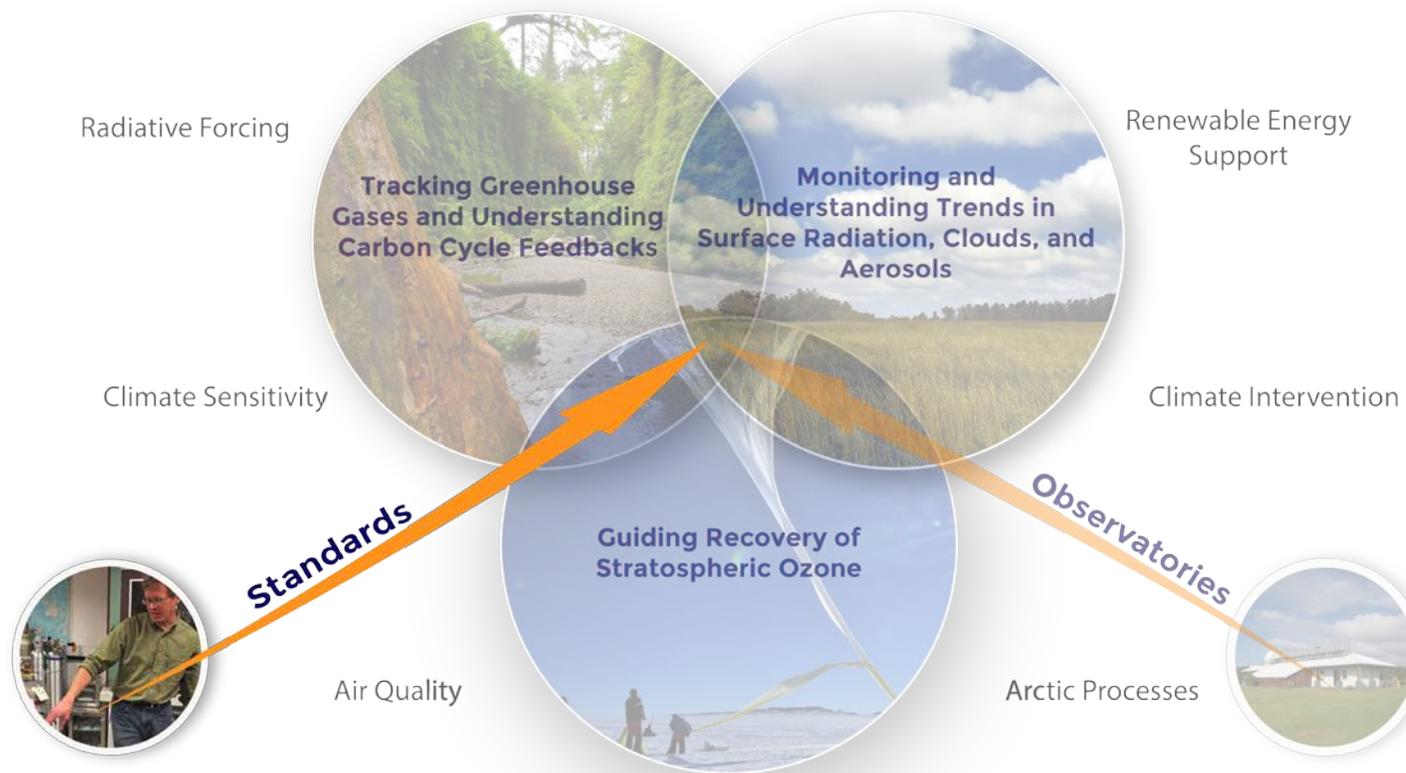


Calibration and Standards Activities

GMD Research Themes and Applications



Solar & Terrestrial Radiation

Dobson Column Ozone

Trace Gases

Federated Aerosol Network



Solar & Terrestrial Radiation

Trace Gases

Dobson Column Ozone

Federated Aerosol Network

NIST



BIPM



Max Planck Institute
for Biogeochemistry



Common Aspects

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



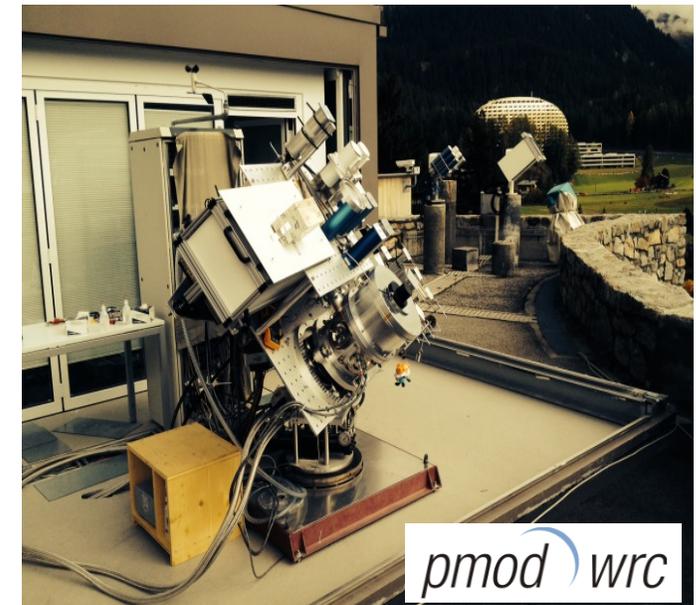
Solar & Terrestrial Radiation

- 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)

