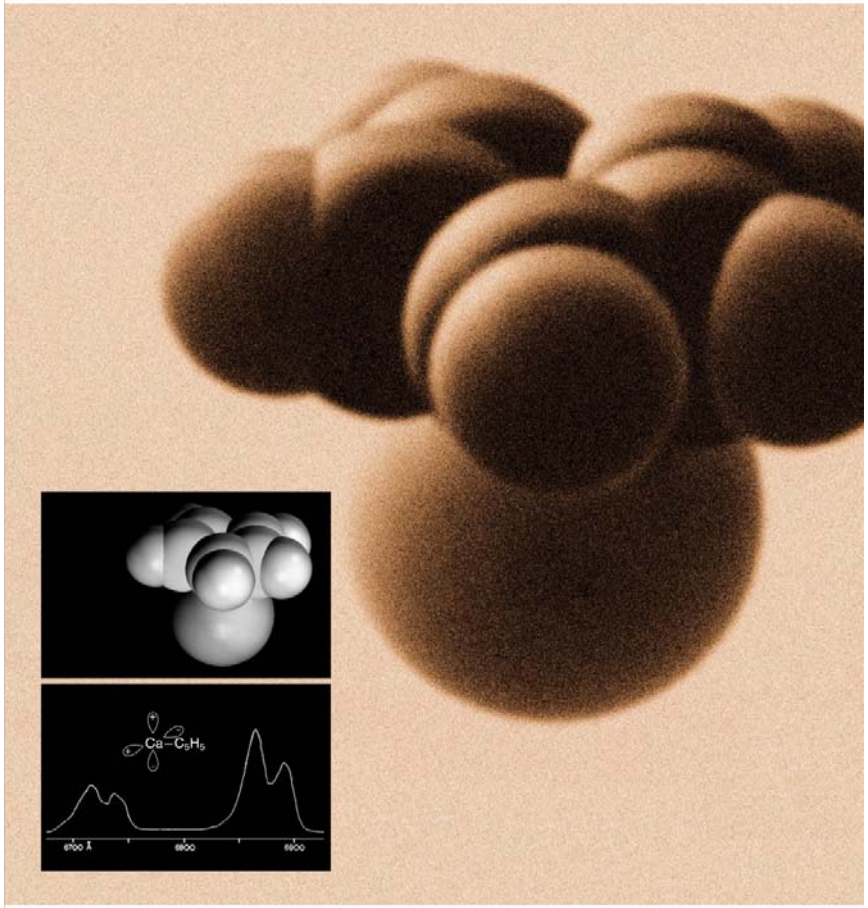
Second Edition-April 2005



Now includes line strength formulas and their derivation for microwave (JPL), infrared (HITRAN) and electronic transitions plus light scattering.

The Atmospheric Chemistry Experiment (ACE): An Overview

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University of Waterloo

Waterloo, Ontario

Canada

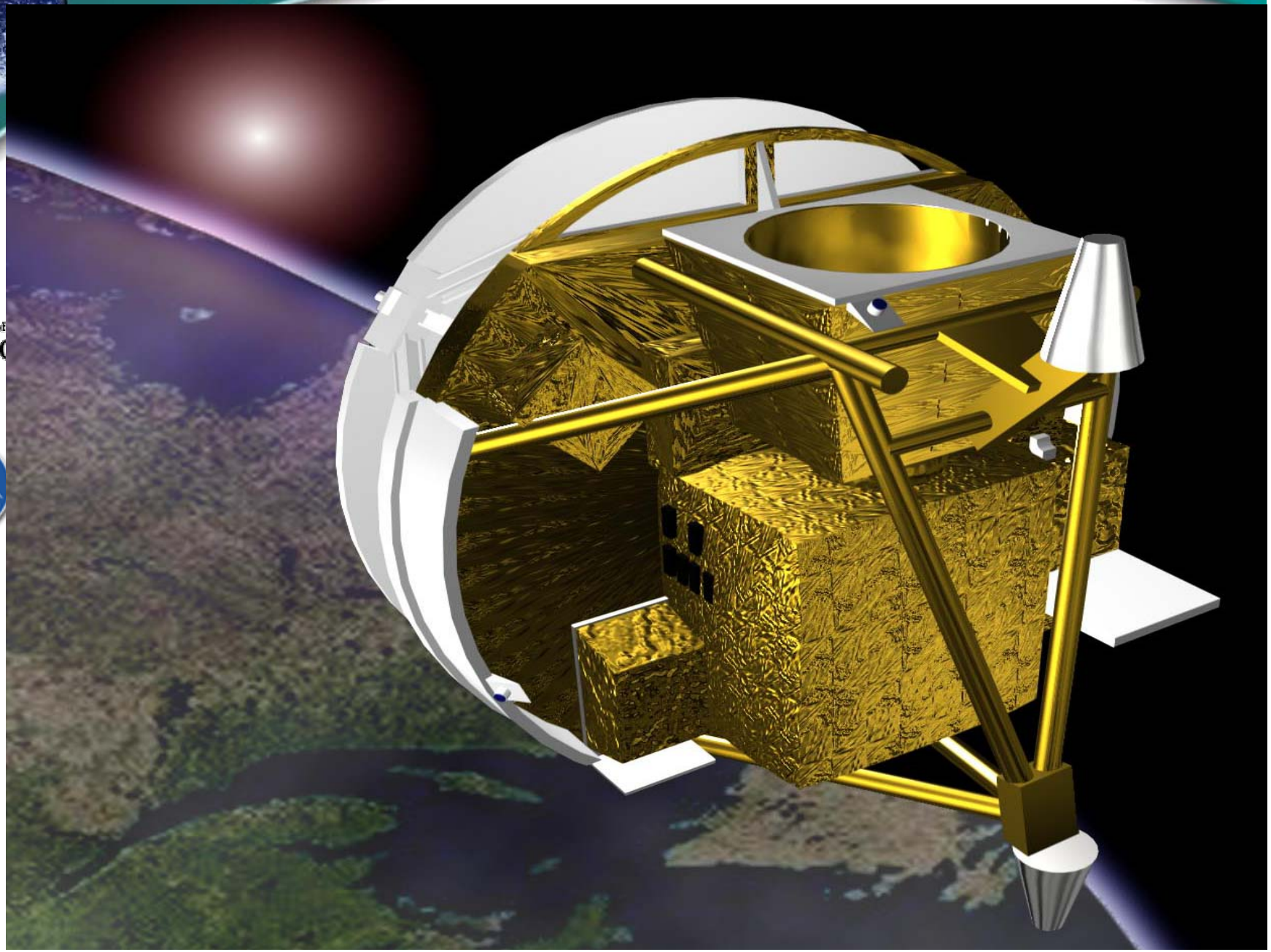
ACE Goals

To investigate the chemical and dynamical processes that control the distribution of ozone in the stratosphere and upper troposphere with a particular focus on the Arctic winter stratosphere.

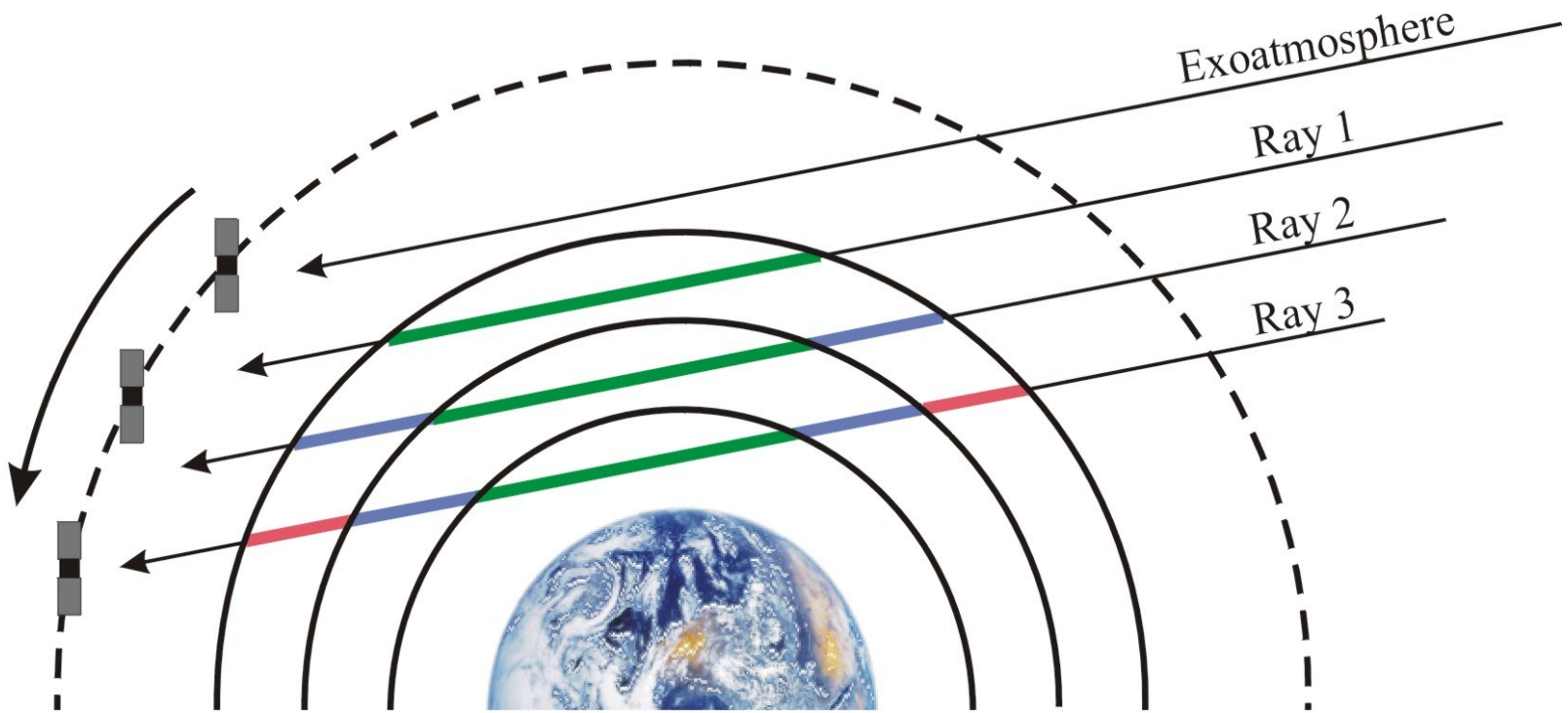
To accomplish this,

- Temperature and pressure will be measured.
- ACE will measure the concentrations of more than 30 molecules as a function of altitude.
- Aerosols will be measured and quantified.

