Fractional Contribution of TRMM-Defined MCSs to Rainfall: Regional and Seasonal Variations

Ed Zipser[1]*, Chuntao Liu[1], and Steve Nesbitt[2]

1. Department of Meteorology, University of Utah
2. Department of Atmospheric Science, Colorado State University

1. INTRODUCTION

The University of Utah database of TRMM Precipitation Features (PFs) now includes about 17 million PFs, of which about 0.7% are mesoscale convective systems (MCSs). The MCSs are defined as in Nesbitt et al. (2000) using a combination of minimum contiguous precipitation area of >2000 km^2, including 2000 km^2 85 GHz brightness temperature (polarization-corrected) <250K, and at least one pixel <225K. This definition, originally developed with SSM/I data using passive microwave criteria alone. We have maintained it during the TRMM era to be able to examine MCSs over a long time period. That is, one can use SSM/I data before TRMM and other passive microwave sensors during the time gap between the end of TRMM and the beginning of the GPM.

This paper first demonstrates the MCS fractional contributions to rainfall with the current definition. Then, we ask how much rain falls from mesoscale rain areas >2000 km2 that are missed by the current MCS definition because of its ice scattering. The work concludes by showing the regional and seasonal distribution of rainfall fraction contributed by PFs of different size and intensity with alternative definitions of mesoscale rain systems.

2. MCS RAINFALL AND INTENSITY

Using 5 years of TRMM PF data, the monthly average precipitation from all PFs and only from MCSs were calculated. The MCS fractional contributions to rainfall are shown in Fig. 1a. MCSs contribute most over subtropical continents, parts of Africa, and the Ganges Plain, not over tropical oceans. This is rather similar to the distribution of convective intensity (not shown), as indicated by the locations of[*] extremely low 85 GHz or 37 GHz brightness temperatures, or extremely great heights reached by 20, 30, or 40 dBZ PR reflectivity, or high lightning flash rates (Cecil et al., 2004). This is a surprising result, as it is well-known that tropical oceans have abundant populations of MCSs, having substantial portions with stratiform rain (Schumacher and Houze 2003). We now ask what rain

areas that are large enough to be mesoscale, but that are missed by the Nesbitt et al. definition.

[*]*Corresponding author address:* Ed Zipser, Department of Meteorology, University of Utah, SLC, UT, USA, E-mail:ezipser@met.utah.edu

Figures 1b and 1c answer this question for *amount*, showing some moderately large differences over some of the rainiest parts of the tropical oceans and over Indonesia. Fig. 1d answers the question for *fraction of total rainfall*. The Nesbitt et al. definition misses about 15-25% in most of the rainy tropical oceans, less over most land areas. It misses the largest fraction of rainfall over the subtropical oceans, leading us to speculate that many of the systems missed may be cool season frontal rain systems that may not meet other criteria for being called mesoscale *convective* systems.

Figure 2 shows that there are lots of PFs with 'warm' 85 GHz brightness temperatures (T_b) and low 20 dBZ tops, although most of the PFs with very large rain volumes have both cold T_bs and high echo tops. We examine next the distribution of PFs that are mesoscale in area but not meeting the Nesbitt et al. criteria.

3. RAIN FROM ALTERNATIVELY-DEFINED MCSs

Using the TRMM PF database, we can modify the definition of an MCS. For example, we can relax or remove the requirement for specific ice scattering values, while retaining only the contiguous area of near-surface rain (Contiguous PR 2A25 surface rain area > 2000 km^2). By this definition, the number of "MCSs" tripled, but there is no guarantee that the PFs so defined have any deep convection at all, so it would be more accurate to call them MPFs (mesoscale precipitation features). Fig. 3a shows the rainfall fraction from all MPFs regardless of rain rate. Fig. 3b (3c) shows the rainfall fraction from MPFs with mean rain rate <5 (>5) mm/hr.

Over some regions of the tropical oceans, notably the central-to-east Pacific, MPFs with light rain rates contribute up to half the total rain. This implies a greater role for extensive precipitation areas with at most, weak-moderate convection. On the other hand, more than 60% of total rainfall over central Africa, Argentina and south-central U.S. are from MPFs with mean rain rate > 5 mm/hr). These MPFs are, as we have seen, those which also have strong convection, and are properly called MCSs. It remains to be seen whether all light-rain MPFs should still be called MCSs.

