Cloud Radar Studies at the CRYSTAL-FACE Eastern Ground Site on July 29, 2002

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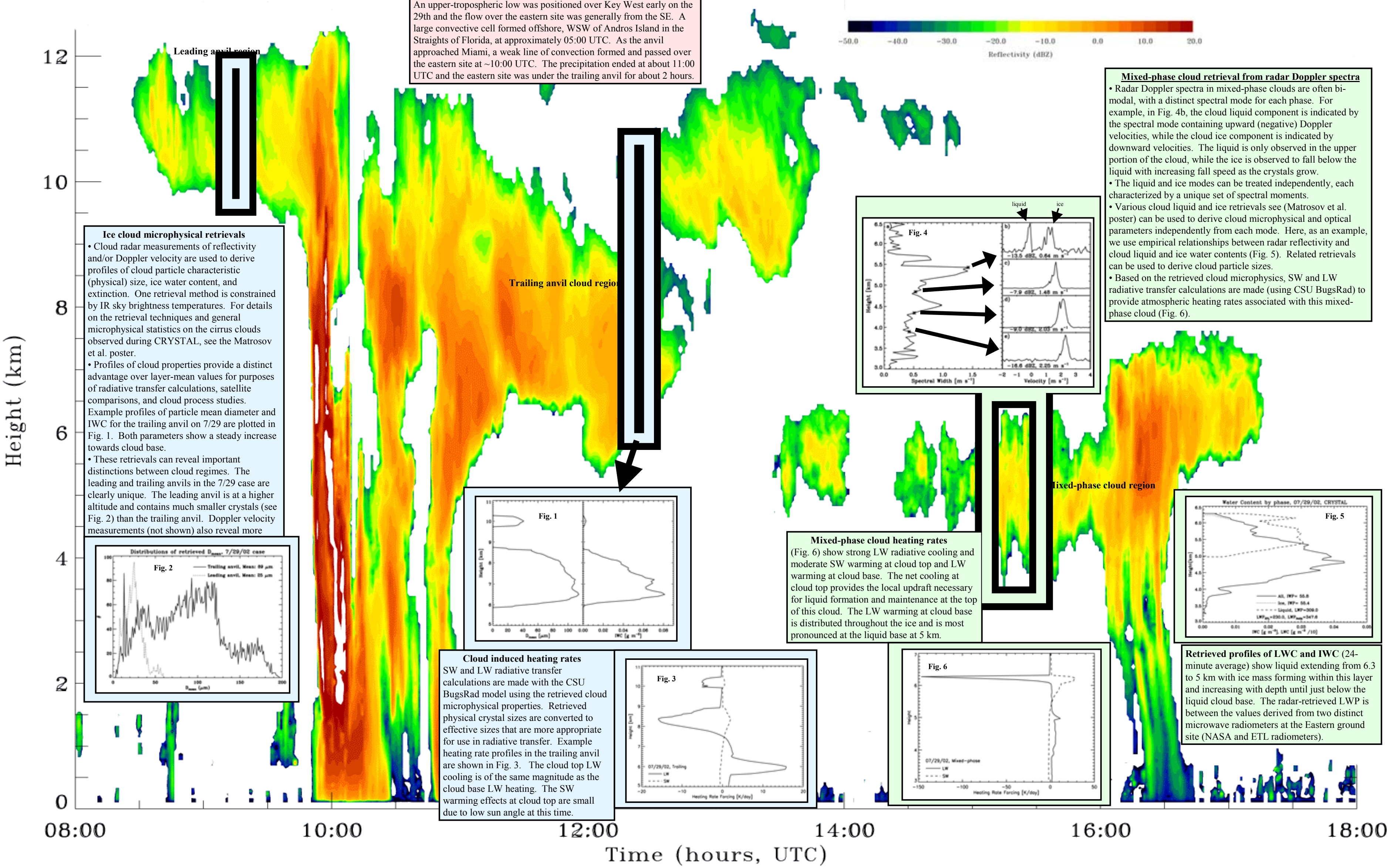
Synoptic Situation on July 29th

An upper-tropospheric low was positioned over Key West early on the 29th and the flow over the eastern site was generally from the SE. A large convective cell formed offshore, WSW of Andros Island in the Straights of Florida, at approximately 05:00 UTC. As the anvil approached Miami, a weak line of convection formed and passed over the eastern site at ~10:00 UTC. The precipitation ended at about 11:00 UTC and the eastern site was under the trailing anvil for about 2 hours.



Ice cloud microphysical retrievals

- Cloud radar measurements of reflectivity and/or Doppler velocity are used to derive profiles of cloud particle characteristic (physical) size, ice water content, and extinction. One retrieval method is constrained by IR sky brightness temperatures. For details on the retrieval techniques and general microphysical statistics on the cirrus clouds observed during CRYSTAL, see the Matrosov et al. poster.
- Profiles of cloud properties provide a distinct advantage over layer-mean values for purposes of radiative transfer calculations, satellite comparisons, and cloud process studies. Example profiles of particle mean diameter and IWC for the trailing anvil on 7/29 are plotted in Fig. 1. Both parameters show a steady increase towards cloud base.
- These retrievals can reveal important distinctions between cloud regimes. The leading and trailing anvils in the 7/29 case are clearly unique. The leading anvil is at a higher altitude and contains much smaller crystals (see Fig. 2) than the trailing anvil. Doppler velocity measurements (not shown) also reveal more

Cloud induced heating rates

SW and LW radiative transfer calculations are made with the CSU BugsRad model using the retrieved cloud microphysical properties. Retrieved physical crystal sizes are converted to effective sizes that are more appropriate for use in radiative transfer. Example heating rate profiles in the trailing anvil are shown in Fig. 3. The cloud top LW cooling is of the same magnitude as the cloud base LW heating. The SW warming effects at cloud top are small due to low sun angle at this time.

Mixed-phase cloud retrieval from radar Doppler spectra

- Radar Doppler spectra in mixed-phase clouds are often bi-modal, with a distinct spectral mode for each phase. For example, in Fig. 4b, the cloud liquid component is indicated by the spectral mode containing upward (negative) Doppler velocities, while the cloud ice component is indicated by downward velocities. The liquid is only observed in the upper portion of the cloud, while the ice is observed to fall below the liquid with increasing fall speed as the crystals grow.
- The liquid and ice modes can be treated independently, each characterized by a unique set of spectral moments.
- Various cloud liquid and ice retrievals see (Matrosov et al. poster) can be used to derive cloud microphysical and optical parameters independently from each mode. Here, as an example, we use empirical relationships between radar reflectivity and cloud liquid and ice water contents (Fig. 5). Related retrievals can be used to derive cloud particle sizes.
- Based on the retrieved cloud microphysics, SW and LW radiative transfer calculations are made (using CSU BugsRad) to provide atmospheric heating rates associated with this mixed-phase cloud (Fig. 6).

Mixed-phase cloud heating rates

(Fig. 6) show strong LW radiative cooling and moderate SW warming at cloud top and LW warming at cloud base. The net cooling at cloud top provides the local updraft necessary for liquid formation and maintenance at the top of this cloud. The LW warming at cloud base is distributed throughout the ice and is most pronounced at the liquid base at 5 km.

Retrieved profiles of LWC and IWC (24-minute average) show liquid extending from 6.3 to 5 km with ice mass forming within this layer and increasing with depth until just below the liquid cloud base. The radar-retrieved LWP is between the values derived from two distinct microwave radiometers at the Eastern ground site (NASA and ETL radiometers).