Laboratoire de Climatologie et Topoclimatologie

PremaSol

METEOCLIM PhD Symposium 6 June 2014

Solar irradiance modelling over Belgium using WRF-ARW :

Sensitivity analysis of Mellor-Yamada-Nakanishi-Niino (MYNN) boundary layer scheme parameters

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Solar irradiance modelling over Belgium using WRF-ARW :

Overview

- Context
- Simulation set-up
- Results
- Focus : modelling of different weather/clouds types
  - Low clouds (St, Sc)
  - Convective clouds (Cu)
  - Clear skies and thermal inversions
- A Modèle Atmosphérique Régional (MAR) / WRF-ARW comparison
- Conclusions

Solar irradiance modelling over Belgium using WRF-ARW :

I. Context

- **PREMASOL** project :

  - Photovoltaic production day-ahead → **Solar Incident Irradiances** (SWD) forecasting (+ 2m Wind and T°) using WRF-ARW forced by GFS

  - Global and diffuse irradiance measurement at Centre Spatial de Liège (CSL)

- **PhD** :

  Regional Climate Model version calibrated for solar irradiance, wind and temperature modelling over Belgium → forecasting and future changes

Solar irradiance modelling over Belgium using WRF-ARW :

II. Simulations set-up

- WRF-ARW v3.6 (released April 2014)

Surface schemes : 6

Short-wave schemes : 7

Cumulus schemes : 9

microphysic schemes : 16

boundary layer schemes : 10

surface layer schemes : 7

Inner domain : 5 km

Time-scale : 15 minutes

- **Observations : SWD measured at Liège (Sart-Tilman)**

- **Validation : Two periods → November – December 2013**
  → March – April 2014
  Relative BIAS and RMSE (in %)

Solar irradiance modelling over Belgium using WRF-ARW :

III. Results

→ Huge number of possible set-ups

→ Lot of them tested at our laboratory

NO SIGNIFICANT CHANGES

→ **In spring :** significant positive (dry) BIAS (+20%) and RMSE ~ 40 %

→ **In winter :** slight negative BIAS (-10%) but very large relative RMSE (~70%)

→ Get inside scheme codes for further calibration

Surface scheme : Noah lsm	Microphysics scheme : Thompson
SW scheme : Dudhia	Surface layer scheme : Monin-Obukhov
Cumulus scheme : Kain-Fritsch	Boundary layer scheme : **MYNN 2.5**

Solar irradiance modelling over Belgium using WRF-ARW :

III. Results

Over a « long » period : no significant changes/improvements

→ **But for some days, changes can be important …**

November – December 2013

	rBIAS(%)	rRMSE(%)
Alp5 = 0.5	-9,4	76,3
Alp5 = 1.0	-11,8	77
Alp5 = 5.0	-5,8	68,9
Alp5 = 10.0	0	71,6

March – April 2014

	rBIAS(%)	rRMSE(%)
Alp5 = 0.5	22,7	41,4
Alp5 = 1.0	22,2	41,5
Alp5 = 5.0	23	42,2
Alp5 = 10.0	21,1	42,6

