



Revisiting Mesoscale: how MPAS can make wind resource modeling really seamless

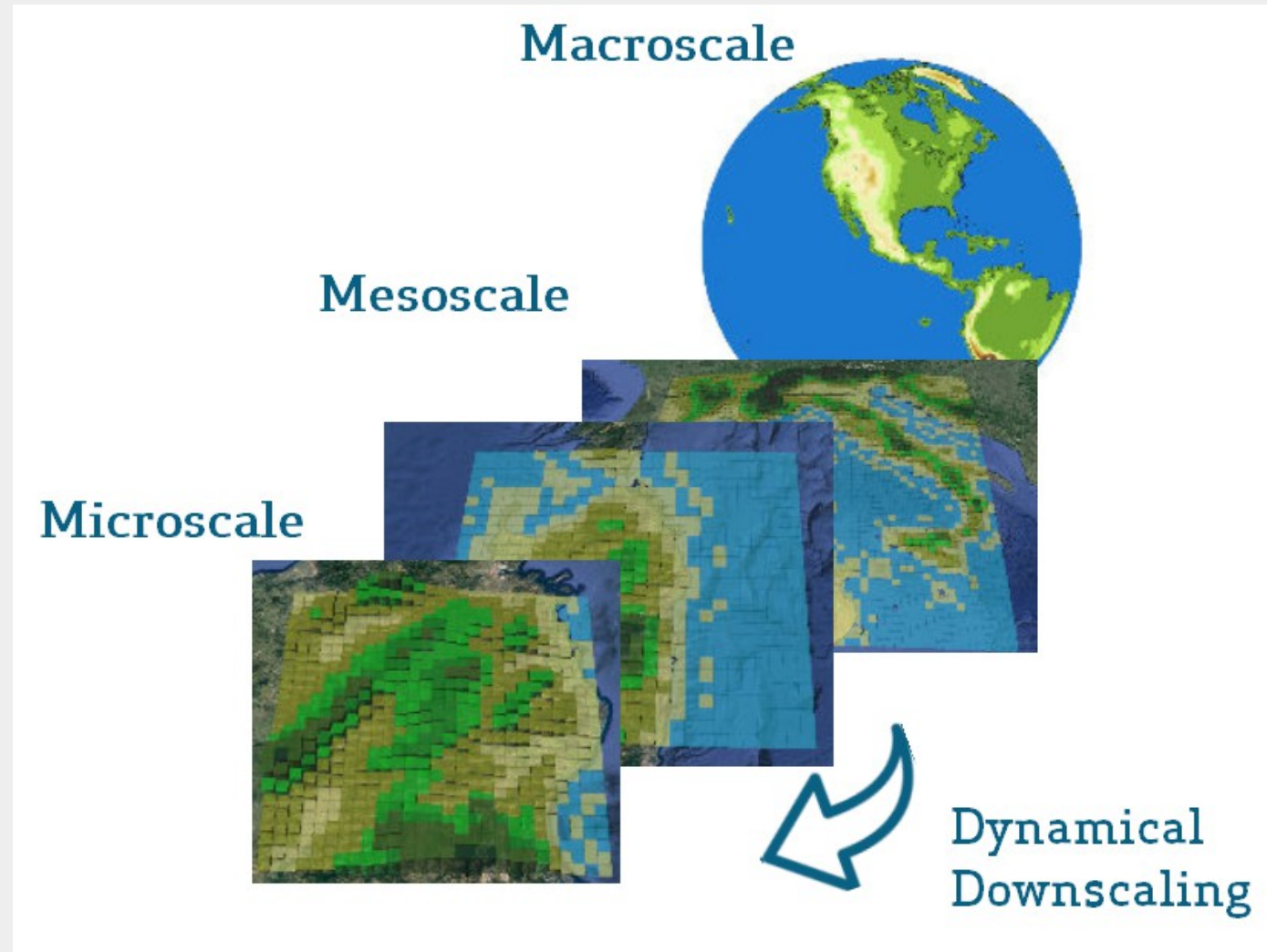
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VORTEX

