MIDDLE ATMOSPHERE LIDAR OBSERVATIONS IN SOUTHERN ARGENTINA AND THE SOUTH POLE

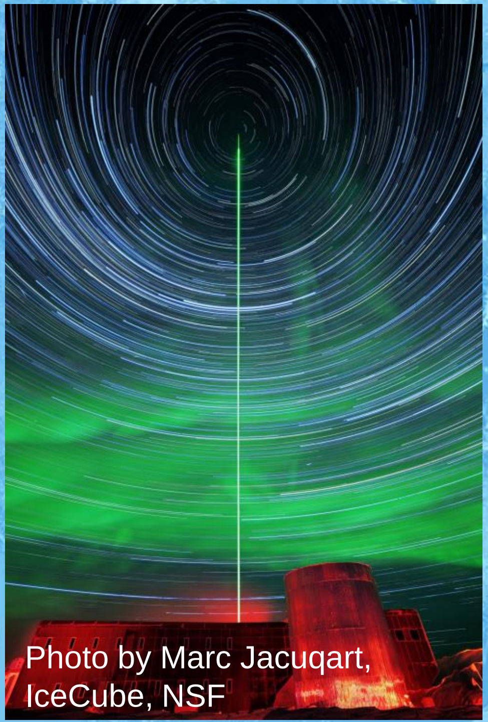


Photo by Marc Jacuqart, IceCube, NSF

Natalie Kaifler and Bernd Kaifler

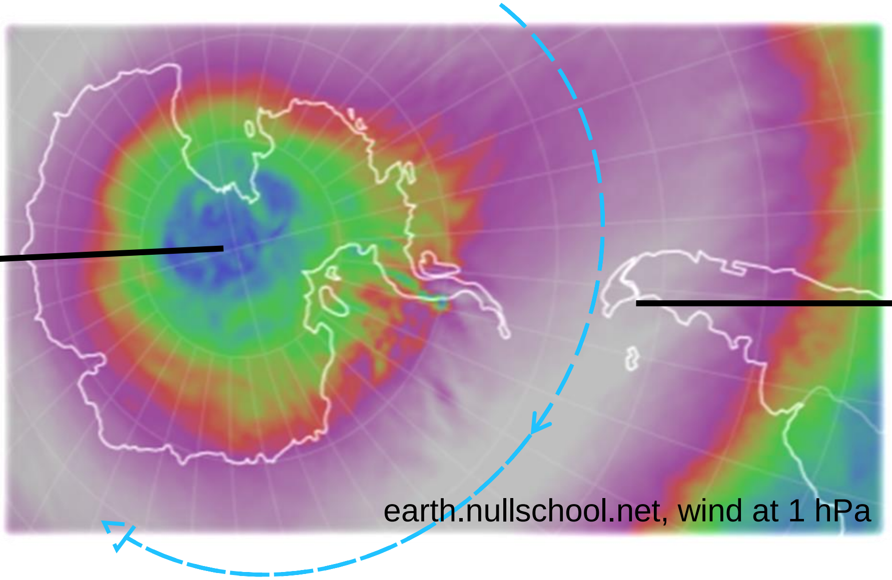
Institute of Atmospheric Physics, German Aerospace Center

ANGWIN workshop, 6-10 Oct 2025, Utah State University, Logan, Utah

Lidar instruments

- Twin Rayleigh lidar instruments, 532 nm, in darkness
- measure atmospheric temperature @ 30-90 km altitude

