Statkraft

Statkraft beta test

Windsim User Meeting 2024

19 JUNE 2024

Biography

Name Ove Undheim
Position Principal Wind Resource Analyst at Wind & Site at Statkraft
Title PhD Computational Fluid Dynamics and Turbulence Modelling

2001 – 2005	PhD at IFE / NTNU
2005 – 2019	Kjeller Vindteknikk
2019 – 2023	Norconsult / Kjeller Vindteknikk
2023 – 2024	Statkraft

Experience
Pre- and Post Construction EYAs onshore and offshore, Due Diligences, LTC, Icing estimates and icing warranty methods, SCADA data analyses, wind measurement campaign design and installation, wind engineering for bridges using met masts and scanning lidars.

Overview

- The beta testing is carried out for a Norwegian site.
- The coordinates and absolute levels in the figures are hidden (despite it is possible to locate from the maps).
- Comparison between:
  - Simulation grids and set-up
  - Elevation and roughness maps
  - Sector wise wind speed and TI for 270º as example
  - Sector wise wind shear
  - Cross prediction errors for 5 met masts at the site
  - Final mean wind speed maps (only for standard Windsim cloud)
  - TI90 map

Standard Windsim cloud vs Windsim Beta: Grid details

Standard Windsim cloud

- Cells: 6.9 mill
- Refinement: 20 m
- Cells in vertical: 35 (2 m first grid cell)
- Vertical expansion: Geometrical
- Height distribution factor: 0.2
- Total area: 22.5 km x 23.9 km
- Refinement: 6.5 km x 7.9 km
- Domain height: 3408 m
- Largest cell: E 352m, N 352m, H 479m

Windsim Beta

- Cells: 4.99 mill
- Refinement: E 21.9 m, N 22.0 m
- Cells in vertical: 35 (2 m first grid cell)
- Vertical expansion : Geometrical
- Height distribution factor: 0.2
- Total area: 26.7 km x 27.5 km
- Refinement: 6.1 km x 6.9 km
- Domain height: 3535 m
- Largest cell: E 477m, N 483m, H 589m

Statkraft

Standard Windsim cloud vs Windsim Beta: Simulation details

Standard Windsim cloud

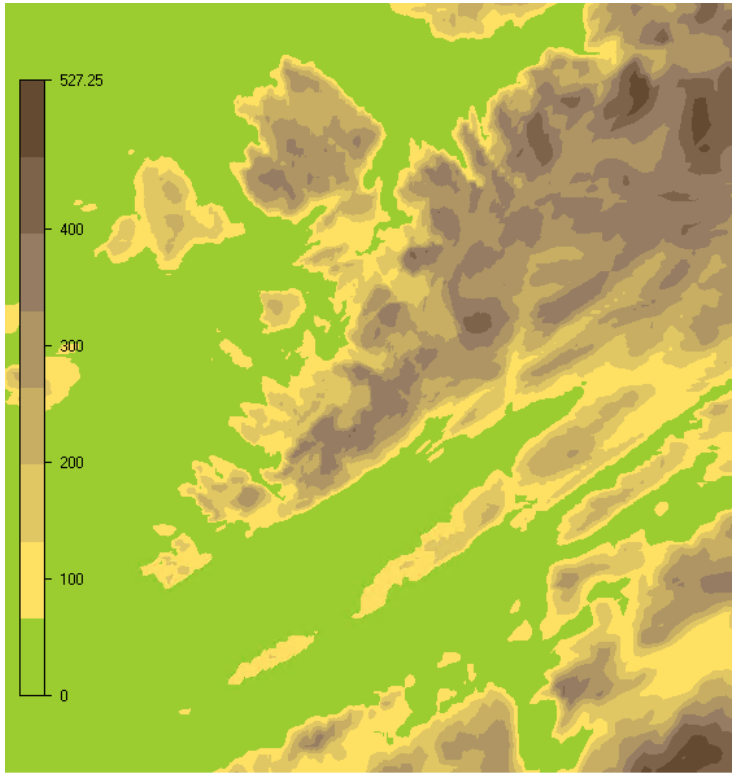
- 30 deg sectors
- Height of boundary layer: 500 m
- Speed above boundary layer: 10 m/s
- Boundary condition at top: Fixed pressure
- Neutral conditions
- Solver: ParallelGCV
- Number of iterations: 999
- Convergence criteria: 0.0005

Windsim Beta

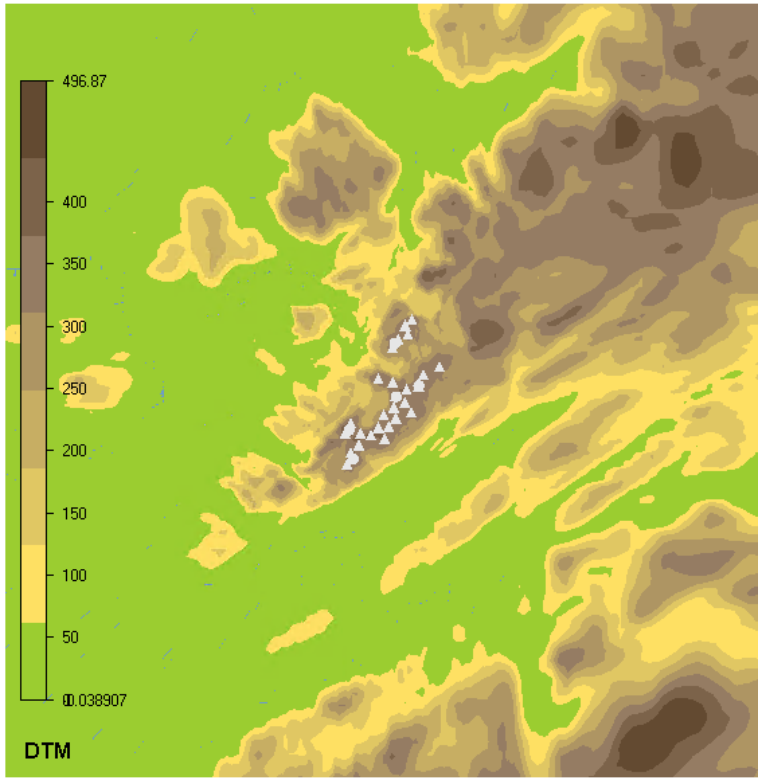
- 30 deg sectors
- Height of boundary layer: 500 m
- Speed above boundary layer: 10 m/s
- Boundary condition at top: Fixed pressure
- Neutral conditions
- Solver: ParallelGCV
- Number of iterations: 999
- Convergence criteria: 0.0005

