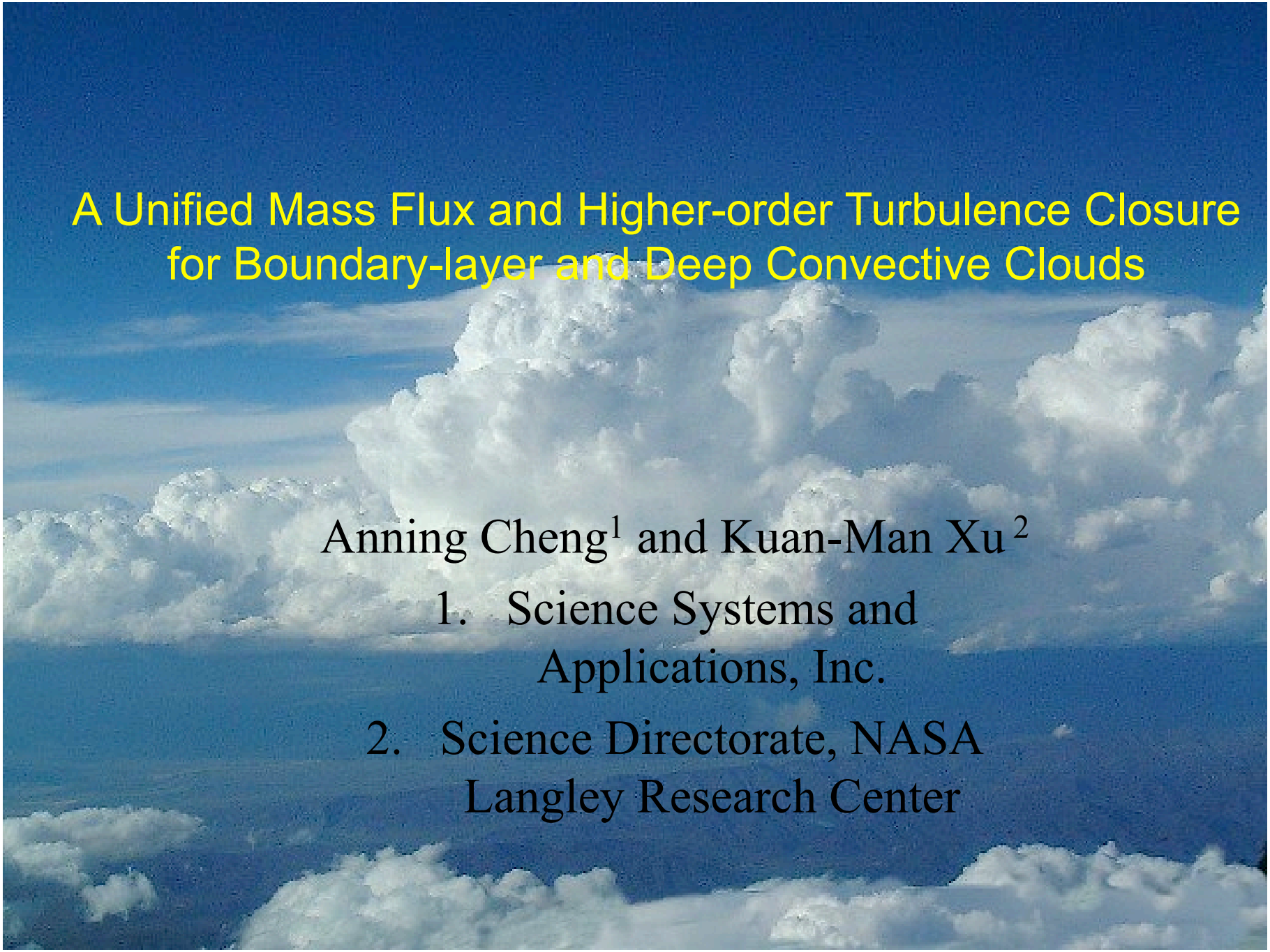

A Unified Mass Flux and Higher-order Turbulence Closure for Boundary-layer and Deep Convective Clouds

