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True Sea State….?

Comparing Different Sensors and Analysing Techniques

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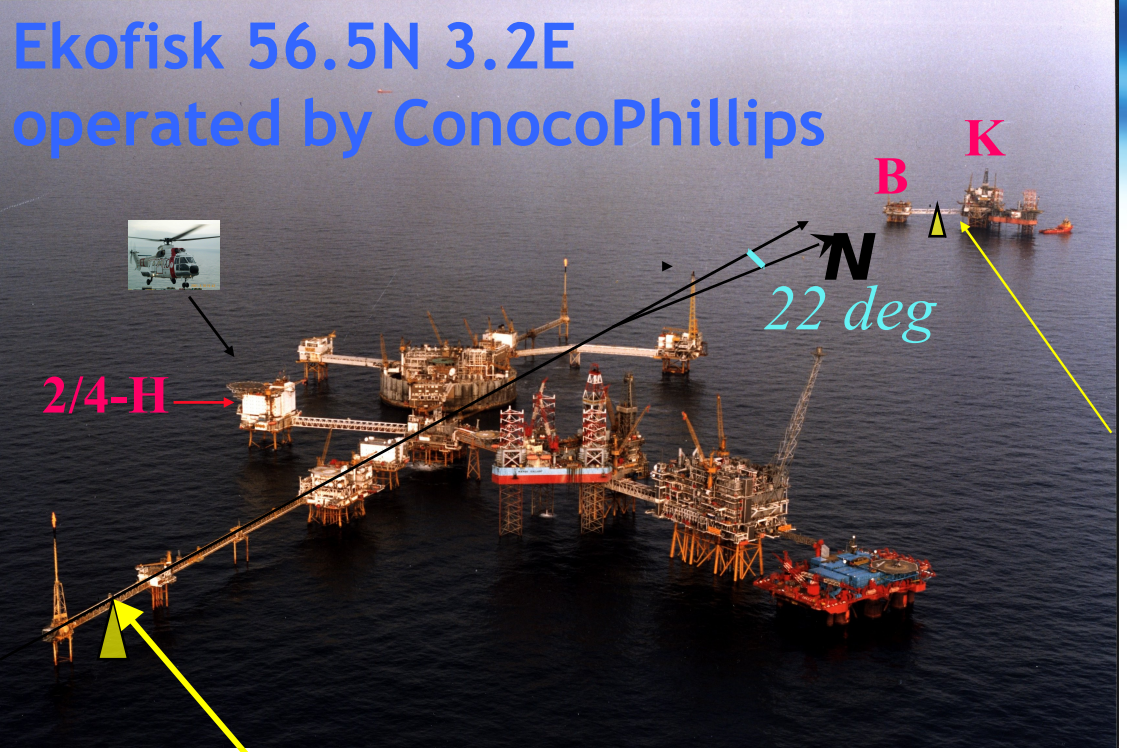
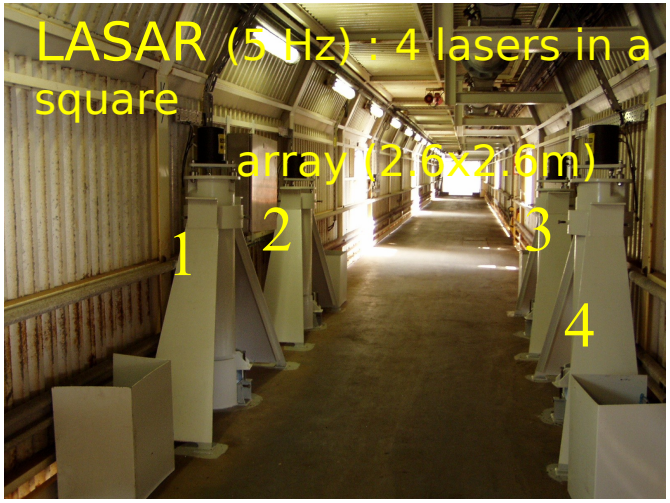
Wave measurements from Ekofisk

View from helicopter landing on 2/4-H, view towards east (old platforms in foreground, new platforms towards east. 3 jackups on site as well.

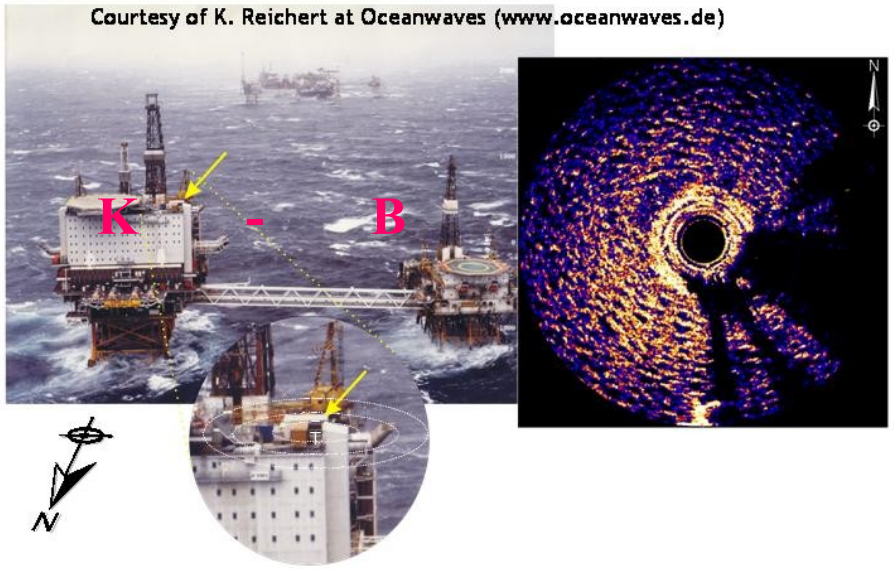
Ekofisk 56.5N 3.2E
operated by ConocoPhillips





Datawell Waverider Heave buoy (2Hz)

WaMoS on Ekofisk 2/4 k



Analysis of measurements in the Andrea storm

Data recorded in a system at 2/4-K :

- 5Hz data from LASAR (4 lasers, 'H1' or 'H1-5Hz','H2','H3','H4')

Data recorded in a system at 2/4-H in the 'EMS- system' (Environmental Monitoring System) :

- 2hz data from Waverider ('WR',hz1)
- 2hz data from LASAR (down sampled from 5Hz data from H1 by EMS system provider (presently MIROS) ('H1-2Hz', hz2)
- 2hz data from MIROS RANGE FINDER ('MRF',hz3)

Motivation for study

- A ”true sea state” is needed for validation of wave forecasting models and wave forecasts
- This ”True sea state” is difficult to assess – especially with many sensors around!

Experience from forecasting and monitoring:

- *Some large differences are seen in Hs (as much as 20%) between the different sensors*
- *Also a problem: Hs has very high variability within 20 minutes measurements*

Results

- Comparing measurements (sensors) demands careful analysis and sorting of data to avoid sheltering effects
- Downsampling of Laser measurements from 5Hz to 2 Hz on height distributions seems not to be too much influencing height distribution (but front steepness!).
- Skewness of laser data is higher than the MRF. Waverider has low, as expected (0.08).
- Comparison of front height and crest steepness of highest waves from the three sensors is shown at end for case with Hs = 4m and probably (!) no sheltering effects.

  Maximum Crest front steepness:

  LASAR: 0.45, WR: 0.35 , MRF: 0.28

References

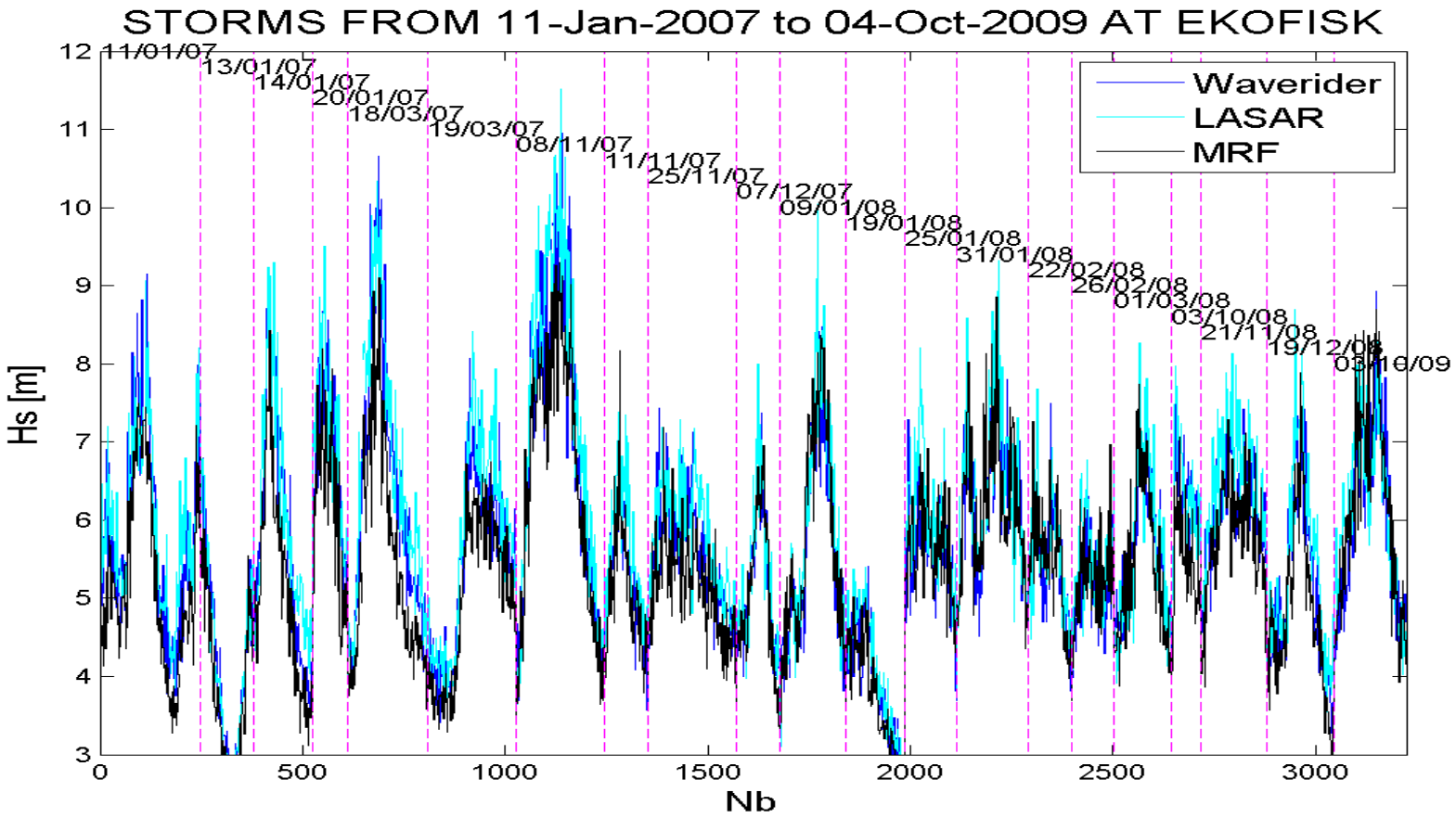
WACSIS: Wave Crest Sensor Intercomparison Study

- A Joint Industry Project (JIP) by **SHELL Global Solutions U.S.** and **IFREMER**
- Dec 1997-may 1998: a set of wave sensors were mounted on the Dutch Meetpost Noordwijk measurement platform (on coast of the Netherlands)
  - Baylor wave staff
  - THORN wave height sensor (an upgrade of the EMI laser)
  - MAREX SO5 wave radar
  - Vlissingen step gauge and Marine 300 step gauge
  - directional waverider buoy
  - SMART 800 GPS buoy
  - WAVEC directional buoy
  - S4ADW current meter and pressure sensor

- Report, January 2001: Marc Prevosto, George Z. Forristall, Sylvie Van Iseghem, Benjamin Moreau

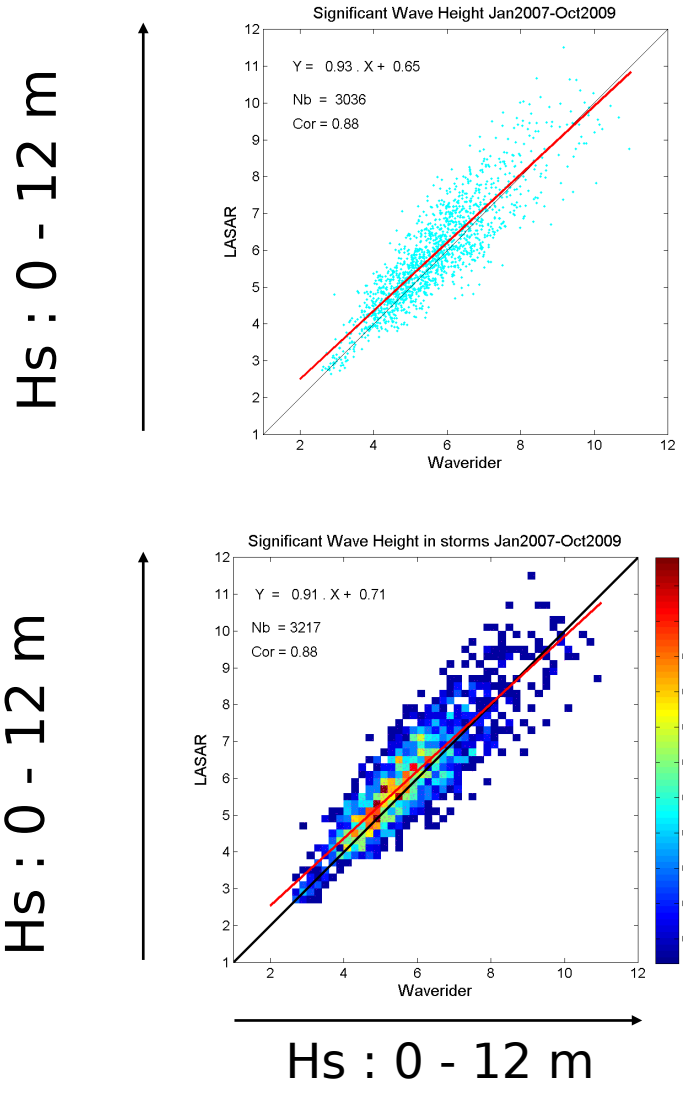
DATA : 20 STORMS CASES FROM 2007 and 2008

(From 11th Wave Workshop, Halifax)