Standard cloud vs Windsim Beta: Elevation data

Standard Windsim cloud



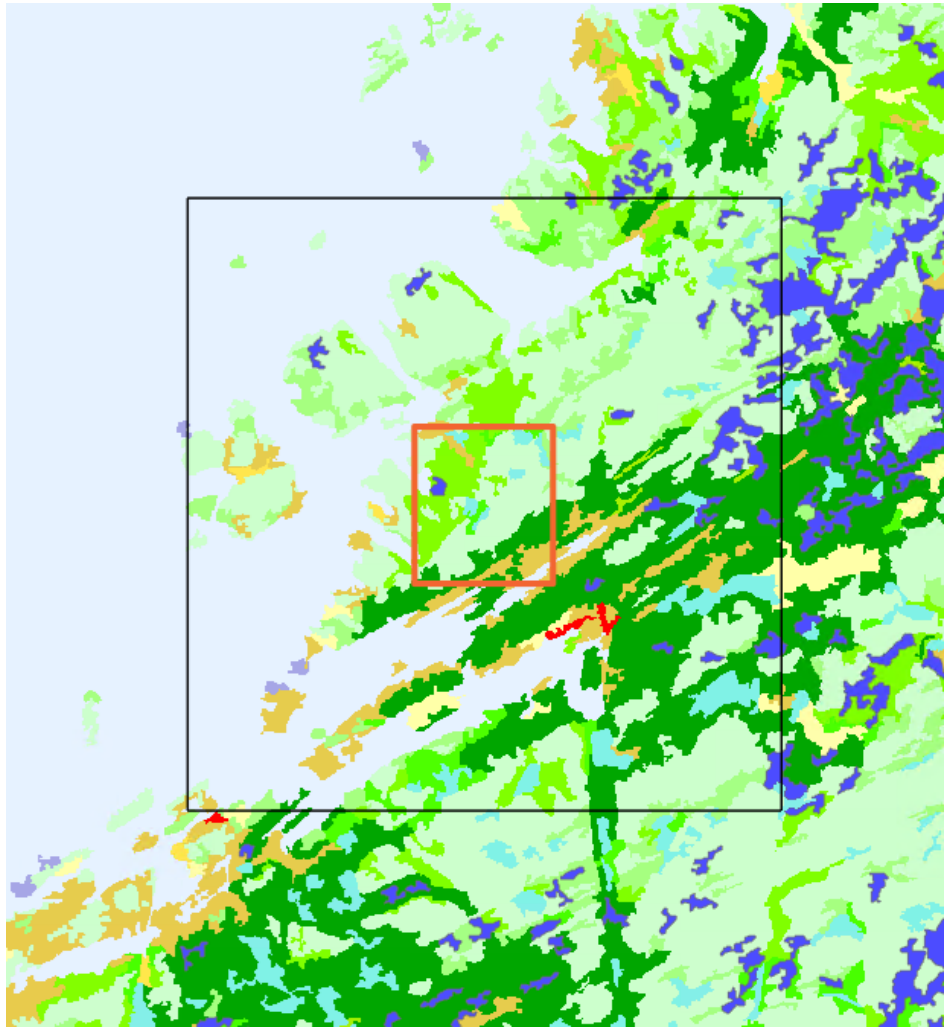
Windsim Beta



Statkraft

Windsim Beta: Roughness (Europe)

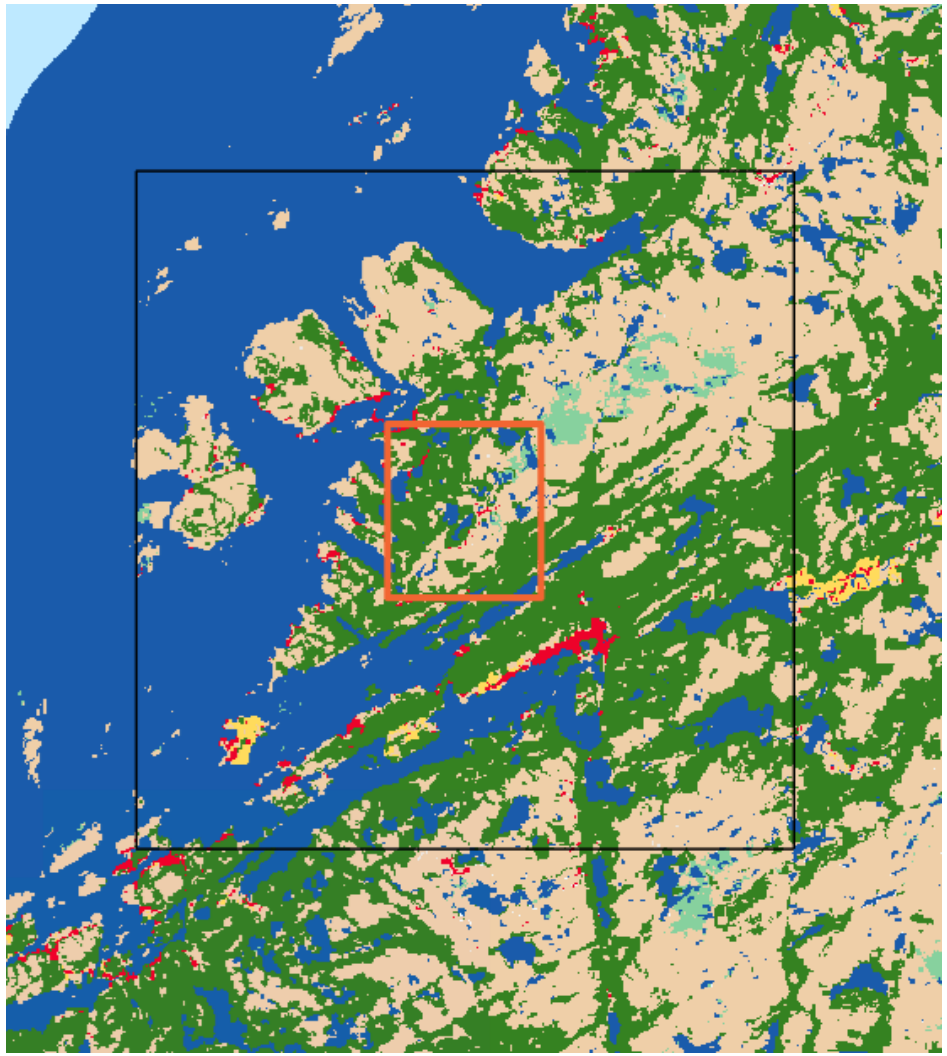
Continuous urban fabric	Roughness * 1	Vineyards	Roughness * 0.3	Beaches, dunes, sands	Roughness * 0.003
Discontinuous urban fabric	Roughness * 0.8	Fruit trees and berry plantations	Roughness * 0.4	Bare rocks	Roughness * 0.05
Industrial or commercial units	Roughness * 0.7	Olive groves	Roughness * 0.4	Sparsely vegetated areas	Roughness * 0.03
Road and rail networks and associa...	Roughness * 0.1	Pastures	Roughness * 0.03	Burnt areas	Roughness * 0.2
Port areas	Roughness * 0.5	Annual crops associated with perm...	Roughness * 0.1	Glaciers and perpetual snow	Roughness * 0.005
Airports	Roughness * 0.01	Complex cultivation patterns	Roughness * 0.15	Inland marshes	Roughness * 0.05
Mineral extraction sites	Roughness * 0.3	Land principally occupied by agricul...	Roughness * 0.2	Peat bogs	Roughness * 0.03
Dump sites	Roughness * 0.3	Agro, forestry areas	Roughness * 0.5	Salt marshes	Roughness * 0.02
Construction sites	Roughness * 0.3	Broad-leaved forest	Roughness * 1	Salines	Roughness * 0.005
Green urban areas	Roughness * 0.8	Coniferous forest	Roughness * 1.2	Intertidal flats	Roughness * 0.0001
Sport and leisure facilities	Roughness * 0.2	Mixed forest	Roughness * 1.1	Water courses	Roughness * 0.0001
Non-irrigated arable land	Roughness * 0.05	Natural grasslands	Roughness * 0.03	Water Bodies	Roughness * 0.0001
Permanently irrigated land	Roughness * 0.03	Moors and heathland	Roughness * 0.05	Coastal lagoons	Roughness * 0.0001
Rice fields	Roughness * 0.03	Sclerophyllous vegetation	Roughness * 0.07	Estuaries	Roughness * 0.0001
		Transitional woodland, shrub	Roughness * 0.4	Sea and ocean	Roughness * 0.0001



