Network for the Detection of Atmospheric Composition Change: *Tracking Changes in the Earth's Atmosphere*

Can the NDACC Working Group Structure Serve as a Guide in GRUAN Implementation?

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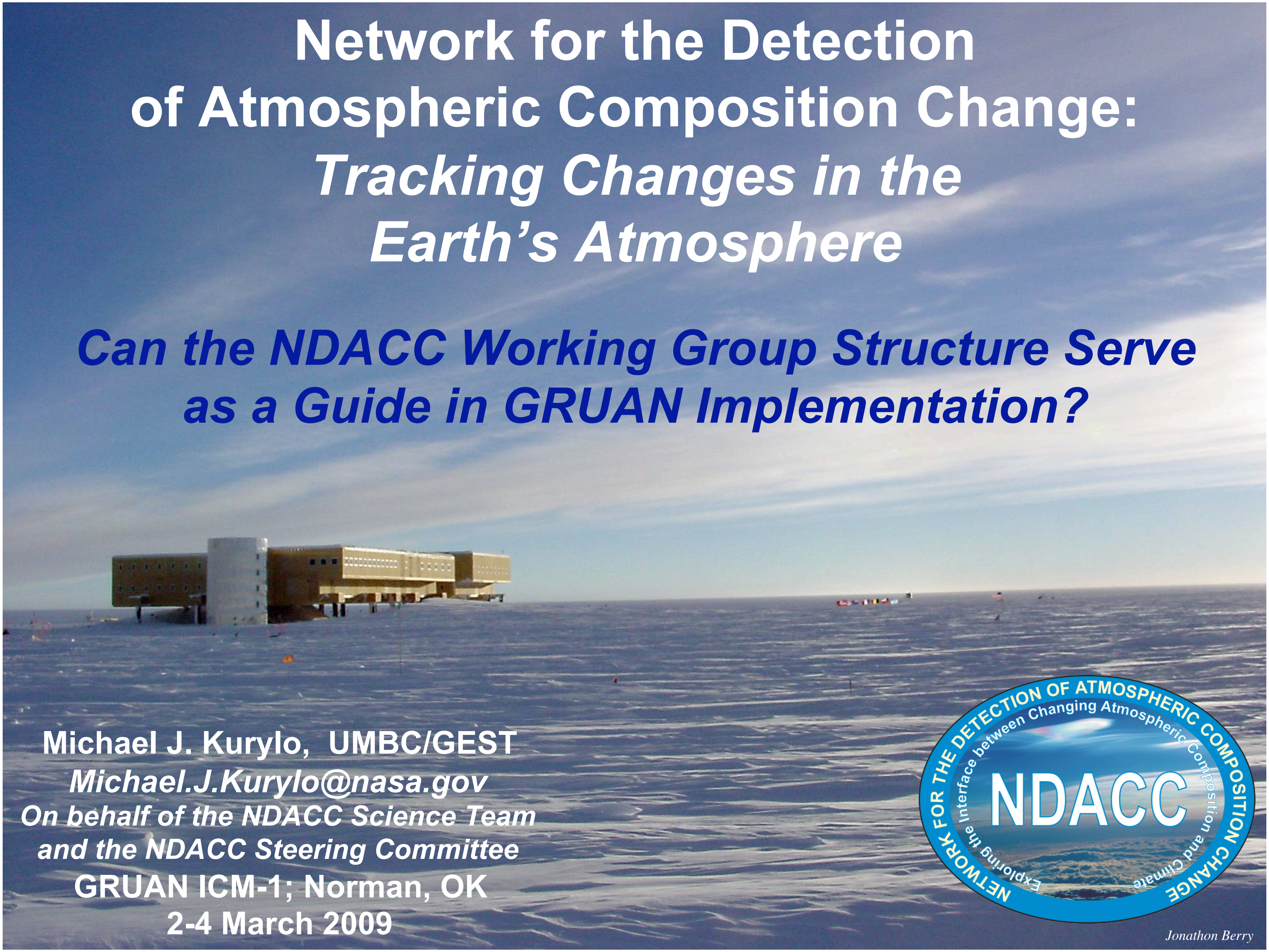
On behalf of the NDACC Science Team and the NDACC Steering Committee

GRUAN ICM-1; Norman, OK
2-4 March 2009



Jonathon Berry

What is the NDACC?

