# Deep Propagating Gravity Wave Experiment over New Zealand

# DEEPWAVE 2014 Radiosonde Data Quality Report

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*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, K., W. Brown and D. Lauritsen, 2014: DEEPWAVE 2014 quality controlled radiosonde data set.*

# DEEPWAVE 2014 Quality Controlled Radiosonde Dataset

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# I. Dataset Overview

The Deep Propagating Gravity Wave Experiment (DEEPWAVE) was a research project conducted over New Zealand to study how topography and tropospheric winds can induce the formation of gravity waves which propagate upward through the troposphere, into the stratosphere. Important observational components of DEEPWAVE included in-situ measurements from the NSF/NCAR HIAPER Gulfstream-V research aircraft along with surface, airborne and satellite-based remote sensing. NCAR's Earth Observing Laboratory (NCAR/EOL), also deployed an Integrated Sounding System (ISS) with a radar wind profiler and other ground instrumentation to Hokitika, located on the West Coast of the island (Figure1).
One hundred forty five balloon-borne radiosondes were launched between May 25 and July 28, 2014. This document contains information on the sounding file format, data parameters included in each of the files, and details regarding the quality control measures applied to the sounding data.

For more information on the DEEPWAVE project please visit:
https://www.eol.ucar.edu/field_projects/deepwave


Figure 1. Map showing Integrated Sounding System (ISS) site location in Hokitika, NZ

