Dynamics of the Madden-Julian Oscillation

DYNAMO 2011-2012 Radiosonde Data Quality Report

July 9

2012

The radiosonde data for this project were quality controlled and are maintained by the Earth Observing Laboratory at the National Center for Atmospheric Research (NCAR). NCAR is sponsored by the National Science Foundation (NSF). In the event that information or plots from this document are used for publication or presentation purposes, please provide appropriate acknowledgement to NSF and NCAR/EOL and make reference to Young et al. (2012, J. Wang, W. Brown and D. Lauritsen: DYNAMO 2011 quality controlled Diego Garcia radiosonde data set.)

Dynamics of the Madden-Julian Oscillation (DYNAMO) 2011 Quality Controlled Radiosonde dataset from Diego Garcia

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I. Dataset Overview

Dynamics of the Madden-Julian Oscillation (DYNAMO) was a field campaign aimed at examining and improving upon the modeling of key processes of the Madden-Julian Oscillation (MJO); which is thought to considerably influence weather and climate. The project was conducted in the tropical Indian Ocean during the Fall 2011 and Spring 2012. It employed the use of numerous atmospheric instruments including; multiple radar, land and ship based radiosonde sounding systems, as well as NCAR GAUS radiosonde systems on the island Diego Garcia and Ship R/V Revelle (Fig. 1). From September 30, 2011 through January 15, 2012, a total of 690 Vaisala RS92 radiosondes were launched at Diego Garcia (Fig. 2). A total of 679 quality controlled soundings are contained in the final DYNAMO data set.

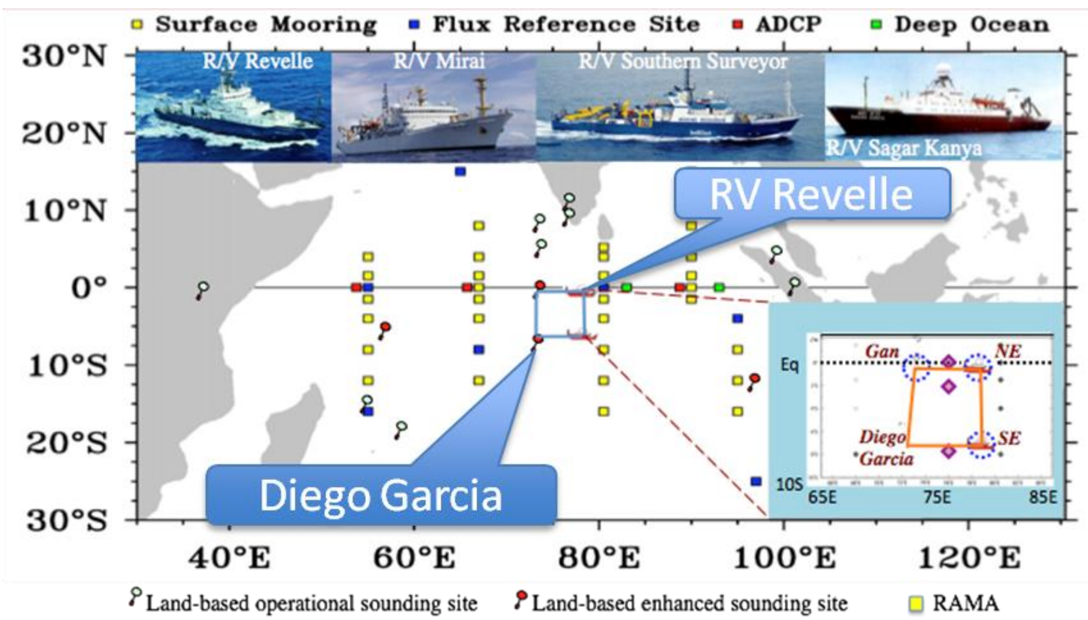

Fig. 1 Map of DYNAMO field campaign domain with instrument sites, including soundings sites. (adopted from DYNAMO project page: http://www.eol.ucar.edu/projects/dynamo)

