Global Monitoring Division

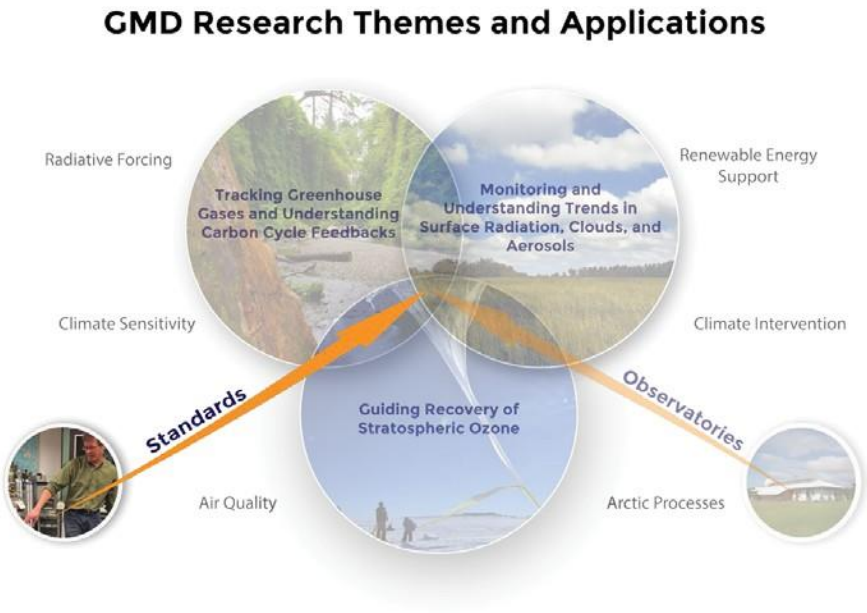
Supporting Infrastructure Presentations

2013-2017 Review

May 21-24, 2018

Contents: page

Calibration and Standards Activities



Solar & Terrestrial Radiation

Dobson Column Ozone

Trace Gases

Federated Aerosol Network

Solar & Terrestrial Radiation

Trace Gases

Dobson Column Ozone

Federated Aerosol Network

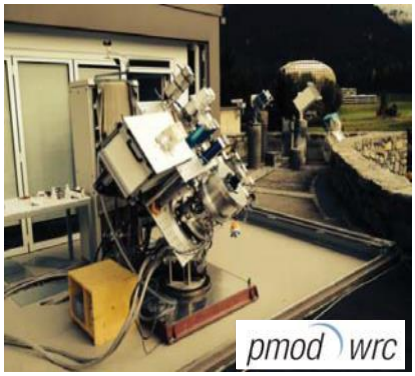
Common Aspects

- ☐ **Support GMD Measurements**
- ☐ **Commitment to Consistency**
- ☐ **Regional/Global Scope (e.g. WMO)**
- ☐ **Hierarchical Approach**
- ☐ **Collaborative**
- ☐ **Research Component**
- ☐ **Cost-Sharing**
- ☐ **Transparency/Accessibility**

Solar & Terrestrial Radiation

- Calibration support for GMD observatories and Baseline Surface Radiation Network (BSRN) sites at Kwajalein, Bermuda
- GMD reference cavity radiometers - traceable to World Radiation Center (Davos, Switzerland)

Hall, Traceability to WRC (P-38)



PMOD World Standard Group Cavity Pyrheliometers

IPC 2015 Results for the six NOAA Active Cavity Pyrheliometers

Pyrheliometer	AWX 31114	AWX 32448	AHF 28553	AHF 30710	AHF 14917	TMI 67502
WRR factor	1.002	1.001	0.998	1.002	0.998	1.002

- WMO Region IV National Radiometric Calibration Center for the U.S.
- Expanding calibration services to include instruments in the U.S. Climate Reference Network (NOAA Air Resources Lab)

Solar & Terrestrial Radiation

Central UV Calibration Facility (CUCF)

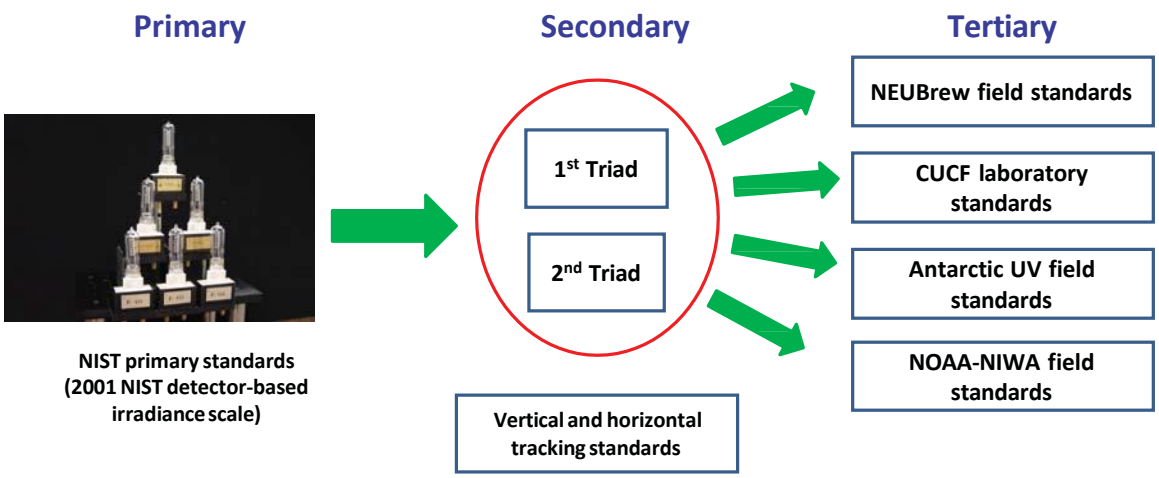
- NIST traveling primary standards:
  - limited lifetime
  - vertical orientation only
  - high cost (~$15K)

