Deep Propagating Gravity Wave Experiment over New Zealand 2014

DEEPWAVE Dropsonde Data Quality Report

January 27

2015

The dropsonde 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. (2014, T. Hock and C. Martin: DEEPWAVE 2014 Dropsonde Data Quality Report.)

UCAR/NCAR - Earth Observing Laboratory. 2016. NSF/NCAR GV HIAPER QC Dropsonde Data, Version 3.0. UCAR/NCAR - Earth Observing Laboratory. http://dx.doi.org/10.5065/D6XW4GTB. Accessed 08 Sep 2016.

DEEPWAVE 2014 Quality Controlled Dropsonde Dataset

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Document Version Control

Version	Date	Author	Change Description
1.0	01-27-2014	*K. Young*	Initial Document Release
2.0	06-21-2016	*K. Young*	A dry bias in the RD94 and mini-dropsonde (NRD94) relative humidity measurements was discovered in data collected from 2010 to present, including all of the HS3 dropsonde datasets. The dry bias is strongly temperature dependent. It is considered small at warm temperatures and it becomes stronger at cold temperatures. This RH dry bias has been corrected for. The dropsonde files that have received this correction contain an indicator in the header of the file, 'TDDryBiasCorrApplied'.
3.0	09-08-2016	*K. Young*	Dewpoint temperature was recalculated using the corrected RH measurements (V2.0)

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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. The NSF/NCAR HIAPER Gulfstream-V research aircraft collected in-situ measurements using an automated Airborne Vertical Atmospheric Profiling System (AVAPS) dropsonde system. Two hundred eighty two dropsonde sounding data files, collected between June 6 and July 20, 2014, are contained in the quality controlled dropsonde data archive. This document contains information on the data file format, data parameters included in each of the files, and details regarding the quality control measures applied to the sounding data.

Table 1 - Summary of Research Flights

RF#	Dates	Soundings in final archive
RF01	June 06	4
RF02	June 11	6
RF03	June 13	12
RF04	June 14	23
RF05	June 16	21
RF06	June 18	14
RF07	June 19	15
RF08	June 20	8
RF09	June 24	22
RF10	June 25	6
RF11	June 28	12
RF12	June 29	20
RF13	June 30	20
RF14	July 01	10
RF15	July 03	0
RF16	July 04	16
RF17	July 05	10
RF18	July 07	9
RF19	July 08	7
RF20	July 10	12
RF21	July 11	7
RF22	July 13	2
RF23	July 14	5
RF24	July 15	7
RF25	July 18	11
RF26	July 20	3
Total # of Soundings		**282**

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

For more information on the **NCAR Dropsonde System** please visit the following site:
http://www.eol.ucar.edu/instrumentation/sounding/dropsonde

