README Document for the Creating a Long Term Multi-Sensor Ozone Data Record project

Solar Backscattered Ultraviolet
Level 3 Monthly Zonal Mean Products:

BUVN04L3zm
SBUVN07L3zm
SBUV2N09L3zm
SBUV2N11L3zm
SBUV2N14L3zm
SBUV2N16L3zm
SBUV2N17L3zm
SBUV2N18L3zm
SBUV2N19L3zm

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Revision History

Revision Date	Changes	Author
02/28/2012	Original	James E. Johnson
05/11/2012	Added new NOAA-19 Product SBUV2N19L3zm	James E. Johnson

Table of Contents

1. Introduction

This document provides basic information for using the Solar Backscattered Ultraviolet (SBUV) Level 3 Monthly Zonal Mean (MZM) products, part of the Creating a Long Term Multi-Satellite Ozone Data Record project.

1.1 Data Product Description

The SBUV Level 3 monthly zonal mean (MZM) products are derived from the Level 2 retrieved ozone profiles. The MZM data products are generated for each satellite separately and span the entire time series for that satellite. Individual satellite time series begin with the first full month and end with the last full month in the data record.

1.1.1 BUV aboard Nimbus-4

The Nimbus 4 Backscatter Ultraviolet (BUV) spectrometer experiment was designed to monitor the vertical distribution and total amount of atmospheric ozone on a global scale by measuring the intensity of UV radiation backscattered by the earth/atmosphere system during daylight, using 12 wavelengths in the 2500 to 3400 Å spectral band. The primary instrumentation consisted of a double monochromator (Ebert-Fastie type) containing all reflective optics and a photomultiplier detector. An interference filter photometer was designed to make measurements of the UV radiation in an ozone non-absorbing 50 Å band centered at 3800 Å. In the South Atlantic Anomaly (SAA) region the detector was affected by high energy particles such that data in this region near the equator are usually rejected.

The BUV instrument was launched on the Nimbus-4 spacecraft on April 8, 1970, in to a sun synchronous polar orbit at an altitude of 1100 km. BUV provided full global daylight coverage between 80°S and 80°N. The sub-satellite point at nadir crossed the equator in increments of 27 degrees in longitude between successive passes. The horizontal resolution provided by BUV was 200 km x 200 km.

The BUV instrument was operational from April 10, 1970 until May 6, 1977. In July of 1972 the solar power array on Nimbus 4 partially failed such that operation of BUV had to be curtailed. Data in the later years was increasingly sparse as the period of operation was decreased, particularly in the equatorial zone. This is reflected as sporadic zonal means in the later years.

1.1.2 SBUV aboard Nimbus-7

The Nimbus-7 Solar Backscatter Ultraviolet (SBUV) instrument consisted of a double Ebert-Fastie spectrometer and a filter photometer similar to the BUV on Nimbus 4. The SBUV spectrometer measured solar UV backscattered by the earth's atmosphere at 12 wavelengths between 255 and 340 nm, with a spectral bandpass of 1 nm. The SBUV used three detectors: a photomultiplier tube (PMT) and a photodiode for the monochromator, and one photodiode for the photometer. The addition of a chopper to the detector largely eliminated the problem of particle contamination in the SAA (South Atlantic Anomaly) that had been a problem with BUV.

SBUV was launched on the Nimbus-7 spacecraft on October 24, 1978 into a sun synchronous polar orbit at an altitude of 995 km. The equator-crossing time of Nimbus-7 was approximately 1145 initially, and drifted slightly earlier after maneuvering fuel ran out in 1984. SBUV measurements are made along the orbital track from approximately 81°S to 81°N, with orbits spaced approximately 26 degrees apart in longitude. The horizontal resolution provided by SBUV was 180 km x 180 km. The SBUV instrument was operational from October 30, 1978 until June 26, 1990, when increasing chopper errors made the data unusable.

1.1.3 SBUV/2 aboard NOAA-9, -11, -14, -16, -17, -18, and -19

The second generation Solar Backscatter Ultraviolet Radiometer (SBUV/2) instruments have been flown on the NOAA Polar-orbiting Operational Environment Satellites (POES). The SBUV/2 instruments are designed to map total ozone concentrations on a global scale, and to provide the vertical distribution of ozone in the earth's atmosphere. The instrument design is based upon the technology developed for the first SBUV flown on Nimbus 7. The SBUV/2 instrument measures backscattered solar radiation in an 11.3-degree field of view in the nadir direction at 12 discrete wavelength bands between 252.0 and 339.8 nm, with a spectral bandpass of 1.1 nm. Solar irradiance is determined at the same 12 wavelength bands by deploying a diffuser which reflects sunlight into the instrument's field of view. The SBUV/2 also measures the solar irradiance or the atmospheric radiance with a continuous spectral scan from 160 to 400 nm in increments of 0.148 nm. The SBUV/2 has another narrowband filter photometer channel, called the cloud cover radiometer (CCR), which continuously measures the earth's surface brightness at 380 nm, with a field of view of 11.3 degrees.

