

**10<sup>th</sup> Session of the GLOSS Group of Experts**

**A Workshop on Real-time Transmission and Processing Techniques:  
Improving the Global Sea Level Observing System's contribution to  
multi-hazard warning systems**

**Intergovernmental Oceanographic Commission of UNESCO**

**Paris, France**

**5<sup>th</sup> of June 2007**

# Application of Radar Gauges to Measure the Water Level and the Sea State

by

Christoph J Blasi

Federal Institute of Hydrology

Department of Hydrometry and Hydrological Survey

Am Mainzer Tor 1

D - 56002 Koblenz, Germany

# **Investigation of radar gauges**

**The Federal Institute of Hydrology made the first investigation of radar devices in the year 2000**

**Additional tests were made as radar technology developed to understanding the core foundation for measurement of:**

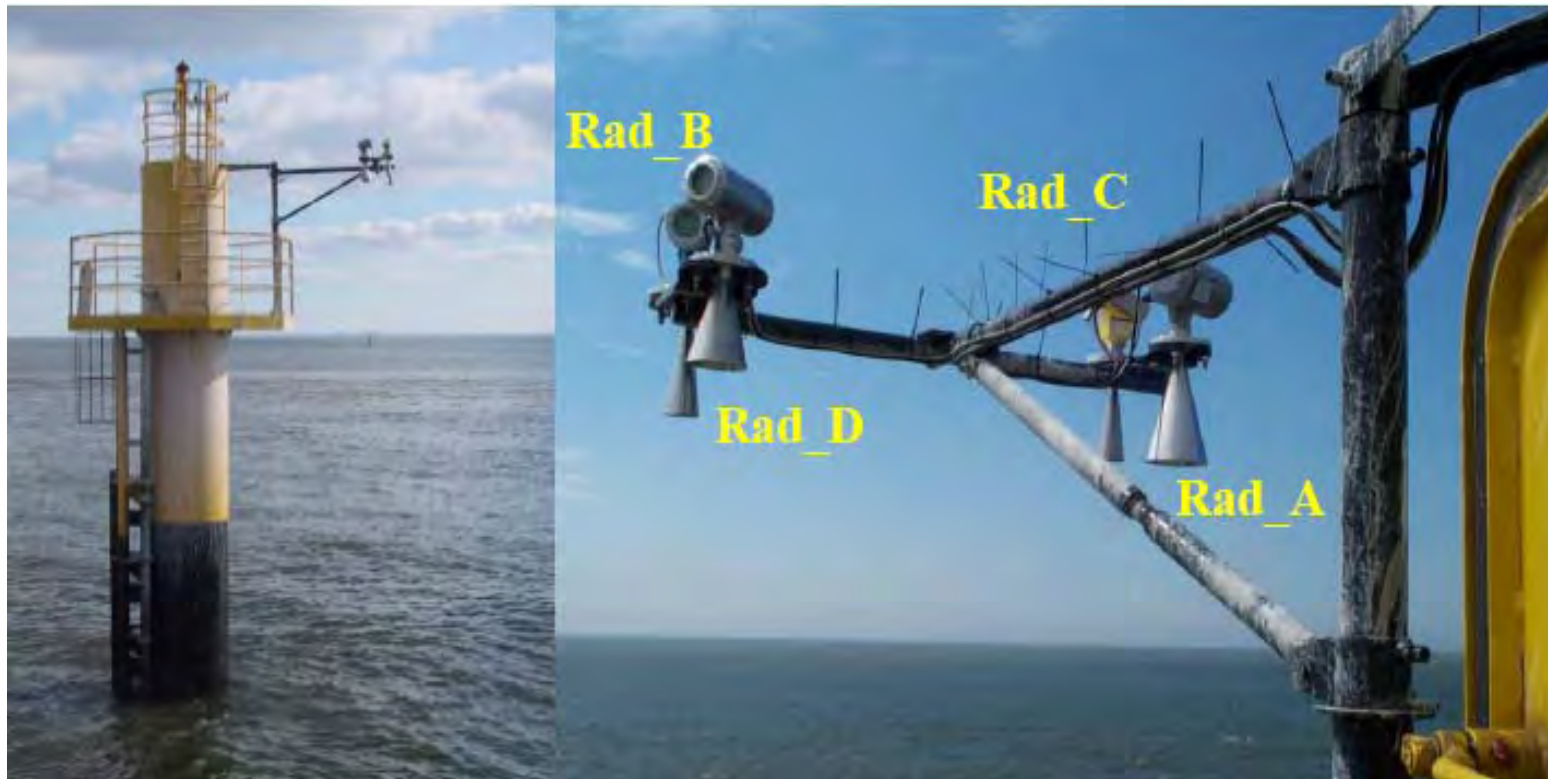
- Waves**
- Sea State**
- Water Level**
- Thickness of Ice**

**Results: <http://www.bafg.de/servlet/is/7833/> (app. 270 pages)**

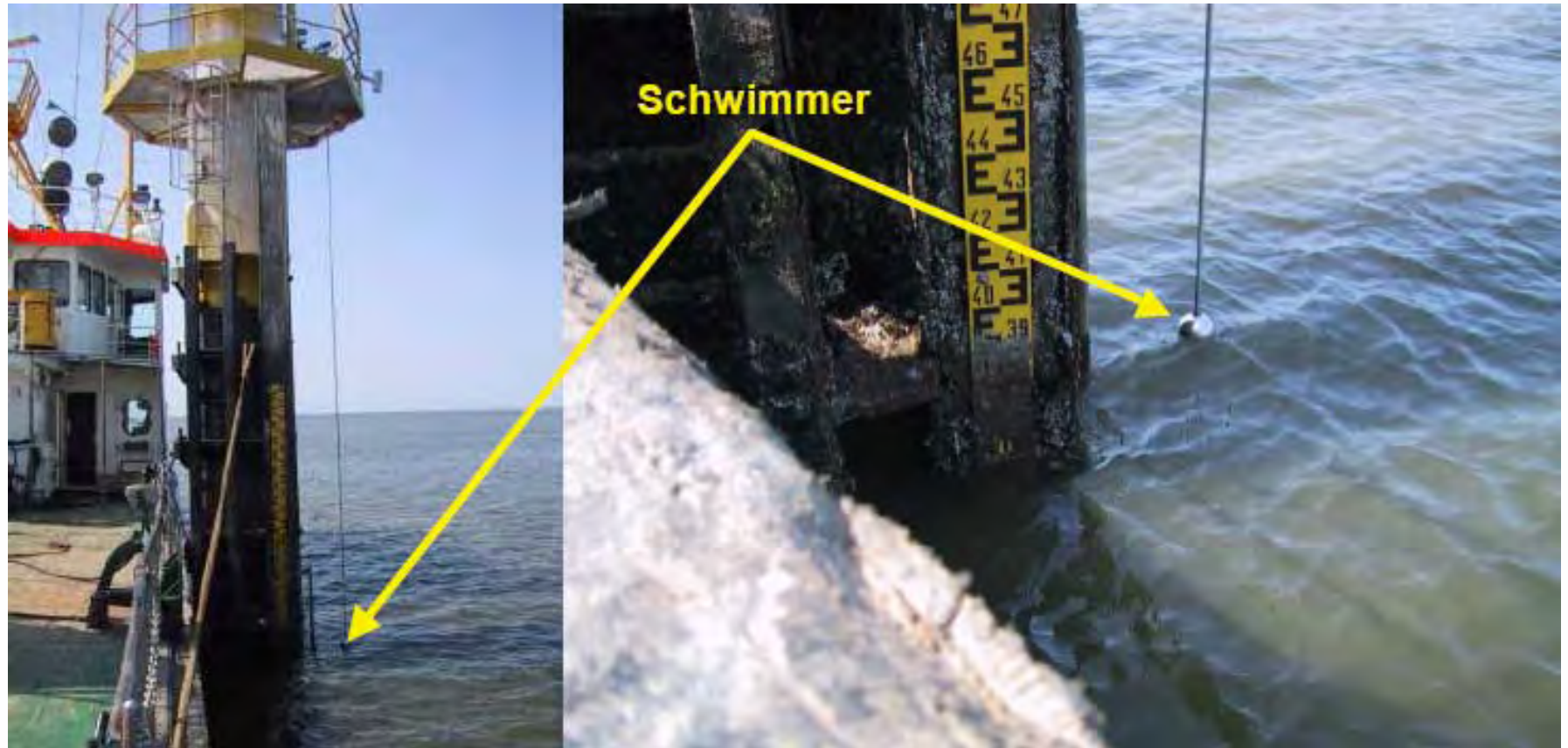
# Field test at Tide Gauge 'Borkum Südstrand'



