Forecasting a 100-Year Wave Event

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Meteorologisk institutt
marked.met.no

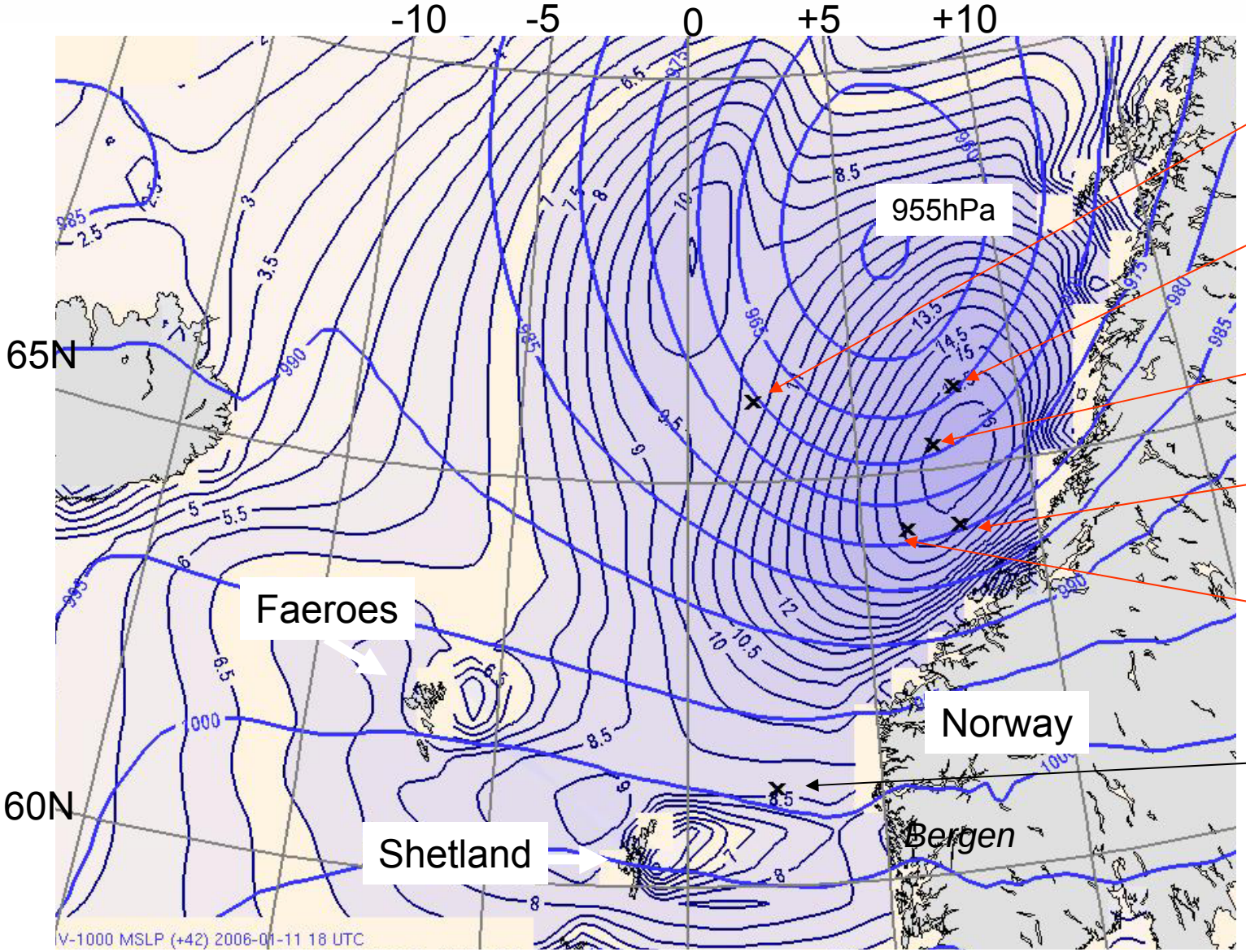
Forecasting a 100 year wave event

- Was it a 100 year event ?

  - Model forecasts / analysed fields

  - Observations
    - upstream (Faeroe-Shetland)
    - In the area close to maximum

Wave forecast 10. January 2006 00UTC
+42 hrs : Valid 11th at 18 UTC : > 16m



Polarfront:
N 66.0 E 2.0

Norne:
N 66.0 E 8.1

Heidrun:
N 65.3 E 7.3

Draugen:
N 64.3 E 7.8

Njord:
N 64.3 E 6.3

Gullfaks :
N 61.2 E 2.3

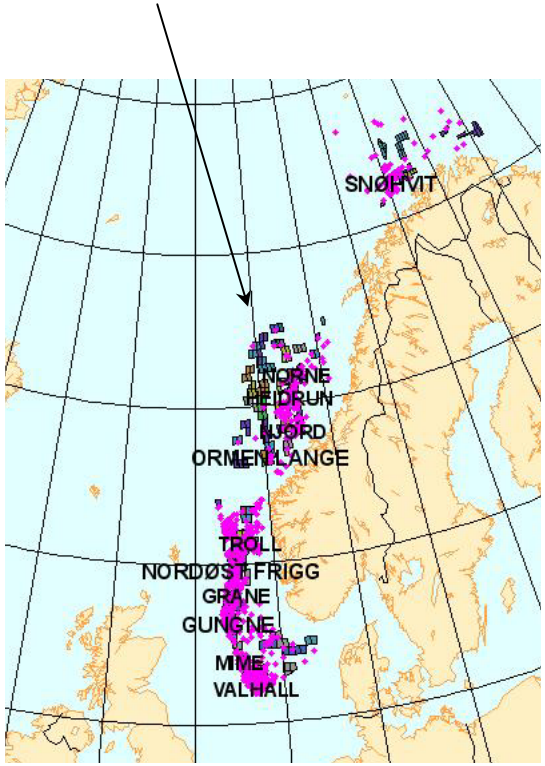
Historical records and 100 year value

Since 1981:

> 12m : 10 cases
> 13m: 6 cases
> 14m: 1 case (1993) 13.7m (2001)

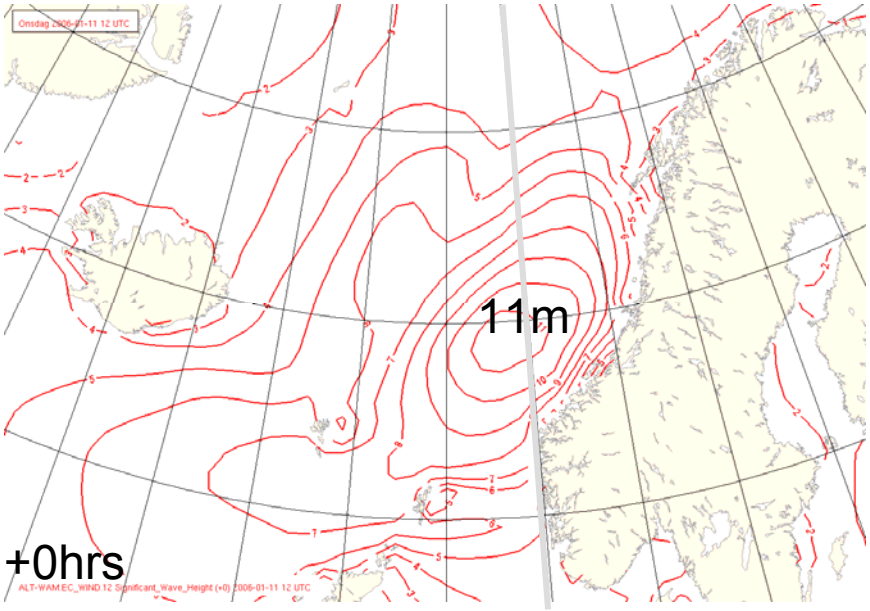
$Hs_{100years}$ = 16m

In the Haltenbanken area

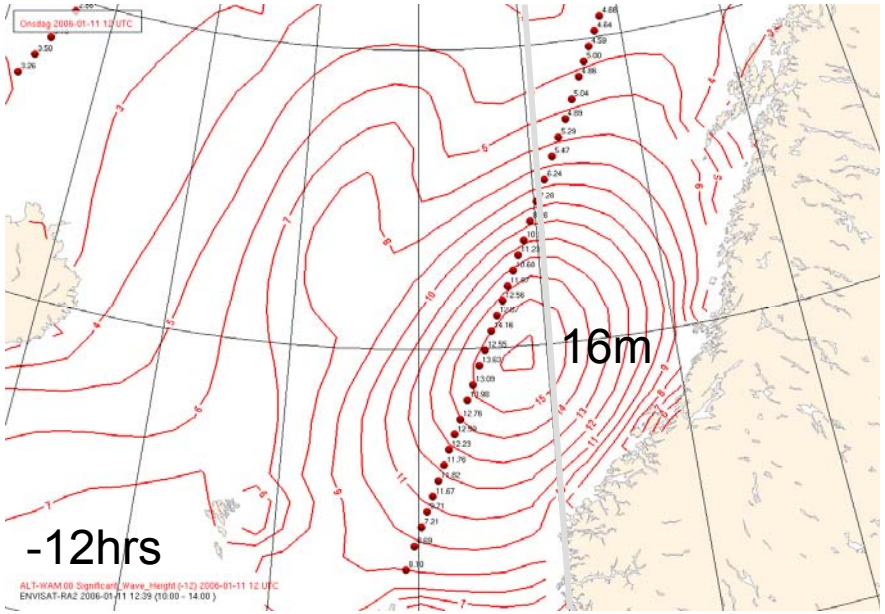


Hs at 11.January 2006 12 UTC

ECMWF (wind/waves: 75km)

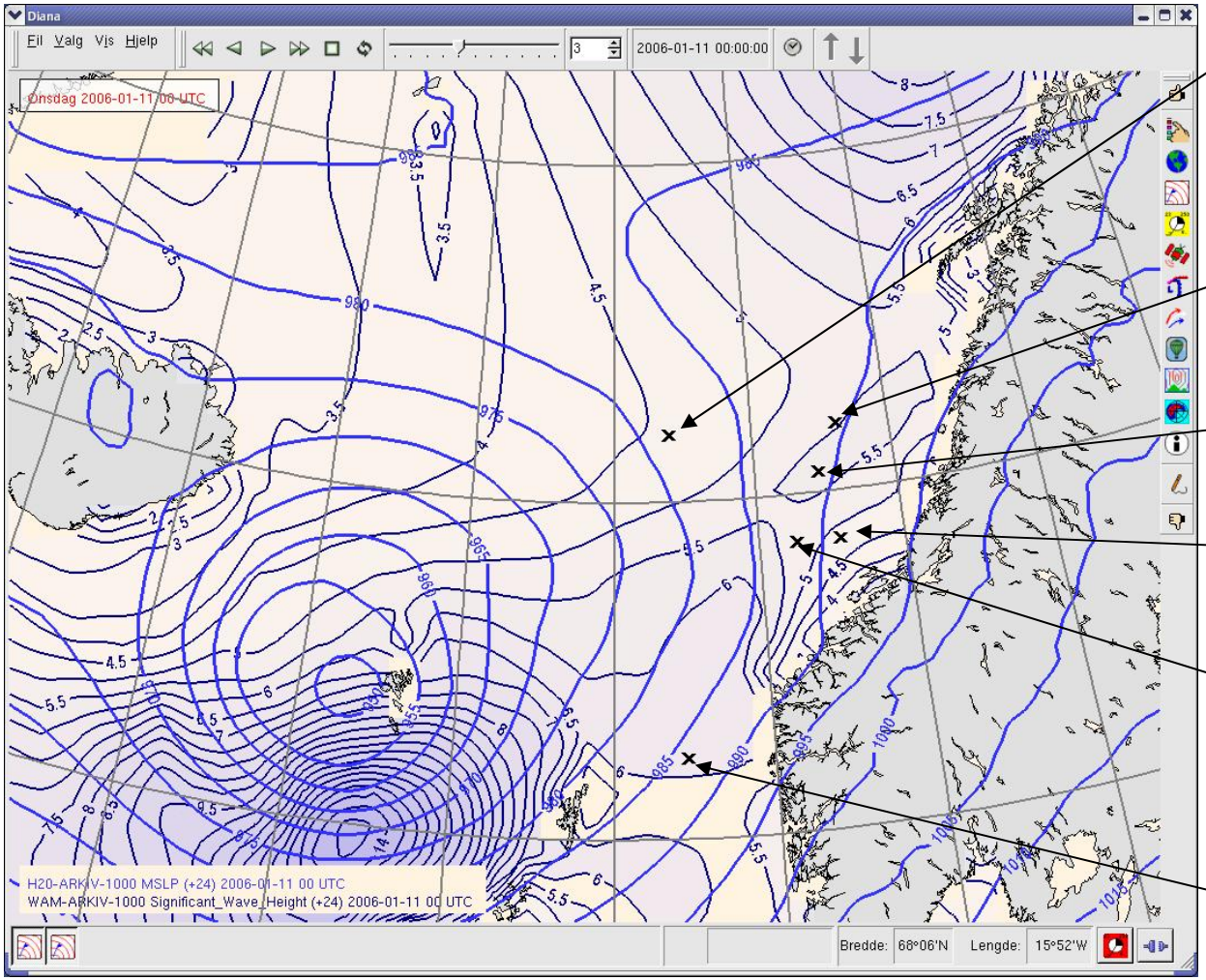


met.no (wind/waves: 20km/45km)



- Model prognoses and analysis:
  - met.no : → **15 -17 m**
  - ECMWF: → **11-12 m**