The NOAA series satellites are launched in Sun-synchronous polar orbits with altitudes of about 850 km. The SBUV/2 horizontal resolution is slightly smaller than Nimbus-7 SBUV (approximately 168 km x 168 km). There are about 14 orbits per day each separated by about 26 degrees at the equator. Most SBUV/2 instruments have been launched into afternoon orbits with an initial Equator-crossing time of approximately 1400 (NOAA-17 was launched into a morning orbit). These satellites drift towards later Equator-crossing times (earlier for NOAA-17)

during their mission, leading to higher solar zenith angles at all latitudes. This orbit drift affects the availability of the SBUV/2 measurements, which are only useful when the solar zenith angle is between 30 and 84 degrees. Table 1-1 lists the launch and dates that SBUV/2 measurements were used in this study. Note that NOAA-16, NOAA-17, NOAA-18, and NOAA-19 continue to operate at this time (May 2012).

Satellite	Launch	Data Measurements Used
NOAA-9	Dec. 12, 1984	Feb. 1985 – Jan. 1998
NOAA-11	Sept. 24, 1988	Jan. 1989 – Mar. 2001
NOAA-14	Dec. 30, 1994	Mar. 1995 – Sep. 2006
NOAA-16	Sept. 21, 2000	Oct. 2000 – Dec. 2011
NOAA-17	June 24, 2002	Aug. 2002 – Dec. 2011
NOAA-18	May 20, 2005	Jul. 2005 – Dec. 2011
NOAA-19	Feb. 06, 2009	Mar. 2009 – Dec. 2011

Table 1-1

1.2 Algorithm Background

Ozone retrievals are generated from the version 8.6 SBUV algorithm. A Level 3 MZM file computes zonal means covering 5 degree latitude bands for each calendar month. There are a total of 36 latitudinal bands, 18 in each hemisphere. The equator denotes a latitudinal boundary that separates the two hemispheres.

The MZM product averages retrievals that meet the criteria for a good retrieval as determined by error flags in the Level 2 data. A good retrieval is defined as satisfying the following conditions:

1) Profile Error Flag = 0 or 1 (0 = good retrieval; 1 = solar zenith angle > 84°)

2) Total Error Flags = 0, 1, 2 or 5 (0 = good retrieval; 1 = not used; 2 = solar zenith angle > 84°; large discrepancy between profile total and best total ozone)

NOTE: Total error flag = 5 is anomalously applied at high latitudes and high solar zenith angle where B-Pair total ozone estimate is not as reliable as profile under these conditions. This error flag may be removed in future version of the algorithm.

The zonal means computed for each month are screened according to the following statistical criteria:

1) number of good retrievals for the month greater than or equal to 2/3 of the samples for a nominal month

2) mean latitude of good retrievals less than or equal to 1 degree from center of latitude band

3) mean time of good retrievals less than or equal to 4 days from center of the month (i.e., day = 15)

4) data are averaged for either the ascending phase of the orbit only or the descending phase of the orbit, whichever gives the best coverage

   NOTE: nominal sampling was optimized for each satellite. The earliest satellites, in particular Nimbus-4 BUV, typically have fewer samples in a month-latitude bin than the later satellites equipped with SBUV/2 sensors. Due to the satellite orbit drift discussed in Section 1.1.3, the NOAA-9, NOAA-11, NOAA-14, and NOAA-16 satellites have crossed the terminator and changed from ascending phase to descending phase for their primary measurements. Table 1-2 lists the approximate transition date for each of these satellites.

Satellite	Terminator Crossing Date
NOAA-9	December 1990
NOAA-11	October 1995
NOAA-14	July 2002
NOAA-16	September 2009

Table 1-2

1.3 Data Disclaimer

These data were produced under the NASA MEaSUREs program. While the goal was to apply a consistent instrument-to-instrument calibration so that the data could be used for long term trend analysis, the quality of the data varies depending on the instrument. Data from NOAA 9, 11, and 14 in particular are of somewhat lower quality. Papers currently (2012) being produced should be consulted for our evaluation of the quality of the data.

The SBUV instruments are designed to provide continuous measurements of the sunlit hemisphere of the Earth. However, instrument and spacecraft problems sometimes interfere with this objective. The following list identifies intervals of three or more days where data coverage is limited or unavailable for each instrument. Note that this list does not address Nimbus-4 BUV, which has a complex operational history, particularly after July 1972.

Nimbus-7: No Northern Hemisphere descending node data due to special solar measurements.

