WIND KNOWLEDGE | IS WIND POWER

Meso-microscale coupling

WindSim 15th User Meeting, Tønsberg 6 June 2019

windsim

PRESENTED BY: Pablo Duran

In collaboration with:

MAINSTREAM RENEWABLE POWER

e·on

voltalia

Content

- What is meso-microscale coupling?
- Why meso-microscale coupling?
- Meso-microscale coupling in WindSim
  - Solution 1: One case per wind direction
    - Validation sites
    - Results of validation study
    - Limitations
  - Solution 2: Predominant cases obtained by machine learning
    - Preliminary results
- Conclusions and further work

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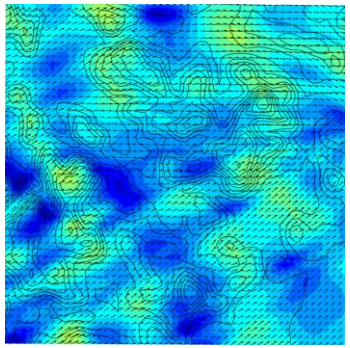
What is meso-microscale coupling?

Meso/Regional Models
WRF (9 - 1 km)

Description of **regional** flows and atmospheric conditions



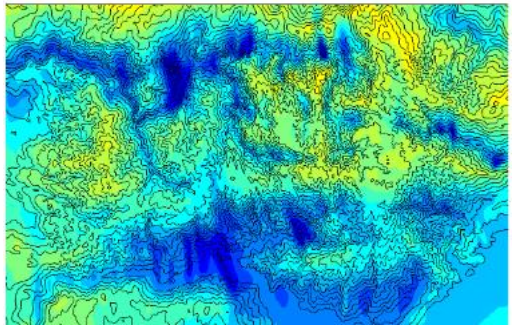
Atmospheric stability

Wind shear

Wind veer

Micro Model
WindSim (100 - 10 m)

Detailed description of **local** flow



Orography

Forest

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Why meso-microscale coupling?

Avoid tuning of model parameters

Monin-Obukhov length (MOL)?

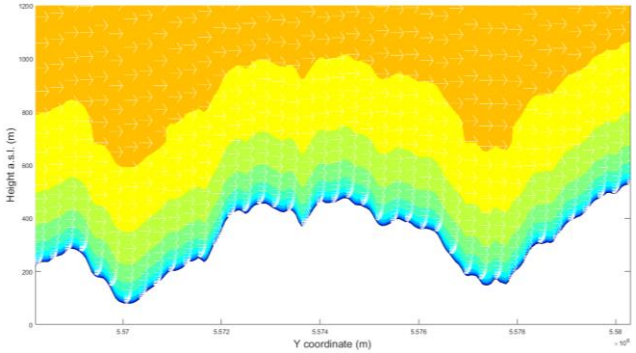
Planetary Boundary Layer (PBL) height?

Wind speed above PBL?

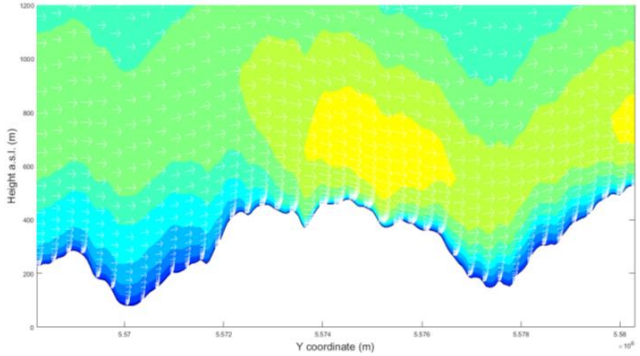
Temperature gradient?

Realistic inlet profiles

Standalone



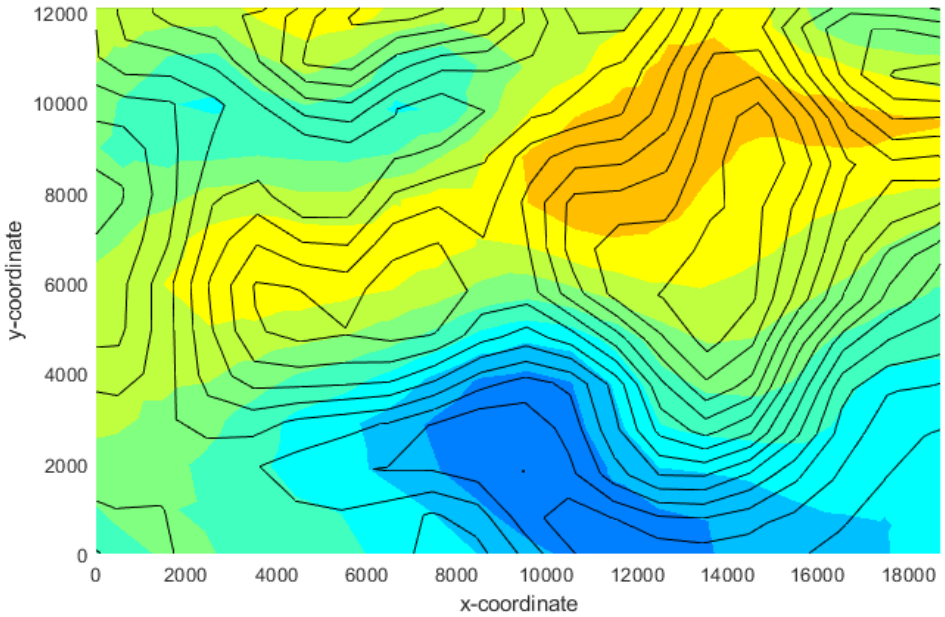
Coupled

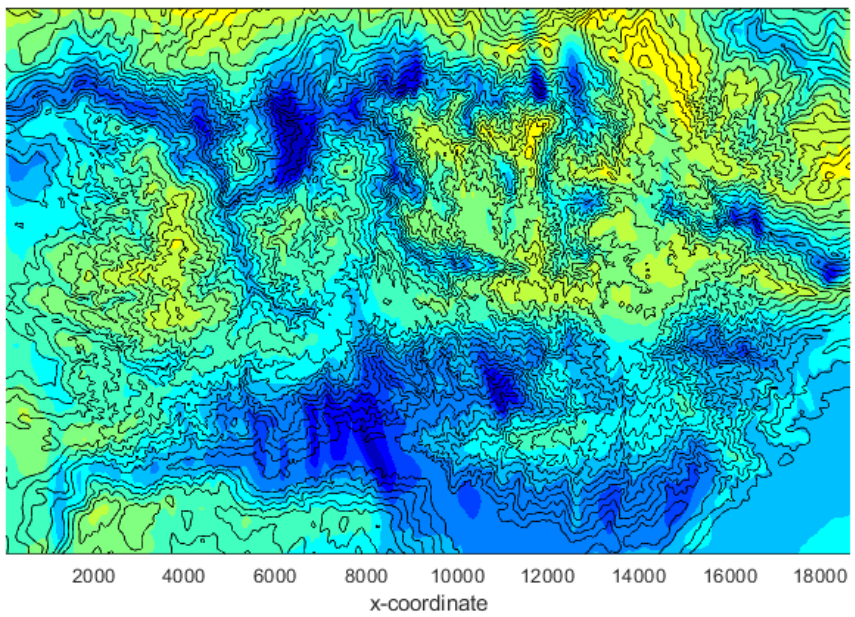


Why meso-microscale coupling?

Modelling of more complex weather patterns

Mesoscale model → Coupled WindSim

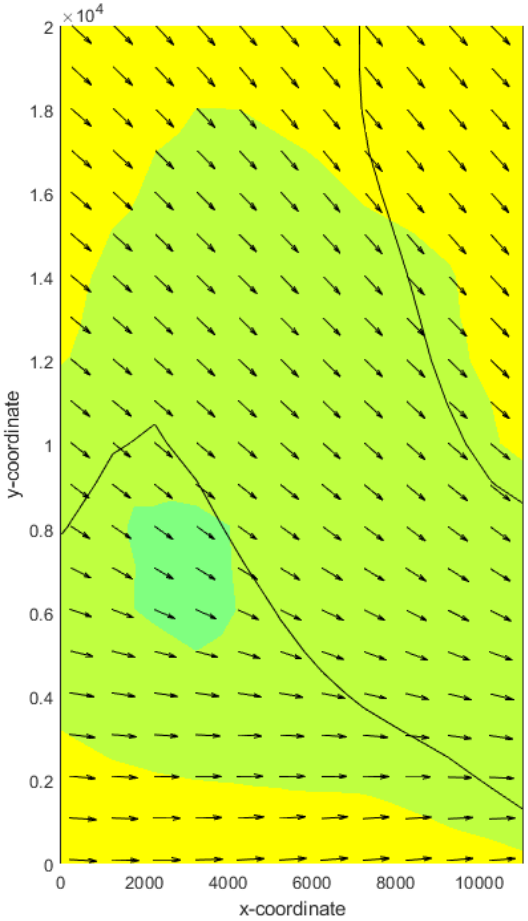




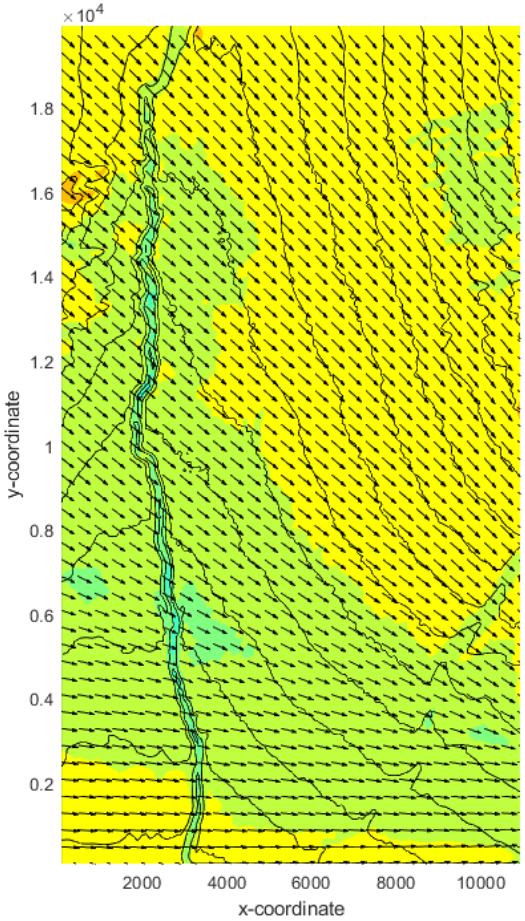
Why meso-microscale coupling?

Inclusion of wind veer

Mesoscale model



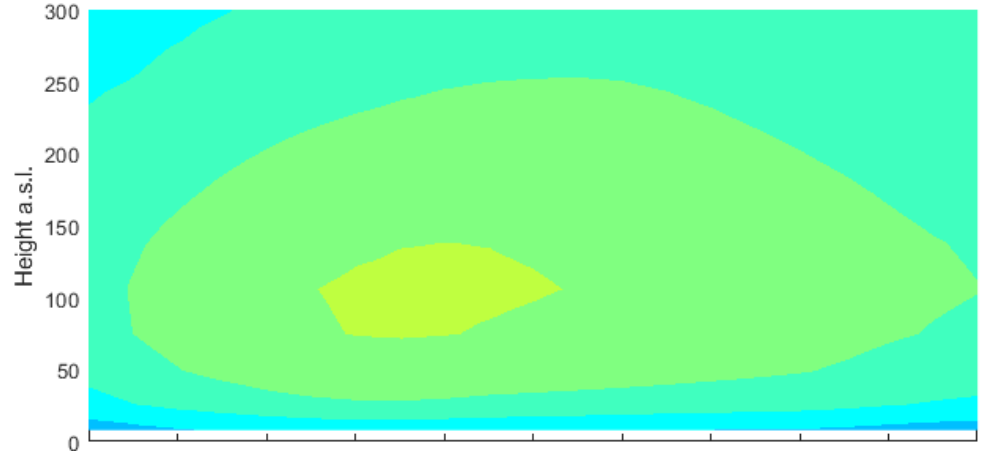
Coupled WindSim



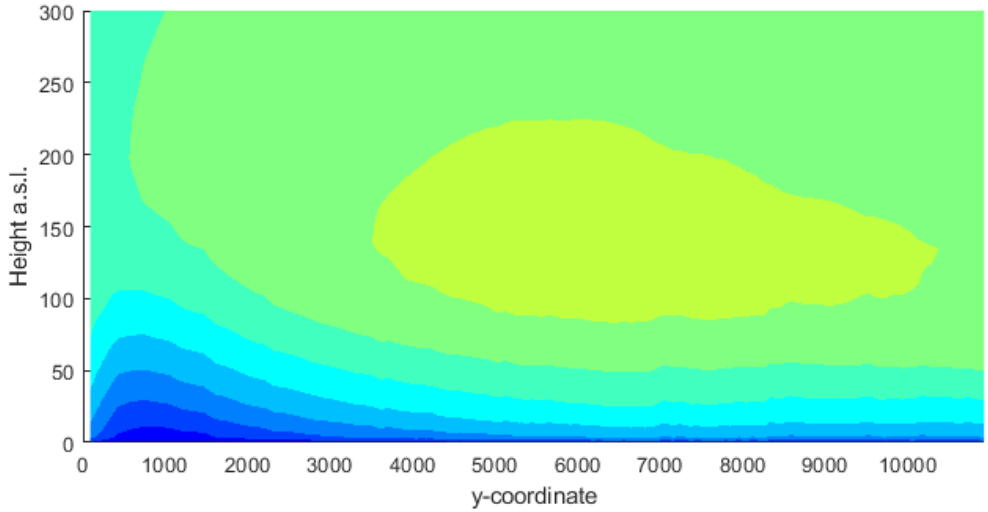
Why meso-microscale coupling?

