Wave climate in the Baltic Sea 2011

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Key message

Due to the ice conditions, wave measurements in the beginning of the year could be done only at some of the stations. In the southern parts of the Baltic Sea, the early spring was on average rougher than usual. The summer and early autumn months were rather typical for the season, except at latitudes 58° N – 60°N where September and October were rougher than usual. At all the stations November was on average rather calm, followed by a clearly rougher December. The highest significant wave heights during the period measurements were made were 6.5 metres in the Bothnian Sea (December), 4.8 metres in the central Gulf of Finland (December), 7.2 metres in the Baltic Proper (February), 4.7 metres in the Western Baltic Sea (November) and 7.4 metres in Skagerrak (November).

Results and assessment

In 2011 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.

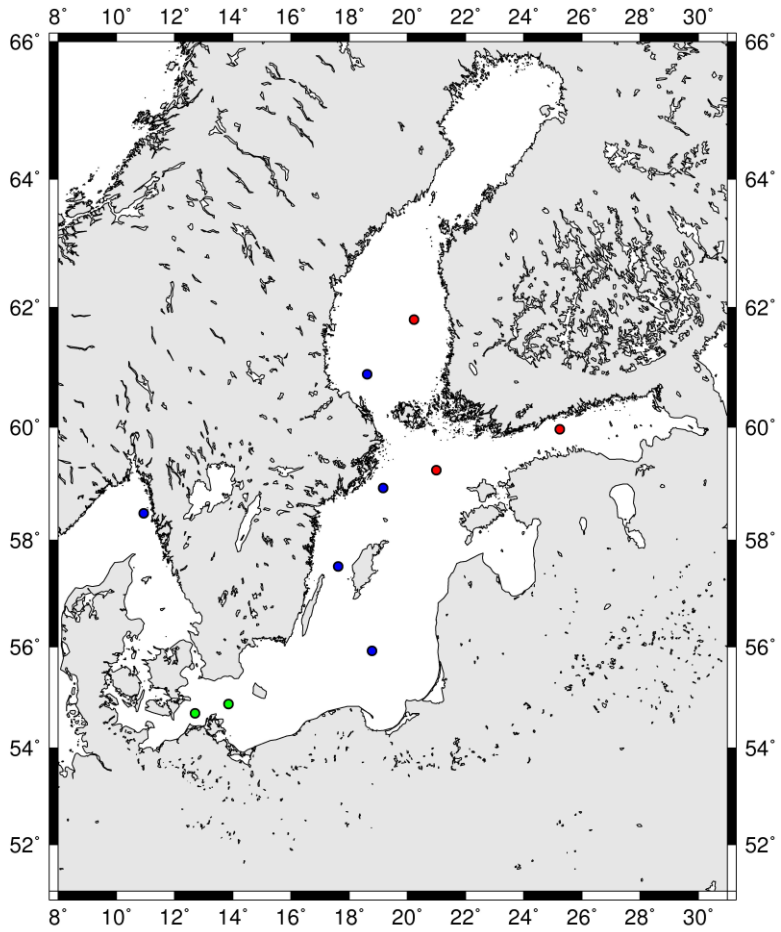

Figure 1. The position of wave measuring sites in 2011. Red dots indicate FMI buoys in the Bothnian Sea, in the Northern Baltic Proper and in the Gulf of Finland (station Helsinki), blue dots SMHI buoys in the Southern Bothnian Sea (station Finngrundet), in the Baltic Proper (stations Huvudskär Ost, Knolls Grund and Southern Baltic Proper) 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 positions of the buoys.

The Gulf of Bothnia

The Central Bothnian Sea

Measurements at this new station started in late May and the buoy was operational to the end of the year. June was the calmest of the summer months, the significant wave height remained under 1.5 metres. On August 8th, a significant wave height of 3.1 metres was measured. From September to November, the significant wave height exceeded four metres once, on November 28th (4.4 metres). In average, November was rather calm like at the other stations in the Baltic Sea. December was the roughest month of the measuring period and the significant wave height exceeded five metres twice. A significant wave height of 6.5 metres was measured December 26th, which is so far the highest

measured value in the whole Bothnian Sea. On December 9th, when the waves were at highest at station Finngrundet further southwest (Fig. 1), a significant wave height of 5.2 metres was measured.

