NDACC and Water Vapor Raman Lidars

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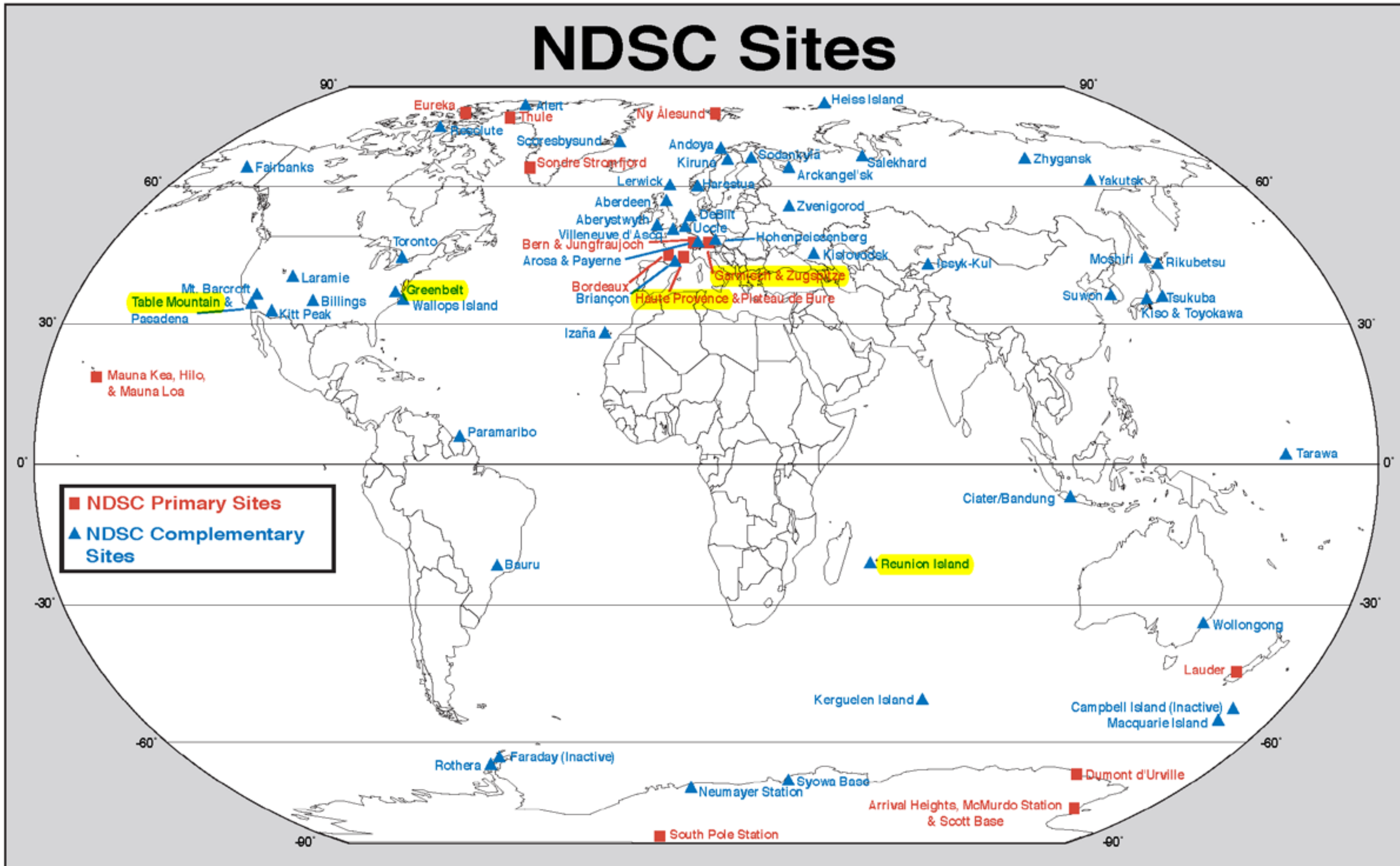
NDACC and Water Vapor Raman Lidar 1. Measuring goals

- Water vapor plays significant role in radiative balance of the UTLS
- Water Vapor variability is very high in both space and time
- High resolution water vapor measurements in the UTLS has remained sparse until today

- ➔ **2002: It was proposed to add water vapor Raman lidars to the set of NDACC instruments with the specific following requirements:**

- Capable of measuring water vapor near and above the tropopause
- Capable of measuring down to a few ppm
- Capable to sustain relatively high vertical and temporal resolution

NDACC and Water Vapor Raman Lidar 2. Existing wv lidars



NDACC and Water Vapor Raman Lidar: 3. Technique/retrieval

- Vibrational Raman backscatter technique at two wavelengths
- UV:
  - Laser emission at 355 nm
  - Reception at 387 nm (Raman N2) and 407.5 nm (H20)
- Visible:
  - Laser emission at 532 nm
  - Reception at 607 nm (Raman N2) and 660 nm (H20)
- Lidar signals corrected for background noise, saturation/pile-up effects, signal induced noise, range, Rayleigh extinction.
- Small additional correction due to temperature dependence of the H2O cross-section is needed occasionally if using very narrow filter
- After correction, the ratio of the lidar signals at the two wavelengths is proportional to water vapor mixing ratio.

➔ Needs calibration !