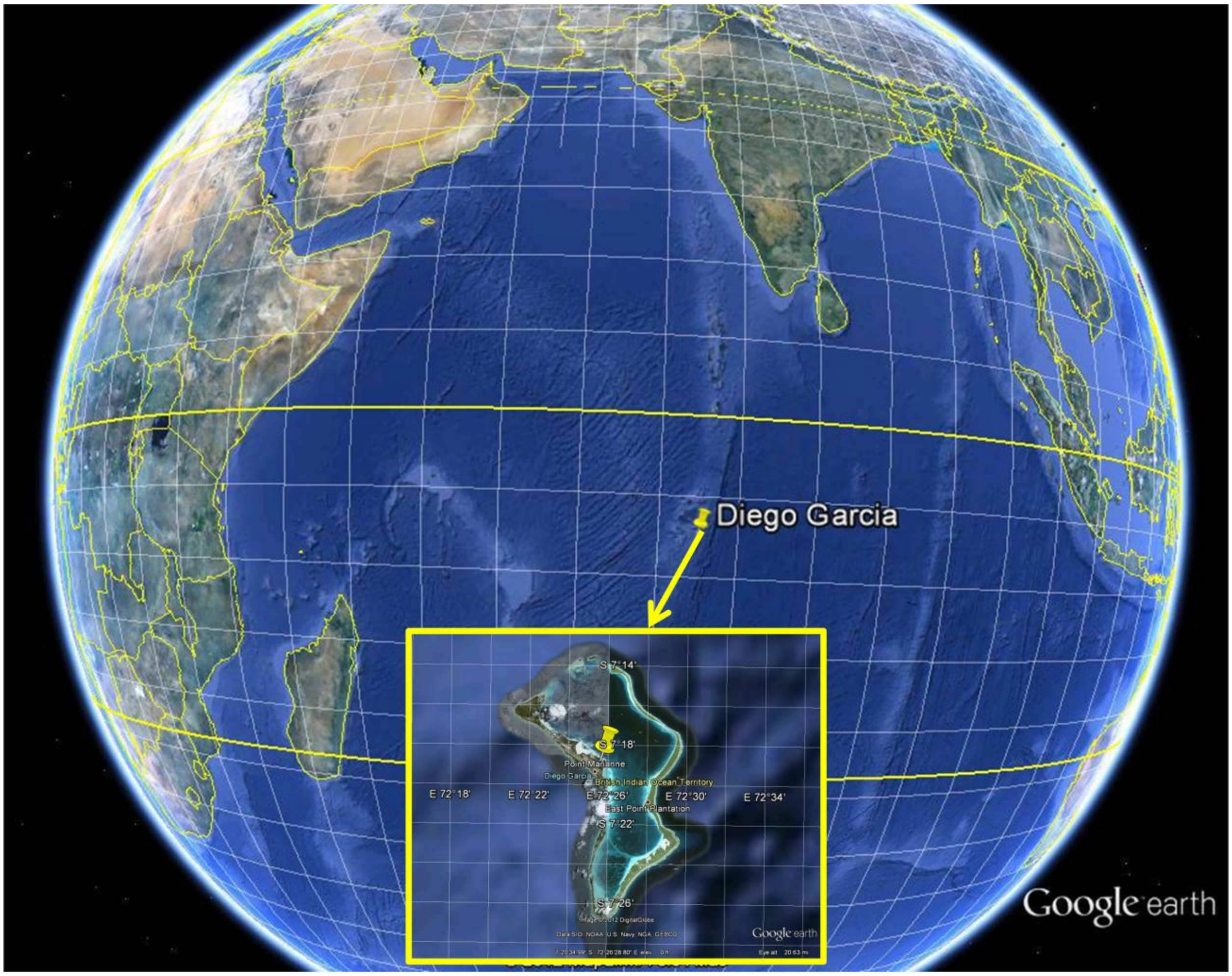

Fig. 2 Map of EOL Diego Garcia radiosonde ISS site

II. EOL Sounding File Format and Data Specifics

The EOL format is an ASCII text format that includes a header (Table 1), with detailed project and sounding information, and seventeen columns of high resolution data (Table 2). The "QC.eol" files are one-second resolution data files with appropriate corrections and quality control measures applied. The naming convention for these files is "D", followed by "yyyymmdd_hhmmss_P.1.PreCorr.SRDBcorr.QC.eol" where yyyy = year, mm = month, hh = hour of the day GMT, mm = minute of the hour, ss = second of the hour (which refer to the launch time of the sonde), and "QC.eol" refers to the EOL file format type.