The Southern Bothnian Sea, station Finngrundet

The buoy at Finngrundet was not operating during January to June, mainly due to the ice conditions in the Bothnian Sea. In general significant wave heights in the Bothnian Sea during 2011 were lower or close to the long term means for this position. Maximum significant wave heights were below 2.5 metres except for three occasions in October, November and December. The highest measured significant wave height during the measurement period was 4.0 metres on December 9th, which is highest for December since wave measurements started at this location in 2006. At this occasion even the highest mean significant wave height ever for December was registered with 1.3 metres, which is 0.2 metres above the climatically mean.

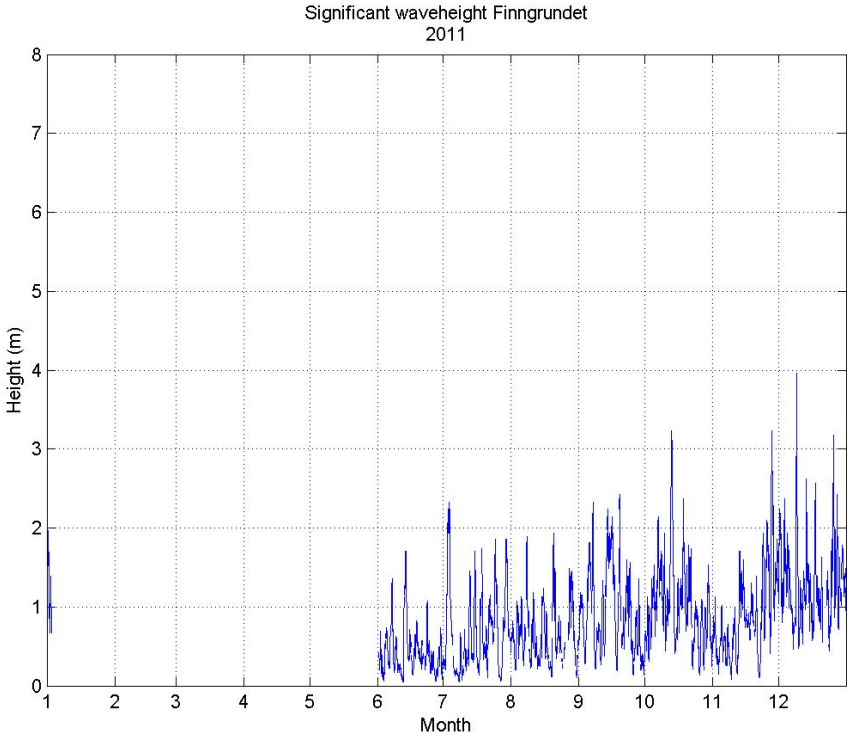

Figure 2. Time series of significant wave height at station Finngrundet.

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 2011 the buoy could be deployed in mid-May 2011 and the buoy was operational to the following year. In average, the summer months were typical for the season. On June 23rd the buoy

measured a significant wave height of 3.2 metres, which is the highest value measured in June since the measurements started in 2001. During the rest of the summer period, the significant wave height remained under two metres except once in August when it reached 2.6 metres. September and October were rougher than usual, and on 14th September a record high significant wave height for the month was measured: 4.1 metres. Like at the other stations, November was slightly calmer than usual, except the end of the month when the significant wave height reached 4.2 metres (evening of November 27th). December was clearly rougher, the average was 0.6 m higher than usual. The highest significant wave height for the measuring period was 4.8 metres, measured on December 26th, during the same storm when high waves were measured in the Central Bothnian Sea. On December 9th, when high waves were measured at several of the wave stations in the Baltic Sea, the significant wave height was 3.1 metres at highest.

The Baltic Proper

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

Due to the risk of ice, the wave buoy at station Northern Baltic Proper was recovered in early January and redeployed in mid-May. The wave climate at this station behaved similarly than at the station Helsinki in the Gulf of Finland, although the values were higher. In average summer months were rather typical for the season. The highest significant wave height, 4.1 metres, was measured during the same high wind event as at stations Helsinki, on June 23rd. September and October were rougher than usual, the significant wave height reaching a record high monthly value of 5.8 metres on 14th September. A slightly calmer November was followed by an exceptionally rough December, the average was 0.9 metres higher than usual and the significant wave height exceeded five metres in six events. The highest significant wave height for the measuring period was 6.9 metres, measured on 9th December. During the storm November 27th-28th, the significant wave height reached 5.4 metres in the evening of November 27th.