A set of more than 70 high-quality, remote-sensing research stations/sites for

- *observing and understanding the physical / chemical state of the stratosphere and upper troposphere*
- *assessing the impact of stratospheric changes on the underlying troposphere and on global climate*

Goals of the NDACC

1. *To study the temporal and spatial variability of atmospheric composition and structure*

2. *To provide early detection and subsequent long-term monitoring of changes in the chemical and physical state of the stratosphere and upper troposphere, thereby providing the means to discern and understand the causes of such changes*

3. *To establish the links between changes in stratospheric O_3, UV radiation at the ground, tropospheric chemistry, and climate*

Goals of the NDACC

4. *To provide independent validation, calibration, and complementary data for space-based sensors of the atmosphere*

5. *To support process-study field campaigns occurring at various latitudes and seasons*

6. *To provide verified data for testing and improving multidimensional chemistry and transport models of the stratosphere and troposphere*

Quality Control

A Commitment to Data Quality

- *Investigators subscribe to protocols designed to ensure that archived data are of as high a quality as possible within the constraints of measurement technology and retrieval theory.*
- *Validation*
  - *Instruments and data analysis methods are evaluated and continuously monitored.*
  - *Formal intercomparisons are used to evaluate algorithms and instruments.*

Data Archiving and Availability

- *Data are submitted to the Data Host Facility within one year of measurement*
- *Data are publicly available within two years of measurement*
  - *However, many PIs approve immediate availability upon submission to the DHF*
- *Many NDACC data are available on shorter timescale via collaborative arrangement with the appropriate PIs.*

NDACC Operational Structure

✧ *NDACC Steering Committee*

- *Primary managerial body*
  - *Two Co-Chairs*
  - *Science Team Working Group Representatives*
  - *Peer Reviewers and Cooperating Network Representatives*
  - *Ex-Officio Representatives from Sponsoring / Partnering International Agencies / Institutions*

✧ *NDACC Science Team*

- *Forum for Conducting Network Operations*
  - *PIs from All Sites / Stations*
  - *Coordinated through Working Groups (WGs) – Annual Meetings*
    - *Specific Instrument Types*
    - *Measurement Parameter / Species (currently O_3 & H_2O)*
    - *Relevant Activities (Satellites, Theory & Modeling, etc.)*
    - *Ad Hoc (Future Measurement Strategies and Emphases)*

Instrument WG Functions

✧ *Measurement Quality Control*

- *Protocol Development*
  - *Instrument-specific Performance Requirements*
  - *Validation*
  - *Calibration*
- *Recommendations on Proposed Affiliations*
- *Instrument / Measurement Intercomparison Campaigns*
- *Algorithm Intercomparisons*
  - *Decisions on Common Basis Parameters*

✧ *Data Reporting and Archiving*

- *Adherence to Data Protocol*
- *Archiving Formats*
- *Consistency in Reporting the Same Quantity*
  - *Important in Utilizing Measurements from Existing Networks*

Parameter / Species WG Functions

- ***Assess Various Measurement Techniques***
  - *Accuracy and Precision*
  - *Operating Procedures for Different Sensor Types*
  - *Future Potential*
  - *Calibration / Validation for Multiple Techniques*
    - *Best Practices for Data Comparison or Satellite Validation*
  - *Retrieval Aspects*
    - *Basis Parameter Issues*
- ***Building a Homogeneous Dataset***
  - *Combining and Merging Different Datasets*
  - *Development of Trends*

Examples from NDACC Ozone and Water Vapor Working Group Meetings

NDACC / GAW / IGACO
Ozone Theme Meeting
21-23 April 2008

✧ *Dobson & Brewer Column Measurements*

- *Systematic Comparison with Satellites*
  - *Leverage from WMO Ozone SAG*
  - *Indication of Need for Some Data Reprocessing*
- *SAUNA Campaigns*
- *Interferences and Seasonal Dependencies*