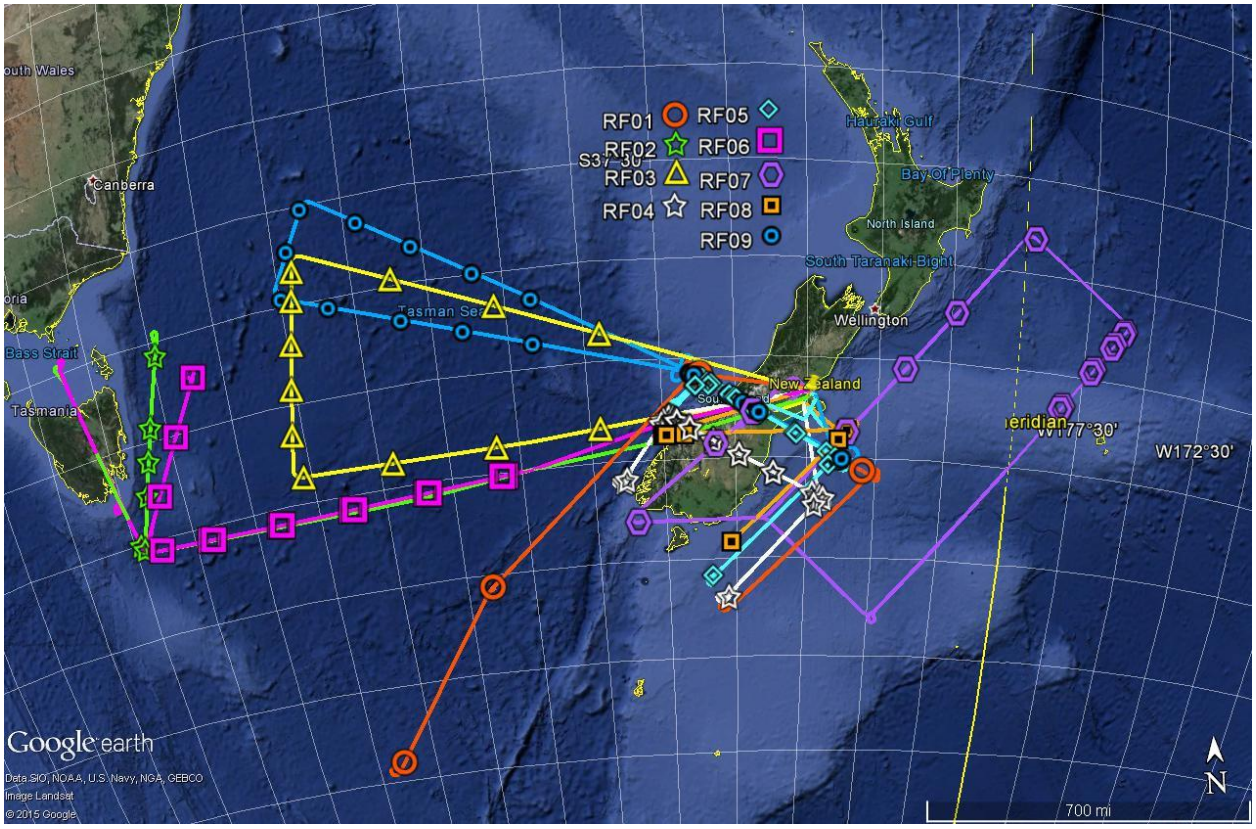

Figure 1 Map of DEEPWAVE Research Flights 1 through 9. Points indicate dropsonde launch locations. Lines connecting the dropsonde locations represent the aircraft flight tracks