- **Practical Solution**: Collaboration with NIST and others .... GMD calibrates 1000 watt standard lamps in *horizontal and vertical* orientations, traceable to the NIST scale (Yoon, et al. 2003)

Portable Calibration Unit

Solar & Terrestrial Radiation

Hierarchical Approach



Solar & Terrestrial Radiation

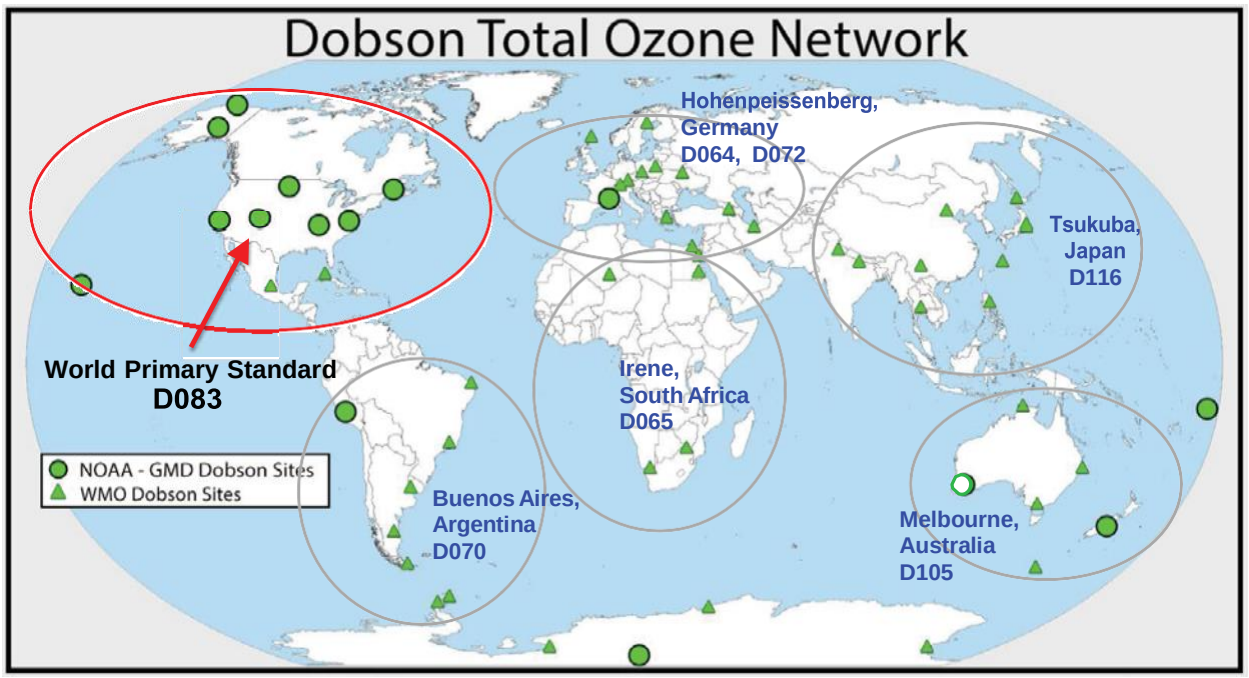
WMO/GAW Regional Calibration Center

Performing a Field Calibration

- **CUCF Activities:**
  - Absolute spectral irradiance calibrations (~40 per year)
  - Laboratory facility at GMD + portable calibration system
  - Characterization (spectral response, angular response, +more)
  - Host comparison activities (Lantz et al. 2001, Lantz et al. 2008)