NDACC and Water Vapor Raman Lidar: 4. Calibration

- Calibration techniques:

  - **Internal/theoretical**: Very challenging because requires accurate knowledge of transmission ratios of **ALL** the lidar optical and electro-photonic components

    ➔ virtually impossible to achieve at required accuracy

  - **Semi-empirical:** Use of a Calibration lamp to illuminate lidar receiver in conditions that mimic real measurements: Difficult, but possible

    ➔ Accuracy depends mostly of lamp calibration accuracy

  - **External:** Use of independent measurements, e.g., radiosonde, microwave

    ➔ Easy to implement but accuracy limited by that of independent measurement

NDACC and Water Vapor Raman Lidar 5. CONCLUSION

Important requirements for NDACC long-term measurements and associated challenges to lidar community:

1. **High capability lidar**
   ➔Capable of detecting a few ppm at tropopause

2. **Stable calibration constant**
   ➔ Simultaneous multiple calibration techniques must be available to cross-validate calibration constants from each technique, and insure long-term stability

The Raman Lidar at Table Mountain Facility: Overview 1

Laser energy:
- 700 mJ/pulse

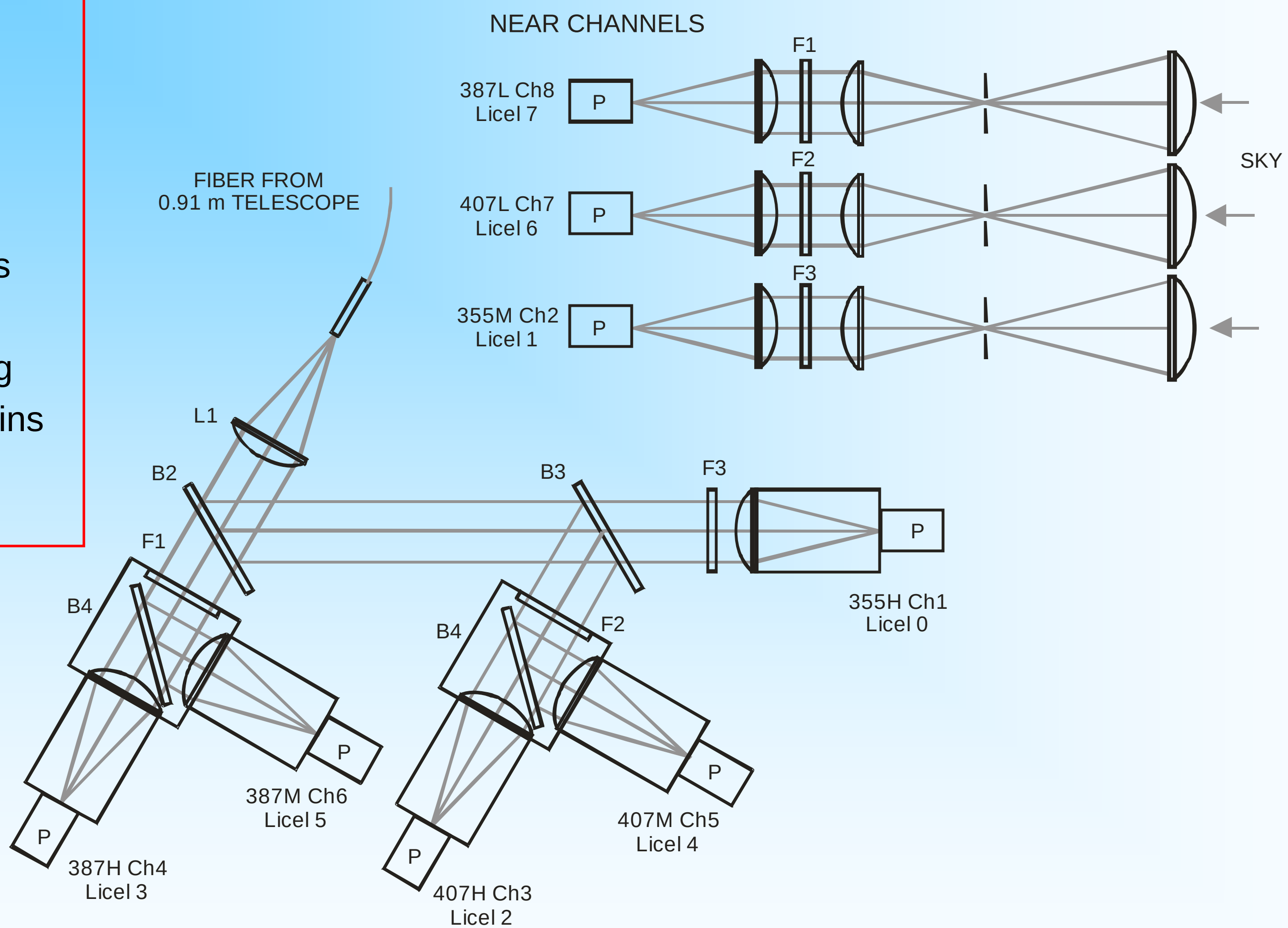
8 channels:
- 3 w.v. ranges

3 telescopes:
- One 90 cm
- Three 6 cm

Hamamatsu PMTs

Licel
- photocounting
- 8000 7.5-m bins

Vertical resolution
- 75-m



The Raman Lidar at Table Mountain Facility: Overview 2

- Calibration used so far:
  - Radiosondes: Vaisala Humicap RS-92 sensors

- Future plans:
  - UV lamp, GPS, Microwave
  - Simultaneous, multiple calibration techniques

- Important requirement for NDACC long-term measurements:
  - Stable calibration constant

