The Atmospheric Chemistry Experiment (ACE): Mission Overview and Recent Results

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SPARC Data Assimilation Workshop - 6 September 2007

ACE Goals

Primary goal of the ACE mission:

To investigate the chemical and dynamical processes that control the distribution of ozone in the stratosphere and upper troposphere

– particular focus on ozone decline in the northern mid-latitudes and the Arctic.

This is accomplished by determining:

- Concentrations of atmospheric trace gas species as a function of altitude
- Atmospheric extinction due to aerosols and clouds
- Temperature and pressure

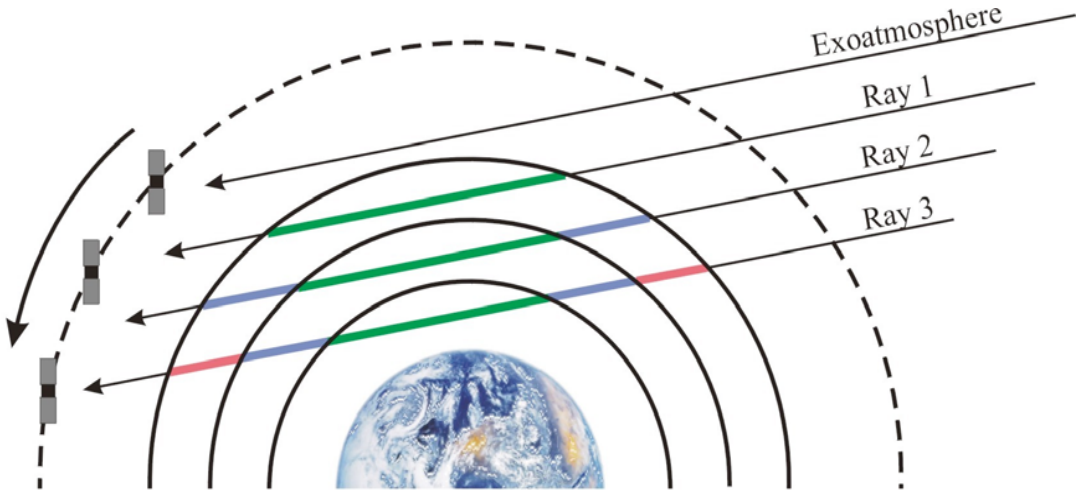
Technique: Solar Occultation

Advantages:

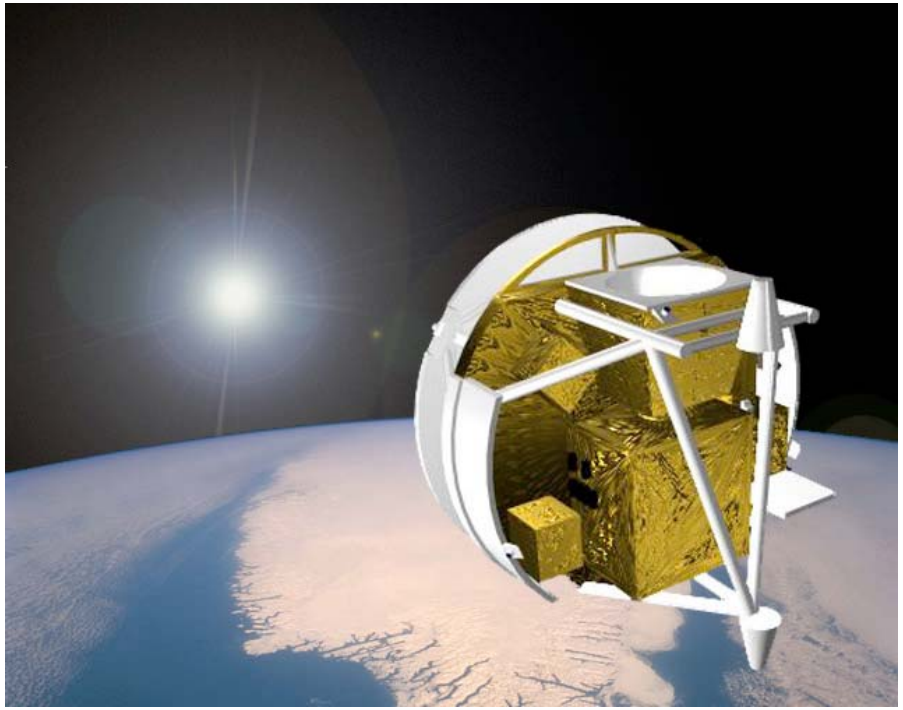
- Radiance of sun gives higher S/N than emission
- Limb view gives longer path length ~500 km (lower detection limits) than nadir
- "Self-calibrating" so excellent long-term accuracy and precision

Disadvantages:

- Modest global coverage
- Samples only free troposphere



SCISAT-1 Satellite



Size: 1.12 m dia. x 1 m

Total mass: 152 kg

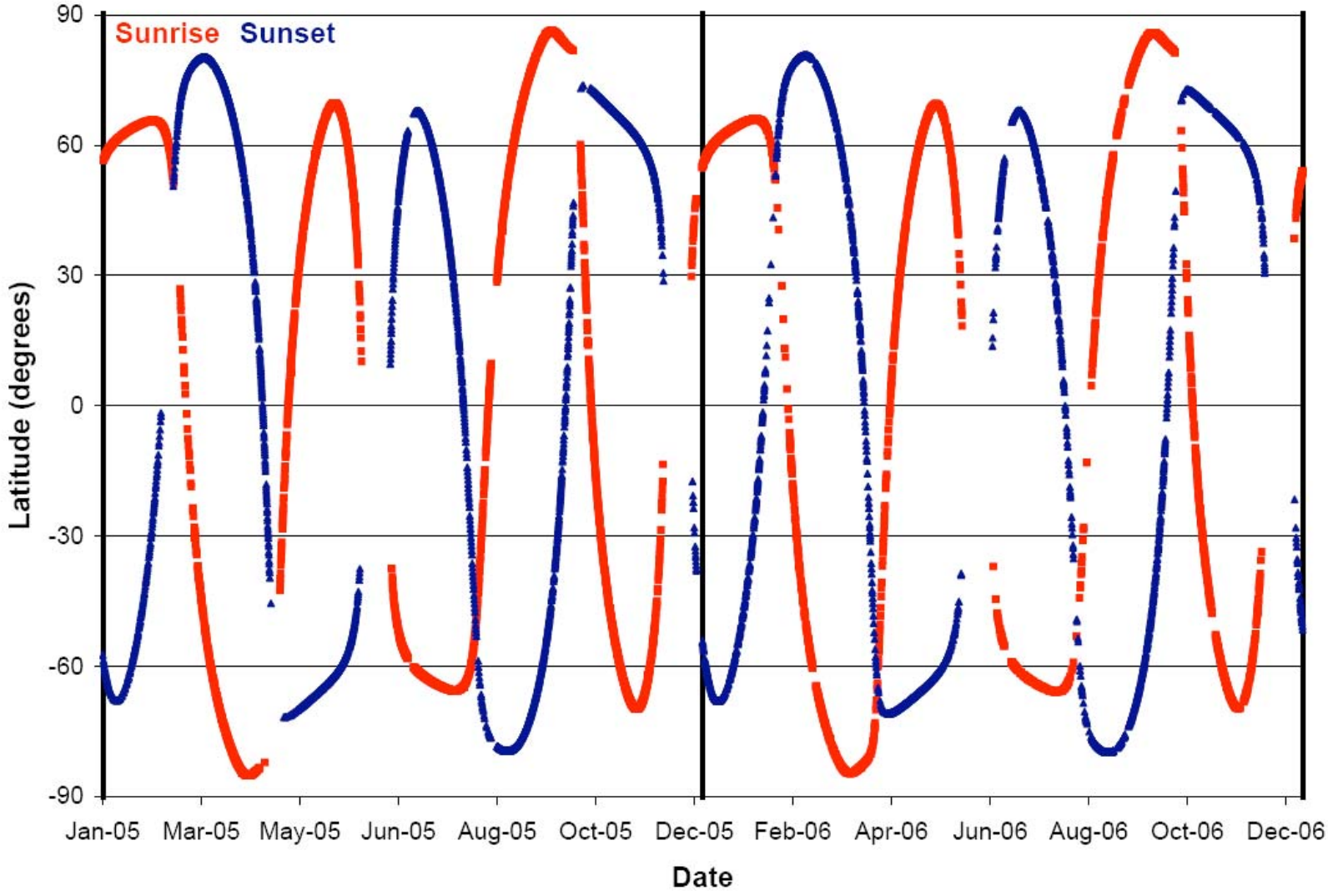
Total power: 70 W
(from single solar panel)

