Wave climate in the Baltic Sea 2018

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Key message

The wave climate in September north of the latitude 57° N in the Baltic Sea and Skagerrak was rougher in nearly all of the measurement sites, especially in Skagerrak where a significant wave height of 8.5 metres was measured. This is the highest value ever measured in these sea areas. June was rougher and November and December were calmer than usual in most of the stations in the northern parts. Wave climate in the southern parts, in the western Baltic Proper, was close to the long-term averages and the roughest month was March.

Results and assessment

In 2018 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.

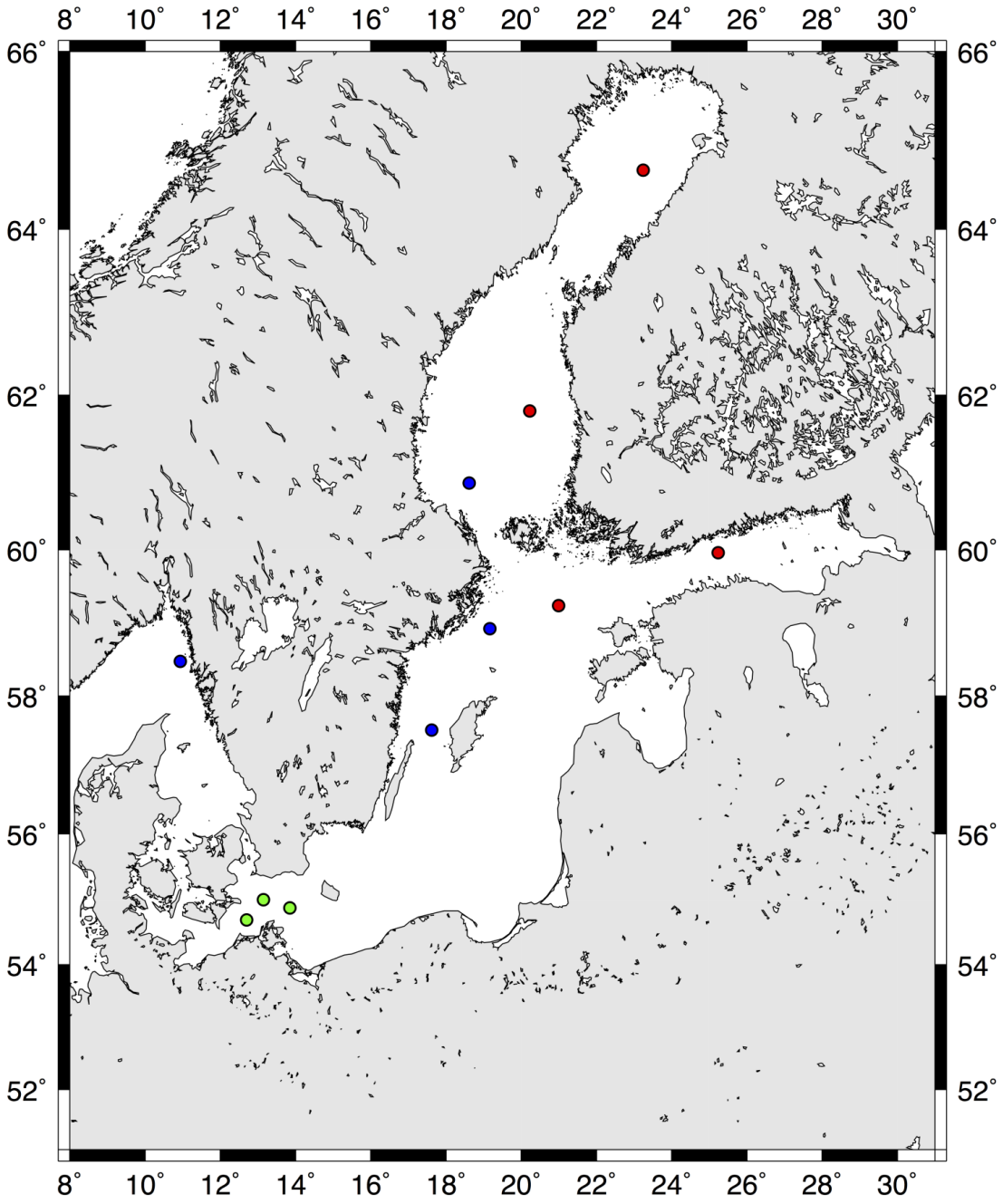

Figure 1. The positions of the wave buoys in 2018. Red dots indicate FMI buoys in the Bay of Bothnia, in the Bothnian Sea, in the Northern Baltic Proper and in the Gulf of Finland (station Helsinki), blue dots SMHI buoys in the Southern Bothnian Sea (station Finngrundet), in the Baltic Proper (stations 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 mid-June to the end of November 2018.

