



Twenties
Transmitting wind

European project, demo “NETFLEX”
For large integration of renewables using DLR,
PST and PMU.

Ampacimon
Overhead Line Monitoring

8 February 2012

Université
de Liège



EUROPEAN COMMISSION

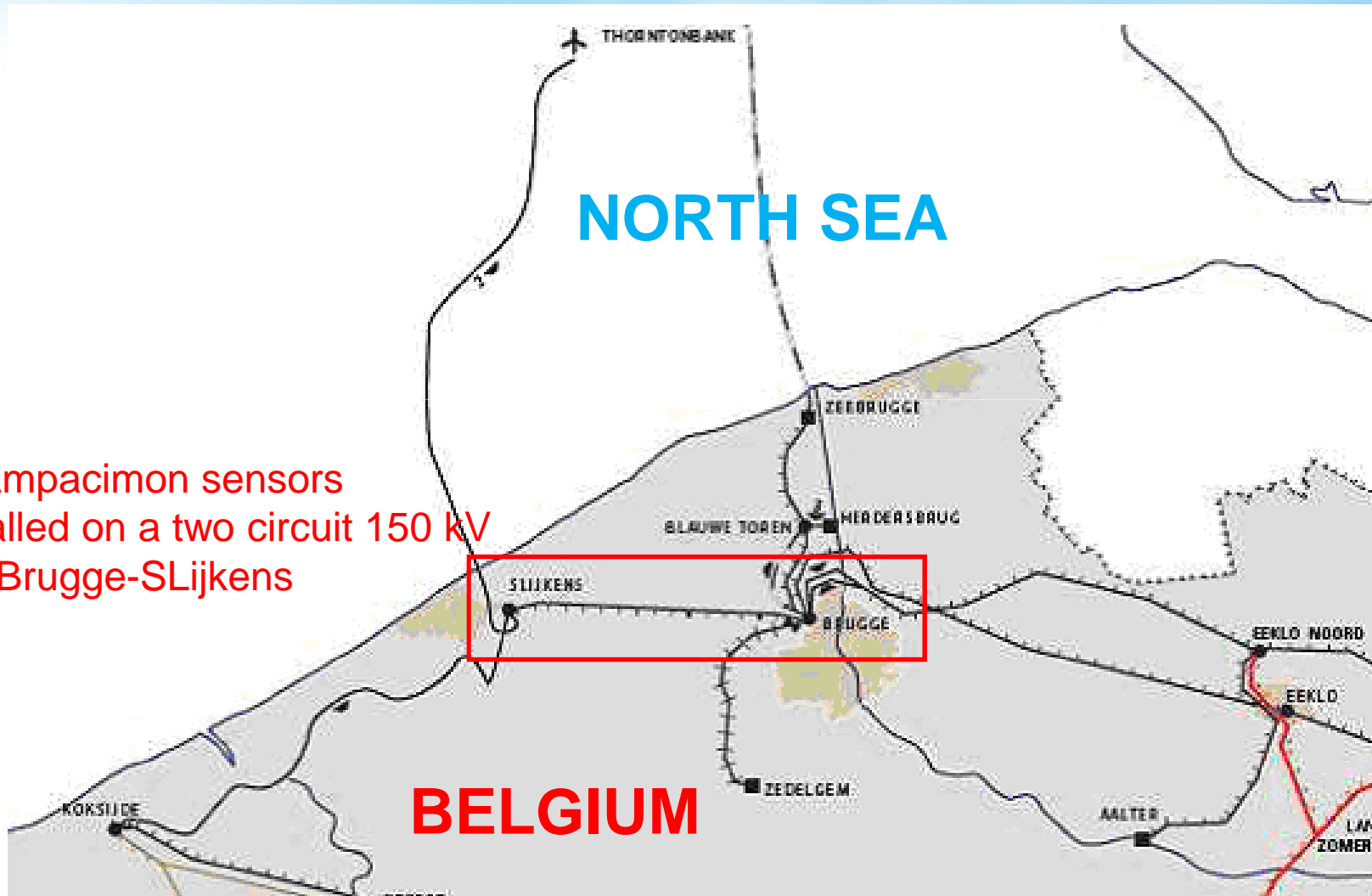
TWENTIES = Transmission system operation With large penetration of Wind and other Renewables Electricity Sources in Networks by means of Innovative tools and integrated energy solutions.

- **2010 to 2013 , budget : 57 M€**
- **26 partners (many TSO's , large actors, some universities)**
- **2020 european electrical energy goal =
20% renewables, 20% energy savings, 20% less CO2**
- **2 demos with DLR and wind farms (one in Spain, one in
CWE)**

NETFLEX Demo location

DLR Location selection in Belgium(ELIA/ULg)

