

Two-Moment Cloud Microphysics in the GFDL AM3 GCM

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why two moment microphysics?

- **permits different droplet numbers for equal liquid water content depending on aerosol concentration**
 - > important for parameterization of collision-coalescence (“auto-conversion”)
 - > aerosol indirect effects

motivation

- **aerosol – cloud ice coupling**

AM3

- developed at GFDL
- finite volume core, 48x48x6 cube-sphere horizontal grid
- 48 (32) vertical layers

parameterizations in AM3

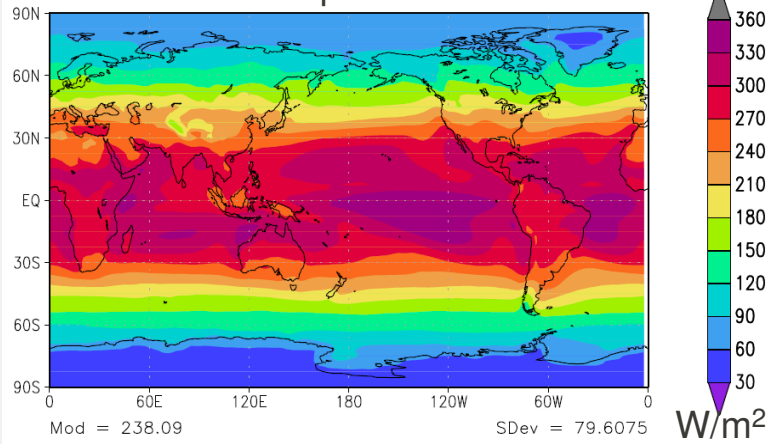
- deep convection (Donner, 1993)
- shallow convection (Bretherton et al., 2004)
- PBL (Lock et al., 2000)
- stratiform clouds (Tiedtke, 1993, Rotstayn, 1997, Jacob and Klein, 2000)
- prognostic equations for cloud droplet number (Ming et al., 2007)
- droplet activation (Ming et al., 2007)
- assume Gaussian sub-grid vertical velocity PDF

AM3

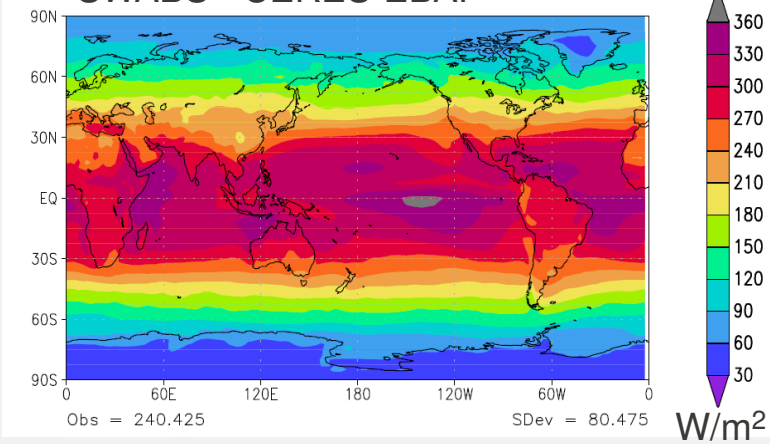
- prognostic aerosols (Magi et al., 2009) and gas phase chemistry (Horowitz et al., 2003)
- three different microphysics schemes (in stratiform clouds, deep convection, shallow convection)

short-wave absorption (SWABS)

