Energy and Moisture Fluxes in the Giga-LES

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MOTIVATION

This study will give a better understanding of deep convection. The process of deep convection is the reason clouds exist. This study will help find the best combination of temperature, precipitation, and vertical velocity to create deep convection. It could assist in improving models and, therefore, providing better forecasts.

DATA

Giga-LES

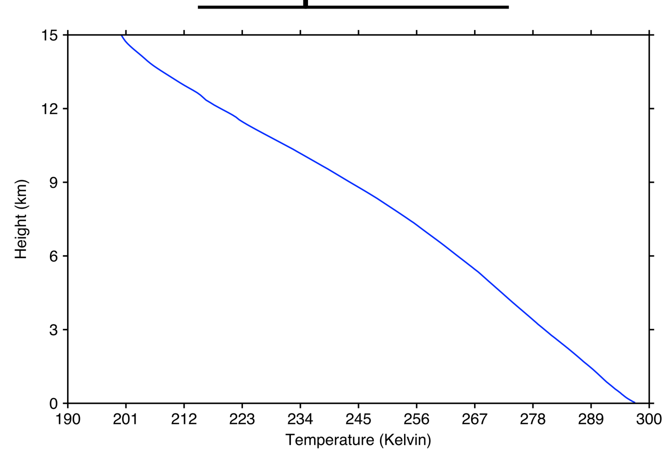
- A large domain large-eddy simulation (LES) of the idealized GATE case
- Very high resolution simulation that has grid cells small enough to detect all the turbulence in the atmosphere rather than only large amounts of turbulence
- Time period of 24 hours, which is a long time period compared to the life time of a cloud
- Covers large enough domain to represent a tropical convective system (~205km x 205km x 27km)
- Number of grid points (2048 x 2048 x 256) is approximately 10^9 hence "Giga"-LES

METHOD

- Looked at last hour of simulation (24th hour)
- Concentrated on surface level to the highest cloud top
- Looked at vertical velocity, non-precipitating condensate (water and ice), water vapor, and absolute temperature

