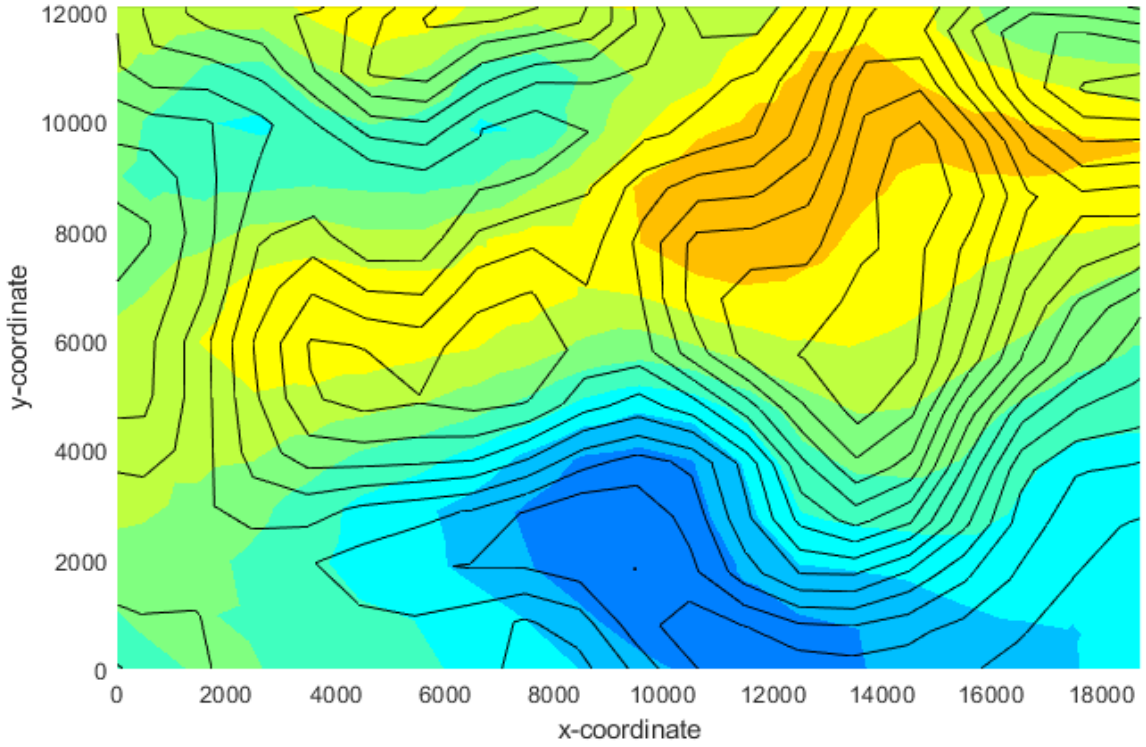
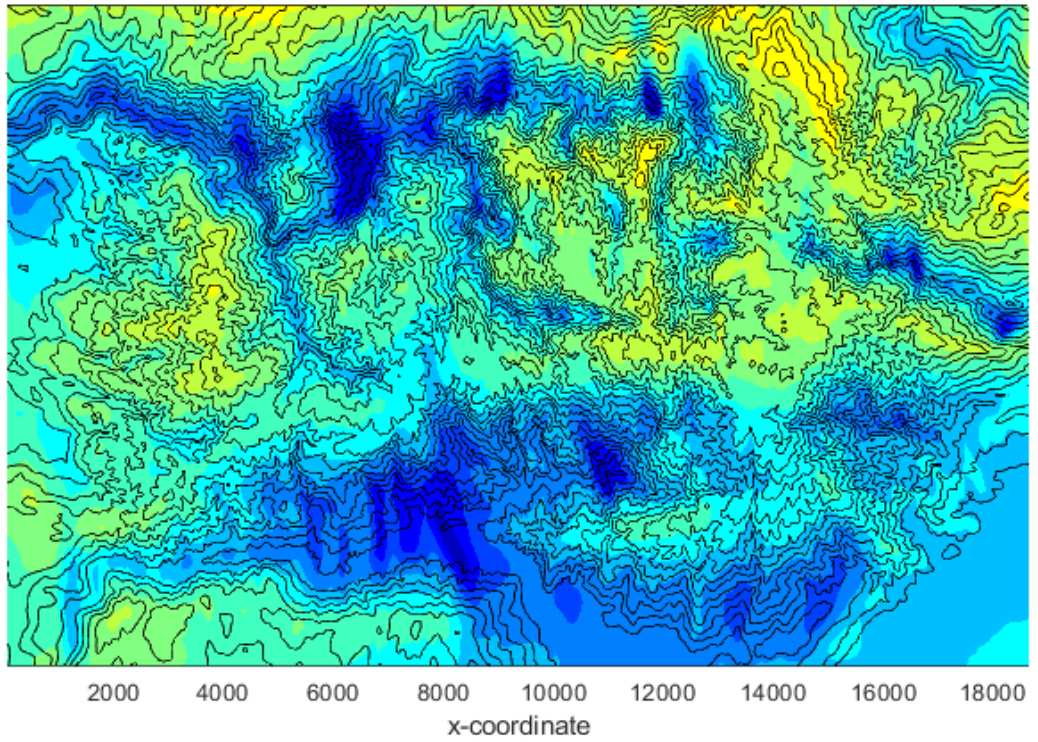
Carrying-out Yield Assessment using Meso-Micro Coupling