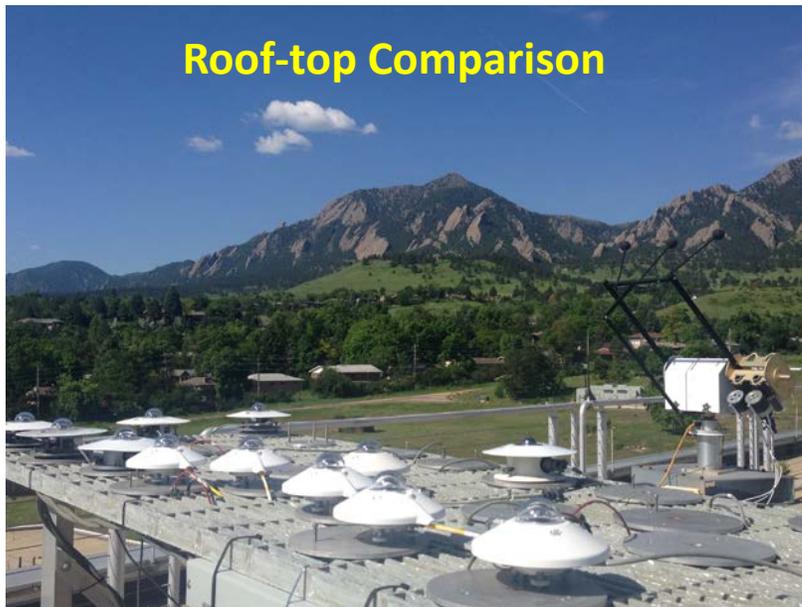
IPC 2015 Results for the six NOAA Active Cavity Pyrheliometers

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



PMOD World Standard Group Cavity Pyrheliometers

Roof-top Comparison



- 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)

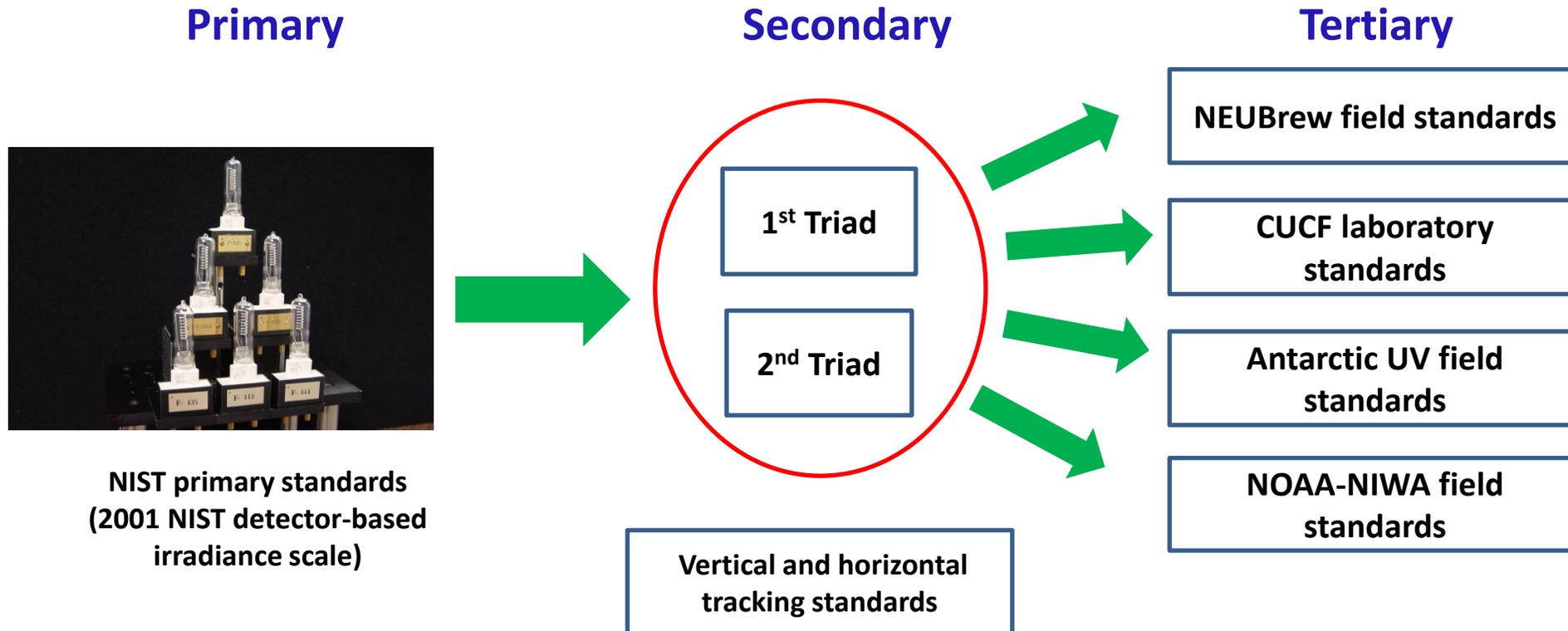
Central UV Calibration Facility (CUCF)

