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AVDC/NDACC LIDAR Data Reporting Guidelines

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Abstract:	This document describes the AVDC/NDACC data reporting requirements for LIDARs
See Also:	Bojkov *et al.*, 2002, 2006

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1 Overview

This document outlines data reporting requirements for the Light Detection And Ranging (LIDAR) systems of the Network for the Detection of Atmospheric Composition Change (NDACC). These guidelines were developed by the LIDAR Working Group of the NDACC and the Aura Validation Data Center (AVDC) to facilitate the submission of LIDAR datasets in the AVDC/Envisat HDFv4 file formulation (Bojkov *et al.*, 2002) to the AURA Validation Data Center (AVDC) and the NDACC Data Handling Facility (DHF).

2 Guidelines

2.1 Instrument naming

Although LIDAR systems have the capability to measure multiple entities simultaneously, the instrument names of the different LIDAR systems are based on the primary measured entity to be reported in a file:

Table 2.1: LIDAR instrument names

Primary Measured Entity	AVDC Instrument Name
Ozone	LIDAR.O3
Water vapor	LIDAR.H2O
Temperature	LIDAR.TEMPERATURE
Aerosols	LIDAR.AEROSOL

2.2 Variable Reporting

Each primary measured entity requires a mandatory set of variables, with set units, to be reported within a file.

2.2.1 Ozone

For a LIDAR retrieving ozone using differential absorption, the following 20 variables are required:

Table 2.2.1: Mandatory variables for LIDAR ozone reporting

#	Variables	Units	Comment
1	LATITUDE.INSTRUMENT	deg	*Inst. geolocation*
2	LONGITUDE.INSTRUMENT	deg	*Inst. geolocation*
3	ALTITUDE.INSTRUMENT	m	*Inst. Geolocation*
4	DATETIME	MJD2000	*Weight. meas. time*
5	ALTITUDE	M	*Actual meas. grid*
6	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL	Molec m-3	
7	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.RANDOM	%	
8	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.SYSTEMATIC	%	
9	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.TOTAL	%	
10	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_RESOLUTION.ALTITUDE	M	
11	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_RESOLUTION.ALTITUDE.STD	TBD	*Common definition TBD*
12	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_START.TIME	MJD2000	*Meas. start*
13	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_STOP.TIME	MJD2000	*Meas. end*
14	O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_INTEGRATION.TIME	H	*Actual int. time*
15	PRESSURE_INDEPENDENT	hPa	*P profile for mix. ratio*
16	TEMPERATURE_INDEPENDENT	K	*T profile for mix. ratio*
17	O3.MIXING.RATIO_ABSORPTION.DIFFERENTIAL	ppmv	
18	O3.MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.RANDOM	%	
19	O3. MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.SYSTEMATIC	%	
20	O3. MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.TOTAL	%	

The reference temperature and the reference pressure profiles are reported in support of the determination of the ozone mixing ratio. These variables may be derived from LIDAR measurements or originate from external sources such as model analysis or radiosondes.

2.2.2 Temperature

The reporting of temperature data from LIDAR measurements requires the following 22 variables:

Table 2.2.2: Mandatory variables for temperature

#	Variables	Units	Comment
1	LATITUDE.INSTRUMENT	deg	*Inst. geolocation*
2	LONGITUDE.INSTRUMENT	deg	*Inst. geolocation*
3	ALTITUDE.INSTRUMENT	m	*Inst. Geolocation*
4	DATETIME	MJD2000	*Weighted meas. time*
5	ALTITUDE	m	*Actual meas. grid*
6	TEMPERATURE_BACKSCATTER	K	*Raman or Rayleigh-Brillouin*
7	TEMPERATURE_BACKSCATTER_UNCERTAINTY.RANDOM	%	
8	TEMPERATURE_BACKSCATTER_UNCERTAINTY.SYSTEMATIC	%	
9	TEMPERATURE_BACKSCATTER_UNCERTAINTY.TOTAL	%	
10	TEMPERATURE_BACKSCATTER_RESOLUTION.ALTITUDE	m	
11	TEMPERATURE_BACKSCATTER_RESOLUTION.ALTITUDE.STD	TBD	*Common definition TBD*
12	TEMPERATURE_BACKSCATTER_START.TIME	MJD2000	*Meas. start*
13	TEMPERATURE_BACKSCATTER_STOP.TIME	MJD2000	*Meas. end*
14	TEMPERATURE_BACKSCATTER_INTEGRATION.TIME	h	*Actual integration time*
15	PRESSURE_BACKSCATTER or AIR.NUMBER.DENSITY_BACKSCATTER	hPa molec m-3	
16	PRESSURE_BACKSCATTER_UNCERTAINTY.RANDOM or AIR.NUMBER.DENSITY_BACKSCATTER_UNCERTAINTY.RANDOM	%	
17	PRESSURE_BACKSCATTER_UNCERTAINTY.SYSTEMATIC or AIR.NUMBER.DENSITY_BACKSCATTER_UNCERTAINTY.SYSTEMATIC	%	
18	PRESSURE_BACKSCATTER_UNCERTAINTY.TOTAL or AIR.NUMBER.DENSITY_BACKSCATTER_UNCERTAINTY.TOTAL	%	
19	PRESSURE_INDEPENDENT_NORMALIZATION or DENSITY_INDEPENDENT_NORMALIZATION or AIR.NUMBER.DENSITY_INDEPENDENT_NORMALIZATION	hPa kg m-3 molec m-3	*Norm. P, ρ or T*
20	ALTITUDE_INDEPENDENT_NORMALIZATION	m	*Norm. altitude (scalar)*
21	PRESSURE_INDEPENDENT_INITIALIZATION or TEMPERATURE_INDEPENDENT_INITIALIZATION	hPa K	*Initial P, or T*
22	ALTITUDE_INDEPENDENT_INITIALIZATION	m	*Initial. altitude (scalar)*

Variable 19: Depending on the retrieval codes, the corrected lidar signals, once proportional to atmospheric density, might or might not be normalized to an external atmospheric density value taken at the specified altitude (variable 20). This value is usually taken from a model or radiosonde measurement, and the reference quantity is

either pressure, density or number density. Data originator shall include in variable 19 only the quantity used in his/her retrieval.

Variable 21: Depending on the retrieval codes, the retrieved lidar relative density profile will be integrated from the top using the hydrostatic balance, and using a “seed” temperature or pressure value taken at the altitude specified in variable 22. This process is often called “initialization”. The seed pressure or temperature value is usually taken from a model, an independent Sodium lidar temperature, or an independent satellite measurement. Data originator shall include in variable 19 only the quantity used in his/her retrieval, i.e., either pressure or temperature.

2.2.3 Water Vapor (Raman)

The reporting of water vapor data from Raman LIDAR measurements requires additional investigation by the LIDAR Working Group, and is presented for discussion purposes only.

Table 2.2.3: Mandatory variables for water vapor from Raman LIDAR.

#	Variables	Units	Comment
1	LATITUDE.INSTRUMENT	deg	*Inst. geolocation*
2	LONGITUDE.INSTRUMENT	deg	*Inst. geolocation*
3	ALTITUDE.INSTRUMENT	m	*Inst. Geolocation*
4	DATETIME	MJD2000	*Weighted meas. time*
5	ALTITUDE	m	*Actual meas. grid*
6	H2O.CONCENTRATION_ BACKSCATTER	g kg-1	
7	H2O.CONCENTRATION_ BACKSCATTER _UNCERTAINTY.RANDOM	%	
8	H2O.CONCENTRATION_ BACKSCATTER _UNCERTAINTY.SYSTEMATIC	%	
9	H2O.CONCENTRATION_ BACKSCATTER _UNCERTAINTY.TOTAL	%	
10	H2O.CONCENTRATION_ BACKSCATTER _RESOLUTION.ALTITUDE	m	
11	H2O.CONCENTRATION_ BACKSCATTER _RESOLUTION.ALTITUDE.STD	TBD	*Common definition TBD*
12	H2O.CONCENTRATION_ BACKSCATTER _START.TIME	MJD2000	*Meas. start*
13	H2O.CONCENTRATION_ BACKSCATTER _STOP.TIME	MJD2000	*Meas. end*
14	H2O.CONCENTRATION_ BACKSCATTER. _INTEGRATION.TIME	h	*Actual integration time*
15	PRESSURE_INDEPENDENT	hPa	*profile for RH*
16	TEMPERATURE_INDEPENDENT	K	*profile for RH*
17	RELATIVE.HUMIDITY_ BACKSCATTER	%	*calculated*
18	RELATIVE.HUMIDITY_ BACKSCATTER _UNCERTAINTY.RANDOM	%	
19	RELATIVE.HUMIDITY_ BACKSCATTER _UNCERTAINTY.SYSTEMATIC	%	
20	RELATIVE.HUMIDITY_ BACKSCATTER _UNCERTAINTY.TOTAL	%	

Note that the reference temperature and reference pressure profiles are reported in support of the determination of the relative humidity. These usually originate from external sources such as model analysis or radiosondes.

