

CF Standard Names for RADAR and LIDAR data in CfRadial

Mike Dixon, EOL, NCAR
Scott Ellis, EOL, NCAR
Matt Hayman, EOL, NCAR
Joe Hardin, PNNL, DOE
Ken Kehoe, NOAA, OU
Samuel Haimov, University of Wyoming
Daniel Michelson, Environment Canada
Mark Curtiss, Bureau of Meteorology, Australia

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Introduction

In order to have the CfRadial format formally recognized by the CF user community, we need to agree upon a list of standard names for RADAR and LIDAR. Thus far, only reflectivity and radial velocity are in the approved list of CF standard names.

Links

The CF conventions page is:

<http://cfconventions.org/latest.html>

The guidelines for standard names are provided here:

<http://cfconventions.org/Data/cf-standard-names/docs/guidelines.html>

The CF FAQ is here:

<http://cfconventions.org/faq.html>

Table 1 - standard names for radar/lidar/sonar sensor geometry

Proposed standard name	Description	Units
unit_vector_component_x	The component of a unit vector, along the X coordinate axis	unitless (0-1)
unit_vector_component_y	The component of a unit vector, along the Y coordinate axis	unitless (0-1)
unit_vector_component_z	The component of a unit vector, along the Z coordinate axis	unitless (0-1)

platform_heading_angle	<p>platform_heading_angle is the horizontal angle between the reference direction, which is often due north, and the longitudinal axis of the platform. The angle is measured clockwise positive, starting from the reference direction.</p> <p>If the reference is not north a comment attribute should be added to specify the reference details.</p> <p>See also platform_pitch_angle and platform_roll_angle.</p> <p>platform_heading_angle differs from platform_azimuth_angle, in that the former refers to the orientation of the platform itself, while the latter refers to the angle from an observation point to the platform.</p>	degree
sensor_to_target_azimuth_angle	<p>sensor_to_target_azimuth_angle is the horizontal angle between a reference direction, which is often due north, and the direction of observation from the sensor to the target.</p> <p>The angle is measured clockwise positive, starting from the reference direction.</p> <p>If the reference is not north a comment attribute should be added to specify the reference details.</p> <p>sensor_to_target_azimuth_angle differs from sensor_azimuth_angle in that the former is the angle from the sensor to the observation point, while the latter is the angle from an observation point to the sensor. Because of path distortion (e.g. from refraction) they are not necessarily 180 degrees apart.</p>	degree
sensor_to_target_elevation_angle	<p>sensor_to_target_elevation_angle is the vertical angle between the direction from the sensor to the target and the horizontal plane at the sensor location. The angle is measured upward positive, starting from the horizontal plane.</p> <p>A sensor_to_target_elevation_angle of -90.0 degrees is equivalent to a sensor_view_angle of 0.0 degrees.</p>	degree
sensor_to_target_rotation_angle	<p>sensor_to_target_rotation_angle is the angle between a reference plane, often the vertical plane, which contains the axis of rotation of the instrument, and the direction of observation from the sensor to the target. The angle is measured clockwise positive, starting from the reference plane.</p> <p>A comment attribute should be added to specify the reference plane details.</p> <p>sensor_to_target_rotation_angle is used in specialized cases, such as aircraft tail radars.</p>	degree

sensor_to_target_tilt_angle	<p>sensor_to_target_tilt_angle is the angle between the direction from the sensor to the target and a reference plane at the sensor location and orthogonal to the plane of rotation. The angle is measured starting from the reference plane.</p> <p>A comment attribute should be added to specify the sign of the angle quantity.</p> <p>sensor_to_target_tilt_angle is used in specialized situations, such as aircraft tail radars.</p>	degree
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Table 2 - standard names for radar moments variables

Note:

- copolar horizontal means transmit H, receive H
- copolar vertical means transmit V, receive V
- crosspolar horizontal means transmit V, receive H
- crosspolar vertical means transmit H, receive V

