National Aeronautics and Space Administration

SAGE III/ISS

Stratospheric Aerosol and Gas Experiment

An Earth Science Mission on the International Space Station

Stratospheric Aerosol and Gas Experiment III on the International Space Station (SAGE III/ISS) Validation of the Latest Version 5.2 Data Products

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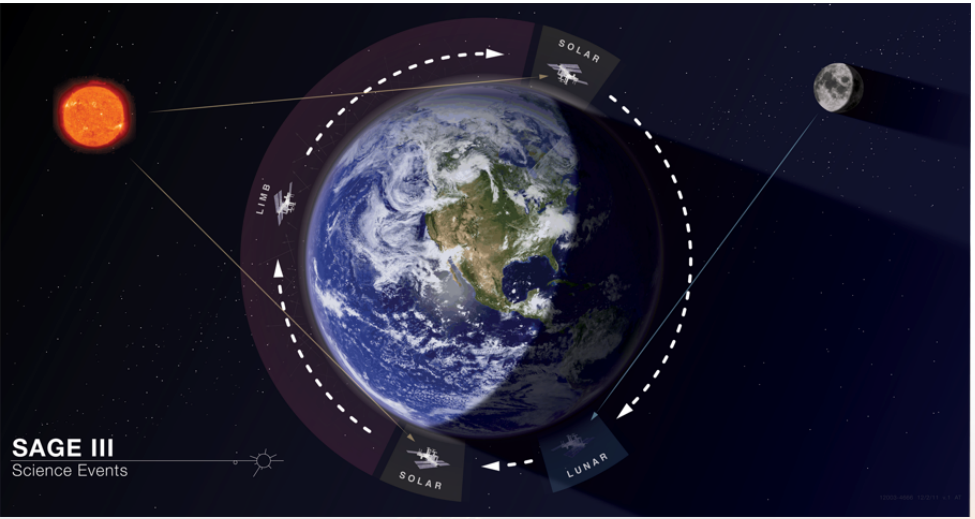
Stratospheric Aerosol and Gas Experiment III on the International Space Station (SAGE III/ISS)



Sunrise Moonset *(Moonrise*)*

SAGE III/ISS has almost completed four years of data collection and production of science data products. It continues the legacy of previous SAGE instruments dating back to the 1970s to provide data continuity of stratospheric constituents critical for assessing trends in the ozone layer. Three ozone data products are available for each solar event (one for lunar). When comparing solar events, this presentation focuses on the ozone reported in the ozone_AO3 data product. The SAGE III/ISS water vapor is still considered a preliminary product. All of the comparisons in this presentation focus on the first three years of SAGE III/ISS data, June 2017 – May 2020.

The SAGE III/ISS is a solar and lunar occultation instrument that scans the light from the Sun and Moon through the limb of the Earth's atmosphere to produce vertical profiles of aerosol, ozone, water vapor, and other trace gases. ***This event depiction includes a lunar moonset. An event with an alternate orbit direction would depict a lunar moonrise.***

Updates to SAGE III/ISS Algorithms for v5.2 Data Release

- Updated geopotential height conversion to geometric altitude.
- Updated tropopause altitude calculation.
- Minor improvements made to time registration.
- Dropping of all lunar downscans has been fixed.
- Minor changes to the lunar dark current calculation (off-target baseline signal).
- Overhauled the scan mirror "ratefix" module, affecting elevation angle calculation.
- Improved NO_2 clearing at low altitudes.
- Modified path length calculation to partially account for vertical gradients within a layer.
- Removed Rayleigh and O_4 errors from uncertainty calculations.
- Omitted the routine to correct for rectangular FOV on a circular target.
- Automated the eclipse flag.
- Updated the wavelength registration and slightly changed event-by-event adjustments.
- Updated the point-spread function.
- Updated the cross-section interpolation in temperature space for all species.
- Water Vapor Retrieval: Decreased algorithm retrieval step to 0.5km. Changed algorithm initialization to reduce instabilities (keel-overs). Removed normalization and smoothing of transmission. Allowed negative mass path values in LM iterative procedure. Recovered lost water vapor profiles.
- Water Vapor Retrieval: Shifter retrieval pixels 1 group redward. Removed high aerosol - low h2o bias.
- The aerosol extinction product is now derived from the ao3_ozone retrieval rather than the mlr_ozone retrieval.
- Corrected error in uncertainty smoothing.

SAGE III/ISS Validation Using Balloon Launched Data and MLS

The ozonesonde data used for this comparison are taken from measurements collected from NDACC, WOUDC, NOAA ESRL, and SHADOZ databases. The water vapor frost point hygrometer data used for this comparison are obtained from the NDACC. The Microwave Limb Sounder instrument on NASA's Earth Observing System (EOS) Aura satellite also provides ozone and water vapor for this comparison. The MLS version 4.23 data is used.

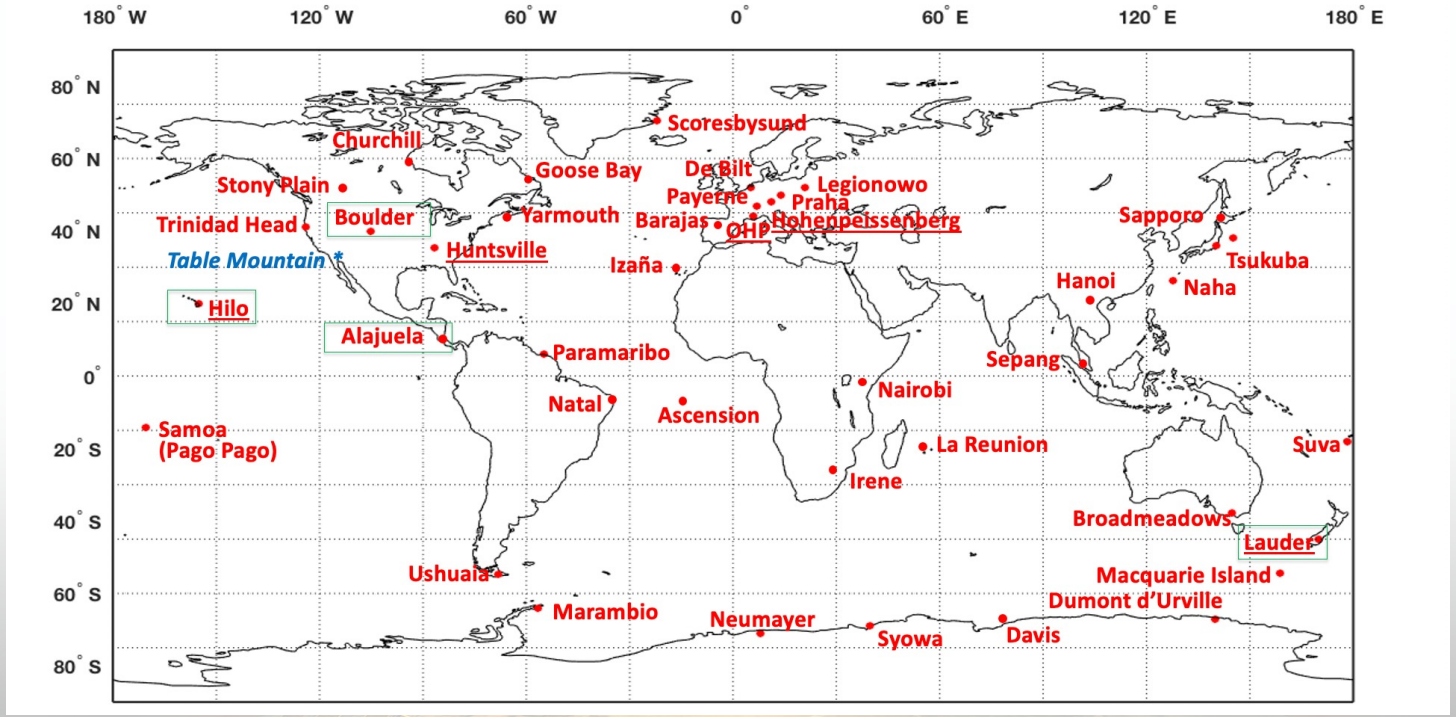
Matching a sonde event with SAGE requires an event within 5 degrees latitude and 24 hours time, with the closest match in distance chosen (only accepted when distance is less than 1000km.) Matching criteria with MLS requires an event within 2 degrees latitude and 24 hours time, with the closest match in distance chosen (only accepted when distance is less than 1000km.) Only MLS nighttime data is used. Meteorological data from JPL Derived Meteorological Products were used for improved ozone profile matching. Particularly geopotential height for the SAGE and MLS products, and pressure and temperature for calculations to convert MLS ozone concentrations to number density.