Kaifler and Kaifler, AMT, 2021
10.5194/amt-14-1715-2021

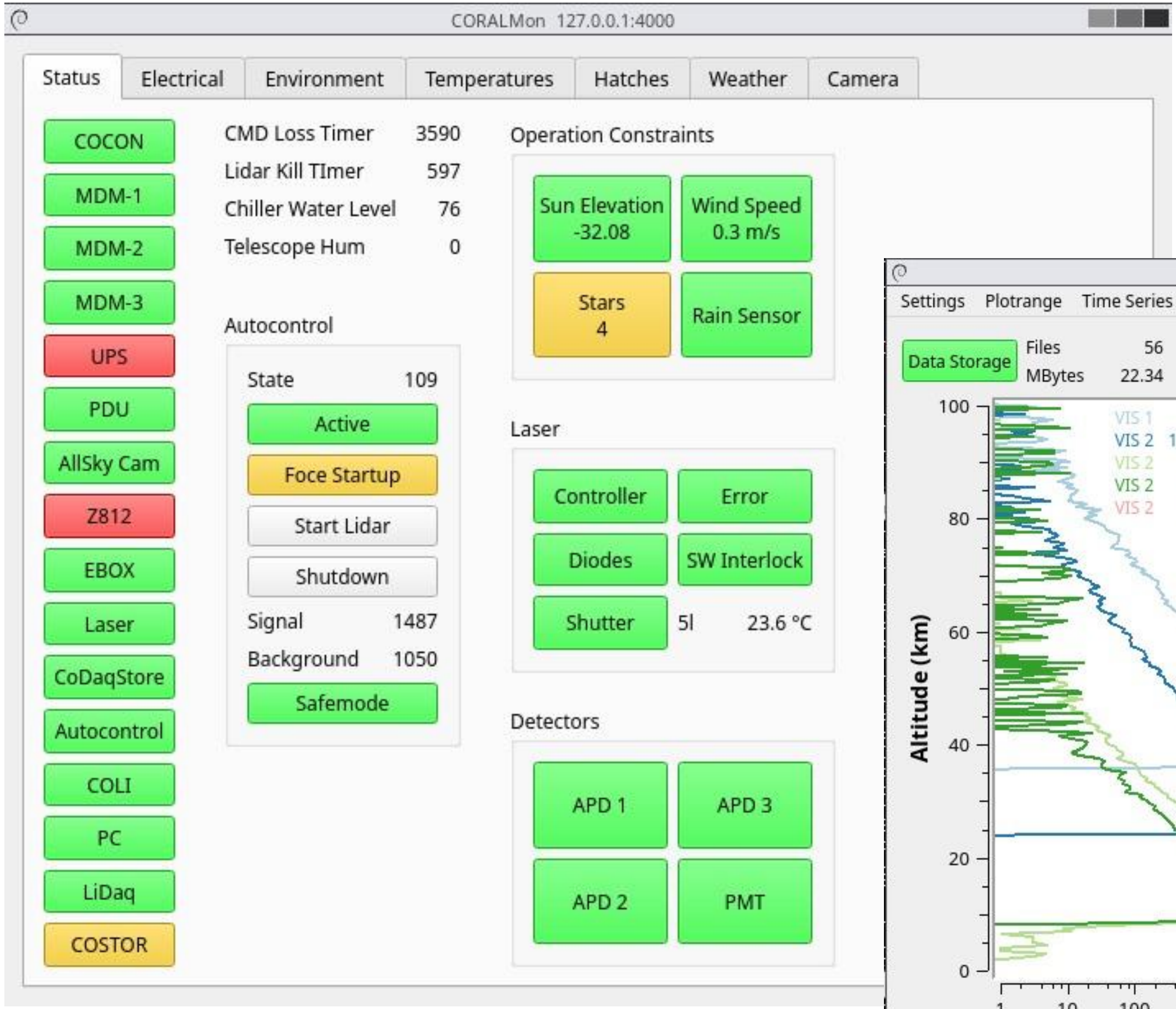


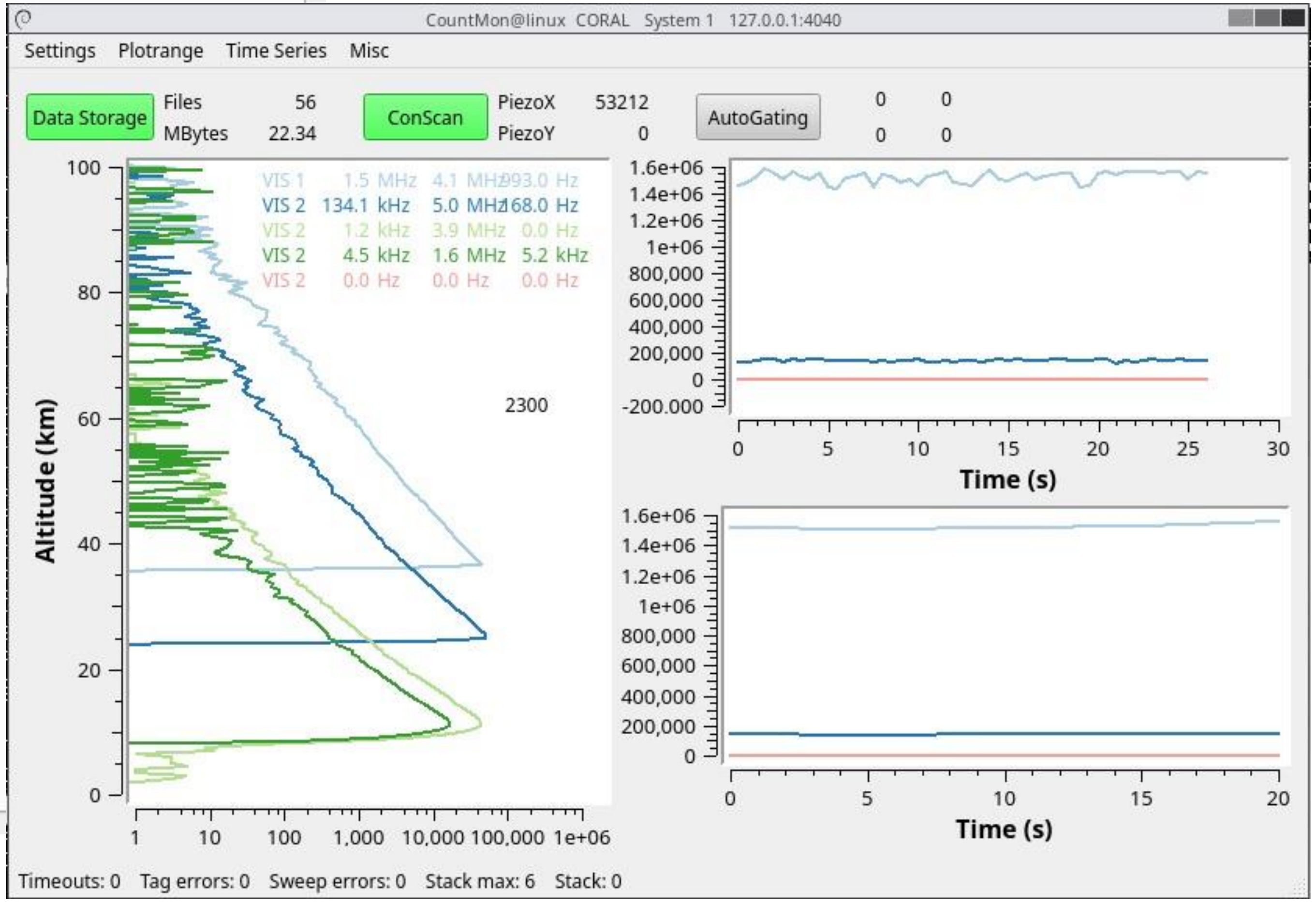
- TELMA at South Pole (polar vortex center)
- three winters: 2023, 2024, 2025

- CORAL at Rio Grande (polar vortex edge)
- since November 2017

Automatic operation & remote monitoring

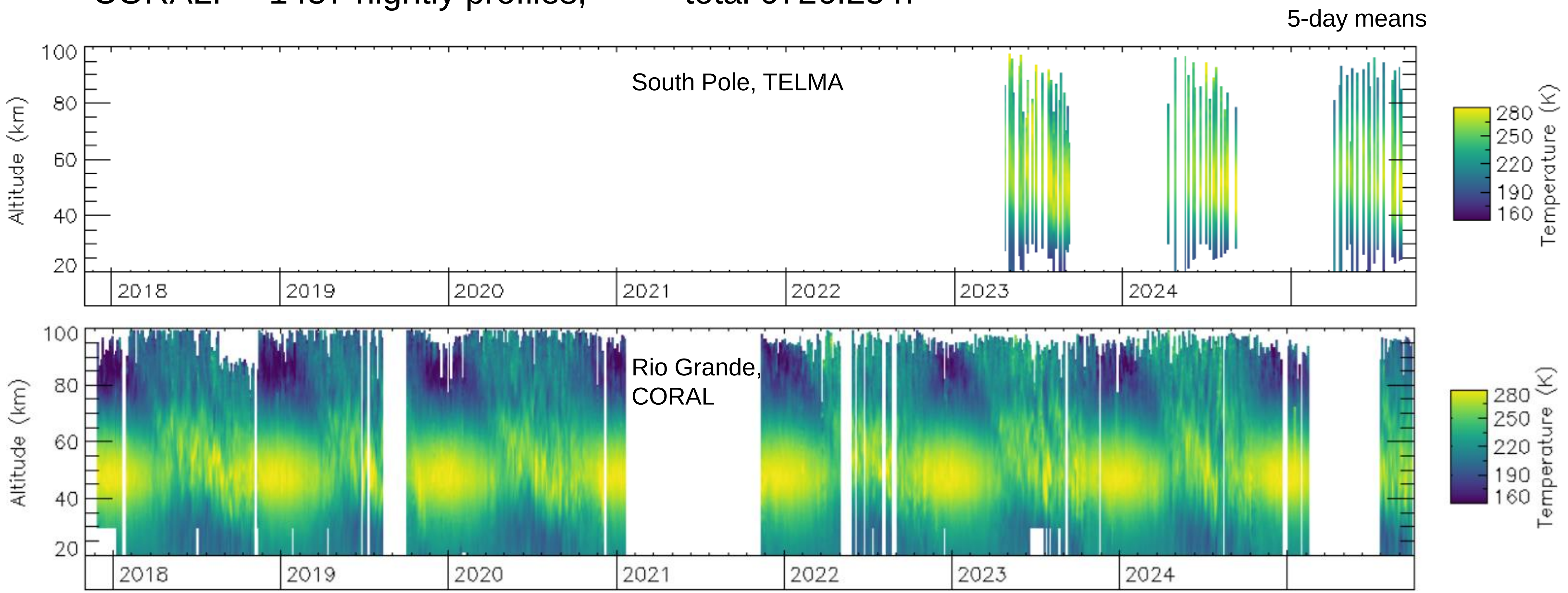
- C client-server architecture
- real-time operation
- socket to Qt GUIs and web interface





Atmospheric temperature

- TELMA: 63 nightly profiles, total 2616.50 h
- CORAL: 1457 nightly profiles, total 6726.25 h

