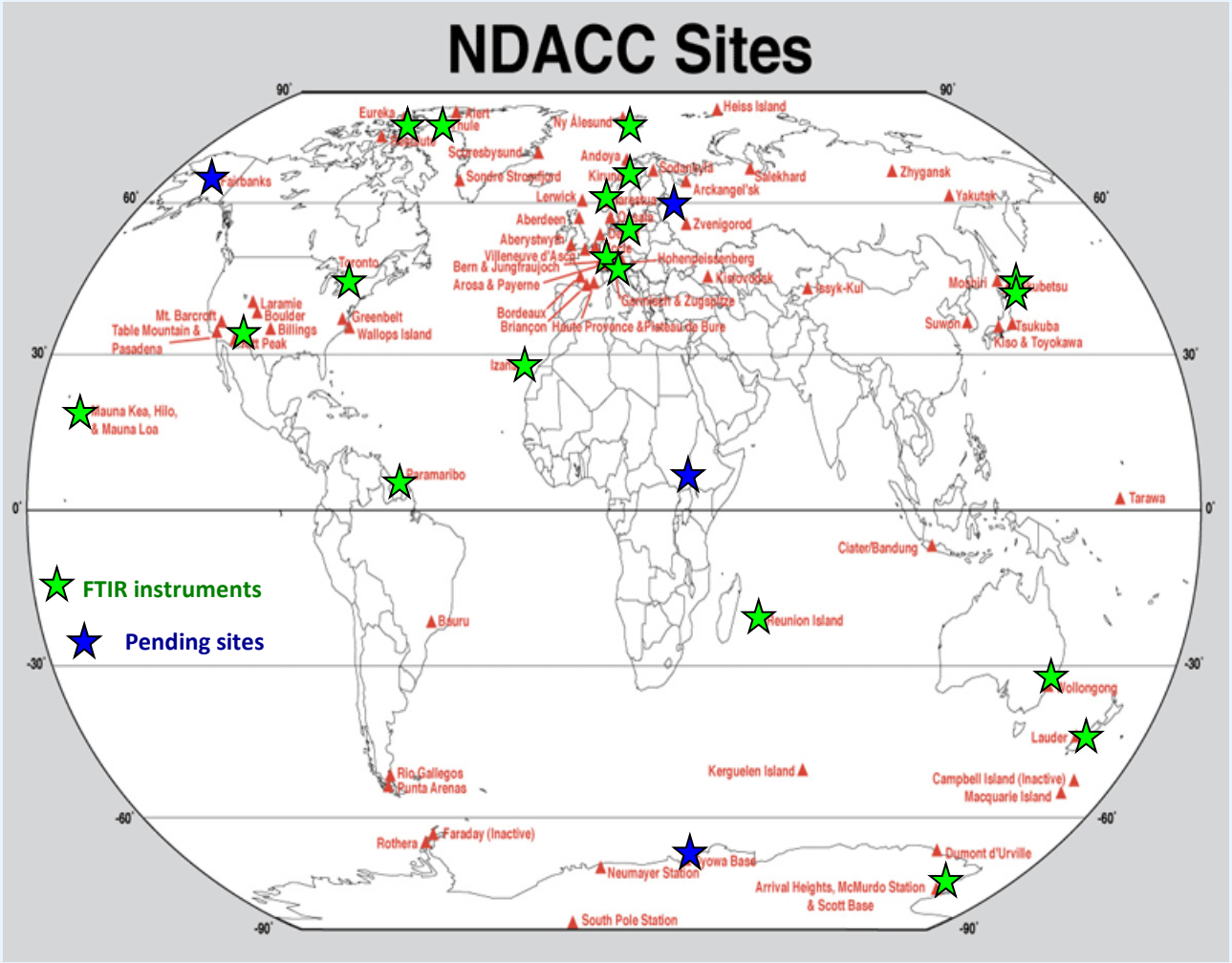
NDACC FTS Trace Gas Analyses and the Revitalized MLO FTS System

J. Hannigan, M. T. Coffey, R. B. Batchelor

Dedicated to Curtis P. Rinsland

Outline

- Changing NDACC/IRWG Network
  - Data homogenization process
  - Data products
- MLO & Boulder Retrievals
- MLO FTS Observation Program
  - Data record
  - Status and future plans



Member sites: 19

Candidate or Affiliated Sites (4 +):

Poker Flat, AK, Addis Ababa, Ethiopia, Syowa Station Ant. (Japan)

St. Petersburg, Russia

IRWG Instrumentation / Retrievals / Data Products

NCAR

- Solar viewing, high resolution, broad band
  - High signal to noise
  - Narrow field of view
  - Fully resolve any atmospheric line to Doppler width
  - Observe 20+ species
    - Greenhouse or minor species (CO_2, CH_4, N_2O, O_3, CO, H_2O)
    - Trace species (HCN, OCS, NO, NO_2, H_2CO, $ClONO_2$, HNO_3, HF, HCl, HCFC-22, CFC-11, CFC-12, HCOOH, C_2H_2, C_2H_6…)
    - Isotopes of several of these species (HDO, $H_2{}^{18}O$, $H_2{}^{17}O$, $^{13}CO_2$, CH_3D)
  - Required: HCl, HF, O_3, HNO_3, $ClONO_2$, CO, CH_4, N_2O, HCN, C_2H_6
- Improved homogenization across network
  - Site a priori from WACCM global CCM model 1980-2020 mean for each site/gas *(Eyring et al., 2006)*
  - Consistent spectral windows, retrieval grids, a priori line list (HITRAN) and other parameters
  - Calibration cell spectral results feed back into retrievals
  - Optimal Estimation retrieval method

IRWG Instrumentation / Retrievals / Data Products

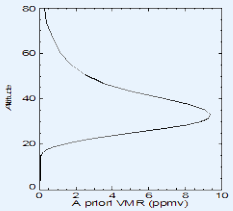
NCAR

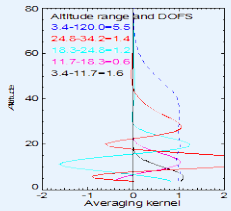
- Data Products
  - Total vertical column
  - Partial column / mixing ratio over narrower altitude ranges
    - Number of ranges and altitude width dependent on site & gas
    - Defined by degrees of freedom for signal (DOFS) of the retrieval
    - DOFS range: ~1 eg. HCN to ~6 eg. O_3

- Data available at *www.ndacc.org*
  - Total columns in Gains & Hipskind format
  - Mixing ratio profiles + much ancillary data available in HDF format
  - Many gases from most sites available (but not all…)

