



# Improving Offshore Atmospheric Mesoscale model results The case study of Berlengas

14th Conference on Mesoscale Processes

Los Angeles, 1-4 August 2011

Section 8 – Mesoscale Predictability and data assimilation II

[paulo.costa@lneg.pt](mailto:paulo.costa@lneg.pt)

[miguel.fernandes@lneg.pt](mailto:miguel.fernandes@lneg.pt)

[ana.estanqueiro@lneg.pt](mailto:ana.estanqueiro@lneg.pt)



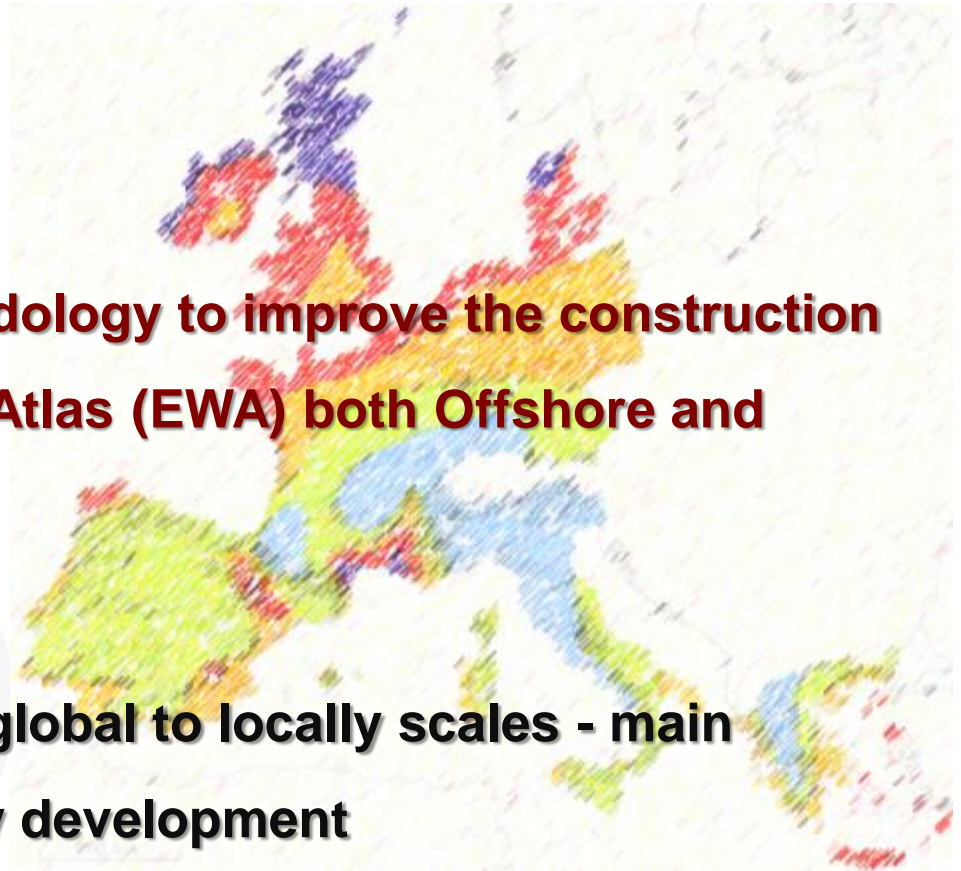
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# Objectives

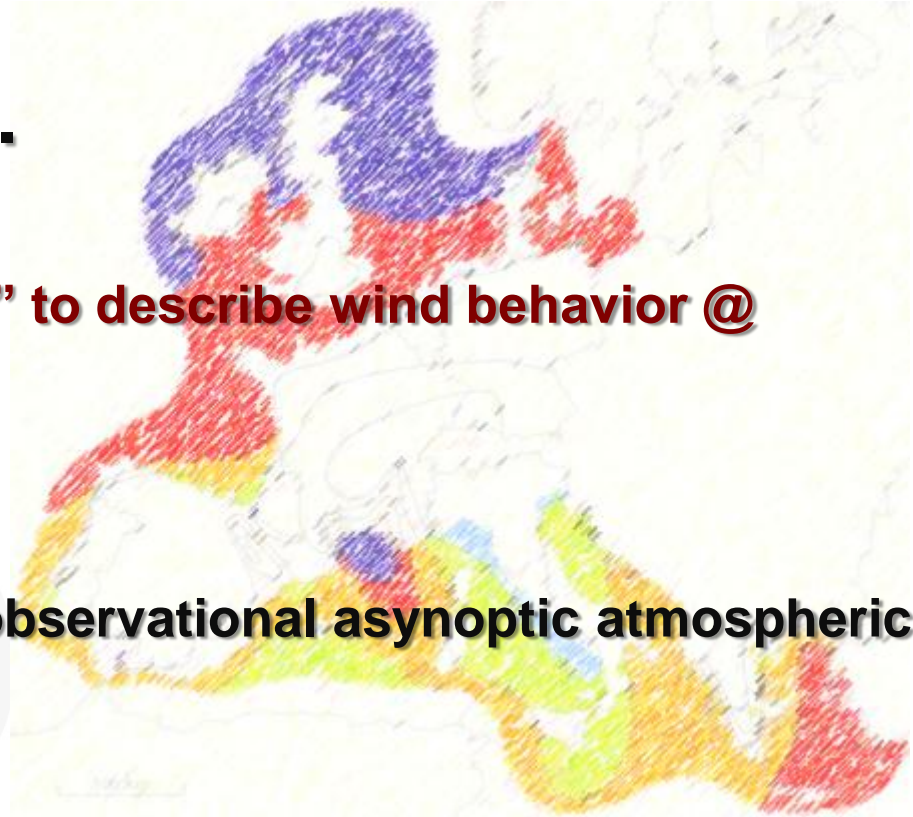
## A quick look...

