

Stratospheric Aerosol and Gas Experiment III on the International Space Station(SAGE III/ISS) Validation of Ozone and Water Vapor Data



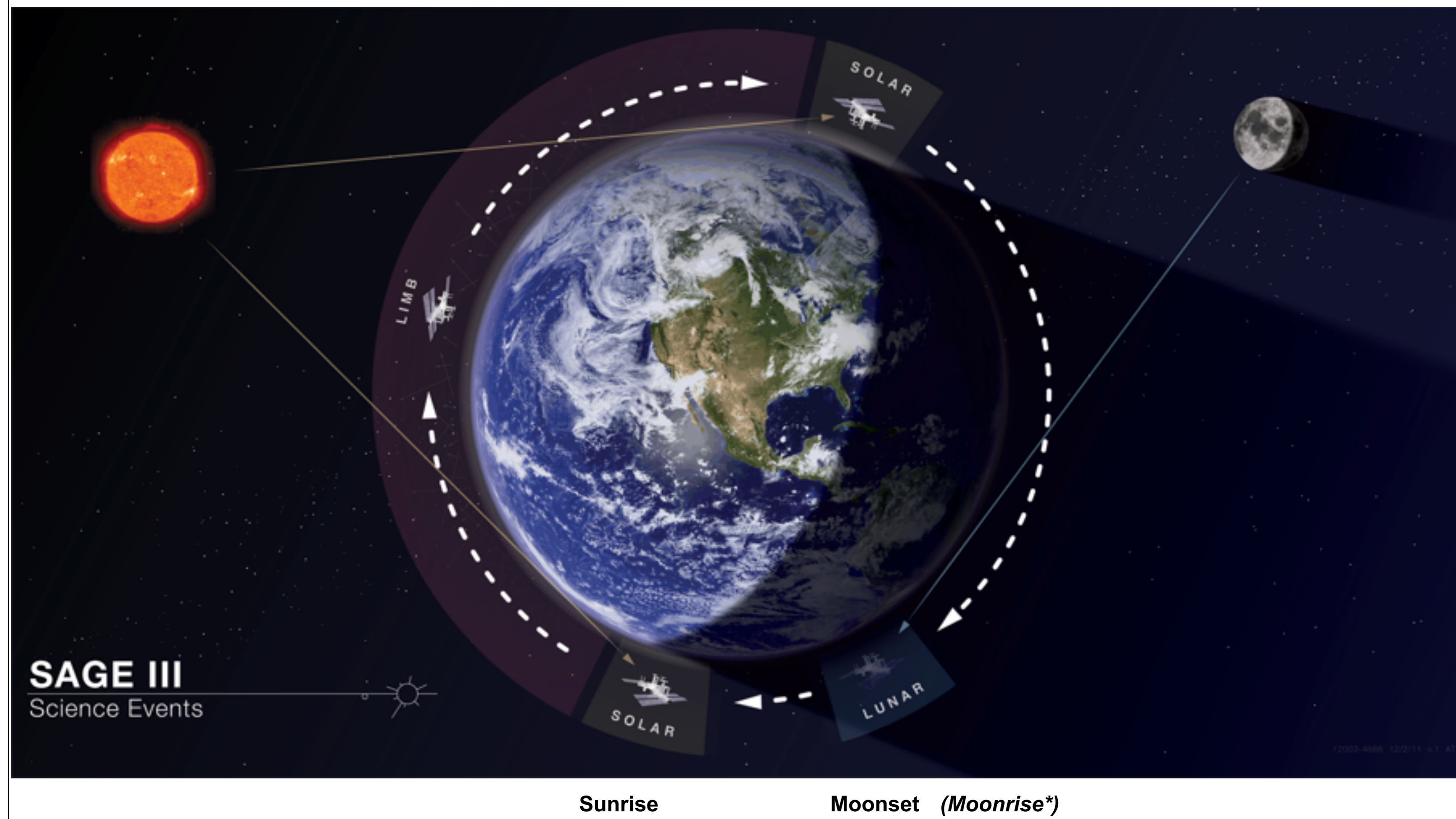
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Abstract

The Stratospheric Aerosol and Gas Experiment III (SAGE III) instrument installed on the International Space Station (ISS) has completed four years of data collection and production of science data products. 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. 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. Recently, the latest version 5.2 data product has been released to the public. This presentation shows the validation results of comparing v5.2 SAGE III/ISS ozone and water vapor vertical profiles with those of in situ and satellite data.

