10th WindSim User Meeting

24-25 June 2015, Tønsberg

WindSim 7.0 and recent developments

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windsim

Content

- Developments in the last year
- WindSim 7.0 - Latest Features
- Research activities in WindSim

Developments in the last year

Release of WindSim 7.0 in April 2015

- New plug-ins
- Wished features from UM 2014
- Improved post-processing
- Optimized GCV

Wind Atlas Method

WindSim Web Portal

Improved/New tools:

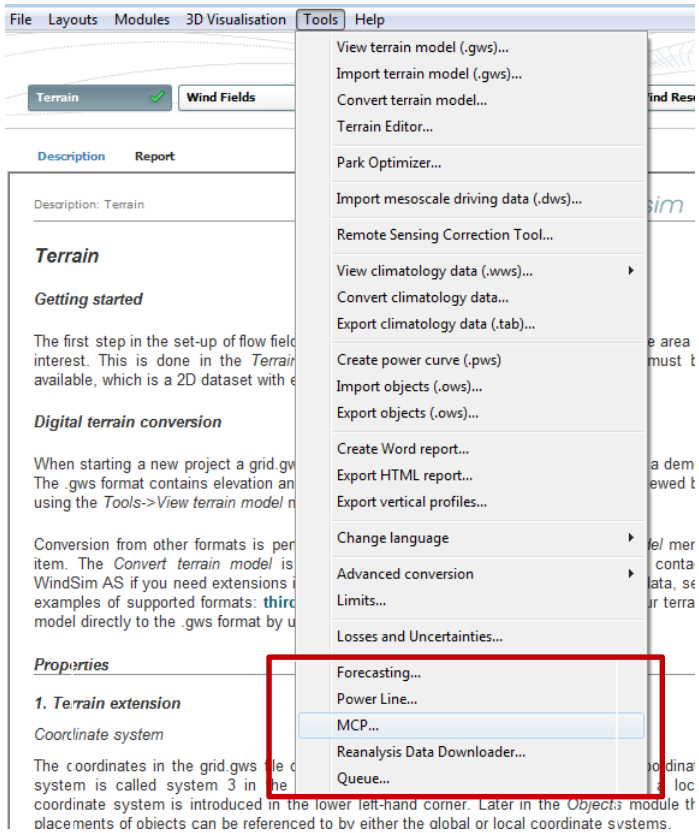
- WindSim Express
- WindSim Power Line

Validation wake models/forest model

WindSim 7.0

New Features:

- WindSim Queuing
- WindSim MCP
- WindSim Reanalysis Data Downloader
- Break a run properly
- New wall functions
- Improved post processing
- Power density calculation
- WindSim Terrain complexity



WindSim 7.0 – latest features

- Power history export weighted, naming of export files
- Choose WRG export dimension
- You can choose the forest model and the divergence wind speed
- Improved smoothing
- Recoding forest – less patches – faster calculations
- Wake decay factor as direct input parameter

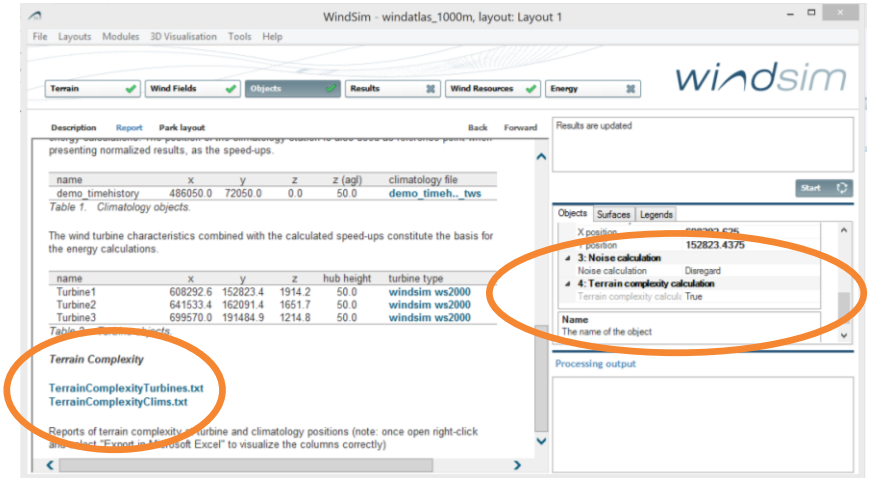
WindSim 7.0

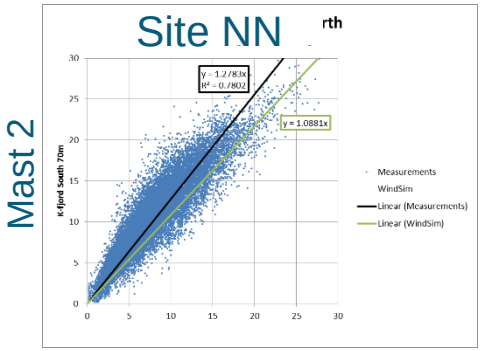
Terrain complexity

- **Share your cross-correlation and terrain complexity values with WindSim**

- Anonymous: No geo-referencing of the site,

- Outcome: Statistics on modeling accuracy according to terrain complexity indicators
  - Input for losses & uncertainty calculation
  - Improved understanding of the wind conditions
  - Improved modeling

