Solar Occultation: Present Status and Future Prospects

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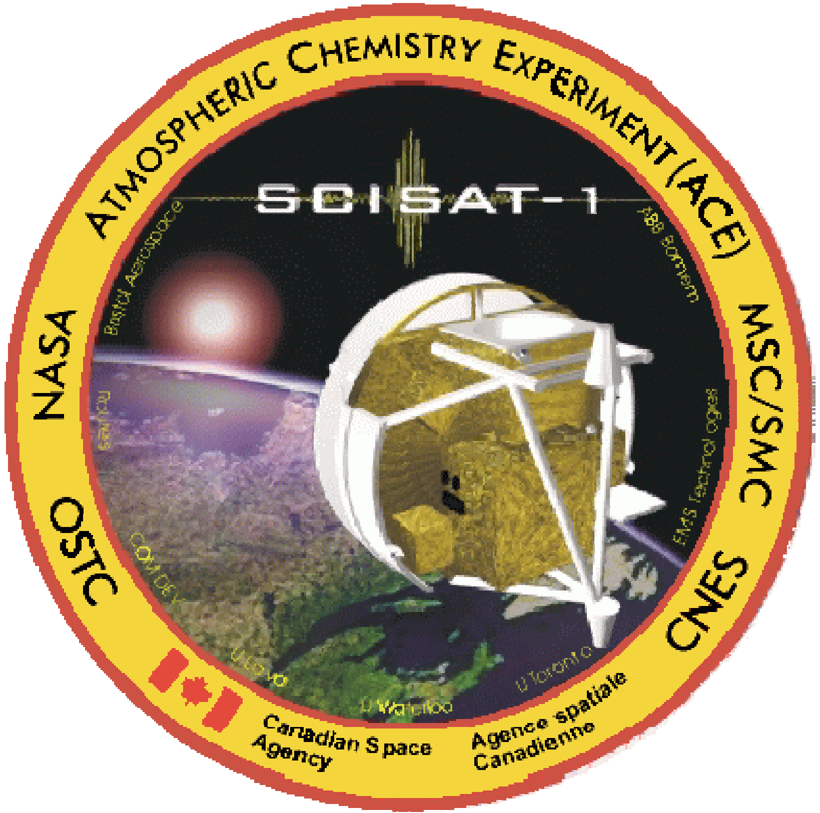


IR Remote Sensing with the Sun

Solar Occultation Instruments

PAST

Visible region/near-IR: SAGE-II, SAGE-III, POAM-II, POAM-III

Infrared region: ATMOS, ILAS-II, HALOE

PRESENT

Visible/near-IR: MAESTRO on ACE, SCIAMACHY on ENVISAT

Infrared region: ACE-FTS on ACE, SOFIE on AIM

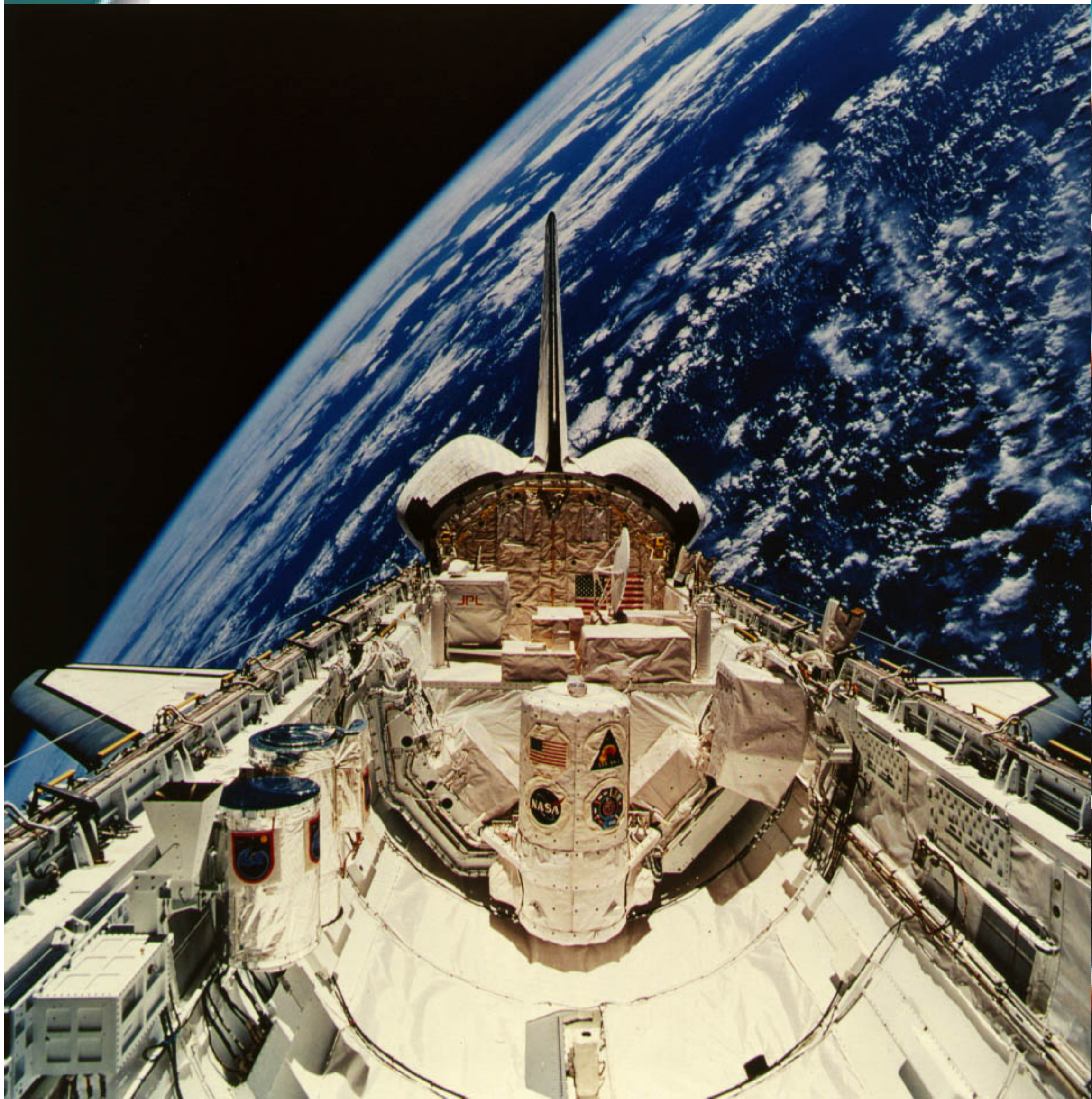
FUTURE

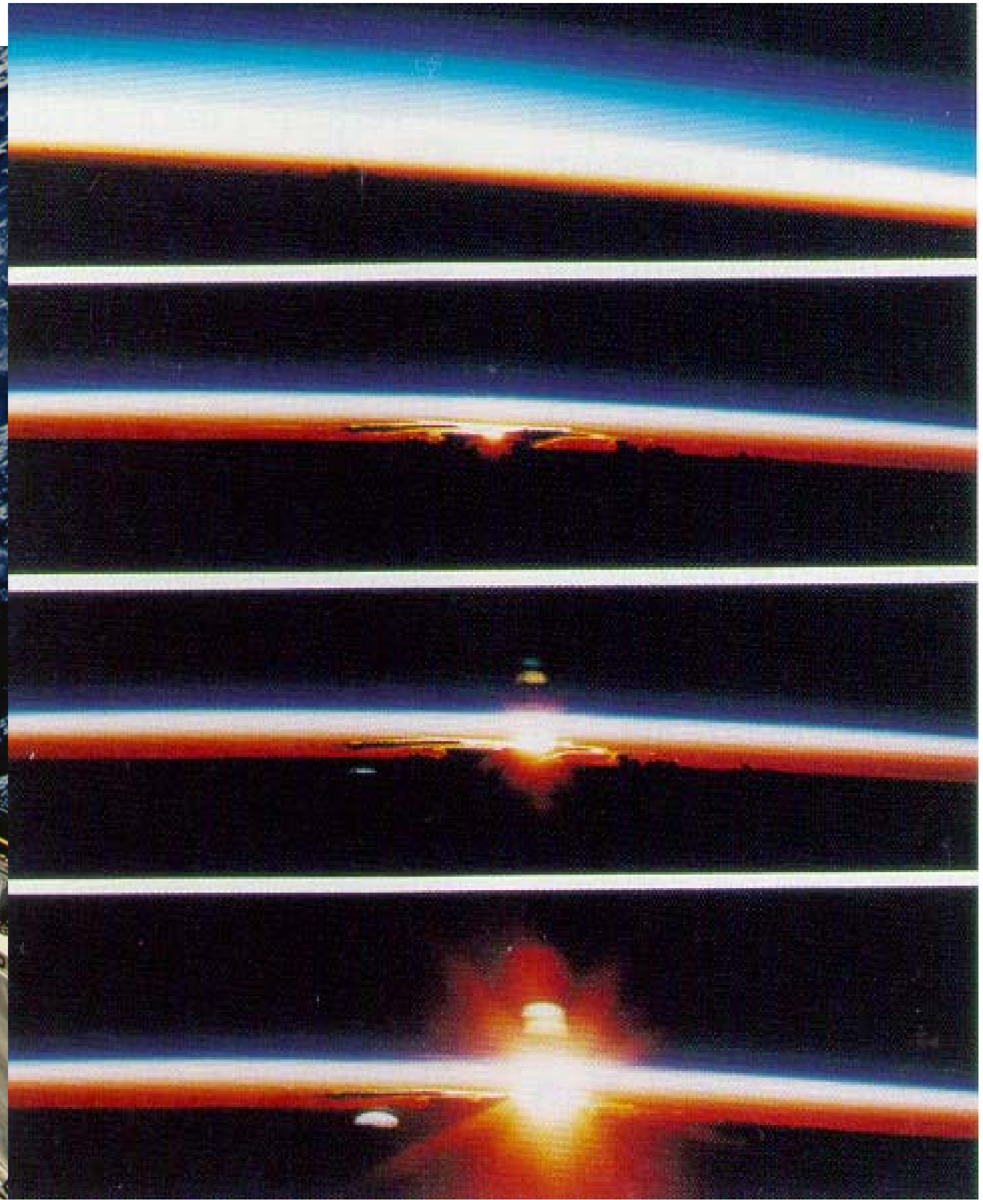
SAGE-III and ACE-FTS on Space Station ?

MATMOS (for Mars)

ATMOS on Space Shuttle (1985, 1992, 1993, 1994)

