Comparative Study of Forecasts

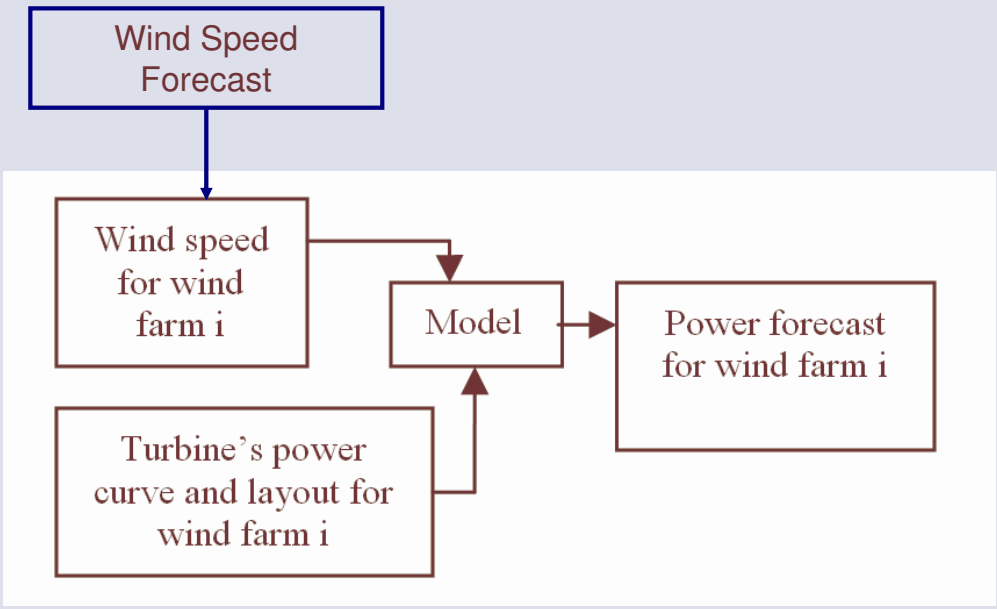
Eng. Ana RosaTrancoso (IST)
Eng. Rui Pestana (REN)
Prof. José Delgado Domingos (IST)

ana.rosa.maretec@ist.utl.pt

Goal

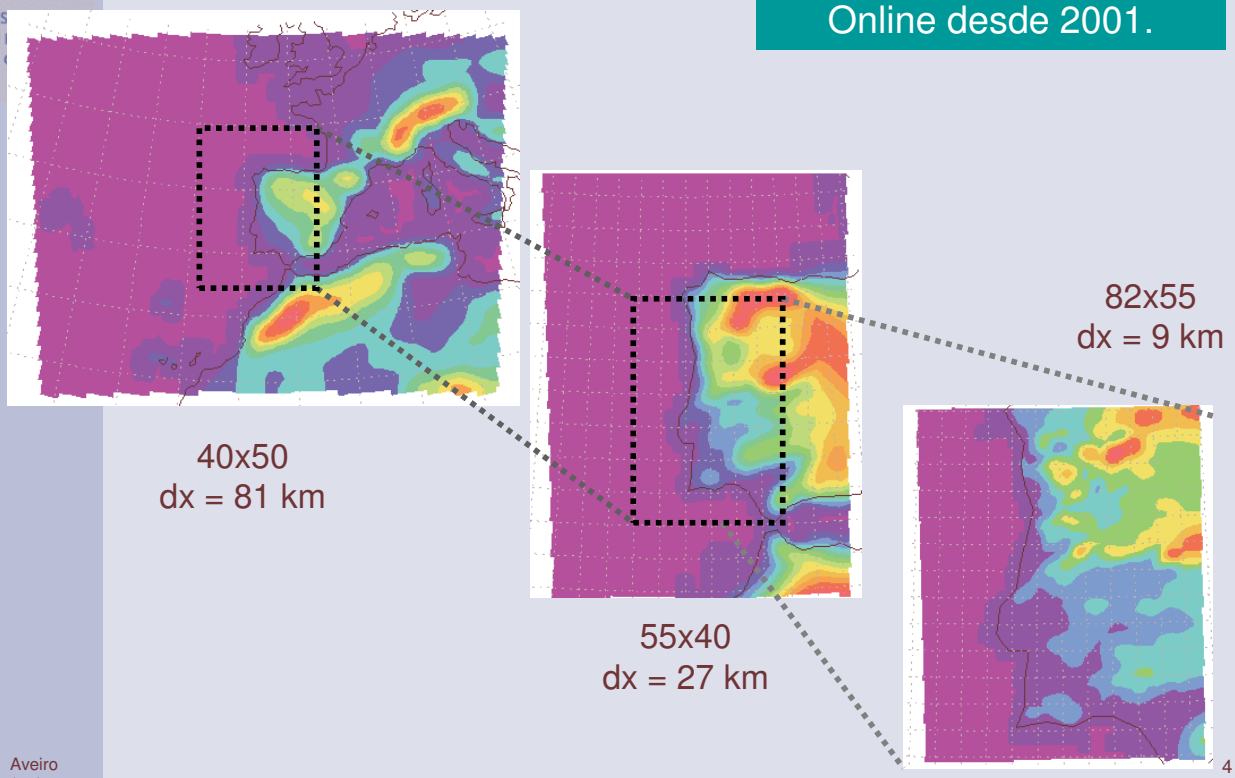
- Eolic Power Forecast for TSO (Transmission System Operator)
  - Load scheduling strategy (daily basis)
  - Dispatching decisions (hourly basis)
- Motivation
  - MM5 runs 4 times per day (00,06,12,18) with 72h forecasts, 23 vertical levels and GFS 80km.
  - Best prediction?
  - WRF 80km? WFR 40km?