The header contains information including data type, project name, site location, actual release time, and other specialized information. The first seven header lines contain information identifying the sounding. The release location is given as: lon (deg min), lon (dec. deg), lat (deg min), lat (dec. deg), altitude (meters). Longitude in deg min is in the format: ddd mm.mm'W where ddd is the number of degrees from True North (with leading zeros if necessary), mm.mm is the decimal number of minutes, and W represents W or E for west or east longitude, respectively. Latitude has the same format as longitude, except there are only two digits for degrees and N or S for north/south latitude. The following three header lines contain information about the data system and auxiliary information and comments about the sounding. The last 3 header lines contain header information for the data columns. Line 12 holds the field names, line 13 the field units, and line 14 contains dashes (--- characters) signifying the end of the header. Data fields are listed below in Table 2.

The files contain data calculated at one-second intervals. The variables pressure, temperature, and relative humidity are calibrated values from measurements made by the radiosonde. The dew point is calculated from the relative humidity and temperature. The geopotential altitude is calculated from the hydrostatic equation using pressure, temperature, and relative humidity. The rate of ascent is calculated from pressure. The radiosonde position (lat, lon, GPSAlt) and winds are measured by use of a GPS receiver in the sonde. The raw wind values are subjected to a digital filter to remove low frequency oscillations due to the sonde pendulum motion beneath the balloon when run through NCAR's Atmospheric Sounding Processing ENvironment (ASPEN) software. The quality of the GPS altitude is somewhat questionable. The accuracy of the sensor is typically +/-20 m, and may show large variability. For this reason, investigators are encouraged to use geopotential altitude over GPS altitude.

Table 1 - EOL Sounding File Format (dropsonde and radiosonde)

```
Data Type/Direction:                     GAUS SOUNDING DATA/Ascending
File Format/Version:                     EOL Sounding Format/1.1
Project Name/Platform:                   DYNAMO/NCAR GAUS
Launch Site:                             Diego Garcia
Launch Location (lon,lat,alt):           72 25.59'E 72.426578, 7 18.85'S -7.314117, 2.0
UTC Launch Time (y,m,d,h,m,s):           2011, 11, 27, 14:15:07
Sonde Id/Sonde Type:                     001434642/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:       Campbell Scientific CR10/14:!5:03
System Operator/Comments:                Steph S/none, Good Sounding
Post Processing Comments:                Aspen Version 3.1; Created on 22 June 2012 15:11 UTC; Configuration upsonde-1s

/
  Time   -- UTC  --    Press    Temp   Dewpt    RH     Uwind   Vwind   Wspd     Dir     dZ    GeoPoAlt     Lon        Lat     GPSAlt  Wwind  Wwind_f
   sec   hh mm   ss     mb       C       C       %      m/s     m/s     m/s     deg    m/s       m        deg        deg        m     m/s    m/s
-------- -- -- ----- ------- ------- ------- ------- ------- ------- ------- ------- ------- -------- ----------- ---------- -------- ------ --------
```

Table 2 - Lists data fields provided in the EOL format ASCII soundings

Field No.	Parameter	Units	Measured/Calculated
1	Time	Seconds	-------------
2	UTC Hour	Hours	-------------
3	UTC Minute	Minutes	-------------
4	UTC Second	Seconds	-------------
5	Pressure	Millibars	Measured
6	Dry-bulb Temp	Degrees C	Measured
7	Dewpoint Temp	Degrees C	Calculated
8	Relative Humidity	Percent	Measured

9	U Wind Component	Meters/Second	Calculated
10	V Wind Component	Meters/Second	Calculated
11	Wind Speed	Meters/Second	Measured
12	Wind Direction	Degrees	Measured
13	Descent Rate	Meters/Second	Calculated
14	Geopotential Altitude	Meters	Calculated
15	Longitude	Degrees	Measured
16	Latitude	Degrees	Measured
17	GPS Altitude	Meters	Measured

III. Data Quality Control Process

1. Profiles of raw temperature, relative humidity, wind speed and ascent rate versus pressure are first examined to determine if there are problematic sounding files which could be a result of malfunctioning of the launch detect, sounding system lock-up (a result of weakening of the sonde signal in flight), sensor failure, sensor offsets or biases, and slow radiosonde ascent rates. Corrections are made where possible to address these specific problems.