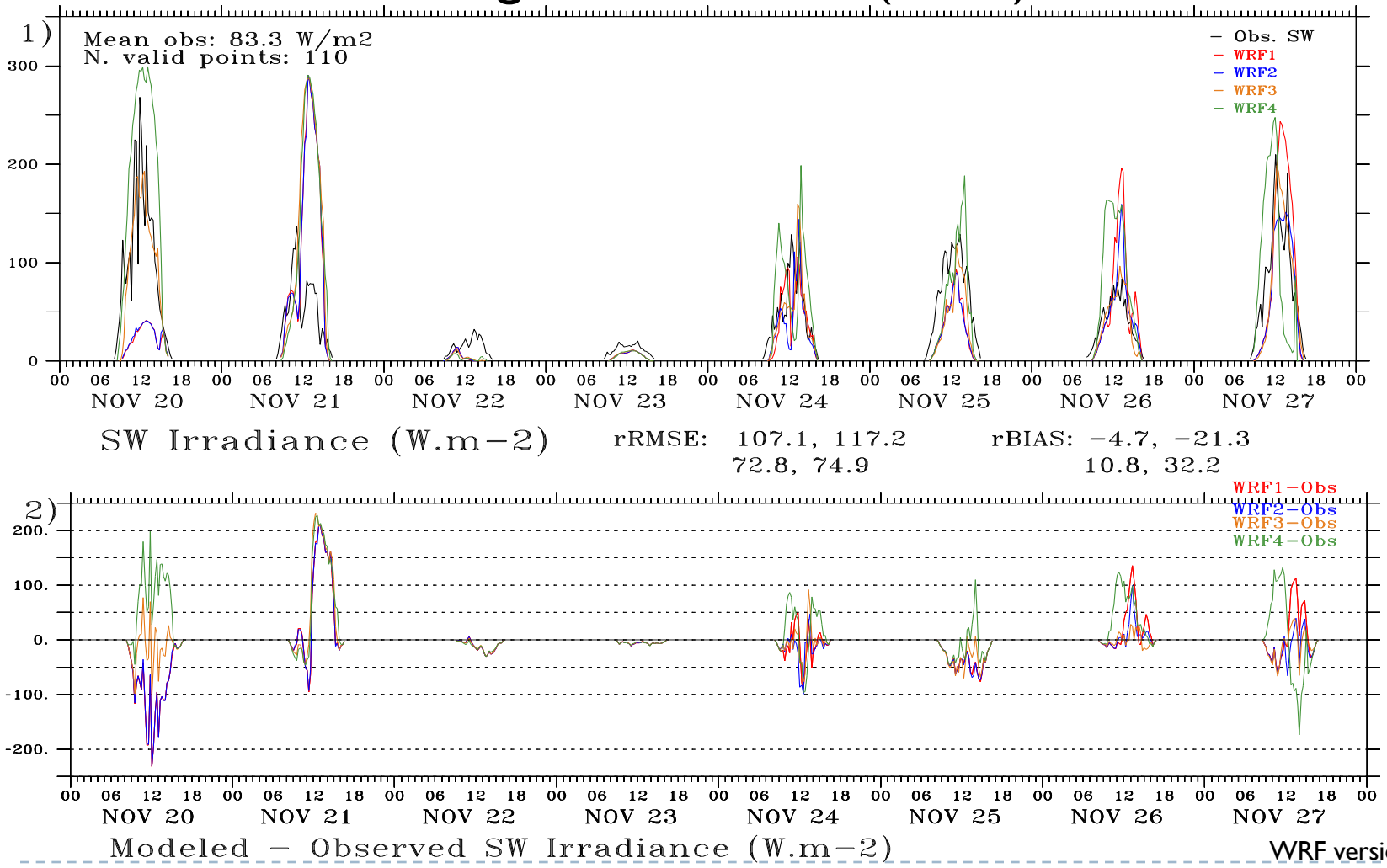
Relative (in %) BIAS and RMSE for the modelling of solar irradiance (SWD) using different WRF versions at Liège (Sart-Tilman)

Alp5 : in winter → reduced negative BIAS for increasing values
→ increase mixing length → fastest cloud clearance

Solar irradiance modelling over Belgium using WRF-ARW :

IV. Focus : modelling of low clouds (St, Sc)

Modelled vs Observed
SWD at Liège (Sart-Tilman)

