North Sea Cases of Extreme Individual Waves

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Motivation

Knowledge on rogue waves in the German Bight is important for shipping and for the construction of wind turbines. Hs is important for supply ships, Hrog is important as a construction parameter.

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Methodology

Cold air outbreaks over the NorthSea are correlated with occurence of rogue waves.

Travelling fetch is a possible explanation, as is shown by 2 steps:

1.Estimate Hs in duration limited cases for gusts beyond cloud cells travelling across the North Sea.

2.Estimate individual wave maxima from Rayleigh statistics for the area size of the gust.

By the second step we assume that the Gaussian statistic assumption for sea surface elevation is valid

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Content

Individual Waves from Radar Satellites

Three rogue wave events:

Rescue cruiser Krupp (Draupner-), Britta-storm, Tilo-storm

Details about estimations of wind gusts and rogue waves

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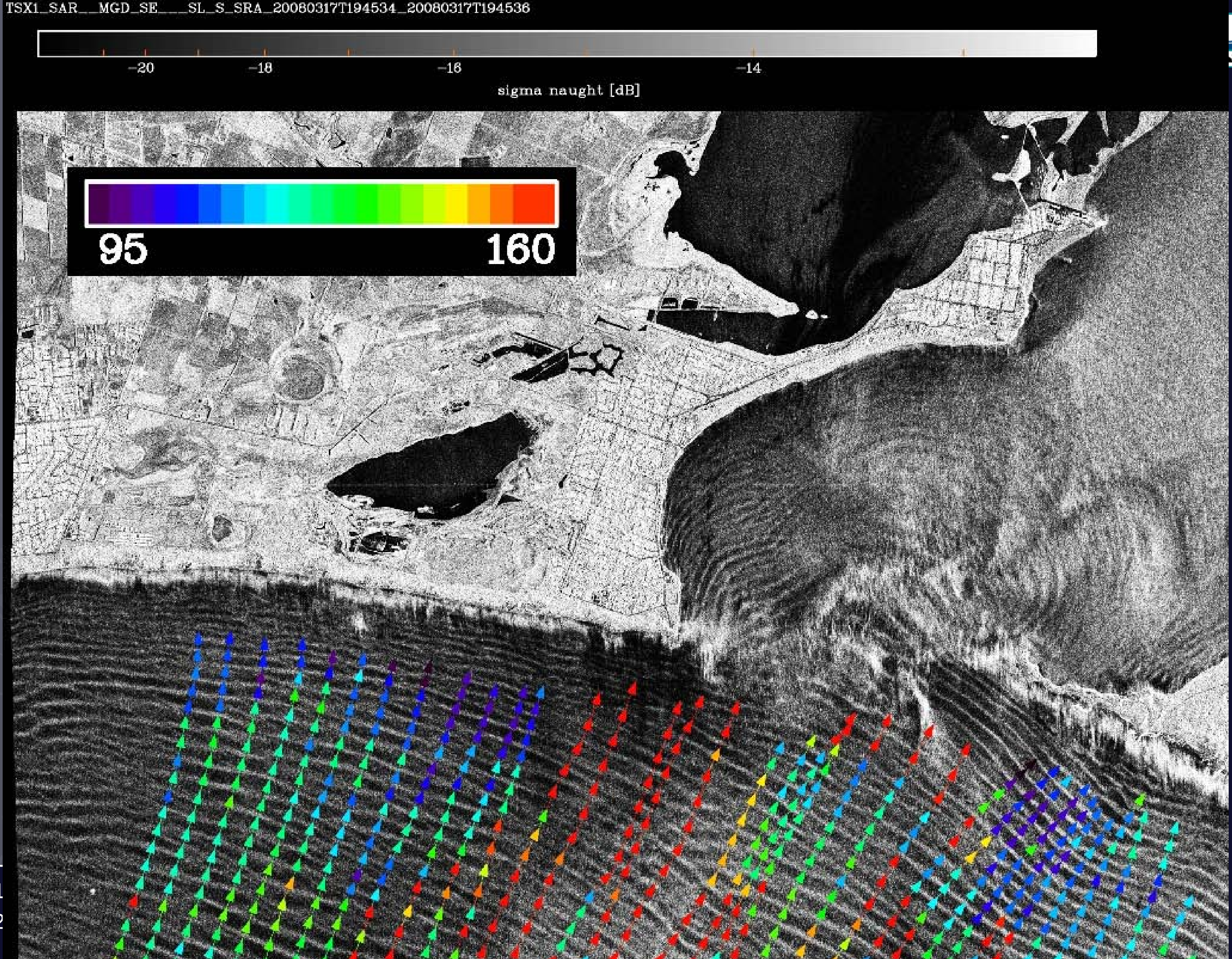
TSX1_SAR__MGD_SE___SL_S_SRA_20080317T194534_20080317T194536
−20
−18
−16
−14
sigma naught [dB]
95
160

1
2

New Year Wave

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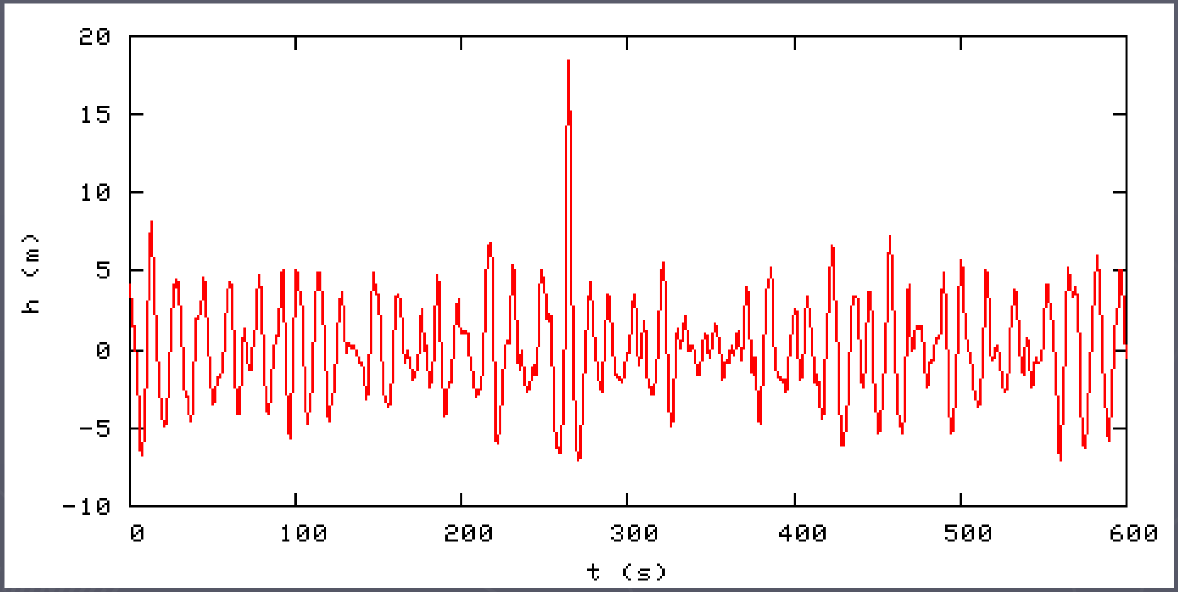
Time Series Wave Height at Draupner, Jan, 1st 1995 15:20



