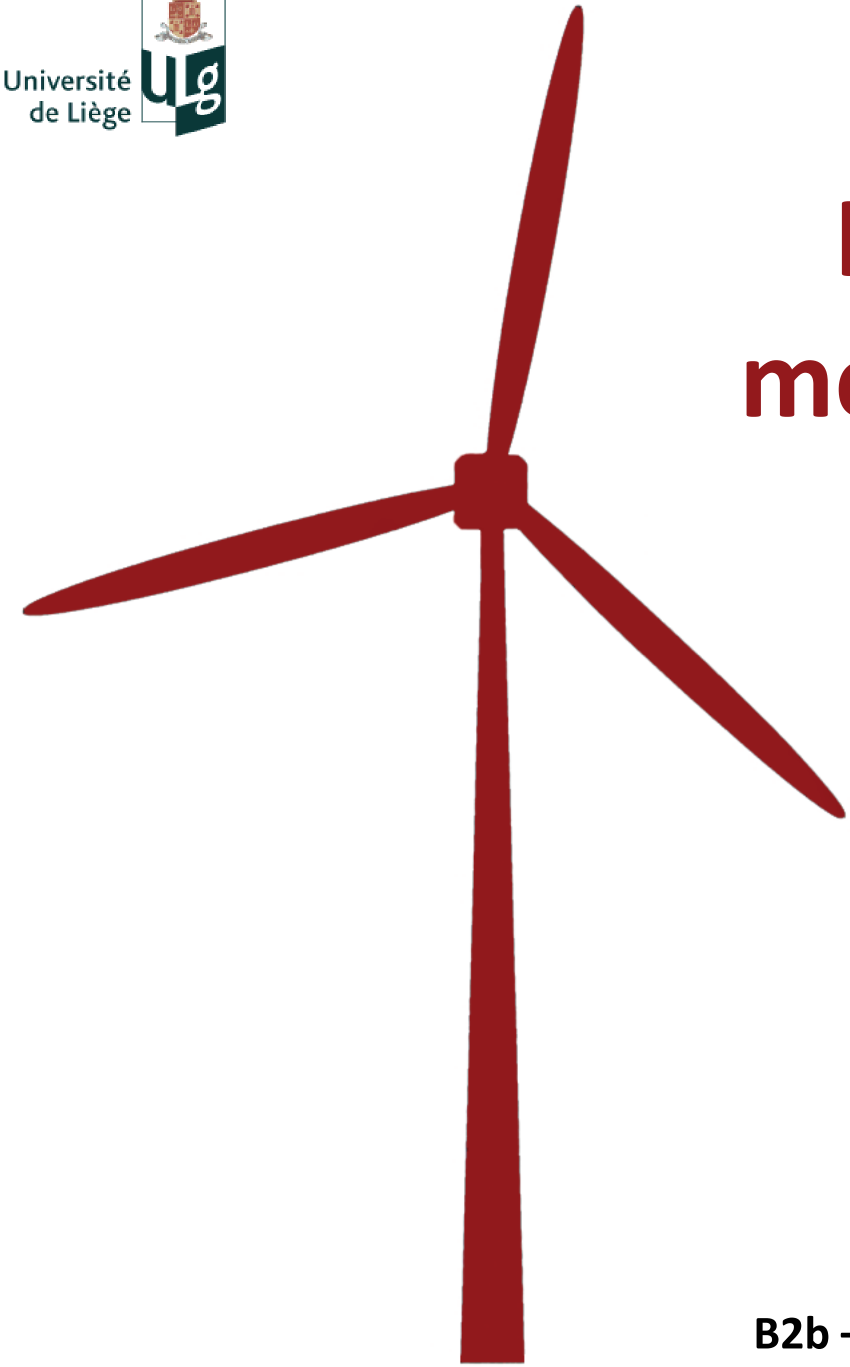

Interests of regional modelisation for wind power forecasting

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4th Belgian Geography Days,
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B2b – Meteorology for sustainable energy production