- **Develop a “robust” methodology to improve the construction of the 2<sup>nd</sup> European-Wind-Atlas (EWA) both Offshore and Onshore;**
- **Modeling the winds from global to locally scales - main objective for methodology development**

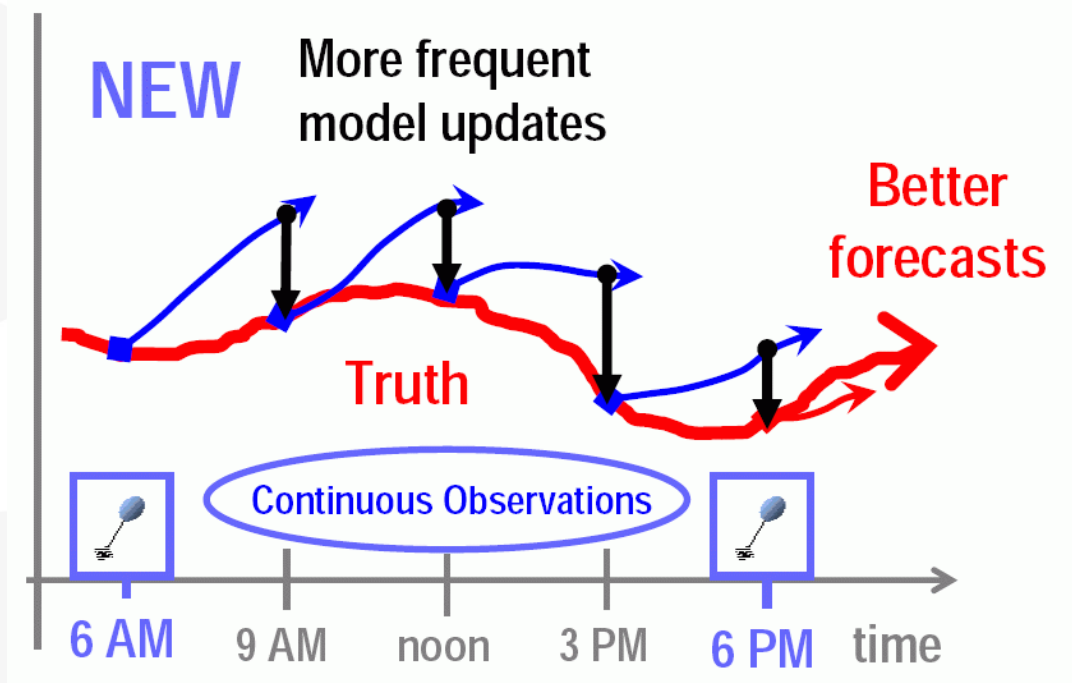


## Mesoscale models...

- **The most important “tool” to describe wind behavior @ regional scales;**
- **Capability to assimilate observational asynoptic atmospheric data!**



# Assimilation advantages



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



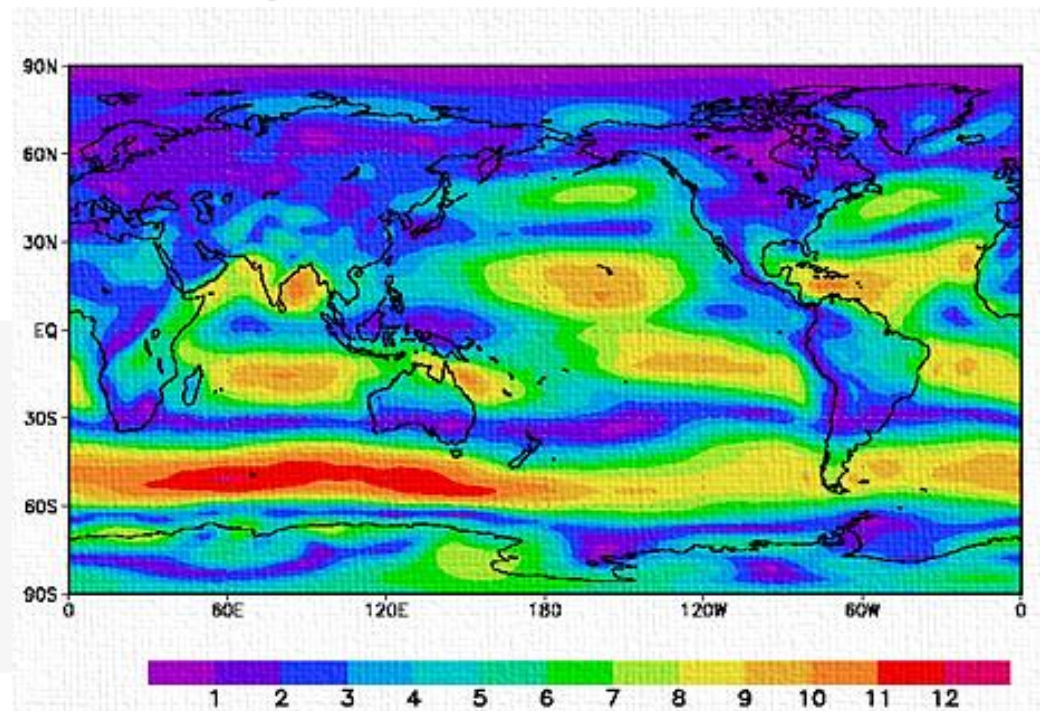
# Start Point

## Reanalysis ...

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

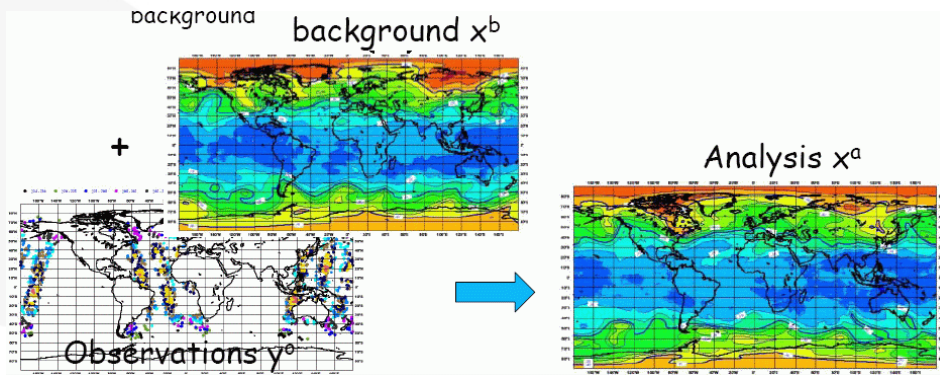
Ingested on initial and  
boundary conditions;