RESULTS - Vertical Profiles

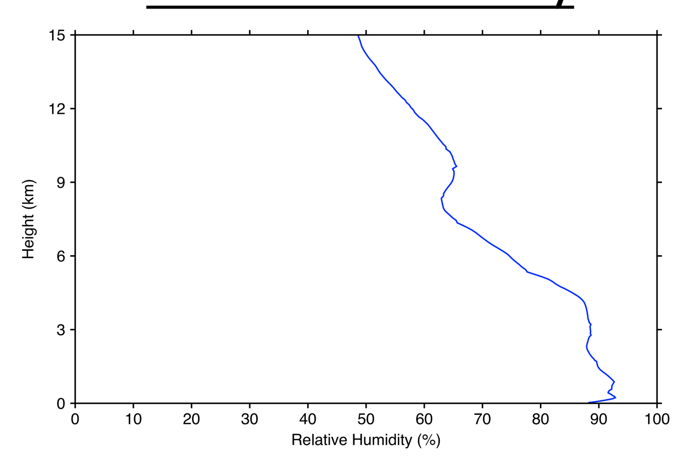
Temperature



•No inversions

•Lapse Rate increases in upper troposphere

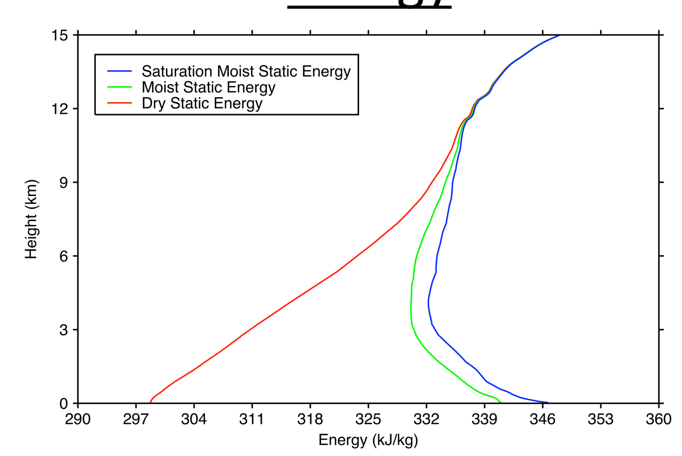
Relative Humidity



•Maximum close to ground

•Weak maxima at 4km and 9km show where clouds end

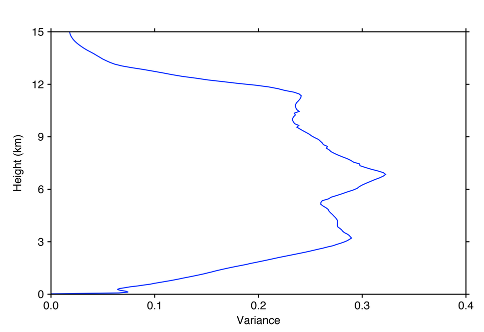
Energy



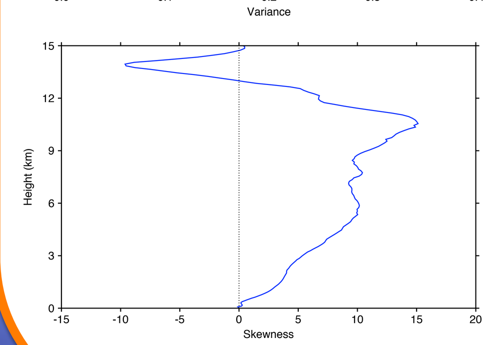
CAPE can be computed by following the moist static energy straight up through the atmosphere and finding the area between that line and the saturated moist static energy.