SAGE III/ISS



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 and ozone_meso data products when comparing solar events. *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 NO2 clearing at low altitudes.
- Modified path length calculation to partially account for vertical gradients within a layer.
- Removed Rayleigh and O4 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 Event Prediction Locator
<https://sage.nasa.gov/validation>

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.

Ozone Comparisons

A comparison of the SAGE III/ISS v5.2 level 2 ozone_AO3 concentrations shows good agreements with coincident measurements from ozonesondes, LIDAR, MLS and ACE-FTS. The ozonesonde data used for this comparison are taken from measurements collected from NDACC, WOUDC, NOAA ESRL, and SHADOZ databases. The LIDAR data used for this comparison are taken from the NDACC. Figure 1 and 2 shows the statistics of the mean SAGE, MLS and ACE-FTS matched solar events to the mean ozonesonde and LIDAR events, respectively, with a good agreement in the stratosphere.

Matching criteria of satellite data with in-situ data 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.) 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. For more information on SAGE solar ozone comparison criteria, refer to the paper "Validation of SAGE III/ISS Solar Ozone Data with Correlative Satellite and Ground Based Measurements", H.J. Ray Wang et al, JGR 2020 (<https://doi.org/10.1029/2020JD032430>).

The Mean Percent Difference is calculated using the interpercentile range. When comparisons are stratified according to season, occultation type (sunrise, sunset, moonrise, moonset), individual station, etc., the number of coincidences are greatly reduced with the amount of stringency placed on the comparisons. A relatively large number of matches remain when plotting sonde data with SAGE solar data with only parsing according to latitude range.

