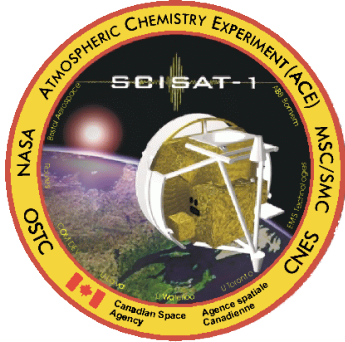




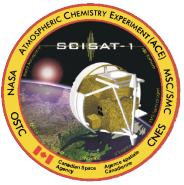
Update on ACE: Mission Status and Recent Validation Results

Kaley A. Walker¹, Patrick E. Sheese¹, Niall J. Ryan¹, and Christopher E. Sioris²

¹Department of Physics, University of Toronto, Toronto, Canada

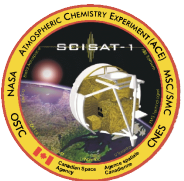
²Environment and Climate Change Canada, Toronto, Canada

SAGE III/ISS Science Team Meeting – Hampton, Virginia – 29 October 2019



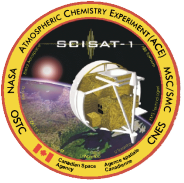
SCISAT/ACE Mission Status

- Now starting 17th year in orbit – designed for 2 year lifetime
 - Starting to see some degradation in ACE-FTS performance and ACE-MAESTRO continues to “age gracefully”
- Since launch, satellite and instrument operations nominal
 - Routine operations began on 21 February 2004
 - ~50% of occultations occur in polar regions (> 60 degrees)
- Operation of SCISAT has been approved until end of March 2021
 - Following mission level review by CSA in Fall 2017



ACE Data Products

- ACE-FTS profiles (new version 4.0; validated version 3.5/3.6; previous v2.2+updates):
 - Tracers: H_2O , O_3 , N_2O , NO , NO_2 , HNO_3 , N_2O_5 , H_2O_2 , HO_2NO_2 , N_2 , SO_2
 - Halogen-containing gases: HCl , HF , ClONO_2 , CFC-11 , CFC-12 , CFC-113 , COF_2 , COCl_2 , COFCl , ClO , CF_4 , SF_6 , CH_3Cl , CCl_4 , HCFC-22 , HCFC-141b , HCFC-142b , HFC134a , HFC-23
 - Carbon-containing gases: CO , CH_4 , CH_3OH , H_2CO , HCOOH , C_2H_2 , C_2H_4 , C_2H_6 , OCS , HCN , acetone , CH_3CN , peroxyacetyl nitrate (PAN), CO_2 in lower atmosphere, pressure / temperature from CO_2 lines
 - Isotopologues: Minor species of H_2O , CO_2 , O_3 , N_2O , CO , CH_4 , OCS , NO_2 , HNO_3
- MAESTRO profiles (current version 3.13; validated version 1.2):
 - O_3 , NO_2 , optical depth, aerosol and water vapor (v31)
- IMAGERS profiles (current version 4.0; validated versions 3.5 and 2.2):
 - Atmospheric extinction & aerosol extinction at 0.5 and 1.02 microns



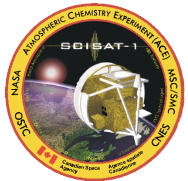
Comparison of ACE-FTS V4.0 to other data sets

Methodology for difference calculations in satellite instrument comparison:

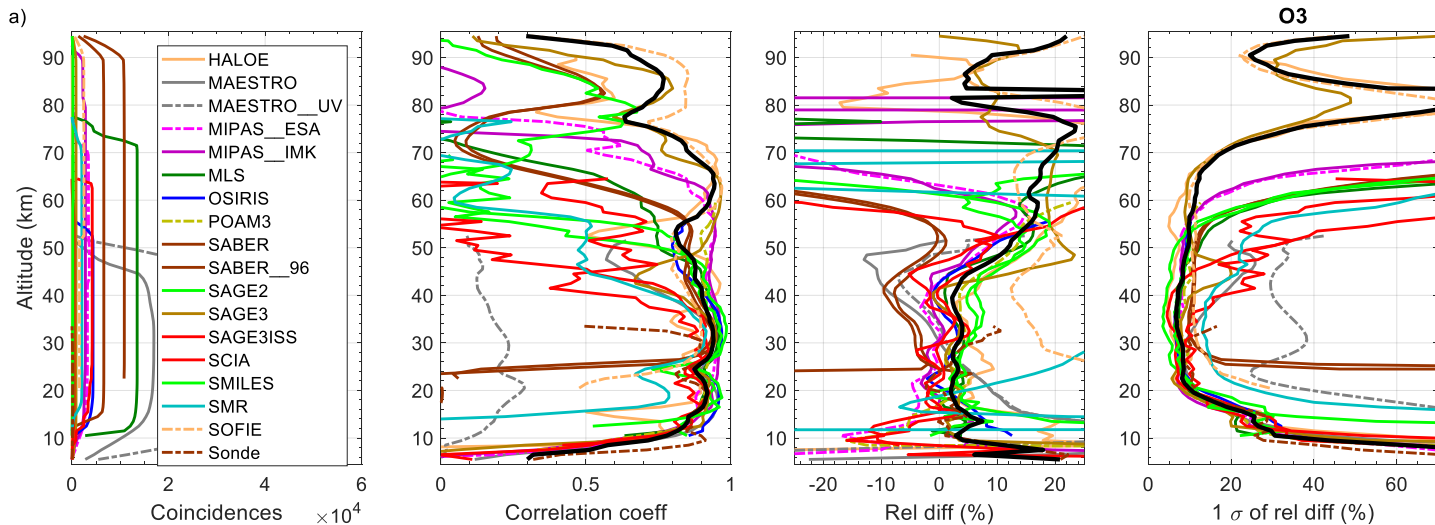
- ACEv4.0 – INST or ACEv3.6 – INST
- INST – One of suite of limb viewing remote sensing instruments used (UV, VIS, IR, MW)
 - Coincidence criteria used: $\pm 2\text{h}$, $\pm 5^\circ$ latitude, $\pm 15^\circ$ longitude
 - All comparisons are global for plots shown
- Relative differences with respect to mean of two measurements
- Mean of differences (absolute and relative) shown along with correlation coefficient