Inclusion of low-level jets (LLJ)

Mesoscale model



Coupled WindSim

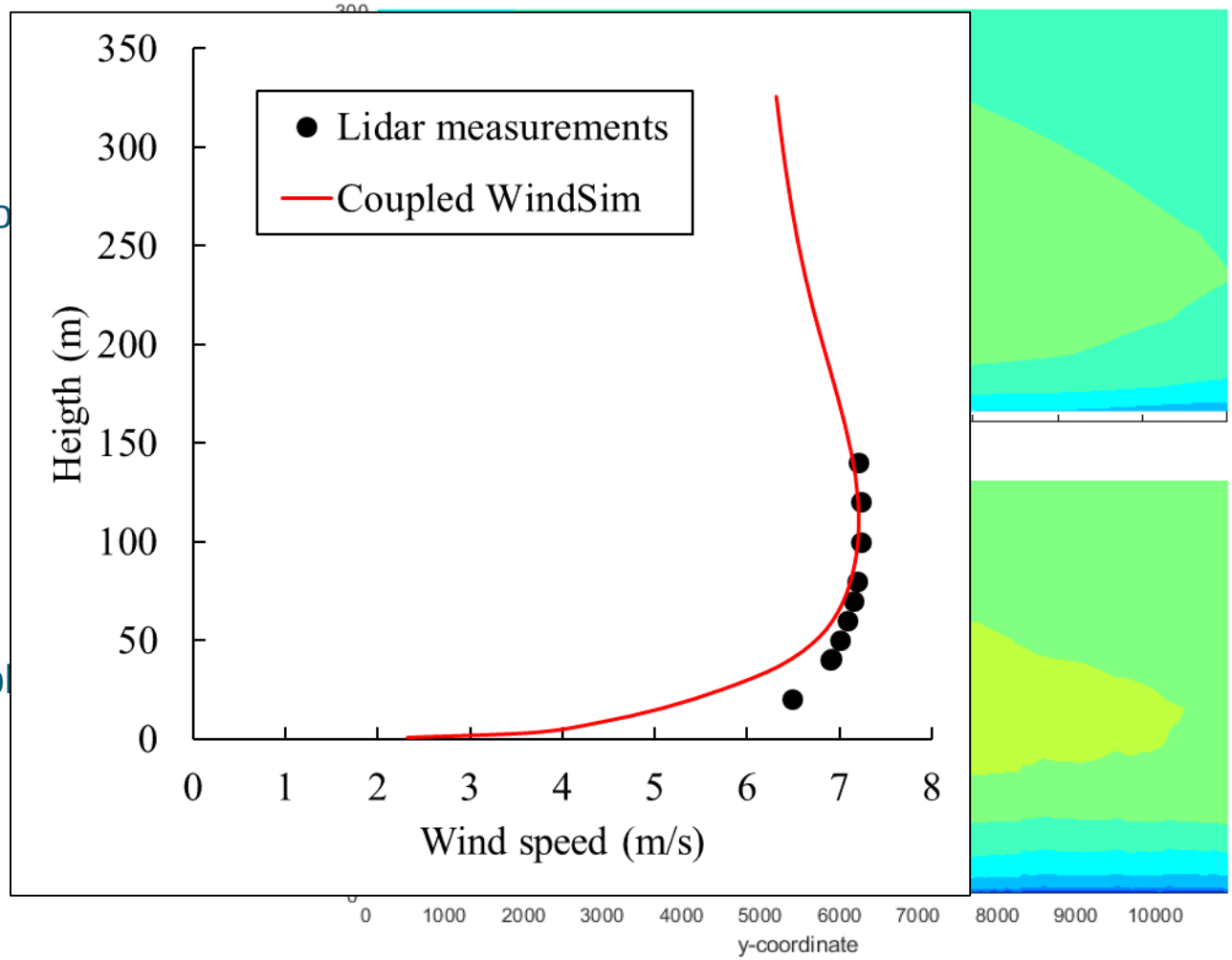


Why meso-microscale coupling?

Inclusion of low-level jets (LLJ)

Meso

Coupl



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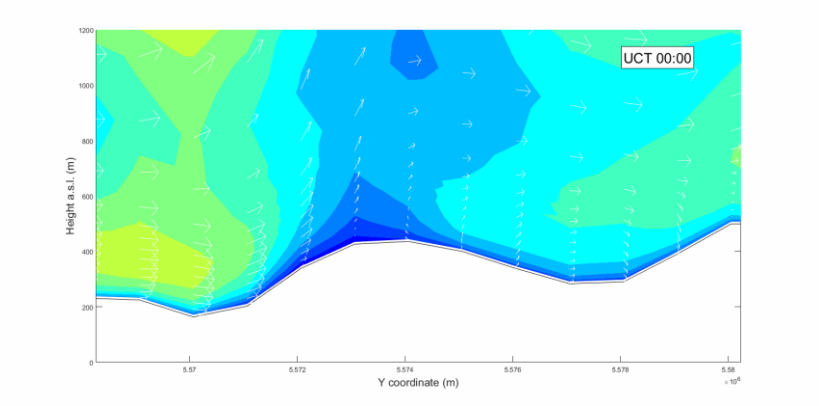
Meso-microscale coupling in WindSim

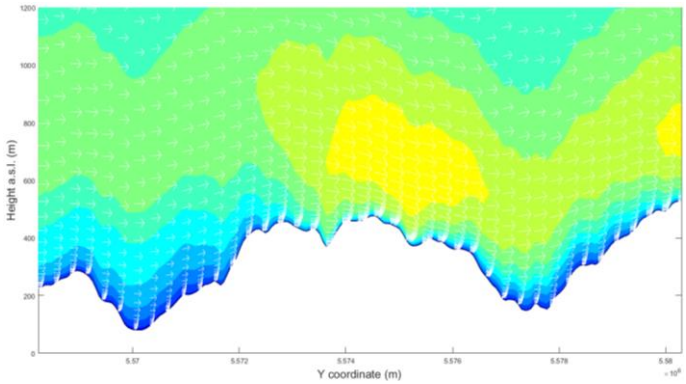
How can we use this meso-microscale coupling for wind resource assessment?

Mesoscale models are transients (time-dependant)



?

WindSim is a steady-state model (static)



Meso-microscale coupling in WindSim

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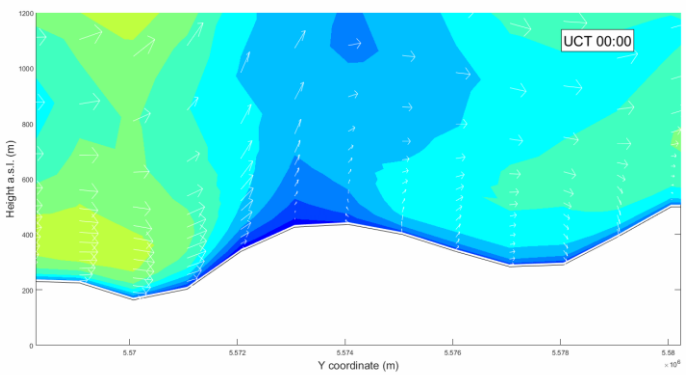

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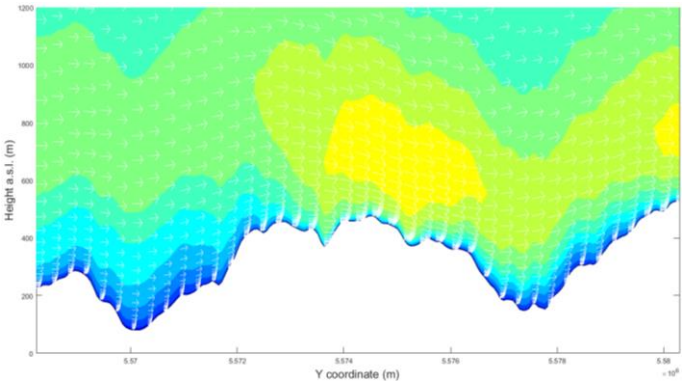

We need to find representative cases!

Meso-microscale coupling in WindSim

Solution 1:
One case per wind direction

- ✓ Easy to implement
- ✓ Post-processing is business as usual
- x Big loss of information (specially for sites with a very predominant wind direction)

Solution 2:
Predominant cases obtained by machine learning

- x More complex approach
- x Post-processing has to be adapted
- ✓ Limited loss of information

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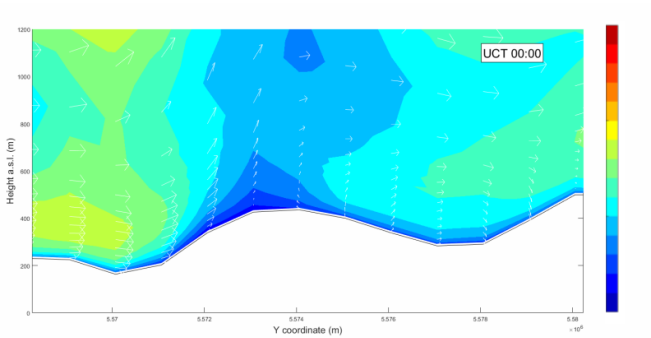
Meso-microscale coupling in WindSim

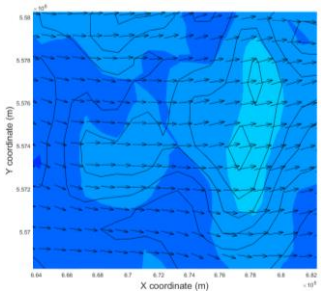
Solution 1:
One case per wind direction

1 year of mesoscale model output

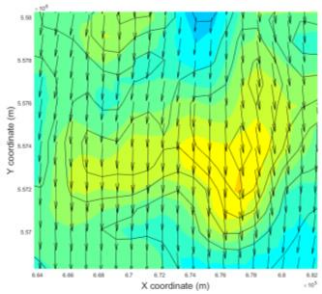
Average timesteps with the same wind direction



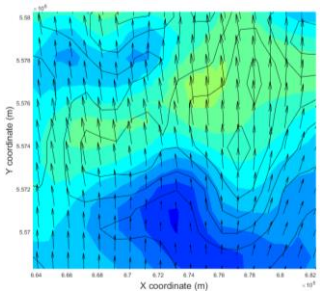
Sector 270°



Sector 0°



Sector 180°



One **averaged** mesoscale field per directional sector

*Processes
*Data

Meso-microscale coupling in WindSim

Solution 1: Validation sites

Name	Location	Terrain	Meteorology	Wind measurements
GB	North America	Flat	Cold climate	6 meteorological masts 1 LIDAR
CM	Southern Cone	Complex, forested	Oceanic climate	2 meteorological masts 2 LIDAR
CL	Southern Cone	Flat	Dry, Coastal, Mountain-valley system	1 meteorological masts 3 LIDAR
CK	Southern Cone	Flat ramp	Dry, Mountain-valley system	2 meteorological masts 3 LIDAR