- 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

Hierarchical Approach

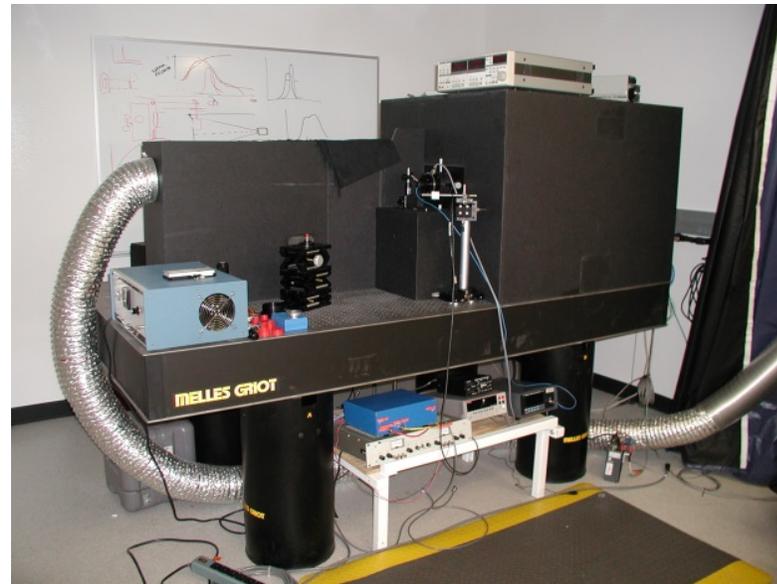


WMO/GAW Regional Calibration Center

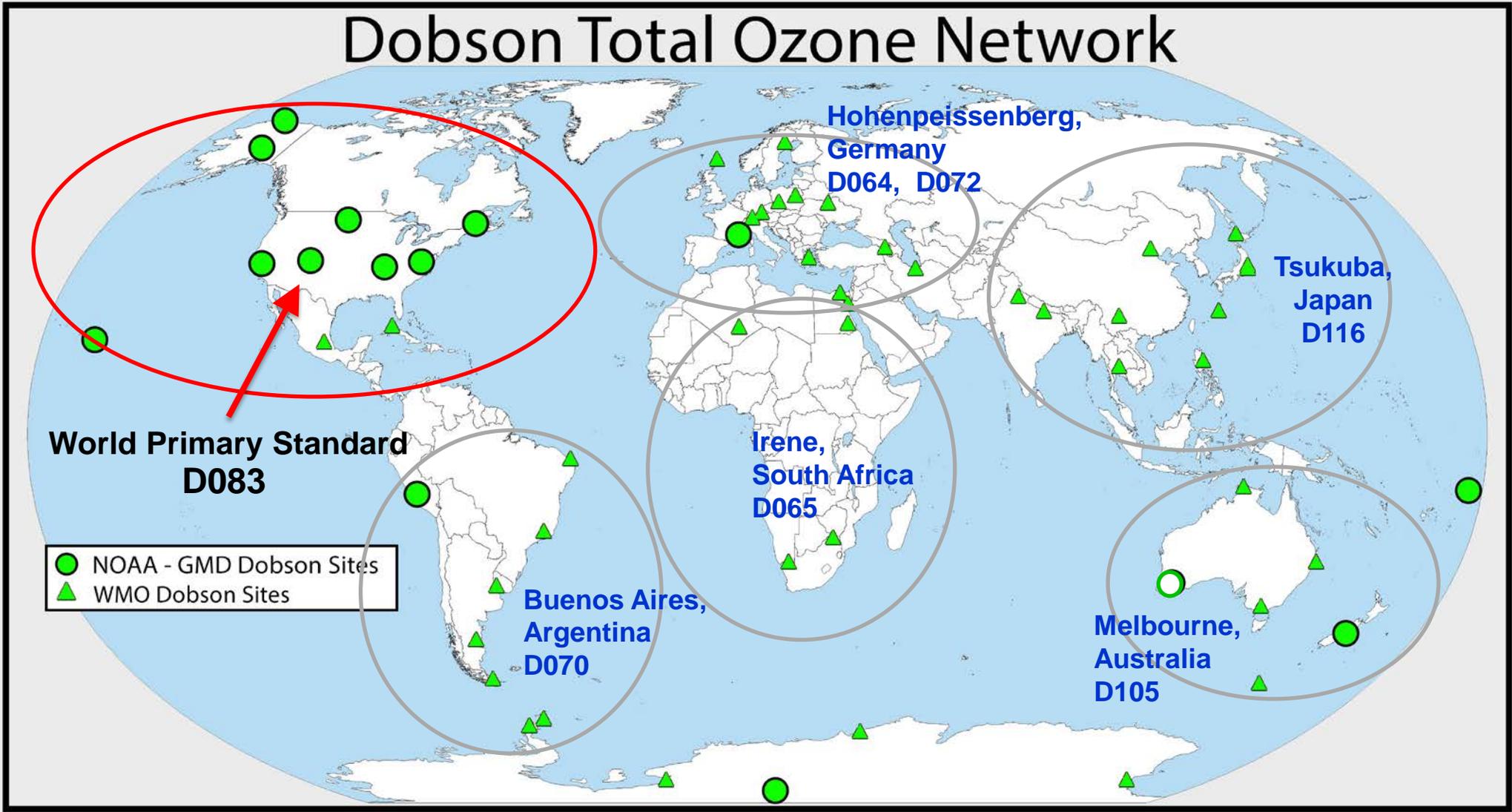


Performing a Field Calibration

- **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)

