IDEAL

Instabilities, Dynamics, and Energetics accompanying Atmospheric Layering
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October 23 - November 15, 2017 Dugway Proving Grounds, Utah

NCAR/EOL Integrated Sounding System
915 MHz Radar Wind Profiler Data Report

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(Photo courtesy of Dugway Proving Grounds)

This document describes Quality Controlled (QC'ed) data from a 915 MHz wind profiler at the IDEAL [1] field project at Dugway Proving Grounds, Utah, Oct 23 - Nov 15, 2017. In the event that information from this document are used for publication or presentation purposes, please provide appropriate acknowledgement to NSF[1] and NCAR/EOL and make reference to *Brown, W.O.J. (2018): IDEAL 2018 NCAR/EOL ISS 915 MHz Radar Wind Profiler Data Quality Report.*

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[1] *The National Center for Atmospheric Research and the Earth Observing Lab are managed by the University Corporation for Atmospheric Research and are sponsored by the National Science Foundation.*

CITATIONS:

If data from this wind profiler is used for research resulting in publication, please acknowledge EOL and NSF and include the following citation in your paper as appropriate:

- UCAR/NCAR Earth Observing Laboratory. NCAR/EOL ISS QC 915 MHz Profiler 30 Minute Consensus Winds and Moments, Version 1.0. *http://dx.doi.org/10.5065/D67D2SZ2*

IDEAL EOL Webpage: https://www.eol.ucar.edu/field_projects/ideal
IDEAL Data Archive: http://data.eol.ucar.edu/project/IDEAL

INTRODUCTION:

NCAR/EOL operated a radar wind profiler for the IDEAL (Instabilities, Dynamics, and Energetics accompanying Atmospheric Layering) [1] field campaign, Oct 23 - Nov 15, 2017. The site was approx 120 km southwest of Salt Lake City UT on the U.S. Army's Dugway Proving Grounds. The area is a wide arid sage brush covered plane, with the nearest terrain being Granite Peak 10 km to the west. The profiler was deployed with an Integrated Sounding System (ISS) [2] [Parsons et.al., 1994]. The ISS also included two Lufft Smart Weather Sensors (measuring winds, precip, temperature, relative humidity and pressure at the 2 m and 10 m levels), a PTB210 digital barometer, and a Vaisala MW41 sounding systems from which 93 RS41 radiosondes were launched.

The profiler is a Vaisala LAP3000 915 MHz DBS (Doppler Beam Swinging) radar wind profiler using LapXM hardware and software. This class of wind profiler was originally developed at the NOAA Aeronomy Lab (Ecklund et al, 1990) and has undergone a series of improvements as they were developed into the commercial product (the LAP3000), initially by Radian Inc, then by Vaisala (and now Scintec) [3].

Instrument	Vaisala LAP3000	915 MHz radar wind profiler
Location	Dugway Proving Ground	40° 7'16"N, 113° 7'43"W, alt: 1317m
Antenna	64 element phased array	X-plane 263°, elevation 69°
Data Collection Software	LapXM (version 2.6.1)	Produces raw files in various formats
Data Processing Software	NIMA (EOL version r7727)	Produces corrected wind and moment data files

The profiler used the standard DBS (Doppler Beam Swinging) technique to measure winds. Raw Doppler spectra data were recorded every 30 seconds in SPC files as the radar antenna was steered along five beam directions. Winds were calculated from spectral moments averaged over 30 minutes. The raw spectra and moments were saved so it is possible to reprocess the data for shorter (or longer) averaging periods, however wind estimates at periods shorter than ten minutes may have significant errors due to inhomogeneities in the wind and the widely separated sampling volumes in the oblique beams.

The radar is controlled and raw data is recorded using Vaisala software known Lap-XM. This produces a range of files including raw spectral files in a binary format, as well as processed data such as wind profiles and Doppler moments in netcdf and ascii formats. For IDEAL the profiler was operated in low height range mode only, sampling from around the 200 meter level up to 4.5 km in approx 60 m steps, although due to the dry stable conditions winds were more typically only measured up to around the 2km level.

PROCESSING:

The IDEAL profiler used Vaisala LapXM data systems with LapXM software version 2.6.1. This software applies a number of algorithms to process the data including wavelet and Gabor filtering of the raw IQ time series data. Spectral moments are estimated with a multiple peak picking algorithm and used to determine consensus averaged winds, which are filtered using the Weber Wuertz algorithm [3][Bianco et. al. 2013]. These wind estimates made up the preliminary data release.