Produced by assimilation  
methodologies



# Assimilation schemes

## The old “BLUE” method ...



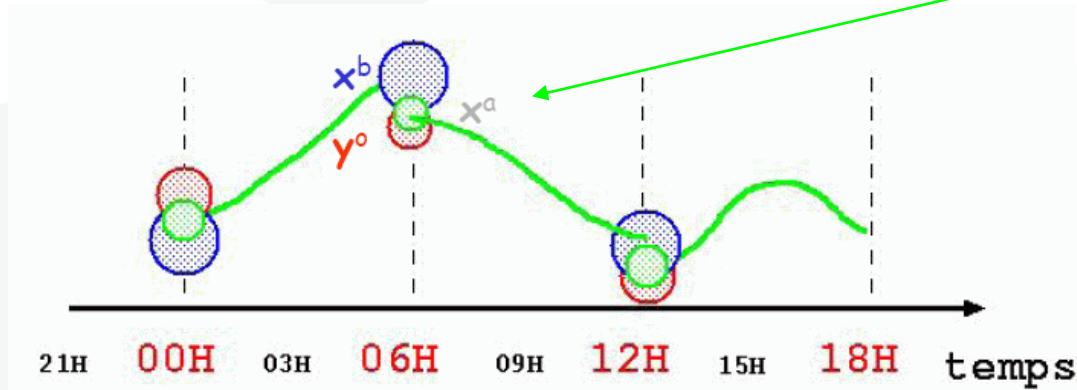
“Best Linear Unbiased Estimate”

$\cong$  Kalman Filter

$$\begin{aligned} x^a &= x^b + dx \\ &= x^b + K(y^o - H(x^b)) \end{aligned}$$

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

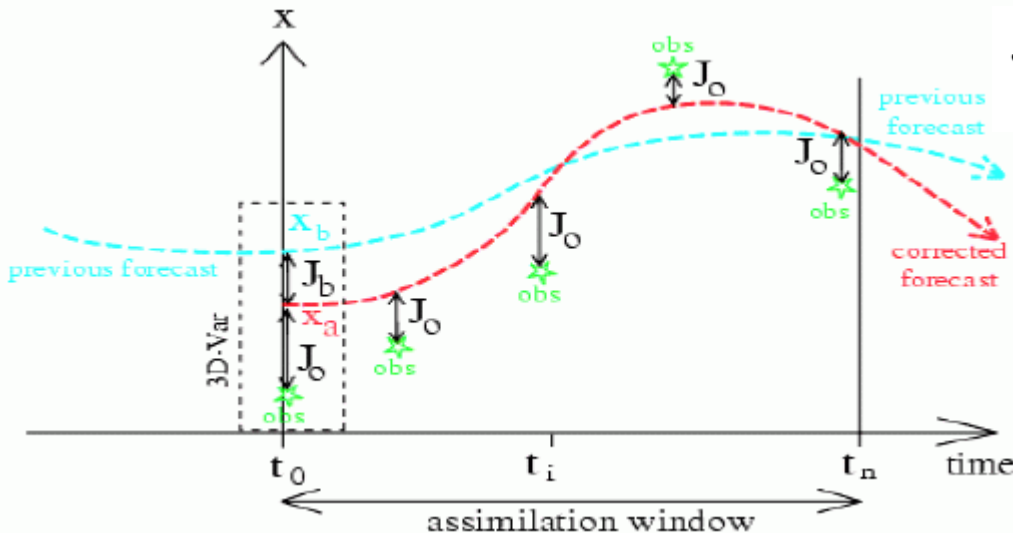
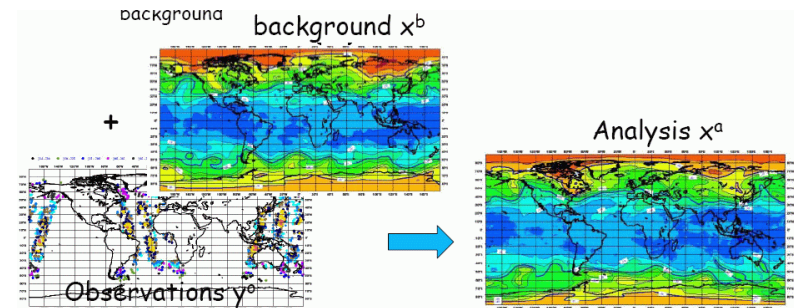
**Inovation**  $d = y^o - H(x^b)$



# Assimilation scheme

## The 4D-VAR method ... “complicated”

Minimization of a “cost 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 schemes

## “BLUE” & 4D-VAR...

mainly used on the state-of-the-art forecasting cycles of General Circulation Models (e.g. ECMWF, GFS, ARPEGE);

Developed for ingesting meteorological synoptic data @ 3h interval;

Very low usage on the ingestion of asynoptic data  
(e.g. anemometric mast data with data averaged frequency of 10min.)



# Assimilation schemes

## “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 ;**

**But... It's usage should be restrictly to the model domains (*nesting*) that will not be used for wind atlas construction or forecast**



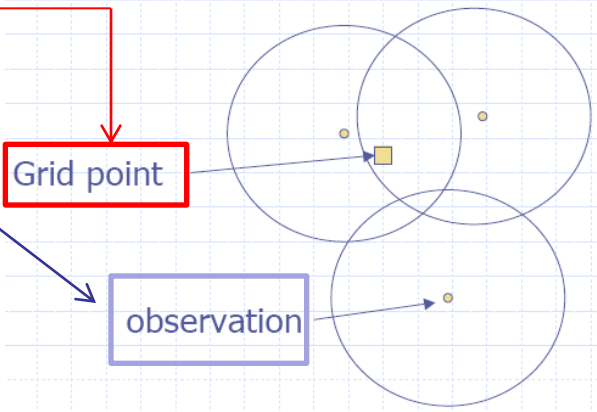
# Assimilation schemes

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**

**Already implemented on WRF-ARW model!**



# Case study

## The region of Berlengas...



# Case study

## Berlengas...

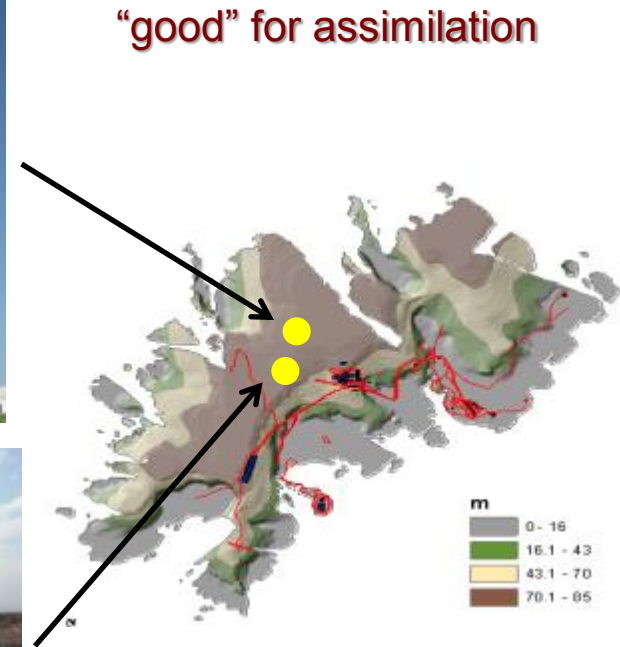
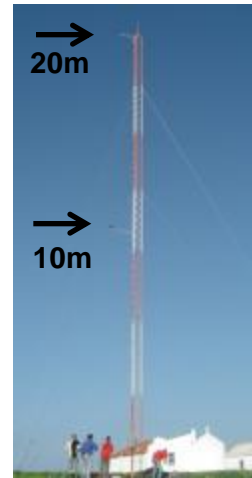
- **A small rocky island in the ocean located about 10km from western coastal region of Continental Portugal;**
- **Horizontal dimensions: ~ 2x2km ;**
- **Maximum height: 85m;**
- **Very low roughness**



