

Recent Advances in Stratospheric Monitoring Using Balloon-borne Sondes

Dale Hurst, Emrys Hall, Allen Jordan



Global Monitoring Laboratory

Earth System Research Laboratories

Elizabeth Asher, Troy Thornberry



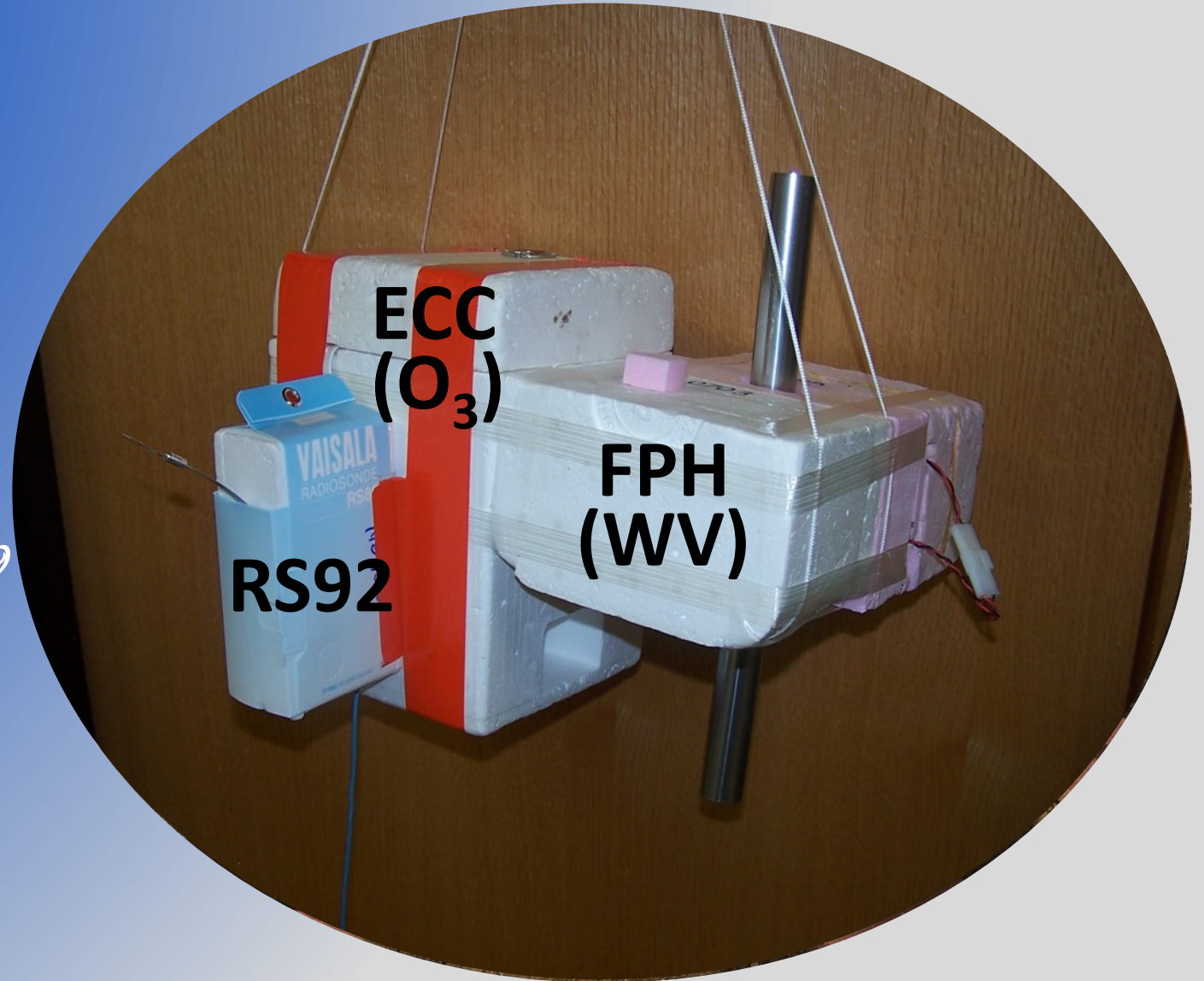
Chemical Sciences Laboratory

Earth System Research Laboratories

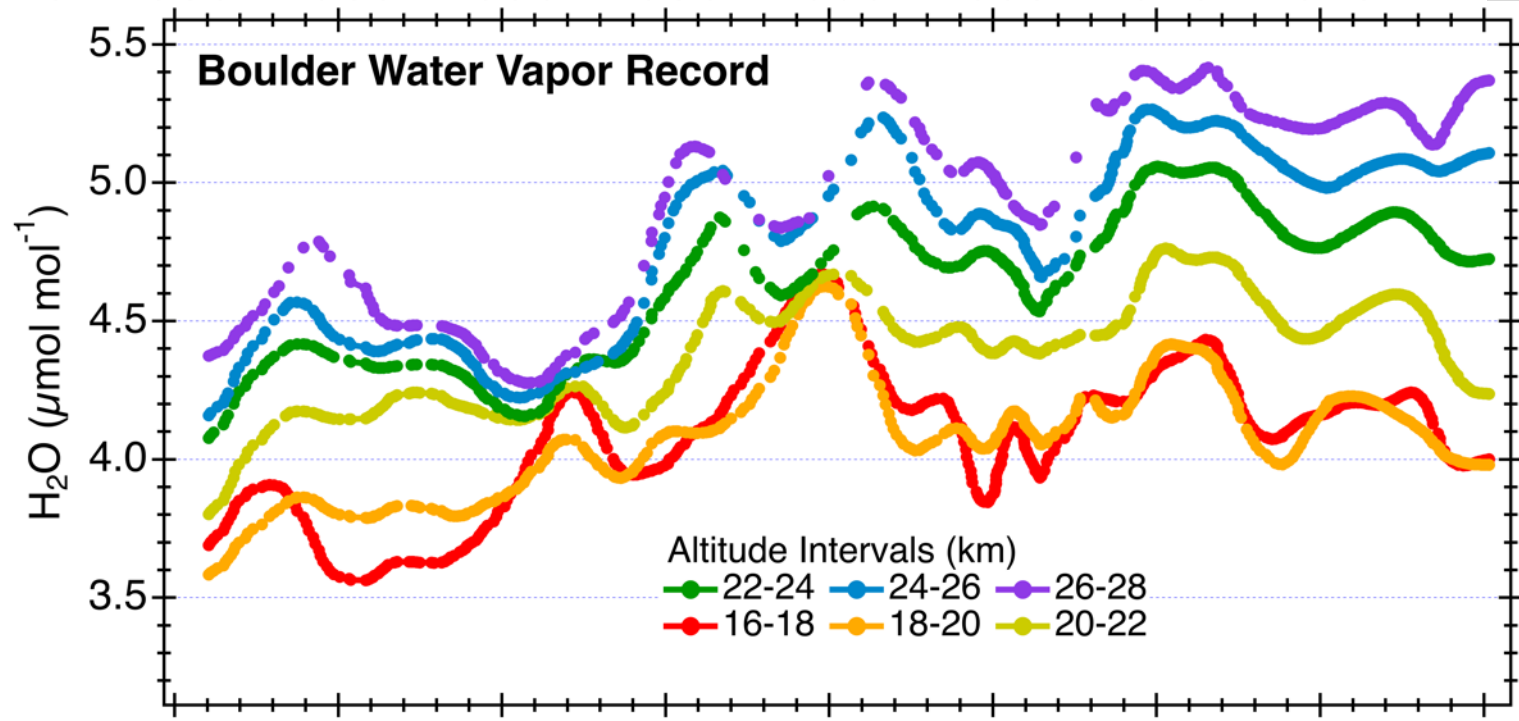
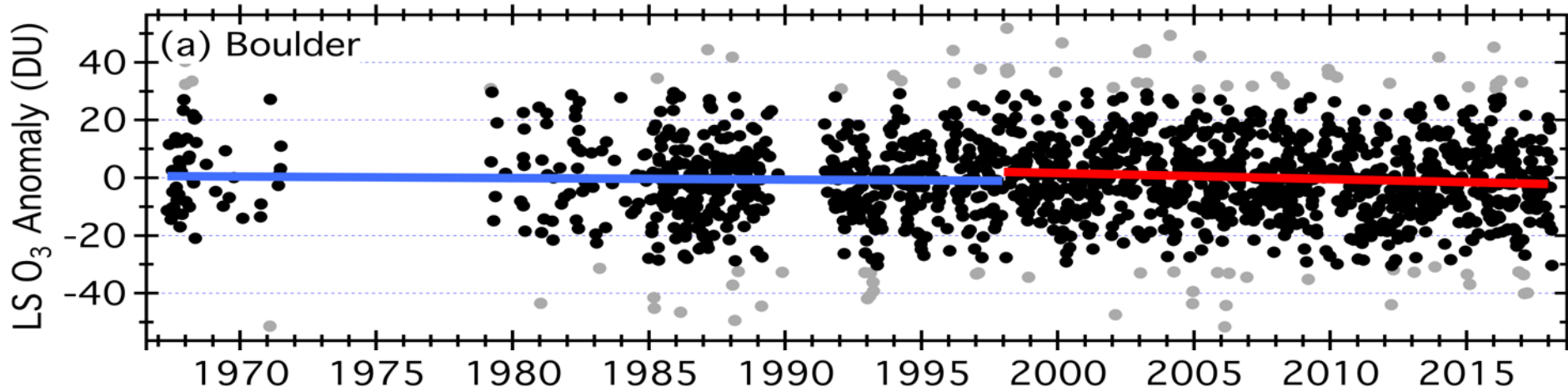


