Sites' activities for alternatives to R23

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With contributions from Christian Rolf, Dale Hurst and Holger Vömel

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Requirements for a GRUAN site

2.2. A fully equipped GRUAN site shall make at least double, and preferably triple, redundant measurements of all GRUAN priority 1 and 2 ECVs[3] and, specifically:

i) Four times daily radiosonde measurements of temperature and pressure to 30 km, and water vapour in the troposphere, also submitted in NRT to the WMO Information System (WIS);

ii) Weekly ozone profile measurements;

iii) Monthly water vapour profile measurements to ~30 km; and

iv) Hourly observations of integrated precipitable water vapour.

2.3. Minimum requirements for a GRUAN site include:

i) Weekly radiosonde measurements of temperature and pressure to 30 km and humidity in the troposphere; and

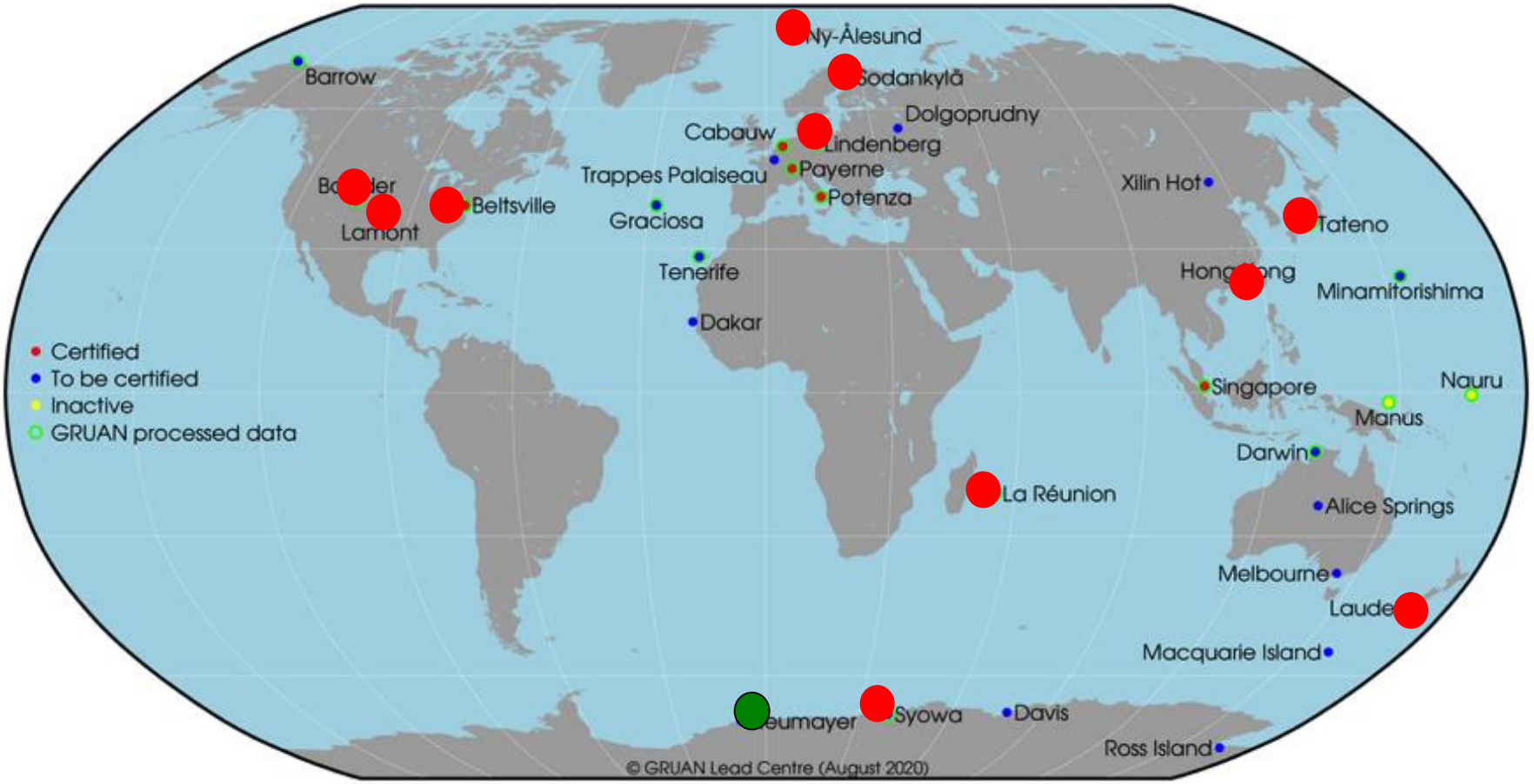
ii) Monthly water vapour profile measurements to ~30 km. Where several GRUAN sites are located sufficiently close to each other, where the sufficiency shall be guided by scientific studies, individual site flight schedules should be coordinated to share the burden of making these measurements.

iii) At least twice daily observations of integrated precipitable water vapour.

