2015 Thule & Mauna Loa Site Reports

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Mauna Loa, Hawaii

Thule, Greenland

NDACC/IRWG Archival Status

- All NDACC/IRWG species archived
  - MLO (1995-2012)
  - TAB (1999-2013)
- ClONO2 not archived for MLO
  – Not able to get satisfactory DOFs
- Re-Analysis with SFIT4 and Full Error Analysis
- One gas per year per file
- Currently working on processing retrievals up to end of 2014 for both sites
- Water is pre-retrieved for all relevant species
- If a pre-retrieved water profile is not available we use ERA-Interim daily water profile

Site	Gas	Dates
Mauna Loa	O3	1995-2012
	HCl	1995-2012
	HF	1995-2012
	HNO3	1995-2012
	N2O	1995-2012
	CH4	1995-2012
	CO	1995-2012
	C2H6	1995-2012
	HCN	1995-2012
Thule	O3	1999-2013
	HCl	1999-2013
	HF	1999-2013
	ClONO2	1999-2013
	HNO3	1999-2013
	N2O	1999-2013
	CH4	1999-2013
	CO	1999-2013
	C2H6	1999-2013
	HCN	1999-2013

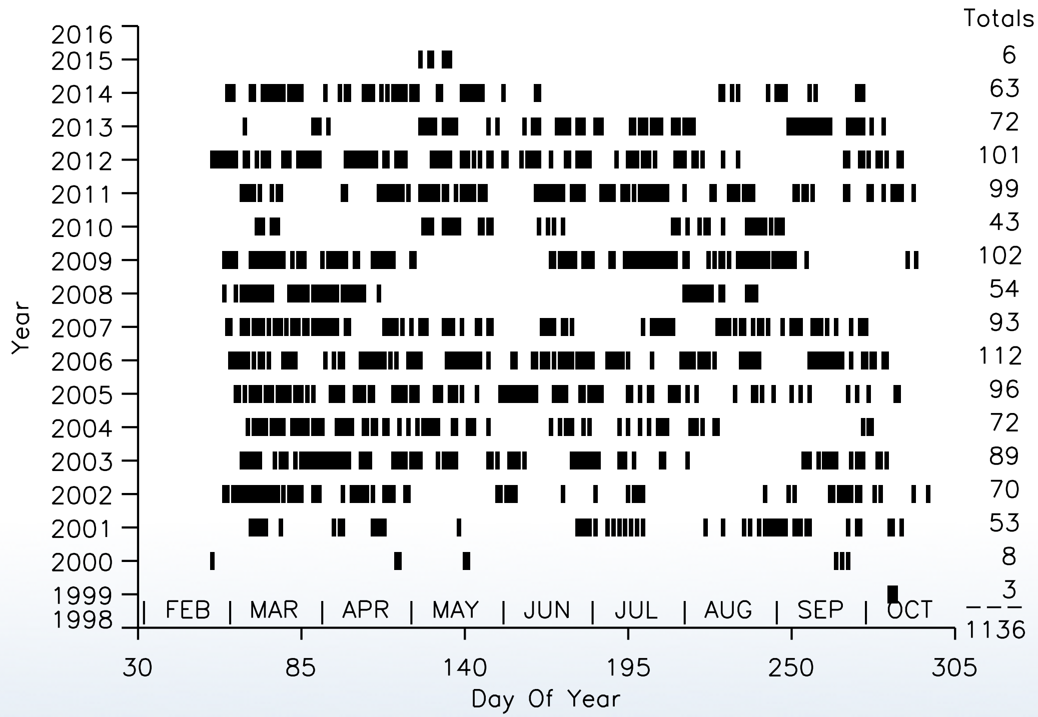
Recent / Current Publications

- **Reference upper-air observations for climate: From concept to reality,** G.E. Bodeker, D. Cimini, R.J. Dirksen, M. Haeffelin, J.W. Hannigan, D. Hurst, F. Madonna, M. Maturilli, A.C. Mikalsen, R. Philipona, T. Reale, D. Seidel, D.G.H. Tan, P.W. Thorne, H. Vömel, J. Wang, Bull. Amer. Met. Soc. 2015, http://dx.doi.org/10.1175/BAMS-D-14-00072.1
- **Trends of ozone total columns and vertical distribution from FTIR observations at eight NDACC stations around the globe**, Vigouroux, C, T Blumenstock, Michael Coffey, Q Errera, O Garcia, N Jones, James Hannigan, F Hase, B Liley, E Mahieu, J Mellqvist, J Notholt, M Palm, G Persson, M Schneider, C Servais, D Smale, L Thölix, M De Mazière, 2015:. *Atmospheric Chemistry and Physics*, 10.5194/acp-15-2915-2015
- **Volcanoes: Composition of Emissions**. Coffey, M.T., Hannigan, J.W., 2015. In: Gerald R. North (editor-in-chief), John Pyle and Fuqing Zhang (editors). *Encyclopedia of Atmospheric Sciences*, 2nd edition, Vol 1, pp. 446–449.
- **Identifying fire plumes in the Arctic with tropospheric FTIR measurements and transport models** Viatte, C, K Strong, James Hannigan, Eric Nussbaumer, Louisa Emmons, S Conway, C Paton-Walsh, J Hartley, J Benmergui, J Lin, 2015:. Atmospheric Chemistry and Physics,10.5194/acp-15-2227-2015
- **Identifying fire plumes in the Arctic with tropospheric FTIR measurements and transport models** Viatte, C, K Strong, James Hannigan, Eric Nussbaumer, Louisa Emmons, S Conway, C Paton-Walsh, J Hartley, J Benmergui, J Lin, 2015, NDACC Newsletter
- **Recent northern hemisphere hydrogen chloride increase due to atmospheric circulation change,** E. Mahieu, M.P. Chipperfield, J. Notholt, T. Reddmann, J. Anderson, P.F. Bernath, T. Blumenstock, M.T. Coffey, S. Dhomse, W. Feng, B. Franco, L. Froidevaux, D.W.T. Griffith, J. Hannigan, F. Hase, R. Hossaini, N.B. Jones, I. Morino, I. Murata, H. Nakajima, M. Palm, C. Paton-Walsh, J.M. Russell III, M. Schneider, C. Servais, D. Smale, K.A. Walker, 104-107, Nature, Vol 515, 6 November 2014, doi:10.1038/nature13857
- **Measurements of the absorption cross section of $^{13}CHO^{13}CHO$ at visible wavelengths and application to DOAS retrievals,** N. R. Goss, E. M. Waxman, S. C. Coburn, T. K. Koenig, R. Thalman, J. Dommen, J. W. Hannigan, G. S. Tyndall and R. Volkamer, J. Phys. Chem. A, Dec 31, 2014, DOI: 10.1021/jp511357s

Thule News & Observations

- March 2014
  - Tracker door failed causing possible water damage to Bruker
  - 120M low-pass filter failed
- May 2015
  - New OT solar tracker
  - New 125HR
- Still working out the bugs of the New automated observation system