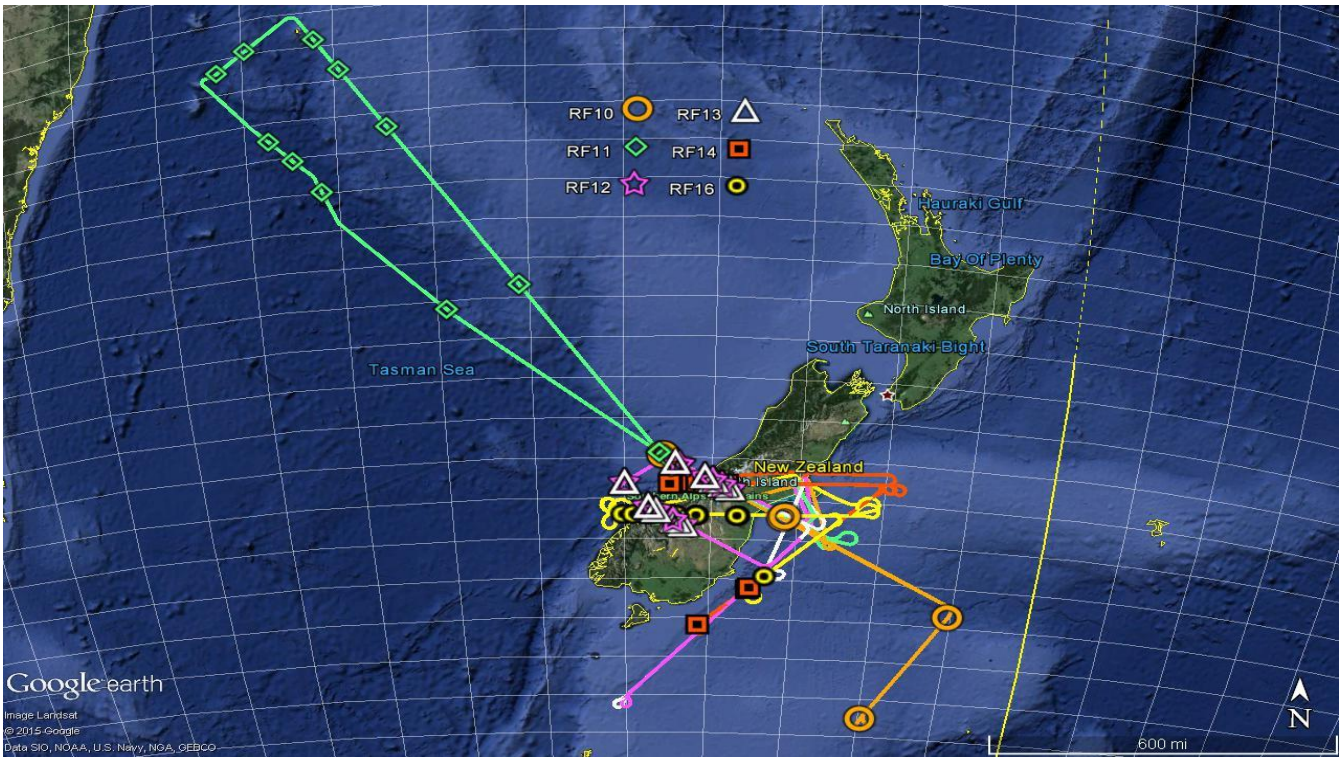

Figure 2 Map of DEEPWAVE Research Flights 10-16. Points indicate dropsonde launch locations. Lines connecting the dropsonde locations represent the aircraft flight tracks

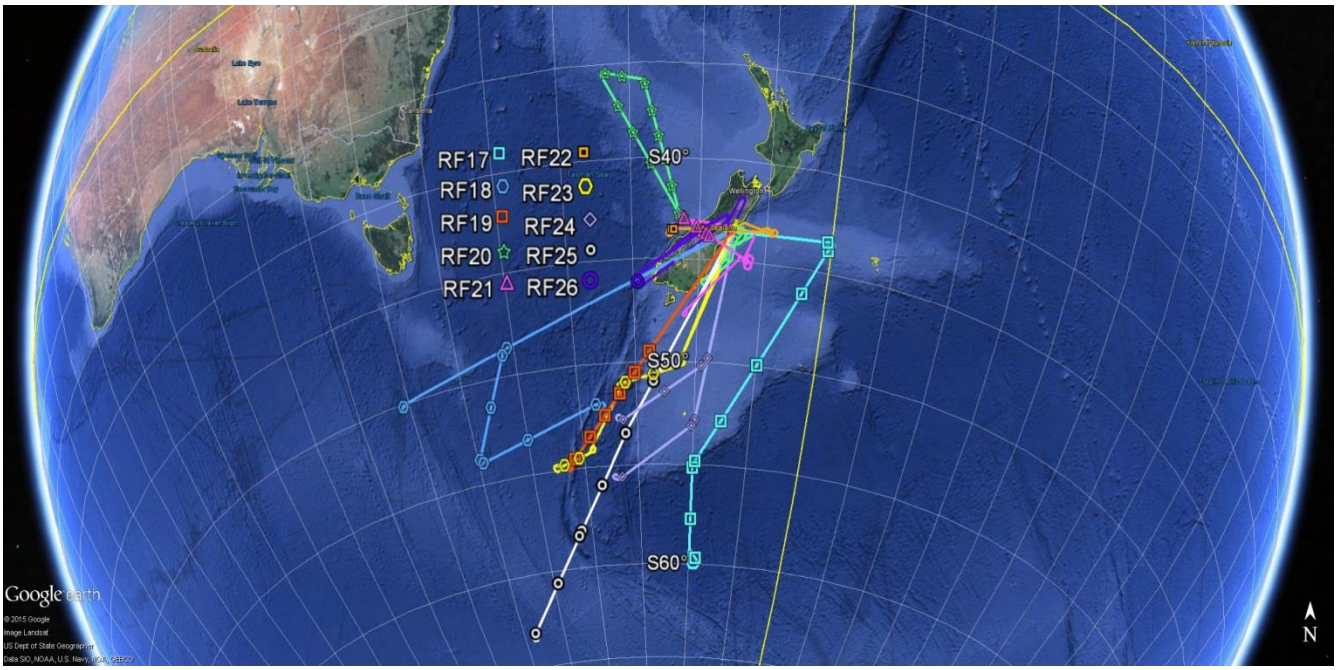

Figure 3 Map of DEEPWAVE Research Flights 17 through 26. Points indicate dropsonde launch locations. Lines connecting the dropsonde locations represent the aircraft flight tracks