Launch date: August 12, 2003

Launch vehicle: Pegasus XL
(provided by NASA)

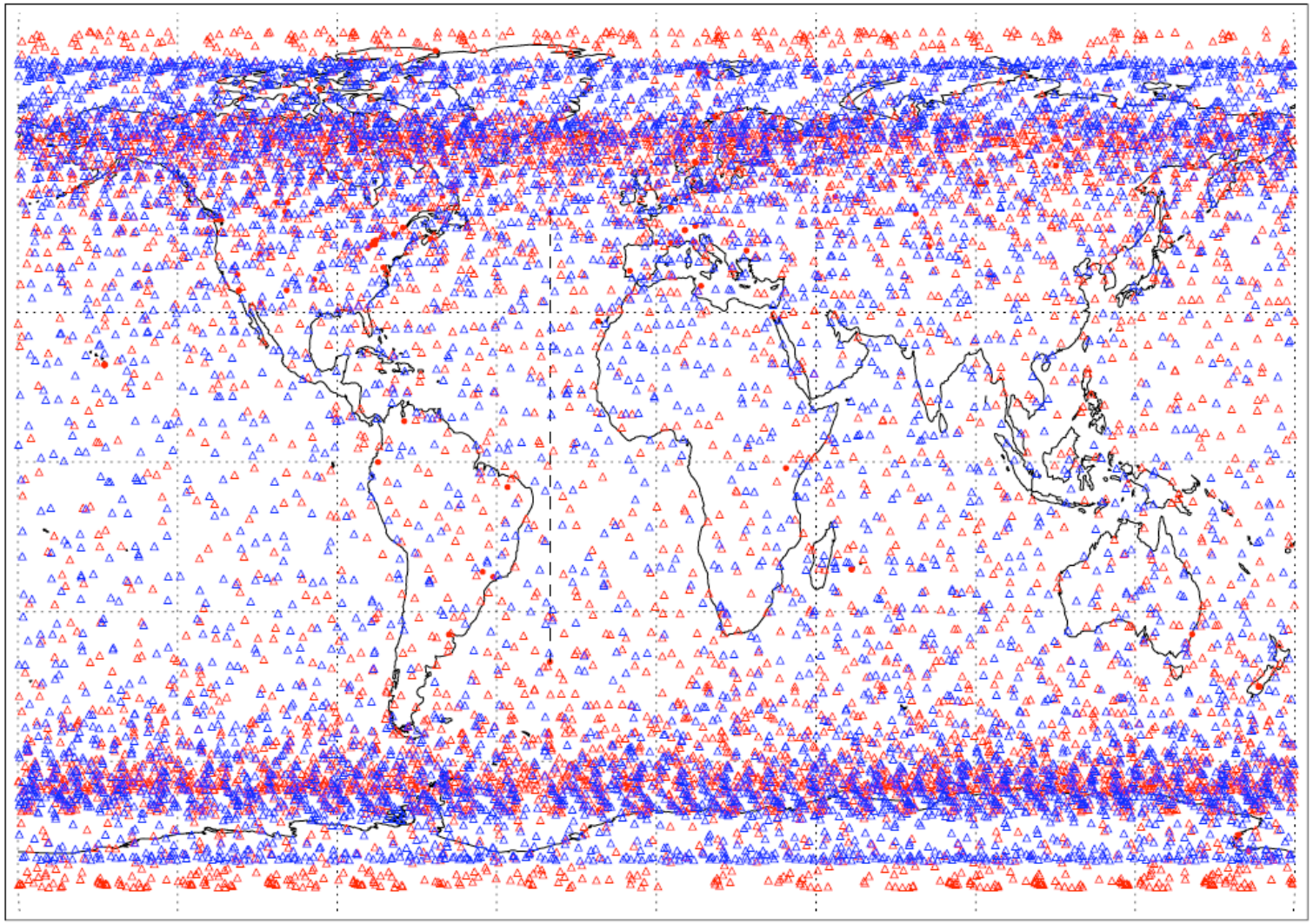
Orbit: 74° inclined circular orbit
at 650 km

ACE Latitude Coverage 2005/2006



Distribution of Occultations (3 years)

△ SR
△ SS



ACE Instruments

ACE-FTS:

- a high resolution (0.02 cm^{-1}) infrared Fourier transform spectrometer operating between 2-13 microns
- 2-channel visible/near infrared imager operating at 0.525 and 1.02 microns

MAESTRO:

- dual UV / Visible / NIR spectrometer measuring from 0.285 to 1.030 microns, resolution ~1-2 nm

Measurement modes: solar occultation (primary mode), backscatter (MAESTRO), calibration (sunscans)

Instrument Pointing: suntracker located within ACE-FTS

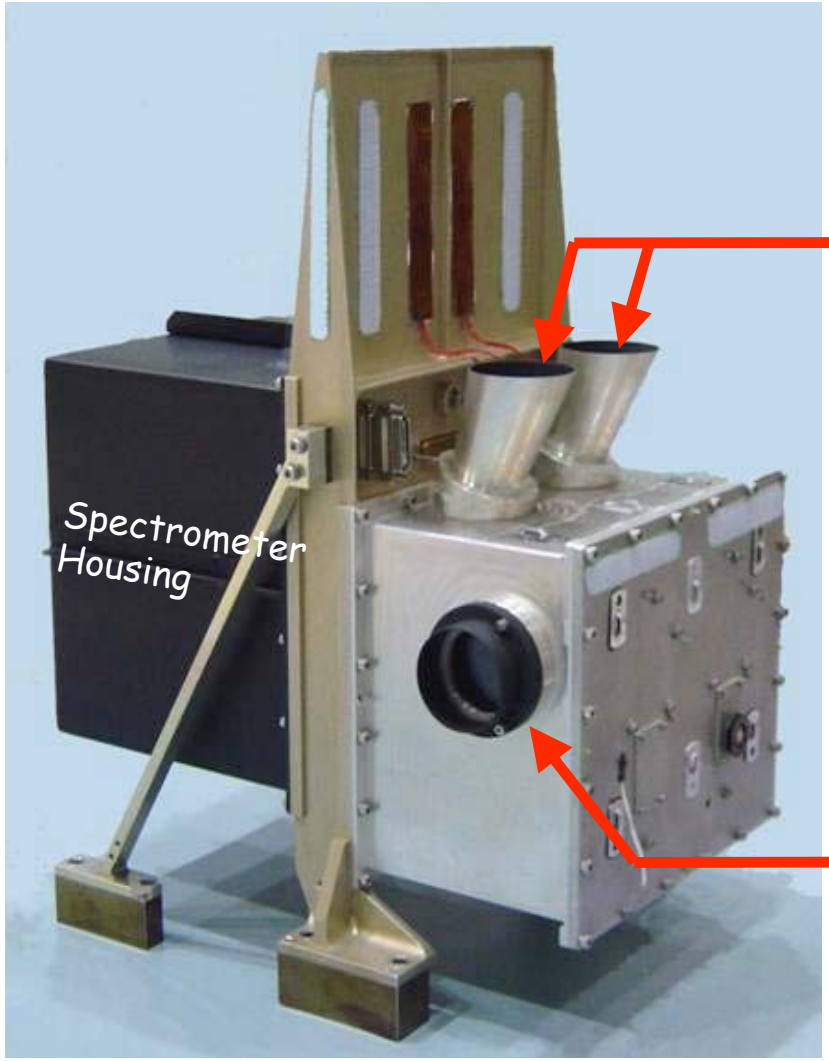
ACE-FTS (ABB-Bomem)

Interferometer-side

Input optics-side

ACE-MAESTRO (EMS, MSC, UoT)

