Impact of explicit and non-explicit treatment of aerosols on simulated deep convective cloud properties

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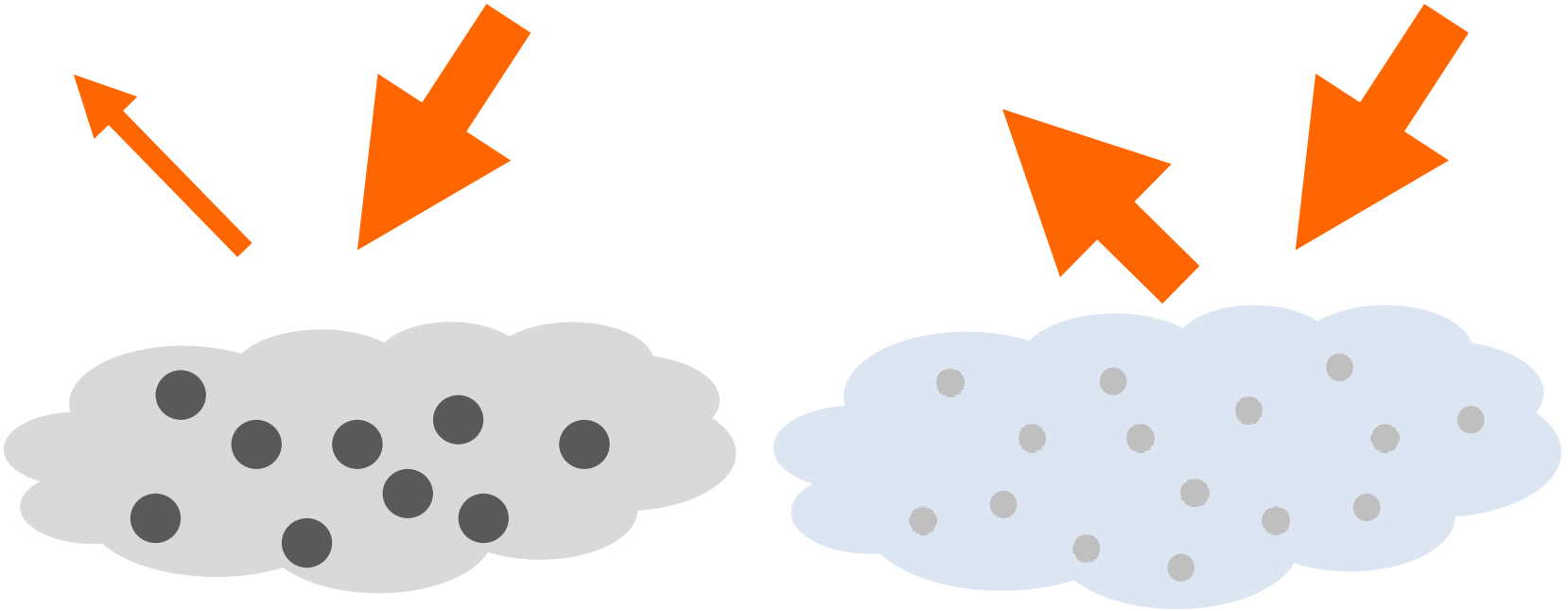
The (first) aerosol indirect effect



