INVESTIGATIONS INTO HIGH RESOLUTION MAPPING OF PRECIPITATION FEATURES UTILIZING THE TRMM PRECIPITATION RADAR

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1. INTRODUCTION

The joint NASA/JAXA Tropical Rainfall Measuring Mission (TRMM) satellite has been collecting precipitation data over the tropics since November 1997. TRMM carries both passive and active microwave sensors resulting in an unprecedented precipitation data record including surface information and measured precipitation profiles from the TRMM Precipitation Radar (PR) [1]. This currently 11 year data record affords the opportunity to investigate localized precipitation features on a very small scale while maintaining reasonable sampling characteristics. At small space scales climatological, orographic precipitation features can be resolved yielding insight into not only the meteorology of these regions but possible issues with the TRMM PR retrieval algorithms over land. This work expands on other high-resolution mapping studies (e.g. [2][3]) by extending the time period of data to 11 years, adding corrections for slant range geometry for precipitation aloft, and continuing to investigate the global three dimensional climatology of TRMM PR data.

2. CONSTRUCTION OF HIGH RESOLUTION GRID

The TRMM PR has an instantaneous field of view of 4-5km at nadir depending on the orbit altitude which changed from a mean of 350km to 402km above the Ellipsoid in August 2001. The PR swath consists of 49 rays with ~0.7degree 3dB along and cross track beam widths. The data is processed and made available at NASA at the Precipitation Processing System. The raw echo data is passed through a suite of algorithms culminating with the instantaneous precipitation profiling algorithm designated as 2A25 [4]. The 2A25 product contains attenuation corrected reflectivity and rainfall rate profiles at each instantaneous field of view (ifov) along the slant range from the radar. Sensor geolocation is performed in post-processing using onboard attitude information and the definitive ephemeris. The latitude and longitude of each ifov is given at the intersection of the PR ray and the WGS88 Ellipsoid. In this study the latitude and longitude are used to place each ifov in a 0.05degree grid extending to +/- 37degrees in latitude. The attitude control system onboard TRMM is held to a 0.2degree requirement, however, geolocation quality control has indicated that limit has been exceeded at times, especially after the altitude boost in August 2001. Corrections to the reported attitude have been investigated [5] and are included in the latest Version 6 product files. Additional geolocation quality control utilizing coastline matching with data from the high resolution Visible and Infra-red Scanner (VIRS) on-board TRMM indicates the geolocation accuracy is roughly 1-2km on the Ellipsoid.

2.1. Precipitation filters

The Level-1 PR algorithm has a per ifov rain/no-rain classification scheme based on the echo power and vertical continuity thresholds (designated as the minimum echo flag). Each PR ray is flagged as rain/no-rain and the higher level algorithms key off this assignment flag which is used in our study to determine if the ifov will be included in the raining statistics. We also compare that filter with rain/no-rain classifications based on the presence of estimated-surface or near-surface rain as precipitation aloft with no measureable surface precipitation would be included in the previous case. The estimated-surface rain rates are generally 6% lower in the mean than the near-surface retrievals.

2.2. Slant range geometric corrections

The geolocation of each ifov is reported as the latitude and longitude at the intersection of the PR ray with the Earth Ellipsoid. The PR scan geometry has incident angles of ~ +/-17 degrees at the edges of the scan resulting in displacements both vertically and horizontally above the ifov latitude and longitude positions on the Ellipsoid. For example consider a stationary orographic precipitation feature; as the satellite passes over the feature at various angles for ascending and descending portions of the orbit the effect would be to smear out the location of the feature in the horizontal to adjacent grid boxes. This effect would be most pronounced away from nadir and for precipitation aloft. Utilizing only near-nadir PR data minimizes the smearing at the cost of reducing the number of samples. A simple correction to the ifov location can be utilized as a function of latitude and spacecraft orientation to compensate for this effect.

3. EXAMPLE OF PRECIPTIATION OCCURRENCE

Eleven years of data (1998-2008) from the TRMM PR has been processed and Figure 1 gives an example of the percentage precipitation occurrence based on the PR rain/no-rain flag. The percent occurrence is constructed as the number of raining ifovs divided by the total number of non-missing, valid measurements. As previous studies have shown, this representation of the data yields insight into mesoscale processes beyond what is available in the standard TRMM data products. These high resolution grids also present an opportunity to investigate issues with the PR retrieval algorithms.

3.1 Clutter rejection

Unlike the TRMM passive retrieval algorithm, the PR algorithm does not utilize alternate retrieval algorithms over land. However, PR is subject to contamination of the precipitation echo near the surface due to surface clutter. The TRMM PR algorithm uses an early prototype of digital elevation model data from the JPL MISR project DTED Intermediate Dataset (DID). The data set consists of 1km resolution elevation and surface type and is used by the PR algorithm to define a first guess and window about which the surface echo should exist. The accurate detection of the surface echo is a key step in removing ground clutter contamination as the signal from the surface is much stronger than precipitation echo. Misregistration or omission of mountains and islands in the topographic database and/or misidentification of the lowest clutter free bin by the PR algorithm are observed using the high resolution grids and result in unrealistic precipitation occurrences.

4. SUMMARY

These high resolution maps represent a unique perspective into tropical meteorology but also the robustness of the TRMM PR retrieval algorithms. Additional maps will be presented at various heights above the Ellipsoid utilizing the PR's unique ability to provide actual measurements of vertical structure including corrections compensating for the PR geometry and investigations on the impact of precipitation filters. The upcoming Global Precipitation Mission will utilize a dual frequency radar (DPR) at Ku (similar to TRMM PR) and a 35GHz Ka radar extending the satellite coverage to +/-65degrees in latitude where the observed land mass will be increase. This also represents challenges for DPR clutter rejection due to quality of the topographic databases at higher latitudes. The NASA/JAXA

Joint DPR Algorithm Team will likely use the Shuttle Radar Topography Mission as the initial database for GPM, which should provide more accurate topography data.

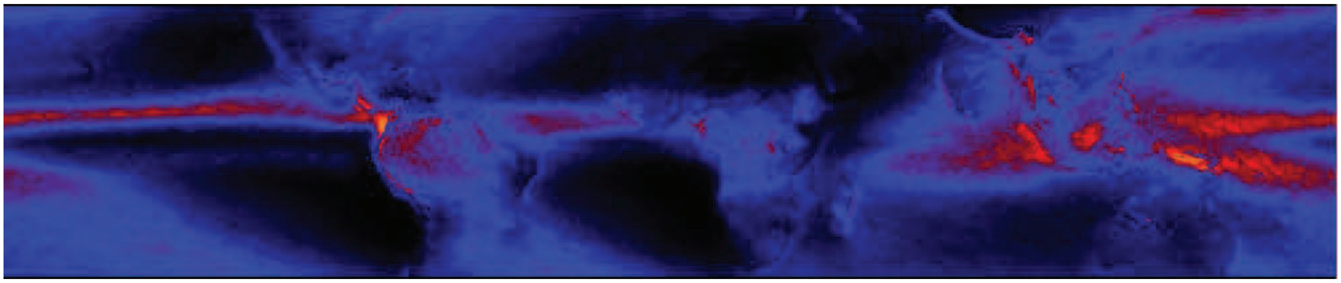

Figure 1. Image of percent rain as (number of raining observations)/(total observations) from 0% (black), 20% (red) through 30% (yellow/white). No continental outlines have been used. This image is highly degraded in resolution to constrain the abstract submission size. The high resolution grid dimensions are 7200 x 1480.

4. REFERENCES

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