# Atmospheric Chemistry Experiment (ACE): Recent Results

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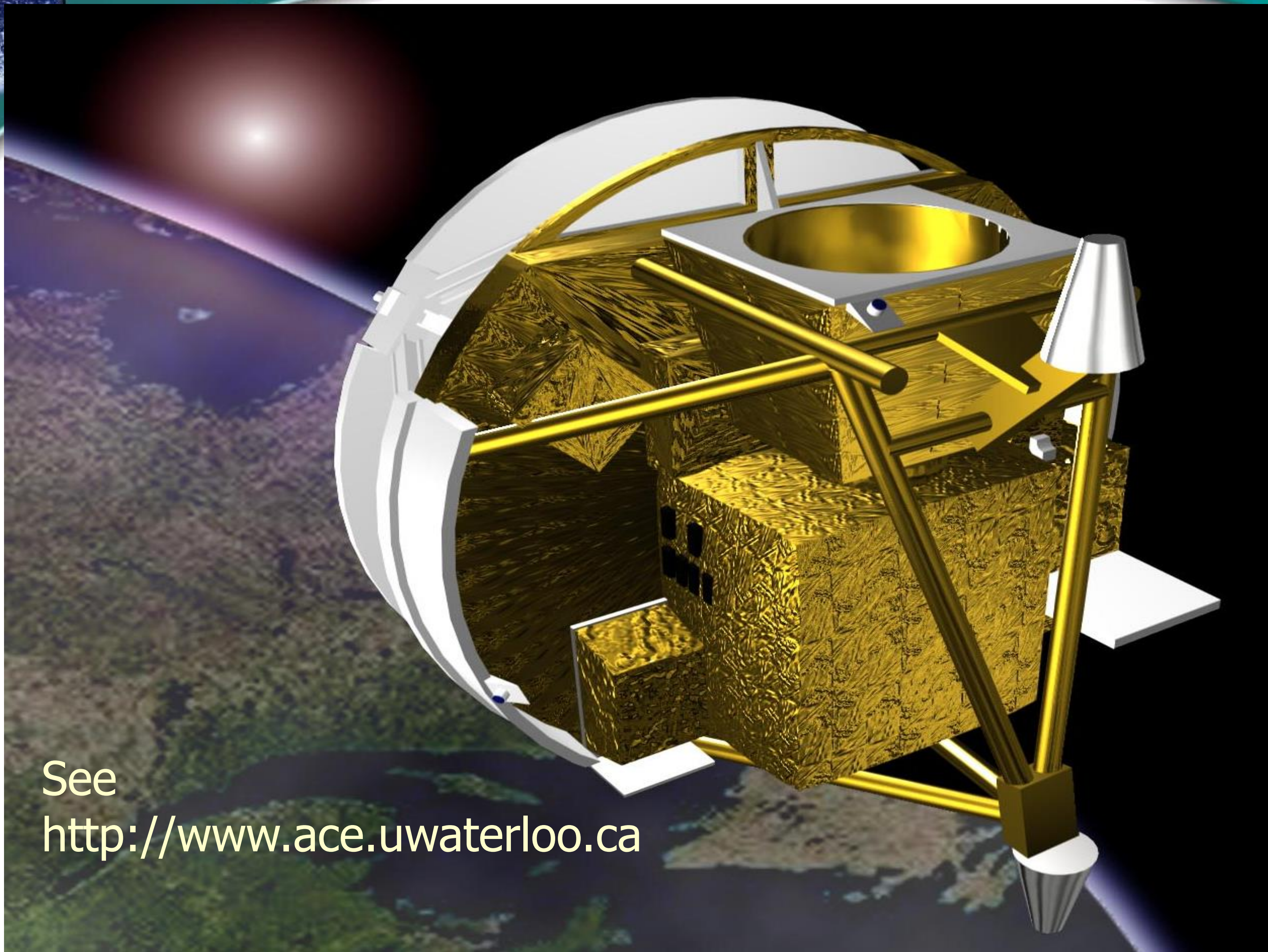
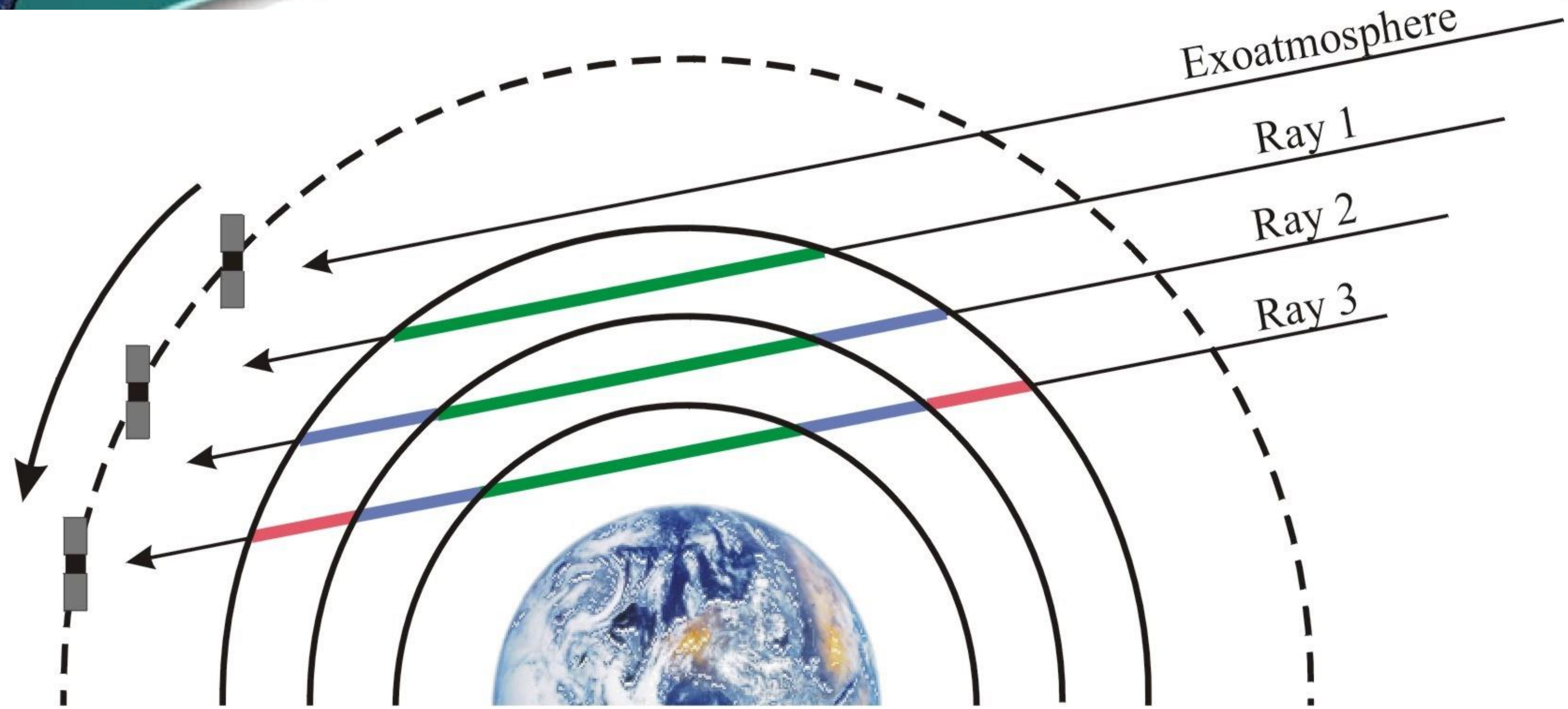
# ACE Satellite



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

# 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 <u>and</u> precision
**Disadvantages**:
Modest global coverage
Samples only free troposphere

# 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
- Feb. 2006 Arctic campaign
- Feb. 2007 Arctic campaign
- Feb. 2008 Arctic campaign

First ACE data Feb. 2004, mission currently approved to March 2010. Mission had a 2-year lifetime – fifth anniversary Aug. 2008.

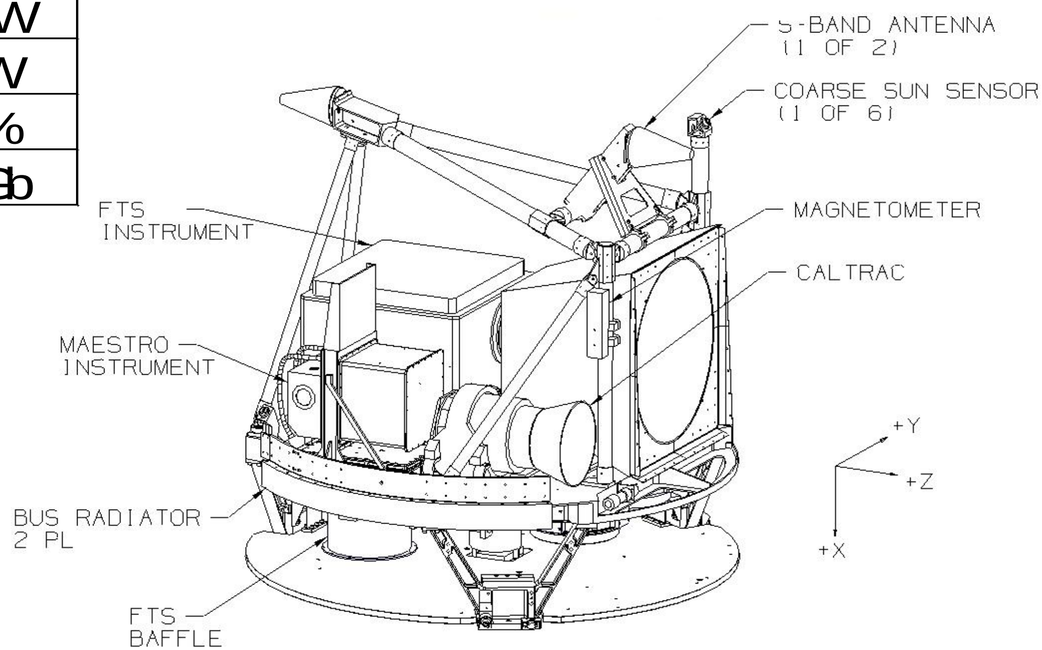
# Instruments

- 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) 0.4 to 1.03 microns, resolution ~1-2 nm
- Startracker

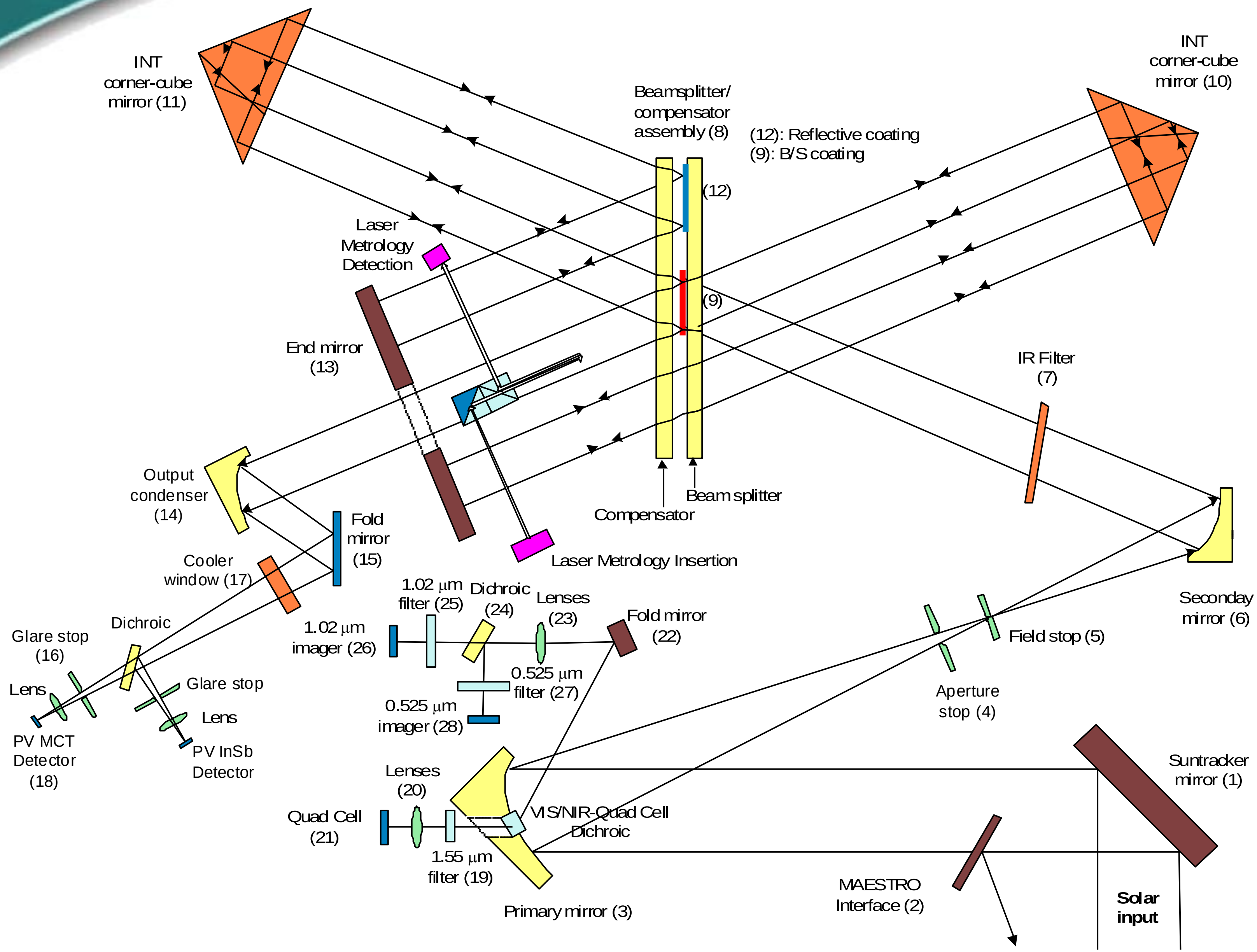
Bernath et al. GRL, 32, L15S01 (2005)

