Improving Gap Flow Simulations Near Coastal Areas of Continental Portugal

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Section Met Ocean Conditions

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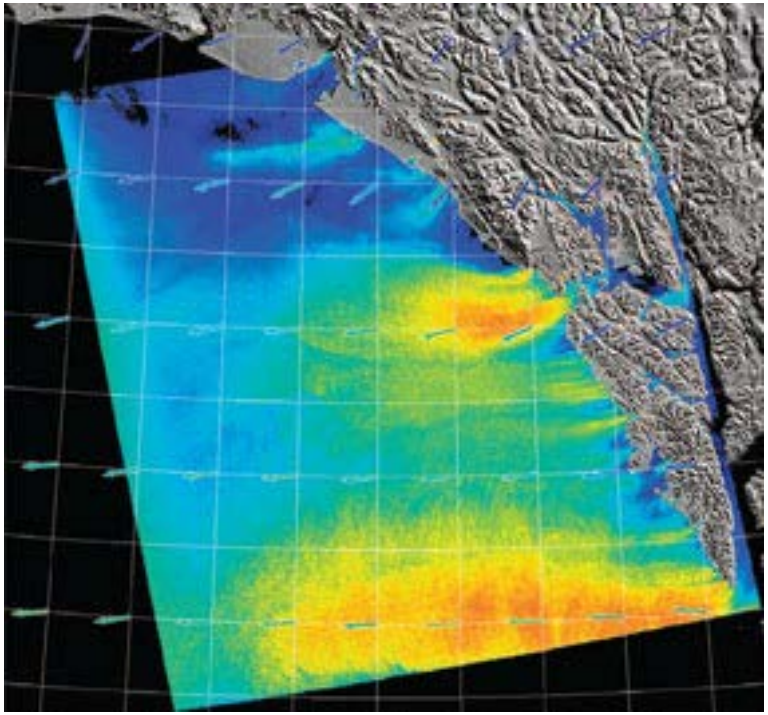
Gap Flows

- **Gap flows are locally generated wind currents that spread abruptly to the ocean, triggered by non-linear atmospheric phenomena.**

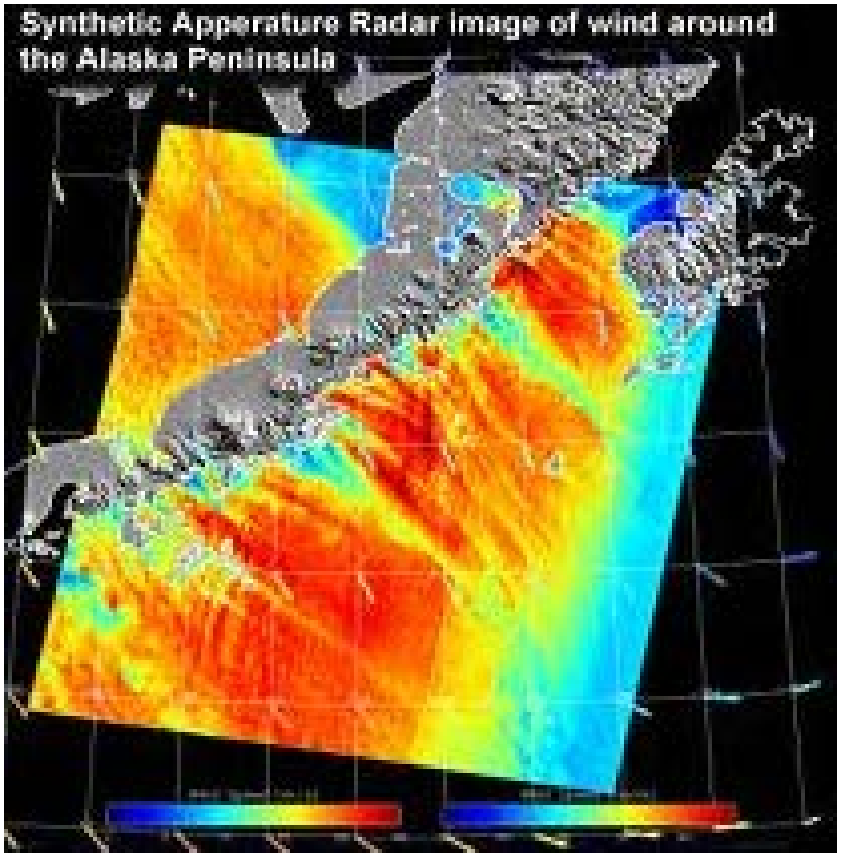
- **Its intensity and spreading may bring several impacts near coastal areas in particularly where offshore wind parks can be deployed.**



Gap Flows

- **Modelling this phenomena is still a challenge from the meteorological point of view since models still not reproduce efficiently way gap flows, especially, the ones occurring very near the coasts.**

- **A high resolution satellite SAR image is nowadays the "*best observational spatial wind tool*" to detect the phenomena in action**



Gap Flows in Portugal

- **At 9th December 2010 strong gap flows were identified along some western coastal regions of Continental Portugal**

- **This region contains several promising sea areas with high sustainable wind resource for offshore wind park's deployment**