> 1980/198 – 1980/324
>
> 1981/183 – 1981/261
>
> 1984/139 – 1984/204
>
> 1986/177 – 1986/219

NOAA-9: No data available.

> 1991/060 – 1991/090
>
> 1993/213 – 1993/243
>
> 1995/213 – 1995/258
>
> 1996/143 – 1996/170

NOAA-9: Limited longitude coverage.

> 1997/189 – 1998/050: 30-80°W at Equator
>
> 1997 (late August, early September): 100-150°E at Equator also available

NOAA-11: No data available

> 1991/060 – 1991/090
>
> 1995/100 – 1997/195

<u>NOAA-14</u>: No data available (grating drive lock-up).

1996/158 – 1996/163

1996/334 – 1996/341

1998/159 – 1998/161

2003/335 – 2003/337

<u>NOAA-18</u>: No data available (chopper wheel stalled)

2008/144 – 2008/238

2008/315 – 2008/317

A volcano contamination index (VCI) flag has been developed to identify effects in the MZM product following eruptions of El Chichón (April 1982) and Mt. Pinatubo (July 1991). The VCI flag uses the absolute value of monthly zonal mean profile ozone in layer 1 (639-1013 hPa) and the standard deviation of monthly zonal mean profile ozone values in layer 10 (10.1-16.1 hPa) as indicators of possible volcano effects in the data. This flag is currently relevant for Nimbus-7 SBUV data following the El Chichón eruption, and for NOAA-11 SBUV/2 data following the Mt. Pinatubo eruption. VCI screening for NOAA-9 SBUV/2 data after Mt. Pinatubo is more complicated because of the high solar zenith angle values observed in the near-terminator orbit at this time. It should be noted that the VCI flag is not a definitive technique, and that some NOAA-11 data do have this flag set for months prior to the Mt. Pinatubo eruption.

2. Data Organization

The products contain time-series of monthly zonal means of data from the BUV, SBUV and SBUV/2 instruments. Each individual satellite instrument is saved to its own collection or data product, with a single data file per collection.

2.1 File Naming Convention

The MZM data product files are named according to the following convention:

<Instrument>-<Satellite>_<Level>_<Version>.<Suffix>

where:
o Instrument = either BUV, SBUV or SBUV2.
o Satellite =   either Nimbus04 (for BUV), Nimbus07 (for SBUV), or one of NOAA09, NOAA11, NOAA14, NOAA16, NOAA17, NOAA18, or NOAA19 (for SBUV2)
o Level = L3zm (Level-3 zonal mean)
o Version =   product collection version in format <Major>.<Minor>-<Created> where
  1. Major = 2 digit major version (e.g. 01)
  2. Minor = 2 digit minor version (e.g. 00)
  3. Created = file creation time in format YYYYmMMDDtHHMMSS (e.g. 2012m0203t144019)
o Suffix = the file format (always h5)

```
File name example: SBUV2-NOAA18_L3zm_v01-00-2012m0203t144012.h5
```

2.2 File Format and Structure

The SBUV MZM data product files are written in HDF5 which is developed by the HDF Group, formerly the National Center for Supercomputing Applications (http://www.hdfgroup.org/). Each data file contains a single HDF5 group object (akin to a directory or folder) named Data_Fields which contains the measured parameters and ancillary information which are stored as HDF5 dataset (n-dimensional array) objects. Within each file there is a set of global attributes which define the metadata for that data product. Section 3.0 (below) describes the dimensions, global attributes, and data fields in more detail.

2.3 Key Science Data Fields

The primary science data fields are the vertical ozone profiles and mixing ratios, as well as the total column ozone. The full list of measured parameters and ancillary data fields is given in section 3.3 below.

2.3.1 Ozone Profiles (DU)

The data contain profiles of ozone (in Dobson units or DU) at 21 pressure layers: 1013.25, 639.318, 403.382, 254.517, 160.589, 101.325, 63.9317, 40.3382, 25.4517, 16.0589, 10.1325, 6.39317, 4.03382, 2.54517, 1.60589, 1.01325, 0.639317, 0.403382, 0.254517, 0.160589 and 0.101325 hPa (referenced from the bottom of the layer)

2.3.2 Ozone Mixing Ratio (ppmv)

The data contain ozone mixing ratios (in parts per million by volume or ppmv) at 15 pressure levels: 0.5, 0.7, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 7.0, 10.0, 15.0, 20.0, 30.0, 40.0 and 50.0 hPa.

