

Relative humidity fields in the Annecy Alpine valley observed by Ro-Vibrational Raman lidar in the framework of L-WAIVE

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Lidar Remote Sensing of the Atmosphere – Alexandre Baron – Thursday, 7 May

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Presentation plan

A rapid overview of the L-WAIVE campaign

Instrumentation and datasets

Thermodynamic measurements of WALI

Calibrations of the temperature

Error budgets for T, WVMR and RH

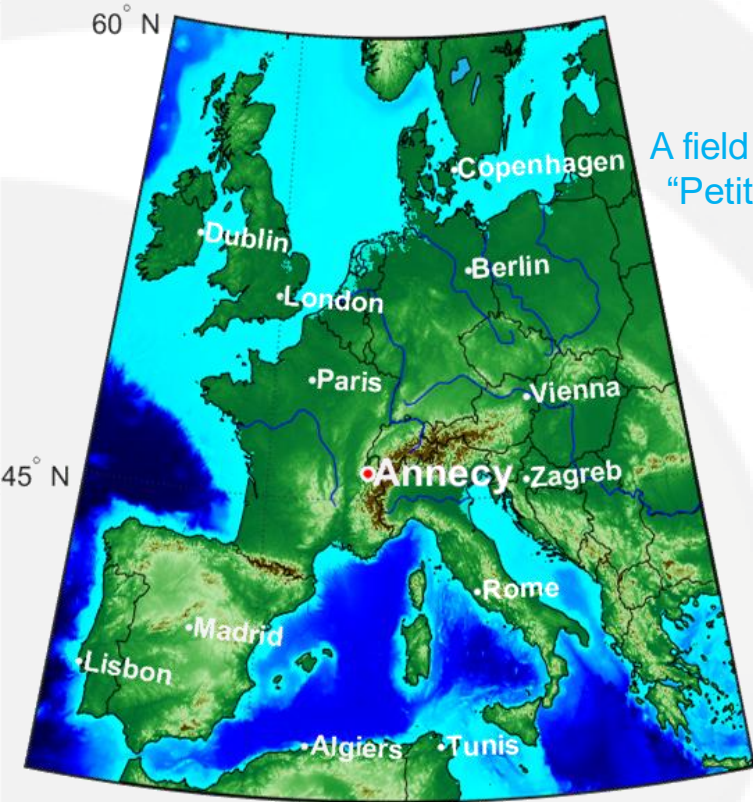
Profiles inter-comparisons



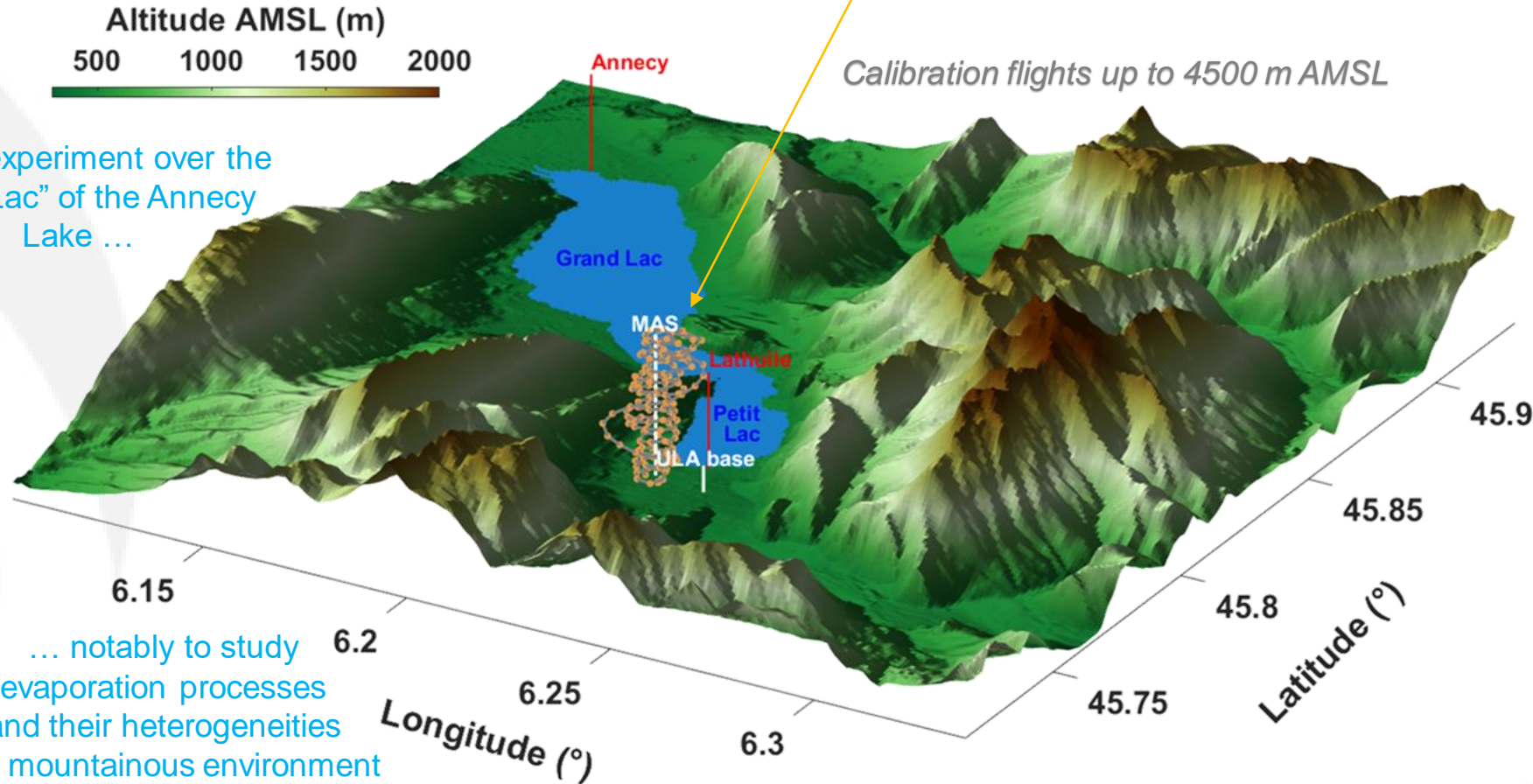
A rapid overview of the L-WAIVE campaign