High resolution IR Fourier transform spectrometer

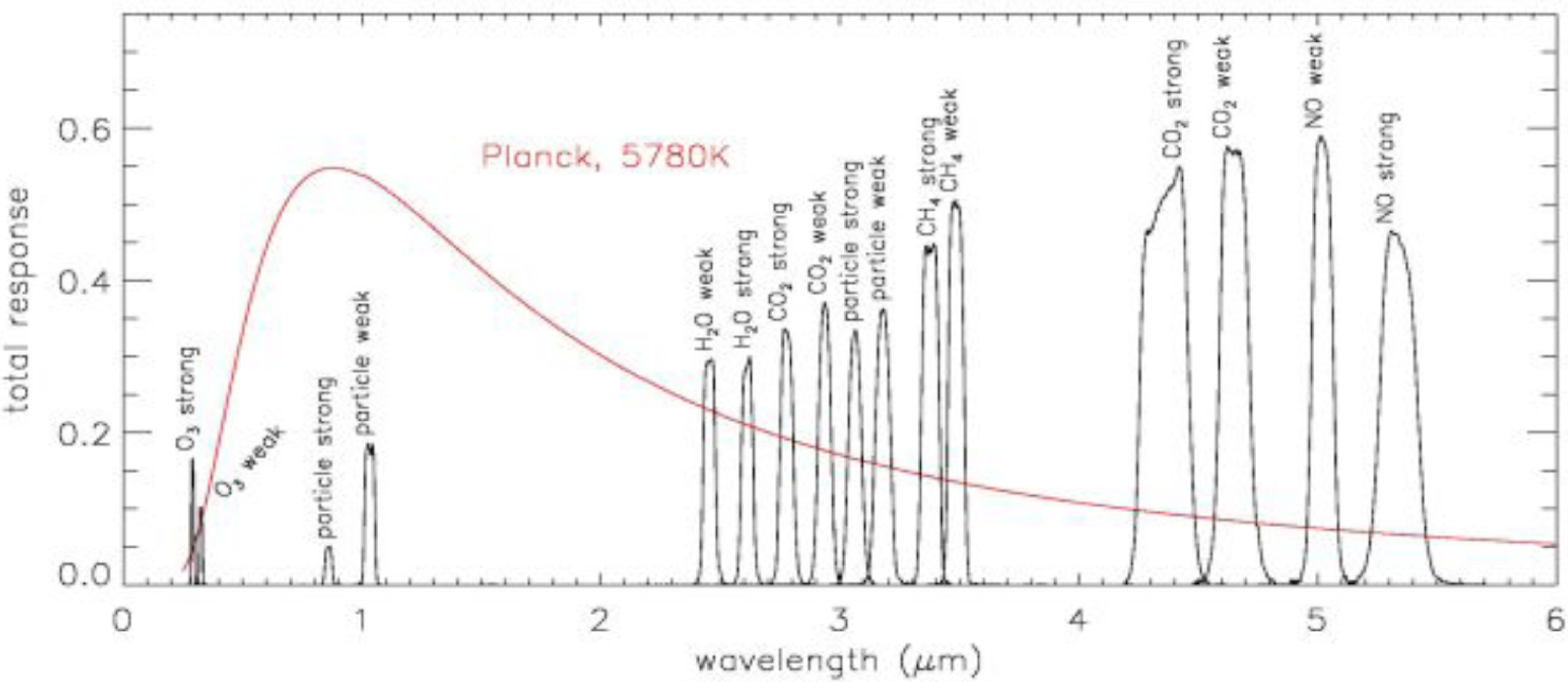




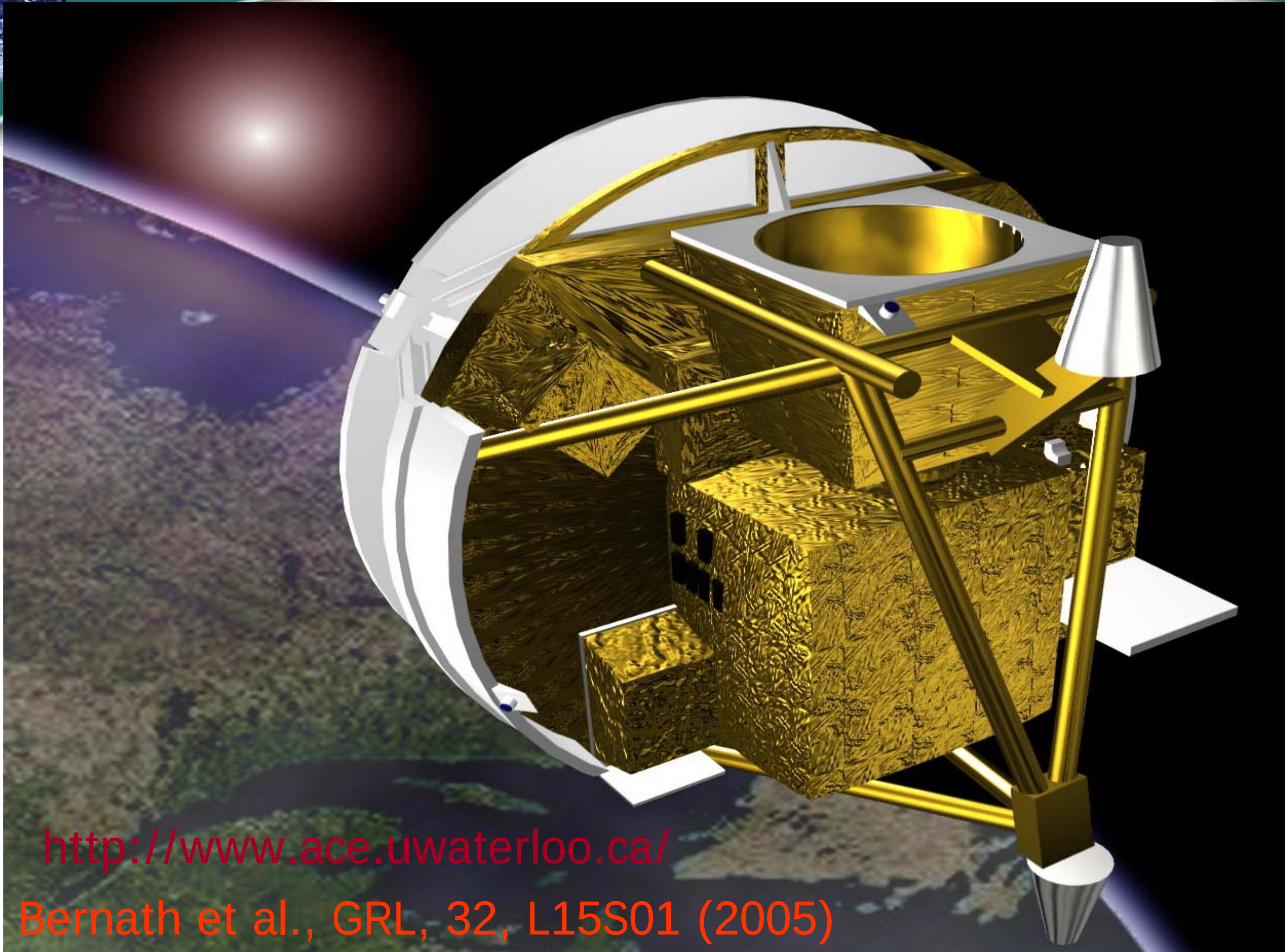
SOFIE on AIM (NASA)

AIM: Aeronomy of Ice in the Mesosphere; SOFIE: Solar Occultation for Ice Experiment (to study Polar Mesospheric Clouds, PMCs)
Low resolution filters for O_3, CH_4, NO, H_2O, CO_2 (mainly for T), on and off absorption bands like HALOE

- 8 channels (16 wavelengths)
  - each channel pairs a strong and weak absorption region



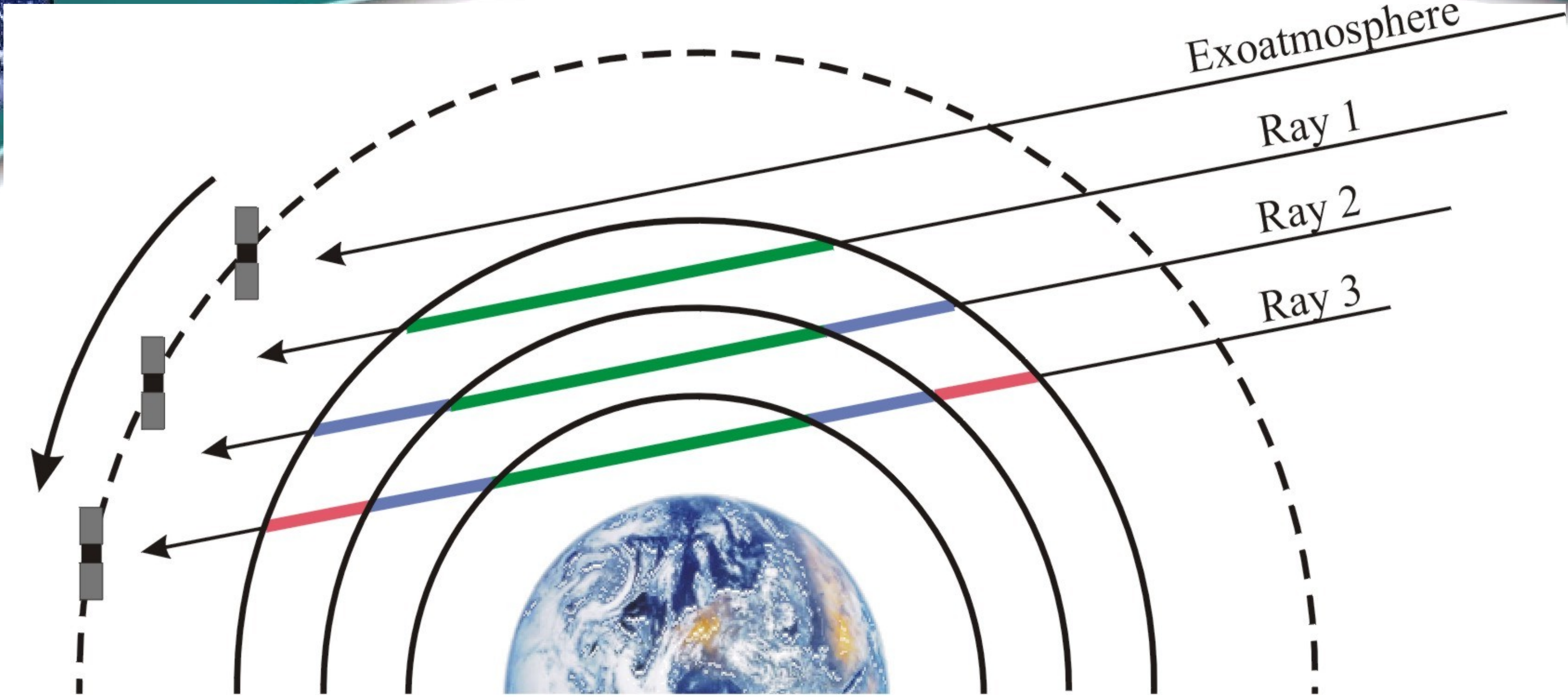
ACE Satellite



http://www.ace.uwaterloo.ca/

Bernath et al., GRL, 32, L15S01 (2005)

Solar Occultation



Advantages:

1.Radiance of sun gives higher S/N than emission

2.Limb view gives longer path length ~500 km (lower detection limits) than nadir (but lower horizontal resolution)

3.“Self-calibrating” so excellent long-term accuracy <u>and</u> precision

Disadvantages:

1.Modest global coverage

2.Samples only free troposphere (>5 km or so)

Timeline ("faster, cheaper")

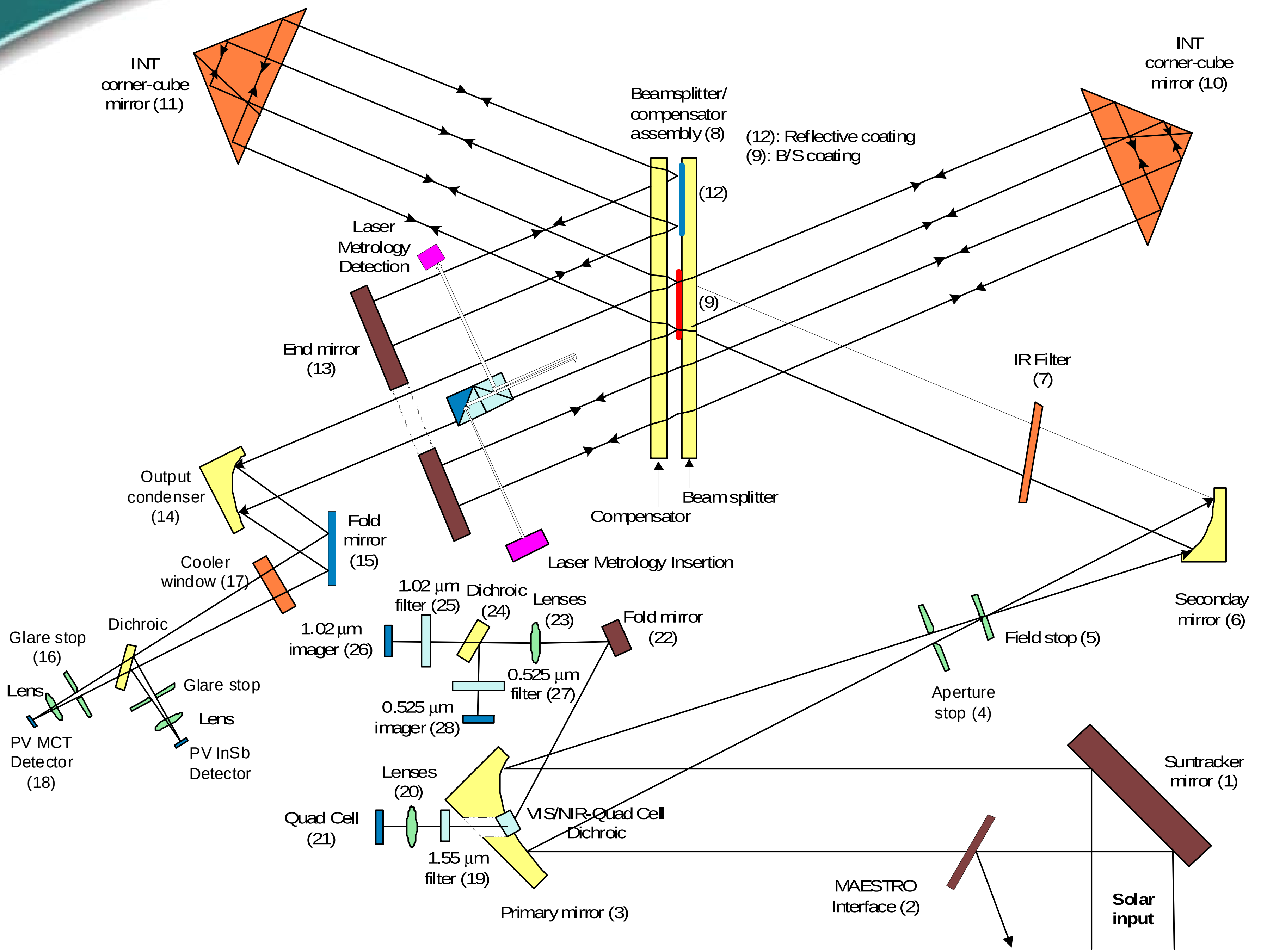
- Jan. 1998 Proposal to Canadian Space Agency (CSA)
- Feb. 2001 FTS and Imager CDR
- Mar. 2001 MAESTRO CDR
- Jun. 2001 Bus CDR
- Sept. 2002 S/C integration & test
- Mar. 2003 Instrument test (Toronto)
- May 2003 Final integration (DFL)
- Aug. 2003 Launch
- Sept. 2003 Commissioning
- Feb. 2004 Routine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

First ACE data Feb. 2004, mission currently approved to March 2012. Mission had a planned 2-year lifetime – seventh anniversary Aug. 2010.

