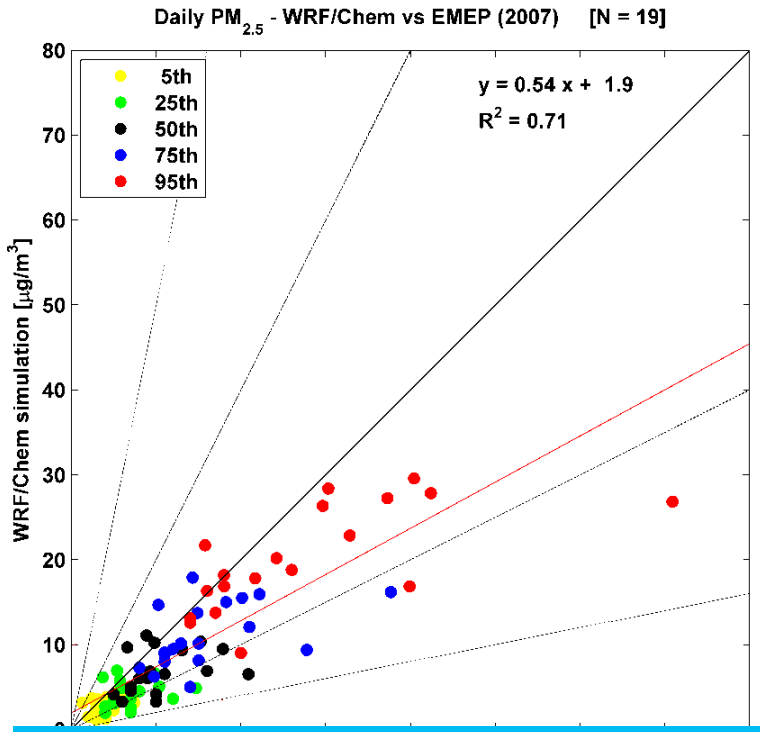
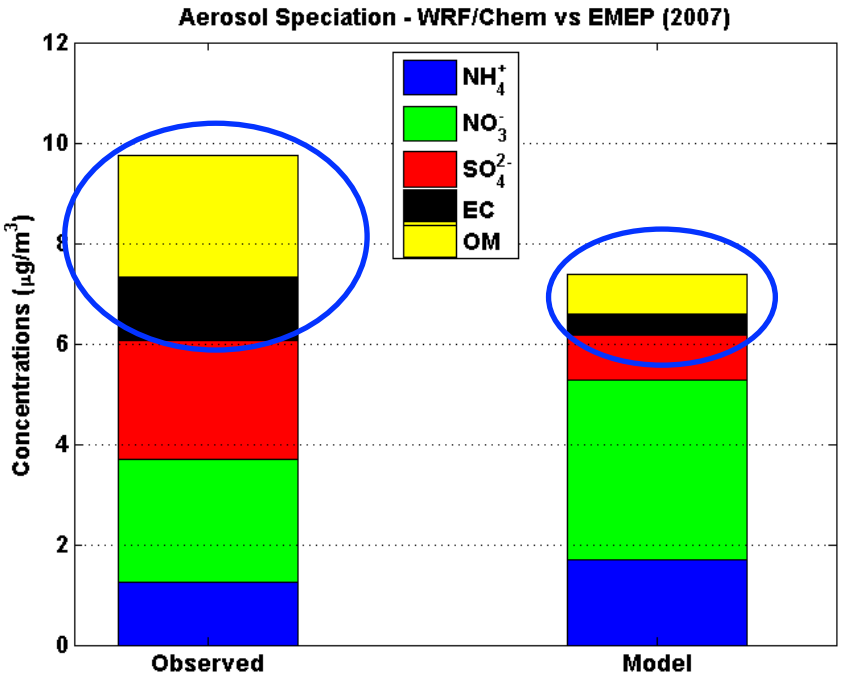
Simulation of aerosol-cloud-radiation interaction over Europe with a new SOA scheme within WRF/Chem: Evaluation against IMPACT-EUCAARI and MODIS data

Paolo Tuccella, Gabriele Curci, Guido Visconti, Suzanne Crumeroylle, Jean-Christophe Raut, and Kathy Law

Background and motivations



Using the traditional configuration (RADM2/MADE/SORGAM), PM2.5 mass is underestimated by a factor of 2.



The underestimation is due to carbonaceus fraction.
OM bias: -76%!!!

[Tuccella et al., JGR, 2012]

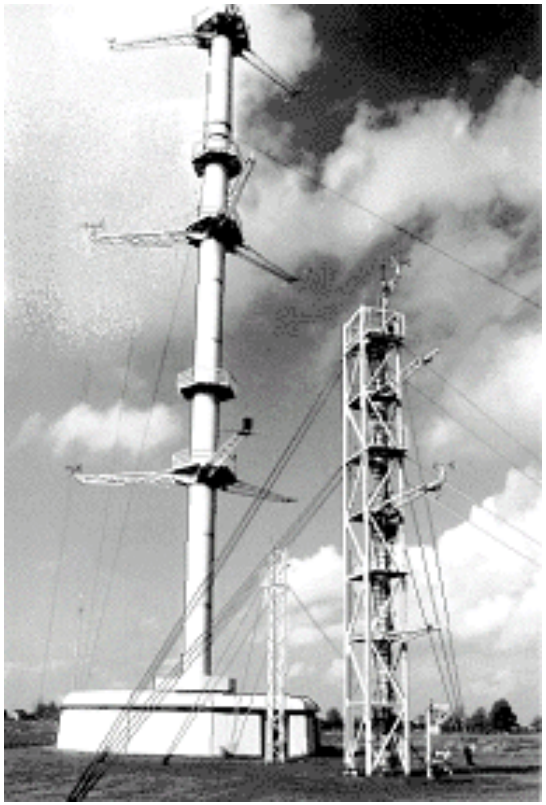
THE RACM/MADE/SOA-VBS MECHANISM

[Ahmadov et al., JGR, 2012]

1) The production of SOA is based on the Volatility Basis Set approach (VBS).
2) The new scheme contains 4 volatile bins for each SOA class (16 SOA and 8 OCVs).
3) The SOAs are formed by anthropogenic and biogenic sources.
4) The gas phase chemistry is simulated with the Ragional Atmospheric Chemistry Model (RACM)
5) Particle parameterization: MADE.