ACE Satellite



Solar Occultation



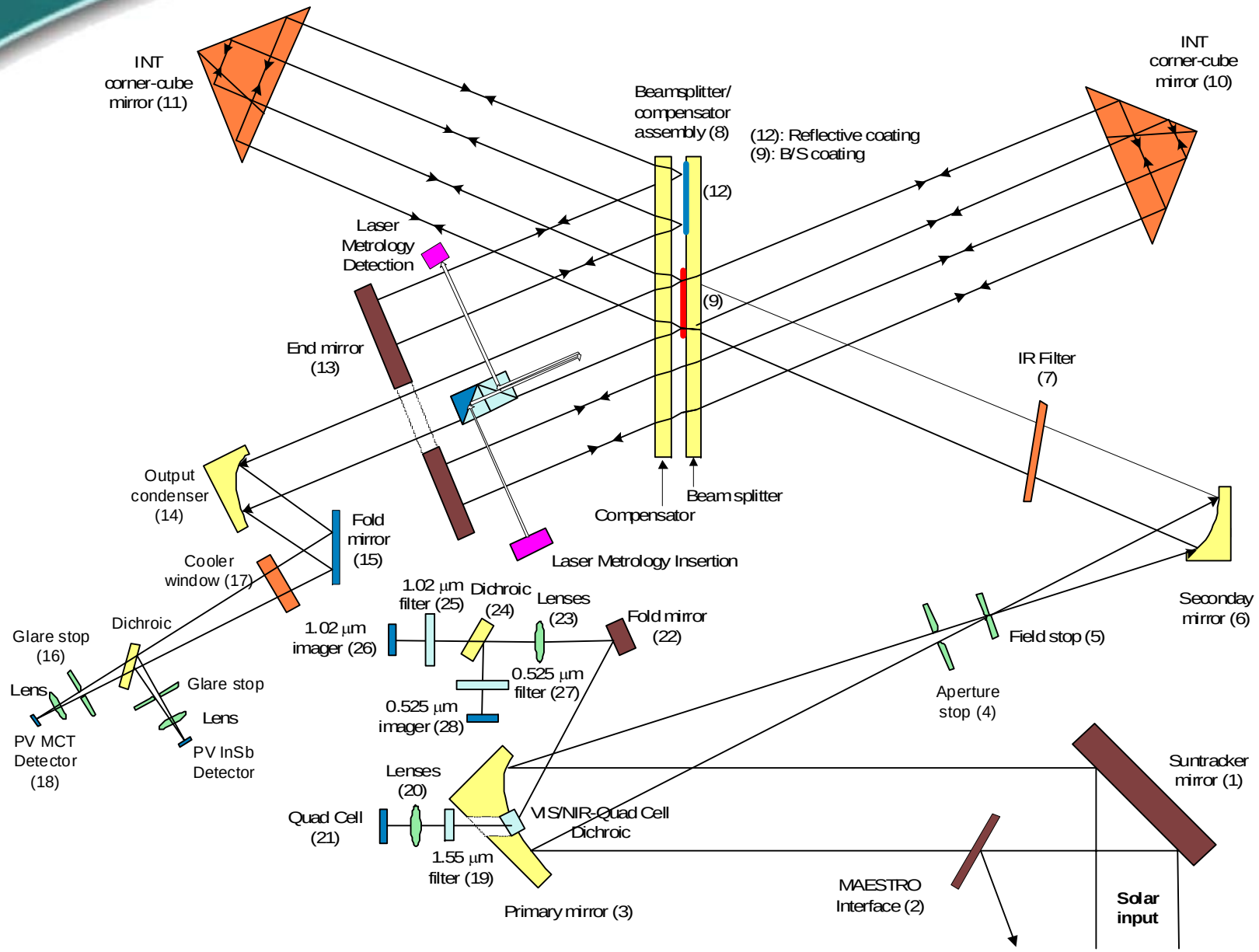
Timeline

- Jan. 1998 Proposal to CSA
- Feb. 2001 FTS and Imager CDR
- Mar. 2001 MAESTRO CDR
- Jun. 2001 Bus CDR
- Sept. 2002 S/C integration & test
- Mar. 2003 Instrument test (Toronto)
- May 2003 Final integration (DFL)
- Aug. 2003 Launch
- Sept. 2003 Commissioning
- Feb. 2004 Routine operations
- Mar. 2004 Arctic campaign
- Feb. 2005 Arctic campaign

Instruments

- Infrared Fourier Transform Spectrometer operating between 2 and 13 microns with a resolution of 0.02 cm^{-1}
- 2-channel visible/near infrared Imagers, operating at 0.525 and 1.02 microns (cf., SAGE II)
- Suntracker keeps the instruments pointed at the sun's radiometric center.
- UV / Visible spectrometer (MAESTRO) 0.285 to 1.03 microns, resolution ~1-2 nm
- Startracker

Optical Layout (ABB-Bomem)

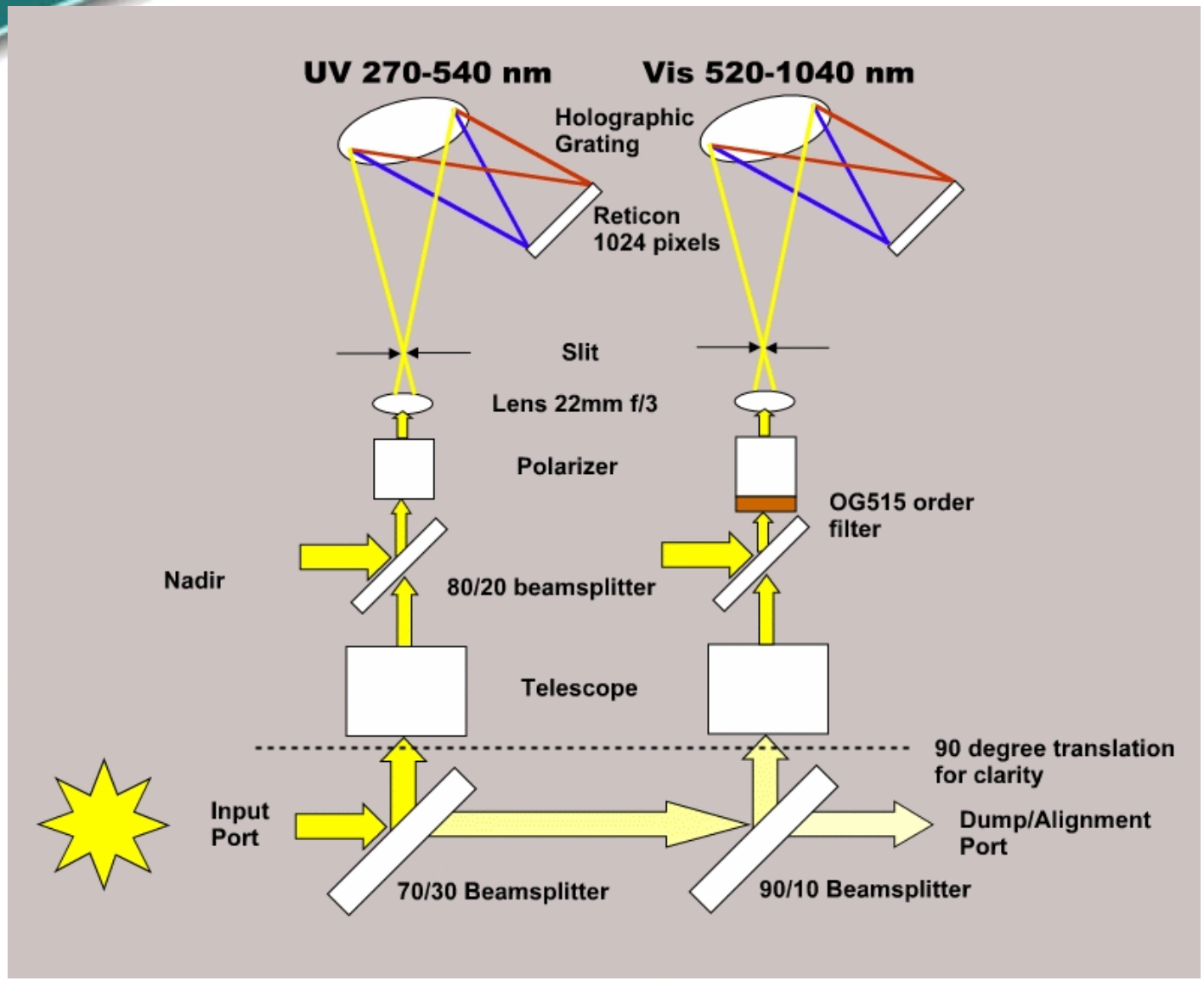


ACE-FTS (ABB-Bomem)

Interferometer-side

Input optics-side

MAESTRO



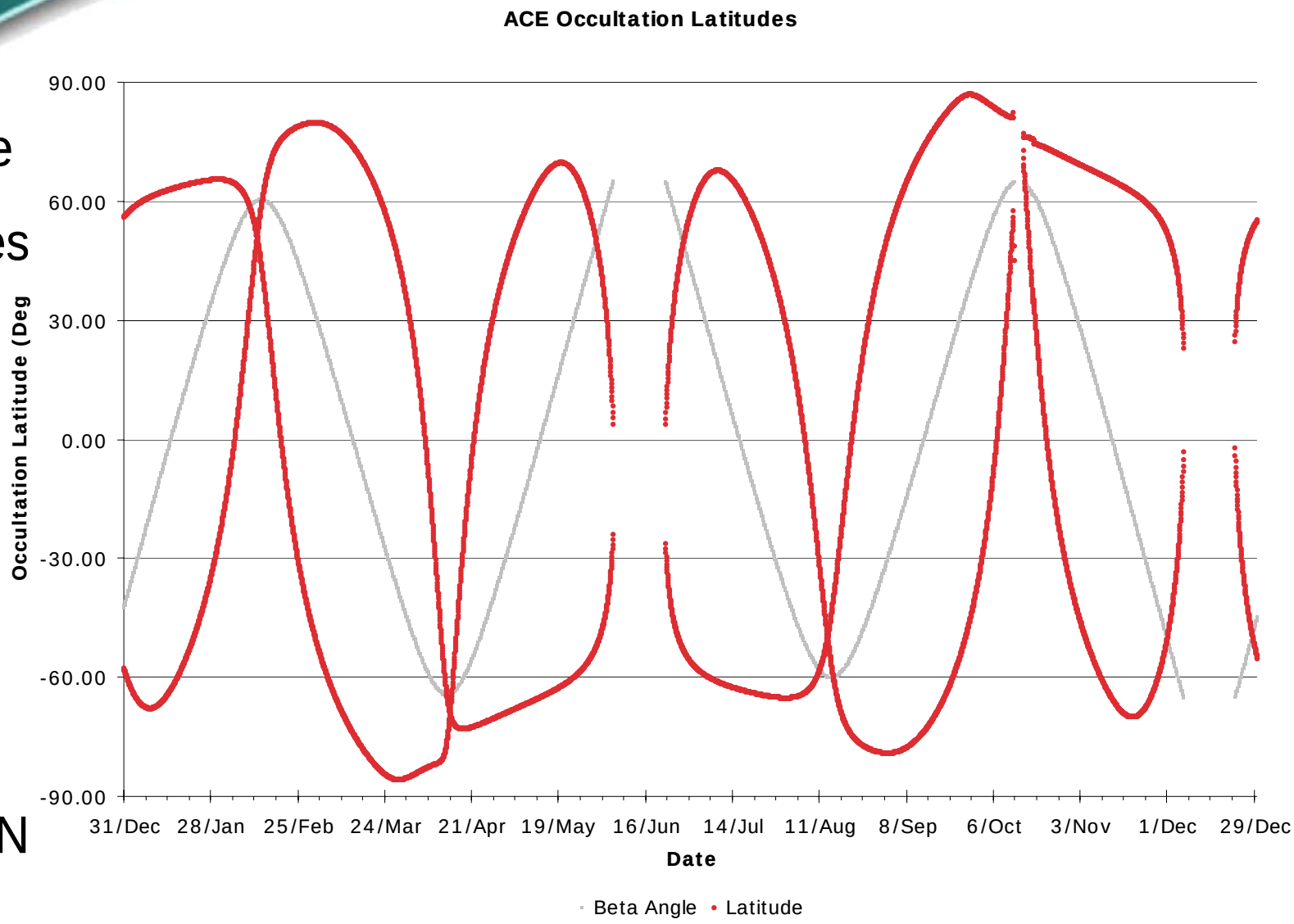
MAESTRO
PI:
T. McElroy,
MSC

Dual concave grating spectrograph, 1-2 nm resolution

MAESTRO (Flight Model)

