Southern Oxidant & Aerosol Study

SOAS 2013 Radiosonde Data Quality Report

October 30

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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 et al. (2013, J. Wang, W. Brown and D. Lauritsen: SOAS 2013 quality controlled radiosonde data set.)

Southern Oxidant & Aerosol Study 2013
Quality Controlled Radiosonde Dataset

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I. Dataset Overview

The Southern Oxidant and Aerosol Study was a field campaign aimed at gaining a better understanding of biosphere-atmosphere interactions and establishing the links between atmosphere composition, air quality and climate change (Fig. 1). The project took place in Alabama from June 1 to July 15, 2013 and was a collaborative effort between a number of Universities and Institutions deploying a multitude of instrumentation for data collection. One of these was the NCAR/EOL Integrated Sounding System, which is a suite of instruments that includes a GPS Advanced Upper-air Sounding System (GAUS). It was located in Alabama's Talladega Forest (Fig. 2), where it collected a total of 105 quality controlled soundings, all of which are contained in the final SOAS radiosonde data set. 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 set.

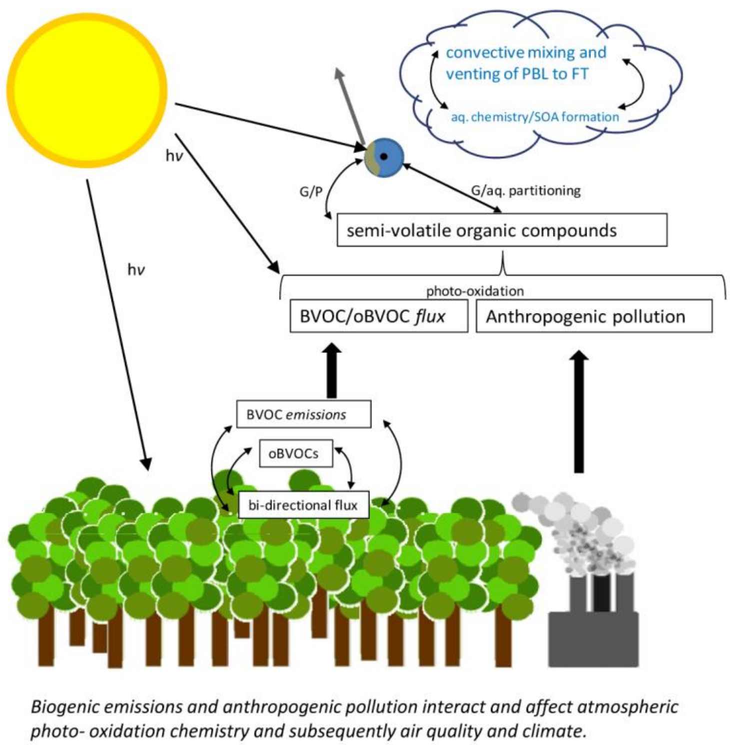

Figure 1 Depicts the biosphere-atmosphere interactions of interest for the SOAS field campaign (adopted from Rutgers SOAS project page: http://soas2013.rutgers.edu/)

Figure 2 Map of ISS site located in the Talladega Forest near Brent, Alabama.

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), “PreCorr” and “SRcorr” denote pressure ground-check and temperature solar radiation corrections (see Section III), respectively, 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:                     DC3 ops MGAUS/NCAR GAUS
Launch Site:                               dc3
Launch Location (lon,lat,alt):             104 41.37'W -104.689577, 40 23.15'N 40.385752,  1422.64
UTC Launch Time (y,m,d,h,m,s):             2012, 06, 05, 21:58:54
Sonde Id/Sonde Type:                       001831258/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:         Vaisala WXT510/21:58:54.00
System Operator/Comments:                  tim/none, none
Post Processing Comments:                  Aspen Version 3.1; Created on 19 Dec 2012 21:07 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 (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 systematic biases in the radiosonde data (Figure 3).

3. All of the data files were adjusted to correct initial geopotential surface heights. A GPS sensor was used to measure the surface height of the site. This height was then converted to geopotential height, by taking into account the both the geoid altitude and 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 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.