SOA-VBS scheme was coupled with radiation and cloud microphysics using the existing treatment for aerosol feedback *[Fast et al., JGR, 2006; Chapman et al., ACP, 2009]*

MODEL EVALUATION: IMPACT-EUCAARI CAMPAIGN



Comparison of WRF/Chem results to observations issued in the frame of *Intensive Cloud Aerosol Measurement Campaign* (IMPACT) of EUCAARI project.

During IMPACT campaign aerosol and cloud measurements were collected at the Cabauw Tower (near Amsterdam, The Netherlands) and aboard of the ATR-42 aircraft above The Netherlands.

[Kulmala et al., ACP, 2009]

WRF/Chem CONFIGURATION AND SETUP

PROCESS	WRF/Chem OPTION
Cloud Microphysics	Morrison
Long-wave Radiation	RRTMG
Short-wave Radiation	RRTMG
Land Surface Model	Noah
Surface Layer	Monin-Obukov
Boundary Layer	MYNN2
Cumulus Convection	Grell New (domain 1 and 2)
Photolysis	Fast-J
Gas Chemistry	RACM
Aerosol Scheme	MADE / VBS
Aerosol Direct and Indirect Eff.	Yes
Wet deposition	Updraft and large scale
Aqueous Chemistry	Updraft and large scale (CMAQ)

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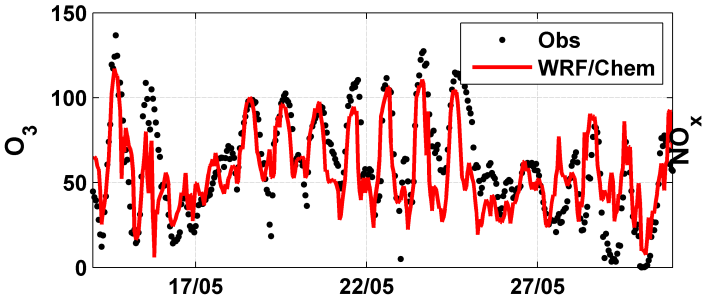
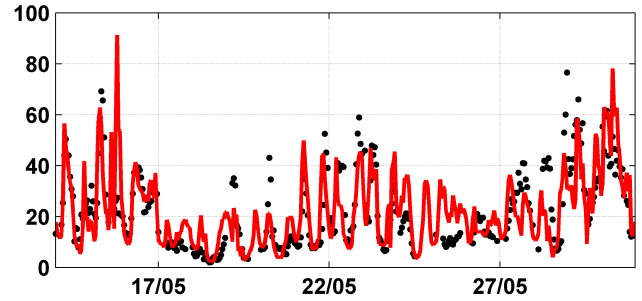
Simulate
14-15 Ma
16-20 Ma
From 23 May: period dominated by long range transport from Sahara desert and passage of several fronts.

