Dynamics and Microphysics of Cumulus Clouds: Can We Model Both?

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Marine stratocumulus (Khairoutdinov and Kogan 1999)

- LES dynamics (Boussinesq)
- Spectral microphysics: 19 aerosol bins, 25 drop bins
- Good agreement with ASTEX observations for stratocumulus dynamics and microphysics
- Transitioning to a new dynamical framework that supports parallel processing and deep convection

Marine stratocumulus (Khairoutdinov and Kogan 1999)

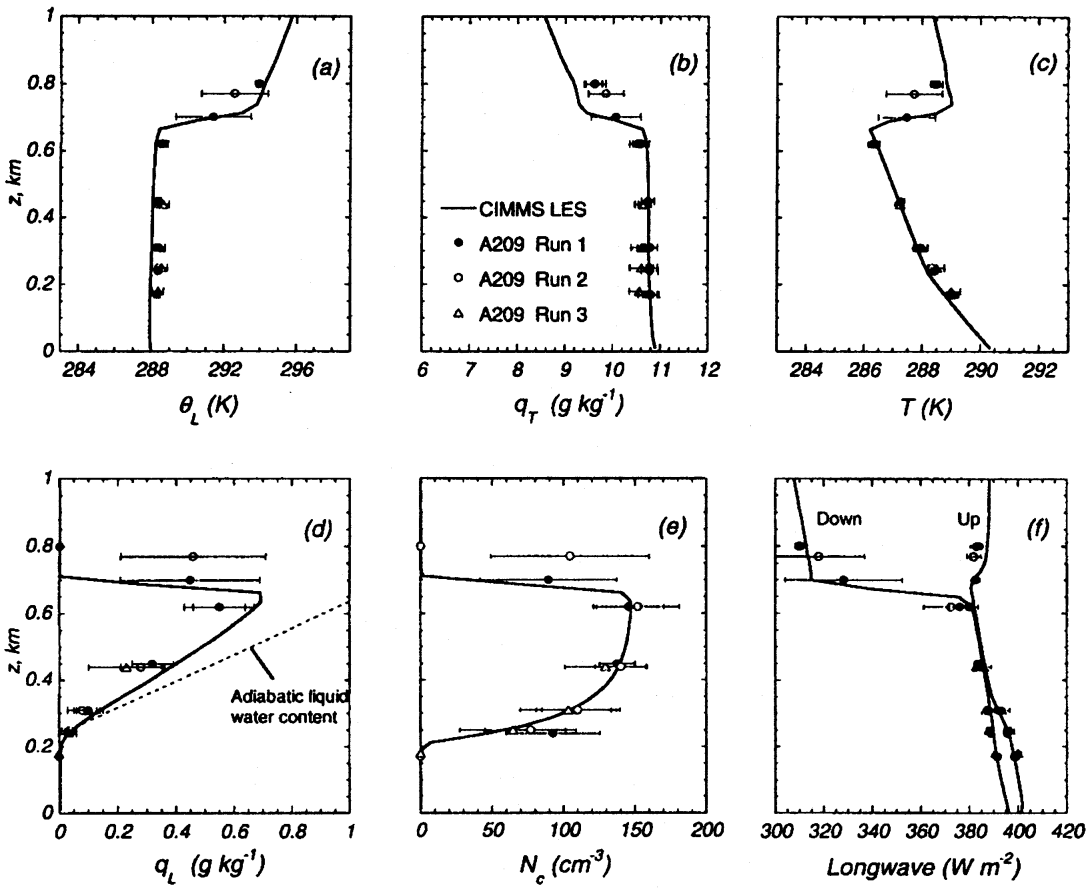


FIG. 9. Simulated (solid lines) vs observed during the ASTEX flight A209 (symbols) profiles of (a) liquid water potential temperature, (b) total water mixing ratio, (c) absolute temperature, (d) liquid water content, (e) drop concentration, and (f) longwave radiation fluxes. The standard deviation of the observed values is indicated by bars.

Marine stratocumulus (Khairoutdinov and Kogan 1999)