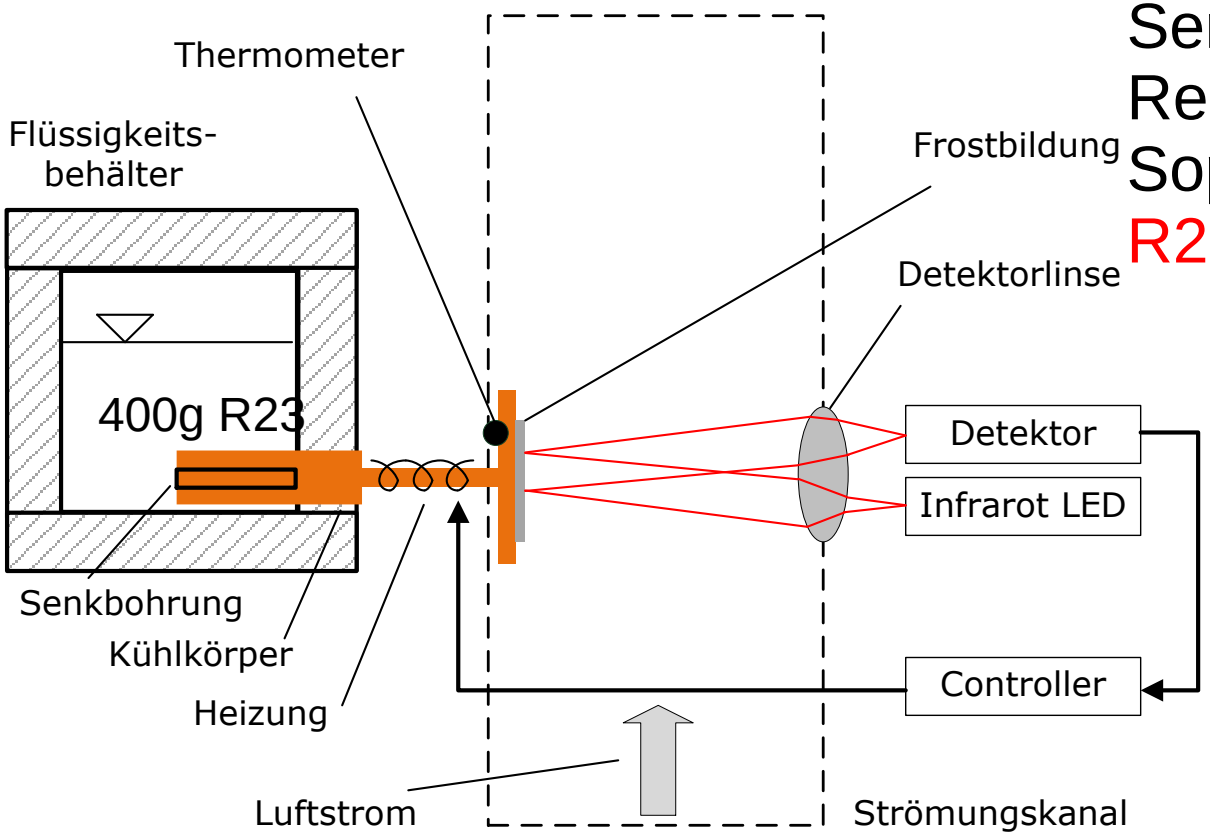
GRUAN Manual (GCOS-170)

Sites with stratospheric hygrometer soundings

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Chilled mirror instruments - principle



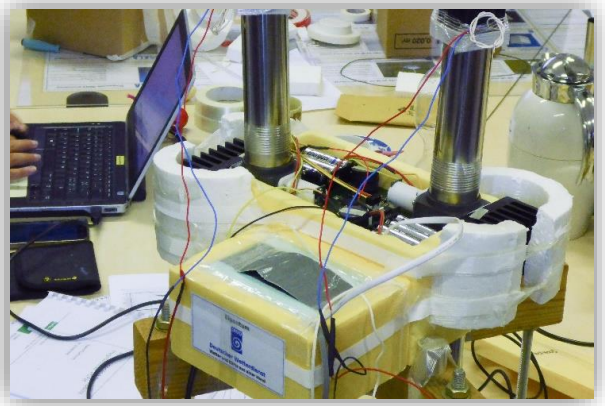
Frostpoint: H_2O partial pressure
Sensitivity 1-10^5 ppmv
Response time ~20s (strat.)
Sophisticated controller
R23 cryogen (CF3)

R23 regulations

- Ideal thermodynamic properties for CFH/FPH application
- GWP ≈ 14,000
- EU regulation 517/2014, reduction of f-gases
  - Ban on R23 starting 2020
- Reduced availability
  - sales ban EU & Japan
  - Import restrictions
- Transition to another cooling method necessary

Solutions? [ICM-12]

- Alternative cooling method
  - LC – TU Dresden cooperation: cold Ethanol
  - FZJ: Dry ice/ethanol
    - LC, BOU
  - Liquid N_2?