MAESTRO P.I. Tom McElroy



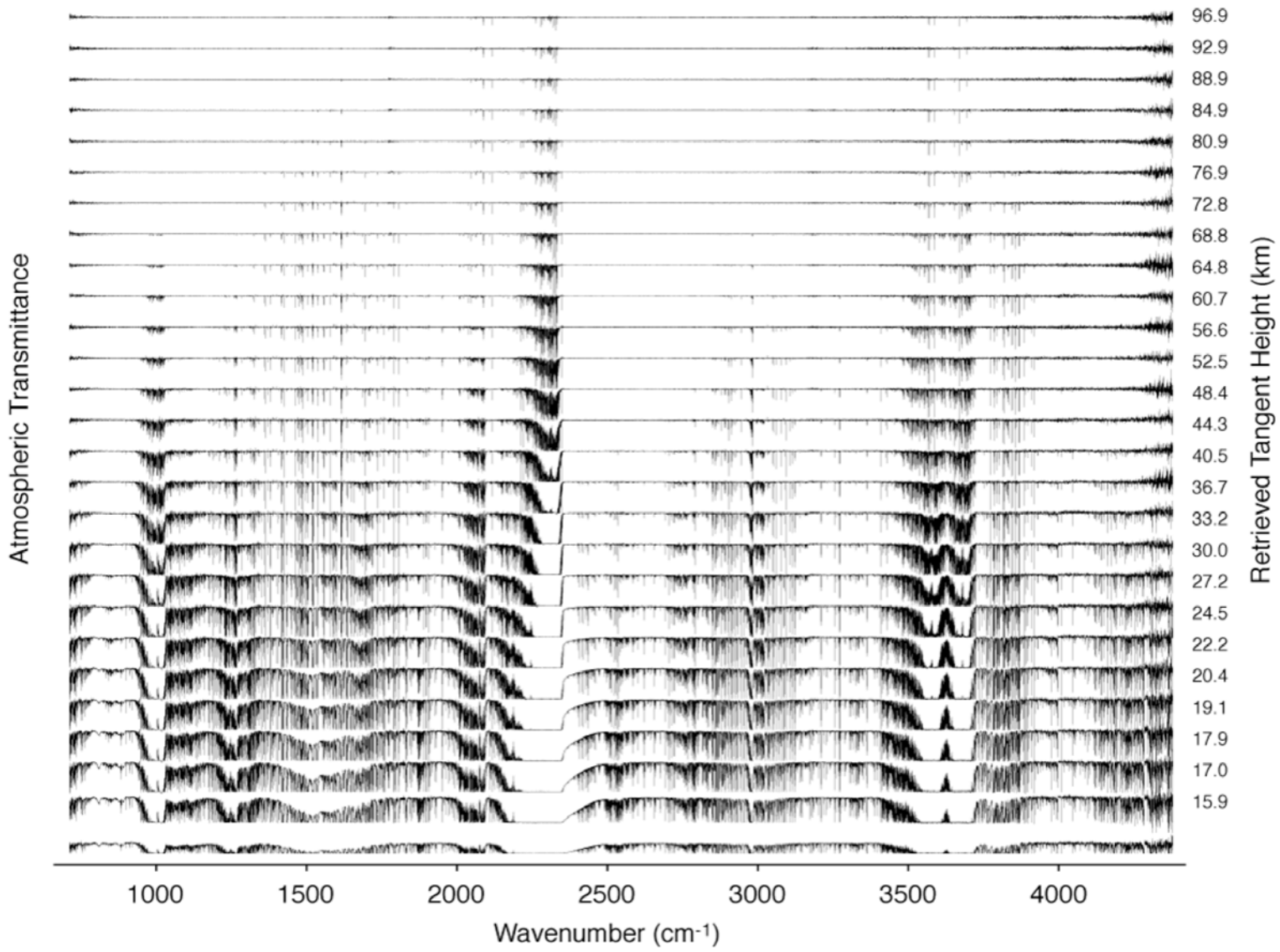
ACE-FTS Occultation sequence

Sunset 2245

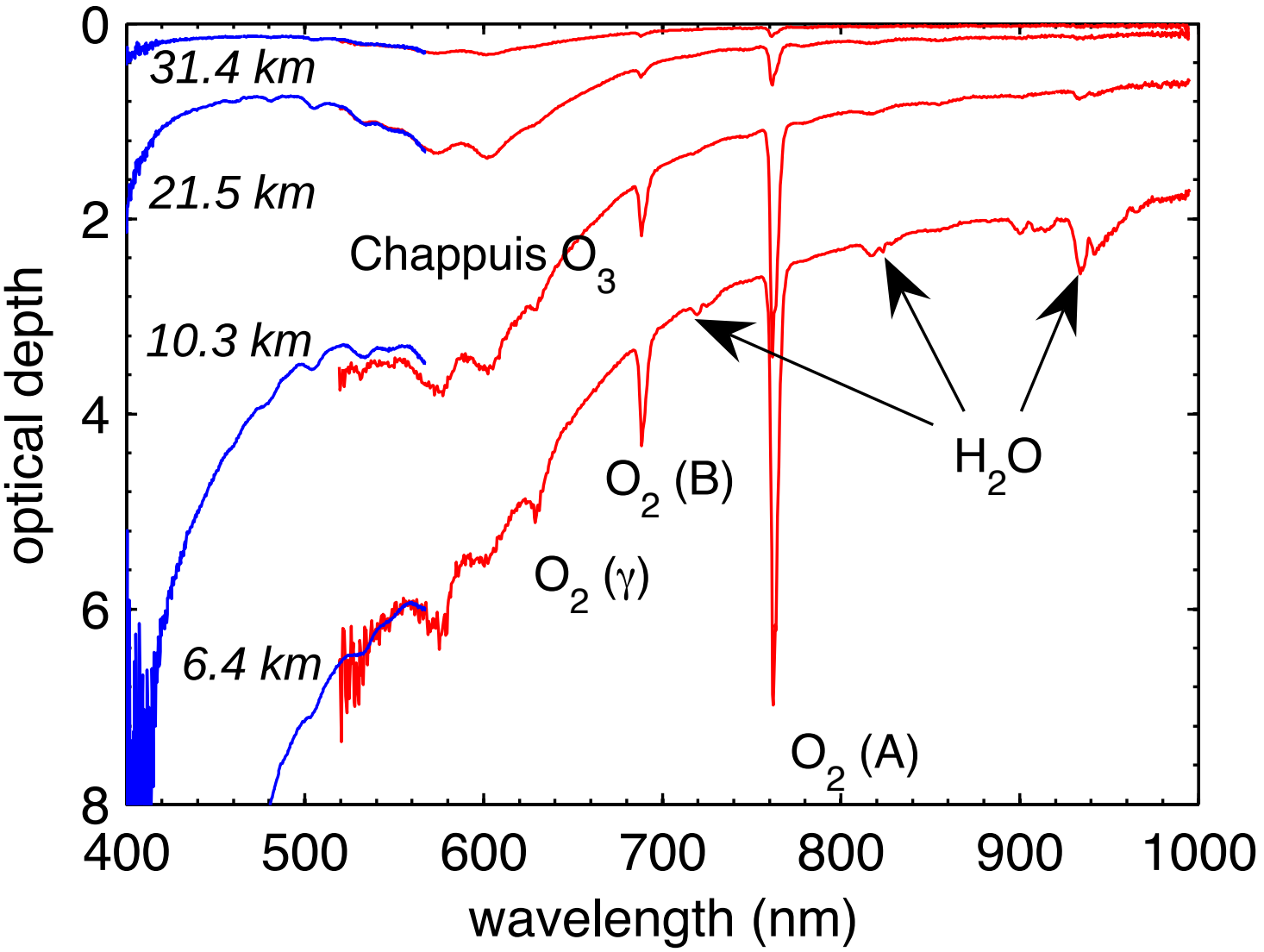
Jan. 12, 2004
9:50:23UTC

Lat: 67°S

Lon: 168°W



(Selected) MAESTRO Spectra



ACE Data Products

- ACE-FTS profiles (version 2.2 + O_3, N_2O_5 & HDO updates):
  - Baseline: O_3, H_2O, CH_4, N_2O, NO_2, NO, HNO_3, HCl, HF, CO, CFC-11, CFC-12, N_2O_5, $ClONO_2$, temperature and pressure from CO_2 lines
  - Other routine: COF_2, CHF_2Cl, CF_4, CH_3Cl, C_2H_6, SF_6, OCS, HCN
  - Research: CCl_4, HOCl, H_2O_2, HO_2NO_2, CCl_2FCClF_2, CH_3CClF_2, ClO, C_2H_2, N_2 and additional isotopologues
- MAESTRO profiles (version 1.2):
  - O_3, NO_2, and optical depth (available very soon!)
- IMAGERS profiles (version 2.2):
  - Atmospheric extinction at 0.5 and 1.02 microns