Balloon Launches at Boulder, Colorado

2010



Boulder Balloon-borne Records of Ozone



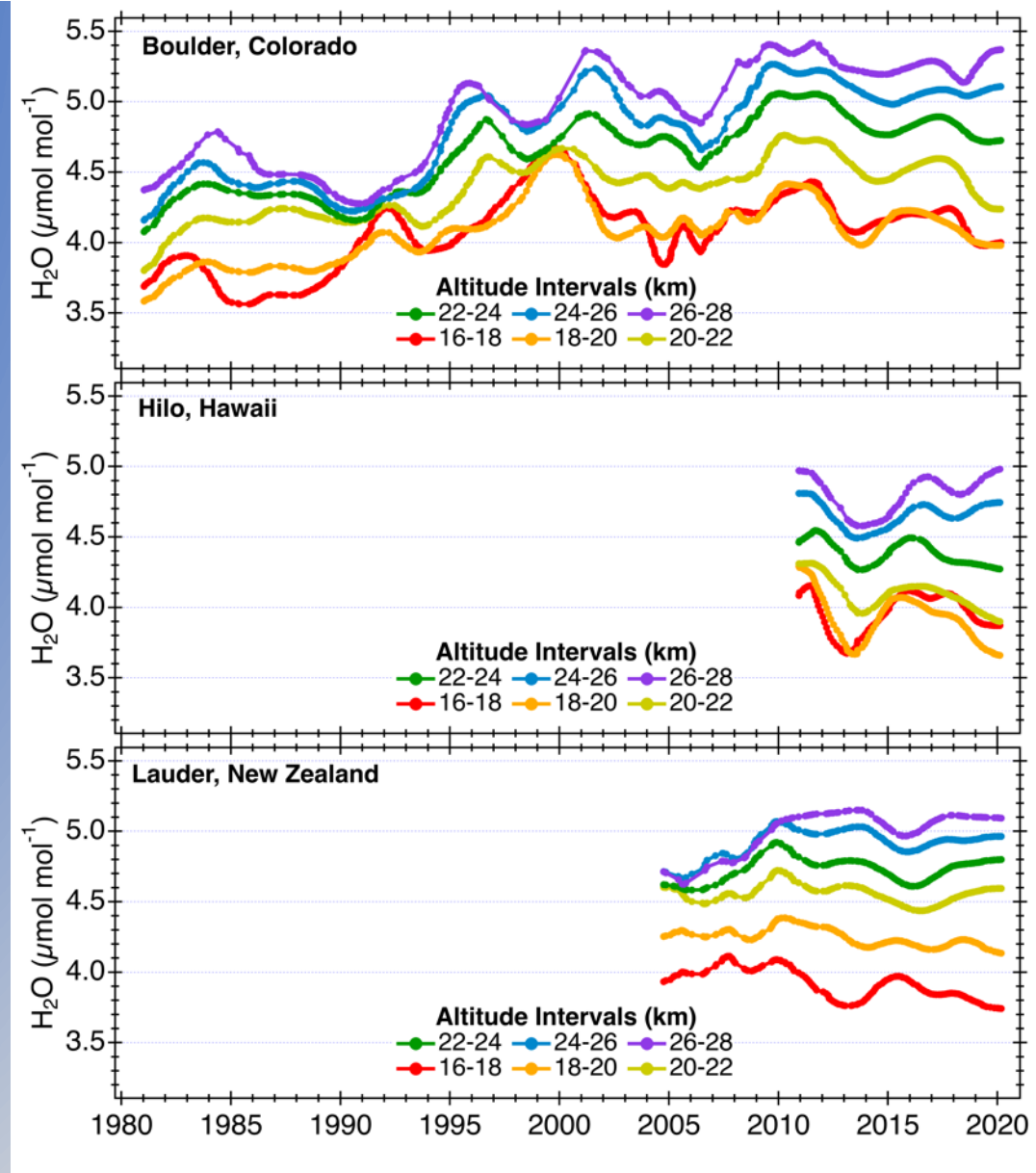
*Surpassed 40 years in
April 2020!*



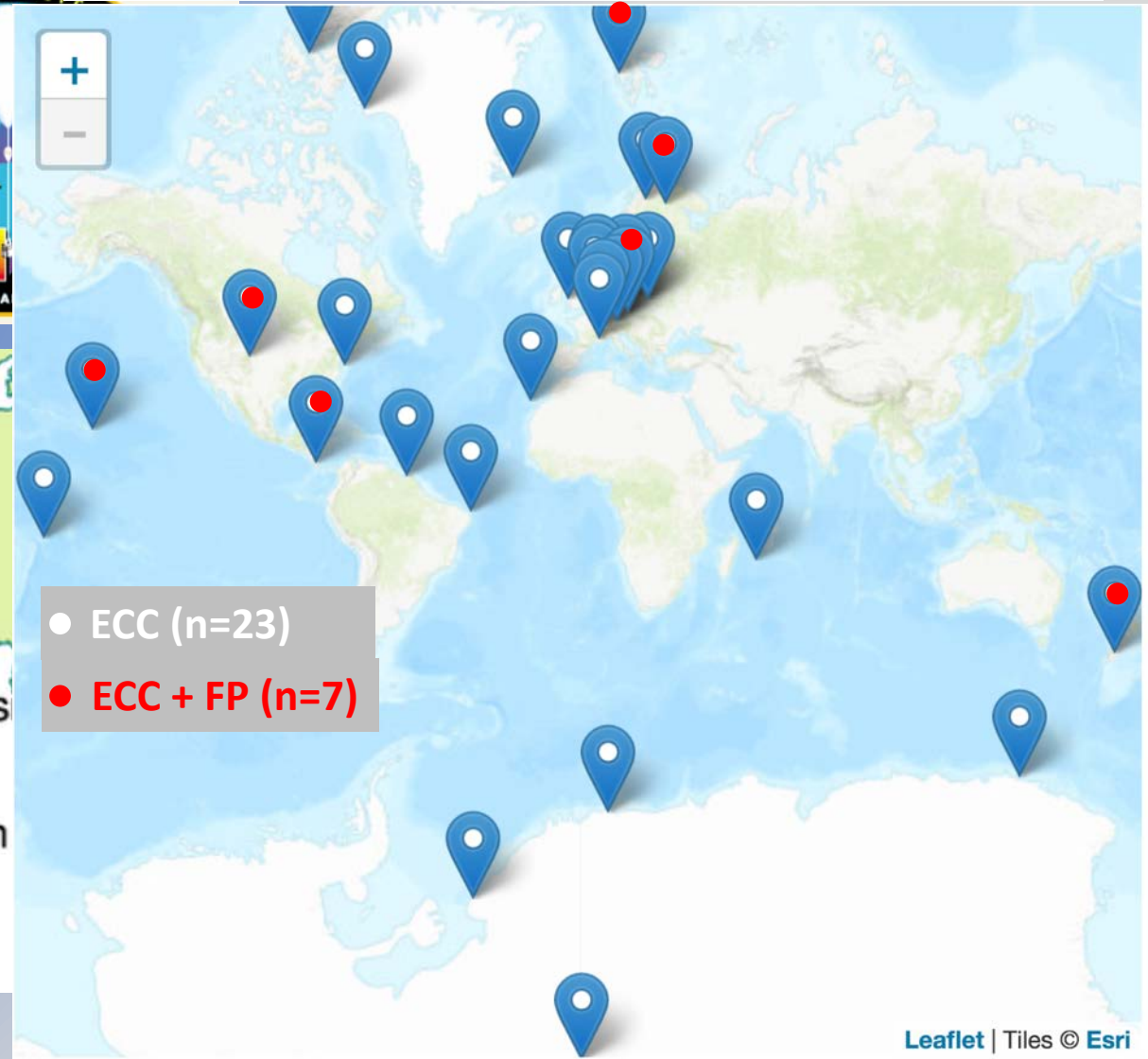
GML Balloon Sounding Networks

GML Ozonesonde Sites

Trinidad Head, CA	41°N
Boulder, CO	40°N
Hanoi, Vietnam	21°N
Hilo, HI	20°N
Watukosek, Indonesia	8°S
American Samoa	14°S
Suva, Fiji	18°S
La Réunion Island	21°S
Lauder, New Zealand	45°S
South Pole, Antarctica	90°S



Network for the Detection of Atmospheric Composition Change



GCOS Upper-Air Network (GUAN)

Global Network of ~200 Operational Radiosonde Sites

- Most are National Met Service sites (for NWP)
- 2-4x daily soundings
- ECVs measured:
P, T, RH, winds