Statkraft

Windsim Beta: Roughness (global)

Water	Roughness * 0.0003
Trees	Roughness * 0.5
Trees 1	Roughness * 0.5
Trees 2	Roughness * 0.5
Flooded Vegetation	Roughness * 0.1
Crops	Roughness * 0.05
Crops 2	Roughness * 0.05
Built Area	Roughness * 0.5
Bare Ground	Roughness * 0.03
Snow/Ice	Roughness * 0.001
Snow/Ice 1	Roughness * 0.001
Clouds	Roughness * 0.03
Rangeland	Roughness * 0.05
No Data	Roughness * 0.03

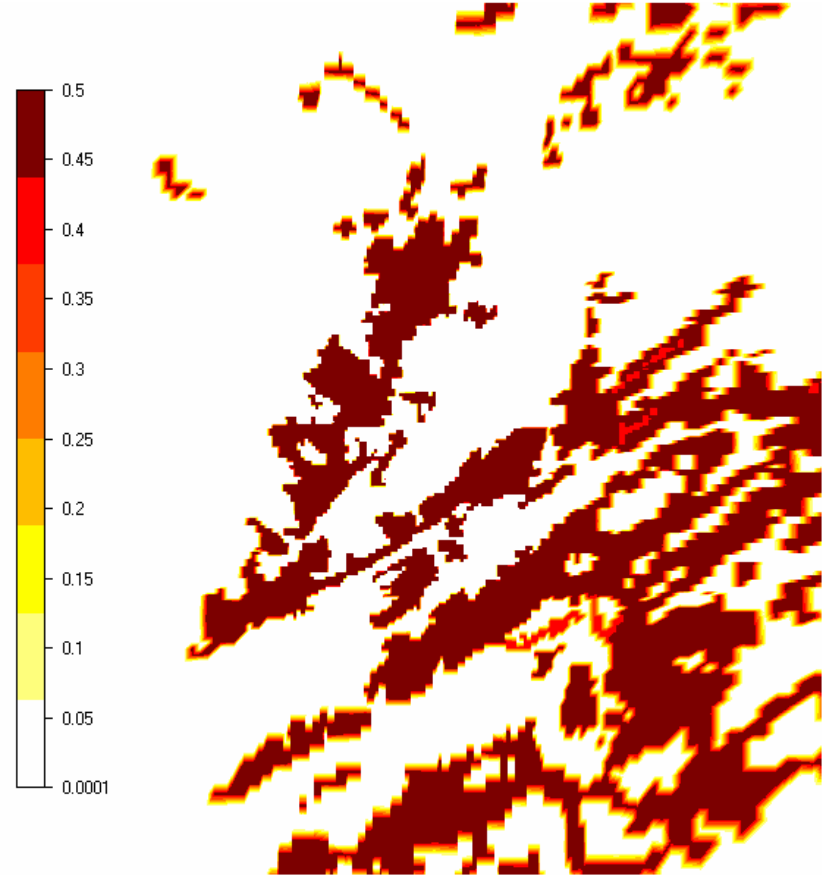


Global roughness data: Generally much lower and too low roughness values (0.5 m for forests, compared to 1.0-1.2 m in the European dataset). This dataset turned out to be the used dataset.