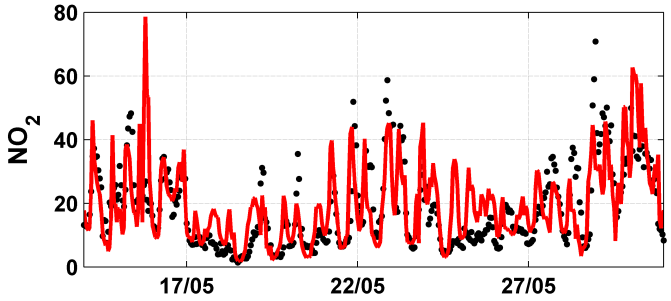
SURFACE GAS PHASE

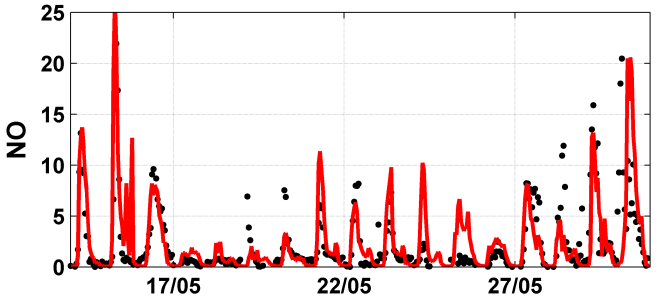




O_3 corr. 0.72

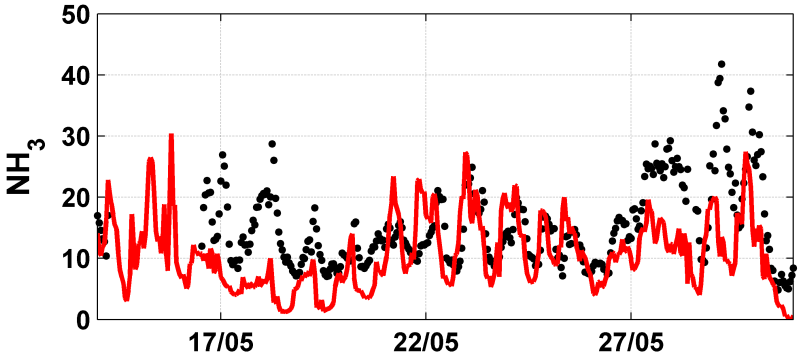
NO_x corr. 0.70





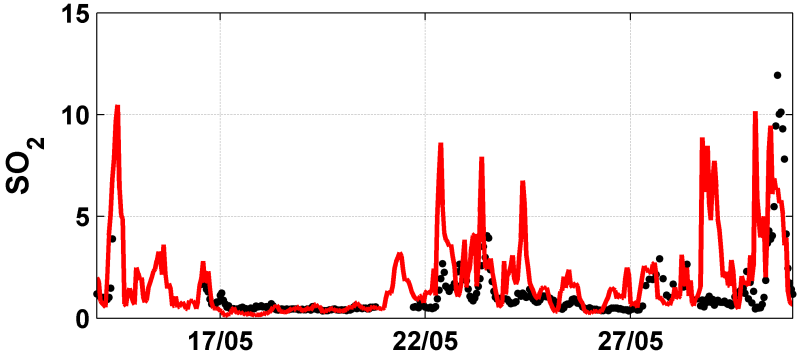
NO corr. 0.65

NO_2 corr. 0.66



CORR: 0.43

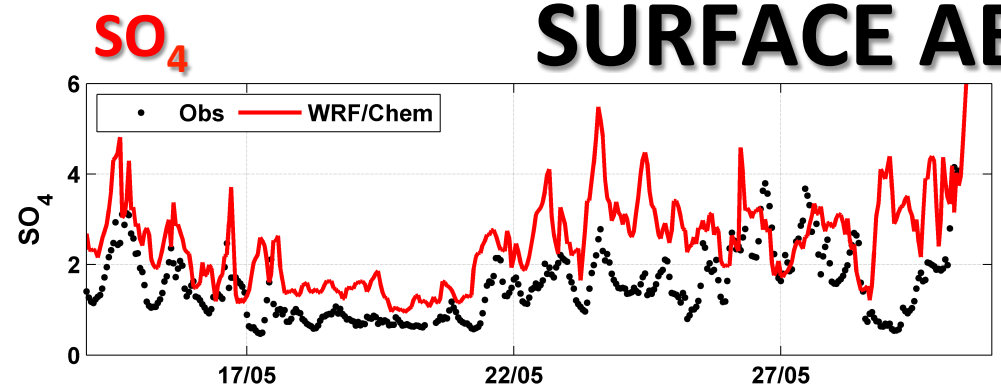
BIAS: -28%

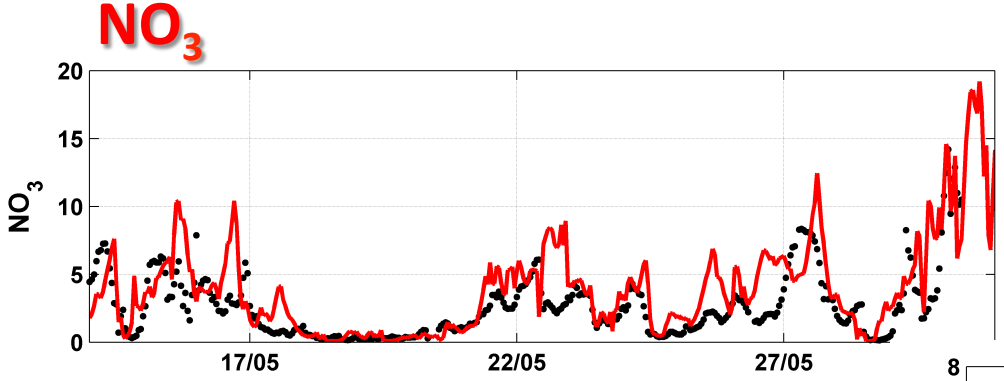


CORR: 0.48

BIAS: +90%

SURFACE AEROSOLS



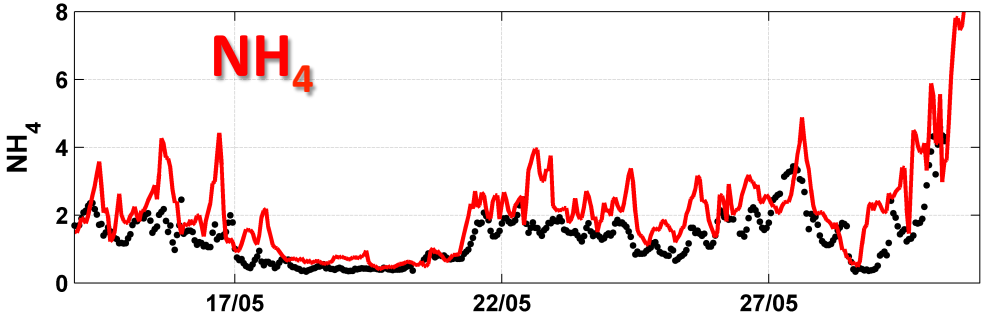


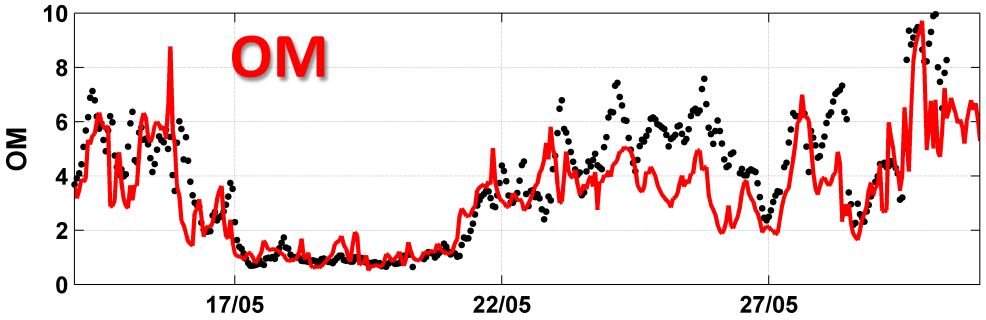
SO_4 is overestimated (due to SO_2 overestimation and excessive production within the clouds).

Modelled NO_3 does not present a systematic bias.