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Contents

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Introduction

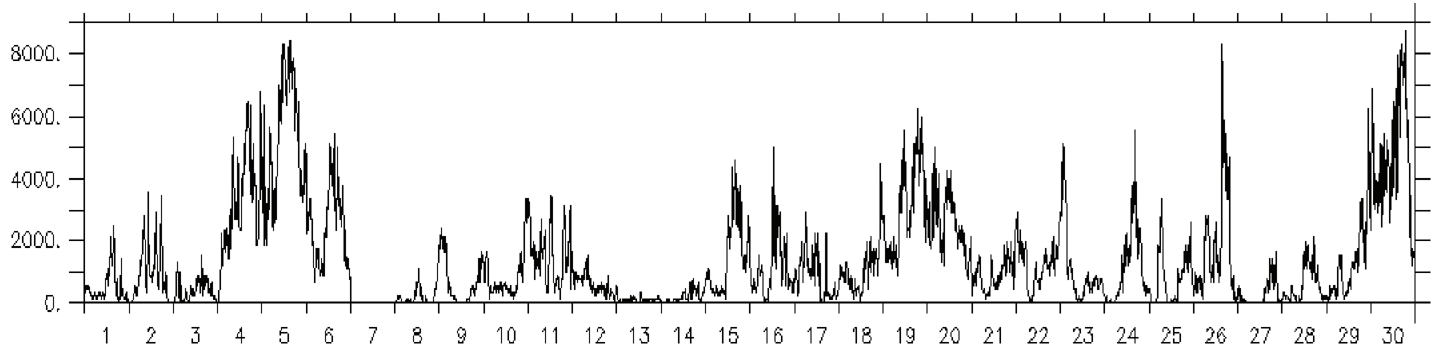
❖Context :

- Climate
  - Greenhouse gases from fossil fuels :
    - ↑ temperature of the Earth
- Energy
  - Extremely dependant on fossil fuels
    - ↓ Oil reserves
      - ↑ Price of energy
- One of the multiple solutions : **Use of the Wind Energy !**

Problematic of wind energy

- The wind energy is dependant on the weather conditions :

  - This implies :
    - As you know
      - if the wind speed **drops** : Production also **drops**
      - If there is **no wind** : There is **no production**
    - But, if the wind speed is **too high** : Production **stops**



Production (in kWh) of 5 wind turbines near Amel in Belgium on September 2010

Problematic of wind energy

Introduction

Problematic of wind energy

Forecast Models

Evaluation

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Conclusions

- Therefore, we must :
  - forecast the wind speed
    - Minimum one day in advance
    - Every 15 minutes

to use efficiently the wind power

- Who are the users of the wind forecasts ?
  - Managers of electric grids
    - To balance the production and consumption of electricity
  - Producer / Provider of electricity
    - To negotiate the best price on the electricity market

Forecast Models

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GFS (Global Forecast System):

- Global Meteorological Model
  - Available over the **world**
- Resolution outputs : **0.5° and 3h**
- Outputs are provided by the NOAA
  - We can't change the parameters of the model

WRF (Weather Research Forecast model) :

- Regional model forced by GFS
  - Centred over **Belgium** (defined by the user)
- Resolution (defined by the user) : **4 km and 15 min**
- Original code is provided by the NCAR/NCEP
  - Open Source code
  - We can adapt the code/parameters as we wish

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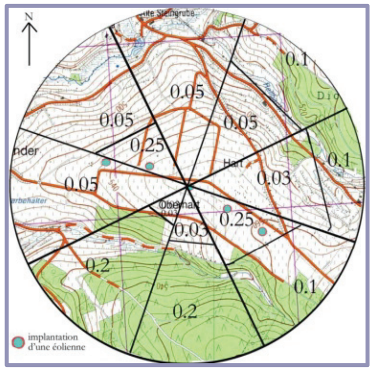
GFS Method

❖ GFS :

- ~20min to obtain forecasts at +24h

GFS outputs 0.5° and 3h → Linear interpolation every 15 min → Tunings to adjust the wind forecasts + Transform the wind speed into electric production → **Wind power production forecasts**

- Tunings depend on :
  - Roughness roses
    - According to roughness of the terrain
  - Air density
  - Some instability parameters