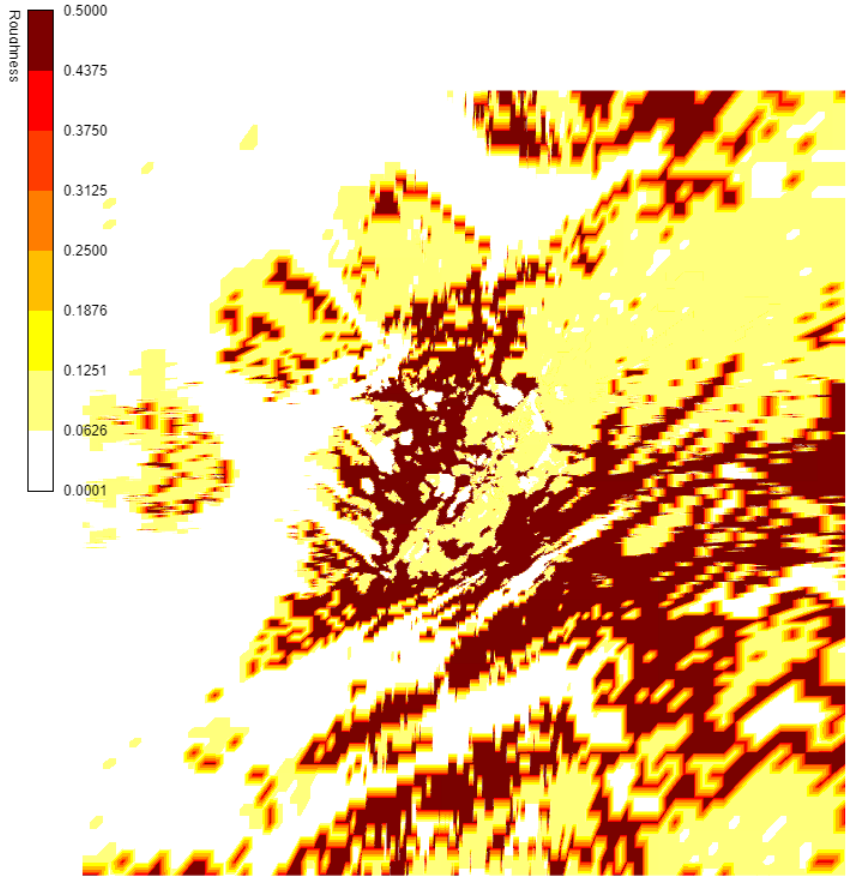
Statkraft

Standard Windsim cloud vs Windsim Beta: Roughness

Standard Windsim cloud



Windsim Beta

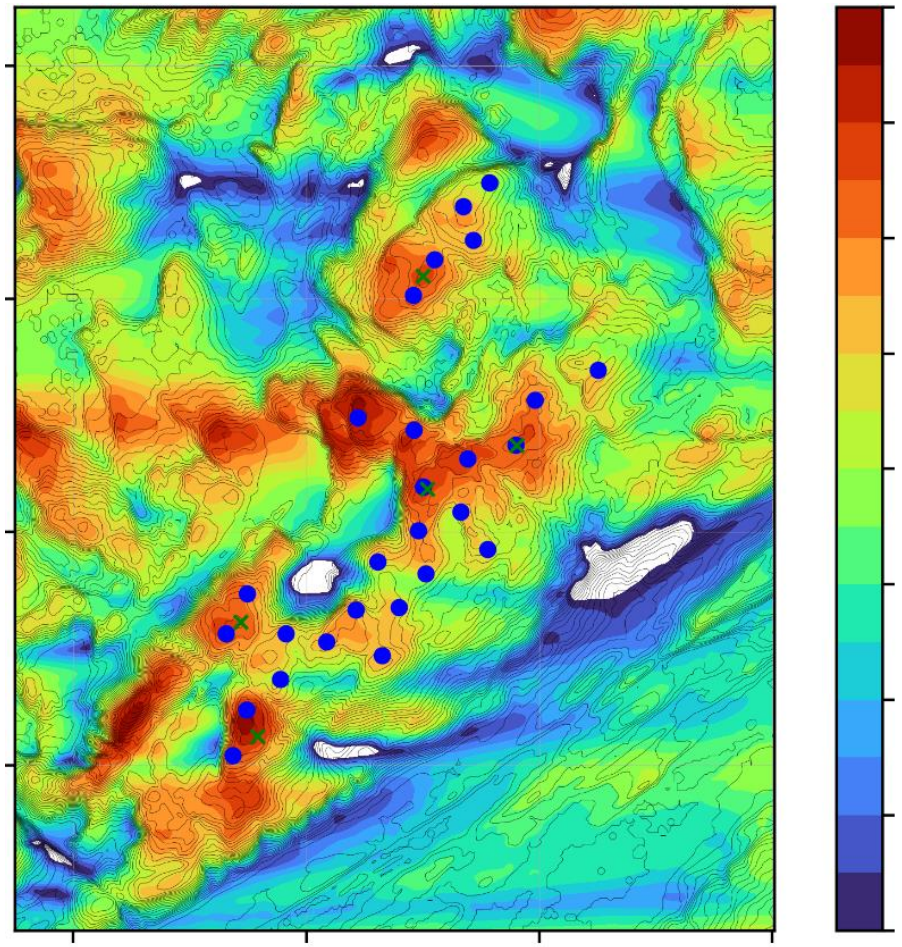


Standard Corine used for «Standard Windsim Cloud», except for mountain area changes from 0.2 m to 0.05 m. Forested areas have roughness 0.5 m.

