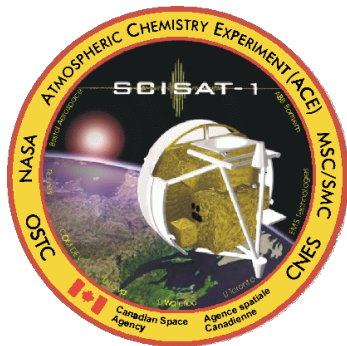




Update on ACE: Mission Status and Recent Validation Results

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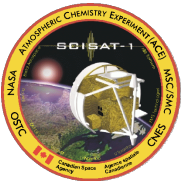
²Department of Chemistry, University of Waterloo, Waterloo, Canada

SAGE III/ISS Science Team Meeting – Online – 19 October 2020



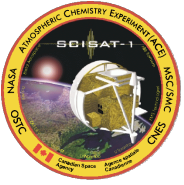
SCISAT/ACE Mission Status

- Now into 18th 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
 - Mission level review by CSA for 3-year extension is underway now



ACE Data Products

- ACE-FTS profiles (new version 4.1; 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 (5-18 km and >60 km), 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 4.1; validated versions 3.5 and 2.2):
 - Atmospheric extinction & aerosol extinction at 0.5 and 1.02 microns



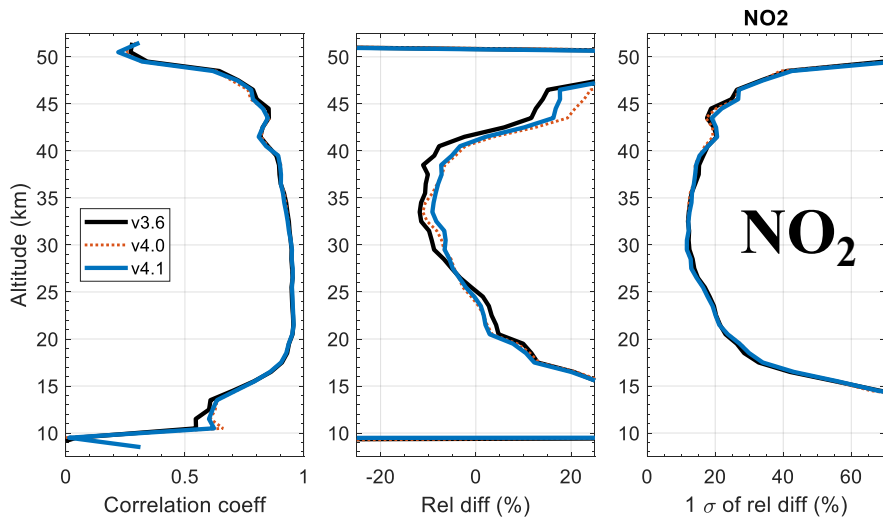
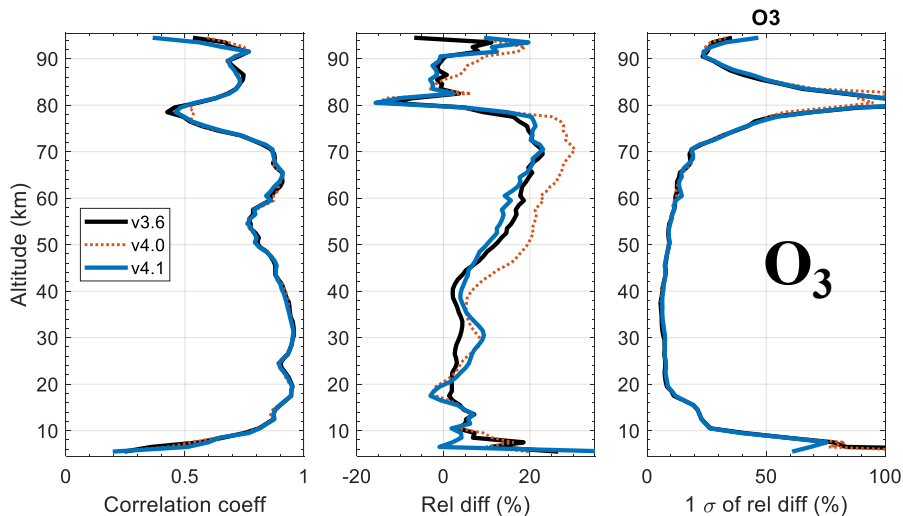
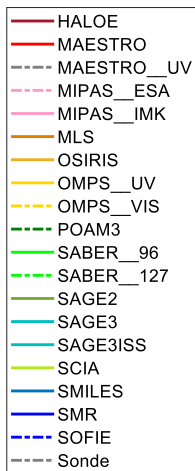
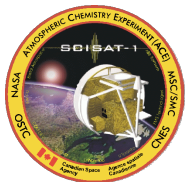
Comparison of ACE-FTS v4.1 to other data sets

