The Atmospheric Chemistry Experiment (ACE) Satellite Mission: Overview, Mission Status and Results

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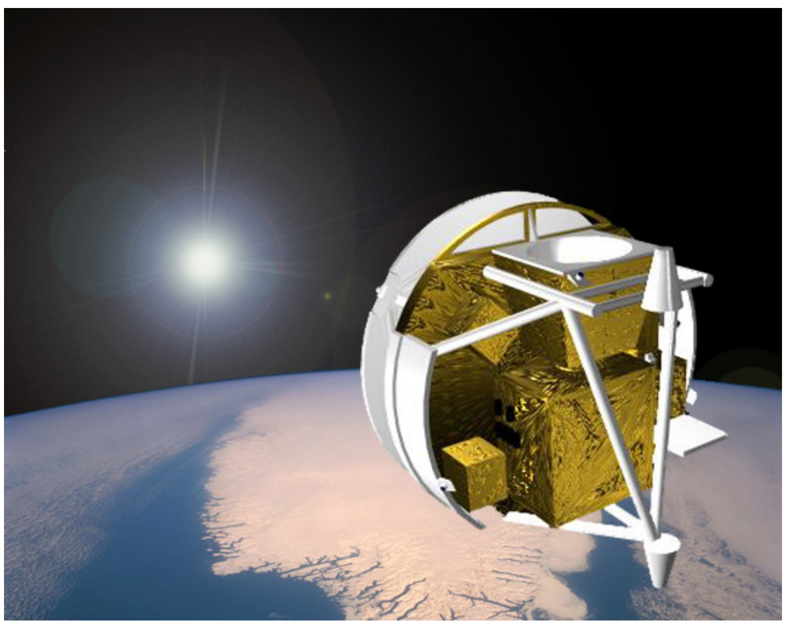
ACE on SCISAT-1

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

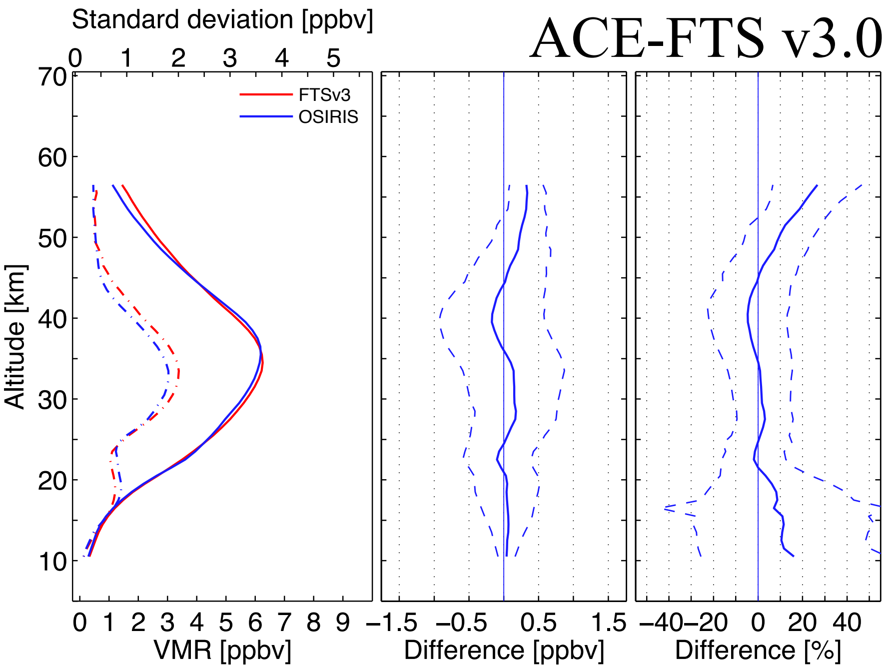
- Now finishing 10th year in orbit – designed for 2 year lifetime
  - Starting to see some degradation in ACE-FTS performance and MAESTRO continues to "age gracefully"
- Since launch, satellite and instrument operations nominal
  - Routine operations began on 21 February 2004
  - On 12 June 2013, SCISAT completed its 52,950th orbit!
  - ~50% of occultations occur in polar regions (> 60 degrees)
- Operation of ACE mission approved until end of March 2014
  - CSA will be conducting reviews in coming months