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Introduction



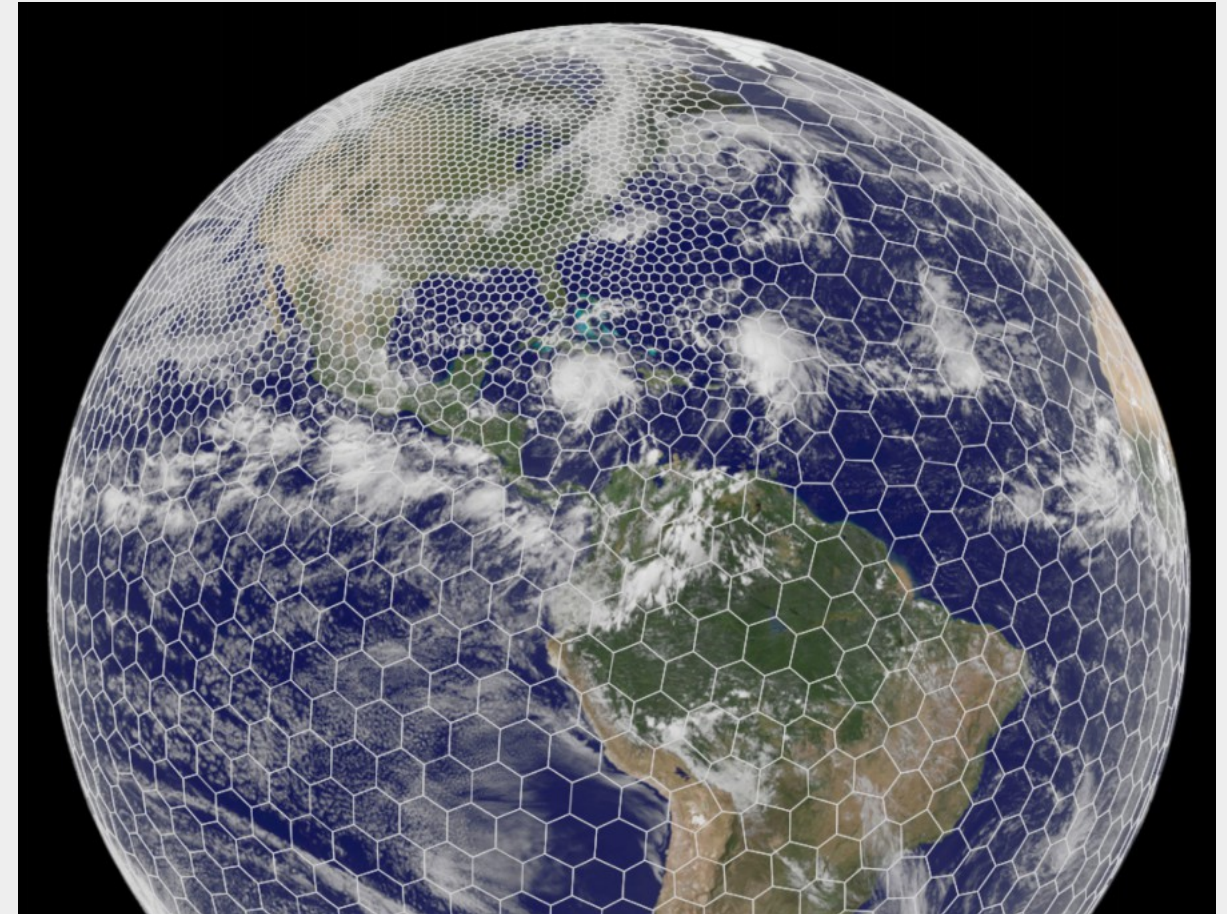
- Industry has improved:
 - Better macroscale input data (reanalysis like ERA5)
 - Better microscale models (like WRF-LES)
- Reference downscaling tool: **WRF model**

Is it time to change the downscaling method itself?

Outline



- Introducing MPAS
- Why a new model?
- Validation of wind towers
 - WRF & MPAS simulations
 - Results
- Conclusions & Next Steps
- Questions & Answers

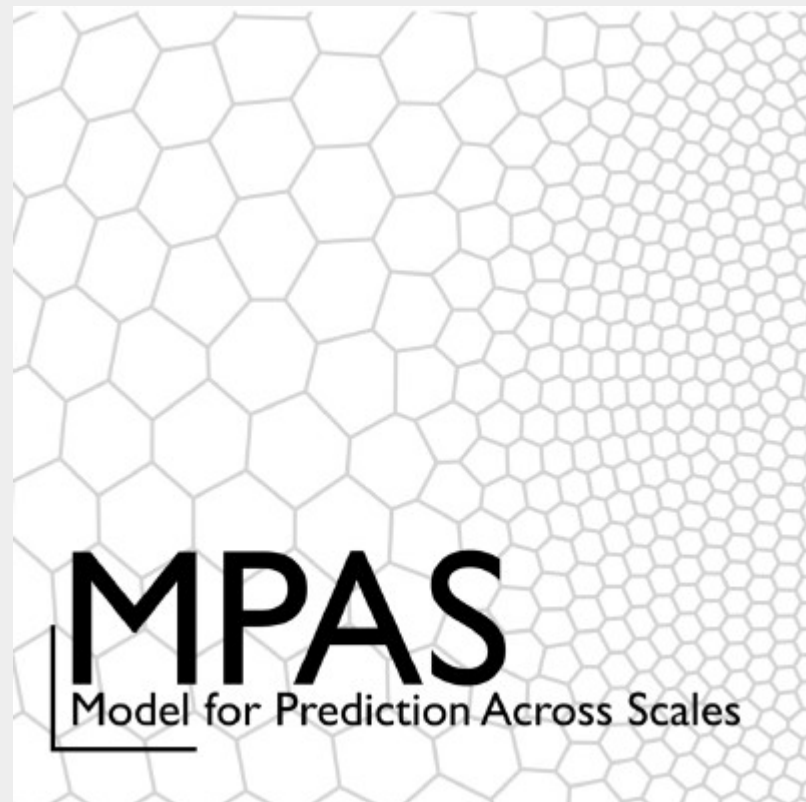


Source: MPAS Tutorial

Introducing MPAS



“The Model for Prediction Across Scales (MPAS) is a collaborative project for developing atmosphere, ocean and other earth-system simulation components for use in climate, regional climate and weather studies.”