# Case study

## Why Berlingas?

- **Nov 2006 - LNEG installed an anemometric mast equipped with wind and vane sensors at 10m and 20m height – data is continuously been gathered with good quality;**
- **October 2009 - a ZephIR/LIDAR system was installed. Five heights are being monitored: 20m; 40m; 80m; 120m and 200m – wind profiler**



“good” for model validation

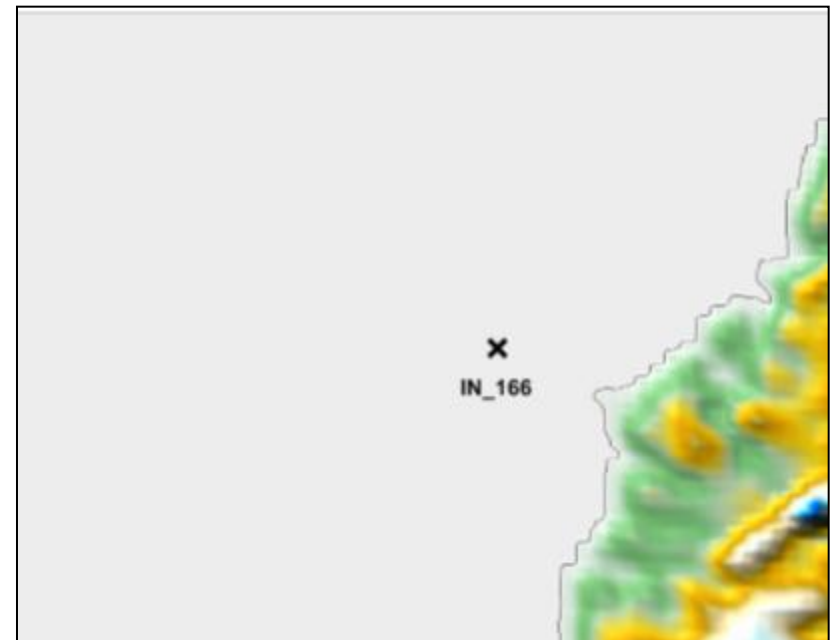


# Case study

## 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**

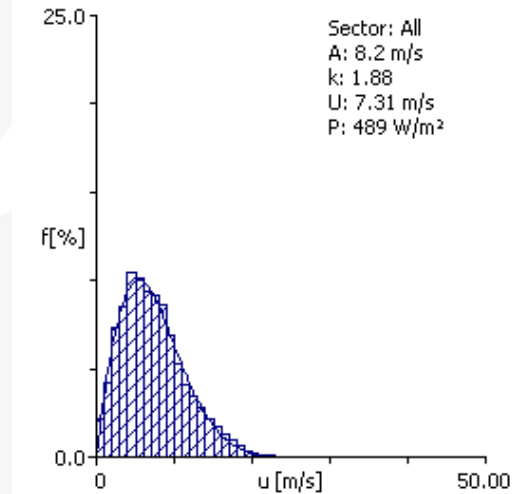
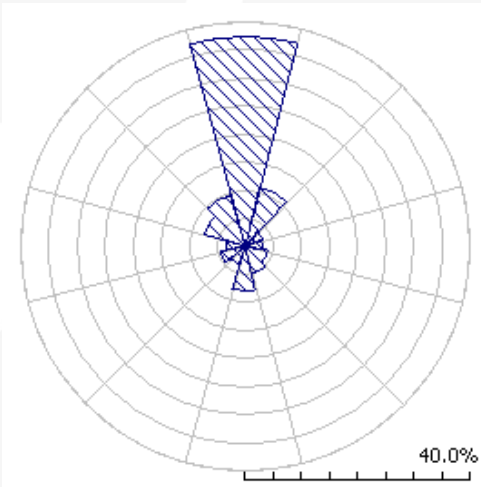
WRF domain area @ 2x2km



# Case study

## Assimilated asynoptic data:

### Anemometric mast on Berlengas:



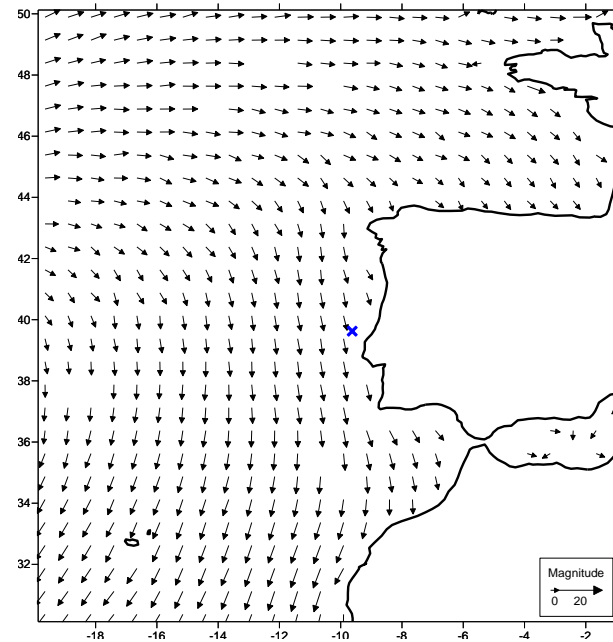
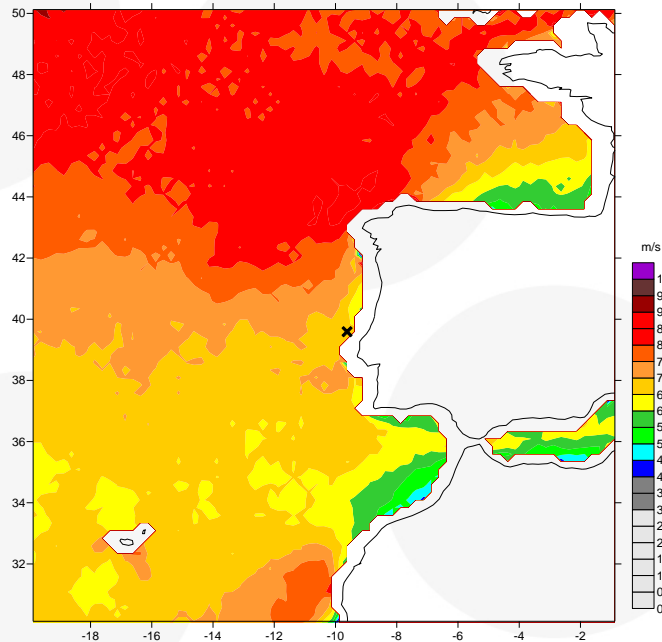
Used wind data at 20m ingested with 10min interval



