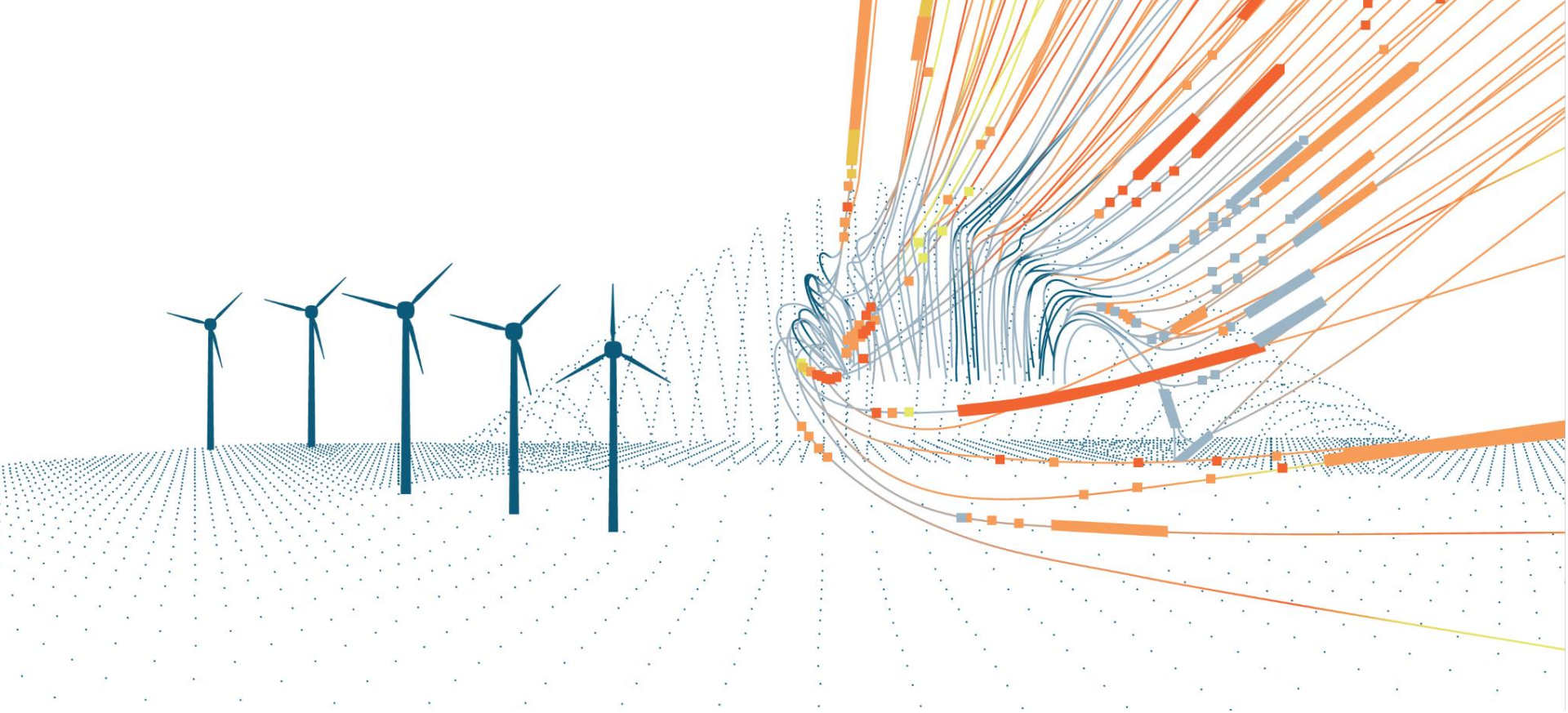


Power Forecasting

WindSim

PRESENTED BY: Matteo Mana

windsim

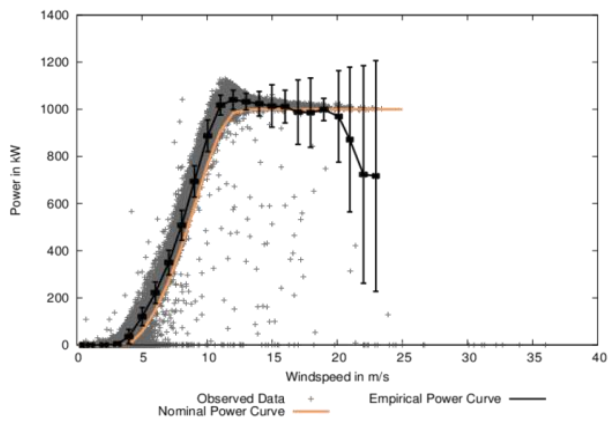
Agenda

- **Basics**
- **Forecasting API**
- **Hybrid strategy**

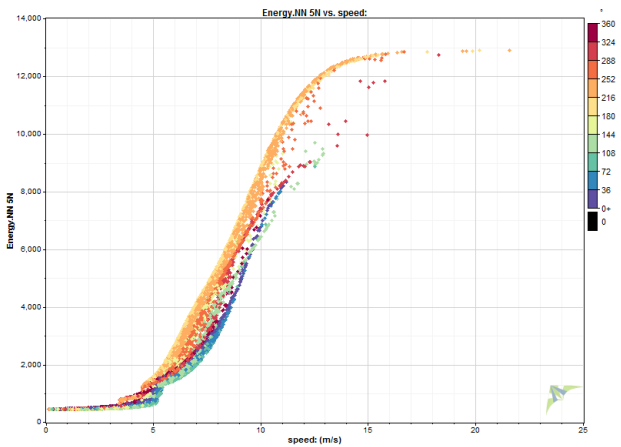
Basics

- **Converting forecasted wind speed to wind energy**

Empirical Power Curve



Artificial Neural Network "Power Curve"

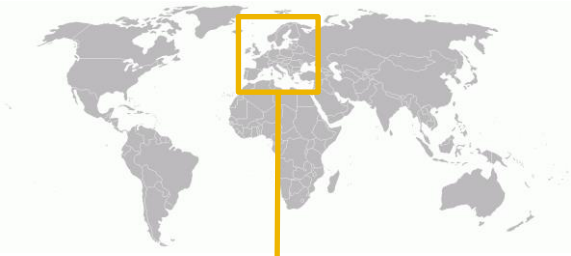


- **In short "ANN WIND-POWER"**

Basics

- **Coupling Mesoscale and CFD**

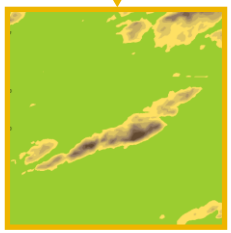
Global Models
100 - 16 km
e.g. ECMWF, GFS



