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

Sean Davis
sean.m.davis@noaa.gov
NOAA Chemical Sciences Laboratory, Boulder, CO

Rob Damadeo, Dave Flittner, Karen Rosenlof, Mijeong Park, Bill Randel, Emrys Hall, Dave Huber, Dale Hurst, Allen Jordan, Susan Kizer, Luis Millan, Rennie Selkirk, Ghassan Taha, Kaley Walker, Holger Vömel

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

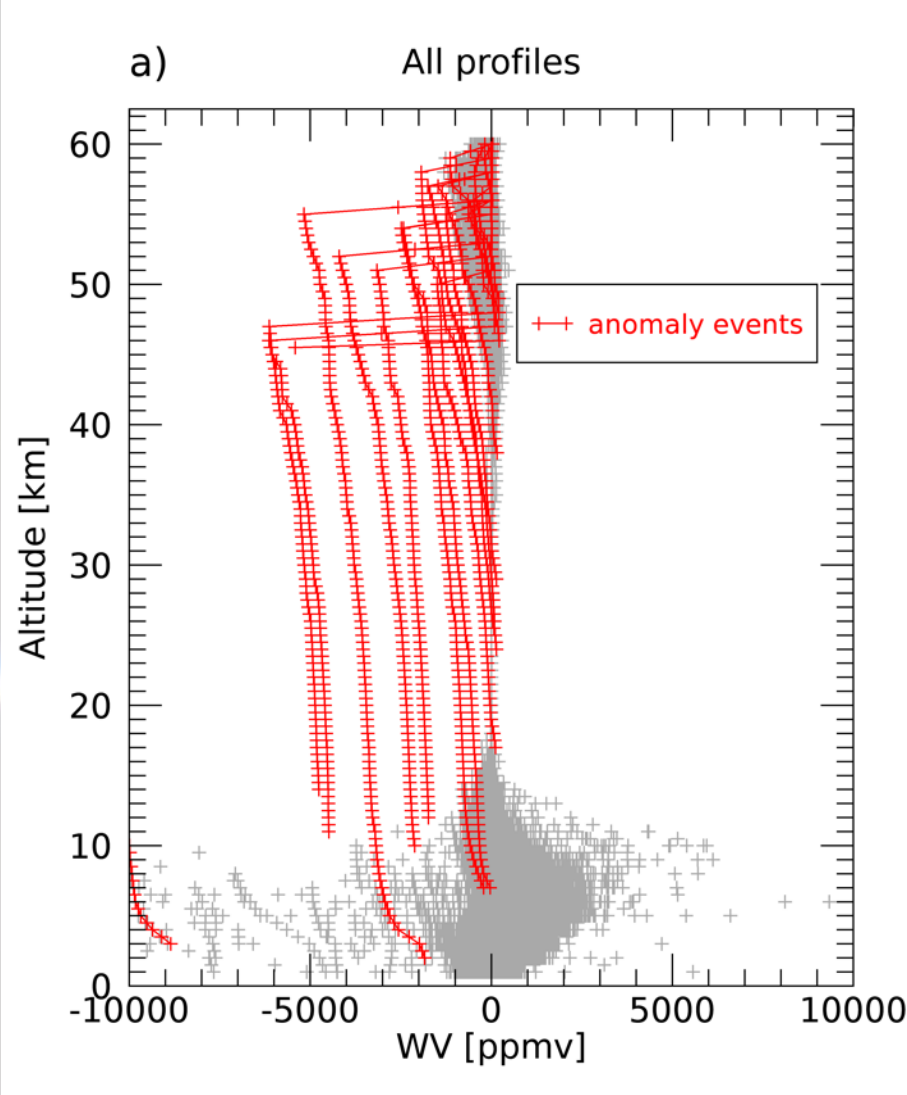
<u>Overall goals:</u> Establish SAGE III/ISS WV data quality and provide data user guidance

- 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

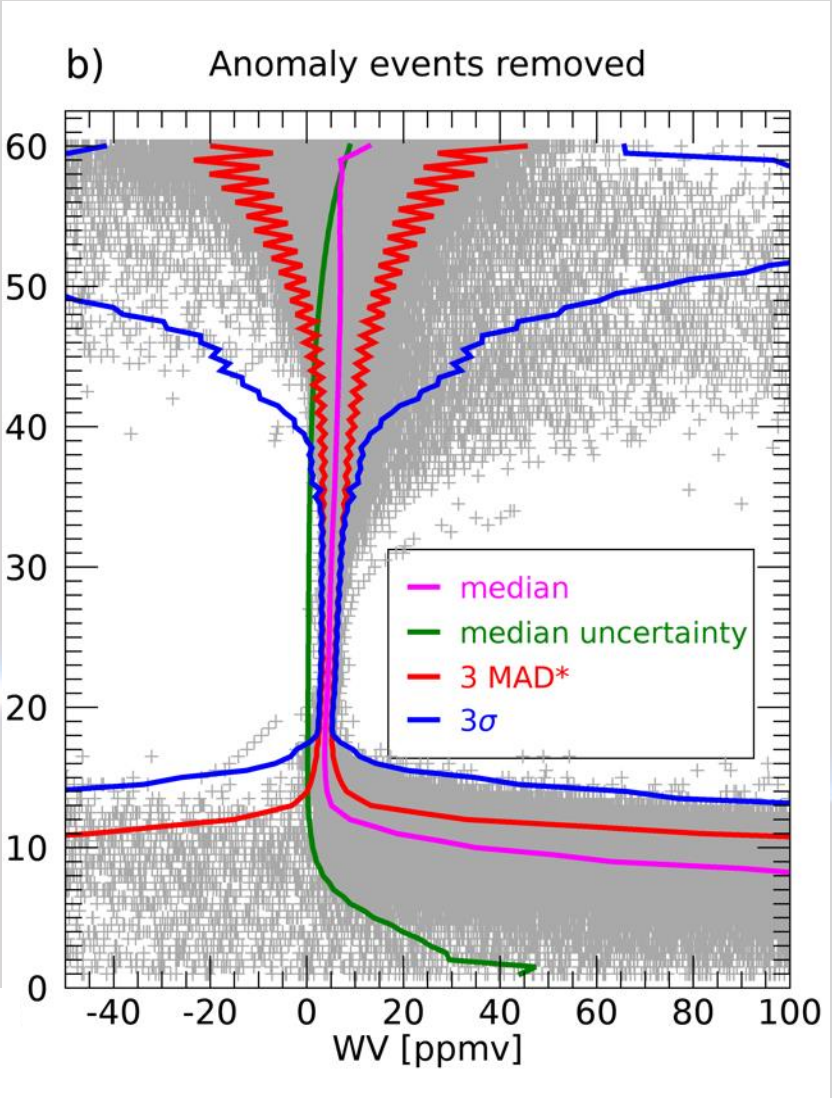
Event number	Date	Time	Latitude	Longitude	Reason
1128120	2018-05-11	12:51:54	-39.97	60.35	anomaly
1495410	2019-01-02	16:59:41	43.92	-139.92	anomaly
1587720	2019-03-03	3:01:49	-54.70	-122.50	anomaly
1587920	2019-03-03	6:07:17	-54.45	-169.04	anomaly
1589520	2019-03-04	6:50:56	-52.29	178.72	anomaly
1592220	2019-03-06	0:34:43	-48.09	-89.27	anomaly
1596720	2019-03-08	22:08:09	-39.07	-55.50	anomaly
1630910	2019-03-30	22:05:22	-43.44	123.49	anomaly
1632310	2019-03-31	19:44:11	-45.70	159.39	anomaly
1683520	2019-05-03	18:50:00	-46.95	-30.86	anomaly
1739820	2019-06-09	0:20:16	33.84	-78.85	anomaly
1756710	2019-06-19	22:29:33	-1.39	113.57	anomaly
1762620	2019-06-23	17:13:27	-32.26	-3.68	anomaly
1766110	2019-06-25	22:25:57	28.04	100.89	anomaly
719620	2017-08-21	20:23:56	-6.69	-36.65	eclipse