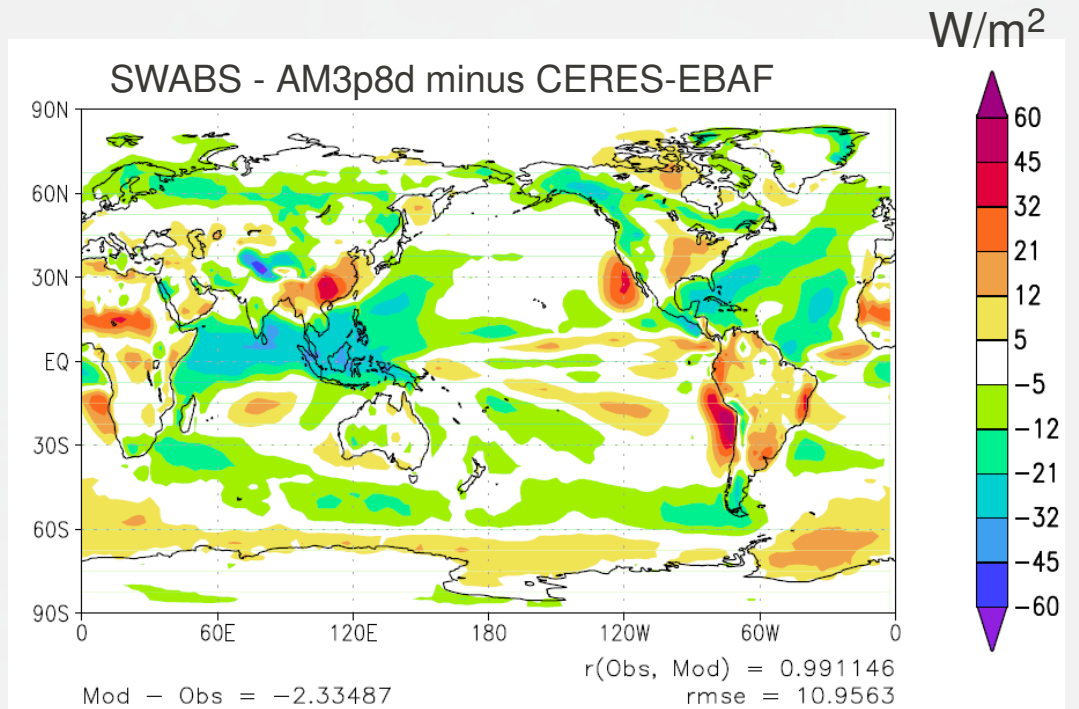
SWABS – AM3p8d



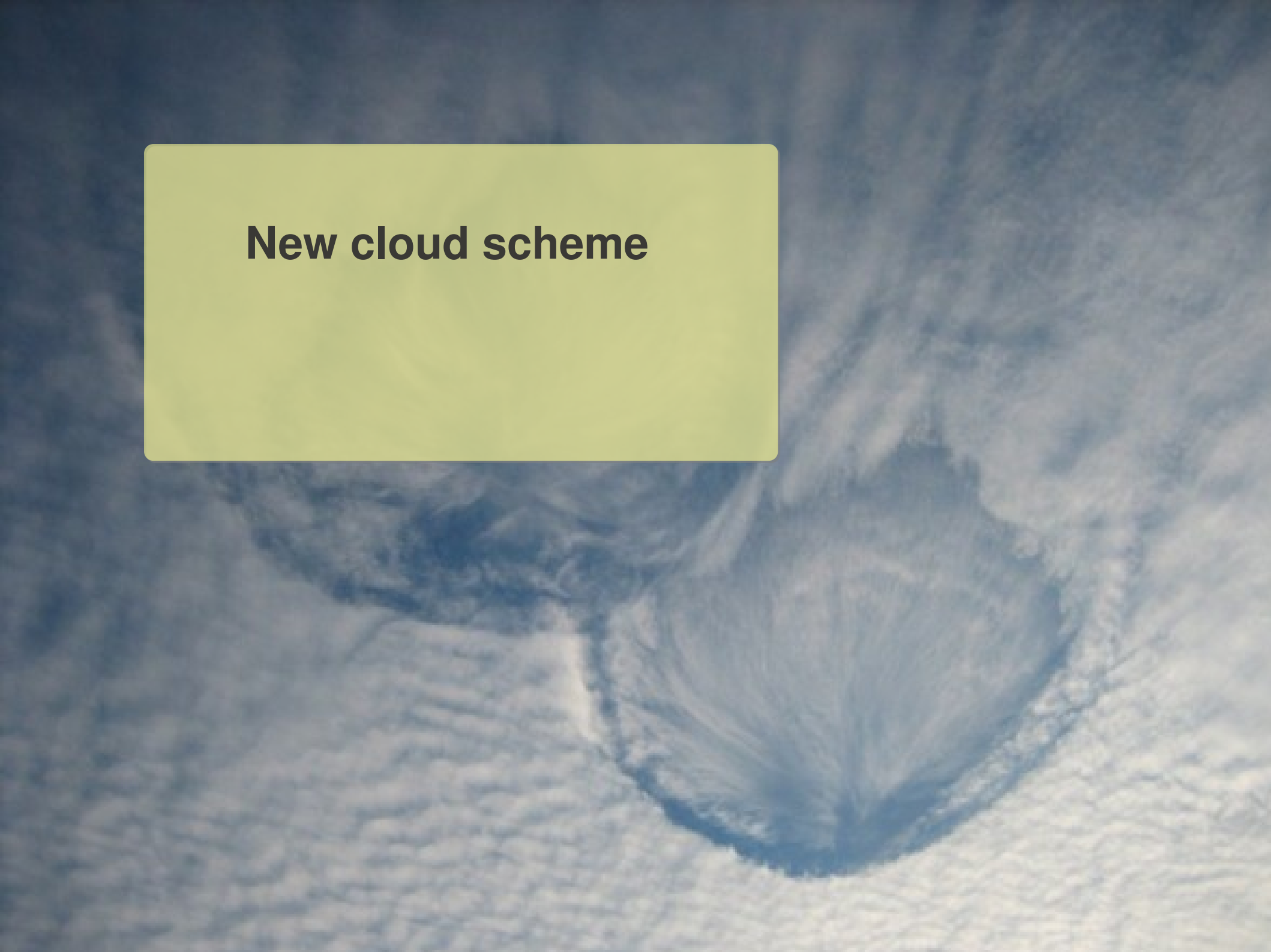