The buoy at Huvudskär Ost is located SWW from the buoy at station Northern Baltic Proper and closer the shoreline (Fig. 1). Due to ice conditions measurements could only be conducted between June and November. The mean significant wave height during most of the time measurements were conducted was close to long term means, ranking from 0.6 metres in June to 1.4 metres in October. The highest significant wave height during 2011, 4.2 metres (maximum individual wave height 7.4 metres), was measured on October 18th. Due to the passage of low pressure systems with stormy winds significant wave heights above 3 metres could be observed at a number of occasions during September and October. Often in such cases around the same time significant wave heights are high even at other wave buoy locations. Depending on the path of the system this locations can include the buoy in the Skagerrak and the buoys in the central Baltic and the Bothnian Sea. Aside from October 18th to 19th this can be seen on October 10th and on September 7th and 13th to 14th when comparing the plots of significant wave heights for the different lotions.

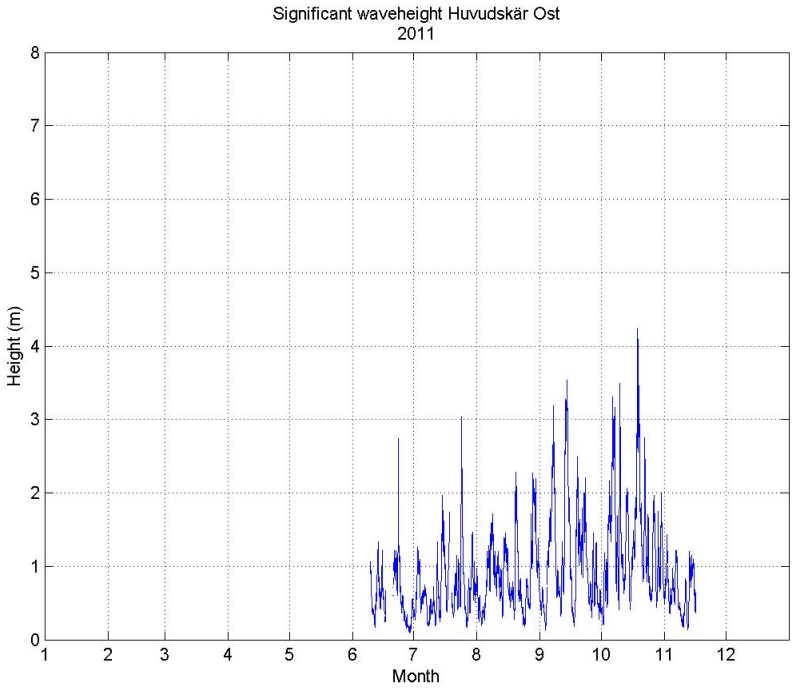

Figure 3. Time series of significant wave height at the station Huvudskär Ost.

Southern Baltic Proper, station Southern Baltic and Knolls Grund

Wave measurements at the position Southern Baltic were only conducted until April 16th. The buoy is temporarily moved to a new position between Öland and Gotland at 57°31' north, 17°37' east (Knolls Grund). During the time the buoy was positioned at the position Southern Baltic a number of intense low pressure systems moved through resulting in high significant wave heights. The most intense storm with gusts up to 40 m/s measured at the meteorological station Hanö resulted in a maximum significant wave height of 7.2 metres, the highest ever during February and second highest for this position. Mean significant wave heights for February (1.9 metres), March (1.4 metres) and April (1.1 metres, observe that this is the mean for the first half of the month only) were the highest ever for those month since deployment of a wave buoy at this position in 2005. Even maximum significant wave heights in March and April were among the highest for these months with 4.9 metres in March and 3.2 metres in April.