Gap Flows in Portugal

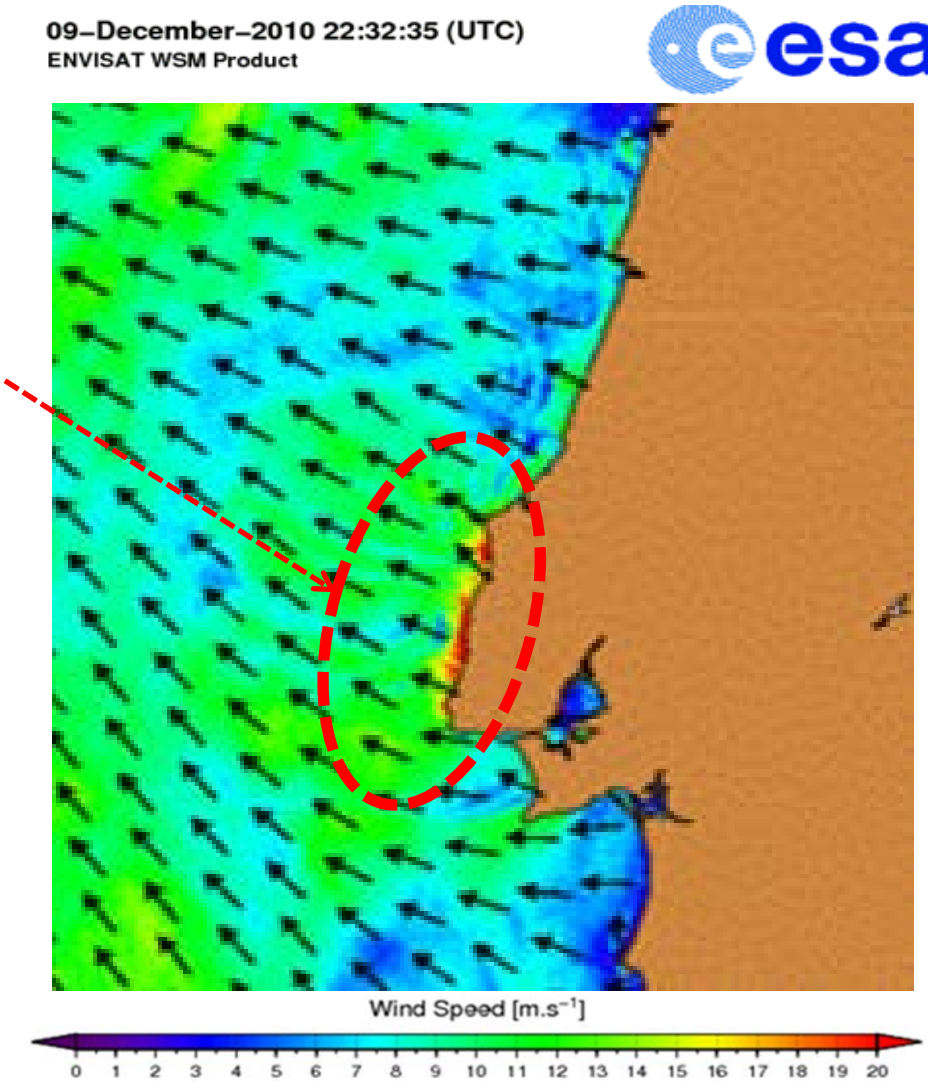
The phenomena in action…

This "zoomed" SAR image on day, 9th December 2010 @ ~ 22:30h shows the gap flows (surface).