Regional Models
9 - 1 km
e.g. WRF

Description of the atmospheric conditions

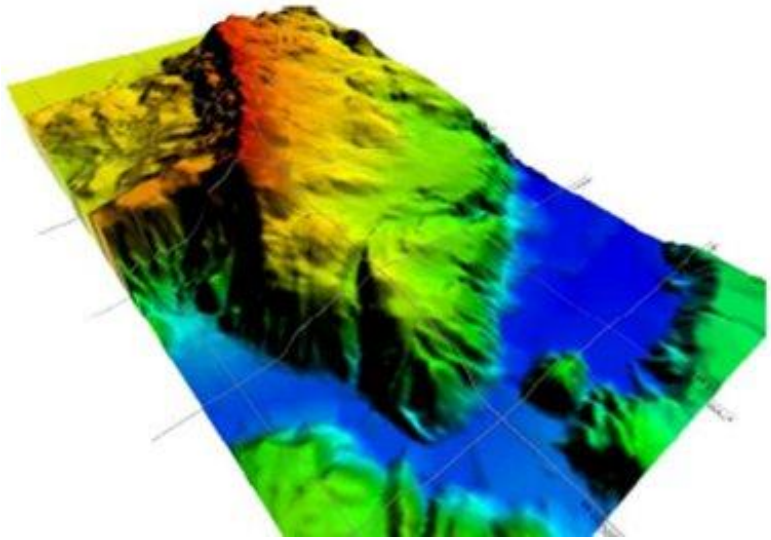
Micro Model
100 - 10 m
WindSim



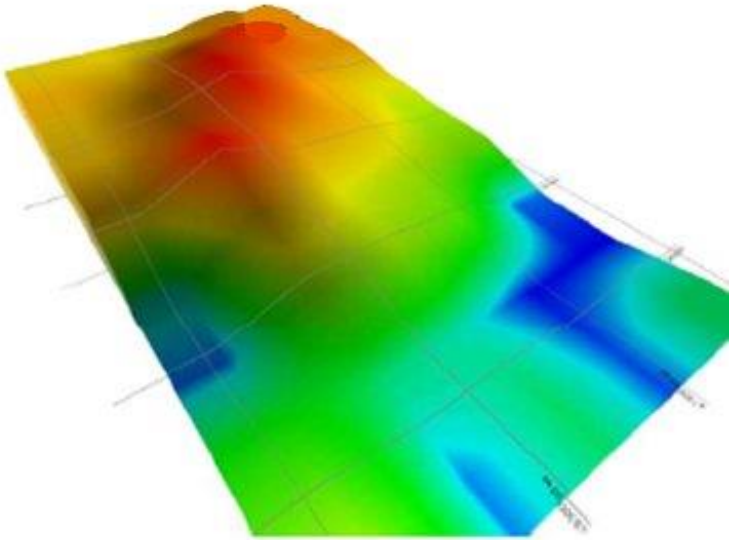
Accurate description of the local flow field and the wake effects

