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Sea Level Variability in the Swedish Exclusive Economic Zone and adjacent seawaters: Influence on a Point Absorbing Wave Energy Converter

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Abstract. Low-frequency sea level variability can be a critical factor for several wave energy converter (WEC) systems, for instance linear systems with at a limited stroke length. Consequently, when investigating suitable areas for deployment of those WEC systems, sea level variability should be taken into account. In order to facilitate wave energy developers in finding the most suitable areas for wave energy park installations, this paper describes a study that gives them an additional tool by exploring the annual and monthly variability of the sea level in the Baltic Sea and adjacent seawaters, with focus on the Swedish Exclusive Economic Zone. Over 10 years of reanalysis data from the Copernicus project have been used to conduct this investigation. The results are presented by means of maps showing the maximum range and the standard deviation of the sea level with a horizontal spatial resolution of about 1 km. A case study illustrates how the results can be used by the WEC developers to limit the energy absorption loss of their devices due to sea level variation. Depending on the WEC technology one wants to examine, the results lead to different conclusions. For the Uppsala point absorber L12 and the sea state considered in the case study, the most suitable sites where to deploy WEC parks are found in the Gotland Basins and in the Bothnian Sea, where the energy loss due to mean level variations is negligible.

Nomenclature

H_s	Significant wave height
MSL	Mean sea level
MSL_{1h}	Hourly mean sea level
MMSLR	Maximum mean sea level range
$MMSLR_y$	Annual maximum MSL range based on MSL_{1h}
$MMSLR_{10y}$	Decadal maximum MSL range based on MSL_{1h}
$MMSLR_{m,10y}$	Monthly maximum MSL range for each month based on MSL_{1h} averaged over 10 years
SD	Standard deviation
SD_y	Annual standard deviation of MSL_{1h}
SD_{10y}	Decadal standard deviation of MSL_{1h}
$SD_{m,10y}$	Monthly standard deviation of MSL_{1h} for each month, pooled over 10 years

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SDR_{10y}	Standard deviation of the $MMSLR_y$ over 10 years
SEEZ	Swedish Exclusive Economic Zone
SMHI	Swedish Meteorological and Hydrological Institute
SWERM	Swedish wave energy resource mapping
T_e	Energy period

1 Introduction

In the Baltic Sea, the variations of mean sea level (MSL) are controlled by meteorological and climatological processes, including the hydrological balance (Johansson et al., 2001). Tides give a small contribution to these variations, since the Scandinavian basins are characterized by low tidal levels during the year. As suggested by (Ekman, 2009), the Baltic Sea has no real tides, but storm winds could raise the sea level locally by more than 2.4 m. The largest amplitudes reach up to 3 – 4 m as storm surges and seiches in the Gulf of Finland (Kulikov et al., 2014). In general, the tide is a few centimeters high, with peaks of about 24 cm in the Gulf of Finland, as estimated by (Medvedev et al., 2016). In (Samuelsson and Stigebrandt, 1996) the sea level variations are classified as ‘external’ and ‘internal’: respectively, long-term winds transporting water between the Atlantic Ocean and the Baltic Sea, and short-term winds together with changes of density and barometric pressure, redistributing water within the Baltic Sea. Those two types of variability may exhaustively explain the low-frequency MSL changes in the Baltic Sea. Being that those changes are predominantly influenced by air pressure and wind stress, the variability is mostly of random character and seasonal cycles are dominant (Kulikov et al., 2014). According to Hünike et al. (2005) during the summer, temperature and precipitation explain part of the MSL variability except in the Kattegat region. Furthermore, MSL exhibits an annual cycle peaking in the winter months.

MSL variations are of great importance and have been thoroughly investigated by many researchers for example with the purpose of broadening the knowledge on climate change (IPCC, 2018), spatial patterns (Ekman, 1996) (Donner et al., 2012), land uplift (Miettinen et al., 1999), pole tide (Ekman, 1996) (Medvedev et al. 2014) in the Baltic Sea. The reason why the study presented in this paper has been carried out is to give wave energy developers an additional tool to use when looking for suitable sites for their devices. Generically, a wave energy converter (WEC) technology does not by definition have to be influenced by MSL variations: It depends on the design. However, the power production capability of many WEC technologies existing today is affected by changes in MSL. To give an example, let us consider the Uppsala WEC, shown in Fig. 1. The WEC consists of a surface-floating buoy vertically driving an encapsulated linear generator on top of foundation acting as a fixed reference on the sea floor. The tension in the connection line and the distance between the buoy and the sea bed is influenced by low-frequency sea variations: for a significantly low MSL, the connection line is slack and the translator rests on the bottom of the generator; while for a significantly high MSL, the translator continuously hits the upper end-stop, which results in additional stresses on the hull of the generator and in a reduced stroke of the translator itself. In both cases, the energy absorption decreases drastically, together with the lifetime and survivability of the WEC (Castellucci et al., 2016). The same problem is experienced by other technologies, such as oscillating water columns, as suggested in Muetze and Vining (2006) and Lopez et al. (2015), and in more general terms by WECs which have a part that is fixed in position relative to the seabed and a part that moves with the waves. Well-known point absorbers, such as Carnergie CETO (Kenny, 2014), Ocean Power Technologies Powerbuoy (OPT, 2018), and Archimedes Wave Swing (Beirdol et al., 2007) are challenged by MSL changes, either because of a limited stroke length or because of the exponential decrease in available energy with depth.

The work presented in this paper is part of a bigger wave energy project on Swedish wave energy resource mapping (SWERM) financed by the Swedish Energy Agency (Strömstedt et al., 2017). The project aims to generate and combine different layers of information, like bathymetry, sea ice coverage, wave climate, wave energy conversion potential, etc., for the Swedish Exclusive Economic Zone (SEEZ) in order to identify the most suitable areas for wave energy conversion. This paper presents the results for the MSL variations over a larger area, that includes the SEEZ and adjacent seawaters (see Fig. 2). The input data and the methodology are discussed in Chapter 2. The results shown in Chapter 3 by means of maps, which will be available on-line or on request, so that detailed data can be extracted. Finally, discussion and conclusion are presented in Chapters 4 and 5.