# The Installation of the Radar Devices



# Reference: Magnetostrictive - Sensor



# **Environmental Condition at Field Site**

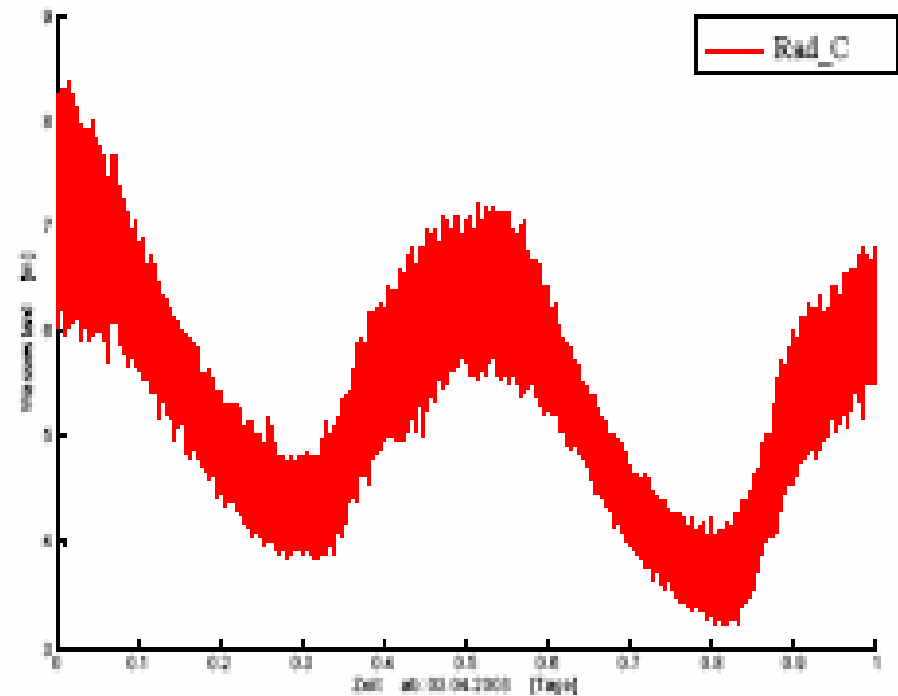
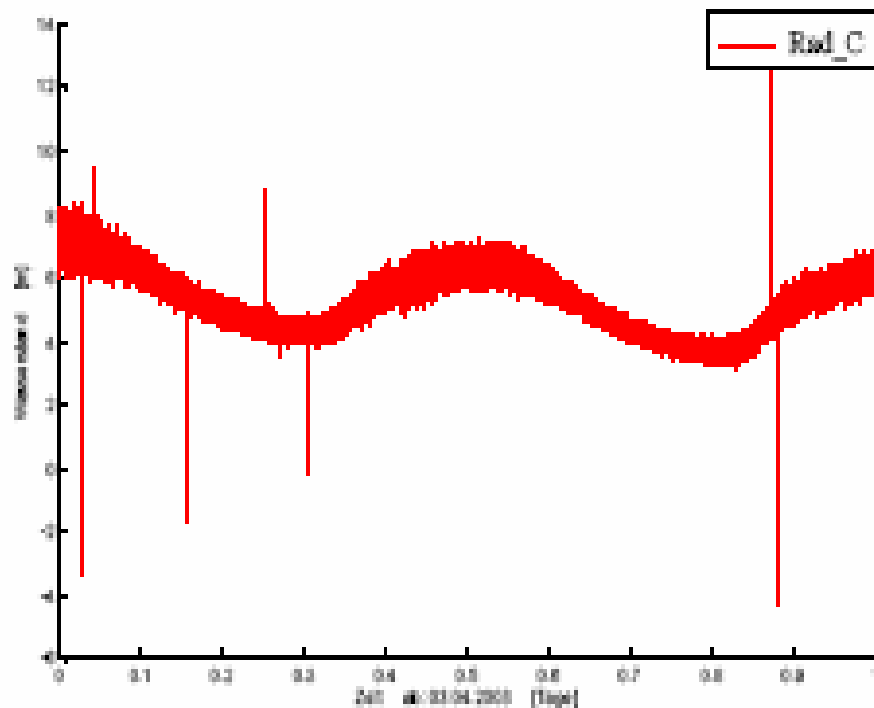
- Tidal Range**
- Various Types of Waves**
- Sea State**
- Rough Sea**
- Change of Salinity**
- Saline Air**
- Annual Temperature Variation**

