Atmospheric Chemistry Experiment

Ozone profiles measured by the ACE satellite

Peter Bernath, Kaley Walker & Tom McElroy

University of York University of Toronto Environment Canada

On behalf of the ACE science team...

ACE FTS ACE / SciSat-1 MAESTRO
Overview

Introduction
Data Comparison
Discussion of future measurements
Conclusions
SCISAT-1 Satellite

Size: 1.12 m dia. x 1 m
Total mass: 152 kg
Total power: 70 W
(from single solar panel)
Launch date: 12 August 2003
Launch vehicle: Pegasus XL
(provided by NASA)
Orbit: 74° inclined circular orbit at 650 km
ACE Latitude Coverage 2005/2006

Orbit allows repeat of measurement locations each year
SCISAT-1

ACE-FTS:
- Fourier transform infrared 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

Pointing: suntracker in ACE-FTS
Primary measurement mode: solar occultation
ACE Data Products

- ACE-FTS profiles (version 2.2 + O$_3$, N$_2$O$_5$ & HDO updates):
  - Baseline: O$_3$, H$_2$O, CH$_4$, N$_2$O, NO$_2$, NO, HNO$_3$, HCl, HF, CO, CFC-11, CFC-12, N$_2$O$_5$, ClONO$_2$, T and p from CO$_2$ lines
  - Other routine: COF$_2$, CHF$_2$Cl, CF$_4$, CH$_3$Cl, SF$_6$, OCS, HCN
  - Research: CCl$_4$, H$_2$O$_2$, HO$_2$NO$_2$, COClF, COCl$_2$, CCl$_2$FCClF$_2$, CH$_3$CClF$_2$, ClO, C$_2$H$_2$, C$_2$H$_4$, C$_2$H$_6$, CH$_3$OH, HCOOH, H$_2$CO, N$_2$, (HOCl), additional isotopologues

- IMAGERS profiles (version 2.2):
  - Atmospheric extinction at 0.5 and 1.02 microns (aerosols soon)

- Version 3.0 is now being processed - total number of species (including isotopologues) is almost 60
ACE Ozone Comparisons

Overview of all profile comparisons versus:
SAGE II, SAGE III, POAM III, HALOE, SMR, OSIRIS, MLS, SABER, ASUR, SCIAMACHY, GOMOS, MWR, MIPAS, Eureka DIAL, ozonesondes

Agreement: ACE-FTS +5%; ACE-MAESTRO ±5%
Mean calculated as (ACE-comp)/average: Solid red: SR; Dashed blue: SS; Dot-Dash black: both SR/SS; criteria: ±5º lat. and ±10º long., ±6 hr

Dupuy et al., ACP, 9, 287-343, 2009
ACE-FTS vs. SAGE II

- Example of comparison between ACE-FTS (v2.2 ozone update) and SAGE II (v6.20)
- Average differences of +5-6% (ACE-SAGE) between 18 and 42 km for both SR and SS occultations
- Measurement overlap period for coincidences: 9 August 2004 - 6 May 2005

Absolute difference calculated as (ACE-FTS - SAGE II); Relative difference as (ACE-FTS - SAGE II)/average; criteria: ±5° lat. and ±10° long., ±6 hr

Dupuy et al., ACP, 9, 287-343, 2009
ACE-FTS vs. SAGE III

- Example of comparison between ACE-FTS (v2.2 ozone update) and SAGE III (v3.0)
- Mean differences less than ±6% (ACE-SAGE) between 12 and 42 km and generally smaller than ±2% in this range
- Measurement overlap period for coincidences: 21 February 2004 - 9 October 2005

Absolute difference calculated as (ACE-FTS - SAGE III);
Relative difference as (ACE-FTS - SAGE III)/average;
criteria: ±5° lat. and ±10° long., ±6 hr

Dupuy et al., ACP, 9, 287-343, 2009
v3.0 versus v2.2 Ozone Update

- Compared to v2.2 Ozone Update, VMRs for v3.0 have decreased by approx. 2-3% between ~15-35 km.
- At altitudes above ~35 km, greater decrease in VMRs is seen of ~5%.

Claire Waymark in progress.
Comparisons with HALOE v19: southern high latitudes 2004/05

- At altitudes above ~35 km, the percentage differences have decreased by ~5%
- Criteria used: ±5º lat. and ±10º long., ±6 hr; ~35 profiles

Claire Waymark, in progress
MAESTRO

- Dual concave holographic diffraction grating spectrophotometers
- RETICON Photodiode array detectors

- MAESTRO profiles (version 1.2):  
  - O$_3$, NO$_2$, and total optical depth
- Version 3.0 under test (problems getting the operational version going)  
  - Includes aerosol optical depth & profiles  
  - Water vapour profiles
Long-term sensitivity changes - Vis

Visible high-sun reference spectra 2004 c.f. 2009
Long-term sensitivity changes - UV

UV high-sun reference spectra 2004 c.f. 2009
SOAR
Solar Occultation for Atmospheric Research

Three instruments make up SOAR payload

- **SOAR-IR**
  - Infrared Fourier transform spectrometer to measure broad range of species (almost forty) and temperature and pressure Target vertical resolution 1.5 km

- **SOAR-OPTICAL**
  - UV-visible-near-infrared spectrometer to provide very high resolution (~0.5 km) profiles of aerosols and key species

- **SOAR-IMAGER**
  - Solar imaging cameras to provide profiles of aerosols and clouds and enhanced pointing information to derive altitudes, temperatures and densities
Conclusions

• The overlap period with SAGE has provided a good inter-calibration for SAGE v. ACE
• The hardware appears to be robust and stable
• Satellite appears to have experienced little degradation
• A future mission providing this sort of information is needed
• Overlap with ACE is HIGHLY desirable
• The SOAR mission has been proposed but has not been selected
• A small ‘constellation’ of instruments capable of the UV-Vis-NIR component could provide global coverage that would be useable in a data assimilation role
The End
Thank you for your attention.

ACE Arctic Validation Campaign

The End
Thank you for your attention.