Proposed standard name	Description	Units
equivalent_reflectivity_factor (already in CF)	"Equivalent reflectivity factor" is the radar reflectivity factor that is calculated from the measured radar backscatter return power assuming the target is composed of liquid water droplets whose diameter is less than one tenth of the radar wavelength, i.e., treating the droplets as Rayleigh scatterers. The actual radar reflectivity factor would depend on the size distribution and composition of the particles within the target volume and these are often unknown. The quantity is corrected for range, radar wavelength and other operating characteristics such as transmit power and pulse length.	dBZ
equivalent_reflectivity_factor_h	This is the equivalent_reflectivity_factor, for the copolar horizontal receive signal.	dBZ
equivalent_reflectivity_factor_v	This is the equivalent_reflectivity_factor, for copolar vertical receive signal.	dBZ
radial_velocity_of_scatterers_away_from_instrument (already in CF)	A velocity is a vector quantity. "Radial velocity away from instrument" means the component of the velocity of the scatterers along the line of sight of the instrument where positive implies movement away from the instrument (i.e. outward). The "instrument" (examples are radar and lidar) is the device used to make the observation, and the "scatterers" are what causes the transmitted signal to be returned to the instrument (examples are aerosols, hydrometeors and refractive index irregularities), of whatever kind the instrument detects.	m s ⁻¹

radial_velocity_of_scatterers_away_from_instrument_h	Radial velocity for the copolar horizontal receive signal.	m s-1
radial_velocity_of_scatterers_away_from_instrument_v	Radial velocity for the copolar vertical receive signal.	m s-1
radar_doppler_spectrum_width	A measure of the dispersion of radial velocity within the radar measurement volume. This is analogous to the standard deviation of the distribution of velocities for all particles in the measurement volume.	m s-1
radar_doppler_spectrum_width_h	radar_doppler_spectrum_width for the copolar horizontal receive channel.	m s-1
radar_doppler_spectrum_width_v	radar_doppler_spectrum_width for the copolar vertical receive channel.	m s-1
radar_differential_reflectivity_hv	The ratio of the copolar horizontal reflectivity to the copolar vertical reflectivity. Commonly referred to as ZDR.	dB
radar_linear_depolarization_ratio	The ratio of the received power from one polarization to the received power from the orthogonal polarization, for a pulse transmitted in the orthogonal polarization. Commonly referred to as LDR.	dB
radar_linear_depolarization_ratio_h	radar_linear_depolarization_ratio for horizontal transmit. That is, the ratio of the vertical received power to the horizontal received power, for horizontal transmit.	dB
radar_linear_depolarization_ratio_v	radar_linear_depolarization_ratio for vertical transmit. That is, the ratio of the horizontal received power to the vertical received power, for vertical transmit.	dB
radar_differential_phase_hv	The horizontal copolar received phase minus the vertical copolar received phase. Commonly referred to as PHIDP.	degrees
radar_specific_differential_phase_hv	The rate of change of radar_differential_phase_hv with distance (i.e. range from the instrument). Commonly referred to as KDP.	degrees/km
radar_differential_phase_copolar_h_crosspolar_v	The horizontal copolar received phase minus the vertical crosspolar received phase.	degrees
radar_differential_phase_copolar_v_crosspolar_h	The vertical copolar received phase minus the horizontal crosspolar received phase.	degrees
radar_correlation_coefficient_hv	The complex correlation coefficient between the copolar horizontal received signal and the copolar vertical received signal.	unitless (0-1)
radar_correlation_coefficient_copolar_h_crosspolar_v	The complex correlation coefficient between the copolar horizontal received signal and the crosspolar vertical received signal, for a horizontal transmit pulse.	unitless (0-1)
radar_correlation_coefficient_copolar_v_crosspolar_h	The complex correlation coefficient between the copolar vertical received signal and the crosspolar horizontal received signal, for a vertical transmit pulse.	unitless (0-1)
radar_received_signal_power	Received power, unspecified channel.	dBm