# Impression of the condition at the test site

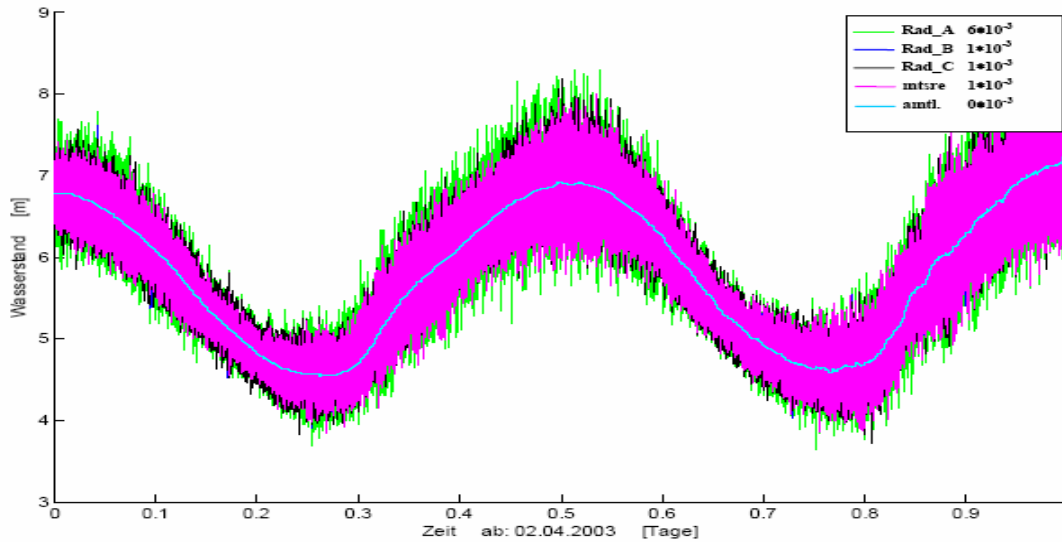




# Collected data over a time period of 24 hours



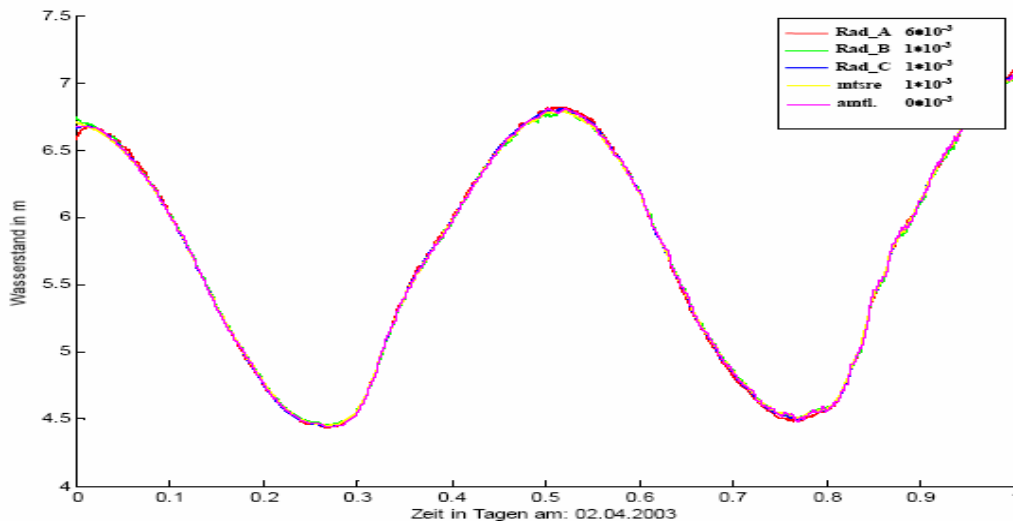
# Water levels with exponential smoothing