Significant Waveheight 11.9m
Peak Period 16.7 sec
Maximum crest Height 18.5 m
Adjacent trough -7.1m and –6.5m
Depth 70m

Return Period of 1-5 years

Higher than the 100 year crest

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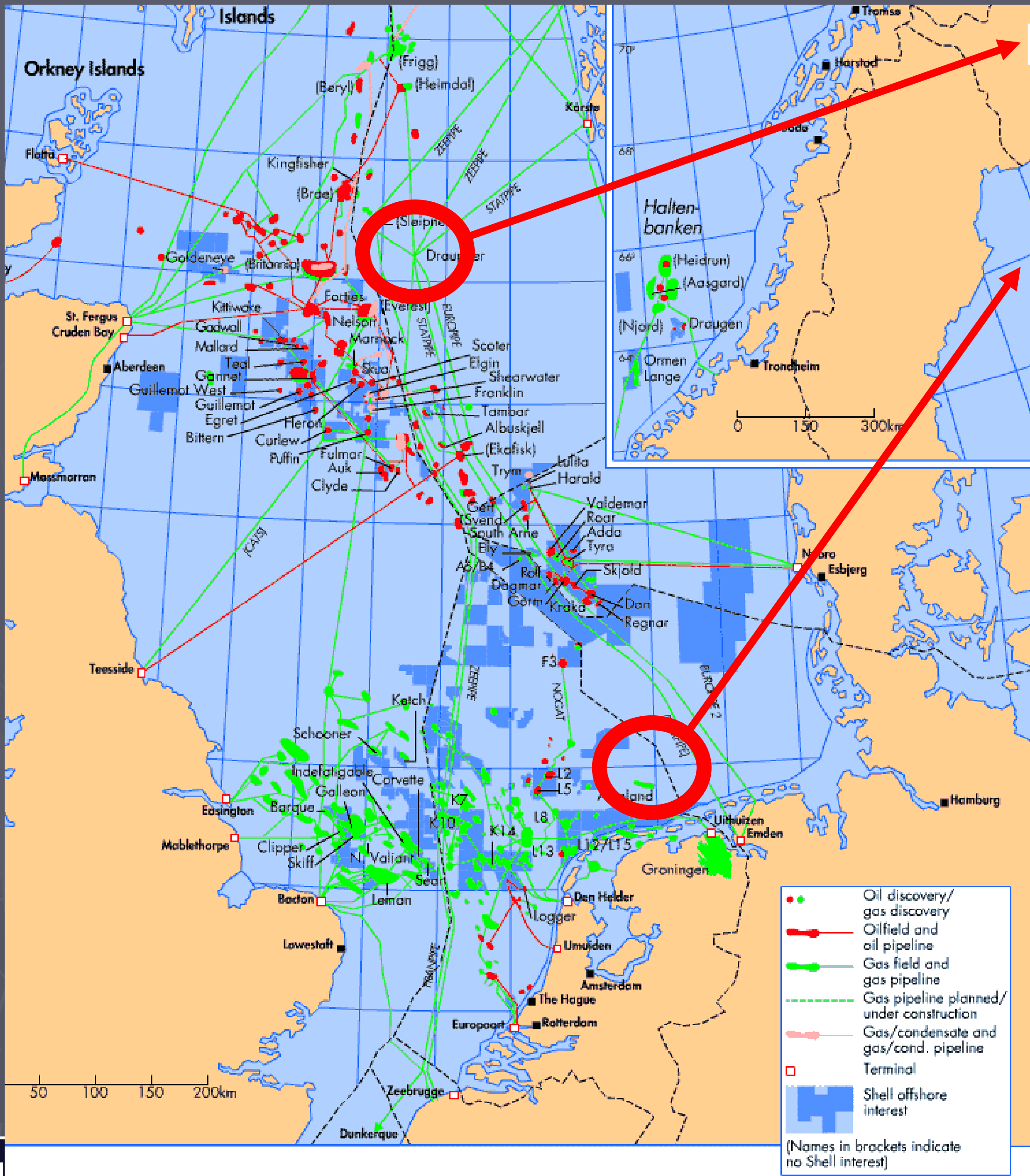

Draupner

58, 11 N / 2,28 E

FINO

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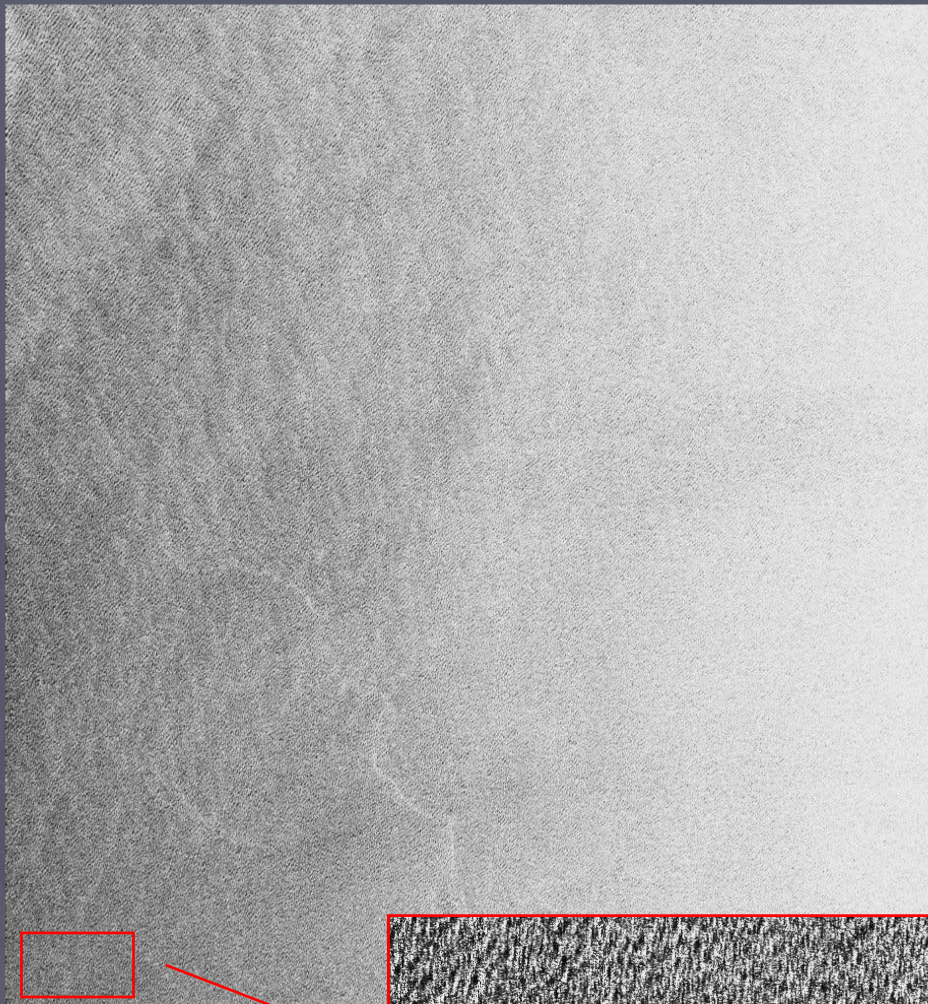
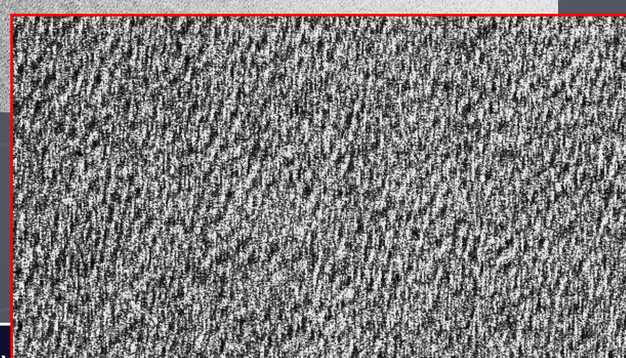
Draupner oil platform



