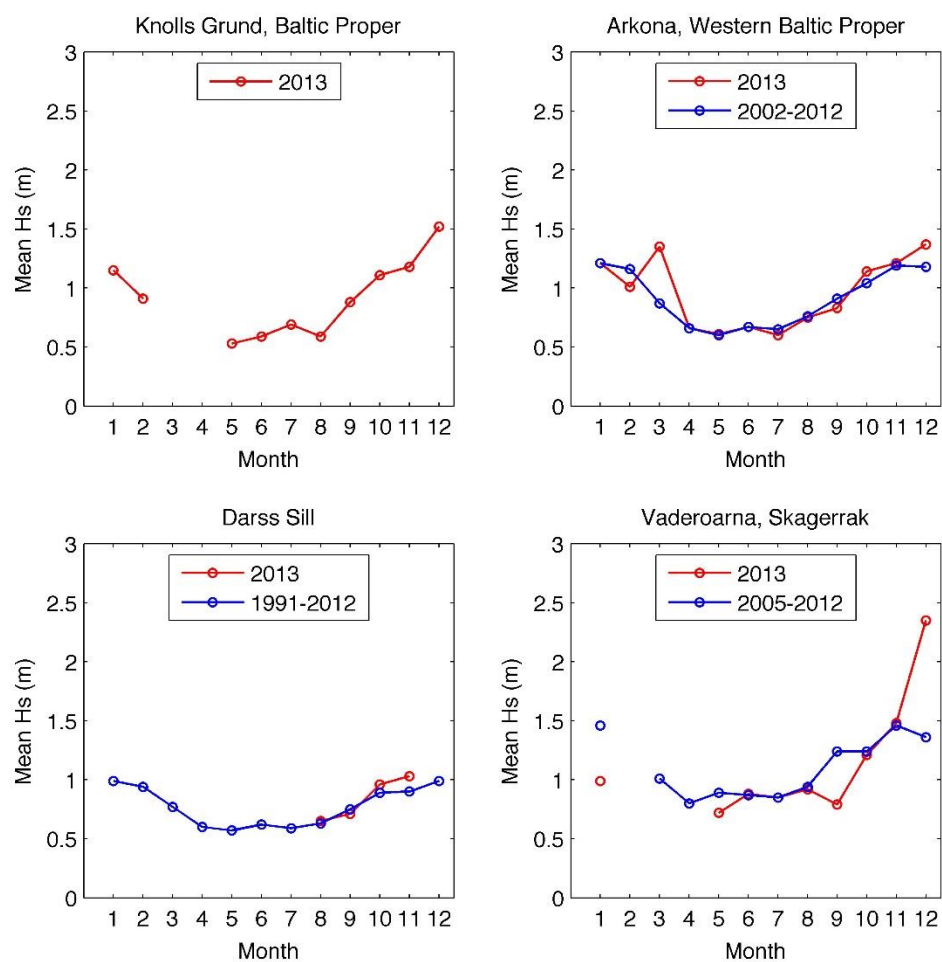


Figure 7. The monthly means of significant wave heights in the Central Baltic Proper, the Western Baltic Proper and Skagerrak. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