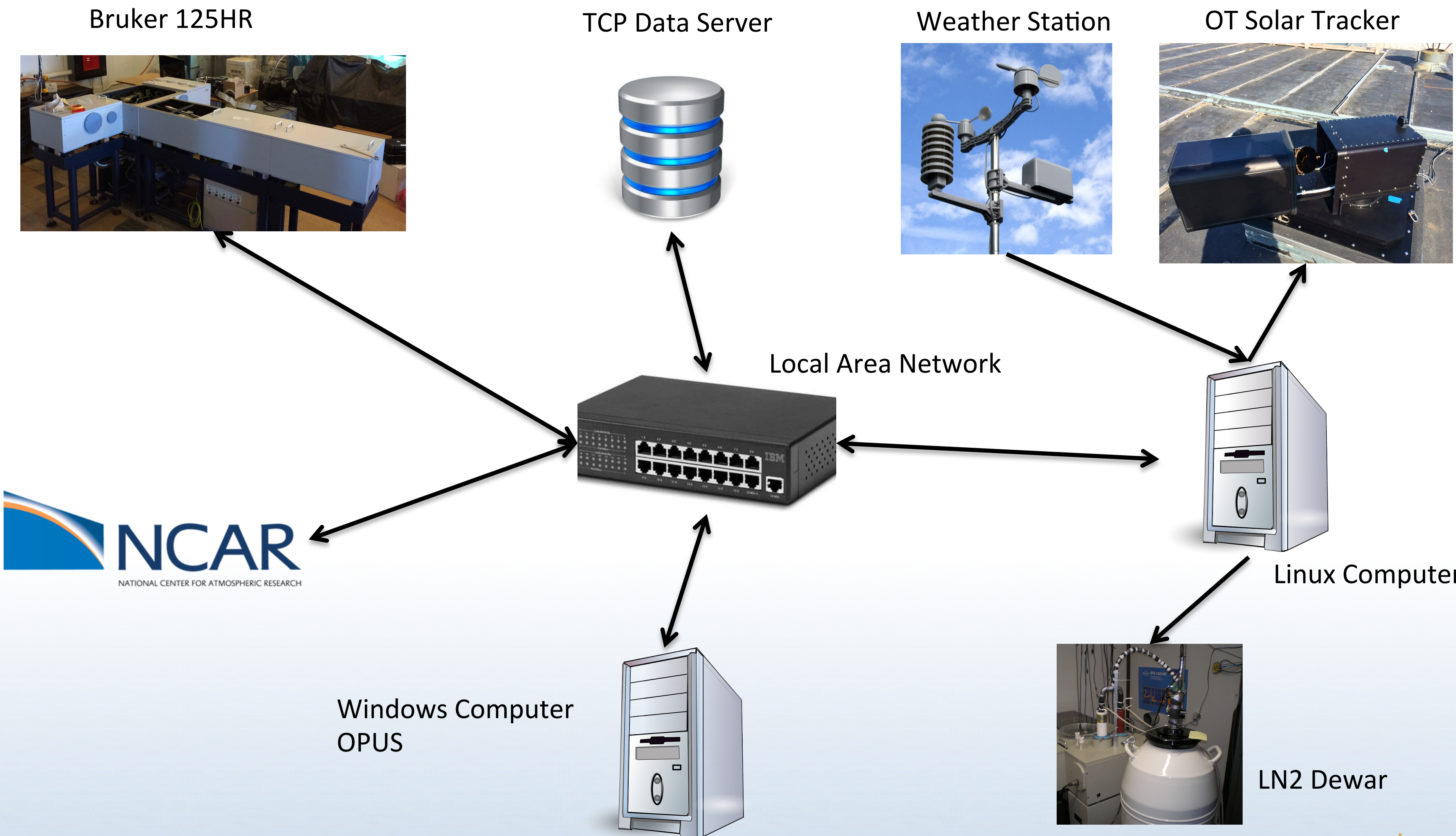
Observation Days by Year



Thule Autonomous Configuration

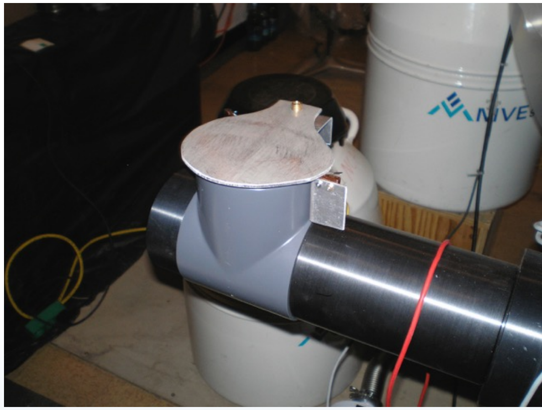
- Two separate computers
  - Windows computer solely for running OPUS
  - Linux computer for everything else (running solar tracker, storing data, TCP data server, weather station, etc)
- All computers and Bruker are connected on a Local Area Network (LAN)
- All programs communicate with each other via TCP data server
  - This allows for real-time observation of system status from anywhere
  - Allows for control of observation system from anywhere
- Communication to OPUS occurs through named pipes
  - OPUS macros and pipe system difficult to work with
  - Lack of documentation and support
  - OPUS pipe communication is not stable!!
- OPUS macros automatically determine gain settings
- All programs in C and Python
  - Will be made publically available

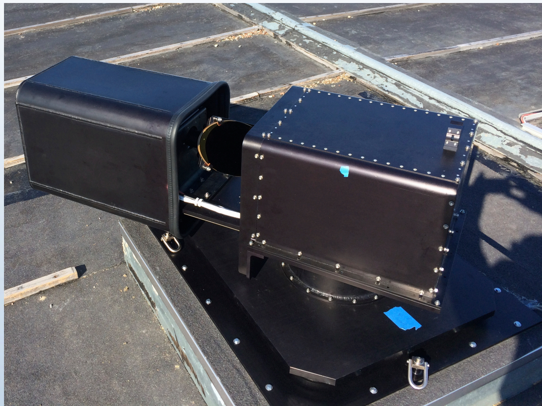
Thule Configuration



Thule Tracker

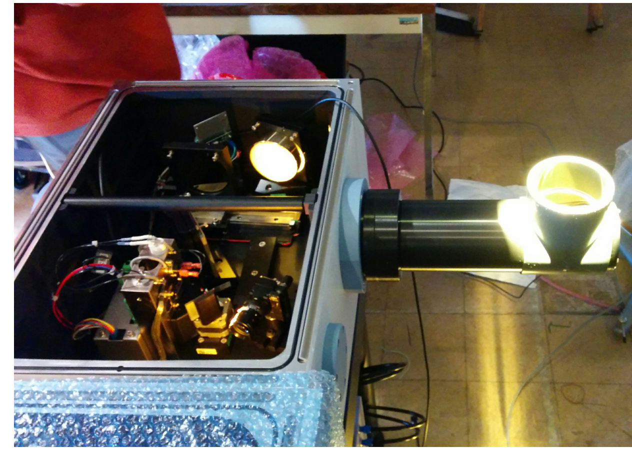
- Similar design to KIT, Dalhousie (Bruker)
- 5.9” clear aperture
  - Options for other solar viewing instruments
- Newport stages
  - Elevation: RVS80PP stepper 0.001º increment
  - Azimuth: RV240PE stepper 0.0002º increment
- Full 360º azimuth, 0-90º elevation view
- Two direction external solar sensor to determine cloudless path to sun
- Borosilicate Au coated mirrors

