



The Contribution of a Wind Data Assimilation Scheme to Improve Offshore Atmospheric mesoscale model results

The case study of Berlengas

EERA Workshop on Wind Conditions

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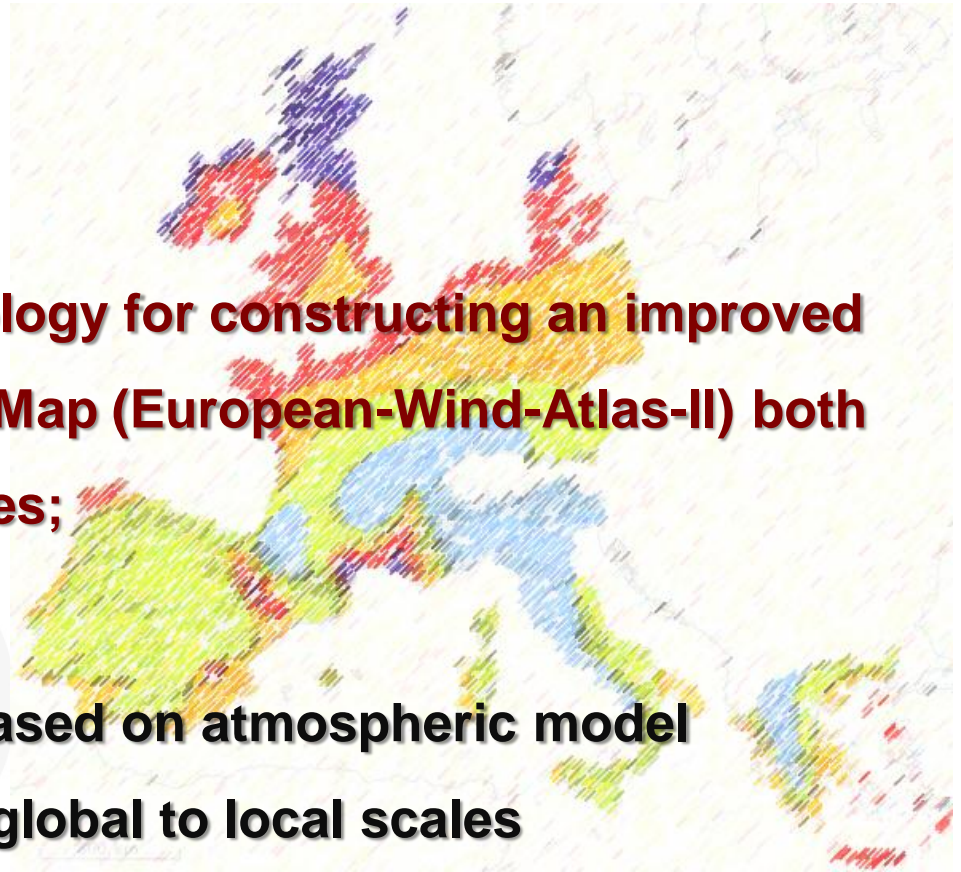
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EERA Objectives

A quick look...

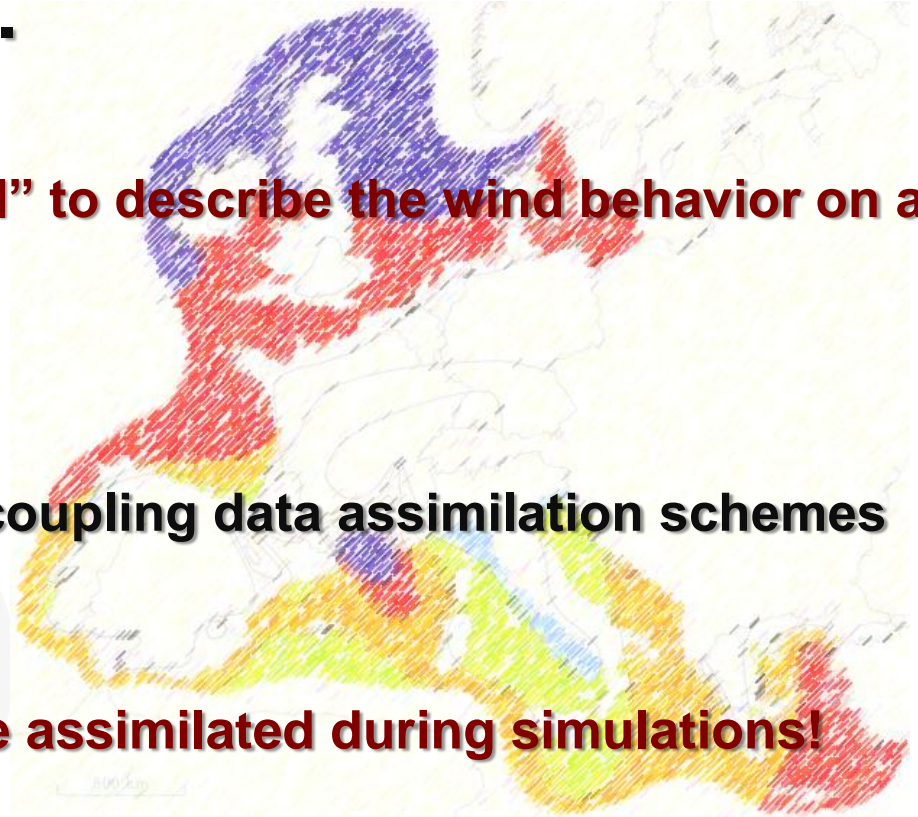
- **Develop a robust methodology for constructing an improved European Wind Resource Map (European-Wind-Atlas-II) both Offshore and onshore cases;**
- **Methodology should be based on atmospheric model capabilities ranging from global to local scales**