UV Spectral Response System

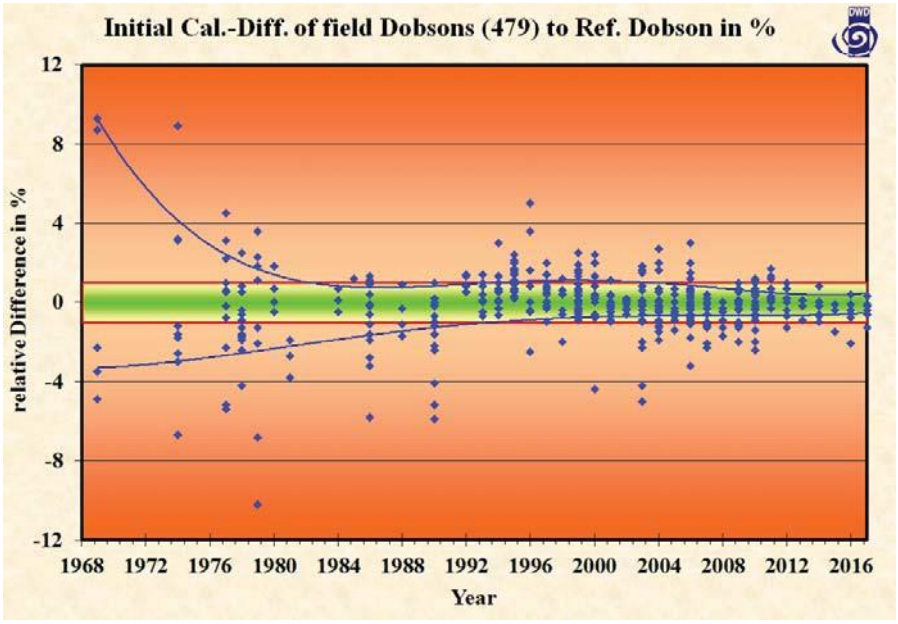
Dobson Column Ozone



McConville, Dobson Ozone Network (P-53)

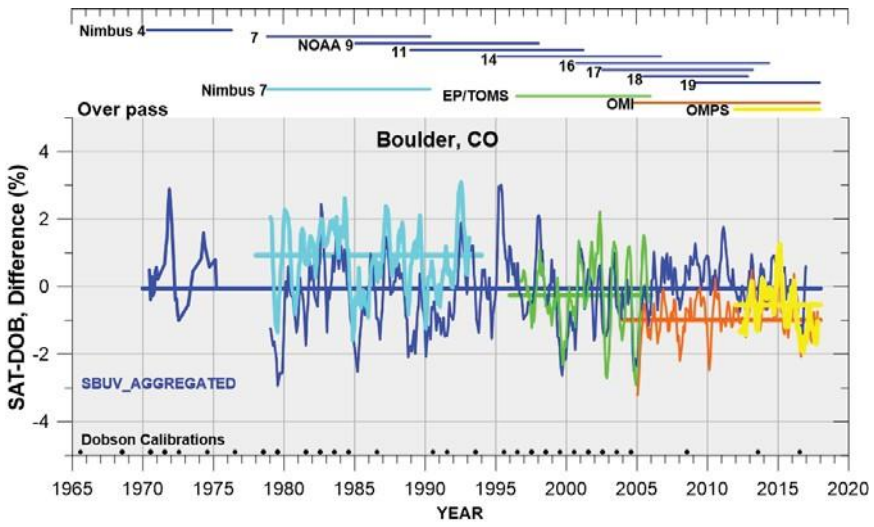
Dobson Column Ozone

Comparison between field instruments and reference instruments



Dobson Column Ozone

- Used to establish consistency of measurement across the network(s)
- Allows us to evaluate:
  - combined datasets
    (important for Ozone Assessment)
  - stability of new satellites (i.e. JPSS)
  - stability of new instruments (i.e. Pandora)

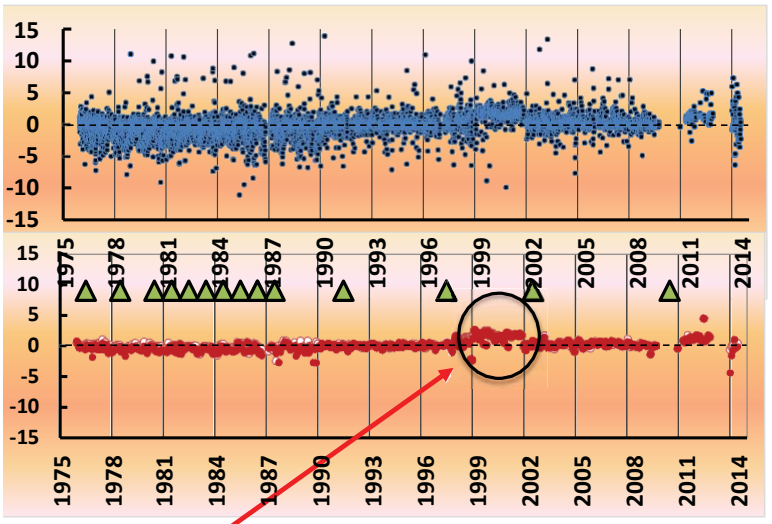


Dobson Column Ozone

Recent Developments: New Software

- WinDobson (developed by the Japan Meteorological Agency)
  - Facilitates near-real-time data
  - Improved QC
  - NRT data needed to support satellites (critical in post-launch year)
  - Efficient reprocessing of archive data