e1_18115_2421_slc
01-01-1995, 10:49 h UTC
100 x 100 km

Draupner
oil platform



5 x 10 km

position:
58, 11 N / 2,28 E

70 m water depth

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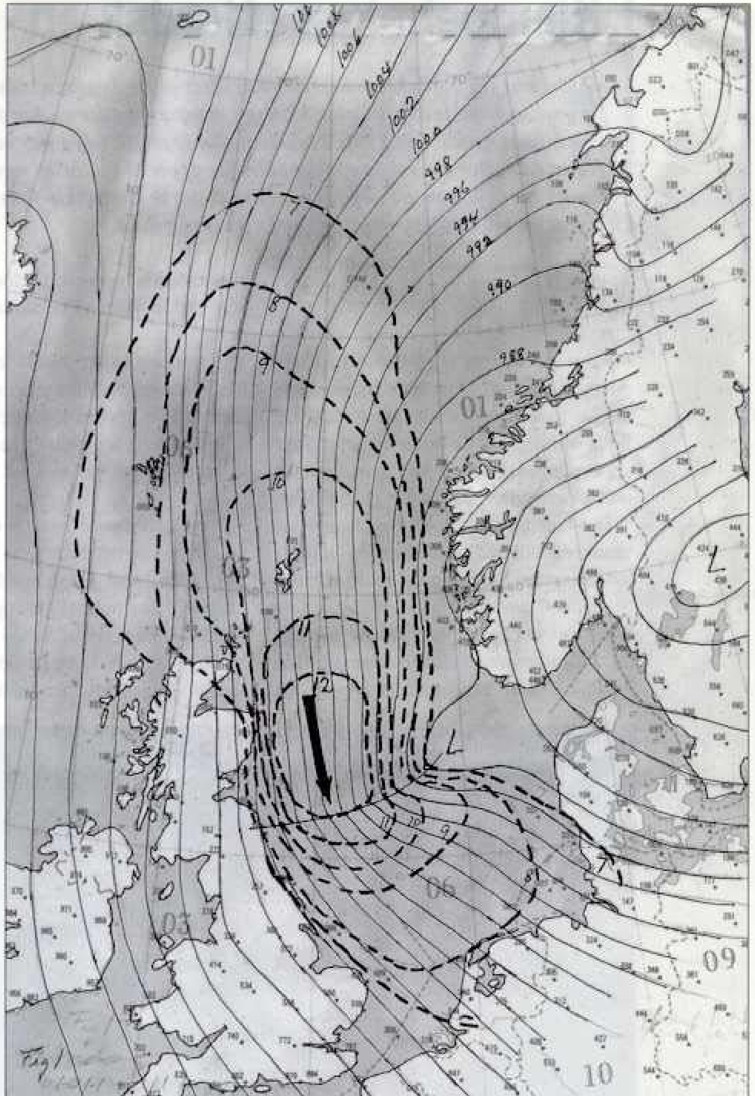
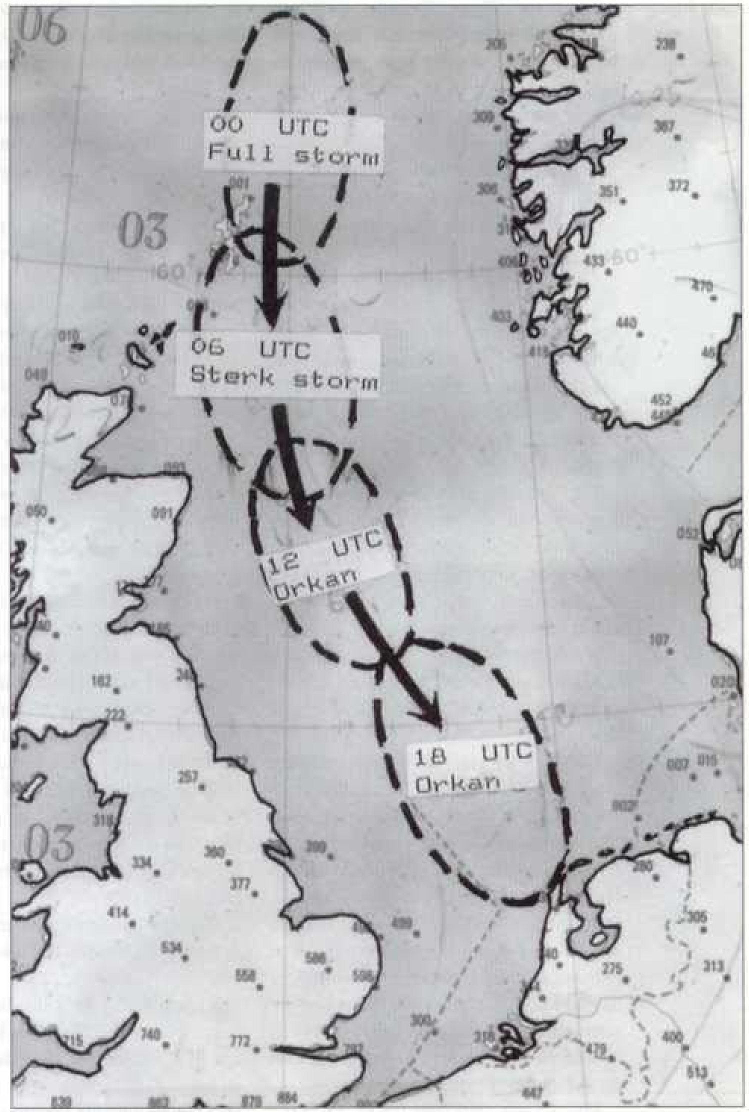
01.01.1995 Hs (--) & mslp



Figur 1. Forenklet værkart for 1. januar 1995 kl. 12 UTC. De tynne linjene er isobarer for hvert 2. hPa. Fra trykkfeltet er beregnet vindfelt. De stiplede kurvene angir vindstyrke i Beaufort. Posisjonen på lavtrykksvirvelen er godt bestemt ut fra satellittbildet fig. 2. Kapteinen på «Color Viking» fortalte om orkan mellom kl. 15 og 18.

01.01.1995 (storm track)



Figur 4. Lavtrykksvirvelen som vi ser vest for Jylland på satellittbildet fig. 2, har vi kunnet følge på tidligere bilder. Virvelen passerte like øst for Shetland tidlig om morgenen, og øket vinden i vestlige Nordsjøen på sin veg sørover, slik som vist på figuren.

