Stratospheric Aerosol and Gas Experiment III on the International Space Station (SAGE III/ISS) Preliminary Science Data Ozone Product Validation

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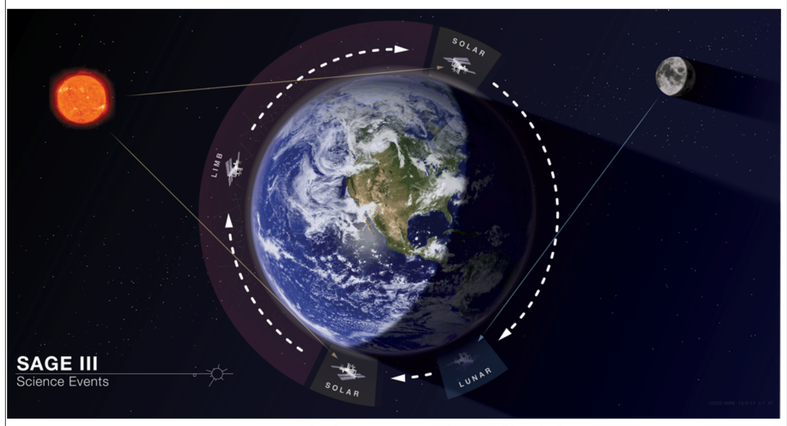
Abstract

The Stratospheric Aerosol and Gas Experiment III (SAGE III) instrument, installed on the International Space Station (ISS), has completed two years of data collection and production of science data products. The SAGE III/ISS is a solar and lunar occultation instrument, scanning the light from the sun and moon, through the limb of the Earth's atmosphere. It was launched in February 2017 and provides data from June 2017 to the present. It continues SAGE's legacy of ozone, aerosol and water vapor profile measurements and extends the lengthy records for monitoring constituents important for understanding stratospheric ozone trends. This presentation shows the preliminary validation results of comparing SAGE III/ISS ozone and water vapor vertical profiles with those of mission-funded ozonesondes and frost point hygrometers, associated LIDAR, and comparisons with other correlative data.

SAGE III/ISS



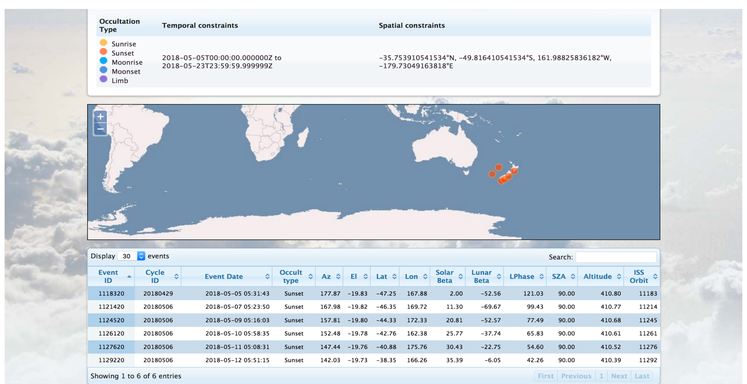
Sunrise **Moonset** ***(Moonrise*)***

The SAGE III/ISS is a solar and lunar occultation instrument. It uses the light from the sun and the moon to take measurements of the Earth's atmosphere through the limb of the planet. Three ozone data products are available for each solar event (one for lunar). This poster focuses on the ozone reported in the ozone_AO3 data product when comparing solar events. **This event depiction includes a lunar moonset. An event with an alternate orbit direction would depict a lunar moonrise.*

SAGE III/ISS Validation Event Prediction Locator
https://sage.nasa.gov/validation

Step 1: Occultation type selector
Step 2: Temporal range selector
Step 3: Geospatial range selector (optional)

Example of results using constraints shown:



Please contact the SAGE III Validation coordinator Carrie Roller at carrie.roller@nasa.gov to stay up-to-date with SAGE forecasted events and possible disruptions to SAGE due to ISS planned events. Coordinating in situ measurements with a SAGE III/ISS flyover would be highly beneficial in the validation of SAGE science data products.