Instruments

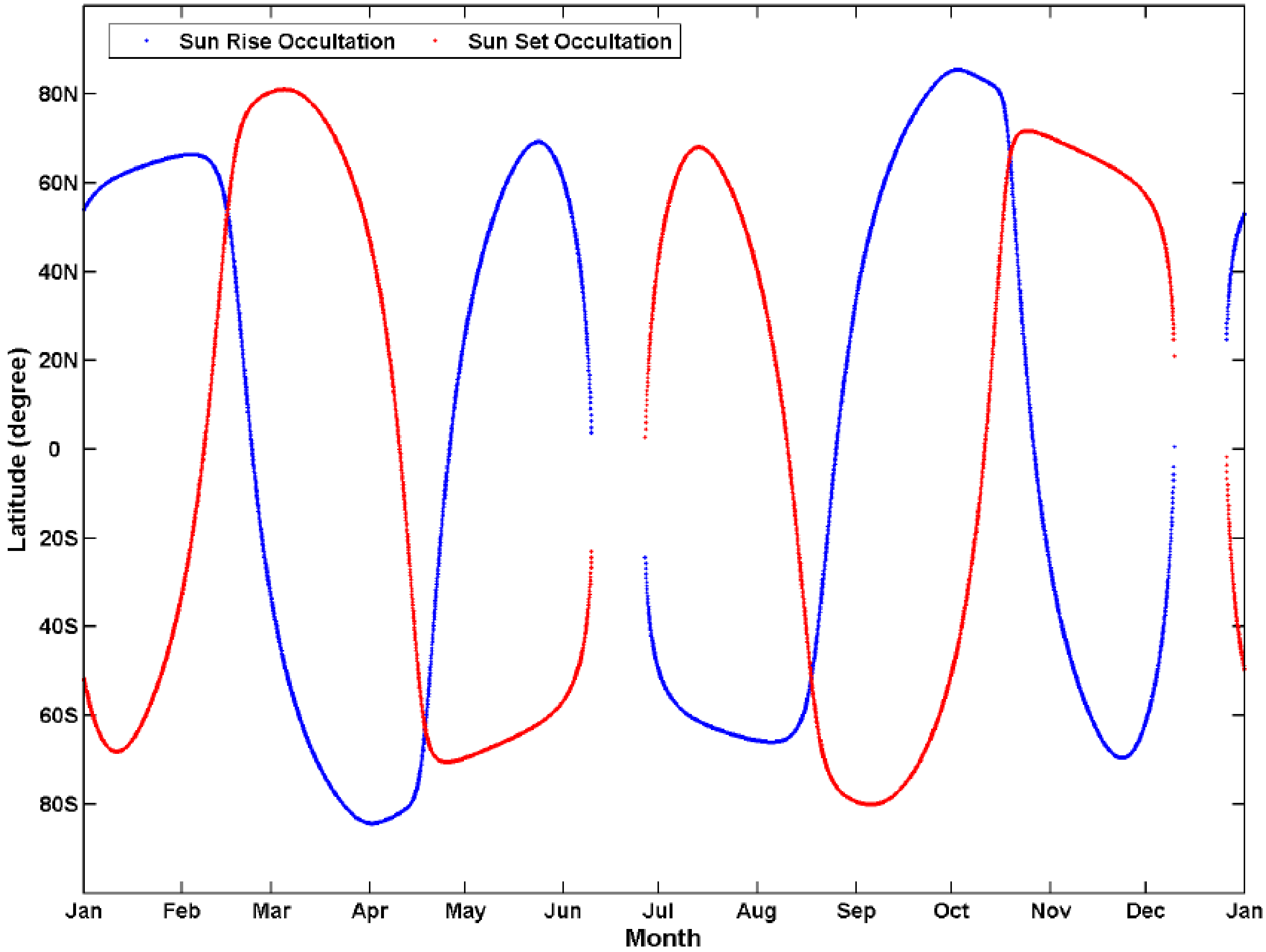
- Infrared Fourier Transform Spectrometer operating between 2 and 13 microns (750-4400 cm^{-1}) with a resolution of 0.02 cm^{-1}
- 2-channel visible/near infrared Imagers, operating at 0.525 and 1.02 microns (cf., SAGE II)
- Suntracker keeps the instruments pointed at the sun's radiometric center.
- UV / Visible spectrometer (MAESTRO) 0.4 to 1.03 microns, resolution ~1-2 nm
- Startracker

Optical Layout (ABB-Bomem)

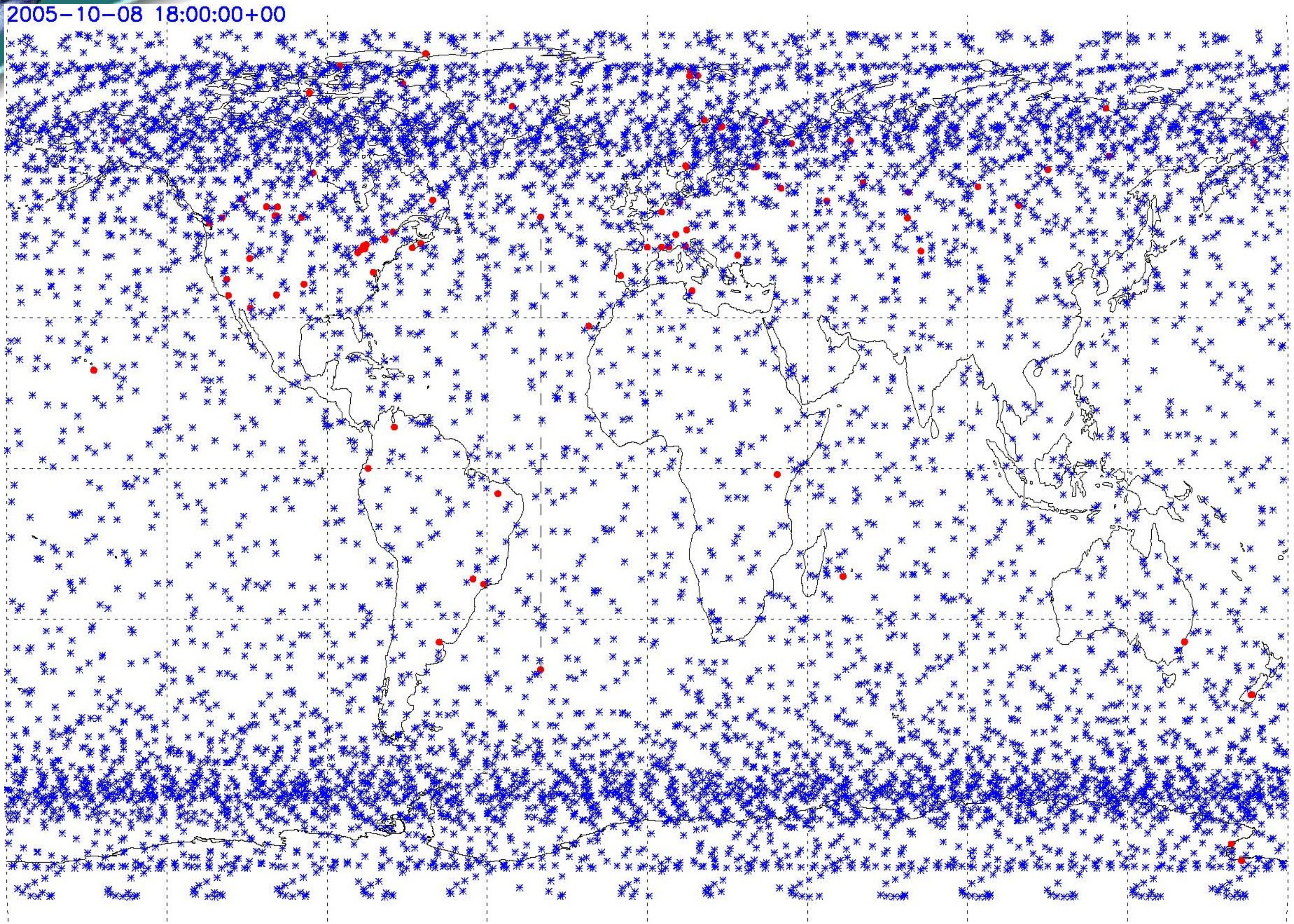


ACE Orbit- Global Coverage

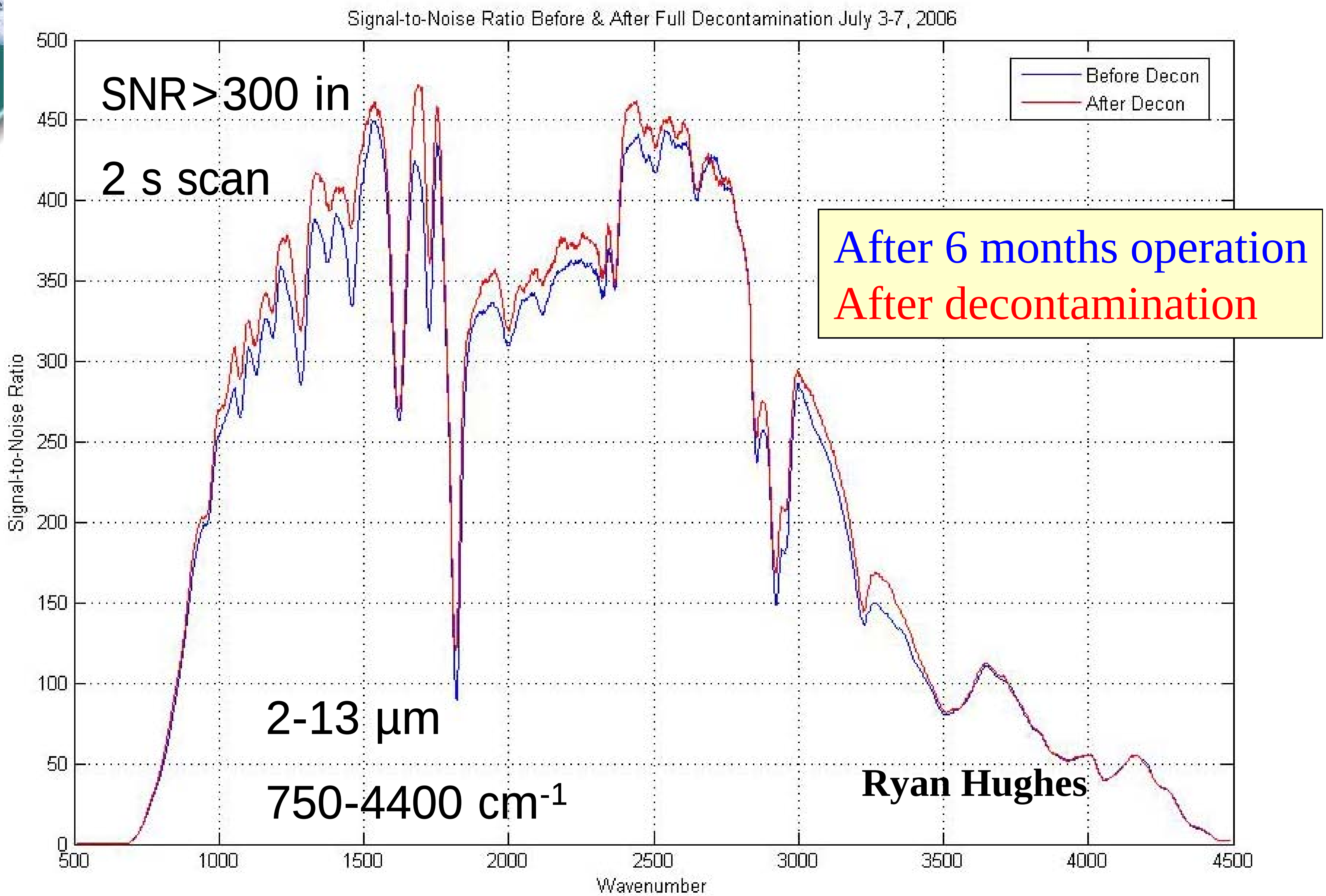
650 km, 74° inclined circular orbit



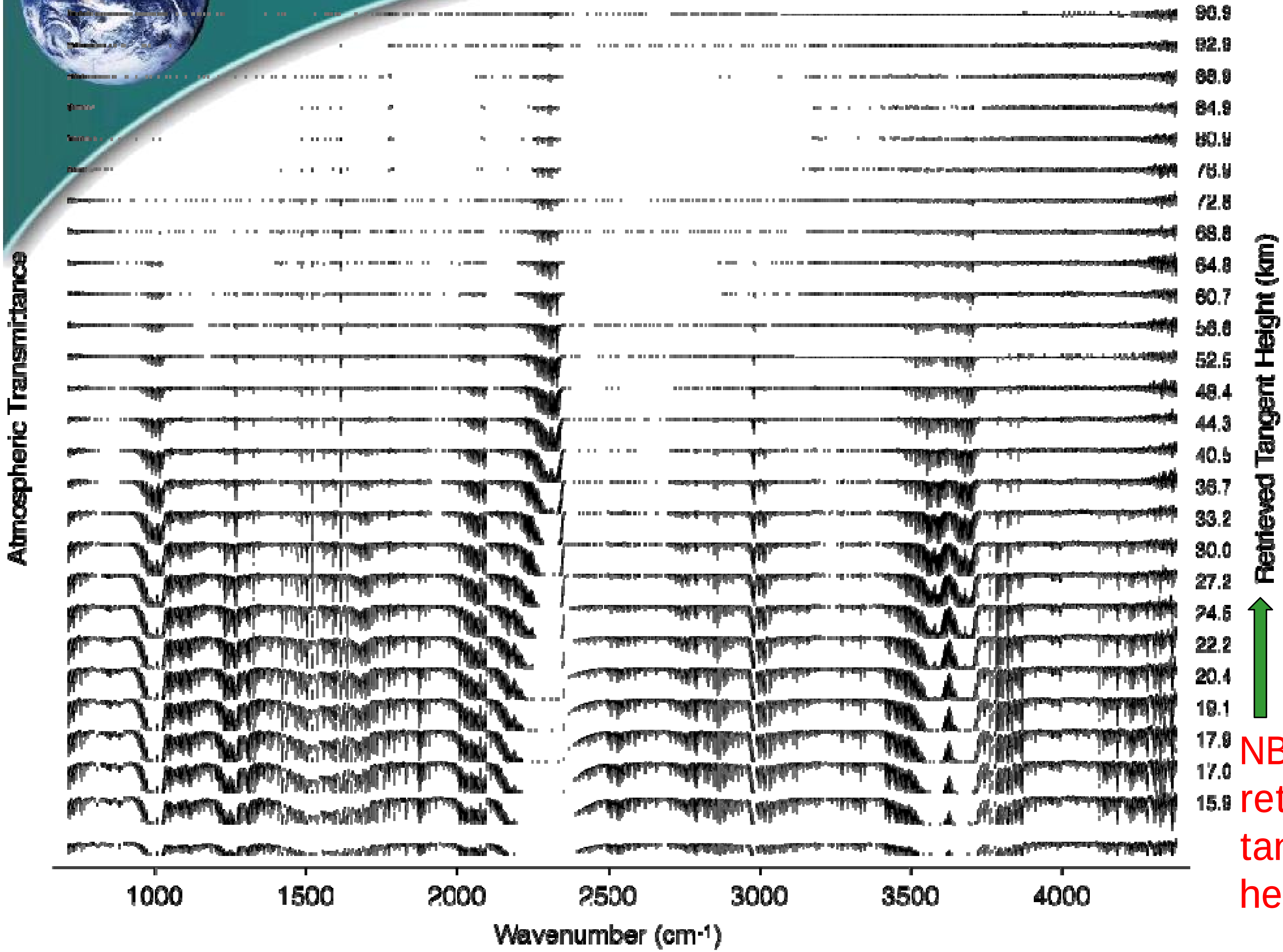
Global Occultation Distribution



FTS – Decontamination Results



Occultation Sequence



NB: retrieved tangent height

ACE-FTS Version 3 Species

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 as well as pressure and temperature from CO_2 lines

Isotopologues: $H_2{}^{18}O$, $H_2{}^{17}O$, HDO, $O^{13}CO$, $OC^{18}O$, $OC^{17}O$, $O^{13}C^{18}O$, $^{18}OO_2$, $O^{18}OO$, $O^{17}OO$, $N^{15}NO$, ^{15}NNO, $N_2{}^{18}O$, $N_2{}^{17}O$, ^{13}CO, $C^{18}O$, $C^{17}O$, $^{13}CH_4$, CH_3D, $OC^{34}S$, $O^{13}CS$

Research species: ClO, acetone, PAN, HFC-23, etc.