Low aerosol loading

High aerosol loading

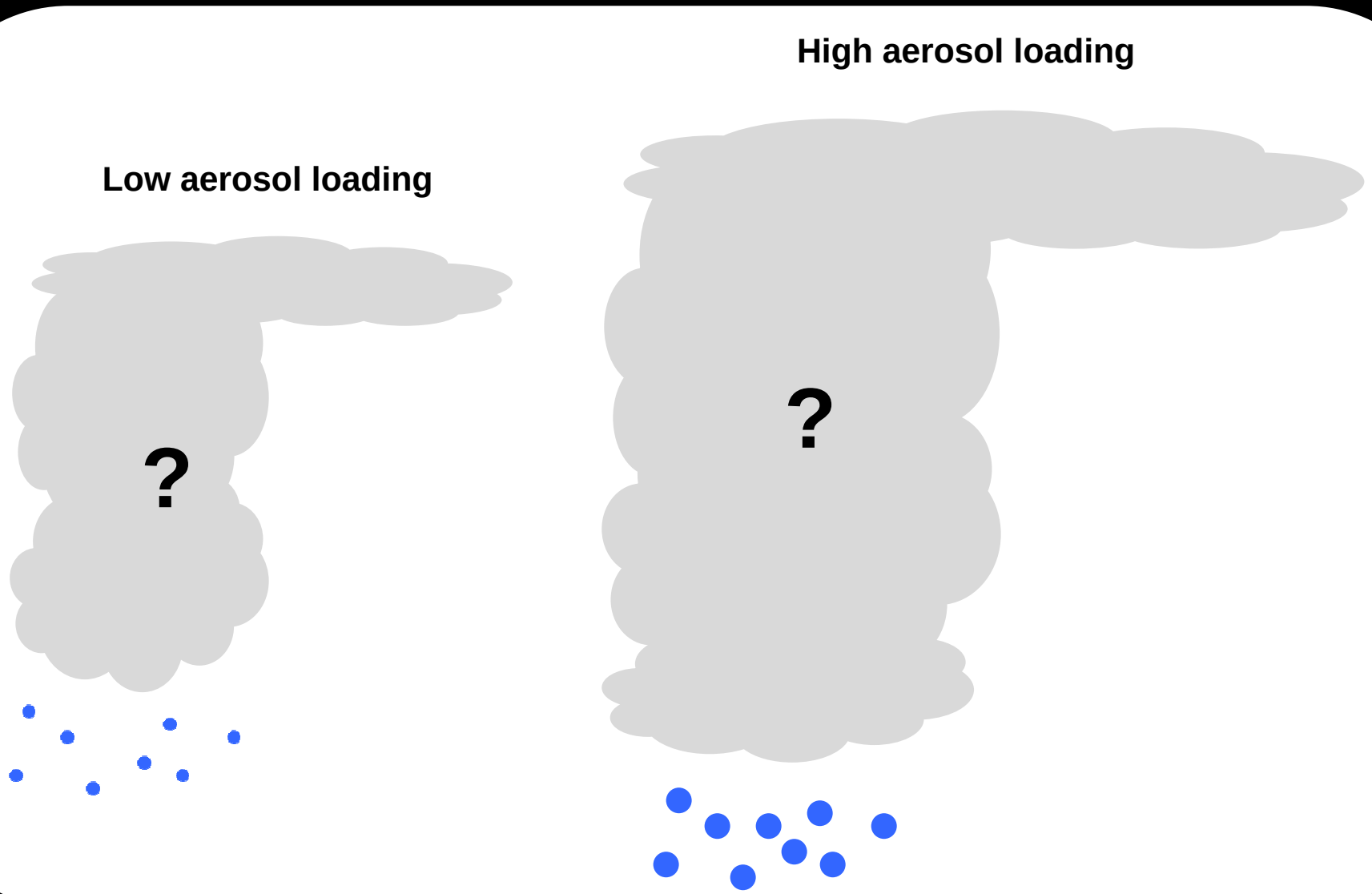
The (second) aerosol indirect effect

Low aerosol loading

High aerosol loading

But this is mainly for warm phase clouds ..

What's the effect on deep convection?



What do models say?

- Increasing precip (Andreae et al., 2004; Lin et al., 2006; van den Heever, 2006; Zhang et al., 2007: Fan et al., 2007;)
- Decreasing precip (Rosenfeld, 1999, 2000; Khain et al., 2004; Lynn et al., 2005; Cui and Carslaw, 2006)
- Could be both (Khain and Pokrovsky, 2004; Wang, 2005;Teller and Levin, 2006;; van den Heever et al., 2006; Ekman et al., 2007; Lee et al., 2008; Rosenfeld et al., 2008)

What is the large-scale effect?

	High CAPE/ Strong Shear	High CAPE/ Weak shear	Moderate CAPE	Low CAPE	Very Low CAPE
Precip. diff. [mm] High-Low Aerosol	12.07	4.51	1.83	-1.09	-0.41