WindSim User Meeting 2021





Agenda

1. Background and experience in Mainstream
2. Complex forested site – Averaged DWS
3. Desert flat site – Averaged DWS
4. Moderately complex forested site – SOM DWS
5. Conclusions so far, advantages and potential improvements

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Background and experience

- Mainstream is active in countries like Chile or South Africa where mesoscale modelling is required for horizontal wind flow extrapolation

- Our standard approach for simple terrain is to use 3rd Party WRF model downscaled to 100 m, provided as WRG file representative of a ‘typical year’

- Nevertheless, 100 m is coarse for some sites and does not capture well enough orographic features or forestry – and in addition WRF not suited for microscale

➔ We started looking into mesoscale coupling with WindSim back in 2017

Background and experience

- Current experience with WindSim coupling:

# of sites	DWS Averaged	DWS SOM
Complex forested sites	3	2
Desertic sites	4	1
Simple sites	3	

- Current process is to use WindSim coupling when mesoscale circulation is suspected across a complex/forested site, or large stability changes occur on a sectorwise, hourly or monthly basis

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Complex forested site – Averaged DWS

- Complex terrain, forested, southern cone

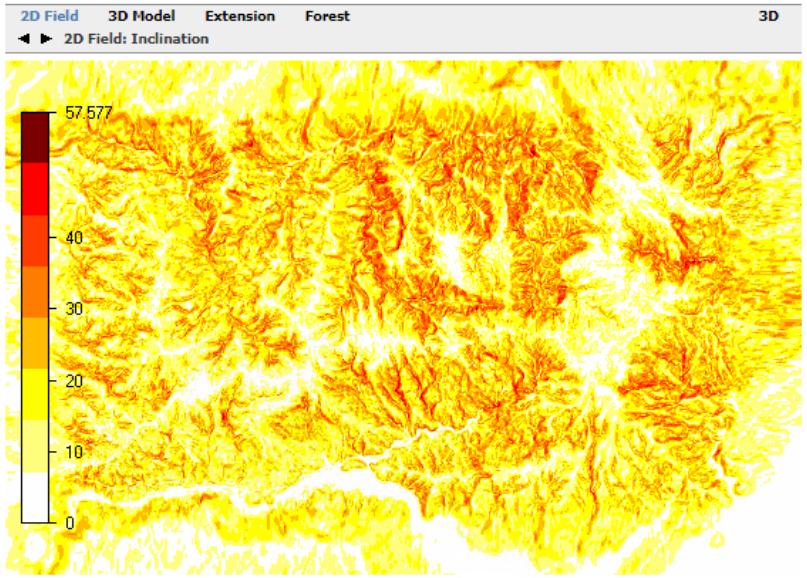


Fig 1. Digital terrain model - Inclination angle (deg).

