Mapping of offshore wind resources

C. B. Hasager, P. Astrup, M. B. Christiansen, M. Nielsen, A. Peña
Charlotte.Hasager@RISOE.DK

For the National Science Council, Taiwan. Visiting Risø DTU, Denmark
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Hasager Astrup Christiansen Nielsen Peña (missing photo)

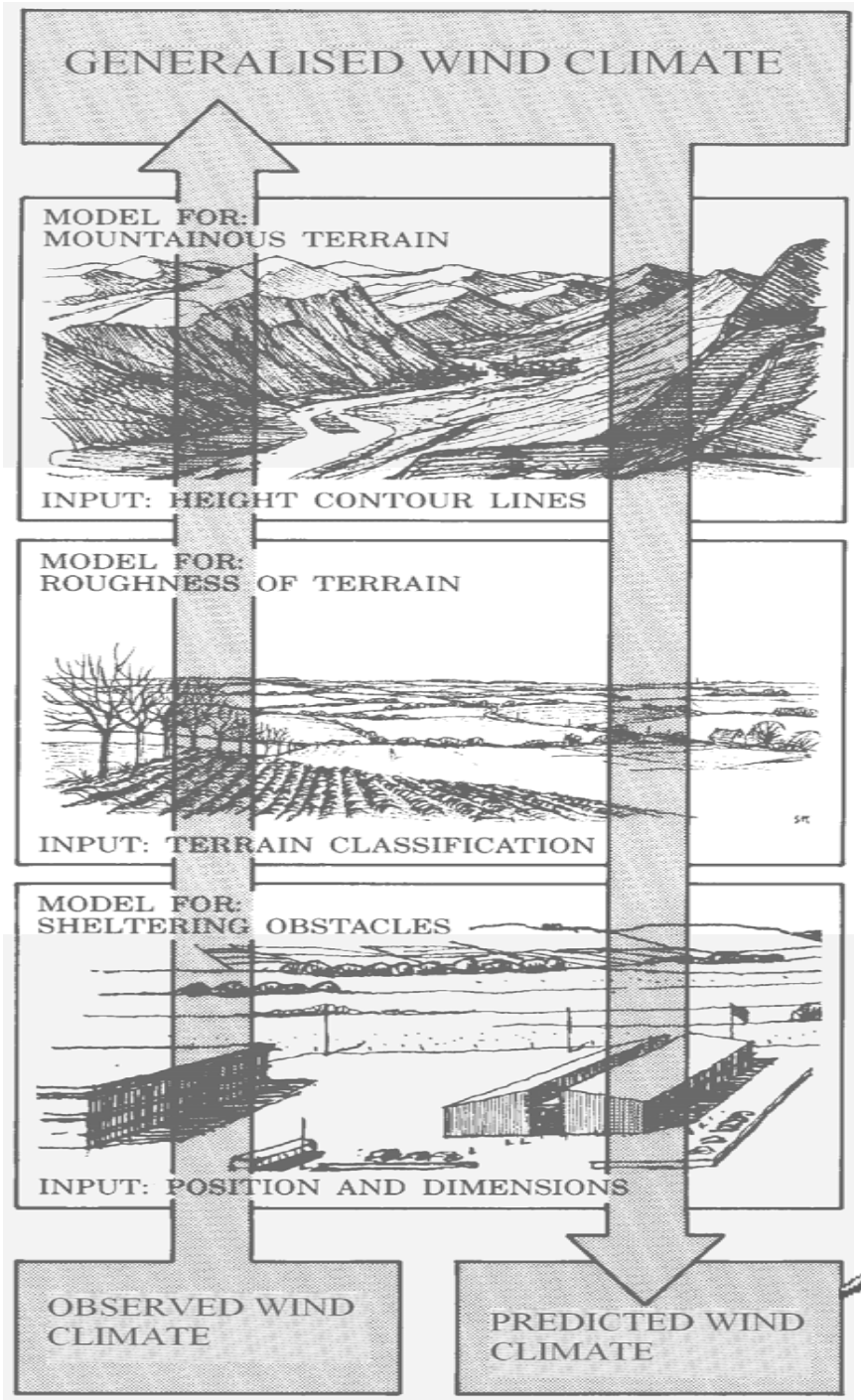
160 m tall mast

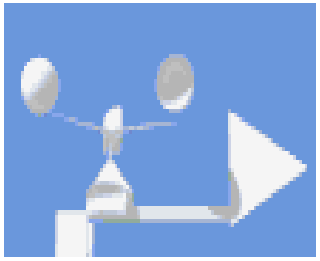
Høvsøre Risø Denmark

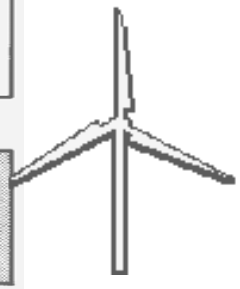
testing power curve

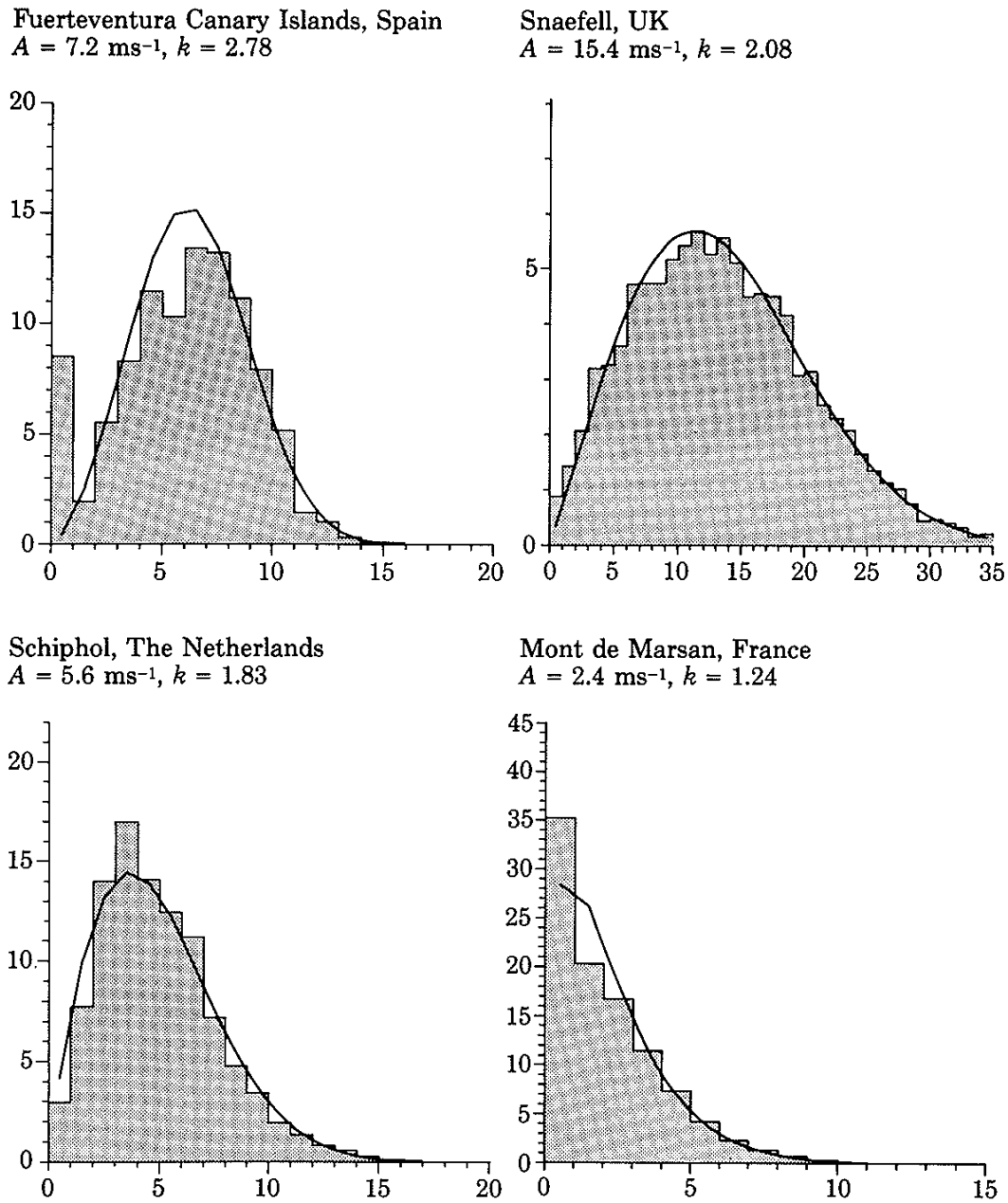
www.WASP.dk

- 2000 users
- 100 countries
- de facto standard









From The European Wind Atlas, Risø

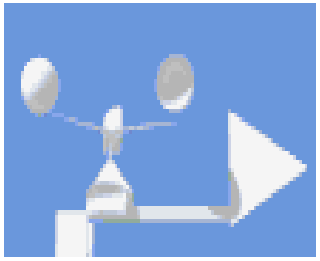
Weibull fitting:

A = scale parameter

k = shape parameter

DTU

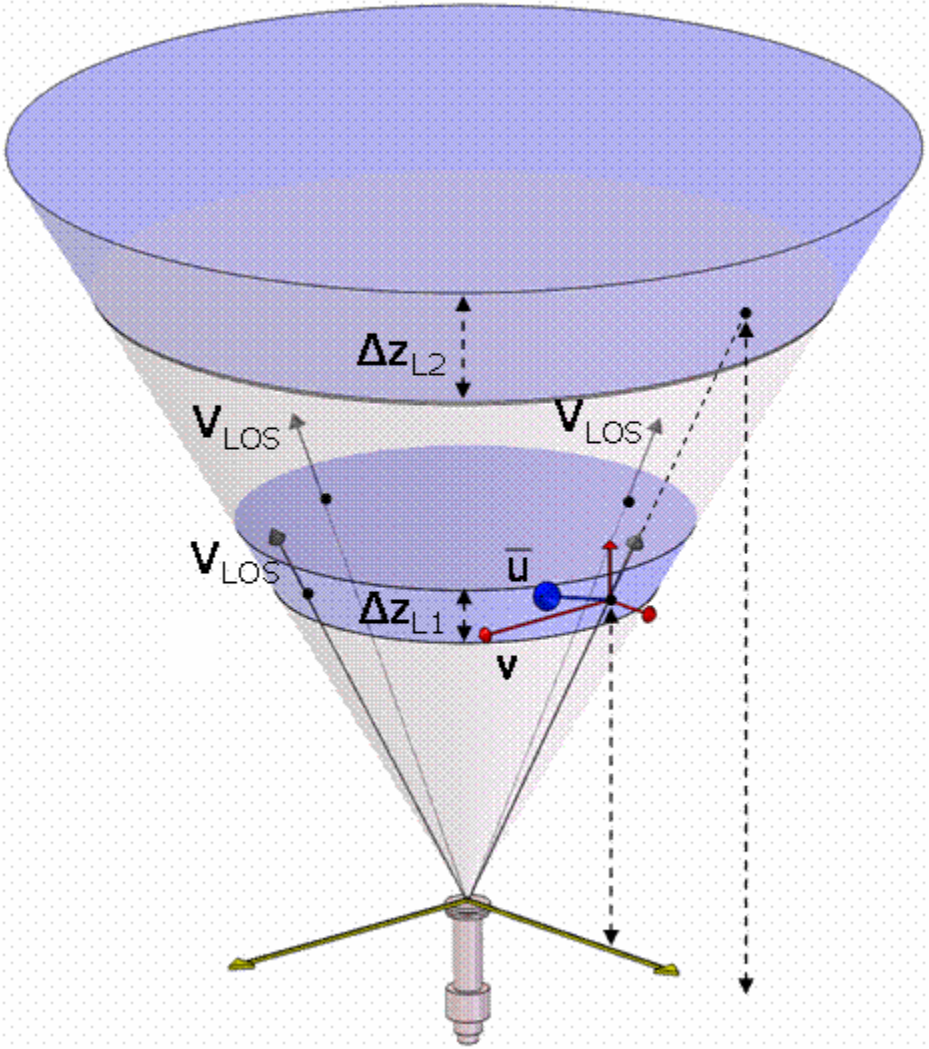
RISØ

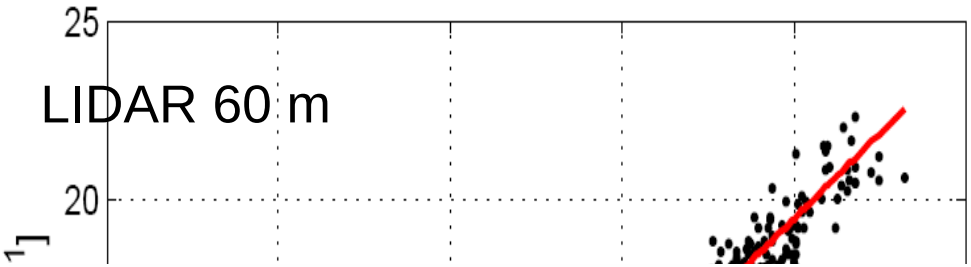


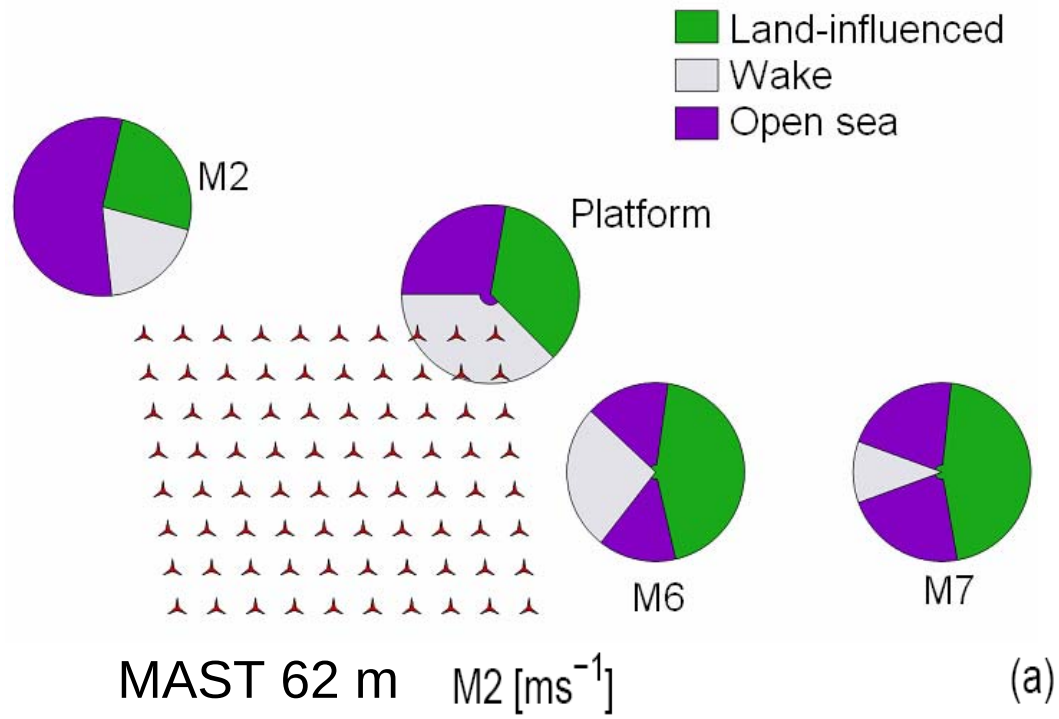

S/N-252
UNI-FLY
HELICOPTER

DTU

RISØ


Δz_{L2}
V_{LOS}
V_{LOS}
V_{LOS}
$\bar{u}$
Δz_{L1}
v





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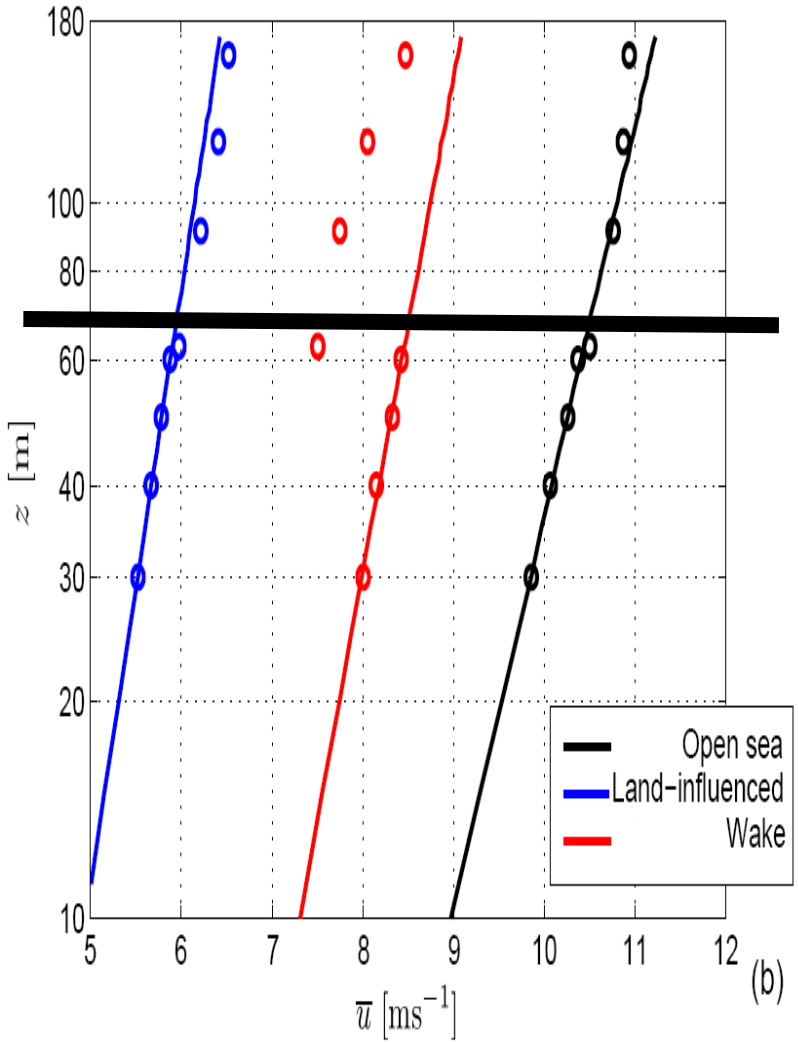
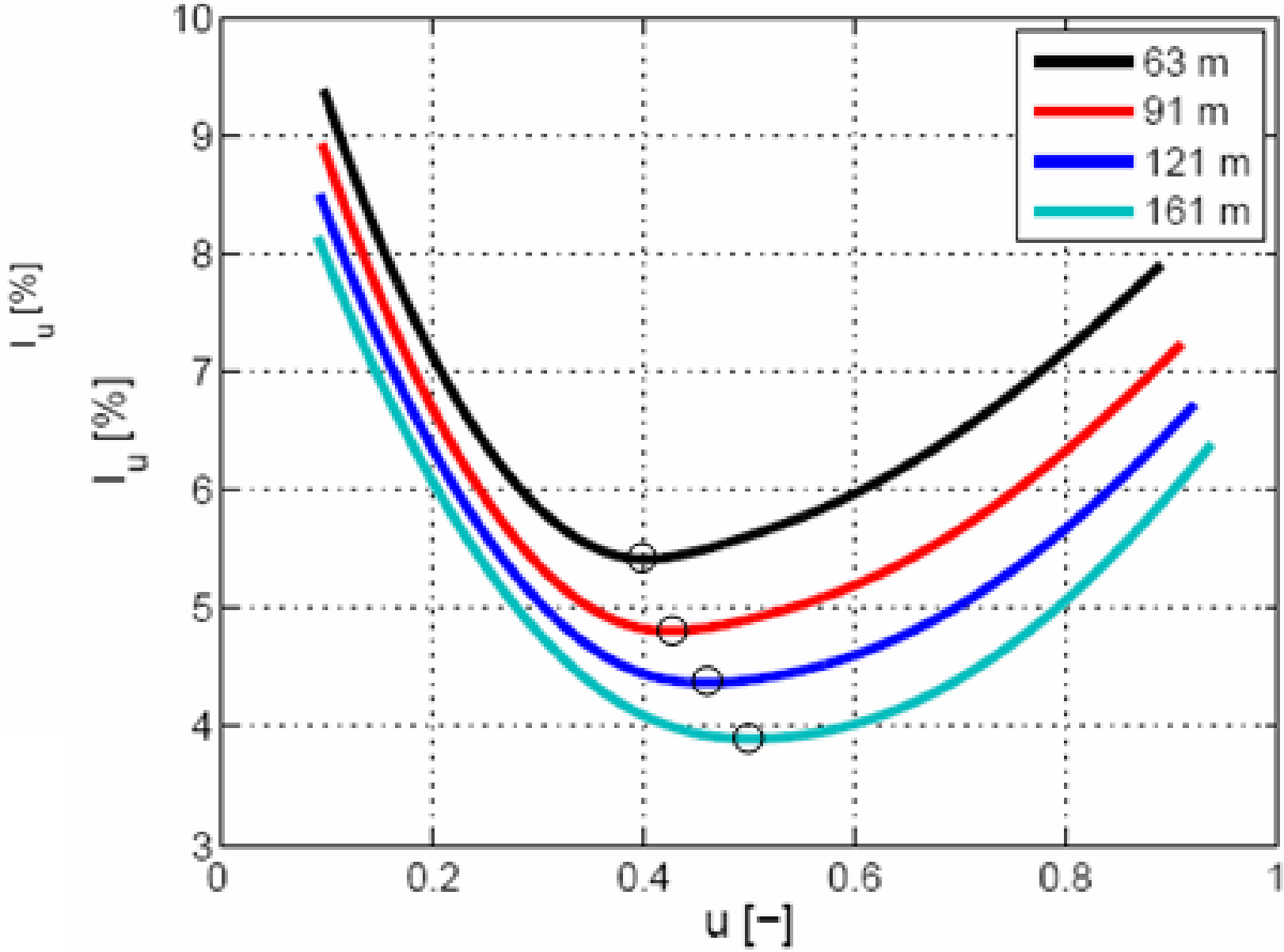
PROFILES above ocean