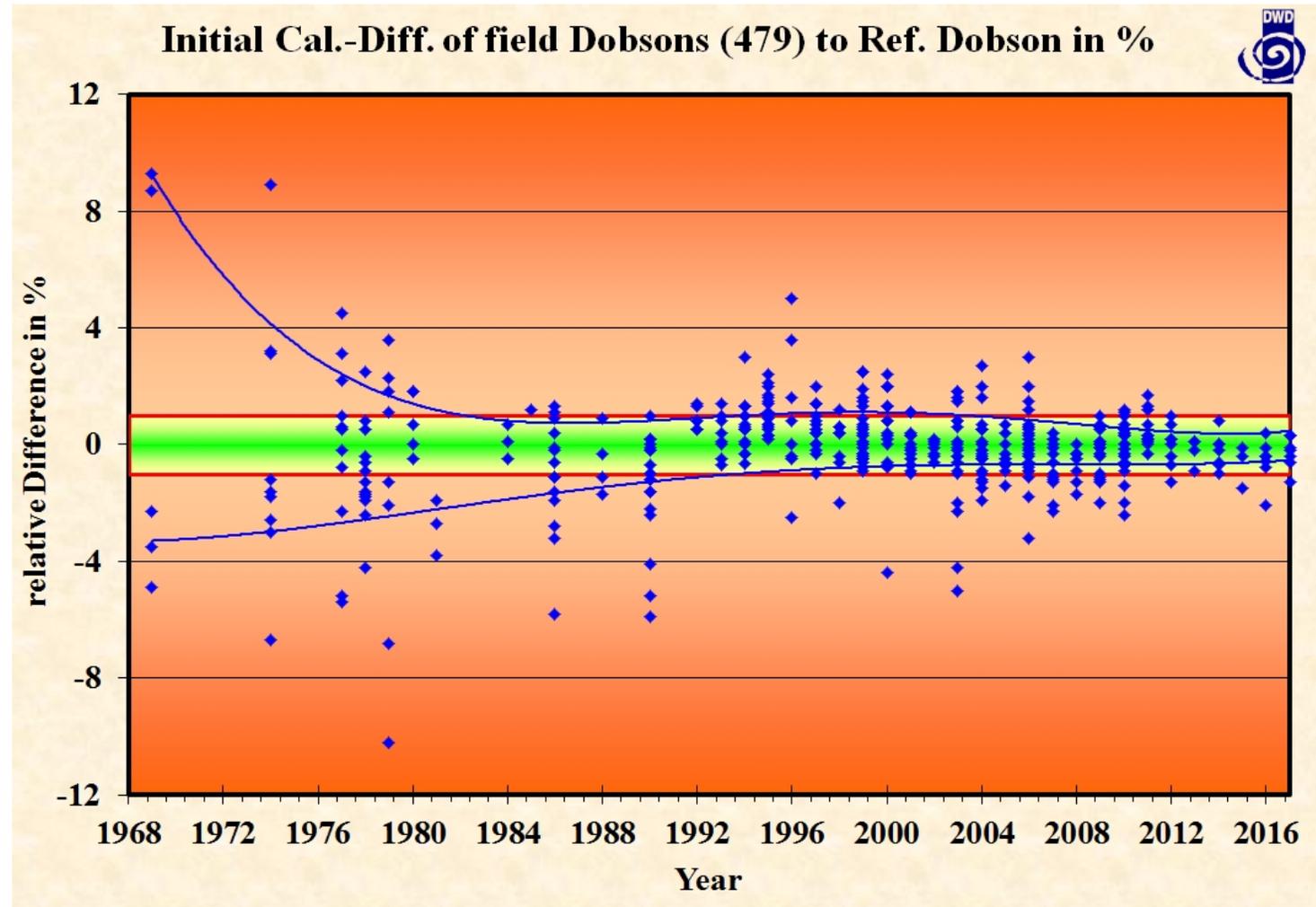


UV Spectral Response System



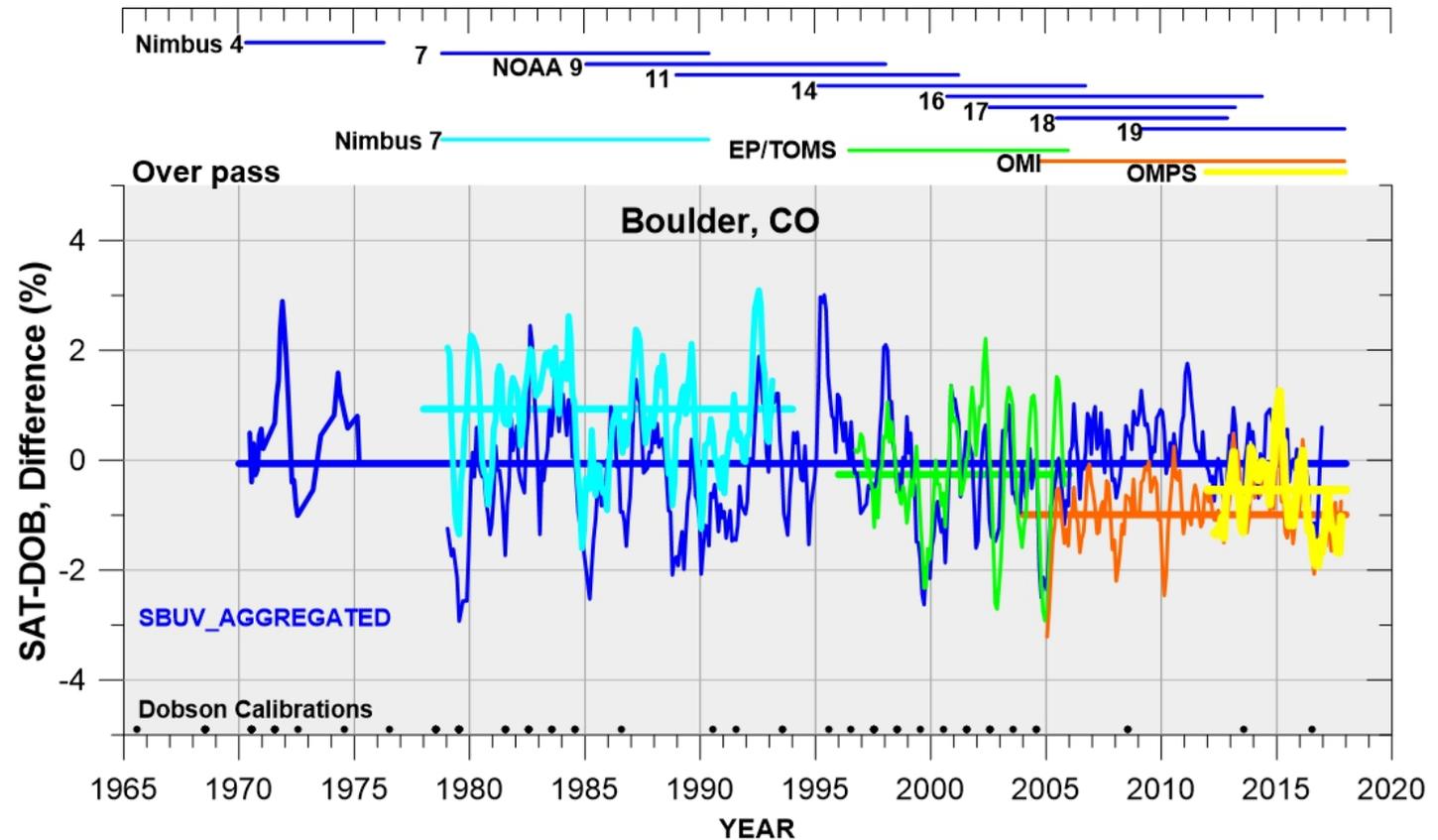
McConville, Dobson Ozone Network (P-53)