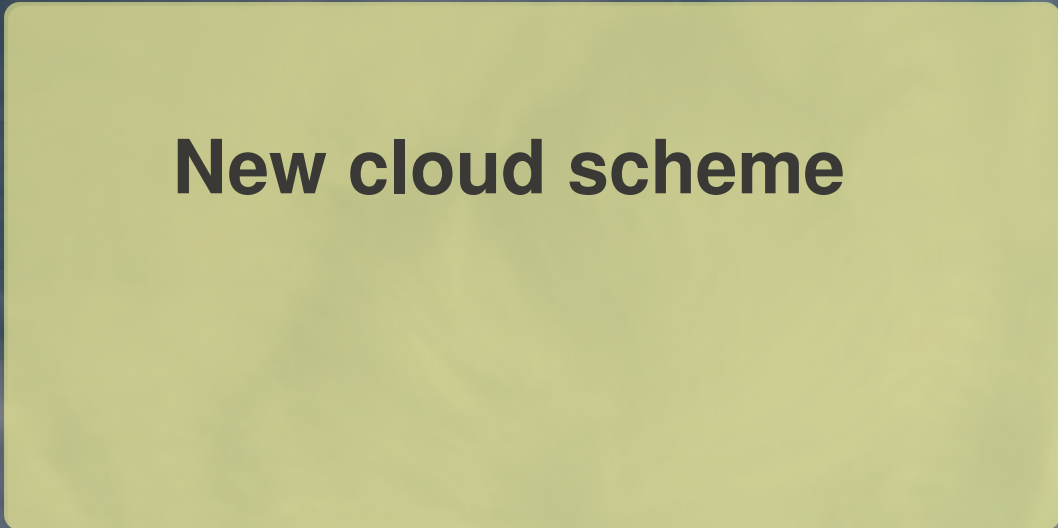
SWABS - CERES-EBAF