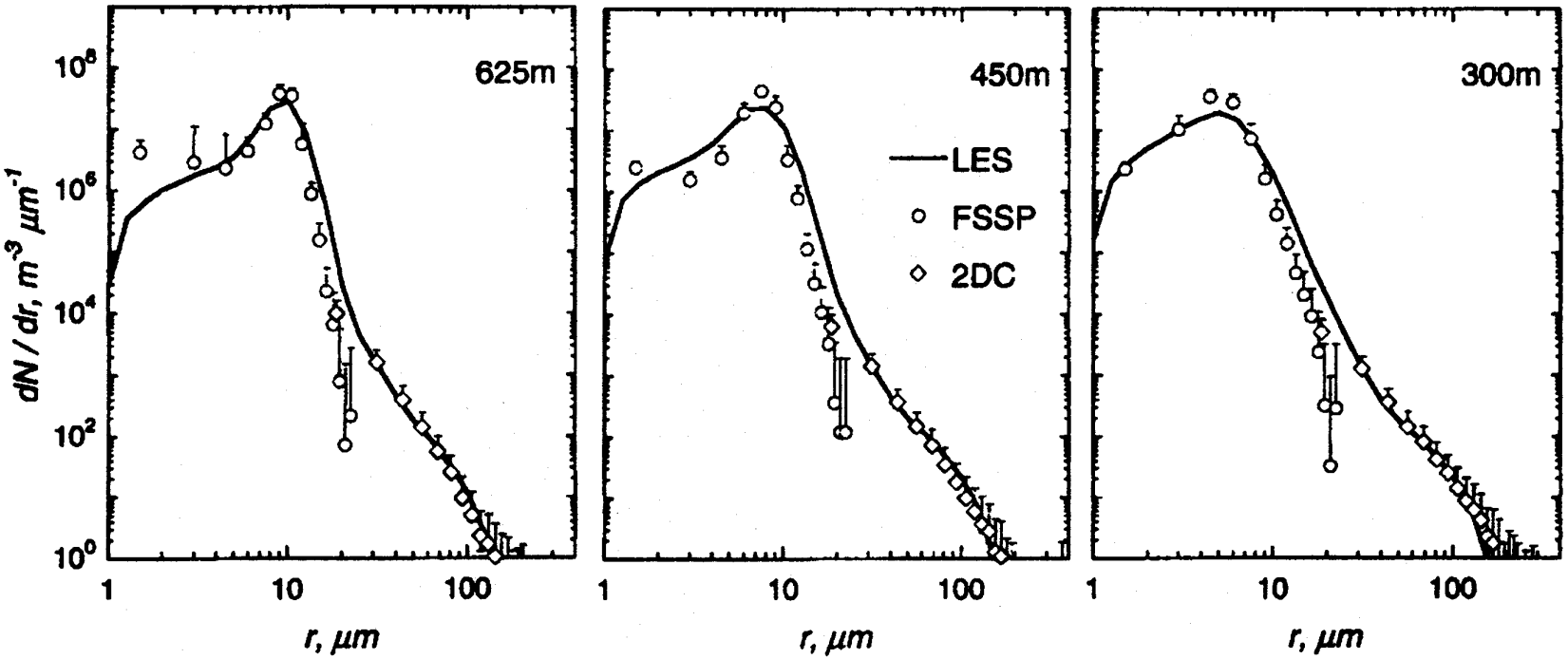


FIG. 11. Simulated (solid lines) vs measured during the ASTEX flight A209 (symbols) drop size spectra at three different levels in stratocumulus cloud layer. The standard deviation of the observed values as indicated by bars.

Precipitating cumulus (Ovtchinnikov and Kogan 2000)

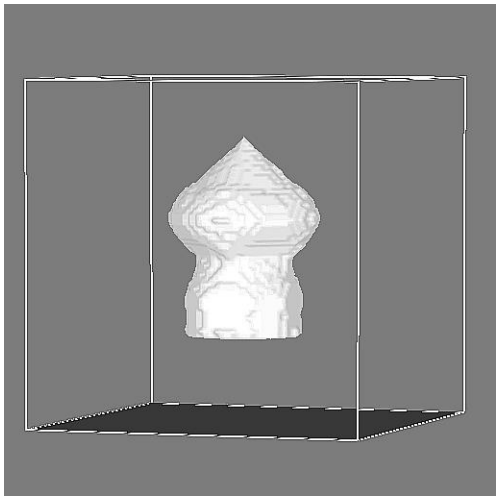
- 3D anelastic dynamics
- Spectral microphysics: 19 aerosol bins, 30 bins for liquid water, 30 bins for ice phase particles
- Small Eddy Initialization (SEI): more efficient mixing and more realistically simulated cloud
- Used successfully on a case study of New Mexico cumulus clouds

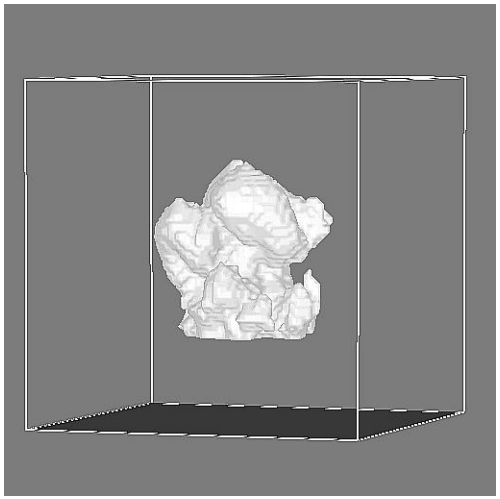
Precipitating cumulus (Ovtchinnikov and Kogan 2000)

