Overview of TOGA Radar Data Collected in NAMMA

Contact

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TOGA Radar Coordinates

14.91972N, -23.48000W, ~100m (MSL).

Period of Operations

00 UTC 15 August – ~1600 UTC 16 September 2006. Testing data was collected on 14 August but this data is not considered to be of sufficient quality for research purposes.

Scanning Strategy

TOGA collected 360º PPI data (no sectors or RHIs) and operated nearly continuously during NAMMA. The radar operated on a 10-minute repeat cycle, starting at the top of the UTC hour. During each 10-minute period, a 1-tilt (0.8º) surveillance scan (272 km maximum range) and one 18-21 tilt volume scan (150 km maximum range) were collected. The multiple tilt volume was chosen according to the existing conditions. There were 3 options:

- *NAMMA FAR*: (elevation angles=0.8, 1.3, 1.8, 2.3, 3.4, 4.5, 5.7, 6.9, 8.2, 9.6, 11.3, 13.0, 15.0, 17.2, 19.8, 22.5, 26.5, 29.5). This is the default volume (18 tilts) and was used most of the time during NAMMA.
- *NAMMA NEAR*: (elevation angles=0.8, 1.5, 2.3, 3.4, 4.5, 5.7, 6.9, 8.2, 9.6, 11.3, 13.0, 15.0, 17.2, 19.8, 22.5, 26.5, 33.0, 39.0, 45.8, 53.4). This volume (20 tilts) was used occasionally when echo was close to the radar.
- *NAMMA EVAD*: (elevation angles=0.8, 1.5, 3.2, 5.5, 7.9, 10.3, 12.7, 15.1, 17.6, 20.0, 22.6, 25.1, 27.8, 30.5, 33.2, 36.1, 39.1, 42.2, 45.4, 48.9, 53.4). This volume (21 tilts) was used on rare occasions when the echo pattern was conducive to collecting data for divergence retrievals.

The file "namma_toga_chkswp.txt" lists the time stamp (YYMMDDHHMM – UTC) and number of tilts collected for all TOGA data collected during NAMMA. This file can be used to determine which volume scan was used for a particular data and time of interest. The file totals for each day can been seen in Fig. 1.

The radar files contain 360 rays/elevation sweep with a bin spacing of 150m. The multiple tilt volumes collected 64 samples/bin and the Nyquist velocity was 13.4 m/s. Additional settings are listed in the science log files.

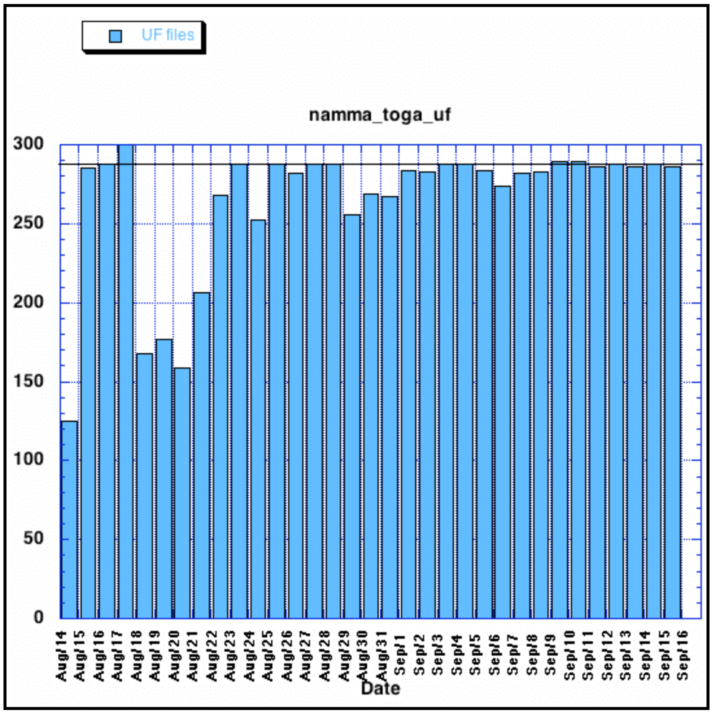


Figure 1. Number of radar data files collected/day. A "perfect" day consisted of 288 files (144 surveillance and 144 multiple volume tilt).

Radar Parameters Collected

Each file (surveillance or multiple tilt) collected "ZT" – unfiltered reflectivity, "DZ" filtered reflectivity, "VR" – radial velocity and "SW" - spectral width. Filter settings are listed in the beginning of the first science log file.