# SCISAT-1 Spacecraft (Bristol)

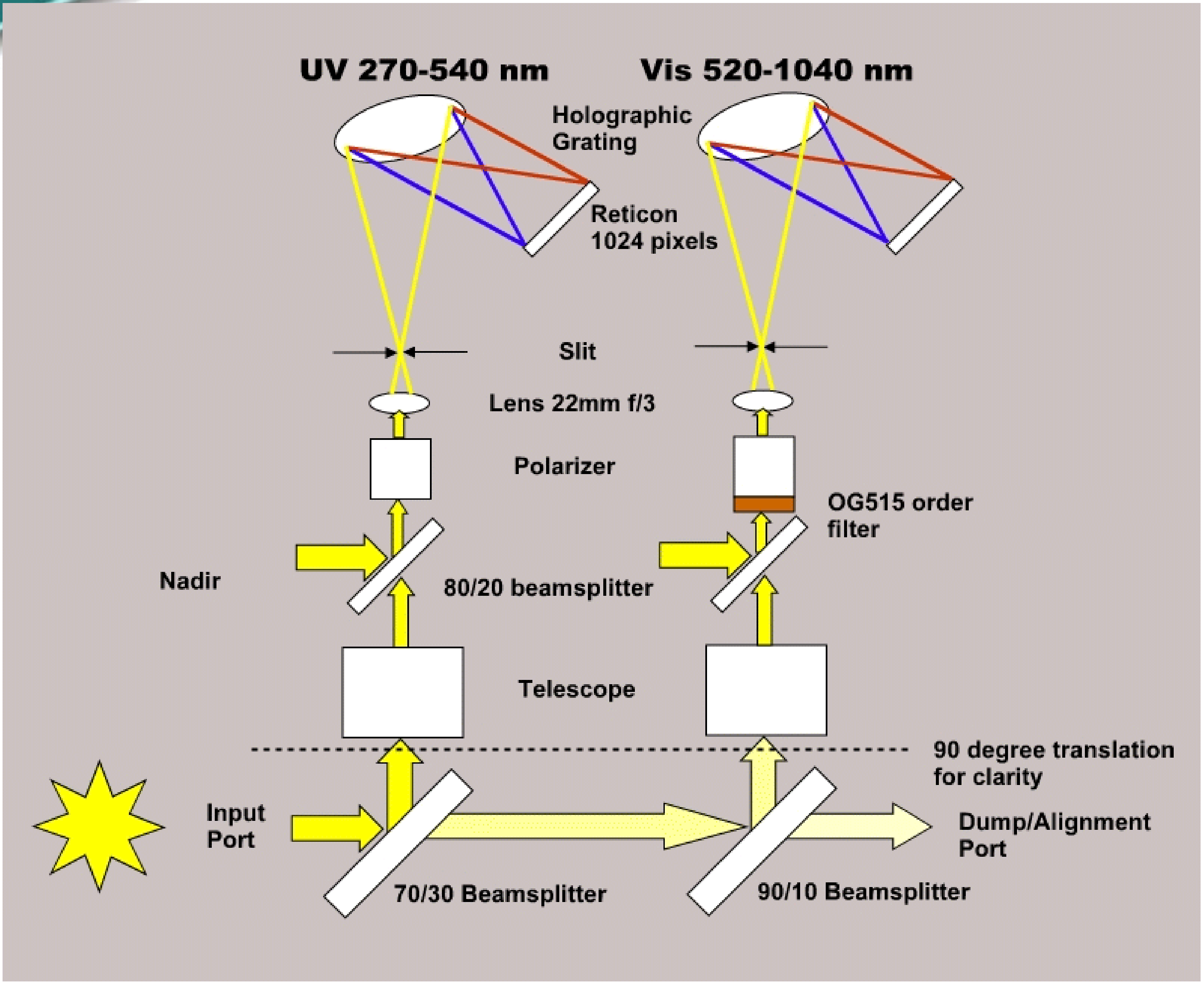
| Key Specifications | |
|---|---|
| Spacecraft diameter | 112 cm |
| Spacecraft mass | 152 kg |
| Pointing control: | |
| Pitch/yaw ($3\sigma$) | $\pm 0.2^{o}$ |
| Roll ($3\sigma$) | $\pm 0.7^{o}$ |
| Pointing knowledge: | |
| Pitch/yaw | $\pm 0.1^{o}$ |
| Roll | $\pm 0.6^{o}$ |
| Solar array EOL power | 175 W |
| Spacecraft OA power | 75 W |
| Bus reliability (2-yrs) | 80 % |
| Mass memory | 1.5 Gb |