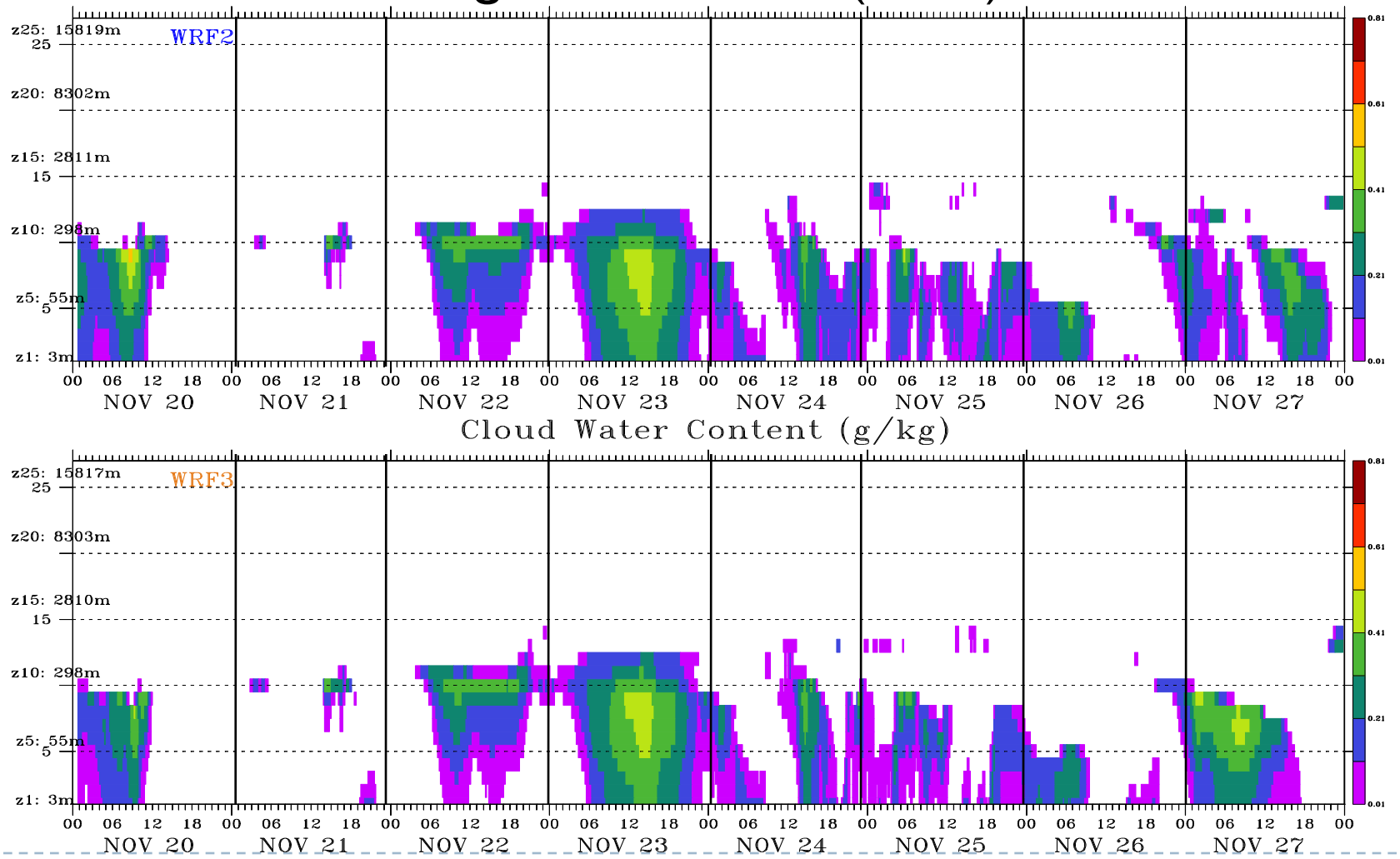


WRF versions :
alp5 = 0.5,1,5,10

Solar irradiance modelling over Belgium using WRF-ARW :

IV. Focus : modelling of low clouds (St, Sc)

Modelled cloud water content over Liège (Sart-Tilman)