Quality Control Procedures

The TOGA radar data contain a number of artifacts that needed to be removed (Fig. 2). An algorithm was developed to automate the QC procedure for the removal of ground clutter, side lobes, multiple trip echo, and sea clutter. Ground clutter and side lobes were removed using template multiple tilt volume scans (one each for NAMMA FAR, NEAR, and EVAD) when conditions were suppressed and clutter was the only target observed by the radar. 2nd trip was eliminated using the VR field: if no velocity data exists, the reflectivity data are set to "bad". Sea clutter was removed using a vertical reflectivity gradient criteria (see Cho et al. 2006 and Berenguer et al. 2006). The output of the QC algorithm was a radar reflectivity field called "CZ" (this field included a calibration bias adjustment – see below).

Although the QC procedure eliminated the vast majority of spurious echos, transient features remain in the data at specific times. Sea clutter is especially difficult to remove since the vertical reflectivity gradient of precipitation and sea clutter overlap (see Fig. 3). Therefore, caution is advised when using the data set provided here. A comparison of DZ and CZ in the movie loops and image files (described below) can be used to provide a sense of when artifacts are present in the data. An improved QC algorithm will be developed and a revised data set will be available in late 2008.

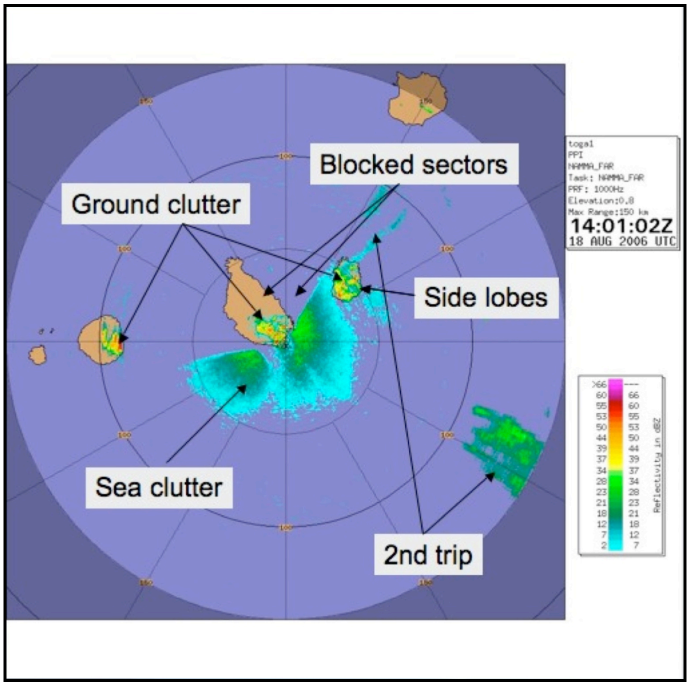


Figure 2. Example of TOGA PPI (0.8º elevation) showing spurious echo features.

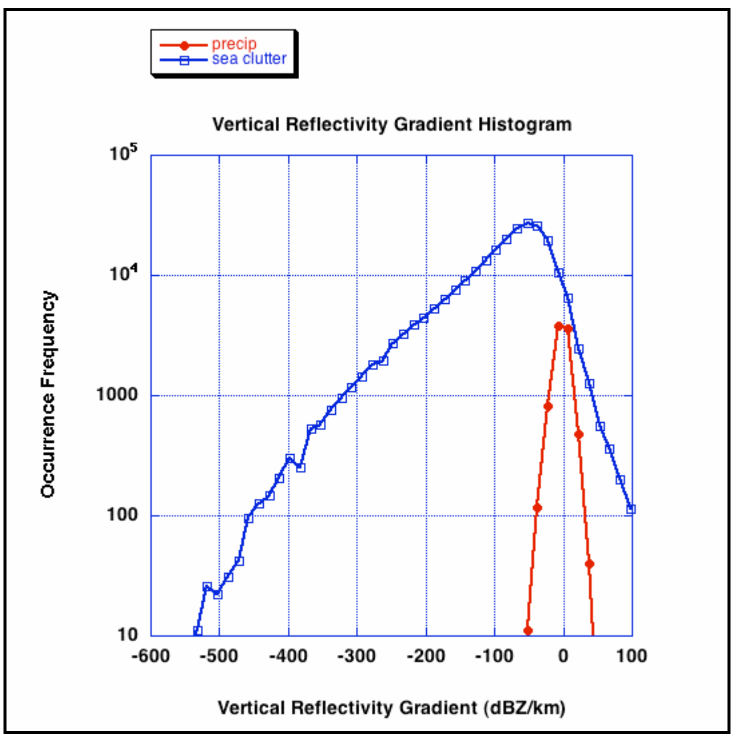


Figure 3. Histogram of radar reflectivity gradient from regions of sea clutter (blue) and precipitation (red). The vertical gradient is calculated as the difference in radar reflectivity (dB) between overlapping pixel locations in the lowest two sweeps.

