

A photograph of three birds in flight, blurred to convey a sense of speed and movement. The birds are white with dark wings and are flying from left to right across the top half of the image.

# Wind Energy Forecasting

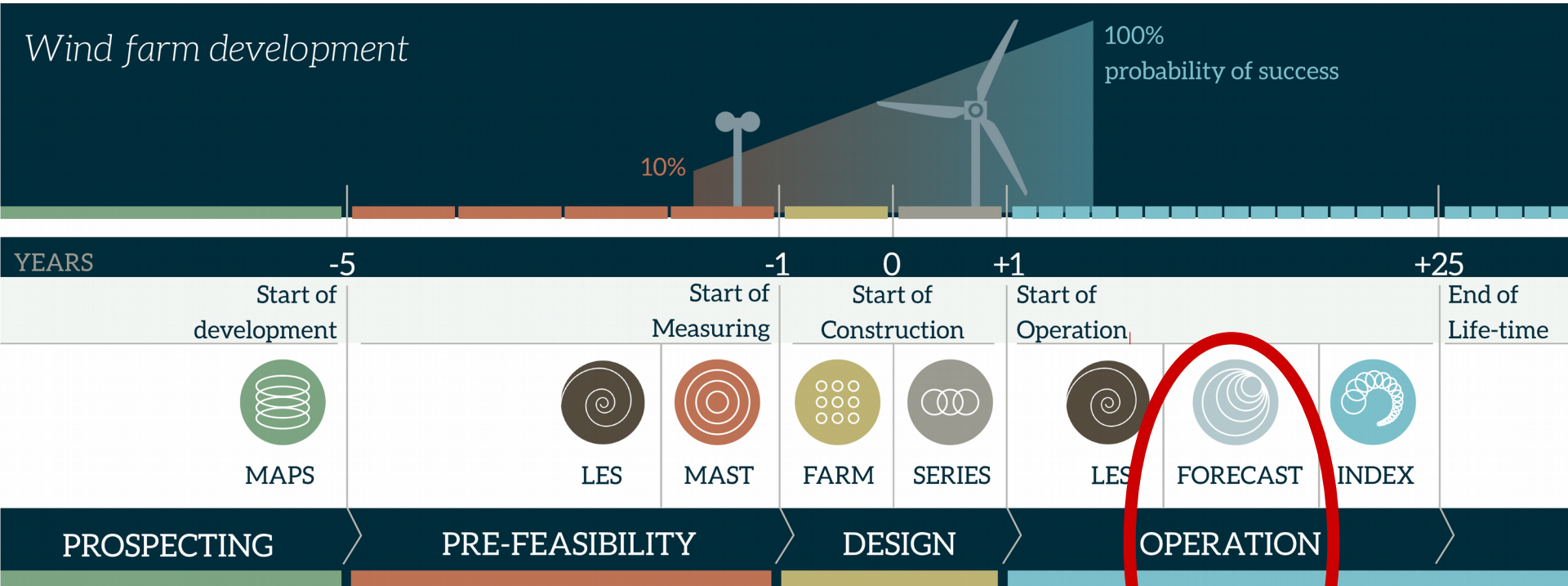
*by Jordi Ferrer*

jordi.ferrer@vortexfdc.com  
Managing Director





# Vortex Products Timeline



# Vortex FORECAST: Why?



FORECAST

Accuracy and a fast response service for Grid Management and Operational and Maintenance.



# Vortex FORECAST: Why?



FORECAST

Accuracy and a fast response service for Grid Management and Operational and Maintenance.

Different necessities



# Vortex FORECAST: Industry expectations

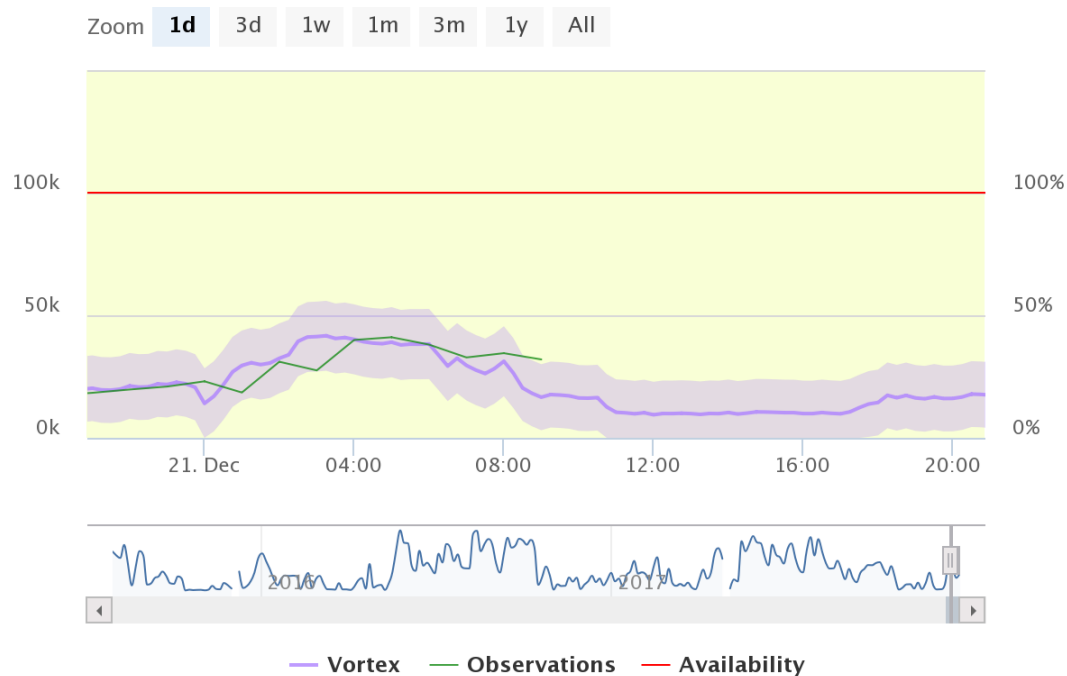


FORECAST

Accuracy and a fast response service for Grid Management and Operational and Maintenance.

· Very short-term forecast

Different necessities



# Vortex FORECAST: Industry expectations



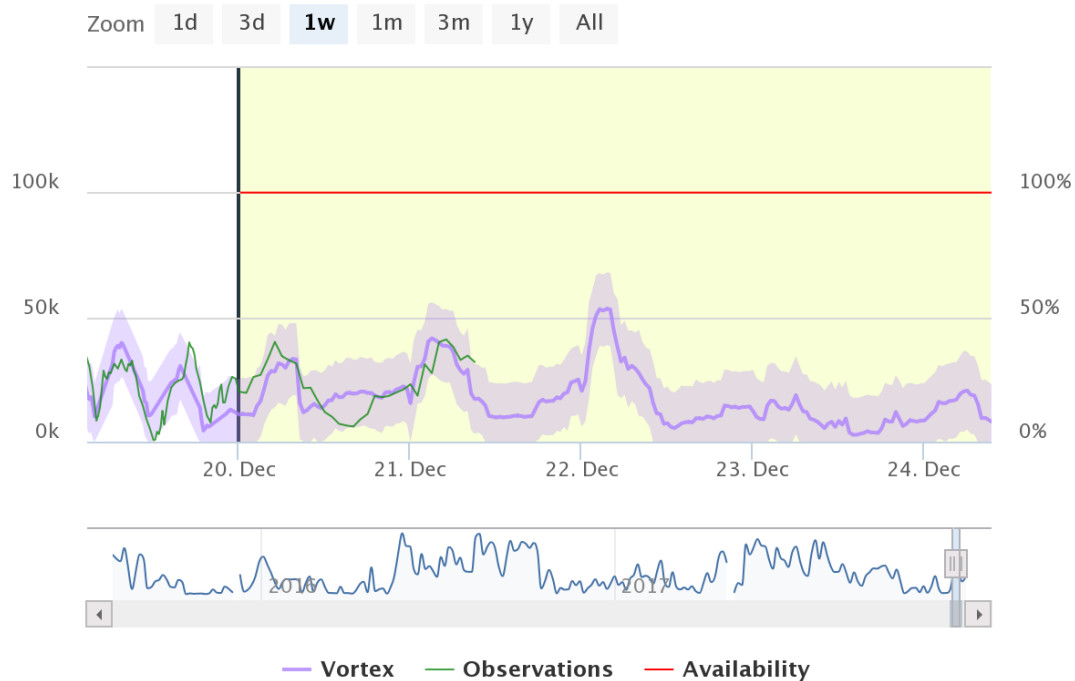
FORECAST

Accuracy and a fast response service for Grid Management and Operational and Maintenance.