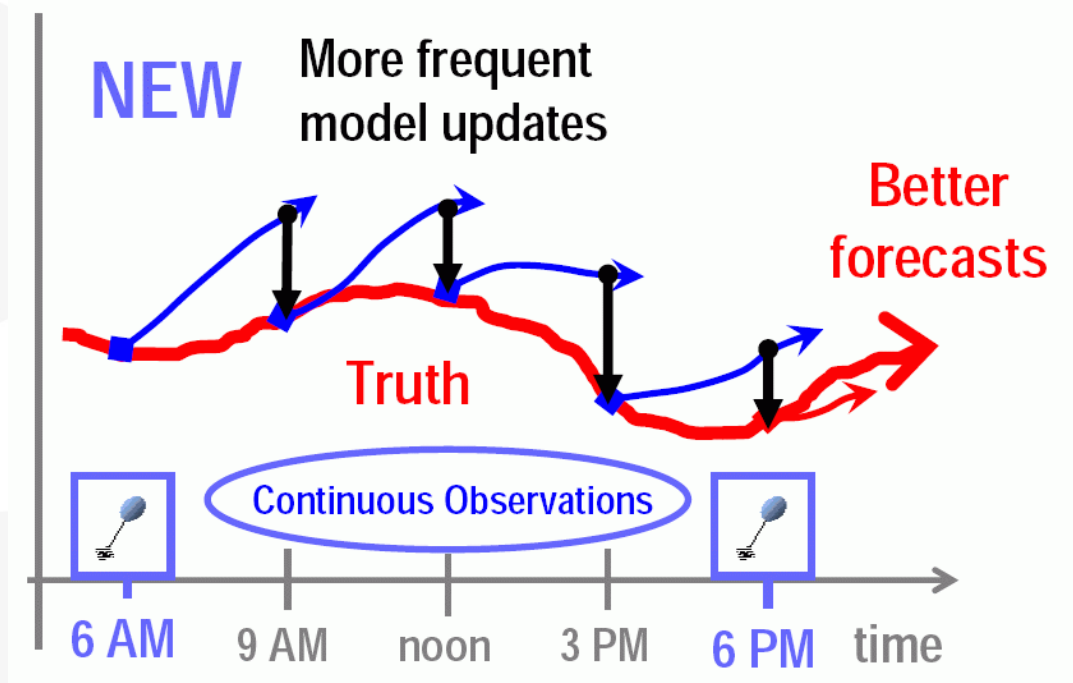
EERA Objectives

Mesoscale models...

- **Can be an important “tool” to describe the wind behavior on a regional scale.**
- **“open” source code for coupling data assimilation schemes**
- **Wind components can be assimilated during simulations!**



Assimilation advantages



- **Assimilation of observations will reduce error forecasts**
- **Reducing error forecasts means getting better forecasts!**

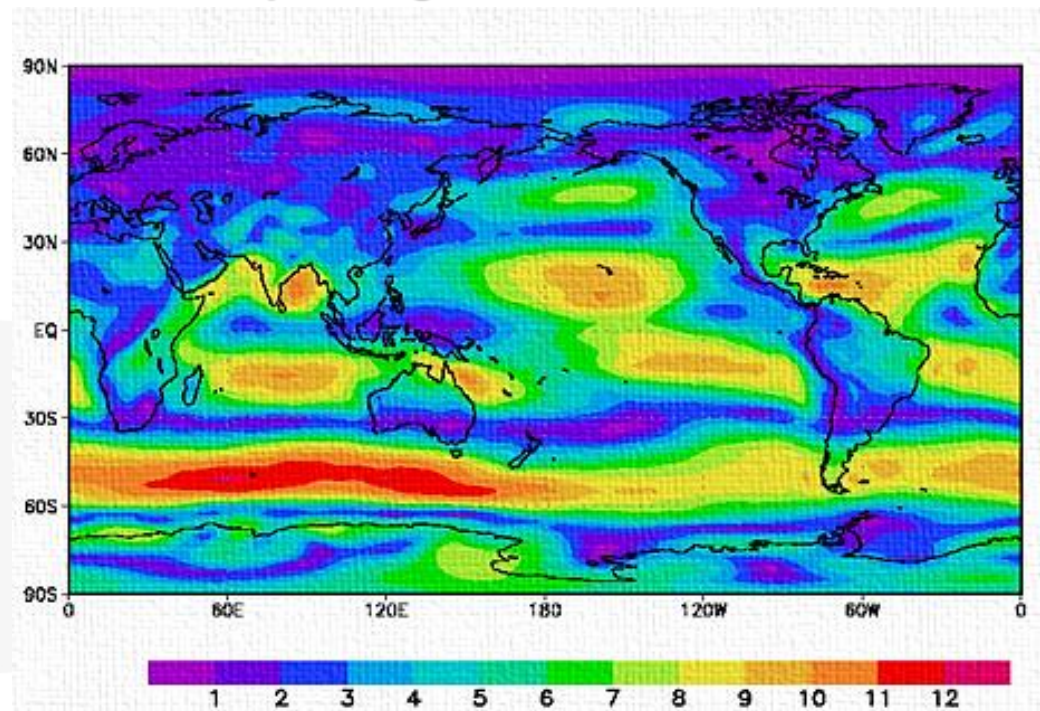
Start Point

Reanalysis ...

Known as the “true state” of the atmosphere generated for a certain time (e.g. 6/6h @ 100x100km spatial resolution);

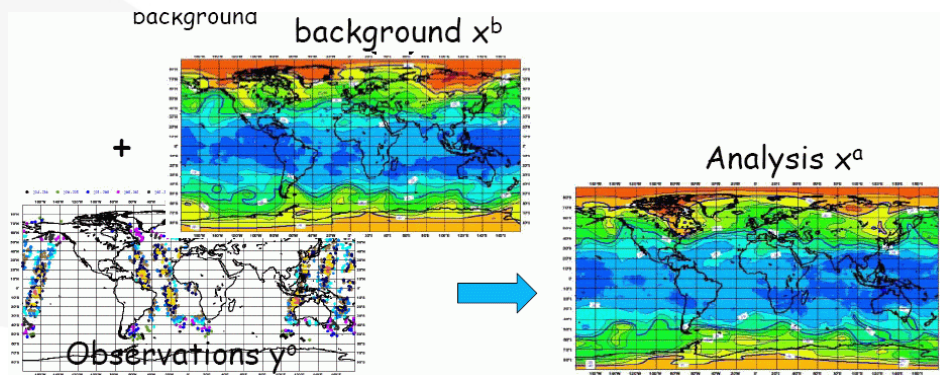
Ingested on initial and boundary conditions;

Produced by assimilation methodologies



Assimilation scheme

The old “BLUE” method ...

