Wave climate in the Baltic Sea 2016

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Key message

In average, the wave climate in 2016 was rather typical for the Baltic Sea. The monthly means of significant wave height fluctuated around long-term mean values with regional differences. North of latitude of 57° August was rougher than usual while it was typical for the month in the South. October was clearly rougher in the South than in North. No extreme values were measured: the highest significant wave heights during the measurement periods were 6.7 m in Skagerrak, 4.0 m in the Western Baltic Proper, 5.7 m in the Northern Baltic Proper, 5.4 m in the Bothnian Sea, 4.1 m in the Bay of Bothnia and 3.6 m in the Gulf of Finland.

Results and assessment

In 2016 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 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.

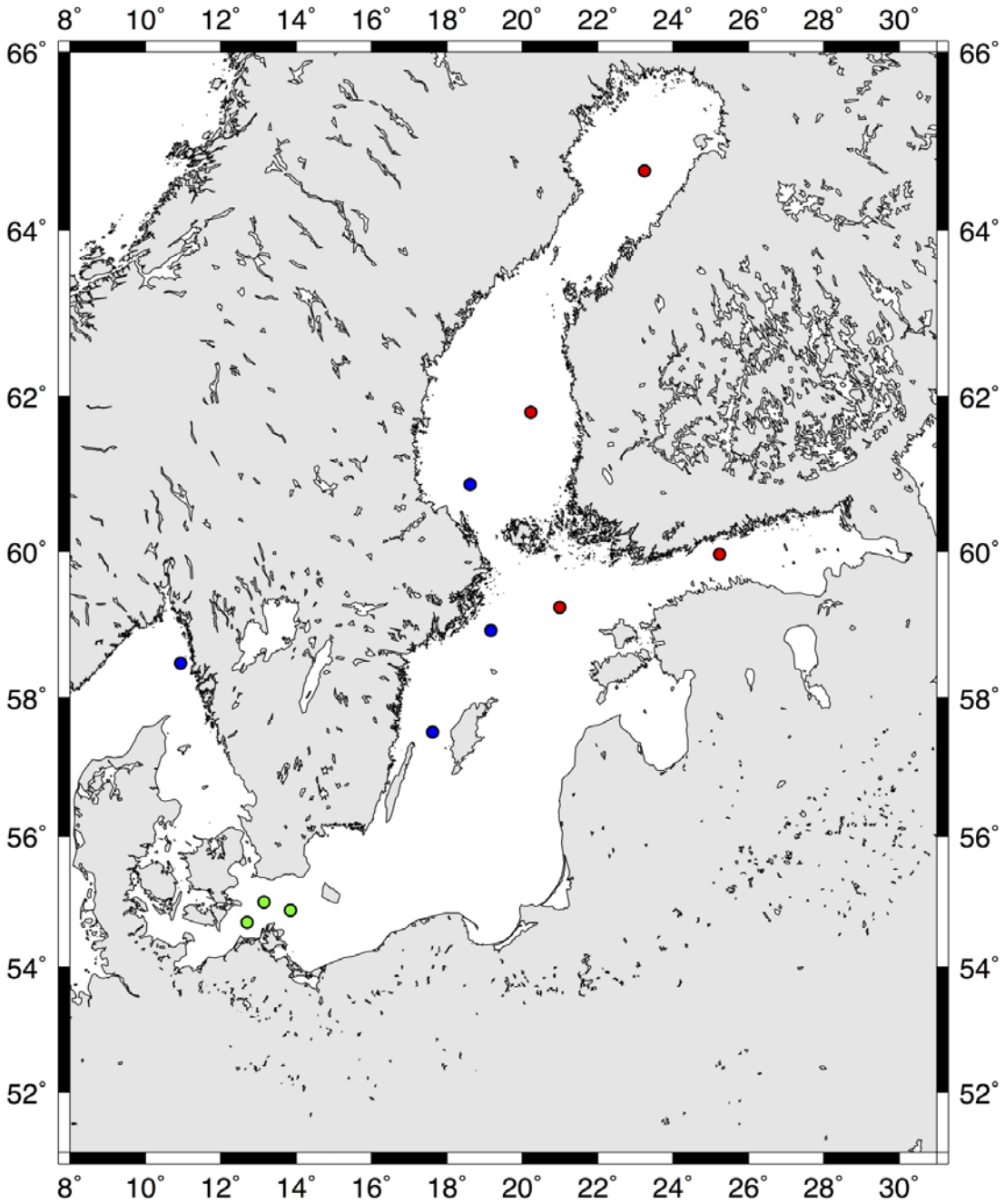

Figure 1. The positions of the wave buoys in 2016. Red dots indicate FMI buoys in the Bay of Bothnia, in the Bothnian Sea, in the Northern Baltic Proper and in the Gulf of Finland (station Helsinki), blue dots SMHI buoys in the Southern Bothnian Sea (station Finngrundet), in the Baltic Proper (stations 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 end of May to beginning of December 2016. The mean significant wave heights in June and July were under 0.5 m follow by a rougher August. September and October were relatively calm and November again rougher. In June there was a three-day period with strong northerly winds and the significant wave height reached 4.0 m on 9 June: this high waves are rare in this time of the year: the significant wave height remained under one metre 89% of the time. The highest significant wave height measured at this site since the measurements started in 2012 is 4.4 m from November 2013. On 27 August the significant wave height reached for the second time 4.1 m during northwestern winds. This was the highest significant wave height during the measuring period in 2016. A significant wave height of three metres was exceeded on 30 September (3.2 m) as well as on 19 (3.1 m) and on 27 (3.2 m) November.

The Central Bothnian Sea

In 2016 the wave buoy in the Central Bothnian Sea was recovered in the end of January and redeployed in the beginning of March. The buoy started drifting later in March and was re-anchored to the right position in mid-April.

January was typical for the season: a significant wave height of 4.5 m was measured on 13 January: this was the same wind event that caused high waves at Finngrundet, see below A significant wave height of three metres was measured on 30 April, while the significant wave height remained under 2.2 m in May. The monthly mean significant wave height from June to November showed correspondent variation as in the Bay of Bothnia. During the high wind event in early June the significant wave height reached 3.3 m (9 June) that was 0.4 m higher than the highest significant wave heights in June since 2011. In the rougher August significant wave heights over three metres were measured three times: on the 9th (3.3 m), on the 16th (3.3 m) and on the 27th (3.1 m). Three metres was exceeded twice in the end of September (3.2 m on the 28th and 3.7 m on the 29th). After a calmer October, a significant wave height of 5.4 m was measured on 27 November. This was the highest value during the deployment period as well as a new record for November. Five meters was exceeded again on 27 December, when a significant wave height of 5.2 m was measured.