Wave forecast from 10. January 2006 00UTC valid +24 hrs : 11th at 00 UTC



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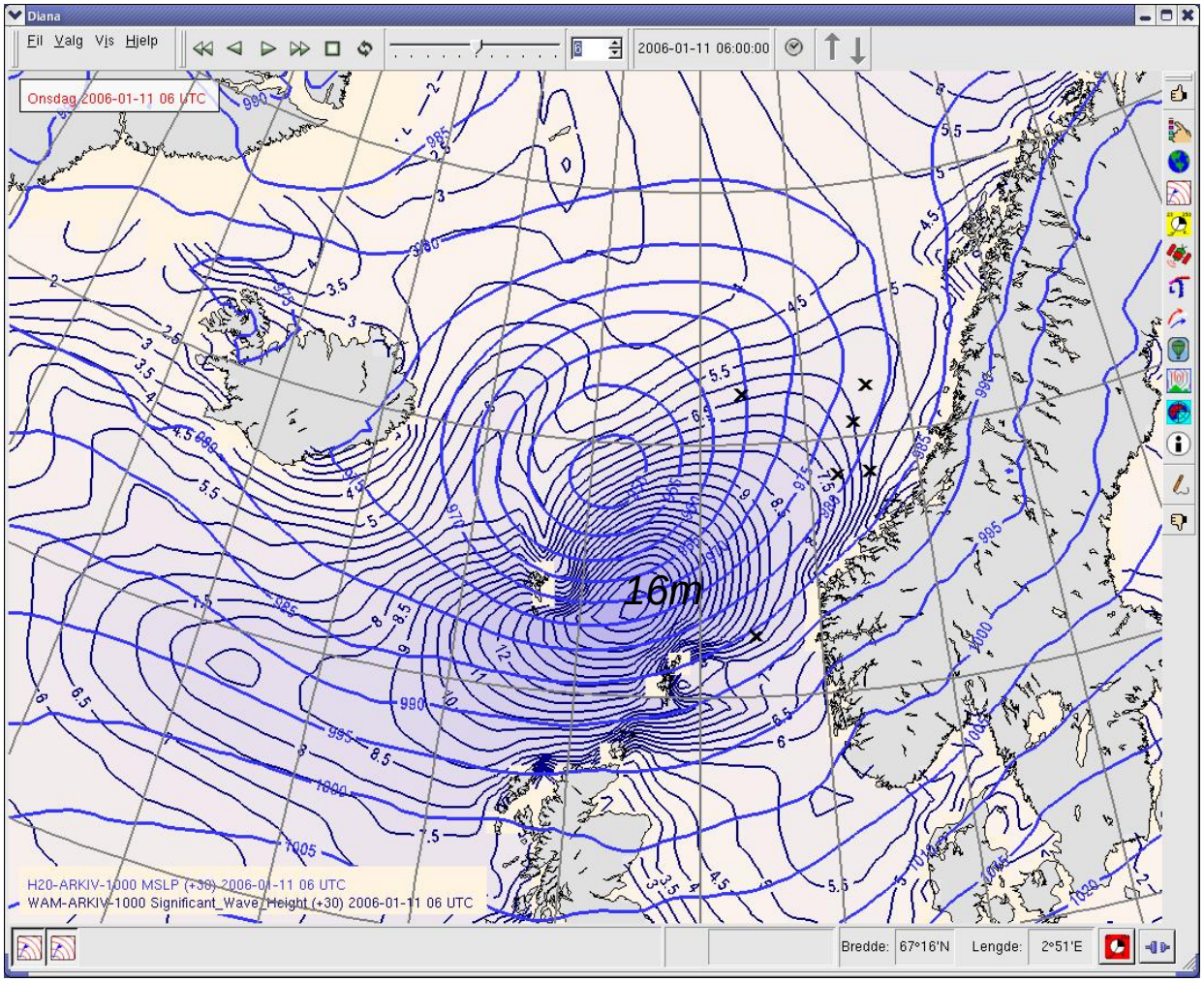
N 64.3 E 7.8