Basics

- **Mesoscale Models resolution limits**



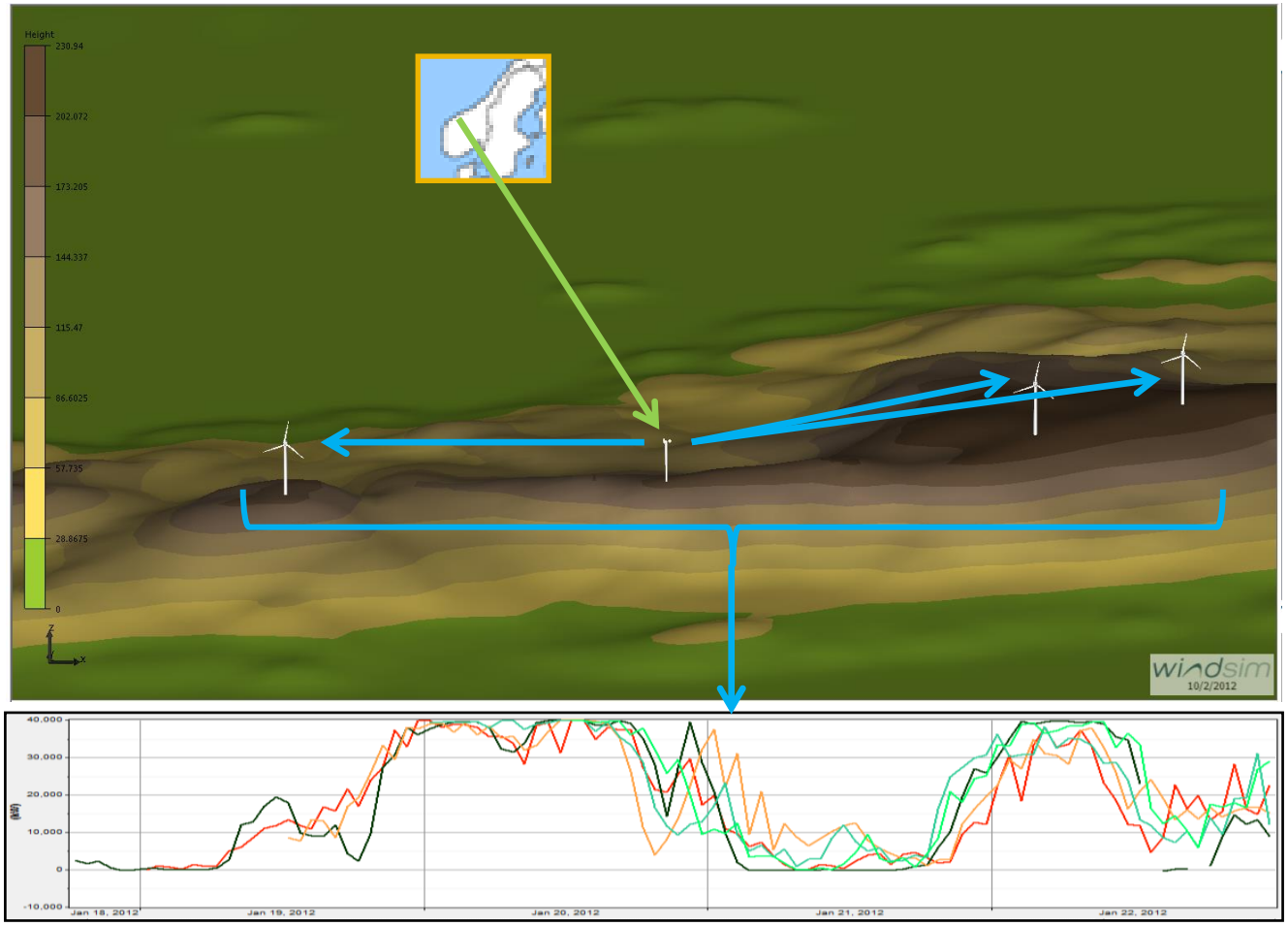
100 meters resolution



3 km resolution

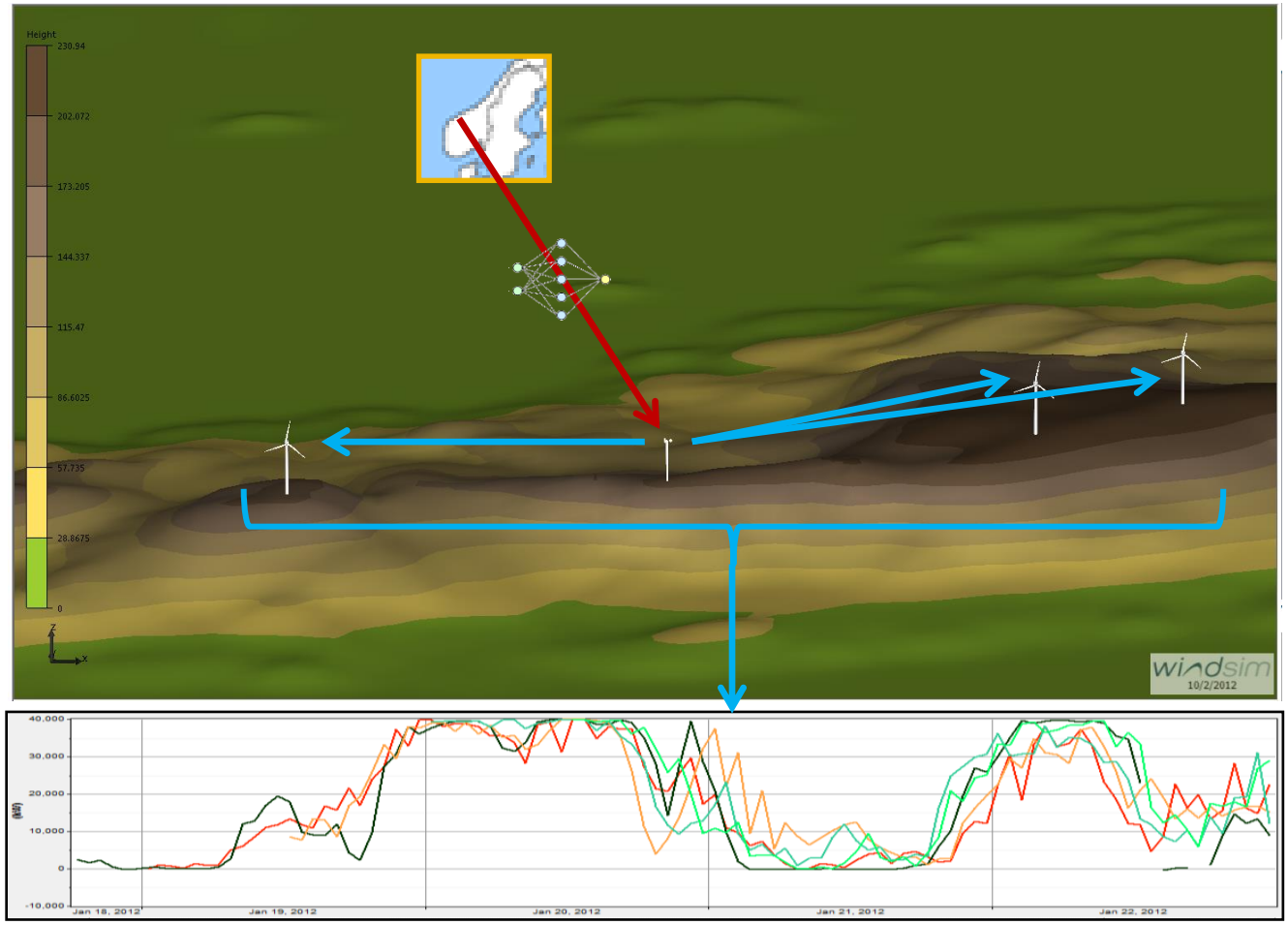
Basics

- **WindSim Forecasting "CFD-Wake" or Direct Coupling**



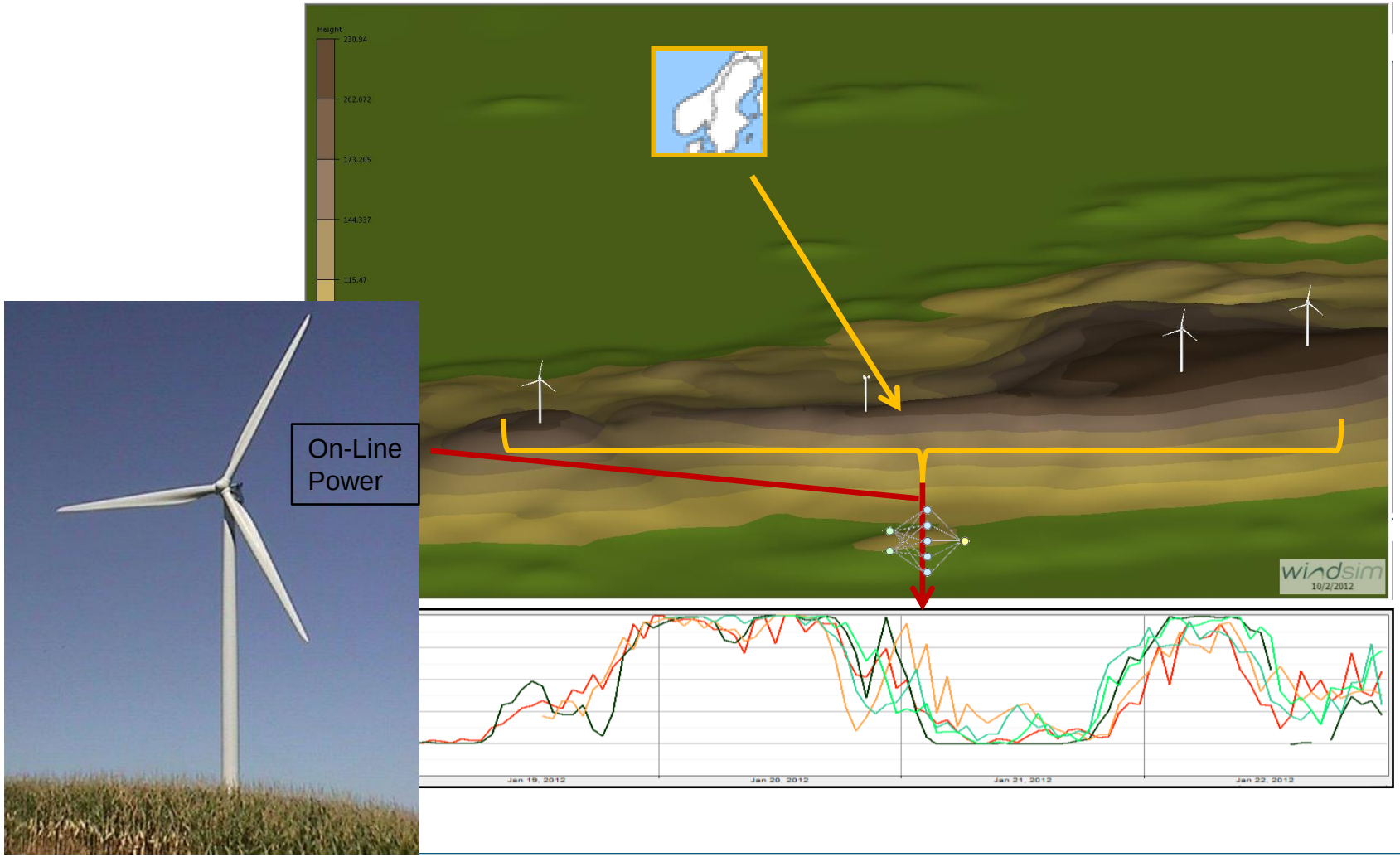
Basics

- **WindSim Forecasting "ANN WIND-WIND, CFD-Wake"**



Basics

- **WindSim Forecasting Portal "ANN ONLINE" Ultra short-term correction of any forecast method**