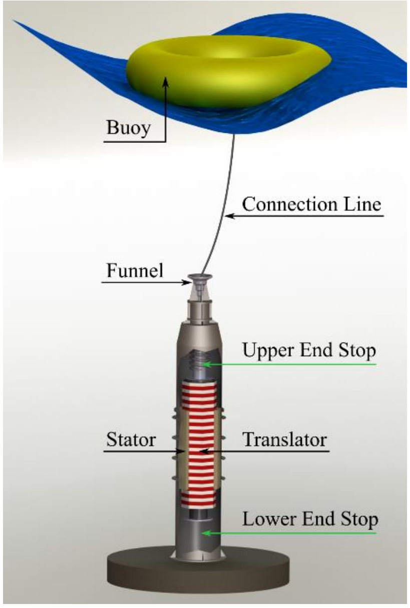

Figure 1: Illustration of the point absorber WEC developed at Uppsala University.

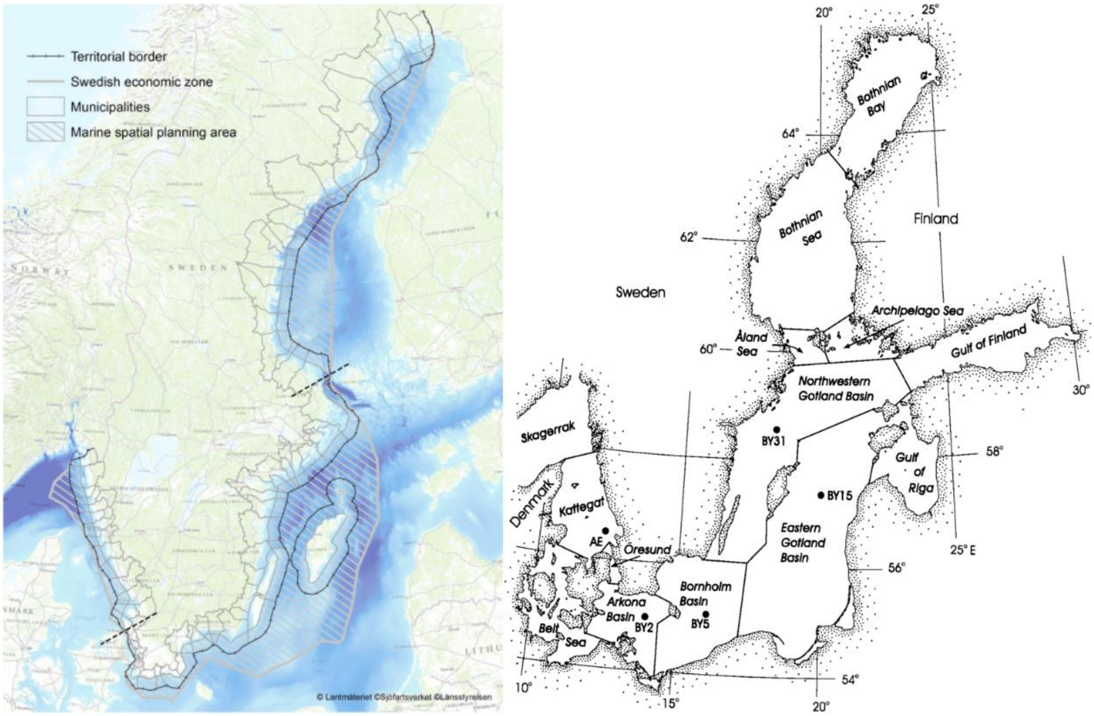

Figure 2: Left) Map of the SEEZ around Sweden in focus for this study. Right) Map of the considered water basins. The same basin terminology is used throughout the article. Credits to HELCOM (2018).

2 Data and methods

In order to produce comprehensive maps of sea surface height in the Baltic Sea as a whole, it is necessary to interpolate the available data over space and time. However, measurement stations are located far from each other, even more than 100 km, and some are visited only once a month. Some may lack observations for very long time periods. In order to compensate for those deficiencies, observations are combined with model simulations to obtain a homogeneous data set with high resolution in time and space, and reasonably close to observations. This can be achieved with a process called data assimilation, in which observations are used to update the circulation model to keep it from deviating too far away from reality (Axell and Liu, 2016). The circulation model used by the Swedish Meteorological and Hydrological Institute (SMHI) to produce the reanalysis data used in this study is HIROMB (High-Resolution Operational Model for the Baltic). MSL is extracted from a coarse storm-surge model, NOAMOD (North Atlantic Model), with 44 km grid resolution. Climatological monthly mean values of salinity and temperature are used at the boundary, i.e. at the western English Channel and along the Scotland-Norway boundary.

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Moreover, ice variables are assumed to be zero. The meteorological forcing is from the HIRLAM (High-Resolution Limited Area Model), with a resolution of 22 to 11 km. The chosen data assimilation method is the 3DEnVar (3-D Ensamble Variational) data assimilation, a multivariate method where many variables are affected by each observation. For more information regarding the model description see (Axell and Liu, 2016) and the product documentation (Copernicus, 2018). In general, the results obtained for MSL in the SEEZ and the adjacent seawaters are rather good: mean correlations of about 0.91 and mean RMS errors of about 9 cm are calculated by comparing hourly instantaneous model data with corresponding coastal observations for three different years. The MSL data available on-line at *marine.copernicus.eu* have a spatial resolution of 1/20 degrees in the north-south direction and 1/12 degrees in the east-west direction, which translates into about 5.5 km resolution. The requirement set by the SWERM project is to work on a common grid of about 1 km^2, hence, the reanalysis data have been linearly interpolated with the purpose of fitting this grid. Moreover, a 10-year data set (2007 to 2016) with a temporal resolution of one hour have been chosen in order to examine the annual and monthly variability of the MSL_{1h} oscillations, neglecting extreme events.

The metrics considered relevant to this study are the maximum range and the standard deviation of the seal level variations. The range, calculated as the highest MSL and lowest MSL during the selected time period, gives an indication of the maximum variation of MSL. Some WEC technologies may be unaffected by variations below a certain range, like the Uppsala WEC in mild wave climates, as discussed in Chapter 4. Furthermore, the highest absorption loss for a device can be estimated by WEC developers as presented in the case study in Chapter 3, and mitigation measures can be adopted. The standard deviation (SD), calculated as the square root of the variance for the chosen data set, quantifies the dispersion of the data from their mean value. The higher the SD, the more spread out the data points are from the expected value, hence, it is a measure of the variability of the MSL variations. When selecting a site for WEC deployment, one may find preferable to choose an area with as constant conditions as possible: the frequency of occurrence of high ranges is greater for higher values of SD and the design costs for a WEC may increase with it. In general, the lower the standard deviation, the better it is. Moreover, both metrics, range and SD, are independent of the choice of reference level, which for sea level is not always self-evident (Johansson et al., 2001). In fact, the data set provided by Copernicus have a zero mean value at the outer boundary, in the Atlantic. In the Baltic Sea, the MSL is higher due to the density difference between the Atlantic Ocean and the Baltic Sea.