From Lee et al., 2008, JGR

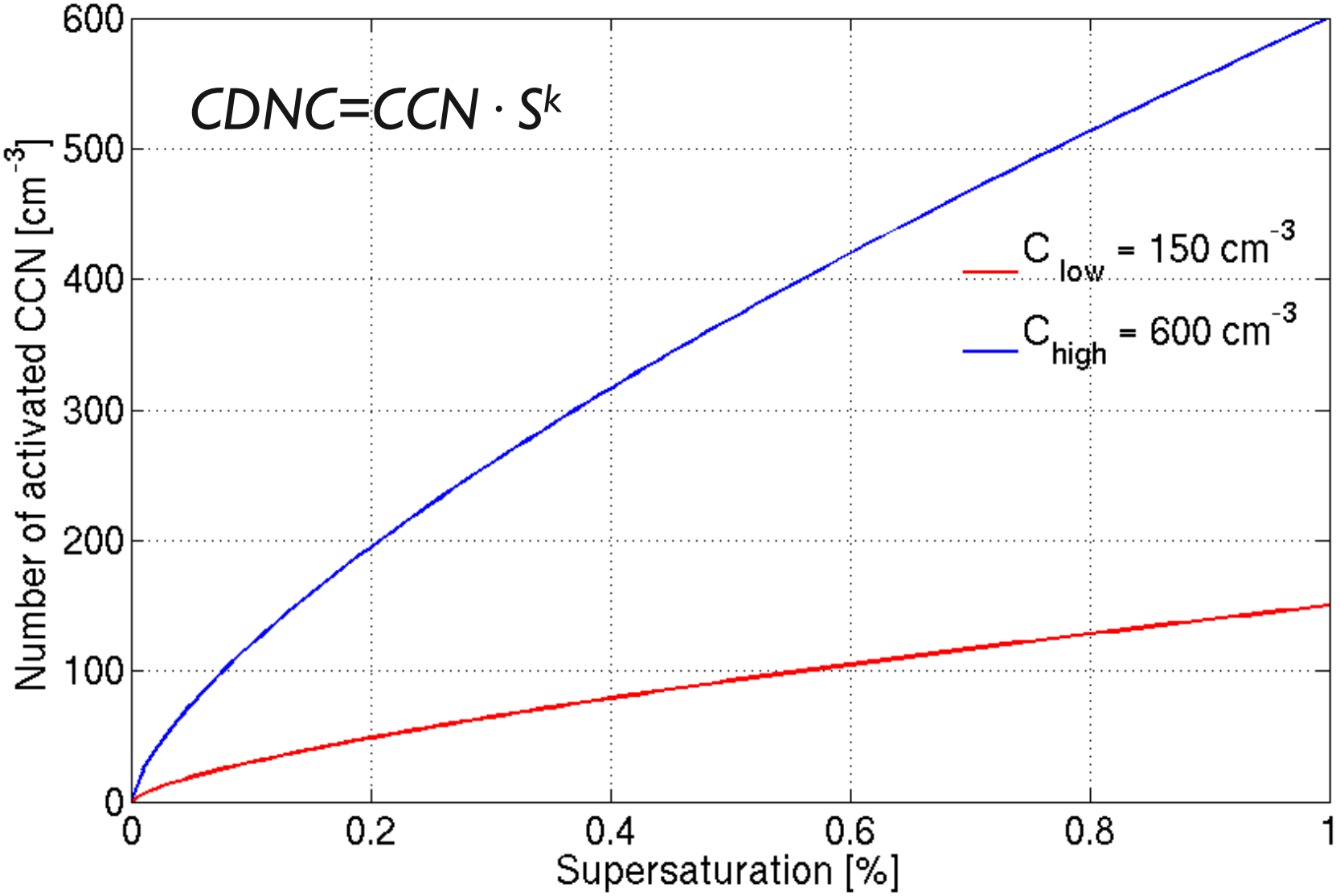
Purpose of study

- Test three different modules of aerosol/CCN activation in a cloud-resolving model (CRM)
- Test the sensitivity of each model version to changes in aerosol/CCN concentration (i.e. perform one ”clean” and one ”polluted” simulation)

Modules of aerosol/CCN activation

Module	Characteristics
EMP-CONST	Empirical relationship for calculating number of activated CCN. Constant CCN concentration.
EMP-ADV	Empirical relationship for calculating number of activated CCN. CCN advected, and nucleation/impact
KÖHLER-AERO	CCN concentrations determined from fully interactive aerosol physics-chemistry model. CCN calculated using Köhler theory .

Empirical model (used for EMP-runs)



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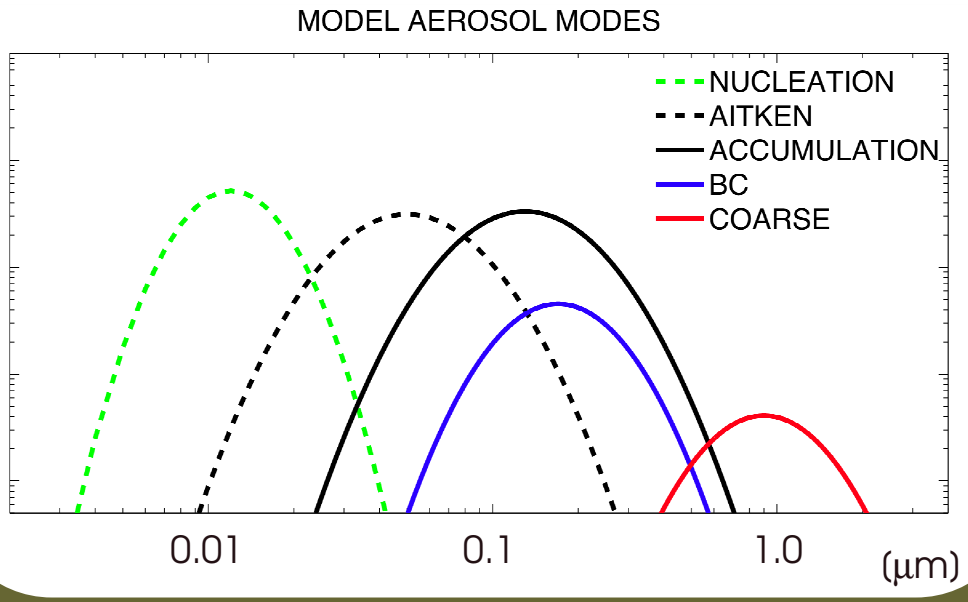
Cloud-Resolving Model (CRM)

