Network for the Detection of Atmospheric Composition Change:

Tracking Changes in the Earth's Atmosphere

Complementarity with GRUAN for Water Vapor Trends Detection

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http://www.ndacc.org/

How Do NDACC and GRUAN Differ?

- ***NDACC is a set of more than 70 high-quality remote-sensing research stations for***
  - *detecting trends in overall atmospheric composition; understanding impacts on stratosphere/troposphere*
  - *establishing links and feedbacks between climate change and atmospheric composition*
- ***NDACC is not a climate-monitoring network per se***
- ***GRUAN is the GCOS Reference Upper Air Network and aims to***
  - *provide the foundation for long-term data sets that can be used to reliably monitor and detect emerging signals of global and regional climate change*
  - *Contribute to satellite validation, mesoscale meteorology*

NDACC Guidance Can Be Helpful in GRUAN Formulation

- ***GRUAN need not reinvent the wheel***
  - *draw on capabilities of established high-quality networks*
    - *e.g., sites, infrastructure, ancillary measurements (Table Mountain Facility, Mauna Loa, & possibly Lauder within NDACC)*
  - *augment these capabilities as needed to provide key climate variables on a global scale*

- ***GRUAN should leverage experience from the NDACC Working Group structure***
  - *with its emphasis on measurement accuracy & precision*
    - *the build-up phase of GRUAN is better supported by an instrument-specific organization*
    - *migrate towards a parameter-specific focus once instrument characterization is mature*
  - *include early engagement of the satellite community*
    - *validation enables patching of long-term datasets*

Instrument Working Group Functions

- ***Measurement Quality Control***
  - *Protocol Development*
    - *Instrument-specific Performance Requirements*
    - *Calibration & Validation*
  - *Recommendations on Proposed Affiliations*
  - *Intercomparison Campaigns*
    - *Instruments & Algorithms*
      - *Decisions on Common Basis Parameters*
    - *Satellite Cal/Val*
- ***Data Reporting and Archiving***
  - *Adherence to Data Protocol*
  - *Archiving Formats*
  - *Consistency in Reporting the Same Quantity*
    - *Important in utilizing measurements from existing networks*
- ***TCCON Guidance – A Success Story***

Parameter / Species Working Group 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*