Transmission System Operator (TSO)



IST-MM5

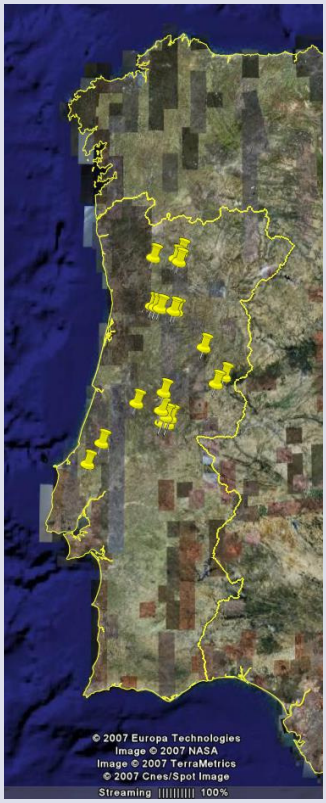
http://meteo.ist.utl.pt
Operacional desde 2000.
Online desde 2001.



REN Power Forecast

- Persistence:
  - 13 online parks (700 MW)
  - Improves short time scales
  - Correct NWP initial forecast
- Outages:
  - Wind farm outages
  - REN lines outages
  - EDP-Distribuição lines outages

http://www.ren.pt/sections/exploracao/dpe/default.asp



Forecasts with MM5

ID	*Description*
MM5_00	MM5 D3 (9km) with GFS 80km, start at 00Z.
MM5_12	MM5 D3 (9km) with GFS 80km, start at 12Z (uses upper air soundings data in Portugal)
REN	Combination of MM5 most recent forecasts.
Reg	Stepwise regression with the 11 available forecasts for each hour.
Coef	Weigthed regression of ***REN*** forecast with observed data, every 6 hours
Coef.Reg	Weigthed regression of ***Coef*** forecast with observed data, every 6 hours

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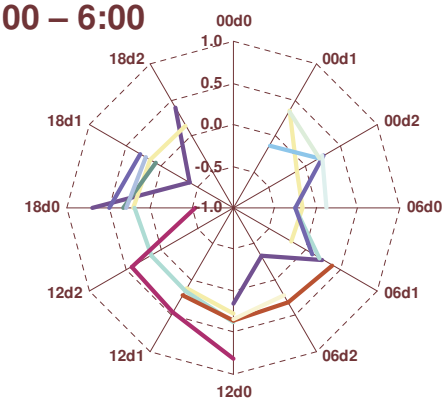
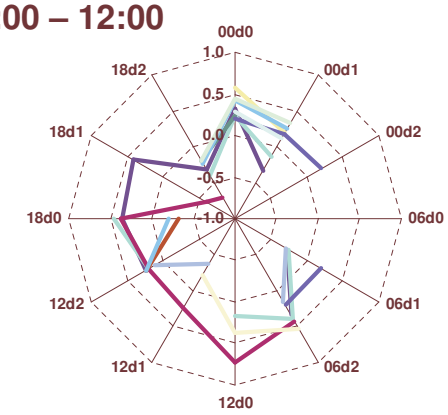
Stepwise Regression