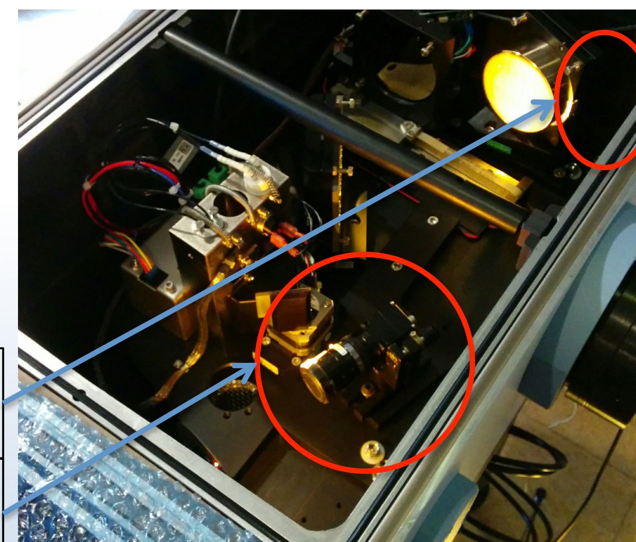




Thule Tracker Algorithm

- Initial pointing of tracker is accomplished by ephemeris calculation including refraction
- Tracker is dynamically controlled by image detection of sun and aperture from CCD camera
  - Image is first passed through a Gaussian Blur filter
  - Image for Sun detection is threshold using Otsu binarization
  - Image for aperture detection is threshold using adaptive thresholding
  - Sun and aperture contours are identified using algorithm from *Suzuki and Abe, 1985*
- Conversion between CCD pixel coordinates and solar tracker angle coordinates is accomplished through a transformation matrix found using least-squares solver with calibration points