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 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. Three 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 if the sonde signal was not reacquired, anything measured by the radiosonde during the ascent, and 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	Pressure at Time of Lock-up
D20130608_150029	Signal lost at 123.50 mb
D20130609_210326	Signal lost at 124.34 mb

D20130715_132131*	*Rushed launch. Contains data from 937.69-206.62 mb

2. Two files, D20130624_150557 and D20130715_132131 experienced brief data loss near the surface as a result of the launch taking place before all steps of the sounding computer software had been completed. As a result, the time indicated in the filename is the time at which the first sonde data point was collected and not the time of the actual launch. Surface met data, from the time that the first sonde data point was collected and entered into the sounding data file. **The pressure correction could not applied to these data files because the correction requires pressure data collected by the radiosonde on the ground, prior to launch, to be used as a baseline.**

3. Three soundings were found to have large differences (>10%) between RH measured by the independent surface met sensor and the sonde prior to launch. These data files were all corrected.

Filename	Correction
D20130607_210053	Radiosonde RH measurements drifted away from surface met values as the sonde sat on an aspirator, prior to launch (reason unknown). The first six RH measurements, after launch, were set to missing.
D20130629_150324	The pre-launch radiosonde data was very noisy. The first six RH measurements, after launch, were set to missing.
D20130702_145219	Surface met data found to be incorrect and was replaced with surface data recorded by the radiosonde.

4. Three soundings contain no GPS information (D20130607_150424 and D20120607_210053), and one file lost the GPS signal prematurely at 748 mb (D20130711_230159)

5. Seven soundings, listed in the table below, were found to have problematic RH profiles. Two data files contained an offset of the two hygrometers (Figure 4). For one of these, based upon evaluation of data collected during the heating cycle we were able to determine that data from RH1 was incorrect. It was removed and replaced with missing values. The other sounding file appears to have had problems with both hygrometers, therefore all RH were replaced with missing values. The remaining soundings had RH profiles that contained artificial "dry spikes" which can be attributed to one of three causes; 1) Icing on the balloon that slowed its ascent, 2)Under-filling of the balloon resulting in a slow ascent rate (typically below 3 m/s), 3) Extreme cold and moist environment. In these cases the RH sensors have not reached equilibrium with the environment (after heating) when they cycle back on, resulting in artificial dry spikes. Additional smoothing has been applied to these RH profiles, however some evidence of the spikes may still exist and we strongly urge researchers to take caution when using these RH data.

Filename	**RH Sensor Problem**	**Correction**
D20130627_210745	Offset in hygrometer measurements	RH1 measurements set to missing
D20130629_230259	Slow ascent in high humidity	Additional smoothing applied
D20130704_210726	Slow ascent in high humidity	Additional smoothing applied
D20130705_150054	Slow ascent in high humidity	Additional smoothing applied
D20130705_210201	Slow ascent in high humidity	Additional smoothing applied
D20130706_145805	Both hygrometers report suspicious RH	All RH data set to missing

D20130706_205830	Slow ascent in high humidity	Additional smoothing applied
D20130711_230318	Slow ascent in high humidity	Additional smoothing applied

