U.S. DEPARTMENT OF ENERGY | Office of Science

DOE/SC-ARM/TR-149

Doppler Lidar Vertical Velocity Statistics Value-Added Product

RK Newsom
C Sivaraman
TR Shippert
LD Riihimaki

July 2015

ARM
CLIMATE RESEARCH FACILITY

DISCLAIMER

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Version 1.0

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Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research

Acronyms

ACF	autocovariance function
AGL	above-ground level
ARM	Atmospheric Radiation Measurement
CBH	cloud-base height
DLWSTATS	Doppler Lidar Vertical Velocity Statistics
NAN	not-a-number
PNNL	Pacific Northwest National Laboratory
SGP	Southern Great Plains
SGPDL	Southern Great Plains Doppler Lidar
SNR	signal-to-noise ratio
VAP	value-added product

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1.0 Introduction

Accurate height-resolved measurements of higher-order statistical moments of vertical velocity fluctuations are crucial for improved understanding of turbulent mixing and diffusion, convective initiation, and cloud life cycles. The Atmospheric Radiation Measurement (ARM) Climate Research Facility operates coherent Doppler lidar systems at several sites around the globe. These instruments provide measurements of clear-air vertical velocity profiles in the lower troposphere with a nominal temporal resolution of 1 sec and height resolution of 30 m. The purpose of the Doppler lidar vertical velocity statistics (DLWSTATS) value-added product (VAP) is to produce height- and time-resolved estimates of vertical velocity variance, skewness, and kurtosis from these raw measurements. The VAP also produces estimates of cloud properties, including cloud-base height (CBH), cloud frequency, cloud-base vertical velocity, and cloud-base updraft fraction.

2.0 Input Data

The DLWSTATS VAP reads in data from the following datastreams:

- <site>dlfpt<facility>.b1
- <site>ceil<facility>.b1
- <site>dlprofwind4news<facility>.c1
- <site>30ecor<facility>.b1
- <site>met<facility>.b1

Specific variables that are used from each of these datastreams are listed in Table 1 through Table 4.

Table 1. Variables and Global Attributes from the <*site*>dlfpt<*facility*>.b1 Datastream Used by the DLWSTATS VAP

Variable Name	Description	Units
base_time	Seconds since 1970-1-1 0:00:00 0:00	sec
time_offset	Time offset from base_time	sec
Range	Distance from Lidar to center of range gate	m
Elevation	Beam elevation	deg
radial_velocity	Radial velocity	ms-1
Intensity	Intensity (SNR + 1)	N/A
Alt	Altitude above mean sea level	m
dlat (global attribute)	Lidar latitude in double precision	deg
dlon (global attribute)	Lidar longitude in double precision	deg

We note that the beam elevation angle is read in from the <*site*>dlfpt<*facility*>.b1 datastream to check that the beam is, in fact, vertical; i.e., elevation = 90°. In general, the <*site*>dlfpt<*facility*>.b1 datastream may contain both vertical or slant-path staring data from the Doppler lidar. Although the vast majority of the time the <*site*>dlfpt<*facility*>.b1 datastream contains vertically pointing data, it is good practice to verify that the elevation angle is within 0.2° of 90°.

Table 2. Variables and Global Attributes from the <*site*>vceil25k<*facility*>.b1 Datastream Used by the DLWSTATS VAP.

Variable Name	Description	Units
base_time	Seconds since 1970-1-1 0:00:00 0:00	Sec
time_offset	Time offset from base_time	Sec
first_cbh	Lowest CBH detected	m
lat	Ceilometer latitude	deg
lon	Ceilometer longitude	deg
alt	Ceilometer altitude	M

Table 3. Variables and Global Attributes from the <*site*>30ecor<*facility*>.b1 Datastream Used by the DLWSTATS VAP.

Variable Name	Description	Units
base_time	Seconds since 1970-1-1 0:00:00 0:00	sec
time_offset	Time offset from base_time	sec
mean_t	30-min averaged temperature	K
mean_q	30-min averaged water-vapor density	mmol m^{-3}
var_rot_u	Variance of easting velocity component	m^2s^{-2}
var_rot_v	Variance of northing velocity component	m^2s^{-2}
var_rot_w	Vertical velocity variance	m^2s^{-2}
ustar	Friction velocity	ms^{-1}
skew_w	Vertical velocity skewness	unitless
kurt_w	Vertical velocity kurtosis	unitless
cvar_rot_wt	Covariance of vertical velocity and temperature	K ms^{-1}
cvar_rot_wq	Covariance of vertical velocity and water-vapor density	mmol m^{-2} s^{-1}
lat	ECOR latitude	deg
lon	ECOR longitude	deg
alt	ECOR altitude	m

Table 4. Variables and Global Attributes from the <*site*>met<*facility*>.b1 Datastream Used by the DLWSTATS VAP.

Variable Name	Description	Units
base_time	Seconds since 1970-1-1 0:00:00 0:00	sec
time_offset	Time offset from base_time	sec
pwd_precip_rate_mean_1min	1-min mean precipitation rate	mm hr-1
Lat	MET latitude	deg
Lon	MET longitude	deg
Alt	MET altitude	m

3.0 Algorithm and Methodology

The DLWSTATS VAP reads in vertical staring data from the <*site*>dlfpt<*facility*>.b1 datastream and computes vertical velocity and cloud statistics using 30-min averaging periods. The VAP produces a single netCDF file per day. The number of profiles in a given file is typically 96, corresponding to a sampling interval of 15 min. The resulting profiles are therefore oversampled, since the VAP uses a 30-min averaging period. No averaging is performed in the height dimension; thus the height resolution of the VAP is equal to that of the radial velocity data in the <*site*>dlfpt<*facility*>.b1 datastream, which is typically 30 min.