Selection of 74 species measured by ACE-FTS shown:

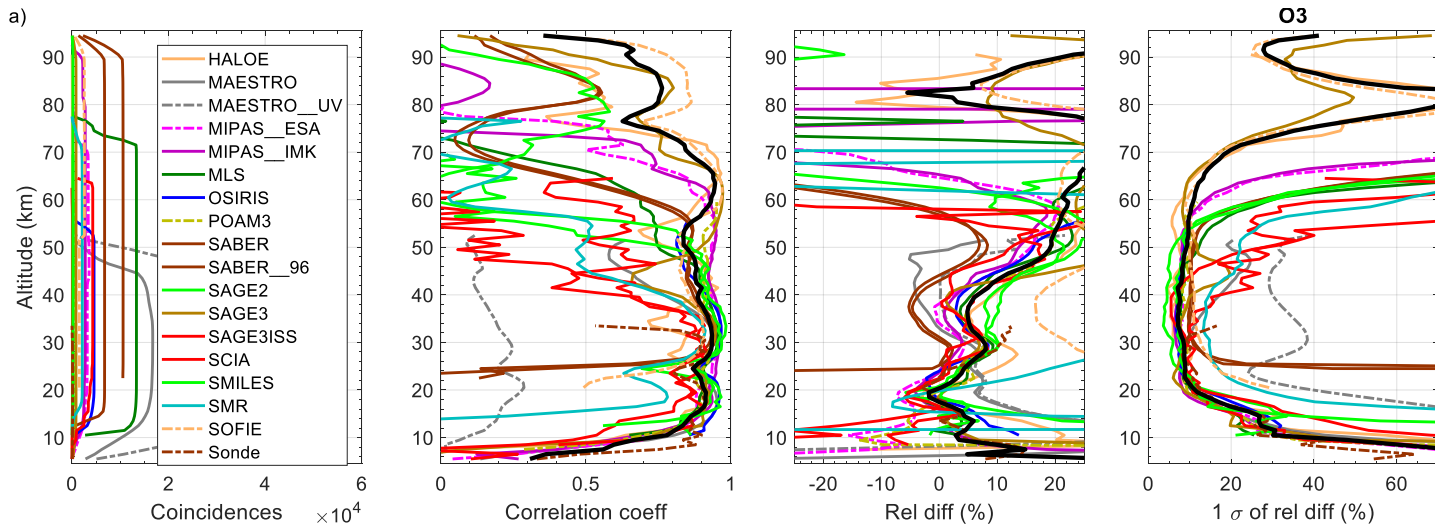
- O_3 , NO_2 , H_2O , HCl will be shown (have other examples if you are interested!)