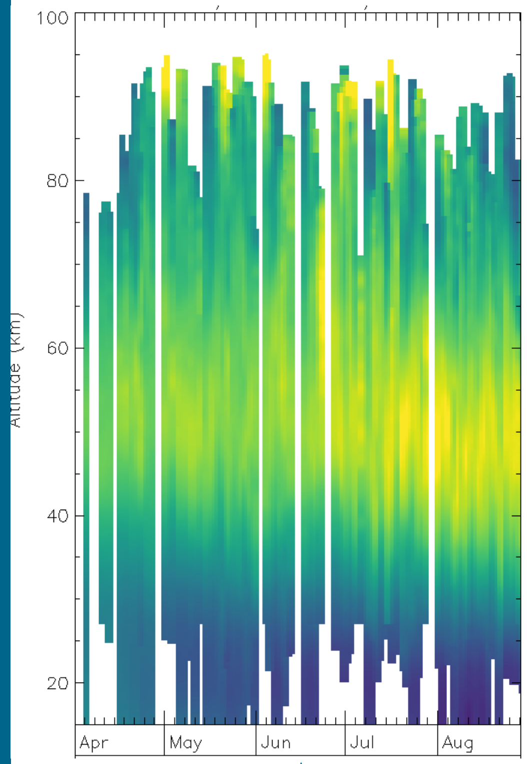


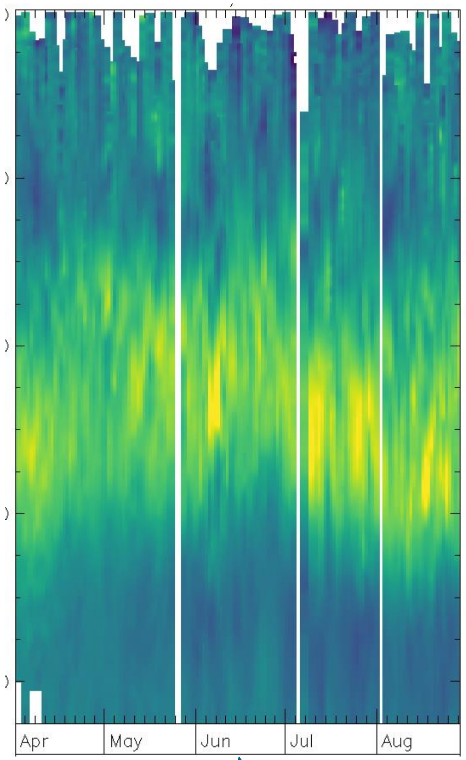
Atmospheric dynamics and effects on temperature