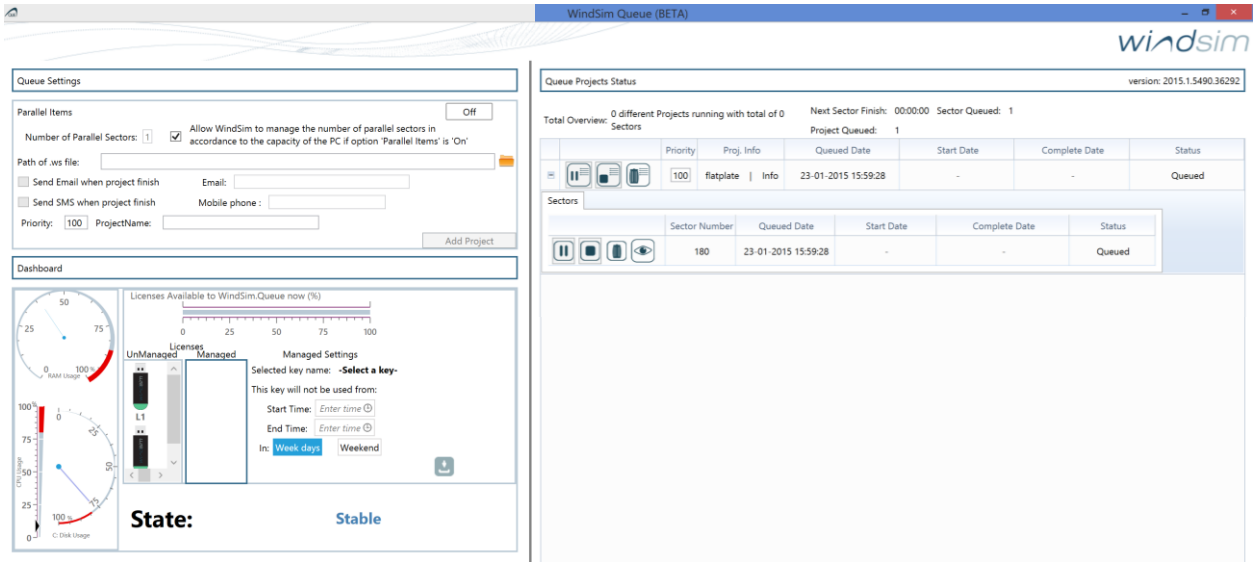




WindSim 7.0

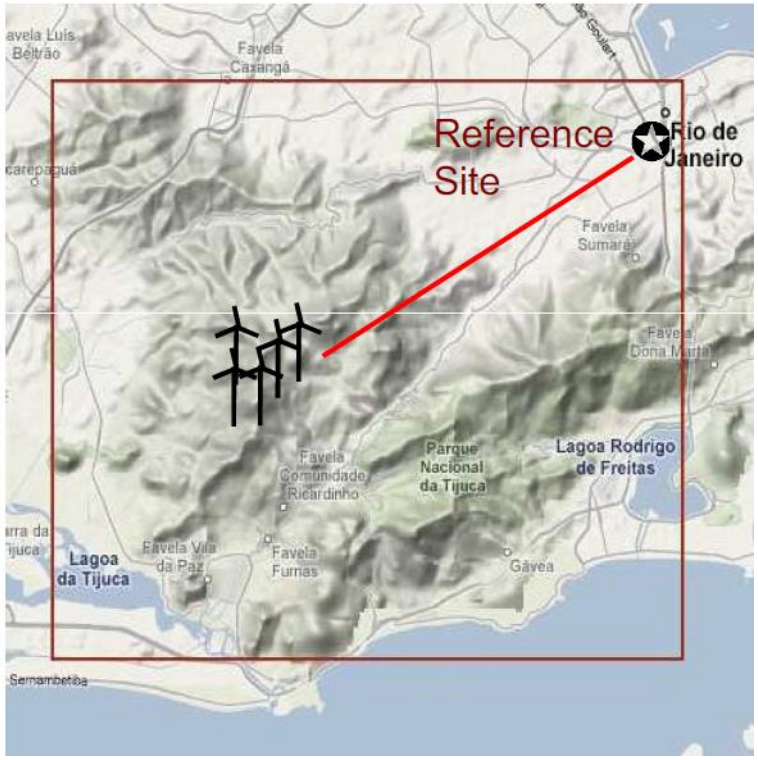
Queuing

- Possibility to run several projects in a consecutive order
- Able to start, stop and pause runs as you would like
- Let WindSim manage your computing resources in the best way



WindSim 7.0

MCP (Measure-Correlate-Predict)



MCP is a statistical technique used for predicting the long term wind resource at a proposed wind farm site by relating measurements from a short-term measurement campaign to the long term data sets of a reference

Find **statistical relationship between a reference observation** (usually long term time series) **and a on site observations** (at least one year)

Traditional reference:

- Meteorological observation stations

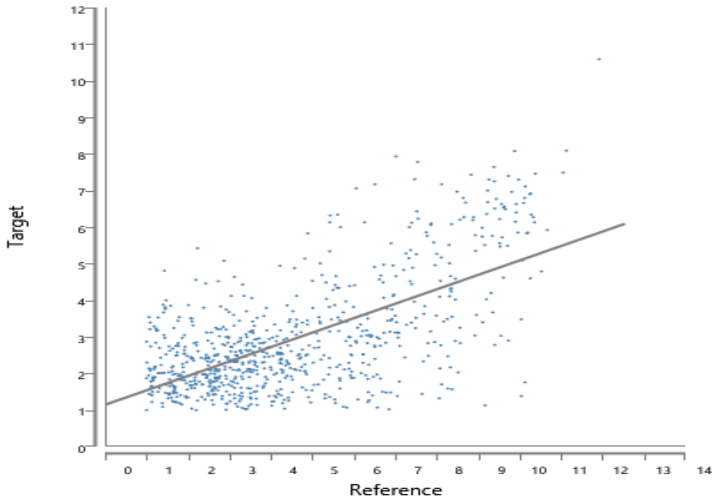
Synthetic reference:

- Forecast models (Merra etc..)

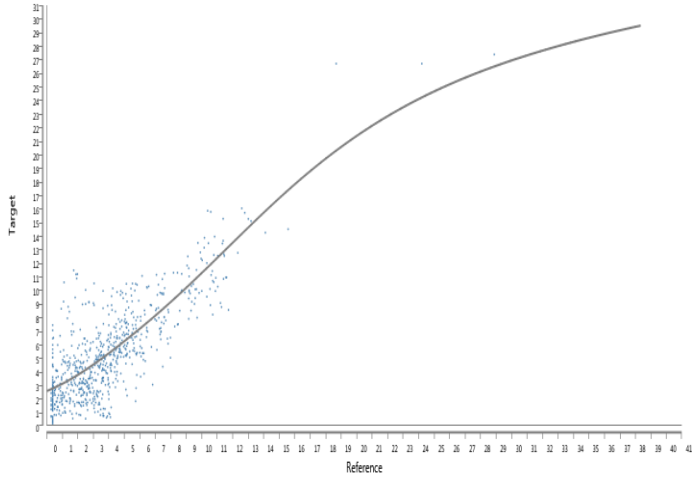
WindSim 7.0

MCP (Measure-Correlate-Predict)

Standard Linear Regression
Linear fit in each direction



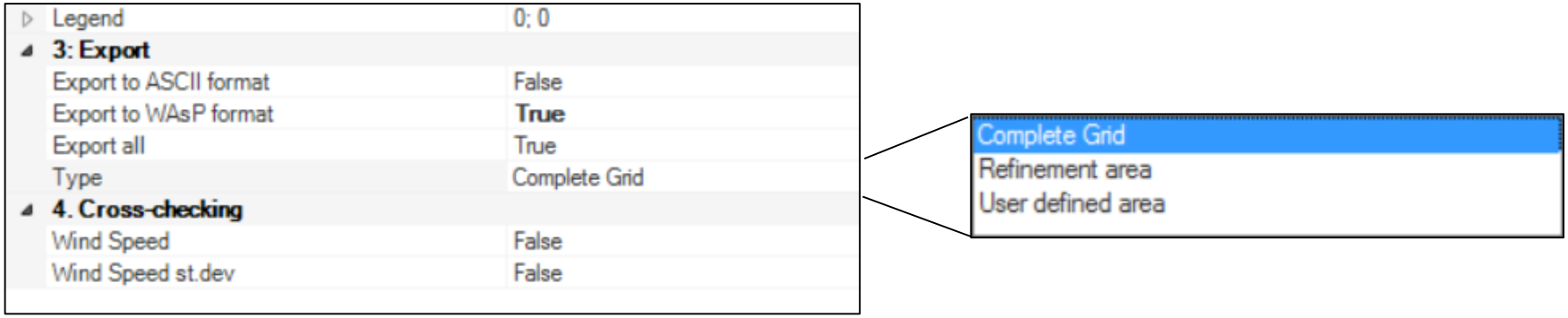
Neural Network
Smooth surface “fit”



