File Revision Date:
September 20, 2019
This file to be modified as re-analysis or new analysis results are available

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NDACC METAFILE FOR JPL TROPOSPHERIC OZONE LIDAR at Table Mountain, Calif. (TMF)

- Applies to instrument and data history from 01-Jan-1989 to 19-Sep-2019
- PLEASE READ IMPORTANT 2019 UPDATE AT THE BOTTOM OF THIS FILE
- The above period covers analyzed and (re-)analyzed data sets available at this time
- Applies to TMF tropopsheric ozone data processed with LidAna version v5.15 or later, and GLASS v1.0 or later
- Does NOT apply to TMF data processed with older program versions, namely v5.00 or SO3ANL
- Does NOT apply to TMF stratospheric ozone data (see other meta data file for that)
- Applies to all Ames files cataloged on NDACC database with the following names:
  tmtoYYMM.mdl
  tmtoYYMM.tll
- Refer to "Reported Events" section for detailed report of unexpected problems
- This file to be modified as re-analysis or new analysis results are available

- ***** See metafile "TMF_aot_ldr_jpl_2019.txt" for stratospheric ozone system and data *****

Data Set Description:

PI: T. Leblanc (before 2013: I. Stuart McDermid)
Instrument: Lidar
Site(s): Table Mountain Observatory, CA, USA
Measurement Quantity:Tropospheric Ozone

Contact Information:

Name: Thierry Leblanc (TL)
Address: Jet Propulsion Laboratory
Table Mountain Facility
P.O. Box 367, Wrightwood, CA 92397-367
Phone: W: (760) 249-1070 C: (818) 468-2708
FAX: (760) 249-5392
Email: thierry.leblanc@jpl.nasa.gov

Reference Articles:

Please refer to the file named "jpl_publications_2000.txt" for publications list.

Instrument Description:

- DIAL tropospheric ozone lidar with 4 Rayleigh channels (2 pairs at 289/299 nm)
- Ozone profiles between 3-20 km

- Extended ozone profiles (3-28 km) when using 355 nm Intensity channel from co-located water vapor or stratospheric lidar (hybrid DIAL)
- Please refer to the publications list for more details

Description of Algorithms:

I - LidAna 5.xx and LidAna 6.xx (1999 - 2018)

Temperature/ozone/aerosol analysis program LidAna v5.xx, by Thierry Leblanc (TL) first released in June 1999. LidAna v5.00 (in IDL) replaced the old FORTRAN analysis program SO3ANL v4.62 by Eric Sirko. This v5.00 no longer used.

LidAna data processor is manual processing, using 20+ keywords tailored for a specific type of science application. The results are quality-checked visually, manually, during analysis.

- Data set from beginning to December 2004 analyzed with versions 5.40 or later.
- Data set from January 2005 to 2018 analyzed with versions 6.2x or later.

An analysis overview is described below. Please refer to T. Leblanc for details.

a) Raw signals are corrected for saturation, background noise, solid angle factor, Rayleigh extinction, and NO2 absorption if necessary.
b) Ozone calculation uses classic DIAL method: Calculating the derivative of the ratio of the slopes of the logarithm of the absorbed and non-absorbed corrected signals. Signal is smoothed to reduce statistical noise by applying derivative filter (default is Savitsky-Golay).
c) Ozone profile extended to 25-28 km using 355 nm low range signal from stratospheric system re-binned onto the tropospheric vertical grid.
d) More details on analysis not relevant to tropospheric ozone is given in TMF metafile JPL_TMF.txt.

Expected Precision/Accuracy of Instrument:

a) Ozone overall precision is calculated statistically during analysis and provided at 1-sigma in Ames files. The errors taken into account are the statistical error associated to photon counting, and systematic errors due to various corrections. The overall precision runs from 5% in the free troposphere, to 15% at the top of the profiles (above 20 km).
b) Unexpected - but identified - errors are reported in this metafile in the "Reported Events" section.

Ames description:

This section gives a few details on the Ames files content:

- All units are MKSA except pressure (in hPa), and mixing ratio (in ppmv).
- "Hour-Mean" and "Minute-Mean" is the averaged time of measurements
- "Hour-Stop" and "Minute-Stop" is the time at which the measurements stopped
- "Day of year (UT xxx.xx)" is the time at which the measurements started
- "pres/dens code" is the source of the "a priori" dens. and press. information
- "channel code" indicates which channels have been used: code based on 4 ranges
  If Raman channel (or pair of channels) used alone, then code=2**0 = 1
  If Low Rayleigh channel (or pair of channels) used alone, then code=2**1 = 2

If Med Rayleigh channel (or pair of channels) used alone, then code=2**2 = 4
If High Rayleigh channel (or pair of channels) used alone, then code=2**3 = 8
If Low Rayleigh and High Rayleigh combined, then code=2**1 + 2**3 =10
etc...