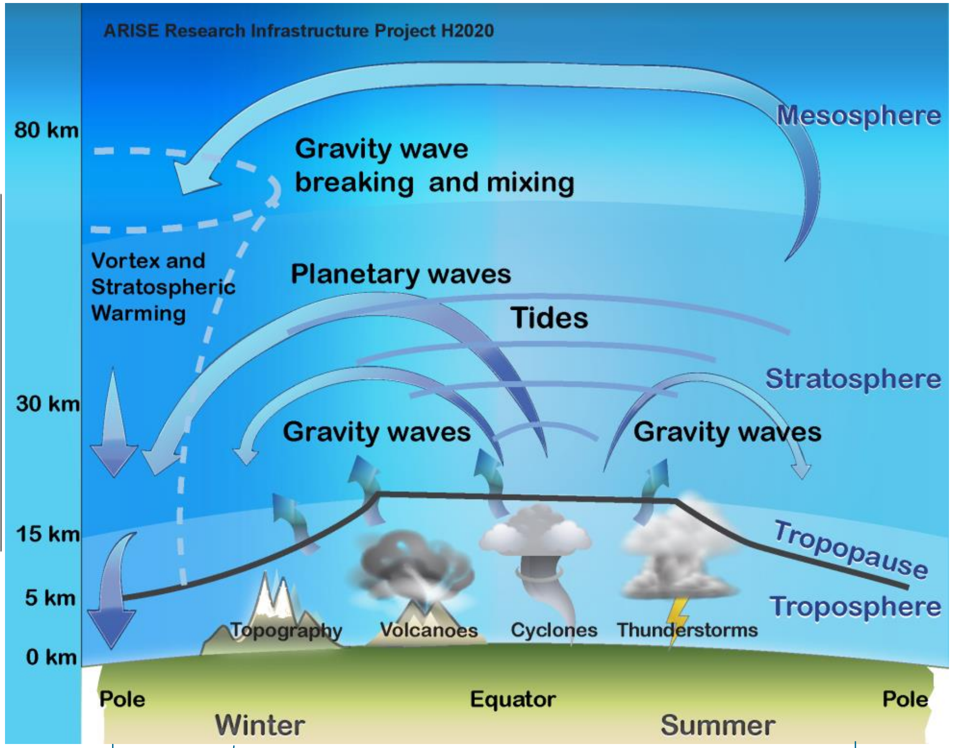
South Pole, winter
3-day mean
2023-2025

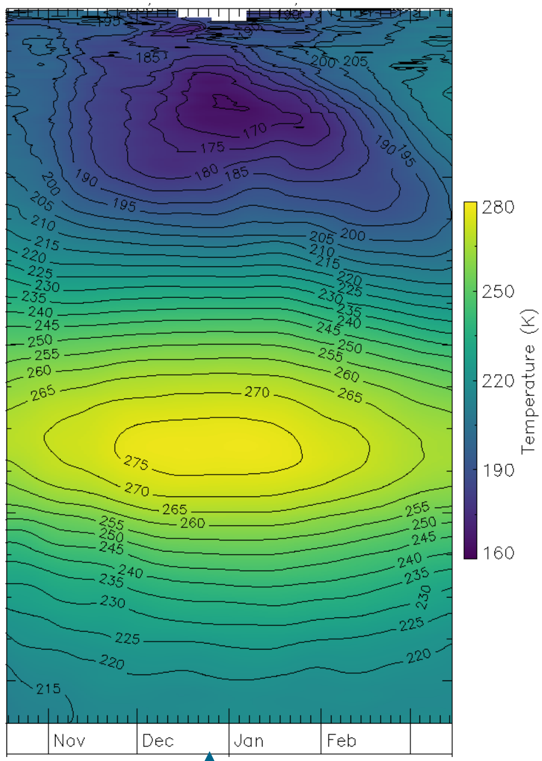
Rio Grande winter,
3-day mean
2020

Rio Grande, summer,
30-day mean
2017-2025







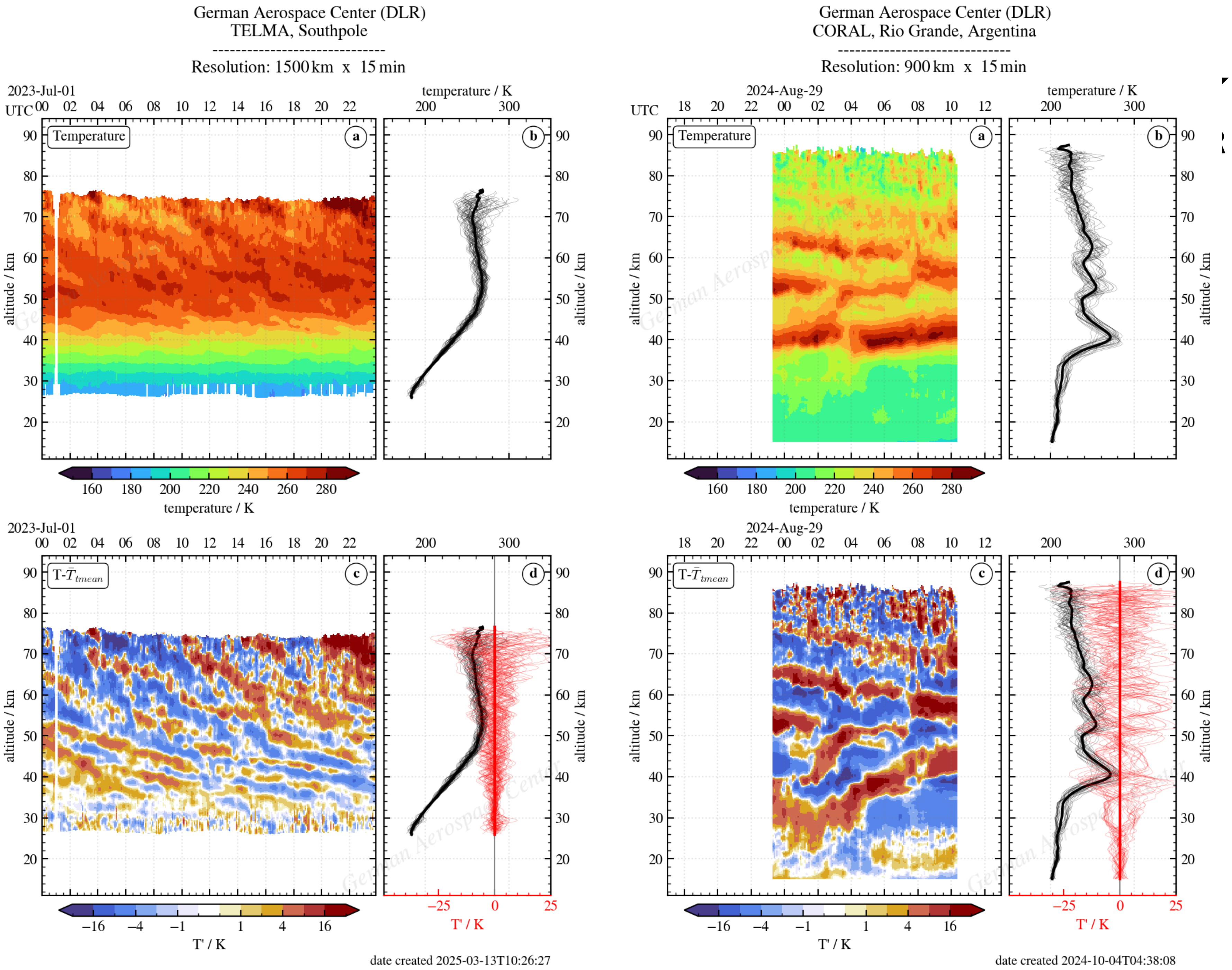


High variability in winter stratosphere
due to gravity waves

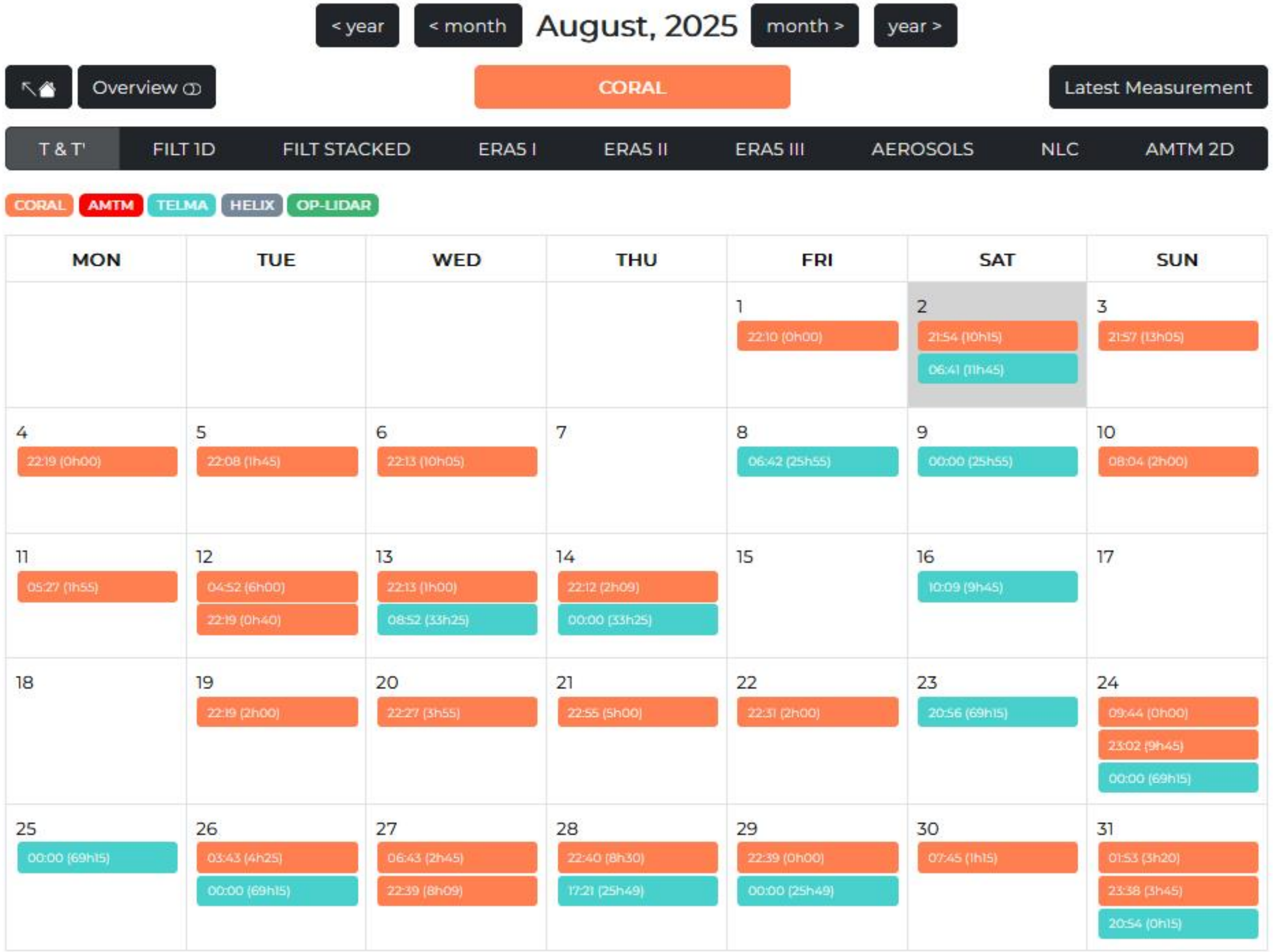
Cold summer mesopause
→ noctilucent clouds

