TITLE: Version 2.3 DYNAMO TOGA radar data (April 2014)

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1.0 DATA SET OVERVIEW:

Version 2.3 TOGA radar data
CF-Radial Polar Coordinate Volumes (PPIs & RHIs)
Cartesian Grids (PPIs only)
Cruise 1: 29 August - 22 September 2011
Cruise 2: 1-30 October 2011
Cruise 3: 7 November - 8 December 2011
Cruise 4: 16 December 2011 - 2 January 2012
dynamo_toga_cruise#_latlon.txt files - Iris RAW file name, from which you can extract time/date (to1YYMMDDhhmmss.RAW####), and then latitude and longitude (decimal degrees), arranged in columns respectively

2.0 INSTRUMENT DESCRIPTION:

C-band Doppler radar

Wavelength	5.35 cm
Beamwidth	1.65°
Pulse Length	1 μs (125-m gate spacing)
PRF	1 kHz
Scan Rate	~15° s-1 (PPI), ~2° s-1 (RHI)
PPI azimuthal spacing	1°
Max unambiguous range	150 km
Nyquist Velocity	13.38 m s -1

INU corrected for ship motion (pointing only, Cruise 1)
INU corrected for ship motion (pointing and velocity, Cruises 2-4)

Notable publications using TOGA radar data:
Short et al. (1997)
Anagnostou and Morales (2002)
Cifelli et al. (2002)
Cifelli et al. (2010)

3.0 DATA COLLECTION AND PROCESSING:

10-minute update cycle
FAR (PPIs 0.8-21.5°) run most of time
NEAR (PPIs 0.8°-35.9°) run when FAR could not top
HH:00 - 360° PPI volume, HH:09 RHI volume on scientist-selected target
HH:10 - 360° PPI volume, HH:19 RHI volume
HH:20 - 360° PPI volume, HH:29 long-range (500-Hz PRF) 0.8° sweep
HH:30 - 360° PPI volume, HH:39 RHI volume
HH:40 - 360° PPI volume, HH:49 RHI volume
HH:50 - 360° PPI volume, HH:59 long-range (500-Hz PRF) 0.8° sweep

When echo non-existent or uninspiring, RHIs were not done.

Quality Control
See supplementary documentation for details, including IDL-based QC scripts.

Pointing angle checked via solar tracking, both in motion and stationary. Performance was excellent.

Calibration checked via solar gain calibrations and TRMM PR intercomparison
TOGA 1.5 dB hot, -1.5 dB applied to reflectivity across all cruises.

Reflectivity deleted where no velocity signal exists. This filtered second-trip and RF noise.

Despeckling applied - along a ray, 8 gates of contiguous echo or less (≤1 km length) was deleted. This filtered random noise, skin paints from passing ships, and sidelobe.

Sea clutter was typically not a major problem. Subjectively developed algorithm based on behavior of sea clutter during project. Evaluate successive sweeps at every ray/gate (i.e., vertical continuity check), if reflectivity echo within 75 km range remains 2 km or below, delete it. If radar beam does not get above 2 km at highest tilt, delete it; this effectively removes all echo within 5-8 km of radar.

All reflectivity below 0 dBZ was deleted. This filtered weak non-raining boundaries, remaining sea clutter, noise, and sidelobe.

The TOGA version 1 gaseous attenuation correction modeled after established C-band value of 0.008 dBZ km-1 each way (maximum 150-km correction +2.4 dBZ). Attenuation correction by rain was based on the GATE algorithm (Patterson et al. 1979), which iteratively corrects Z at a gate based on the theoretical treatment of attenuation by all the rainfall up to the given gate. The potential correction was capped at +8 dBZ, but for TOGA typical maximum corrections were in the +1-2 dBZ range. Z-R used for this process was $\mathbf{Z}=178\mathbf{R}^{1.44}$ (MISMO relationship). Note: Attenuation corrections only applied at 5 km MSL or lower, to focus on liquid water and near-surface air densities. Corrections only applied after all filtering performed.