SWABS - AM3p8d minus CERES-EBAF



New cloud scheme

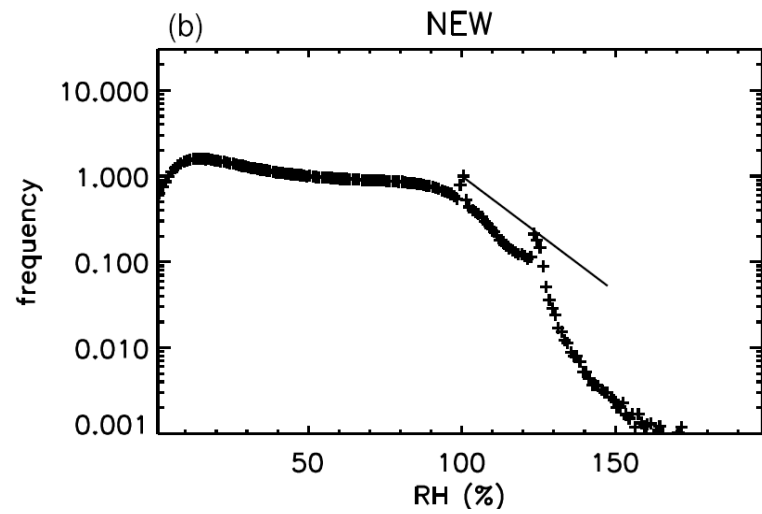
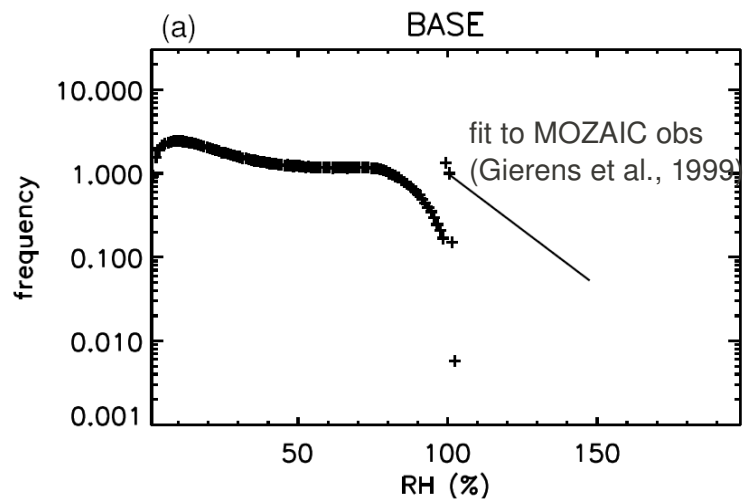


