

Modeling of the July 10 STERAO storm with the RAMS model: Tracer transport and impact of microphysical scheme in the framework of the WMO cloud modeling workshop investigating chemistry transport in deep convection

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Introduction

Deep convection is a very efficient process to transport chemical species from planetary boundary layer to upper troposphere and lower stratosphere.

The role of deep convection in the chemical composition of the atmosphere is not well understood. The future international AMMA campaign (2006) is planned to improve the representation of tropical convection in numerical modeling. The July 10 STERAO storm (Dye et al., 2000) is an interesting test case for assessing the simulation of deep convection by the RAMS model. The case is well documented and its simulation is done in the framework of the WMO cloud modeling workshop, which took place in Hamburg last July.

Conditions of the July 10 STERAO storm simulation with the RAMS model

Description: http://box.mmm.ucar.edu/individual/barth/Chem_Convec_Intercomparison/SimulationSetup.html

Configuration of the RAMS model (Cotton et al., 2003)

Moving grid 120x120 km with $u_s = 1.5 \text{ m/s}$ and $v_s = -5.5 \text{ m/s}$
 $\Delta x = \Delta y = 1 \text{ km} / \Delta t = 5 \text{ s}$

Chemical Tracer

Ozone, CO, NO, NO_x and $\text{NO}_{x\text{,}}$ storm i.e. NO_x produced by lightning (Pickering et al., 1998)

51 vertical levels Microphysics (Walko et al., 1995; Meyer et al., 1997)

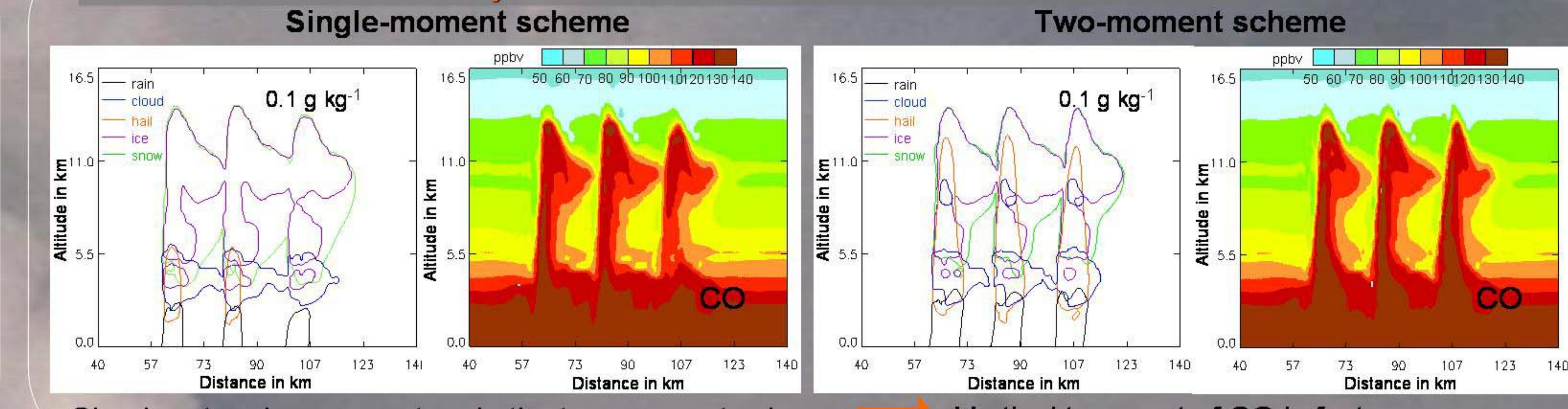
Duration = 2:30 h Hydrometeors: cloud, rain, pristine ice, snow, hail. Prediction of M (mass mixing ratio) for the single-moment scheme and of M and N (number concentration) for the two-moment one

Comparison with other models of the cloud modeling workshop and measurements

Model	Anvil area (km^2)	Flux ($\text{kg m}^{-2} \text{s}^{-1}$)	CO Flux ($10^{-5} \text{ mol m}^{-2} \text{s}^{-1}$)	NOx Flux ($10^{-8} \text{ mol m}^{-2} \text{s}^{-1}$)
measures	315	5.9	1.9	5.8
RAMS_two	332.13	7.68	2.29	6.5
RAMS_single	328.18	7.83	2.32	5.15
WRF-AqChem	185.2	7.88	2.34	2.16
C.Wang	446.9	6.72	1.95	2.55
DHARMA	531.9	7.69	2.39	
Meso-NH		5.41	1.59	2.84
UMd/GCE	274	9.06	2.54	9.55