The Mean Percent Difference is calculated using the interpercentile range.

For additional details in comparing ozone data products with SAGE, please refer to "Validation of SAGE III/ISS Solar Occultation Ozone Products With Correlative Satellite and Ground-Based Measurements" by H.J. Ray Wang et al, JGR Atmospheres, June 2020.

For additional details in comparing water vapor data products with SAGE, please refer to "Validation of SAGE III/ISS Solar Water Vapor Data With Correlative Satellite and Balloon-Borne Measurements" by S.M. Davis et al, JGR Atmospheres, January 2021.

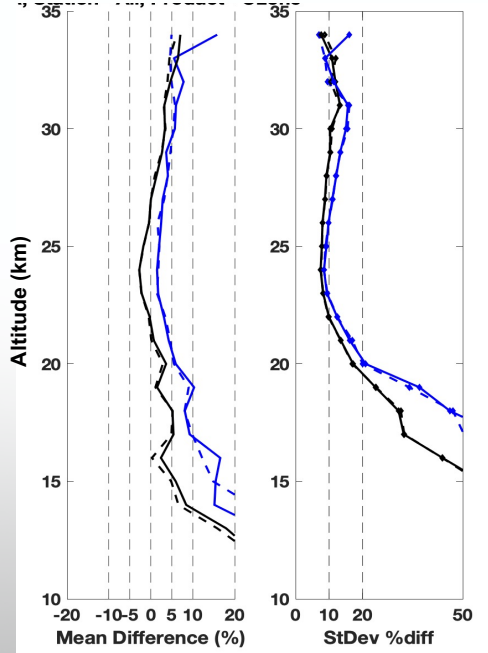
In Situ Site Locations



Map of ozonesonde sites matched to SAGE III data within June 2017 to May 2020 and are shown in red. Sites that also have NDACC LIDAR data that have been matched to SAGE are underlined. One site has NDACC LIDAR data without an ozonesonde match which is shown in blue. NDACC FPH sites matched to SAGE III water vapor are outlined in green.

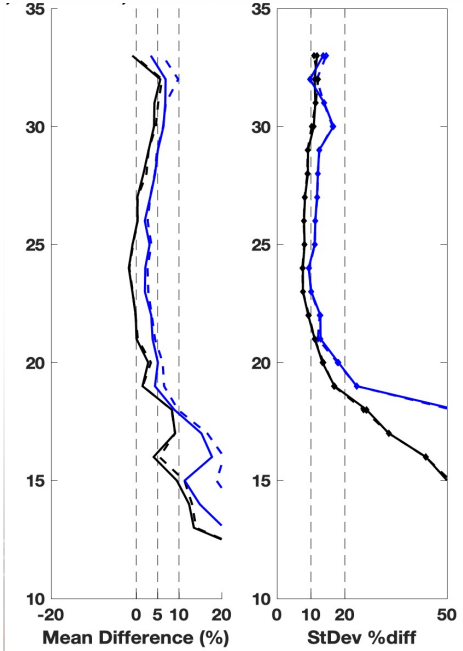
SAGE III/ISS v5.1 and v5.2 Ozone Validation w/Sondes

Sunrise Ozone Comparison
SAGE/Sonde/MLS



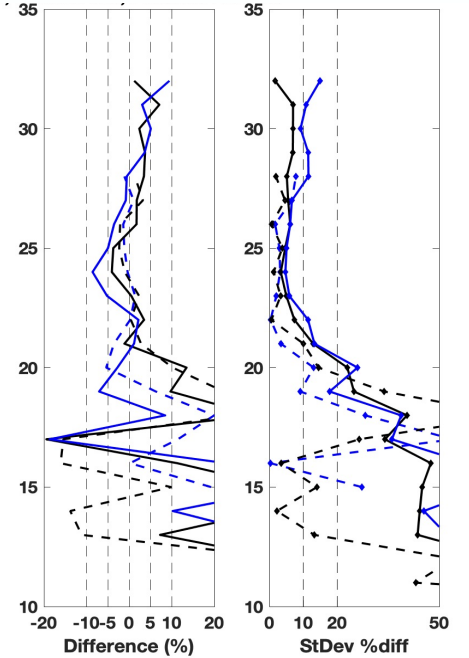
SAGE v5.2 – Sonde (Solid)
SAGE v5.1 – Sonde (Dashed)
MLS – Sonde (Solid)
MLS – Sonde (Dashed)
328 events