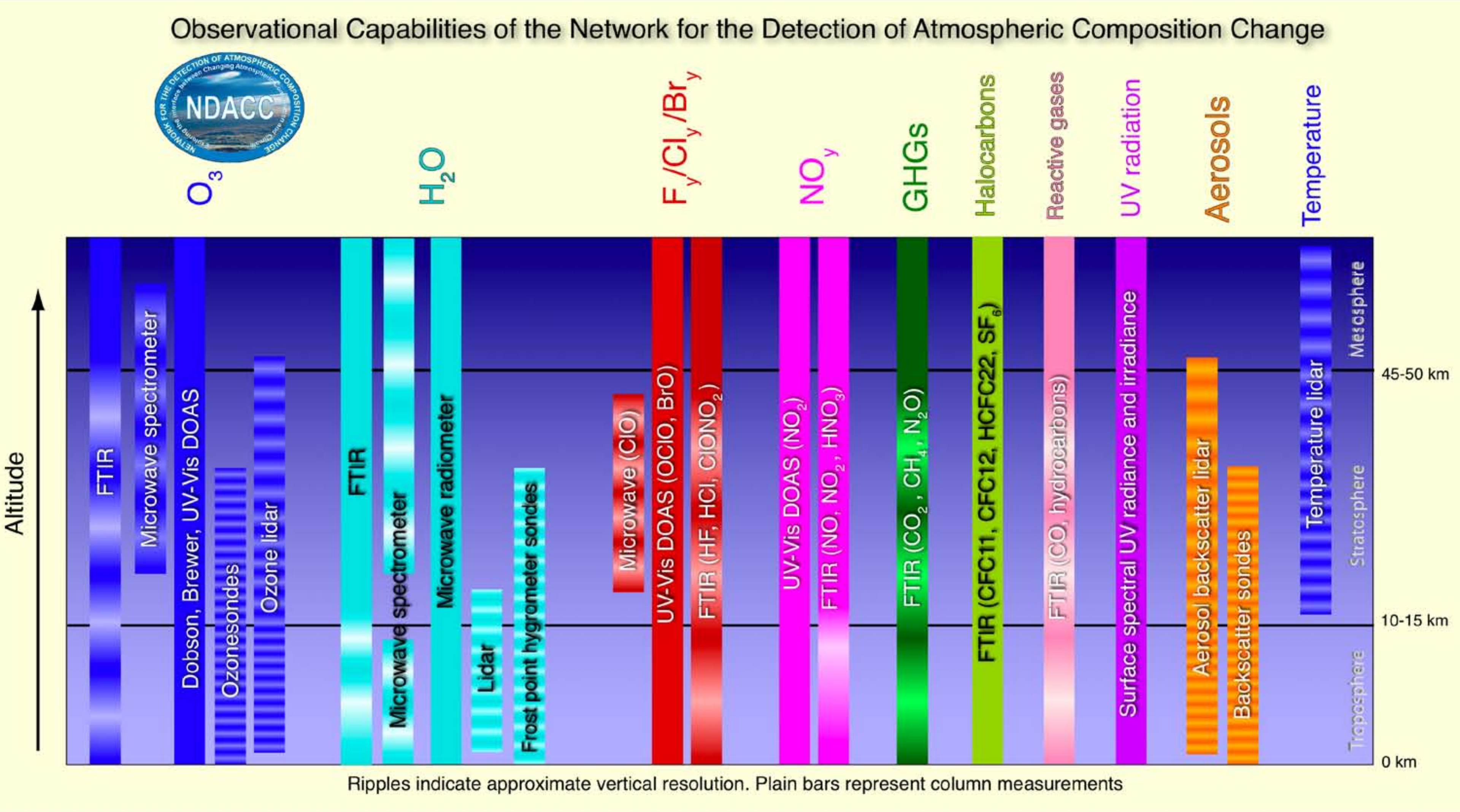
- ***Building a Homogeneous Dataset***
  - *Combining and Merging Different Datasets*
  - *Development of Trends*

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*

NDACC Measurement Capabilities

http://www.ndacc.org/


Observational Capabilities of the Network for the Detection of Atmospheric Composition Change

Ripples indicate approximate vertical resolution. Plain bars represent column measurements

The MOHAVE 2009 Campaign

Measurements of Humidity in the Atmosphere and Validation Experiments

JPL-Table Mountain Facility, California (October 11-27, 2009)

Participating Water Vapor Instruments:

- 3 water vapor Raman lidar (JPL & GSFC) [0-20 km]
- 16 CFH launches (JPL & GSFC) [0-30 km & total column]
- 4 Frost-point Hygrometer (FPH) launches (NOAA) [0-30 km & total column]
- 58 RS92 launches (JPL & GSFC) [0-30 km & total column]
- 2 improved water vapor radiometers (NRL & Univ. Bern) [20-80 km]
- 1 FTIR (JPL) [total column]
- 2 GPS receivers (GSFC & JPL/NOAA) [total column]

Other measurements:

- Stratospheric ozone lidar (JPL & GSFC) [0-30 km]
- Tropospheric ozone lidar (JPL) [3-12 km]
- ECC ozonesondes (JPL, GSFC, & NOAA) [0-30 km]