Methodology for difference calculations in satellite instrument comparison:

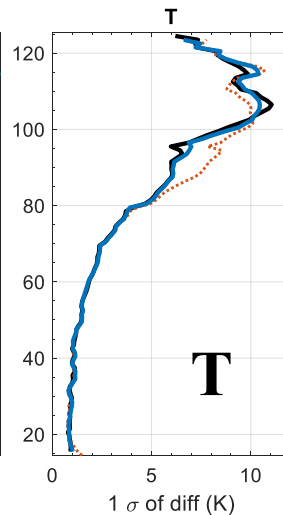
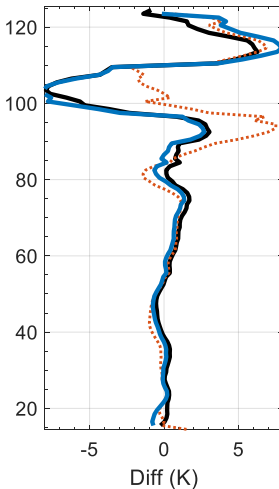
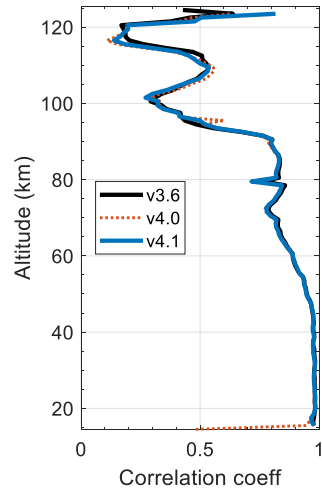
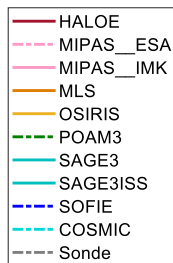
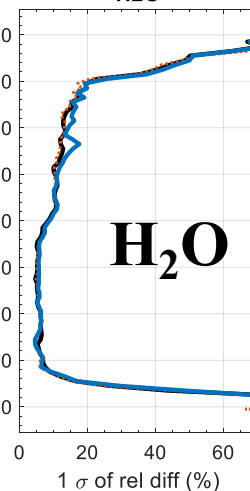
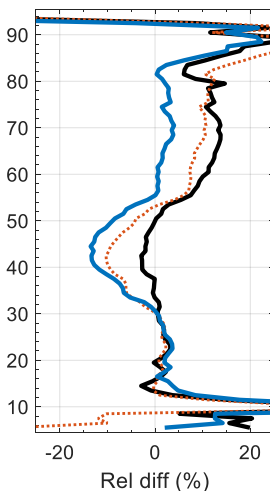
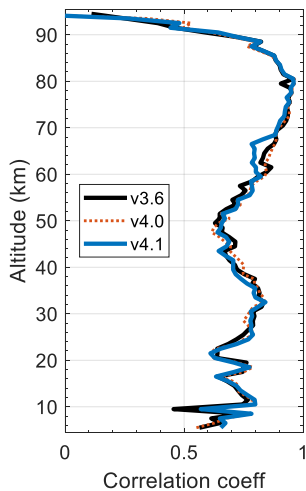
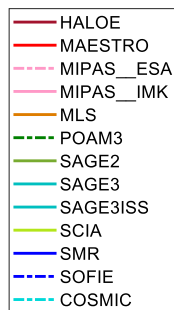
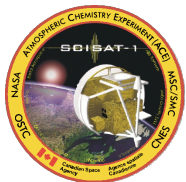
- ACE – INST for versions 3.6, 4.0, and 4.1 (used same occultations between versions)
- INST – One of suite of limb viewing remote sensing instruments used (UV, VIS, IR, MW)
 - Coincidence criteria used: ± 5 h, 500 km
 - All comparisons are global for plots shown
- Relative differences calculated with respect to mean of two measurements
- Mean and 1- σ of relative differences shown along with correlation coefficient