QC screening

- Median absolute deviation (MAD) – outlier resistant dispersion metric
  - Gaussian distribution: MAD* ~ σ

MAD* and σ diverge below ~17 km and above ~40 km
→ Large outliers



QC screening

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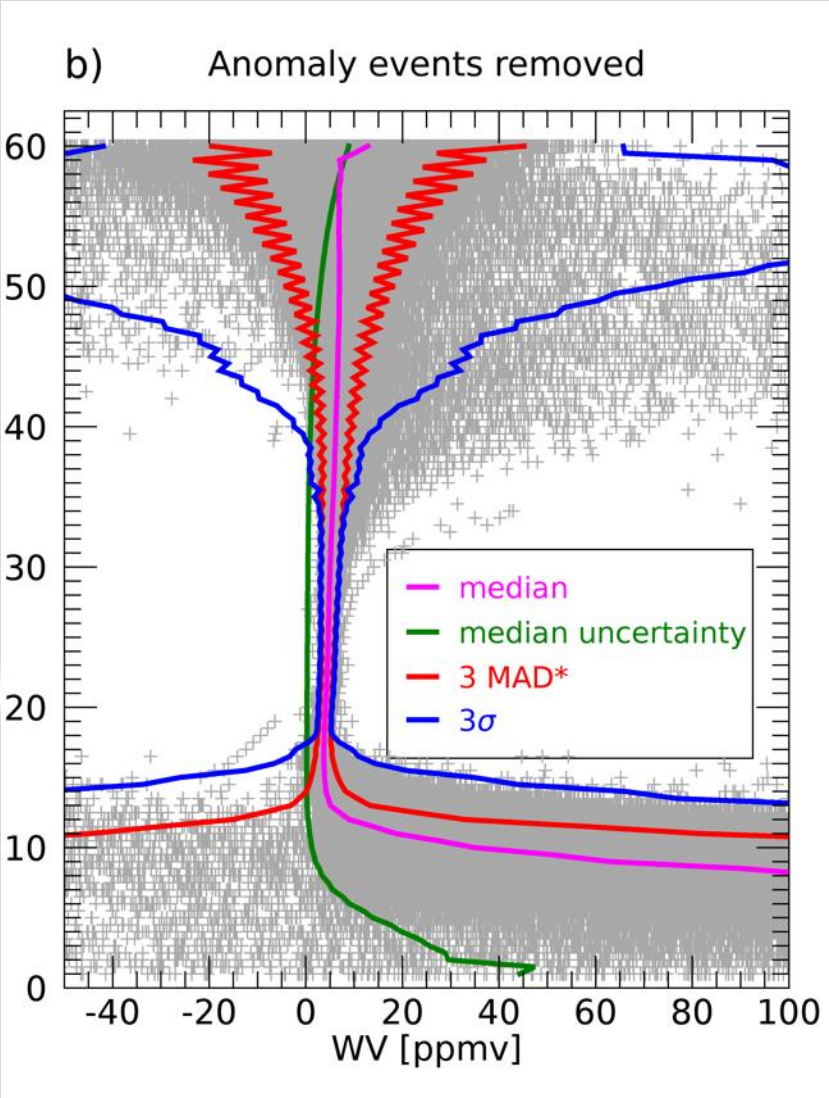
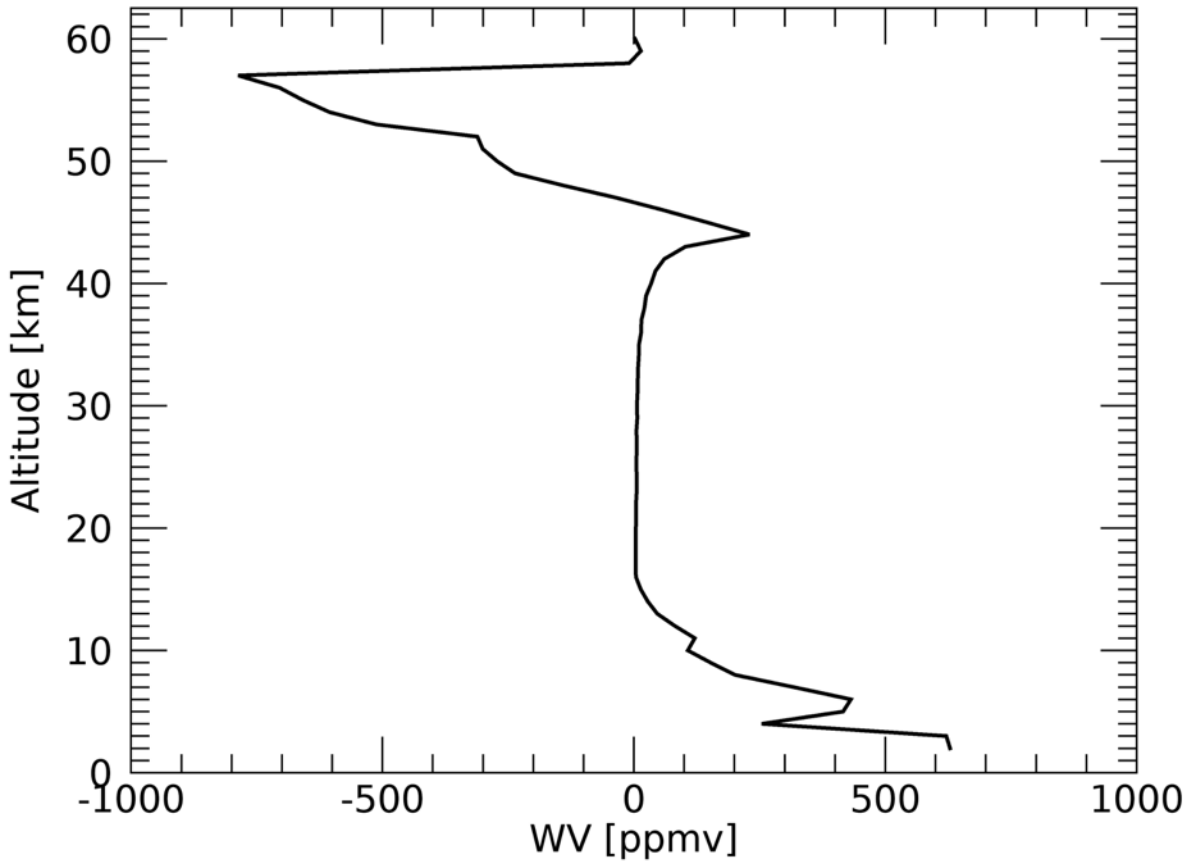
- Above 35 km, we remove "keel over" profiles
- Below 20 km, we remove cloud-impacted profiles



