ECMWF

5th workshop on waves and wave-coupled processes

10-12 April 2024

ECMWF and UK Met Office offshore blowing winds: impact of horizontal resolution and coastal orography

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European Centre for Medium-Range Weather Forecasts

UK Met Office

Japan Meteorological Agency


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San Marino
Pisa
Florence
Split
Niš
Ниш
Mostar
Makarska
Italy
Montenegro
Adriatic Sea
Pescara
Podgorica
Подгорица
Kosovo
Corse
Rome
North
Macedonia
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Taranto
Brindisi
Alghero
Sorrento
Lecce
Sardegna
Tyrrhenian Sea
Ioannina
Ιωάννινα
Sarandë
Corfu
Κέρκυρα
Greece
Cagliari

Wave forecast in the Adriatic Sea operational since 1992 using ECMWF winds – derived WAM wave heights strongly underestimated wrt measured data (altimeters, buoys, ISMAR tower) –

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Comparison with scatterometer data showed that wind speeds were strongly underestimated

Enhancement of wind speeds by fixed percentage led to quite satisfactory Hs results

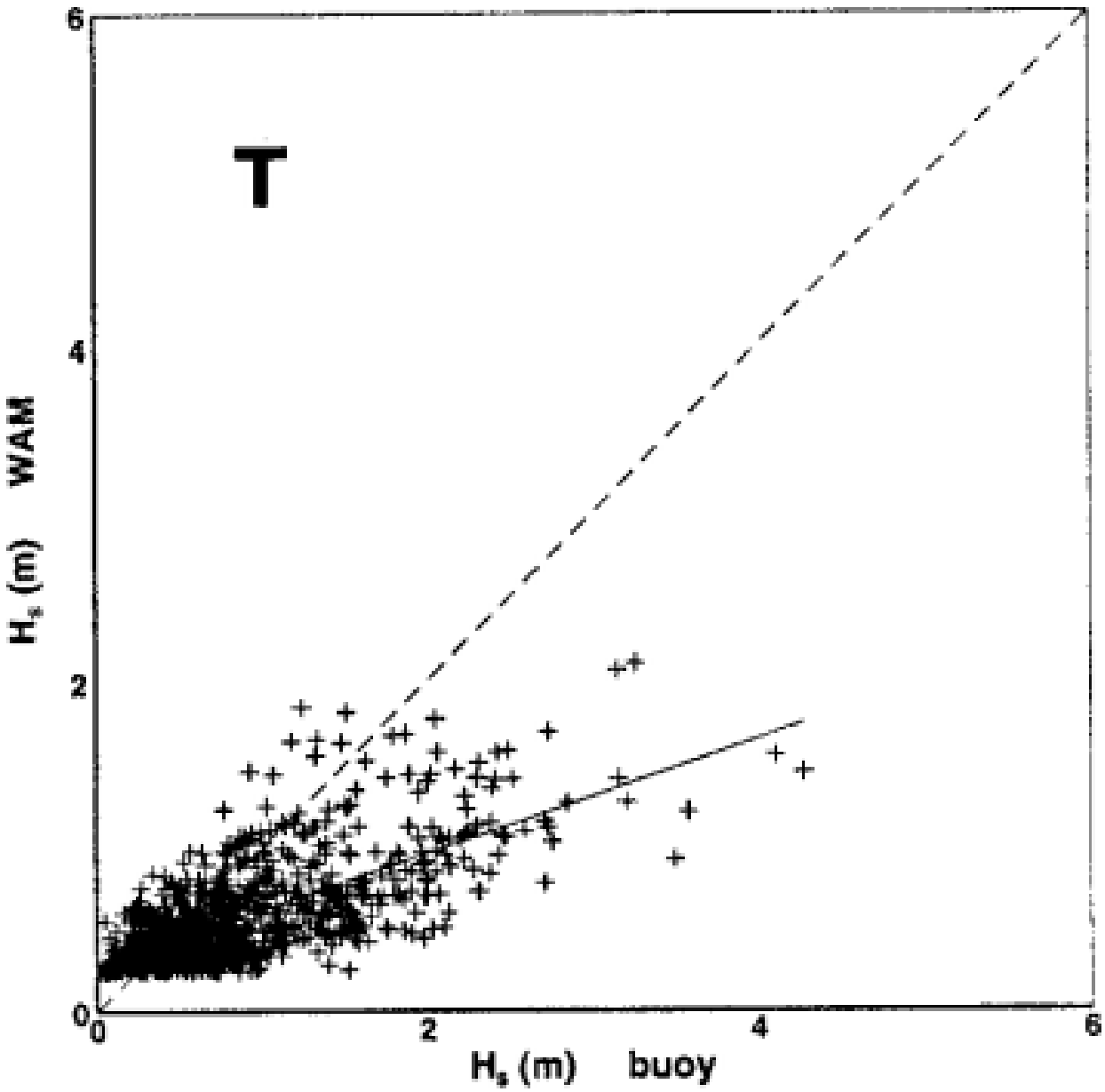
NOTES AND CORRESPONDENCE

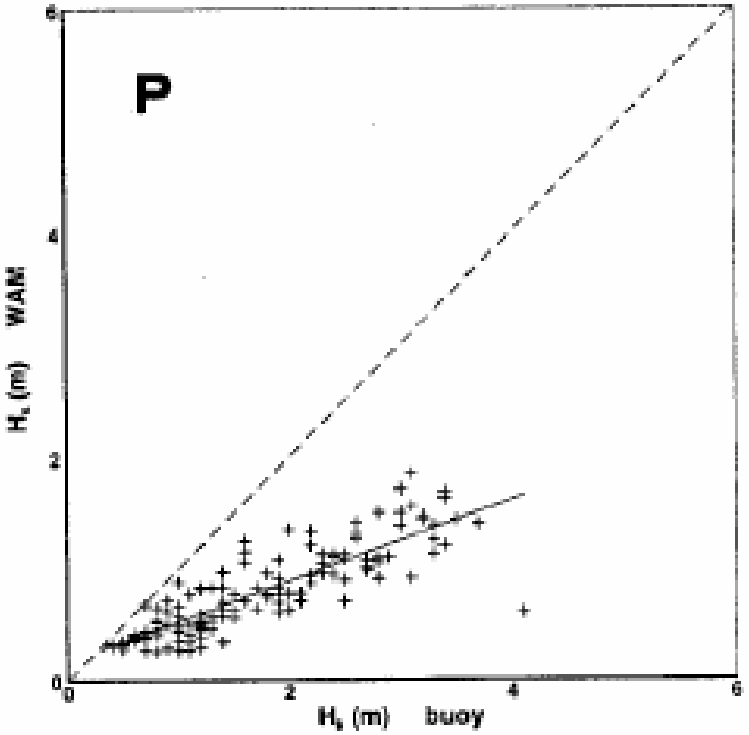
In Search of the Correct Wind and Wave Fields in a Minor Basin