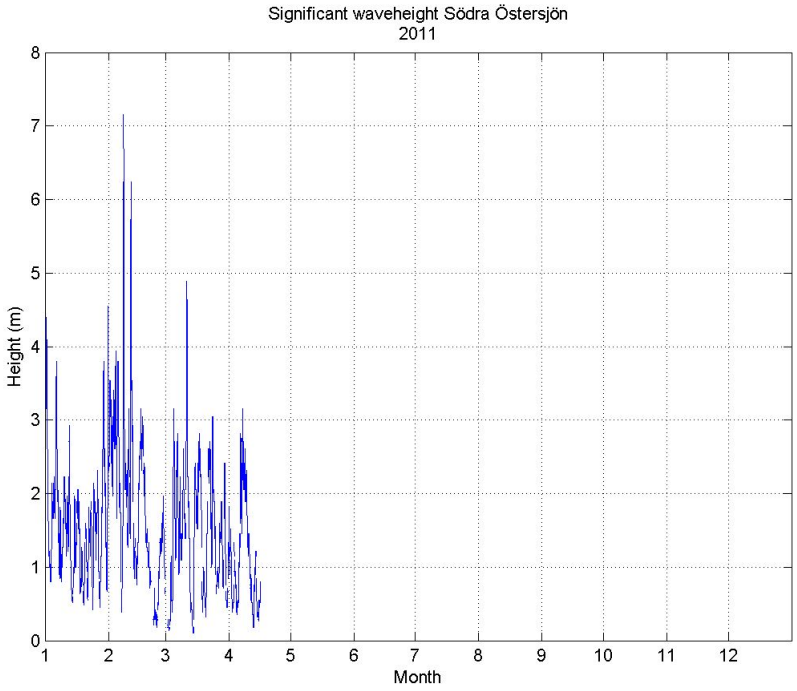

Figure 4. Time series of significant wave height at the station Southern Baltic.

On November 19th a wave buoy was deployed at 57°31' north, 17°37' east (Knolls Grund). Between November 24th and 29th two storms resulted in significant wave heights above one metre during this period. The highest measured wave height during this month was registered on November 28th with 3.4 metres. During December significant wave heights exceeded three metres at four occasions, on December 1st, 3rd, 9th and 29th. The highest significant wave height in December was 3.6 metres on the 3rd. The development of significant wave heights during storms at this position corresponds well with that at Väderöarna (Skagerrak) and Finngrundet (Bothnian Sea).

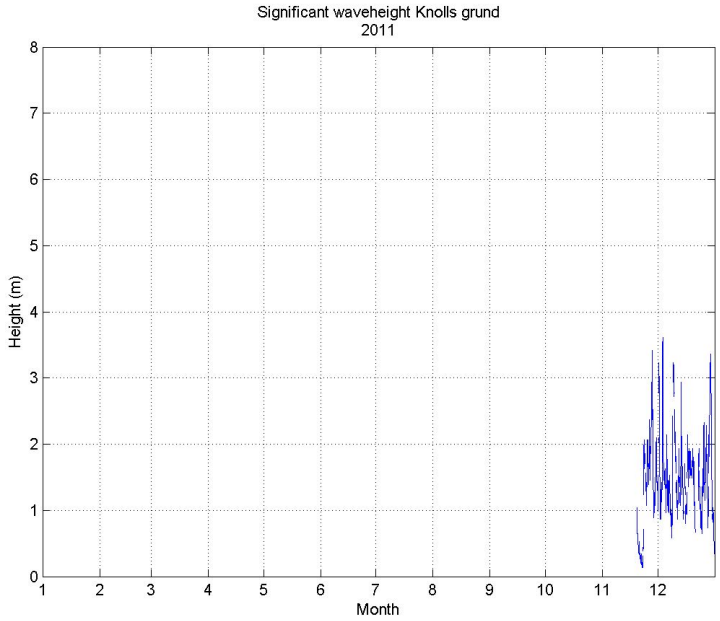

Figure 5. Time series of significant wave height at the station Knolls Grund.

Western Baltic Proper, stations Darss Sill and Arkona

Mean significant wave heights in the area of Darss Sill typically are 0.6 m in summer and 0.9 m in winter; the annual mean is 0.8 m. Wave heights at the Arkona station are slightly higher, ranging from about 0.6 m to 1.2 m, with an annual mean of 0.9 m. The most frequent wind direction, and thus also the predominant wave direction, is west-southwest (WSW), especially during storm events. Wind fetch in this offshore direction is much longer at the Arkona Basin than at Darss Sill, i.e. waves reaching the Arkona station have more time to grow. But also with other wind and wave directions, the larger distance from the coast and deeper water at the Arkona station are important factors contributing to higher wave heights.

Wind conditions in 2011 were relatively calm, as in the two previous years. The mean wind speed in the western Baltic Sea was about 5 % below the long-term mean. The frequency of strong winds of 6 Bft (11 m/s) or more was even 10 % below the mean value. Wind and waves came more frequently than normal from the predominant SW-W sector, while easterly directions were less frequent than normal. At both measuring stations, the mean significant wave height during most of the year was equal to or lower than the long-term mean. It was exceeded only in February and December, by about 0.2 m. By contrast, the maxima of significant wave heights in all months of the year were below historical extreme values. Like at several other wave stations in the Baltic Sea, the highest significant wave heights were observed in the Arkona Basin on November 28th and on December 9th , caused by WSW storms of up to 8 Bft (17-20 m/s). During the two storm events, the historical maximum values were almost reached. Easterly to northeasterly storms, which may also cause extreme wave conditions in the western Baltic Sea, did not occur in 2011.