ACE Orbit- Global Coverage

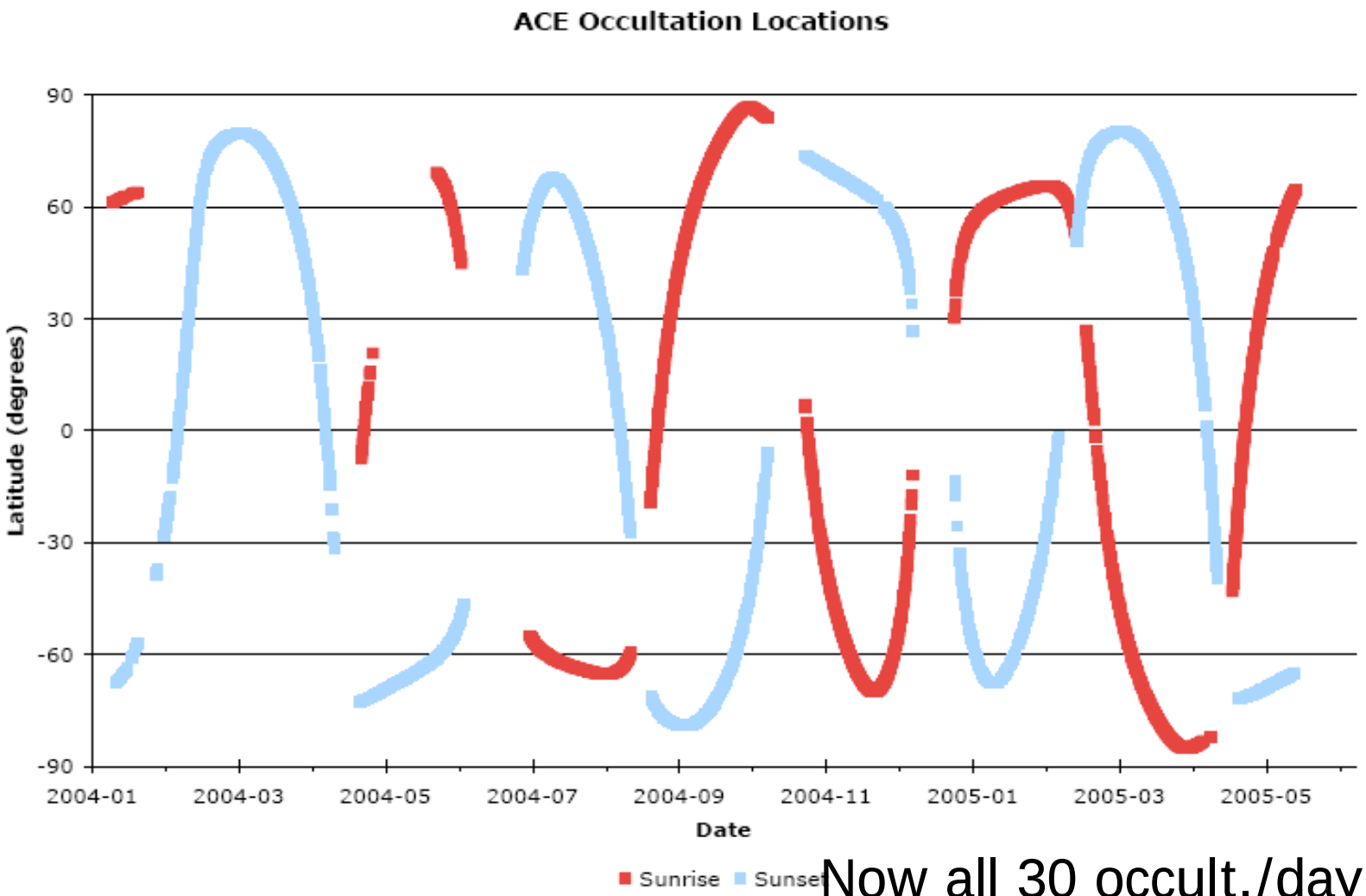
Latitude /degrees



650 km, 74° inclined circular orbit, RAAN 55.7°

Jan. 1, 2004 to Dec. 29, 2004

ACE Data (Latitude)



Ground Stations:

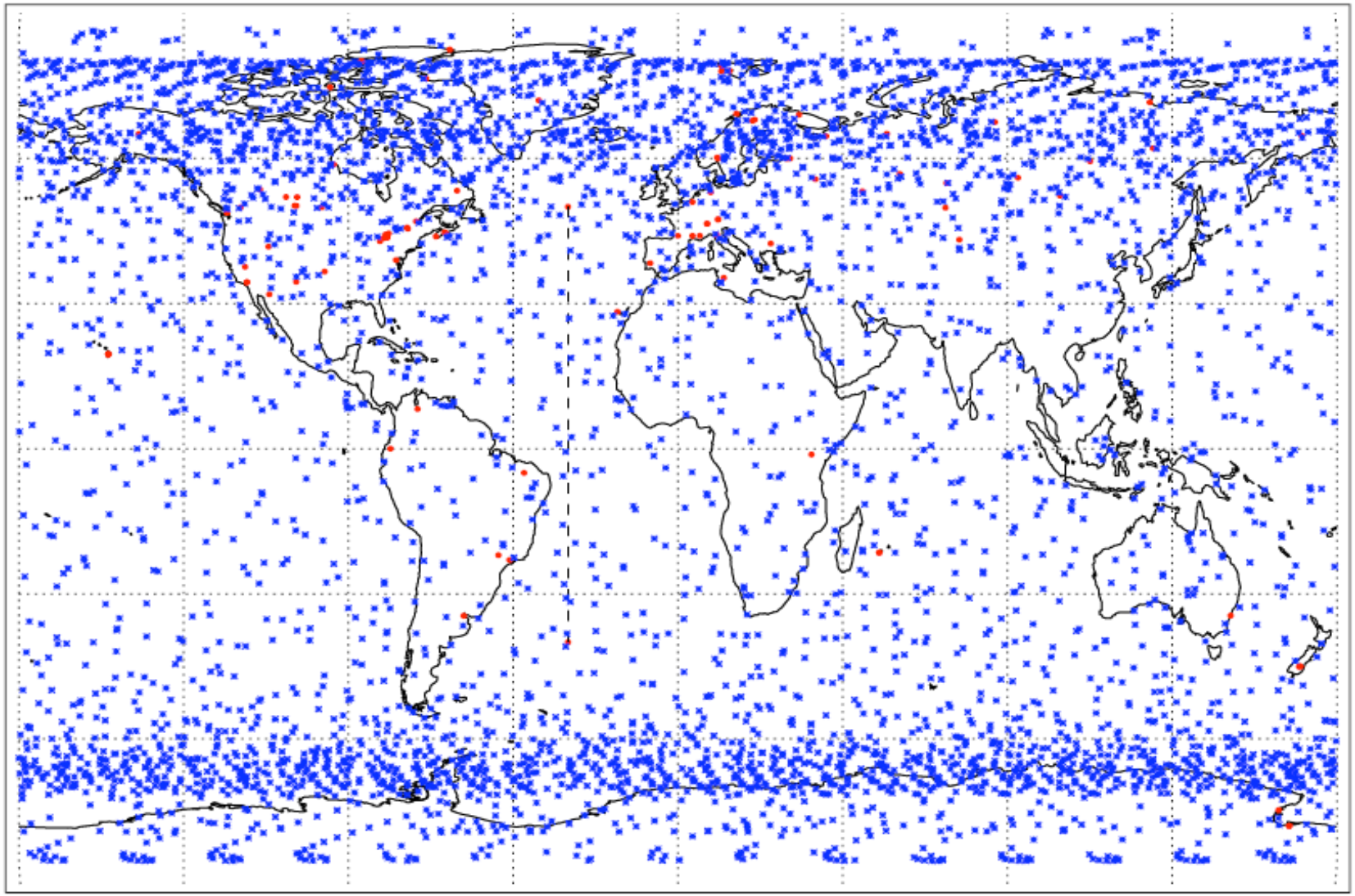
2 Canada

1 NASA

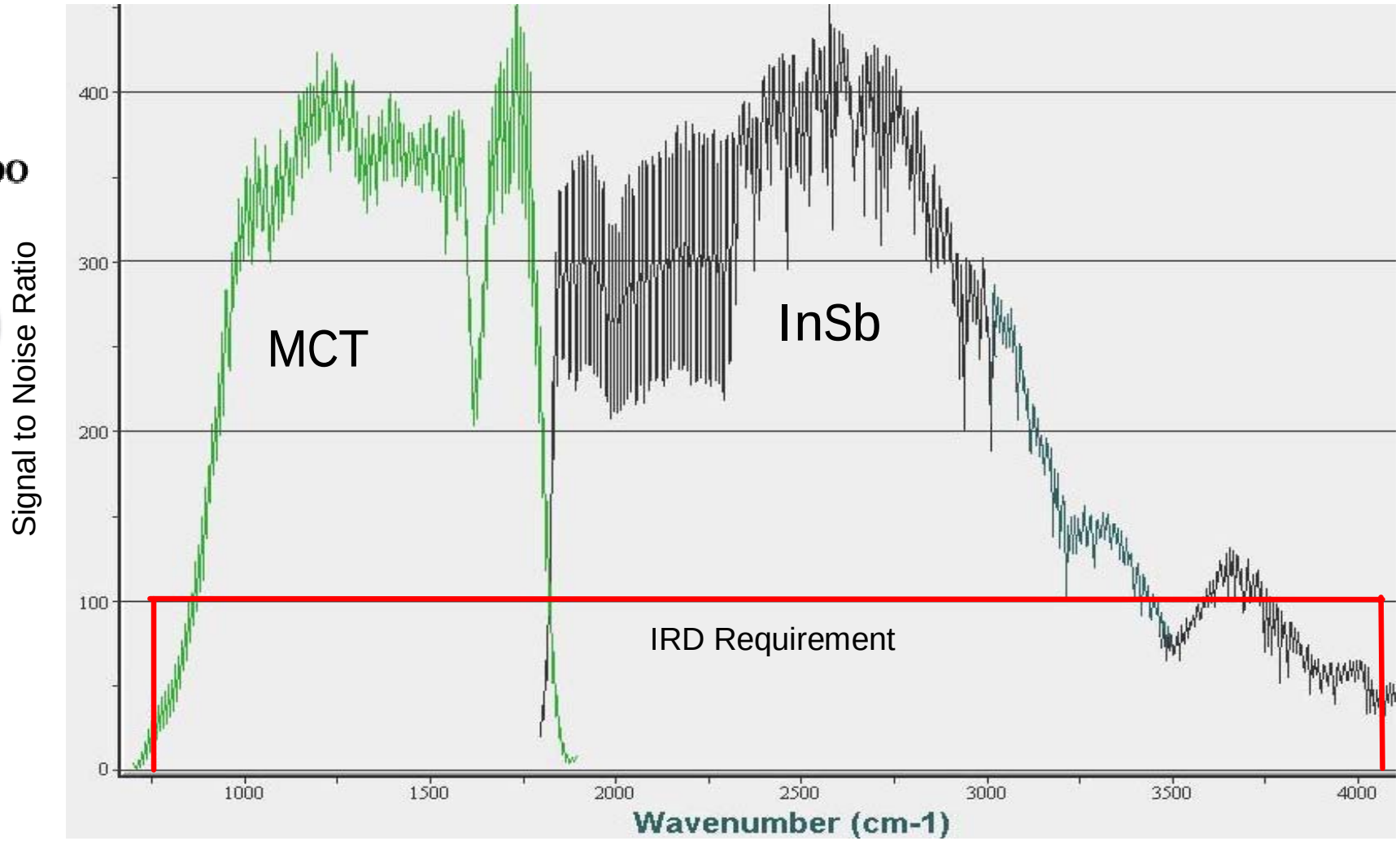
1 ESA

Now all 30 occult./day are measured.

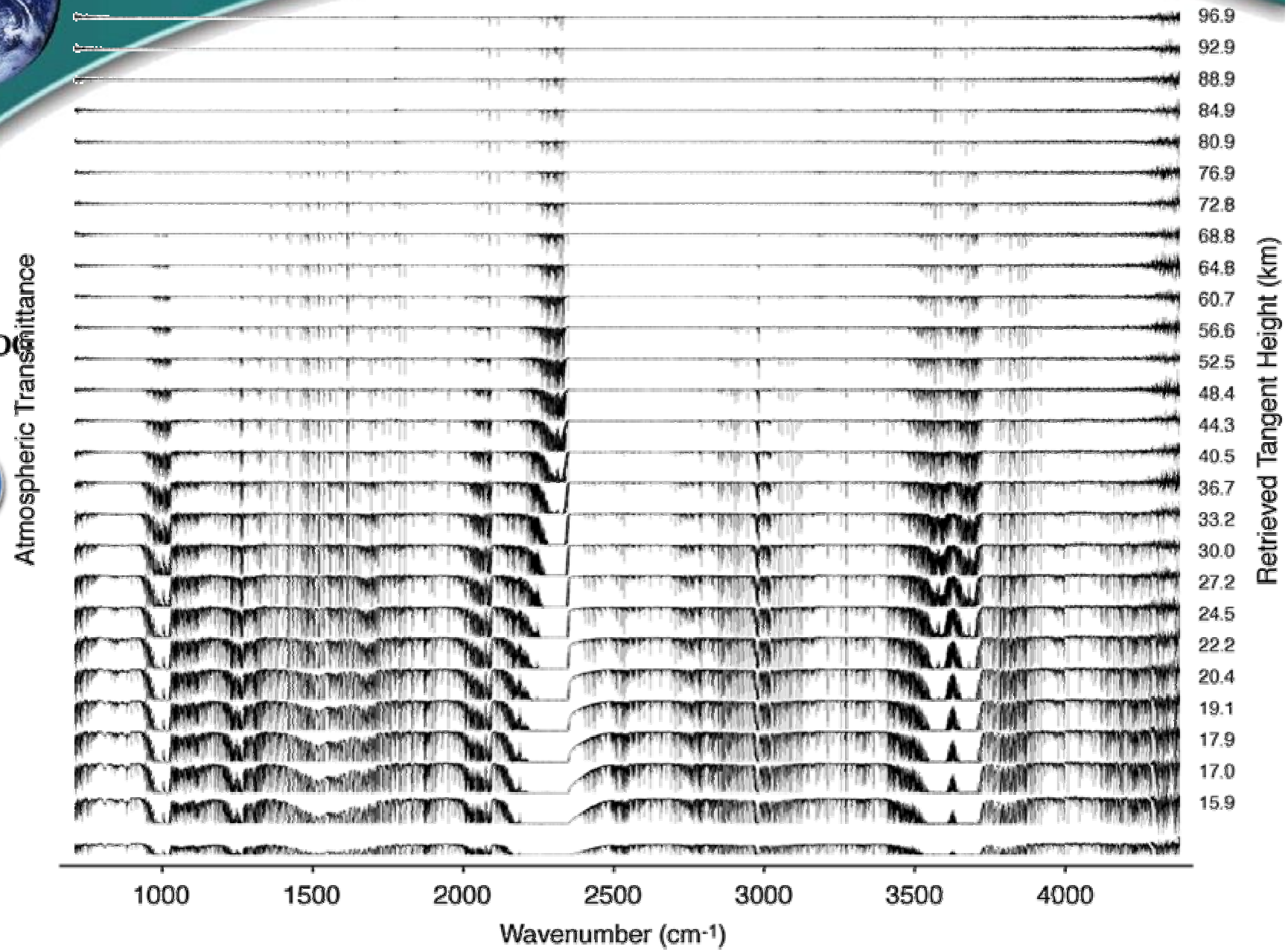
Global Occultation Distribution



Excellent SNR Performance



Occultation sequence



ACE-FTS Species Measured

- Baseline species (version 2.2):