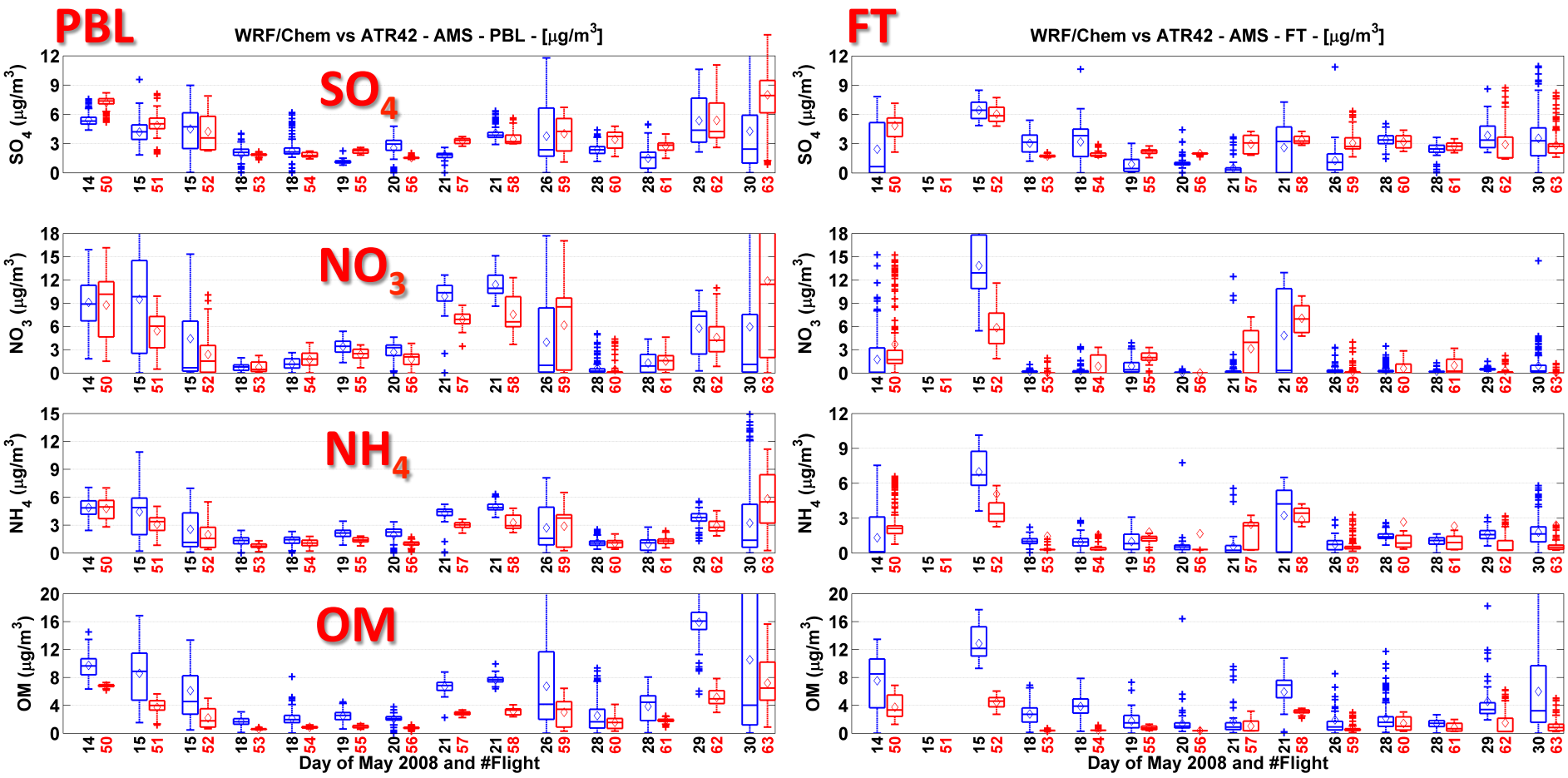
NH_4 is related to the modelled trend of NO_3.

OM is underetsimated by 0.4 µg/m³.





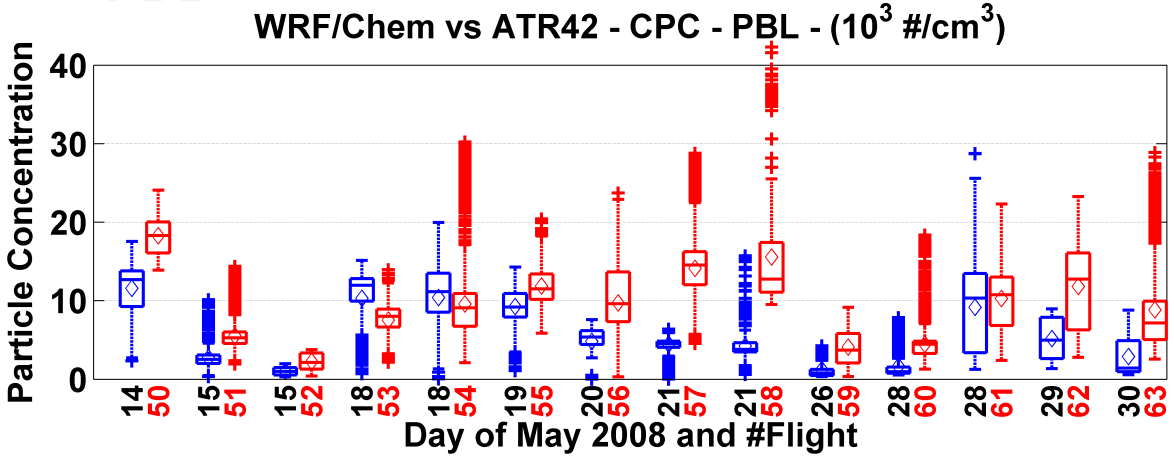
AIRCRAFT DATA: AEROSOL MASS



- SO_4 is overestimated in most of the flights
- NO_3 and NH_4 are underpredicted in 8/14 flights
- Predicted OM concentration is at lower end of the observed variability