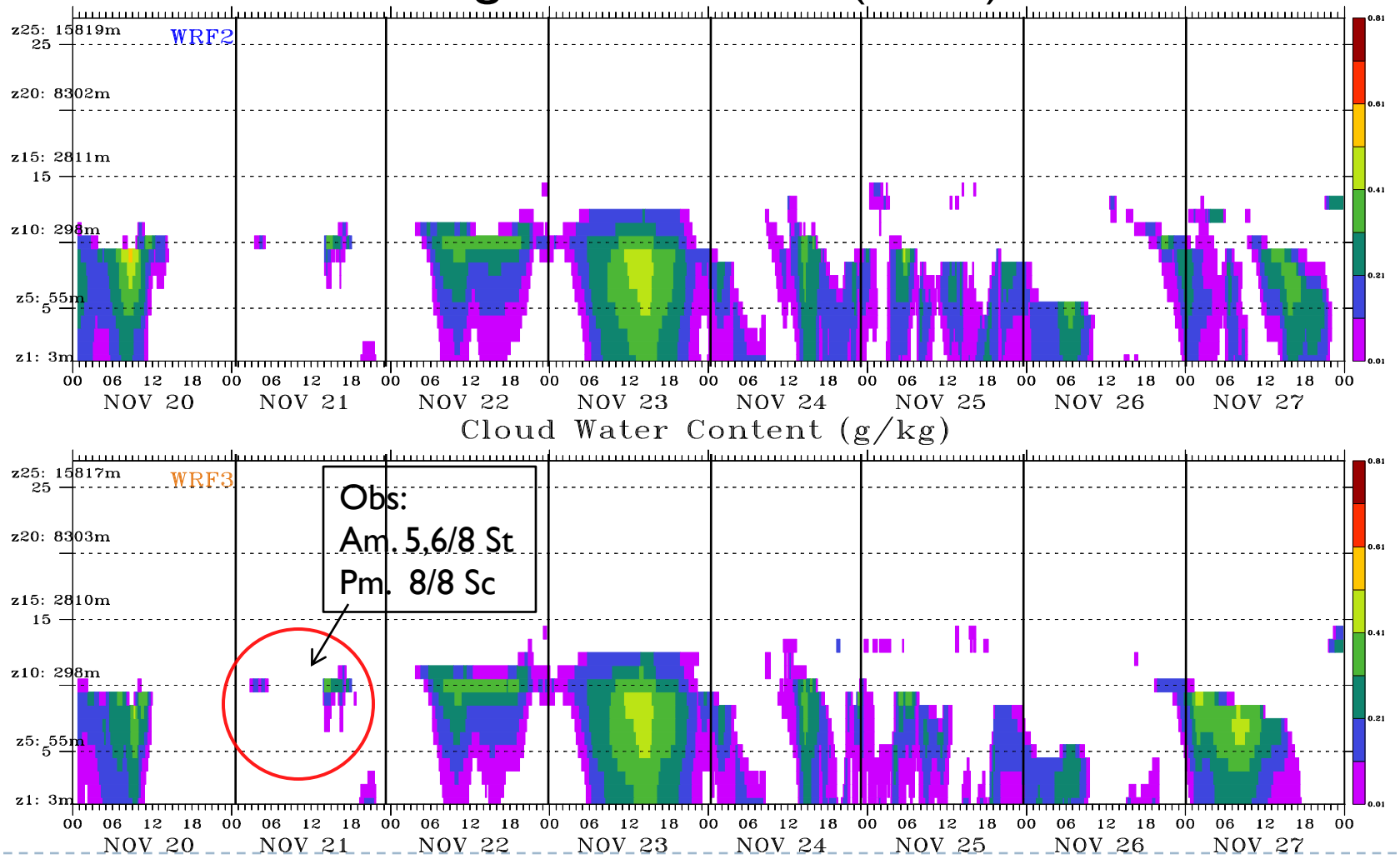


WRF versions : alp5 = 1,5

Solar irradiance modelling over Belgium using WRF-ARW :

IV. Focus : modelling of low clouds (St, Sc)

Modelled cloud water content over Liège (Sart-Tilman)