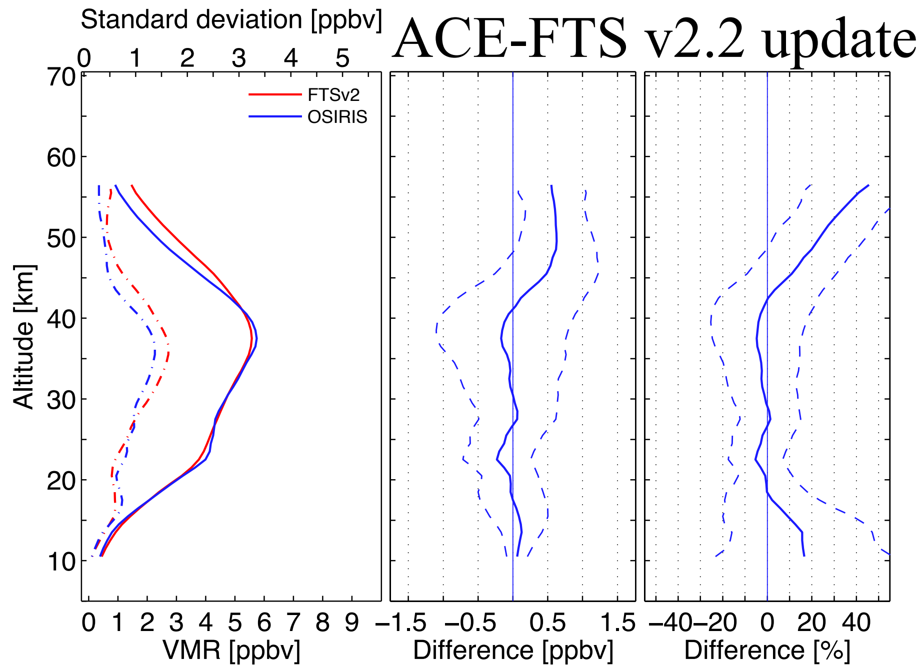
ACE Data Products

- ACE-FTS profiles (current version 3.0/3.5; previous v2.2+updates/2.5):
  - Tracers: H_2O, O_3, N_2O, NO, NO_2, HNO_3, N_2O_5, H_2O_2, HO_2NO_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_3Cl, CCl_4, HCFC-22, HCFC-141b, HCFC-142b
  - Carbon-containing gases: CO, CH_4, CH_3OH, H_2CO, HCOOH, C_2H_2, C_2H_4, C_2H_6, OCS, HCN and pressure / temperature from CO_2 lines
  - Isotopologues: Minor species of H_2O, CO_2, O_3, N_2O CO, CH_4, OCS
  - Research species: ClO, acetone, PAN (peroxyacetyl nitrate), etc.
- MAESTRO profiles (current version 3.12b; validated version 1.2):
  - O_3, NO_2, optical depth and aerosol (water vapor being developed)
- IMAGERS profiles (current version 3.0; validated version 2.2):
  - Atmospheric extinction at 0.5 and 1.02 microns (aerosols in v3.0)

ACE-FTS versus OSIRIS O_3

- Continuing inter-comparisons to assess v3.0/v3.5 and examine changes over lifetime of instrument
- Example shown for ACE-FTS v3/v2, OSIRIS v5.07 ozone profiles
- Used all coincident pairs within 1000 km and 6 hours; note different subsets of files used for each ACE version





