

WaMoS II - Wave Monitoring System



X-Band radar as a tool to determine spectral and single wave properties

**Konstanze Reichert
November 2004**

WaMoS II - Wave Monitoring System



- ☆ History of WaMoS II – 25 Years of progress
- ☆ Application of WaMoS II for offshore and shipping
- ☆ WaMoS wave data
- ☆ MaxWave & SinSee- Single wave detection
- ☆ Recent developments and future applications

WaMoS II - Wave Monitoring System



15 Years of WaMoS development at the German research centre GKSS

1991, 1992, 1995 Testing of the equipment on German RV Gauss,

1994/1996 Technology transfer to commercialise WaMoS II

1997: Prototype of today's WaMoS Technology – deep water applications

1998: Operational Measurements in shallow waters and on board ships

1998: Since then continuous participation in international research projects

2001: Type approval by Germanischer Lloyd and Det Norske Veritas

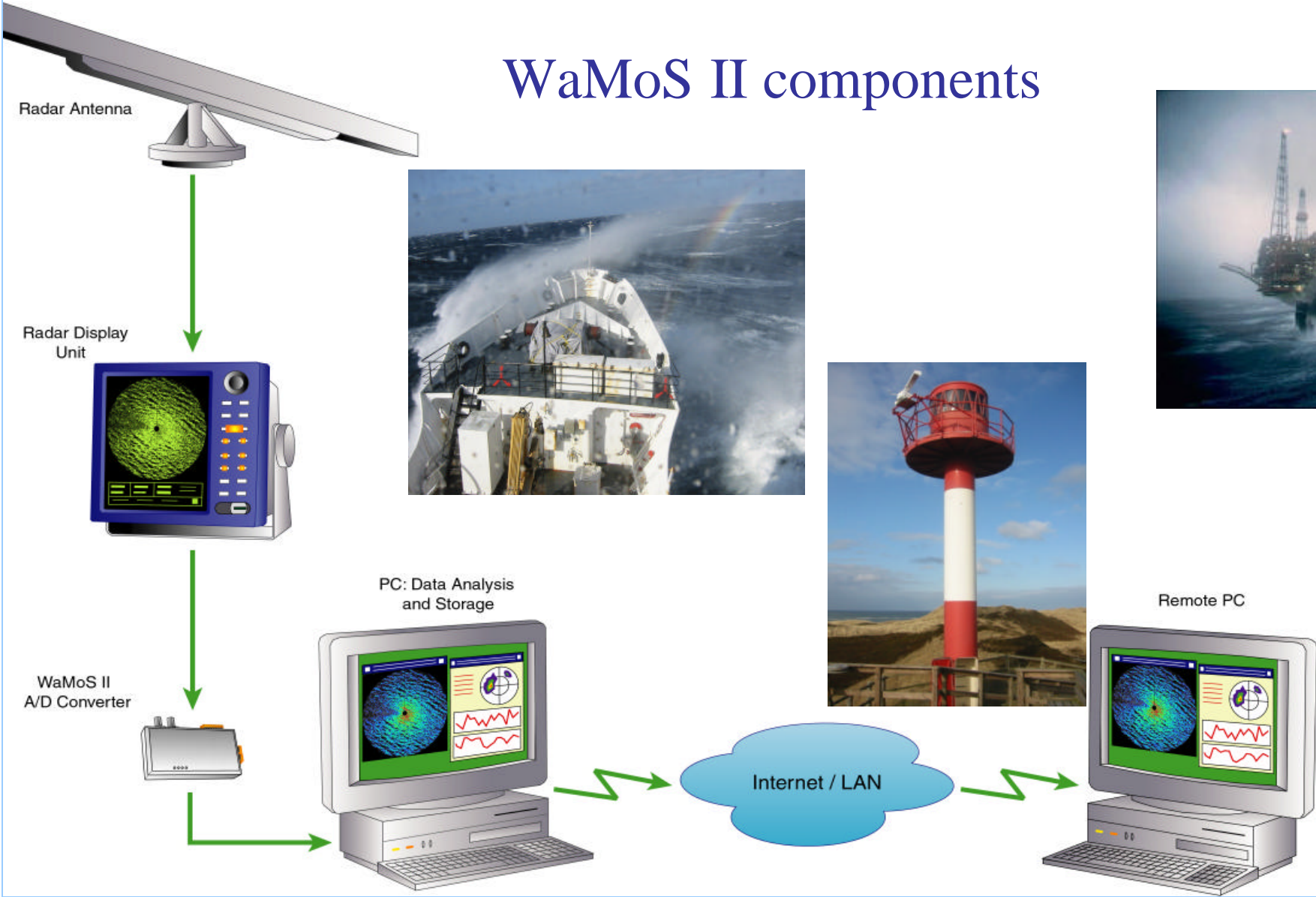
2003: MaxWave- Beginning of single wave detection - continued

2004: Implementation of high resolution bathymetry and current measurements

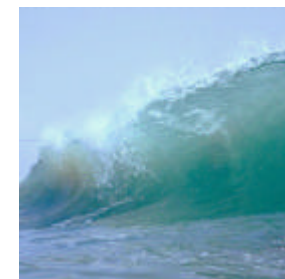
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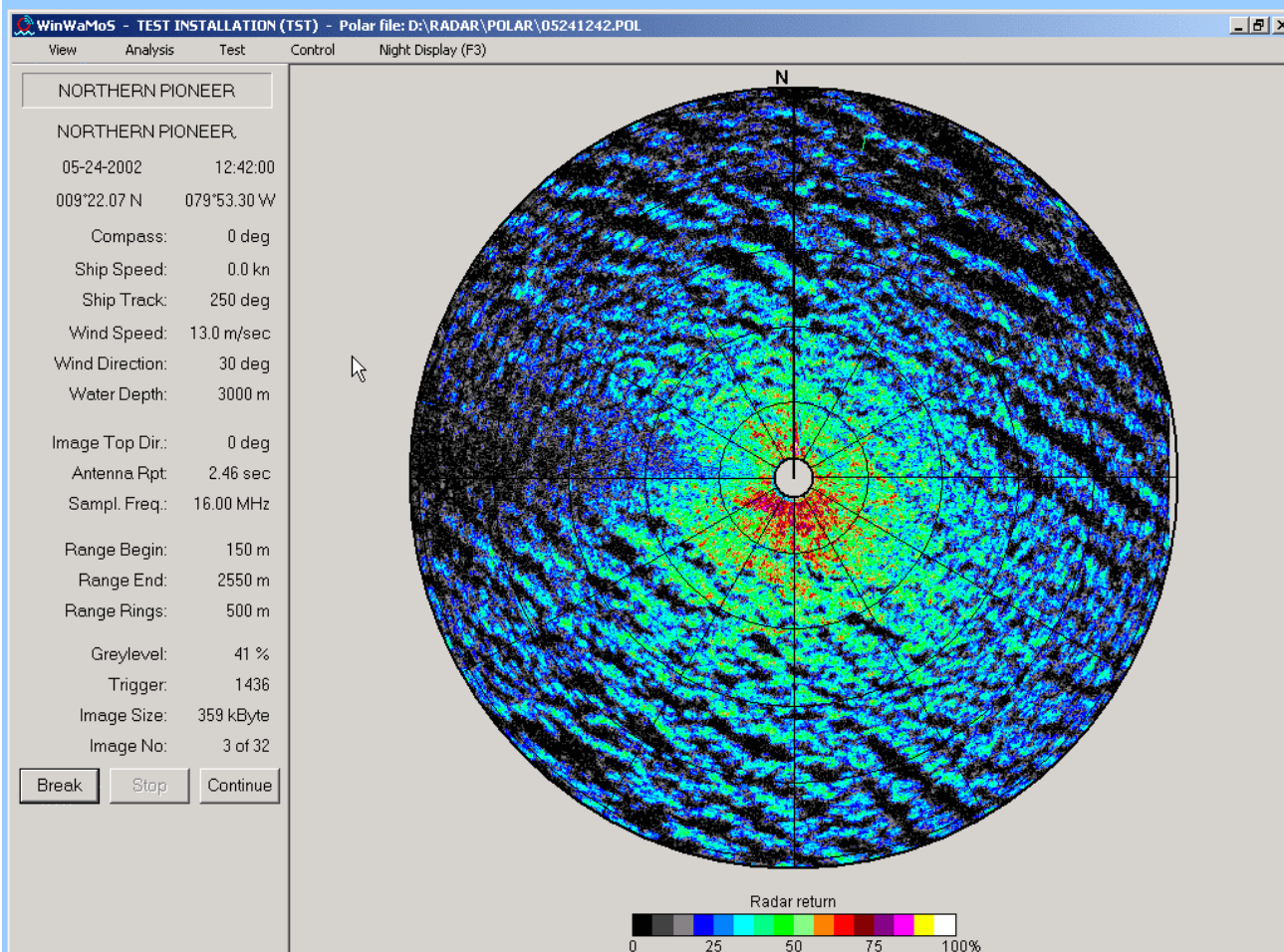
WaMoS II components



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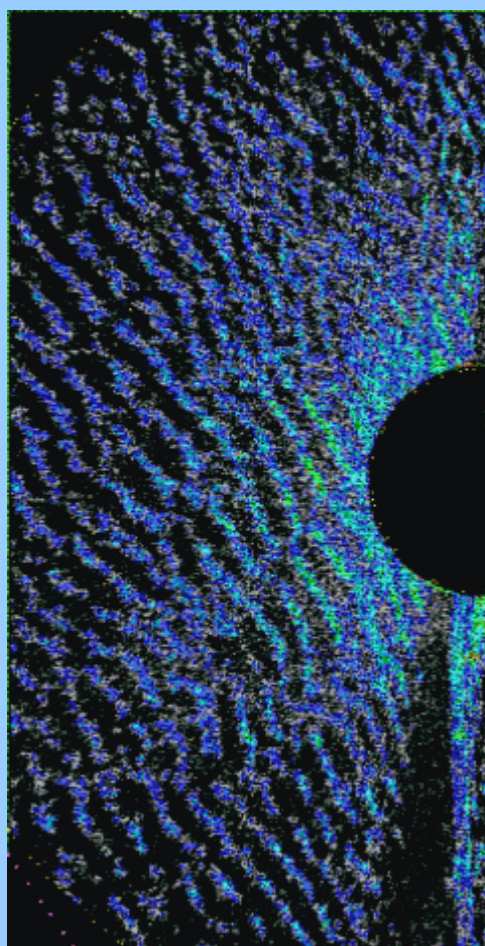
1 Radar polar image

A measurement consists of a consecutive series of images.