Calibration Adjustment

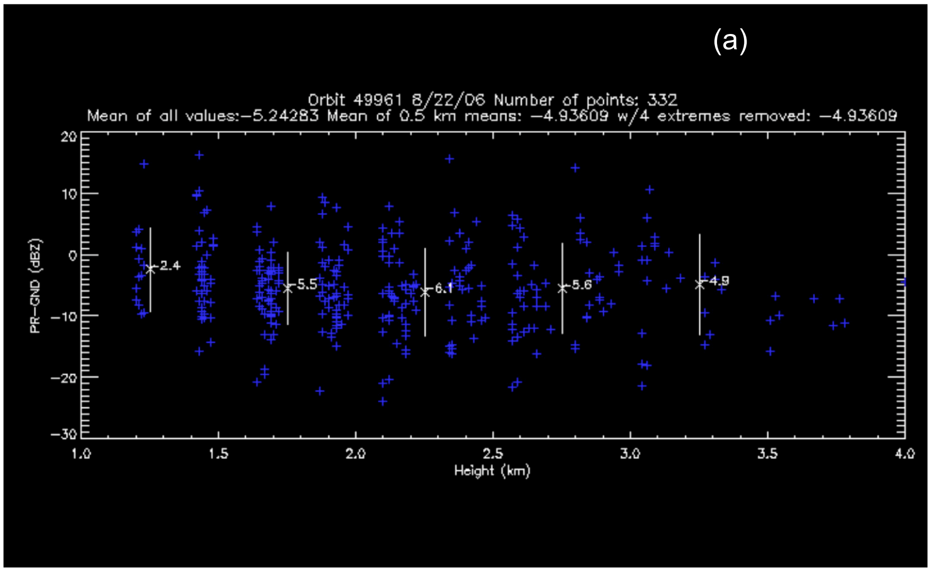
Internal receiver calibration tests and comparisons with TRMM precipitation radar (PR) data were used to assess the overall calibration in the TOGA data. Four TRMM overpasses had sufficient echo coverage in the vicinity of TOGA during NAMMA and were used to assess calibration bias: 060822 1031 UTC; 060903 1911 UTC; 060912 2351 UTC; and 060914 1351 UTC. To perform the comparison, the TRMM-PR and TOGA data were interpolated to a common grid and all data between 30-100 km range from TOGA were used.

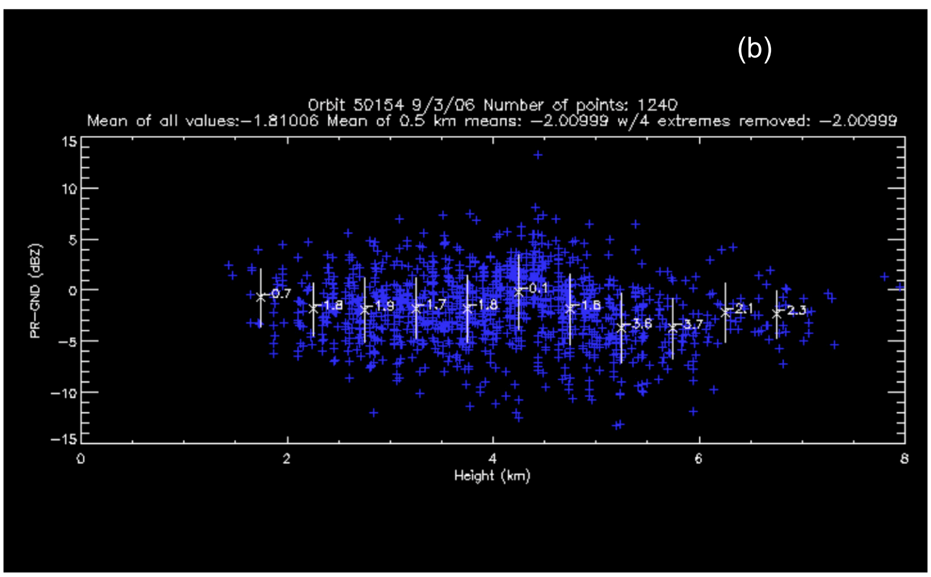
The results are shown in Fig. 4 and summarized below in Table 1. The 3 September overpass exhibited a smaller bias compared to the other three events. To determine whether the bias in the 3 September case was an artifact of changes in the TOGA radar system, statistics of ground clutter and noise from selected regions (islands and open ocean) were sampled on a number of days throughout NAMMA during suppressed conditions. The results (not shown) indicate that there were no sudden “jumps” in the received power and that the TOGA system was stable throughout the experiment. Therefore, a uniform bias was chosen based on an average of the overpass comparisons.