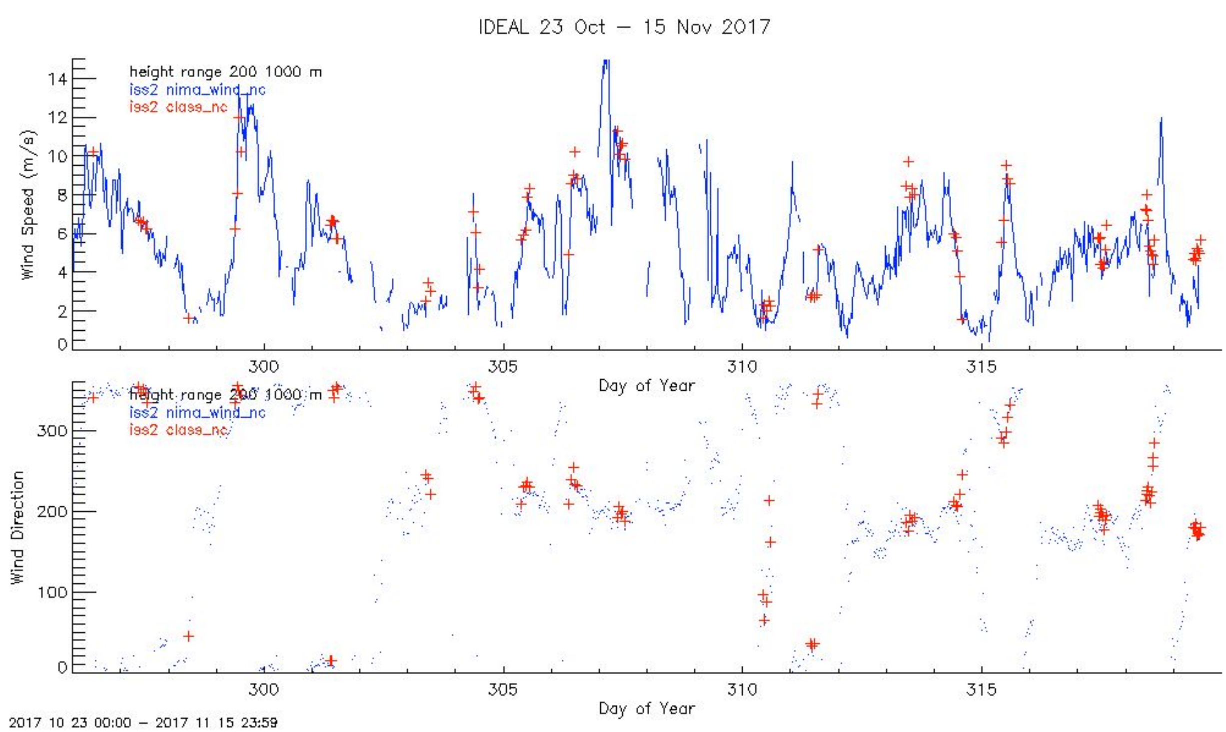

Figure 1: Time series of wind speed and direction averaged over the 0.2 - 1 km range. The red crosses show the corresponding radiosonde sounding measurements.

The LapXM spectral data was reprocessed using the NCAR/RAL NIMA (NCAR Improved Moments Algorithm) [4] which uses image processing and fuzzy logic techniques to analyze the spectral data and separate atmospheric echoes from unwanted signals such as radio interference and clutter. NIMA enables recovery of winds in weak or noisy data, for example typically extending the range 100 to 300 meters. In the case of the IDEAL campaign, NIMA provided a wind estimate almost 90% of the time, whereas the LapXM processing provided an estimate 72% of the time. NIMA also unwraps Doppler velocities that exceed Nyquist aliasing limits, for example during hail or very high winds. The version of NIMA used is EOL version r7727, which is based on RAL version 2.8.

Figure 1 shows time series of averaged winds from NIMA processing for the entire operations period for the lowest one kilometer, with sounding winds overlaid. Winds were generally light, (being under 10 m/s 90% of the time and the max being 15 m/s) and mainly either northerly or southerly.