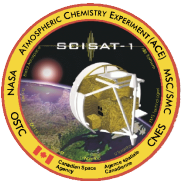


O₃
V3.6



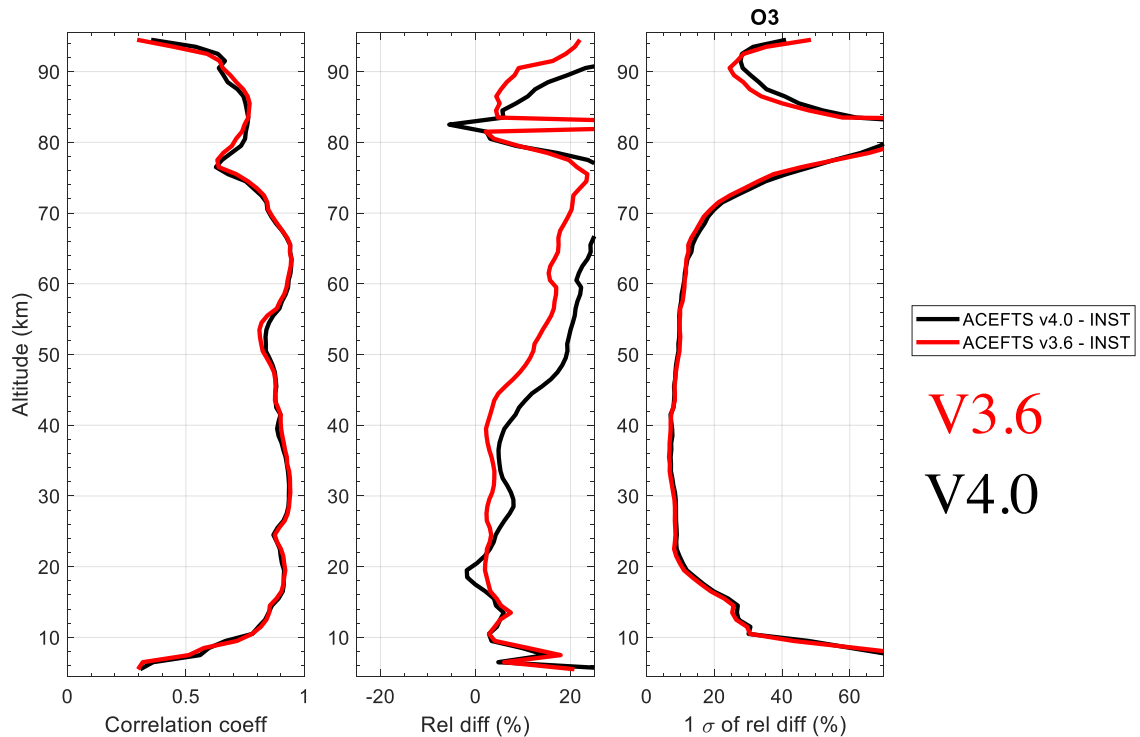
V4.0

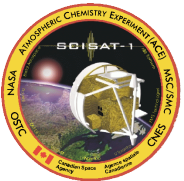




Ozone – v4.0 versus v3.5/3.6

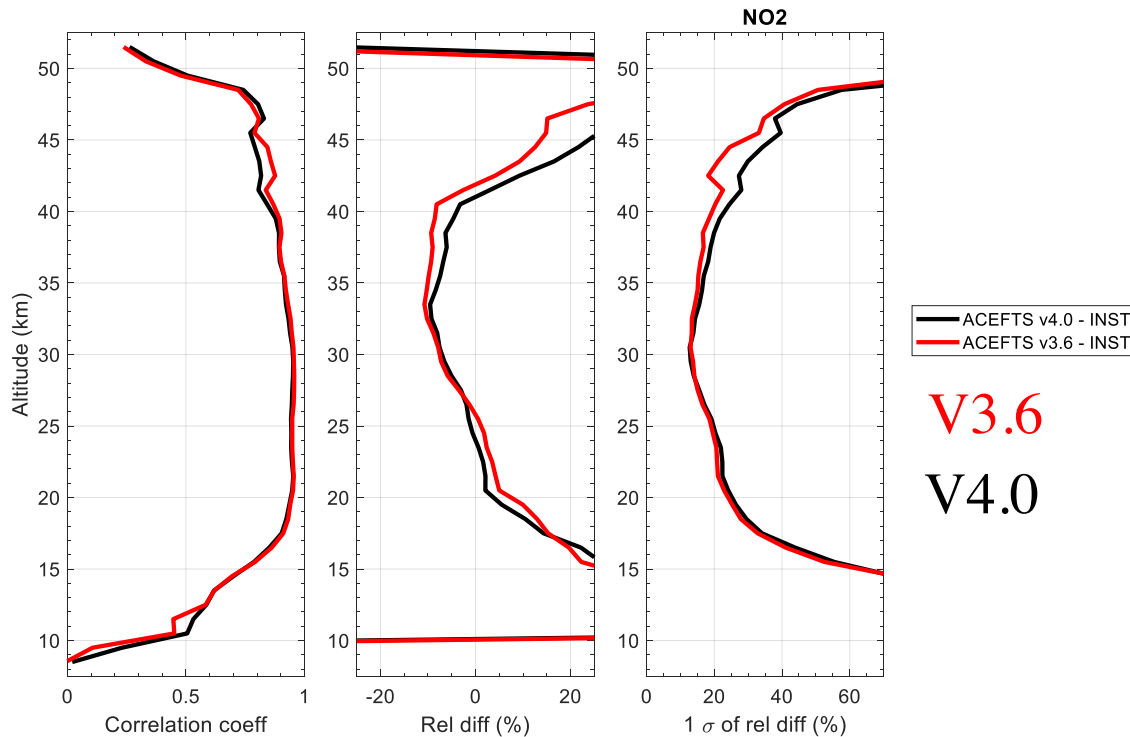
HALOE
MAESTRO
MAESTRO UV
MIPAS ESA
MIPAS IMK/IAA
MLS
OSIRIS
POAM III
SABER 1.27
SABER 9.6
SAGE II
SAGE III/M3M
SAGE III/ISS
SCIAMACHY
SMILES
SMR
SOFIE
Sondes

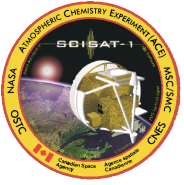




Nitrogen Dioxide – v4.0 versus v3.5/3.6

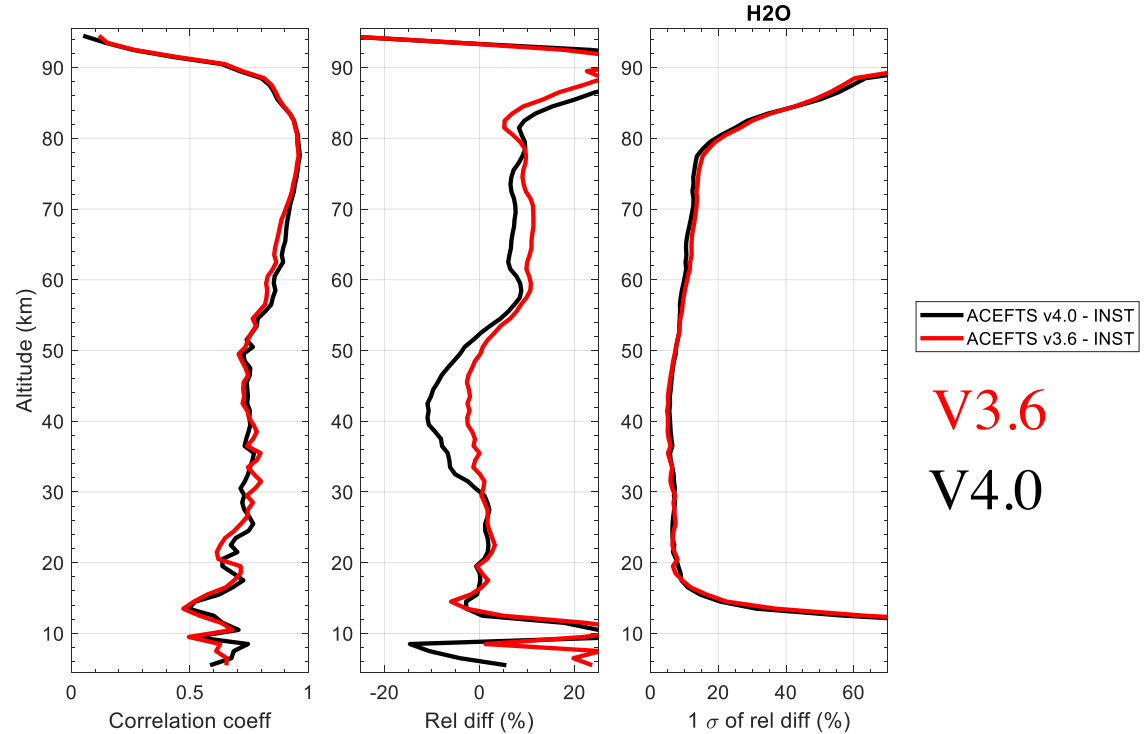
HALOE
MAESTRO
MIPAS ESA
MIPAS IMK/IAA
OSIRIS
POAM III
SAGE II
SAGE III/M3M
SAGE III/ISS
SCIAMACHY

