Direct comparison of LES of cumulus convection with ARM-SGP observations

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Introduction

- A good understanding of size-dependent behavior of clouds is necessary for modern scale-aware parameterizations (e.g., ED(MF)^n)
- We use LES (using MicroHH), LIDAR, and TSI to characterize cumulus convection as a function of cloud size

Method

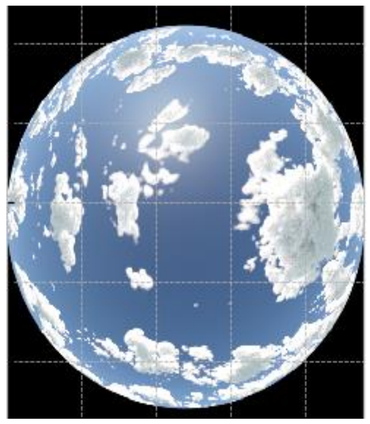
- LES simulations using MicroHH; 25m resolution, 25km domain
- Cases based on GCSS intercomparisons (BOMEX, ARM, RICO) and LASSO Alpha 2; results are robust between cases
- TSI Simulator developed using Blender
- Comparison of measured and simulated cloud chord properties at ARM SGP

Take Home Messages

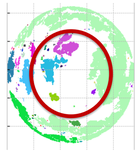
- Our LES results match well with observations based on a TSI Simulator comparison
- A maximum overlap assumption ignores the dominant terms in the actual overlap of individual clouds (hence cloud fields)
- Comparing 2D cloud slices from LES to LIDAR requires rotating cloud slice to match wind direction
- Cloud chord vertical velocity at cloud base increases with chord length

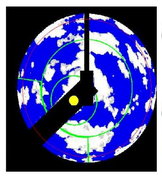
TSI Simulator in LES – With Jessica Kleiss

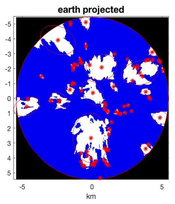
LES TSI



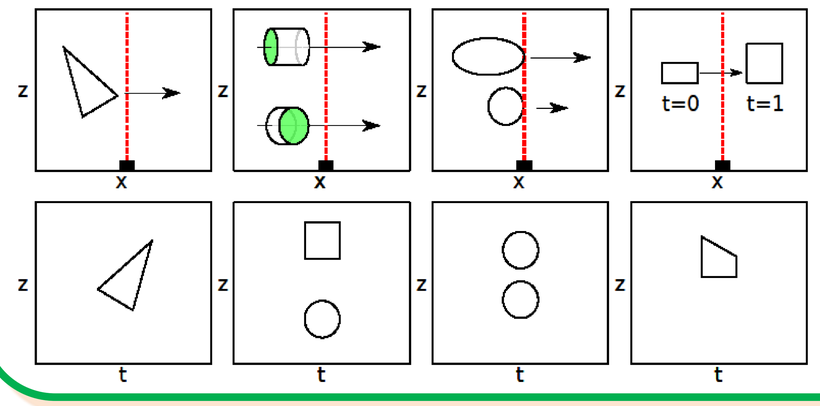
Object identification for CSDs. Ring represents 50deg





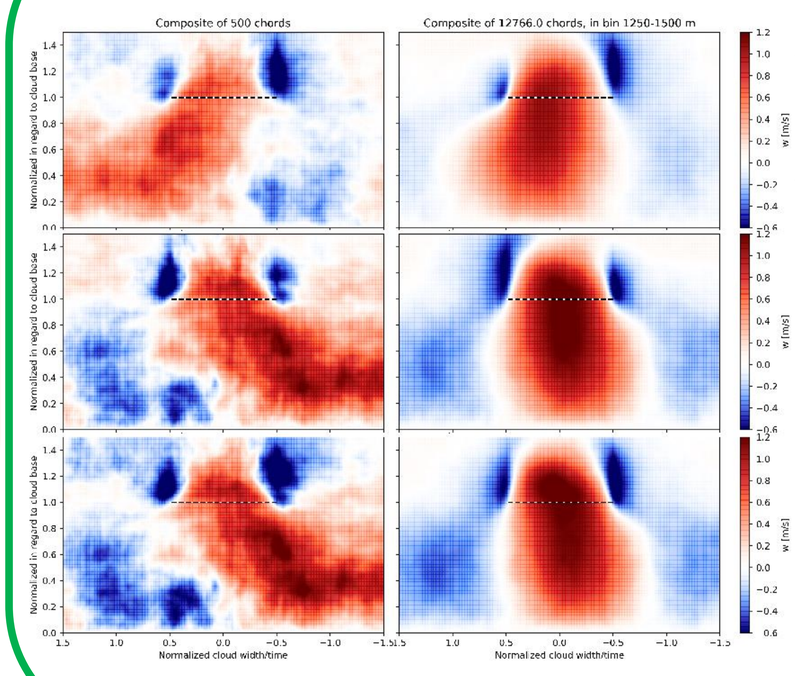


From 3D LES fields to LIDAR chords – With Neil Lareau



Sketches illustrate reasons that 2D slices through a 3D LES snapshot differ from a time height LIDAR profile.