WindSim 7.0

WRG Export (Wind Resource Module)

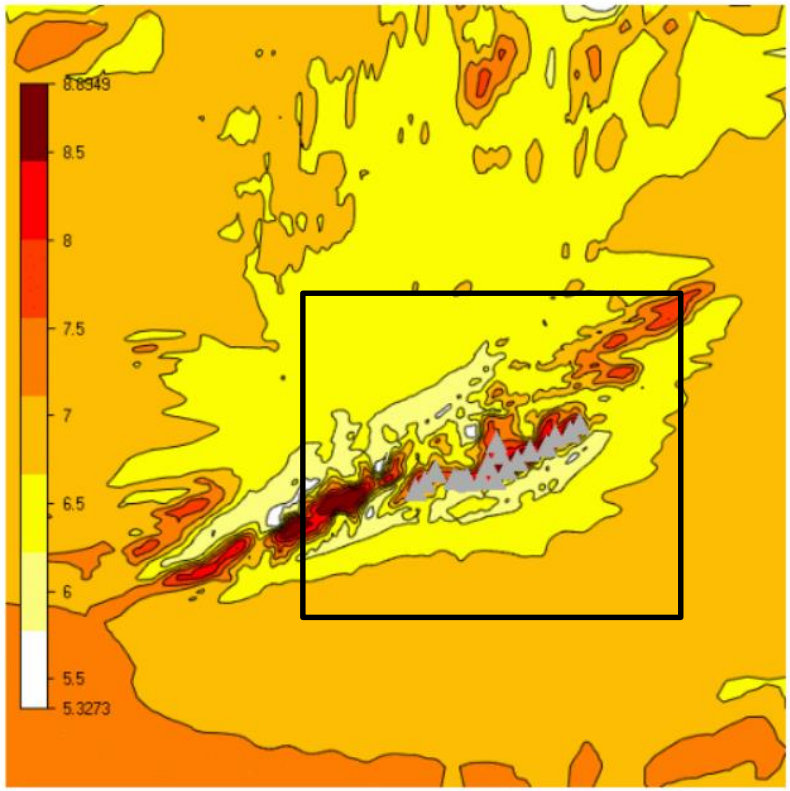
- Export Wind Resource Grid in Wasp Format.
- Export Wind Resource weighted over all Climatolgies.
- Define the area of the export and resolution.



WindSim 7.0

WRG Export (Wind Resource Module)

- User defined area



	Export to ASCII format	False
	Export to WAsP format	**True**
	Export all	True
	Type	**User defined area**
▷	X-range	**322991; 328984**
▷	Y-range	**7183991; 7188984**
	Resolution	**100**

Export WAsP

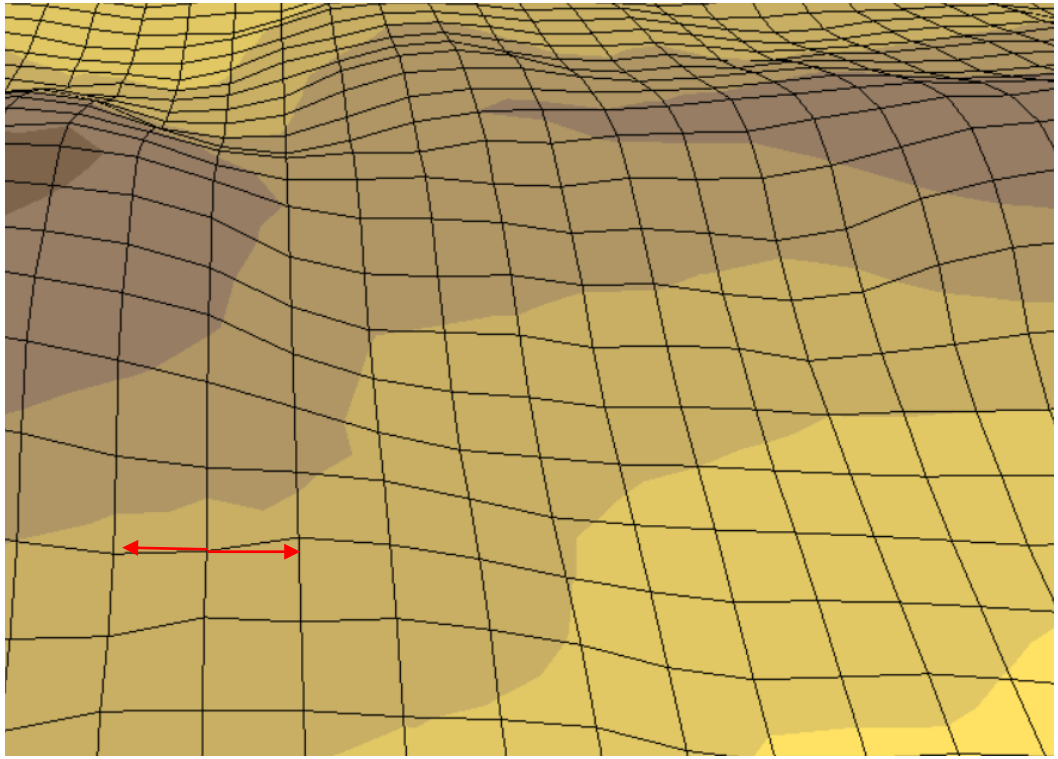
wind_resources_clim_Hundhammer_83m_0080_area.rsf
wind_resources_clim_Hundhammer_83m_0080_area.wrg
wind_resources_clim_Hundhammer_30m_0080_area.rsf
wind_resources_clim_Hundhammer_30m_0080_area.wrg
wind_resources_climall_0080_area.rsf
wind_resources_climall_0080_area.wrg

Smoothing improvements (Terrain Module)

Smoothing: iterative process that decrease the local second order derivative until it is lower than a defined limit (default 0.01).