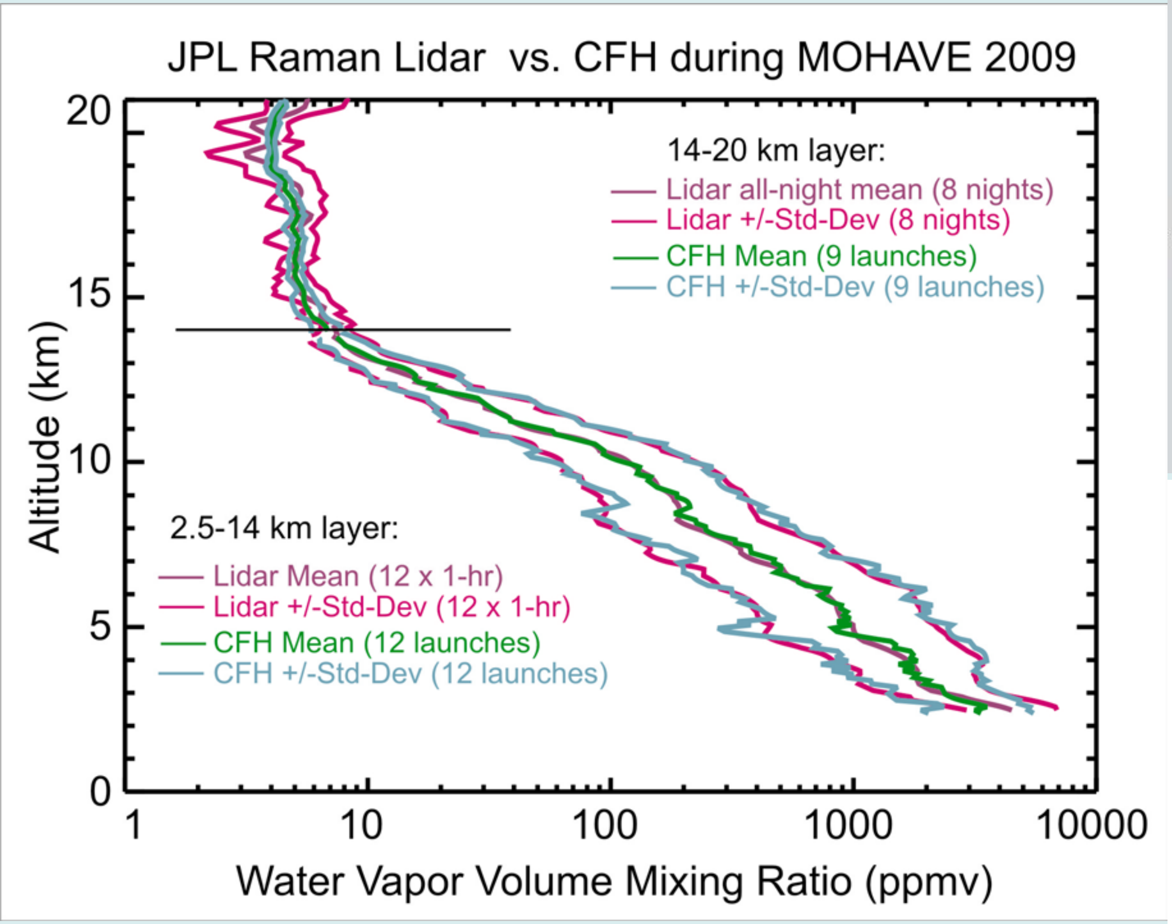
Theory/Modeling:

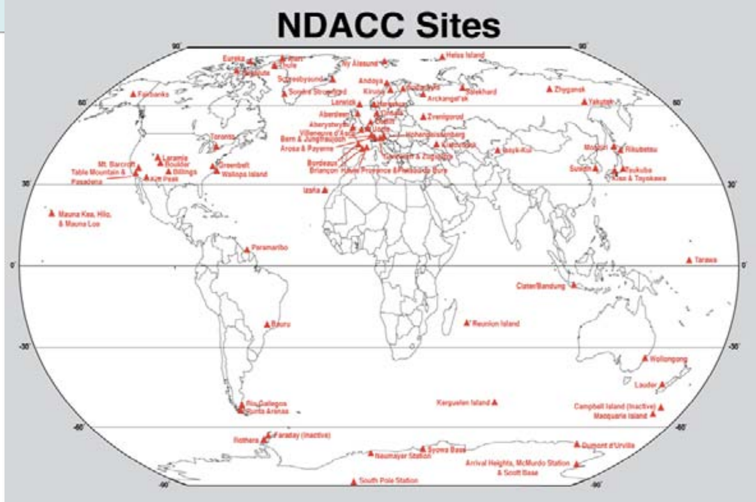
- MIMOSA PV: Forecast and Analysis of PV (JPL, CNRS)
- MIMOSA-CHIM UT/LS: Forecasts and Analysis of H2O and cirrus (CNRS)