Climate Change

Scientists reveal that bears have stopped hibernating

Climate Change vs Mother Nature

By Elizabeth Nash
in Madrid

Bears have stopped hibernating in the mountains of northern Spain, scientists revealed yesterday, in what may be one of the strongest signals

lumbering through the forests of Spain's Cantabrian mountains, when normally they would already be in their long, annual sleep.

Bears are supposed to slumber throughout the winter, slowing their body rhythms to a min-

The Independent

21 Dec. 2006

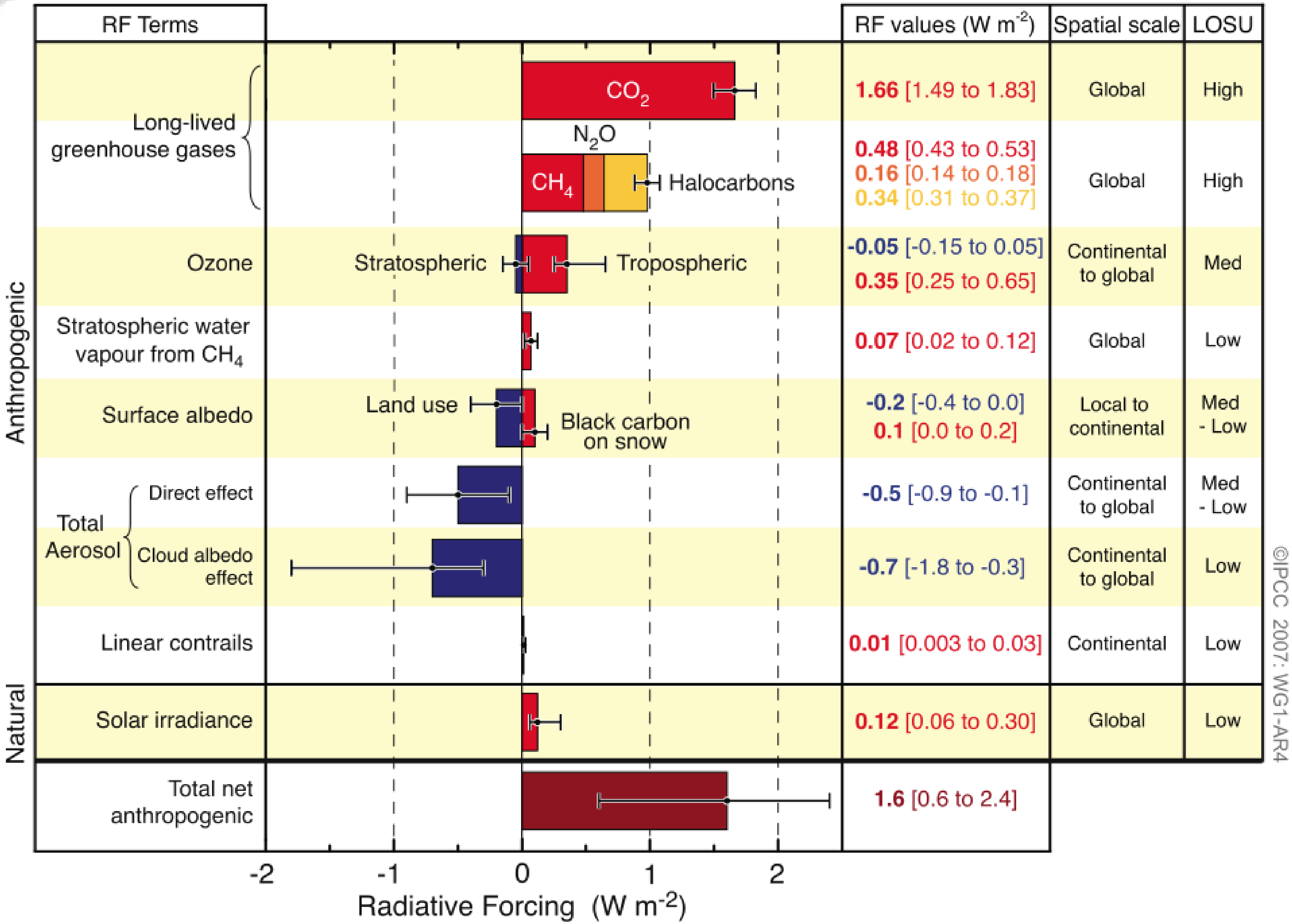
Greenhouse Gases (GHGs)

1. CO_2
2. CH_4
3. N_2O
4. Halocarb.
5. Trop. O_3
6. Strat. H_2O

"Indirect GHGs"

1. CO
2. NO_X
3. VOCs

plus aerosols



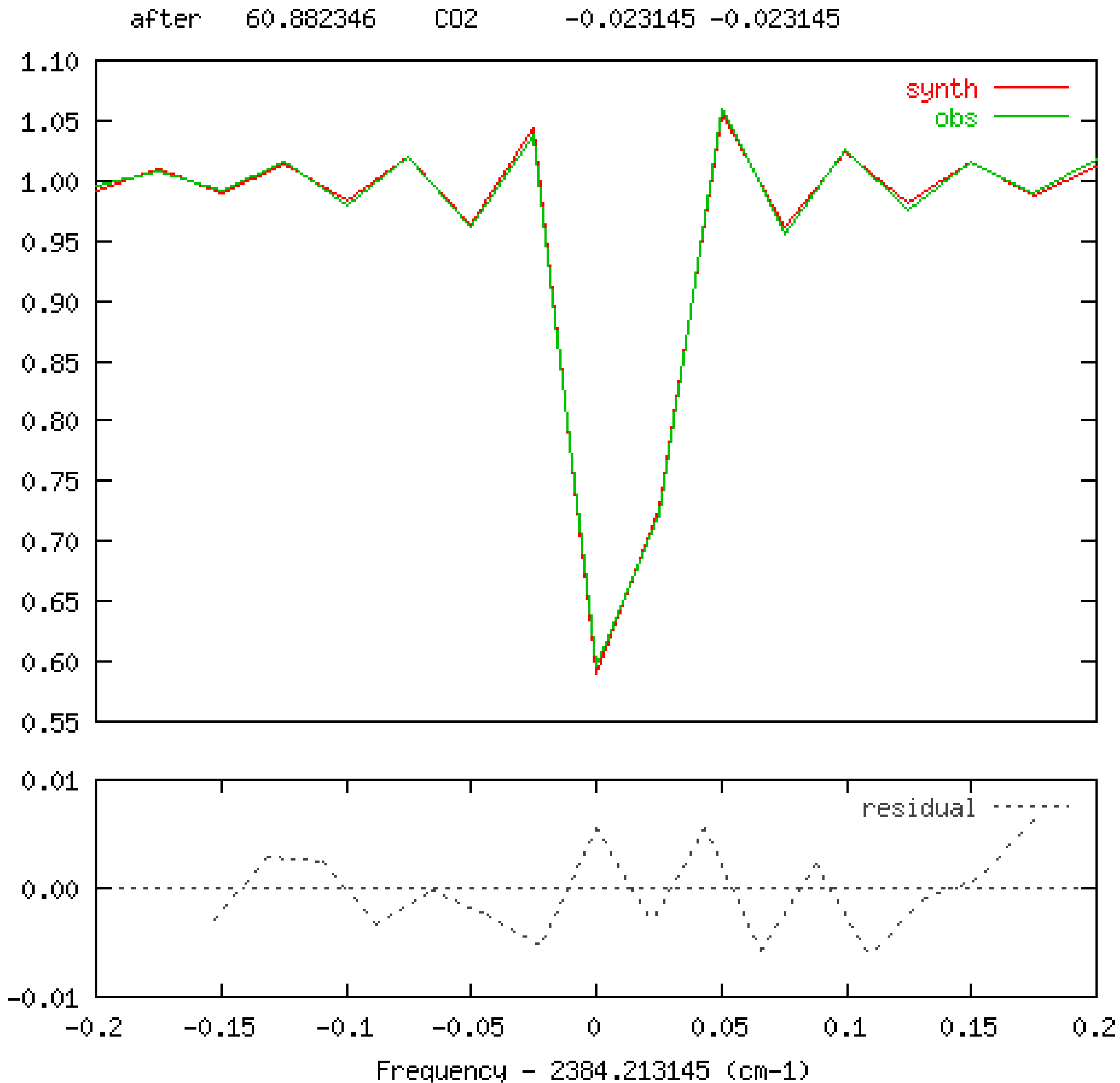
All can be measured by solar occultation IR spectroscopy.

ACE-FTS CO_2 line near 61 km

ACE-FTS measures CO_2, main greenhouse gas, but…

Temperature from relative CO_2 line intensities; pressure from CO_2 line absorption, assuming a constant CO_2 concentration.

Note: results are plotted on the raw measurement grid (unapodized).



Average CO_2 Profile 60-100 km

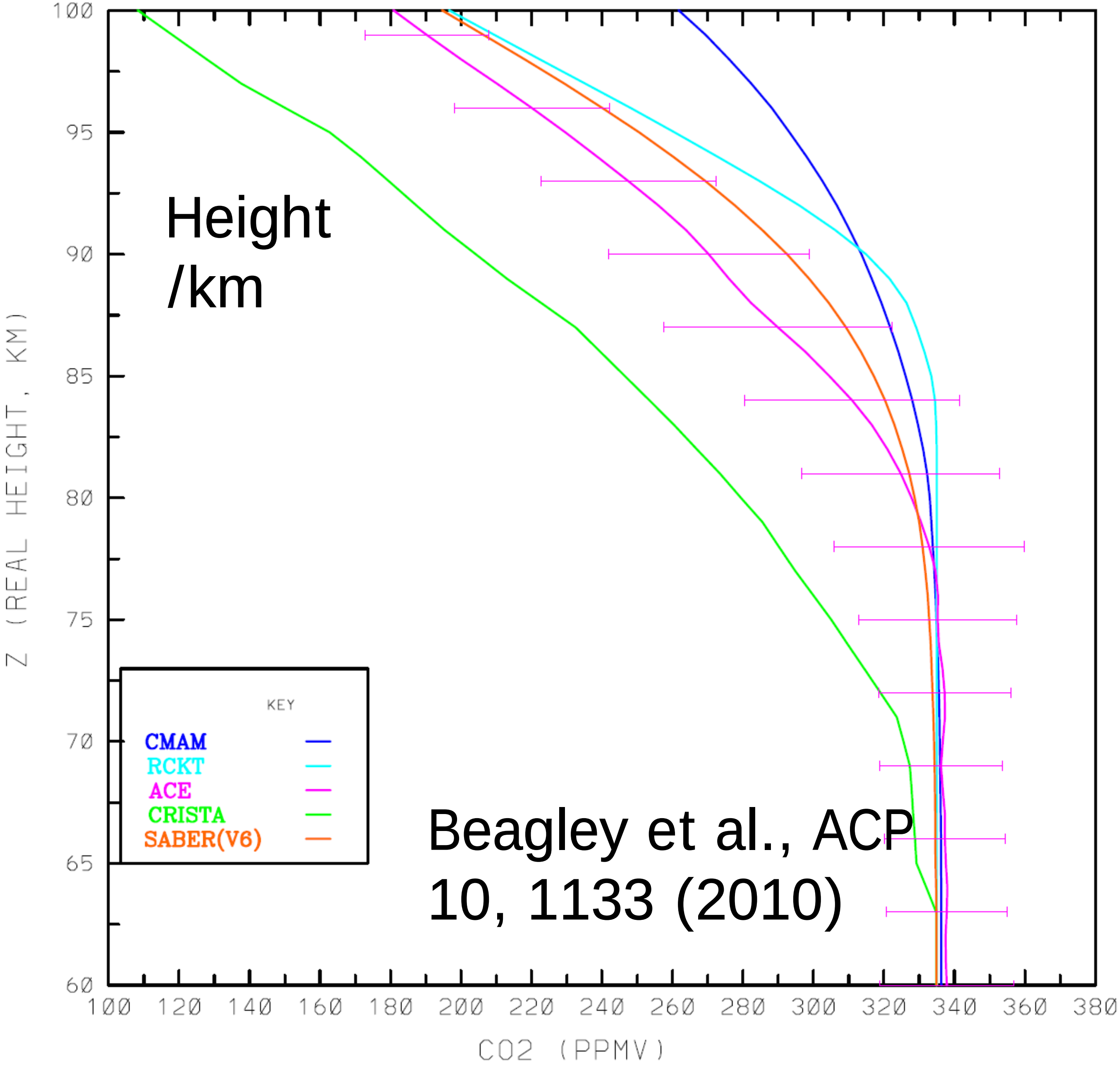
CO_2 Mystery:

$CO_2 + h\nu \rightarrow CO + O$

ACE profile (purple) does not agree with CMAM model (blue)