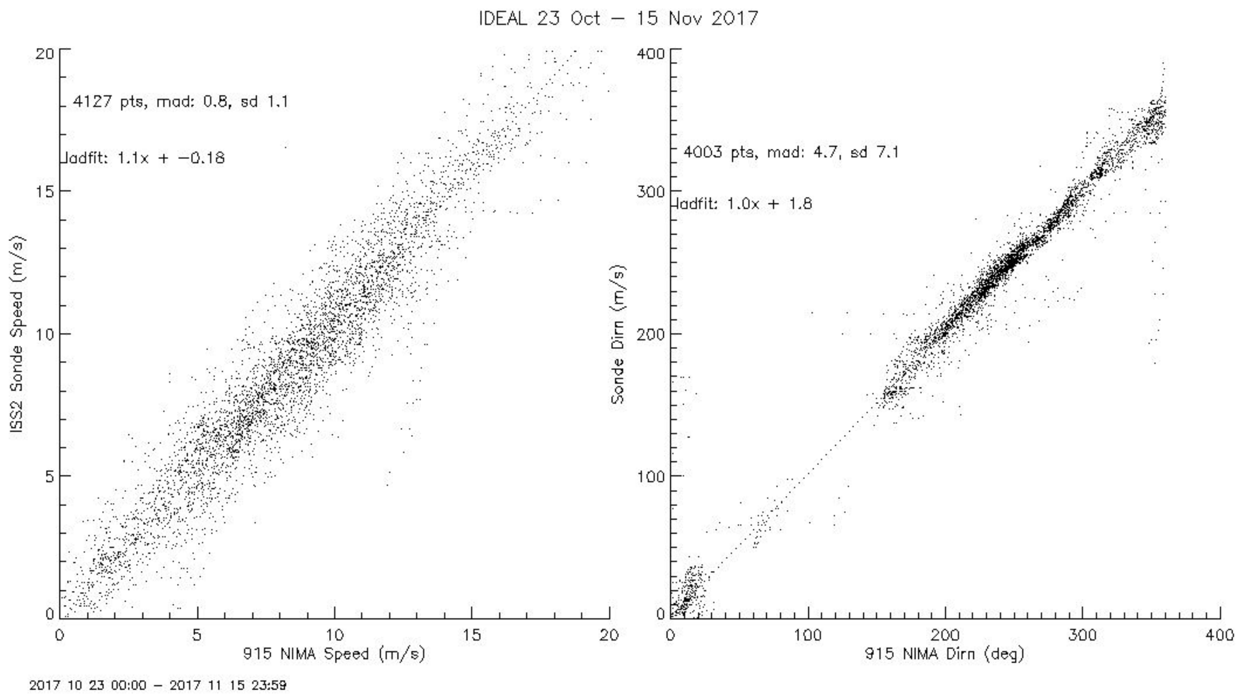

Figure 2: Scatter plot of wind speed and direction from the wind profiler vs radiosonde soundings over all height ranges. The best fit slopes were 1.07 for speed and 1.0 for direction, with almost no offset for speed and just a 2 degree offset for direction. Overall the median absolute deviation and standard deviation of wind speeds was 0.8 m/s and 1.1 m/s respectively; 4.7 degrees and 7.1 degrees for wind directions.

93 radiosonde soundings were launched during the campaign, primarily during the night and early morning hours. Figure 2 plots wind measurements from these soundings verses winds derived from the NIMA processing of the profiler data. The NIMA winds agreed very well (to within about 1 m/s in speed and less than 10 degrees in direction). There is little variation in agreement with altitude or time. The agreement for the LapXM processed winds was a little

degraded with standard deviations of 1.9 m/s and 11 degrees for speed and direction respectively.

