Department of Atmospheric Sciences Ph.D. Dissertation Announcement

Department of Atmospheric Sciences, **S.O.E.S.T.,** University of Hawai'i at Mānoa
2525 Correa Road, HIG 350; Honolulu, HI 96822 ☎956-8775

Hybrid Event: In-Person & Virtual

An In Situ Analysis of Marine Stratocumulus Environments and the Associated Boundary Layer, Turbulent, and Preferential Concentration Characteristics

Mr. Dillon Dodson
Ph.D. Candidate
Department of Atmospheric Sciences
University of Hawai'i at Mānoa

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Seminar Time: **9:00am**
Location: **IPRC Conference Room, POST 414**
Join Zoom Meeting: https://zoom.us/j/578008313?pwd=UkRlNzhBUzlhOGtMNFptQjVpc0pDUT09
Meeting ID: 871 6477 9715
Passcode: 816929

Abstract:

It is well known that fluid turbulence can affect cloud droplet motion, leading to preferential concentration (or droplet clustering), which in turn can impact precipitation formation through influences on collision-coalescence. Previous work suggests that droplet clustering occurs on the order of the Kolmogorov length scale η, with the magnitude of said clustering depending on the Stokes number *St*. The accuracy of these theories remains largely unquantified for in situ atmospheric clouds however. Along with this, developing a better understanding of processes occurring on subgrid scales is important for better representing stratocumulus (Sc) decks, with most models struggling to resolve boundary layer vertical structure and turbulence, important variables in determining Sc cloud properties. Although turbulence is a critical component to boundary layer and microphysical processes, literature describing cloud-related turbulence based on in situ data is scarce.

This work therefore analyzes (1) boundary layer and turbulent characteristics, along with synoptic-scale changes in these properties over time; (2) the in situ characteristics of droplet clustering and the associated effects of drop size *d* and turbulence. This is done using data collected onboard the CIRPAS Twin Otter Aircraft during the Variability of the American Monsoon Systems (VAMOS) Ocean-Cloud-Atmosphere-Land Study Regional Experiment (VOCALS-REx) through 18 research flights at Point Alpha (20°S, 72°W) in October and November 2008. This campaign sampled the weakly turbulent Peruvian marine Sc deck. Spatial statistics of cloud droplet arrival times recorded by the phase-Doppler interferometer are analyzed by means of the one-dimensional pair-correlation function η(l).

The average boundary layer depth is found to be 1148-m, with 28% of the boundary layer profiles analyzed displaying decoupling. An increase in boundary layer height z_i is accompanied by a decrease in turbulence within the boundary layer. As z_i increases, cooling near cloud top cannot sustain mixing over the entire depth of the boundary layer, resulting in less turbulence and boundary layer decoupling. A total of 10 of the 18 flights display two peaks in turbulent kinetic energy (TKE) within the cloud layer, one near cloud base and another near cloud top, signifying evaporative and radiational cooling near cloud top and latent heating near cloud base. Decoupled boundary layers tend to have a maximum in turbulence in the sub-cloud layer, with only a single peak in turbulence within the cloud layer. Measures of TKE averaged in-cloud over all 18 flights display a maximum near cloud middle (between normalized in-cloud height Z_* values of 0.25 and 0.75).

Droplet clustering occurs in 95% of cases analyzed, with the magnitude of said clustering becoming significant in the turbulence dissipation range, at a length scale of ~2η. Analyzing η(l) as a function of Z_* indicates (i) a maximum in the magnitude of average droplet clustering occurs near Sc middle, at $Z_* = 0.47$, (ii) droplet clustering and *St* are found to be strongly correlated at a statistically significant rate. An enhanced (reduced) aerosol number concentration N_a is found to result in enhanced (reduced) clustering at spatial scales below 1-mm, but a reduction (enhancement) in the length scale at which clustering becomes significant. The presence of droplet polydispersity results in a saturation value in the preferential concentration being reached, where enhanced (reduced) polydispersity for low (high) N_a environments leads to a reduction (enhancement) in clustering below 1-mm.