  H_2O, O_3, N_2O, CO, CH_4, NO, NO_2, HNO_3, HF, HCl, N_2O_5, $ClONO_2$, CCl_2F_2, CCl_3F, as well as pressure and temperature from CO_2 lines

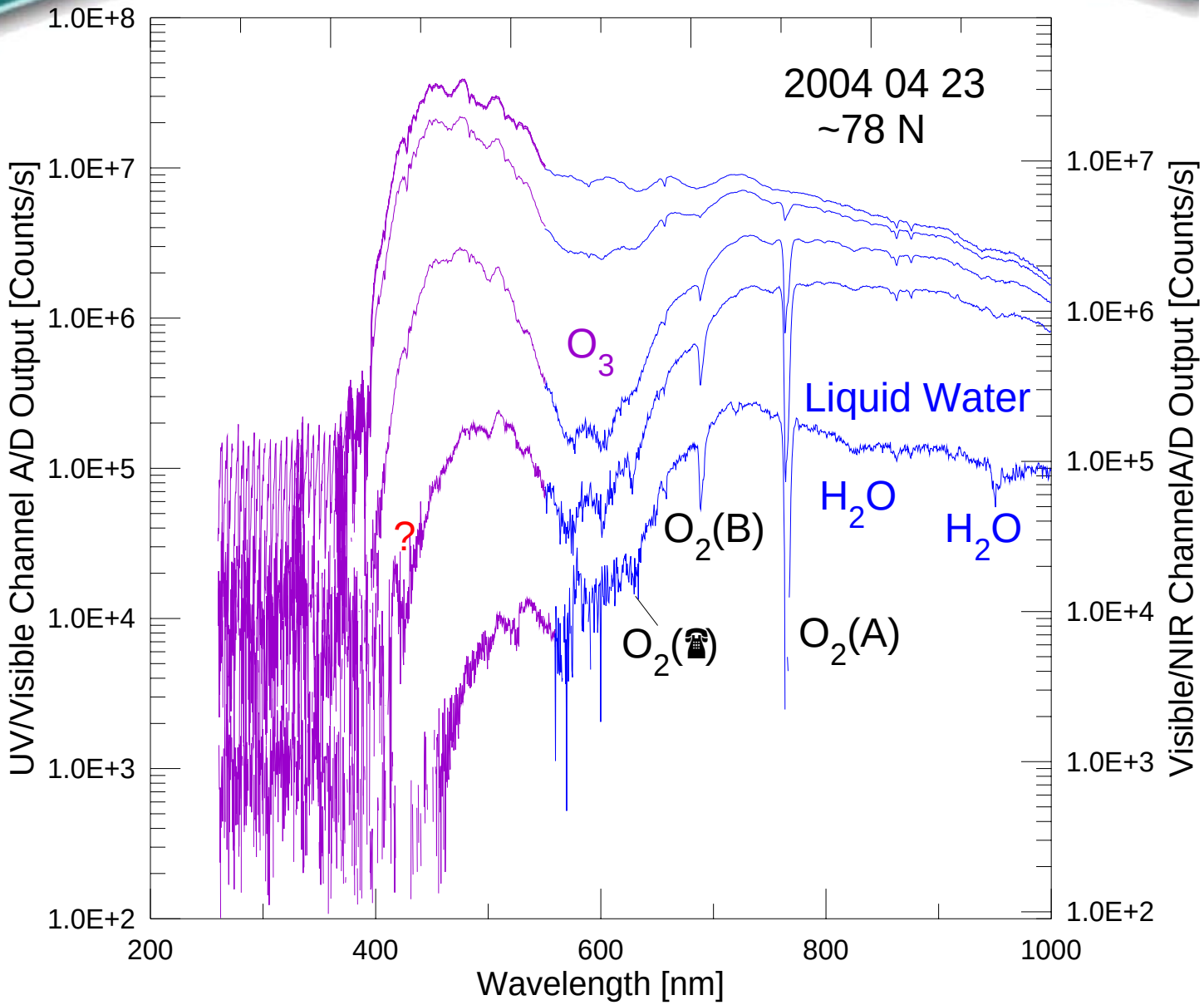
- Other routine species:

  COF_2, CHF_2Cl, CF_4, CH_3Cl, C_2H_6, SF_6, OCS, HCN

- *Research* species:

  CCl_4, HOCl, H_2O_2, HO_2NO_2, CCl_2FCClF_2, CH_3CClF_2, ClO, C_2H_2, N_2 and additional isotopologues

