



MPAS-powered downscaling solution for wind resource assessment

Marta Gil Bardají

R&D Wind Analyst, Vortex FdC

Other authors:

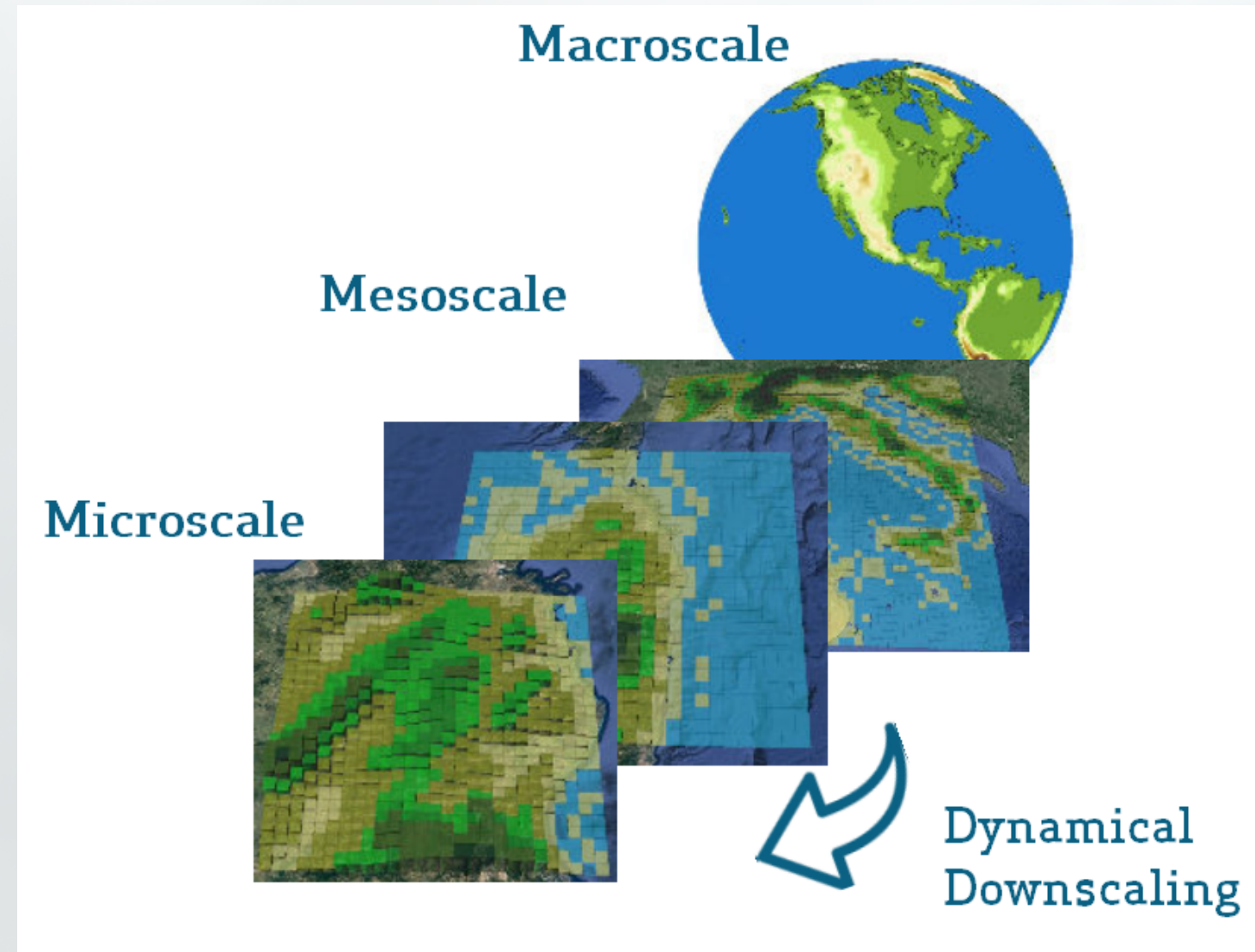
Gerard Caverro and Pau Casso (Vortex FdC)

Pedro Peixoto (University of Sao Paolo)



Overview

Industry application: Generation of virtual wind data for wind resource assessment.



GOAL
**Evaluate the
performance of
regional MPAS in
wind resource
assessment**

OUTLINE

Vortex: modeling the wind

MPAS' regional meshes for the wind industry

WRF "equivalent" simulations

Sensitivity test

Benchmark: One-year time series validation

Conclusions & Further Questions

OUTLINE

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WRF "equivalent" simulations