The effect of wind direction on 2D LES chords



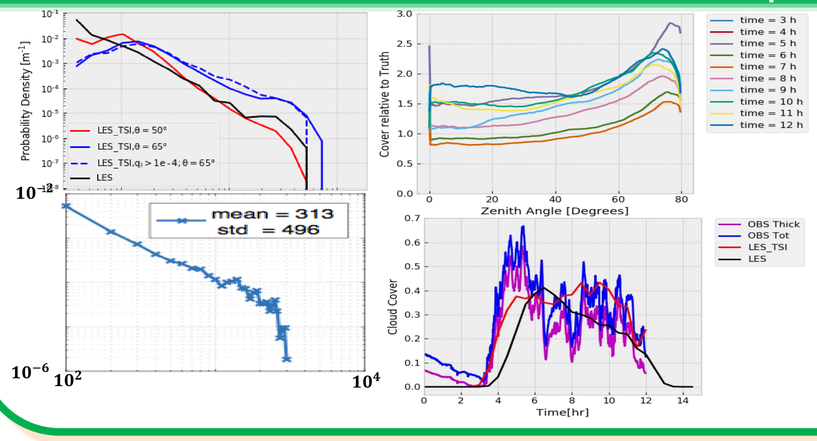
2D Chord composites of vertical velocity regularized by cloud base height and extent.

Top row:
No modifications

Middle row:
Chord composite weighted by wind direction at cloud base

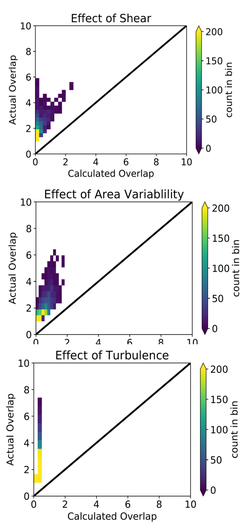
Bottom row:
Chord composite weighted by wind direction at each height independently

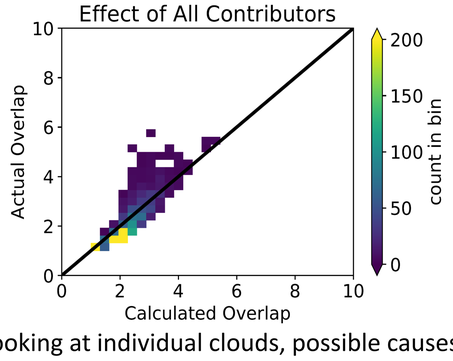
TSI Cloud size comparison

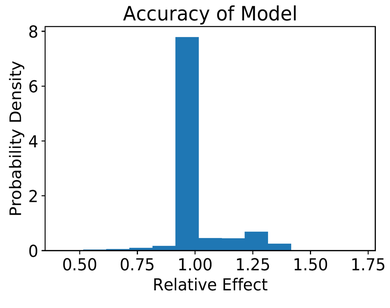


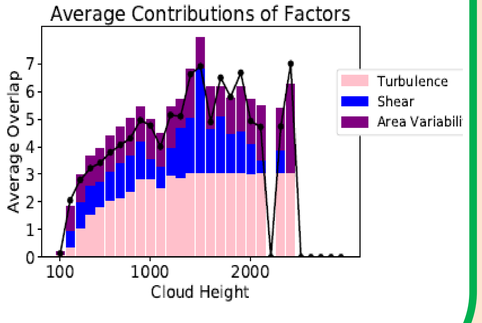
- LES generates a cloud size distribution and cloud cover that is in good agreement with TSI
- The simulator tends to overestimates cloud cover a bit, but still ok for reasonable zenith angles
- Cloud cover matches between TSI and the simulator, but “real” LES shows later cloud onset

Cloud Overlap for individual clouds



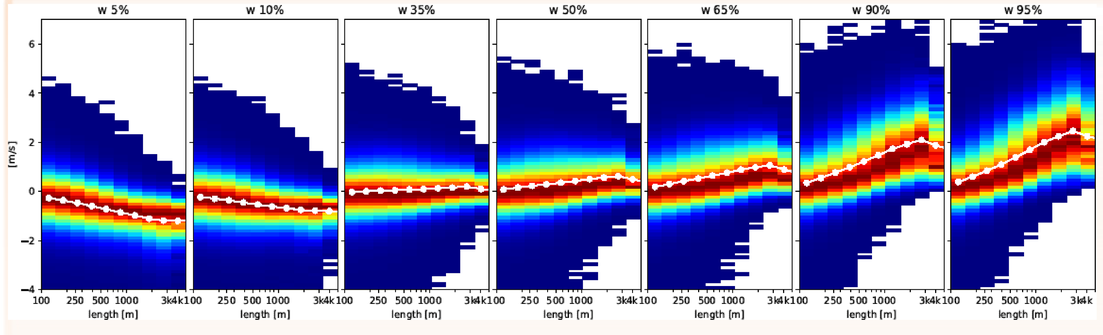






- Looking at individual clouds, possible causes of overlap are:
- 1) **Area variability** (e/.g., anvils) – modeled as maximum overlap
- 2) **Shear** - estimated by recentering all cloud layers on top of each other
- 3) **Small scale turbulence –** modeled by a 3D Koch curve
- Maximum Overlap captures less than half the ovelap; including the others allow us to model overlap well across cloud sizes

Cloud base vertical velocity binned by chord length



-3 LASSO days run with MicroHH at 25 m resolution provide roughly 2 million chords

-Sorting by size shows that the percentiles of vertical velocity at cloud base scale with chord length.