

Applications of Coastal Radars in the Baltic Sea

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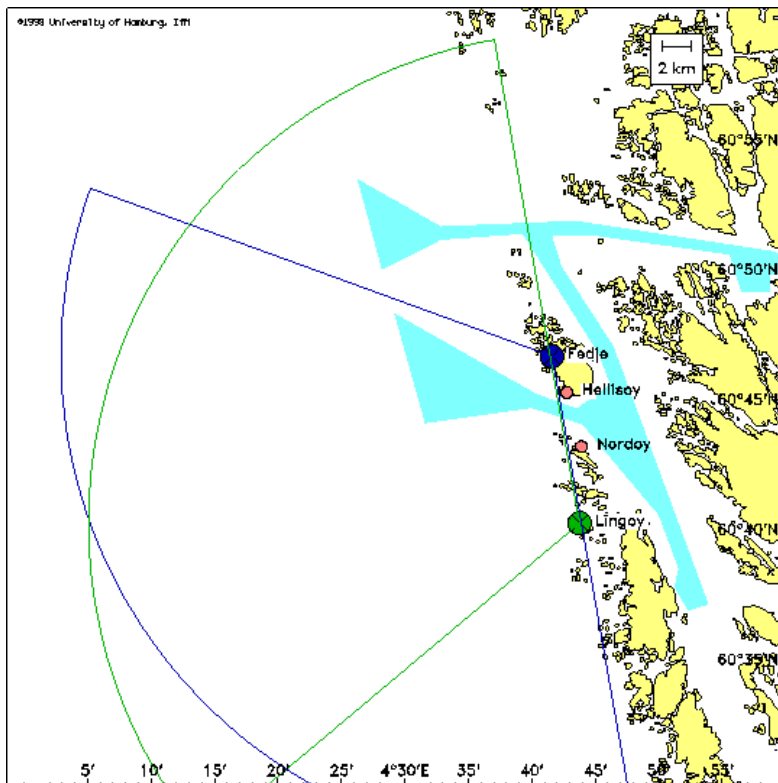
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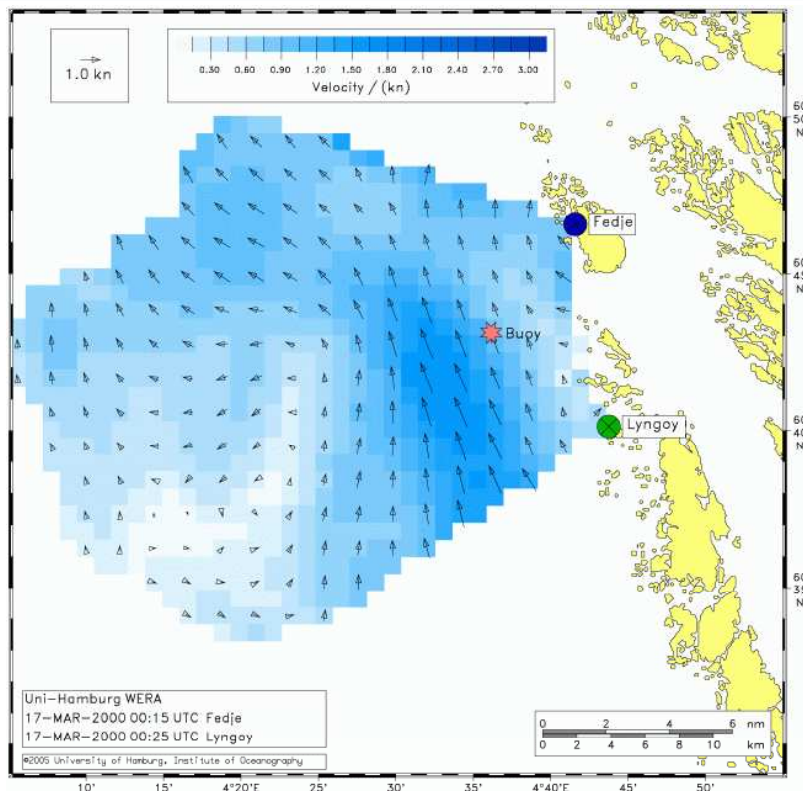
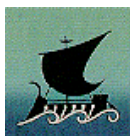
Fedje experiment