Claire Waymark

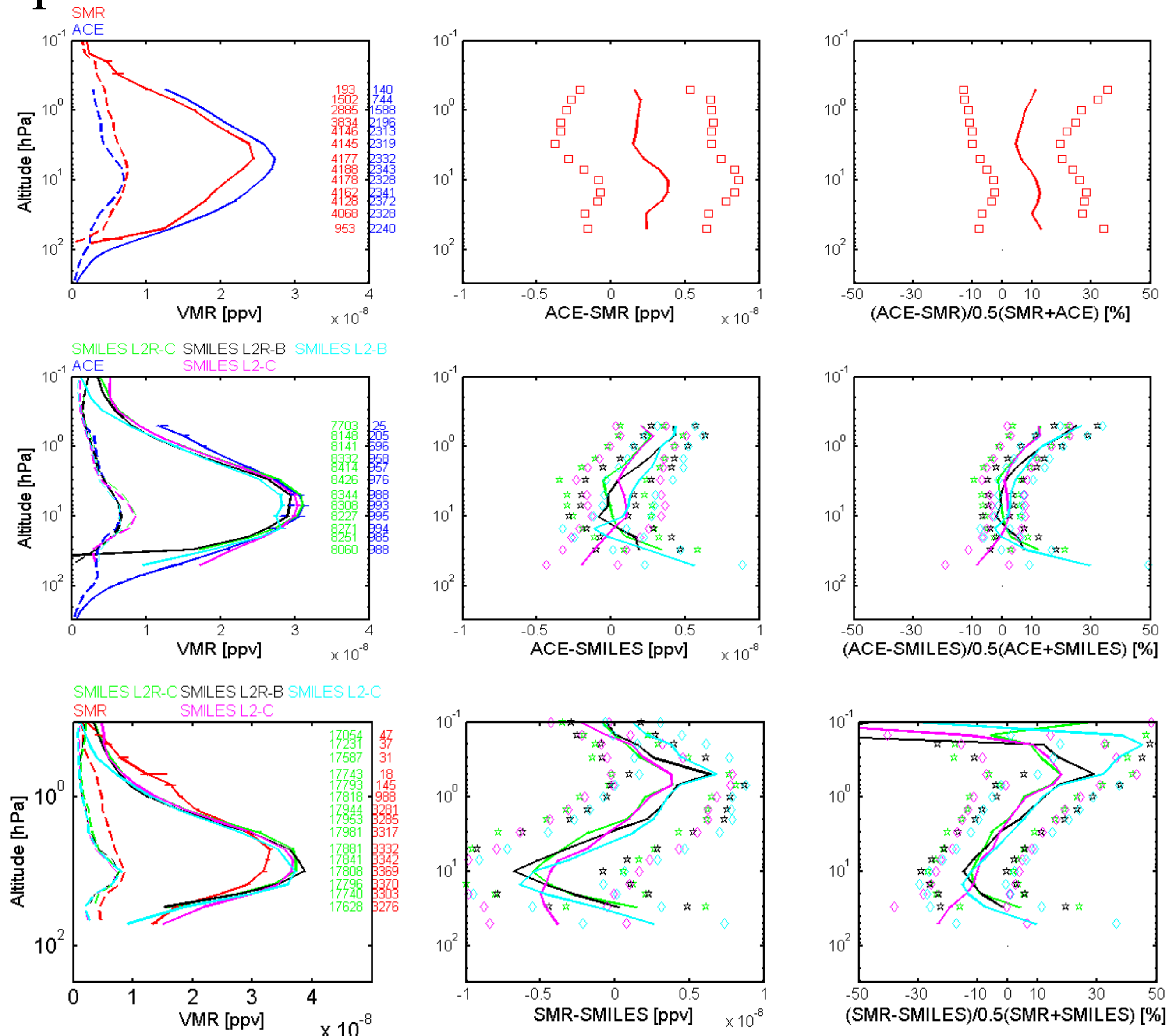
Ozone Isotopologue Comparisons – $^{16}O^{16}O^{18}O$ (Asym-18)

