Aerosol-Cloud-Drizzle-Turbulence Interactions in Boundary layer Clouds

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LONG-TERM GOALS

The long term-goal of this project is to provide an improved description and understanding of the effects of aerosol-cloud interactions and drizzle and entrainment processes in boundary layer clouds for the purpose of developing, improving, and evaluating cloud and boundary layer representations in LES, mesoscale and large-scale forecast models.

OBJECTIVES

The scientific objectives are to: 1) document the structure and characteristics of entrainment circulations in marine stratocumulus and fair-weather-cumuli, 2) characterize the vertical distribution of drizzle and how it relates to cloud and mesoscale circulations; 3) investigate the relative role of cloud thickness, cloud turbulence intensity, and aerosols on drizzle production; 4) study the processing of aerosols by cloud processes; and 5) explore mass, moisture, and aerosol transports across interfacial regions at cloud base and at the capping inversion.

APPROACH

The observations needed for this study will be made using NAVY CIRPAS Twin Otter research aircraft and will include the use of an FMCW cloud radar to track drizzle and cloud features while making simultaneous *in situ* measurements of aerosols and cloud characteristics. Further, we plan to make use of the cloud radar with radar chaff to track air motions in and out of the clouds. Cloud seeding techniques demonstrated in an earlier ONR funded study will be extended to study the response of cloud and drizzle processes to the artificial introduction of CCN and giant nuclei under differing aerosol backgrounds. In addition, a set of aerosol and cloud observations in trade wind cumulus clouds using the CIRPAS aircraft with the cloud radar will be developed. The observational components of this study will be made in environments where we expect strong-aerosol-cloud variability. This will include observations during VOCALS (VAMOS Ocean Cloud Atmosphere Land Study) Regional Experiment off the coast of Chile (Oct.-Nov. 2008) where satellite observations indicate strong gradients in cloud properties off the coast. Further we will make use of observations from the South Florida area of fair-weather cumulus clouds (Jan. 2008) where clouds with both marine and continental characteristics are observed. Following these two deployments we plan stratocumulus and fair-weather cumulus seeding and aerosol transport studies in 2010 and 2012 that will make use of study areas off the coast of California and Florida. These studies include the participation of one graduate student and a technician/data analyst. For the VOCALS study we will collaborate with Dr. Carl Friehe (U. Calif. Irvine) on turbulence observations from the Twin Otter and with Dr. Patrick

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14. ABSTRACT
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Chaung (U. Calif. Santa Cruz) on cloud physics measurements. For the later studies, we will consider the possibility of using the towed, instrumented platform being developed by Dr. Friehe. This platform could allow for turbulence observations at two levels across key interfaces at cloud top and cloud base to study entrainment transport processes.

WORK COMPLETED

During Januray-February 2008, the CIPAS Twin Otter was used to study aersosl, cloud, precipitation and turbulence observation in the South Florida area. A total of 15 flights were flown and provided sampling over a wide range of aerosol, cloud and boundary layer conditions. Flights were made over water and over land to provide boundary layer turbulence variations. Substantial boundary layer variations were observed and cloud conditions encountered included nearly solid stratocumulus, shallow non-precipitating cumulus, and shallow precipitating cumulus. Thus a full range of aerosol, cloud, and boundary layer conditions were sampled during the deployment and a rich data set for understaing key physical processes operating in these clouds was obtained. Work is currently in progress to analyze the data that were collected during these aircraft missions.

CIRPAS Twin Otter field operations in South Florida allowed five University of Miami gaduate students (one funded by this grant) to participate in this study as on-board scientists and to obtain unique field experience. Further, undegradaute meterolgy students from UM toured the Twin Otter facility and received instument tutorials as an enhancement to their meterological intrumentation class.

RESULTS

Although the analyses from the January-February Miami data sets are preliminary, it was possible to document boundary layer and aerosol variability across the western-edge of the Gulf Stream on one of the flights. Strong northerly winds following the passage of a cold front on 28 June 2008, the turbulence levels over the warmer Gulf Stream were, as expected, substantially enhanced relative to those over the colder waters near the coast. One interesting feature observed was that the concentrations of aerosols near the surface were substantially lower over the disturbed Gulf Stream ocean surface (white caps clearly evident) than over the more quiescent coastal waters (no white caps). The variations in sea surface temperature, winds, and aerosols observed across the west boundary of the Gulf Stream are illustrated in *Fig.* 1 which shows near surface observations made from the aircraft during this case. Work is in progress to explain this variability and to examine possible variability in clouds and cloud-aerosol processing effects across the interface.

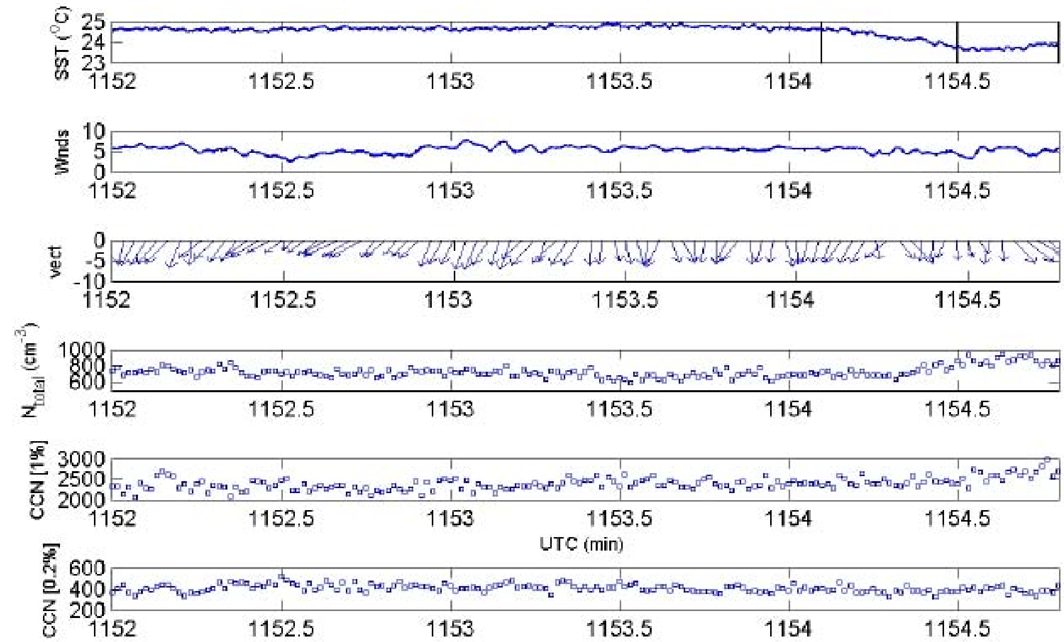

Figure 1. Low-level variations as a function of time of the sea surface temperature (SST), winds (speed in m/s), aerosol concentrations (from PCASP), and CCN concentrations at 2 super-saturations for 28 January 2008. The two short vertical lines indicate the (on the SST plot) show the transition zone.

IMPACT/APPLICATIONS

The results from these studies are intended to provide an improved understanding of the physical processes associated with cloud-aerosol-drizzle-turbulence interaction that will lead the way to improved representation of the processes in models operating over a wide rang of scale and particularly for mesoscale and large-scale forecast models used in coastal and marine environments. We are establishing opportunities for model-observation evaluations and development through collaboration with Dr. Shouping Wang at NRL Monterey.