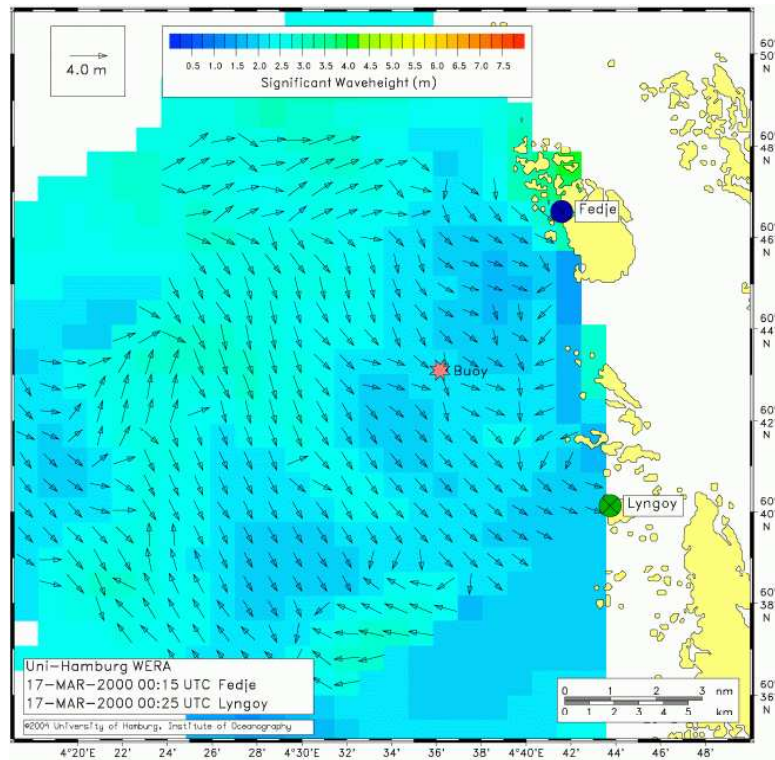
Wera station

- Lingoy
- Fedje

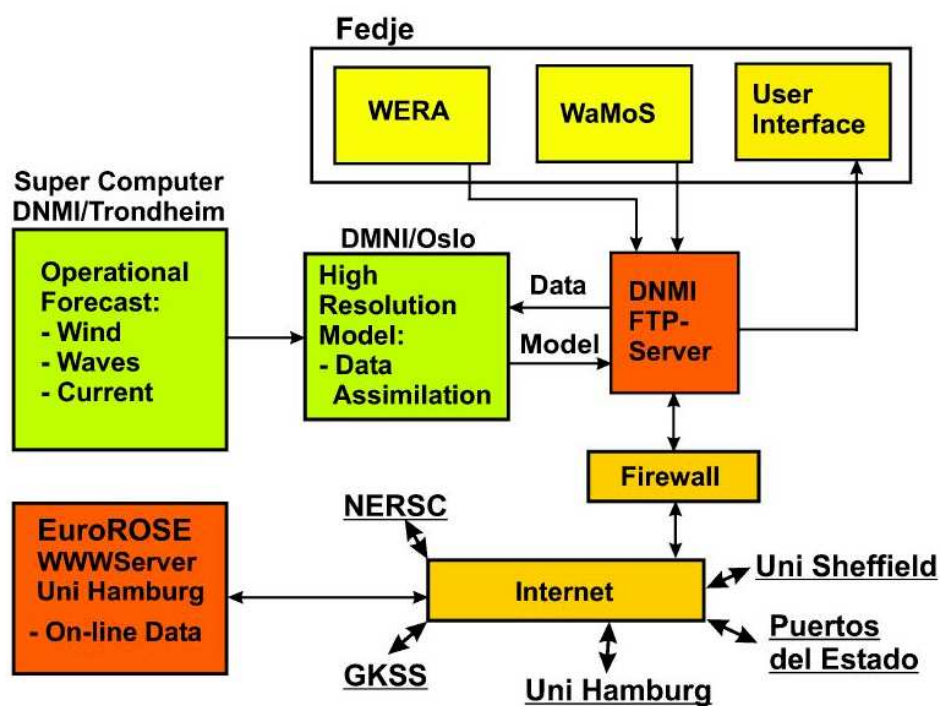
WaMoS station

- Hellisoy
- Nordoy





Data Flow and Communication





sig. Wave Height and Direction

Current Speed and Direction



High-frequency Radar

- 3-30 MHz band (wavelengths between 100m and 10m),
- HF signal is propagated at the electrically conductive ocean water surface,
- It travels well beyond the line-of-sight,
- Signal scatters off a wave that is exactly half the transmitted signal wavelength,
- 5 – 10 minutes to scan and analyse a full current map

