# A new software tool for the generation of orographic fields for atmospheric models

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## Abstract

The parameterization of unresolved orographic drag has been recognized as crucial to simulate a realistic mid-latitude circulation in general circulation models (GCMs), since all orographic scales are found to commensurately influence the atmospheric flow. Accurate orographic drag parameterizations can reduce some of the long-standing circulation biases affecting weather and climate models, but they are still considered an important source of errors, because of uncertainties involving some loosely constrained physical parameters. In addition, these schemes require appropriate boundary conditions to characterize the physical features of sub-grid orography. The precise methods used in the creation of these sub-grid orographic fields and model mean orography can profoundly affect the resulting simulated orographic stress and ultimately model biases. Nevertheless, strategies for the generation of such boundary conditions can vary widely among different modeling centres and they are often poorly documented (Elvidge et al. 2019).

Here we present OROGLOBO (OROGraphic ancillary files generator for GLOBal atmospheric mOdels), a novel software tool written in Python for the generation of orographic boundary conditions for atmospheric models.

This unique open-source tool is designed to exploit a state-of-the-art, high resolution global Digital Elevation Model (DEM, Copernicus GLO-90) to generate boundary conditions for the orographic gravity wave drag (OGWD) and turbulent orographic form drag (TOFD) schemes commonly implemented in GCMs, gathering the main algorithms and techniques available in the literature in a single software. This novel tool also consistently generates the model mean orography, allowing an optimal and self-consistent representation of all orographic scales, and allows the user to control and configure the entire data processing chain, from the raw DEM to the orographic parameters defined on the model grid and saved in netcdf format, exploiting consolidated algorithms.

While developed in the context of the update of the orographic drag parameterization package of the GLOBO model, a global GCM developed at the Institute for Atmospheric Science and Climate of the Italian National Research Council (ISAC-CNR), its flexible and modular design allows OROGLOBO to be easily adapted to other model grids of any resolution.

OROGLOBO code will soon be released here: https://github.com/GuidoDavoli/oroglobo

## References

Beljaars, A.C.M. et al., (2004), A new parametrization of turbulent orographic form drag. *QJRMS*

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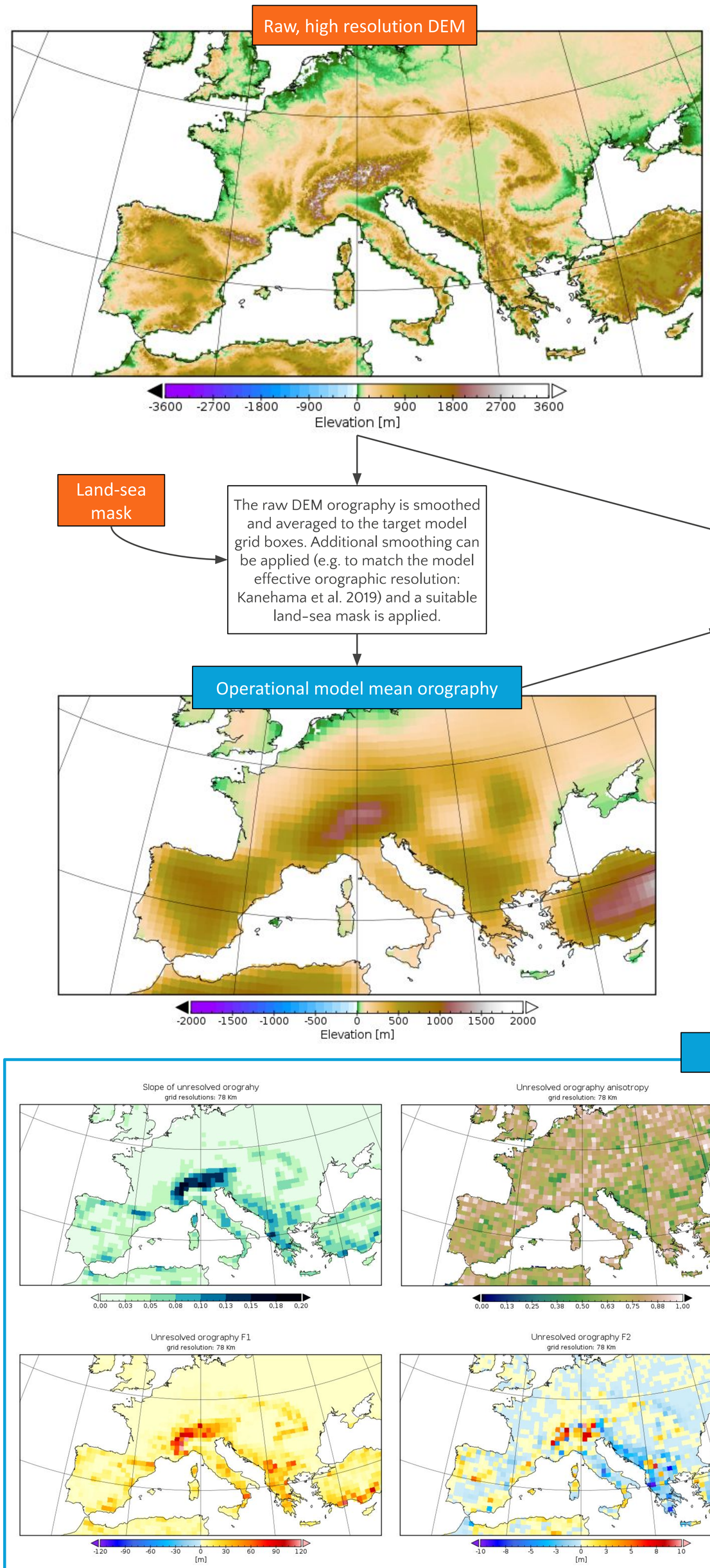
## Methods




The software, written in python, uses the Copernicus global, 90 m resolution Digital Elevation Model (COP-DEM_GLO-90, https://doi.org/10.5270/ESA-c5d3d65) as source orographic dataset, and creates suitable model ancillary files at the desired model target grid resolution. It generates the orographic boundary conditions needed by state-of-the-art unresolved orographic drag parameterizations, such as the van Niekerk and Vosper, 2021 (vNV21), Lott and Miller, 1997 (LM97) and Beljaars et al., 2004 (B04) schemes. Moreover, it creates a consistent model mean orography at the corresponding resolution. The software calculates the following parameters:

- unresolved orography standard deviation
- unresolved orography orientation
- unresolved orography slope
- unresolved orography anisotropy

on scales above and below 5 km, to be used by OGWD and TOFD parameterizations respectively, and also F1, F2, F3, hamp parameters needed by the (vNV21) scheme. The tool uses state-of-the-art procedures available in the literature, and save the results in netcdf files at the desired resolution.

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## Conclusions and future work

The methods used for the generation of orographic fields for atmospheric models vary significantly among different modeling centres; they are often poorly documented and they can determine uncertainties and errors in parameterized surface stress, leading to systematic model biases. OROGLOBO, the novel software presented here, constitutes a unique and powerful tool. In fact, it gathers the main state-of-the-art procedures for generating model mean orography and boundary conditions for Earth System Models orographic drag parameterization in a single, open-source code. The user can exploit state-of-the-art elevation data to build suitable ancillary boundary files for atmospheric models, controlling and configuring the entire data processing chain. At present, the software supports regular latitude-longitude grids only, but thanks to its flexible and modular design we plan to extend its functionality to work with any user-specified grid.