Response to referee 1 (referee remarks are given in Italics)

1) The title, introduction and conclusion give quite a lot the focus on NPP. This focus is not that much supported by the methods, results and discussions parts, except for the thermal pollution / waste heat. Most of the study comprises investigation and modelling of local oceanographic conditions in a defined region. Why the defined region is selected (is there a plan for NPP, paper mill, airport or other installation), does not influence the content and results of this type of study. There is only one paper cited with direct NPP relevance (von Hippel, 2010). Other citations refer to observational data obtained for the EIA procedure, or preliminary modelling results of the same EIA. All the other citations are from oceanography. I suggest condensing of the NPP-related wording.

We have reformulated the title in order to better reflect the content of this study and have rewritten the introduction (p.1, line 20 - p.2, line 27 in the original text) to take into account the NPP-related studies.

New title:

Assessment of extreme hydrological conditions in the Bothnian Bay, Baltic Sea and the impact of the nuclear power plant "Hanhikivi-1" on local thermal regime

New introduction:

In recent decades the use of nuclear energy has been extending to a large scale. New nuclear power plants (NPPs) are designed and constructed, including those situated on the shores of the seas and oceans, which provides free access to water needed for cooling processes as discussed in (Rubbelke & Vogele, 2010). However, during the construction of this kind of objects it is absolutely necessary to carry out a preliminary examination, including the assessment of risks associated with extreme natural conditions that may lead to technogenic disasters, as recently happened at the Japanese NPP in Fukushima, damaged during the earthquake and the subsequent tsunami (see Acton & Hibbs, 2012; Buesseler et al., 2011; Srinivasan & Gopi Rethinaraj, 2013). There exists a twofold oppositely directed influence: 1) NPPs are affected by the environment, 2) NPPs have impact on the environment with possible negative effects manifested, in particular, in the release of warm cooling water [Chuang et al., 2009; Thermal standards for cooling water…, 2011).

Ensuring the safety of the operation of existing and planned NPPs requires solving the following two scientific problems: 1) evaluation of extreme external conditions (meteorological, hydrological, seismic) followed by an assessment of their impact on the NPPs, and 2) producing Environmental Impact Assessment (EIA) for NPPs. In contrast to the first problem, which has been studied extensively in meteorology and oceanography in recent decades, researches on EIA methods, especially for the marine environment in the case of existing and planned NPPs operating in a regular mode, are not too numerous (see, for example, Zeng et al., 2002; Abbaspour et al., 2005; Kaplan et al., 2016).

The environmental impact of a NPP results from the nuclear fuel cycle, the effects of nuclear accidents, and NPP operation. It is known that the greenhouse gas emissions from nuclear fission power are much smaller than those associated with coal, oil and gas, and the routine health risks are much smaller than those associated with coal. However, there is a "catastrophic risk" potential if containment fails (von Hippel, 2010), which in nuclear reactors can be brought about by over-heated fuels melting and releasing large quantities of fission products into the environment. This potential risk could wipe out the benefits. Some predictions of the impact of severe accidents at NPP on radionuclide contamination of the near-surface environment are given in (Rumynin, 2015).

The environmental impact of NPP due to operation has been studied less than nuclear fission effects. During the process of nuclear power generation large volumes of water are used. The uranium fuel inside reactors undergoes induced nuclear fission which releases great amounts of energy that is used to heat water. The water turns into steam and rotates a turbine, creating electricity. Nuclear plants must collect around 600 gallons/MWh for this process (Tellinghuisen, 2016), so the plants are built near bodies of water.

As with all thermoelectric plants, NPPs need the cooling systems. The most common systems for thermal power plants, including nuclear, are:

- Once-through cooling, in which water is drawn from a large water body, passes through the cooling system, and then flows back into the water body.
- Cooling pond, in which water is drawn from a pond dedicated to the purpose, passes through 5 the cooling system, and then returns to the pond.
- Cooling towers, in which water recirculates through the cooling system until it evaporates from the tower.