The ARM Doppler lidars operate in the near infrared region and are thus sensitive to scattering from aerosol and insensitive to molecular scattering. As a result, reliable clear-air radial velocity measurements are usually constrained to the lower troposphere, where aerosol concentrations are typically much higher. The DLWSTATS VAP is therefore configured to process clear-air vertical velocity statistics up to a maximum height of 4 km. By contrast, strong scattering from cloud bases enables reliable estimates of cloud-base vertical velocities up to the maximum sensing height of 10 km.

3.1 Doppler Lidar Vertical Velocity Statistics

Noise fluctuations in the radial velocity measurements can have a large impact on higher-order statistical moments, particularly even moments. The noise generally increases with decreasing signal-to-noise ratio (SNR) up to the limit imposed by the receiver bandwidth. Figure 1 shows estimates of the radial velocity noise (i.e., radial velocity precision) as a function of SNR for the Southern Great Plains Doppler lidar (SGPDL). This example was computed from vertical staring data collected on 10 August 2013.

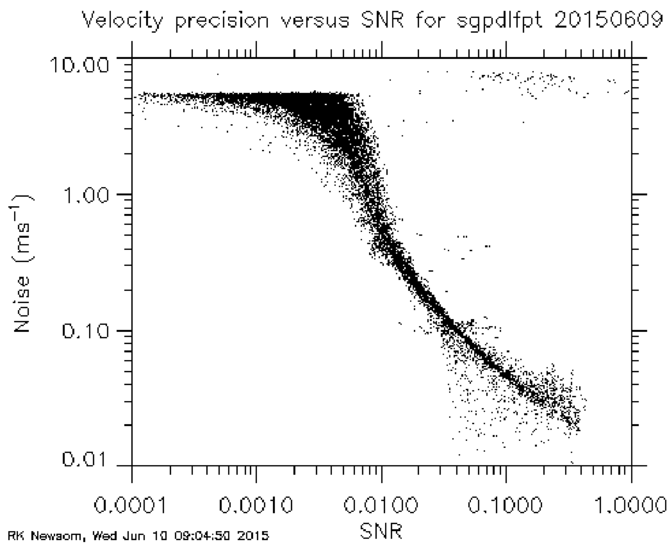

Figure 1. Radial Velocity Noise Standard Deviation (i.e., precision) Estimates versus SNR for the SGPDL from Time Series Analysis of Vertical Staring Data on 9 June 2015

To help mitigate the effects of noise in the measurements, the DLWSTATS VAP computes height- and time-resolved estimates of clear-air vertical velocity variance using the noise-correction technique described by Lenschow et al. (2000) and Pearson et al. (2009). For a given range gate, a 30-min time series of radial velocity is extracted from the <*site*>dlfpt<*facility*>.b1 datastream. The atmospheric and noise contributions to the total signal variance are estimated from the autocovariance function (ACF) of the time series. The i^{th} lag of the ACF is given by

$$ACF_i = \frac{1}{N-i}\sum_{j=0}^{N-1-i} u_{rj} u_{ri+j} \quad , \tag{1}$$

where u_{rj} is the radial velocity, and N is the number of samples in the time series. The ACF is useful for distinguishing between the noise and atmospheric contributions because random, uncorrelated noise in the signal manifests itself as a delta function spike in the zeroth lag of the ACF.

Computation of the ACF requires that the data be evenly sampled in time. In general, gaps exist in the vertical staring data record because the lidar periodically performs other scans. Thus, the first step in this process involves filling these gaps with uniformly spaced not-a-number (NAN) samples.

Once the gaps have been filled, the first six lags of the ACF are computed. The variance due to atmospheric motion is estimated by extrapolating the ACF in lags one through five to the zeroth lag, as illustrated in Figure 2. This extrapolation is accomplished by fitting a straight line to the ACF in lags one through five. The noise contribution to the total signal variance is then obtained by simply taking the difference between the zeroth lag and the extrapolated atmospheric variance. The DLWSTATS VAP saves these noise estimates, and the corresponding median SNR values (for the same 30-min time series) to the final netCDF output file. This information is used in post processing to help characterize the radial velocity measurement precision for other VAPs (e.g., the Doppler lidar wind (DLWIND) VAP).