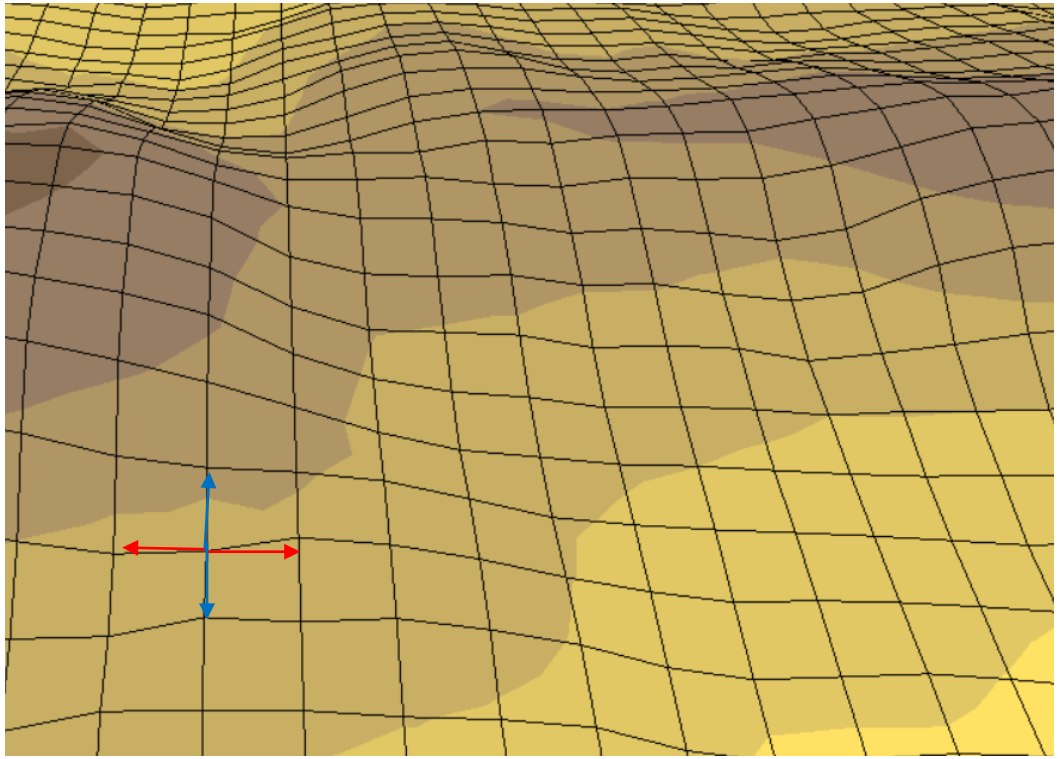
WindSim 7.0

- Bi-linear Smoothing: decrease second order derivative first in X then Y direction. Considering only point in each direction separately



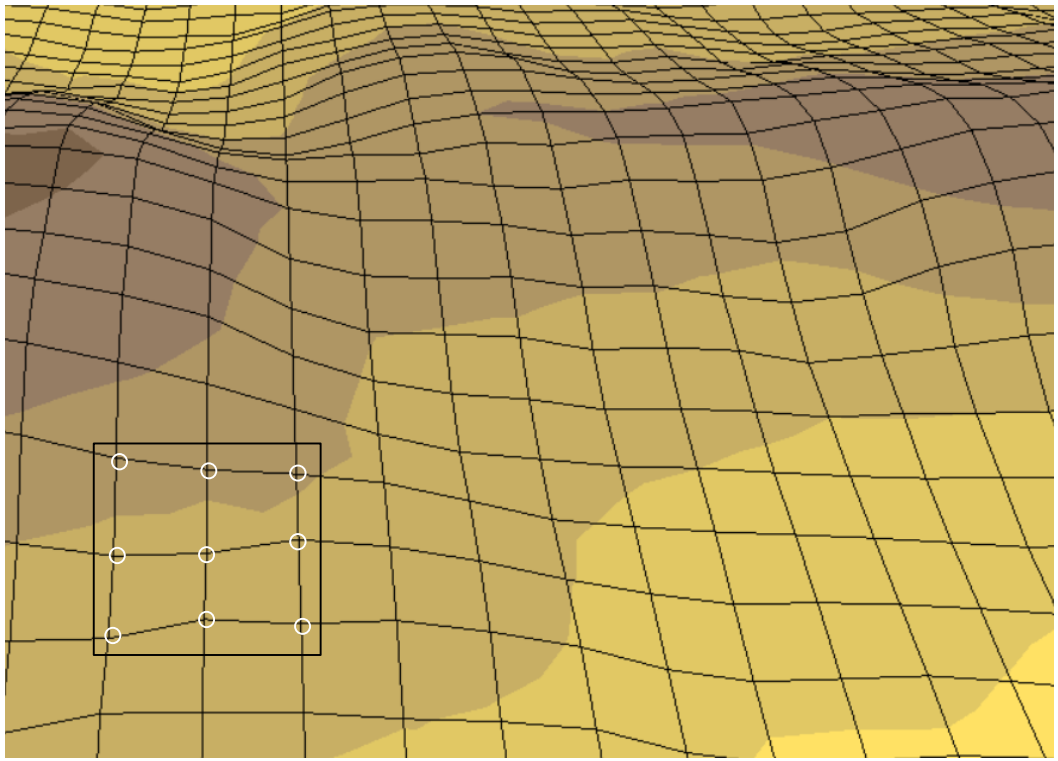
WindSim 7.0

- Bi-linear Smoothing: decrease second order derivative first in X then Y direction. Considering only point in each direction separately



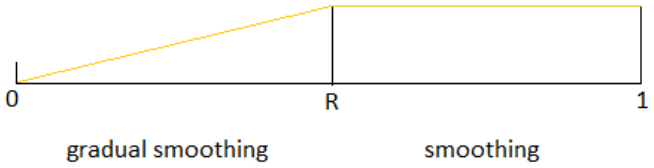
WindSim 7.0

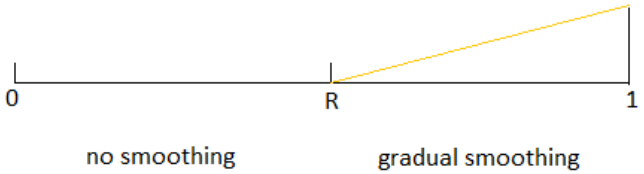
- Gaussian Smoothing: decrease second order derivative first in X then Y direction. Considering all surrounding points with Gaussian weight

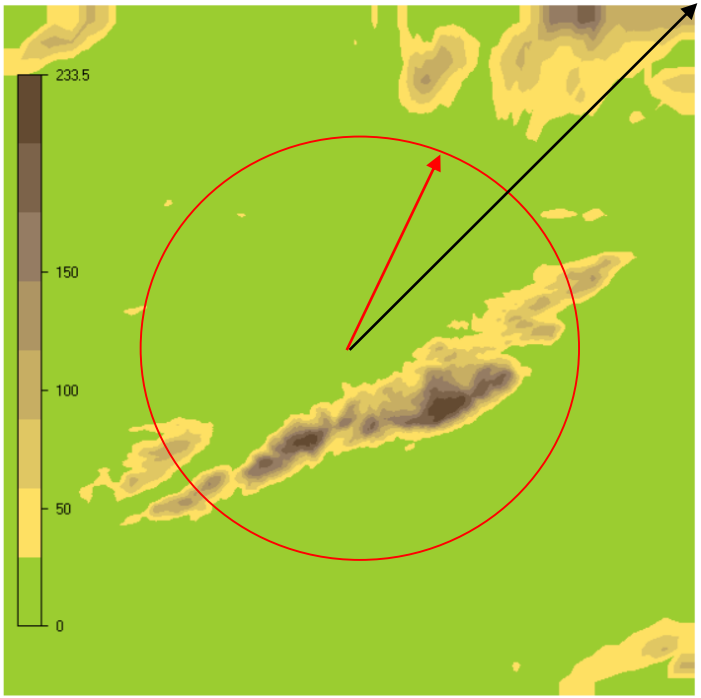


WindSim 7.0

- Radial Smoothing
- Inner/Outer gradual smooothing







R defined between 0 and 1, centered circle.