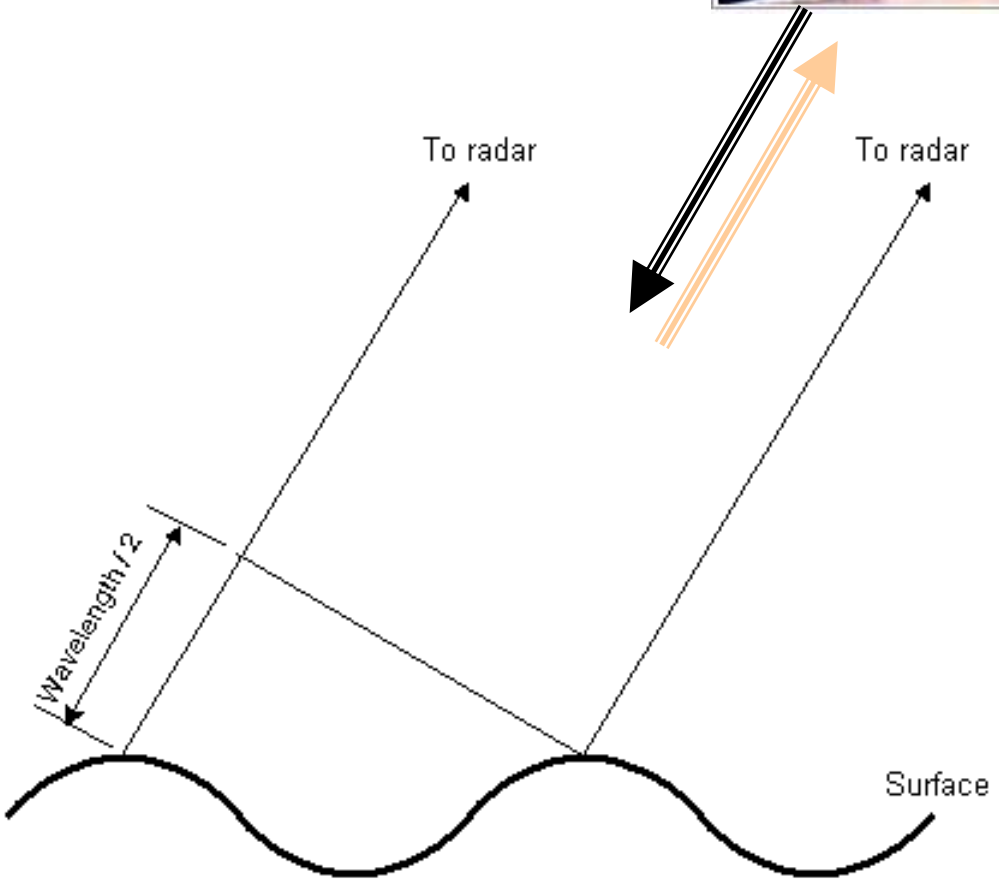


Longitudinal turbulence intensity



(b)

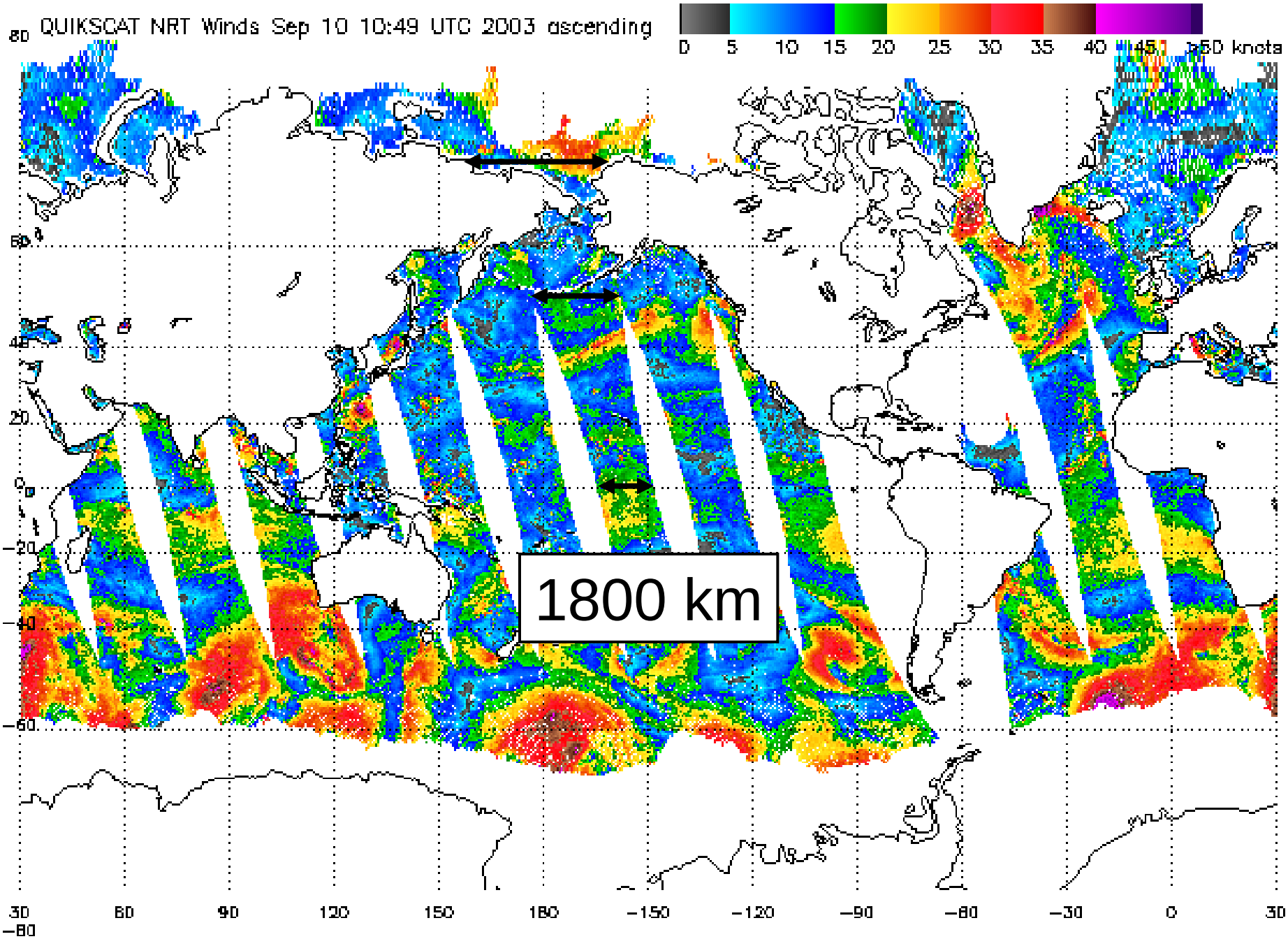
$$NormalizedRadarCrossSection = f(windspeed, winddirection)$$

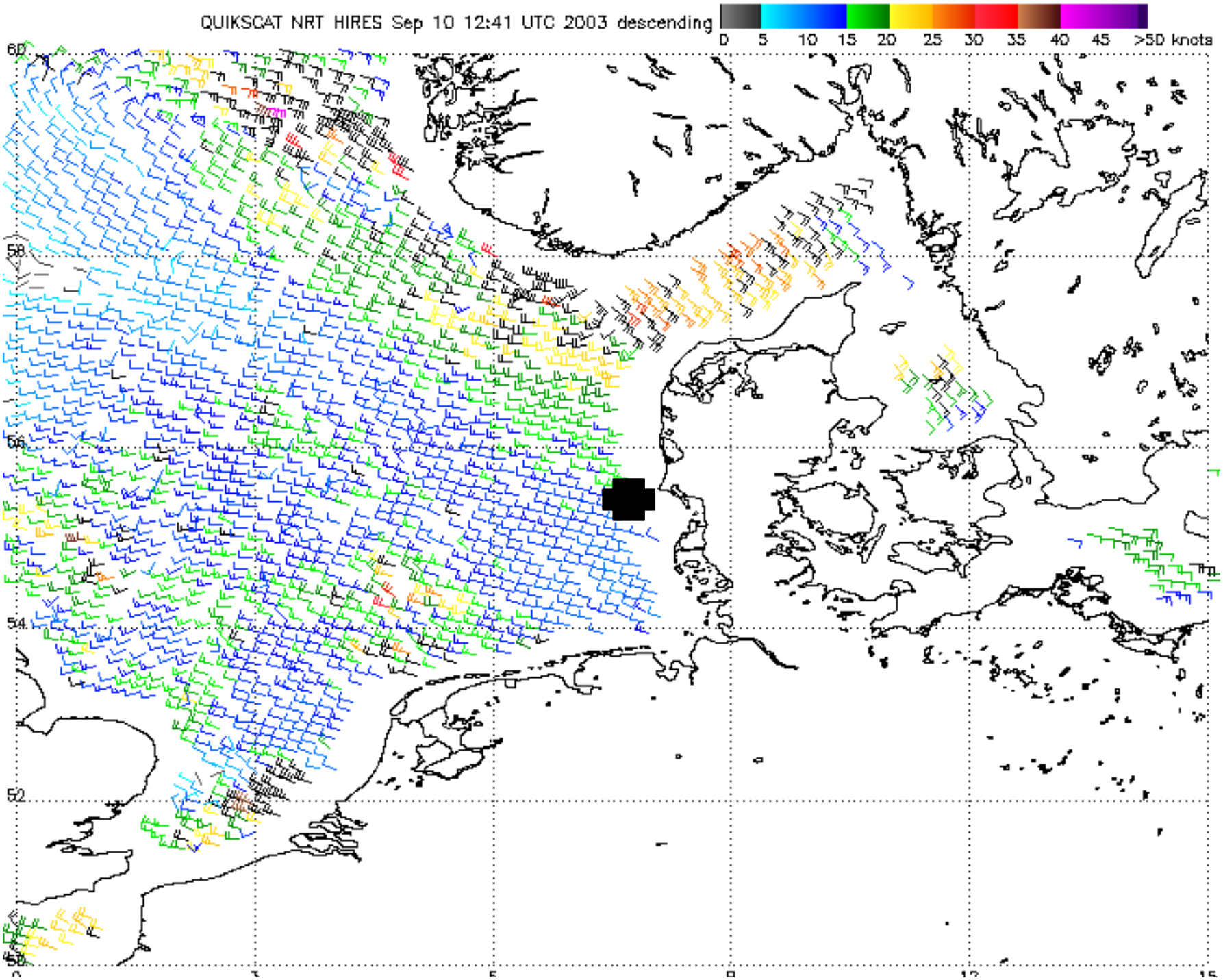


Physics

Ocean surface roughens by wind interaction: Capillary and short gravity waves are generated.

More wind causes more steep waves causes higher backscatter.