EOL Sounding File Format and Data Specifics

The EOL format is an ASCII text format that includes a header (Table 2), with detailed project/ sounding information, and seventeen columns of high resolution data (Table 3). The "QC.eol" files are quarter-second resolution data files with appropriate corrections and quality control measures applied. Note that the thermodynamic data (pressure, temperature and humidity (PTU)) are only available at half-second resolution and wind data is available at quarter-second resolution. The naming convention for these files is "D", followed by "yyyymmdd_hhmmss_P.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, 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 3. The last line of the header contains information about the current version of ASPEN and its configuration used for the final data QC. It also contains a flag, 'TDDryBiasCorrApplied', indicating the files have been corrected for a temperature dependent dry bias in the relative humidity measurements (for more information, please see 'Data Quality Control Process' in Section II.

The variables pressure, temperature, and relative humidity are calibrated values from measurements made by the dropsonde. The AVAPS software applies a .4 mb dynamic correction to the pressure measurements, in real time. The dew point is calculated from the relative humidity and temperature using the vapor pressure equation (Bolton 1980).. The geopotential altitude is calculated from the hydrostatic equation, typically from the ocean's surface upward. For dropsondes that failed to transmit useful data to the surface, we integrate geopotential altitude from flight level down. The descent rate of the sonde is computed using the time-differentiated hydrostatic equation. The position (lat, lon) and wind data come directly from the GPS sensor. The uncertainty of the GPS altitude is estimated to be less than 20 m. Investigators should follow meteorological convention and use geopotential altitude.

Table 2 - EOL Sounding File Format (dropsonde and radiosonde)

Data Type/Direction:	AVAPS SOUNDING DATA, Channel 2/Descending
File Format/Version:	EOL Sounding Format/1.1
Project Name/Platform:	GV System - DEEPWAVE,/none, none
Launch Site:	
Launch Location (lon,lat,alt):	168 55.44'E 168.924000, 44 31.18'S -44.519600, 11911.94
UTC Launch Time (y,m,d,h,m,s):	2014, 06, 30, 06:39:47
Sonde Id/Sonde Type:	134625105/
Reference Launch Data Source/Time:	IWGADTS Format (IWG1)/06:39:47
System Operator/Comments:	Remote Operator/none, none
Post Processing Comments:	Aspen Version 3.1-7741; Created on 17 Dec 2014 22:19 UTC; Configuration mini-dropsonde;`TDDryBiasCorrApplied`

```
/
 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 12 37 25.00  178.91  -64.87  -72.21   38.67   26.39   13.64   29.71  242.66 -999.00 12864.22 -109.951000   33.083000 12896.00
    0.00 12 37 26.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00  -999.00 -999.000000 -999.000000  -999.00
    0.25 12 37 26.25 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00  -999.00 -999.000000 -999.000000  -999.00
    0.50 12 37 26.50 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00  -999.00 -109.950826   33.082335 12869.25
```

Table 3 - 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	Air 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

II. Data Quality Control Process

1. Profiles of pressure, temperature, RH, wind speed and descent rate from the raw D-files are examined to determine if all of the files contain data, and to identify features that may warrant further investigation. Corrections are applied where appropriate.

2. A pressure correction was applied to the entire profile for each sounding during the QC process. The pressure correction value is unique for each sonde and is determined in the final testing of the dropsonde during production. During the final testing of the dropsonde an independent precision pressure sensor is used as the reference for determining the pressure offset value from the dropsonde pressure measurement. The corrected pressure $P = P_{RS} + (P_{0REF} - P_{0RS})$, where P_{RS} is the pressure measured by the dropsonde, P_{0REF} is the pressure as

indicated by the reference sensor and P_{0RS} is the pressure as indicated by the dropsonde during calibration testing.

3. All aircraft flight level data contained in the sounding files are subjected to an altitude correction that converts GPS altitude (ie Ellipsoid height) to geopotential altitude. Ensuring an accurate flight level geopotential altitude is particularly important for soundings made over land that require calculation of the geopotential altitude from flight level downward; as was the case with 65 DEEPWAVE dropsondes.

