Karlsruhe Institute of Technology

KIT-Campus Alpin
IMK-IFU: Atmospheric Environmental Research

Powerful Raman-Lidar for water vapor in the free troposphere and lower stratosphere as well as temperature in the upper stratosphere and mesosphere

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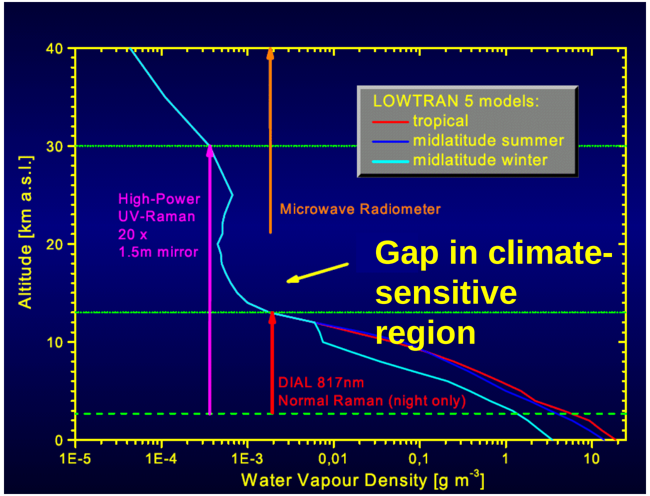
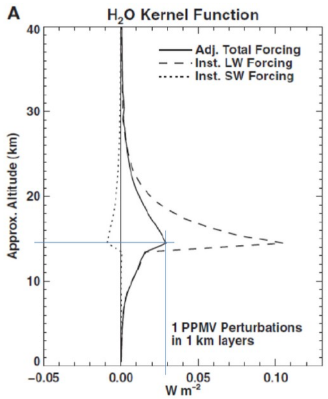
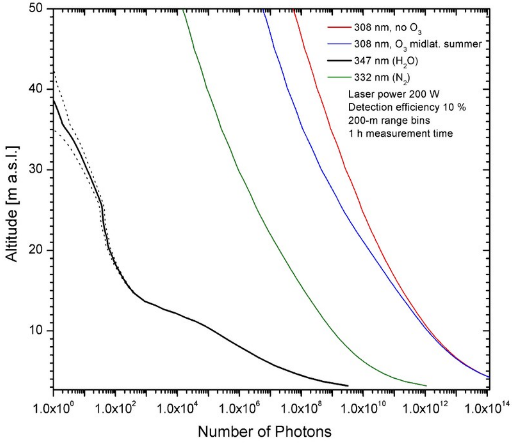
The Motivation

- **Radiative forcing of water vapor in the climate system is most sensitive in the upper troposphere and lower stratosphere.**
- **Ground based Differential Absorption Lidar (DIAL) is limited to the troposhere.**
- **Microwave radiometers are limited to altitudes > 30km.**
- **Water vapor Raman lidars are bound to nocturnal darkness and usually need long integration times (several hours) for stratospheric profiling.**
- **Pure Raman backscatter is too weak for temperature profiling up to the mesopause (≈90km).**