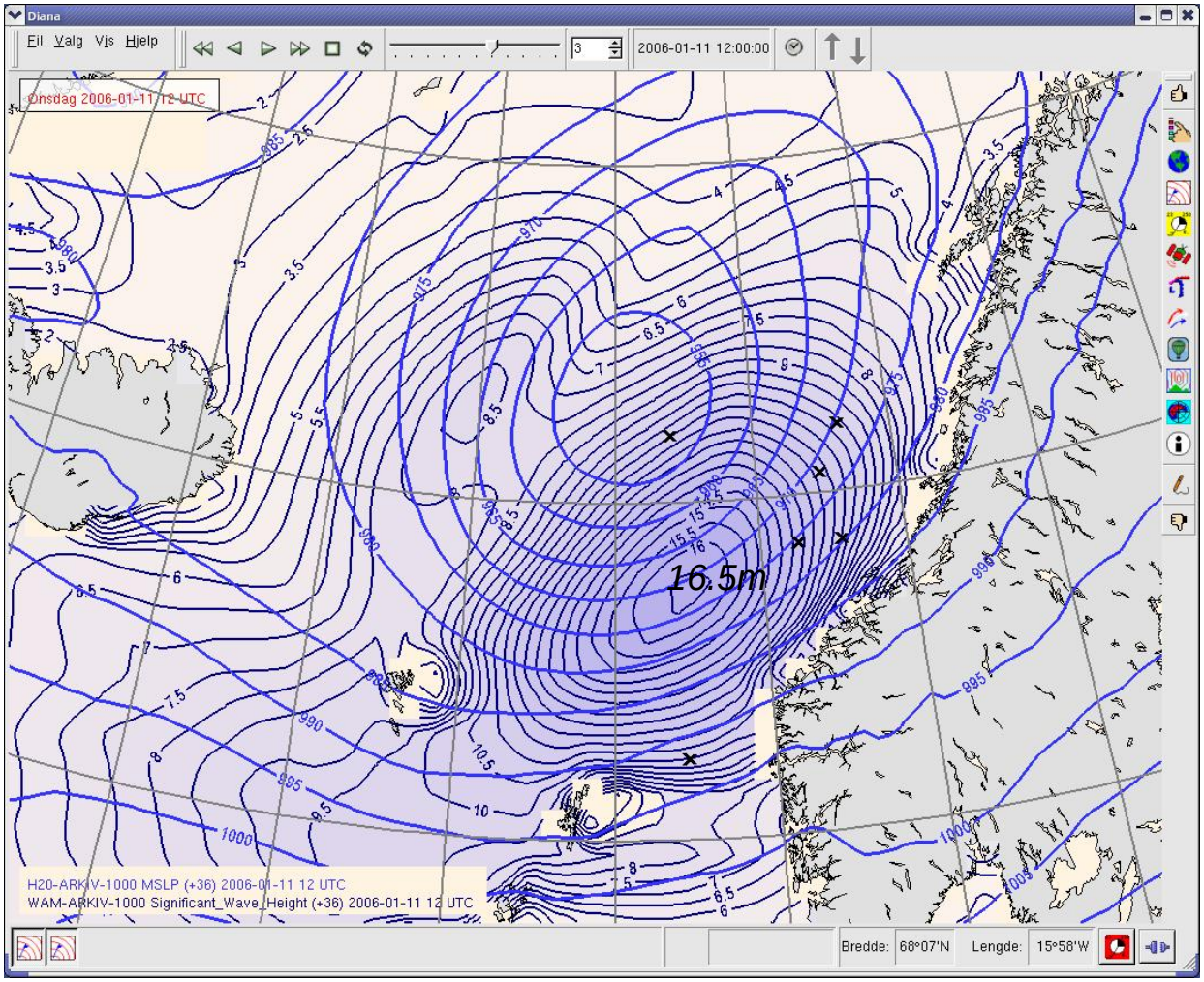
Njord:
N 64.3 E 6.3

Gullfaks :
N 61.2 E 2.3

Wave forecast from 10. January 2006 00UTC
+30 hrs : 11th at 06 UTC

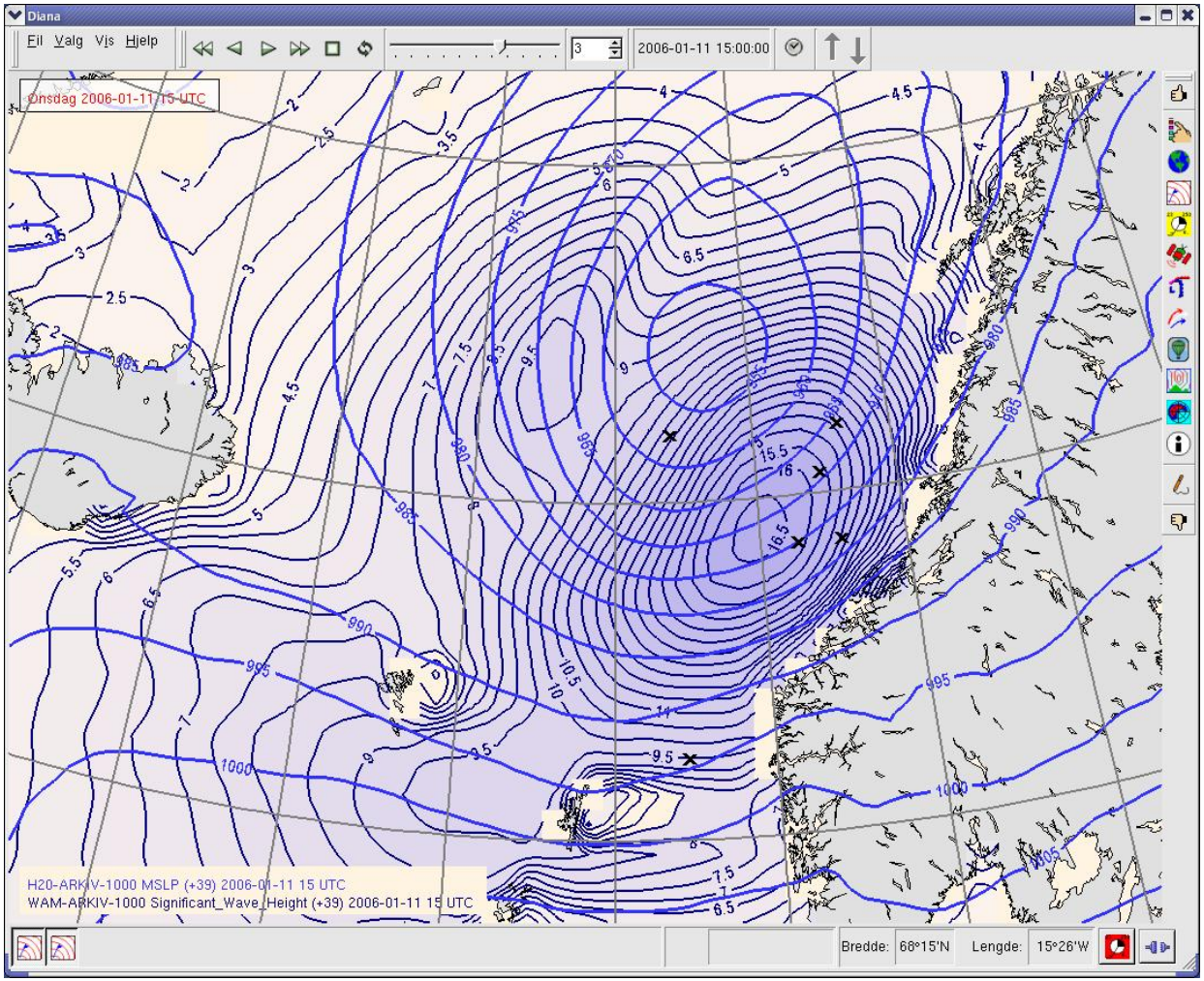


Wave forecast from 10. January 2006 00UTC
+36 hrs : 11th at 12 UTC

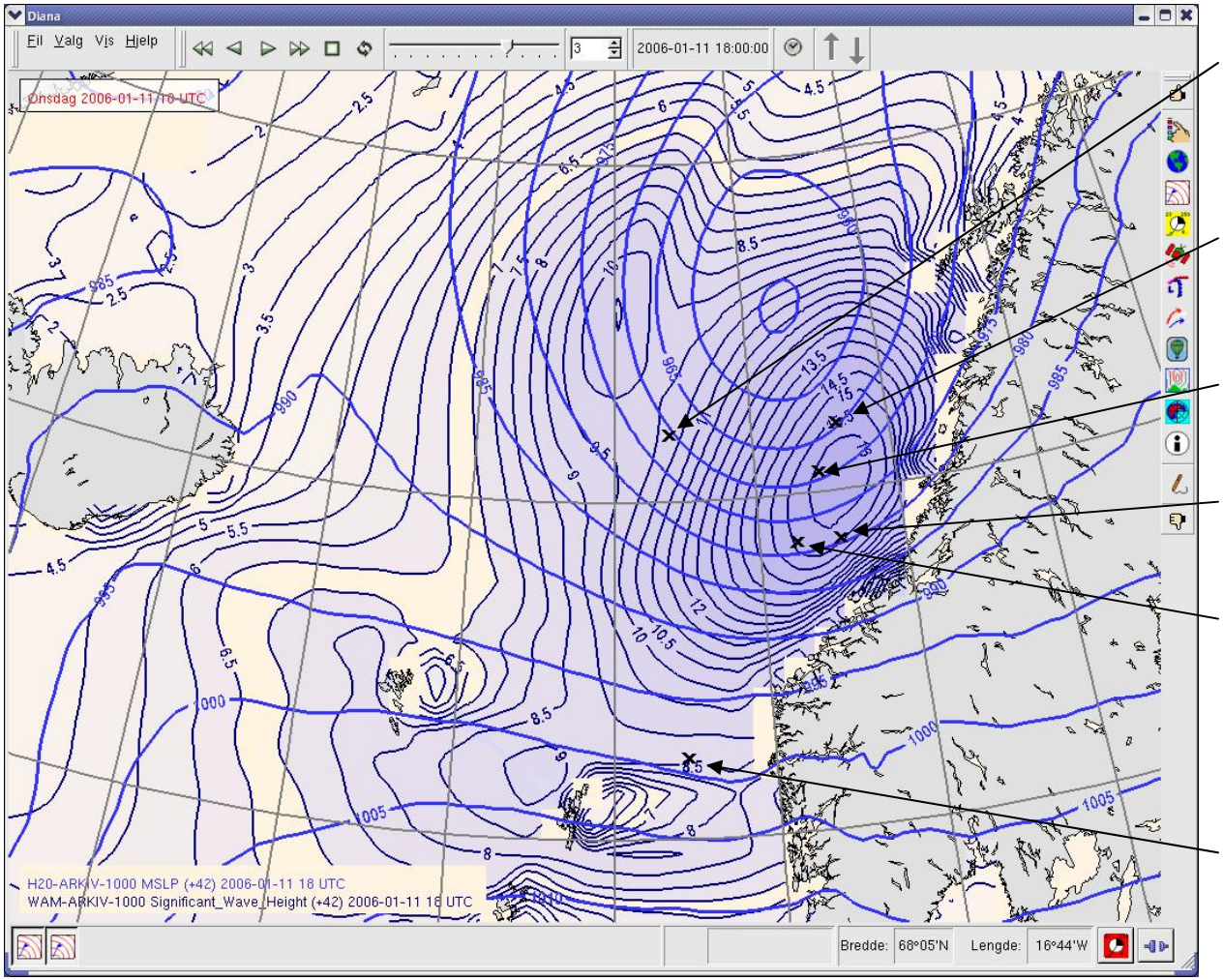


Wave forecast from 10. January 2006 00UTC
+39 hrs : 11th at 15 UTC

Forecasted:
Maximum
Hs = 16.5m
At 15 utc



Wave forecast from 10. January 2006 00UTC
+42 hrs : 11th at 18 UTC



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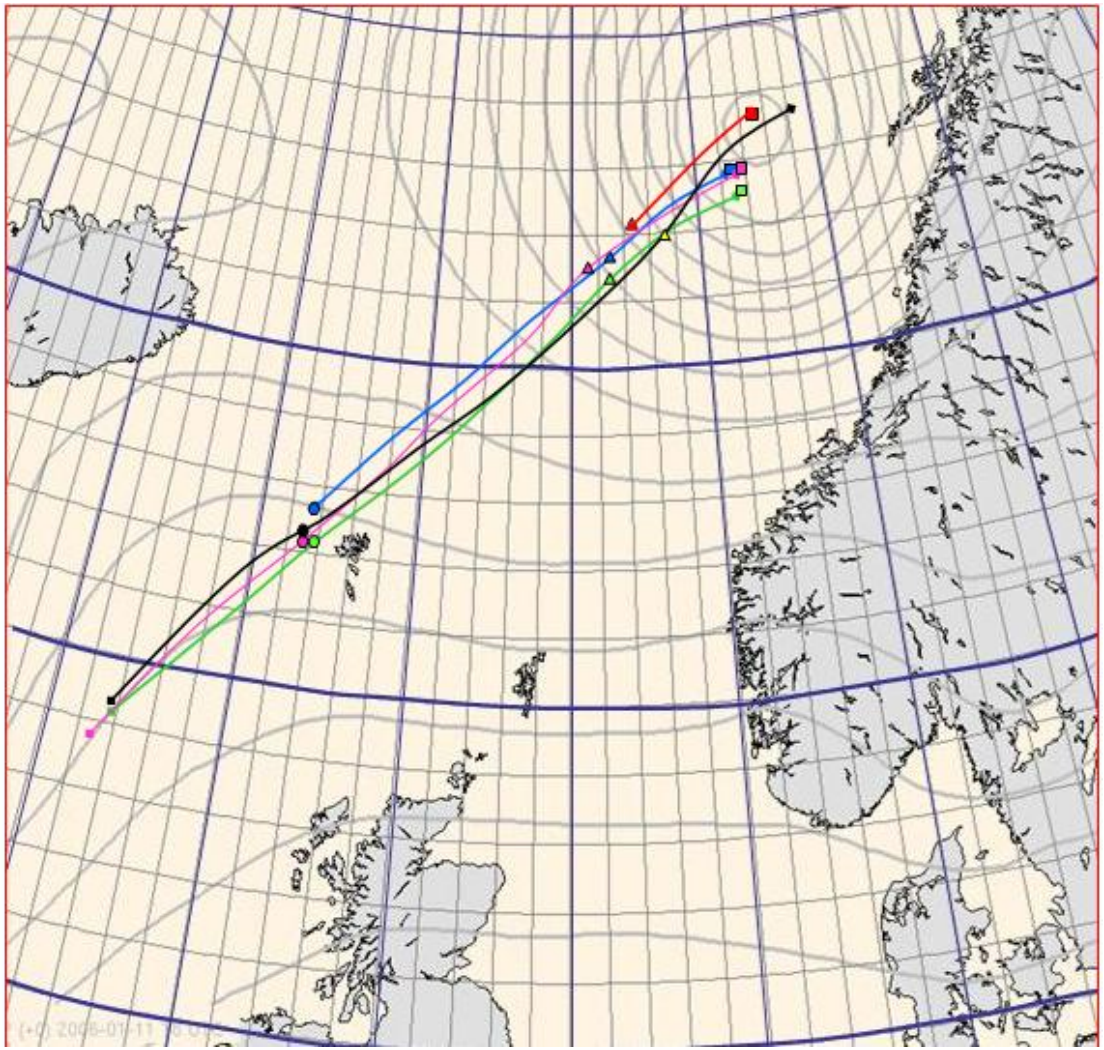
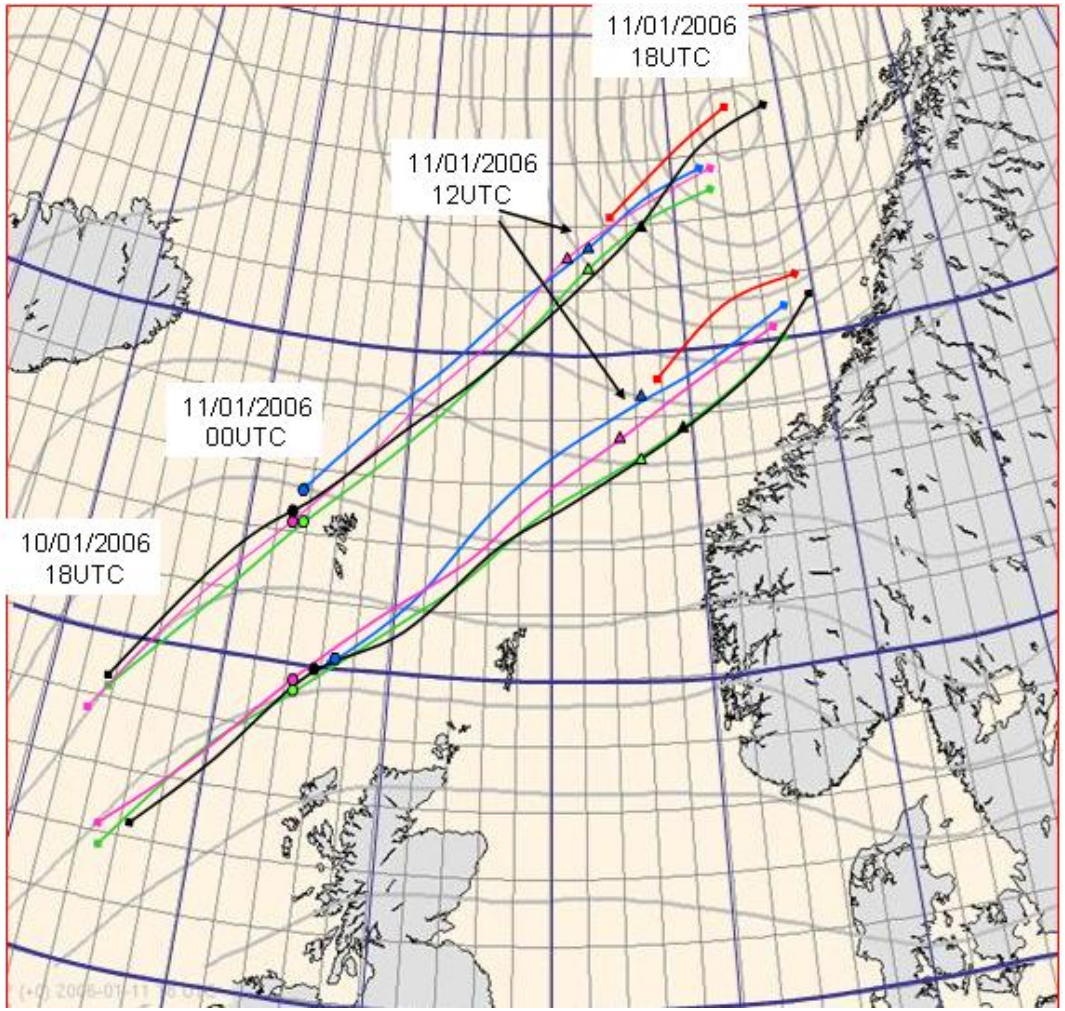
N 61.2 E 2.3