The MSL range is calculated as the difference between the absolute maximum and minimum values over the 10-year data set, $MMSLR_{10y}$, and over 10 years per each month, $MMSLR_{m,10y}$. The SD has been obtained as the average of annual SDs over the 10-year data set, SDR_{10y}, and as the square root of the pooled variance to aggregate monthly SD over 10 years, $SDR_{m,10y}$. Finally, a case study is presented in order to give an idea of how the results can be used by wave energy developers. The Uppsala WEC technology is considered. In particular the energy absorption of an L12 generator is simulated by hydrodynamic modeling. The following features are assumed: a cylindrical buoy of radius 3 m and draft 0.6 m; a translator stroke length of about 2.5 m; a total weight of the moving parts but the buoy of 10 tonnes; a damping factor of about 135 kNs/m. For more details regarding the model and its limitations see (Castellucci et al., 2016). For the mere purpose of providing an example of WEC energy absorption at different MSLs, a sea state characterized by a significant wave height $H_s = 1$ m and energy period

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T_e = 5 s is used as input to the model. These values are considered to be a reasonable approximation of the wave climate in the Baltic Sea (Soomere et al., 2007) (Soomere et al., 2011) (I. Zaitseva, 2013).

3 Results

The results for MSL range and SD are summarized in Sect. 3.1.1 and 3.1.2 respectively. The energy absorption as a function of the MSL for an Uppsala WEC is estimated for a specific sea state and presented in Sect. 3.2.

3.1 Sea level metrics

3.1.1 Range

The MMSLR variations during the years 2007 to 2016 has been calculated from the interpolated reanalysis data sets. Fig. 3 shows the highest monthly ranges over the 10-year period ($MMSLR_{m,10y}$) in the Scandinavian basins. Fig. 4 shows, on the left, the average of the annual maximum ranges ($MMSLR_y$) and, on the right, the absolut maximum range over 10 years ($MMSLR_{10y}$). The variability of $MMSLR_y$, estimated as the standard deviation of the $MMSLR_y$ over 10 years (SDR_{10y}), has a minimum value of 0.05 m between the Danish islands and the coast of Germany and a maximum of 0.5 m in the innermost part of the Gulf of Finland. In general, a quite moderate variation (SDR_{10y} < 0.3 m) is calculated along the Swedish coast. The semester from April to September (summer-time) appears to be the one with the lowest ranges compared to the period October to March (winter-time) as shown in Fig. 3. The spatial pattern is clear and almost independent of the time of the year: the greatest oscillations of $MMSLR_{m,10y}$ occur in the Bothnian Bay, the Gulf of Finland, the Kattegat and in the Danish straits. The legend in Fig. 3 is capped at 2 m to better illustrate the variations inside the SEEZ, but the MSL can actually reach 4 m in the eastern parts of the Finnish gulf. The Northwestern Gotland Basin is the most stable area, characterized by $MMSLR_{10y}$ ranges of 1.2 to 1.5 m (see Fig. 4). However, during summer-time the range is likely to be lower than 0.7 m.

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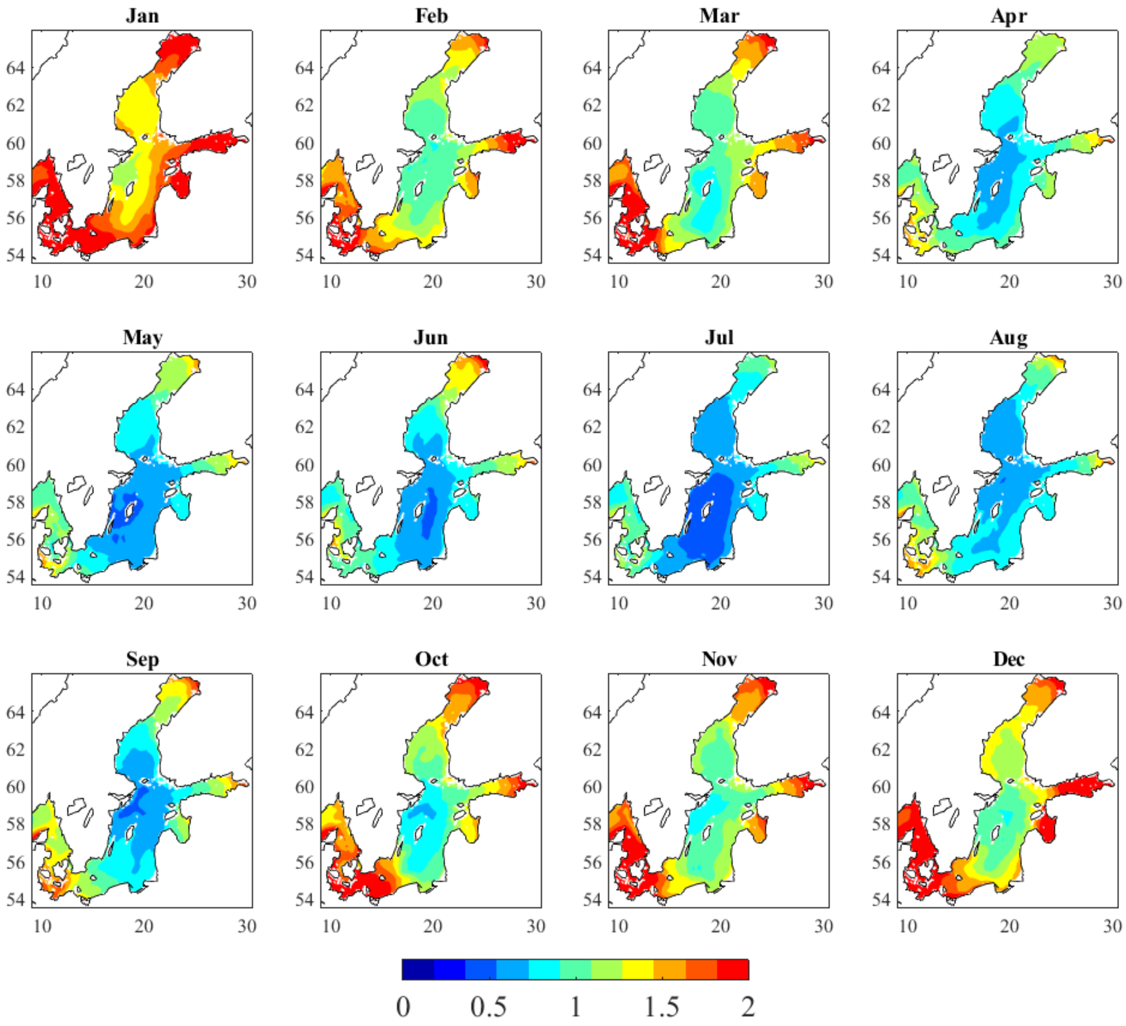