Inner/Outer gradual smooothing

Enable the user to smooth more the area of less interest and speed up the CFD simulation avoiding to solve complex area far from the wind farm.

WindSim 7.1

Release autumn 2015

Faster parallel solver

Better forest/wake models

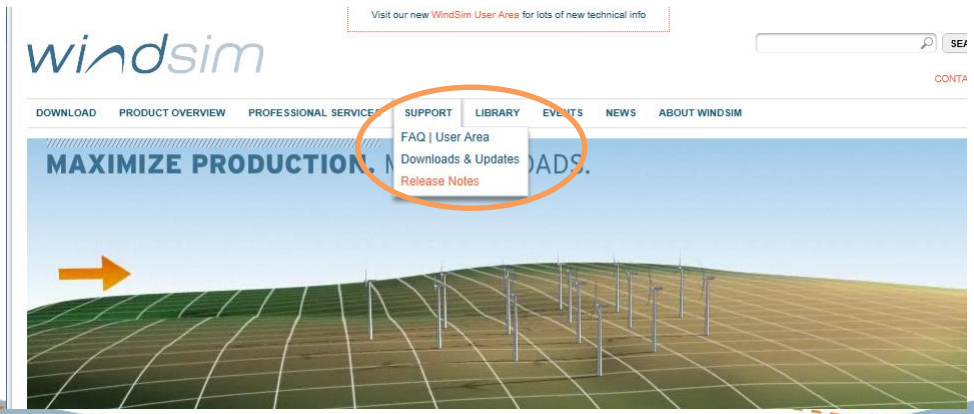
Binary output files

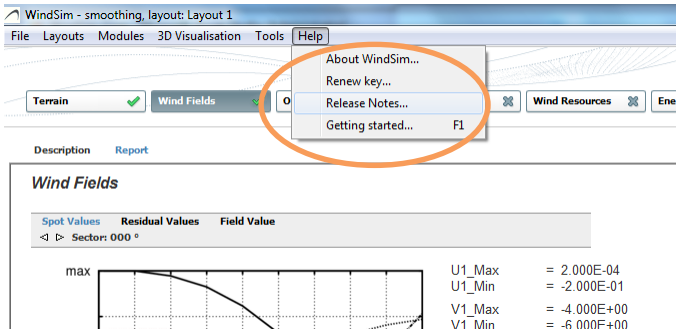
Look-up tables for the WindSim Web Portal

Bug fixes and user wishes from 7.0

Release Notes

Noted on the web and in the software





Research activities in WindSim

Forest

Master thesis by Karsten Busch beginning summer 2014

Validation project with Iberdrola

Validation by Siemens

Wake modeling

Master thesis by Fredric Seim

Cooperation with Juwi

Actuator disc

Phd thesis by Nikolaos Simisiroglou started in 2013

Mesoscale coupling

ENERGIX Research project with CHAM

Forecasting

ENERGIX Research project with the UniComputing in Bergen

Wake model validation – DEWEK presentation together with JUWI

- Introduction
- Wake models in Windpro and WindSim
- Sensitivity studies

  →Validation on an offshore wind farm

  →Validation on an onshore wind farm
- Conclusions

Introduction

- Today analytical wake models are the work horse of the industry as other methods are too computational expensive
- There are many different models and even more ways to implement them numerically into WRA software
- Users want to understand how the implementations differ in the different software and which wake models should be used
- Wake models have different parameters which need to be adjusted and it is important to understand which parameters need to be changed to get good results and how sensitive the results are for these parameters

Wake models in WindPro and WindSim

- Two wake models which are the same: Jensen and Larsen (other models: WindPro - Ainslie etc., WindSim - Ishihara)
- General findings over the years: Jensen is the best model to use
- Focus on Jensen and Larsen in this talk

→ Jensen: simplest model which only accounts for different wake decay factors dependent on the roughness

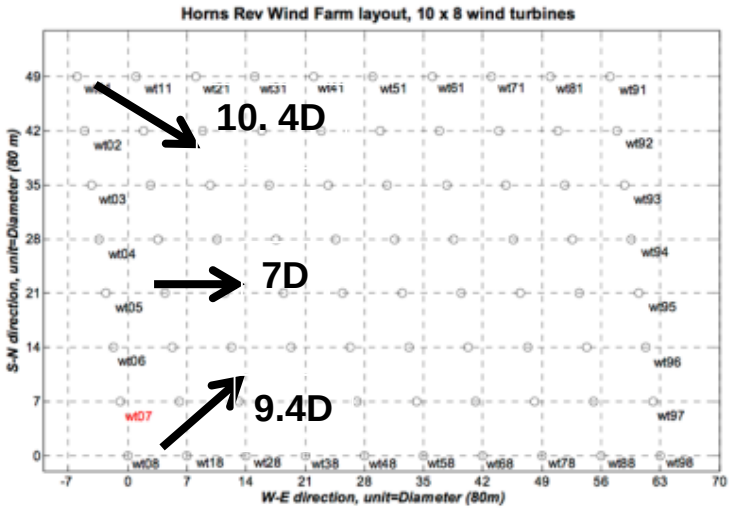
→ Larsen: Includes turbulence intensity which can also be induced by other turbines => should be more accurate

Sensitivity studies

- **Wind farms used:**

Offshore: Horns Rev, new data sets from 2005 to 2010, filtered by stability to contain only neutral cases (data courtesy Kurt S. Hansen, DTU Wind Energy)

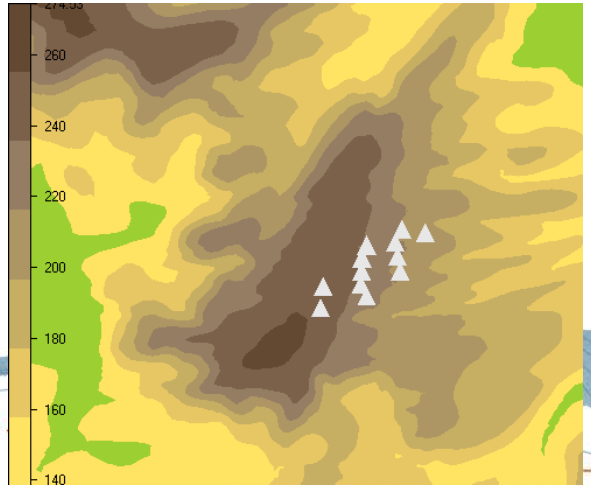
Onshore: Own Park with different stages of development, moderate terrain, roughness