Storm Britta

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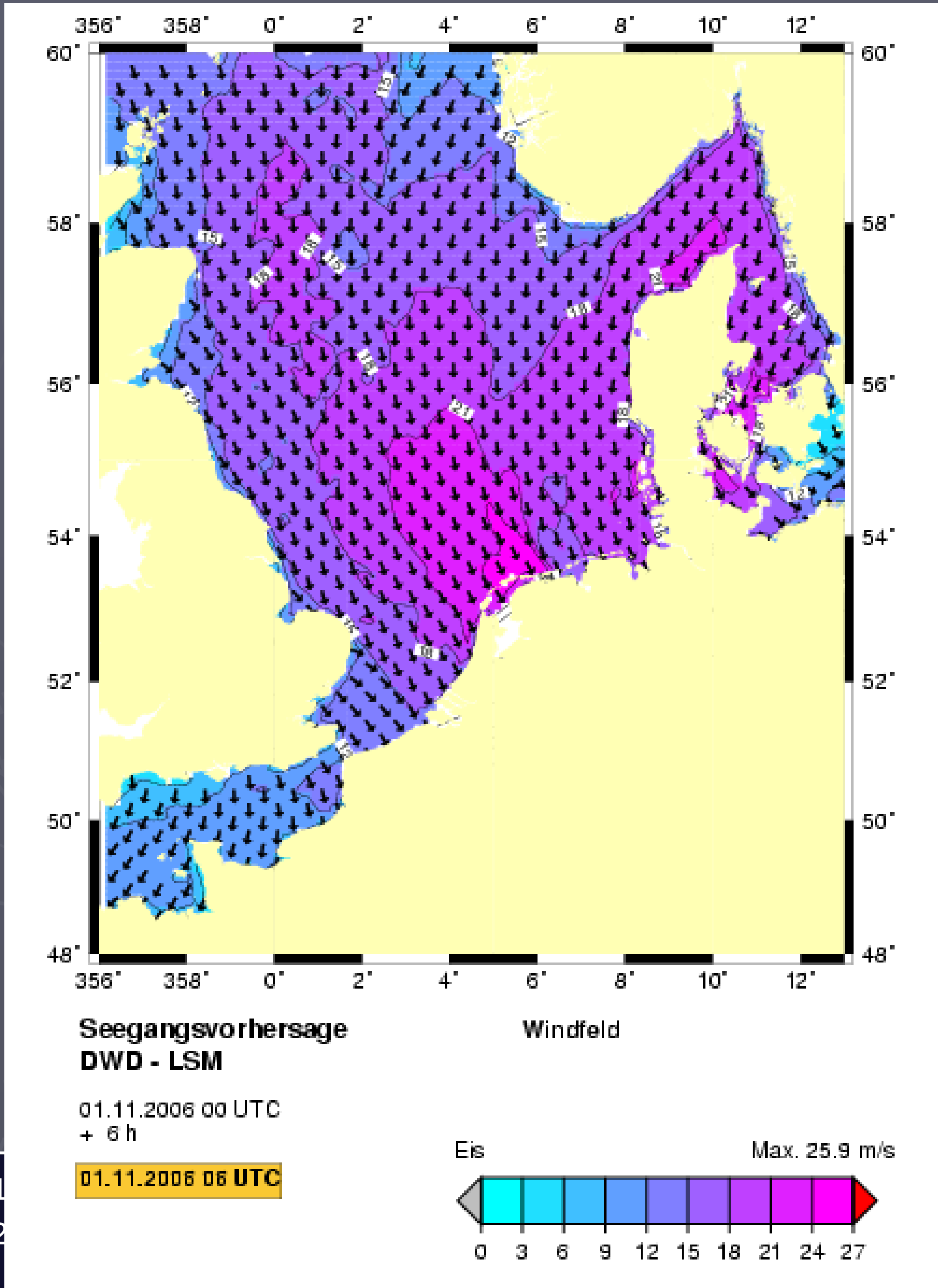
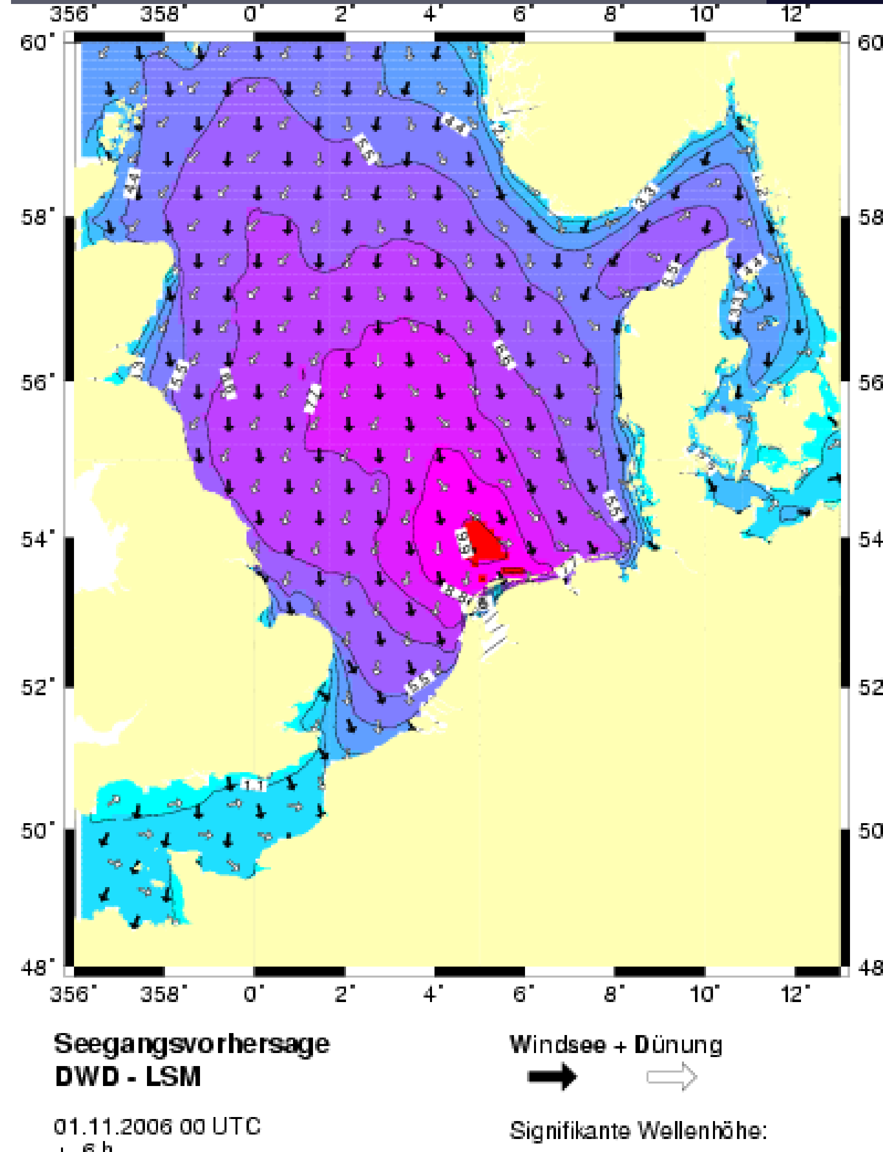
Storm event of the 1st Nov. 2006

