Wave climate in the Baltic Sea 2020

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Key message

For all the stations where measurements were available, the beginning of the year was clearly rougher than usual due to the mild and windy winter. July was also rougher than usual in all stations that were in operation. New monthly maxima were recorded at some of the stations, but the yearly maxima remained under long term values.

Results and assessment

In 2020 waves were measured in 11 locations in the Baltic Sea and Skagerrak (Figure 1) using buoys or a directional radar gauge. These measurement systems provide real time information of the sea state 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.

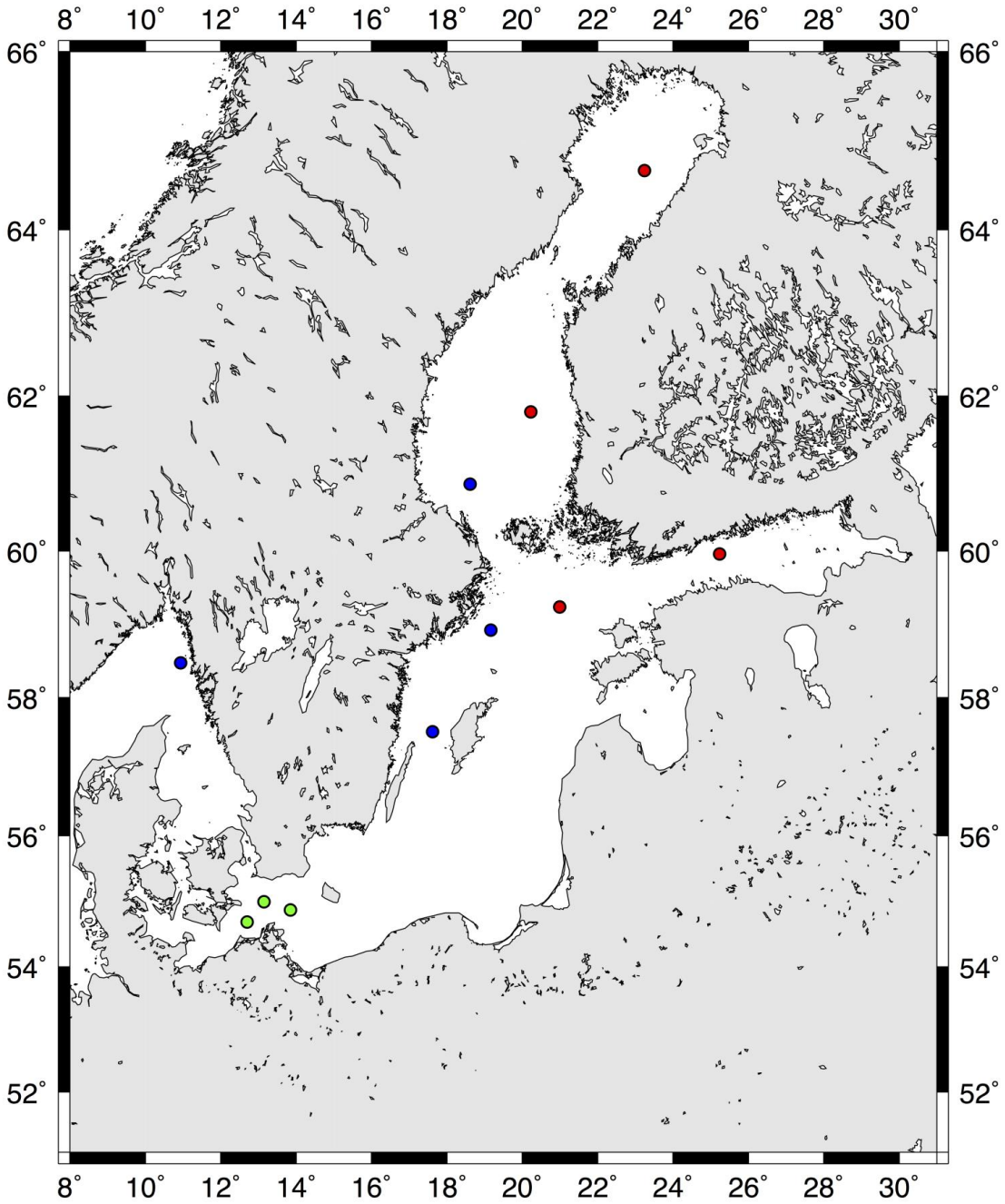

Figure 1. The positions of the wave monitoring stations in 2020. Red dots indicate FMI buoys in the Bay of Bothnia, in the Bothnian Sea, in the Northern Baltic Proper and in the Gulf of Finland (station Helsinki), blue dots SMHI buoys in the Southern Bothnian Sea (station Finngrundet), in the Baltic Proper (stations Huvudskär Ost and Knolls Grund) and in Skagerrak (station Väderöarna) and green dots the BSH stations in the Western Baltic Proper: Fino 2 (buoy until September 2020, then a directional radar gauge), off Cape Arkona and on the Darss Sill (buoys). See section Metadata for the exact coordinates of the locations.