# Optical Layout (ABB-Bomem)



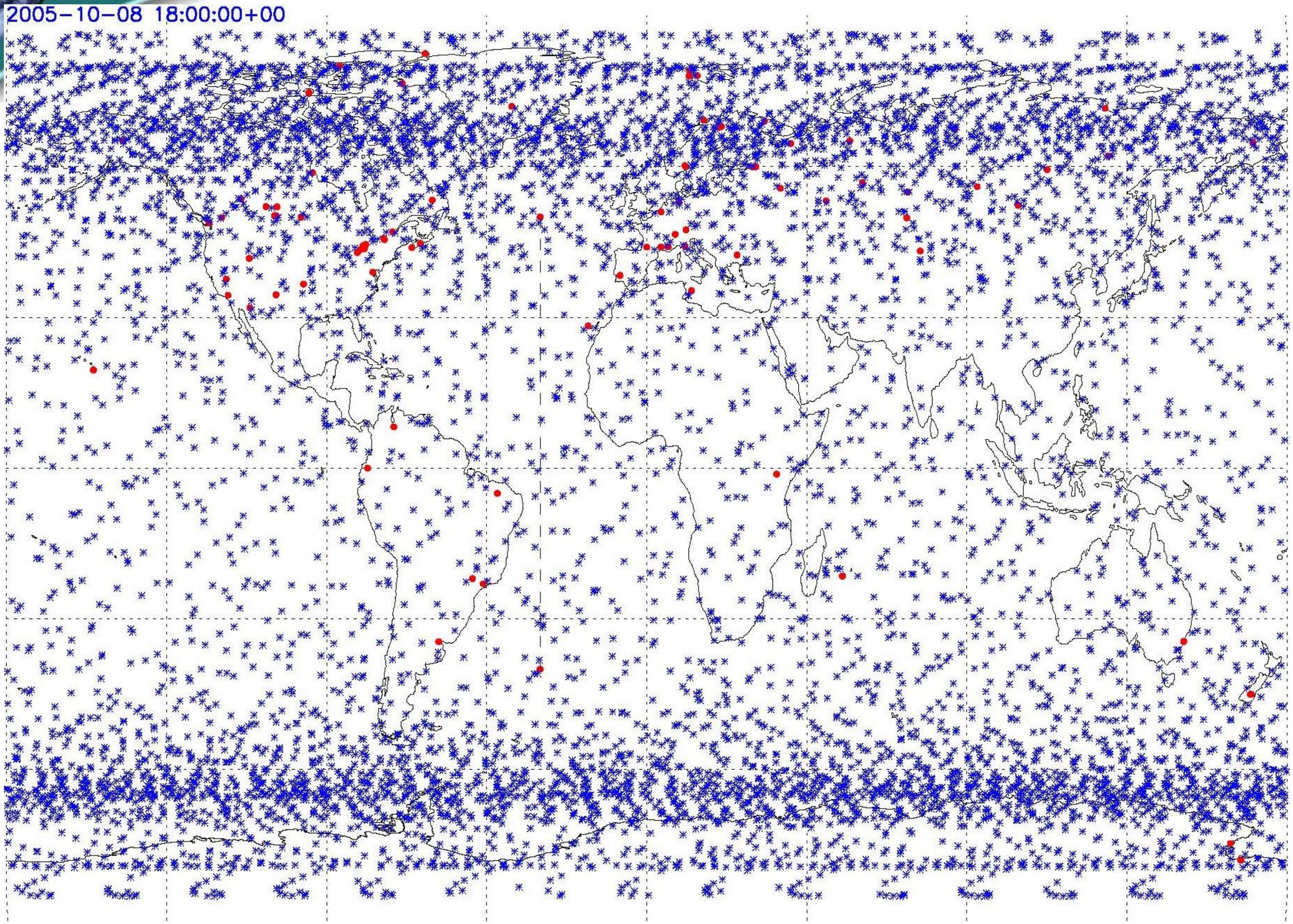
# MAESTRO



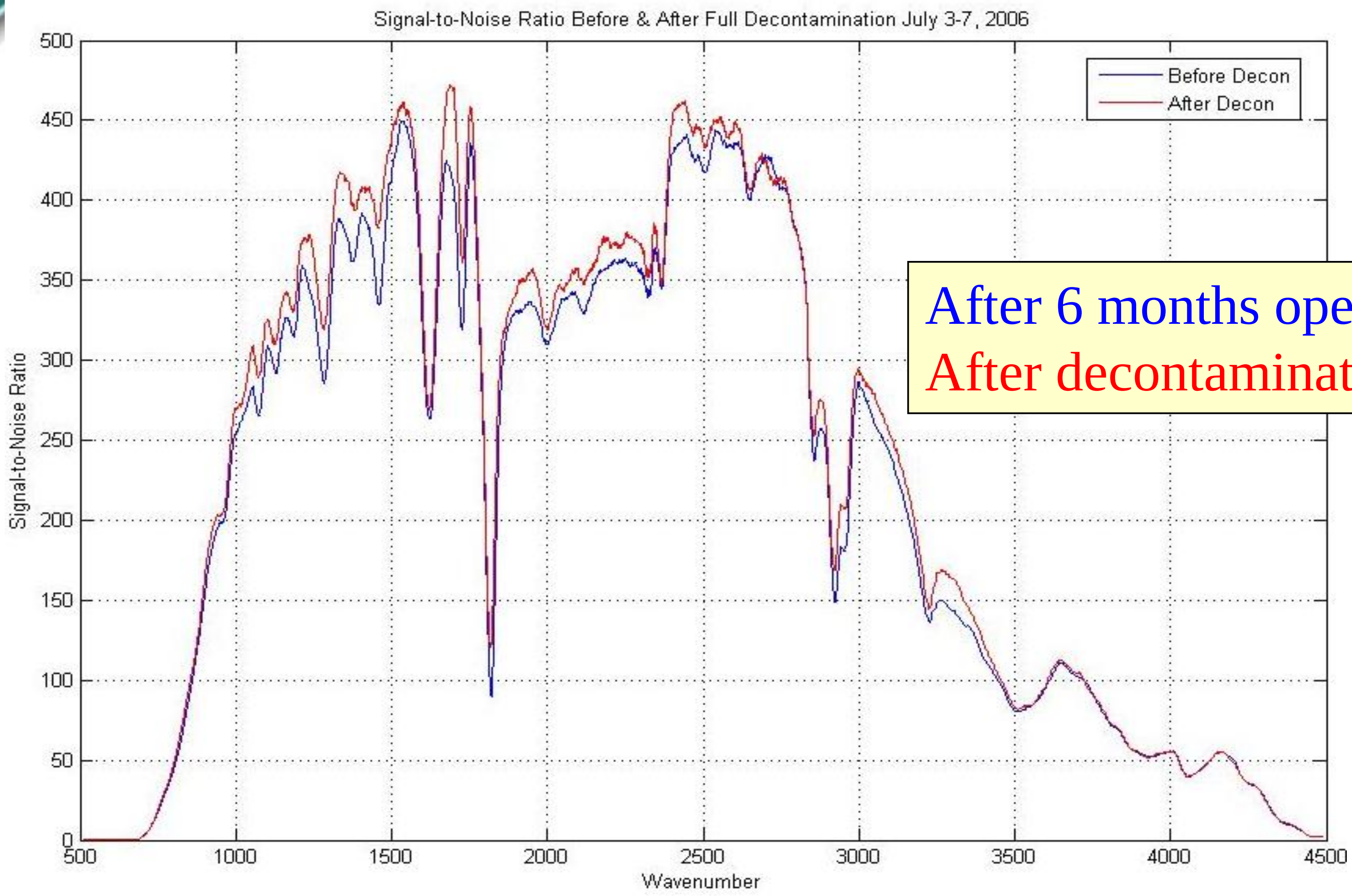

MAESTRO PI:
T. McElroy, MSC

Dual concave grating spectrograph, 1-2 nm resolution

# Global Occultation Distribution



# FTS – Decontamination Results

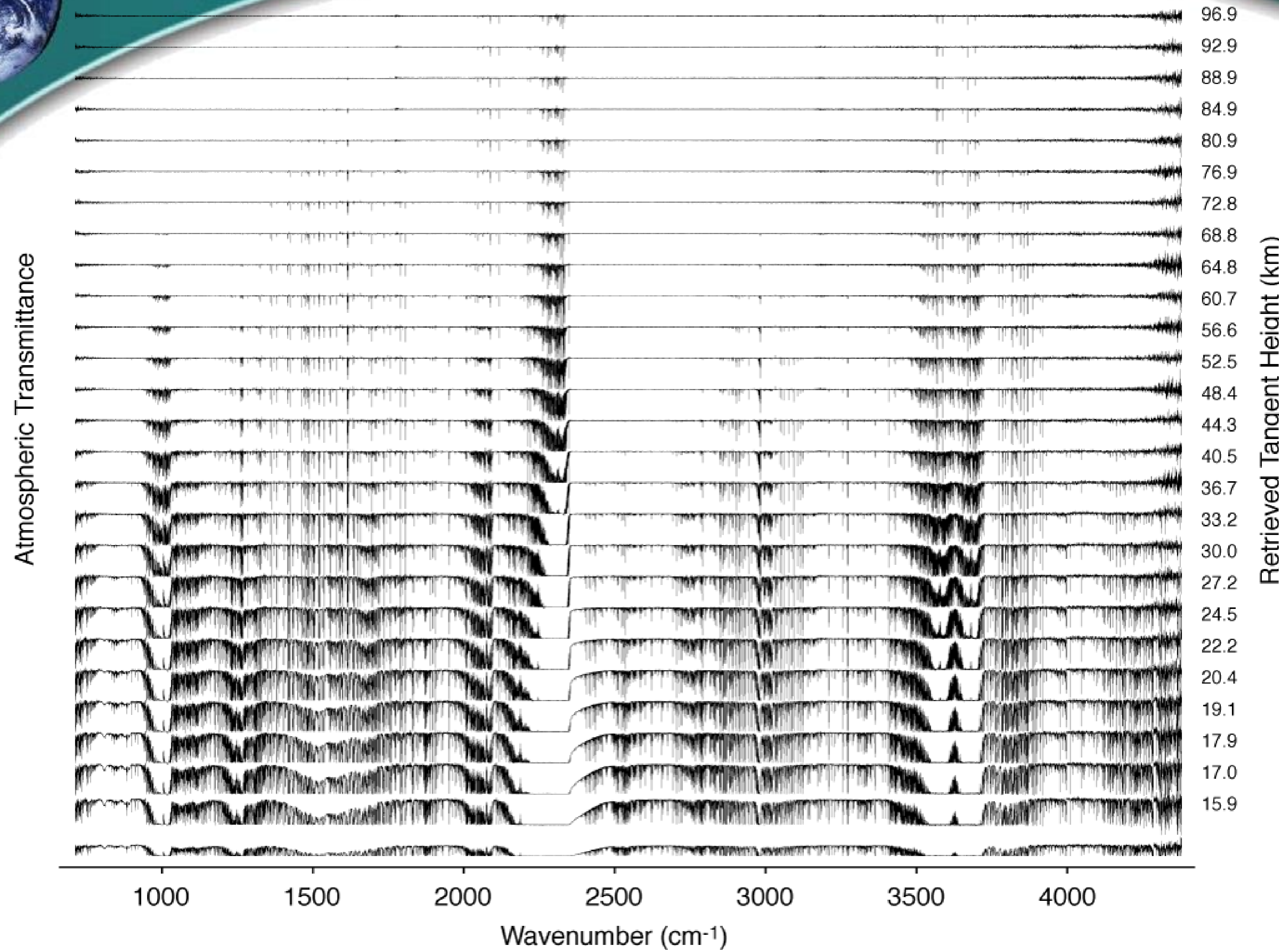



After 6 months operation

After decontamination

**Ryan Hughes**

# 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:

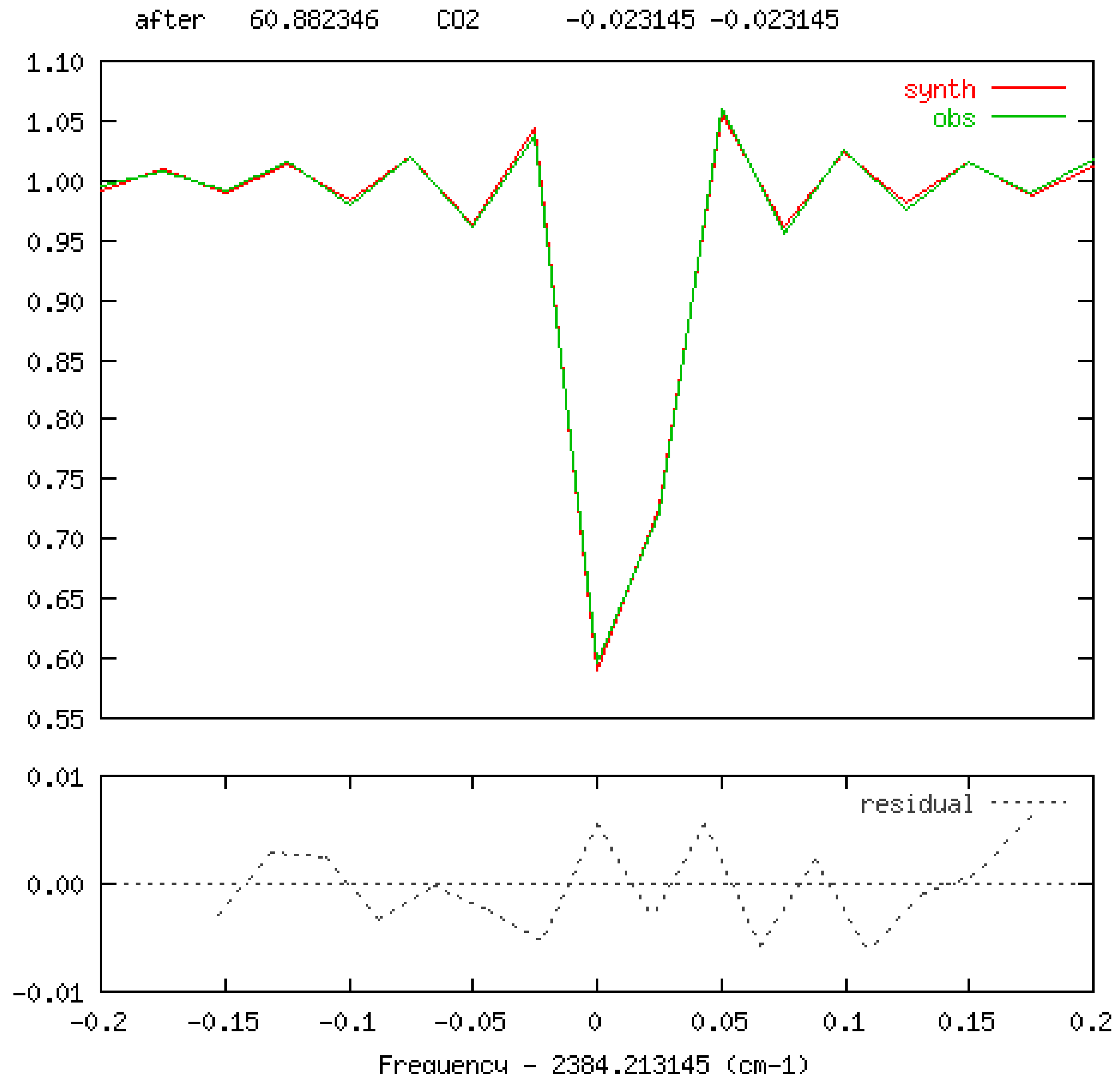
  $CCl_4$, HOCl, $H_2O_2$, $HO_2NO_2$, $CCl_2FCClF_2$, $CH_3CClF_2$, ClO, $C_2H_2$, $C_2H_6$, COFCl, $COCl_2$, $CH_3OH$, HCOOH, $H_2CO$, $N_2$ and additional isotopologues

# $CO_2$ line near 61 km

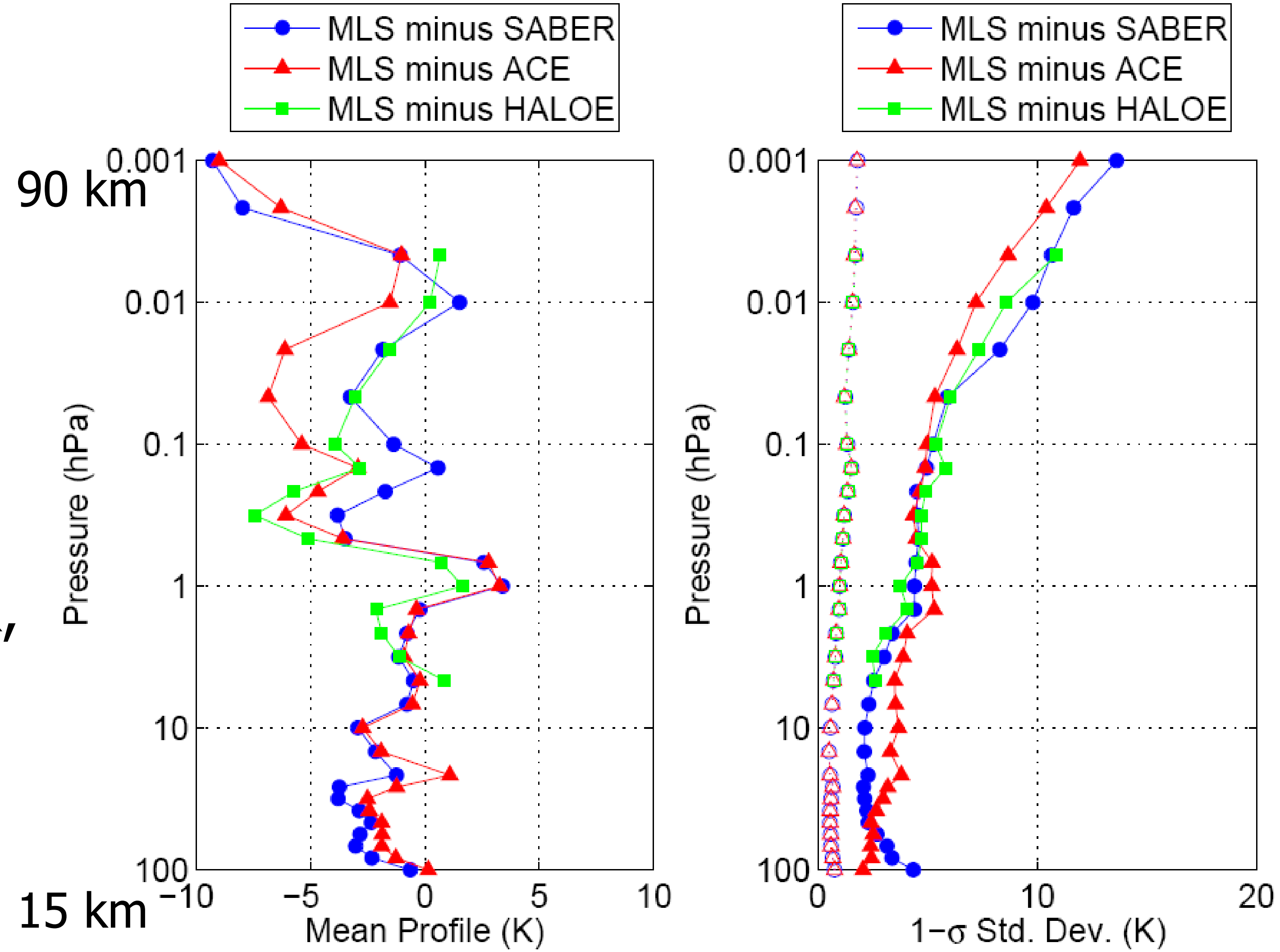
Typical ACE-FTS fitting results

Note: results are plotted on the raw measurement grid

Boone et al. Appl. Opt. 44, 7218 (2005)



# Temperature Retrievals-$CO_2$




Schwartz et al. JGR, 113, D15S11 (2008)

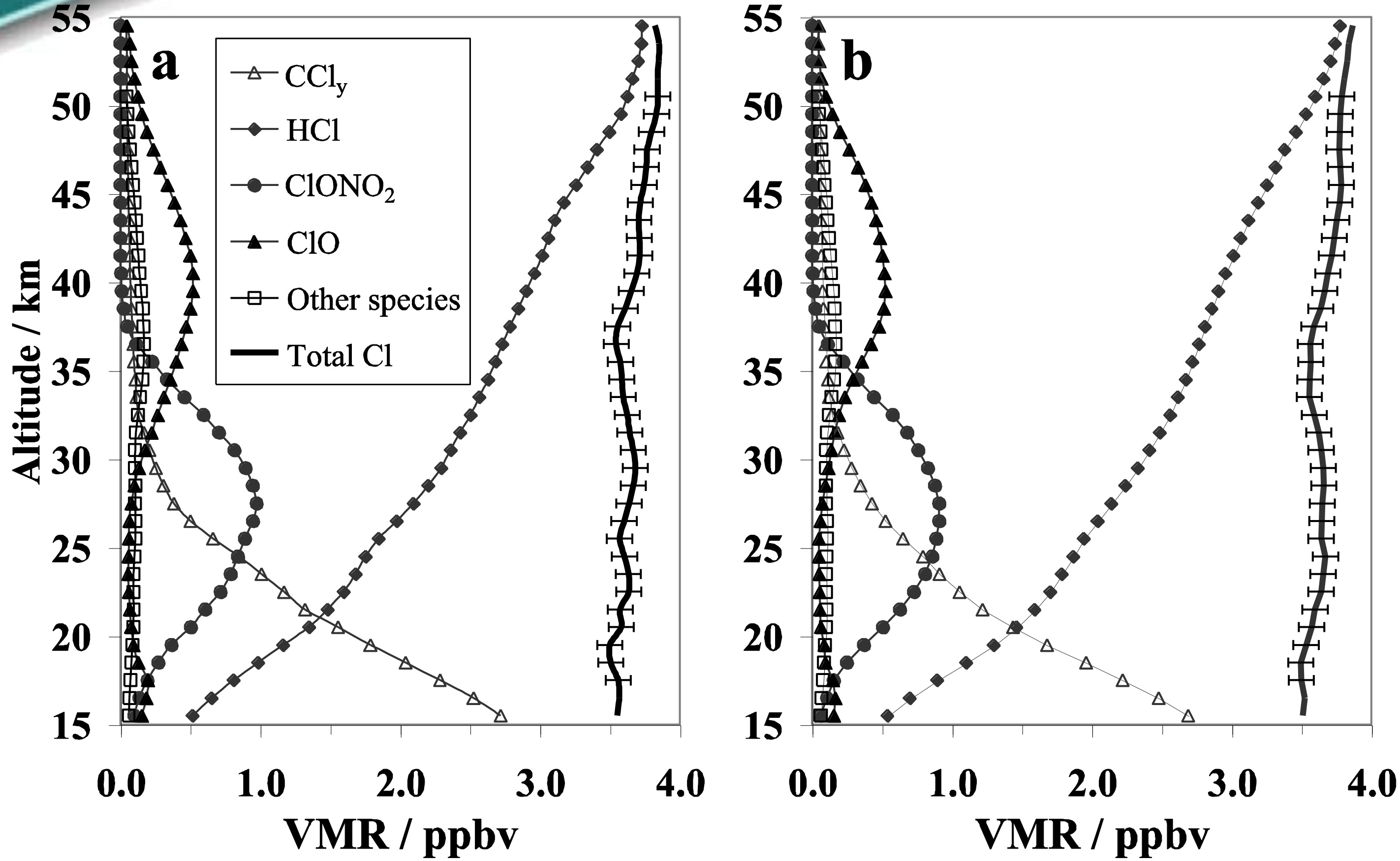
# Stratospheric Chlorine Budget

Nassar et al.

