Demonstration of water vapor and Isotopes measurements from lidar using a multi-platform, multi-instrumental approach

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EGU22-12076 | Vienna | GI4.1

Scientific motivation

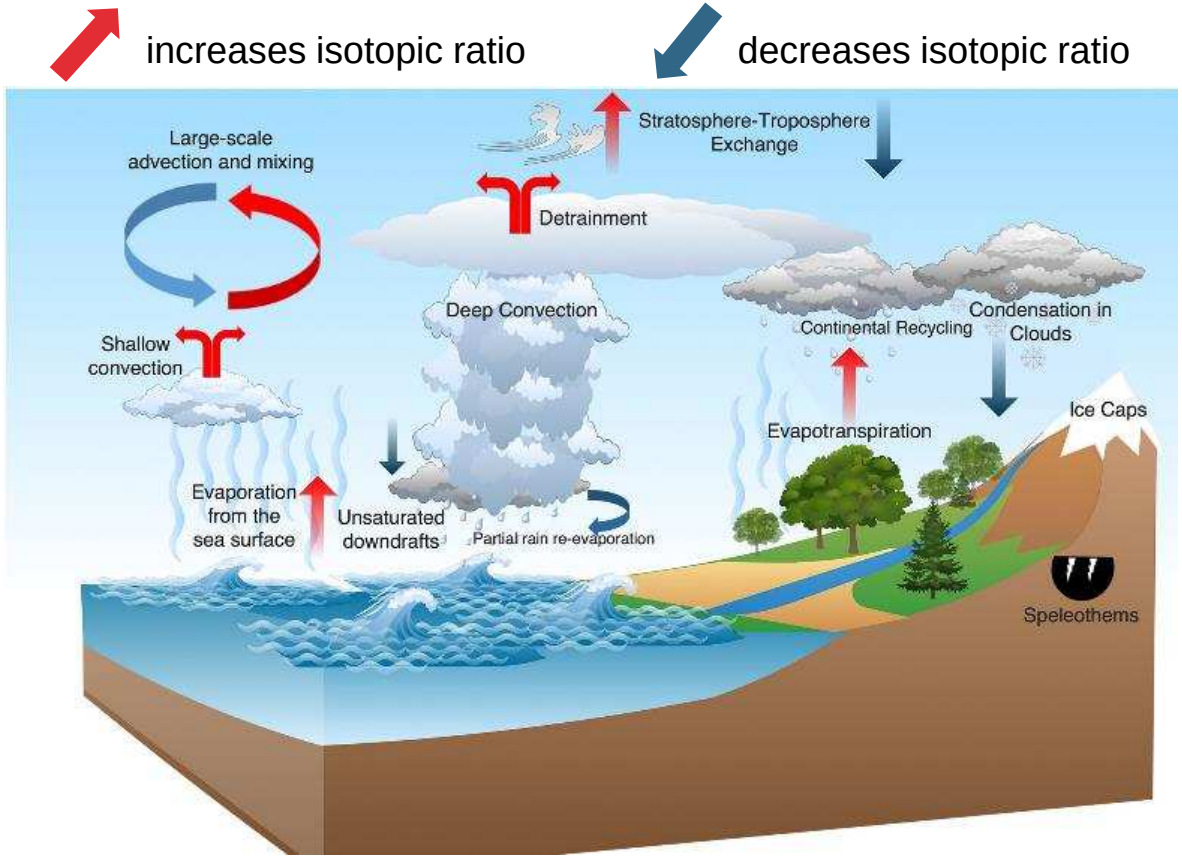
- Water isotopes of interest:

  Main isotope: $H_2{}^{16}O$
  " lightest molecule…evaporates faster "

  Semi-heavy water: $HD^{16}O$
  " heavier molecule…condensates faster"

- Concept of the isotopic ratio: $\frac{HD^{16}O}{H_2{}^{16}O}$

  - ➢ geophysical tracer to study history and evolution of air moisture
  - ➢ need for observations in order to increase accuracy of weather/climate models