Forecasting techniques

Divided into two type:

- Deterministic Tools
  - NWP models
  - WindSim CFD

  Describes the Physic of what is happening and get the forecast from the models

- Statistical Tools
  - ANN
  - Empirical Power Curves

  Use the information of past historical power productions to create a statistics of if and use to do forecast

Forecasting techniques

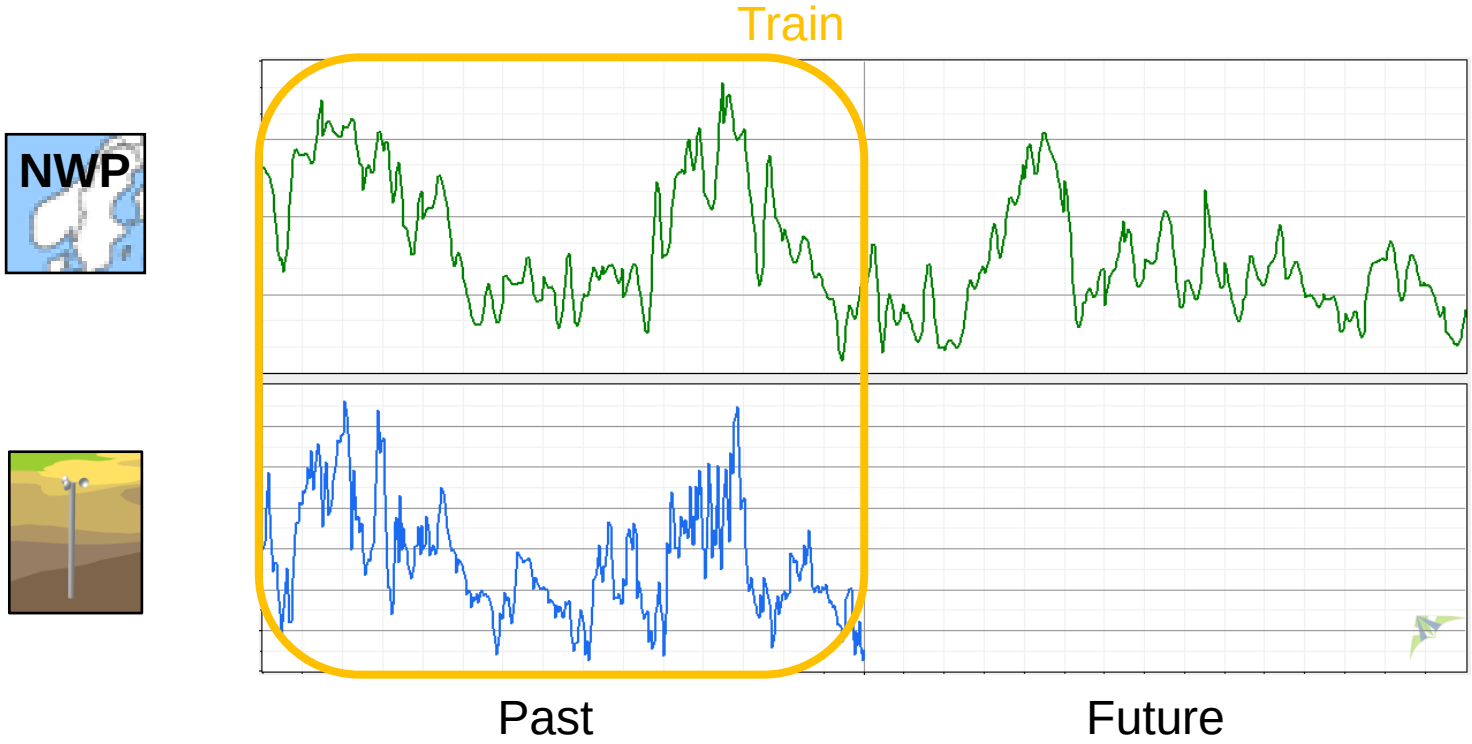
Properties of each approach

- Deterministic Tools
  - Robustness and theoretically optimal
  - Long calculations
  - Describe better extreme events
    (events with low statistical weight)

- Statistical Tools
  - High dependency on the data cleaning
  - Fast calculations
  - Better forecast most of the time

Cleaning of the training data for ANNs

- The network learn from the data provided so wrong data leads to errors in the prediction



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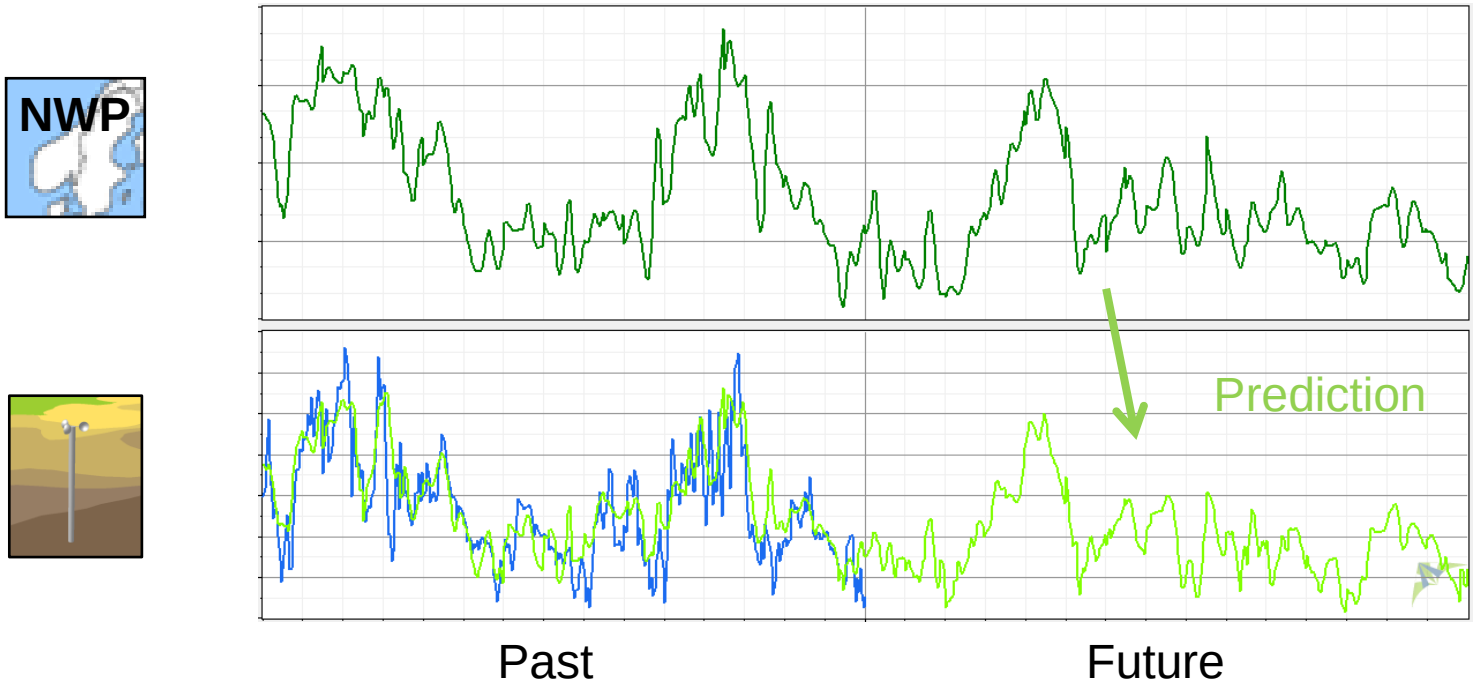