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

SKN + 15 m
Mean HW + 12,5 m





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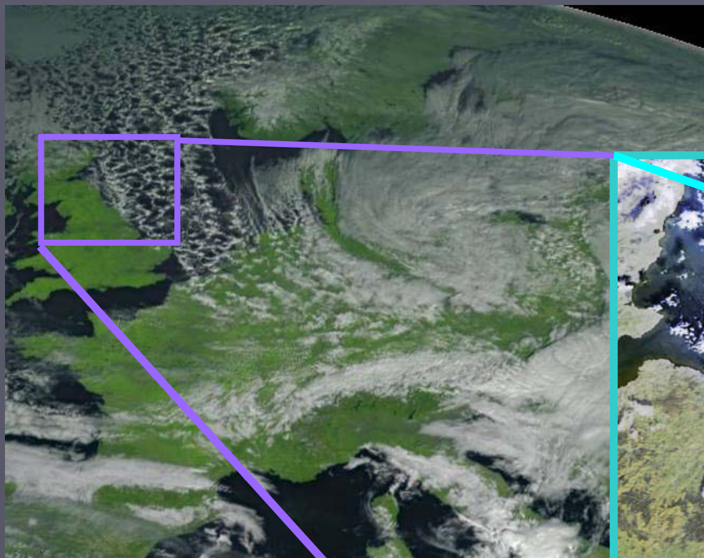
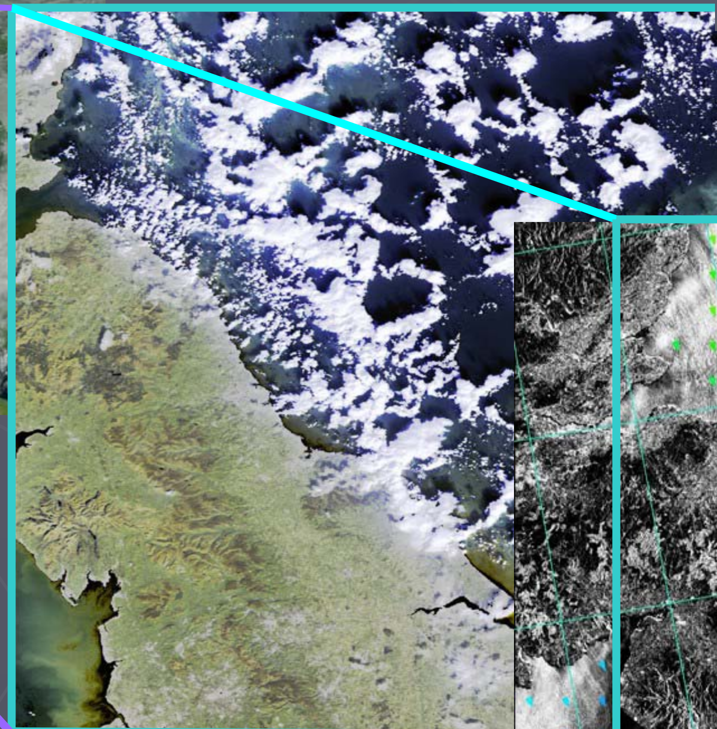
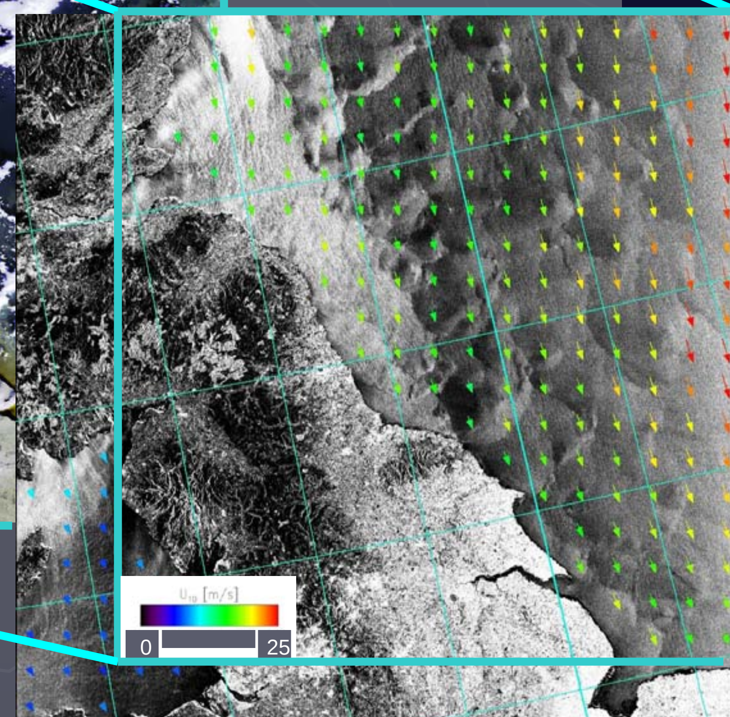
MSG



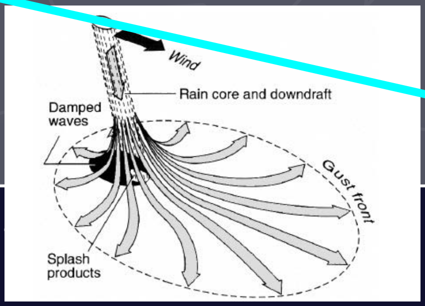
MSG-1 image acquired on Nov 1, 2006, 10:30 UTC