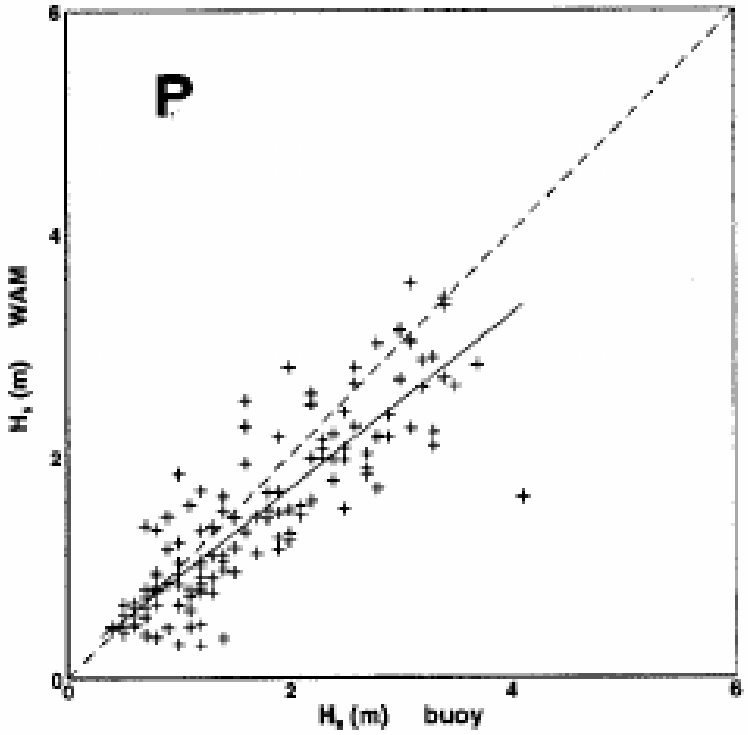
LUIGI CAVALERI AND LUCIANA BERTOTTI

Istituto Studio Dinamica Grandi Masse, Venice, Italy

26 May 1996 and 26 October 1996


T
6
4
2
0
0
2
4
6
H_s (m) WAM
H_s (m) buoy


P
H_s (m) WAM
H_s (m) buoy
0
2
4
6


P
H_s (m) WAM
H_s (m) buoy
0
2
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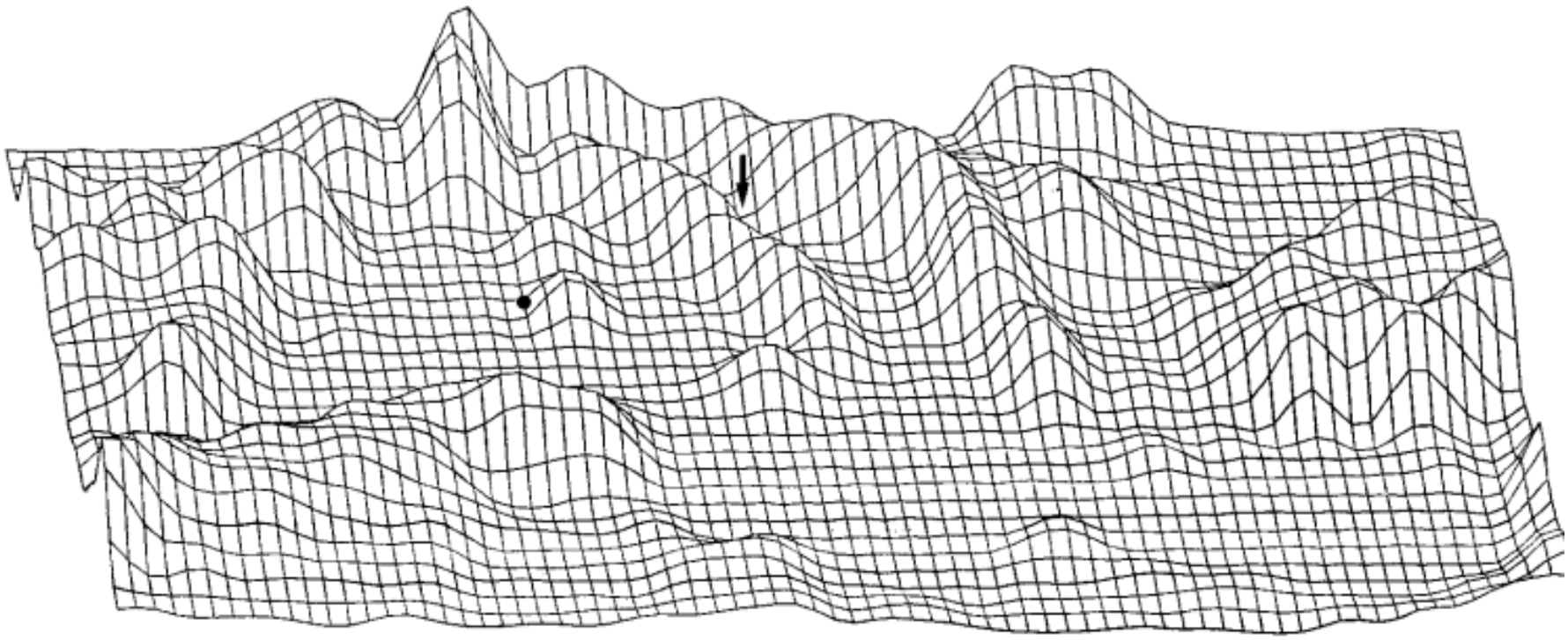