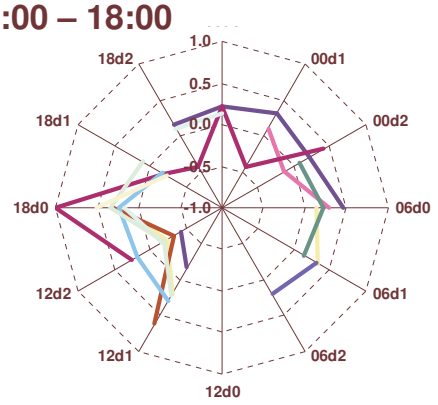
1:00 – 6:00



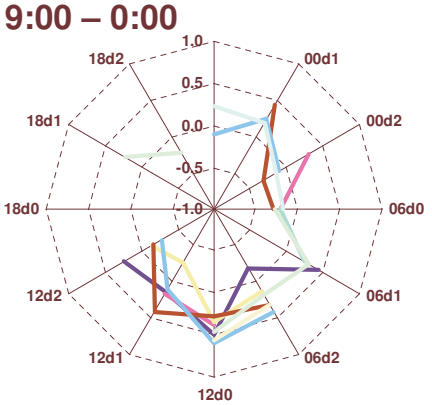
7:00 – 12:00



13:00 – 18:00



19:00 – 0:00



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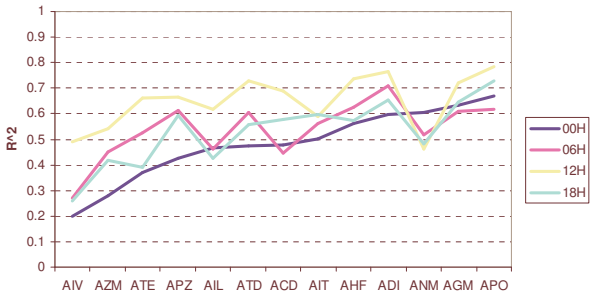
Stepwise Regression