10 Ampacimon sensors
installed on a two circuit 150 kV
line Brugge-Slijkens



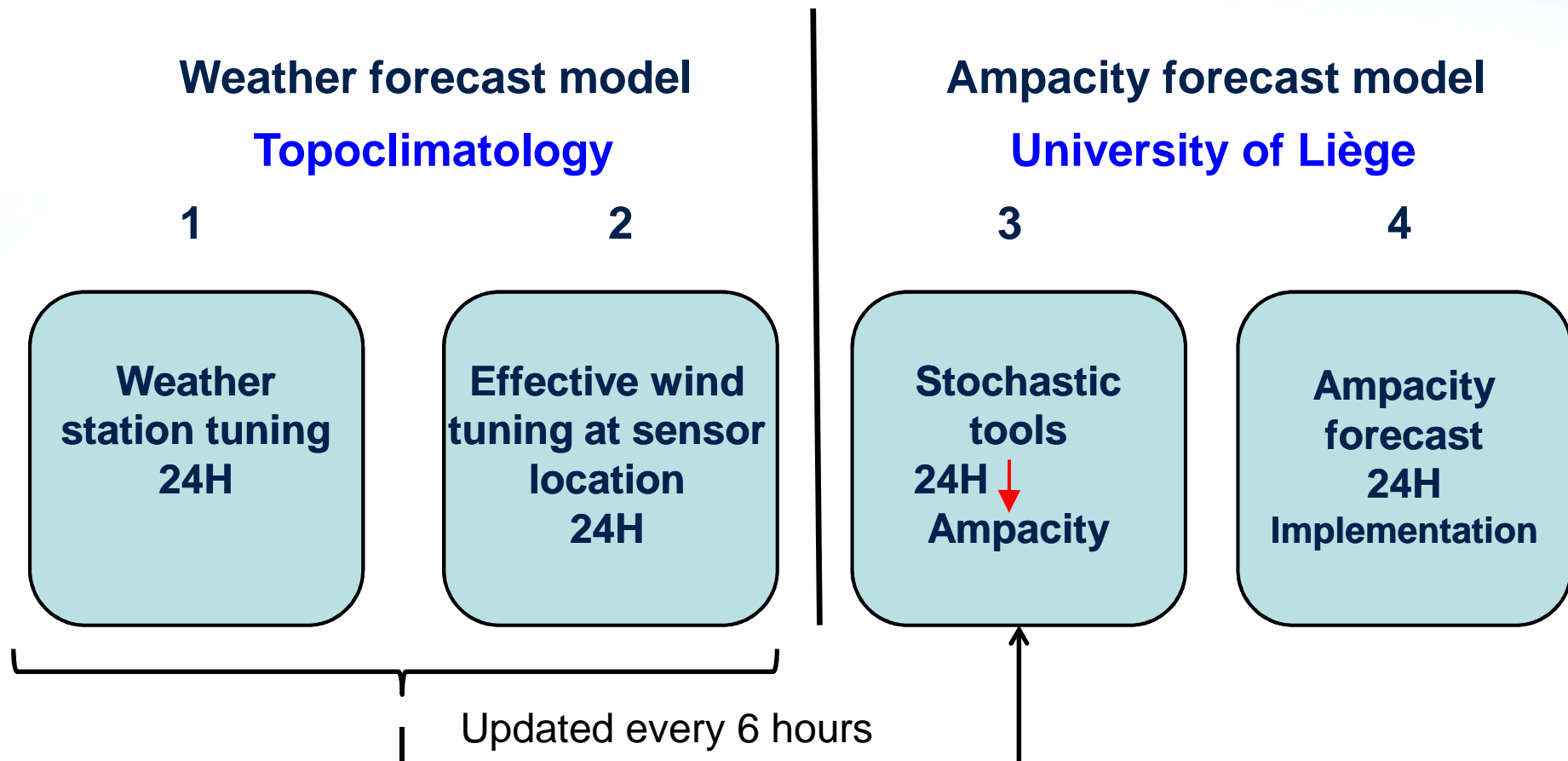
DLR sensor installation



Installation of 10 DLR Ampacimon sensors on 150 kV line in Belgium (to cover two circuits of about 30 km each)

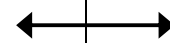
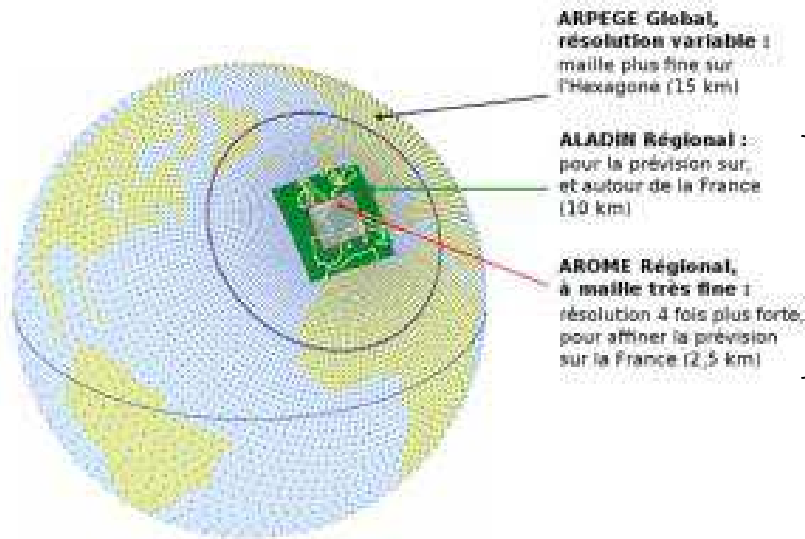
Netflix demo with DLR sensors.

Step 1 : ampacity forecast based on meteo forecast only (one day ahead)



1.1 Météo Forecast : how it works worldwide

Météo numerical forecast processing



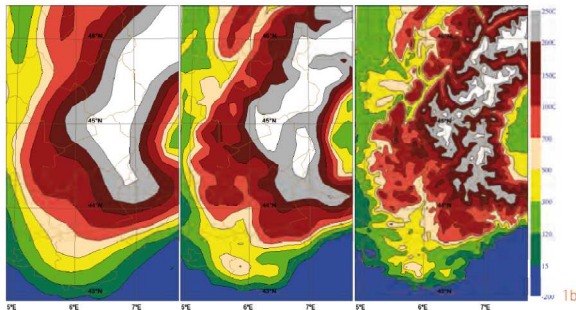
GFS

(mesh of 50km/every 3h)

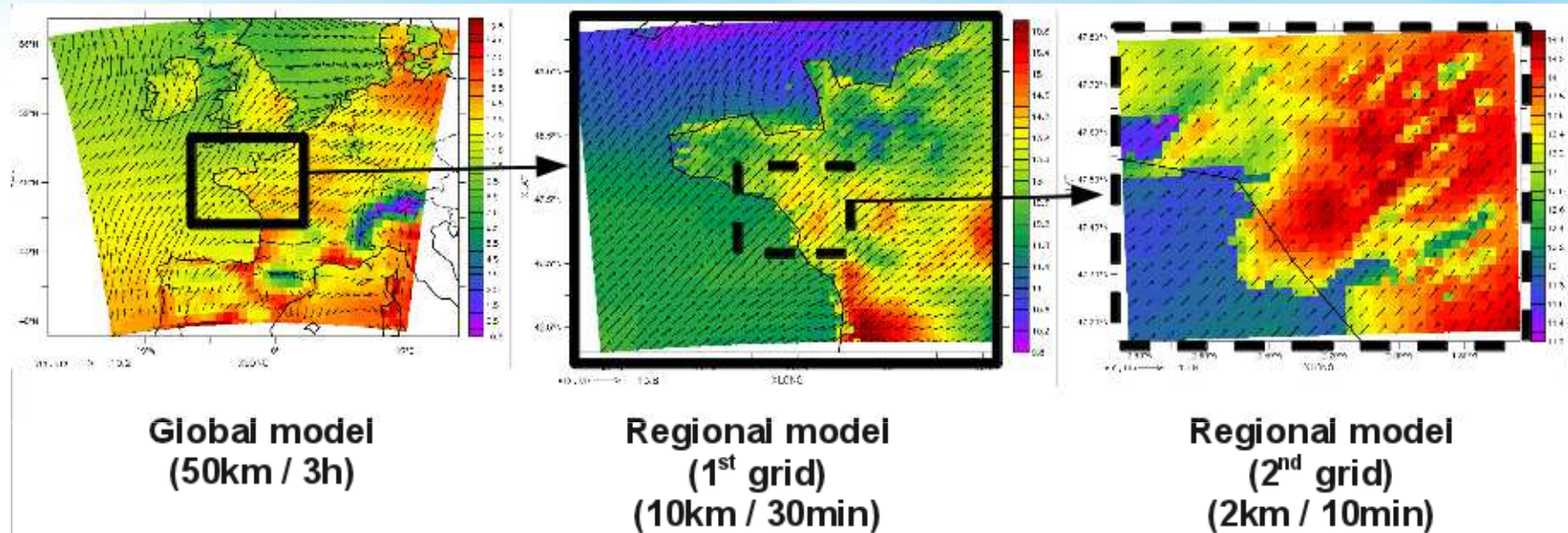


WRF

(10km/30min)
(2km/10min)