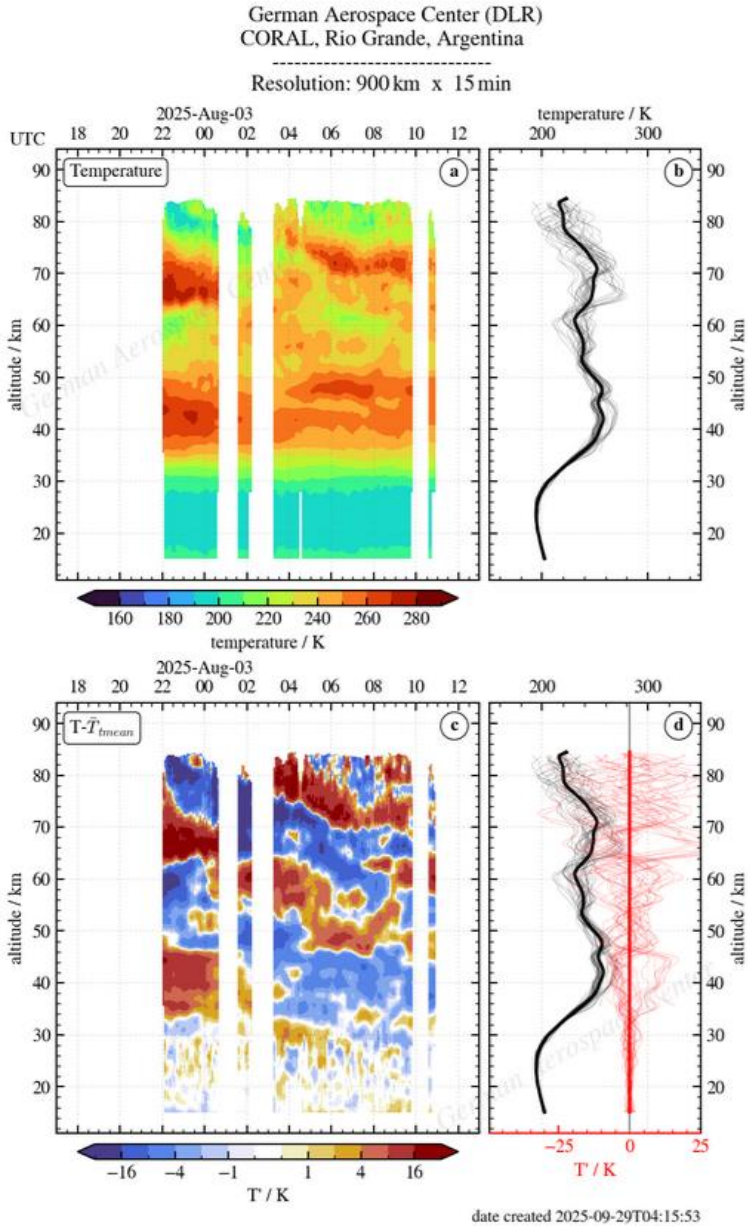
Gravity waves

- Two different but typical winter measurements:
- Weaker, shorter-scale inertia-GW at South Pole (left)
- Mountain waves at Rio Grande (right)



Online measurement calendar

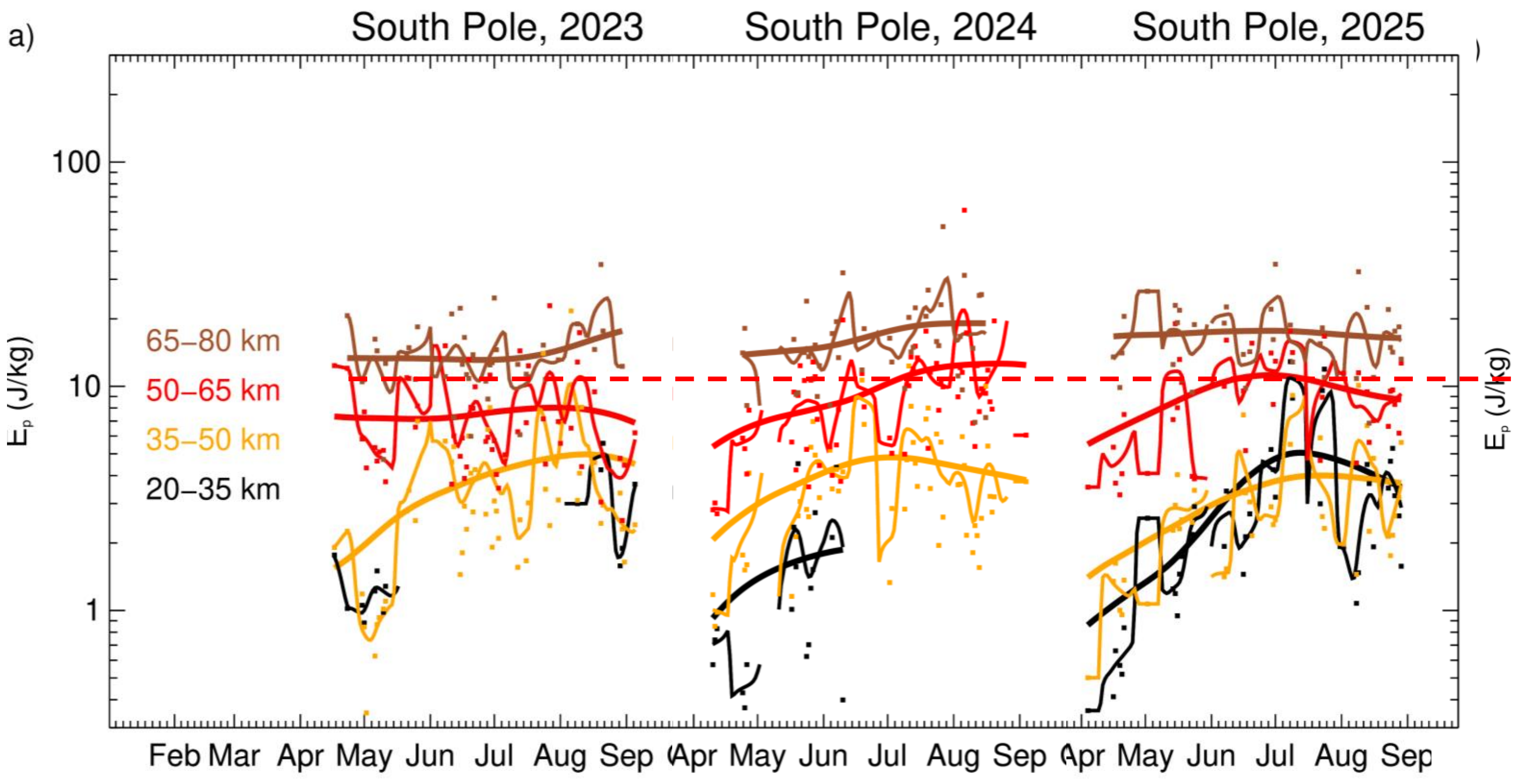


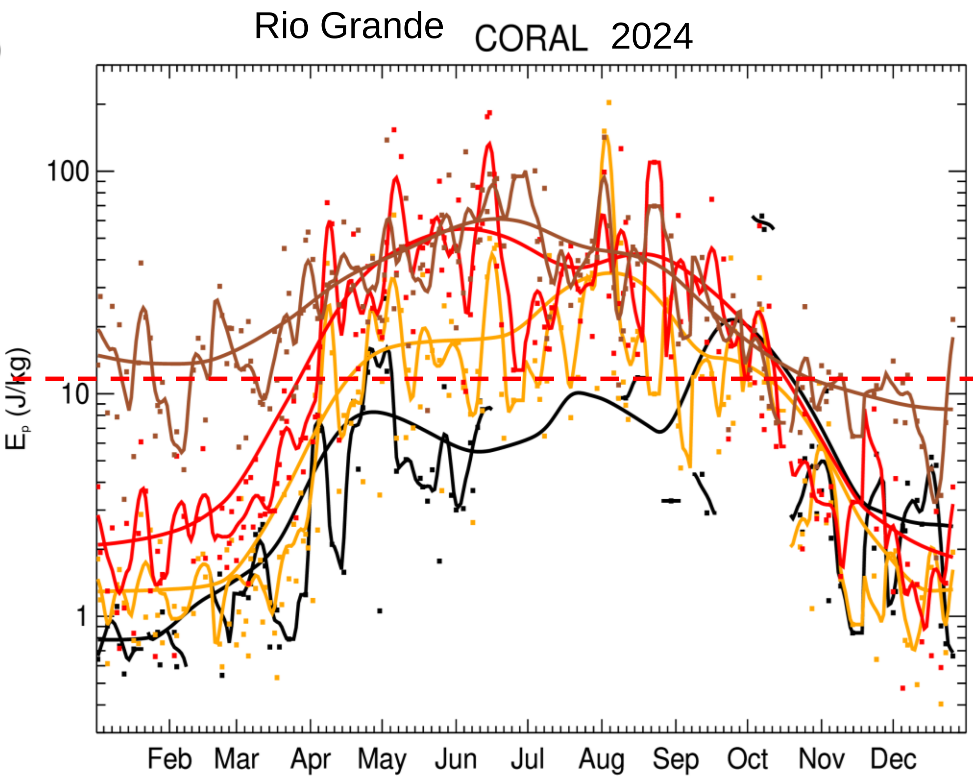


https://extern05.pa.op.dlr.de/ma-lidar-calendar/php_calendar/calendar.php

Gravity wave potential energy density

- increase to the upper mesosphere at South Pole; saturation at Rio Grande
- Ep at South Pole about a factor of 5 below Ep at Rio Grande