Figure 3: MMSLR$_{m,10y}$ (Monthly maximum ranges [m] for each month over 10 years, 2007-2016, of re-analysis data). The red areas illustrate MMSLRs higher than about 1.8 m, up to 4 m.

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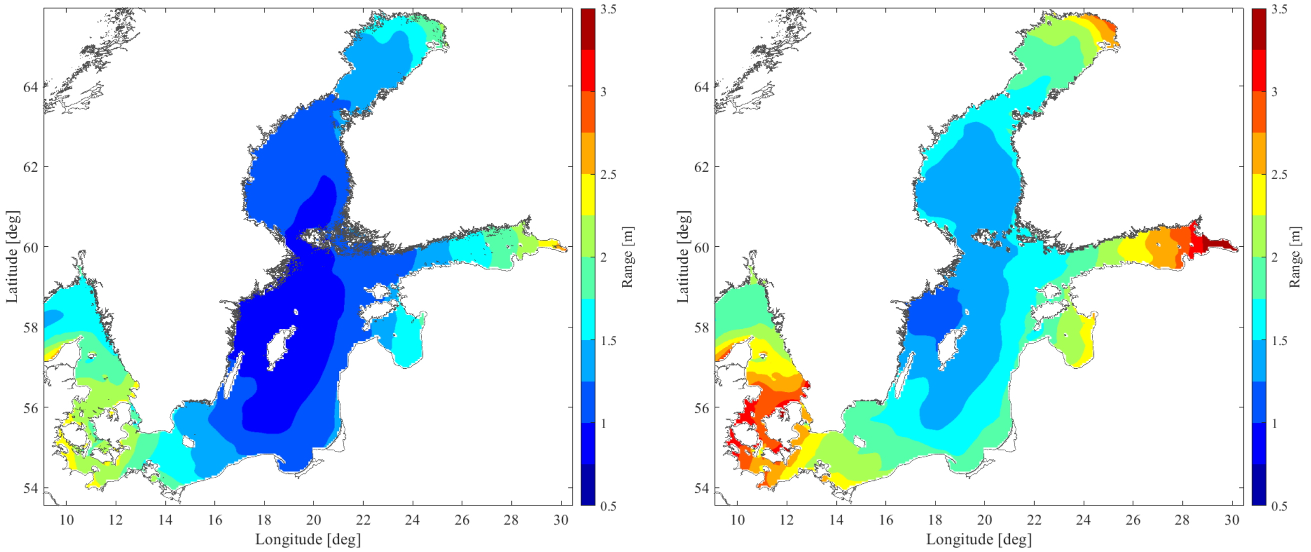

Figure 4: Left) Average MMSLR$_y$ (average annual maximum ranges over the 10-year window). Right) MMSLR$_{10y}$ (decadal maximum ranges over the 10-year window).

3.1.2 Standard deviation

The standard deviation (SD) of the MSL$_{1h}$ has been evaluated in order to have a better understanding of the variability of the data set. The SD of the MSL$_{1h}$ has been calculated for each month and, then, aggregated by month over the 10-year windows by computing a pooled SD (SD$_{m,10y}$). The results are shown in Fig. 5. Afterwards, the monthly SDs have been pooled over each year to obtain the annual pooled SDs. The average of those 10 annual SDs, SD$_{10y}$, is shown in Fig 6.

With reference to Fig. 5, the spatial and temporal patterns are once again clear. In the Gotland Basins the pooled SD$_{m,10y}$ is the lowest, expecially in the summer-time when the SD$_{m,10y}$ values can be as low as 0.05 m (May). The SD$_{m,10y}$ increases as we move out from the center of the Baltic Sea and a peak of 0.4 m is calculated in the Skagerrak, by the northern coast of Danmark, during the month of January. In the same area, the SD$_{10y}$ is found to be 0.32 m, while the lowest SD$_{10y}$, about 0.08 m, is found in the Northwestern Gotland Basin (see Fig. 6). As expected, the variability of the data determined as the average of annual SD, SD$_{10y}$, turns out to have a smaller interval than the pooled monthly SD (SD$_{m,10y}$) used to aggregate monthly SDs over 10 years.