- No Raman channel used for tropospheric ozone

II - GLASS 1.xx (2018 - Present)

Temperature/ozone/aerosol analysis program GLASS v1.xx, by Thierry Leblanc (TL) first released in early 2017. This program overrides all previous analysis programs (LidAna, SO3ANL, see section I above)
New GLASS data processor does not require manual processing. Analysis is automated, using 100+ keywords tailored for a specific type of science application.
The results are quality-checked visually, manually, after analysis is completed.
This new automation capability allows for the re-analysis of a large number of measurements without user intervention.
- Data set from XXXXXX to present analyzed with versions 1.00, to be released in 2019.

An analysis overview is described below. Please refer to T. Leblanc for details.

a) Raw signals are corrected for saturation, background noise, solid angle, Rayleigh extinction, NO2 and SO2 absorption if applicable.
b) Ozone Number Density calculation uses standard DIAL method: Calculating the derivative of the ratio of the slopes of the logarithm of the absorbed and non-absorbed corrected signals. Natural vertical grid is geometric altitude.
Signal is smoothed to reduce statistical noise by applying a derivative filter.
Raman channel is used below 30 km to avoid contamination by aerosols (systematically used since early 2001).
f) All results output in HDF-5 (native format), and HDF-4 (GEOMS template) following NDACC requirements
g) In the HDF files, the measured quantities are provided together with the Ozone mixing ratio. This product is obtained using either the density-pressure profiles measured by lidar, or a priori density-pressure profiles coming from NCEP or radio-sounding. Refer to "HDF description" section for more details.

<u>Expected Precision/Accuracy of Instrument:</u>

a) Ozone overall precision is calculated statistically during analysis and provided at 1-sigma in Ames files. The errors taken into account are the statistical error associated to photon counting, and systematic errors due to various corrections. The overall precision runs from 5% in the free troposphere, to 15% at the top of the profiles (above 20 km).
b) Unexpected - but identified - errors are reported in this metafile in the "Reported Events" section.

<u>HDF File description:</u>

This section provides details on the HDF files content:
- All units are MKSA except pressure (in hPa), and mixing ratio (in ppmv).
***** Due to the novelty of the GLASS program and its HDF outputs, *****

***** this section is still under construction. It will be updated *****
***** as further documentation is available *****

Instrument History:

- 1990 - Start of program. System configured for simultaneous tropospheric aerosol and ozone measurements.
- 1991-1997 - System configured for tropospheric aerosol (Pinatubo) only. Ozone measurements sidelined.
- 1999 - System reconfiguration: one system split into two
- Nov 1999 - Start of tropospheric ozone routine measurements (NDSC archive)
- Oct 2000 - Various instrumental failures leading to few archived profiles
- Nov 2000 - Mechanical shutter failure leading to no run throughout the month
- 2000/2001 - Various optimization steps to conserve high power of aging laser
- Jan 2013 - Data acquisition sampling resolution changed from 75 m to 7.5 m
  Also, addition of 2 very-low range channels, not used in NDACC retrieval
- Jan 2018 - Installation of new Licel Transient Recorders, now using both PC and Analog
  Also, new data acquisition software, allowing full automation

Reported events 1989-2006:

Below is a chronological list of notes describing unexpected events affecting the results quality. The notes are referenced in the comment section of the Ames files.

- 99-A Start measurement early November 1999: First archive 1999/11/16

- 00-A Aerosol status as of January 2000: Undetectable.

- 00-B Daytime measurements: Daytime measurements OK for low channels.
  NOT OK for high channels due to saturation and signal-induced-noise in 299H-d channel.

- 00-C Ozone laminae event on Mar 21, 2000: Filament tracking using continuous measurements (daytime and nighttime) from Mar 19 to Mar 22, 2000, in coordination with A. Hauchecorne PV- advection model forecast. Bad weather and bad timing of the filament pass over (midday) led to moderate success of this tracking project.

- 00-D Various instrumental failures leading to experiment shortage in Oct 2000. Only 1 profile archived (October 25). October 19 profile (high channel only) available upon request.

- 00-E Mechanical shutter failure leading to NO experiments in November and December 2000. No profiles archived between October 25, 2000 and January 3rd, 2001.

- 01-A Tropospheric ozone measurements resume on January 3, 2001 after 2 months interruption.

- 01-B Aging system leading to reduced laser power throughout 2001.

- 01-C Shutter/receiver alignment re-designed. 3 weeks interruption between January 3rd and January 31st, 2001.