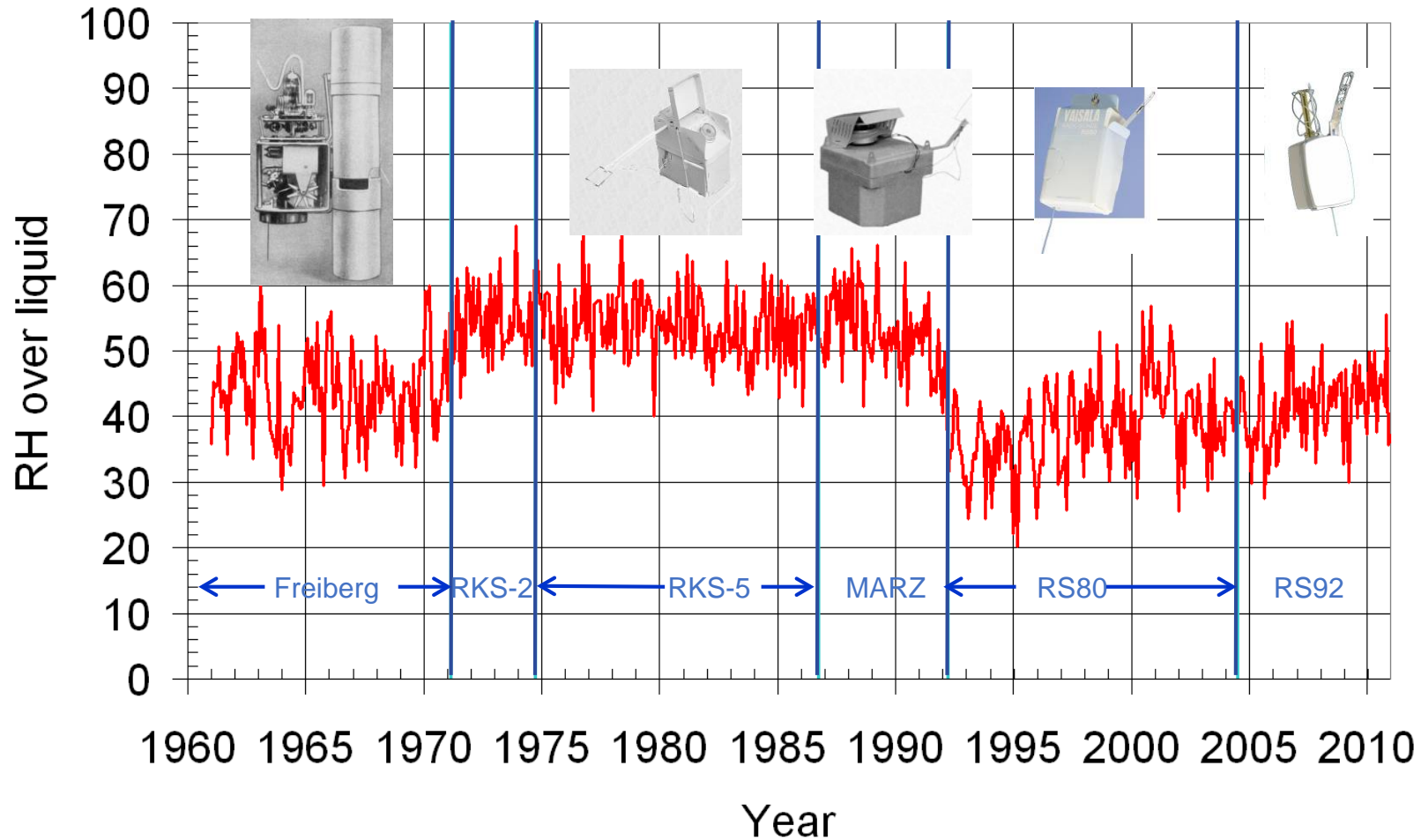
Climate Record Issues

- Mixture of RS types
- Nonexistent (or different) ground-checks
- Data processed and corrected by black box
- No change management



Change Management

Lindenberg, Germany; Alt=8 km (0:00 UTC)

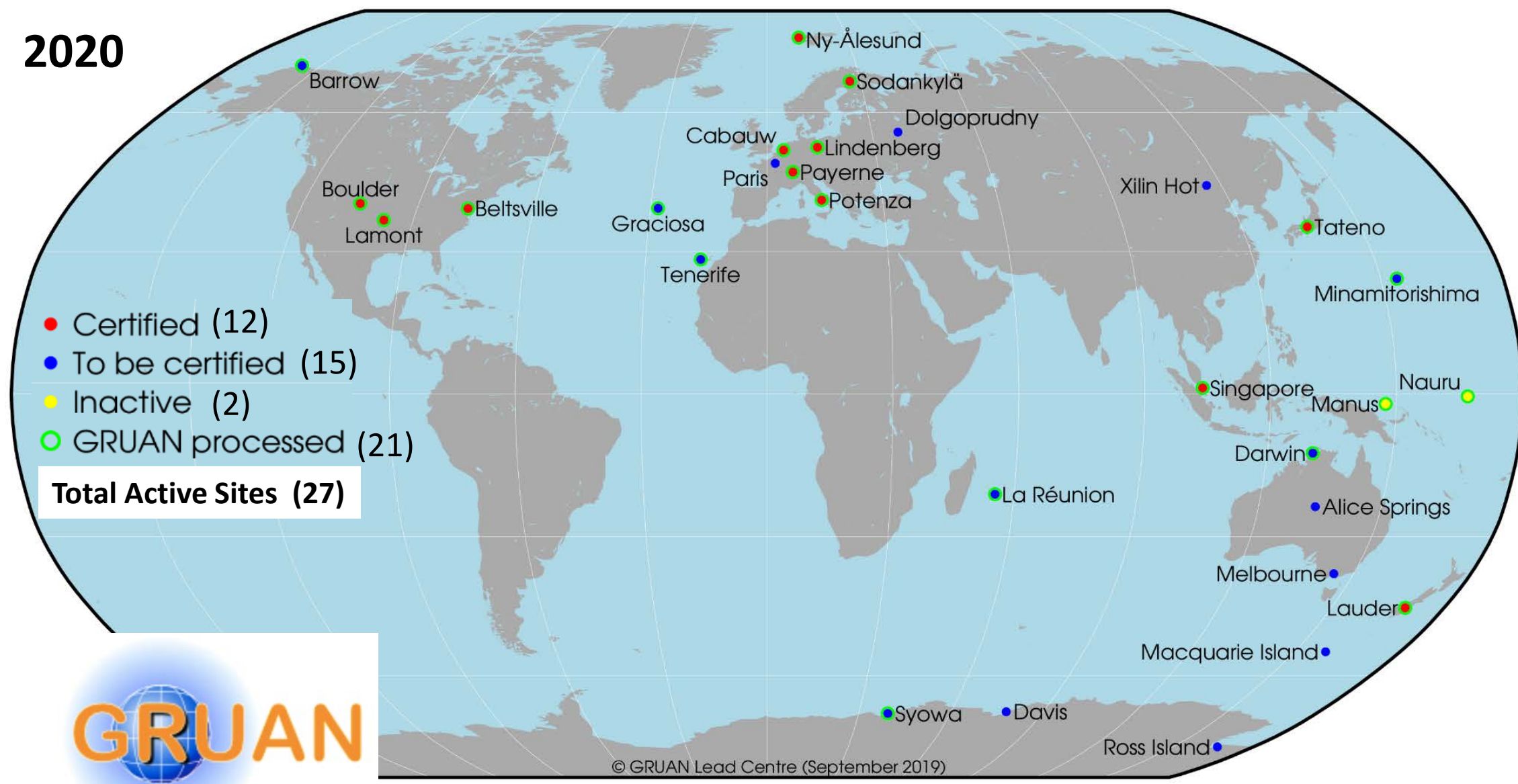


Climate Records Need:

- **Managed Change: overlap and documentation**
- **Certified Sondes**
- **Best Practices (SOPs) including standardized ground-checks**
- **No black-box corrections**
- **Homogenous (centralized) data processing with full uncertainty analysis**

GCOS Reference Upper-Air Network (GRUAN)

2020



Change Management in GRUAN: RS92 -> RS41

2016: Vaisala ceased production of RS92

2017: Some sites began dual launches (RS92, RS41)

- Different climatic zones
- All seasons
- Daytime and nighttime
- Planned overlap of 2 years

2018-2020: Lab tests of RS41 sensor corrections

Laboratory investigations of RS41 sensors at GRUAN Lead Centre

Corrections for:

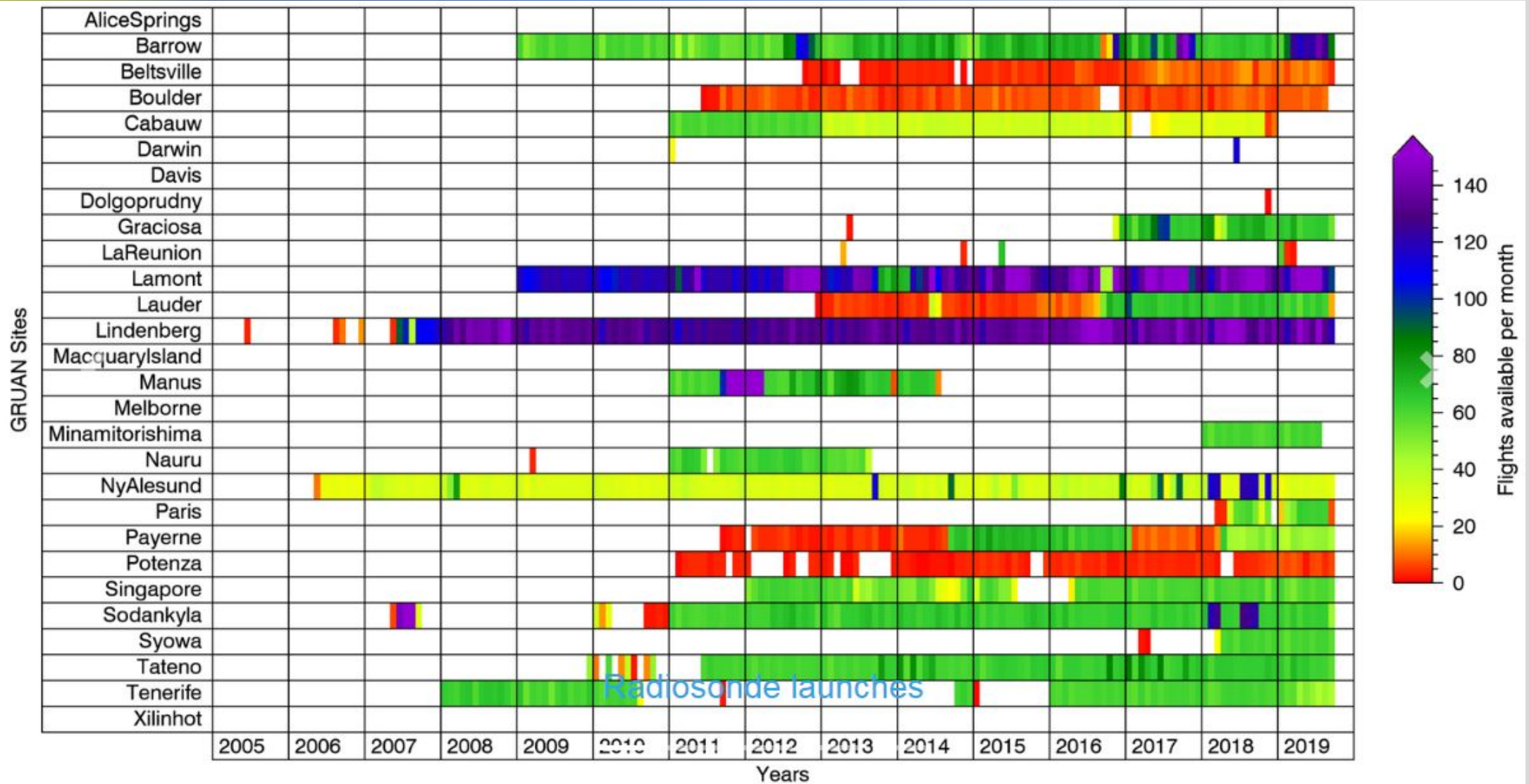
- *solar radiation*
- *calibration offsets*
- *time lags in sensor responses*

Progress in managing the transition from the RS92 to the Vaisala RS41 as the operational radiosonde within the GCOS Reference Upper-Air Network

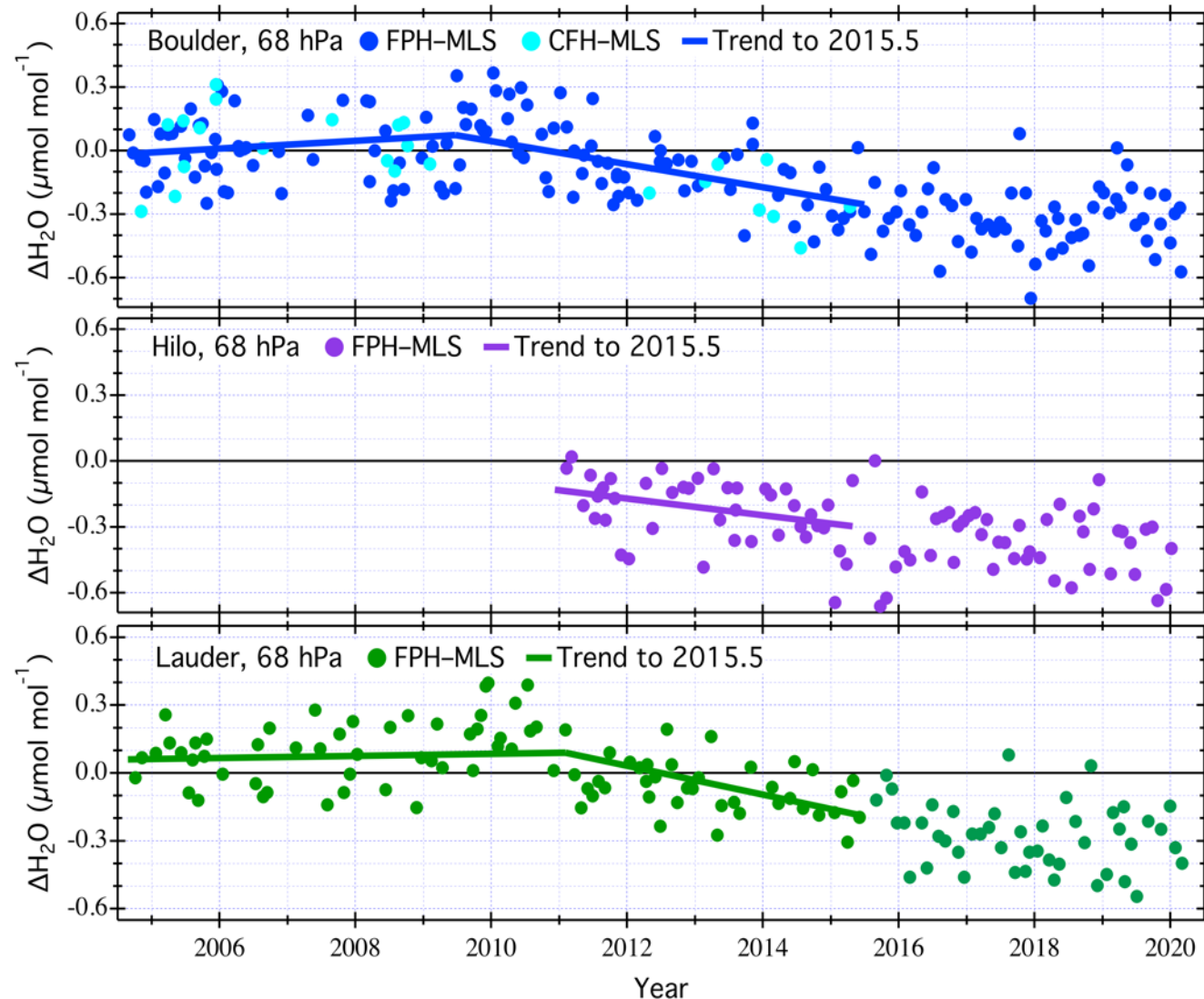
Ruud J. Dirksen¹, Greg E. Bodeker², Peter W. Thorne³, Andrea Merlone⁴, Tony Reale⁵, Junhong Wang⁶, Dale F. Hurst⁷, Belay B. Demoz⁸, Tom D. Gardiner⁹, Bruce Ingleby¹⁰, Michael Sommer¹, Christoph von Rohden¹, and Thierry Leblanc¹¹



GRUAN radiosonde launches through September 2019 (N = 97,992)



