WESC 2021
25 – 28 MAY web conference from Hannover

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The Pragmatic Choice of Wind Model in Complex Terrain – Decision Tool Development

WESC2021 Mini-Symposium "The pragmatic choice of wind models for Wind Resource Assessment"

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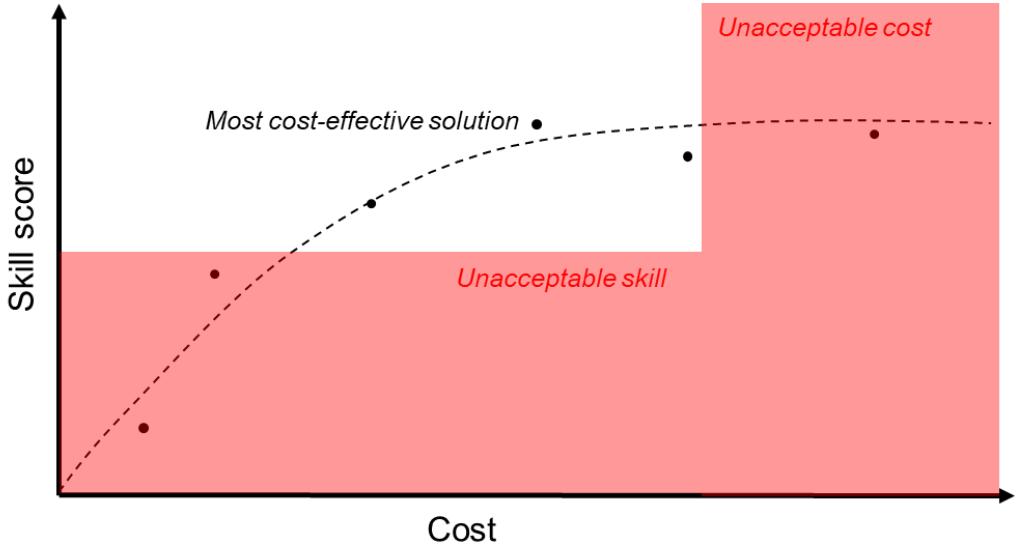
Contents

- The problem and the proposed solution.
- Project description.
- Simulation set-ups and results.
- Next steps.

The problem and the proposed solution

- **The problem:** Wide range of simulation tools with varying accuracies and costs → which is the best compromise?
- **The solution:** Development of a new decision tool for choosing the most effective WRA workflow for a given project:
  - Predicting costs and skill scores BEFORE carrying out simulations would allow modellers to be able to identify the most cost-effective model for a given project as follows:



Users need to be able to easily make predictions → Google Form survey with "best guess" answers on a scale of 0-100% → skill and cost estimation parameters.

Estimations are probably dependent upon terrain complexity → complex flow score.

(See my other WESC2021 presentation "Reducing the uncertainty of Wind Resource Assessments through a new complex flow scoring system")

The project

Development of a new decision tool for choosing the most effective WRA workflow for a given project

Weighted parameters → skill and cost "before"

RMSE between measurements and simulations → skill "after"

IEA Wind Task 31 Comparison metrics simulation challenge

Stage 1

Site 1: Perdigão

Stage 2 – on-going

Open

Initial study on Bolund Hill → Definition of parameters and comparison metrics process → Application to five sites → Decision tool design → Decision tool test

E.g. Complexity of mathematical model, quality of calibration method, grid size, convergence quality, AEP method, skill of user, license costs, set-up effort, run-time

Site 2: Stötten

Site 3: ewz

Site 4: Enercon

Site 5: ADEV

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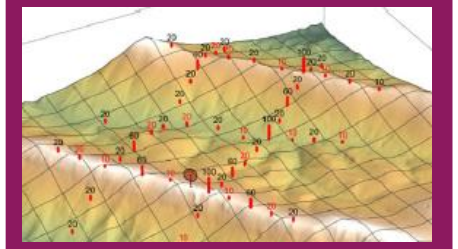
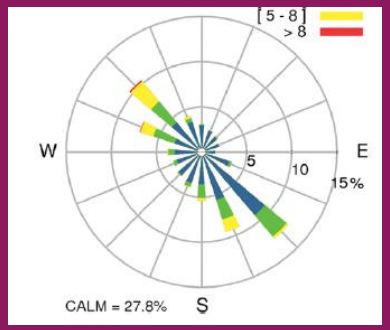
The five sites