Nuclear plants exchange 60 to 70 % of their thermal energy by cycling with a body of water or by the evaporation of water through a cooling tower. According to the World Nuclear Association data (http://www.world-nuclear.org), this thermal efficiency is somewhat lower than that of coal-fired power plants, thus creating more waste heat.

When intaking water for the cooling process, nuclear plants, like all thermal power plants, use special structures. Water is often drawn through screens to minimize the entry of debris. The problem is that many aquatic organisms are trapped and killed against the screens, through a process known as impingement. Aquatic organisms small enough to pass through the screens are subject to toxic stress in a process known as entrainment. Billions of marine organisms, such as fish, seals, shellfish, and turtles, essential to the food chain, are sucked into the cooling systems and destroyed.

The long-term experience related to the world-wide operating of NPPs shows that, under normal safe operating conditions, the non-radiological impact on the environment becomes dominating. One of the major factors is the heat pollution of the surface water bodies due to the discharge of waste heat from the condensers of NPPs. If heated condenser water is not cooled for re-use in a cooling tower, the waste heat may be discharged either into artificial reservoirs (ponds) or directly into surface waters like rivers, lakes, and sea bays.

Nuclear power plants, among other things, release the warm water into the sea, which can significantly affect the functioning of marine ecosystems on a local scale. In (Hong & Guixiang, 2012) a significant negative impact of the warm cooling waters ejection of the coastal power plant, located in the tidal Xiangshan Bay (China), on phytoplankton was shown. Similar conclusions are given in (Chuang et al., 2009) after the assessment of the impact of discharged water from a coastal nuclear power plant, located in Taiwan. Also the impact assessment of the discharged water from a nuclear power plant, located on the Atlantic coast in Brazil (Ilha Grande Bay) has shown the changes in the composition and structure of marine fish species as it was shown by (Teixeira et al., 2009). All the studies were carried out on the basis of field measurements and observations.

In the work by (Bork & Maier-Reimer, 1978) by means of numerical simulation the thermal regime in the tidal river Elbe was reproduced. As it was expected, the results showed a clear oscillatory nature of the spread of the warm water induced by the tidal currents. It can be assumed that, in contrast to the spread of the heated water in the tidal river, which always has its own flow velocity, in tidal coastal area the oscillating contribution would be more pronounced. In (Abbaspour et al., 2005) the modeling of the warm waters spread from the coastal thermal power plant (Bandar Abbas Thermal Power Plant, BATP), located in the Persian Gulf, was carried out and shown good results of this method in the prediction of the discharged water spread in the basin with strong tidal oscillations. In the work by (Zeng et al., 2002) the physical and numerical modeling of the warm discharged water transport spreading from a coastal nuclear power plant located in the tidal area of Daya Bay (China) near Hong Kong was carried out and also performed good results in the simulation of the studied process.

Beside the field observations and numerical modeling, the usage of the satellite data can also be useful in such assessments, as it was shown, for example, in the work by (Chen et al., 2003) presenting the analysis of thermal pollution from a nuclear power plant, located on the shores of the tidal South China Sea. The paper noted that it is more difficult to evaluate the effect of thermal pollution from a power plant that in tidal seas than in non-tidal.

At present, there are five operating NPPs on the shores of the Baltic Sea: two Swedish (Forsmarks NPP, the electric capacity of 3210 MW, Oskarshamns, 2308 MW), two Finnish (Loviisa NPP, 1020 MW, Olkiluoto NPP, 1760 MW) and one Russian (Leningrad NPP, 4000 MW). Two of them (Forsmark and Olkiluoto) are located on the coast of the Bothnian Sea. On January 19, 2016, the construction of NPP "Hanhikivi-1" with the capacity of 1200 MW was started. This event had been preceded by examination of hydro-meteorological conditions in the area of construction, which included not only the estimation of extreme conditions in the vicinity of Peninsula Hanhikivi (Pyhäjoki municipality) in the Bothnian Bay in the Baltic Sea, but also the possible impact of future power plant on the marine environment in this area.