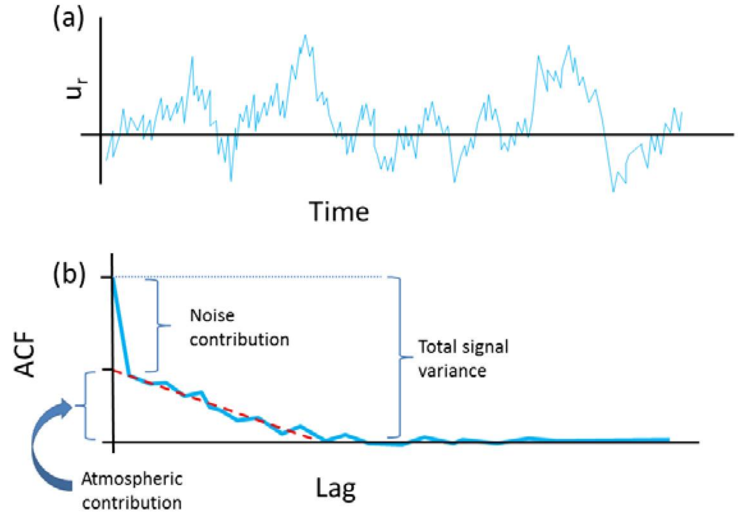

Figure 2. Illustration of the Process for Estimating the Atmospheric and Noise Contributions to the Total Signal Variance. Panel (a) shows the raw time series, and panel (b) shows the corresponding ACF.

Figure 3 displays examples of the total variance, noise, and atmospheric (noise-corrected) variance during a three-day period at the Southern Great Plains (SGP) site. The effect of the noise correction becomes clear by comparing Figures 3a and 3c. Also, a good rule of thumb is to reject variance estimates in which the noise exceeds 1 m^2s^{-2}. Thus, the atmospheric variance field shown in Figure 4c has been filtered using a maximum noise threshold of 1 m^2s^{-2}.

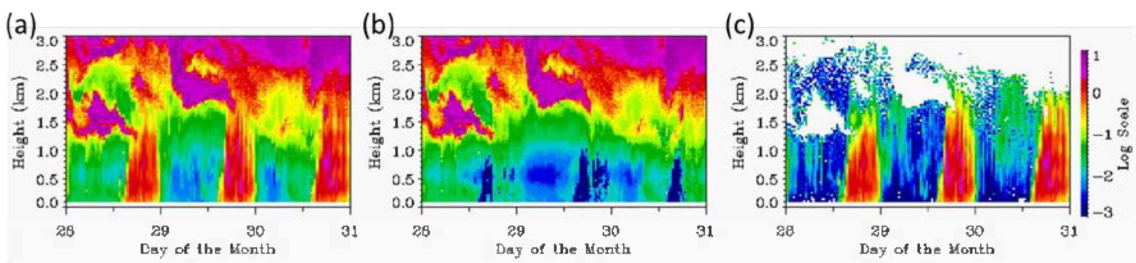

Figure 3. Time-Height Displays Showing the (a) Total Signal Variance, (b) Noise Variance, and (c) Atmospheric Variance at SGP over a Three-Day Period from 28 through 30 August, 2012. The atmospheric variance field (c) has been filtered to remove estimates where the noise variance exceeds 1 m^2s^{-2}.

Skewness and kurtosis estimates are computed from the same 30-min time series used in the variance calculation. However, the skewness and kurtosis fields are computed using a much simpler technique based on SNR thresholding. The skewness and kurtosis field are computed using only radial velocities that exceed a minimum SNR threshold (a typical SNR threshold is 0.008). The resulting fields therefore contain missing values in regions where the SNR is low.

3.2 Doppler Lidar Cloud Statistics

The DLWSTATS VAP computes the cloud frequency, cloud-base updraft fraction and the median values of cloud-base vertical velocities and heights over each 30-min averaging period. The cloud frequency is the fraction of time that a cloud is detected at any altitude, and the cloud-base updraft fraction is the fraction of time over which positive cloud-base vertical velocities are observed during a given averaging period.

The DLWSTATS VAP uses a matched filter technique to identify the location of cloud bases. The filter is a narrow Gaussian-like function that is designed to mimic the shape of the lidar return due to scattering from typical cloud bases. This filter function is convolved with each SNR profile in a given 30-min averaging interval. The height corresponding to the maximum value of the convolution for which the convolution exceeds a prescribed threshold value is taken to be a CBH. The radial velocity at the CBH is taken to be the cloud-base vertical velocity. The final reported CBH and vertical velocity estimates are given by the median values over the 30-min averaging period. The VAP also reports the 25th and 75th percentile values.

3.3 Additional Data Products

The DLWSTATS VAP also incorporates CBH data from the ceilometers, surface turbulence measurements from the eddy correlation system, and precipitation rate measurements from the surface met station. CBH data from the ceilometers are obtained from the <*site*>ceil<*facility*>.b1 datastream. As in the case of the Doppler lidar, the final reported CBH for the ceilometer is given by the median value during the 30-min averaging period, and the final reported cloud frequency is the fraction of profiles for which a cloud is detected at any height during the 30-min averaging period. In addition to the median values, the VAP also reports the 25th and 75th percentile values in the ceilometer CBHs.

Finally, turbulence and surface meteorological measurements are read in from the <*site*>30ecor<*facility*>.b1 and <*site*>met<*facility*>.b1 datastreams. The 30-min data from <*site*>30ecor<*facility*>.b1 are interpolated to the time grid of the DLWSTATS VAP. Measurements include the surface temperature; water-vapor density; vertical velocity variance- skewness and kurtosis; turbulent kinetic energy; and kinematic, sensible, and latent heat flux. The 1-min precipitation rate measurements from <*site*>met<*facility*>.b1 are averaged within each 30-min time interval of the DLWSTATS VAP. The mean, maximum, and minimum precipitation rate for each 30-min averaging period are written to the output file.