1. Perdigão

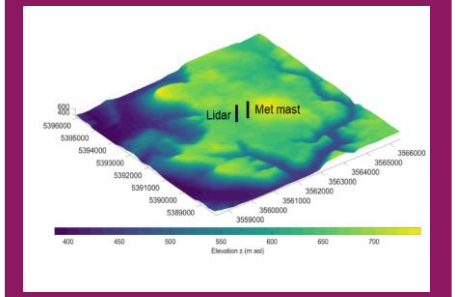


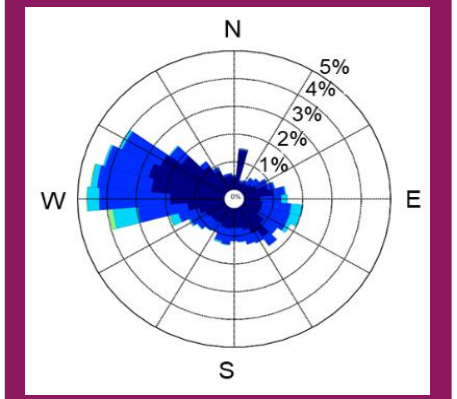


Portugal

Calibration: met mast 29
Validation met masts 25 and 20

2. Stötten

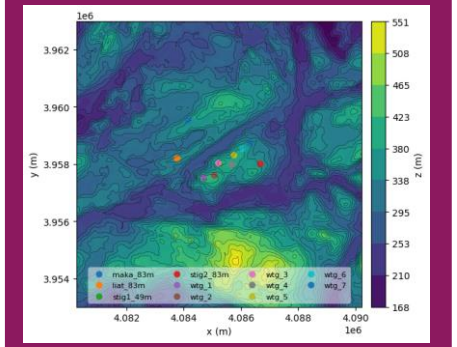


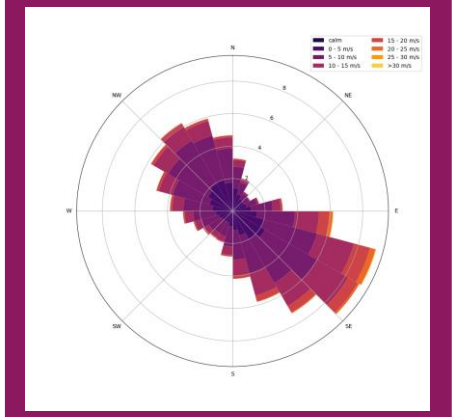


Germany

Calibration: met mast
Validation: lidar

3. ewz

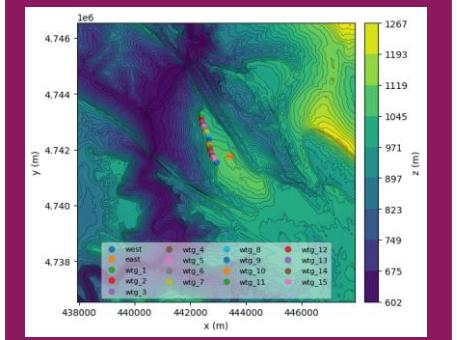


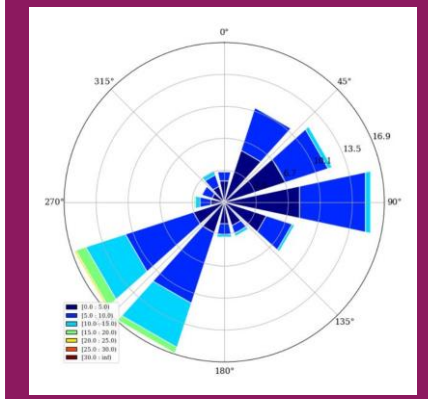


Norway

Calibration: met mast STIG2
Validation: met mast STIG1

4. Enercon

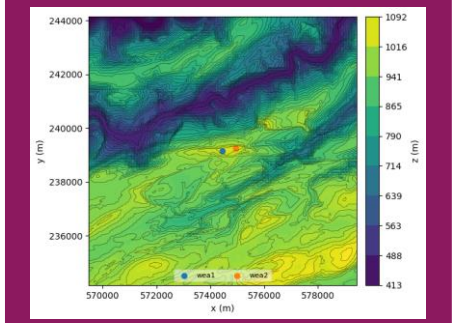


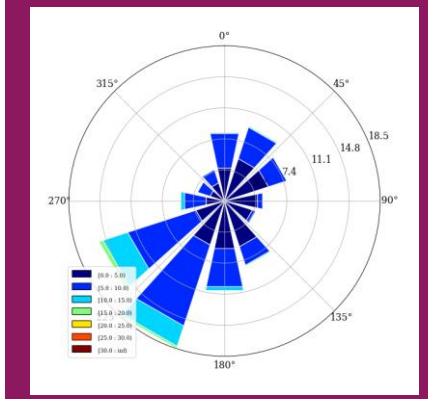


Spain

Calibration: met mast WEST
Validation: met mast EAST

5. ADEV





Switzerland

Calibration: WTG1
Validation: WTG2

The applied workflows

- Site 1 (Perdigão), part of an IEA Wind Task 31 simulation challenge:

Name	Organisation	Model	Description
UTD_UTD-WF_sim01	University of Texas at Dallas	UTD-WF	In-house high-resolution large-eddy simulation code
UTD_UTD-WF_sim02	University of Texas at Dallas	UTD-WF	With canopy model
org01_model01_sim01	Anonymous	Anonymous	Structured mesh
org01_model01_sim02	Anonymous	Anonymous	Unstructured mesh
org04_model01_sim01	Anonymous	Anonymous	
org08_model01_sim01	Anonymous	Anonymous	K-epsilon turbulence model
org08_model01_sim02	Anonymous	Anonymous	K-kl-omega turbulence model
org08_model01_sim03	Anonymous	Anonymous	K-omega turbulence model
ost_fluent_sim01	OST	Fluent RANS	In-house automated workflow
ost_wasp_sim02	OST	WAsP	
QAIR_MeteoDyn_sim01	Freelancer	Meteodyn	