✧ *UV/Vis and FTIR Column Measurements*

✧ *Ozone Profile Measurements*

- *Sondes, Lidars, Microwave Radiometers, FTIR, UMKEHR, Satellites*

NDACC / GAW / IGACO
Ozone Theme Meeting
21-23 April 2008

- ***Absorption Cross-Section Needs***
  - *UV and Visible – focus of 2009 Ozone Theme meeting (May 11-13)*
  - *Infrared*
- ***Co-Located FTIR & Brewer Measurements Differ Systematically by ~5% (1% goal)***
- ***Lack of Knowledge / Appreciation of the Specific Strengths and Weaknesses of Various Measurements***

Dobson Calibration Example

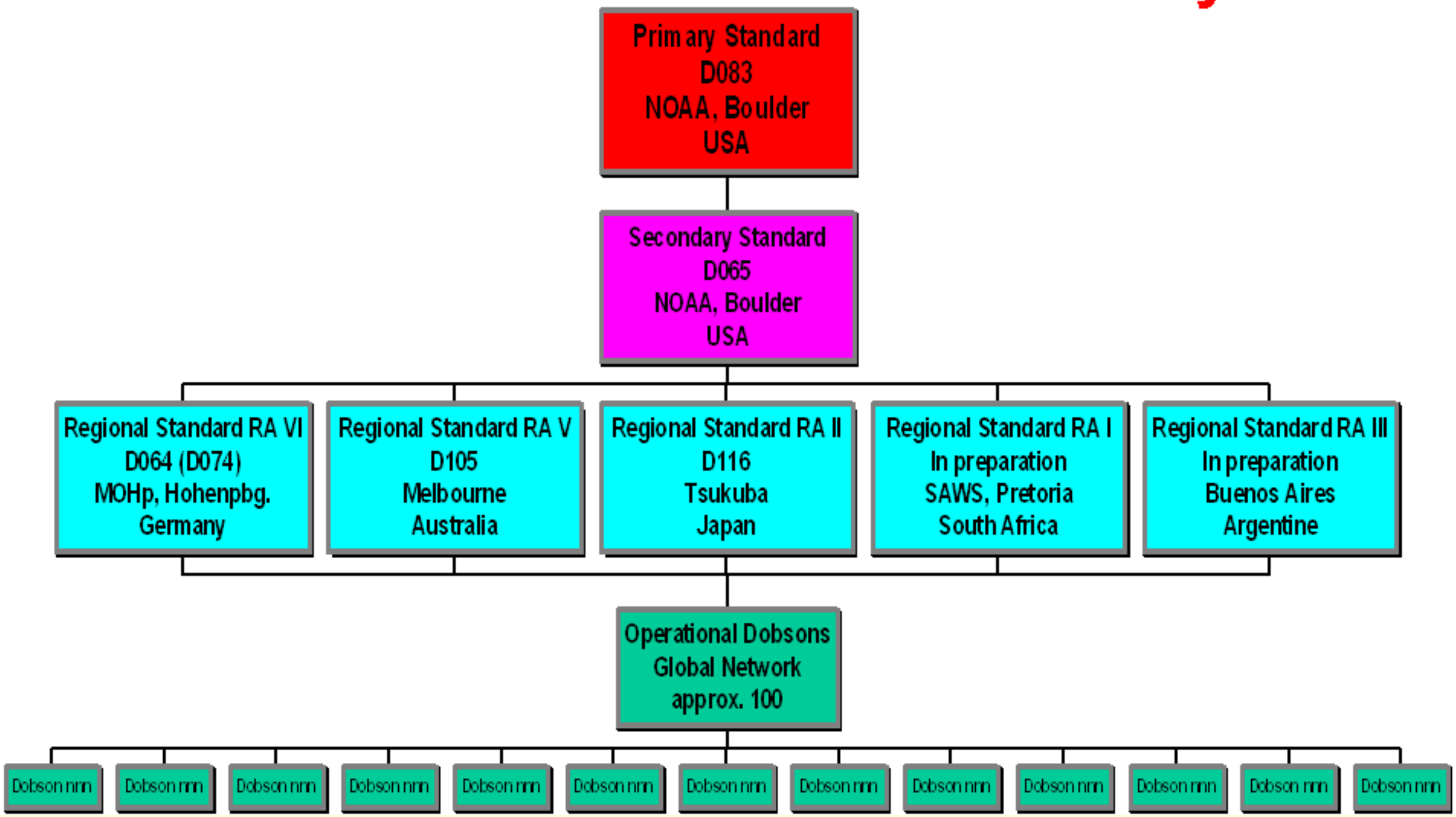
- The global total ozone network started in the 1950's, using Dobson spectrophotometers; Brewer spectrophotometers have been in use since the early 1980's.
- In the first decade all Dobsons were operated with the factory constants; performance was essentially not controlled by regular intercomparisons with well-calibrated instruments (e.g., reference or standard Dobsons).
- In the 1970's, when the importance of high quality data in ozone research and monitoring was recognized and subsequently larger differences between instruments had been detected, more and more but still sporadic Dobson Intercomparison Campaigns (DIC) were conducted.