Improvements in time:

year	model	resolution Km	correction factor
1991	T213	95	1.50
2000	T511	40	1.35
2006	T799	25	1.25
2010	TL1279	16	1.20
2016	Tco1279	9	1.16

Tellus (2004), 56A, 167–175
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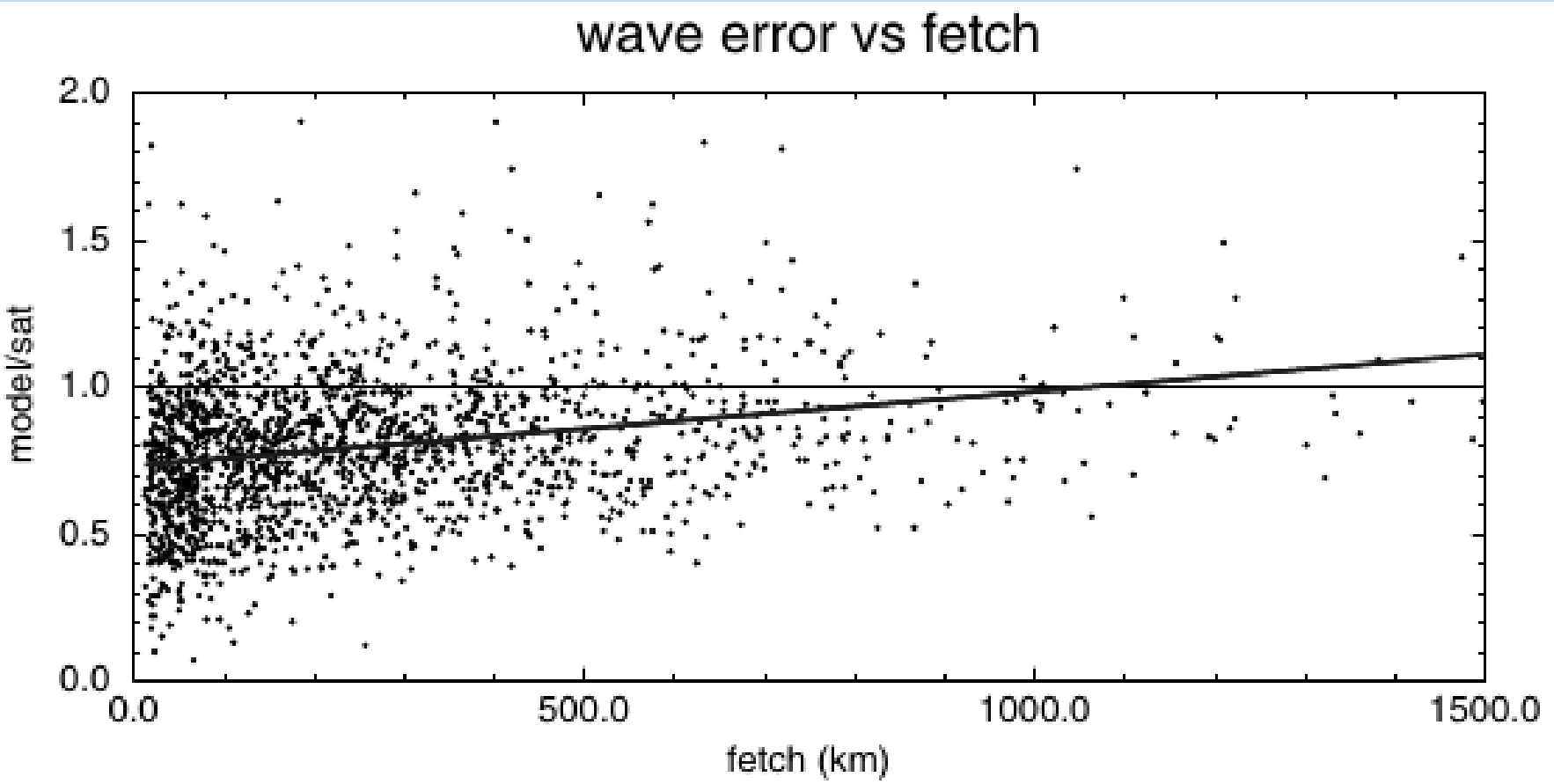
TELLUS

Accuracy of the modelled wind and wave fields in enclosed seas

By LUIGI CAVALERI* and LUCIANA BERTOTTI, *ISMAR, S. Polo 1364, 30125 Venice, Italy*

(Manuscript received 30 September 2002; in final form 10 September 2003)


wave error vs fetch
model/sat
2.0
1.5
1.0
0.5
0.0
0.0
500.0
1000.0
1500.0
fetch (km)


Dolomites
Alps
Venice
Genoa
Balkans
Ligurian Sea
Apennines
Gulf of Lion
18:00
Adriatic Sea
C
D
16:00
Corsica
Italy
B
Western Mediterranean Sea
14:00
Sardinia
Tyrrhenian Sea
12:00
10:00
A
Sicily
Tunisia

Following the “Adrian” (“Vaia” in Italy) storm (29 October 2018), we organised a three month study, exploring how good were the wind fields when blowing to offshore from the coast

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Starting from scatterometer data within 200 km from the coast, we backtrace the wind particle path till and inside the coast, relating the wind underestimate to this “fetch” and other conditions.