· Very short-term forecast

· Days ahead forecast

Different necessities



# Vortex FORECAST: Industry expectations



FORECAST

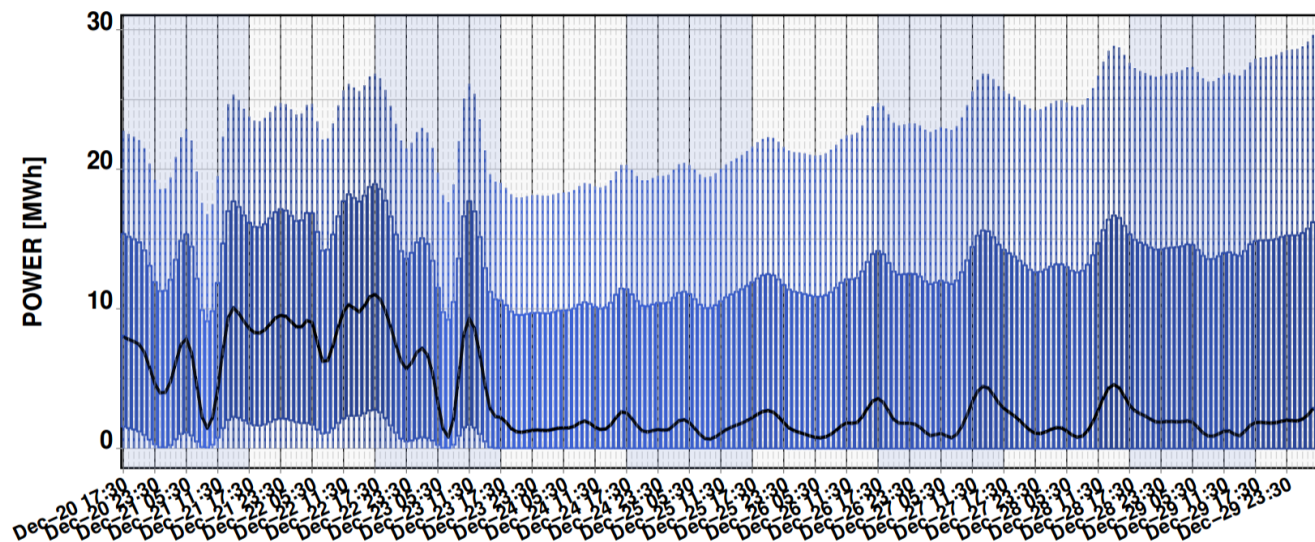
Accuracy and a fast response service for Grid Management and Operational and Maintenance.

Different necessities

· Very short-term forecast

· Days ahead forecast

· 10-days ahead forecast



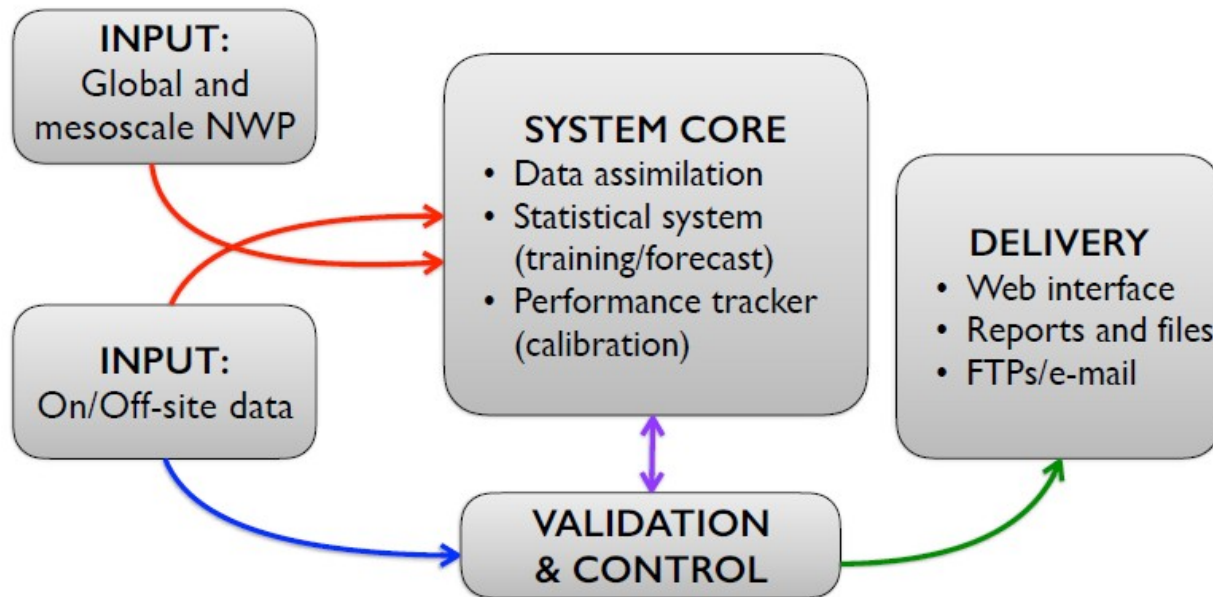


# Vortex FORECAST: Approach



FORECAST

VORTEX system is a hybrid physical-statistical scheme.

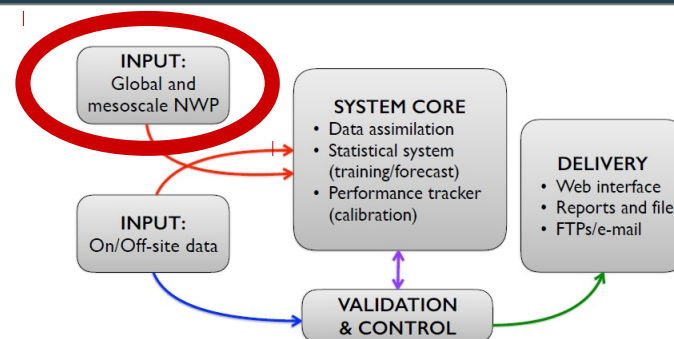


# Vortex FORECAST: Approach



VORTEX system is a hybrid physical-statistical scheme.

Forecast are generated by calibrating physical input from global/mesoscale NWP models against historical wind farm data.



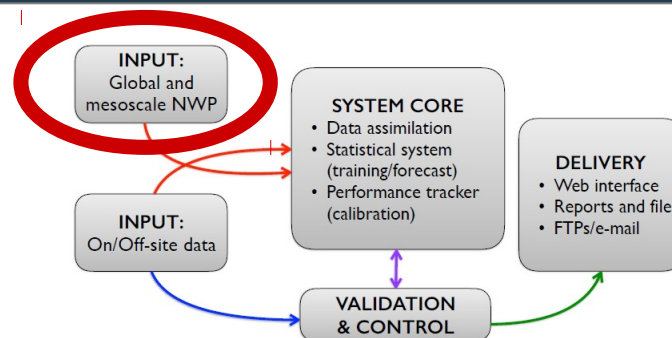
· HRES-ECMWF: 0,125x0,125 deg<sup>2</sup>, 10-days ahead

# Vortex FORECAST: Approach



VORTEX system is a hybrid physical-statistical scheme.

Forecast are generated by calibrating physical input from global/mesoscale NWP models against historical wind farm data.