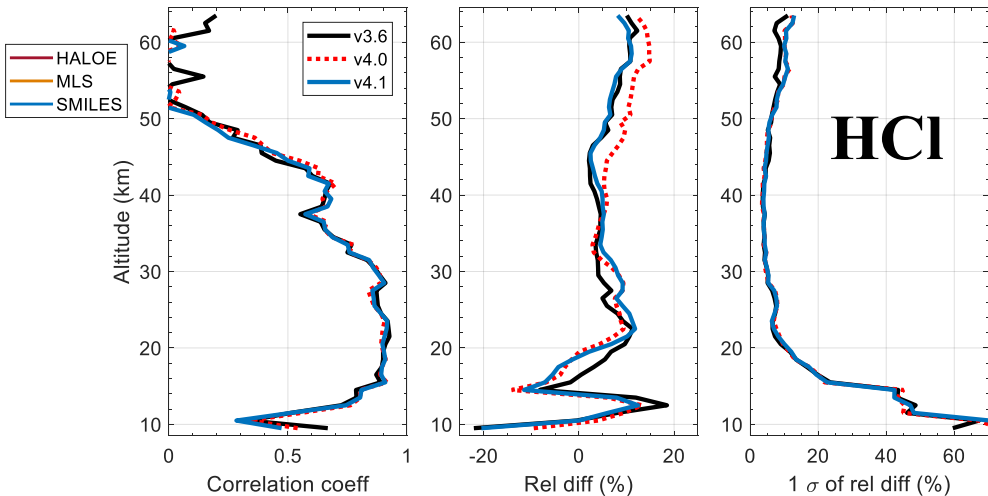
Selection of 74 species/isotopologues measured by ACE-FTS shown:

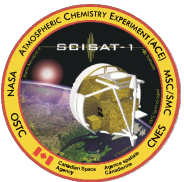
- O₃, NO₂, H₂O, T, HCl, and HNO₃ will be shown
- Looked at species measured by more than one other limb sounder



Note, these have not been scaled diurnally for comparison.

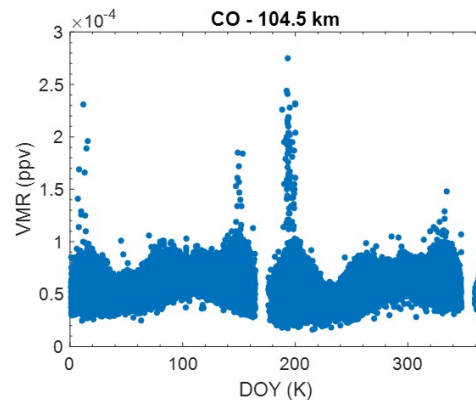
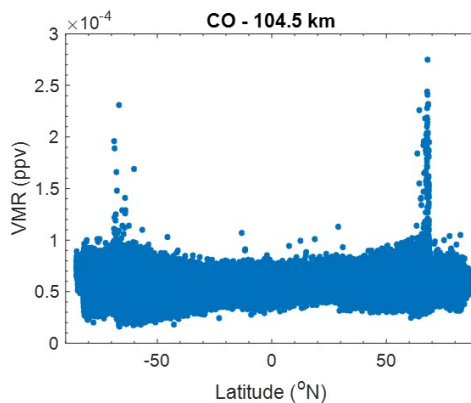
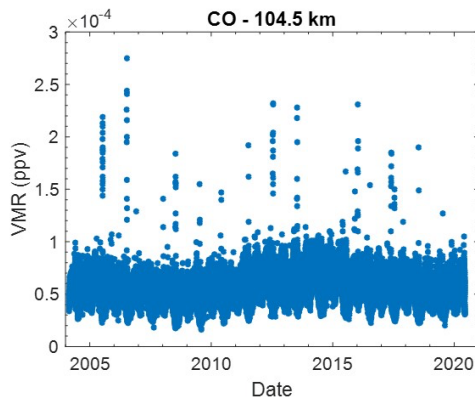


