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

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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: $\text{H}_2\text{O}$, $\text{O}_3$, $\text{N}_2\text{O}$, NO, $\text{NO}_2$, $\text{HNO}_3$, $\text{N}_2\text{O}_5$, $\text{H}_2\text{O}_2$, $\text{HO}_2\text{NO}_2$, 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$_3$Cl, CCl$_4$, HCFC-22, HCFC-141b, HCFC-142b, HFC134a, HFC-23
  – Carbon-containing gases: CO, CH$_4$, CH$_3$OH, H$_2$CO, HCOOH, C$_2$H$_2$, C$_2$H$_4$, C$_2$H$_6$, OCS, HCN acetone, CH$_3$CN, peroxyacetyl nitrate (PAN), CO$_2$ in lower atmosphere, pressure / temperature from CO$_2$ lines
  – Isotopologues: Minor species of $\text{H}_2\text{O}$, CO$_2$, $\text{O}_3$, $\text{N}_2\text{O}$ 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: ±2h, ±5° latitude, ±15° 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:

- O₃, NO₂, H₂O, HCl will be shown (have other examples if you are interested!)
Ozone – v4.0 versus v3.5/3.6

V3.6
V4.0
Nitrogen Dioxide – v4.0 versus v3.5/3.6
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

V3.6
V4.0
Hydrogen Chloride – v4.0 versus 3.5/3.6

V3.6
V4.0
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., $W_{INST} = \frac{1}{\sigma^2_{INST}}$
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

P. E. Sheese et al., in preparation.
Ozone Drift in v4.0

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

P. E. Sheese et al., in preparation.
MAESTRO Water Vapour Product

- 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
Comparisons for ACE-MAESTRO v31

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

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

Soufrière Hills eruption 17-22°N

Aerosol rising up in tropical stratosphere by Brewer-Dobson circulation

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://databace.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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