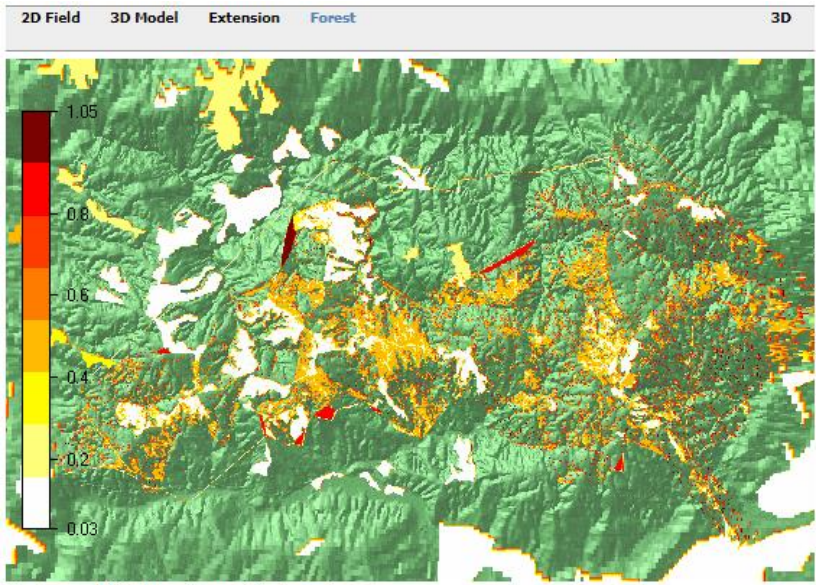
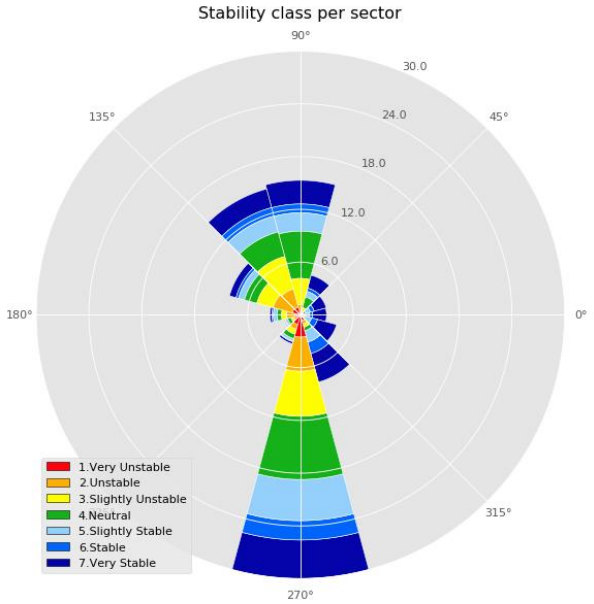


Fig 1. Digital terrain model - Forest



- 5 masts available (4 x 120 m and 1 x 80 m), 2 SoDARs

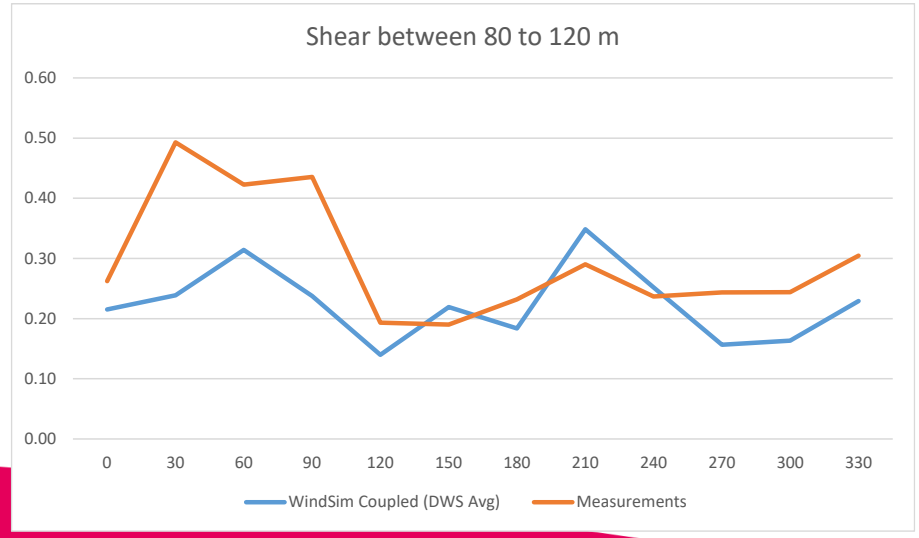
Complex forested site – Averaged DWS

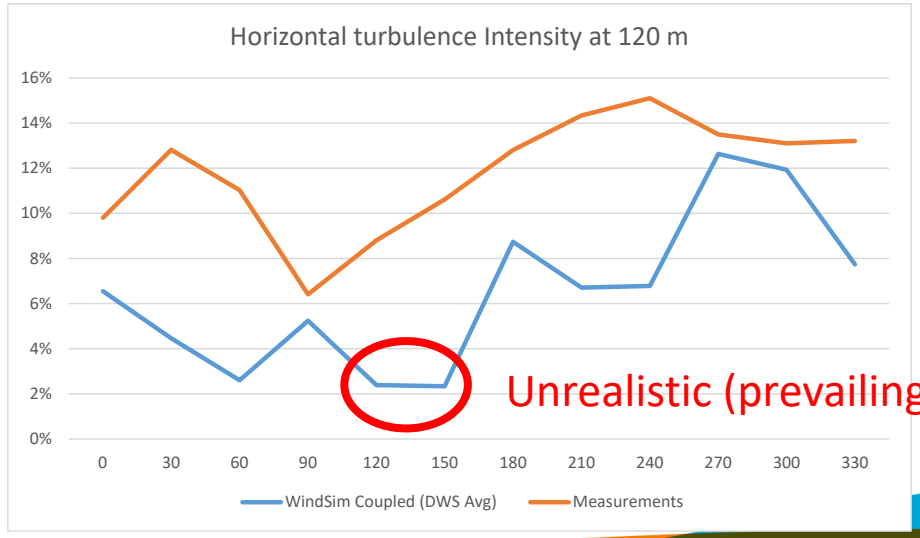
- Horizontal cross prediction results, mean averaged absolute error, 120 m