Sunset Ozone Comparison
SAGE/Sonde/MLS



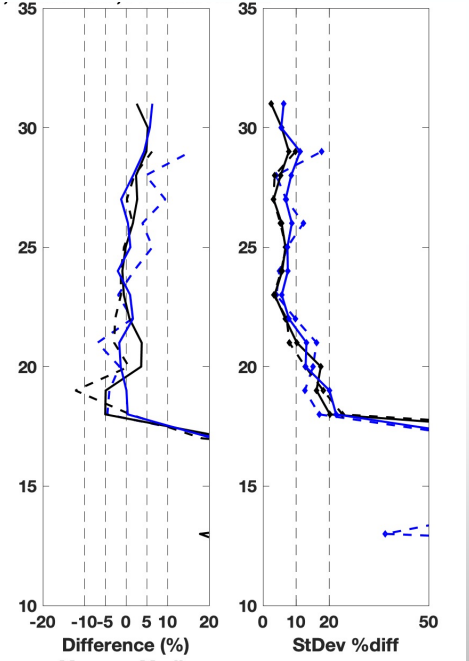
300 events

Moonrise Ozone Comparison
SAGE/Sonde/MLS



SAGE v5.1: 2 events
SAGE v5.2: 10 events

Moonset Ozone Comparison
SAGE/Sonde/MLS

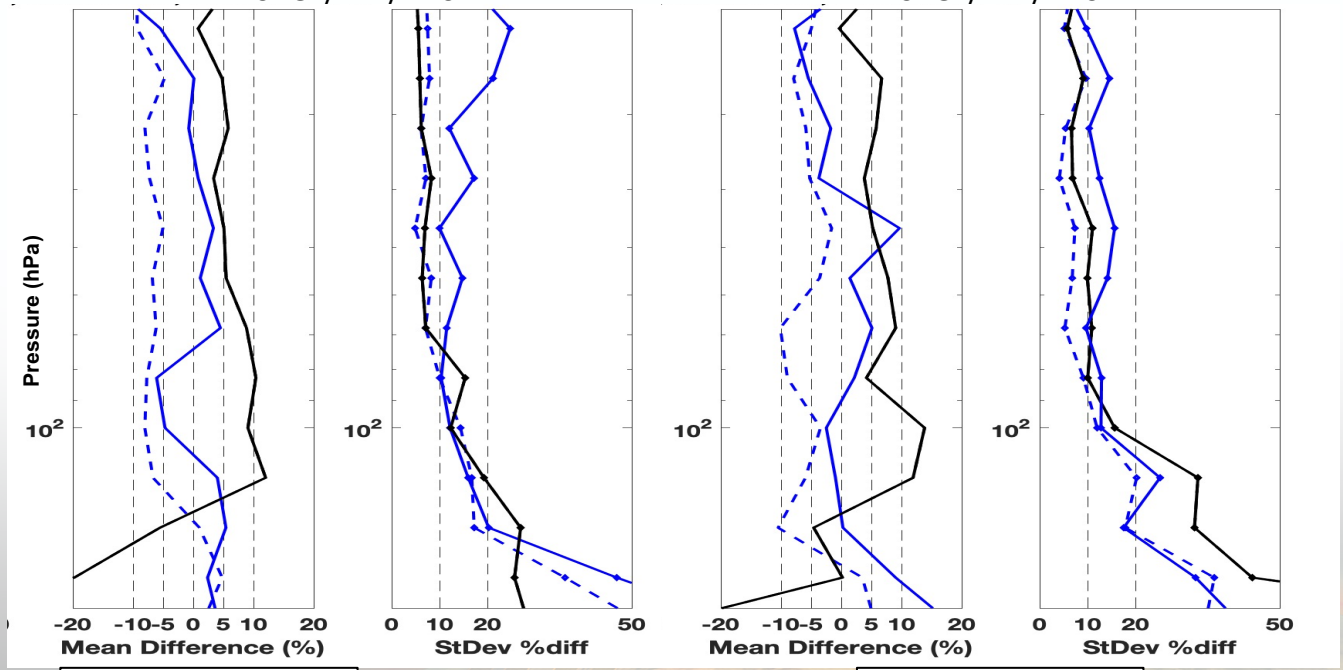


SAGE v5.1: 8 events
SAGE v5.2: 10 events

SAGE III/ISS v5.1 and v5.2 Water Vapor Validation w/FPH

Sunrise H_2O Comparison
SAGE/FPH/MLS

Sunset H_2O Comparison
SAGE/FPH/MLS



Compared to the FPH Data:

No longer a consistently ~5% SAGE dry bias.

MLS shows a 5+% wet bias.

SAGE v5.2 removes smoothing in the water vapor algorithm. Increased variability is seen in this comparison with v5.2.

SAGE v5.2 – FPH (Solid)
SAGE v5.1 – FPH (Dashed)
MLS – FPH (Solid)
MLS – FPH (Dashed)
27 events

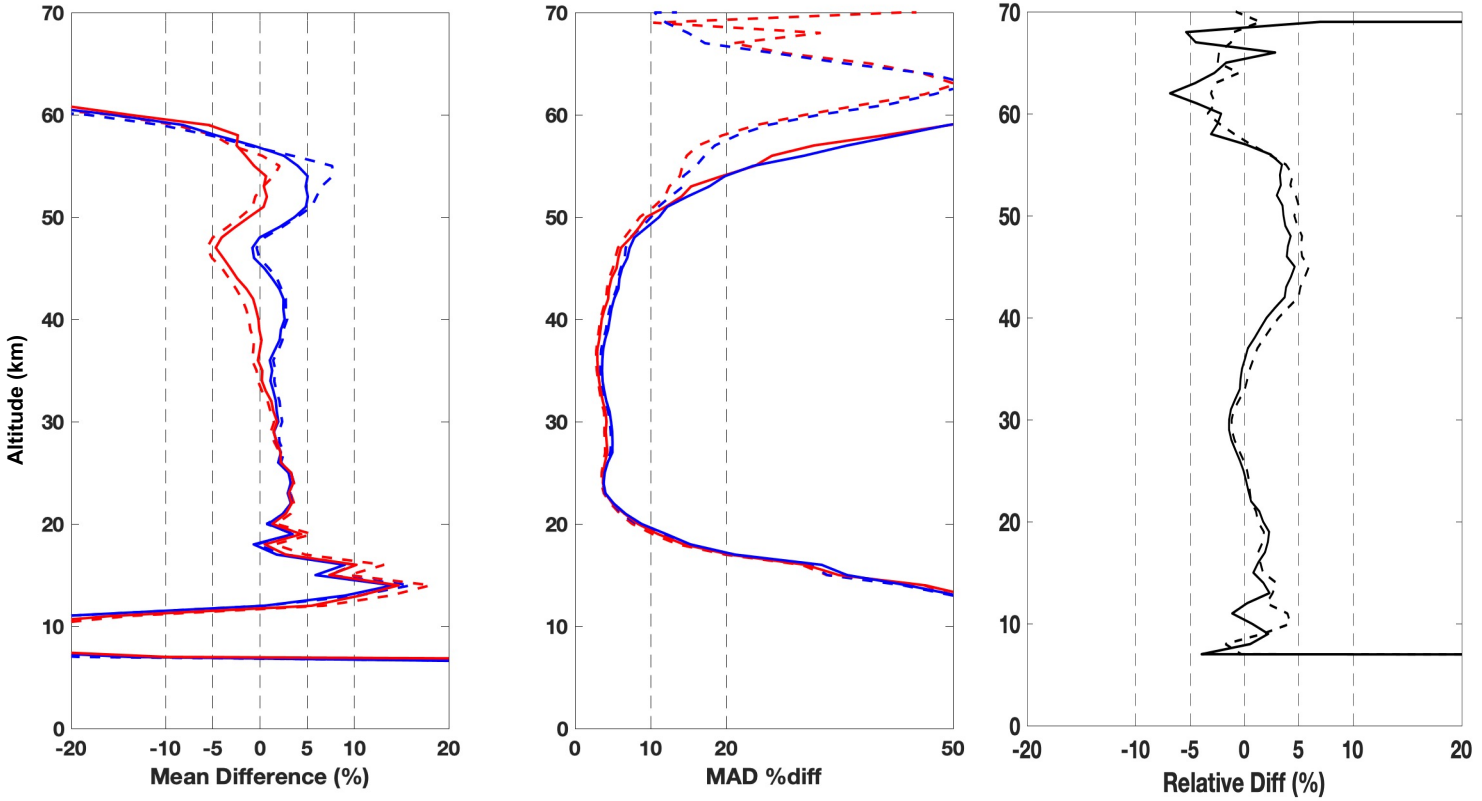
SAGE v5.1: 17 events
SAGE v5.2: 18 events