2.2.4 Water Vapor (DIAL)

The reporting of water vapor data from DIAL measurements requires additional investigation by the LIDAR Working Group, and is reported in this section as a temporary template only.

Table 2.2.4: Mandatory variables water vapor from DIAL systems.

#	Variables	Units	Comment
1	LATITUDE.INSTRUMENT	deg	*Inst. geolocation*
2	LONGITUDE.INSTRUMENT	deg	*Inst. geolocation*
3	ALTITUDE.INSTRUMENT	m	*Inst. Geolocation*
4	DATETIME	MJD2000	*Weighted meas. time*
5	ALTITUDE	m	*Actual meas. grid*
6	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL	molec m-3	
7	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.RANDOM	%	
8	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.SYSTEMATIC	%	
9	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.TOTAL	%	
10	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_RESOLUTION.ALTITUDE	m	
11	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_RESOLUTION.ALTITUDE.STD	TBD	*Common definition TBD*
12	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_START.TIME	MJD2000	*Meas. start*
13	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_STOP.TIME	MJD2000	*Meas. end*
14	H2O.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_INTEGRATION.TIME	h	*Actual int. time*
15	PRESSURE_INDEPENDENT	hPa	*profile for mxr and RH*
16	TEMPERATURE_INDEPENDENT	K	*profile for mxr and RH*
17	H2O.MIXING.RATIO_ABSORPTION.DIFFERENTIAL	ppmv	
18	H2O.MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.RANDOM	%	
19	H2O.MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.SYSTEMATIC	%	
20	H2O.MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.TOTAL	%	
21	RELATIVE.HUMIDITY_BACKSCATTER.RAMAN	%	*calculated*
22	RELATIVE.HUMIDITY_BACKSCATTER.RAMAN_UNCERTAINTY.RANDOM	%	
23	RELATIVE.HUMIDITY_BACKSCATTER.RAMAN_UNCERTAINTY.SYSTEMATIC	%	
24	RELATIVE.HUMIDITY_BACKSCATTER.RAMAN_UNCERTAINTY.TOTAL	%	

The reference temperature and the reference pressure profiles are reported in support of the determination of the relative humidity. These usually originate from external sources such as model analysis or radiosondes.

2.2.5 Aerosol measurements

Aerosol measurement formulations will be formulated at a later date by the LIDAR Working Group.

2.2.6 Additional Notes

The variable **MJD2000** is the Modified Julian Day Fraction, starting on January, 1st, 2000 at 00:00:00 UTC.

The variable **DATETIME** is a single weighted mean time of the measurement, i.e. after accounting for periods where there is no data acquisition because of poor weather conditions, calibrations etc.

The variable **INTEGRATION.TIME** is the effective integration time of the data used in the retrieval, which will be less than - or equal to - the difference between the start and stop times (after accounting for data acquisition gaps).

Reported altitude ranges: The altitude range (i.e., min and max altitudes) will be determined by that of the primary measured variables. If other variables are undefined over part of this range, fill values (see section 2.3) should be used.

2.3 Variable fill values

The variable fill value is a number inserted as a substitute data element if a data element of a variable is missing or erroneous. Special care must be given to the number of positions reported for the data format (VIS_FORMAT) to also accommodate the fill value. In most cases the reported variable fill value will be -90000, with precision and format as defined by VIS_FORMAT, as shown in the examples in Table 2.3 (and Table 2.2).

Table 2.3: Fill value examples

Variable numeric type (VAR_DATA_TYPE)	Formatting (VIS_FORMAT)	Fill value (VAR_FILL_VALUE)
REAL	F9.2	-90000.00
REAL	E10.2	-9.00E+004
DOUBLE	E11.3	-9.000E+004
LONG	I6	-90000

2.4 File Granularity

The reporting granularity for LIDAR system measurements is one file per measurement.