	Error
Linear model	9.7%
WindSim Neutral	9.0%
WindSim Coupled (DWS Avg)	4.0%
3rd Party Consultant (CFD RANS with stability)	2.2%

Coupling divided error by 2

- AEP calculated using WRG output from WindSim, in line with EYA consultant
- Shear in line with measurements, some issues with turbulence noted (unrealistic low values)





Unrealistic (prevailing sector)

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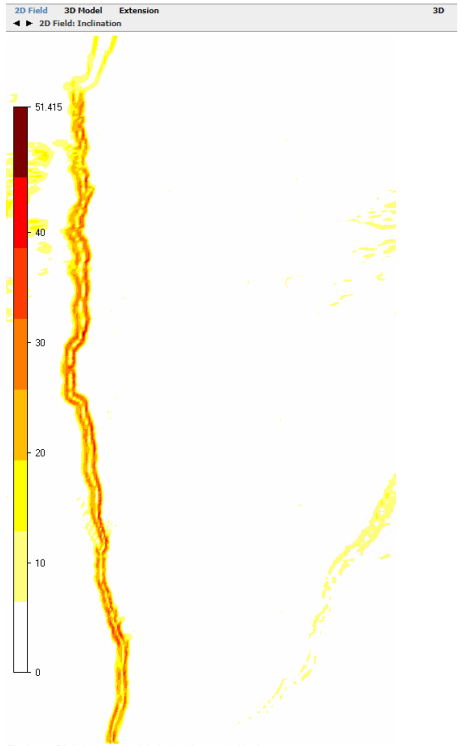
Desert flat site – Averaged DWS

> Flat desert site, southern cone



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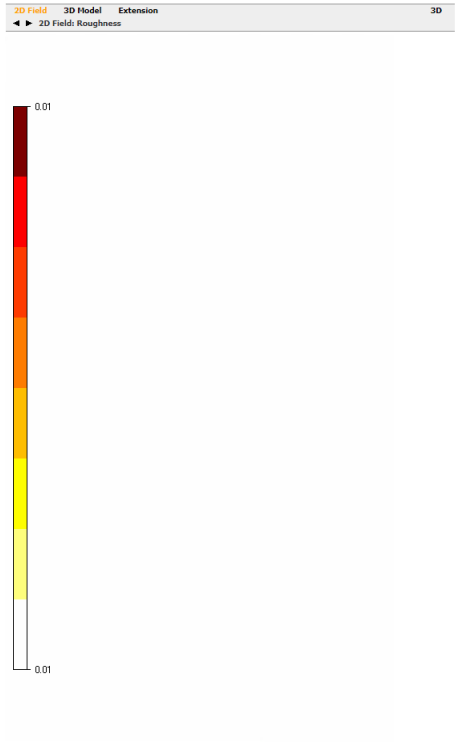
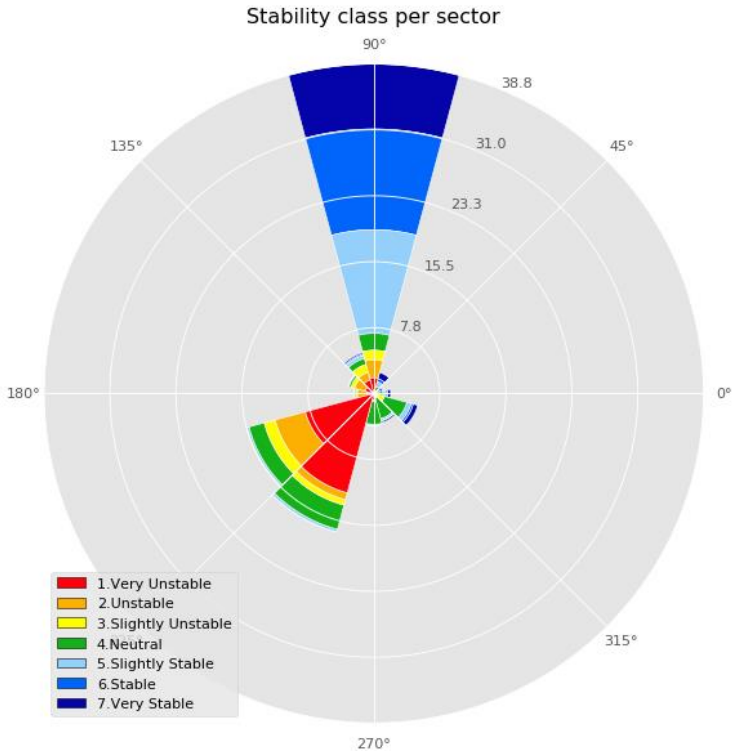


Fig 1. Digital terrain model - Roughness height (m).