SAGE III/ISS v5.1 and v5.2 Ozone Validation w/MLS

SR/SS Ozone Comparison 20 – 60 N

	# events
SS SAGE V5.2 (Solid)	3868
SS SAGE v5.1 (Dashed)	3510
SR SAGE v5.2 (Solid)	4353
SR SAGE v5.1 (Dashed)	3997

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE SS –SR)/MLS * 100

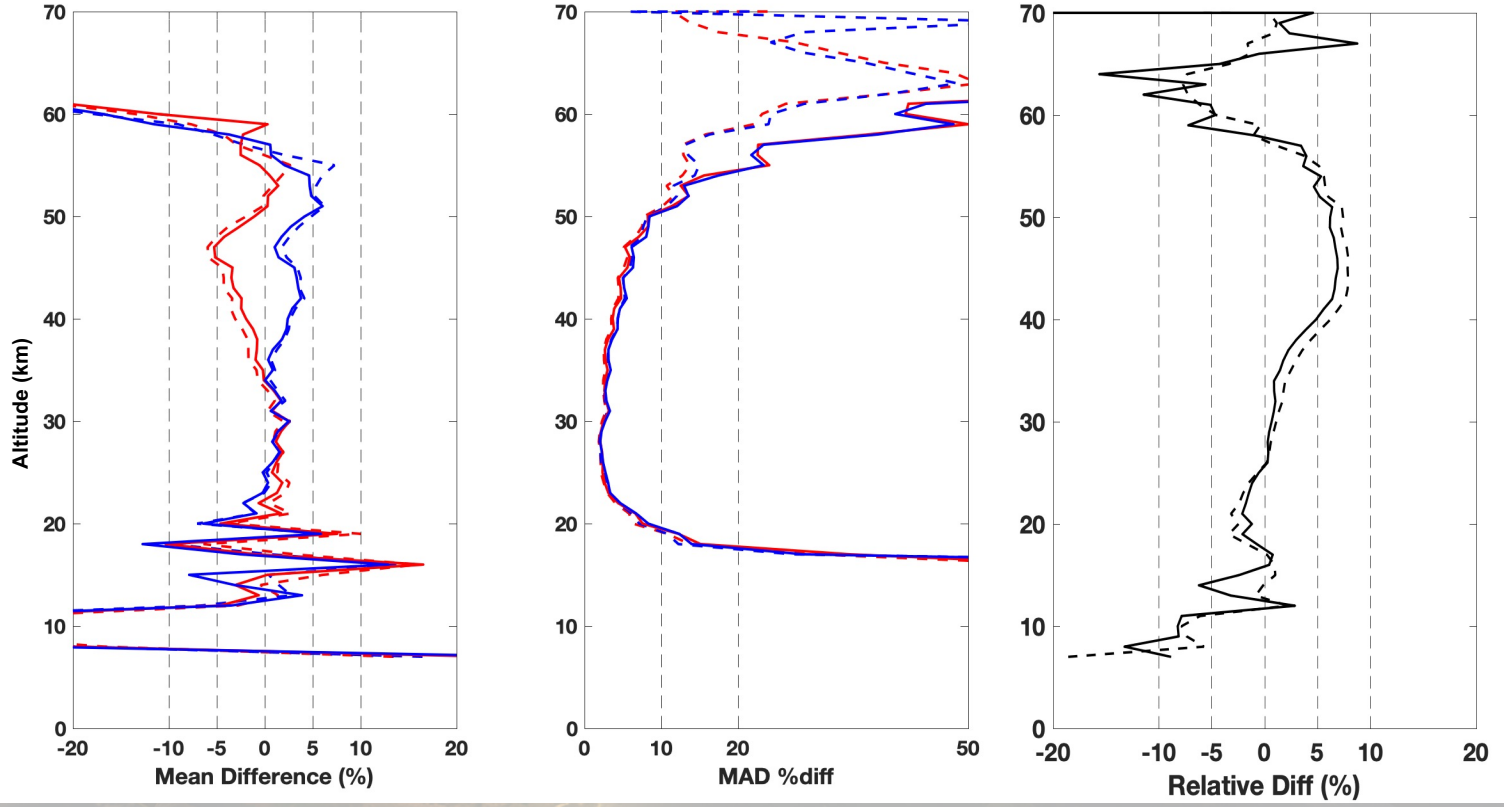


SAGE III/ISS v5.1 and v5.2 Ozone Validation w/MLS

SR/SS Ozone Comparison 20 N – 20 S

	# events
SS SAGE V5.2 (Solid)	1323
SS SAGE v5.1 (Dashed)	1177
SR SAGE v5.2 (Solid)	1413
SR SAGE v5.1 (Dashed)	1315

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE SS –SR)/MLS * 100

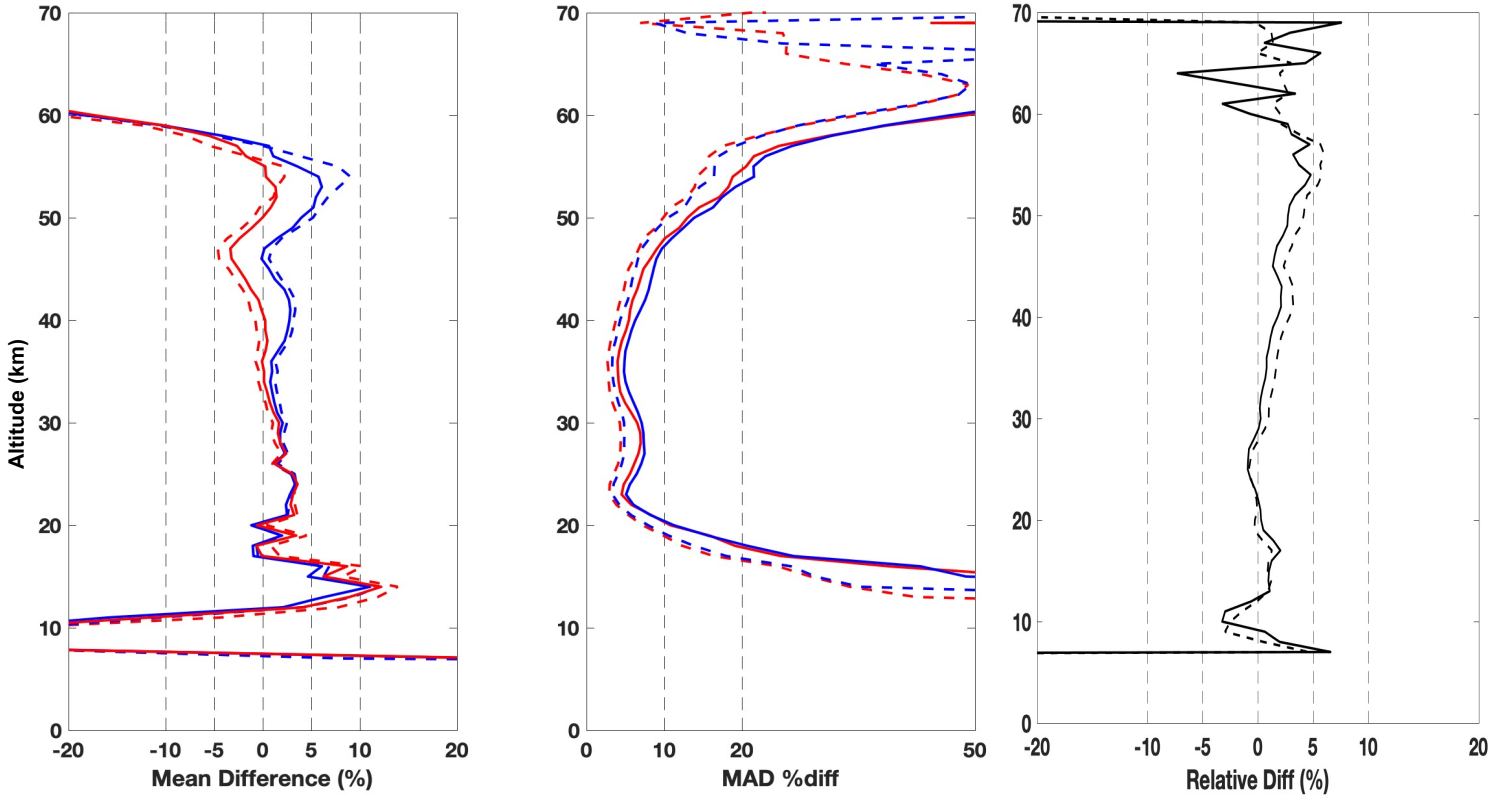


SAGE III/ISS v5.1 and v5.2 Ozone Validation w/MLS

