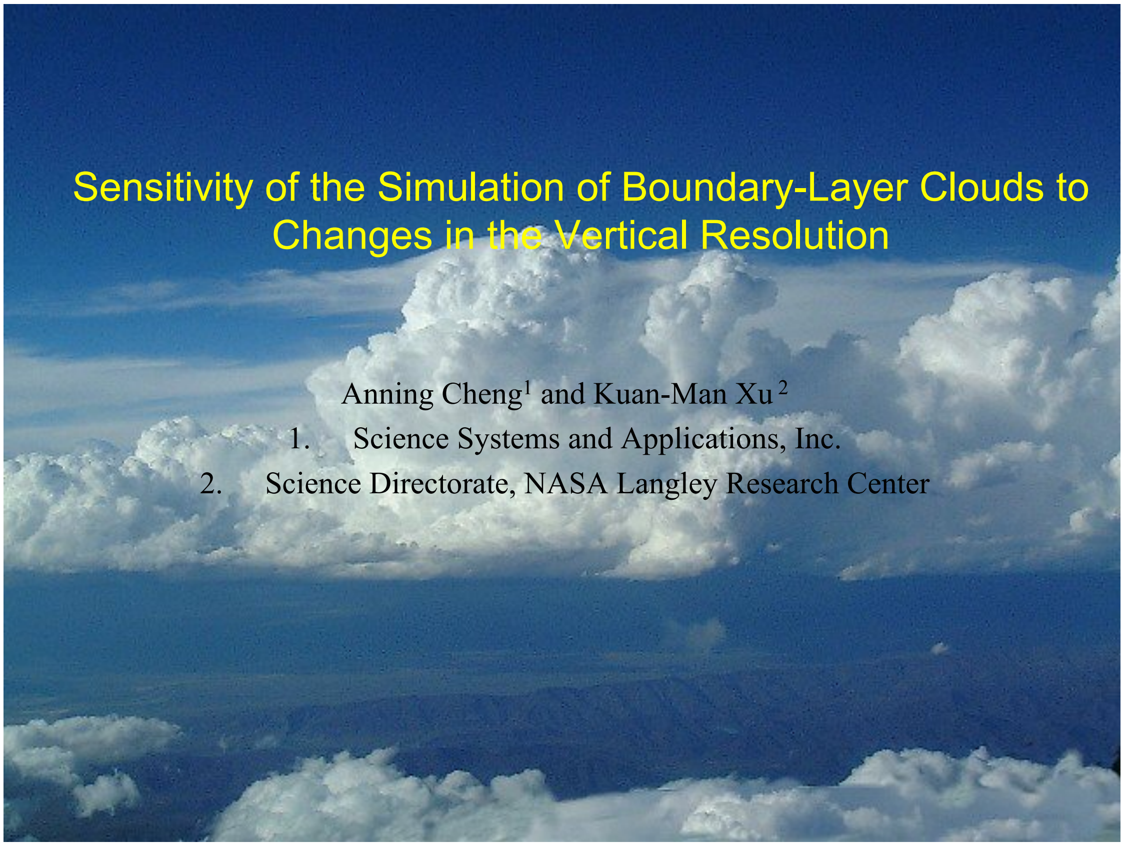

Sensitivity of the Simulation of Boundary-Layer Clouds to Changes in the Vertical Resolution