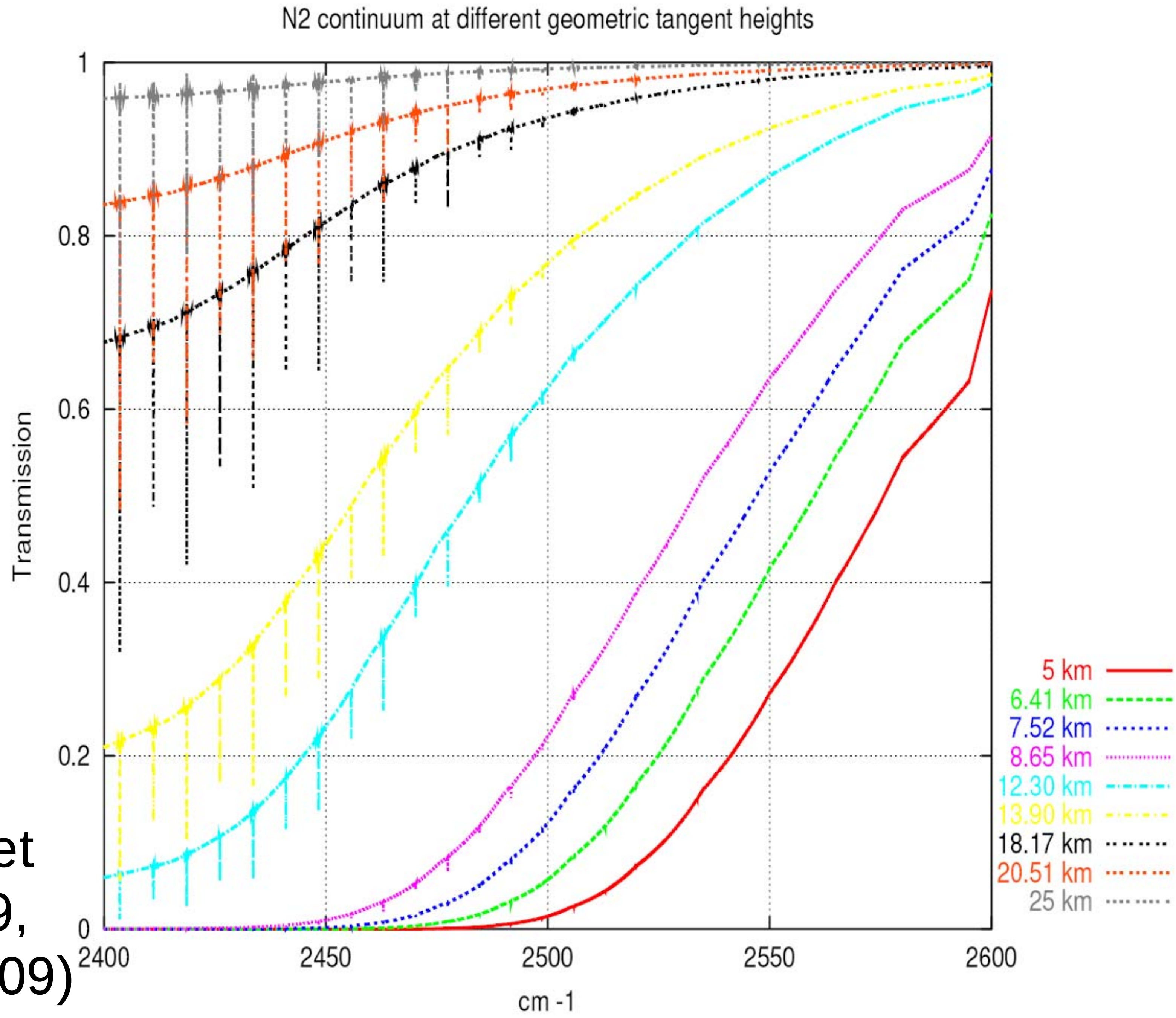
Good agreement for CO, however.

Not clear where has CO_2 gone. Perhaps there are reactions with meteoritic dust?

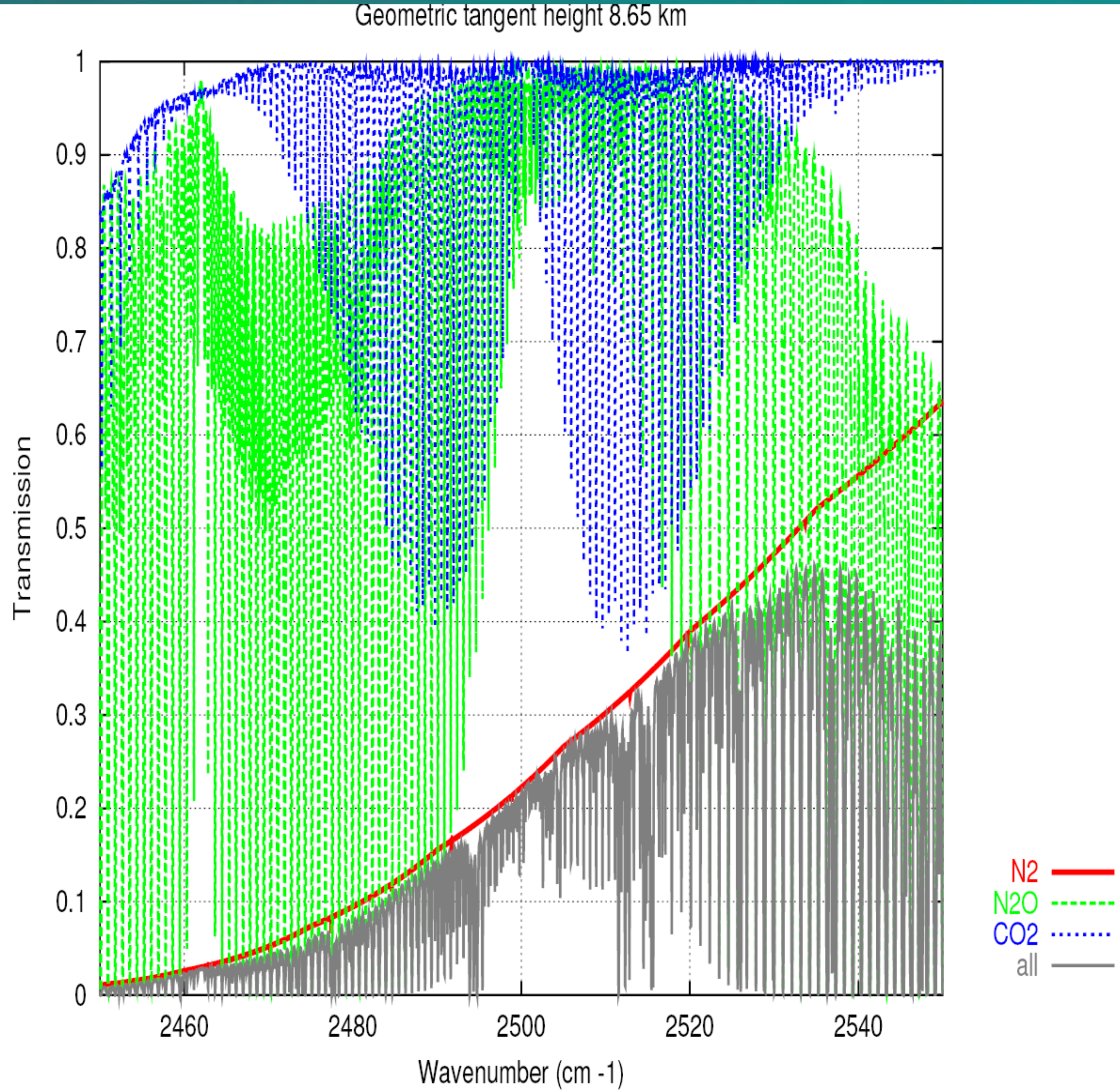


CO_2 Profiles from ACE-FTS

Normal ACE retrieval uses constant CO_2 VMR to get T, p and tangent heights. Use N_2 continuum instead and then retrieve CO_2 VMR in 5-25 km altitude range.

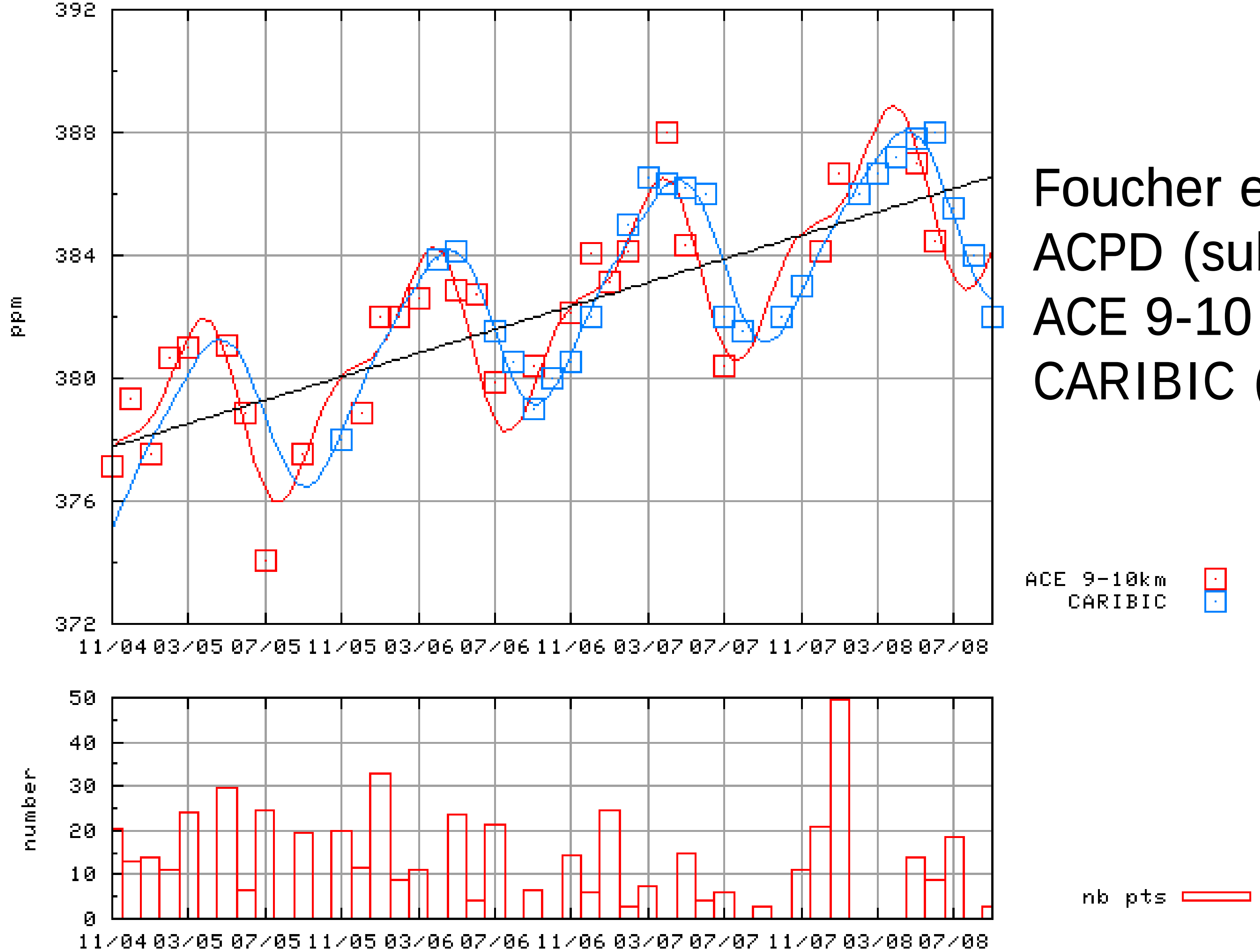


Foucher et al., ACP 9, 2873 (2009)



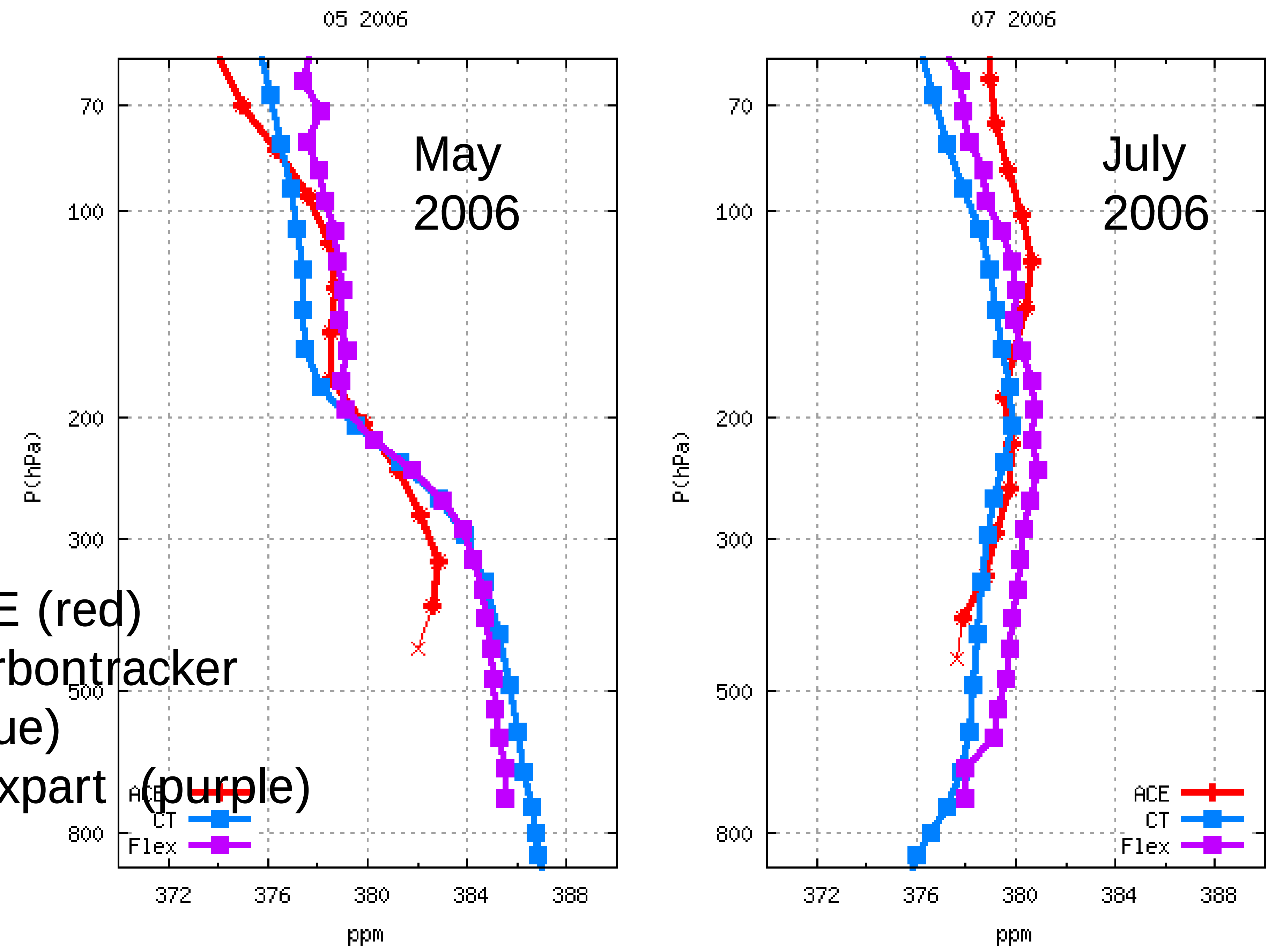
Geometric tangent height 8.65 km
Transmission
Wavenumber (cm -1)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
2460
2480
2500
2520
2540
N2
N2O
CO2
all

