CORRELATION OF SEVERE STORMS IDENTIFIED WITH AIRS AND HEAVY PRECIPITATION MEASURED WITH AMSRE ON THE EOS AQUA.

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Extended Abstract

The association of cloud tops colder than 230 K with heavy rainfall goes back to Adler and Fenn (1979). Reynolds (1980) used infrared radiometer data from early geosynchronous satellites and noted the correlation between cloud tops colder than 210 K and severe storms. We used data from the first six years of the Atmospheric Infrared Sounder (AIRS, Chahine et al. 2006) to compare the frequency and rain rate associated with extremely cold cloud tops for the Tropical Warm Pool (TWP) and the tropical oceans excluding the TWP. We identified clouds tops colder than 210 K. using the AIRS 1231 cm^{-1} window channel and refer to them as T210 clouds. Based on the analysis of the strong water line at 1419 cm^{-1} this selection places the top of the T210 cloud within 20 mb of the tropopause cold point (Aumann et al. 2006). The rain rates at the T20 clouds were obtained from the Advanced Microwave Scanning Radiometer for EOS (AMSRE, Imaoka et al. 2007). Both instruments are on the Aqua satellite of the NASA's Earth Observing System (EOS), which was launched into polar 705 km altitude orbit on May 4, 2002, and both have been in routine data gathering mode essentially uninterrupted since September 2002. The effective footprint size of AIRS averaged across a scan line is 18 km, the AMSRE rain rate is presented as mean in a 0.25 degree bin. The measurements are time coincident within a few minutes of comparable spatial scale. The AMSRE rain rate measurements were validated using surface gauges and rain radar (Wilheit et al 2003).

In order to obtain a statistically representative result we analyzed data from 115 days, every 24^{th} day between 20020901 and 200902. Typically 6,000 T210 clouds are observed each day in the entire tropical oceans, about 50% of these are observed in the TWP. AIRS sees only the tops of cirrus ice clouds, which are formed from water vapor carried aloft in tall convective towers. The cirrus ice cloud expands into an area much larger than the diameter of the convective tower until it reaches the tropopause. If these cirrus clouds were un-associated with nearby and present heavy convection, i.e. consisting of cirrus remaining from convection form several hour previous, the

rain rate associated with the T210 clouds would equal the average rain rate in the ocean, about 0.2 mm/hr based on the AMSRE data.

The results of our analysis are summarized in Table 1. in terms of 1) The T210 fraction, which is the ratio of the count of T210 events and the total number of potentially available footprints. This fraction is to first order footprint size independent. 2) the mean rain rate at the T210, 3)The standard deviation of the rain rate at the T210 cloud. 4) The fraction of T210 clouds with a rain rate of less than 0.2mm/hr . 5) The mean rain rate for all AMSRE data.

	day w/o TWP	day TWP	night w/o TWP	night TWP
Fraction of T210	0.0019	0.016	0.0024	0.020
Mean rain rate at the T210	3.1 mm/hr	2.5 mm/hr	3.7 mm/hr	2.9 mm/hr
Standard Deviation of the rain rate	3.3 mm/hr	2.9 mm/hr	3.4 mm/hr	3.0 mm/hr
Fraction of DCC with rain rate less than 0.2 mm/hr	0.11	0.19	0.11	0.22
Mean rain rate	0.11 mm/hr	0.14 mm/hr	0.24 mm/hr	0.27 mm/hr

Table 1. Summary of detection frequencies and rain rates of T210 events in the tropical oceans.

Comparison of the day/night results and the TWP and tropical oceans outside the TWP lead to a number of interesting observation:

1) The 3 mm/hr mean rain rate associated with each T210 cloud confirms the association of the cirrus ice within 20 mb of the tropopause cold point with present extreme precipitation. The rain rate is almost day/night independent. but the rain rate in the TWP is consistently about 10% less. We have no short explanation for this.

2) The fraction of T210 clouds in the TWP is about eight times higher than outside of the TWP. Since the mean surface temperature in the TWP is 302 K, while the tropical oceans mean surface temperature is 299 K, the fraction of T210 events is clearly very sensitive to the mean surface temperature. This sensitivity is likely to be highly non-linear.

3) In both areas the night fraction of T210 clouds is significantly larger than the day fraction. This is due to the solar heating of the cloud tops.

4) The fact that the mean and the standard deviation of the rain rate associated with each T210 event are almost equal indicated a gamma distribution. Gamma distributions are typical of the distribution of precipitation.

5) About 20% of the T210 clouds in the TWP, about 11% outside, are associated with less than 0.2mm of rain, close to the rain rate measure for the entire area. For 10 to 20% of the cases the intense precipitation associated on average with the T210 clouds has either not started, or is

already over. We interpret the latter as a cirrus life time effect, consistent with the 4 hour life time reported by Horvath and Soden (2008) for tropical deep convection

6) The mean rain rate associated with T210 events in the tropical oceans outside of the TWP is 3.4 mm/hr in 0.0022 of the area (day/night mean). This mean that T210 events contribute 3.4*0.0022= 0.0075 mm/hr to the mean rain rate of 0.17 mm/hr, i.e. 4%. The contribution of the T210 clouds to the total rain rate in the TWP is of the same magnitude. Most of the rain observed by AMSRE is associated with much lower clouds than 210K.

The fact that T210 clouds tend to form large clusters has been known for some time (Mapes and Houze 1993). The strong correlation of each T210 event with intense precipitation suggests an association between T210 clusters and tropical cyclones. This requires further analysis.

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