Tracking the drift in Aura MLS water vapor



Hurst et al. (2016), AMT

Recent divergences in stratospheric water vapor measurements by frost point hygrometers and the Aura Microwave Limb Sounder

Post-2010 wet biases in MLS water vapor have persisted at the level of ~ 0.4 ppm

MLS team is currently producing data version 5 which will account for some of the drift in SWV

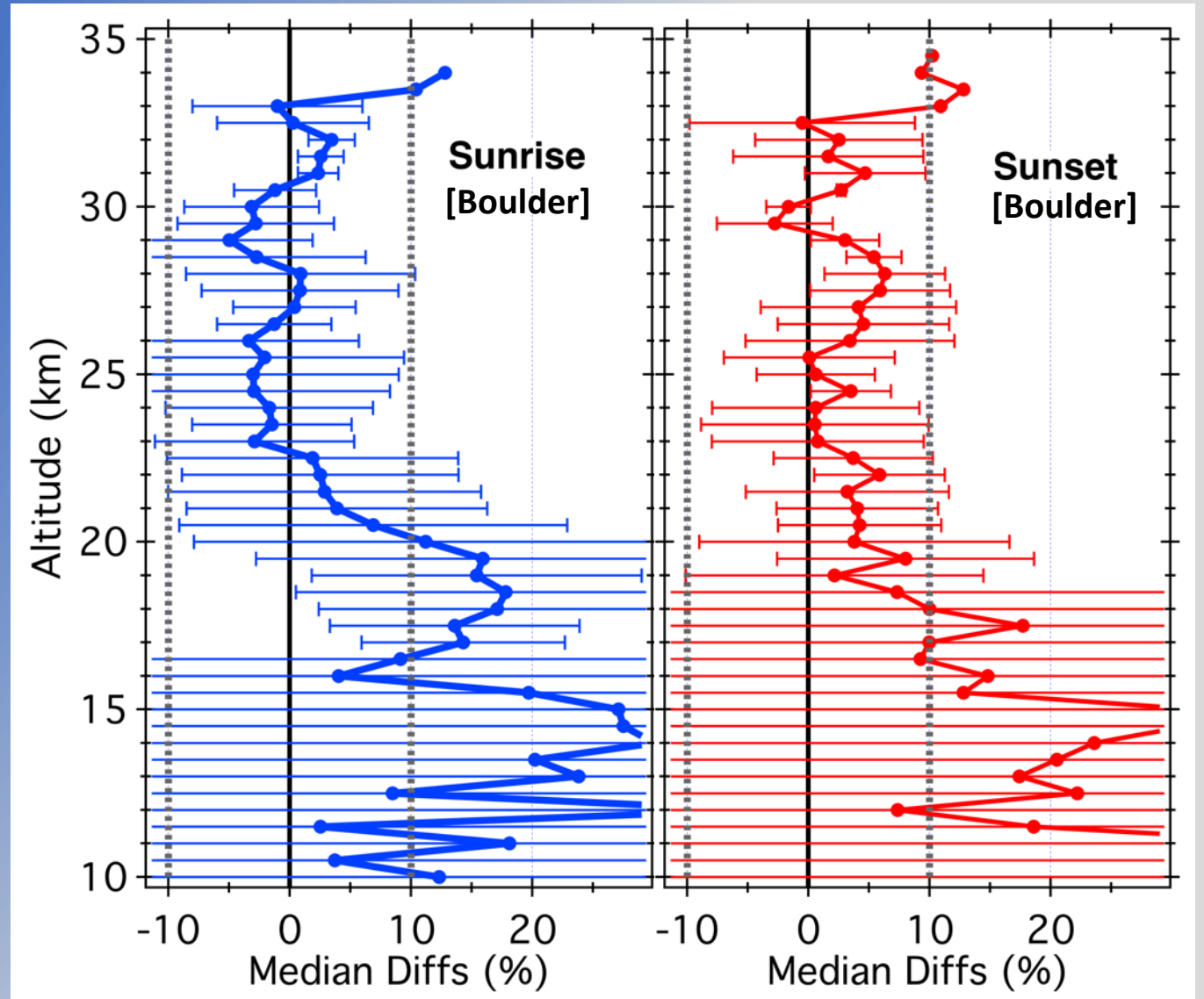
Validation of SAGE III/ISS O₃ Measurements

GML has launched balloons from Boulder and Lauder in coordination with SAGE III/ISS overpasses since August 2017