The Gulf of Bothnia

The Bay of Bothnia

The wave buoy in the Bay of Bothnia was operational from 6 June to the end of the year 2020.

At the buoy location, the mean significant wave height during summer months remained close to the long-term mean values. From September to December rougher-than-average months alternated with slightly calmer-than-average months and the roughest month of the measurement period was November with a mean significant wave height of 1.5 m. The monthly maxima followed the same pattern than the mean significant wave height: the highest significant wave heights for the measuring period were 4.3 m on 16 September and 4.2 m on 2 November.

The Central Bothnian Sea

The wave buoy in the Central Bothnian Sea was operational throughout the year 2020.

The first months of the year 2020 were clearly rougher than usual and the highest mean significant wave height for the year was measured in January, 1.6 m, although the significant wave height did not reach new record heights. May and June were typical for the season, and from July to the end of the year, the rougher months alternated with months that were slightly calmer than usual. New records for monthly maxima were observed 24 July (3.2 m) and 17 September (5.5 m). The latter was also the highest measured significant wave height at this location in 2020.

The Southern Bothnian Sea, station Finngrundet

The wave buoy at station Finngrundet was operational for almost the entire year 2020, except for a few short breaks in December.

The mild and windy winter 2020 gave slightly higher mean significant wave heights than usual during January to April. But due to a short fetch of the dominating southwesterly winds, no new record heights were measured. From May through December the mean significant wave heights were mostly near the normal, but with lower than the normal values in June and in August. The highest mean significant wave heights at this station were measured in February and in December with 1.2 m.

The highest significant wave height for single occasions were several times 3.7 m (22 February, 17 September and 25 December), but this is far from the overall record high of 6.4 m from January 2019 and November 2006. A second highest significant wave height for April was measured on 3 April (3.4 m).

The Gulf of Finland

The middle parts of the Gulf of Finland, station Helsinki

Winter 2019-2020 was so mild that the wave buoy in the Gulf of Finland could be kept deployed the whole year, the first time since the measurements started at this location.

The wave conditions at this station followed the pattern observed in other stations around the Finnish coast: at least January and April were rougher than usual, and from June to December the slightly calmer months alternated with the rougher months. The highest monthly mean significant wave height was observed in February, 1.5 m. The highest significant wave height at this station was observed on 3 January, 4.0 m. In February and March, during the period when the area is usually ice covered, the highest significant wave heights were 4.0 m (18 February) and 3.3. m (15 March). From May to December, the monthly maxima remained clearly below the long-term maxima, 1.6 m (June) – 3.6 m (November).

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 2020.

Similarly to the conditions in the Gulf of Finland and the Bothnian Sea, the monthly mean significant wave heights in the Northern Baltic Proper were clearly higher than in the average during the first four months of the year. From June to December the same pattern with alternating slightly calmer and rougher months was observed. The highest monthly mean significant wave height was observed in February, it was as high as 2.4 m. July was also rough for the season, 1.1 m. In the rough February, a monthly record in significant wave height was recorded: the significant wave height reached 7.6 m during a southern storm, Ciara, on 10 February. This was also the highest value measured in 2020 and the third highest observed value at this station. The high significant wave heights were also observed in January (5.3 m), February (6.7 m), March (5.4 m), April (5.0 m), November (6.2 m) and December (5.6 m).

The wave buoy at station Huvudskär Ost was only partly working in January and February 2020, then out of operation until 8 May. For the rest of the year the station was fully operational until 8 December.

Despite the low availability in January and February a new maximum significant wave height for February was observed on 9 February (4.3 m), in the beginning of the storm Ciara, just before the station got out of order. Most likely the significant wave heights increased further, later that day. Another event with high significant wave height was on 6 June (3.6 m), when the second ever highest record for the month of June was observed. On 21 November the highest significant wave height for this year (4.9 m) was noted as an intense low was passing northeast. The ever highest significant wave high for this station is also recorded in November, but in the year 2007 with 5.7 m.

The monthly averages of significant wave height from May to November was variating with above the normal in May, July and November, and below the normal in June and August. For the months January to April and December, no mean values are calculated due to lack of data.

Central Baltic Proper, station Knolls Grund

The wave buoy at station Knolls Grund was operational entire 2020, with only some minor gaps in the measurements. Lowest availability was 97 percent in December.

As was the case with the stations further north, the winter months were rougher than normal and new records in mean significant wave heights were noted for both February (1.6 m) and March (1.2 m). In December the mean significant wave height was the same (1.5 m) as the old record from 2011 and 2013. During the months April to November the mean significant wave heights varied around the normal, with above the normal especially in July and below the normal in June and August.