QUIKSCAT NRT Winds Sep 10 10:49 UTC 2003 ascending
0 5 10 15 20 25 30 35 40 45 >50 knots
1800 km
80
60
40
20
0
−20
−40
−60
30 60 90 120 150 180 −150 −120 −90 −60 −30 0 30
−80


QUIKSCAT NRT HIRES Sep 10 12:41 UTC 2003 descending
0 5 10 15 20 25 30 35 40 45 >50 knots
60
58
56
54
52
50
0
3
5
8
12
15

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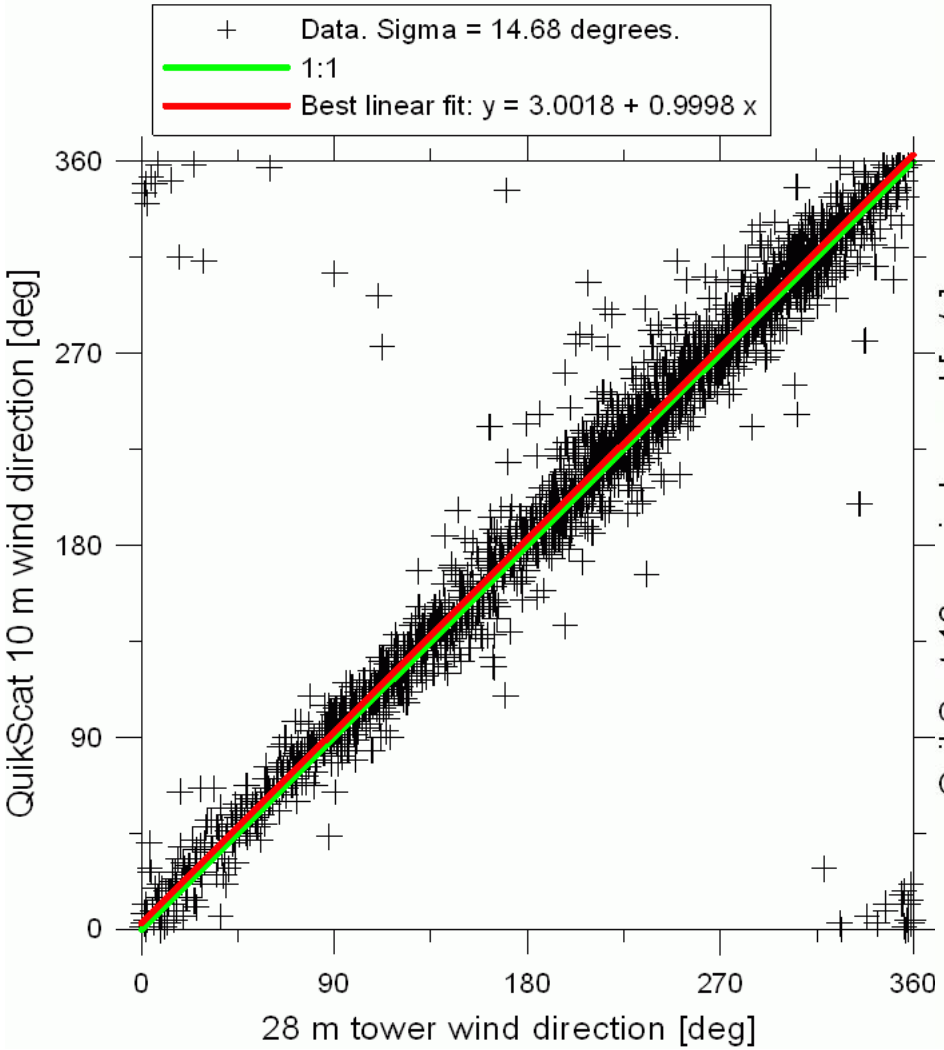
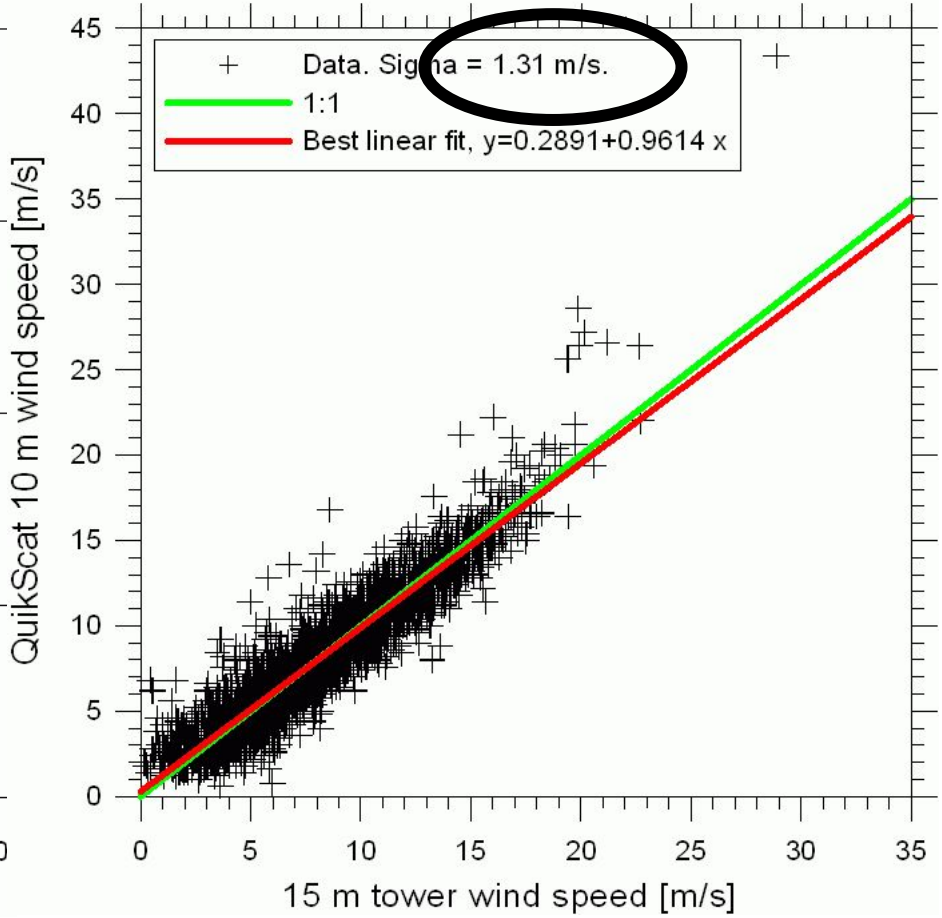
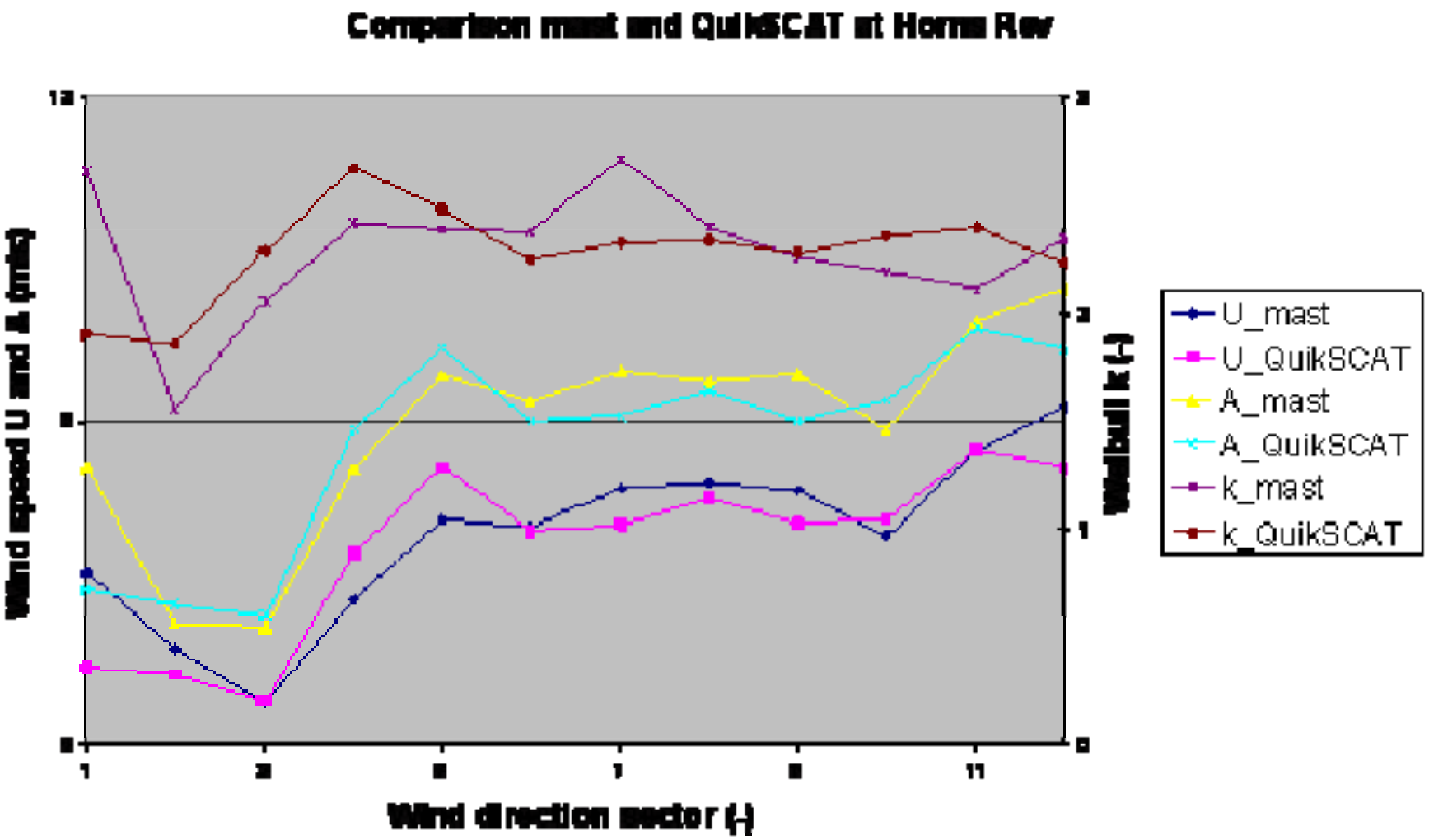
Comparison of QuikScat satellite determined wind directions to 60 minute mean tower measurements at Horns Rev.
Data screened on QuikScat as well as Horns Rev 15 m wind speeds to exceed 5 m/s.