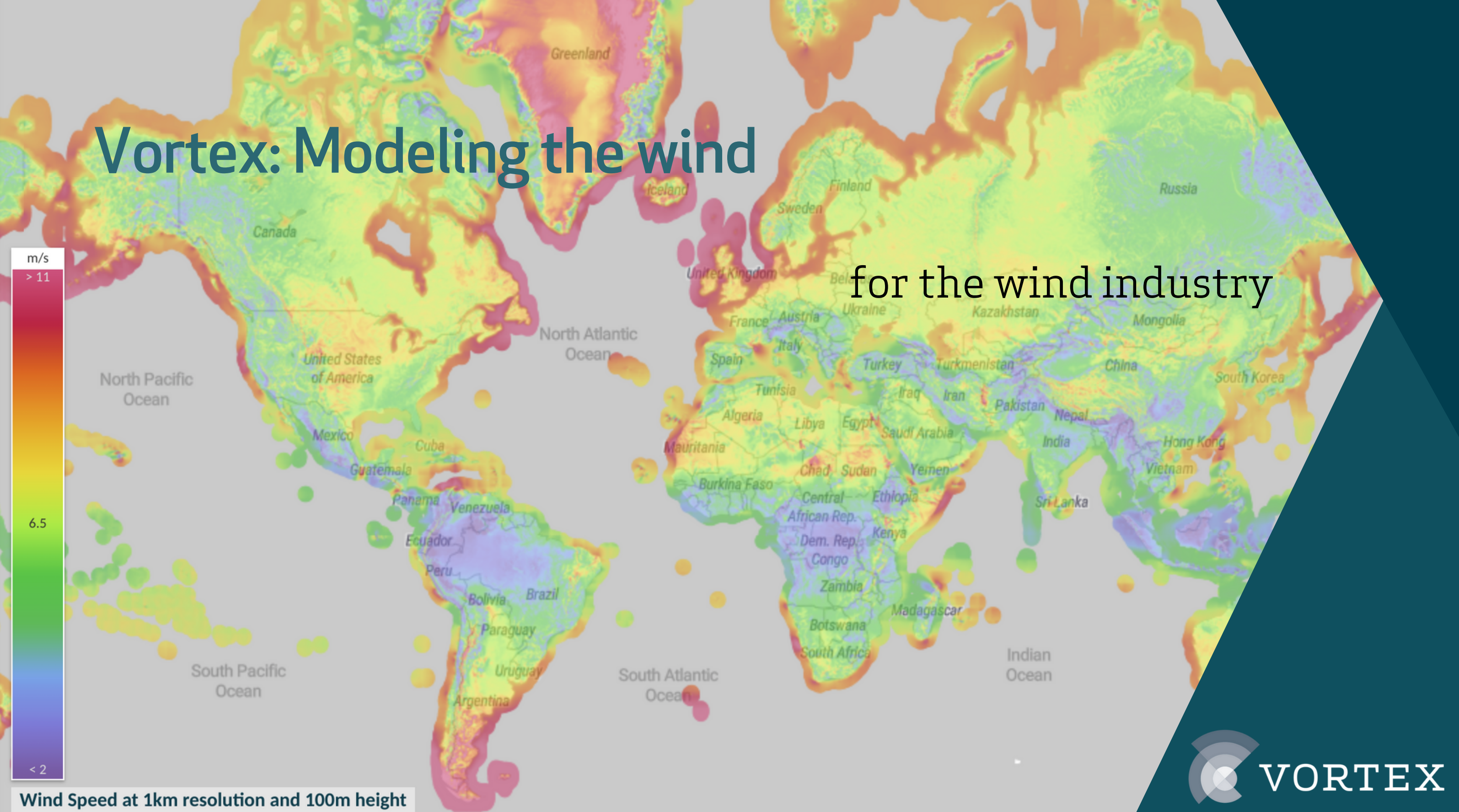
Sensitivity test

Benchmark: One-year time series validation

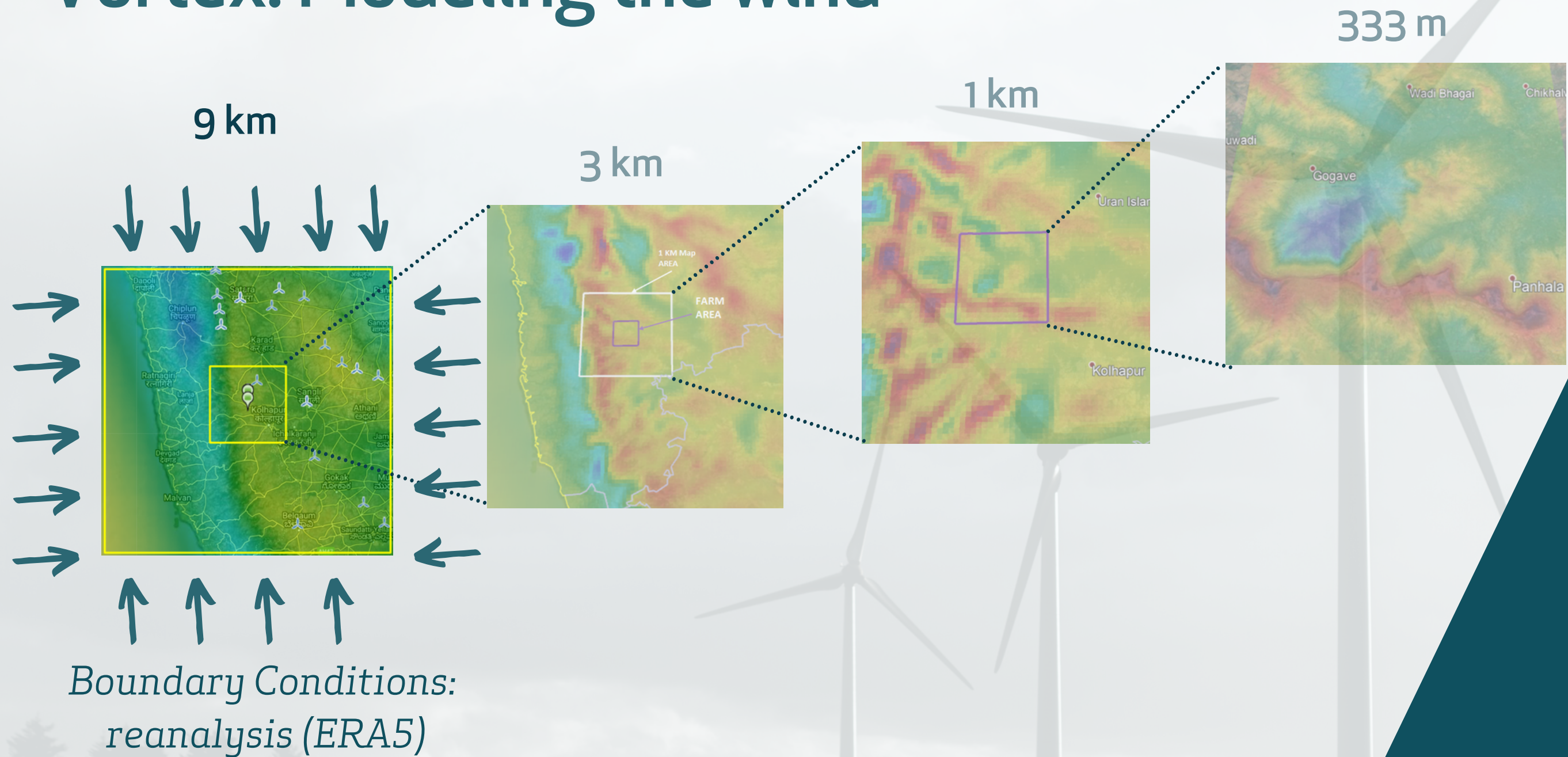
Conclusions & Further Questions

Vortex: Modeling the wind

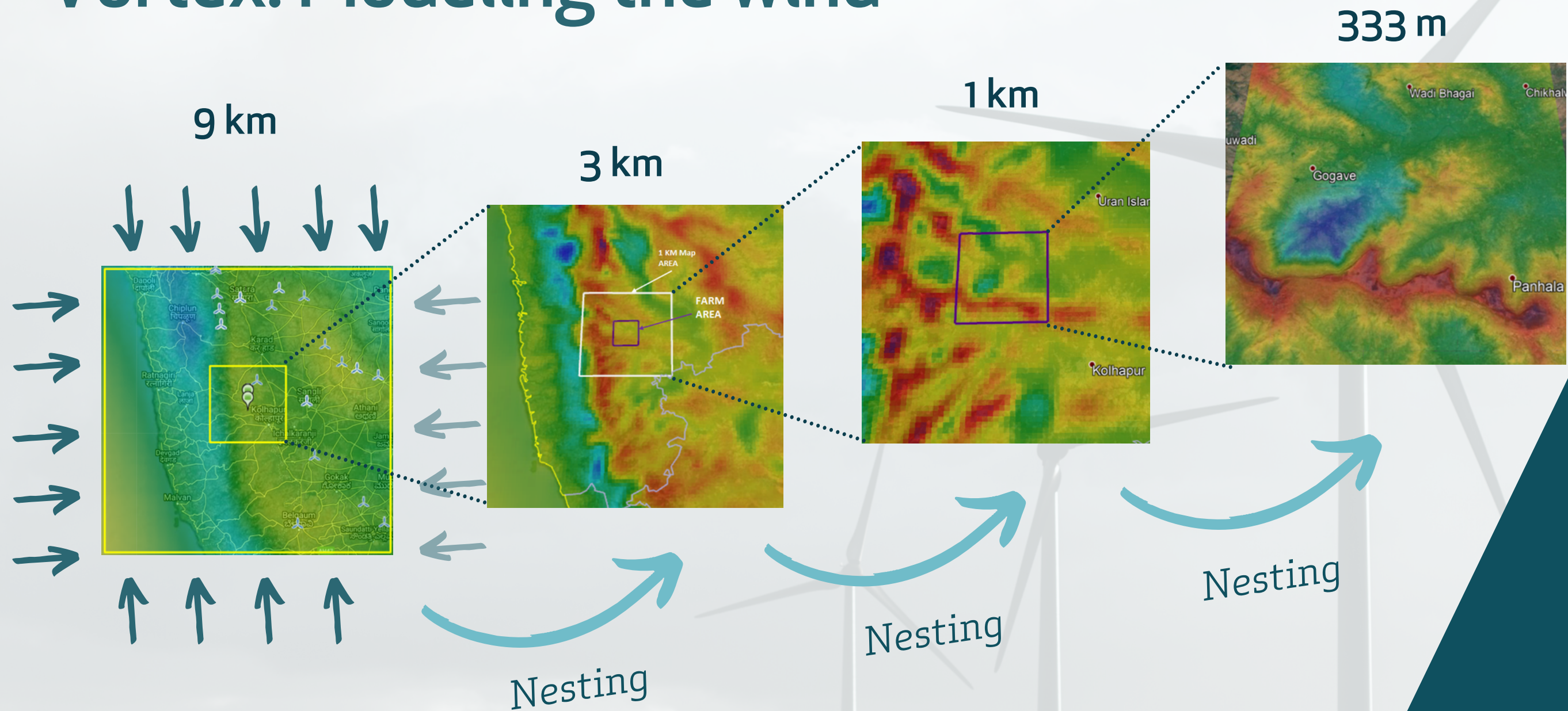
for the wind industry



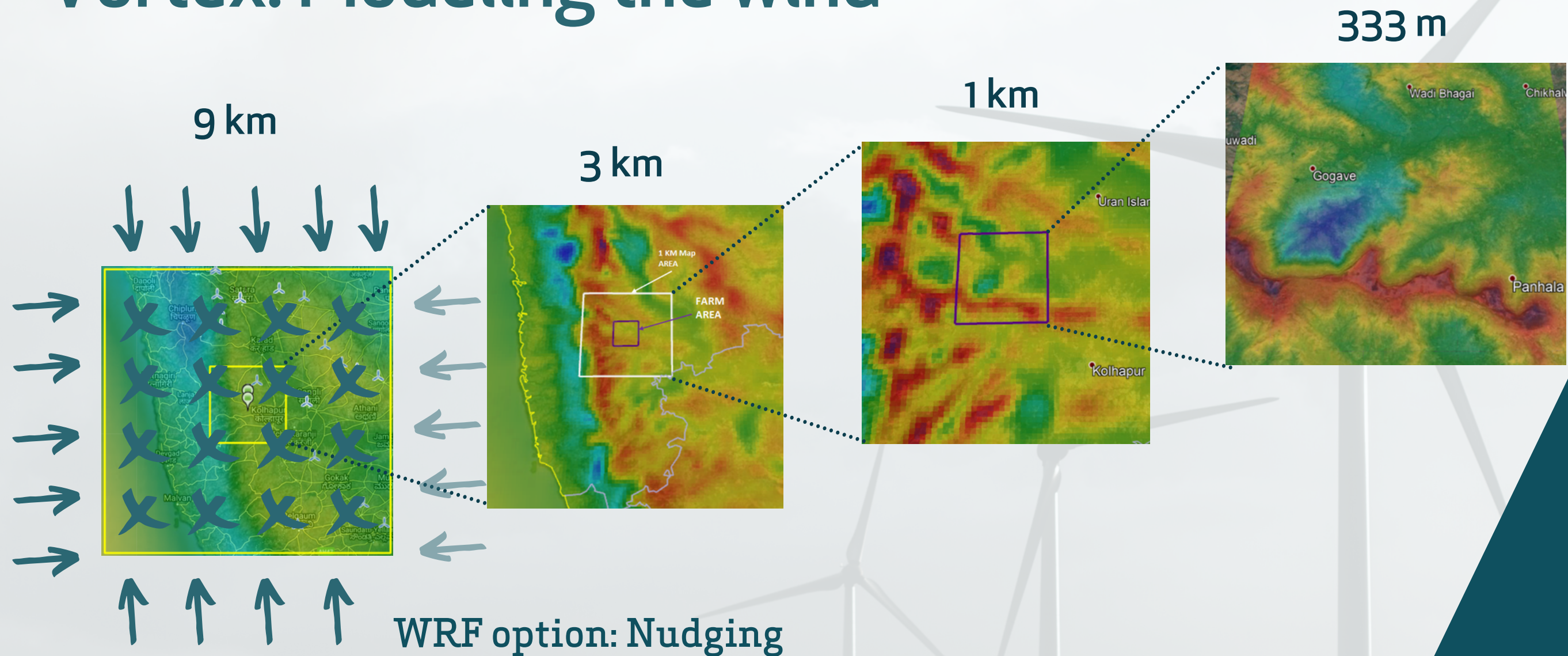
Vortex: Modeling the wind



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Renalysis influences the whole inner domain

- *improves wind resource assessment simulations*

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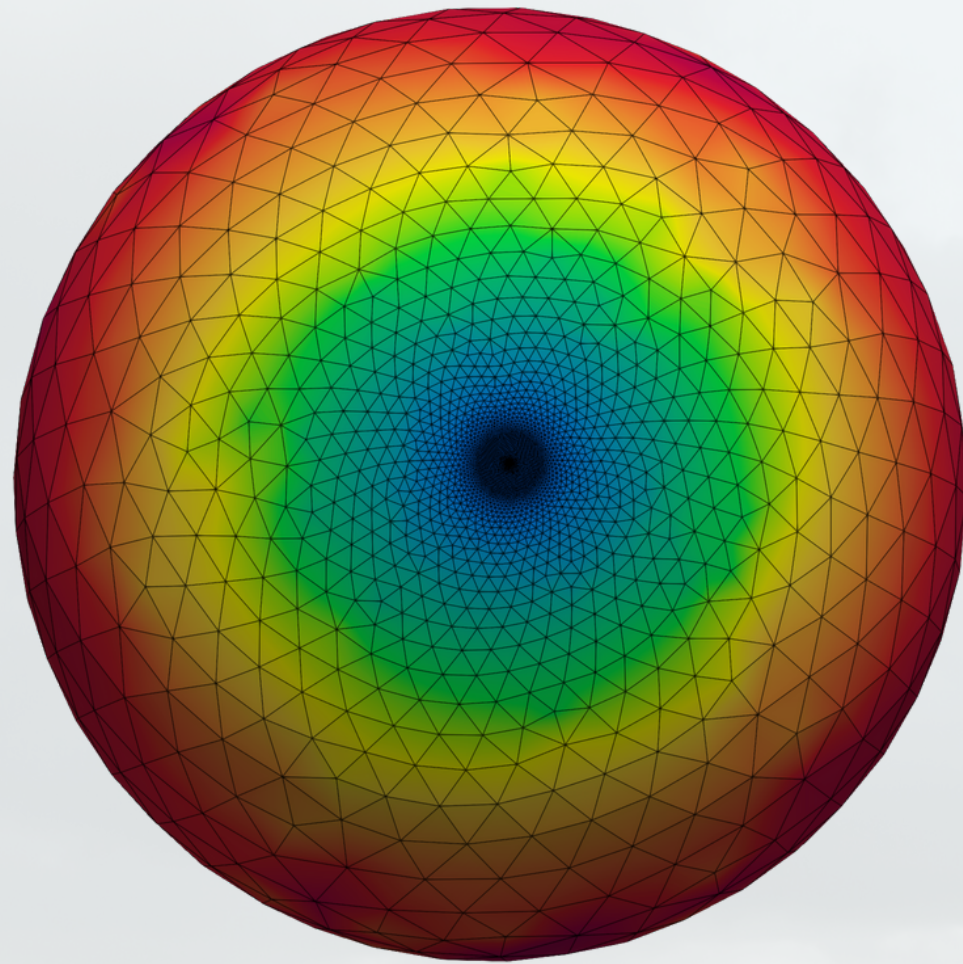
Conclusions & Further Questions

MPAS' regional meshes for the wind industry

Long term wind data time series at specific locations or small regions

- Variable resolution mesh:
 - * Central high resolution area
 - * Smooth transition to low resolution (reanalysis)
- Smallest possible number of cells.