WRF Method

❖ WRF :

- ~1h to obtain forecasts at +24h

GFS outputs 0.5° and 3h

Static data

WRF model: regionalisation

WRF outputs: 4km and 15min

Few tunings to adjust the wind forecasts
+
Transformation of the wind speed into electric production

Wind power production forecasts

- Tunings
  - Slightly reduce the wind speed
  - **Not use of** roughness rose
    - WRF integrates the topography roughness

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Evaluation

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❖ Four evaluation indexes :

- **RMSE** (Root Mean Square Error) :

$$\sqrt{\frac{1}{n\ \Sigma(obs - forecast)}}$$

- **r²** (coefficient of determination):

$$\left(\frac{(n\sum(obs forecast)) - (\sum obs \sum forecast)}{\sqrt{(n\sum obs^2 - (\sum obs)^2) * (n\sum forecast^2 - (\sum forecast)^2)^2}}\right)^2$$

- **PC** (Percentage) $\sum(1 - ABS\left(\frac{obs - forecast}{obs}\right))$

- **PC60** (Conditioned Percentage)

$$If(obs \geq 60\%\ \max prod)\ then \sum\left(1 - ABS\left(\frac{obs - forecast}{obs}\right)\right)$$

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❖ From January 2010 to September 2010

	GFS	WRF
RMSE	1583	1500*
R^2	0,54	0,57
PC	11674	11224
PC60	1245	1356

(kWh)

- WRF has better forecasts
  - Except for PC
- WRF has better forecasts when the production is high
  - Indicated by the PC60
  - The high production events are more important

* : These results may not be significantly different

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Results

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- Conclusions

❖ Seasonally

- January to February

	GFS	WRF
RMSE	1695	1662*
R^2	0,65	0,66*
PC	2860	3001
PC60	528 *	524

(kWh)

- March to May

	GFS	WRF
RMSE	1629	1593 *
R^2	0,49	0,53
PC	4003	3597
PC60	458	534

(kWh)

- June to September

	GFS	WRF
RMSE	1490	1340
R^2	0,46	0,51
PC	4811	4609
PC60	259	323

(kWh)

* : These results may not be significantly different

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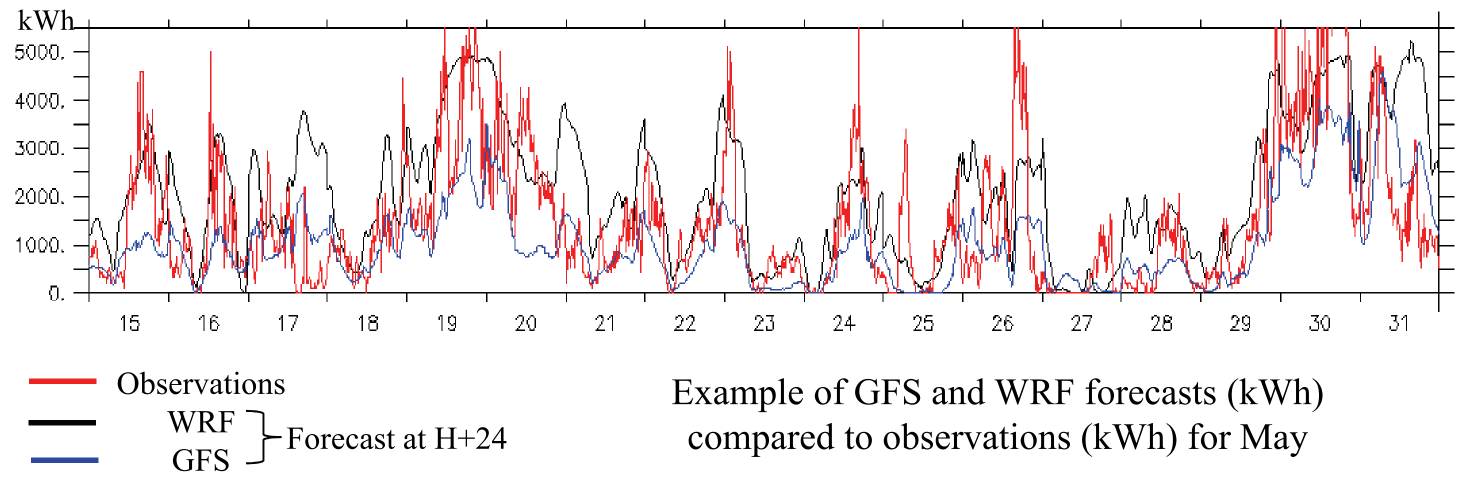
Results