WMO Ozone Report 2006

JGR, 111, D22312 (2006)

Northern Midlatitudes | Southern Midlatitudes

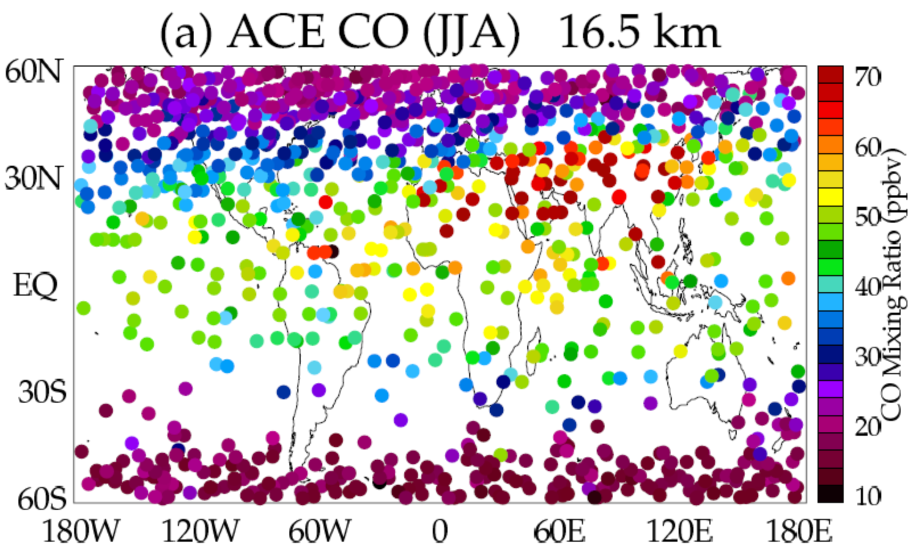


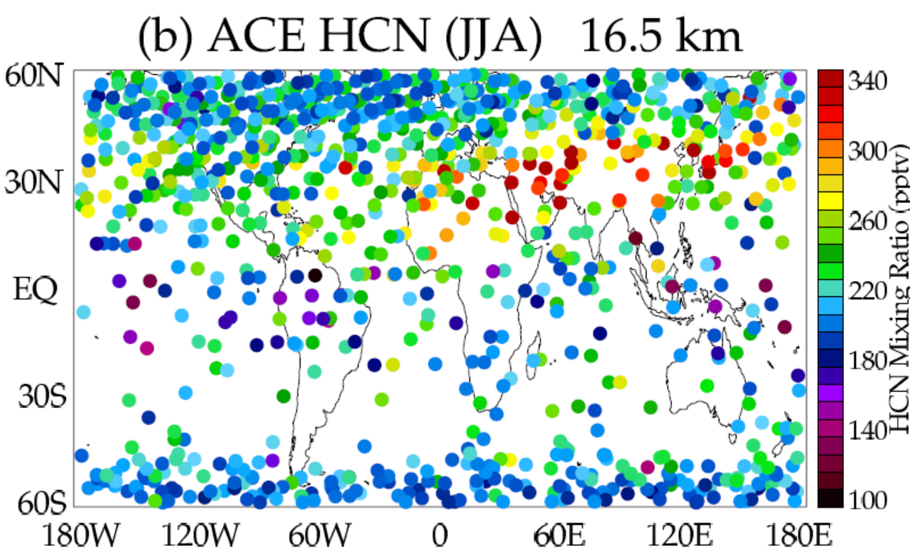

Current HALOE value 3.3 ppb

| | 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 |

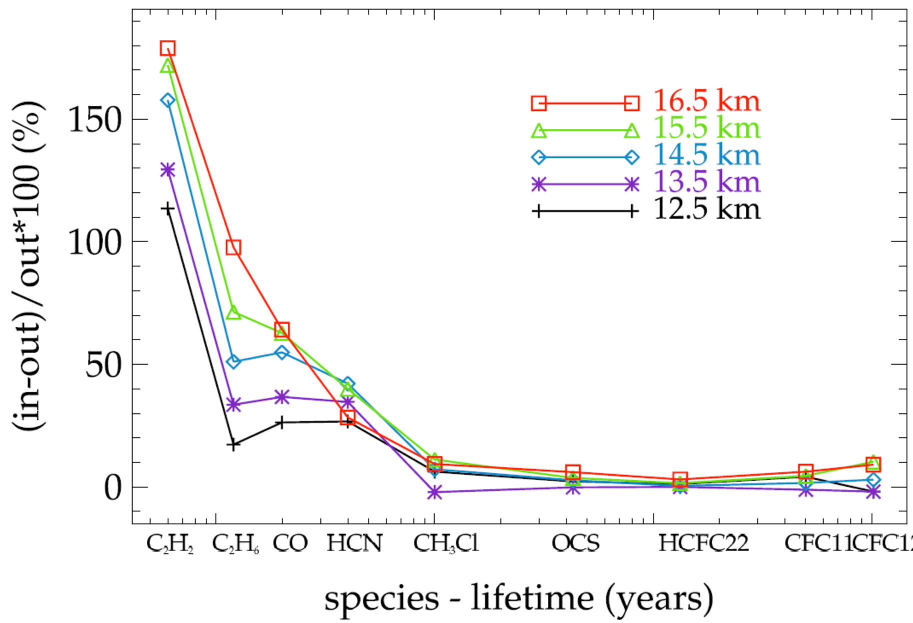
CFC-11, CFC-12 , HCFC-22, $CCl_4$, $CH_3Cl$, $CF_4$, CFC-113, HCFC-142b, HFC134a, $F_2CO$, ClFCO, $Cl_2CO$

# Asian Monsoon Anticyclone

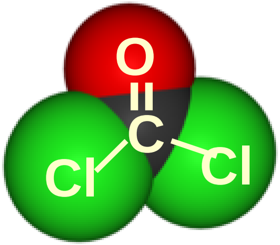


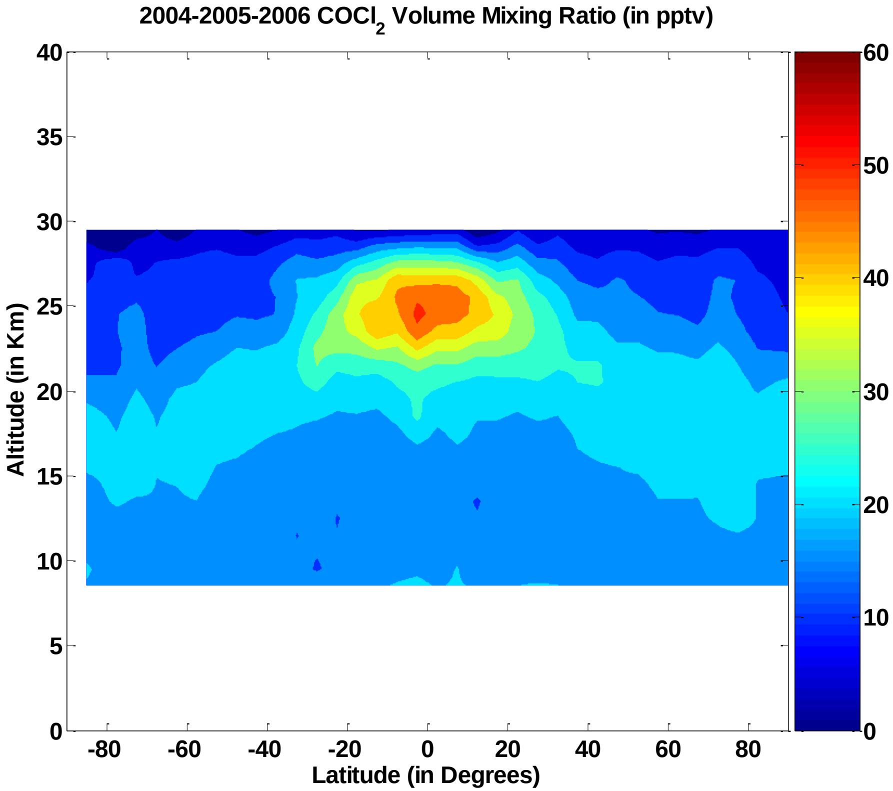

Park et al., ACP, 8, 757 (2008)