radar_received_signal_power_copolar_h	radar_received_signal_power for copolar horizontal receive, from a horizontal polarization transmit pulse.	dBm
radar_received_signal_power_copolar_v	radar_received_signal_power for copolar vertical receive, from a vertical polarization transmit pulse.	dBm
radar_received_signal_power_crosspolar_h	radar_received_signal_power for crosspolar horizontal receive, from a vertical polarization transmit pulse.	dBm
radar_received_signal_power_crosspolar_v	radar_received_signal_power for crosspolar vertical receive, from a horizontal polarization transmit pulse.	dBm
radar_signal_to_noise_ratio	The ratio of the signal power to the system noise. The signal power is computed as the total measured power minus the noise power.	dB
radar_signal_to_noise_ratio_copolar_h	radar_signal_to_noise_ratio for copolar horizontal receive, from a horizontal polarization transmit pulse.	dB
radar_signal_to_noise_ratio_copolar_v	radar_signal_to_noise_ratio for copolar vertical receive, from a vertical polarization transmit pulse.	dB
radar_signal_to_noise_ratio_crosspolar_h	radar_signal_to_noise_ratio for crosspolar horizontal receive, from a vertical polarization transmit pulse.	dB
radar_signal_to_noise_ratio_crosspolar_v	radar_signal_to_noise_ratio for crosspolar vertical receive, from a horizontal polarization transmit pulse.	dB
radar_normalized_coherent_power	The lag1 power of the received signal, divided by the lag0 power of the received signal.	unitless (0-1)
radar_normalized_coherent_power_copolar_h	radar_normalized_coherent_power for copolar horizontal receive, from a horizontal polarization transmit pulse.	unitless (0-1)
radar_normalized_coherent_power_copolar_v	radar_normalized_coherent_power for copolar vertical receive, from a vertical polarization transmit pulse.	unitless (0-1)
radar_estimated_precipitation_rate	Precipitation rate based estimated by radar.	mm/hr
radar_scatterer_classification	Dominant scatterer type in a radar return for a sample volume.	unitless (0-255)

Table 3 - standard names for radar covariance quantities

This section lists the proposed standard names for radar covariance variables.

These are the fundamental quantities from which many of the radar moments are computed.

Lag0 covariances for a single channel (e.g. horizontal copolar to horizontal copolar) are real.

All other covariances are complex. These are stored as (complex, phase) pairs.

Proposed standard name	Description	Units
Lag-0 powers (real)		
radar_lag0_covariance_of_copolar_h_and_copolar_h	Lag-0 covariance for the horizontal copolar signal. This is the received horizontal copolar power.	dBm
radar_lag0_covariance_of_copolar_v_and_copolar_v	Lag-0 covariance for the vertical copolar signal. This is the received vertical copolar power.	dBm
radar_lag0_covariance_of_crosspolar_h_and_crosspolar_h	Lag-0 covariance for the horizontal crosspolar signal. This is the received horizontal crosspolar power.	dBm
radar_lag0_covariance_of_crosspolar_v_and_crosspolar_v	Lag-0 covariance for the vertical crosspolar signal. This is the received vertical crosspolar power.	dBm
Lag-0 covariances (complex) stored as power/phase		
radar_lag0_covariance_of_copolar_h_and_copolar_v	Lag-0 covariance of the horizontal copolar signal to the vertical copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag0_covariance_of_copolar_h_and_crosspolar_v	Lag-0 covariance of the horizontal copolar signal to the vertical crosspolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag0_covariance_of_copolar_v_and_crosspolar_h	Lag-0 covariance of the vertical copolar signal to the horizontal crosspolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
Lag-1 covariances (complex) stored as power/phase		
radar_lag1_covariance_of_copolar_h_and_copolar_h	Lag-1 covariance for horizontal copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag1_covariance_of_copolar_v_and_copolar_v	Lag-1 covariance for vertical copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag1_covariance_of_copolar_h_and_copolar_v	Lag-1 covariance for horizontal to vertical copolar signals. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag1_covariance_of_copolar_v_and_copolar_h	Lag-1 covariance for vertical to horizontal copolar signals. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag1_covariance_of_crosspolar_h_and_crosspolar_v	Lag-1 covariance for horizontal to vertical crosspolar signals. This is a complex quantity, stored as power/phase.	dBm/degree