Dobson Calibration Example

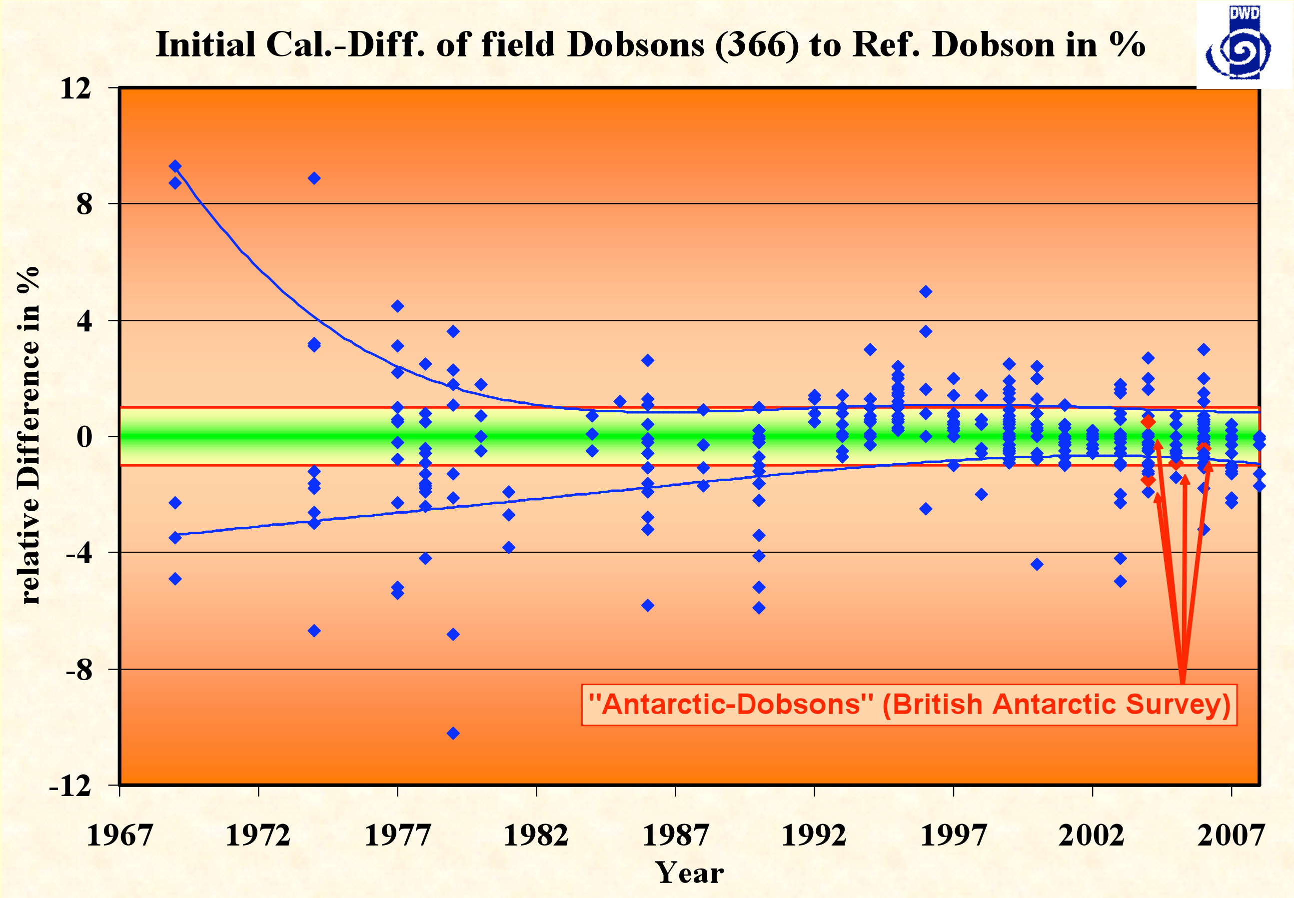
- Since the 1980’s a preliminary calibration system was developed and established under NOAA. DIC’s were organized more often and regularly.
- After integration of the Dobson network into the WMO GAW this preliminary calibration system became part of the QA/QC task of GAW. This process gave a fresh impetus to develop and improve the currently existing calibration system. The responsibility of the World Dobson Calibration Center WDCC (NOAA, GMD, Boulder) for organization and implementation of most of the international campaigns was delegated to Regional Dobson Calibration Centers (RDCC), established for each WMO Regional Association. Five RDCC’s, three of which are fully operational, are now responsible for the regular maintenance and calibration services of the Dobsons in their network.