Since the station is rather young, starting in November 2011, there were a lot of new monthly maximum records in significant wave height. On 10 February, 5.6 m was recorded, in connection with the storm Ciara, which is the third ever highest notation for this station. Highest ever record is 6.0 m on 6 January 2018. Other months with new record highs were March (4.1 m), June (3.3 m) and December (4.8 m). In April the second highest maximum significant wave height for the month, was noted with 3.4 m.

Western Baltic Proper, stations Darss Sill, Arkona and Fino 2

In 2020, the three stations in the western Baltic Sea unfortunately recorded relatively little data. After its breakdown at the end of November 2019, the Arkona buoy only measured again from May (but then continuously for the rest of the year). The Darss buoy, on the other hand, which has actually measured reliably every year so far, broke down from April onwards, so that data is only available for the first three months of the year. As in previous years, the buoy at Fino 2 recorded data only very occasionally. Data from the buoy are only available for the months of July to September. After an additional radar gauge was installed on the platform at the end of October, the buoy was immediately out of action again, so that only a few days of comparative measurements from the buoy and radar gauge are available. The radar gauge, which has been successfully used at some locations in the North Sea after longer comparison periods, has measured data very reliably since its installation, so that there is hope of obtaining a more complete measurement series for the Fino 2 station in the future.

The existing data in the western Baltic Sea indicate an average year in terms of wave heights in 2020. While February (based only on data from the Darss Buoy) and July were somewhat rougher than the long-term mean, August and December were somewhat calmer. The remaining months (with the exception of April, in which unfortunately no buoy measured data) were very much in line with the long-term means.

The highest significant wave height measured in the Western Baltic Proper in 2020 was just under 4.1 metres at Arkona station on 14 October, whereby this value was significantly below the long-term maximum. Nevertheless, there was a record value in 2020: On 27 December, 3.7 metres were measured at Fino 2, which means a new December record for Fino 2. However, the data availability at this station is still very sparse, so that one can certainly not speak of an exceptionally high value here. During this event, 3.3 metres were measured at Arkona - a value that is almost 2 metres below the long-term December maximum.

In conclusion, it can be said that no exceptional or significant event was recorded by the measuring stations in the Western Baltic Proper in 2020.

Skagerrak

Skagerrak, station Väderöarna

The wave buoy at station Väderöarna was operational almost the entire 2020. Only some minor data gaps occurred with a lowest availability in December with 92 percent.

The position in Skagerrak made the station exposed to the frequent low activity in the beginning of the year, and like in the northern parts of the Baltic Sea, the conditions were rougher than normal from January to May. The highest mean significant wave height was observed in January with 2.1 m and in February with 2.3 m, which is the highest monthly mean for February, since the station started. During the summer, the mean significant wave height was lower than the normal in June (0.6 m) and August (0.7 m), but in July higher than the normal (1.3 m). Through the autumn the conditions alternated, with above the normal in September (1.4 m) and November (1.7 m), and below the normal in October and December (1.1 m).

The maximum record in significant wave height was beaten for some of the winter months. In February 7.1 m on 23 February, which also was the highest observation for the entire year. In April 5.2 m was observed on 2 April. The second ever highest notation for the month of July was recorded on 5 July (5.4 m). The highest ever record for this station is 8.5 m on 21 September 2018.