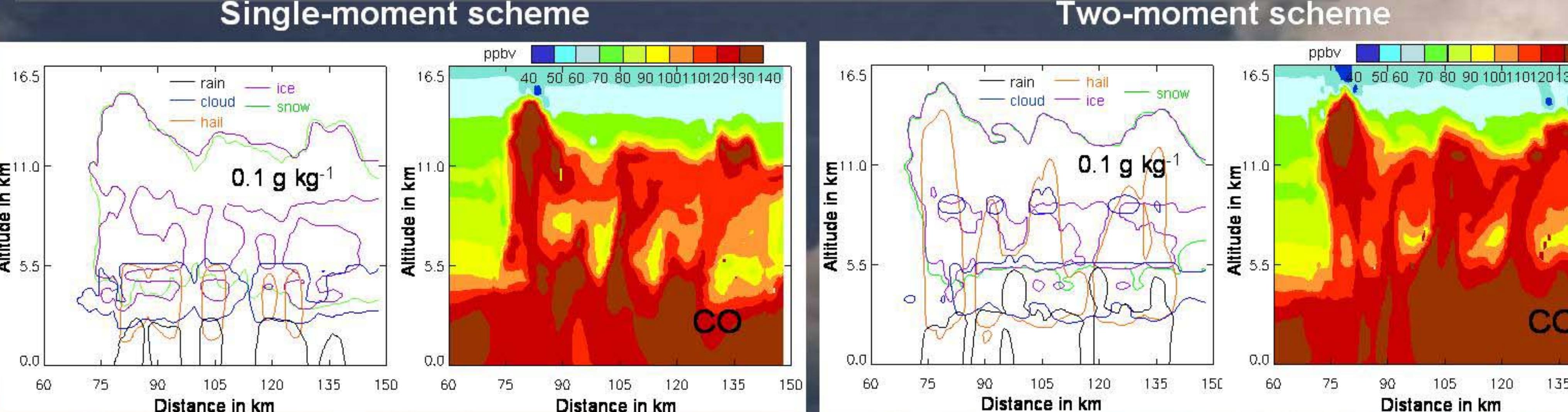
RAMS
 Good comparison with measurements and others model
 Small differences between microphysical schemes except for NO_x flux \leftrightarrow production from lightning

Structure of the cloud system and redistribution of CO at one hour



Cloud system is more mature in the two-moment scheme → Vertical transport of CO is faster

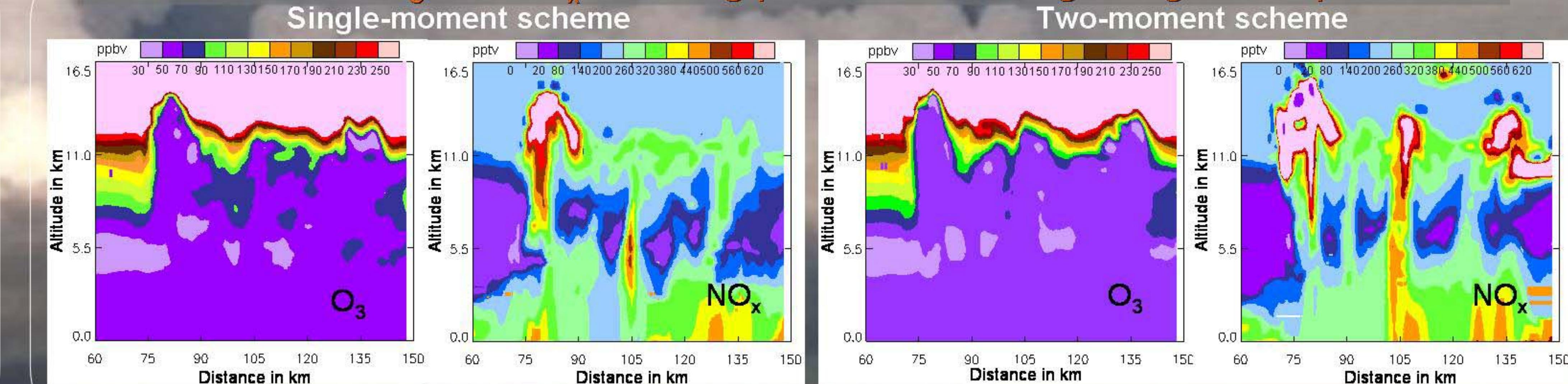
Structure of the cloud system and redistribution of CO at half past two



Differences in hail and rain vertical extension

No significant differences in CO redistribution

Redistribution of O_3 and NO_x including production from lightning at half past two



No significant differences for ozone

NO_x production by lightning is more efficient for the two-moment scheme

The simulated fluxes and anvil surface area show a good agreement with other models participating at the intercomparison exercise and with values from airborne measurements.

Significant differences between the two microphysical schemes appear for NOx fluxes, which are higher for the two-moment scheme

Detailed analysis of the structure of the cloud system and of chemical tracers redistribution show:

- Earlier development of the cloud system for the simulation using the two-moment scheme for cloud microphysics,
- More efficient vertical transport in the multi-cellular stage of the cloud for the two-moment scheme,
- No significant differences in tracer redistribution during the super-cell stage of the storm between the two microphysical schemes,
- More efficient production of NO_x from lightning with the two moment scheme due to a more realistic vertical distribution of hail in the storm.

Conclusion

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