Dobson Calibration Example

Global Dobson Calibration System



Dobson Calibration Example



- The frequency of calibrations has been significantly enhanced, resulting in clear improvements in instrument calibration.
- A similar system for calibration has been now established at least for the European Brewer network.

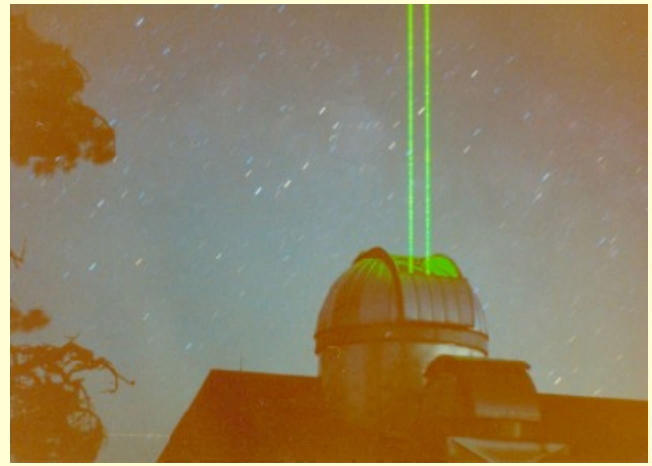
2005: Inception of NDACC Working Group on Water Vapor

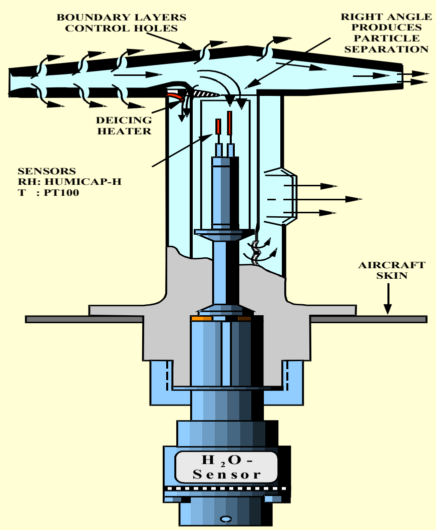
- ***Aim: Investigate, in detail, various aspects of H_2O measurements***
  - *Accuracy of different sensor types*
    - *in situ (balloon and aircraft) – radiosondes, frost point and Lyman-α hygrometers, …*
    - *remote sensing – FTIR, Raman and DIAL lidars, microwave radiometers, solar and star occultation sensors, …*
  - *Calibration issues*
  - *Spectroscopic issues*
  - *Retrieval aspects - volume mixing ratios, number density, averaging kernels, altitude resolution, …*
  - *Synergy of combining and merging data obtained by different techniques*
  - *Validation and campaigns*

2005: NDACC Steering Committee Establishes a Working Group on H_2O

- *Three workshops conducted (July 2006, February 2008, September 2008)*
- *International team on H_2O established within* INTERNATIONAL SPACE SCIENCE INSTITUTE
- *Team Lead - Nik Kämpfer* UNIVERSITÄT BERN