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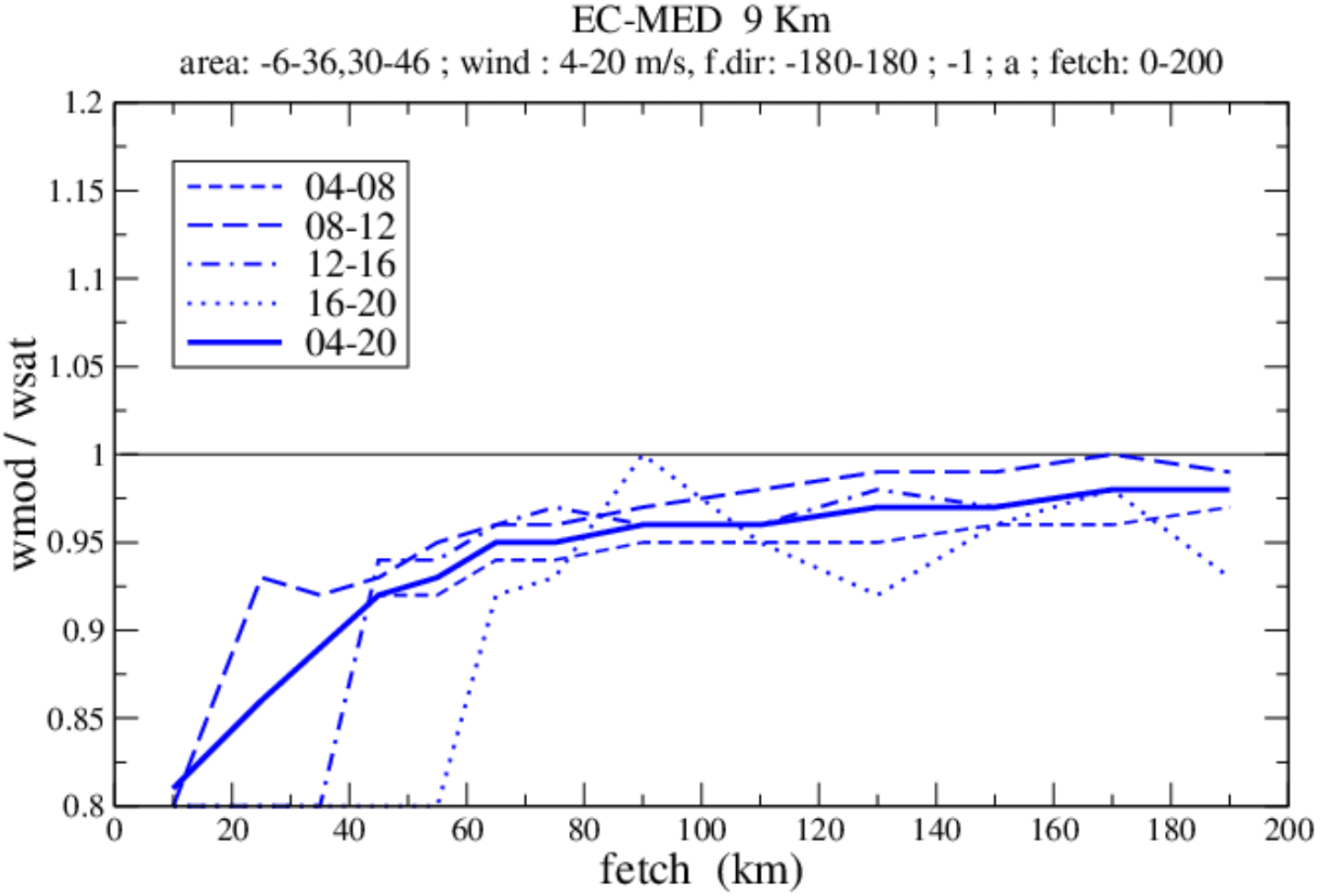
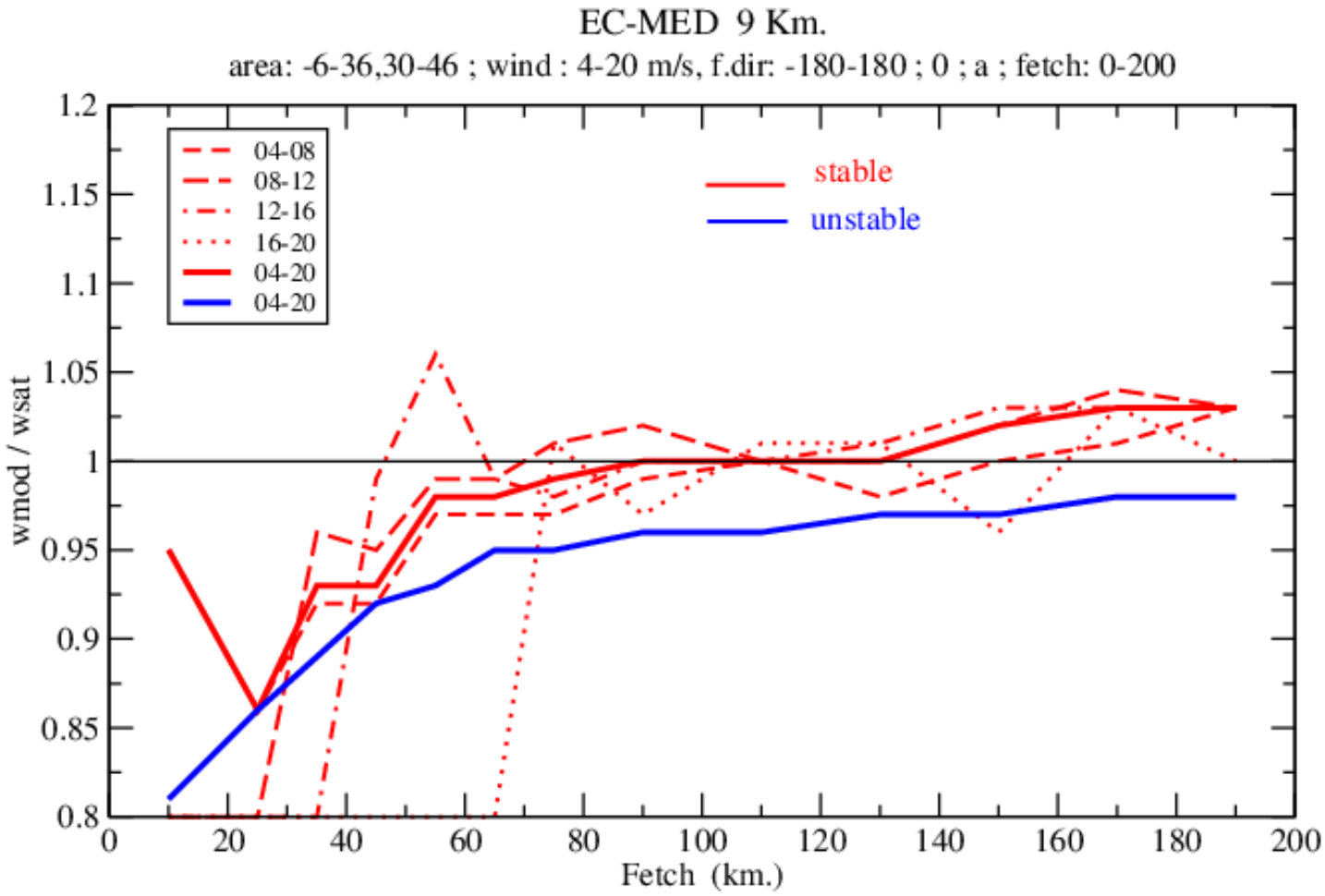
Starting from scatterometer data within 200 km from the coast, we backtrace the wind particle path till and inside the coast, relating the wind underestimate to this “fetch” and other conditions.