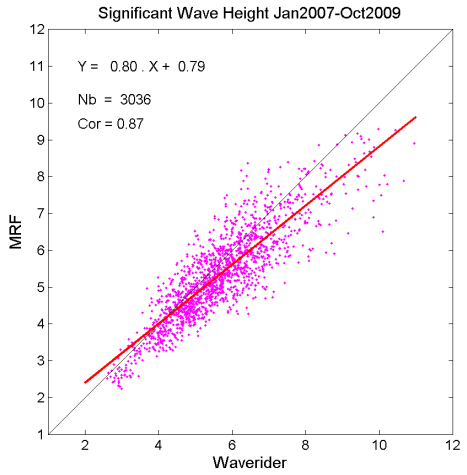


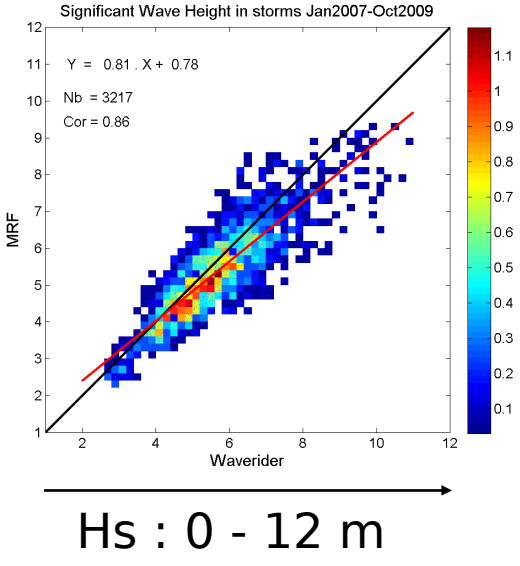
Comparison of Hs in 20 storms jan2007-dec2008

LASAR vs Waverider

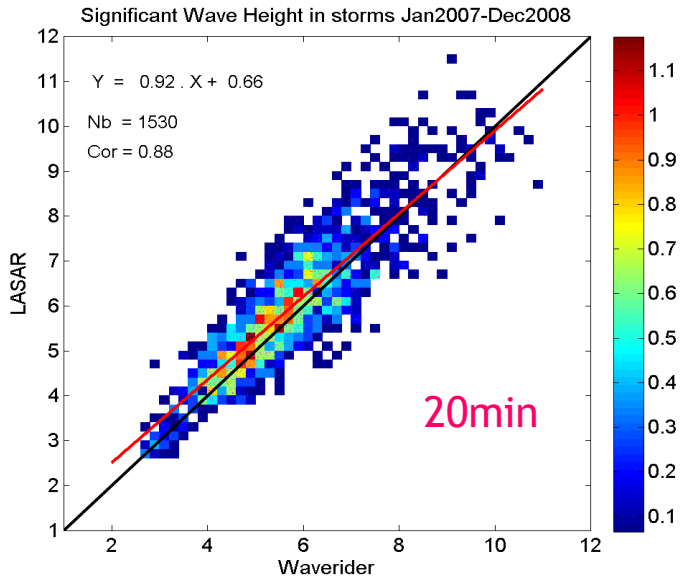


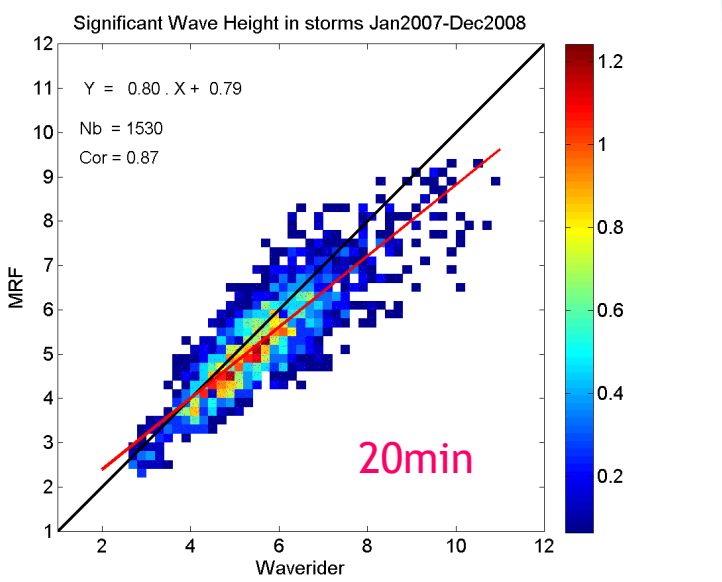
Miros MRF vs Waverider





Results (Halifax)

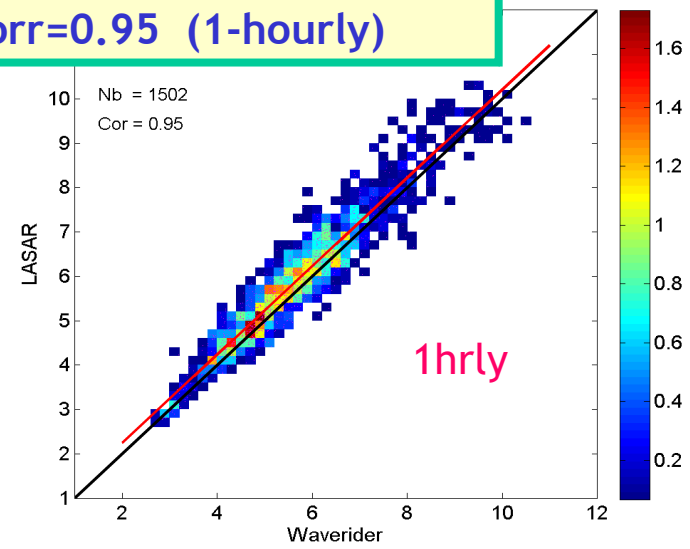




Hourly averages have higher correlations

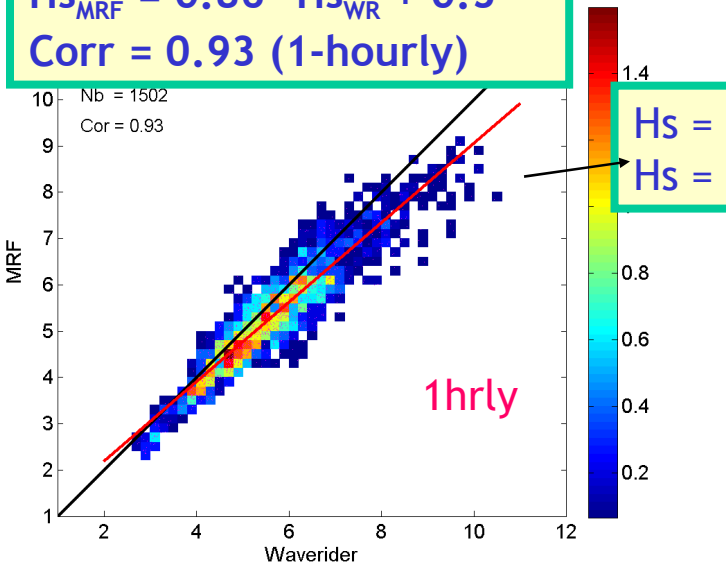
$Hs_{LASAR} = 0.99.Hs_{WR} + 0.28$

Corr=0.95 (1-hourly)



$Hs_{MRF} = 0.86 * Hs_{WR} + 0.5$

Corr = 0.93 (1-hourly)

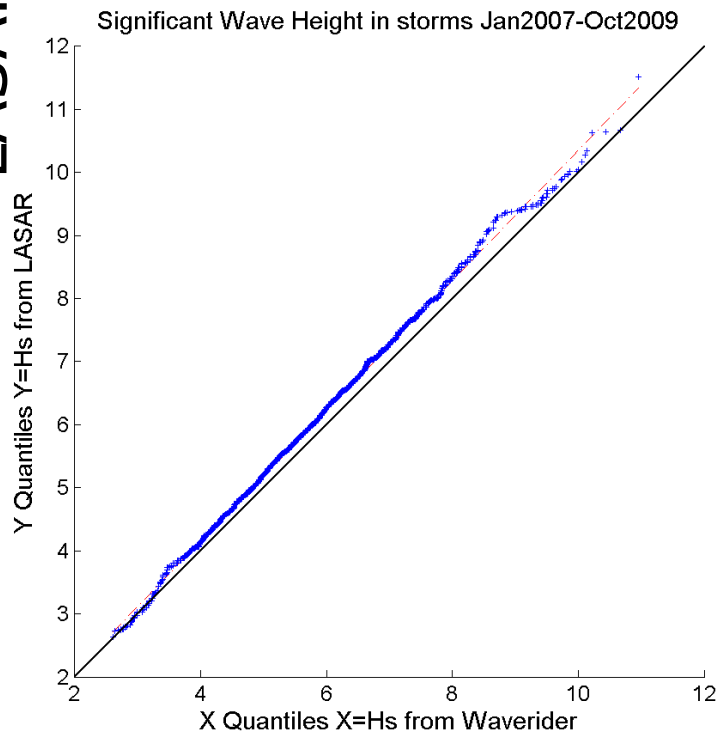


Hs = 5 m : 5 % lower

Hs = 10 m : 10 % lower

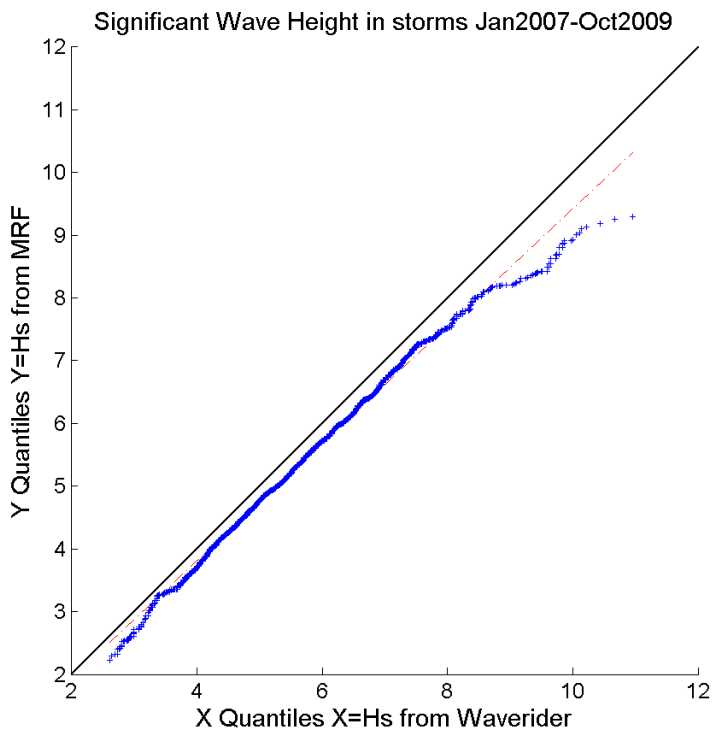
Comparison of Hs in 20 storms jan2007-oct2009 qq-plot

