Twelve Years of the Atmospheric Chemistry Experiment (ACE) Satellite: Mission Status and Recent Results

Kaley A. Walker¹,², Patrick E. Sheese¹, Chris Boone², Peter Bernath³,⁴, and C. Thomas McElroy⁵

¹Physics, University of Toronto; ²Chemistry, University of Waterloo; ³Chemistry and Biochemistry, Old Dominion University; ⁴Chemistry, University of York (UK); ⁵Earth and Space Science and Engineering, York University

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Atmospheric Chemistry Experiment (ACE) Satellite Mission:

Mission to measure atmospheric composition: profiles of trace gas species, cloud and aerosol extinction and temperature/pressure

Launch date: 12 August 2003  
Orbit: 74° inclination at 650 km  
Measurement mode: solar occultation

ACE-FTS:
- FTIR spectrometer, 2-13 microns at 0.02 cm\(^{-1}\) resolution
- 2-channel visible/NIR imager, 0.525 and 1.02 microns

MAESTRO:
- dual UV / visible / NIR grating spectrophotometer, 285 to 1030 nm at ~1-2 nm resolution

Pointing: suntracker in ACE-FTS
ACE Mission Status

• Now completing 12th year in orbit – designed for 2 year lifetime
  – Starting to see some degradation in ACE-FTS performance and MAESTRO continues to “age gracefully”

• Since launch, satellite and instrument operations nominal
  – Routine operations began on 21 February 2004
  – On 1 July 2015, SCISAT will complete its 64,000th orbit!
  – ~50% of occultations occur in polar regions (> 60 degrees)

• CSA conducted review of ACE during the first half of 2014
  – Based on the positive response from the panel, CSA has approved operation of SCISAT until end of March 2018
ACE Data Products

• ACE-FTS profiles (current version 3.5; previous v2.2+updates/2.5):
  – Tracers: H$_2$O, O$_3$, N$_2$O, NO, NO$_2$, HNO$_3$, N$_2$O$_5$, H$_2$O$_2$, HO$_2$NO$_2$, N$_2$
  – Halogen-containing gases: HCl, HF, ClONO$_2$, CFC-11, CFC-12, CFC-113, COF$_2$, COCl$_2$, COFCl, CF$_4$, SF$_6$, CH$_3$Cl, CCl$_4$, HCFC-22, HCFC-141b, HCFC-142b
  – 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 and pressure / temperature from CO$_2$ lines
  – Isotopologues: Minor species of H$_2$O, CO$_2$, O$_3$, N$_2$O CO, CH$_4$, OCS
  – Research species: ClO, acetone, PAN (peroxyacetyl nitrate), etc.

• MAESTRO profiles (current version 3.12.1; validated version 1.2):
  – O$_3$, NO$_2$, optical depth and aerosol (water vapor research version)

• IMAGERS profiles (current version 3.5; validated version 2.2):
  – Atmospheric extinction & aerosol extinction at 0.5 and 1.02 microns
ACE-FTS v3.5/v2.5 Update

Fix for processing issue from October 2010 onward:

- Versions 2.2 and 3.0 results should not be used because of problems with pressure and temperature information obtained from the Canadian Meteorological Center.

- New processing versions (starting with v3.5, then v2.5) are being completed to provide corrected results for the affected time period (October 2010 onward).
  - Version 3.5 will include research products for high altitude CO, C₂H₆, HCFC-22, polar N₂O
  - There is also a new “research” product for CH₄
  - This version will be released in “batches” with the first made available in Sept. 2014 – we are working on completing the second batch for release in the coming months
Version 3.5 Release

- The “preliminary” release of version 3.5 includes:
  - ACE-FTS & ACE-Imager profiles for this version
  - Also, geolocation information along the measurement path is available for the 1-km and tangent grid data
  - New data flagging has been developed for ACE-FTS profiles
  - Derived Meteorological Products (DMPs) are available

- Also, we have identified multiple periods with missing data so we are going back to “rescue” occultations as processing continues for v3.5
  - Ensure those processed in v2.2 and 3.0 are present in v3.5

- Also with the v3.5 ACE-FTS release, a new version of ACE-MAESTRO has been released (v3.12.1)
Data Flagging for v3.5 Profiles

- Developed to provide better guidance to teams for use of ACE-FTS profiles
  - To provide more quality advice than the Data Issues List and fitting error ranges for removing outliers
  - Employing a better way to deal with outliers when data distributions are not symmetric
- Uses two step process using 1-km grid dataset
  - For given height and latitude region, calculate “expected” density distribution (Gaussian mixture distribution)
  - For each day, using 15-day running median filter with ±10 times the median average deviation (MeAD)

P. E. Sheese et al., AMT, 8, 741-750 (2015).
Examples for Antarctic SR

First Step - PDFs Calculated
- For 30 degree latitude ranges, type of observation and each altitude (on 1 km grid)

Second step – 15-day filter
- Used 15-day running median filter with ±10 times the MeAD rather than MAD (median absolute deviation) for efficacy
- Shown for N₂O at 35.5 km

P. E. Sheese et al., AMT, 8, 741-750 (2015).
MAESTRO “Research” H$_2$O

- Match observed differential optical depth (DOD) in the ~940 nm band with simulated DOD using iterative retrieval (i.e. Chahine-updating of VMR profile) [Sioris et al. Adv. Space Res., 2010]

- Retrieval errors calculated by perturbation - Smallest relative errors in mid-trop (5 km)

- Vertical resolution of water vapour profile approaches vertical sampling

- WAVAS-II validation shows few issues: e.g., 1 ppm dry bias in Antarctic in summer

- 2004-02 to 2013-03 available

C. Sioris et al., in preparation
New ACE-FTS v3.5 Climatology

- Building on work by Jones et al., ACP (2011) and that done for SPARC Data Initiative
- \( \text{O}_3, \text{H}_2\text{O}, \text{CH}_4, \text{N}_2\text{O}, \text{CO}, \text{NO}, \text{NO}_2, \text{N}_2\text{O}_5, \text{HNO}_3, \text{HCl}, \text{HF}, \text{ClONO}_2, \text{CFC-11} \) and CFC-12
  - \( \text{C}_2\text{H}_6, \text{C}_2\text{H}_2, \text{HCN}, \text{OCS}, \text{HCOOH}, \text{CH}_3\text{OH}, \text{H}_2\text{CO} \)
  - 45 levels up to 0.0001 hPa as data available (was 0.1 hPa)

J.-H. Koo and A. Jones
Summary

• ACE Instruments and satellite are continuing to function nominally and produce excellent results
  – v3.5 to fix processing issue released with new data flags
• Data being used for scientific and validation studies
  – Reprints available from http://www.ace.uwaterloo.ca
  – Climatological datasets and atlases available from website
  – Validation results published in Atmos. Chem. Phys.: http://www.atmos-chem-phys.net/special_issue114.html

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• Canadian Space Agency (CSA)
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• Natural Environment Research Council (NERC)
• This fall we will be holding a joint SCISAT-Odin Science Team Meeting in Toronto, Canada (19 – 21 Oct. 2015)
  – All are welcome to attend and present at the meeting
  – We are interested in developing new collaborations so come and learn more about ACE and Odin
  – Let me know if you would like to be on the mailing list for the meeting!