We have used ECMWF and UKMO winds. NCEP was contacted as well, but no reaction


EC-MED 9 Km
area: -6-36,30-46 ; wind : 4-20 m/s, f.dir: -180-180 ; -1 ; a ; fetch: 0-200
04-08
08-12
12-16
16-20
04-20
wmod / wsat
fetch (km)
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0
20
40
60
80
100
120
140
160
180
200


EC-MED 9 Km.
area: -6-36,30-46 ; wind : 4-20 m/s, f.dir: -180-180 ; 0 ; a ; fetch: 0-200
04-08
08-12
12-16
16-20
04-20
04-20
stable
unstable
wmod / wsat
Fetch (km.)
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0
20
40
60
80
100
120
140
160
180
200

Message home:

ECMWF coastal winds underestimated (up to 15-20%) close to coast, catching up after 100-200 km

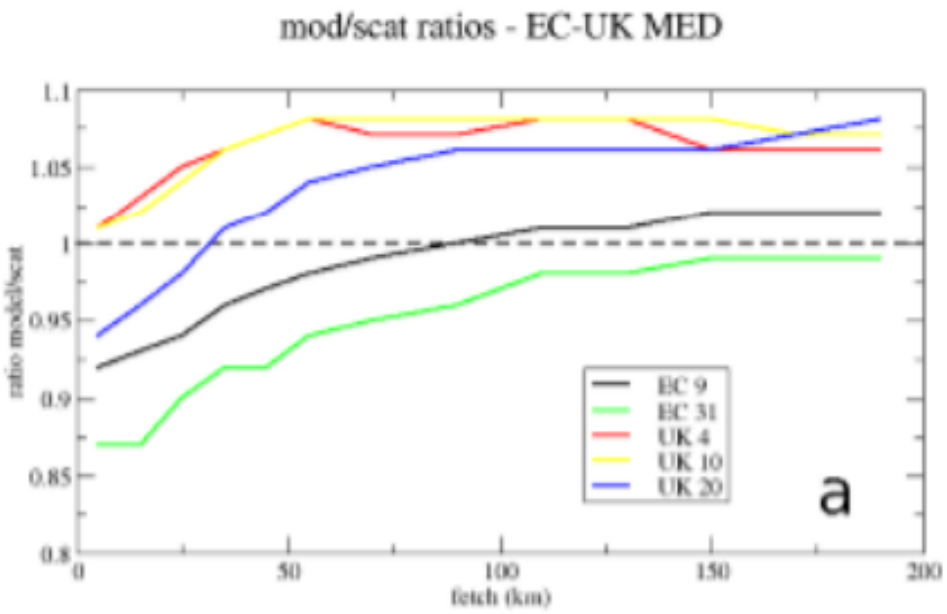
UKMO winds are higher, often higher than scatterometer data, they too increasing with distance (wrt scatterometer)

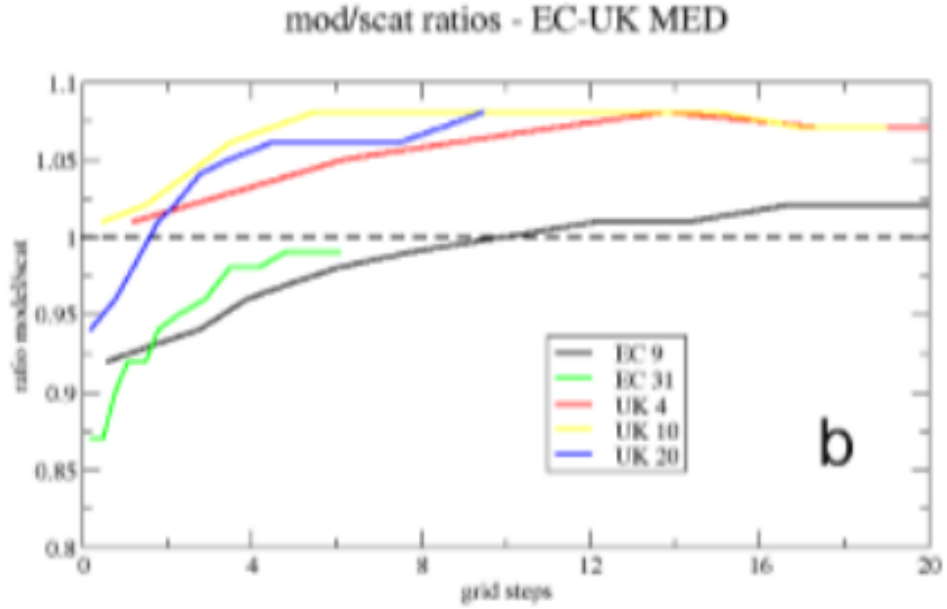
unstable conditions lead to lower wind model values (wrt scatterometer)

Next question:

Why are coastal winds underestimated?