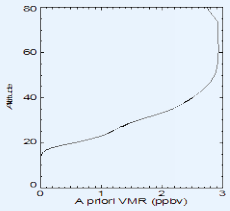
Example Sensitivities

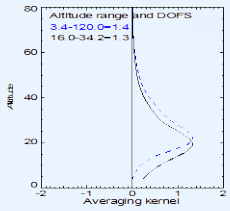
Mixing Ratio Averaging Kernels:





- ✓ From OE retrieval
- ✓ Summed from retrieval layers to DOFS~1
- ✓ Total column

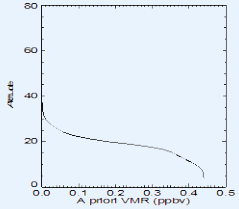


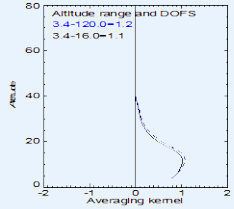


O_3

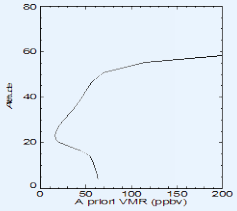
HCl

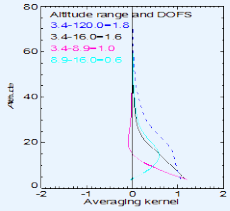
Altitude Resolution Depends on:





- ✓ *Vertical profile / site*
- ✓ *Spectroscopy*
- ✓ *Interfering species*
- ✓ *Spectral Resolution*
- ✓ *Spectral SNR*
- ✓ *Solar zenith angle*
- ✓ *Inst. response or compensation*

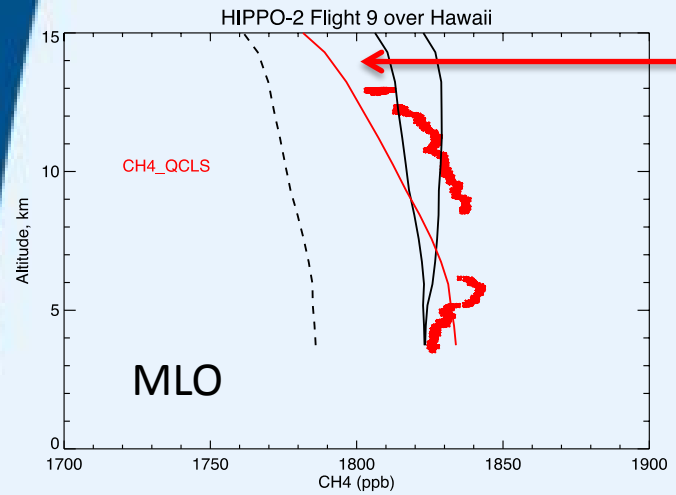




C_2H_6

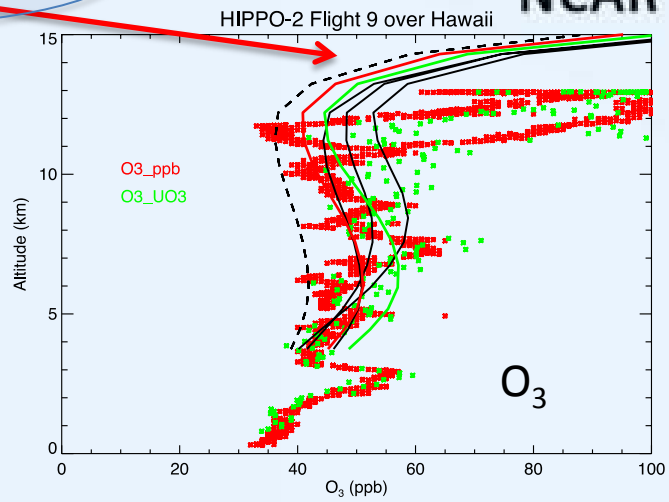
CO

HIPPO Comparisons : O_3, CH_4, CO



CH_4

Smoothed to strat. A priori

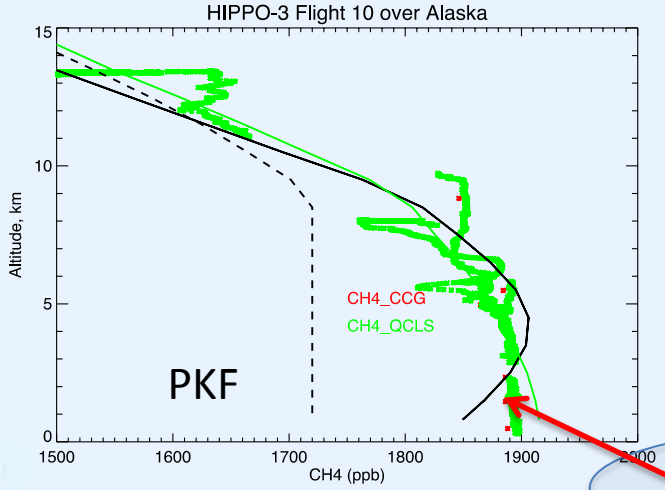


Red/green symbols
– in situ data

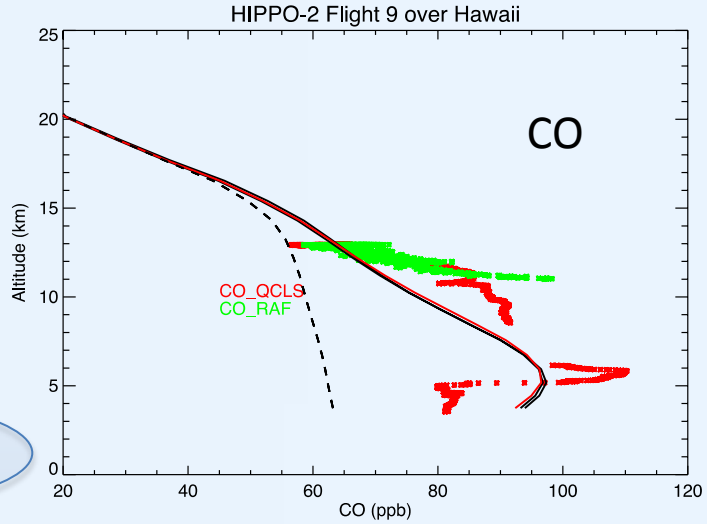
Red/green curves
– in situ smoothed to FTS