LASAR



Waverider

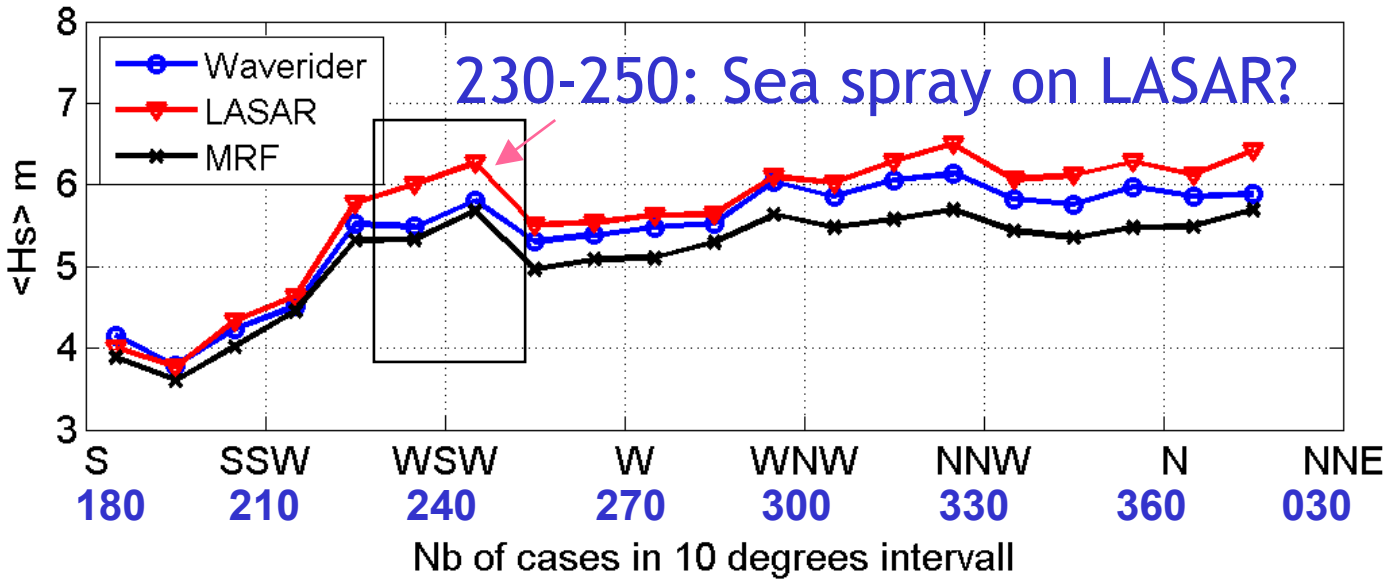
MRF

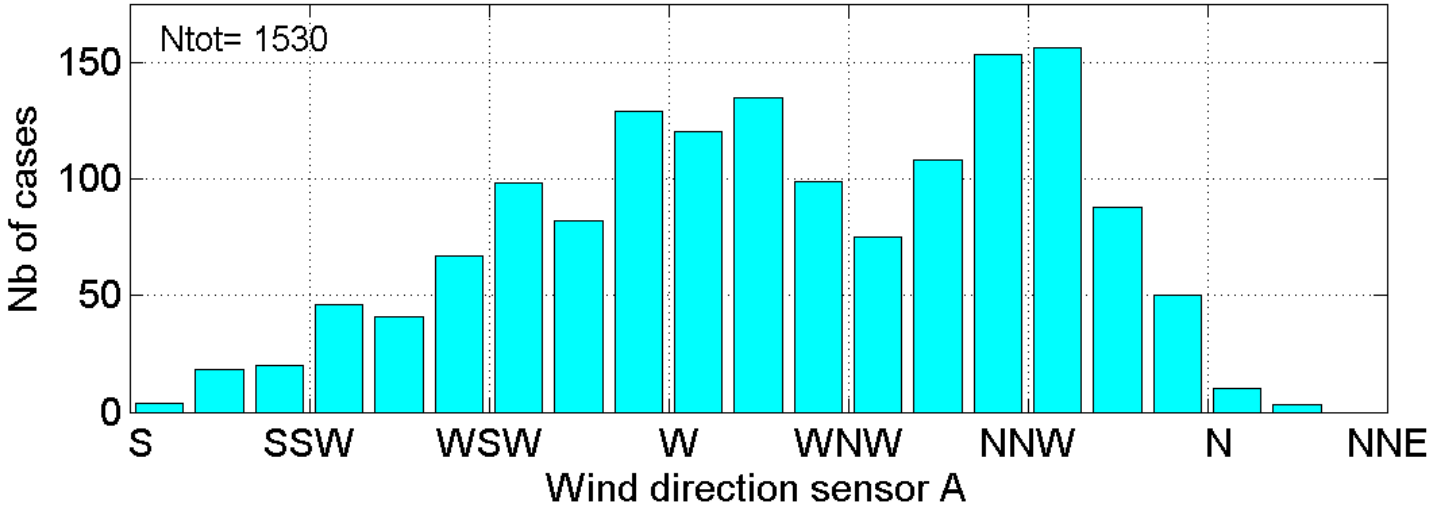


Waverider

Axes: 2-12m

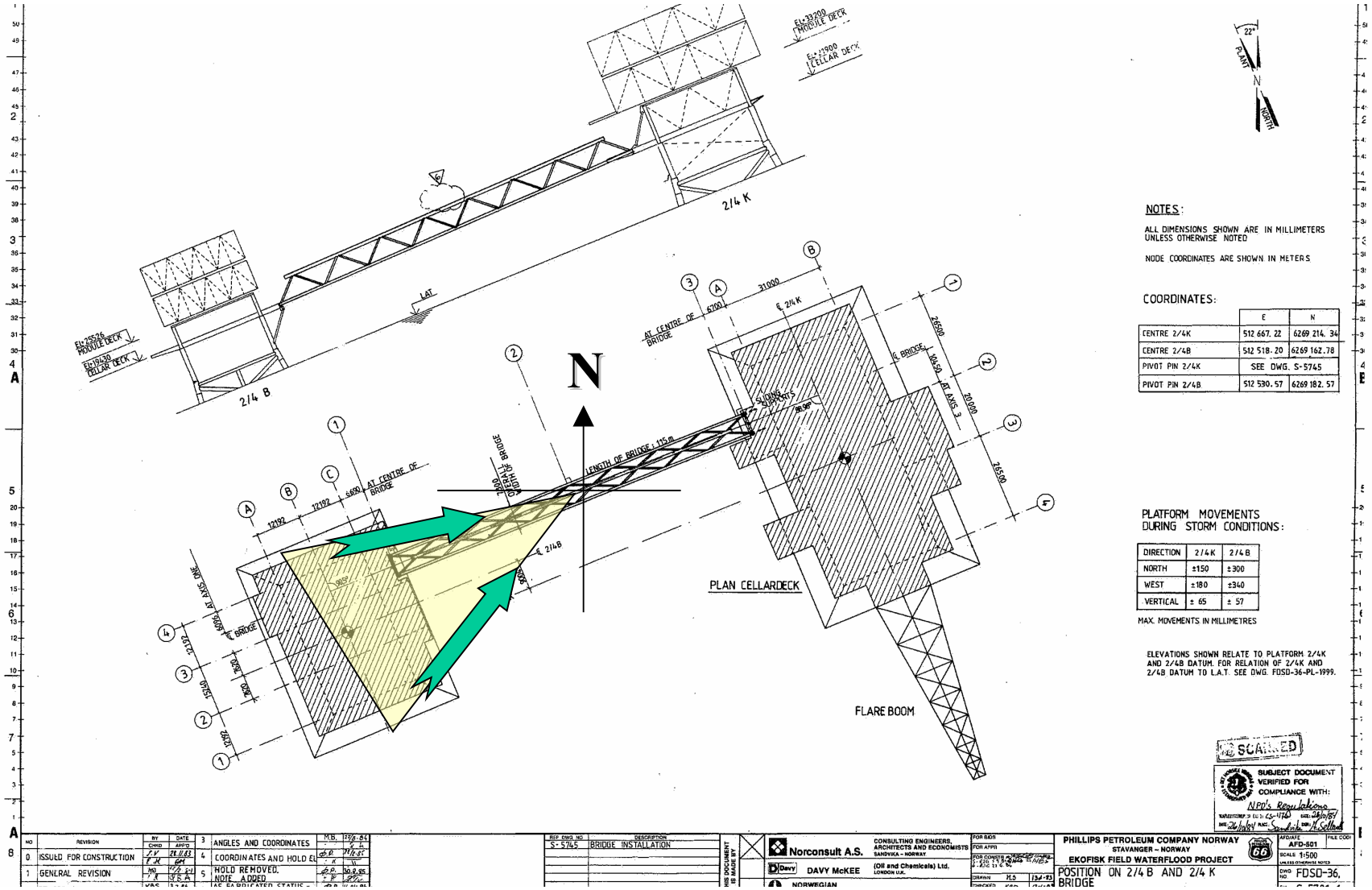
Average Hs in Wind dir sectors (dθ=10°)



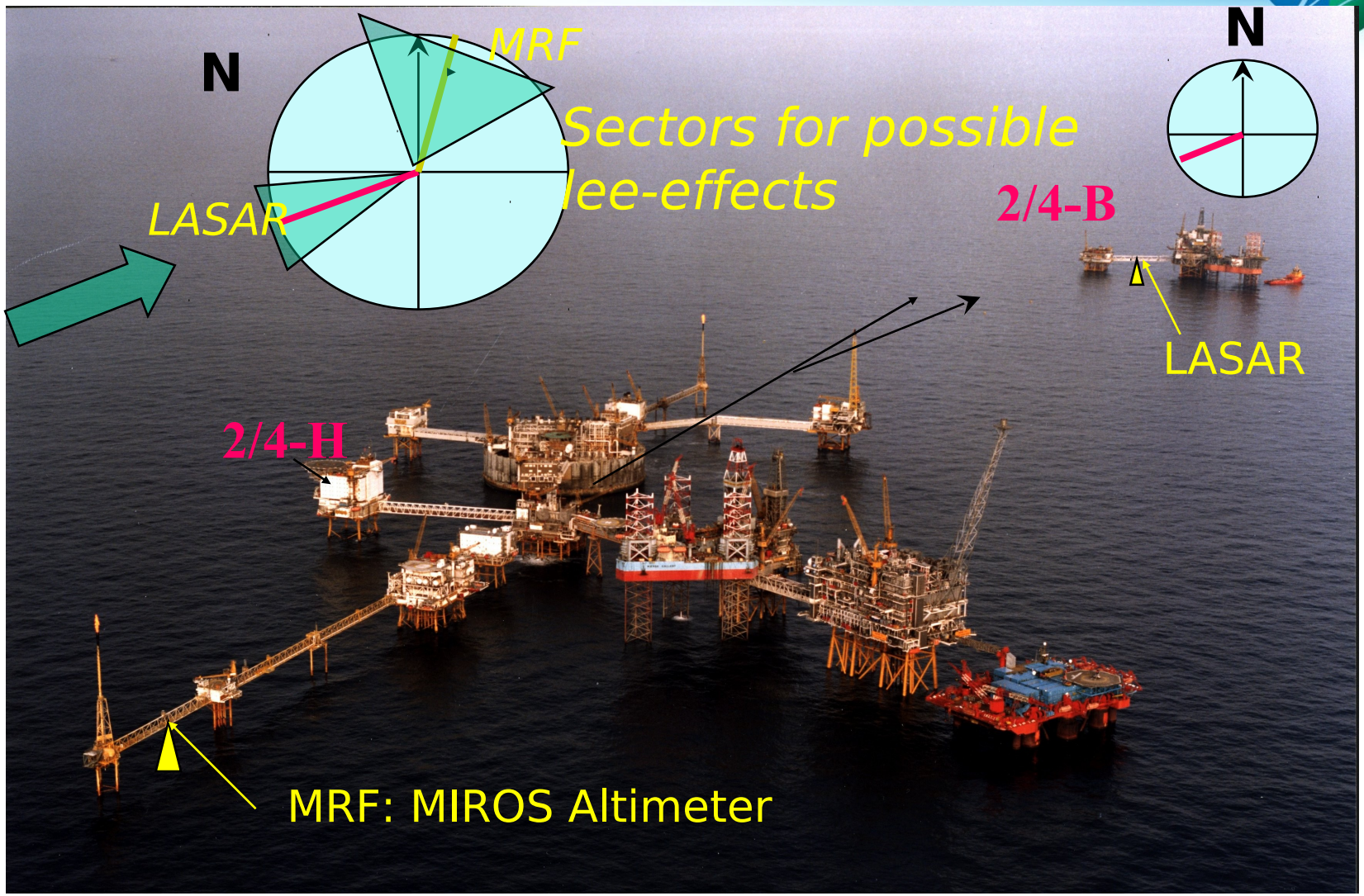


We expect

- Exceedance of sea spray in waves coming from sector [215- 250], a 35° sector
- Open sector: waves coming from 160-215 + 250-030

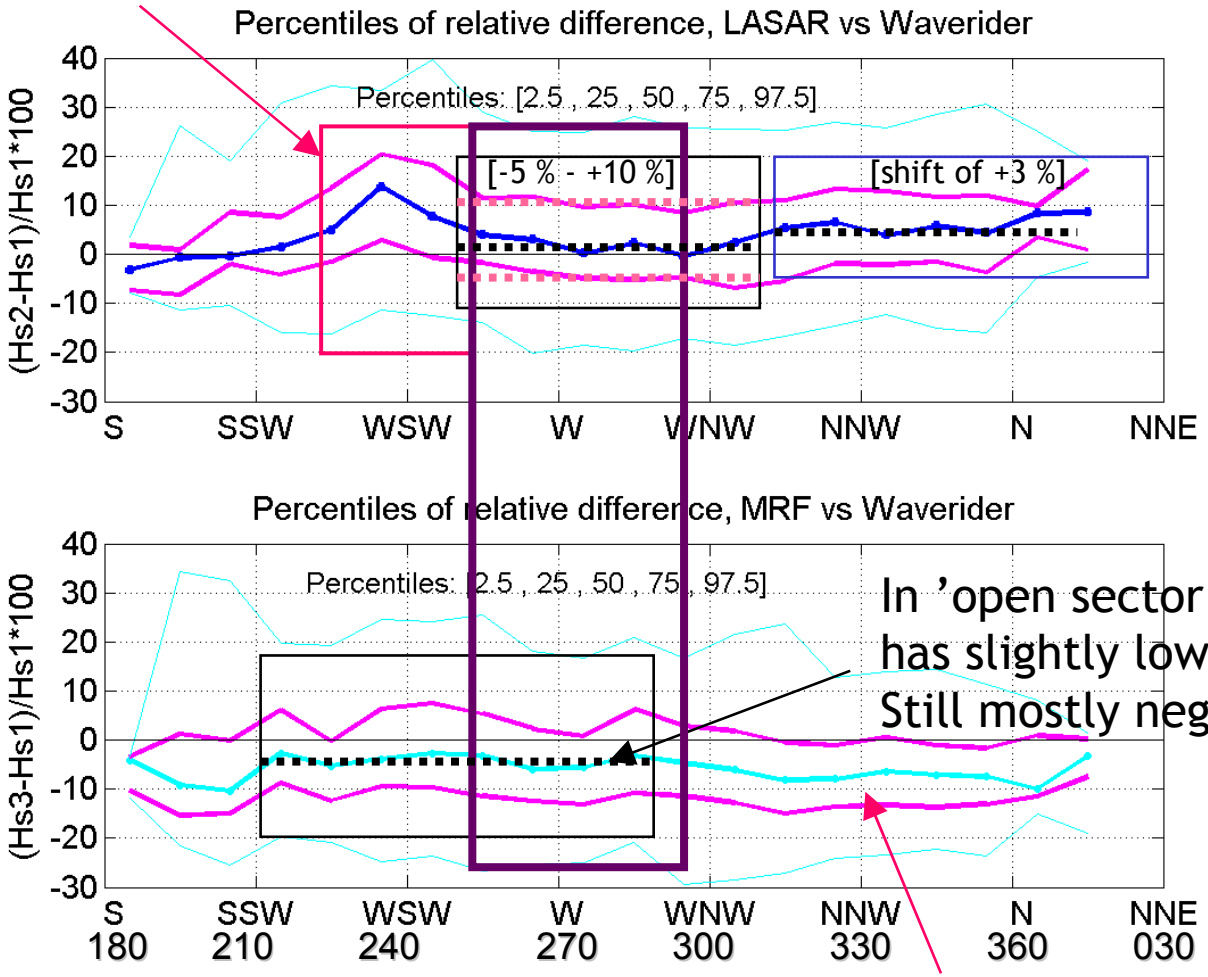


Looking for directional dependence (Halifax, 2009)



Searching for a common open ('exposed') sector

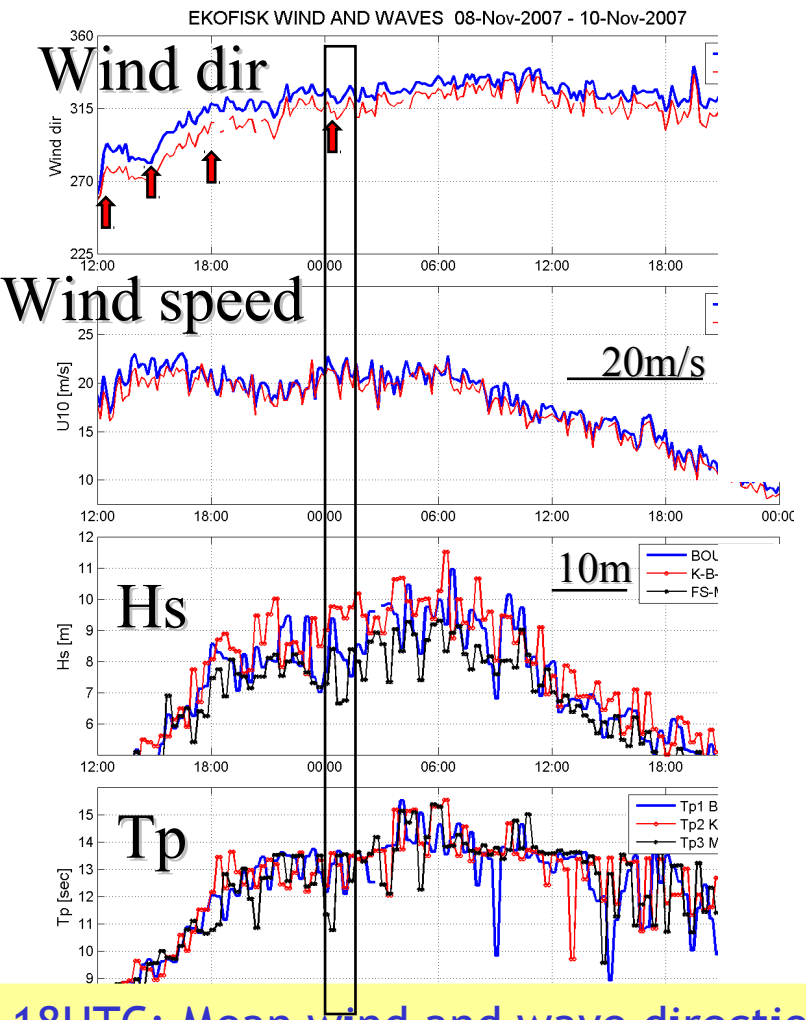
The sea spray sector

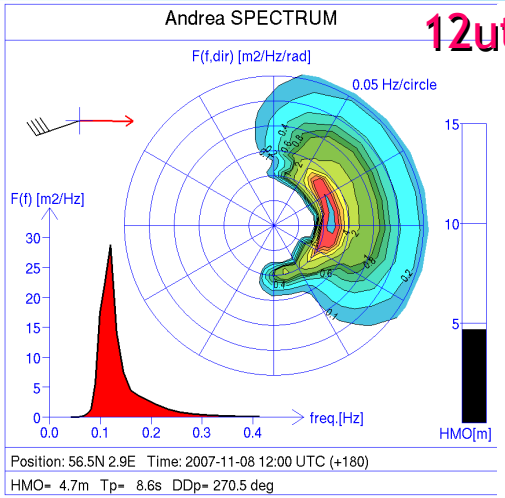


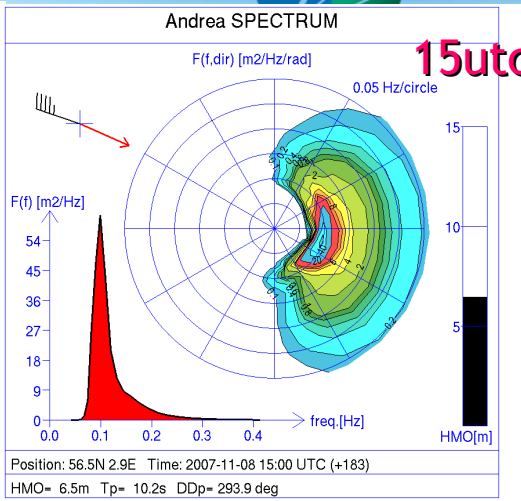
In 'open sector' the MRF has slightly lower <Hs> (3-6%) Still mostly negativ.