# 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.SRcorr.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:                     DEEPWAVE Hokitika/NCAR GAUS
Launch Site:                               20140528
Launch Location (lon,lat,alt):             170 59.11'E 170.985127, 42 42.87'S -42.714538,    68.92
UTC Launch Time (y,m,d,h,m,s):             2014, 05, 27, 23:17:10
Sonde Id/Sonde Type:                       004823082/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:         Manual Entry/23:05:25.61
System Operator/Comments:                  Bill/Used sonde for surface met, Good Sounding
Post Processing Comments:                  Aspen Version 3.1-7741; Created on 18 Nov 2014 22:06 UTC; Configuration upsonde-1s
/
  Time   -- UTC  --    Press    Temp   Dewpt     RH    Uwind   Vwind    Wspd     Dir      dZ  GeoPoAlt      Lon          Lat       GPSAlt
   sec   hh mm   ss      mb       C       C       %      m/s     m/s     m/s     deg     m/s        m       deg          deg           m
-------- -- -- ----- ------- ------- ------- ------- ------- ------- ------- ------- ------- -------- ----------- ----------- --------
   -1.00 23 17  9.00 1019.32    8.46    7.61   94.36 -999.00 -999.00 -999.00 -999.00 -999.00    68.95  170.985127  -42.714538    68.92
    0.00 23 17 10.00 1019.39    8.55    7.33   91.97    0.09    0.12    0.15  218.77    1.29    68.41  170.985200  -42.714440    65.73
```

**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 (can result in RH errors). Corrections are made where possible to address these specific problems.

**2.** 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 to find biases in the radiosonde data (Figure 3). These plots allow us to determine if the ground check pressure correction (see #4 below) is needed, and they allow us to investigate large differences in temperature and relative humidity.

**3.** All of the data files were adjusted to correct initial geopotential surface heights. A geometric surface height, from the site, was obtained. This height was then converted to geopotential height, by taking into account latitude at the site location. This ensures an accurate starting point for the geopotential altitude calculation.

**4.** A pressure ground check (GC) correction is applied to the entire profile for most soundings (see exceptions in table below). 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.

**5.** All 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.

**6.** The raw soundings are processed through Batch ASPEN, which analyzes the pressure, temperature, relative humidity and GPS wind data, performs smoothing, and filters out 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. Three radiosondes encountered either vertical downdrafts or balloon icing that caused descent of the balloon package for a period of time during flight. These are referred to a 'loop' soundings because of the loop feature shown in the dzdt profile versus height, when ascent rate becomes negative and then recovers. Data collected during descent were been retained and quality controlled.

| "Loop" Sounding Filenames |
|---|
| D20140624_111941 |
| D20140629_140424 |
| D20140630_080034 |

2. One sounding, D2014614_050917, experienced loss of signal. The signal was eventually recaptured, however that data was stored in another sounding file, D20140614_053042. These data files were concatenated into one and quality control was applied, however there is a gap in the data during the time that the signal was lost.

**3.** Four soundings, listed in the table below, were found to have questionable RH data. One data file, D20140624_111941, contained an offset of the two hygrometers. RH data for this file was removed and replaced with missing values. The other soundings listed contained suspicious RH data resulting from turbulent atmospheric conditions which, at various time, significantly slowed the ascent rate of the balloons introducing 'noisier RH data than expected' . Additional smoothing was applied to these RH profiles, however some evidence of the noise and/or artificial dry spikes may still exist. **We strongly urge researchers to take caution when using these RH data.**

| Filename | RH Sensor Problem | Correction |
|---|---|---|
| D20140624_111941 | Contained RH offset | RH all set to missing values |
| D20140624_165843 | Turbulent atmosphere, noisy | Additional RH filtering |

| | | |
|---|---|---|
| | data. 39% of file had ascent rates < 3 m/s. | applied |
| D20140624_225656 | Turbulent atmosphere, noisy data. 37% of the data file had ascent rates < 3 m/s | Additional P/T/RH filtering applied |
| D20140625_051048 | Turbulent atmosphere, noisy data. 30% of the data file had ascent rates < 3 m/s | Additional P/T/RH filtering applied |

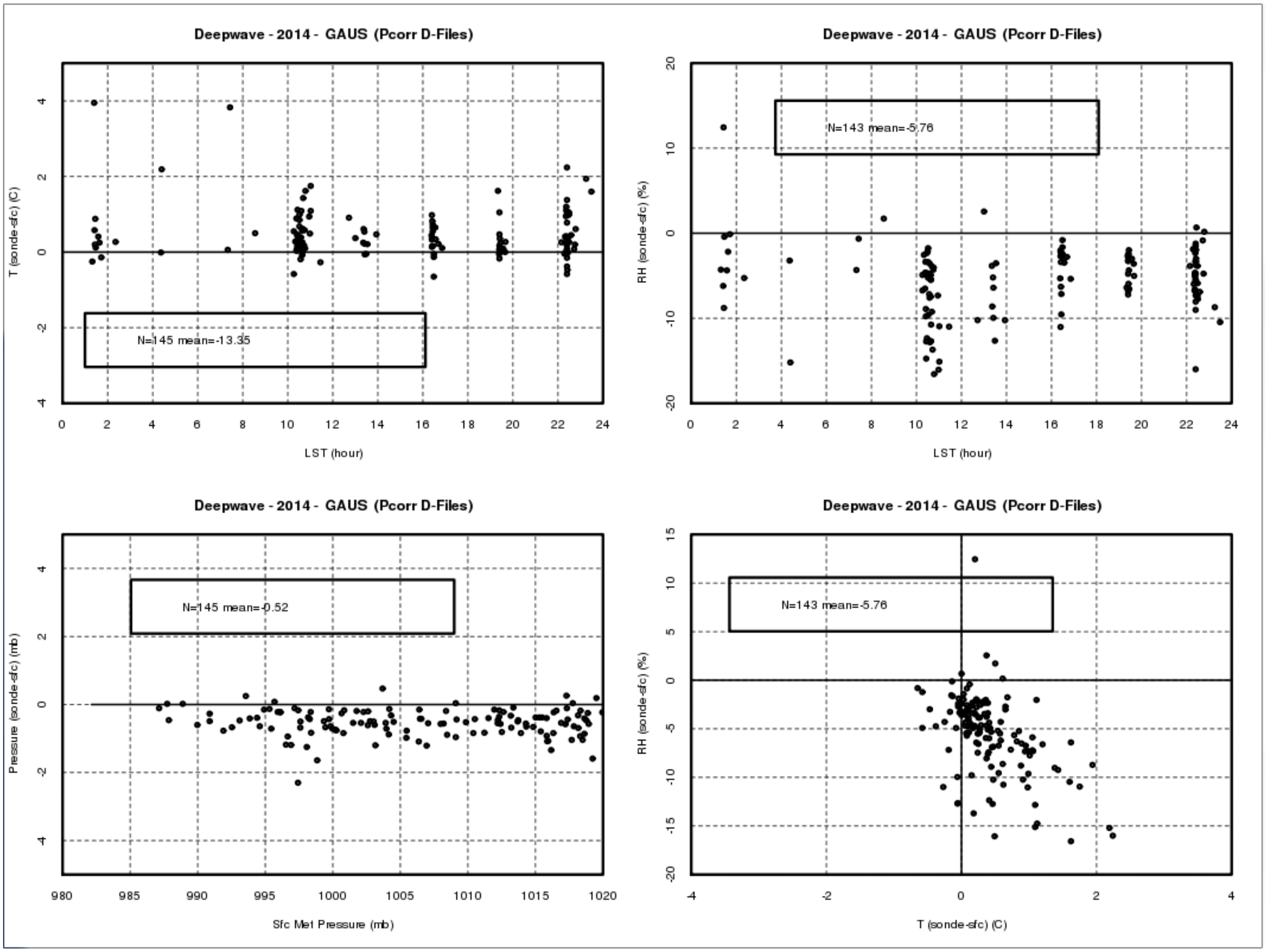


Figure 3 Plots above show measurement differences between prelaunch surface radiosonde and an independent surface met station. The upper left-hand shows differences in temperature, upper right shows RH differences, and lower left shows systematic pressure offsets on average of ~.8 mb (before correction), and lower right shows negative correlation between Tdiff and RHdiff, likely caused by placement of ISS tower over grass while the radiosondes were launched over pavement.