The Raman Lidar at Table Mountain Facility: Overview 3

TMF

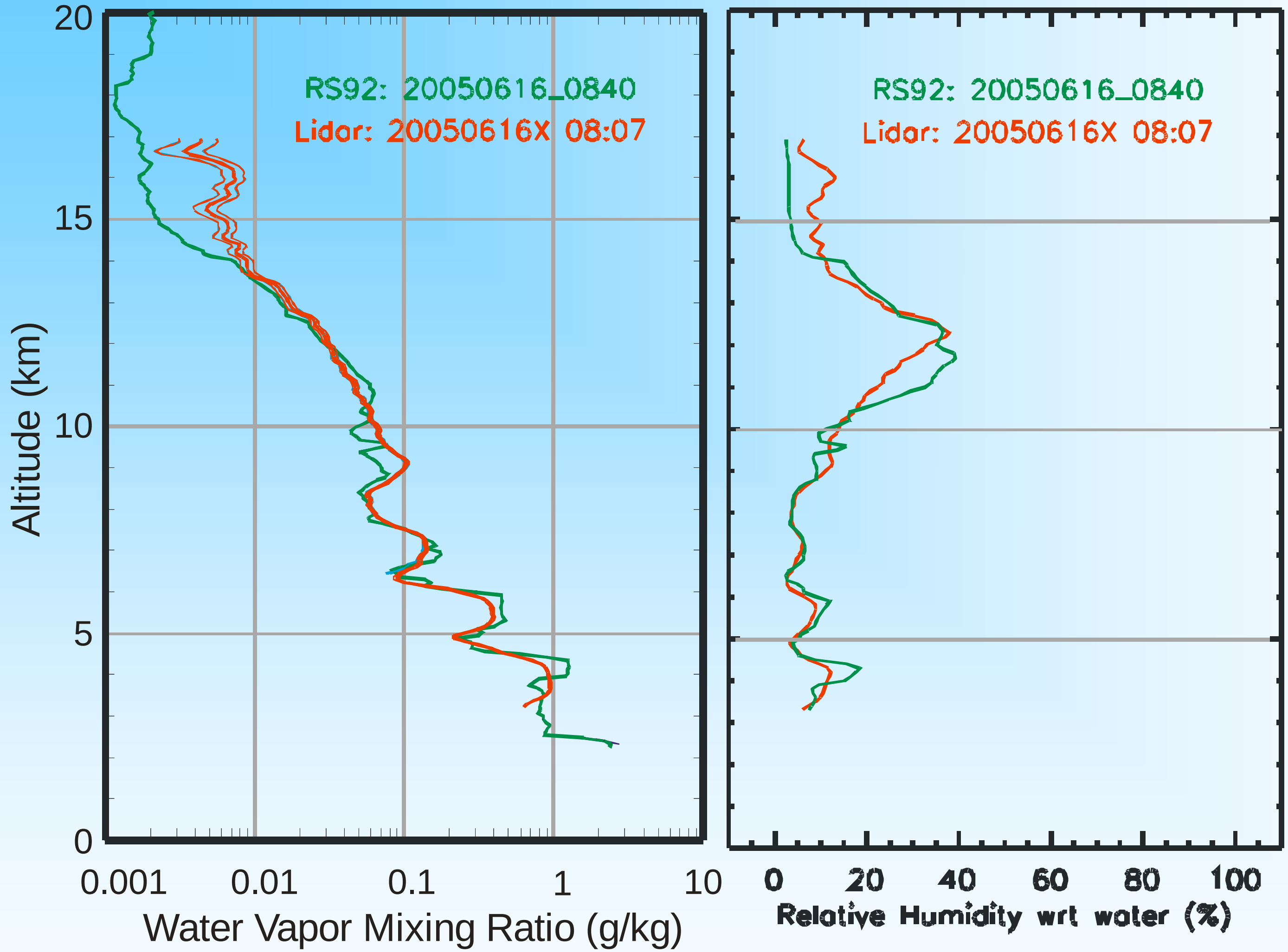
- 50 miles NE of Los Angeles
- Lat: 34.4ºN
- Long: 117.7ºW
- Alt: 2285 m (7500 ft)