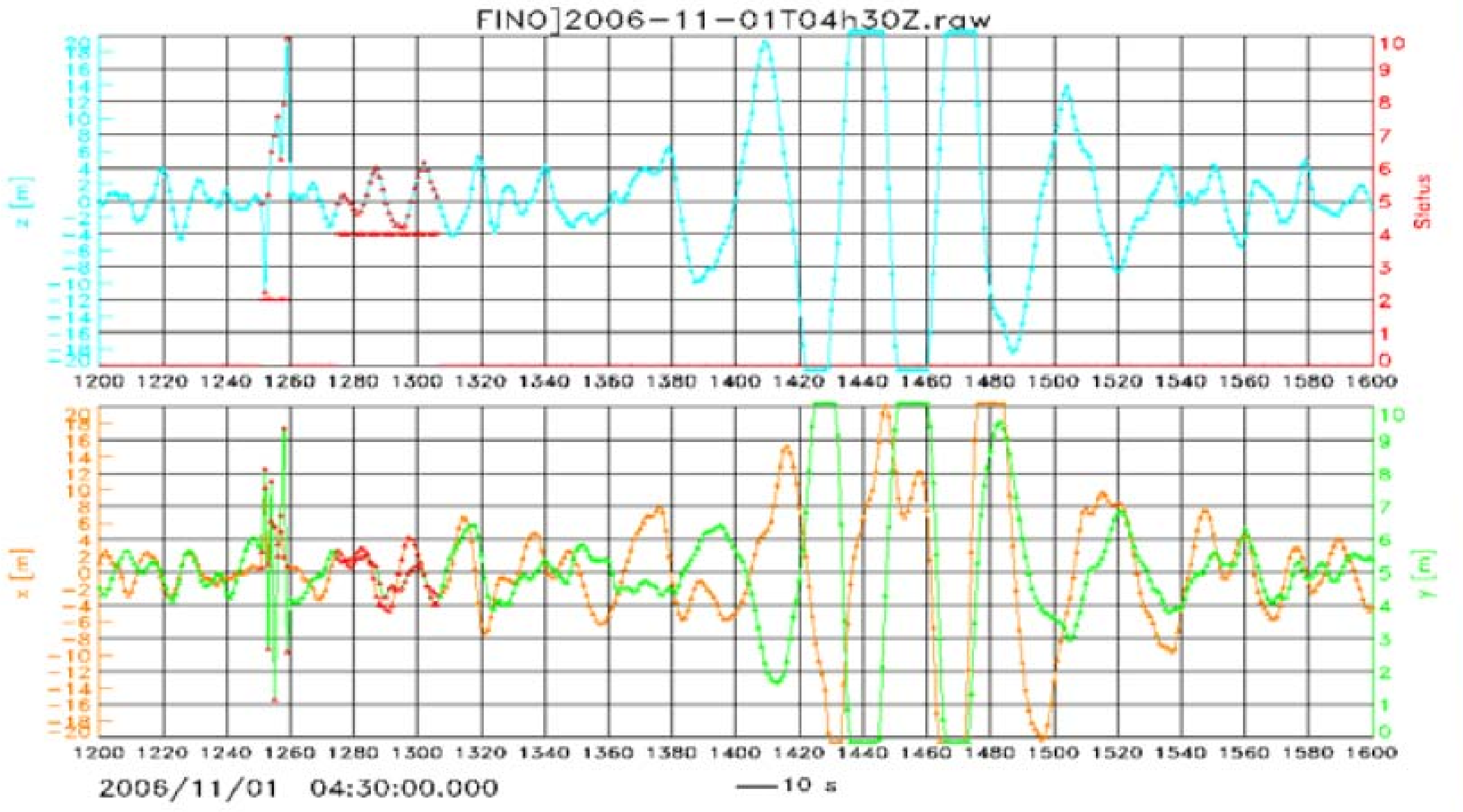
MERIS FR LEVEL 2 aquired on Nov 01, 2006





ASAR WSM acquired on Nov 1, 2006 10:26 UTC with overlayed windfield





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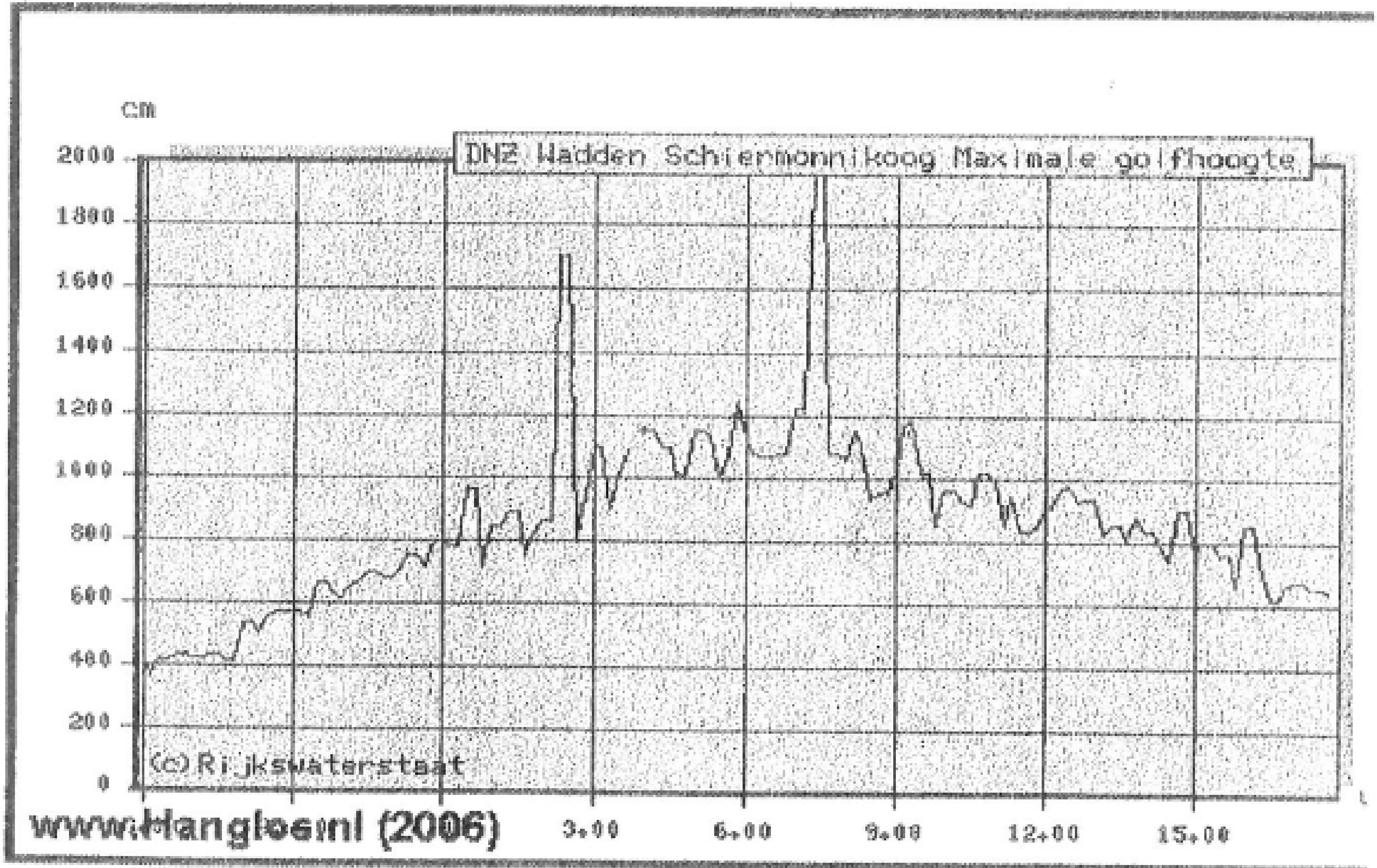


www.Hangloes.nl (2006)

Storm Tilo

O. Outzen, K. Herklotz,
H. Heinrich, BSH

C. Lefebvre, DWD

DEWI MAGAZIN NO. 33, AUGUST 2008

Fig. 1: On 9 November 2007, broken wooden planks on the working platform 15 m above chart datum (left). Basement of the FINO 1 research platform and location of the working platform.

Abb. 1: Am 9.11.07 zerbrochene Holzbohlen auf der Arbeitsplattform in 15 m ü. SKN (links). Basement der Messplattform FINO 1 und Lage des Arbeitsplattform (rechts).

