Using wave model to evaluate the quality of the surface wind fields in the Baltic Sea

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Models and forecast parameters

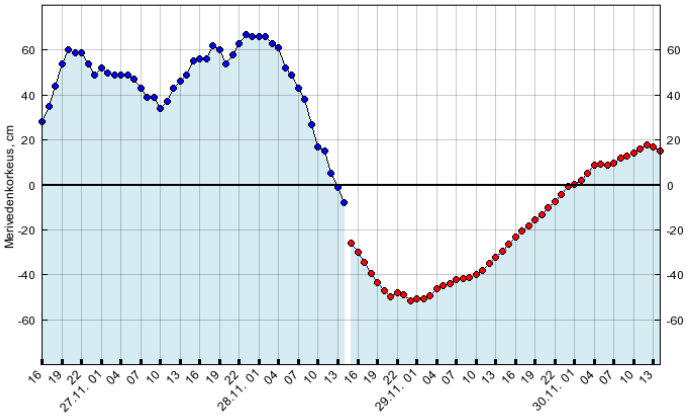
3D hydrodynamic model (HBM, NEMO)
- Temperature
- Salinity
- Currents
- Sea level variation

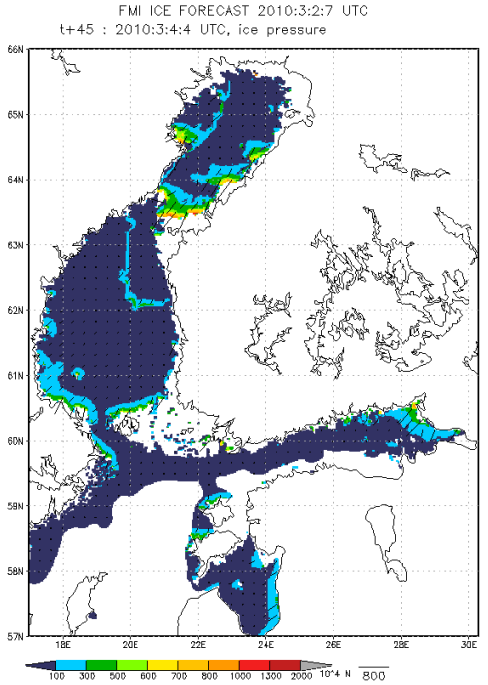
2D hydrodynamic models (OAAS, Wetehinen)
- Sea level variation

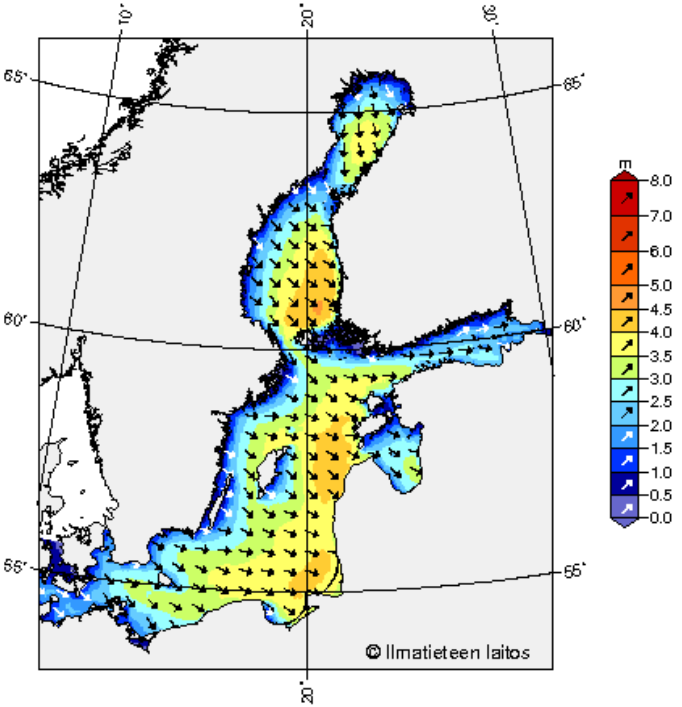
Wave model (WAM)
- Wave spectrum
- Significant wave height
- Wave direction
- Wave length and period

Ice model (HELMI)
- Ice concentration
- Ice thickness
- Different ice categories
- Ice compression

Drift model (SeaTrackWeb)
- Drift of substances





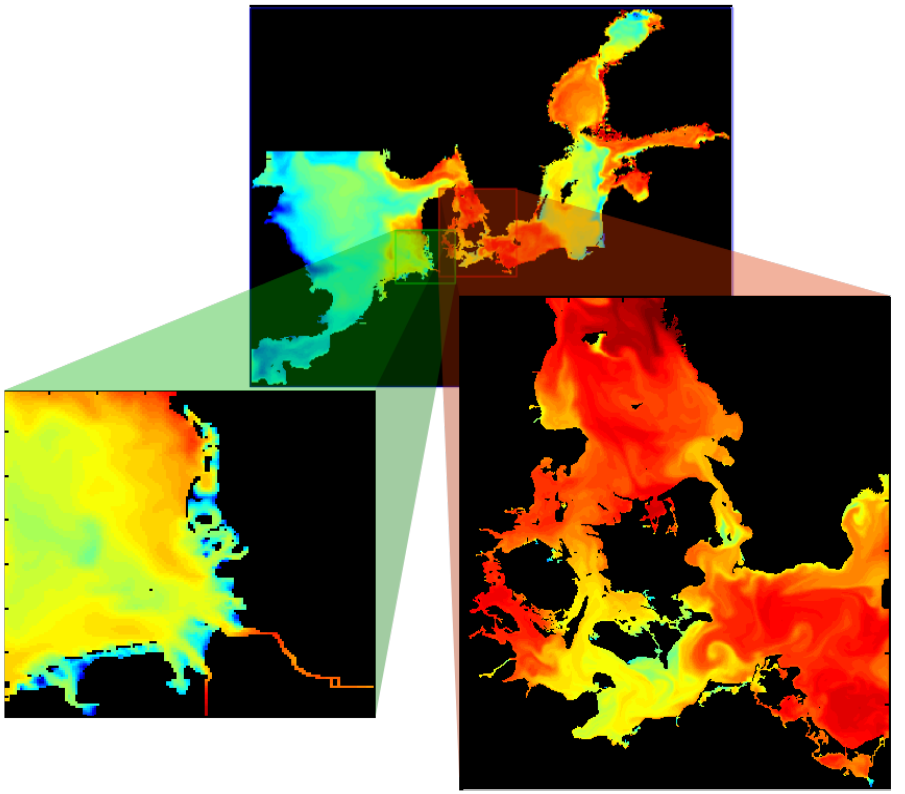


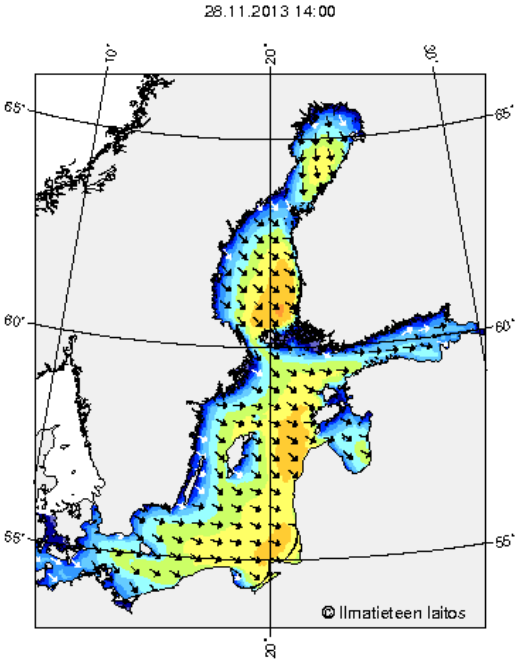
Model domains

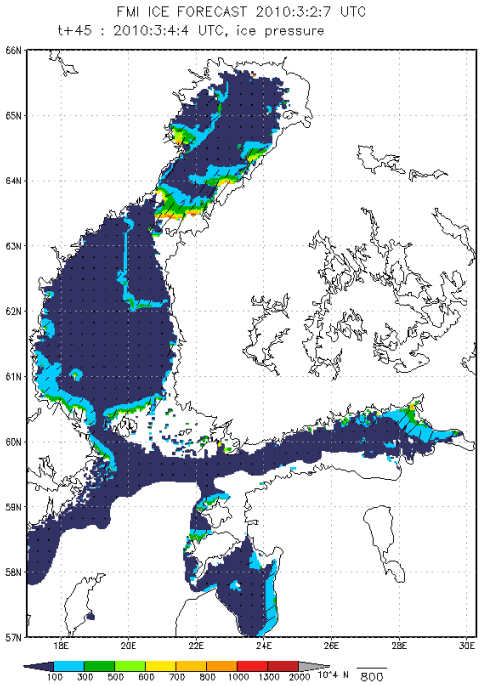
- Northern part of the Baltic Sea
  Ice model (HELMI)
- Baltic Sea
  Wave model (WAM)
  2D hydrodynamic models (OAAS, Wetehinen)
- Baltic Sea and North Sea
  3D hydrodynamic model (HBM)