During the measuring period from June to November, two months, June and September, were clearly rougher, while the remaining months were typical for the season. Even if the buoy was operational only the latter half of June, the mean significant wave height was 0.7 m. The average significant wave height in September was 1.2 m, and the highest significant wave height was 4.6 m (27 September), measured during north-western winds. This is the highest measured significant wave height at this location since 2012, but the timeseries do not cover the whole ice-free periods and this value is not the highest possible at this location. In July the significant wave height remained under 1.5 m and was under 0.2 m for nearly six days (from 8th to 14th). On August 11th a significant wave height of 3.9 m was measured, and the highest significant wave heights in October and November were 3.0 m (21 October) and 2.8 m (5 November).

The Central Bothnian Sea

In the beginning of 2018 the wave buoy in the Central Bothnian Sea was operational to 22 February. The buoy was redeployed in the beginning of April and was operational the rest of the year.

January was very typical for the season, both the average significant wave height and the highest significant wave height, 5.8 m (7 January), were close to the long-term values. The highest significant wave height measured in January was also the highest for the whole measurement period. February, April, May and July were calmer than usual, and the significant wave height remained under 3.3 m (1 February), 1.5 m (21 April), 1.9 m (17 May) and 1.4 m (27 July), respectively. The significant wave height remained under 0.2 m between 11 and 16 July, a little shorter and later period than in the Bay of Bothnia. Like in the Bay of Bothnia, June and September were clearly rougher than usually, as well as August. A monthly record for June was measured when the significant wave height reached 4.4 m on 22 June. The highest measured significant wave heights for August were 3.7 m (11 August) and for September 4.1 m (22 September). The mean significant wave height for September was 0.60 m higher than the long-term average. The monthly means of significant wave height in October, November and December were practically the same. October and November were typical to the season with highest significant wave heights of 3.7 m on 30 October and 5.0 m on 29 November. December was calmer than usual and the highest significant wave height reached 5.2 m on the 5th.

The Southern Bothnian Sea, station Finngrundet

Due to ice conditions the buoy at station Finngrundet was out of operation during March and April. Else during 2018 it was operational.

There were no exceptional significant wave heights observed during 2018, but for the month of June the maximum height reached the old record high of 2.9 m from 2009. The highest maximum significant wave height this year was observed on 16 January with 3.9 m, far from the overall record of 6.4 m for this site,

measured on 1 November 2006. The monthly averages of significant wave height were near the long-term averages, except for November and December, which were lower.

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 in the end of January 2018 and redeployed mid-April. The buoy was operational to the end of the year.

The monthly averages of significant wave height remained under or close to the long-term values, except in September. Reflecting the wave climate in the Gulf of Bothnia, the highest significant wave heights in June and September reached the long-term maxima: 3.2 m on 22 June and 4.1 m on 26 September. The September value was also the highest measured significant wave height for the measuring period. The highest measured significant wave height in January was 3.8 m (7th), 1.4 m on 20 April and on 1 May, 2.0 m on 28 July and 2.1 m on 19 August. Similarly to the Gulf of Bothnia, the significant wave height remained under 0.3 m for a period of six days in July (10th – 16th). From October to December, the monthly averages and highest significant wave heights were close to each other: the highest significant wave heights were 3.1 m (22 October) and 3.0 m (30 November and 5 December).

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 2018.

The variation of the wave climate at the buoy location showed same features than the wave climate in the central part of the Gulf of Finland. The monthly mean values of significant wave height were below or close to the long-term means, except in September. The highest significant wave heights from January to May were clearly lower than the long-term maxima: 5.7 m (16 January), 3.8 m (1 February), 2.8 m (20 March), 3.6 m (6 April) and 2.1 m (1 May). Reflecting the wave climate in the Gulf of Bothnia and the Gulf of Finland, June was little bit rougher, and the significant wave height reached 3.8 m (22 June). The calm period in July at this station lasted nearly nine days from 8th to 17th. During this period the significant wave height remained under 0.5 m. The highest significant wave height in July was 2.3 m (28th) and in August 3.1 m (23rd). The highest significant wave height in rough-in-the-mean September was 5.5 m (26th) and in October the significant wave height reached 4.4 m on the 30th. November was calmer than usual, but the highest significant wave height was as high as the long-term value for the month: 6.9 m on the 30th. This was also the highest measured significant wave height at this station in 2018. During this storm the significant wave height was over 5.8 m for 24 hours. December was also calmer than usual and the highest significant wave height was 5.4 m, measured 1 December, when the wave field was decaying after the storm that caused the November/yearly maximum.

The buoy at station Huvudskär Ost was in operation until end of February, then out of operation during the major part of March and until 20 April, due to risk of sea ice. Another period with very low accessibility was in December. Else during 2018 the station was operational.