  > 340 clear nights/year

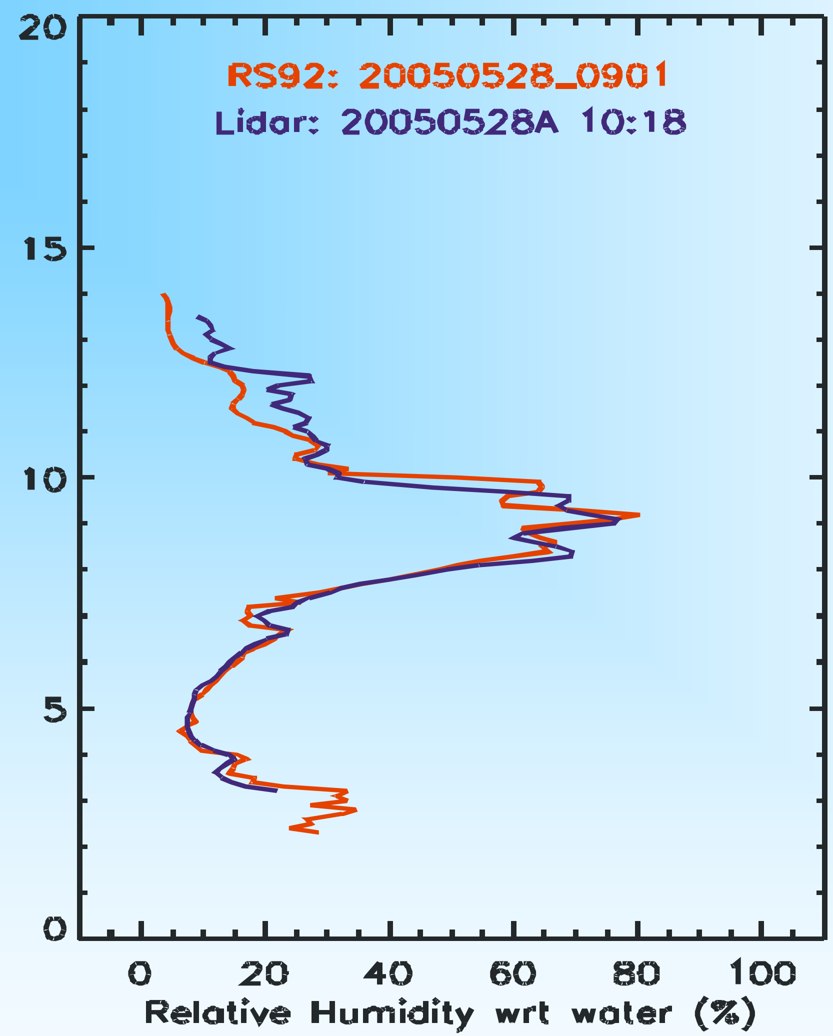
Dataset

- TMF water vapor measurement program started in late 2004
- **November 2004 – Present**:
  - Radiosonde P,T, (2.3-20 km), RH (2.3-15 km)
- **April 2005 – Present**:
  - Raman Lidar (4-19 km)
- **Lidar vertical resolution and accuracy**:
  - 75 m instrumental, 2-h routine integration (5-minutes minimum)
  - WV total error estimated to ~5-8 ppm at tropopause

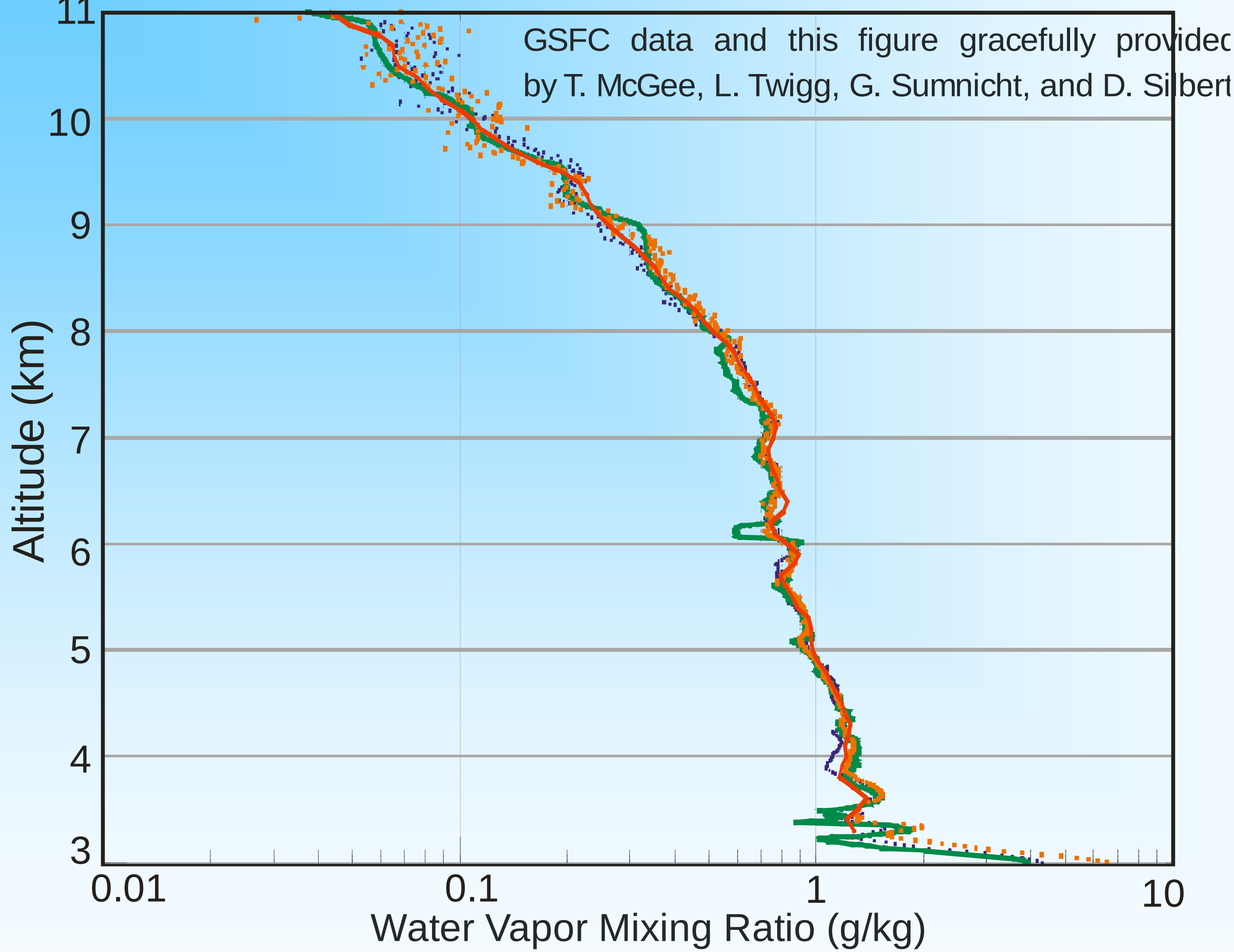
The Raman Lidar at Table Mountain Facility: Overview 4



