

Comparison of Concurrent Radar and Aircraft Measurements of Cirrus Clouds

A summer 2015 field project was conducted near Cape Canaveral, Florida, and was designed to help the United States Navy continue improvements to both the radar reflectivity-liquid water content relationship for the Mid-Course Radar (MCR) and the representation of ice within the Navy's computer forecast models. During the field project, in-situ and remote measurements of thunderstorm anvils near Cape Canaveral, Florida, were concurrently obtained. The North Dakota Citation Research Aircraft obtained measurements using airborne cloud probes, and the MCR obtained measurements using both its narrowband and wideband beams with along-range resolutions of 37 m and 0.5 m, respectively. The aircraft location was downlinked to the MCR in real-time which enabled a specialized scan to be performed which tracked the aircraft within the MCR's wideband beam. This specialized scan thus allowed for concurrency between the in-situ and radar measurements for prolonged periods of flight, a first in meteorology.

Radar reflectivity is derived using effective liquid particle sizes and total particle concentrations from the Two-Dimensional Stereographic probe (2D-S) and accounts for the dielectric factor differences between water and ice. Effective liquid particle sizes are derived from the 2D-S two-dimensional particle size measurements and an effective density of the ice particles assuming the mass of water is equal to the mass of ice. The effective ice particle density is derived using the total (all measured particles) particle mass obtained using a Nevzorov Water Content Probe, along with the total particle volume obtained from the 2D-S. The effective particle density accounts for the presence of non-solid ice particles and is verified against other published research. The derived radar reflectivity is compared to the reflectivity from the narrowband and wideband beams of the MCR. Eight cases are analyzed from two MCR scanning strategies, four cases from vertical stare data on 8 August 2015 and four cases from aircraft tracking data on 1 August 2015. Direct and statistical comparisons of the three radar reflectivity data sets from both scanning strategies are also completed. The statistical comparison between independent measurements of each of the radar reflectivity data sets is conducted using an autocorrelation function to find if and when the data sets agree.

Early findings have shown that the comparison at the ideal times when the aircraft and the MCR are aligned in space is ineffective because the return signal from the aircraft fills the MCR's beams with artificial noise. It is also ineffective to directly compare the data sets at times when the aircraft is not over the MCR because such comparisons are for different parts of the thunderstorm anvil, which can have sufficiently different properties. Therefore, a statistical comparison will help to alleviate these issues by not requiring the measurements to align precisely in space. Instead, the MCR data are compared to the aircraft measurements over a layer centered about the vertical aircraft position and when a slight offset in position is used during the tracking scans in order to remove the spurious aircraft return from the analysis. In addition, the uncertainty in both radar reflectivity data sets and the aircraft measurements are calculated, and, in the end, it is expected that both the narrowband and wideband data sets will agree with the 2D-S derived radar reflectivity within the respective measurement uncertainties.