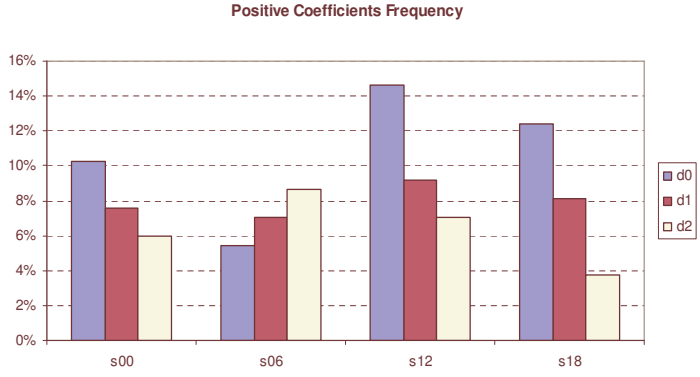
R^2 of Regressions



Park

Reg from 13:00-18:00 is the one with higher correlation

Contributions of each forecast in the regressions



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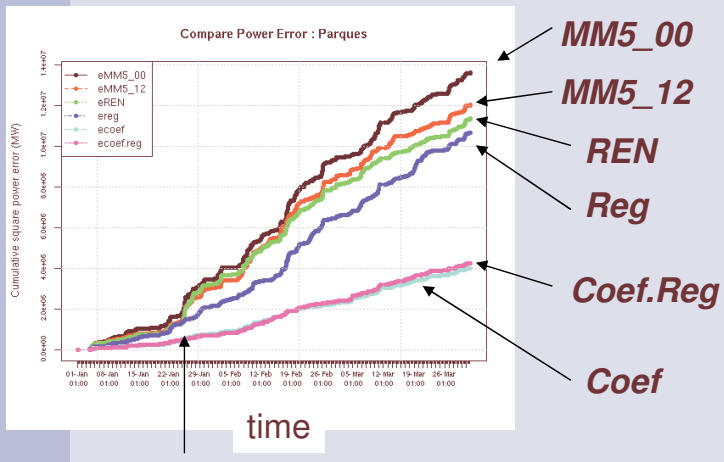
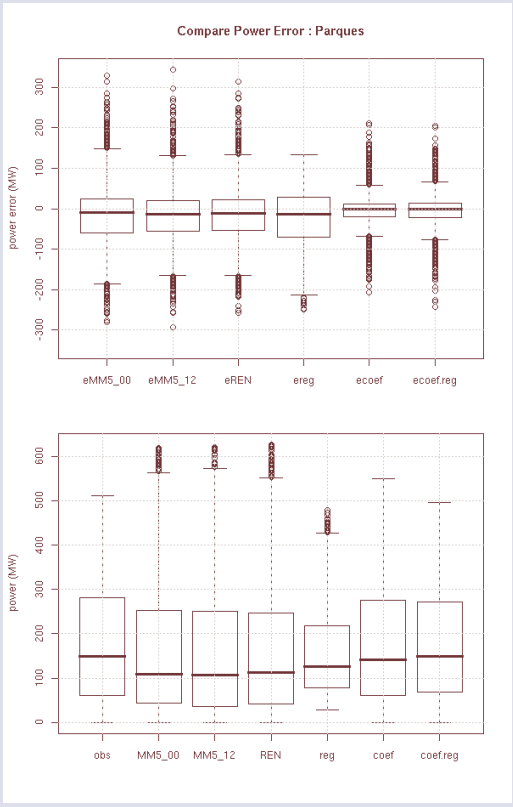
Cumulative Square Error

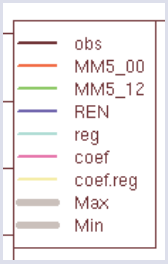
- Jan, Fev, Mar 2007 for 13 parks

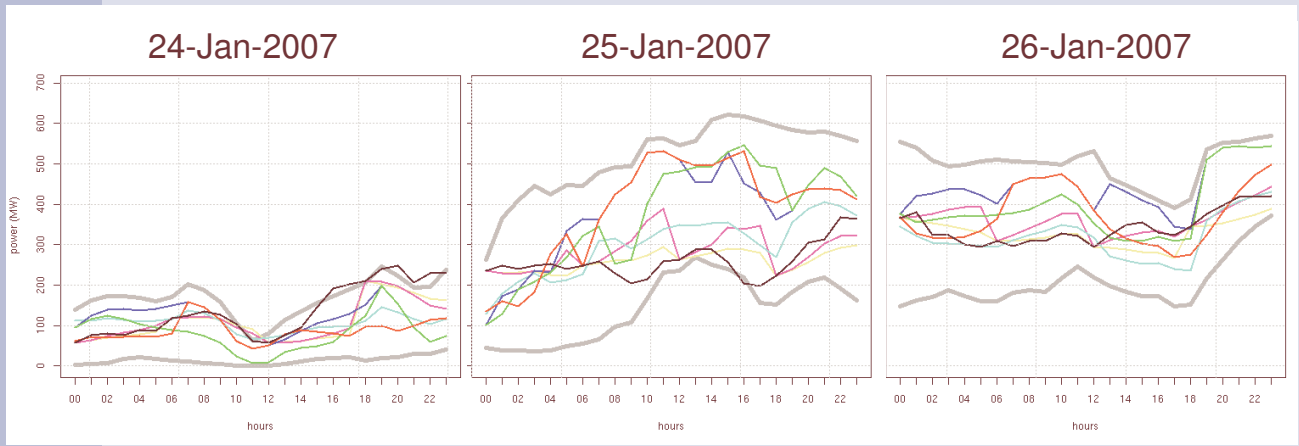


Increase
in wind velocity!