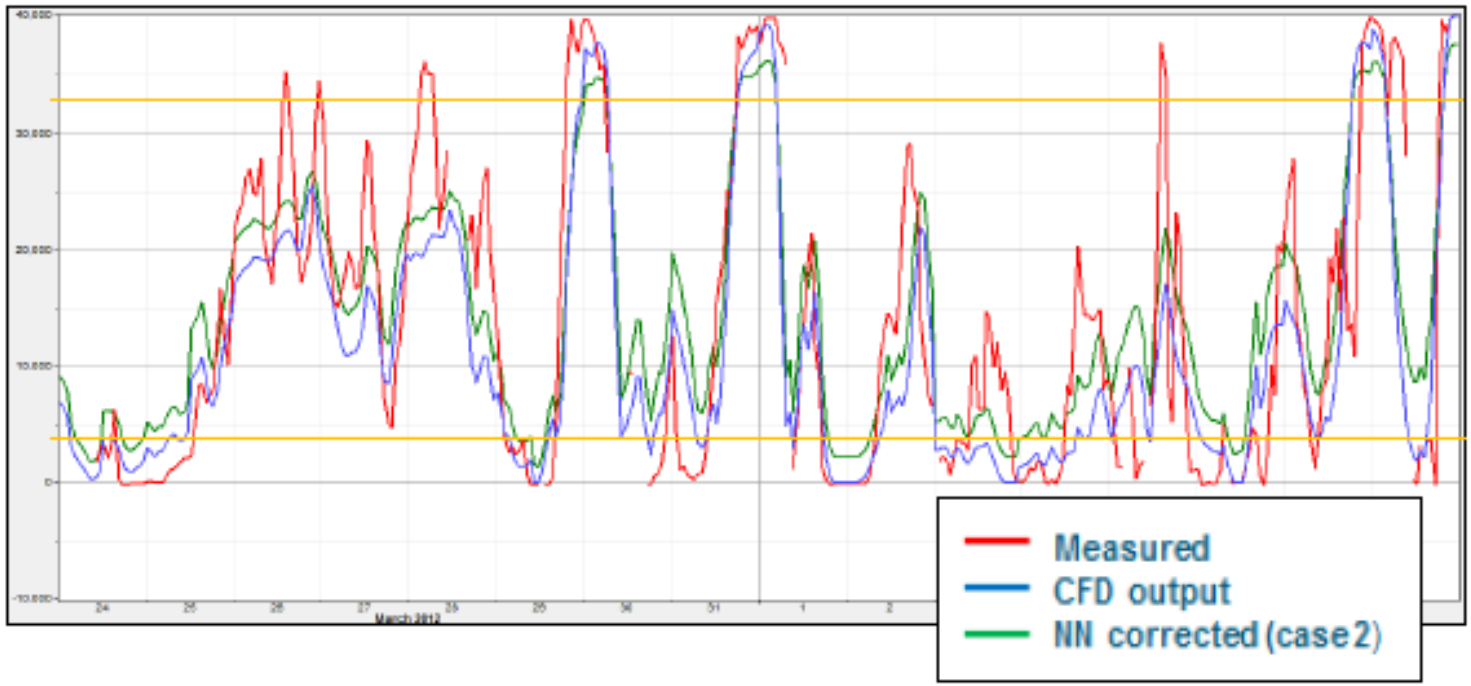
Forecasting API

http://forecasting-api-a80cd9d6.northeurope.cloudapp.azure.com/api/forecast/DemoProject

Hybrid strategy

Post process of the CFD and ANN based power forecast to improve the performance

Simple approach described in the poster “EWEA2013_Mana.pdf”