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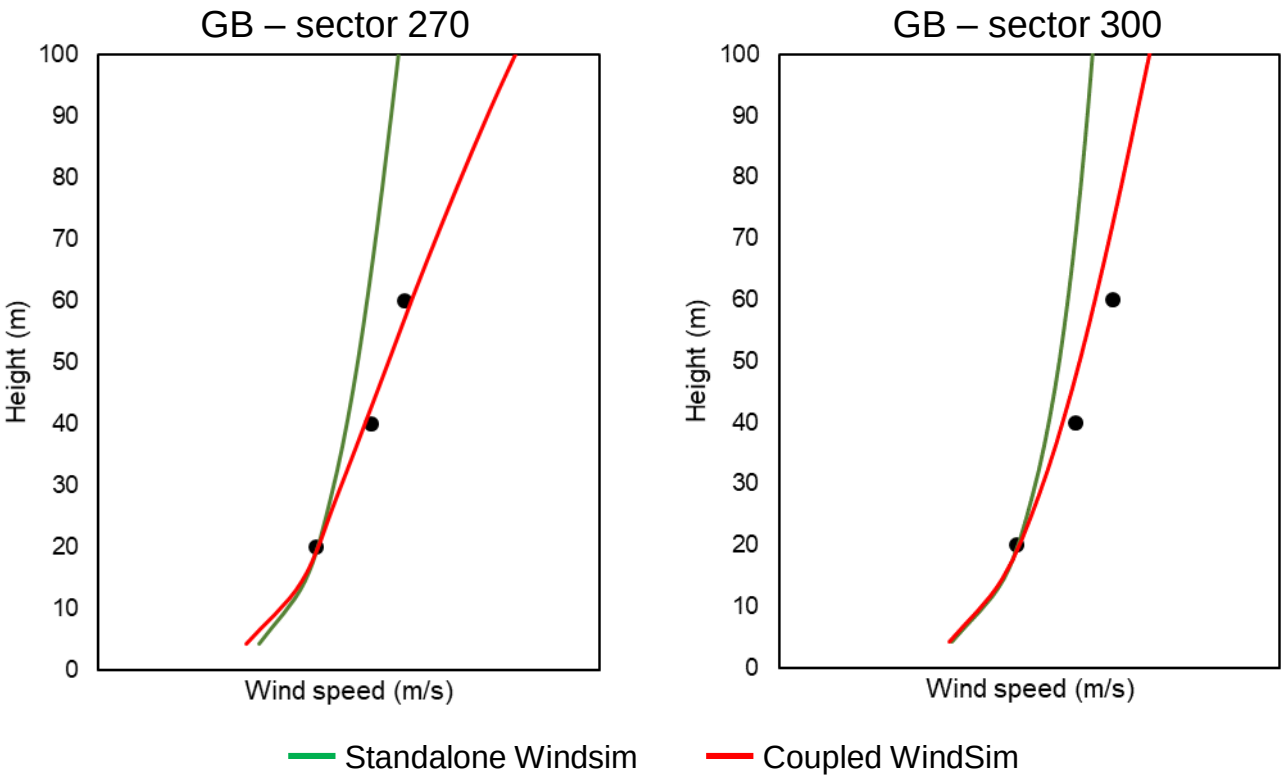
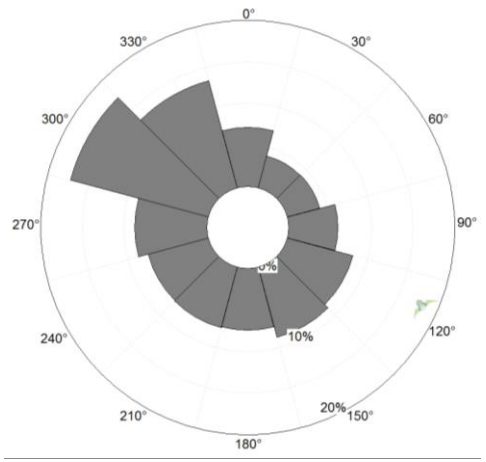
Solution 1: Validation study – Results

Improved vertical profiles – GB site (flat)

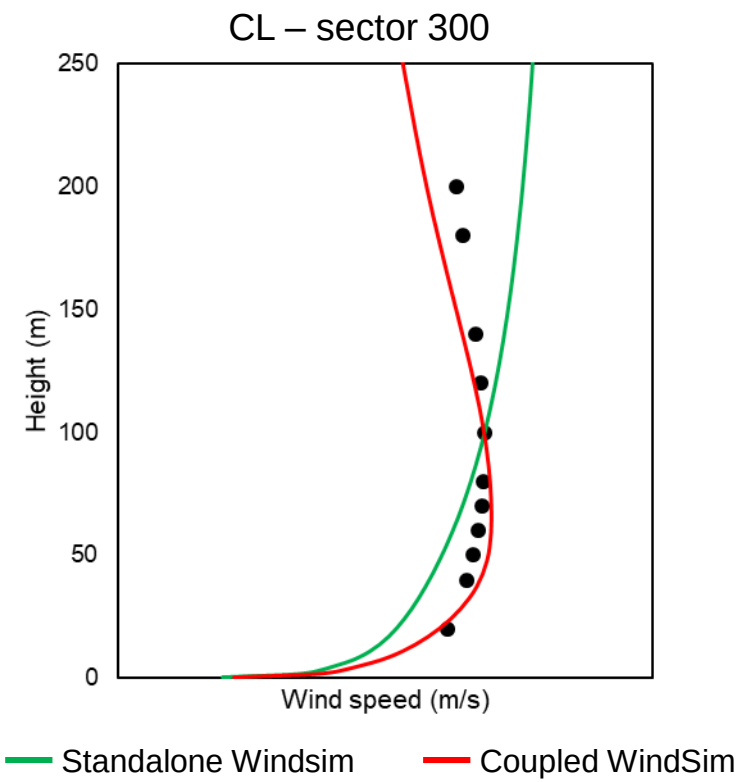


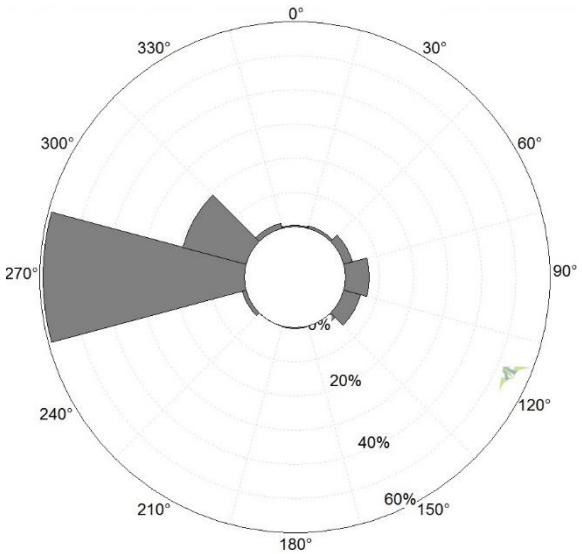


Meso-microscale coupling in WindSim

Solution 1: Validation study – Results

Improved vertical profiles – CL site (flat + strong diurnal cycle)





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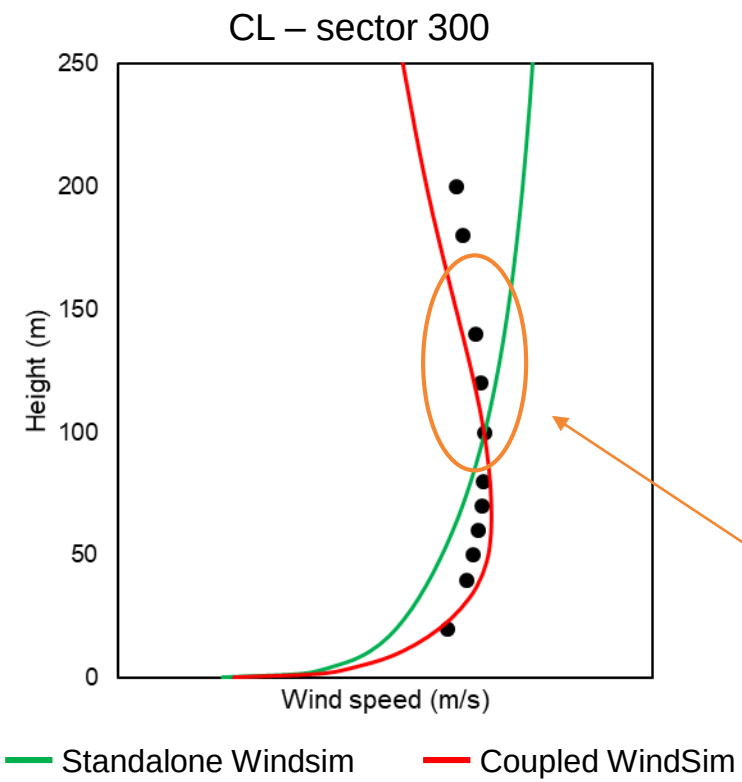
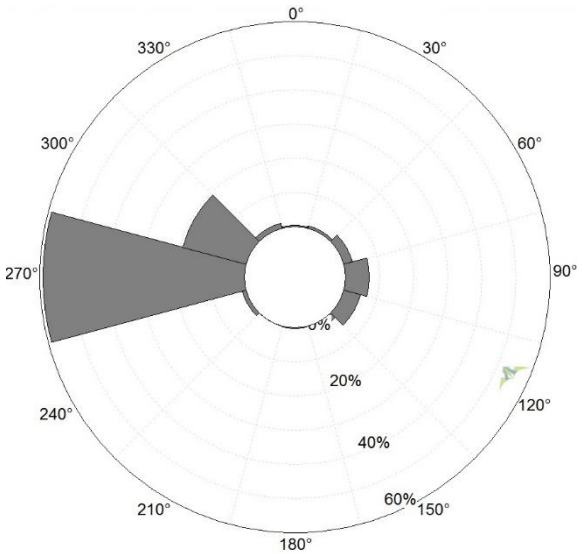
Improved vertical profiles – CL site (flat + strong diurnal cycle)

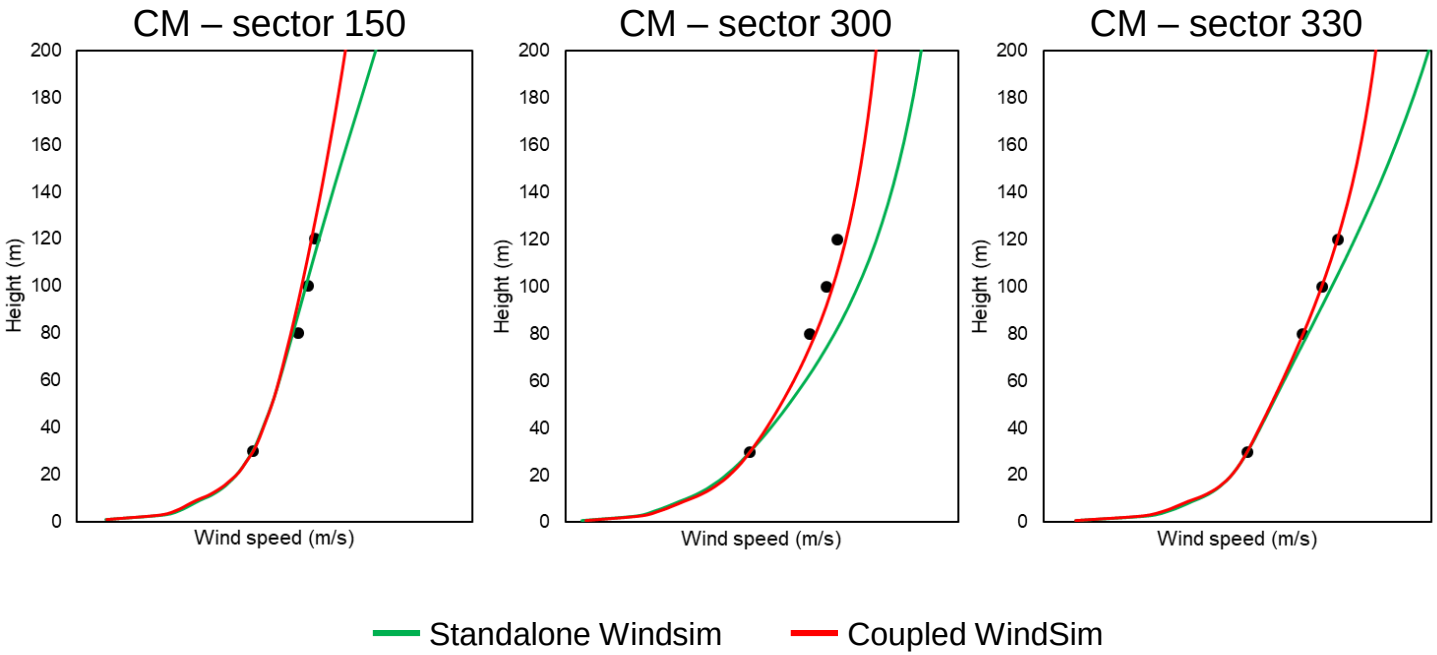


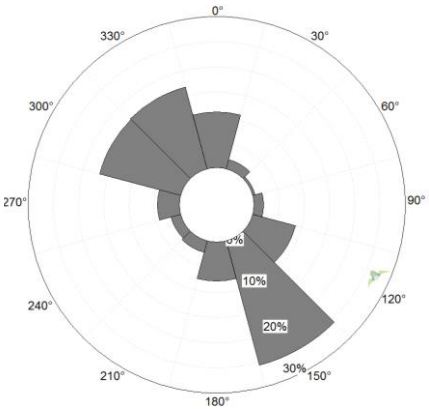


Negative shear is captured. Not possible in standalone WindSim

Solution 1: Validation study – Results

Improved vertical profiles – CM site (very complex)