The Raman Lidar at Table Mountain Facility: Overview 5



The Raman Lidar at Table Mountain Facility: Overview 6



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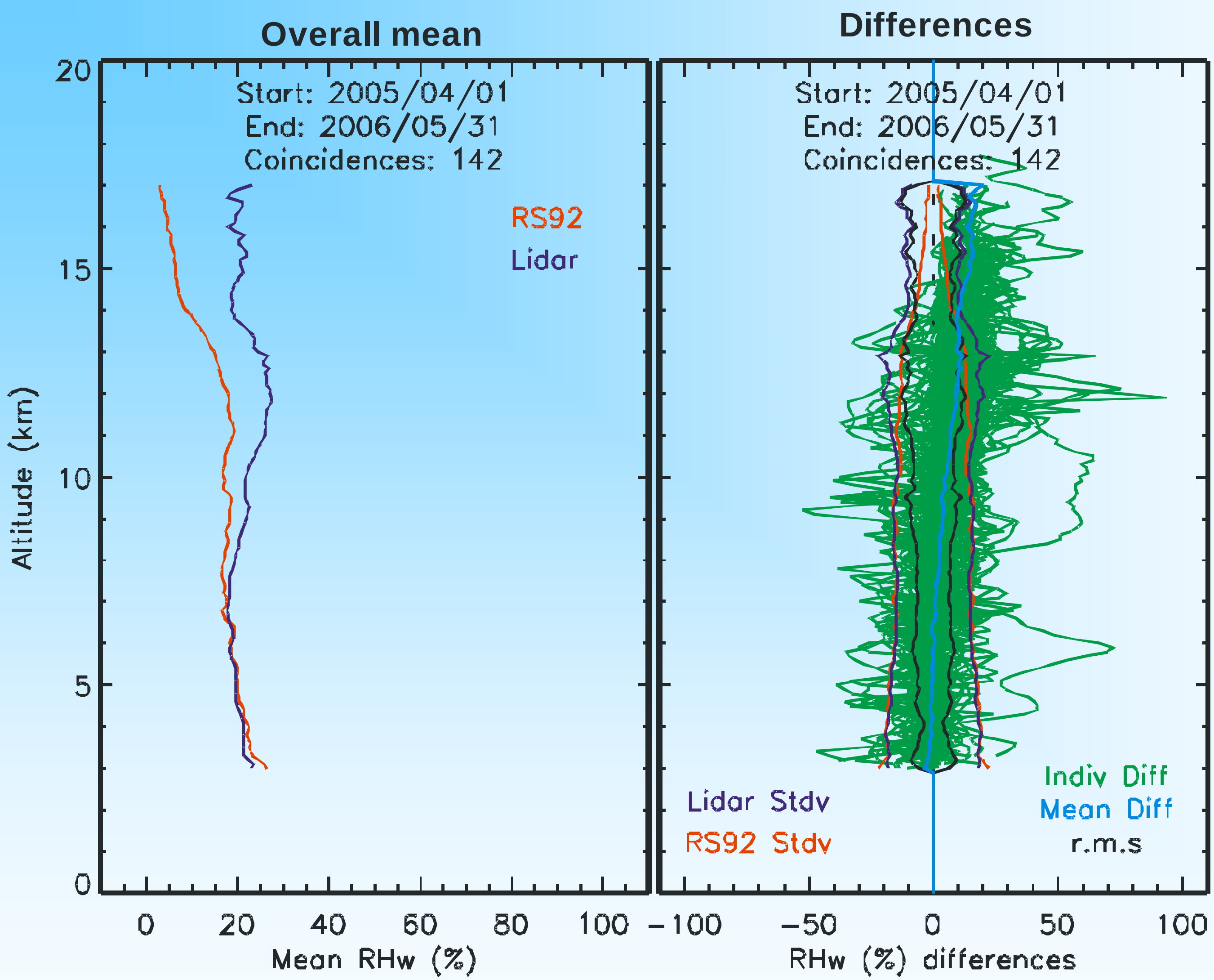

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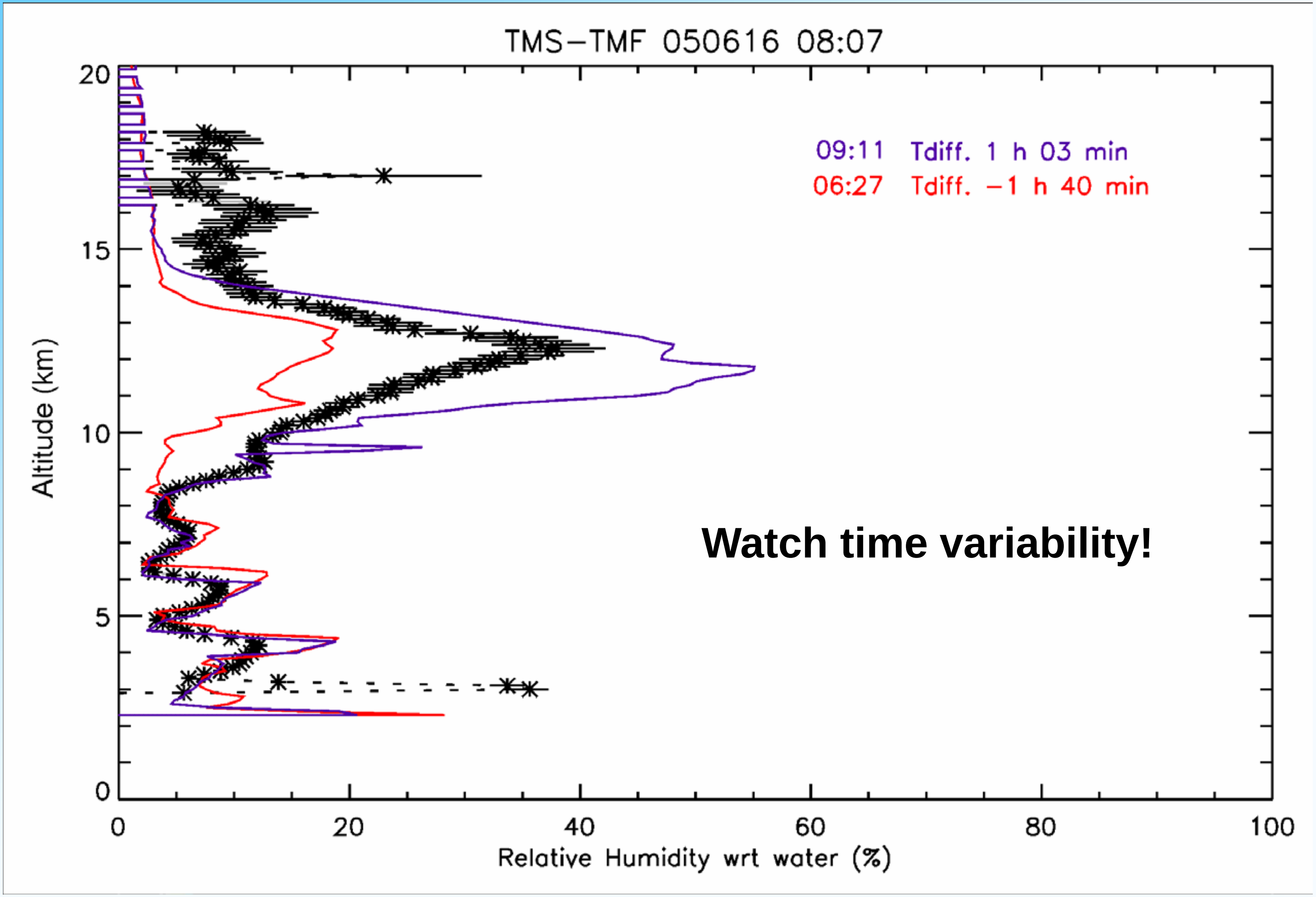