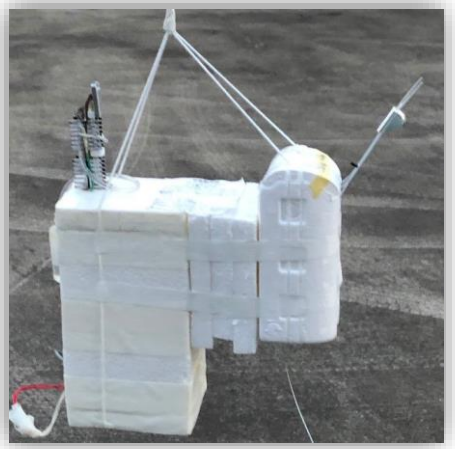


PCFH

- Alternative instruments
  - Skydew, PCFH, FLASH-B (succeeding presentations)

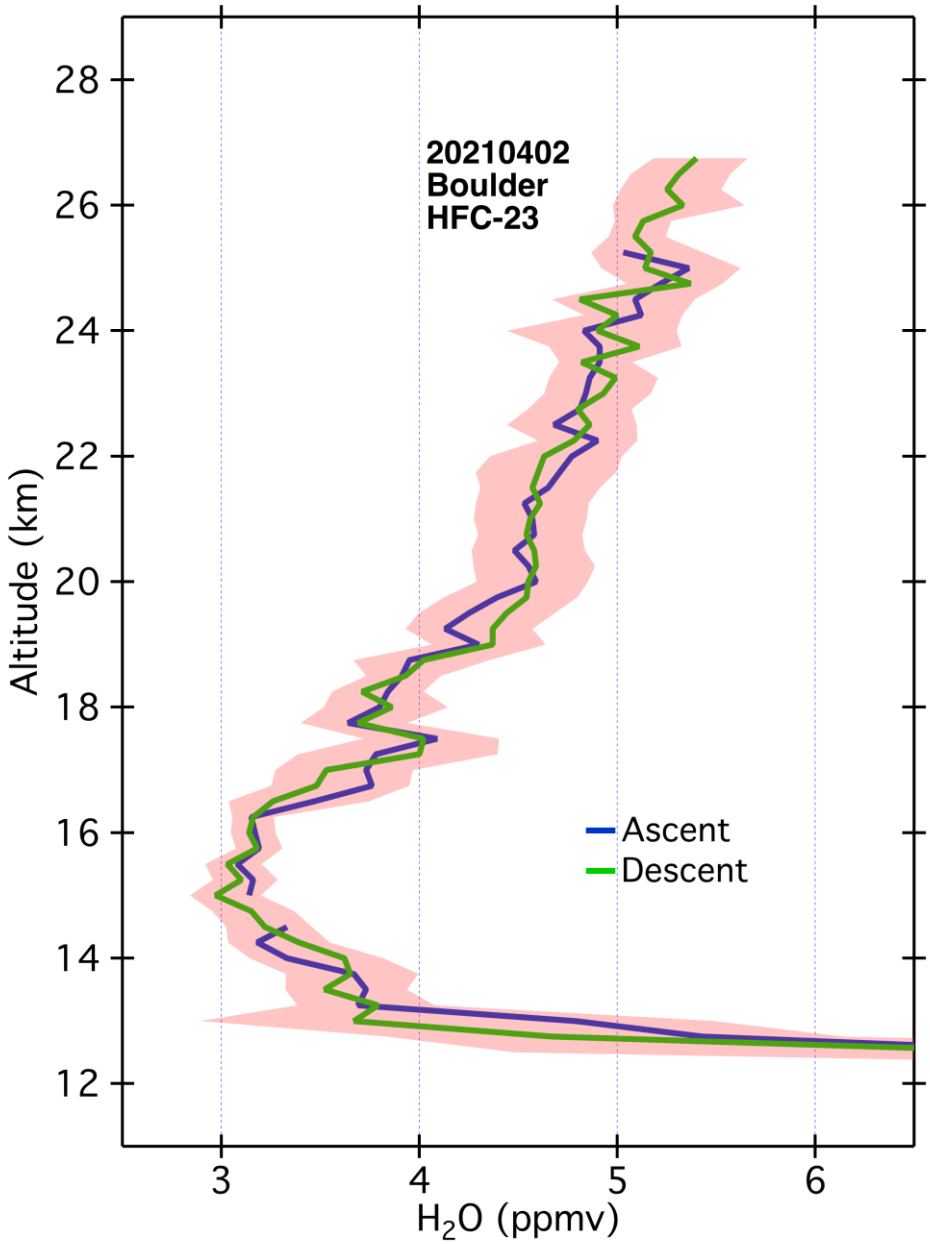
FPH/CFH

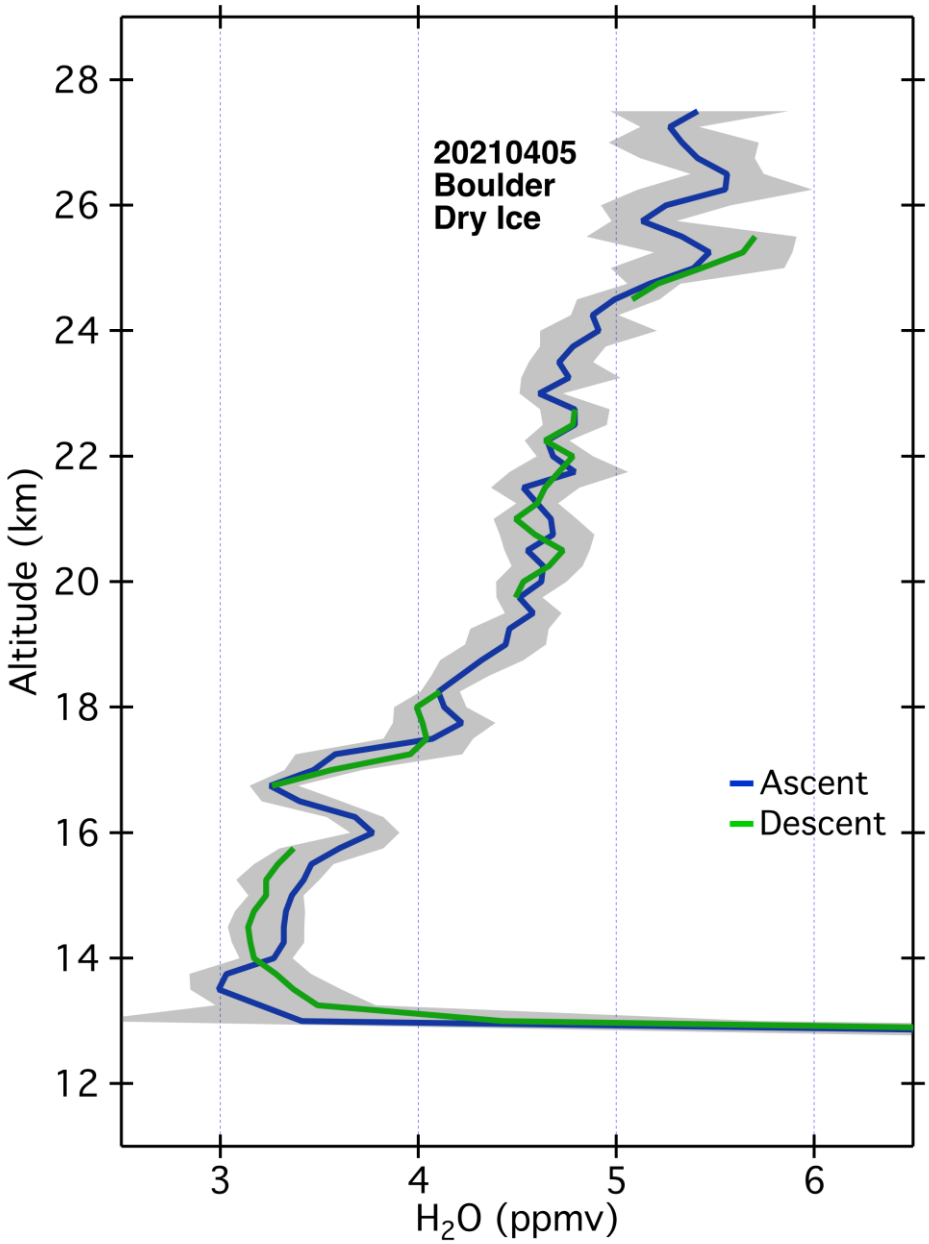
FLASH-B



Skydew

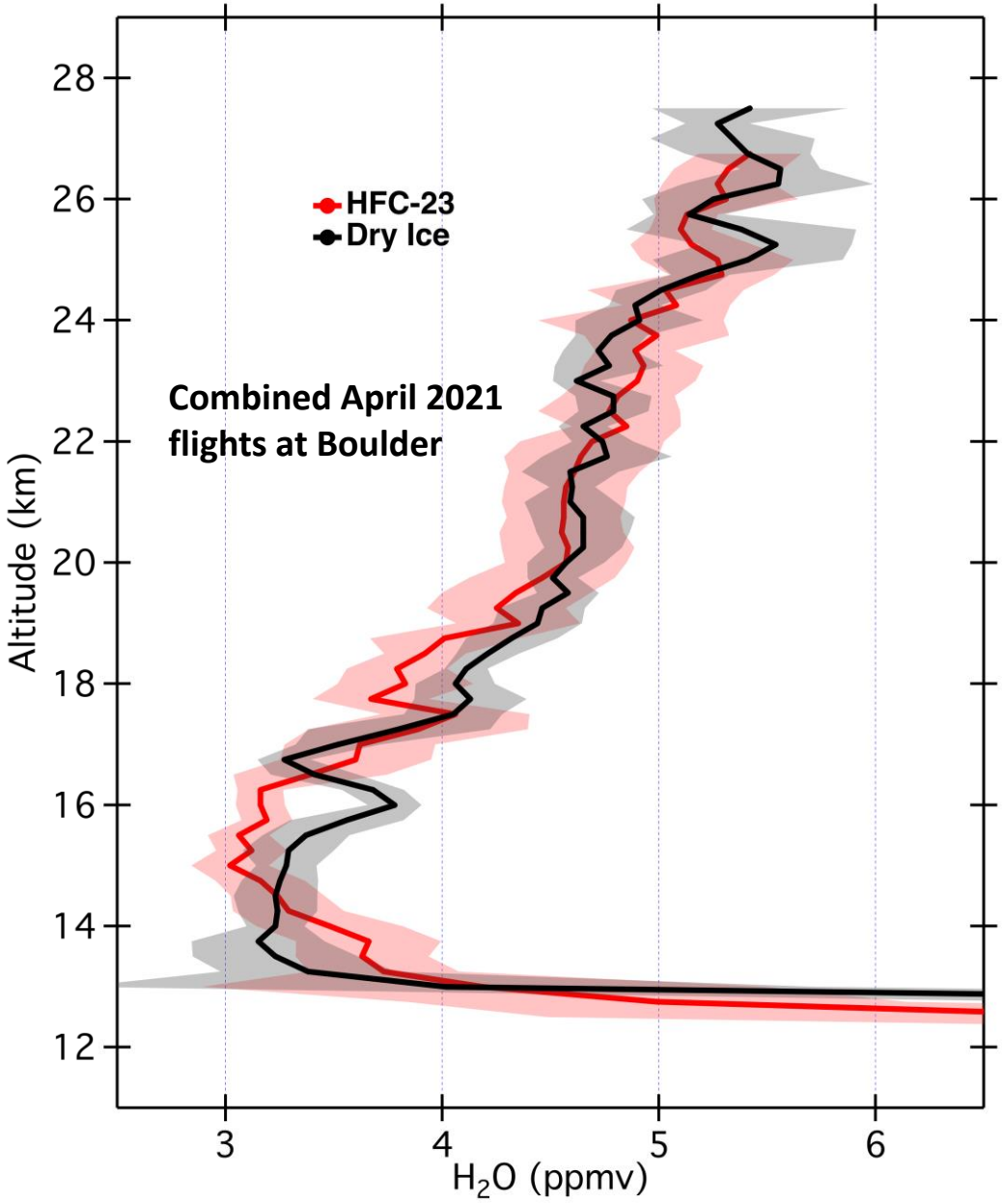
NOAA FPH Flights using R23 and Dry Ice/Ethanol at Boulder





POC: Dale Hurst
Dale.Hurst@noaa.gov

NOAA FPH Flights using R23 and Dry Ice/Ethanol at Boulder



The two profiles agree within their 95% confidence intervals.

Minor exception at 16 km

The minimum frost point temperature measured was –90.2 ° C.

Need similar flights in the tropical stratosphere

Plans for dual flights at Hilo, Hawaii have been postponed due to dry ice shortage on the Big Island.

Just another impact of the continuing pandemic!