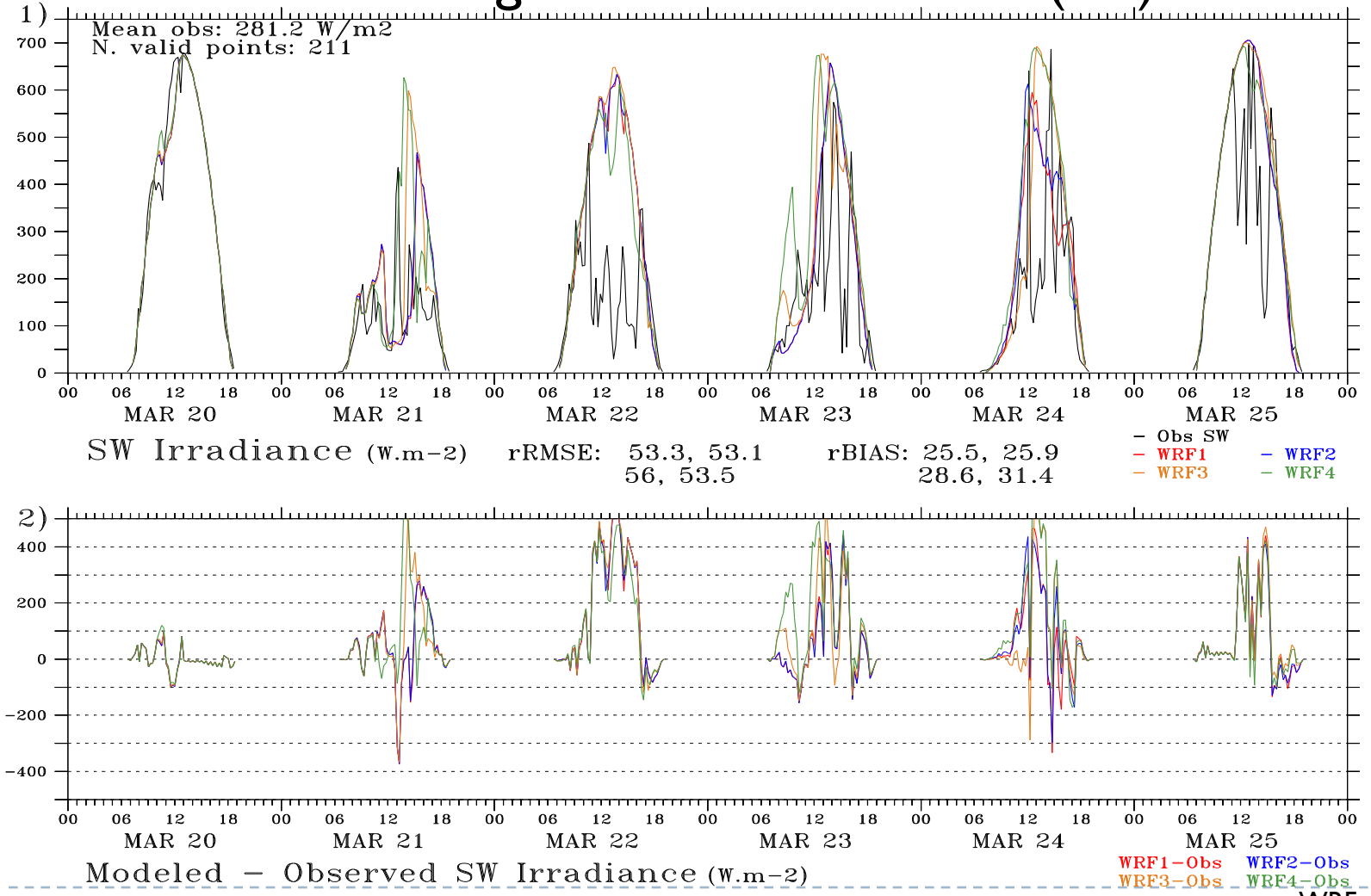


WRF versions :
alp5 = 1,5

Solar irradiance modelling over Belgium using WRF-ARW :

IV. Focus : modelling of convective clouds (Cu)

Modelled vs Observed
SWD at Liège (Sart-Tilman)



WRF versions :
alp5 = 0.5,1,5,10

Solar irradiance modelling over Belgium using WRF-ARW :