Black dashed
– FTS a priori

Black solid
- FTS retrieved

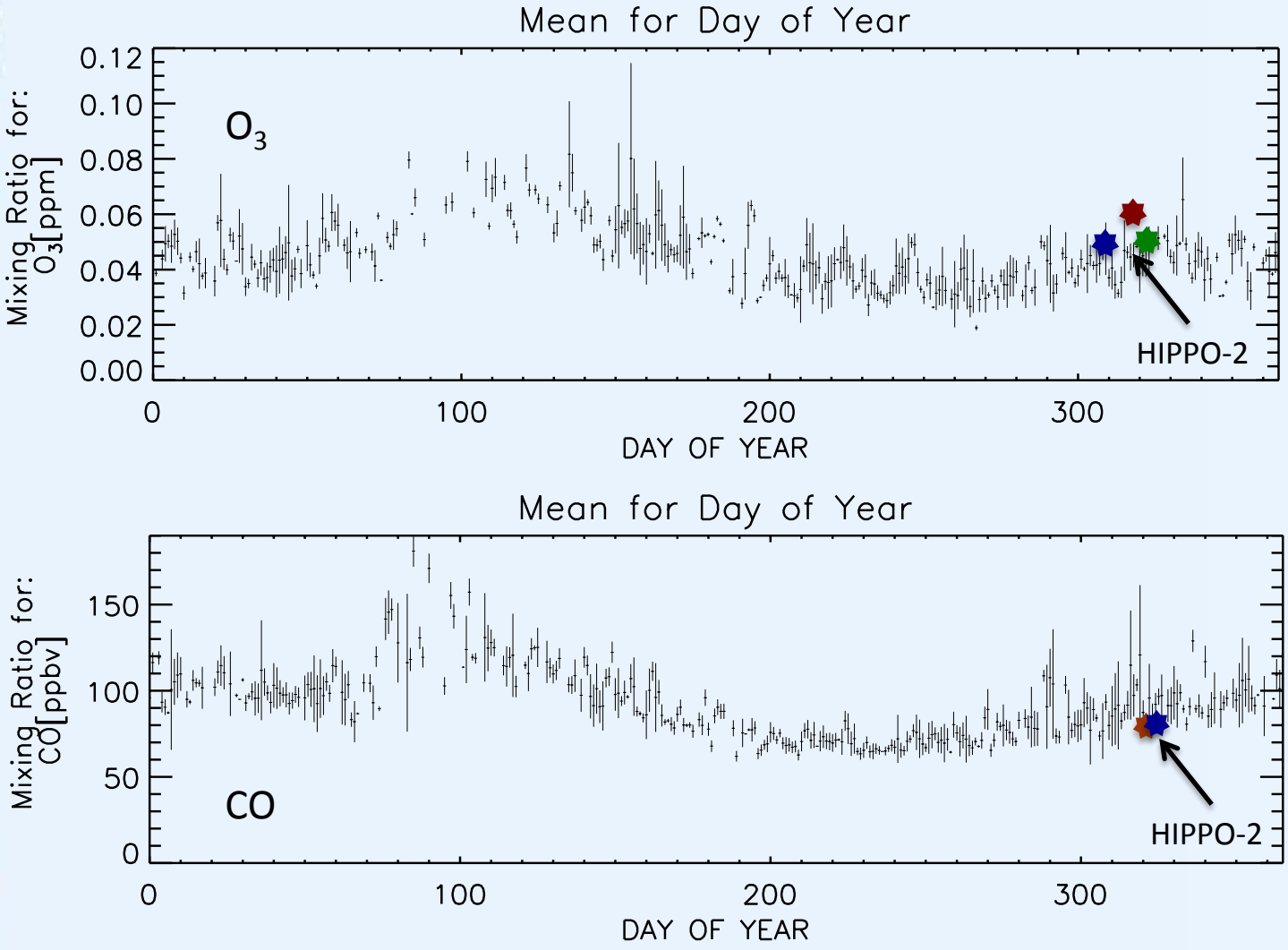


Spectroscopic constraint



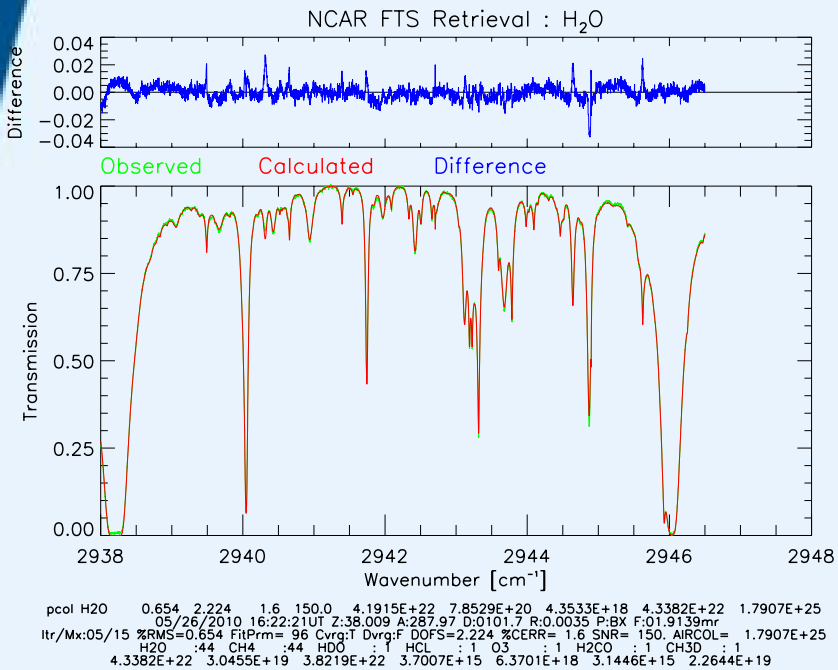
CH_4 profiles provided by Akiko Kagawa and Yasko Kasai, NICT, Japan

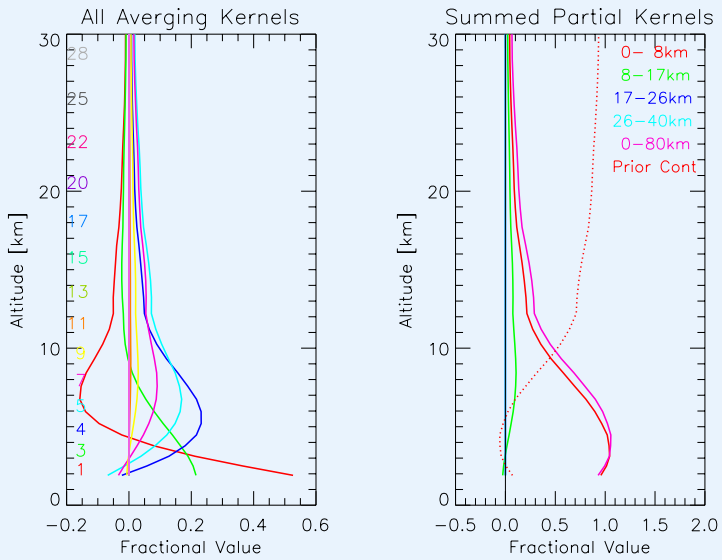
HIPPO measurements in context of long term record of CO & O_3 From MLO FTS