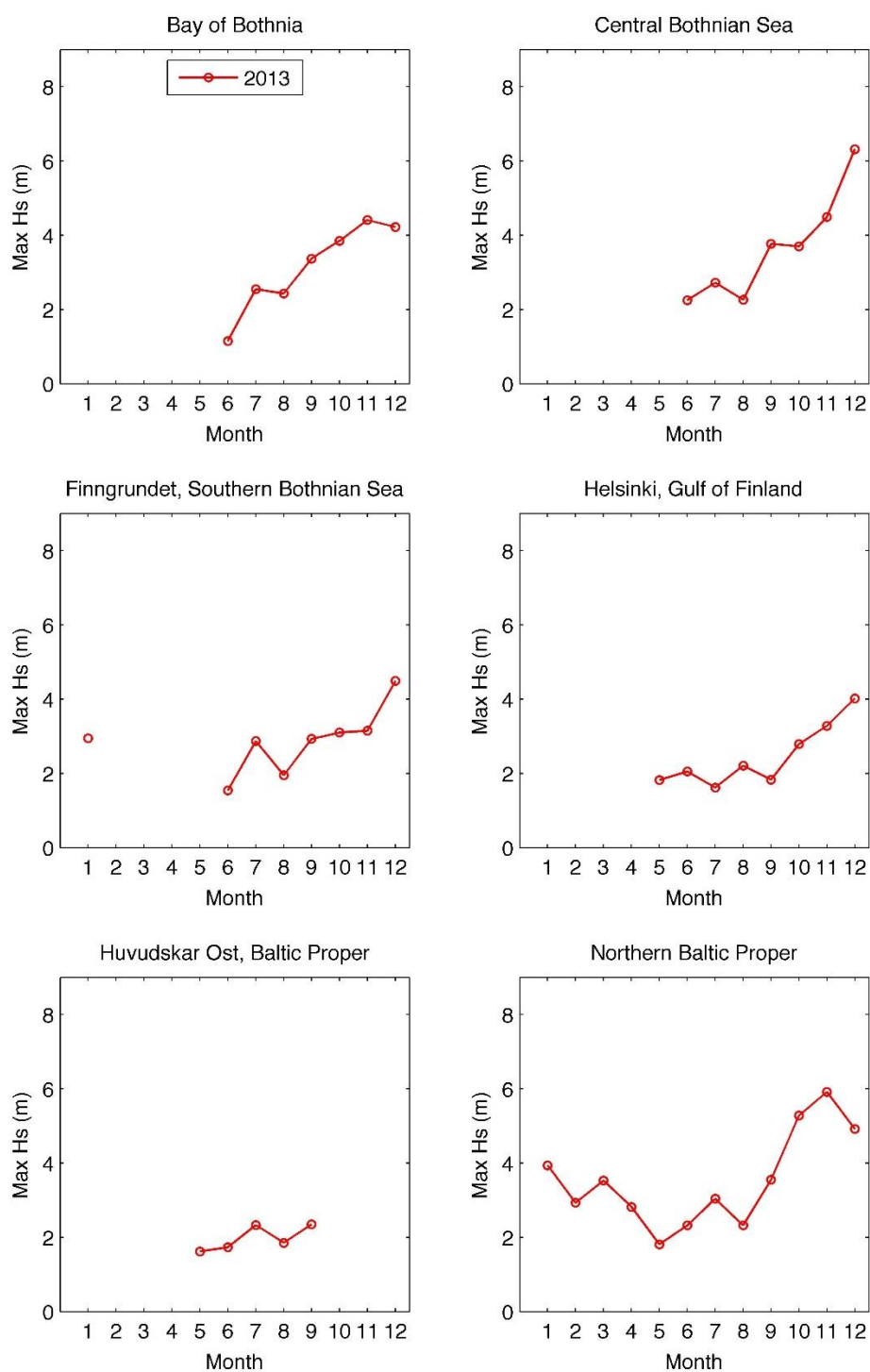


Figure 8. The monthly maxima of significant wave heights in the Bay of Bothnia, the Bothnian Sea, the Gulf of Finland and the Northern Baltic Proper.

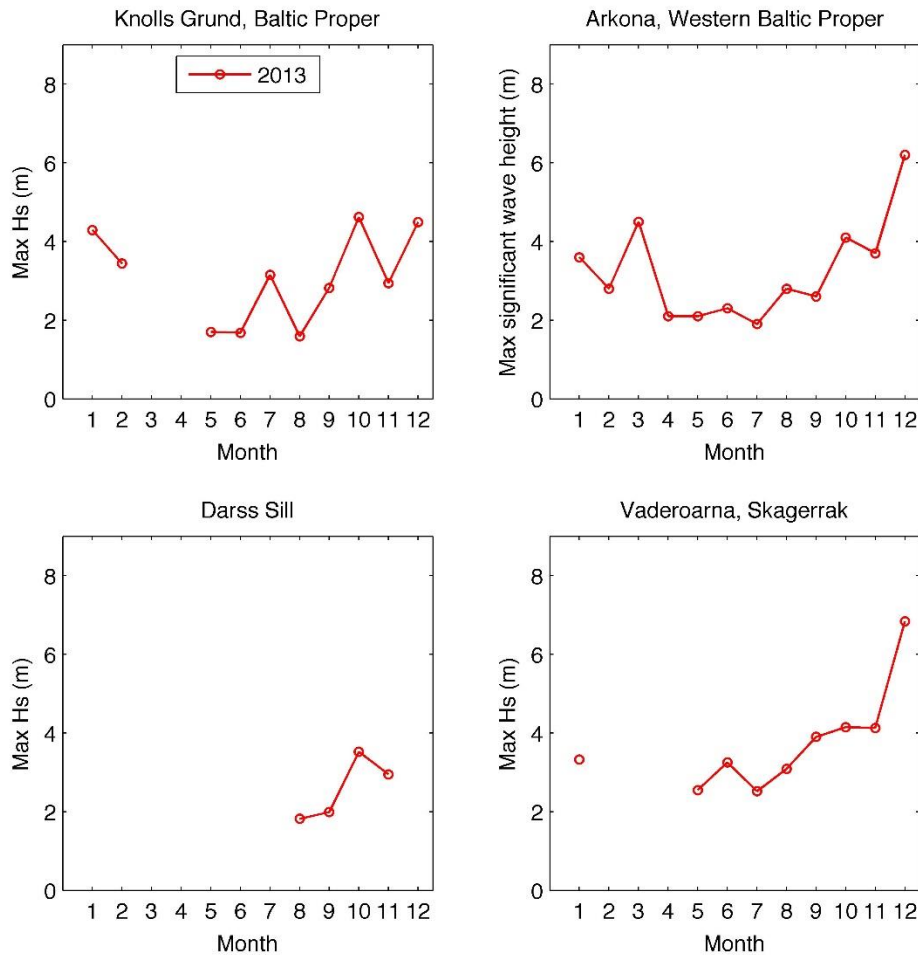


Figure 9. The monthly maxima of significant wave heights in the Central Baltic Proper, the Western Baltic Proper and Skagerrak.

Metadata

In 2013 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° 54' 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).

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), and since 2002 at a station northwest of Cape Arkona (54° 52.9'N, 13° 51.5'E), where measurements are made 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 waves at each station are measured with surface following buoys, Seawatch, Directional Waveriders and Waveriders. Measurements were collected app. every hour via Iridium, HF link, Argos-satellite, Orbcomm system and dataloggers. The significant wave height is calculated onboard the buoys over 1600 - 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 2013 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 6 and 7 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 timeseries in the statistics they should be used with caution.

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