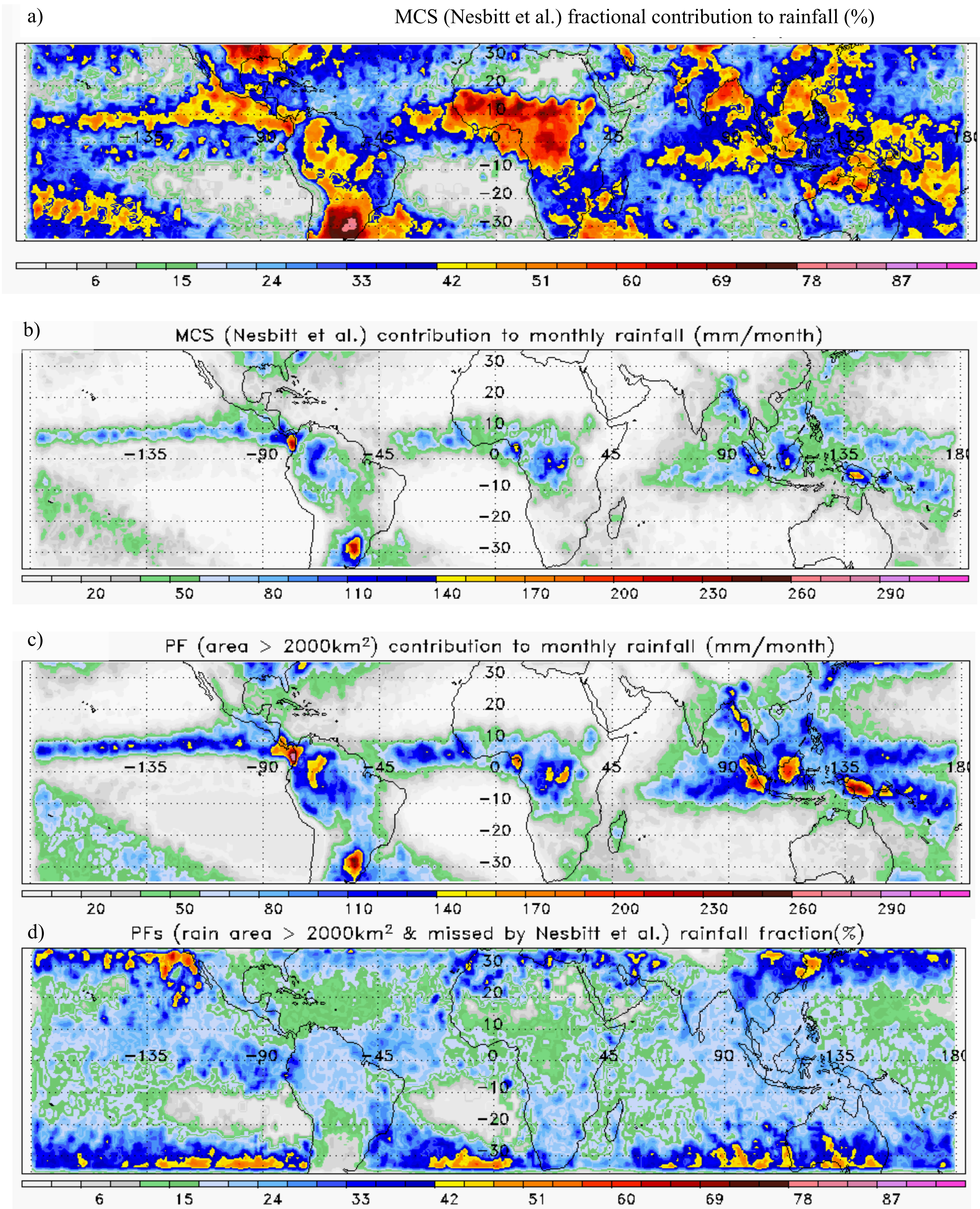

Figure 1. Rainfall amounts and fraction of total PR rainfall from MCSs and from mesoscale rain areas regardless of ice scattering properties, 5-year average. (a) Rainfall fraction and (b) rainfall amount from MCSs (Nesbitt et al. definition). (c) Rainfall amount from all mesoscale precipitation features. (d) Fraction of total rainfall included in (c) but omitted from (b); *i.e.,* rain fraction from mesoscale precipitation features with weak or absent convection.