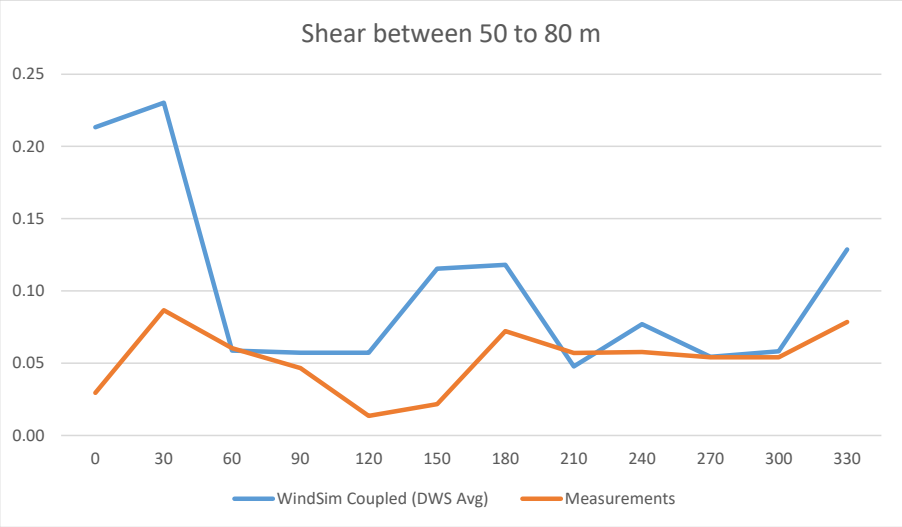
> 2 x 80 m masts available, 2 SoDARs, 3 LiDARs

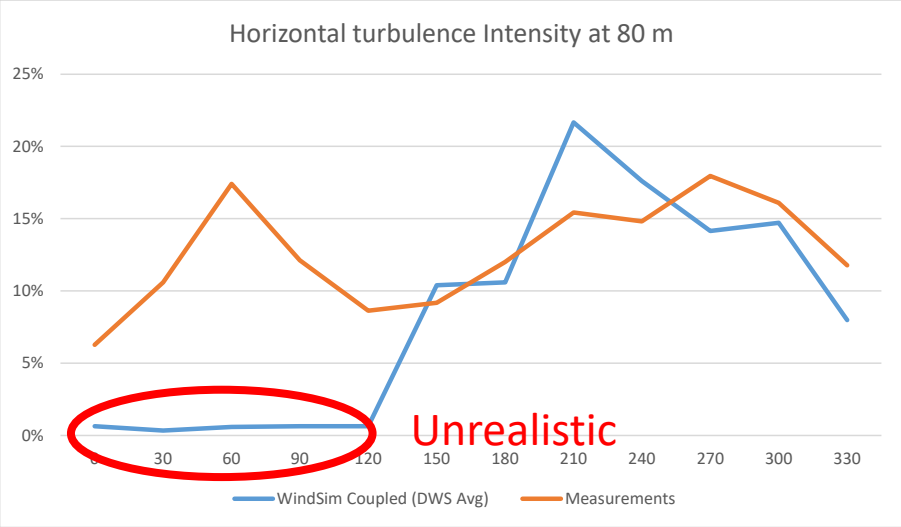
Desert flat site – Averaged DWS

- Horizontal cross prediction results, mean averaged absolute error, 80 m

	Error
Linear	3.5%
3rd Party Mesoscale (WRF 100 m)	4.4%
WindSim Coupled (DWS Avg)	2.5%

- Overall good fit of shear and turbulence to measurements, except for north-eastern sectors where TI is unrealistically low