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)

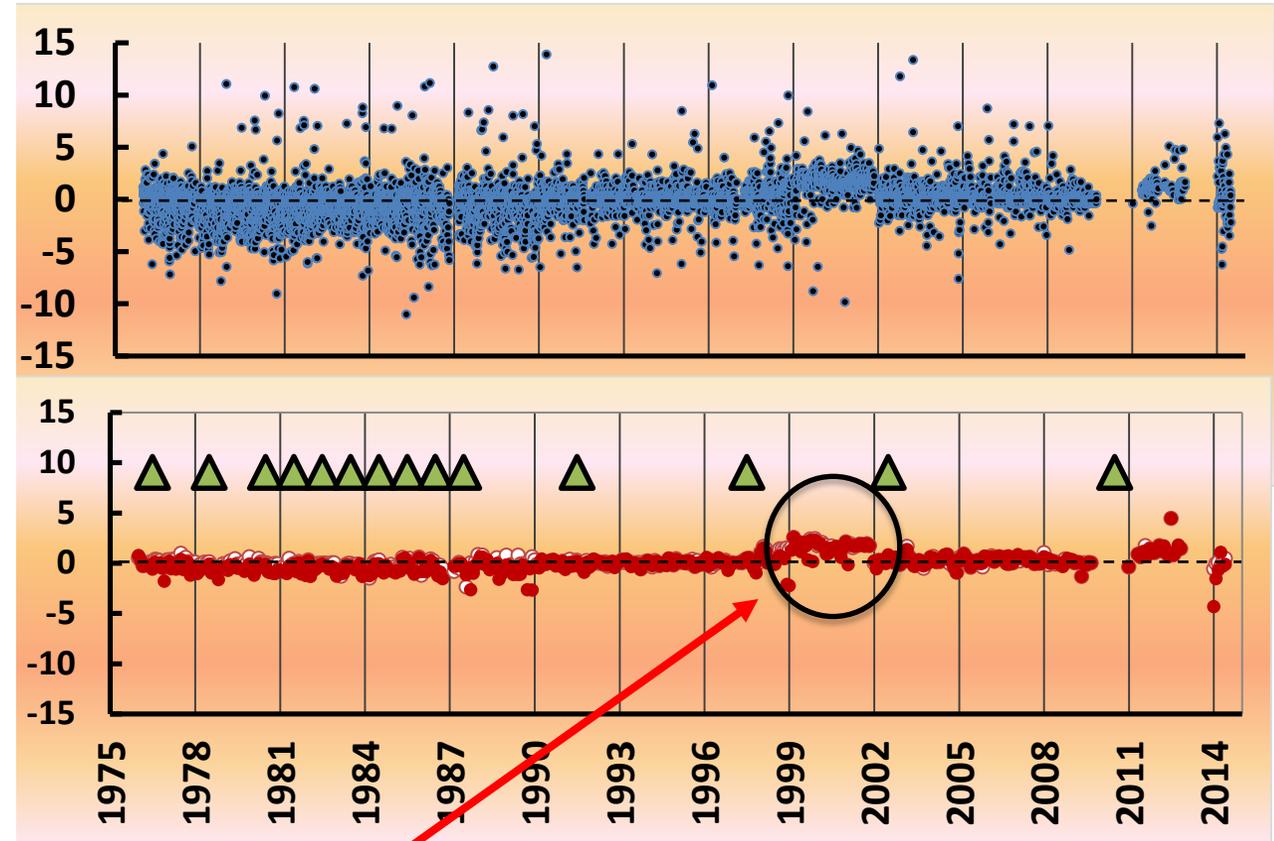


Recent Developments: New Software

- 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



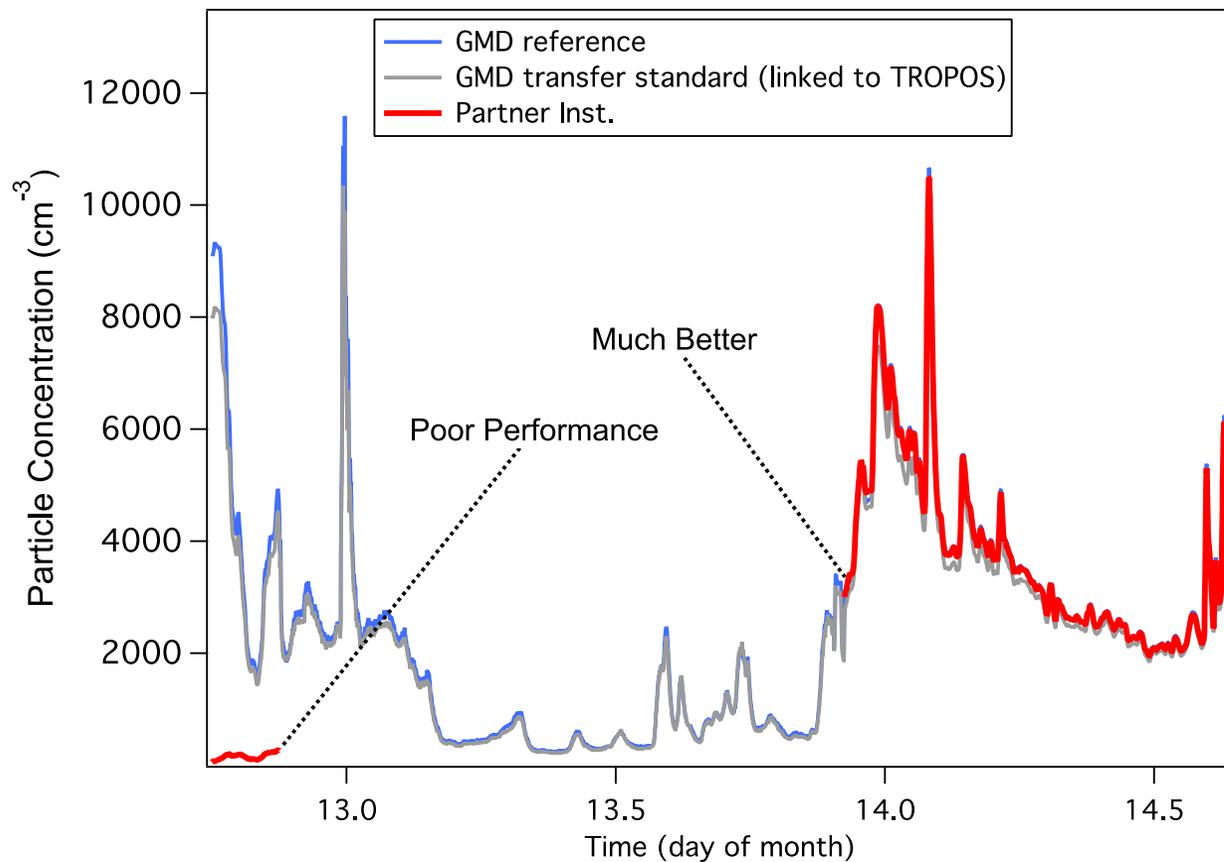
SMO: % Change after reprocessing



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

from Evans et al., 2017

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