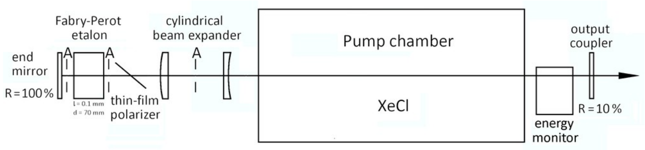


Solomon et al. 2010

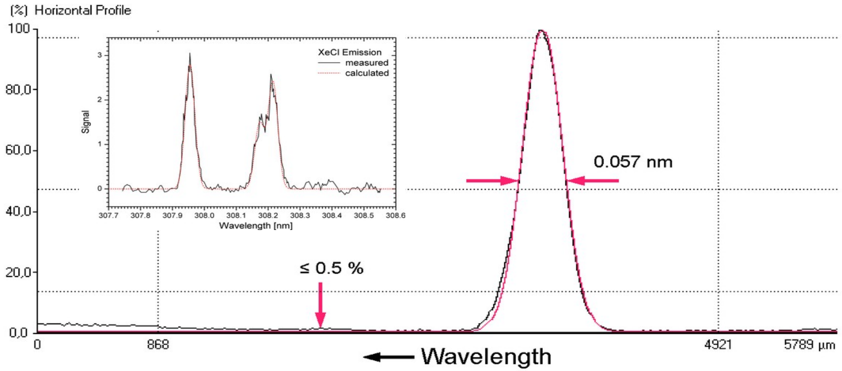


Simulated performance of a powerful Raman lidar at a high altitude site

Implementation



- **Scaling up a Raman lidar with**
  - **a very powerful laser (180W)**
  - **a large receiver telescope (1.5m)**
- **Setup the lidar on a high mountain**
  - **Zugspitze observatory (2675m asl)**
  - **Far from light pollution**
  - **more clear sky nights**



Laser emission spectrum before and after the implementation of an etalon in the resonator of the powerful (180W) XeCl Excimer laser. The narrowband operation allows for a more efficient suppression of background photons by narrow interference filters.

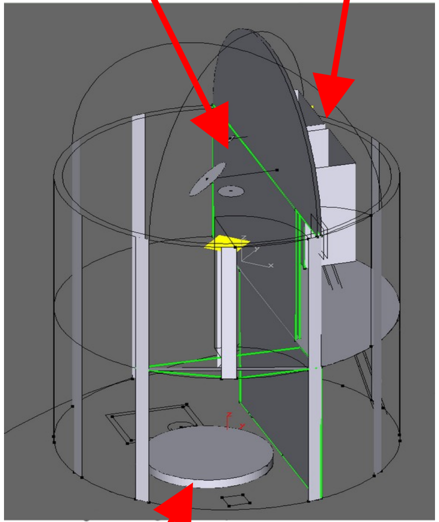
➡ Higher backscatter signals and shorter integration times