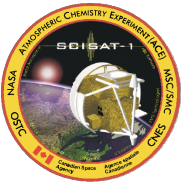




Version 4.1 data issues at high altitudes

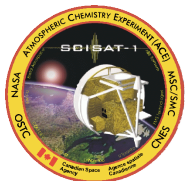
- Issue in MLT polar summer, more so in NH (not seen for these in previous versions)
- CO has enhancements in lower thermosphere ~95-110 km
 - Similar issue also seen in H₂O and O₃ near 95 km
 - T has cold spikes around mesopause
- Related to using temperature sensitive CO₂ lines for this altitude region, become too weak at very low temperatures – will be fixed in v5.0





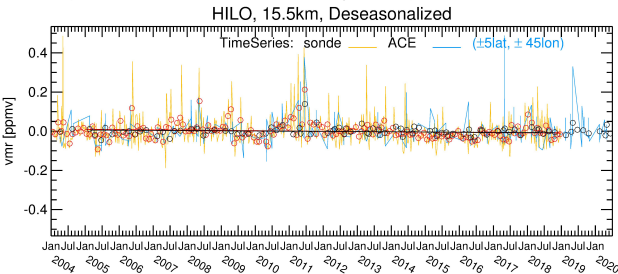
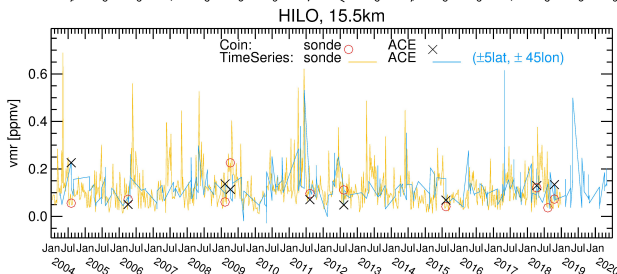
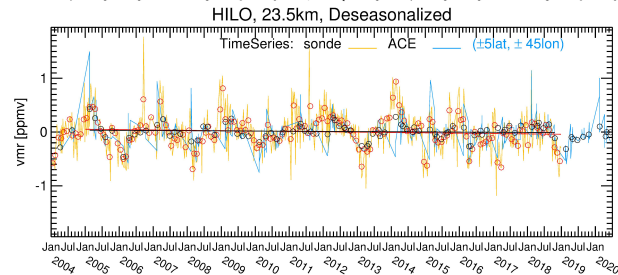
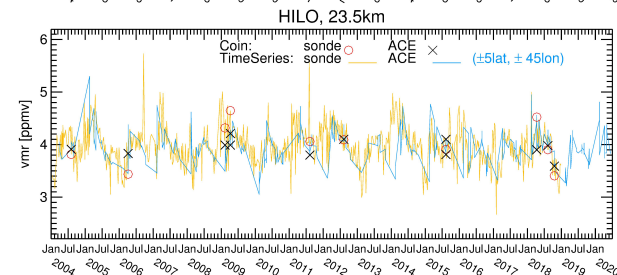
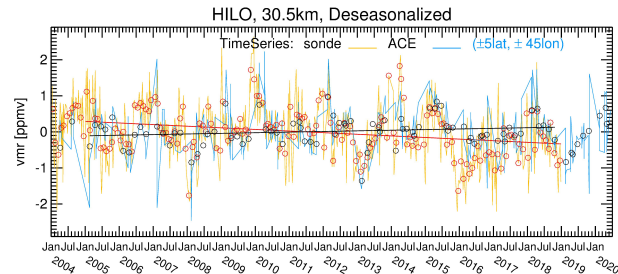
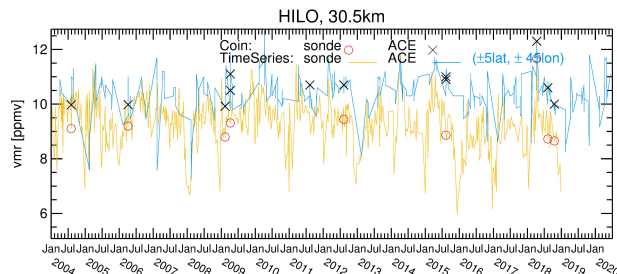
Validation comparisons for ACE-FTS v4.1