see also Reichert et al., JGR, 2022

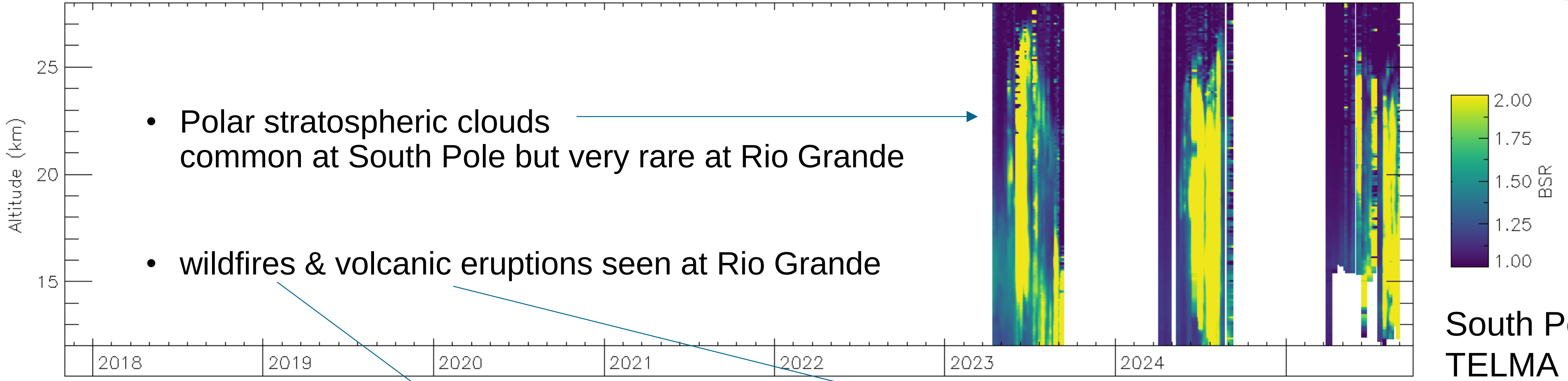
Stratospheric aerosol

- green/yellow = aerosol
- deep yellow = polar stratospheric clouds

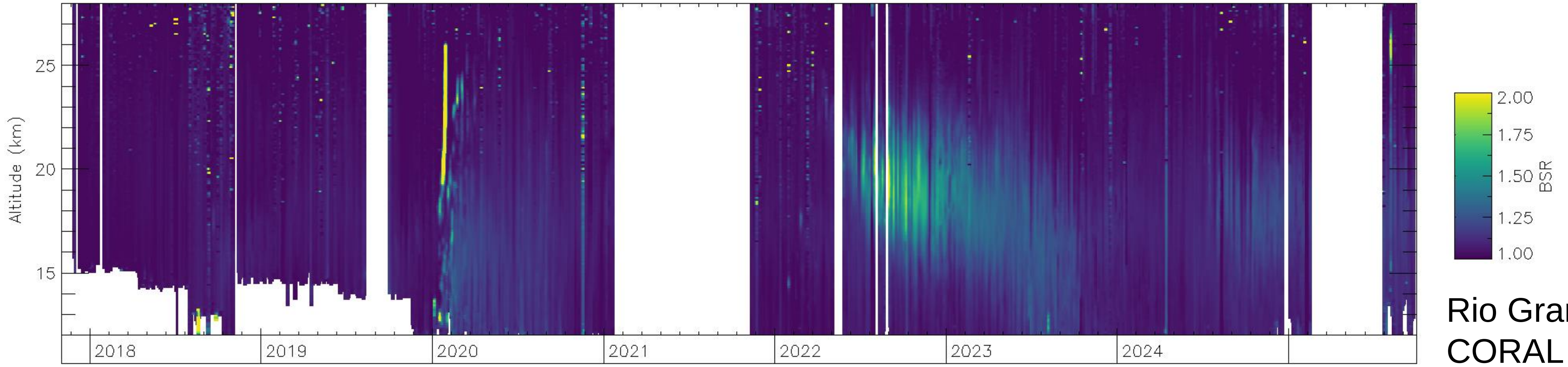
5-day means

- Polar stratospheric clouds
  common at South Pole but very rare at Rio Grande

- wildfires & volcanic eruptions seen at Rio Grande



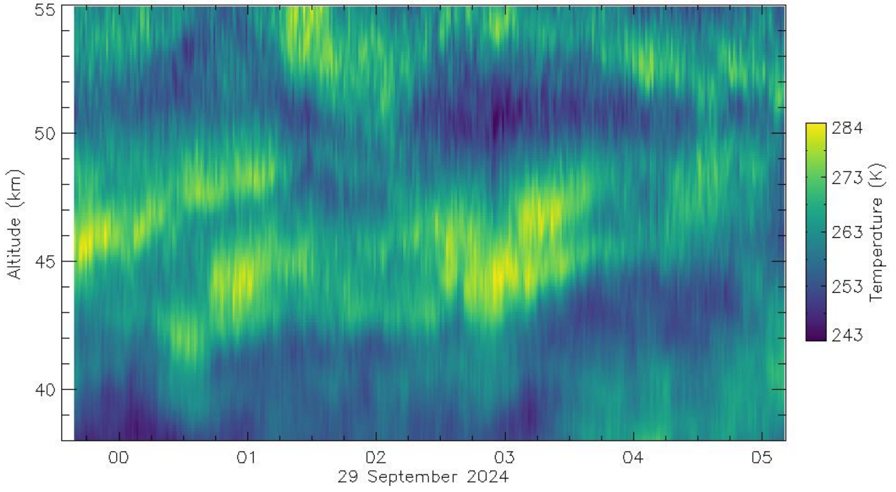
South Pole
TELMA

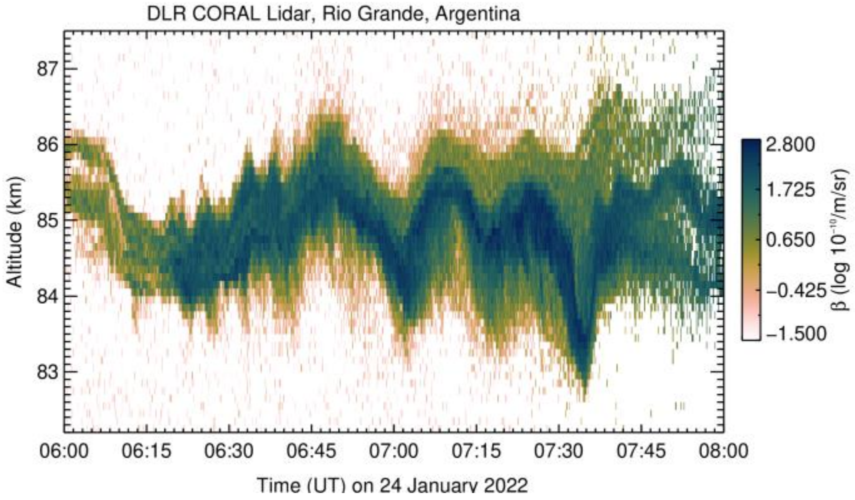