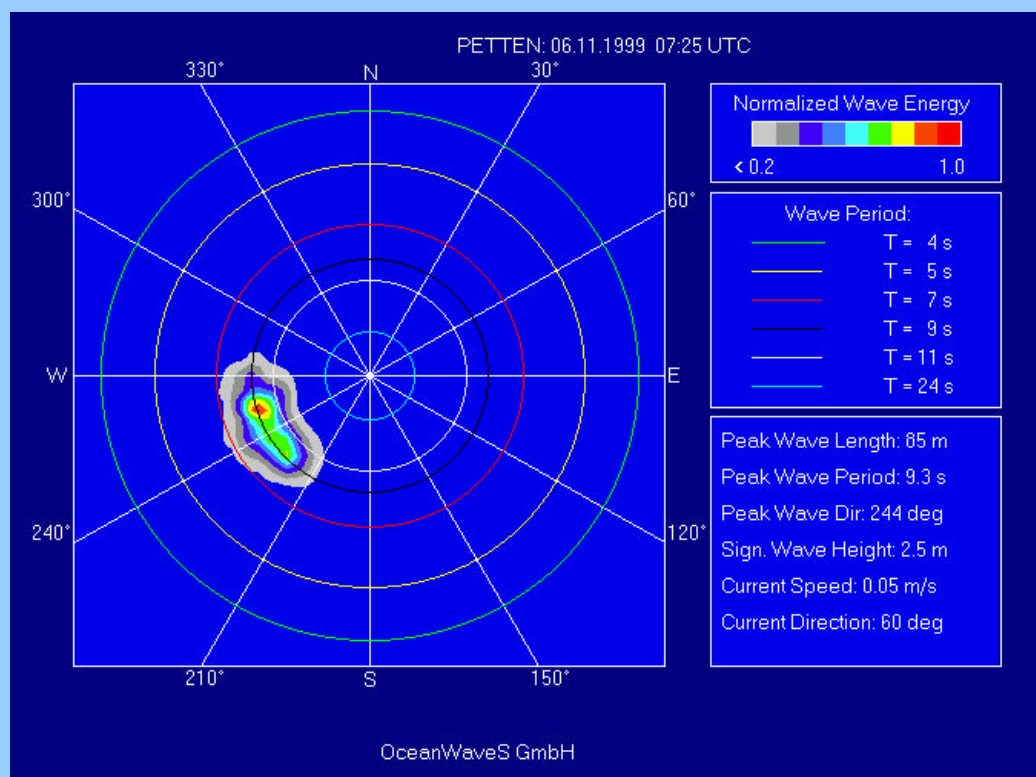
The antenna is located at the centre of the image

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WaMoS radar images from the Dutch coast, time series of 'seaclutter' image' with directional unambiguity

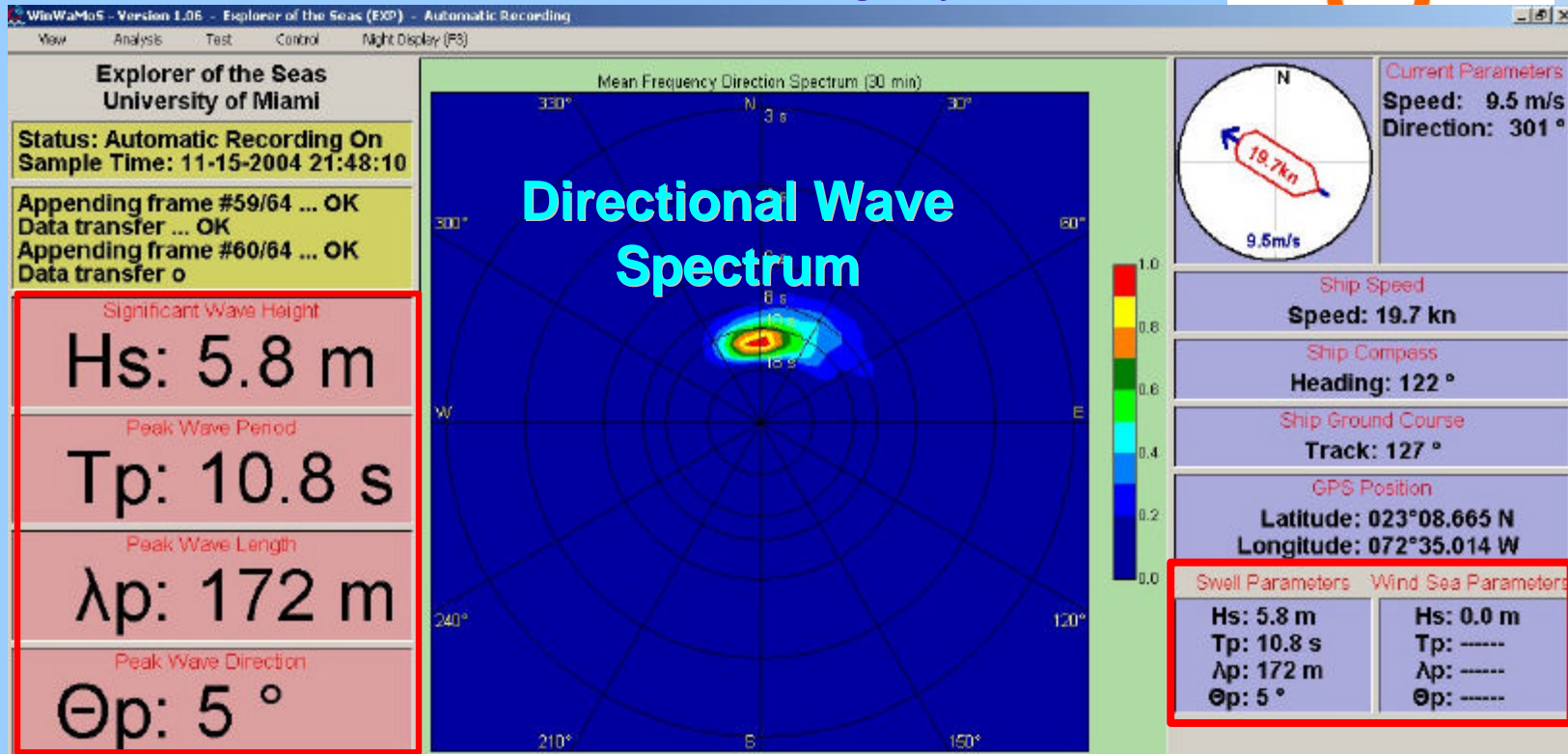


Corresponding 2-dimensional spectrum



Example of User Interface

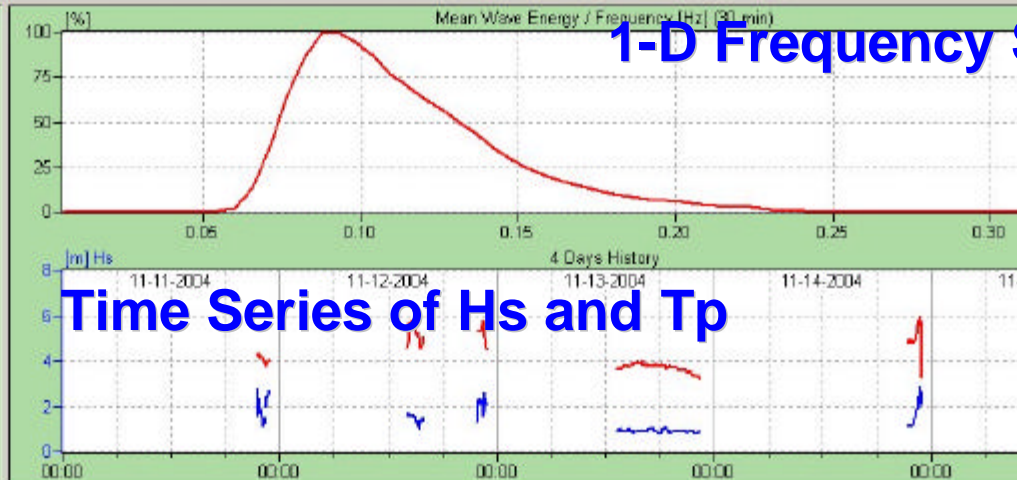
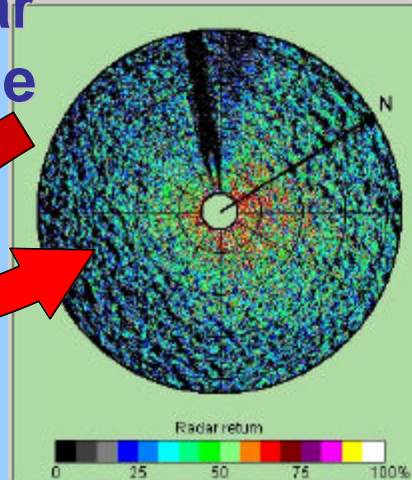
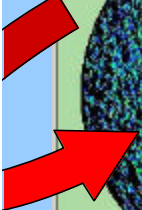
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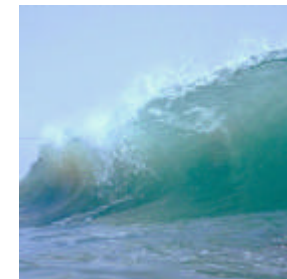
Average Surface Current Vector