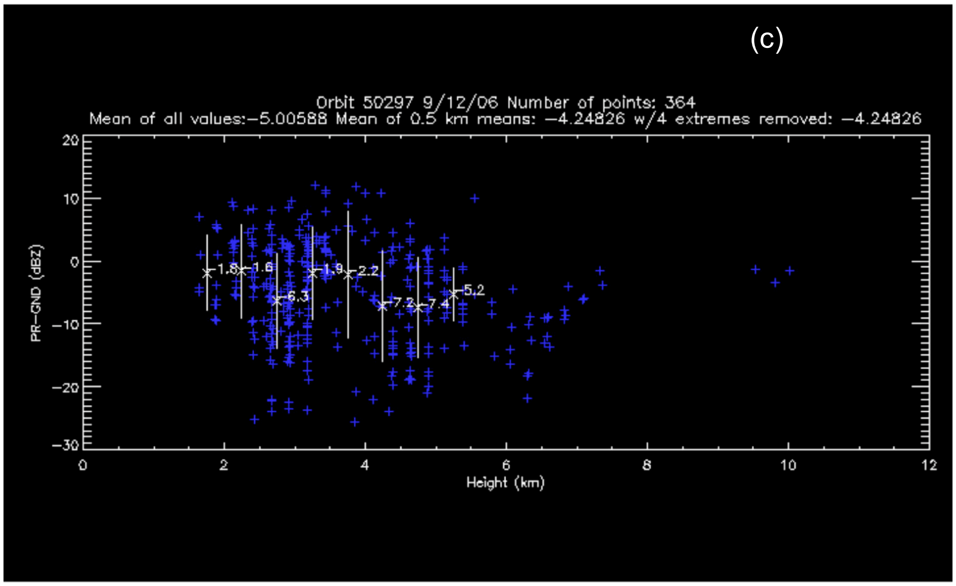
It was assumed that TOGA was 4.0 dB high (with an overall uncertainty of 2.0 dB) and all TOGA reflectivities were adjusted by this amount during the QC process to produce the “CZ” field.

Table 1. Comparison of TRMM PR and TOGA Reflectivity During NAMMA

Overpass	**Date**	**Time**	**PR-GND(all)**	**PR-GND (≥ 5km)**	**PR-GND (≤ 4km)**
49961	22 August	10:35	-5.2 [322]	NA	-5.2 [522]
50154	3 September	19:11	-1.8 [1240]	-3.3 [241]	-1.8 [595]
50297	12 September	23:55	-5.0 [364]	-7.2 [58]	-3.6 [277]
50322	14 September	13:51	-3.9 [2765]	-5.2 [544]	-3.3 [1860]
Minimum			-1.8	-3.3	-1.8
Maximum			-5.2	-7.2	-5.2
Average			**-4.0 ±2.2**	**-5.2 ±2.0**	**-3.5 ±1.7**


(a)
Orbit 49961 8/22/06 Number of points: 332
Mean of all values:−5.24283 Mean of 0.5 km means: −4.93609 w/4 extremes removed: −4.93609
PR−GND (dBZ)
Height (km)


(b)
Orbit 50154 9/3/06 Number of points: 1240
Mean of all values:−1.81006 Mean of 0.5 km means: −2.00999 w/4 extremes removed: −2.00999
PR−GND (dBZ)
Height (km)



