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	2023
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 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	---
Data storage capacity	(Gbytes)	---	---	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

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

2023 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" – to be submitted

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.

The situation is well summarised by the two following figures. Figure 1 shows clearly how the underestimate of the ECMWF offshore blowing coastal winds strongly depends on the orographic level of the mountains at the coast. The rougher the orography, the stronger the model underestimate. Figure 1, that we reported also in the final report of the 2020-2022 Special Project, provides good

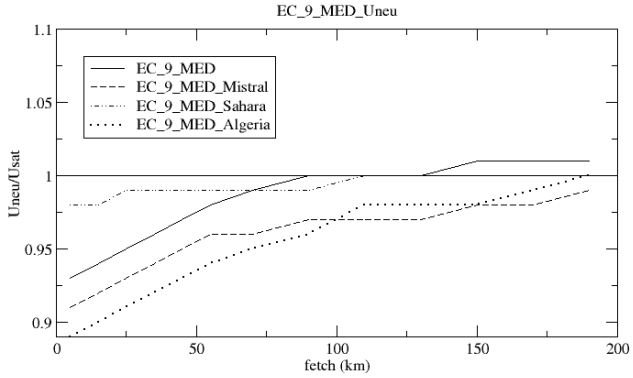

Figure 1 - Ratio between model neutral and scatterometer wind speed values as a function of fetch (km) and of the wind speed at the measurement point. Note the differences between the overall results (EC_9_MED) and the ones for areas characterized by high mountains (Mistral, Algeria) and flat terrain (Sahara) on the back coastal zone.

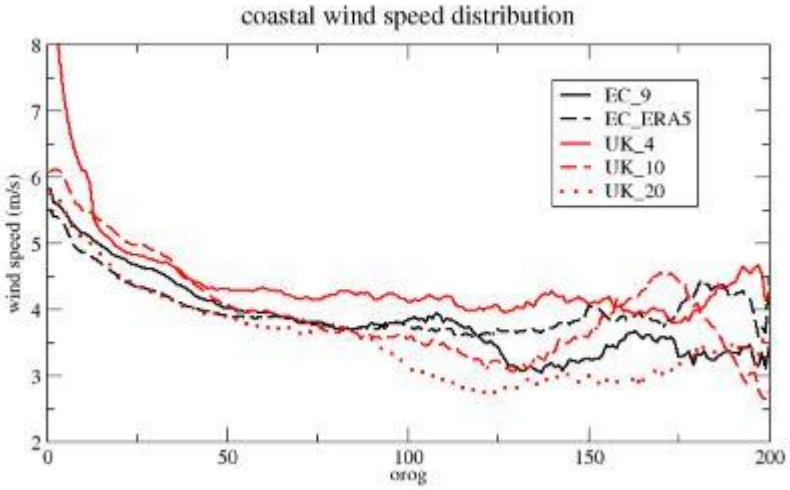

Figure 2 – Statistical distribution of the coastal wind speeds for both the IFS and UM models according to their respective resolution. The orog parameter summarizes the roughness of the last 200 km of orography before the wind reaches the coast.

evidence in this respect. Where the orography is pronounced, i.e. mistral valley, Algeria, Mediterranean coast in general, the wind speeds just off the coast are strongly underestimated by the model. On the contrary, when blowing off a rather flat coast, as in the example the Sahara coast, the underestimate is much reduced. As a complementary information, Figure 2 shows how for evry model and each resolution, the just off the coast offshore blowing winds are more and more underestimated the coarser the orography. This coarseness is represented by the orog parameter. This is calculated taking into account the height of the mountains close to the coast, their steepness, and finally their coarseness, i.e. how many “up-downs” there are on the descending slope towards the coast.

A further problem we are tackling is the dynamical balance in the ECMWF model between an improved orographic resolution and the associated improvement, i.e. increase, of the coastal offshore blowing winds. A more detailed, hence coarser, orography should imply a higher surface drag, hence in principle lower wind speeds. However, our direct experience as users shows that an increase of resolution leads to higher coastal winds. Logically this must be associated to a careful balance of the orographic drag in the model physics.

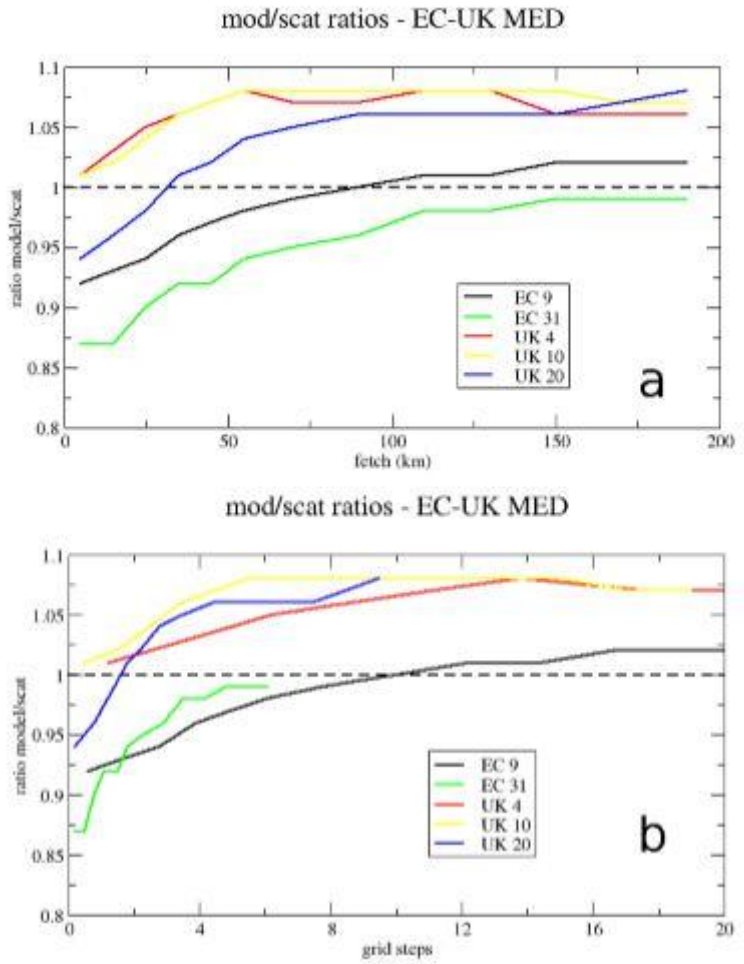

Figure 3 – Underestimate of coastal wind speeds according to the ECMWF and UKMO meteorological models and their possible resolutions. Note how the curve of each centre tend to converge if, instead of distance from the coast, we judge the results according to their resolution, i.e. the number of grid steps necessary by each model to reach determined results.

One of the most enlightening results has been to judge the models performance according to their spatial resolution. In practice, granted the underestimate just off the coast, the space required by each resolution to reach a certain level of performance is practically the same for each resolution if, instead of space (distance in km), we consider for each resolution the number of grid steps. In practice we need four grid steps for the meteorological model to adapt to the change of surface roughness passing from the coastal orography to the sea.