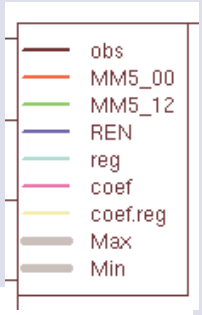


Increase

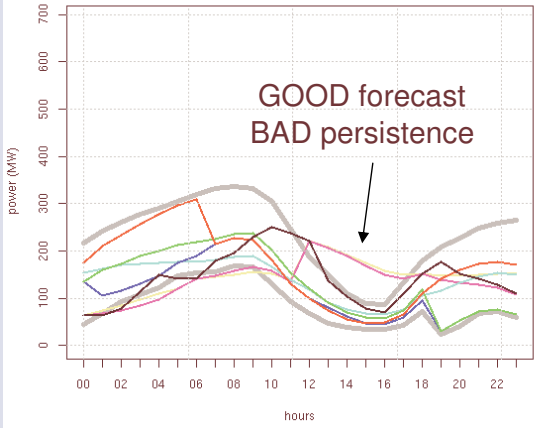




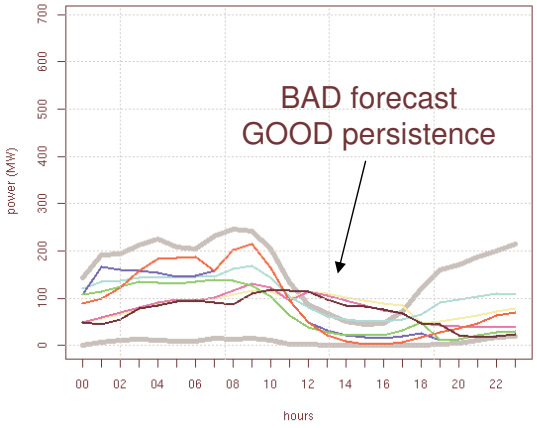
Decrease



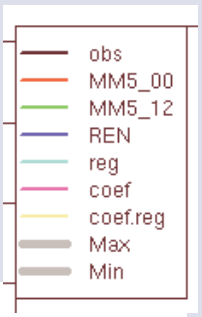
12-Jan-2007



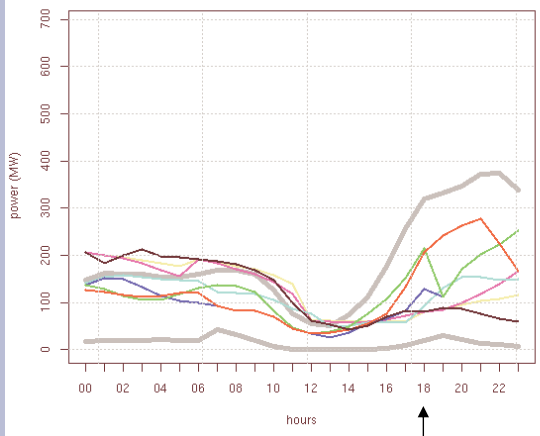
14-Jan-2007



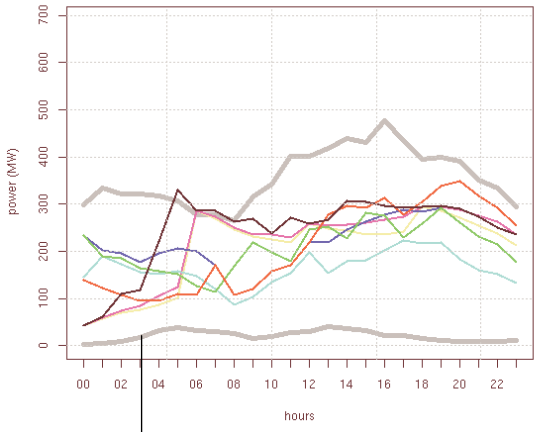
Antecipated Increase



21-Jan-2007



22-Jan-2007



Predicted at 18h... **Ocurred at 03h**

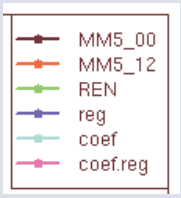
Error Decomposition

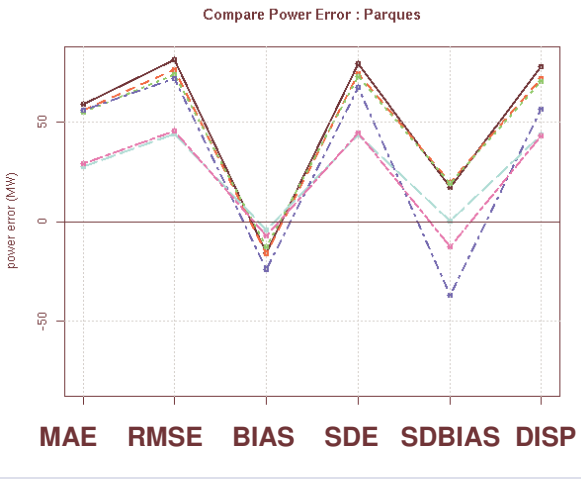
$$rmse^2 = bias^2 + sde^2 = bias^2 + sdbias^2 + disp^2$$

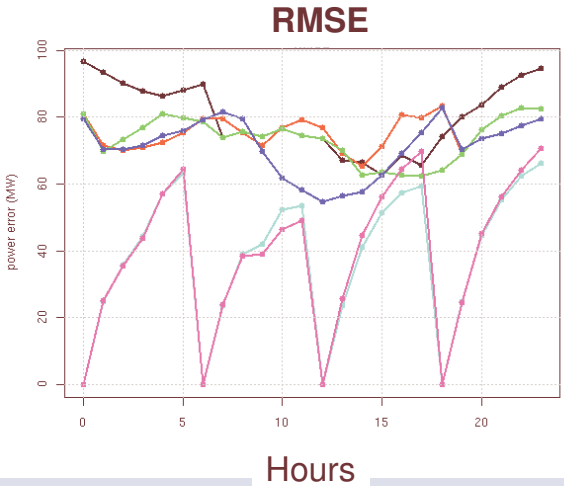
$\varepsilon = x_{prd} - x_{obs}$	Error
$rmse = \sqrt{\varepsilon^2}$	Root Mean Square Error
$bias = \bar{\varepsilon}$	Bias