Aerosols
(provide IN & CCN)



- Binary (H_2SO_4-H_2O) nucleation
- Coagulation
- Condensation of H_2SO_4

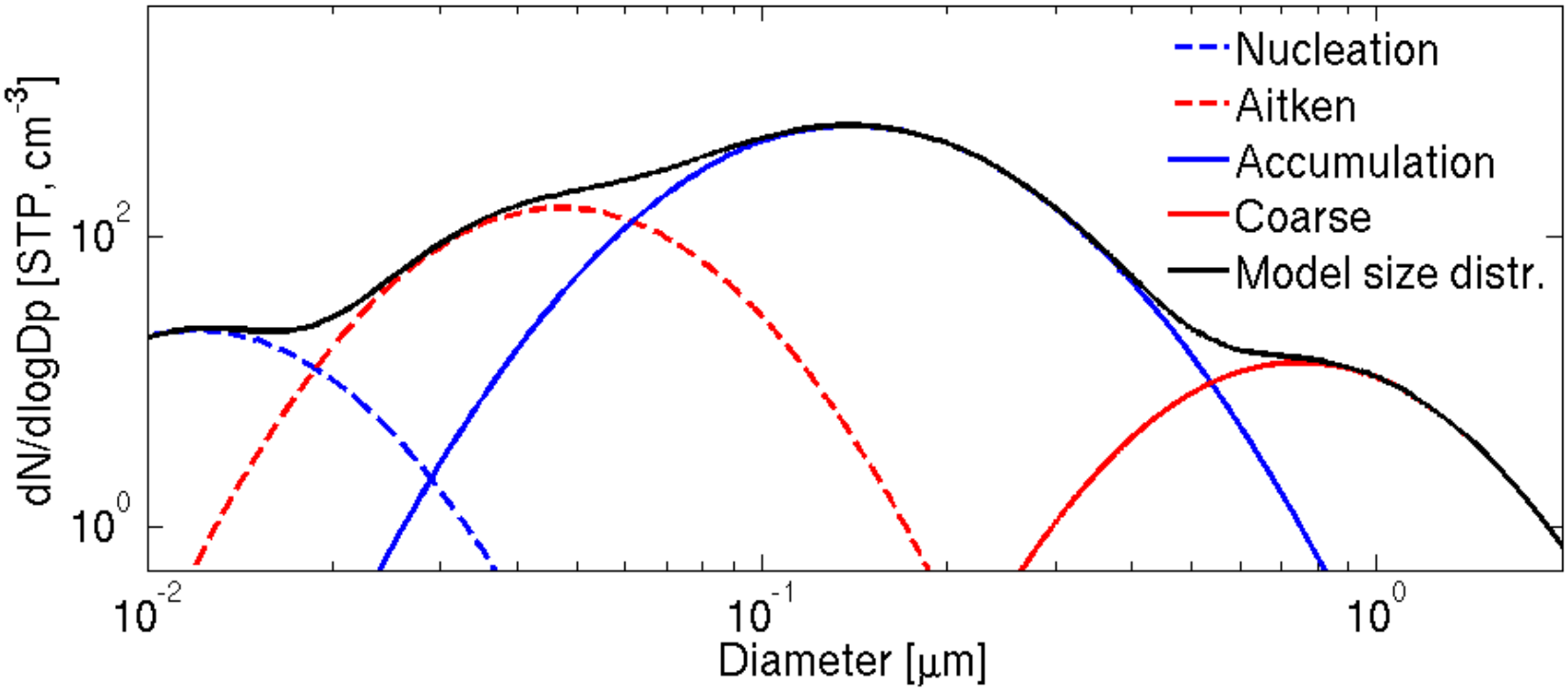
Radiation
δ-four-stream
including ice cloud

Cloud
Physics & Dynamics
4 types of Hydrometeors
(Q & N)

Chemistry
Species: 25g+16c,r+7i
Reactions:
35g + 21eq + 32aq + 7h

References: Wang and Chang, 1993; Wang et al., 1995; Wang and Prinn, 2000; Wang 2002; Ekman et al., 2004; Ekman et al., 2006