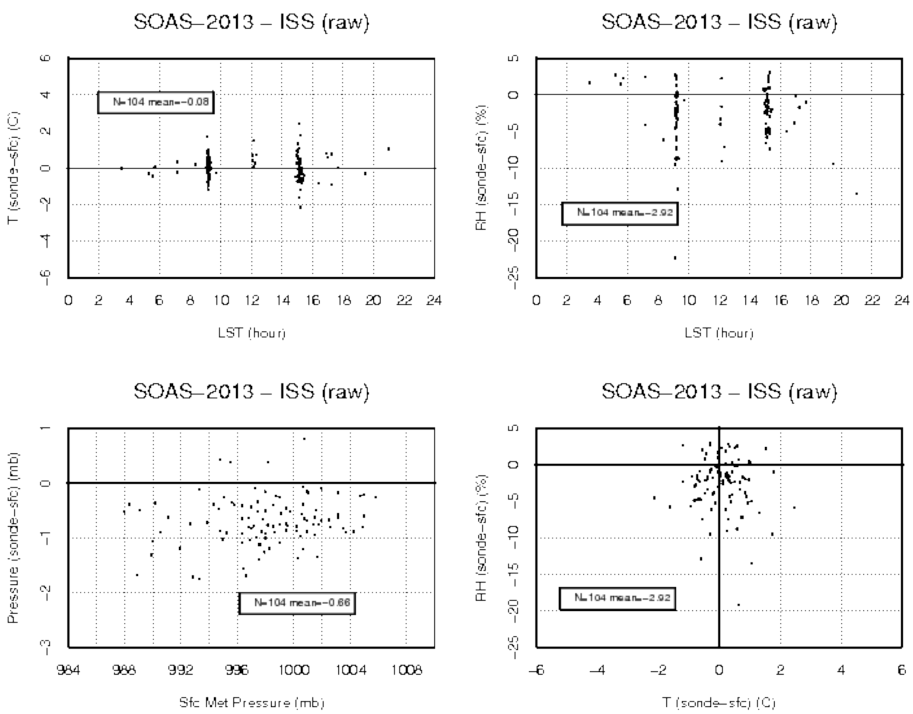

Figure 3 Plots above show measurement differences between prelaunch surface radiosonde and an independent surface met station. The upper left-hand shows differences in temperature, upper right shows larger than expected RH differences, with radiosondes measuring drier, and lower left shows systematic pressure offsets in the of ~.5 mb (before correction), and lower right shows no correlation between Tdiff and RHdiff.

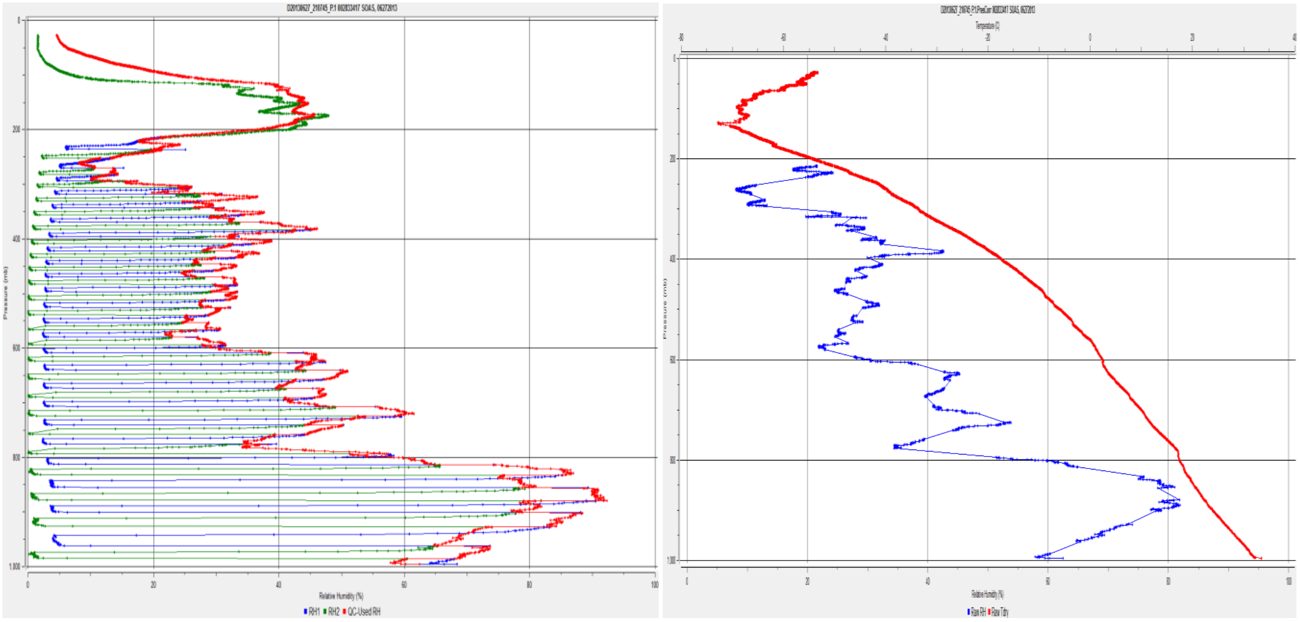

Figure 4 Left profile shows “RH offsets” caused by incorrect measurements of RH from one of the sondes two hygrometers; RH1 (blue), RH2 (green), and red is combined RH profile from sensors 1 and 2. Right-hand profile shows RH (blue) and Temperature (red) after RH1 data was set to missing and QC was applied.