4.0 Output Data

This section gives a summary of the primary scientific output variables and other variables that are useful in assessing data quality. A full list of output variables is given in the sample netCDF header in Appendix A.

4.1 Primary Output Variables

The primary Doppler lidar-derived output variables are listed in Table 5.

Table 5. Primary Doppler lidar-Derived Variables in the DLWSTATS VAP.

Description	Variable name
Vertical velocity variance	w_variance
Vertical velocity skewness	w_skewness
Vertical velocity kurtosis	w_kurtosis
Median CBH	dl_cbh
Fraction of time that a cloud is detected during averaging period	dl_cloud_frequency
Median Doppler lidar cloud-base vertical velocity	cbw

4.2 Other Output Data

The VAP also includes several variables derived from non-Doppler lidar datastreams. These include the following:

- ceil_cbh (ceilometer CBH)
- ceil_cloud_frequency (fraction of time that a cloud is detected by the ceilometer during averaging period)
- ecor_temp (temperature from eddy correlation [ECOR] system)
- ecor_h2o (water-vapor density from ECOR system)
- ecor_tke (turbulence kinetic energy from ECOR system)
- ecor_ustar (friction velocity from ECOR system)
- ecor_w_var (w variance from ECOR system)
- ecor_w_skew (w skewness from ECOR system)
- ecor_w_kurt (w kurtosis from ECOR system)
- ecor_wt (wt covariance from ECOR system)
- ecor_wq (wq covariance from ECOR system)
- smet_spr_mean (mean surface precipitation rate from Surface Meteorological Instrumentation [MET])

This ancillary information can be used to assess the quality of the lidar-derived vertical velocity statistics. For example, precipitation may bias the vertical velocity statistics. For this reason, the VAP includes measurements of precipitation rate from surface met stations when available. Also, the surface measurements of vertical velocity variance, skewness and kurtosis from the ECOR provide a valuable sanity check on the lidar result, albeit at the surface only.

5.0 Summary

The DLWSTATS VAP provides height- and time- resolved measurements of vertical velocity variance, skewness, kurtosis, median CBH, median cloud-base vertical velocity, cloud-base updraft fraction and cloud fraction. These statistics are computed from 1-sec vertical staring data from the Doppler lidar. The temporal resolution of DLWSTATS VAP output is nominally 30 min and the temporal sampling interval is nominally 10 min. The height resolution of the output is equal to the height resolution of the raw Doppler lidar data, which is typically 30 m. The minimum height of the lidar-derived vertical velocity statistics is approximately 100 m, and the maximum height varies based on the atmospheric conditions. Typically, under clear-sky conditions and in a mid-latitude convective boundary layer, the maximum height will be roughly equal to the depth of the boundary layer (i.e., 1 to 3 km above-ground level [AGL]). On the other hand, cloud-base statistics may be computed as high as 10 km AGL.

The DLWSTATS VAP also includes several variables that are derived from non-Doppler lidar datastreams. These data are useful for assessing the quality of the lidar-derived vertical velocity statistics. For example, surface measurements of vertical velocity variance, skewness and kurtosis from the ECOR provide a valuable sanity check on the lidar results, and precipitation rate data from the surface meteorological station is useful for identifying periods when the lidar results may be biased by precipitation.

6.0 Example Plots

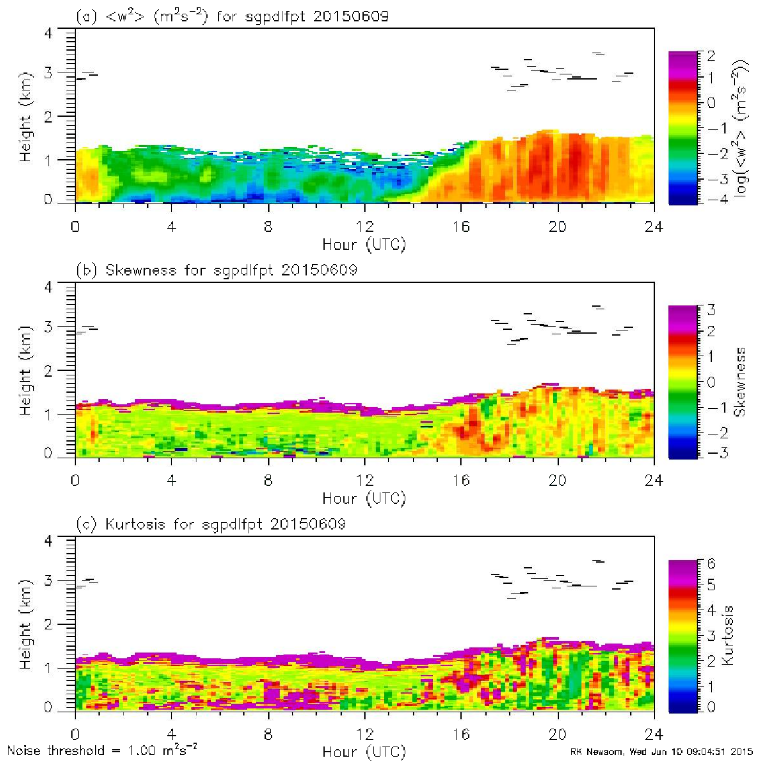

Figure 4. Height-Time Displays of Vertical Velocity Variance (a), Skewness (b) and Kurtosis (c) Computed from Doppler Lidar Data at the SGP Site for 9 June 2015. CBH estimates are also indicated by the black dashes.

