SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2024
Project Title:	**The role of orography and model resolution in the underestimate of modelled offshore blowing winds**
Computer Project Account:	SPITWM
Principal Investigator(s):	Luciana Bertotti
Affiliation:	CNR-ISMAR, Venice, Italy
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Jean Bidlot Josh Kousal Nils Wedi
Start date of the project:	01 January 2023
Expected end date:	31 December 2025

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	600000	---	600000	---
Data storage capacity	(Gbytes)	200	---	200	--

Summary of project objectives (10 lines max)

This line of research arose from some preliminary results by Luciana Bertotti and Luigi Cavaleri who had obtained undeniable evidence that in their daily wave forecast in the Adriatic Sea (East of Italy) the speed of the ECMWF wind fields had to be regularly increased to match the scatterometer measured values and consequently to get the correct modelled wave heights. This turned out to be a regular feature of all the coastal winds (when blowing to offshore) and it led to the previous Special Project where a number of interesting results emerged. For instance it was soon clear, as progressively confirmed along the successive increases of resolution of the ECMWF high resolution meteorological model. Indeed in the years the required "enhancement" factor decreased from 1.50 (with T213) to 1.35 (T511), 1.27 (T799), 1.21 (T1279), 1.16 (Tco1279).

Summary of problems encountered (10 lines max)

The activities derived from the previous project, terminated at 31 Dec 2022, have implied and imply a strong interaction between ECMWF and UKMO, with exchange of respective results that we have analysed in details. While the picture of the situation is pretty clear, with a marked underestimate of the ECMWF wind speeds blowing to offshore from the coast, the reasons are not yet clear. There is definitely a strong role of orography whose physics is not yet clear, mainly because touching this subject we are moving into the basic meteorological/orographic problem of the quantification of the surface orography drag as a compromise between the correct local surface wind speed values and the optimisation of the forecast quality.

Summary of plans for the continuation of the project (10 lines max)

We plan to dig more deeply in the obtained results to find out a) the physical reasons for the coastal underestimate, 2) how and how much this depends on the characteristics of the coastal orography, c) how much, for a given orography, this depends on the physics of the meteorological model, in particular on the orographic drag.

List of publications/reports from the project with complete references

2024, L.Cavaleri, G.Balsamo, A.Beljaars, L.Bertotti, S.Davison, J.Edward, T.Kanehama, and N.Wedi, "ECMWF and UK Met Office offshore blowing winds: impact of horizontal resolution and coastal orography", *J.Geoph.Res., Atm.*, 129, e2023D039673, https://doi.org/10.1029/2023JD039673