CH₃Br
CH₃Cl
CH₃I
CH₂Br₂
CHBr₃
CH₂BrCl
CHBr₂Cl
CH₂I₂
CH₂BrI
CH₂ClI
CF₄

Solvents

CH₃CCl₃ CClH₂CClH₂
CCl₄ TCE
CHCl₃ PCE
CH₂Cl₂

Halons

Halon-1211
Halon-1301
Halon-2402

Sulfur Gases

COS SO₂F₂
CS₂ CF₃SF₅
SF₆

Hydrocarbons

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

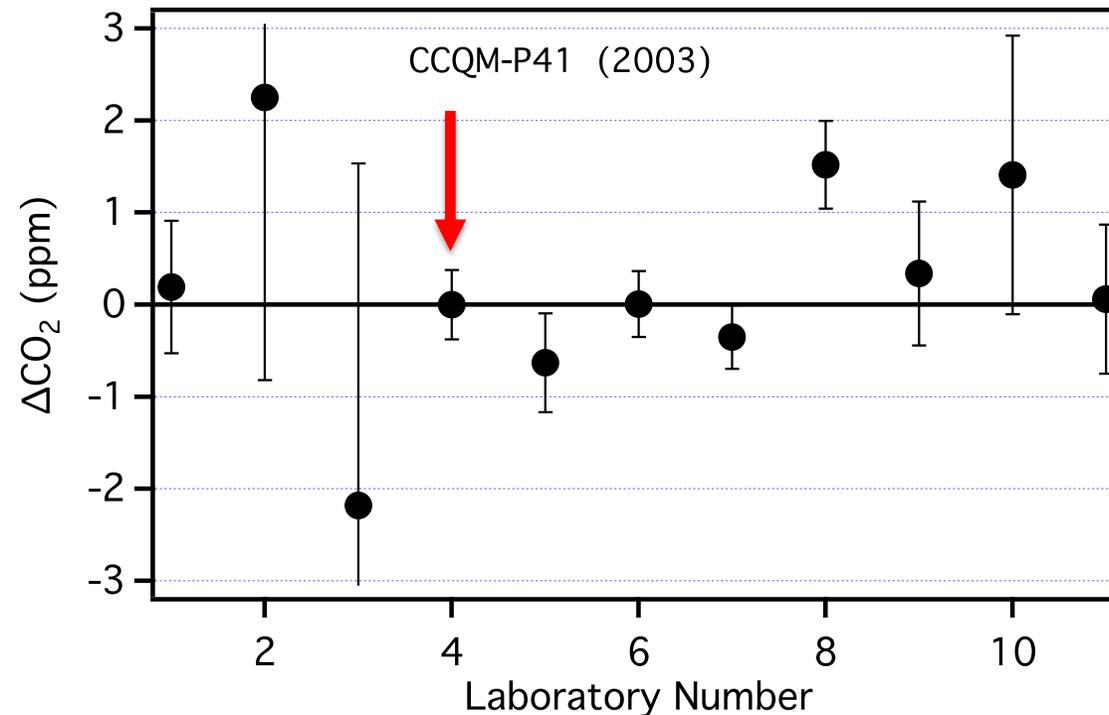
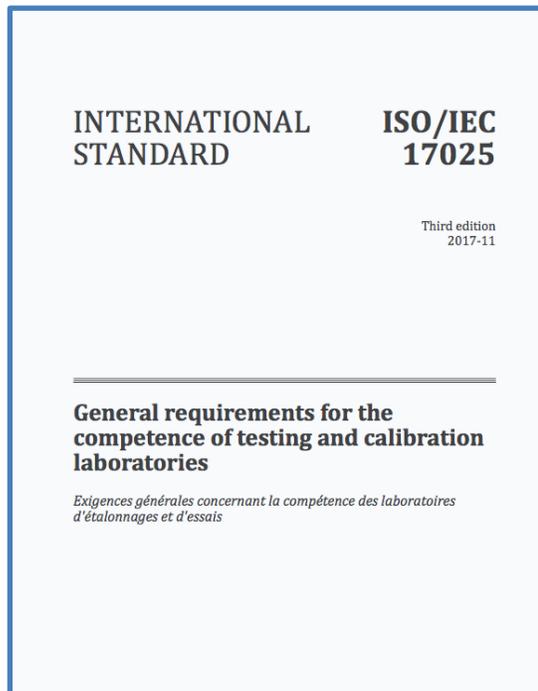
Other