2.3.3 Total Column Ozone (DU)

The data contain the total column ozone (in Dobson units or DU) measured from the surface to the top of the atmosphere. This is the sum of the profile layer amounts.
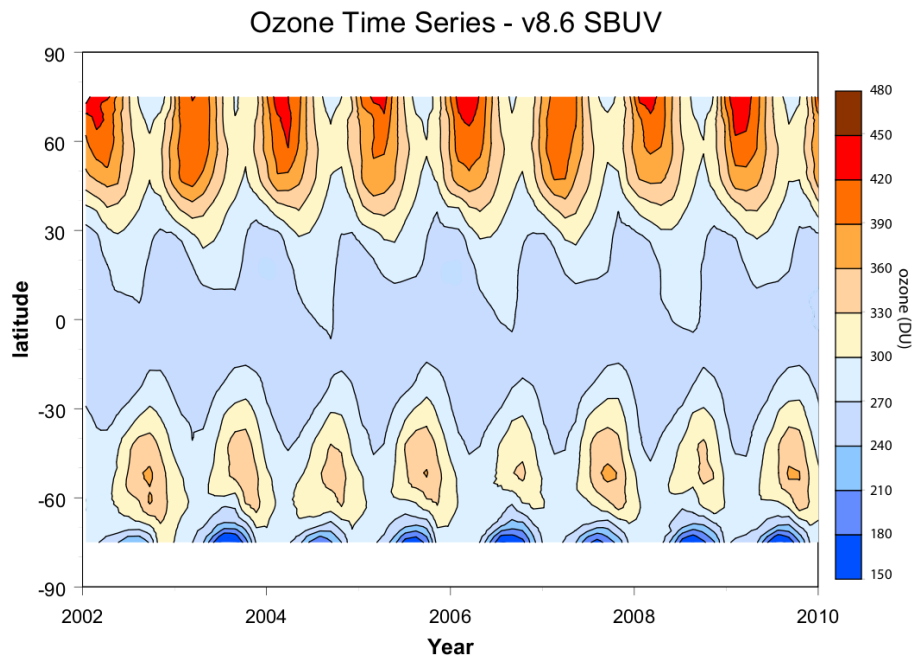

Figure 1: Zonal Mean Time Series of Total Column Ozone from SBUV/2 on NOAA-17

3. Data Contents

3.1 Dimensions

Name	Size	Description
nTimes	varies	Number of months in time series (nTimes depends on the total number of months in the time series and so is a variable).
nLats	36	Number of 5 degree latitude bands between 90S and 90N
nLevels15	15	Number of pressure levels for ozone mixing ratios, VMR
nLevels21	21	Number of pressure levels for retrieved ozone profile.
nLevels20	20	Number of pressure levels for data fields that are only calculated to 0.1 hPa. These fields do not analyze the top layer.
nChannels10	10	Maximum number of SBUV channels used in ozone retrieval. Nominal wavelengths for these channels are 252, 273, 283, 287, 292, 297, 302, 306, 313, 318 nm.

Table 3-1: List of dimensions associated with data fields.

3.2 Global Attributes

Name	Type	Size	Description
CalibrationVersion	STRING	Scalar	Version number for soft calibration (e.g., C7)
CollectionVersion	STRING	Scalar	Collection Version Number
ContactPersonName	STRING	Scalar	Name of Responsible Person, Richard McPeters
ContactPersonRole	STRING	Scalar	Principle Investigator for this MEaSUREs Program
ContactPersonLocation	STRING	Scalar	NASA Goddard Space Flight Center
ContactPersonEmail	STRING	Scalar	Email address of contact person, richard.d.mcpeters@nasa.gov
CreationDate	STRING	Scalar	Day, month, time, time zone (EDT) and year assigned to creation of hdf file.
EastBoundingLongitude	32-BIT FLOAT	1	East bounding longitude value, 180 degrees.
InstrumentShortName	STRING	Scalar	Acronym for instrument (SBUV2, SBUV for older instruments)
L2AlgorithmVersionNumber	STRING	Scalar	The version number of SBUV Level 2 retrieval algorithm (Version 8.6.0)

LocalGranuleID	STRING	Scalar	name of file
LocalityValue	STRING	Scalar	Actual is "Global."
LongName	STRING	Scalar	The ESDT Long Name for the product (e.g., "SBUV2/NOAA-17 Ozone (O3) Profile and Total Column Ozone Monthly L3 Global 5.0deg Lat Zones")
NorthBoundingLatitude	32-BIT FLOAT	1	Northernmost latitude (90)
ParameterName	STRING	Scalar	Nadir Profile and Total Column Ozone
ProductType	STRING	Scalar	L3 Monthly Zonal Mean
RangeBeginningDate	STRING	Scalar	First Date Record in time series denoting beginning year and month of zonal mean time series
RangeBeginningTime	STRING	Scalar	First Time Record in time series denoting beginning time of zonal mean time series
RangeEndingDate	STRING	Scalar	Last Date Record in time series denoting ending Year and month of zonal mean time series
RangeEndingTime	STRING	Scalar	Last Time Record in time series denoting ending time of zonal mean time series
Satellite	STRING	Scalar	Name of Satellite (e.g., NOAA 17)
SensorShortName	STRING	Scalar	Double Monochrometer
ShortName	STRING	Scalar	The short name of the product (e.g., "SBUV2N17L3zm")
SoftwareDeveloper	STRING	Scalar	Developer of Level 3 Zonal Mean Software (Brad Fisher)
SouthBoundingLatitude	32-BIT FLOAT	1	Southernmost latitude (-90 degrees)
VerticalCoordinate	STRING	Scalar	Pressure (hPa)
WestBoundingLongitude	32-BIT FLOAT	1	West bounding longitude value, -180 degrees.
ZonalSpacing	32-BIT FLOAT	1	5
ZonalSpacingUnit	STRING	Scalar	Degrees
numLatBands	16-BIT SIGNED INTEGER	1	Number of Latitude Bands, 36
numPresLevels	16-BIT SIGNED INTEGER	1	Number of Pressure Levels for Ozone Profile, 21
numTimes	16-BIT SIGNED INTEGER	1	Number of months in zonal mean time series