The Southern Bothnian Sea, station Finngrundet

The mild winter 2015-2016 allowed the buoy at Finngrundet to be out all winter. During the autumn 2016 it was hit twice by fishing vessels, therefore data is missing from the beginning of October.

On 13 January a northerly wind of up to 22 m/s caused a significant wave height of 4.7 m at Finngrundet, the second highest value there since the start of measurements in 2006. A somewhat stronger, but less persistent, southerly wind caused a significant wave height of only 3.3 m on 28 January. The wind remained below 20 m/s and the significant wave height only touched 3 m for the rest of 2016 until the

measurement was interrupted on 2 October. The monthly maximum significant wave heights were well below long-term (2006-2015) values except for August which almost reached the earlier maximum value.

The Gulf of Finland

The middle parts of the Gulf of Finland, station Helsinki

The wave buoy off Helsinki was recovered mid-January 2016 and redeployed already mid-March because of the mild winter.

The wave climate from March to May was rather calm, the highest significant wave heights were 1.3 m (18 March) and 1.8 m (25 April and 26 May). June and July were typical for the season, a significant wave height of 2.8 m was measured on 18 June, while the significant wave height remained under 1.8 m in July. Three metres was exceeded on 27 August (3.2 m), 30 September (3.6 m, highest in the measurement period), 1 October (3.1 m), and 5 December (3.1 m). The significant wave height in November remained under three metres.

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 2016.

The monthly variation of the mean significant wave height was similar to the variation at station Helsinki in the Gulf of Finland except the magnitudes were larger. The period from January to May was in average calmer than usual. In the end of January, a significant wave height of five metres was measured twice, 5.1 m on the 28th and 5.0 m on the 29th. A significant wave height of 4.2 m was measured on 2 February. In March and April the significant wave height remained under 2.9 m and under 2 m in May. In June and July the significant wave height remained under 2.6 m. Like in the Gulf of Finland, August was rougher than usual and 3.8 m was measured on 9 August. Even if September was calmer than usual, a significant wave height of 5.2 m was measured on 30 September. October and November were slightly rougher than usual, but no extreme values were measured: 3.8 m on 8 October and 4.5 m on 1 November. The highest significant wave height at this station in 2016 was measured on 24 December, 5.7 m.