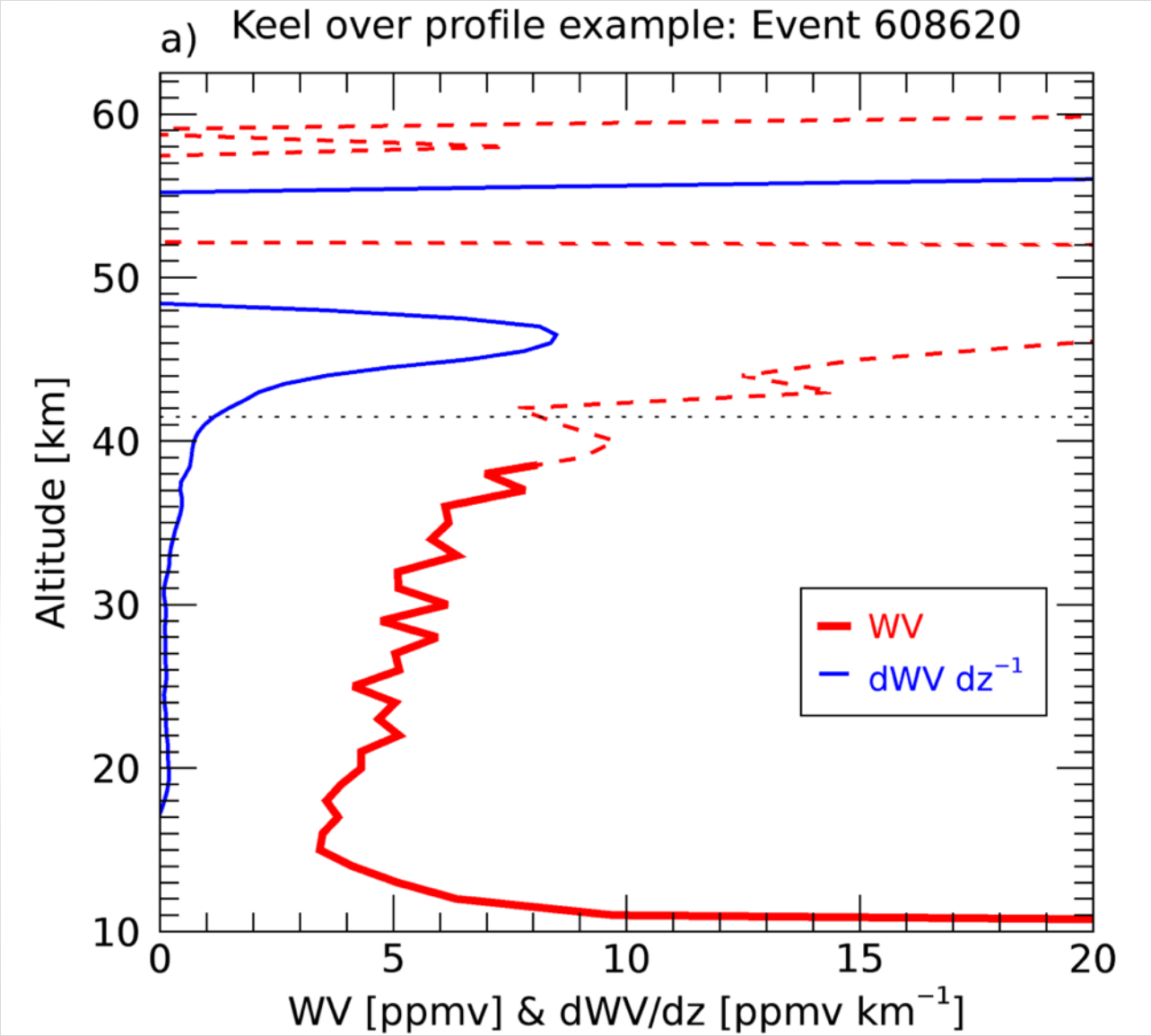
Keel over profiles

- Profiles with abrupt jumps



Keel over profiles

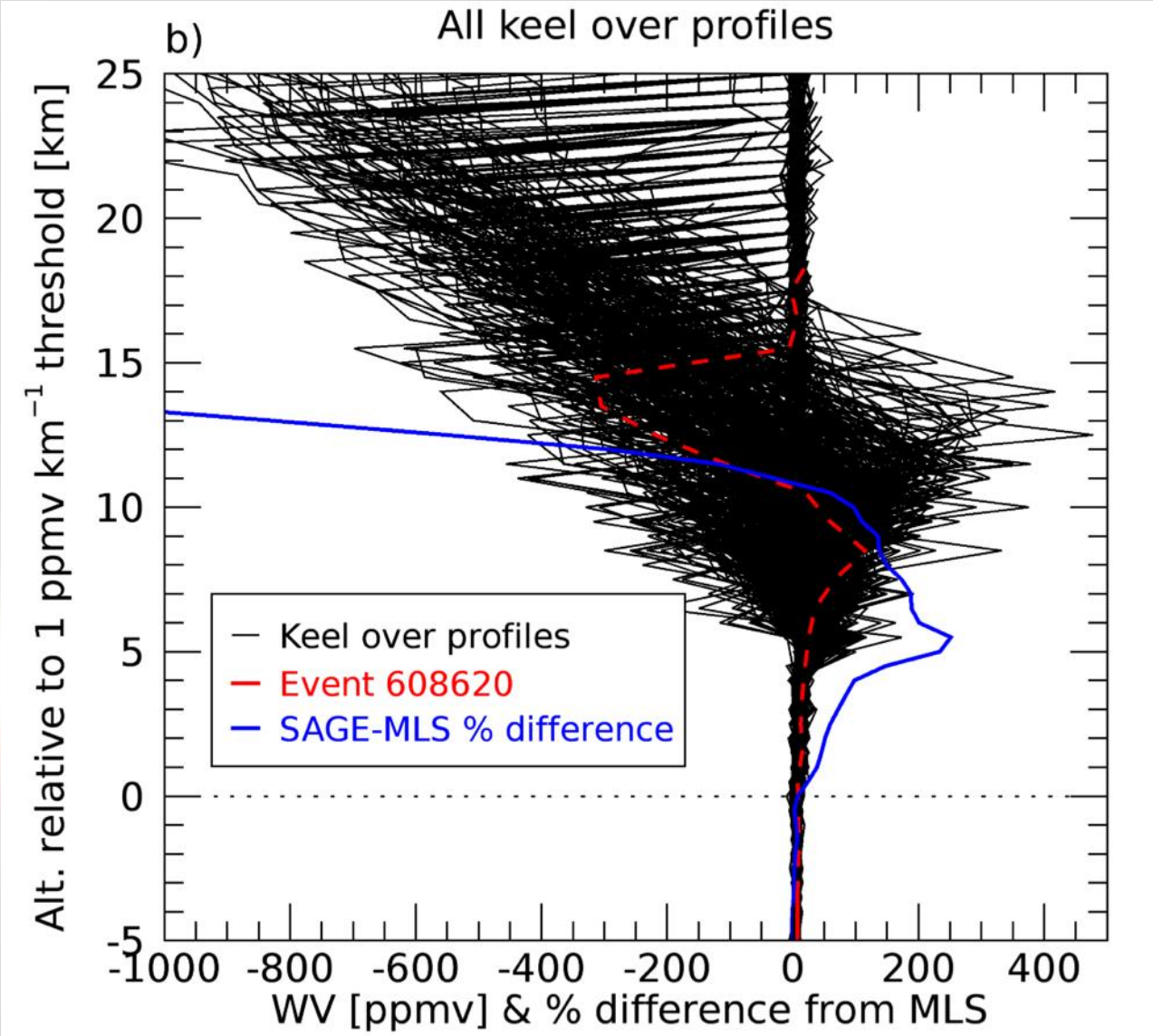
- Filtering based on vertical derivative
  - Remove points from 5 km below where derivative exceeds 1 ppmv km^{-1}