SMO: % Change after reprocessing

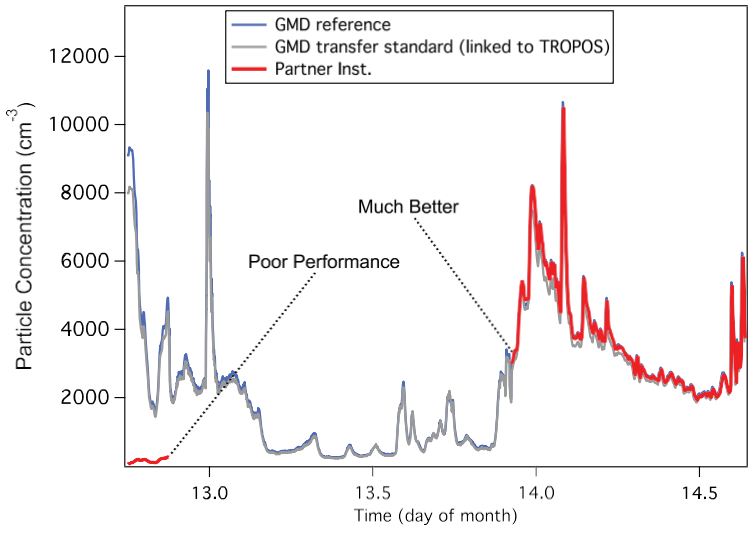


Identified 1-2% errors in SMO record
(overall correction, all stations ~0.1%)

from Evans et al., 2017

Federated Aerosol Network

Particle Counter Comparison



Sheridan, Network Overview (P-33)

- Calibration derived from TROPOS (Germany)
- Network support, capacity-building role
- QA/QC

Trace Gases

- Primary methods – traceable to SI *(to the extent possible)*
- Flexibility – compatible with measurement method
- Support instrument development, complete understanding

Gas Blending Manifold

Compressed Gas Standards

Trace Gases

Scales Developed within GMD

CFCs
CFC-11
CFC-12
CFC-113
CFC-114
CFC-115
CFC-13

HCFCs
HCFC-22
HCFC-141b
HCFC-142b
HCFC-133a
HCFC-21

HFCs
HFC-134a HFC-365mfc
HFC-152a HFC-236fa
HFC-143a HFC-227ea
HFC-125 HFC-23
HFC-32

Other Halocarbons
CH_3Br
CH_3Cl
CH_3I
CH_2Br_2
$CHBr_3$
CH_2BrCl
$CHBr_2Cl$
CH_2I_2
CH_2BrI
CH_2ClI
CF_4

Solvents
CH_3CCl_3 $CClH_2CClH_2$
CCl_4 TCE
$CHCl_3$ PCE
CH_2Cl_2

Halons
Halon-1211
Halon-1301
Halon-2402

Sulfur Gases
COS SO_2F_2
CS_2 CF_3SF_5
SF_6

Hydrocarbons
acetylene n-pentane
ethane i-pentane
propane hexane
n-butane benzene
i-butane toluene

Other
CO_2 CH_4
N_2O CO
hydrogen
peroxyacetylnitrate
water vapor
perfluoro-amines
NF_3

WMO/GAW CCL
w̃ẽll developed
s̃ẽẅi developed
limited

Designated Institute of WMO

- For select gases: CO_2, CH_4, N_2O, CO, SF_6
- ISO 17025 – Quality Management System reviewed in 2015
- Participate in Key Comparisons – BIPM, National Metrology Institutes

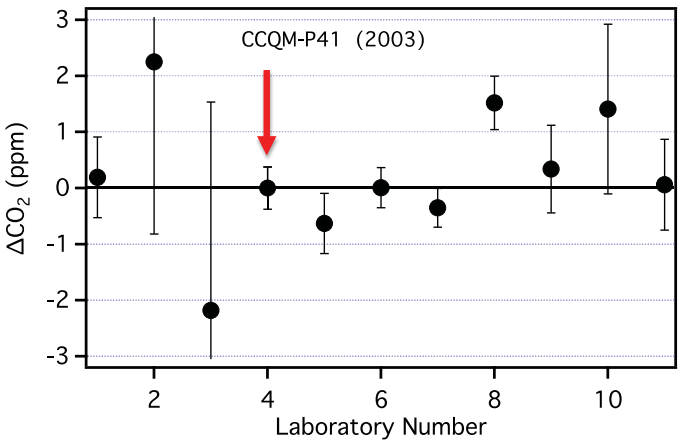

INTERNATIONAL STANDARD

ISO/IEC 17025

Third edition 2017-11

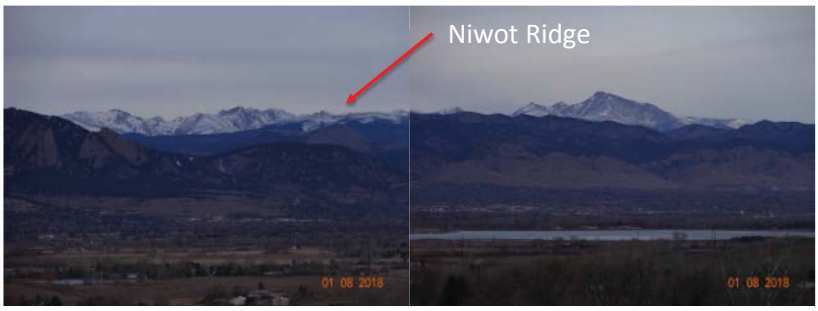
General requirements for the competence of testing and calibration laboratories