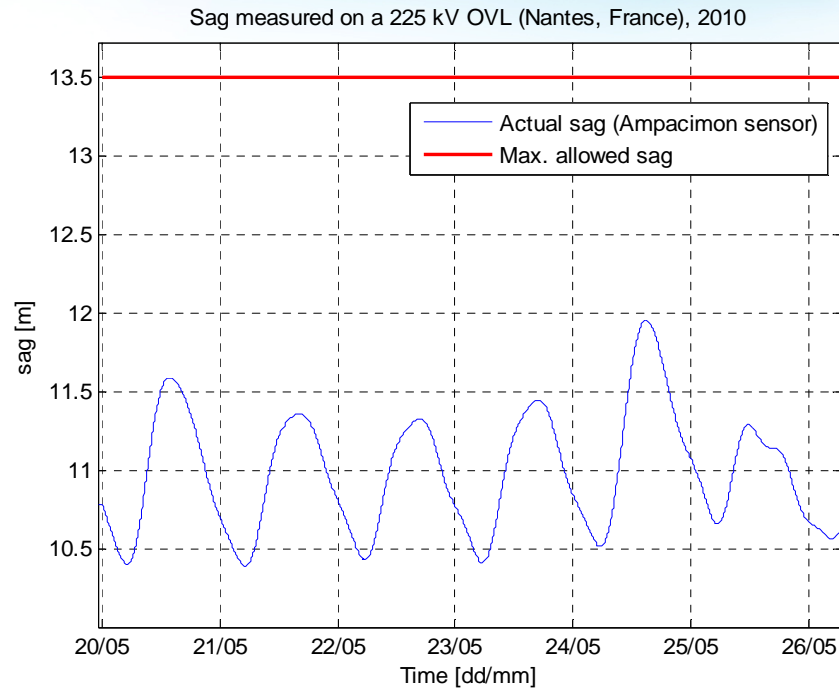


1.2 One-Day ahead meteo forecast : downsizing

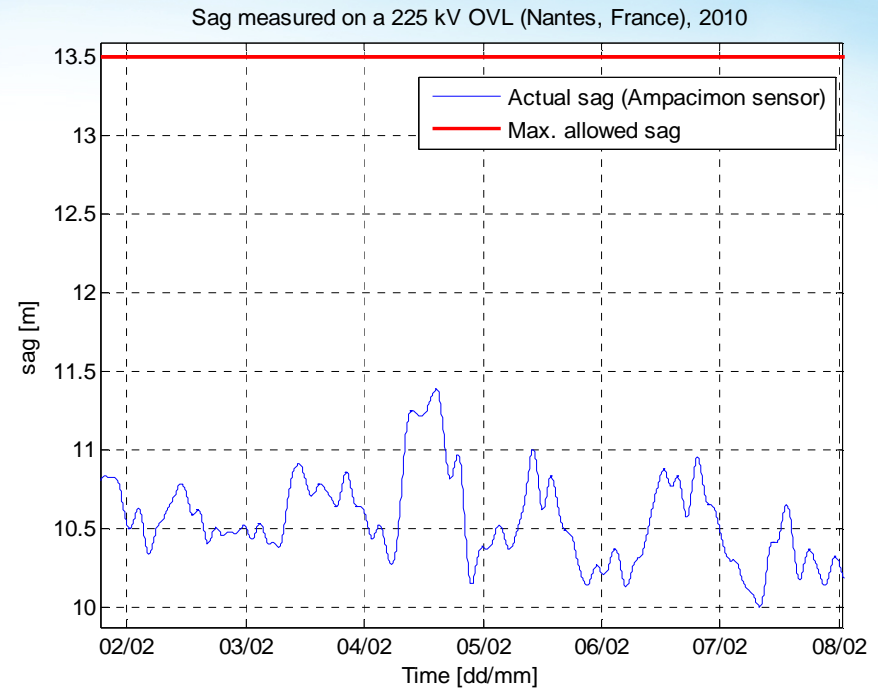


- **Analyses were carried out on a 220kV line in Nantes**
 - One year of data (2009-2010) at our disposal
 - On regional model, appropriate tuning is required for low wind speed forecast (very much related to local data)

Example. Basic real time data used for validation. Sag changes in real time as direct sensor output



Summer period (one week) :
sag output from Ampacimon
sensor. (max sag 13.5 m)

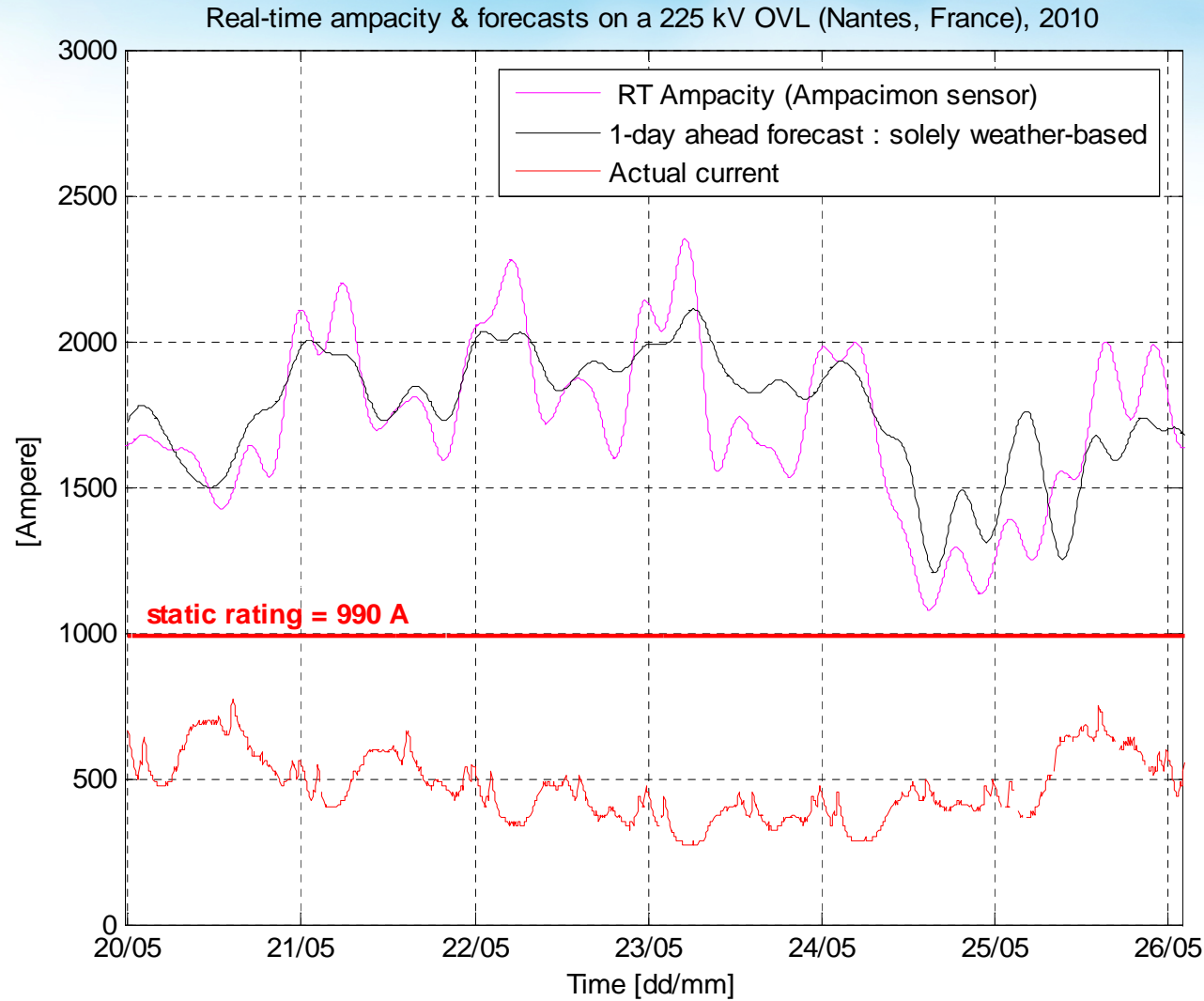


Winter period (one week) :
sag output from Ampacimon
sensor. (max sag 13.5 m)

From sag to effective weather conditions then to ampacity

Example of outputs.