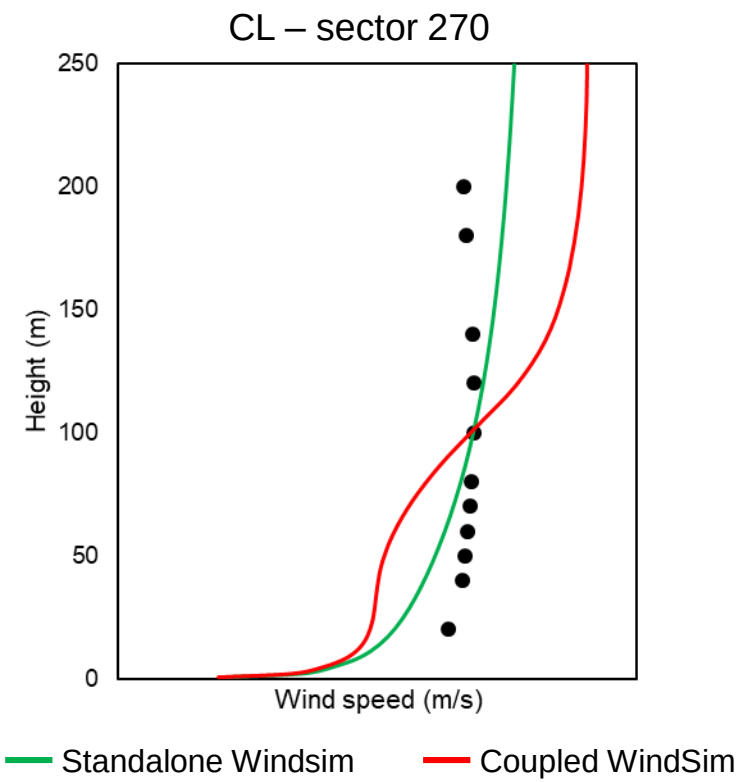


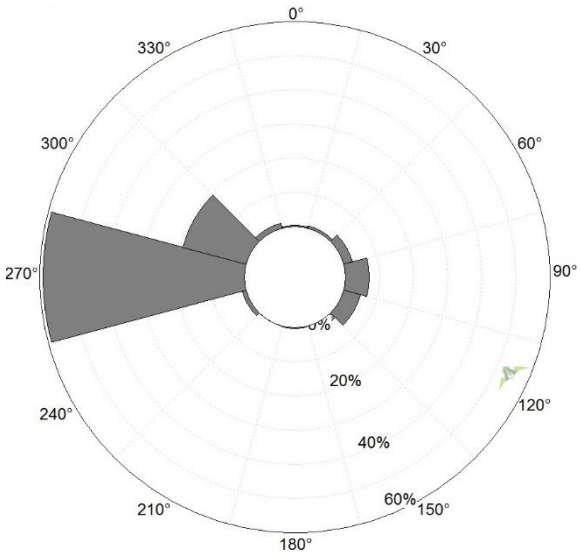


Meso-microscale coupling in WindSim

Solution 1: Validation study – Results

Limitations in vertical profiles – CL site (flat + strong diurnal cycle)





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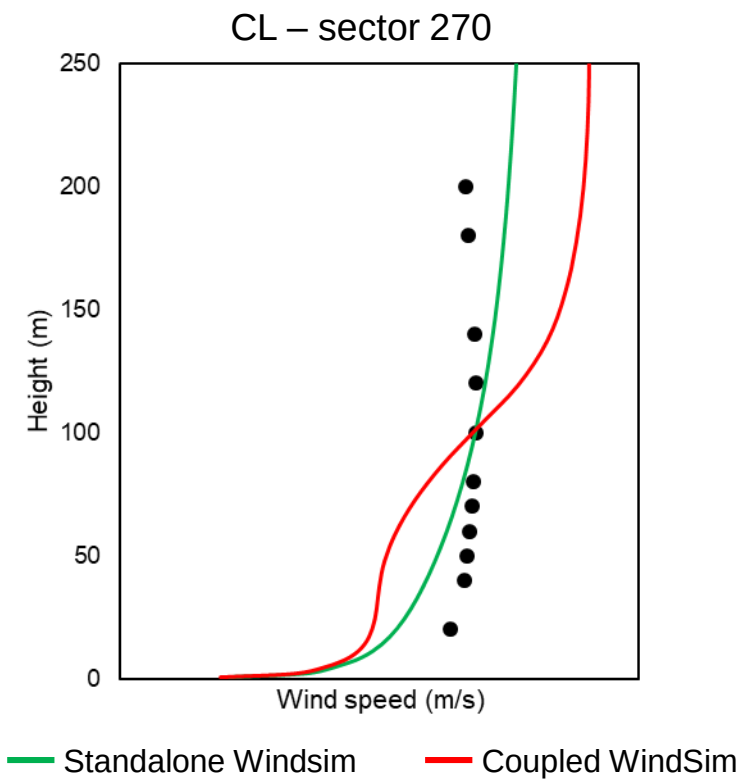
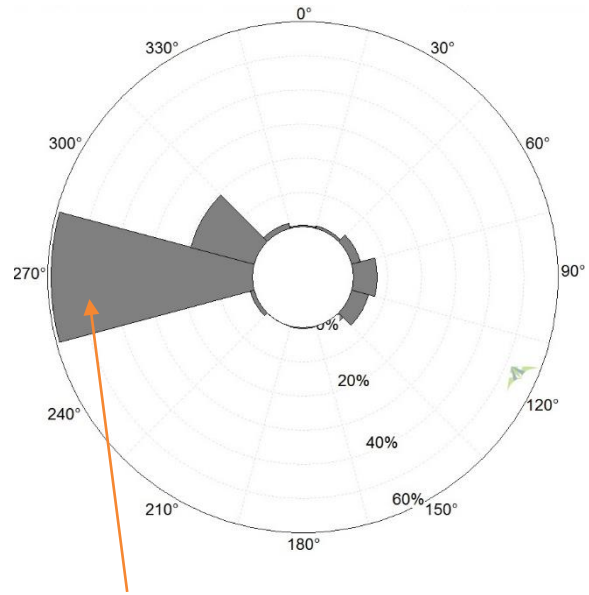
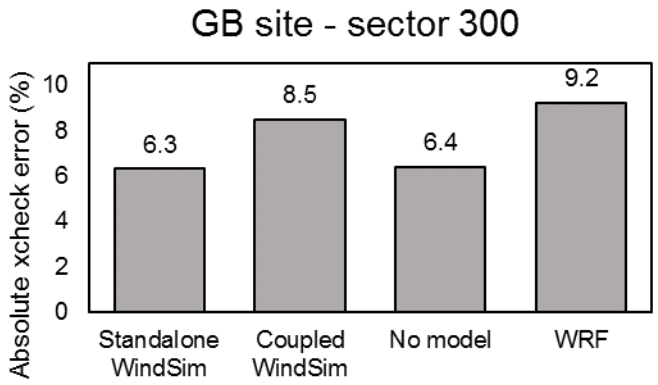


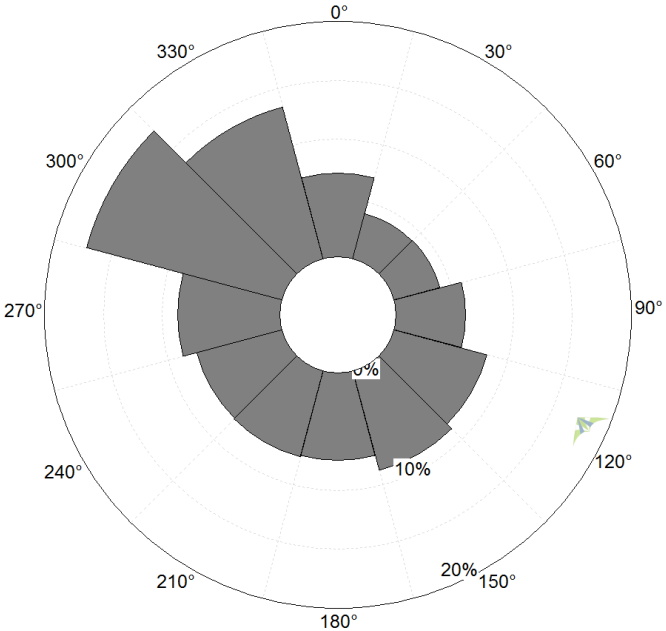


The sector is so predominant that different atmospheric conditions are averaged

Solution 1: Validation study – Results

Flat sites: No improvements in horizontal extrapolation





Meso-microscale coupling in WindSim

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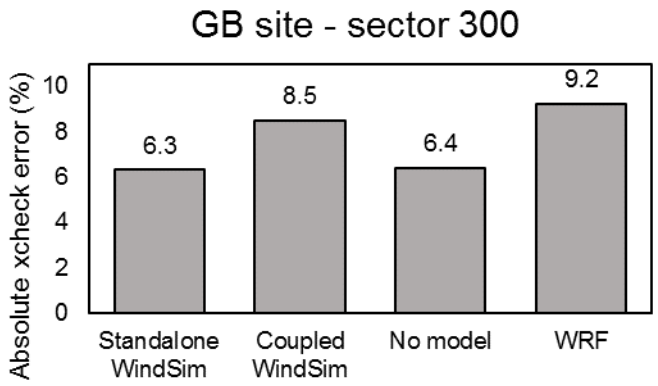

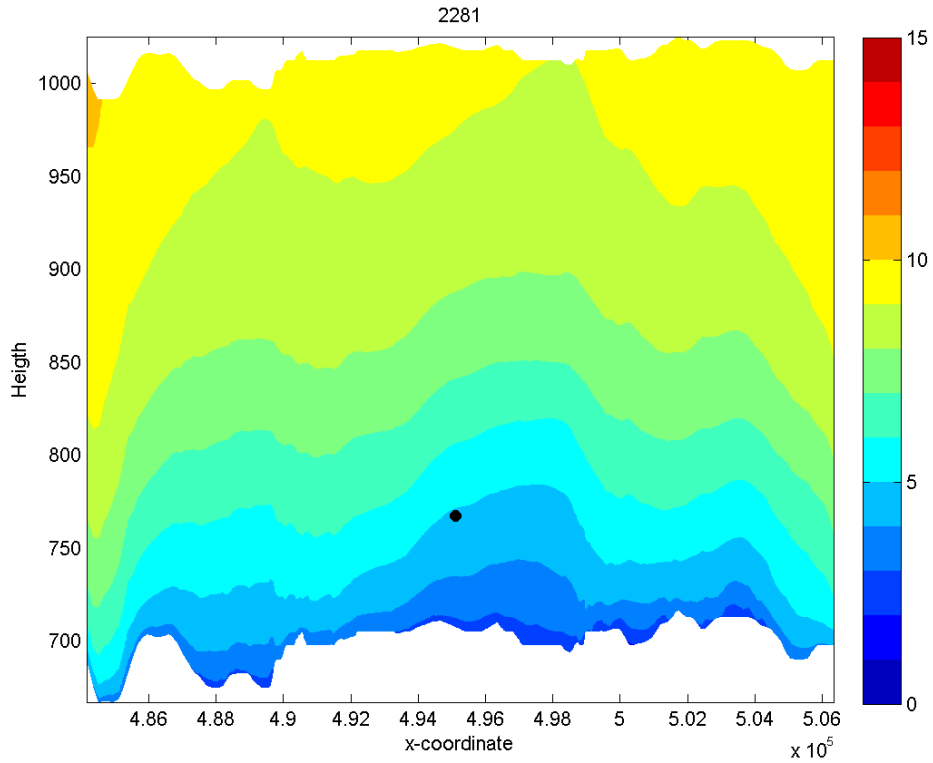

Forcing at the top of the domain from the mesoscale is not enough

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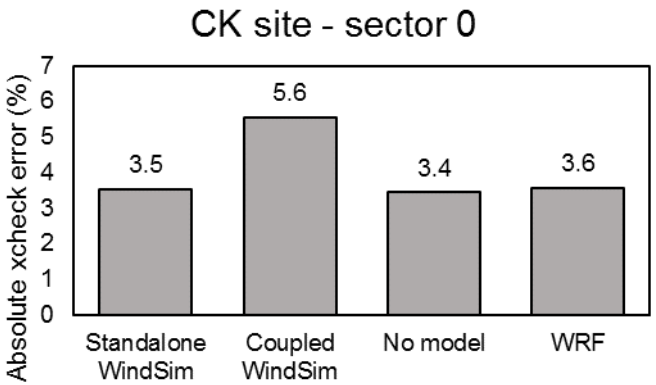