Data

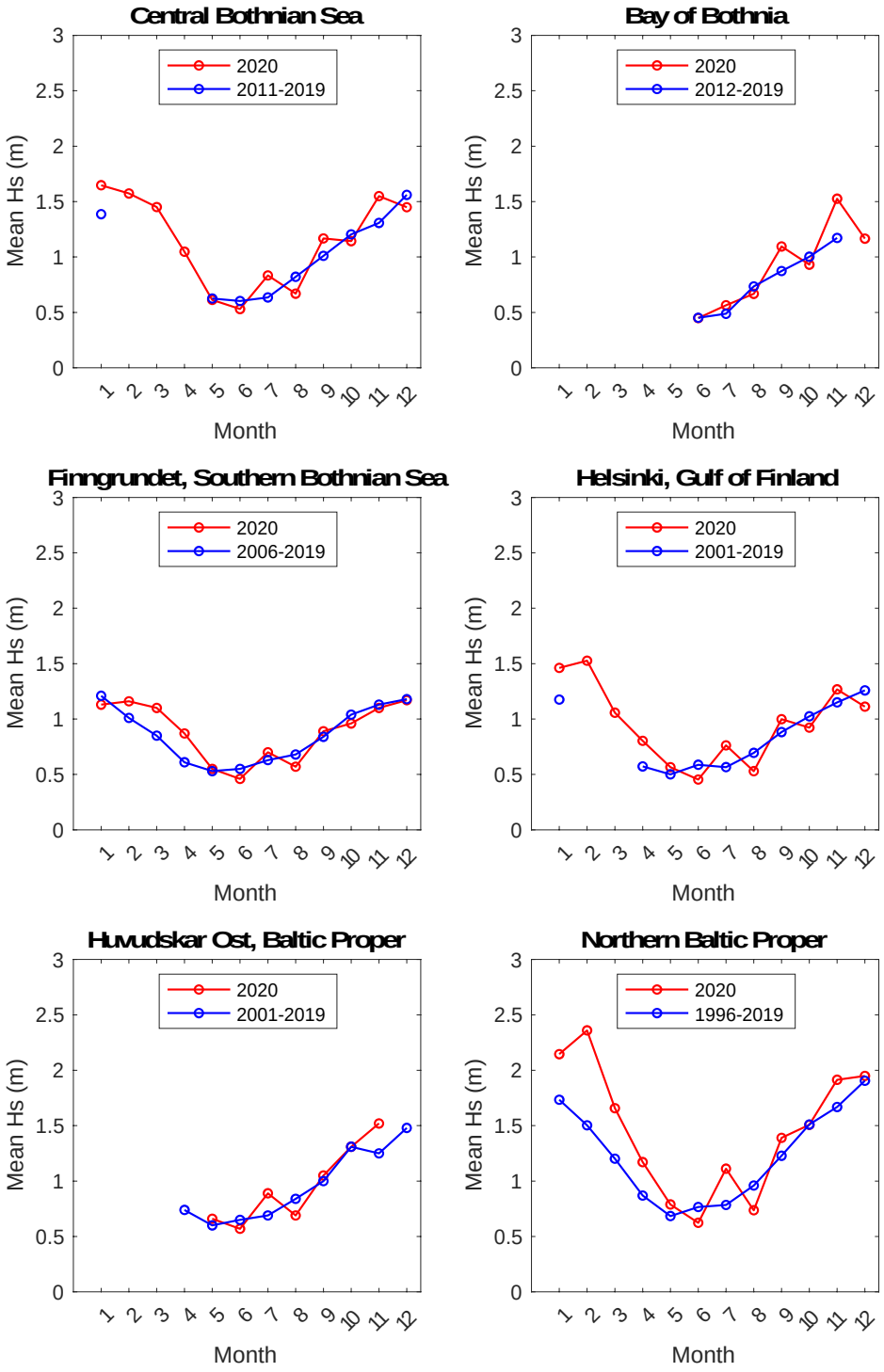

Figure 2. The monthly means of significant wave heights in the Bothnian Sea, the Gulf of Finland and the Northern and Central Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