O₃ Match Criteria
 $\pm 5^\circ$ Lat, $\pm 10^\circ$ Lon, ± 24 hrs

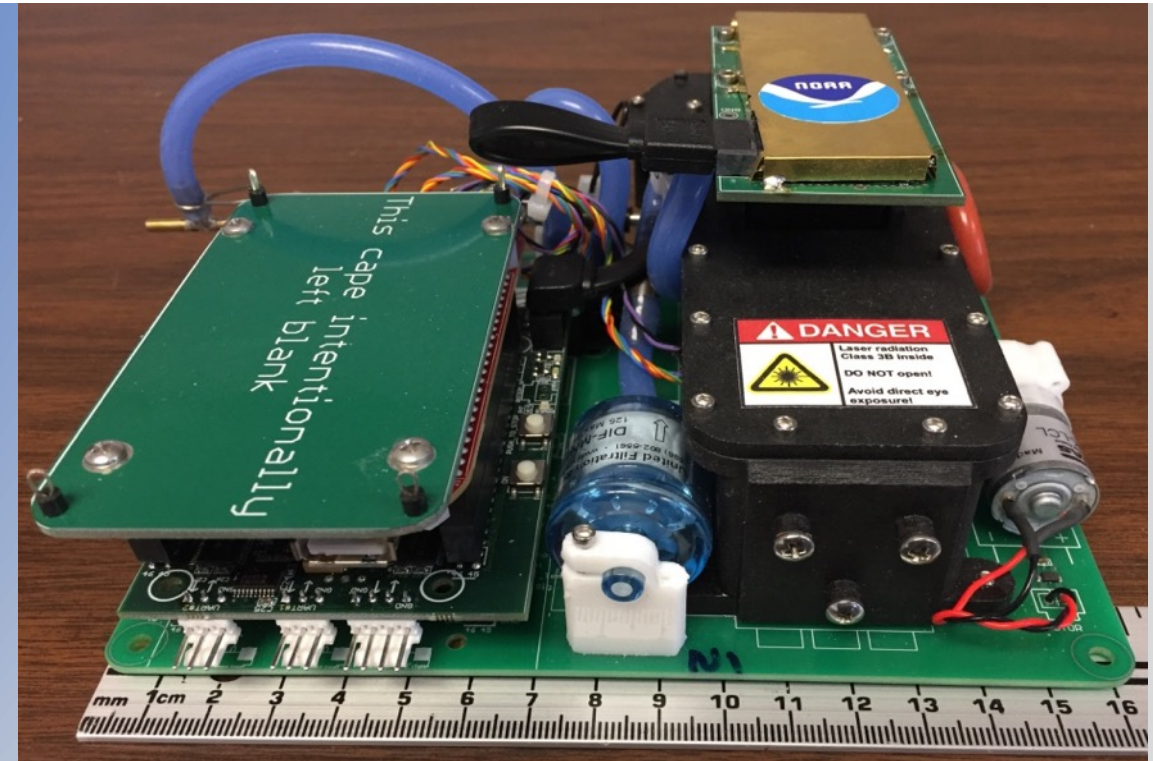
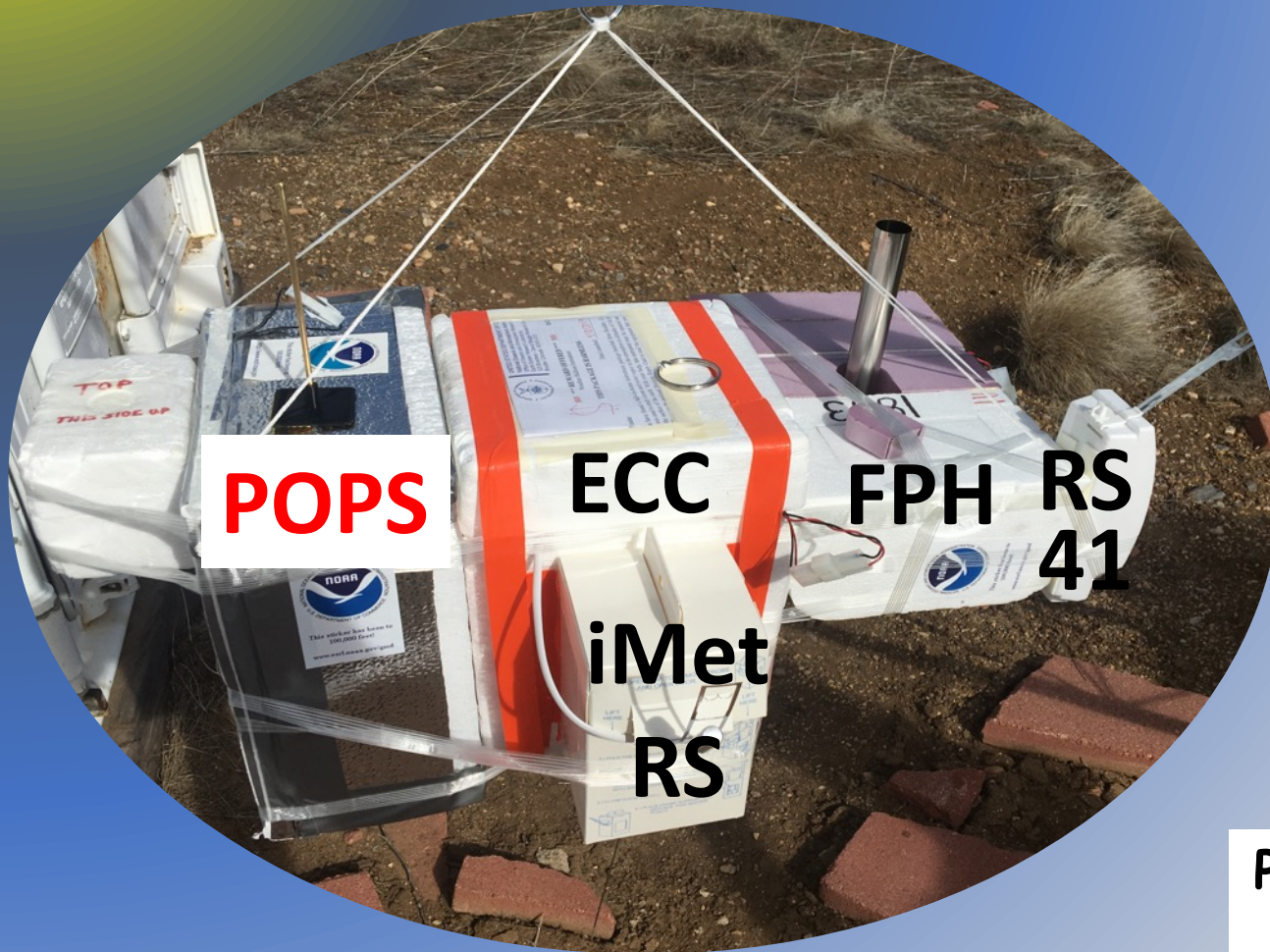
Coordinated Soundings:

	<u>ECC</u>	<u>& FPH</u>
Boulder	53	30
Lauder	15	15



Validation of SAGE III/ISS Aerosol Measurements