Rio Grande
CORAL

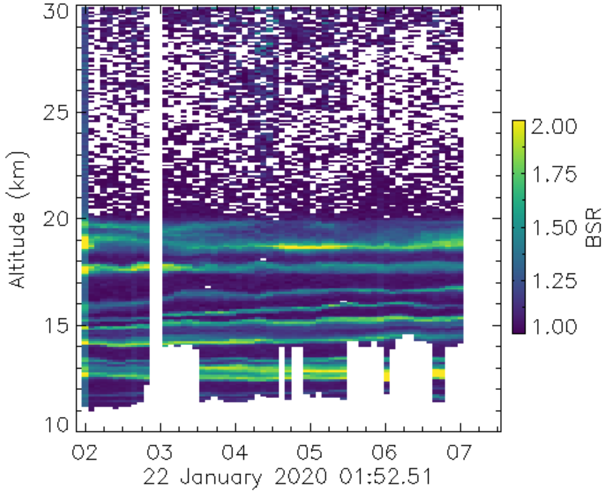
Ohneiser et al., ACP, 2022

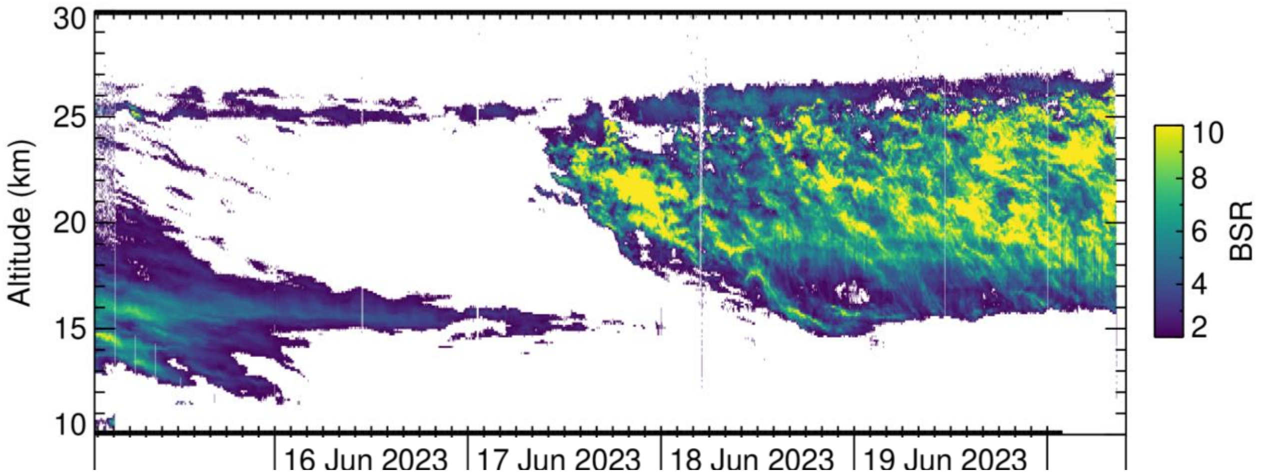
High-resolution observations





N. Kaifler et al., ACP, 2025 10.5194/acp-24-14029-2024



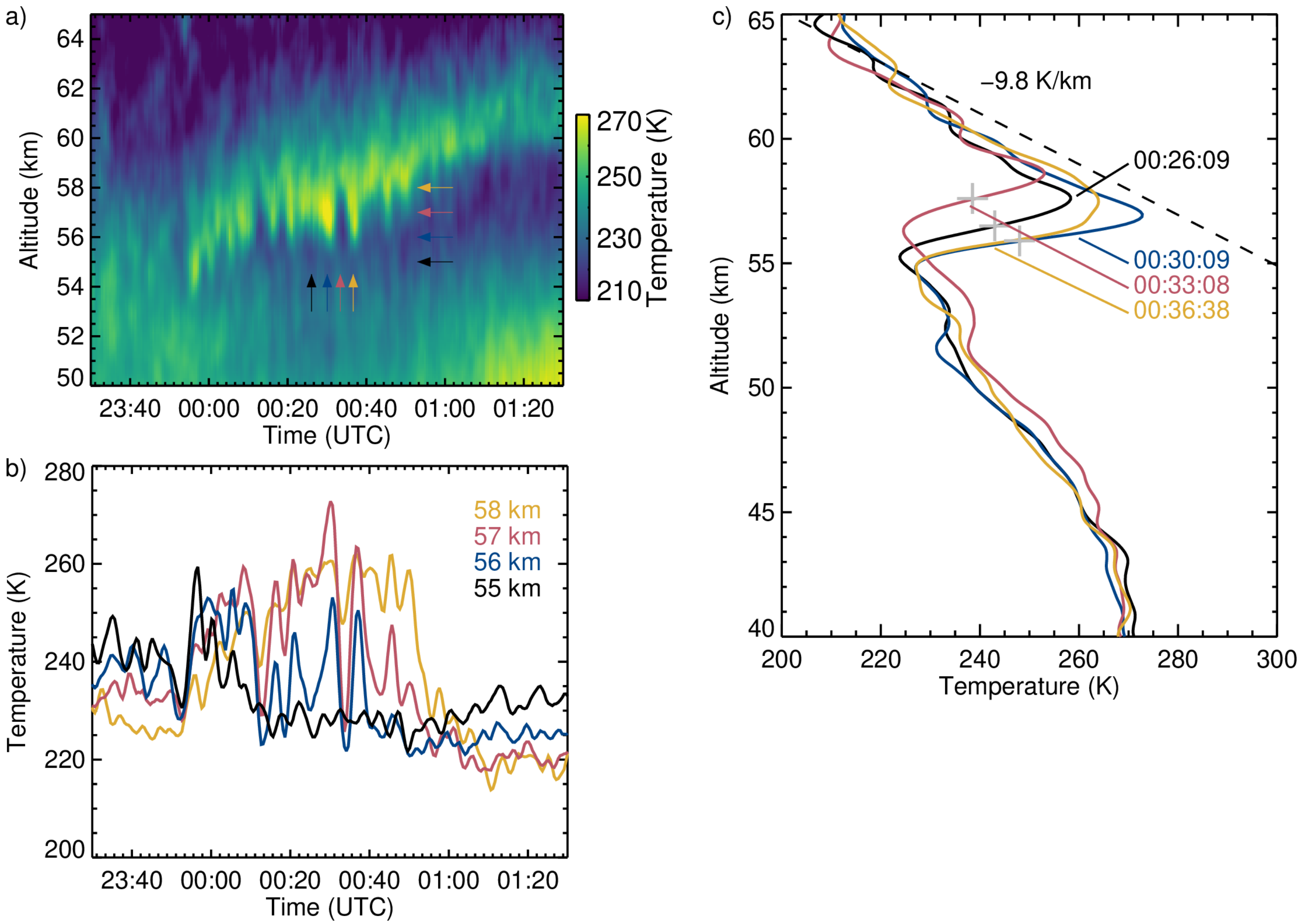


- scales of few minutes and hundred meters in (clockwise from top left) stratospheric temperature, noctilucent clouds, polar stratospheric clouds and stratospheric aerosol layers