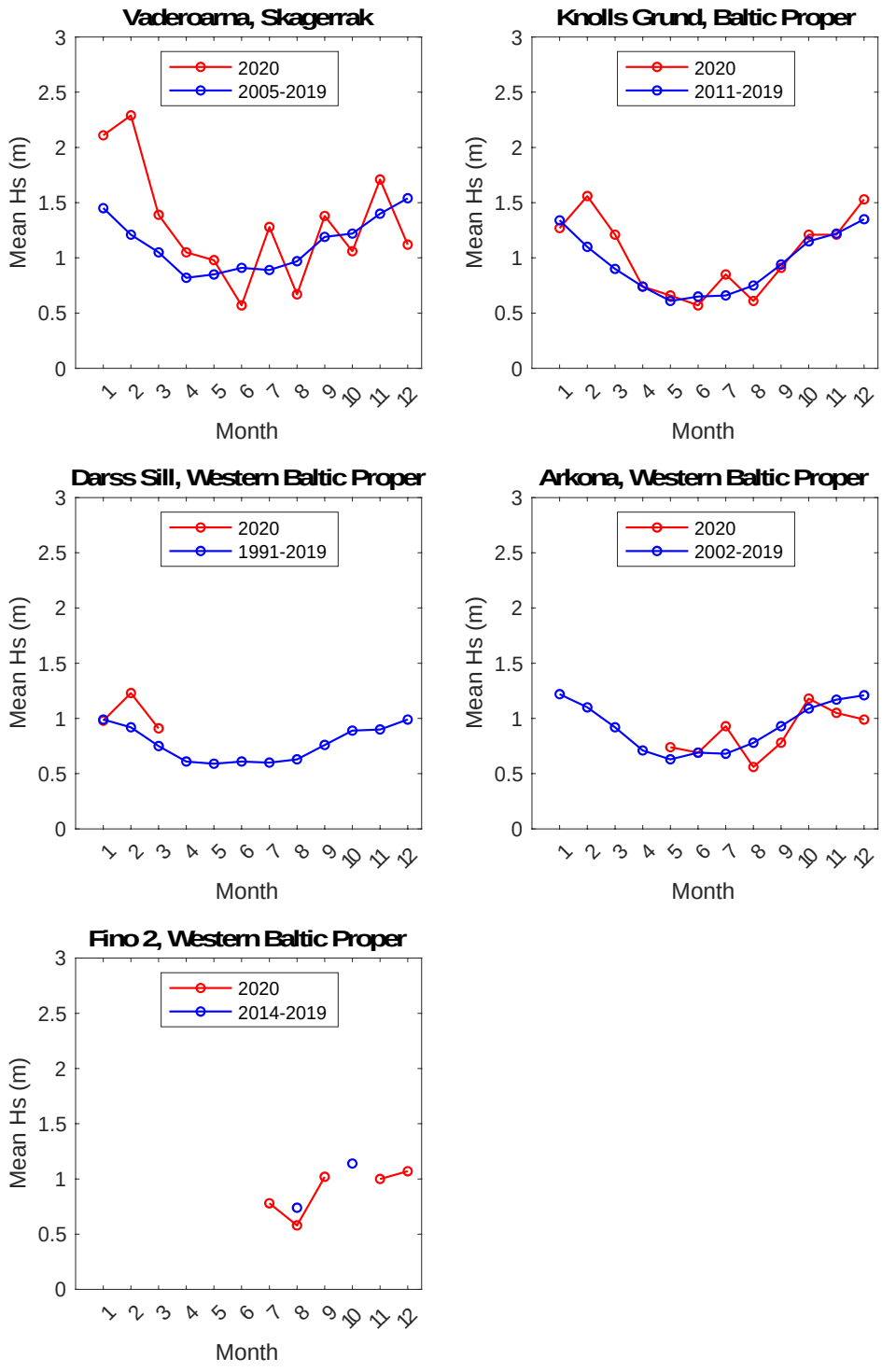

Figure 3. The monthly means of significant wave heights in Skagerrak, Central and Western Baltic Proper. In some months the long-term statistics are calculated over fewer years (but at least over four years) than indicated in the legend.