- Using all pairs within 800 km and 12 hours & consistent sPV

ACE-FTS vs. SMR

ACE vs. SMILES-J / SMILES-N

SMILES-J / SMILES-N vs. SMR



Ashley Jones, in preparation

Isotopic Fractionation

- The ratios of isotopologues can be changed through atmospheric processes
  - This leads to an enrichment or depletion of the isotopologue, *Q*
- We define this as:

$$\delta^{Q}O_3(\%) = \left(\frac{R_s}{R_0} - 1\right) \times 100$$

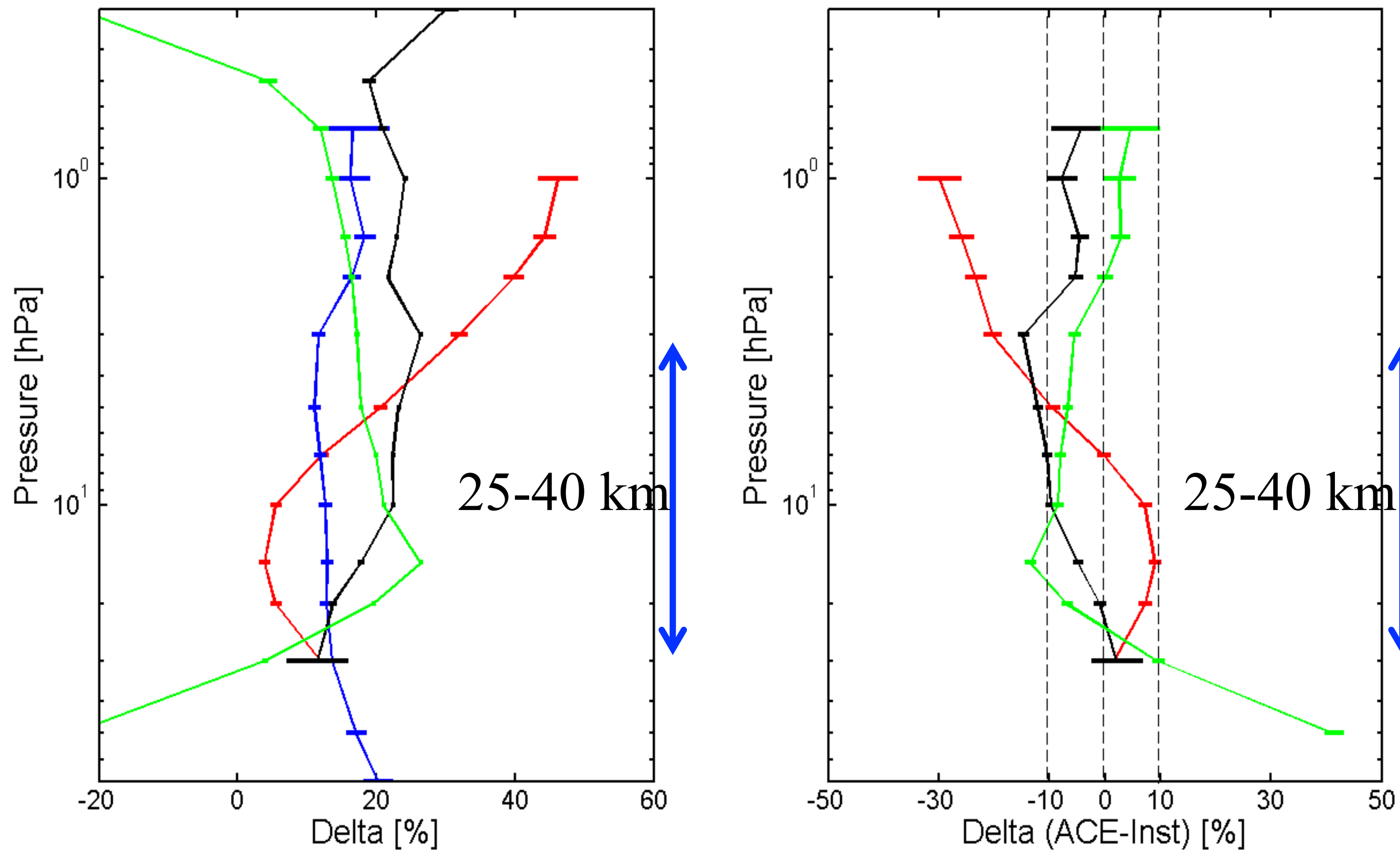
  - Where, R_s is the ratio of the isotopologue to a reference (e.g. $[^{asym\text{-}18}O_3]/[^{normal}O_3]$)
  - Where, R_0 is reference value, for example, SMOW oxygen (e.g.$[^{18}O]_{SMOW}/[^{16}O]_{SMOW}$)