Boulder H_2O Retrieval

Example 26 May 2010





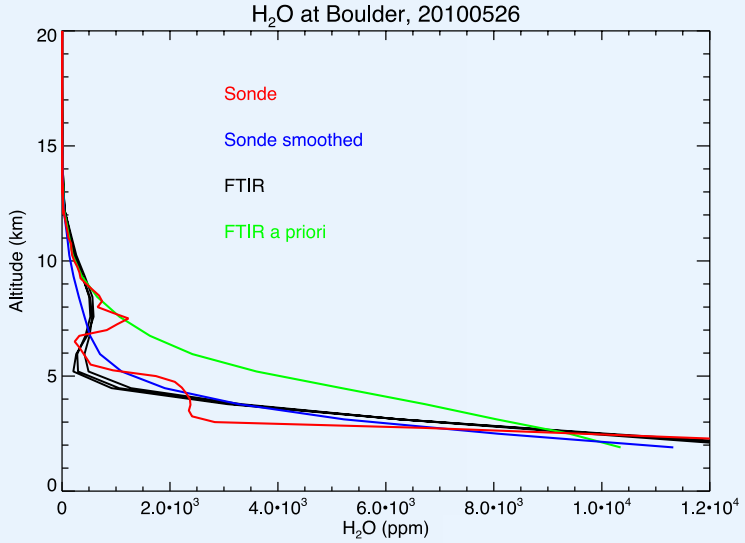
Left: Spectral fit

Below Left: Averaging Kernels

Below Right: Profiles

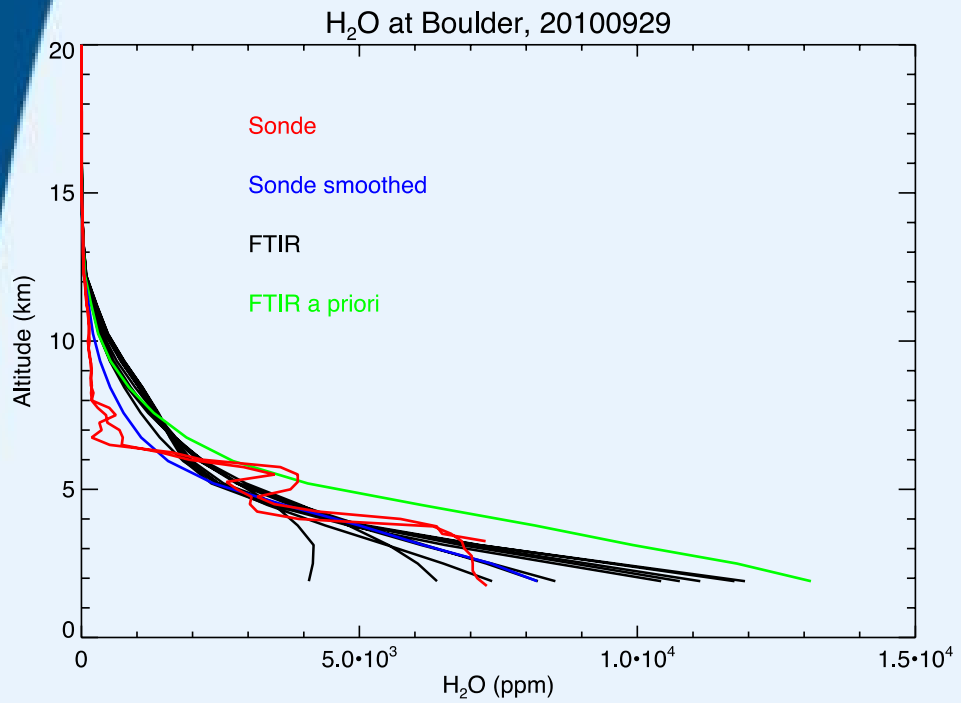
14 Coincidences to date

Possible GRUAN measurement



Boulder FPH sonde data

Thanks Dale Hurst, Emrys Hall



NCAR

20100929 Launch at 17:24UT

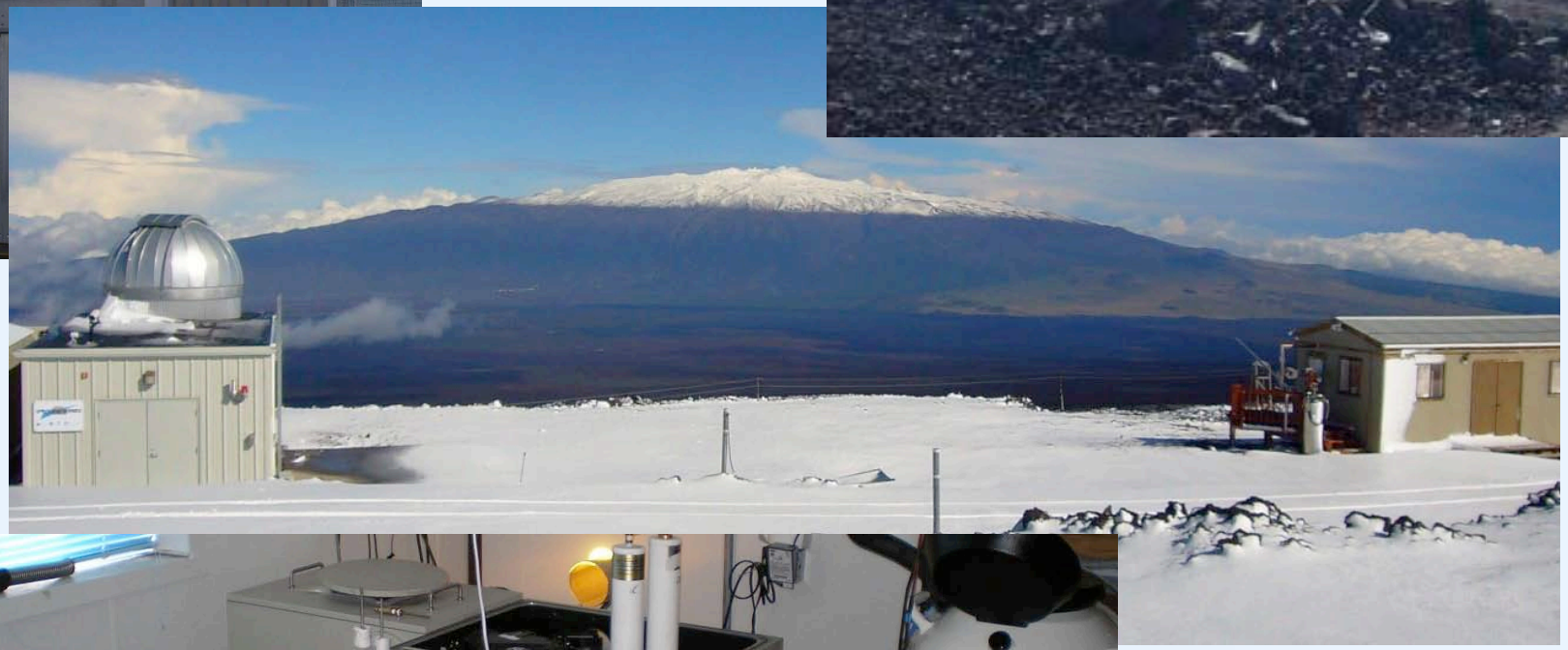
- 7.3e3ppm at surface (1.75km)
- Retrievals from 2h prior to 4 post launch show continuous increase at surface through day
- On descent sonde stops at 3.25km & 7.3e3ppm