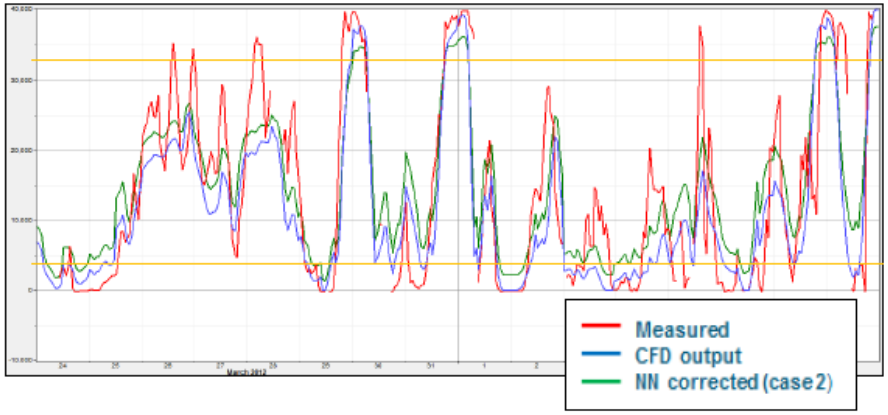


Hybrid strategy

ANN Wind-Power

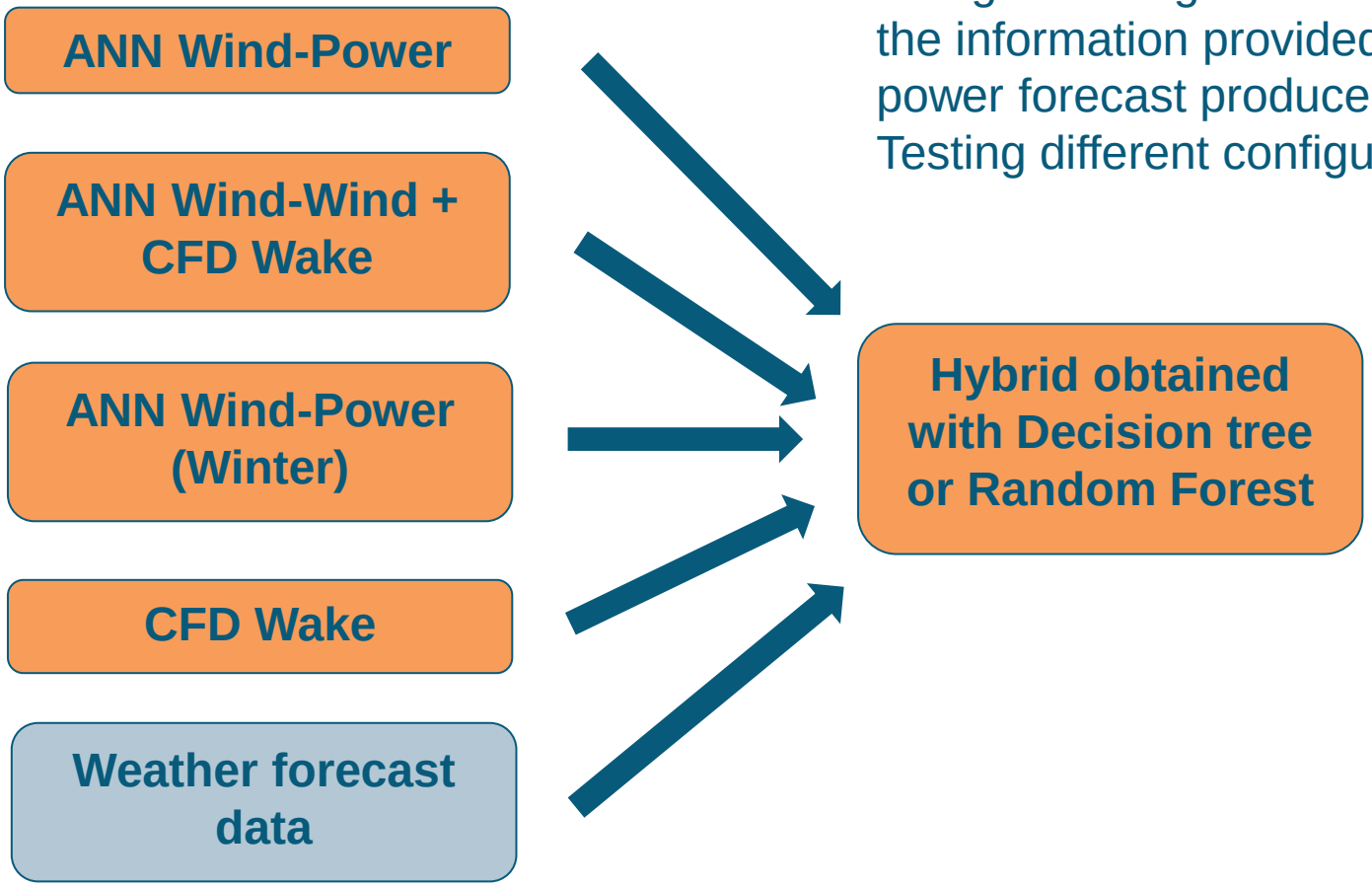
ANN Wind-Wind + CFD Wake

Hybrid obtained defining thresholds



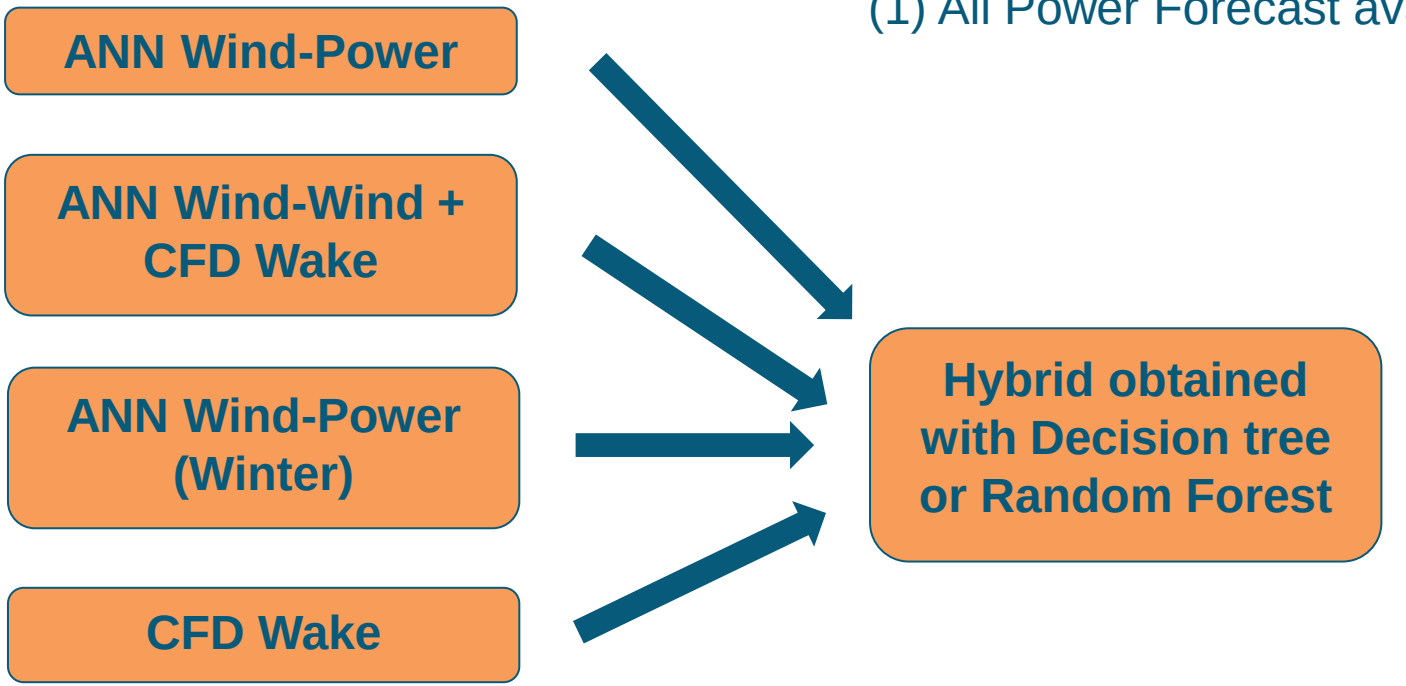
Hybrid strategy

The goal is to gain the best out of the information provided each of the power forecast produced
Testing different configurations!



Hybrid strategy

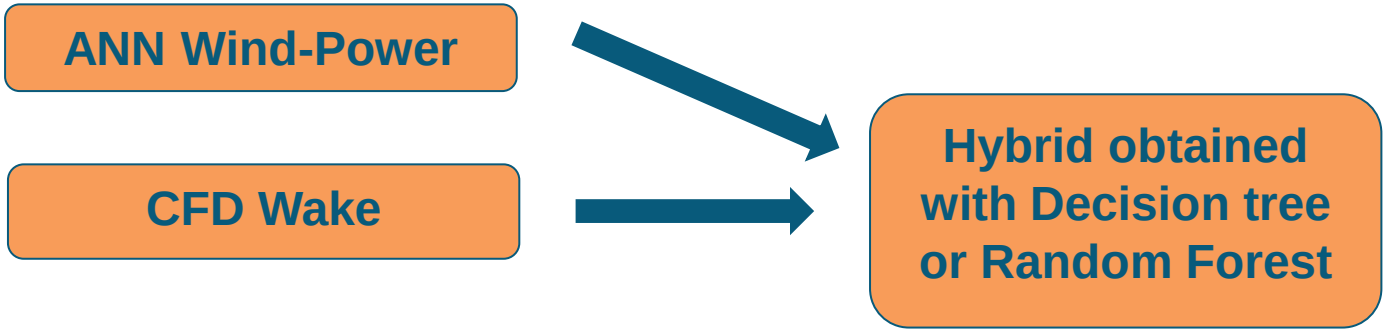
(1) All Power Forecast available



Natural case: approach using the results of all strategies activate for that case