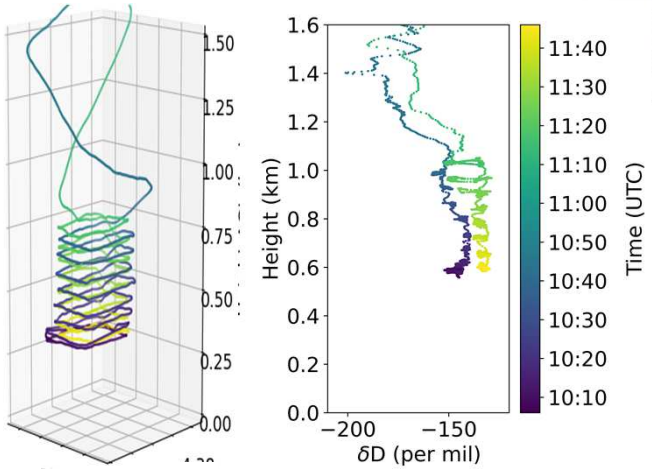
Galewsky, J., Steen-Larsen, H. C., Field, R. D., Worden, J., Risi, C., and Schneider, M. (2016), Stable isotopes in atmospheric water vapor and applications to the hydrologic cycle, *Rev. Geophys.*, 54, 809– 865

How to measure isotopic water vapor in the atmosphere?

⇒ **Example of the September 2021, Aubenas, France, campaign**

Un-selective but remote

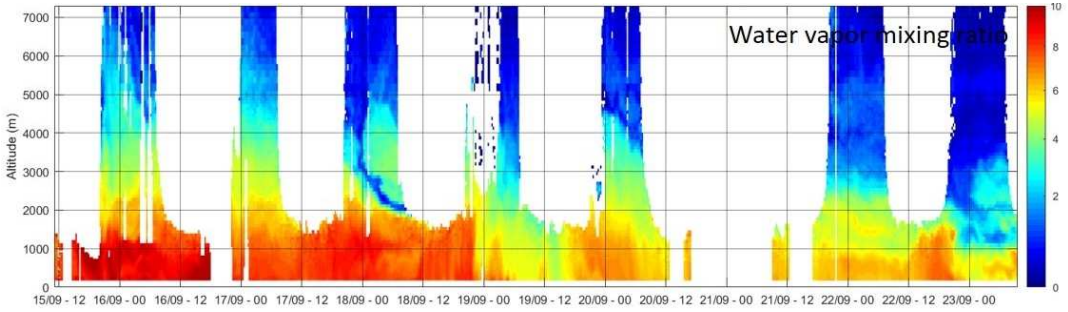
Radio soundings



Cavity-ring-down spectrometer (CRDS)
Selective but in situ
$H_2{}^{16}O$ and **$HD^{16}O$**

=> Ultralight borne

Raman water vapour lidar (WALI LSCE Lidar)



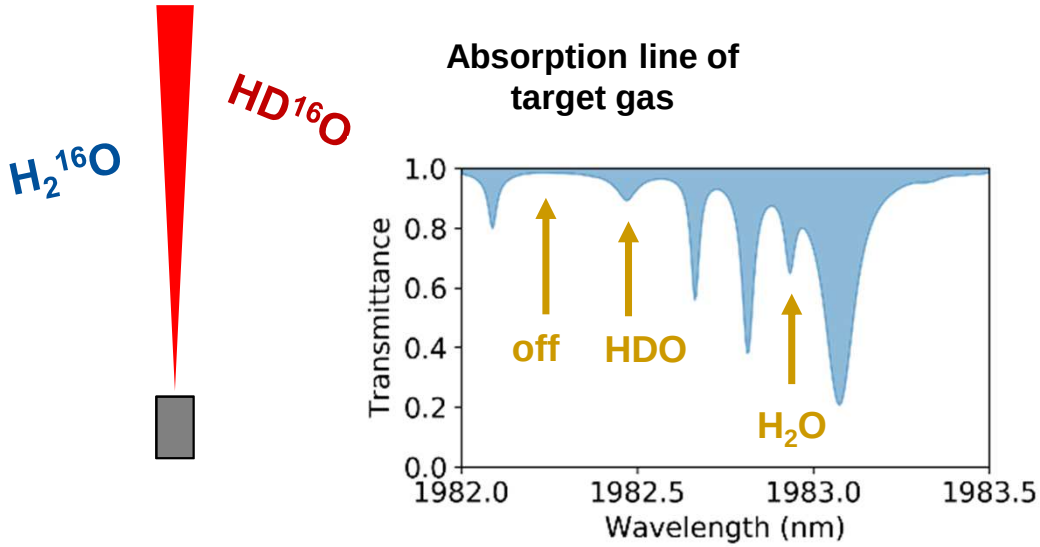
Tuesday's presentation :
EGU22-6295 | BG2.2
Temporal and spatial variability of water vapor isotopic composition in the lower troposphere: insights from ultralight aircraft measurements

