P1.22 Improvements of CMORPH Resulting from Limb Adjustments and Normalization of AMSU-B Rainfall

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1. INTRODUCTION

Beam position bias exists in current NESDIS algorithm rainfall rates derived from NOAA spacecraft AMSU-B instruments. Unlike retrievals from the conical scanning SSMI, TMI, and AMSR-E passive microwave instruments, the 89 GHz field of view (FOV) from the cross-tracking AMSU-B scanner increases from ~16 km from near nadir beam positions to ~45 km at the limb. In order to compensate for the increasing earth coverage of limb beam rainfall retrievals relative to those of nadir, some damping of heavy and very light rain rate frequencies should occur. However, the relative non-existence of limb retrieval AMSU-B rainfall rates greater than 20 mm/hour does not agree with TRMM 2A-12 TMI rainfall averaged to the earth coverage of the nearest AMSU-B limb estimate. A passive microwave based rainfall algorithm such as CMORPH will inherently suffer problems when combining and propagating rainfall derived from vastly different frequencies, sampling characteristics, and estimation algorithms resulting in pronounced biases. However, the skill of the AMSU-B to estimate rainfall has been shown to be generally better than IR and most likely any other current geostationary satellite sensor.
An AMSU-B rainfall product is derived from matching AMSU-B rainfall with TRMM TMI derived precipitation. Histograms of AMSU-B rainfall are accumulated in small beam position groups, from heaviest to lightest rates, land and ocean separately, for different latitude regions. High resolution TMI rainfall (temporally/spatially coincident with the AMSU-B rainfall) is then "synthetically sampled/averaged" to the exact mapped rainfall region of each beam position within the variable FOV AMSU-B cross-track scan. From these distributions, normalization corrections are derived from frequency matching the histograms dependent on surface type, latitude region, and AMSU-B beam position group.

2. DATA

Instantaneous passive microwave rainfall estimates from TRMM TMI, and NOAA AMSU-B instruments are mapped to a half hourly, 8-km grid (Joyce et al. 2004), separate for both sensor types. The higher resolution TMI rainfall is simply "box-averaged" to the 8-km grid. For the AMSU rainfall, the 8-km grid points within the region nearest to each AMSU-B retrieval centroid are populated the with the rain rate of that estimate. Surface rainfall derived from the TMI instrument is a product of NASA's TRMM Science Data and Information System (TSDIS) 2A12 algorithm. The AMSU-B instrument is currently operational aboard the NOAA-15, NOAA-16 and NOAA-17 polar orbiting satellites. The AMSU-B has five window channels and its cross track swath width (approximate 2200km) contains 90 beam positions. The NESDIS AMSU-B rainfall algorithm (Weng et al, 2003) performs a physical retrieval of ice water path (IWP) and particle size.

3. METHODOLOGY

An improved "level 3" AMSU-B rainfall product is derived by matching AMSU-B rainfall with spatially/temporally coincident high resolution TMI (or SSMI) derived precipitation, synthetically sampled to the exact mapped rainfall region of each beam position within the AMSU-B cross-track scan. Initially histograms of AMSU-B rainfall are accumulated in 0.2 mm/hour categories, and 15 beam position groups consisting of 6 adjacent positions, ocean (Fig. 1) and land (Fig.2) separately, for 5 latitude regions.

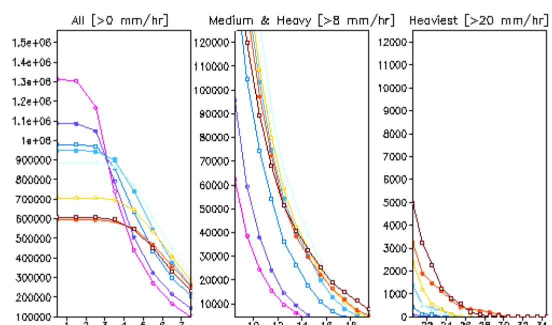

Fig. 1 Cumulative histograms of AMSU-B derived rain rates (mm/hr), latitude band 20S–20 N, ocean surface 17 December 2004 – 12 January 2005. Purple: beam positions 80-85 (limb), Blue:74-79, Light Blue: 68-73, White: 62-67, Yellow:55-61, Orange: 49-54, Red: 43-49 (nadir).