CO₂ CH₄
N₂O CO
hydrogen
peroxyacetylnitrate
water vapor
perfluoro-amines
NF₃

WMO/GAW CCL
well-developed
semi-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

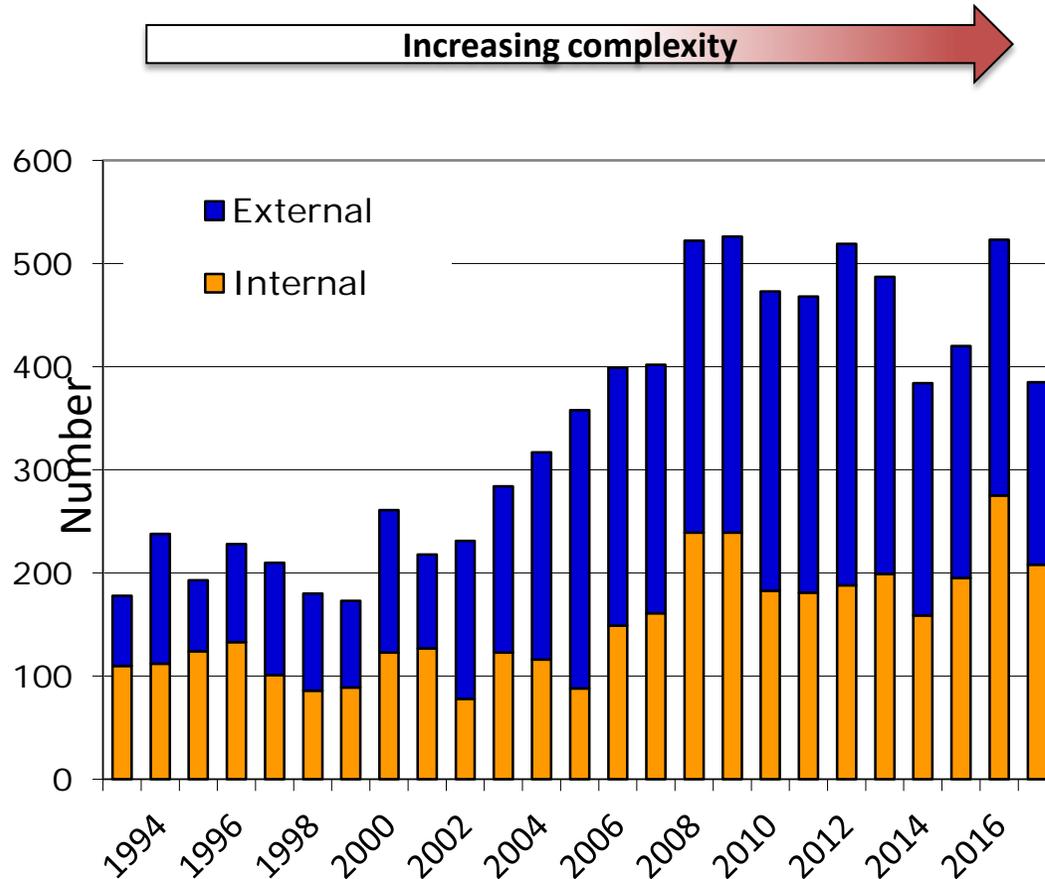


Whole-Air Standards

- 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



WMO/GAW Central Calibration Laboratory



New CO₂/CH₄ analytical system

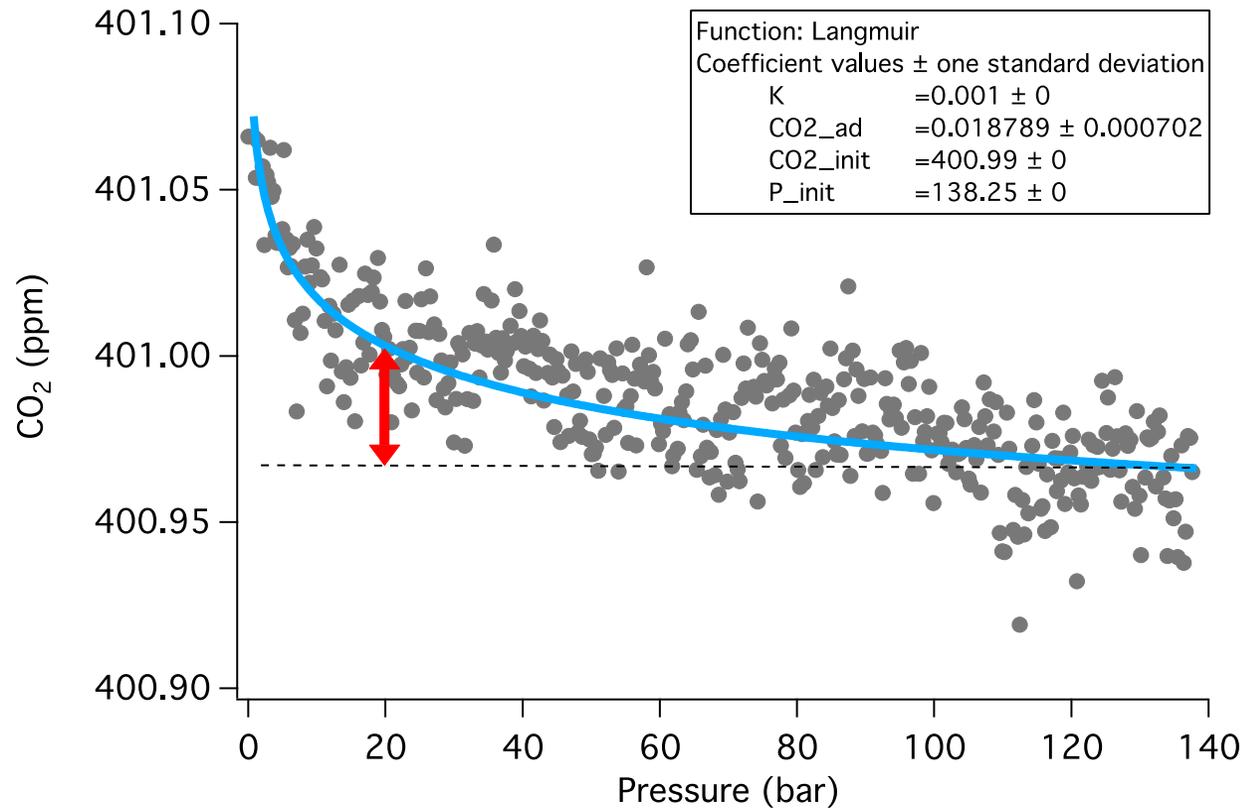


Since April, 2016

Crotwell, Carbon Monoxide (P-21)

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

Research Component: Stability of CO₂ in aluminum cylinders