How to measure isotopic water vapor in the atmosphere?

Proposed method

Ground-based differential absorption lidar (DIAL)

=> *Range resolved sensing*



Laser source requirements:

- Single-frequency 1.98 µm laser emission
- Tunable in 1-nm window to access on/off-wavelengths (shot-to-shot)
- Pulse energies in mJ range

DIAL sensitivity analysis :

Hamperl, J., et al.: Differential absorption lidar for water vapor isotopologues in the 1.98 µm spectral region: sensitivity analysis with respect to regional atmospheric variability, Atmos. Meas. Tech., 14, 6675–6693, https://doi.org/10.5194/amt-14-6675-2021, 2021.

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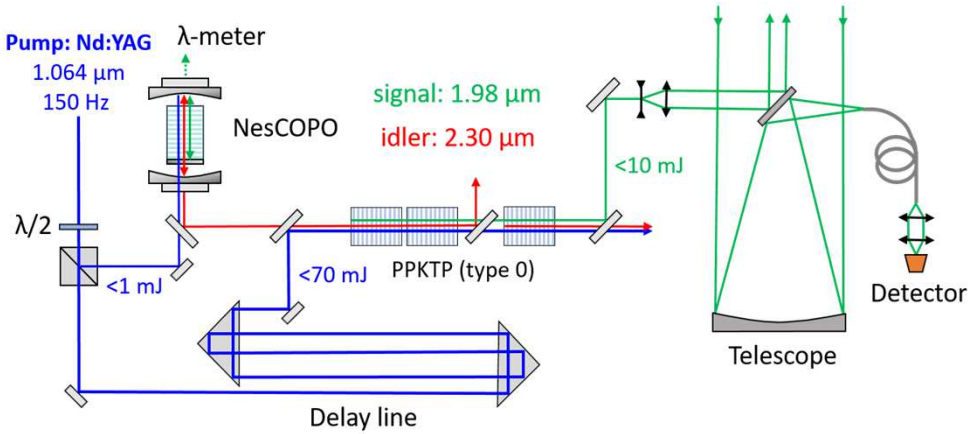
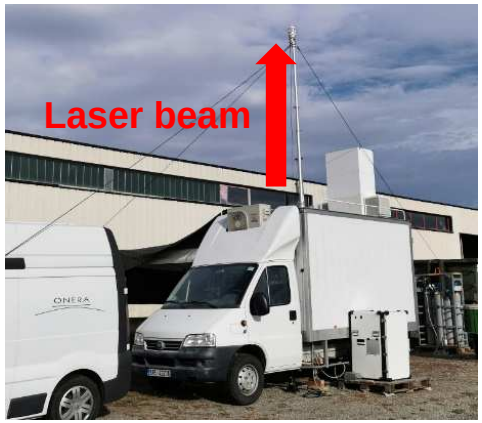
Lidar setup (transmitter + receiver)