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Introduction

- Accomplishment

Modularization and testing of IPHOC

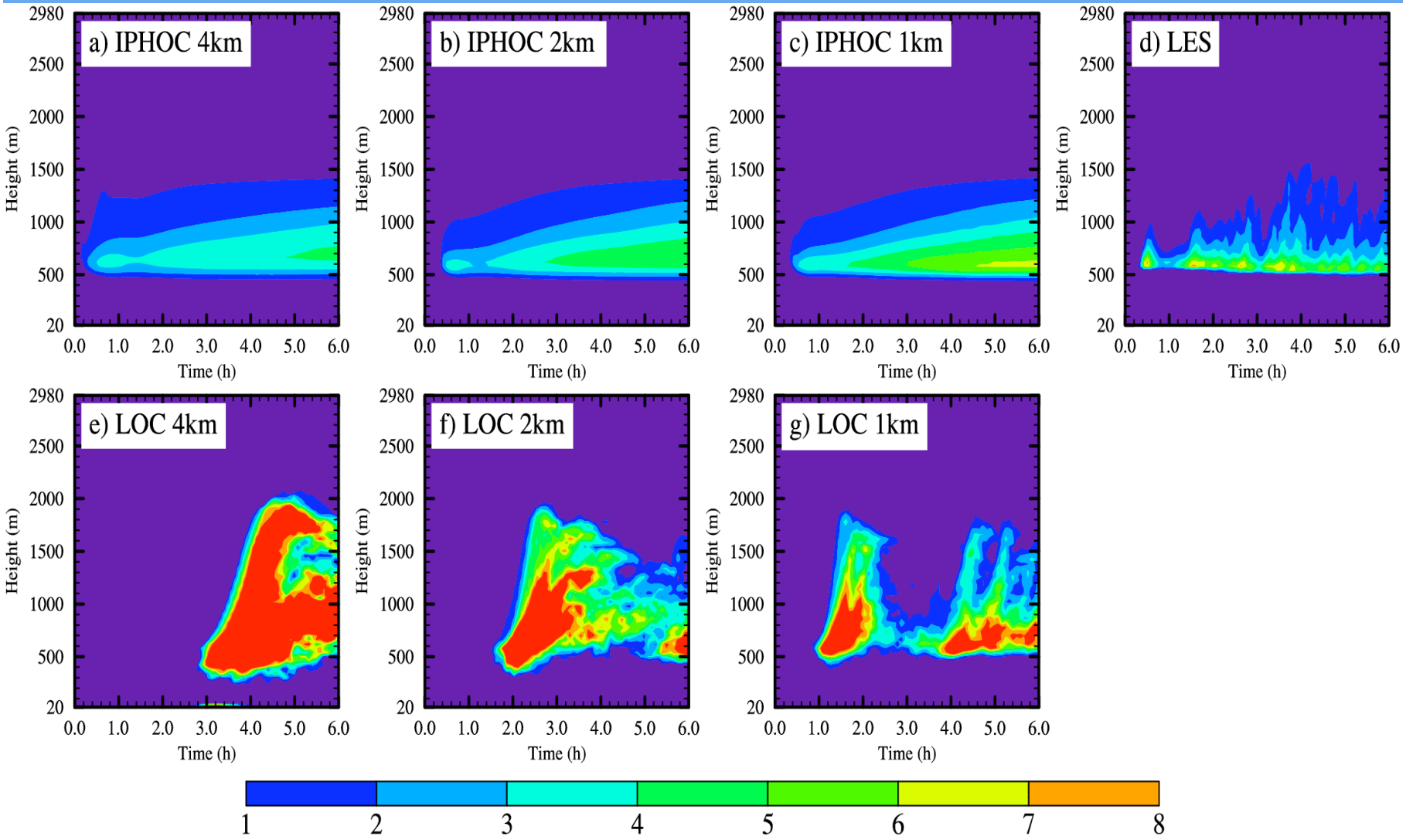
- Short term goal