Table 3-2: Global metadata attributes associated with the file.

3.3 Data Fields

Name	AprioriProfileOzone			
Type	32-BIT FLOAT			
Dimensions	nTimes x nLats x nLevels21			
Description	The 21 layer a priori ozone profile averaged for each month and 5 latitude band.			
Attributes				
Name	Type	Size	Value	
units	STRING	Scalar	DU	
long_name	STRING	Scalar	Mean 21 Layer A Priori Ozone Profile	
_FillValue	32-BIT FLOAT	1	-9999.0	

Name	AprioriTotalColumnOzone			
Type	32-BIT FLOAT			
Dimensions	nTimes x nLats			
Description	The mean a priori column ozone between the surface and the TOA, averaged for each month over a 5 degree latitude band.			
Attributes				
Name	Type	Size	Value	
units	STRING	Scalar	DU	
long_name	STRING	Scalar	Mean 21 Layer A Priori Total Column Ozone	
_FillValue	32-BIT FLOAT	1	-9999.0	

Name	Date			
Type	32-BIT SIGNED INTEGER			
Dimensions	nTimes			
Description	Year and Month in format YYYYMM			
Attributes				
Name	Type	Size	Value	
units	STRING	Scalar	NoUnits	
long_name	STRING	Scalar	Year and Month in format yyyymm	
_FillValue	32-BIT SIGNED INTEGER	1	-9999	

Name	IntegratingKernelProfile			
Type	32-BIT FLOAT			
Dimensions	nTimes x nLats x nLevels20 x nLevels20			
Description	Mean averaging kernel averaged for each month and 5 latitude band. It is computed from the surface (layer 1) up to layer 20.			
Attributes				
Name	Type	Size	Value	
units	STRING	Scalar	NoUnits	
long_name	STRING	Scalar	Integrating Kernel for layers 1 to 20	
_FillValue	32-BIT FLOAT	1	-9999.0	

Name	IntegratingKernelTotalColumn		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats x nLevels20		
Description	Mean column ozone averaging kernel computed for each month and 5 degree latitude band, computed from the surface (layer 1) up to layer 20.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	NoUnits
long_name	STRING	Scalar	Column Integrating Kernel
_FillValue	32-BIT FLOAT	1	-9999.0

Name	JacobianDNDX		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats x nLevels20 x nChannels10		
Description	Change in N-value with respect to change in layer ozone. Each value represents the Jacobian averaged for a given month and 5 degree latitude band.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	DU^-1
long_name	STRING	Scalar	Mean DN/DX Jacobian for channels 1 thru 10 and layers 1 to 20
_FillValue	32-BIT FLOAT	1	-9999.0

Name	Latitude		
Type	32-BIT FLOAT		
Dimensions	nLats		
Description	Center of Latitude Band for Zonal Mean		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	degrees_north
long_name	STRING	Scalar	Center of Latitude for Zonal Mean
_FillValue	32-BIT FLOAT	1	-9999.0
valid_max	32-BIT FLOAT	1	90.0
valid_min	32-BIT FLOAT	1	-90.0

Name	LocalStandardTime		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	Mean Local time during overpass		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	hour
long_name	STRING	Scalar	Local Standard Time
_FillValue	32-BIT FLOAT	1	-9999.0
valid_max	32-BIT FLOAT	1	24.0
valid_min	32-BIT FLOAT	1	0.0

Name	MixingRatioPressureLevels		
Type	32-BIT FLOAT		
Dimensions	nLevels15		
Description	Mid-Level Pressure for Mixing Ratio 15-Layer Vertical Pressure Scale. The actual values are 0.5, 0.7, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 7.0, 10.0, 15.0, 20.0, 30.0, 40.0 and 50.0 hPa.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	hPa
positive	STRING	Scalar	down
long_name	STRING	Scalar	Mid-Level Pressure for Mixing Ratio 15-Layer Vertical Pressure Scale
_FillValue	32-BIT FLOAT	1	-9999.0
valid_max	32-BIT FLOAT	1	50.0
valid_min	32-BIT FLOAT	1	0.5