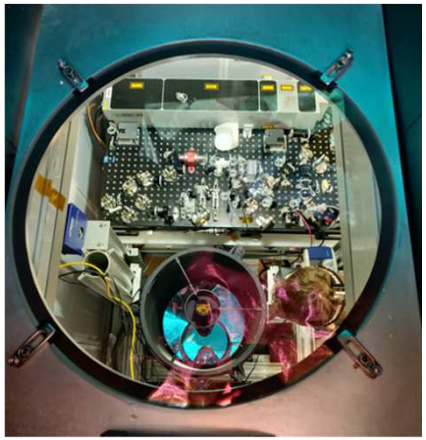
DIAL system integrated in lidar truck

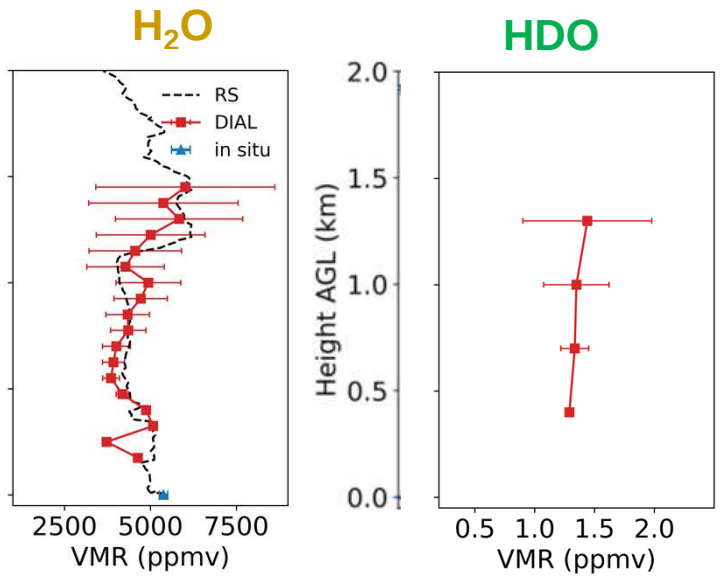
- **Emitter :** specific emitter design
- **Telescope:** 25 cm Newton-type
- **Detector:** InGaAs PIN photodiode + amplifier (BW: 3.5 MHz)
- **Wavelength measurement**: High Finesse IR-wavemeter

Towards a transportable, zenith-looking DIAL



LSCE Lidar truck





- 150 m range cells
- 75 m sampling

- 600 m range cells
- 300 m sampling

RS=RadioSounding

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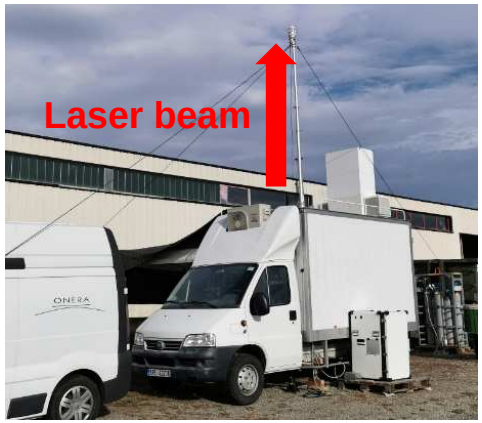

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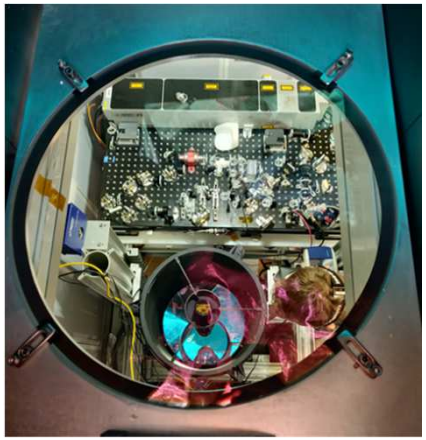
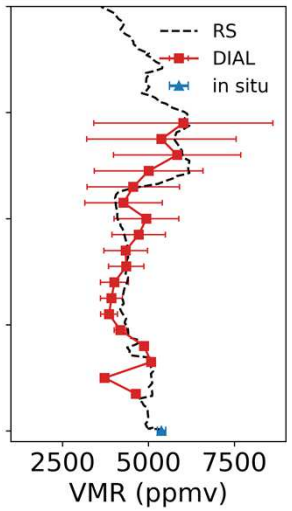