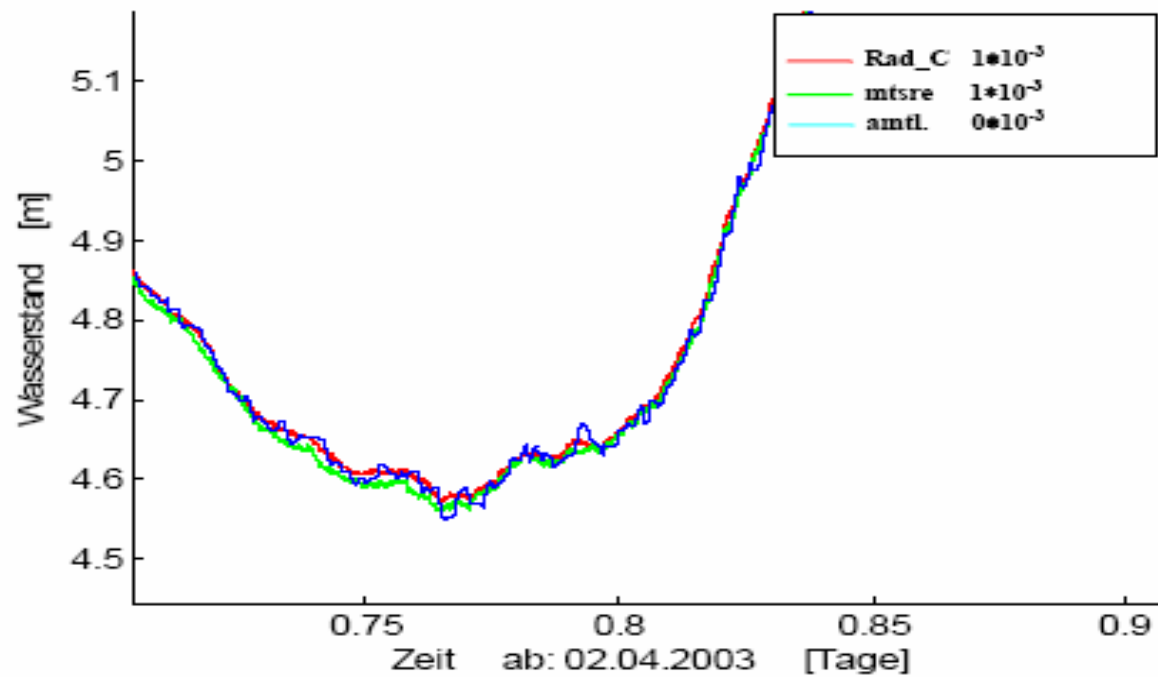
## Smoothing of water levels

Weighting factor of 0.001,  
sample rate 1.3 Hz

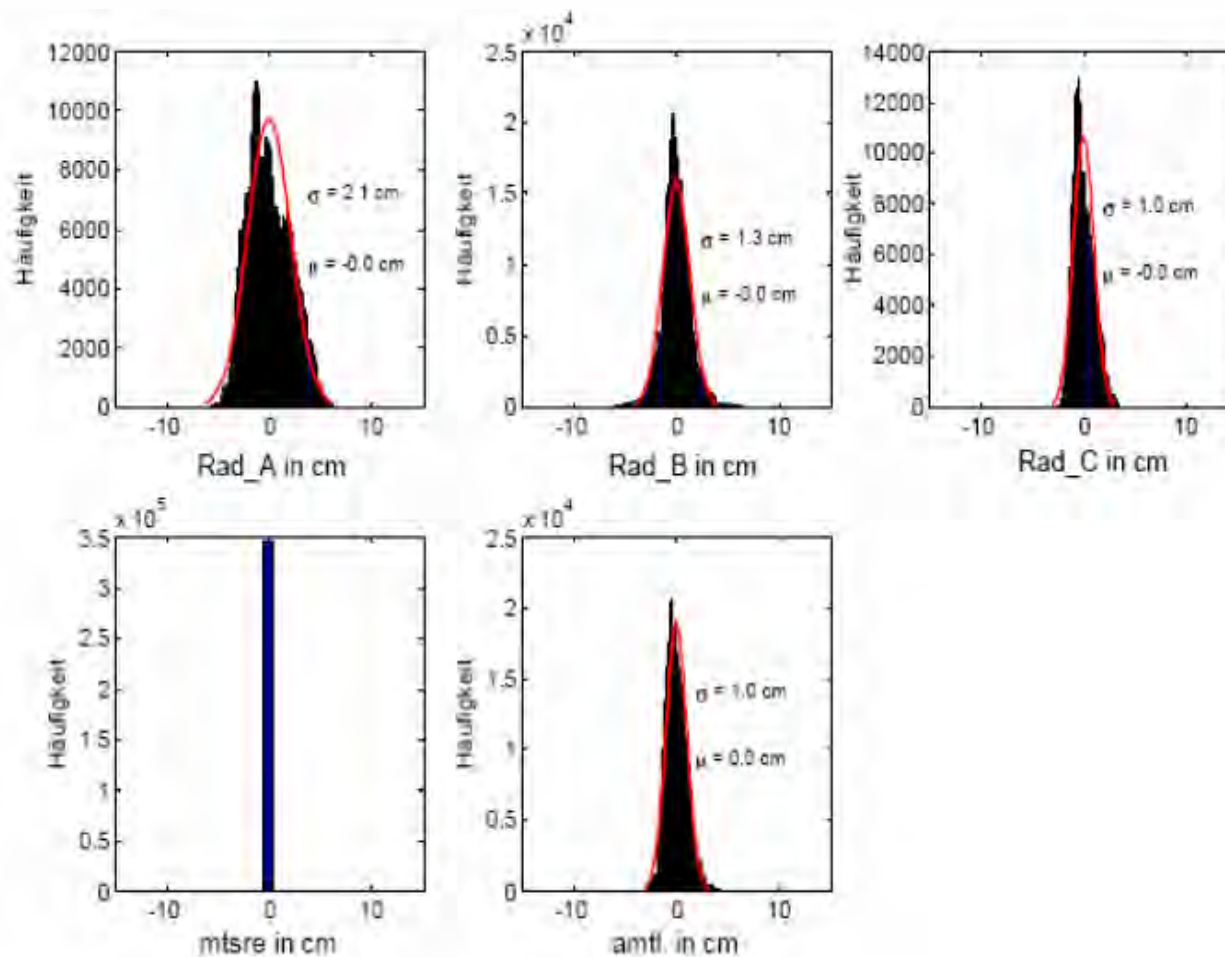
$$x_{i(\text{geglättet})} = \alpha x_i + (1 - \alpha) x_{i-1(\text{geglättet})}, \quad \text{mit } \alpha = 1 \dots 0$$



# Water level in more detail



# Error probability



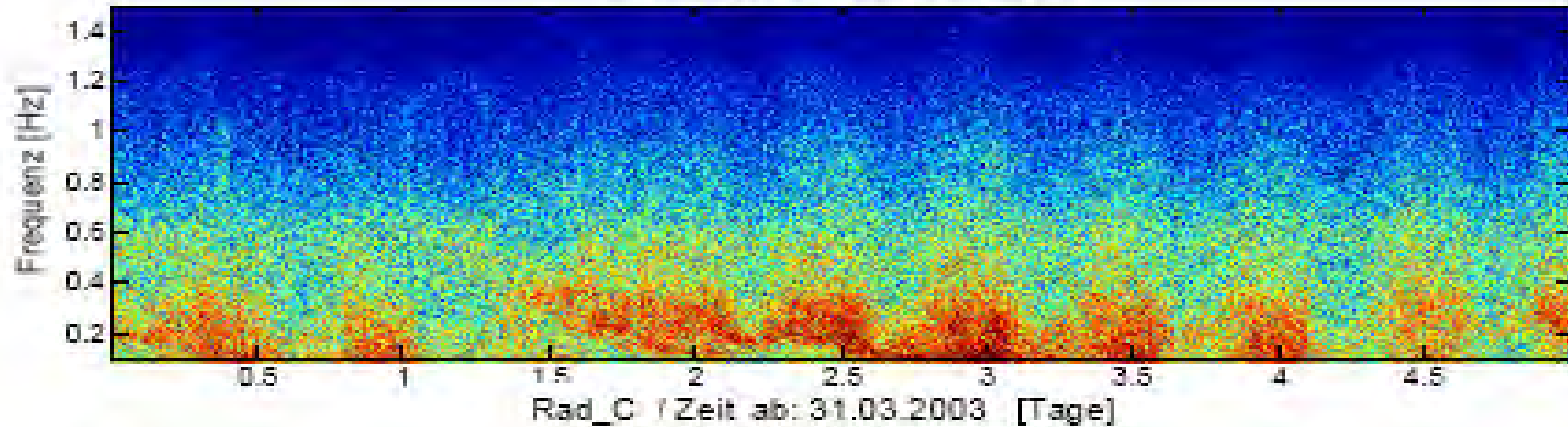
# **Measuring the Sea State we need: Very fast measurements of water level**

**Very fast means:**

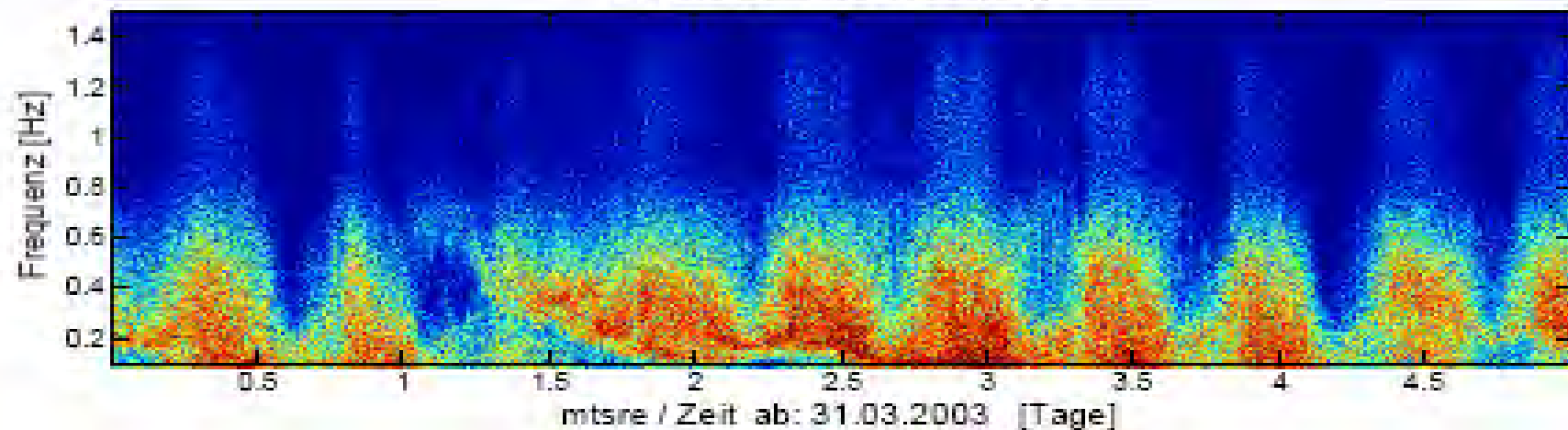
**Use a radar device, which is able to measure water level in high frequency and low noise level.**