Kattegat and Skagerrak

Kattegat, station Läsö Ost

During 2011 no buoy was operating at this position. In 2012 it is planned to continue measurements at a new position, most likely more to the south in the Kattegat area.

Skagerrak, station Väderöarna

The buoy at Väderöarna was recovered in the middle of January and redeployed in the end of March to prevent ice damage. During the passage of an intense low pressure system on May 24th a new record for the maximum significant wave height during this month at Väderöarna was measured with 4.9 metres. During autumn and early winter maximum significant wave heights above six metres were being observed at four occasions. Namely on September 13th 6.2 metres, on November 27th 7.4 metres (the highest ever, the same height was measured January 2007) and twice during December, on the 9th 6.0 metres and on the 29th 6.9 metres. Mean significant wave heights for this period in general were above the long term means by about 0.3 metres. An exception was November as the winds until the 24th were very moderate, leading to a mean significant wave height of 1.3 metres, 0.3 metres below the long term mean for this month. In contrast to that the mean significant wave height during December was 2.3 metres, being the highest for that month and the second highest ever.

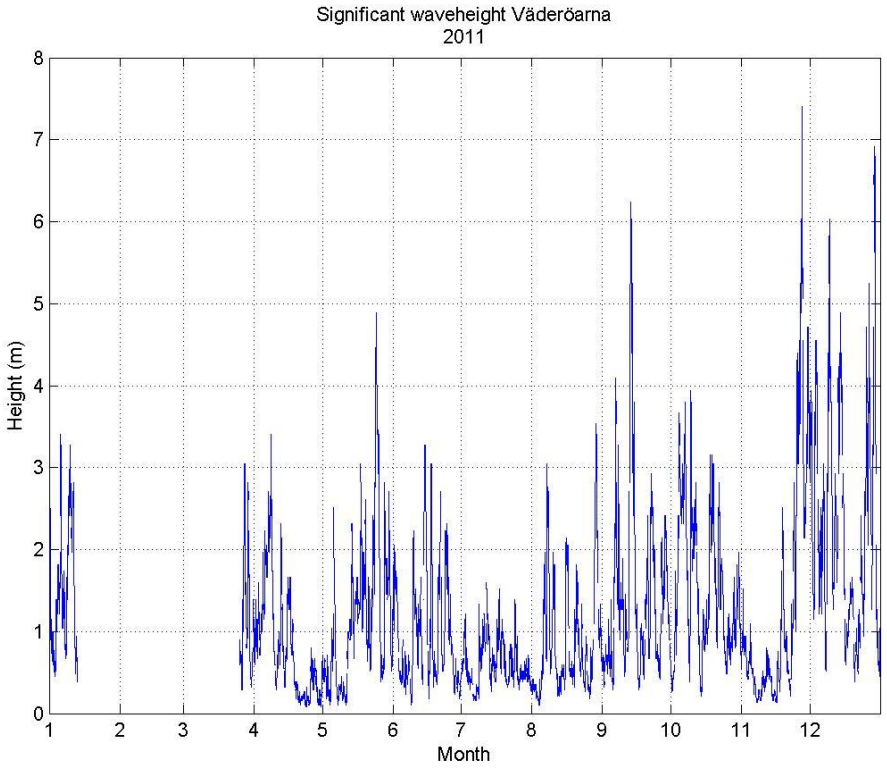

Figure 6. Time series of the significant wave height at the station Väderöarna.