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

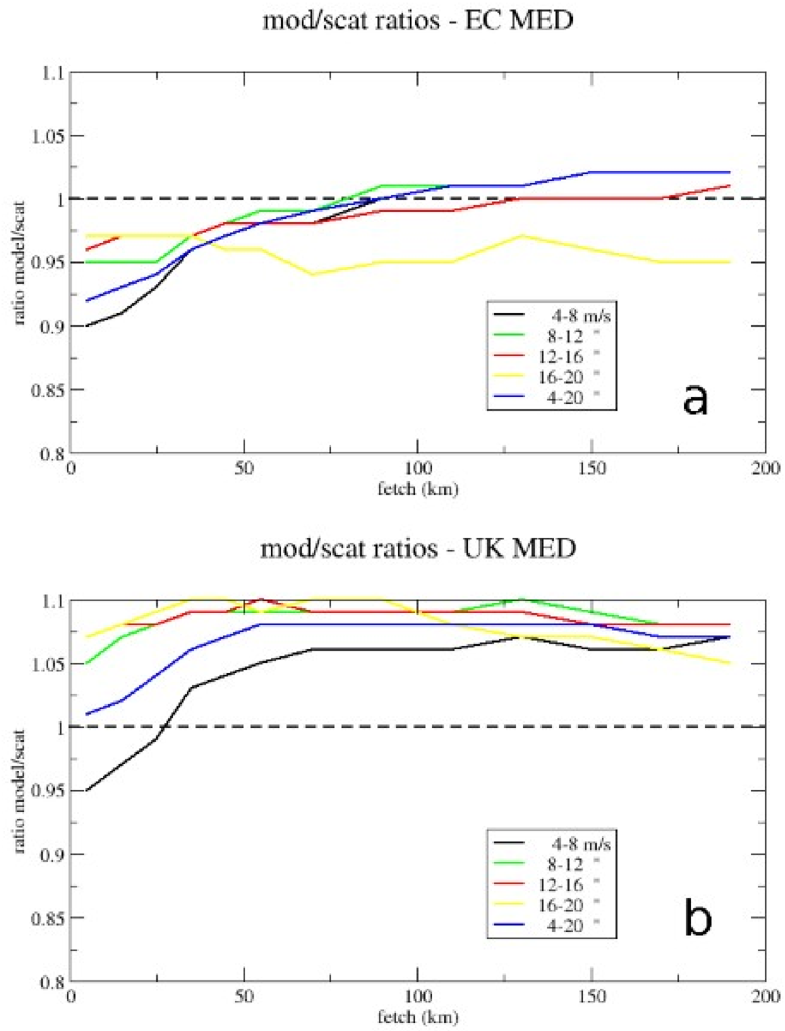

Figure 1 – Ratios between model results for offshore blowing coast winds and corresponding scatterometer data. Note the underestimate of the ECMWF results (panel a) versus (panel b) the overestimate of the UKMO corresponding results. The results are shown for different ranges of wind speeds.

In the previous report we had focused our attention on the resolution of the model, hence on the time required by the, blowing from land, sea entering wind fields to reach more or less approximate wind speed values consistent with the scatterometer measured ones. Figure 1 summarizes the general situation for both the ECMWF and UKMO global models, specified for wind speed range. The general situation is that there is an extended zone of underestimated wind speeds by the ECMWF model, while the opposite is true for the UKMO global one.

A further basic result was that the required distance from land to reach more or less correct wind speed values decreases with improving resolution. More specifically, we found that for each location a given number of computer steps is required to reach the same wind quality. See the first and second panels of Figure 2. On top of this result, we explored also the effect of time. The question to reply to was if, apart from space, also the wind speed itself is a factor affecting the model results. The third panel of Figure 2 shows this is indeed the case, at least in the first 50 km or so. Note that the lower panel reports the results for also the UKMO model results, with quite different results with respect to ECMWF, i.e. an overestimate of offshore blowing surface winds.