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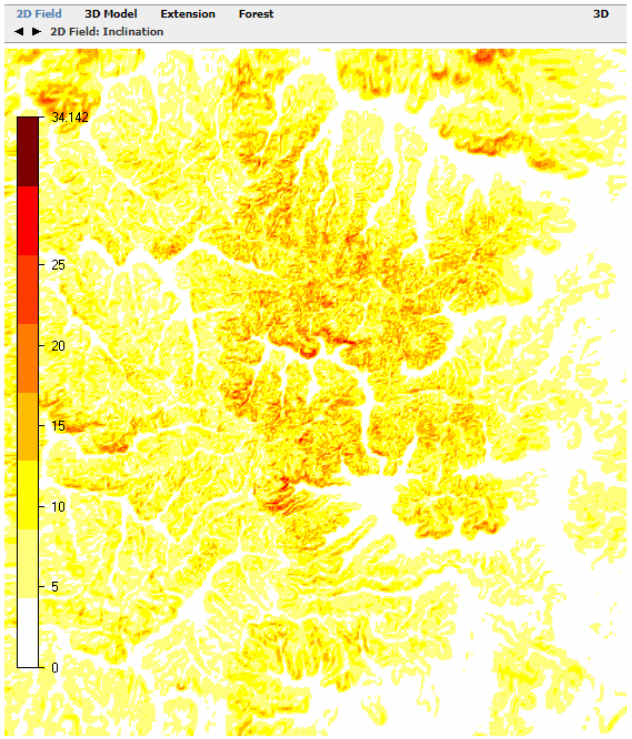
Moderately complex, forested – SOM DWS

- Moderately complex, forested, southern cone



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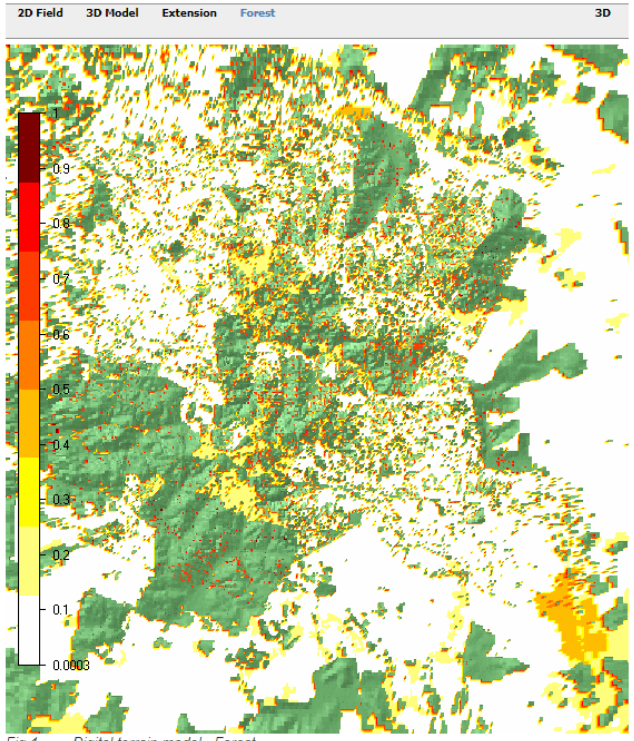

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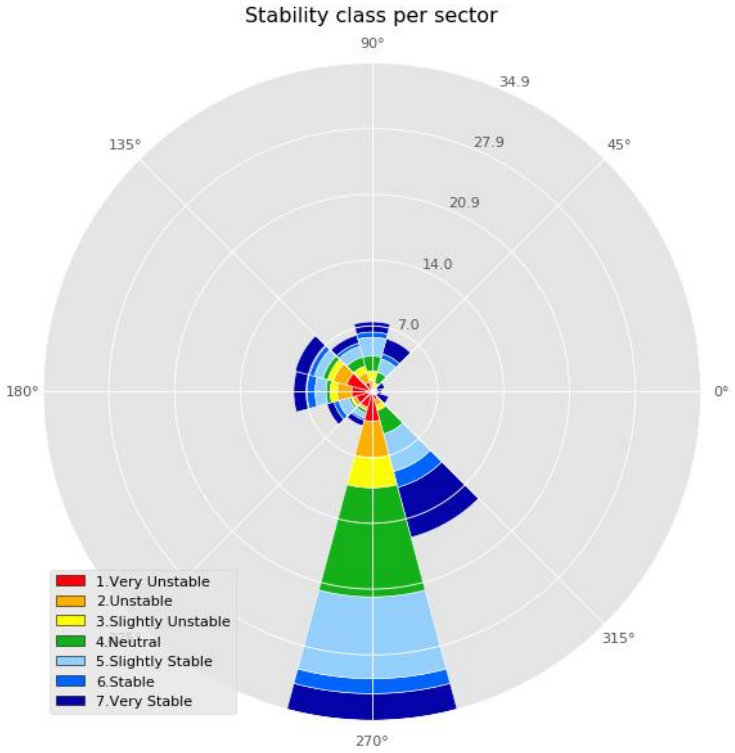
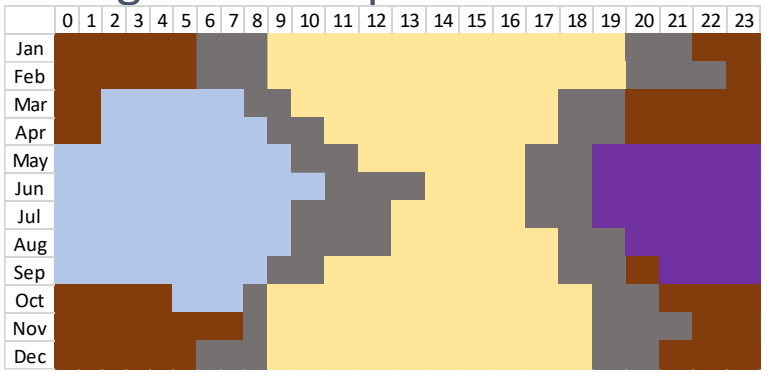