3 Metadata

3.1 Global Attributes

Each LIDAR.[*] file requires one set of **Global Attributes**. These have been grouped in to three categories describing the file contents, namely **Originator Attributes**, **Dataset Attributes** and **File Attributes**. An example of a LIDAR ozone global attributes measurement at GSFC is given in Table 3.1.

Table 3.1: Global attributes

Global Attribute Label	Global Attribute Value (example)	Comment
PI_NAME	McGee; Thomas J.	
PI_AFFILIATION	NASA Goddard Space Flight Center;NASA.GSFC	
PI_ADDRESS	NASA GSFC Code 613.3;Greenbelt, MD 20771;UNITED STATES	
PI_EMAIL	thomas.j.mcgee@nasa.gov	
DO_NAME	Twigg; Laurence	
DO_AFFILIATION	NASA Goddard Space Flight Center;NASA.GSFC	
DO_ADDRESS	NASA GSFC Code 613.3;Greenbelt, MD 20771;UNITED STATES	
DO_EMAIL	twigg@aurora.gsfc.nasa.gov	
DS_NAME	Bojkov; Bojan R.	
DS_AFFILIATION	NASA Goddard Space Flight Center;NASA.GSFC	
DS_ADDRESS	NASA GSFC Code 613.3;Greenbelt, MD 20771;UNITED STATES	
DS_EMAIL	bojan.bojkov@gsfc.nasa.gov	
DATA_DESCRIPTION	Atmospheric ozone profiles from ground-based LIDAR measurements	*Free format*
DATA_DISCIPLINE	ATMOSPHERIC.PHYSICS;REMOTE.SENSING;GROUNDBASED	*Refer to standard*
DATA_GROUP	EXPERIMENTAL; PROFILE.STATIONARY	*Refer to standard*
DATA_LOCATION	GSFC	*Refer to standard*
DATA_SOURCE	LIDAR.O3_NASA.GSFC001	*Refer to standard*
DATA_LEVEL	H2	*Refer to standard*
DATA_VARIABLES	LATITUDE.INSTRUMENT; LONGITUDE.INSTRUMENT; ALTITUDE.INSTRUMENT; DATETIME; ALTITUDE; O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL; O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.RANDOM; O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.SYSTEMATIC; O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.TOTAL; O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_RESOLUTION.ALTITUDE O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_START.TIME; O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_STOP.TIME; O3.NUMBER.DENSITY_ABSORPTION.DIFFERENTIAL_INTEGRATION.TIME; PRESSURE_INDEPENDENT; TEMPERATURE_INDEPENDENT; O3.MIXING.RATIO_ABSORPTION.DIFFERENTIAL; O3.MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.RANDOM; O3.MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.SYSTEMATIC; O3.MIXING.RATIO_ABSORPTION.DIFFERENTIAL_UNCERTAINTY.TOTAL	
DATA_START_DATE	20050110T043056Z	*ISO8601*
DATA_FILE_VERSION	5.0	
DATA_MODIFICATIONS	NONE	*Free format*
DATA_CAVEATS	NONE	*Free format*
DATA_RULES_OF_USE	Please contact T. McGee	*Free format*
DATA_ACKNOWLEDGEMENT		*Free format*
FILE_NAME	groundbased_lidar.o3_nasa.gsfc001_gsfc_h2_20050110t043056z_5.0.hdf	*Naming convention*
FILE_GENERATION_DATE	20050512T143444Z	*ISO8601*
FILE_ACCESS	AVDC; NDACC	*Project*

		dependent
FILE_PROJECT_ID		*Project dependent*
FILE_ASSOCIATION	NDACC	*Project dependent*
FILE_META_VERSION	02R012; IDLCR8HDF	*Refer to standard*

3.2 Variable Attributes

Each variable reported in a LIDAR.[*] file requires one set of **Variable Attributes**. These have been grouped into two categories describing the variable, namely the **Variable Description Attributes** and the **Variable Visualization Attributes**. An example of an attribute set is given in Table 3.2.