The TOGA version 2 correction changed attenuation correction method to a direct relationship between A and Z. The relationships is based on 2 years of seasonal disdrometer data from Manus that was processed by E. Thompson (2014). The relationship for the 2-way attenuation is:

$Ah = 9.2944492\ 10^{-6} * Z^{0.879}$ Eqn. 1

The attenuation correction is not applied above the assumed freezing level of 5.0 km.

The data are also despeckled (as in V1)

The 1.5 dB offset (TOGA hot) is applied (as in V1)

Removal of sea clutter is attempted on PPIs (NOT RHIS) based on vertical continuity tests (If echo at a specific range within 75 km stays below height 2.0 km, it is assumed sea clutter and deleted.; same as V1)

An attempt is made to delete echoes associated with noise, sfc boundaries and side lobes (same as V1)

Variables:

DZ - Original, attenuated reflectivity

AZ – Attenuation corrected reflectivity via A-Z relationship

CZ – Attenuation corrected reflectivity based on rainrate calculated from MISMO Z-R relationship (same as V1)

AH – Calculated attenuation from Eq 1.

CH – Accumulated attenuation calculated from rainrate-based correction method

4.0 DATA FORMAT:

Version 2 CF-Radial files for all volumes except the long-range sweeps (typically HH:29 & HH:59 volumes)

Variables: Unfiltered Reflectivity - DZ, Filtered Reflectivity – CZ, Attenuated Filtered Reflectivity – AZ, Doppler Velocity - VR, Spectrum Width - SW, Signal Quality Index – SQI)

Version 2 NetCDF grids for PPIs only x:-150 to +150 km, y:-150 to +150 km, z:0.5 to 20 km MSL; resolution 2 km horizontal and 0.5 km vertical

NetCDFs created using REORDER with center of grid always at ship
Radius of influence: horizontal 1.5 km, vertical 1.2 km
Variables: DZ, CZ, AZ, VR

CZ and AZ in PPIs – Everything filtered; RHIs – Everything but sea clutter removal
DZ corrected only for calibration, CZ and AZ aggressively filtered and corrected.

5.0 DATA REMARKS:

INU provides ship position & motion correction information, and is dependent upon GPS satellite lock. When satellite lock lost (excessive rocking, water infiltration, etc.), position information goes haywire. A few different ways of manifesting: Loss of rays, pure rotation, and weird interspersing of ray loss and rotation. Manifestation #2 may be correctable, but this was not attempted. Typically < 2% of volumes were affected by INU issues. See the supplementary documentation for a list of all affected volumes.

Second-trip deletion was a double-edged sword, can remove echo when velocity goes haywire, or there is embedded 2nd trip in real echo. Attempts to repopulate via querying higher tilts let in excessive 2nd trip and sea clutter, and thus this was not done and the over-filtering was left in the dataset.

Cruise 1-specific issues:
RF Noise – Created by SeaTel C-band satellite Internet antenna. Easy to delete (no velocity), but reduces sensitivity.
Doppler velocity sign flipped - When correcting for ship motion, this compounds the error. Not fixed until end of cruise, motion correction for Doppler velocity turned off about 1 week into cruise.

CZ likely instances of over-correction, focus of use would be statistics where everything absolutely has to be meteorological. Use DZ to inform adjustments for case studies. VR not corrected for either sign error (Cruise 1) or folding.

6.0 REFERENCES:

Anagnostou, E. N., and C. A. Morales (2002), Rainfall estimation from TOGA radar observations during LBA field campaign, J. Geophys. Res., 107, 8068, doi:10.1029/2001JD000377.

Cifelli, R., T. J. Lang, S. A. Rutledge, N. Guy, E. J. Zipser, J. Zawislak, and R. Holzworth, 2010: Characteristics of an African easterly wave observed during NAMMA. Journal of Atmospheric Science, 67, 3-25.

Cifelli, R., W. A. Petersen, L. D. Carey, S. A. Rutledge, and M. A. F. da Silva Dias (2002), Radar observations of the kinematic, microphysical, and precipitation characteristics of two MCSs in TRMM LBA, J. Geophys. Res., 107, 8077, doi:10.1029/2000JD000264.