Keel over profiles

- Keelovers have a similar profiles

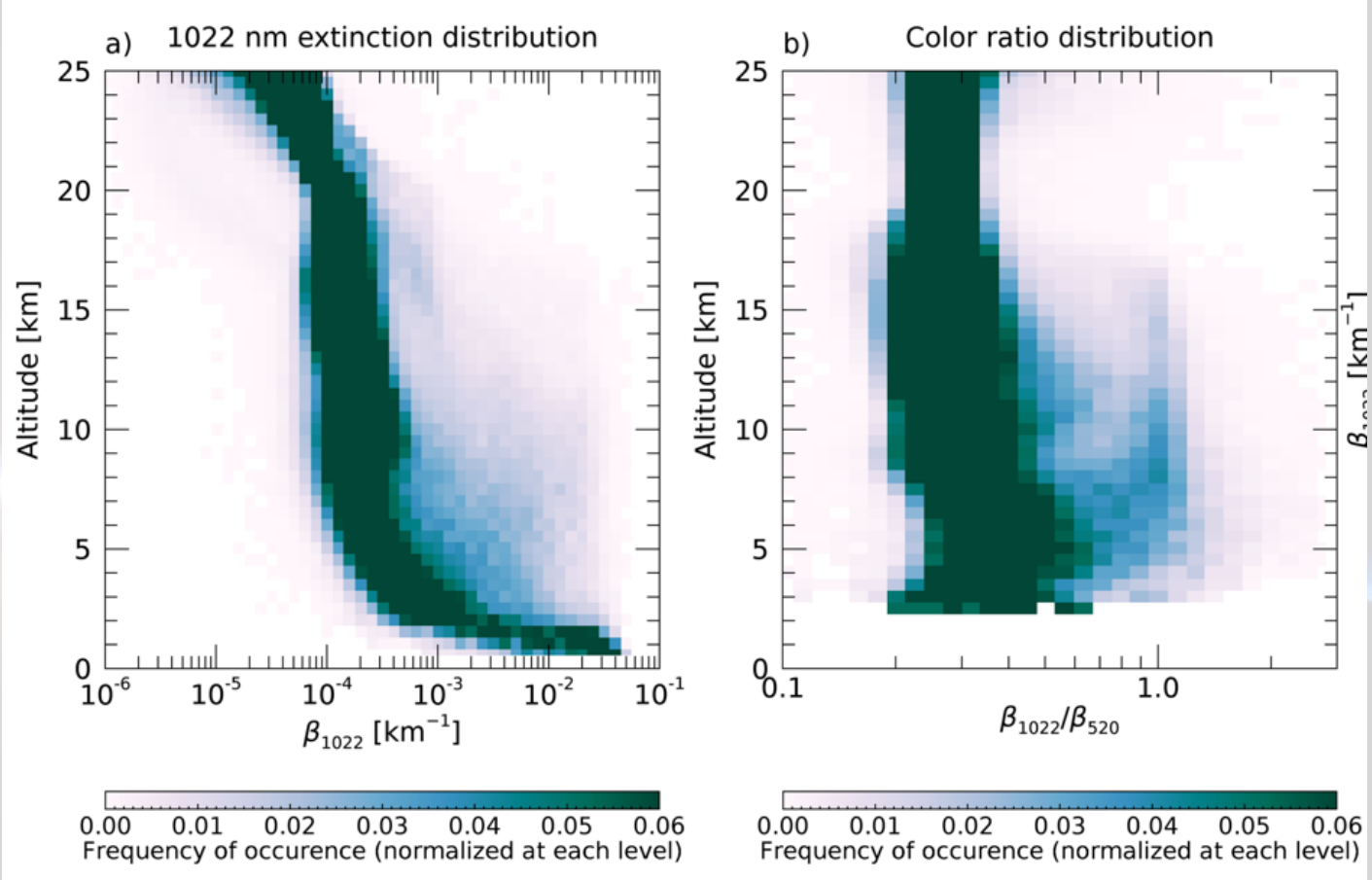
- Below keelover point SAGE and MLS agreement is normal for keel over events
  → Bottom part of keelover is OK