AIRCRAFT DATA: AEROSOL PARTICLES

PBL

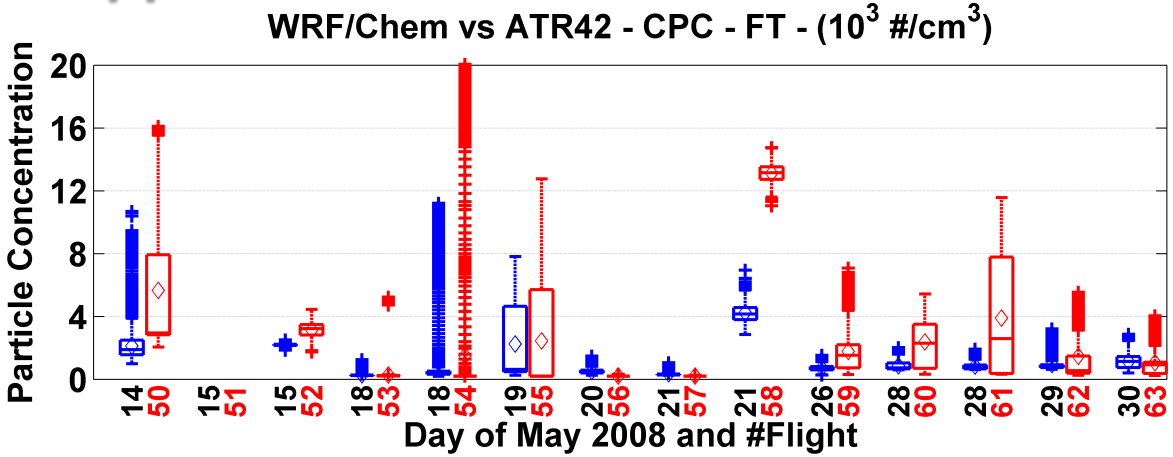


PBL: In average WRF/ Chem overestimates the CN by a factor 1.4

FT: In average WRF/ Chem overestimates the CN by a factor 1.7

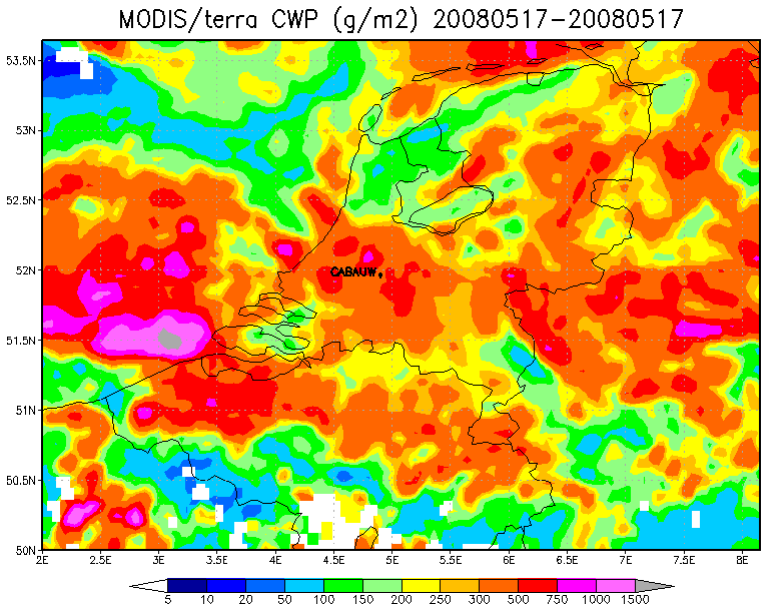
Positive bias may be due to an excessive nucleation and/or to uncertainties of the anthropogenic emissions of primary aerosols .