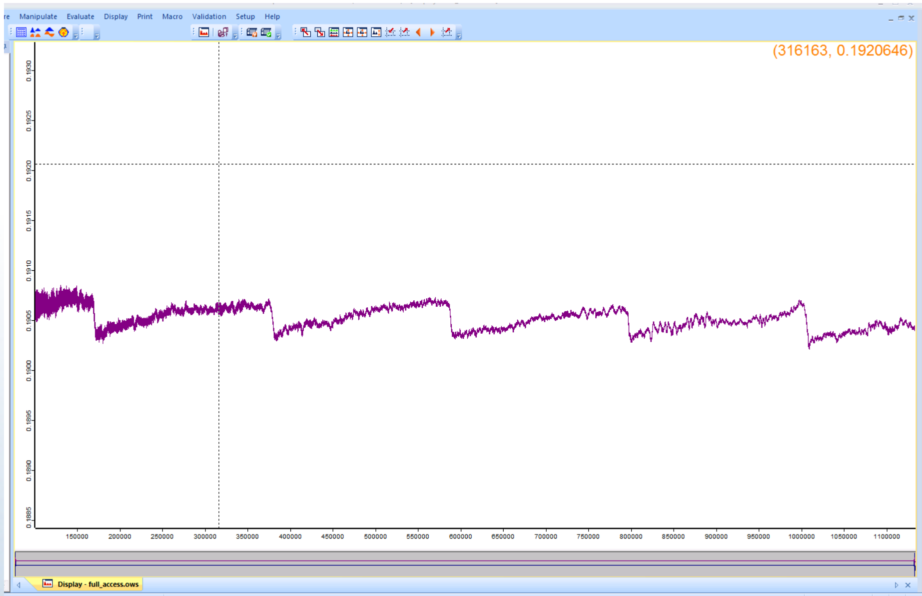


Final placement of CCD camera

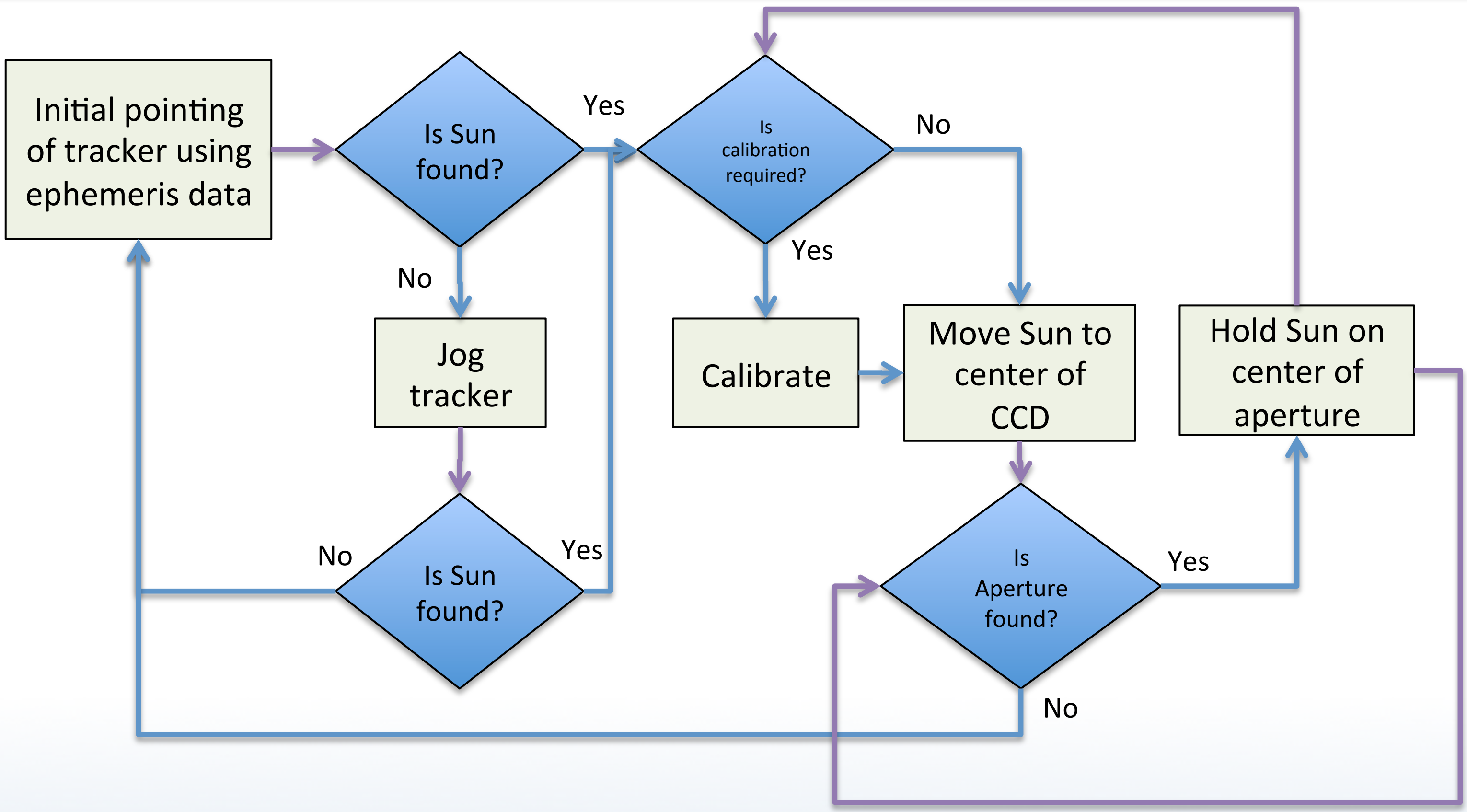
Initial placement of CCD camera

Thule Tracker Algorithm

- Pointing precision is ~ 100 micro-radians