Table 3.2: Variable attributes

Attribute Label	Attribute Value	Comment
VAR_NAME	O3.MIXING.RATIO_ABSORPTION.DIFFERENTIAL	*Refer to standard*
VAR_DESCRIPTION	Calculated ozone mixing ratio	*Free format*
VAR_NOTES		*Free format*
VAR_DIMENSION	1	
VAR_SIZE	210	*The number of elements in each dimension*
VAR_DEPEND	O3.NUMBER.DENSITY_ABSORPTION DIFFERENTIAL; PRESSURE_INDEPENDENT; TEMPERATURE_INDEPENDENT	*INDEPENDENT, CONSTANT or a previously given one dimensional variable*
VAR_DATA_TYPE	REAL	*Allowable formats are INTEGER, LONG, REAL, DOUBLE*
VAR_UNITS	ppmv	*Refer to standard for permissible units*
VAR_SI_CONVERSION	1e6; DIMENSIONLESS	*Refer to standard*
VAR_VALID_MIN	0.00	
VAR_VALID_MAX	20.00	
VAR_AVG_TYPE	NONE	*Refer to standard*
VAR_FILL_VALUE	-9000.00	*Needs to be outside VAR_VALID_MIN and VAR_VALID_MAX values*
VIS_LABEL	O3 mixing ratio (ppmv)	*Free format*
VIS_FORMAT	F9.2	*Needs to accommodate valid minimum, valid maximum and the fill values*
VIS_PLOT_TYPE	NONE	*Refer to standard*
VIS_SCALE_TYPE	NONE	*Refer to standard*
VIS_SCALE_MIN	NONE	*Refer to standard*
VIS_SCALE_MAX	NONE	*Refer to standard*

3.3 Metadata updates

Minor metadata updates and clarifications have been incorporated into the original Envisat Cal/Val metadata guidelines (Bojkov *et al.*, 2002). A detailed description of these changes[a] can be found in the AVDC addendum (Bojkov *et al.*, 2006).

Table 3.3: Summary of metadata changes.

Attribute Name	Attribute Type	Change	Comment

[a] ESA has committed to synchronizing the Envisat Cal/Val metadata requirements to NASA's AVDC.

DATA_TYPE	Global Attribute	DATA_LEVEL	*New name for clarity*
DATA_FILE_VERSION	Global Attribute	Additional entry formats allowed	*Now can also describe processing version. For example v8, 5.01, etc.*
FILE_META_VERSION	Global Attribute	Requires 2 mandatory entries	*Attribute entries are the metadata version and the conversion tool name.*
VAR_MONOTONE	Variable Attribute	Removed	
VIS_SCALE_TYPE	Variable Attribute	Entry change	*If VIS_PLOT_TYPE set to NONE, then VIS_SCALE_TYPE must be set to NONE;NONE*
VIS_SCALE_MIN/MAX	Variable Attribute	Entry change	*If VIS_PLOT_TYPE set to NONE, then VIS_SCALE_MIN and VIS_SCALE_MAX must be set to NONE*

4 HDF4 Implementation

The HDF version 4 (NCSA, 2001) file formulation is limited to: 1) the global attributes containing the file metadata, and 2) the scientific data sets (SDS) model to represent each variable with appropriate variable metadata. A similar file structure has been developed by the AVDC for the HDF 5 type files. A detailed description of the AVDC HDF 4 and the HDF 5 type files is provided by Bojkov *et al.*, 2006.

5 Acronyms

AVDC	Aura Validation Data Center
DHF	NDACC Data handling Facility
DIAL	Differential Absorption LIDAR
HDF	Hierarchical Data Format
LIDAR	Light Detection And Ranging
MJD2000	Modified Julian Date 2000
NCSA	National Center for Supercomputing Applications
NDACC	Network for the Detection of Atmospheric Composition Change
NDSC	Network for the Detection of Stratospheric Change

6 Version History

20050831 Final ozone and preliminary temperature guidelines.

20060924 Final temperature guidelines, update acronym change.

20070410 Clarified the temperature reporting guidelines and corrected variable descriptor “INITIAL” to “INITIALIZATION” in Table 2.2.2.

7 References

B.R. Bojkov, De Mazière, M. and R. Koopman, Generic metadata guidelines on atmospheric and oceanographic datasets for the Envisat Calibration and Validation Project, Version 01R001, April 23, 2002.

B.R. Bojkov, Boyd, I., De Mazière, M. and R. Koopman, Addendum to the "Generic metadata guidelines on atmospheric and oceanographic datasets for the Envisat Calibration and Validation Project" as implemented by the Aura Validation Data Center (AVDC), August 31, 2006. Available for download at http://avdc.gsfc.nasa.gov/Documentation/Metadata/

NCSA, National Center for Supercomputing Applications – HDF 4 home page: http://hdf.ncsa.uiuc.edu/hdf4.html