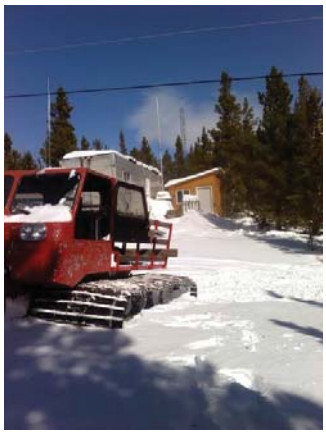
Exigences générales concernant la compétence des laboratoires d'étalonnages et d'essais



Whole-Air Standards

- GMD distributes whole-air standards (tertiary)
  - Related to secondary/primary standard by analysis
  - A few other labs also make whole air standards (SIO, CSIRO, ICOS, NIWA)
  - GMD makes **custom mixtures**
  - Access to un-polluted whole air is extremely valuable to GMD

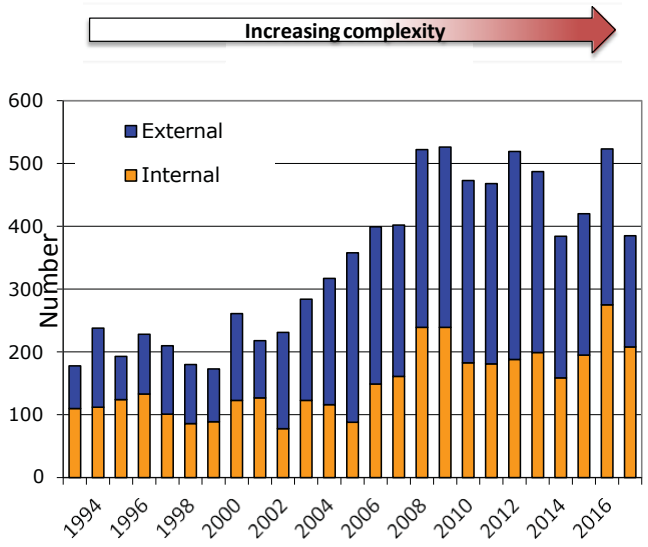




Trace Gases

Tarasova, WMP/GAW (P-1)

WMO/GAW Central Calibration Laboratory



New CO_2/CH_4 analytical system

Since April, 2016

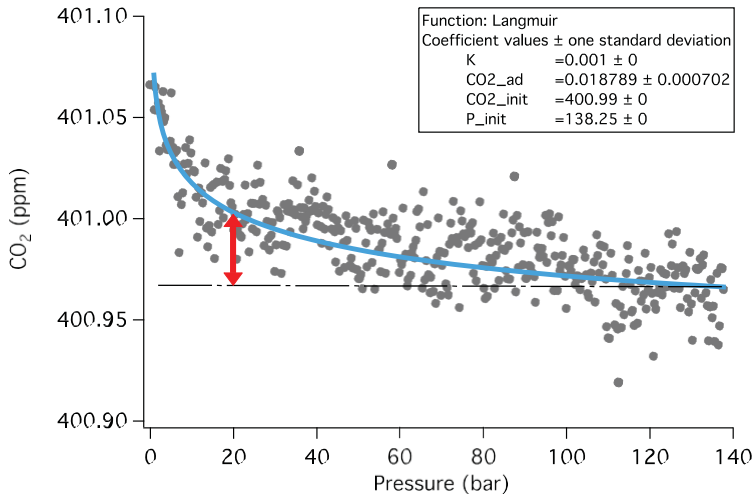
Crotwell, Carbon Monoxide (P-21)

https://www.esrl.noaa.gov/gmd/ccl/ccl.html

Trace Gases

Research Component:

Stability of CO_2 in aluminum cylinders



Schibig et al., 2018

CO_2 increases as pressure drops

Remarkably consistent

~0.04 ppm increase (1 part in 10,000)

(comparable to compatibility goals)

Future Directions

Solar & Terrestrial Radiation

- Continue to facilitate a comparison to evaluate a new standard for longwave irradiance (with NREL/PMOD) (interim standard currently in use)
- Collaborate with NREL and National Central University, Taiwan to improve shortwave irradiance calibrations regarding infrared loss from sensors
- Improve direct-sun calibrations of the Brewer spectrophotometer to improve Aerosol Optical Depth retrievals

Stierle, AOD Retrievals (P-49)

Dobson Column Ozone

- Possibly move D083 to MLO (eliminate risk of transport)
- Continue Dobson/Pandora/Satellite comparisons