Is it coastal roughness or a matter of resolution?


mod/scat ratios - EC-UK MED
ratio mod/scat
fetch (km)
EC 9
EC 31
UK 4
UK 10
UK 20
a


mod/scat ratios - EC-UK MED
ratio mod/scat
grid steps
EC 9
EC 31
UK 4
UK 10
UK 20
b

Next question:

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Resolution matters: what matters is
the number of grid steps

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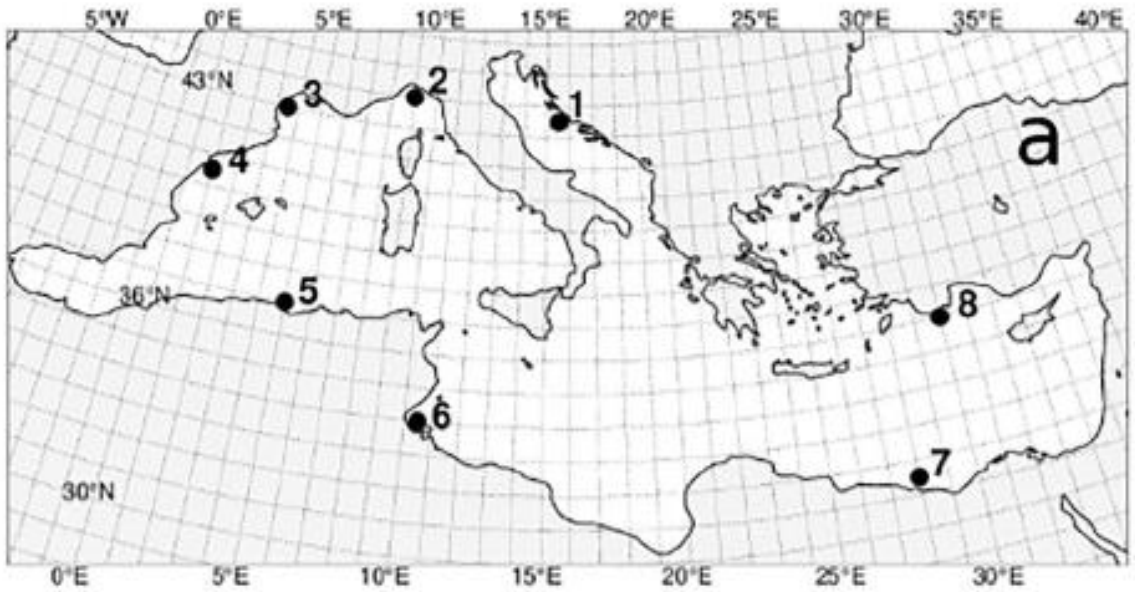
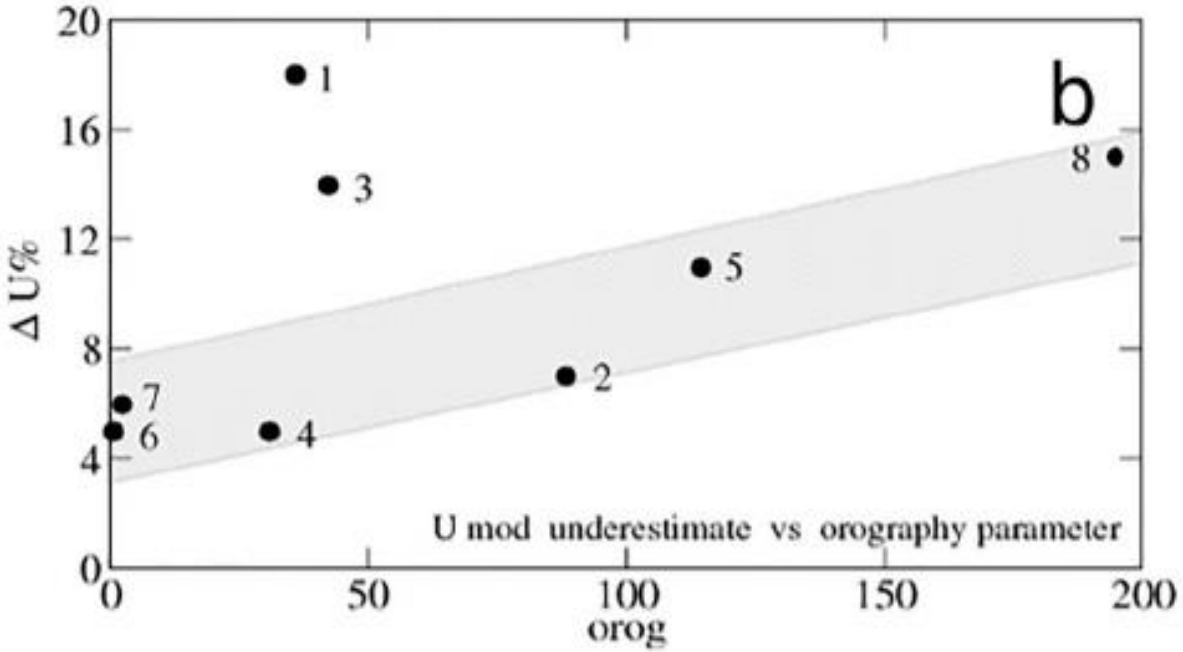
About coastal roughness: we estimated
a “rough” parameter representing the roughness
of the 200 km inland orography


5°W
0°E
5°E
10°E
15°E
20°E
25°E
30°E
35°E
40°E
43°N
36°N
30°N
1
2
3
4
5
6
7
8
a


20
16
12
8
4
0
Δ U%
0
50
100
150
200
orog
1
2
3
4
5
6
7
8
b
U mod underestimate vs orography parameter