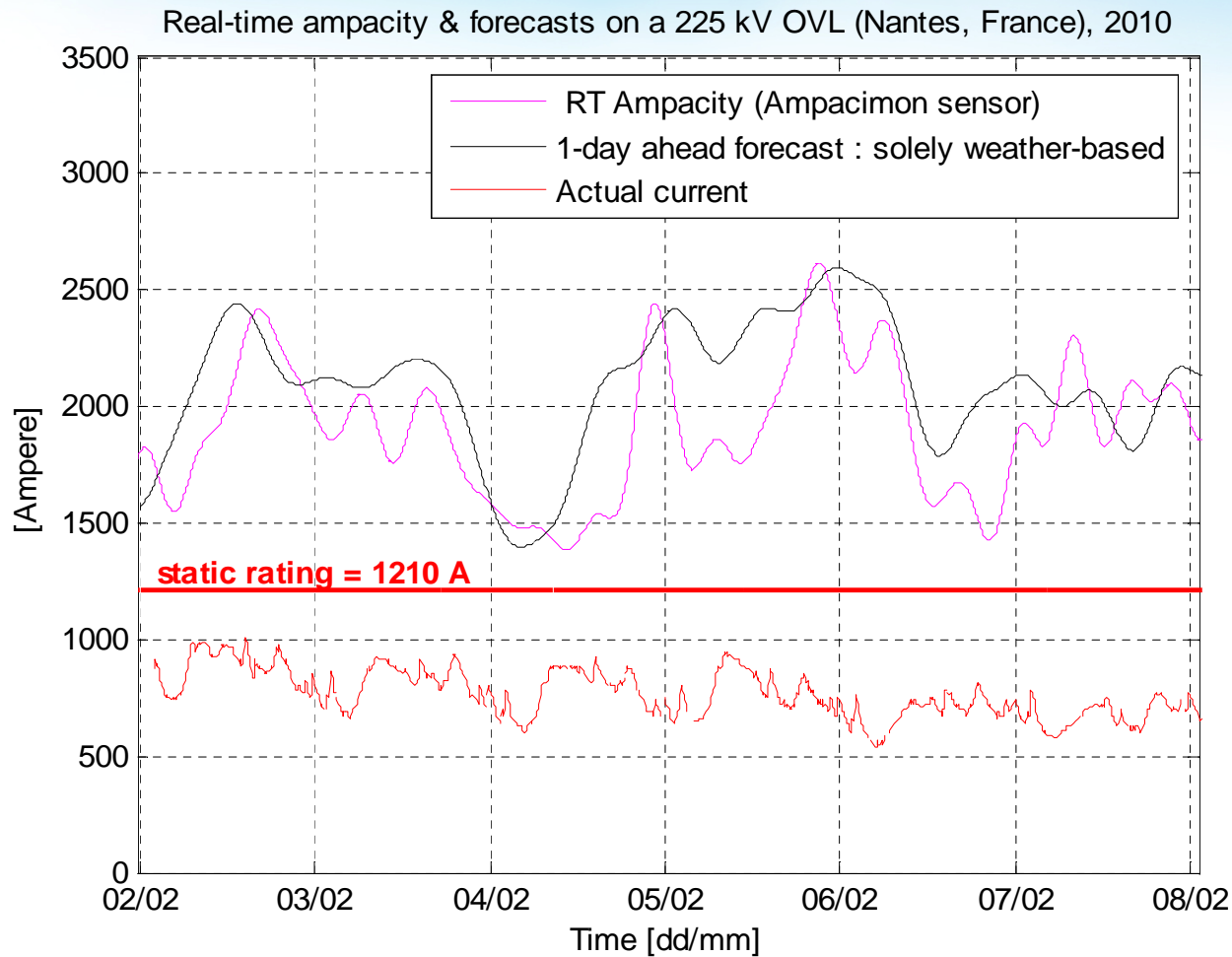
One-Day ahead forecast based on meteo only (step 1)



Summer period
(one week) part 1

Example of outputs.

One-Day ahead forecast based on meteo only



Winter period
(one week) part 1

Step 2. One-Day ahead ampacity forecast updating using data mining

- 1. Statistical and temporal analyses
- 2. Learning machine algorithms
- 3. Multi-Linear regressions

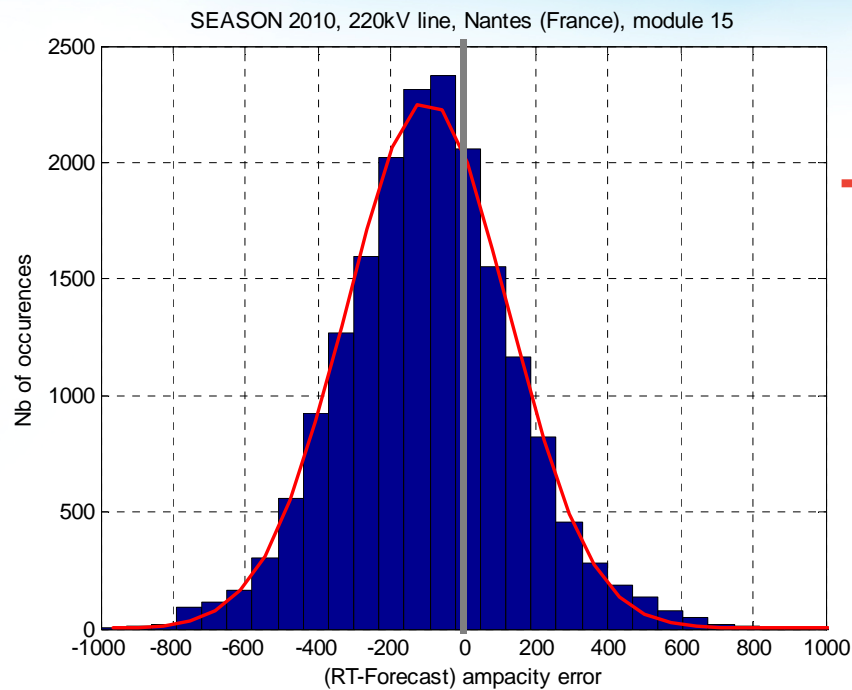
$$\text{Ampa}_i = \alpha_0 + \alpha_1(v)_i + \alpha_2(\text{dirv})_i + \alpha_3(\text{ambT})_i + \alpha_4(\text{AmpaFO})_i + \dots$$

$$i = 1, \dots, n \quad \text{samples}$$

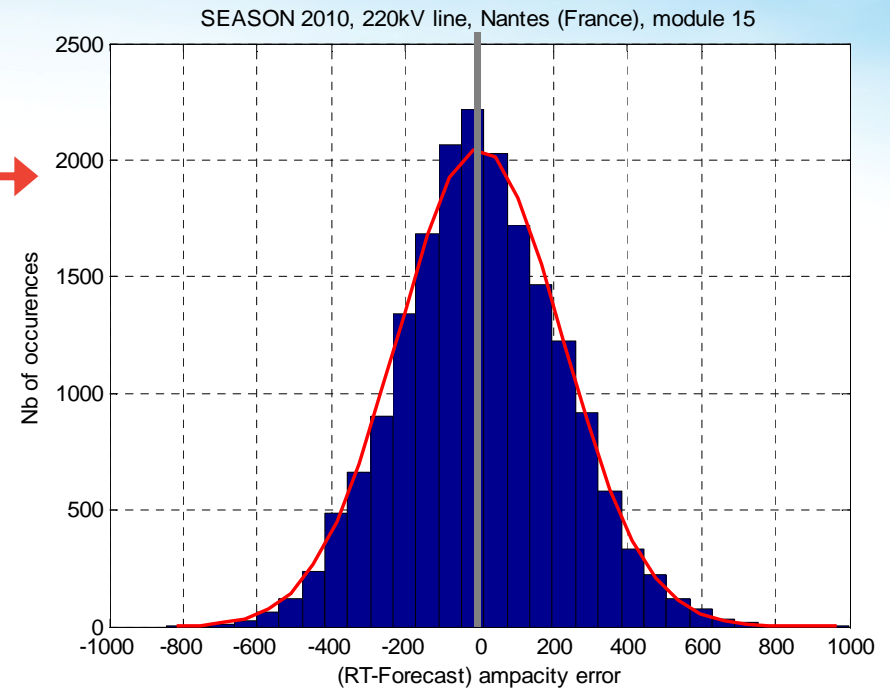
→ Find α

2.1 Data mining first update : ML regression

Summer (May-Sept 2010)