· HRES-ECMWF: 0,125x0,125 deg<sup>2</sup>, 10-days ahead

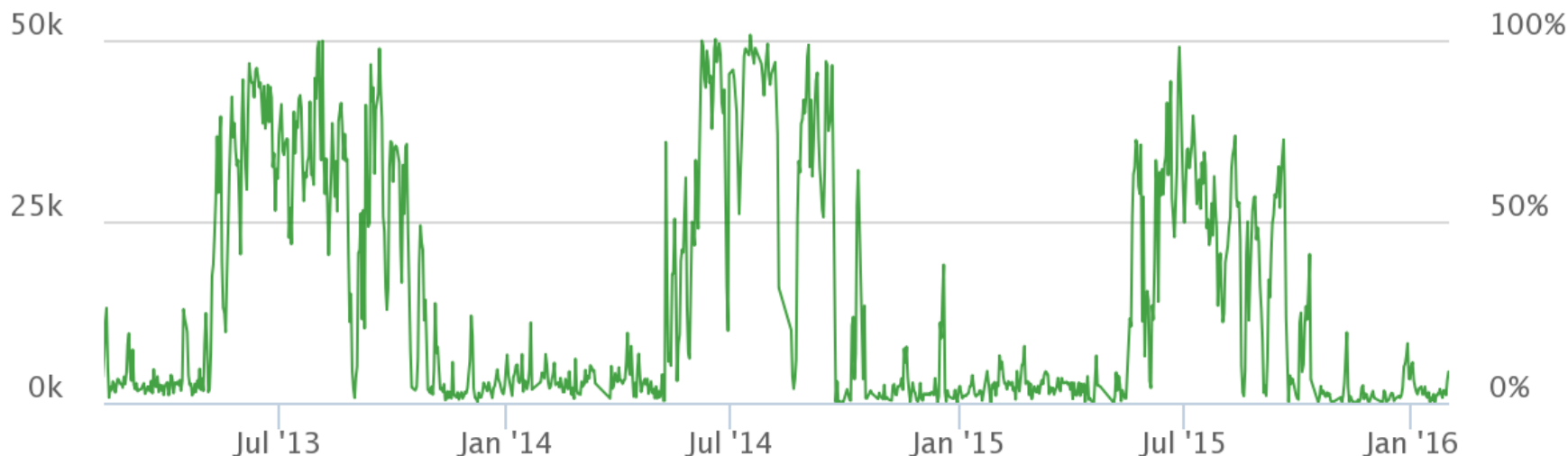
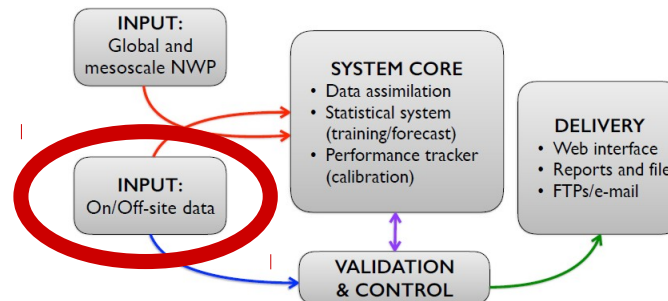
· GFS - NOAA: 0,5x0,5 deg<sup>2</sup>, 2 weeks ahead

# Vortex FORECAST: Approach



VORTEX system is a hybrid physical-statistical scheme.

Forecast are generated by calibrating physical input from global/mesoscale NWP models against historical wind farm data.

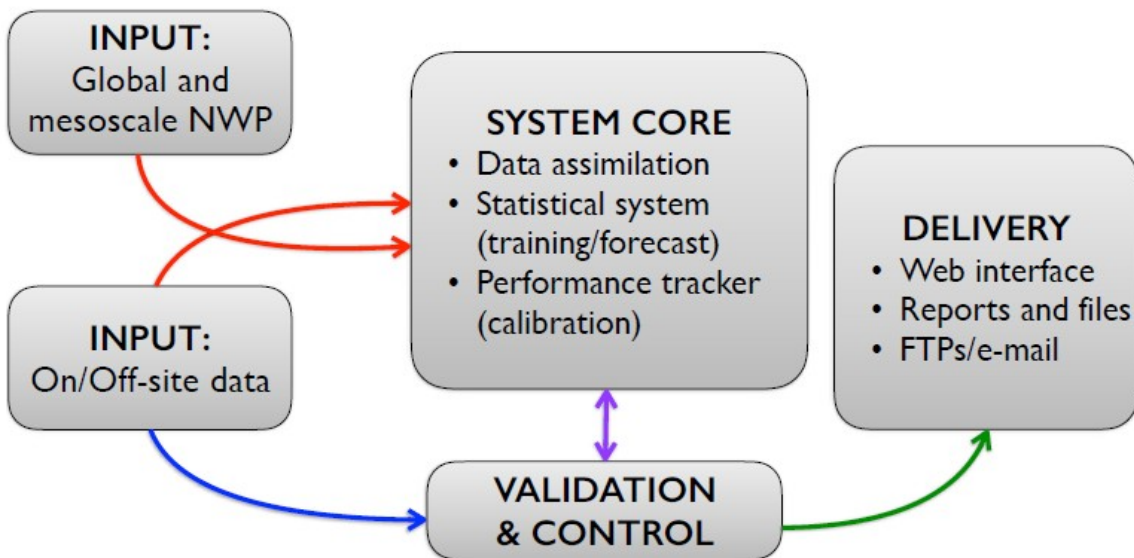


# Vortex FORECAST: Approach



VORTEX system is a hybrid physical-statistical scheme.

Forecast are generated by calibrating physical input from global/mesoscale NWP models against historical wind farm data.



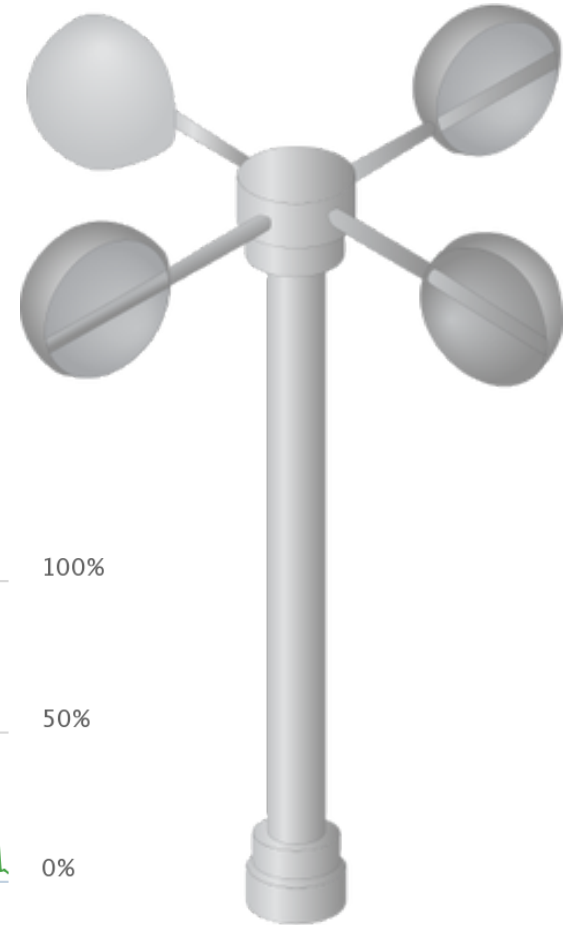
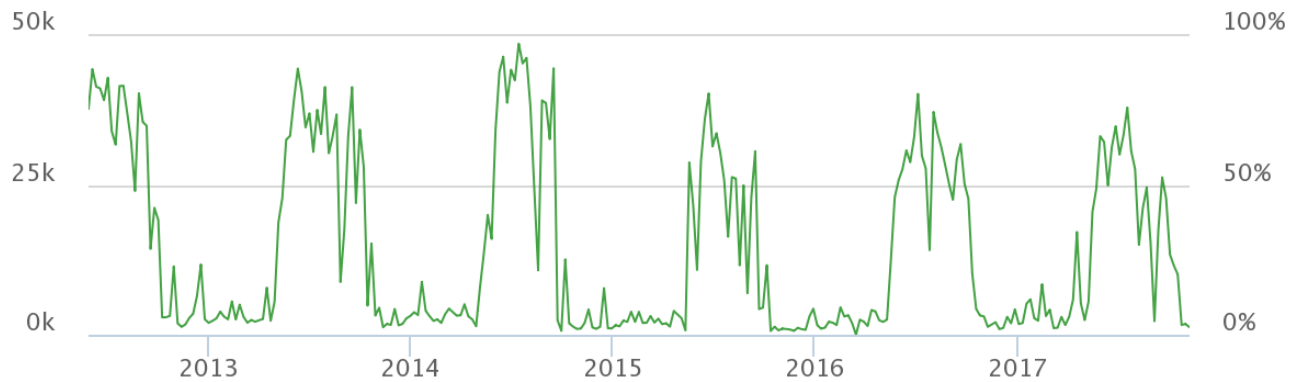
# Vortex FORECAST: Set Up



FORECAST

Necessary to train the model:

- Wind farm location
- Nominal power production
- Historical real-time power production
- Historical real-time availability





What if **NO** historical **DATA** is available?



What if **NO** historical **DATA** is available?