The Huvudskär buoy was deployed on 13 April 2016 and remained operational until 3 October 2016. Over the years, compared with the other (Waverider) buoys, the availability of the Huvudskär buoy has been low. It is a Watchmate-type buoy which has a large number of sensors and thus is more error-prone.

During May-September the mean significant wave height was close to the long-term (2001-2015) average whereas the monthly maximum significant wave height fell well below earlier records.

Central Baltic Proper, station Knolls Grund

The wave buoy at Knolls Grund has been in position during all of 2016. Overall, we now have five years of data from Knolls Grund.

The sea state was relatively calm during 2016 until November when the two highest sea states so far occured within one month: 4.9 m and 4.8 m on 2 and 28 November, respectively. In both cases the wind was up to 18-19 m/s slowly turning from northwest to northeast during a couple of hours.

The monthly mean significant wave heights in 2016 were close to the long-term (2011-2015) mean values except for October and November when it was higher. The monthly maxima were clearly lower except for August and November which were slightly higher.

Western Baltic Proper, stations Darss Sill, Arkona and Fino2

While we have a complete data set for the year 2016 from station Darss Sill, buoys at both Arkona and Fino2 did not operate during the first months of the year – Arkona started in February (whereas a full and therefore representative data set is only available since April), Fino2 in March.

At Darss Sill wave conditions from January to March were significantly calmer compared to the long-term mean value. In March conditions at Fino2 were also relatively calm – but a comparison to long-term mean at this station is still not possible because Fino2 started operating in October 2014, so that up to now only two years of data are available. During the rest of the year all three stations were in good agreement with each other and show a similar behaviour: The months April to August and also the November were in good agreement with long term statistics, while September and December were calmer than usual.

The October was significantly rougher than the long-term mean and clearly the roughest month in 2016 at all three stations. During a remarkable high wind event on 5-6 October, the maximum significant wave heights were 4.0 m at Arkona, 3.4 m at Fino2 and 2.7 m at Darss Sill. Especially it is worth to mention that at Arkona all measurements from 5 October, 15 UTC until 6 October, 23 UTC (so for more than 30 hours) were above 3.0 m and that during this event the second highest measurement at Fino2 in total and the highest for October was measured (but keeping in mind that the time series at Fino2 is still quite short). Whereas this event was the 2016-maximum at Arkona and Fino2, at Darss Sill an even higher significant wave height was measured at 26 December (3.3 m). Unfortunately this December event was not captured by the two other stations because due to technical reasons these two stopped operating just before Christmas – so maybe at Arkona and Fino2 the highest wave heights in 2016 were not recorded.

Skagerrak

Skagerrak, station Väderöarna

The wave buoy at Väderöarna operated continuously during 2016.

Three times, on 2 February, 29 September and 12 December, the significant wave height reached 6.7 m. The wind was southwesterly 20 m/s in connection with the first event. During the other two the wind was stronger, 25 m/s from southwest.

The 2016 monthly maximum significant wave heights were clearly lower than previously 2005-2015 for all months, except in February and September when they were slightly higher. January and October stand out as unusually calm periods on average. The monthly mean significant wave heights fluctuated close to the average long-term (2005-2015) values.