SR/SS Ozone Comparison 20 – 60 S

	# events
SS SAGE V5.2 (Solid)	3932
SS SAGE v5.1 (Dashed)	3513
SR SAGE v5.2 (Solid)	3769
SR SAGE v5.1 (Dashed)	3346

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE SS –SR)/MLS * 100

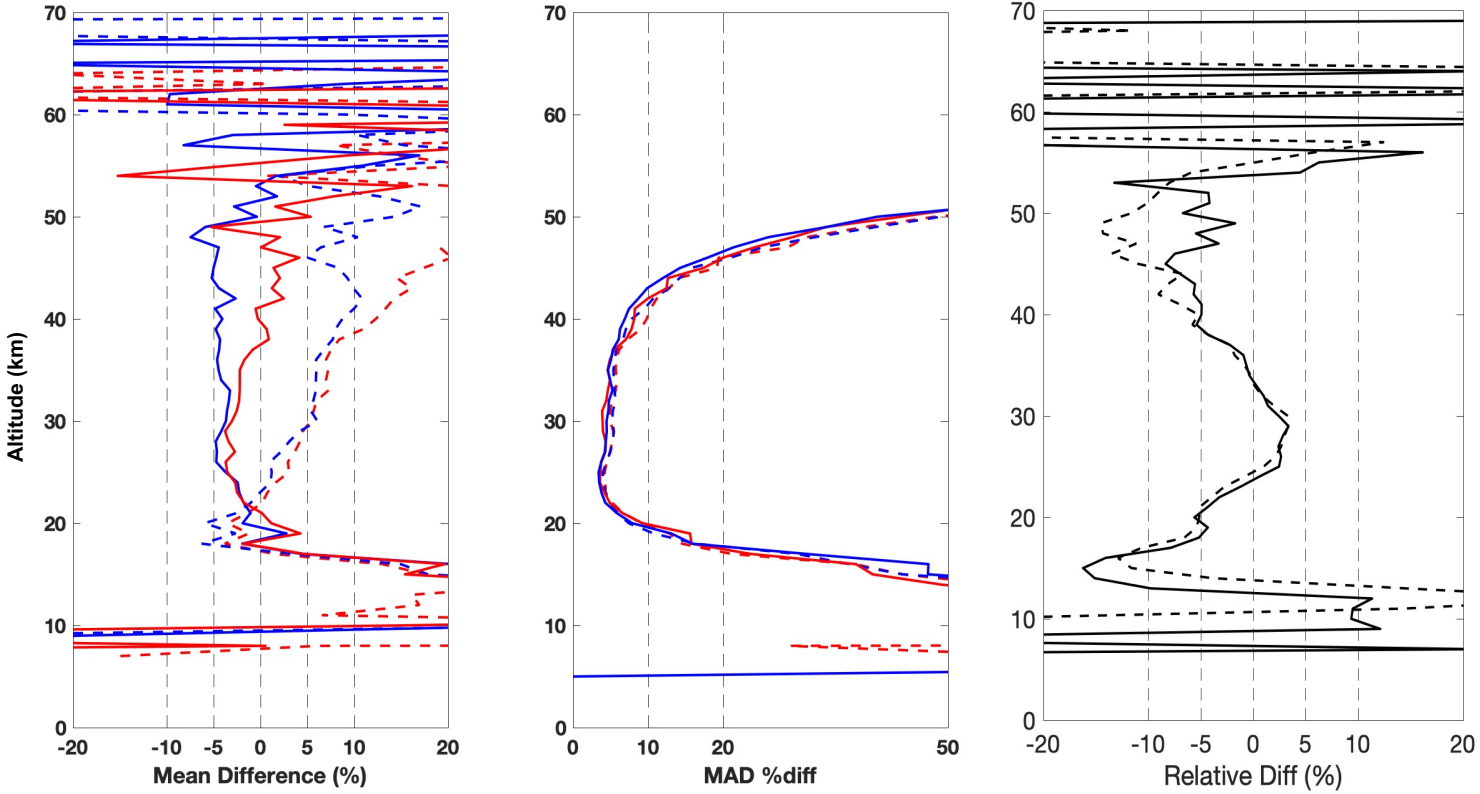


SAGE III/ISS v5.1 and v5.2 Ozone Validation w/MLS

MR/MS Ozone Comparison 20 – 60 N

	# events
MS SAGE V5.2 (Solid)	442
MS SAGE v5.1 (Dashed)	442
MR SAGE v5.2 (Solid)	185
MR SAGE v5.1 (Dashed)	185

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE MS –MR)/MLS * 100

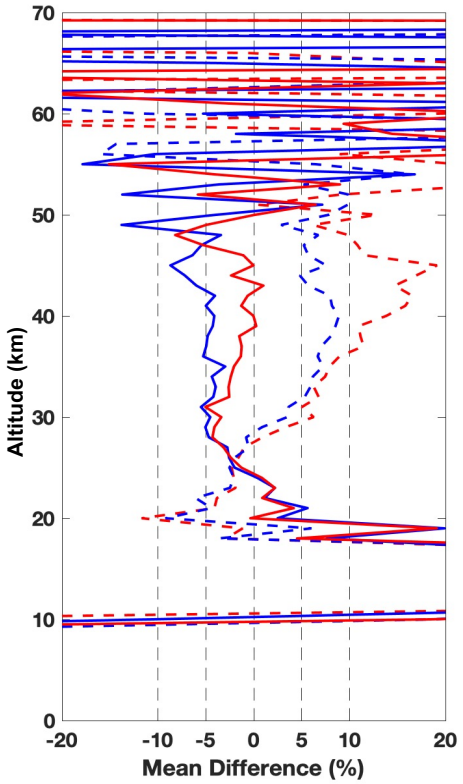


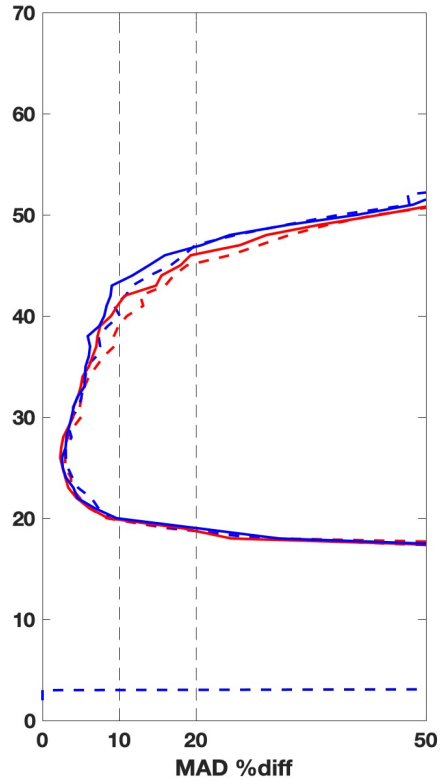
SAGE III/ISS v5.1 and v5.2 Ozone Validation w/MLS