<https://mpas-dev.github.io/>

- MPAS infrastructure - NCAR, LANL, others.
- **MPAS - Atmosphere (NCAR)** ← Advanced Research WRF
- MPAS - Ocean (LANL)
- MPAS - Land and Sea Ice, etc. (LANL and others)



Introducing MPAS



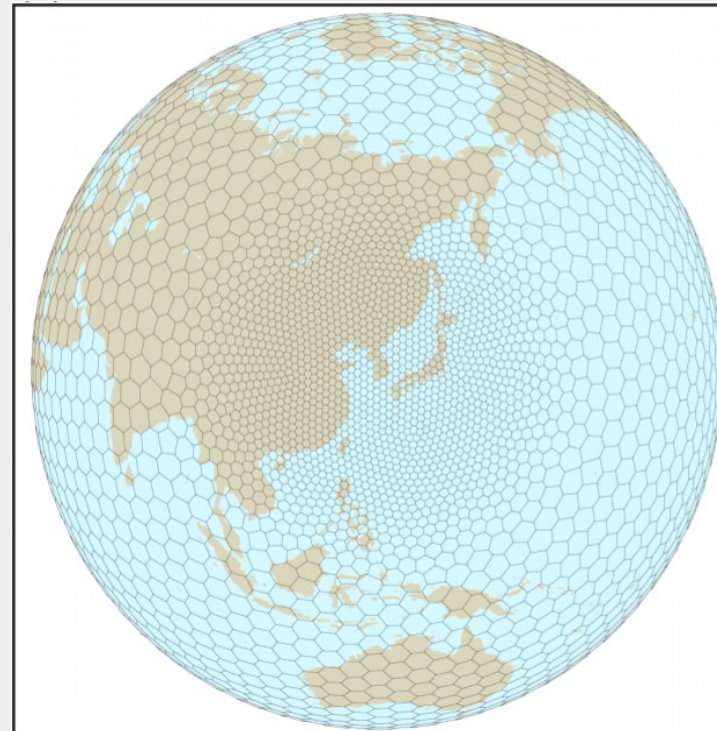
MPAS MESH

- Unstructured 2D horizontal grid:
Spherical Centroidal Voronoi Tessellation
- Regions are cut from global meshes
→ they can have variable resolution
- **Seamless interaction between scales**

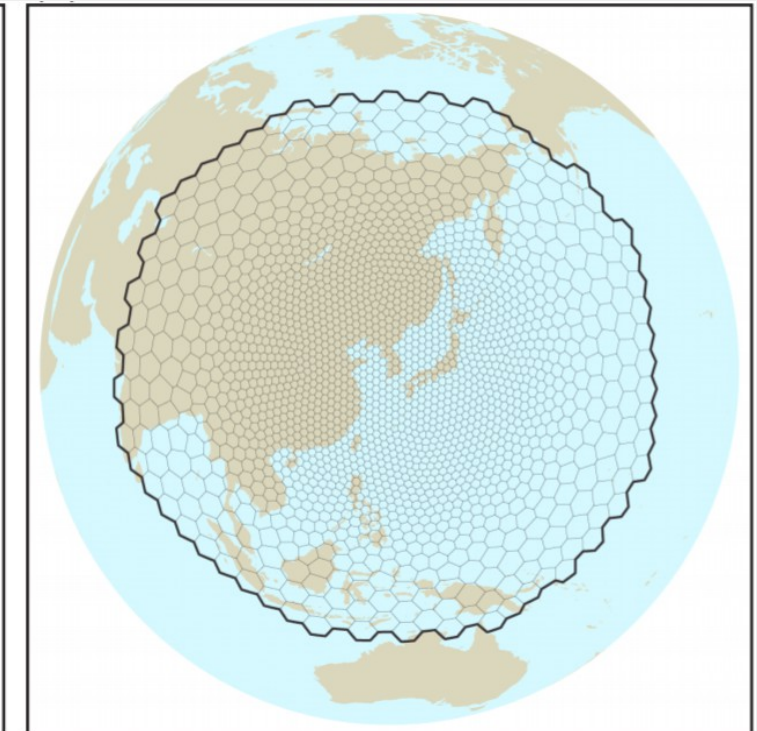
Generation:

Iterative process (Lloyd's method) to generate an approximated valid mesh from a user-defined density function.

Global



Limited Area (since version 7)