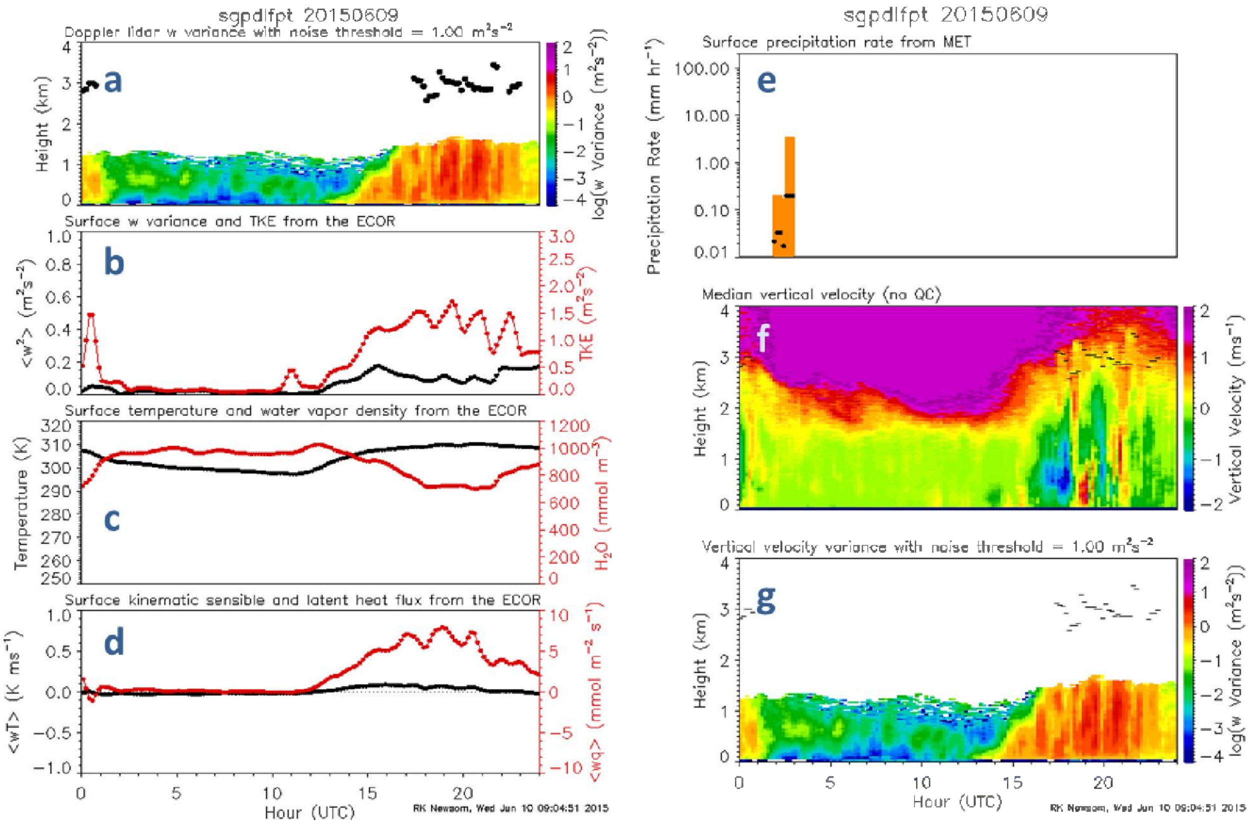

Figure 5. DLWSTATS Results for SGP on 9 June 2015 showing a) Doppler lidar-derived vertical velocity variance and CBH; b) ECOR vertical velocity variance (black) and turbulence kinetic energy (red); c) ECOR temperature (black) and water-vapor concentration (red); d) ECOR kinematic vertical heat flux (black) and vertical water-vapor flux; e) precipitation rate from the surface met station; f) Doppler lidar-derived mean vertical velocity with no quality control; g) same as panel a).

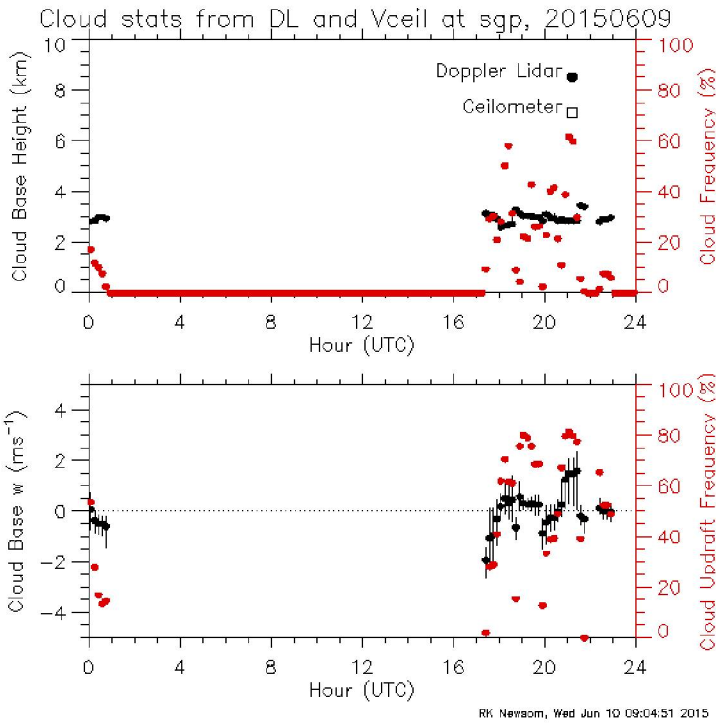

Figure 6. DLWSTATS Results for SGP on 9 June 2015. The top panel shows the Doppler lidar-derived and ceilometer CBHs (black) and cloud frequencies (red). The bottom panel shows the Doppler lidar-derived cloud-base vertical velocity (black) and updraft fraction (red).