H_2O



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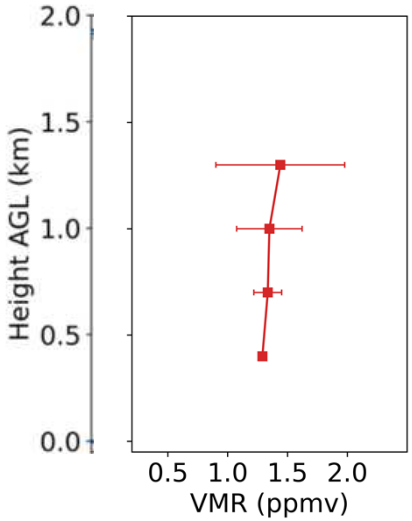
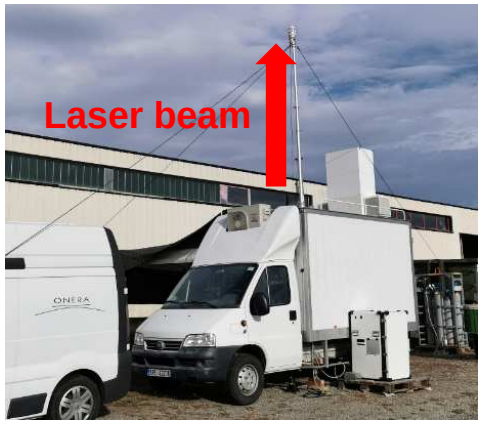
HDO



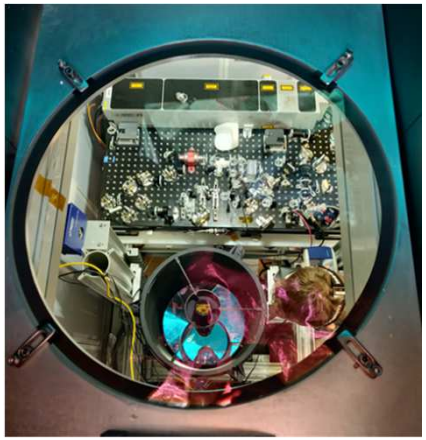
- 600 m range cells
- 300 m sampling

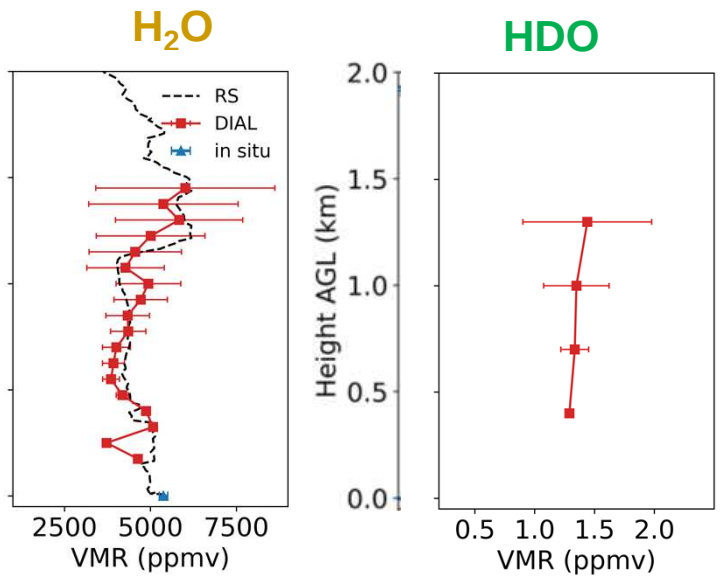
- compact, transportable setup ✓
- vertical measurement of H_2O and HDO ✓
- range resolution: 100–200 m
  - ✓ H_2O ✗ HDO

Towards a transportable, zenith-looking DIAL



LSCE Lidar truck





- 150 m range cells
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- compact, transportable setup ✓
- vertical measurement of H_2O and HDO ✓
- range resolution: 100–200 m
  - ✓ H_2O ✗ HDO

- Comparison with other sensors (Picarro CRDS, Raman Lidar) to perform
- System improvement in LEMON project towards multispecies (CO_2, H_2O, HDO) better sensitivity & airborne capacity

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