Ozonesonde Comparisons

A first-look at the SAGE III/ISS v5.1 level 2 ozone_AO3 concentrations shows good agreements with coincident measurements from ozonesondes and LIDAR. The ozonesonde data used for this comparison are taken from the Aura Validation Data Center (AVDC) which provides measurements collected from NDACC, WOUDC, NOAA ESRL, and SHADOZ and put in a uniform HDF database. The LIDAR data used for this comparison are taken from the NDACC. The stations that provided data in HDF are used: Hohenpeissenberg, Obervatoire de Haute Provence (OHP), and Huntsville. Figure 1 shows the statistics of the mean SAGE matched events to the mean AVDC ozonesonde and NDACC LIDAR events with a good agreement in the stratosphere for data dates of June 2017 through January 2019. Matching criteria requires an event within 5 degrees latitude, 10 degrees longitude, and 24 hours time. Table 1 lists the ozonesonde organization acronyms and associated station names as well as number of coincidences per station that have ozone matches with SAGE III. Figure 2 shows the comparison of SAGE with the same in situ data as a function of time at an altitude of 25km. The event matches are labeled according to location. Figure 3 shows the comparison of Hohenpeissenberg, Lauder, and Boulder, three of the top-matching stations. Please note that no stratification has been performed here to analyze according to season, occultation type (sunrise, sunset, moonrise, moonset), reported uncertainty, etc. so all coincidences are used. The initial results show agreement of SAGE III with ozonesondes within about 5% difference in the 20km – 30km range in the stratosphere.

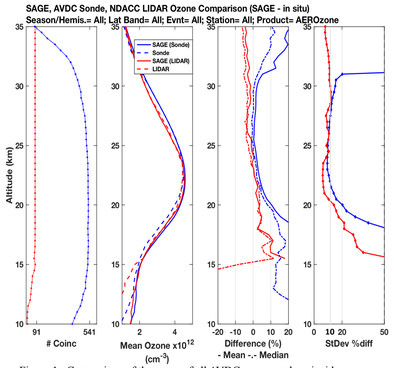


Figure 1. Comparison of the mean of all AVDC ozonesonde coincidences with SAGE III ozone_AO3 product from June 2017 – January 2019. Matching criteria requires an event within 5 degrees latitude, 10 degrees longitude, and 24 hours time.

Table 1: Coincidences by Organization ID & Station
(Number of coincidences with SAGE III/ISS in parentheses)

ABM	BroadMeadow (21), Davis (9), Macquerie Island (15)
AEMET	Izaña (6)
AWI	Neumayer (2)
CHMI	Praha (18)
CNRS	Dumont d Urville (2), Haute Provence (OHP) (14)
DMI	Scoresbysund (1)
DWD	Hohenpeissenberg (98)
ESRL	Boulder (35), Hilo (9), Huntsville (8), Pago Pago (9), Suva (4), Trinidad Head CA (29)
FMI	Marambio (15)
GSFC	Alajuela (12), Ascension (3), Hanoi (3), Natal (6)
IMGW	Legionowo (9)
INM	Barajas (25)
JMA	Naha (6), Sapporo (12), Syowa (5), Tsukuba (18)
KNMI	DeBilt (5), Paramaribo (4)
LACY	Reunion (3)
MCH	Payerne (35)
MMS	Sepang (6)
MSC	Churchill (3), Goose Bay (14), Stony Plain (14), Yarmouth (12)
NIWA	Lauder (36)
PSU	Nairobi (6)
SAWS	Irene (3)
SMNA	Ushuaia (6)

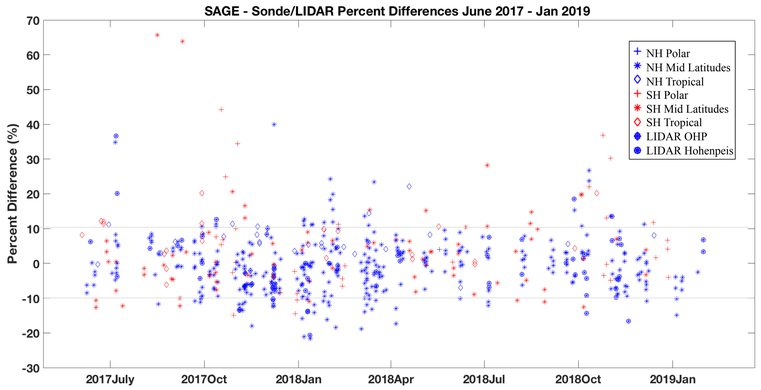


Figure 2. SAGE and in situ data percent differences as a function of time at 25km. Red indicates Southern Hemisphere (SH) and blue indicates Northern Hemisphere (NH) measurements.

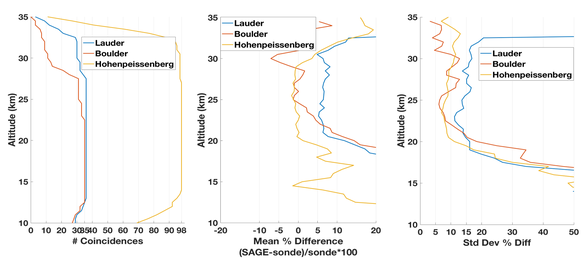


Figure 3. Plotted together for comparison, three ozonesonde locations with a relatively large number of coincidences. No constraints are placed on the matched data set other than spatial and temporal as mentioned above. It is possible that a larger set of matching data points, for example, Hohenpeissenberg having almost 100 events to analyze, allows for better agreement overall.