Data

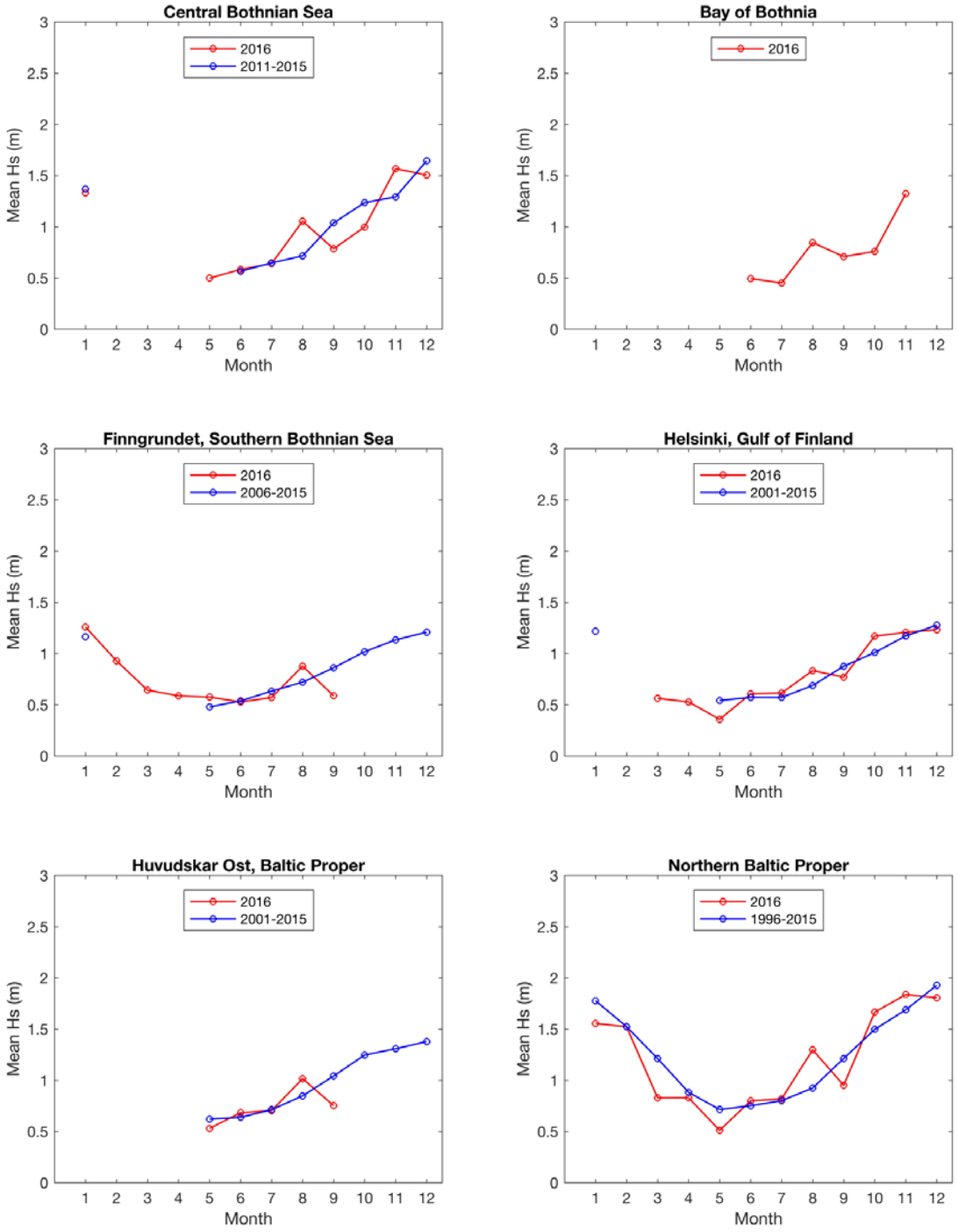

Figure 2. The monthly means of significant wave heights in the Bothnian Sea, the Gulf of Finland and the Northern and Central Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