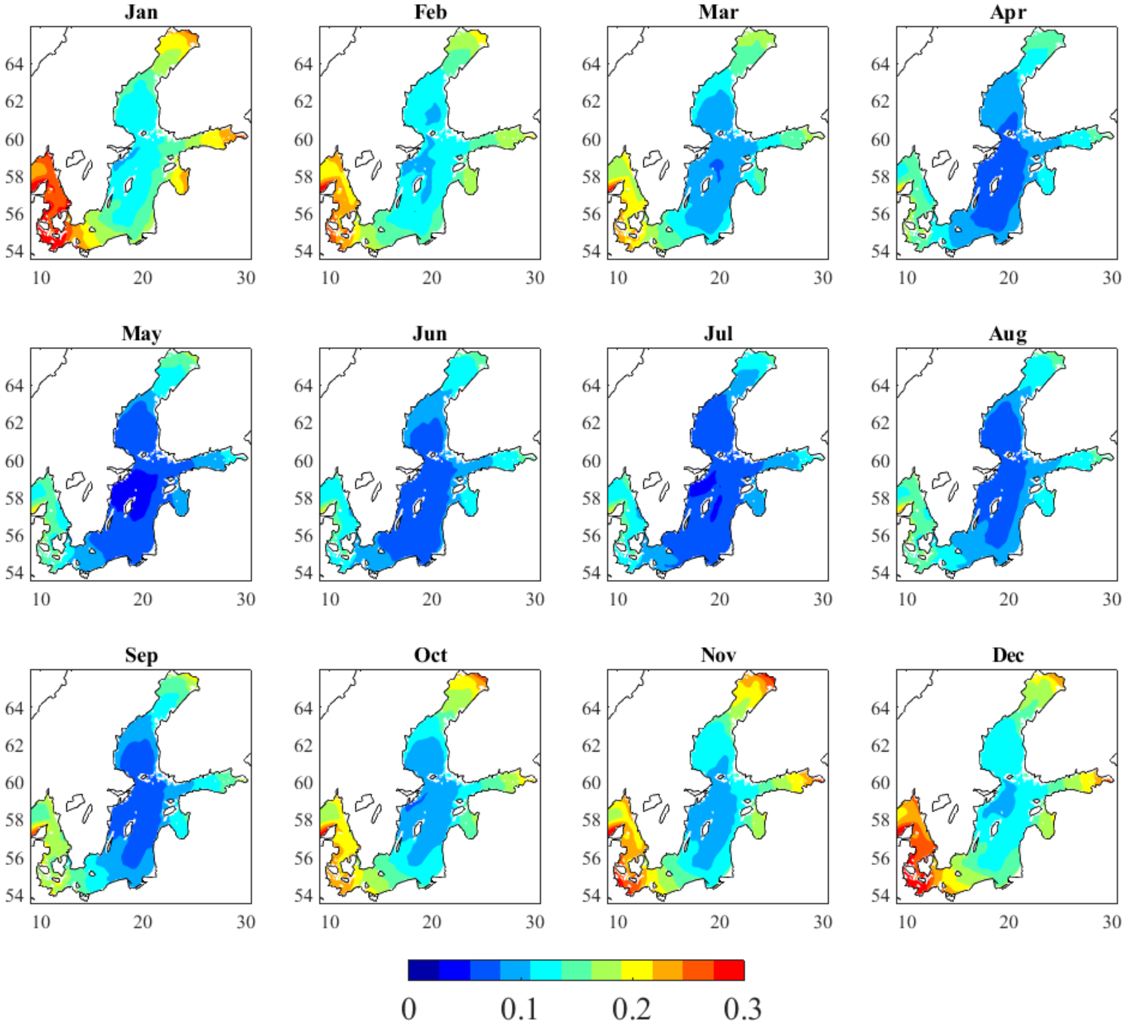

Figure 5: SD$_{m,10y}$ (Monthly SD [m] for each month over 10 years, 2007-2016, of re-analysis data).

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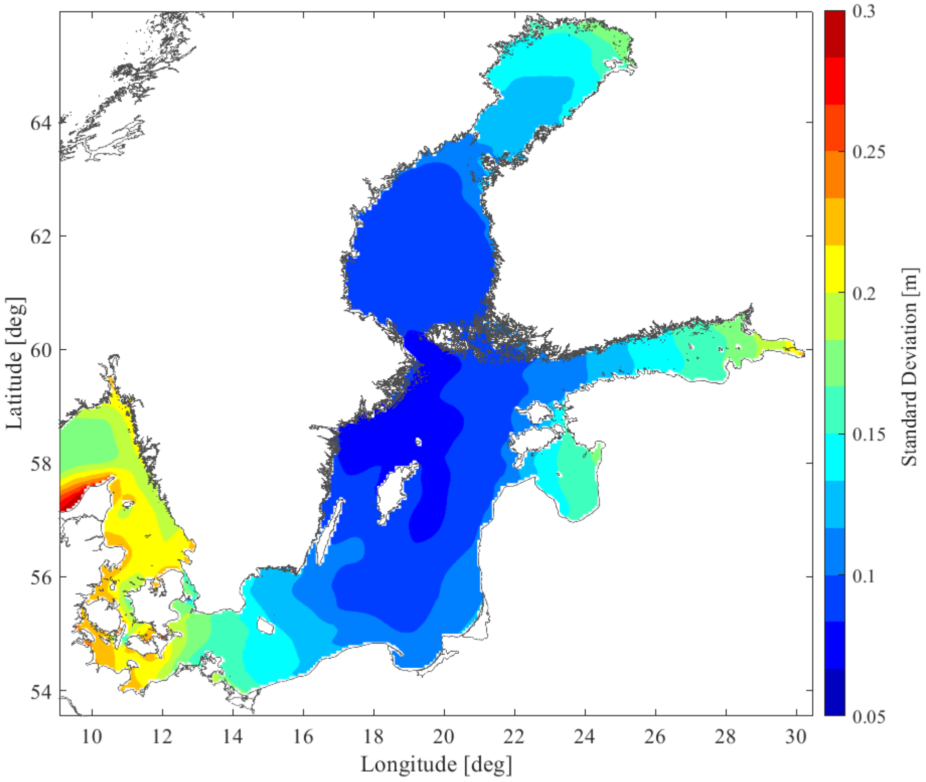

Figure 6: SD$_{10y}$ (SD of the MMSLRy over the 10-year window).

3.2 Case study

In Castellucci et al. (2016) the hydro-mechanic model that analyses the behaviour of the point absorber is described. The output of the model is among others an evaluation of the impact of MSL variations on the power absorption of the WEC as function of different sea states. Note that power is absorbed as long as the translator moves within the stator (see Fig. 1). An example is presented in Fig. 7 with the purpose of pointing out the effect of MSL changes on the performance of the Uppsala WEC denoted L12 (Castellucci et al., 2016). Let's assume that the hypothetical wave energy developer is interested to deploy a wave energy park where the significant wave height is not greater than 1 m. The normalized annual energy absorption for MSL in the range ±0.8 m is close to 100 % and it drops drastically for $|MSL| > 0.8$ m, as illustrated in Fig. 7. When the MSL exceeds the stroke length of the translator, i.e. 2.5 m, then the WEC is not capable of absorbing any power. In fact, when the $MSL > 2.5$ m, the translator is stuck on the upper part of the generator hull and the buoy is submerged; on the contrary, when $MSL < -2.5$ m, the translator is resting on the lower end stop and the connection line to the buoy is slack.