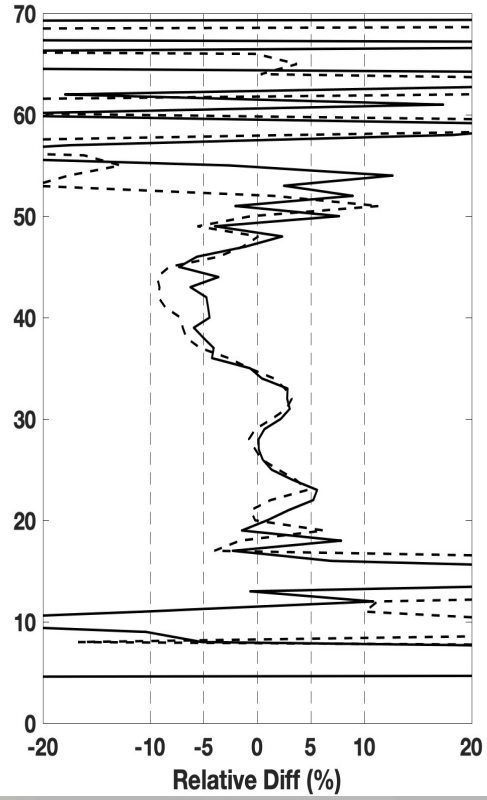
MR/MS Ozone Comparison 20 N – 20 S

	# events
MS SAGE V5.2 (Solid)	123
MS SAGE v5.1 (Dashed)	124
MR SAGE v5.2 (Solid)	116
MR SAGE v5.1 (Dashed)	116

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE MS –MR)/MLS * 100





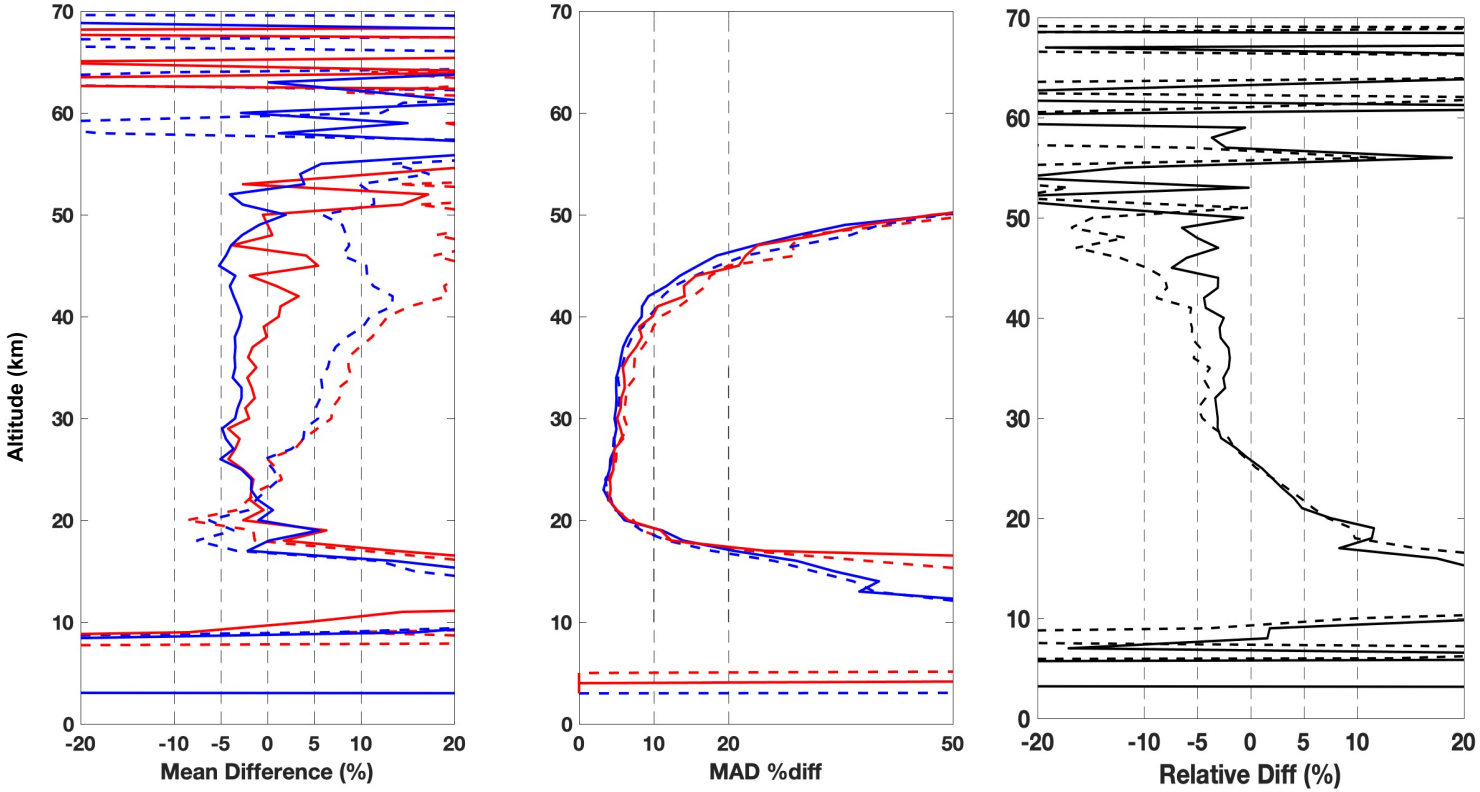


SAGE III/ISS v5.1 and v5.2 Ozone Validation w/MLS

MR/MS Ozone Comparison 20 S – 60 S

	# events
MS SAGE V5.2 (Solid)	435
MS SAGE v5.1 (Dashed)	435
MR SAGE v5.2 (Solid)	156
MR SAGE v5.1 (Dashed)	156

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE MS –MR)/MLS * 100

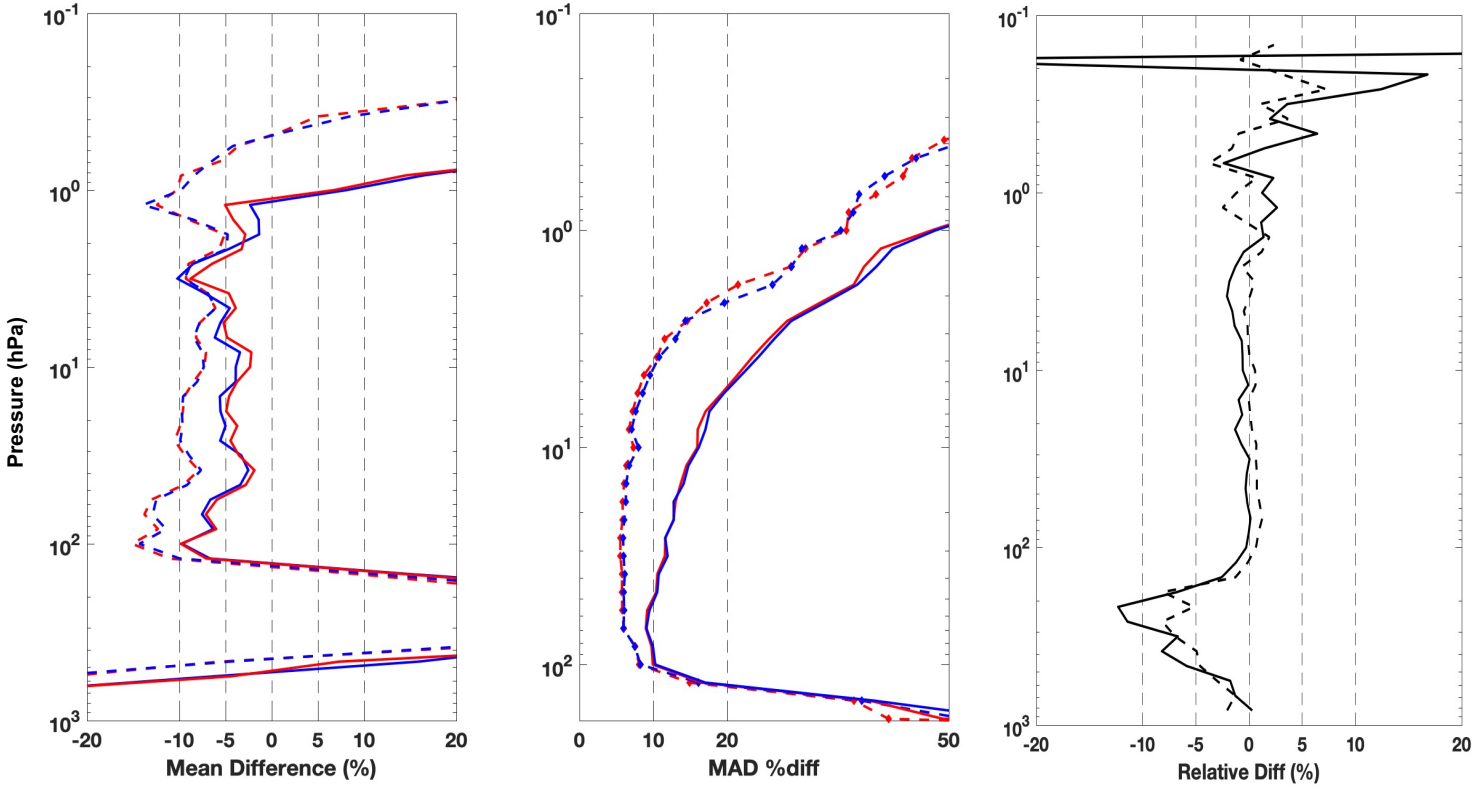


SAGE III/ISS v5.1 and v5.2 Water Vapor Validation w/MLS

SR/SS Water Vapor Comparison 20 – 60 N

	# events
SS SAGE V5.2 (Solid)	3376
SS SAGE v5.1 (Dashed)	3327
SR SAGE v5.2 (Solid)	3846
SR SAGE v5.1 (Dashed)	3764

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE SS –SR)/MLS * 100

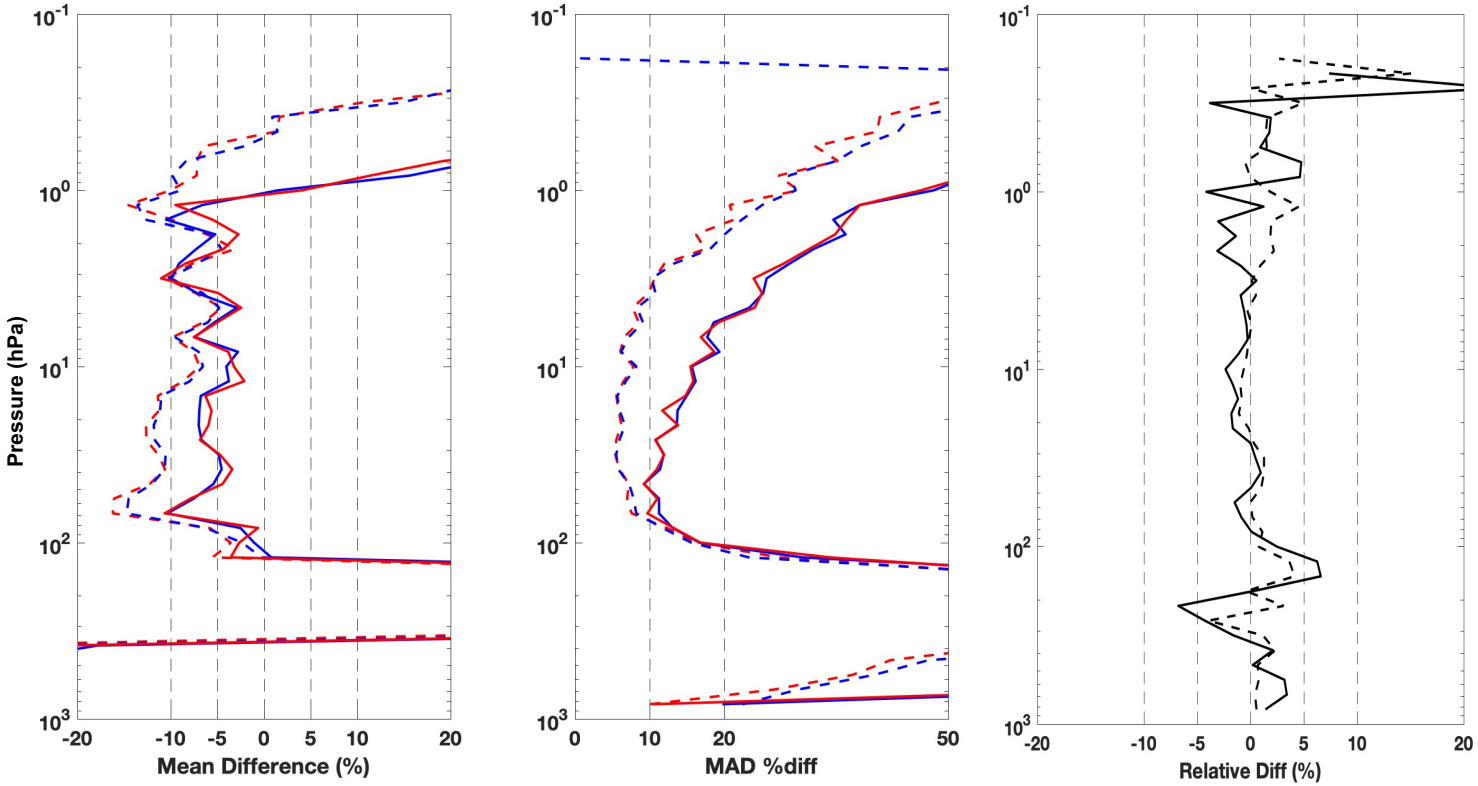


SAGE III/ISS v5.1 and v5.2 Water Vapor Validation w/MLS

SR/SS Water Vapor Comparison 20 N – 20 S

	# events
SS SAGE V5.2 (Solid)	1040
SS SAGE v5.1 (Dashed)	1024
SR SAGE v5.2 (Solid)	1122
SR SAGE v5.1 (Dashed)	1108

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE SS –SR)/MLS * 100