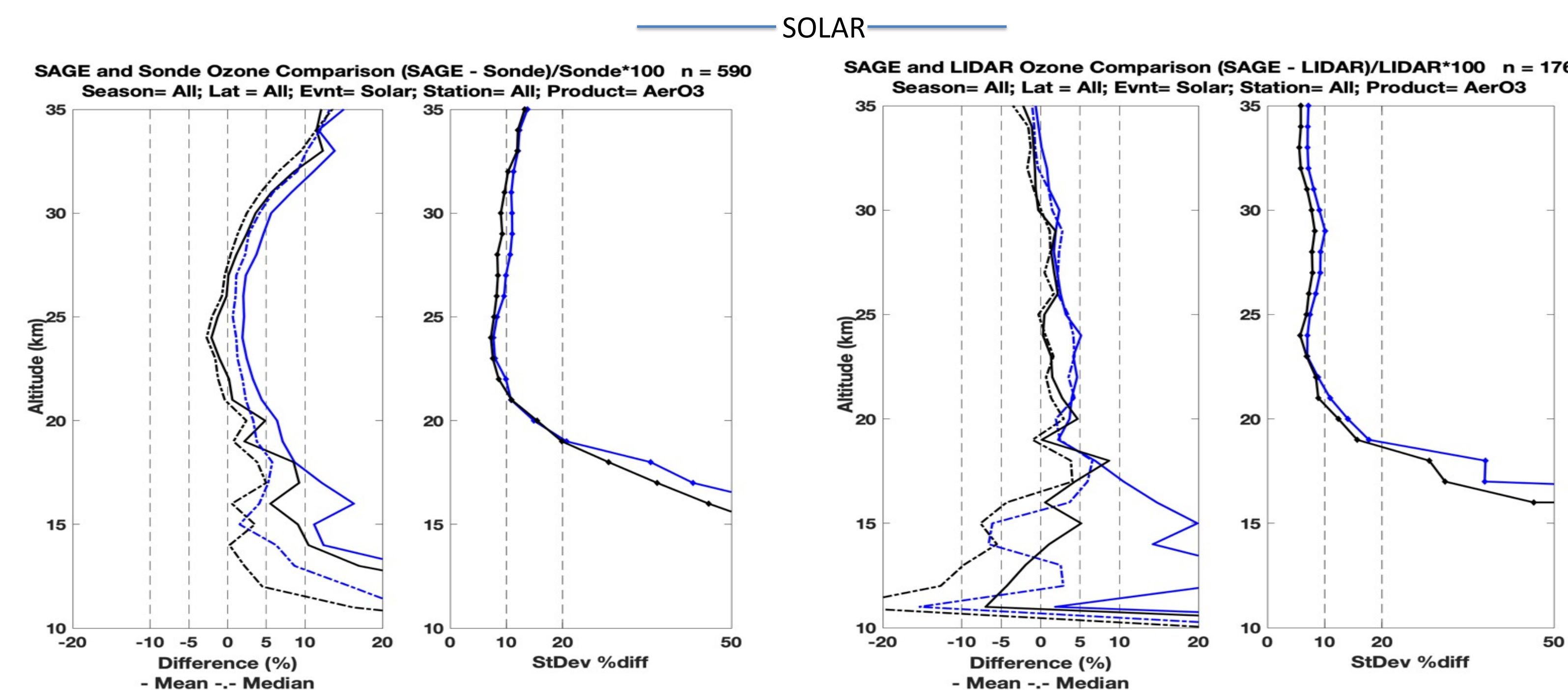


Figure 1. Comparison of the mean of all ozonesonde coincidences with SAGE III ozone_AO3 solar product from June 2017 - May 2020. Matching criteria with the sonde requires an event within 5 degrees latitude, 1000km distance, and 24 hours time. Figure 2. Comparison of the mean of all LIDAR coincidences with SAGE III ozone_AO3 solar product from June 2017 - September 2019. Matching criteria requires an event within 5 degrees latitude, 10 degrees longitude, and 24 hours time.