Oxygen Ratio in SMOW (Standard Mean Ocean Water) isotopic ratio:

$^{16}O : {}^{17}O : {}^{18}O \;=\; 1 : 1/2700 : 1/500$

Asym-18 $^{18}O_3$ Enrichment (30-50N)

ACE-FTS SMR SMILES L2N-B SMILESL2J-B



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Comparison of Enrichment Values

Platform	Altitude Range (km)	Latitude Coverage	$\delta(^{18}O)$ for Asym-18 O_3
FIRS-2 (Johnson et al., 2000)	25-35	30-25N, 68N	12.2 ± 1.0
ATMOS (Irion et al., 1996)	25-40	80S – 80N	15.0 ± 6.0
Ground FTIR (Meier et al., 1996)	Total column	79N	13.5 ± 4.0
ACE-FTS	25-40	30-50N	12.3 ± 0.2/0.9
SMILES L2N band B	25-40	30-50N	20.9 ± 0.1/5.8
SMILES L2J band B	25-40	30-50N	29.3 ± 0.1/7.6
SMR	25-40	30-50N	11.7 ± 0.2/6.4

- $\delta(^{18}O)$ for Asym-18 O_3 shown with ± 1 sigma precision / 1 std (%)

Ashley Jones, in preparation

SPARC Lifetime Assessment

- SPARC (Stratospheric Processes And their Role in Climate) group is sponsoring a report entitled "Reevaluation of the Lifetimes of Dominant Stratospheric Ozone Depleting Substances (ODSs)".
- This is important: "Because the lifetimes of ODSs are used to predict their future evolution, to perform top down emission estimates, and to calculate the ozone-depletion potentials (ODPs) of those species, it is of critical importance to have the best possible estimates of ODS lifetimes."
- ACE data is contributing to Chapter 4 on "Inferred lifetimes from observed trace gas distributions" – Utilizing tracer-tracer correlations with CFC-11, following the method of Volk et al., 1997.