7.0 References

Lenschow DH, V Wulfmeyer, C Senff. 2000. Measuring Second- through Fourth-Order Moments in Noisy Data. Journal of Atmospheric and Oceanic Technology, 17, 1330-1347.

Pearson G, F Davies, and C Collier. 2009. An Analysis of the Performance of the UFAM Pulsed Doppler Lidar for Observing the Boundary Layer. Journal of Atmospheric and Oceanic Technology, 26, 240-250.

Appendix A

Output Data

Appendix A: Output Data

```
netcdf sgpdlprofwstats4newsC1.c1.20150203.000500 {
dimensions:
    time = UNLIMITED ; // (144 currently)
    height = 133 ;
    bound = 2 ;
variables:
    int base_time ;
        base_time:string = "2015-02-03 00:00:00 0:00" ;
        base_time:long_name = "Base time in Epoch" ;
        base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
        base_time:ancillary_variables = "time_offset" ;
    double time_offset(time) ;
        time_offset:long_name = "Time offset from base_time" ;
        time_offset:units = "seconds since 2015-02-03 00:00:00 0:00" ;
        time_offset:ancillary_variables = "base_time" ;
    double time(time) ;
        time:long_name = "Time offset from midnight" ;
        time:units = "seconds since 2015-02-03 00:00:00 0:00" ;
        time:bounds = "time_bounds" ;
    double time_bounds(time, bound) ;
    float height(height) ;
        height:long_name = "Height above ground level to mid-point of range gate" ;
        height:units = "m" ;
    float snr(time, height) ;
        snr:long_name = "Median SNR" ;
        snr:units = "unitless" ;
        snr:missing_value = -9999.f ;
        snr:cell_methods = "time: median height: point" ;
    float snr_25(time, height) ;
        snr_25:long_name = "SNR 25th percentile" ;
        snr_25:units = "unitless" ;
        snr_25:missing_value = -9999.f ;
    float snr_75(time, height) ;
        snr_75:long_name = "SNR 75th percentile" ;
        snr_75:units = "unitless" ;
        snr_75:missing_value = -9999.f ;
    float w(time, height) ;
        w:long_name = "Median vertical velocity" ;
        w:units = "m/s" ;
        w:missing_value = -9999.f ;
        w:cell_methods = "time: median height: point" ;
    float w_25(time, height) ;
        w_25:long_name = "Vertical velocity 25th percentile" ;
        w_25:units = "m/s" ;
        w_25:missing_value = -9999.f ;
    float w_75(time, height) ;
        w_75:long_name = "Vertical velocity 75th percentile" ;
```

```
        w_75:units = "m/s" ;
        w_75:missing_value = -9999.f ;
    float noise(time, height) ;
        noise:long_name = "Variance of random noise in vertical velocity" ;
        noise:units = "m^2 s^-2" ;
        noise:missing_value = -9999.f ;
    float w_variance(time, height) ;
        w_variance:long_name = "Noise corrected vertical velocity variance" ;
        w_variance:units = "m^2 s^-2" ;
        w_variance:missing_value = -9999.f ;
    float w_skewness(time, height) ;
        w_skewness:long_name = "Vertical velocity skewness using SNR threshold" ;
        w_skewness:units = "unitless" ;
        w_skewness:missing_value = -9999.f ;
    float w_kurtosis(time, height) ;
        w_kurtosis:long_name = "Vertical velocity kurtosis using SNR threshold" ;
        w_kurtosis:units = "unitless" ;
        w_kurtosis:missing_value = -9999.f ;
    float dl_cbh(time) ;
        dl_cbh:long_name = "Median Doppler lidar cloud base height" ;
        dl_cbh:units = "m" ;
        dl_cbh:missing_value = -9999.f ;
        dl_cbh:cell_methods = "time: median" ;
    float dl_cbh_25(time) ;
        dl_cbh_25:long_name = "Doppler lidar cloud base height 25th percentile" ;
        dl_cbh_25:units = "m" ;
        dl_cbh_25:missing_value = -9999.f ;
    float dl_cbh_75(time) ;
        dl_cbh_75:long_name = "Doppler lidar cloud base height 75th percentile" ;
        dl_cbh_75:units = "m" ;
        dl_cbh_75:missing_value = -9999.f ;
    float dl_cbh_zmax ;
        dl_cbh_zmax:long_name = "Maximum detection height for dl_cbh" ;
        dl_cbh_zmax:units = "m" ;
        dl_cbh_zmax:missing_value = -9999.f ;
    float dl_cloud_frequency(time) ;
        dl_cloud_frequency:long_name = "Fraction of time that a cloud is detected during averaging
period from DL" ;
        dl_cloud_frequency:units = "unitless" ;
        dl_cloud_frequency:missing_value = -9999.f ;
    float cbw(time) ;
        cbw:long_name = "Median Doppler lidar cloud base vertical velocity" ;
        cbw:units = "m/s" ;