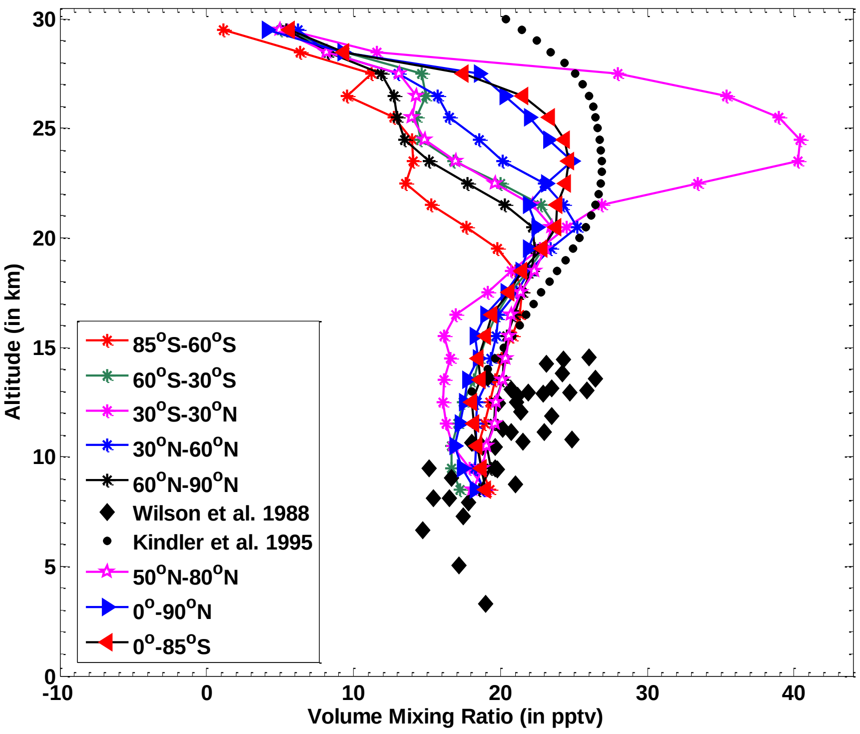


# Global Distribution of Phosgene, $Cl_2CO$



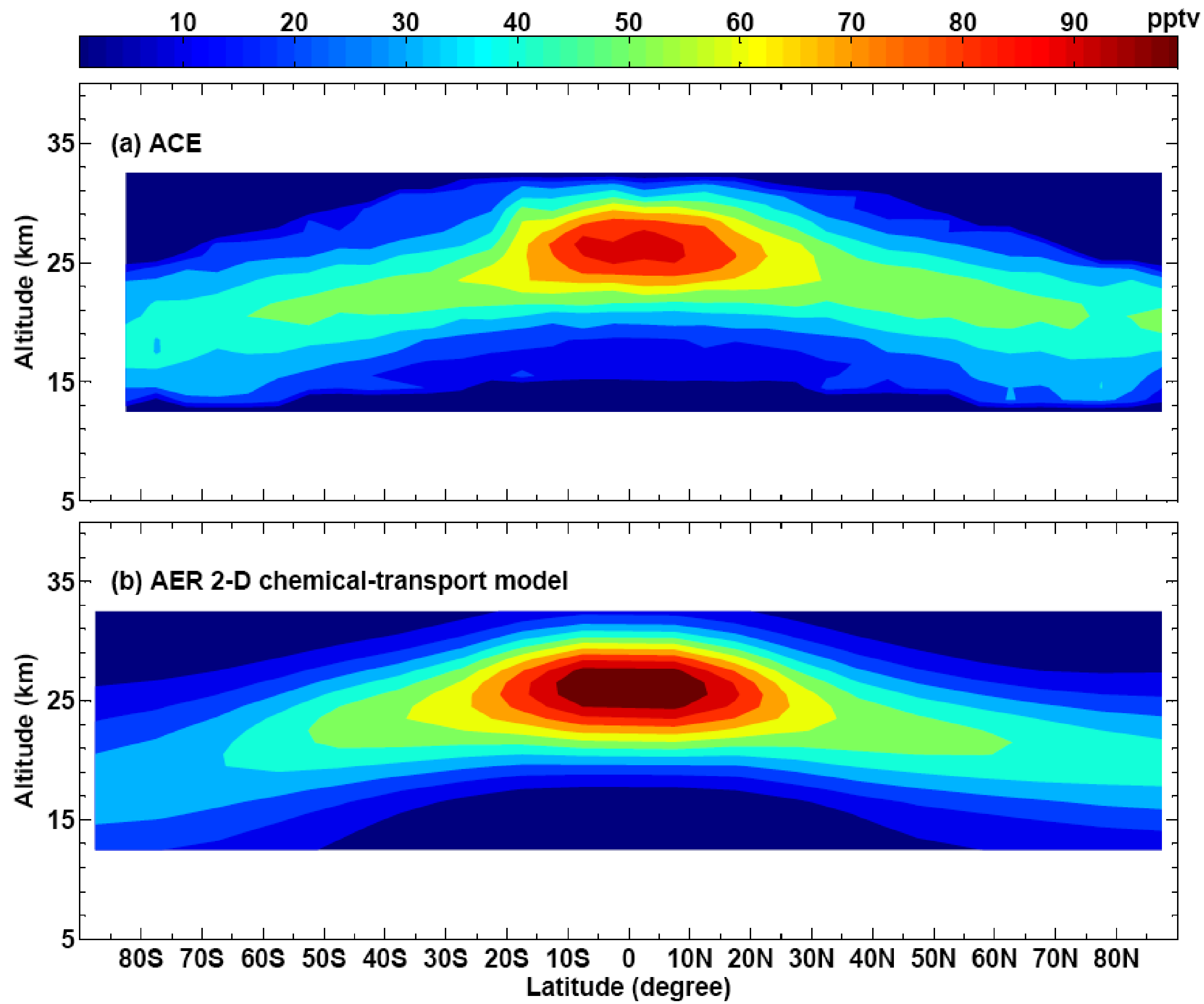

Fu et al. GRL, 34, L17815 (2007) (Toon et al.'s calculated linelist for $\nu_5$ near 850 $cm^{-1}$)



# Distribution of COClF

- Carbonyl chlorofluoride is a product of chlorofluorocarbon (CFC-11 mainly) decomposition
- Previously studied by aircraft (5 - 12 km)
- First global picture obtained from ACE-FTS
- Spectroscopy based on Brown's ATMOS linelist created from Kitt Peak spectra, with rough intensities.

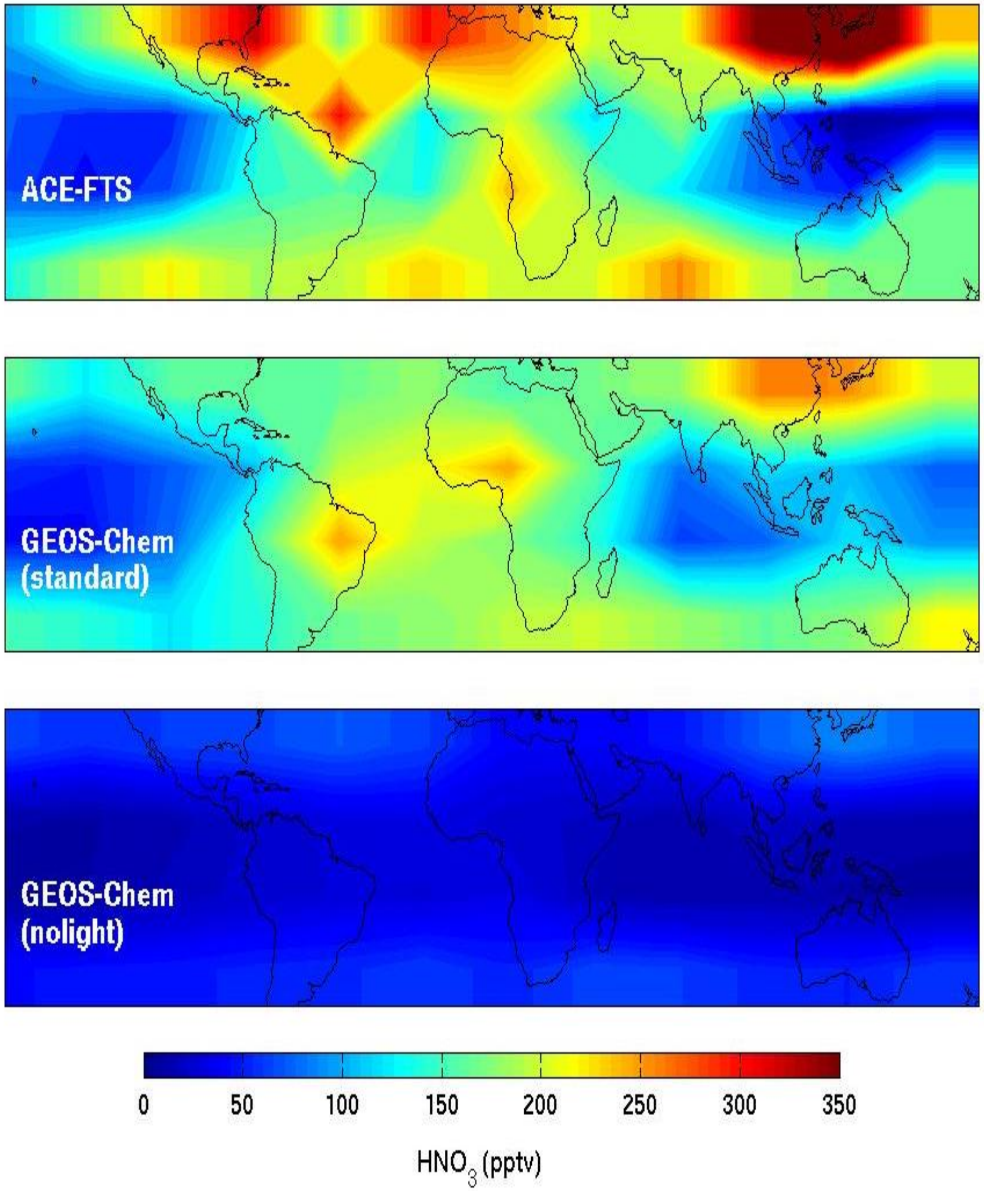


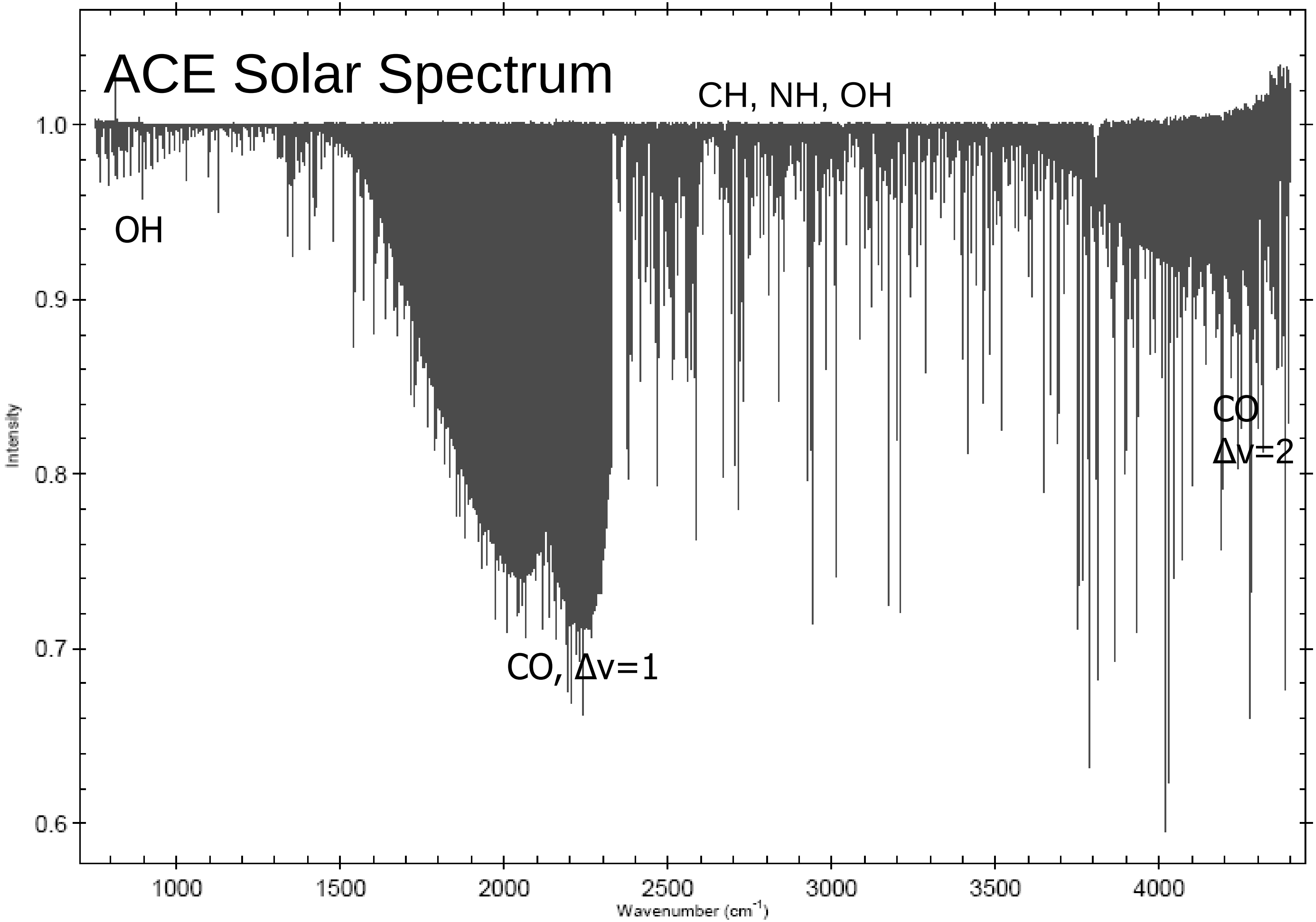

D. Fu *et al.*, to be submitted

# Effect of Lightning ($HNO_3$)

Lightning produces NO, which is oxidized to $HNO_3$.

Need to have 6 Tg N/yr from lightning to match ACE observations of tropospheric $HNO_3$ (Martin et al. JGR, 112, D09309 (2007))

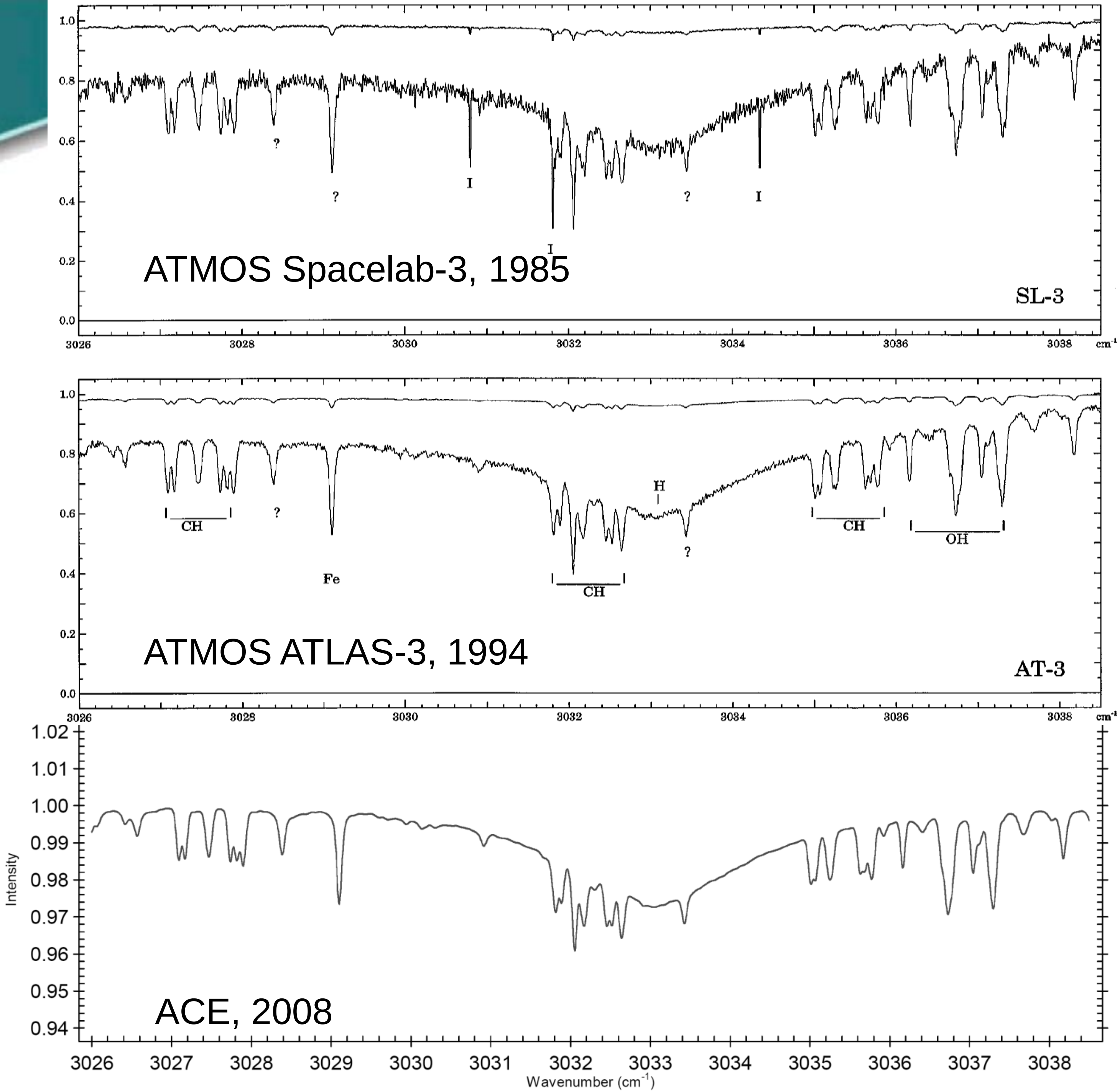





ACE solar spectrum (F. Hase): 224782 spectra added, improvement over ATMOS, no telluric lines, but 0.02 $cm^{-1}$ vs 0.01 $cm^{-1}$ resolution (resolution largely determined by width of solar lines) and 750-4400 $cm^{-1}$ vs 600-4800 $cm^{-1}$.