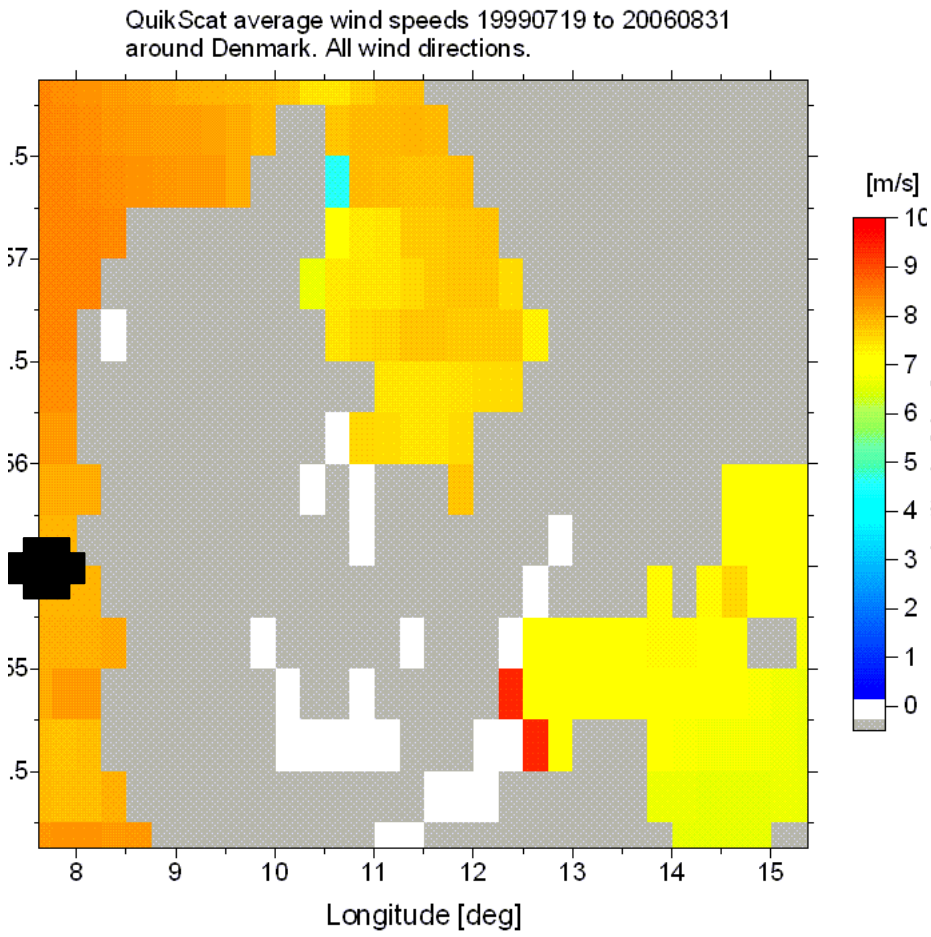
Comparison of QuickScat satellite determined wind speeds to 60 minute mean tower measurements at Horns Rev.

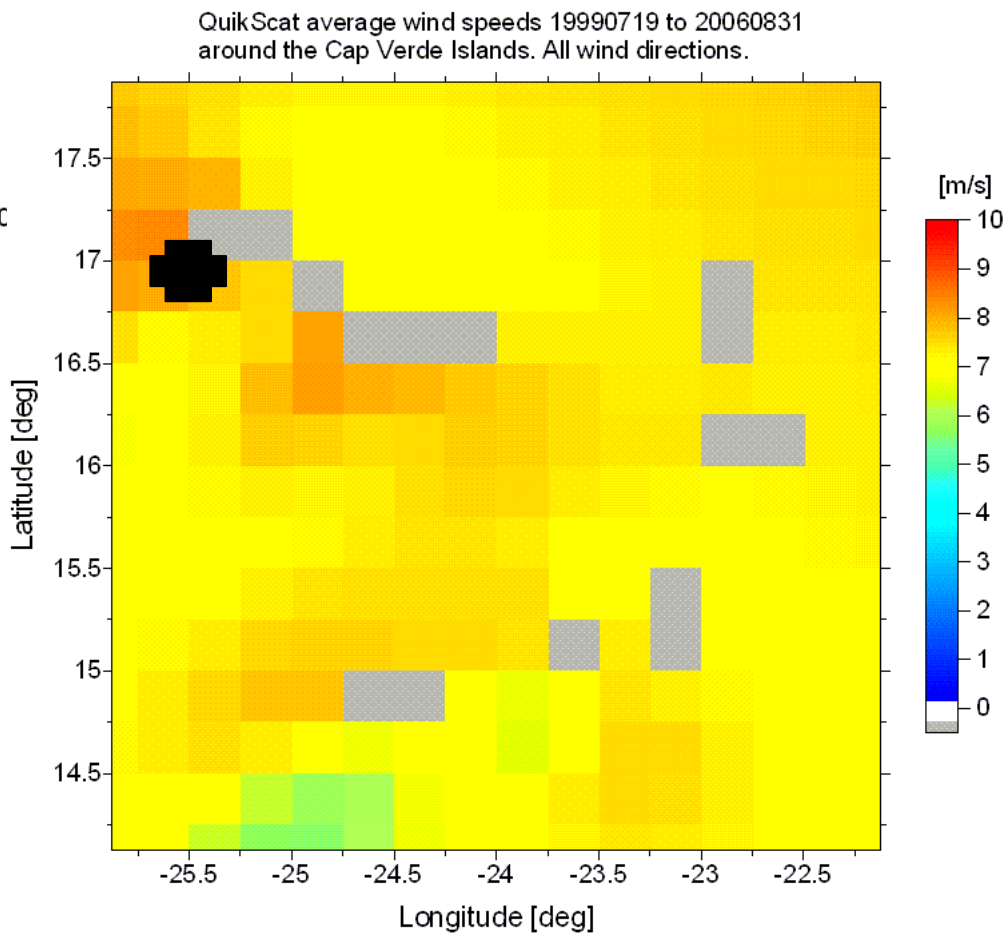




Courtesy of mast data: DONG energy A/S.

QuikSCAT wind maps twice daily for seven years





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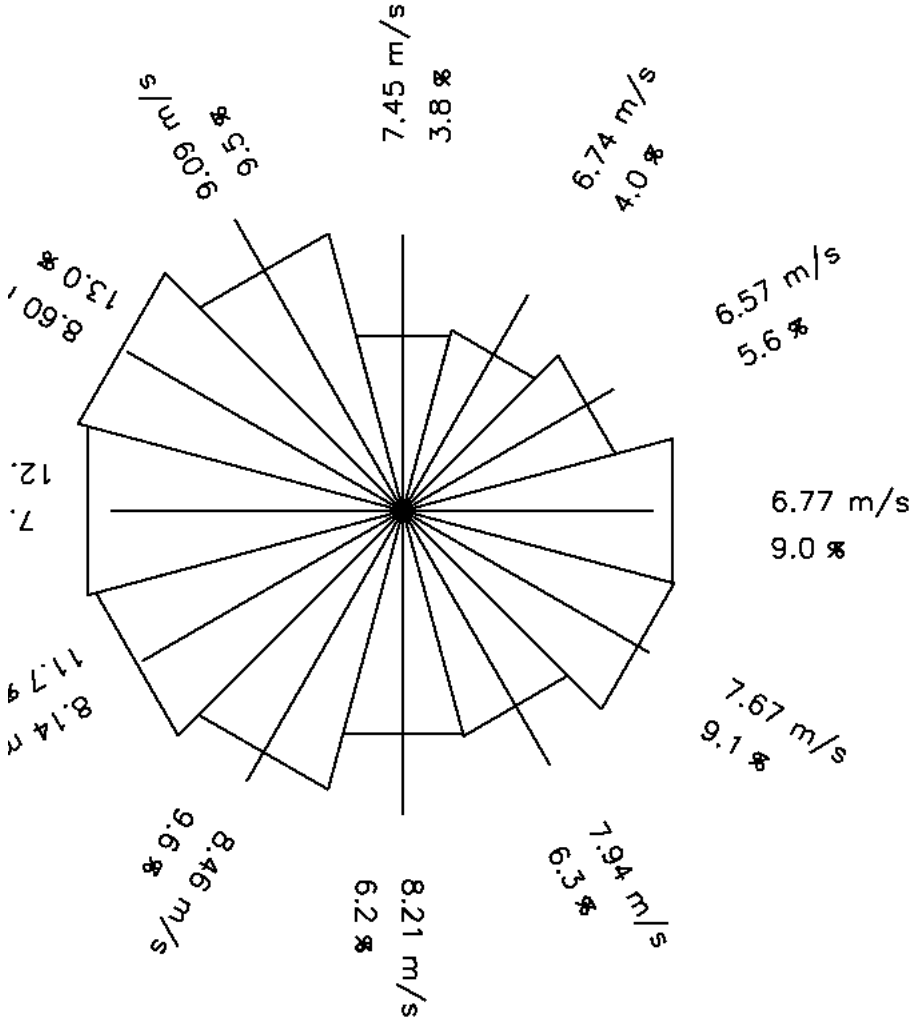
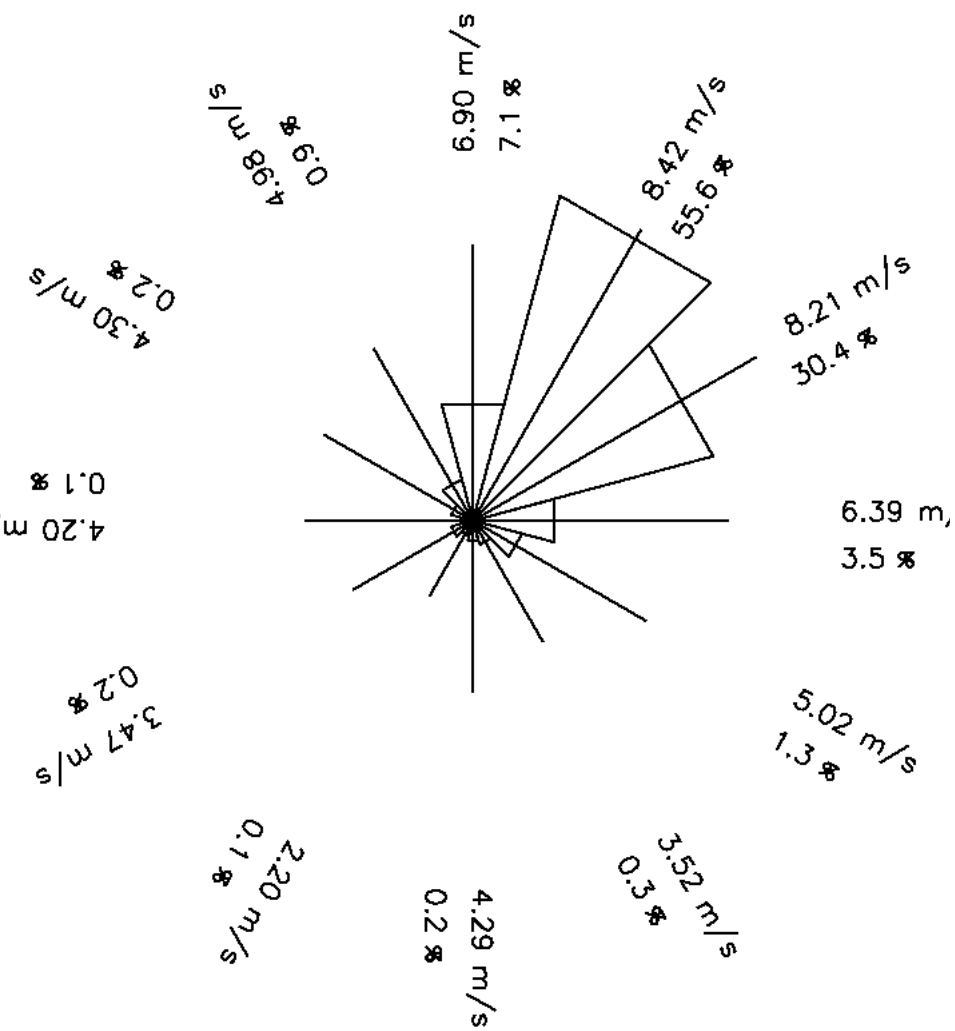
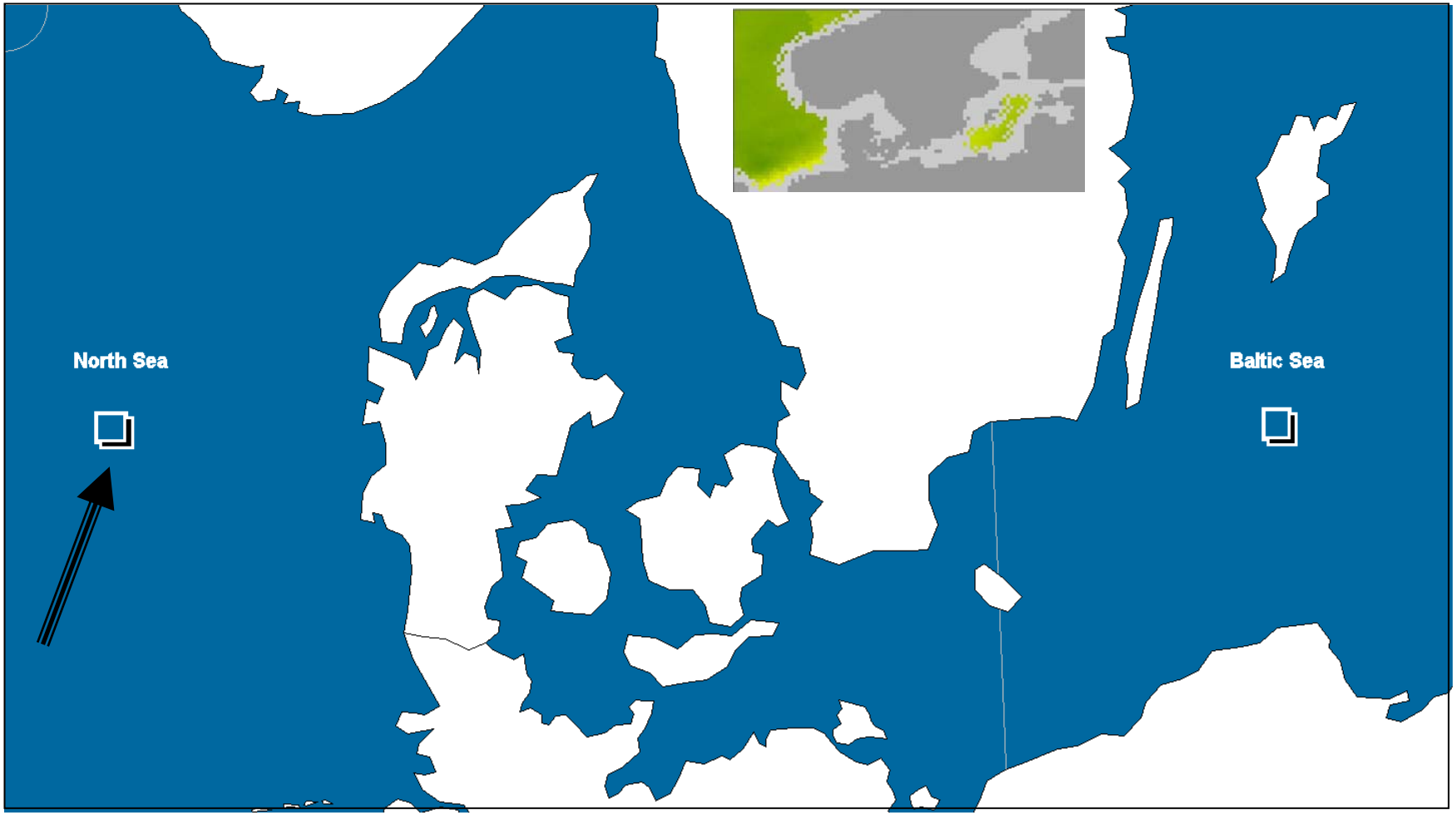
North Sea