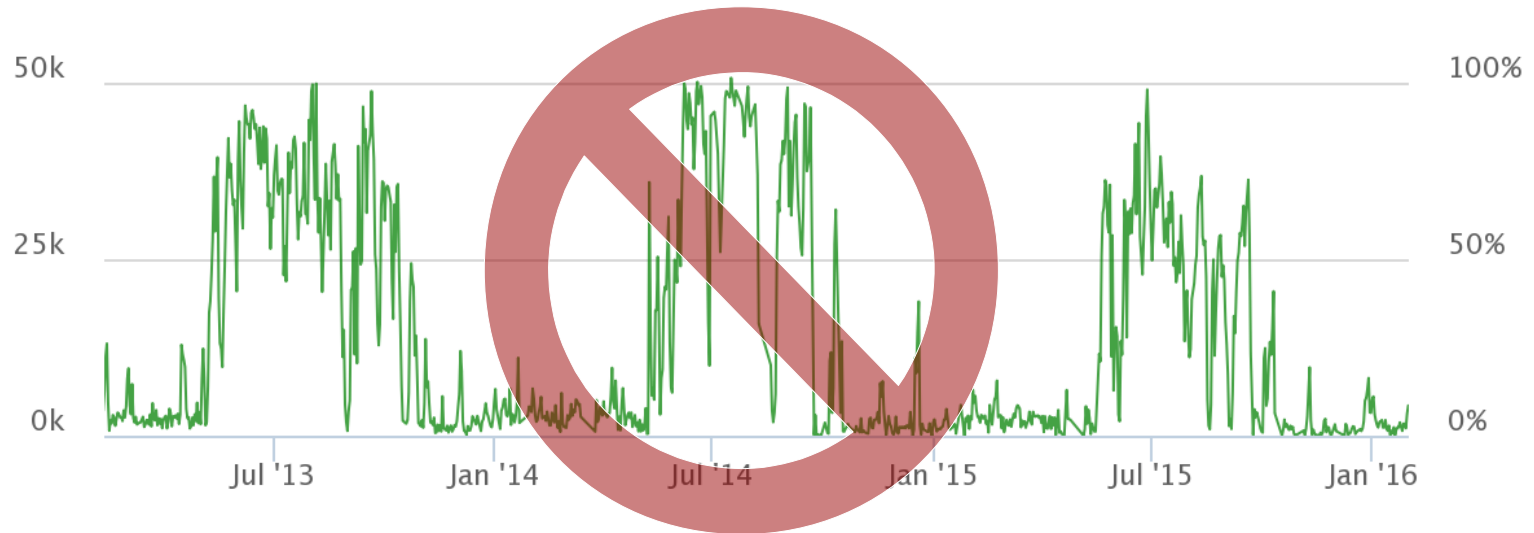
**NO** reliable data or **new Wind Farm**





What if **NO** historical **DATA** is available?

**NO** reliable data or **new Wind Farm**





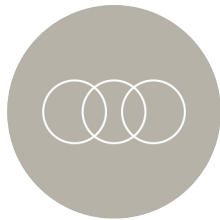
What if **NO** historical **DATA** is available?

Use of **Synthetic data** and **Wind plant model**



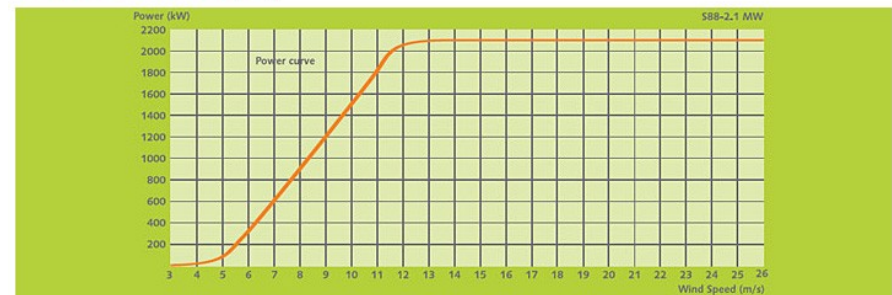
What if **NO** historical **DATA** is available?

Use of **Synthetic data** and **Wind plant model**



VORTEX  
SERIES

S88-2.1 MW: WIND SPEED (M/S)



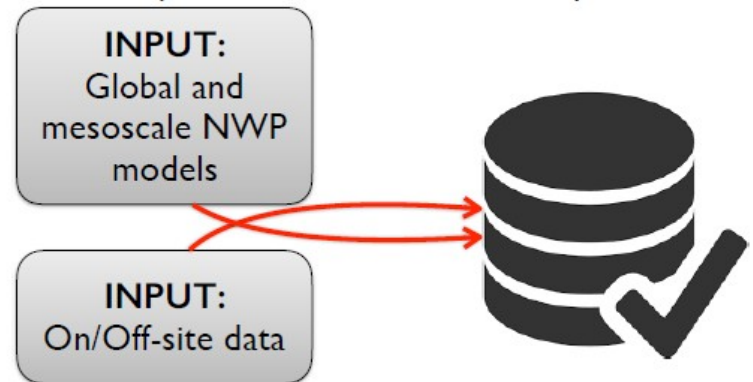
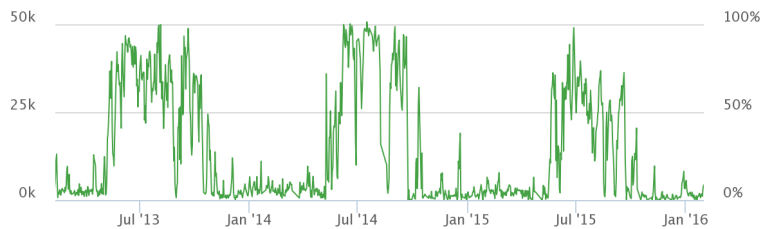
source: [www.suzlon.com](http://www.suzlon.com)

# Vortex FORECAST CORE: Data assimilation



FORECAST

Data assimilation is in charge of integrating into a ddbb all the inputs needed by the system to perform training and forecasting tasks.



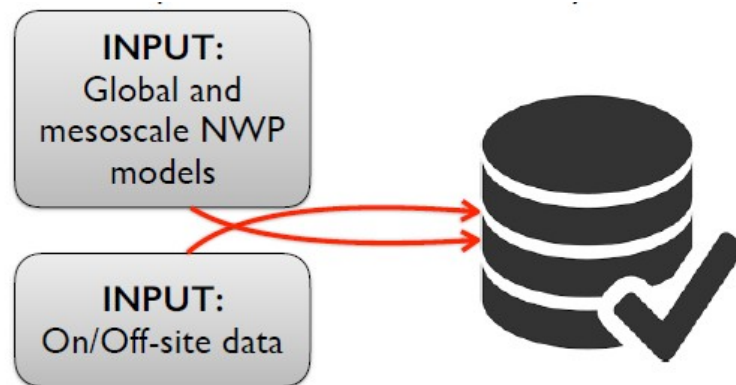
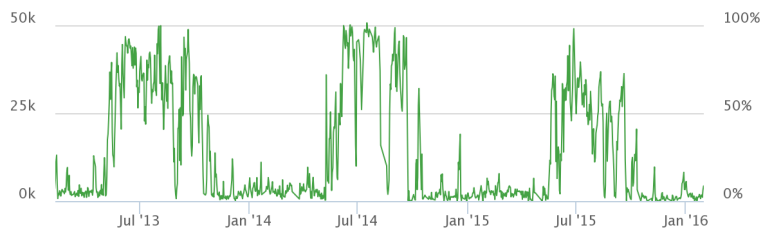
# Vortex FORECAST CORE: Data assimilation



FORECAST

Data assimilation is in charge of integrating into a ddbb all the inputs needed by the system to perform training and forecasting tasks.

Automatically download, pre-processed and quality asses data from NWP models (global and mesoscalar) and wind farms, prior to be included in the system.