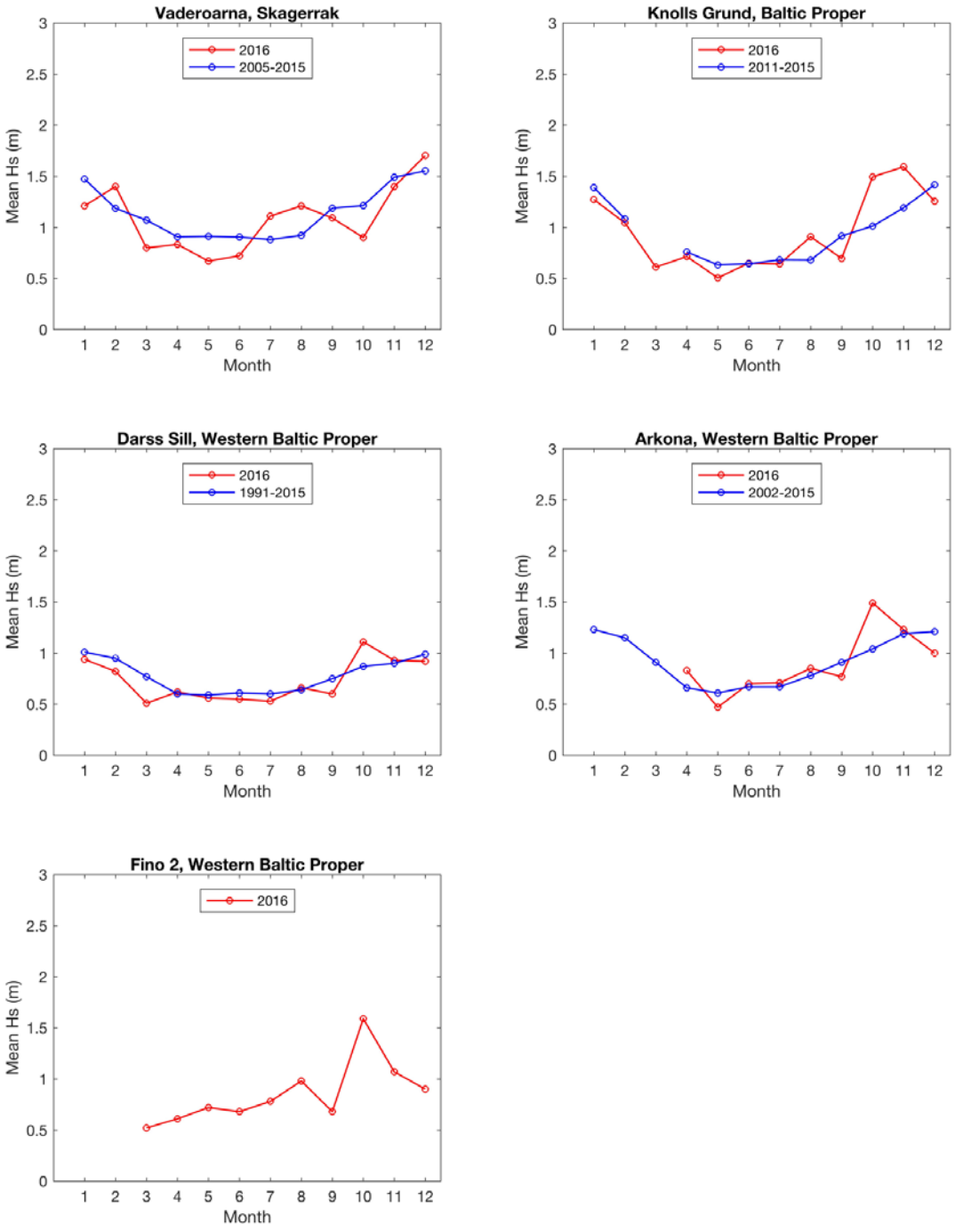

Figure 3. The monthly means of significant wave heights in Skagerrak, Central and Western Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