Large

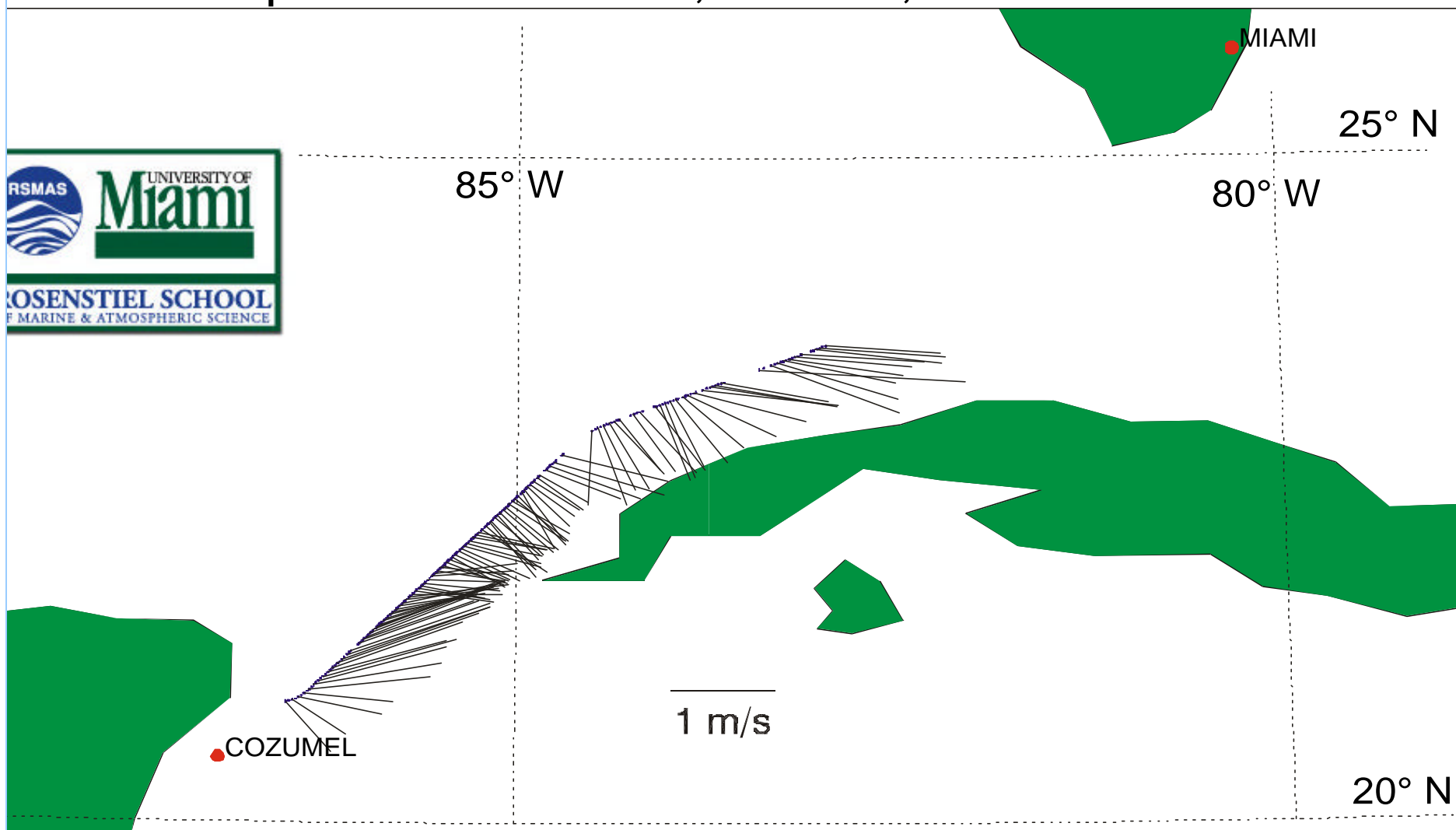


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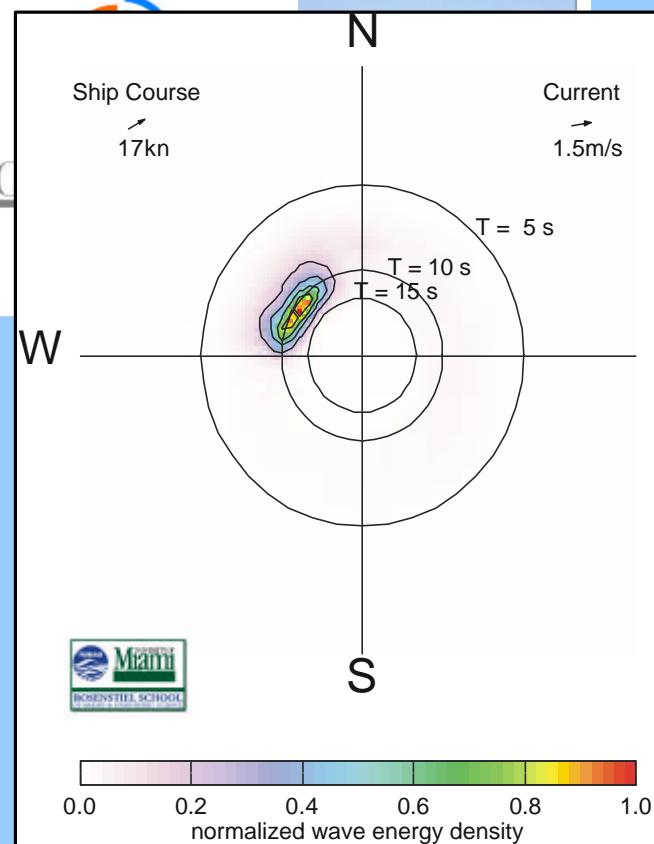
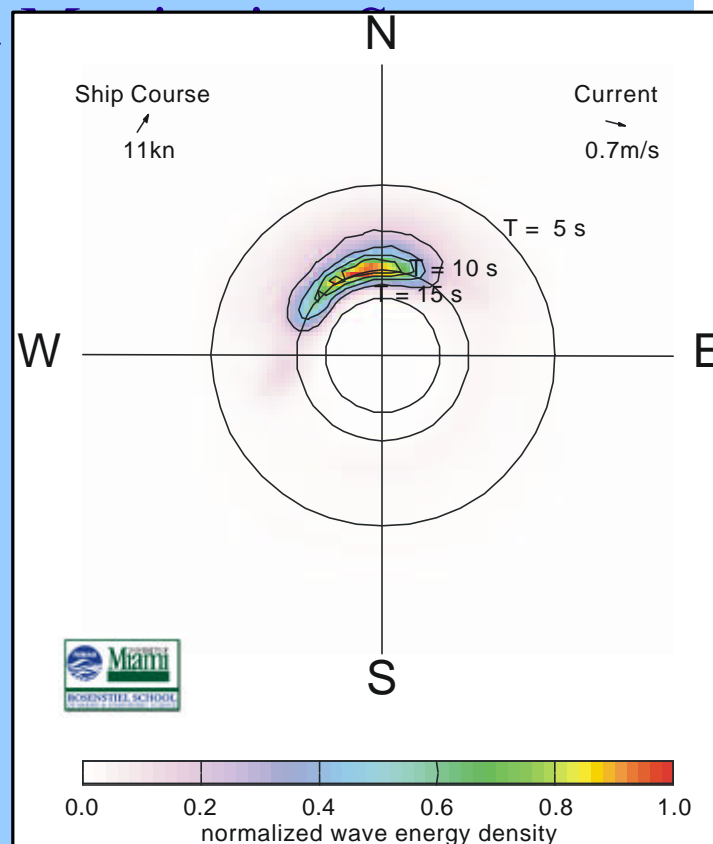
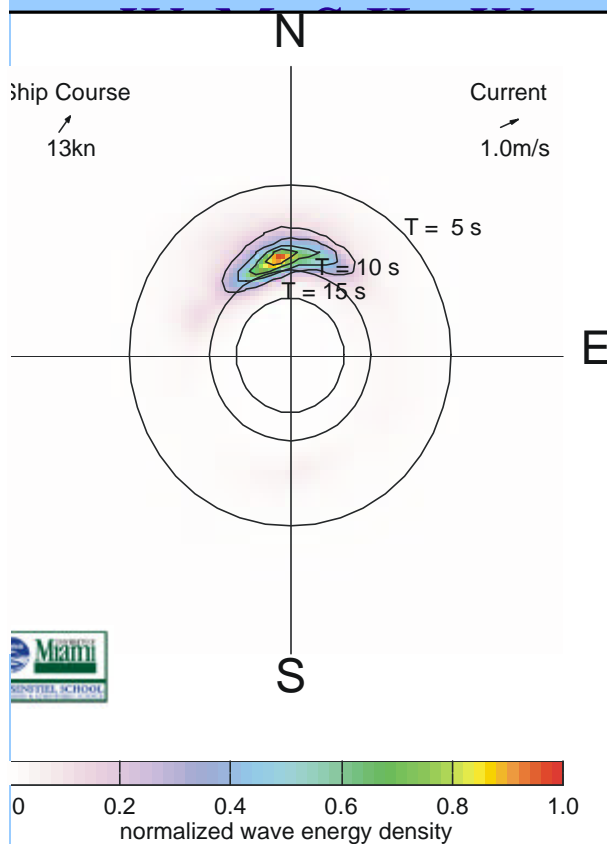
Explorer of the Seas: Surface currents



Explorer of the Seas, Jan. 24, 2003



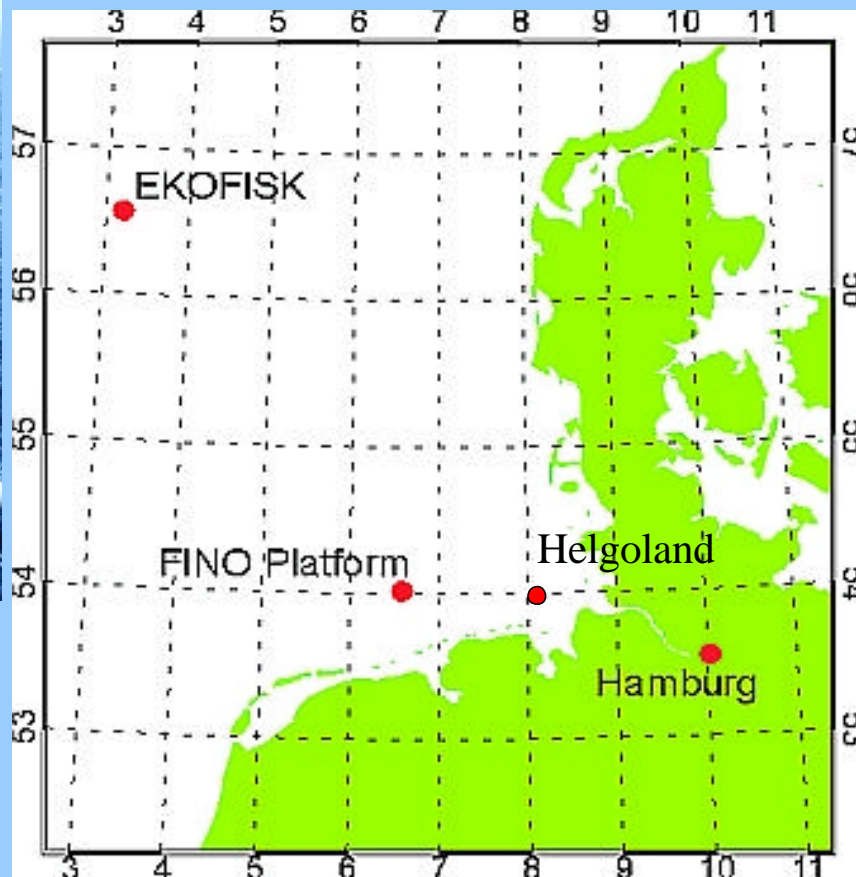
Wave Variability in Florida Current



Date	H_s	T_p	$?_p$	L_p
Jan 24, 2003, 06:00 UTC	2.2m	7.8s	355°	95m
Jan 24, 2003, 10:00 UTC	2.3m	8.7s	345°	117m
Jan 24, 2003, 19:57 UTC	3.8m	9.6	311°	141m

WaMoS II - Wave Monitoring System

WaMoS II on Ekofisk 2/4
platform, since 1992
by Statoil



WaMoS II on FINO offshore
wind test platform, since 2000
by the Federal Maritime and
Hydrographic Agency

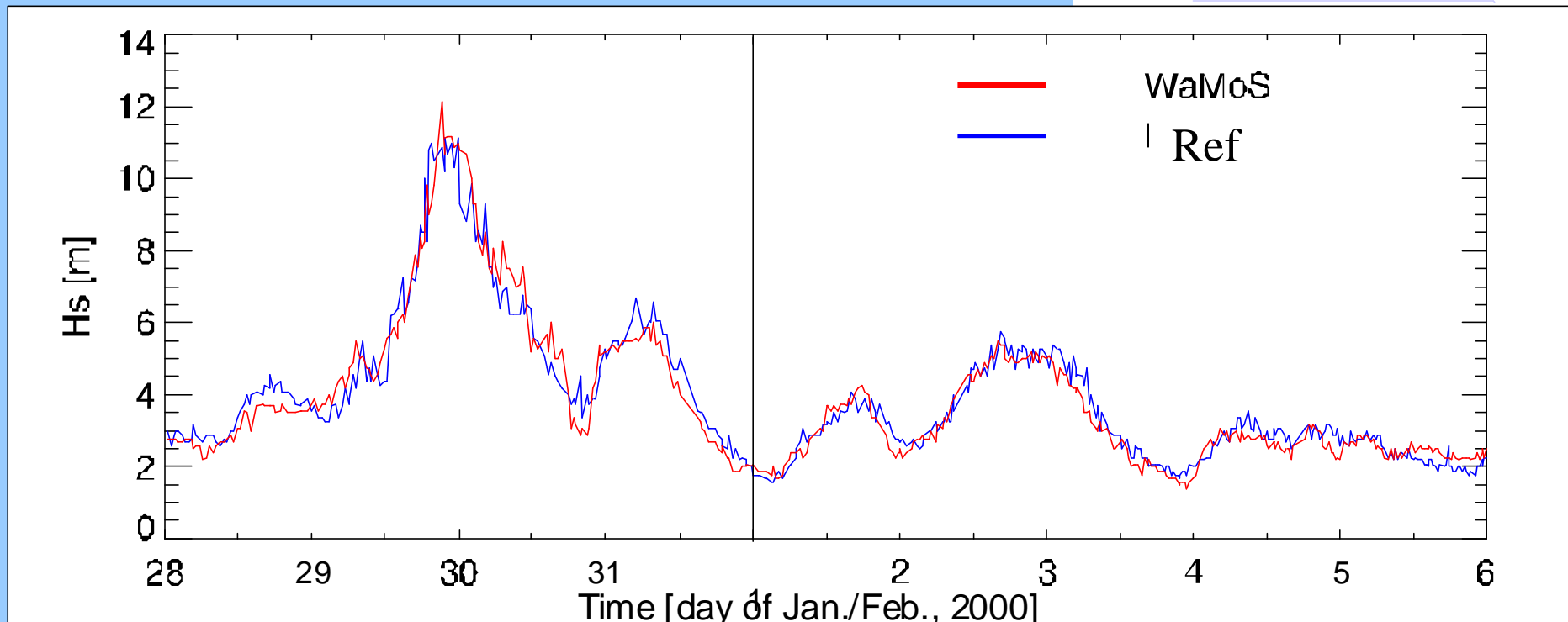


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Ekofisk 2/4 platform, in operational use since 1992 by ConocoPhillips