Application of IPHOC to MMF

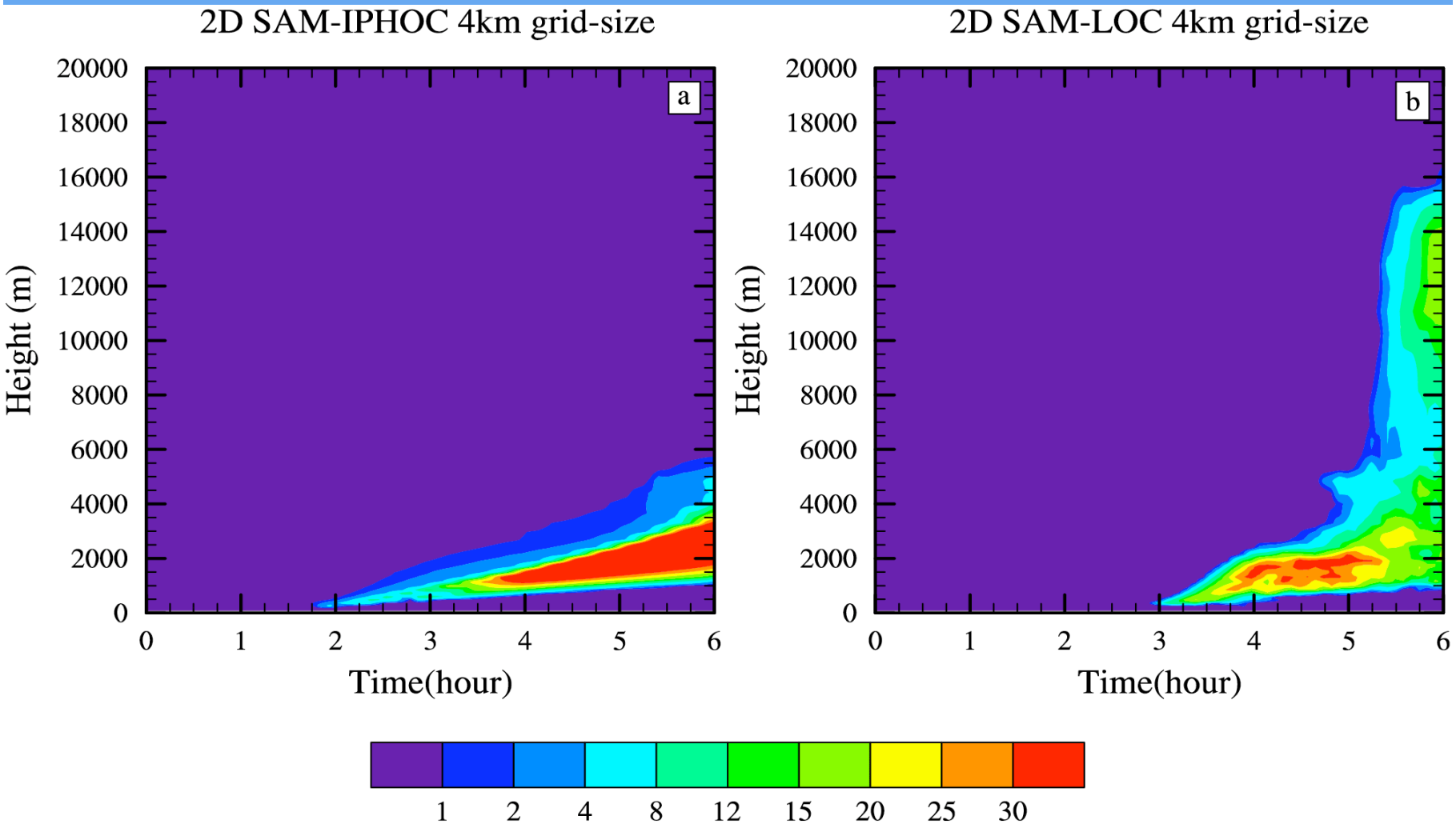
- Long term project

A new single parameterization for all types of clouds: triple Gaussian pdf based IPHOC