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 ≡ $\beta_{1020\,nm} / \beta_{520\,nm}$



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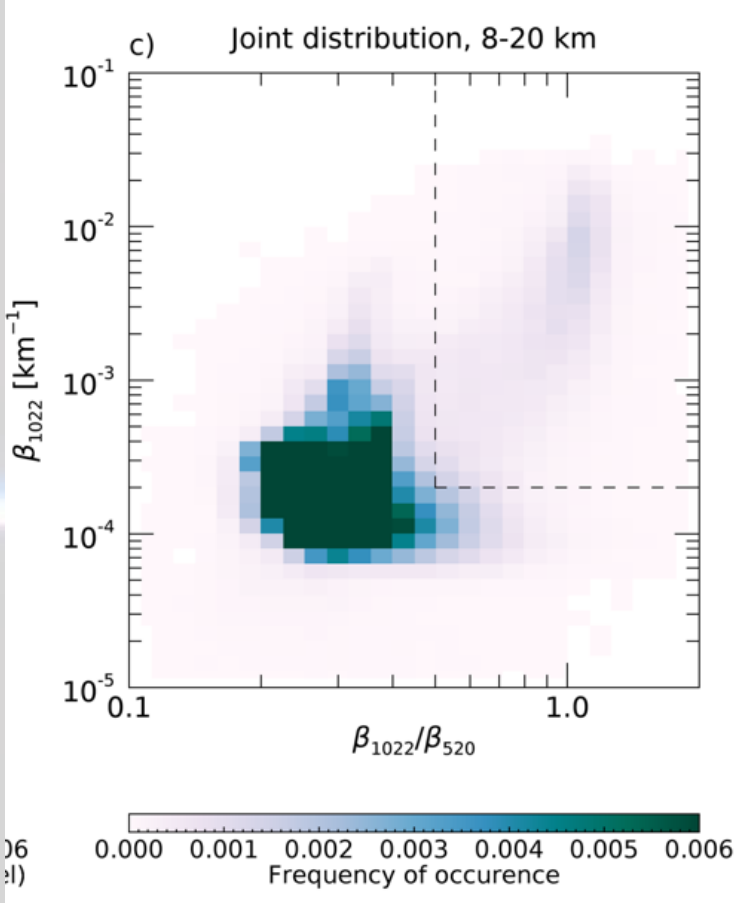
- Cloud identification
  - Large extinction & color ratio
  - Color ratio ≡ $\beta_{1020\,nm}$ / $\beta_{520\,nm}$
- Joint distribution of $\beta_{1020\,nm}$ and CR is bimodal

Truncate profile below where CR > 0.5 & $\beta_{1020\,nm} > 2 \times 10^{-4}$ km^{-1}