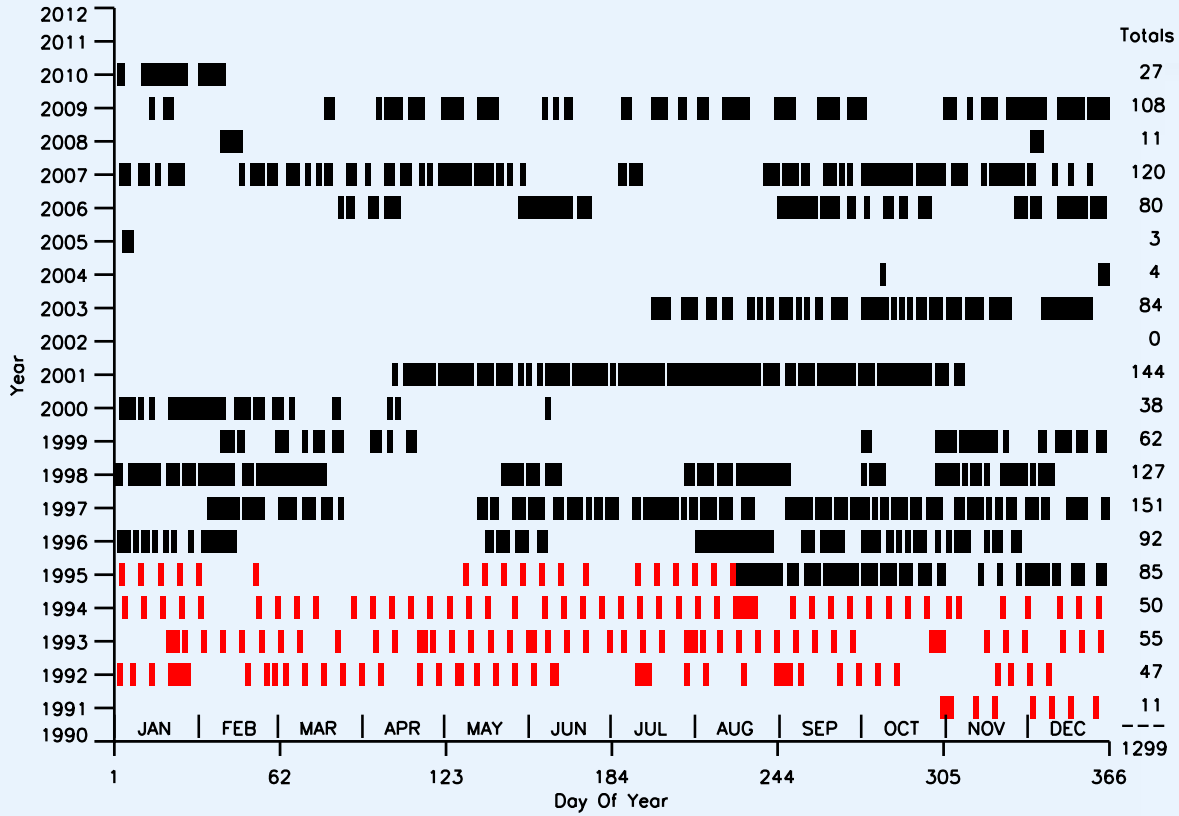
UT	SZA	SAZIM	RMS	DOFS	COLUMN	PPM @2km	PPM @2.5	PPM @3km
15:22:14	63.9	298.4	1.00	2.3	3.26E+22	4.1E+03	4.2E+03	4.2E-03
16:05:19	57.0	307.9	0.98	2.2	4.06E+22	6.4E+03	6.0E+03	5.5E-03
16:09:06	56.5	308.8	1.00	2.2	3.97E+22	7.4E+03	6.5E+03	5.5E-03
17:22:35	47.2	329.1	0.88	2.3	4.54E+22	8.5E+03	7.4E+03	6.1E-03
17:30:14	46.5	331.5	0.88	2.3	4.50E+22	8.2E+03	7.3E+03	6.2E-03
19:15:26	43.0	8.9	0.88	2.2	4.85E+22	1.0E+04	8.5E+03	6.5E-03
19:57:44	45.3	23.7	0.95	2.2	5.07E+22	1.1E+04	9.1E+03	6.9E-03
20:05:02	45.9	26.1	0.93	2.2	5.03E+22	1.1E+04	8.9E+03	6.8E-03
20:58:50	51.7	42.3	1.06	2.3	5.25E+22	1.2E+04	9.5E+03	7.2E-03
21:02:34	52.2	43.3	1.08	2.3	5.23E+22	1.2E+04	9.6E+03	7.2E-03