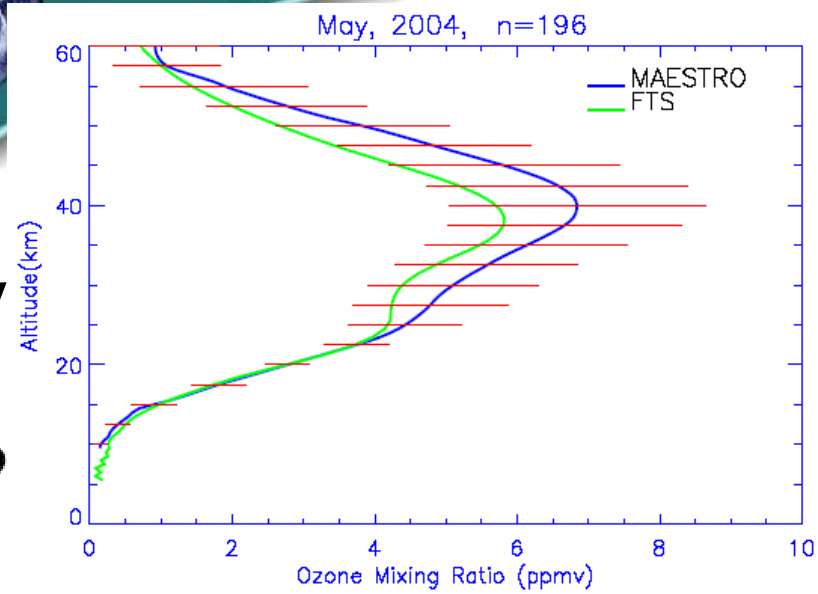
MAESTRO Spectra

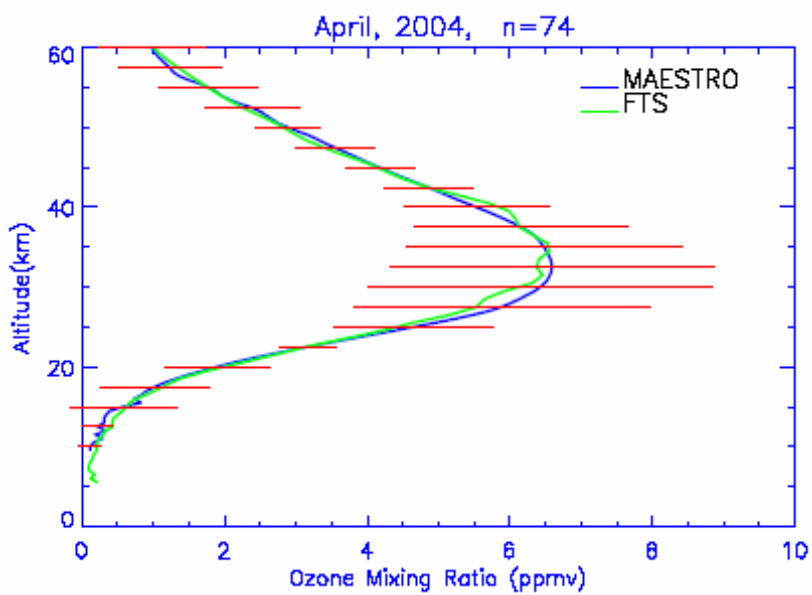


Data products: O_3 and NO_2 profiles, atmospheric extinction

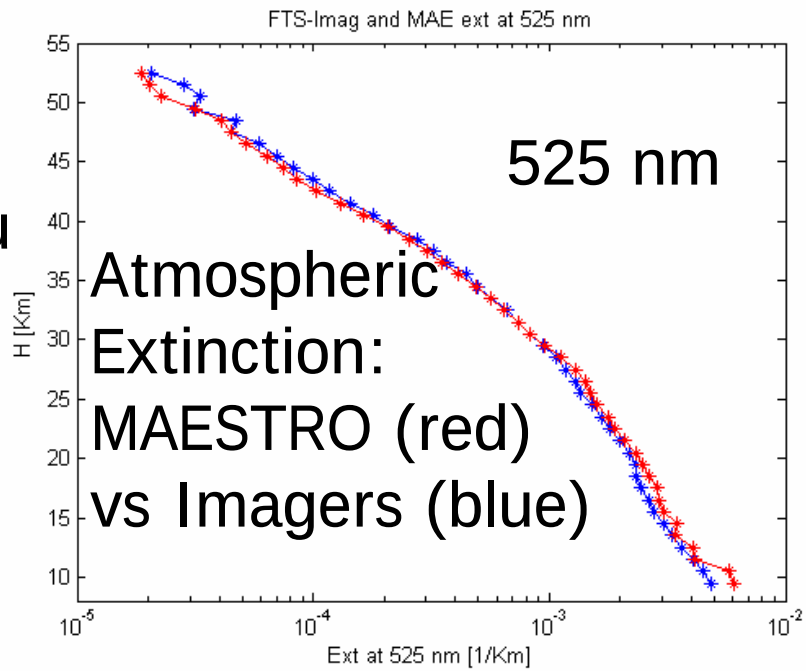
Ozone: ACE-FTS vs MAESTRO

McElroy

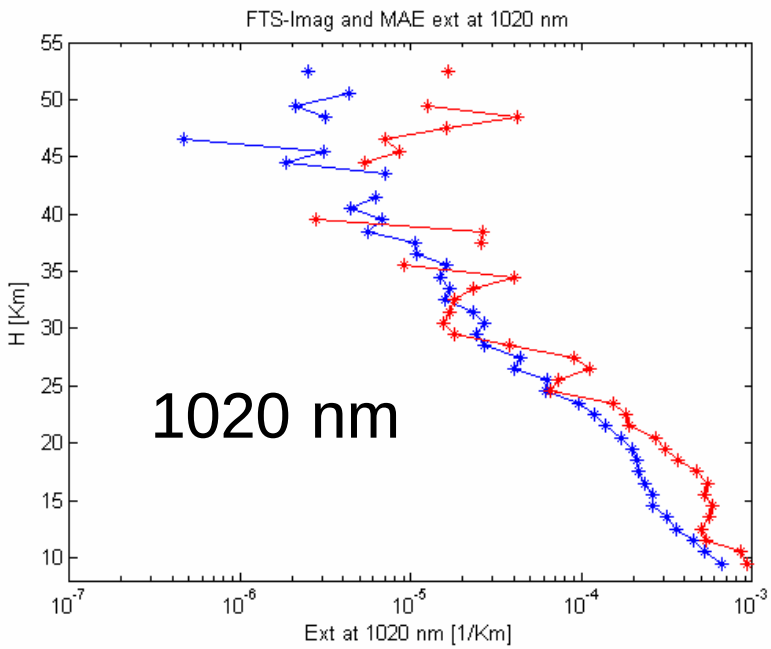




Nichitiu



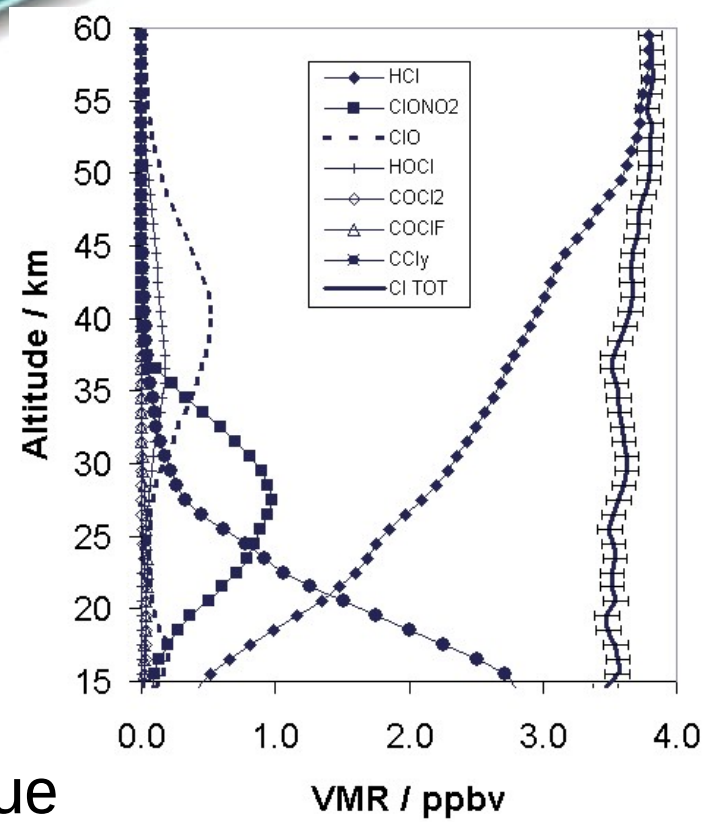
Atmospheric Extinction: MAESTRO (red) vs Imagers (blue)



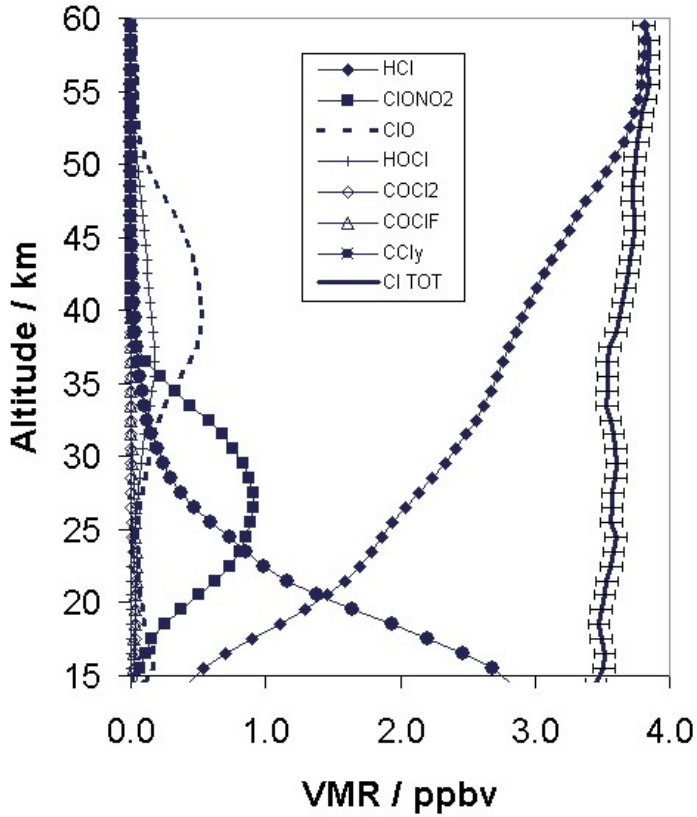
Stratospheric Chlorine Budget

Nassar

Northern Midlatitudes



Southern Midlatitudes

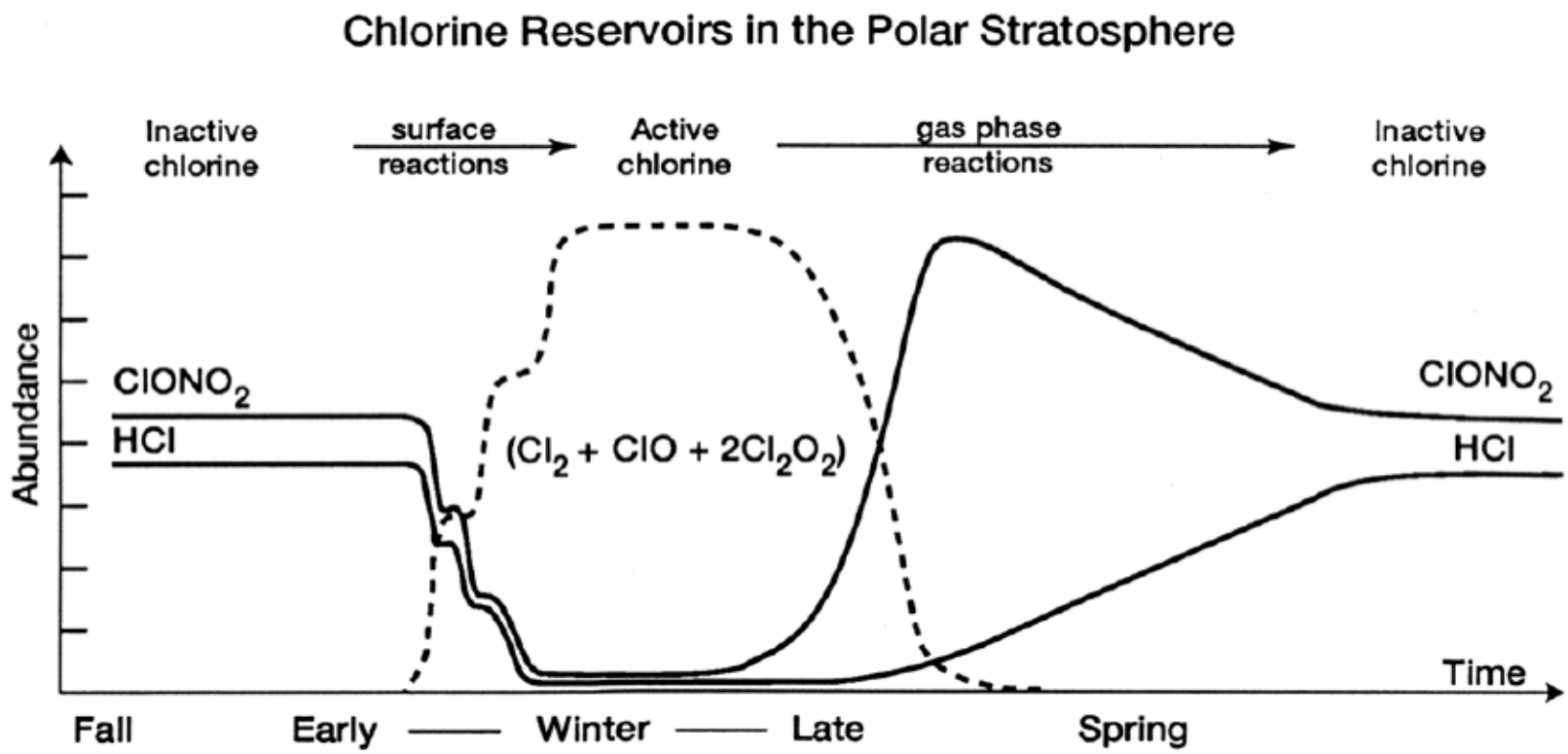


Current HALOE value 3.3 ppb

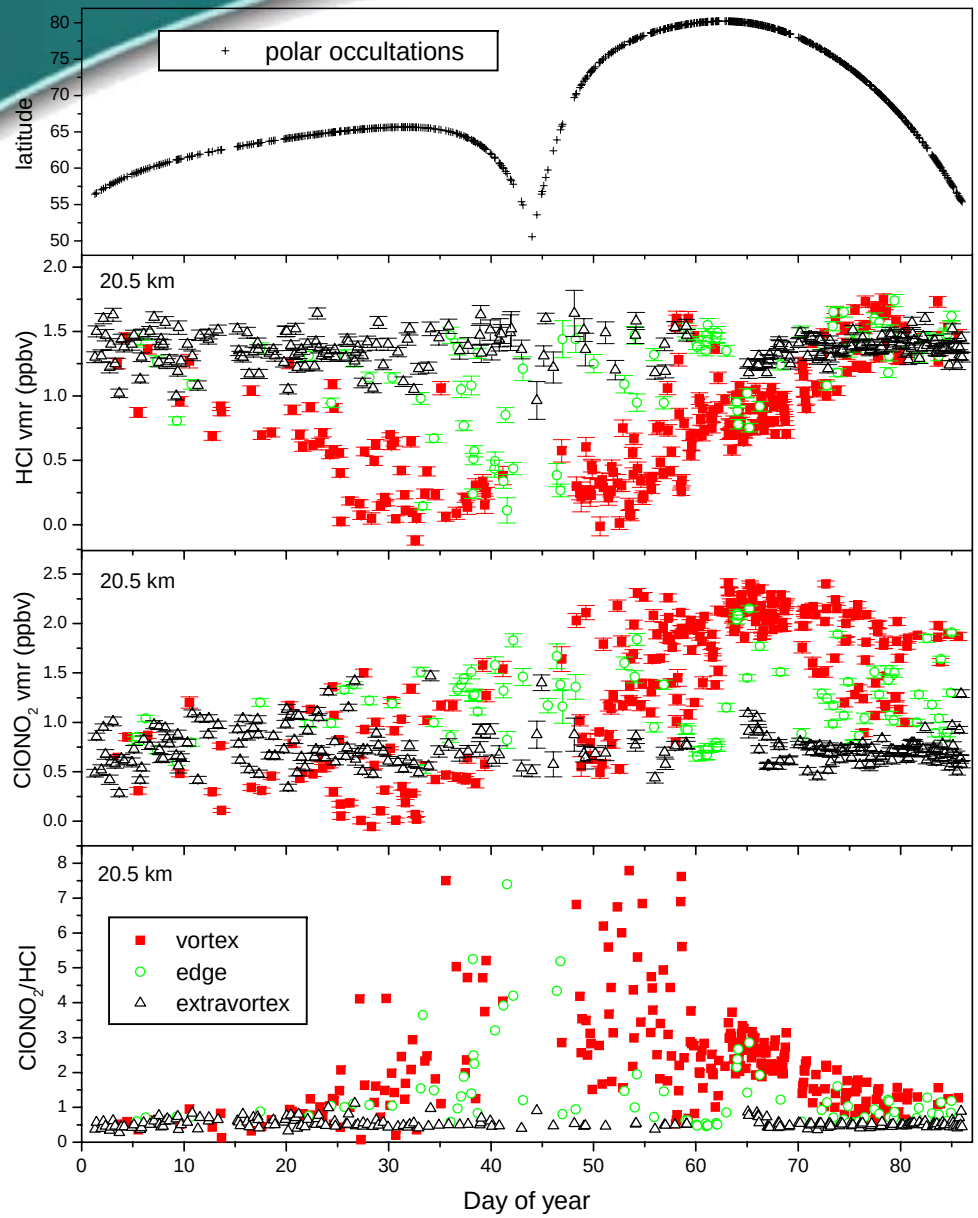
	Cl_{TOT} (ppbv)	slope (ppbv/km)
Northern high latitudes	3.66 ± 0.13	0.0118
Northern midlatitudes	3.60 ± 0.09	0.0071
Tropics	3.55 ± 0.10	0.0048
Southern midlatitudes	3.61 ± 0.08	0.0070
Southern high latitudes*	3.50 ± 0.52	0.0421

Stratospheric Cl in Polar Vortex

From the WMO Report 1994:

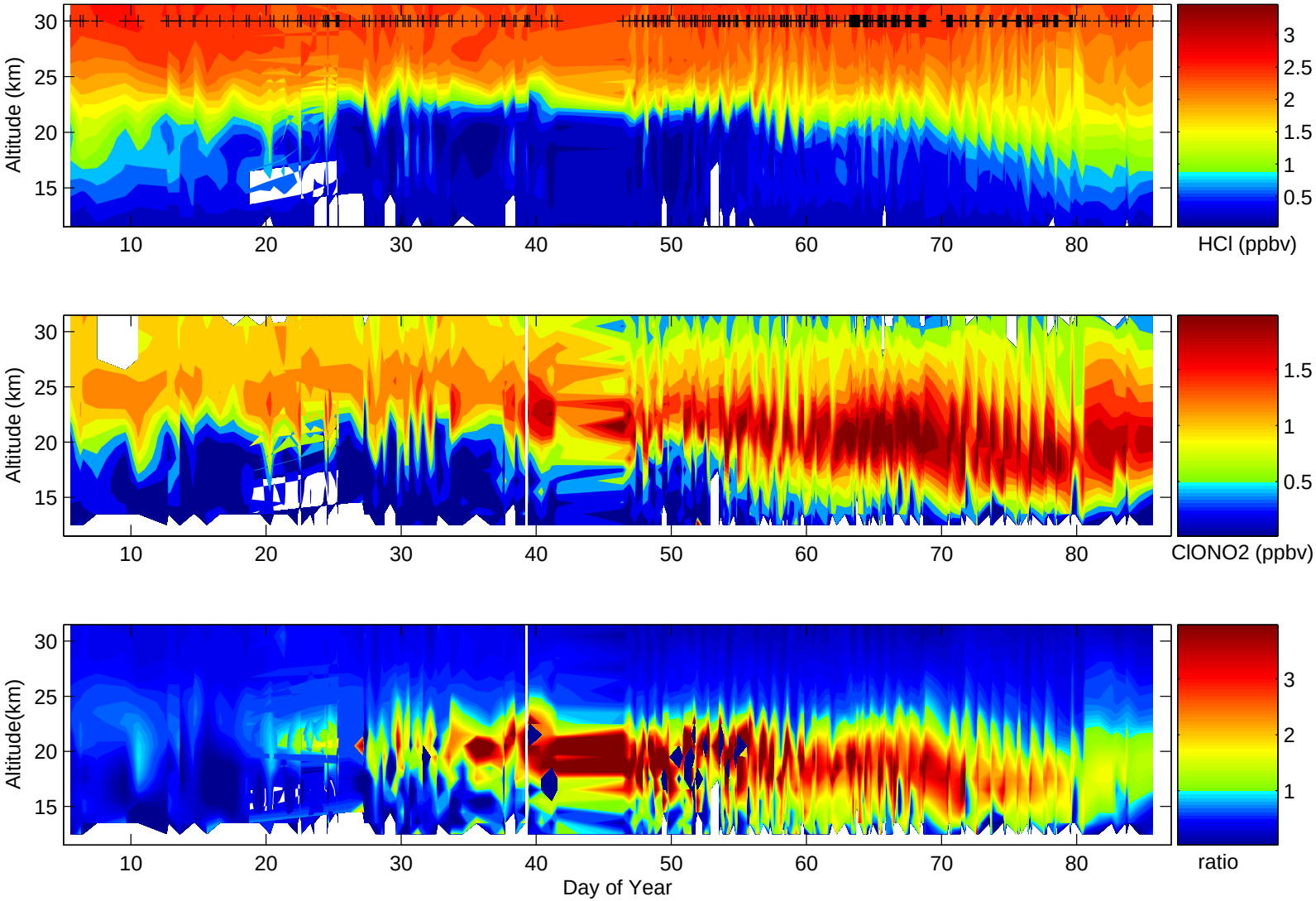


HCl, $ClNO_3$, ClO Jan. - Mar. 2005

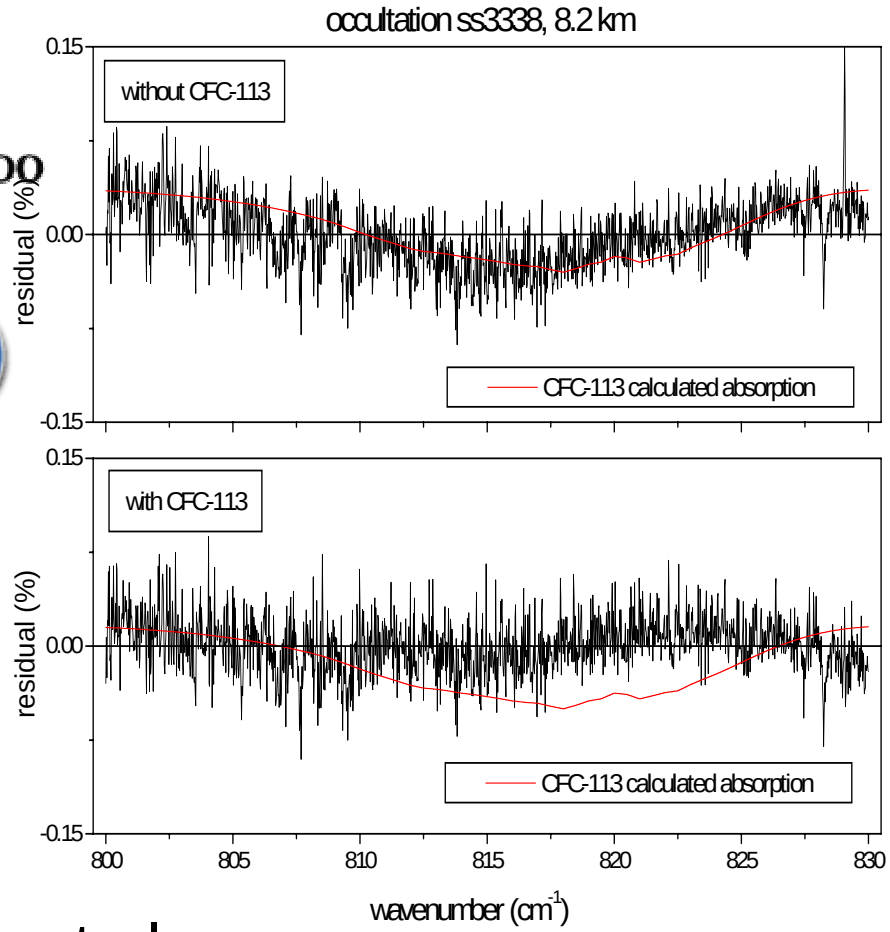


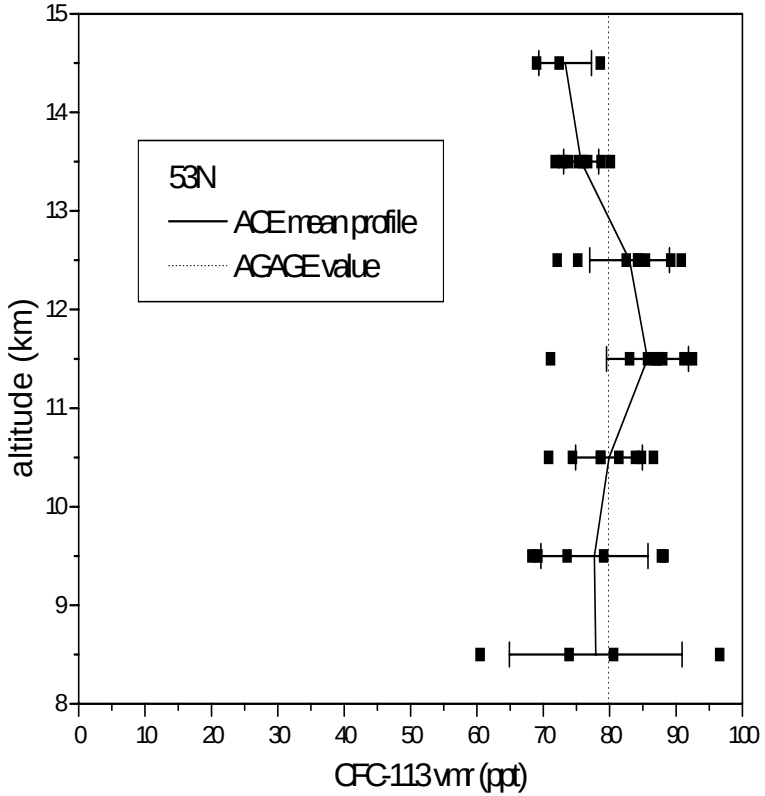
Dufour et al.

HCl and $ClNO_3$ Jan. - Mar. 2005



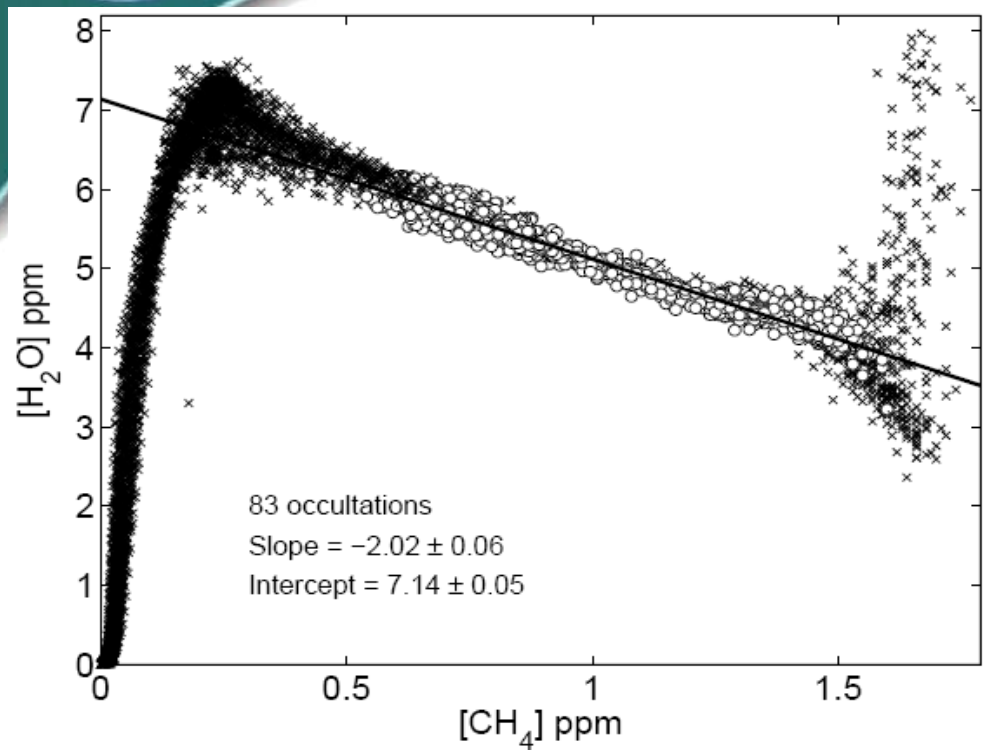
CFC-113 (CCl_2FCClF_2) from Space

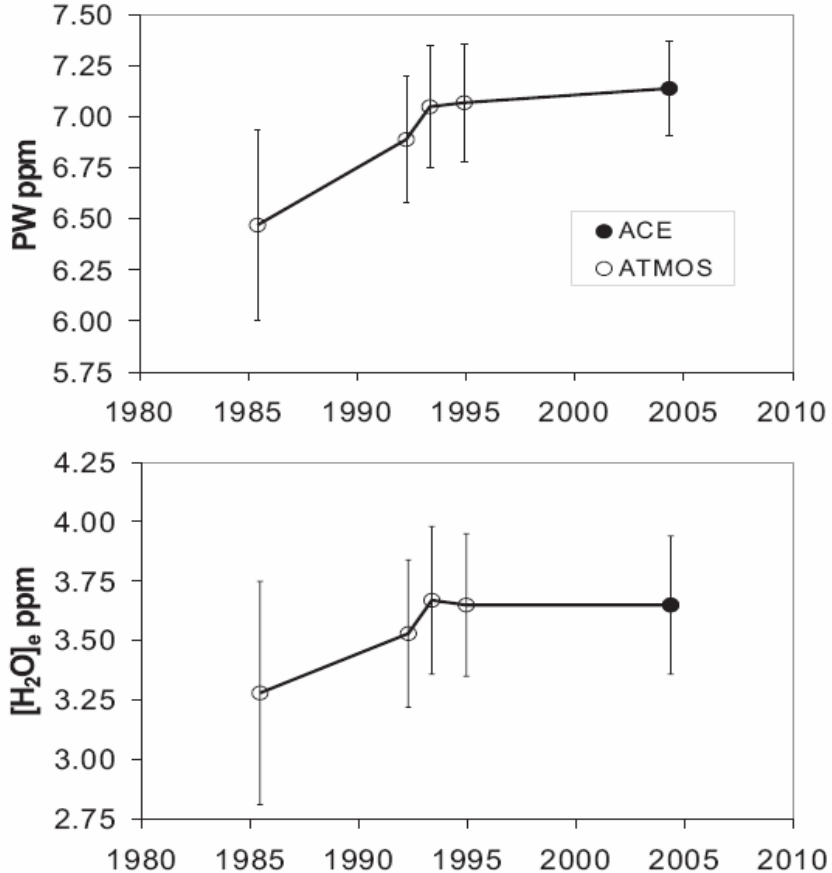




Dufour et al.