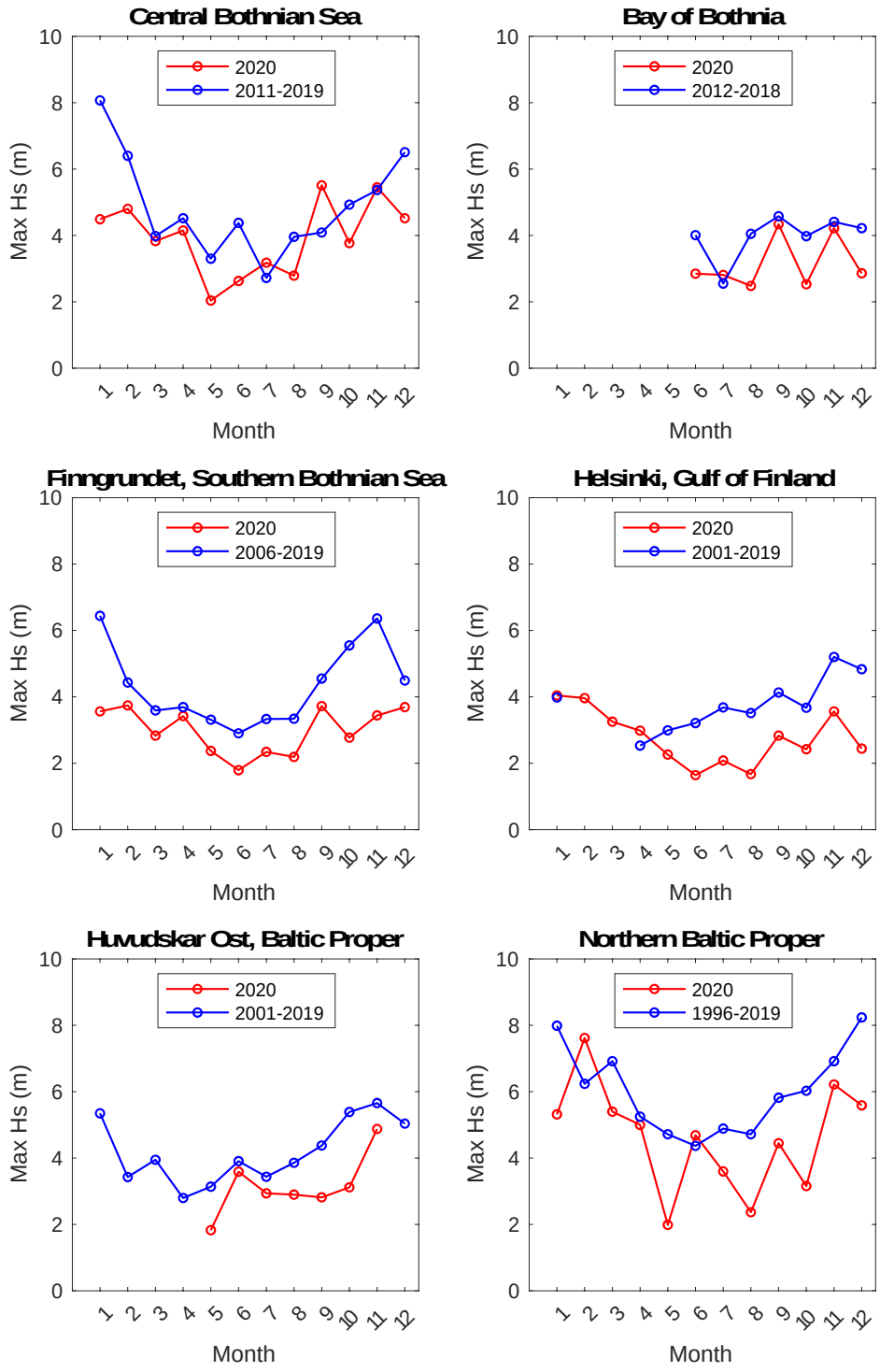

Figure 4. The monthly maxima of significant wave heights in the Gulf of Bothnia, the Gulf of Finland and the Northern Baltic Proper. Data gaps occur in some of the months.

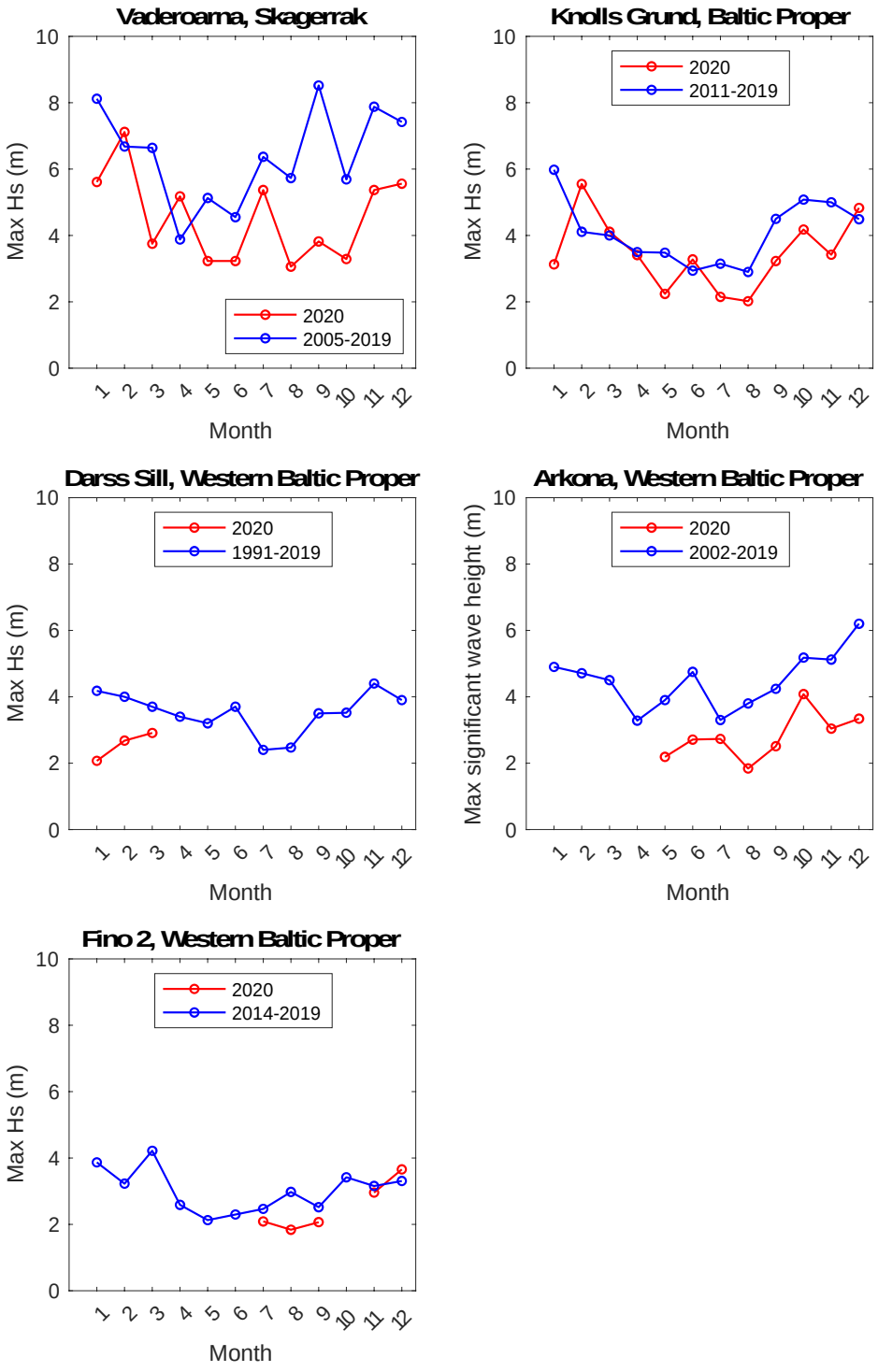

Figure 5. The monthly maxima of significant wave heights in Skagerrak, the Central and the Western Baltic Proper. Data gaps occur in some of the months.