Horisontal resolutions: 1 - 6 nmi

Coastal high-resolution applications

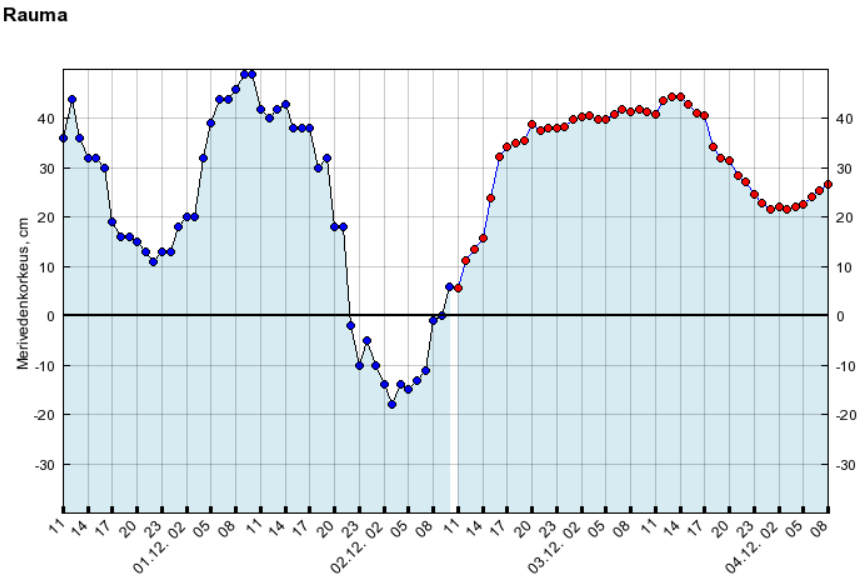


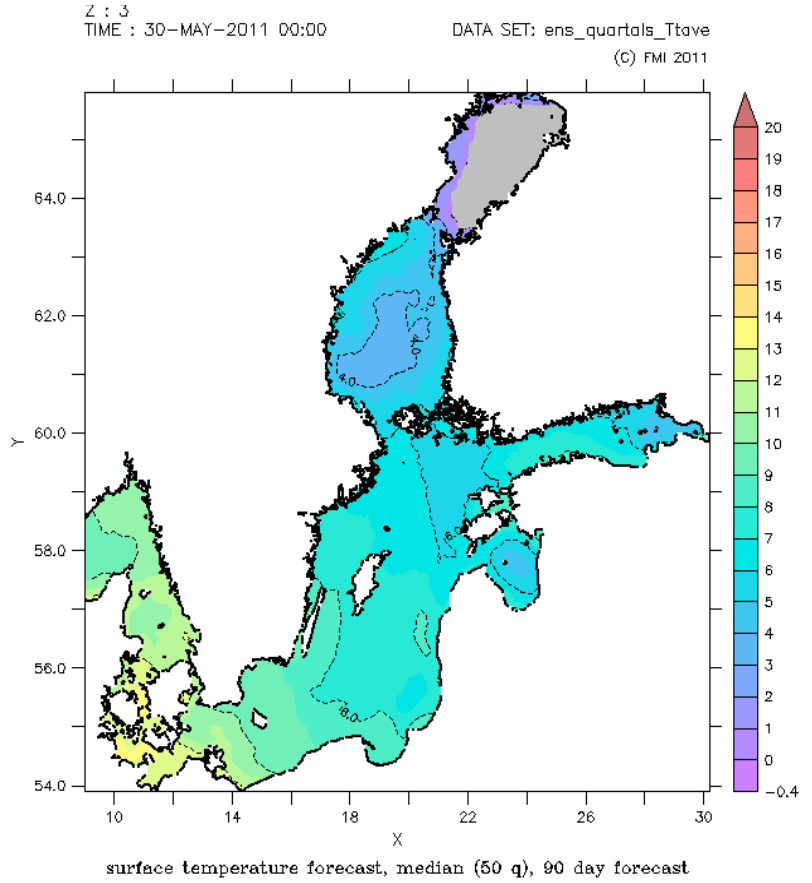




Forecasts for

- Safety at the seas and flow of shipping
  - 2-5 days forecasts of wave, sea level and ice conditions
- Early warning systems
  - flooding, safety at the seas
- Drift of objects and substances
  - nowcast
- For planning of operations
  - Monthly and seasonal marine ensemble forecasts





surface temperature forecast, median (50 q), 90 day forecast

Meteorological forcing used in FMI's oceanographic models

For deterministic forecasts most models use both

- FMI-HIRLAM
- ECMWF

And

- Starting from 2016

FMI-HARMONIE

Parameters used:

Wind field (at 10 m height)

Atmoshperic pressure

Air temperature

Humidity

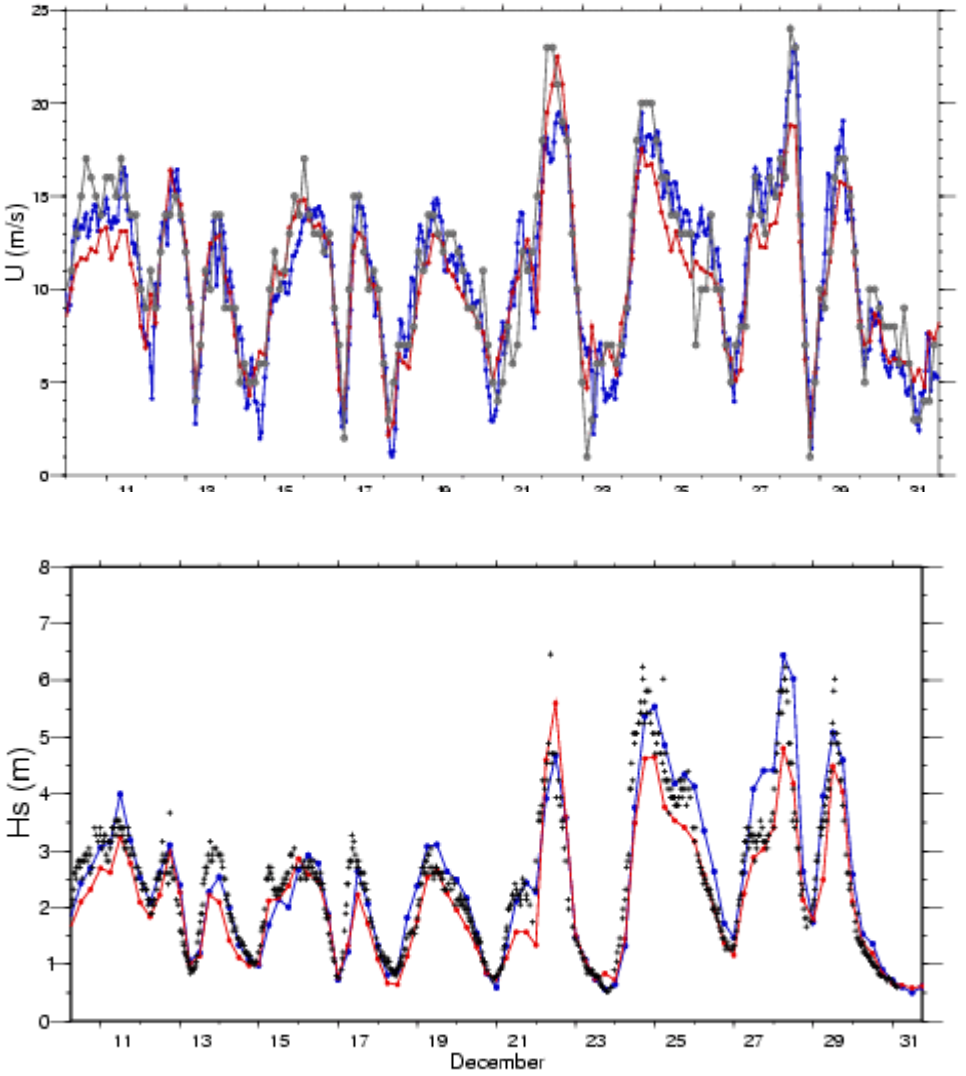
Total cloud cover

Precipitation

Surface waves

- **Surface waves are an integrated affect of the forcing wind field**
- **Wind forcing is the largest source of error in the wave forecasts**

$$H_s \propto U^2$$



SST – 3D ocean model

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Vertical temperature dynamics in the Northern Baltic Sea based on 3D modelling and data from shallow-water Argo floats

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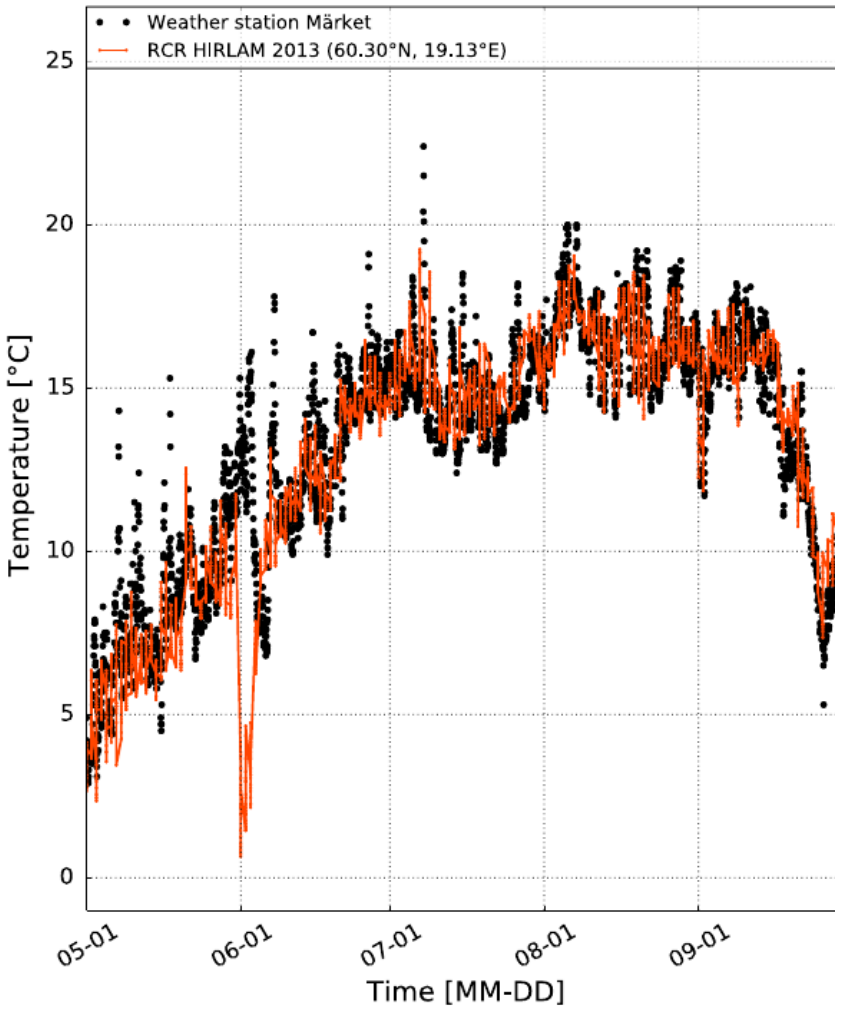
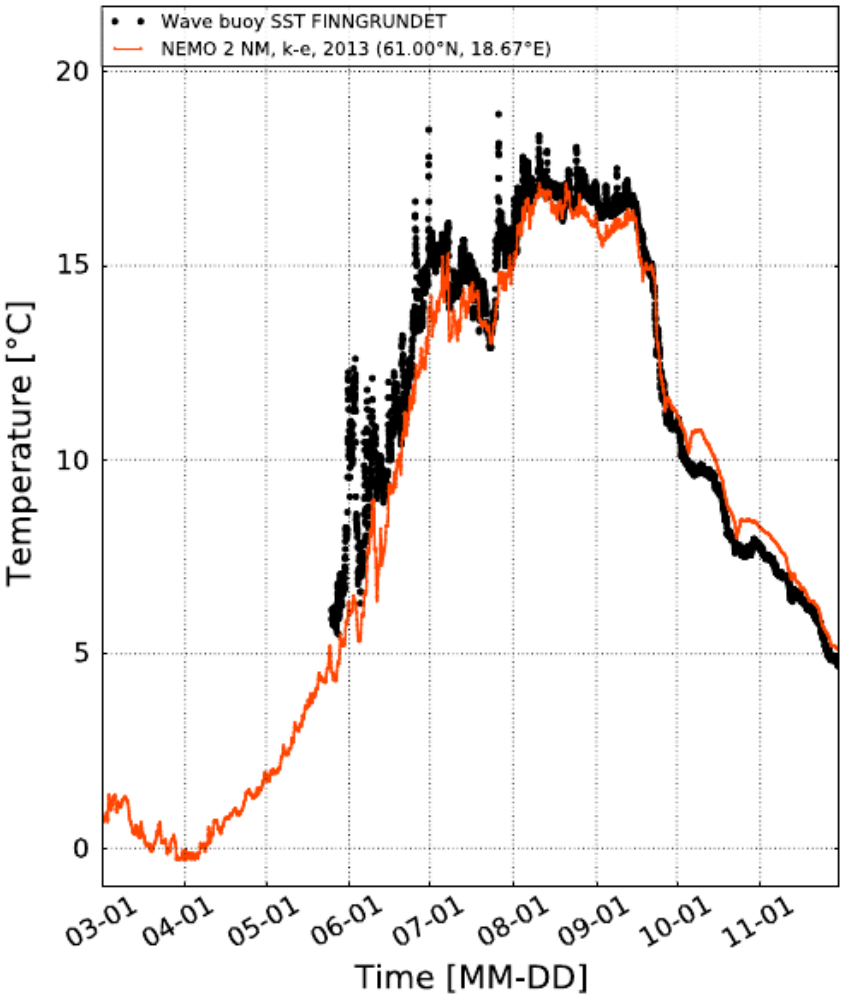
Finnish Meteorological Institute, Marine Research, Erik Palménin aukio 1, P.O. Box 503, FI-00101 Helsinki, Finland