# Case study

## Assimilated asynoptic data:

### Surface QuikSCAT satellite data:



Frequency:

*two images  
per day*

**At October 2009, the QuikSCAT satellite was operational !!**



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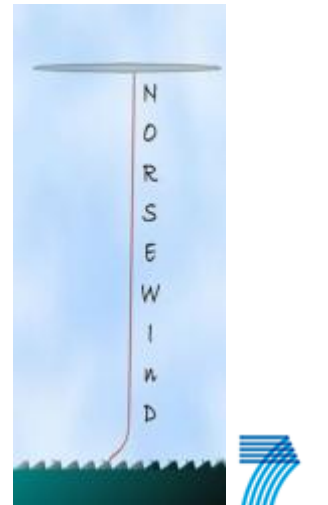
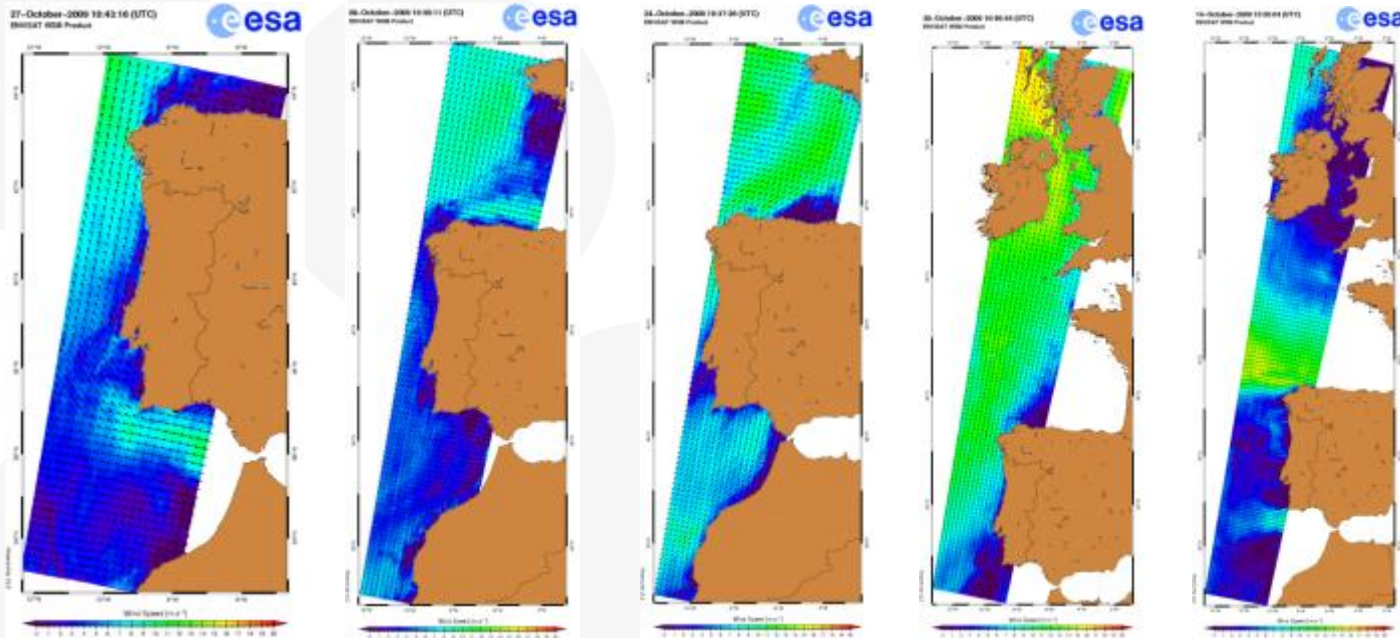
# Case study

## Assimilated asynoptic data:

### Surface SAR satellite data:

Frequency:

*five images per month*



2007 - 2013



Thanks to: Alexis Mouche (CLS - FR) and Charlotte Hasager (RISOE-DK)

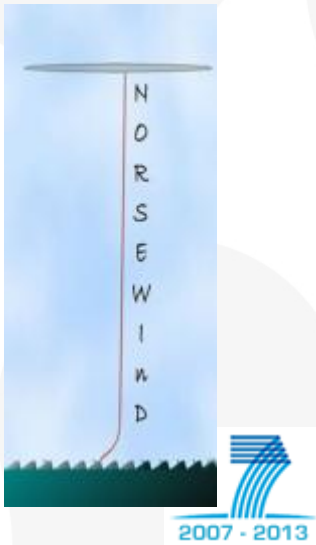
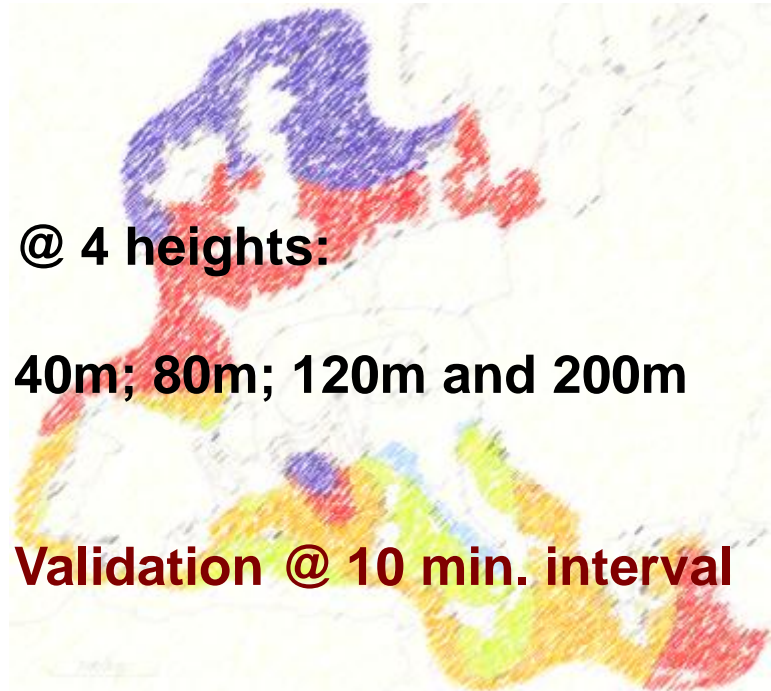