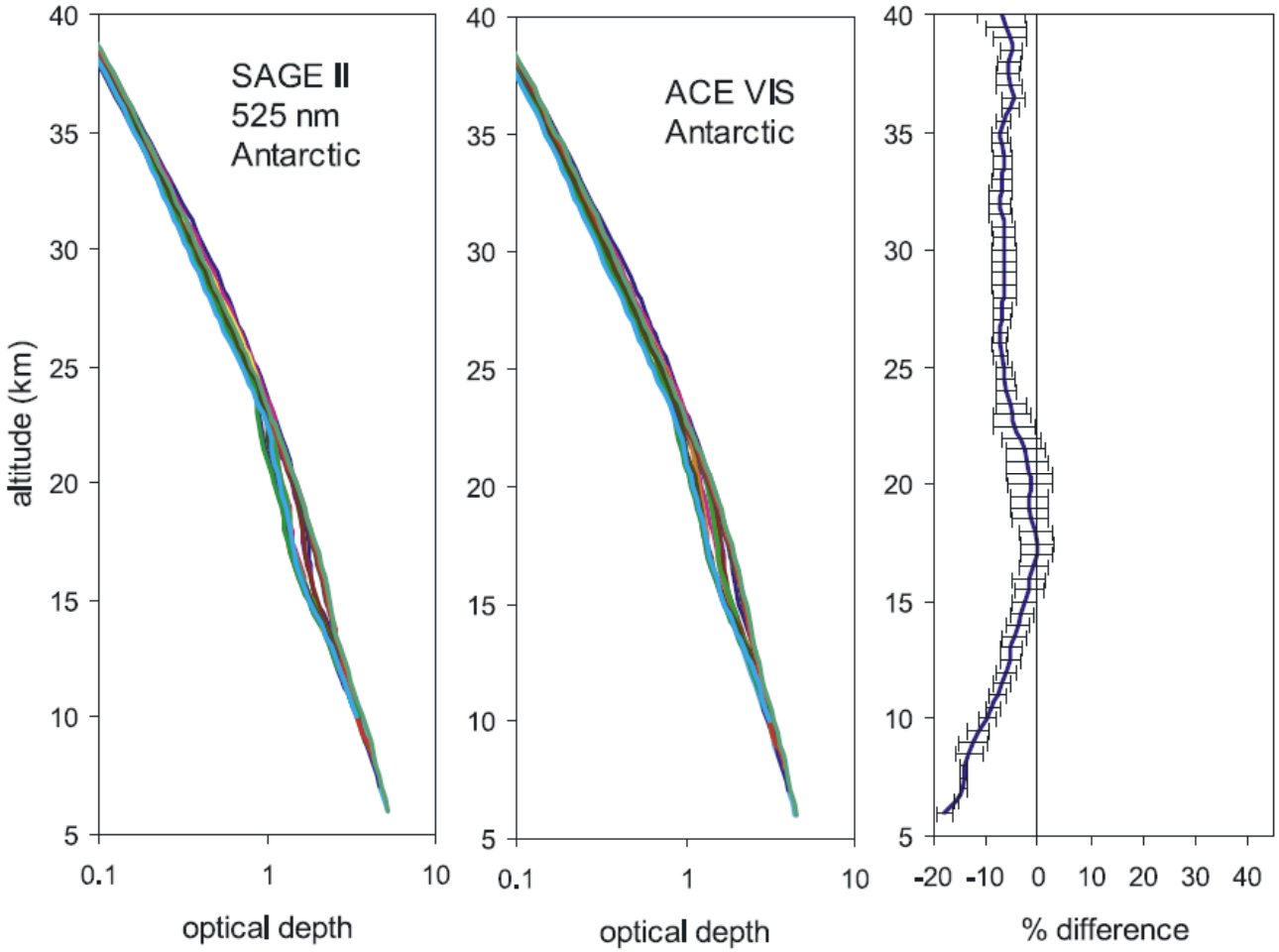
ACE Mission Status

- Just started 5th year in orbit – designed for 2 year lifetime
- Since launch, satellite and instrument operations nominal
  - Both instruments have been acquiring as much data as possible ~16,700 occultations recorded since January 2004
  - On 1 May 2007, SCISAT-1 completed its 20,000th orbit of the Earth!
- Currently, the only dedicated solar occultation mission in orbit
  - SCIAMACHY on ENVISAT does some occultation
- Extension of ACE mission approved through to end of IPY
  - Until end of March 2009

ACE-Imagers vs. SAGE II (0.5 µm)

SAGE II, SAGE III, POAM III,HALOE and ILAS II no longer operating:

ACE can extend the time series for atmospheric aerosol and cloud at 0.5 and 1 micron



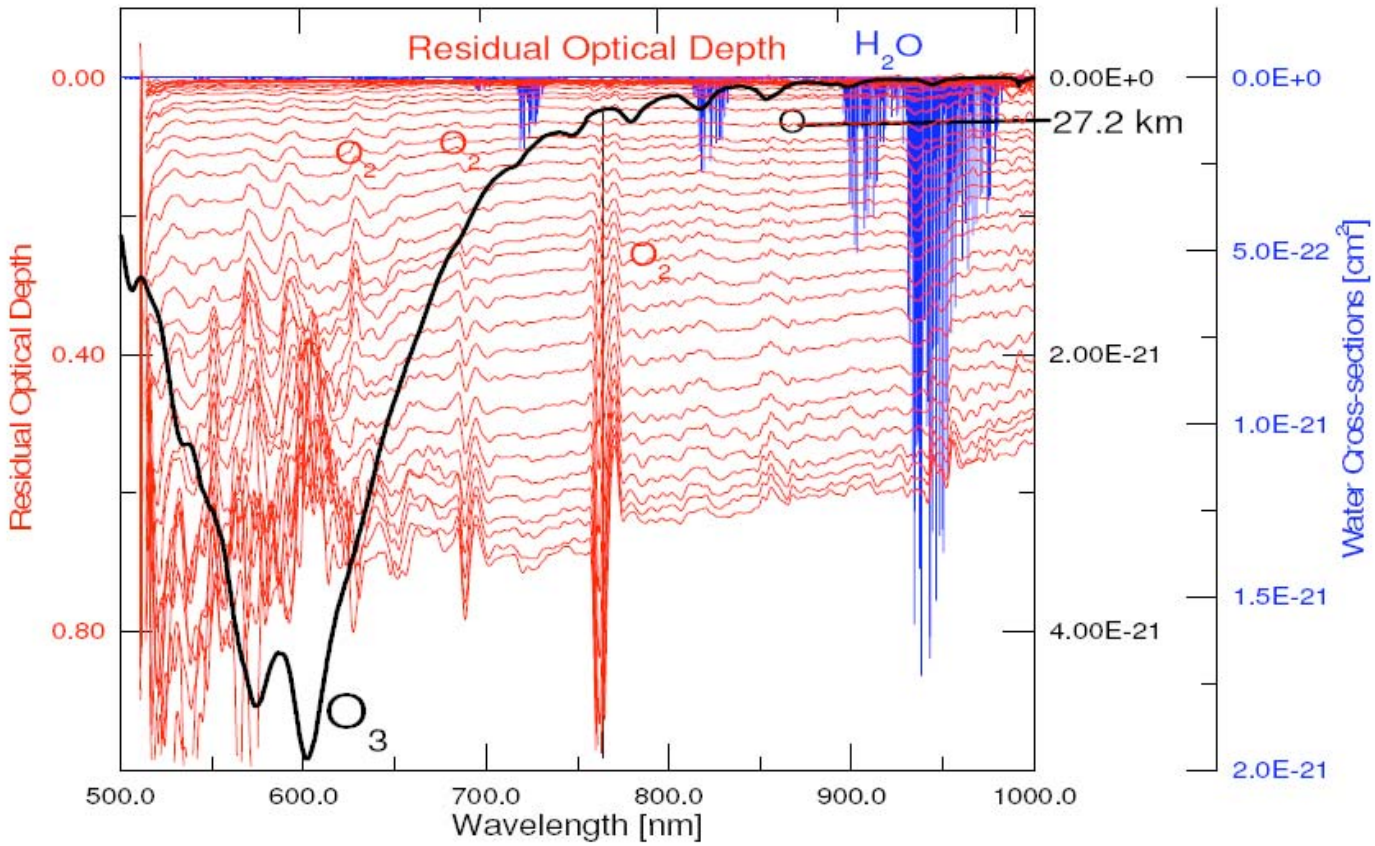
Data from November 2004
15 coincident profiles found within 200 km and 1 hour

K. L. Gilbert *et al.*, JGR, 112, D12207 (2007)

Residual Aerosol Extinction

New Product!