*"**red zones**" wind speeds ~ 20 to 30m/s*

*"**green zones**" – vicinity ~ 10 to 13 m/s*

*"**blue zones**" -around ~ 3 to 6 m/s*



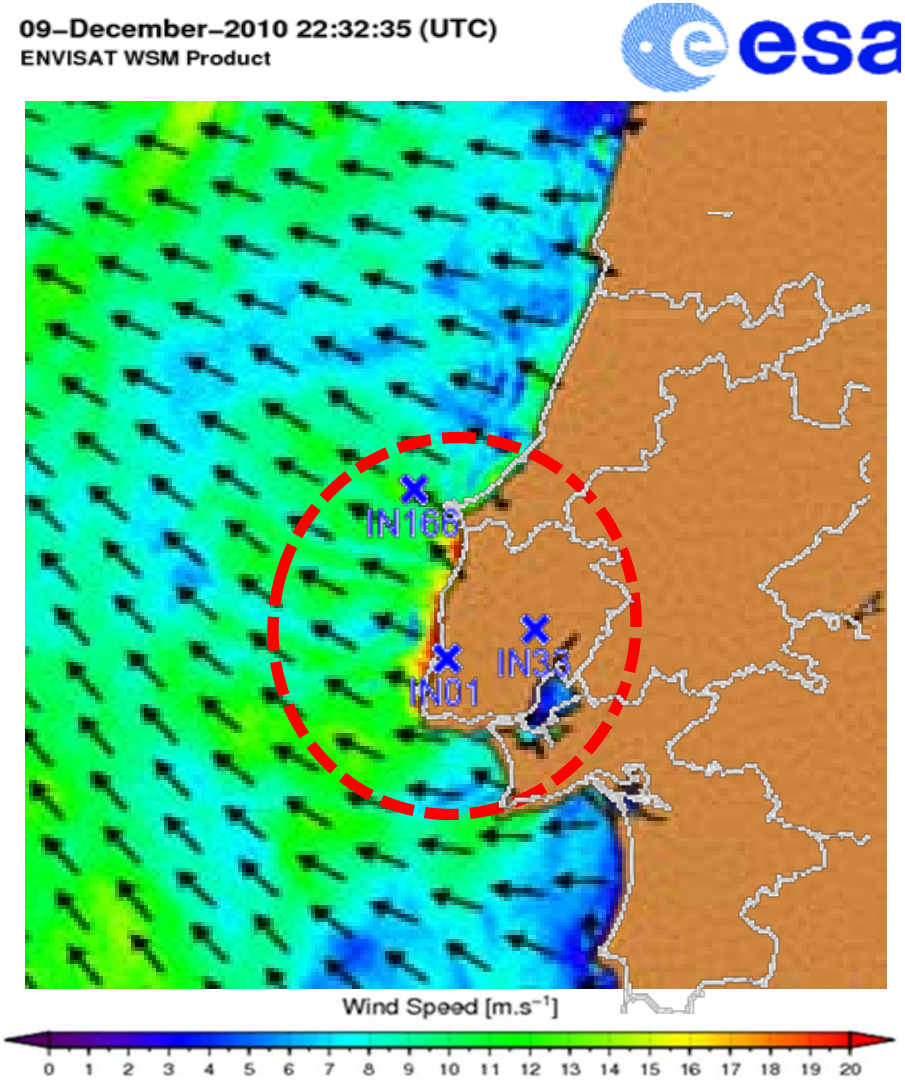
Gap Flows in Portugal

LNEG operates three anemometric masts in the region. At that day & time, observed mean wind speed and direction was:

IN01 (sensor height 10m):
~ 9.86 m/s ; ~ 90º

IN33 (sensor height 10m):
~ 8.76 m/s ; 65º

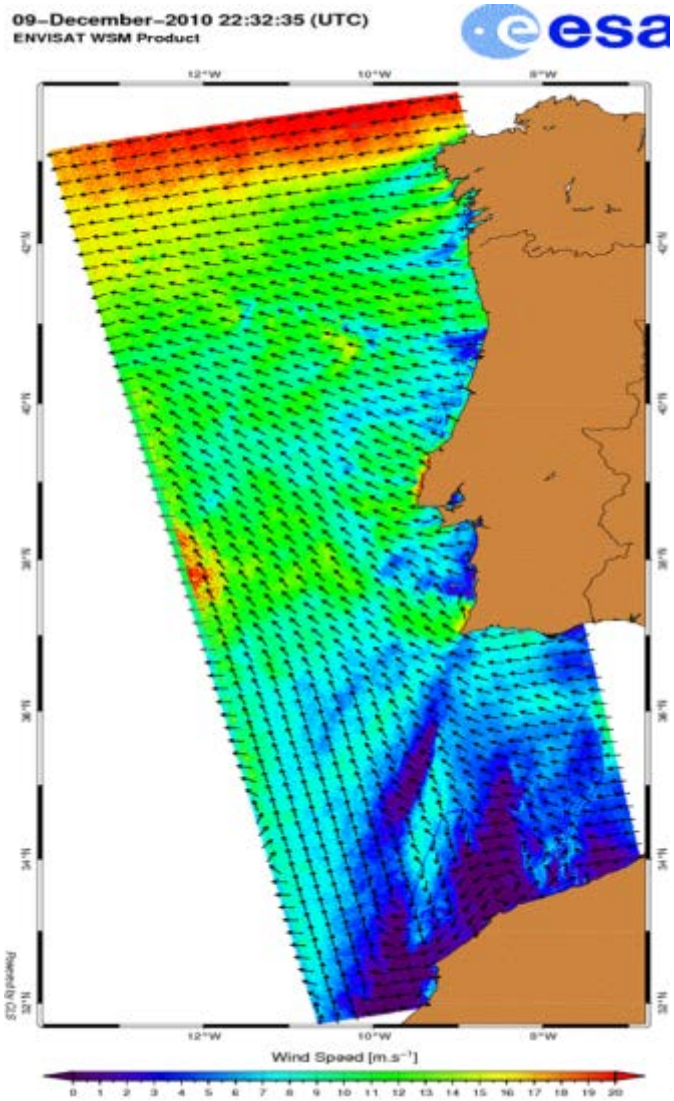
IN166 (sensor height 21m):
~ ? m/s ; ?º
(data with -9999 error code)