$sde = \sigma(\varepsilon)$	Standard Deviation of Error
$sdbias = \sigma(x_{prd}) - \sigma(x_{obs})$	Variability Error
$disp = \sqrt{2\sigma(x_{prd})\sigma(x_{obs})(1-r)}$	Dispersion (phase error)

Lange M. (2005). *On the Uncertainty of Wind Power Predictions — Analysis of the Forecast Accuracy and Statistical Distribution of Errors*. Journal of Solar Energy Engineering. Vol. 127:177-184.

Error Decomposition







Bias > 0 : underestimation

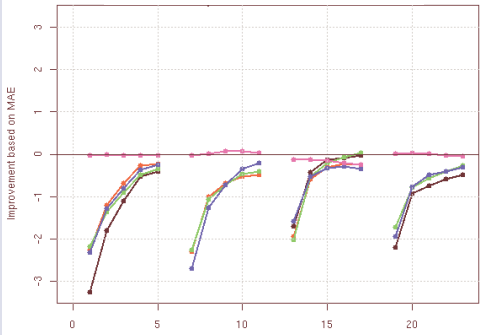
RMSE ~ SDE ~ DISP : Phase Errors

RMSE of ***coef*** prediction increases steeply. Try to reduce with regression

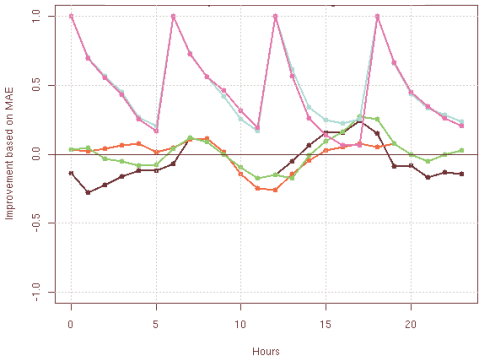
Decrease in RMSE near end of day (18h) → higher winds