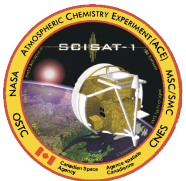
- Overall impression: biases have mostly improved over v4.0
 - The only region where v4.1 is significantly worse than both v3.6 and v4.0 is H₂O in upper stratosphere (but mesospheric H₂O greatly improved)
- Drifts seen in v3.5/3.6 are no longer present in v4
 - For trend analysis, ACE-FTS v4.1 should be used



Comparison of v4.1 ACE-FTS with ozonesondes

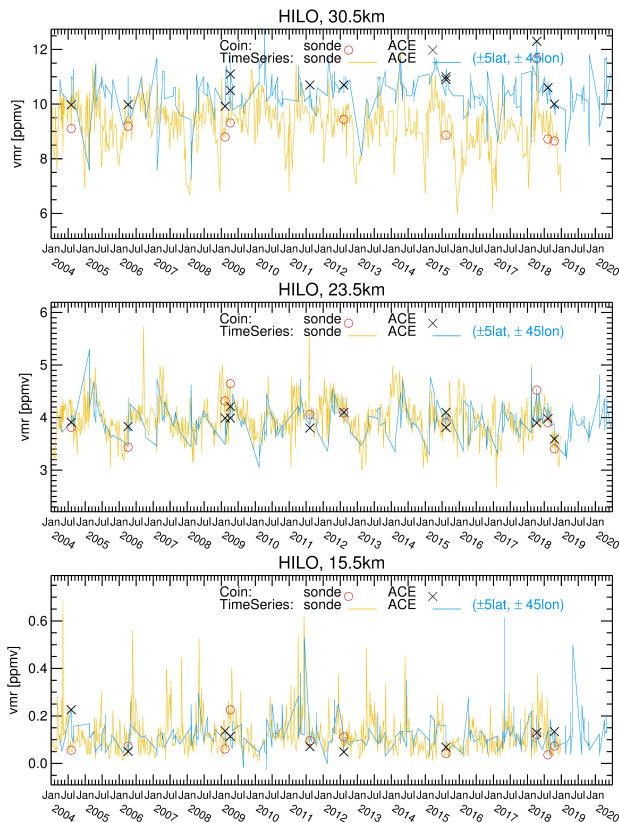
- Comparison of biases and linear trends in ozone
- Coincident pairs found for each station
- ± 5 degree latitude range with wide longitude ranges
- Deseasonalized monthly means used for analysis
- Hilo example (19.7 N)



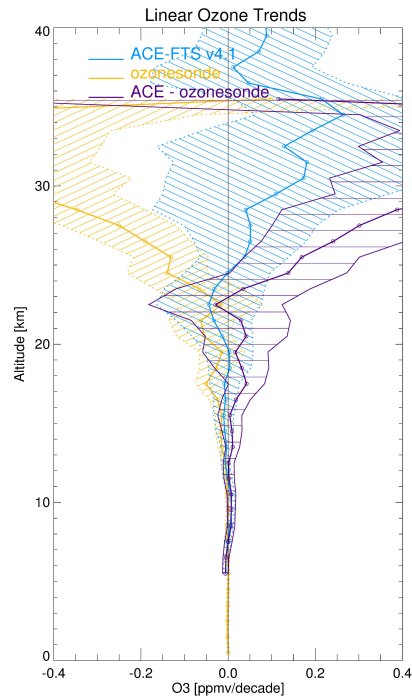


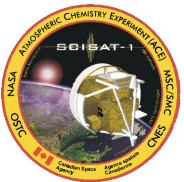
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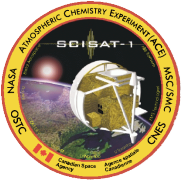
Station: HILO, lat= 19.40, lon= 204.60
Ground Instrument: O3SONDE
Station Data Source: SHADOZ
Station Data period: 2004/215 - 2018/289
ACE Time Series: ± 5 lat, ± 45 lon