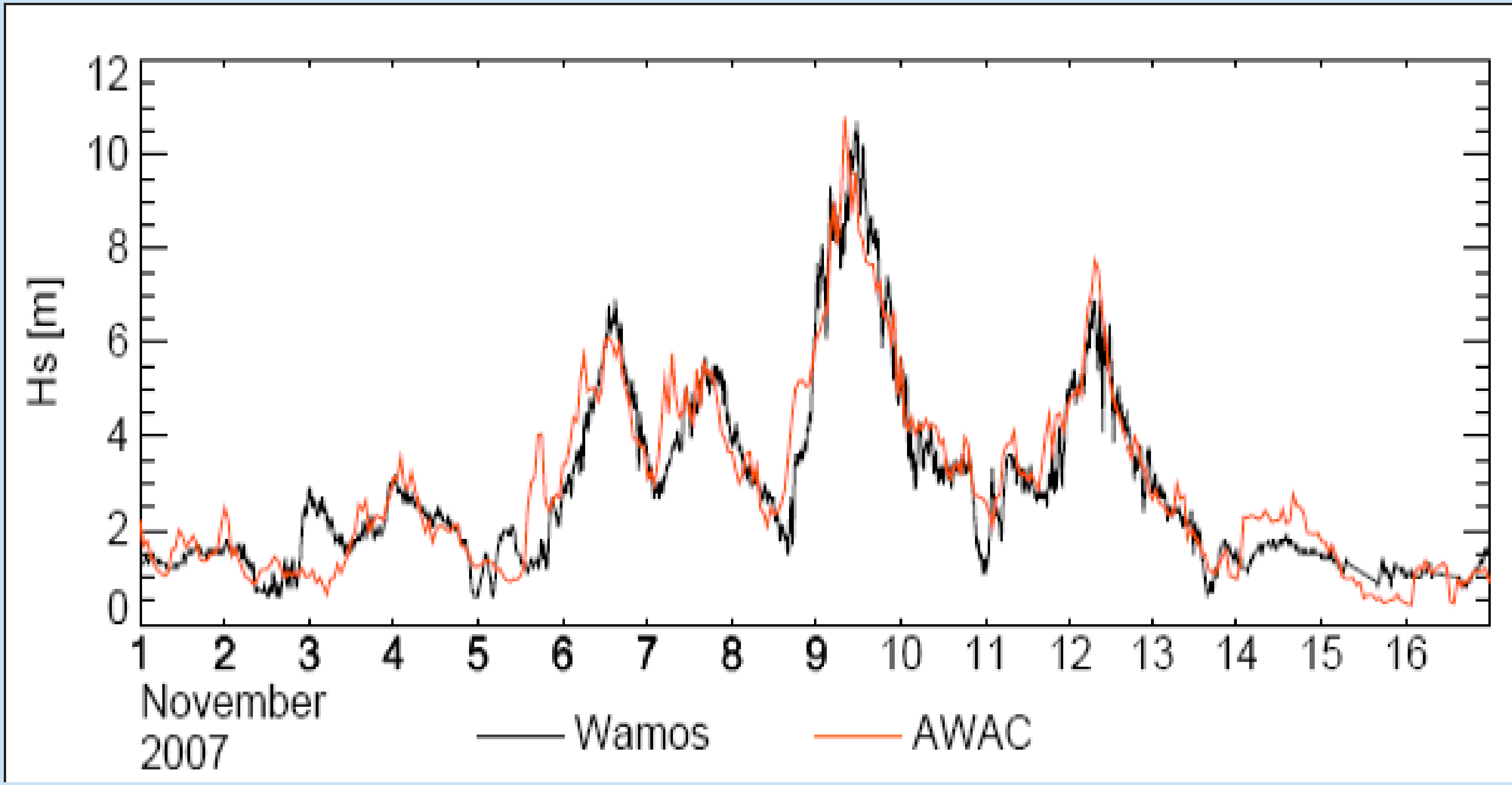
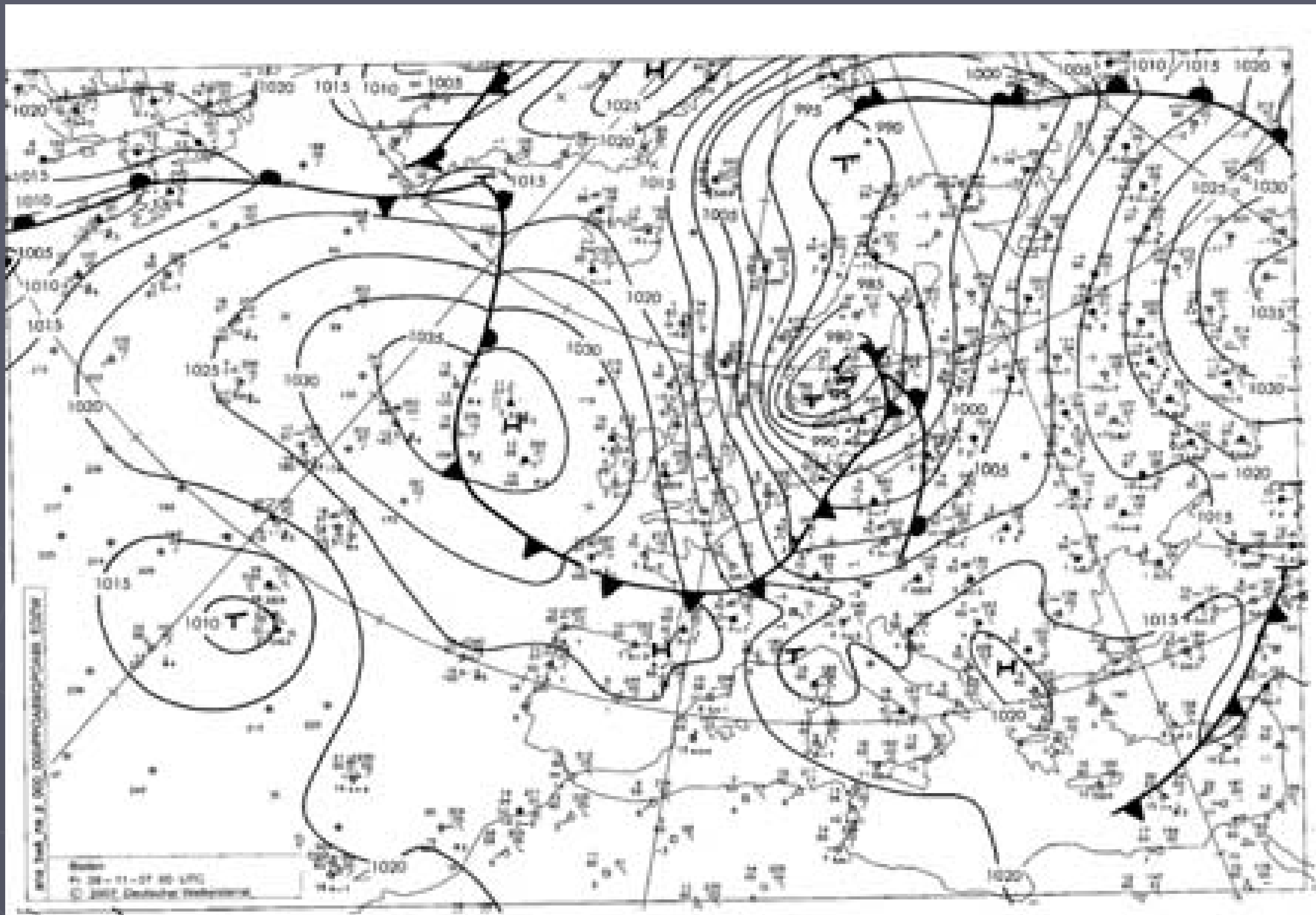
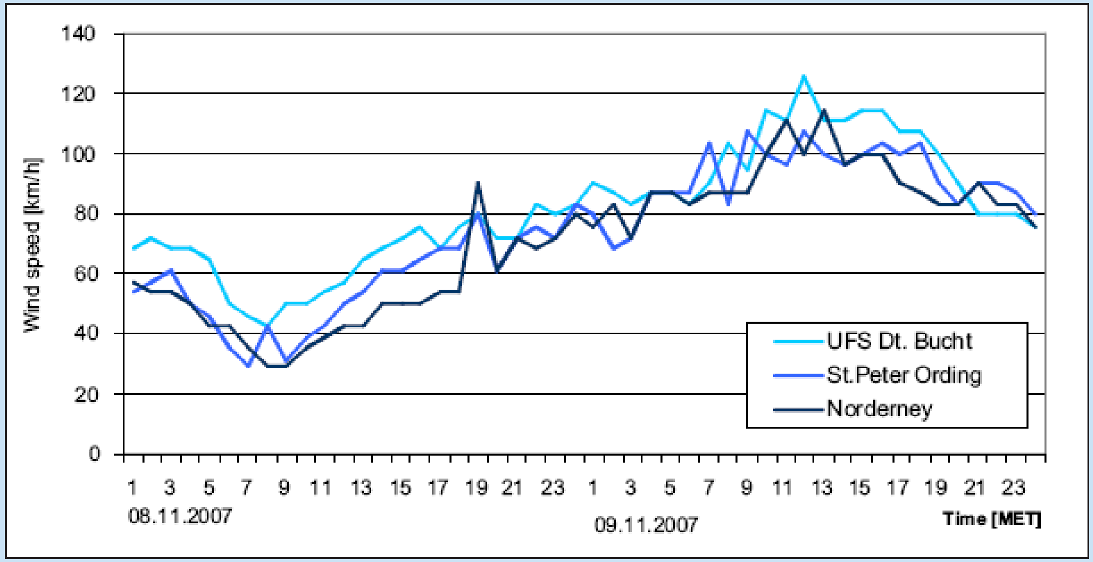