In particular, the evaluation of extreme weather and sea events in the Bothnian Bay in the case of the absence of the NPP was carried out by the Swedish Meteorological and Hydrological Institute (SMHI, 2014). To find the extreme values of sea temperature and water level SMHI used long time series of observations of these characteristics complemented by the results obtained by HIROMB runs with horizontal resolution of 1×1 nautical mile and vertical resolution of 4-8 m. The analysis was limited by the period of 1990-2011 in the case of temperature and by the whole period of observations in the case of water level. The similar assessment was made by the company Fennovoima Oy with making use of only available observational data in the area of the planned construction (Fennovoima report, 2015; Alenius, 2015). Both estimates are based on statistical methods by means of which the maximum and minimum values and the extremes probability and frequency were calculated. As for the EIA of the proposed NPP, that estimates were usually based on the observational data, as well as on simple dispersion models for jet propagation in liquid and expert assessments (Fennovoima report, 2014) and thus both estimates can be considered as preliminary and indicative. The method proposed below which is based on three-dimensional modeling of hydrodynamics on ultra-high resolution grids provides more reliable assessments.

The purpose of this study was two-fold: 1) to estimate the possible extreme marine phenomena in this region (wind waves, sea level changes); 2) to estimate the impact of the NPP on the local thermal regime in the future. To do this, we used different hydrodynamic models. Results of this examination are presented below.

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Thermal standards for cooling water from new build nuclear power stations. Scientific advisory report series 2011, no 008, British Energy Estuarine and Marine Studies, EDF Energy, 146 pp., 2011.

Zeng, P., Chen, H., Ao, B., Ji, P., Wang, X., Ou, Z.: Transport of waste heat from a nuclear power plant into coastal water, Coastal Engineering, 44, 301-319, 2002.

2) The study presents a good example, how "core services" in operational oceanography, covering the full basins with reasonable resolution, can be used to provide custom-tailored "downstream" results with sufficiently high local resolution. This philosophy, developed over decades by EuroGOOS and several EU projects, is now realized as Copernicus Marine Environment Monitoring Service (CMEMS) http://marine.copernicus.eu/ . The core oceanographic products can be directly obtained in real time via CMEMS portal by everybody. The MS used the earlier approach of CMEMS where the authors obtained the results from core national services by bilateral agreements, but the physical and numerical approaches to the service provision are essentially the same. Within the parallel use of "core" and "downstream" products, it is important to know how much local model improves the forecast/nowcast skill of basic oceanographic variables, such as sea level, temperature and salinity (incl stratification), waves, ice conditions. The MS concludes qualitatively "the models gave the consistent results and reproduced the sea level changes correctly", "POM reproduces the observed vertical profiles of temperature slightly better than HIROMB". Here quantitative comparison (validation) of model data from core and downstream versions against observational data would be of great value and would ensure novelty that is a precondition of scientific publication.

We rewrote a part of section 2.6(from p.6, line 21 to p.8, line 10), replaced Figure 2 by a new one, added new Figure 3.1 and two new Tables. At the end of the section 2.6 (after p.9, line 11) the conclusion on the performance of modeling system used in this study will be added.

2.6 Verification of the models

Taking into account the main objective of this study - to estimate extreme values of the sea level and height of wind waves in the vicinity of NPP Hankikivi-1 and estimate the maximum thermal pollution produced by the NPP, the proposed model is verified with respect to sea level, significant wave height, sea water temperature and sea-ice area against all available observational data for the selected period 2010- 2015. This data includes data on sea level at 6 stations (Ratan, Furuogrund, Kalix, Kemi, Raahe, Pietarsaari) on the shores of the Gulf of Bothnia (ftp://myocean.smhi.se/Core/INSITU_BAL_NRT_OBSERVATIONS_013_032/history/mooring/), vertical temperature profiles for hydrographic stations BO3, F3 (data from BED) and PP5 (Fennovoima report, 2014), and data on the significant wave height at the stations PP2 and PP4 (Fennovoima report, 2013), the average monthly data on the area of the ice cover (http://www.aari.ru/).