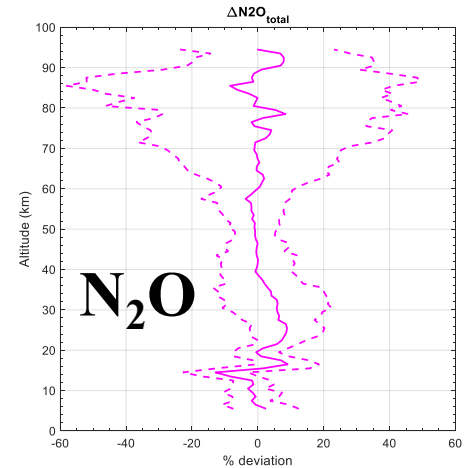
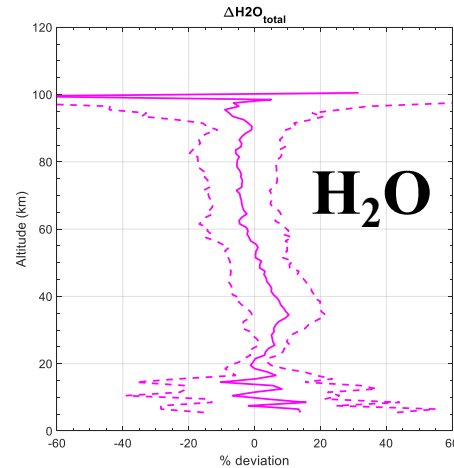
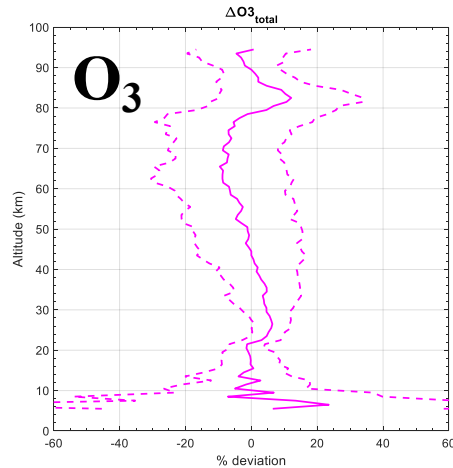
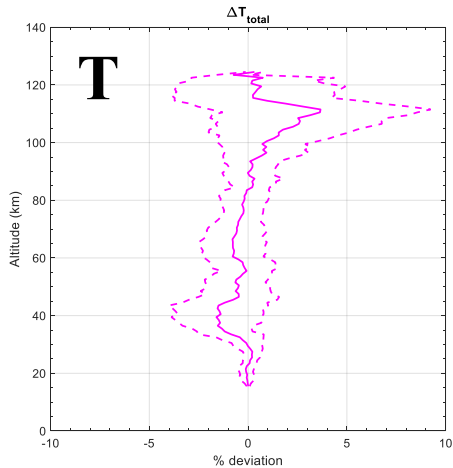
Assessment of ACE-FTS uncertainty budget

- To support SPARC TUNER activity, uncertainty budget being done for ACE-FTS
 - Using v3.6 retrievals as development platform
- Selecting 100 random occultations from full ACE-FTS data set, re-retrieving profiles with perturbation of one of the uncertainty components
 - Uncertainty is the MAD of differences between standard and perturbed retrievals
 - The median of the differences would give estimate of bias
 - Sources considered include: FOV modelling, ILS modelling, altitude registration, measurement noise, temperature measurement noise, convergence tolerance, derivative recycling – spectroscopic uncertainty in progress

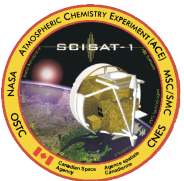


Total uncertainties (no spectroscopic uncertainty)

- Total uncertainty is calculated as the root sum square of the uncertainty components
- Total bias is sum of biases from the different bias components
- Dominated by FOV modelling uncertainty, then altitude registration uncertainty