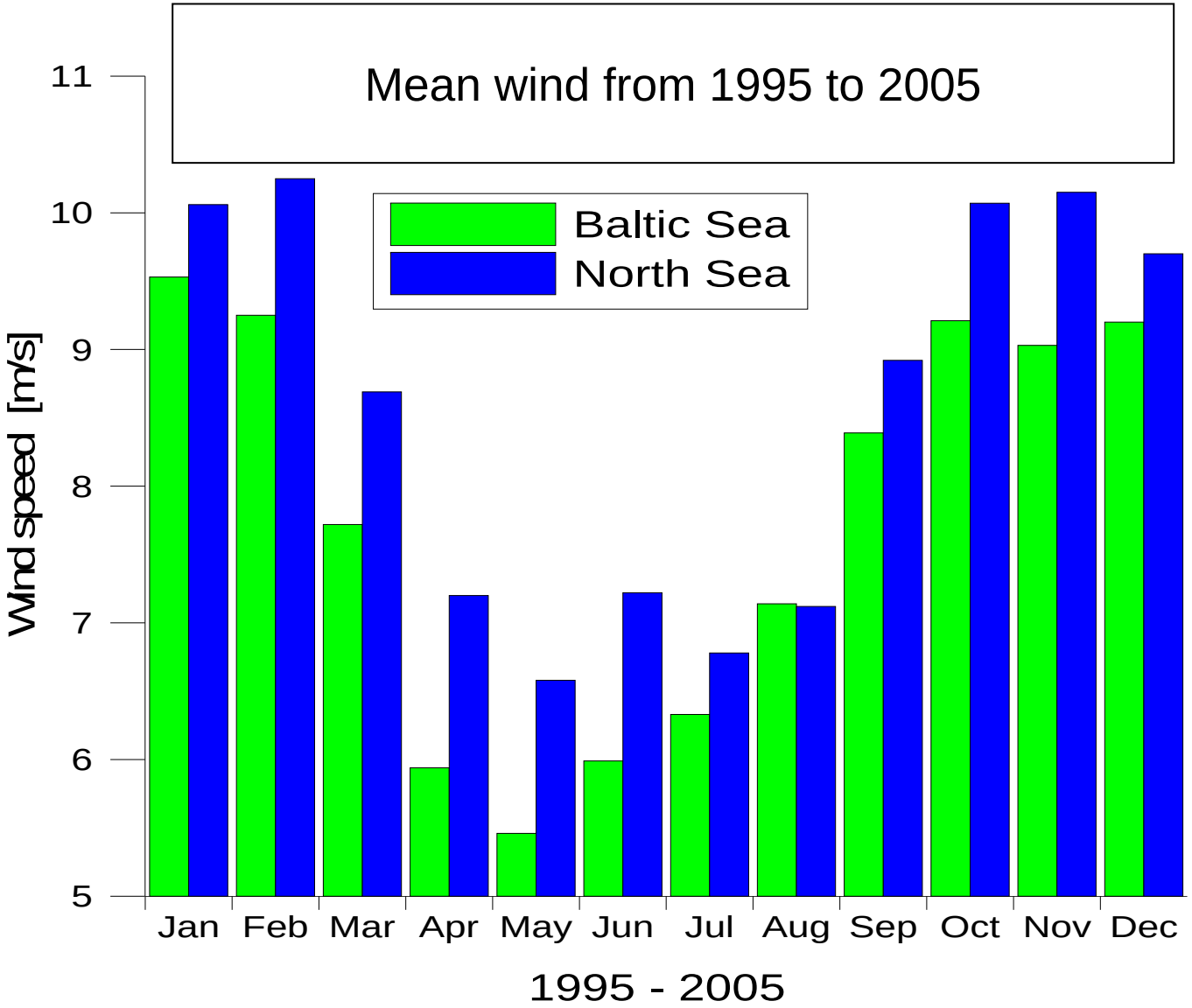


Cape Verde

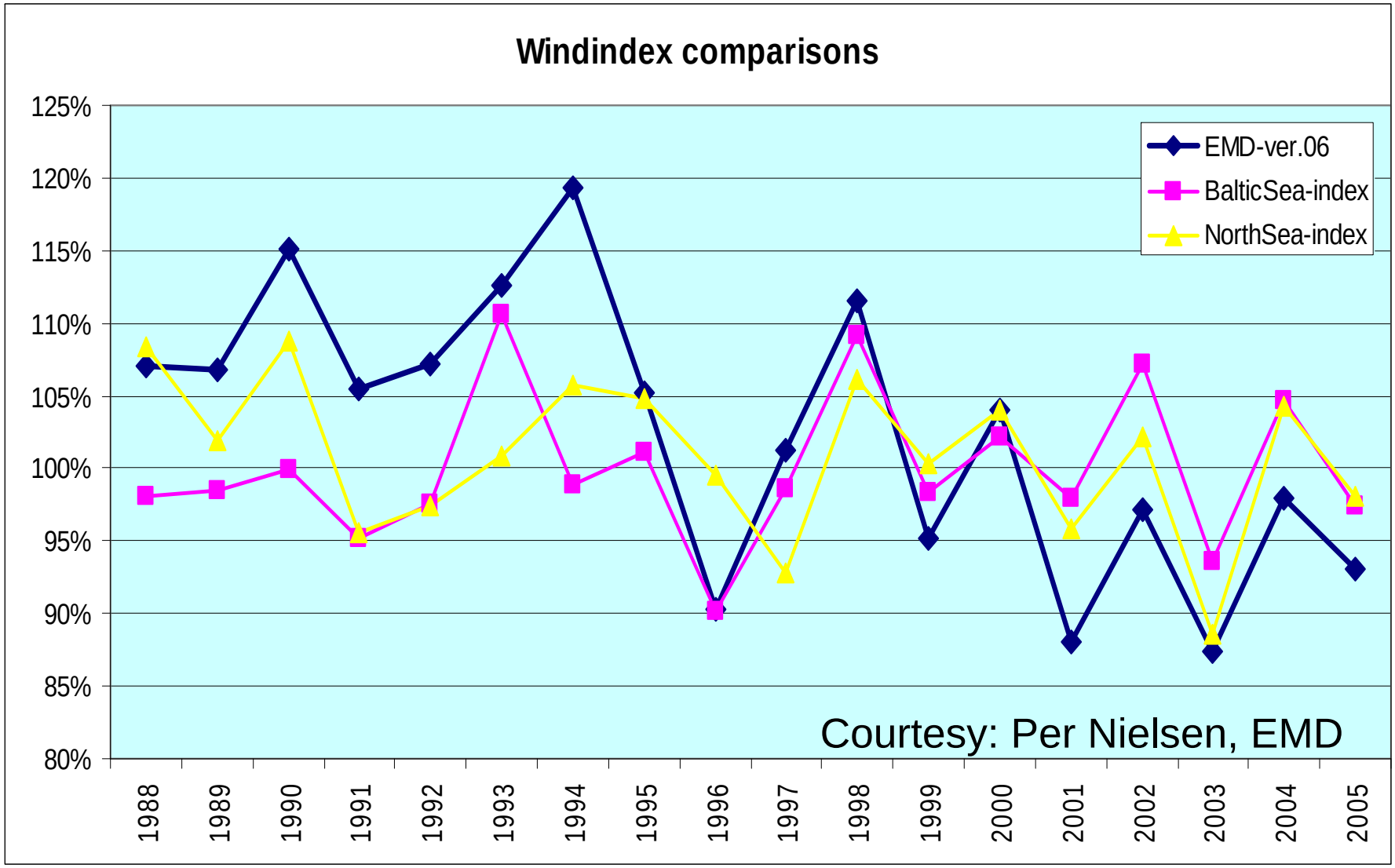


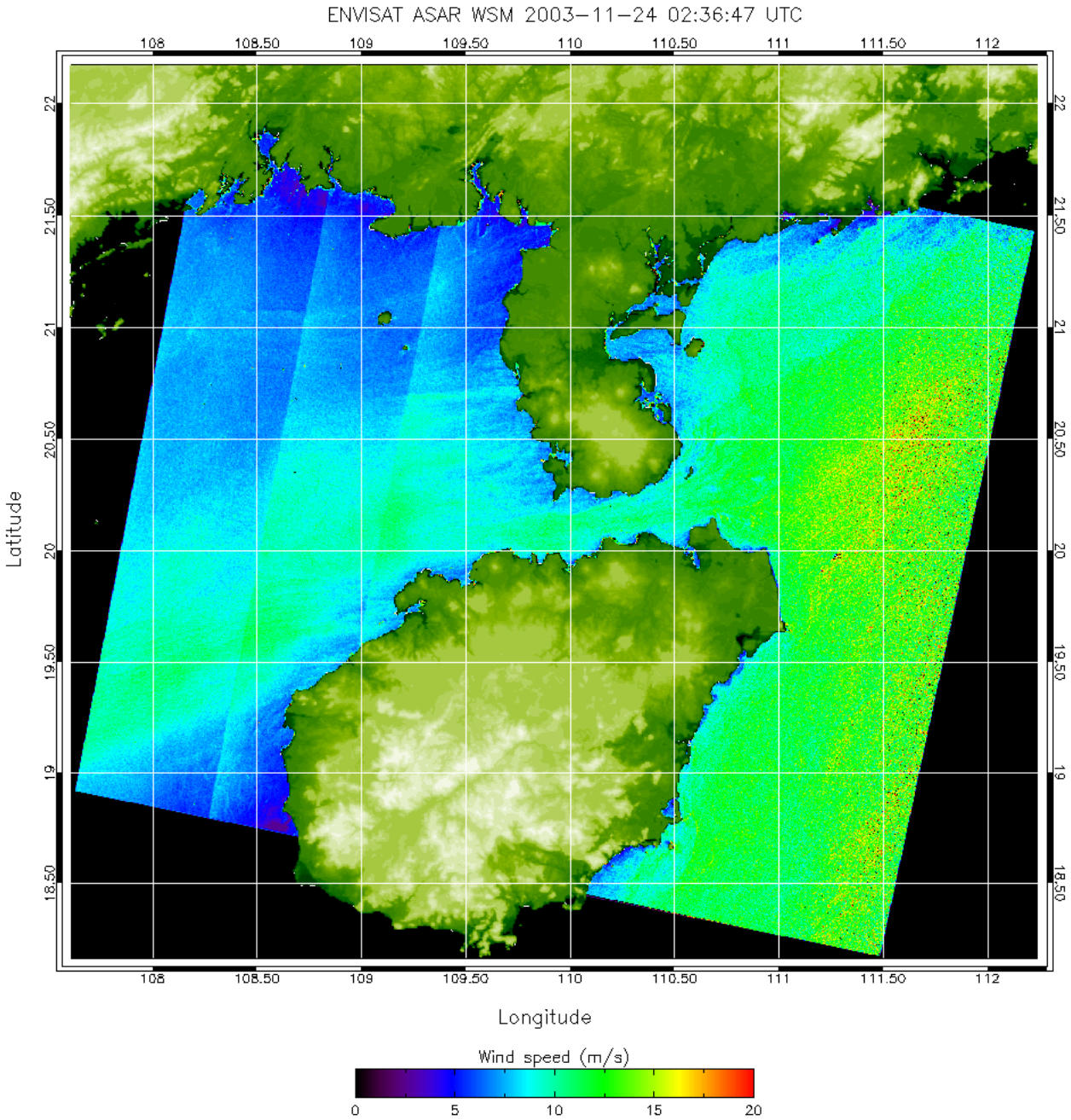
SSM/I

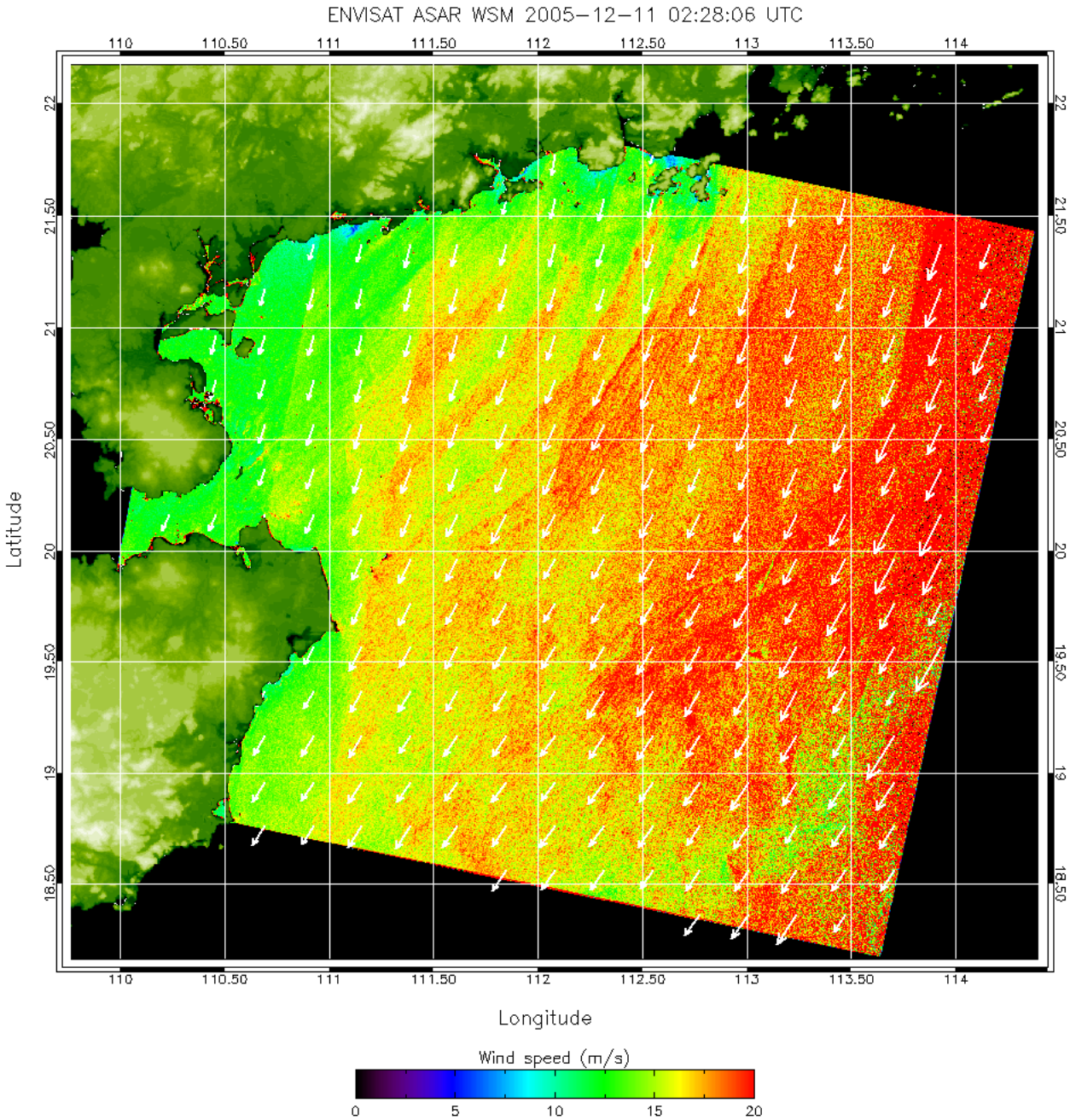



Mean wind from 1995 to 2005
Baltic Sea
North Sea
Wind speed [m/s]
11
10
9
8
7
6