The Lacustrine – Water vApor Isotope inventory Experiment (L-WAIVE) took place in the Annecy Alpine valley from 12 to 23 June 2019

Typical spiral flight plan used for calibration purposes (in grey and orange) above the **Mobile Atmospheric Station (MAS)** containing the **Weather and Aerosol Lidar (WALI)**



A field experiment over the
“Petit Lac” of the Annecy
Lake ...



... notably to study evaporation processes and their heterogeneities in mountainous environment

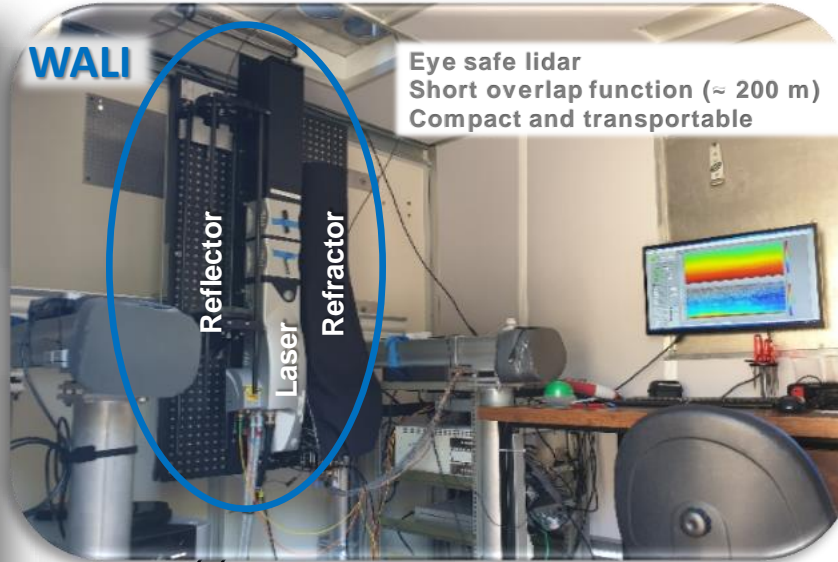
For a comprehensive presentation of the L-Waive field campaign, please refer to the presentation of P.Chazette et al. in the session “*The atmospheric water cycle: processes, dynamics and characteristics*” (AS4.6)

Instrumentation and datasets

Mobile Atmospheric Station (MAS)