❖ Examples



Example of GFS and WRF forecasts (kWh) compared to observations (kWh) for May

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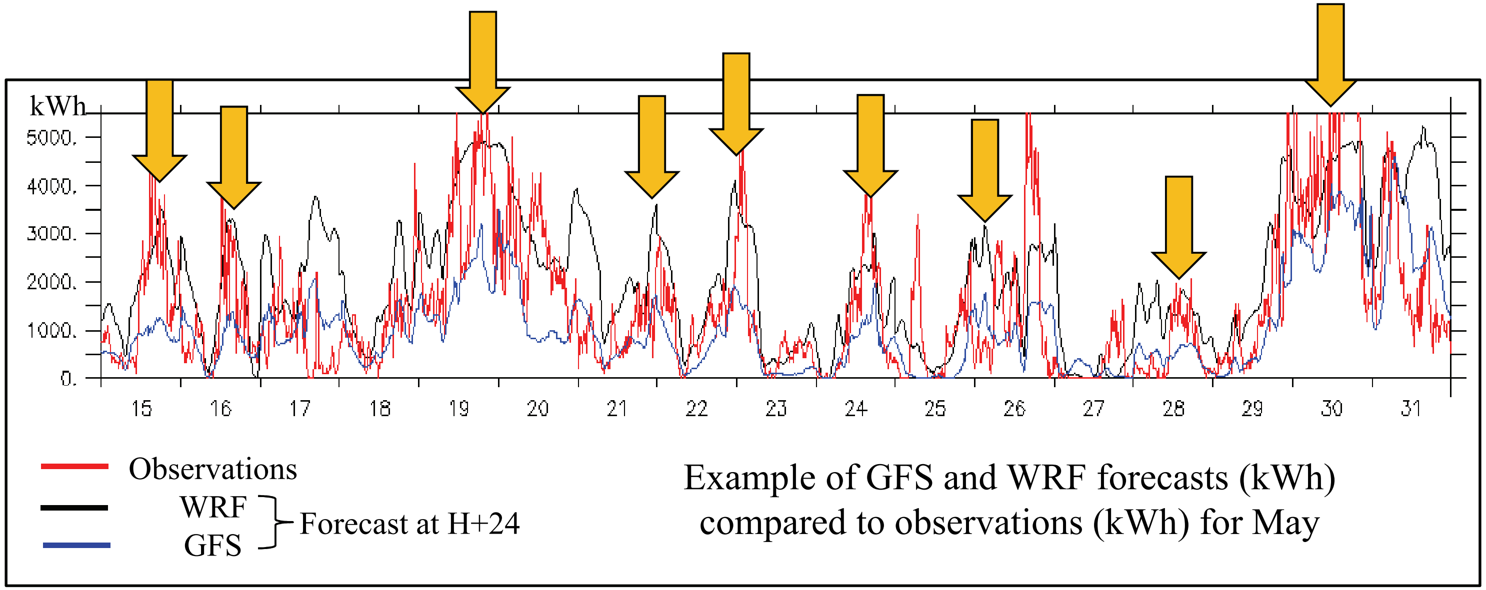
❖ Examples