Name	OrbitMode		
Type	16-BIT SIGNED INTEGER		
Dimensions	nTimes		
Description	Satellite orientation at equator crossing (ascending = 1, descending = -1 or terminator = 0)		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	noUnits
long_name	STRING	Scalar	Satellite orientation at equator crossing (Ascending = 1, descending = -1 or terminator = 0)
_FillValue	16-BIT SIGNED INTEGER	1	-9999

Name	ProfileOzone		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats x nLevels21		
Description	The 21 layer retrieved ozone profile averaged for a given month and 5 degree latitude band.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	DU
long_name	STRING	Scalar	Mean 21 Layer Retrieved Ozone Profile
_FillValue	32-BIT FLOAT	1	-9999.0

Name	ProfileOzoneStdev		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats x nLevels21		
Description	The 21 layer retrieved ozone profile standard deviation averaged for a given month and 5 degree latitude band.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	DU
long_name	STRING	Scalar	Mean 21 Layer Retrieved Ozone Profile Standard Deviation
_FillValue	32-BIT FLOAT	1	-9999.0

Name	ProfilePressureLevels
Type	32-BIT FLOAT
Dimensions	nLevels21
Description	21 Bottom Level Pressure Level Scale for Retrieved Ozone Profiles. The actual values are 1013.25, 639.318, 403.382, 254.517, 160.589, 101.325, 63.9317, 40.3382, 25.4517, 16.0589, 10.1325, 6.39317, 4.03382, 2.54517, 1.60589, 1.01325, 0.639317, 0.403382, 0.254517, 0.160589 and 0.101325 hPa.

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	hPa
positive	STRING	Scalar	down
long_name	STRING	Scalar	Bottom Level Pressures for 21-Layer Vertical Pressure Scale
_FillValue	32-BIT FLOAT	1	-9999.0
valid_max	32-BIT FLOAT	1	1013.25
valid_min	32-BIT FLOAT	1	0.101325

Name	SmoothingErrorProfile
Type	32-BIT FLOAT
Dimensions	nTimes x nLats x nLevels20
Description	Smoothing Error for month and 5 degree latitude band from layer 1 to layer 20.

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	Smoothing Error for Ozone Profile for layers 1 to 20
_FillValue	32-BIT FLOAT	1	-9999.0

Name	SmoothingErrorTotalColumn
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	Smoothing Error for month and 5 degree latitude band for total column ozone.

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	%
long_name	STRING	Scalar	Mean Smoothing Error for Total Column Ozone
_FillValue	32-BIT FLOAT	1	-9999.0

Name	SolarZenithAngle
Type	32-BIT FLOAT
Dimensions	nTimes x nLats
Description	Mean Solar Zenith Angle.

Attributes			
Name	Type	Size	Value
units	STRING	Scalar	degrees
long_name	STRING	Scalar	Mean Solar Zenith Angle
_FillValue	32-BIT FLOAT	1	-9999.0

valid_max	32-BIT FLOAT	1	88.0
valid_min	32-BIT FLOAT	1	0.0

Name	Time		
Type	32-BIT FLOAT		
Dimensions	nTimes		
Description	Fractional Year based on day 15 of the month (year + Julian_Day/365), where Julian_Day = [15,45,74,105,135,166,196,227,258,290,321,351].		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	year
long_name	STRING	Scalar	Time
_FillValue	32-BIT FLOAT	1	-9999.0

Name	TotalColumnOzone		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	Mean Retrieved Total Column Ozone.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	DU
long_name	STRING	Scalar	Mean Retrieved Total Column Ozone
_FillValue	32-BIT FLOAT	1	-9999.0

Name	TotalColumnOzoneStdev		
Type	32-BIT FLOAT		
Dimensions	nTimes x nLats		
Description	Retrieved Total Column Ozone Standard Deviation.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	DU
long_name	STRING	Scalar	Retrieved Total Column Ozone Standard Deviation
_FillValue	32-BIT FLOAT	1	-9999.0

Name	TotalCovarianceMatrix		
Type	32-BIT FLOAT		
Dimensions	nLevels20 x nLevels20 x nLats		
Description	Covariance matrix of an ensemble of states about the mean state. The total covariance matrix relates changes in a layer to changes in other 20 layers in the profile.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	DU^2
long_name	STRING	Scalar	Total Covariance Matrix for layers 1 to 20 (covariance matrix of an ensemble of states about the mean state)
_FillValue	32-BIT FLOAT	1	-9999.0