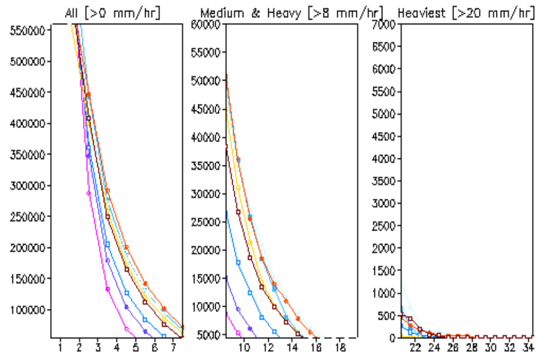

Fig. 2 Cumulative histograms of AMSU-B derived rain rates (mm/hr), latitude band 20S–20 N, ocean surface 17 December 2004 – 12 January 2005. Purple: beam positions 80-85 (limb), Blue:74-79, Light Blue: 68-73, White: 62-67, Yellow:55-61, Orange: 49-54, Red: 43-49 (nadir).

In order to provide a comparison of high resolution TMI rainfall to AMSU-B sensor rainfall at each beam position group, masks of the nearest AMSU rainfall estimate, for each beam position retrieval, are marked within the 8-km populated mapped AMSU-B rainfall.

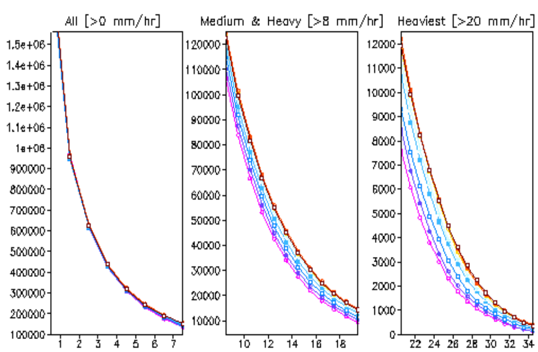

Fig. 3 Cumulative histograms of TRMM TMI derived 2A-12 rain rates (mm/hr) averaged to mapped AMSU-B beam position coverage, latitude band 20S–20 N, ocean surface 17 December 2004 – 12 January 2005. Purple: beam positions 80-85 (limb), Blue:74-79, Light Blue: 68-73, White: 62-67, Yellow:55-61, Orange: 49-54, Red: 43-49 (nadir).

Temporally/spatially coincident TMI rainfall is then “synthetically sampled/averaged” for each of the 90 AMSU-B beam positions. This insures that the distributions of TMI rainfall can be compared by beam position, at the region masked to the nearest AMSU-B rainfall centroid.

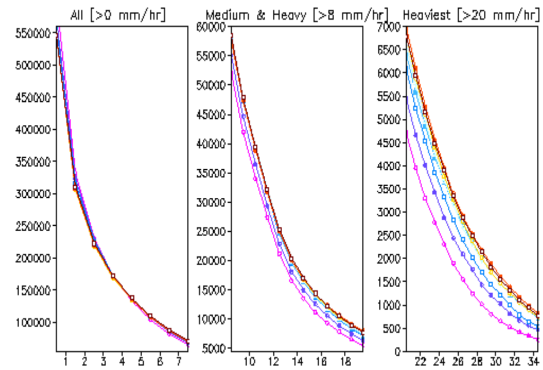

Fig. 4 Cumulative histograms of TRMM TMI derived 2A-12 rain rates (mm/hr) averaged to mapped AMSU-B beam position coverage, latitude band 20S–20 N, land surface 17 December 2004 – 12 January 2005. Dark blue: beam positions 80-85 (limb), Blue:74-79, Light Blue: 68-73, White: 62-67, Yellow:55-61, Orange: 49-54, Red: 43-49 (nadir).