The applied workflows

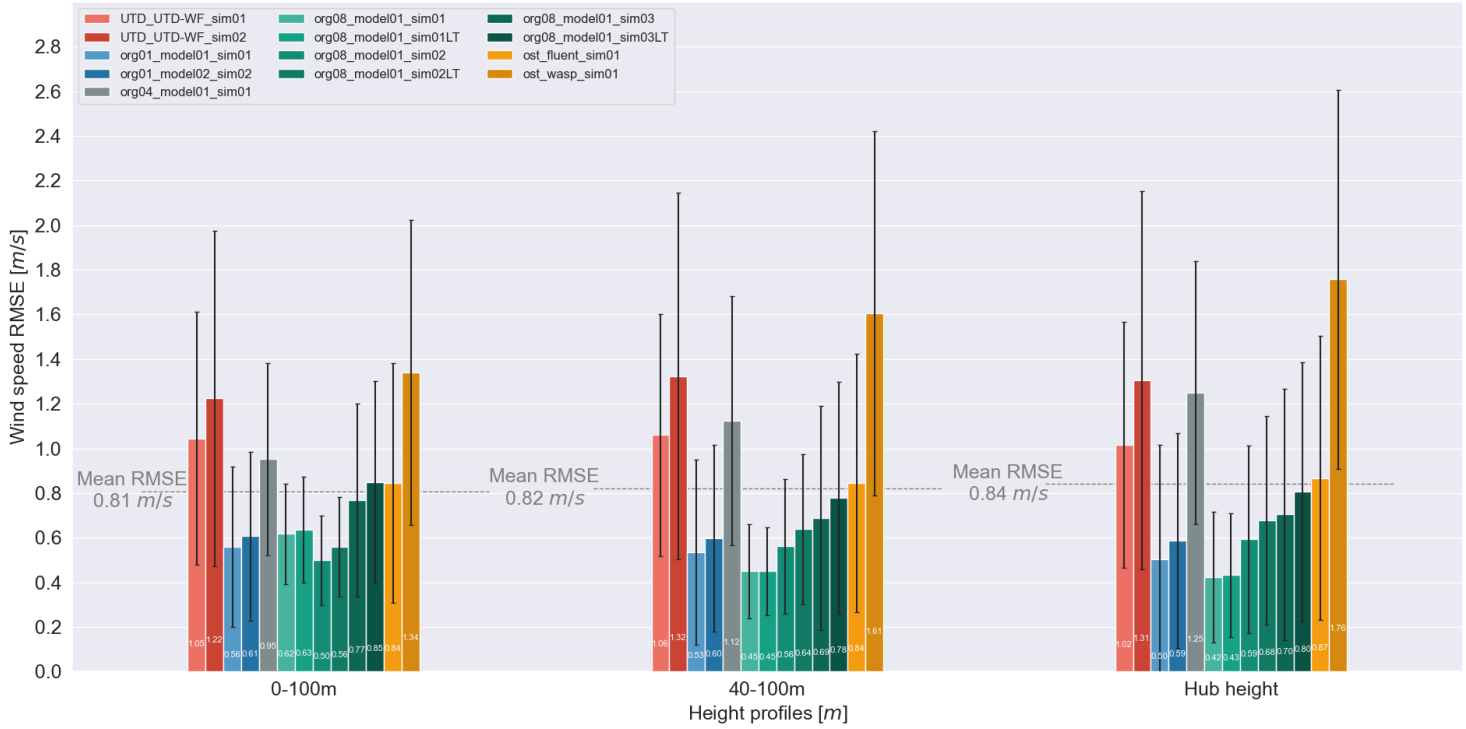
- Sites 2-5: part of joint research project between OST, Meteotest and Hochschule Esslingen:

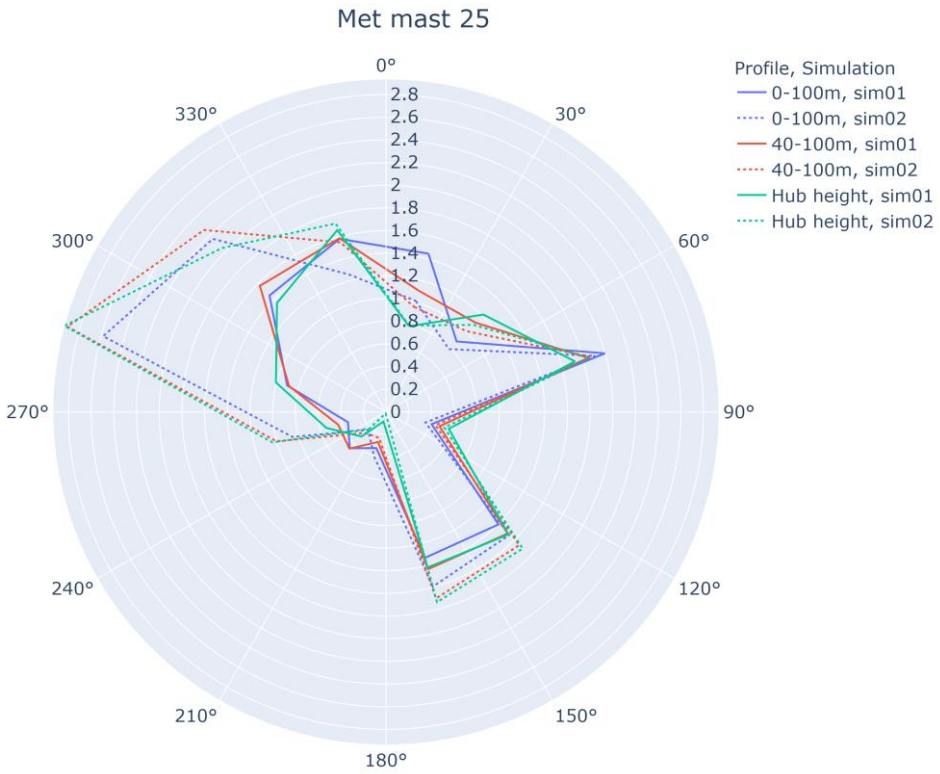
Name	Organisation	Model	Description
WF-1	Meteotest	WindPro	Standard industry tool (linear model)
WF-2	Meteotest	WindSim	Standard industry tool (RANS CFD)
WF-3T	HSE	CFX	Steady-state RANS CFD (with flow turning)
WF-4	OST	Fluent RANS	Steady-state RANS CFD (without flow turning)
WF-4T	OST	Fluent RANS	Steady-state RANS CFD (with flow turning)
WF-5a	OST	Fluent SBES	Unsteady SBES (without flow turning)
WF-5aT	OST	Fluent SBES	Unsteady RANS SBES (with flow turning)
WF-6	Meteotest	PALM	Large-Eddy Simulations
WF-7	Enercon	E-Wind	Steady-state RANS CFD (based on OpenFOAM)

Some simulation results: site 1 (Perdigão)

- Wind speed profile: mean RMSE between simulations and measurements:

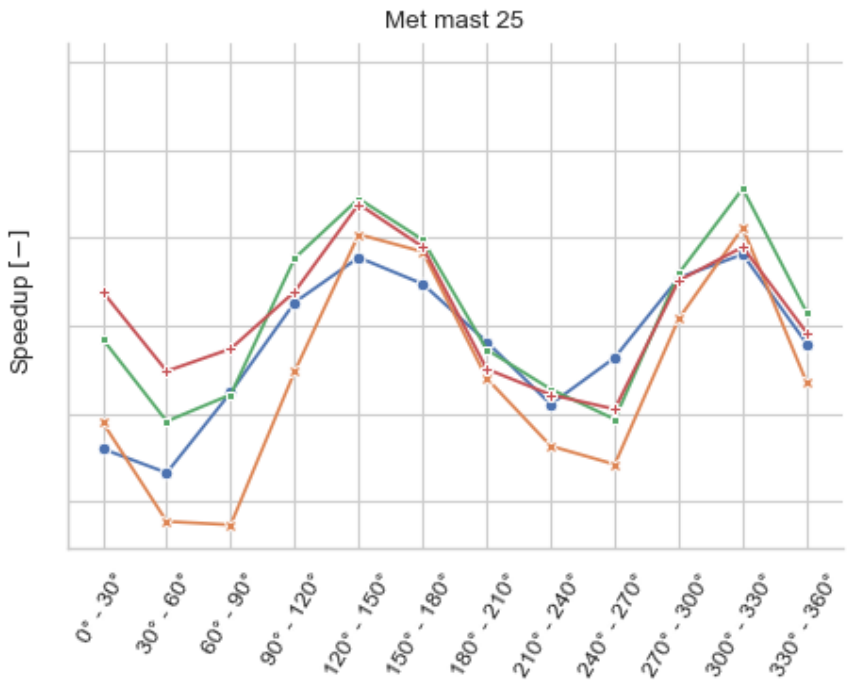
Met mast 25

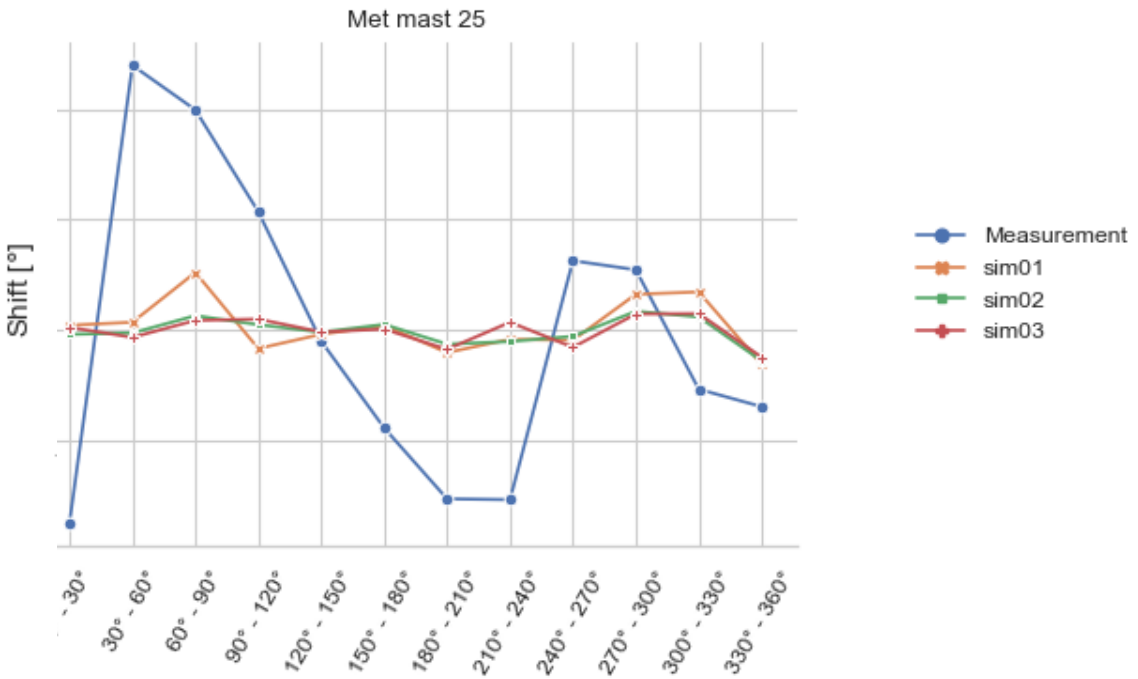




Some simulation results: site 1 (Perdigão)

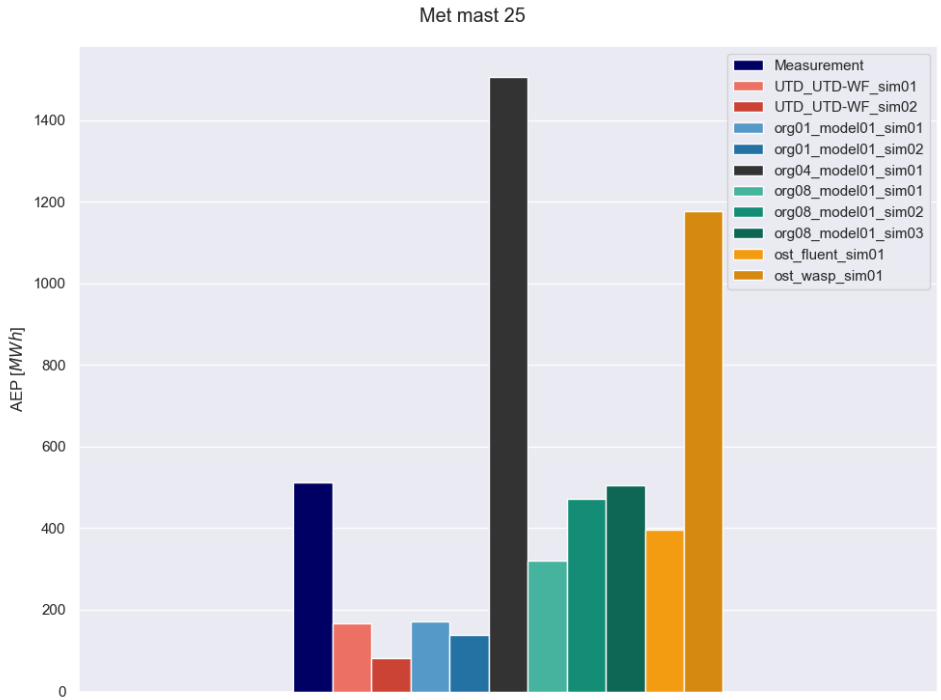
- Speed-up factor and direction shifts compared to mast 29 per sector for org08 (example):