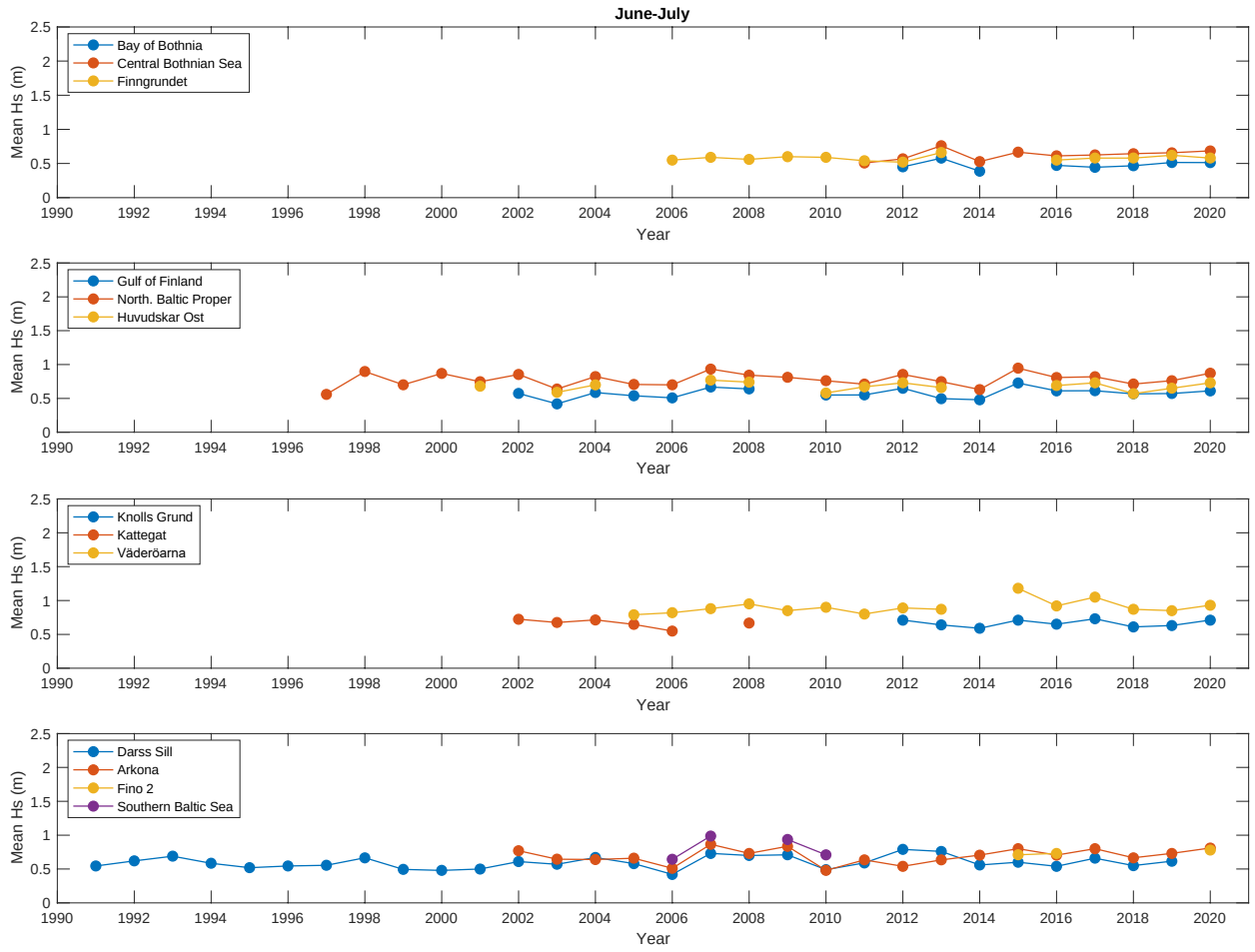

Figure 6. The yearly variation of the mean significant wave height Hs in the period of June-July. In some years the data do not fully cover the whole period.