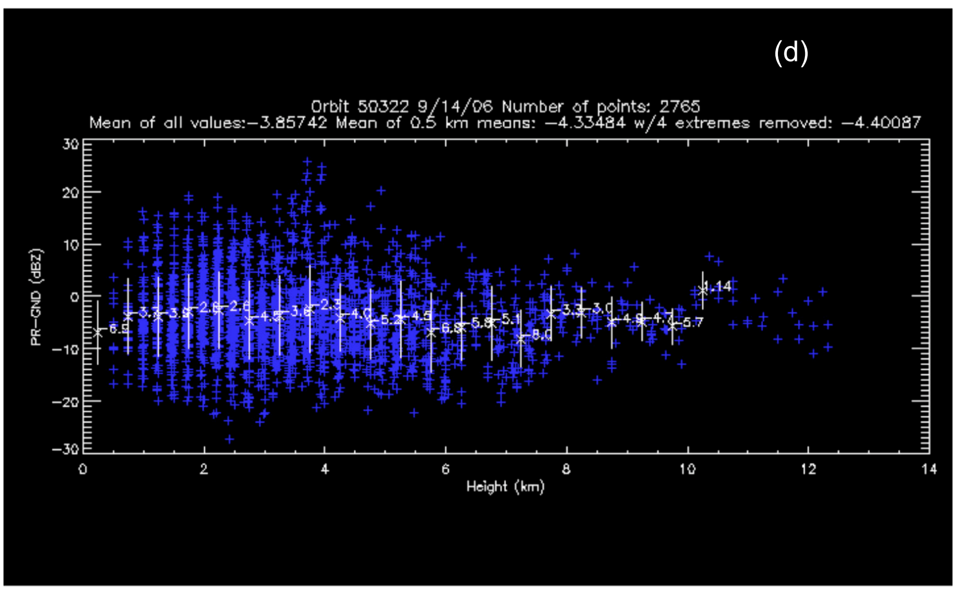


Figure 4. Comparison of TRMM PR minus TOGA reflectivity for selected heights during overpass on (a) 22 August 1031 UTC, (b) 3 September 1911 UTC, (c) 12 September 2351 UTC, and (d) 14 September 1351 UTC. Blue asterisks indicate results for each grid point within the overlap region. White lines indicate the standard deviation and mean difference at each height.

Attenuation Correction

After QC and calibration adjustment, the radar data were passed through an algorithm to correct for precipitation attenuation at C-band using a GATE Z-R relation (see Austin and Geotis 1979 and Hudlow 1979). This attenuation corrected radar reflectivity field "CA" was written out both to the TOGA radar files (UF format) and Cartesian gridded data products (described below). *The CA field represents the best estimate of TOGA radar reflectivity.*

Data Products

The following data products are available from the multiple tilt scan files:

- Daily Movie loops (Quicktime format) of uncorrected radar reflectivity "DZ", corrected radar reflectivity "CZ", and radial velocity "VR". These files are in the subdirectory "daily_movies".

- Individual image files (png format) of uncorrected radar reflectivity "DZ", corrected radar reflectivity "CZ", and radial velocity "VR" are available in the subdirectory "images".

- Gridded data files (NETCDF format) of uncorrected radar reflectivity "DZ" and attenuation corrected radar reflectivity "CA" (i.e.,the best estimate of radar reflectivity) are available in the subdirectory "gridded". These files were generated using the NCAR REORDER software and consist of interpolated data in a 200 x 200 km box surrounding the TOGA radar site. The grid extends from 1.5 to 20 km in the vertical. The 3 km grid spacing was chosen to approximate the actual size of the beam at maximum distance from the radar in the grid (100 km). The data were interpolated using a Cressman filter and a 1.5 km radius of influence. Finer resolution grids can be generated, if desired (contact the P.I.).

- Radar data files (UF format) of unfiltered radar reflectivity "ZT", uncorrected radar reflectivity "DZ", corrected radar reflectivity "CZ", attenuation corrected reflectivity "CA", radial velocity "VR", and spectral width "SW". These are the data files used (DZ and CA fields) to generate the gridded NETCDFs described above. A variety of software packages are available to view and edit the data in UF format, including the NASA TRMM Office Radar Software Library (RSL - http://trmm-fc.gsfc.nasa.gov/trmm_gv/index.html - follow the "software" link). Contact the P.I. if you would like to work with the data in UF format.

References

Austin, P. M., and S. G. Geotis, 1979: Raindrop sizes and related parameters for GATE. *J. Appl. Meteor.,* **18**, 569–575.

Berenguer, M., D. Sempere-Torres, C. Corral, and R. Sánchez-Diezma, 2006: A fuzzy logic technique for identifying nonprecipitating echoes in radar scans. *J. Atmos. Oceanic Technol.,* **23**, 1157–1180.

Cho, Y.-H., G. W. Lee, K.-E. Kim, and I. Zawadzki, 2006: Identification and removal of ground echoes and anomalous propagation using the characteristics of radar echoes. *J. Atmos. Oceanic Technol.,* **23**, 1206–1222.

Hudlow, M. D., 1979: Mean rainfall patterns for the three phases of GATE. *J. Appl. Meteor.,* **18**, 1656–1669.