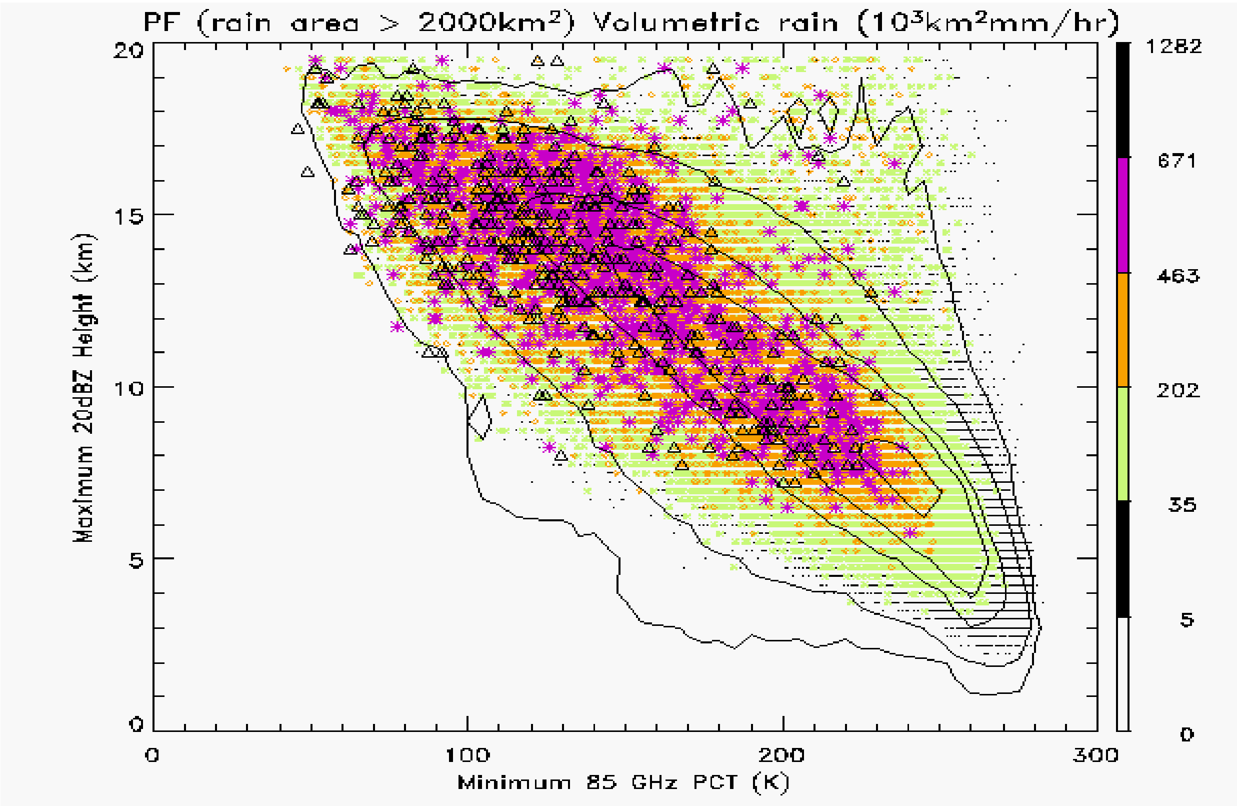

Figure 2. Scatterplot of precipitation feature maximum 20 dBZ height vs. minimum 85 GHz T_b (PCT). Plot includes all PFs in TRMM's PR swath for 5 years. Symbols correspond to total volumetric rain in the PF, according to the color scale on the right. Solid lines are contours of frequency distribution, contours are 10, 100, 1000, 2000, 5000 PFs for the bin sizes with 5K (Tb) and 1km (20 dBZ ht). There is a high frequency of PFs without Tb cold enough to rate as MCSs by the Nesbitt et al. definition, but most of them have modest rain volumes.

4. SUMMARY AND CONCLUSIONS

Using the University of Utah TRMM database, the global distribution and fractional rainfall from MCSs was displayed. The regions with the largest contributions from MCSs are mostly over continents, and are the same regions that have the most intense convection, as indicated by many proxies such as extreme height of radar echoes, very low brightness temperatures, and high lightning flash rates. They include Argentina, central Africa, the Ganges plain, and the south central United States (Fig. 3d). When the definition of mesoscale systems are generalized to include all contiguous precipitation areas regardless of microwave Tb, or simply mesoscale precipitation features >2000 km2, then most of the tropical oceans also have a high fraction of total rainfall from these MPFs. However, these oceanic MCSs have rather low rainfall rates in many areas. The next step in this research is to explicitly combine the stratiform and convective fractions (after Schumacher and Houze 2003) with the quantitative descriptions possible with the Utah database to assess the physical nature of the 'weak" oceanic MCSs around the tropics, regionally and seasonally.

REFERENCES

Cecil, D.J., E.J.Zipser and S.W. Nesbitt, 2004: Three years of TRMM precipitation features. Part I: Radar, Radiometric, and Lightning Characteristics. *Mon. Wea. Rev.,* **132,** in review.

Nesbitt, S. W., E. J. Zipser, and D. J. Cecil, 2000: A census of precipitation features in the tropics using TRMM: radar, ice scattering, and lightning observations. *J. Climate*. **13**, 4087-4106.

Schumacher, C., and R.A.Houze Jr., 2003: Stratiform rain in the tropics as seen by the TRMM precipitation radar. *J. Climate*, **16**, 1739-1756.