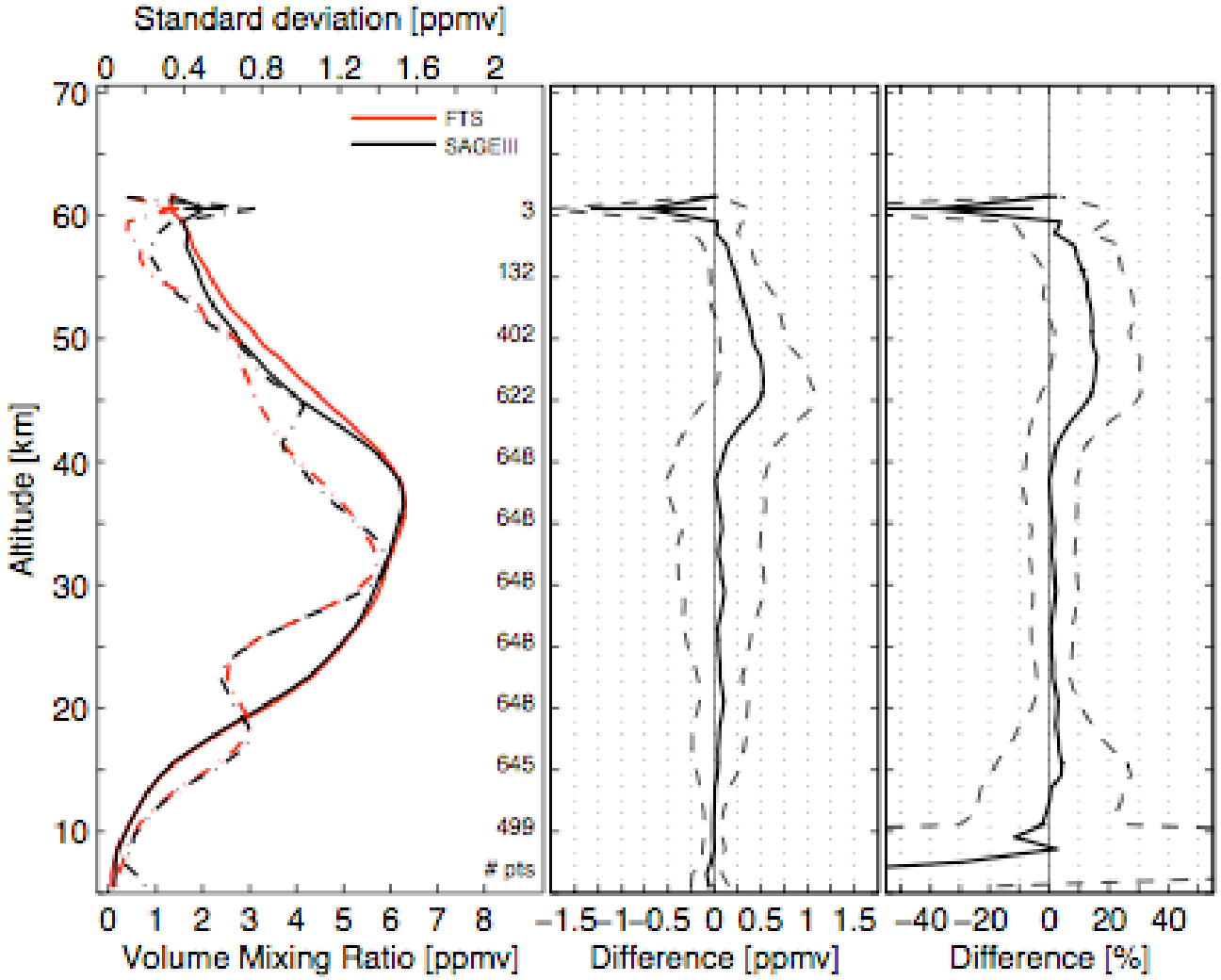
- Aerosol optical depth obtained by subtracting molecular signal from fit
- Uncorrected residual from H_2O and O_2 (A, B, and gamma bands)



T. McElroy

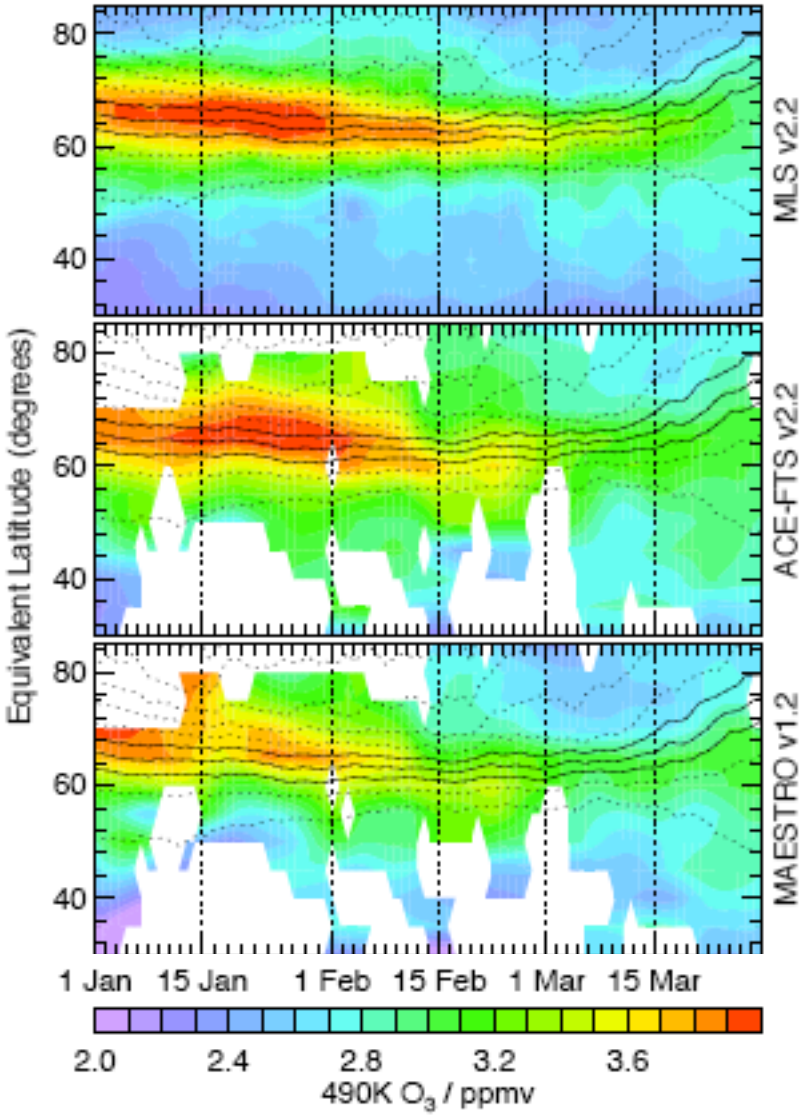
Ozone: ACE-FTS vs. SAGE III

- Pairs found within 2 hours; 5° lat., 10° lon. from Feb 2004 – Dec 2005
- ACE-FTS larger than SAGE III from 13 – 42 km by 0-6% (typically 1-2%)
- ACE-FTS much higher above 40 km – feature seen in other O_3 comparisons