Error mean: -95 A
Standard deviation : 225 A



MULTI-LINEAR regression

Error mean: 6 A
Standard deviation : 220 A

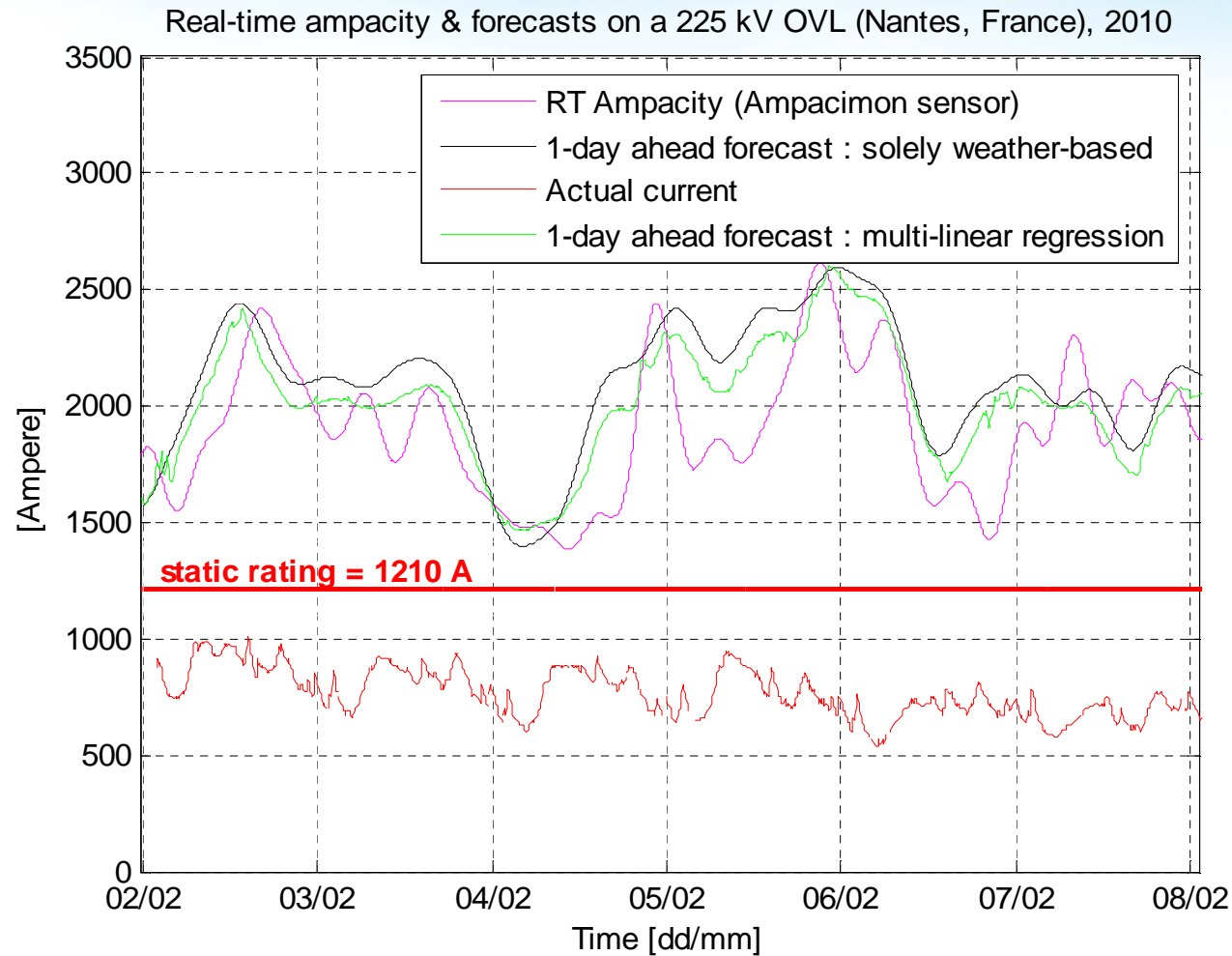
Example of outputs. The ampacity first update , step 2 from black to green curves (summer)



Summer period
(one week) part 2

Example of outputs. (winter)

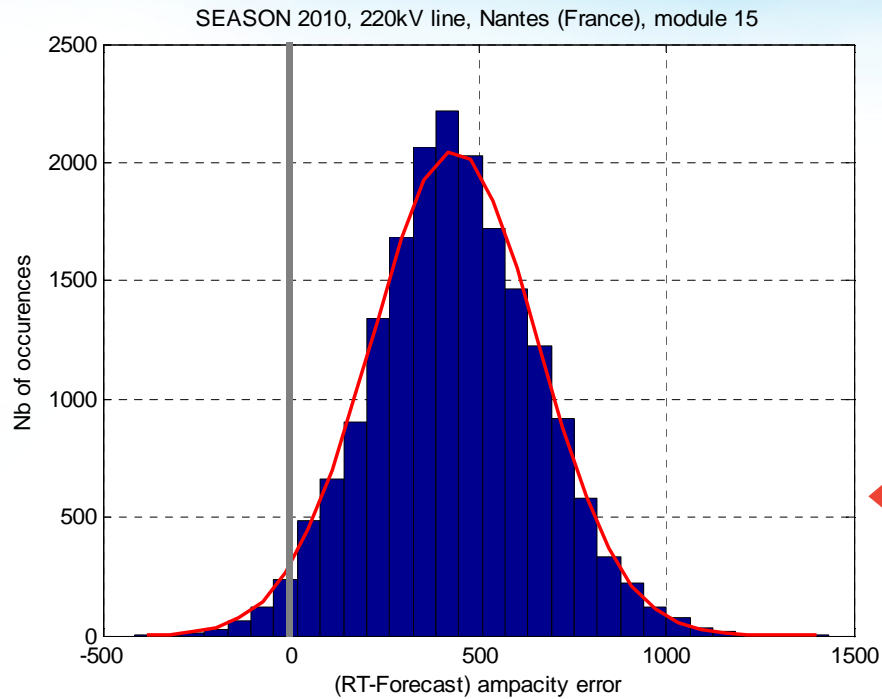
the ampacity first update : from black to green curves