5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1995 - 2005

EMD International A/S

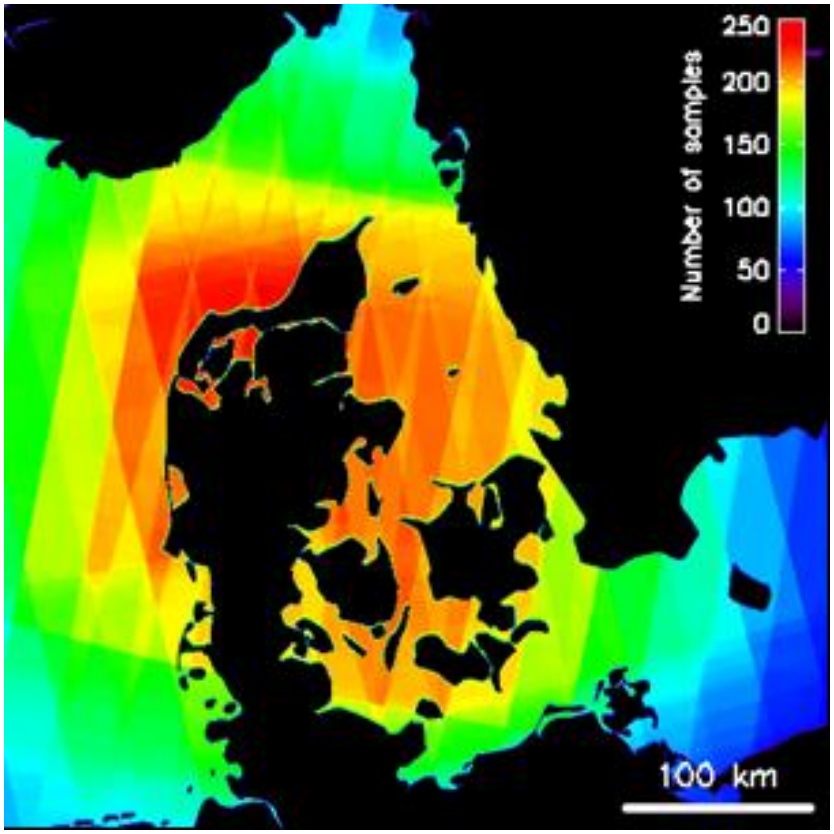



ENVISAT ASAR WSM 2003-11-24 02:36:47 UTC
108
108.50
109
109.50
110
110.50
111
111.50
112
22
21.50
21
20.50
20
19.50
19
18.50
Latitude
Longitude
Wind speed (m/s)
0
5
10
15
20