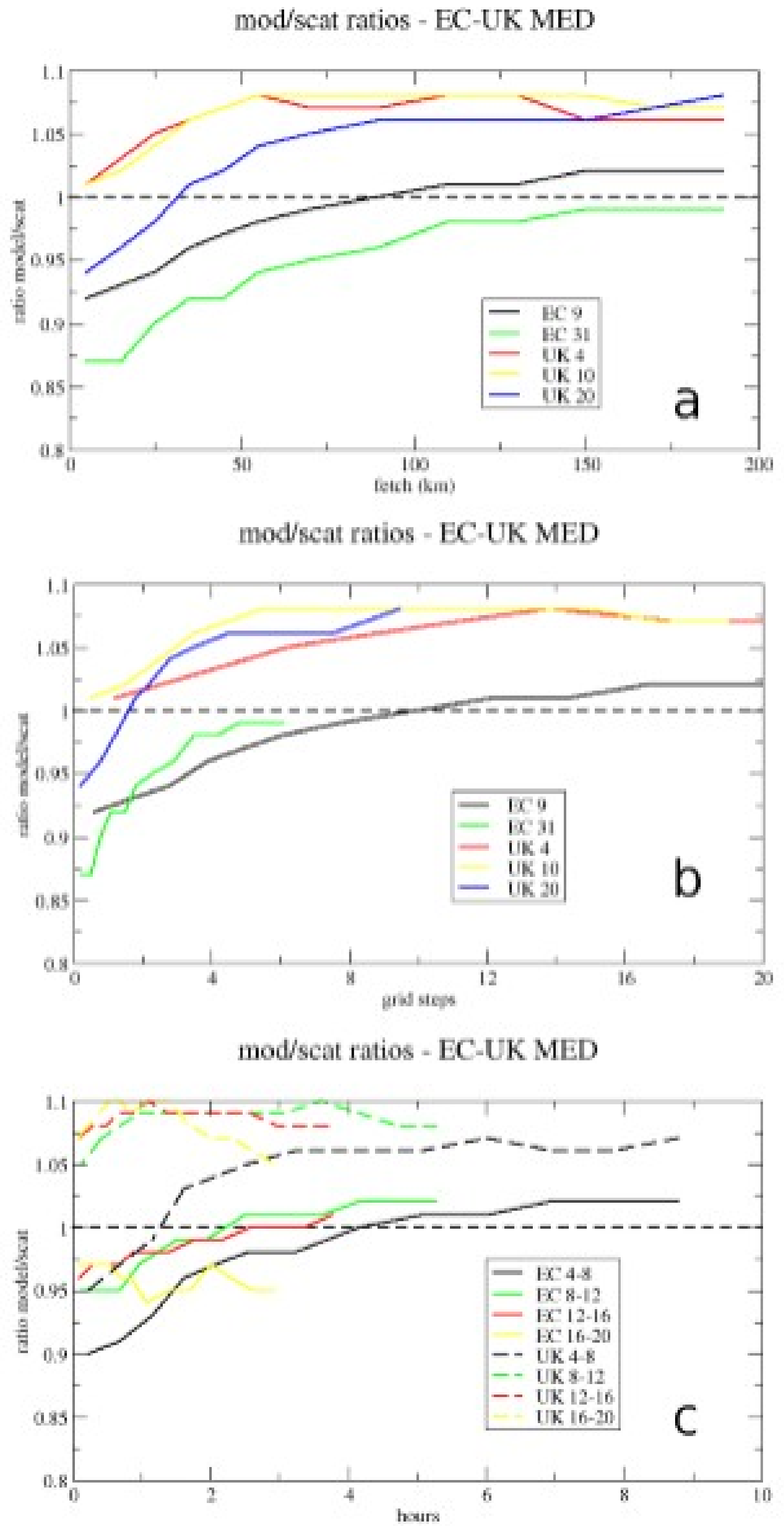

Figure 2 – Panels a and b show the already reported results, i.e. a) the underestimate with fetch of the ECMWF model surface wind speeds when entering sea from land according to model resolution; b) how the spatial extent of the underestimate is a function of the number of model grid steps. On the contrary, now in c) we explore if the spatial extent of the underestimate is a function of also the wind speed. Both ECMWF and UKMO model results are reported.

Focusing our attention on the characteristics of the coastal orography, granted the much distributed mountains along the Mediterranean coasts, we have selected a few locations characterized by more or less pronounced orographic features or, at the other extreme, by a very flat country. Figure 3 reports the attenuation curves similar to the previous figures, but for the indicated three different coastal locations. It is immediately evident how the wind speeds emerging into the sea from the highly mountainous Gulf of Lion and Algeria coasts are much lower than the ones emerging from the flat Sahara desert.

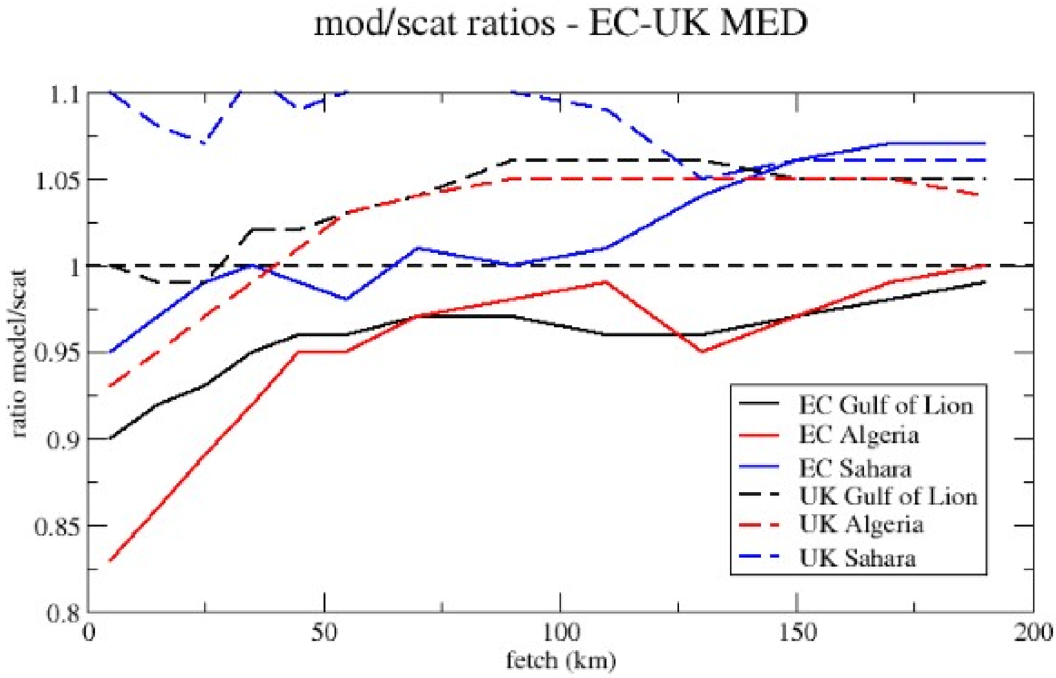

Figure 3 – Ratios between model and scatterometer wind speeds for to offshore blowing winds in the two mountainous coastal locations of Gulf of Lion and Algeria versus the flat one of the Sahara coastline. Results are shown for both the ECMWF and UKMO global models.