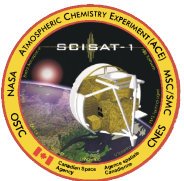




Water Vapour – v4.0 versus v3.5/3.6

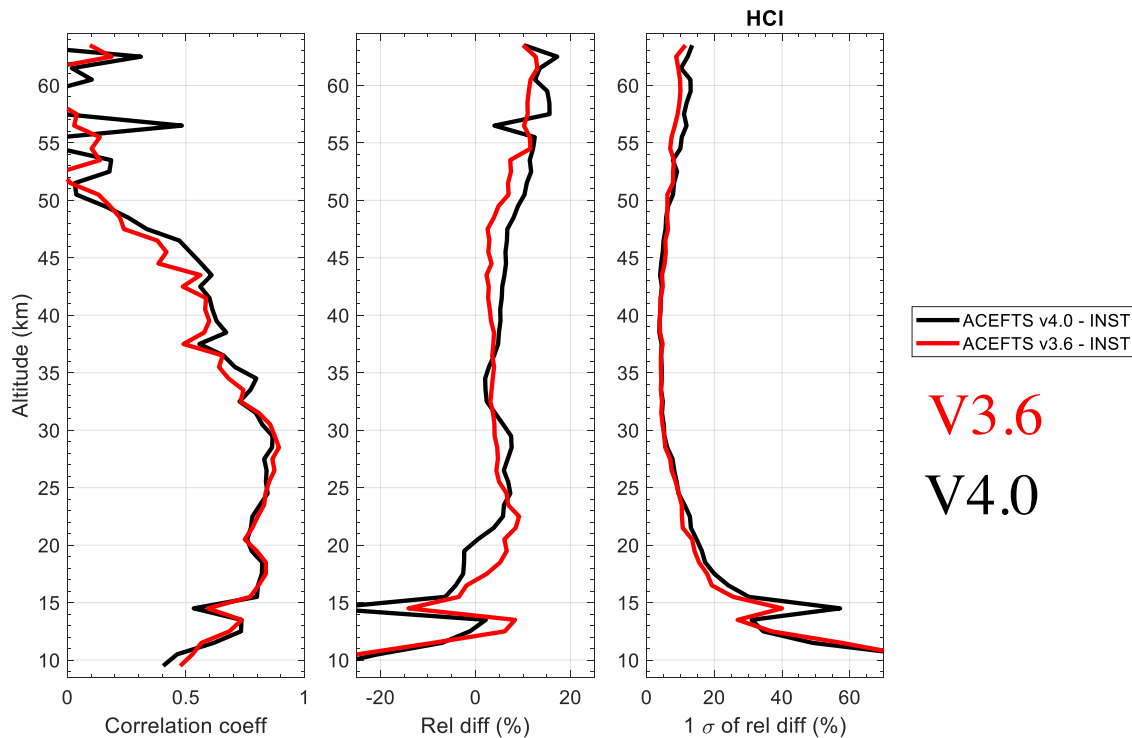
COSMIC
HALOE
MAESTRO
MIPAS ESA
MIPAS IMK/IAA
MLS
POAM III
SAGE II
SAGE III/M3M
SAGE III/ISS
SCIAMACHY
SMR
SOFIE