BALMFC Wave model setup

Wave model WAM cycle 4.5.4 is used to produce the BALMFC wave forecast.

Meteorological forcing from FMI-HARMONIE

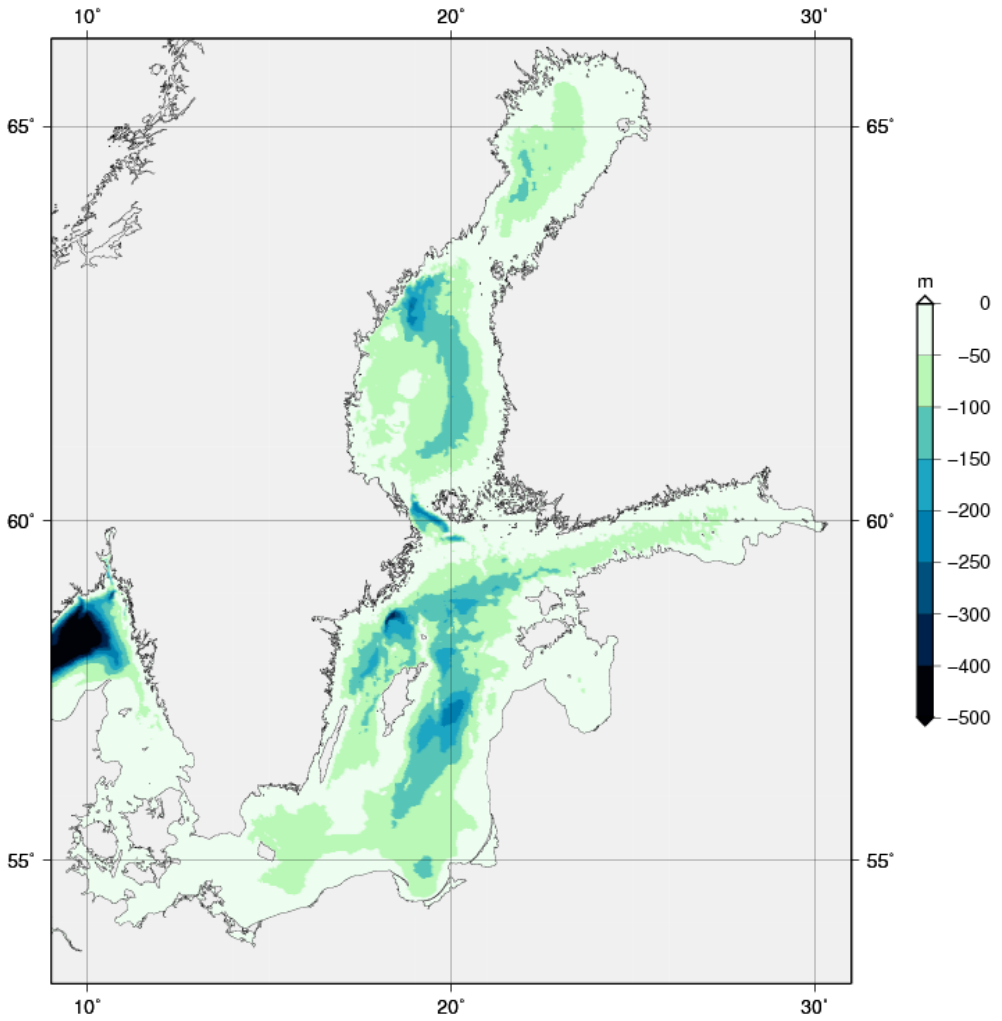
2 days forecast twice a day 00 and 12 UTC.

Model domain is the Baltic Sea with open boundary at Skagerrak.

Horizontal resolution of 1 nmi, spectra with 36 directions and 35 frequencies.

FMI 24/7 operational monitoring will monitor the production. Support from Operational oceanography group.

Backup system will be run at MSI.