MPAS' regional meshes for the wind industry



Mesh generation tool:

- based on Dr. Pedro Peixoto's work
- uses mpas-tools and jigsaw

Resolution map  MPAS mesh

Open source repository (work in progress):

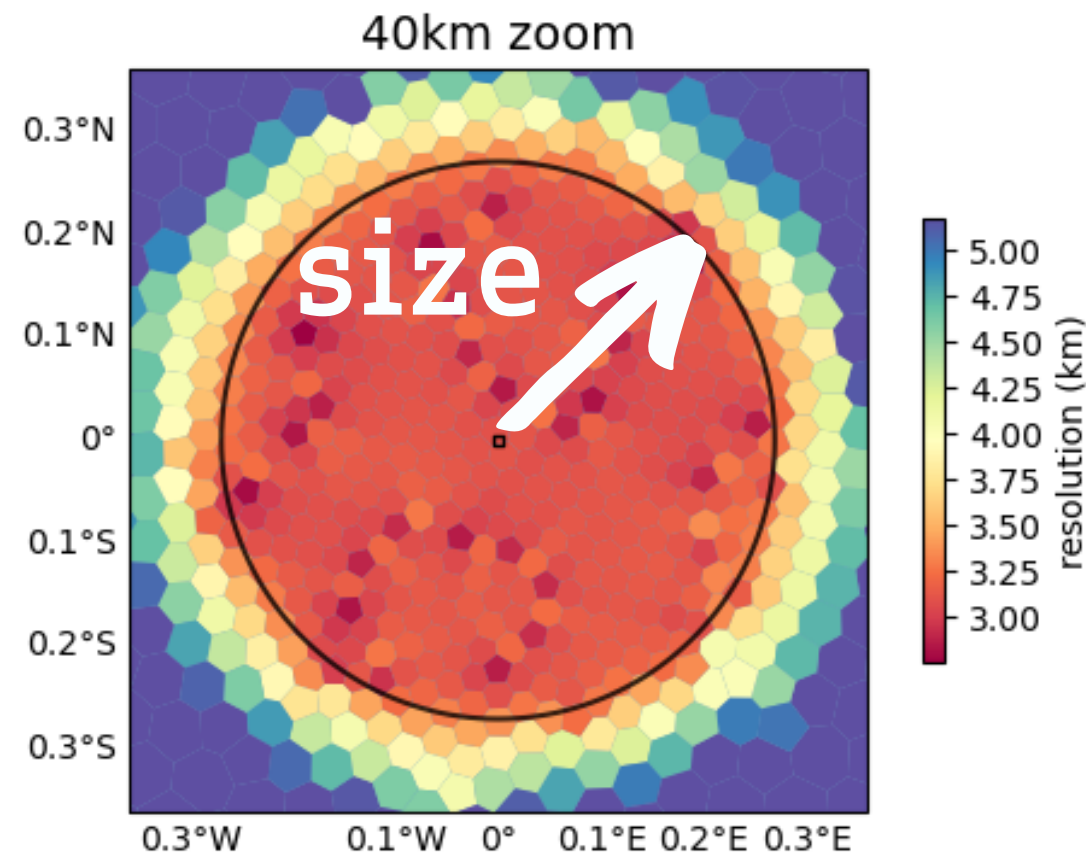
`marta-gil/vtx-mpas-meshes`

MPAS' regional meshes for the wind industry

Template meshes

*Central high
resolution circle*

*resolution = 3km
size = 30km*

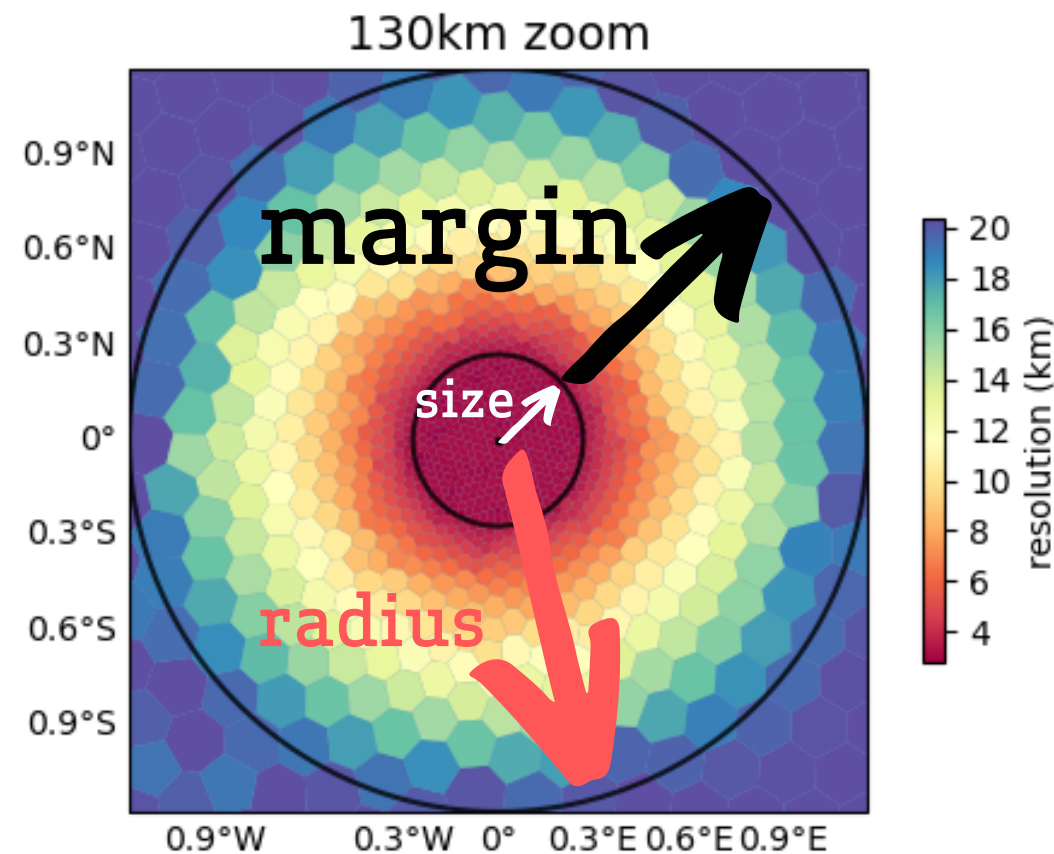


MPAS' regional meshes for the wind industry

Template meshes

*Linear increase
of resolution
until resolution
threshold.*

*Defines the
radius of the
region.*

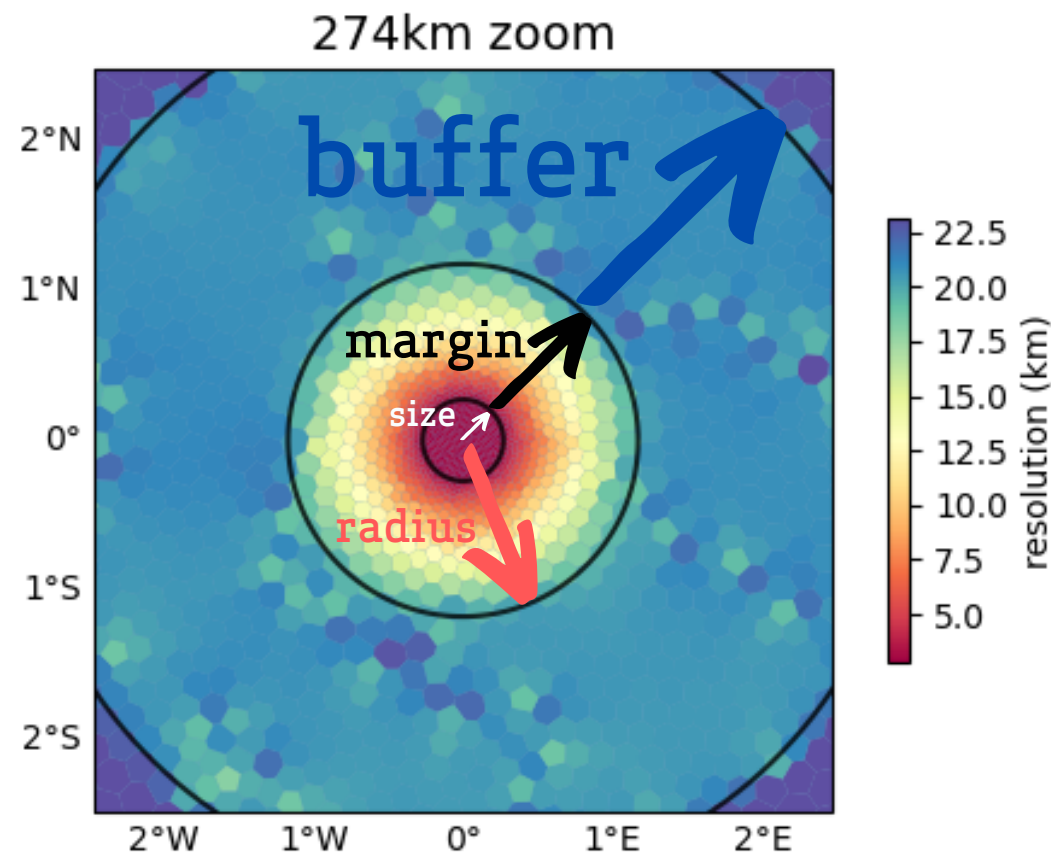


*margin = 100km
threshold_resolution = 20km*

MPAS' regional meshes for the wind industry

Template meshes

Keep the resolution constant in a ring wide enough to include the region's buffer.