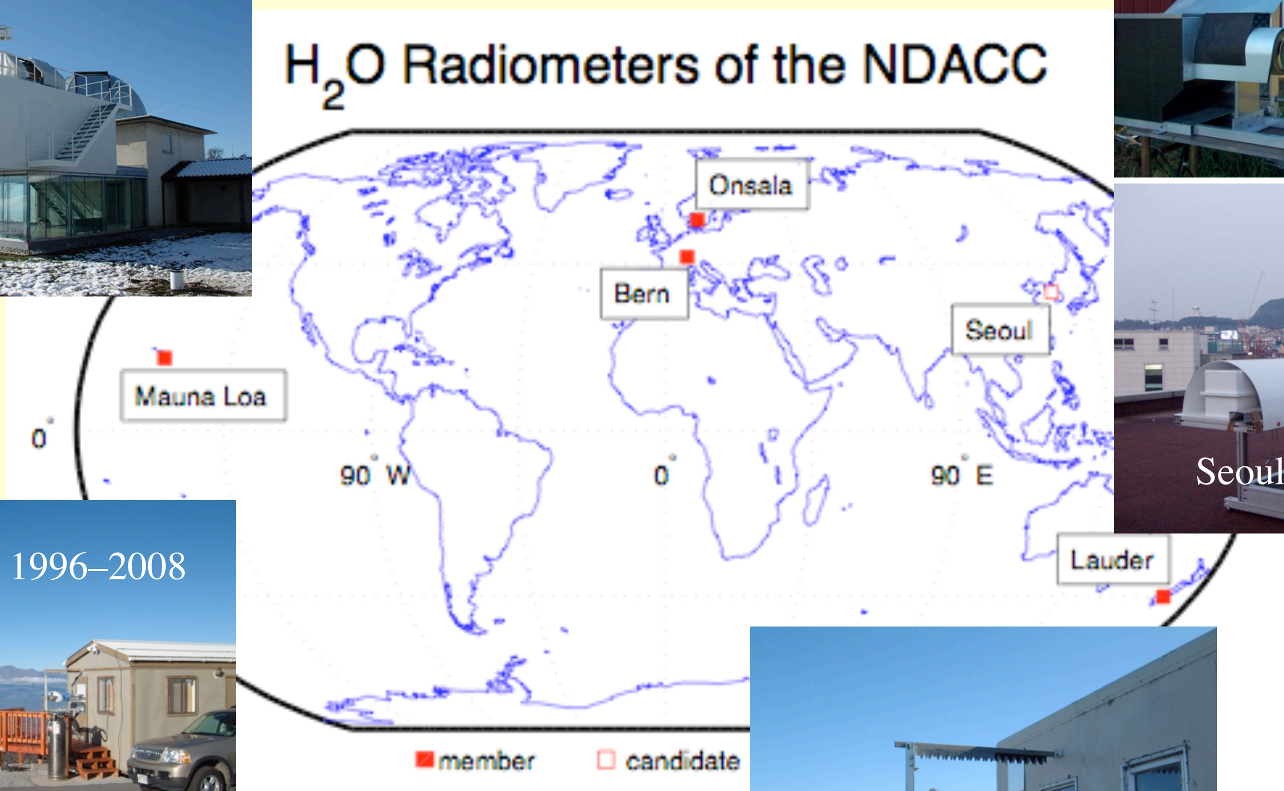
Different Techniques to Measure H_2O





Comparison of NDACC Microwave Instruments with MLS / AURA


Bern: 2007–2008



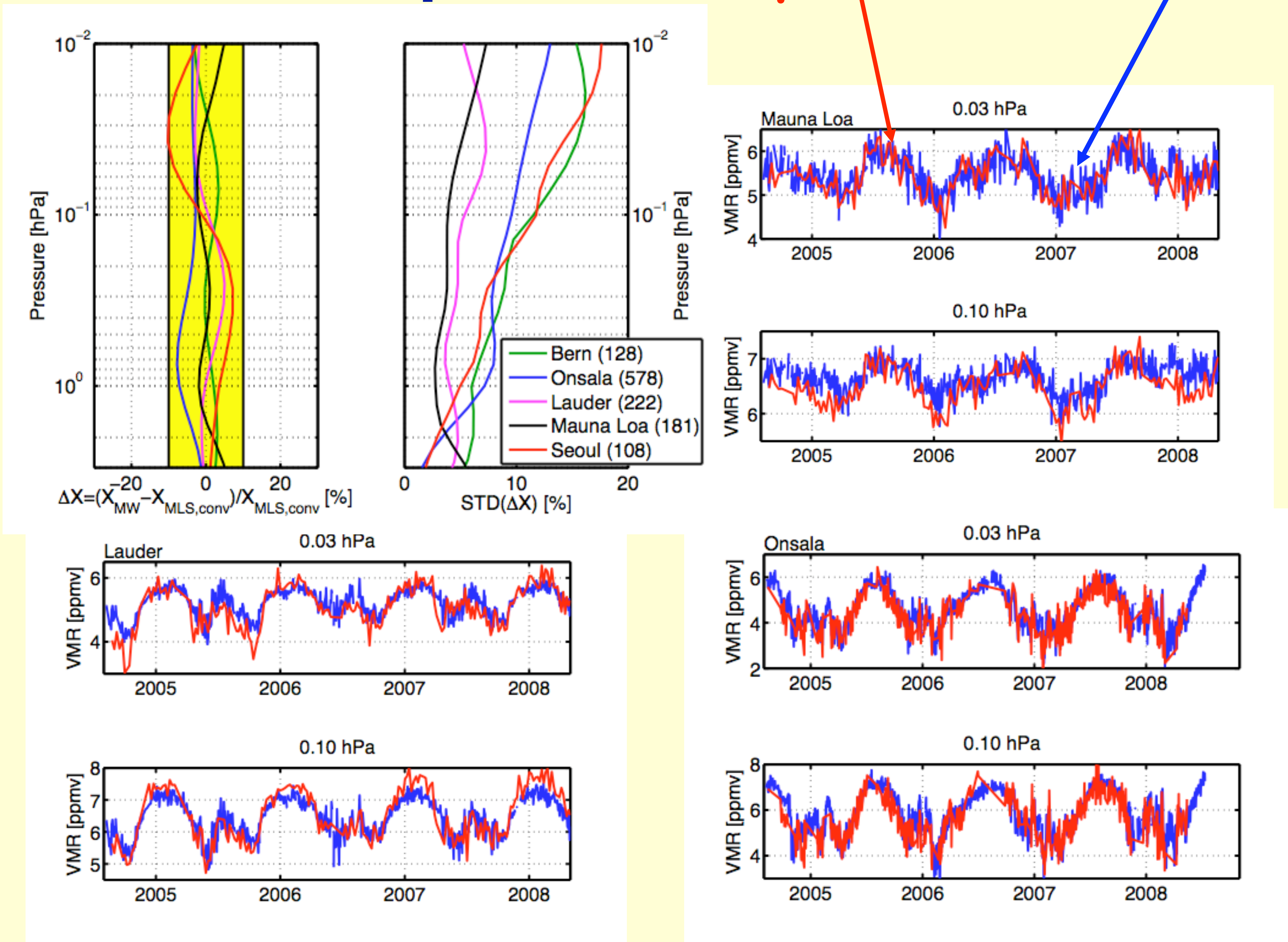

Onsala: 2002–2008


Seoul: 2006–2008


Mauna Loa : 1996–2008


Lauder: 1994–2008

Results: Comparison of μwave with MLS



Outcome of H_2O Group

✧ ***ISSI Book on Water Vapor Covering***

- *Technical discussions of different measurement techniques*
- *Role within networks such as NDACC or GRUAN*
- *Multidimensional characterization of satellites*
- *Survey of cross-validation*

✧ ***Fact sheets characterizing techniques and specific instruments***

- *Best practises for data comparison and satellite validation*

✧ ***Publication in preparation on microwave comparison with MLS as "travelling standard"***

✧ ***Improved coordination for MOHAVE intercomparison campaign in California***

✧ ***Literature database hosted by the University of Bern***

MOHAVE 2009

Measurements of Humidity in the Atmosphere and Validation Experiments

JPL-Table Mountain Facility, California (October 12-24, 2009)

Participating Water Vapor Instruments:

- TMF water vapor Raman lidar (Leblanc/JPL)
- AT mobile lidar (McGee/GSFC)
- ALVICE mobile lidar (Whiteman/GSFC)
- WVVMS microwave (Nedoluha/NRL)
- MIAWARA microwave (Kampfer/IAP-Univ. Bern)
- MkIV FTIR (Toon/JPL)
- 10+ CFH (Vömel/DWD)
- 10+ IMET PTU radiosondes
- 50+ Vaisala RS92 PTU radiosondes (Leblanc/JPL)
- 2 GPS (Whiteman/GSFC, and Manucci/JPL)