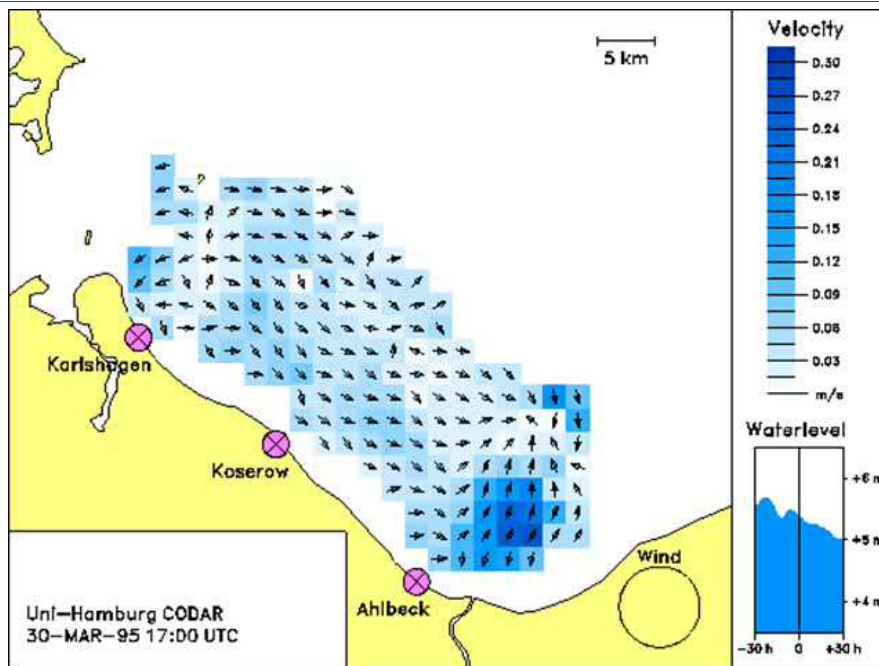
HF-Radar working range, resolution, radar frequency and ocean salinity

f_0 [MHz]	P_{Bragg} [s]	λ_{Bragg} [m]	R_8 [km]	R_{16} [km]	R_{35} [km]	R_{opt} [km]	R_{min} [km]	R_{resol} [km]
8.00	3.47	18.75	107.0	158.5	218.0	300.0	200.0	2.0
12.00	2.83	12.50	65.0	100.0	143.0	180.0	115.0	1.5
16.00	2.45	9.38	45.5	70.5	102.5	130.0	75.0	1.2
20.00	2.19	7.50	34.0	53.0	78.0	100.0	60.0	1.0
25.00	1.96	6.00	25.5	40.0	59.5	75.0	45.0	0.5
30.00	1.79	5.00	20.0	32.0	47.0	50.0	30.0	0.25

- f_0 Radar frequency
- P_{Bragg} Period of Bragg scattering ocean wave
- λ_{Bragg} Length of Bragg scattering ocean wave
- R_8 Working range at 8 PSU salinity (propagation model)
- R_{16} Working range at 16 PSU salinity(propagation model)
- R_{35} Working range at 35 PSU salinity(propagation model)
- R_{opt} Working range at 35 PSU salinity, optimum sea state (literature)
- R_{min} Working range at 35 PSU salinity, high sea sea state (literature)
- R_{resol} Highest range resolution possible

Change in Working Range:
Atlantic □ Baltic Sea: -50%

Example: Application in the Baltic Sea



7 PSU

29.85 MHz Radar
Frequency

Other Parameter High-frequency Radar

- The working range for wave measurements is less than the maximum ranges for current because a higher signal to noise ratio is necessary.
- Empirical algorithms exist to extract significant wave height and wind direction from the radar return.
- Ship detection is possible

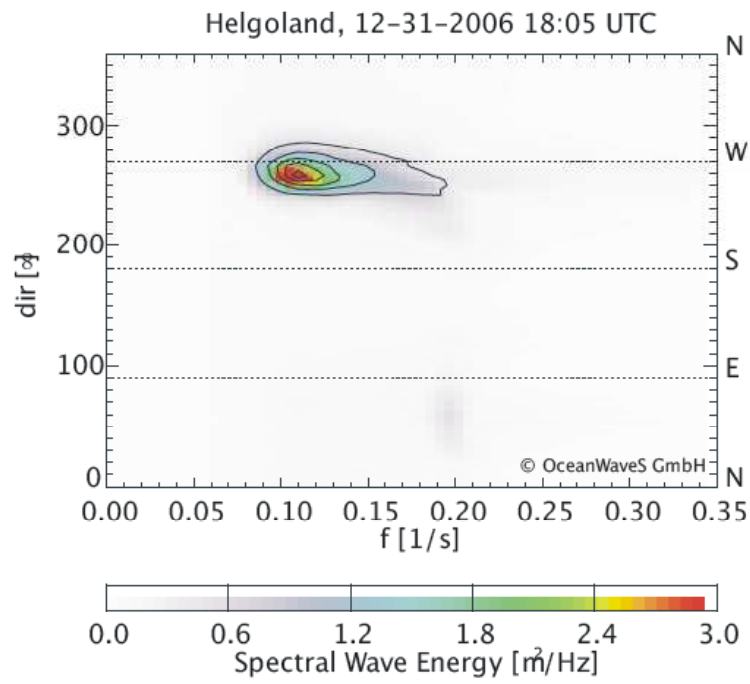
More detailed information and examples are presented at the web sides:

- <http://ifmaxp1.ifm.uni-hamburg.de/WERA.shtml>
- <http://www.codar.com>

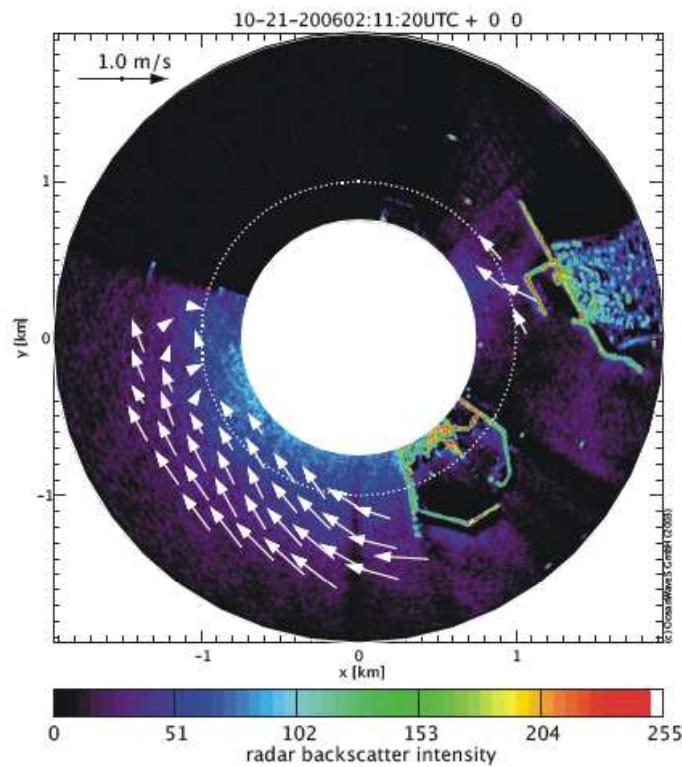
Micro Wave Radar

- Microwave radars mainly use available marine X-Band radar.
- The electromagnetic wave length is a few centimetres.
- The operating range is from 0.1 km to 3 km and depends on the wind speed and on the installation height.
- The spatial and temporal changes of the radar backscatter from the sea surface (sea clutter) are analyzed to determine directional wave and surface current information.
- The wave frequency range is 0.02 Hz - 0.35 Hz (Wave periods 50 s - 3 s)
- The minimum wind speed required for measurements is 3 m/s.
- The complete two-dimensional wave spectrum is derived.
- The surface current vector is average over the analysis window (normally 200 by 400m) and an upper surface layer of a few metres depending on the sea state.

Wave Spectrum (WaMoS II)



Current Map (WaMoS II)