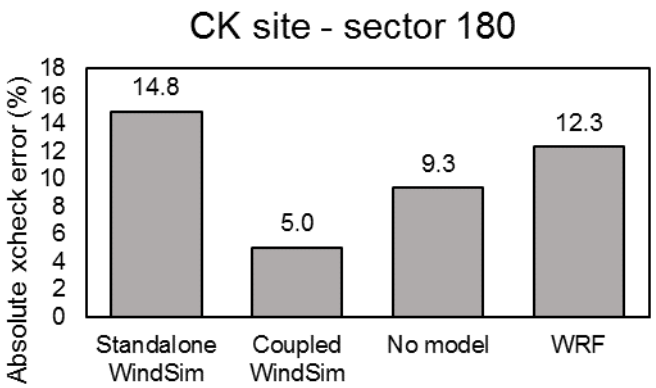

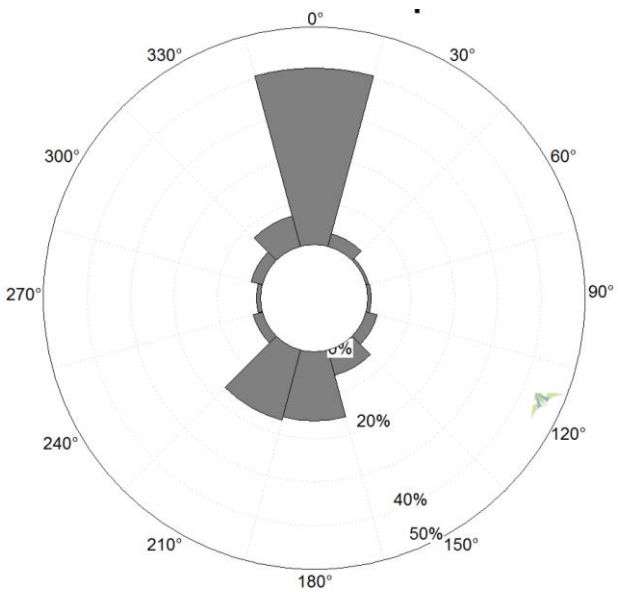

Meso-microscale coupling in WindSim

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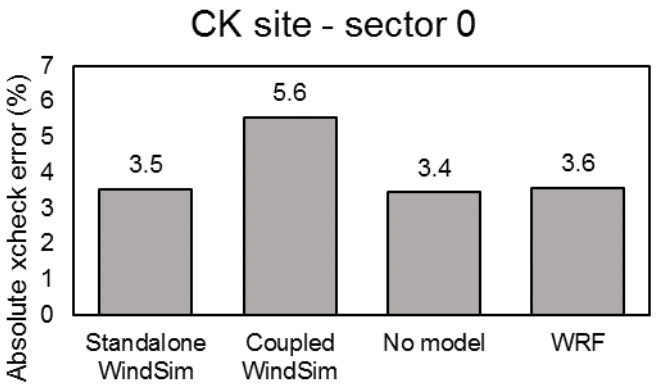
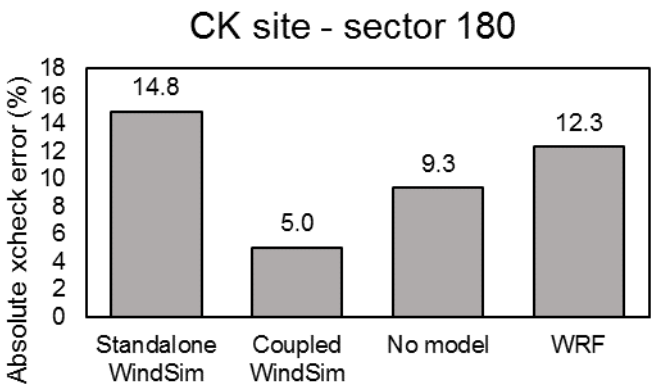
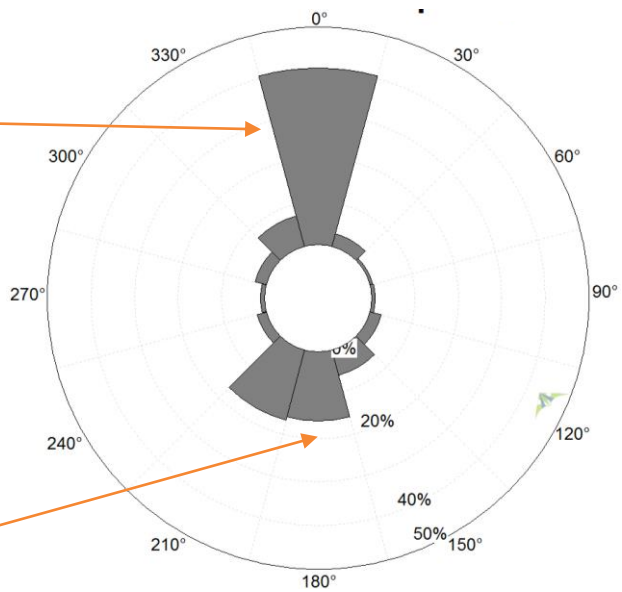




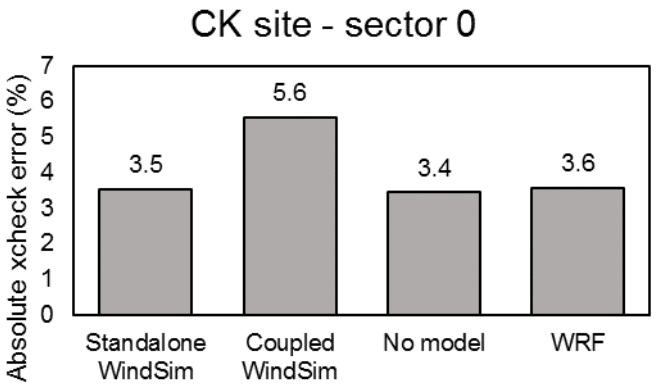


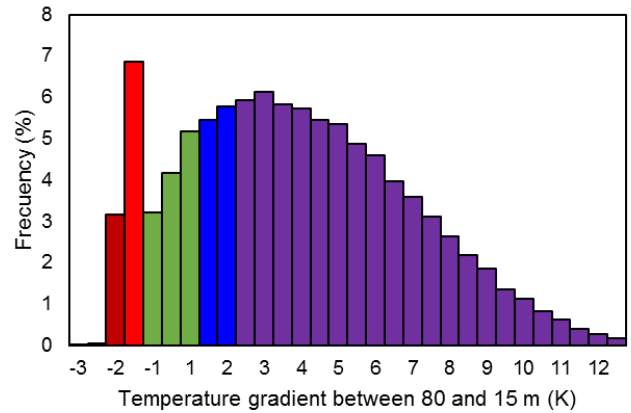
As before, to average high frequency sectors do not seem proper

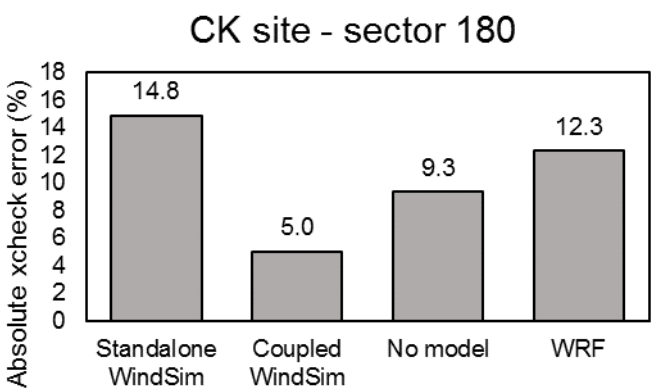
Meso-microscale coupling in WindSim

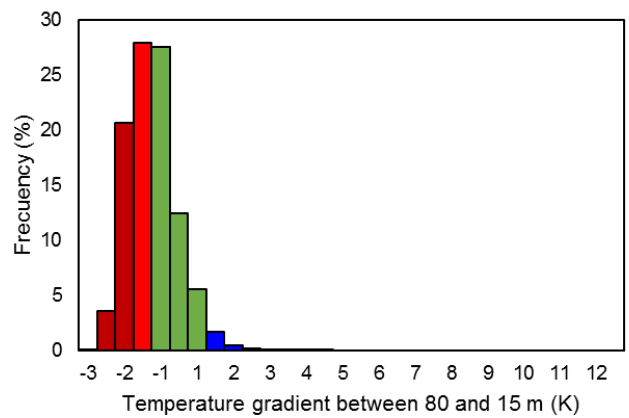
Solution 1: Validation study – Results

Flat sites: No improvements in horizontal extrapolation









- Very unstable
- Unstable
- Neutral
- Stable
- Very stable

Meso-microscale coupling in WindSim

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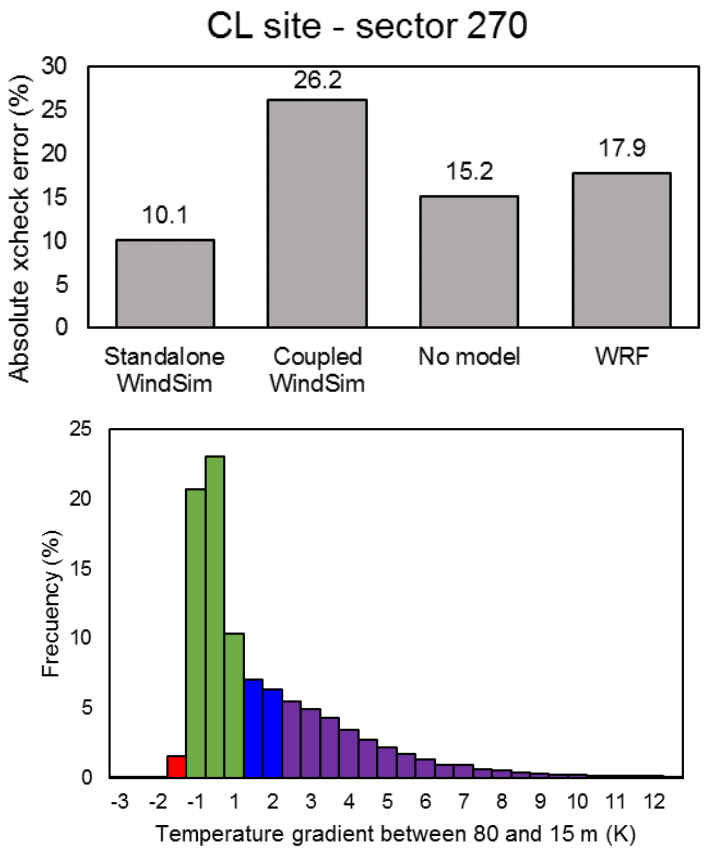
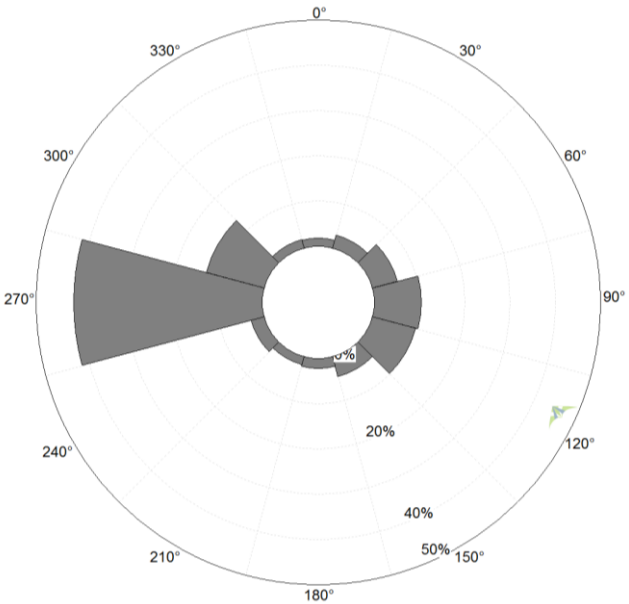
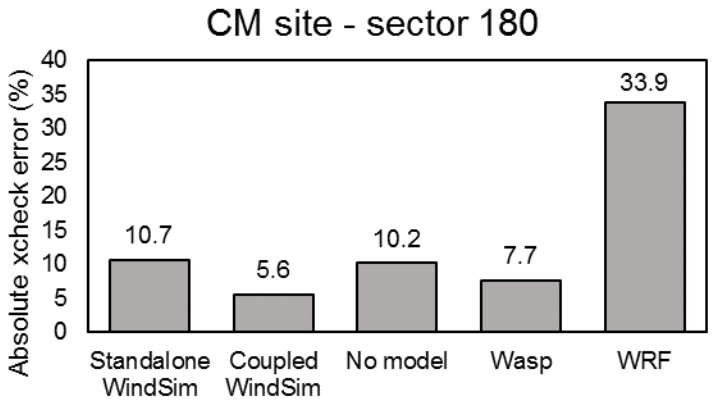
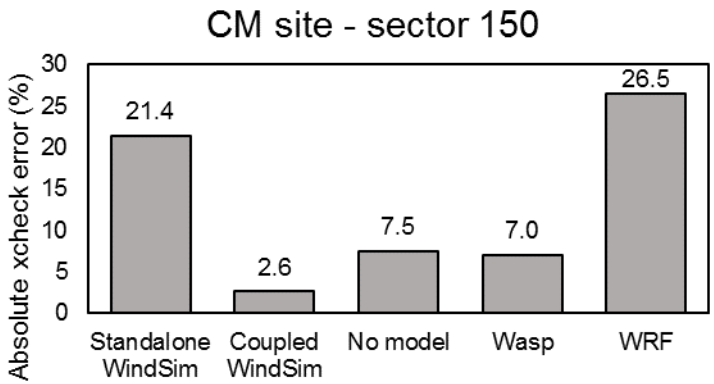