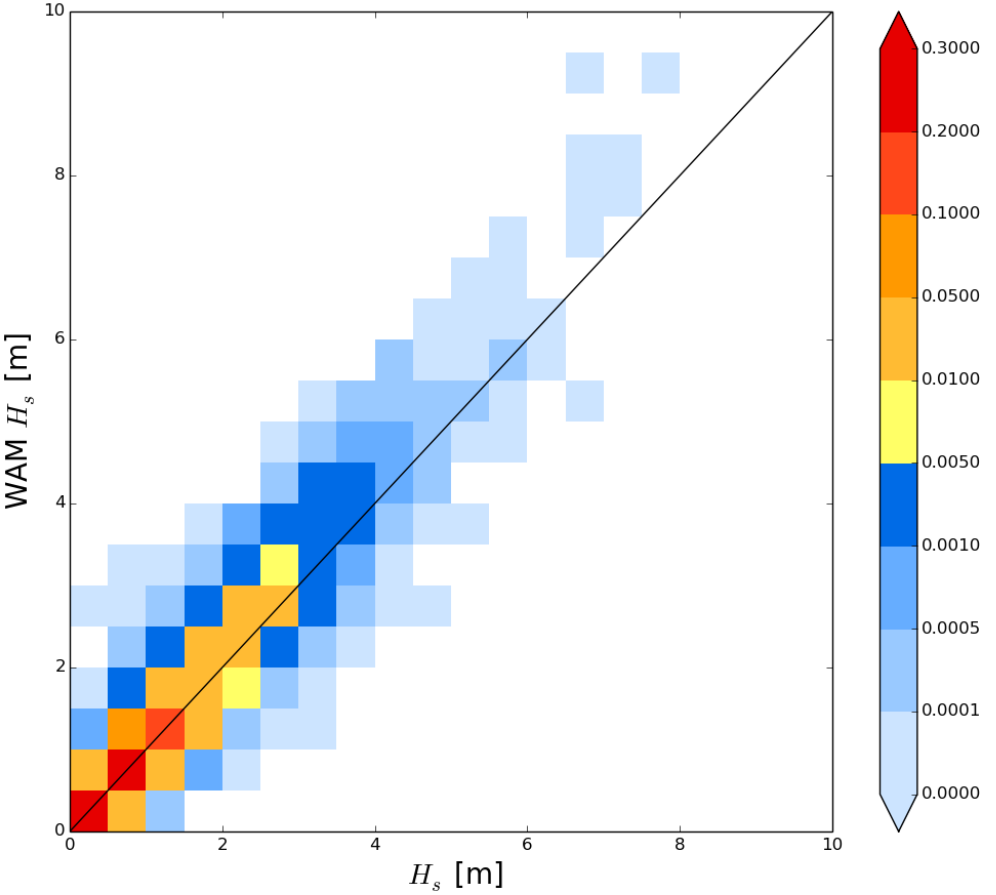
BALFMC wave forecast

Pre-operational qualification period: 01.06.2014–31.5.2016

Wind forcing: FMI-HARMONIE

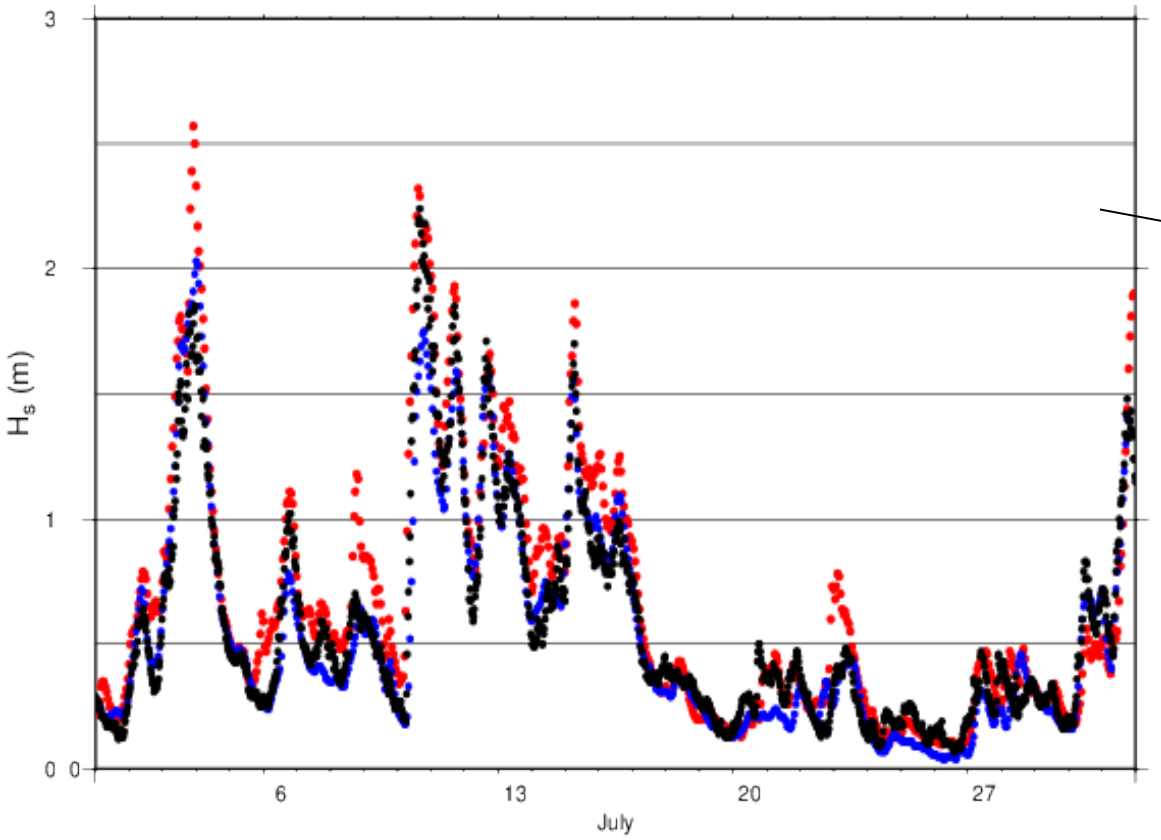
Significant wave height

The significant wave height (SWH) was fairly well hindcast by the model. The wind forcing used for the wave model has tendency to slightly overestimate the high wind situation resulting to slight overestimation in the larger values of significant wave height. The bias over the whole model domain was 0.09 m and the rmsd 0.27 m.



Wind forcing

Hirlam forcing
Harmonie forcing
NBP buoy



DMI oceanographers - experiences

Comparison of forcing wind fields used for sea level forecasts (3D oceam model HBM):
DMI-Hirlam-SKA (3 km)
DMI-Harmonie-NEA (2.5 km).

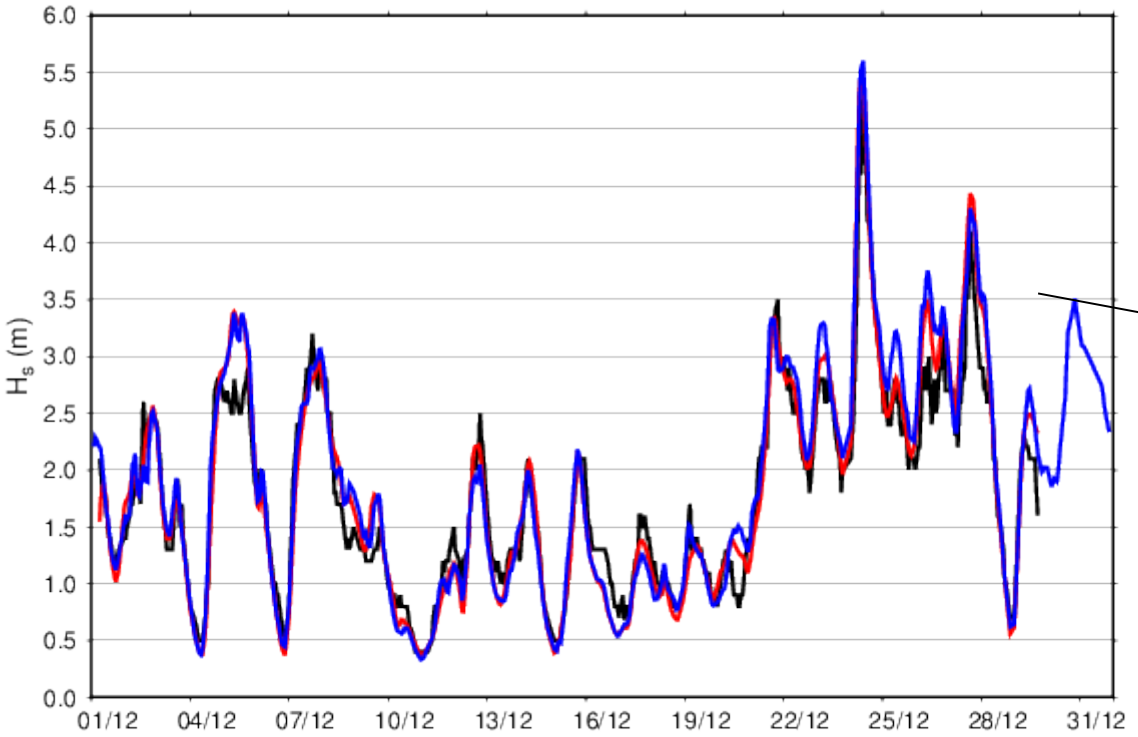
The study period is Dec 2016 - Feb 2017,

Hourly data. Analysis, 1, 2, 3, 4, 5 hour forecast.

HARMONIE - HIRLAM

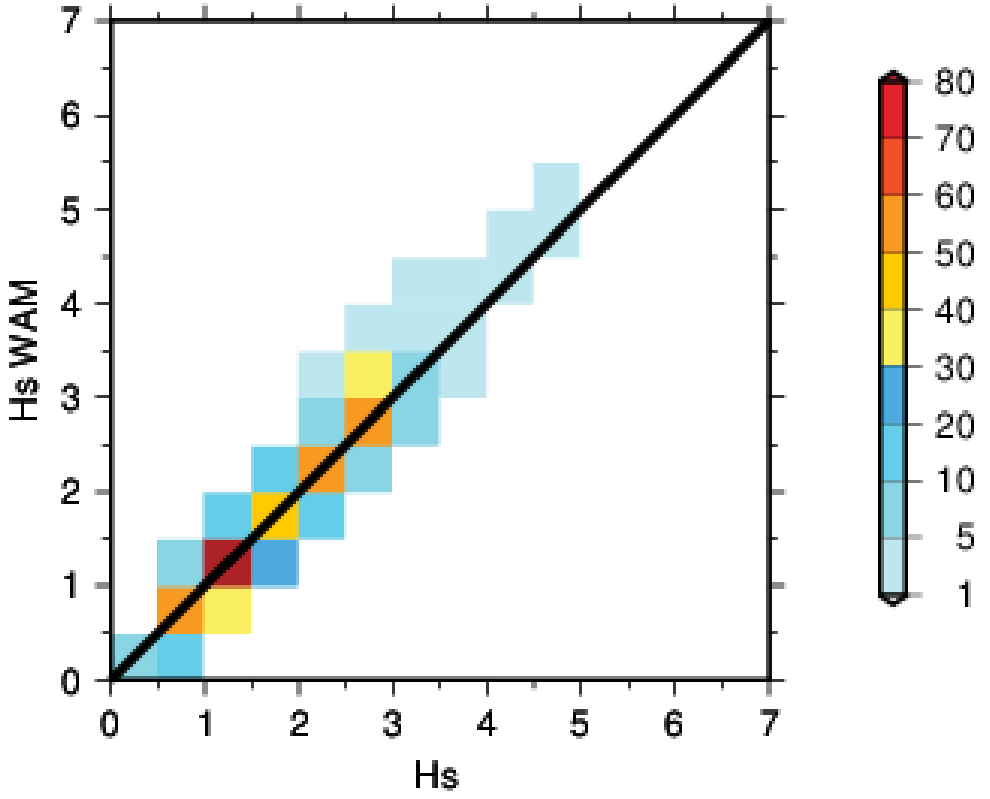
North Sea / Skagerrak: +0.23 m/sec
Domestic Waters (Skagen-Bornholm): +0.26 m/sec
Wadden Sea / German Bight: +0.17 m/sec
Baltic Sea, east of Bornholm: +0.09 m/sec