2.6.1 Circulation model verification

Sea level

Model verification with respect to the sea level was carried out using the series of hourly sea level values for the period from 00 hours of 1 January 2010 to 23 hours of December 31, 2015, obtained from observational data and modeling results in the 6 stations mentioned above. Statistical characteristics (correlation coefficient R and standard deviation σ) of sea level at the coastal stations (Table 1) indicate that both models reproduce the level with high enough accuracy everywhere in the Gulf of Bothnia. The observed and calculated sea levels for the short periods of 14-16.10.2010 and 5-7.12.2015 at the station Raahe nearest to the NPP are presented as an example (Figure 2). As seen, that although the two models underestimate the amplitude of sea level changes, they give in general the consistent results and reproduce the sea level changes with sufficient accuracy. These periods were chosen as periods of strong storm surges causing the large fall and rise of sea level, respectively, at station Raahe. The extreme high and low sea level values are estimated in section 3.1.2, using information about the initial conditions for the hypothetical calculations of extreme values of the level just for the moments of the beginning of these two periods.

Temperature

Comparison of the results of temperature simulation on the coarse grid with the available data of field observations in the Gulf of Bothnia from BED (http://www.balticnest.org/bed) was performed for two stations: BO3 (64.30 ° N 22.35 ° E) and F3 (65.17 ° N 23.23 ° E). At these stations for the period 2010-2014 in open access there are 40 vertical profiles of temperature: 12 for BO3 and 28 for F3. Comparison of mean values and standard deviations for the observed vertical profiles of temperature with the similar characteristics obtained on 2 nm grid using HIROMB (Model data (HIROMB BS01), 2014), and on 1 nm grid using POM (this work) is presented in Table 2. Figure 3 shows examples of profiles for both stations in January and June 2010.

Analysis of Table 2 shows that when considering all profiles, POM with respect to average temperature values m is closer to the observation data than HIROMB in 58% of cases, and with respect to the standard deviation σ - only in 50% of cases. When considering the stations separately, for station BO3 POM is better with respect to m and σ in 58 and 75% of cases, while the estimates for station F3 are 57 and 39%, respectively. In general, from this comparison it can be concluded that the performance in reproducing the water temperature in the Bothnian Bay on coarse grids for both models are about the same.

Obviously, the coarse grid with step of 1-2 nm is not able to reproduce the spread of plumes of warm water from the NPP Hanhikivi 1 discharge point because the characteristic length scale of the plume of the order of 1 km. Proposed in this study fine nested grid for the vicinity of NPP Hanhikivi 1 with the steps from 35 to 180 m will allow to solve this problem; i.e. accurately reproduce the size and shape of thermal pollution plumes around the station. It is important that the solution on the fine grid significantly closer to observational data in comparison with the solution on the coarse grid (see Figure 3-1).

It will be inserted at the end of section 2.6 (after p.9, line 11):

Summarizing the above, we can say that the proposed modeling system based on the POM, allows at least not worse than the best model of the Baltic Sea HIROMB, to reproduce the principal characteristics of hydrodynamic regime (level, water temperature, altitude wind waves, sea ice) on the coarse grid and gives considerably better description of the temperature field on the fine grid. An advantage of POM important for the prognostic runs is the fact that the POM unlike HIROMB is not assimilating observational data.