radar_lag1_covariance_of_crosspolar_v_and_crosspolar_h	Lag-1 covariance for vertical to horizontal crosspolar signals. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag1_covariance_of_copolar_h_and_crosspolar_v	Lag-1 covariance for horizontal copolar to vertical crosspolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag1_covariance_of_crosspolar_v_and_copolar_h	Lag-1 covariance for vertical crosspolar to horizontal copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag1_covariance_of_copolar_v_and_crosspolar_h	Lag-1 covariance for vertical copolar to horizontal crosspolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag1_covariance_of_crosspolar_h_and_copolar_v	Lag-1 covariance for horizontal crosspolar to vertical copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
Lag-2 covariances (complex), stored as power/phase		
radar_lag2_covariance_of_copolar_h_and_copolar_h	Lag-2 covariance for horizontal copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag2_covariance_of_copolar_v_and_copolar_v	Lag-2 covariance for vertical copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
Lag-3 covariances (complex), stored as power/phase		
radar_lag3_covariance_of_copolar_h_and_copolar_h	Lag-3 covariance for horizontal copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag3_covariance_of_copolar_v_and_copolar_v	Lag-3 covariance for vertical copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
Lag-4 covariances (complex), stored as power/phase		
radar_lag4_covariance_of_copolar_h_and_copolar_h	Lag-4 covariance for horizontal copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag4_covariance_of_copolar_v_and_copolar_v	Lag-4 covariance for vertical copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
Lag-5 covariances (complex), stored as power/phase		
radar_lag5_covariance_of_copolar_h_and_copolar_h	Lag-5 covariance for horizontal copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_lag5_covariance_of_copolar_v_and_copolar_v	Lag-5 covariance for vertical copolar signal. This is a complex quantity, stored as power/phase.	dBm/degree
Lag-0 powers for staggered PRT		
radar_long_prt_lag0_covariance_of_copolar_h_and_copolar_h	Lag-0 covariance for the horizontal copolar signal for long PRT. This is a real quantity, power.	dBm