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Significant wave height H_S , WaMoS II (red) and reference sensor (blue), in the period of **Jan. 28 till Feb. 6, 2000**, Values are 20 minute averages. Data: **ConocoPhillips**

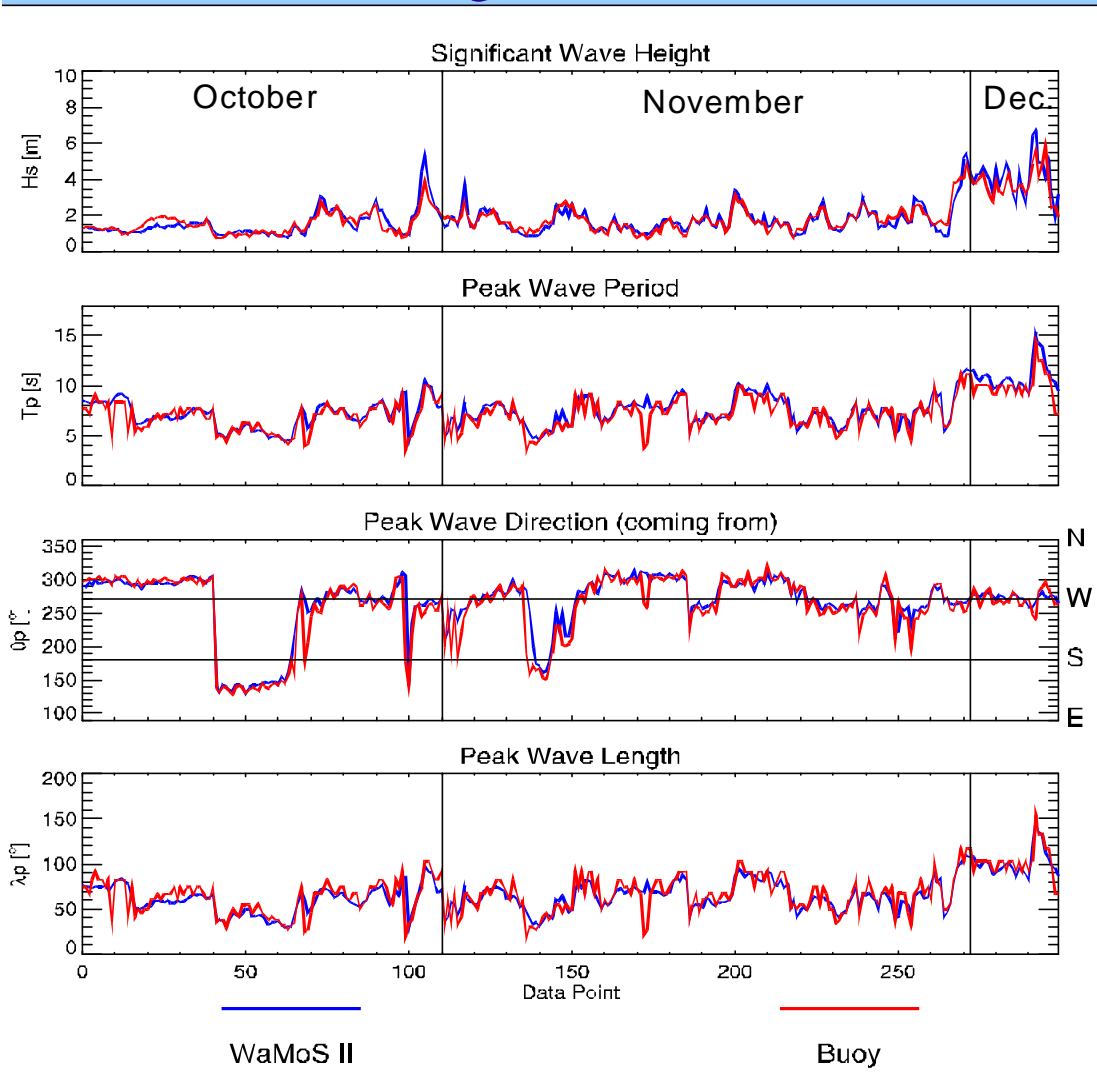
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Data comparison: WaMoS II with a buoy:

Helgoland 1999



WaMoS II on Helgoland since 1998, operated by OWS - shallow water application

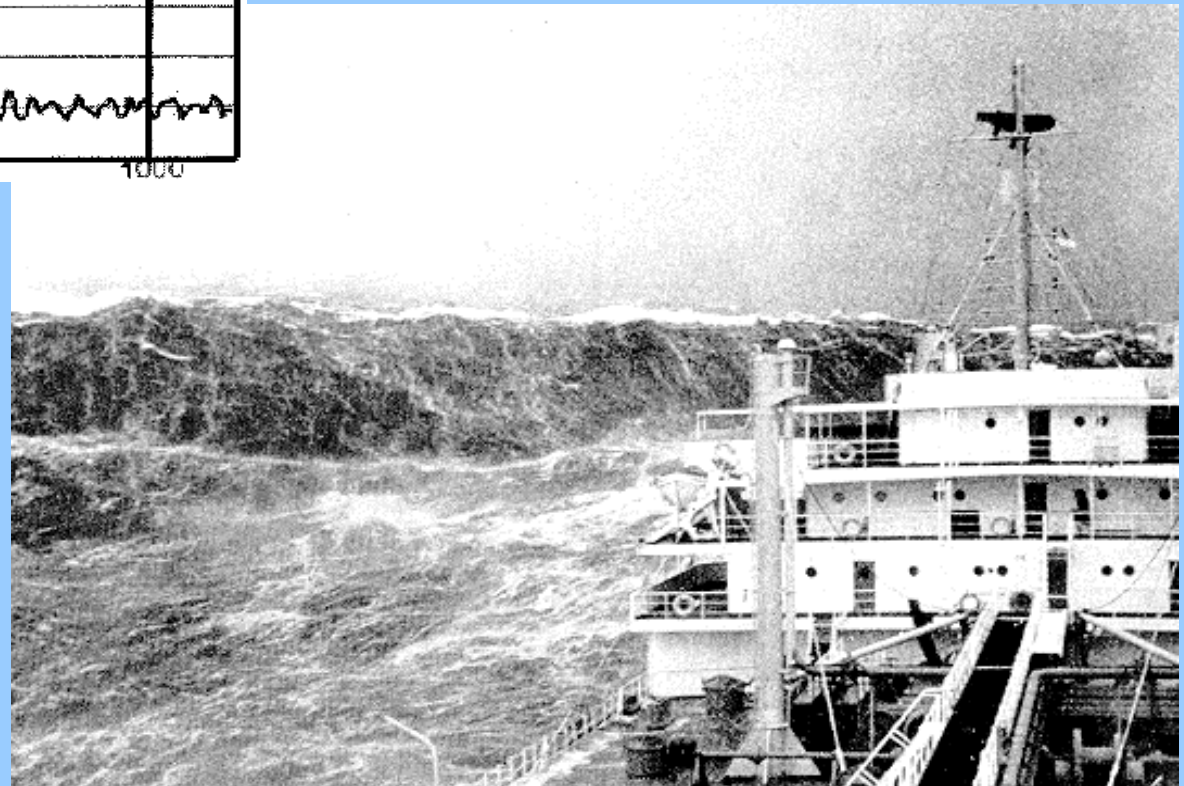
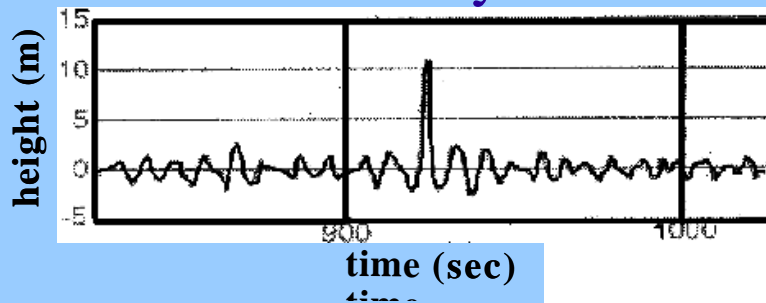


WaMoS II - Wave Monitoring System

EU-project MaxWave, 1.12.2000 – 1.12.2003



- ☆ Forecast and global statistics of extreme waves
- ☆ Ship accidents caused by freak waves



GKSS
DLR
TUB
OWS
KUL
MetNo
UKMetoffice
MeteoFrance
IST
DNV

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National project SinSee (1.10.2002- 30.9.2005)



- ✧ Flensburg ship yard
- ✧ Technical Uni -Berlin
- ✧ Technical Uni-Hamburg/Harburg
- ✧ Hamburg ship model basin
- ✧ OceanWaveS



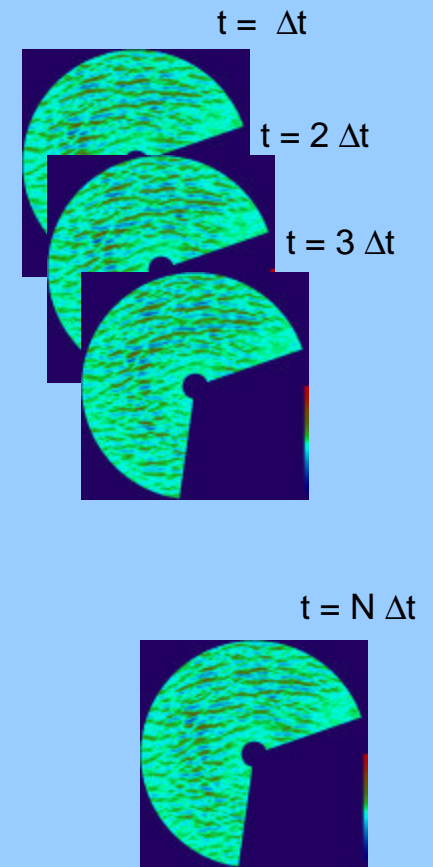
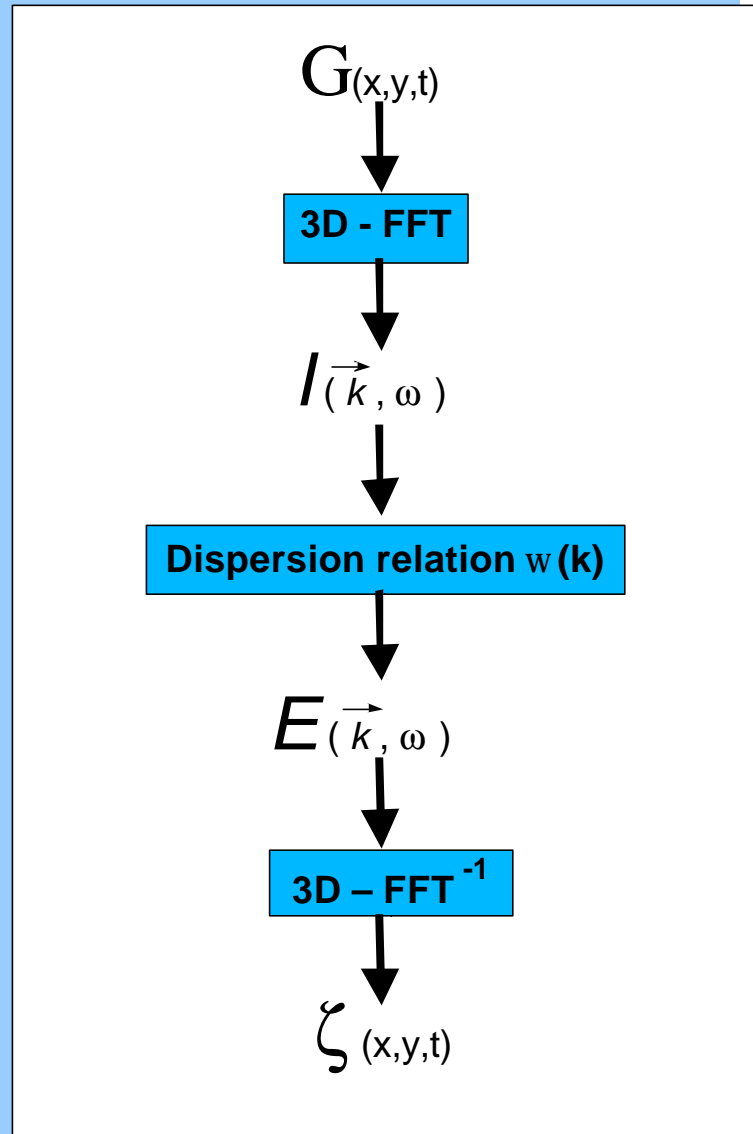
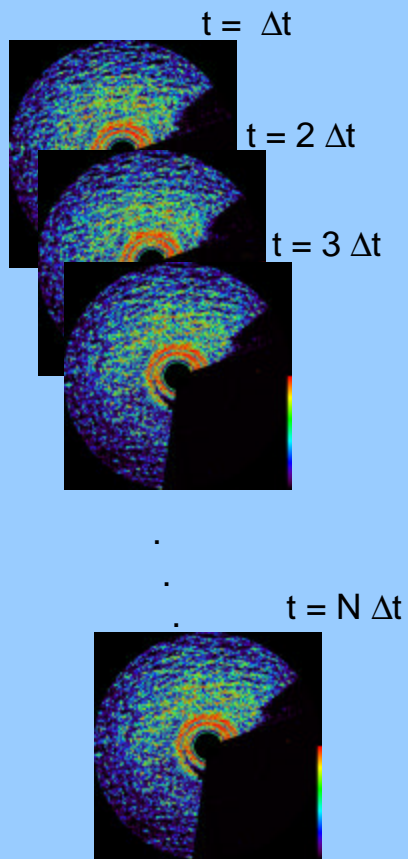
Numerical assessment of intact stability
Design evaluation and optimization based on numerical simulations
Deterministic wave sequences for model testing
Linking numerical and experimental models
Decision support for operation
On board wave monitoring (WaMoS II)



