National Aeronautics and Space Administration Goddard Earth Science Data Information and Services Center (GES DISC)

README Document for Global Ammonia Retrievals from AIRS (Advanced InfraRed Sounder) Satellite Measurements

Last Revised February 1, 2019

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Revision History

Revision Date	***Changes***	***Author***

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1.0 Introduction

This document provides information to read the Global Ammonia Retrievals from AIRS Satellite Measurements products.

The mass concentration ammonia in the atmosphere, consists of products generated for the study of atmospheric ammonia. Atmospheric ammonia is an important component of the global nitrogen cycle. In the troposphere, ammonia reacts rapidly with acids such as sulfuric and nitric to form fine particulate matter. These ammonium containing aerosols affect Earth's radiative balance, both directly by scattering incoming radiation and indirectly as cloud condensation nuclei. Major sources of atmospheric ammonia involve agricultural activities including animal husbandry, especially concentrated animal feeding operations and fertilizer use. Major sinks of atmospheric ammonia involve dry deposition and wt removal by precipitation, as well as conversion to particulate ammonium by reaction with acids. Measurements of ambient NH_3 are sparse, but satellites provide a means to monitor atmospheric composition globally. Using the AIRS/AMSU satellite this algorithm provides monthly measurements of derived atmospheric NH_3 for September 2002 through August 2016. The dataset has the name of AIRSAC3MNH3.

1.1 Dataset/Mission Instrument Description

The Global Ammonia Retrievals from AIRS (Advanced InfraRed Sounder) Satellite Measurements User Guide provides additional information related to the instrument and algorithm used to produce this dataset.

1.2 Data Disclaimer

The current global data products are for daytime over land. The data products are released to the public as is.

1.2.1 Data Citations and Acknowledgment

Warner, J. X., Z. Wei, L. L. Strow, R. R. Dickerson, and J. B. Nowak (2016), The global tropospheric ammonia distribution as seen in the 13-year AIRS measurement record, Atmos. Chem. Phys., 16, 5467-5479, https://doi.org/10.5194/acp-16-5467-2016

The GESDIS would appreciate receiving an electronic copy of your publication, which can be sent via email to (gsfc-dl-help-disc@mail.nasa.gov).

Or it can be forwarded to the following address:

Goddard Earth Sciences DISC Help Desk
Code 610.2
NASA/Goddard Space Flight Center

1.2.2 Contact Information

Inquiries regarding the data product can be directed to Juying X. Warner juying@atmos.umd.edu.

1.3 What's New?

Warner et al. (2016; 2017) used V2 of this algorithm and the current data have been updated to V3. The main difference is that the correlation between a layer above 500 hPa and a layer below is removed. This is because there is very little ammonia information above 500 hPa level in the current algorithm. We also updated AIRS L2 profiles noises, using the same V6 L2 profiles.

2.0 Data Organization

The data consists of monthly 1 degree latitude by 1 degree longitude globally gridded level-3 products. The data consists of daytime land only values.

2.1 File Naming Convention

The AIRSAC3MNH3 monthly files follow the following naming convention:

AIRS_NH3_VMR.*mmm.yyyy***.*V3.nc***

Where:
mmm = 3 character abbreviation for the month
yyyy = 4 digit year number [2002 to 2016]

Filename example: AIRS_NH3_VMR_jul.2006.V3.nc

2.2 File Format and Structure

The AIRSAC3MNH3 monthly files are in NetCDF-4 format. NetCDF is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data that was developed by UCAR/Unidata (http://doi.org/10.5065/D6H70CW6) https://www.unidata.ucar.edu/software/netcdf/.

2.3 Key Science Data Fields

The primary data set is nh3_vmr which is the volume mixing ratio of ammonia in air in the units of mol/mol.

3.0 Data Contents

3.1 Data Set Attributes (File Metadata)

In addition to SDS arrays containing variables and dimension scales, global metadata is also stored in the files. Some metadata are required by standard conventions, some are present to meet data provenance requirements and others as a convenience to users of AIRSAC3MNH3 and AIRSAC3DNH3 products.