Winter period
(one week) part 2

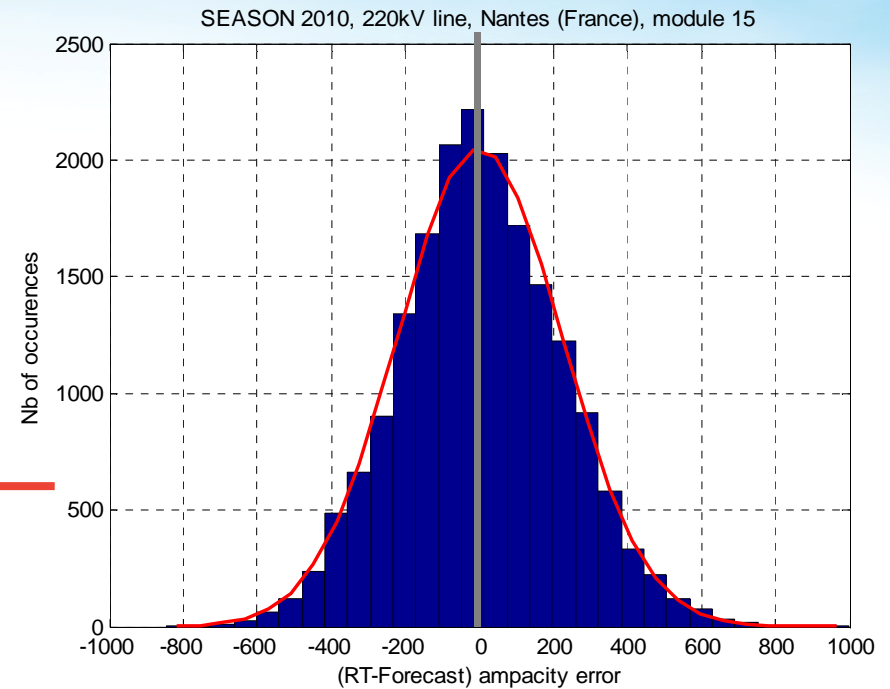
2.2 Data mining second update : histogram push

Summer (May-Sept 2010)



« push »

98% of conservative ampacity

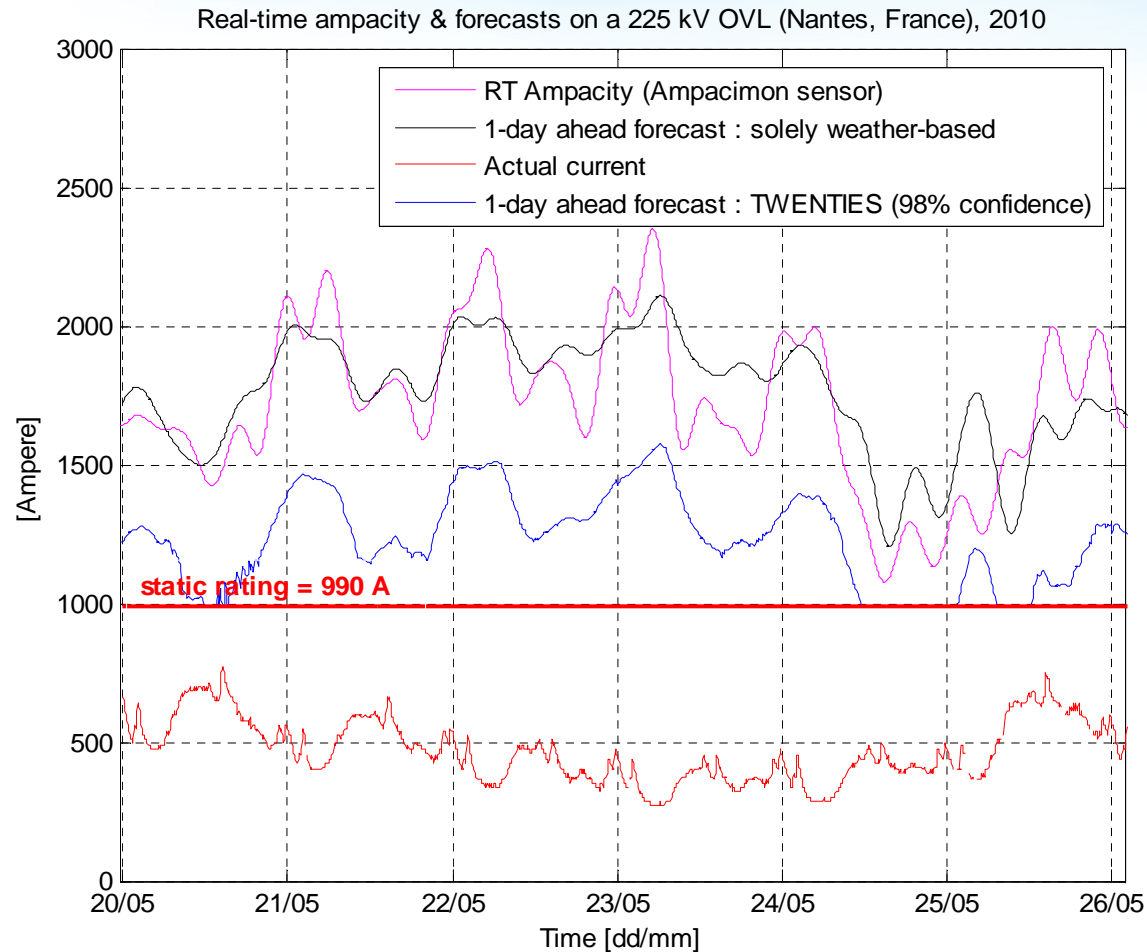


MULTI-LINEAR regression

Standard deviation : 220 A

Example of outputs. (summer)