Source: DOI:10.5772/55922

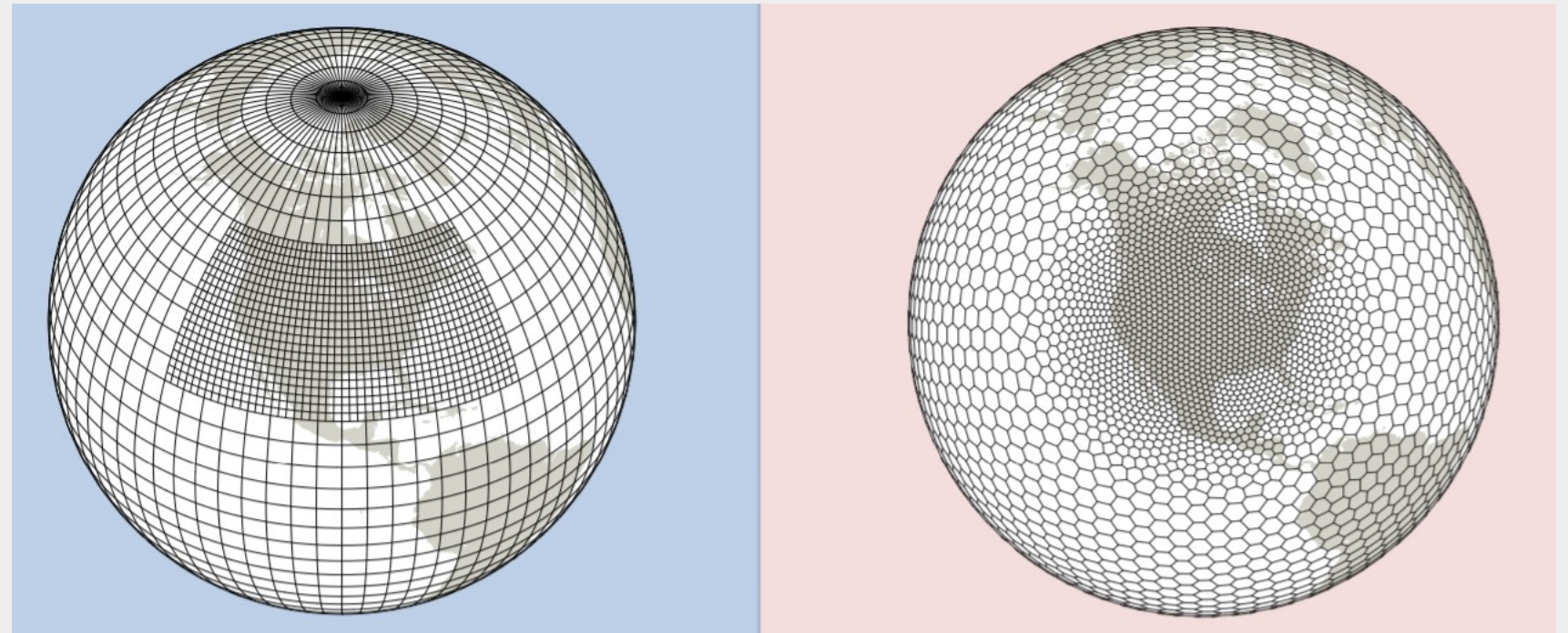


Why a new model?

Why MPAS?

It solves some WRF limitations:

- Deformation due to projections
- Flow distortion at nest boundaries
- Poor interaction between scales
- Poor scaling on parallel computers
- Polar filtering needed



Source: MPAS Tutorial



Why a new model?

Wind Resource Assessment in MPAS

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

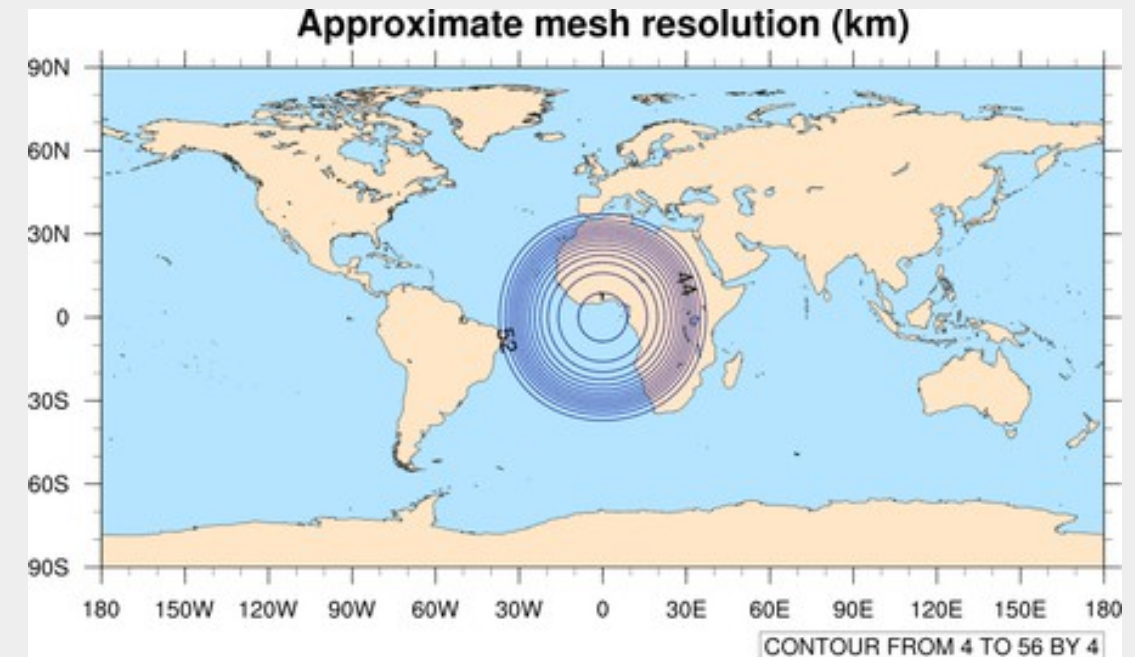
- Required MESH:
 - Variable resolution mesh
 - Central high resolution area to improve the accuracy of the results.
 - Smooth transition from central resolution (high) to low resolution (reanalysis).
 - Smallest possible number of cells to reduce computation cost and time.

Why a new model?