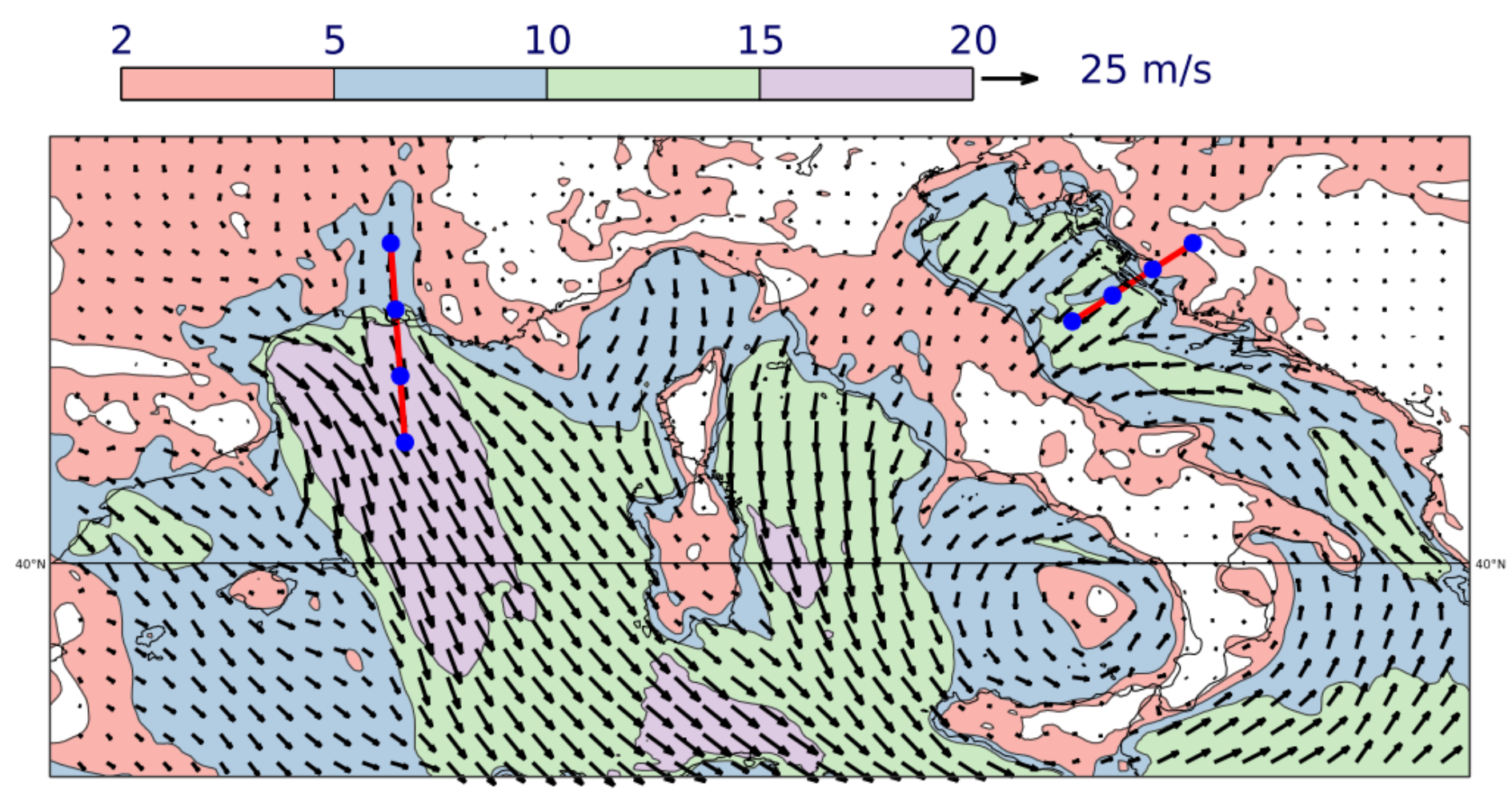
Next question:

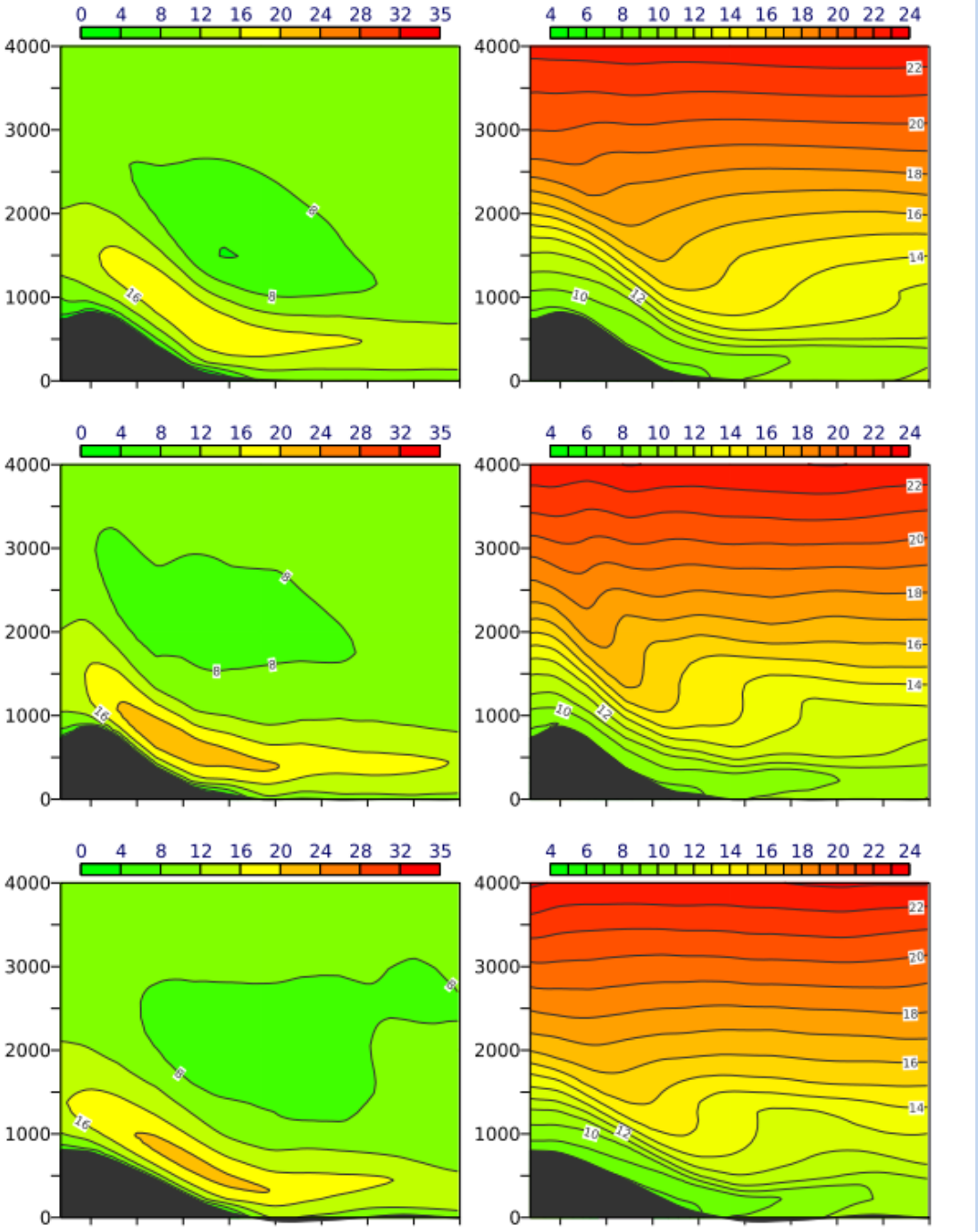
Why are coastal winds underestimated?