← *Launch*

← *End*

MLO
FTS





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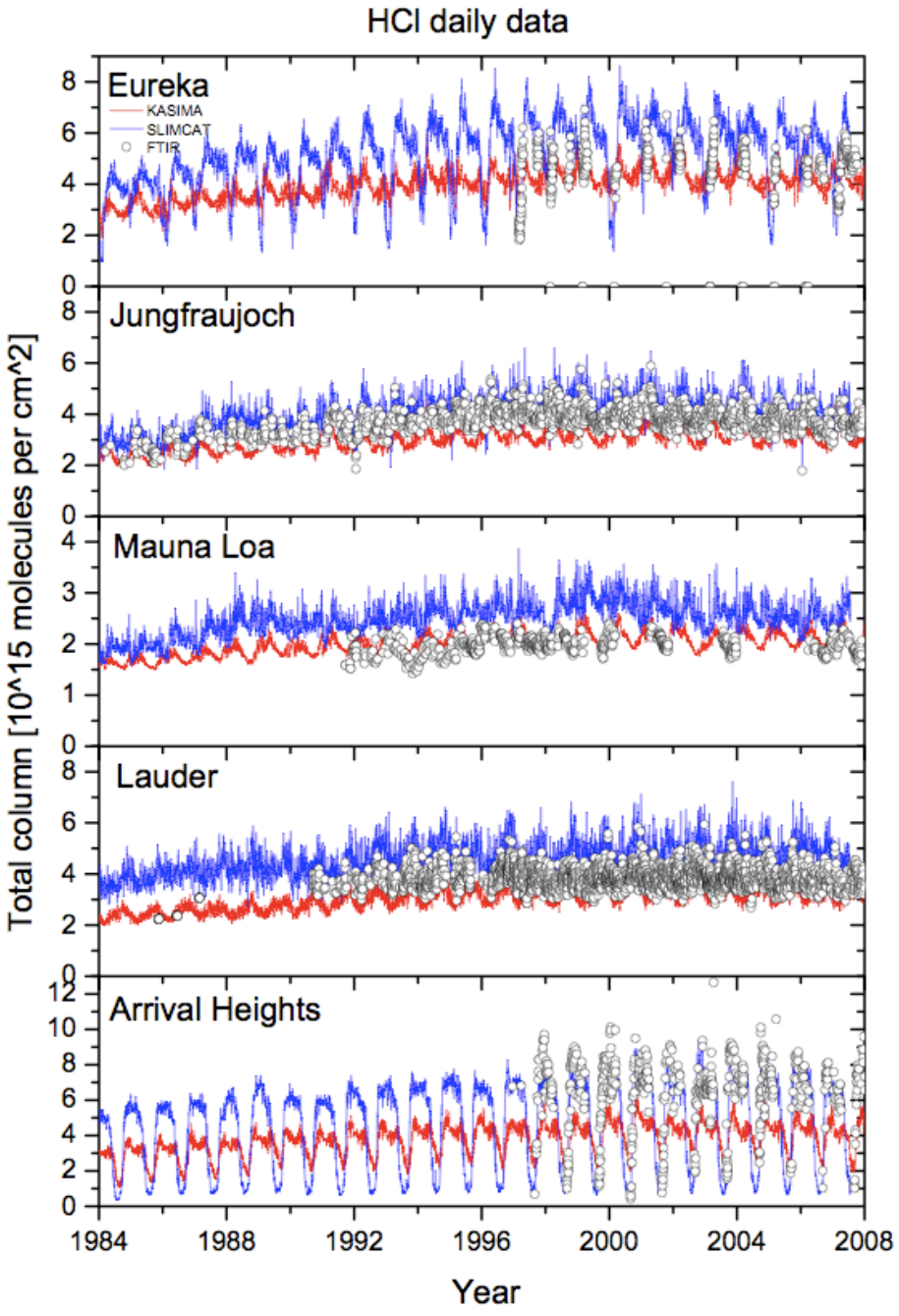
Observation record since 1991

Oct 1991 – Aug 1995 Bomem DA3 FTS - not re-analyzed yet

Aug 1995 - Feb 2010 Bruker 120HR - new analysis in process

Jul 2011 anticipated restart with Bruker 125HR

After Jungfraujoch, Kitt Peak, Lauder – 4th longest FTS record, oldest Bruker 120HR



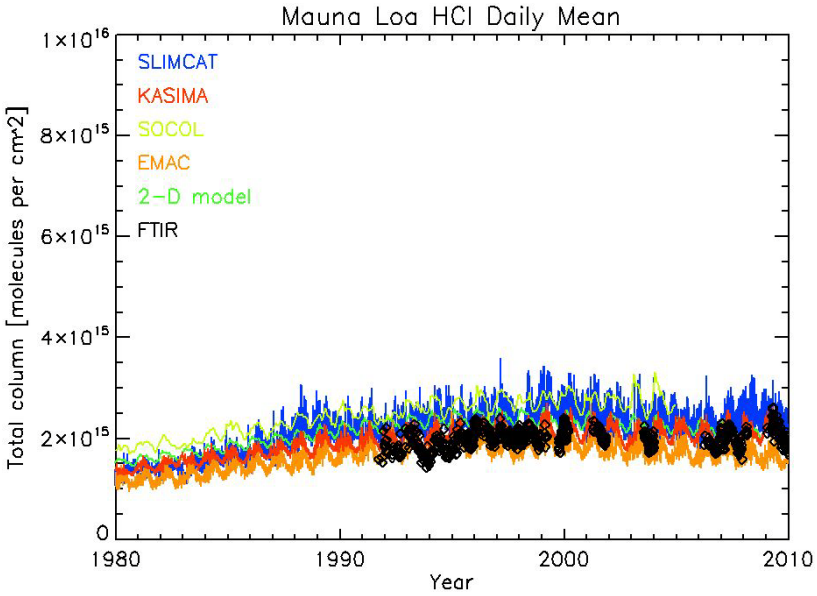
NCAR

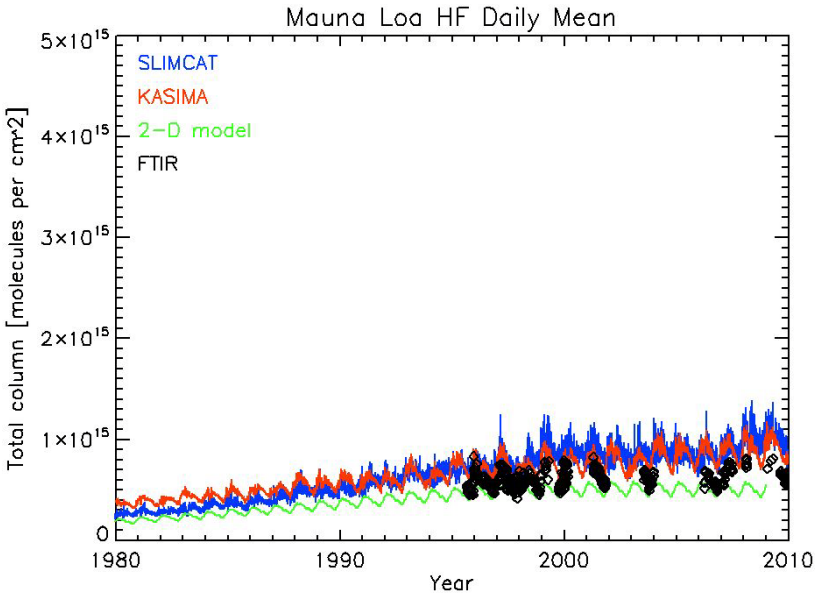
MLO (and others) Multi-Decade Total Column Record