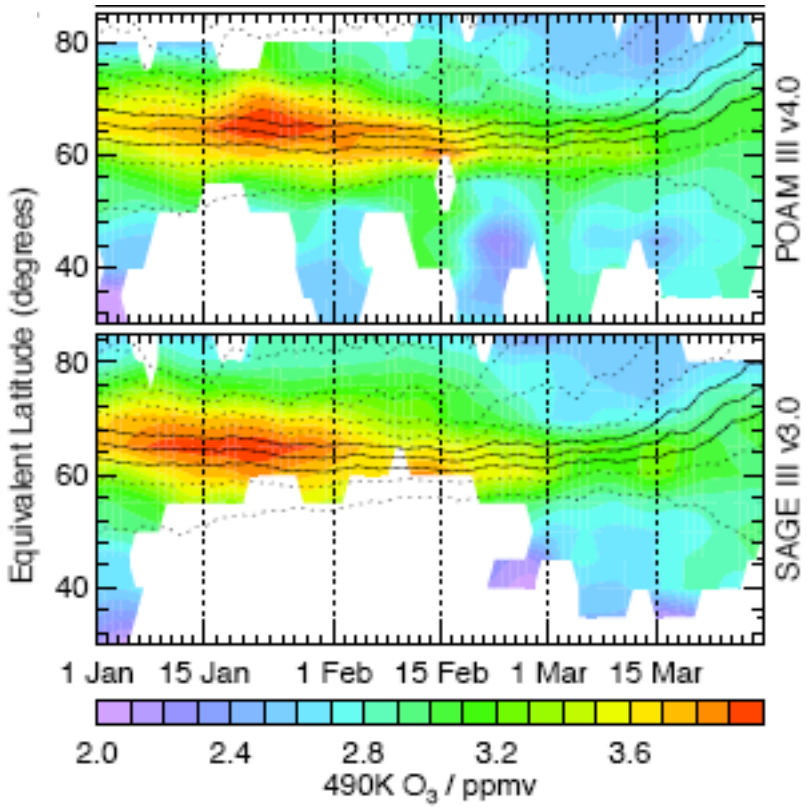


E. Dupuy, in preparation

2005 Winter/Spring Ozone Evolution



- EqL/time series at 490 K using MetO data for EqL mapping

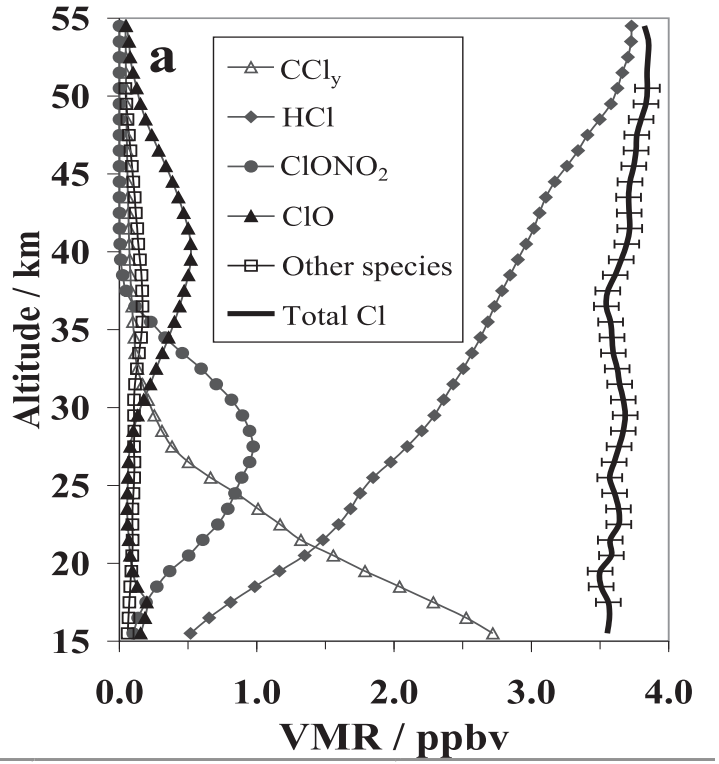


G. Manney *et al.*, JGR, in review

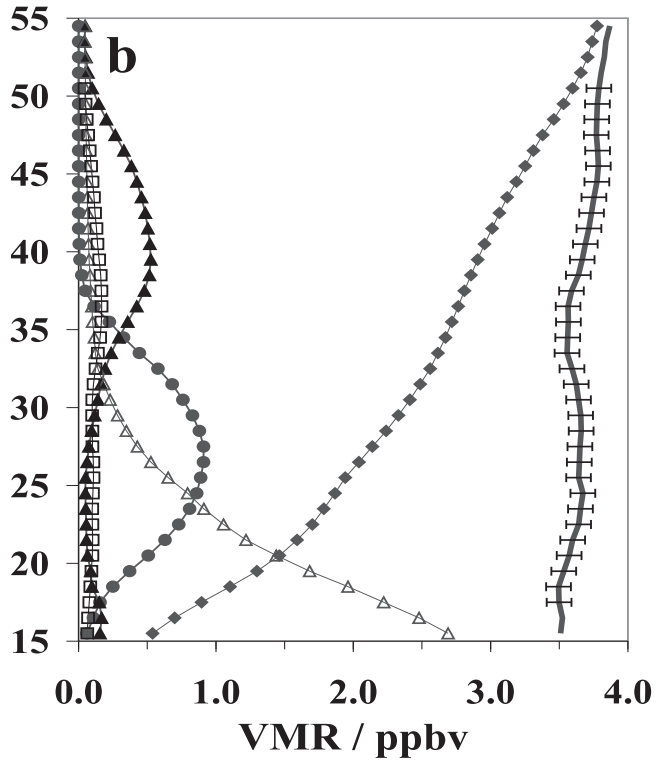
Stratospheric Chlorine Budget

- Budget has been obtained using mainly ACE-FTS plus other measured and model results
- Current HALOE Cl_{TOT} value: 3.3 ppb