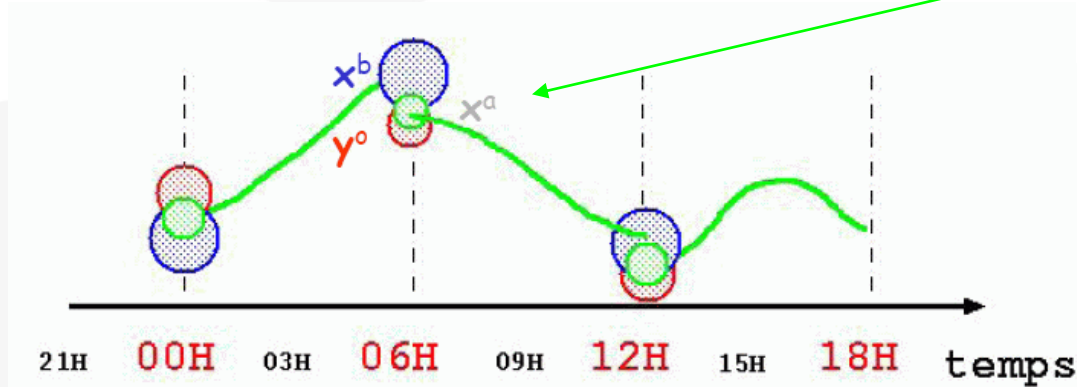


“Best Linear Unbiased Estimate”

\cong Kalman Filter

$$x^a = x^b + dx$$

$$= x^b + K (y^o - H(x^b))$$



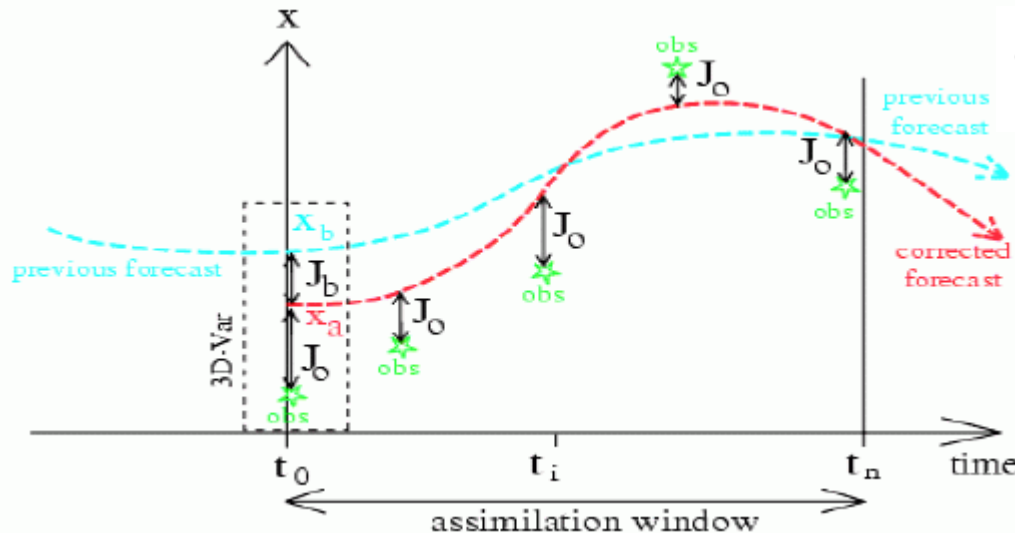
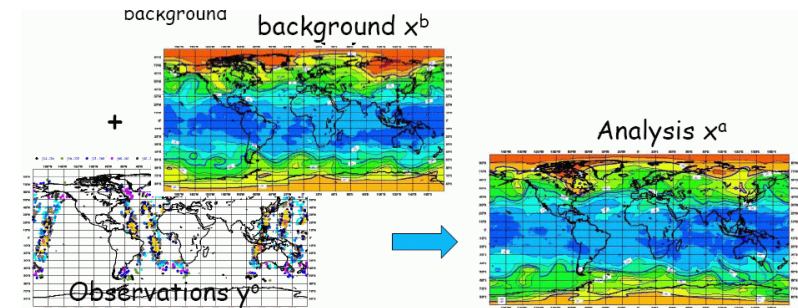
Gain $K = BH^T (HBH^T + R)^{-1}$

Inovation $d = y^o - H(x^b)$

Assimilation scheme

The 4D-VAR method ... “complicated”

Minimization of a “coast function”



$$J(dx) = J_b(dx) + J_o(dx)$$

$$= dx^T B^{-1} dx + (d-H dx)^T R^{-1} (d-H dx)$$

Advantages:

- *assimilation window ;*
- *Use of an Adjoint model – recover the atmospheric baroclinic structures*

Assimilation scheme

“BLUE”& 4D-VAR...

Are used on state-of-the-art forecasting cycles of General Circulation Models (e.g. ECMWF, GFS, ARPEGE, etc..) for weather forecast purposes;

Used to ingest available meteorological data @ 3h interval (e.g. synoptic data);

Very low usage for ingesting asynoptic data (e.g. high frequency data from anemometric masts – 10 min. frequency)



Assimilation scheme

“newtonian” technique...

A simple and an efficient assimilation scheme to ingest asynoptic data;

Can be used on atmospheric mesoscale models for wind atlas generation or even... for weather forecasting purposes ;

Can also be used on all model domains (via *nesting*). Normally used only on intermediate domains and not in the high resolution domain used for wind atlas construction



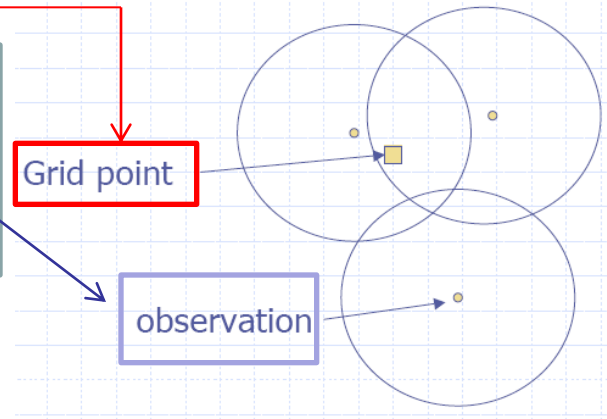
Assimilation scheme

Add a weighted term depending on error deviations between observations and model solution.

dependencies on: distance; height and time window;

$$\frac{\partial \alpha_i(\mathbf{x}, t)}{\partial t} = F(\alpha, \mathbf{x}, t)$$

$$+ G_i \cdot \frac{\sum_{j=1}^N W_j(\mathbf{x} - \mathbf{x}_j, t - t_j) \cdot W_j(\mathbf{x} - \mathbf{x}_j, t - t_j) [\alpha_j - \alpha_i(\mathbf{x}_j, t_j)]}{\sum_{j=1}^N W_j(\mathbf{x} - \mathbf{x}_j, t - t_j)}$$



Model equations

$$W_j = w_{xy}(D_j) \cdot w_{\sigma}(\sigma - \sigma_j) \cdot w_t(t - t_j)$$


Distance


Height


Time window



Case study

The region of Berlengas...



Case study

Berlengas...