ACE-FTS results for the 40°N-60°N latitude band



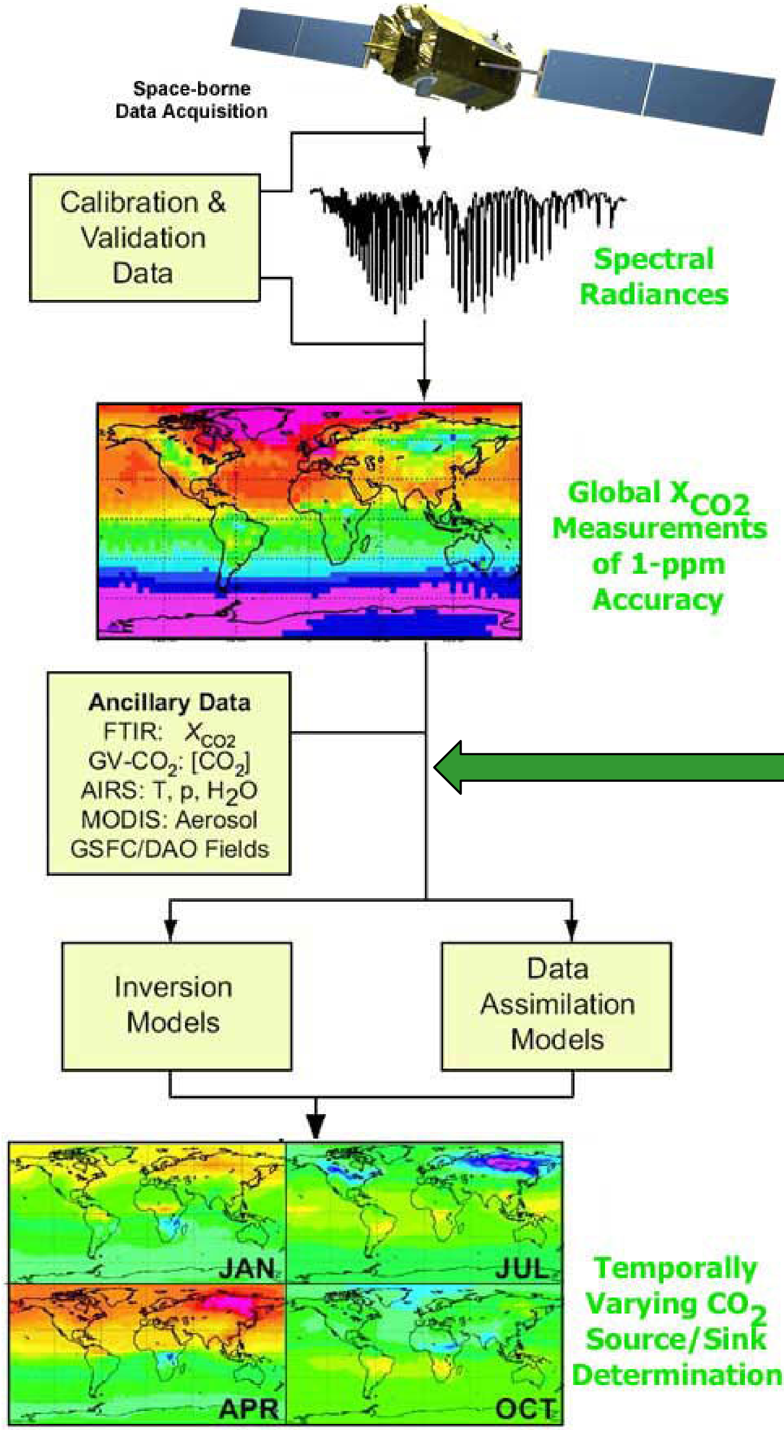
Foucher et al.
ACPD (submitted)
ACE 9-10 km (red)
CARIBIC (blue)

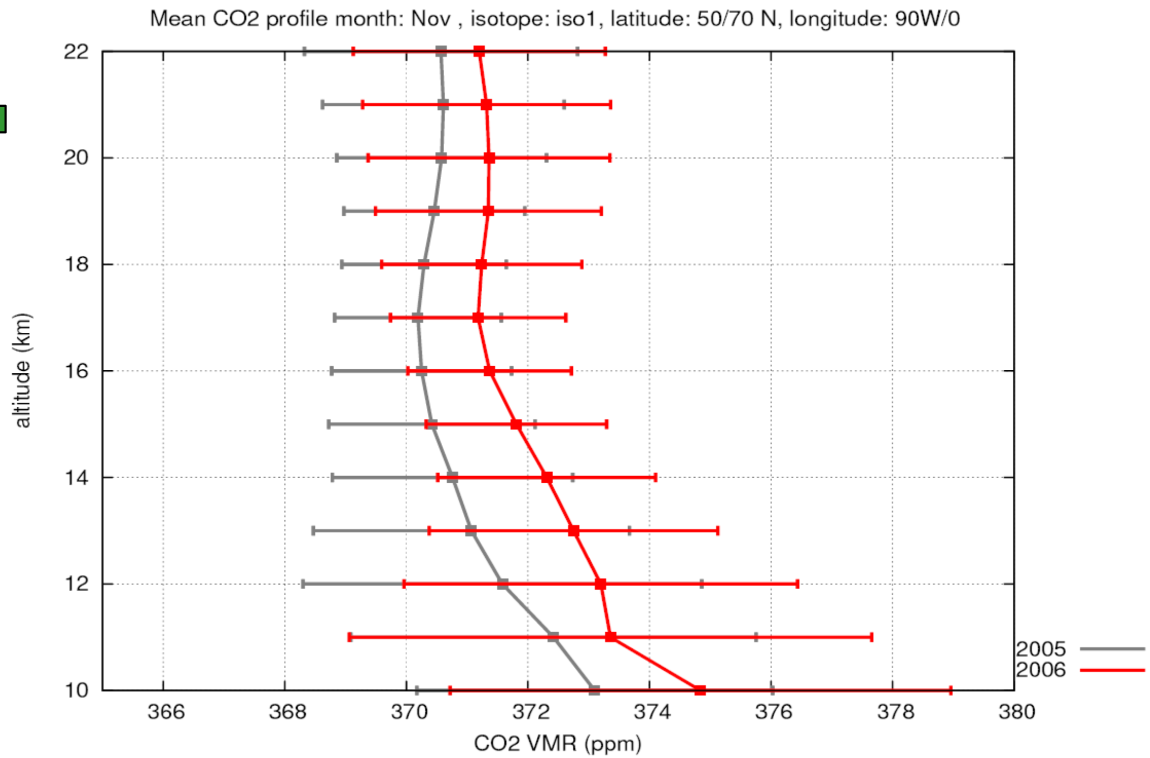
CO_2 Profiles from ACE for the 50°N-60°N latitude band



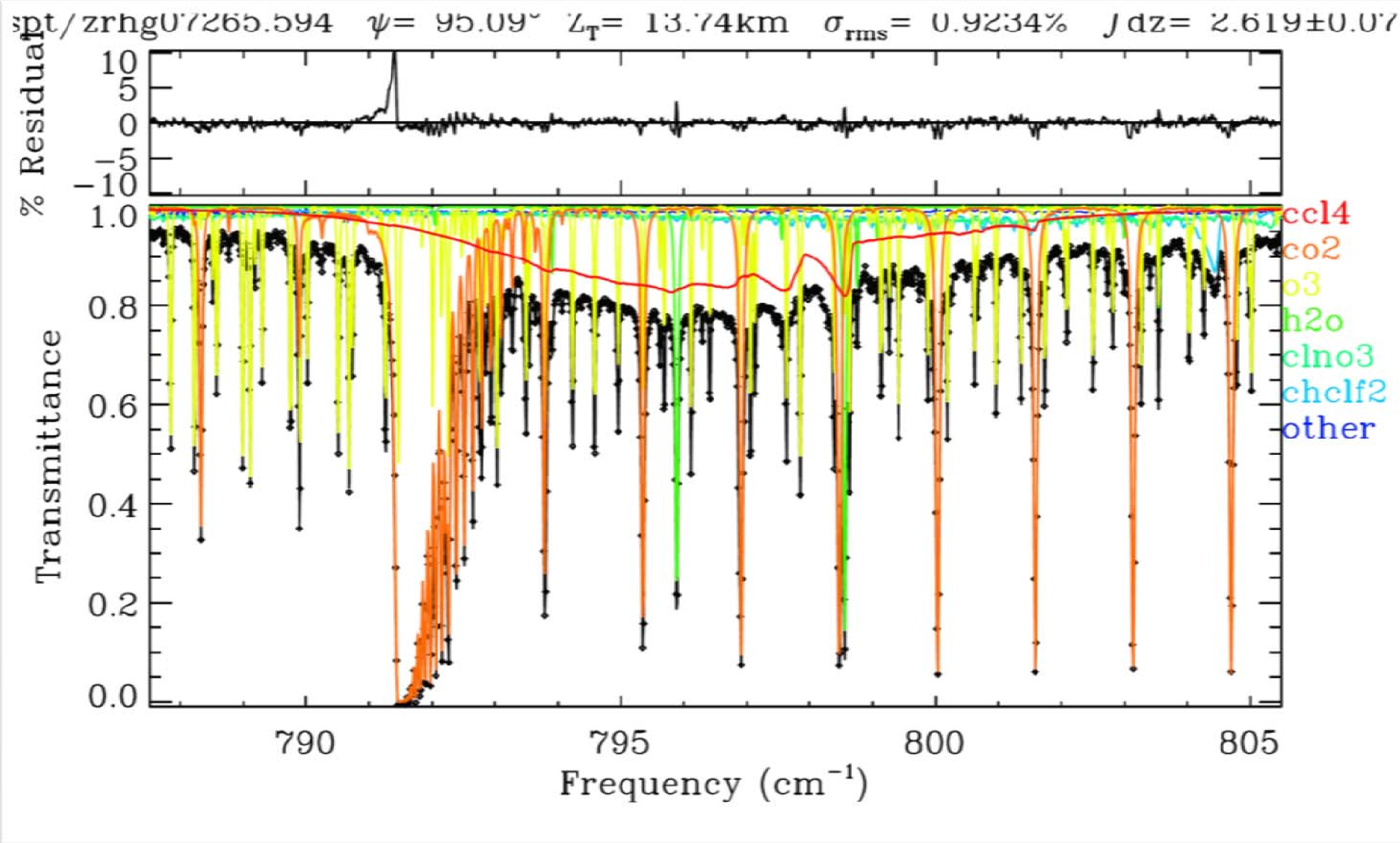
ACE (red)
Carbontracker (blue)
Flexpart (purple)

Helpful to add observed CO_2 profile information to total column observations.