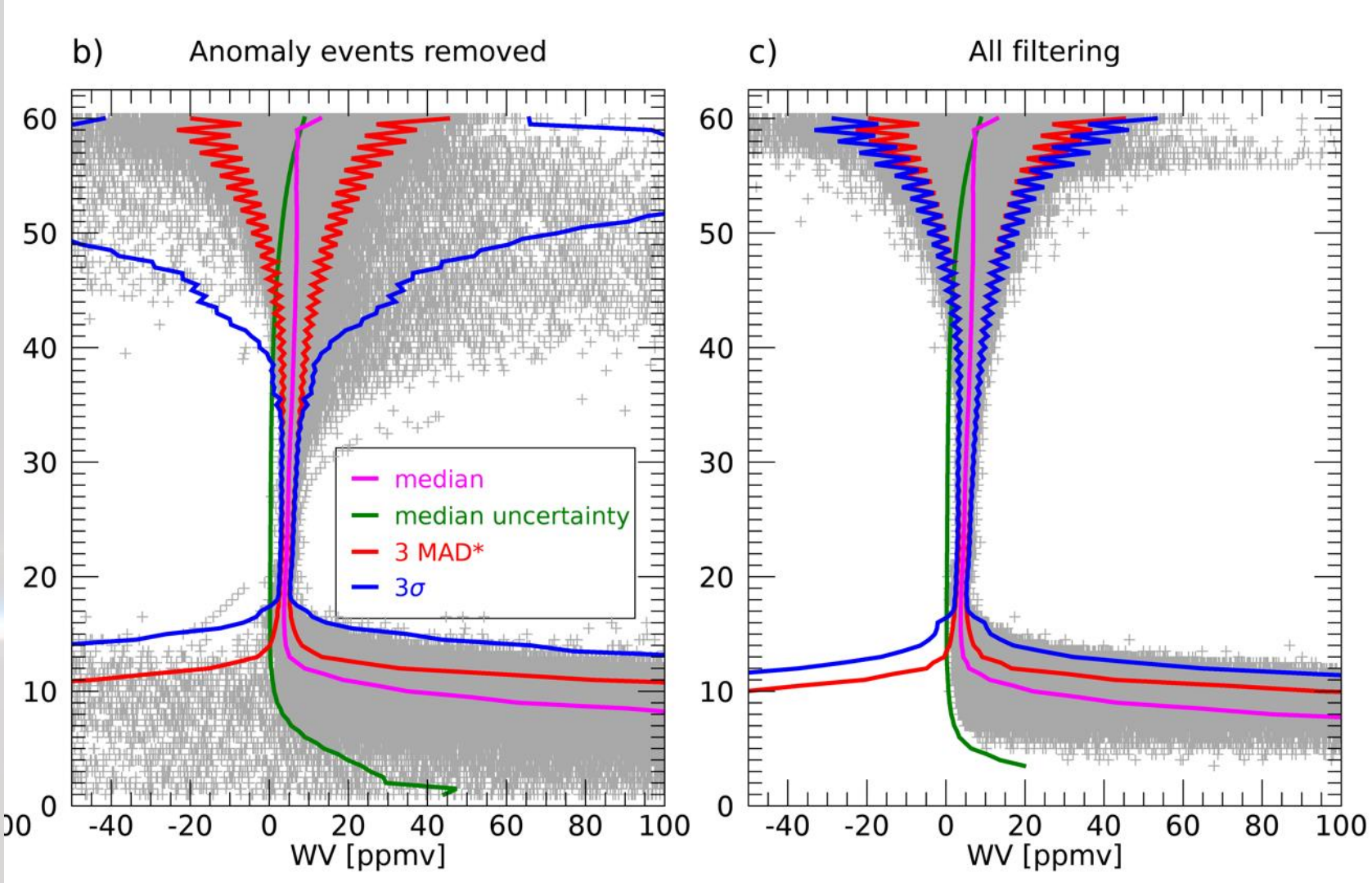
or

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

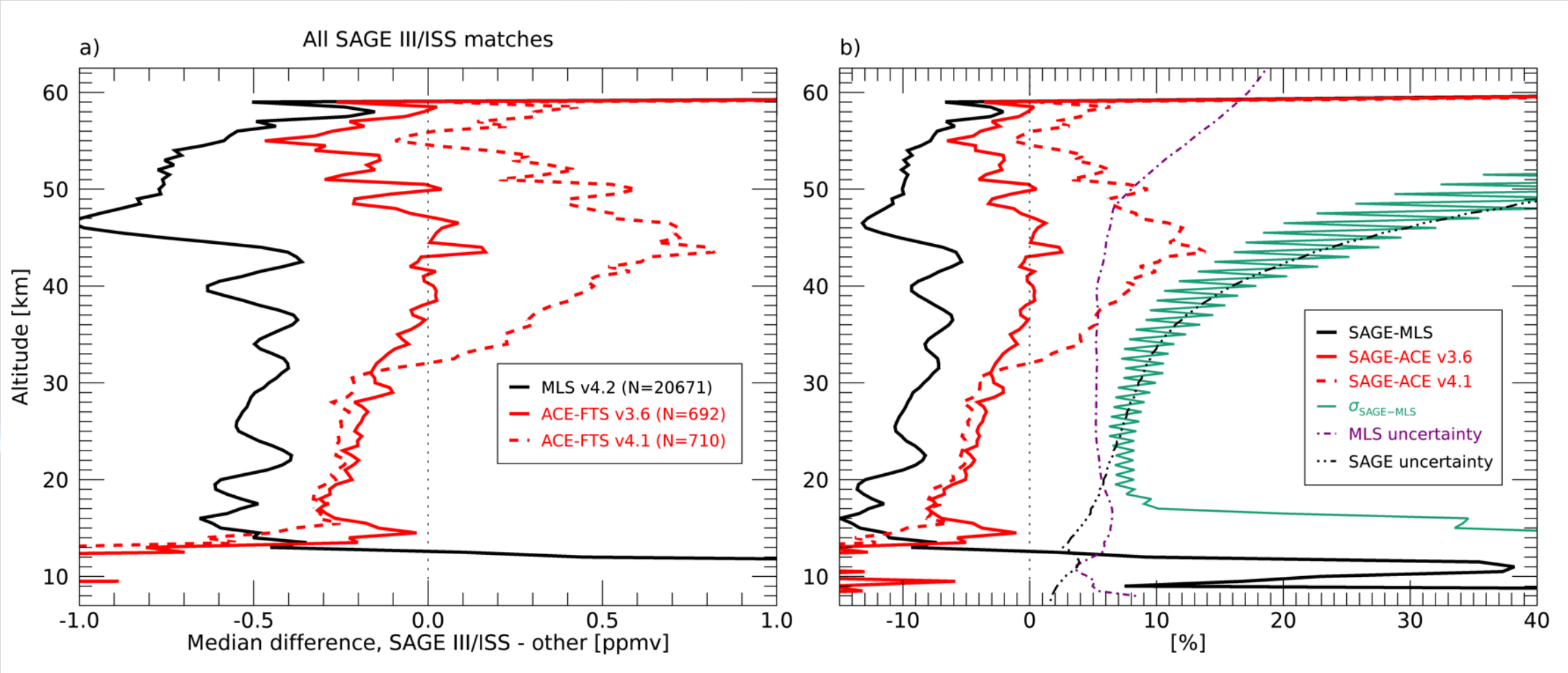
- Comparisons are with MLS, ACE-FTS, and balloon frostpoints
- For each SAGE III profile, look for MLS and ACE-FTS within
  ± 1 day, ± 10° longitude, ± 2° latitude
- For frostpoint comparison, use
  ± 2 days, ± 20° longitude, ± 4° latitude