Northern Midlatitudes



Southern Midlatitudes

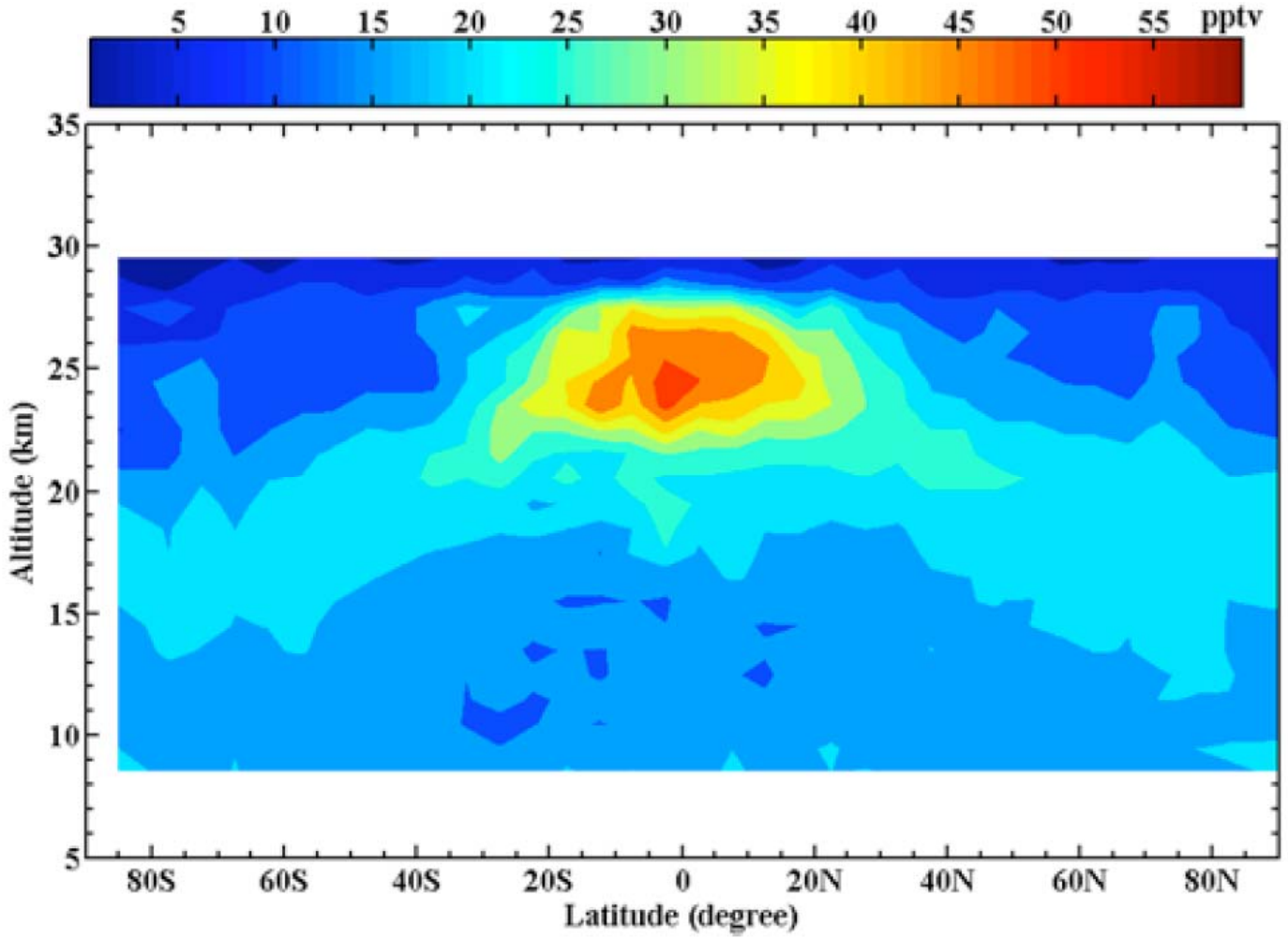


	Mean Cl_{TOT} (ppbv)	slope (ppbv/km)
Northern high latitudes	3.74 ± 0.12	0.010 ± 0.001
Northern midlatitudes	3.65 ± 0.09	0.007 ± 0.001
Tropics	3.62 ± 0.11	0.009 ± 0.001
Southern midlatitudes	3.65 ± 0.09	0.007 ± 0.001
Southern high latitudes	3.71 ± 0.16	0.014 ± 0.001

R. Nassar *et al.*, JGR, 111, D22312, (2006)

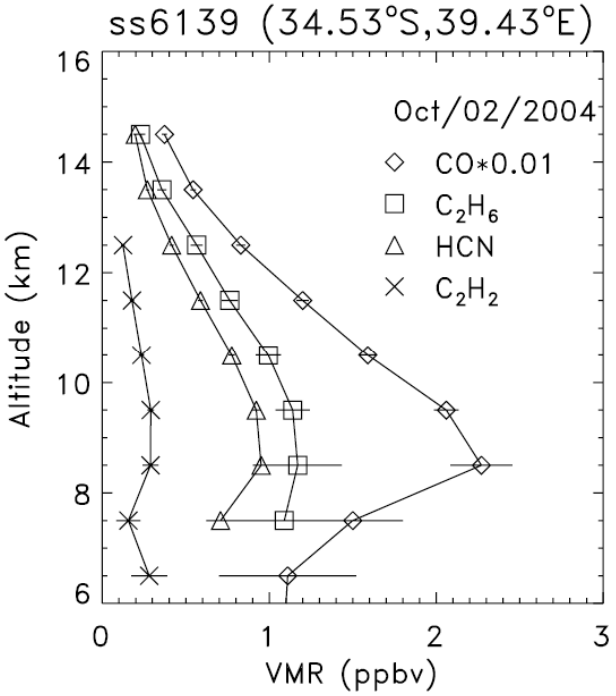
Distribution of Phosgene ($COCl_2$)

- $COCl_2$ is product of chlorocarbon decomposition
- Previously studied by aircraft (5 - 12 km) and MkIV FTIR on balloons
- First global picture

