The effect of the inclusion of online aerosol-cloud feedbacks on solar radiation forecast

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MOTIVATION

- Simulation of clouds is the single major uncertainty in solar energy forecast
- Aerosol-cloud interaction is one of the most influencing and uncertain processes in cloud formation
- Aerosol-cloud feedbacks explicitly simulated only with online meteorological-aerosol-radiation model, such as WRF/Chem used here

TOOLS

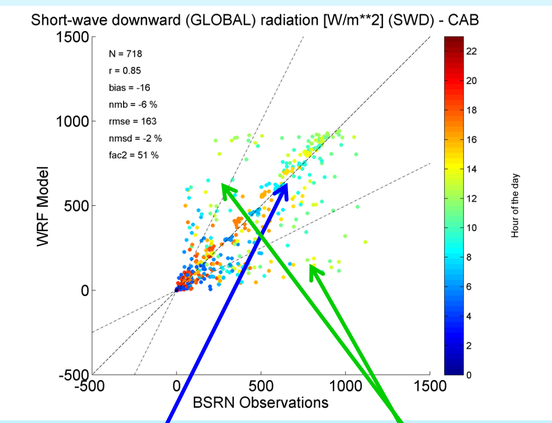
- WRF model, 23 km resolution over Europe
- Simulation period: June 2010, analysis mode (ECMWF operational IC and BC)

Option	WRF	WRF/Chem
Cloud Microphysics	Morrison	Morrison
Cumulus param.	G3	G3
Radiation	RRTMG	RRTMG
PBL scheme	YSU	YSU
LSM	Noah	Noah
Aerosol	-	MADE/VBS with cloud-rad feedback

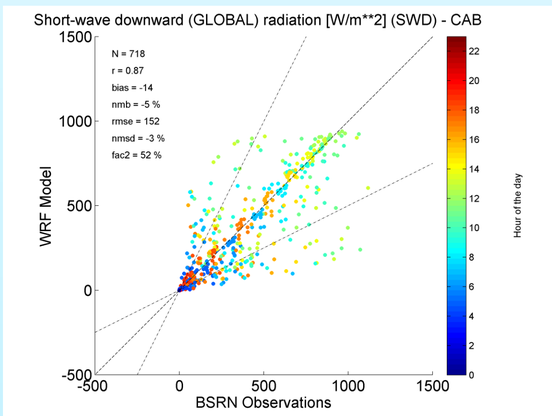
- Comparison with quality-checked ground radiation data from Baseline Surface Radiation Network (BSRN) at five available locations

RESULTS: SHORT-WAVE DOWNWARD RADIATION AT GROUND

WRF vs BSRN in CABAUW



WRF/Chem vs BSRN in CABAUW



WRF has a tendency to overestimation during clean days

Slightly prevalent underestimation during cloudy days

WRF/Chem reduces the bias both during clean and cloudy days

WRF/Chem Short-wave radiation generally improves over WRF at all stations

	CAB		CAR		CNR		PAY		TOR	
SWD (W/m²)	WRF	WRF/Chem	WRF	WRF/Chem	WRF	WRF/Chem	WRF	WRF/Chem	WRF	WRF/Chem
correlation	0.85	**0.87**	0.89	**0.90**	0.87	0.87	0.83	**0.85**	0.85	**0.88**
relative bias (%)	-6	**-5**	7	**6**	-10	**-7**	-1	**0**	**9**	13
RMSE (W/m²)	163	**152**	163	**157**	159	**157**	185	**175**	141	**130**

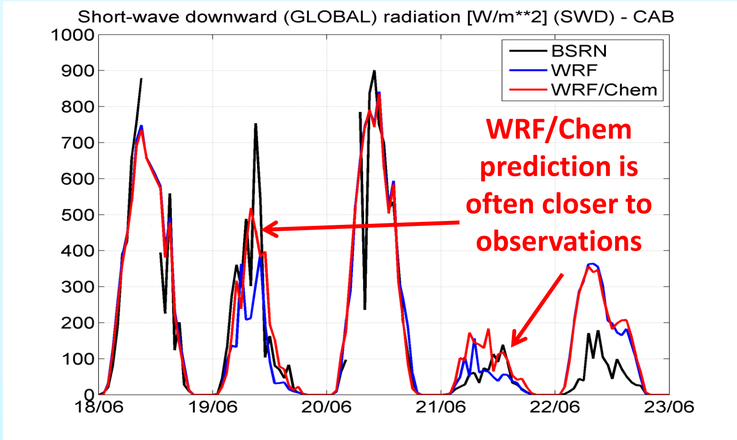
Also surface temperature benefits of a better short-wave simulation