→ Take closest profile in space if > 1 profile match

- MLS WV mixing ratio interpolated to SAGE altitude grid using MERRA2

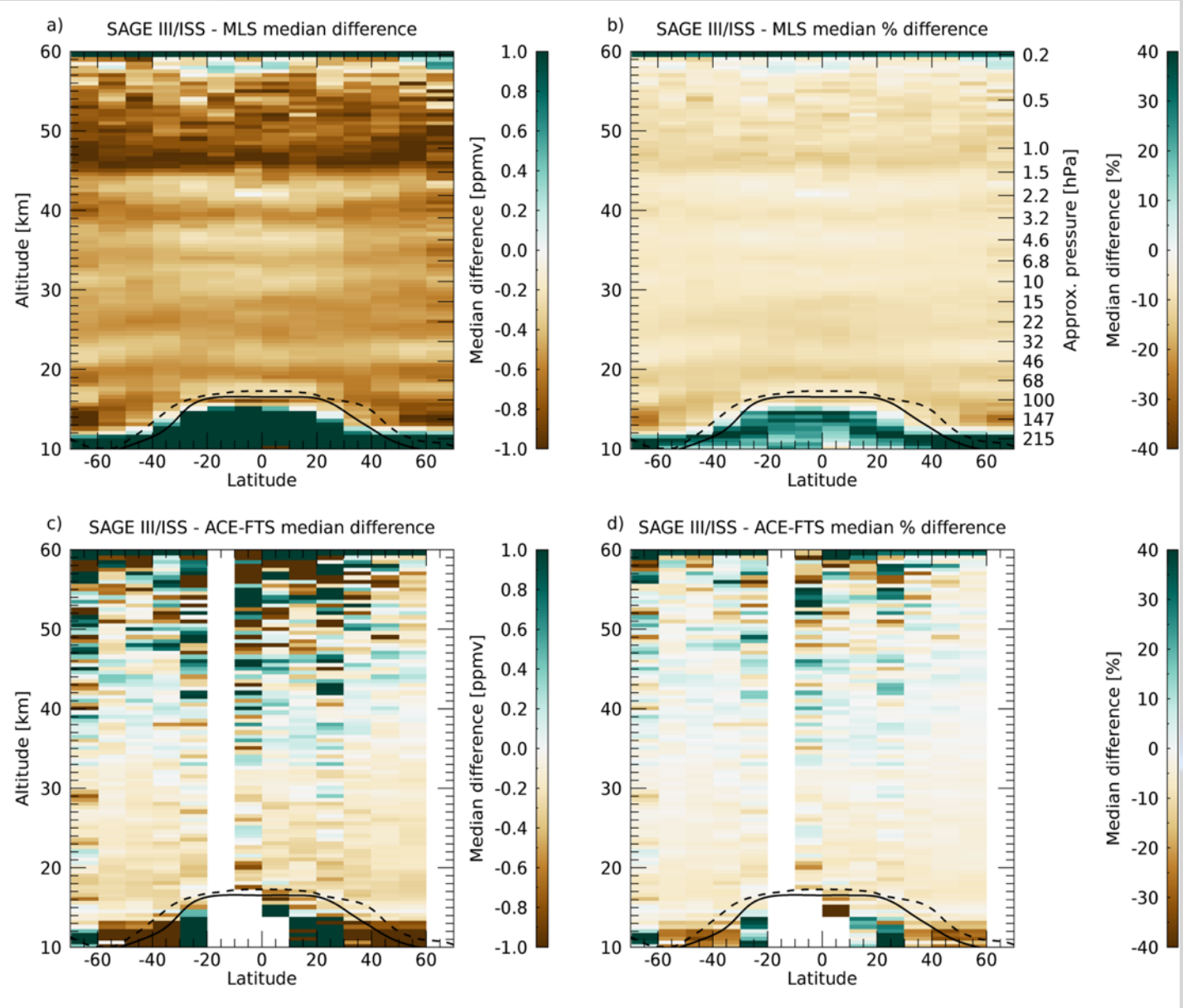
SAGE / MLS / ACE-FTS comparison

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



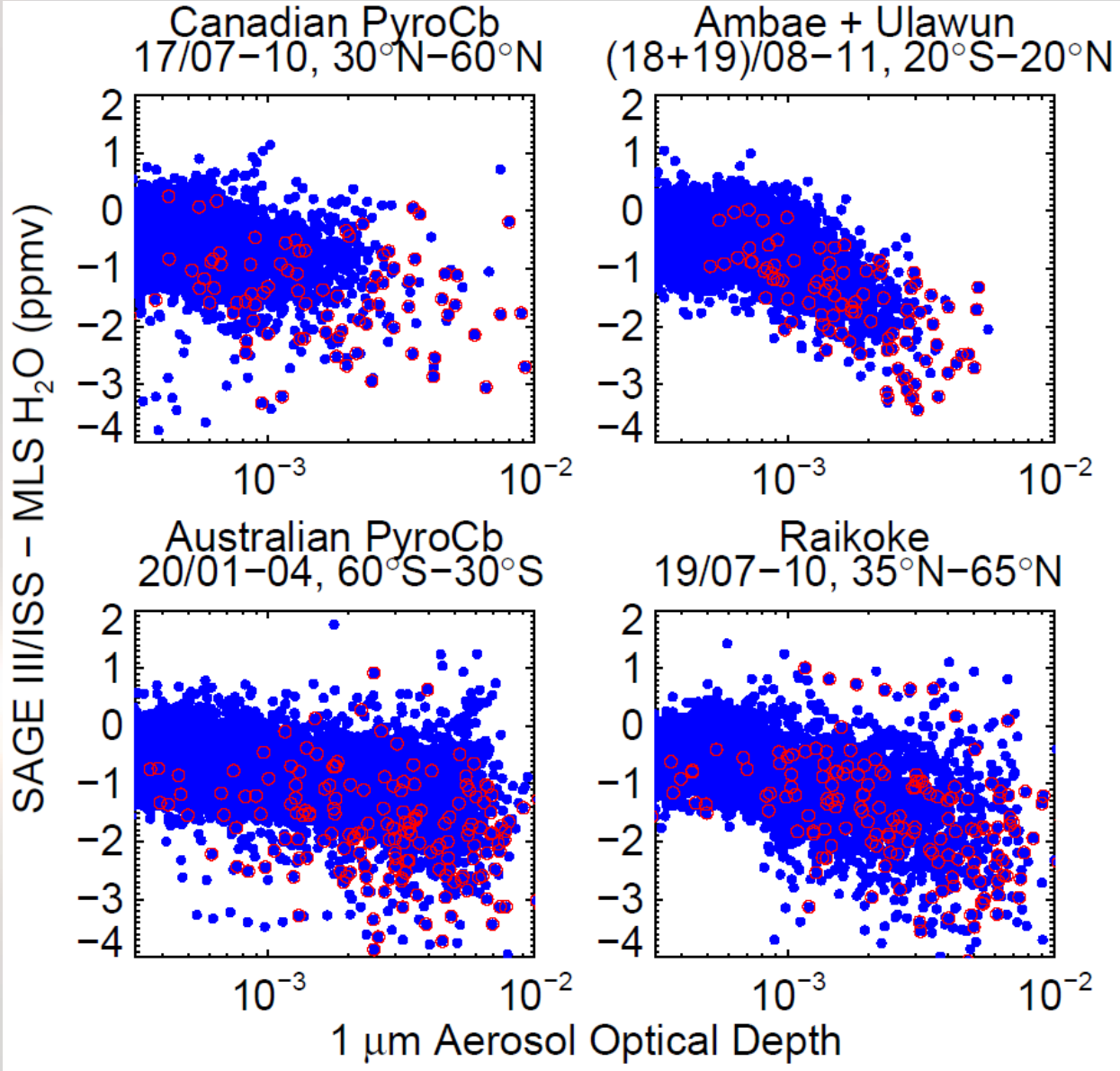
SAGE / MLS / ACE-FTS (v3.6) comparison

- 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 w/ OD
- Eruptions show steeper slope
- Increased uncertainty (red points) at higher OD