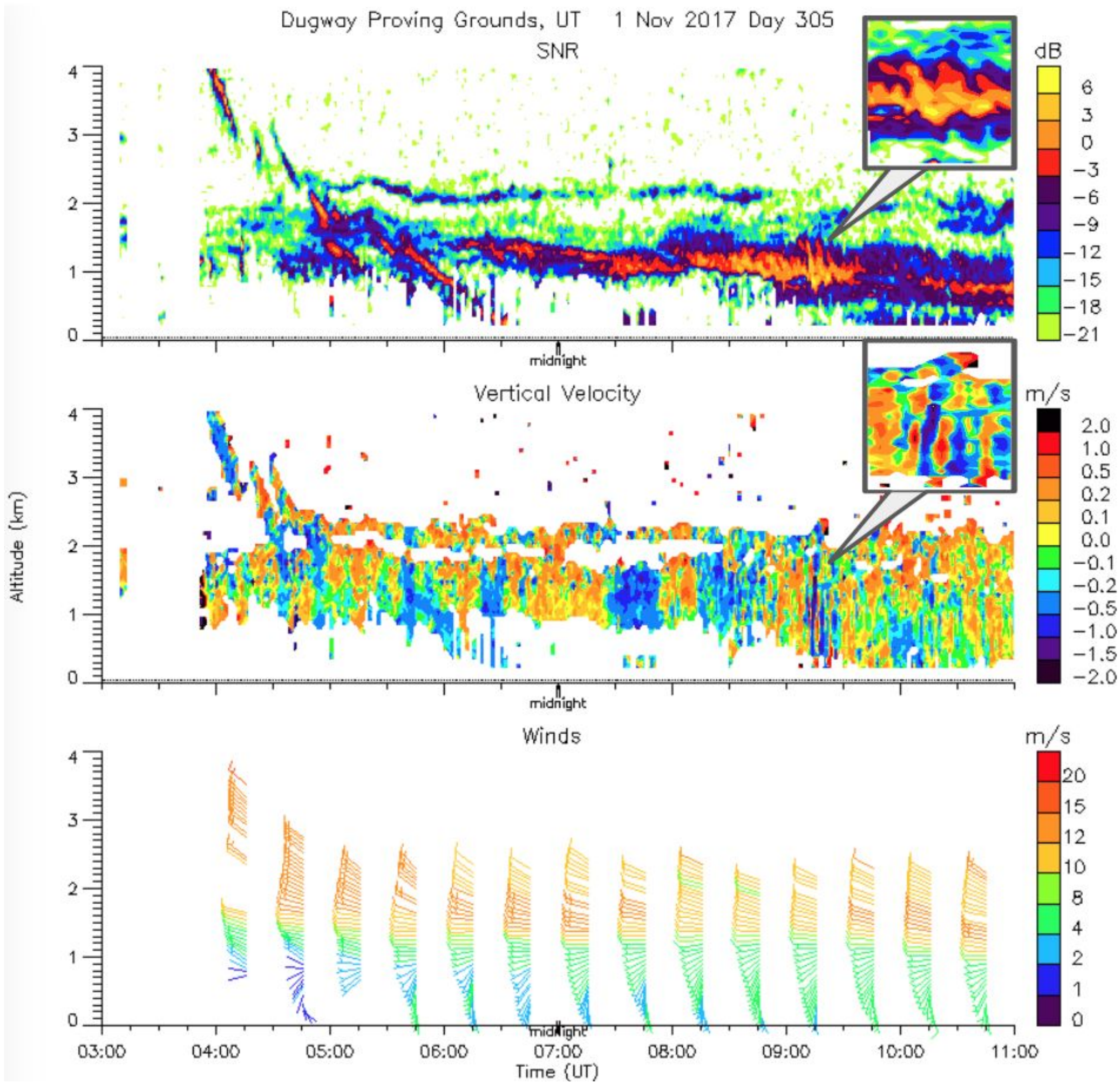

Figure 3. An example of measurements made on November 1, 2017. The time-height plots show Signal to Noise Ratio (SNR) in the top panel which is an indicator of reflected signal strength, vertical velocity in the middle panel (blues are downward and reds upward motion), and wind barbs in the bottom panel. The insets show an enlargements of a 20 minute period from approximately 0905 to 0925.

DATA EXAMPLE:

An example of measurements during the night of November 1 are shown in figure 3. Signal to Noise Ratio, vertical velocity and winds are shown for an 8 hour period from 3 UTC. Prior to 4

UTC, the atmosphere was very dry and cool and very little signal is detected. From 4UTC, a reflectivity layer can be seen descending into view, presumably indicating moisture descending into the area, producing stronger signals on the profiler. Another interesting feature occurs around 9 UTC where strations in the signal can be seen (see insets of figure 3), along with rapidly alternating up and down drafts. A wind shear can be seen in the wind barbs indicating that this feature may be due to Kelvin-Helmholtz rolls.