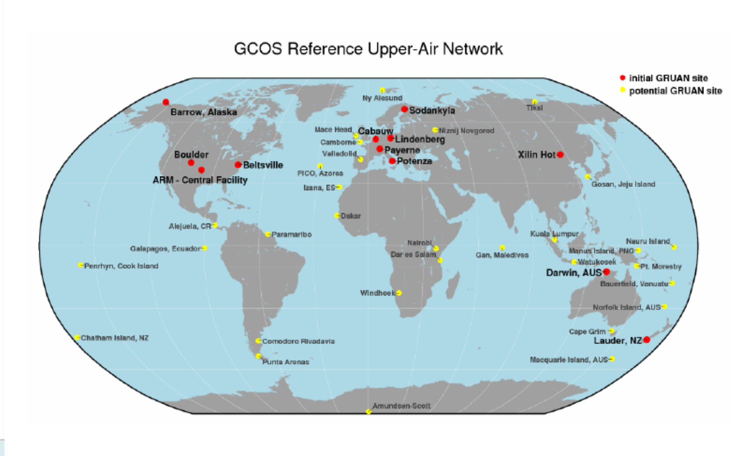
additional details in poster

Water Vapor Monitoring Capabilities:

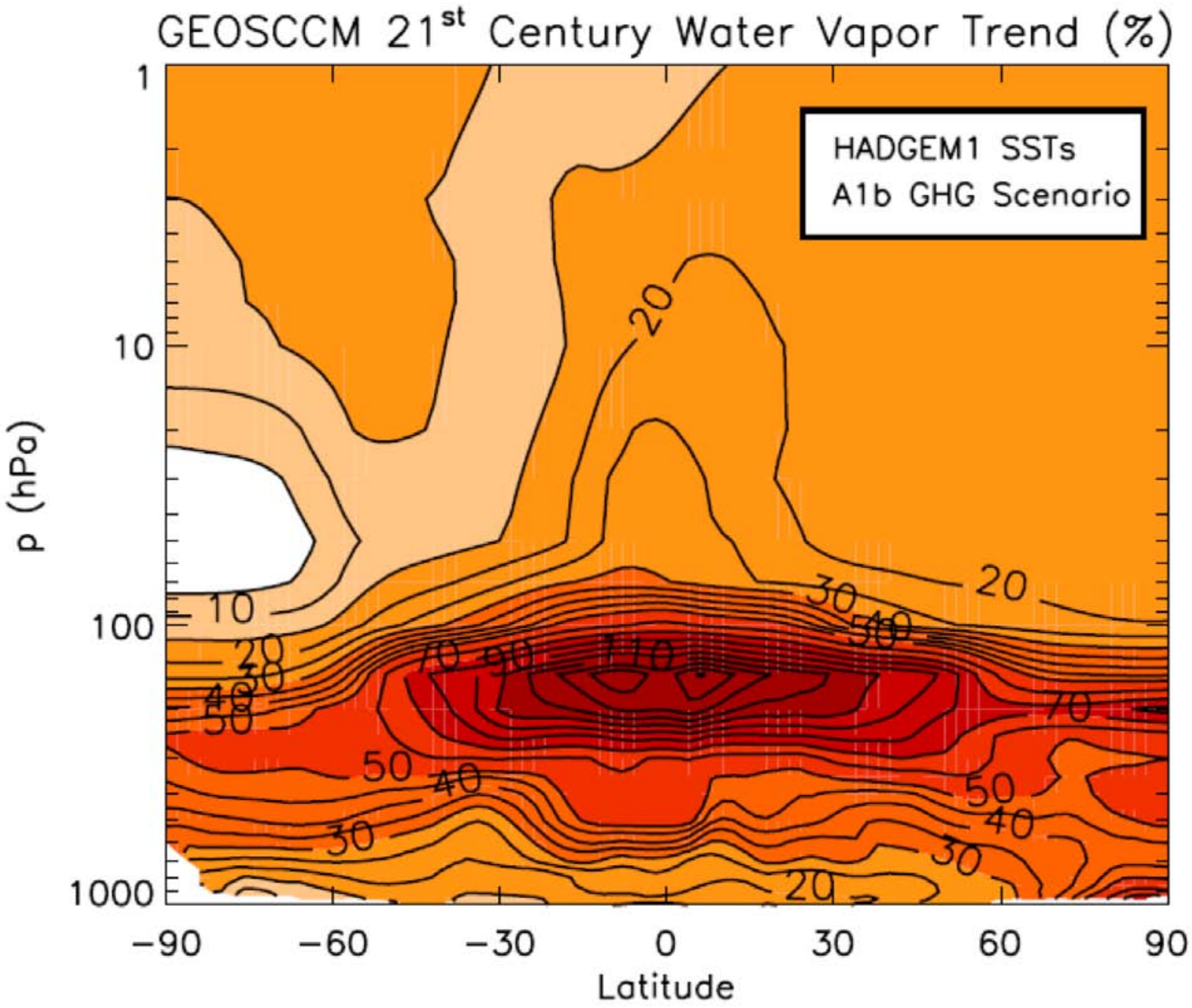
NDACC Raman Lidar vs. GRUAN Balloon-Borne Sensors