WALI



Eye safe lidar
Short overlap function (~ 200 m)
Compact and transportable

Reflector

Reflector

Laser

PTU 300 Vaisala
Pressure
Temperature
Relative Humidity



Tanarg Ultra-Light Aircraft (ULA)

→ 10 days of continuous lidar measurements

- Aerosols
- Water Vapor Mixing Ratio (WVMR)
- Temperature

→ More than 30 scientific flights

- P, T, RH
- Aerosols
- Isotopes

Former field studies:

- ChArMEx (P.Chazette et al, 2014; ACP)
- HyMeX (P.Chazette et al, 2016; ACP)
- PARCS (J.Totems et al, 2019; QJRMIS)

Emitter	100 mJ @ 354.7 nm SLM-injected laser
Receiver	150 mm refractor (2 Rayleigh-Mie channels) & fibered reflector (4 Raman channels)
FOV	3.3 x 0.7 mrad & Ø1.6 mrad
Filtering	Elastic (354.7nm, co-/cross-pol) Vib Raman (N ₂ @387.6nm, H ₂ O@407.5nm) Rot Raman (High J @353.1nm, Low J @354.0nm) for temperature
Digitizer	NI PXI-5124: 12-bit, 200 MHz (photon counting post digitization)

For the aerosol part of the L-Waive campaign, please refer to the presentation of J.Totems et al. of this session (GI4.2/AS4.34)



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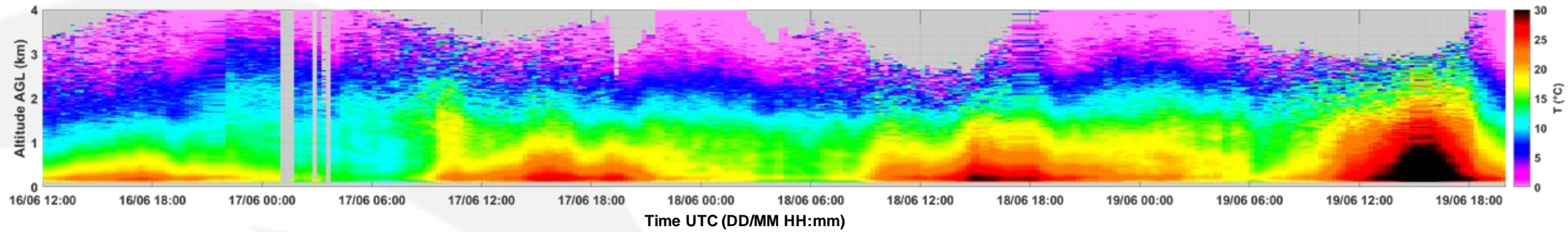
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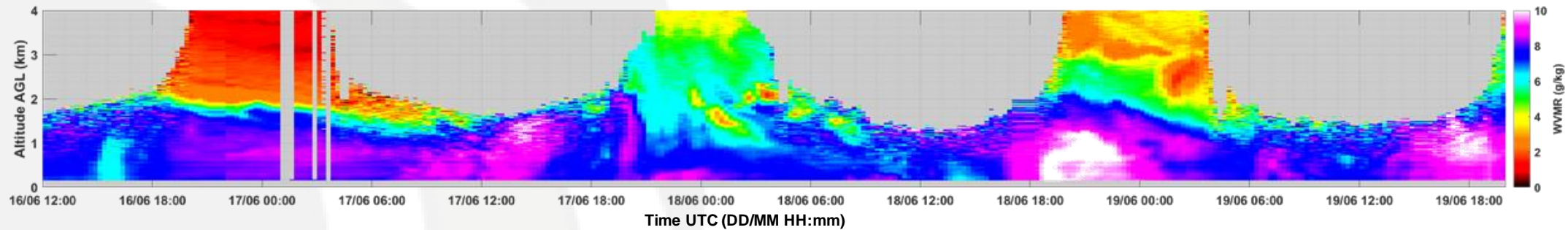
Thermodynamic measurements of WALI