IV. Focus : modelling of convective clouds (Cu)

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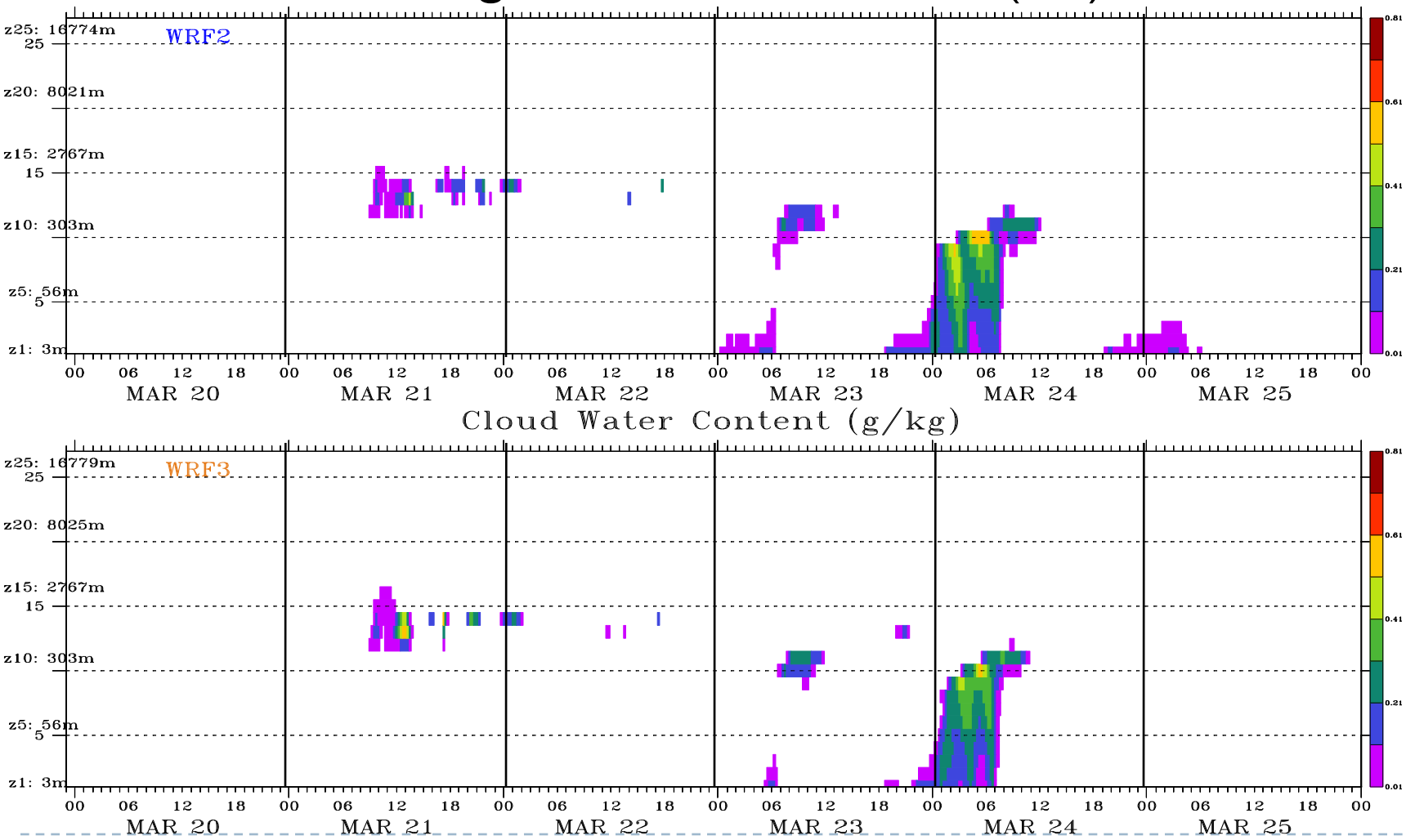
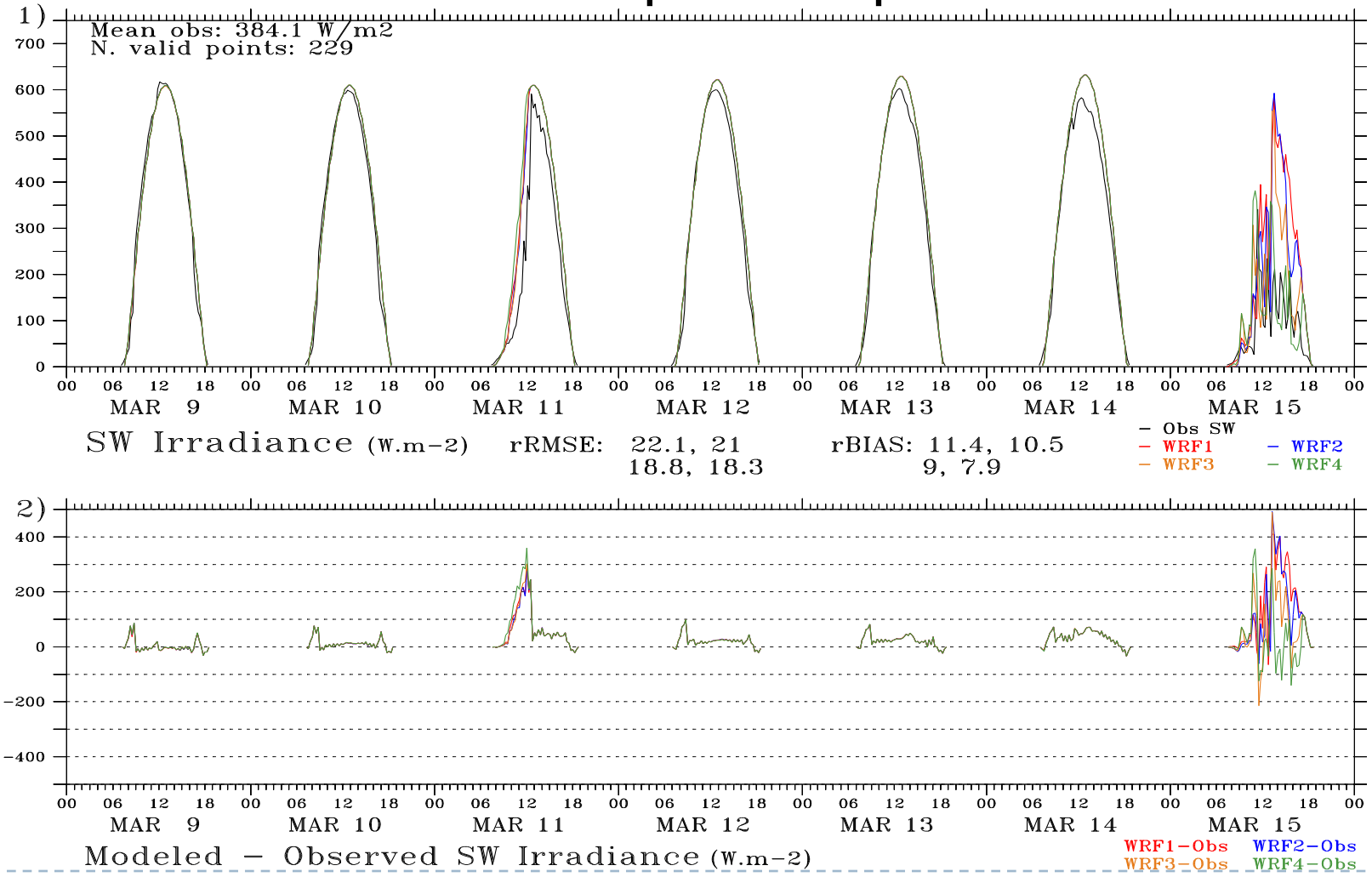