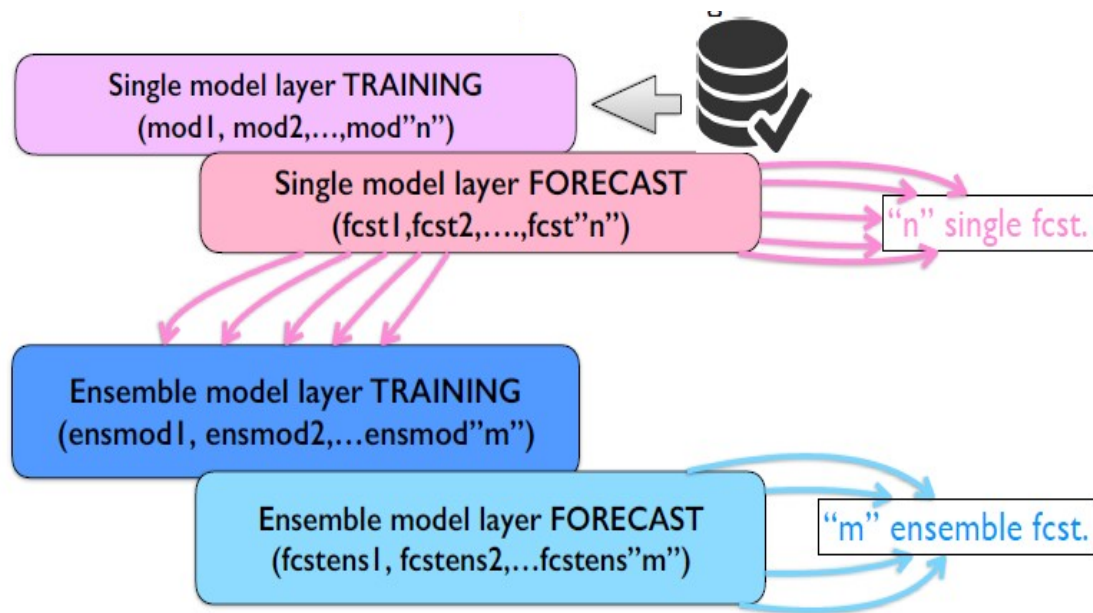


# Vortex FORECAST CORE: Statistical system



FORECAST

A multi-scheme statistical framework is used with several strategies: **Single** and **Ensemble**



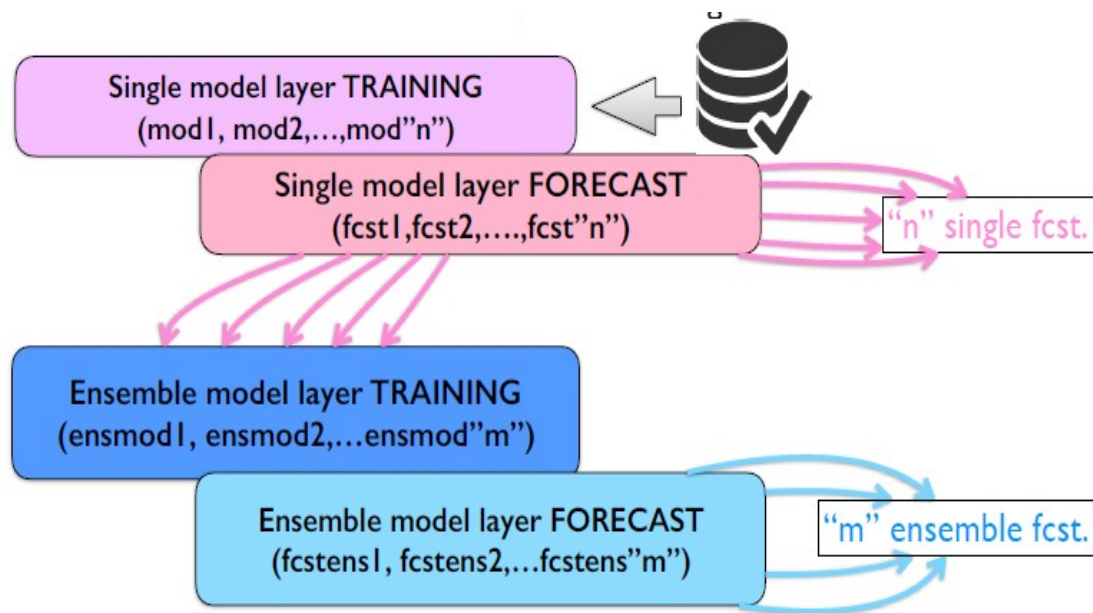
# Vortex FORECAST CORE: Statistical system



FORECAST

A multi-scheme statistical framework is used with several strategies: **Single** and **Ensemble**

Implemented by combining **classifications**, (non-)linear regression, machine learning and clustering models

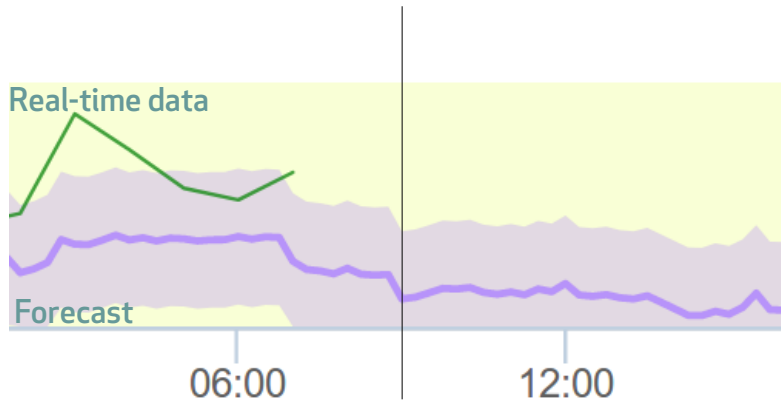


# Vortex FORECAST CORE: Statistical system



FORECAST

(Very) Short-Term forecast: (near) real-time updates of the wind farm data are available.





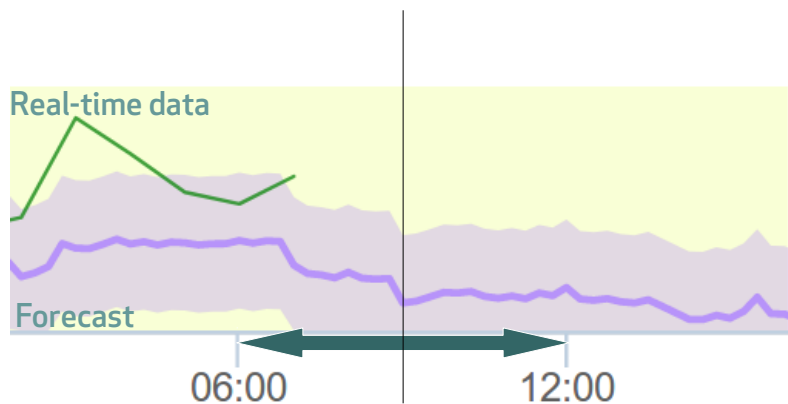
# Vortex FORECAST CORE: Statistical system



FORECAST

(Very) Short-Term forecast: (near) real-time updates of the wind farm data are available.

Several auto-regressive statistical models to generate the forecast for the 3-6 hours of the prediction horizon are used.



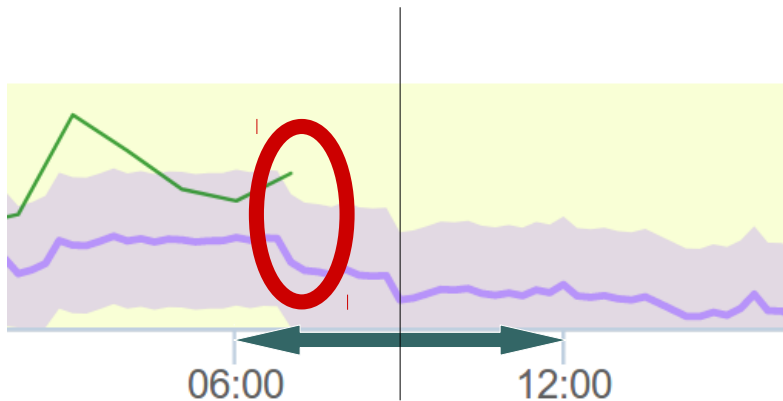
# Vortex FORECAST CORE: Statistical system



FORECAST

(Very) Short-Term forecast: (near) real-time updates of the wind farm data are available.

Several auto-regressive statistical models to generate the forecast for the 3-6 hours of the prediction horizon are used.