ATMOS & ACE H_2O and CH_4 Trends





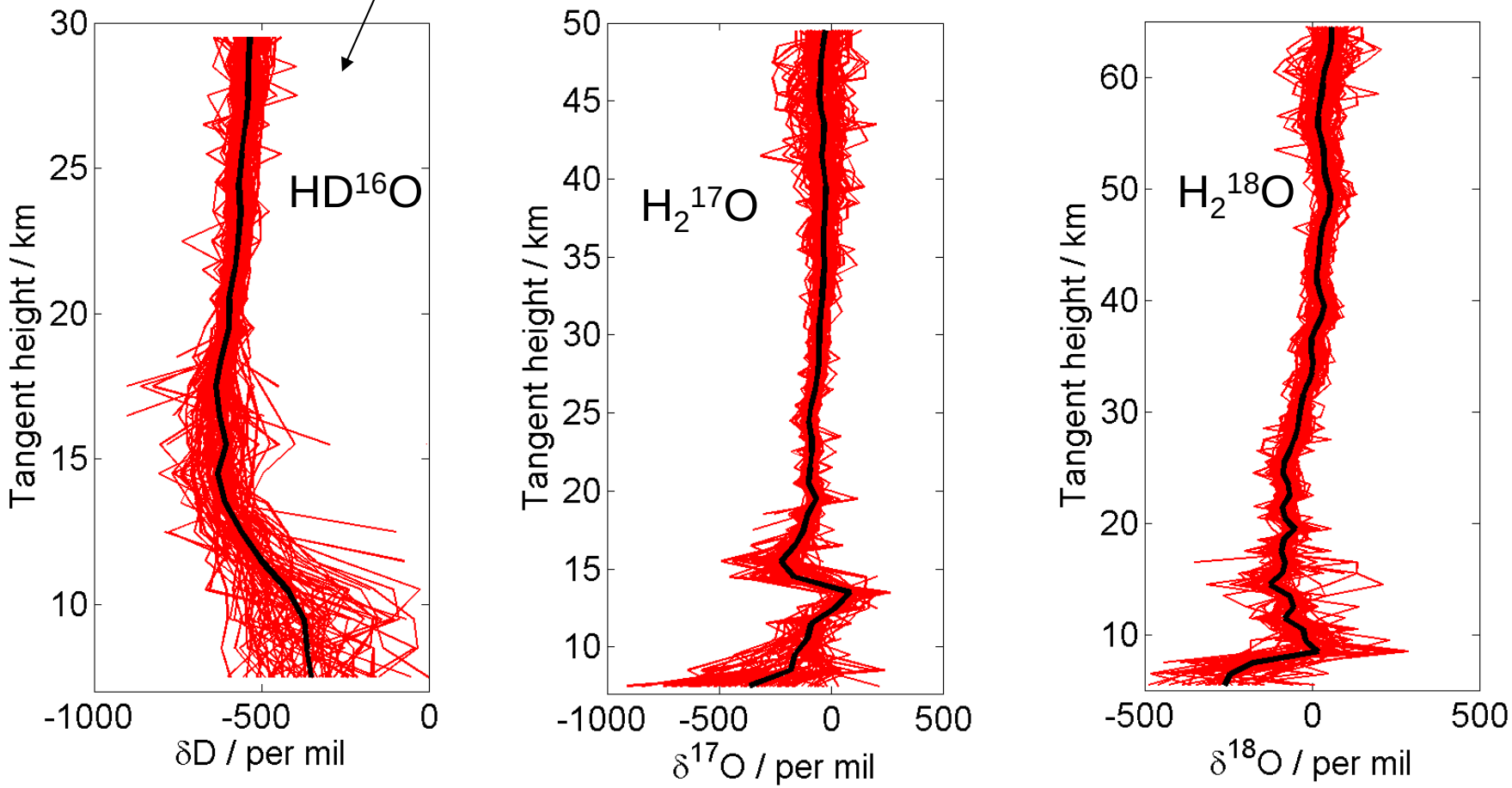
Observations between 18 and 40 km (open circles)

linear fit for 18 to 40 km (solid line)

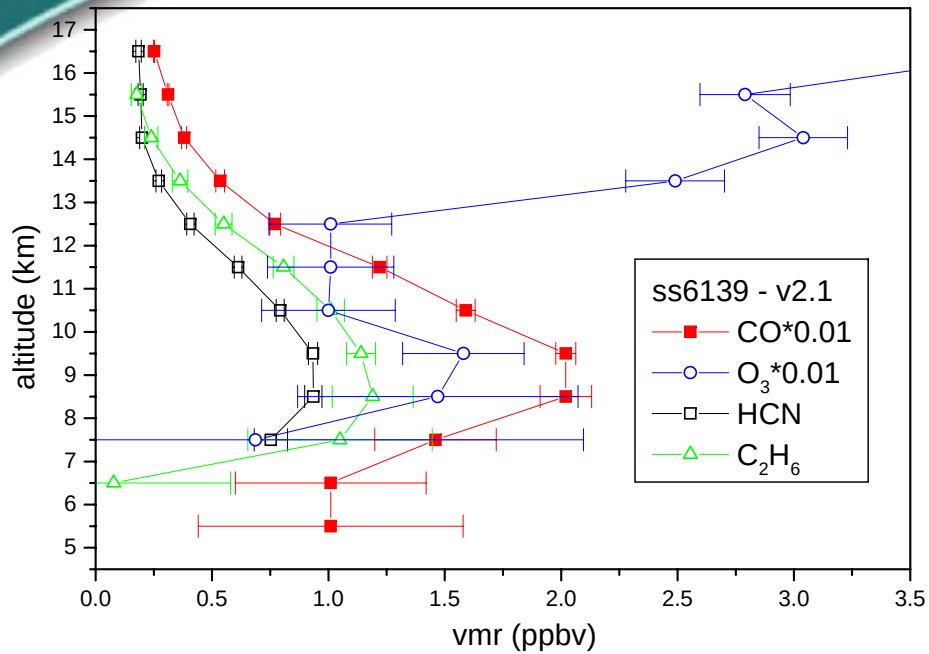
Increase seems to have slowed/ceased consistent with measurements by HALOE (Nedoluha et al., JGR 2003). Beginning of decrease?

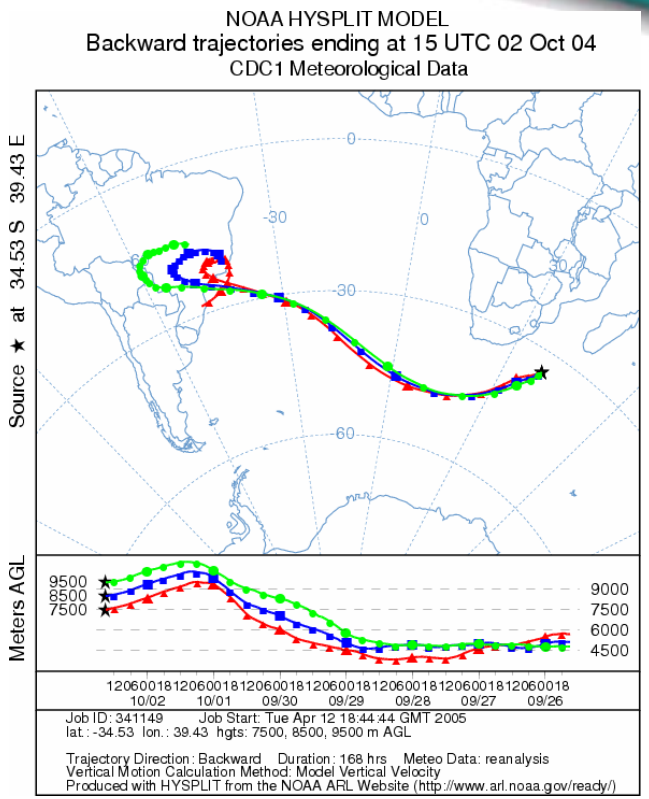
Water Isotopologues

$$\delta D = 1000 \times \left[\frac{\left([HD^{16}O]/[H_2{}^{16}O]\right)_{sample}}{\left([HD^{16}O]/[H_2{}^{16}O]\right)_{VSMOW}} - 1 \right]$$