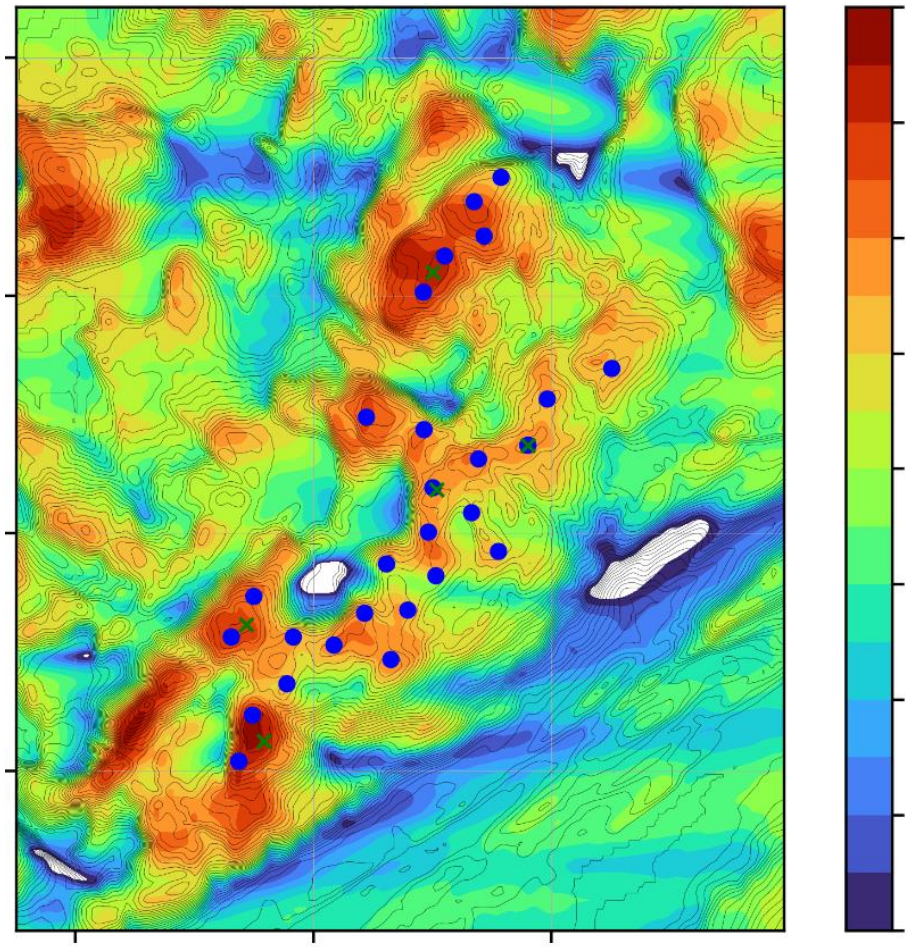
Statkraft

Standard Windsim cloud vs Windsim Beta: U: Dir 270º

Standard Windsim cloud



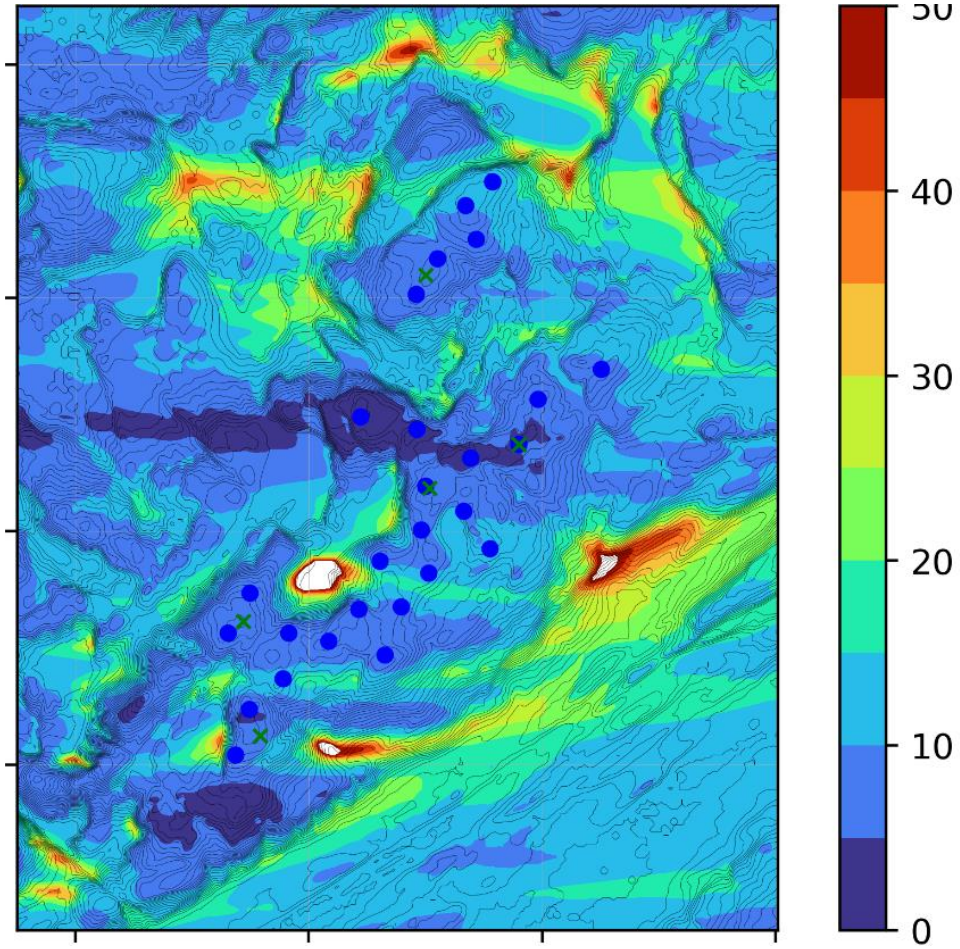
Windsim Beta



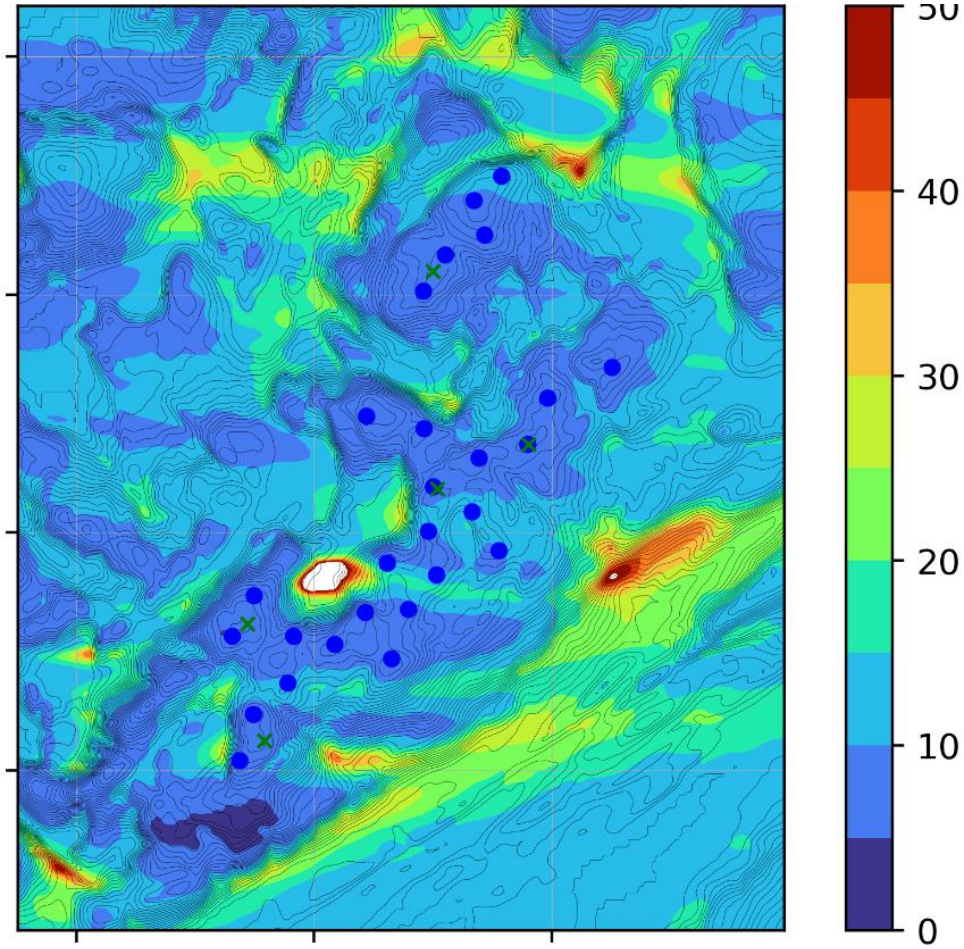
Statkraft

Standard Windsim cloud vs Windsim Beta: TI: Dir 270º

Standard Windsim cloud

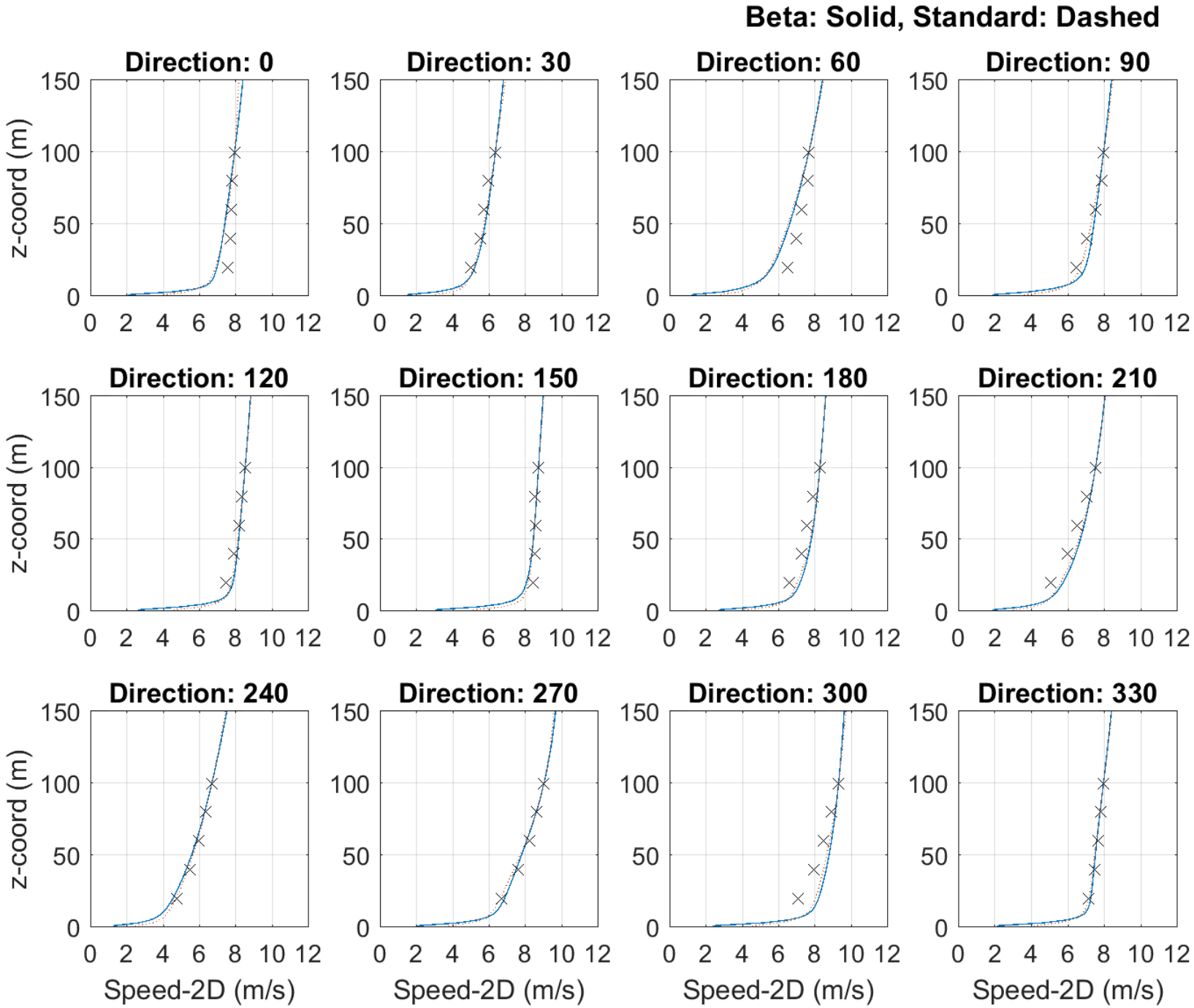


Windsim Beta



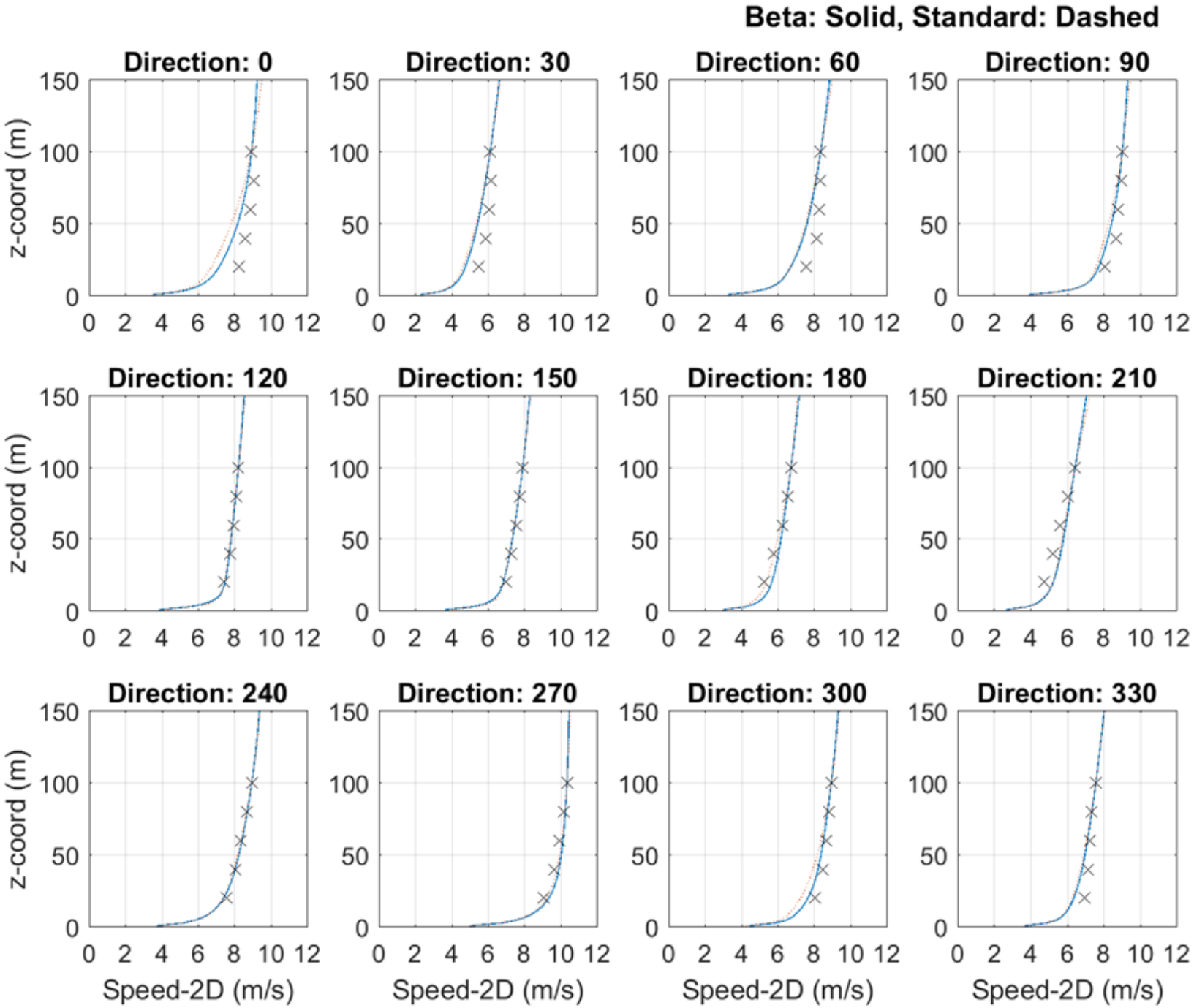
Statkraft

Wind shear



Statkraft

Wind shear



Statkraft

Standard Windsim cloud vs Windsim Beta vs WAsP: Cross prediction

Standard Windsim cloud

MAE					
7.93%	File_1	File_2	File_3	File_4	File_5
File_1	0.00%	-1.49%	6.43%	-4.94%	12.82%
File_2	1.62%	0.00%	8.16%	-2.92%	13.66%
File_3	-5.29%	-6.75%	0.00%	-9.88%	6.29%
File_4	6.58%	2.97%	11.25%	0.00%	19.35%
File_5	-10.14%	-9.95%	-4.45%	-13.58%	0.00%

Windsim Beta

MAE					
6.59%	File_1	File_2	File_3	File_4	File_5
File_1	0.00%	0.46%	7.28%	0.11%	14.27%
File_2	-0.86%	0.00%	6.91%	0.22%	13.42%
File_3	-5.84%	-5.80%	0.00%	-5.27%	7.26%
File_4	0.97%	0.81%	8.02%	0.00%	14.51%
File_5	-11.35%	-11.02%	-5.68%	-11.67%	0.00%

WAsP

MAE					
8.33%	File_1	File_2	File_3	File_4	File_5
File_1	0.00%	1.50%	4.85%	-2.58%	17.13%
File_2	-1.39%	0.00%	4.10%	-4.03%	15.57%
File_3	-3.20%	-1.50%	0.00%	-5.26%	13.53%
File_4	3.52%	4.50%	7.84%	0.00%	20.60%
File_5	-14.71%	-13.26%	-10.95%	-16.69%	0.00%