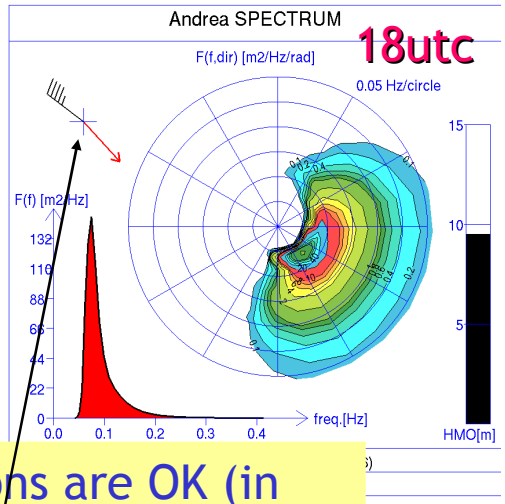
Suspect lee effects for dd>300

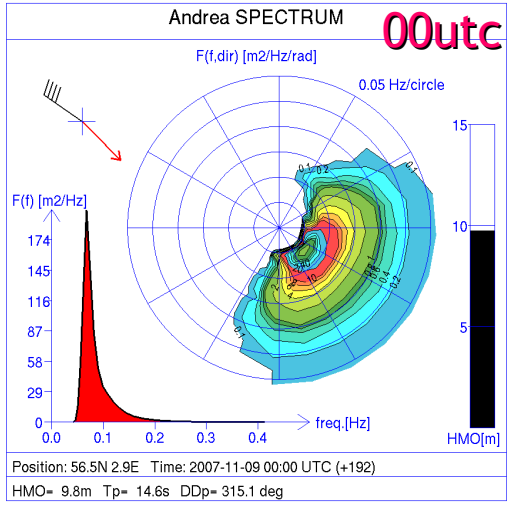
The 'open sector' is not always what it appears to be





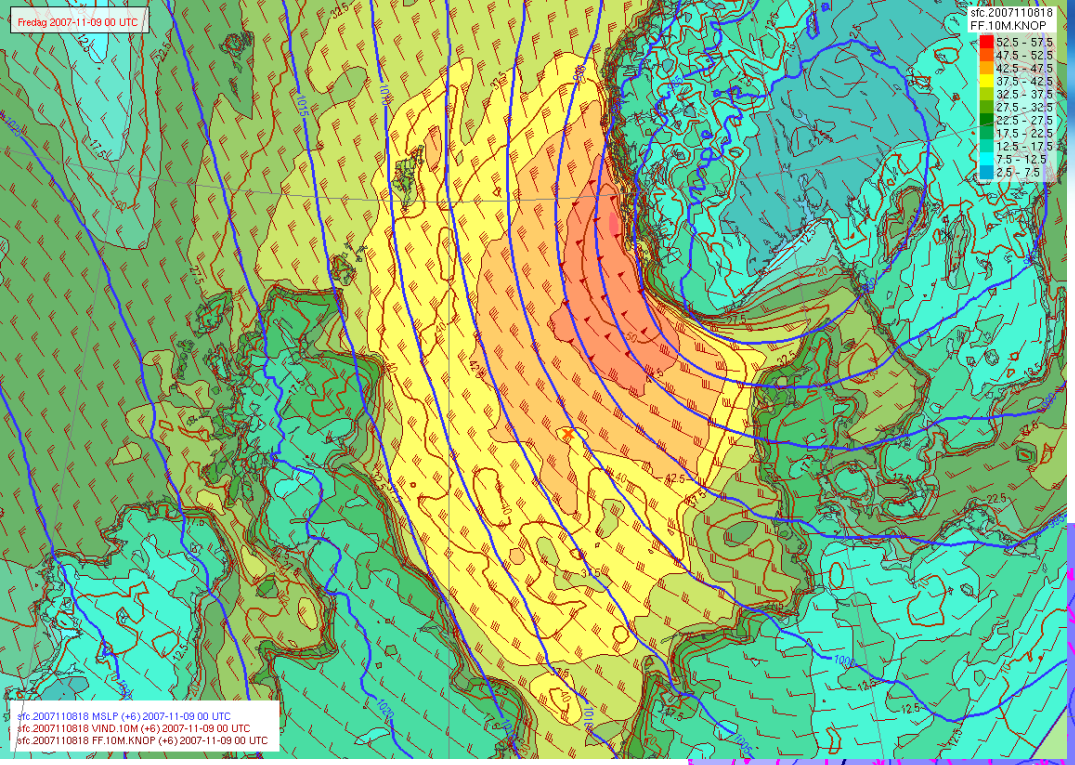




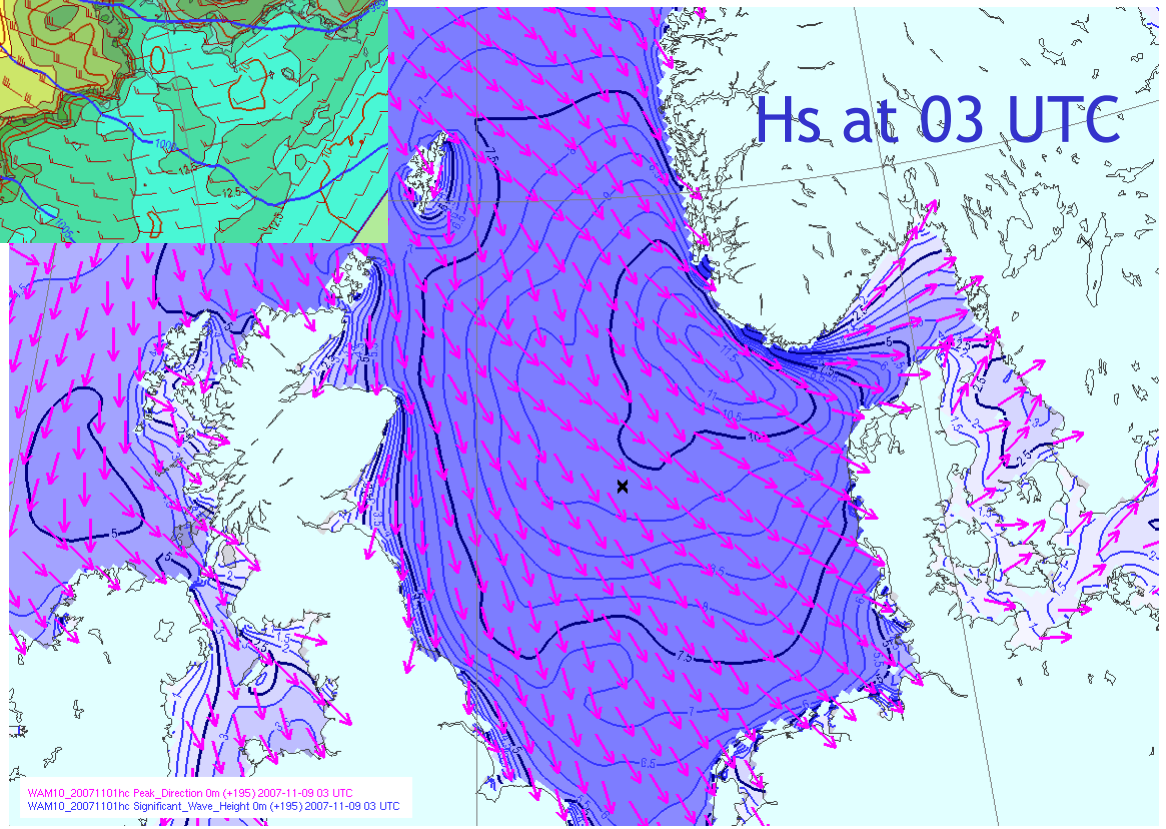


18UTC: Mean wind and wave directions are OK (in open sector), but relatively large amount of wave energi from North (waves at MRF are then partly going through the other platforms