Biomass Burning in Brazil



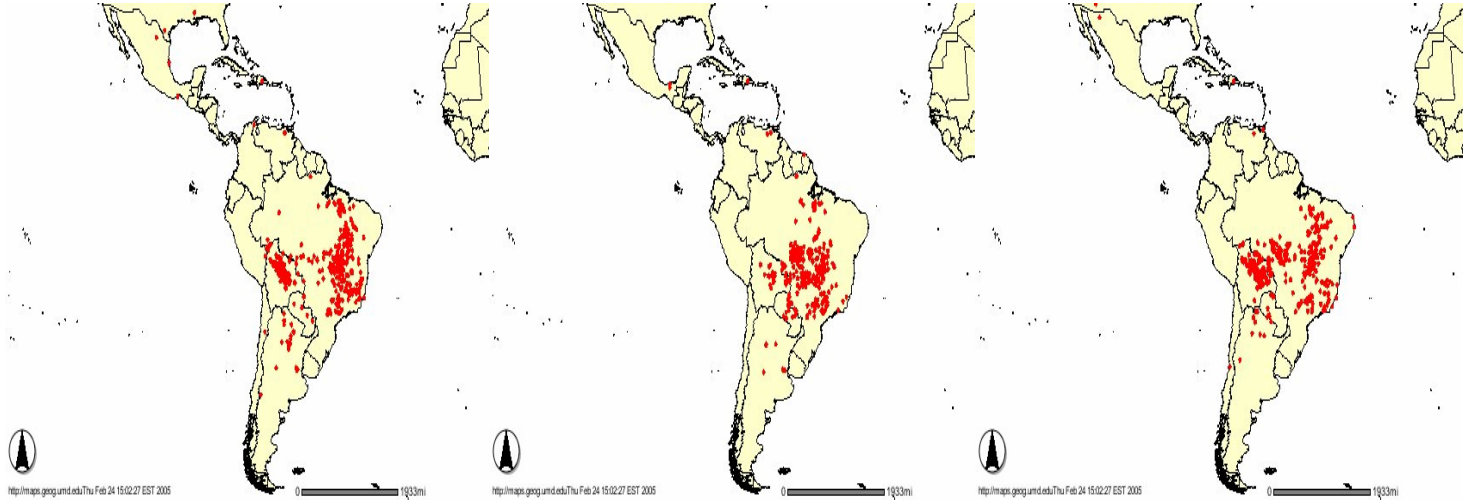


MODIS Fire Counts

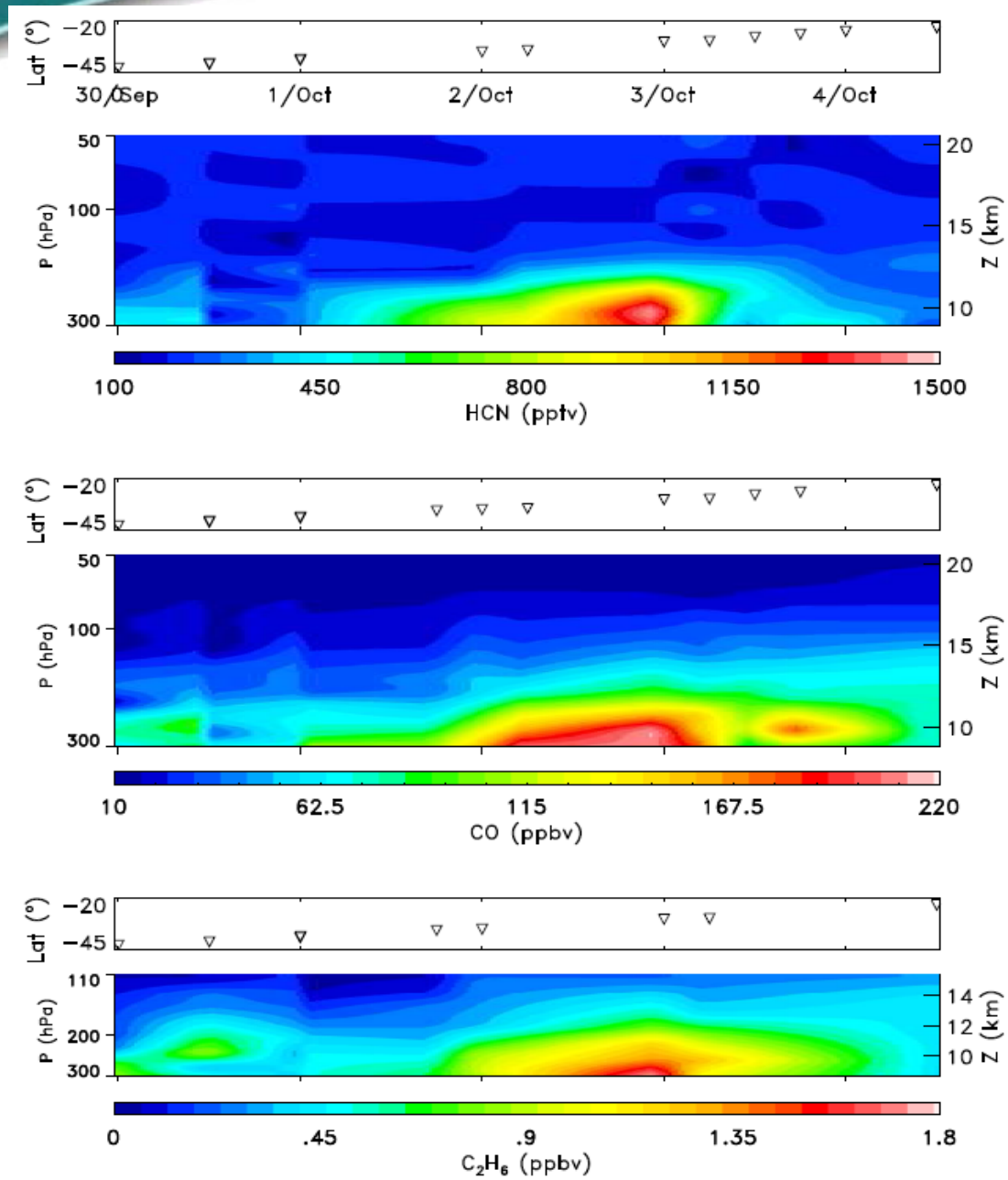
26 Sept. 2004

27 Sept. 2004

28 Sept. 2004



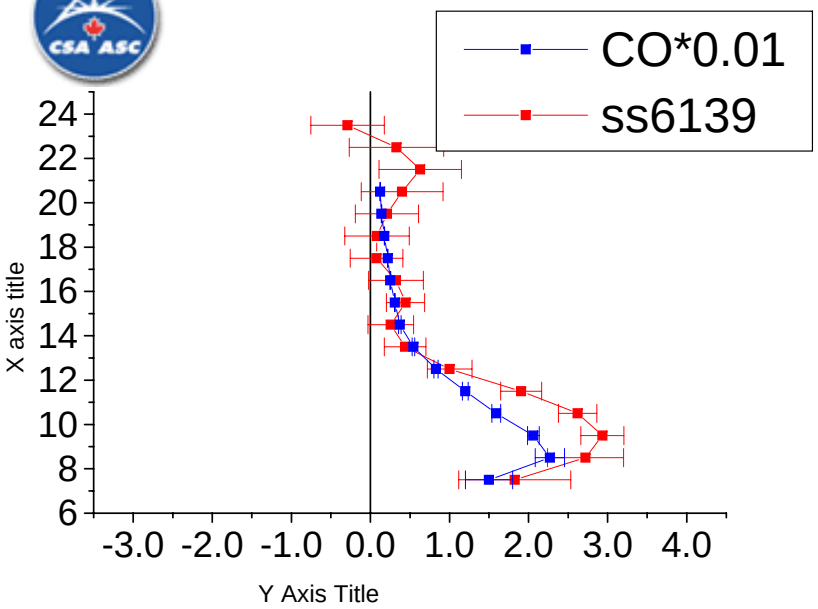
Biomass Burning in Brazil-cont'd



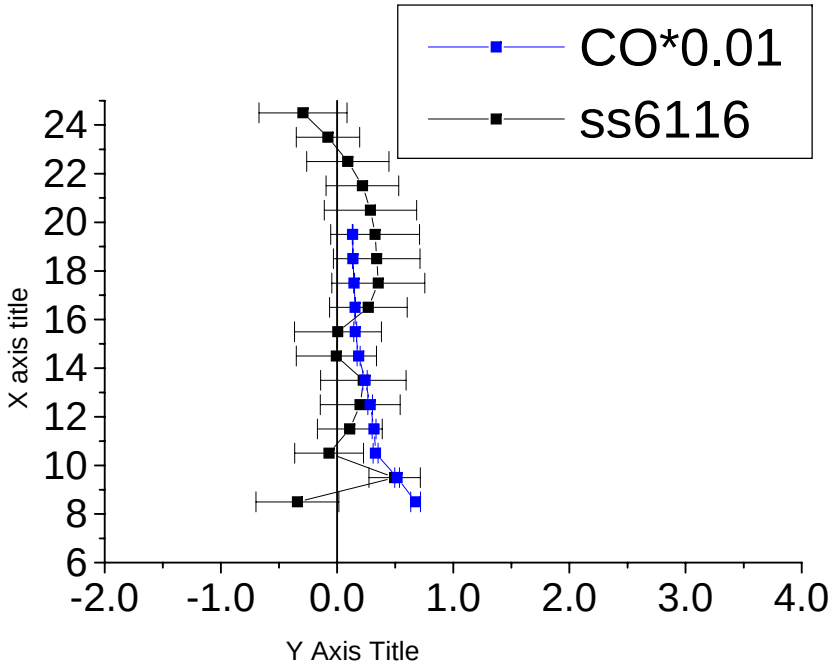
Rinsland et al.

CH_3OH?

Enhanced CH_3OH in a biomass burning plume

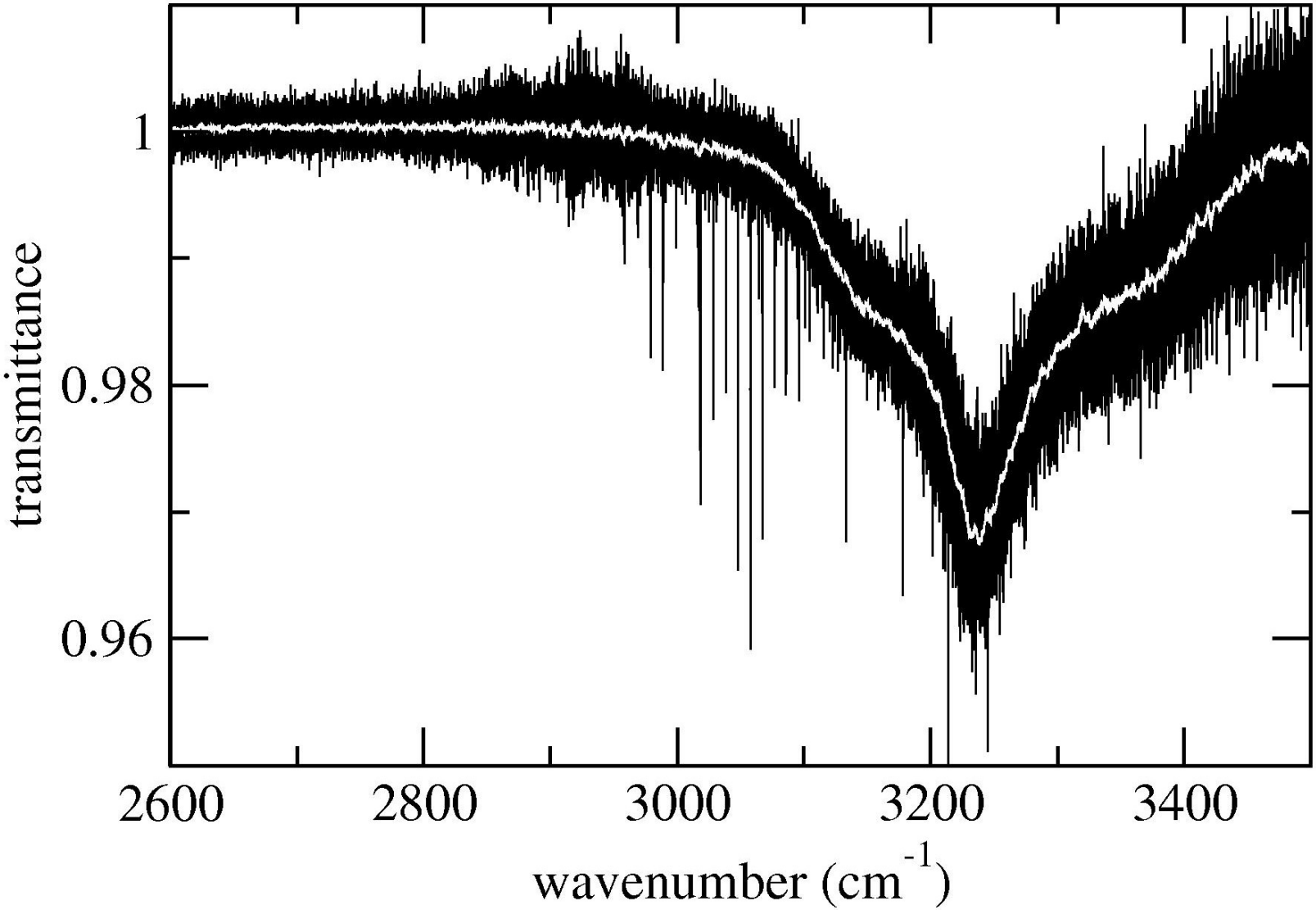


Background CH_3OH



Polar Mesospheric Clouds (Noctilucent Clouds) Finland

First Spectra of Polar Mesospheric Clouds (PMCs)



PSCs also seen

International ACE Partners

- USA- NASA launched ACE and C. Rinsland (NASA-Langley) funded to help with algorithms and cal/val.
- Belgium- R. Colin (ULB) and M. DeMaziere (IASB) and co-workers supplied CMOS imager chips, spectroscopic data, cal/val and algorithms.
- France- C. Camy-Peyret (Paris) cal/val
- Japan- M. Suzuki (NASDA) cal/val

ACE Participants:

Mission Scientist
- Peter Bernath, University of Waterloo

MAESTRO Principal Investigator
- Tom McElroy, MSC

Instrument Test
- Jim Drummond, University of Toronto

ACE Instrument Support (FTS, MAESTRO, Imagers)
- Pierre Tremblay, Université Laval
- Jim Drummond, University of Toronto
- David Turnbull, U.of Western Ontario

Science Operations Center, U. of Waterloo
- Mike Butler, Manager
- Chris Boone, ACE scientist
- Sean McLeod, Computer Support
- Kaley Walker, Cal/Val
- Randall Skelton, ACE Support

Additional Canadian Univ. Participants
- Wayne F. J. Evans, Trent University
- Ian Folkins, Dalhousie University
- Ted Llewellyn, Univ. of Saskatchewan
- Bob Lowe, Univ. of Western Ontario
- Ian McDade, York Univeristy
- Jack McConnell, York University
- Diane Michelangeli, York University
- Jim Sloan, University of Waterloo
- Kim Strong, University of Toronto

Instrument Contractor, ABB-Bomem
- Marc-Andre Soucy, Project Manager

Bus Contractor, Bristol Aerospace
- Ian Walkty, Project Manager

MAESTRO Contractor, EMS / MSC
- Andrew Bell, EMS, Project Manager
- Tom McElroy, MSC, Project Manager

Main International Partners

Belgium:
- Reg Colin, Univ. Libre de Bruxelles
- P. Simon, M. De Maziere, IASB

France:
- Claude Camy-Peyret, LPMA CNRS

USA:
- Curtis Rinsland, NASA Langley

Canadian Space Agency
- Glen Rumbold, ACE Manager
- Randolph Shelly, Bus
- Victor Wehrle, FTS and Science Team
- Marie Yelle-Whitwan, MAESTRO
- Dennis Ewchuk / Dan Showalter, Ground Segment

Sunset over Kitt Peak, AZ