Times-series from 16 to 19 June 2019

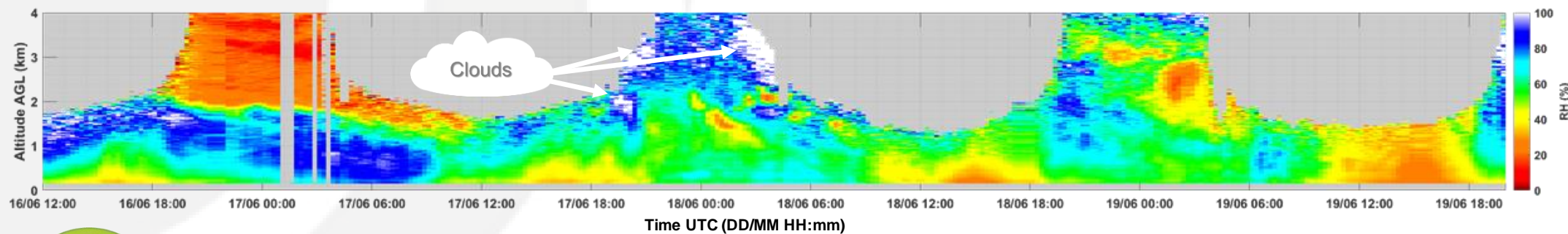
$\Delta t = 30 \text{ min}$; $\Delta z = 15 \text{ m}$



Air Temperature



Water Vapor
Mixing Ratio



Relative Humidity



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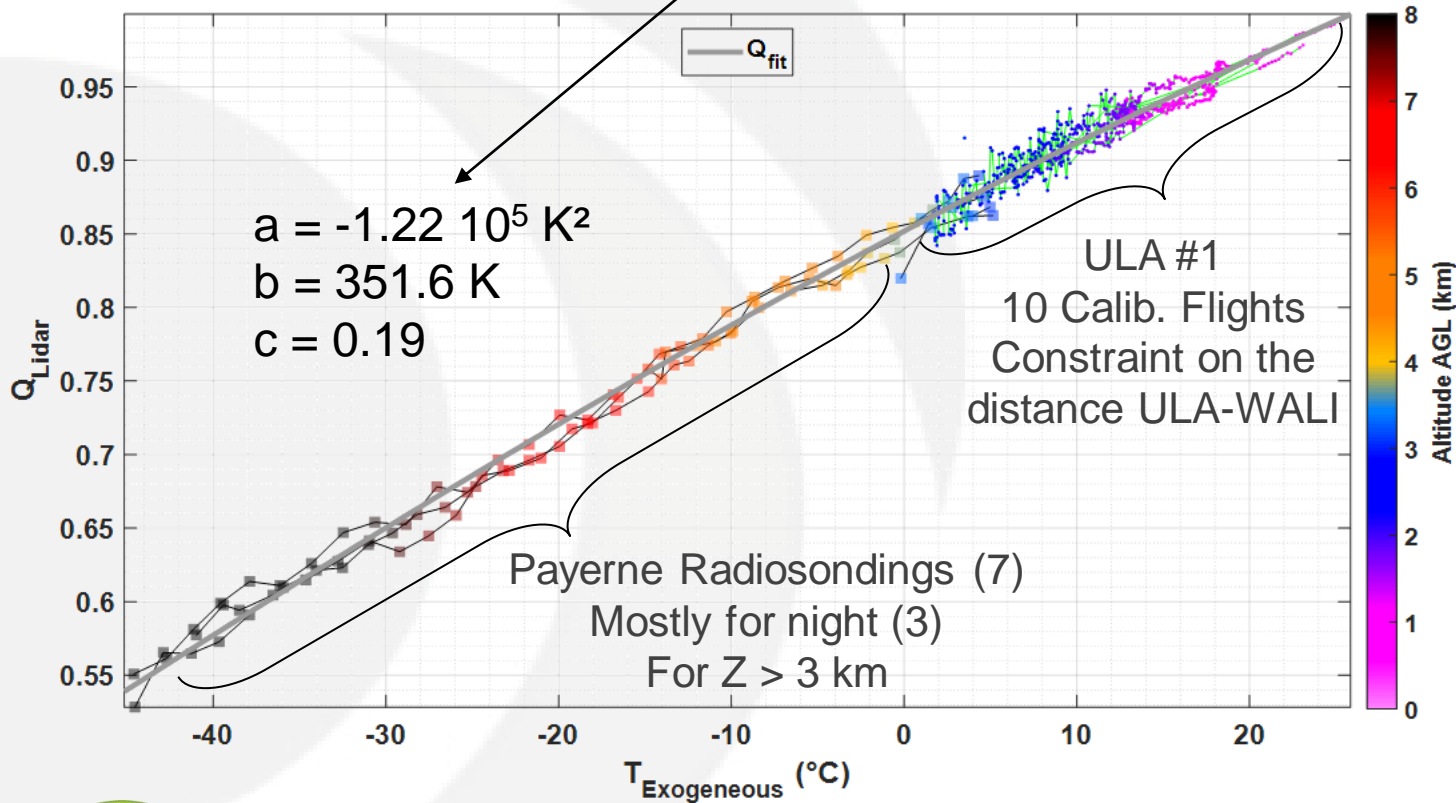
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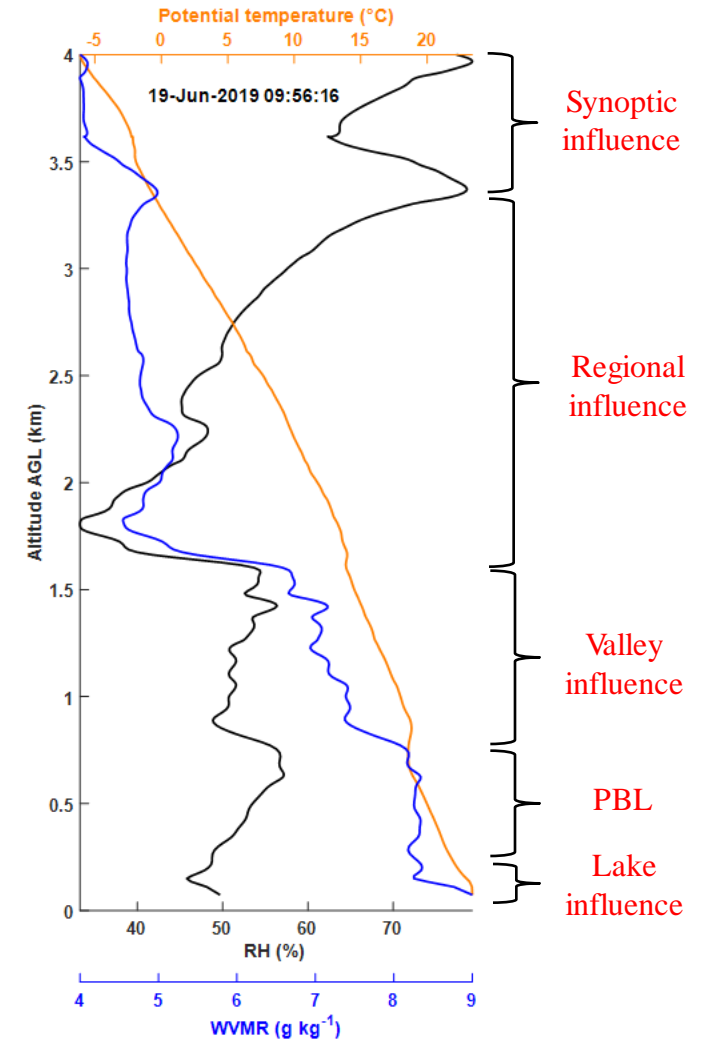
Calibrations of the temperature