- **Parameter varied in general:**

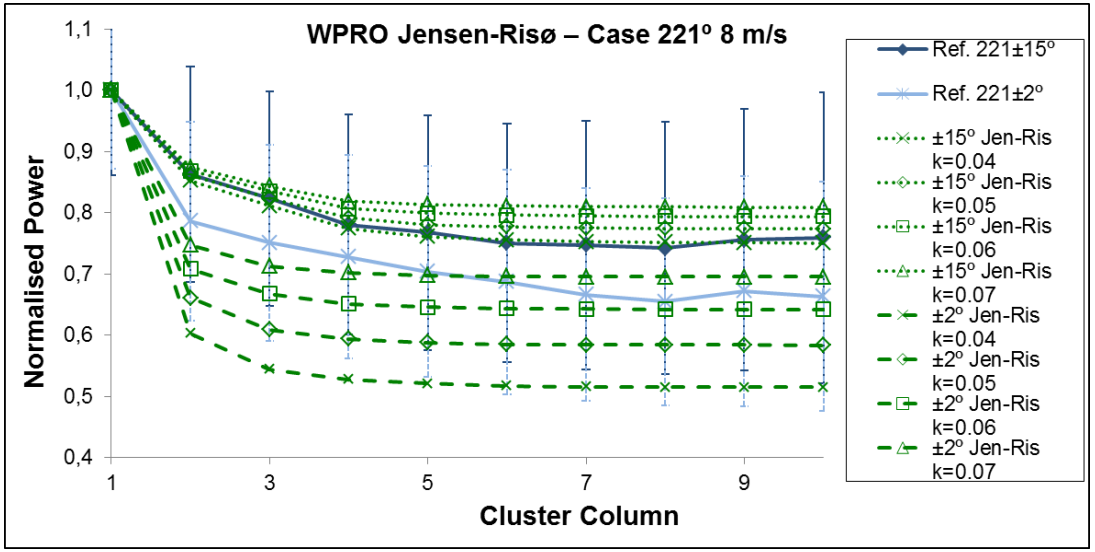
Wake decay (Jensen), TI (Larsen)

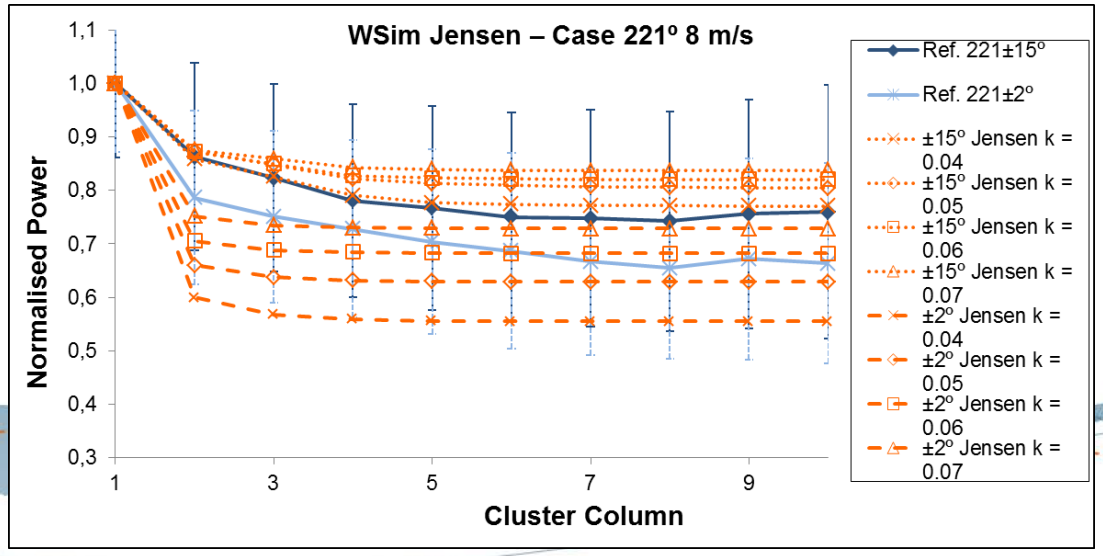
Sub cycles, Rotor diameter influence



Sensitivity studies - Offshore Jensen

- **Wake Decay Variation 9.4D**

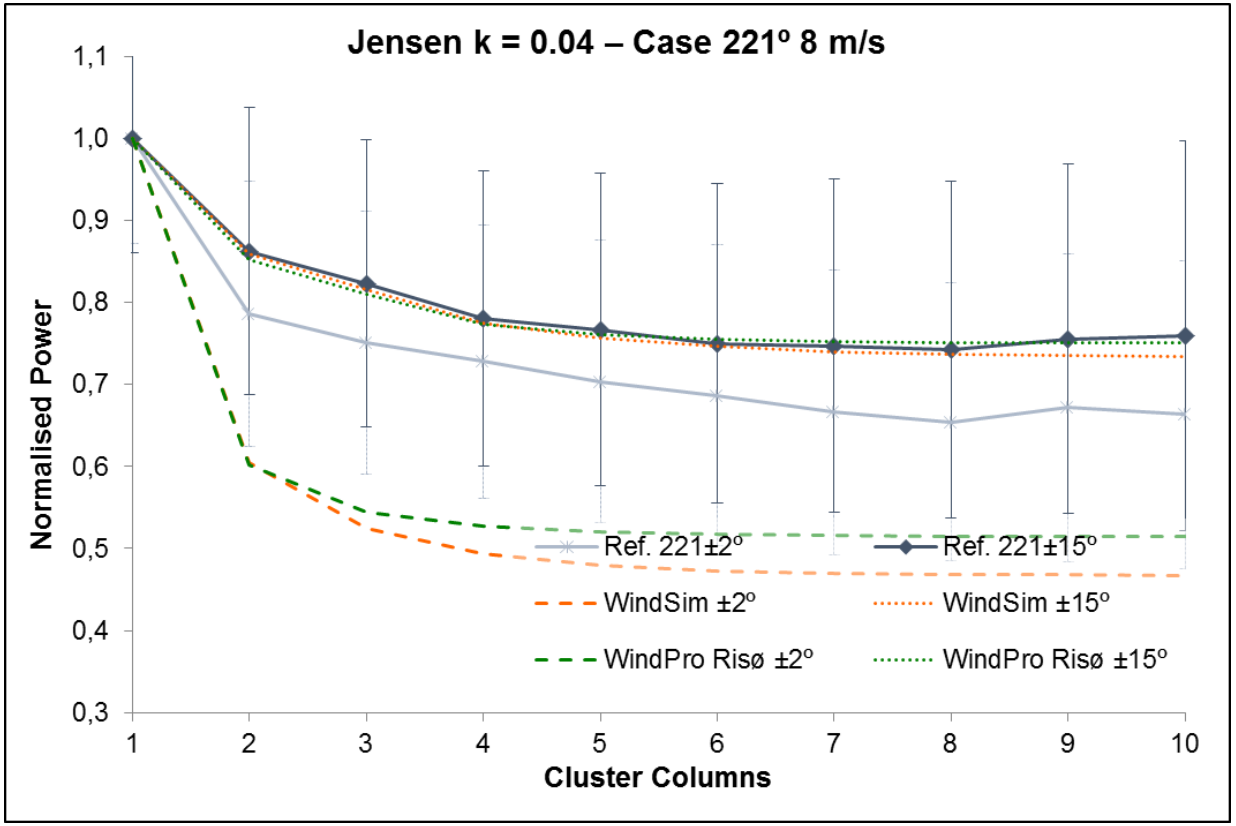




- Same range of influence WDC in both models
- **Sector +-15 °:** analytical wake models are fine
- **Sector +-2 °:** not covered by model theory, bigger differences
- **WS – WP:** WindSims gerenerally gives lower wake effects