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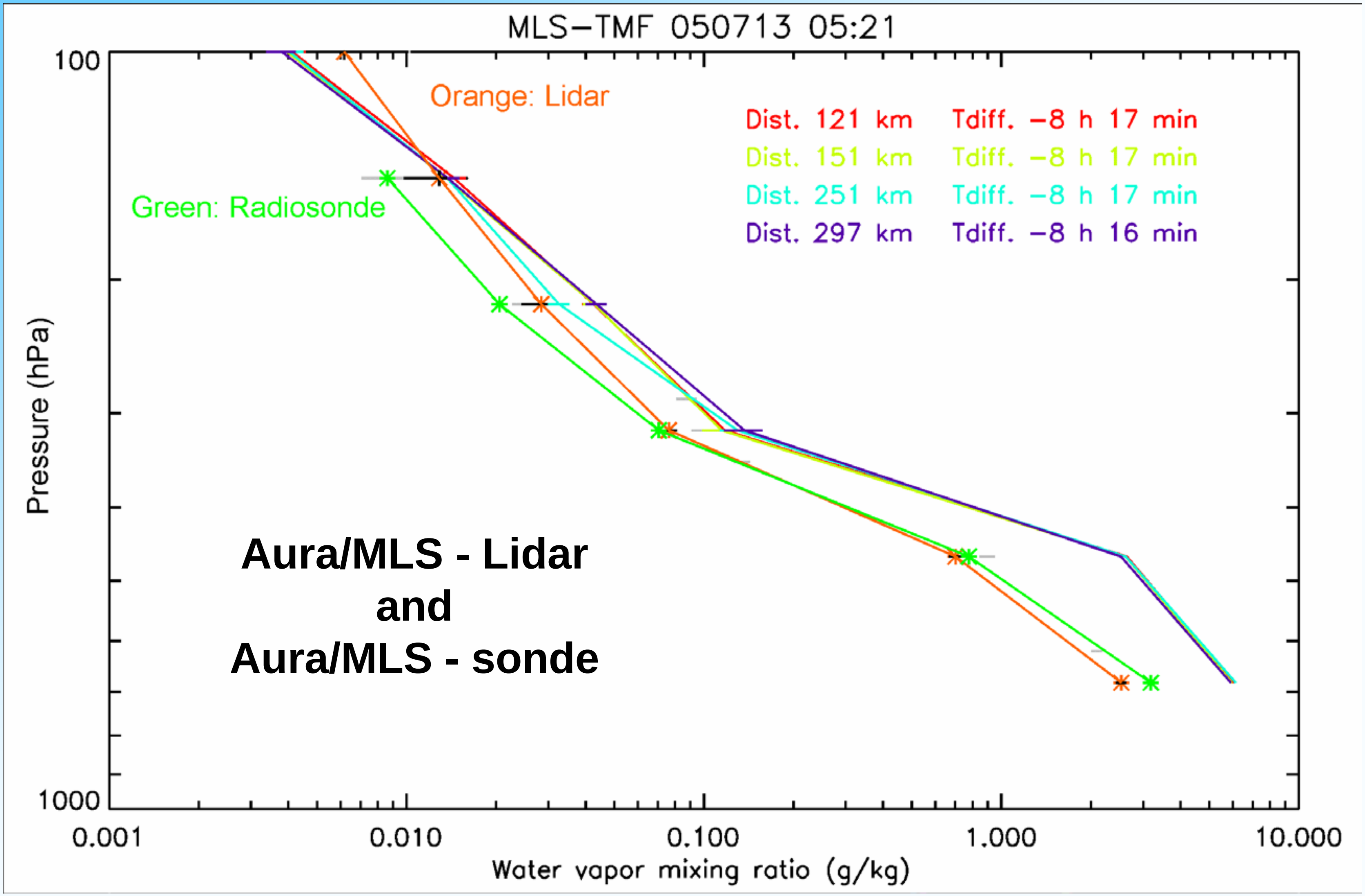

