Validation of SAGE III/ISS solar water vapor data with correlative satellite and balloon-borne measurements

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Overview

• This talk will summarize the recent SAGE III/ISS WV validation paper:
  
  Davis, S. M., et al.: Validation of SAGE III/ISS solar water vapor data with correlative satellite and balloon-borne measurements. JGR-Atmos, in revision

**Overall goals:** Establish SAGE III/ISS WV data quality and provide data user guidance

• Basic QC screening of v5.1 WV data
• Quantify agreement with other instruments
  • MLS, ACE-FTS, and balloon frostpoint coincident profile comparisons
QC screening

• Extreme outliers are manually identified for removal

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QC screening

- Median absolute deviation (MAD) – outlier resistant dispersion metric
  - Gaussian distribution: $\text{MAD}^* \sim \sigma$

$\text{MAD}^*$ and $\sigma$ diverge below $\sim 17$ km and above $\sim 40$ km → Large outliers
QC screening

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  $\text{MAD}^*$ and $\sigma$ diverge below $\sim 17$ km and above $\sim 40$ km
  → Large outliers

- Above 35 km, we remove “keel over” profiles
- Below 20 km, we remove cloud-impacted profiles
Keel over profiles

- Profiles with abrupt jumps
Keel over profiles

- Filtering based on vertical derivative
- Remove points from 5 km below where derivative exceeds 1 ppmv km$^{-1}$
Keel over profiles

• Keelovers have a similar profiles

• Below keelover point SAGE and MLS agreement is normal for keel over events

→ Bottom part of keelover is OK
Cloud filtering

• Basic idea
  • clouds mess up WV retrieval
  • identify highest cloud occurrence and truncate profile below this point

• Cloud identification
  • Large extinction & color ratio
  • Color ratio \( \equiv \beta_{1020\text{ nm}} / \beta_{520\text{ nm}} \)
Cloud filtering

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• Cloud identification
  • Large extinction & color ratio
  • Color ratio \( \equiv \beta_{1020\text{nm}} / \beta_{520\text{nm}} \)
  • Joint distribution of \( \beta_{1020\text{nm}} \) and CR is bimodal

Truncate profile below where CR > 0.5 & \( \beta_{1020\text{nm}} > 2 \times 10^{-4} \text{ km}^{-1} \)
  or
When extinction fill value is reported
Application of cloud/keel over filtering

- These two screenings remove most outliers (upper strat) and negative values (upper trop)

- No other screening recommended

- Large uncertainty events reflect events that are, well, uncertain
Coincident profile comparison

- Comparisons are with MLS, ACE-FTS, and balloon frostpoints
- For each SAGE III profile, look for MLS and ACE-FTS within
  ± 1 day, ± 10° longitude, ± 2° latitude
- For frostpoint comparison, use
  ± 2 days, ± 20° longitude, ± 4° latitude

→ Take closest profile in space if > 1 profile match
- MLS WV mixing ratio interpolated to SAGE altitude grid using MERRA2
SAGE / MLS / ACE-FTS comparison

- SAGE is \(~0.5\) ppmv (10%) drier than MLS through most of the stratosphere
- Closer agreement with ACE-FTS, but version dependent
SAGE / MLS / ACE-FTS (v3.6) comparison

- No strong lat dependence with MLS
- Hint of a lat-dependence with ACE-FTS
  - But poor sampling in tropics
Aerosol sensitivity: pyrocbs and eruptions

- Negative bias increases with OD
- Eruptions show steeper slope
- Increased uncertainty (red points) at higher OD
Aerosol sensitivity: pyrocbs and eruptions

- Negative bias increases w/ OD
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SAGE III/ISS – frostpoint coincident profile comparison

- SAGE dry bias \(~0.1-0.3\) ppmv

- SAGE III/ISS has smaller magnitude bias, and more consistent vertical structure, than SAGE II.
Conclusions

• Overall, SAGE III/ISS v5.1 data provides high quality water vapor measurements.

• SAGE III / ISS WV data require significant filtering, but we have a decent set of criteria to QC the data:
  - Keel-over profile filtering removes most large outliers in upper stratosphere.
  - Extinction + Color ratio filtering to remove clouds in upper troposphere.

• From ~20 – 40 km, SAGE III/ISS WV shows a < ~10% (0.0 - 0.5 ppmv) dry bias relative to MLS, ACE-FTS, and FP balloon measurements.