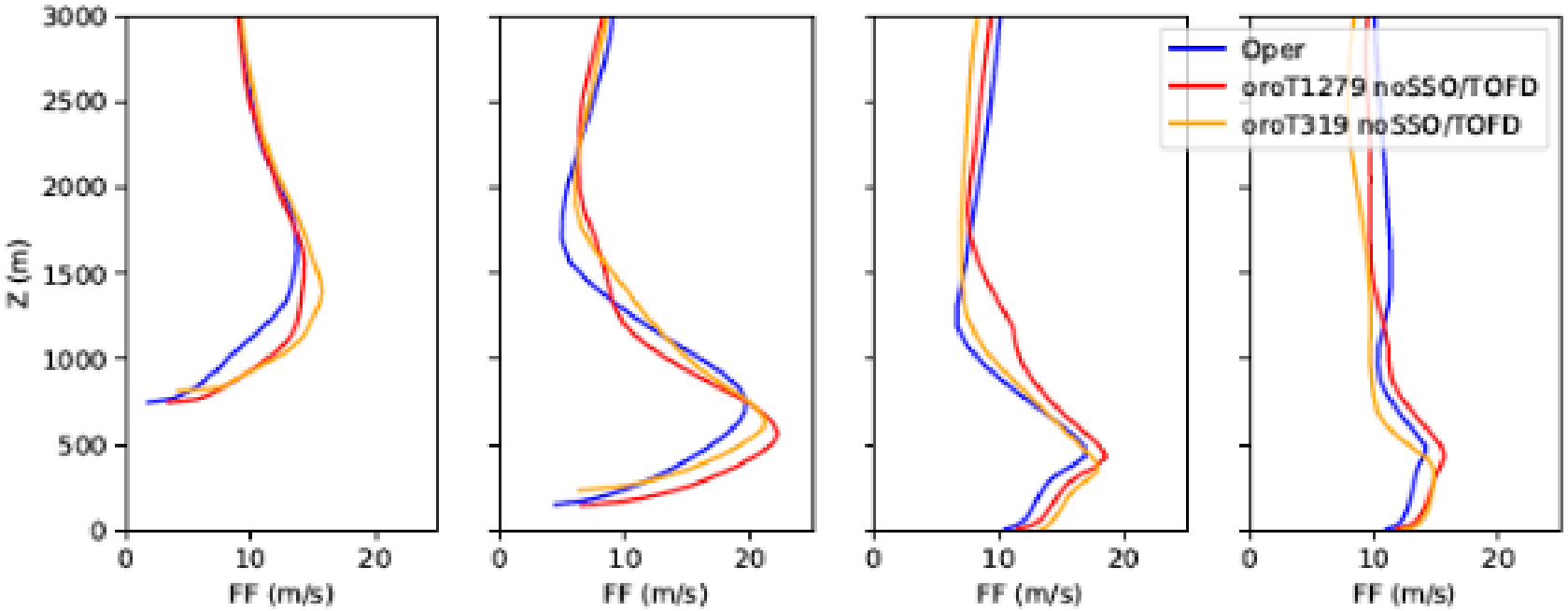
Is it coastal roughness or a matter of resolution?

Resolution matters: what matters is
the number of grid steps

Roughness matters: the rougher the orography,
the higher the underestimate


2
5
10
15
20
25 m/s
40°N
40°N


0 4 8 12 16 20 24 28 32 35
4 6 8 10 12 14 16 18 20 22 24
4000
3000
2000
1000
0
8
16
10
12
14
18
20
22


3000
2500
2000
1500
1000
500
0
Z (m)
0
10
20
FF (m/s)
Oper
oroT1279 noSSO/TOFD
oroT319 noSSO/TOFD

Take home message:

•Our verification study has shown that the 10m wind is too weak at coastal points in both the ECMWF and UKMO models

•The reason is that model dynamics cannot accurately represent a step change from one grid point to the next, e.g. from land to sea. Numerical models will smear out such a step change over a few grid points, typically 4 to 8 points. “Effective resolution” is courser than grid point spacing.

•Near surface wind is lower over land than over sea because the roughness over land is often a lot higher than over sea (order 0.1m over land versus 0.0001m over sea).

•Subgrid scale orography adds drag and slows wind even further, making the land sea transition more pronounced in areas with coastal orography.

Summary:

We developed a reasonable understanding of why ECMWF and UKMO winds are underestimated when blowing offshore

The UKMO winds are generally higher and have therefore less bias in coastal areas

Future solutions:

Increased model resolution

Physical downscaling

Statistical downscaling (AI?)