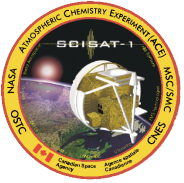




Hydrogen Chloride – v4.0 versus 3.5/3.6

HALOE
MLS
SMILES

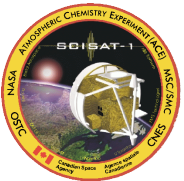




Calculating Drift in ACE-FTS Ozone

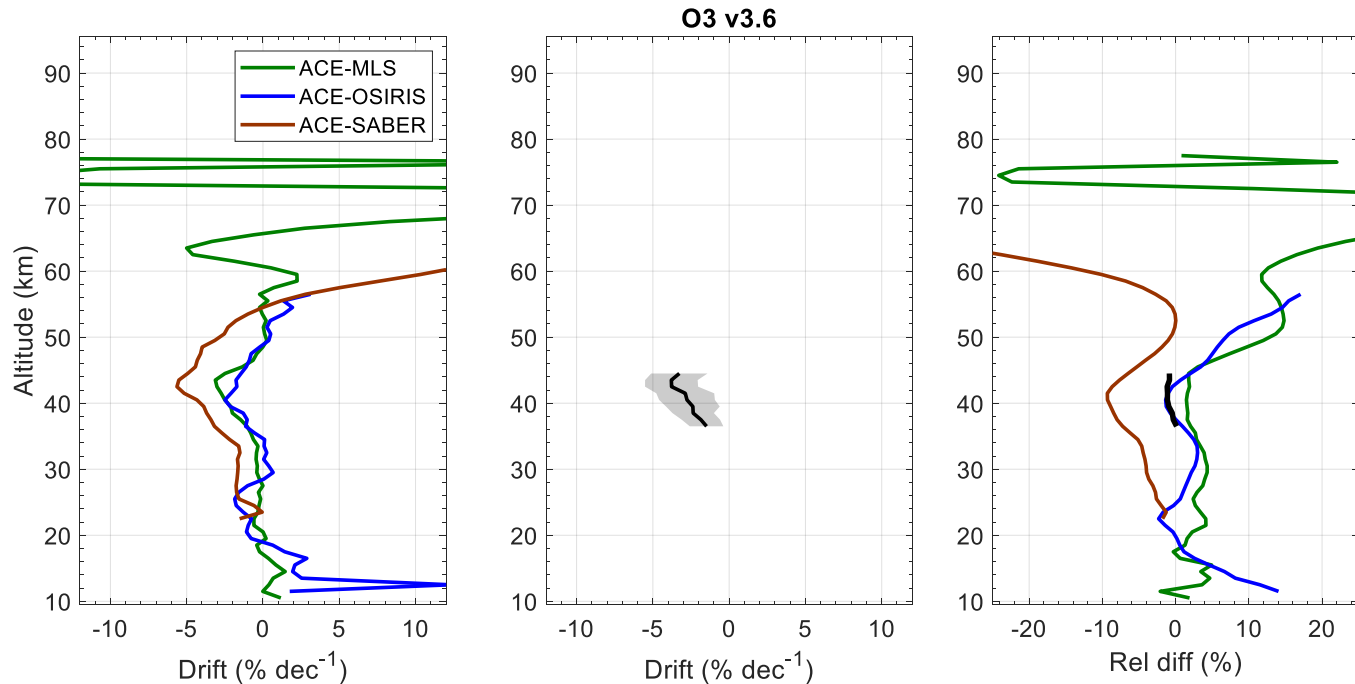
Calculating “drifts” between instruments to understand relative “trends”

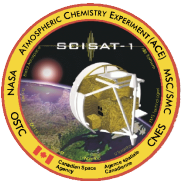
- Using satellite time series that overlap ACE – MLS v4.2, OSIRIS v5.10, SABER v2.0
 - All coincidences from 2004-2018
 - Criteria: within ± 2 h, ± 250 km
 - Daily means of relative differences (ACE-FTS – INST)
 - Monthly variations are removed before trend analysis
 - Data binned by month and twilight, respective means subtracted from binned data
 - Trends determined for all data (not binned)
- Take robust linear fit (iterative reweighted least squares), 99.9% confidence in slope as error bounds
 - Weighted average of values use weights of INST inverse-squared standard deviation of relative differences, i.e., $W_{INST} = \frac{1}{\sigma_{INST}^2}$



Ozone Drift in v3.5/3.6

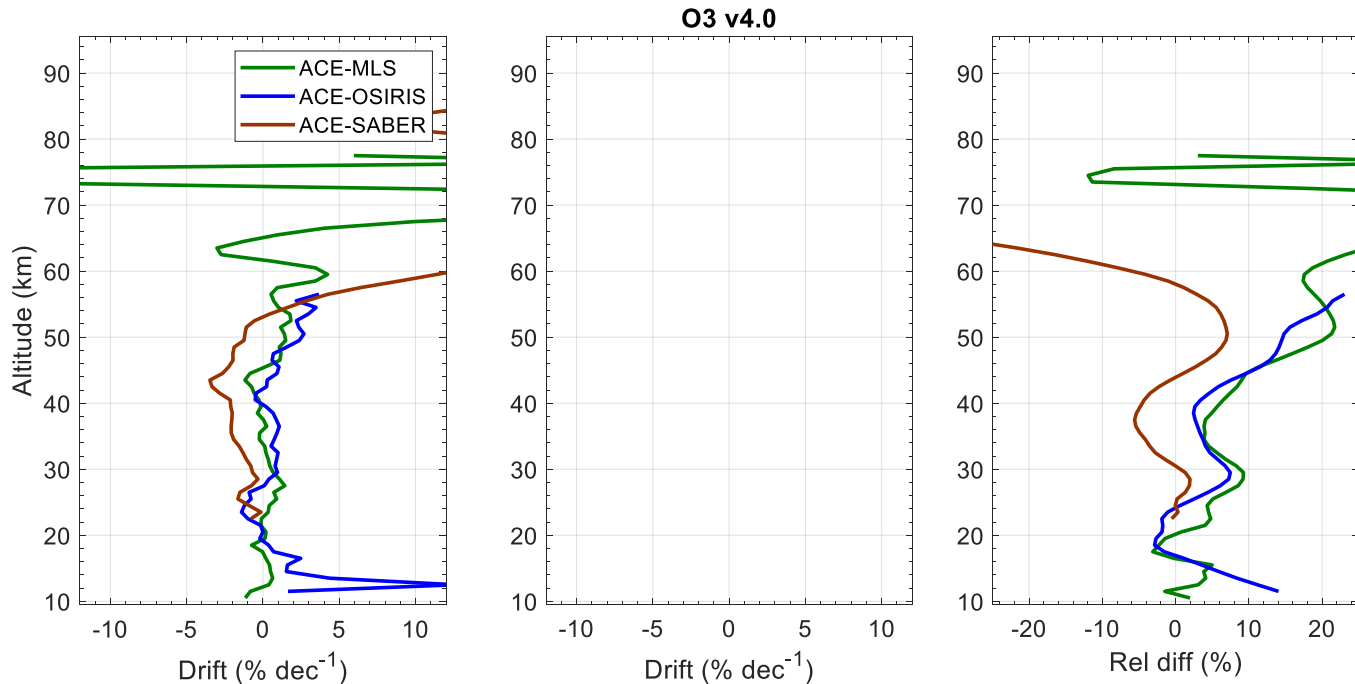
- Near 40 km, v3.6 exhibits a negative drift wrt MLS, OSIRIS, SABER
 - Similar results seen when comparing to MIPAS (shorter time period)
 - To be considered drift, more than 1 instrument must have significant drift within 99.9% confidence