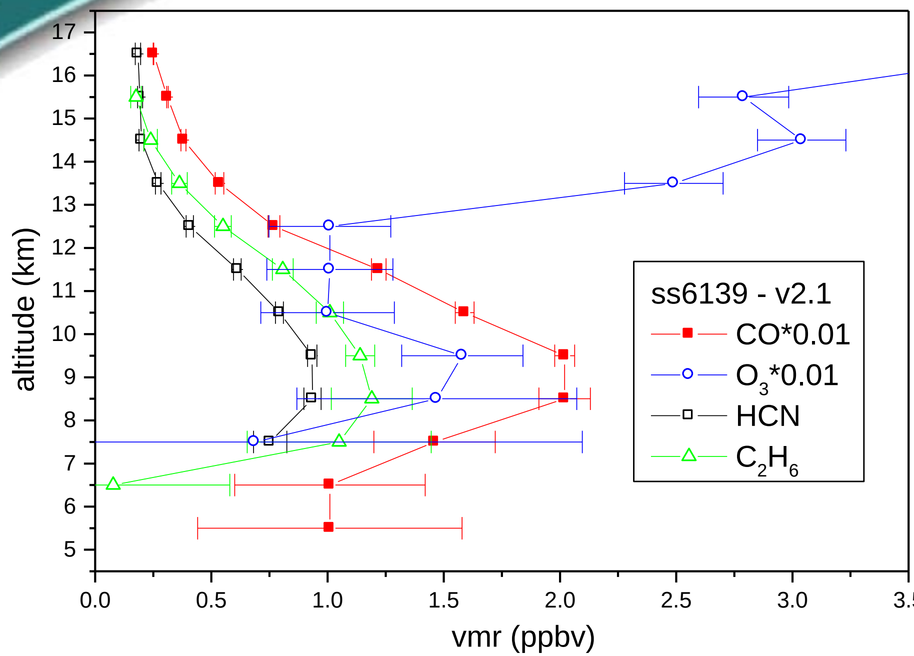
New atomic and molecular assignments (ACE linelist) by L. Wallace (NOAO); improved spectroscopic data for CH, NH and OH.

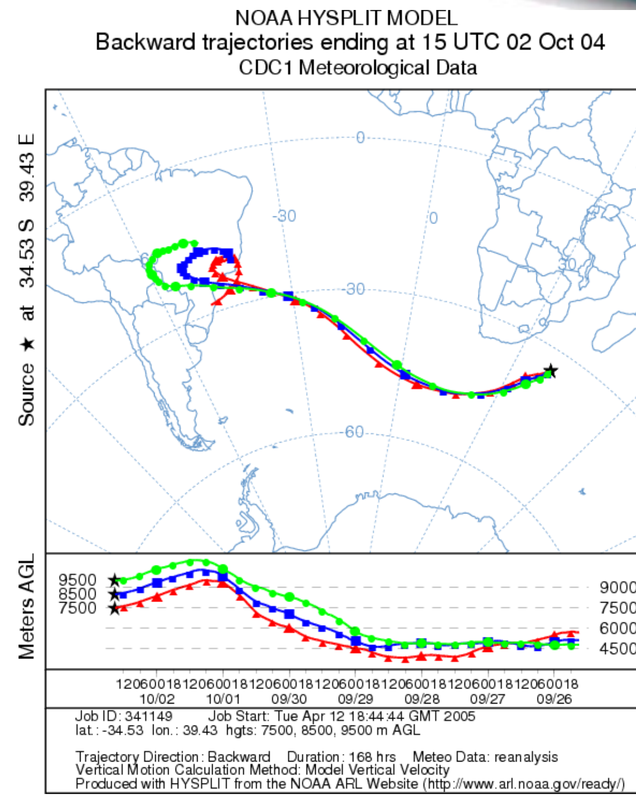
For OH, Reg Colin (ULB) finds v=4 can be improved.