From the TMI rain rate histograms (Ocean Fig. 3, land Fig. 4, note: same y-axis intervals used for AMSU-B histograms) depicting rainfall accumulating from heaviest rates, it is obvious that there is a dampening/enhancement of the heavy/light rainfall populations dependent on the regional coverage of associated AMSU-B beam position group, however, not to the same degree as found in the actual AMSU-B histograms (ocean Fig. 1, land Fig.2).

From these distributions, normalization corrections are derived from frequency matching 10 previous days of TMI/AMSU-B histograms, dependent on surface type, latitude region, and beam position group (Fig 5). The systematic spread from purple to red indicates the increased rate normalization of the limb AMSU-B retrieval estimates relative to the near nadir estimates.

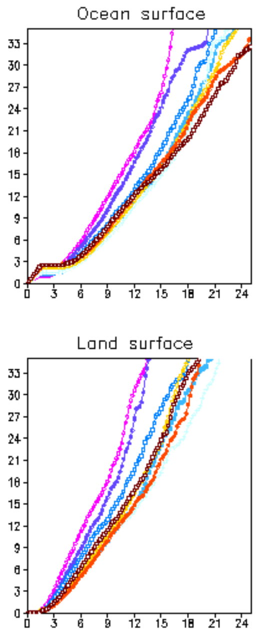

Fig. 5 Frequency matched normalization corrections (y-axis, mm/hr) of original AMSU-B rainfall rates (X-axis, mm/hr) derived from matching TMI 2A-12 with AMSU-B rain rates, latitude band 20S–20 N, (ocean top panel, land bottom panel) 17 December 2004 – 12 January 2005. Purple: beam positions 80-85 (limb), Blue:74-79, Light Blue: 68-73, White: 62-67, Yellow:55-61, Orange: 49-54, Red: 43-49 (nadir).

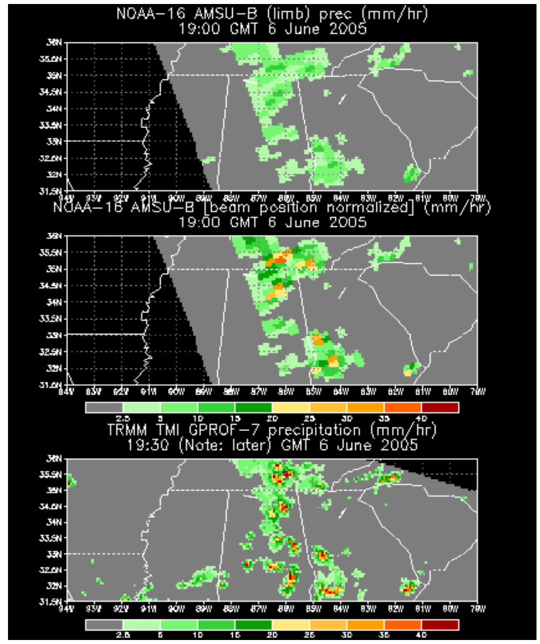

Fig. 6 top panel: AMSU-B rainfall, mm/hr (Weng et al. 2003) 19:00 UTC 6 June 2005, bottom panel: TRMM TMI 19:30 UTC, middle panel: beam position normalized AMSU-B rainfall.

4. Validation

Passive microwave rainfall case study comparisons:

Temporal matches (within 30 minutes) of normalized AMSU-B rainfall with TRMM TMI 2A12 GPROF-7 derived rainfall appear to reveal a much closer match in rainfall intensity between the two instrument types, relative to the original AMSU-B algorithm. Limb rainfall complexes of 10-15 mm/hr are raised to over 30 mm/hr (fig 6, fig 7). Due to the damping of the lighter AMSU-B rainfall rates, in several cases the exaggerated AMSU rain areas also become quite close to those of TMI. In several AMSU-B nadir or near nadir cases the moderate rainfall is elevated to the higher levels determined by the TMI, yet able to reduce lighter rainfall in regions TMI is detecting very light or no rainfall (fig 8).