Future Directions

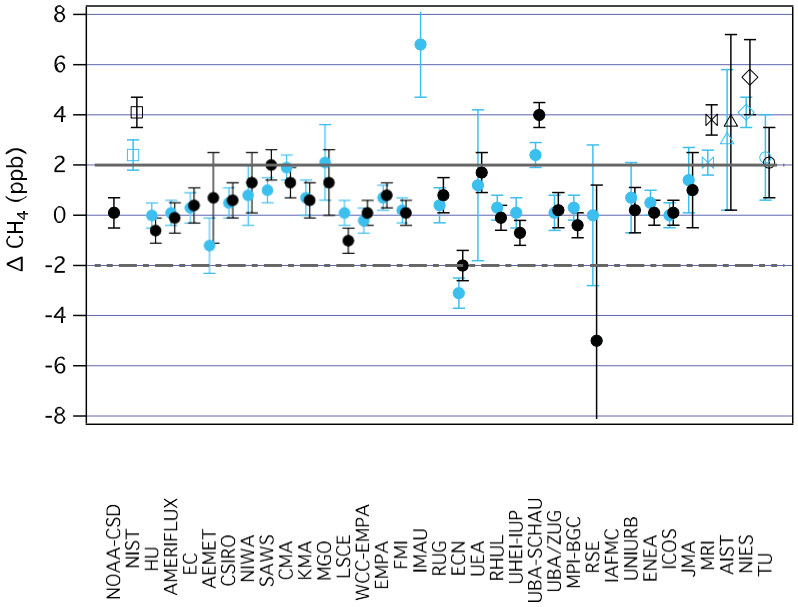
Trace Gases

- Improve uncertainty estimates
- Update CO_2 calibration scale
- Facilitate WMO Round Robin #7

Michel, Stable Isotopes of CO_2 (P-14)

Miller, Uncertainties (P-18)

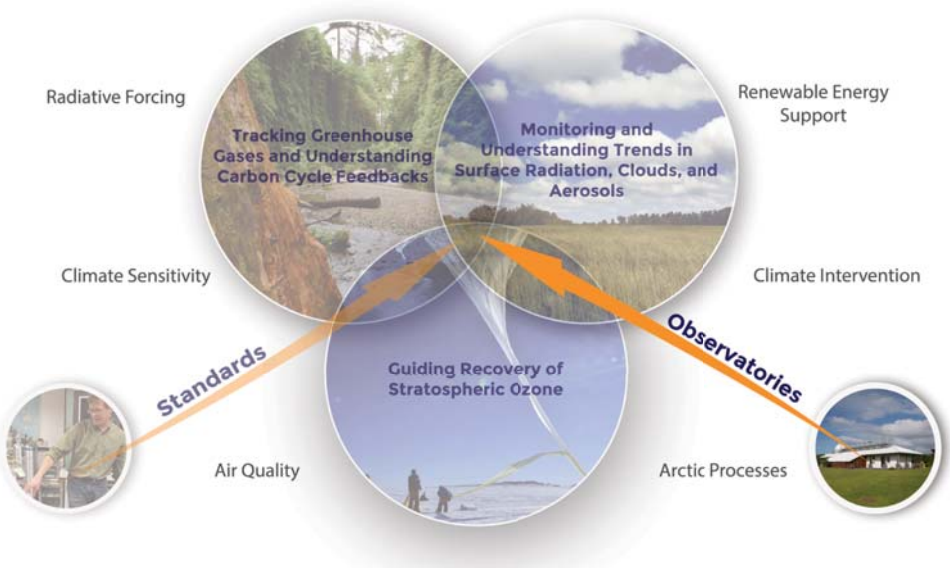
WMO Round Robin Comparison #6 Results: (CH_4)



Summary

- **Calibration activities are an essential component of GMD**
- **We provide calibration links among networks (regional/global scope)**
  - **Including critical support for WMO/GAW**
- **We play an active role in improving measurements**
- **Activities share common aspects: Commitment to consistency**

Atmospheric Baseline Observatories

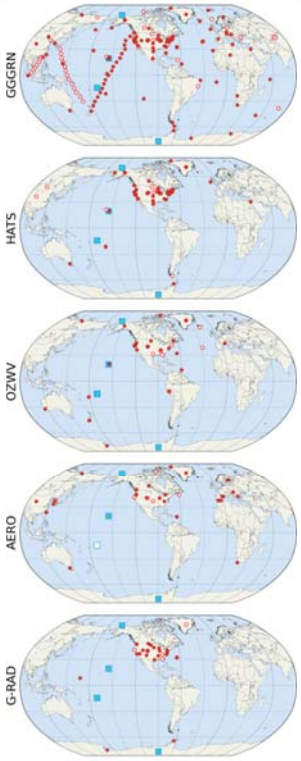


Brian Vasel
Director of Observatory Operations

Backbone of Global Networks

Barrow (BRW)
Elevation: 11m *71.3º N Latitude*

American Samoa (SMO)
Elevation: 42m *14.2º S Latitude*



Mauna Loa (MLO)
Elevation: 3397m *19.5º N Latitude*

South Pole (SPO)
Elevation: 2840m *90º S Latitude*

Observatory Operations Philosophy

ABOs enable and support Science Science drives decisions

- **Stewardship** – Build upon foundation of high-quality observations for over 45 years, continue "national treasure" legacy
- **Customer Service** – Plug and play remote field operations for researchers
- **Resources Tool Kit** – Provide highly skilled workforce & core of supporting measurements (meta-data) at each observatory. Updated meteorology, web cams, all-sky imagery, ceilometers, etc.
- **Efficiency** – Thrifty and resourceful operations; every dollar for operations is a dollar less for science
- **Innovation** – Expand and enhance the use of renewable technology, modernize instrumentation
- **Platform for Growth** – Dependable observatory resources + co-location of measurements = increase in interagency & interdisciplinary science collaboration
  - Promotion of observatory platform to audiences external to GMD
    (Other NOAA line offices, Federal partners, & University PIs)

ABO Historical and Relational Significance

Staff Collaboration

- Federal
- CIRES & JIMAR (Cooperative Institutes)
- STC contractors
- NOAA Corps Officers
  2-3 officers assigned to GMD at any given time