WRF versions :
alp5 = 1,5

Solar irradiance modelling over Belgium using WRF-ARW :

IV. Focus : clear skies and pollution peak?

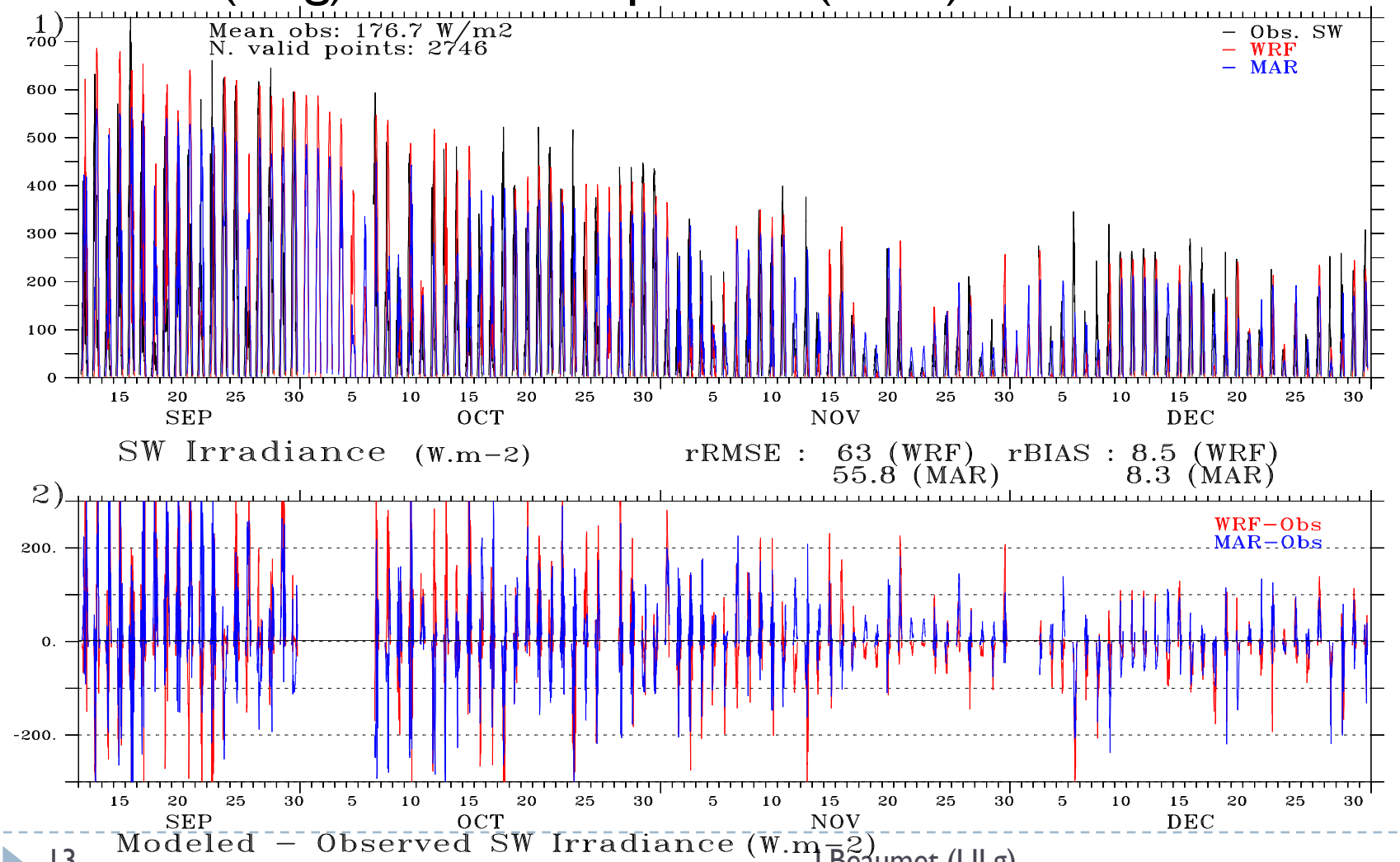
Modelled vs Observed
SWD at Liège (Sart-Tilman)



Solar irradiance modelling over Belgium using WRF-ARW :

V. MAR (ULg) / WRF comparison (2013)

Modelled vs Observed
SWD at Liège (Sart-Tilman)



VI. Conclusions

I. Boundary layer scheme parameters modifications :

- No significant improvement considering long periods
- Lack of convective clouds in WRF simulations unchanged
- Possible strategy for ensembles forecasts

II. Encouraging results for MAR model

Solar irradiance modelling over Belgium using WRF-ARW :

Reference

Nakanishi M. and Niino H., 2004. An improved Mellor Yamada Level-3 model with Condensation physics : its design and verification. *Boundary-Layer Meteorology,* **112**, 1-31.

Mellor G. and Yamada T., 1982. Development of a turbulence closure model for geophysical fluid problems. *Reviews of Geophysics,* **20/4**, 851-875.

Kitamura Y., 2010. Modifications of the Mellor-Yamada-Nakanishi-Niino (MYNN) model for the stable stratification case. *Journal of the Meteorological Society of Japan*, **88-5**, 857-864.

Lopez-Coto I., Bosch J., Mathiensen P. and Kleissl J., 2012. Comparison between several parameterization schemes in WRF for solar forecasting in coastal zones. UCAR technical notes.

Questions ?