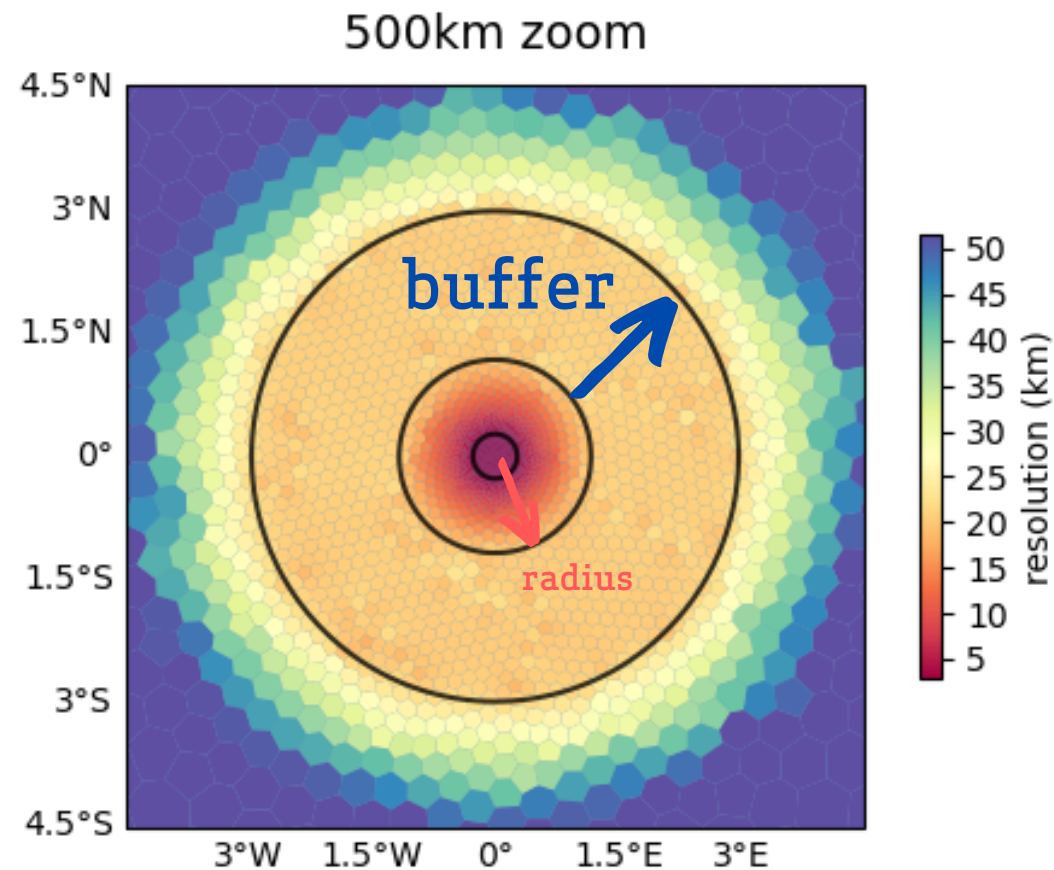


buffer = 200km

MPAS' regional meshes for the wind industry

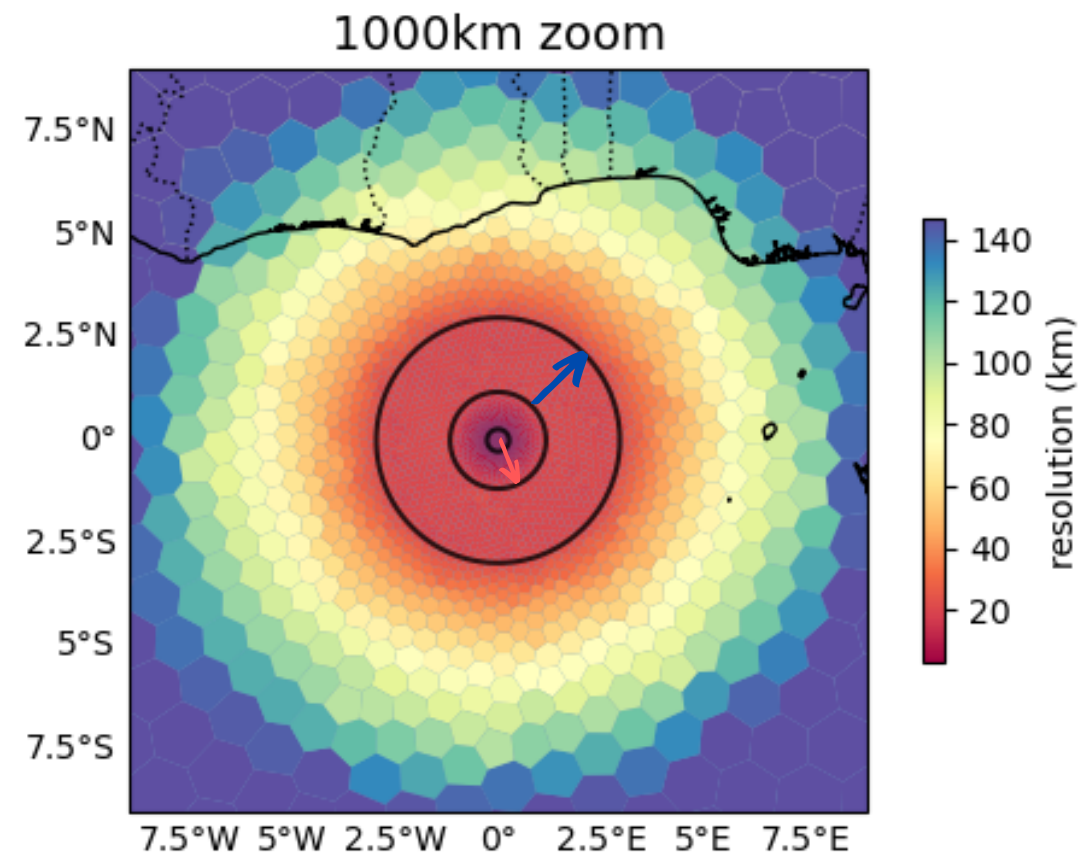
Template meshes

After the buffer, linear increase of the resolution until reaching a maximum value.



MPAS' regional meshes for the wind industry

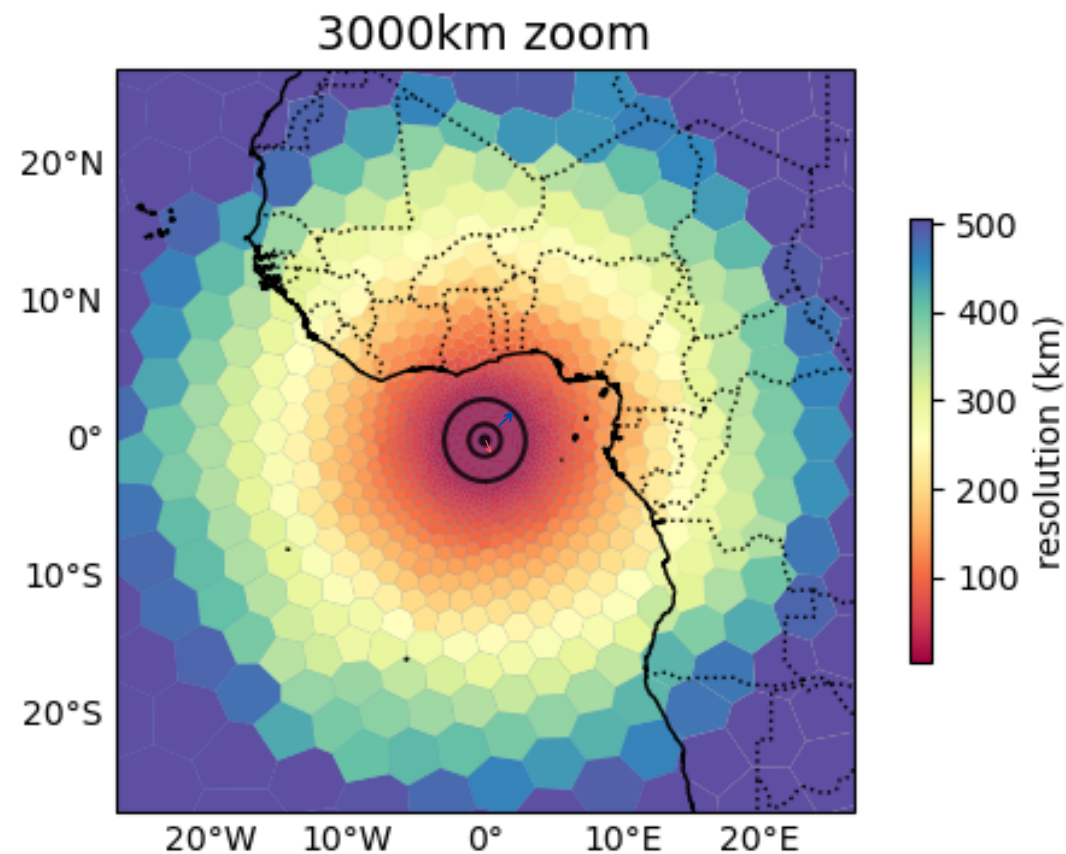
Template meshes



MPAS' regional meshes for the wind industry

Template meshes

When it reaches the maximum resolution value, it is kept constant.