Step 3, Final Output : Ampacity forecast one day ahead blue curve

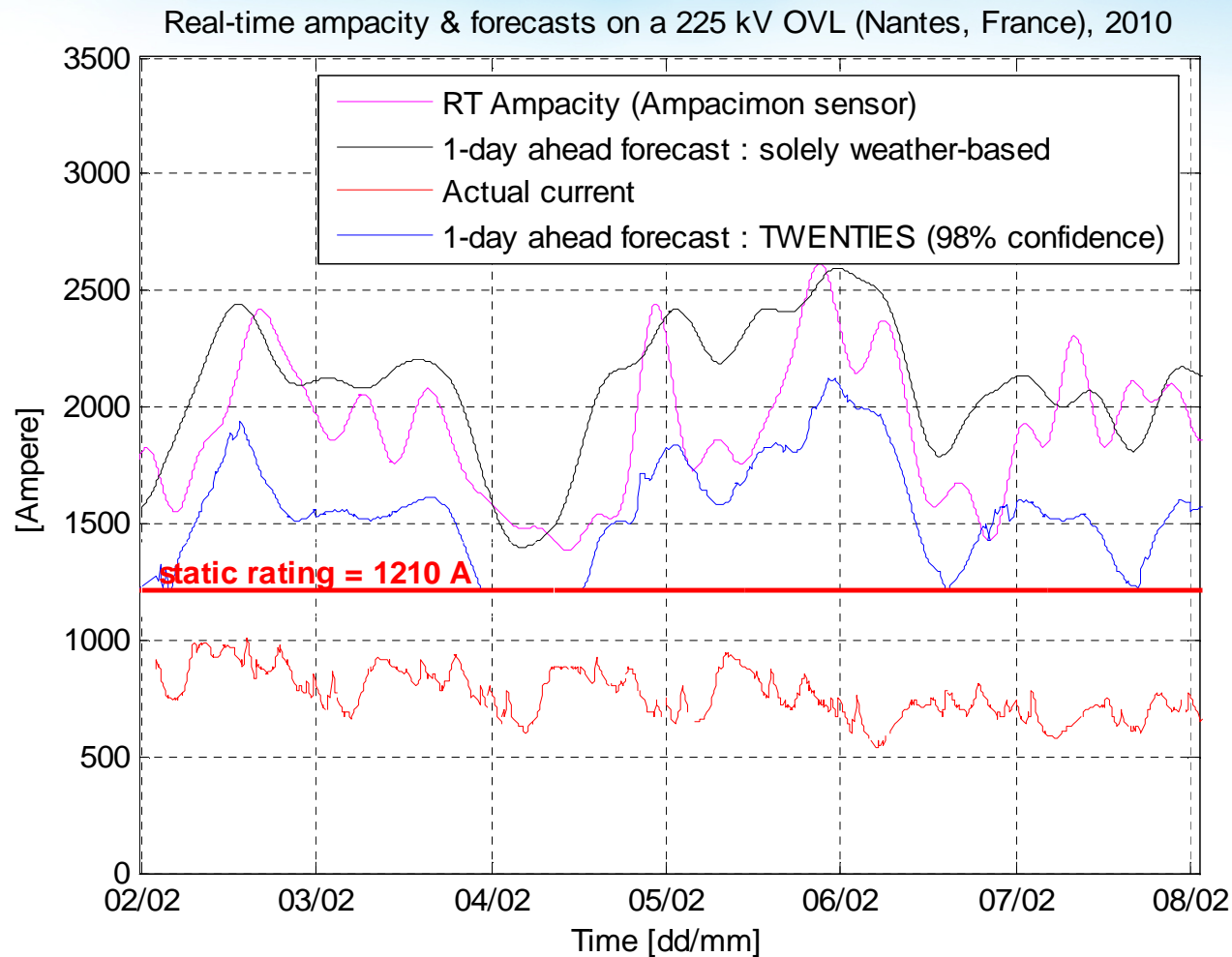


Summer period
(one week) part 3

RT Ampacity : mean 165%; forecasted secure ampacity : 125%

Example of outputs. (winter)

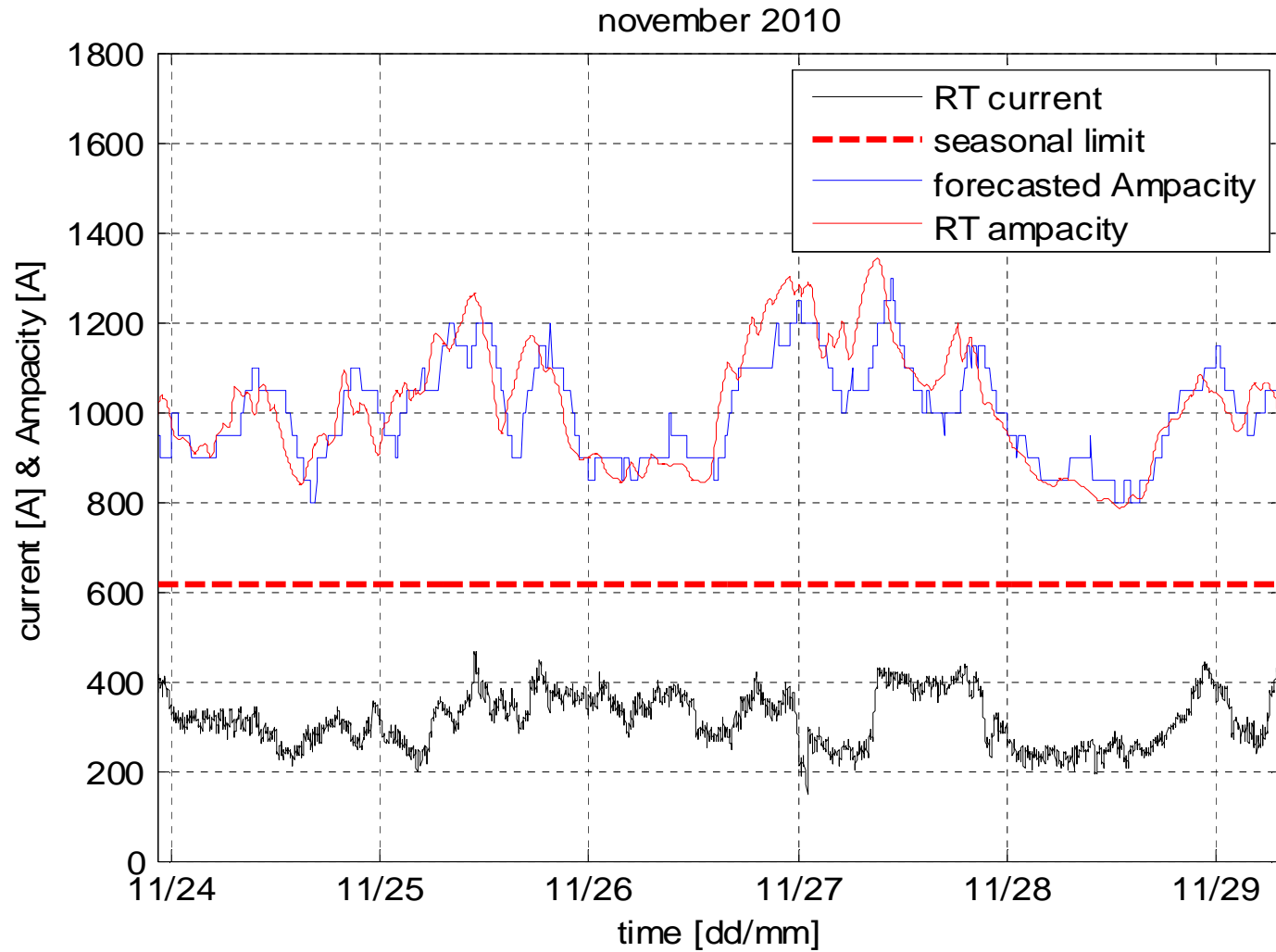
Final Output : Ampacity forecast one day ahead : blue curve