➡ Less background photons and less noise

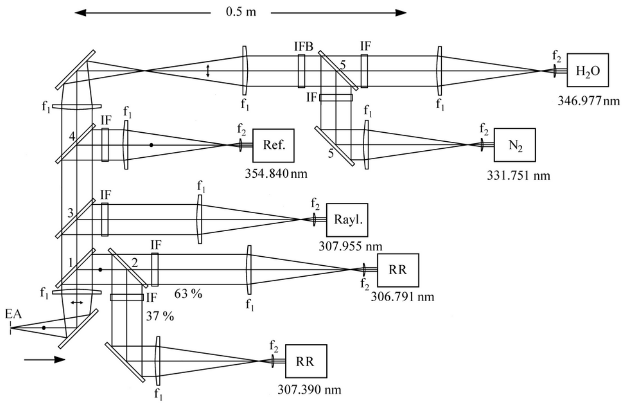
Implementation

Near-field telescope, primary mirror: diameter 0.35 m

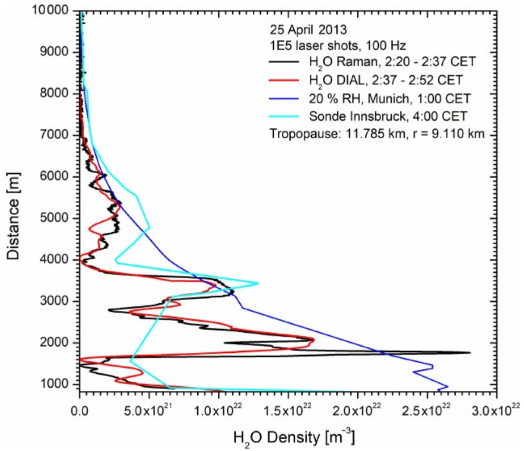
Polychromator boxes



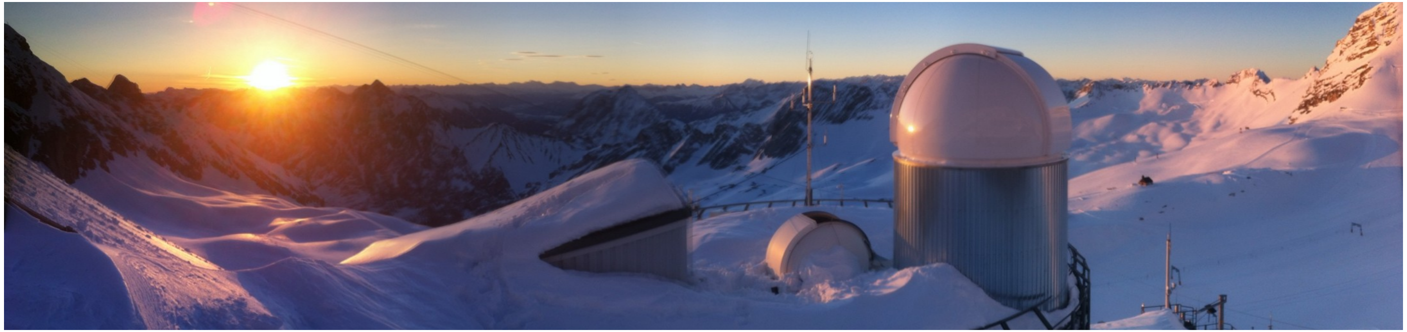
Far-field telescope, primary mirror: diameter 1.5 m



Principal optical design of the Raman lidar reciever. The signals from the PMTs are split into analogue and counting recording devices (LICEL and FastComTec).



Comparison and calibration with the side-by-side operated differential absorption lidar (DIAL).



Results / Validation Water Vapor

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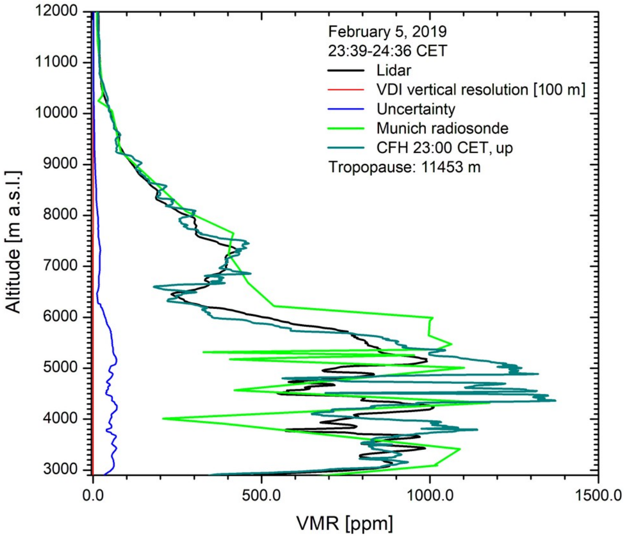