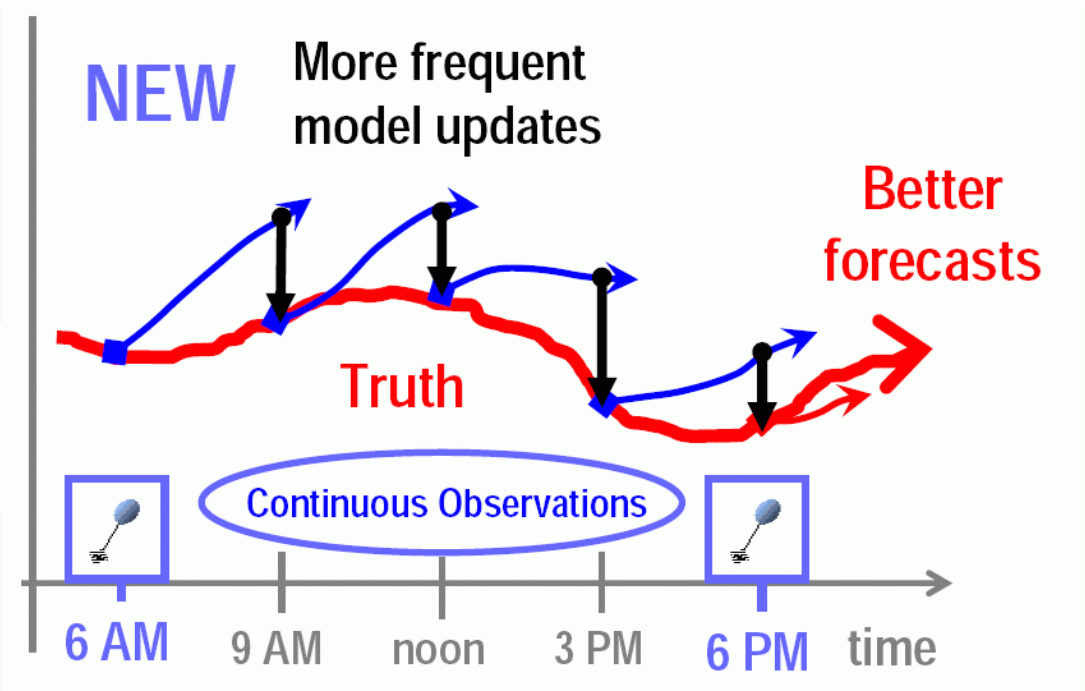
Gap Flow Simulation

Simulation tasks:

- **To set up a high resolution mesoscale simulation with the WRF model for the case study day (09.12.2010);**
- **To use the 3D-VAR data assimilation technique;**
- **To compare model's results with and without data assimilation and to validate the simulated wind flow with LNEG's anemometric masts**



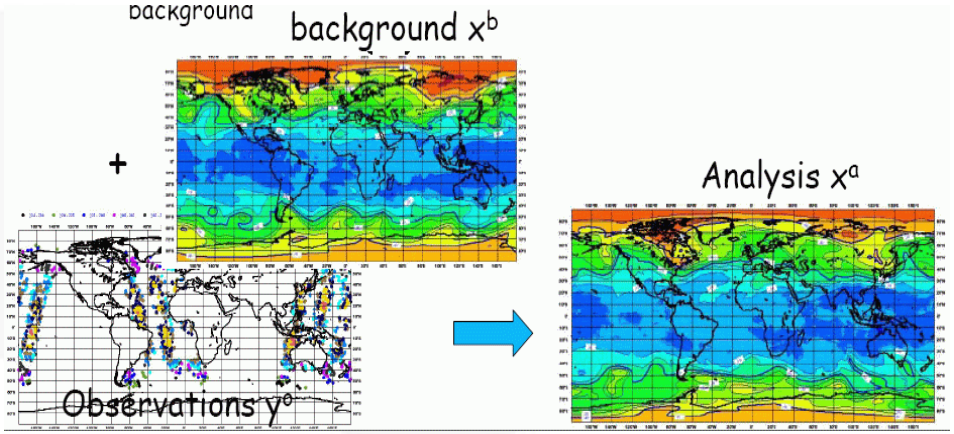
Assimilation advantages



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

3D-VAR assimilation

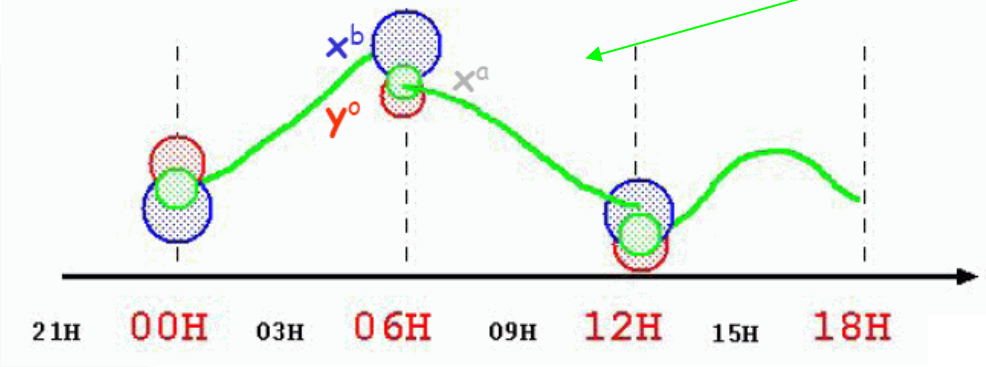
A “BLUE” method ...



“Best Linear Unbiased Estimate”

≅ Kalman Filter

$$x^a = x^b + dx$$
$$= x^b + K\,(y^o - H\,(x^b))$$



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

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

Backgroud error covariance matrix

$$B \longrightarrow \overline{x'x'^T} \approx A\overline{(x^{t2} - x^{t1})(x^{t2} - x^{t1})^T}$$

