WATER VAPOR RAMAN LIDAR WITHIN THE NDSC

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ABSTRACT

This work is a joint effort to provide best water vapor measurements in the upper troposphere lower stratosphere within the NDSC. It is only recently that NDSC decided to include water vapor lidar measurements as a standard tool. While the NDSC project is centered on the stratosphere, detection of the Raman measurements is improved to reach the highest altitude. Here is presented the first step that consist in identifying the potential candidates and to report about the potential homogeneities of the network. Calibration is one of the challenges.

1. INTRODUCTION

Several Raman lidars have already operated around the world to derive water vapor profiles. Despite the efficiency of the Raman cross sections are small, some instruments cover the upper troposphere that is highly relevant for better understanding the stratosphere and exchanges through the tropopause. The locations of the instruments that have already compared their capabilities are plotted in figure 1. There is a group of five instruments in the western part of Europe, 2 instruments at mid-latitude in US and one instrument in the southern tropic. Also the MARL instrument is not represented because it is dedicated for campaign and is a mobile system with no fix location.

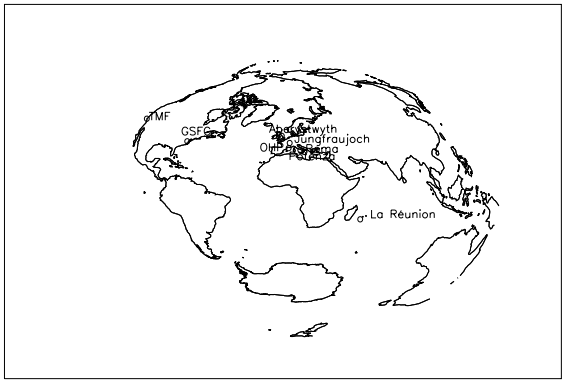

Fig 1. location of the instruments involved in the present project.

2.REQUIREMENTS FOR INSTRUMENT CANDIDATES

There are general rules similar to any other instruments:

- A long-term continuous operation, to insure for a continuous financial and human support and
- The site and operation continuity, and
- Accept to provide data and make it public through the NOAA database.

The other general rules concern the acceptance of participating to any NDSC activities and check for the data quality. Candidates need to describe the status of their validation efforts and give some future plans for further validations including activities organized within the framework of the NDSC.

The more specific requirements for water vapor are:

- While it is difficult to fix threshold, the main argument will be associated to the scientific intend to make effort in reaching the tropopause and above. This can be obvious when considering the scientific topics proposed by the candidate groups. However, actual capabilities need to be already around the mid-tropopause clearly above the boundary layer, c lose to 5-7 km, in 30 mm to 1-hour integration-time. No fixed threshold for the altitude range will be fixed but the actual capabilities with the other factors and future plans will be considered.
- Water vapor using the Raman scattering exhibits a strong limitation for long-term monitoring. This disadvantage compared to other lidar techniques already involved in the NDSC, is the non-absolute nature of the measurements that require a specific calibration. As an emerging technique, it is difficult to know which type of calibration will be the more adapted. However candidates need to describe their technique and their future plans associated with calibration.

3. IMPROVE THE UPPER PART OF THE PROFILE

As one of the objectives is to reach the stratosphere or at list the tropopause region, investigate all the limitation regarding the upper part of the profile is required: effects of signal induced noise or optical fiber fluorescence in the upper part of the WV profiles. One practical way to achieve this goal is to compare instrument capabilities and the corresponding signals.
The instruments already compared are located at different altitudes from 50 to more than 3000 meters (table 1). The upper part of the profiles is then shifted upward. This capability increase is enhanced because most of the attenuation is located in the boundary layer. Most of the system used the wavelength of 355 nm corresponding to the third harmonic of a Nd:Yag laser, except two that used the second harmonic in the visible (532 nm). Lidar power (LP) that can be defined as the product of the laser energy to the receiver area show some values from 1 to 8 that reveal some differences in their respective potential capabilities.

Location	Alt. m	Long.	W.	LP J/m2
MARL Mobile	-	-	355	8,5
Aberystwyth	50	52,4°N	355	2,4
Jungfraujoch	3580	46,6°N	355	2,5
OHP, France	680	43,8°N	532	7,5
Mobile at Roma, Italia	110	41,8°N	355	0,6
Potenza, Italia	820	40,6°N	355	6,3
Mobile at GSFC MD, USA	50	38,8°N	355	4,1
Table Mountain Facility, USA	2300	34,4°N	355	5,9
La Réunion	50	20,8°S	532	26

Tab 1. List of instruments dedicated for monitoring the upper troposphere on a routine basis.

One of the critical issues is the rejection of elastic backscattering light. All the teams have estimated their rejection being larger than 12 magnitudes.
The field of view of the telescope is also a key parameter for the noise level and then the height range. Fields of view of 0,2 to 1 mrad have been used and noise differ from 1 to 100 count per second.
One initiative about signal exchanges in Italy needs to be reported and is described by Daulerio et al (2004).

4. CALIBRATION ISSUE

To perform a long term monitoring, calibration is of great importance. Most of the groups use radiosondes in the valid domain (2-4 km). Also other methods have been tested and need to be compared. These methods include lamp etalon, passive zenith sky observation, additional measurements of the total column, and the calibration of the different optical items. More work need to be done to achieve the quality of calibration.

5. VALIDATION PLANS

Another action that can be supported by the water vapor NDSC sub-group will be the validation issue. What is the best approach? A mobile instrument? Other exercises?
While it is interesting to identify candidates providing a mobile instruments, the satellite validation is also a complementary tools for validation (or at list comparison) among the lidars and gives some knowledge about the network homogeneity. Regarding the validation issue, 3 Italian groups have already decided to start an exercise of inter-comparison for the Raman algorithm for water vapor. The idea is to exchange

real data among their groups and each group applies its own algorithm to data from different groups. This action is already started so after seeing the conclusions we can planned a similar exercise among the whole NDSC groups.

The coming satellite validation exercises urgently require water vapor data. Water vapor is the first priority for AURA. The current estimate for AURA launch is June 2004, and possibly later. So first measurements will be expected around September/October 2004 with a delivery delay of several days to few weeks.

REFERENCE

Cornacchia, C., A. Amodeo, L. Mona, M. Pandolfi, G. Pappalardo, V. Cuomo, The IMAA Raman lidar system for water vapor measurements, ILRC22, 12-16 July 2004.

D'Aulerio, P., C. Cornacchia, M. Iarlori, G. Rocci, F. Congeduti, G. Pappalardo, V. Rizi, L. Mona, F. Fierli, Intercomparison of water vapor retrieval between three Raman lidar stations, ILRC22, 12-16 July 2004.

Leblanc, T., I.S. McDermid, D.A. Haner, T.D. Walsh, A high capability Raman lidar for upper tropospheric and lower stratospheric water vapor measurements, ILRC22, 12-16 July 2004.

Sabatino, D., P. Di Girolamo, D. N. Whiteman, B. B. Demoz, E. V. Browell, S. Ismail, R. Ferrare, S. A. Kooi, A. Behrendt, V. Wulfmeyer, Water vapour measurements during the international H20 project: intercomparisons between scanning Raman lidar and lase, ILRC22, 12-16 July 2004.

Whiteman, D. N., B. Demoz, P. Di Girolamo, J. Comer, Z. Wang, R-F. Lin, K. Evans, I. Veselovskii, NASA/GSFC scanning Raman lidar measurements of water vapor and clouds during IHOP, ILRC22, 12-16 July 2004.