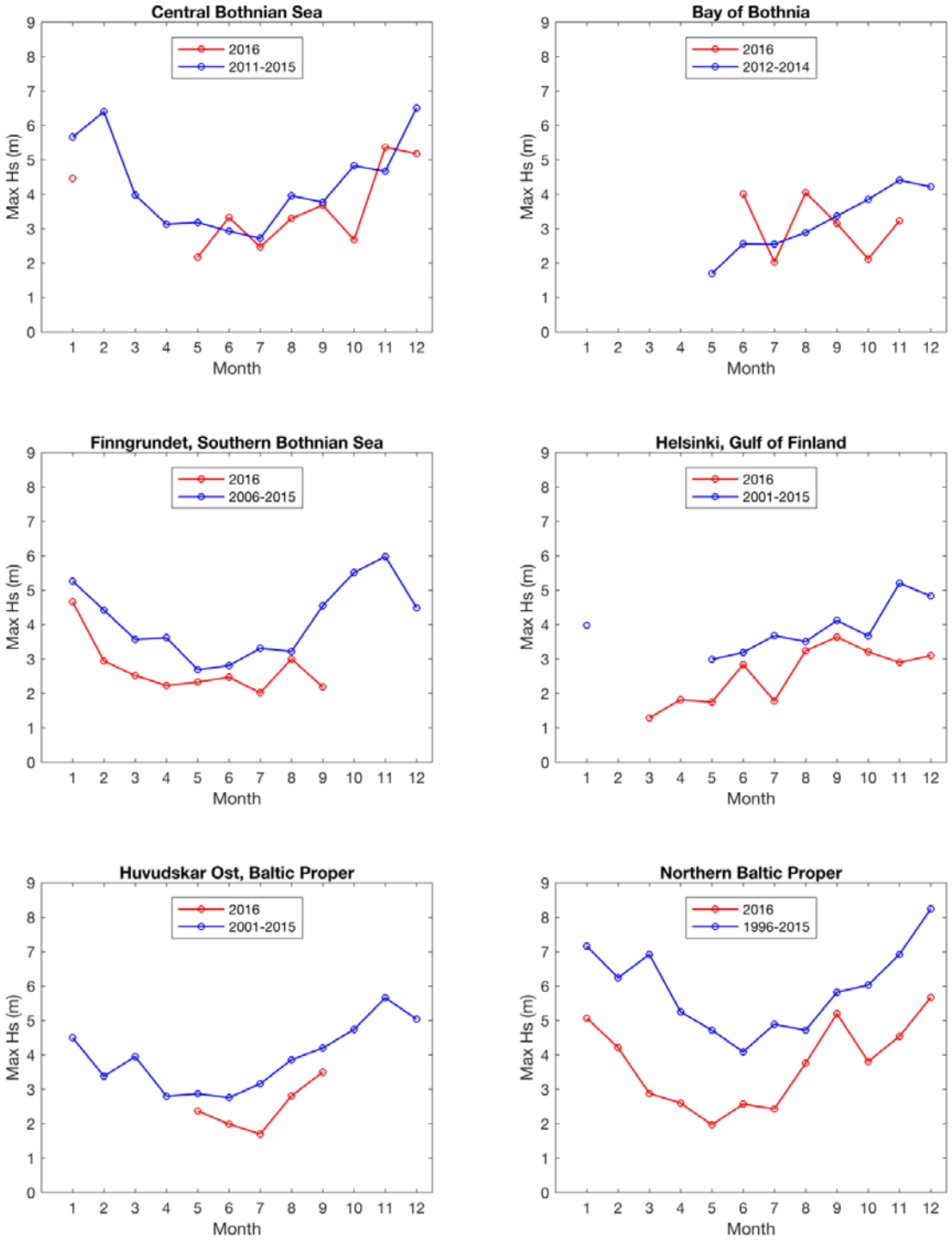

Figure 4. The monthly maxima of significant wave heights in the Gulf of Bothnia, the Gulf of Finland and the Northern Baltic Proper. Data gaps occur in some of the months.