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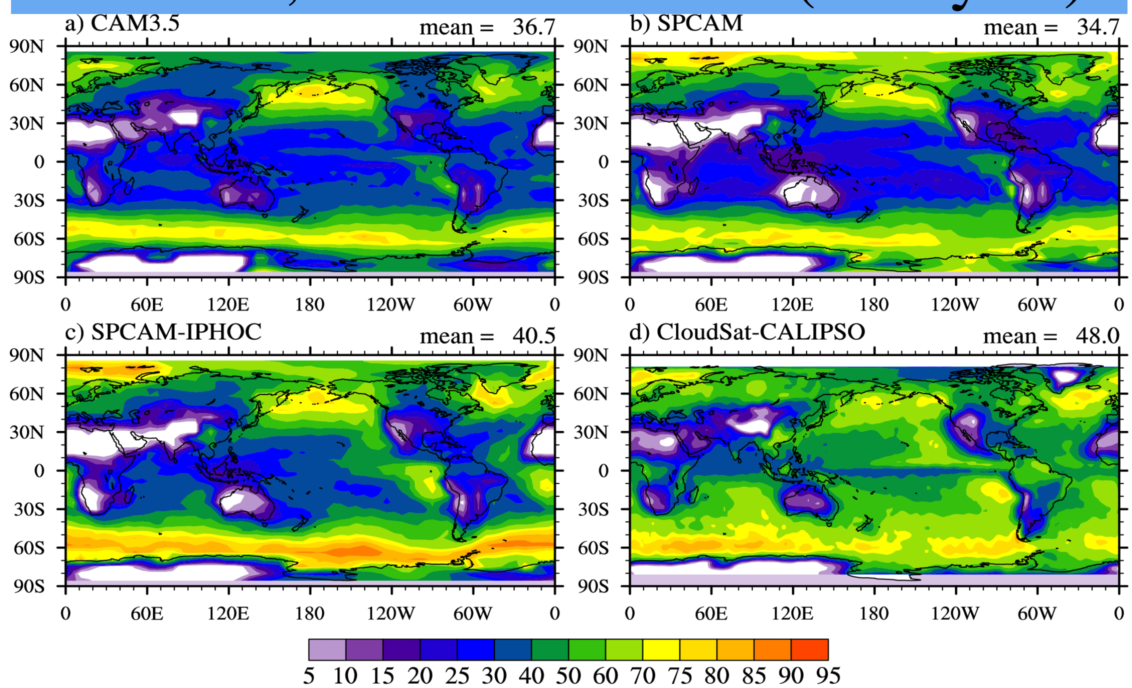
Introduction

- There are 6 levels below 700 hPa in SPCAM. This is too coarse for boundary-layer cloud simulation.
- How well are shallow cumulus and stratocumulus clouds simulated with such a coarse vertical resolution with a CRM incorporating a higher-order turbulence closure (SPCAM-IPHOC)?
- How much will the representation of cloud vertical structure and cloud amount be improved when the vertical resolution increases?
- The goal of this study is to present an off-line testing before a new MMF simulation with the higher vertical resolution is performed.

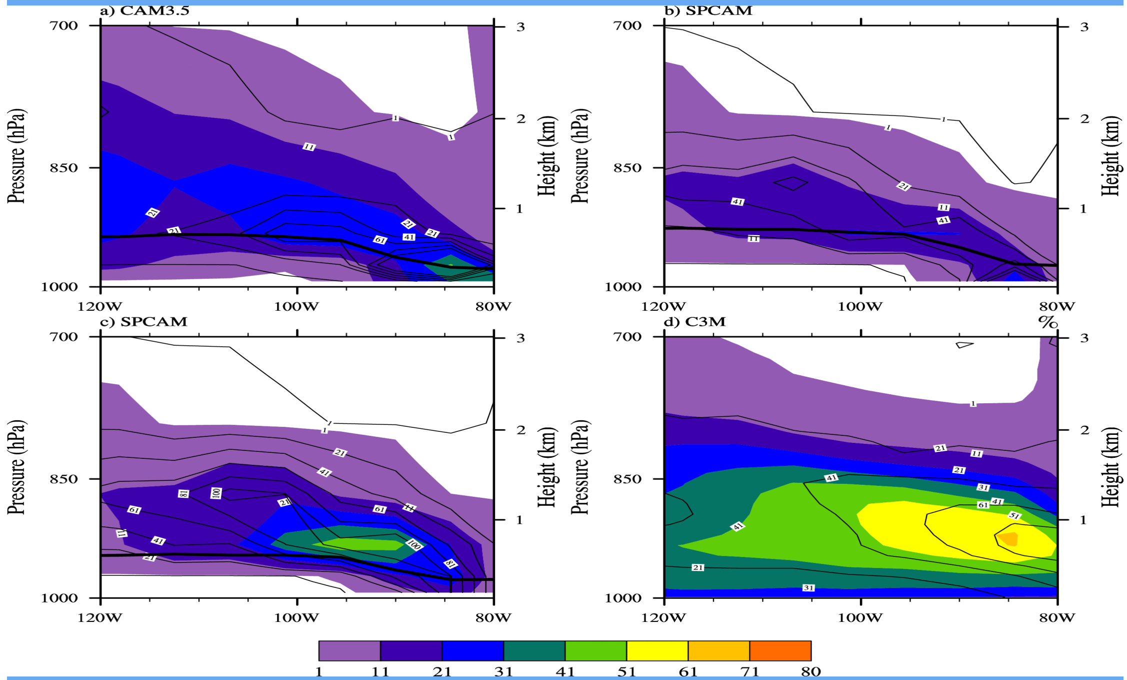
Experiment Design

- Standard initial conditions and forcings for GCSS BOMEX (shallow cumulus), ATEX (shallow-to-stratocumulus transition), and ASTEX (stratocumulus) cases.
- CRM *vertical* grid-spacings tested: LES type (25-40 m), 6 levels, 12 levels, and 75 levels below 3 km, respectively.
- CRM *horizontal* grid-spacing 4 km with 32 columns for all cases, as in MMF setup.
- Integration time: until steady state is reached with a time step of 20 s (3-12 hours depending on cases).