HIRLAM vs HARMONIE

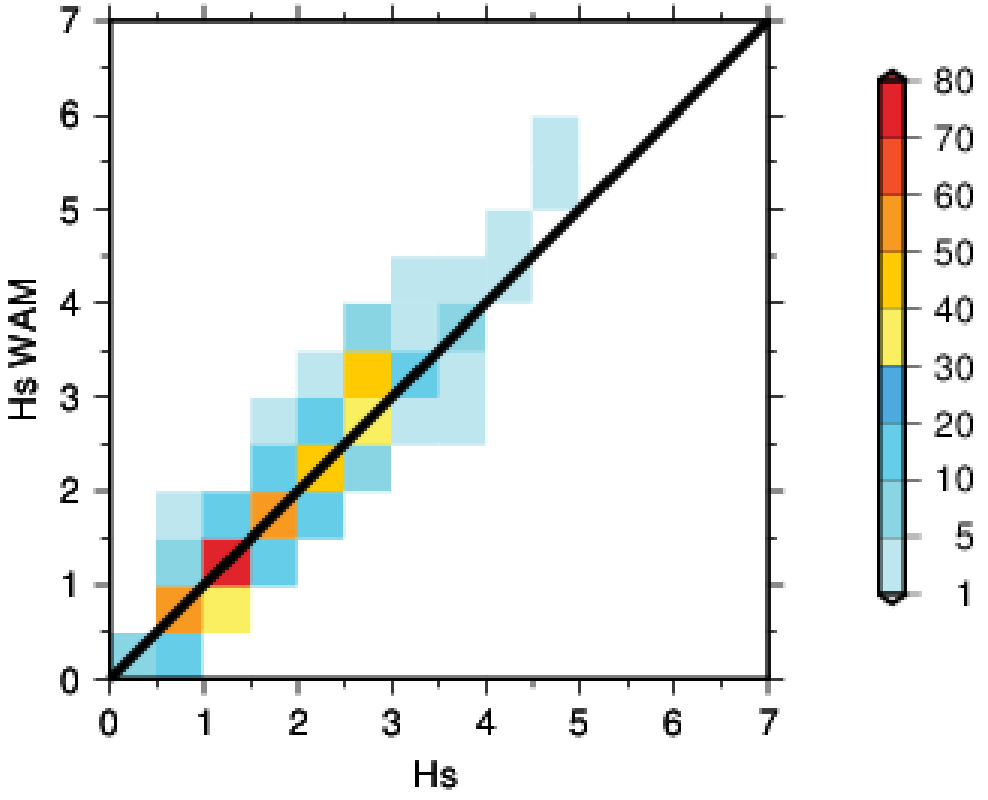


Wave hindcast 2016/12
HIRLAM vs HARMONIE

HIRLAM WAM – NBP



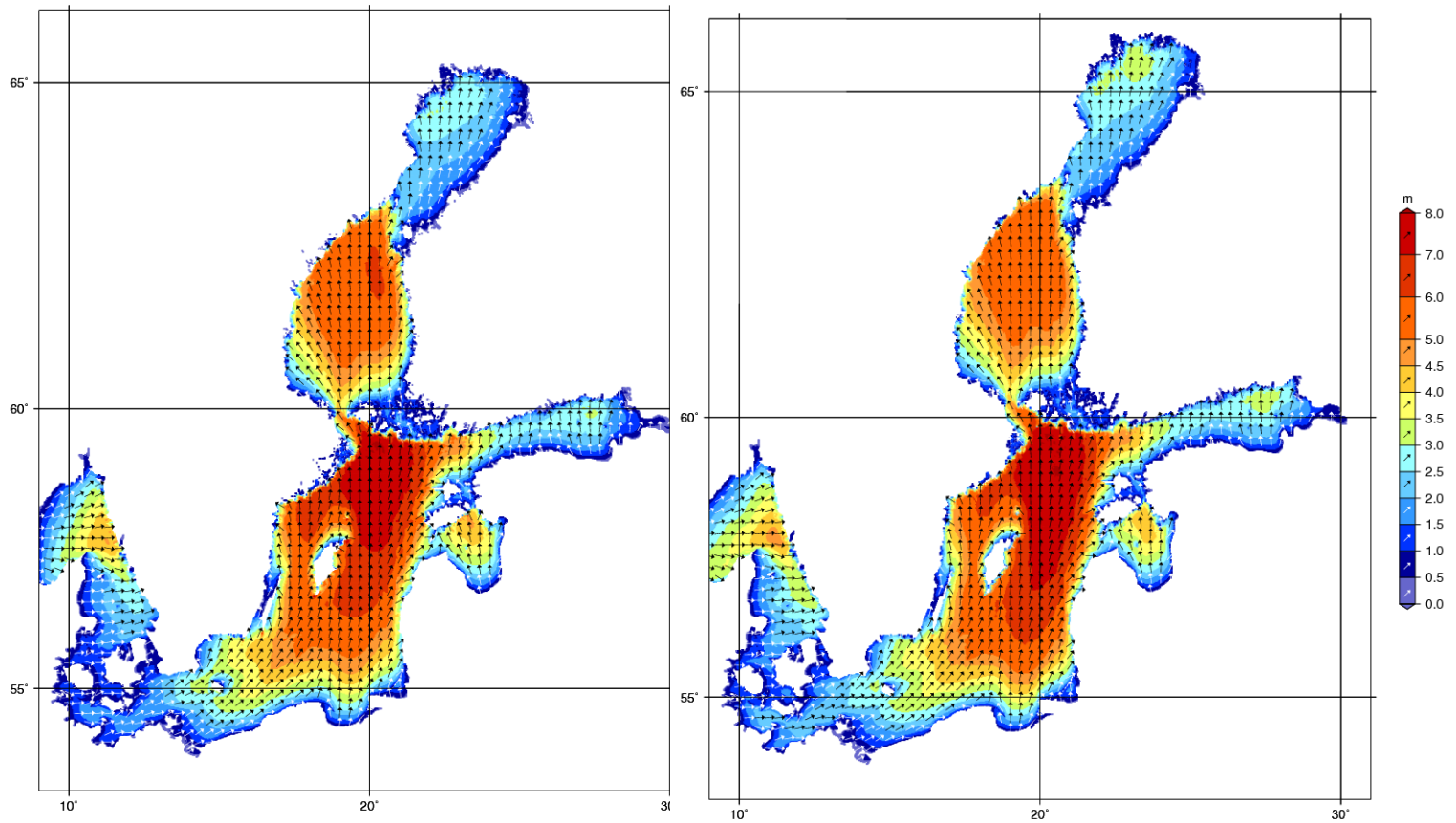
HARMONIE WAM – NBP



Wave field in “Toini” storm Jan/2017

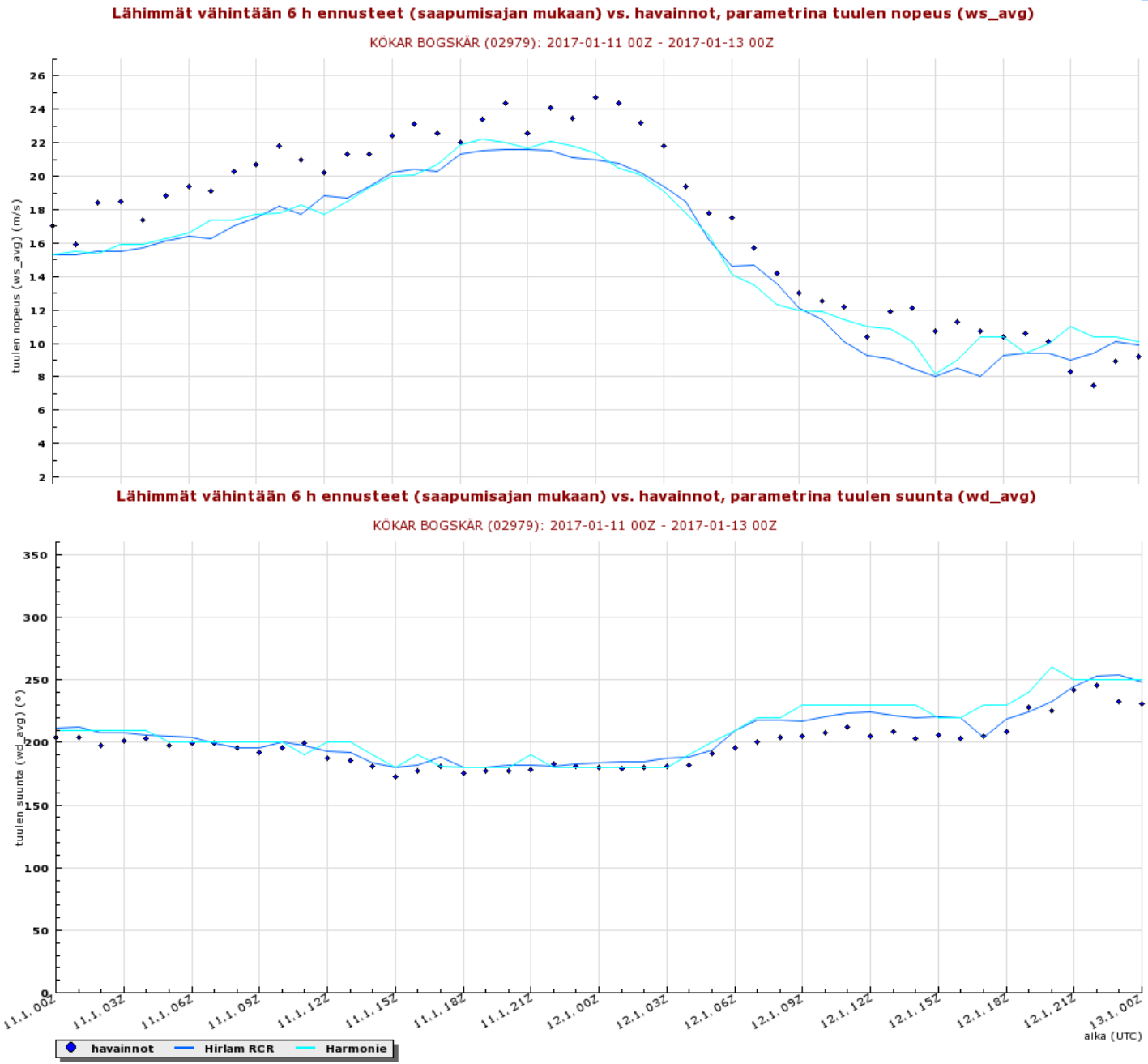
With HIRLAM winds

With HARMONIE winds



The highest measured significant wave height is 8.2 m, which was recorded by the northern Baltic Proper wave buoy in 2004. A significant wave height of over 7 m has been measured five times at this location since the observations started in 1996. The most recent occurrence was in January 2017 during storm 'Toini' when the wave buoy measured a significant wave height of 8.0 m.