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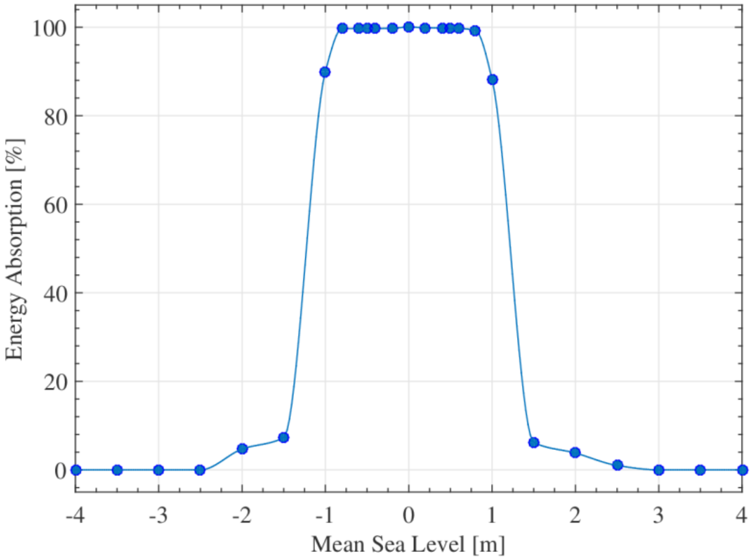

Figure 7: Normalized annual energy absorption as a function of the MSL for a L12 Uppsala WEC and for a sea state characterized by $H_s = 1$ m and $T_e = 5$ s. The markers indicate the results of the hydro-mechanic simulations, while the solid line serves as a guide to the eye.

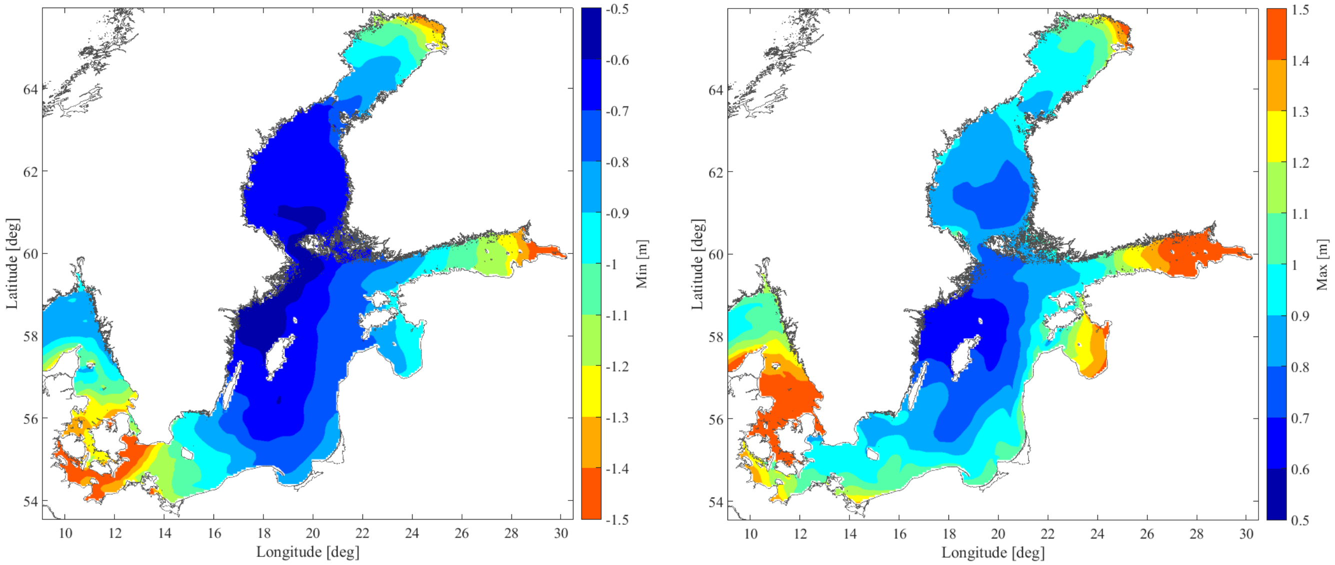

Figure 8: Lowest minima (left) and highest maxima (right) of MSL during the period 2007 to 2016, after subtracting the mean value.

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The validity of the results presented in Fig. 7 are limited to a specific sea state (H_s = 1 m, T_e = 5 s) and mostly dependent on the significant wave height, rather than the energy period (Castellucci et al., 2016). In particular, the plateau shown in Fig. 7 becomes wider with decreasing values of H_s. As a consequence, the energy absorption of WECs deployed in the patches of sea characterized by $H_s \leq 1$ m will be unaffected in the MSL range of ±0.8 m at least. For the technology here considered, the $MMSLR_{10y}$ should be complemented with the minimum and maximum values of MSL: the WEC is not affected if the highest maximum and the lowest minimum do not exceed ±0.8 m at the desired site. The highest maxima and lowest minima in the studied area are shown in Fig. 8. It is interesting to filter out areas with low enough MSL variations to allow 100 % normalized annual wave energy absorption, as described by the case study and Fig. 7, with a typical wave climate for the SEEZ possibly interesting enough for conversion purposes. The H_s for ice-free conditions within the SEEZ is illustrated in Fig. 9.