We are not there yet

- MPAS does not release a mesh generation tool
- Several meshes are available for download:
 - Quasi-uniform meshes
 - from 480km to 3km resolution
 - Variable-resolution meshes
 - Can be rotated



Source: MPAS available meshes

- Best available candidate: 3km- 60km mesh

Too time consuming

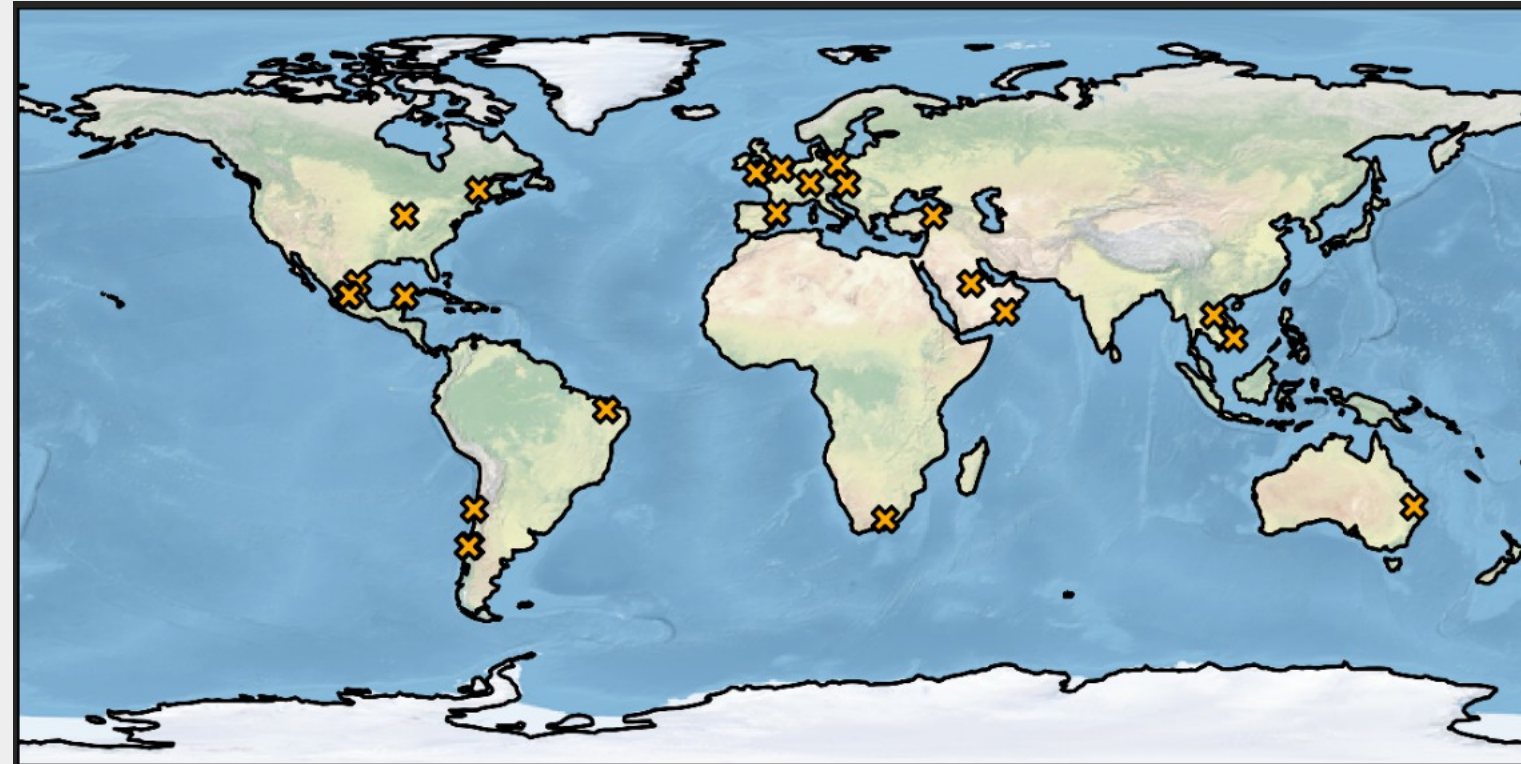
Validation of wind towers



23 sites

4 simulations by site:

- 1 year
- ERA5 reanalysis



MPAS	mpas.15.200	mpas.10.150
resolution	15 km	10 km
radius	200 km	150 km

WRF	wrf.9.wn	wrf.9.nn
resolution	9 km	9 km
nudging*	yes	no

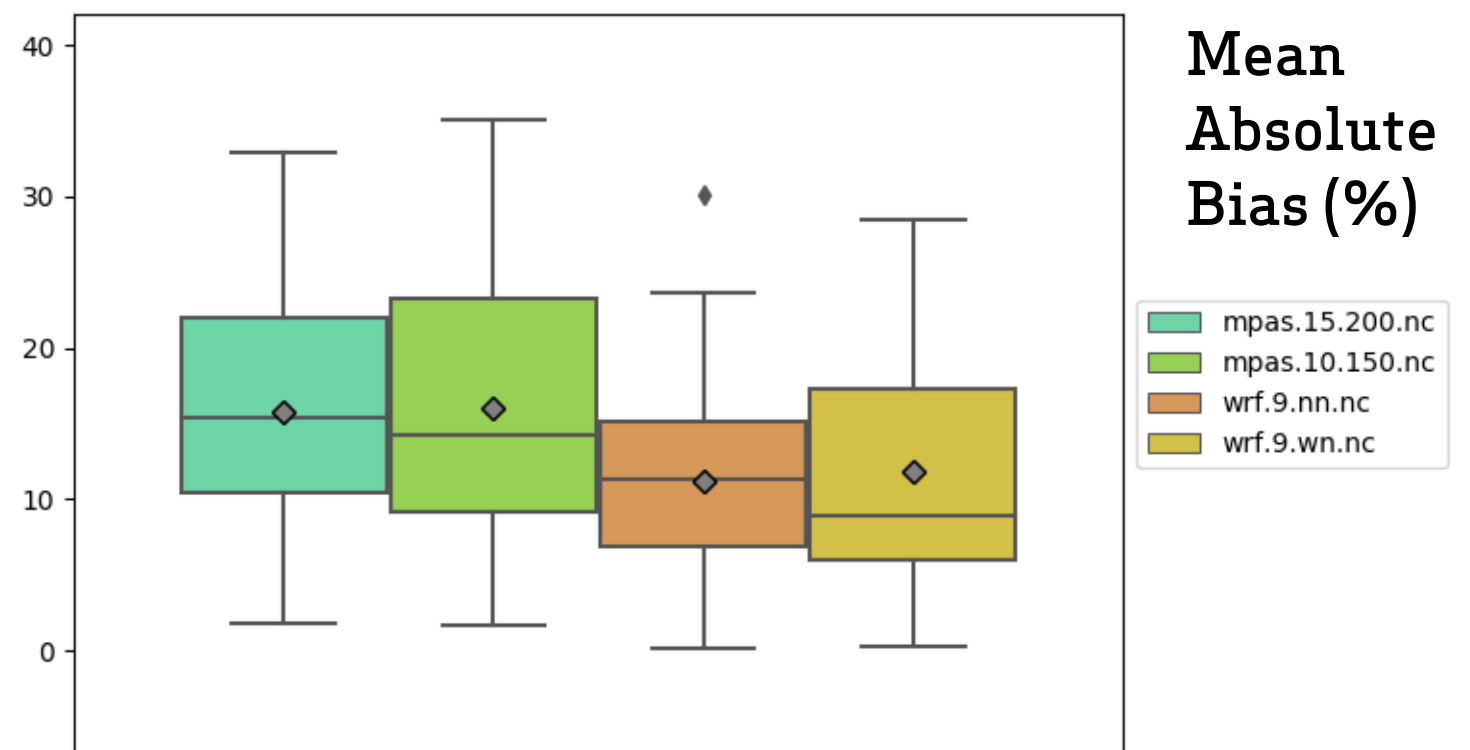
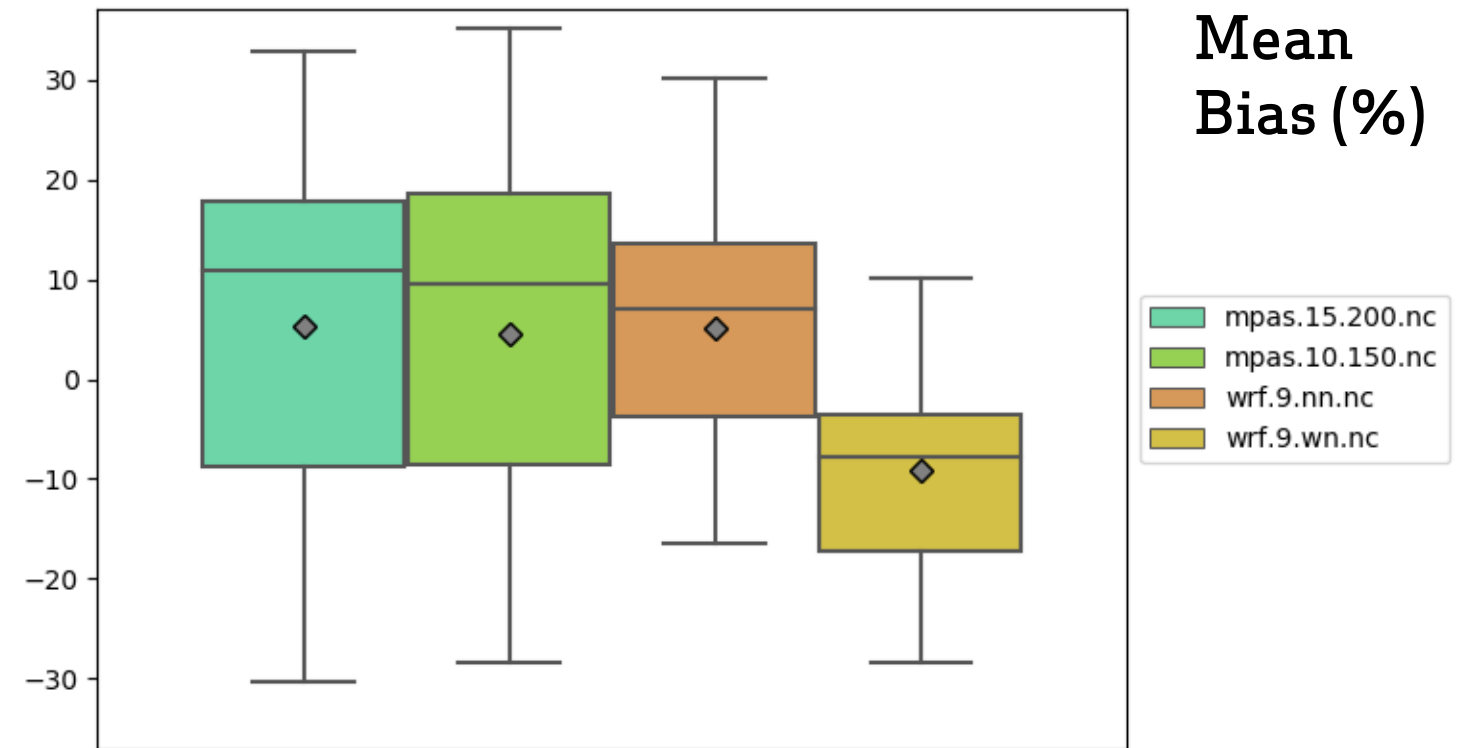
Results