Improvement

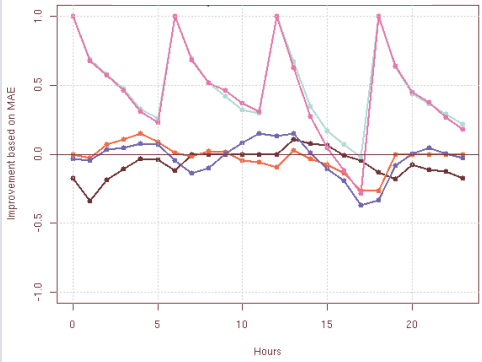
Relative to ***coef***



Relative to ***reg***



Relative to ***REN***



- ***Coef*** is the best prediction
- ***Coef.reg*** improves sligtly (except for 13-18h)
- NWP forecasts better than ***reg*** at day-night transitions
- ***MM5_12*** best than ***REN*** at 1-6h (which is MM5_18)
- ***MM5_00*** best than ***REN*** at 13-18h (which is MM5_06)

→ ***REN*** **could be combination of** ***MM5_00*** **and** ***MM5_12*****.**

Compare MM5 & WRF

MM5_00	MM5 D3 (9km) with GFS 80km, start at 00Z.
WRF_MM5_00	WRF same conditions as MM5_00
WRF_00	WRF with GFS 40km
REN	Combination of MM5 most recent forecasts.
Coef	Weigthed regression of ***REN*** forecast with observed data, every 6 hours

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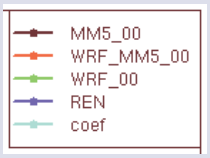
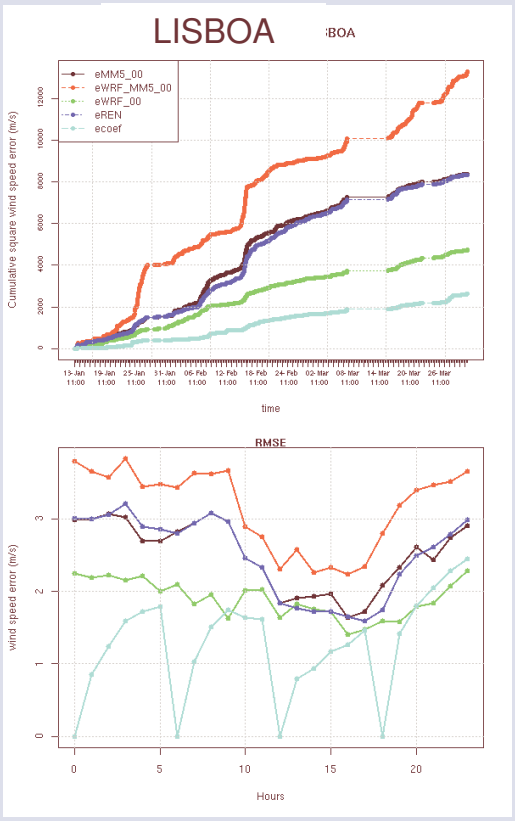
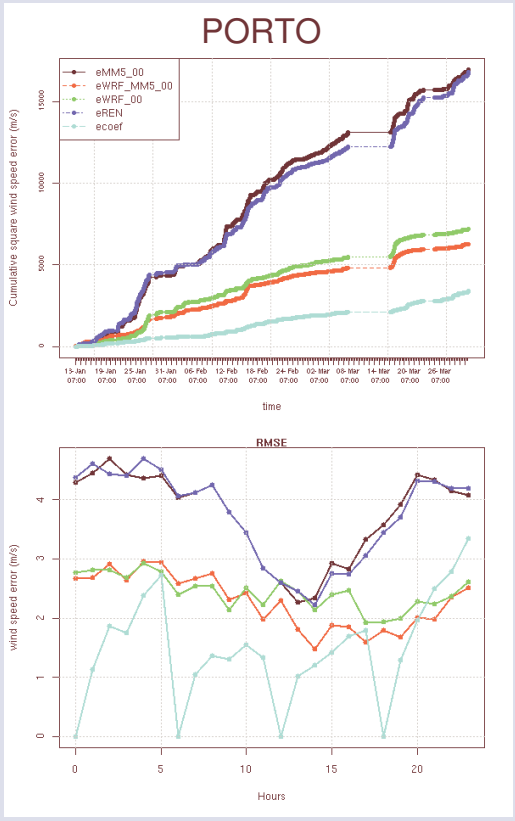
WRF & MM5 – Wind Speed 10m