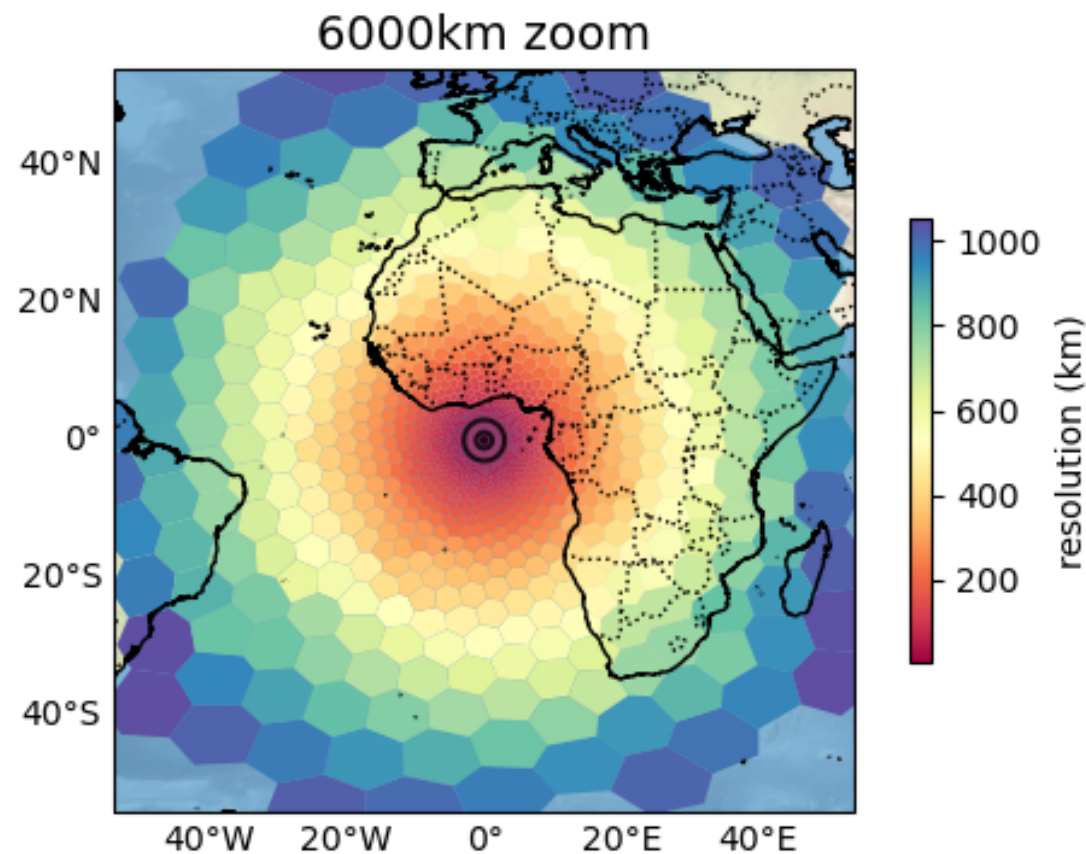
maximum_resolution = 1000km

MPAS' regional meshes for the wind industry

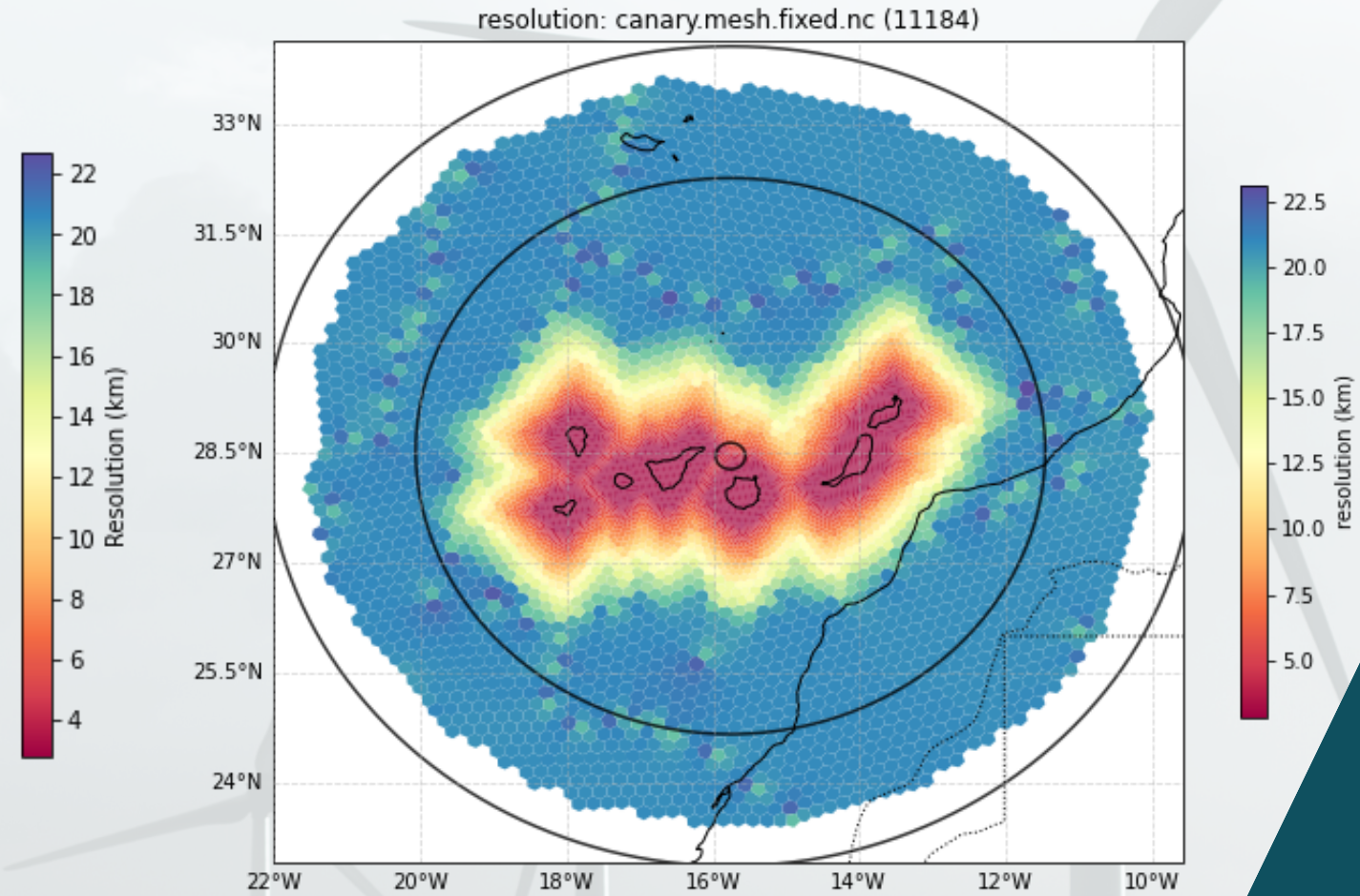
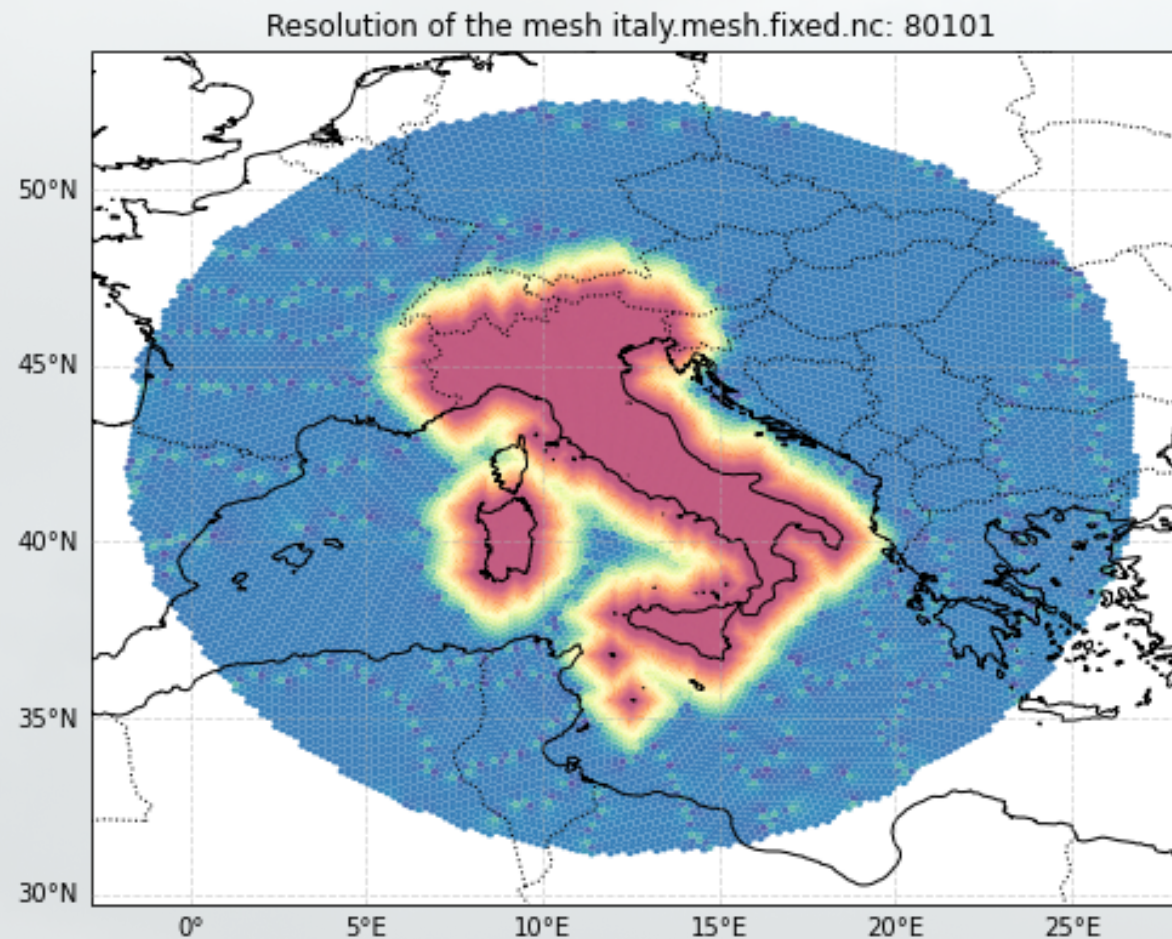
Template meshes

Mesh creation
time:

35 seconds



MPAS' regional meshes for the wind industry



Other meshes can be created!