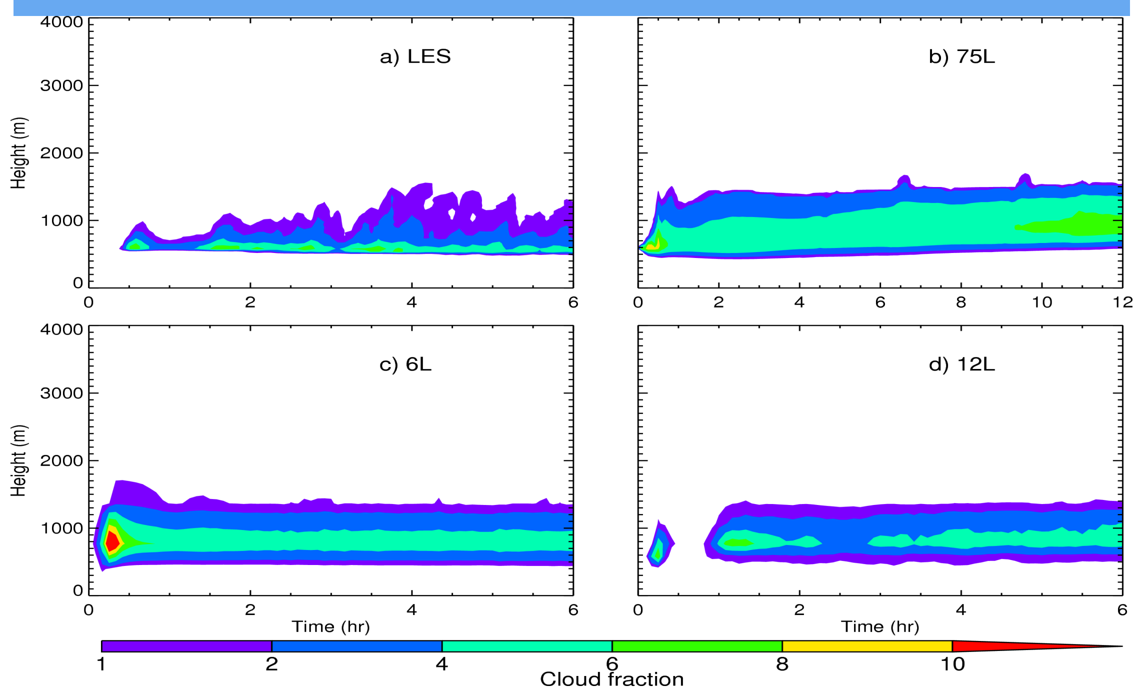
Low-level Clouds from CAM3.5, SPCAM, SPCAM-IPHOC (26 layers)