Top 3 LISBOA:
1º coef
2º WRF_00
3º MM5

Top 3 PORTO:
1º coef
2º WRF_MM5
3º WRF_00





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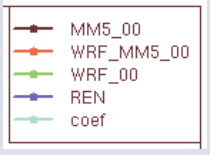
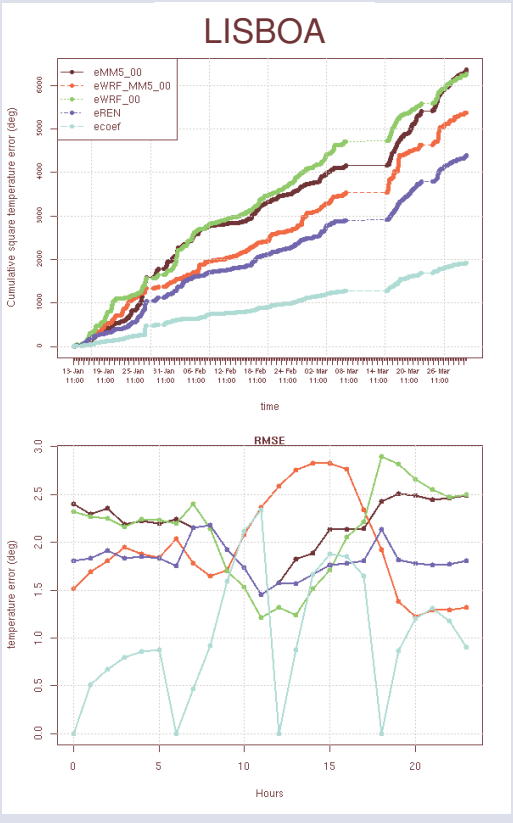
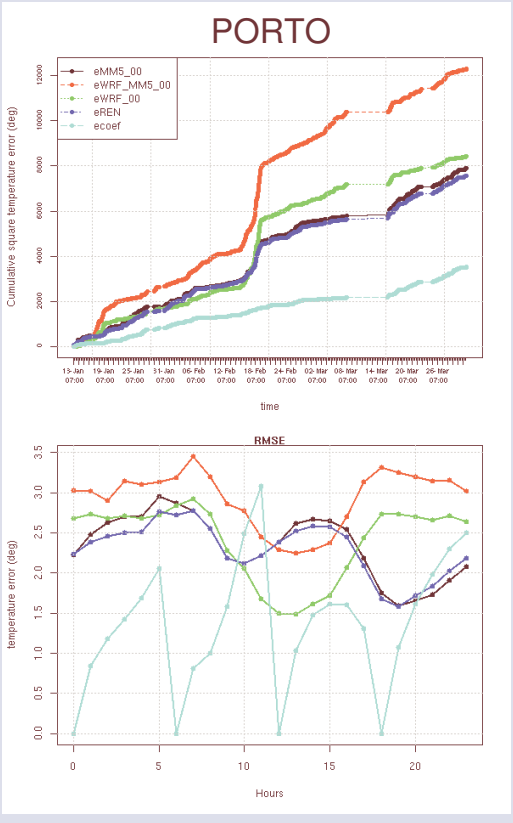
WRF & MM5 – Temperature 2m



Top 3 LISBOA:
1º coef
2º MM5
3º WRF_MM5

Top 3 PORTO:
1º coef
2º MM5
3º WRF_00





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Conclusions

- Caution: Studied only 1st trimester of 2007
- MM5 – Eolic:
  - The best prediction is clearly ***coef*** (RMSE = 45 MW (6% total))
  - However, if real-time observed data is not available, multi-regressing the 11 available predictions for each hour is the second best choice (reg) (RMSE=72 MW (10% total))
  - A small improvement of REN is verified at day-night transitions, where all pure "numeric" forecasts behave best. This suggests diurnal corrections.
  - REN could be combination of only MM5_00 and MM5_12 (which have improved boundary conditions from GFS)
- WRF & MM5:
  - WRF 80 km < MM5 80 km < WRF 40 km
  - MM5 is best for temperature because is more "tunned" to the site.