Raman lidar measurements at the COPS Vosges supersite

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Context

Institut Geographique National (IGN, France) and Service d'Aeronomie (SA, France) have conjointly developed a mobile Raman lidar system. IGN-SA lidar is intended to be used in close relation with GPS measurements for two specific applications: the study of water vapor heterogeneity in lower troposphere and the calibration of GPS measurements for high accuracy GPS positioning.

The IGN-SA Raman lidar has been deployed on the Vosges Site of the COPS campaign. This instrument measures water vapor profiles in the lower troposphere, mainly during nighttime. It has been deployed to monitor the evolution of the water vapor profile, especially in pre-convective situations and has been operating during July 2007.

Description of IGN-SA lidar operation

E	Laser	Nd:Yag
E	Pulse rate	20 Hz
E	Energy per pulse	30 mJ @ 355 nm
R	Telescope diameter	30 cm
R	Focal length	72 cm
R	Aperture	0.3 mrad
R	Resolution	7.5 m × 20 s

TAB I: Technical characteristic

	R/M	N_2	H_2O
λ [nm]	355	387	408
$\Delta\lambda$ [nm]	0.40	0.40	0.40
T [%]	33	62	60

TAB II: Wavelength separation

IGN-SA lidar has been operating during the whole month of July 2007, for about 200 h in 25 measurement sessions. It was first intended to work for nighttime and daytime sessions. However, due to the difficulty to perform accurate water-vapor measurements during daytime sessions, nighttime and transitional periods observations were favored.

25-Jun-07	26-Jun-07	27-Jun-07	28-Jun-07	29-Jun-07	30-Jun-07	01-Jul-07
						04:00-07:00
						16:00-19:00
02-Jul-07	03-Jul-07	04-Jul-07	05-Jul-07	06-Jul-07	07-Jul-07	08-Jul-07
		02:40-08:10				00:00-05:00
09:45-19:30		14:10-19:50		13:25-19:35	15:45-00:00	
09-Jul-07	10-Jul-07	11-Jul-07	12-Jul-07	13-Jul-07	14-Jul-07	15-Jul-07
02:40-07:00			17:00-18:00	19:30-00:00	00:00-09:00	00:00-09:45
13:45-18:50					20:00-00:00	
16-Jul-07	17-Jul-07	18-Jul-07	19-Jul-07	20-Jul-07	21-Jul-07	22-Jul-07
00:00-08:00		00:20-00:40	00:00-08:00	00:00-08:00		20:00-00:00
	22:10-23:00	19:45-00:00	19:45-00:00	20:30-00:00		
23-Jul-07	24-Jul-07	25-Jul-07	26-Jul-07	27-Jul-07	28-Jul-07	29-Jul-07
00:00-08:30		00:00-08:40	00:00-08:30	00:00-01:00		
	20:00-00:00	17:20-00:00	19:35-00:00	10:00-12:00		
30-Jul-07	31-Jul-07	01-Aug-07	02-Aug-07	03-Aug-07	04-Aug-07	05-Aug-07
20:00-00:00	00:00-08:00	00:00-03:50				
	16:30-00:00					

COPS IOP   EUFAR IOP   IGN-SA IOP

	Nighttime	Daytime
Obs. period	19:00 – 03:00	03:00 – 19:00
Max. range	7 km	3 km
Δt [min]	5 – 30	10 – 30
Δz[m]	7,5 – 500	15 – 500

TAB III: Water-vapor mixing ratio profiles

Max. range	10 km
Δt [min]	1
Δz [m]	15

TAB IV: Backscattering profiles

Nighttime measurements have an accuracy that is consistent with the one obtained in previous experiments (e.g. VAPIC 2004). The measurements are carried out with a temporal resolution varying between 5 min-30 min and a range resolution between 15 m and 300 m, up to 6-7 km. During daytime the accuracy is much reduced and mainly limited by diffuse solar irradiance though narrow (0.4 nm) interference filters are now used. The measurement range is between 1 and 3 km at day/night transition, and drops to a few hundred meters at midday. It strongly depends on atmospheric conditions.

Evaluation of water-vapor mixing ratio profiles

Lidar water vapor mixing ratio profiles are calibrated using nighttime collocated radiosoundings from 4M (CNRM-Meteo-France) on the range 1-3 km (10 calibration sessions).