- Only one 120 m mast available for the moment

Moderately complex, forested – SOM DWS

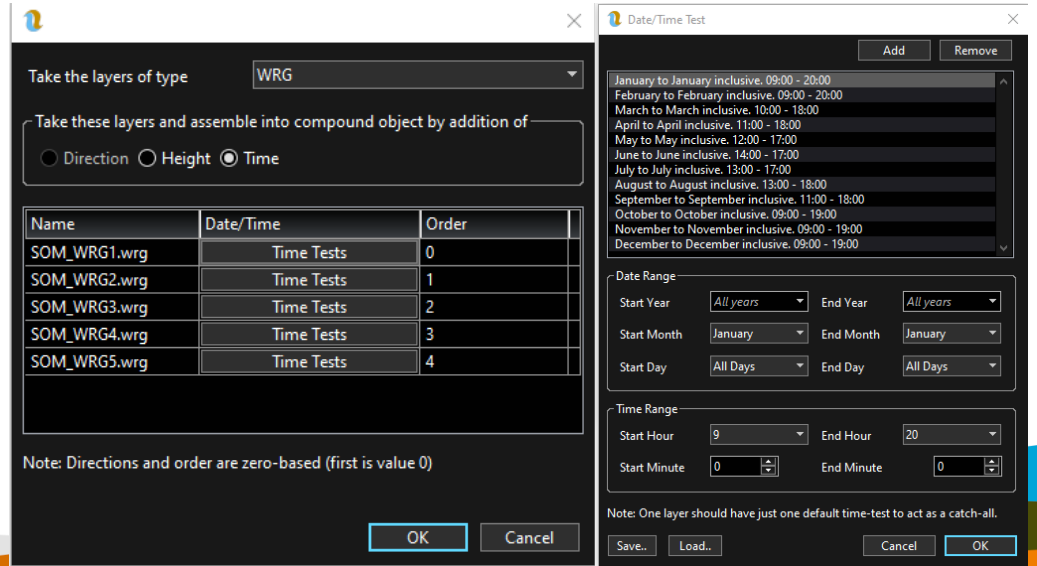
> Self-Organised Map Classification and WRG structure:



WRG	Description	0	30	60	90	120	150	180	210	240	270	300	330
WRG1	Daytime	13	13	N	N	N	2	4	N	**8**	7	11	6
WRG2	Winter nightime	13	13	N	N	N	5	5	N	8	9	9	12
WRG3	Winter dawn/morning	10	13	N	N	N	5	5	N	8	**7**	**7**	12
WRG4	Not winter nightime	10	**13**	N	N	N	2	2	N	8	9	9	12
WRG5	Morning/evening transitio	13	13	N	N	N	2	2	N	8	7	7	6