Stratospheric profiles of aerosol number and size distribution



Portable Optical Particle Spectrometer (POPS)
Aerosol size range: $D_p = 140 \text{ nm} - 2.5 \mu\text{m}$

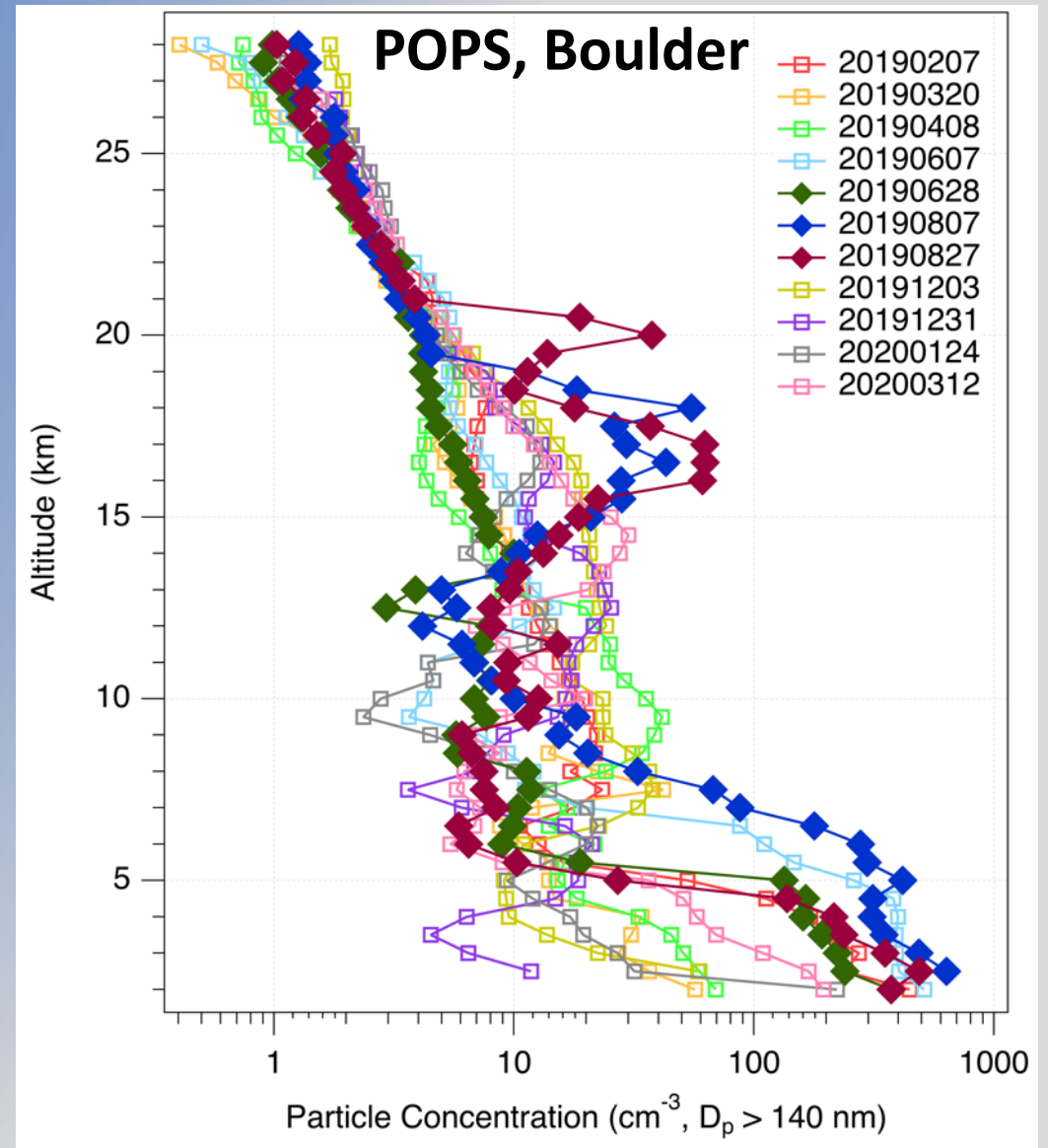
Validation of SAGE III/ISS Aerosol Measurements