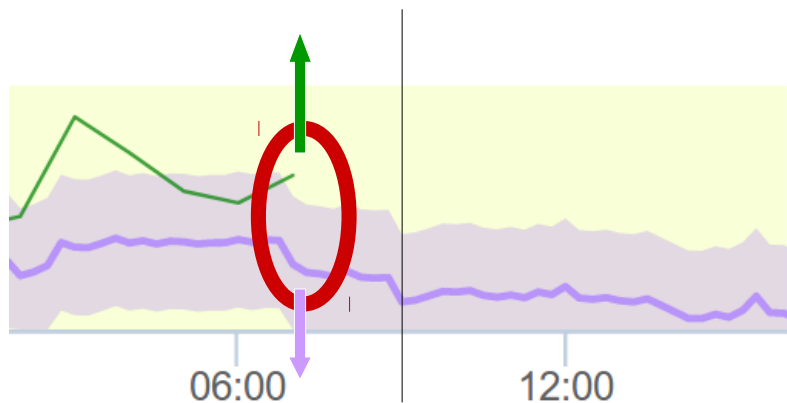
# Vortex FORECAST CORE: Statistical system



FORECAST

(Very) Short-Term forecast: (near) real-time updates of the wind farm data are **available**.

Several **auto-regressive statistical models** to generate the forecast for the **3-6 hours** of the **prediction horizon** are used.



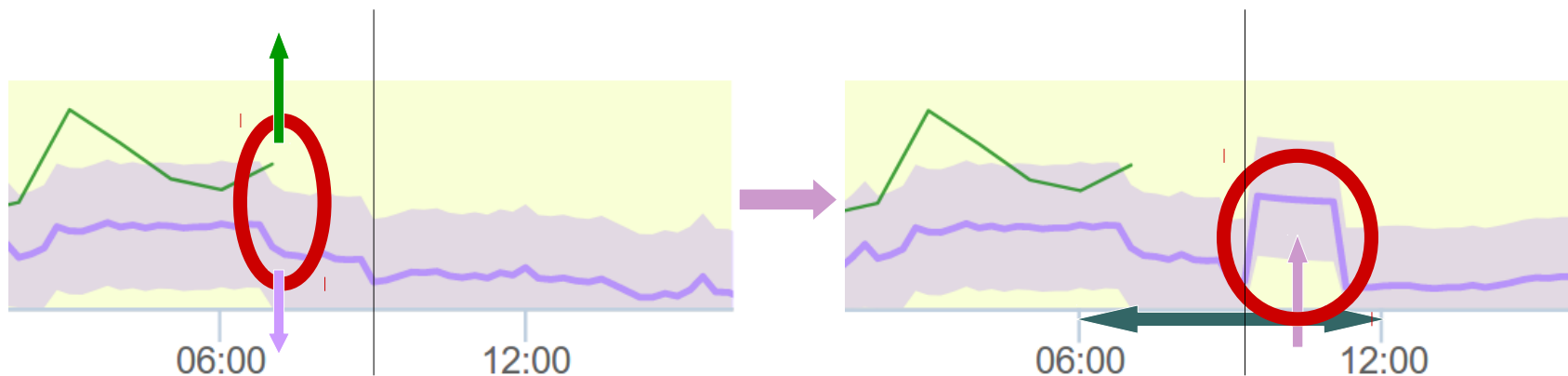
# Vortex FORECAST CORE: Statistical system



FORECAST

(Very) Short-Term forecast: (near) real-time updates of the wind farm data are available.

Several auto-regressive statistical models to generate the forecast for the 3-6 hours of the prediction horizon are used.

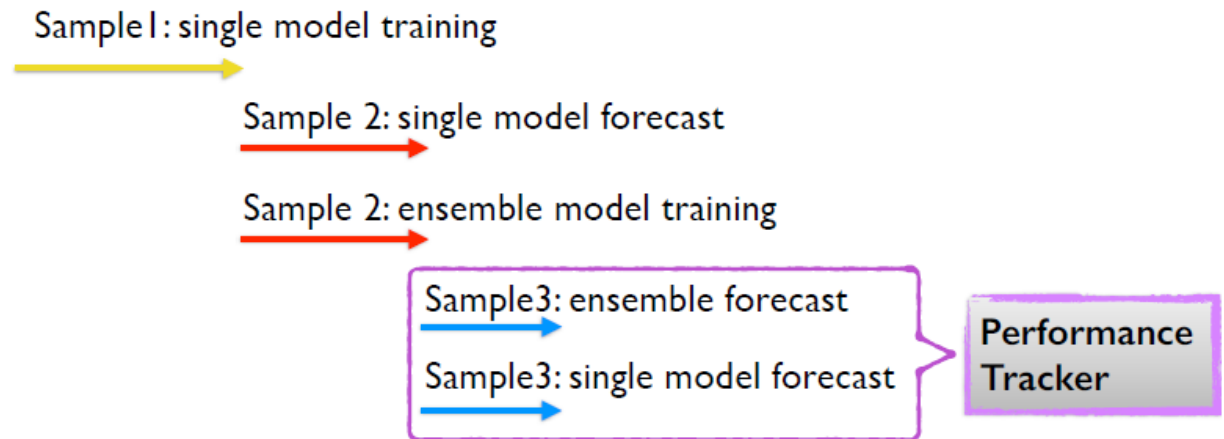


# Vortex FORECAST CORE: Performance Tracker



FORECAST

Performance Tracker detects which forecast (single, ensemble) should be used for **each situation**, variables and look-ahead period.



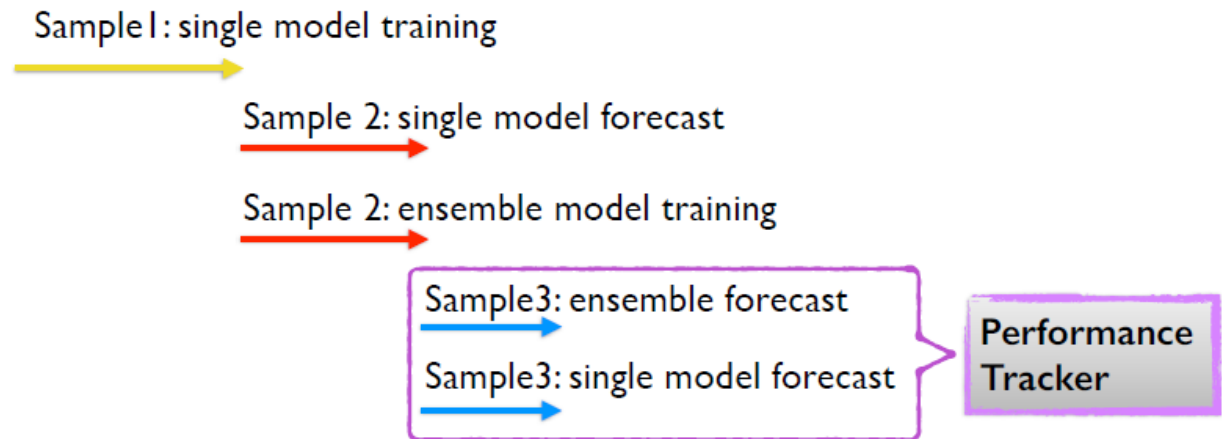
# Vortex FORECAST CORE: Performance Tracker



FORECAST

Performance Tracker detects which forecast (single, ensemble) should be used for **each situation**, variables and look-ahead period.

This is a time adaptive approach.



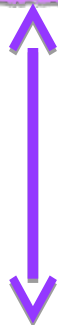
# Vortex FORECAST CORE: Validation and Control



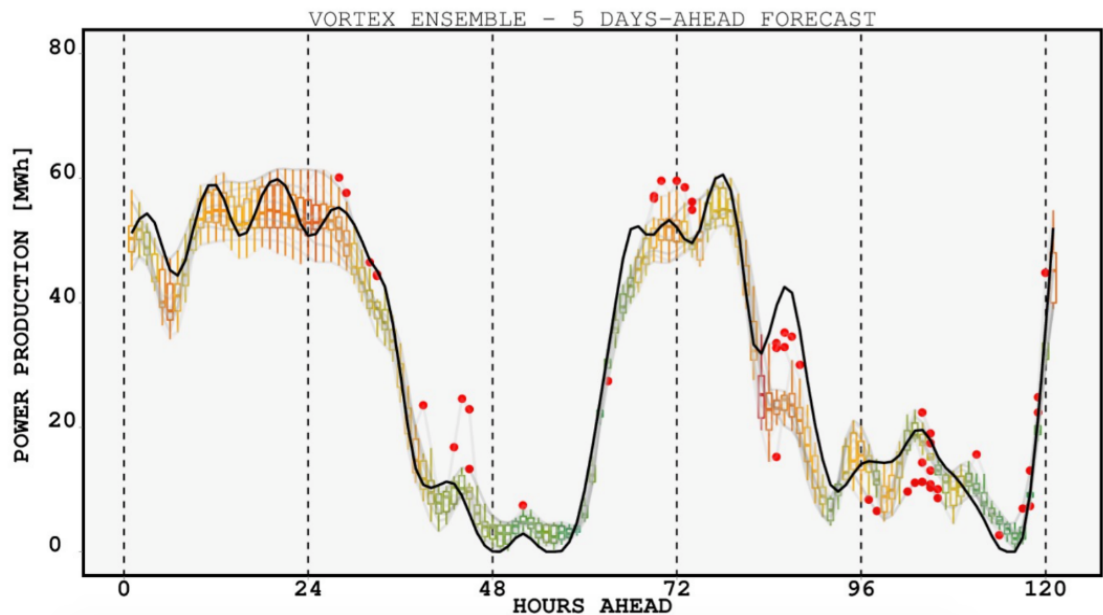
FORECAST

Validation and Control estimate the forecast performance and consistency.