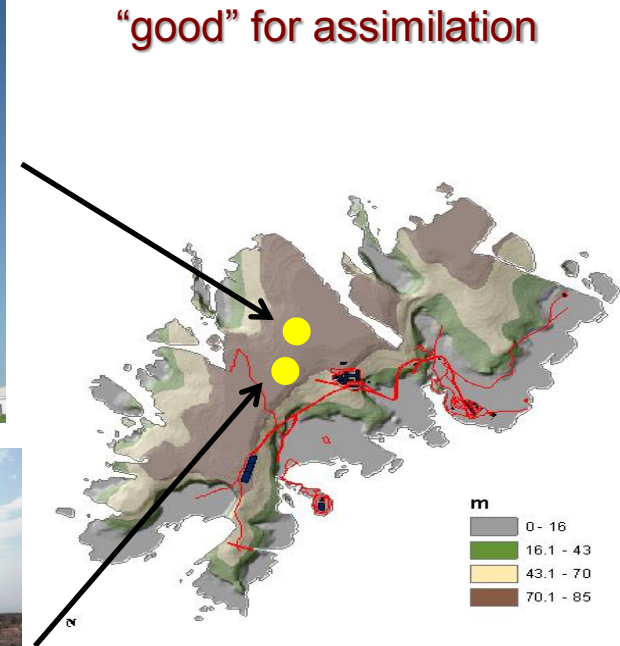
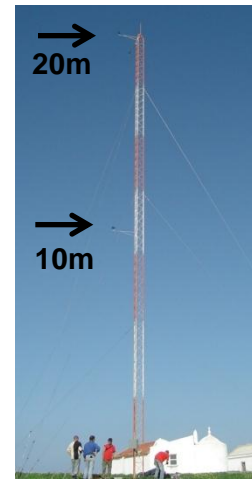
- **A small rocky island in the ocean located about 10km from western coastal regions of Continental Portugal;**
- **Horizontal dimensions: ~ 2x2km**
- **Maximum height: 85m**
- **Low roughness**



Case study

Why Berlingas?

- **Nov 2006 - LNEG installed an anemometric mast equipped with wind and vane sensors at 10m and 20m height – data is currently being gathered;**
- **October 2009 - a ZephIR/LIDAR wind profiler system was installed (FP7 - NORSEWInD Project) - five monitored heights: 20m; 40m; 80m; 120m and 200m**



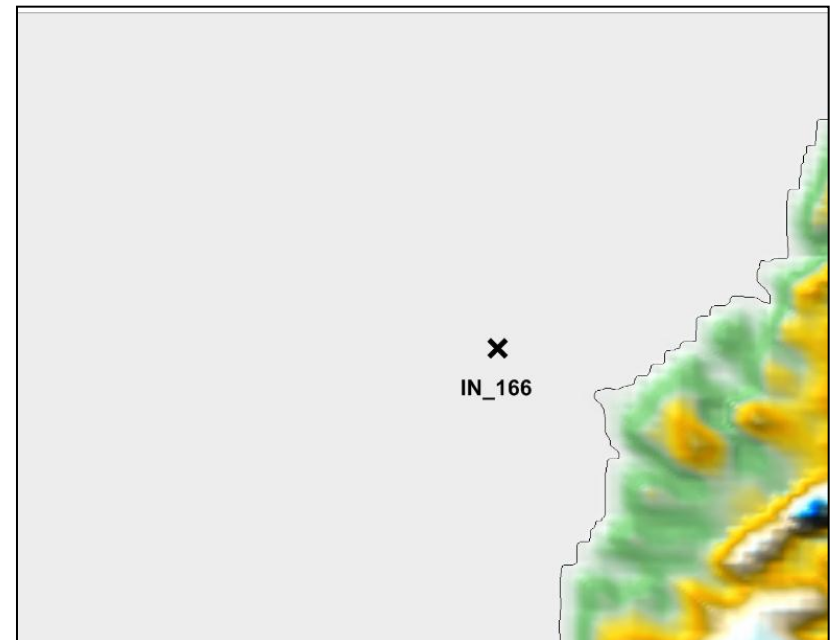
“good” for model validation

Case study

preliminary wind atlas for October 2009

- **Using WRF-ARW atmospheric mesoscale model coupled with 3 nested domains (50km, 10km and 2km spatial resolution);**
- **32 vertical levels;**
- **Data ingested : NCAR's Reanalysis data**
- **Domains @ 50km and 10km used for asynoptic assimilation with the newtonian technique ;**

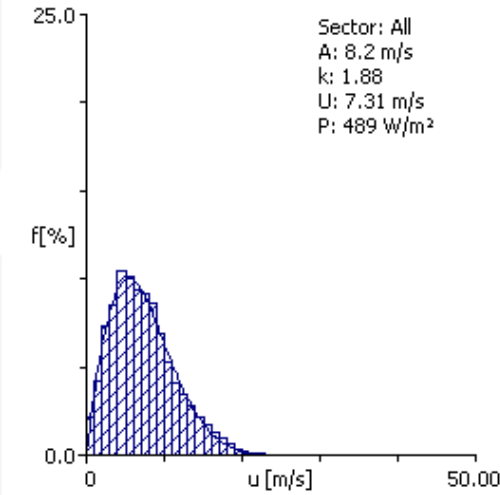
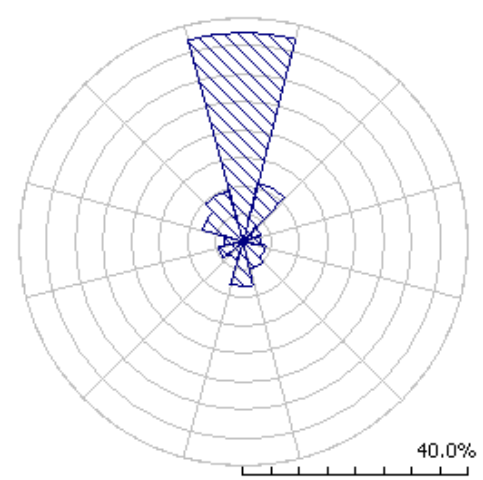
WRF domain area @ 2x2km



Case study

Assimilated asynoptic data:

Anemometric mast on Berlengas:



