Cumulus Photogrammetric, In-situ and Doppler Observations (CuPIDO)
Project Description

The CuPIDO field program will use digital visible spectrum cameras, surface mesonet stations, high temporal resolution soundings and aircraft data to examine the onset and transition of shallow to deep orographic cumulus associated with the North American Monsoon (NAM) in southern Arizona. CuPIDO will take place during the July and August, 2006 over the Santa Catalina Mountains north of Tucson. The aircraft observations, and airborne radar data, are intended to describe the cloud microphysical and thermodynamic structure of cumuli and the mesoscale environment in which they build and decay.

NAM thunderstorms in southern Arizona typically originate over the high terrain and often in low wind or/and low shear conditions. There is a distinct diurnal cycle: convective inhibition vanishes over the 'sky island' and shallow cumuli begin to form at about 9:00 am local time under otherwise clear skies. Convection gradually deepens over a period of several hours to towering cumulus or cumulonimbus. Time lapse photography demonstrates that convection develops in stages, with convective turrets evaporating and new turrets ascending through the remnants of the old ones. The central hypothesis of CuPIDO is that deep convection and precipitation development only occur once the column over the terrain is sufficiently moistened by shallow convection to prevent erosion of convective turrets by entraining dry environmental air. This hypothesis requires detailed monitoring of changes in the potential temperature and mixing ratio in the boundary-layer inflow, as well as in the mid-troposphere. While high values of moist static energy are detrained above the convective boundary-layer (CBL), lower values may be detrained into the CBL by convective downdrafts, contributing the pulsating nature of the towering convection phase. The duration of this phase varies daily, presumably depending on the profiles of wind and thermodynamic properties.

Observing platforms to be used in CuPIDO include a stereo pair of digital cameras that will be located in Oracle, AZ, north of the Santa Catalina Mountains. Stereo image and automatic edge detection (segmentation) techniques developed at ASU will be used to extract quantitative information from the cloud images. These observations will be accompanied by surface observations from a network of ten PAM-III stations, three of which will be equipped with towers to measure surface latent and sensible heat and turbulent momentum transfer. The surface observations will augment those from a 30-meter tower that is located permanently on Mt. Lemmon. We will also use two mobile GPS based sounding systems (MGAUS) one of which will be located on Mt. Lemmon and one at the base of the Catalinas, with the location of the base station depending on prevailing winds. Soundings will be performed starting 8:00 am to sample the pre-convective environment and continued until the deep convection is in place, typically about 1:00 pm.

The University of Wyoming King Air (WKA) will be equipped with the 95GHz (W-band) Wyoming Cloud Radar (WCR). The WCR is capable of 30 m resolution and hence will reveal details of the entrainment processes. Dual-Doppler winds can be derived in horizontal and vertical planes to the right and below the aircraft, to a range of ~3 km. Depending on the strength of the clear-air return, the WCR may also capture the CBL flow feeding cumuli. The WKA/WCR will provide ground truth information for the stereo photogrammetric analysis, and the 3-D cloud edge maps will be combined with WCR transects to outline the difference between the true cloud edge and the radar echo edge. This will assist the interpretation of the drop size distribution and precipitation falling below cloud base.

CuPIDO will consist of at least 10 Intensive Observing Periods (IOPs) that will take place between 18 July and 17 August, 2006. The IOPs will involve coordinated observations by the WKA, MGAUS and stereo cameras, with the PAM-III stations providing data on the evolution of the surface forcing. The cameras and PAM-III stations will run continuously between 1 July and 31 August, 2006.

The advantage of the location for CuPIDO is the regularity of the convection over the Catalina sky island. The WKA and soundings will sample the CBL inflow and mid-level detrainment region from before the onset of the first shallow cumuli until the cumulonimbus stage. We realize that the strength of photogrammetry and WKA/WCR measurements primarily lies in the description of the cumulus cloud evolution. CuPIDO is relatively weak in two areas: the description of ambient tropospheric changes (mainly moisture and stability) leading to or resulting from sky-island convection; and the description of the clear-air CBL flow and the onset and evolution of precipitation. These shortcomings would be alleviated by profiling remote sensors and ground-based scanning radars, respectively, but such probes are not included in CuPIDO at this time.

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