$$Q(T, z) = \frac{S_{RR2}(T, z)}{S_{RR1}(T, z)} = e^{\left(\frac{a}{T^2} + \frac{b}{T} + c\right)} \quad [1]$$



Environment highly
 heterogeneous:
 3km-wide valley with
 various influences
 → Challenging calibration

Typical structuration of the atmospheric column in the valley



[1] A. Behrendt, "Temperature measurement with Lidar," in *Lidar Range-Resolved Optical Remote Sensing of the Atmosphere* (C. Weitkamp, 2005), Ch. 10.

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Error budgets for T, WVMR and RH during daytime

*V = T, WVMR or RH

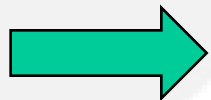
Mean Bias*:

$$MB = \langle V_{ULA} - V_{WALI} \rangle_t$$

Centred Root-Mean-Square Error*

$$RMSE = \sqrt{\langle (V_{ULA} - \overline{V_{ULA}}) - (V_{WALI} - \overline{V_{WALI}}))^2 \rangle_t}$$

Altitude range (km)	T		WVMR		RH	
	MB (°C)	RMSE (°C)	MB (g/kg)	RMSE (g/kg)	MB (%)	RMSE (%)
0.1 – 1	-0.5	0.5	~+0.2	0.3	+4	2.9
1 – 2	-0.3	1.7	<+0.1	0.7	+2	7.8
2 – 3	<+0.1	2.2	~+0.2	1.4	+2	~10