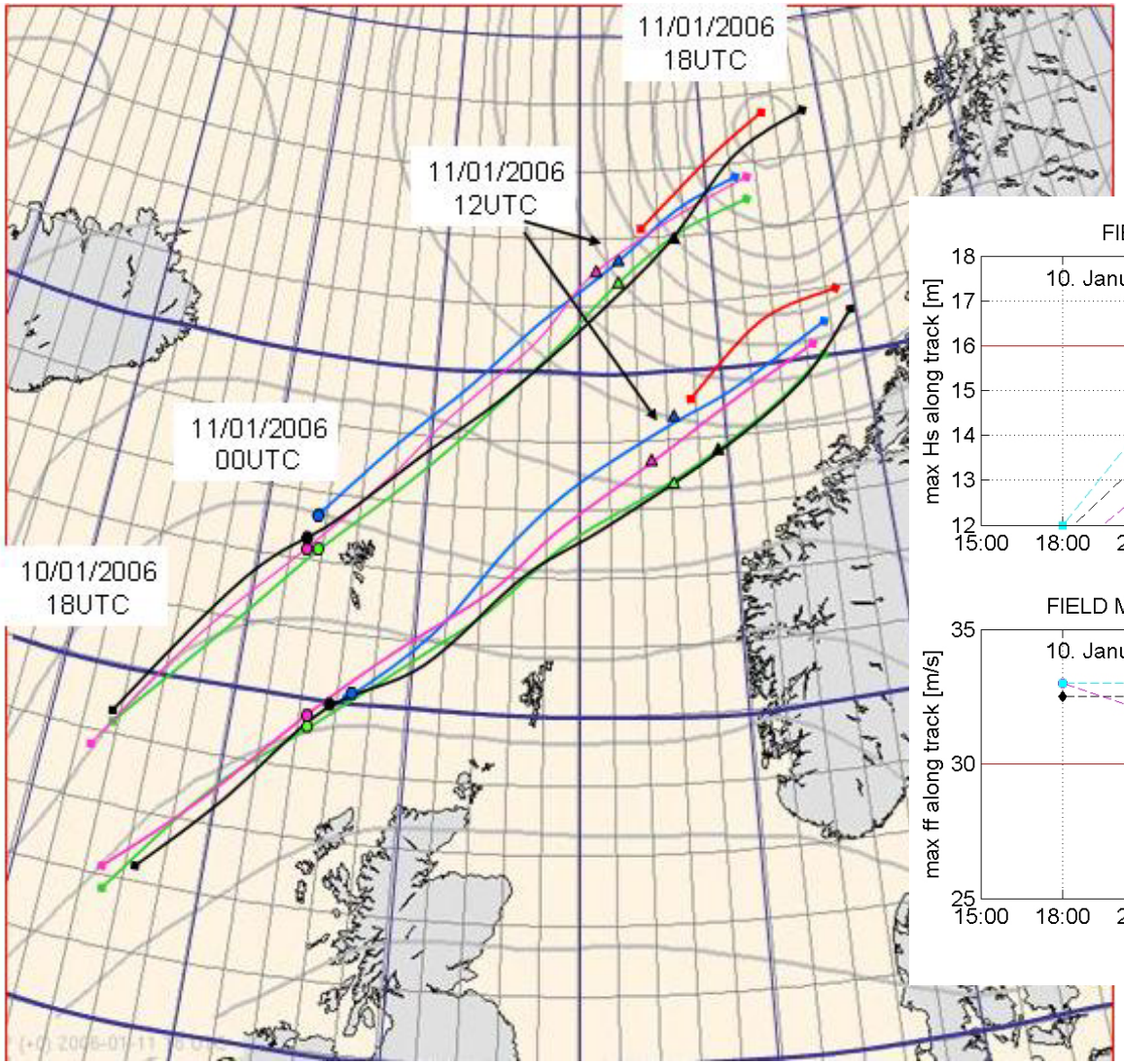
Tracks of Low pressure minima

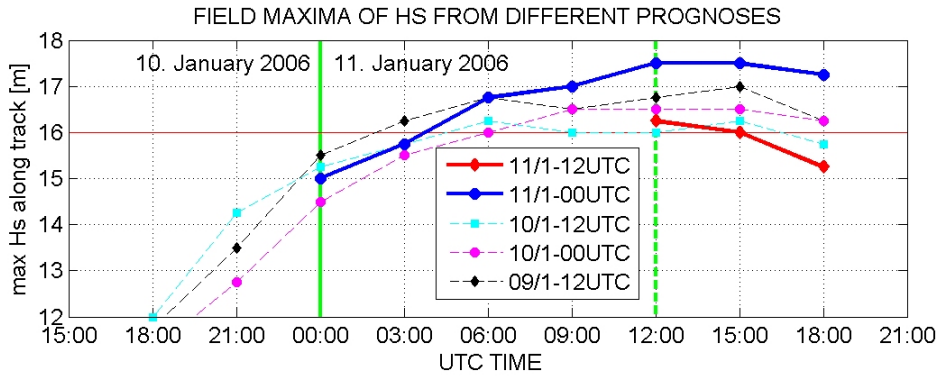


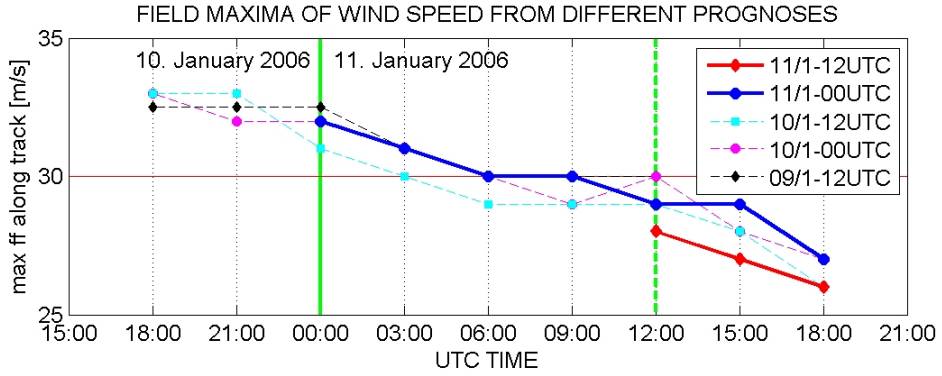
Low pressure and Maximum Hs



All prognoses Hs > 16m

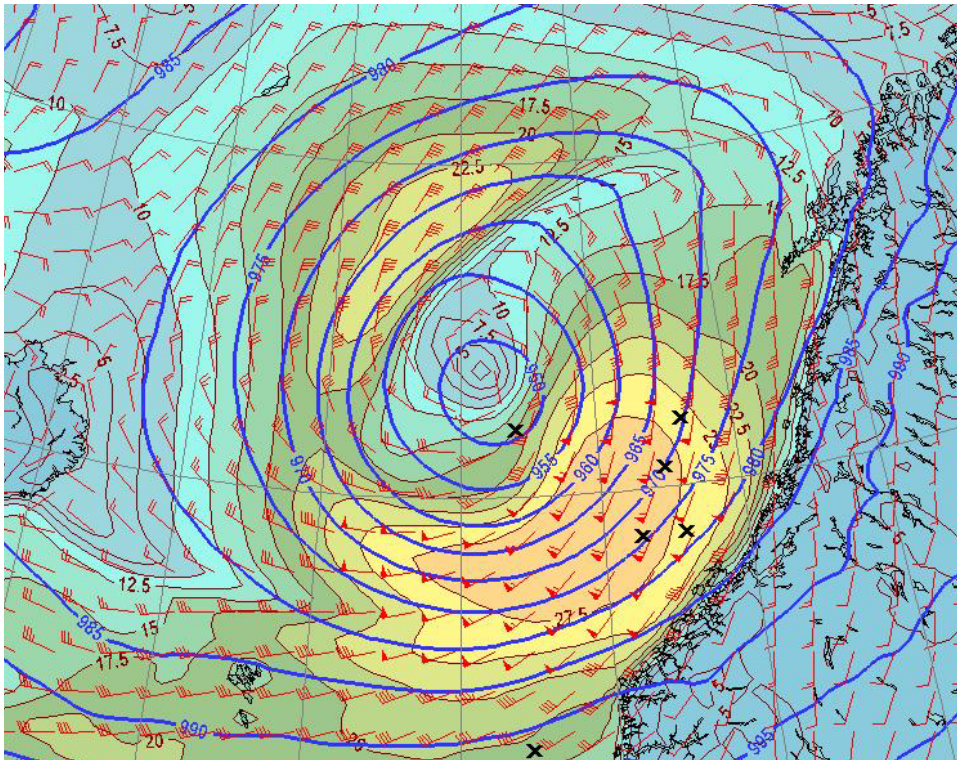




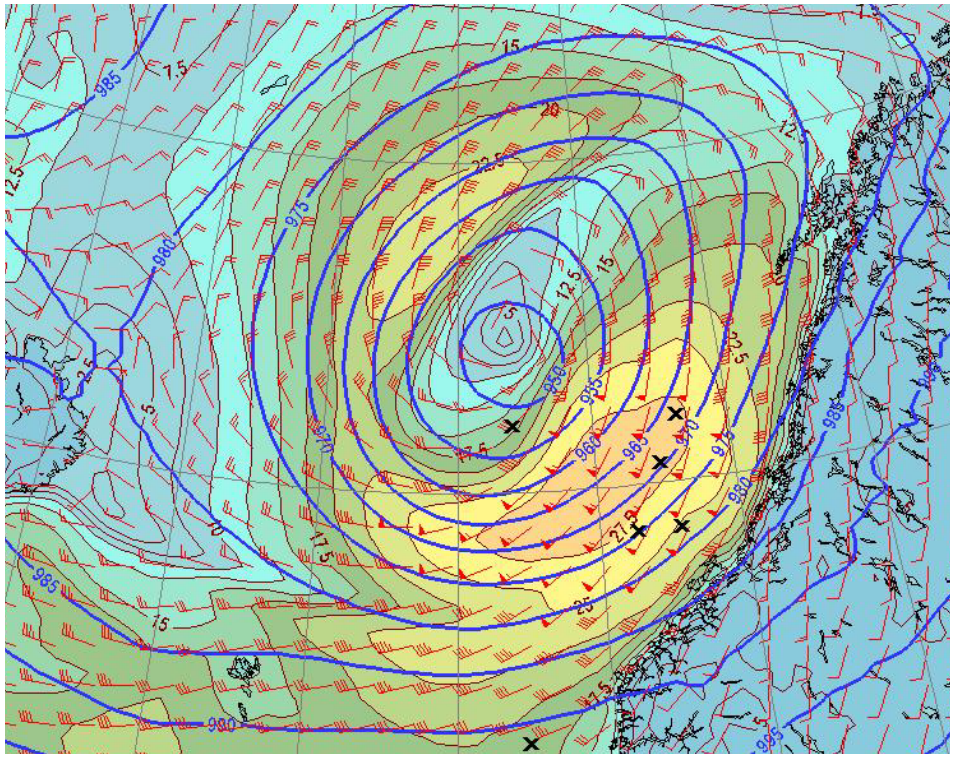


WIND SPEED (darkest color: 27.5-30 m/s)
11.January 2006 12 UT

+12 hrs (11th.00-forecast)

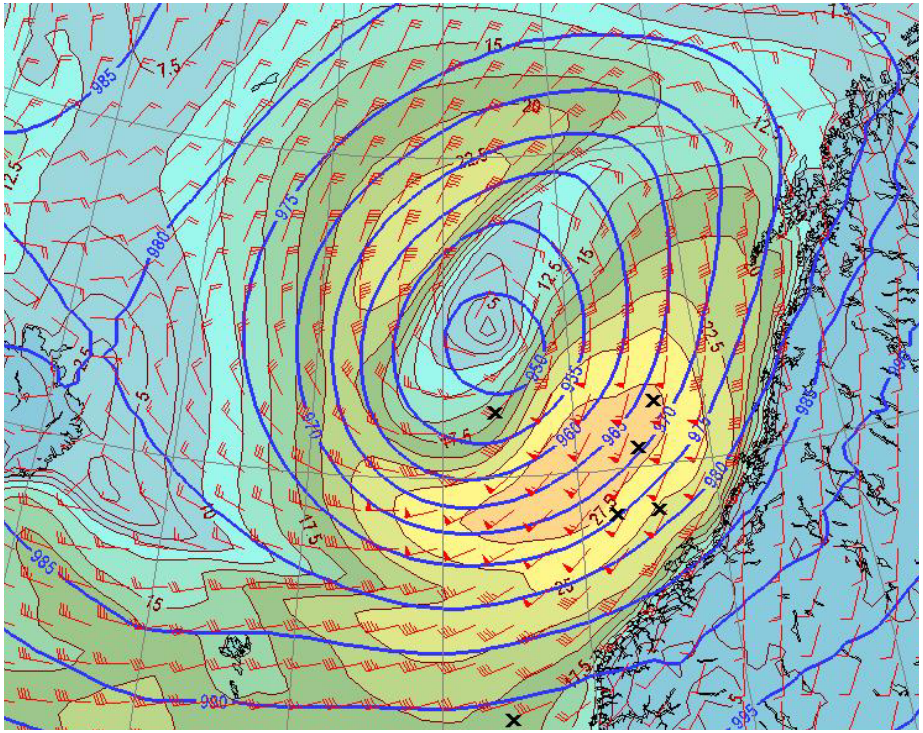


+6hrs (11th.06-forecast)

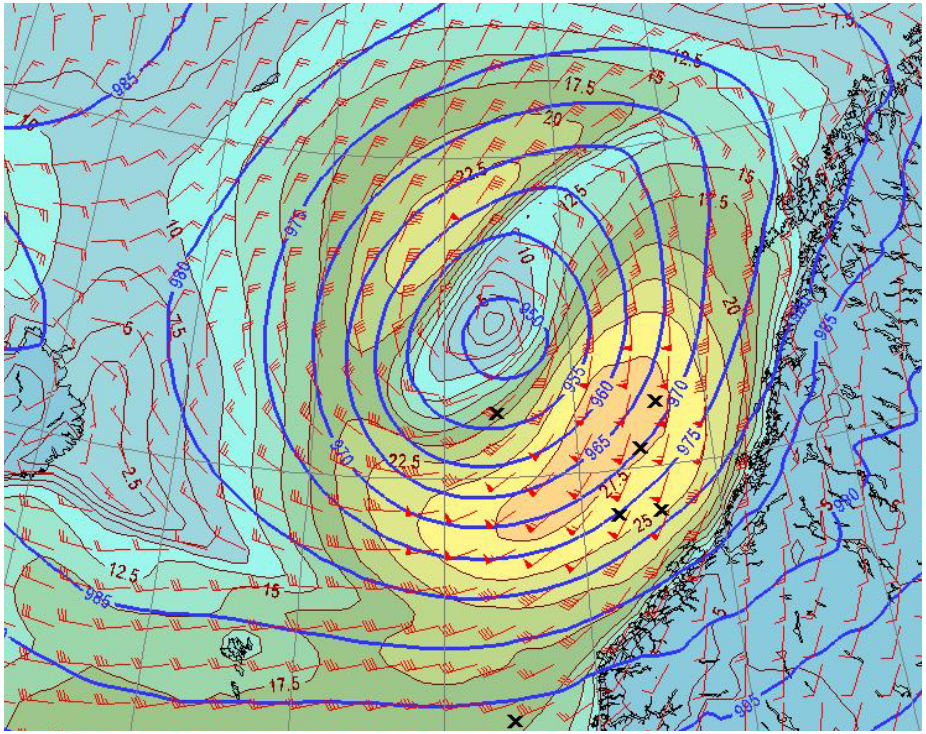


11.January 2006
WIND SPEED (darkest color: 27.5-30 m/s)
11.January 2006 12 UT

+06 hrs (11th.06-forecast)



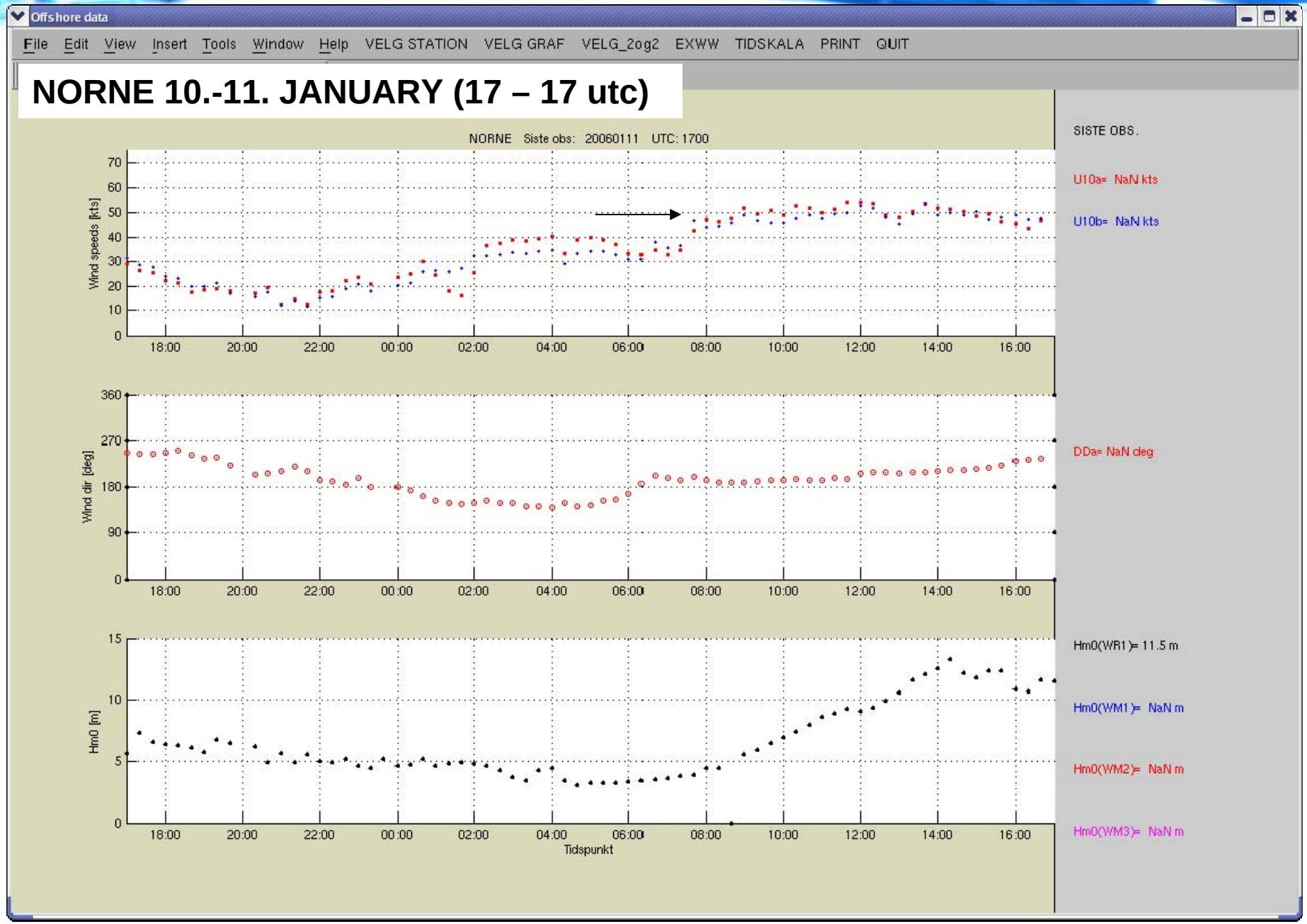
-12hrs (12th.00-forecast)

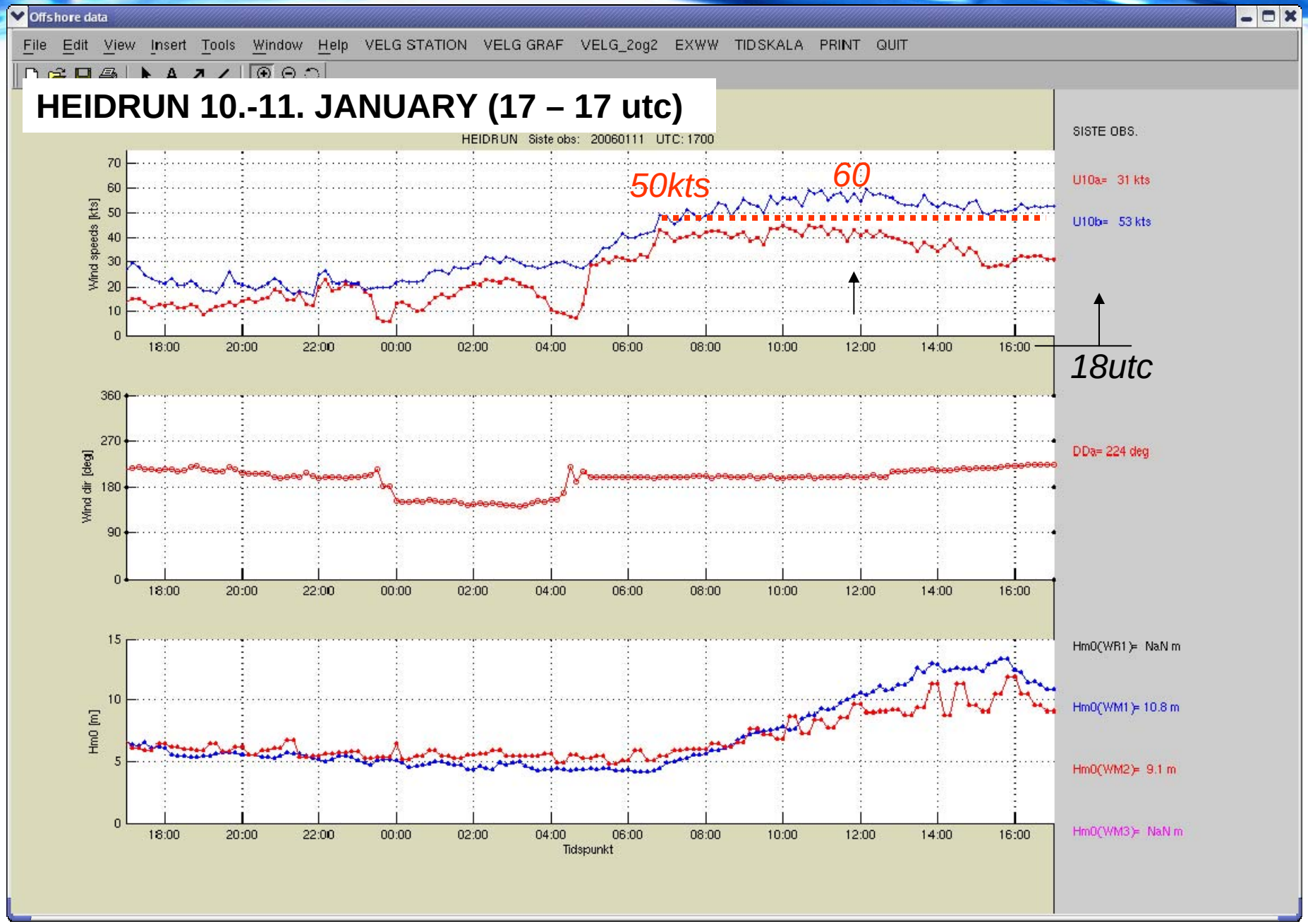


Area with maximum winds (color code: 27.5 m/s ≤ U10 < 30 m/s) is *less the closer to observed time*.