	CAB		CAR		CNR		PAY		TOR	
TEMP (°C)	WRF	WRF/Chem	WRF	WRF/Chem	WRF	WRF/Chem	WRF	WRF/Chem	WRF	WRF/Chem
correlation	0.91	0.91	0.90	0.90	0.93	0.93	0.90	**0.91**	-	-
relative bias (%)	-7	**-5**	-6	**-4**	-15	**-14**	-17	**-15**	-	-
RMSE (°C)	2	2	3	**2**	3	3	4	**3**	-	-

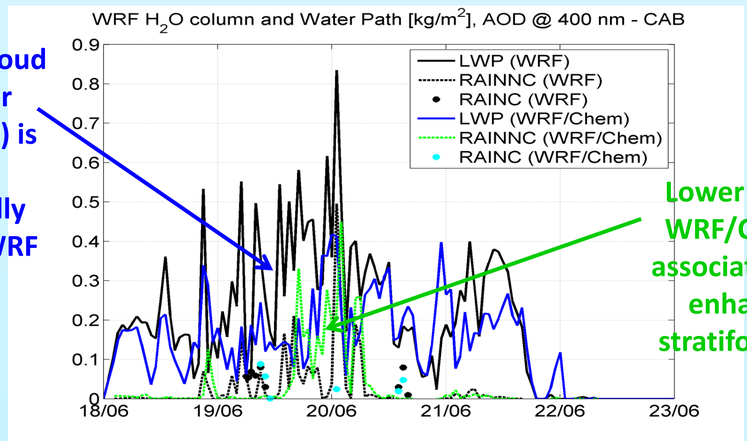
CONCLUSIONS

- WRF generally produces too optically thick clouds and thus tends to underestimate solar surface radiation at the ground on cloudy days.
- WRF/Chem simulates clouds with less liquid water content than WRF and more stratiform rain
- WRF/Chem generally improves the simulation of surface radiation and temperature a the ground
- Considering the low resolution (23 km) this is a promising result for a better forecast of solar energy with WRF/Chem.

RESULTS: FOCUS ON CABAUW 18-22 June

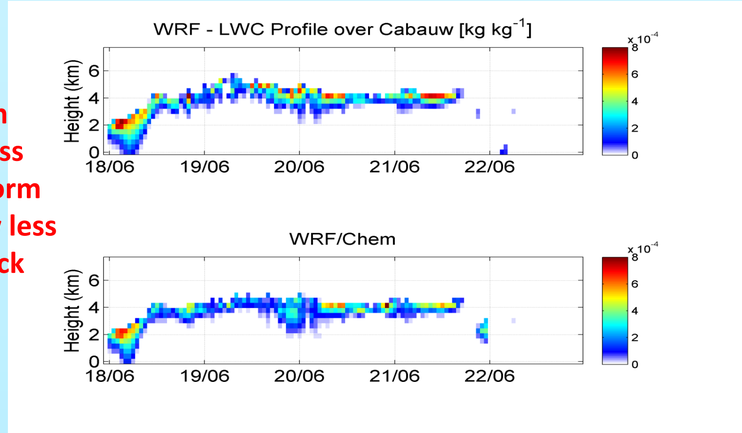


WRF/Chem cloud liquid water column (LWP) is almost systematically lower than WRF

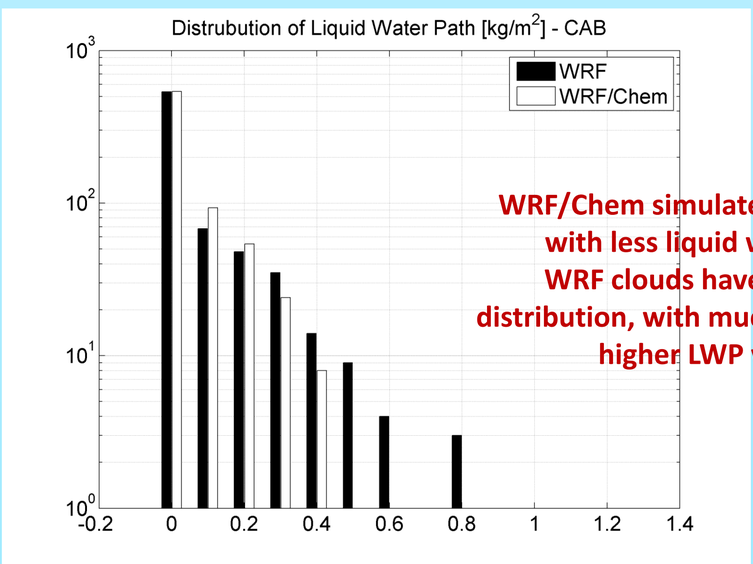


Lower LWP in WRF/Chem is associated with enhanced stratiform rain

WRF/Chem simulates less dense stratiform clouds, usually less optically thick than WRF



DISTRIBUTION OF LIQUID WATER PATH



WRF/Chem simulates more clouds with less liquid water path. WRF clouds have a broader distribution, with much more cases at higher LWP values.