Data

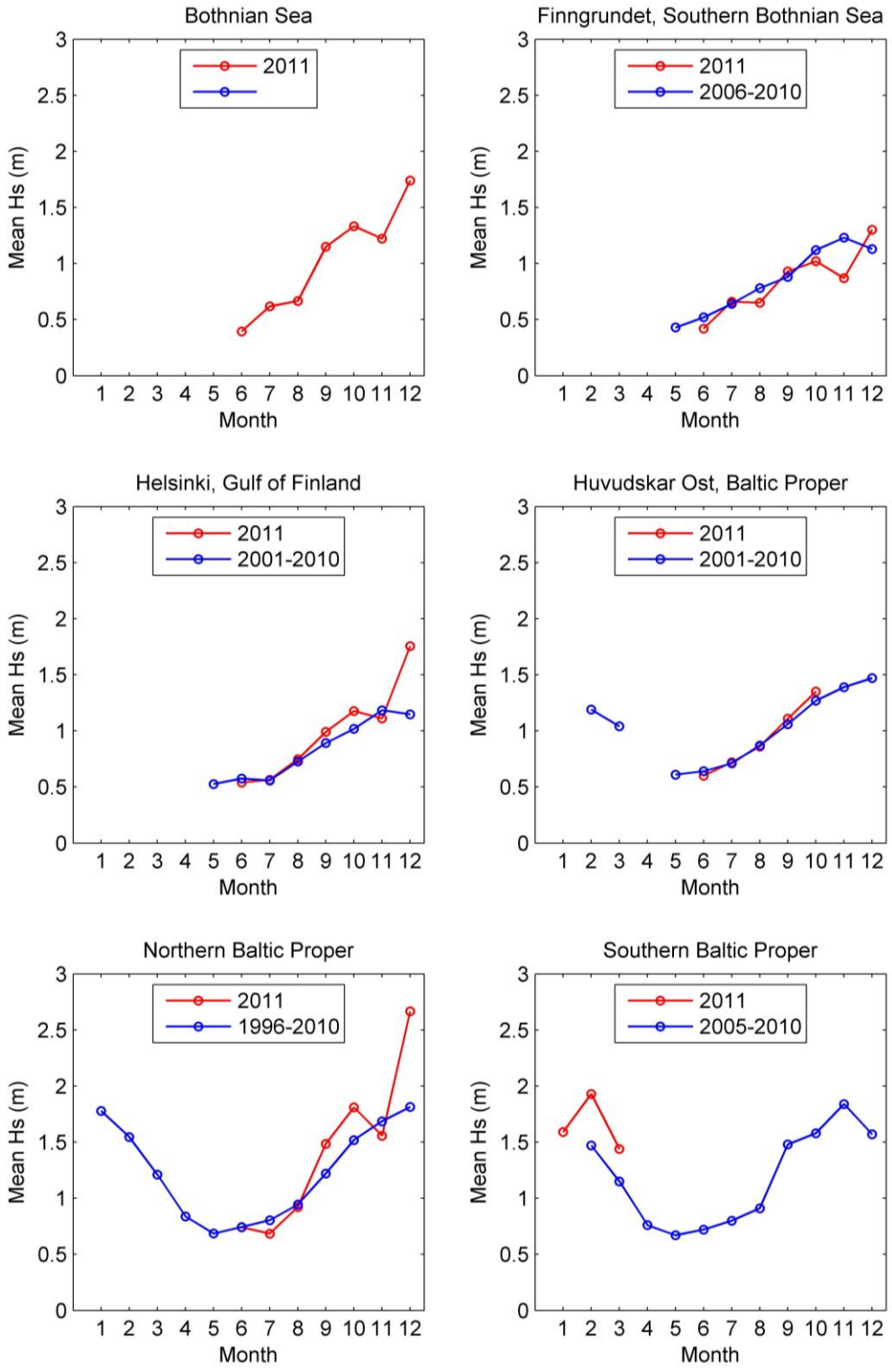

Figure 7. The monthly means of significant wave heights in the Bothnian Sea, the Gulf of Finland and the Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