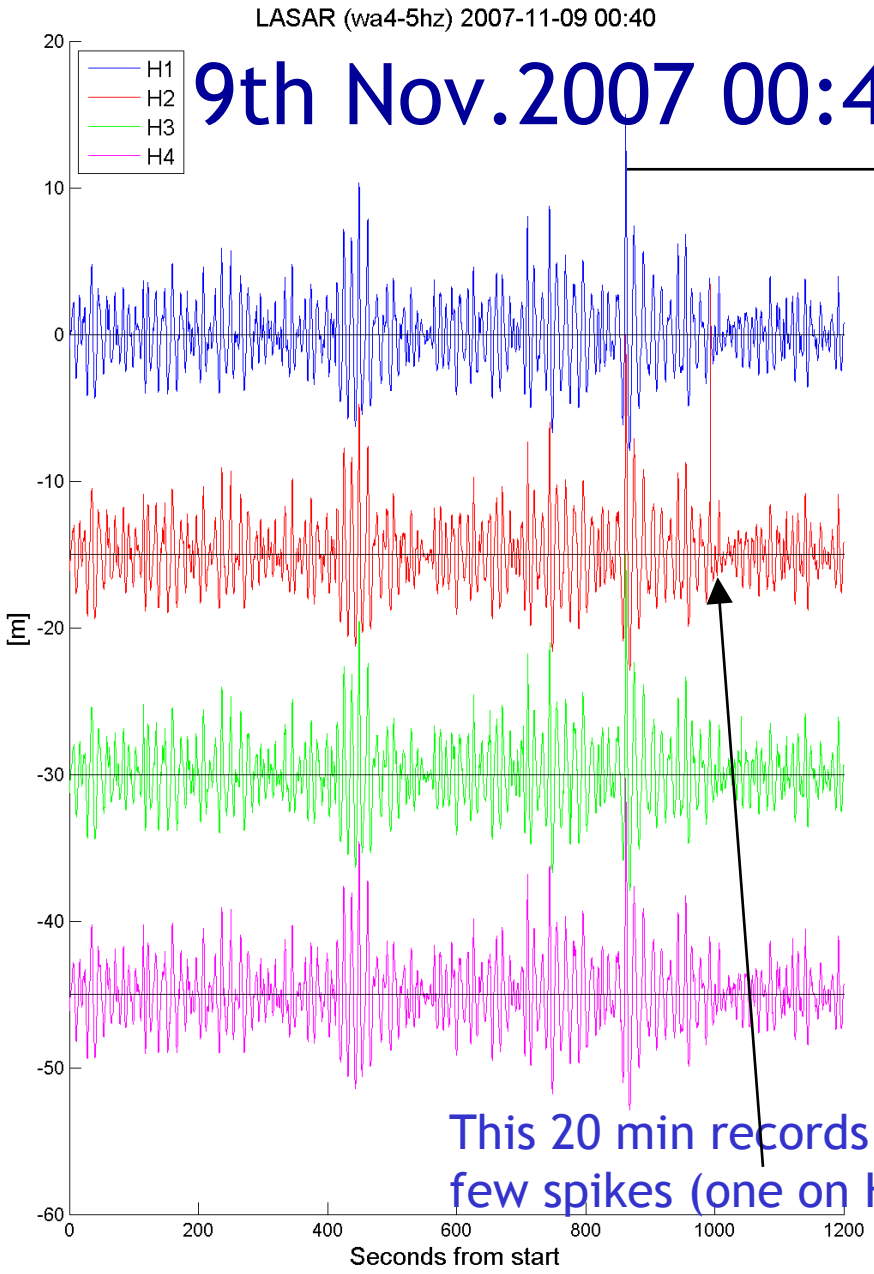
←Wind speed at 00 UTC

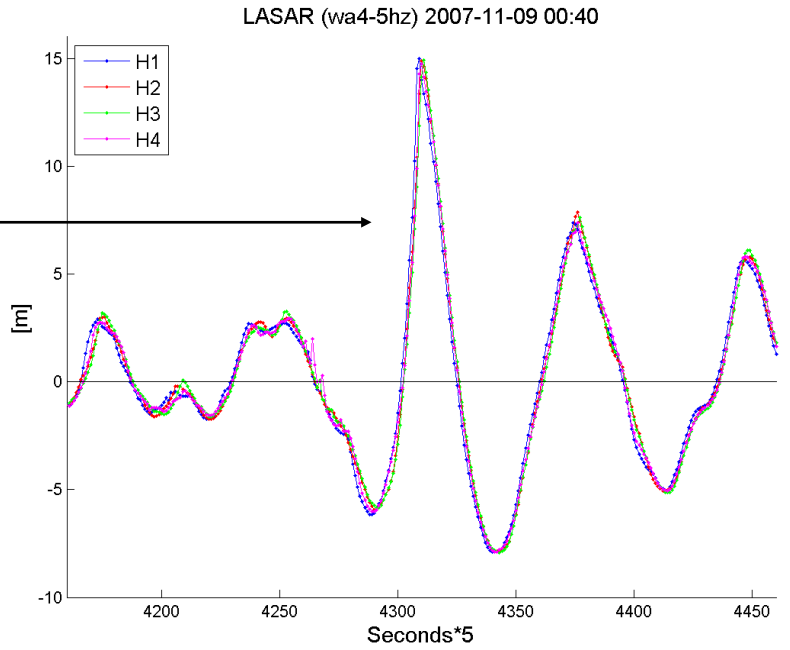


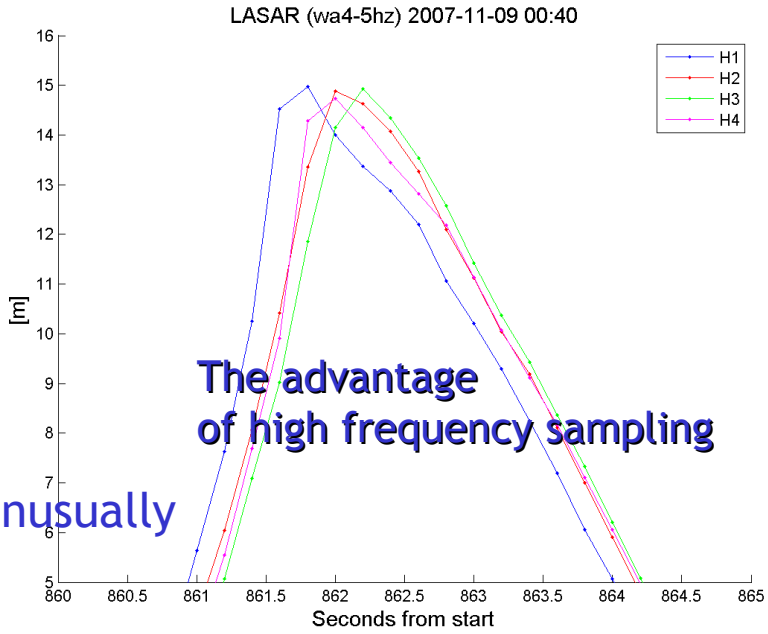
Hs at 03 UTC



9th Nov.2007 00:40





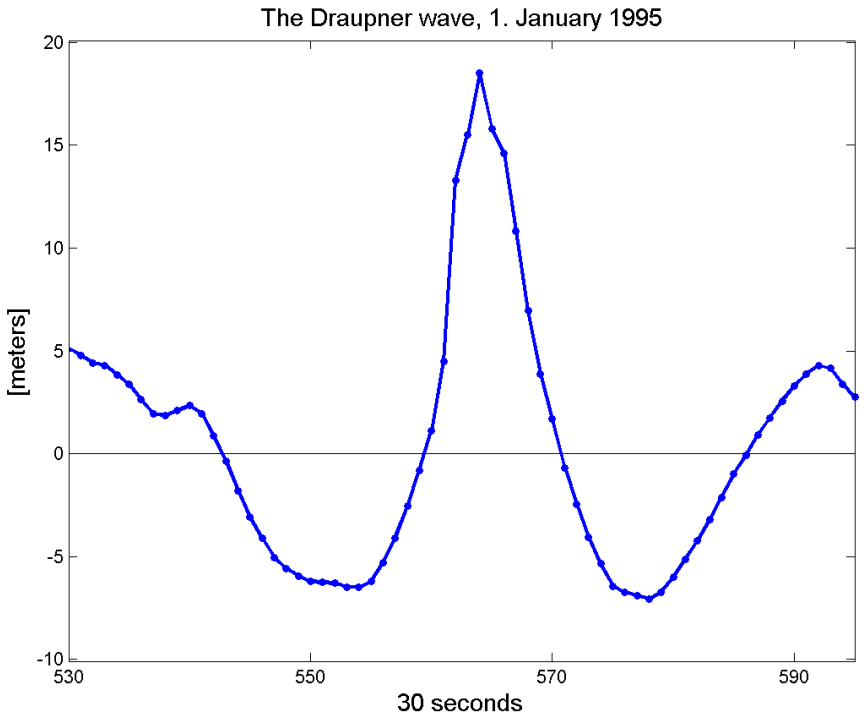


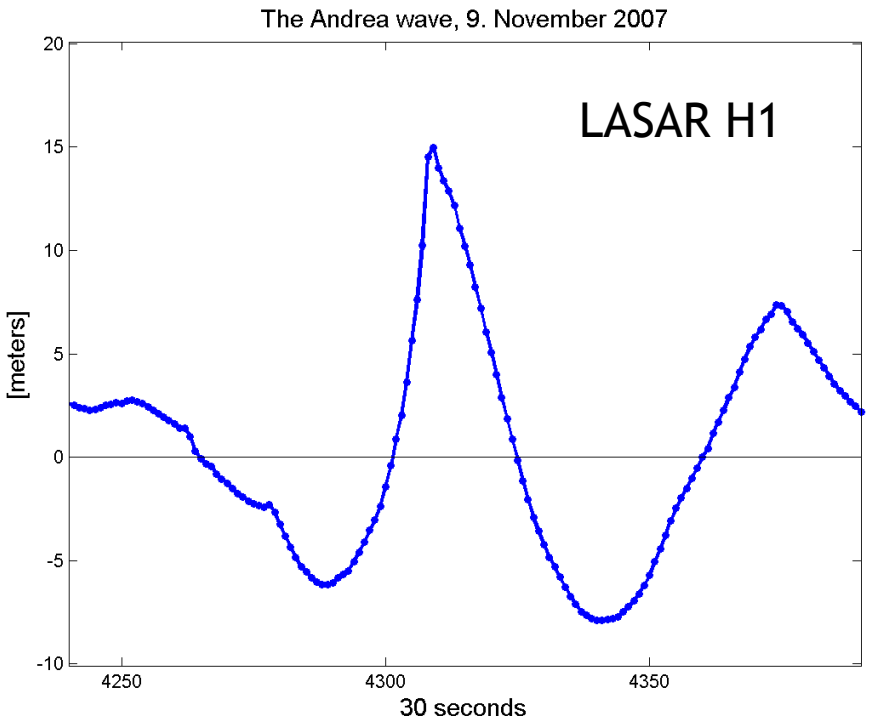
This 20 min records have unusually few spikes (one on H2)

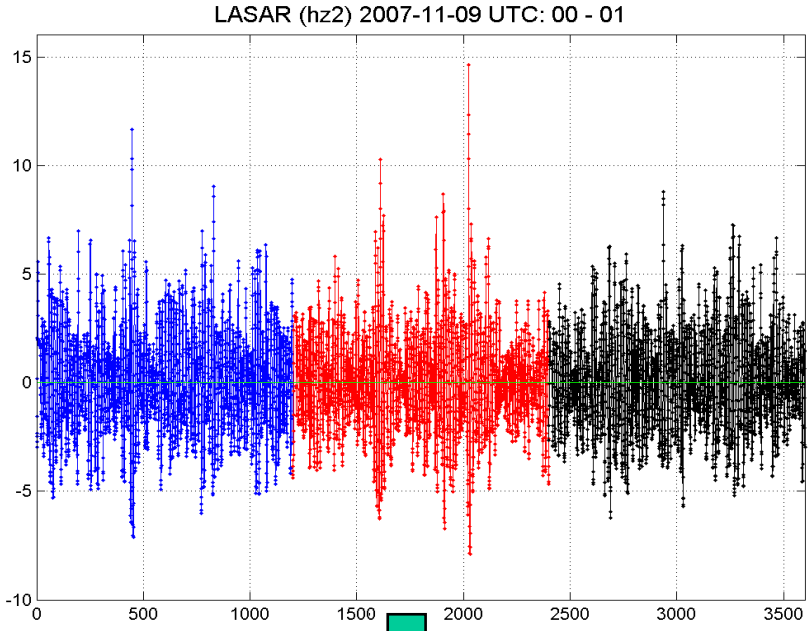
The advantage of high frequency sampling

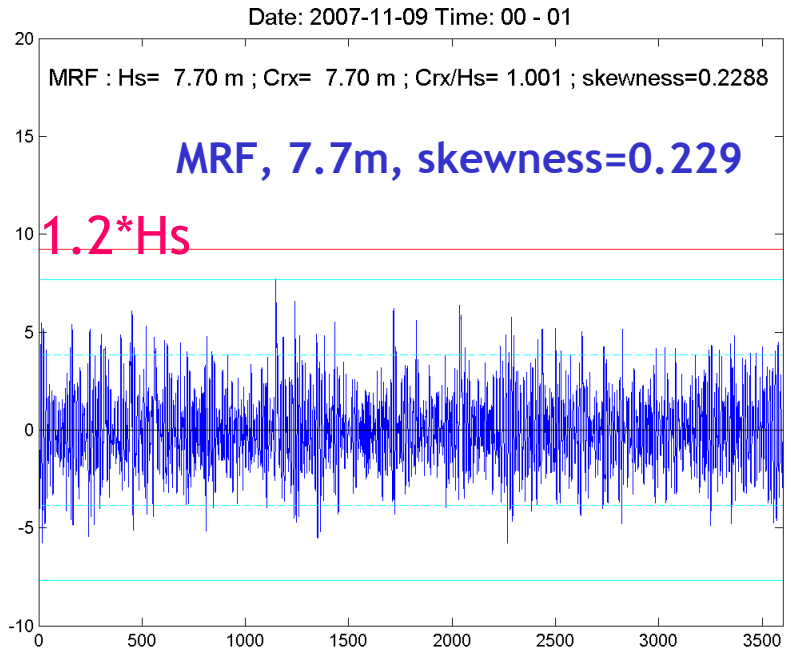
Draupner 1.1.1995 (d >100m)
Hs =11.9m
Crx =18.5m → Crx/Hs = 1.55
Hmax/Hs = 2.15

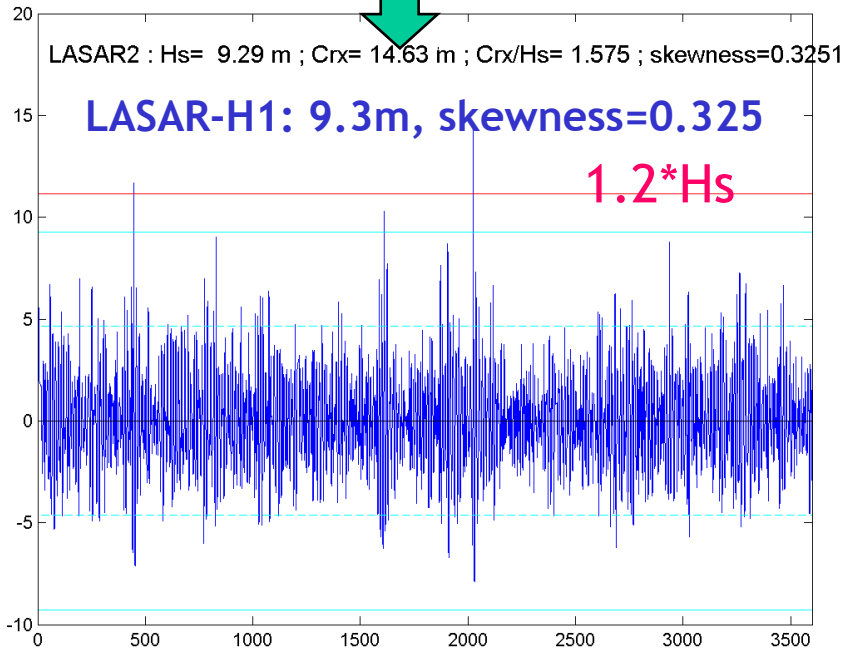
Andrea 9.11.2007 (d=70m)
Hs =9.2m
Crx =15m → Crx/Hs = 1.63
Hmax/Hs = 2.3 (2.5 after crest)