        cbw:missing_value = -9999.f ;
        cbw:cell_methods = "time: median" ;
    float cbw_25(time) ;
        cbw_25:long_name = "Doppler lidar cloud base vertical velocity 25th percentile" ;
        cbw_25:units = "m/s" ;
        cbw_25:missing_value = -9999.f ;
    float cbw_75(time) ;
        cbw_75:long_name = "Doppler lidar cloud base vertical velocity 75th percentile" ;
```

```
        cbw_75:units = "m/s" ;
        cbw_75:missing_value = -9999.f ;
    float cbw_up_fraction(time) ;
        cbw_up_fraction:long_name = "Doppler lidar cloud base vertical velocity updraft fraction" ;
        cbw_up_fraction:units = "m" ;
        cbw_up_fraction:missing_value = -9999.f ;
    int nshots ;
        nshots:long_name = "Number of laser shots averaged per beam for the Doppler lidar" ;
        nshots:units = "unitless" ;
        nshots:missing_value = -9999 ;
    int ngate_samples ;
        ngate_samples:long_name = "Number of raw digitizer samples per range gate for the Doppler
lidar" ;
        ngate_samples:units = "unitless" ;
        ngate_samples:missing_value = -9999 ;
    float averaging_time ;
        averaging_time:long_name = "Averaging time interval" ;
        averaging_time:units = "second" ;
        averaging_time:missing_value = -9999.f ;
    float snr_threshold ;
        snr_threshold:long_name = "Minimum SNR used in skewness and kurtosis calculation for the
Doppler lidar" ;
        snr_threshold:units = "unitless" ;
        snr_threshold:missing_value = -9999.f ;
    float sample_frequency ;
        sample_frequency:long_name = "Doppler lidar digitizer sample rate" ;
        sample_frequency:units = "Hz" ;
        sample_frequency:missing_value = -9999.f ;
    float wavelength ;
        wavelength:long_name = "Doppler lidar wavelength" ;
        wavelength:units = "m" ;
        wavelength:missing_value = -9999.f ;
    float ceil_cbh(time) ;
        ceil_cbh:long_name = "Median ceilometer cloud base height" ;
        ceil_cbh:units = "m" ;
        ceil_cbh:missing_value = -9999.f ;
        ceil_cbh:cell_methods = "time: median" ;
    float ceil_cbh_25(time) ;
        ceil_cbh_25:long_name = "Ceilometer cloud base height 25th percentile" ;
        ceil_cbh_25:units = "m" ;
        ceil_cbh_25:missing_value = -9999.f ;
    float ceil_cbh_75(time) ;
        ceil_cbh_75:long_name = "Ceilometer cloud base height 75th percentile" ;
        ceil_cbh_75:units = "m" ;
        ceil_cbh_75:missing_value = -9999.f ;
    float ceil_cbh_zmax ;
        ceil_cbh_zmax:long_name = "Maximum detection height for ceil_cbh" ;
        ceil_cbh_zmax:units = "m" ;
        ceil_cbh_zmax:missing_value = -9999.f ;
    float ceil_cloud_frequency(time) ;
```

```
        ceil_cloud_frequency:long_name = "Fraction of time that a cloud is detected during averaging
period from ceil" ;
        ceil_cloud_frequency:units = "unitless" ;
        ceil_cloud_frequency:missing_value = -9999.f ;
    float ceil_lat ;
        ceil_lat:long_name = "Ceilometer north latitude" ;
        ceil_lat:units = "degree_N" ;
        ceil_lat:missing_value = -9999.f ;
        ceil_lat:standard_name = "latitude" ;
    float ceil_lon ;
        ceil_lon:long_name = "Ceilometer east longitude" ;
        ceil_lon:units = "degree_E" ;
        ceil_lon:missing_value = -9999.f ;
        ceil_lon:standard_name = "longitude" ;
    float ceil_alt ;
        ceil_alt:long_name = "Ceilometer altitude above mean sea level" ;
        ceil_alt:units = "m" ;
        ceil_alt:missing_value = -9999.f ;
        ceil_alt:standard_name = "altitude" ;
    float ecor_temp(time) ;
        ecor_temp:long_name = "Temperature from eddy correlation system" ;
        ecor_temp:units = "degK" ;
        ecor_temp:missing_value = -9999.f ;
    float ecor_h2o(time) ;
        ecor_h2o:long_name = "Water vapor density from eddy correlation system" ;
        ecor_h2o:units = "mmol/m^3" ;
        ecor_h2o:missing_value = -9999.f ;
    float ecor_tke(time) ;
        ecor_tke:long_name = "Turbulence kinetic energy from eddy correlation system" ;
        ecor_tke:units = "m^2/s^2" ;
        ecor_tke:missing_value = -9999.f ;
    float ecor_ustar(time) ;
        ecor_ustar:long_name = "Friction velocity from eddy correlation system" ;
        ecor_ustar:units = "m/s" ;
        ecor_ustar:missing_value = -9999.f ;
    float ecor_w_var(time) ;