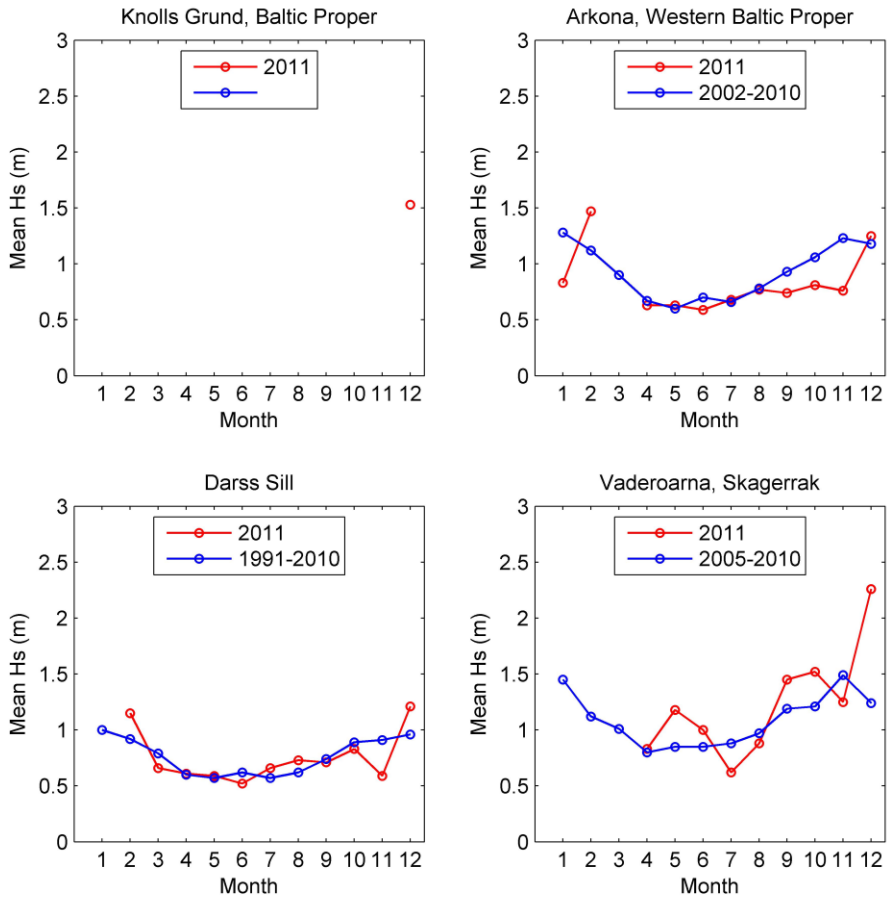

Figure 8. The monthly means of significant wave heights in the Western Baltic Proper and Skagerrak. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