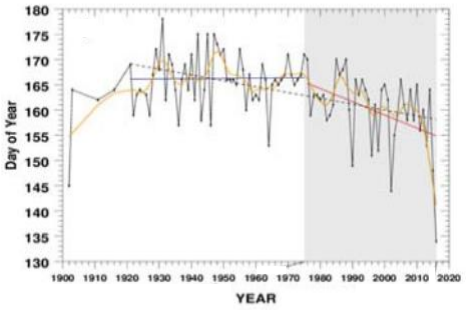
Mauna Loa Dedication June 28, 1956

Longevity

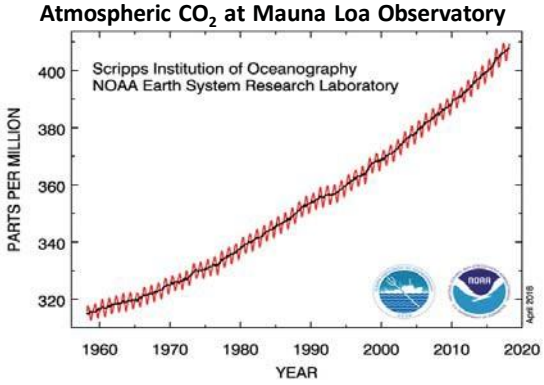
- MLO and SPO records date back to 1956 and 1957 (IGY)
- BRW records begin in 1973, SMO in 1974
- First Geophysical Monitoring for Climatic Change (GMCC) Summary Report (1972)
  "… data are collected by a few observatories whose location .chosen to sample representative latitudes within both hemispheres .where local man-made or biota interferences are minimal'.
  First priority is placed on the collection of impeccable measurements of trace constituents."
- WMO Global Atmospheric Watch (GAW) network modeled on ABOs

ABOs - Home of Scientifically Renowned Records

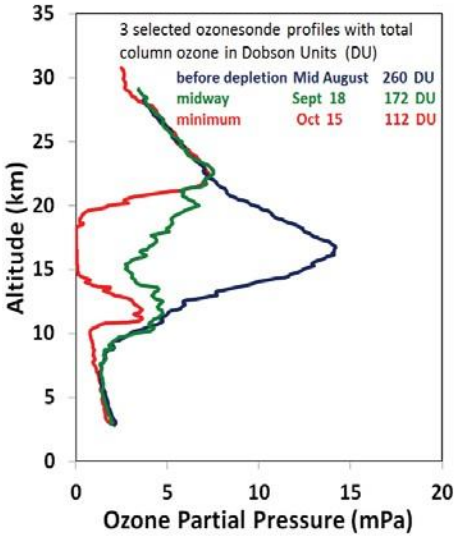
Barrow Snow Melt Date



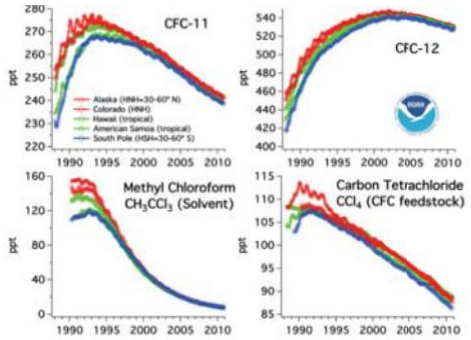
Atmospheric CO_2 at Mauna Loa Observatory



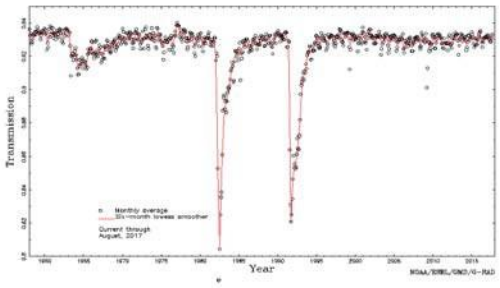
South Pole Ozone Hole



Ozone Depleting Gases



Mauna Loa Apparent Transmission



ABO Stats

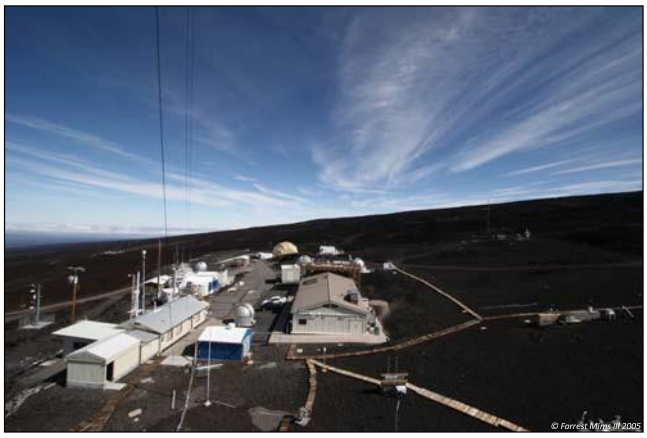
- **Total Peer-reviewed Publications using ABO datasets: 6,307**
- ***2251 Peer-reviewed Publications Since 2013 Review!***
- GMD Data Sets: 775
- Staff: 16
- Vehicle Fleet: 7
- Total Acreage: 135
- Miles of Driveway: 19
- Cooperative Research Projects: 70
- Solar Power: 165 panels {SMO = 33% and MLO = 20% of daytime demand)
- Total Structures: 67

Ozonesonde balloon time-lapse at SPO

Operational Challenges

Operating Field Sites in remote locations poses unique challenges.