Wind speed bias (%)

	Mean bias (%)	Mean absolute bias (%)
mpas.15.200	5.36 ± 17.50	15.78 ± 8.70
mpas.10.150	4.55 ± 18.28	16.07 ± 9.26
wrf.9.nn	5.08 ± 12.52	11.16 ± 7.32
wrf.9.wn	-9.07 ± 11.09	11.77 ± 8.01

- High bias are expected due to resolution
- MPAS results are spread wider than WRF and very similar for both simulations

20-06-10



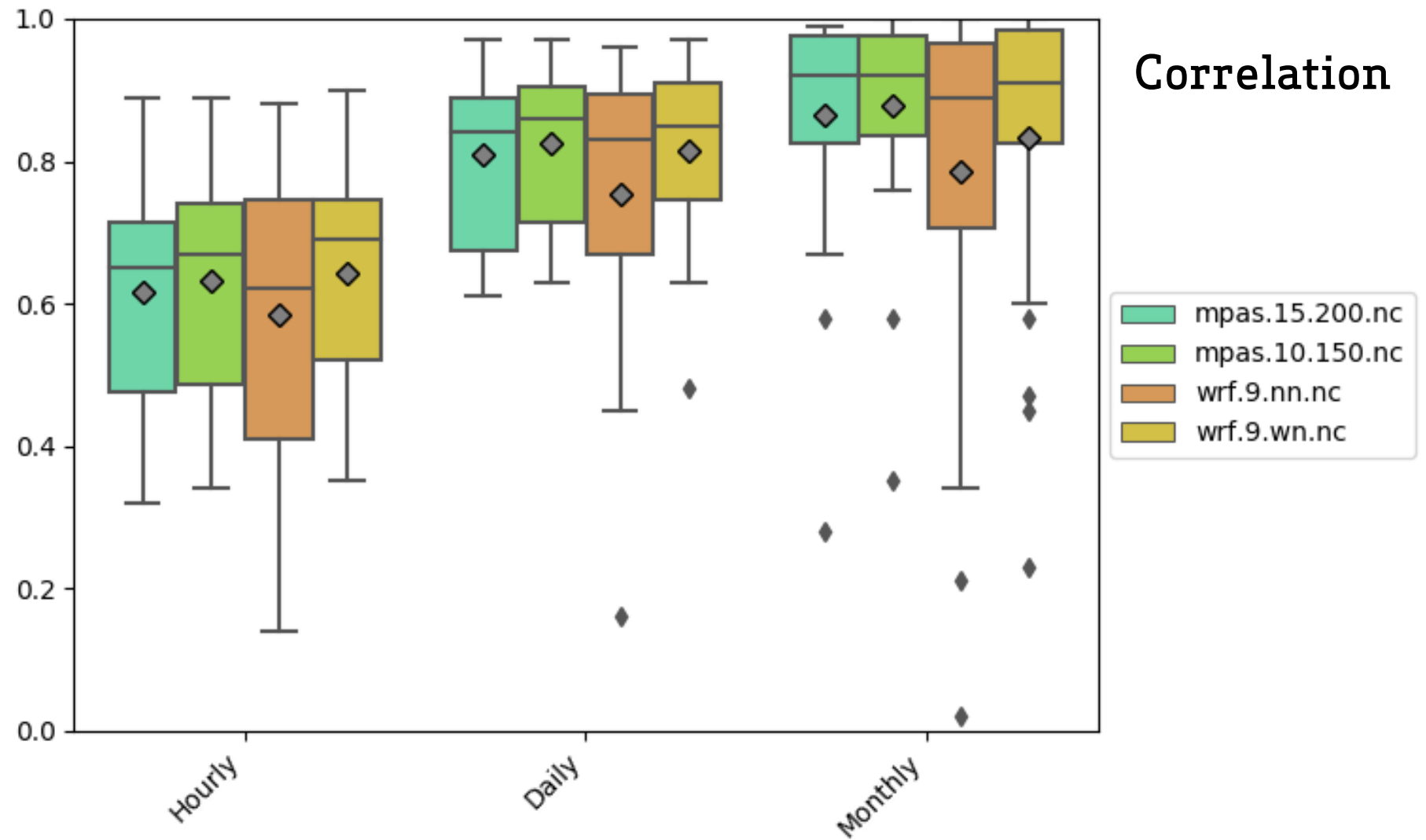
Results



Correlation with wind data

	Hourly	Daily	Monthly
mpas.15.200	.62 ± .16	.81 ± .11	.86 ± .17
mpas.10.150	.63 ± .16	.82 ± .10	.88 ± .15
wrf.9.nn	.58 ± .21	.75 ± .20	.78 ± .27
wrf.9.wn	.64 ± .16	.82 ± .12	.83 ± .21

- Both MPAS simulations (without nudging) correlate better than WRF simulations, even when nudging is applied.