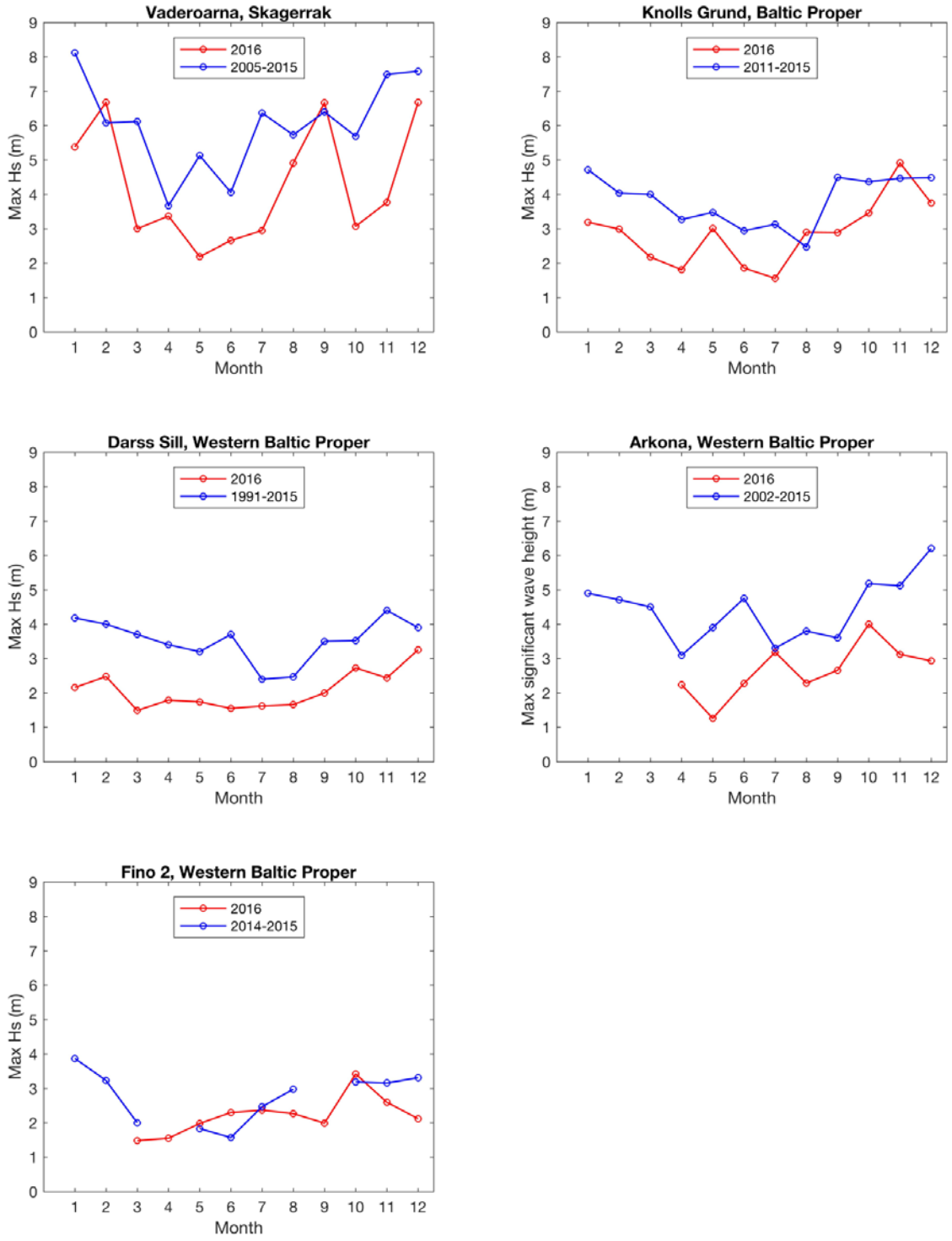

Figure 5. The monthly maxima of significant wave heights in Skagerrak, the Central and the Western Baltic Proper. Data gaps occur in some of the months.

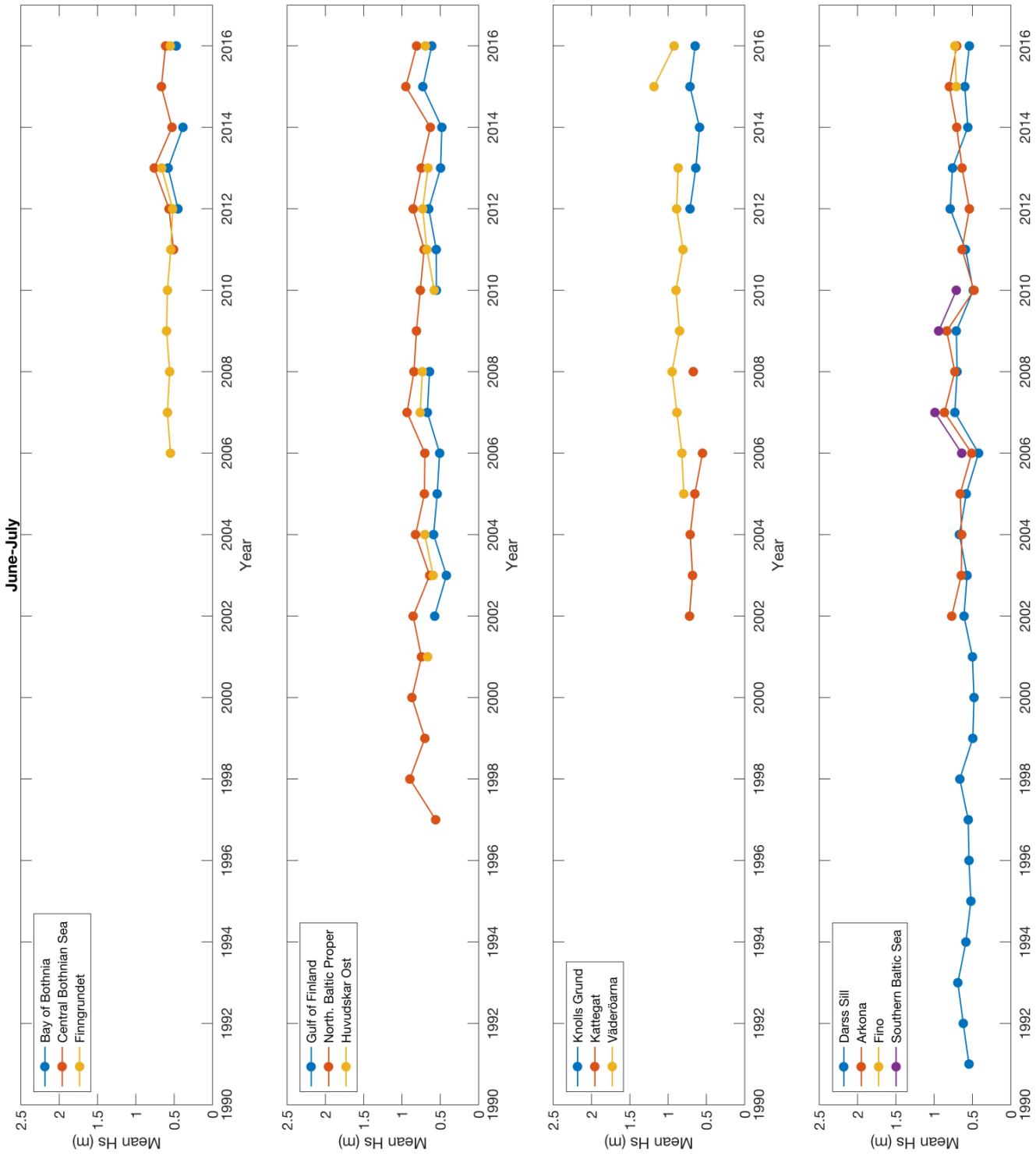

Figure 6. The yearly variation of the mean significant wave height Hs in the period of June-July. In some years the data does not fully cover the whole period.