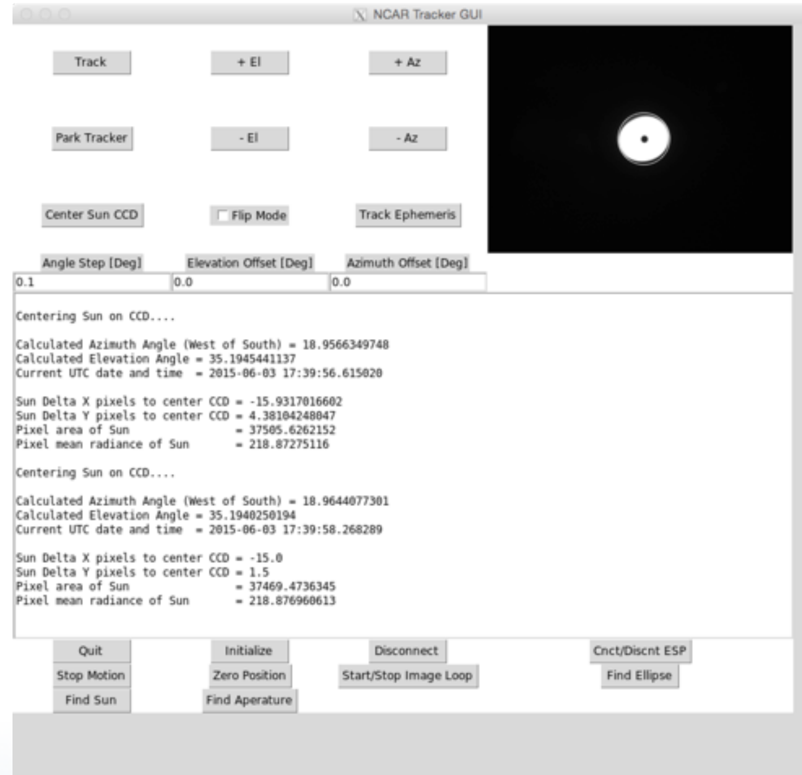
Thule Tracker Algorithm



- Calibration performed every two hours
- Testing of rotation of transformation matrix based on azimuth angle to be done
  - This will enable a single calibration at start up