This is further generalized for the ECMWF model in Figure 4 where we focus our attention on eight different coastal locations of the Mediterranean Sea (panel a). Panel c shows the corresponding 200 km inland orographic profiles (perpendicularly to the coast), making evident the mountainous areas and the flat ones. In panel b we plot the average wind speed underestimate just off the coast versus the so-called orographic parameter orog representing, in a single number, the orographic characteristics of the coast, taking into account the height of the local mountains, the steepness of the slope descending towards the coast, and also how rough, i.e. with slope discontinuity, is this slope. Apart from points 1 and 3 (respectively Croatian coast and Gulf of Lion), there is an obvious relationship between the characteristics of the coast, i.e. the orog parameter, and the underestimate of the offshore blowing winds. Of course points 1 and 3 deserve an explanation. Indeed this is useful to understand better the problem of the correctness of the coastal offshore blowing winds. Points 1 and 3 are characterized by strong winds, respectively (1) the bora and (3) the mistral. These are both valley winds, in that a strong cold flow is channelled in a narrow valley exiting into the sea as a strong concentrated jet. Being elongated valleys, there is no strong orographic feature along the valleys themselves, hence the limited orog parameters. However, what the model cannot resolve is the transversal dimension of the valleys. In the model these turn out overestimated with a consequently, with a correct overall air flow volume, a reduced average wind speed, from which the large ΔU.

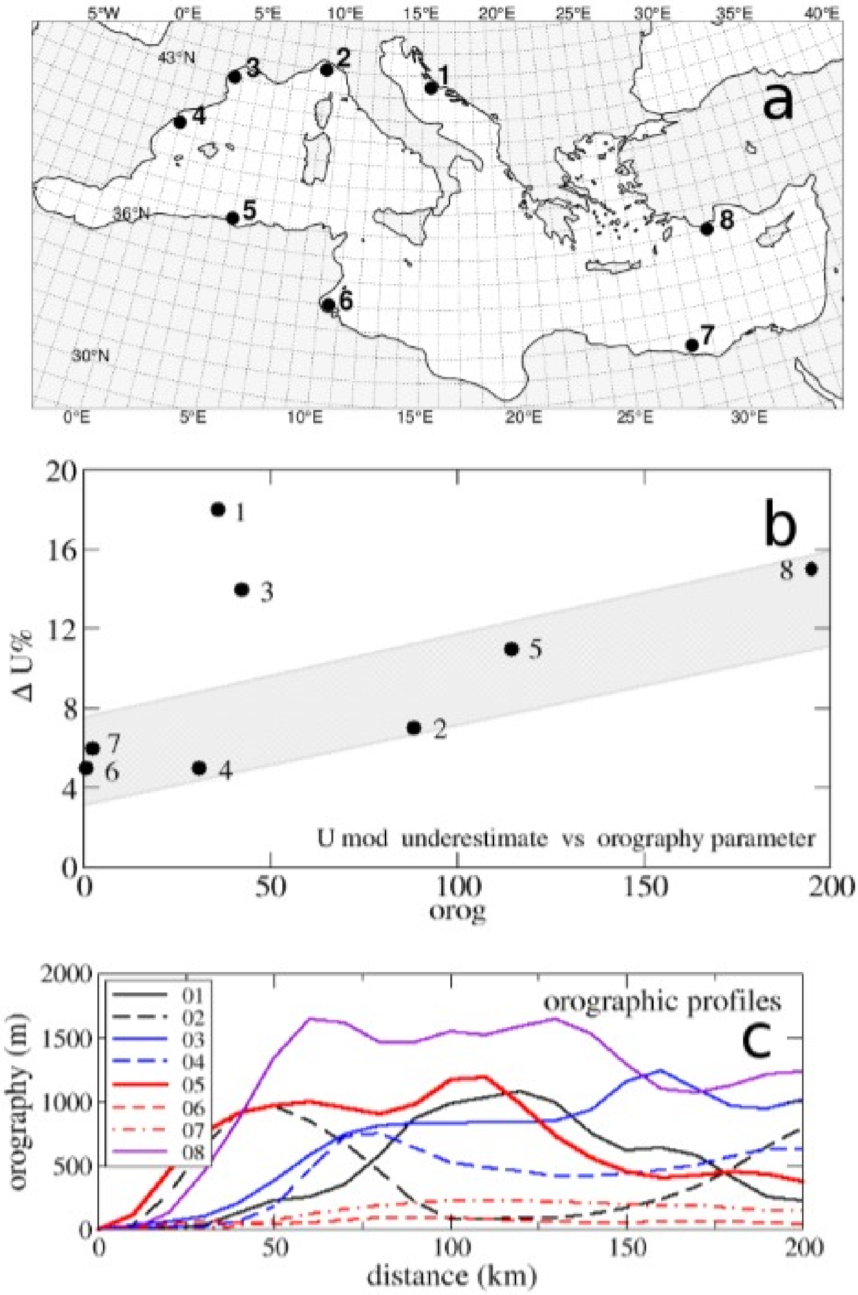

Figure 4 – Having chosen eight Mediterranean coastal locations with different orographic features (see panels a and c), in panel b we plot the corresponding typical model underestimate of the offshore blowing winds. Typically the rougher the orography, the higher the underestimate. See text for the explanation for points 1 and 3.