Hybrid strategy

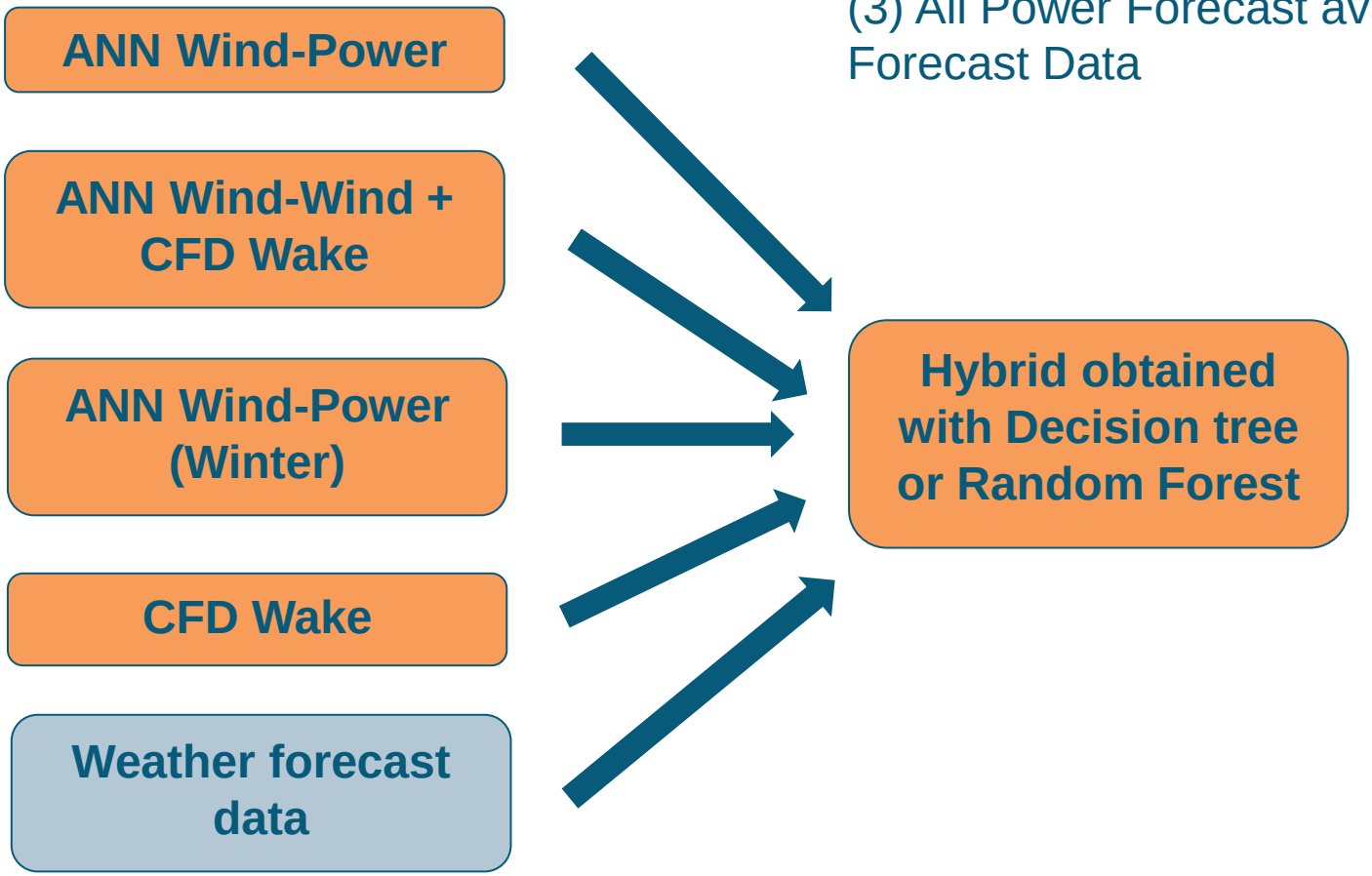
(2) 2 Power Forecast: ANN Wind-Power & CFD



Standard case: Normally we do have less forecasts available

Hybrid strategy

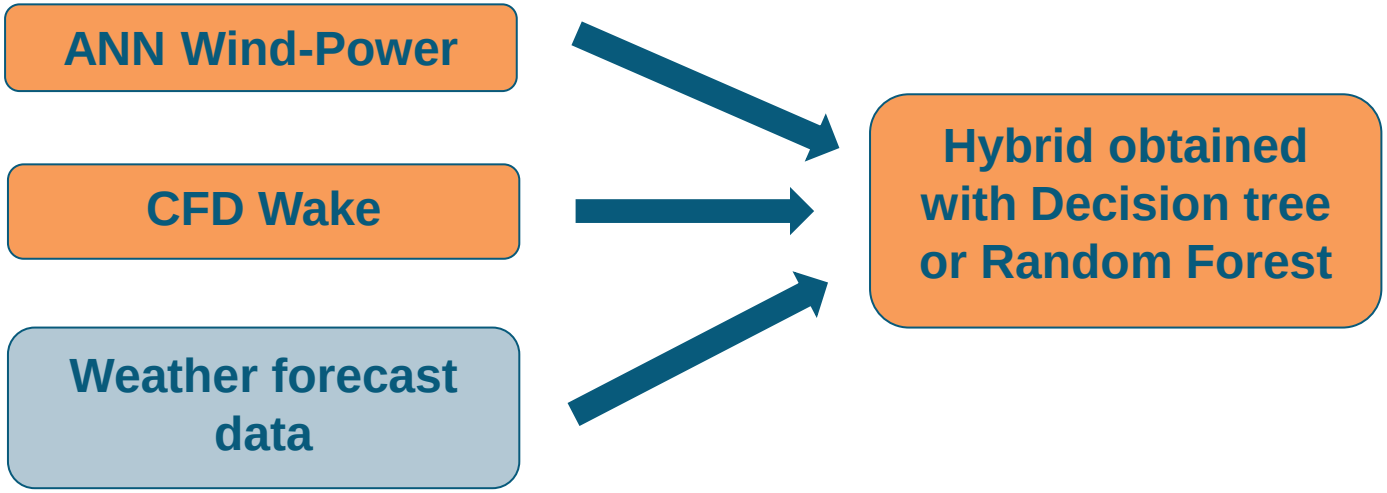
(3) All Power Forecast available & Forecast Data



All in case: approach using the results of all strategies activate for that case plus the forecast data used to produce them

Hybrid strategy

(4) 2 Power Forecast: ANN Wind-Power & CFD & Forecast Data



Standard all in case: Less forecasts available adding the Forecast feed used to produce them

