SYNERGIZING HIGH-RESOLUTION EOS TERRA SATELLITE DATA AND S-POLKA RADAR REFLECTIVITY TO ASSESS TRADE WIND CUMULI PRECIPITATION

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1. INTRODUCTION

The Rain In Cumulus over the Ocean (RICO) field campaign, which took place during Dec '04 and Jan '05, studied fields of trade wind cumulus clouds. Trade wind cumulus are a persistent feature over the oceans between 25° N-S latitude and are present in nearly all satellite imagery from this region. The RICO field campaign set out to comprehensively study these clouds at all scales with an overarching goal of determining their influence on global water and energy budgets (RICO Scientific Overview Document http://www.joss.ucar.edu/rico/). The importance of trade wind cumulus in these budgets is yet to be determined, but discovering how they behave and influence the climate system is of great interest to the climate modeling community, where these clouds are not well represented. (e.g., Arakawa 2004)

Satellites are the only instruments capable of studying these clouds on large temporal and spatial scales. Unfortunately the subpixel nature and low cloud top height of trade wind cumuli make it especially difficult to retrieve their properties accurately (e.g., Wielicki and Parker 1992; Di Girolamo and Davies 1997; Wielicki and Welch 1986; Arching and Childs 1985). However, in RICO a major effort was made to collect very high resolution imagery from the polar-orbiting EOS Terra spacecraft. Radiance data and cloud products from ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) and MISR (Multiangle Imaging SpectroRadiometer) at 15m and 275m-ground resolution respectively, are being used at the time of this writing to determine the characteristics of these clouds from space. ASTER and MISR offer a distinct advantage to studying the small trade wind cumulus by taking very high resolution and multi-angle images within the same field of view. ASTER's 15m ground resolution allows for a very detailed study of the trade wind cumulus structure, size and shape (Fig. 1). Furthermore, MISR uses a stereoscopic technique to retrieve cloud top heights and cloud track winds as standard products and the quality of these products are largely insensitive to the sub-pixel nature of the trade wind cumuli. (e.g., Moroney et al 2004)

To achieve a more complete picture of the trade wind cumulus, the satellite data are being compared directly with ground-based radar data taken by the dual-polarized radar S-POLKA (S-band Polarimetric Radar and K-band Radar). Once the satellite derived cloud properties like cloud top height, area and cloud fraction are collected, a comparison at the pixel level with radar reflectivity and rain rate will be used to develop statistics concerning the trade wind cumulus distribution and precipitation patterns.

Figure 1. ASTER image from November 28, 2004, for the green channel at 15m resolution.

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2. OBSERVATIONS

S-POLKA radar operations began on November 24, 2004 and ended on January 24, 2005. During this time the EOS Terra spacecraft made 15 passes over the radar in which the swath of MISR (360km across) covered the Island of Barbuda. During these scheduled overpass times, the S-POLKA radar employed a scan strategy that included a 360° base level scan (0.5°) at the time the satellite reached its zenith over the radar. Radar variables of interest include radar reflectivity (horizontal polarization), reflected power, Doppler radial velocity and differential reflectivity. MISR data and products include visible and near-IR radiance measurements and stereo cloud top heights. ASTER data included radiance measurements from 12 channels spanning the visible, shortwave-IR and thermal-IR portions of the spectrum.

3. CURRENT ANALYSIS

Before any analysis, filtering of noise, bird echoes and island clutter is completed. The islands are simply cut out of the data and background noise is cleared using a threshold of -115.1 in the dBM field. The large numbers of Frigate birds are especially troublesome in the reflectivity data. Fortunately, the birds have high positive differential reflectivity and their Doppler velocity is typically significantly different from the background flow and can therefore be flagged and removed (Fig. 2).

To compare data from two different remote sensors a common mapping grid is being used. First, each range gate (radar pixel) from S-POLKA has been assigned a latitude and longitude at each gate's center and corners. Next, using MISR's or ASTER's geolocation information and a nearest-neighbor matching algorithm, the radar reflectivity data is assigned to every MISR or ASTER pixel (Fig. 3).