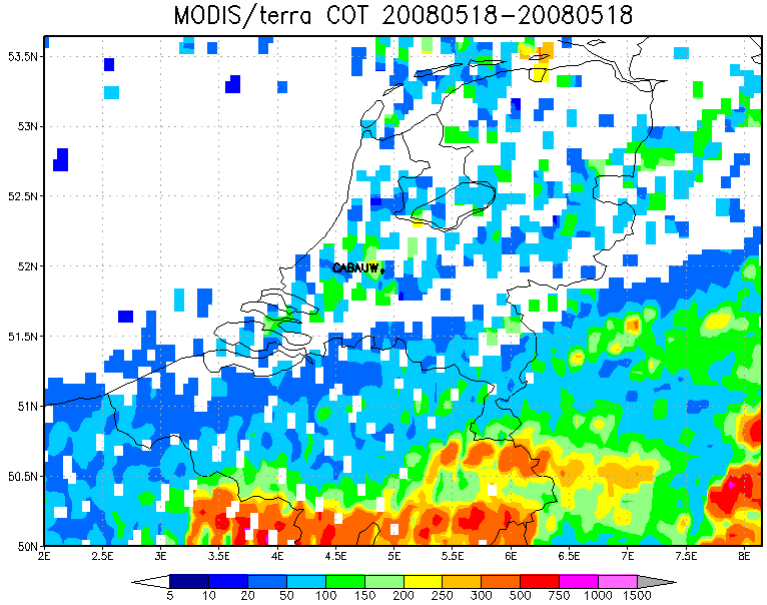
FT



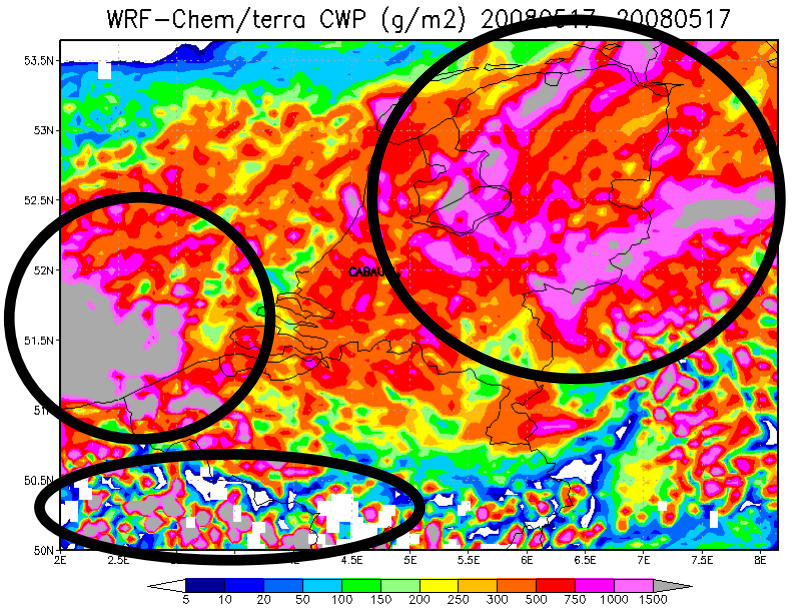
WRF/CHEM vs MODIS CWP

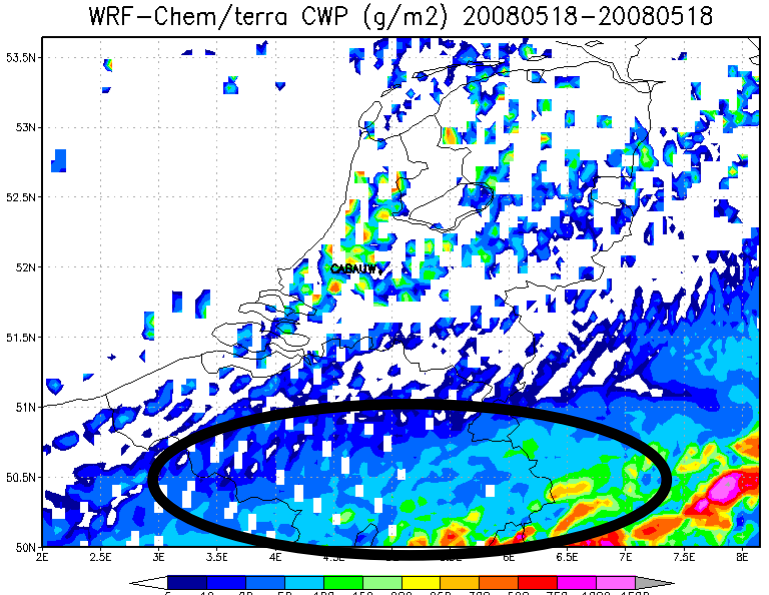
MODIS TERRA L2





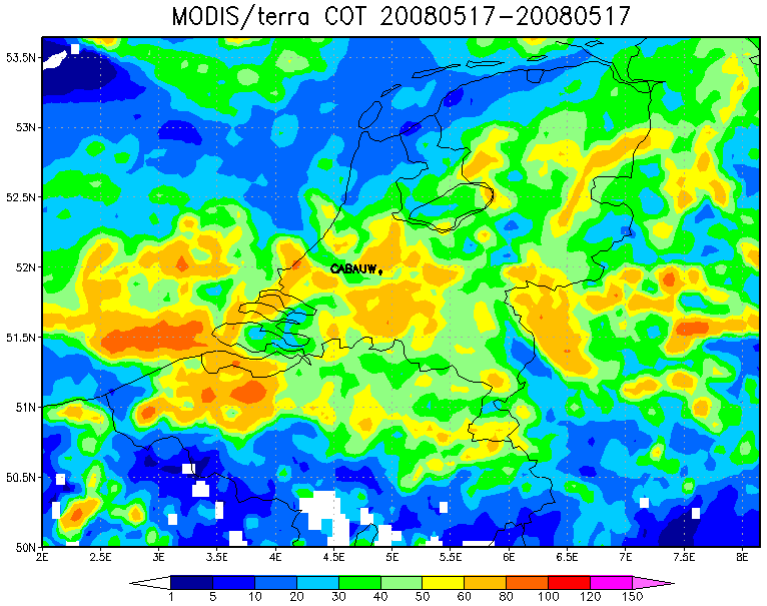
WRF/CHEM



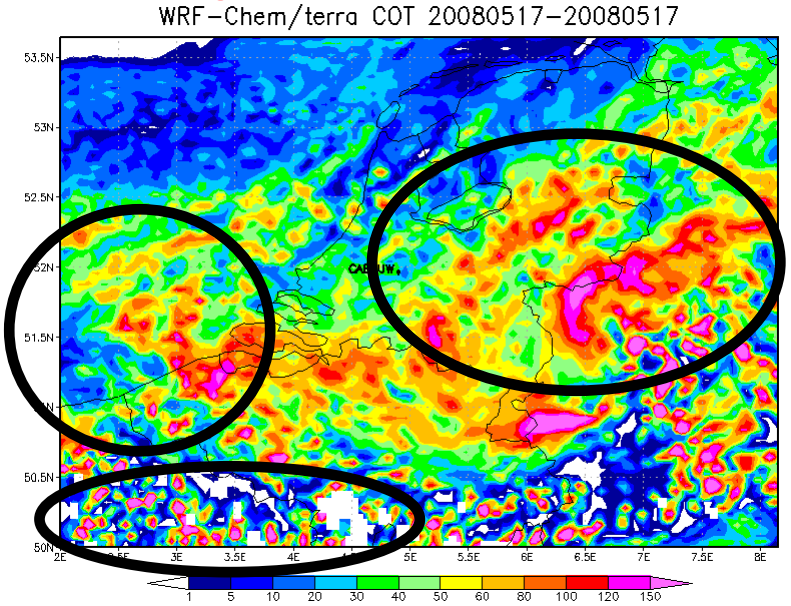


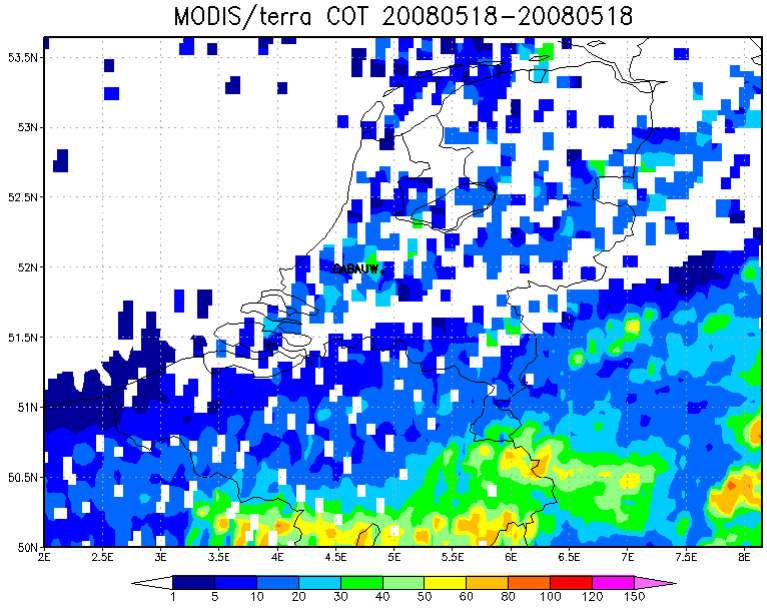
WRF/CHEM vs MODIS COT

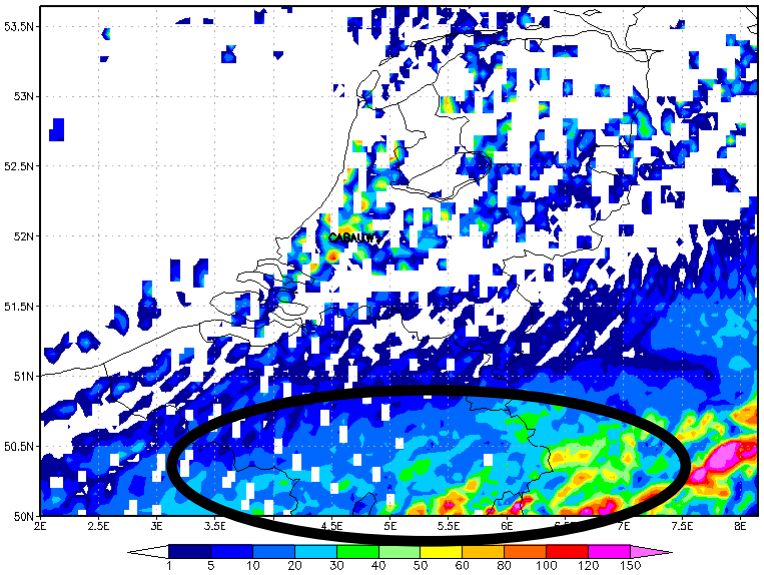
MODIS TERRA L2



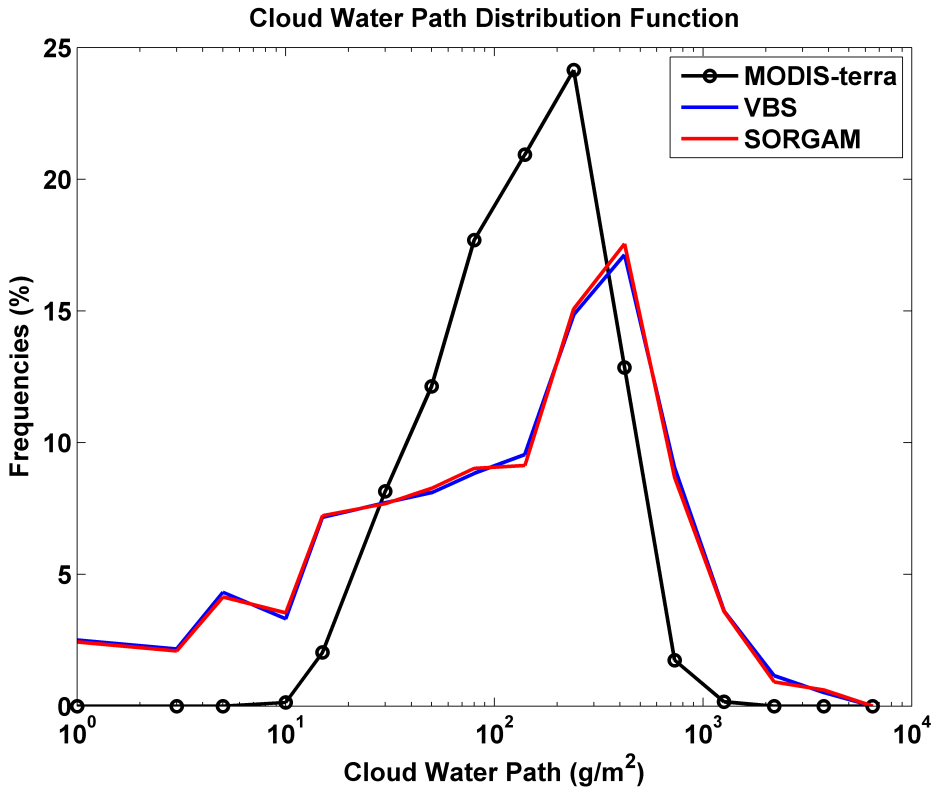
WRF/CHEM