Water Vapor Comparisons

A first-look at the SAGE III/ISS newly released v5.1 level 2 preliminary (Beta) water vapor concentrations compares well with frost point hygrometer sonde data and the Earth Observing System (EOS) Aura Microwave Limb Sounder (MLS) coincident measurements. So far, SAGE has results from 3 collocated sonde sites: Boulder, Lauder, and Alajuela. The agreement has been a good for a first comparison, especially within the stratosphere. Figures 4, 5, and 6 show water vapor concentration and percent differences for three individual event matches for Lauder, Boulder, and Alajuela, respectively. These individual plots are a good representation of the few matches retrieved for each of the three sonde locations. Again, the criteria for matching requires a SAGE event within 5 degrees latitude, 10 degrees longitude, and 24 hours time of the sonde measurements. Multiple MLS matches for the spatial and temporal constraints are averaged for this comparison. SAGE and frost point hygrometer (FPH) data are interpolated to the MLS vertical grid. SAGE, MLS and FPH agreements are within a 20% difference in the stratosphere. Figure 7 (bottom right of poster) shows a map representing the locations of all AVDC ozonesonde sites listed in Table l as well as LIDAR and water vapor station locations that have coincidences with SAGE III to date.

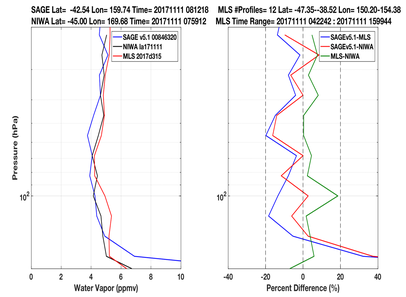


Figure 4. SAGE III and mean MLS matched with NIWA Lauder event on November 11, 2017.

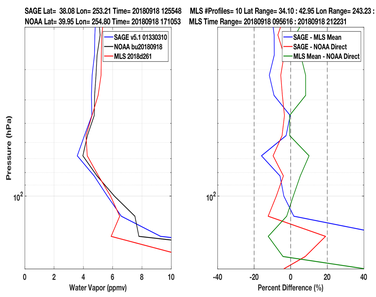


Figure 5. SAGE III and mean MLS matched with NOAA ESRL Boulder event on September 18, 2018.

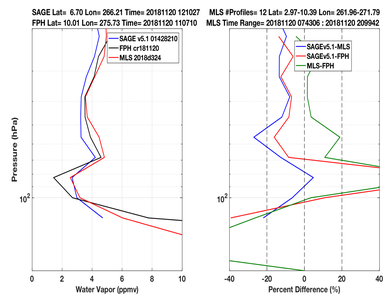
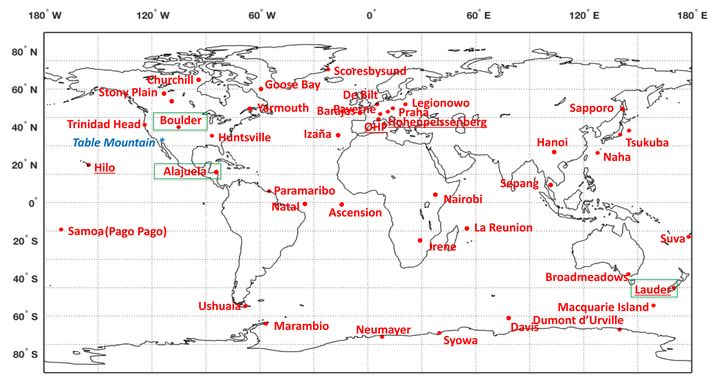


Figure 6. SAGE III and mean MLS matched with NASA GSFC Alajuela event on November 20, 2018.

Figure 7. Below is a map of AVDC ozonesonde sites matched to SAGE III data within June 2017 to January 2019 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 outlined in green. Matching criteria: 5° Lat; 10° Lon; 24 hours. AVDC access is by permission of NASA Goddard. NDACC data is available at: http://www.ndacc.org.

AVDC Ozonesonde/NDACC LIDAR & Water Vapor Locations



Summary

- A first-look at the SAGE III/ISS Level 2 ozone_AO3 concentrations shows good agreement with coincident measurements from the AVDC database sampling of ozonesondes and with three NDACC LIDAR stations. Percent differences are consistently within 10%.
- The SAGE III water vapor preliminary data product is reporting good agreements with MLS and sonde frost point hygrometers with percent differences staying within 20%.
- 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 NOAA-ESRL, NIWA, AVDC, NDACC and NASA-JPL.

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