Record significant wave heights for a month since the start of measurements in 2001, were observed in January, February and October. On 16 January a deep low over western Scandinavia caused a southerly wind of 18 m/s over the Baltic Proper. At Huvudskär Ost a significant wave height of nearly 5.4 m was recorded, the third ever highest significant wave height registered for this station. Another event took place on 30 October, when a north-easterly wind of 17 m/s, again built a significant wave height of 5.4 m. The ever highest significant wave height recorded for this station is from the 9 November 2010 with 5.7 m.

The monthly averages of significant wave height were near the long-term averages, except for September, when it was slightly higher and in November, when it was lower. For January and February there are no long term averages to compare with due to lack of observation data.

Central Baltic Proper, station Knolls Grund

The wave buoy at station Knolls Grund was operational with full data availability almost the entire 2018, except for a 3 week gap in data in May. The weather situation over the Baltic Proper the 16 January with a southerly wind of 18 m/s caused a significant wave height of 6.0 m at Knolls Grund. This was a new overall record for this station since the start in 2011. The previous record was set on 11 January 2017 with 5.6 m. Another situation with southerly winds of 16 m/s the 29 November, caused a significant wave height of 4.7 m, second highest notation for the whole year. Else during the year the maximum significant wave heights were well below the record notation for each month.

The monthly averages of significant wave height were near the long term averages, except for November and December, which were lower.

Western Baltic Proper, stations Darss Sill, Arkona and Fino2

With Arkona there is a station in the Western Baltic Proper for which data are available for the whole year 2018. From the station Darss_Sill there are at least 9 months of data (March, April and November are missing). As in recent years, Fino 2 has again only very little data available. Only in the months March, May, June and December data were recorded, because the buoy was broken away and drifted away several times.

In the Western Baltic Proper the year 2018 was in good agreement with the long-term average - some months were somewhat calmer, others somewhat rougher. In particular November was significantly calmer than the long-term average at Arkona - unfortunately there were no data at Darss Sill and Fino 2 this month. In addition, the winter months of January, February and December were somewhat calmer,

which was recorded by at least two of the three Western Baltic Proper stations. By contrast, the months April, September and, in particular, March were somewhat rougher than the long-term average.

In March, the highest significant wave heights in the Western Baltic Proper in 2018 were also measured - during a storm event on 17 March, 4.0 m were measured at Arkona and 4.2 m at Fino 2 – Darss Sill unfortunately did not record any data during this event. While this value was below the long-term maximum at Arkona, this was the highest significant wave height measured so far at Fino 2. However, Fino 2 has only been measured since 2014 and the measurement time series shows large gaps, so that no real long-term statistics are available for this station yet. The highest significant wave height recorded at Darss Sill was 3.0 m on October 29, which was more than half a metre below the long-term October maximum.

Skagerrak

Skagerrak, station Väderöarna

The wave buoy at station Väderöarna was operational and delivered data almost the whole year 2018, except a gap in the last 4 days of December.

The maximum significant wave heights were generally lower than the record notations for each month. One exception was in September when the storm “Knud” caused south-westerly winds of 28 m/s over Skagerrak on 21-22 September. This generated a significant wave height of 8.5 m at Väderöarna, a new record notation for the station since the start 2005. The previous record was 8.1 m set on 10 January 2015. Another event with high waves was on 25 January, when a deep low over northern Sweden caused south-westerly winds of 24 m/s over Skagerrak. This generated a significant wave height of 6.3 m at Väderöarna. On 10 August, when the storm “Johanne” tracked northeast, Skagerrak was affected by south-westerly winds of 24 m/s. At Väderöarna significant wave heights of 5.0 m then was observed, the second highest notation for the month of August.

The monthly averages of significant wave height were lower or near the normal for most of the months. A windy June gave a monthly average slightly above the long term average. In September the windy weather generated a mean average that was the highest ever recorded for the month.