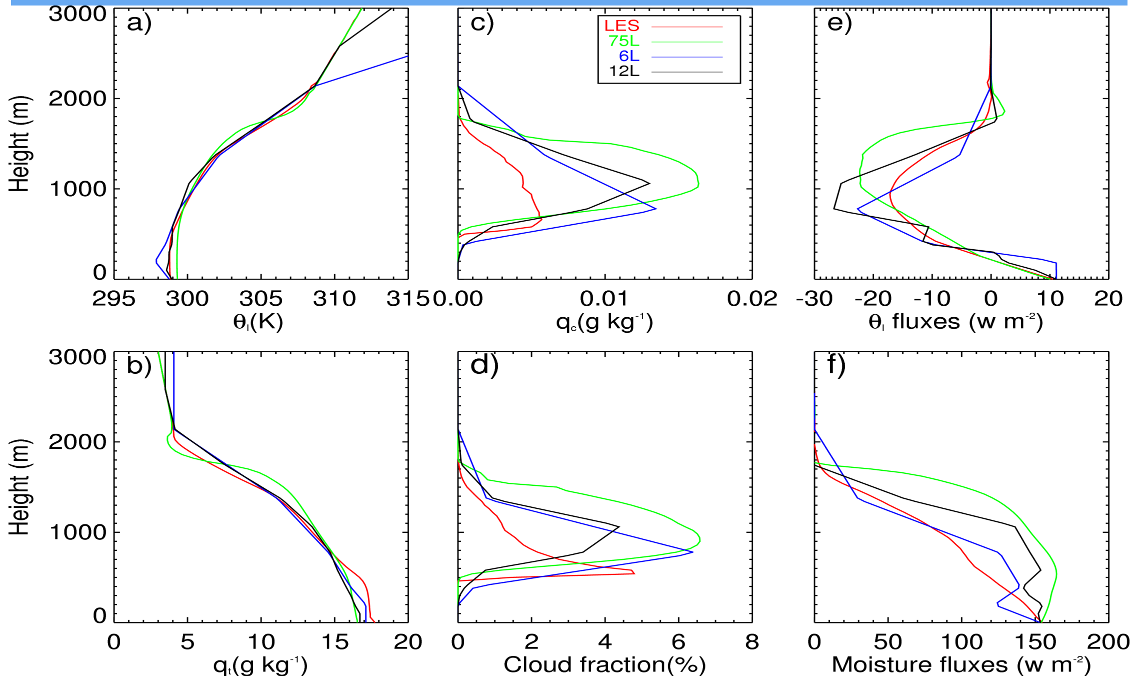
Vertical-zonal Cross-section along 15°S



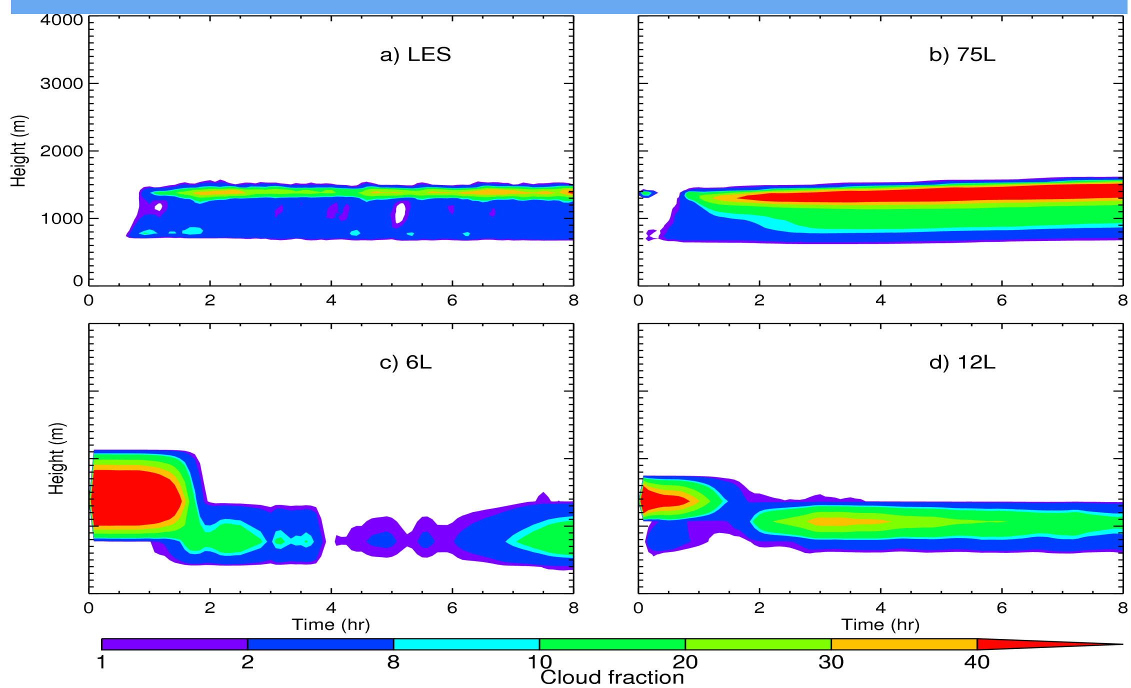
Cloud Evolution for BOMEX from CRM-IPHOC