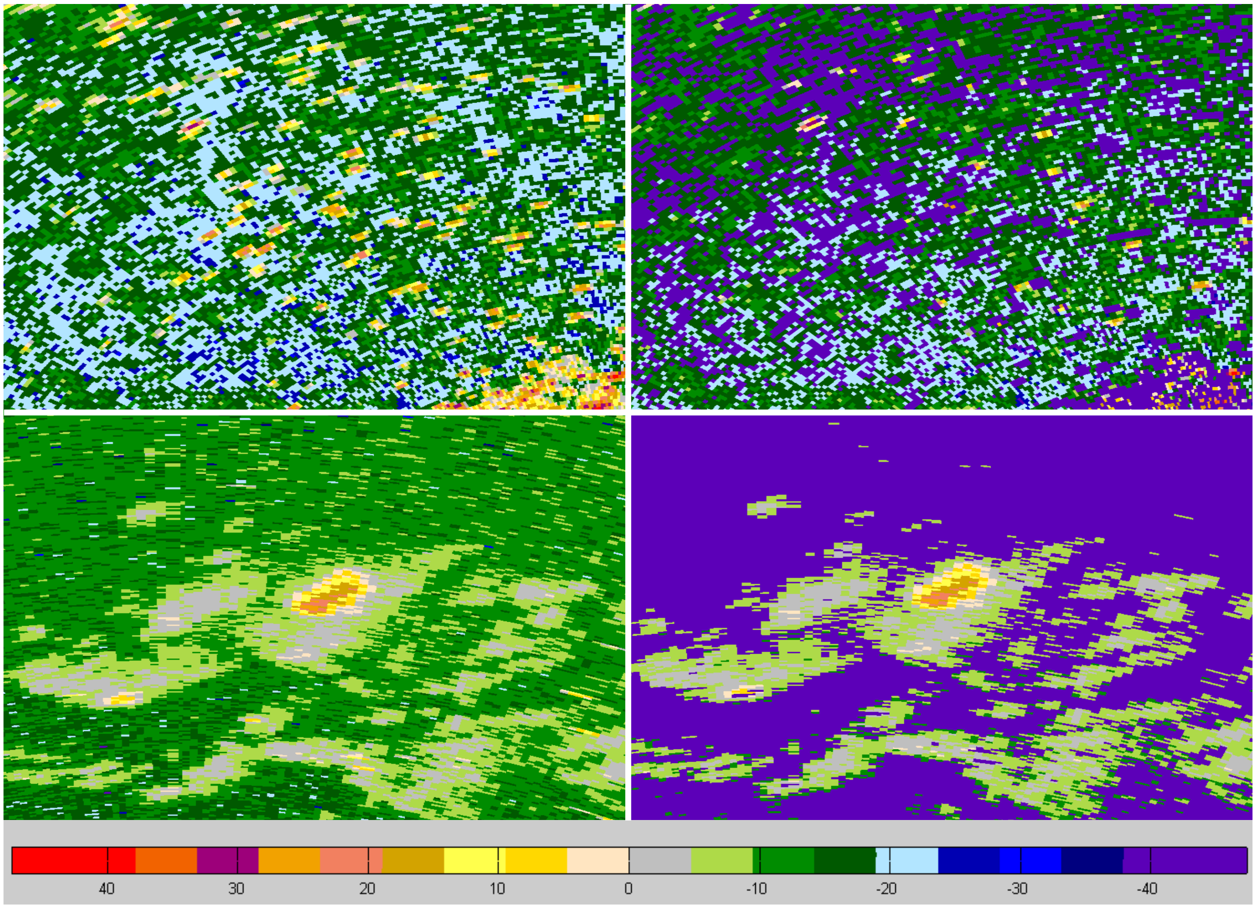

Figure 2. These images are from December 3, 2004. Top Left: Unfiltered reflectivity (dBZ) 20km northeast of S-POLKA, Bottom Left: Unfiltered reflectivity 80km north of S-POLKA. Top Right: Reflectivity filtered to remove birds and background noise 20km northeast of S-POLKA, Bottom Right: Reflectivity filtered to remove birds and background noise 80km north of S-POLKA. Notice the removal of the high reflectivity speckling caused by birds between the top left and right images. Also, in the bottom images, background noise is removed from the right image but Bragg Scattering around the cloud boundary is retained.