new stratiform cloud scheme

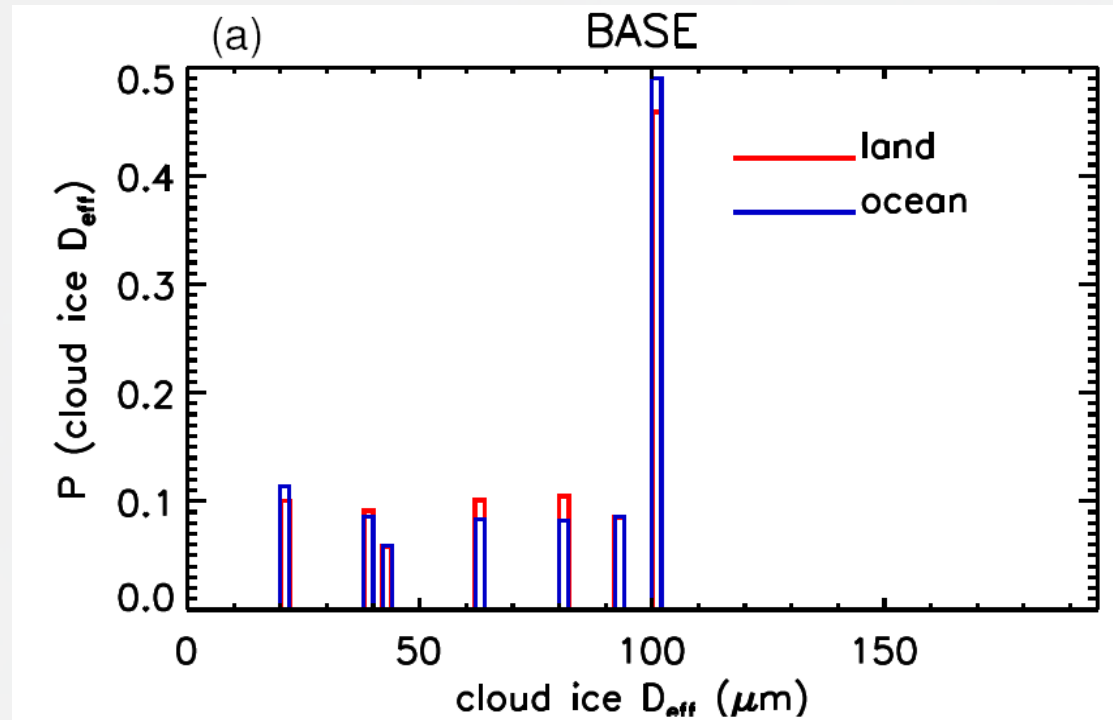
- prognostic treatment of ice number
- two moment bulk microphysics parameterization
(*Morrison and Gettelman, 2008*)
- ice nucleation parameterization (*Liu and Penner, 2005*)
- prognostic cloud cover scheme allowing supersaturation w.r.t ice
(*Tompkins et al., 2007*)
- droplet activation (*Ming et al., 2006, 2007*)