WaMoS II - Wave Monitoring System

MaxWave EU-Project- SinSee Bmbf

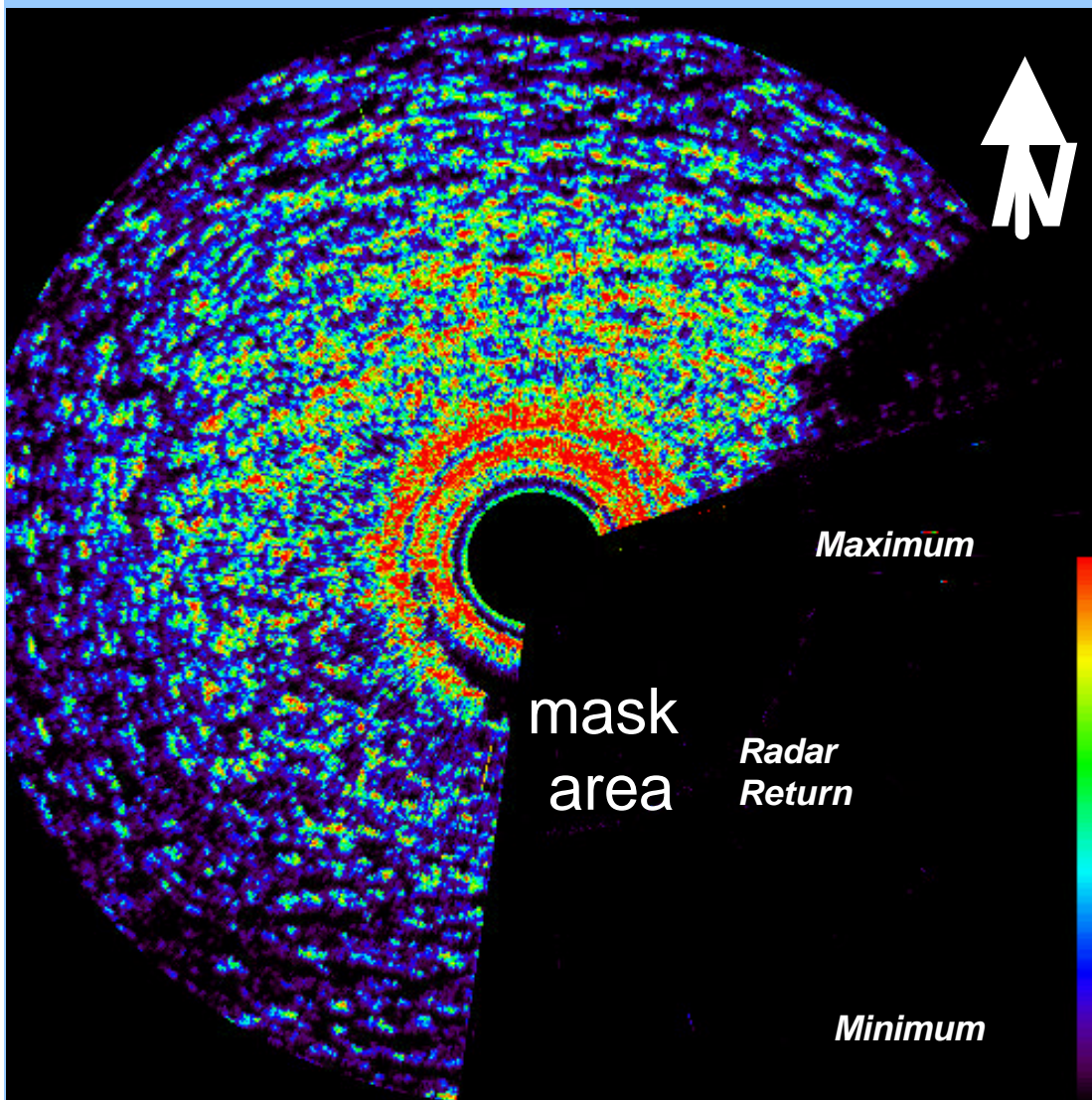
Inversion scheme



WaMoS II - Wave Monitoring System

Ekofisk, April 16, 2001, 17:00 UTC

Radar backscatter



WaMoS:

$H_s = 4.3 \text{ m}$

$T_p = 9.8 \text{ s}$

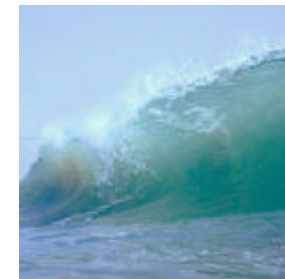
$q_p = 355^\circ$

$l_p = 143 \text{ m}$

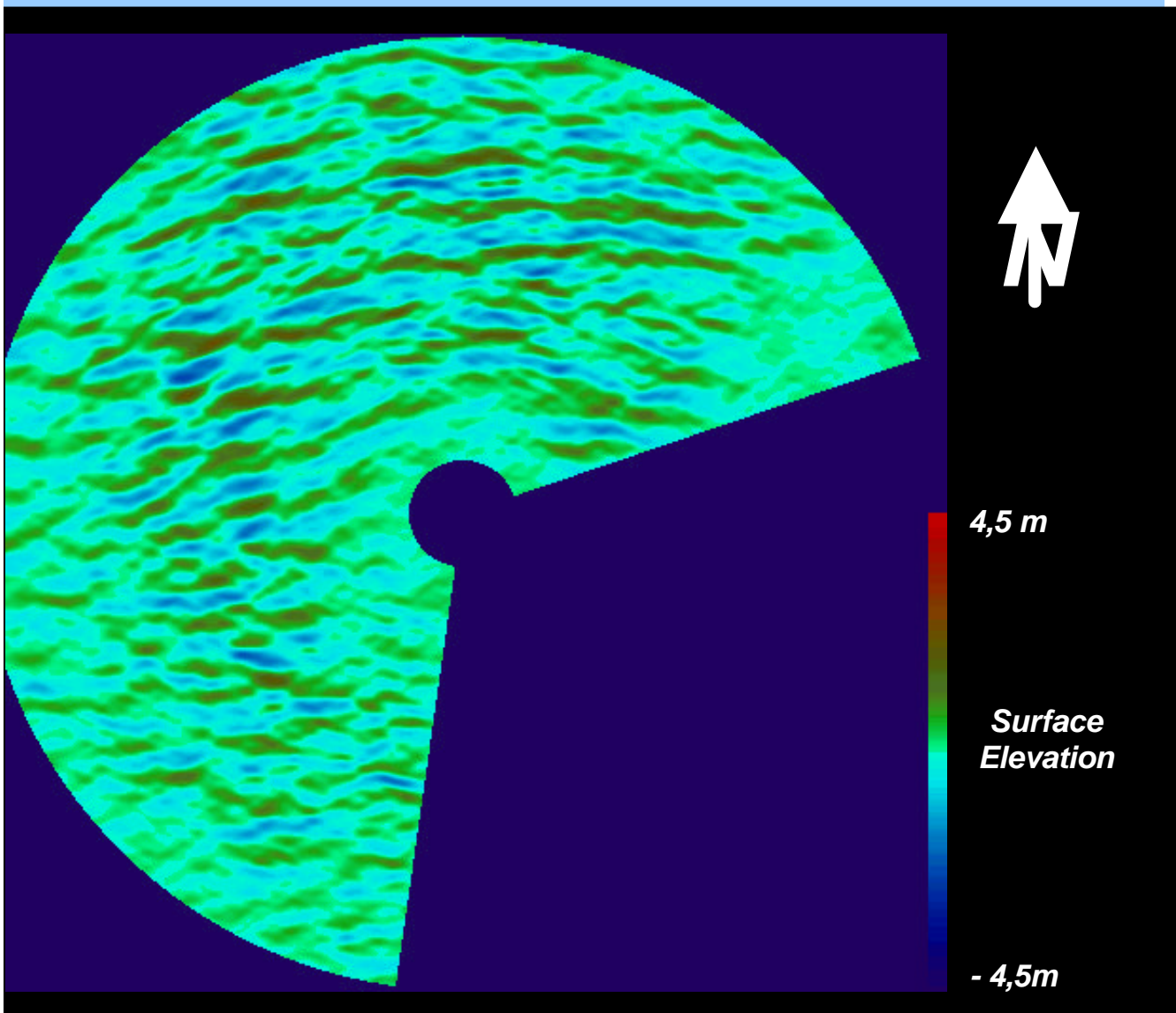
WaMoS II - Wave Monitoring System

Ekofisk, April 16, 2001, 17:00 UTC

Sea surface elevation



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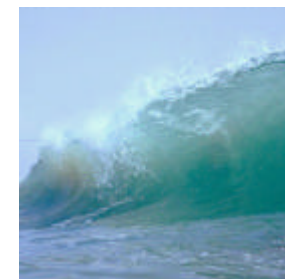