POC: Dale Hurst
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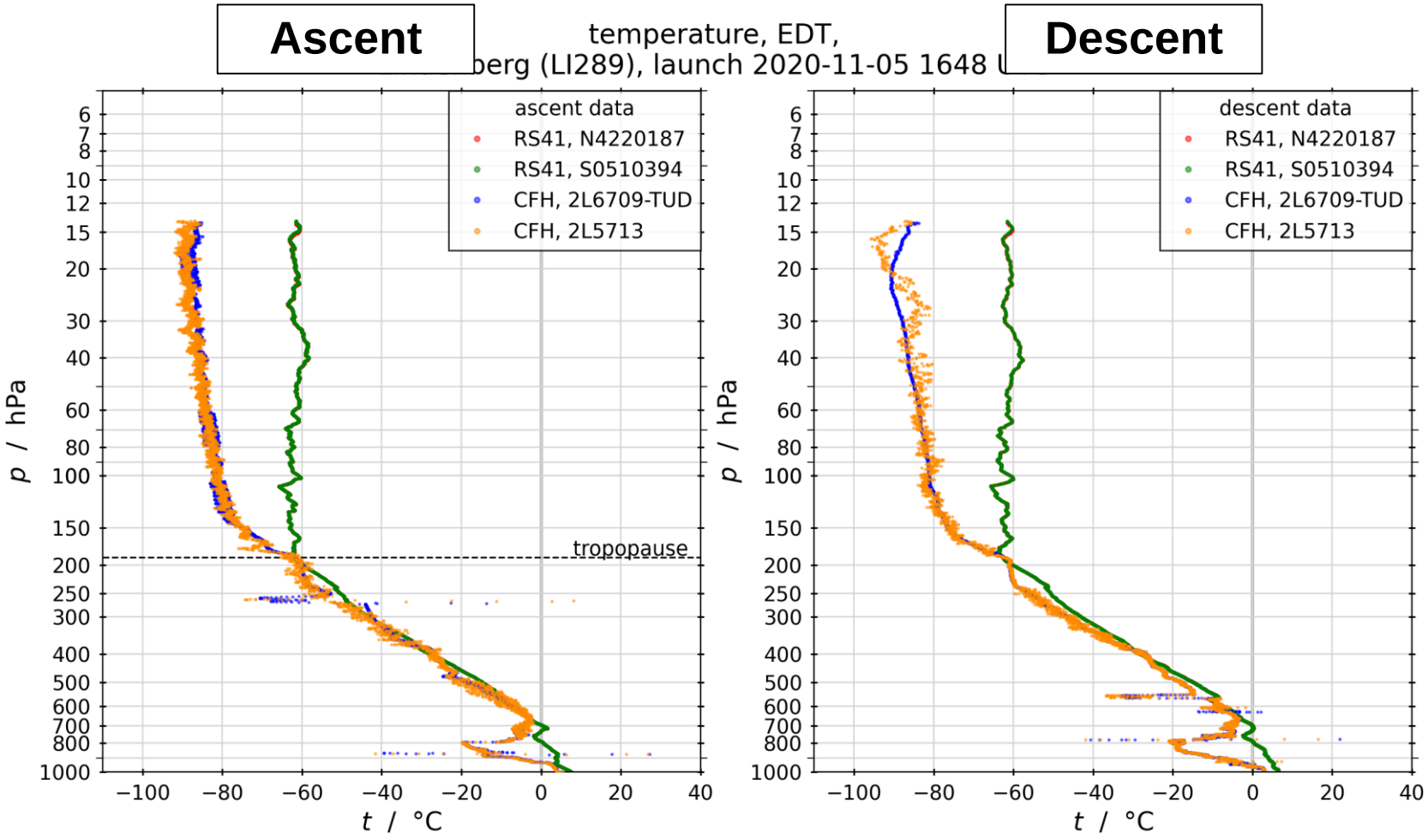