# Air Quality and Biomass Burning

# Biomass Burning in Brazil



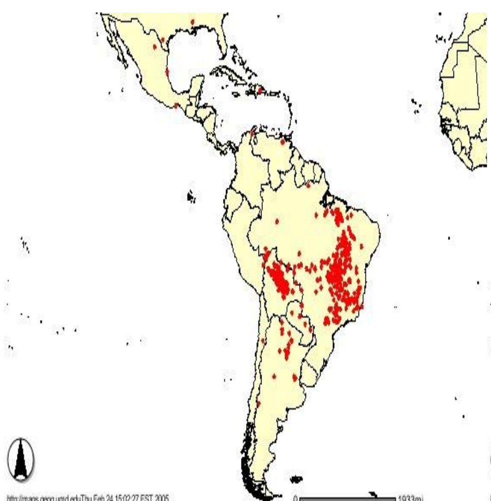



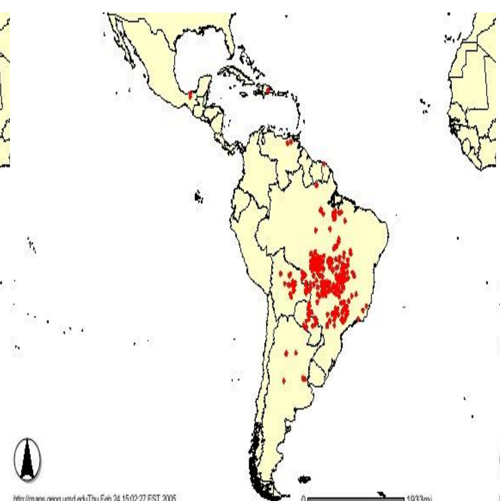

MODIS Fire Counts

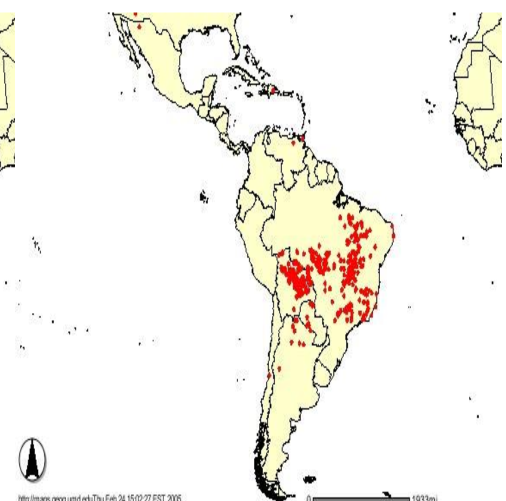
26 Sept. 2004

27 Sept. 2004

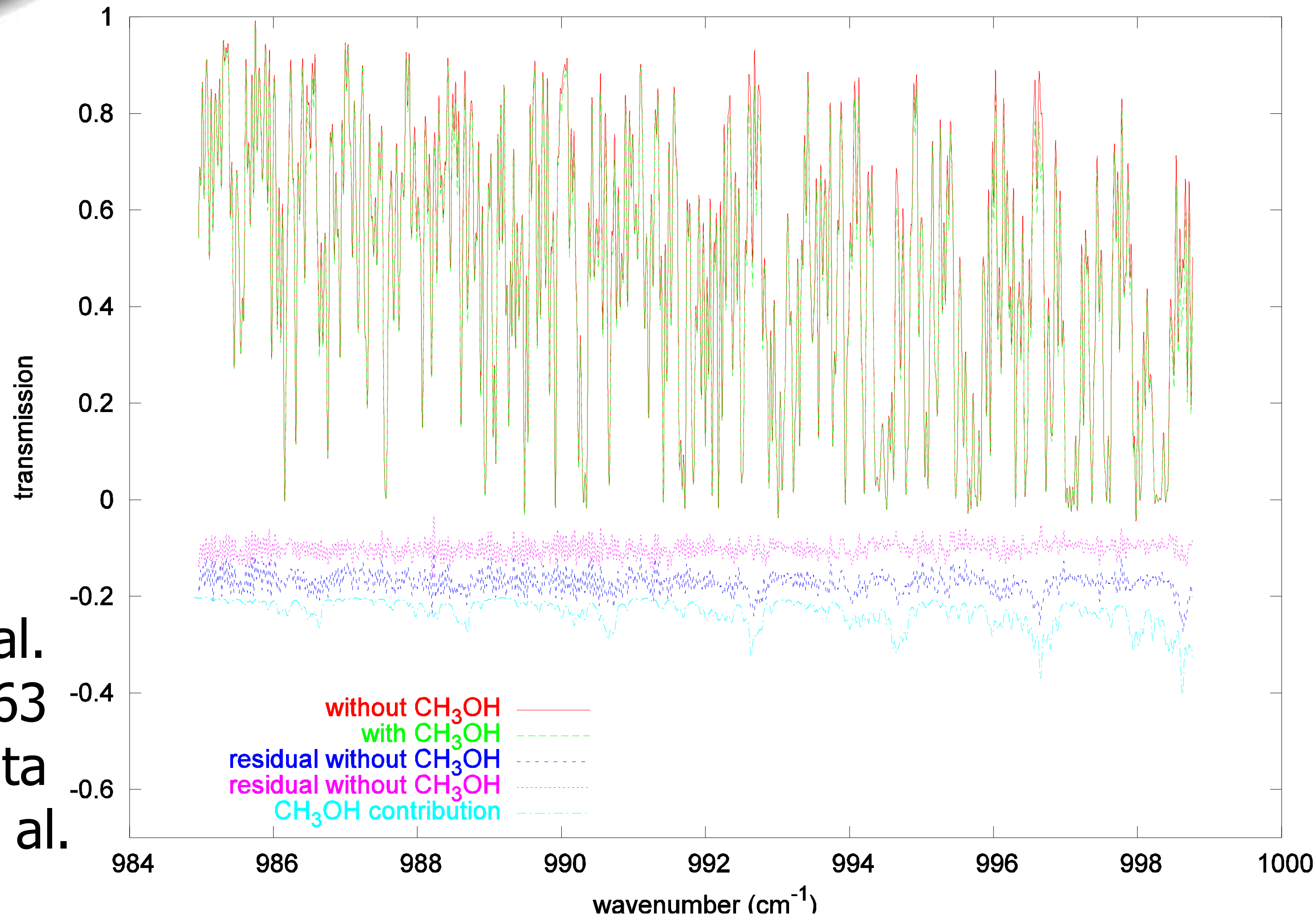
28 Sept. 2004







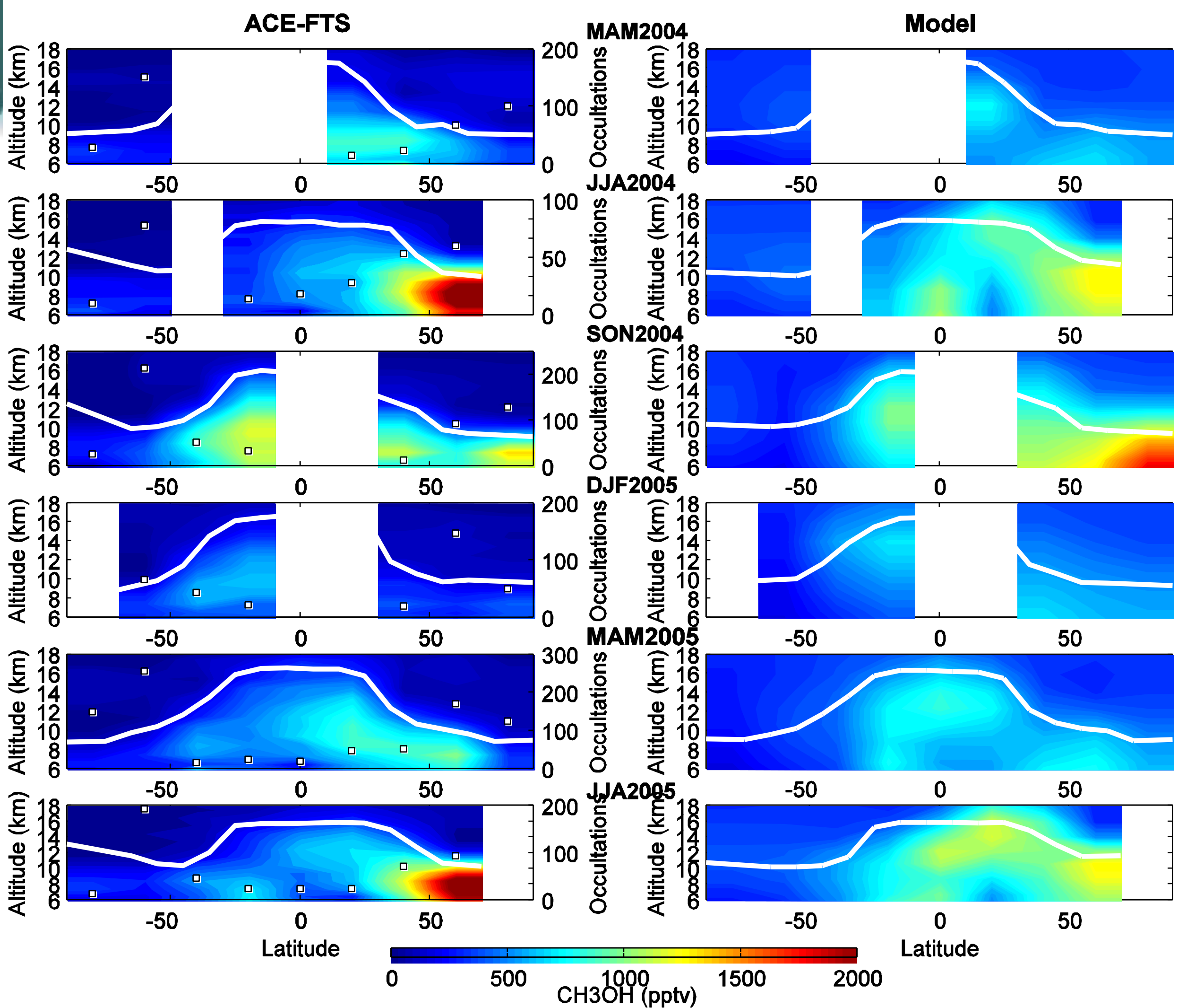
# $CH_3OH$ contribution to the spectrum




Dufour et al. ACP, 6, 3463 (2006); data from Xu et al. 2004

# Global Methanol

ACE is an upper tropospheric "air quality" mission measuring global $CH_4$, $CH_3OH$, HCN, $C_2H_2$, $C_2H_6$, $H_2O_2$, HCOOH, $H_2CO$, plus likely PAN and acetone.

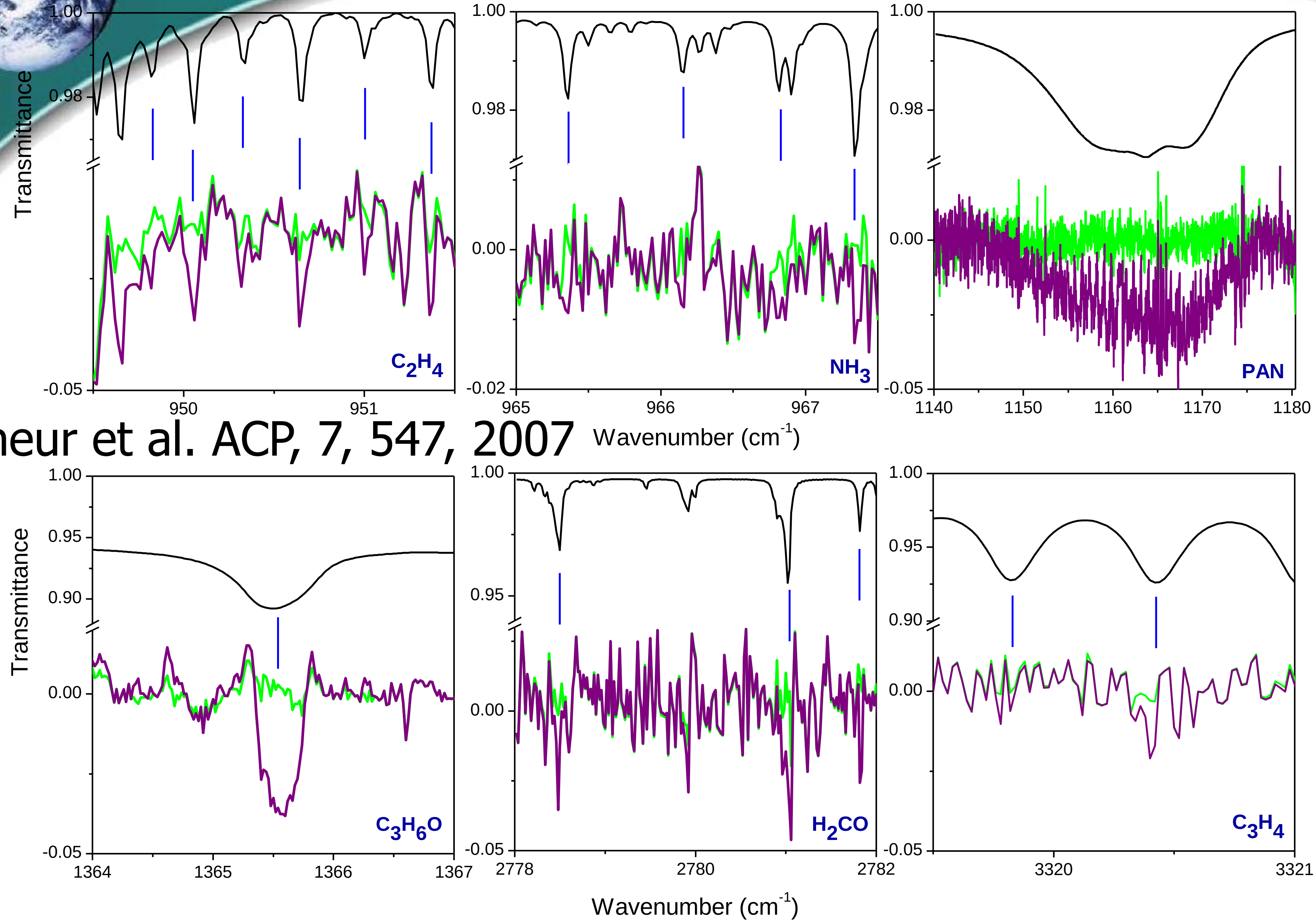



Dufour et al. ACP, 7, 6119, 2007

LDMz-INCA model

(D. Hauglustaine)

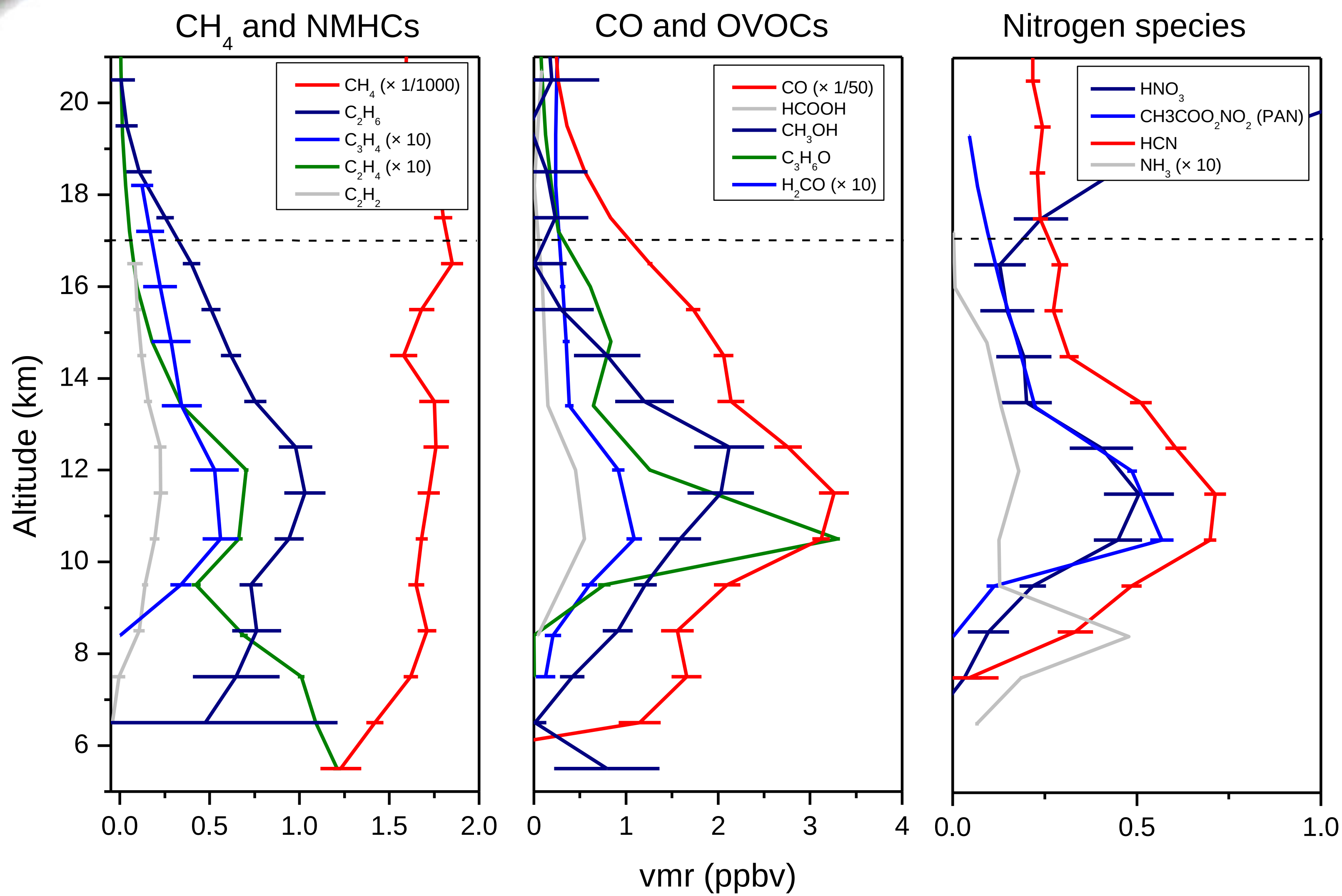
# Young Biomass Burning Plume




Coheur et al. ACP, 7, 547, 2007

# PAN, Peroxyacetyl nitrate, etc.

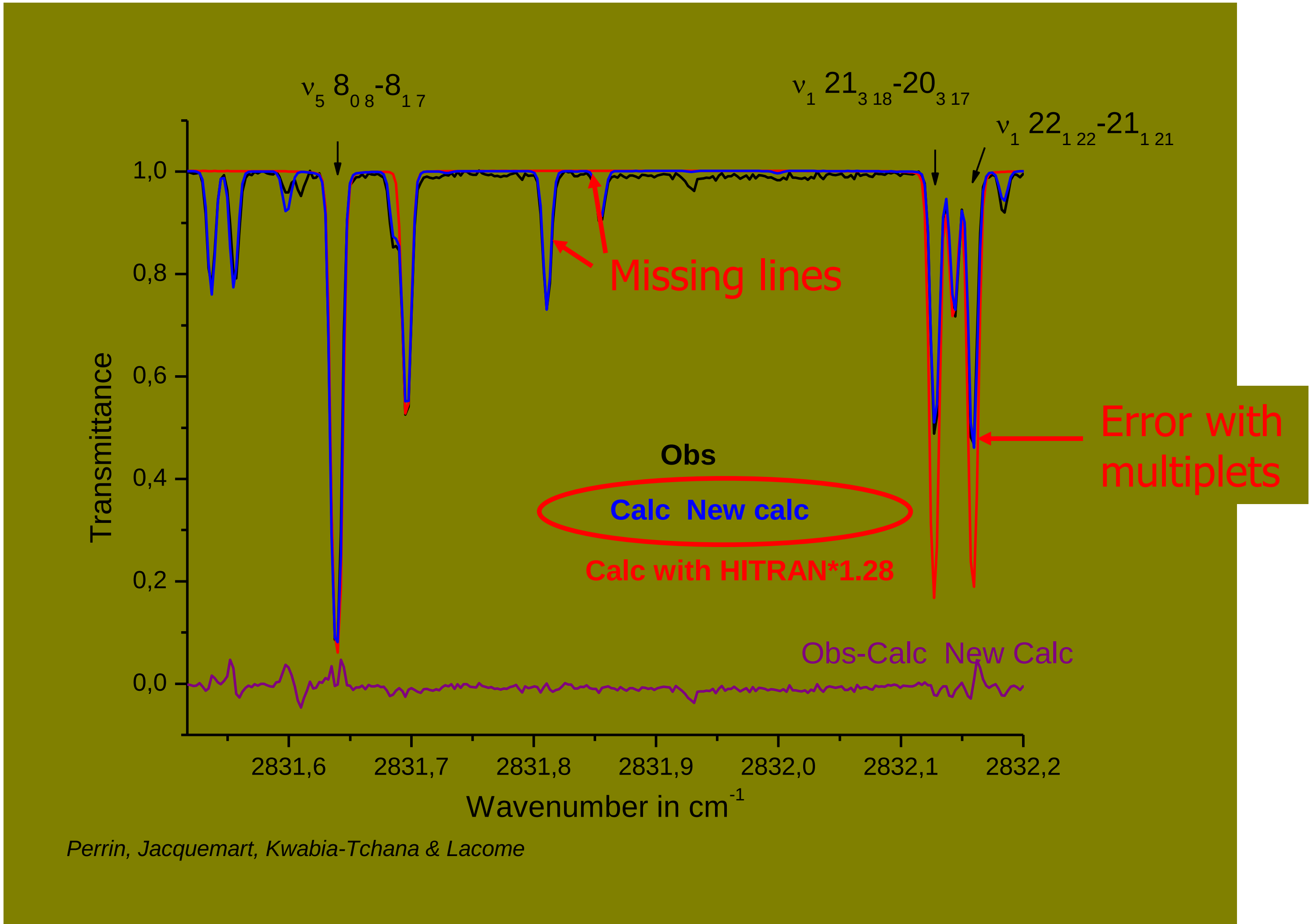
Coheur et al. (Brussels), PAN from a biomass plume near East Africa