- 01-D Very high tropospheric ozone concentrations measured below 15 km on January 31, 2001.

- 01-E System compromised in April 2001 (cooling system problems).
Signals low. Data sparse in Apr and not of good quality (noisy profiles and low cut-off altitudes).

- 01-F Very high tropospheric ozone concentrations measured below 15 km on July 25, 2001.

- 01-G Vertical resolution changed from 60 m to 75 m.
Last experiment with 60 m vertical resolution: 011108A
First experiment with 75 m vertical resolution: 011109A

- 01-H December 2001: Low laser energies caused STNR to be very low.
Data quality affected prior to December 18, 2001.
Reasonable quality back on and after December 18, 2001.

- 02-A January 2002: Roof door and motor damaged on January 12.
No Tropospheric ozone measurements between Jan 12-Feb 5, 2002.

- 02-B Feb 2002: Low channels signals very weak.
No Tropospheric ozone below 10 km. Use mid- and high- chans only.

- 02-C Mar-Apr 2002: All channels signals very weak, especially low chan.
No Tropospheric ozone below 10 km. Use mid- and high- chans only.
Ozone profiles either noisy or with degraded vertical resolution.

- 02-D April 9, 2002: Major laser break down.
No experiment between April 9 and June 5, 2002.

- 02-E June-July 2002: All channels signals still weak.
Ozone profiles either noisy or with degraded vertical resolution.

- 02-F August 2002: Historic laser Dead. New laser arrived late August.
No tropospheric O3 measurements between Aug 2 and Sep 16, 2002.

- 02-G September 2002: New laser operational.
Measurements resume Sep 17, 2002. Quality optimal.

- 02-H Throughout 2002:
Persistent occasional system shutdown due to missing signals
Estimated loss of data: 30%

- 03-A January through early April 2003:
Rare occurrences of the "Missing signals" incident (see 02-H).
Estimated loss of data: below 10%

- 03-B Late April 2003:
Numerous occurrences of the "Missing signals" incident (see 02-H).
Estimated loss of data: >60%
Issue still unresolved as of May 2003.

- 03-C July-August 2003: Few measurements due to various circumstances.
Numerous tests in connection with new Water Vapor lidar
A few tests in connection with new stratospheric lidar receiver
1-time use of 355L from test of new 8-chan TMF for TMO expt 030726A .
2-time use of 355L from test of new TMW for TMO expt 030802A and 030808A

- 04-A April 1-10 2004: ******** NEW 8-CHAN STRATOSPHERIC RECEIVER ********
No strato. chan. due to numerous tests on new 8-chan receiver.
April 1-8: Tropo. profiles do not use any stratospheric channel
Rest of April and May: Used new (temporary) 308L/M or 355M if 308L not available. Resumed "normal" 355M processing after 308L and 308M tests.

- 05-A March/April 2005: STRATO SYSTEM DOWN due to chopper failure
No stratospheric channel from March 29 to April 16.
Profiles valid up to about 16 km only.

- 05-B April-May 2005: Various STRATO system failures
Strato channel from ozone system occasionally available from April 20 to May 13. Strato channel from water vapor system occasionally available from April 20 to May 13. Rest of profiles valid up to about 16 km only.

- 05-C 26-Aug-2005: System cleanup
Signal from all tropo channels jump up (better STNR and laser power UP)

- 05-D 17-Sep-2005: YAG laser Power supply failure
No measurement between September 18 and October 29, 2005.
Measurements resumed October 30, 2005.

- 05-E Nov-Dec 2005: measurements plagued by persisting high clouds
Numerous datasets, especially in December, affected by clouds

<u>Reported events 2006-Present:</u>
Below is a chronological list of notes describing major events affecting the results. These notes are retrospective, and are not included in any other data or meta data files.

January 2013 - Vertical sampling resolution changed from 75 m to 7.5 m

January 2013 - Addition of two very-near-range channels
For the measurement of ozone below 3 km a.s.l. (700 m above ground)
No impact on other channels and ranges. New pair of channels contains unexpected high signal-induced noise(SIN), making their use for scientific studies problematic

2013-2018: Multiple minor failures and repairs.
Details of these problems to be added here later. Main impact is small data gaps, and temporary changes of STNR and profile quality

January 2018: New Licel Transient Recorders and new data acquisition software
New data recorders combine Analog and Photon-counting modes. New data acquisition software allows full automation of operations. Main impact on results is an increased frequency of measurements

January 2018 to Present: Additional systematic TROPOMI daytime measurements
NDACC database now comprises both nighttime (NDACC) measurements and daytime measurements for the validation of TROPOPMI

********** CURRENT END OF LOG OF EVENTS, PENDING UPDATES **********