# Spectrogramme of the Sea State Reference vs Rad\_C during rough sea

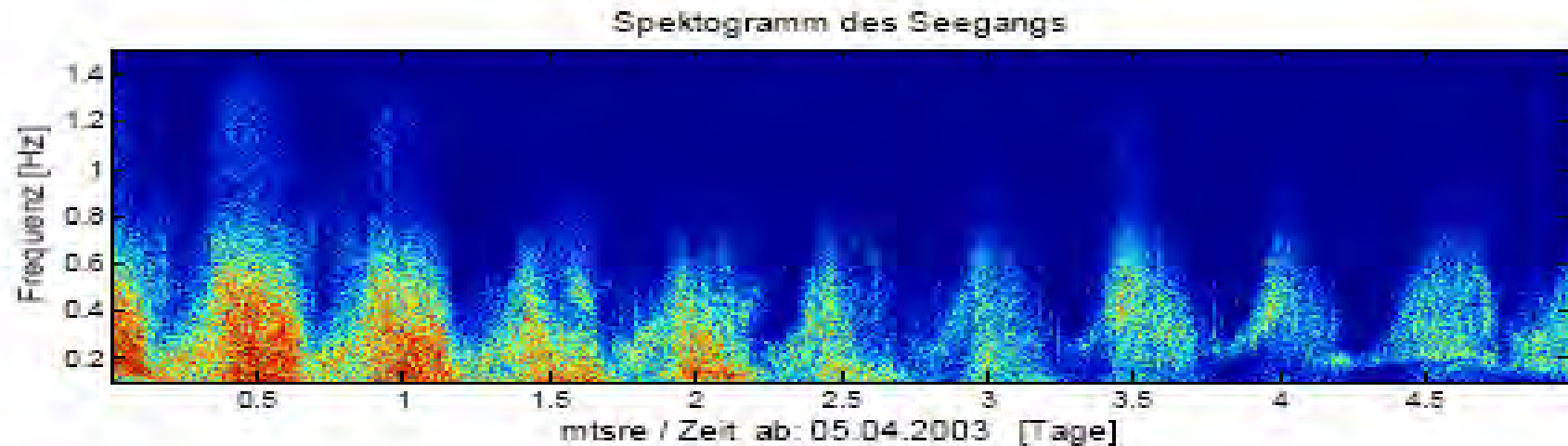
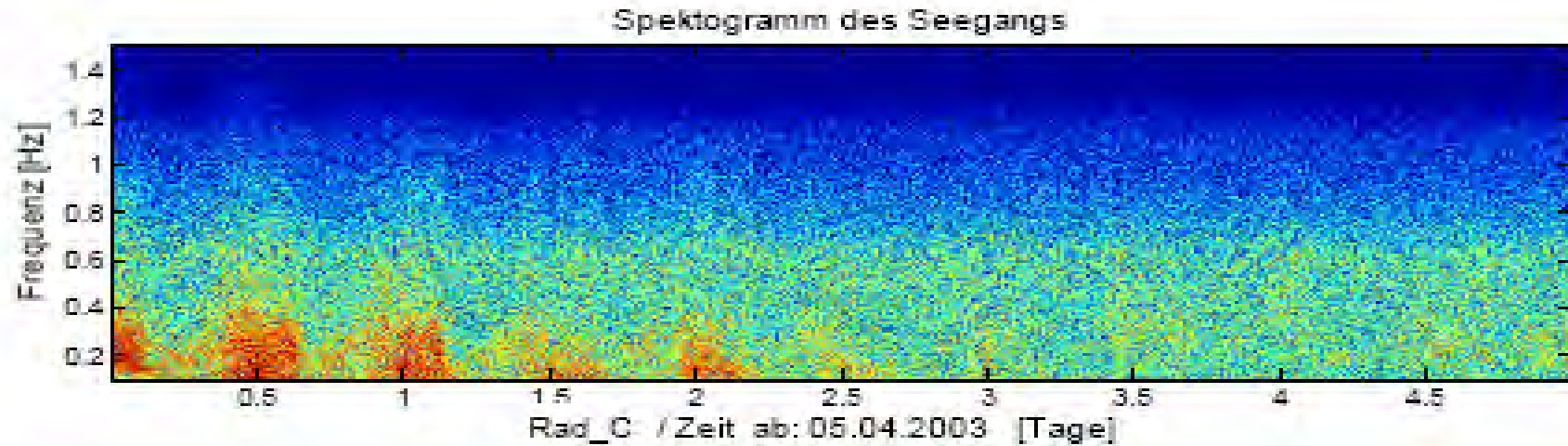
Spektrogramm des Seegangs