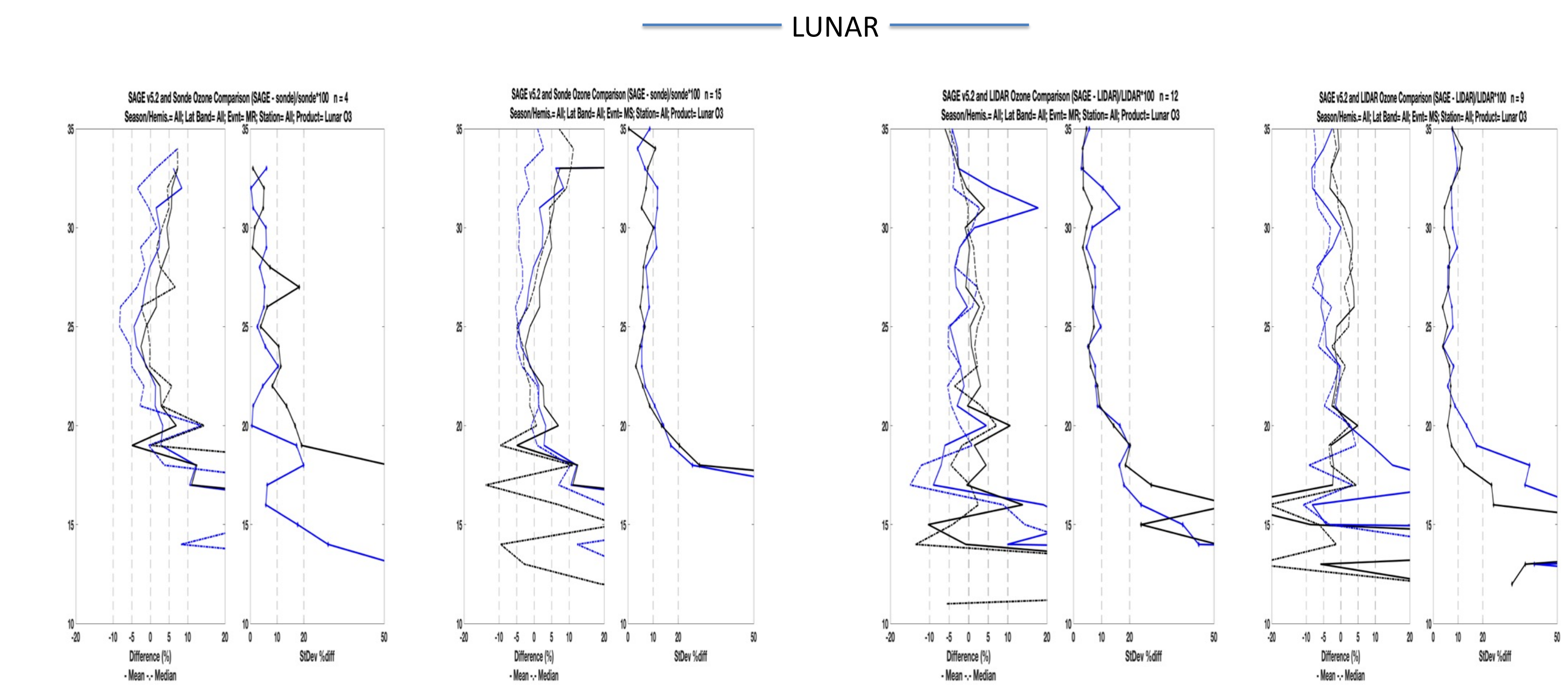