Sensitivity studies - Offshore Jensen

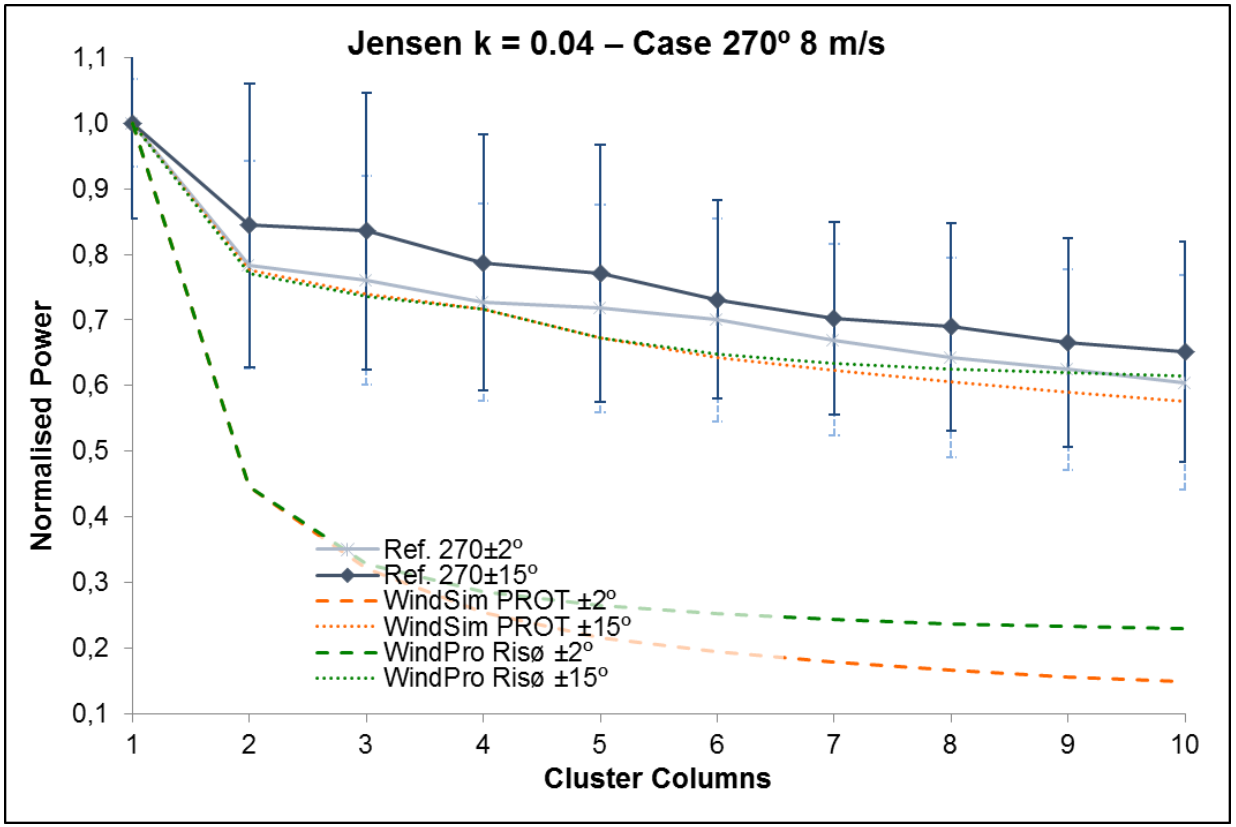
- 9.4D - Spacing



No decrease after row 7, both models capture behaviour and range. New WS summation with combination of Sum of Squares and Linear Sum gives better fit.