Simulated Increases in Atmospheric Water Vapor During the 21st Century



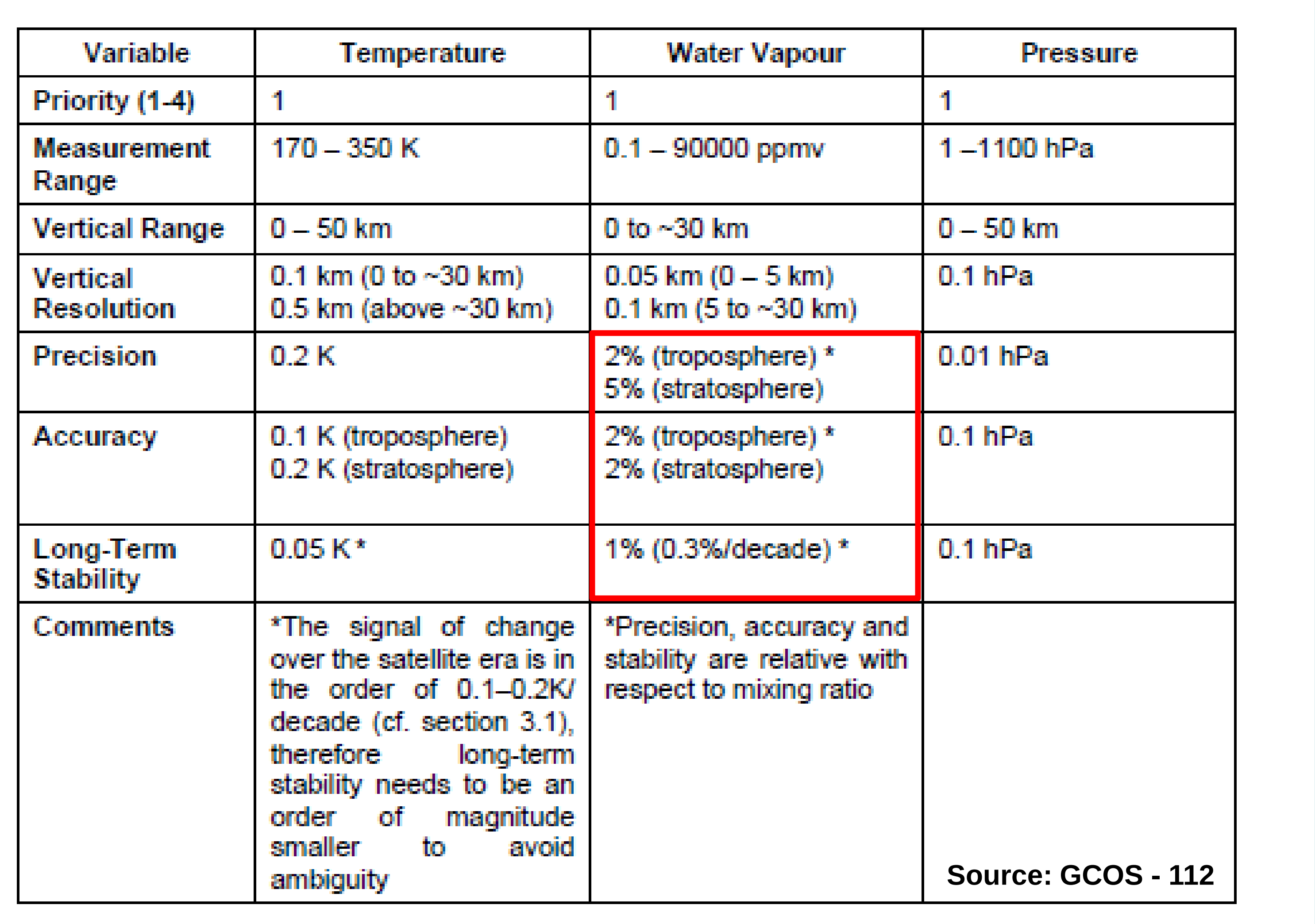
Largest increases are expected in tropical UT