DATA FILES:

The accompanying data files are in netCDF format [5]. There are two types of data file, wind measurements (files with extension *.winds_LO*.nc) and spectral moments data (extension *.mom.nc). The moments data are the zeroth, first, and second moments of signals from each 30 second dwell of the steered beam. These moments are the signal strength (here SNR or Signal to Noise Ratio which can be used to estimate reflectivity), Doppler shift (from which the winds are derived), and spectral width (can be used to estimate turbulence with lots of caveats). We generally recommend that only experienced profiler users analyze the moment data.

The data is arranged in time, height coordinates. For winds (in the *.winds_LO.nc files) use variables wspd and wdir (wdir follows the meteorological convention, ie: the direction the wind comes from, measured clockwise in degrees from north). There is a confidence variable (eg, wind_conf), which describes the degree of confidence (0-1) that the NIMA algorithm places in the derived data. These variables have the same dimension as the wind data. The moments files have similar confidence variables. Use only those data points for which corresponding confidence level exceeds the threshold confidence level. Usually we use a threshold confidence level of 0.5.

Other data files for the profiler are available on request. These include the raw SPC spectral files, LapXM moments (netCDF), LapXM winds in POP (ascii) and netCDF formants, boundary layer depth estimates, and NIMA reprocessed spectral files (netCDF format). A range of plots are also available in addition to the plots on the project web page [1].

References:

[1] IDEAL Campaign:

Webpage: https://www.eol.ucar.edu/field_projects/ideal
Data archive: http://data.eol.ucar.edu/project/IDEAL
Wind Profiler data DOI: *http://dx.doi.org/?????*

[2] ISS Integrated Sounding System

Website:https://www.eol.ucar.edu/observing_facilities/iss
DOI: http://dx.doi.org/10.5065/D6348HF9

Reference: Parsons, D., W. Dabberdt, H. Cole, T. Hock, C. Martin, A-L. Barrett, E. Miller, M. Spowart, M. Howard, W. Ecklund, D. Carter, K. Gage and J. Wilson, 1994: "The Integrated Sounding System: Description and preliminary observations from TOGA COARE". *Bull. Amer. Meteor. Soc.,* 75, 553–567,
doi:10.1175/1520-0477(1994)075.

[3] Profiler: LAP3000 915 MHz Radar Wind Profiler:

Original reference: Ecklund, W. L., Carter, D. A., Balsley, B. B., Currier, P. E., Green, J. L., Weber, B. L., and Gage, K. S., 1990: "Field tests of a lower tropospheric wind profiler", *Radio Sci.*, 25, 899–906. doi: 10.1029/RS025i005p00899

LapXM processing reference: Bianco, L., D. Gottas, and J.M. Wilczak, 2013: Implementation of a Gabor Transform Data Quality-Control Algorithm for UHF Wind Profiling Radars. *J. Atmos. Oceanic Technol.,* **30**, 2697–2703, doi:10.1175/JTECH-D-13-00089.1

Current manufacturer web site:
http://www.scintec.com/english/Web/scintec/Products/LAP%20Radars.aspx

[4] NIMA (NCAR Improved Moment Algorithm):

Website: http://www.ral.ucar.edu/technology/profiler/

Cornman, L. B., R. K. Goodrich, C. S. Morse, and W. L. Ecklund, 1998: A fuzzy logic method for improved moment estimation from Doppler spectra. J. Atmos. Oceanic Technol., 15, 1287–1305. DOI:10.1175/1520-0426(1998)015<1287:AFLMFI>2.0.CO;2

Goodrich, R. K., C. S. Morse, L. B. Cornman, and S. A. Cohn, 2002: A horizontal wind and wind confidence algorithm for Doppler wind profilers. J. Atmos. Oceanic Technol., 19, 257–273. DOI: 10.1175/1520-0426-19.3.257

Morse, C. S., R. K. Goodrick, and L. B. Cornman, 2002: The NIMA method for improved moment estimation from Doppler spectra, J. Atmos. Ocean. Technol., 19, 274-295. DOI: 10.1175/1520-0426-19.3.274

Software: NIMA 2.8 EOL version r7727 subversion repository available at:
http://svn.eol.ucar.edu/svn/iss/nima/branches/nima2

[5] NetCDF:

UCAR/Unidata netcdf web site: http://www.unidata.ucar.edu/content/software/netcdf/