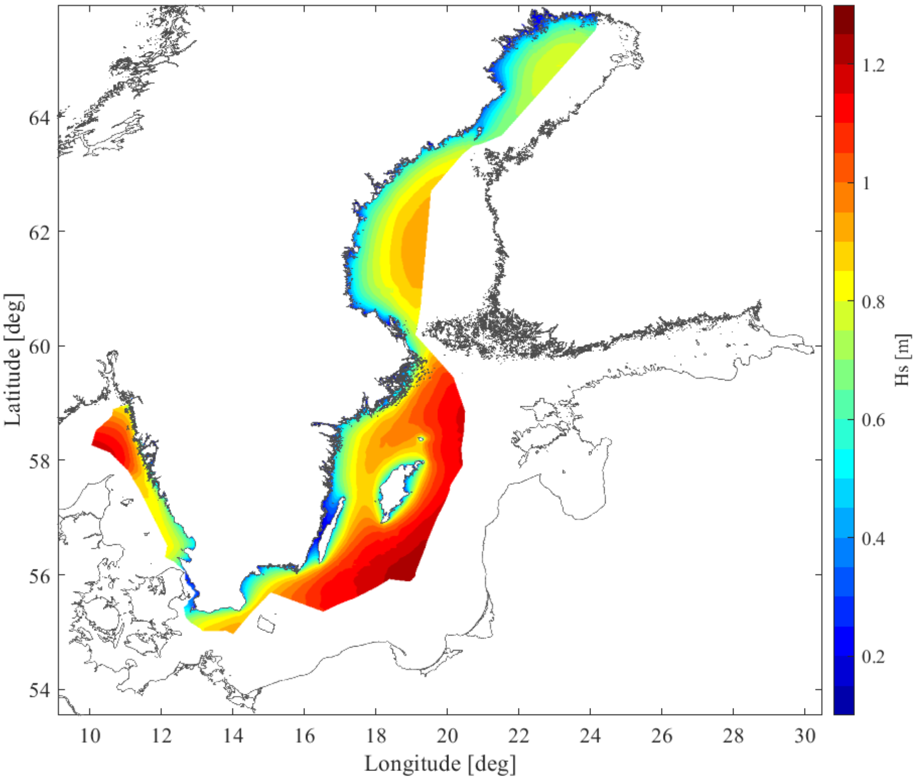

Figure 9. Ice free average significant wave height, H_s, in the SEEZ from a 16 year high-resolution hindcast from the SWERM-project with methods described in (Strömstedt et al., 2017) and (Nilsson et al., 2019).

H_s has been estimated within the SWERM-project (Strömstedt et al., 2017), and methods for modelling are described in Nilsson et al. (2019). In the wave climate modelling ice concentration below 30 % is considered ice-free. Above 30 % ice concentration, the sea is modelled as flat surface and energy is assumed to be completely attenuated by the ice (Tuomi et al., 2011). The percentage of time with ice concentration above 30 %, based on 35 years of ice data from 1980 to 2014, is mapped and presented in (Strömstedt et al., 2017). The difference in annual mean wave power estimates for ice-free conditions and ice-time-included statistics is mapped and presented by Nilsson et al. (2019).

For the purpose of illustrating the most interesting areas with regard to low MSL variations and low negative impact on wave energy absorption the $MMSLR_{10y}$ presented in Fig. 4, is masked using the results in Fig. 8 and 9 as filters. The process of masking the range of MSL with limiting values of maximum (≤ +0.8 m), minimum (≥ -0.8 m) and H_s (≤ 1 m) results in the left image of Fig. 10, which highligths the areas where the WEC energy absorption is unaffected by the changes in MSL, i.e. part of the Northwestern and Eastern Gotland Basins, and a small area in the Bothnian Sea. The right image in Fig. 10 highlights areas where H_s = 0.9 – 1.1 m, corresponding with the H_s that applies to the function in Fig. 7, and where the variations of the MSL are less than ± 0.8 m and thus low enough to always allow a normalized energy absorption of 100 % based on a statistical confidence interval of 95 % defined by two standard deviations ($2SD_{10y}$ < 0.8 m). A hypotetical WEC developer that is willing to pick a site where to deploy a park of Uppsala WECs may be interested to select one of the aforementioned basins with regard to sea level variations.

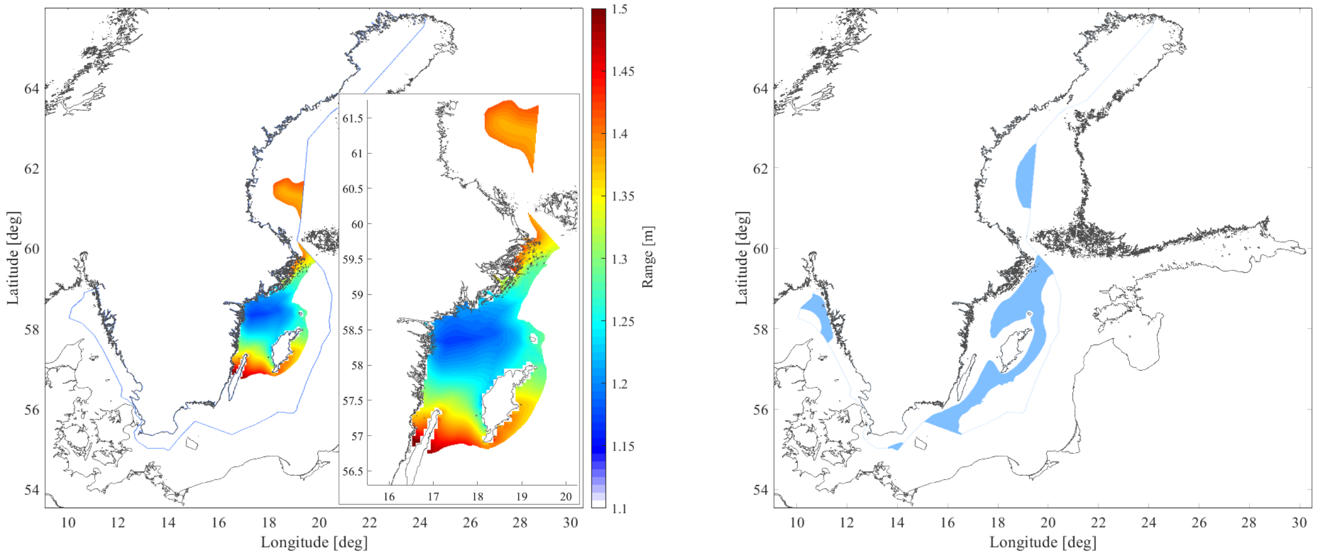

Figure 10: Left) Maximum range ($MMSLR_{10y}$) masked with the limiting values ±0.8 m and significant wave height (≤ 1 m). The blue line indicates the boundary of the SEEZ. Right) The areas where H_s is 0.9 – 1.1 m and where a normalized energy absorption with regard to MSL is 100 % according to Fig. 7 with a confidence interval of 95%.

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4 Discussion

When designing WECs and chosing suitable sites for wave parks deployment one has to consider wave power potential, water depth and seabed profile, distance to shore, accessibility and permissions, ice-concentration, MSL variations, etc. This study, a part of the SWERM project, gives an overview of the MSL variations in the SEEZ and adjacent seawaters by means of the maps presented in Chapter 3.