radar_long_prt_lag0_covariance_of_copolar_v_and_copolar_v	Lag-0 covariance for vertical copolar signal for long PRT. This is a real quantity, power.	dBm
radar_short_prt_lag0_covariance_of_copolar_h_and_copolar_h	Lag-0 covariance for horizontal copolar signal for short PRT. This is a real quantity, power.	dBm
radar_short_prt_lag0_covariance_of_copolar_v_and_copolar_v	Lag-0 covariance for vertical copolar signal for short PRT. This is a real quantity, power.	dBm
radar_long_prt_lag0_covariance_of_crosspolar_h_and_crosspolar_h	Lag-0 covariance for horizontal crosspolar signal for long PRT. This is a real quantity, power..	dBm
radar_long_prt_lag0_covariance_of_crosspolar_v_and_crosspolar_v	Lag-0 covariance for vertical crosspolar signal for long PRT. This is a real quantity, power.	dBm
radar_short_prt_lag0_covariance_of_crosspolar_h_and_crosspolar_h	Lag-0 covariance for horizontal crosspolar signal for short PRT. This is a real quantity, power.	dBm
radar_short_prt_lag0_covariance_of_crosspolar_v_and_crosspolar_v	Lag-0 covariance for vertical crosspolar signal for short PRT. This is a real quantity, power.	dBm
Lag-1 covariances (complex) for staggered PRT, stored as power/phase		
radar_long_prt_lag1_covariance_of_copolar_h_and_copolar_h	Lag-1 covariance for horizontal copolar signal for long PRT. This is a complex quantity, stored as power/phase.	dBm/degree
radar_long_prt_lag1_covariance_of_copolar_v_and_copolar_v	Lag-1 covariance for vertical copolar signal for long PRT. This is a complex quantity, stored as power/phase.	dBm/degree
radar_short_prt_lag1_covariance_of_copolar_h_and_copolar_h	Lag-1 covariance for horizontal copolar signal for short PRT. This is a complex quantity, stored as power/phase.	dBm/degree
radar_short_prt_lag1_covariance_of_copolar_v_and_copolar_v	Lag-1 covariance for vertical copolar signal for short PRT. This is a complex quantity, stored as power/phase.	dBm/degree
		dBm/degree
radar_long_to_short_prt_lag1_covariance_of_copolar_h_to_copolar_h	Lag-1 covariance for horizontal copolar signal for long-to-short PRT. This is a complex quantity, stored as power/phase.	dBm/degree
radar_long_to_short_prt_lag1_covariance_of_copolar_v_to_copolar_v	Lag-1 covariance for vertical copolar signal for long-to-short PRT. This is a complex quantity, stored as power/phase.	dBm/degree
radar_short_to_long_prt_lag1_covariance_of_copolar_h_to_copolar_h	Lag-1 covariance for horizontal copolar signal for short-to-long PRT. This is a complex quantity, stored as power/phase.	dBm/degree
radar_short_to_long_prt_lag1_covariance_of_copolar_v_to_copolar_v	Lag-1 covariance for vertical copolar signal for short-to-long PRT. This is a complex quantity, stored as power/phase.	dBm/degree

Table 4 - standard names for radar spectrum variables

A modern weather radar can typically have up to 4 receive channels: horizontal copolar (Hc), vertical copolar (Vc), horizontal crosspolar (Hx) and vertical crosspolar (Vx). This terminology is receiver-centric: Hx indicates vertical transmit and horizontal receive, and Vx indicates horizontal transmit and vertical receive.

We can compute the spectrum for a single channel, or a cross spectrum between two channels.

The following table shows the possible combinations for cross-spectra. These can be computed as the FFT of the first channel multiplied by the conjugate of the FFT of the second channel. The on-diagonal terms are real – they are the power spectrum for that channel.

	Hc*	Hx*	Vx*	Vc*
Hc	HcHc*	HcHx*	HcVx*	HcVc*
Hx	HxHx*	HxHx*	HxVx*	HxVc*
Vx	VxHc*	VxHx*	VxVx*	VxVc*
Vc	VcHc*	VcHx*	VcVx*	VcVc*

There is redundant information in the items in this table. The above-diagonal terms are conjugate-symmetric with the corresponding below-diagonal terms. We include the names for all possible combinations to provide flexibility in how researchers choose to compute and store the spectra.

Standard name	Description	Units
Power spectrum for a single channel (diagonal terms in table above)		
radar_power_spectrum_of_copolar_h	Power spectrum for the copolar horizontal signal. This is a real value, representing the power only. The phase is discarded.	dBm
radar_power_spectrum_of_copolar_v	Power spectrum for the copolar vertical signal. This is a real value, representing the power only. The phase is discarded.	dBm
radar_power_spectrum_of_crosspolar_h	Power spectrum for the crosspolar horizontal signal. This is a real value, representing the power only. The phase is discarded.	dBm
radar_power_spectrum_of_crosspolar_v	Power spectrum for the crosspolar vertical signal. This is a real value, representing the power only. The phase is discarded.	dBm
Complex spectrum for a single channel (complex FFT of time series)		
radar_complex_spectrum_of_copolar_h	Complex spectrum for the copolar horizontal signal. This is a complex value, stored as power/phase.	dBm/degree
radar_complex_spectrum_of_copolar_v	Complex spectrum for the copolar vertical signal. This is a complex value, stored as power/phase.	dBm/degree
radar_complex_spectrum_of_crosspolar_h	Complex spectrum for the crosspolar horizontal signal. This is a complex value, stored as power/phase.	dBm/degree
radar_complex_spectrum_of_crosspolar_v	Complex spectrum for the crosspolar vertical signal. This is a complex value, stored as power/phase.	dBm/degree
Cross spectra of 2 channels (off-diagonal terms in table above)		