Patterson, V. L., M. D. Hudlow, P. J. Pytlowany, F. P. Richards, and J. D. Hoff, 1979: GATE radar rainfall processing system. NOAA Tech. Memo. EDIS 26, NOAA, Washington, DC, 34 pp. [Available from National Technical Information Service, Sills Building, 5285 Port Royal Road, Springfield, VA 22161.].

Short, D. A., P. A. Kucera, B. S. Ferrier, J. C. Gerlach, S. A. Rutledge, and O. W. Thiele, 1997: Shipboard Radar Rainfall Patterns within the TOGA COARE IFA. Bull. Amer. Meteorol. Soc., 78, 2817-2836.

Thompson, Elizabeth J., Steven A. Rutledge, Brenda Dolan, and Merhala Thurai, 2014: Long Term 2DVD Observations of Rainfall Characteristics in the Equatorial Indian and West Pacific Oceans. ASR PI Meeting, Potomac, Maryland. 10-13 March 2014.

7.0 SUPPLEMENTARY INFORMATION

The idl program uses rsl_in_idl version 1.4 with the 2 corrections. The code is available.

Below is the INU documentation.

Cruise 1 Start is first volume featuring problem, End is last volume featuring problem (times refer to volume start times) RHIs not considered

INU Problems

Start		End	
8-Sep-11	16:20	8-Sep-11	16:30
8-Sep-11	18:30	8-Sep-11	18:40
10-Sep-11	12:00	10-Sep-11	12:10
10-Sep-11	17:00	10-Sep-11	17:10
10-Sep-11	18:40	10-Sep-11	18:50
13-Sep-11	11:10	13-Sep-11	11:20
13-Sep-11	12:30	13-Sep-11	12:40
14-Sep-11	17:50	14-Sep-11	18:00
15-Sep-11	13:10	15-Sep-11	13:20
19-Sep-11	13:10	19-Sep-11	13:40

Transmitter Off

Start		End	
28-Aug-11	8:53	28-Aug-11	23:11
29-Aug-11	3:03	29-Aug-11	3:03
5-Sep-11	0:28	5-Sep-11	4:30
6-Sep-11	1:07	6-Sep-11	1:07
8-Sep-11	4:02	8-Sep-11	4:02
8-Sep-11	5:31	8-Sep-11	5:31
17-Sep-11	10:25	17-Sep-11	10:41
26-Sep-11	3:10	26-Sep-11	5:08

Potential Land Clutter

Start		End	
29-Aug-11	1:37	29-Aug-11	1:56
29-Aug-11	5:15	30-Aug-11	2:35
4-Sep-11	16:00	5-Sep-11	8:50

Strict Real-Time QC

Start		End	
10-Sep-11	0:40	10-Sep-11	0:50
10-Sep-11	2:48	10-Sep-11	2:48
10-Sep-11	3:40	10-Sep-11	8:10
10-Sep-11	8:30	10-Sep-11	11:20

Significant Missing Data

Start	End

Enhanced RF Noise

Start		End	
28-Aug-11	8:53	26-Sep-11	5:08

Cruise 2 Start is first volume featuring problem, End is last volume featuring problem (times refer to volume start times) RHIs not considered

INU Problems

Start		End	
1-Oct-11	5:00	1-Oct-11	5:50
2-Oct-11	4:30	2-Oct-11	4:40
2-Oct-11	10:40	2-Oct-11	11:00
3-Oct-11	4:20	3-Oct-11	4:30
3-Oct-11	6:30	3-Oct-11	9:30
12-Oct-11	9:50	12-Oct-11	10:00
13-Oct-11	9:40	13-Oct-11	9:50
14-Oct-11	3:40	14-Oct-11	3:50
14-Oct-11	9:40	14-Oct-11	9:50
16-Oct-11	20:00	16-Oct-11	20:10
22-Oct-11	16:50	22-Oct-11	17:00
23-Oct-11	2:20	23-Oct-11	2:30
23-Oct-11	3:50	23-Oct-11	4:00
26-Oct-11	9:00	26-Oct-11	9:10
30-Oct-11	1:20	30-Oct-11	5:50