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WRF "equivalent" simulations

Sensitivity test

Benchmark: One-year time series validation

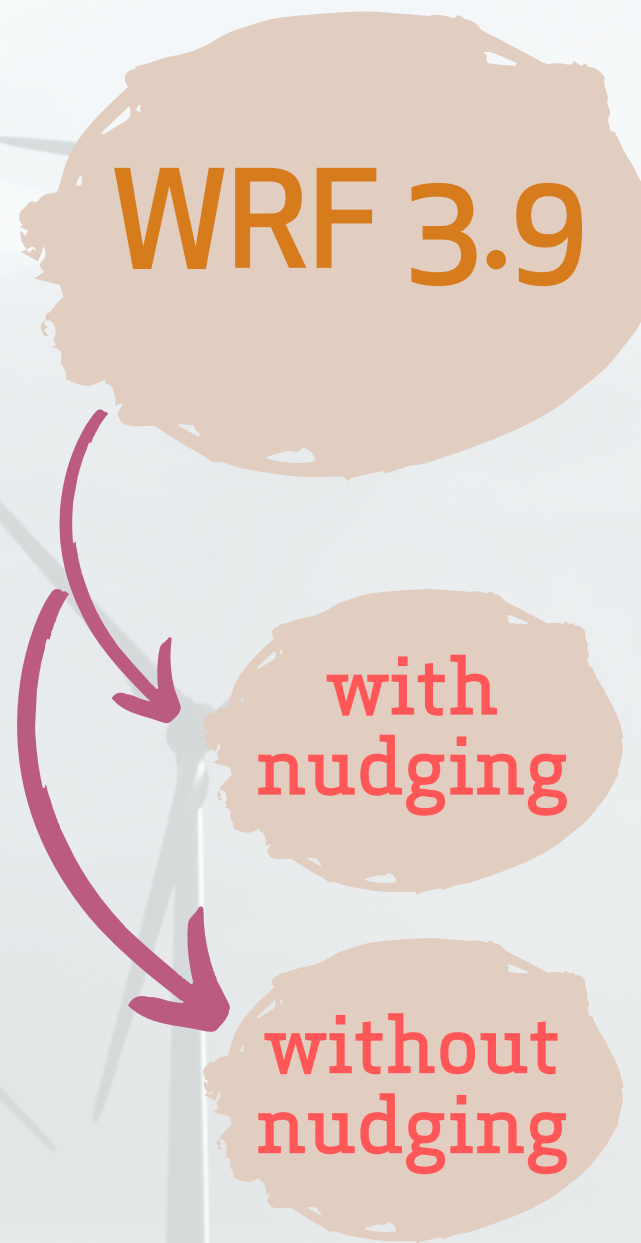
Conclusions & Further Questions

WRF "equivalent" simulations

Compare an MPAS simulation fairly against WRF simulations.

Take into account:

- Sizes and resolutions
- Static fields
- Vertical level
- Parametrizations
- Set WRF to one-way nesting



WRF 3.9

The diagram illustrates the branching of WRF 3.9 simulations. It features three orange, hand-drawn style ovals. The top oval is labeled 'WRF 3.9' in orange text. Two curved purple arrows originate from the bottom of this oval. One arrow points to a middle oval labeled 'with nudging' in red text, and the other points to a bottom oval labeled 'without nudging' in red text. The background of the slide shows a faint image of wind turbines and a dark teal diagonal shape on the right side.

with
nudging

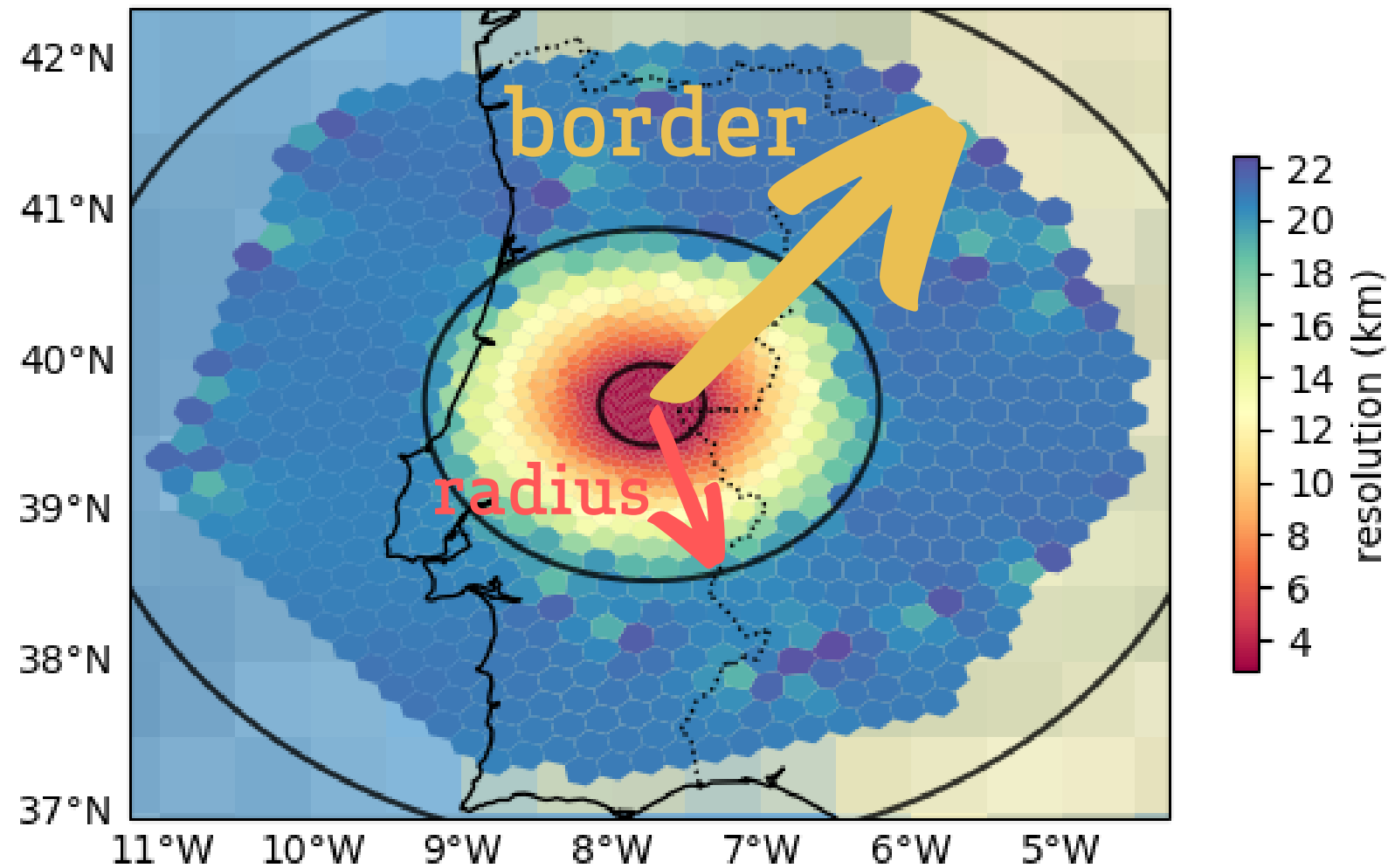
without
nudging

WRF "equivalent" simulations

Example

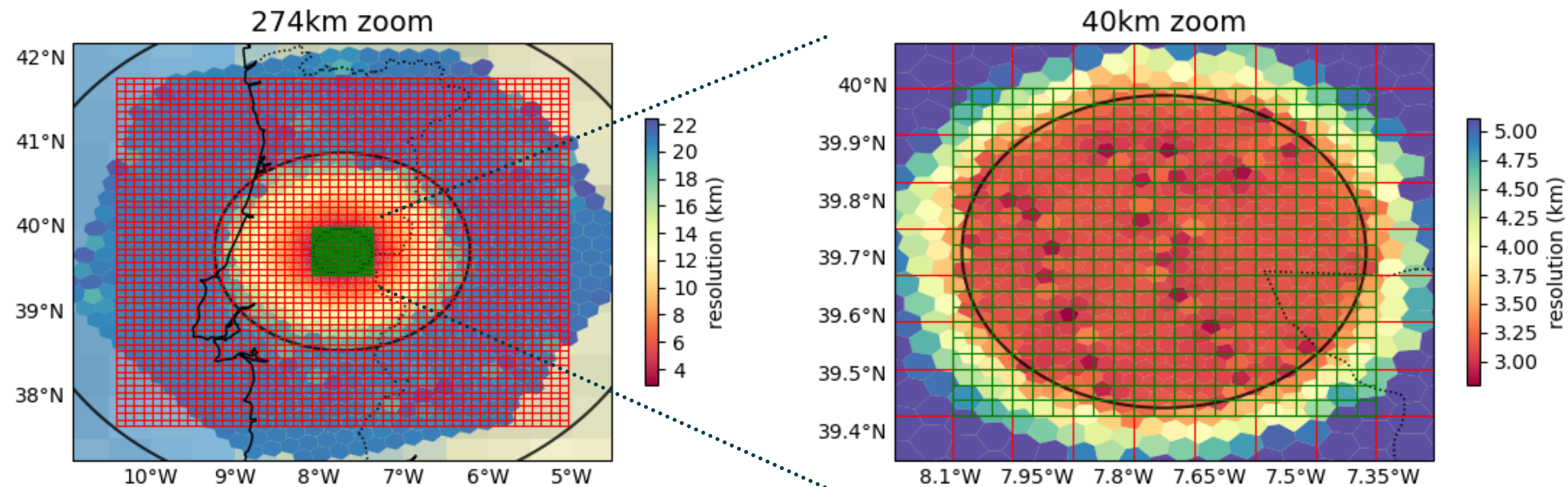
MPAS global mesh:

- rotated
- region created (MPAS-Limited-Area)