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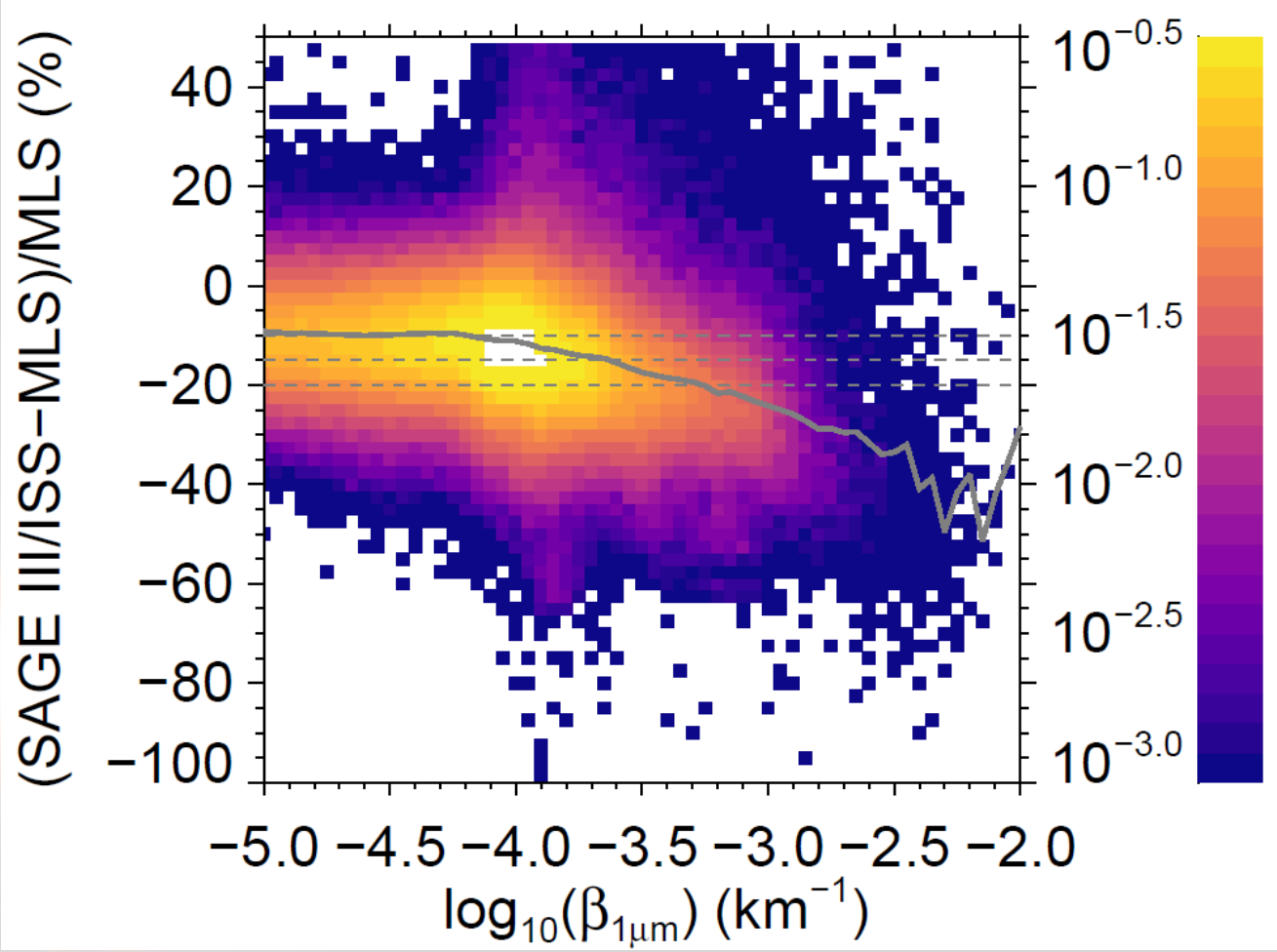
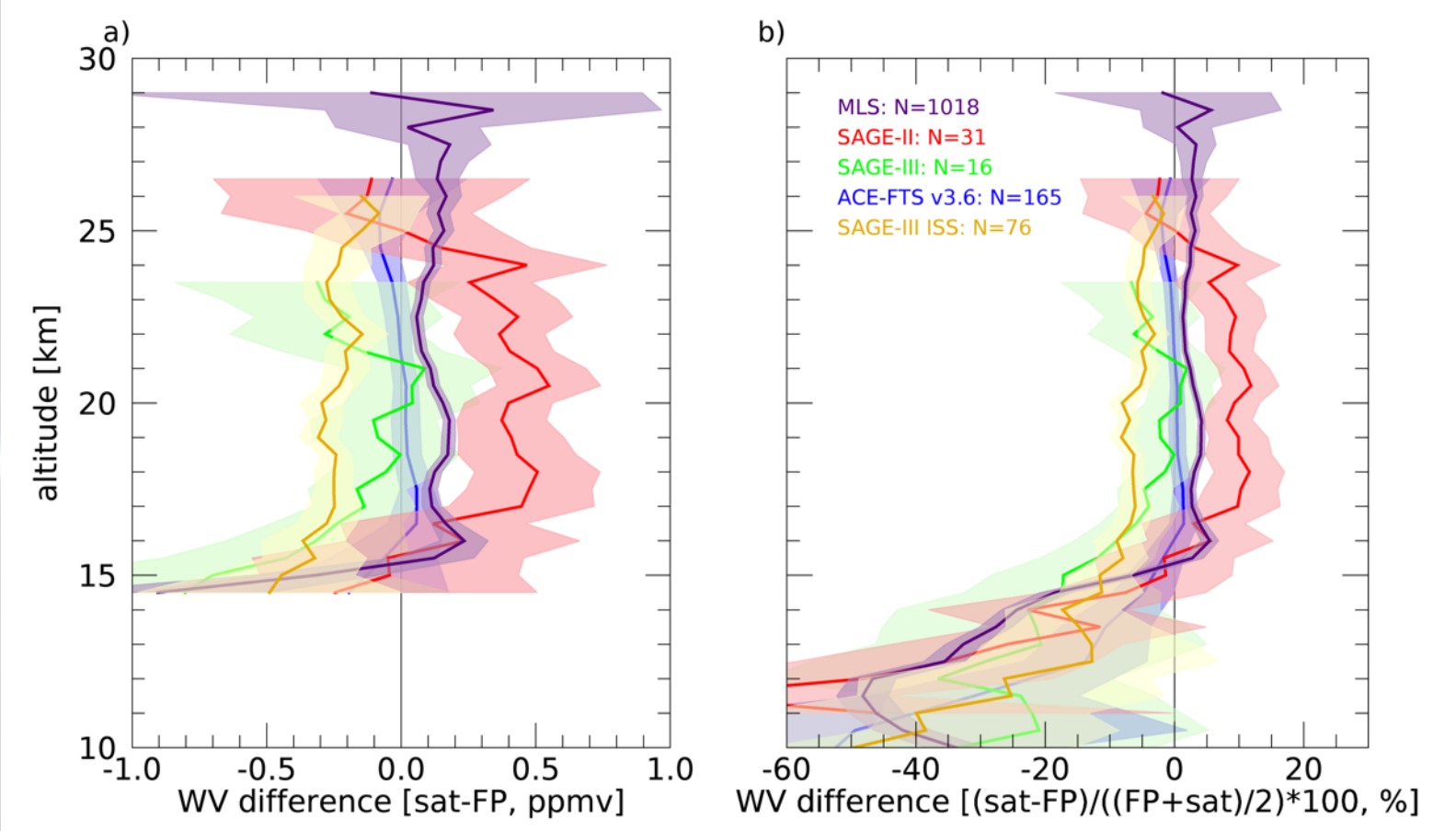


SAGE III/ISS – frostpoint coincident profile comparison

- 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