Sensitivity studies - Offshore Jensen

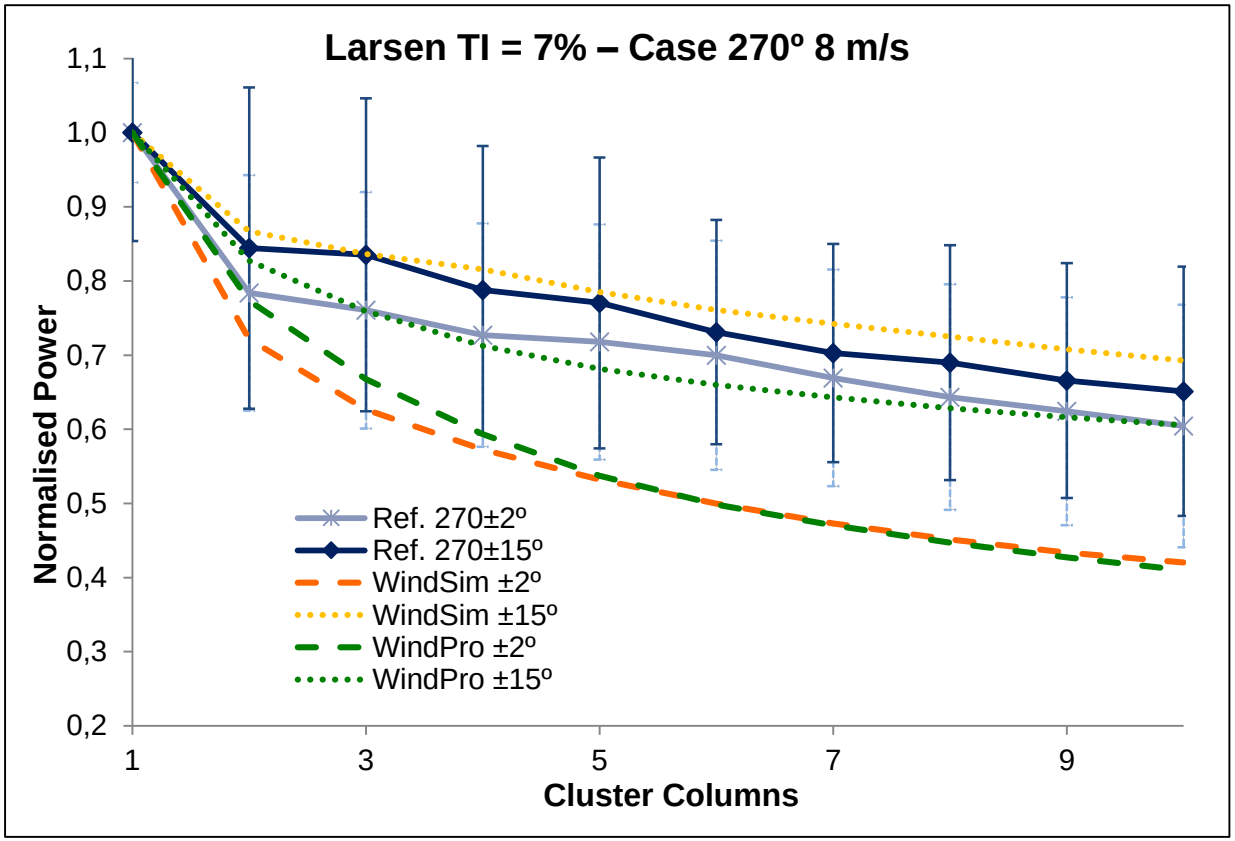
- 7D - Spacing



Wake loss persists through all columns, both models overestimate wake, WS captures decrease after row 7 better.

Sensitivity studies - Offshore Larsen

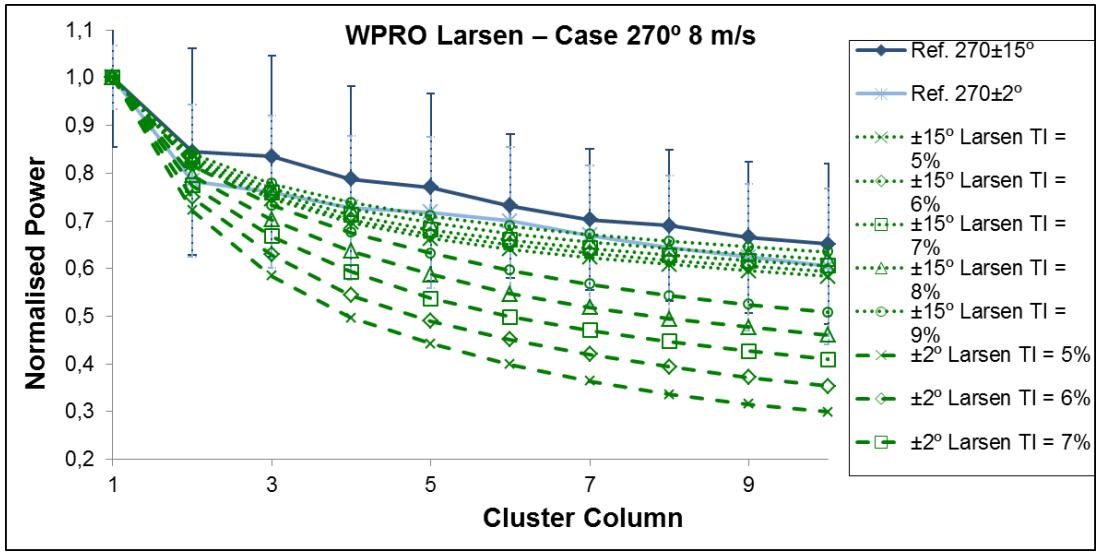
- 7D - Spacing

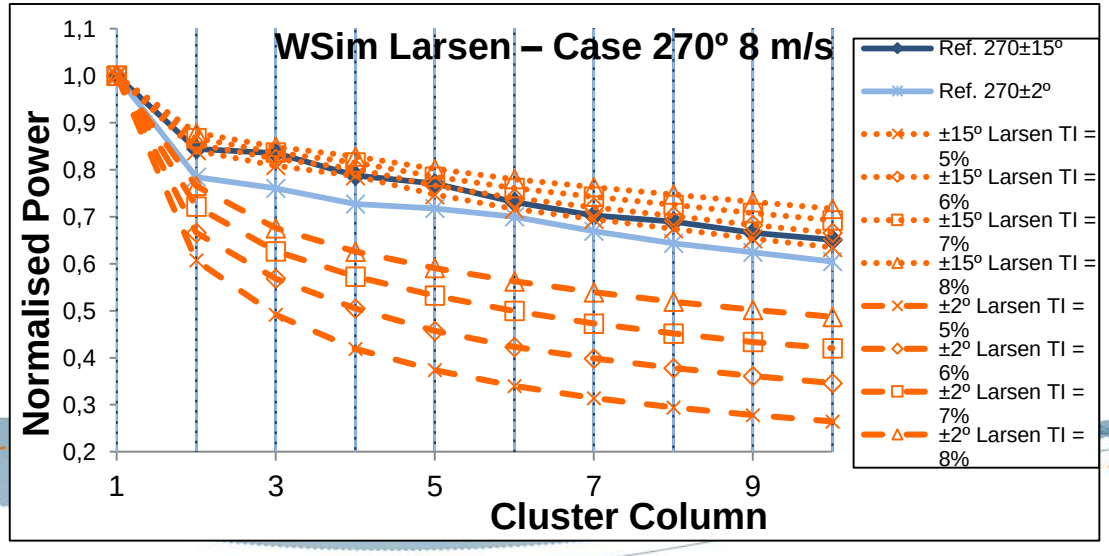


WindSim represents the trend better in the first columns where WP overestimates
Generally poorer match than with Jensen

Sensitivity studies - Offshore Larsen

- **Wake Decay Variation 7D**





- For Larsen (15°) WP generally too high wake effects and WS too low wake effects
- Again similar sensitivity to changes in TI

windsim

Sensitivity studies - Offshore Jensen

- **Subcycle Variation**

Subcyles of the climatology to distribute wake effects

Jensen	Sector subcycles	Degree subcycles	Wake Losses (%)
12	1	30	21.48
12	2	15	5.69
12	3	10	11.67
12	4	7.5	11.02
12	5	6	6.92
12	6	5	9.57
12	8	3.75	10.02
12	10	3	8.96
12	12	2.5	9.35
12	15	2	9.84
12	20	1.5	8.84
12	30	1	9.45
12	40	0.75	9.35
12	50	0.6	9.20
12	60	0.5	9.33
12	120	0.25	9.28
12	300	0.1	9.30

Larsen	Sector subcycles	Degree subcycles	Wake Losses (%)
12	1	30	17.89
12	2	15	4.43
12	3	10	9.50
12	4	7.5	5.90
12	5	6	6.73
12	6	5	6.20
12	8	3.75	6.33
12	10	3	6.32
12	12	2.5	6.34
12	15	2	6.38
12	20	1.5	6.37
12	30	1	6.37

Jensen gets independant with 1°/30 cycles, Larsen already with 5°

Conclusion

- It is not easy to do a fair comparison between the same wake models in different software; attention should be paid how the wind speed is inserted
- There is a high sensitivity regarding the choice of wake decay constant and TI in both models and the range of sensitivity is similar
- The Jensen model gives best results in both software and the results of both software are comparable when different techniques of multiple wake addition are used