- ☆ Individual waves
- ☆ Crest length
- ☆ Wave transformation
- ☆ Wave groups

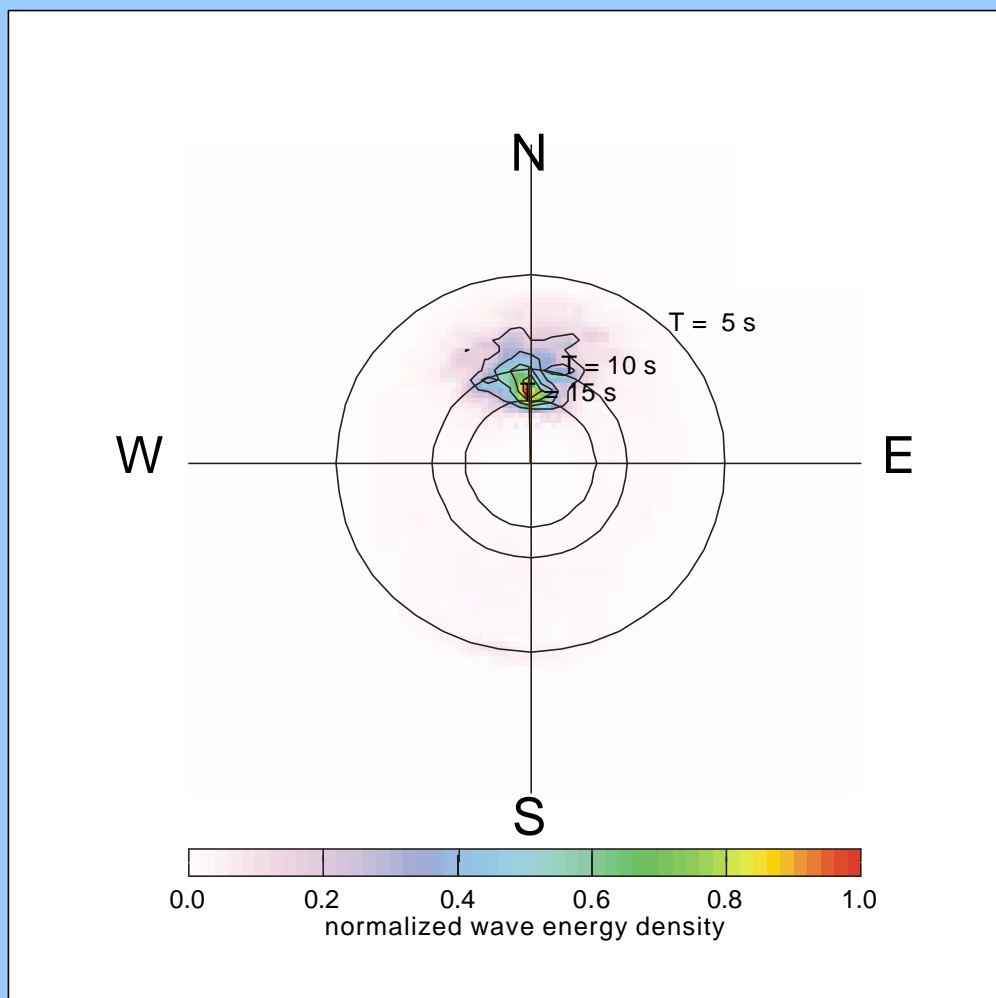
WaMoS II - Wave Monitoring System

Ekofisk, April 16, 2001, 17:00 UTC

Frequency direction spectrum



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WaMoS:

H_s = 4.3 m

T_p = 9.8 s

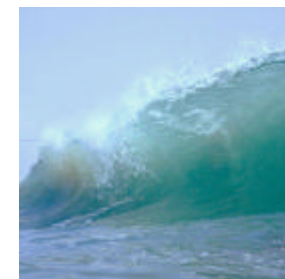
q_p = 355°

l_p = 143 m

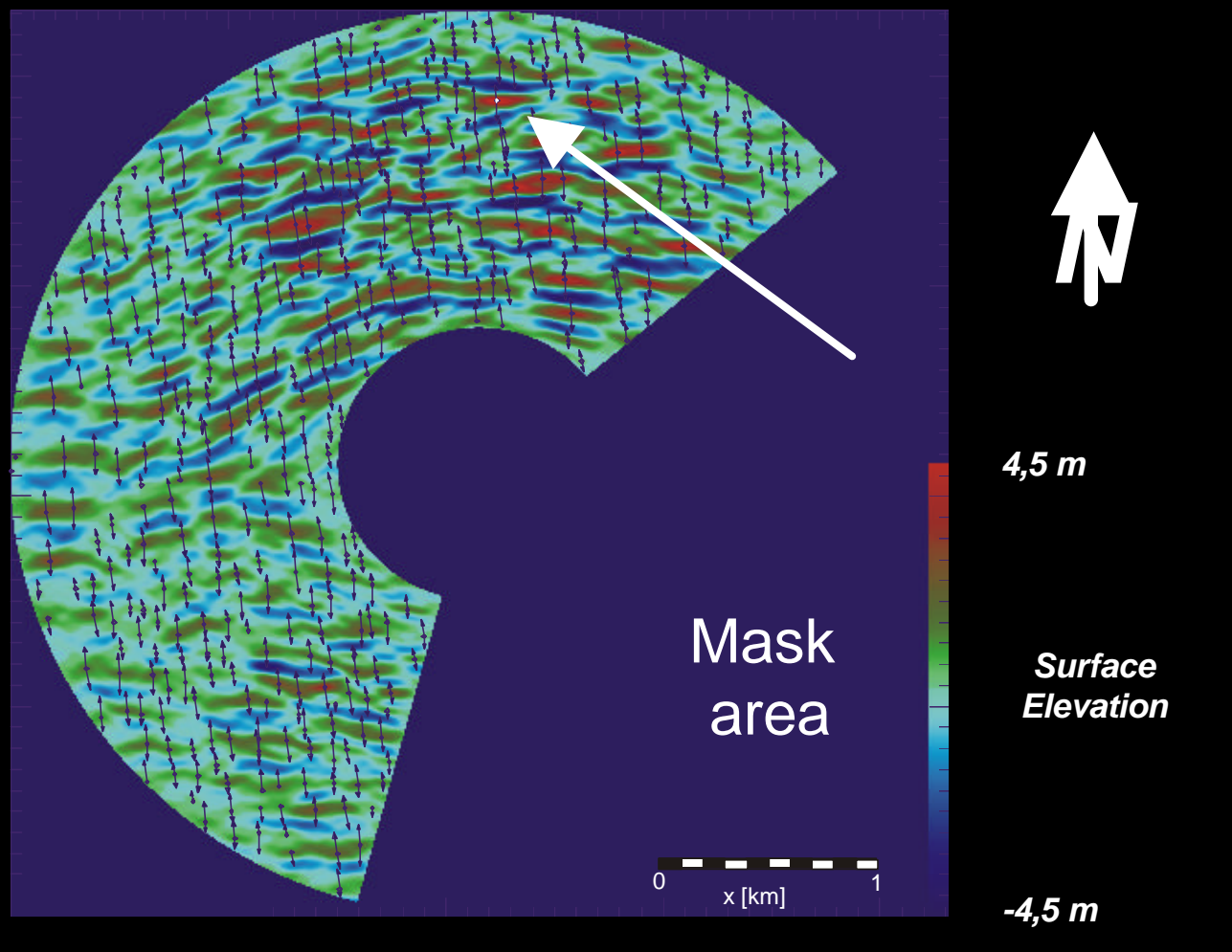
WaMoS II - Wave Monitoring System

Ekofisk, April 16, 2001, 17:00 UTC

directional wave finding



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$$H_s = 4.3 \text{ m}$$

$$q_p = 355^\circ$$

$$H_{\max} = 8.8 \text{ m}$$

$$N_{\text{waves}} = 739$$

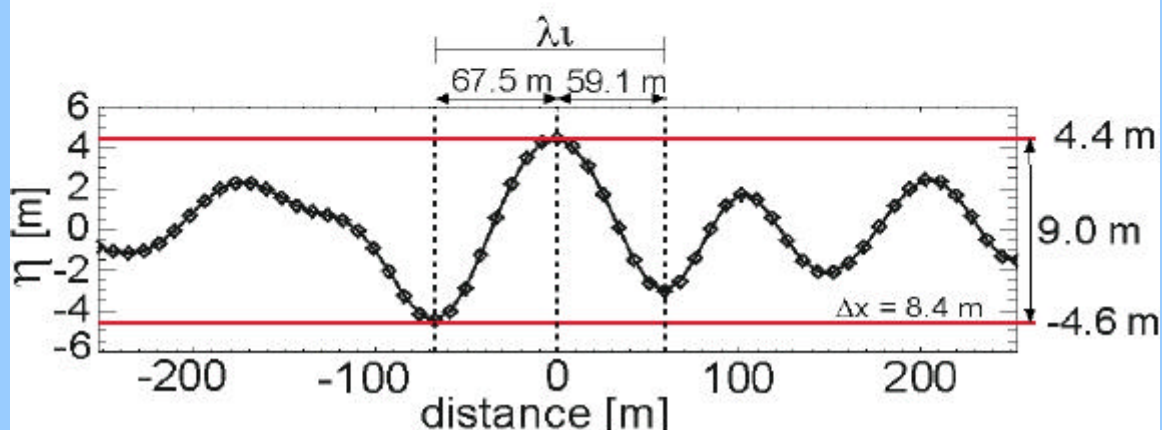
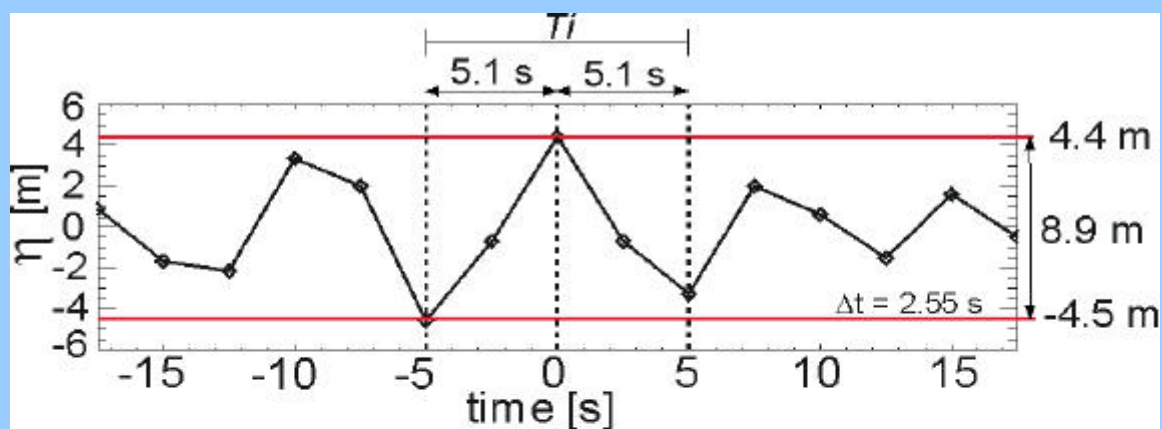
$$l_{\max} = 1.5 \cdot l_p$$

$$H_{1/3} = 4.5 \text{ m}$$

WaMoS II - Wave Monitoring System

Transect of sea surface elevation map

Ekofisk, April, 16, 2001 17:00 UTC



Temporal transect:

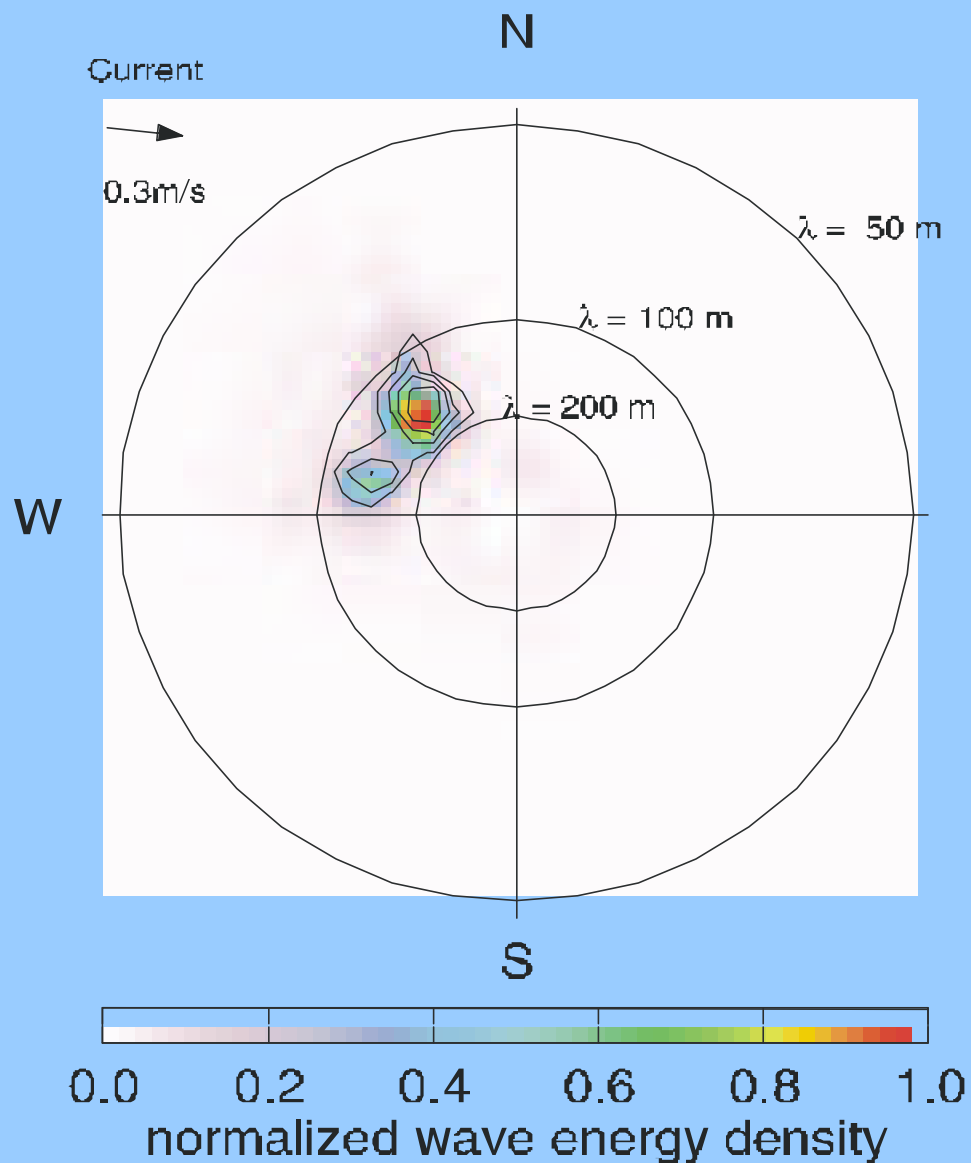
- individual wave period $T_i = 10.2$ s
- (spectral wave period $T_p = 9.8$ s)

Spatial transect:

- individual wave length $\lambda_l = 126.6$ m
- (spectral wave length $\lambda_p = 143.0$ m)

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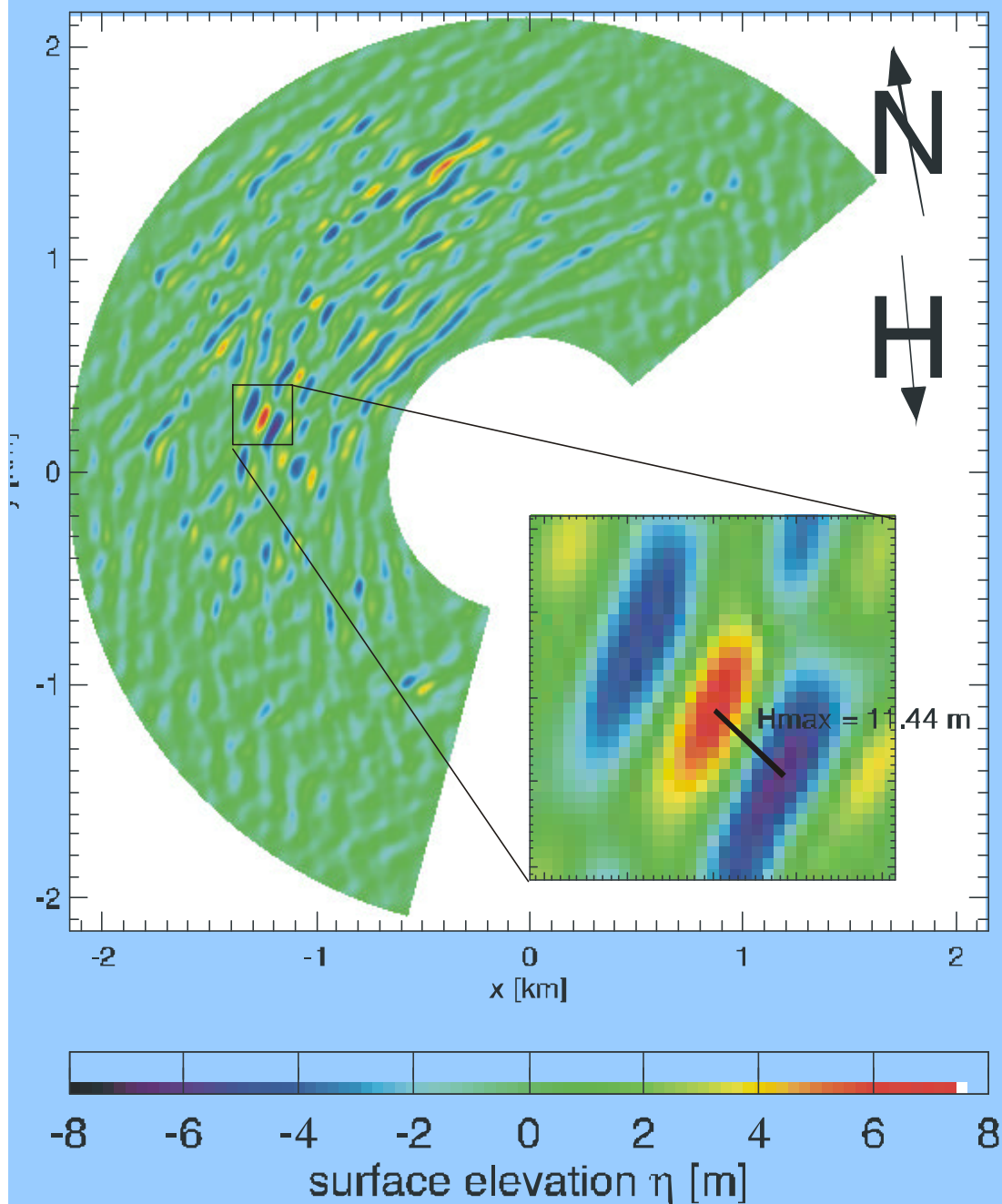
normalized wave number spectrum



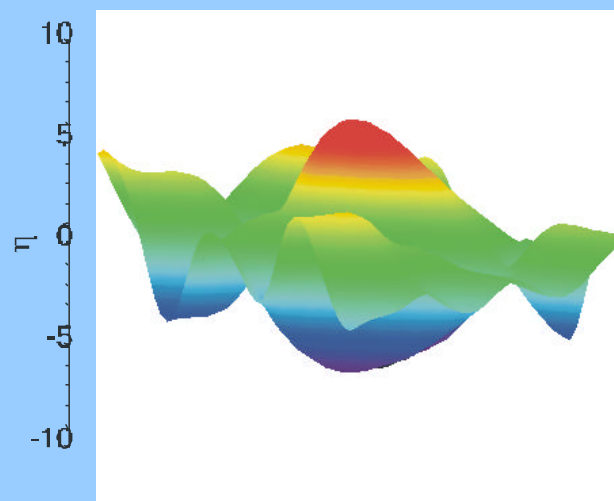
Wave number spectrum at Ekofisk
May, 29. 2001, 15:05 UTC

$H_s = 4.5$ m
 $T_p = 9.2$ s
 $\lambda_p = 133$ m

WaMoS II - Wave Monitoring System



Sea surface elevation map Ekofisk
May, 29. 2001, 15:05 UTC
Data: Phillips petrol, MetNo



$H_s = 4.5$ m $H_{max} = 11.44$ m
 $T_p = 9.2$ s
 $l_p = 133$ m

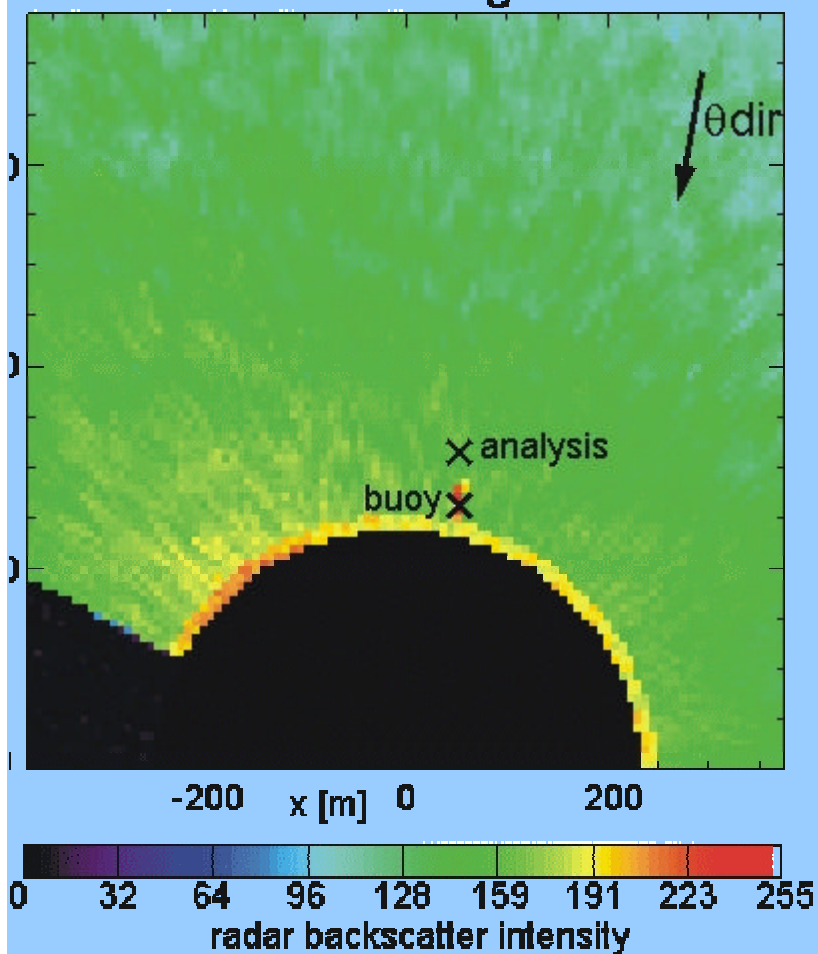
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Validation of sea surface elevation