Name	VCI			
Type	16-BIT SIGNED INTEGER			
Dimensions	nTimes x nLats			
Description	Data Quality Flag Designating Periods Affected by volcanic eruptions.			
Attributes				
	Name	Type	Size	Value
	units	STRING	Scalar	noUnits
	long_name	STRING	Scalar	Volcano Contamination Index Designating Periods Affected by Volcanic Eruptions (0 = unaffected, 1 = affected)
	_FillValue	16-BIT SIGNED INTEGER	1	-9999

Name	VolumeMixingRatio			
Type	32-BIT FLOAT			
Dimensions	nTimes x nLats x nLevels15			
Description	Mean 15 Layer Retrieved Mixing Ratios at 0.5, 0.7, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 7.0, 10,0, 15.0, 20.0, 30.0, 40.0, 50.0			
Attributes				
	Name	Type	Size	Value
	units	STRING	Scalar	ppmv
	long_name	STRING	Scalar	Mean 15 Layer Retrieved Mixing Ratios
	_FillValue	32-BIT FLOAT	1	-9999.0

Name	VolumeMixingRatioStdev			
Type	32-BIT FLOAT			
Dimensions	nTimes x nLats x nLevels15			
Description	VMR estimates for ozone concentrations at 15 pressure levels.			
Attributes				
	Name	Type	Size	Value
	units	STRING	Scalar	ppmv
	long_name	STRING	Scalar	Mean 15 Layer Retrieved Mixing Ratio Standard Deviation
	_FillValue	32-BIT FLOAT	1	-9999.0

Name	Wavelength			
Type	16-BIT SIGNED INTEGER			
Dimensions	nChannels10			
Description	Nominal SBUV Wavelengths used in retrieval (actual number of channels used can vary from 7 to 10 depending on latitude and TO3).			
Attributes				
	Name	Type	Size	Value
	units	STRING	Scalar	nm
	long_name	STRING	Scalar	Nominal SBUV Wavelengths used in retrieval (actual number of channels used can vary from 7 to 10 depending on latitude and TO3)
	_FillValue	16-BIT SIGNED INTEGER	1	-9999

Name	nSamples		
Type	16-BIT SIGNED INTEGER		
Dimensions	nTimes x nLats		
Description	Number of Good Retrievals used to compute zonal mean. It represents the number of samples per month per 5 deg. zonal mean.		
Attributes			
Name	Type	Size	Value
units	STRING	Scalar	noUnits
long_name	STRING	Scalar	Number of Good Retrievals Used in Mean
_FillValue	16-BIT SIGNED INTEGER	1	-9999

Table 3-3: Data fields are located under the HDF5 group object named Data_Fields. No scale factors are applied to the data fields.

4. Options for Reading the Data

There are many tools and visualization packages (free and commercial) for viewing and dumping the contents of HDF5 files. Libraries are available in several programming languages for writing software to read HDF5 files. A few simple to use command-line and visualization tools, as well as programming languages for reading the MZM HDF5 data files are listed in the sections below. For a comprehensive list of HDF5 tools and software, please see the HDF Group's web page at http://www.hdfgroup.org/products/hdf5_tools/.

4.1 Command Line Utilities

4.1.1 h5dump (free)

The h5dump tool, developed by the HDFGroup, enables users to examine the contents of an HDF5 file and dump those contents, in human readable form, to an ASCII file, or alternatively to an XML file or binary output. It can display the contents of the entire HDF5 file or selected objects, which can be groups, datasets, a subset of a dataset, links, attributes, or datatypes. The h5dump tool is included as part of the HDF5 library, or separately as a stand-alone binary tool at:

http://www.hdfgroup.org/HDF5/release/obtain5.html

4.1.2 ncdump (free)

The ncdump tool, developed by Unidata, will print the contents of a netCDF or compatible file to standard out as CDL text (ASCII) format. The tool may also be used as a simple browser, to display the dimension names and lengths; variable names, types, and shapes; attribute names and values; and optionally, the values of data for all variables or selected variables. To view HDF5 data files, version 4.1 or higher is required. The ncdump tool is included with the netCDF library. **NOTE: you must include HDF5 support during build.**

http://www.unidata.ucar.edu/downloads/netcdf/

4.1.3 H5_PARSE (IDL/commercial)

The H5_PARSE function recursively descends through an HDF5 file or group and creates an IDL structure containing object information and data values. You must purchase an IDL package, version 8 or higher, to read the MZM HDF5 data files.