Global Attribute	Description	Type
title	basic title for dataset	string
comment	data producers and instrument used. This data are produced by Drs. Juying Warner and Zigang Wei using measurements from the AIRS instrument	string
keywords	relevant science keywords: EARTH SCIENCE > ATMOSPHERE > Atmospheric	string

Global Attribute	Description	Type
	Chemistry > Ammonia	
source	source for data: Aqua AIRS AMSU	string
shortname	GES DISC dataset name: AIRSAC3MNH3	string
longname	AIRS AMSU NH3 Volume Mixing Ratio L3 grid from NASA Aqua v03 (AIRSAC3MNH3) at GES DISC	string
format	data format: netCDF	string
versionid	data set version number: 3	string
rangebeginningdate	start date in yyymmdd format	string
rangebeginningtime	start time in hh:mm:ss:fraction format	string
rangeendingdate	endding date in yyymmdd format	string
rangeendingtime	endding time in hh:mm:ss:fraction format	string
identifierproductdoiauthority	DOI number: http://dx.doi.org/10.5067/06YIT7GX74FN	string
processing_level	processing level [0 through 4]: 3	string
product_start_date_time	yyyy-mm-dd hh:mm:ss	string
product_end_date_time	yyyy-mm-dd hh:mm:ss	string
product_name_type_id	processing level: L3	string
acknowledgment	Support for this research was provided by NASA HQ through ROSES: NNX12AJ05G, NNX14AJ24G, and NNX16AQ67G	string
instrument	Aqua AIRS AMSU	string
product_name_extension	type of data: nc	string
featuretype	grid	string
data_structure	grid	string

Global Attribute	Description	Type
summary	The Level-3 monthly mean ammonia VMRs in daytime and over land, derived using the measurements from the AIRS and AMSU instruments on the NASA Aqua platform.	string
contributor_name	Dr. Juying Warner, University of Maryland, College Park, MD	string
contributor_role	Research PI	string
creator_name	NASA/GSFC GES DISC	string
history	AIRS ammonia from Sep. 2002 through Aug. 2016	string
creator_email	gsfc-dl-help-disc@mail.nasa.gov	string
creator_url	http://disc.gsfc.nasa.gov/	string
institution	NASA GSFC GES DISC	string
metadata_link	http://disc.sci.gsfc.nasa.gov/	string
references	Warner, J. X., R. R. Dickerson, Z. Wei, L. L. Strow, Y. Wang, and Q. Liang (2017), Increased atmospheric ammonia, over the world's major agricultural areas detected from space, Geophys. Res. Lett., 44, doi:10.1002/2016GL072305 Warner, J. X., Z. Wei, L. L. Strow, R. R. Dickerson, and J. B. Nowak (2016), The global tropospheric ammonia distribution as seen in the 13-year AIRS measurement record, Atmos. Chem. Phys., 16, 5467-5479,https://doi.org/10.5194/acp-16-5467-2016	string
doi	10.5067/06YIT7GX74FN	

3.2 Data Dimensions

Global Attribute	Description	Dimensions

time	seconds since 1970-01-01 00:00:00Z	1
latitude	latitude of the center of the cell, starting at -89.5, by 1 degree increments	180
longitude	longitude of the center of the cell, latitude starting at -179.5, by 1 degree increments	360
press_level	atmospheric pressure in hPa.	12 levels at the following pressures: 506.1, 545.1, 606.8, 650.1, 695.0, 741.7, 790.0, 840.0, 891.7, 918.1, 945.0, and 972.3
ntime	time_bnds array dimension	2

4.0 Products/Parameters

4.1 Data Fields

Data Field Name	Longname/Description	Type	Dimensions	Undefined Value	Units
nh3_vmr	NH3 volume mixing ratio	32-bit floating-point	(time, lat, lon,press_level)	-999.9	mol/mol, number of moles of ammonia per mole of air
lat	latitude, latitude starting at -89.5, by 1 degree increments	32-bit floating-point	lat (180)		degrees_north

Data Field Name	Longname/Description	Type	Dimensions	Undefined Value	Units
lon	longitude, longitude starting at -179.5, by 1 degree increments	32-bit floating-point	lon (360)		degrees_east
time	time_bnds	64-bit floating-point	time (1)		seconds since 1970-01-01 00:00:00Z
press_level	atmospheric layer equivalent pressure	32-bit floating-point	press_level (12)		hPa
time_bnds	start and end time of the month, in seconds since 1970-01-01 00:00:00Z	64-bit floating-point	ntime (2)		seconds since 1970-01-01 00:00:00Z

4.2 Fill Values

Variable Type	Fill Value
float	-999.9

5.0 Options for Reading the Data

5.1 Command Line Utilities

5.1.1 ncdump

The ncdump tool can be used as a simple browser for HDF data files, to display the dimension names and sizes; variable names, types, and shapes; attribute names and values; and optionally,

the values of data for all variables or selected variables in a netCDF file. The most common use of ncdump is with the –h option, in which only the header information is displayed.