~1%/year increase over the next century

These increases extend to +/- 30 degrees of latitude

For climate monitoring, the focus should be on the UT (150 -250 hPa)

Original GRUAN Priority 1 Measurement Requirements



Variable	Temperature	Water Vapour	Pressure
Priority (1-4)	1	1	1
Measurement Range	170 – 350 K	0.1 – 90000 ppmv	1 –1100 hPa
Vertical Range	0 – 50 km	0 to ~30 km	0 – 50 km
Vertical Resolution	0.1 km (0 to ~30 km) 0.5 km (above ~30 km)	0.05 km (0 – 5 km) 0.1 km (5 to ~30 km)	0.1 hPa
Precision	0.2 K	2% (troposphere) * 5% (stratosphere)	0.01 hPa
Accuracy	0.1 K (troposphere) 0.2 K (stratosphere)	2% (troposphere) * 2% (stratosphere)	0.1 hPa
Long-Term Stability	0.05 K *	1% (0.3%/decade) *	0.1 hPa
Comments	*The signal of change over the satellite era is in the order of 0.1–0.2K/ decade (cf. section 3.1), therefore long-term stability needs to be an order of magnitude smaller to avoid ambiguity	*Precision, accuracy and stability are relative with respect to mixing ratio	

Source: GCOS - 112

For some variables, such as upper-tropospheric and lower-stratospheric water vapour, the ability to monitor to the specified requirements may not immediately be possible, although some research instruments show considerable promise.

Requirements for Trends Detection

$$Y = \mu + \omega T + N$$

μ constant term

ω trend

T time (months)

N noise

$$n^* \approx \left[\frac{3.3\,\sigma_N}{|\omega_0|} \sqrt{\frac{1+\phi}{1-\phi}} \right]^{2/3}$$

n^* the number of years

ω_0 trend magnitude

σ_N standard deviation

ϕ autocorrelation

“the number of years of data required to detect a real trend of specified magnitude with probability 0.90” (Weatherhead et al., JGR 1998)

Number of Years to Detect Trends Using Different Sensors

Measurement Frequency	GRUAN required sensor	10% sensor	15% sensor
Daily	18	18	19
Every 4 days	22	23	23
Monthly	36	38	39

The use of a sensor meeting GRUAN requirements yields a small decrease in the time required to detect trends vs. a 10% or 15% sensor

The expense of the sensor that can provide 10% accuracy in the UT currently limits its use to once per month at selected sites

Potential Synergy between NDACC Raman Lidar Effort & GRUAN

- **RS92 has measurement difficulty in the critical region ~ 200 mb (Miloshevich et al., JGR, 2009)**
  - *Optimized, relatively inexpensive Raman lidar can reach these altitudes reliably through long-term averaging*
- **Hybrid product of lidar + corrected RS92 can provide better profile data than radiosondes alone**
  - *Lidar calibration & stability potentially superior to CFH (CFH error budget 9-10% in UT/LS; Vömel et al., JGR, 2007)*
  - *Hybrid product is a potential GRUAN reference measurement sufficient for UT trend detection*
    - *Synergy between GRUAN RS92 sondes & NDACC Raman lidars could provide more frequent climate quality measurements*
- **GRUAN is considering the use of traveling standards as in NDACC for MOHAVE**

What’s Next?