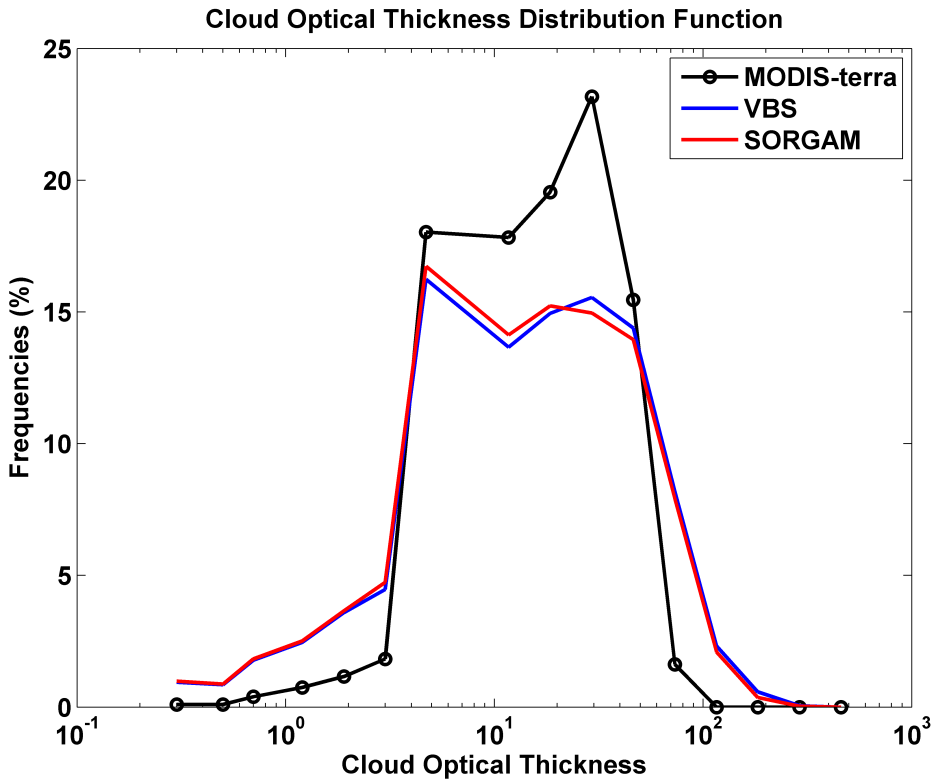






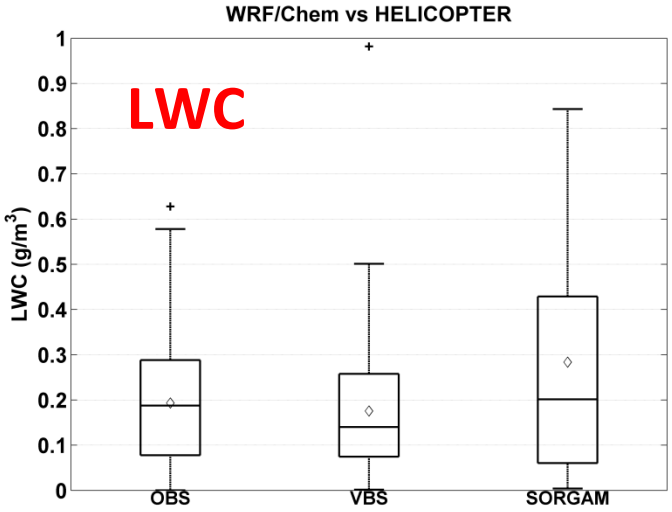
VBS vs SORGAM – MODIS DATA (17-18/05/2008)



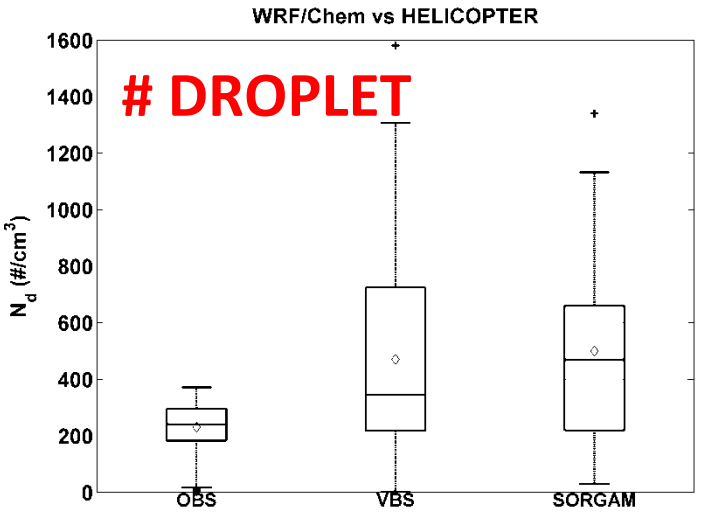


- In both cases, WRF/Chem overestimates the lower/higher end of the distribution functions. The maximum frequencies are underestimated by VBS and SORGAM models
- VBS does not affect the regional distribution functions of the CWP and COT.
- Is it the same at the local scale???