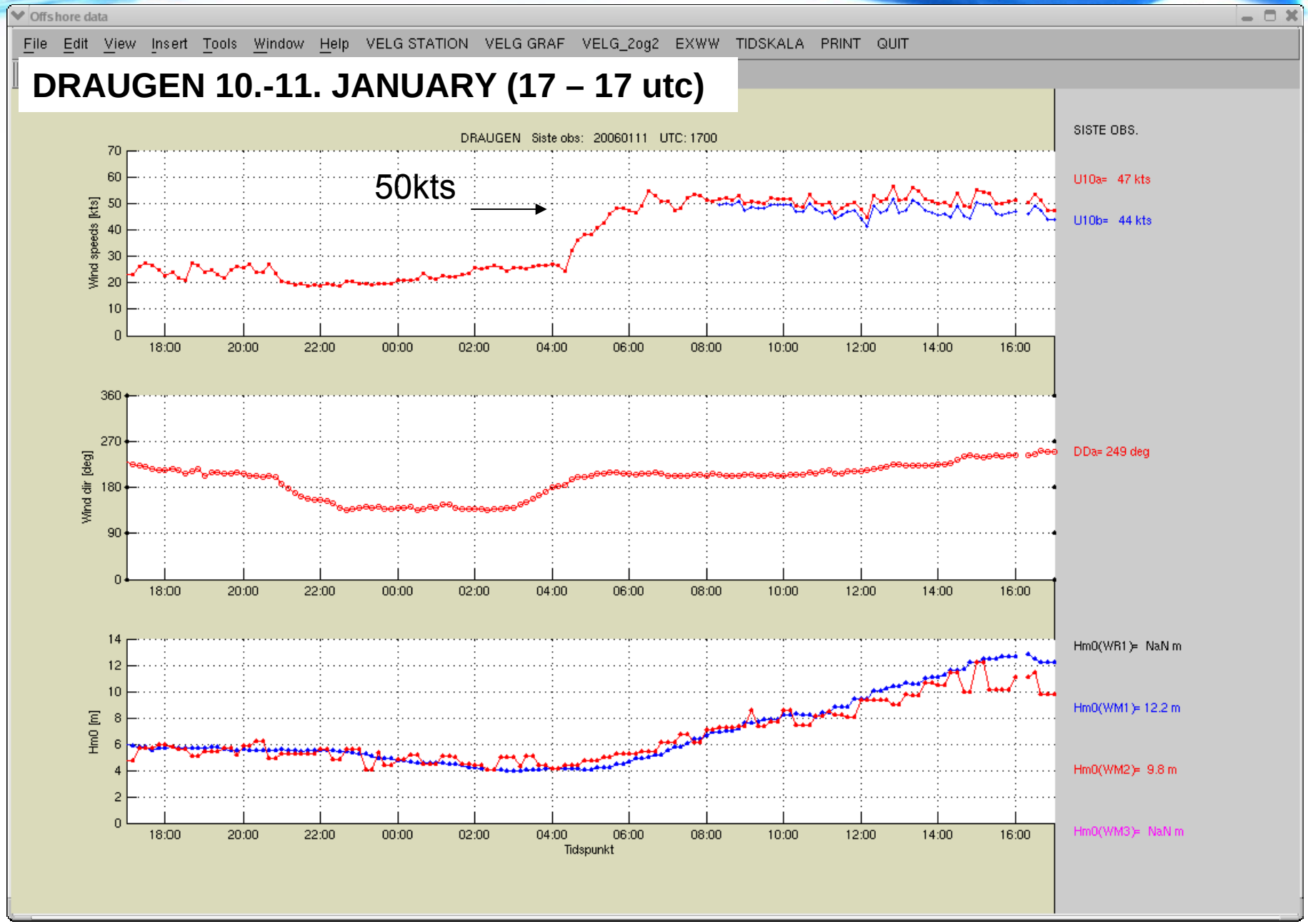
In figure to the right (analysed field) a wide variety of data have been assimilated:
air plane observations / satellite information / ground data.

NORNE 10.-11. JANUARY (17 – 17 utc)




Offshore data
File Edit View Insert Tools Window Help VELG STATION VELG GRAF VELG_2og2 EXWW TIDSKALA PRINT QUIT
HEIDRUN 10.-11. JANUARY (17 – 17 utc)
HEIDRUN Siste obs: 20060111 UTC: 1700
50kts
60
18utc
Wind speeds [kts]
Wind dir [deg]
Hm0 [m]
Tidspunkt
SISTE OBS.
U10a= 31 kts
U10b= 53 kts
DDa= 224 deg
Hm0(WR1)= NaN m
Hm0(WM1)= 10.8 m
Hm0(WM2)= 9.1 m
Hm0(WM3)= NaN m

DRAUGEN 10.-11. JANUARY (17 – 17 utc)

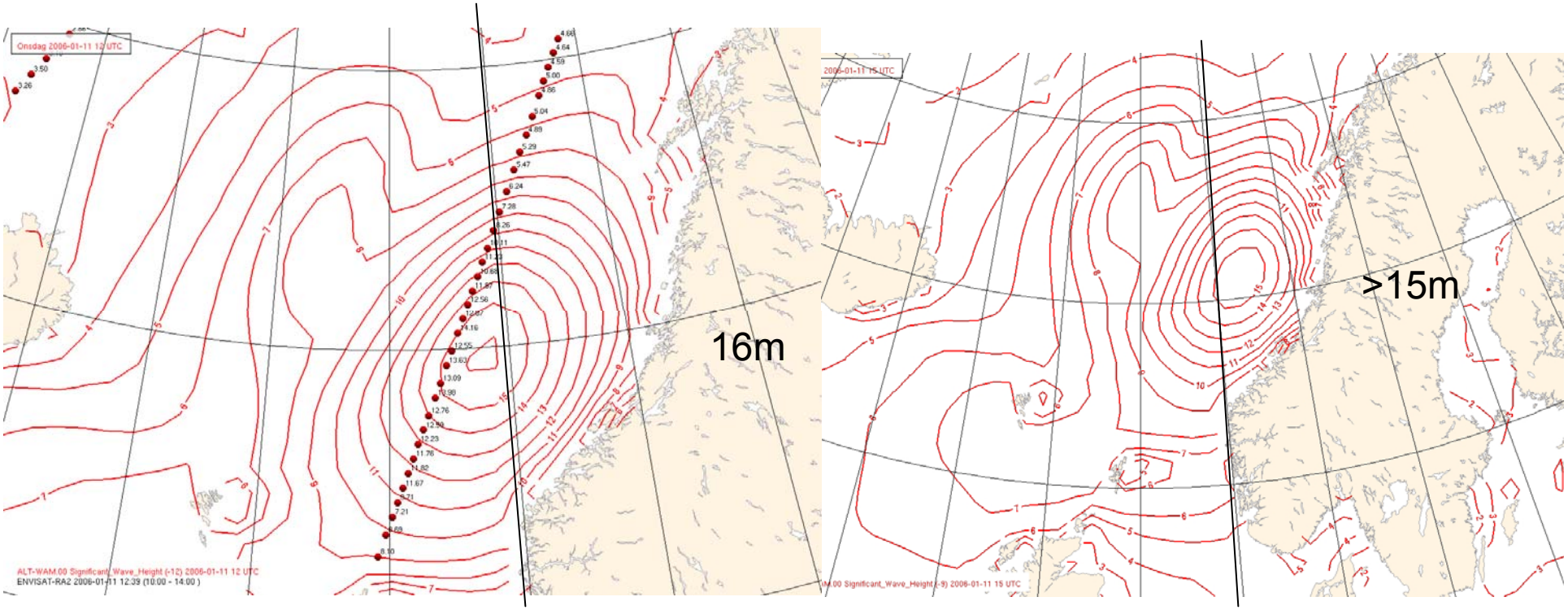


Haltenbanken storm 11. january 2006

From MIROS web site

- **WAVE Observations are uncertain:**
  - Several MIROS directional doppler radars (figure) give 13-13.5 m at maximum (after correction for movement).
  - WAMOS at Norne reports 13 m but has strange behaviour
  - Wave buoy at Norne reports 17 m
  - Satellite tracks report 13-14 m and spurious values up to 17-18 m

Analysed fields of Hs, 12 UTC and 15 UTC



Orientations of MIROS antenna important for wave data quality

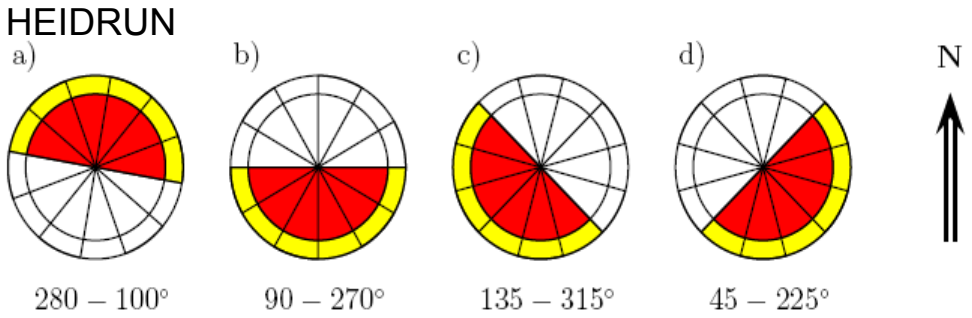


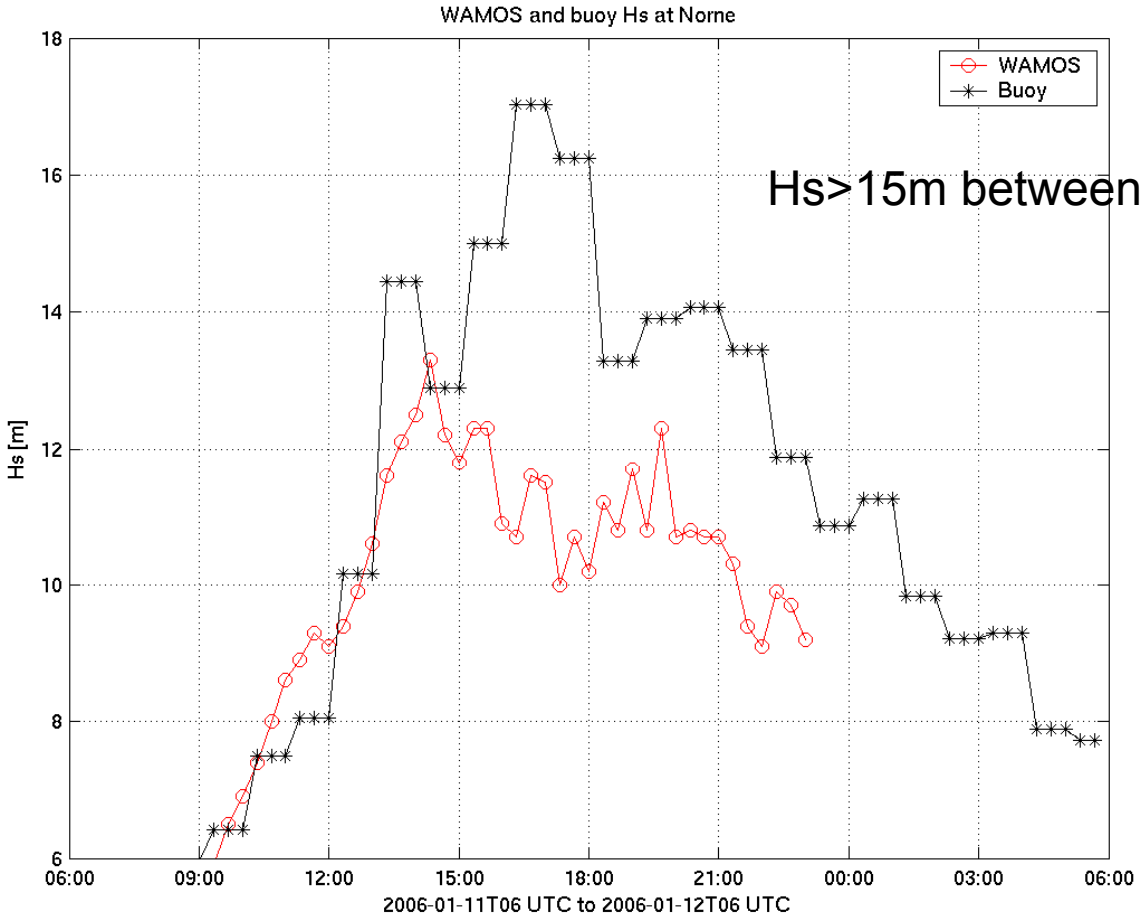
Figure 6.2: *Radar heading: The MIROS-radar scans a 180 degrees sector of open ocean. Red and yellow area represents the free sight sector at a)Heidrun:* $280 - 100°$, *b)Gullfaks C:* $90 - 270°$, *c)Troll A:* $135 - 315°$, *d)Sleipner A:* $45 - 225°$

Heidrun radar is measuring on the Lee side of the waves. It is therefor p**lausible that Hs should be up to 10% higher !!!** (ref analysis performed in 1980's.