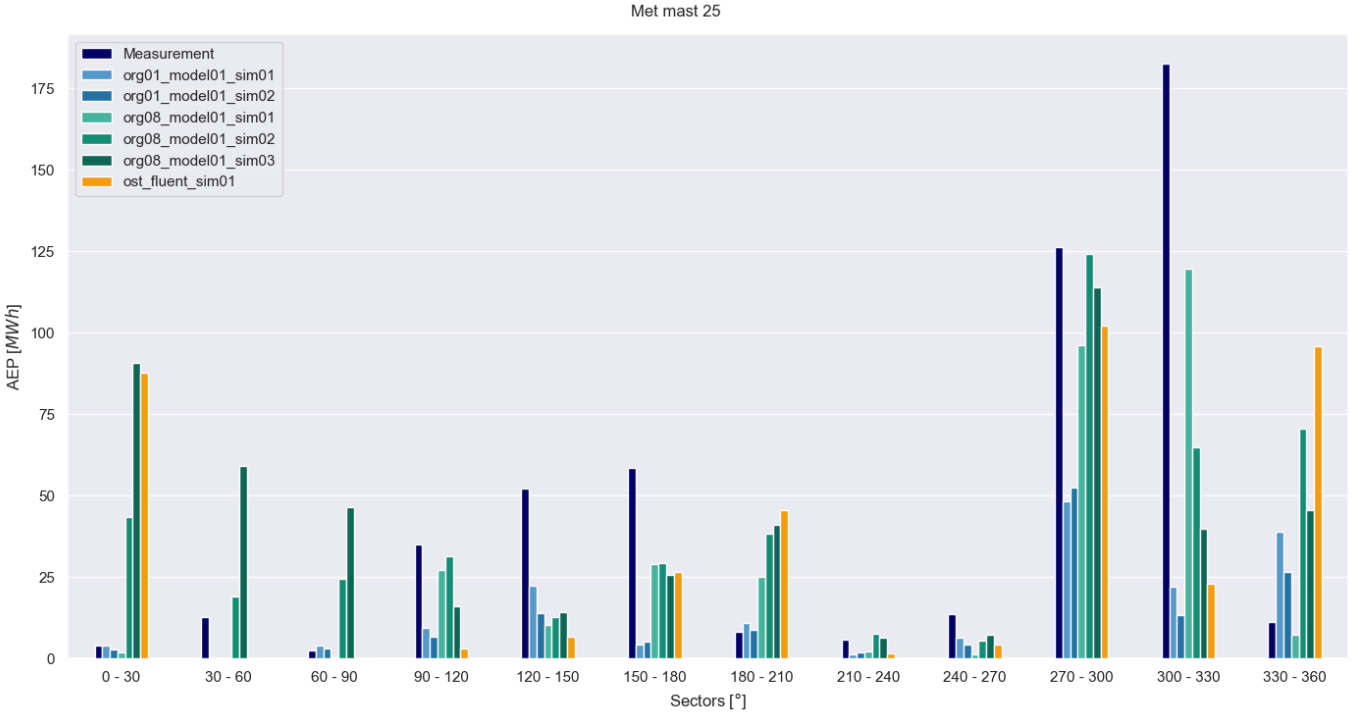




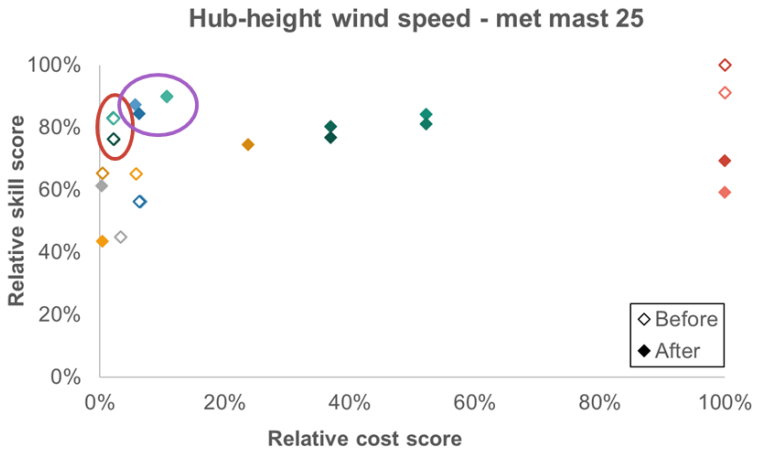
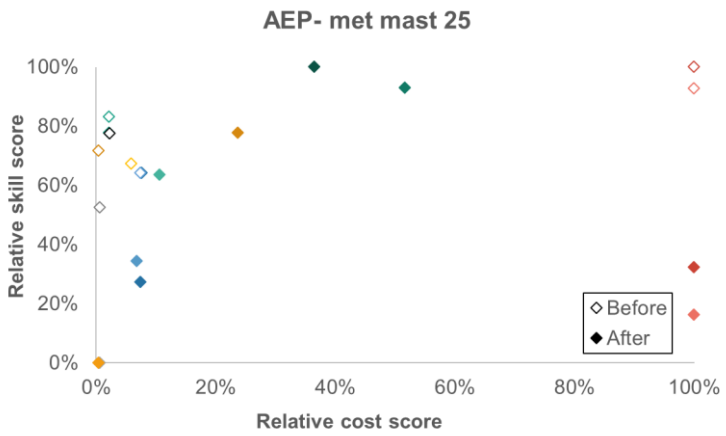
Some simulation results: site 1 (Perdigão)

- Annual Energy Production (AEP) for met mast 25:
  - Enercon E-82 (2 MW).
  - "Measurement" = theoretical value calculated from measurement data multiplied by power curve.