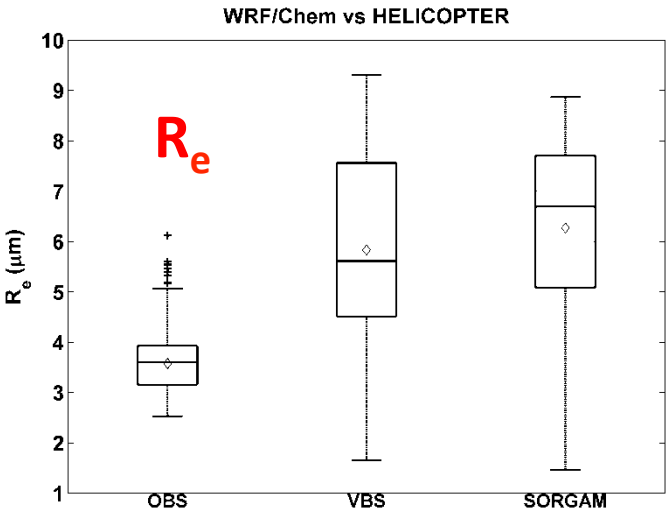
VBS vs SORGAM – HELICOPTER DATA (CABAUW, 18/05/2018 10:00 UTC)

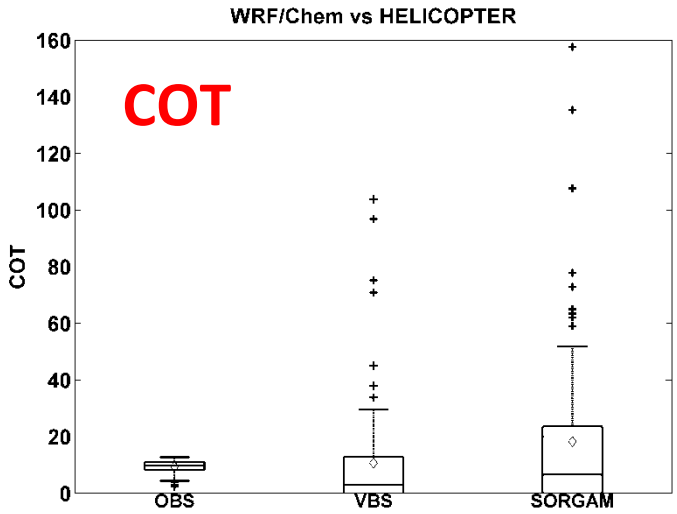


OBS VBS SORGAM



OBS VBS SORGAM





The VBS improves the simulation of cloud-top microphysical properties and COT at local scale.

THANKS FOR YOUR ATTENTION!!!

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asi
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PRISMA

ECLIPSE