Transmitter Off

Start		End	
29-Oct-11	2:10	29-Oct-11	2:10

Potential Land Clutter

Start	End

Strict Real-Time QC

Start		End	
20-Oct-11	4:59	20-Oct-11	5:16

Significant Missing Data

Start	End

Enhanced RF Noise

Start		End	
6-Oct-11	14:40	6-Oct-11	14:40
15-Oct-11	6:10	15-Oct-11	6:10
20-Oct-11	4:50	20-Oct-11	4:50

Cruise 3 Start is first volume featuring problem, End is last volume featuring problem (times refer to volume start times) RHIs not considered

INU Problems

Start		End	
8-Nov-11	8:10	8-Nov-11	8:20
9-Nov-11	8:00	9-Nov-11	8:20
10-Nov-11	8:00	10-Nov-11	8:30
10-Nov-11	16:50	10-Nov-11	17:00
11-Nov-11	8:00	11-Nov-11	8:30
13-Nov-11	1:50	13-Nov-11	2:10
13-Nov-11	15:20	13-Nov-11	15:30
19-Nov-11	7:20	19-Nov-11	7:30
20-Nov-11	1:50	20-Nov-11	2:00
20-Nov-11	7:10	20-Nov-11	7:40
20-Nov-11	15:10	20-Nov-11	15:20
24-Nov-11	20:50	24-Nov-11	21:00
25-Nov-11	6:00	25-Nov-11	7:20
25-Nov-11	11:20	25-Nov-11	11:40
26-Nov-11	6:50	26-Nov-11	7:10
27-Nov-11	2:00	27-Nov-11	2:10
27-Nov-11	6:40	27-Nov-11	7:00
27-Nov-11	11:00	27-Nov-11	11:20
29-Nov-11	6:40	29-Nov-11	6:50
29-Nov-11	10:40	29-Nov-11	11:00
30-Nov-11	3:30	30-Nov-11	4:00
30-Nov-11	6:30	30-Nov-11	7:10
30-Nov-11	10:50	30-Nov-11	11:00
1-Dec-11	6:30	1-Dec-11	6:40
2-Dec-11	4:40	2-Dec-11	5:00
2-Dec-11	6:00	2-Dec-11	7:10
3-Dec-11	4:50	3-Dec-11	5:00
3-Dec-11	6:20	3-Dec-11	7:10
4-Dec-11	6:20	4-Dec-11	6:40
4-Dec-11	10:50	4-Dec-11	11:00
6-Dec-11	15:30	6-Dec-11	15:40
7-Dec-11	15:10	7-Dec-11	15:40

Transmitter Off

Start		End	
5-Nov-11	8:24	5-Nov-11	8:24
7-Nov-11	9:30	7-Nov-11	12:50

Potential Land Clutter

Start		End	
4-Nov-11	8:39	4-Nov-11	9:04

Strict Real-Time QC

Start		End	
16-Nov-11	3:33	16-Nov-11	3:36
1-Dec-11	7:29	1-Dec-11	7:29
1-Dec-11	7:39	1-Dec-11	7:39

Significant Missing Data

Start		End	
11-Nov-11	12:20	11-Nov-11	12:20

Enhanced RF Noise

Start		End	
14-Nov-11	4:00	14-Nov-11	4:00
15-Nov-11	3:10	15-Nov-11	3:20
15-Nov-11	6:40	15-Nov-11	6:50

Cruise 4 Start is first volume featuring problem, End is last volume featuring problem (times refer to volume start times) RHIs not considered

INU Problems

Start	End

Transmitter Off

Start	End

Strict Real-Time QC

Start		End	
26-Dec-11	0:49	26-Dec-11	2:54
26-Dec-11	3:30	26-Dec-11	5:43
28-Dec-11	1:00	28-Dec-11	2:46
30-Dec-11	5:30	30-Dec-11	5:46
1-Jan-12	23:39	2-Jan-12	2:23

Enhanced RF Noise

Start	End

Potential Land Clutter

Start		End	
14-Dec-11	6:53	14-Dec-11	7:10

Significant Missing Data

Start	End