2. All of the soundings are then subjected to a radiation correction, applied to the temperature measurements, that takes into account the solar angle at time of launch and removes solar heating that could skew the temperature measurements.

3. A pressure ground check (GC) correction is applied to the entire profile for each sounding. The surface pressure measured by an independent surface sensor is used as a reference for the correction. The corrected pressure $P = P^{RS} * P_0^{REF} / P_0^{RS}$, where P^{RS} is the pressure measured by radiosonde, P_0^{REF} is the ground check pressure as indicated by the reference sensor, and P_0^{RS} is the ground check pressure as indicated by the radiosonde on the ground.

4. A daytime radiation dry bias correction is applied to soundings collected during daytime . The correction is adopted from Wang et al. (2012) and is a function of pressure, temperature, humidity and the solar elevation angle. *Wang, J., L. Zhang, A. Dai, F. Immler, M. Sommer and H. Voemel, 2012: Radiation dry bias correction of Vaisala RS92 humidity data and its impacts on historical radiosonde data. J. Atmos. Oceanic Technol., submitted.*

5. Scatter plots of the raw data are created to check differences in pressure, temperature and RH between the surface met and the last available surface radiosonde measurement before launch.

6. The raw soundings are processed through ASPEN, which analyzes the data, performs smoothing, and removes suspect data points.

7. Profiles of quality controlled temperature, RH, wind speed and wind direction versus geopotential altitude are examined. These enable us to visually evaluate the final data product for outliers, or any other obvious problems that may have previously gone undetected.

IV. Special Problems to Note (Important Information for Users)

Performing the quality control procedures outlined above allows us to identify and, in many cases, resolve issues that could potentially impact research performed using these data sets.

The following issues were found, and where necessary, corrections were applied:

1. Eleven sounding files were removed from the final archive. Four terminated prematurely (balloon burst), four required re-launches with another radiosonde (manual termination), three files were found to have the same sonde IDs (redundant files).

2. Fourteen sounding files listed below were found to have problematic RH profiles. They may contain artificial "dry spikes" that can be attributed to under-filling of the balloon (Fig 3). This can occur if the hygrometers are not sufficiently ventilated due to the slow ascent rate (below 3 m/s) of the balloon. In these cases, the RH sensors are unable to reach equilibrium with the environment before being turned back on (after heating). Three the files were corrected by applying additional filtering to layers where the obvious spikes occurred. All of these soundings were processed through ASPEN with slightly more restrictive quality control parameters applied than those typically used for radiosondes. Despite these additional measures, we want to caution data users that the RH data may still contain errors and may not accurately reflect true environmental conditions.

Slow Ascent Soundings	
D20111002_052321	D20111123_112307
D20111007_021743	D20111124_202147
D20111009_052103	D20111128_201842
D20111010_081614	D20111130_051545
D20111010_233459	D20111201_112026
D20111109_051543	D20111218_051502
D20111109_201542	D20120115_120331

3. Twelve of the radiosondes encountered either vertical downdrafts or balloon icing that caused descent of the balloon package for a period of time during flight (Fig. 3). These files were processed through ASPEN with slightly more restrictive quality control parameters applied than those typically used for radiosondes, and artificial dry spikes (Fig. 3) introduced during slow ascent have been removed. The additional filtering (performed using ASPEN) removes excessive noise that may be present in the pressure, temperature and RH. One

important thing to note; because ASPEN can only handle monotonically changing pressure, it removes any portion of the file where the radiosonde experiences increasing changes in pressures. As a result, data acquired during descent are set to missing.

Downdraft/Iced Soundings	
D20111008_000138	D20111108_142158
D20111008_022346	D20111109_082135
D20111009_082356	D20111115_233117
D20111010_112334	D20111128_231950
D20111010_121457	D20111201_232100
D20111016_053357	D20111220_053032

4. The soundings listed below experienced errors with the automatic launch detect. This occurs most often when the sonde is not able to collect a sufficient amount of surface data prior to launch, or the operator fails to complete all steps of the sounding system software before launch. The result is a delay in the launch detect mechanism, which relies on change in pressure to determine when the balloon release occurs. Four of the five sounding files lost near surface data (~20-30 mb) which was unable to be recovered. The filenames and launch times indicated in those four files (below in red) reflect the time that launch detect triggered and not the actual time of launch.