A. T. Brown *et al.*, ACPD, 13, 4221 (2013)

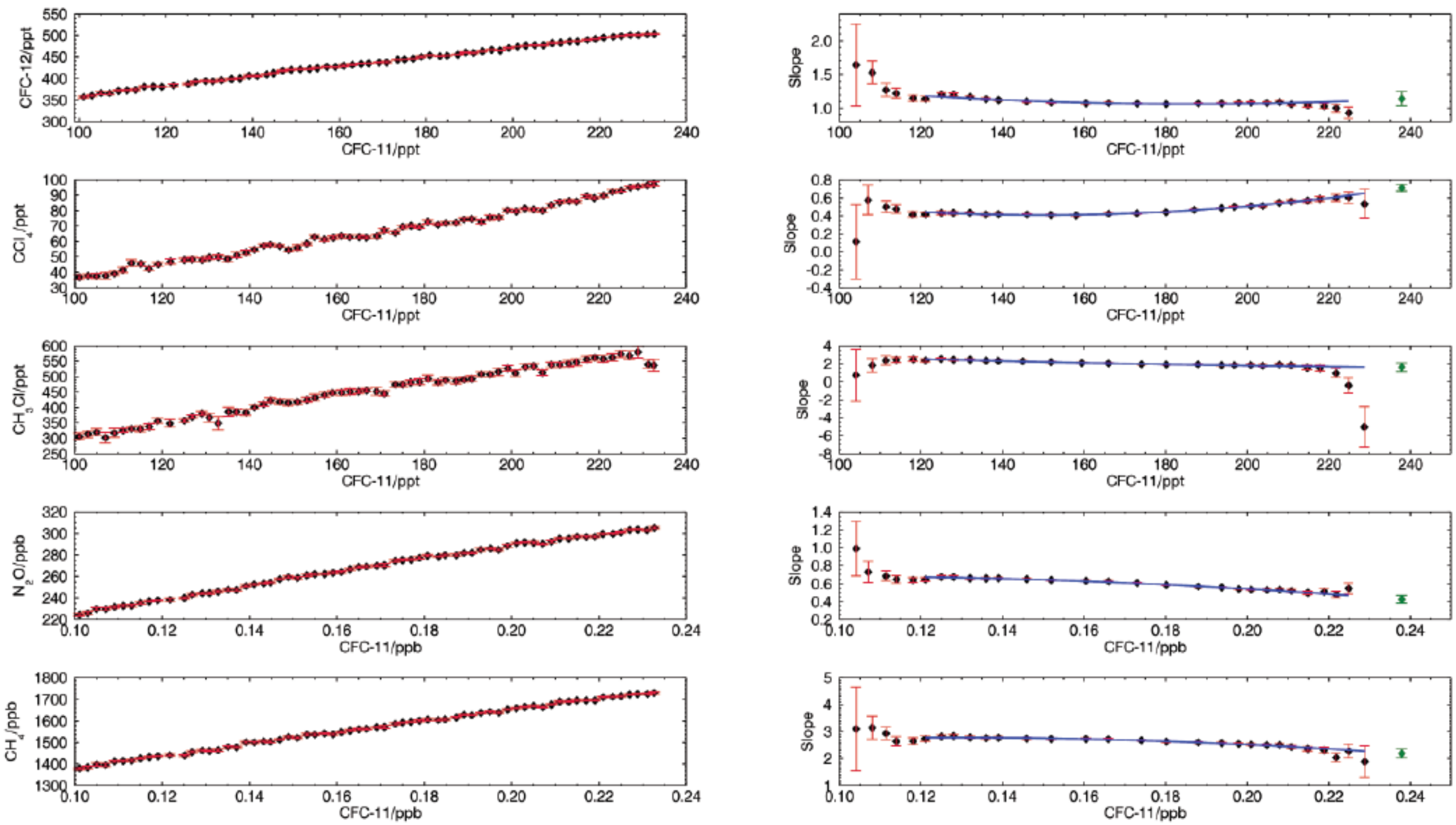

Fig. 1. Correlations between the volume mixing ratios of CFC-12, CCl_4, CH_4, CH_3Cl and N_2O and CFC-11 for the data from the Northern Hemisphere during the stratospheric winter of 2008. Left panels: the mean correlation curves. Each point represents the mean of the VMR, of both CFC-11 and CFC-12, in a window of 2 ppt of CFC-11. The error on these points is the standard deviation of the data within each 2 ppt window. Right panels: The local slope of data in an 80 ppt of CFC-11 window. The error on the points is the fitting error of this fit. The blue line is a second degree polynomial fit to the local slopes. The green point is the extrapolated slope at the tropopause.

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Stratospheric Lifetime Assessment

- Using slope of correlation with CFC-11 at the tropopause, lifetimes were calculated for CFC-12, CCl_4, CH_3Cl, N_2O, CH_4
  - Corrections were made to the correlations for changing atmospheric concentrations of these species
  - Used stratospheric lifetime of 45 years for CFC-11
- No significant hemispheric or seasonal dependency was found
- Weighted mean lifetime values were determined to be:
  - CFC-12: 113+(-)26(18) years (within errors of WMO value)
  - CCl_4: 35+(-)11(7) years (within errors of WMO value)
  - CH_4: 195+(-)75(42) years (larger than Volk et al., 1997)
  - CH_3Cl: 69+(-)65(23) years (first value determined)
  - N_2O: 123+(-)53(28) years (within errors of WMO value)