Data

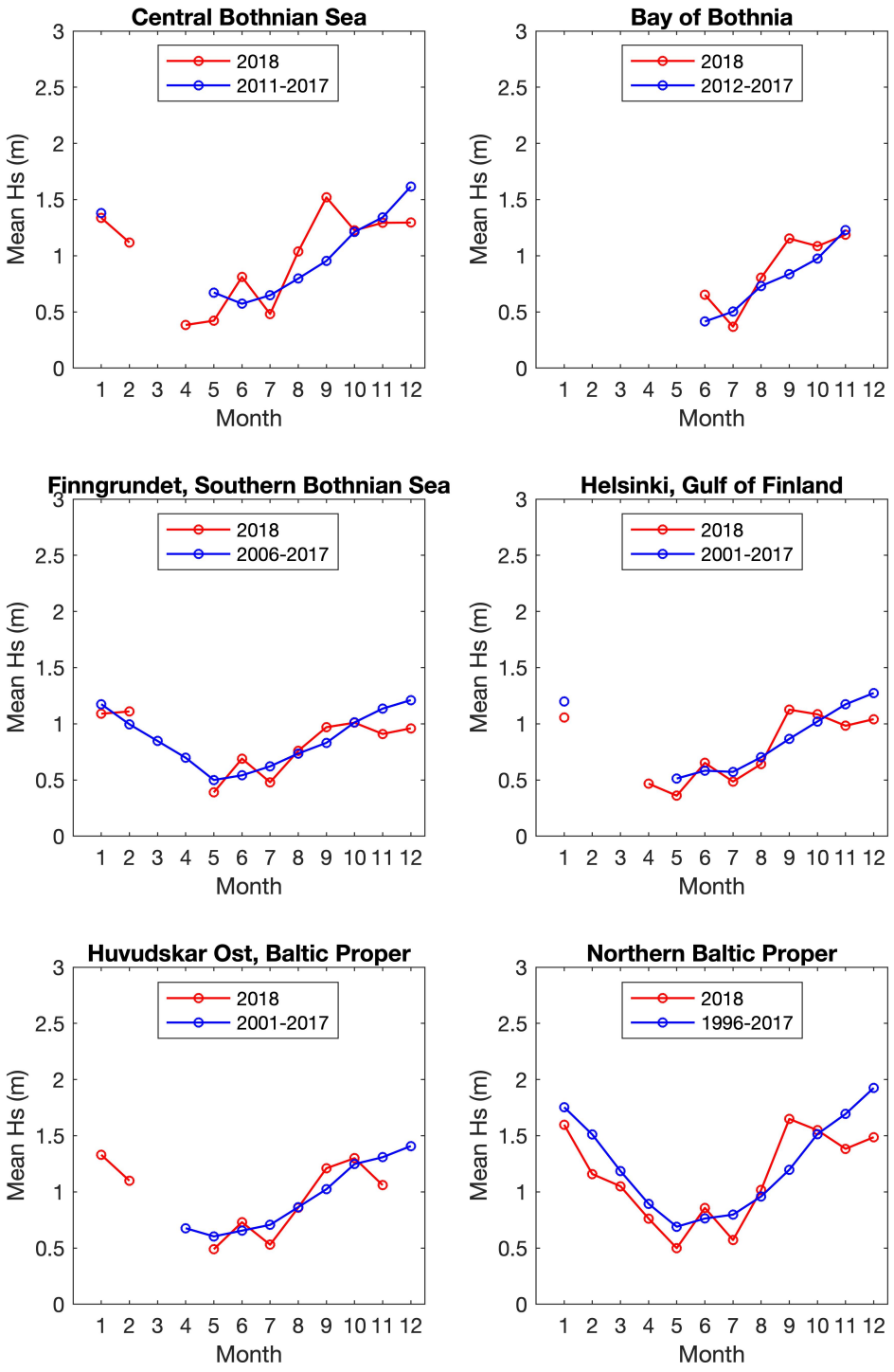

Figure 2. The monthly means of significant wave heights in the Bothnian Sea, the Gulf of Finland and the Northern and Central Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