Comparison metrics results (site 1)

1. Perdigao			Flow complexity score: *51% ± 20%*
	Wind speed prediction quality*: *5*	AEP prediction quality*: *6*	

Prediction: org08 "most effective"

Reality: org01 and org08 "most effective"

Prediction: ost_wasp_sim01 and org08 "most effective"

Reality: org08 and ost_fluent_sim01 "most effective"

**Mast 25*

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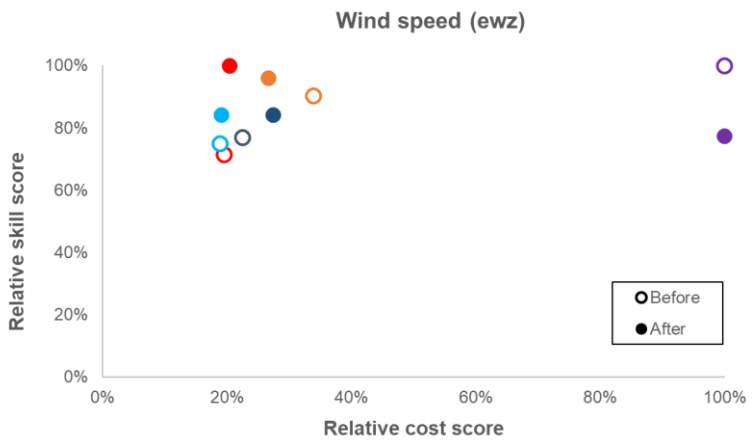
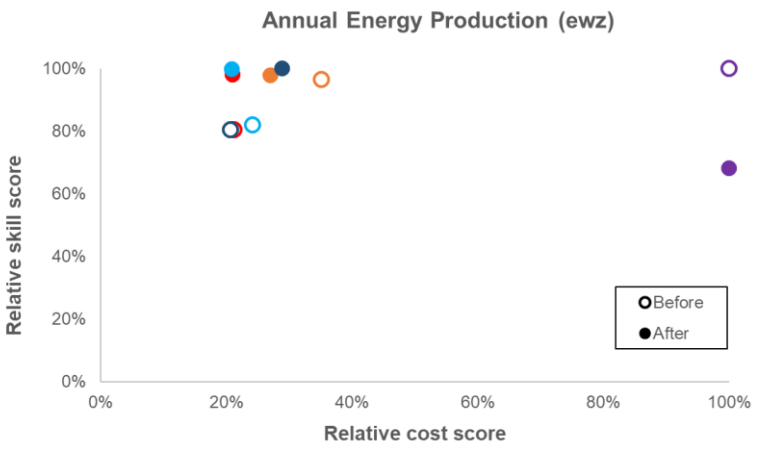
Comparison metrics results (site 3)

- WF-1
- WF-2
- WF-3T
- WF-4T
- WF-5aT
- WF-6
- WF-7

3. ewz	 	Flow complexity score *41% ± 2%*
	Wind speed prediction quality *5*	AEP prediction quality *7*

Prediction: WF-1 and WF-4T "most effective"
Reality: WF-1 and WF-2 "most effective"

Prediction: WF-1 and WF-4T "most effective"
Reality: WF-1 and WF-4T "most effective"