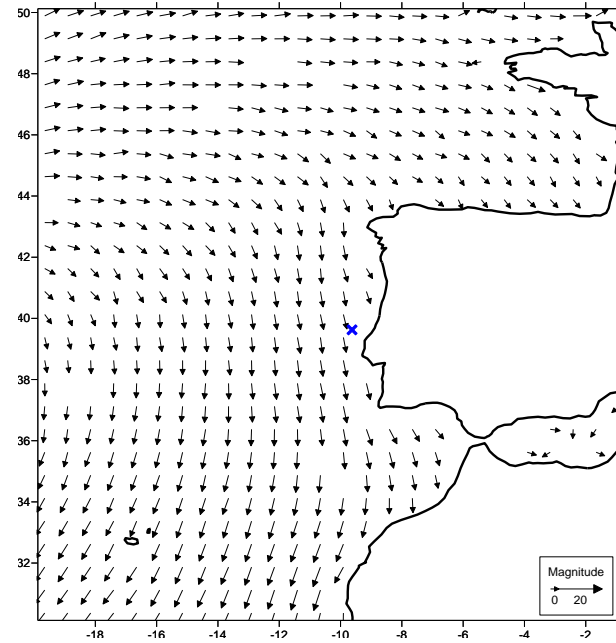
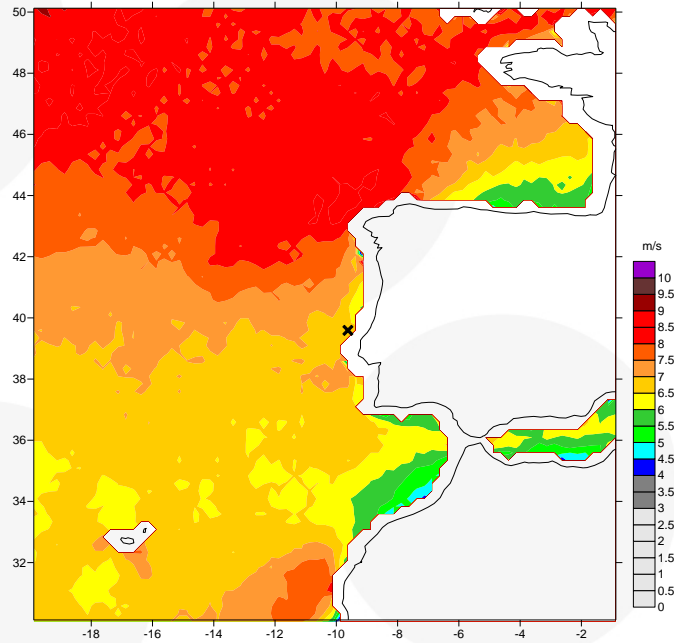
Used wind data at 20m ingested with 10min interval



Case study

Assimilated asynoptic data:

Surface QuikSCAT satellite data:



Frequency:

*two images
per day*

At October 2009, the QuikSCAT satellite was operational !!

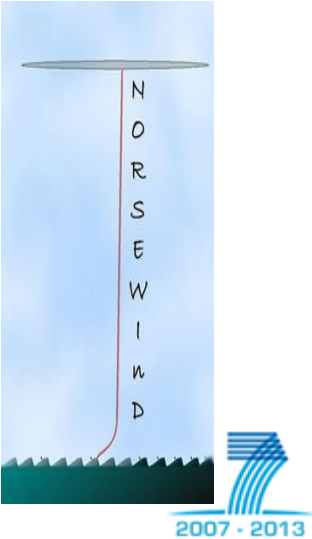
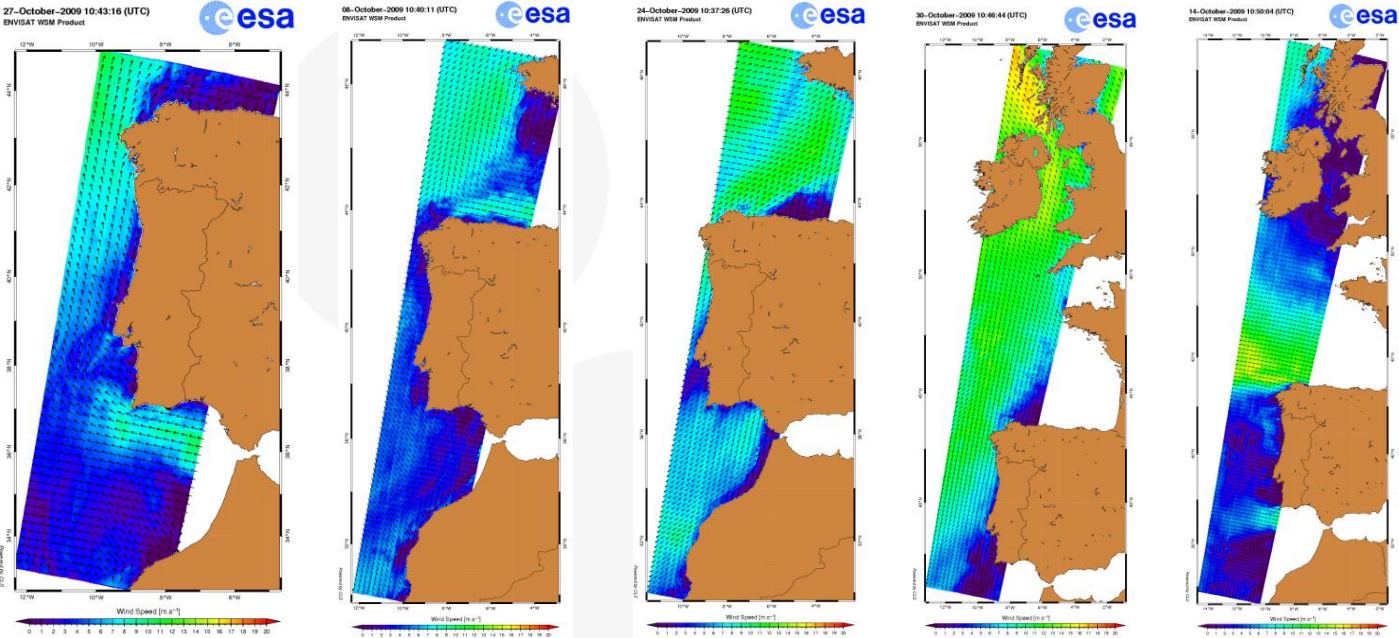
Case study

Assimilated asynoptic data:

Surface SAR satellite data:

Frequency:

five images per month



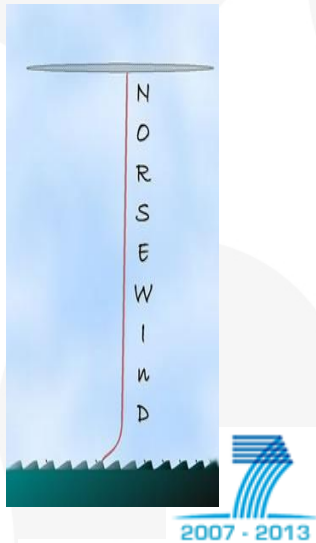
Thanks to Alexis Mouche (IFREMER) and Charlotte Hasagar (RISOE)



Case study

Validation data:

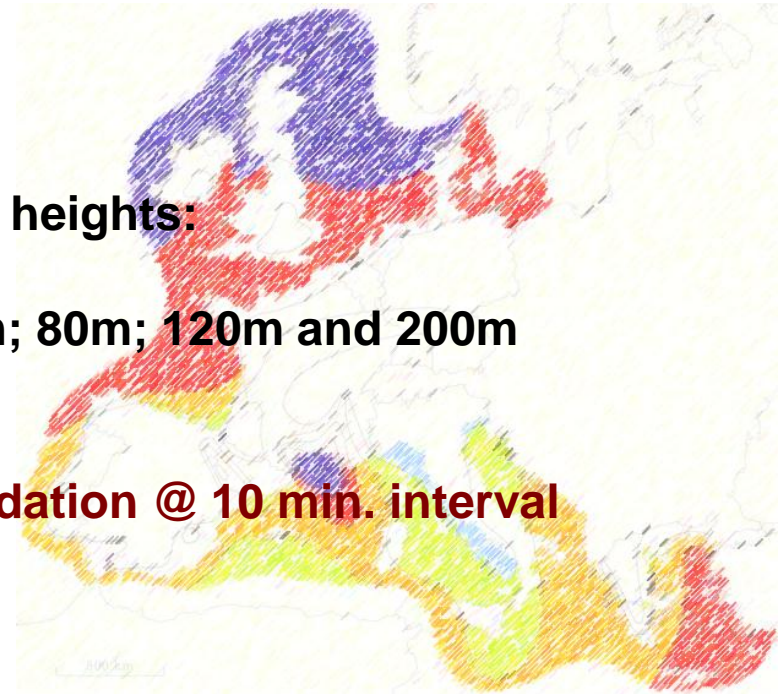
ZephIR/LIDAR wind data:



@ 4 heights:

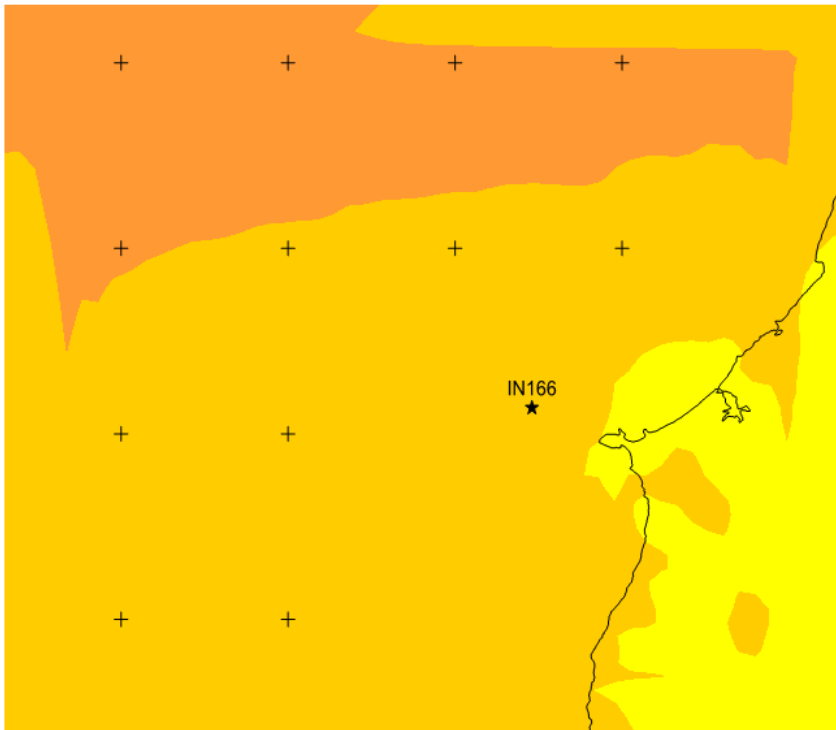
40m; 80m; 120m and 200m

Validation @ 10 min. interval

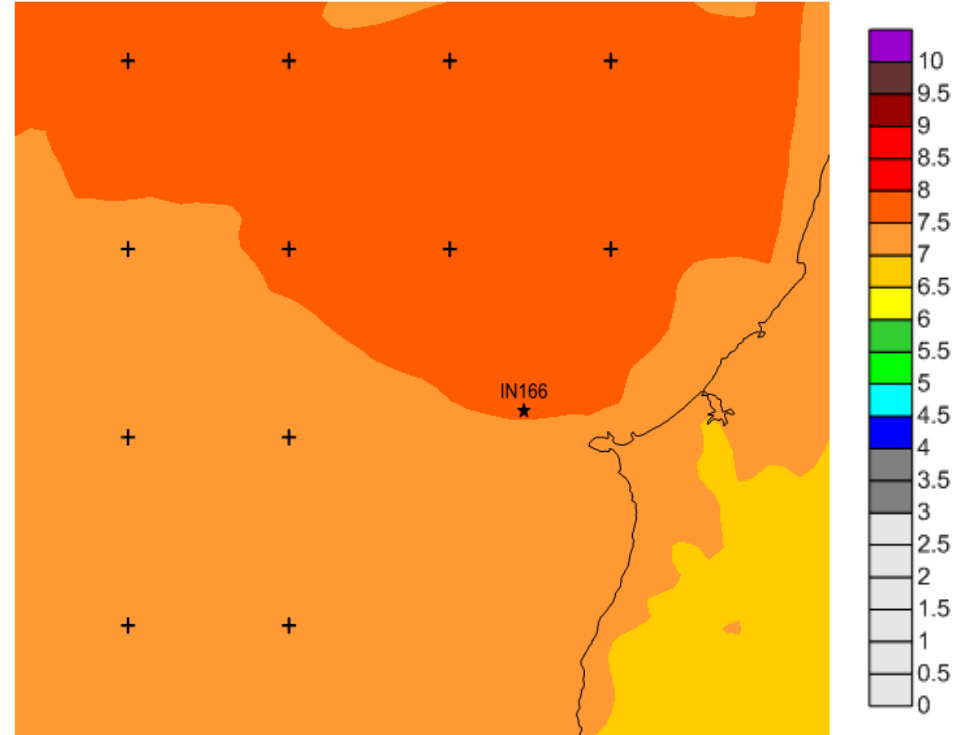


Mean wind atlas

Preliminary results @ 80m height



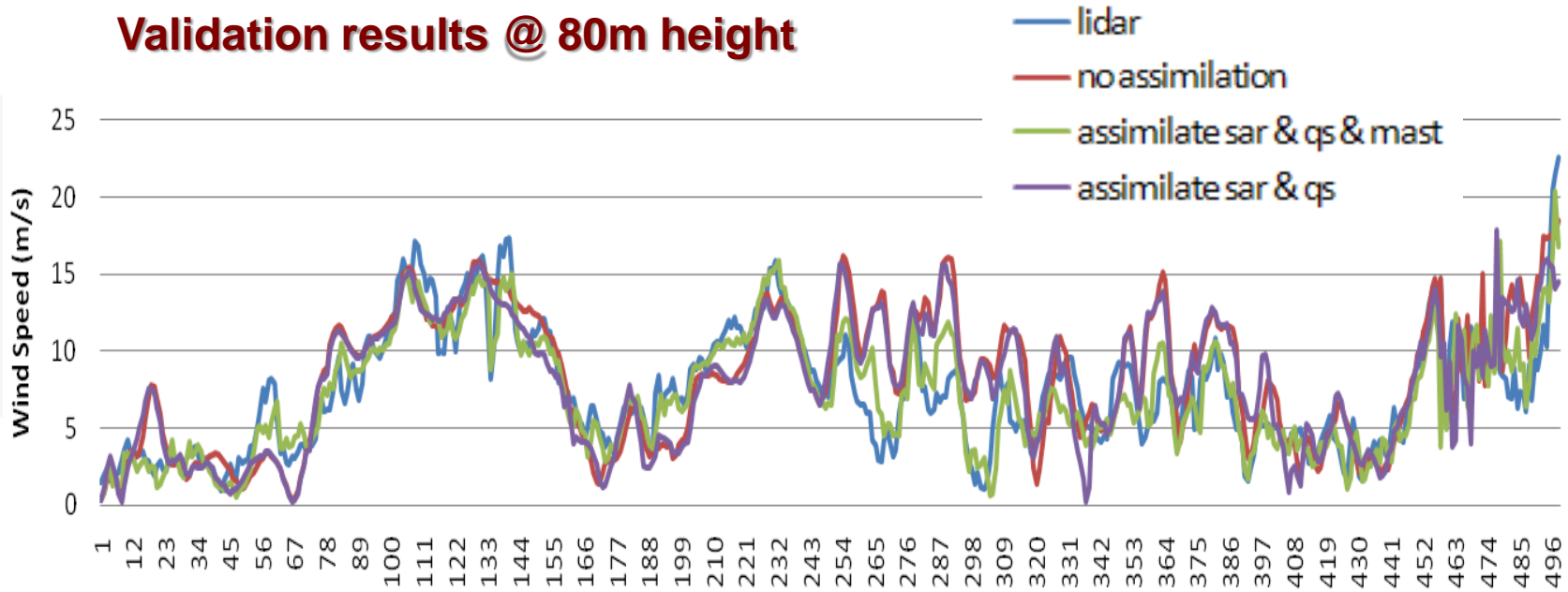
with assimilation



no assimilation

Mean wind atlas

Validation results @ 80m height

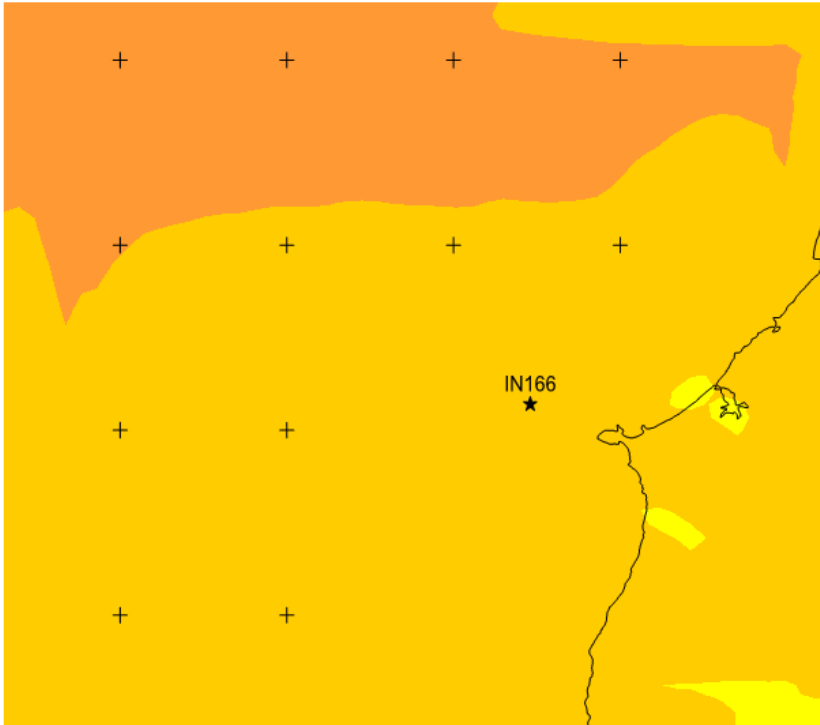


	Assimilate sar_qs	Assimilate Sar & qs & mast	No assimilation
Correlation (%)	73.88	90.08	71.15
RMSE speed (m/s)	3.09	1.71	3.10