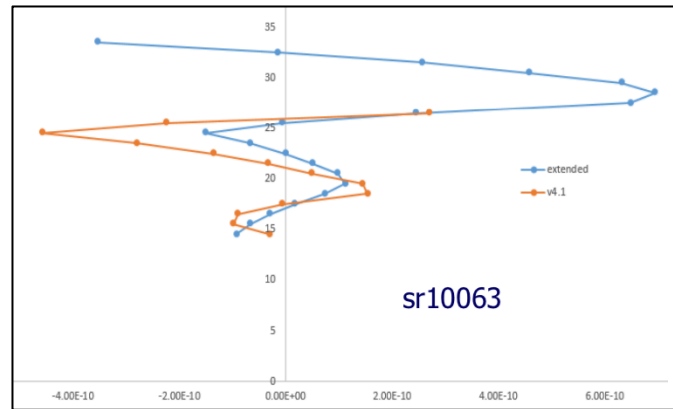
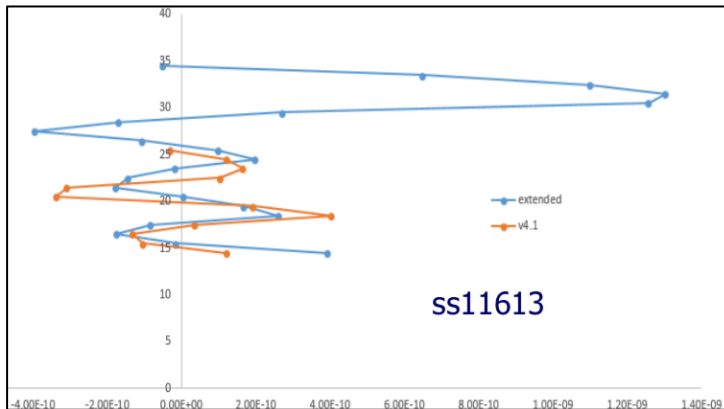


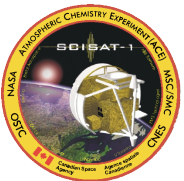
NOTE: different scale for T



ClO improvements for v5.0

- It was originally anticipated that ClO results would only be good during enhanced polar spring conditions
- v4.1 results for background conditions seem viable (with sufficient averaging)
 - Here examples of pushing the retrievals higher to capture the secondary peak
- This new upper altitude limit to be used in v5.0 processing