4. The raw soundings D-files with the corrected pressure offset and updated flight level data are then processed through the Atmospheric Sounding Processing ENvironment (ASPEN) software, which analyzes the data, performs smoothing, sensor time response corrections, and removes suspect data points. The ASPEN software version and configuration file used for this program are included in the header of each "QC.eol" sounding file.
   For more information on ASPEN or to download the software please visit: http://www.eol.ucar.edu/software/aspen

5. Time series plots of quality controlled temperature, RH, wind speed, and fall rate, are used to examine the consistency of soundings launched during each flight, and to show the variability of soundings from different missions. These plots are also used to determine if the sounding did not transmit data to the surface, or if there was a "fast fall" caused by failure of the parachute to properly deploy.

6. Profiles of temperature, RH and winds from the quality controlled soundings are visually evaluated for outliers, or any other obvious issues.

7. A dry bias in the relative humidity measurements was discovered, in the Spring of 2016, in all RD94 dropsondes from 2010 to present and all mini-dropsondes (NRD94) collected. This dry bias is strongly temperature dependent and most significant at cold temperatures. It is considered small at warm temperatures. All sounding files undergoing post-processing have been corrected for this error and contain the flag, 'TDDryBiasCorrApplied', in the last line of the header to confirm that this correction has been applied. For more information on the dry bias, please access the technical note, linked below, which contains information on the origin, magnitude and impact of the dry bias.

   NCAR/EOL Technical Note: Dropsonde Dry Bias

   https://www.eol.ucar.edu/system/files/software/Aspen/Windows/W7/documents/Tech%20Note%20Dropsonde_Dry_Bias_20160527_v1.3.pdf

8. Finally, histograms of pressure, temperature, relative humidity, wind speed and wind direction, for all soundings contained in the final QC archive, are created to examine the distribution, range, and characteristics of each parameter.

III. Special Issues 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, noted in table 4, were found. Where necessary, corrections have been applied. Following the table are more detailed descriptions of the data quality issues discovered and information on how they were addressed.

Table 4 – Summary of Data Quality Issues Found with the MPEX Dropsonde Data

Data Quality Issue	# of soundings
Data files removed from archive	3
Fast Falls (engineering dropsondes)	3
Fast Falls (standard dropsondes)	3
Dropsondes over land	64
Dropsondes over water, data not to surface	2

1. **Files Containing No Atmospheric Data:** Three files were created, but contained only pre-launch data from the aircraft and were removed from the final archive. The dropsondes were initialized for a sounding, but were not launched.

Files Not in Final Archive	**Notes**
D20140629_110741, D20140701_101644	2 sondes started up no launch occurred
D20140701_101644	1 file contained missing values due to a failed sensor module which occurred at launch

2. **Fast fall:** Six soundings were classified as "fast fall drops", meaning the parachute failed to properly deploy resulting in dropsondes falling at an accelerated rate. Flight RF01 deployed only experimental engineering mini dropsondes which have a different parachute deployment mechanism, these sondes were not planned to part of the field experiment but since they do contain useful data they are included in the DEEPWAVE data set. When a fast fall occurs, GPS wind measurements can be unreliable (due to irregular motion of the dropsonde) and a lag in the response of the T/RH and sensors may occur. In extreme cases where tumbling of the sondes results in very noisy winds, those data are set to missing. For these six sondes the fall velocities were extremely high (~40 m/s), indicating the parachute deployed but did not properly inflate. The orientation of the dropsondes was vertical and the wind data were deemed acceptable and were retained in the final data archive. For the soundings listed below, we strongly caution data users about the validity of wind speed, wind direction, U/V winds, Temperature and RH data contained in each profile.

Fast Fall Soundings
D20140606_064724*
D20140606_073100*
D20140606_113051*

D20140616_093504
D20140616_114949
D20140624_064129

*engineering dropsondes

3. **Dropsondes Launched Over Land** – Sixty four dropsondes were launched over land. These dropsonde files are identified as 'Drops Over Land" in the comments section of each sounding file header. Two of these continued to transmit data after impact. The surface data was removed, as it is not representative of the atmosphere. For these sondes the hydrostatic calculation of heights was computed from the aircracft down to the surface.