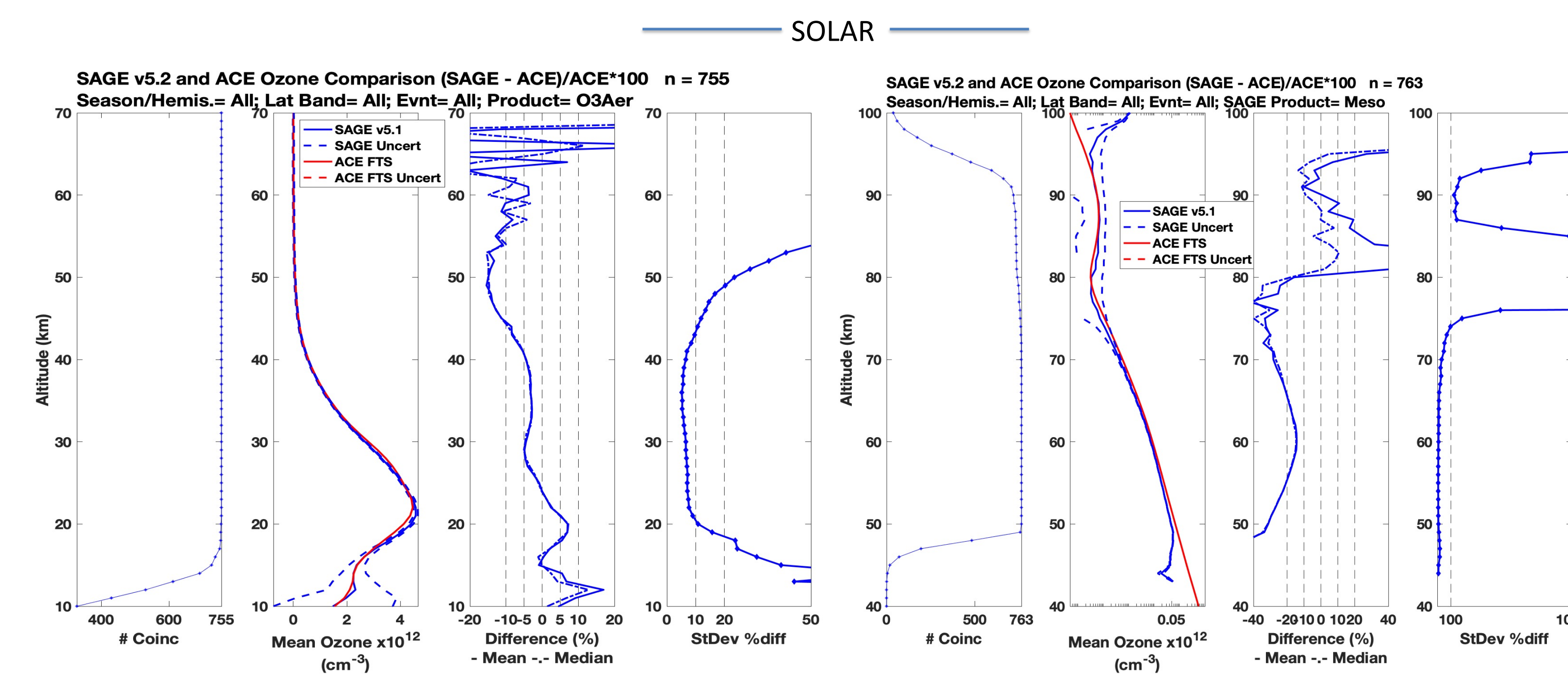