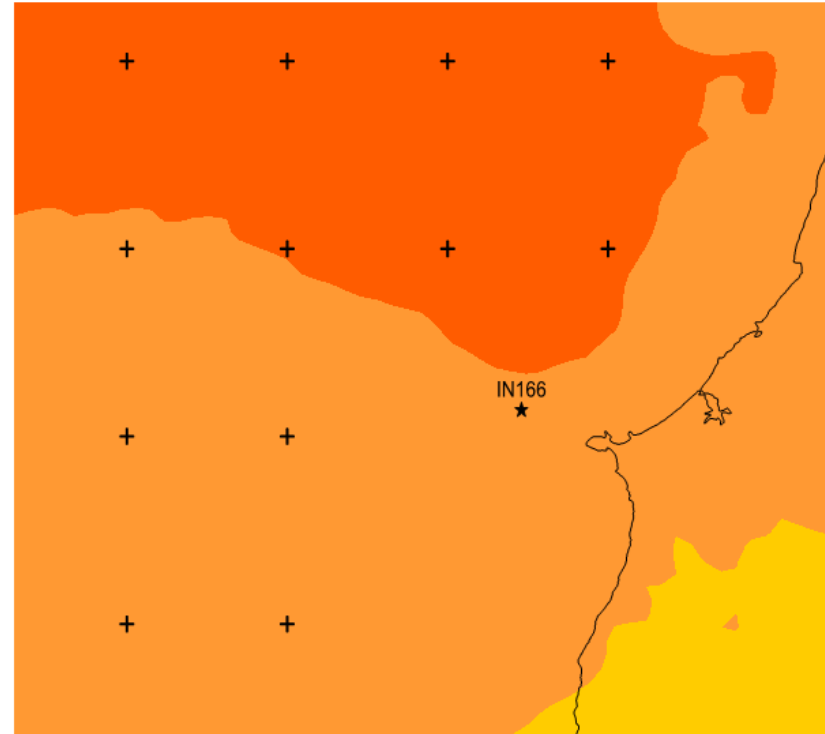


Mean wind atlas

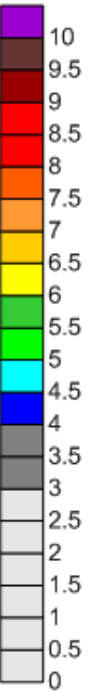
Preliminary results @ 200m height



with assimilation

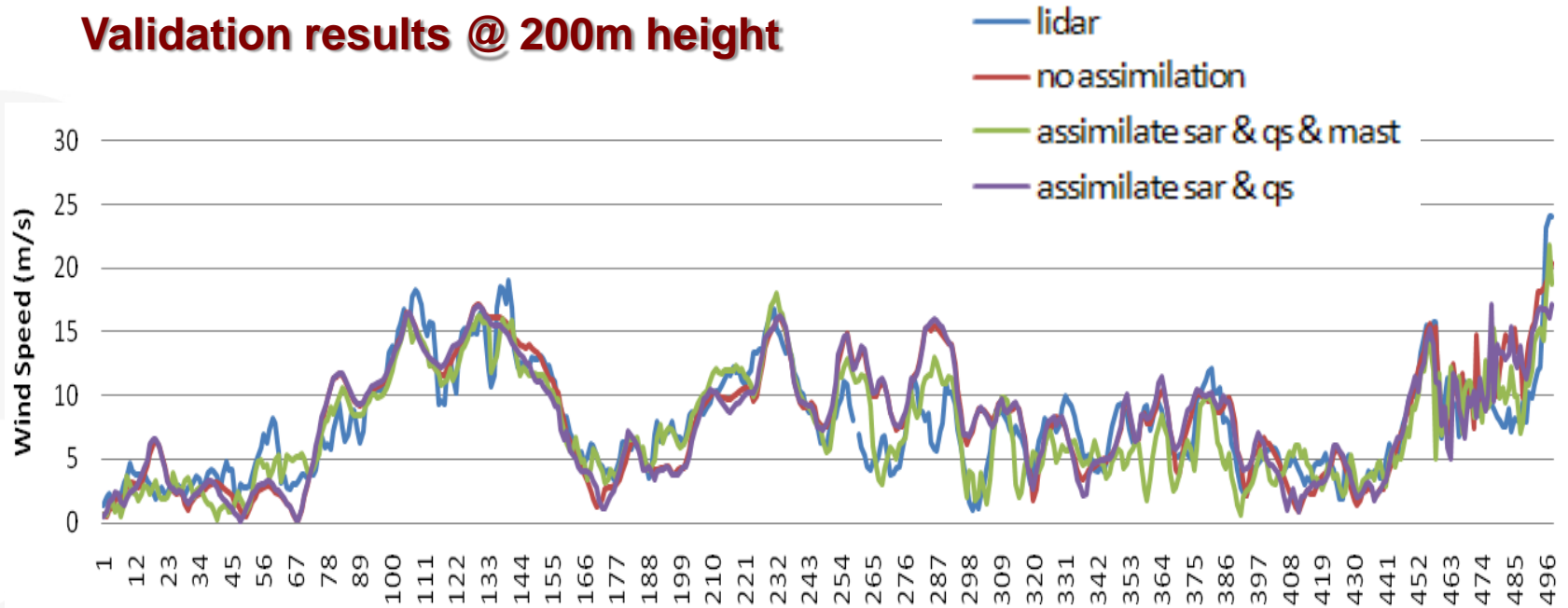


no assimilation



Mean wind atlas

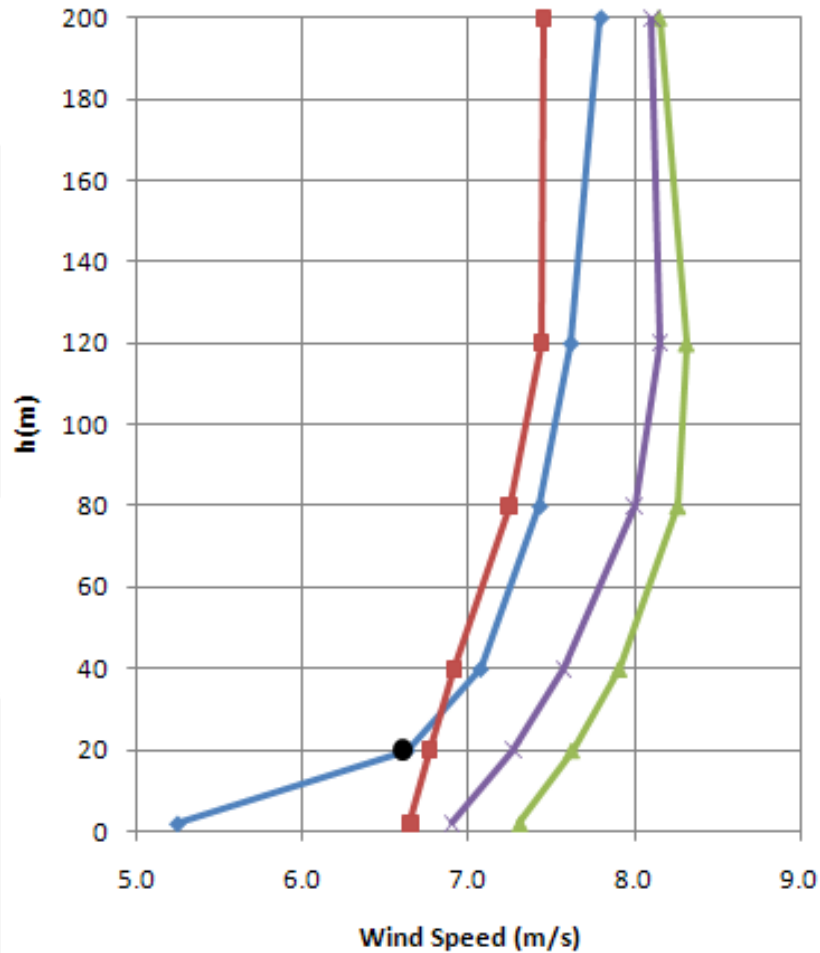
Validation results @ 200m height



	Assimilate sar_qs	Assimilate Sar & qs & mast	No assimilation
Correlation (%)	82.43	87.61	79.83
RMSE speed (m/s)	2.70	2.16	2.82



Mean wind atlas



Mean vertical wind speed profiler validation results

- lidar
- assimilate sar & qs & mast
- no assimilation
- assimilate sar & qs
- mast



Final remarks

- **Preliminary results confirm that using asynoptic observational wind data can reduce wind deviation errors from mesoscale simulations;**
- **Results here obtained suggest that it can be reliable the usage of the newtonian assimilation technique for developing mesoscale wind maps**
- **This should be taken into account for EERA if mesoscale models will be used for generating wind atlas both offshore and onshore.**



Thank you very much!

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