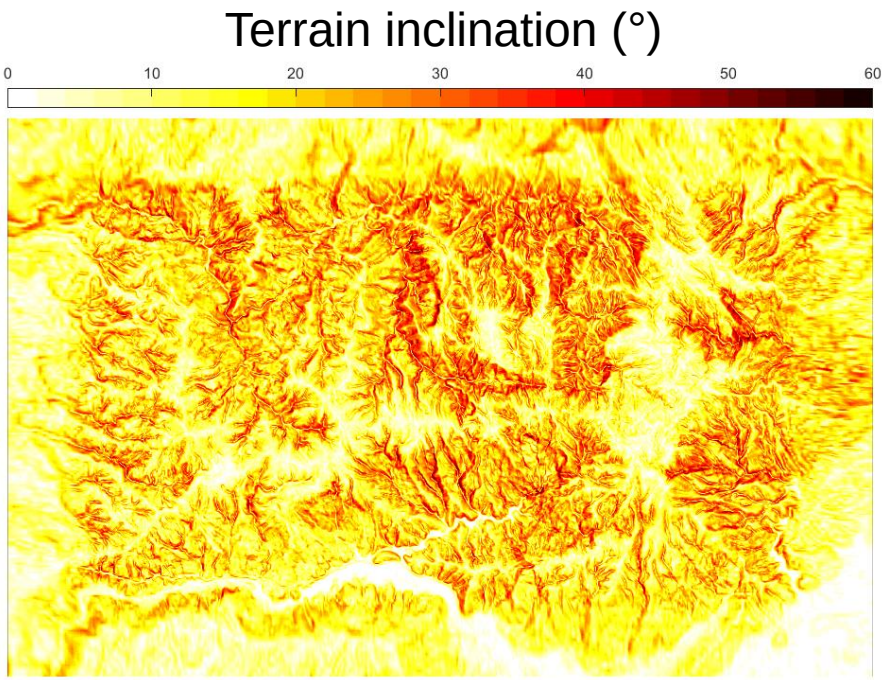


Solution 1: Validation study – Results

Complex sites: Important improvement







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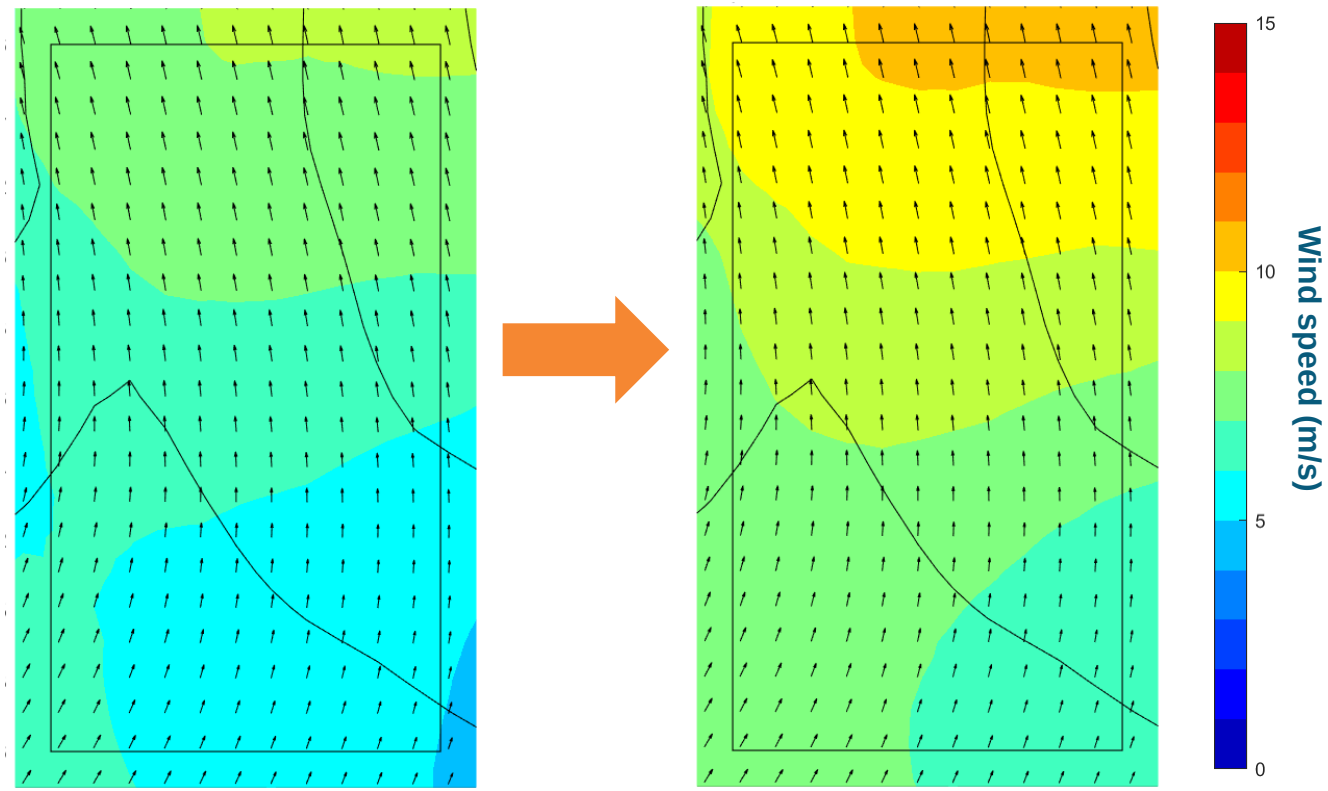
Solution 1: Limitations

Convergence of sectors with low wind speed

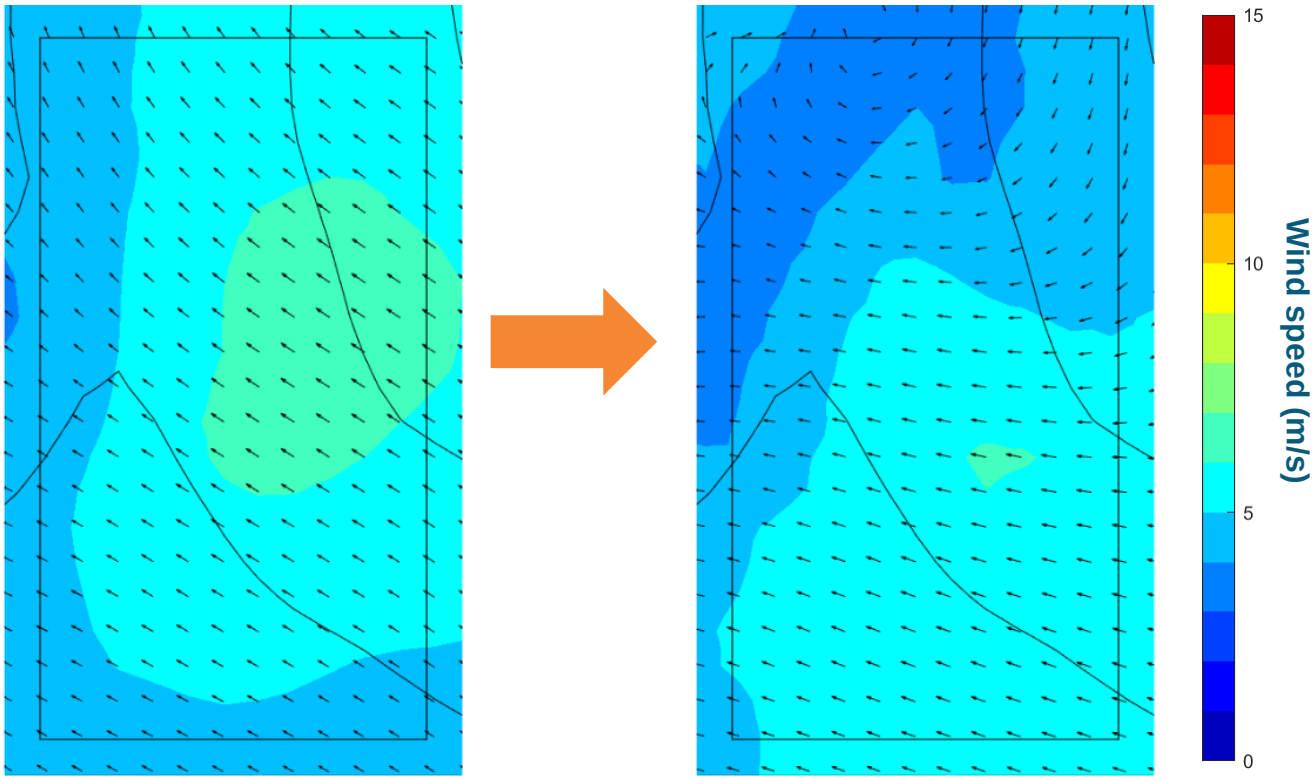
- Typically occurs in low frequency sectors