- individual waves,
- bathymetry maps,
- Wind speed maps

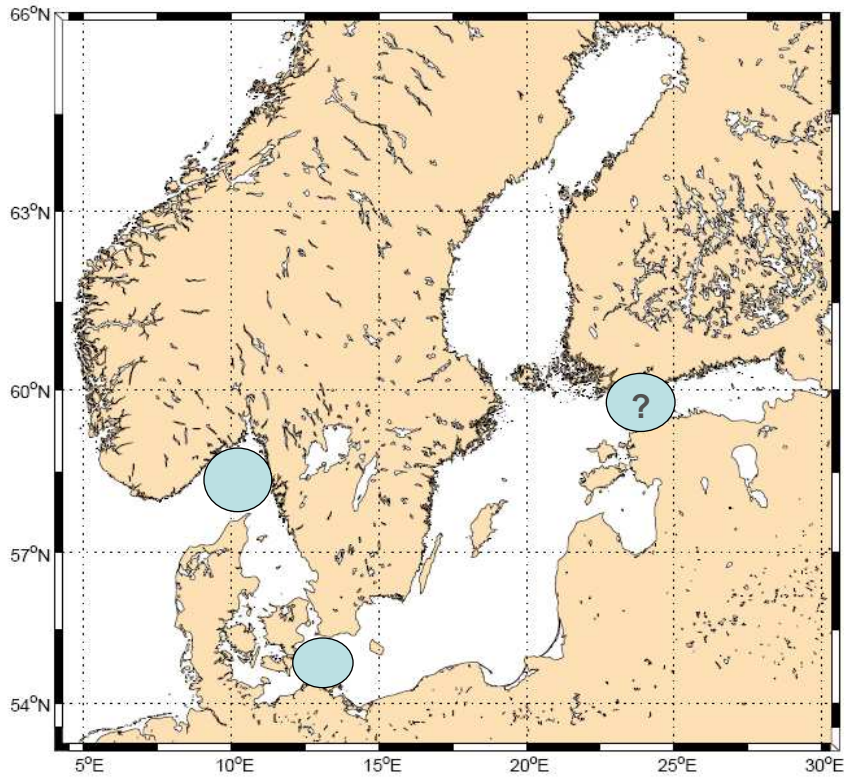
More detailed information and examples are presented at the web sides:

- <http://www.oceanwaves.de>
- <http://miros.no/wavex.php>

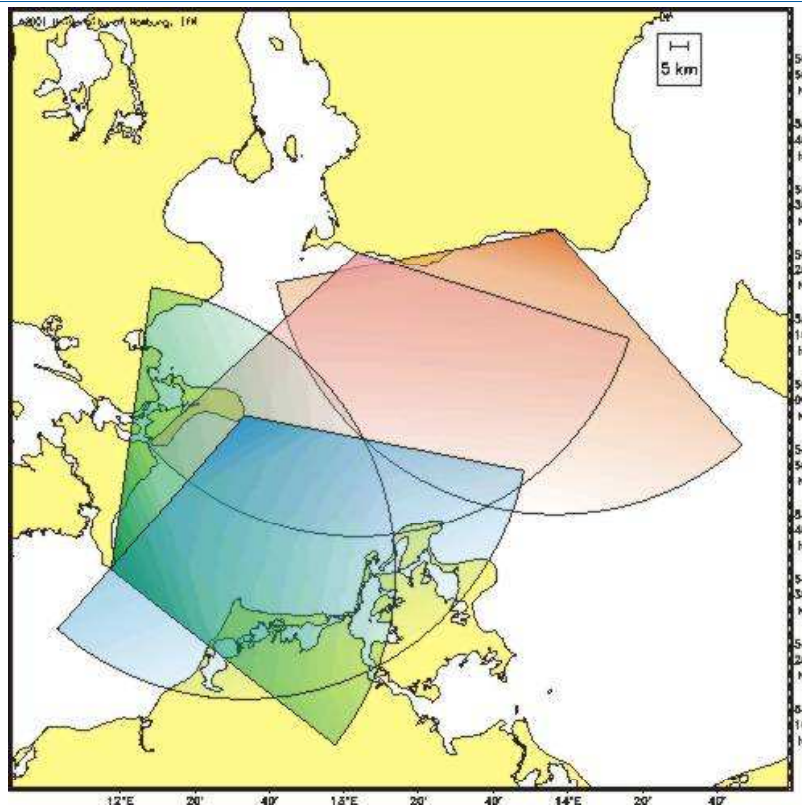
Possible sites in the Baltic Sea

HF Radar in the Baltic Sea for operational monitoring is a compromise between working range and range resolution, because of the relatively low salinity.

- § **to monitor the in- and outflow of the Baltic Sea water through the straits between Denmark and Germany with a high resolution of a few 100 m.**
- § **to monitor the structure of the current and wave patterns in a larger area (range of about 50 km) in the southern Baltic Sea e.g. between Denmark, Germany and Sweden with a resolution of about 1 km.**
- § **to monitor near costal areas or bays further East and North (ranges up to 30 km, resolutions about 500 m – 1 km).**



Coverage of the Arkona Basin by four HF-radars



- Wave measurements at sites exposed to the sea like lighthouses, coastal cliffs, off-shore platforms or open port approaches. Special sites have to be proposed by local authorities.
- Highly recommended is to combine the radar with ferrybox measurements on ships, which would allow getting objective wave measurement together with the other observations. In particular this will be a unique opportunity to measure full wave information in the open Baltic Sea.
- For current measurements the system is mainly interesting for the straights between Denmark, Germany and Sweden mounted e.g. on the bridges to monitor in- and outflows.