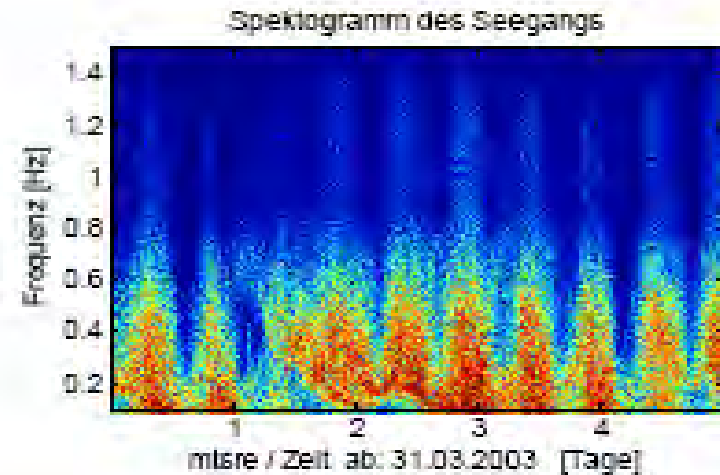
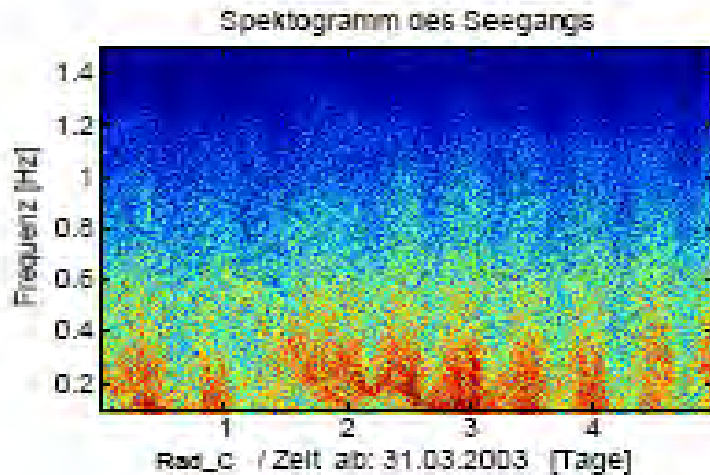
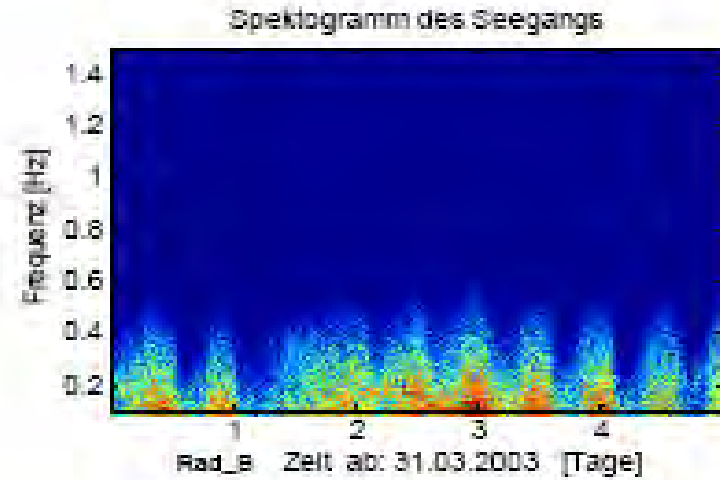
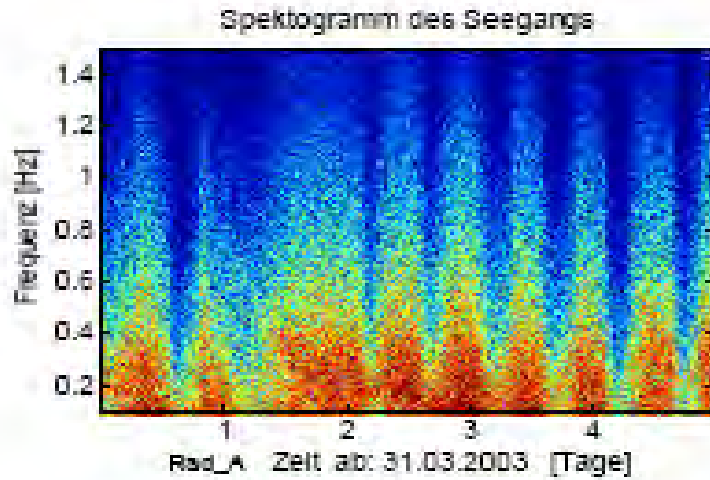
Spektrogramm des Seegangs