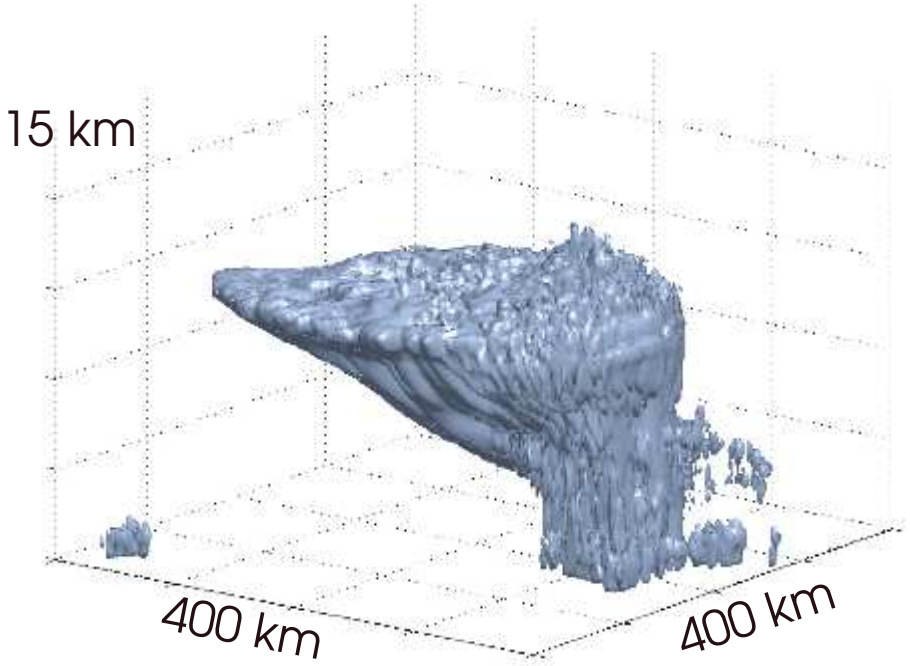
Initial aerosol distribution (for AERO run)

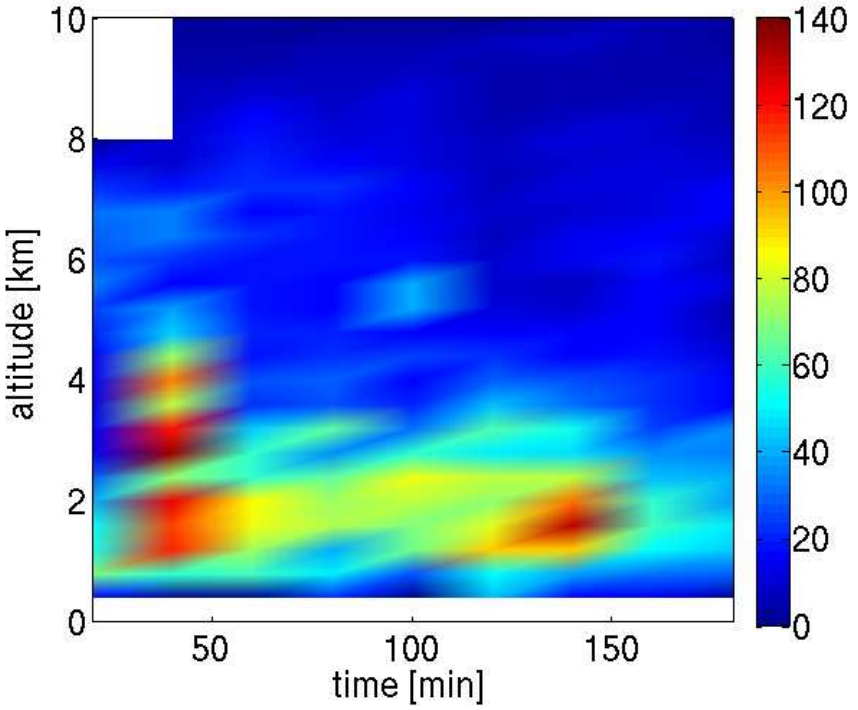


- For EMP runs : all aerosols in Aitken + Accumulation mode are assumed to be potential CCN