radar_cross_spectrum_of_copolar_h_and_copolar_v	Cross spectrum of copolar horizontal signal to copolar vertical signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_copolar_h_and_crosspolar_h	Cross spectrum of copolar horizontal signal to crosspolar horizontal signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_copolar_h_and_crosspolar_v	Cross spectrum of copolar horizontal signal to crosspolar vertical signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_copolar_v_and_copolar_h	Cross spectrum of copolar vertical signal to copolar horizontal signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_copolar_v_and_crosspolar_h	Cross spectrum of copolar vertical signal to crosspolar horizontal signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_copolar_v_and_crosspolar_v	Cross spectrum of copolar vertical signal to crosspolar vertical signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_crosspolar_h_and_copolar_h	Cross spectrum of crosspolar horizontal signal to copolar horizontal signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_crosspolar_h_and_copolar_v	Cross spectrum of crosspolar horizontal signal to copolar vertical signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_crosspolar_h_and_crosspolar_v	Cross spectrum of crosspolar horizontal signal to crosspolar vertical signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_crosspolar_v_and_copolar_h	Cross spectrum of crosspolar vertical signal to copolar horizontal signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_crosspolar_v_and_copolar_v	Cross spectrum of crosspolar vertical signal to copolar vertical signal. This is a complex quantity, stored as power/phase.	dBm/degree
radar_cross_spectrum_of_crosspolar_v_and_crosspolar_h	Cross spectrum of crosspolar vertical signal to crosspolar horizontal signal. This is a complex quantity, stored as power/phase.	dBm/degree

Table 5 - standard names for Lidar measured quantities

Standard name	Description	Units
lidar_copolar_combined_backscatter_photon_count	Lidar backscatter photon count from both gas molecules and particles (aerosols plus cloud particles), in the co-polarization (transmit) channel. Backscatter implies a scattering angle of 180 degrees.	unitless
lidar_crosspolar_combined_backscatter_photon_count	Lidar backscatter photon count from both gas molecules and particles (aerosols plus cloud particles), in the cross-polarization channel. Backscatter implies a scattering angle of 180 degrees.	unitless
lidar_colopar_molecular_backscatter_photon_count	Lidar backscatter photon count from gas molecules only, in the co-polarization (transmit) channel. Backscatter implies a scattering angle of 180 degrees.	unitless
lidar_volume_depolarization_ratio	Ratio of the combined crosspolar signal to the combined copolar signal.	unitless
lidar_particle_depolarization_ratio	Depolarization ratio caused by particles (aerosols and cloud particles). This is the volume depolarization ratio with the effect of molecular depolarization removed.	unitless
lidar_backscatter_ratio	Ratio of the sum of the combined copolar and crosspolar backscatter signals to the molecular backscatter signal.	unitless
lidar_backscatter_coefficient	Probability of 180 degree scattering per unit length per unit solid angle. This is a calibrated value that quantifies the level of backscatter from a sample volume.	(/m)(/sr)
lidar_extinction_coefficient	Rate of power extinction per unit distance. This can also be considered the probability of photon scattering and absorption per unit path length. (<i>Theory of Lidar</i> , © Springer International Publishing Switzerland 2015)	(/m)
lidar_optical_depth	The aerosol optical depth or optical thickness (τ) is defined as the integrated extinction coefficient over a vertical column of unit cross section. Extinction coefficient is the fractional depletion of radiance per unit path length. (https://www.researchgate.net)	unitless