Figure 3. Comparison of the mean of all ozonesonde coincidences with SAGE III ozone_AO3 lunar product from June 2017 - May 2020. Matching criteria requires an event within 5 degrees latitude, 1000km distance, and 24 hours time. Figure 4. Comparison of the mean of all LIDAR coincidences with SAGE III ozone_AO3 lunar product from June 2017 - September 2019. Matching criteria requires an event within 5 degrees latitude, 10 degrees longitude, and 24 hours time.



Water Vapor Comparisons

The SAGE III/ISS v5.2 Level 2 preliminary (Beta) water vapor concentrations compare well with frost point hygrometer (FPH) sonde data and the Earth Observing System (EOS) Aura Microwave Limb Sounder (MLS) coincident measurements. 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 data are interpolated to the MLS vertical grid. SAGE, MLS and FPH agreements are within a 20% difference in the stratosphere.

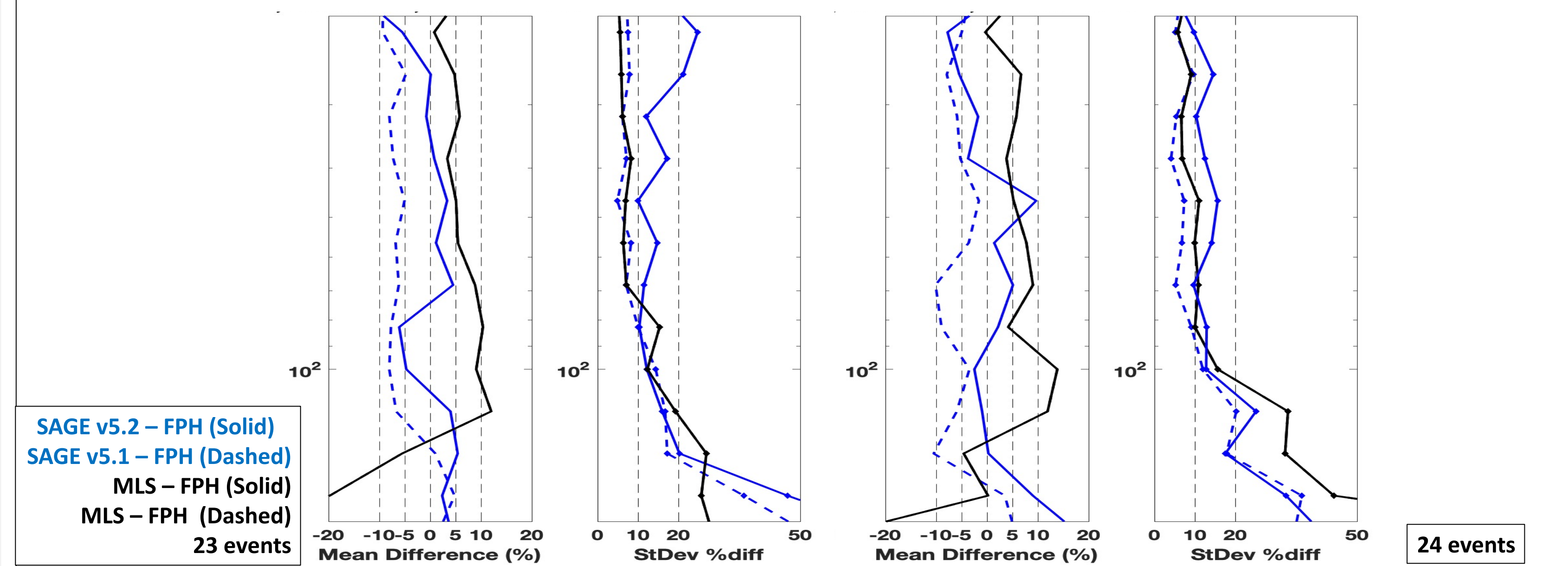
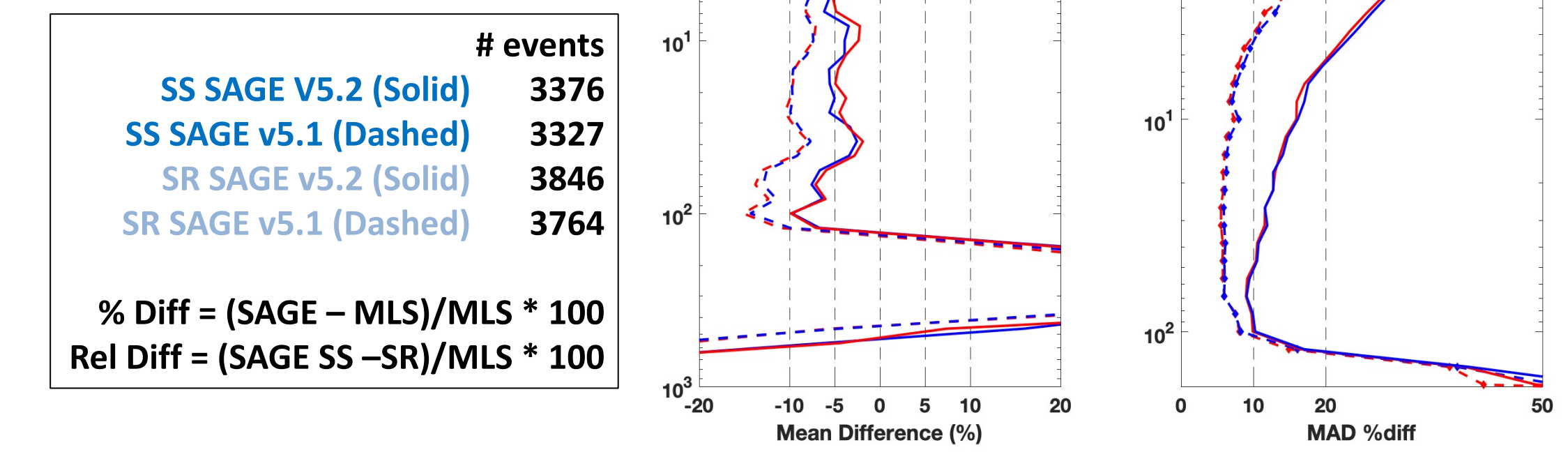


Figure 6. Comparison of the mean of all FPH coincidences with SAGE III and Aura MLS water vapor from June 2017 - May 2020.

SR/SS Water Vapor Comparison 20 - 60 N



Summary

- The SAGE III/ISS Level 2 ozone_AO3 concentrations show good agreement with coincident measurements from the in-situ database sampling of ozonesonde and LIDAR stations. SAGE solar data agrees within percent differences of 5% in the altitude range of 20-30km with mid-latitude sondes and LIDAR. SAGE lunar percent differences are within 10% in this altitude range.
- The SAGE III water vapor preliminary data product is reporting good agreements with MLS and sonde frost point hygrometers with percent differences staying within 10% in the middle stratosphere.
- 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. 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.