Solution 1: Limitations

Convergence of sectors with low wind speed

- Typically occurs in low frequency sectors

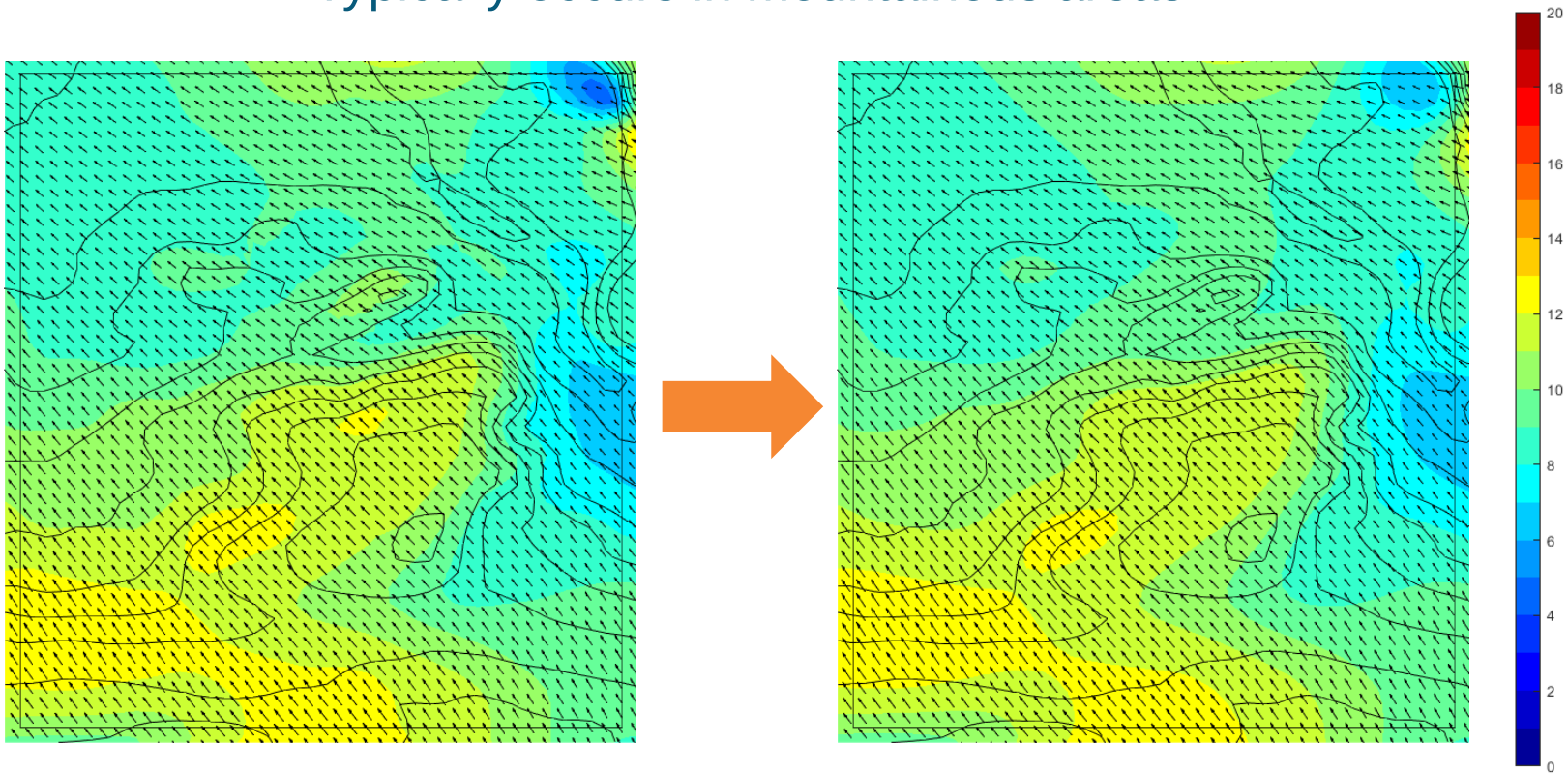


Meso-microscale coupling in WindSim

Solution 1: Limitations

Convergence of sectors with low wind speed “bubbles”

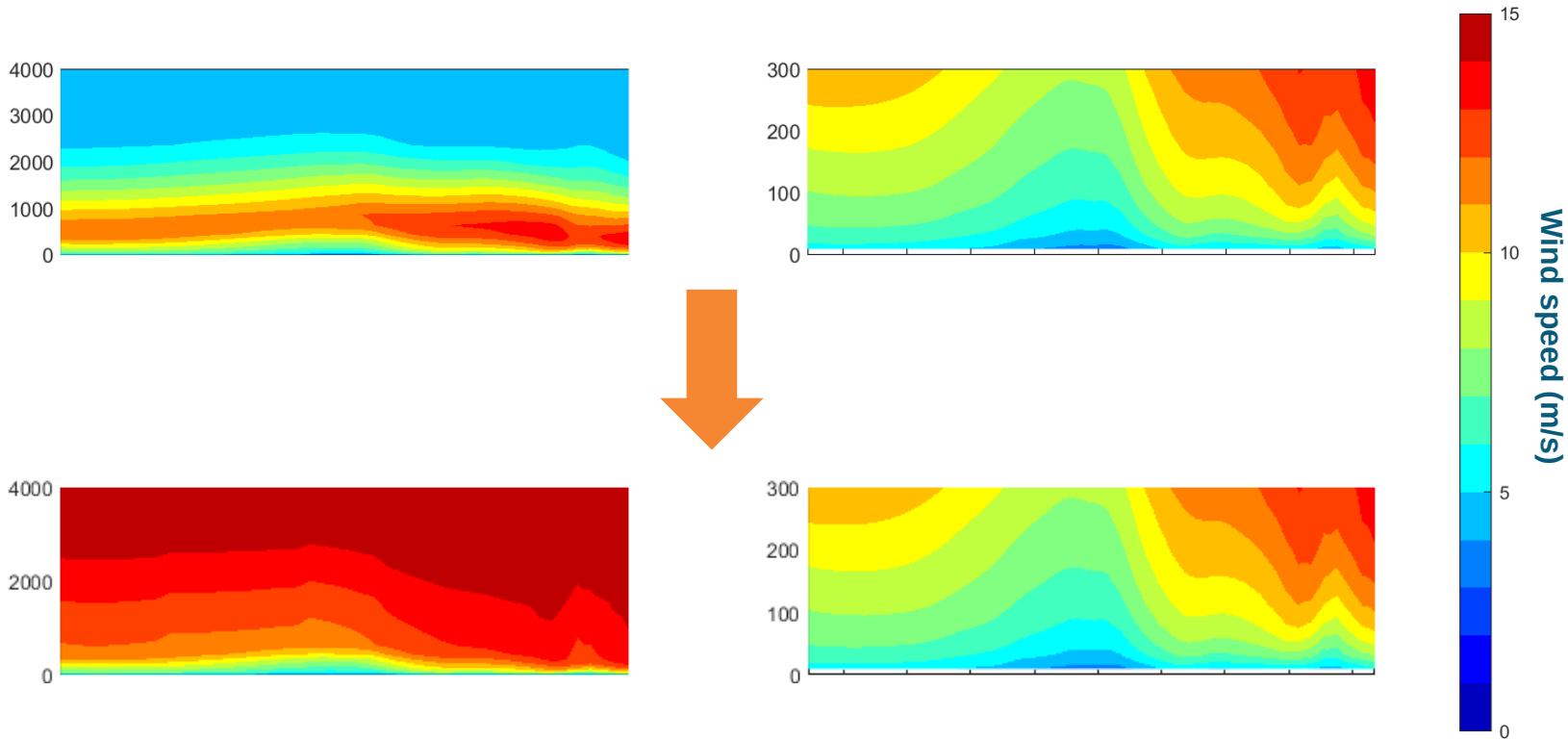
- Typically occurs in mountainous areas



Meso-microscale coupling in WindSim

Solution 1: Limitations

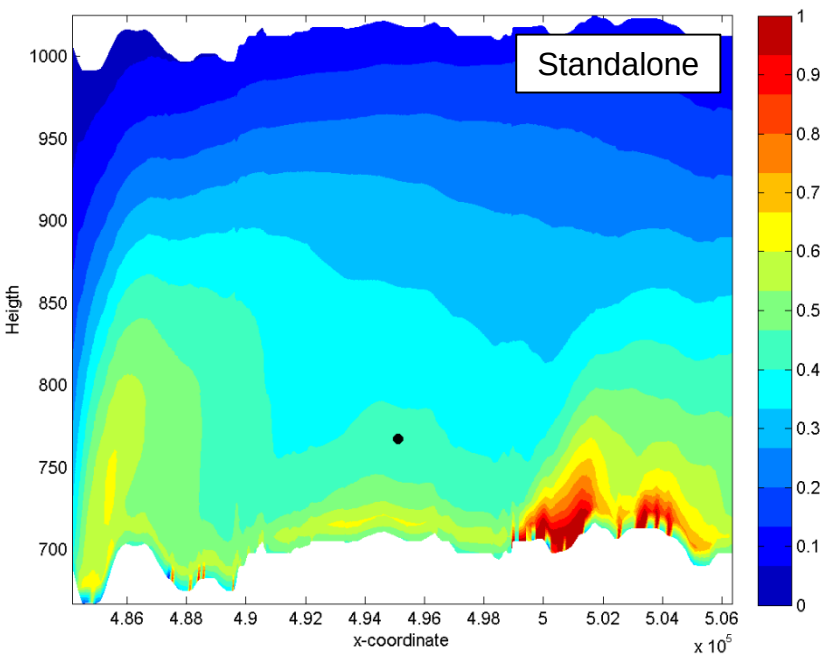
Convergence of sectors with strong low-level jets (LLJ)

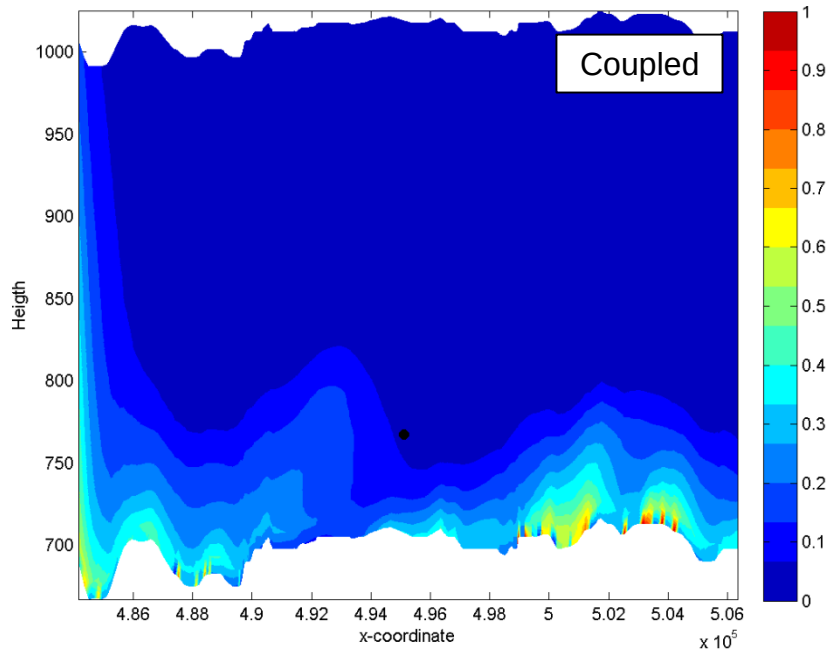


Meso-microscale coupling in WindSim

Solution 1: Limitations

Too low turbulence: Seems MOST* approach is not enough





*MOST: Monin-Obukhov similarity theory

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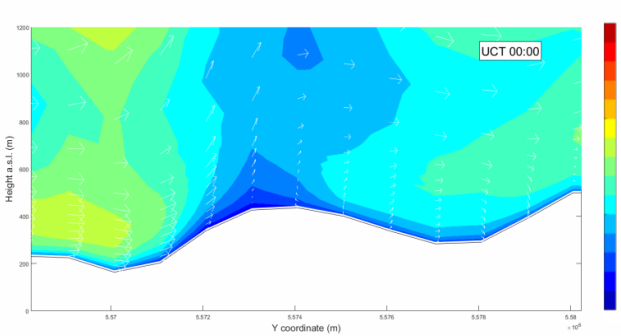
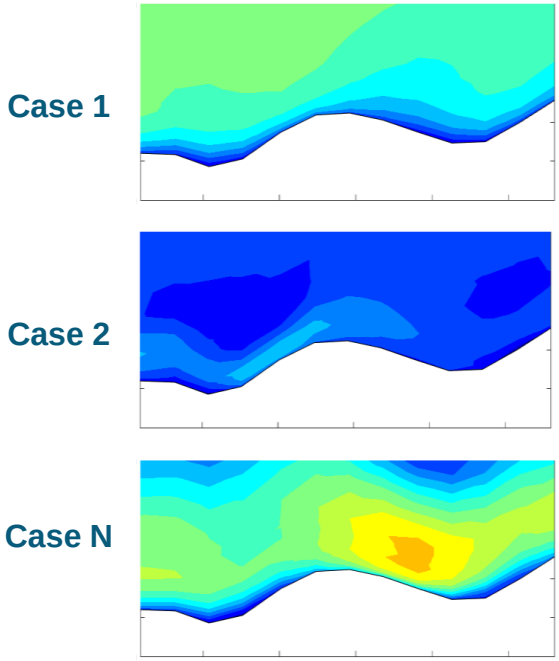
Meso-microscale coupling in WindSim

Solution 2:
Predominant cases obtained by machine learning

1 year of mesoscale model output

Automated classification using Self-organizing maps (SOM)