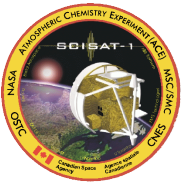




Ozone Drift in v4.0

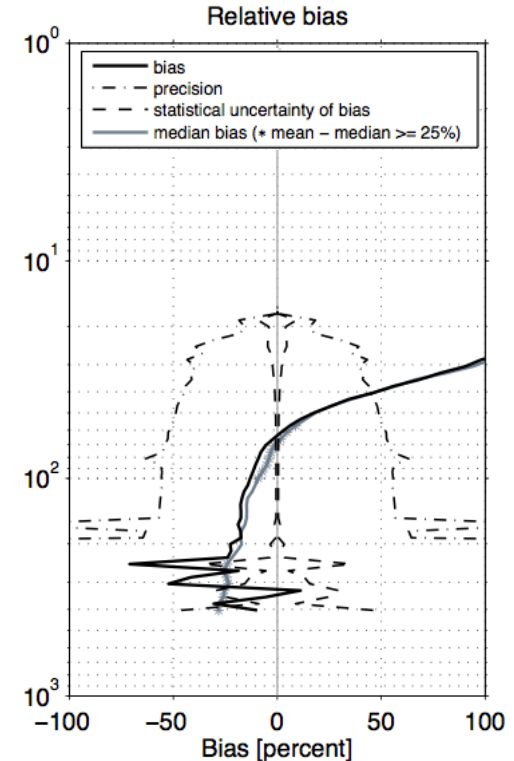
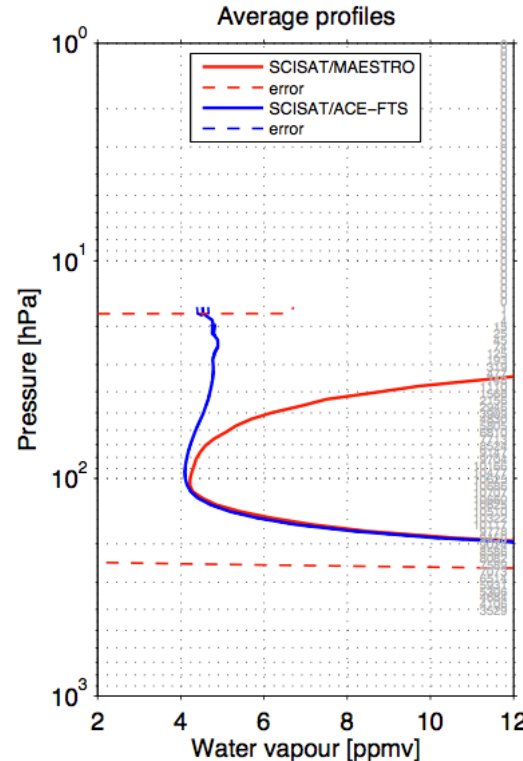
- Used same methodology as for v3.5/3.6
- v4.0 does not exhibit any drift at any altitude





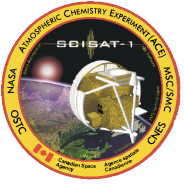
MAESTRO Water Vapour Product

- Method described by Sioris et al., Adv. Space Res. (2010)
- Chahine inversion using observed differential optical depth spectra from 926.0–969.7 nm
- UTLS product from ~5 km (cloud tops) to ~22 km
- Tends to be too wet in tropics; too dry in south pole summer
- Being used in ESA Water Vapour CCI project (as is ACE-FTS)

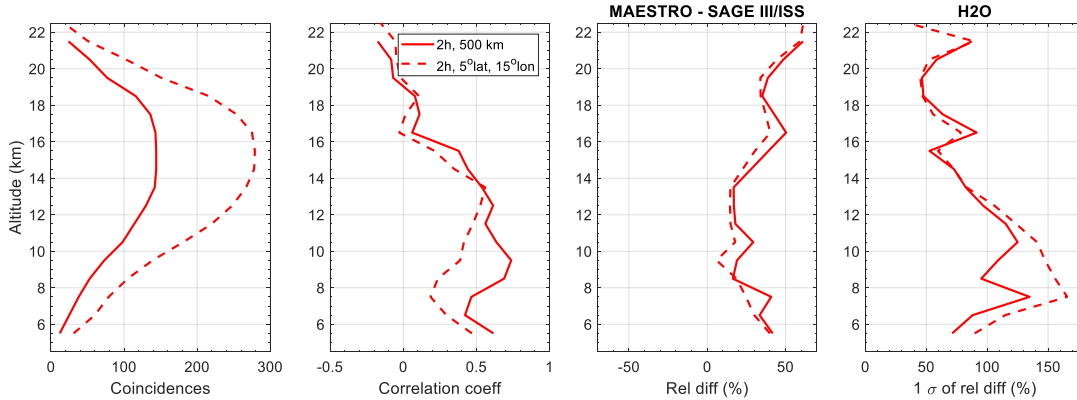


2004-2010 global; 12541 pairs; **ACE-FTS**; **MAESTRO**

Chris Sioris and Stefan Lossov.