Left: Initial plot of total column HCl to 2008

From:
"Observed and simulated time evolution of HCl, ClONO2, and HF total columns", R. Ruhnke et al. ACP to be submitted
Plots: Roland Ruhnke & Regina Kohlhepp Karlsruher Institut für Technologie

- 17 FTS sites
- Records 1977-present



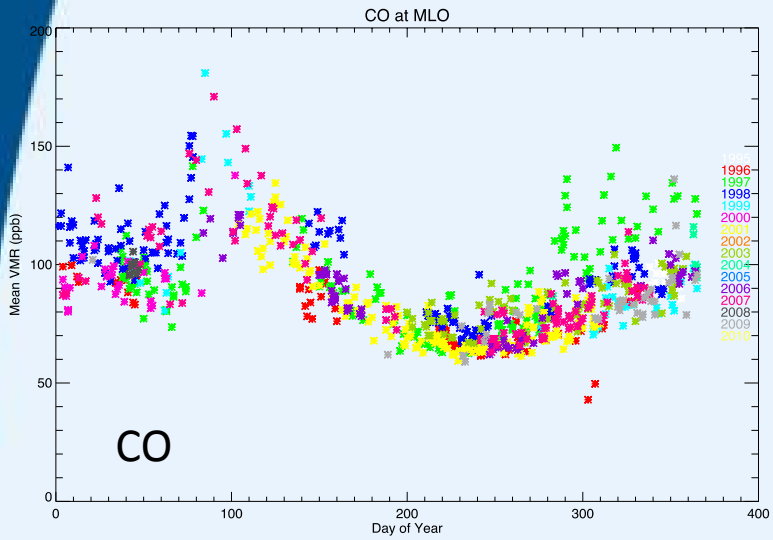


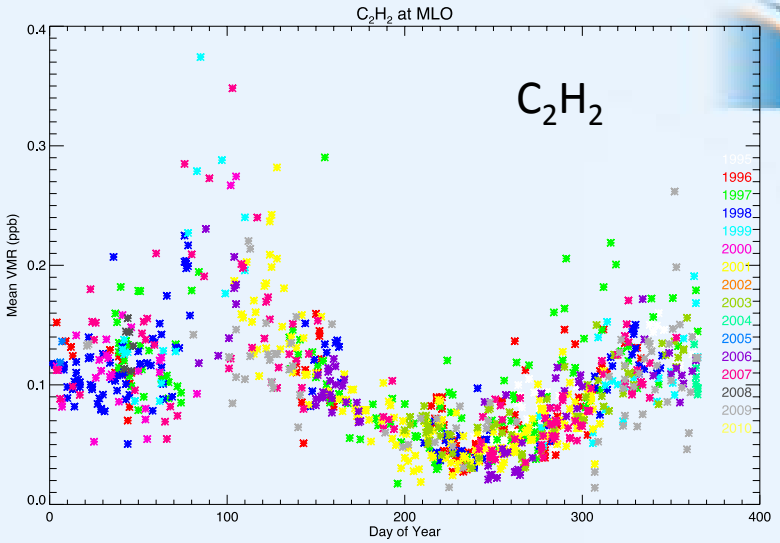
Left: Total column HCl model and MLO data to 2010

Below : Total column HF model and MLO data to 2010

<u>Other species, recent or pending studies:</u>

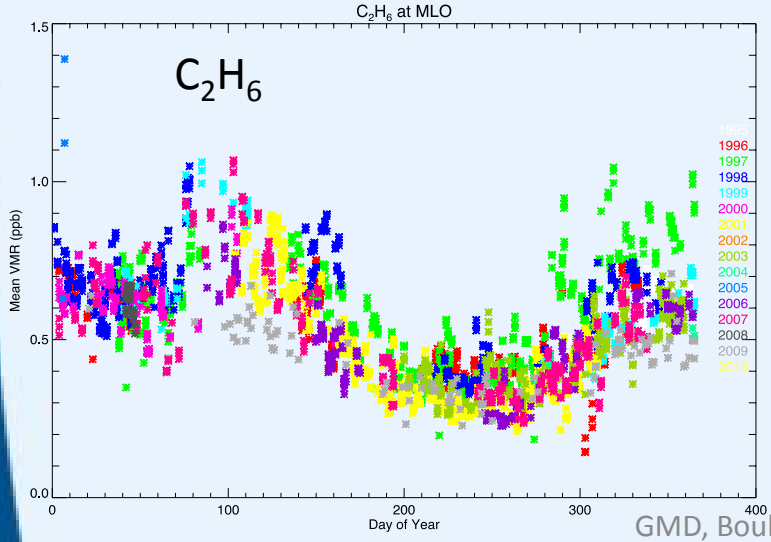
HCOOH, F. Paulot et. al. 2010
Ethane, C. Paton-Walsh, et. al.
Methane, R. Sussmann, et. al.