Results

RH_{ice}

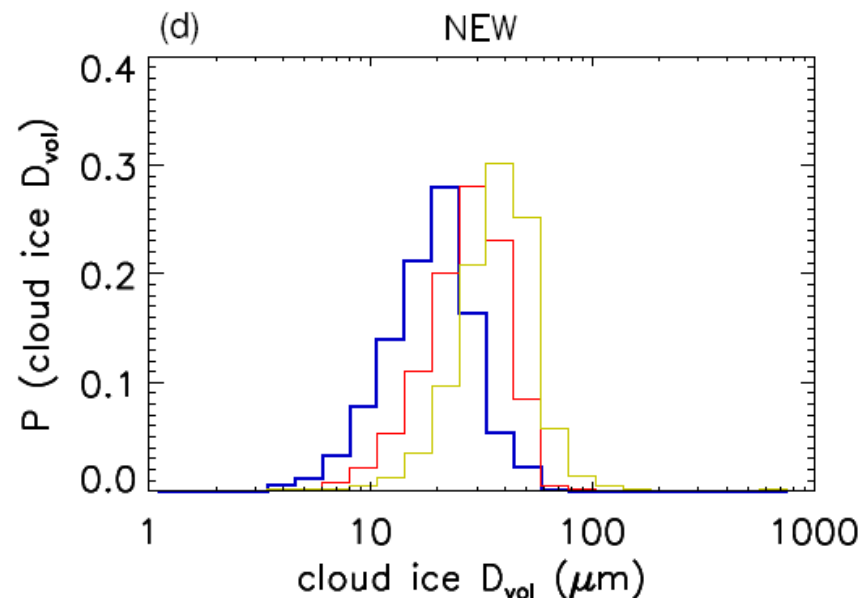
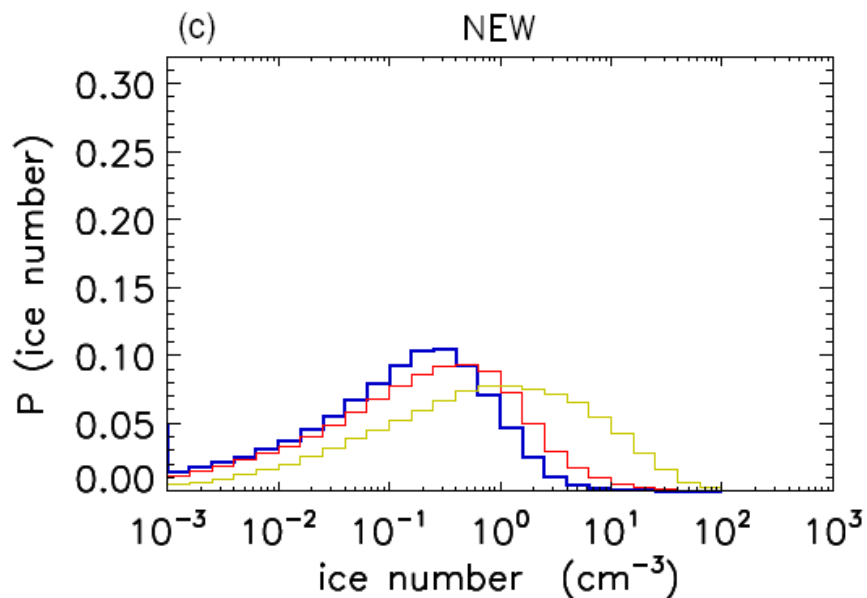
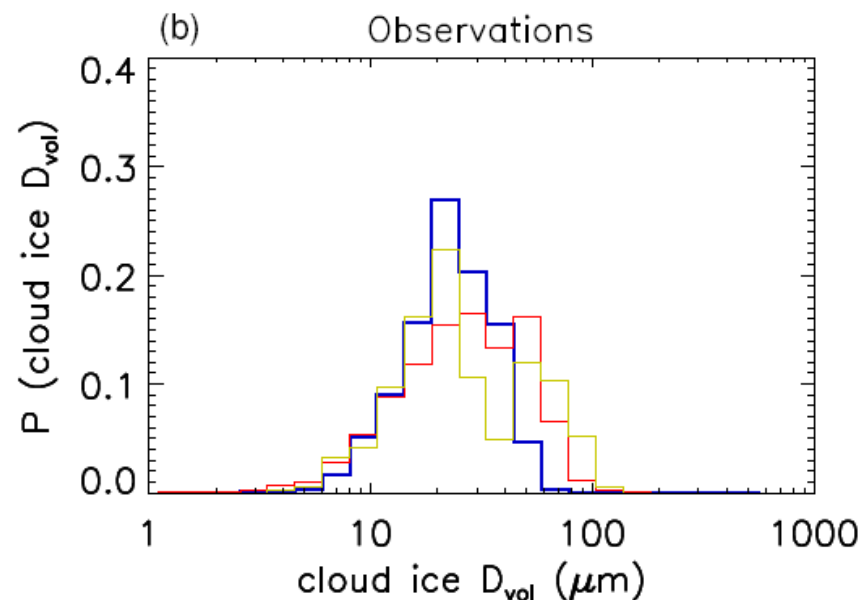
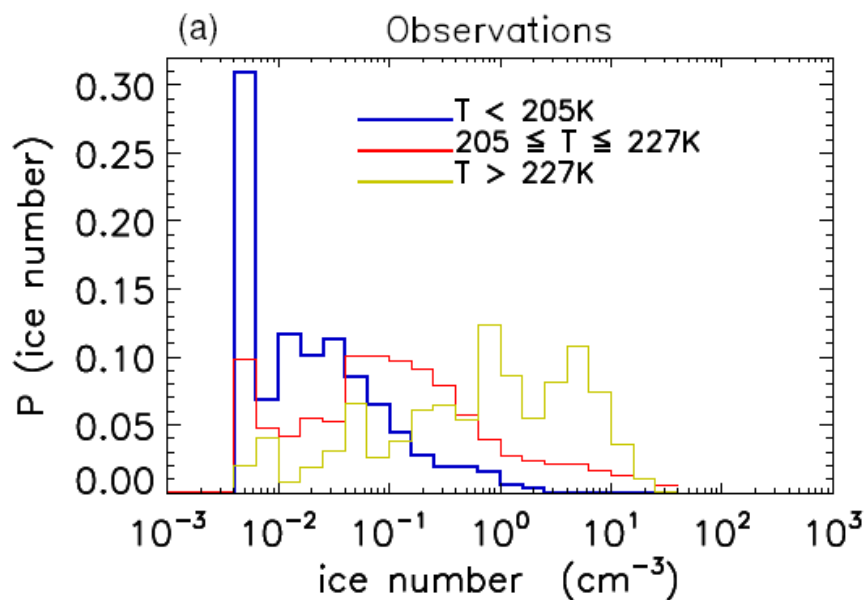


ice particle effective diameter "PDF"