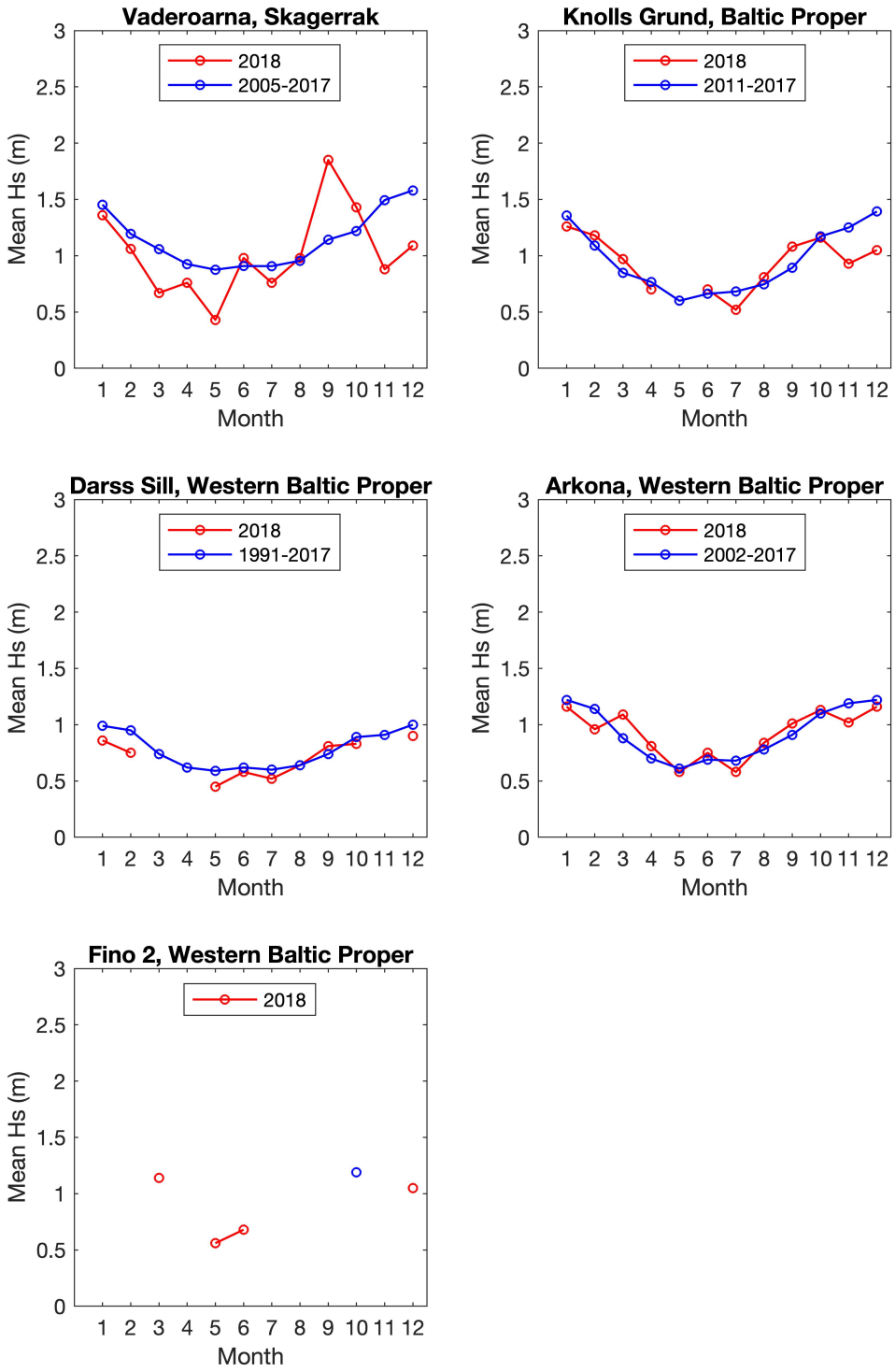

Figure 3. The monthly means of significant wave heights in Skagerrak, Central and Western Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