Mean forecasts @12h - @00h

LNEG

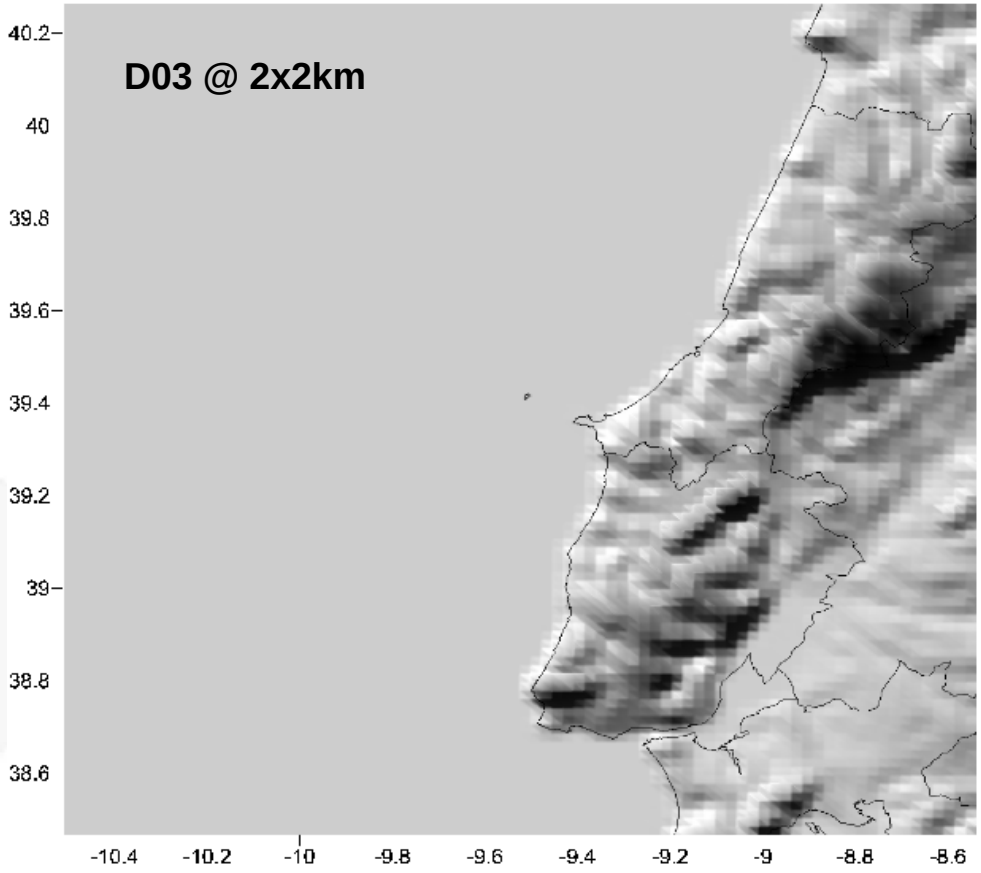
Gap Flow Simulation

Setup WRF model …

As a background “run”

- Three domains covering the area under study; 50x50km ; 10x10km and 2x2km;
- Historical initial and boundary conditions from GFS forecast model @ 0.5x0.5º, ingested every three hours;
- Running period:

  1 day - 1200h 09-12-2010 to 1200h 10-12-2010

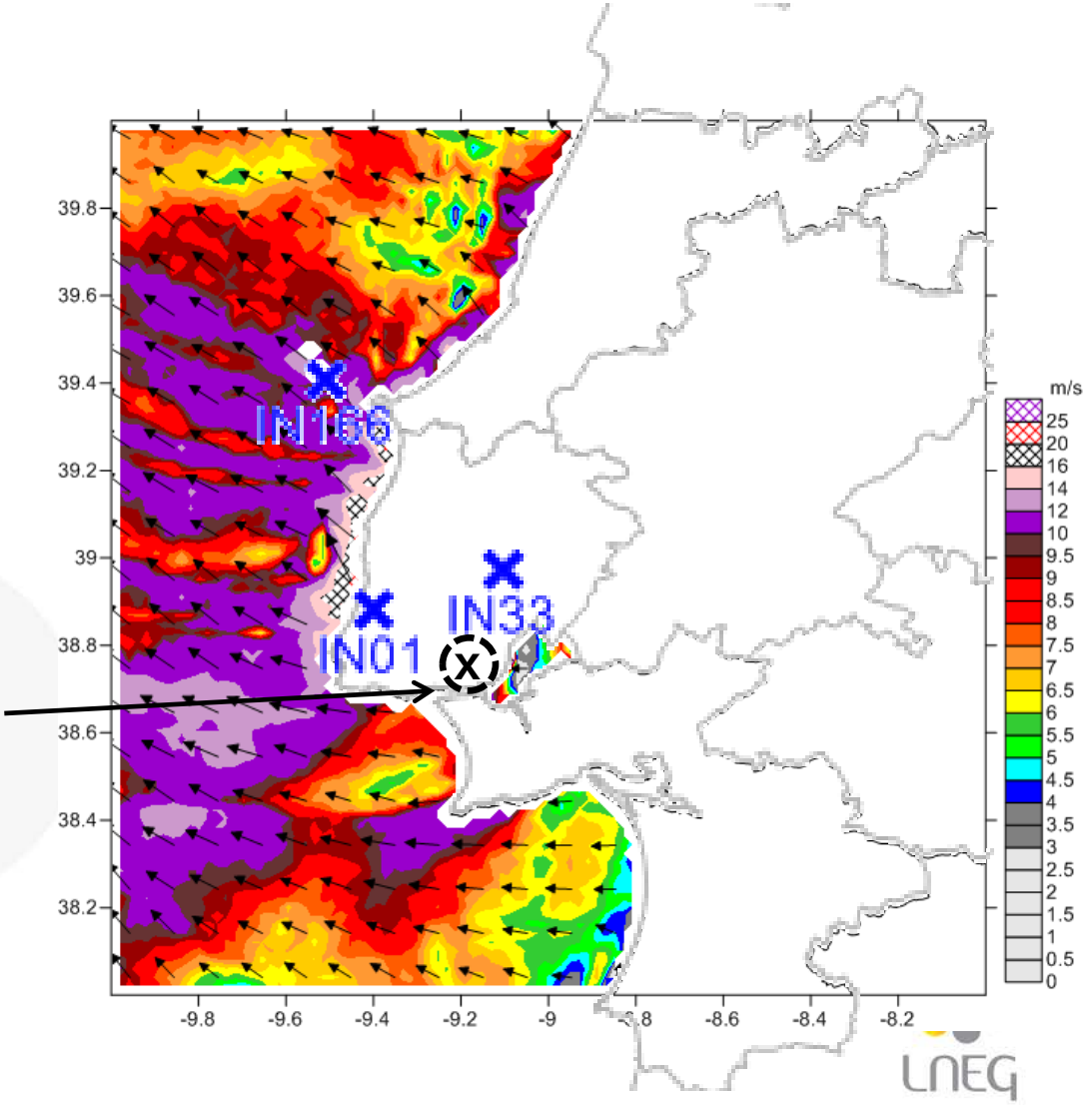


Gap Flow Simulation

Setup WRF model …

Assimilation “run” - 3D-VAR

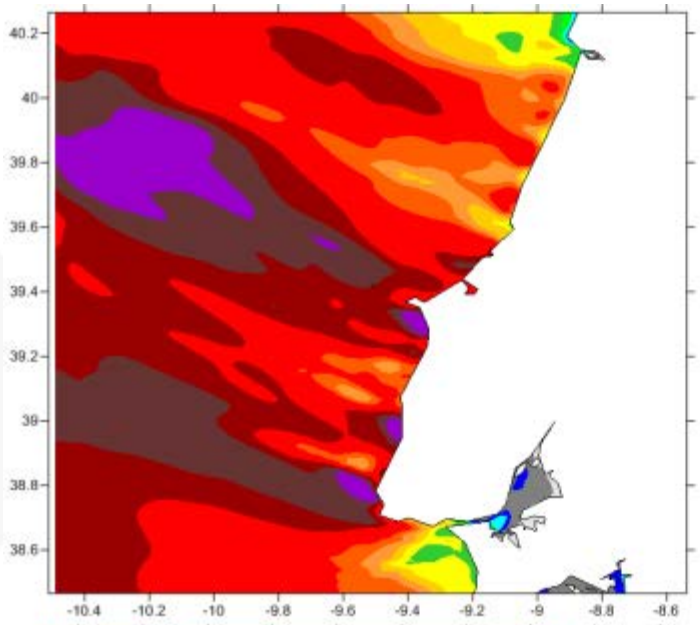
- Assimilated “SAR” wind data image at **21h** (09-12-2010) @ all model domains;
- Assimilated surface synoptic data at **12h, 18h and 21h** from LPPT Lisbon station ***(T,Hr,P,U,V)***
- Assimilated IN01 & IN33 at **12h, 18h** and **21h**;
- Validation: IN01 & IN33 *(daily period)*

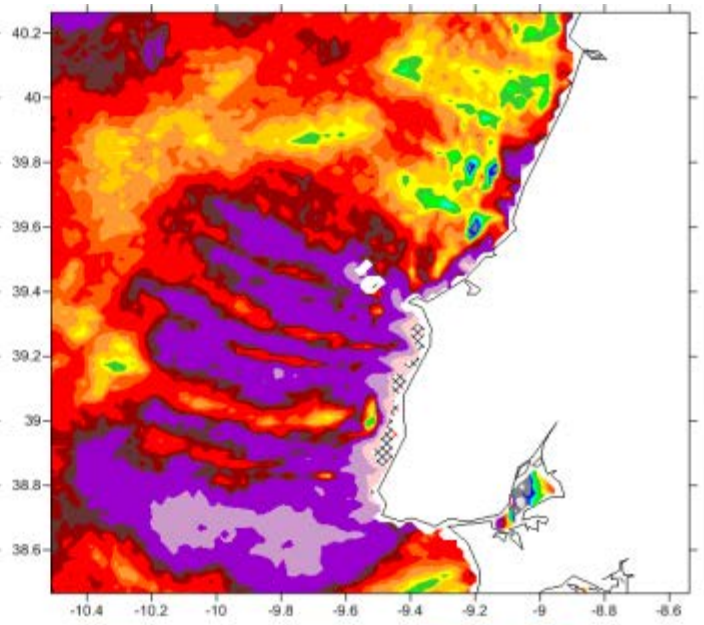


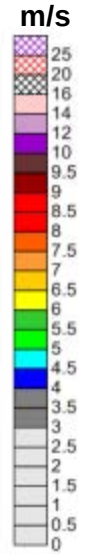
WRF forecasted results (2x2km) – (surface) @ **2200h** 09-12-2010

Control run

No assimilation.