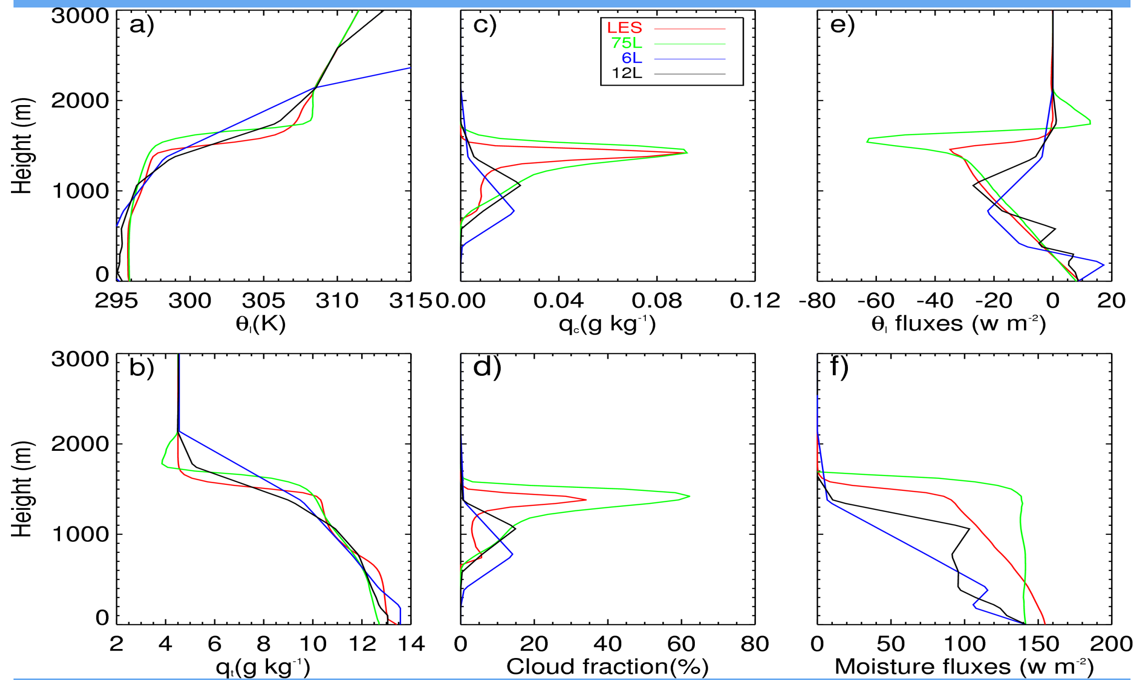
Vertical profiles for BOMEX



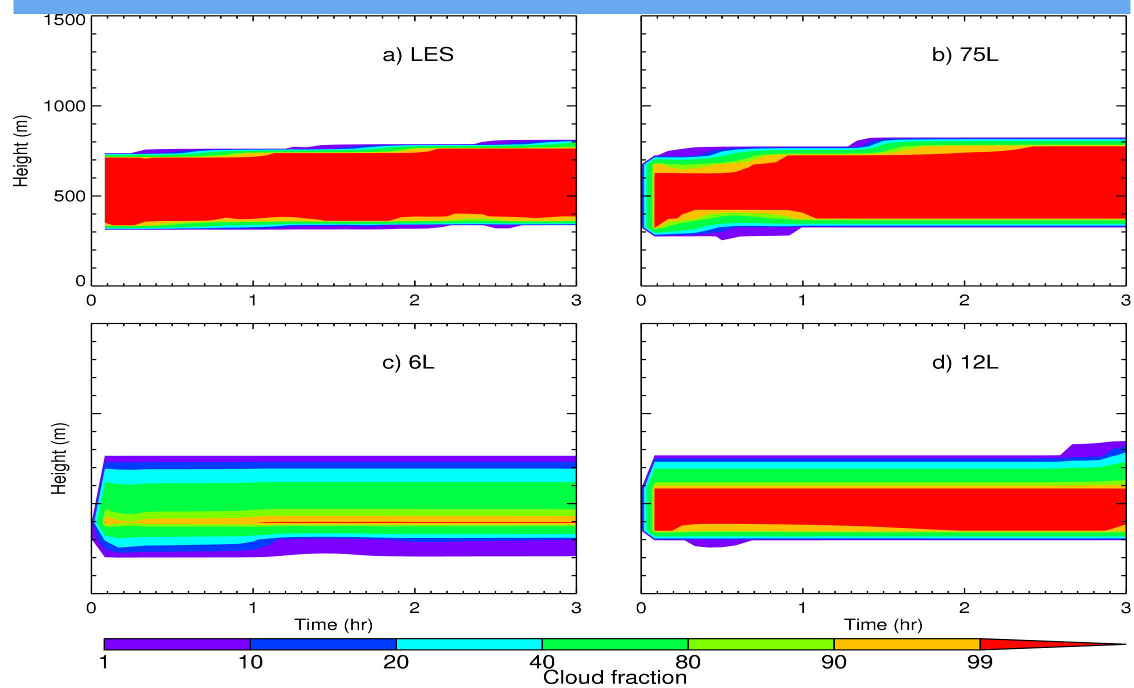
Cloud Evolution for ATEX from CRM-IPHOC



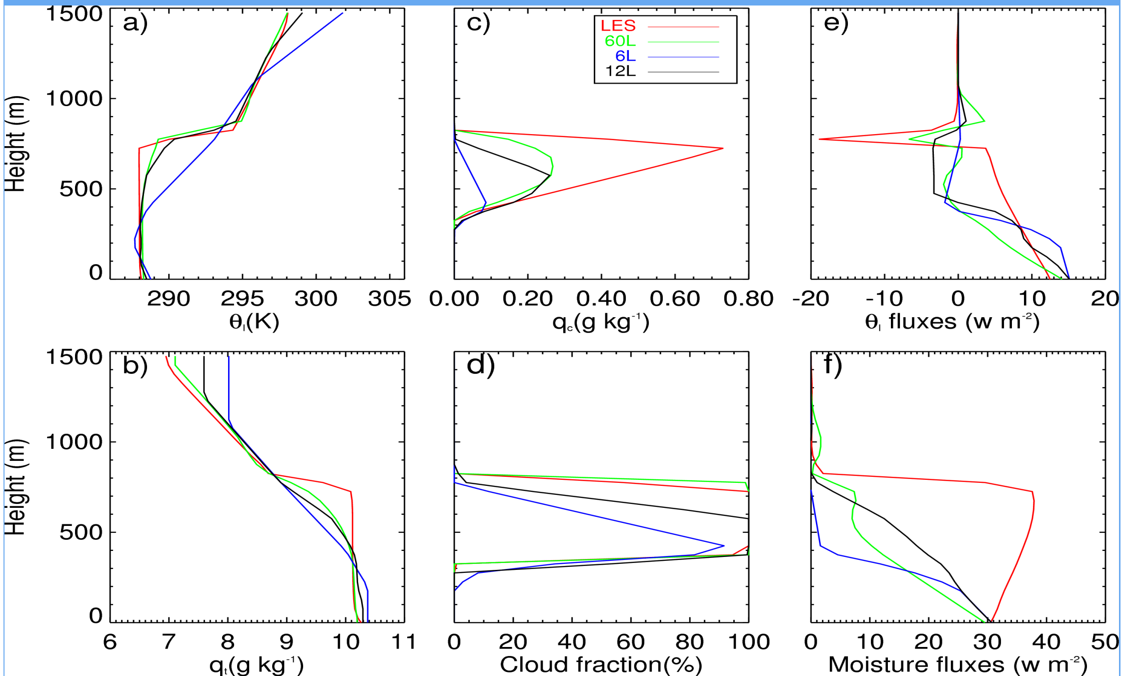
Vertical profiles for ATEX



Cloud Evolution for ASTEX from CRM-IPHOC



Vertical profiles for ASTEX



Summary (I)

- The sensitivity of simulation of boundary-layer cloud on the vertical grid spacing with a higher-order turbulence closure (IPHOC) are studied.
- The representation of the shallow cumuli is fairly reasonable when there are only 6 levels below 700 hPa.
- Results are not degraded much when the vertical levels deceased from 75 levels to 12 levels for stratocumuli.
- The cloud amount of shallow cumuli does not change substantially while that of stratocumuli decreases when the vertical grid-spacing is coarsened.

Summary (II)

- The increase in the depth of the inversion layer, decreased magnitude of d θ /dz, and the smoothing of the mean profile caused by the coarser grid-spacing is the main reason for the decreased cloud amount in the stratocumuli.
- Diagnosis/prediction of the boundary-layer top height is an efficient way for a realistic representation of the cloud amount for stratocumuli in addition to a further increase in vertical resolution (Lappen and Randall 2009). This approach can be tested out in CRM-IPHOC.
- We will use 12L below 700 hPa for a more realistic representation of the stratocumuli in SPCAM-IPHOC in the near future.