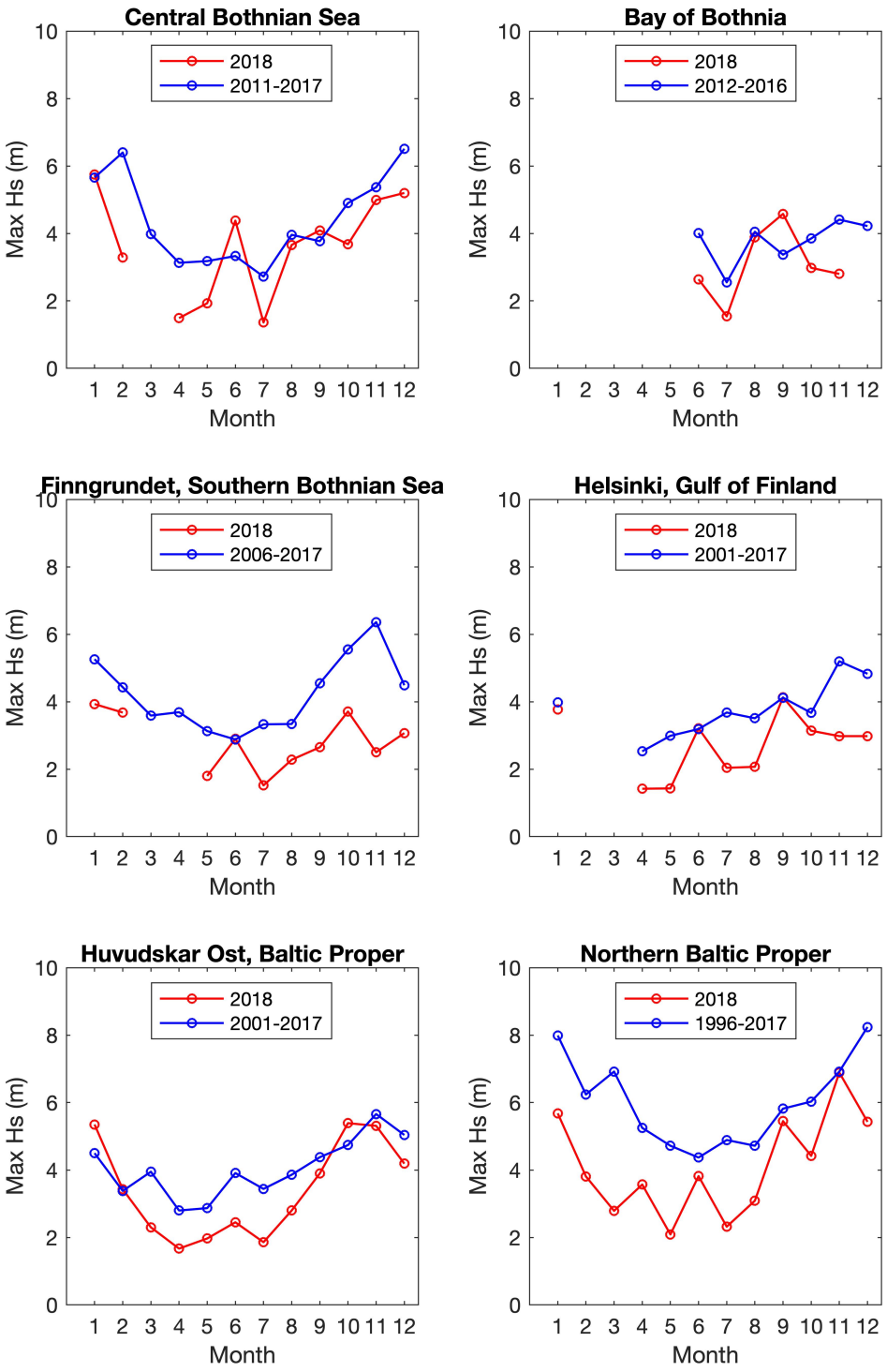

Figure 4. The monthly maxima of significant wave heights in the Gulf of Bothnia, the Gulf of Finland and the Northern Baltic Proper. Data gaps occur in some of the months.