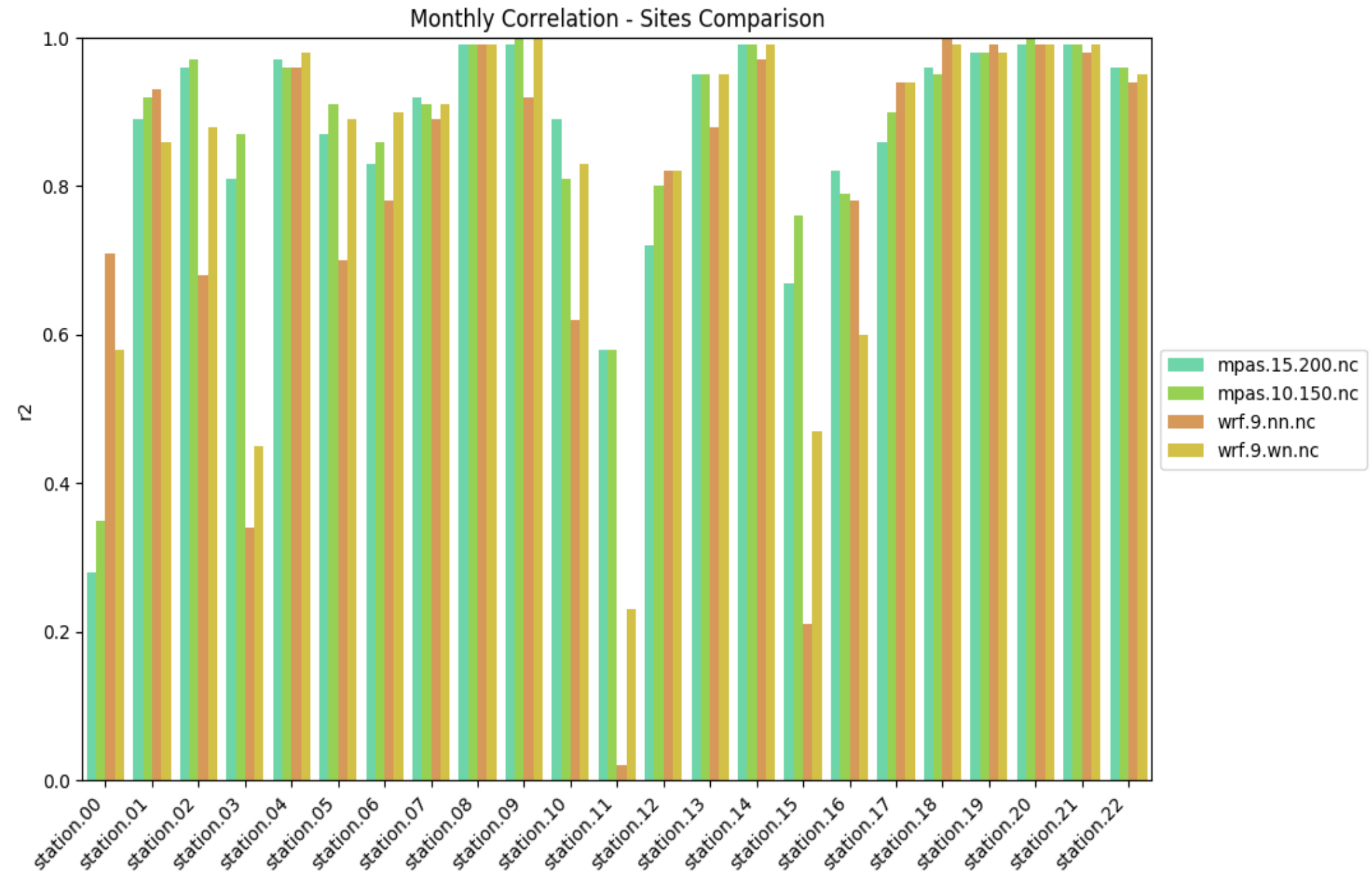


Results



Monthly Correlation. By Sites.

- There are 3 sites where WRF without nudging gives less than 0.4 correlation. Nudging improves a little bit and MPAS performs significantly better.
- In station.00 the opposite happens.



Results



Computation: One Core

	Grid preparation time (min)	Average simulation 30h (min)
mpas.15.200	30	15
mpas.10.150	40	18
wrf.9.nn	0.5	12
wrf.9.wn	0.5	12

- MPAS is prepared to be run in parallel
- The test simulations were run using one core because of Vortex cluster current behaviour.
- Using one core, MPAS does not seem to go faster than WRF (for a comparable number of grid cells)

Conclusions & Next Steps



- Right now there are limitations/doubts:

- The available meshes only reach 3km resolution
- Limited Area regions contain many cells due to a lack of suitable global meshes
- No nudging available.
- MPAS does not seem to go faster than WRF (without parallel computing)

- Some interesting ideas:

- Excellent monthly correlations: does MPAS grid structure capture the long term and large scale characteristics better?
- Parallel computing may be the key to run longer and more demanding simulations



Next Steps & Conclusions

New Version of MPAS coming up

It is interesting to follow the development and perform further tests.

Thank you for your attention

Questions?