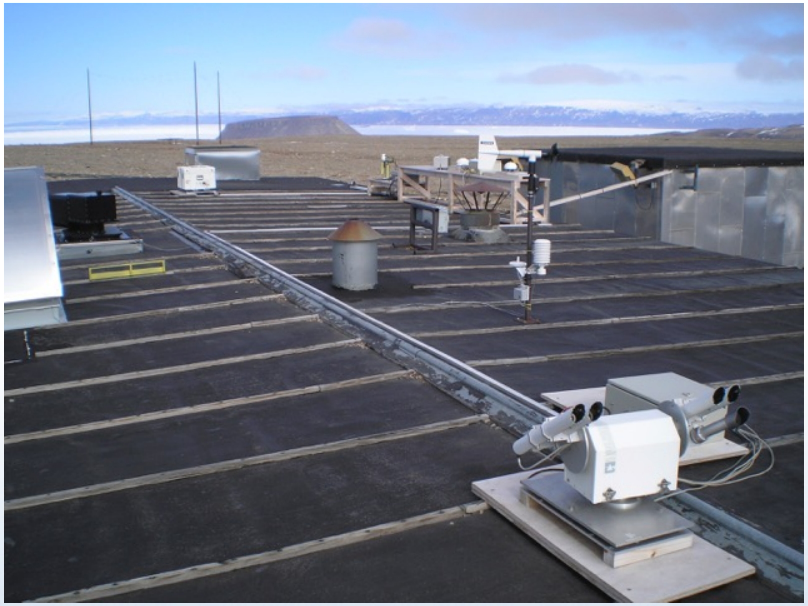
Thule Tracker Algorithm

- Tracker GUI allows for
  - Nominal operation of tracker with real-time display of Sun and aperture along with statistics
  - Operation in flip mode
  - Determination of initial elevation and azimuth offsets
    - These are due to tracker alignment issues
  - Determination of aperture location on CCD
- Day to day operation does not occur in GUI mode



All Instruments are in "NDACC" Building

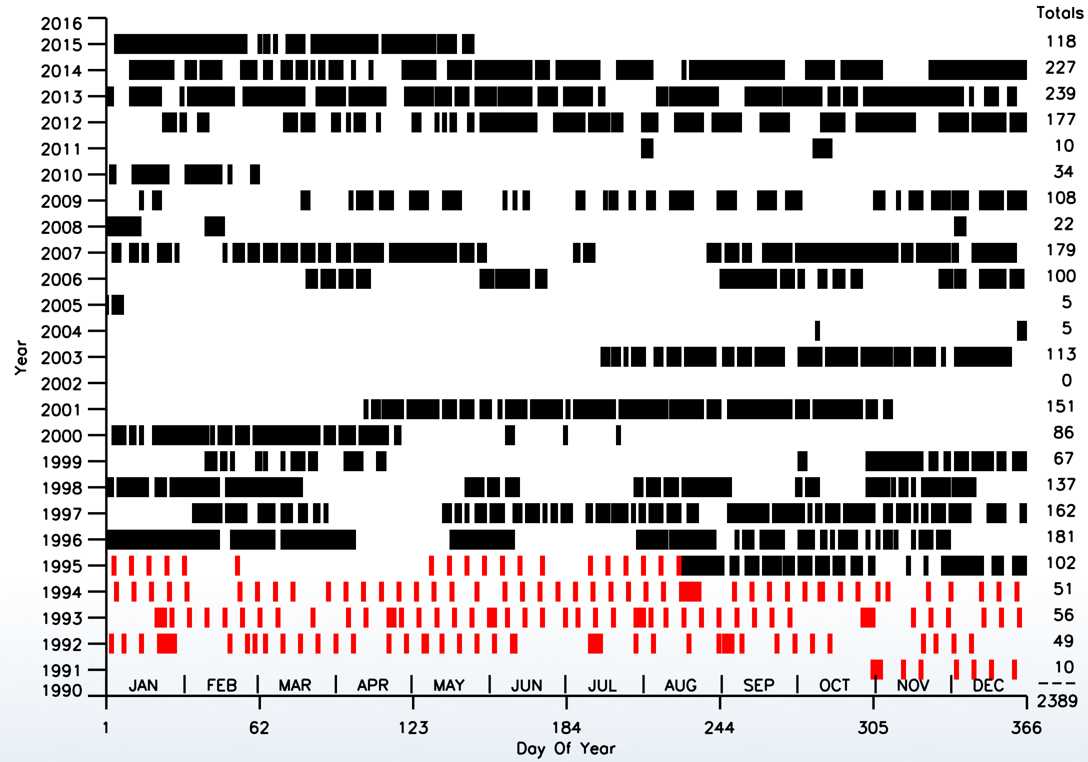
- Sun photometer – AERONET/NASA
- Aerosol LIDAR – U Rome
- Microwave Radiometer – INGV Rome
- O3 Sondes (winter) – DMI
- Aerosol Sampler – U Sienna
- IR Radiometer – U Sienna
- Solar FTS – NCAR
- UV spectro-radiometer – DMI
  - *Removed – but may be returned in 2016*
- Water μ-wave -Univ Bern
  - Campaign Summer 2015



MLO News & Observations

- After 125HR installed in August 2011 consistent operation with small gaps due to solar tracker issues