Winter period
(one week) part 3

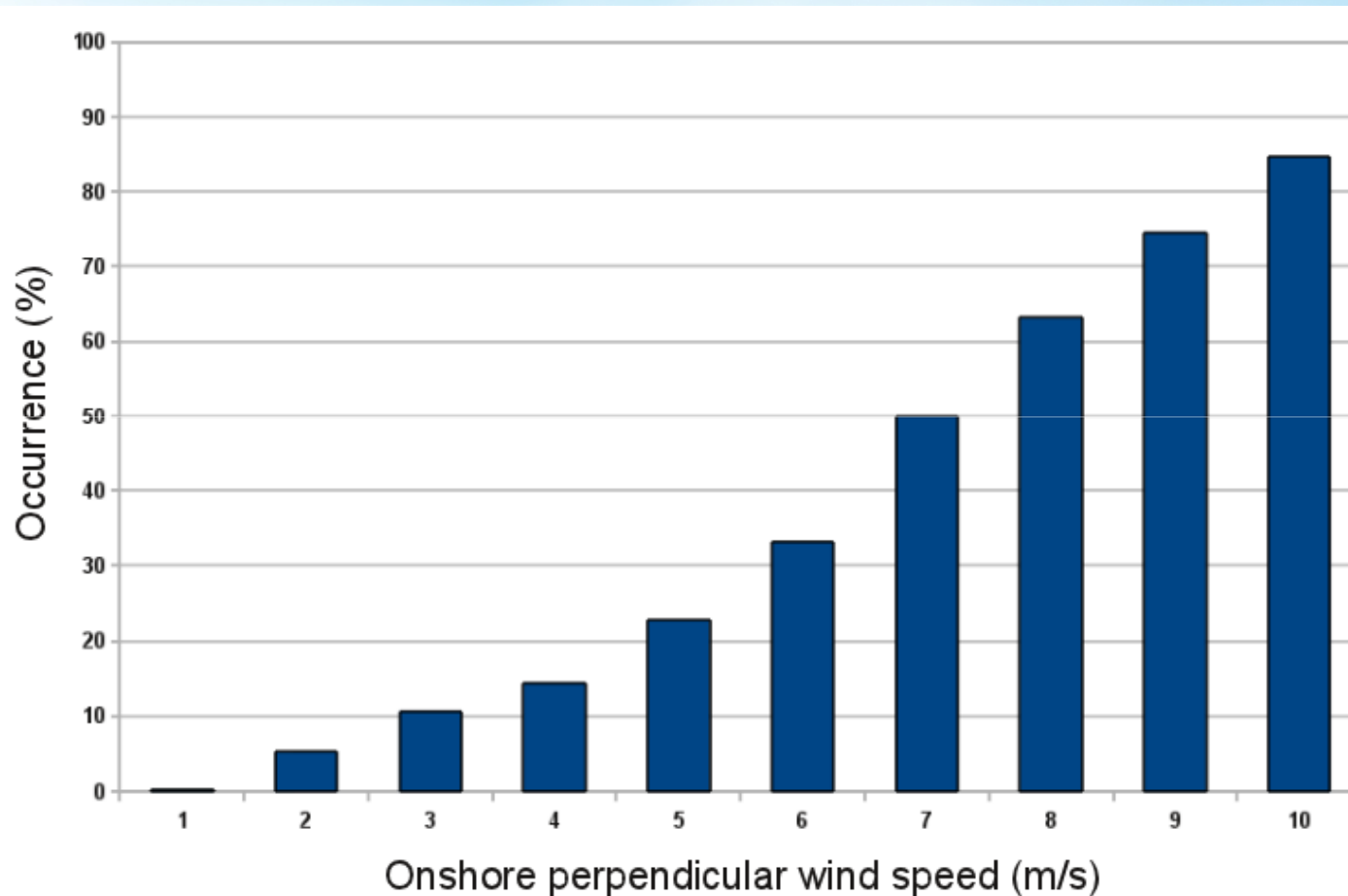
RT Ampacity : mean 165%; forecasted secure ampacity : 125%

Intra-day Forecasting (one hour ahead without meteo informations)



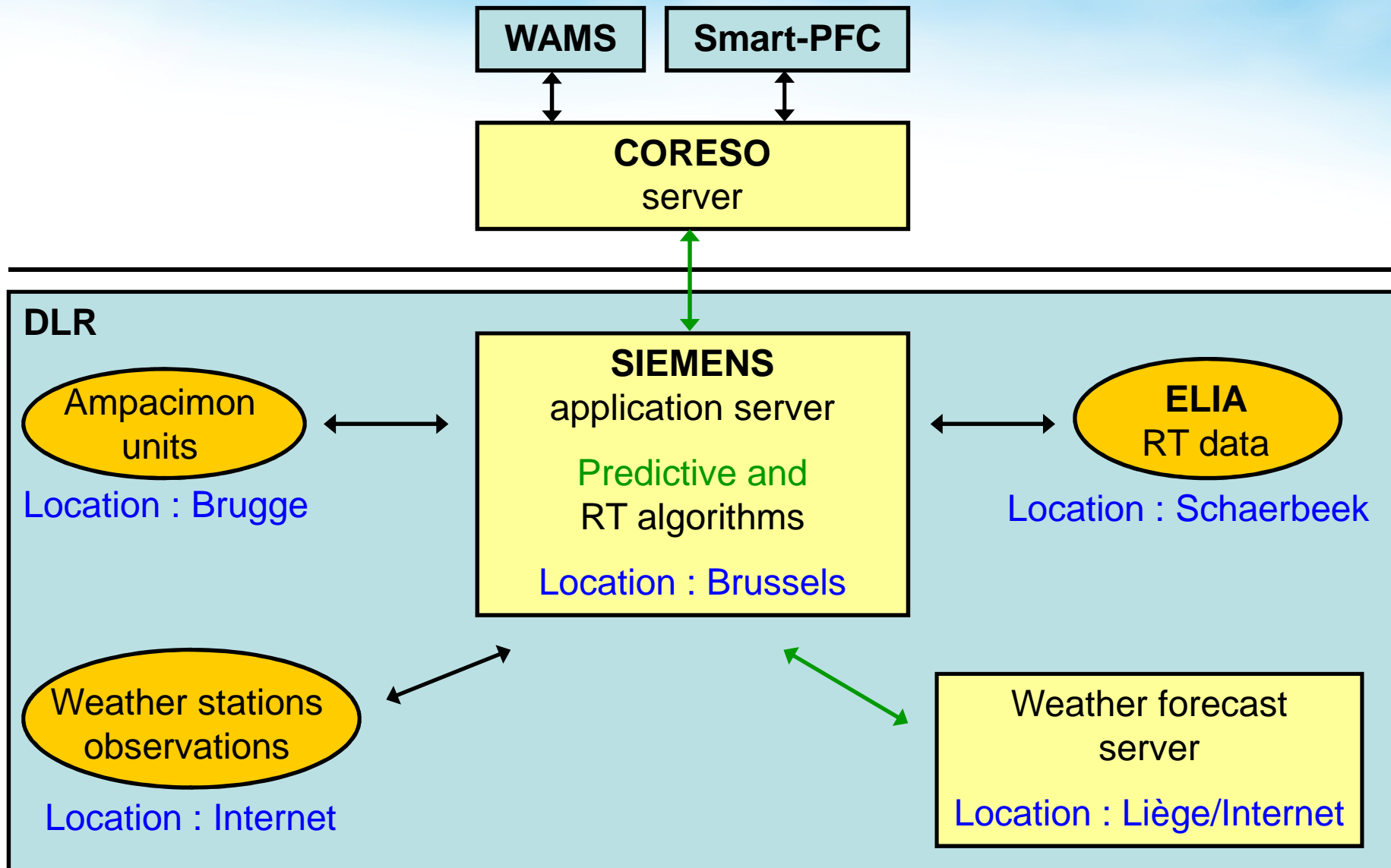
Other typical outputs :

How about wind speed on power lines critical spans during wind generation offshore ?



Occurrence of an onshore (on power line location worst critical span) perpendicular windspeed when the offshore windspeed blows at 10 m/s or more (Statistics of 2010)

Global architecture at CORESO for Active network management using DLR



Combination of DLR/PST and PMU

- **Another target of NETFLEX is to include in the global management system, the potential role of PST (phase shift transformers existing) and PMU (phase monitoring unit)**
 - **« advanced dynamic network management »**
- 0) CORESO estimate one day ahead potential congestions into CWE**
- 1) DLR is giving new thermal limits for critical lines (both in real time and 24 h forecast), some potential congestions may disappear.**
 - 2) PST optimisation scheme is proposing to redirect active power flow into the supervised region (Central Western Region) taking into account DLR limits. This corresponds to optimised angle change at some PST transformers to limit congestion, if any forecasted one is possible as evaluated one day ahead.**
 - 3) PMU is checking if stability limits are still ok (real time) with new power flows and actions may be taken in case of potential problem.**

Conclusions

- **Data mining exploration resulted in multi-linear regression and histogram push to get a reliable ampacity forecast one day ahead.**
- **Specific tuning of weather forecast with emphasis on low windspeed**
- **This approach allows (on our Demo site) an average DLR \geq 125% of static rating, with 98% confidence.**
- **Combining DLR, PST and using PMU helps a lot in large penetration of renewables.**