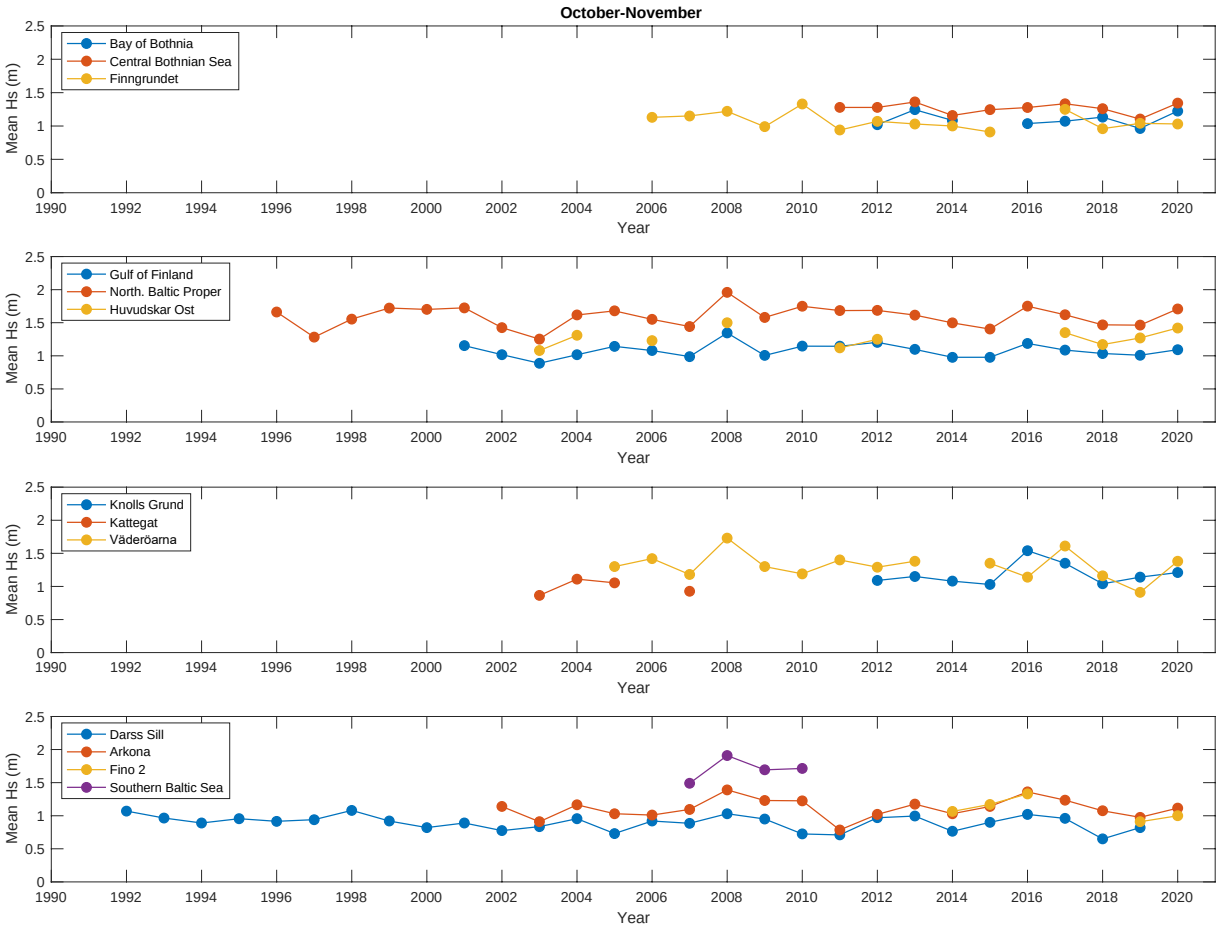

Figure 7. The yearly variation of the mean significant wave height Hs in the period of October-November. In some years the data do not fully cover the whole period. Especially at station Huvudskär Ost, the gaps in the data in years 2011 and 2012 might have left the mean value lower than it should be.

Metadata

In 2020 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. Until November 26 2019 the Helmholtz-Zentrum Hereon was the operator of this buoy. Since November 26, 2019 the buoy is operated by the Federal Maritime and Hydrographic Agency of Germany (BSH). Beyond that, the BSH has performed measurements at a station northwest of Cape Arkona (54° 52.9‘N, 13° 51.5‘E) since 2002 and at the Fino 2 research platform located at 55° 00.5‘N, 13° 09.3‘E since 2014. For the latter position, mostly no long-term climatological wave data are available so far, as the buoy has been torn down very often. Finally, in October 2020, the classic wave buoy was replaced by a directional radar gauge. 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 except for Fino 2 are measured with surface following buoys, Seawatch, Watchmate (at Huvudskär Ost), Directional Waveriders, and Waveriders. Buoy measurements were collected 0.5 - 1 hour via Iridium, HF link, Argos-satellite, Orbcomm system and dataloggers with significant wave height calculated as H_{m0} on board the buoys over 1600 s or 1800 s time series of surface displacement. At Fino 2, the waves are measured by a radar gauge, which calculates H_{m0} every minute over the last 1200s time series of surface displacement. For the calculation of the statistics used in this report, values were taken every 20 minutes, so that each measured value of the surface displacement is reflected in exactly one value of significant wave height. The quality of the measurements was 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 2020 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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