SAR data

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Assimilation run

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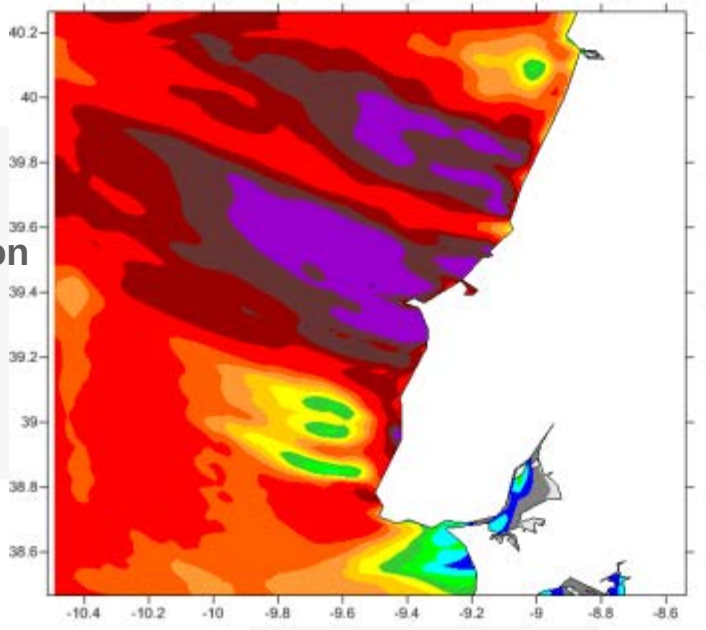

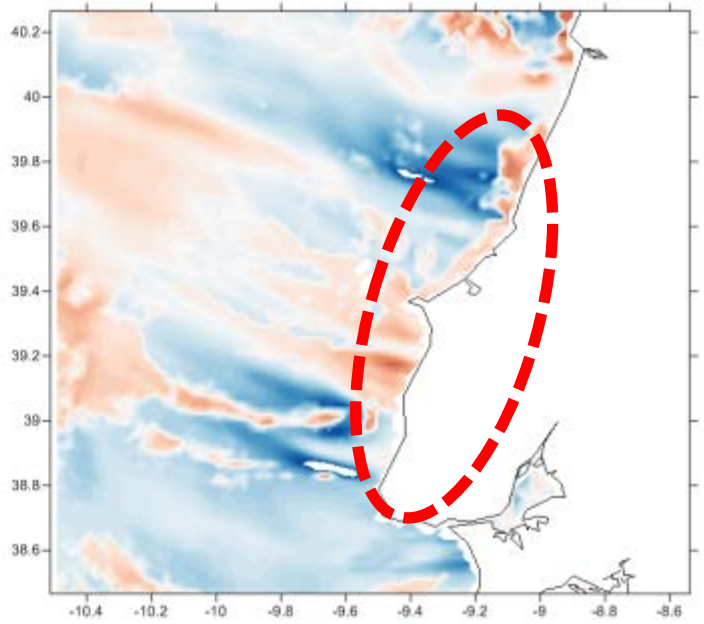

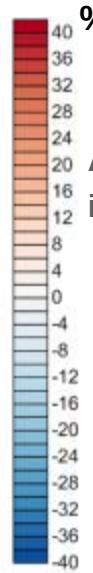

Assimilation improvement

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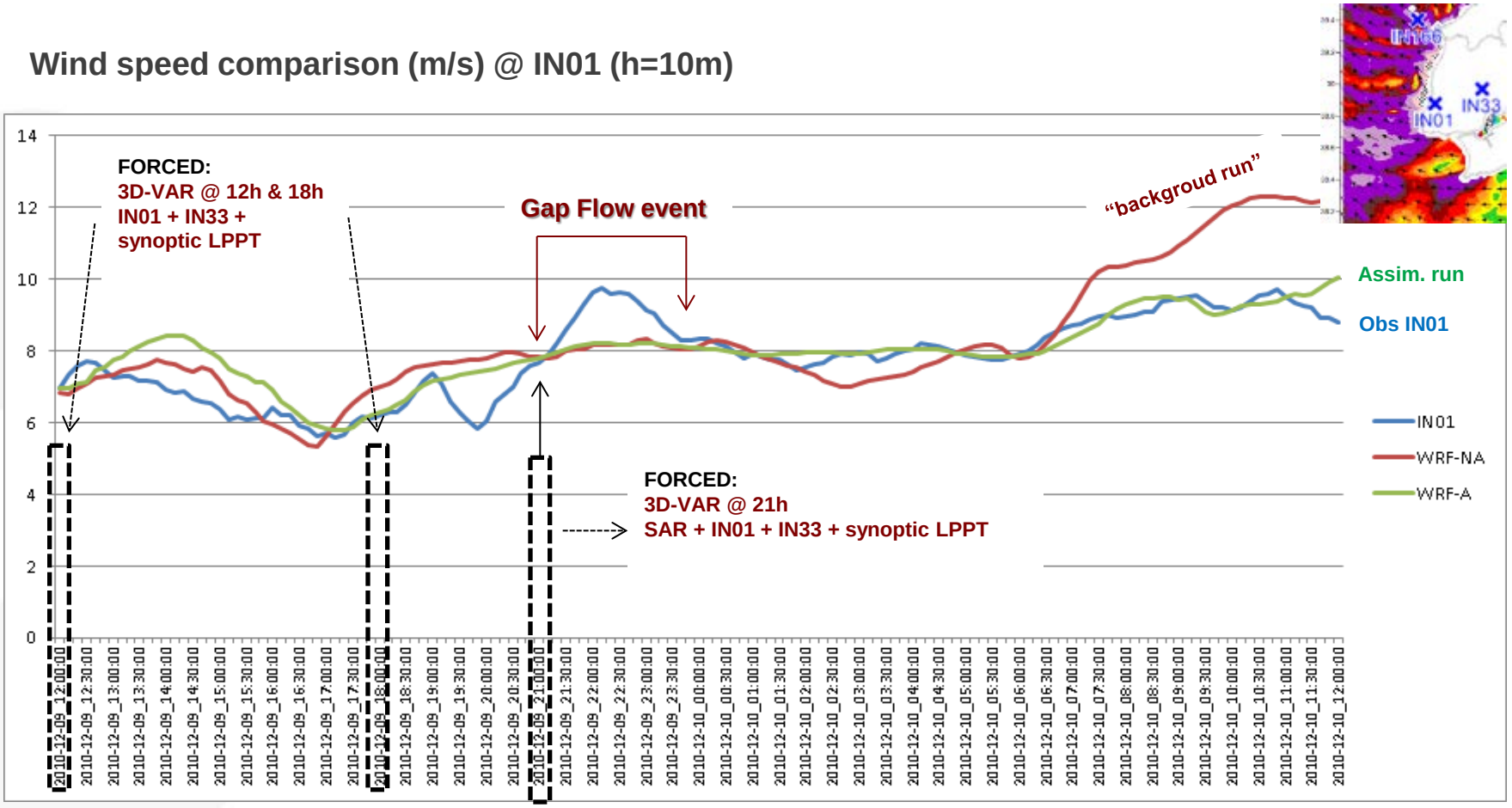
LNEG