WRF "equivalent" simulations

Example



Domain d01

9km resolution / until border

Domain d02

3km resolution / until size

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Sensitivity test

Perdigao Test Site

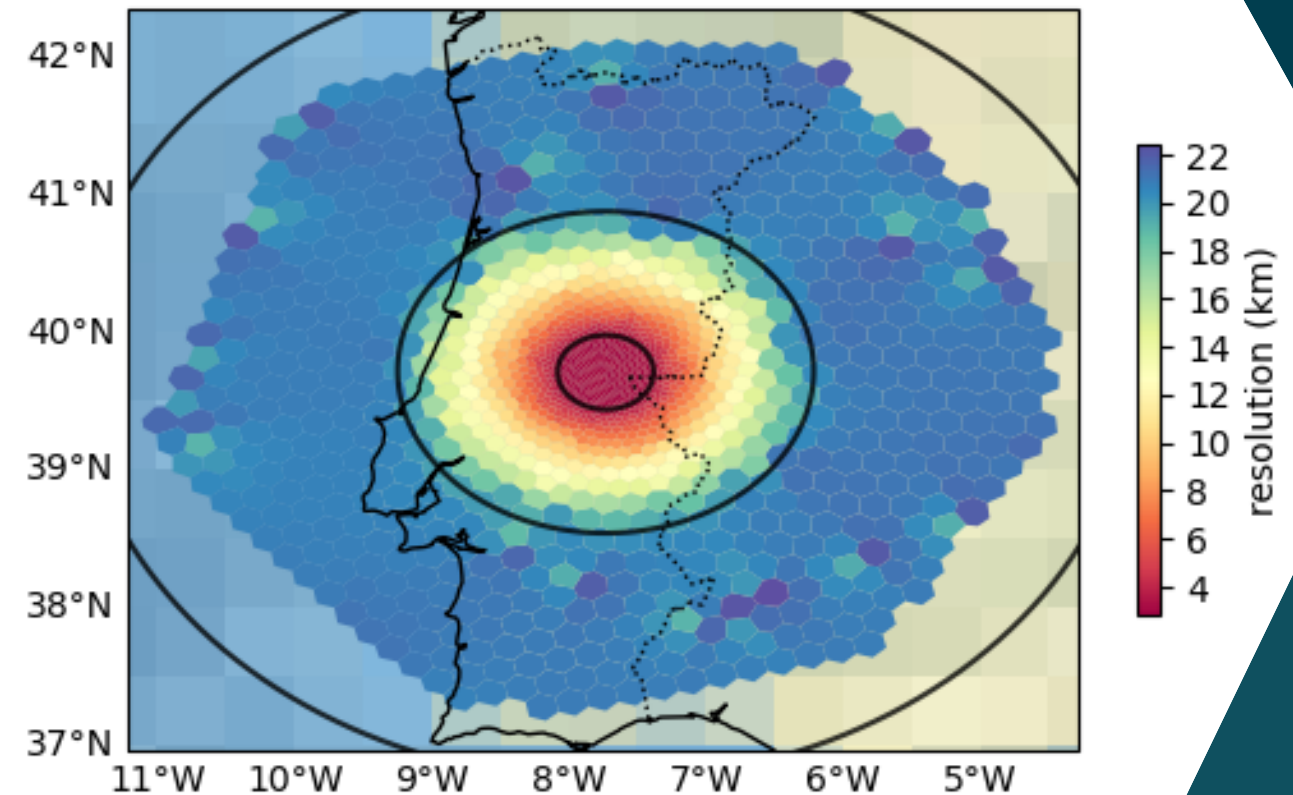
2 months (initialized daily, 6h spinup)

Test several MPAS meshes:

- sizes from 15 to 50km
- margins from 50 to 250 km

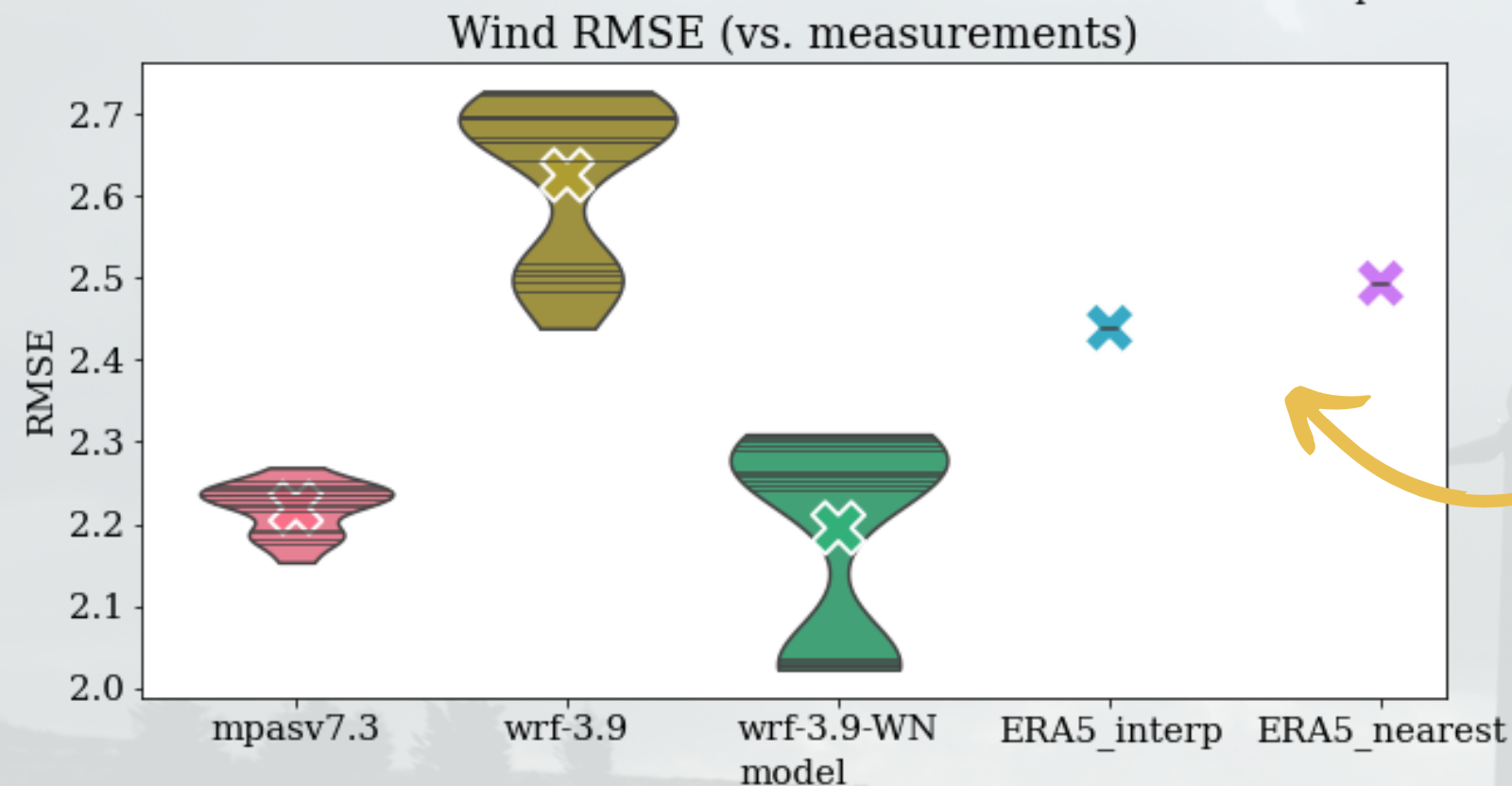
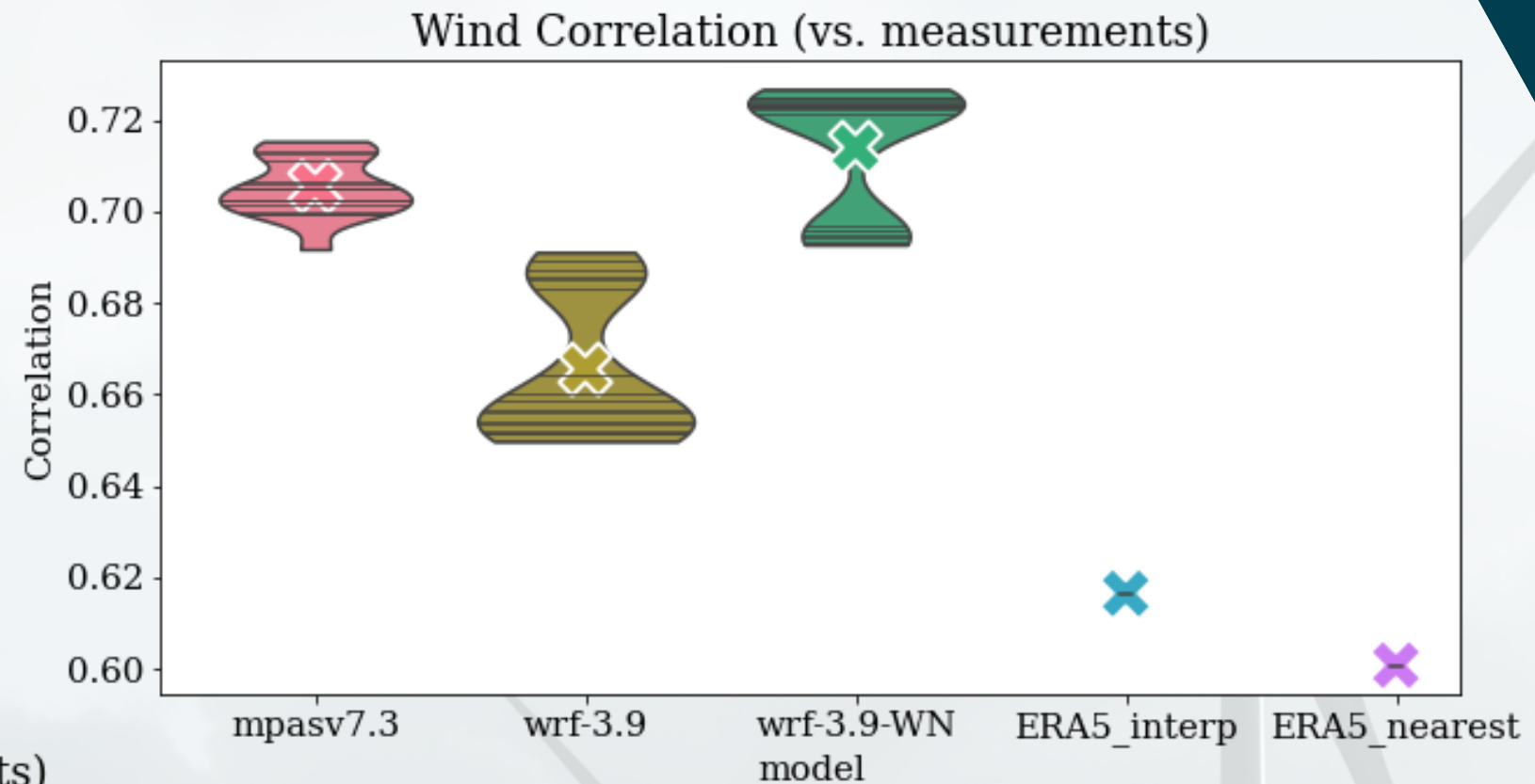
For each mesh run a simulation with:

- MPAS v7.3
- WRF v3.9 without nudging
- WRF v3.9 with nudging



Sensitivity test

Validate the central point
time series at 100m
(2 months)