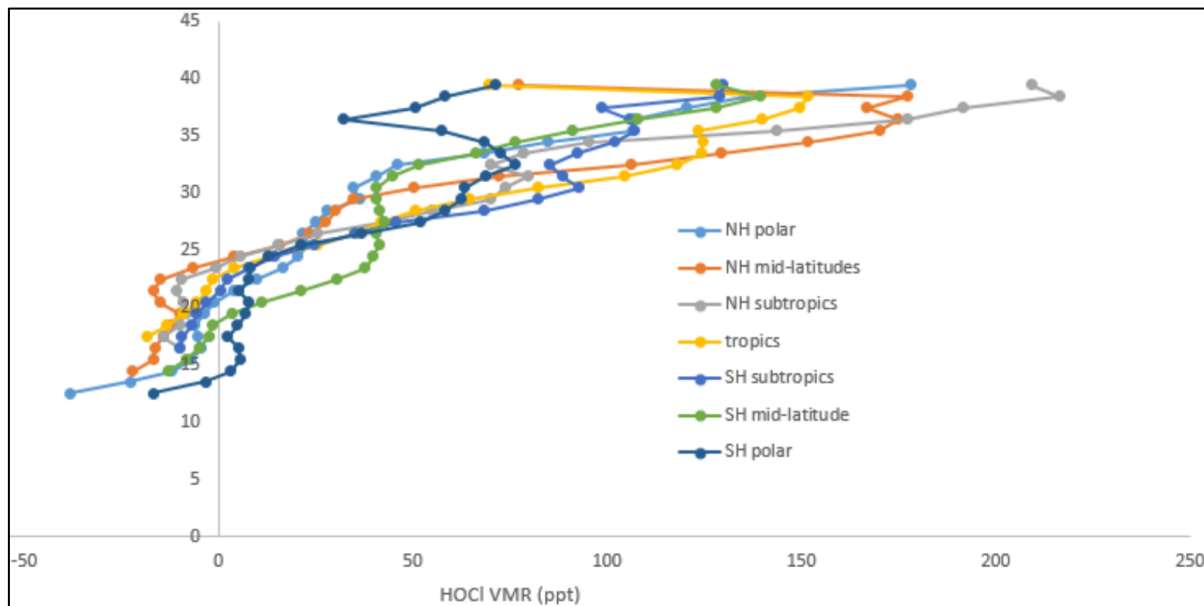


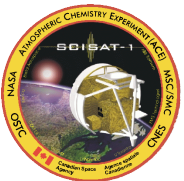


New molecule for v5.0 – HOCl

- HOCl a new molecule for ACE-FTS – very weak absorber
- Preliminary test results show a significant Hemispheric difference, with higher levels in the North.

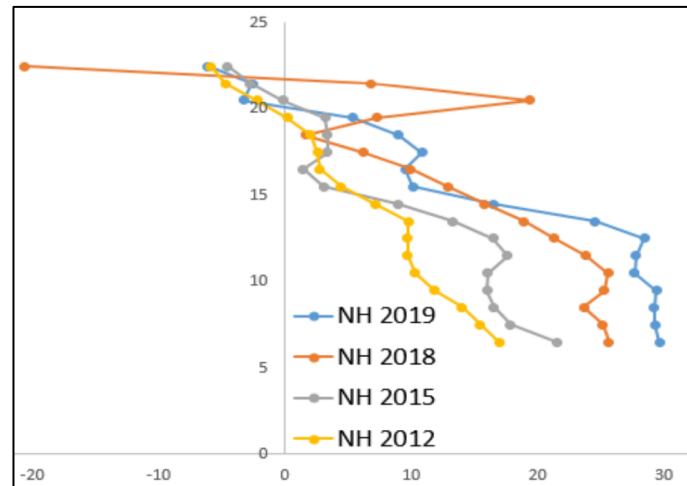
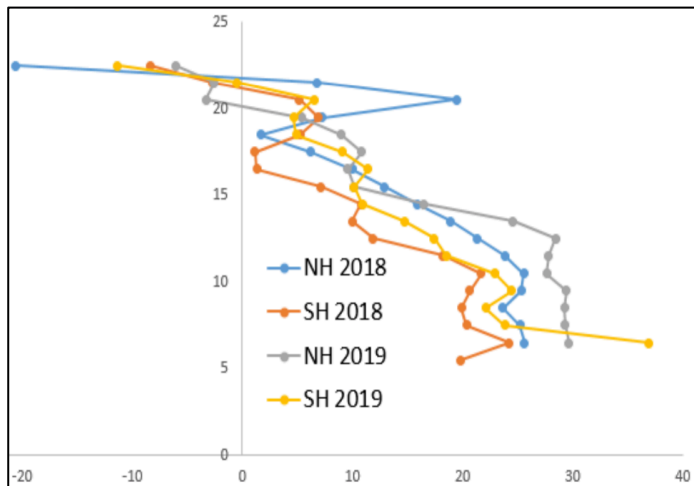
Each profile is an average from 5-10 occultations (2019)

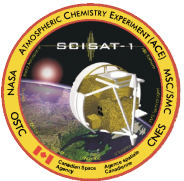




New HFC for v5.0 – HCF-32 - CH_2F_2

- Being used in refrigeration in some countries, will be controlled under Kigali Amendment
- Results are showing Hemispheric differences, as expected, and are varying strongly with time, which is expected for this molecule with a rapidly increasing concentration.
- New retrieval will be included in v5.0.





Summary

- New data version available for ACE-FTS (v4.1) since July 2020
 - Download from <https://database.scisat.ca/level2> (registration required)
 - Data quality flags are being produced separately [doi:10.5683/SP2/BC4ATC](https://doi.org/10.5683/SP2/BC4ATC)
- Validation work continuing for ACE-FTS and ACE-MAESTRO
 - Version 4.1 shows improvement over v4.0 for ACE-FTS and drift has been improved in this version

Funding for ACE and this work provided by:

- Canadian Space Agency (CSA)
- Natural Sciences and Engineering Research Council of Canada

Thanks to:

- Peter Bernath and the SCISAT Science Operations Centre