http://www.exelisvis.com/language/en-US/ProductsServices/IDL.aspx

4.2 Visualization Tools

4.2.1 HDFView (free)

HDFView, developed by the HDFGroup, is a Java-based graphic utility designed for viewing and editing the contents of HDF4 and HDF5 files. It allows users to browse through any HDF file, starting with a tree view of all top-level objects in an HDF file's hierarchy. HDFView allows a user to descend through the hierarchy and navigate among the file's data objects. Editing features allow a user to create, delete, and modify the value of HDF objects and attributes. For more info see:

http://www.hdfgroup.org/hdf-java-html/hdfview/

4.2.2 Panoply (free)

Panoply, developed at the Goddard Institute for Space Studies (GISS), is a cross-platform application which plots geo-gridded arrays from netCDF, HDF and GRIB dataset required. The tool allows one to slice and plot latitude-longitude, latitude-vertical, longitude-vertical, or time-latitude arrays from larger multidimensional variables, combine two arrays in one plot by differencing, summing or averaging, and change map projections. One may also access files remotely into the Panoply application.

http://www.giss.nasa.gov/tools/panoply/

4.2.3 H5_BROWSER (IDL/commercial)

The H5_BROWSER function presents a graphical user interface for viewing and reading HDF5 files. The browser provides a tree view of the HDF5 file or files, a data preview window, and an information window for the selected objects. The browser may be created as either a selection dialog with Open/Cancel buttons, or as a standalone browser that can import data to the IDL main program. You must purchase an IDL package, version 8 or higher to view the MZM HDF5 data files.

http://www.exelisvis.com/language/en-US/ProductsServices/IDL.aspx

4.3 Programming Languages

Advanced users may wish to write their own software to read HDF5 data files. The following is a list of available HDF5 programming languages:

Free:

      C/C++ (http://www.hdfgroup.org/HDF5/release/obtain5.html)

      Fortran (http://www.hdfgroup.org/HDF5/release/obtain5.html)

      Java (http://www.hdfgroup.org/hdf-java-html/)

      Python (http://alfven.org/wp/hdf5-for-python/)

      GrADS (http://www.iges.org/grads/)

Commercial:

      IDL (http://www.exelisvis.com/language/en-US/ProductsServices/IDL.aspx)

      Matlab (http://www.mathworks.com/products/matlab/)

5. Data Services

5.1 Mirador

The GES DISC provides basic temporal and advanced (event) searches through its Mirador search and download engine:

http://mirador.gsfc.nasa.gov/

Mirador offers various download options that suit users with different preferences and different levels of technical skills. Users can start from a point where they don't know anything about these particular data, its location, size, format, etc., and quickly find what they need by just providing relevant keywords, such as a data product (e.g. "SBUV2N09L3zm"), or a parameter such as "ozone".

5.2 OPeNDAP

The Open Source Project for a Network Data Access Protocol (OPeNDAP) provides remote access to individual variables within datasets in a form usable by many OPeNDAP enabled tools, such as Panoply, IDL, Matlab, GrADS, IDV, McIDAS-V, and Ferret. Data may be subsetted dimensionally and downloaded in an ASCII, netCDF3 or binary (DAP) format. The GES DISC offers the SBUV MZM data products through OPeNDAP:

http://measures.gsfc.nasa.gov/opendap/Ozone/contents.html

6. More Information

6.1 Web Resources

For other ozone and related data, please search NASA's Global Change Master Directory at http://gcmd.nasa.gov.

6.2 Point of Contact

Name: GES DISC Help Desk

URL: http://disc.gsfc.nasa.gov/

E-mail: gsfc-help-disc@lists.nasa.gov

Phone: 301-614-5224

Fax: 301-614-5228

Address: Goddard Earth Sciences Data and Information Services Center

Attn: Help Desk

Code 610.2

NASA Goddard Space Flight Center

Greenbelt, MD 20771, USA

7. Acknowledgements

References

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http://www.ncdc.noaa.gov/oa/pod-guide/ncdc/docs/klm/html/c9/sec97-2.htm

"Solar Backscattered Ultraviolet Radiometer (SBUV) Operational Ozone Product System Version 8 Interface Control Document", Prepared by Qiang Zhao and Joel Selekof, Version 1.0, December 2006
http://www.star.nesdis.noaa.gov/smcd/spb/ozone/documents/SBUV_V8_ICD.pdf

"Solar Backscatter Ultraviolet Instrument (SBUV/2) Version 8 Ozone Retrieval Algorithm Theoretical Basis Document (V8 ATBD)", Edited by Lawrence Flynn, Revised February 2, 2007
ftp://www.orbit.nesdis.noaa.gov/pub/smcd/spb/ozone/docs/SBUV2_V8_ATBD_020207.pdf

Nimbus-4 User's Guide, 1970, Edited by R. R. Sabatini for The Nimbus Project, Section 7, NASA Goddard Space Flight Center, Greenbelt, MD, USA

Nimbus-7 User's Guide, 1978, Edited by C. R. Madrid for The Landsat/Nimbus Project, Section 7, NASA Goddard Space Flight Center, Greenbelt, MD, USA.