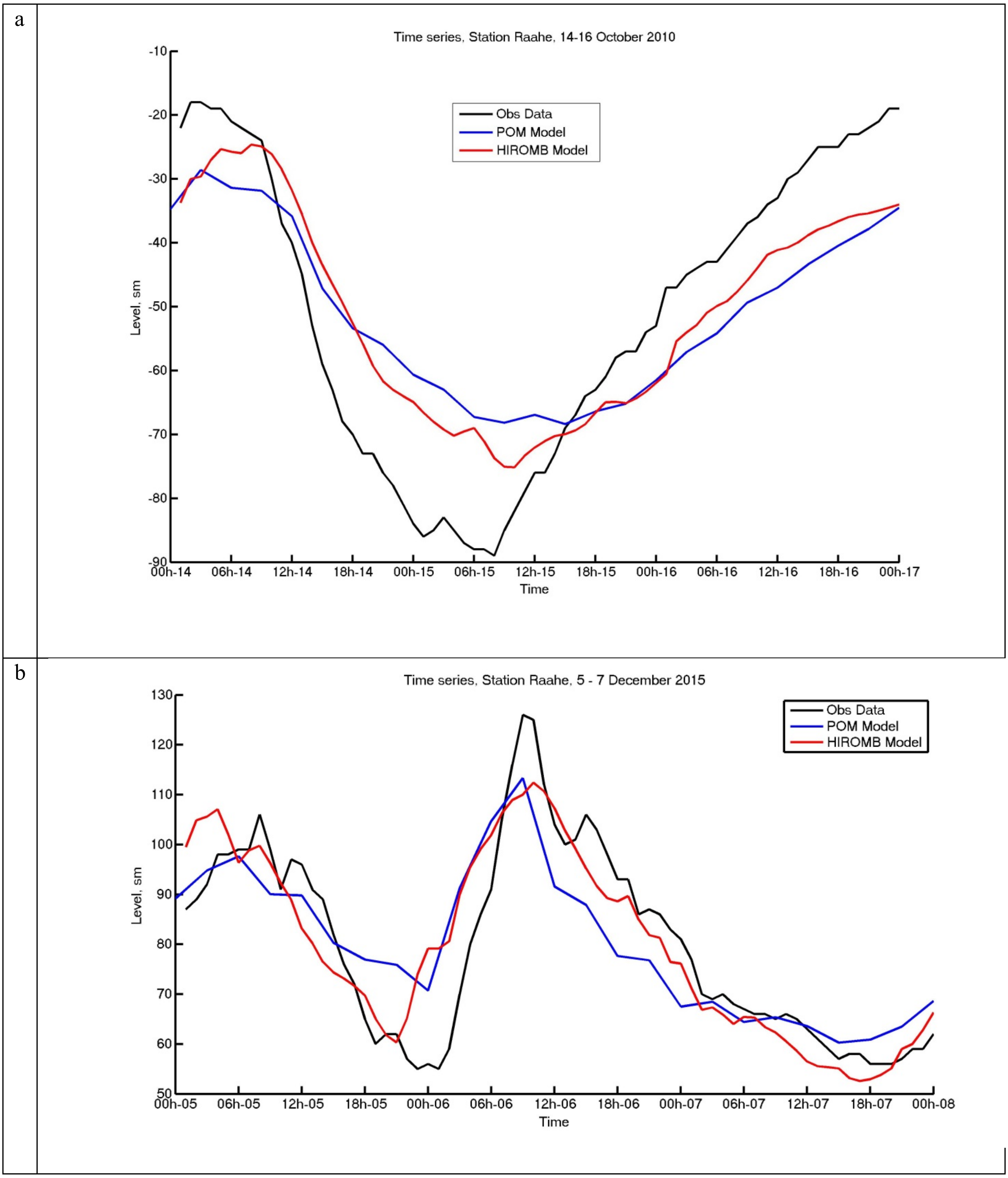

Figure 2: Comparison of POM and HIROMB calculated sea levels at station Raahe located near the NPP Hankikivi-1 for the storm surge periods of 14-16.10. 2010 (a) and 5–7.12.2015(b)