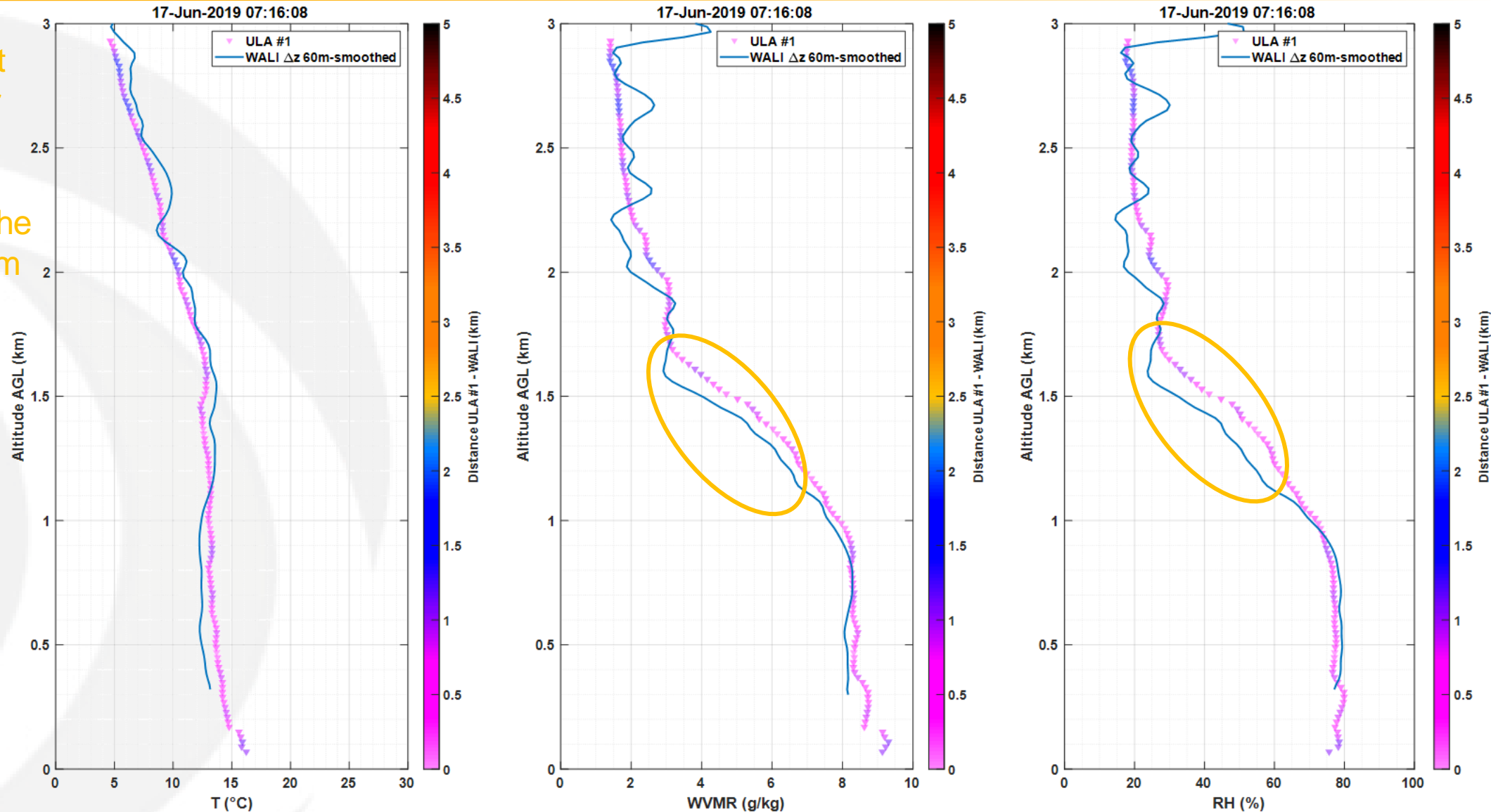


First estimates performed on the closest ($D_{WALI-ULA}$ projected on the ground < 2km) **during daytime**
Heterogeneities induced by the natural spatial variability of these parameters in the valley may remain