# HCHO spectroscopy: new linelist

Use of HCHO line intensities calculated by A. Perrin

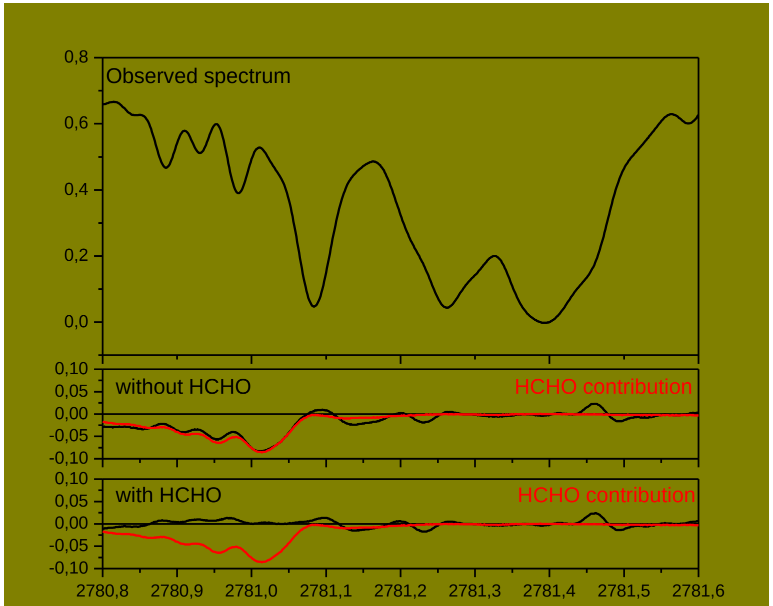
Dufour et al.

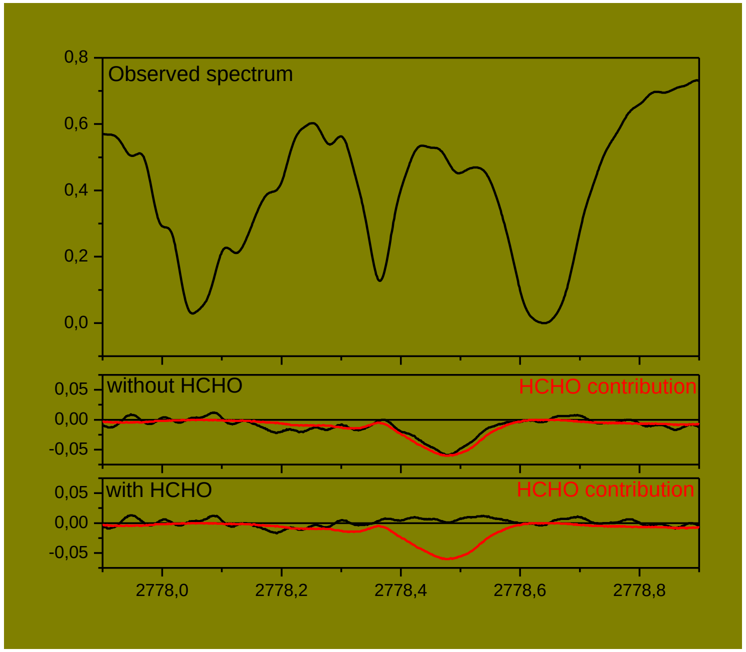


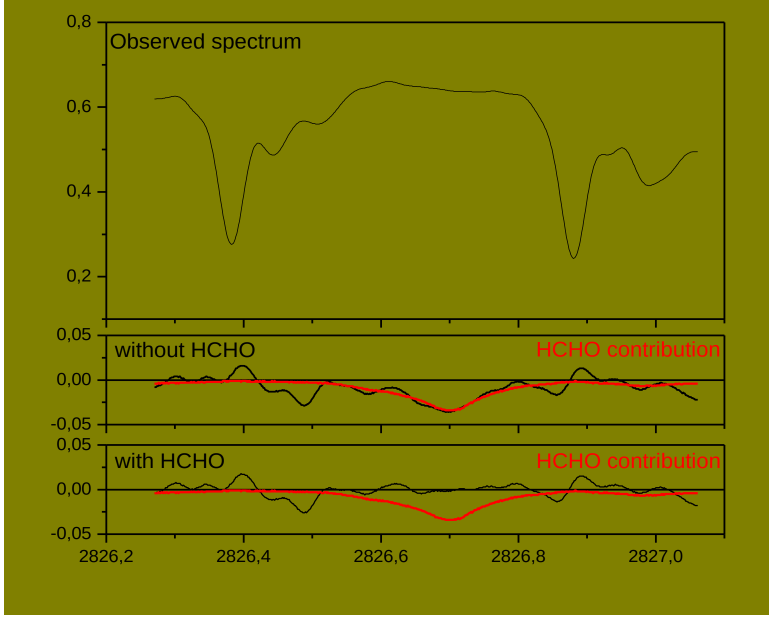
# HCHO contribution to the spectrum

6 spectral windows selected in the range 2735 - 2830 $cm^{-1}$ :

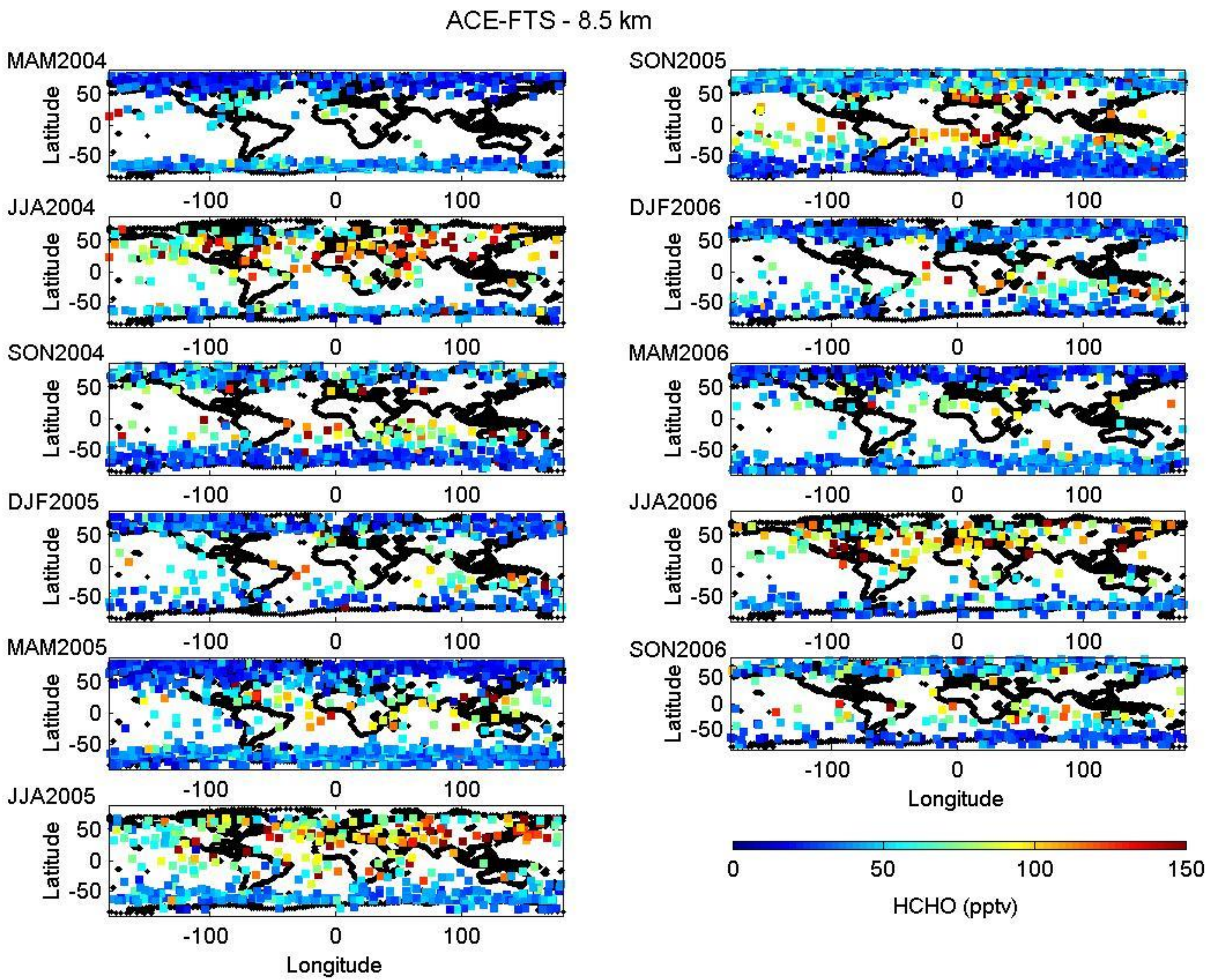
2739.85 ; 2765.65 ; 2778.4 ; 2781.2 ; 2812.25 ; 2826.67



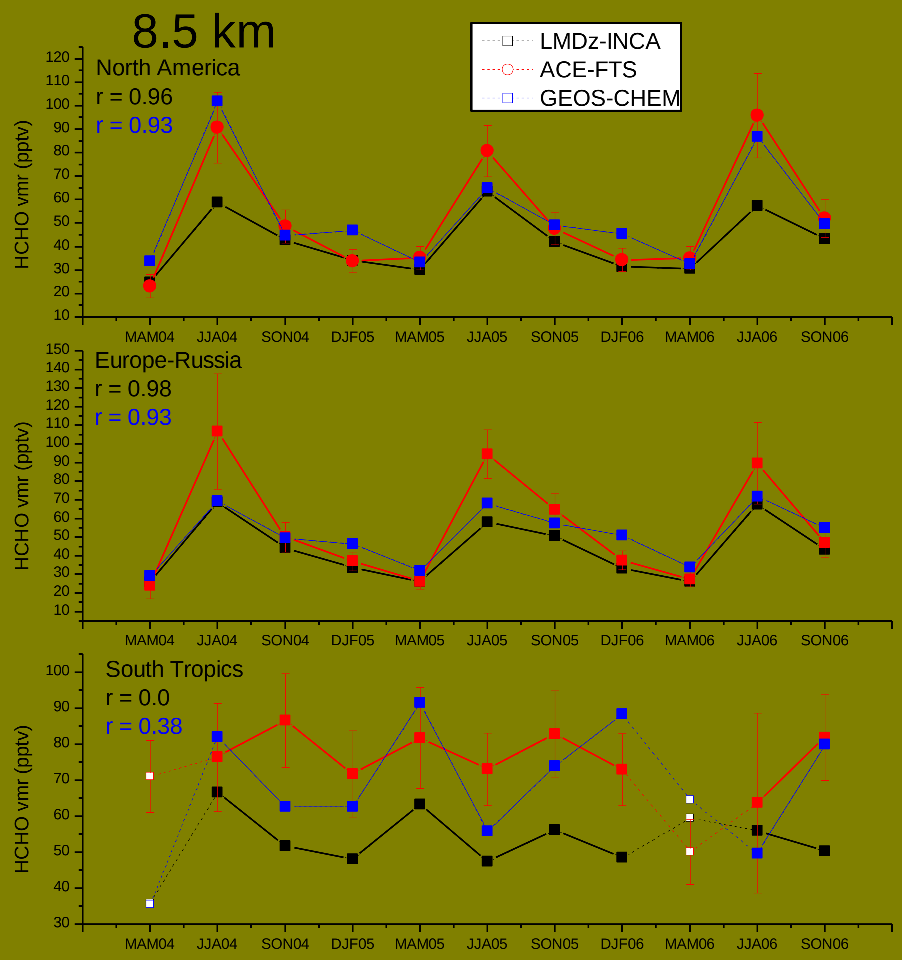



# 3 years of HCHO measurements with ACE-FTS



# Preliminary comparisons with CTMs




Comparison with 2 state-of-the-art models (LMDz-INCA and GEOS-Chem) that use different emissions inventories.

**North Hemisphere**:
seasonality of UT HCHO well reproduced
intensity of the maximum not always reproduced

**South Hemisphere**:
LMDz-INCA systematically smaller

**South Tropics**:
small impact of biomass burning
larger variability in the models

# ACE Partners (Selected)

- Canada- K. Walker, J. Drummond, K. Strong, J. McConnell, W. Evans, T. McElroy, I. Folkins, R. Martin, J. Sloan, T. Shepherd, etc.
- USA- NASA launched ACE: C. Rinsland, L. Thomason (NASA-Langley), C. Randall (U. Colorado), B. Bojkov (NASA-Goddard), M. Santee, L. Froidevaux, 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)
- France- C. Camy-Peyret, C. Clerbaux, C. Brogniez, G. Dufour, D. Hauglustaine (Paris)
- Japan- M. Suzuki,  Y. Kasai (JAXA)
- Sweden- G. Witt (Stockholm)

# Sunset over Kitt Peak, AZ