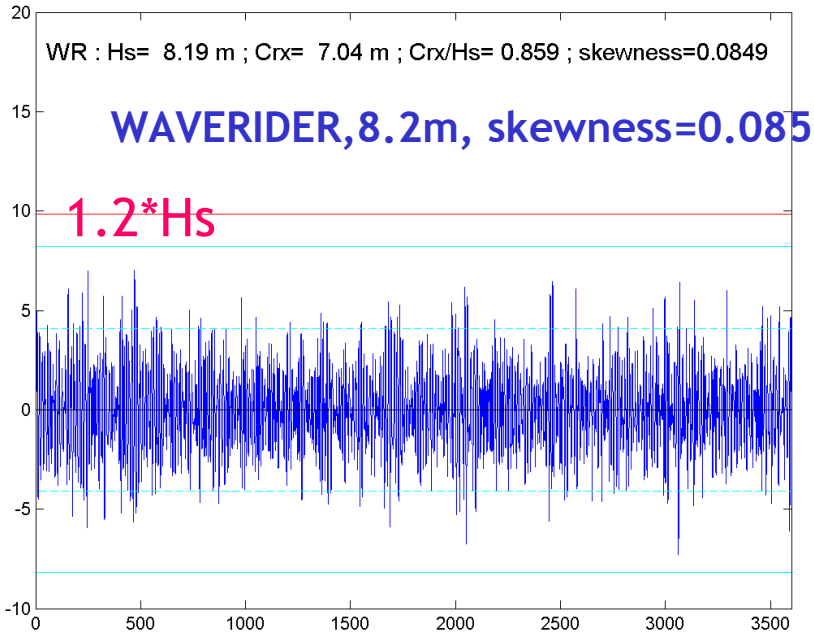


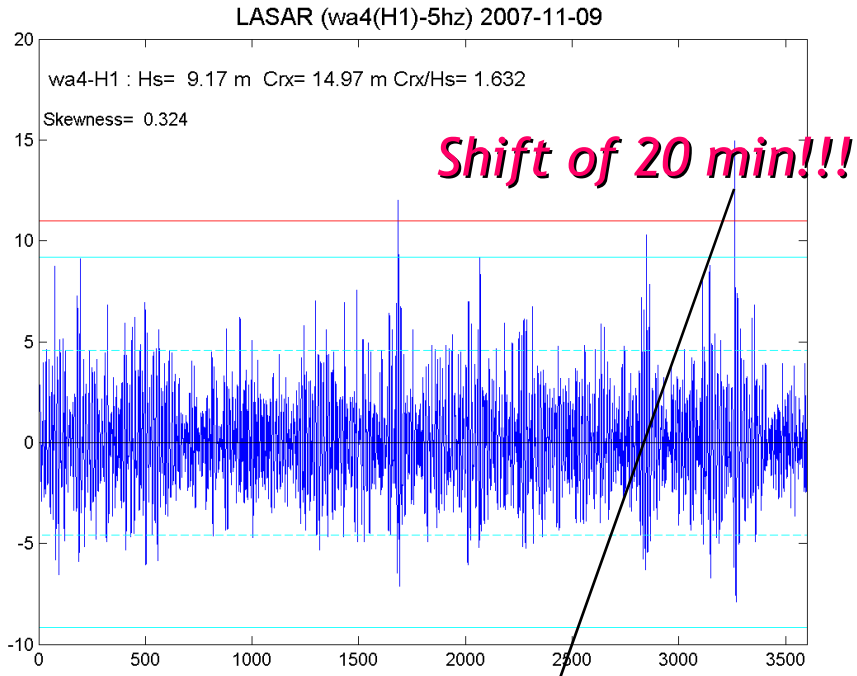


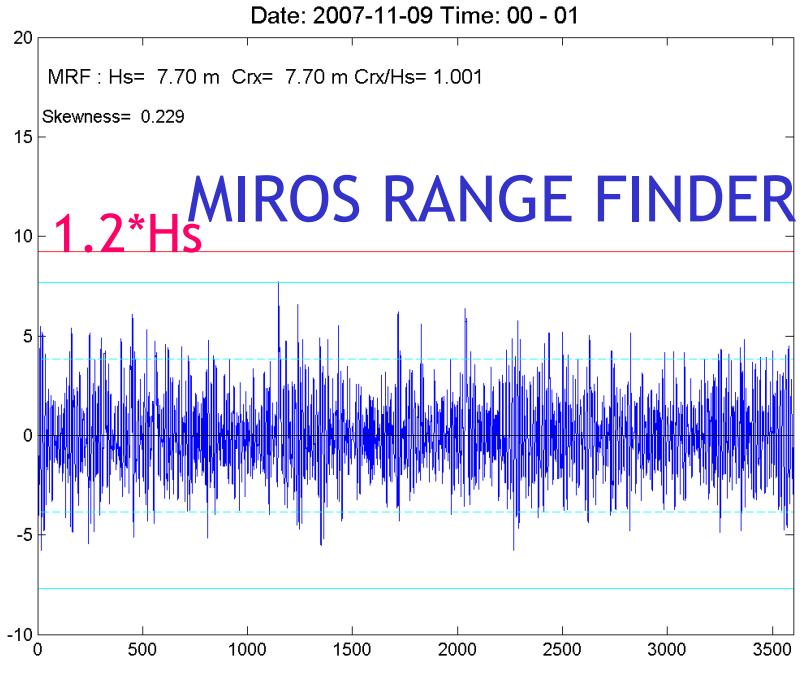

LASAR (hz2) 2007-11-09 UTC: 00 - 01

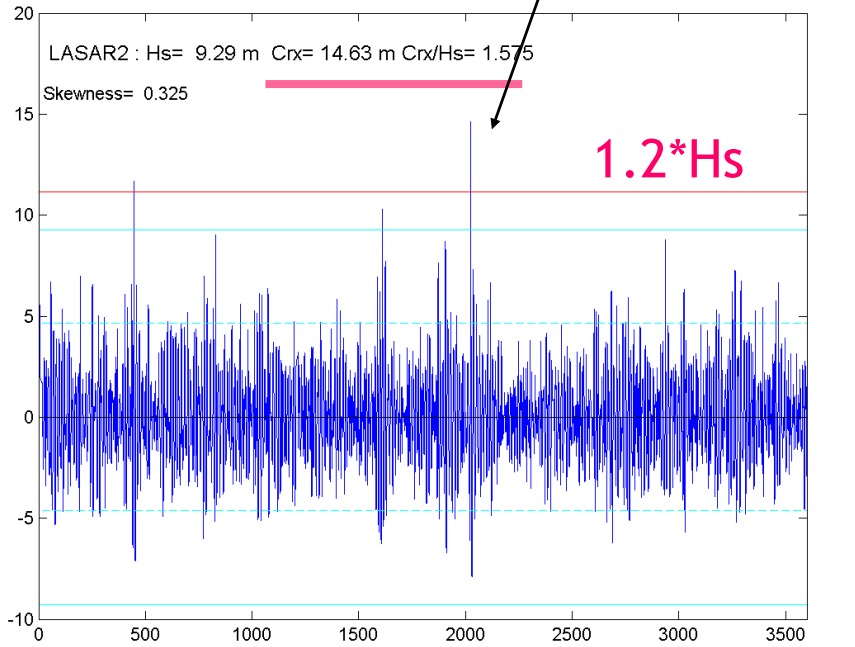

Date: 2007-11-09 Time: 00 - 01
MRF : Hs= 7.70 m ; Crx= 7.70 m ; Crx/Hs= 1.001 ; skewness=0.2288
MRF, 7.7m, skewness=0.229
1.2*Hs

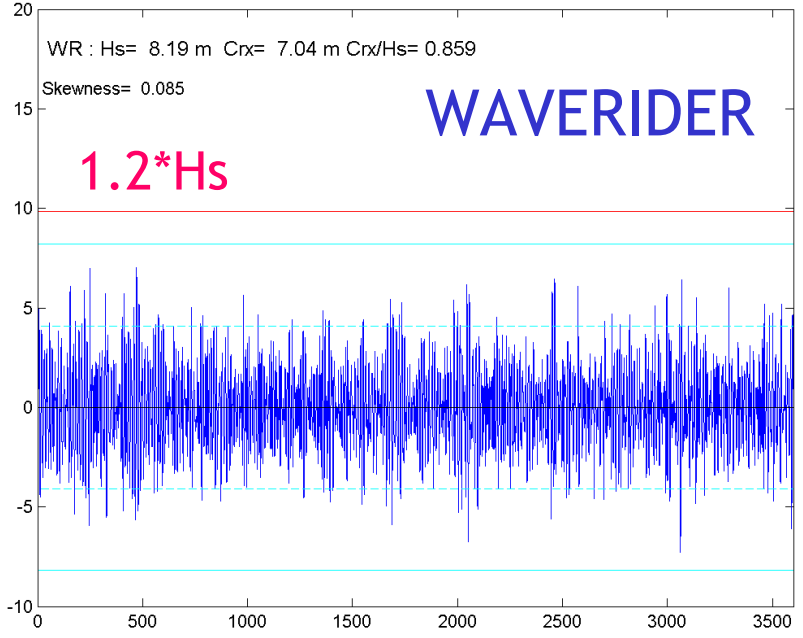

LASAR2 : Hs= 9.29 m ; Crx= 14.63 m ; Crx/Hs= 1.575 ; skewness=0.3251
LASAR-H1: 9.3m, skewness=0.325
1.2*Hs

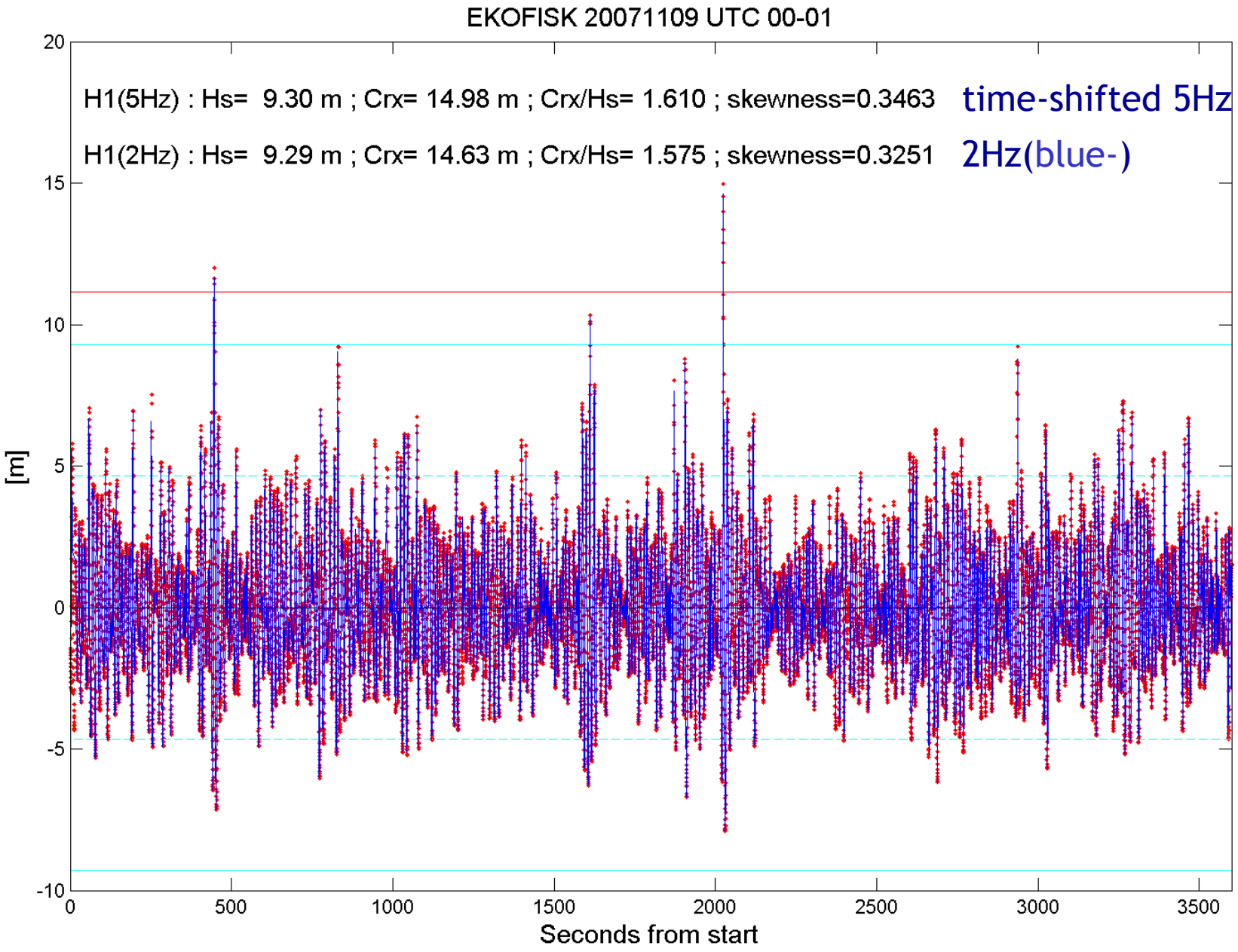

WR : Hs= 8.19 m ; Crx= 7.04 m ; Crx/Hs= 0.859 ; skewness=0.0849
WAVERIDER,8.2m, skewness=0.085
1.2*Hs

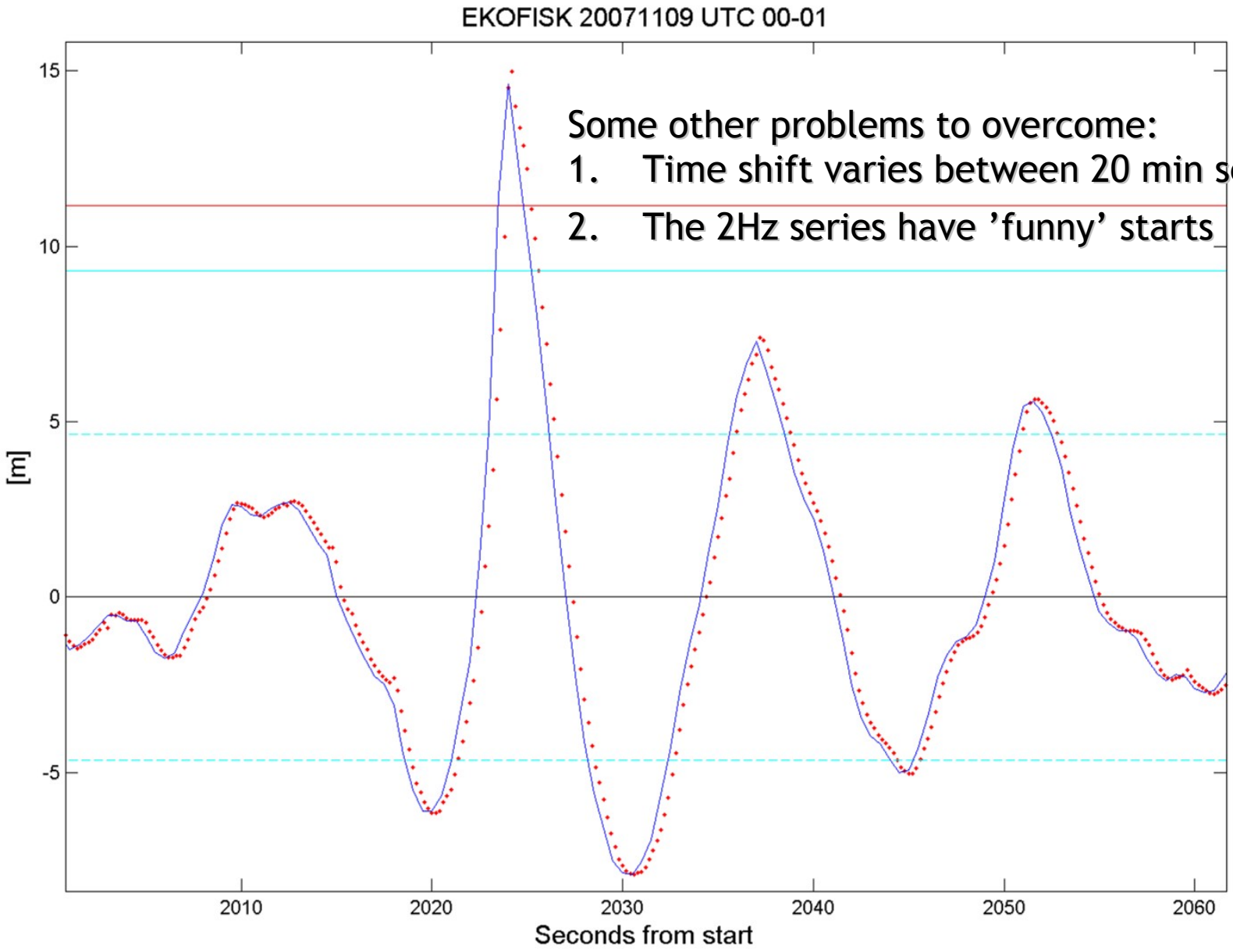

LASAR (wa4(H1)-5hz) 2007-11-09
wa4-H1 : Hs= 9.17 m Crx= 14.97 m Crx/Hs= 1.632
Skewness= 0.324
Shift of 20 min!!!