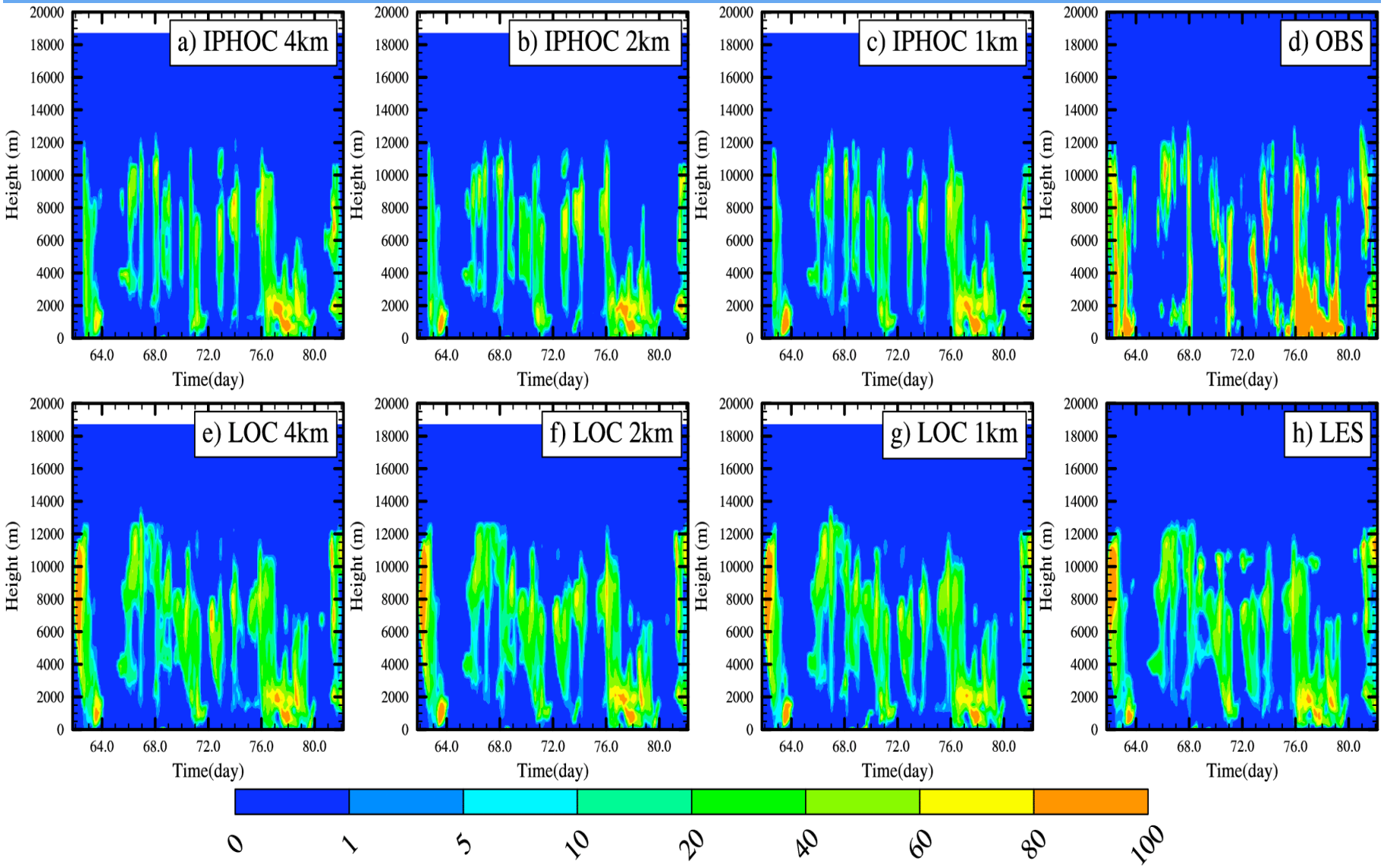
BOMEX Shallow Cumuli



A shallow-to-deep Convective Cloud Transition Case



Comprehensive ARM SGP Case



Application of IPHOC to climate models

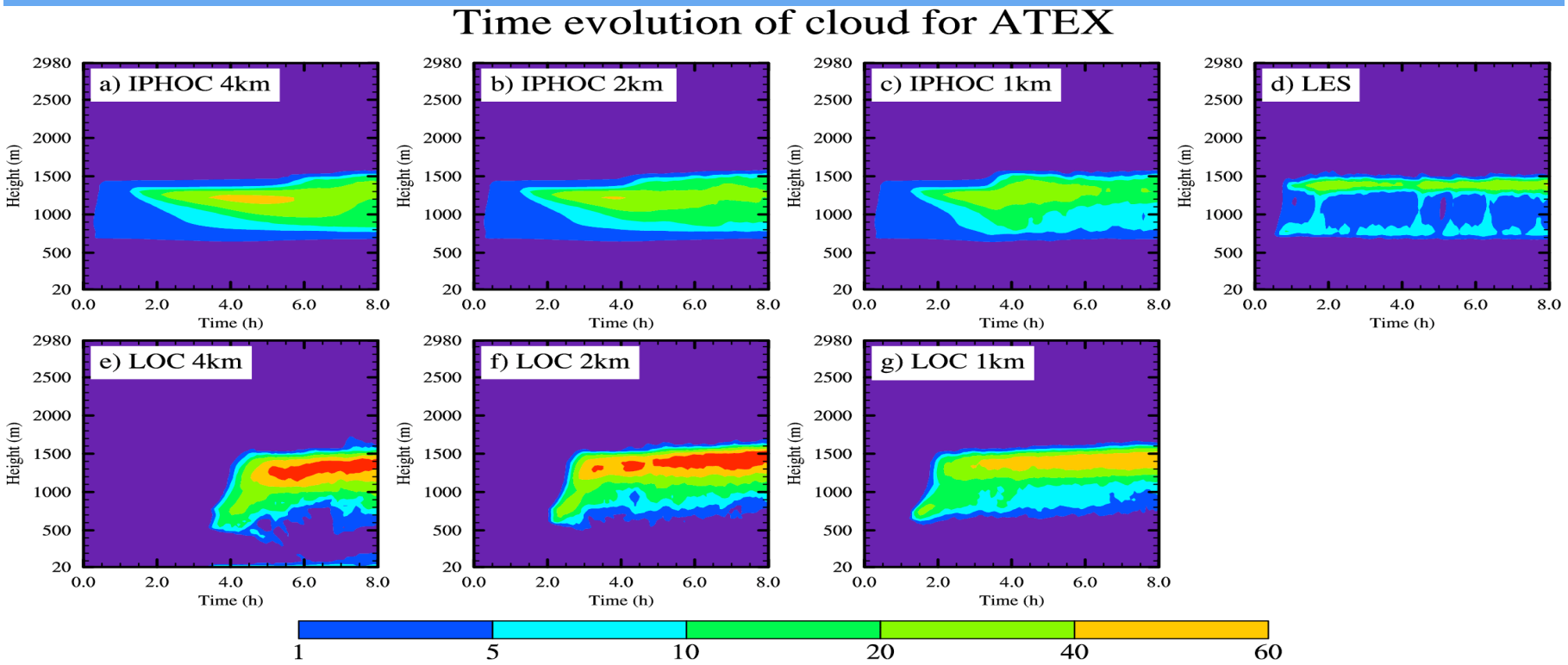
Used in MMF and CRM to compare against observations

Expected improvements:

1) BL cloud amount and global distribution
2) Diurnal cycle
3) Low cloud and radiation feedbacks
4) Microphysics and turbulence
5) Surface fluxes --> MJO

Aspects to be improved

- Not good at some BL regimes



- Unable to parameterize deep convective clouds

Unification of Mass Flux and IPHOC Schemes

- Distinguishing three Gaussians representing the updrafts, the downdrafts, and the environment, respectively.
- Lifting a pdf or part of pdf in IPHOC to find the updraft: positively buoyant or $w > 0$; The same way for downdraft.
- Using information from mass flux approach to close the joint triple-Gaussian based pdf

29 parameters needed to determine the pdf

12 predicted equations and 17 parameters determined from the mass flux approach and physically based assumptions

A Framework Based on MMF

- Detailed subgrid-scale information
- A platform to implement new components such as advanced microphysical and radiation schemes
- Scale interactions similar to MMF but in pdf space

Comparison with IPHOC

- All parameters of the joint pdf determined physically
- Each Gaussian has clear physical meaning
- Applicable for all type of clouds
- Easy to diagnose problems in the scheme

Comparison with Mass Flux Approach

- Lifting a pdf (a group of parcels) instead of a parcel or a type of cloud: Easy to implement buoyancy sorting mechanism
- Parameterization of detrainment and entrainment not needed: changing the shape of the pdf to represent the effects of entrainment and detrainment
- Quasi-equilibrium assumption not needed: Mass fluxes predicted
- A spectra of clouds not needed: Applicable to grid-size range from a few meters to hundreds of kilometers.

Comparison with LES/CRM

- Computationally cheaper
- Information obtained in pdf space instead of physical space
- Easier to compare with the pdf datasets such as cloud object data derived from satellite observations

Summary

- Modularized IPHOC and implemented it in SAM
- Applying the scheme to climate models
- Further improve the simulations of BL clouds
- Propose a new approach based on a triple-Gaussian based pdf for boundary-layer and deep convective clouds for climate models

--------Please see our poster for a diagnostic study