“Toini” storm



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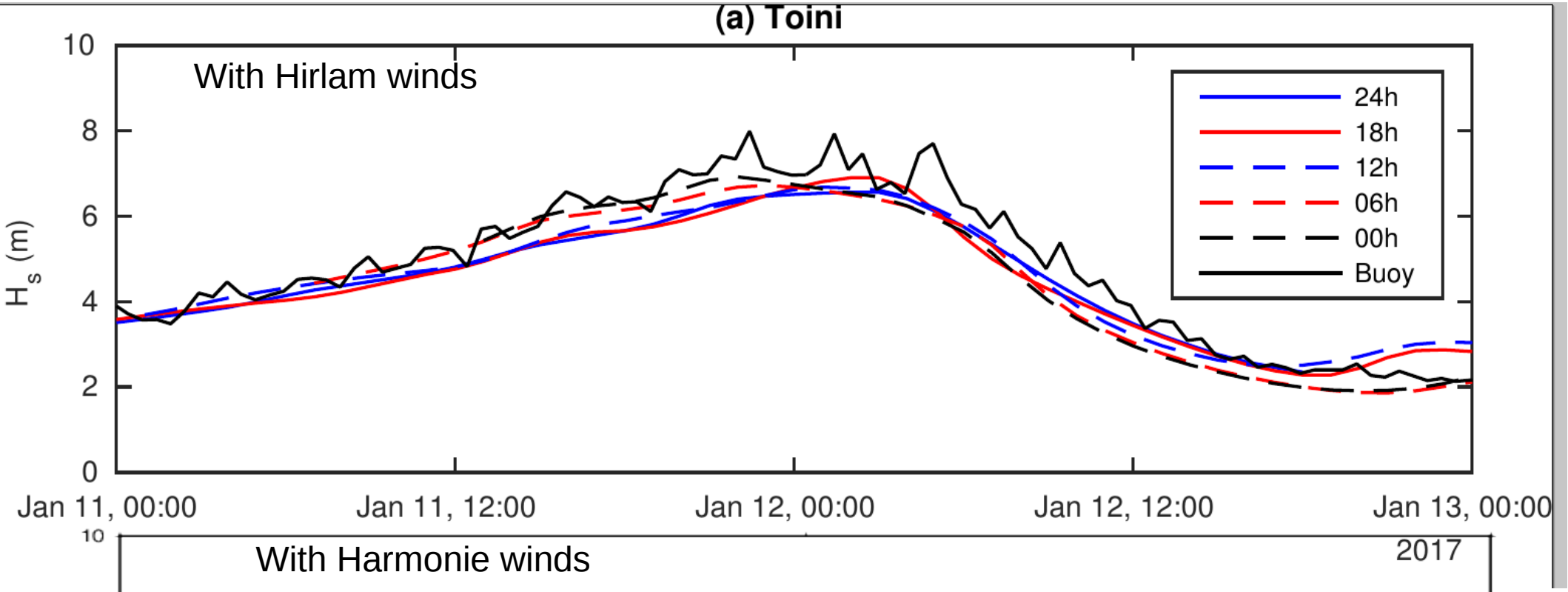
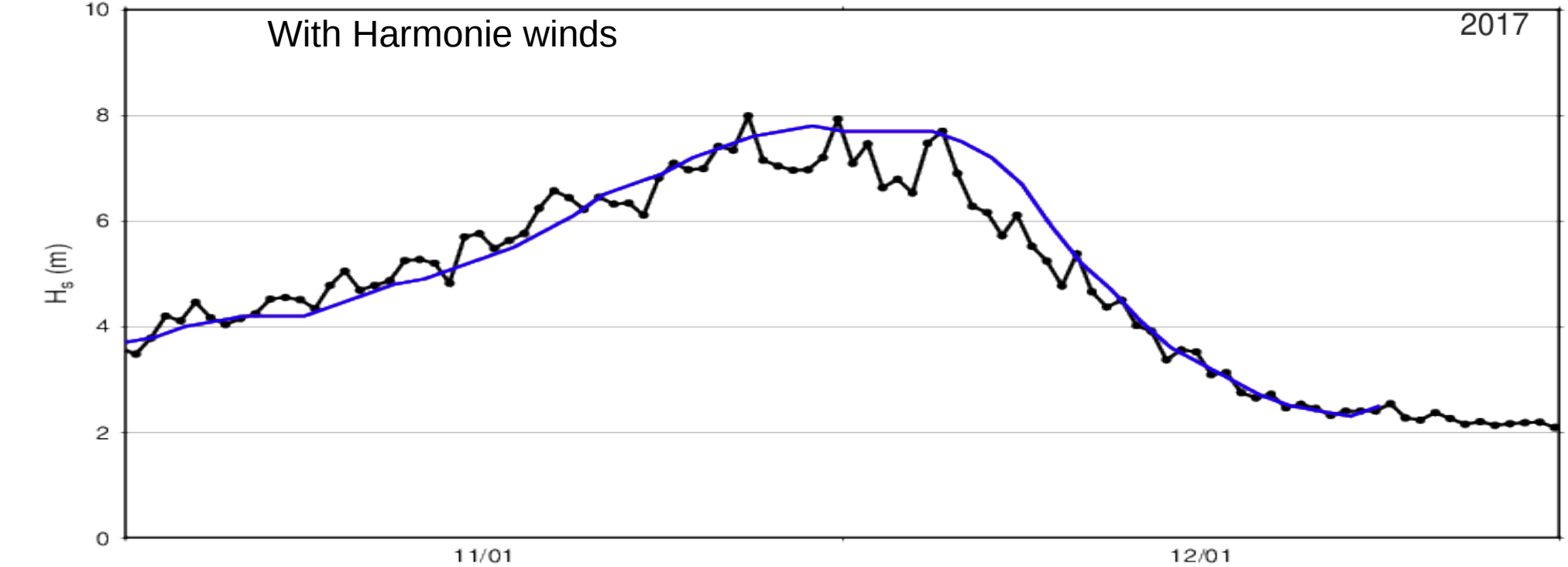
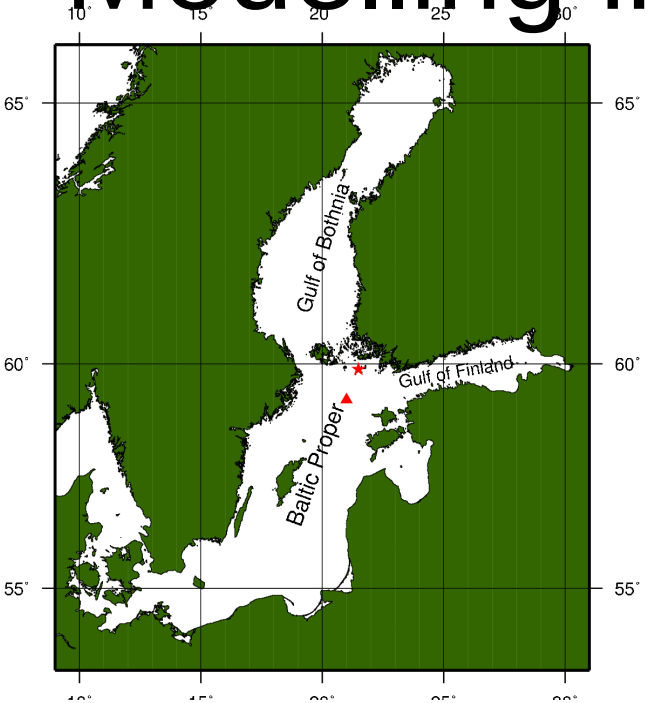
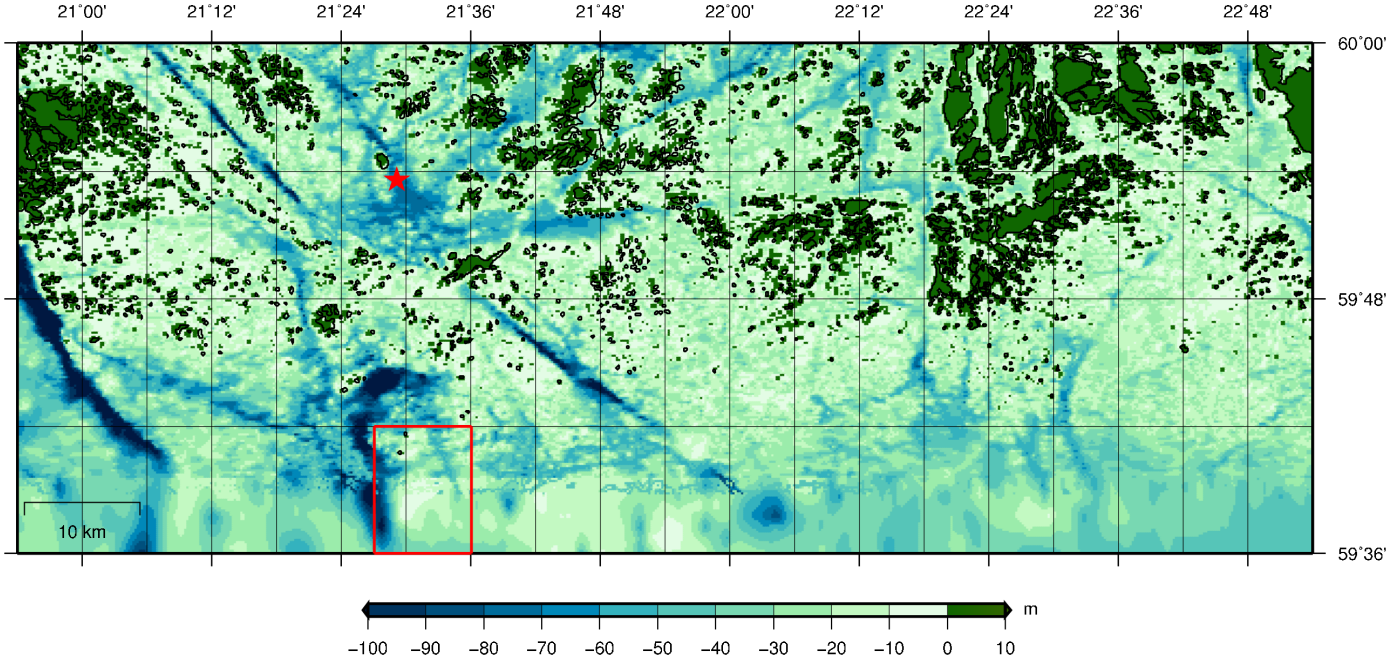
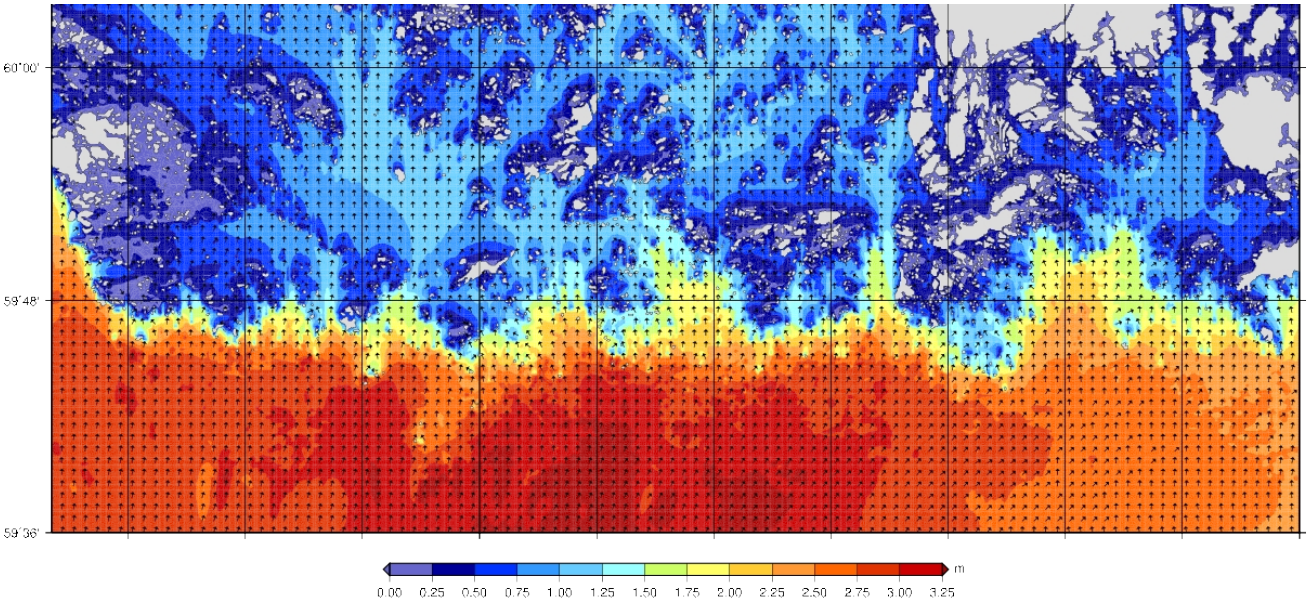