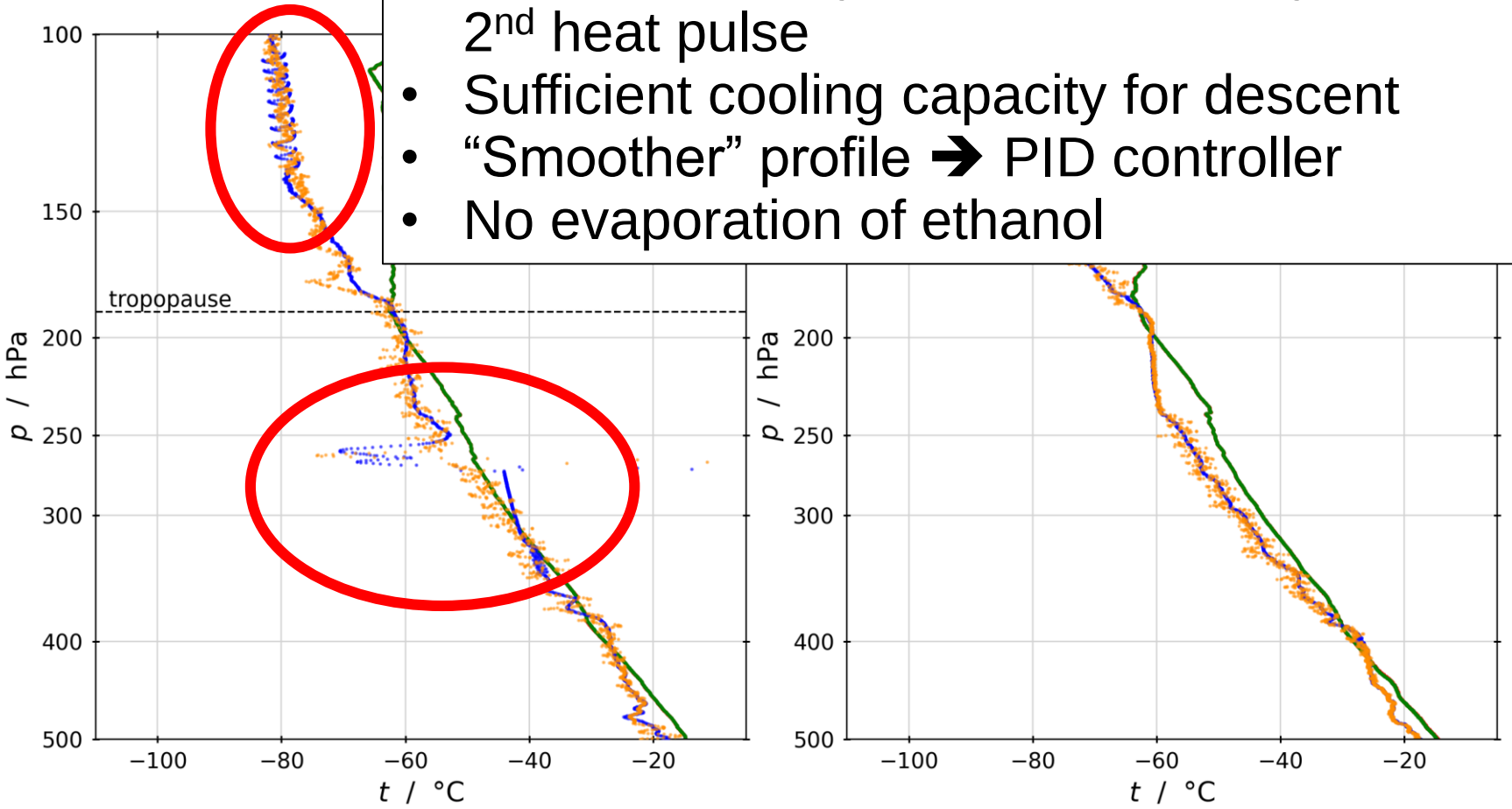
Ethanol/dry ice - results