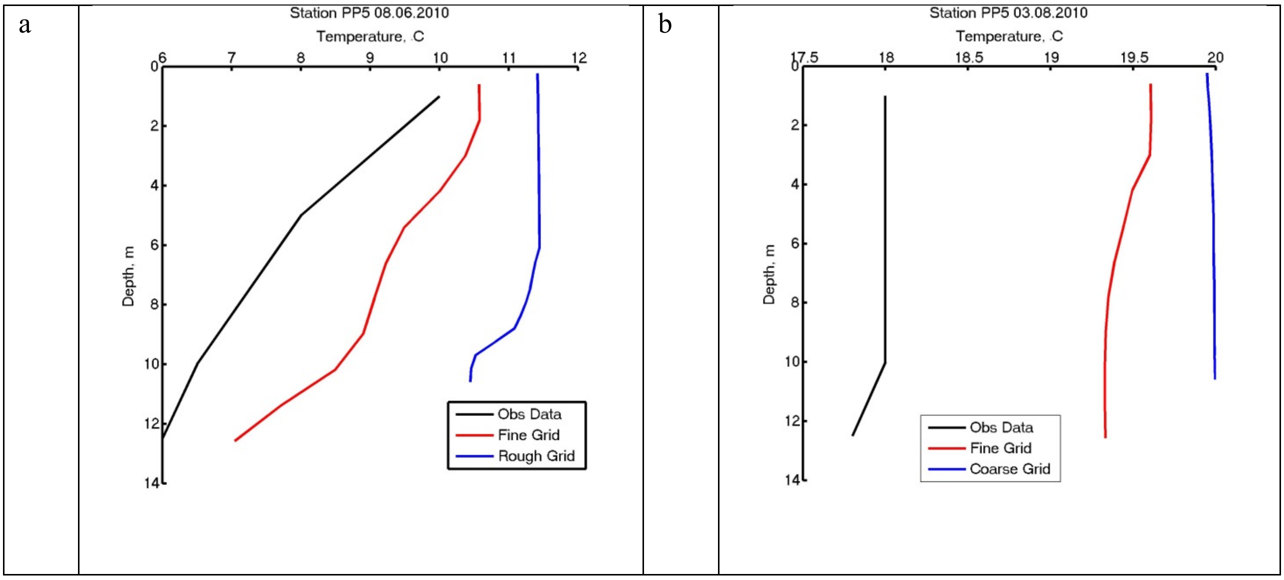

Figure 3-1: Comparison of the computed temperature profiles by POM on coarse and fine grids (blue and red curves, respectively) with observations (black curves) (Fennovoima report, 2014) at station PP5 near the NPP Hankikivi 1 in the Bothnian Bay. Location of station PP5 is presented in Fig. 1b. (a) 2010-06-08; (b) 2010-08-03.

Table 1. Statistical characteristics (correlation coefficient R and standard deviation σ) of water level at coastal stations in the Bay of Bothnia in 2010-2015 according to observations, results from HIROMB and POM (this study).

Characteristic	R,	R,	σ, m	σ, m	σ, m
Station	data – POM	data – HIROMB	data	POM	HIROMB
Ratan	0.88	0.88	0.24	0.21	0.22
Furuogrund	0.88	0.89	0.25	0.22	0.24
Kalix	0.88	0.88	0.27	0.24	0.25
Kemi	0.89	0.90	0.28	0.25	0.27
Raahe	0.88	0.89	0.23	0.26	0.25
Pietarsaari	0.80	0.82	0.21	0.22	0.23

Table 2. Statistical characteristics (mean value m and standard deviation σ) of vertical temperature profiles at oceanographic stations BO3 and F3 in the Bay of Bothnia in 2010-2012 according to BED observations, results from HIROMB and POM (this study).

Station Number	Station Name	Station Date	m,°C Data	m,°C HIROMB	m,°C POM	σ ,°C Data	σ,°C HIROMB	σ,°C POM
1	BO3	2010-01-18	1.29	2.90	2.02	1.36	2.64	1.77
2	BO3	2010-01-18	0.60	1.44	0.53	0.56	1.43	0.57
3	BO3	2010-06-06	1.73	2.20	1.89	1.10	1.14	1.11
4	BO3	2010-08-22	4.05	6.50	7.11	4.80	5.16	4.56
5	BO3	2011-01-24	0.82	1.47	0.76	0.88	1.10	0.67
6	BO3	2011-05-29	1.30	1.92	1.76	1.01	1.56	1.23
7	BO3	2011-08-21	5.76	6.37	8.34	4.65	6.01	4.64
8	BO3	2012-05-31	1.99	2.71	2.93	1.07	1.49	1.17
9	BO3	2012-08-23	6.13	7.83	8.38	4.13	4.85	3.98