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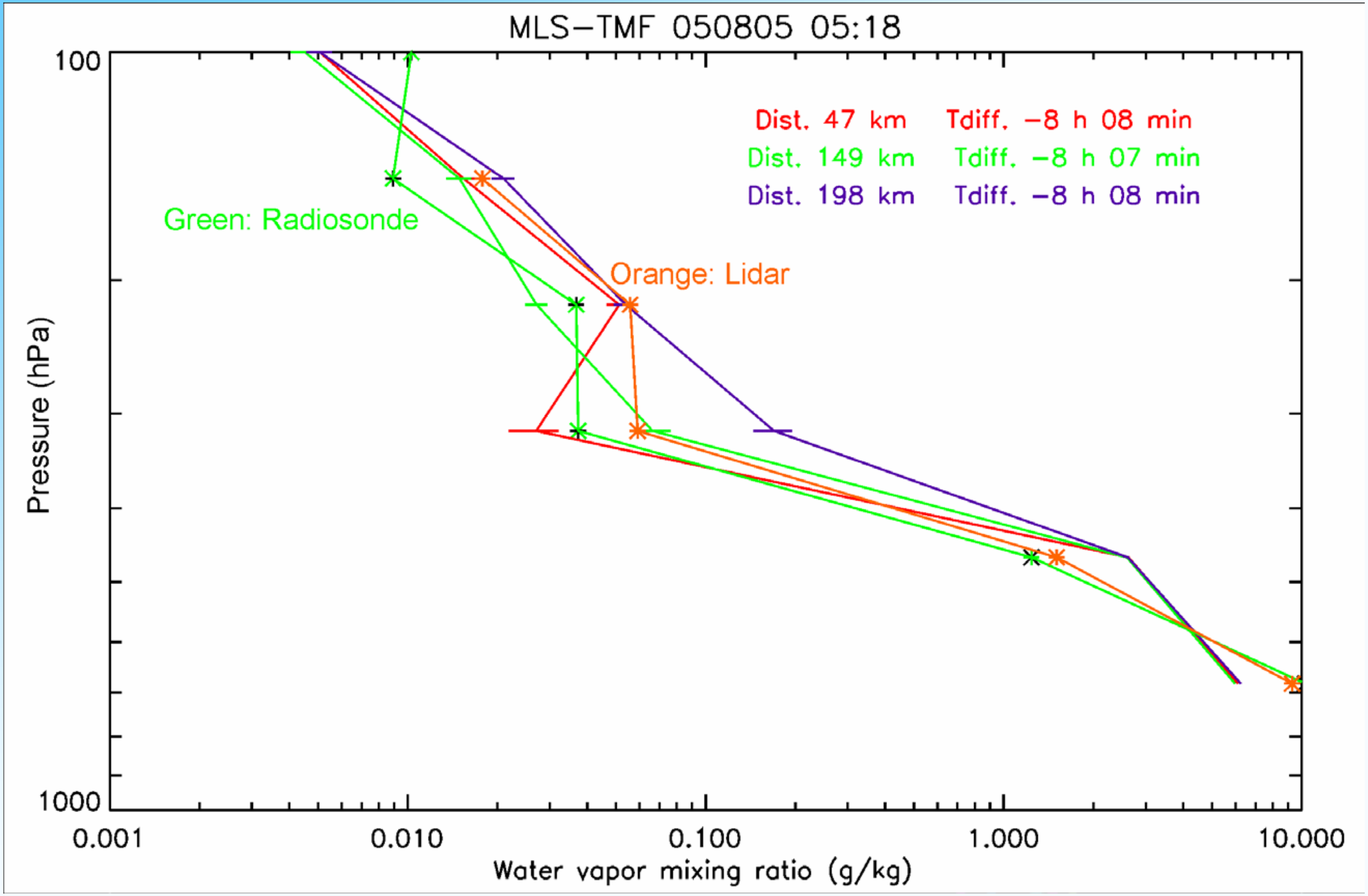
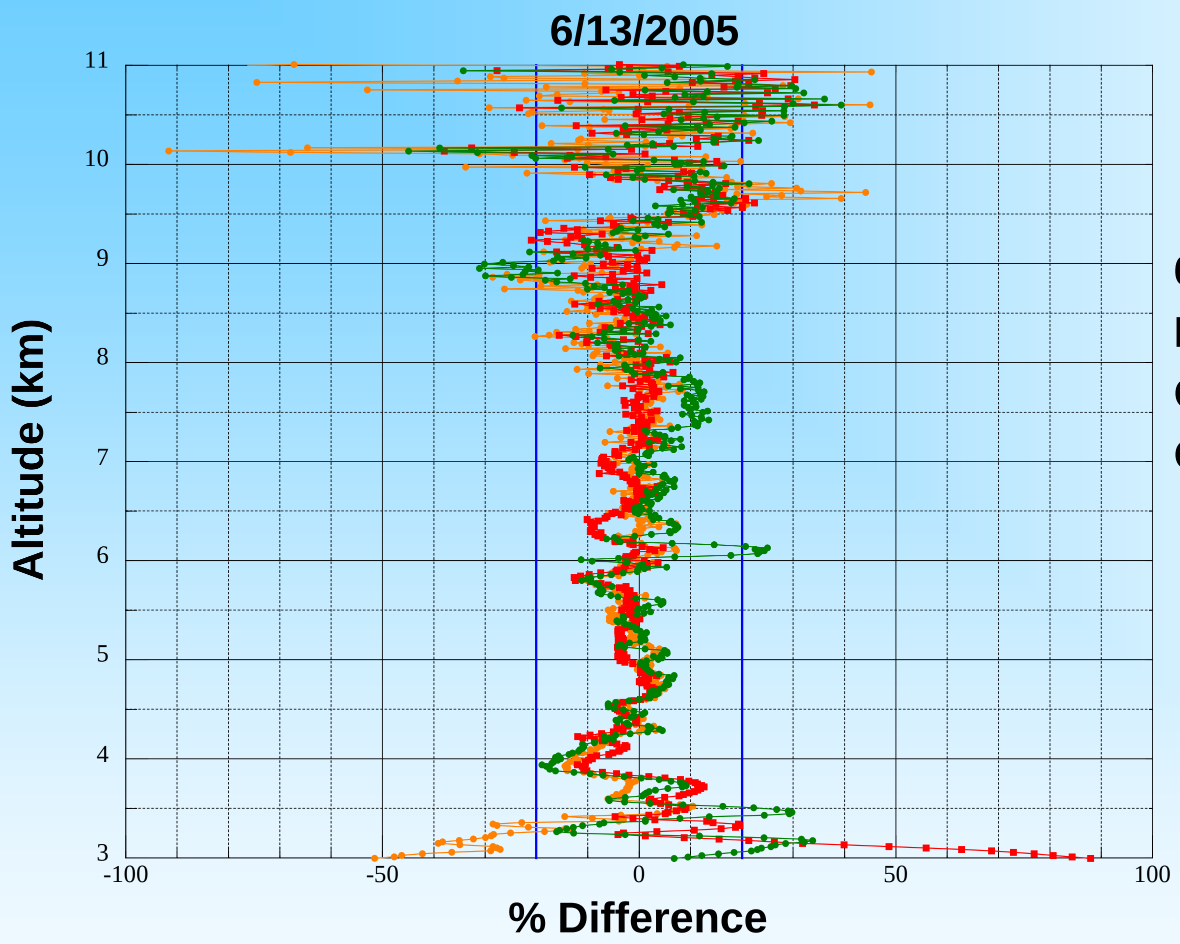