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# Case study

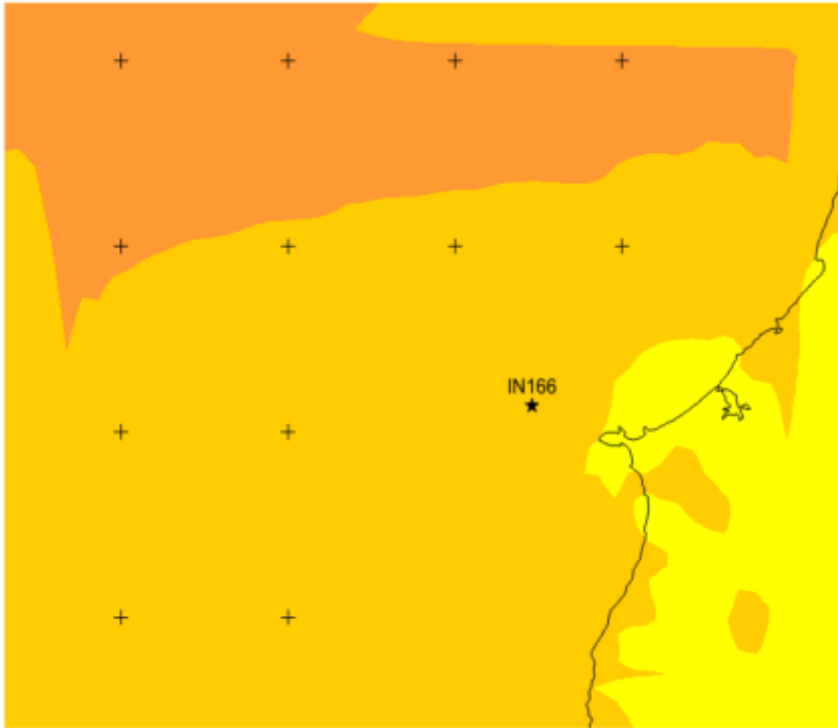
## Validation data:

### ZephIR/LIDAR wind data:

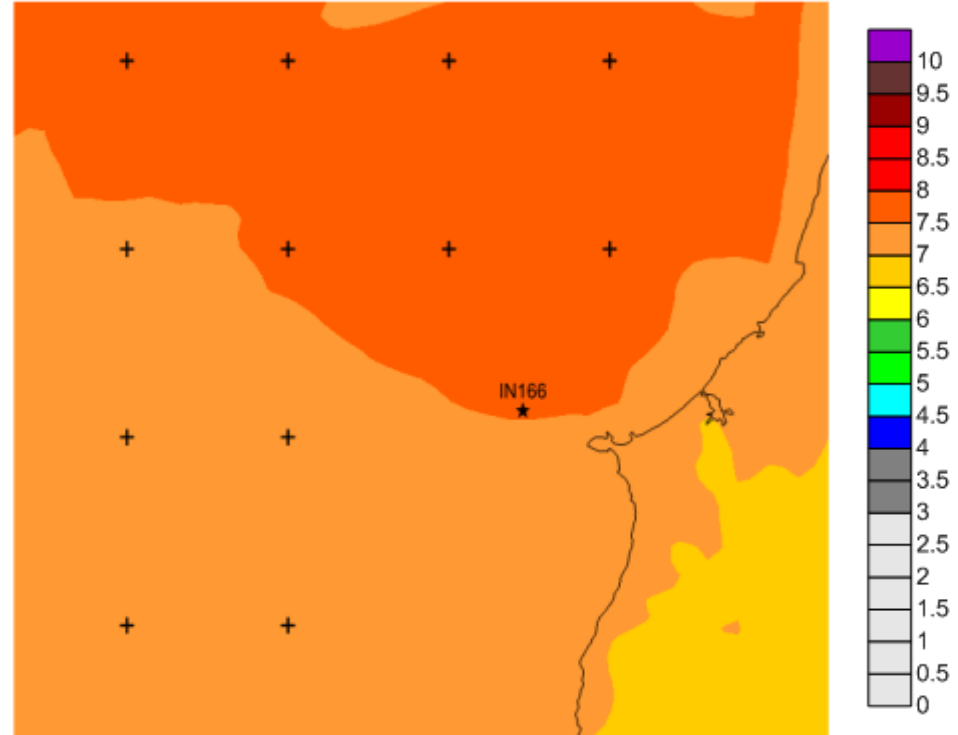


# Mean wind atlas

Preliminary results @ 80m height



with assimilation



no assimilation

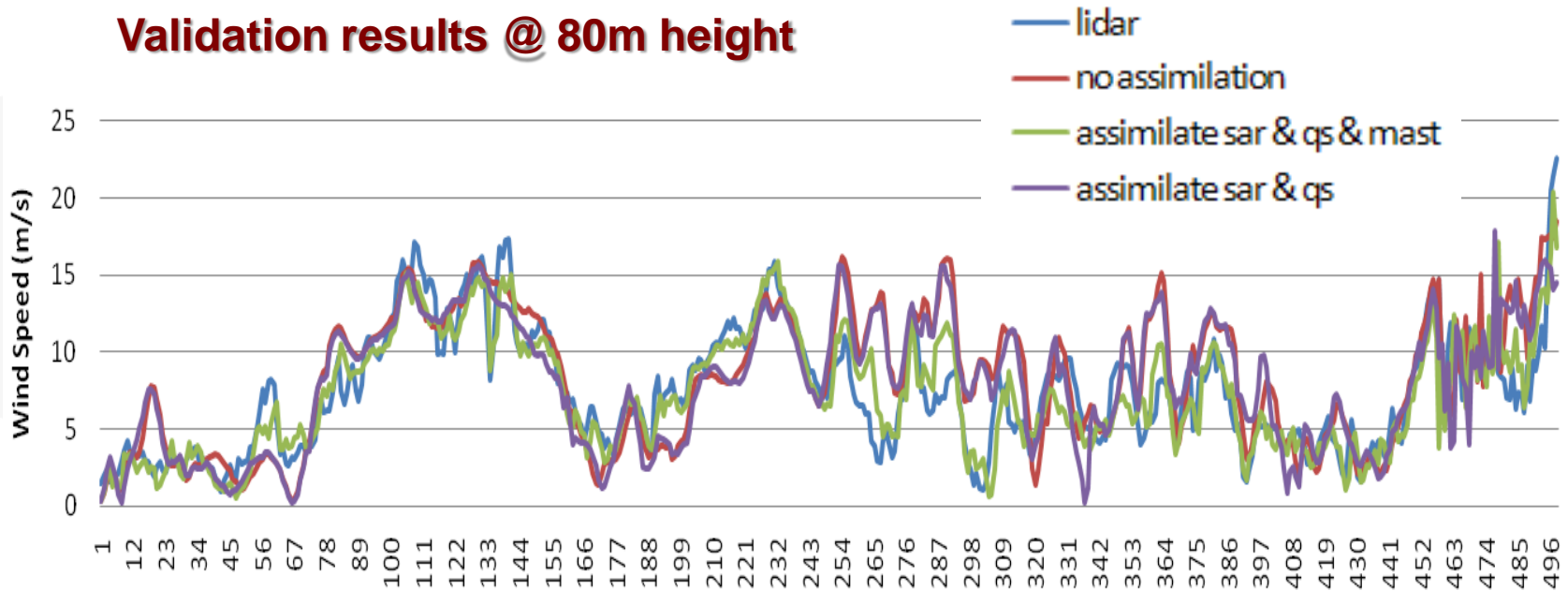


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# Mean wind atlas

## Validation results @ 80m height

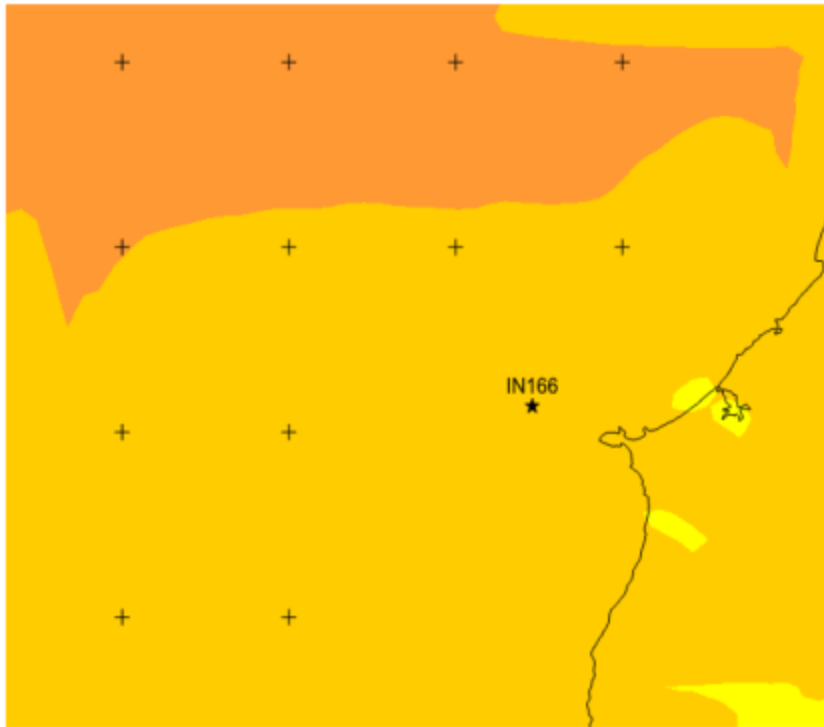


	Assimilate sar_qs	Assimilate Sar & qs & mast	No assimilation
Correlation (%)	73.88	90.08	71.15
RMSE speed (m/s)	3.09	1.71	3.10