# Spectrogramme of the Sea State Reference vs Rad\_C during flat sea

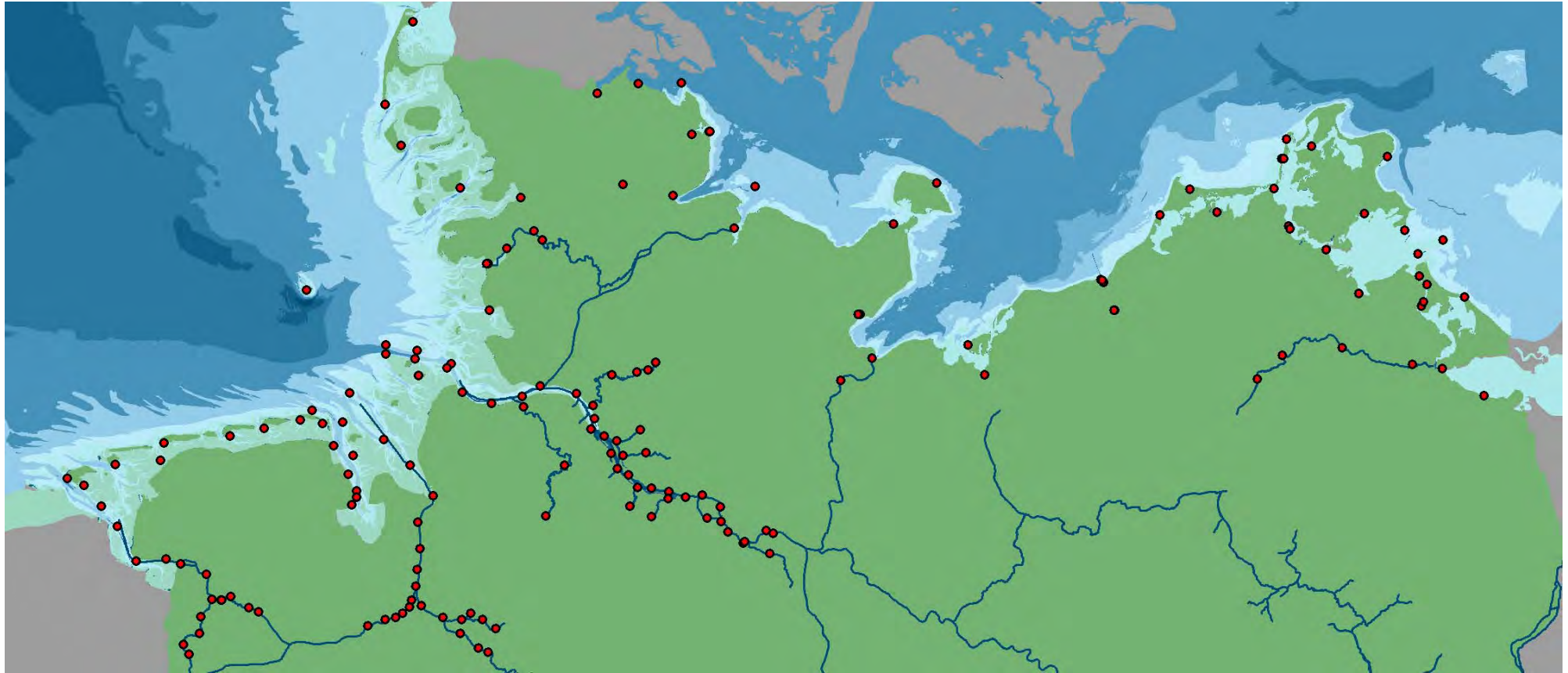


# Spectrogrammes of all radar sensors during rough sea





# Measuring of Waves at Light House 'Alte Weser'



# Measuring of Waves at Light House 'Alte Weser'

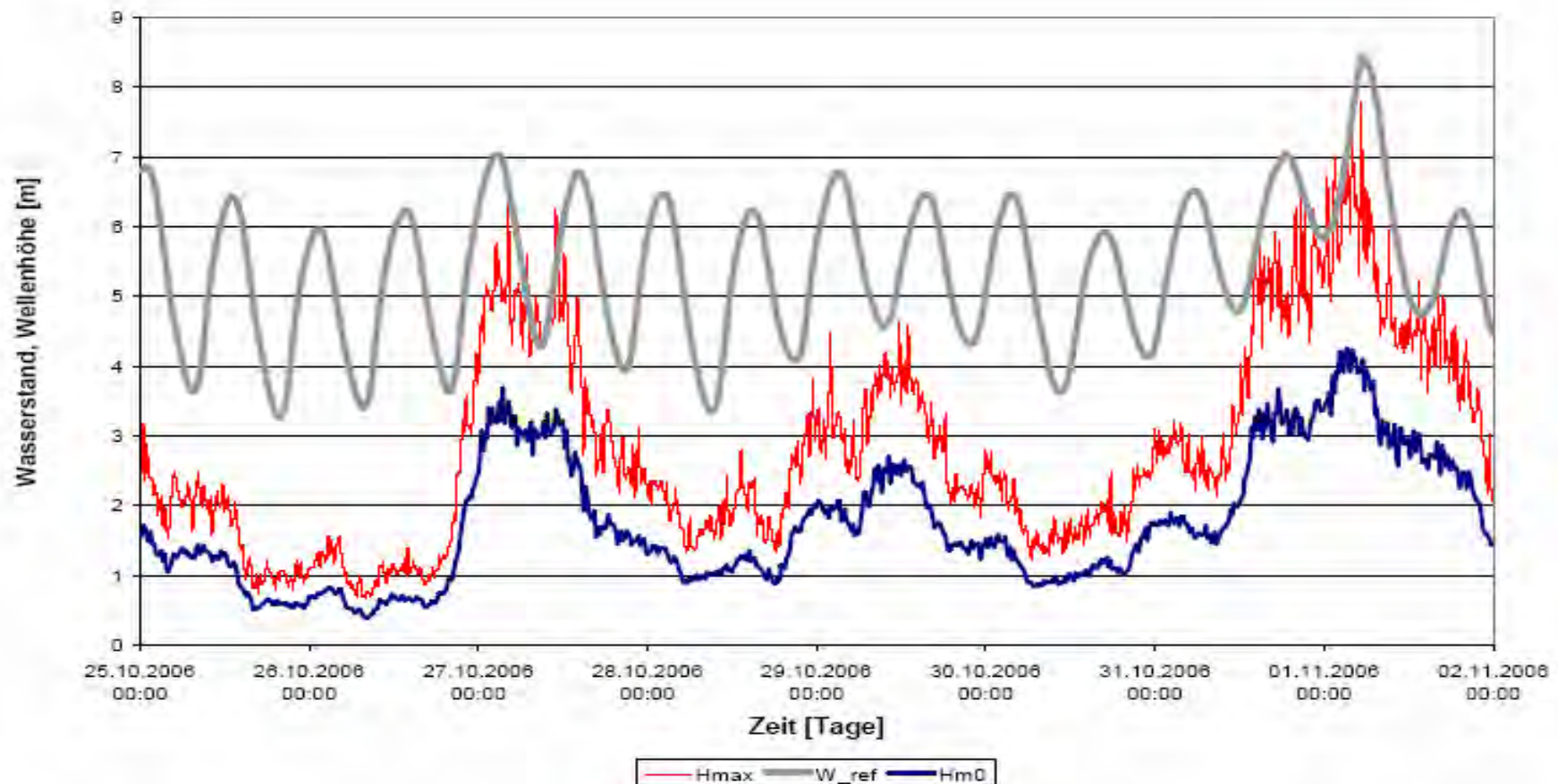


# Analysed data during the storm on the 1<sup>st</sup> of November 2006

Water level

Significant wave height

Highest values

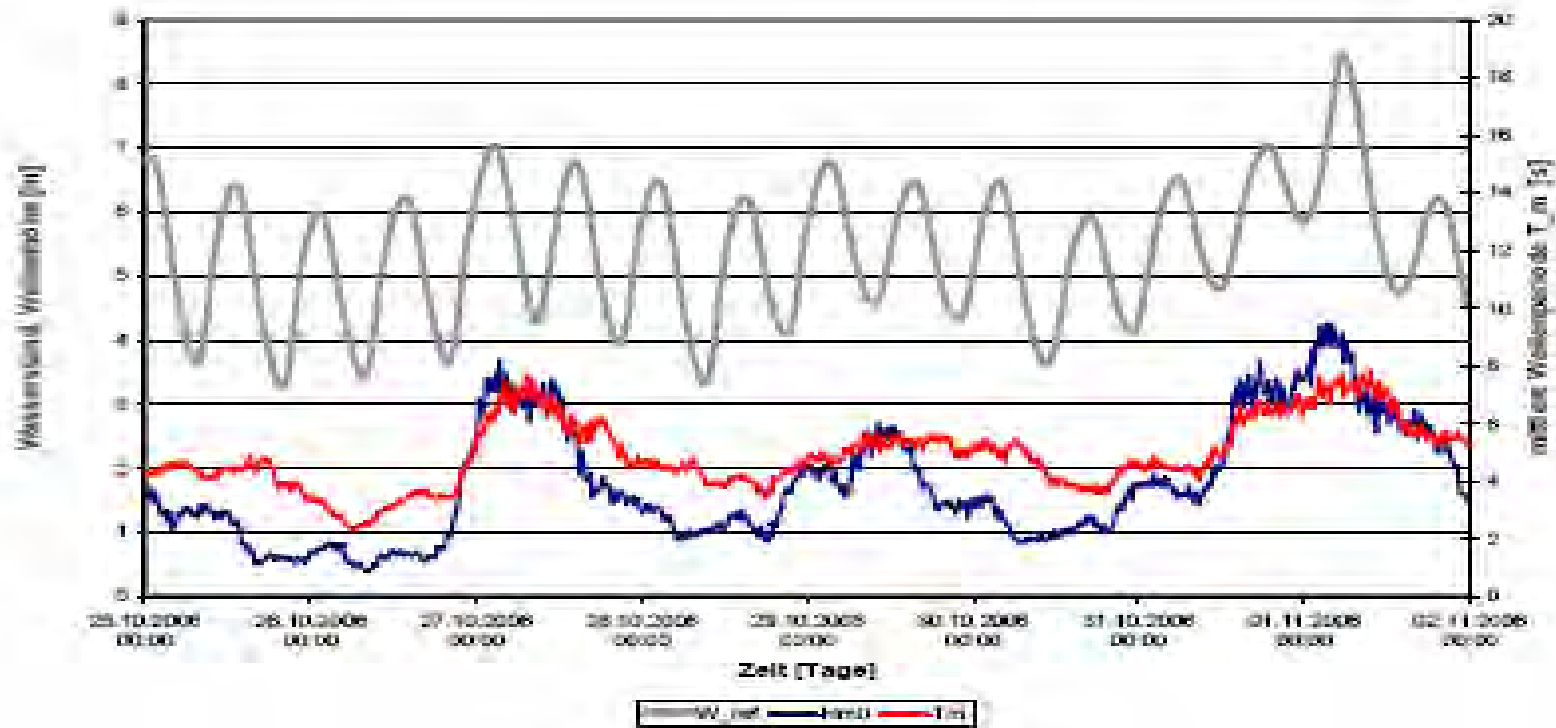