(a) Toini
With Hirlam winds
24h
18h
12h
06h
00h
Buoy
H_s (m)
0
2
4
6
8
10
Jan 11, 00:00
Jan 11, 12:00
Jan 12, 00:00
Jan 12, 12:00
Jan 13, 00:00


With Harmonie winds
2017
H_s (m)
0
2
4
6
8
10
11/01
12/01

Modelling in coastal areas





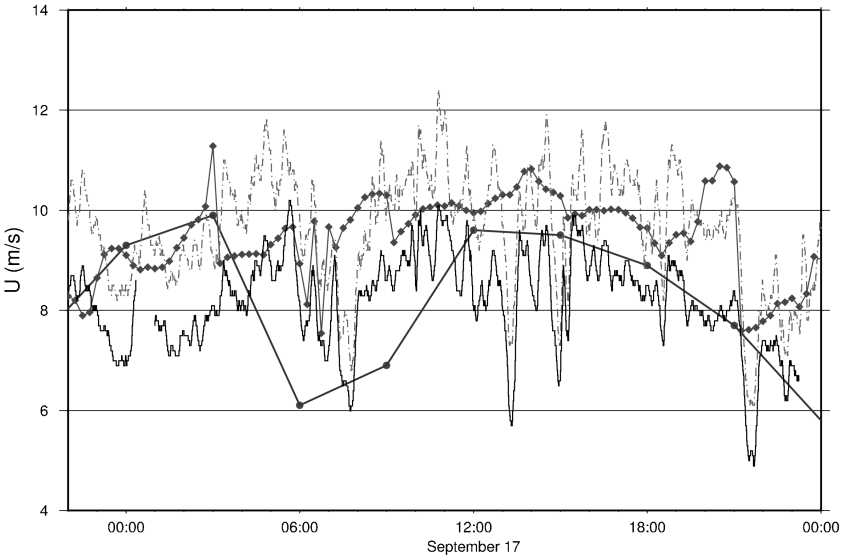


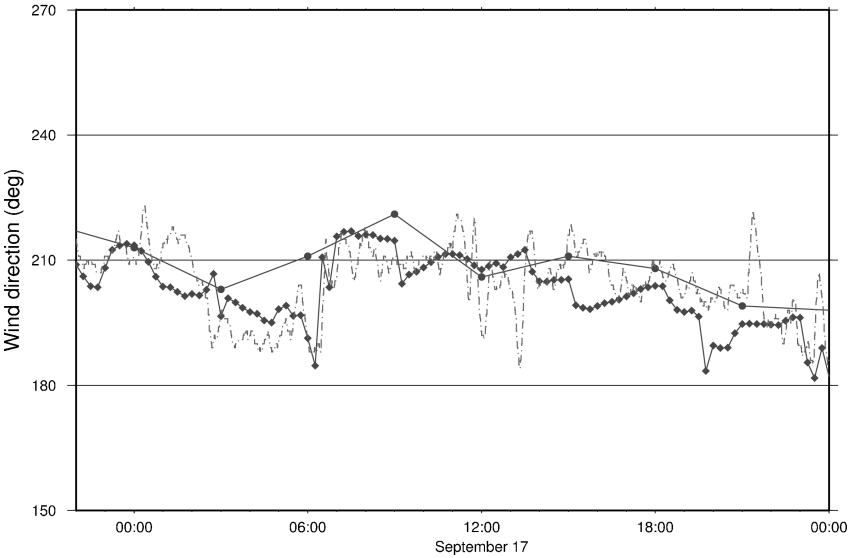
Modelling in coastal areas needed in future:

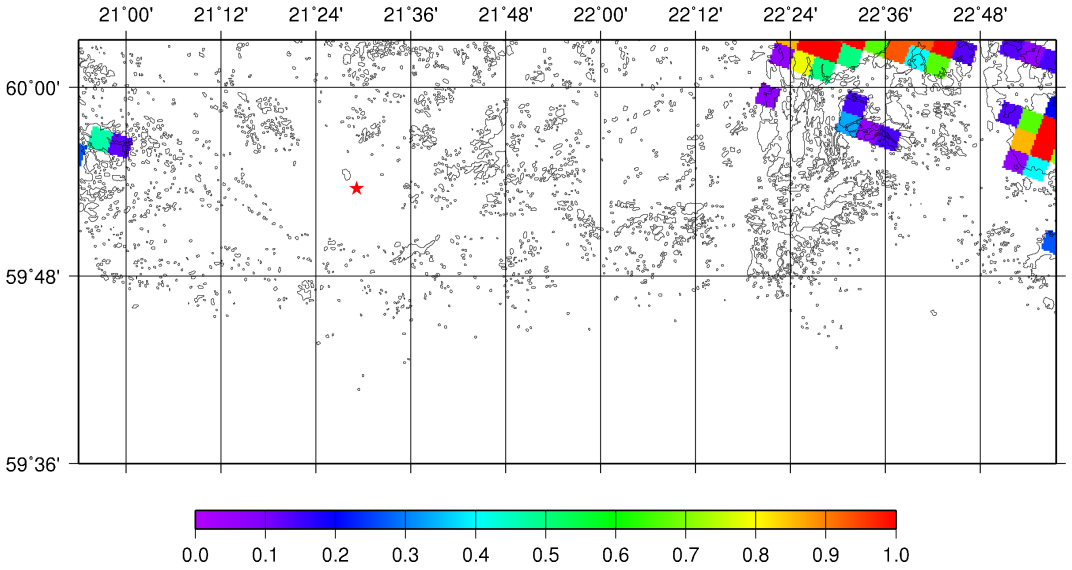
Forecasting, offshore construction,
planning of harbours and coastal construction,
marine spatial planning

Modelling in coastal areas

Irregular shoreline and archipelago is a challenge for both atmospheric and oceanographic models







Wave forecasts for the Archipelago Sea

Wind fields with high spatial and temporal accuracy needed.

Coastal Engineering 83 (2014) 205–220

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Wave modelling in archipelagos

Laura Tuomi *, Heidi Pettersson, Carl Fortelius, Kimmo Tikka, Jan-Victor Björkqvist, Kimmo K. Kahma