Hybrid strategy

(5) Only Forecast Data

Weather forecast data → **Hybrid obtained with Decision tree or Random Forest**

Control case: approach using only the Weather forecast data

Note: The Decision Tree or Random Forest act as ANN wind-power

Hybrid strategy

Forecast type	Norm.RMSE	NMAE	R^2	note
P_SUM_ANN	0.182	0.124	0.562	ANN Wind-Power per turbine
P_ALL(ANN-0)_ANN	0.181	0.125	0.568	ANN Wind-Power complete windfarm
P_ALL_CFD	**0.179**	**0.120**	**0.578**	CFD-Wake
P_SUM_ANN2	0.186	0.127	0.543	ANN Wind-Power per turbine (2)
P_ALL(ANN-0)_ANN2	0.198	0.137	0.484	ANN Wind-Power complete windfarm (2)
P_ALL_ANNCFD	0.223	0.143	0.346	ANN Wind-Wind + CFD-Wake
Hybrid thresholds	**0.184**	**0.122**	0.555	hybrid on P_SUM_ANN and P_ALL_CFD
Hybrid Tree (1)	0.230	0.157	0.303	All Power Forecast available
Hybrid Tree (2)	0.229	0.155	0.309	2 Power Forecast: ANN Wind-Power & CFD
Hybrid Tree (3)	0.232	0.157	0.290	All Power Forecast available & Forecast Data
Hybrid Tree (4)	0.235	0.161	0.276	2 Power Forecast: ANN Wind-Power & CFD & Forecast Data
Hybrid Tree (5)	0.234	0.158	0.283	Only Forecast Data
Hybrid Forest 10 (1)	0.174	0.124	0.600	All Power Forecast available
Hybrid Forest 10 (2)	0.181	0.126	0.570	2 Power Forecast: ANN Wind-Power & CFD
Hybrid Forest 10 (3)	0.177	0.126	0.587	All Power Forecast available & Forecast Data
Hybrid Forest 10 (4)	0.180	0.128	0.575	2 Power Forecast: ANN Wind-Power & CFD & Forecast Data
Hybrid Forest 10 (5)	0.181	0.128	0.568	Only Forecast Data
Hybrid Forest 100 (1)	**0.169**	**0.121**	**0.624**	All Power Forecast available
Hybrid Forest 100 (2)	**0.175**	0.122	**0.596**	2 Power Forecast: ANN Wind-Power & CFD
Hybrid Forest 100 (3)	**0.171**	0.122	**0.616**	All Power Forecast available & Forecast Data
Hybrid Forest 100 (4)	**0.174**	0.124	**0.603**	2 Power Forecast: ANN Wind-Power & CFD & Forecast Data
Hybrid Forest 100 (5)	**0.175**	0.124	**0.597**	Only Forecast Data

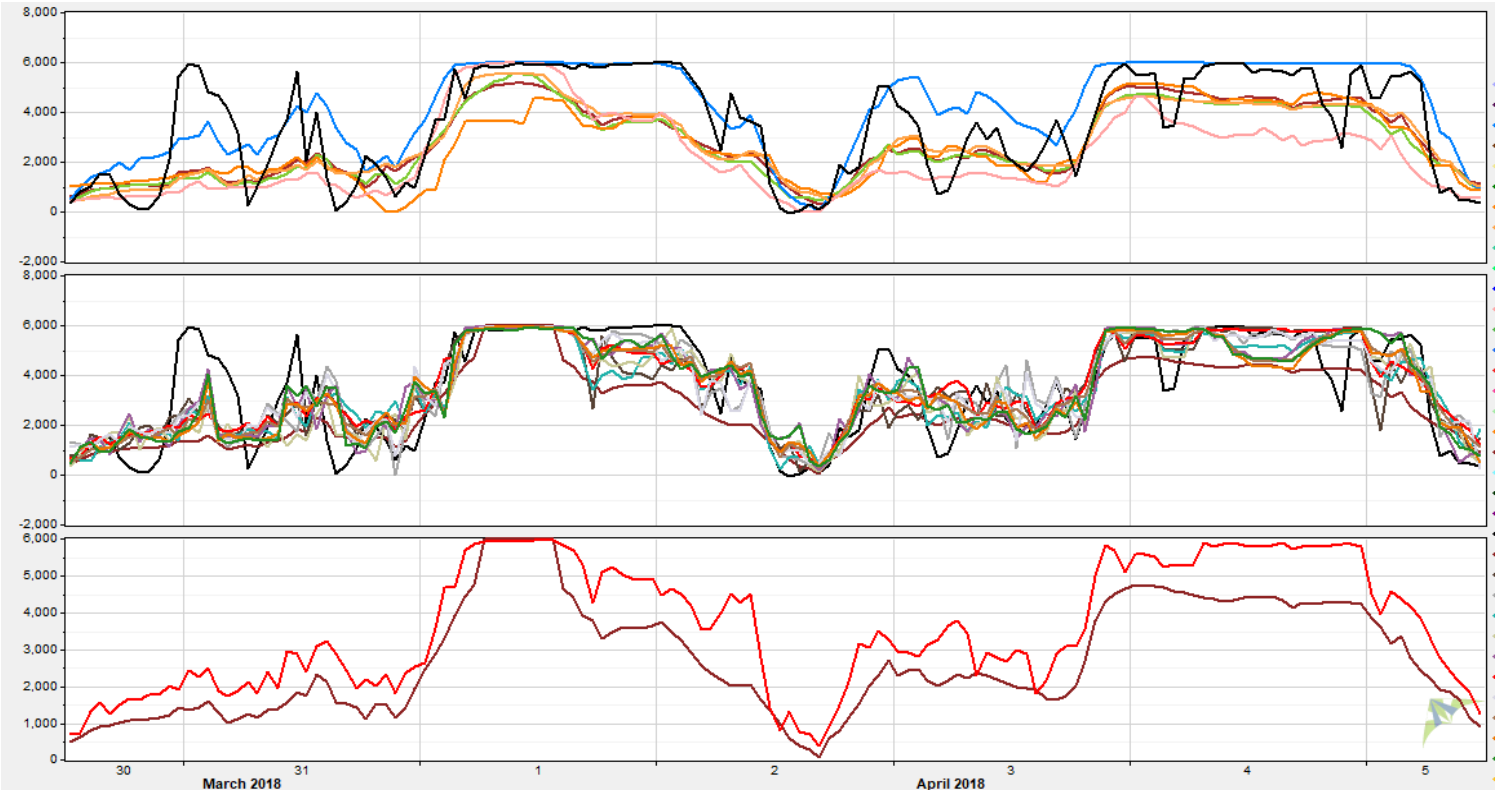
Hybrid strategy

Comparing **observed data** and power forecast produced: black is the

Original forecasts

Hybrid forecasts

Original Hybrid forecasts and new winner red



Hybrid strategy

Advanced methods using more inputs

the weather forecasts info and the forecasted power are loaded and used by Decision Tree and Random Forest to produce the best result from the ensemble.

Different approaches proposed and tested in on a test case.

- The Random Forest looks to be the best approach
- The best input set is defined by validation on dataset different from the one used in training

The best performing approach is site dependent, test many approaches and chose the best per each site.

More tests on different sites should be run.

Thank you

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