Original Filename	New Filename
D20111031_130035	D20111031_111810*
D20111120_101257	D20111120_082403*
D20111122_040827	D20111122_022815
D20111109_141226	No rename required*
D20111121_232427	No rename required*

*indicates soundings with incorrect launch times in filename and also contained in the data file.

5. The following sounding files needed repair because they experienced sounding system lock-up caused by weakening or loss of the radiosonde signal. The original sounding files were not saved in the correct format or to the correct file names. They contained no LAU (launch) or A00 (surface met) data lines, and were missing the standard 19 line tail at the end of the raw data file; all things necessary in order for ASPEN to run properly. Data before the lock-up was preserved, however anything measured by the radiosonde after the lock-up was lost. Filenames for these soundings were changed to reflect the actual launch time, determined by pressure change and GPS dz/dt, and surface met data collected just prior to launch was retrieved and entered into the sounding files.

New Filenames with Corrected Launch Times	
D20111002_082818	D20111101_021552
D20111003_052726	D20111117_051830
D20111003_232450	D20111205_232140
D20111011_082001	D20111206_052133

D20111012_083844	D20111211_051807
D20111012_142643	D20111211_111914
D20111012_171805	D20111215_052223
D20111013_081957	D20111218_171630
D20111014_081831	D20120112_051426
D20111014_141943	D20120115_120331
D20111018_052052	D20120115_234246

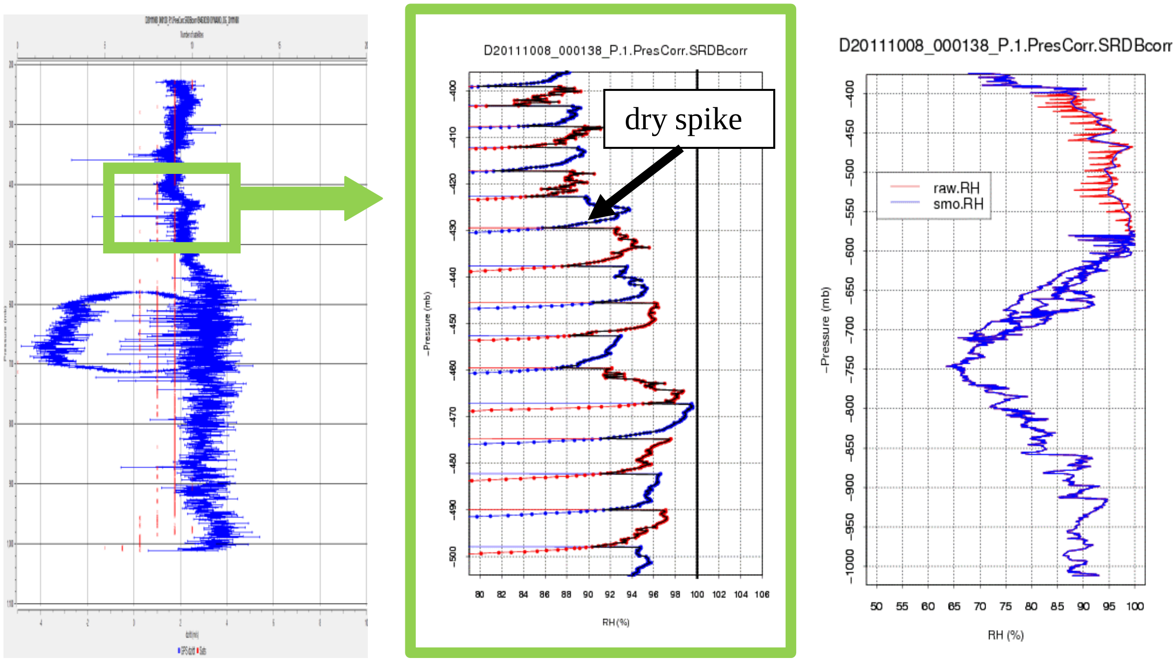

Figure 3 Left panel shows GPS measured ascent (m/s) rate versus pressure (mb). Ascent rates less than 4 m/s can introduce artificial dry spikes (center panel) corresponding to the heating cycle, caused by inadequate ventilation of the RH sensor during flight. Layers containing artificial spikes are subjected to additional filtering (right panel).