ncdump [-c|-h] [-v ...] [[-b|-f] [c|f]] [-l len] [-n name] [-d n[,n]] filename
Options/Arguments:
[-c] Coordinate variable data and header information
[-h] Header information only, no data
[-v var1[,...]] Data for variable(s) <var1>,... only data
[-f [c|f]] Full annotations for C or Fortran indices in data
[-l len] Line length maximum in data section (default 80)
[-n name] Name for netCDF (default derived from file name)
[-d n[,n]] Approximate floating-point values with less precision filename File name of input netCDF file
(https://www.unidata.ucar.edu/software/netcdf/workshops/2011/utilities/Ncdump.html)

5.1.2 HDFView

HDFView is a Java based graphical user interface created by the HDF Group which can be used to browse HDF files. The utility allows users to view all objects in an HDF file hierarchy which is represented as a tree structure. Additional information about HDFView can be found at https://support.hdfgroup.org/products/java/hdfview/ and for HDF at https://portal.hdfgroup.org/display/support

5.2 Tools/Programming

The product files can be read and queried using the NetCDF4 library and tools maintained by Unidata (http://www.unidata.ucar.edu/software/netcdf/). Support for reading NetCDF is offered in many programming languages, including Python, Matlab, IDL, C/C++ and Fortran. NetCDF4 files are legal HDF5 files with additional bookkeeping information managed by the NetCDF4 library. It is therefore possible to inspect and copy data out of the NetCDF4 files by using the HDF5 utilities and libraries maintained by the HDF Group (https://www.hdfgroup.org/products/hdf5_tools/index.html) or by using the HDF5 interface in your favorite programming language. However, the two libraries should not be considered fully interchangeable.

Matlab users should note that the Matlab NetCDF4 interface is currently (as of version R2017a) not able to read attributes that are string arrays, and will throw an exception if that is attempted.

5.2.1 Python

The following python code snippet shows how to read the variable lat, lon, and nh3_vmr from the dataset with the name “filename”. Also shown are some basic information about the size of the variables arrays.

```
import netCDF4
from netCDF4 import Dataset

nc_fid = netCDF4.Dataset( filename ,mode='r',format='NETCDF4')

#read in the variables
lat = nc_fid.variables['lat'][:]
lon = nc_fid.variables['lon'][:]
nh3 = nc_fid.variables['nh3_vmr'][:]
press = nc_fid.variables['press_level'][:]

# print out the minimum, maximum, and dimensions for the three variables
print("-- lat  Min/Max values", lat[:].min(), lat[:].max())
print("lat.shape:", lat.shape)
print("-- lon Min/Max values:", lon[:].min(), lon[:].max())
print("lon.shape:", lon.shape)
print("-- nh3 Min/Max values:", nh3[:].min(), nh3[:].max())
print("nh3.shape:", nh3.shape)
print("-- Min/Max values:", press[:].min(), press[:].max())
print("press.shape:", press.shape)
```

6.0 GES DISC Data Services

If you need assistance or wish to report a problem:
Email: gsfc-dl-help-disc@mail.nasa.gov
Voice: 301-614-5224
Fax: 301-614-5268
Address:
Goddard Earth Sciences Data and Information Services Center NASA Goddard Space Flight Center Code 610.2 Greenbelt, MD 20771 USA

6.1 How To Articles

The GES DISC web site contains many informatiative articles under the “How To Section”, “FAQ” (frequently asked questions), “News”, “Glossary”, and “Help” . A sample of these articles

includes:

Earthdata Login for Data Access

How to Download Data Files from HTTPS Service with wget

How to Obtain Data in NetCDF Format via OpeNDAP

Quick View Data with Panoply

How to Read Data in NetCDF Format with R

How to Read Data in HDF-5 or netCDF Format with GrADS

How to read and plot NetCDF MERRA-2 data in Python

How to Subset Level-2 Data

How to use the Level 3 and 4 Subsetter and Regridder

7.0 Acknowledgments

Support for this research was provided by NASA HQ through ROSES proposals: NNX12AJ05G, NNX14AJ24G, and NNX16AQ67G.

8.0 References

Warner, J., Carminati, F., Wei, Z., Lahoz, W., and Attié, J.-L.: Tropospheric carbon monoxide variability from AIRS under clear and cloudy conditions, Atmos. Chem. Phys., 13, 12469–12479, doi:10.5194/acp-13-12469-2013, 2013.

Warner, J. X., Z. Wei, L. L. Strow, R. R. Dickerson, and J. B. Nowak (2016), The global tropospheric ammonia distribution as seen in the 13-year AIRS measurement record, Atmos. Chem. Phys., 16, 5467-5479, https://doi.org/10.5194/acp-16-5467-2016

Warner, J. X., R. R. Dickerson, Z. Wei, L. L. Strow, Y. Wang, and Q. Liang (2017), Increased atmospheric ammonia over the world's major agricultural areas detected from space, Geophys. Res. Lett., 44, doi:10.1002/2016GL072305.