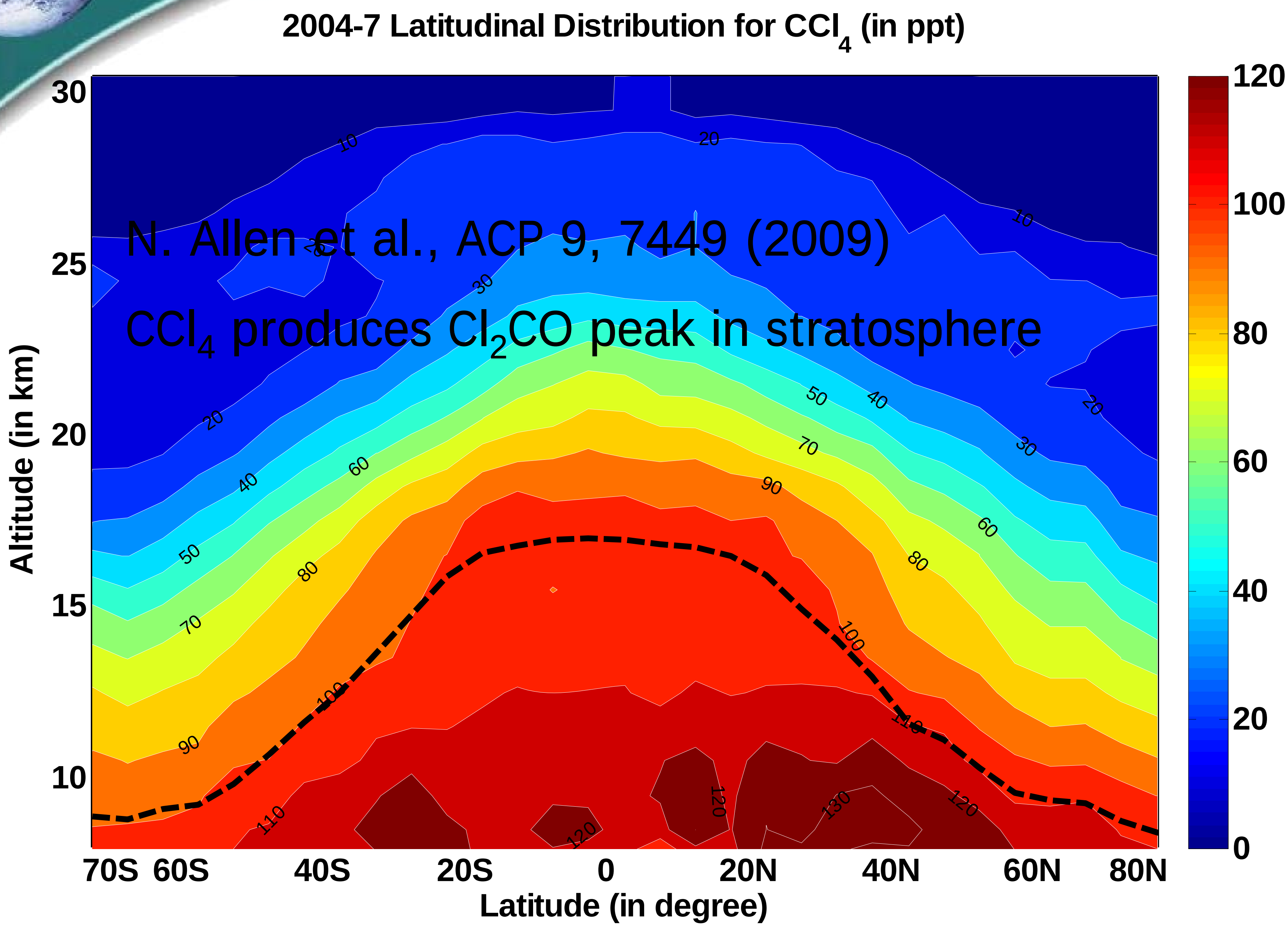


Atmospheric CCl_4



From Geoff Toon; Note line mixing in CO_2 Q-branch

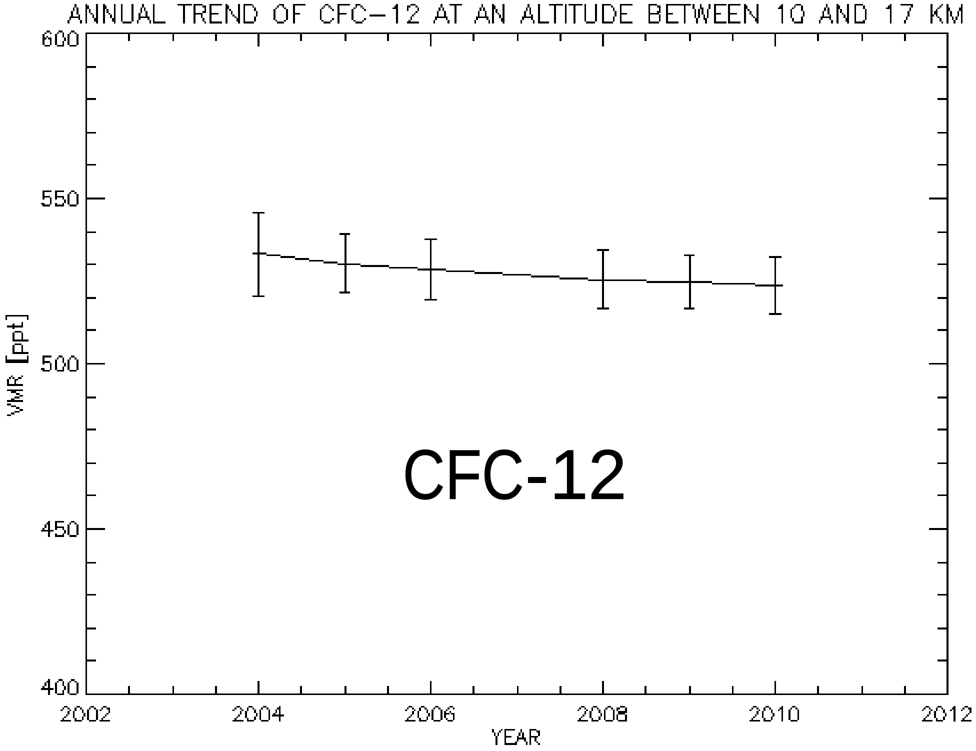
First Global CCl_4 Distribution



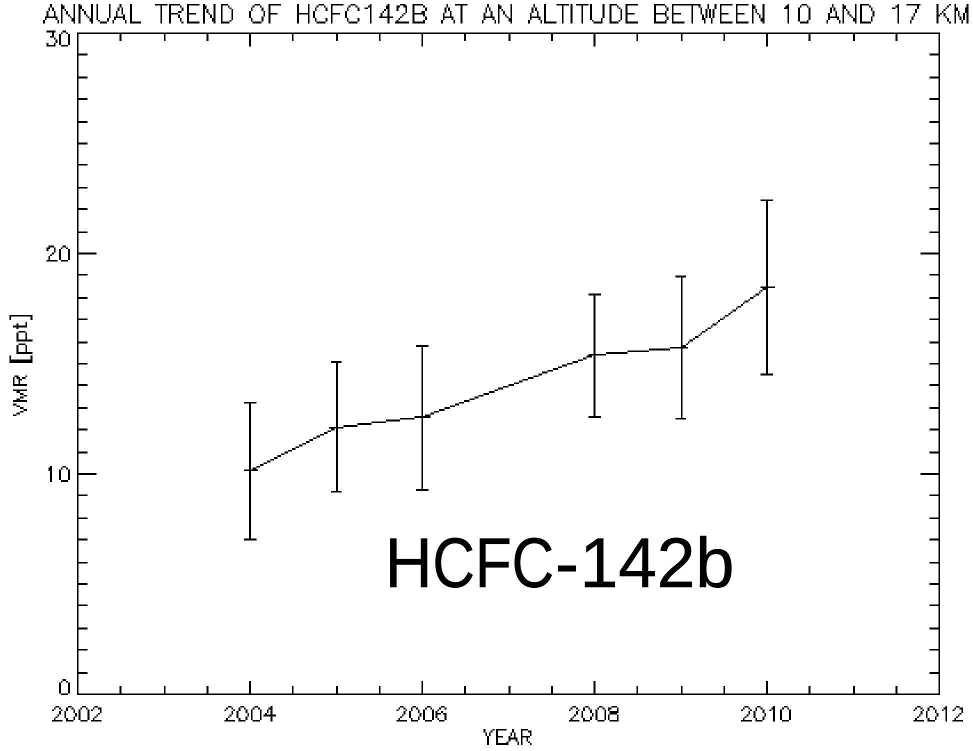
Halogen Budget and Trends

Retrievals v. 3: CFC-11, CFC-12 , CFC-113, HCFC-22, HCFC-141b, HCFC-142b, CCl_4, CH_3Cl, CF_4, SF_6, (HFC-134a), F_2CO, ClFCO, Cl_2CO, HCl, HF, $ClONO_2$, (ClO)

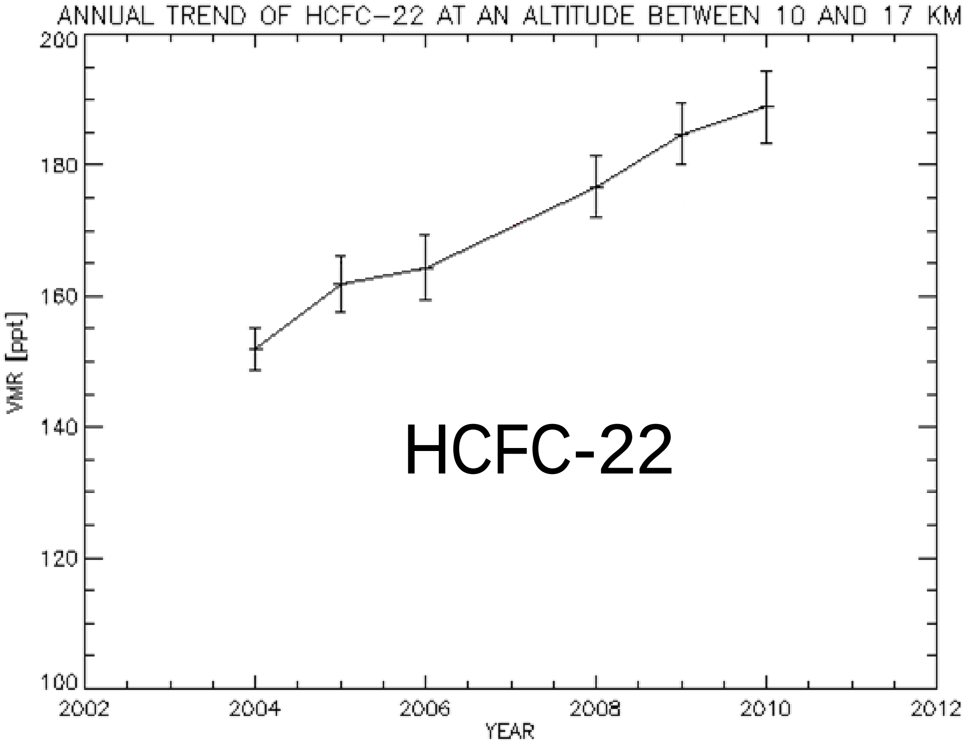
Species	Global Warming Potential (20 year time horizon)
Carbon Dioxide	1
Methane	72
Nitrous Oxide	289
CFC - 11	6,730
CFC - 12	11,000
CFC - 113	6,540
Carbon Tetrachloride	2,700
HCFC - 22	5,160
HCFC - 141b	2,250
HCFC - 142b	5,490
HFC - 134a	3,830
Sulphur Hexafluoride	16,300
Carbon Tetrafluoride (PFC - 14)	5,210



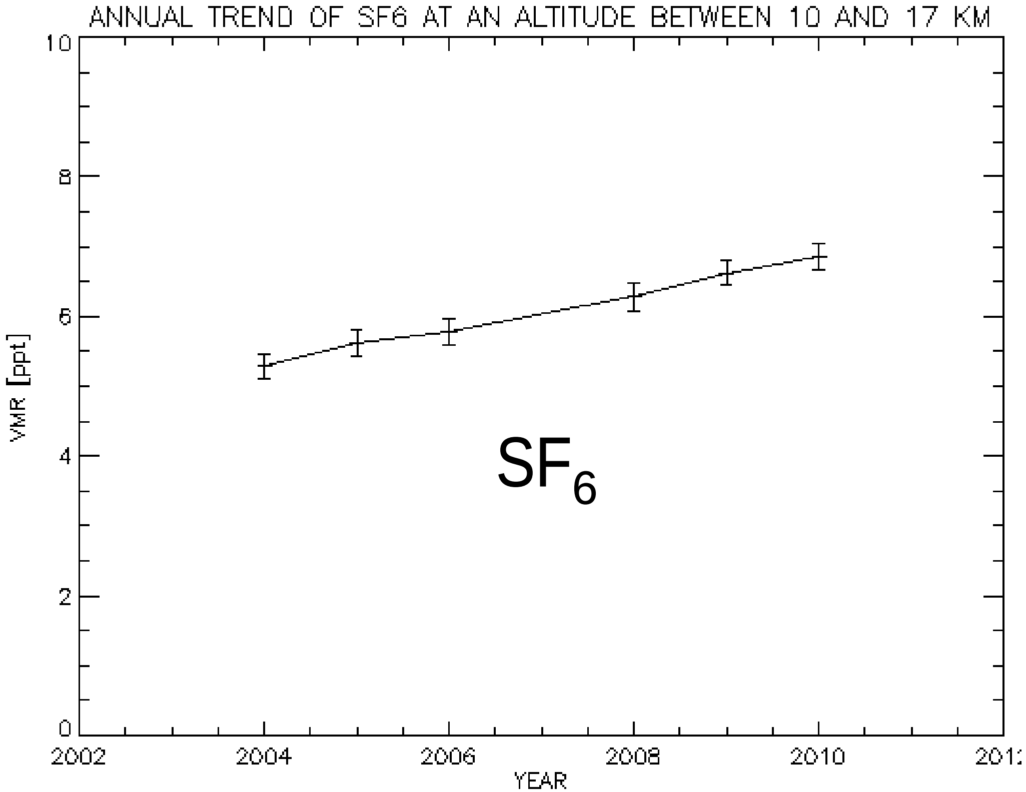
ANNUAL TREND OF CFC−12 AT AN ALTITUDE BETWEEN 10 AND 17 KM
VMR [ppt]
YEAR
CFC-12