- Tight procurement & shipping timelines
- Dirty power
- Cultural considerations
- Natural disasters
- Extreme climates
- Clean Air Sector management
- NEPA & State Historic Preservation Office (SHPO} requirements
- Training of observatory personnel to provide reliable science support workforce
- Infrastructure maintenance



Mauna Loa Observatory from tower

Facility Deferred Maintenance

Facility Condition Assessments (FCAs) – NOAA OCAO effort across agency

BRW - April 2015

- *".the Observatory is in poor condition and appears to have outlived its useful life."* Executive Summary, Page 10

SMO - April 2017

- *". the Observatory Site is in Poor condition and is rated as a D. condition is still somewhat adequate, but the assets are headed toward the latter half of their lifecycle."* Executive Summary, Page 4

MLO - June 2017

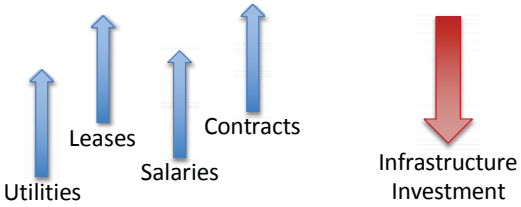
- *". the Observatory is in working order, however, OAR should plan for upcoming capital costs related to component renewals."* Executive Summary, Page 7

Total = $1.BM in deferred maintenance projects

Keeping the Lights On

Simple Math

- Inflation: Increasing Cost of Business
- Steady Science Mission
- Flat Observatory Budget
- Increasingly Difficult to Manage



Prioritized Investments

- Life/facility safety
- Failures/repairs
- Improvements

Critical Mass

- Infrastructure investment essential to service science & maintain quality
- Science suffers without dependable resources

Cyclone Gita Damage at SMO February 2018

Considerations for THO & SUM

Hard Decisions

No longer support Trinidad Head, CA (THD) or Summit, Greenland (SUM) as NOAA "Atmospheric Baseline Observatories". However, still have critical measurements at each site.

- Rationale for sites & impact to partners
- Current facilities & planned upgrades
- Local influences vs. background? Science requirements.
- Efficiency - logistics requirements for each project:
  - Removed cargo/staff intensive projects
  - Kept low maintenance/power projects
- Ongoing Measurements:

THD	SUM
Aircraft flasks	CCGG flasks
HATS flasks	HATS flasks
Ozonesondes	Aerosol suite
Surface ozone	Meteorology

Trinidad Head, CA

New York ANG LC-130 at SUM

Cooperative Research Projects

- Currently ~70 projects across the observatory network are supported

1. Management process redesigned for cooperative projects to leverage Google platform benefits:
   - Email, calendar, forms, drive storage, and secure sharing to field sites
2. New & improved external support webpage created to enhance information sharing with partners, to include:
   - New request/renewal process
   - Logistics
   - Site access,
   - Fee structure, etc.

- ***We currently bring in $250K in reimbursable funds from partners***

Near Term Observatory Goals

Efficiency - Greening the Observatories:
- Renewable energy
- LED Lighting 2018 DOC Green Grant

Building on Partnerships:
- Hilo office {NWS)
- USCG flight/cargo support
- NSF Office of Polar Programs {Arctic & Antarctic)
- Cooperative Projects
- Australia BOM/CSIRO staff training & exchange

Investment in Science:
- New Barrow Observatory Main Building
- New ARO at South Pole
- Additional land buffer at Mauna Loa
- NOTAMs for CAS no-fly zones
- Increase project cost reimbursements

Solar Panels installed at MLO

Observatory Take Away

- **Unique to OAR and NOAA**
- **Effective Spending**
- **Collaboration**
- **Innovation and Evolution**
- **Maintenance of Global Leadership**
- **Expand relevance to meet societal need**

World-class science demands world-class facilities

Our Bi-Polar Observatory Team Thanks You!

March 21st, 2018

***Sunrise* at the Barrow Atmospheric Baseline Observatory** - *Vernal Equinox*

***Sunset* at the South Pole Atmospheric Baseline Observatory** - *Autumnal Equinox*

Questions?

The Night Sky over South Pole Station

Observatory Relevant GMAC Presentations:

- Oral Session 3 - Morris
- Oral Session 3 - Cox
- Oral Session 4 - Johnson
- Oral Session 4 - Petropavlovskikh
- Oral Session 4 - Witte
- Oral Session 8 - Davis
- Poster 2 - Williams
- Poster 3 - Ivey
- Poster 35 - He
- Poster 43 - Barnes
- Poster 44 - Shiobara
- Poster 48 - Disterhoft
- Poster 54 - Sun
- Poster 70 - Dix
- Poster 71 - Koenig
- Poster 74 - McClure-Begley
- + 14 additional