**Performance Tracker**



**VALIDATION & CONTROL**



# Vortex FORECAST: Features



FORECAST

Accuracy and a fast response service for Grid Management and Operational and Maintenance.

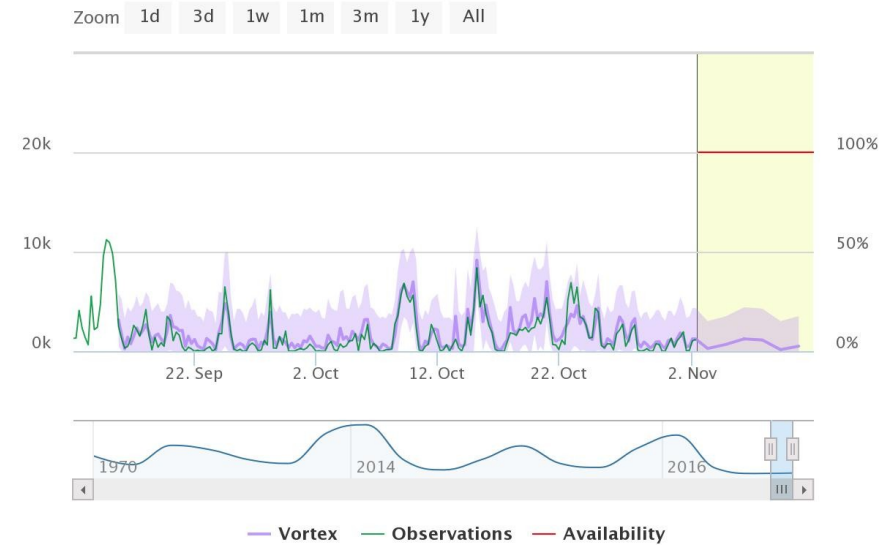
Combination of up to 36 different algorithm in an attempt to deliver the best forecast current technology can provide.

Based on downscale-modeling,

based on statistical training only.

With historical data available or not with VORTEX Series

Client customize delivery



Variable

Date/Hour

<b>Start</b>	15/09/2016 22:00
<b>End</b>	04/11/2016 00:00
<b>Matches</b>	1130
<b>Rated Power (KW)</b>	17560

	ME	MAE	RMSE	Units
<b>Absolute</b>	345.6	909.8	1318.1	KW
<b>Relative to Observations</b>	23.4	61.7	54.7	%
<b>Relative to Rated Power</b>	2.0	5.2	7.5	%