WRF forecasted results (2x2km) – (surface)

from 1200h 09-12-2010 to 1200h 10-12-2010

Wind speed comparison (m/s) @ IN01 (h=10m)



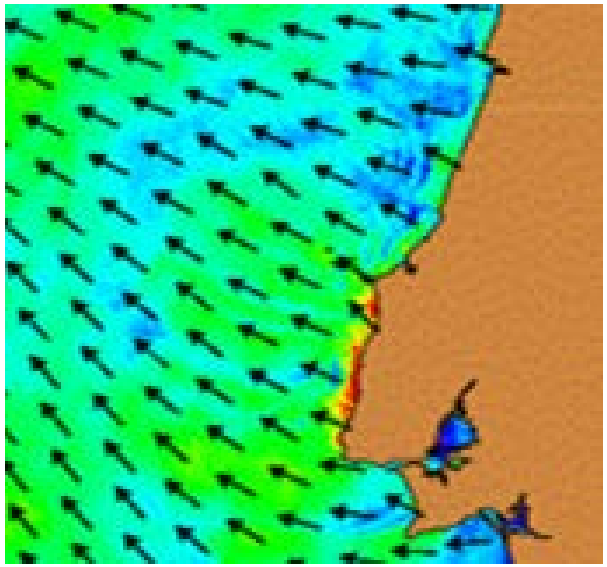
Correl –NA (%)	Correl – A (%)
77.22	83.19

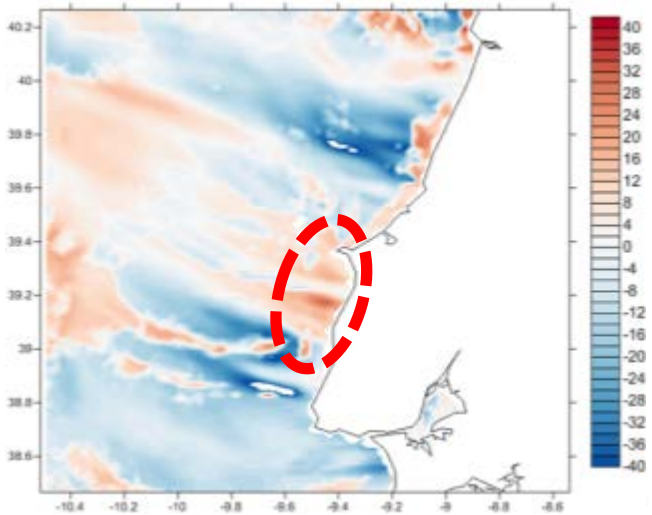
wind speed (m/s) @ **22h**		
WRF-NA	WRF-A	Obs
8.18	8.21	9.60

Mean wind speed (m/s)		
WRF-NA	WRF-A	Obs
8.29	7.98	7.83

Results

- **Observational assimilated data slightly improved WRF forecasted estimates in IN01 place - very near to the coast.**
- **SAR image helped in the description of the phenomena - with positive (30%) and negative (-35%) impacts when compared with “background run”. The origins of the phenomena are being studied and further simulations are being conducted in order to improve its performance.**
- **Other similar coastal phenomena cases will be investigated and, if possible, on other countries’ offshore wind deployment areas.**





This work was partially sponsored by the European Union FP7 under project DEMOWFLOAT

DEMOWFLOAT
Demonstration of the WindFloat Technology

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

CLS
COLLECTE LOCALISATION SATELLITES

Thank you!

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EERA
European Energy Research Alliance

EERA DeepWind 2014
11th Deep Sea Offshore Wind R&D Conference

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