Standard Windsim cloud; Meso-corr

MAE					
0.95%	File_1	File_2	File_3	File_4	File_5
File_1	0.00%	-0.80%	0.12%	-0.90%	0.72%
File_2	0.86%	0.00%	1.11%	-0.11%	0.72%
File_3	-0.97%	-0.80%	0.00%	-1.79%	-0.24%
File_4	1.73%	0.11%	2.10%	0.00%	0.97%
File_5	-1.51%	-1.49%	-0.49%	-1.46%	0.00%

Windsim Beta ; Meso-corr

MAE					
0.89%	File_1	File_2	File_3	File_4	File_5
File_1	0.00%	-1.85%	-1.11%	-1.01%	-0.36%
File_2	1.30%	0.00%	1.11%	0.11%	1.21%
File_3	0.43%	-0.58%	0.00%	-0.67%	0.85%
File_4	1.95%	0.00%	1.36%	0.00%	0.73%
File_5	-0.32%	-0.81%	-0.62%	-1.35%	0.00%

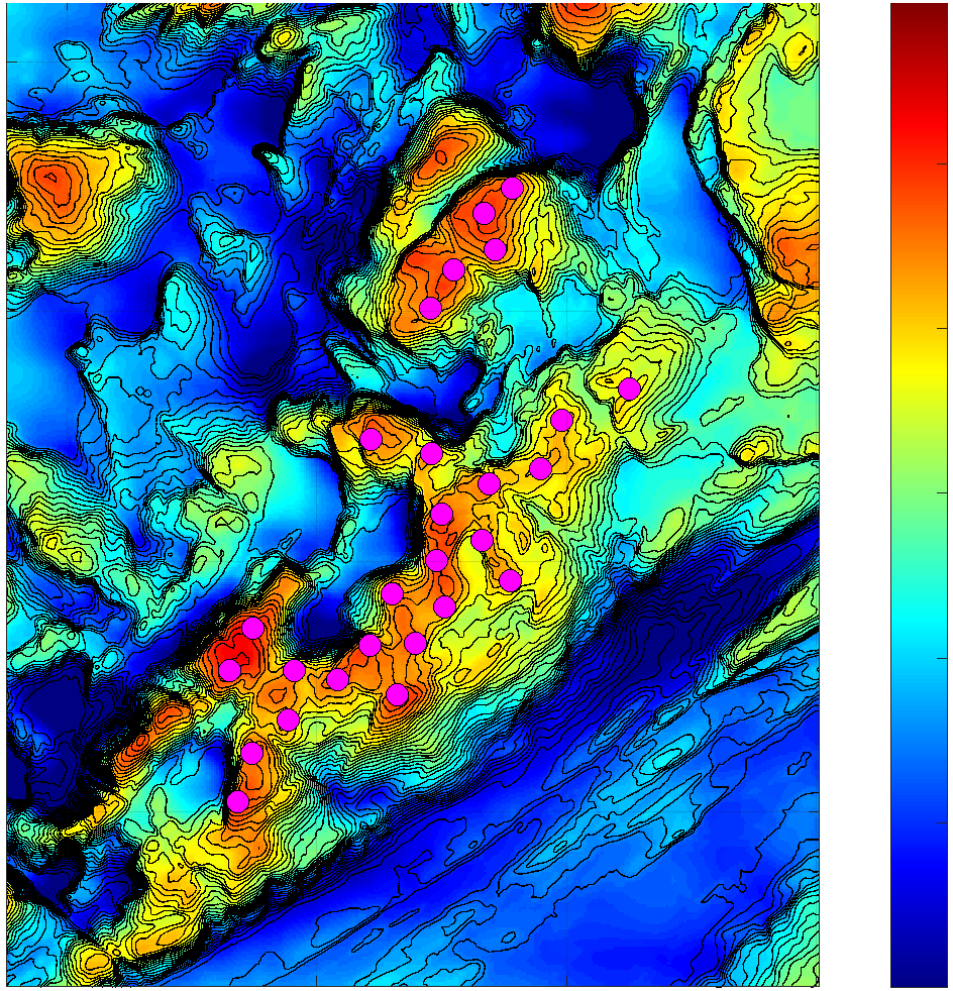
WAsP ; Meso-corr

MAE					
2.16%	File_1	File_2	File_3	File_4	File_5
File_1	0.00%	4.38%	5.38%	4.71%	4.56%
File_2	-4.80%	0.00%	0.88%	-0.34%	-0.84%
File_3	-4.06%	0.58%	0.00%	0.00%	0.60%
File_4	-4.06%	0.46%	1.37%	0.00%	-0.48%
File_5	-4.27%	0.69%	0.63%	0.11%	0.00%