Fig. 5: Significant wave heights H_s in November 2007, measured using WAMOS (black) and ADCP (red) on the FINO 1 offshore platform. The averaging period used to determine the statistical wave parameters significant wave height, peak wave direction and peak wave period is 30 min with the wave radar system, and 20 min with the ADCP (AWAC).



Weatherrmap from 9.Nov 2007, 0.00 UTC



Station	Max. Gust (km/h)
North Sea	
Spiekeroog	146.5
UFS Deutsche Bucht	127.4
Strucklahnungshörn	124.6
List auf Sylt	120.2
Norderney	115.9
Hallig Hooge	111.6
Helgoland	110.5
Sankt Peter-Ording	108.7
Büsum	108.4
Bremerhaven	100.4
Borkum-Süderstraße	96.8
Brunsbüttel (Schleuse)	95.4
Cuxhaven	94.0
Leck	90.4
Emden	86.4

Wind gusts in the German Bight/ North Sea on 9. Nov. 2007 as a time series (above).

Max. Gusts at different stations (below)

t on 9
.2007

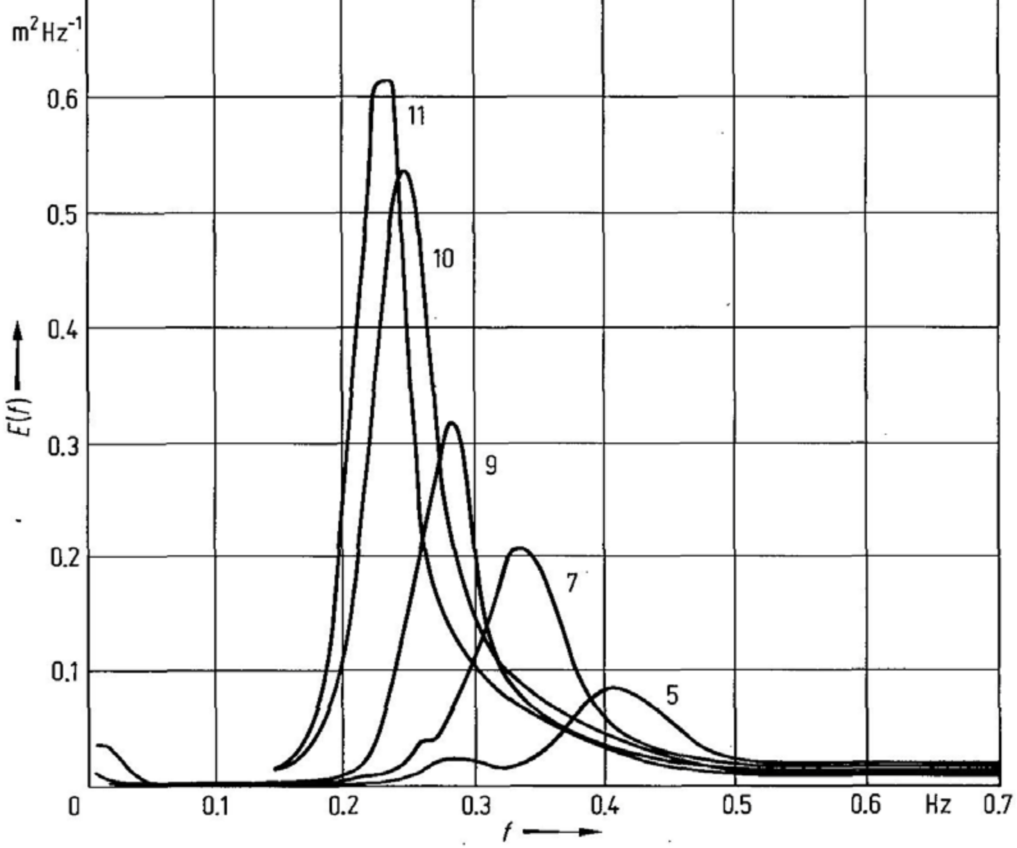


Fig. 3. Evolution of a wave spectrum with increasing fetch for offshore winds. Increasing numbers refer to stations with increasing distance from shore [73 H].

Wind Sea parameters in deep water in fully developed state

Wind speed m/s	Period T (s)	Group velocity m/s	Phase velocity m/s	Wave length m	Hs fully developed , m
6.5	5	3.8	7.5	37.5	1.0
13	10	7.5	15	150	5.0
20	15	11.3	22.5	338	11
26	20	15	30	600	20
32	24	18	36	864	28.8

From Rayleigh distribution:
N is the number of individual waves for a given significant wave height $H_{1/3}$, for which on the average one wave exceeds the height H_N .

$$N = \exp(2(H_N/H_s)^2)$$

$$H_N = H_s(0.5 \ln(N))^{0.5}$$

$H_N \geq 2 H_s$ is our working definition for monster wave

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$H_N \geq 2\ H_S$ is our working definition for a monster wave

N	H_N/H_S
7.4	1
1000	1.86
3000	2.07

Average observed number N of single waves until the encounter with an individual wave height H_N and a significant wave height H_S

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Conclusions

- To determine the shape and the height of individual waves radar satellites are crucial. The modern wave models are at present of no help. They only deliver averaged sea state parameters (no high resolution variability).
- We anticipate that fast travelling small scale storms embedded in larger depressions are an effective source for extraordinary high energy wave fields, that travel at the speed of the small scale storms.
- With higher resolved wind fields the present wave models can in principle forecast extreme sea states.

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