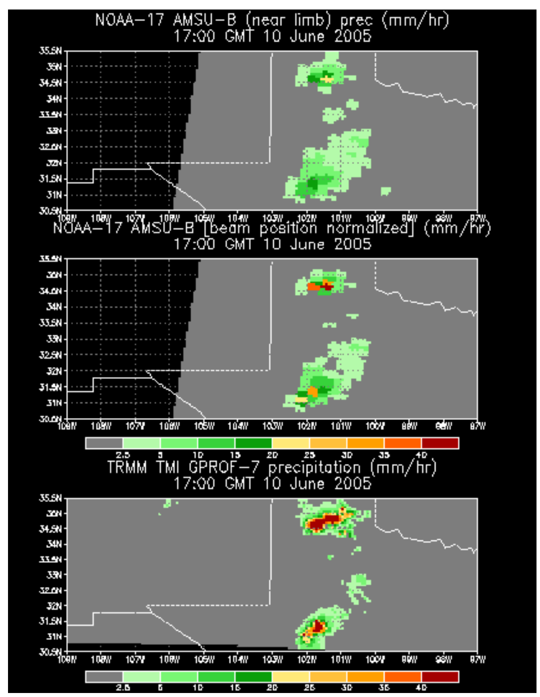

Fig. 7 top panel: AMSU-B rainfall in mm/hr (Weng et al. 2003) 17:00 UTC 10 June 2005, bottom panel TRMM TMI 17:00 UTC, middle panel: beam position normalized AMSU-B rainfall

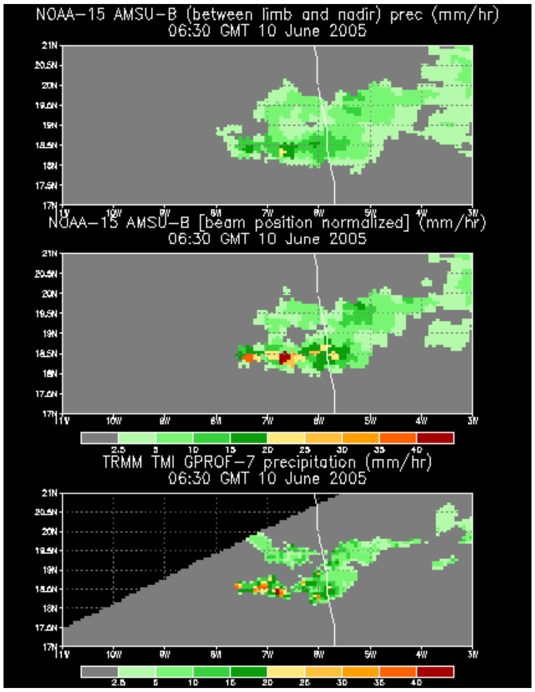

Fig. 8 top panel: AMSU-B rainfall in mm/hr (Weng et al. 2003) 06:30 UTC 10 June 2005, bottom panel TRMM TMI 06:30 UTC, middle panel: beam position normalized AMSU-B rainfall

5. CONCLUSIONS

Limb adjustments of AMSU cross track microwave retrieval products through statistical comparisons to an observational mean is not a new practice. Goldberg et al. (2000) used mean nadir observations to adjust limb position AMSU-A brightness temperatures.

Correlation of normalized AMSU-B rainfall (not shown) with TMI rainfall is about the same as the current NESDIS algorithm AMSU rainfall, however, the increased range of the normalized rain rates are more realistic compared to AMSU FOV averaged TMI rainfall.

The frequency matching normalization method breaks down in circumstances when AMSU-B rainfall (or any candidate sensor for normalization) depicts less areal rainfall coverage than the control sensor. As in the case of AMSU-B rainfall over ocean, the middle and higher rainfall rates can be matched, but the lighter rainfall will be missed, yielding lesser total rainfall amounts.

REFERENCES

Goldberg, Mitchell D., David S. Crosby, and Jihang Zhou, 2000: Limb Adjustments of AMSU-A Observations. Preprints, 10th Conf. On Satellite Meteor. And Ocean., 9-14 January 2000, Long Beach, CA, 248-251.

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