- Production peaks are better forecasted with WRF than with GFS



Example of GFS and WRF forecasts (kWh) compared to observations (kWh) for May

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Results

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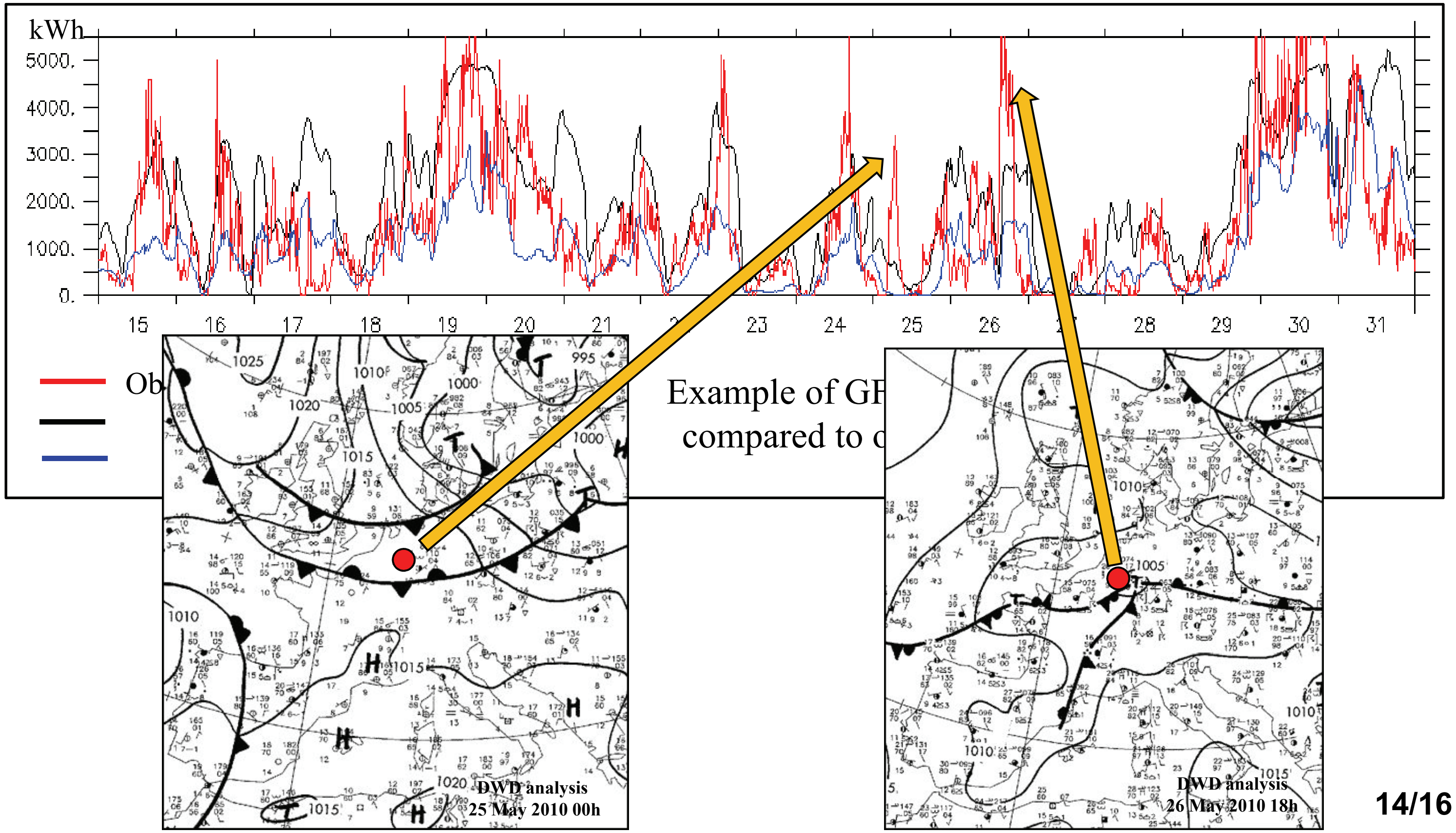
❖ Examples