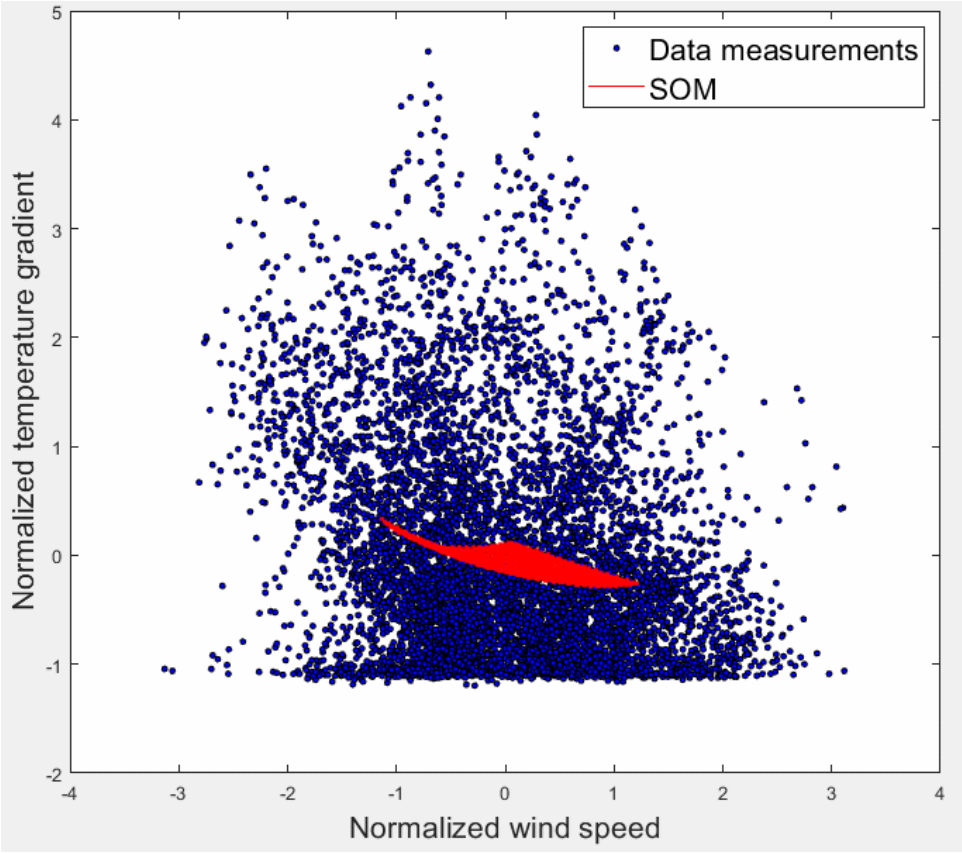




*Processes
*Data

Meso-microscale coupling in WindSim

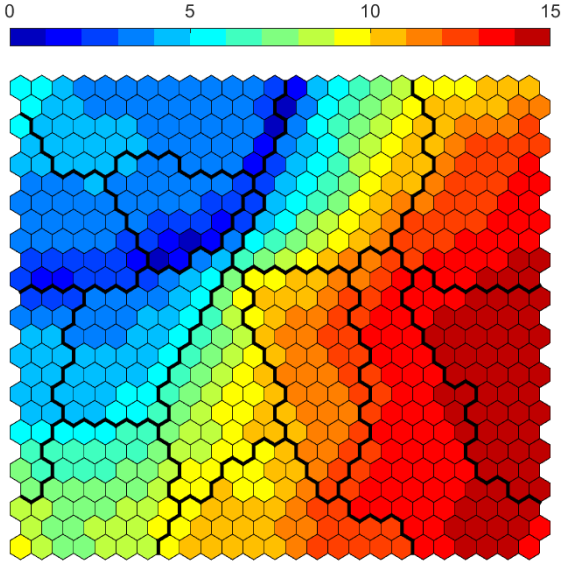
Solution 2:
Predominant cases obtained by machine learning



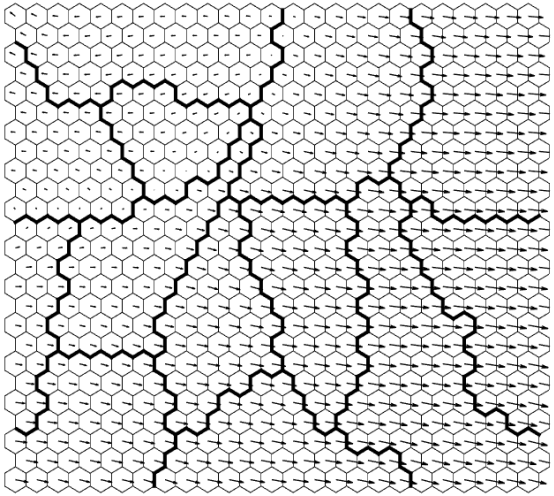
Meso-microscale coupling in WindSim

Solution 2:
Preliminary results

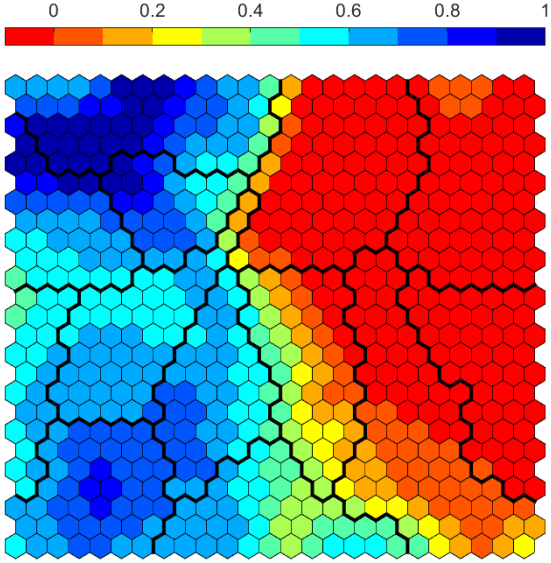
Wind speed @ 100m



Wind direction @ 100m



ΔPotential temperature (T_{100}-T_7)



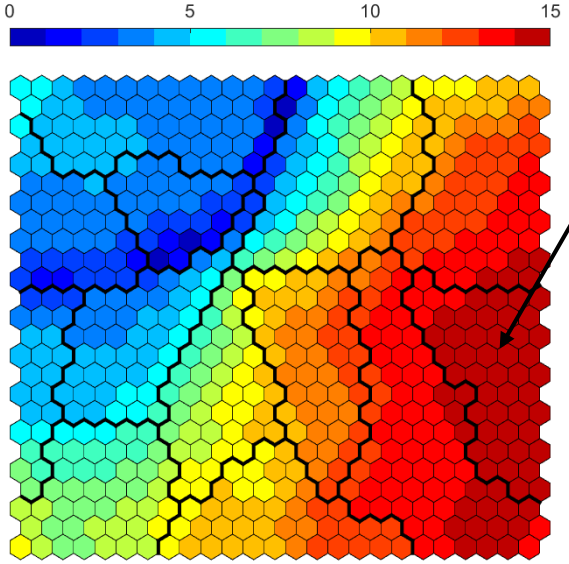
Meso-microscale coupling in WindSim

Solution 2:
Preliminary results

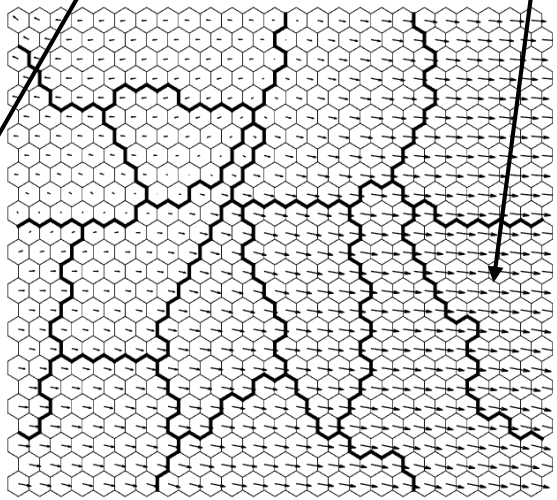
Class 10:

High wind speed Sector 270 Unstable conditions

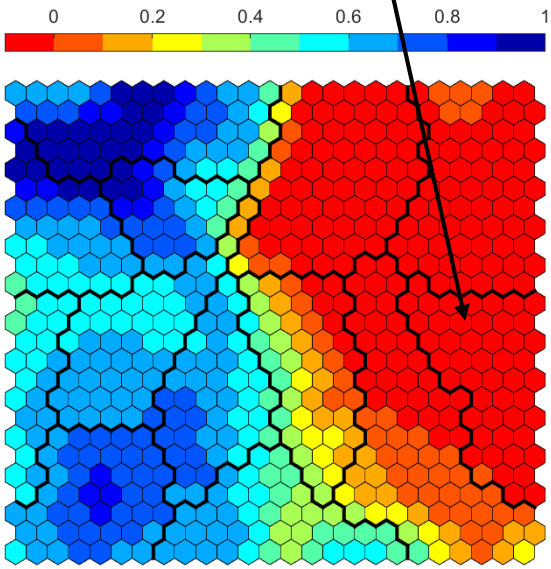
Wind speed @ 100m



Wind direction @ 100m



ΔPotential temperature (T_{100}-T_7)

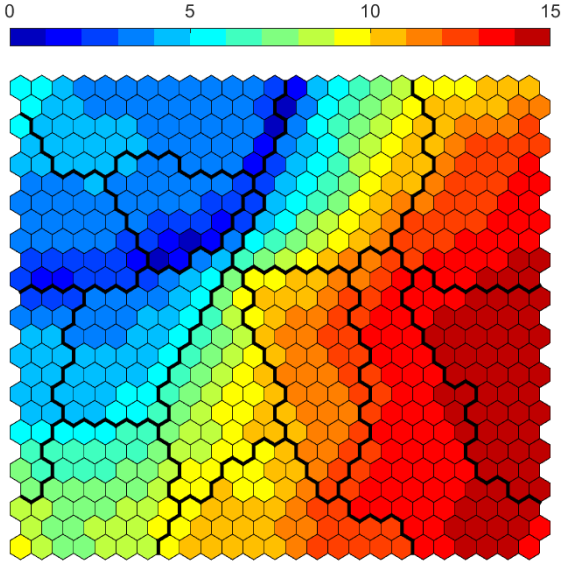


Meso-microscale coupling in WindSim

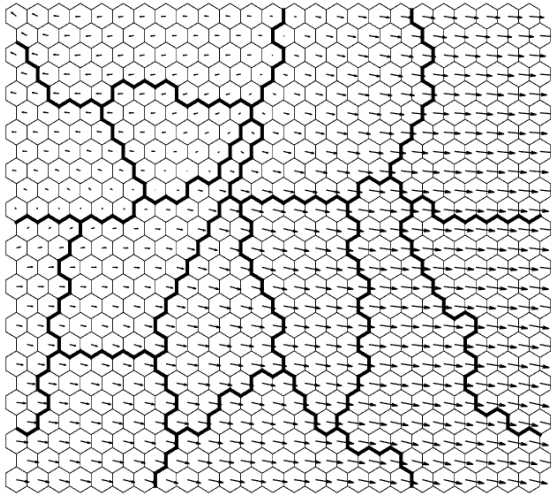
Solution 2:
Preliminary results

- ✓ Cases with different wind speed scale
- ✓ Cases with different atmospheric stability
- ✓ Cases with different wind directions
- ✓ Reasonable amount of cases (13 to 25)

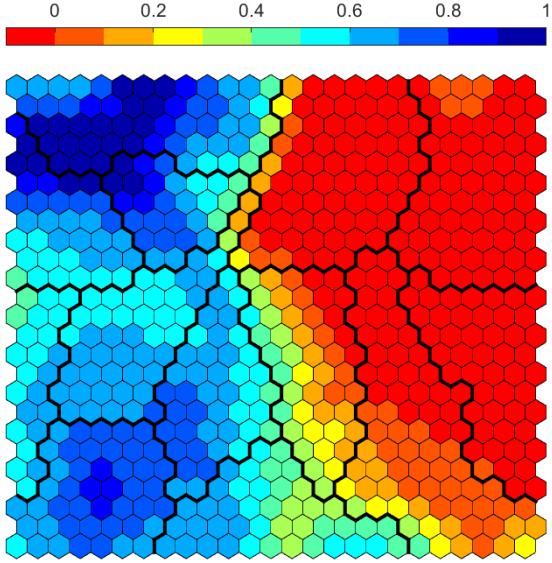
Wind speed @ 100m



Wind direction @ 100m



ΔPotential temperature (T_{100}-T_7)



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Conclusions and further work

Achievements:

- ✓ In complex terrain, **coupled WindSim** presents considerable improvements in the **vertical and horizontal wind flow**.
- ✓ If atmospheric conditions are similar for a given sector, the coupled simulations present an **improved vertical profile**.
- ✓ In general, the coupled simulations present **more realistic wind speeds at higher heights** compared to analytical profiles.
- ✓ Coupled WindSim can capture some interesting phenomena like **LLJs**.

Conclusions and further work

Challenges:

- For some cases, convergence may be harder to reach. This can be dealt with proper corrections
- For flat sites, seems that the mesoscale do not provide enough forcing at the top of the model. No-friction wall may correct this problem.
- If there is more than one predominant atmospheric condition from a given wind direction, the average condition is not representative.
- Current method to prescribe TKE BC is not proper. A better approach might be to directly interpolate it from the mesoscale model.

Thank you

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