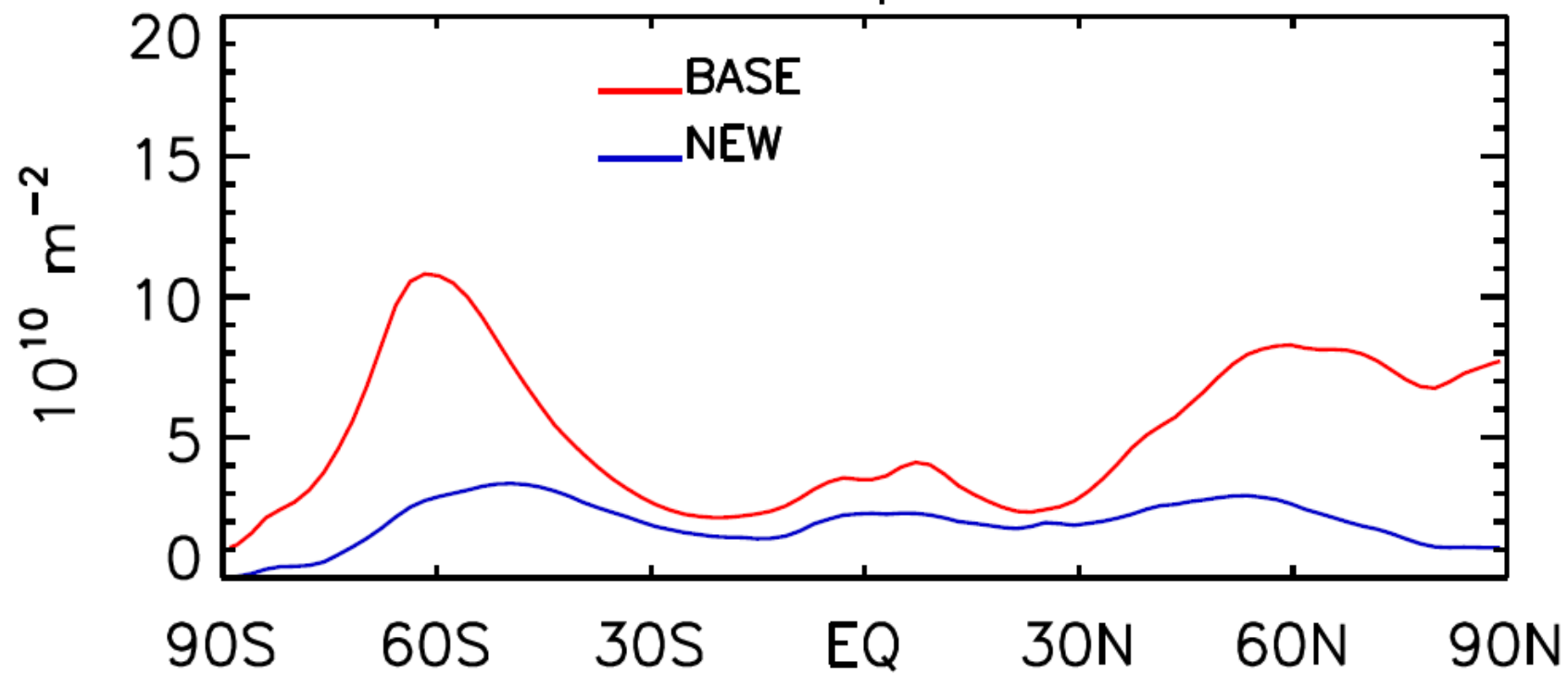


ice PDFs

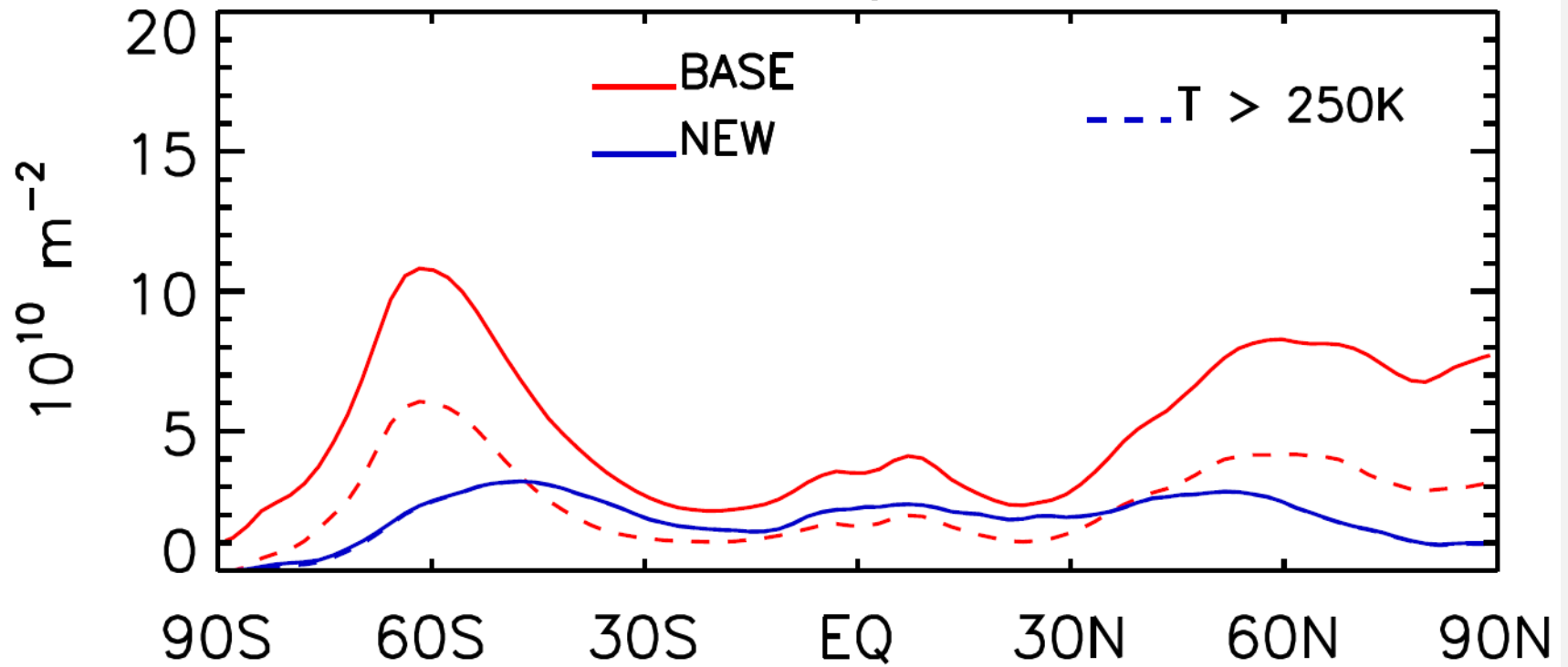
observations: Krämer et al., 2009



In-cloud droplet number



In-cloud droplet number



summary

new scheme:

- **more sophisticated presentation of cloud ice**
- **prerequisite for study of potential anthropogenic effects via ice phase**
 - large difference in column integrated droplet numbers due to implementation of the Wegener-Bergeron-Findeisen process (but similar cloud liquid- and ice water path as with old scheme)

acknowledgments

GFDL Global Atmospheric Model Development Team (GAMDT)

co-authors:

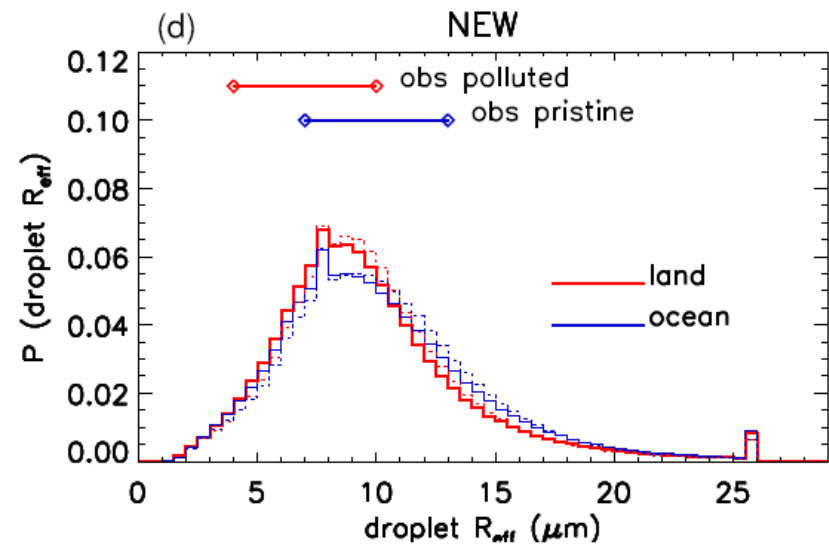
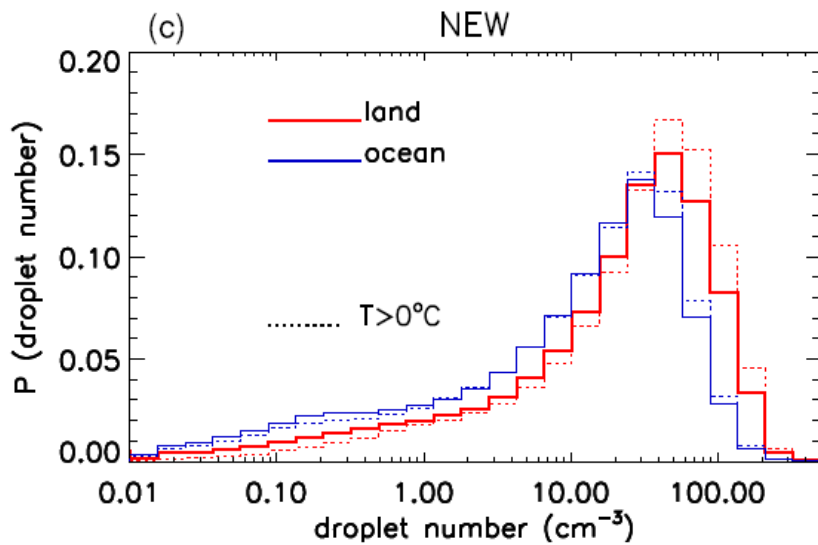
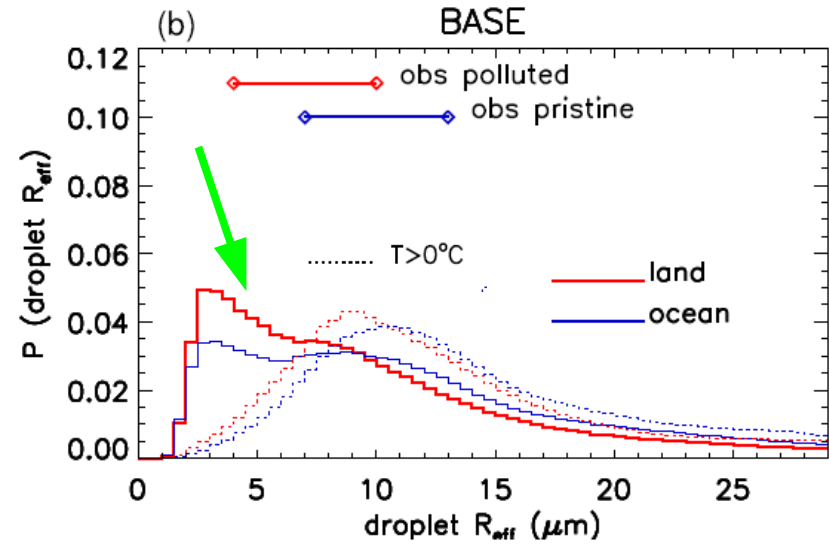
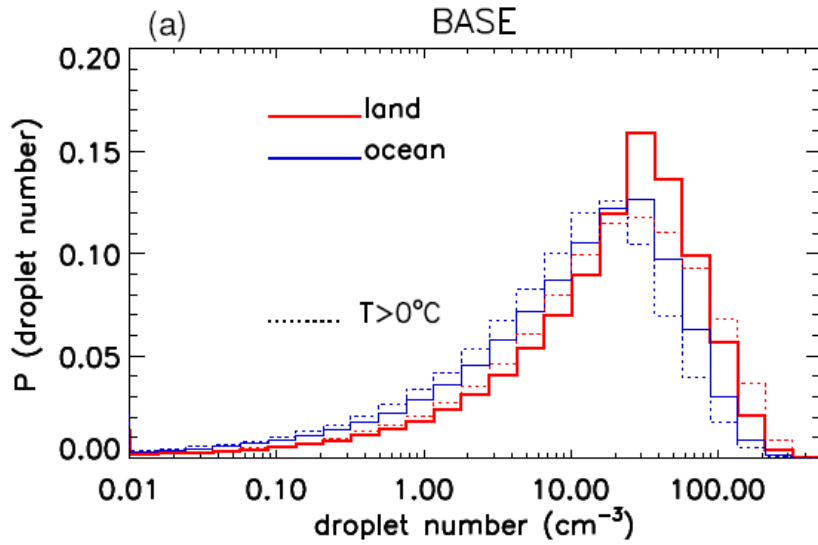
Leo Donner, Yi Ming, Chris Golaz, Paul Ginoux, Martina
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Thank you!



liquid PDFs



ice PDFs