10	BO3	2010-12-02	3.61	2.91	3.01	0.44	1.14	1.32
11	BO3	2011-12-11	3.30	2.92	3.53	0.52	0.80	0.17
12	BO3	2012-12-10	3.58	3.93	4.08	0.39	1.21	1.21
13	F3	2010-01-19	1.74	2.45	2.41	1.53	2.22	2.47
14	F3	2011-01-24	0.95	1.14	1.27	0.93	1.08	1.29
15	F3	2010-03-05	0.41	2.14	1.81	1.12	2.28	1.79
16	F3	2010-03-23	0.73	1.91	1.92	1.09	2.04	1.95
17	F3	2010-05-05	0.92	2.44	2.29	1.11	1.94	1.67
18	F3	2010-05-19	1.29	2.22	2.20	0.88	1.78	1.44
19	F3	2010-06-09	3.74	3.53	2.94	2.79	0.34	0.72
20	F3	2010-06-30	5.30	5.76	5.07	4.24	2.71	2.75
21	F3	2010-08-04	7.05	7.82	7.63	6.43	5.33	4.66
22	F3	2010-09-01	6.49	6.43	7.67	6.02	5.16	4.29
23	F3	2010-10-27	4.01	5.39	6.18	1.30	1.26	0.34
24	F3	2010-12-08	2.82	2.28	2.84	1.09	0.61	1.05
25	F3	2011-03-15	0.15	1.44	1.24	0.50	1.13	1.02
26	F3	2011-05-18	1.69	1.03	1.13	1.15	1.13	0.76
27	F3	2011-06-08	3.66	3.11	2.60	2.03	1.57	1.17
28	F3	2011-07-06	6.41	5.58	5.36	5.50	4.03	3.66
29	F3	2011-07-20	7.25	6.98	7.13	6.59	5.41	5.00
30	F3	2011-08-03	9.02	8.00	8.37	8.49	6.25	5.69
31	F3	2011-08-17	6.41	7.03	7.35	5.50	5.48	5.03
32	F3	2011-09-07	9.02	6.52	7.44	8.49	4.94	4.52
33	F3	2011-10-26	5.42	5.53	6.89	2.70	2.18	0.84
34	F3	2011-12-07	4.62	4.56	4.89	0.44	0.22	0.23
35	F3	2012-01-18	2.22	1.88	2.46	0.12	0.12	0.52
36	F3	2012-03-20	2.22	-0.05	0.16	0.12	0.04	0.24
37	F3	2012-04-25	0.27	0.29	0.20	0.25	0.38	0.20
38	F3	2012-05-09	0.67	0.53	0.55	0.20	0.21	0.10
39	F3	2012-08-29	7.67	6.60	7.10	6.66	5.68	4.99
40	F3	2012-12-22	1.73	1.99	2.51	2.02	1.35	1.55

Additional references

1. Model data (HIROMB BS01). http://www.smhi.se/en/services/open-data/model-data-hiromb-bs01-1.33361. Last updated Apr 23, 2014
2. ftp://myocean.smhi.se/Core/INSITU_BAL_NRT_OBSERVATIONS_013_032/history/mooring/

3) Regarding the transport of thermal pollution, the region under study is unique, with almost missing tides but with strong ice cover during the winter. It would be interesting if these results will be compared with the patterns apparent in tidal areas where most of the NPP are located.

We have inserted two paragraphs in the new introduction section given above in which some features of the thermal pollution in the tidal basins are described. The two above-mentioned paragraphs are:

Nuclear power plants, among other things, release the warm water into the sea, which can significantly affect the functioning of marine ecosystems on a local scale. In (Hong & Guixiang, 2012) a significant negative impact of the warm cooling waters ejection of the coastal power plant, located in the tidal Xiangshan Bay (China), on phytoplankton was shown. Similar conclusions are given in (Chuang et al., 2009) after the assessment of the impact of discharged water from a coastal nuclear power plant, located in Taiwan. Also the impact assessment of the discharged water from a nuclear power plant, located on the Atlantic coast in Brazil (Ilha Grande Bay) has shown the changes in the composition and structure of marine fish species as it was shown by (Teixeira et al., 2009). All the studies were carried out on the basis of field measurements and observations.