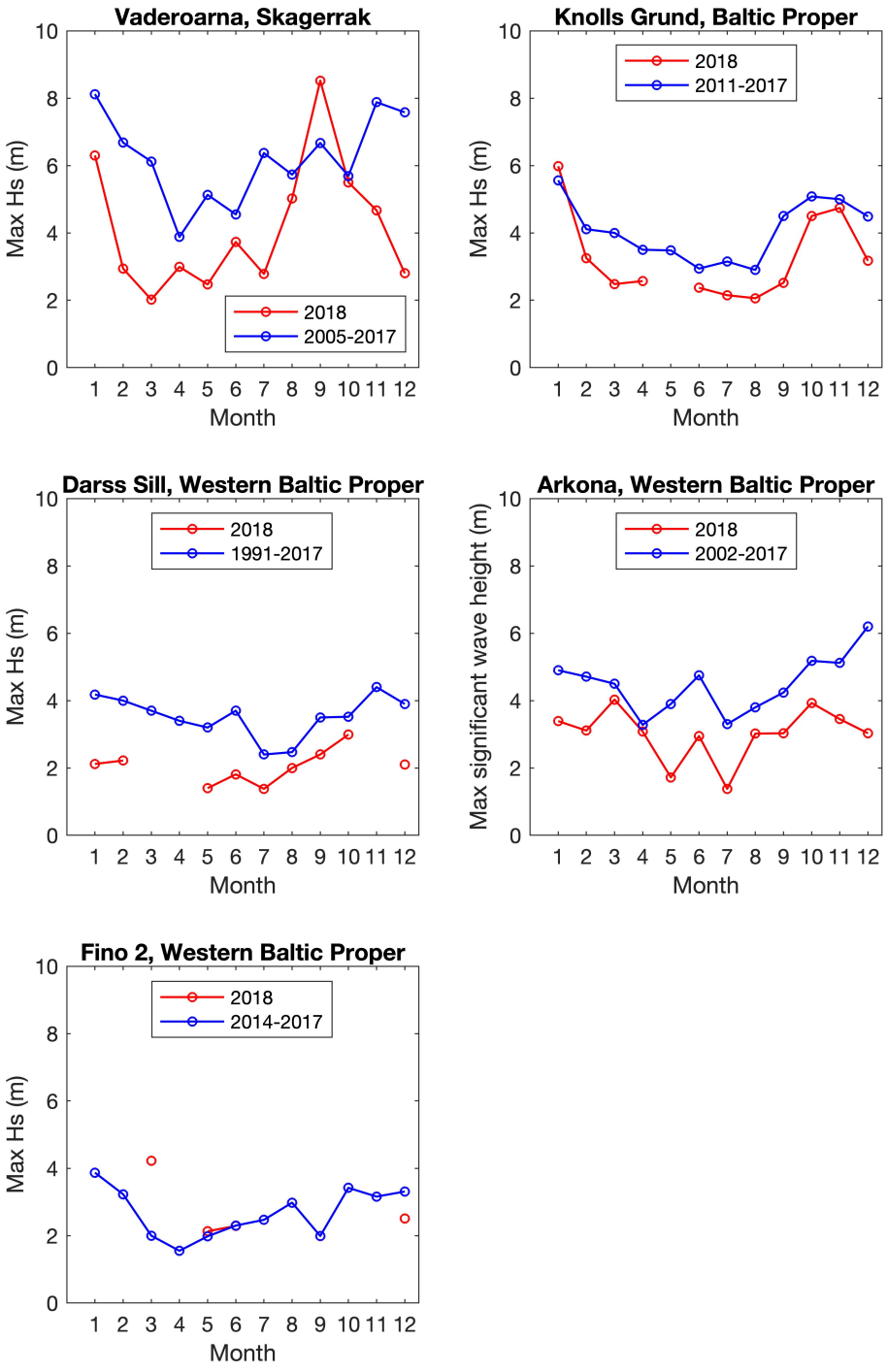

Figure 5. The monthly maxima of significant wave heights in Skagerrak, the Central and the Western Baltic Proper. Data gaps occur in some of the months.

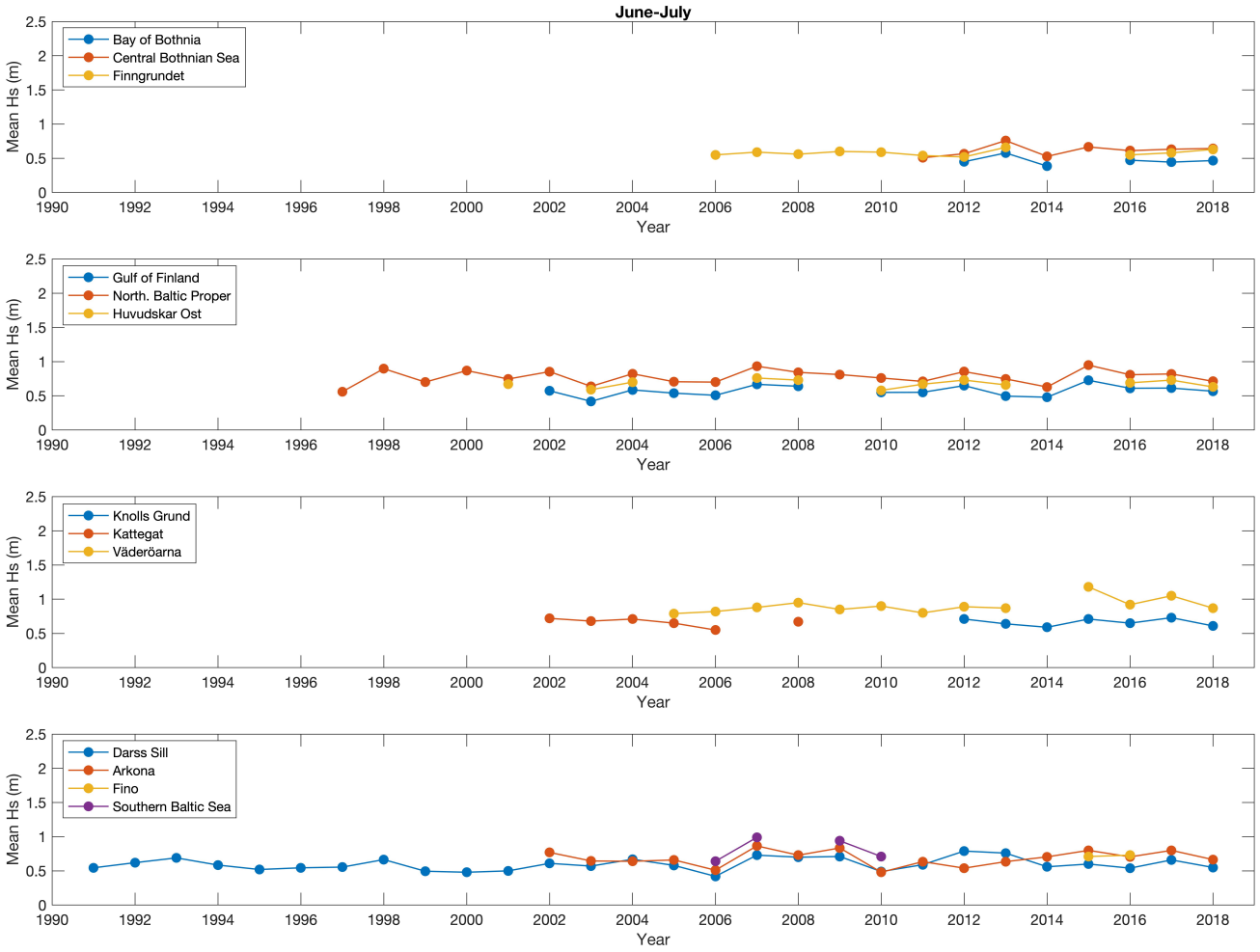

Figure 6. The yearly variation of the mean significant wave height Hs in the period of June-July. In some years the data does not fully cover the whole period.