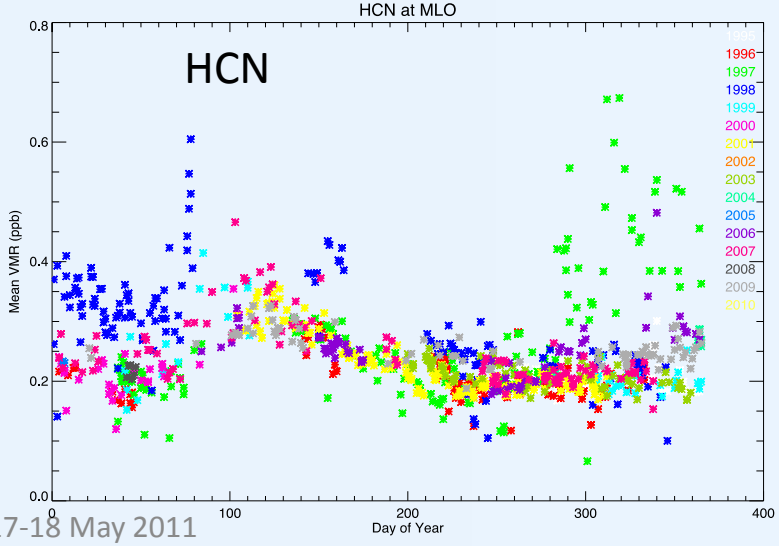


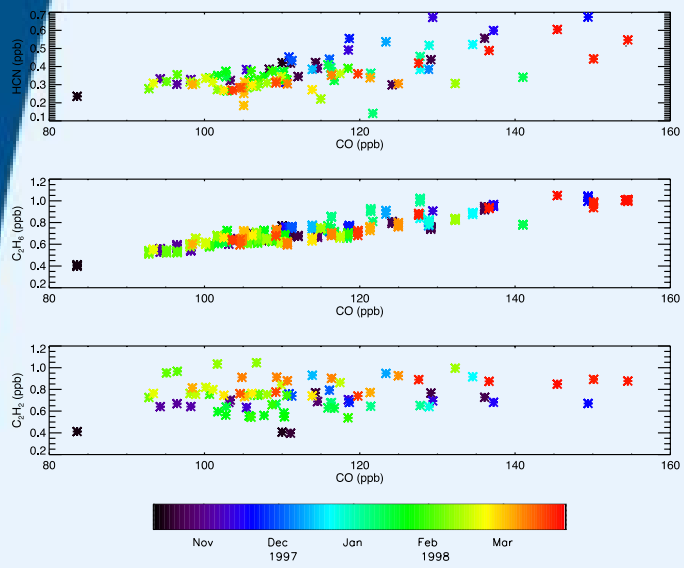


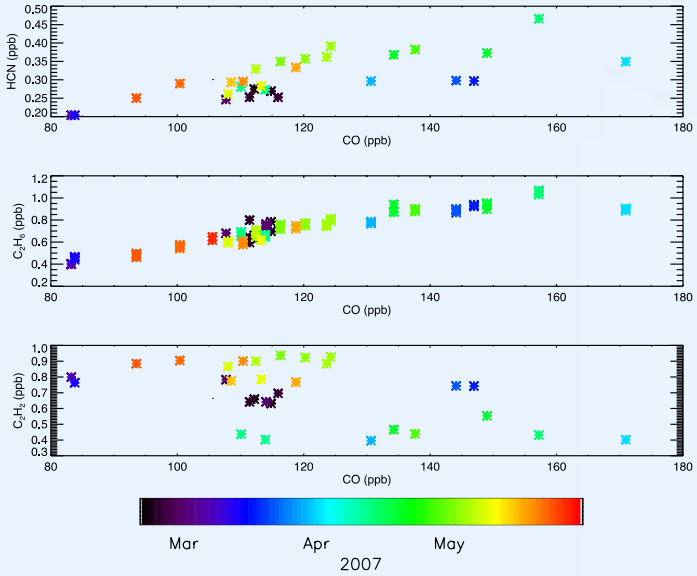
NCAR

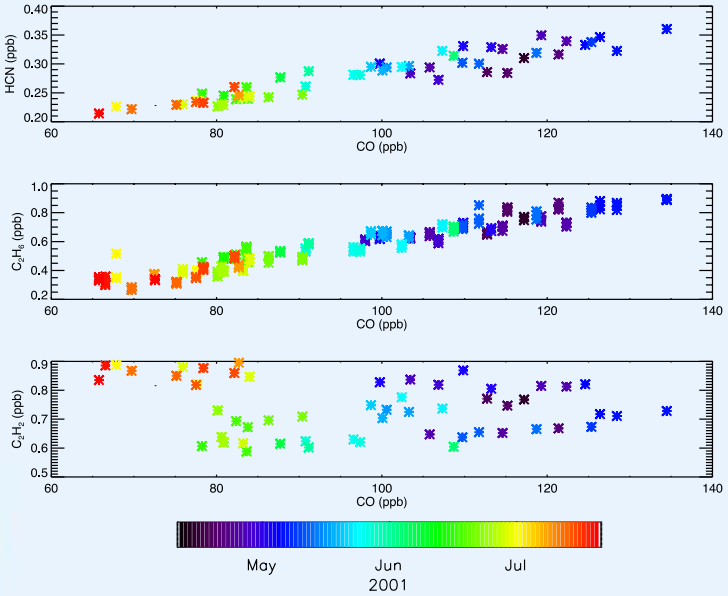
1996-2010 Mean tropospheric VMR (3.5-14.7km) Seasonal Cycles











Correlations free tropospheric HCN, C_2H_6 and C_2H_2 vs CO

Upper left fall 1997 through spring 1998
Lower left spring 2001
Upper right spring 2007

Best correlation C_2H_6 & Lower values of HCN
Little with C_2H_2

New MLO FTS

- Refurbished instrument -> *current 125HR specifications*
- New motor drive sub-system -> *improved instrument response & stability*
- New control and data electronics -> *no limit on band width, increased SNR*
- New dual aperture wheel and motors -> *improved alignment stability and stray light reduction*
- Additional optical filter changer -> *increased # spectral bands for narrow (high SNR eg H_2CO, SF_6) to NIR (better CO_2 & isotopologues)*
- Additional detectors, from 2 to 4 -> *eg. InGaAs NIR*
- Linux system Improved communication & operational stability -> *increased data rate*

ETA July 2011

Summary

- Recent advances in retrievals provide new course vertical profiles & improved total columns
- Homogenization of NDACC-IRWG retrieval processing will yield more consistent global data
  - Data for many species/sites already archived
- MLO data set re-analysis well in process
- *New MLO FTS should be online July 2011

MLO FTS is supported by NOAA, NASA, NSF
thanks to support from J. Barnes and P. Fukumura-Sawada at MLO

Network for the Detection of Atmospheric Composition Change

2011 NDACC Symposium

An International Symposium Celebrating 20 Years of Global Atmospheric Research Enhanced by NDACC/NDSC Observations

7-10 November 2011, Reunion Island, France

- **Long-term evolution and trends in ozone, atmospheric composition, temperature, aerosols, and surface UV in the polar regions and at mid- latitudes**
- **Tropical and sub-tropical observations and analyses**
- **Interactions between atmospheric composition and climate, in collaboration with NDACC Cooperating Networks**
- **Satellite calibration / validation**
- **New observational capabilities**

- end