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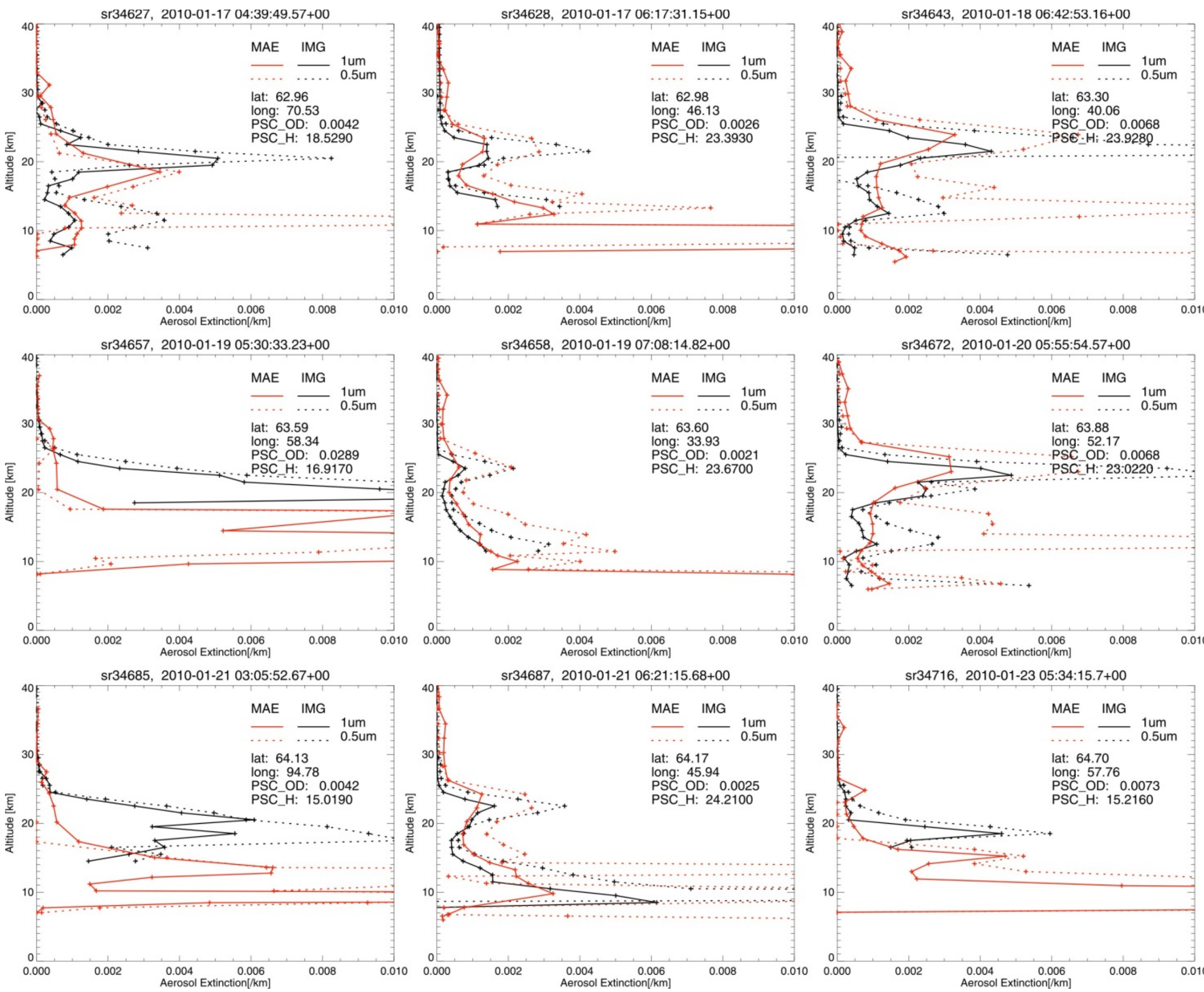
MAESTRO/ACE-Imagers Aerosols



- From January 2010 sunrises, MAESTRO aerosols at 525 and 1025 nm taken from 10 wavelength bands
- MAESTRO
- IMAGER

  --- 525 nm

  — 1025 nm
- MAESTRO PSC Height and Optical Depth are calculated

Tom McElroy

SCISAT/ACE 10th Anniversary

The fall ACE Science Team meeting will be held as a celebration of 10 years of SCISAT measurements

- 22 October 2003 marks the date of first spectral measurements from ACE-FTS and ACE-MAESTRO during commissioning

- Dates: Wed. 23 October – Fri. 25 October 2013
- Location: York University, Toronto, Canada

Summary

- ACE Instruments and satellite are continuing to function nominally and produce excellent results
- 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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