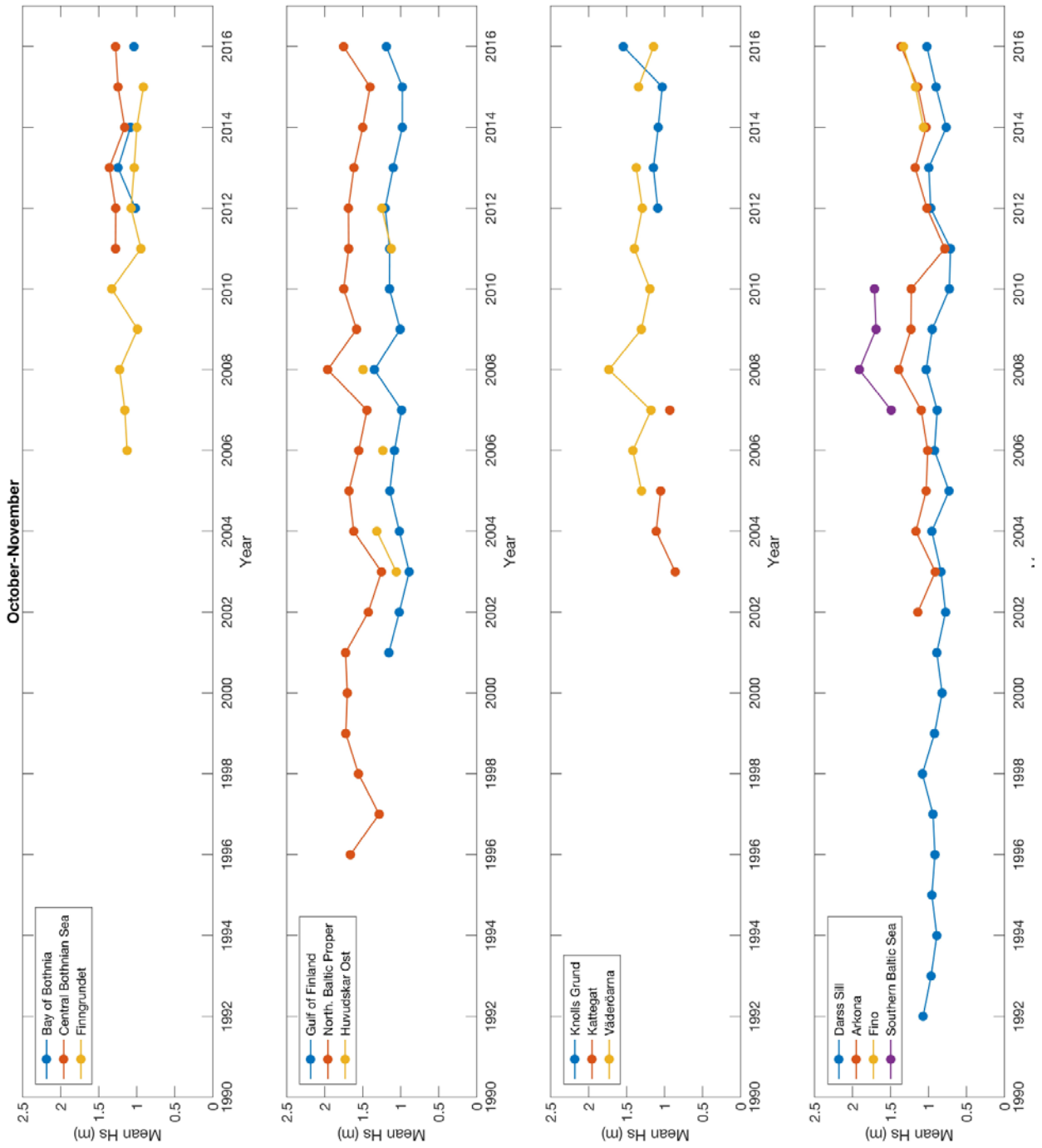

Figure 7. The yearly variation of the mean significant wave height Hs in the period of October-November. In some years the data does not fully cover the whole period. Especially at station Huvudskär Ost, the gaps in the data in years 2011 and 2012 might have left the mean value lower than it should be.

Metadata

In 2016 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 waves at each station are measured with surface following buoys, Seawatch, Watchmate (at Huvudskär Ost), 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 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 2016 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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