Balloon launches with POPS began in February 2019 at Boulder and April 2019 at Lauder

Aerosol Match Criteria (same)
 $\pm 5^\circ$ Lat, $\pm 10^\circ$ Lon, ± 24 hrs

Coordinated Soundings:

	<u>ECC</u>	<u>& FPH</u>	<u>& POPS</u>
Boulder	53	30	15
Lauder	15	15	6



NOAA's Earth Radiation Budget Program

Balloon Baseline Stratospheric Aerosol Profiles (BBSAP)

- Collaborative work between GML and CSL
- Started June 2020



BBSAP Initial Goals

(-> May 2021)

- Double the frequency of FPH+ECC+POPS soundings at Boulder (to 2 per month)

Future Goals

- Add POPS to monthly FPH+ECC soundings at Lauder [currently 4/year]
- Same at Hilo [currently none]

Summary

SHADOZ has expanded the number of tropical ECC sounding sites since 1998

GML's SWV sounding program (FPH) added a new site (Hilo) in 2010

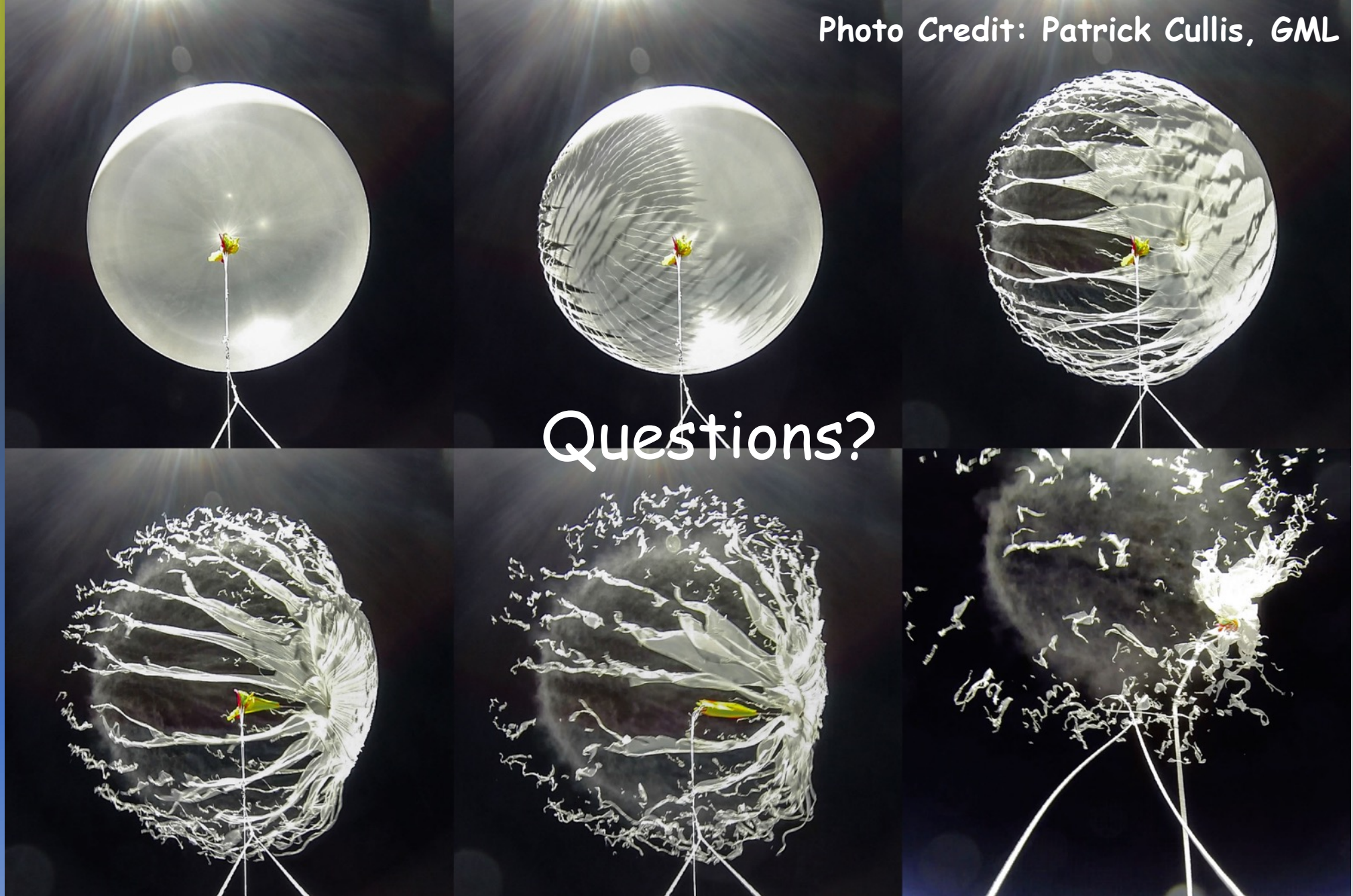
NDACC's balloon sonde component now has 30 ECC and 7 FPH sounding sites

GRUAN's radiosonde component is producing climate records of P, T, RH and horizontal winds at 21 sites (with 6 more contributing soon)

GRUAN is increasing the number of worldwide ECC and FPH sounding sites

More sondes are being launched for the validation of satellite-sensor measurements of O_3 , WV and aerosols than ever before

NOAA's ERB program will initially double the frequency of ECC, FPH and POPS soundings at Boulder and possibly expand to Lauder and other sites in the future



Questions?