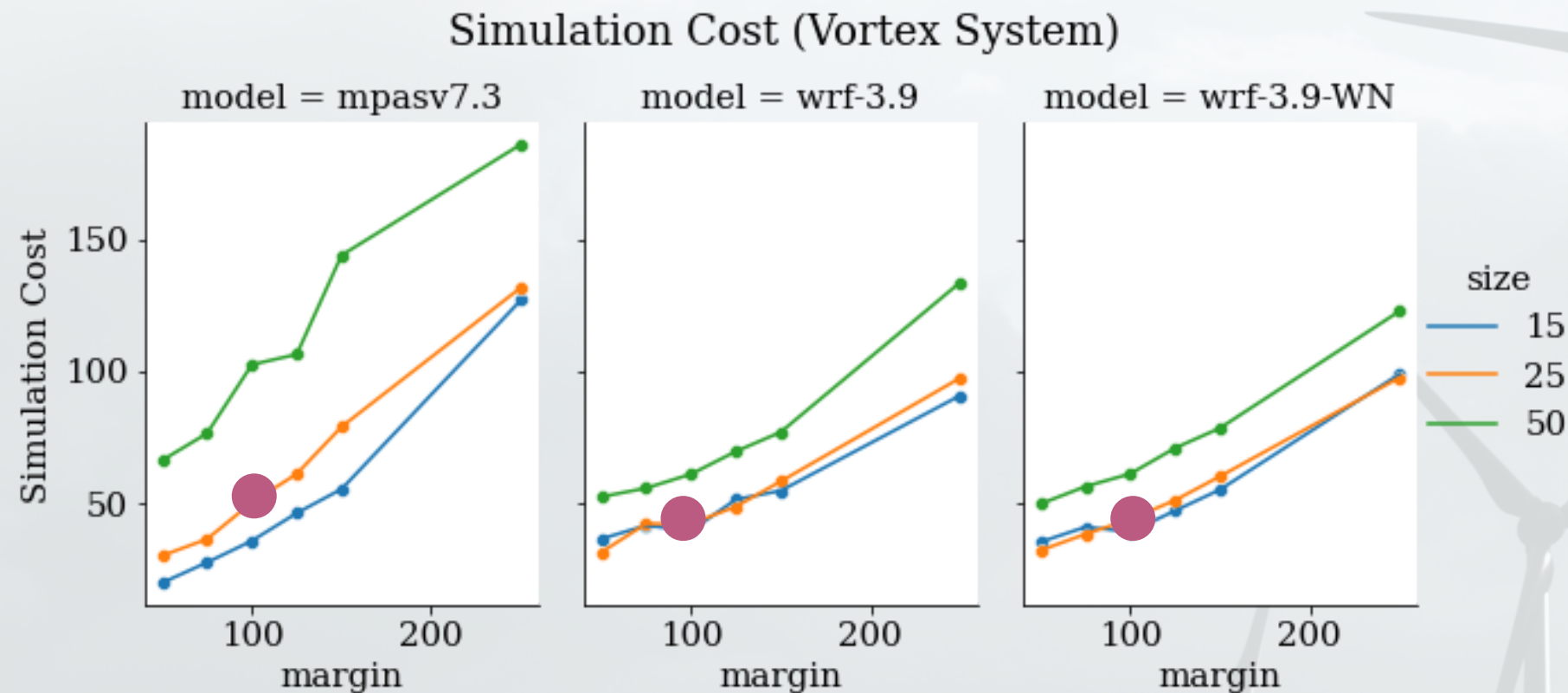


Reanalysis ERA5
(0.25°x0.25° resolution)

Observations:
<https://perdigao.fe.up.pt/station/29>

Sensitivity test

The MPAS meshes show robustness, reasonable cost and good accuracy



No Parallelization
No GPUs

We distribute tasks
among the Vortex
cluster

- Mesh chosen for further tests:
100km margin, 30km size

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Benchmark: One-year time series validation

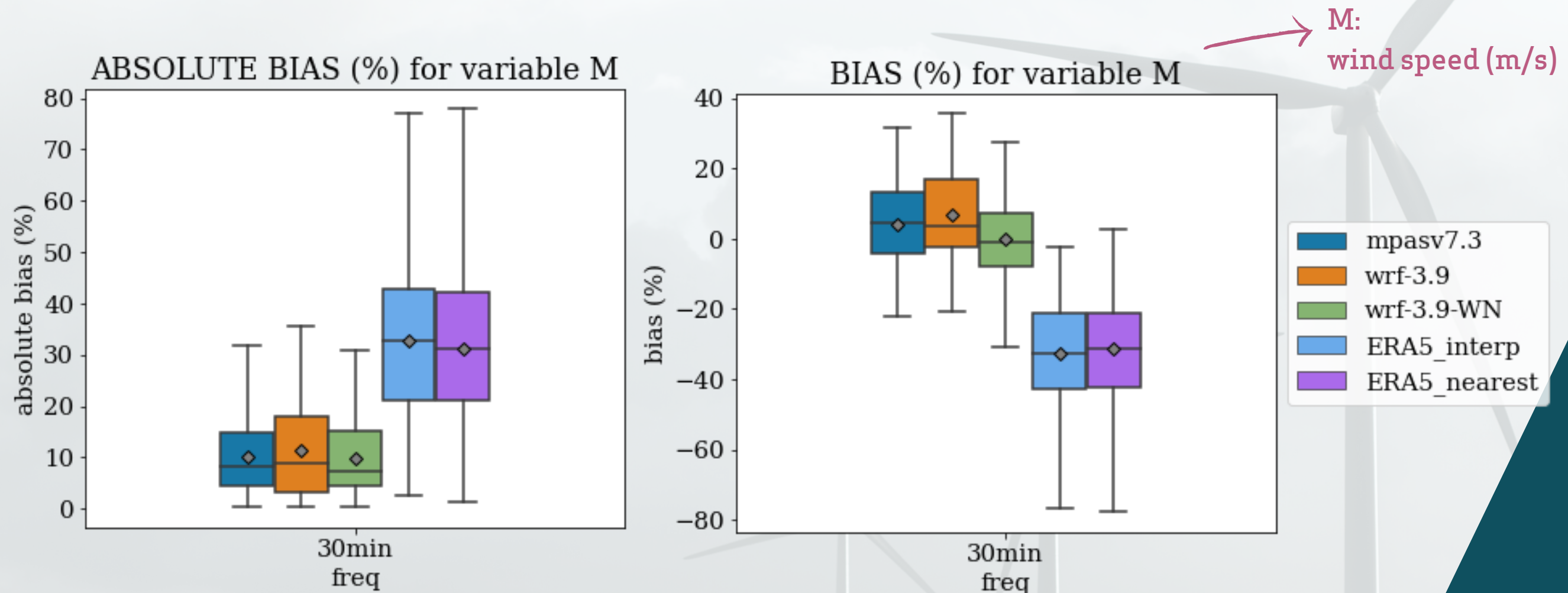
Methodology

- 50 sites around the globe
- Use the MPAS mesh selected in the sensitivity test (size 30km, margin 100km)
- For each site run a simulation with MPAS, and "equivalent" WRF w/wo nudging

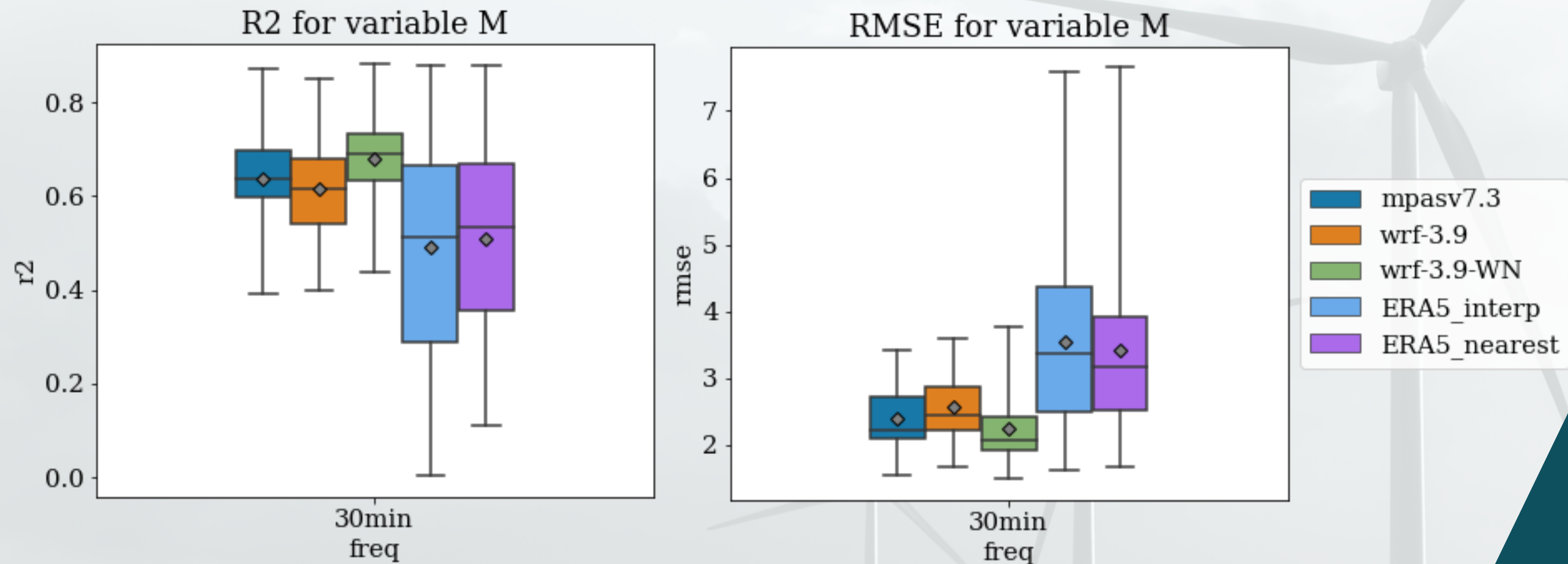


Wind industry sites with diverse characteristics (flat and complex terrain, forest, offshore)

Benchmark: One-year time series validation



Benchmark: One-year time series validation



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Conclusions & Further Questions

Conclusions & Further Questions

- The regional mesh generation strategy is robust
- A methodology to produce equivalent WRF simulations has been established
- The accuracy of MPAS lies between that of WRF with and without nudging
 - Does this mean MPAS better transports the reanalysis information to the central region?
 - Further test: 1km resolution runs (using 3 WRF domains)

Conclusions & Further Questions

MAIN OUTCOME

MPAS can be run for wind resource assessment purposes in an operative scenario

FUTURE DEVELOPMENTS OF INTEREST

- MPAS-LES to model higher resolutions
- Nudging in MPAS? Would it help?
- Local time-stepping schemes to reduce computational cost

Thank you!

For questions, contact
marta.gil@vortexfdc.com