The Raman Lidar at Table Mountain Facility: Summary

- **So Far:**
  - TMF Water Vapor Raman Lidar is doing well
  - Capable to reach 15-18 km for a 2-hour integration
  - As of today, used only radiosonde for calibration

- **Next:**
  - Introduce new calibration techniques:
    - Lamp
    - GPS?
    - Microwave?
  - Improve lidar power/aperture capability to reach final objectives of detection level of 2 ppm at 15 km

The Raman Lidar at Table Mountain Facility: Overview 1



6/13/2005

Red = JPL-AT

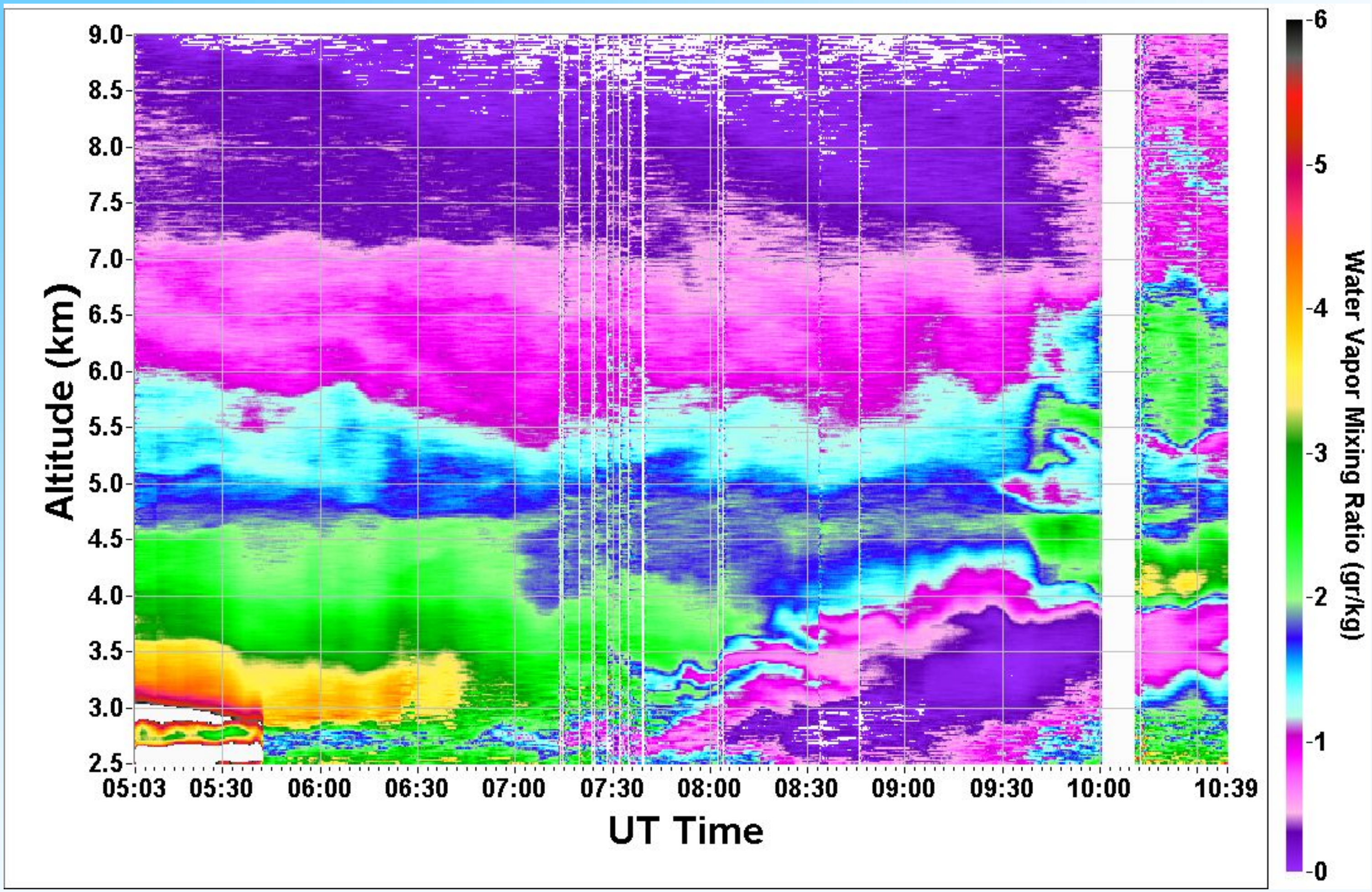
Green = Sonde-AT

Orange = STROZ-Lite – AT

From:

Tom McGee and Larry Twigg, NASA-GSFC

The GSFC Raman Lidars: Overview 2



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