Lindenberg – 2020-11-5

Ethanol/dry-ice - results

- Slower recovery of condensate layer after 2nd heat pulse
- Sufficient cooling capacity for descent
- “Smoother” profile ➔ PID controller
- No evaporation of ethanol



CFH activities – H. Vömel

- Test flights FZ-Jülich, La Reunion, and Lindenberg (2020)
- Modifications to enhance heat conductivity
- Further tests outstanding

LN_2 AS CFH COOLING AGENT ALTERNATIVE

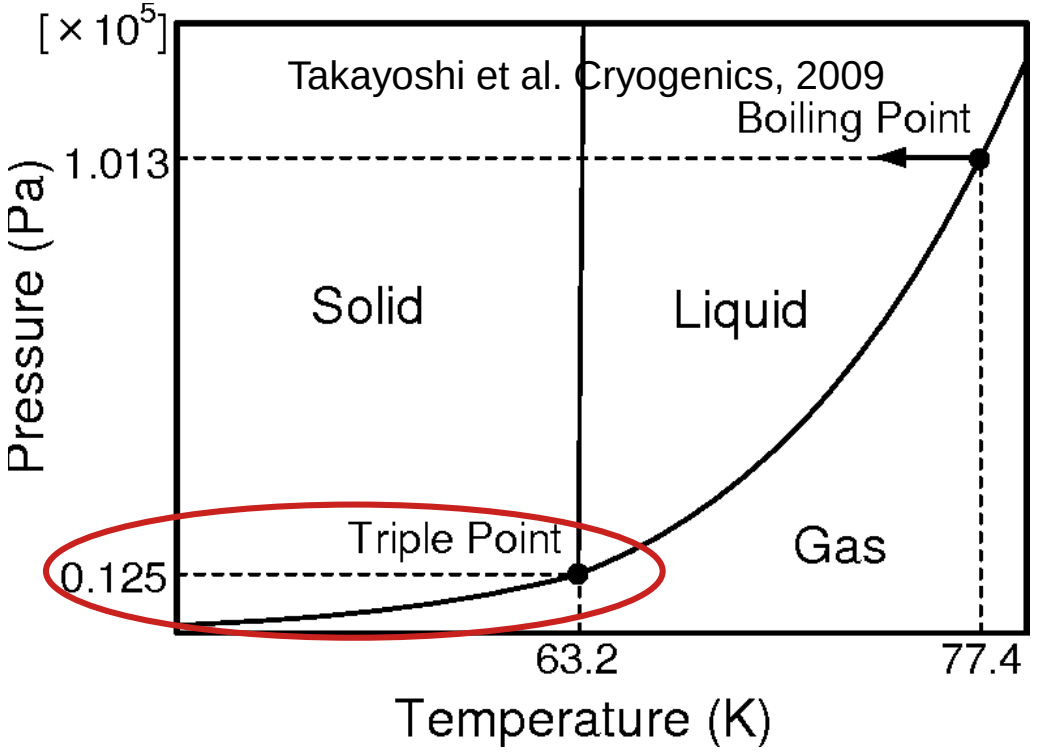
08.11.2021 I CHRISTIAN ROLF

Mitglied der Helmholtz-Gemeinschaft

JÜLICH
Forschungszentrum

LIQUID NITROGEN (LN_2)

Properties

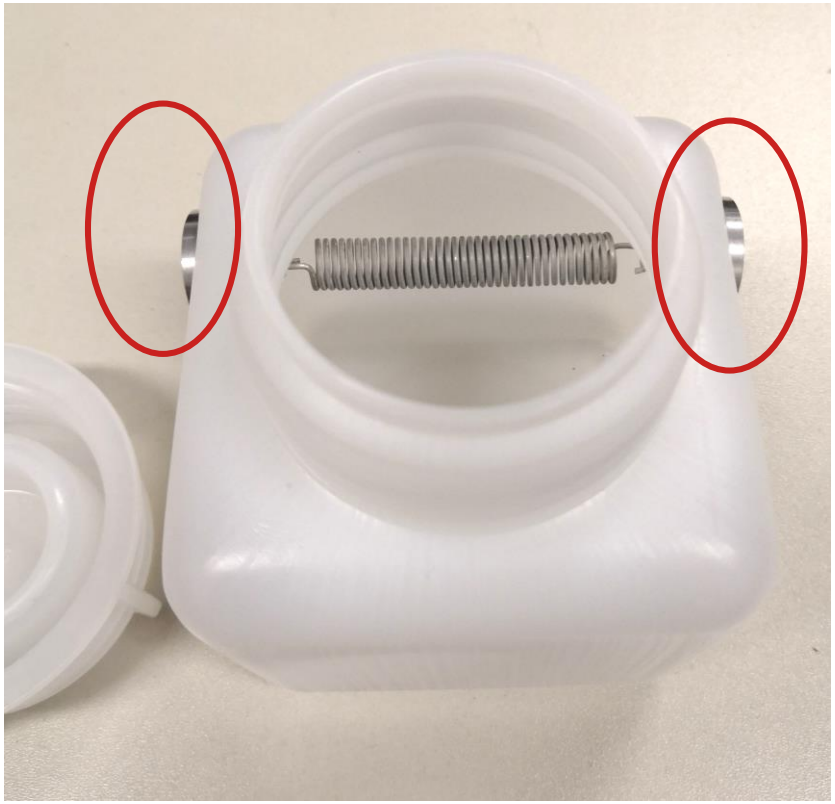


- Liquid nitrogen gets solid at pressures < 125hPa
- **Need for pressure vessel to keep pressure always > 125hPa during balloon sounding**
- Small value of evaporation enthalpy
- **Amount of LN_2 must be larger, compared to R23 (~0,7 L)**

	R23	Liquid Nitrogen
Boiling Temperature	-82,2 °C	-196 °C
ΔH_v enthalpy of evaporation	17,03 kJ/mol	5,59 kJ/mol

LN_2 AS CFH COOLING AGENT

Pressure vessel



- Two valves with rubber ring and a spring connected to both lids
- Holds pressure to > 125 hPa tested in a climate chamber down to ambient pressures of 10 hPa → No freezing of LN_2
- Plans:
  - Connecting cold finger of CFH to LN_2 (pressure-tight) with Epoxy
  - Overpressure valve for safety reasons

LN_2 AS CFH COOLING AGENT

Specifications

- Frost safe over pressure valve
- Cooling power: 10-15 Watt
- Operation endurance: 3 hours
- Weight of the system: < 2 kg
- Integration into the CFH, with thermal connection to the cold finger
- Ready for testing 1. quarter of 2022