# Analysed data during the storm on the 1<sup>st</sup> of November 2006

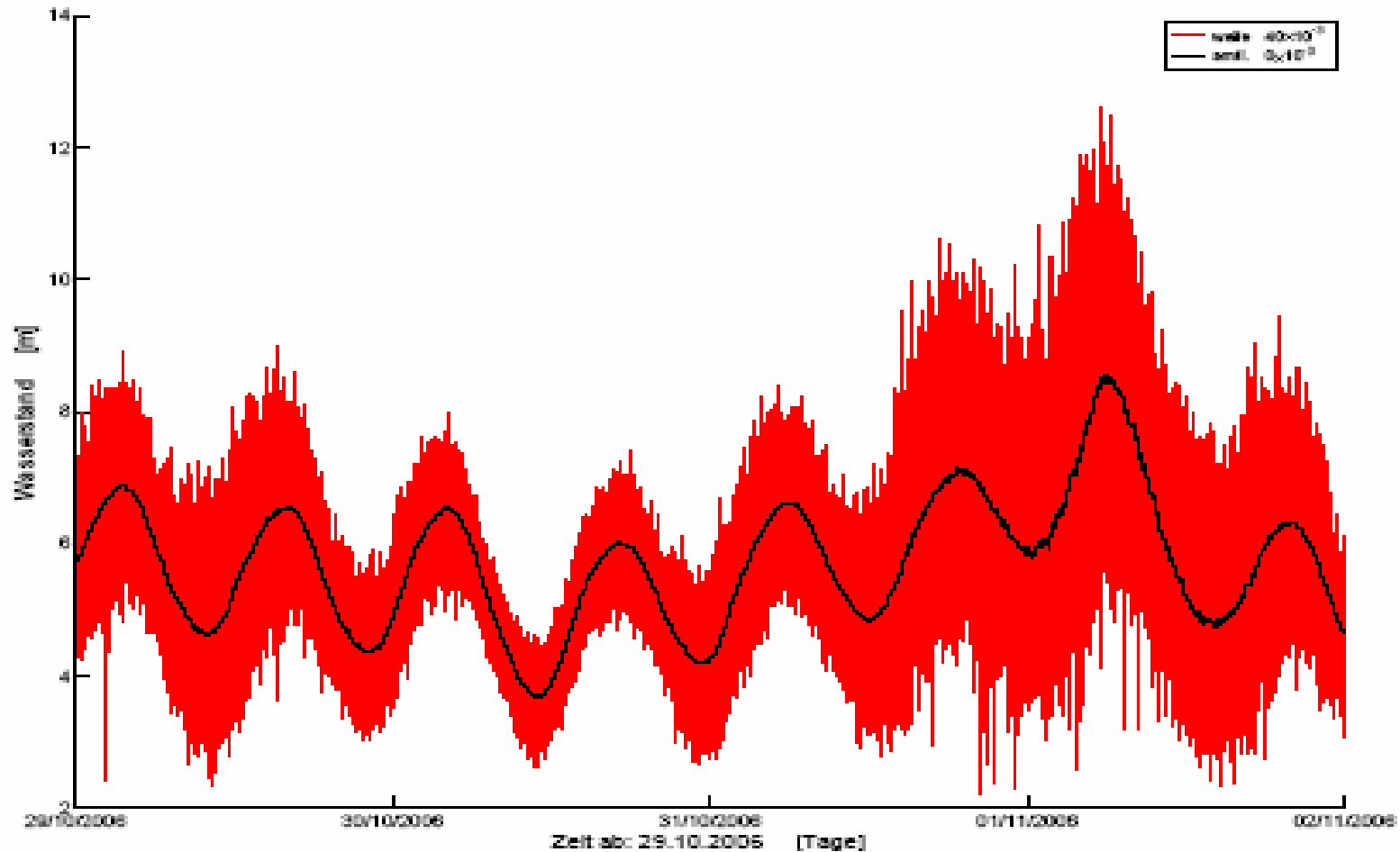
Water level

Significant wave height

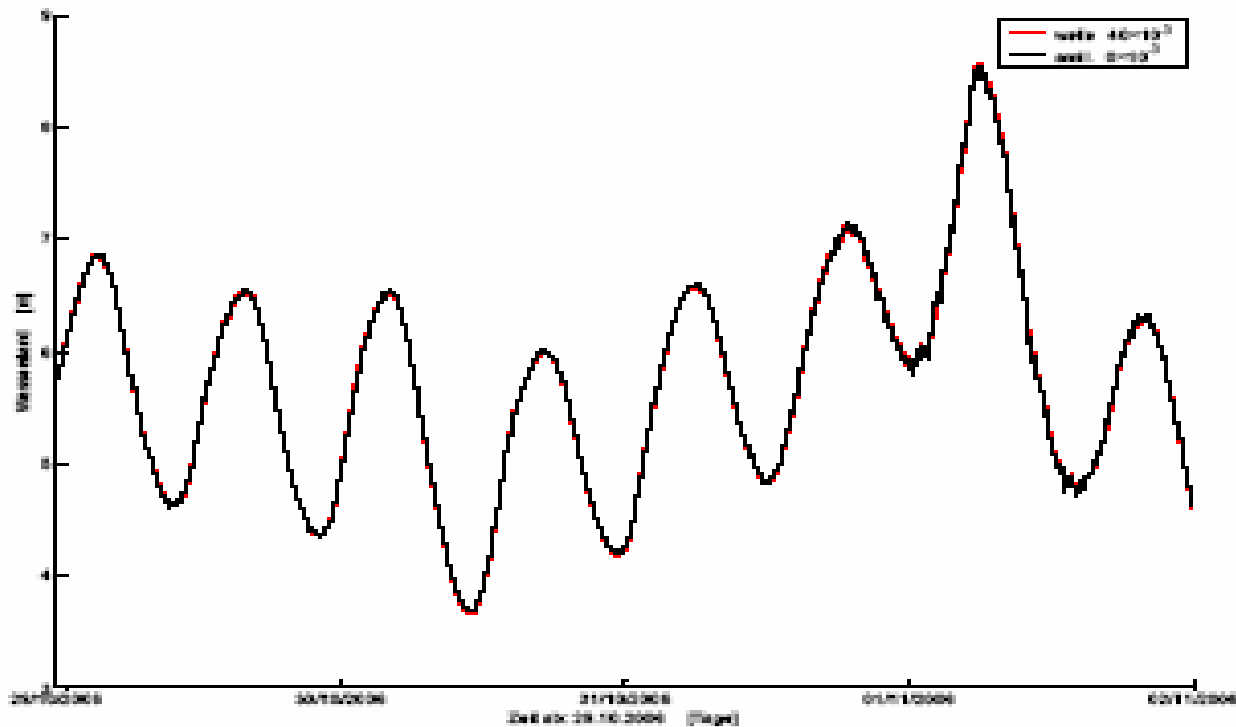
Mean wave period



# Collected data during this event



# Radar gauge versus official tide gauge



# **Conclusion**

**Radar sensors are useful devices to measure both**

**Water level and the Sea state**

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Thank you for attention