In the work by (Bork & Maier-Reimer, 1978) by means of numerical simulation the thermal regime in the tidal river Elbe was reproduced. As it was expected, the results showed a clear oscillatory nature of the spread of the warm water induced by the tidal currents. It can be assumed that, in contrast to the spread of the heated water in the tidal river, which always has its own flow velocity, in tidal coastal area the oscillating contribution would be more pronounced. In (Abbaspour et al., 2005) the modeling of the warm waters spread from the coastal thermal power plant (Bandar Abbas Thermal Power Plant, BATP), located in the Persian Gulf, was carried out and shown good results of this method in the prediction of the discharged water spread in the basin with strong tidal oscillations. In the work by (Zeng et al., 2002) the physical and numerical modeling of the warm discharged water transport spreading from a coastal nuclear power plant located in the tidal area of Daya Bay (China) near Hong Kong was carried out and also performed good results in the simulation of the studied process.

4) Conclusions do not present new information. Everybody knows that coastal NPP-s can be significantly affected by extreme sea conditions. It is nice to know, that thermal impact of NPP extends over 2 km of sea area, but there should be scientific conclusion(s) as well.

We rewrote Conclusions section (p.21,line 3- p.21, line7):

5 Concluding remarks

1. The approach used in this study based on the method of nested grids is well-known in oceanography. Here it has been used together with consideration of: 1) model situations (setting the maximum possible wind of a certain direction in the selected periods of storm surges, prescribing direction and wind speed in the simulation of wind waves) to evaluate the extreme changes in sea level and wind wave parameters in the selected area – the construction area of NPP "Hanhikivi-1" in the Bothnian Bay, Baltic Sea, and 2) the scenarios of "warm" and "cold" years for the detailed assessment of the thermal pollution of the NPP neighborhood. One important feature of the used nested grids should be emphasized: the grid vertical structure does not change when going from coarse to fine grid. This avoids the situation with arising of unstable stratification in fields interpolated on the fine grid and ensures the absence of numerical noise, which often causes the instability of computing. The scientific value of this approach is the fact that, unlike traditional statistical estimates of the extreme values of marine characteristics and their repeatability by observations from meteorological stations, it can be used in the local areas where the duration of the time series of observations is small (for example, in high-latitude Arctic seas).

2. The most important results from the engineering point of view for the neighborhood of NPP "Hanhikivi-1" are as follows. Model calculations of wind waves have shown that the most dangerous (in terms of the generation of wind waves in the NPP area) is a north-west wind with the direction of 310°. The maximum height of the waves in the Bothnian Bay near the NPP for this wind direction with wind velocity of 10 m s^{-1} is 1.2-1.4 m. According to the model estimates, the highest possible level of the sea near the NPP is 248 cm, the minimum level is -151 cm, for the western and eastern winds, respectively. An important feature of thermal pollution around the station is that in

the point of water intake for cooling the reactor, in the warm year the sea surface temperature in winter is not lower than the water freezing point and the ice cover is not formed, while in the cold year in the period from the end of December to March in this area there is ice cover with thickness of a few tens of centimeters. Thus, the extreme values of significant wave height, sea level, water temperature in the vicinity of the future NPP "Hanhikivi-1" can be significant and sometimes catastrophic.

3. Numerical experiments for the cold (2010) and the warm year (2014) showed that the permanent release of heat into the marine environment from the operating NPP for the cold year will increase the temperature in the upper layer of 250 m zone (from the heated water discharge point) by 10°C (in average) in winter – spring and by 8 ° C in summer – early autumn, and in the bottom layer of the same zone by 5°C in winter - spring and 3°C in summer - early autumn. For the warm year, these temperature changes will be smaller. In both cases, in the one-km vicinity of the station throughout the whole year there is a vertical temperature structure with a pronounced thermocline at a depth of 1-2 meters. Ice cover in both cases will disappear in two-kilometer vicinity of the NPP. The above warming of the marine environment is important to assess possible changes in the functioning of the natural aquatic ecosystems, including fish, when commissioning the NPP, as well as in choosing a site for the creation of aquaculture farms.

4. According to the estimates, the scale of the thermal impact of the NPP on the marine environment is substantial and, therefore, this impact should be taken into account, when assessing local climate changes and marine environmental impact in the future.