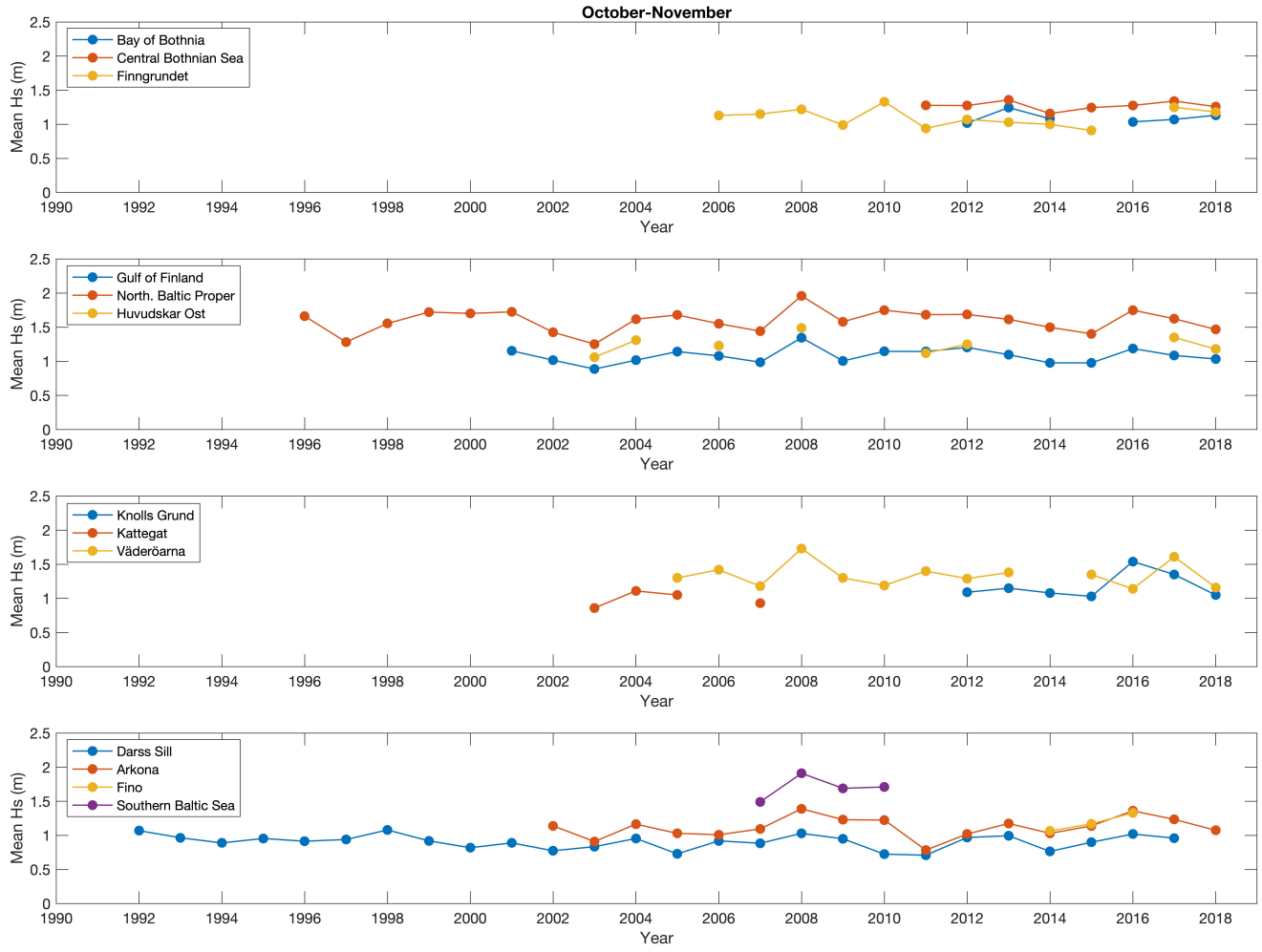

Figure 7. The yearly variation of the mean significant wave height Hs in the period of October-November. In some years the data does not fully cover the whole period. Especially at station Huvudskär Ost, the gaps in the data in years 2011 and 2012 might have left the mean value lower than it should be.

Metadata

In 2018 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 Fino 2 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 2018 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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