R2 0.57



# Vortex FORECAST : NIWE experience in Tamil Nadu



FORECAST

3 years collaboration with NIWE



# Vortex FORECAST : NIWE experience in Tamil Nadu



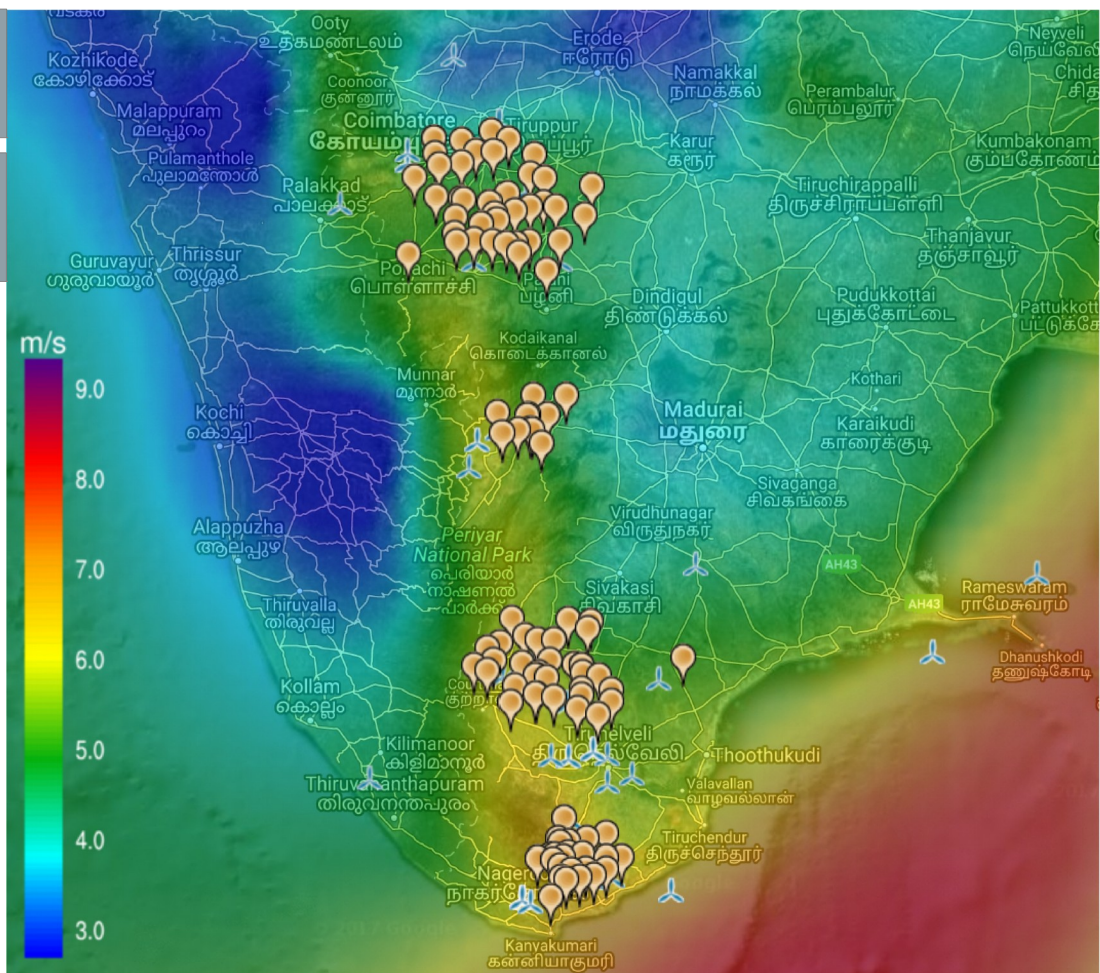
FORECAST

3 years collaboration with NIWE

107 SS individual forecast at Tamil Nadu



नीवे NIWE



# Vortex FORECAST : NIWE experience in Tamil Nadu



FORECAST

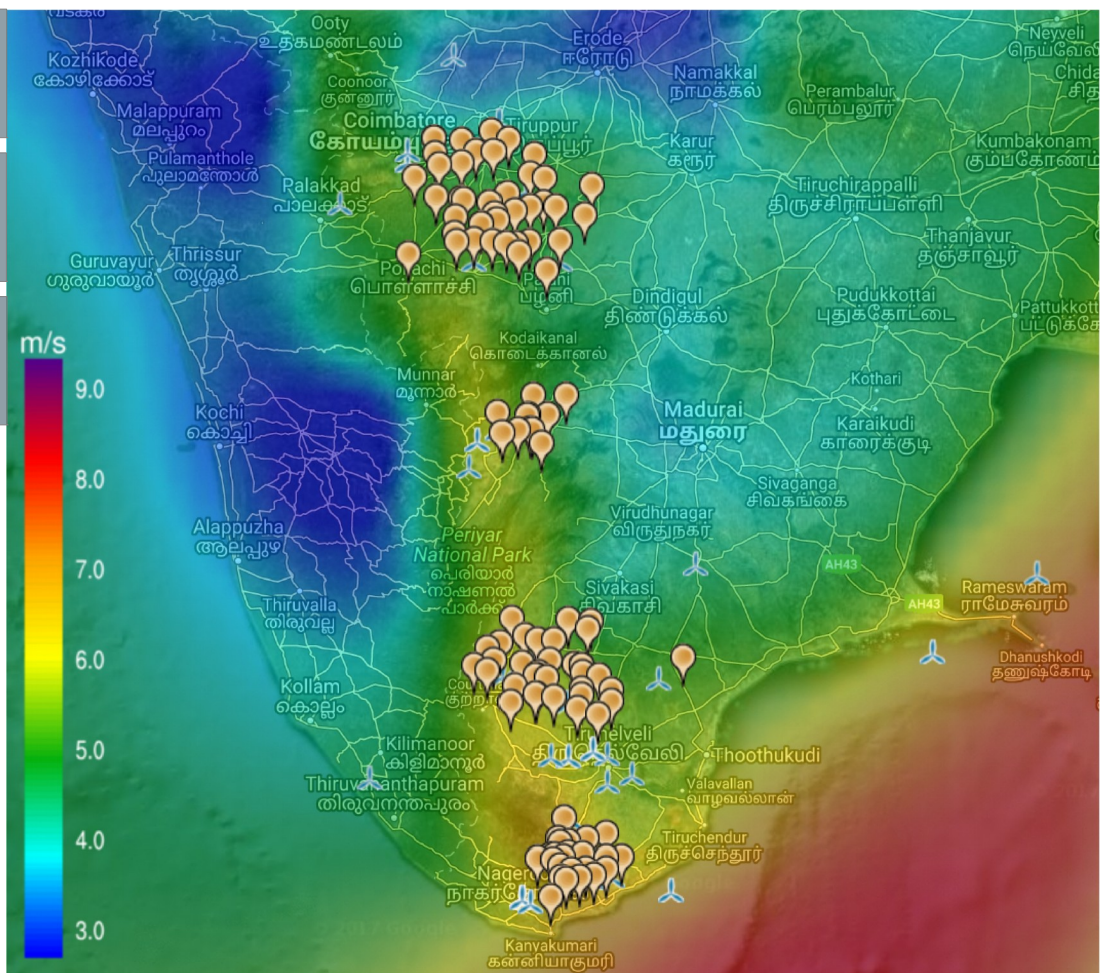
3 years collaboration with NIWE

107 SS individual forecast at Tamil Nadu

Intraday, Day ahead and 10-days forecast



नीवे NIWE



# Vortex FORECAST : NIWE experience in Tamil Nadu



FORECAST



INTERFACE



नीवे NIWE

Friendly interface to view individual SS forecast.

Operative Analysis

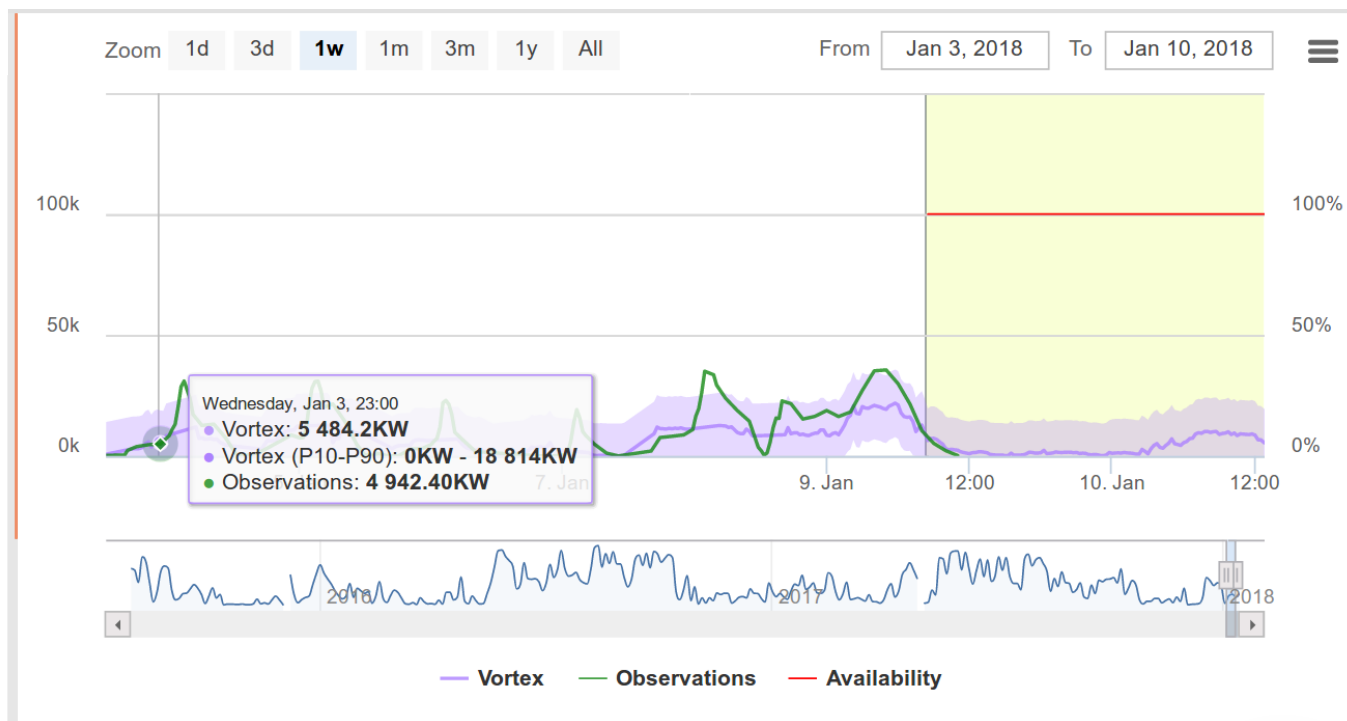
Variable Power

Date/Hour 2018-01-09 08:30

Start	03/01/2018 22:00
End	10/01/2018 13:48
Matches	43
Rated Power (KW)	91505

	ME	MAE	RMSE	Units
Absolute	-2706.0	4917.5	6425.0	KW
Relative to Observations	-24.2	43.9	43.6	%
Relative to Rated Power	-3.0	5.4	7.0	%

R2 0.71



# Vortex FORECAST : NIWE experience in Tamil Nadu



FORECAST



नीवे NIWE

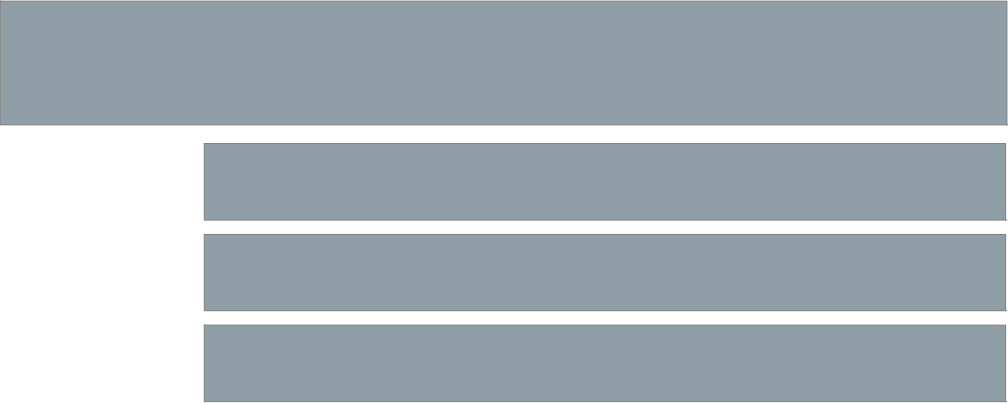
## Cooperation learning:

- System customization for INDIA
- Improving every monsoon
- Continuous training for machine learning
- Better historical data for better forecast





FORECAST



## Wind & Site



MAPS



MAST



FARM



SERIES



INTERFACE



LES

Thank you



## Vortex FdC, S. L.

Parc Tecnològic Barcelona  
Carrer Marie Curie, 8-14  
08042, Barcelona, Spain  
+34 933 285 868  
*info@vortexfdc.com*

Bruxelles  
Miami  
Pune  
Beijing

[www.vortexfdc.com](http://www.vortexfdc.com)

Get in touch:  
[jordi.ferrer@vortexfdc.com](mailto:jordi.ferrer@vortexfdc.com)