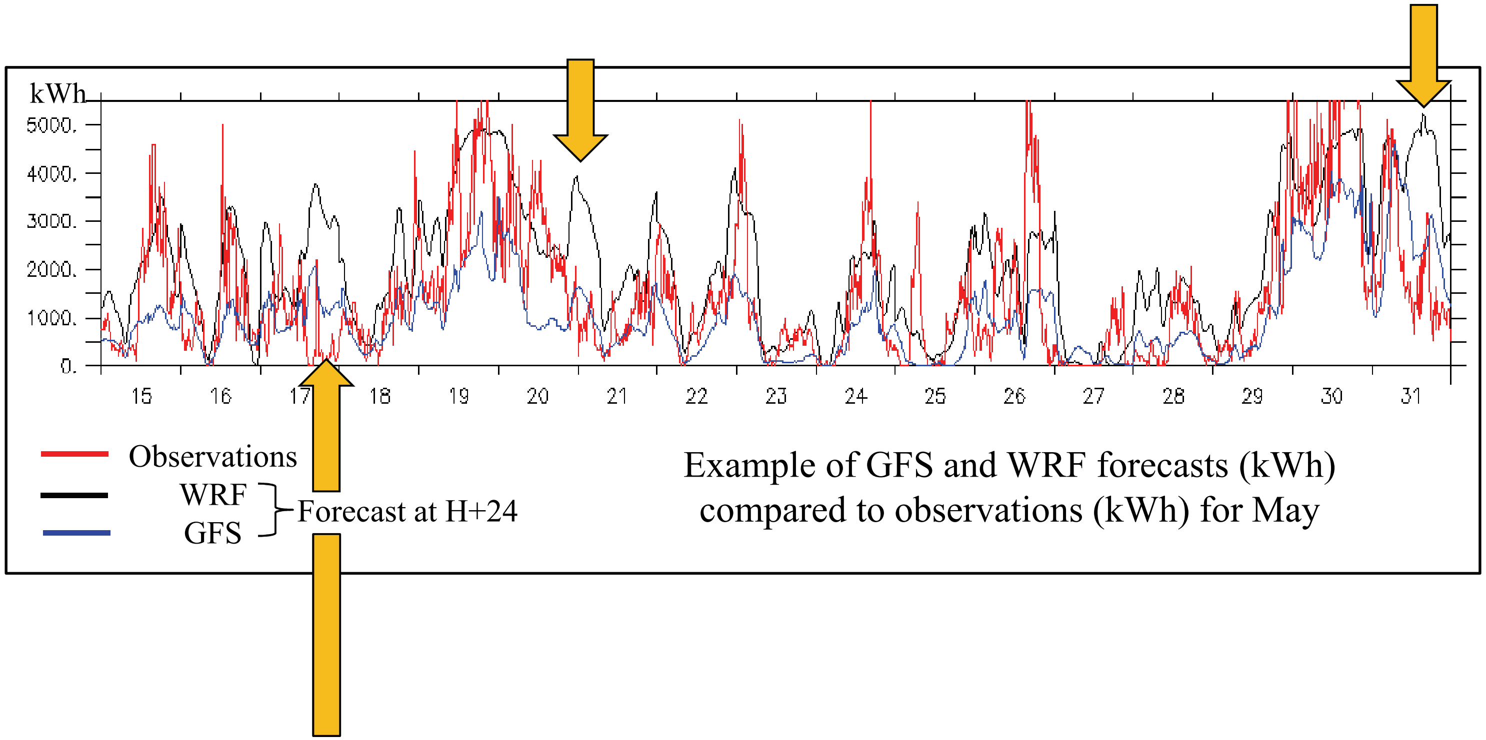
- Some remarkable periods are not modelled neither by WRF nor by GFS
  - The pass of a cold front or a convective zone



Results

❖ Examples

- Wrong forecasts



Example of GFS and WRF forecasts (kWh) compared to observations (kWh) for May

- Halt of one or more wind turbines

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Conclusions

❖ Interests of using WRF :

- **Outputs** are available in a resolution of **4km** and **15 min**
  - **Decrease the errors created by the spatial and temporal interpolation**
- **Production peaks** are successfully forecasted
  - **High production events are more important for the users of these forecasts**
- Influences of the **topography** are integrated in the WRF calculation
  - **Roughness rose is not needed**
- **Configurable** as we wish
  - **We are not dependant on an other meteorological organism**

❖ Disadvantage of WRF

- Forced by GFS
  - If the GFS forecasts are wrong → the WRF forecasts will also be wrong

Thanks for your attention