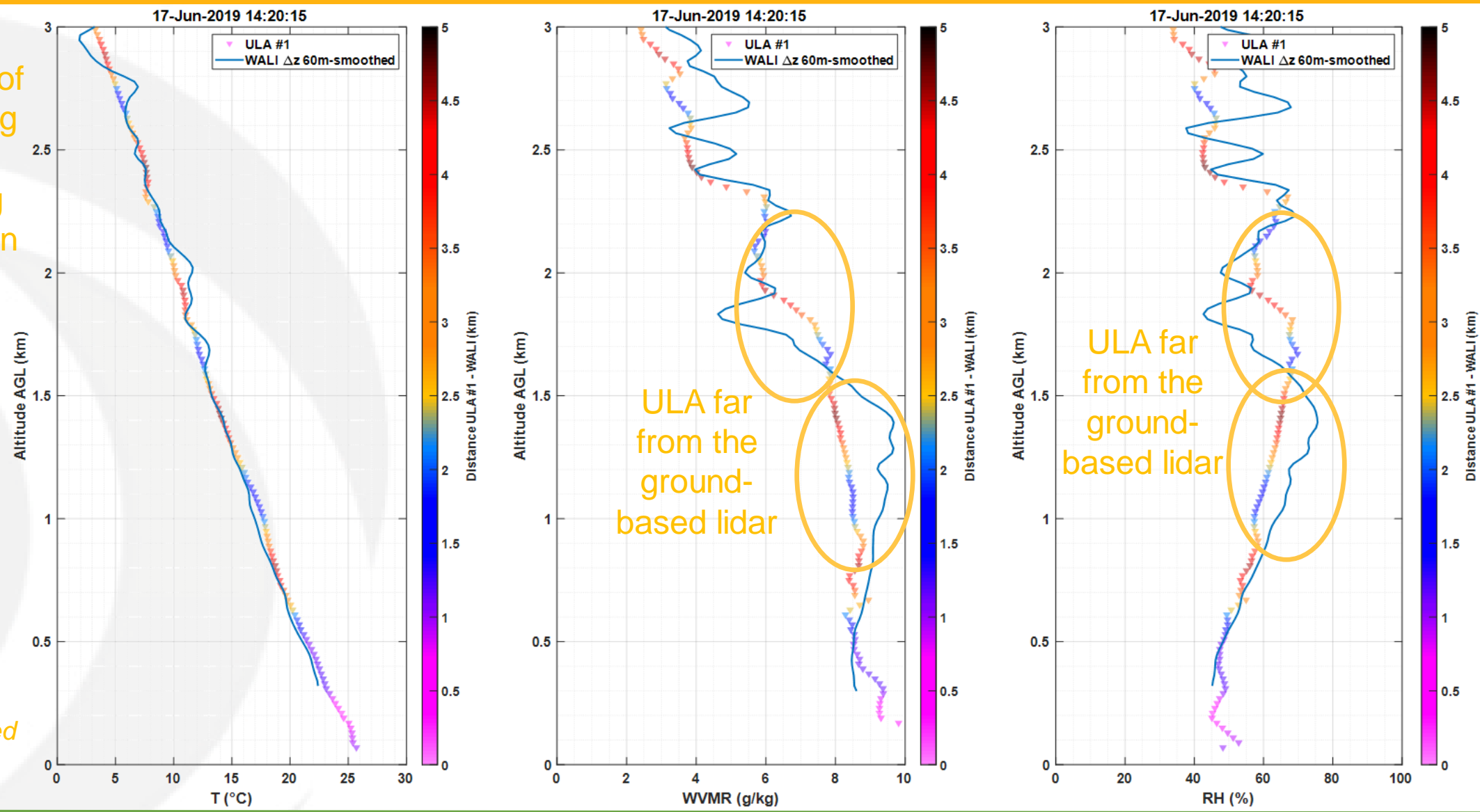
Profiles inter-comparisons: closest profiles

Good agreement
close to the lidar
location
Still some
imprecision near the
inversion at 1.5 km



Profiles inter-comparisons: ULA excursions farer

Good agreement of the T-profile during the afternoon.
Still some strong heterogeneities on WVMR and RH



→ Work to be continued



Conclusions & Perspectives

- ✓ Difficulties of calibration in mountainous environment
- ✓ A lot of heterogeneities of meteorological parameters in the valley to link with the diurnal cycle of the valley dynamics → ongoing work

Next steps

- Improve calibration robustness for T retrievals
- Combining RH measurements with aerosol lidar-derived properties.

Friendly acknowledgements to:

*L-WAIVE campaign participants: E. Dieudonné, A. Monod, H. Sodemann, C. Diana, P. Doira, F. Maignan, S. Ravette, A. Durand, C. Flamant;
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