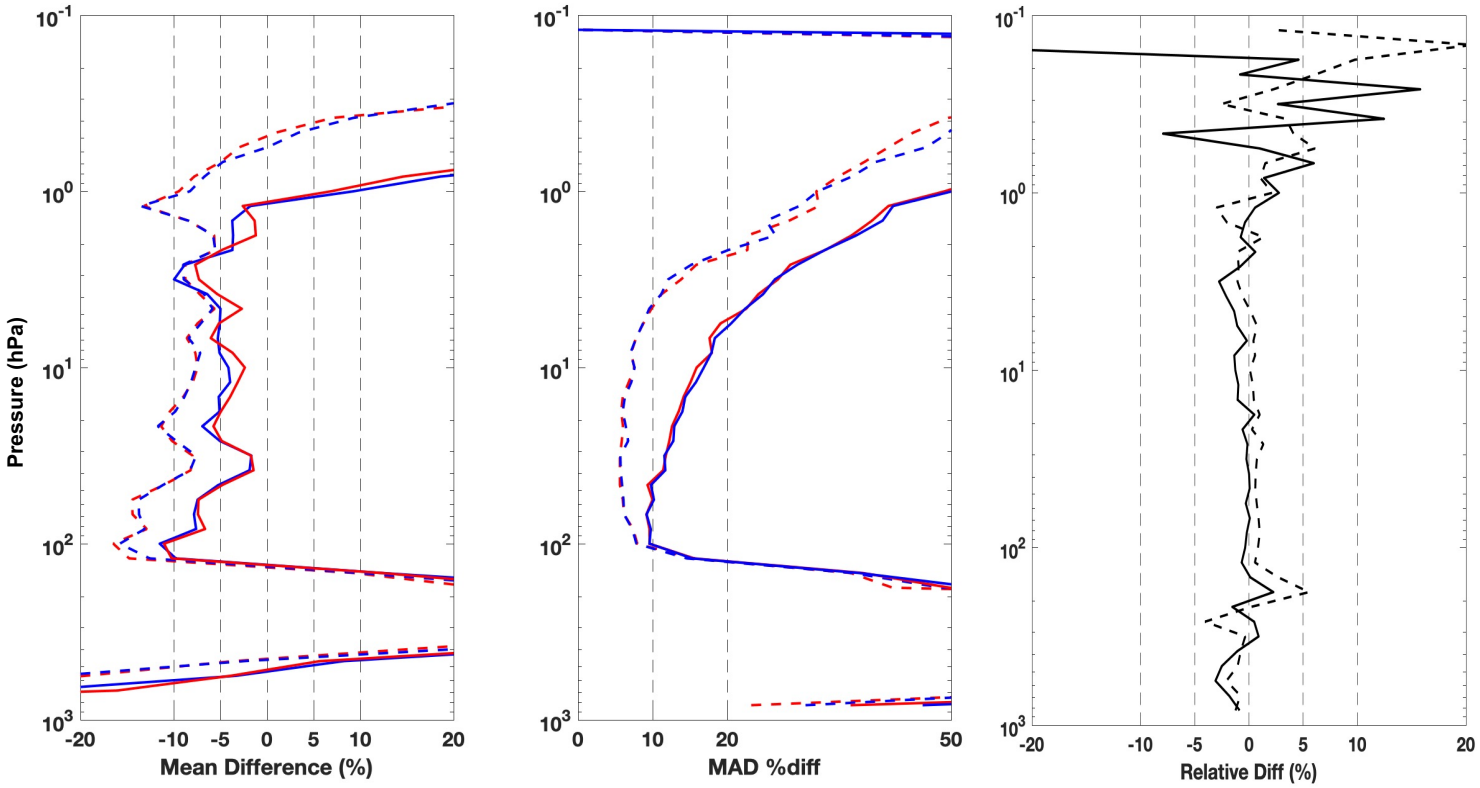


SAGE III/ISS v5.1 and v5.2 Water Vapor Validation w/MLS

SR/SS Water Vapor Comparison 20 – 60 S

	# events
SS SAGE V5.2 (Solid)	2988
SS SAGE v5.1 (Dashed)	2925
SR SAGE v5.2 (Solid)	2891
SR SAGE v5.1 (Dashed)	2830

% Diff = (SAGE – MLS)/MLS * 100
Rel Diff = (SAGE SS –SR)/MLS * 100



Summary

- The SAGE III/ISS Level 2 ozone_AO3 concentrations show little change from v5.1 to v5.2 but continue to show good agreement with coincident measurements from the ozonesonde database. SAGE solar data agrees within percent differences of +/-5% in the mid-stratosphere. SAGE v5.2 lunar percent differences show an improvement in that the agreements with MLS are within +/-5% in the mid-stratosphere and show less of a slope possibly due to altitude registration.

- The SAGE III v5.2 water vapor shows a considerable decrease in the dry bias as seen with v5.1 when comparing with the correlative data. MLS shows a wet bias of about 5+% with the FPH data. The SAGE III preliminary water vapor data product is reporting good agreements with FPH with percent differences staying within 5% in the middle stratosphere. SAGE III v5.2 is biased wet at about 5% with MLS. This is again a marked improvement from v5.1 showing 10% percent differences.

- Stations such as the NOAA Earth System Research Laboratory (ESRL) in Boulder, CO and the National Institute of Water and Atmospheric Research (NIWA) in Lauder, NZ have planned ozonesonde launches to coincide with SAGE III/ISS overpasses. The number of stations within the NDACC community that use the SAGE III Validation tool to plan balloon launches with a SAGE flyover is growing. Please take advantage of the SAGE III/ISS Validation Prediction Tool when planning LIDAR, ozonesonde, frost point hygrometer, etc. measurements.

- We would like to acknowledge the upper atmosphere observational community for their active participation in the on-going SAGE III/ISS validation program. Particularly NDACC (www.ndacc.org), WOUDC (www.woudc.org), NOAA ESRL (https://www.esrl.noaa.gov/gmd/), and SHADOZ (https://tropo.gsfc.nasa.gov/shadoz/index.html). Please visit these sites for individual station and contact information. The NASA JPL Aura MLS project and data retrieved from https://earthdata.nasa.gov/. Meteorological data provided by the JPL Derived Meteorological Products (https://mls.jpl.nasa.gov/dmp/) were used with the ozonesondes, SAGE and MLS for improved event matching.