        ecor_w_var:long_name = "Vertical velocity variance from eddy correlation system" ;
        ecor_w_var:units = "m^2/s^2" ;
        ecor_w_var:missing_value = -9999.f ;
    float ecor_w_skew(time) ;
        ecor_w_skew:long_name = "Vertical velocity skewness from eddy correlation system" ;
        ecor_w_skew:units = "unitless" ;
        ecor_w_skew:missing_value = -9999.f ;
    float ecor_w_kurt(time) ;
        ecor_w_kurt:long_name = "Vertical velocity kurtosis from eddy correlation system" ;
        ecor_w_kurt:units = "unitless" ;
        ecor_w_kurt:missing_value = -9999.f ;
    float ecor_wt(time) ;
        ecor_wt:long_name = "Wt covariance from eddy correlation system" ;
        ecor_wt:units = "K m/s" ;
        ecor_wt:missing_value = -9999.f ;
```

```
float ecor_wq(time) ;
    ecor_wq:long_name = "Wq covariance from eddy correlation system" ;
    ecor_wq:units = "mmol/(s m^2)" ;
    ecor_wq:missing_value = -9999.f ;
float ecor_lat ;
    ecor_lat:long_name = "North latitude of eddy correlation system" ;
    ecor_lat:units = "degree_N" ;
    ecor_lat:missing_value = -9999.f ;
    ecor_lat:standard_name = "latitude" ;
float ecor_lon ;
    ecor_lon:long_name = "East longitude of eddy correlation system" ;
    ecor_lon:units = "degree_E" ;
    ecor_lon:missing_value = -9999.f ;
    ecor_lon:standard_name = "longitude" ;
float ecor_alt ;
    ecor_alt:long_name = "Altitude above mean sea level of eddy correlation system" ;
    ecor_alt:units = "m" ;
    ecor_alt:missing_value = -9999.f ;
    ecor_alt:standard_name = "altitude" ;
float met_spr_mean(time) ;
    met_spr_mean:long_name = "Mean surface precipitation rate from MET" ;
    met_spr_mean:units = "mm/hr" ;
    met_spr_mean:missing_value = -9999.f ;
    met_spr_mean:cell_methods = "time: mean" ;
float met_spr_min(time) ;
    met_spr_min:long_name = "Minimum surface precipitation rate from MET" ;
    met_spr_min:units = "mm/hr" ;
    met_spr_min:missing_value = -9999.f ;
    met_spr_min:cell_methods = "time: minimum" ;
float met_spr_max(time) ;
    met_spr_max:long_name = "Maximum surface precipitation rate from MET" ;
    met_spr_max:units = "mm/hr" ;
    met_spr_max:missing_value = -9999.f ;
    met_spr_max:cell_methods = "time: maximum" ;
float met_lat ;
    met_lat:long_name = "North latitude of MET system" ;
    met_lat:units = "degree_N" ;
    met_lat:missing_value = -9999.f ;
    met_lat:standard_name = "latitude" ;
float met_lon ;
    met_lon:long_name = "East longitude MET system" ;
    met_lon:units = "degree_E" ;
    met_lon:missing_value = -9999.f ;
    met_lon:standard_name = "longitude" ;
float met_alt ;
    met_alt:long_name = "Altitude above MSL of MET system" ;
    met_alt:units = "m" ;
    met_alt:missing_value = -9999.f ;
    met_alt:standard_name = "altitude" ;
float lat ;
    lat:long_name = "North latitude" ;
```

```
        lat:units = "degree_N" ;
        lat:valid_min = -90.f ;
        lat:valid_max = 90.f ;
        lat:standard_name = "latitude" ;
    float lon ;
        lon:long_name = "East longitude" ;
        lon:units = "degree_E" ;
        lon:valid_min = -180.f ;
        lon:valid_max = 180.f ;
        lon:standard_name = "longitude" ;
    float alt ;
        alt:long_name = "Altitude above mean sea level" ;
        alt:units = "m" ;
        alt:standard_name = "altitude" ;

// global attributes:
        :process_version = "$State $" ;
        :command_line = "idl -D 0 -R -n dlprof_wstats -D -R -s sgp -f C1 -d 20150203" ;
        :dod_version = "dlprofwstats4news-c1-0.1" ;
        :Conventions = "ARM-1.1" ;
        :site_id = "sgp" ;
        :platform_id = "dlprofwstats4news" ;
        :location_description = "Southern Great Plains (SGP), Lamont, Oklahoma" ;
        :datastream = "sgpdlprofwstats4newsC1.c1" ;
        :data_level = "c1" ;
        :facility_id = "C1" ;
        :input_datastreams = "sgpceilC1.b1 : 1.1 : 20150202.000011-20150204.000006\n",
            "sgpdlfptC1.b1 : 2.10 : 20150202.230019-20150204.000018\n",
            "sgp30ecorE14.b1 : 13.1 : 20150202.000000-20150204.000000\n",
            "sgpmetE13.b1 : 4.28 : 20150202.000000-20150204.000000" ;
        :serial_number = "0710-07" ;
        :doi = "DOI:10.5439/1178583" ;
        :doi_url = "http://dx.doi.org/10.5439/1178583" ;
        :history = "created by user shippert on machine copper at 2015-05-04 23:27:45, using $State $" ;
}
```

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