Date: 2007-11-09 Time: 00 - 01
MRF : Hs= 7.70 m Crx= 7.70 m Crx/Hs= 1.001
Skewness= 0.229
MIROS RANGE FINDER
1.2*Hs


LASAR2 : Hs= 9.29 m Crx= 14.63 m Crx/Hs= 1.575
Skewness= 0.325
1.2*Hs


WR : Hs= 8.19 m Crx= 7.04 m Crx/Hs= 0.859
Skewness= 0.085
WAVERIDER
1.2*Hs


EKOFISK 20071109 UTC 00-01
H1(5Hz) : Hs= 9.30 m ; Crx= 14.98 m ; Crx/Hs= 1.610 ; skewness=0.3463
H1(2Hz) : Hs= 9.29 m ; Crx= 14.63 m ; Crx/Hs= 1.575 ; skewness=0.3251
time-shifted 5Hz (red
2Hz(blue-)
[m]
Seconds from start
20
15
10
5
0
-5
-10
0
500
1000
1500
2000
2500
3000
3500


EKOFISK 20071109 UTC 00-01
15
10
5
0
-5
[m]
2010
2020
2030
2040
2050
2060
Seconds from start
Some other problems to overcome:
1. Time shift varies between 20 min series
2. The 2Hz series have 'funny' starts

Results: Wave heights statistics

- Wave height, crest and trough probability distributions
  1. LASAR H1 : 2Hz and 5 Hz differences
  2. 3 sensors:
     - LASAR 2Hz
     - MRF (Miros range finder)
     - WR (waverider)

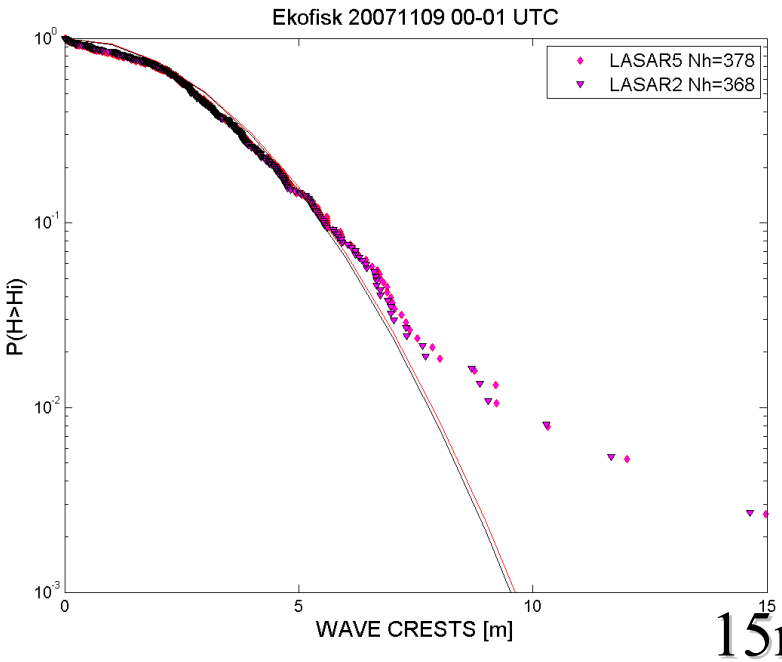
A: Andrea storm 00-01 UTC

B: Andrea storm: 8/11: 13.30 – 14.30

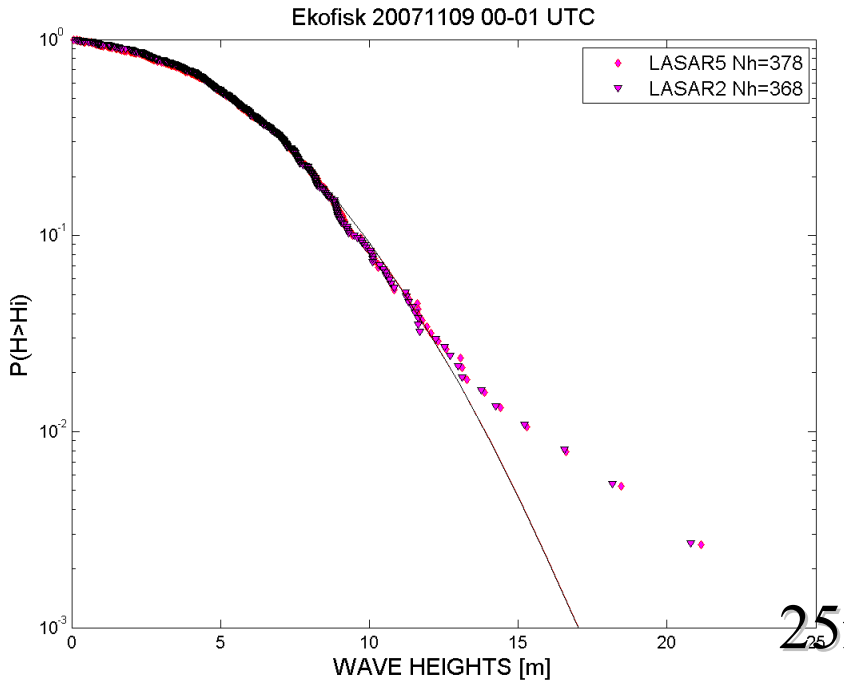
(C: Andrea storm: 9/11: 06-12)

A: Andrea storm 00-01 UTC

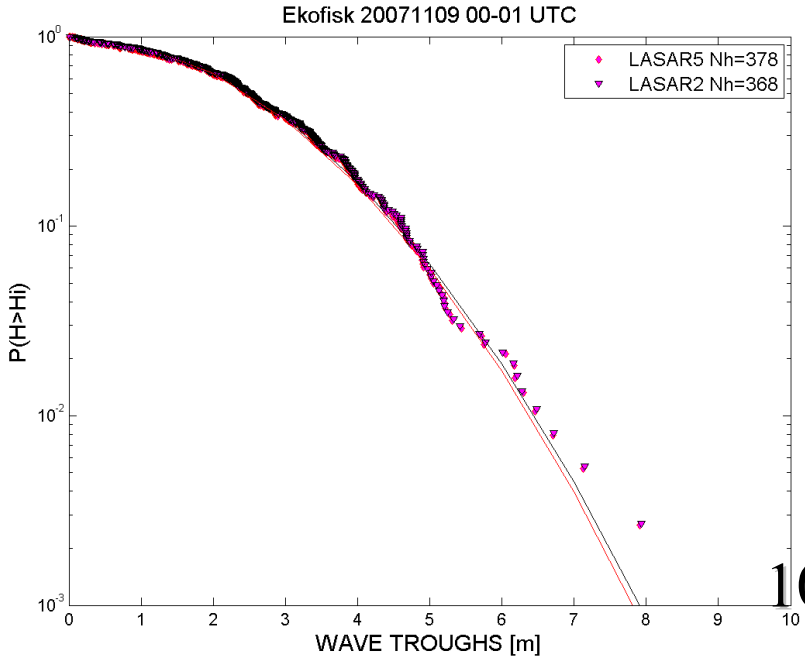
- Laser (5Hz)
- Laser (2Hz)