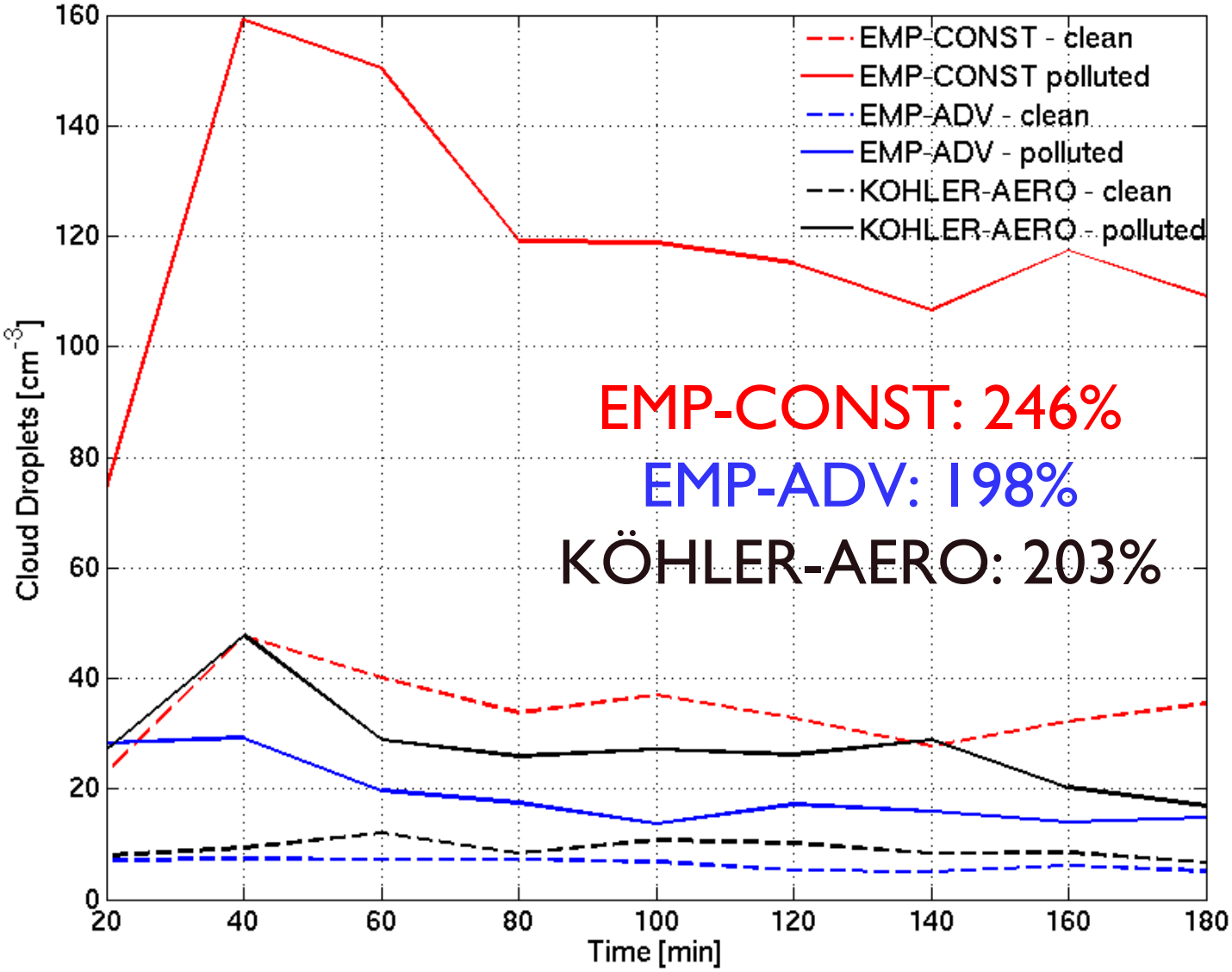
Cloud development

t=3h qtt=0.01 gkg^{-1} CDNC [cm^{-3}]