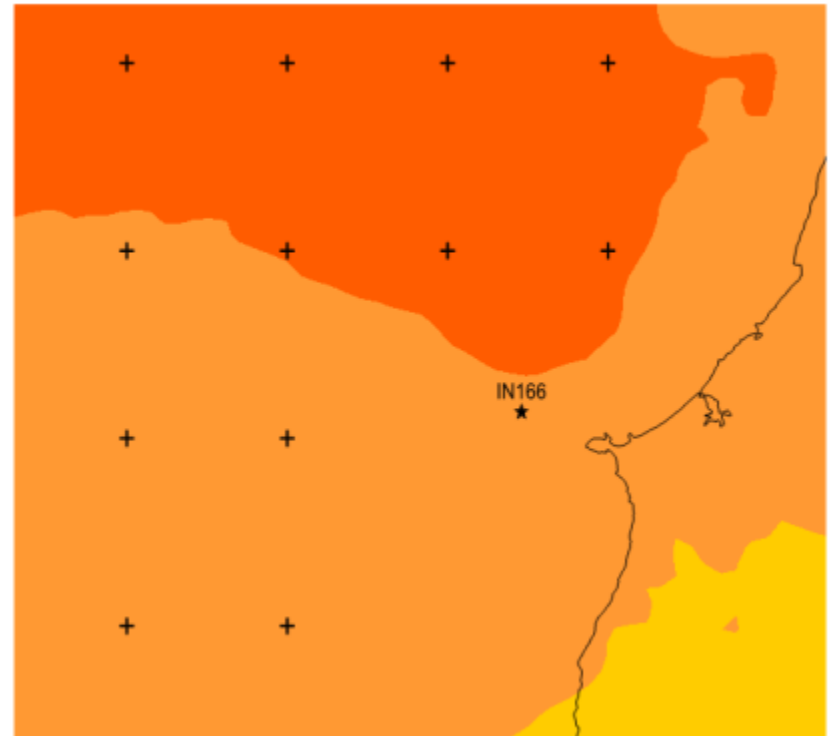


# Mean wind atlas

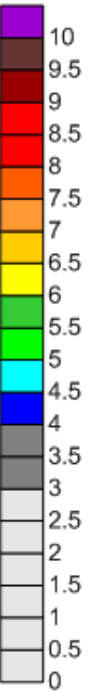
Preliminary results @ 200m height



with assimilation

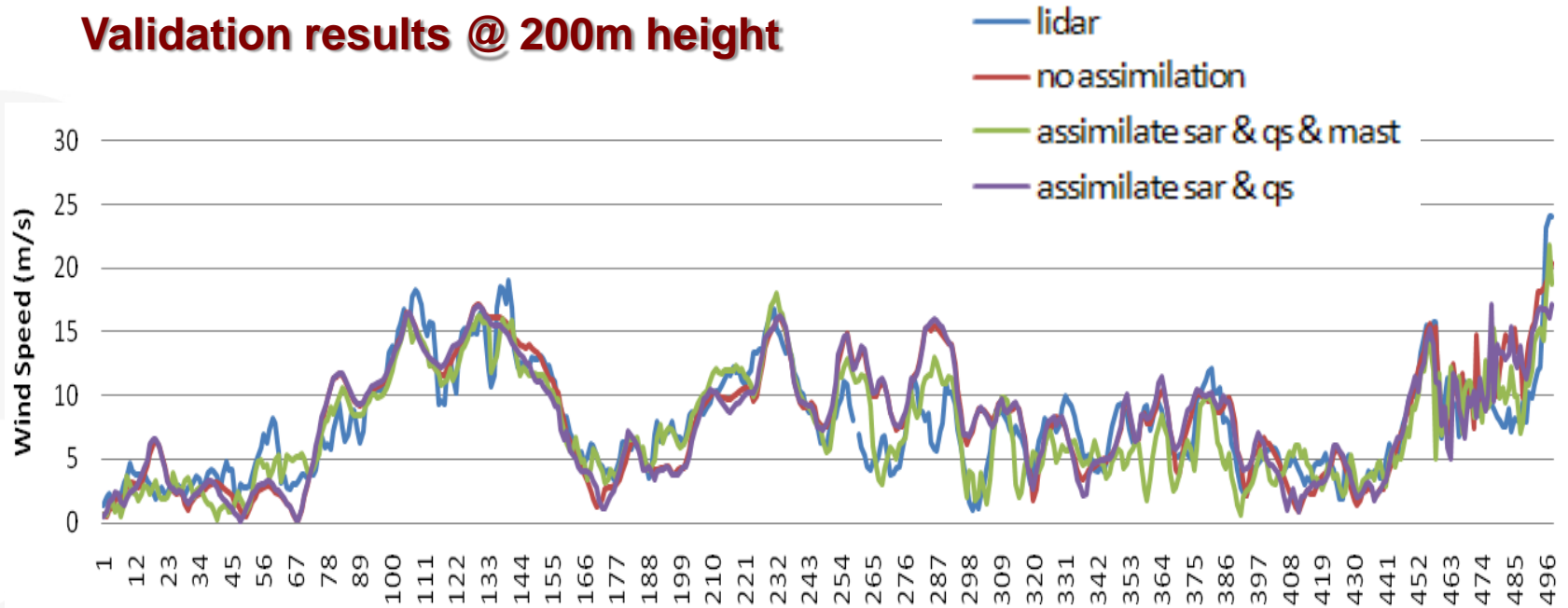


no assimilation



# Mean wind atlas

## Validation results @ 200m height

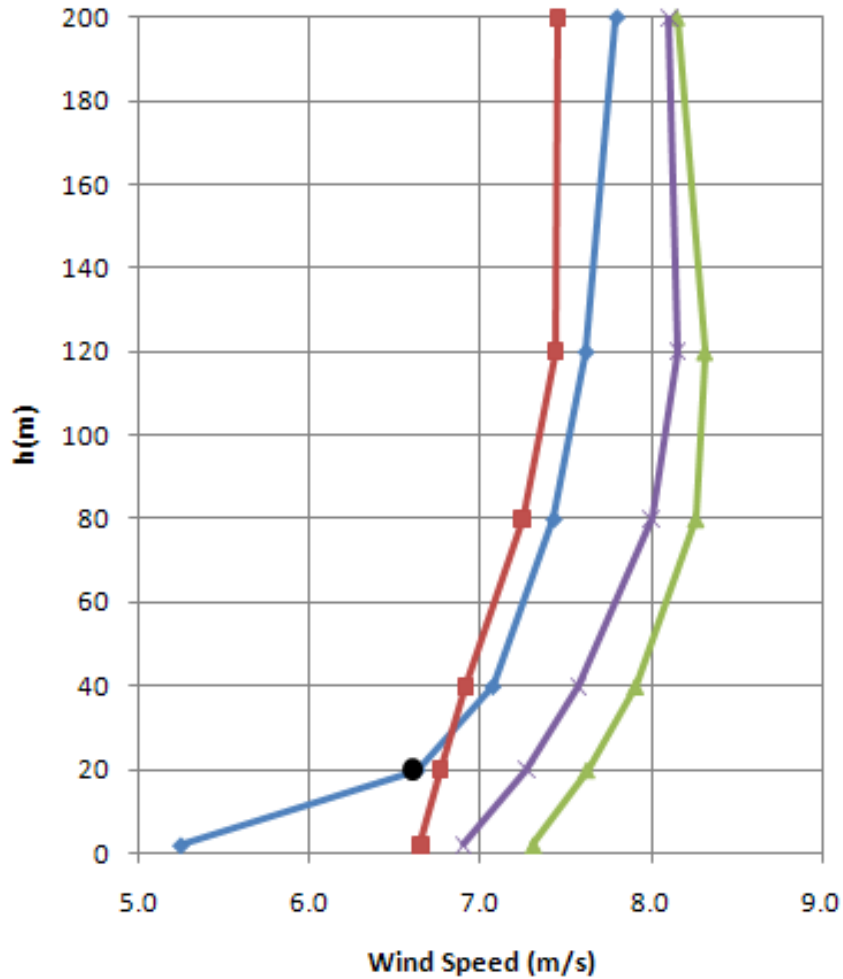


	Assimilate sar_qs	Assimilate Sar & qs & mast	No assimilation
Correlation (%)	82.43	87.61	79.83
RMSE speed (m/s)	2.70	2.16	2.82



# Mean wind atlas

## validation results



## Mean vertical wind speed profiler

- 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 - mesoscale simulations;**
- **Obtained results suggests how reliable could be the use of the newtonian assimilation technique for wind atlas development;**
- **This should be taken into account for the development of the 2nd European Wind Atlas - offshore & onshore cases.**



# Thank you very much!

**Paulo Costa**  
**paulo.costa@lneg.pt**

**Miguel Fernandes**  
**miguel.fernandes@lneg.pt**

**Ana Estanqueiro**  
**ana.estanqueiro@lneg.pt**



LNEG - Laboratório Nacional de Energia e Geologia, I.P.

[www.lneg.pt](http://www.lneg.pt)