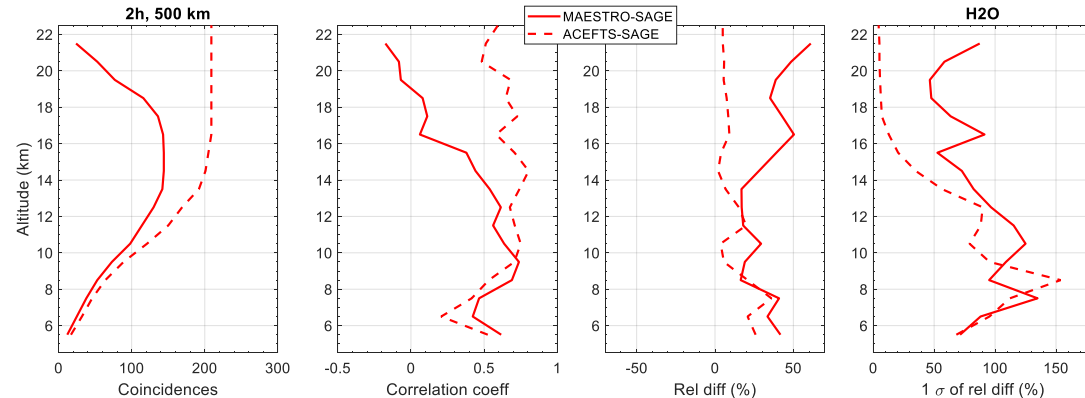


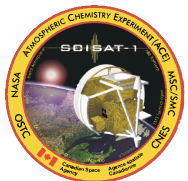
Comparisons for ACE-MAESTRO v31



- SAGE III/ISS beta version H₂O
- MAESTRO shows better correlation with SAGE III than ACE-FTS below 9 km

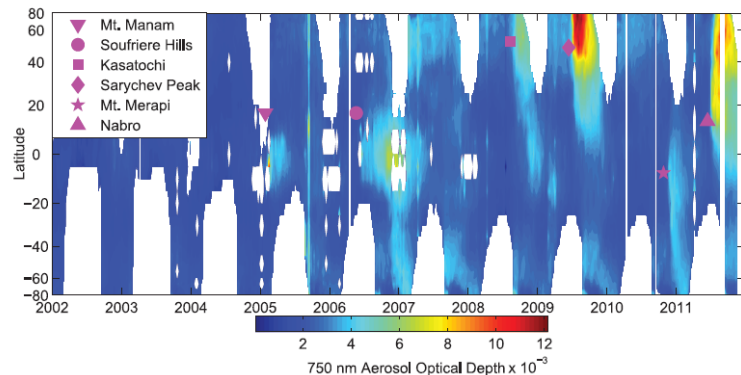
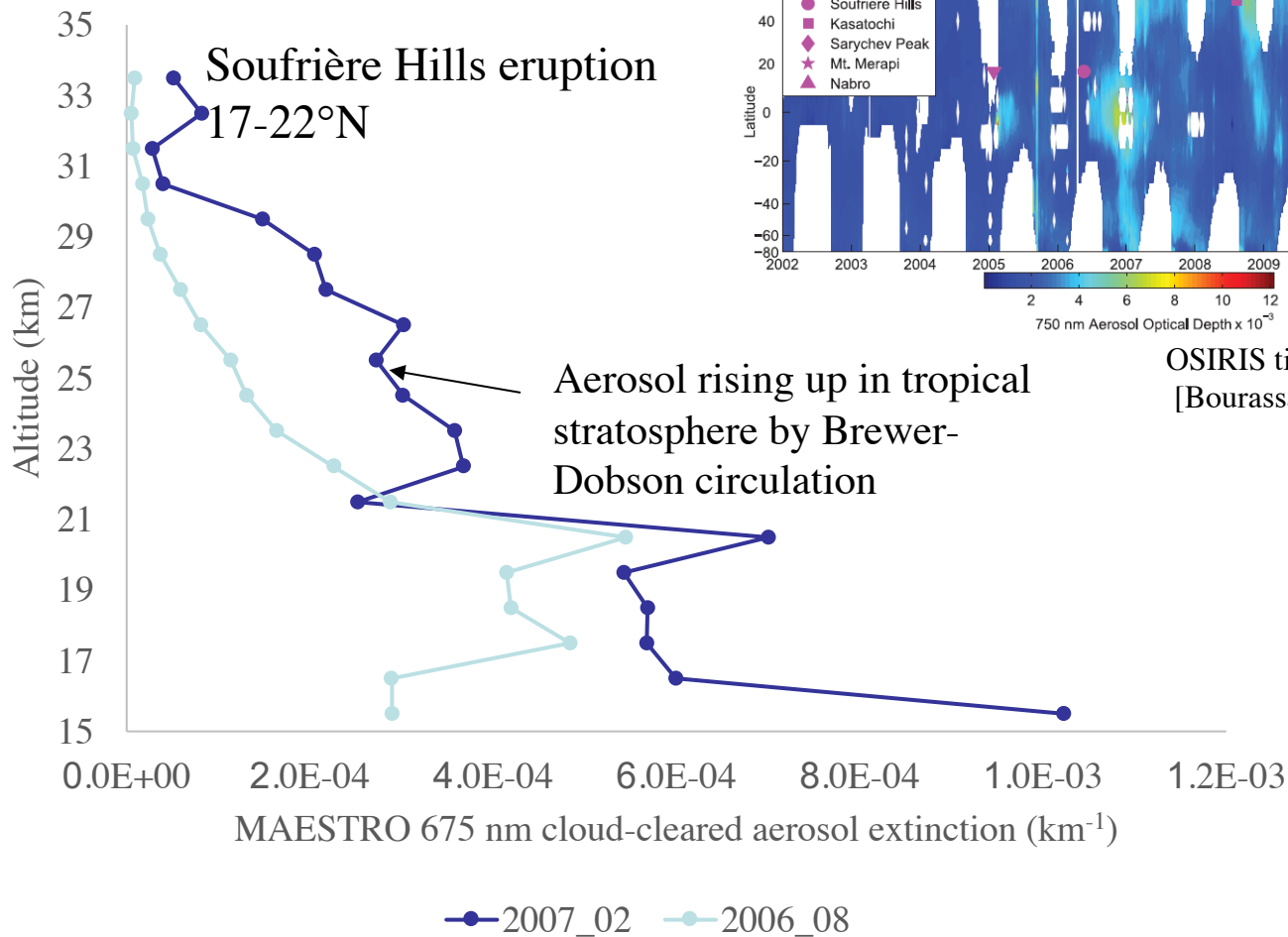
- SAGE III/ISS comparisons from June 2017 – March 2019
- Tighter spatial coincidence improves correlation between SAGE III/ISS and MAESTRO