Hs = 13.5m measured

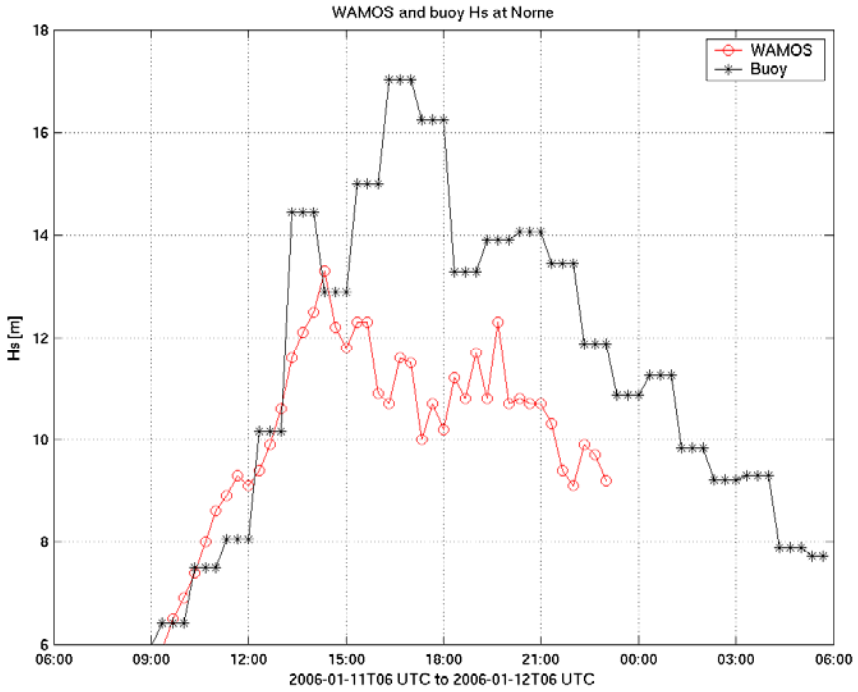
Hs = 14.5 – 15.0 m plausible on 11. january 2006

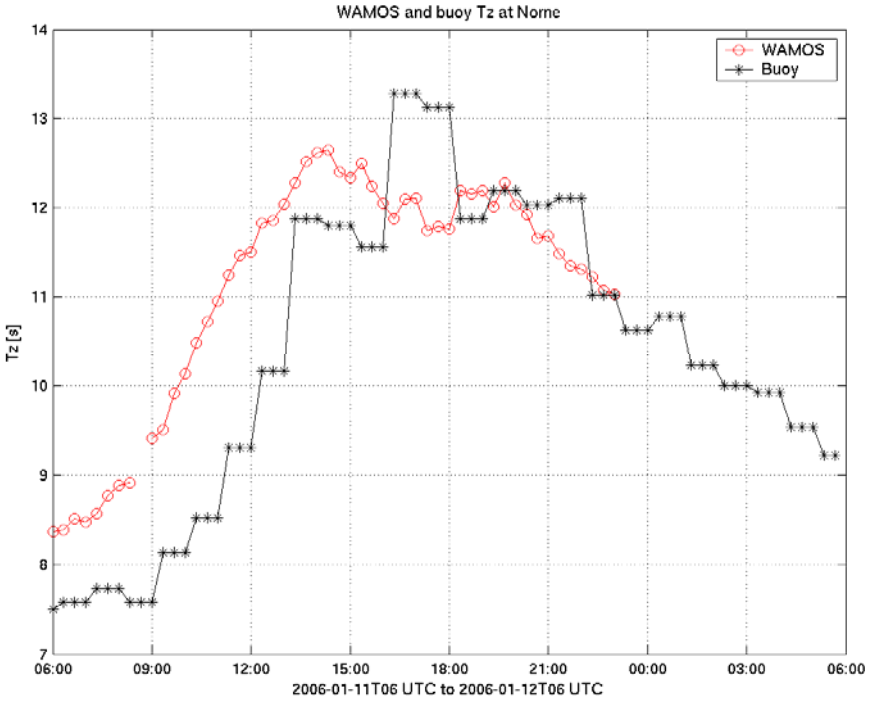
Hs at NORNE



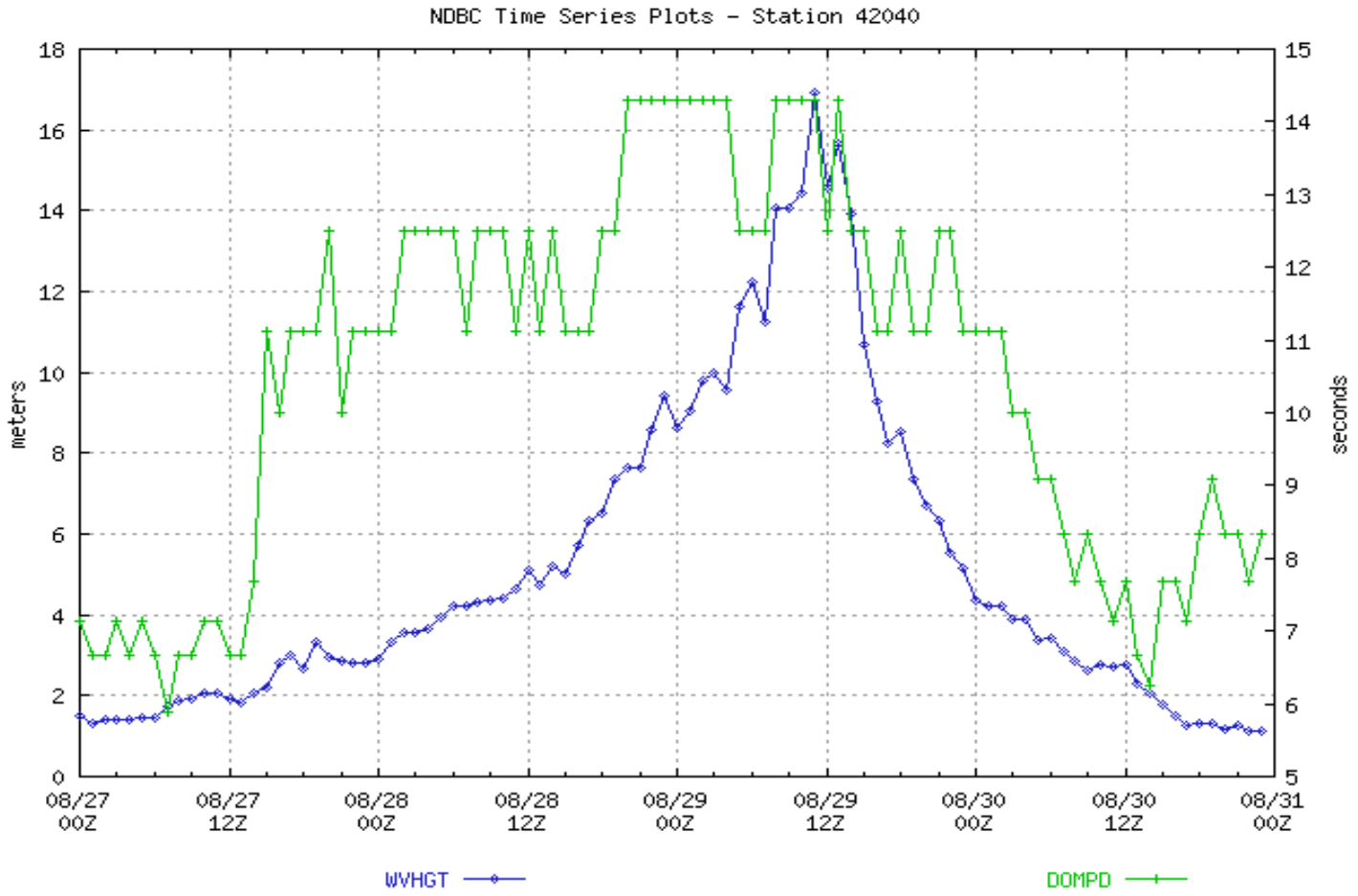
Hs>15m between 15 and 18 UTC, for 3 hours

Hs and Tz

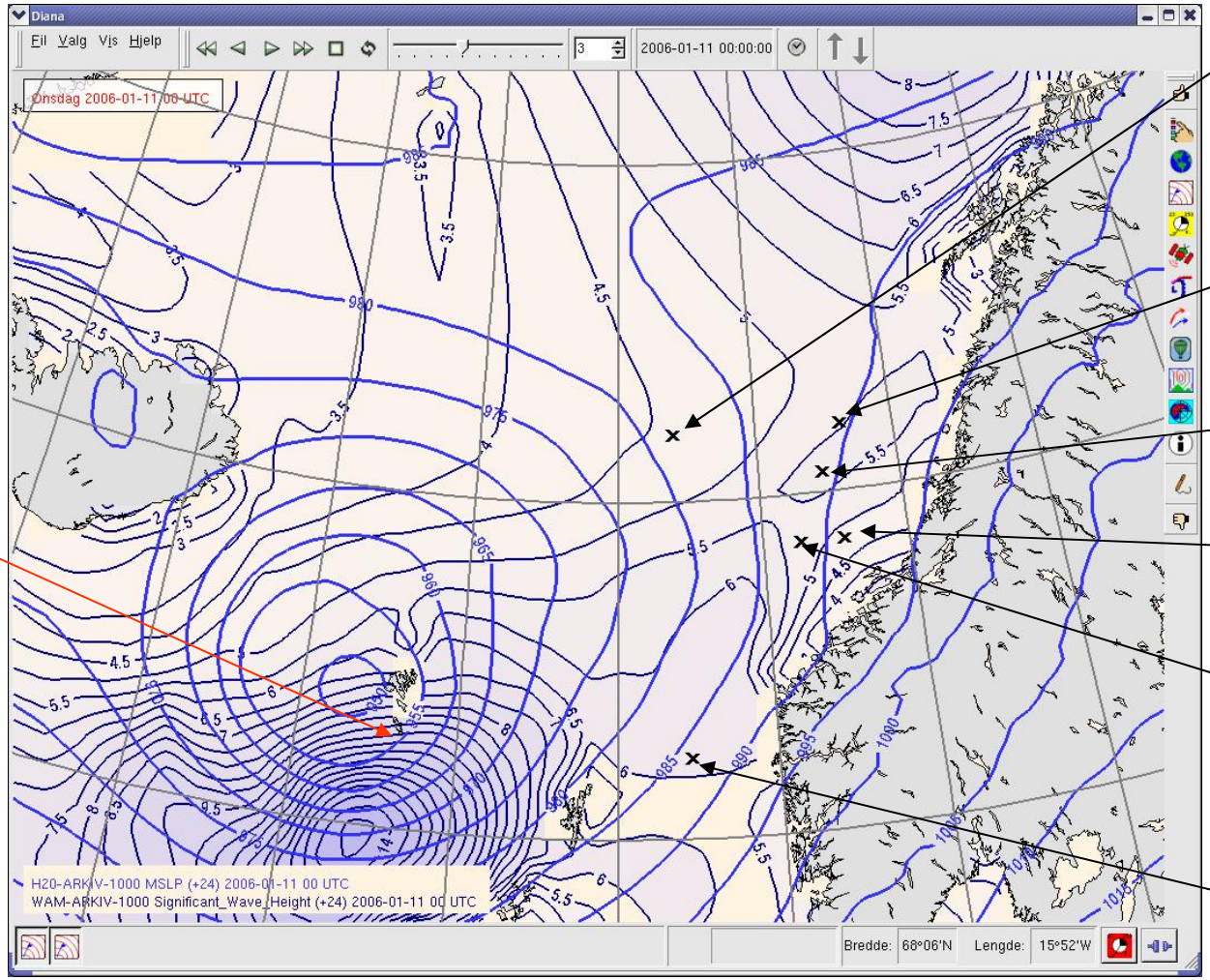

WAMOS and buoy Hs at Norne
WAMOS
Buoy
Hs [m]
18
16
14
12
10
8
6
06:00
09:00
12:00
15:00
18:00
21:00
00:00
03:00
06:00
2006-01-11T06 UTC to 2006-01-12T06 UTC


WAMOS and buoy Tz at Norne
WAMOS
Buoy
Tz [s]
14
13
12
11
10
9
8
7
06:00
09:00
12:00
15:00
18:00
21:00
00:00
03:00
06:00
2006-01-11T06 UTC to 2006-01-12T06 UTC

Wave record from TC Katrina



Wave forecast from 10. January 2006 00UTC valid +24 hrs : 11th at 00 UTC



buoy

Polarfront:
N 66.0 E 2.0

Norne:
N 66.0 E 8.1

Heidrun:
N 65.3 E 7.3

Draugen:
N 64.3 E 7.8

Njord:
N 64.3 E 6.3

Gullfaks :
N 61.2 E 2.3

Wave buoy at Faeroes

Observations from GTS system

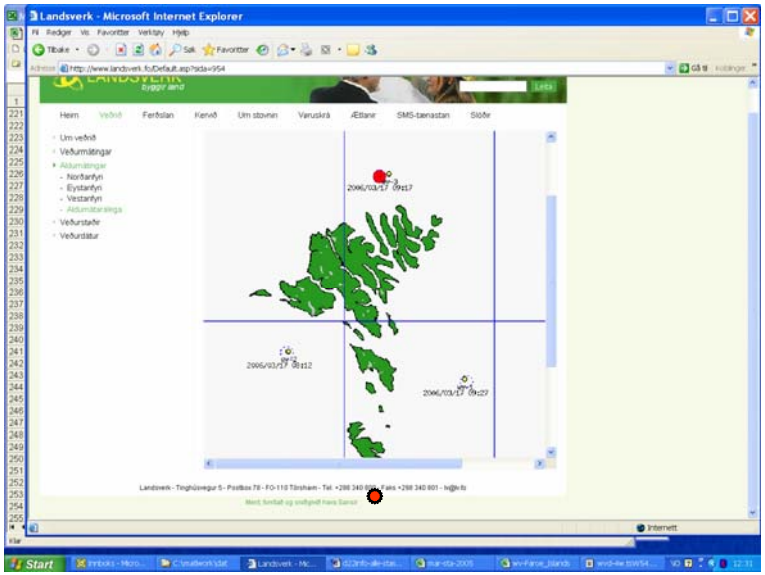
Buoy data south of Faeroes:

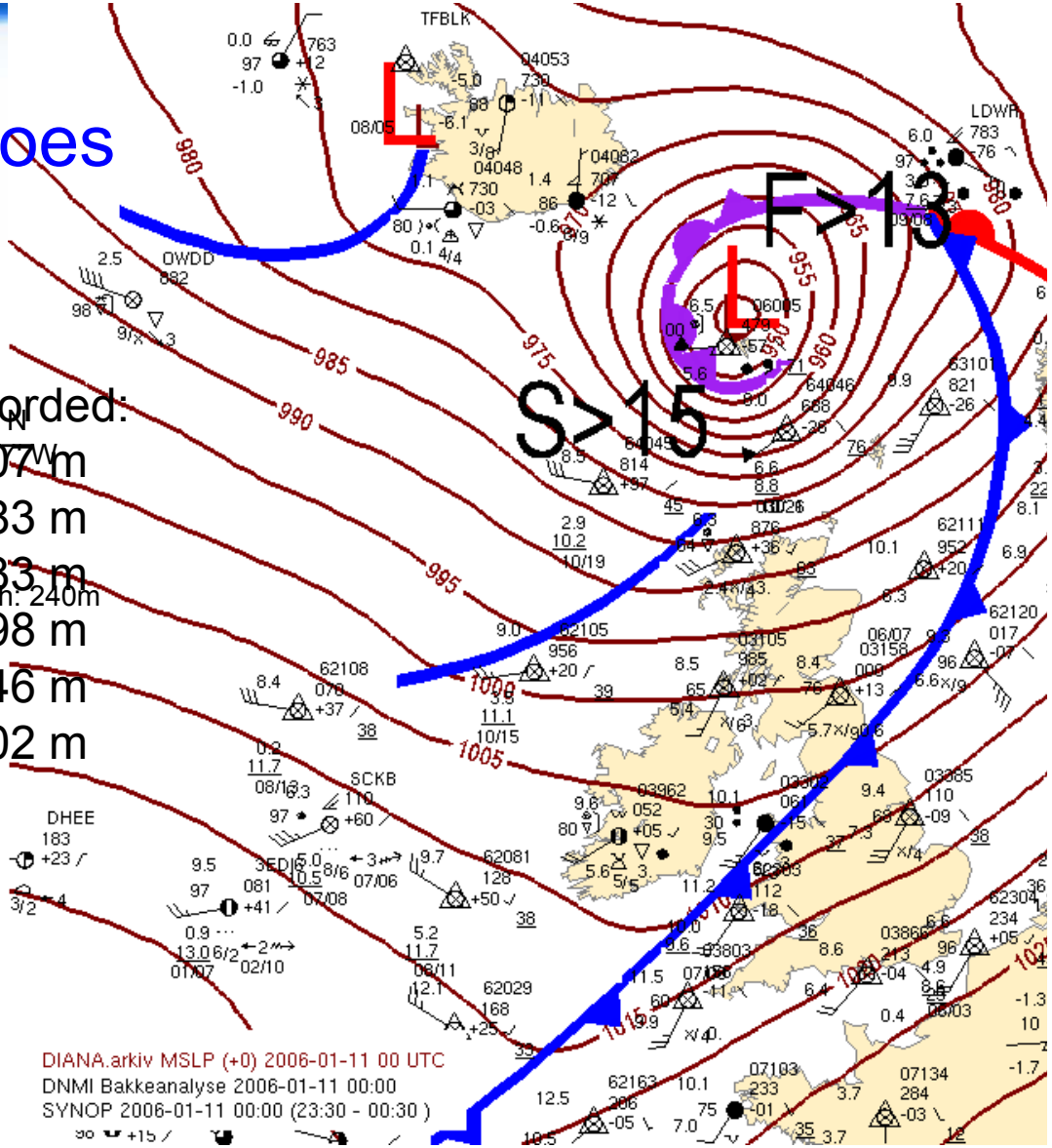
- 11th 02utc: 11 m
- 11th 03 utc: nil
- 11th 04 utc: 10.3 m

Values recorded:

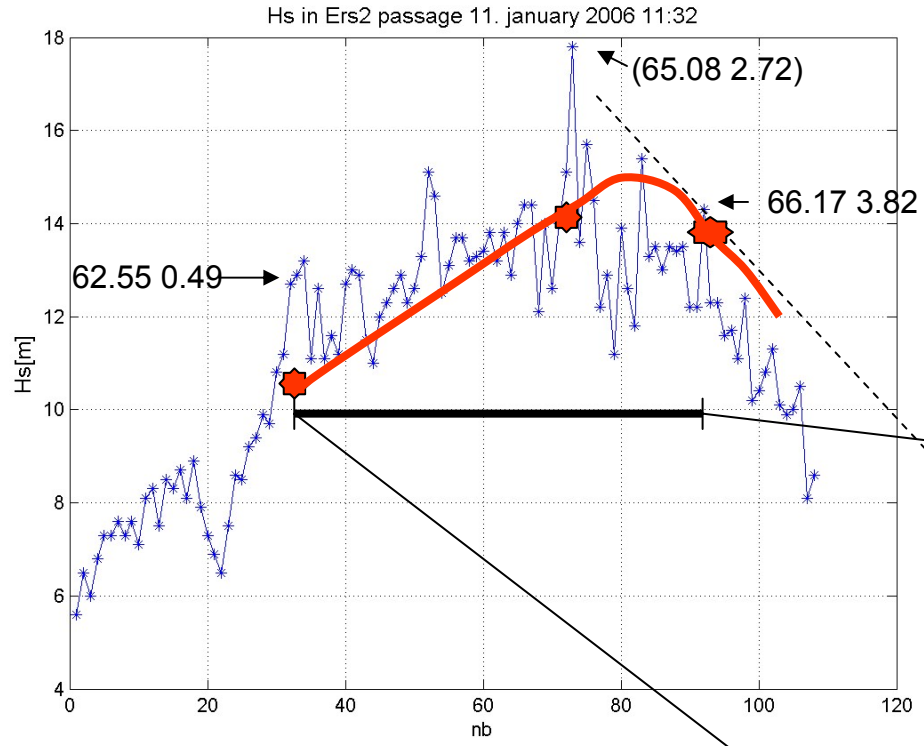
1.18 N
10.07 W
Depth: 240m

22.54: 10.07 m
23.54: 11.83 m
00.54: 12.33 m
01.54: 12.98 m
02.54: 11.46 m
03.54: 10.02 m





ERS-2 altimeter data provided by SOS through the ESA project CAMMEO

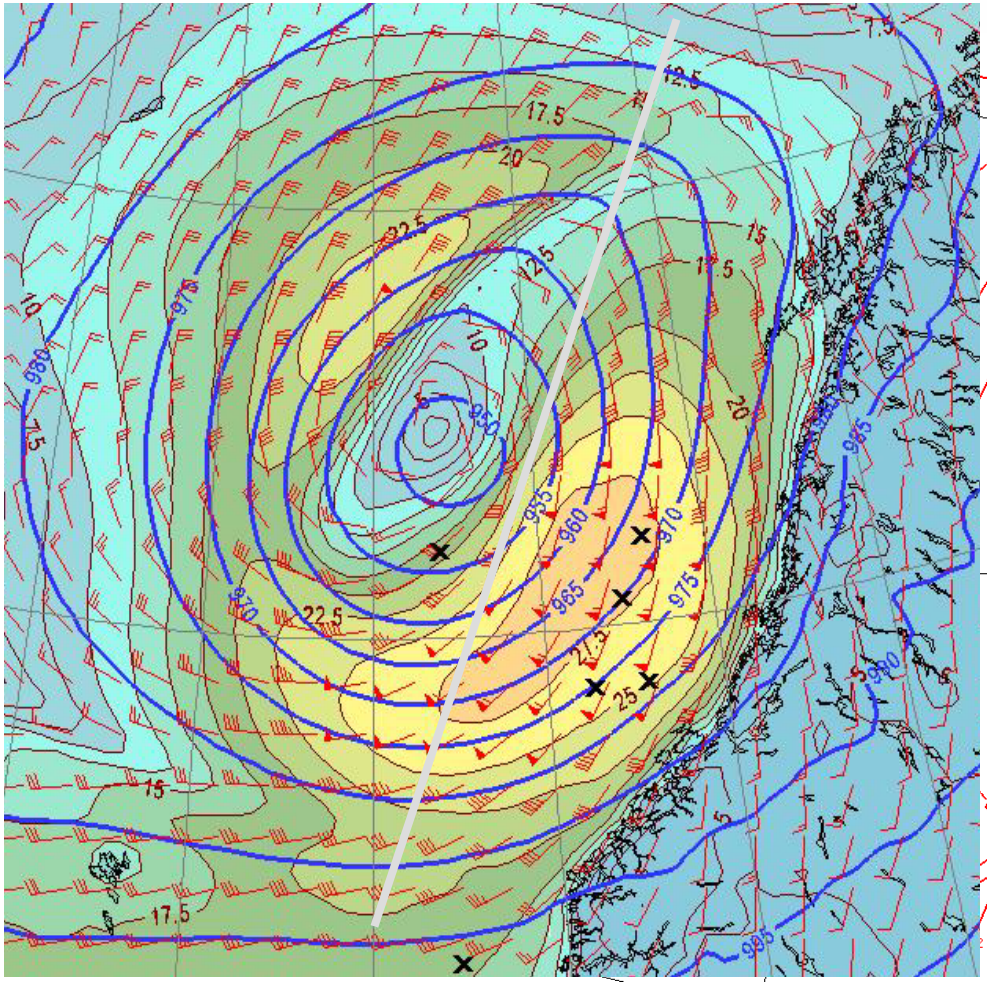


Polarfront

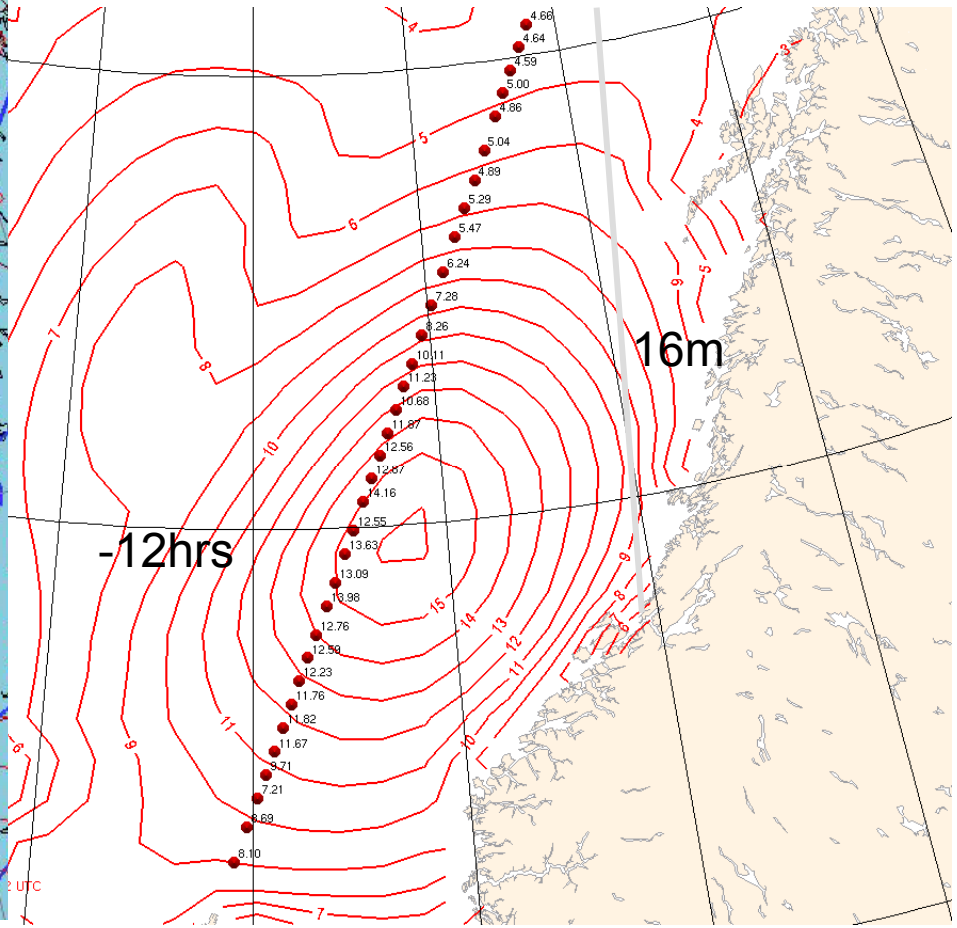
ALT-WAM.00 Significant_Wave_Height (-12) 2006-01-11 12 UTC
ENVISAT-RA2 2006-01-11 12:39 (10:00 - 14:00)

Anne Karin Magn

Hs at 11.January 2006 12 UTC



met.no (wind/waves: 20km/45km)



Summary and recommendations

- **Observations are uncertain: between 13 and 17m**
  - **Heidrun: 13.5m + 5-10% → 14.5m**

- **A 100 year event (16m) may have passed to the west of the installations.**

- **Severity is much less than in nov. 2001 storm, when waves came from W then NW directions, with mixed seas for a time.**

- **Recommendations:**
  - Reanalysis – Atmospheric and wave models with finer scale
    - At met.no: rerun case with HIRLAM_10km and WAM_10km (new operational resolutions)
    - EC_new resolution
    - Add this case to JCOMM's extreme wave database
    - Make a new 'SWAMP' (1984?)- model intercomparison
  - Importance of Satellite data. Validity of Hs, and Wind speed at high Hs values.

Acknowledgments

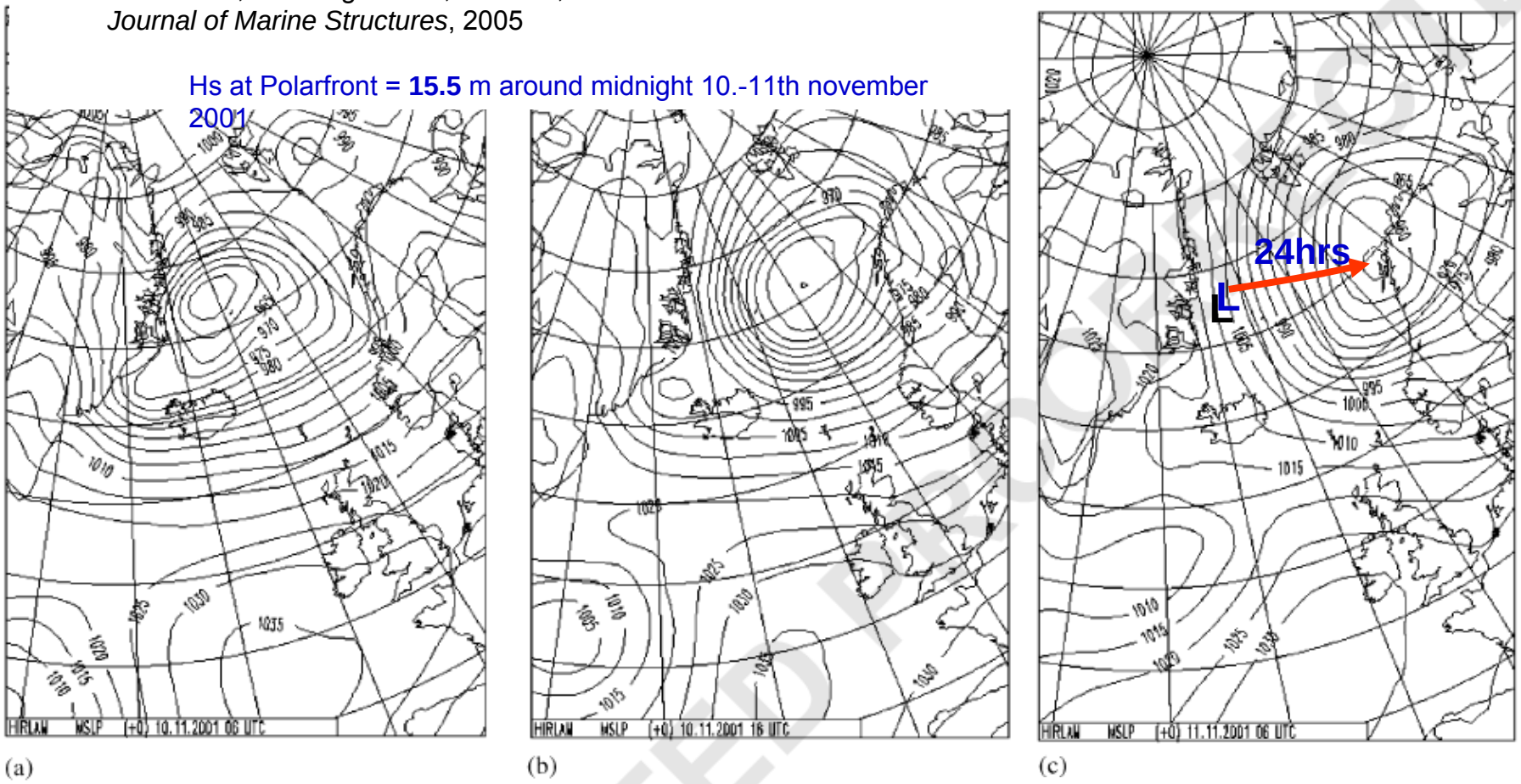
- ESA project CAMMEO (2004-2005 + → 1yr, mid-2007)
- Bárdur Niclasen from the university of Faeroes and the *Landsverk* authorities of the Faeroes for making the buoy observations available for this study