4. **Negative longitudes** – Nine dropsondes from RF07 were deployed East the International dateline where longitudes are negative (Figure 5). All other dropsondes used for the project were deployed West of this line and contain positive longitudes.

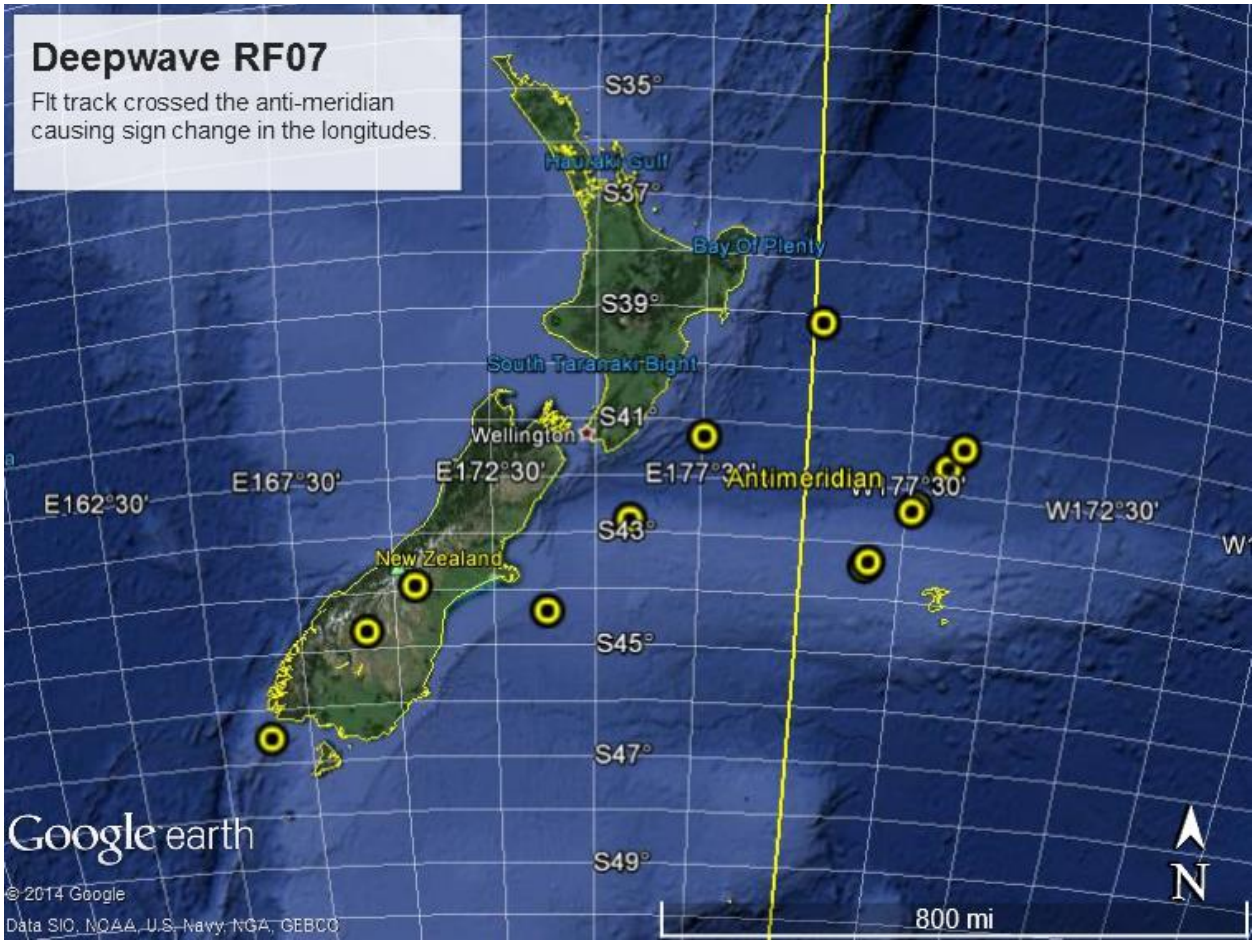

Figure 4 Shows locations of 9 dropsondes deployed East of the Antimeridian (International Date Line) which contain negative longitudes.