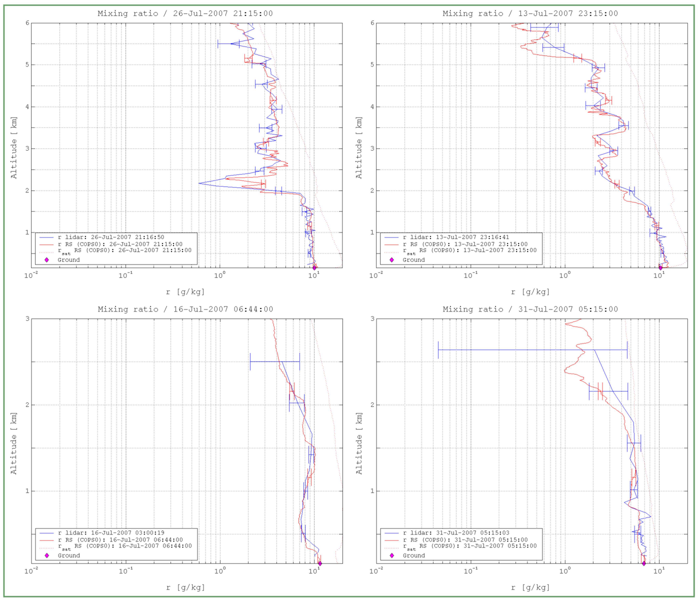
The agreement between water vapor mixing ratio profiles retrieved by lidar and collocated radiosoundings up to maximum range are rather good with a very similar sensing of the different inversion layers. For nighttime measurements, bias remains low (from 0.0 to 0.2 g/kg up to 7 km). Values appear larger during daytime (larger than 2.0 g/kg at 2 km).

Layer [km]	n	b [g/kg]	e [%]
[0 - 1]	14	0.0	11.1
[1 - 2]	14	0.2	12.6
[2 - 3]	14	0.2	17.6
[3 - 4]	14	0.0	16.0
[4 - 5]	14	-0.0	26.6
[5 - 6]	13	0.1	30.7
[6 - 7]	12	0.2	46.6

TAB V: Nighttime difference lidar – radiosounding. Bias and relative error.

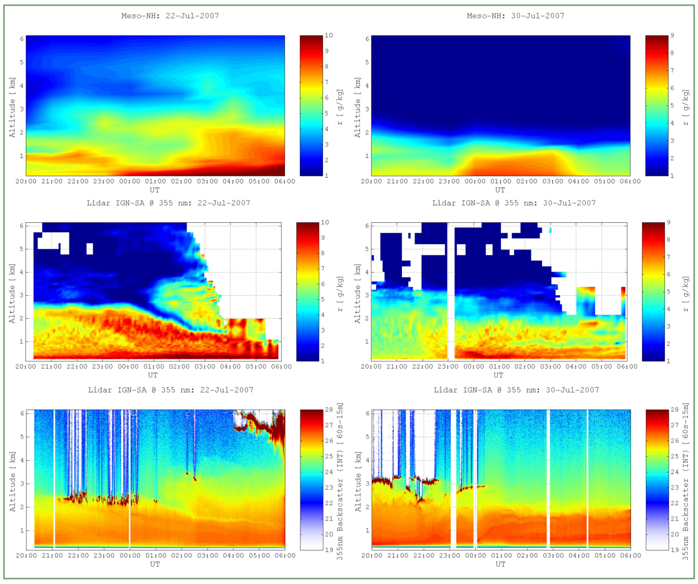
Layer [km]	n	b [g/kg]	e [%]
[0 - 1]	19	-0.5	21.2
[1 - 2]	18	0.2	31.2
[2 - 3]	5	2.3	71.7
[3 - 4]	4	1.4	79.1

TAB VI: Daytime difference lidar – radiosounding. Bias and relative error.



Water vapor mixing ratio profiles evolution

The evolution of the mixing ratio profiles observed by lidar gives an interesting view into the evolution of the nocturnal atmospheric boundary layer and the day/night transitions. This product can be an important additional information source to numerical weather prediction models for water-vapor evolution studies. These data help connecting daytime measurements, which were the primary objective of the experiment, especially for situations leading to convection or preceding the arrival of fronts. Such situations will be analyzed in more details in the near future. (Meso-NH data: Courtesy E. Richard, LA/CNRS).



Future work

We are now going to collaborate on a more general intercomparison study including different water-vapor sensors (see oral presentation "Water vapor intercomparison effort in the frame of COPS"). We also attend to study more accurately and to evaluate 355nm-backscatter profiles retrieval from Rayleigh/Mie measurements.

Regarding our specific issue, wet delays from lidar water vapor mixing ratio profiles have to be retrieved. These delays will be evaluated with respect to GPS estimates and finally, lidar measurements will be used as a correction of GPS signals in a precise point positioning processing using a ray-tracing algorithm.

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