Signatures of Mountain Wave Breaking in the Lower Mesosphere

B. Kaifler et al., in preparation

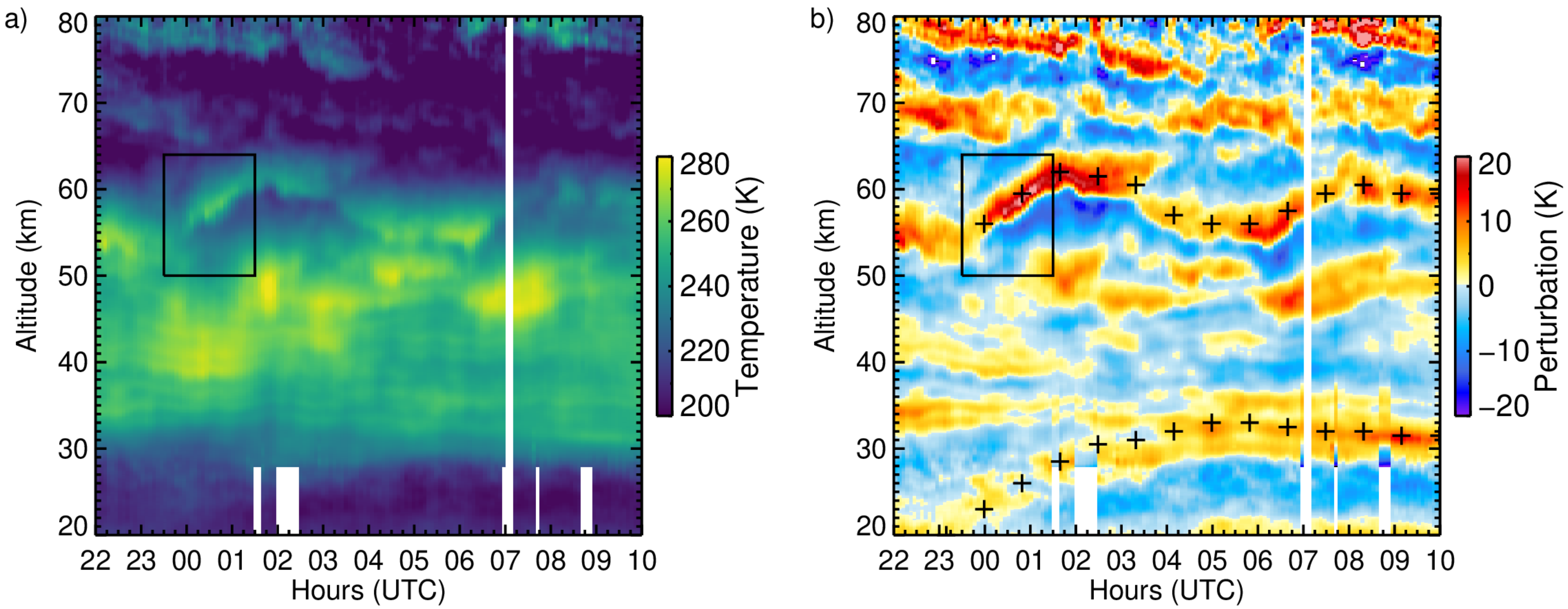
- Rapid temperature oscillations of 2-4 min period
- Observed coolings and warmings of up to 37 K



Signatures of Mountain Wave Breaking in the Lower Mesosphere

B. Kaifler et al., in preparation

- Temperature analysis at 1 min resolution possible in the lower stratosphere
- We realized there occur high-res oscillations on the bottomside of mountain wave warm phases



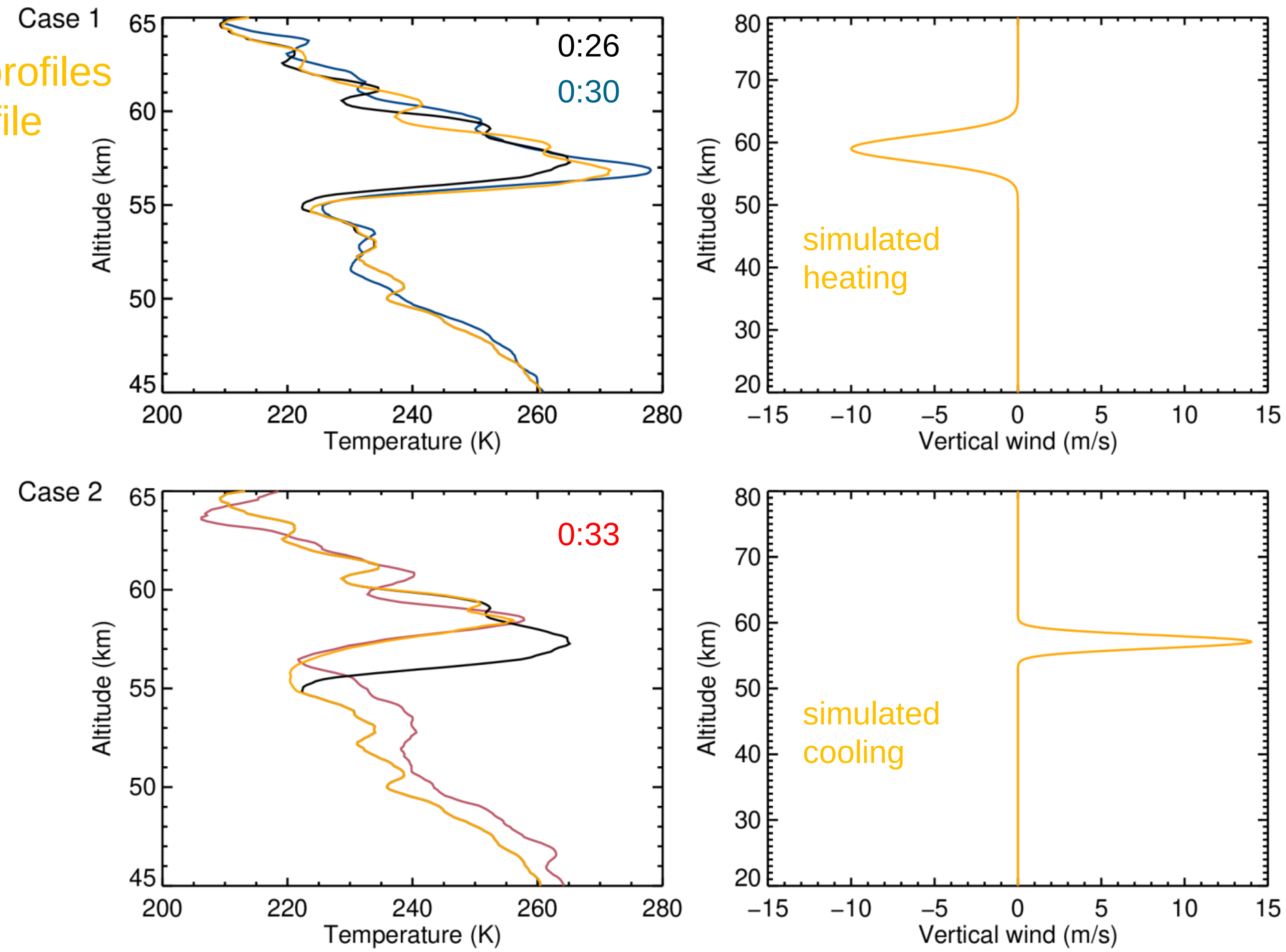
Signatures of Mountain Wave Breaking in the Lower Mesosphere

B. Kaifler et al., in preparation

orange = simulated profiles
100 s after black profile

- Simulations of adiabatic vertical motions show comparable temperature changes

→ Evidence for temperature oscillations caused by mountain wave breaking



Thank you!