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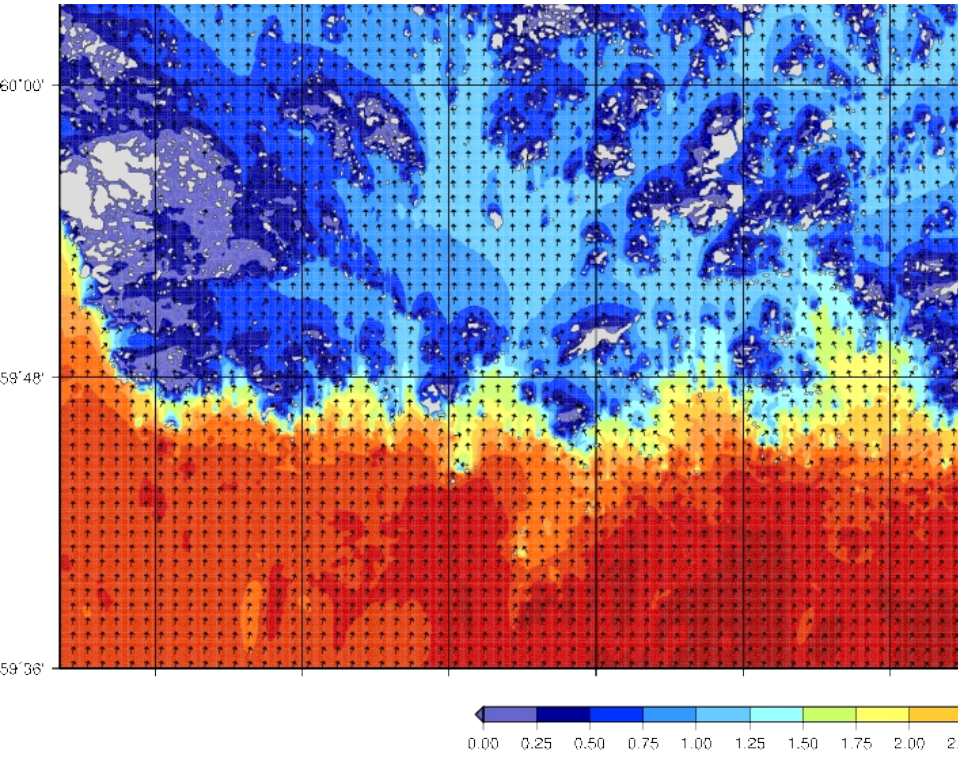
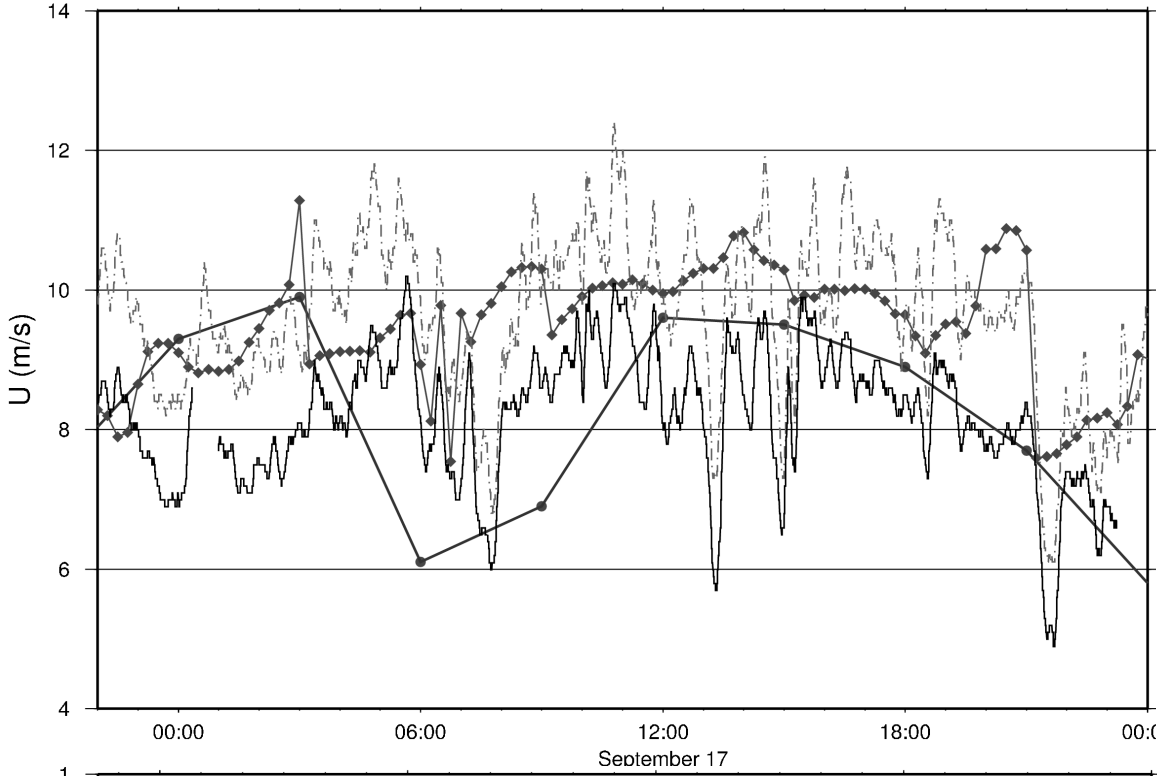
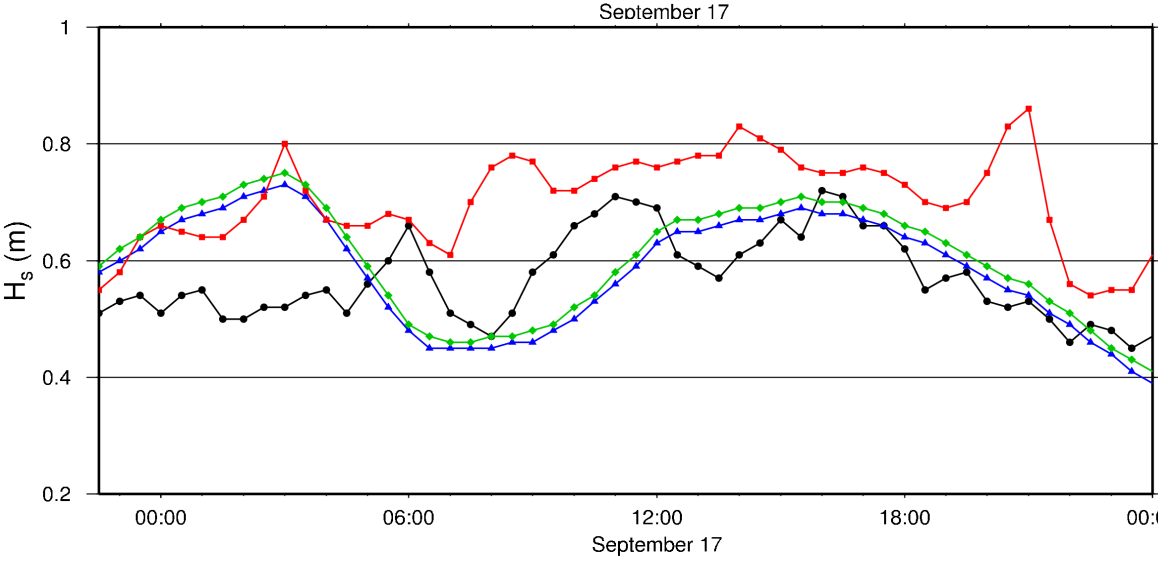
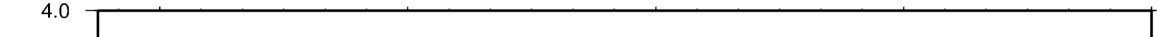
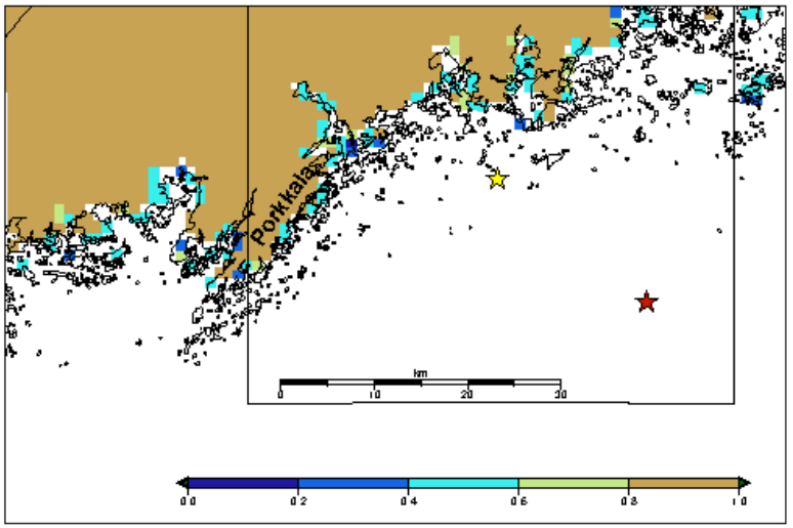








Wave forecasting in coastal areas



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Improved estimates of nearshore wave conditions in the Gulf of Finland

Jan-Victor Björkqvist*, Laura Tuomi, Carl Fortelius, Heidi Pettersson, Kimmo Tikka, Kimmo K. Kahma

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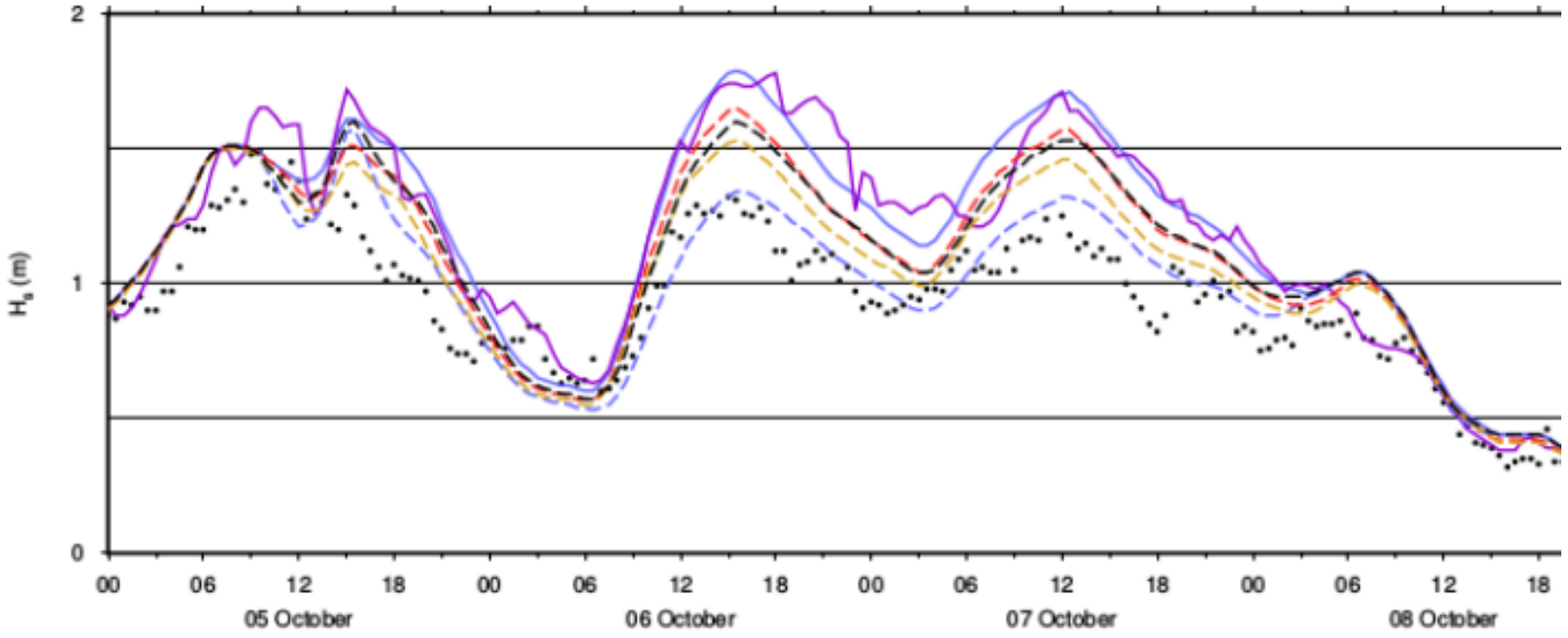

Summary

- Oceanographic models will 'sense' the changes in the accuracy of the meteorological forcing
- Although, verification of wave models will not tell the absolute truth about the accuracy of the forcing fields, it implies the changes in accuracy over the whole Baltic Sea
- HARMONIE results have improved in open sea areas of the Baltic Sea
- Work still needed near the coastal areas