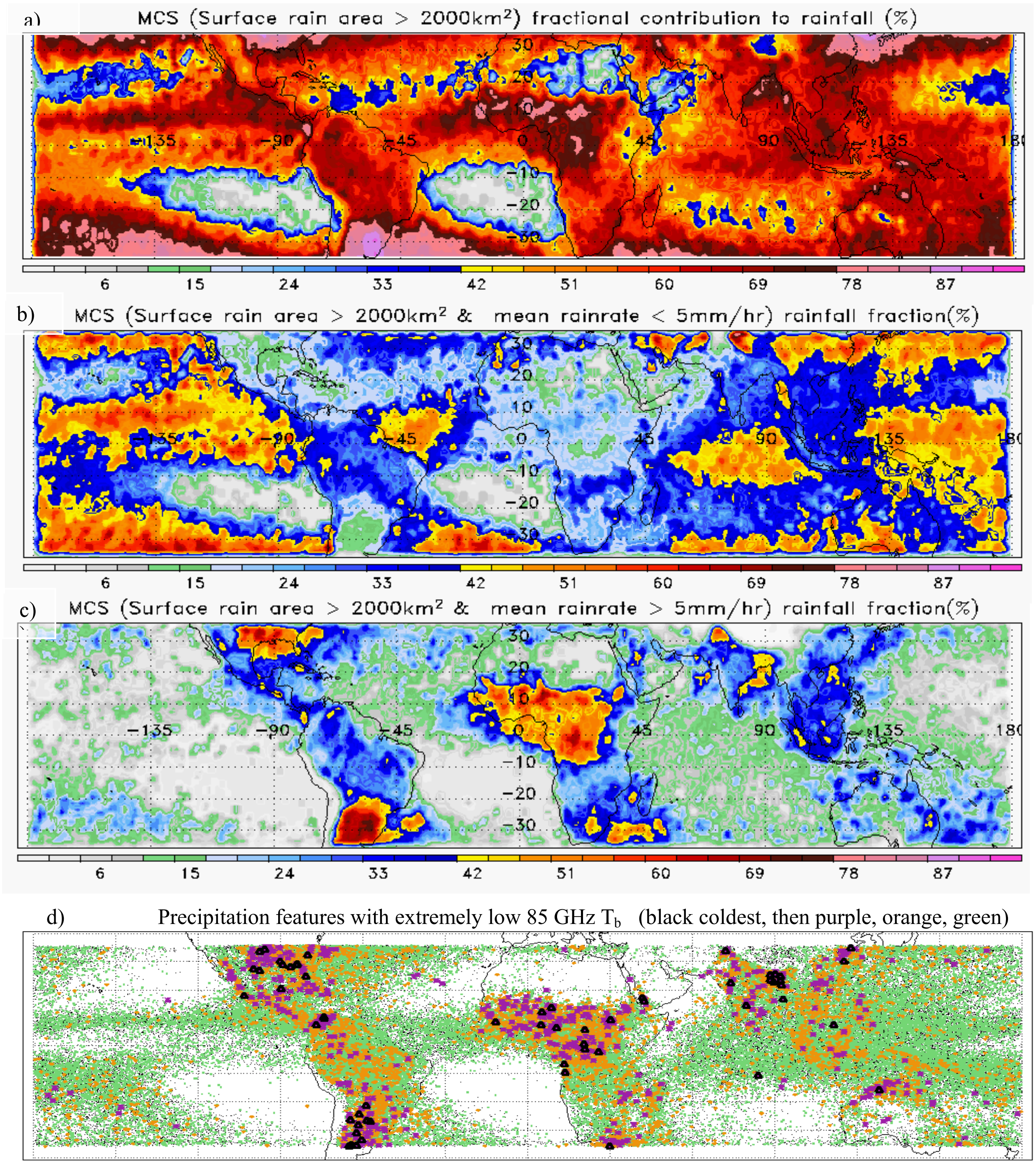

Figure 3. Fractional contribution to 5-year total rainfall from mesoscale precipitation features (here called "MCSs" for convenience only). (a) from all PFs with contiguous rain area > 2000 km2, (b) as in (a) but with mean rain rate < 5 mm/hr, (c) as in (a) but with mean rain rate > 5 mm/hr. Note that (b)+(c)=(a). (d) Location of PFs with very low 85 GHz brightness temperature (after Cecil et al. 2004). Note the correspondence of the purples (Tb from 57-74K) and blacks (Tb from 42-57K) to the areas with highest fractional rainfall from mesoscale PF with high rain rates (3c) and with highest fractional rainfall from Nesbitt et al. defined MCSs (1a).