As discussed among others by Johansson et al. (2001), Ekman (1996) and Stramska et al. (2013) the variability at a specific location shows no apparent trend on a short time scale (10 days to 3 months), while it does on a seasonal time scale, when significantly higher variations in winter- compared to summer-time are observed. Moreover, they argue that the spatial behaviour of the SD is clear on both interannual and seasonal time scales and it follows a specific pattern. These findings are in strong agreement with the results presented in this paper (see Fig. 5 and 6).

The highest decadal ranges presented in Fig. 4 show that the range of oscillations increases as we move out from the Northwestern Gotland Basin (Min value = 1.2 m) to the Bothnian Bay, the Danish straits and the Gulf of Finland (Max value = 4.3 m). The monthly ranges shown in Fig. 3 confirm the same spatial pattern and a not surprising seasonal tendency: the range is lower during summer-time and higher during winter-time, in particular, July is the mildest month and January the one with the highest ranges.

The SD of the MSL_{1h} confirms the same spatial and temporal patterns. Based on the $SD_{m,10y}$ (see Fig. 5), the most pronounced variability appears to occur during the winter-time (Nov-Jan), while the summer-time (May-Jul) is the one with the smallest variability. In general, the values of SD are quite large if compared with the rest of the globe (see (Ducet et al., 2000) Plate 1 and (Thompson et al., 2016) Fig. 3), meaning that the variability of the MSL_{1h} is rather big. With reference to Fig. 6, the lowest SD_{10y} values are found in the Bothnian Sea, Åland and Archipelago Sea, Gotland Basins, characterized by $SD_{10y} \leq 0.1$ m.

Note that a gap in the MSL_{1h} data set has been identified during few days in February 2008 and from the 24/2 to the 10/3 of 2012. This does not influence the results in a drastic way considering that February and March are not the most critical months and that the missing data points are a small percentage (~ 0.5 %) of the total analysed data set. Regarding the peaks of MSL_{1h} that are important when calculating the maximum ranges, the reanalysis model of SMHI tends to underestimate them. However, the correlation between model and observations is 0.91, and the RMS error is 9 cm for the Baltic Sea (Copernicus, 2018). An educated guess by SMHI would be that the underestimation is about 10 %. In general, the model responds correctly to changes in air pressure, winds, tides, and so on.

As mentioned before, low-frequency changes in MSL may compromise the performance of WECs. The case study presented in this paper aims to give an idea of the magnitude of the problem and to provide an example for WEC developers. A specific point absorber, the Uppsala WEC, and a representative annual average significant wave height (H_s) of 1 m are here considered. The first assumption limits the validity of the results for other devices: the energy absorption as function of the MSL variation (Fig. 7) should be carefully simulated or measured case by case. The second assumption reduces the scatter diagram of the sea state occurrences to one average state at an unspecified site: a WEC developer should select the most suitable sites on the basis

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of e.g. the accessibility and the wave power resource, than calculate the energy output for different sea states and aggregate the results in order to narrow down the number of suitable sites.

For the examined case, the areas where the WEC energy absorption is unaffected by the changes in MSL are part of the Gotland Basins and a limited area of the Bothnian Sea, where the $MMSLR_{10y}$ is contained in the interval [1.15 - 1.55] m (see Fig. 10). If a more detailed analysis would be carried out, considering e.g. the full scatter diagram of sea states at each site, then the basins highlighted in Fig. 10 would certainly be different. Moreover, solutions for mitigating the negative effect of MSL variations may be considered, e.g. the stroke length of the Uppsala WEC could be extended by applying changes in the design of the generator, or a compensation system to regulate the length of the connection line could be included in the design of the converter (Castellucci et al., 2016). Integrating a solution into the WEC design would increase the number of sites for wave parks deployment.

Finally, it should be mentioned that according to the wave power technology one wants to investigate, a more detailed analysis of the frequency of occurrence of high ranges at a chosen site could be useful. This choice is dictated by the requirements set by every specific wave energy technology.

5 Conclusions

The dependency of the energy absorption on the MSL variation for wave energy converters is a matter of interest for different WEC technologies. For this reason, the changes in MSL in the SEEZ and adjacent seawaters have been investigated in the frame of the SWERM project. The study carried out in this paper aims to give a deeper understanding of the variability of the MSL in those basins in order to provide an additional tool to WECs developers when choosing suitable sites for wave parks deployment.

From the calculation of the MSL_{1h} standard deviation, it is clear that the variation of the high-frequency oscillations during the latest decade are limited especially in the Bothnian Sea, Åland and Archipelago Sea, Gotland Basins, where $SD_{10y} \leq 0.1$ m. The maximum range of these variations increases as we move out from the Northwestern Gotland Basin to the Bothnian Bay, the Danish straits and the Gulf of Finland. The $MMSLR_{10y}$ varies from the lowest value of 1.2 m (Northwesten Gotland Basin) to the maximum value of 4.3 (Gulf of Finland) during the period 2007-2016. The seasonal variability is evident: it is more pronounced during the winter-time and less during the summer-time. The spatial variability is also noticeable and almost independent of the month: the highest oscillations are found in the Bothnian Bay, the Gulf of Finland, the Kattegat and in the Danish straits, reaching up to 4 m in the Gulf of Finland. More constant conditions are found in the Northwestern Gotland Basin, characterized by $MMSLR_{10y}$ of 1.2 to 1.5 m, with very low range during summer-time (< 0.7 m).

With the purpose of comprehending how the MSL can affect a point absorber WEC, an example has been shown. An Uppsala WEC with specified features has been considered and the energy absorption as function of the MSL has been evaluated,

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assuming a wave climate of relevance for wave energy conversion with a high rate of occurrency in the SEEZ and adjacent seawaters. From a $MMSLR_{10y}$-point-of-view, areas suitable for deployment are found in the Bothnian Sea, Northwestern and Eastern Gotland Basins, where the 10-year maximum range is contained in the interval [1.15 – 1.55] m.

The data sets here displayed by means of geographic maps are available on-line or on request, and can be used by WEC developers to perform analysis according to the technology and models they work with. Moreover, the data will be used to complete the SWERM project that intends to merge different layers of ocean data for the SEEZ.

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