4. FUTURE WORK

Bragg scattering in the reflectivity data provide an excellent measure for determining cloud boundary (Bottom Fig. 3). By determining the reflectivity threshold in the S and Ka band data for the break between Bragg and Rayleigh scattering (e.g., Knight and Miller 1998), appropriate rain and cloud area statistics will be derived. Furthermore, comparing cloud and rain area seen in the reflectivity data to a cloud mask in the satellite data, cloud area and rain area size statistics will be used to classify precipitating and non-precipitating cloud. Moreover, the effects of resolution will be apparent by comparing the satellite imagery to radar data. Finally, it has been shown that precipitation is a function of cloud geometrical thickness. Using cloud top heights from MISR Stereo Heights and cloud base information from rawinsondes and aircraft data, classification of precipitating and non-precipitating trade cumulus by geometrical thickness will be studied.

4. SUMMARY

This conference poster will present a comparison between the trade wind cloud field's satellite-derived cloud properties and radar derived precipitation characteristics by focusing on the relationship between radar reflectivity, derived rain rate, and the satellite visible radiance, cloud fraction, height and thickness. Furthermore, analyses concerning the relationship between cloud area estimated by satellite and cloud area estimated by radar Bragg and Rayleigh scattering will be further discussed. The resolution effects between visible satellite data from the ASTER instrument at 15m ground resolution and the S-POLKA radar data will also be examined. Finally, The potential applications of these results to the estimation of trade wind cumuli's role in returning water to the ocean through precipitation, and to cloud and climate model parameterization will be discussed.

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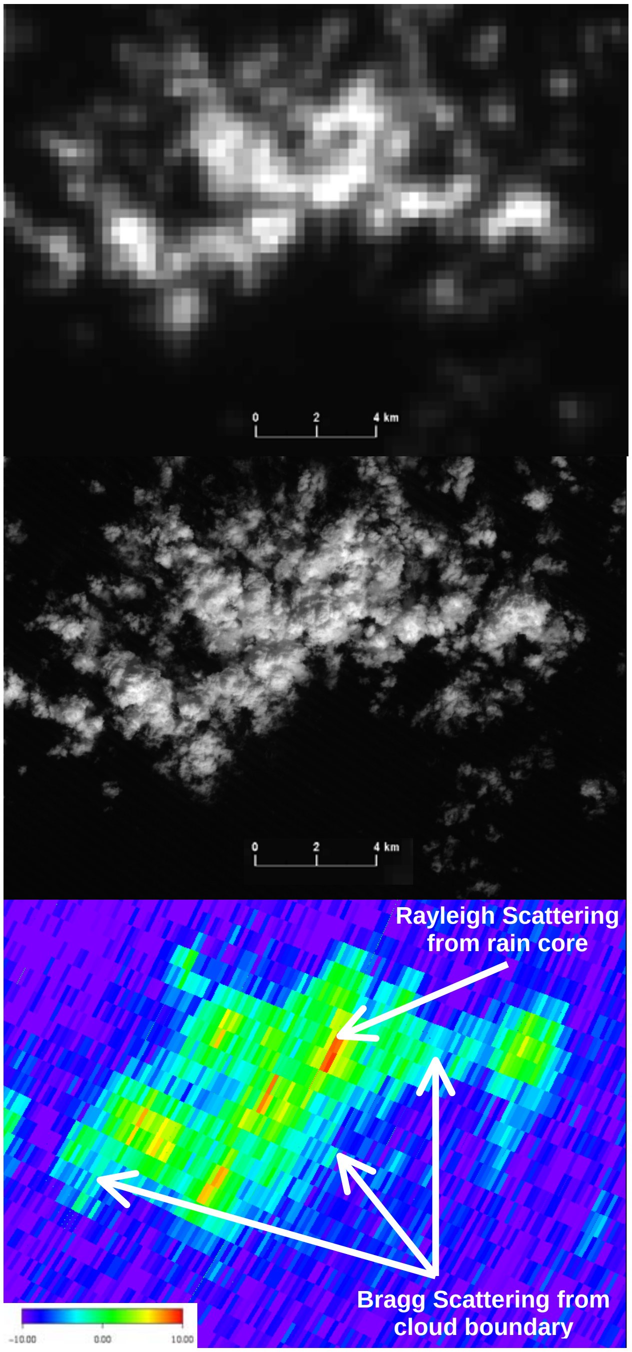

Figure 3. These images are from November 28, 2004 at 14:42 Z. TOP: Near-IR MISR radiance data at 275m resolution. MIDDLE: Near-IR ASTER radiance data at 15m resolution. BOTTOM: S-POLKA radar reflectivity (unfiltered) re-sampled to the ASTER grid. Also seen here is the cloud boundary created by Bragg scattering and rain core where Rayleigh scattering is dominant

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