15m



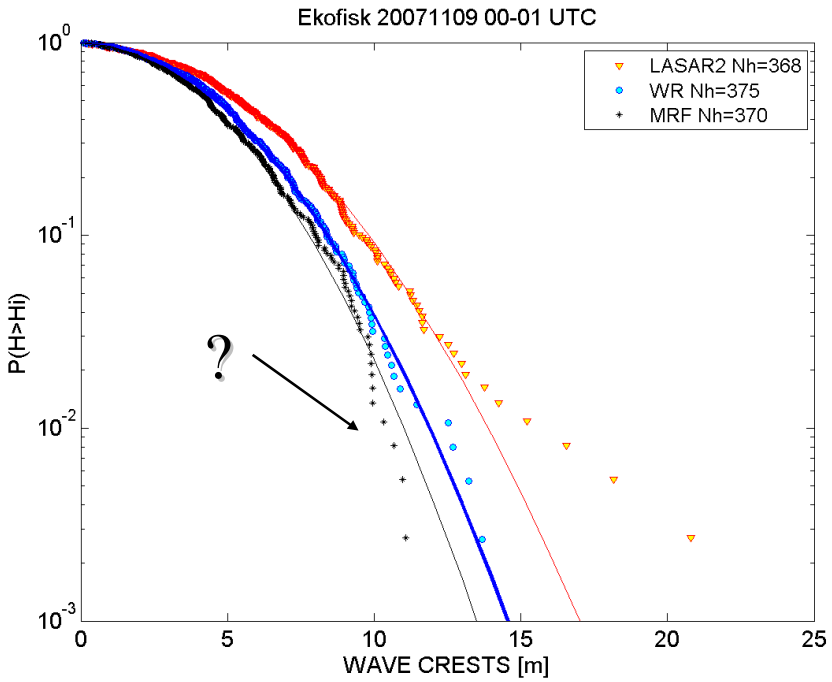
25m

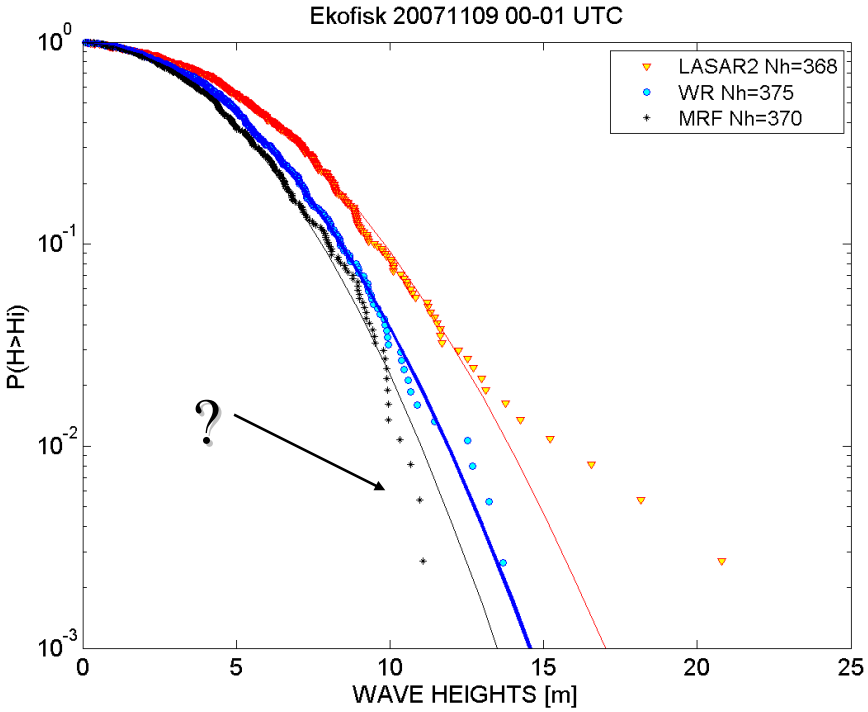


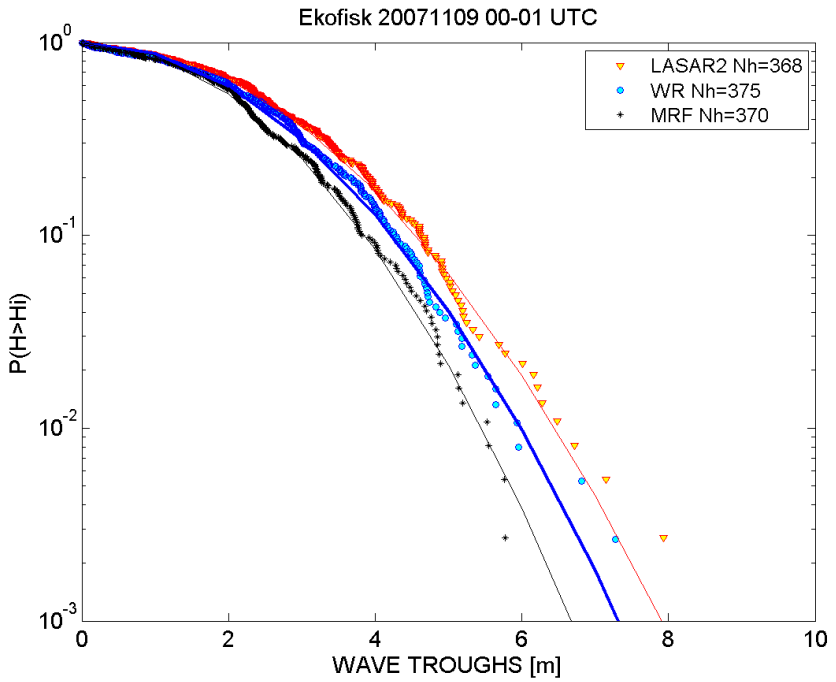
10m

A: Andrea storm 00-01 UTC

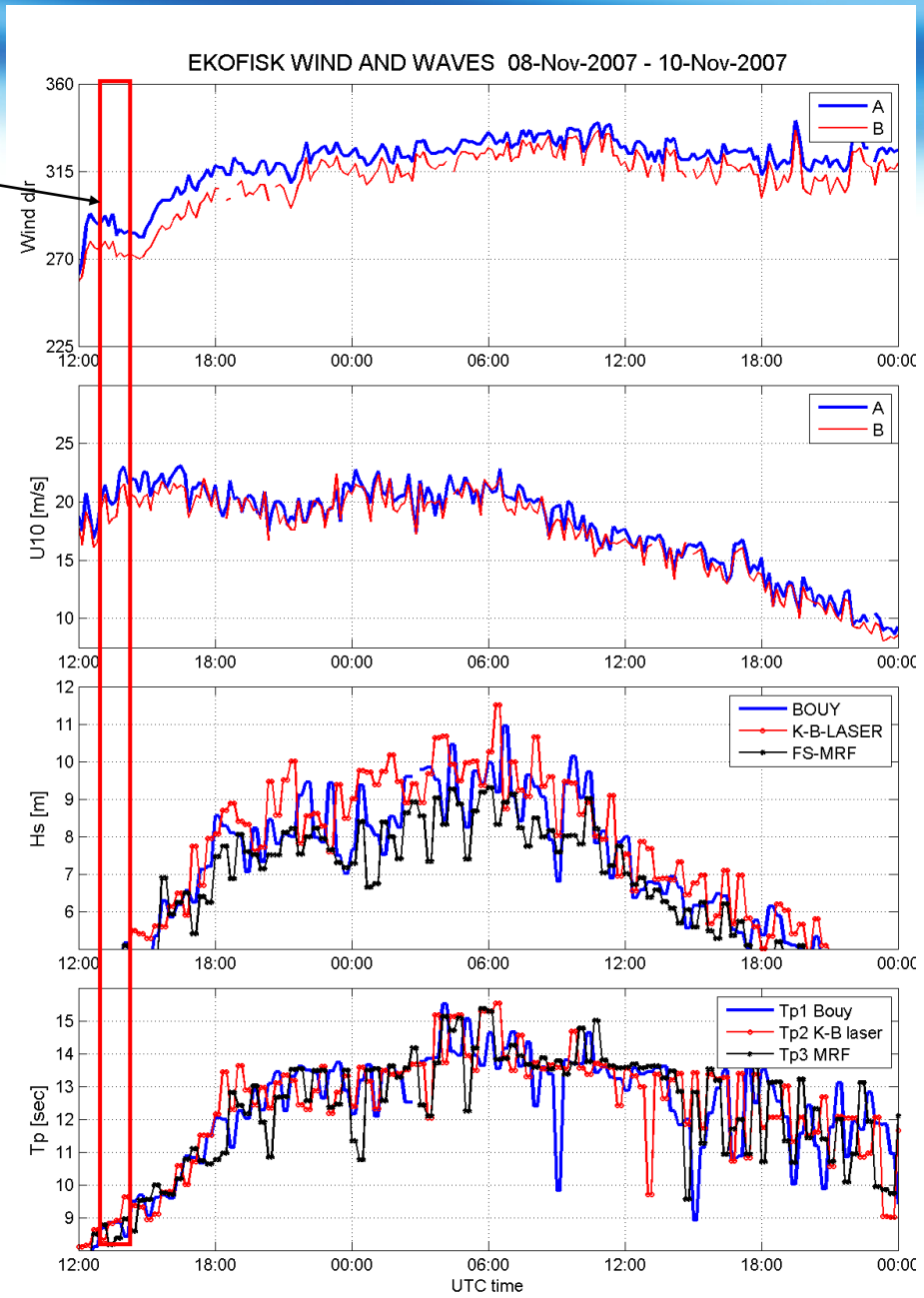
- Laser (2Hz)
- Waverider
- MRF





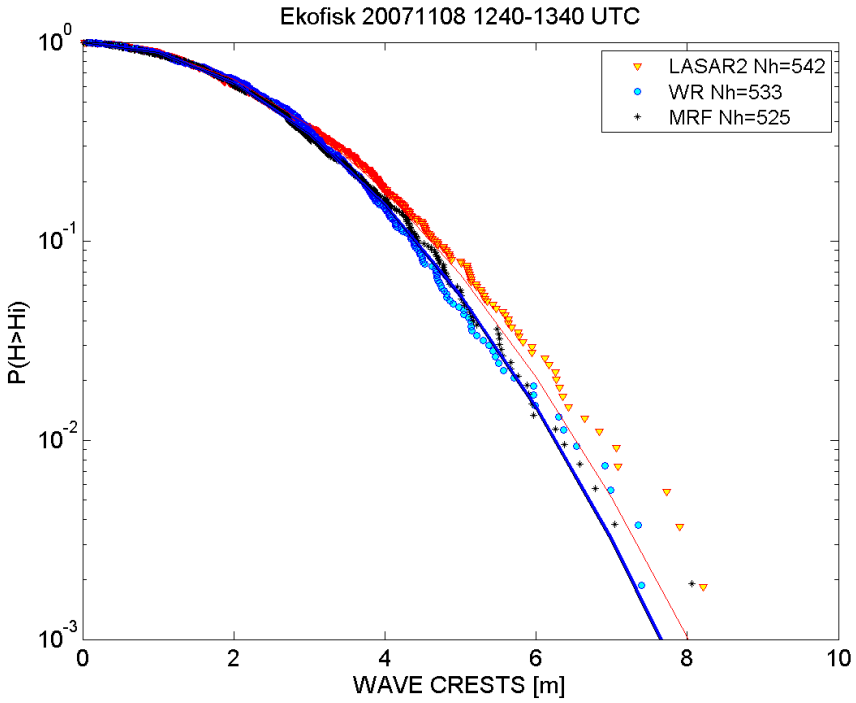


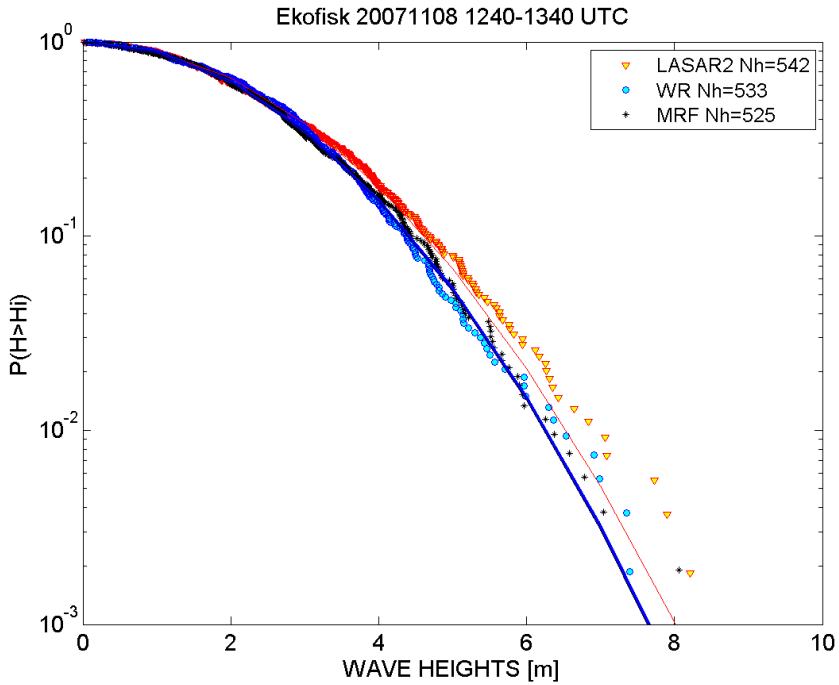
Case with westerly direction (285°)

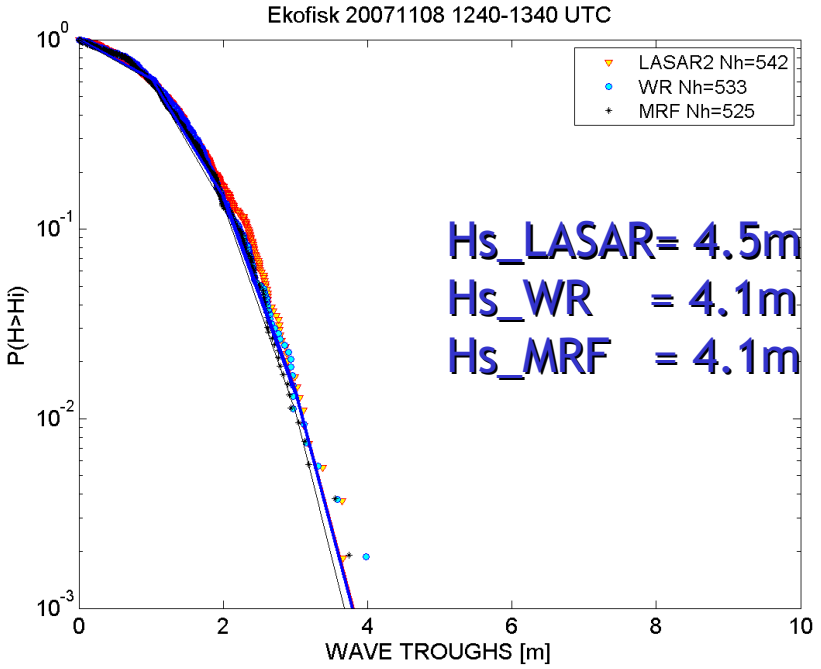


Case with westerly direction (285°)

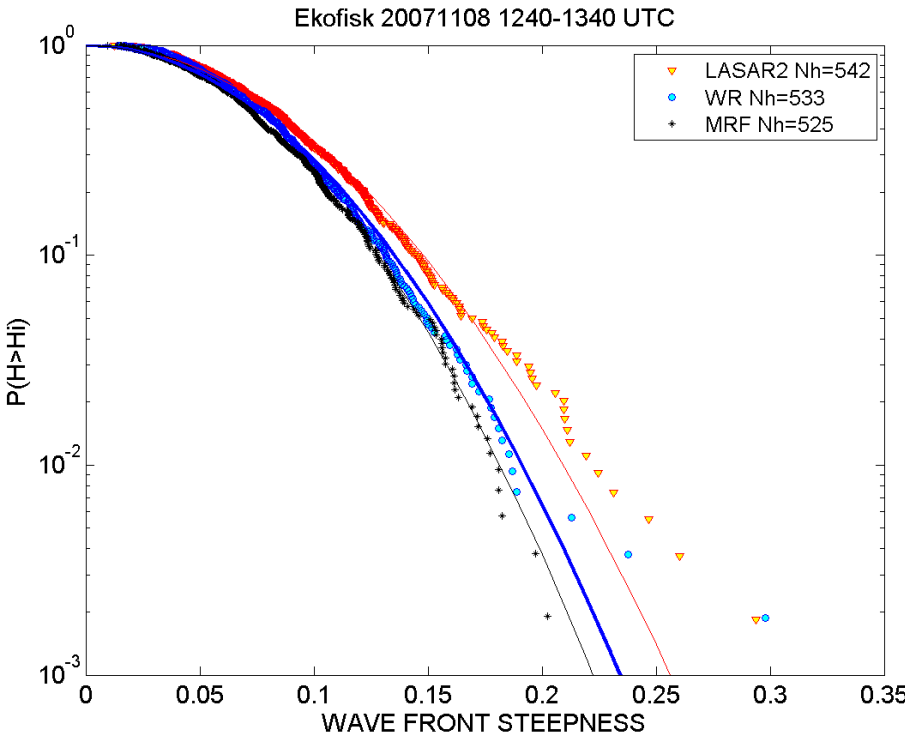
- Distributions of MRF look normal (highest values above Rayleigh fit), but show still lower Crests (and Heights) compared to WR and LASAR

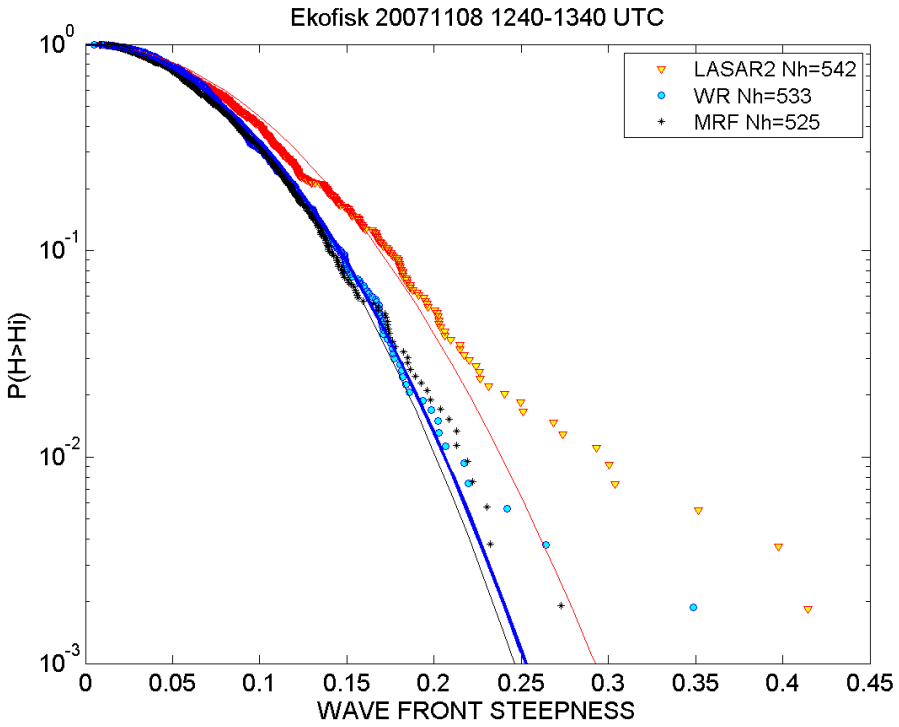






Steepness

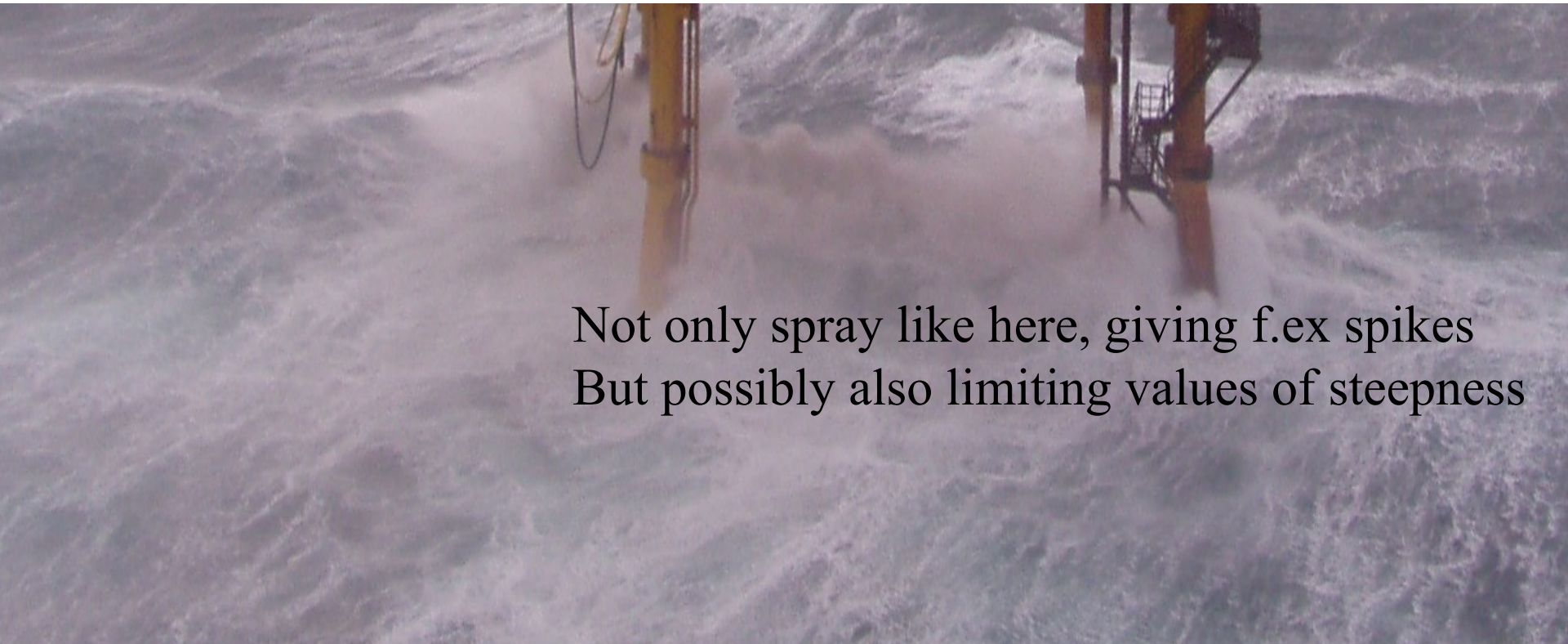




Hs_LASAR= 4.5m
Hs_WR = 4.1m
Hs_MRF = 4.1m

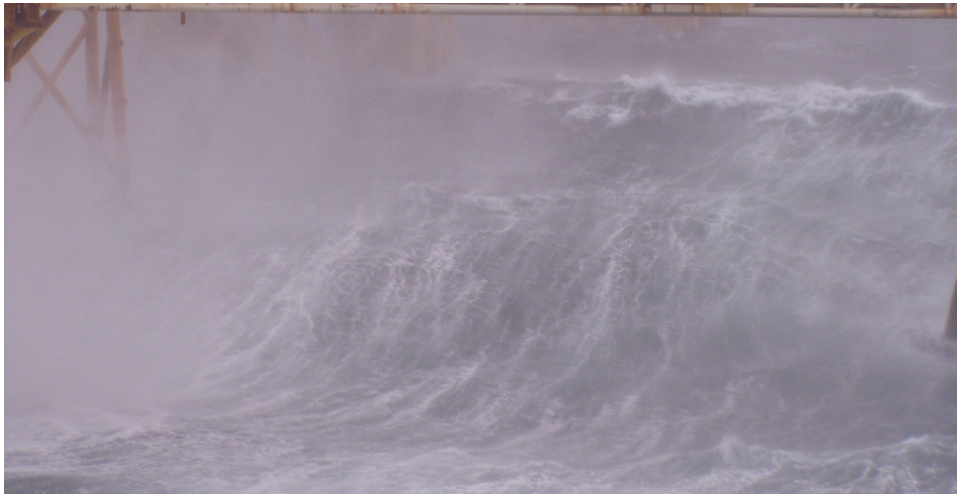
Hypothesis regarding the differences

- Not all differences are due to local effects (sheltering, too much sea spray…)
- Some are due to too strict quality control on raw data
  - ➔ Limiting steepness?



Conclusions

- Different measuring techniques give different wave statistics. (this is common knowledge?)
- The question is if it is because of sheltering effects only!?
- Waverider data, although unskewed, give good Hs up to 9m (… ?)



Take off in the evening