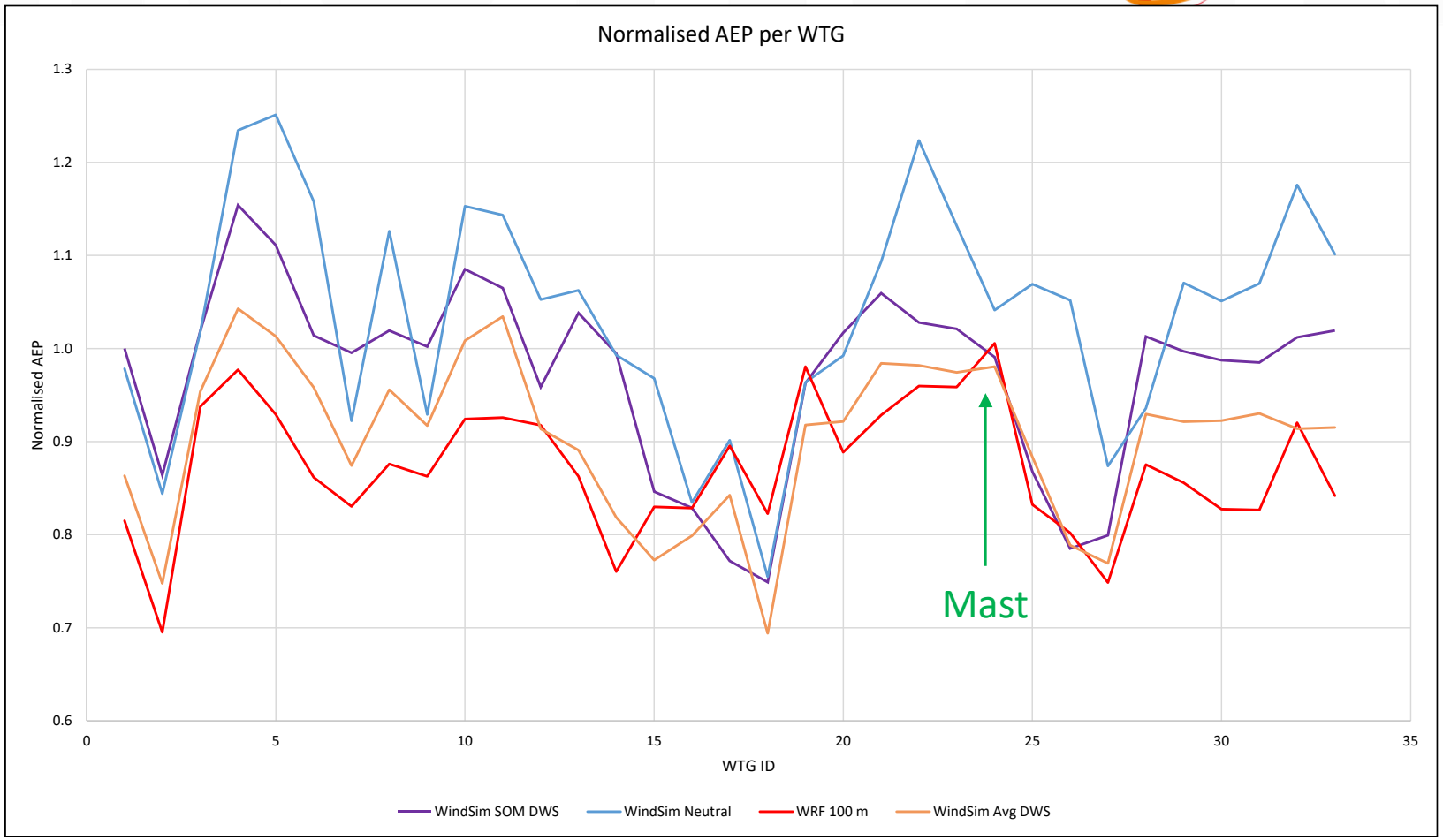
Case	Frequency [%]	Direction [°]	MOL [m]	BLH [m]	WS [m/s]
1	6.2	172	-307	642	10
2	17.1	166	182	341	9
3	11.2	170	446	391	13
4	11.7	173	-56	851	5
5	12.9	165	X	198	9
6	4.7	339	-98	1087	7
7	4.2	285	-64	973	5
8	6.2	242	X	136	5
9	5.0	285	214	205	7
10	4.5	6	X	175	6
11	6.6	292	-140	1030	8
12	4.8	325	39	284	7
13	5.0	13	588	830	11

> Loaded in Openwind for AEP calculations:



Moderately complex, forested – SOM DWS

- AEP per WTG



- Interesting to note that SOM DWS results are between WindSim Neutral and WRF
- Mesoscale effect seems captured in the WindSim simulation (?) – to be confirmed by measurements

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Conclusions and Advantages

- The WindSim coupling is a powerful option for wind flow modelling, and internal research seems to indicate that even ‘traditional’ simple wind farm sites (i.e. northern or western Europe, rolling hills) would benefit from it
- DWS Average showed large benefits on some sites, limited or none on others
- DWS SOM shows promising results, will give more flexibility to users and more ‘physical’ results
- DWS SOM will also allow more accurate prediction of hourly profiles, which could proved valuable in some markets

Potential improvements

Our ‘wish list’ for WindSim coupling moving forward:

- Fixing the issue with very low TI on very stable sites
- Convergence is challenging under some conditions (e.g. very stable, unstable), and convergence monitoring different than for a standard neutral simulation: how could that be improved?
- Creating WRG from DWS SOM is currently tedious, would need automation to reduce the risk of user-error
- Combining SOM WRG into a ‘typical year’ WRG currently not implemented in WindSim, need for a 3rd party software. Having a Vertical Profile and 2D maps of a typical year would help too