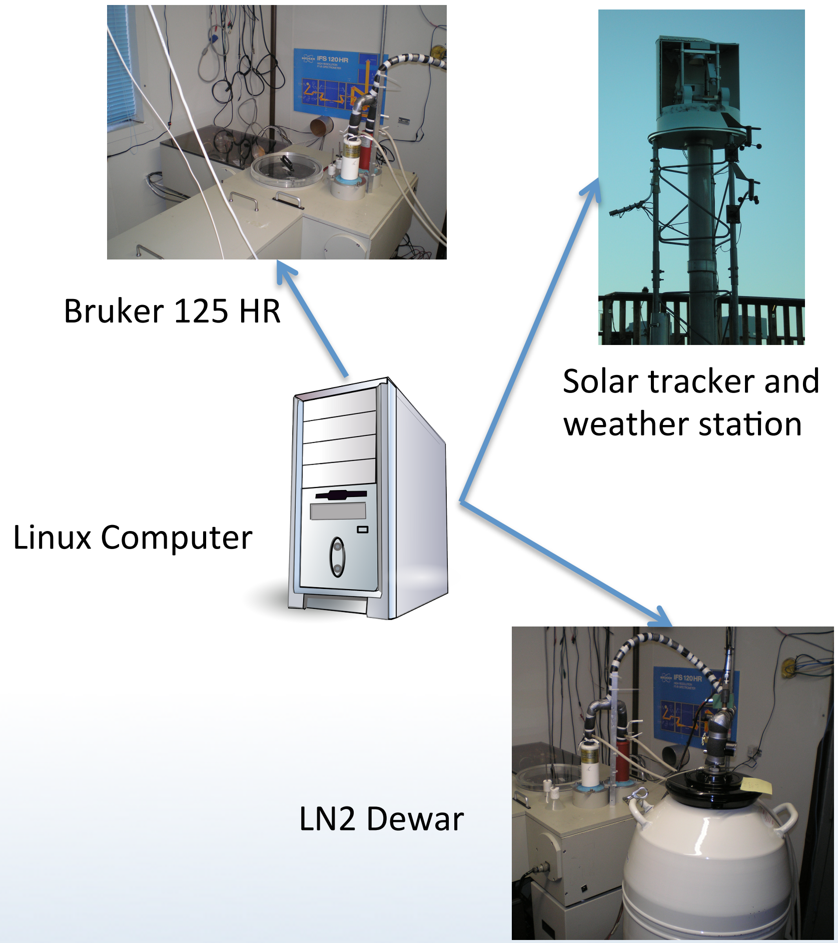
Observation Days by Year



Red indicates Bomem observations from DU. Have yet to be reprocessed.

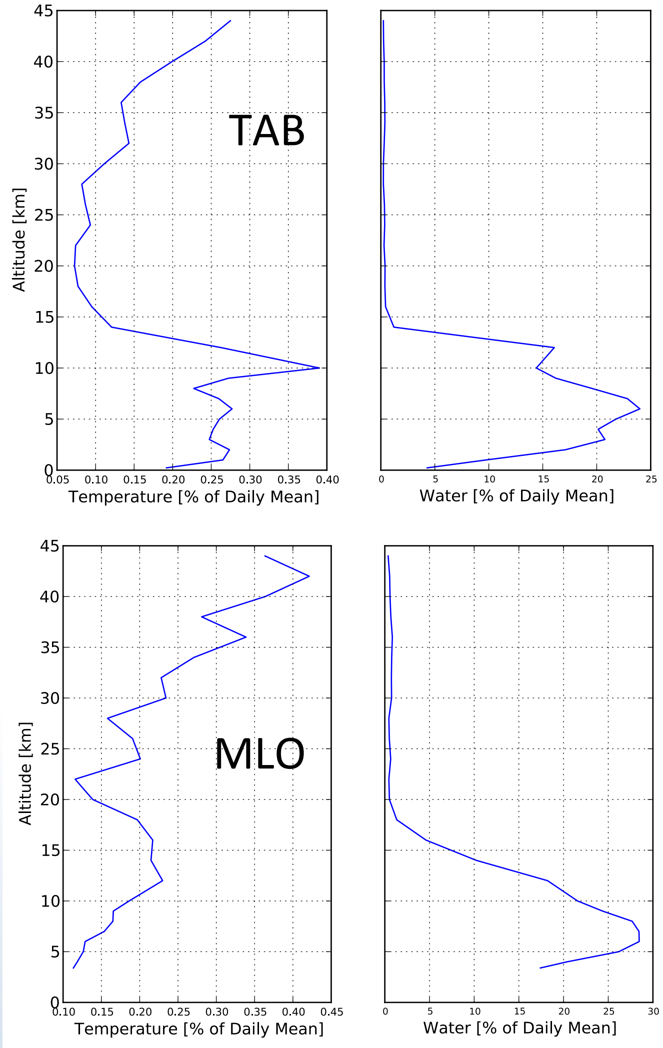
MLO Configuration

- 125HR installed in August 2011
- Single Linux computer controls autonomous operation
  - Solar Tracker
  - Dewar
  - Bruker
  - Weather station
- Running linux version of OPUS
  - Extremely buggy/unstable
  - Not supported
  - Minimal features
- No dynamic solar tracking
  - Based on ephemeris calculation
- XPM files with set gains