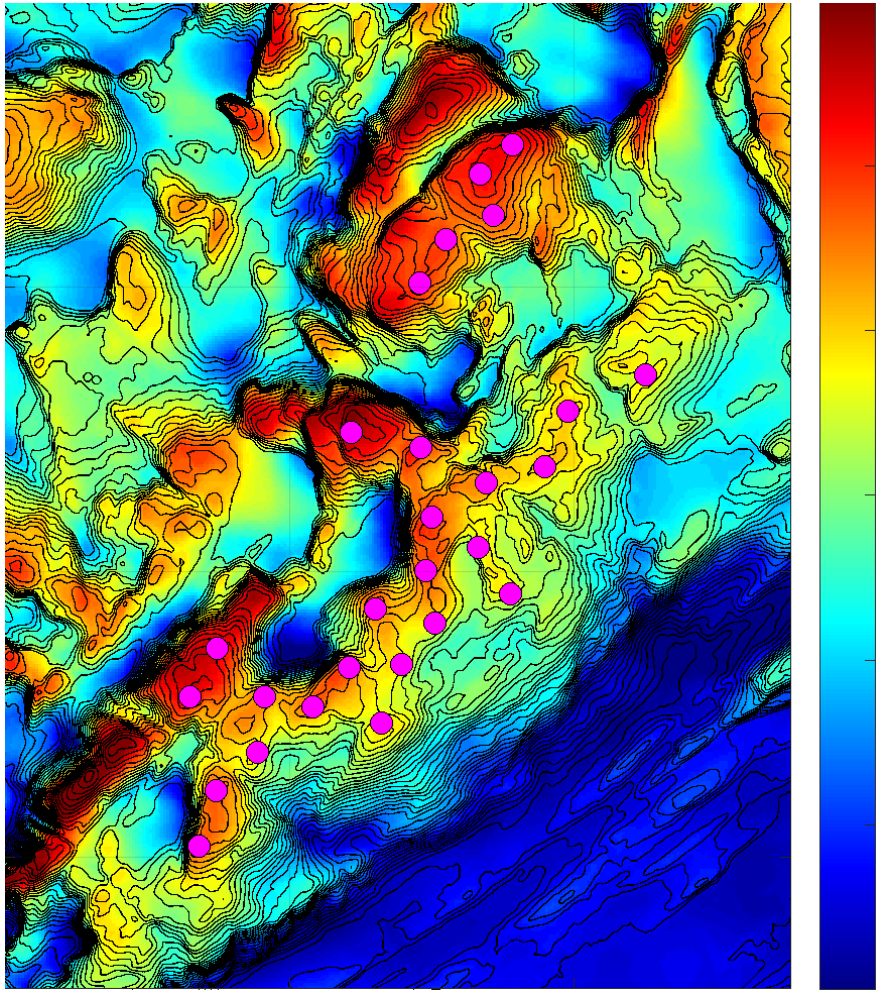
Statkraft

Standard Windsim cloud: Mean wind speed

No meso-correction



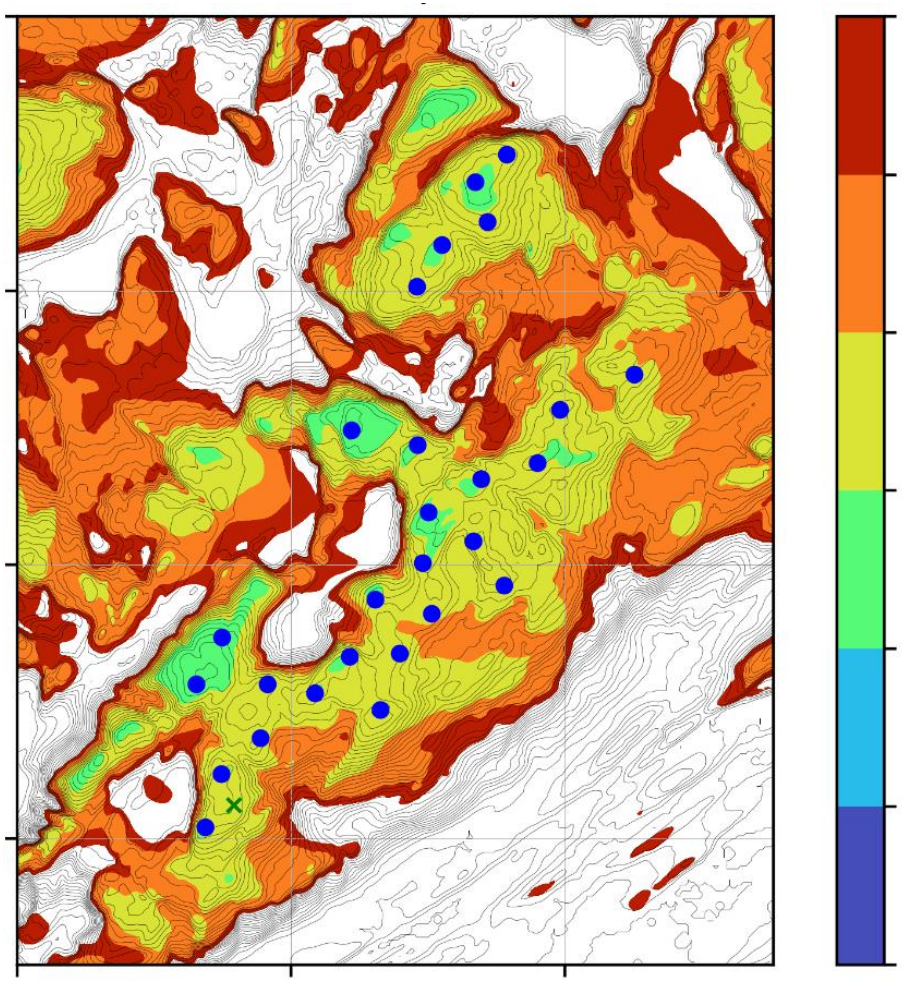
Meso-corrected



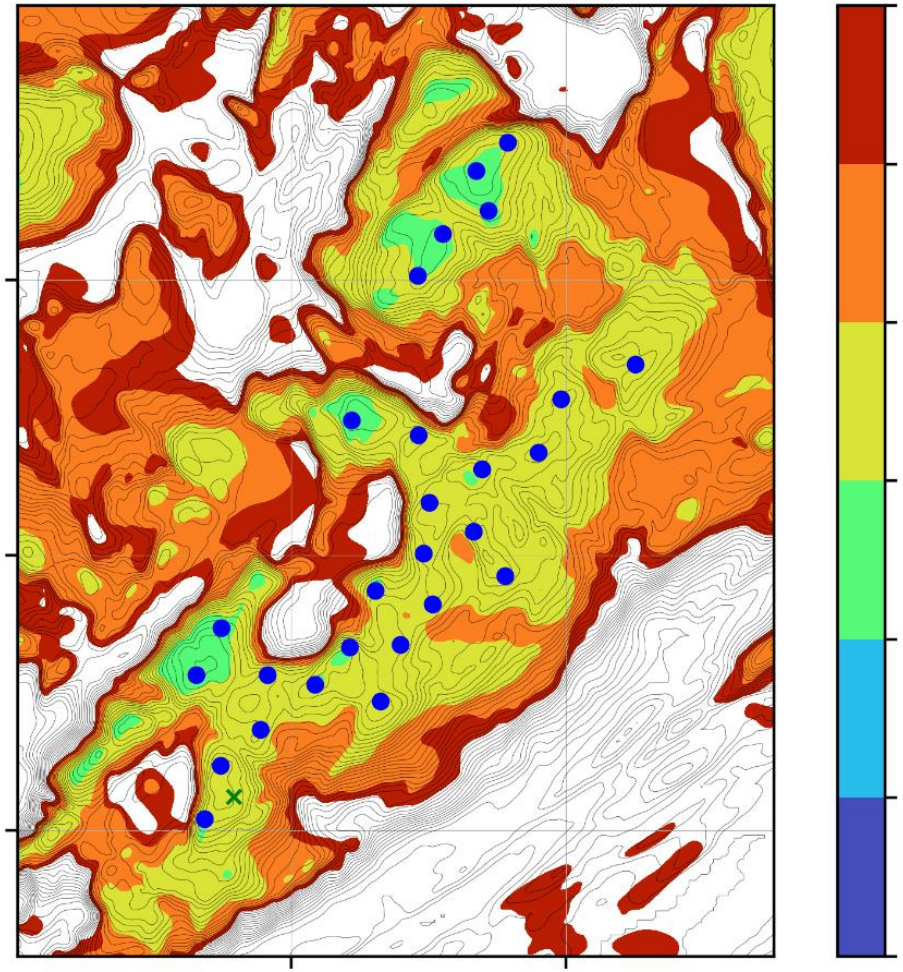
Statkraft

Standard Windsim cloud vs Windsim Beta: TI90 plot

Standard Windsim cloud



Windsim Beta



Statkraft

Summary and conclusions

- Pros:
  - Simple set up of projects (less than 1 hour).
  - Good source data for both height and roughness (in test case area).
  - Usage of grid height is improving the accuracy compared to contour data input.
- Cons:
  - Not able to manually set the refinement grid.
  - Not able to read alternative input sources for height and roughness if not sufficient accuracy in online data sources.
- Windsim Beta cross predictions are in the test case marginally better than standard Windsim cloud. Difference well within the uncertainty of input data, so the results are concluded to be equally accurate.
- Reduced cross prediction errors with Windsim compared to WAsP.

Statkraft

statkraft.com