CO₂ increases as pressure drops

Remarkably consistent

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

(comparable to compatibility goals)

Schibig et al., 2018

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

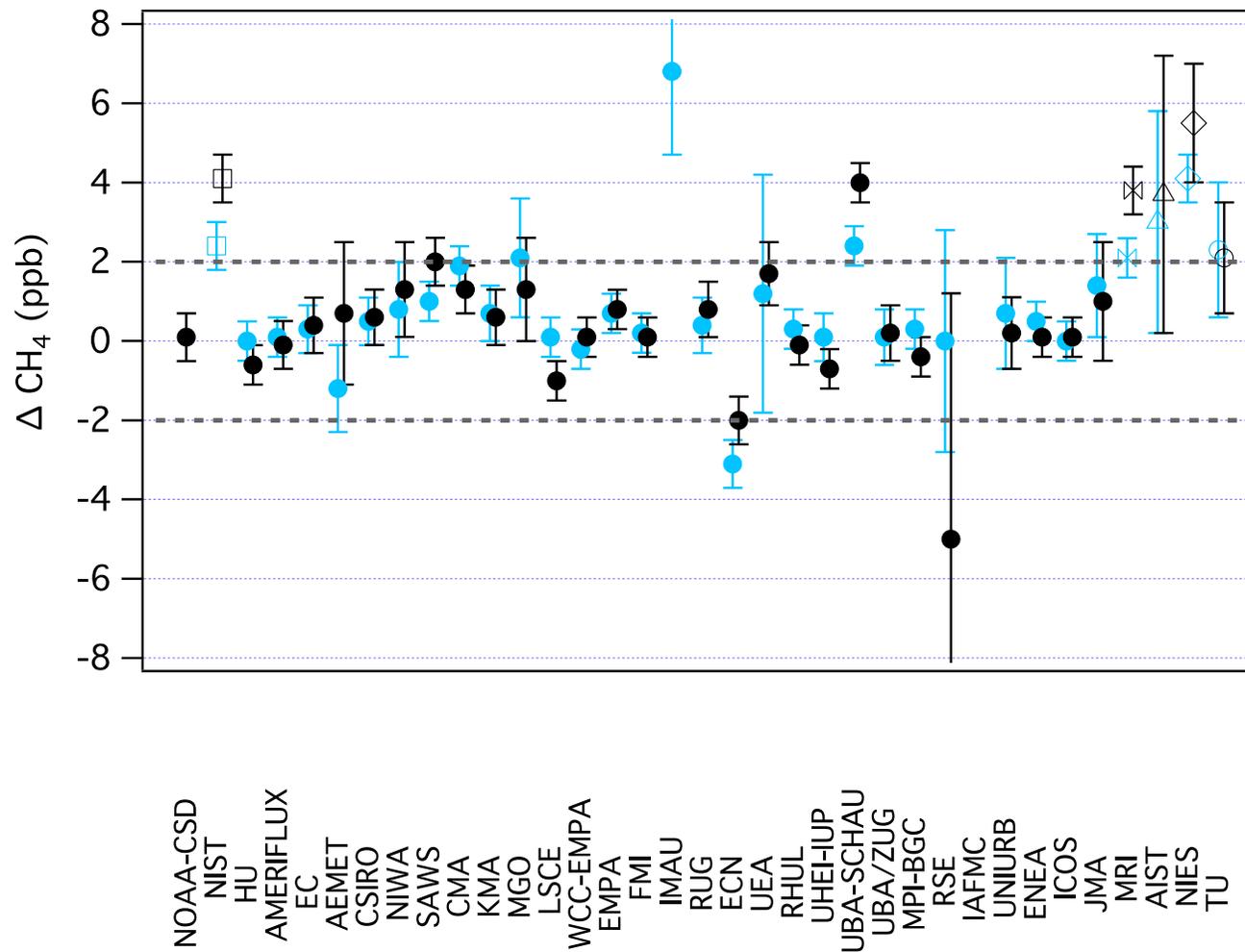
Trace Gases

- Improve uncertainty estimates
- Update CO₂ calibration scale
- Facilitate WMO Round Robin #7

Michel, Stable Isotopes of CO₂ (P-14)

Miller, Uncertainties (P-18)

WMO Round Robin Comparison #6 Results: (CH₄)



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**