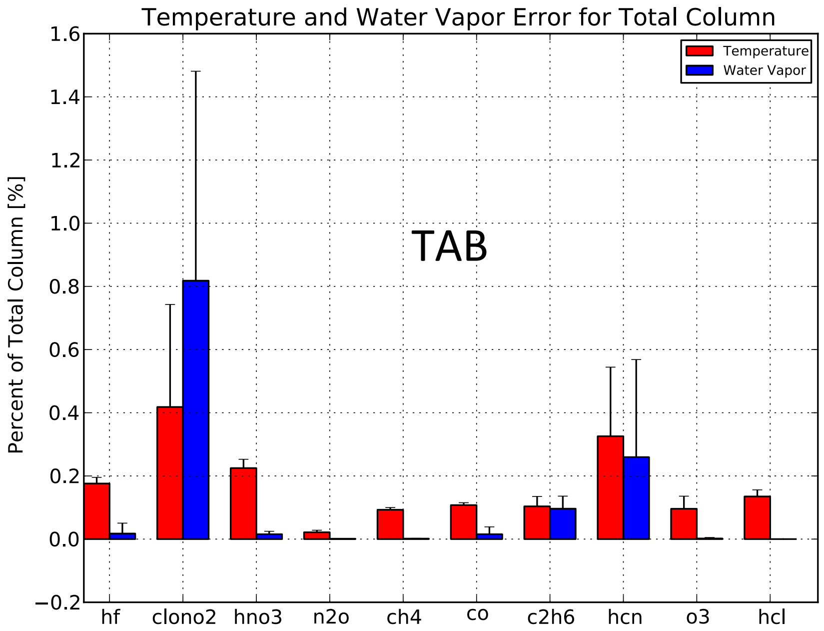
Effect of Diurnal Cycle of Temperature and Water Vapor

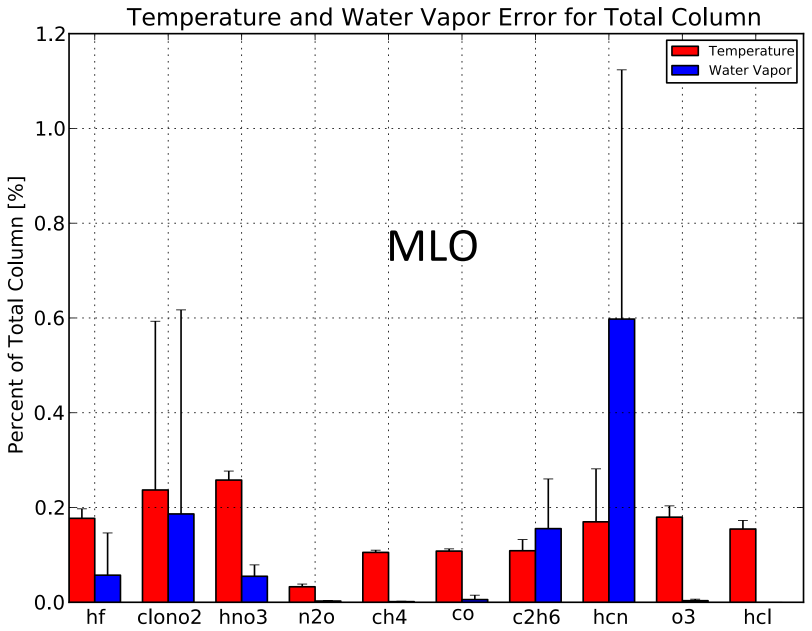
- The error associated with the diurnal variation of water vapor and temperature as presented by ERA-Interim re-analysis was analyzed for all NDACC gases at Thule and Mauna Loa
- Total column error due to diurnal variability of water and temperature depend on
  - Diurnal variability of temperature and water
  - Sensitivity of the retrieval to water vapor and temperature



Effect of Diurnal Cycle of Temperature and Water Vapor

- For Mauna Loa and Thule diurnal variability of temperature and water vapor are not a significant source of error





Boulder News

- On-going measurements in Boulder
- Supporting studies through retrieval of CH_4, C_2H_6, H_2CO, and NH_3
  - *Front Range Air Pollution and Photochemistry Experiment* (FRAPPE)
    - Goal is to characterize and understand the summertime air quality in the Northern Front Range Metropolitan Area
  - *Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality (*DISCOVER-AQ)
    - Coincided with FRAPPE
    - Goals:
      - Relate column observations to surface conditions for aerosols and key trace gases: O_3, NO_2, CH_2O
      - Characterize differences in diurnal variation of surface and column observations for key trace gases and aerosols
      - Examine horizontal scales of variability affecting satellites and model calculations
  - COCCON EM27/SUN
    - March 2015

HBr & N2O Cell Update

- All N2O cells have been filled
  - 1mbar
- Two previous HBr bottles had corroded valves
  - Had to re-order new bottle of HBr
- Remaining cells will be filled week of June 18th
- All cells will be shipped to KIT for calibration
- After initial calibration cells will be shipped back to NCAR and then distributed to each group
- Each group should re-verify calibration of HBr

SFIT4 Development

- List of contributors:
  - Mathias Palm, Stephanie Conway, James Hannigan, Bavo Langerock
- SFIT4 + Spectra Retrieval Environment Development
  - New version of SFIT4 will be released this summer
  - Ability to create GEOMS compliant HDF files for archiving in NDACC database
  - Filtering of retrievals based on a variety of metrics: rms, DOFs, negative partial columns
  - Visualization of results: fitted spectra, profiles, errors, dofs, etc.
  - Full systematic and random error calculations