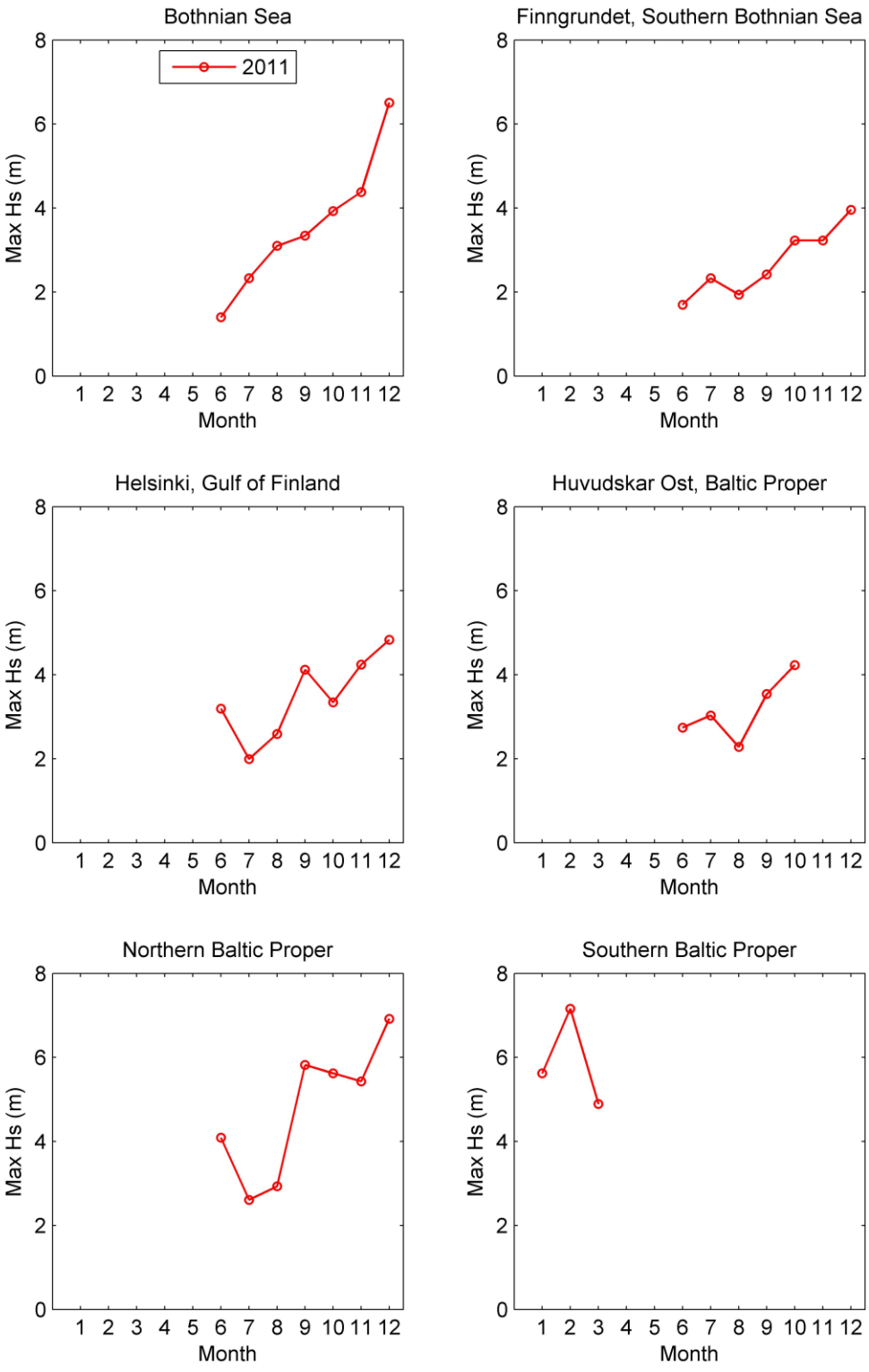

Figure 9. The monthly maxima of significant wave heights in the Bothnian Sea, the Gulf of Finland and the Baltic Proper.

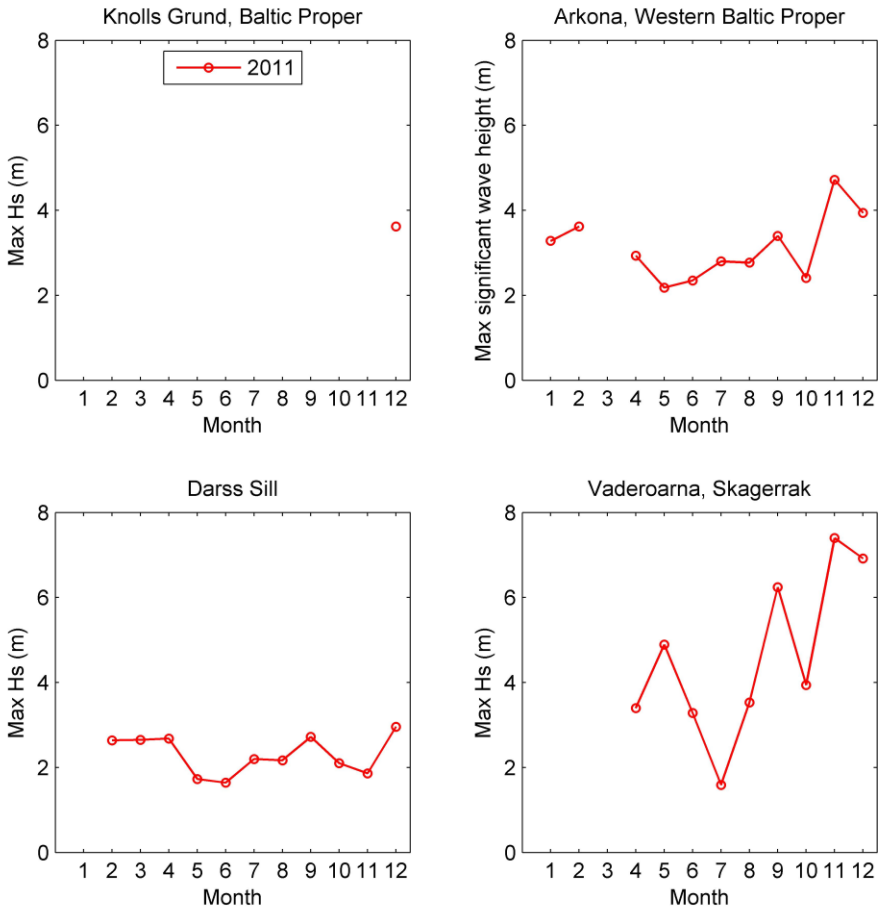

Figure 10. The monthly maxima of significant wave heights in the Western Baltic Proper and Skagerrak.

Metadata

In 2011 Finnish Meteorological Institute (FMI) made real time wave measurements at three locations in the Baltic Sea, in the Central Bothnia Sea (station Bothnian Sea, 61° 48' N, 20° 14' E), in the Northern Baltic Proper (station Northern Baltic Proper, 59° 15' N, 21° 00' E) and in the Gulf of Finland (station Helsinki, 59° 58' N, 25° 14' E). The northern parts of the Baltic Sea freezes 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 five 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 Southern Baltic Proper (station Southern Baltic, 55° 55' N, 18° 47' E and 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 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 2011 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 7 and 8 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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