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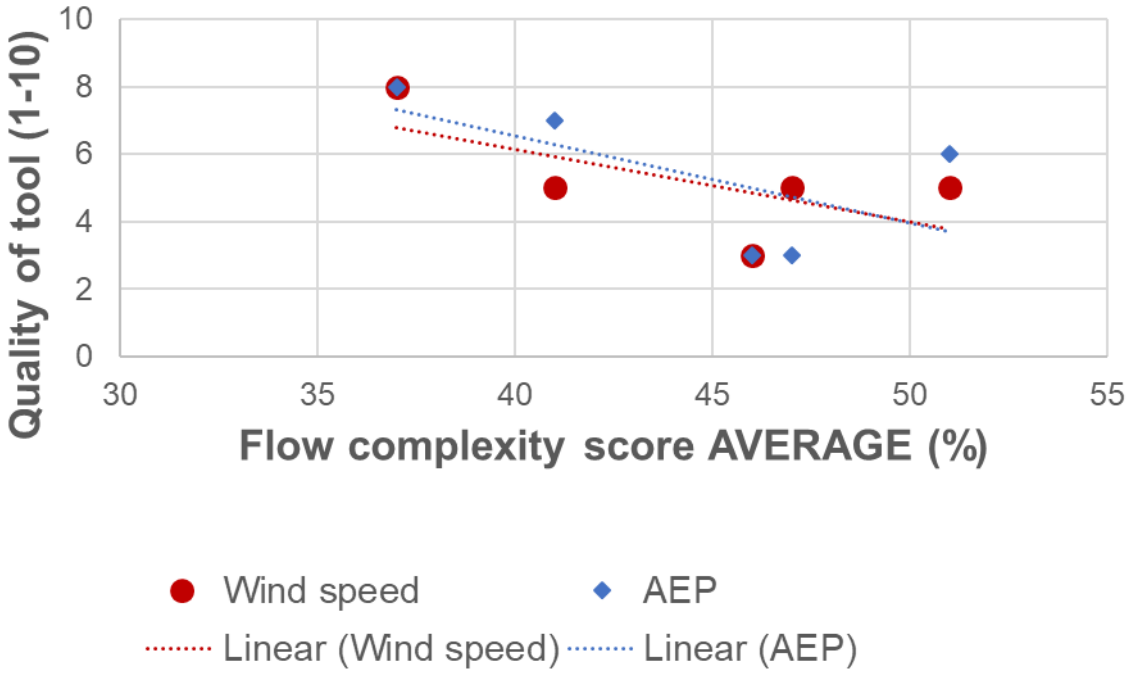
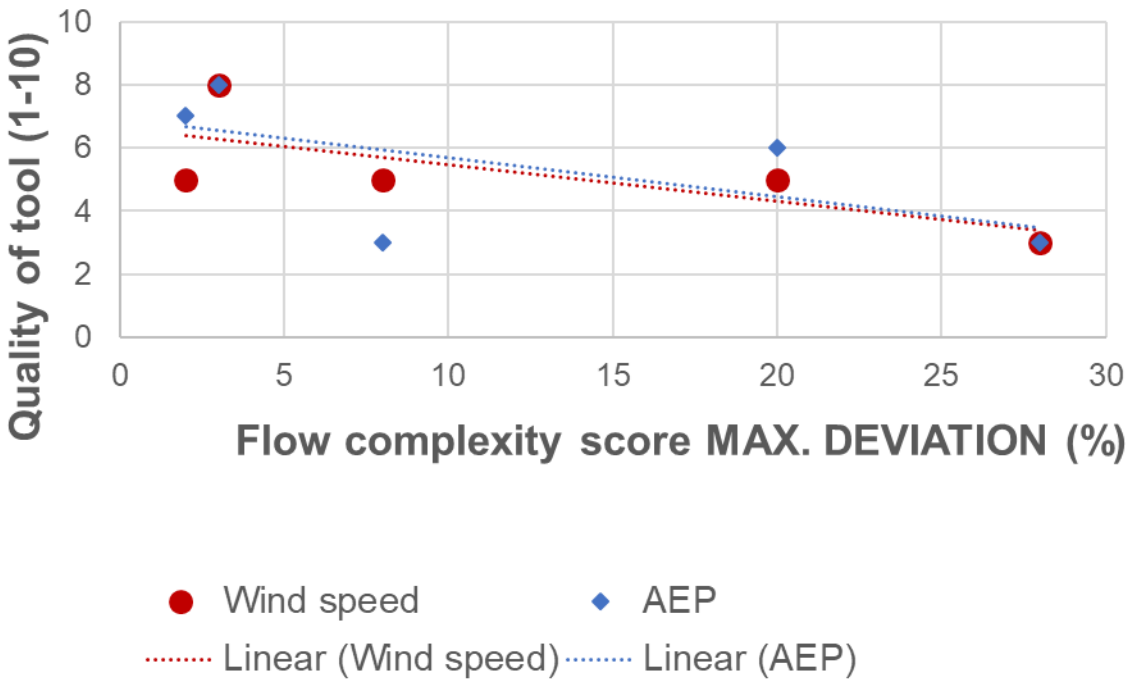
Summary of results





Summary of results

- Conclusions:
  - The method is promising but more analysis is needed.
  - Self-assessment of performance parameters leads to inconsistencies.
  - The "quality" of the decision tool is inversely proportional to flow complexity (the fit isn't great).
  - Some parameters should be weighted according to flow complexity.
- Therefore the new tool will:
  - Transfer model descriptions directly to cost and skill predictions.
  - Include "confidence scores" in the model descriptions.
  - Include weighting of factors due to complex flow classification.
  - Have improve complex flow classification

Next steps

Contribute to our new challenge in collaboration with IEA Wind Task 31

Comparison metrics microscale simulation challenge for wind resource assessment – Stage 2

- Participants asked to submit results of **already existing simulations and WRAs for any site**.
  - Pre-defined template and survey:
    - Details of the site.
    - Tool set-up.
    - Your experience.
    - Estimated set-up and simulation costs.
    - Resulting wind speeds and/or energy production at a location for which measurement data is available.
  - Our decision tool will then estimate skill and cost scores of the submitted results using pre-defined weighted parameters, as well as classify the flow complexity.
  - We will compare the results to the actual skill of the simulations, obtained by comparing the results to the provided measurements. This will help us refine the decision algorithm, parameter weightings and complex terrain classification method.
- The challenge is being run on the new **WeDoWind platform**, which allows goal-oriented collaboration based on real industry challenges. The full challenge description and templates are available on the platform. You can also use the platform to exchange ideas and experience with other participants - and to communicate with the organisers.
- You can register to take part below by May 28th 2021 at the latest. We will be in touch before the end of May with platform access information, which will be provided for free: https://www.wedowind.ch/blog/cm-challenge-stage2

Thank you for your attention!

sarah.barber@ost.ch

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