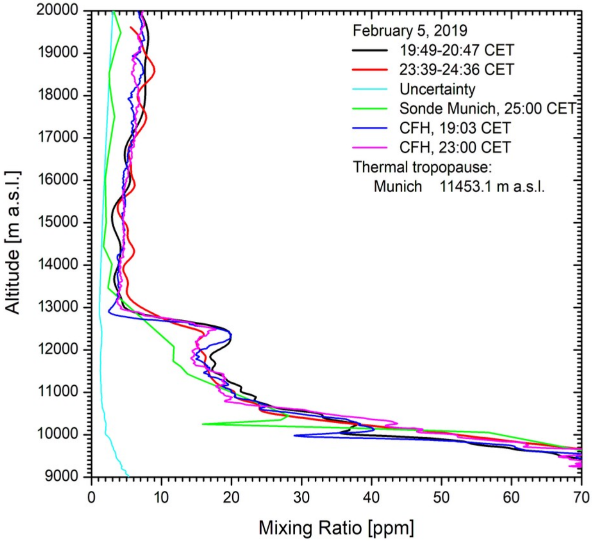

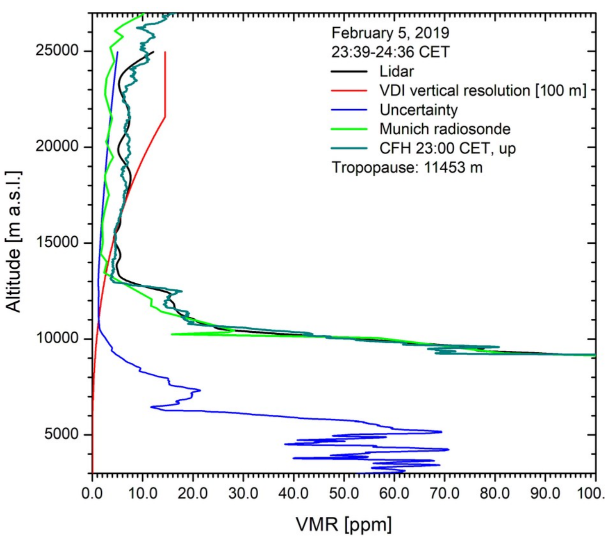

- Water vapor profiles up to 25km with 1h inetegration time
- Almost perfect validation with CFH sonde (launched by FZ Jülich at Garmisch)
- Very high variability in upper troposphere during validation by stratospheric intrusion

Results / Validation Temperature

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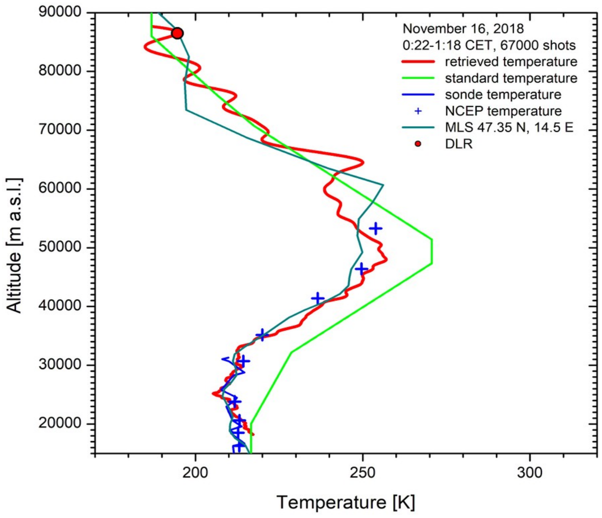

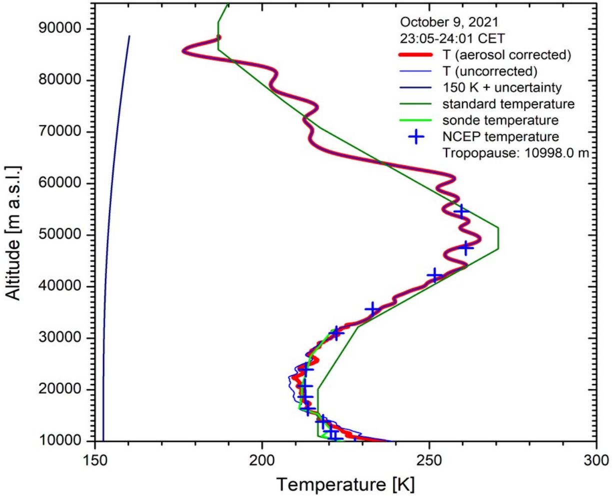

Stratospheric aerosol lidar in operation beside the dome of the Raman lidar

- Reference point at 87km from GRIPS (DLR) at Zugspitze
- Aerosol correction by information from the side-by-side stratospheric aerosol lidar

More details in:
[Klanner et al., Atmos. Meas. Tech., 14, 531–555, 2021, https://doi.org/10.5194/amt-14-531-2021]