ANNUAL TREND OF HCFC142B AT AN ALTITUDE BETWEEN 10 AND 17 KM
VMR [ppt]
YEAR
HCFC-142b



ANNUAL TREND OF HCFC−22 AT AN ALTITUDE BETWEEN 10 AND 17 KM
VMR [ppt]
YEAR
HCFC-22



ANNUAL TREND OF SF6 AT AN ALTITUDE BETWEEN 10 AND 17 KM
VMR [ppt]
YEAR
SF_6

Air Quality and Biomass Burning

Atmospheric Dynamics: Asian Summer Monsoon Anticyclone

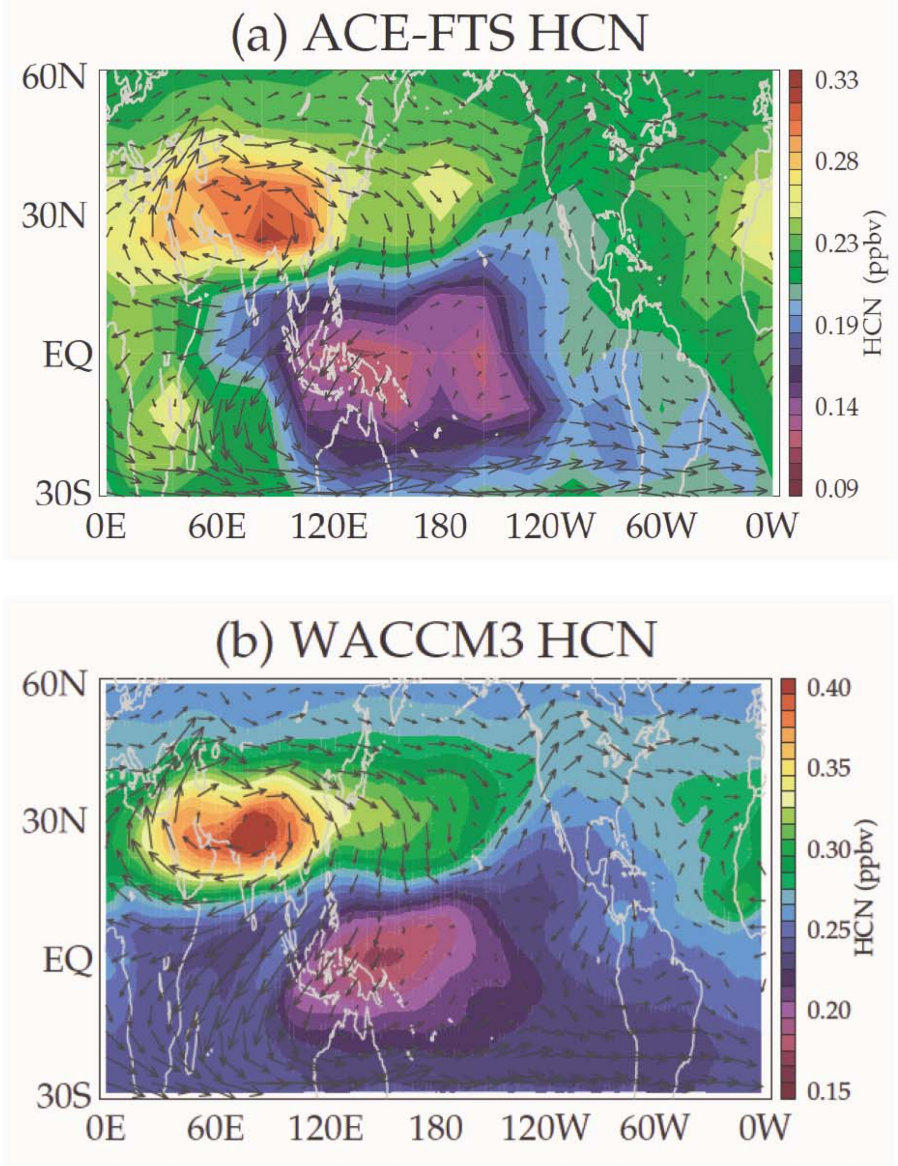
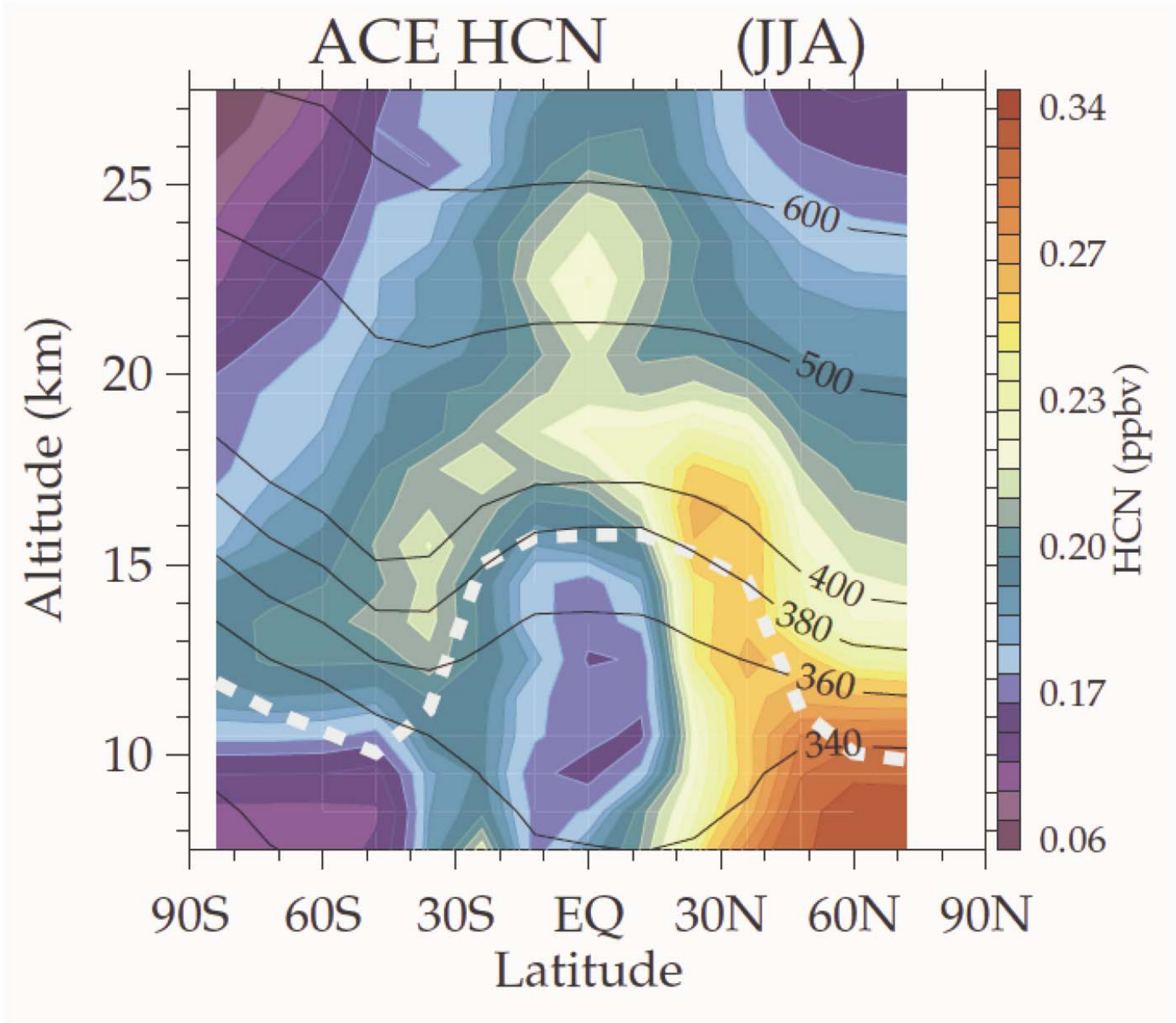


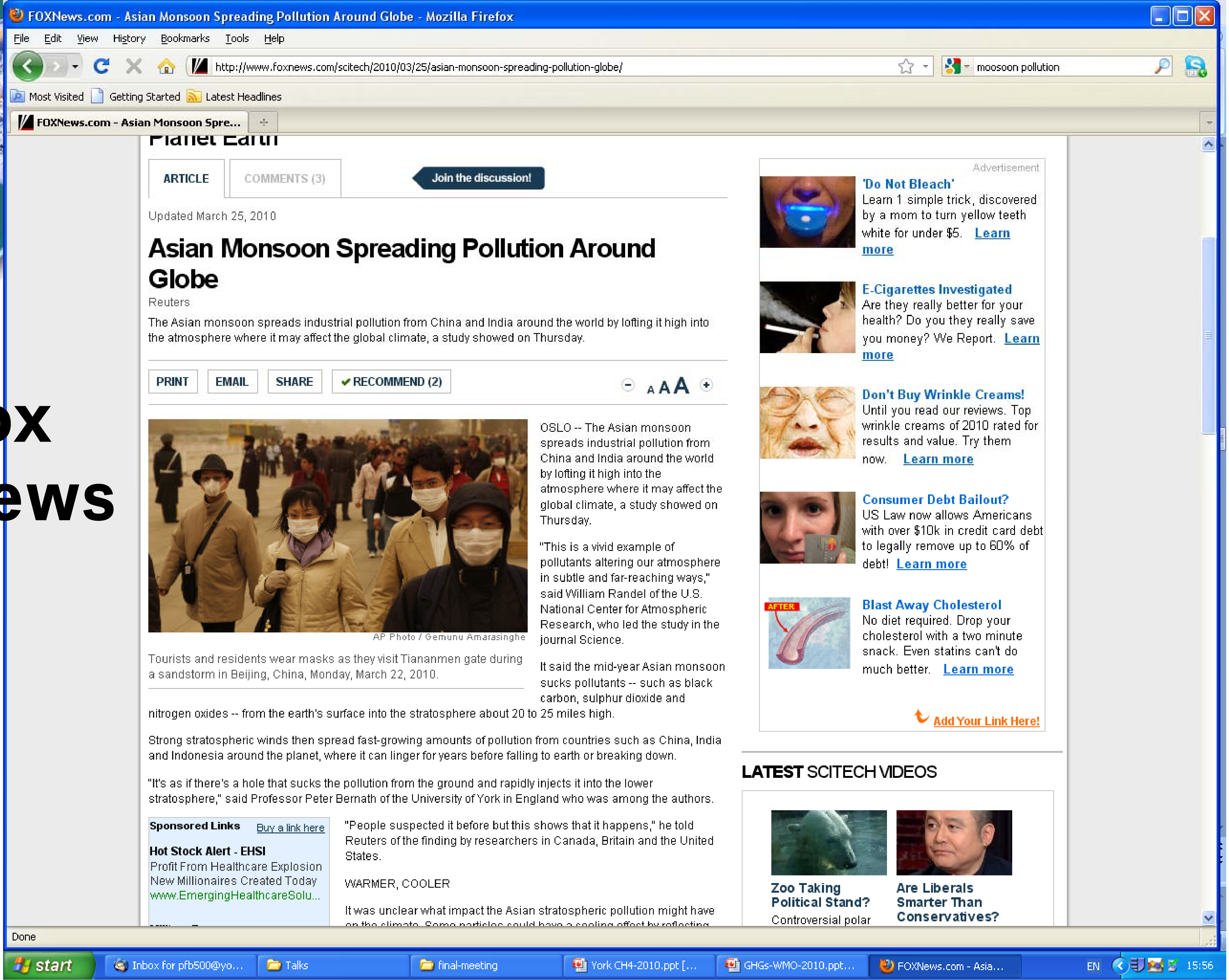
Figure 1. Time average mixing ratio (ppbv) of hydrogen cyanide (HCN) near 13.5 km during boreal summer (June-August) derived from (a) ACE-FTS observations during 2004-2008, and (b) WACCM chemical transport model calculations. Arrows in both panels denote winds at this level derived from meteorological analysis, showing that the HCN maximum is linked with the upper tropospheric Asian monsoon anticyclone.

At 13.5 km in altitude, HCN is high over Tibet because of rapid lofting of polluted air from India and China during summer; it is lower over the Pacific Ocean because of deposition and destruction in the ocean. Randel et al., Science 328, 611 (2010).



2. Time and zonal average mixing ratio (ppbv) of hydrogen cyanide (HCN) during boreal summer (June-August) derived from ACE-FTS satellite measurements. The white dashed line denotes the tropopause, and black lines denote isentropic levels.

Fox News



Planet Earth

ARTICLE COMMENTS (3) Join the discussion!

Updated March 25, 2010

Asian Monsoon Spreading Pollution Around Globe

Reuters

The Asian monsoon spreads industrial pollution from China and India around the world by lofting it high into the atmosphere where it may affect the global climate, a study showed on Thursday.

PRINT EMAIL SHARE RECOMMEND (2)

AP Photo / Gemunu Amarasinghe

Tourists and residents wear masks as they visit Tiananmen gate during a sandstorm in Beijing, China, Monday, March 22, 2010.

OSLO -- The Asian monsoon spreads industrial pollution from China and India around the world by lofting it high into the atmosphere where it may affect the global climate, a study showed on Thursday.

"This is a vivid example of pollutants altering our atmosphere in subtle and far-reaching ways," said William Randel of the U.S. National Center for Atmospheric Research, who led the study in the journal Science.

It said the mid-year Asian monsoon sucks pollutants -- such as black carbon, sulphur dioxide and nitrogen oxides -- from the earth's surface into the stratosphere about 20 to 25 miles high.

Strong stratospheric winds then spread fast-growing amounts of pollution from countries such as China, India and Indonesia around the planet, where it can linger for years before falling to earth or breaking down.

"It's as if there's a hole that sucks the pollution from the ground and rapidly injects it into the lower stratosphere," said Professor Peter Bernath of the University of York in England who was among the authors.

"People suspected it before but this shows that it happens," he told Reuters of the finding by researchers in Canada, Britain and the United States.

WARMER, COOLER

It was unclear what impact the Asian stratospheric pollution might have

LATEST SCITECH VIDEOS

Zoo Taking Political Stand?
Controversial polar

Are Liberals Smarter Than Conservatives?

ACE Partners (Selected)

- Canada- K. Walker, J. Drummond, K. Strong, J. McConnell, W. Evans, T. McElroy, I. Folkins, R. Martin, J. Sloan, T. Shepherd, T. Llewellyn, etc.
- USA- NASA launched ACE: C. Rinsland, L. Thomason (NASA-Langley), C. Randall (U. Colorado), M. Santee, L. Froidevaux, G. Toon, G. Manney (JPL), etc.
- Belgium- supplied CMOS imager chips: R. Colin, P.-F. Coheur, M. Carleer (ULB), D. Fussen, M. DeMaziere (IASB), M. Mahieu, R. Zander (Liege), etc.
- UK- J. Remedios (Leicester), P. Palmer (Edinburgh), M. Chipperfield (Leeds), etc.
- France- C. Camy-Peyret, C. Clerbaux, C. Brogniez, G. Dufour, D. Hauglustaine (Paris)
- Japan- M. Suzuki (JAXA), Y. Kasai
- Sweden- G. Witt (Stockholm)

Funding: CSA, NSERC, NERC

National Centre for Earth Observation

NATURAL ENVIRONMENT RESEARCH COUNCIL

ESA-NASA ExoMars Trace Gas Orbiter

Copy of ACE-FTS (called MATMOS) will go to Mars in 2016 to look for organic signatures of life (e.g., methane).