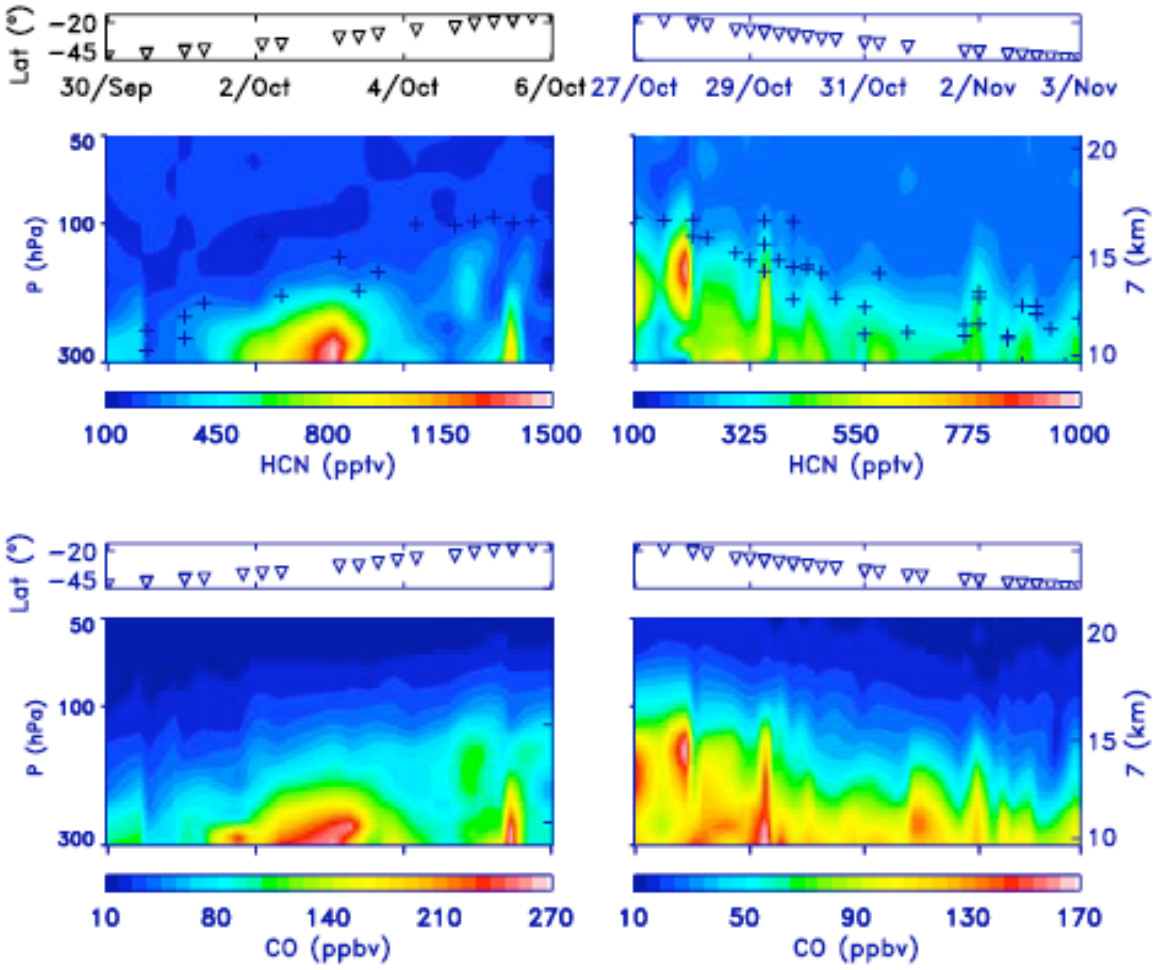


D. Fu *et al.*, GRL, in press

Biomass Burning in Brazil



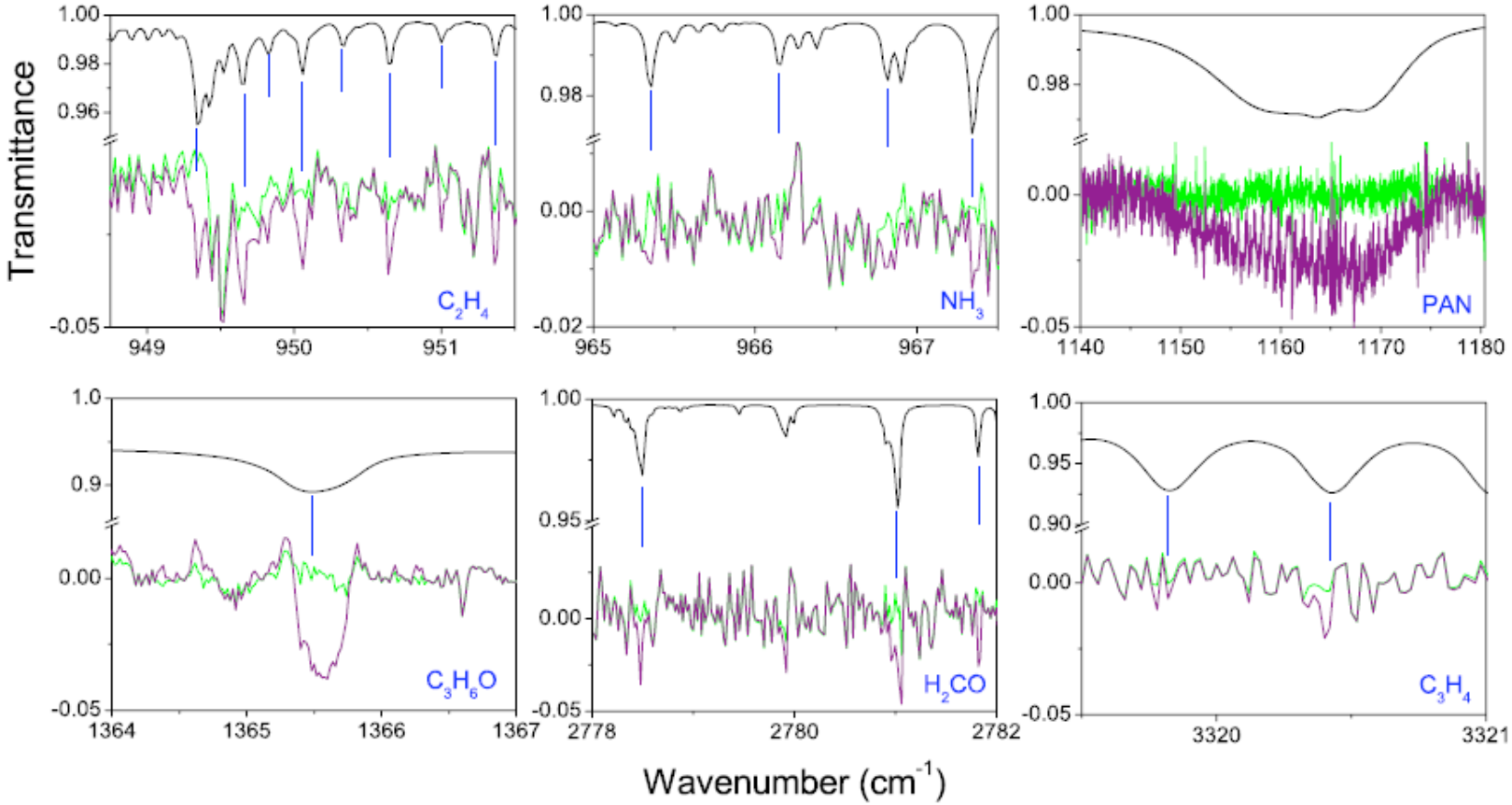
- See enhancements of CO, HCN, C_2H_6 in occultation SE of Africa - originating from fires in Brazil



C. Rinsland et al., GRL, 32, L20803 (2005)

New Tropospheric FTS Species

- Retrievals from profile taken in young biomass burning plume near East Coast of Tanzania (6.95 S, 39.42 E, 8 October 2005)

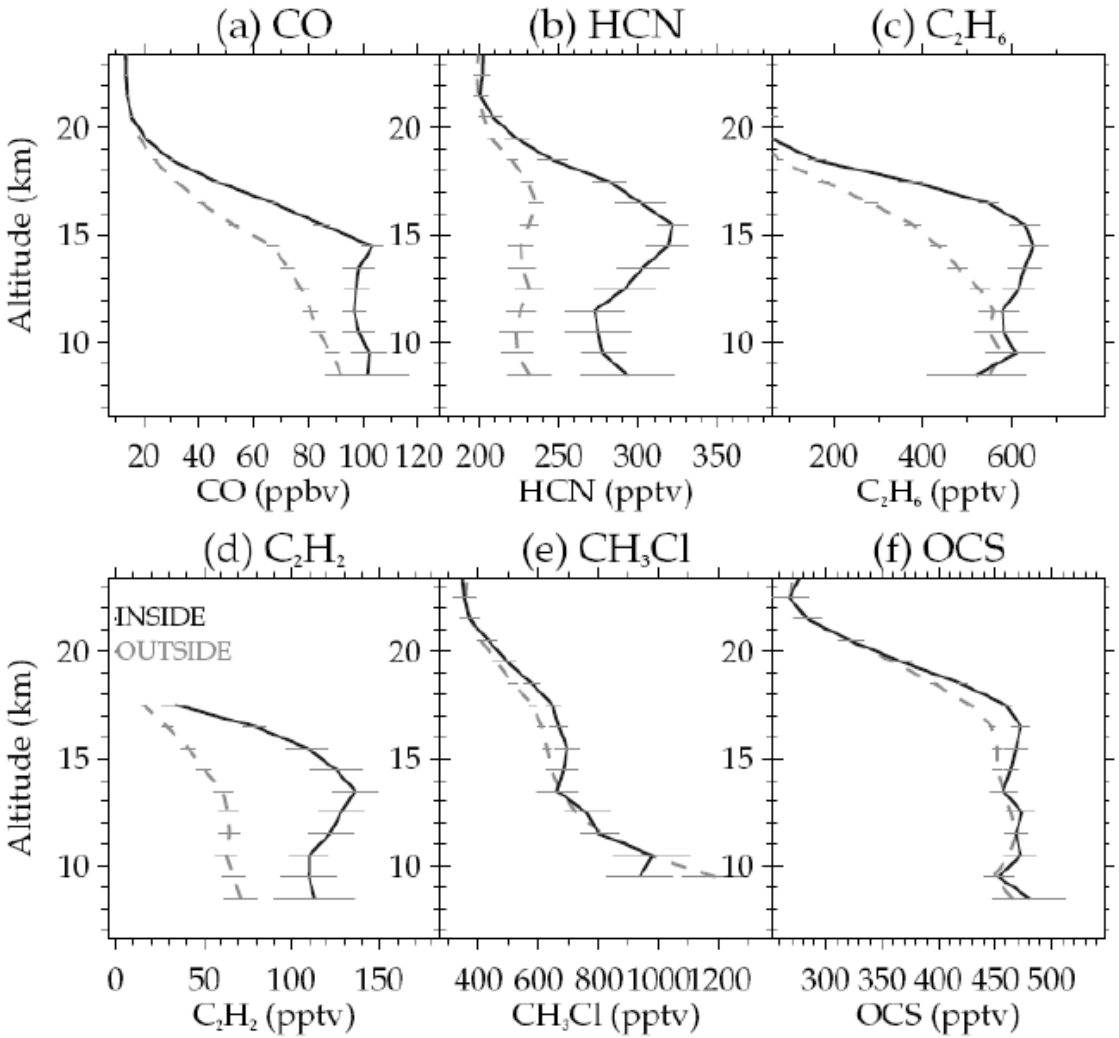


Spectral residuals **without**, **with**

P.-F. Coheur *et al.*, ACPD, 7, 7907 (2007)

Species Isolation in Asian Monsoon

- ACE-FTS profiles from June-August 2004-2006
- Inside/ouside identified using CO threshold where it is >60 ppbv at 16.5 km
- Inside see enhancement of tropospheric species with maximum near ~15 km



M. Park *et al.*, JGR, submitted

ACE Involvement in IPY

- ACE Arctic validation campaigns have been funded by CSA through International Polar Year (2007 – 2008)
- ACE is part of two IPY projects
  - POLARCAT (Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, of Climate, Chemistry, Aerosols, and Transport, Activity ID No. 32)
  - ORACLE-O3 (Ozone layer and UV radiation in a changing climate evaluated during IPY, Activity ID No. 99)
- To use ACE data as part of an IPY project, please contact us!

Summary

- ACE-FTS and ACE-MAESTRO data being used for scientific studies from tropsphere to mesosphere
  - Reprints available from http://www.ace.uwaterloo.ca
- Validation of v2.2 (plus updates) for ACE-FTS and ACE-IMAGERS and v1.2 for MAESTRO is being completed
  - Focusing on O_3, H_2O, CH_4, N_2O, NO_2, NO, HNO_3, HCl, HF, CO, CFC-11, CFC-12, N_2O_5, $ClONO_2$, temperature, atmospheric extinction
  - Public release of the current ACE data products is planned for the end of 2007

Acknowledgement

Funding for ACE provided by:

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

Working with ACE data

If you are interested in using ACE data…

- Please let me know - we welcome collaborations:

  kwalker@atmosp.physics.utoronto.ca

- Public release of ACE-FTS v2.2 (+updates), ACE-MAESTRO v1.2, and ACE-IMAGER v2.2 data, is expected near the end of the year

https://www.ace.uwaterloo.ca/