Other measurements:

- Stratospheric ozone lidar (McDermid/JPL)
- Tropospheric ozone lidar (McDermid/JPL)
- ECC ozonesondes (Leblanc/McDermid/JPL)

Theory/Modeling:

- MIMOSA PV: Forecast and Analysis of PV (JPL, CNRS)
- MIMOSA-CHIM UT/LS: Forecasts and Analysis of H2O and cirrus (CNRS)

Recommendations for GRUAN

✧ *Don't Reinvent the Wheel*

- *Draw On Capabilities of Established High-Quality Networks*
- *Augment These Capabilities as Needed to Provide Key Climate Variables on a Global Scale*

✧ *Instrument-Specific WGs First*

- *GRUAN is the Reference Network for GUAN*
  - *Emphasis on the Quality (Accuracy & Precision) of Various Measurement*
  - *Build-Up Phase is Better Supported by an Instrument-Specific Organization*
  - *Mirror NDACC Instrument WG Functions*

✧ *Parameter-Specific WGs Second*

- *Once Instruments Are Fully Characterized*

NDACC / GRUAN Collaboration

✧ *Commonality of Interests*

- *Water Vapor Profiles*
  - *Possible joint NDACC/GRUAN intercomparison campaign for characterization of water vapor sondes*
- *Ozone Profiles – strong NDACC heritage*

✧ *How can GRUAN benefit from NDACC?*

- *Infrastructure & instruments at NDACC sites can aid in intercomparison campaigns – e.g., Raman Lidar for water vapor profiles*

✧ *How can NDACC benefit from GRUAN?*

- *GRUAN Measurements May Be More Frequent at Some Locations*
- *Useful in Resolving Measurement / Model Differences*
  - *UV Irradiance Example Shown in Next Slide*

From: McKenzie, R.L.; Weinreis, C.; Johnston, P.V.; Liley, B.; Shiona, H.; Kotkamp, M.; Smale, D.; Takegawa, N.; Kondo, Y. (2008). Effects of urban pollution on UV spectral irradiances. *Atmospheric Chemistry and Physics 8*: 5683–5697.

	Spectral Range	UVB			UVA		
		Summer		Winter	Summer		Winter
Effects	Solar Zenith Angle (SZA)	25°	70°	70°	25°	70°	70°
	Observed	-39±11	-38±11	-22±11	-30±10	-31±10	-19±10
E1	Ozone column	- 9	-16	- 0.7	0	0	0
E2	O_3 & T Profiles	-3.5	-0.1	-0.1	-0.2	0	0
E3	Sun-Earth Distance	- 2.6	2.2	+ 2.5	- 2.6	-2.2	+2.5
E4	Altitude	- 1.7	- 1.9	- 1.9	- 1.0	-1.4	-1.4
E5	Horizon obscuration	- 1.5	- 1.9	- 1.9	- 1.0	-1.0	-1.0
E6	NO_2 column	- 0.9	- 0.7	- 1.1	- 1.5	-1.7	-2.5
E7	SO_2 column	- 0.5	- 0.1	- 0.4	- 0.1	0.0	-0.1
E8	Trop O_3/Aerosol inter	- 1.0	- 1.0	- 1.0	0.0	+0.0	+0.0
E9	Clouds/Aerosols	-18±11	-14±11	-17±11	-24±10	-25±10	-17±10

Table 3. Mean percentage differences in UVB and UVA between Tokyo and Lauder and the inferred attribution effects.
Results are shown for summer (SZA: 25º and 70º) and winter (SZA: 70º).
The effect of clouds and aerosols (E9) is defined as the remaining extinction after all identified factors have been considered, (E9 = Obs – (E1+E2+E3+E4+E5+E6+E7+E8)). The uncertainty is the 2σ quadrature sum from the measurements at both sites.

- *http://www.ndacc.org*
- *New informational leaflet*
- *Annual newsletters now available*
- *"News and Highlights" section*
- *Protocols being updated*