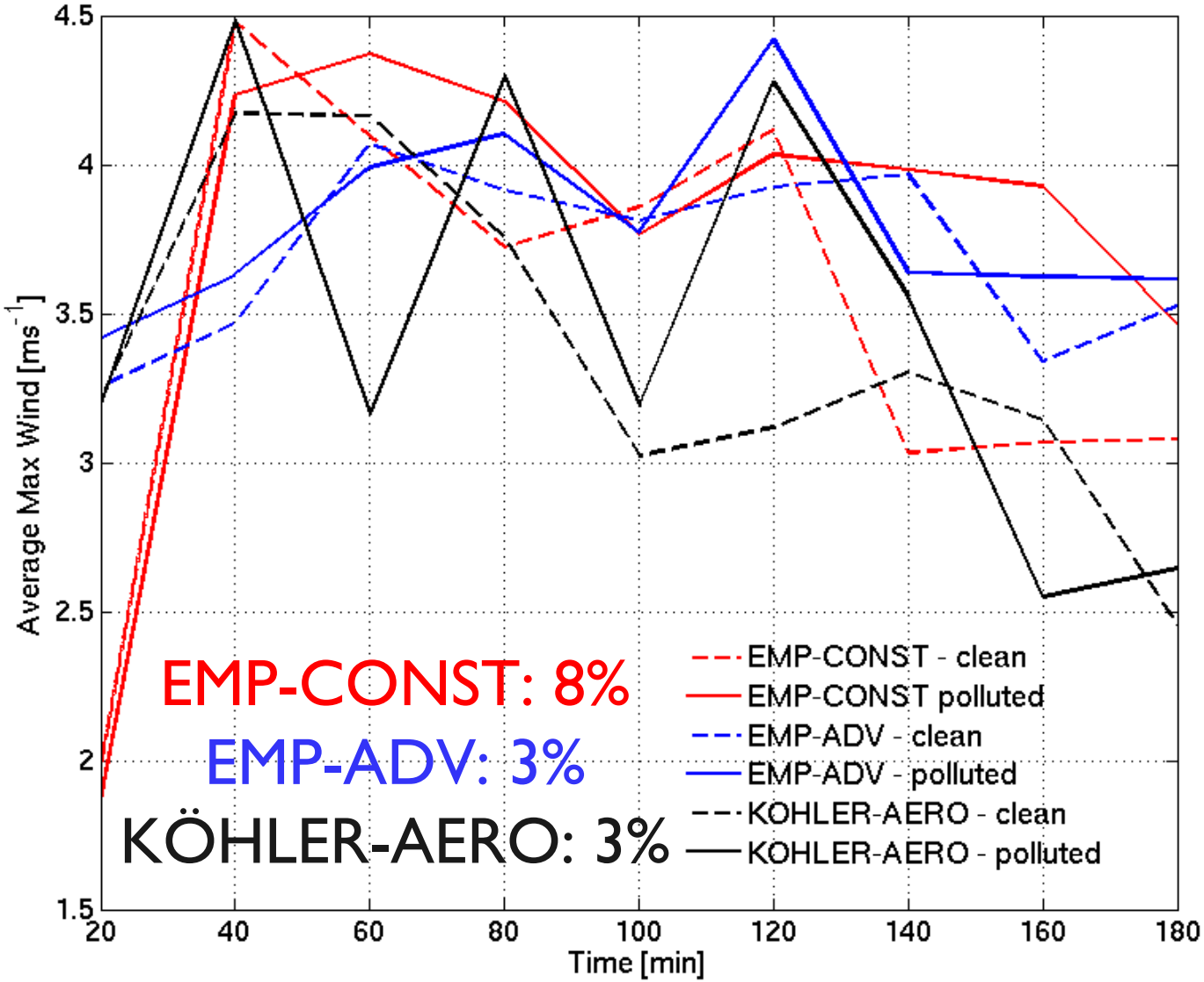




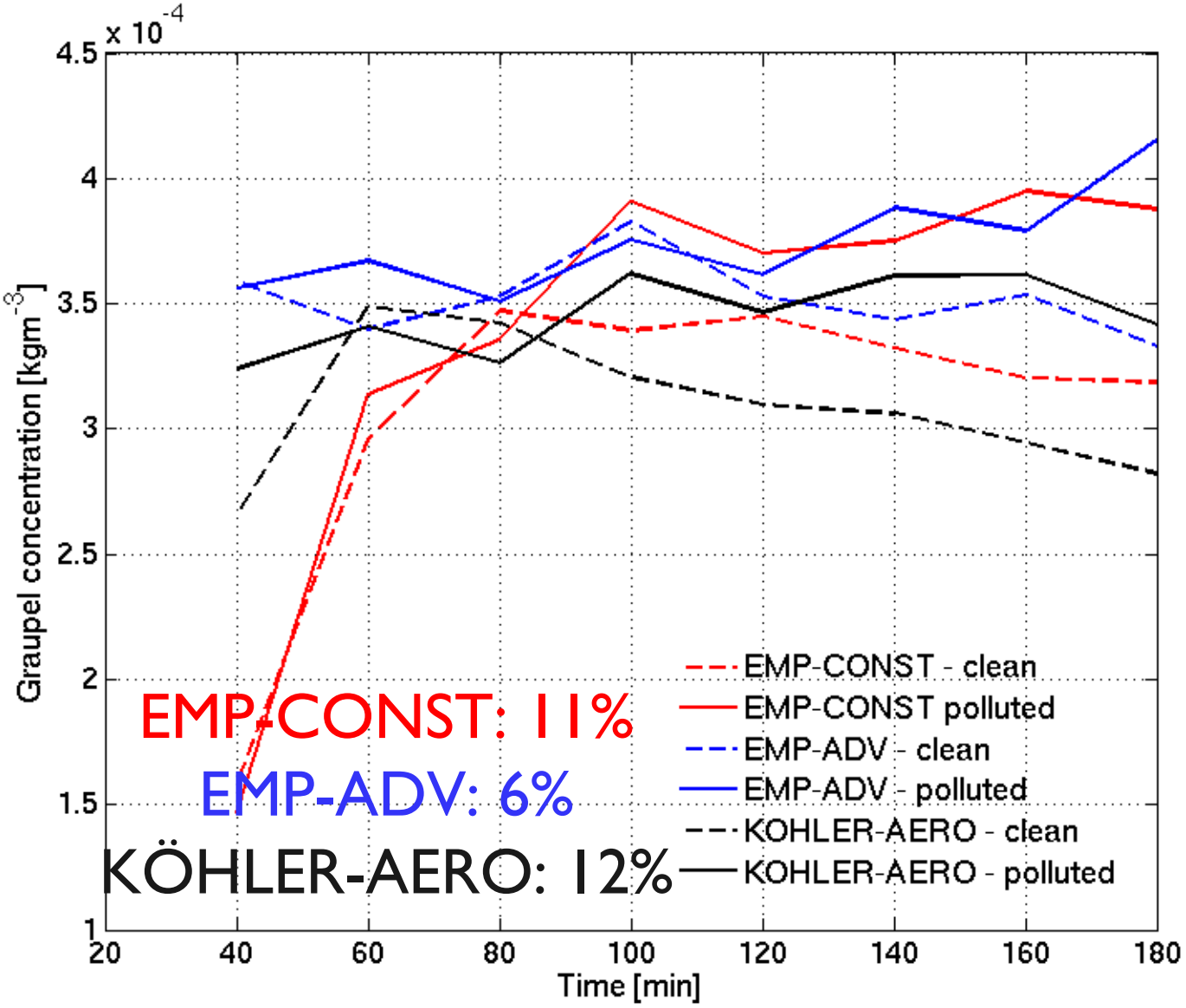
Average CDNC



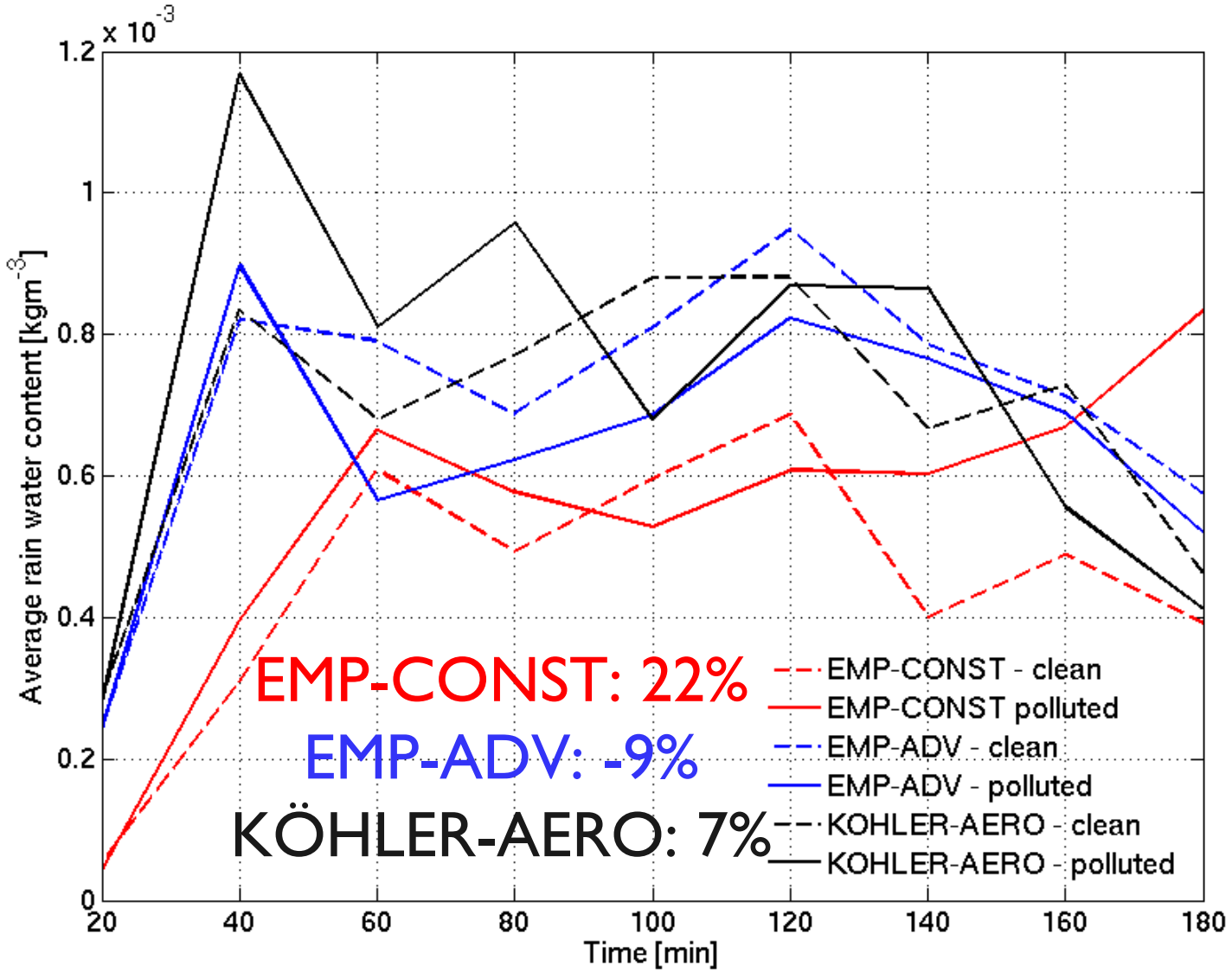
Average vertical wind speed (> 1ms^{-1})



Average graupel content



Rain water content, lowest 1200 m



Conclusions

- Changes in CDNC, updraft and graupel concentration due to changes in CCN/aerosol for explicit and non-explicit aerosol models show fair agreement.
- Although differences in cloud parameters are subtle, the sign of the precipitation change due to changes in CCN concentration may be different between explicit and non-explicit aerosol model.
- Can single cloud studies be of interest? For single cloud studies, during which time interval should comparison be made?