RESULTS - Variance and Skewness

Vertical Velocity

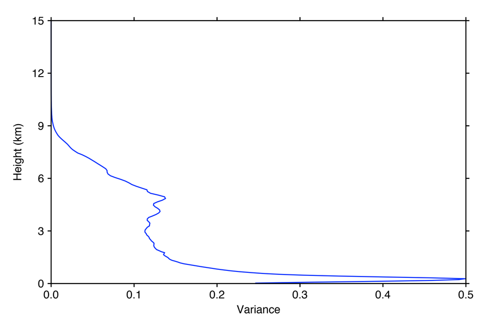


Three maxima may indicate tops of different cloud levels

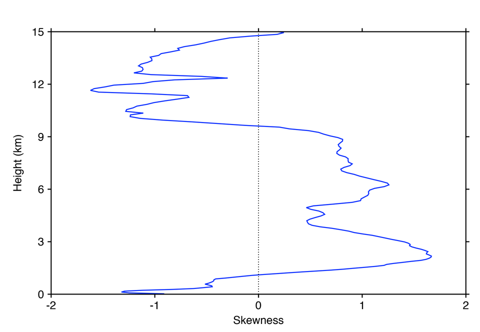


Strongly positive until cloud top

Water Vapor

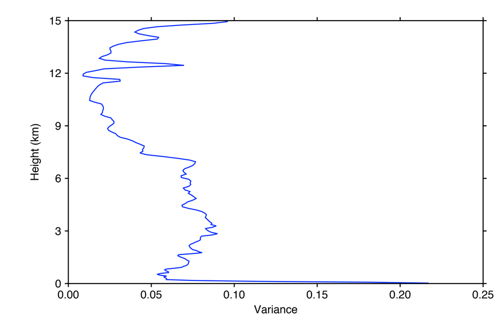


Maximum near surface with small peak near 5km

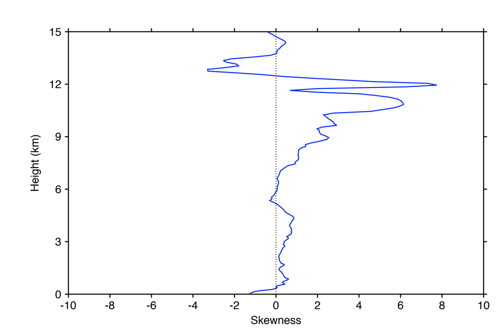


Mostly positive with some negative near surface and near 10km

Temperature



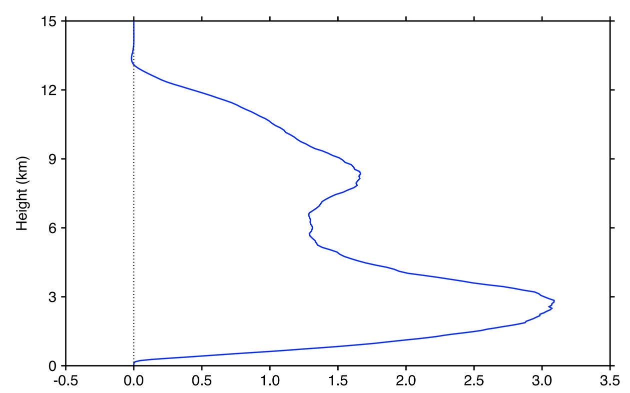
Differences help calculate CAPE



Strongly positive then strongly negative near 13km shows highest cloud top

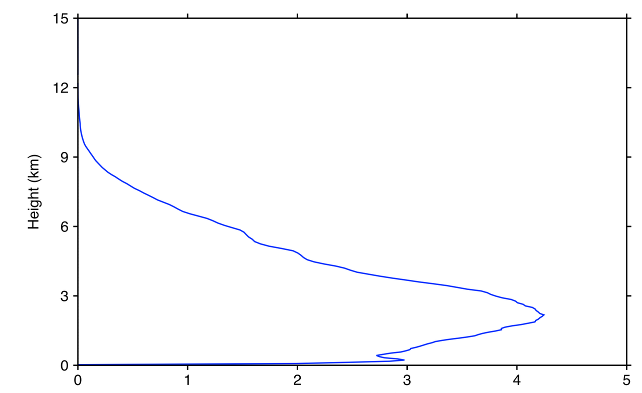
RESULTS - Fluxes

Cloud Water and Ice



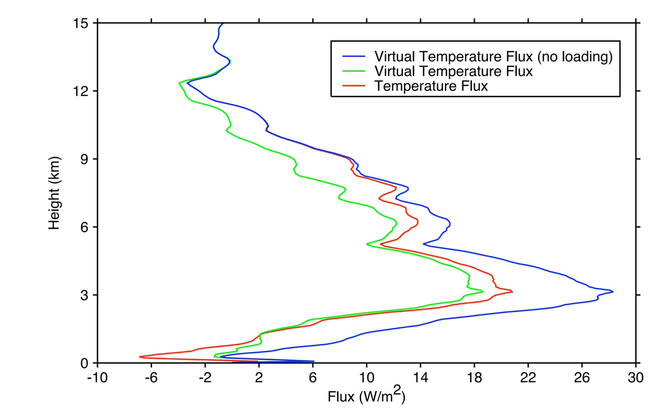
Peak near 3 km signifies shallow cumulus clouds (agrees with water vapor flux)

Water Vapor



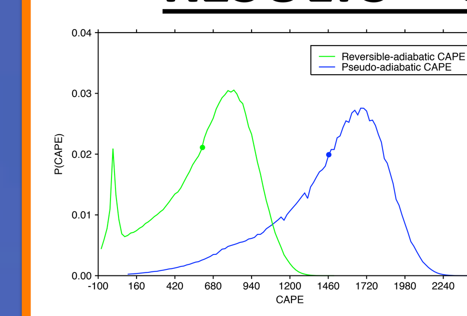
Peak near 3 km signifies shallow cumulus clouds (agrees with cloud water and ice flux)

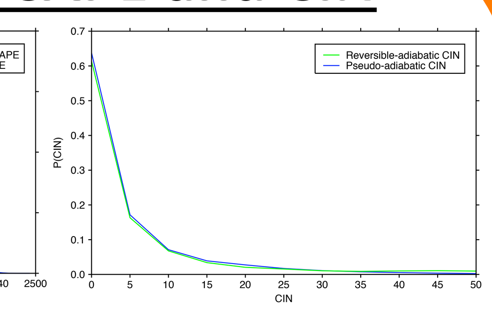
Sensible Heat



Temperature flux is approximately the rate at which CAPE is converted into convective kinetic energy.

RESULTS – CAPE and CIN





- Which parcel should be used to calculate CAPE and CIN?
- Plotted horizontal domain average (denoted by dot) and found CAPE and CIN at each level.
- Parcel population near the surface can give a wide variety of CAPEs.
- Most likely CAPE is not close to average.

FUTURE WORK

Improve thunderstorm forecasting by:

- Continuing to analyze CAPE and CIN and their relation to convective kinetic energy.
- Continuing to work with temperature, precipitation, and vertical velocity in relation to thunderstorm energetics.

REFERENCE

Moeng, C.-H., M. A. LeMone , M. Khairoutdinov , S. Krueger , P. Bogenschutzc and D. A. Randall, 2009: The tropical marine boundary layer under a deep convection system: a large-eddy simulation study. Submitted to JAMES.

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