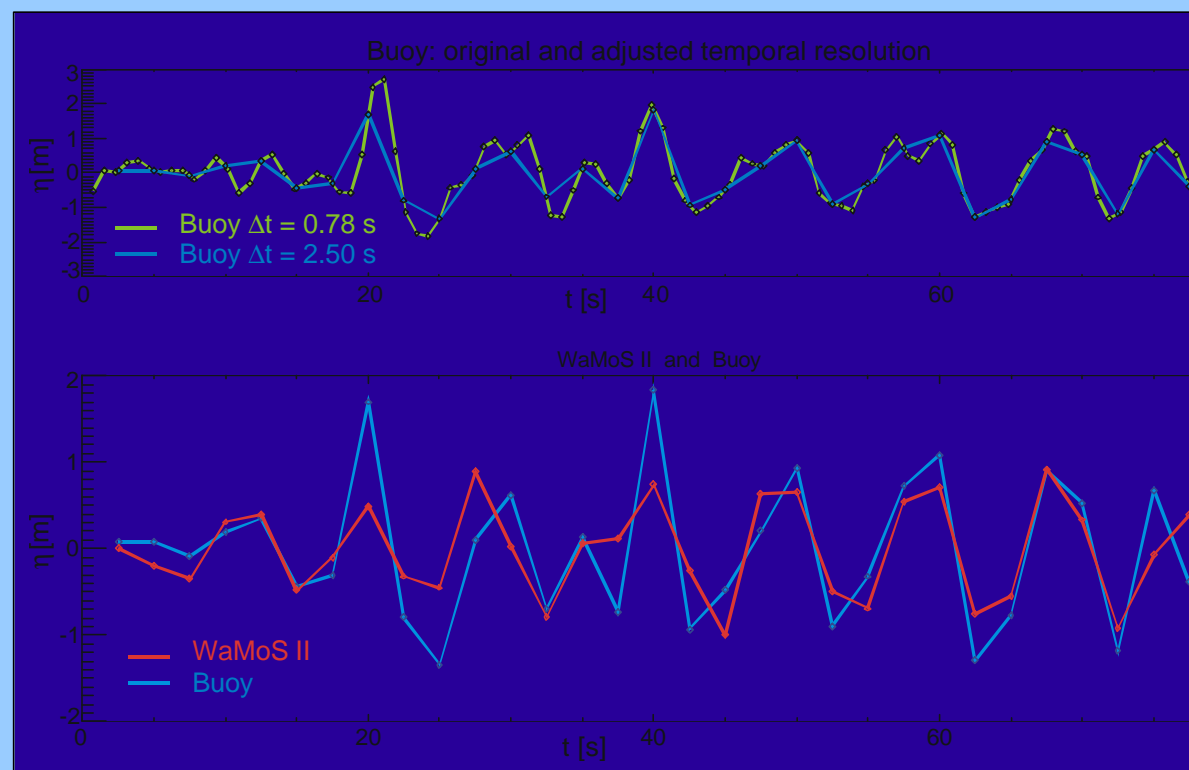
NO, January 13, 2004, 03:12 UTC



mean image



Comparison of sea surface elevation between WaMoS II and buoy



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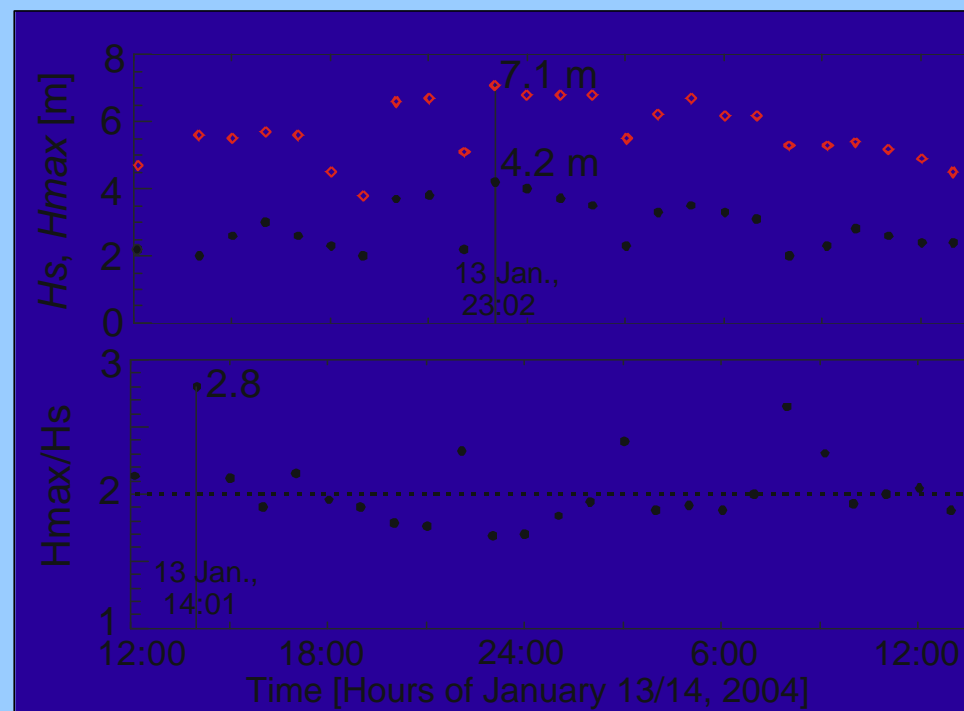
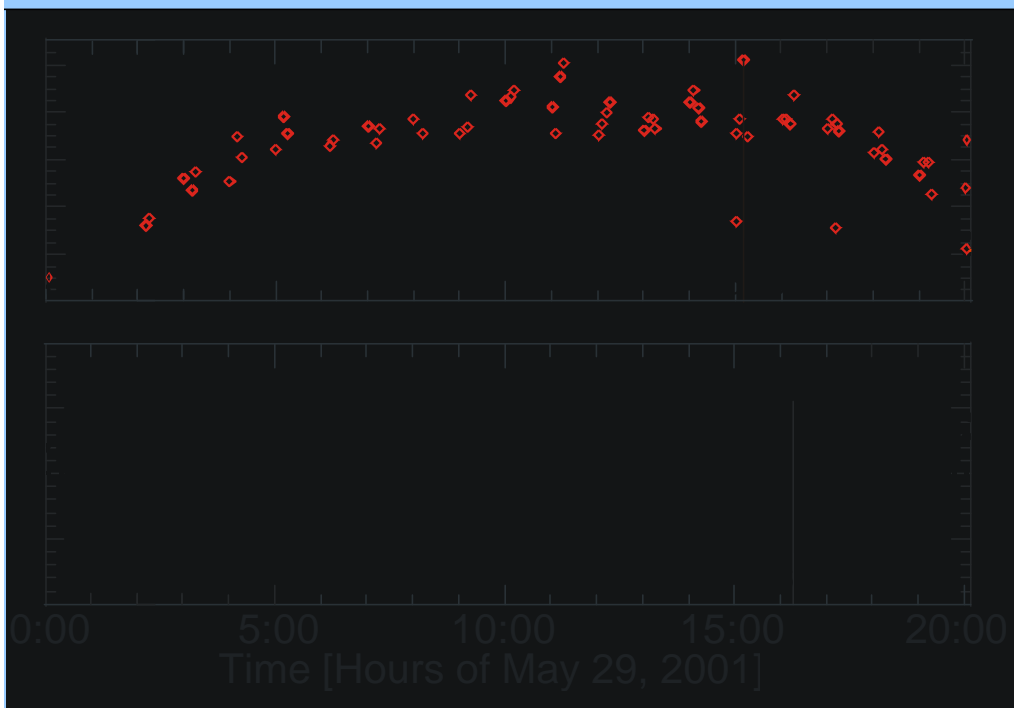
$$H_{max}/H_s > 2 ?$$

Extreme wave criterion for 2D data is needed



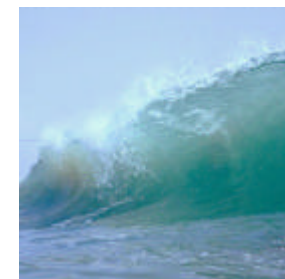
Skofisk, May 29, 2001, 00:00 UTC
until May 29, 2001, 20:00 UTC

FINO, January 13, 2004, 12:00 UTC
until January 14, 2004, 15:00 UTC

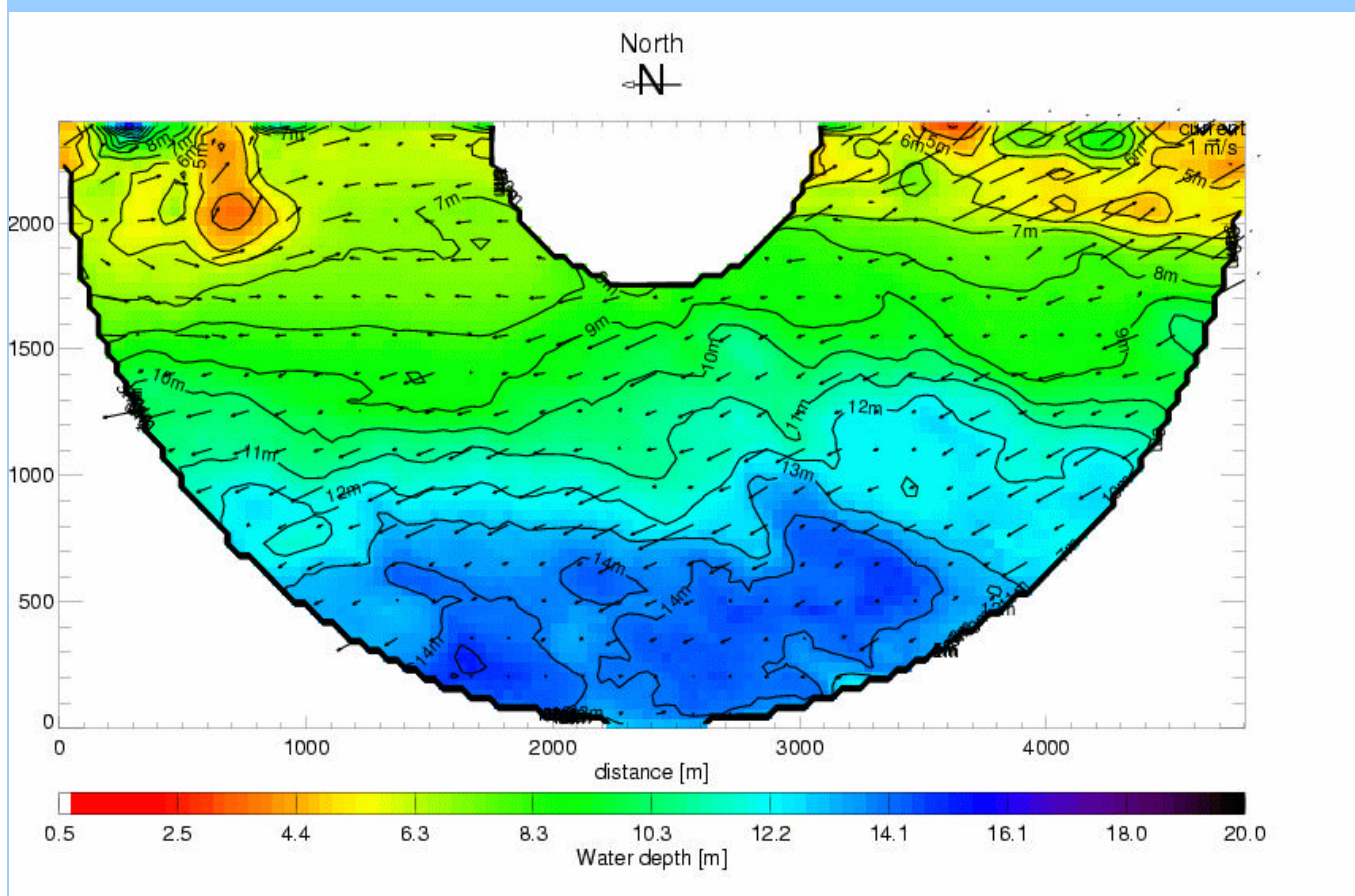


WaMoS II - Wave Monitoring System

High resolution current and water depth measurements



www.oceanwaves.de



Example from the Danish Coast from March 31, 2004.

An extensive validation with independent measurements, for both currents and water depth is currently carried out.

Implementation in standard software expected by spring 2005.

WaMoS II - Wave Monitoring System



Conclusions and future applications

WaMoS II delivers the 2D-wave spectrum and average current in real time
WaMoS II has made further advancements for single wave detection
High resolution currents and bathymetry can be derived
The research that has been carried out within MaxWave and SinSee should be continued
Validation of individual wave data
Definition of critical parameters: wave groups, 'extremes'
Extreme statistics for 2-D data
Transfer to ship application
Prediction when does the 'wave' reach the vessel – what are the changes of its properties

<http://www.oceanwaves.de>