Bubble

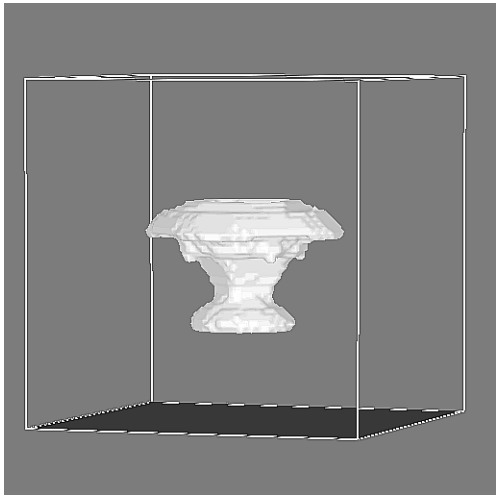
Small eddy initialization

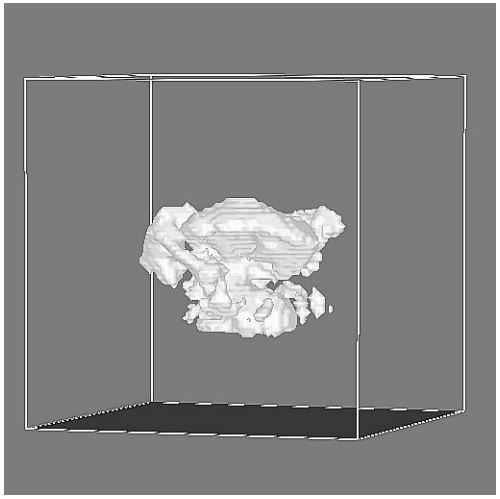
t = 20 min





t = 30 min





Precipitating cumulus (Ovtchinnikov and Kogan 2000)

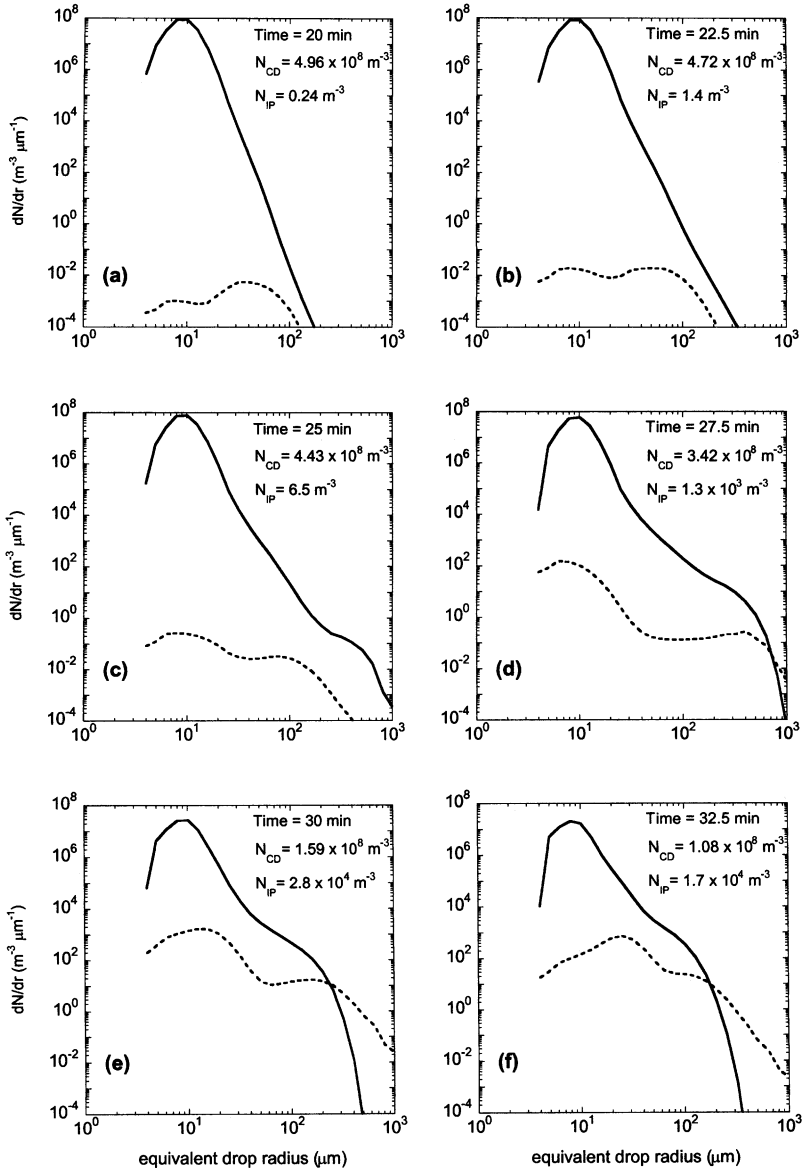


FIG. 10. Simulated cloud drop (solid) and ice particle (dashed) spectra at a location with coordinates (x, y, z) = (3.4, 3.4, 3.9) km. Also indicated are time and total drop (N_{CD}) and ice particle (N_{IP}) concentrations.

Our plan is to participate in RICO by undertaking a numerical modeling complement to the observational phase, using data collected during the field campaign

Science questions:

- What happened to the 19 mm coagulation threshold? Does “turbulent mixing” accelerate rain initiation? Do ultragiant nuclei?
- What are the specific roles of dynamics and turbulence in cloud microstructure formation? What is the role of parcel and drop recycling?

In general, we are interested in verification of the “classical” cloud physics theory of rain initiation and evolution using the integrated dynamics and microphysics dataset that will be collected during RICO.