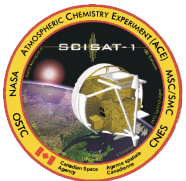


MAESTRO Aerosol

- Showing SR/SS monthly zonal averages for 675 nm
- Can see the enhancement in average profiles
- Has positive bias wrt other sensors but good correlation in time series

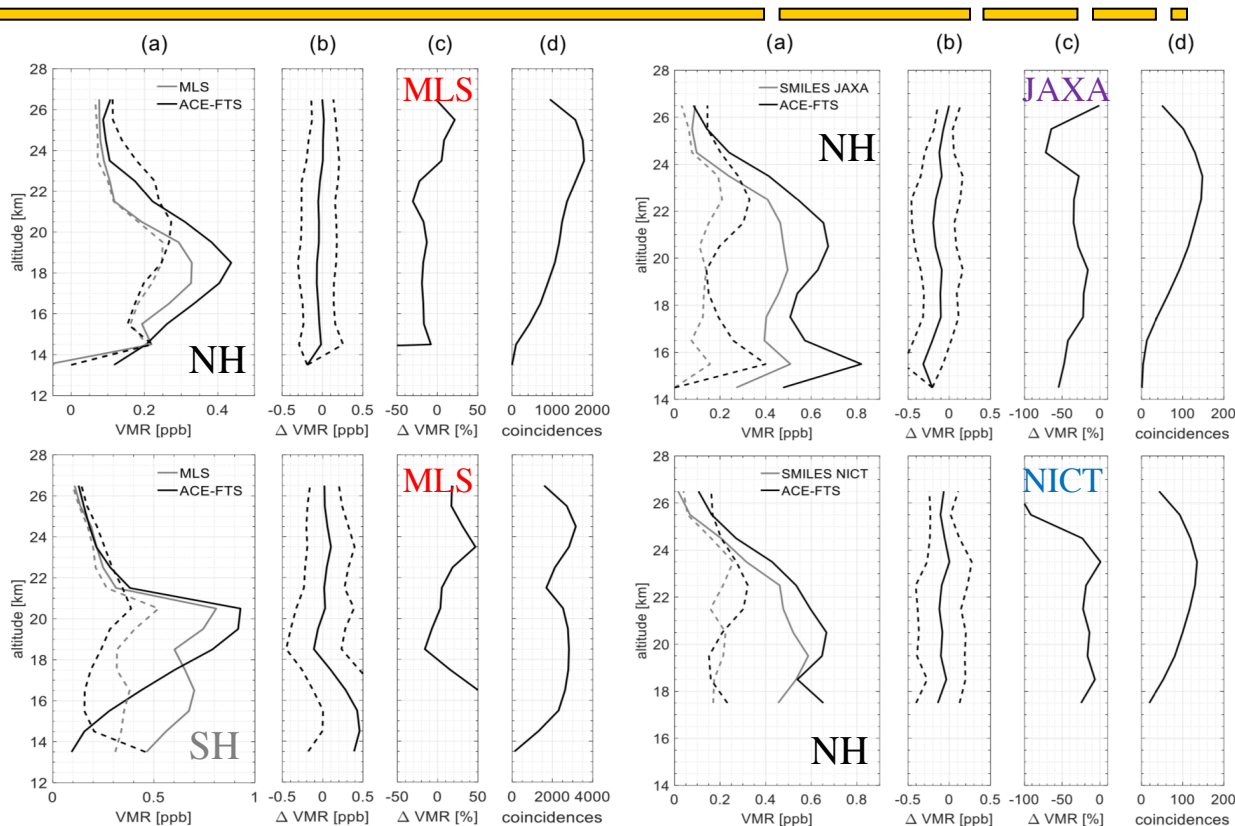


OSIRIS time series
[Bourassa et al., 2012]



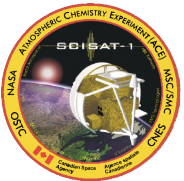
Validation of new product for v4.0 – ClO

- Comparisons with SMILES (JAXA v3.2 and NICT v3.0) and MLS v4.2 within polar vortex
- Medians calculated for each INST; relative wrt to average of median profiles
- MLS within 100 km; SMILES within 300 km
- INST scaled to ACE-FTS local time with box model
- Shape of profiles agree, ACE-FTS shows higher peak values; agreement for most altitudes within precision



Solid line: median; dashed line: MAD

N. J. Ryan et al., in preparation.



Summary

- New data version available for ACE-FTS (v4.0) and MAESTRO (v31 water vapour)
 - Download from <https://database.scisat.ca/level2> (registration required)
- Validation work continuing for ACE-FTS and ACE-MAESTRO
 - Version 4.0 biases are typically worse with respect to v3.6, but drift has improved
 - Version 4.0 may be better than 3.6 for trends; 3.6 better for climatology

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Thanks to:

- SCISAT Science Operations Centre, Chris Boone and Peter Bernath