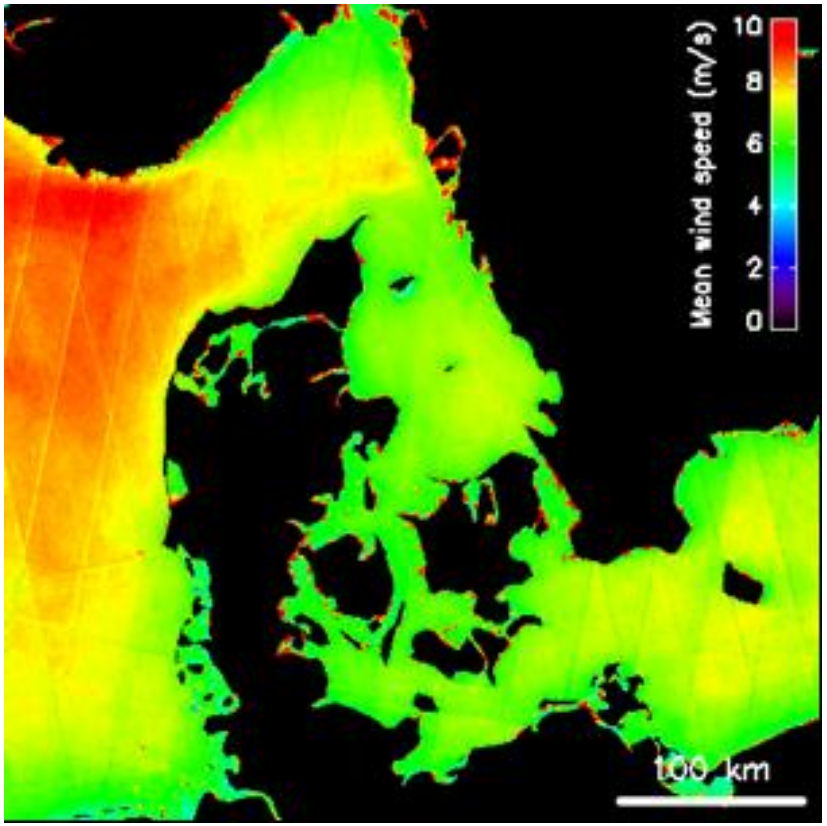

ENVISAT ASAR WSM 2005-12-11 02:28:06 UTC
110
110.50
111
111.50
112
112.50
113
113.50
114
22
21.50
21
20.50
20
19.50
19
18.50
Latitude
Longitude
Wind speed (m/s)
0
5
10
15
20

Synthetic Aperture Radar: Envisat

Number of wind maps

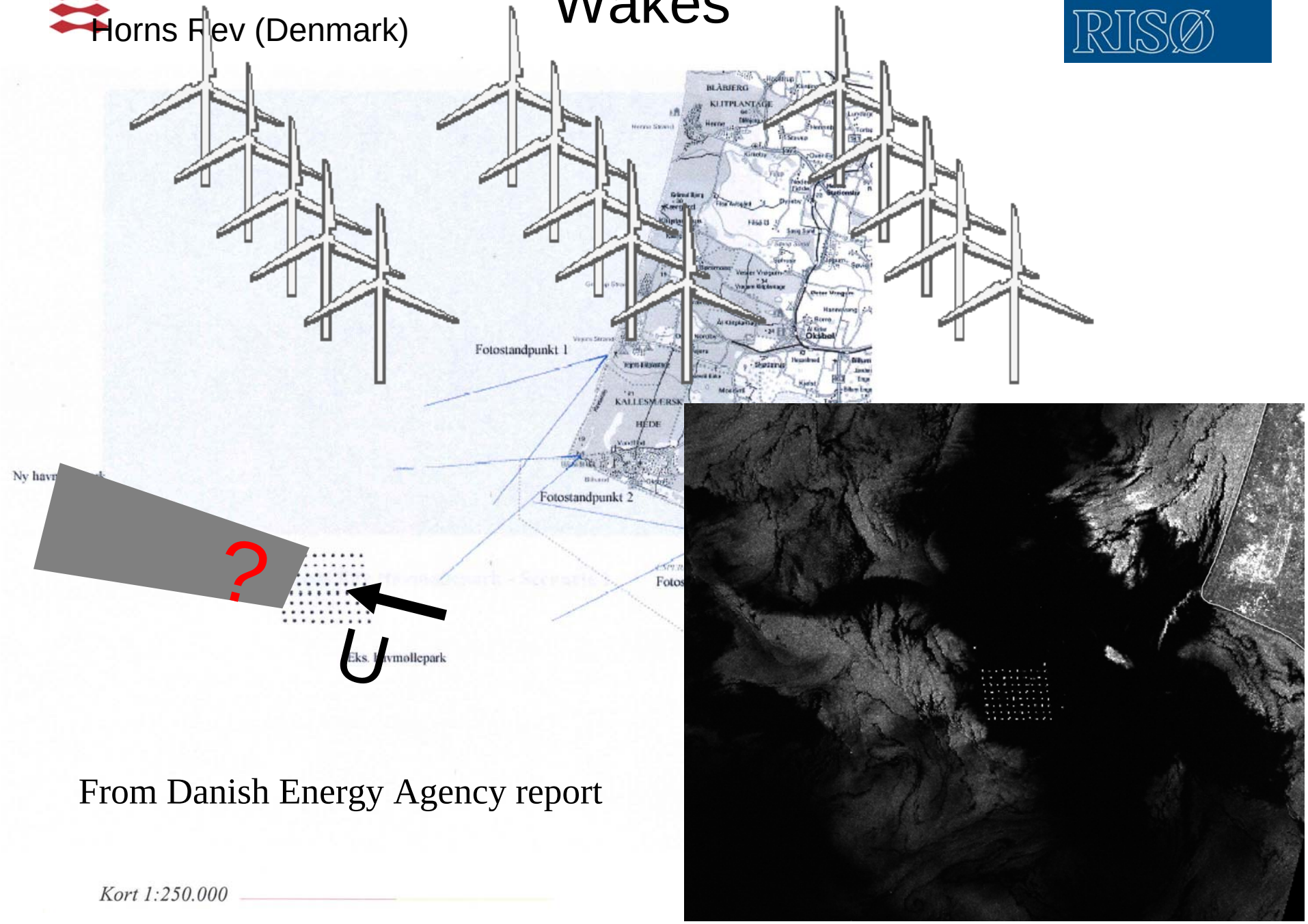


Mean wind speed Denmark offshore

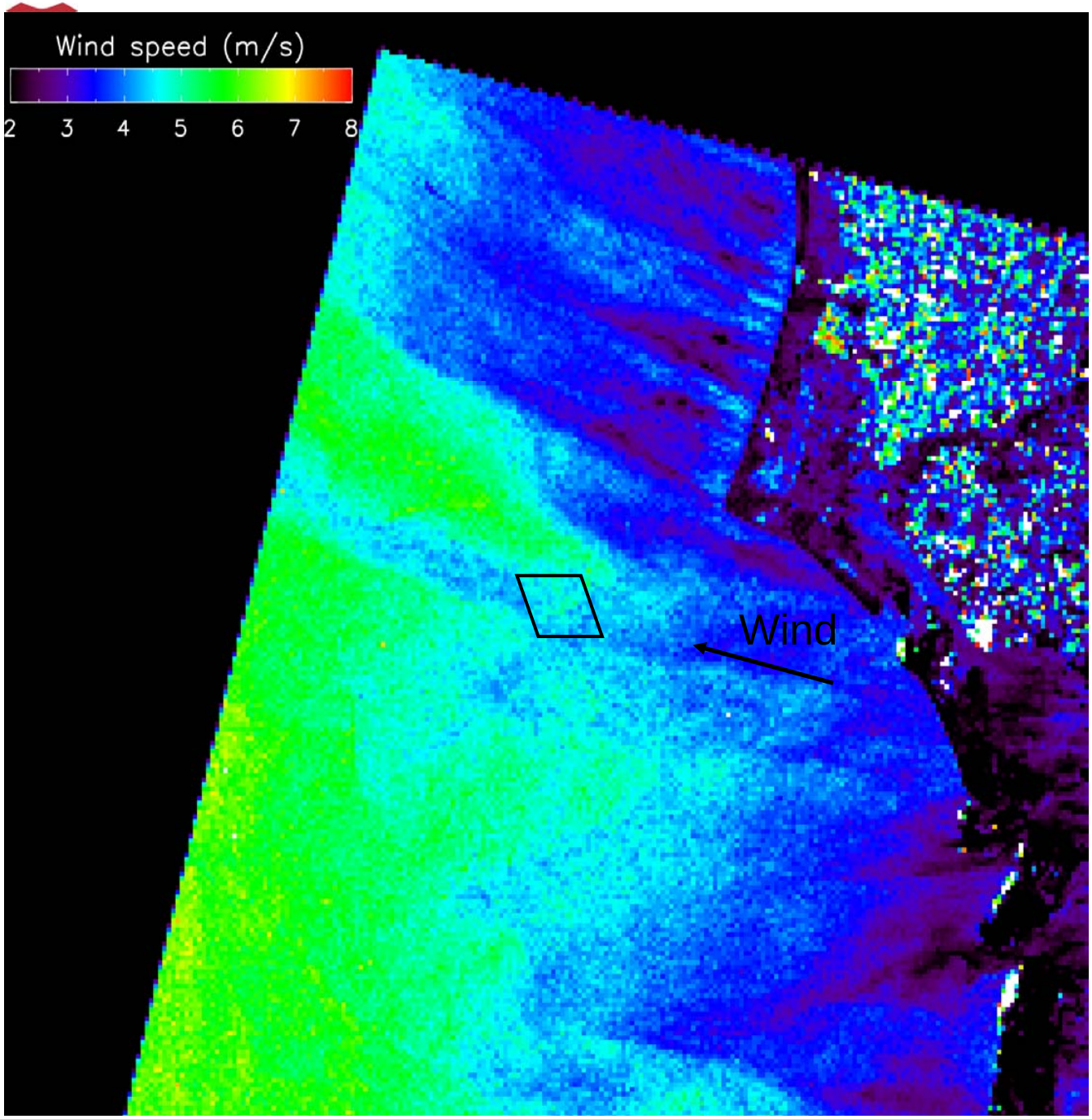


Wakes

Horns Rev (Denmark)



From Danish Energy Agency report



Horns Rev

Wind speed map from ERS

Courtesy: Merete Bruun Christiansen

Mapping offshore wind resources

Conclusions

- Meteorological mast (costly, limited height)
- LIDAR (costly, re-use, mounting on platform, profiling to high levels)
- Satellite (valid 10 m above sea level, accuracy okay for feasibility study)