- **Use lidar water vapor data (CARL, TMF) to characterize noise and autocorrelation**
  - *Error budget better understood than for sondes*
- **Simulate effects of calibration jumps / drifts and data gaps**
- **Establish realistic measurement / calibration requirement for NDACC water vapor lidars**
  - *NDACC Calibration Workshop (NASA/GSFC: May 17-19, 2010)*

Acknowledgements:

(i.e., These guys did the work)

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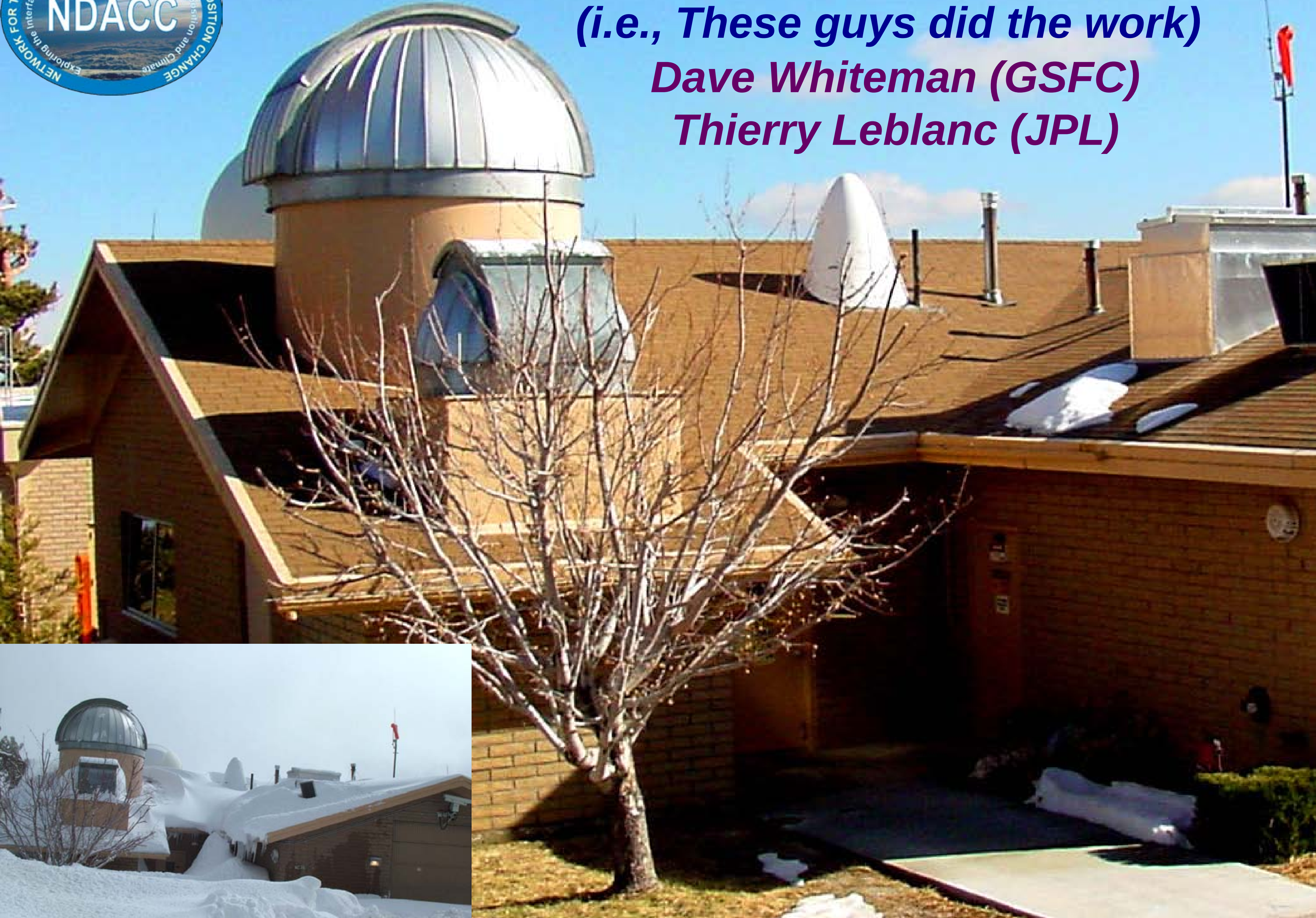

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1/3/37 – 9/11/09

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