- Val Swail and Environment Canada for inviting me to the conference

Case from 10.-11. November 2001

"How severe wave conditions are possible on the Norwegian Continental Shelf?"
M. Reistad, A.K.Magnusson, S.Haver, O.T.Gudmestad and D. Kvamme.
Journal of Marine Structures, 2005

Hs at Polarfront = **15.5** m around midnight 10.-11th november 2001



(a) (b) (c)

10th at 06 utc | 10th at 18 utc | 11th at 06 utc

Comparison

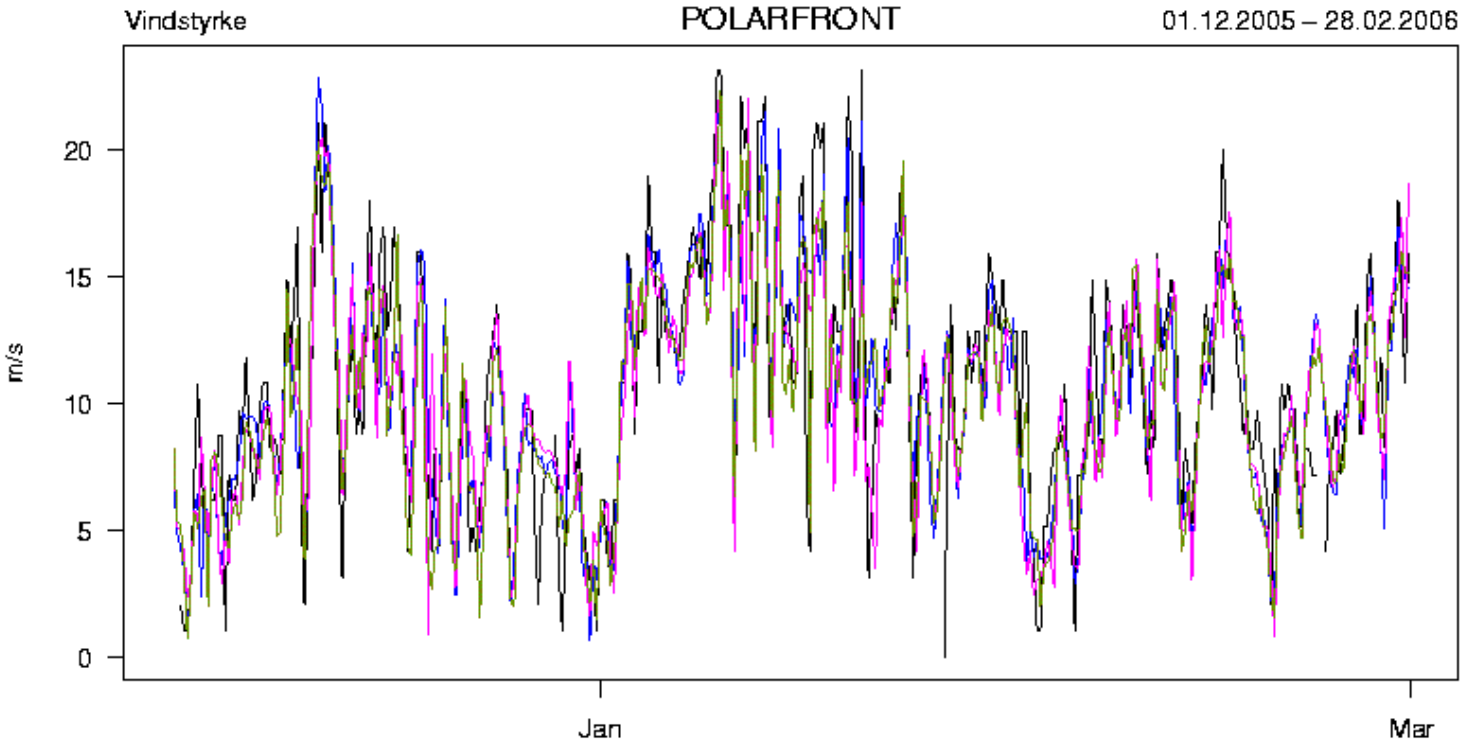
11. November 2001:

- Westerlies (55-60 kts over a large area) are veering NW during storm, and sea state becomes a mixed sea

- → larger response on floating constructions ??

11. January 2006:

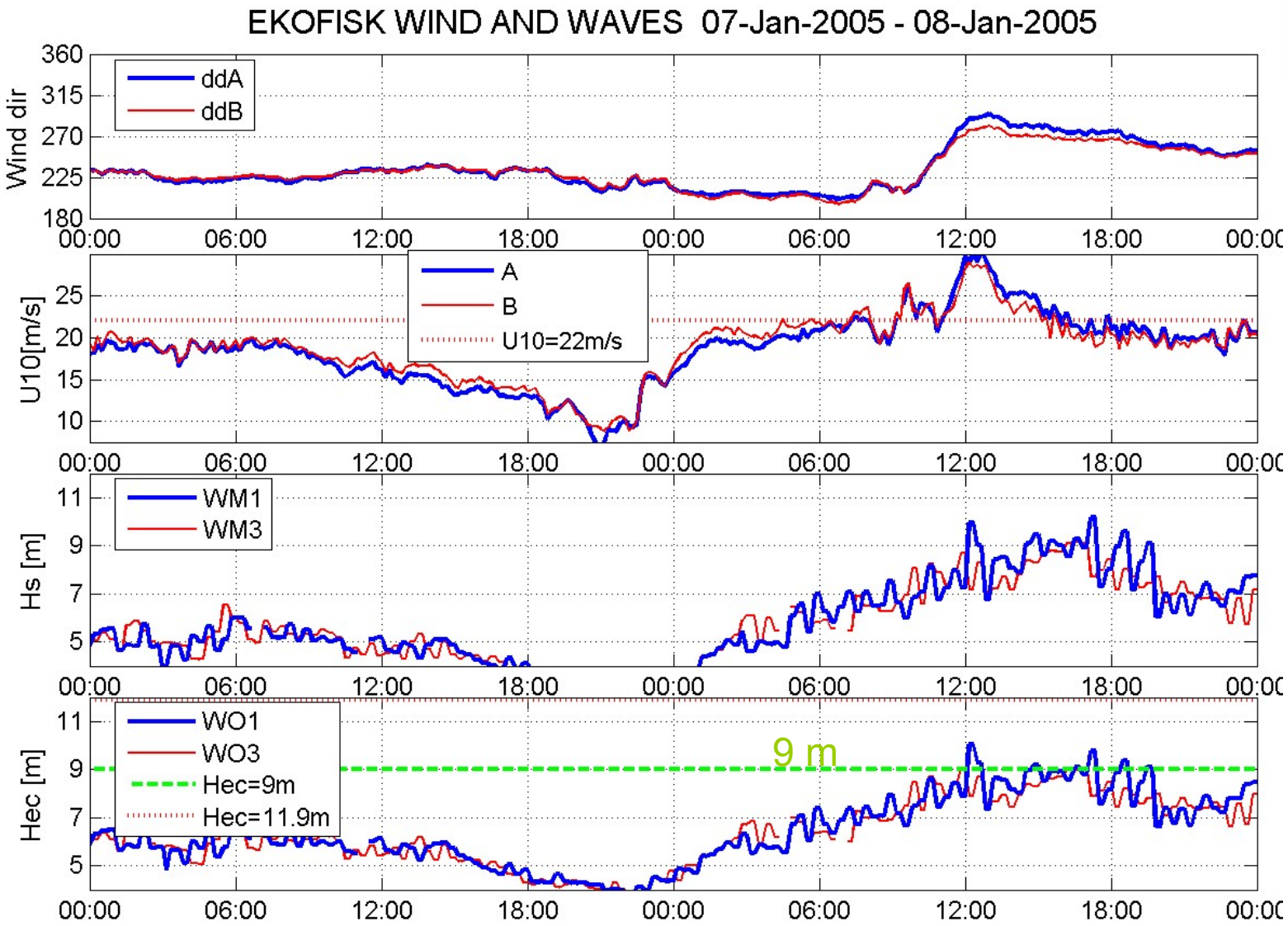
- Waves are only produced in one main direction (SW).



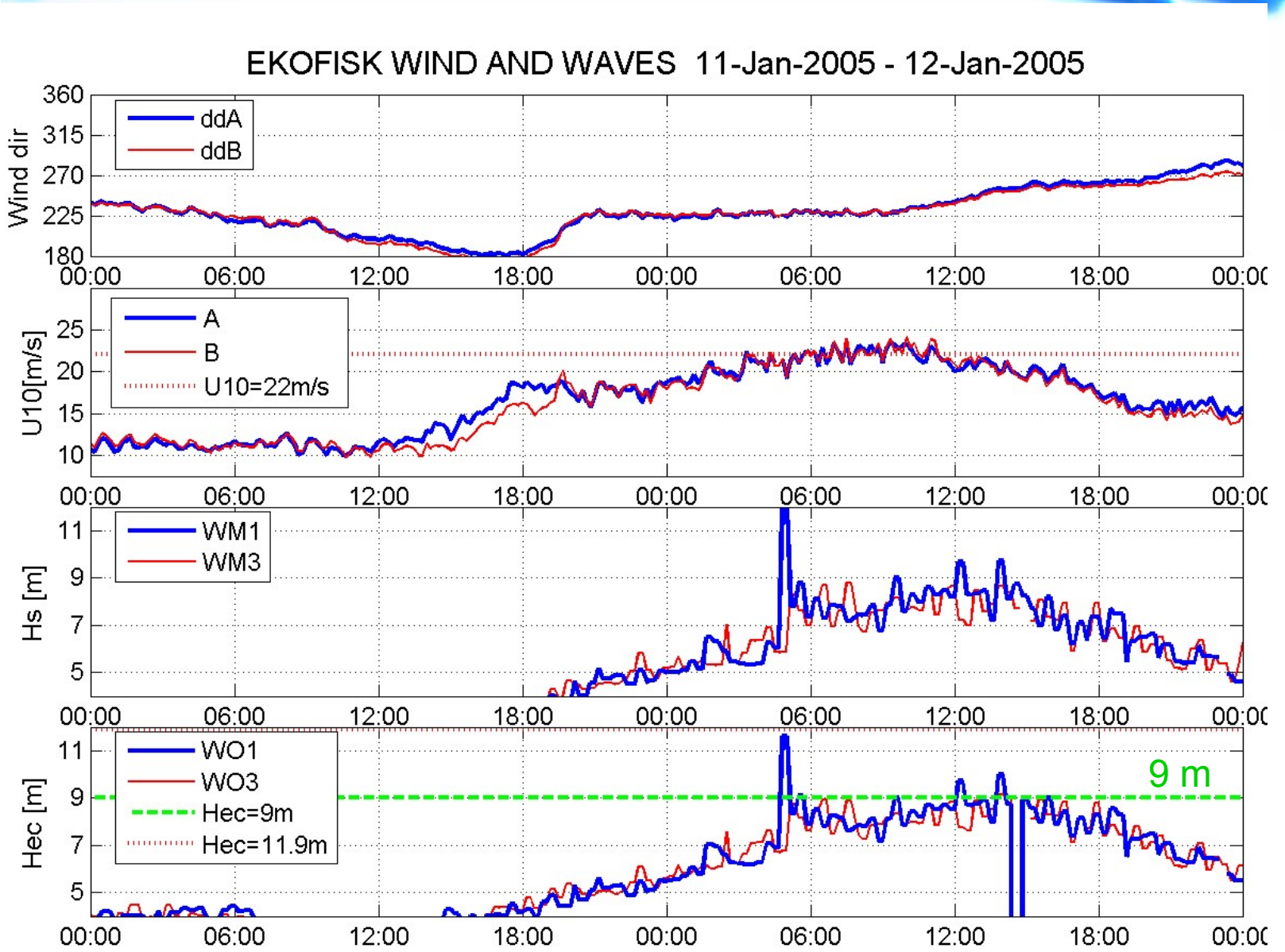
	Min	Middel	Maks	Std	N
synop: 00,06,12,18	0	10.7	23.1	4.8	354
Hirlam20: 12+18,+24,+30,+36	0.6	10.5	22.8	4.3	364
Hirlam10: 12+18,+24,+30,+36	0.8	10.3	22.2	4.2	364
ECMWF: 12+18,+24,+30,+36	0.7	10.2	22.4	4.2	364

	Middelfeil	Std.feil.	RMSE	MAE	Maks.abs.feil	N
Hirlam20 – synop	–0.2	2.7	2.7	1.9	11.9	354
Hirlam10 – synop	–0.4	2.7	2.8	2	11.1	354
ECMWF – synop	–0.5	2.4	2.4	1.8	10.9	354

- Next slides illustrate variability in HS through a storm



Max Hs = 10.0 m Occures only for short periods.


EKOFISK WIND AND WAVES 11-Jan-2005 - 12-Jan-2005
Wind dir
ddA
ddB
U10[m/s]
A
B
U10=22m/s
Hs [m]
WM1
WM3
Hec [m]
WO1
WO3
Hec=9m
Hec=11.9m
9 m
00:00
06:00
12:00
18:00

Max Hs
= 10.0m

An obvious error in measurements