VALIDATION OF GOMOS H_2O DATA PRODUCT WITH BALLOONBORNE LASER AND FROST-POINT HYGROMETERS.

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ABSTRACT

A laser diode sensor (SDLA) and a frost-point hygrometer (ELHYSA) have been combined to provide water vapor, methane, carbon dioxide and aerosols measurements in the UT-LS from stratospheric balloons. The main objective consists of validating the H_2O data yielded by the GOMOS instrument. The instruments were flown several times at mid- and northern latitudes and we report the achieved measurements. At this step, the GOMOS water vapor data are not yet available to permit a valuable comparison as the improvement of the H_2O retrieval algorithm is under way ; the GOMOS data corresponding to the flights are to be processed further. Instead of comparing data, what will be carried out later during the validation campaign, we propose to discuss future balloon activities related to ENVISAT. We have proposed a balloon campaign from Aire sur Adour (43°N) on October 2003 (or on May 2004) to study subtropical intrusions and its impact on stratospheric O_3 and H_2O using *in situ* data (SDLA , ELHYSA, ionic anemometers …), satellite measurements (GOMOS, …) and high-resolution advection and trajectory models.

1. INSTRUMENTATION

The SDLA spectrometer is a balloon borne diode laser spectrometer devoted to the *in situ* measurement of H_2O, CH_4 and CO_2 in the UT-LS [1]. Fig.1 is a picture of the SDLA during its flight from Kiruna within the framework of the ENVISAT validation campaign in August 2002. Three near-infrared laser diodes (each dedicated to a given specie) are coupled by means of optical fibers with a multipass cell (path length of 56m) open to the atmosphere. The laser beams are absorbed by ambient molecules while it is propagated in the optical cell ; the concentration are then retrieved from the recorded absorption spectra using the Beer-Lambert law and *in situ* P and T measurements. The SDLA instrument that was flown several times (THESESO, THESEO-2000, ODIN validation) is described in more details in [2]. ELHYSA is a frost-point hygrometer developed at the Laboratoire de Météorologie Dynamique which has been operated routinely from balloon and airborne platforms for a long period of time and has been already used for satellite validation [3-5]. Both the SDLA and ELHYSA were previously combined for the ODIN validation in 2001; Fig. 2 shows the obtained H_2O and CH_4 data [6]. The instruments provide *in situ* vertical concentration profiles of constituents at high resolution (typically 10m) and with an inaccuracy of a few percents. The SDLA measures H_2O, CH_4 and CO_2 in the troposphere and the lower stratosphere. ELHYSA yields H_2O and aerosols measurements in the lower stratosphere. Both instruments are equipped with accurate P and T sensors and thus provide additional P and T profiles (precision errors of 0.1hPa and 0.1°C). For each flight, ozone soundings are performed which provide additional ozone data as can be seen in Fig.2.

2. RESULTS

The SDLA was first flown on 8 August 2002 from Kiruna (67°N) in northern Sweden. Time and place of the flight were in rather good agreement with GOMOS (and SCHIAMACHY) overpasses. The achieved water vapor and methane measurements are shown in Fig.3. The SDLA was flown from a 100 000 m^3 stratospheric balloon to reach a float altitude of 35 km. The humidity and ozone measurements yielded by a sonde that was launched one hour after the SDLA are also reported in Fig.3. The stratospheric water vapor data were taken during the slow descent of the gondola to prevent corruption of H_2O data by water vapor outgassing from the balloon envelope. Two concentration values were taken every single second; the profiles are made of a few thousands of measurement points. For this flight, the SDLA was equipped with a laser device emitting at 1.602micron to monitor carbon dioxide in the UT-LS; its capability to detect CO_2 was tested during the flight and preliminary data are also shown in Fig.3.

Fig.1. A picture of the SDLA balloonborne diode laser spectrometer during its flight from Kiruna on 8 August 2002 in the framework of the ENVISAT validation campaign.

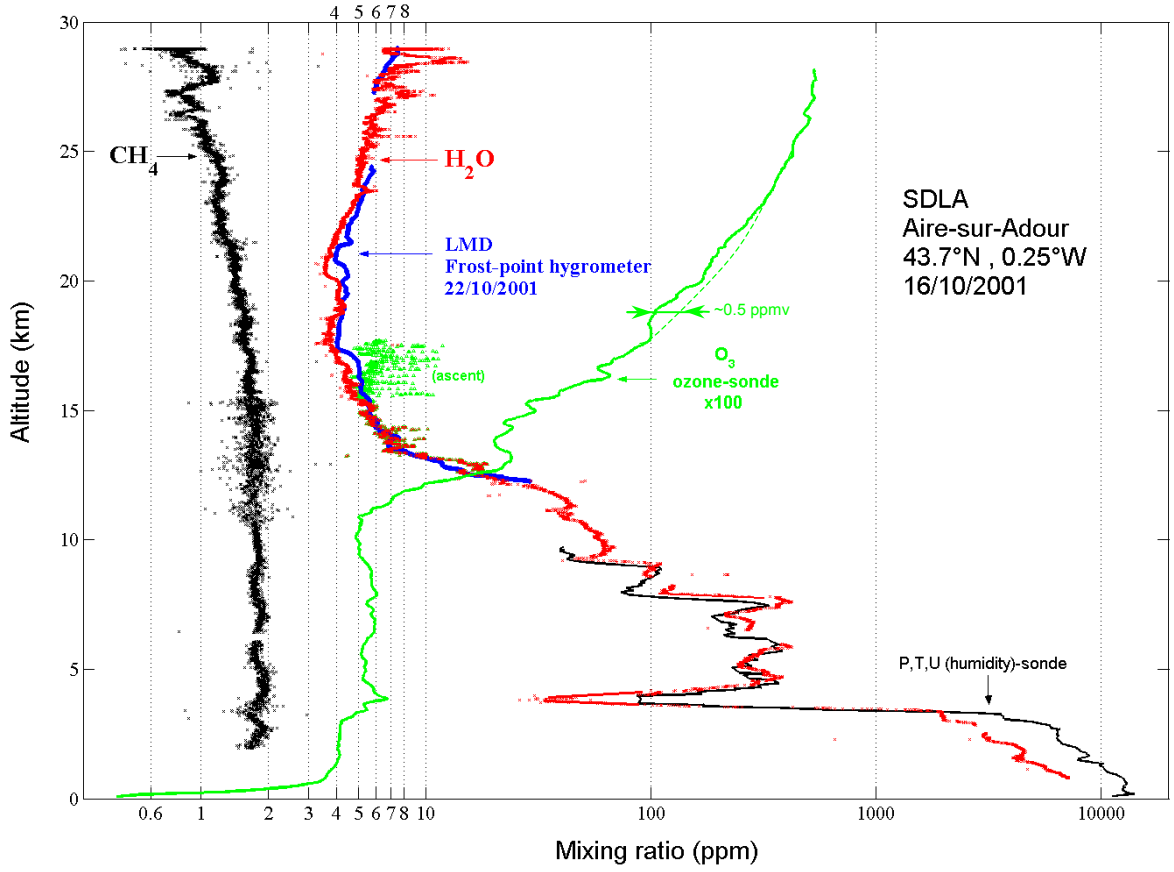

Fig.2. An example of *in situ* H_2O, CH_4 and O_3 vertical concentration profiles yielded by the SDLA and ELHYSA instruments during the ODIN validation campaign in October 2001 [6].

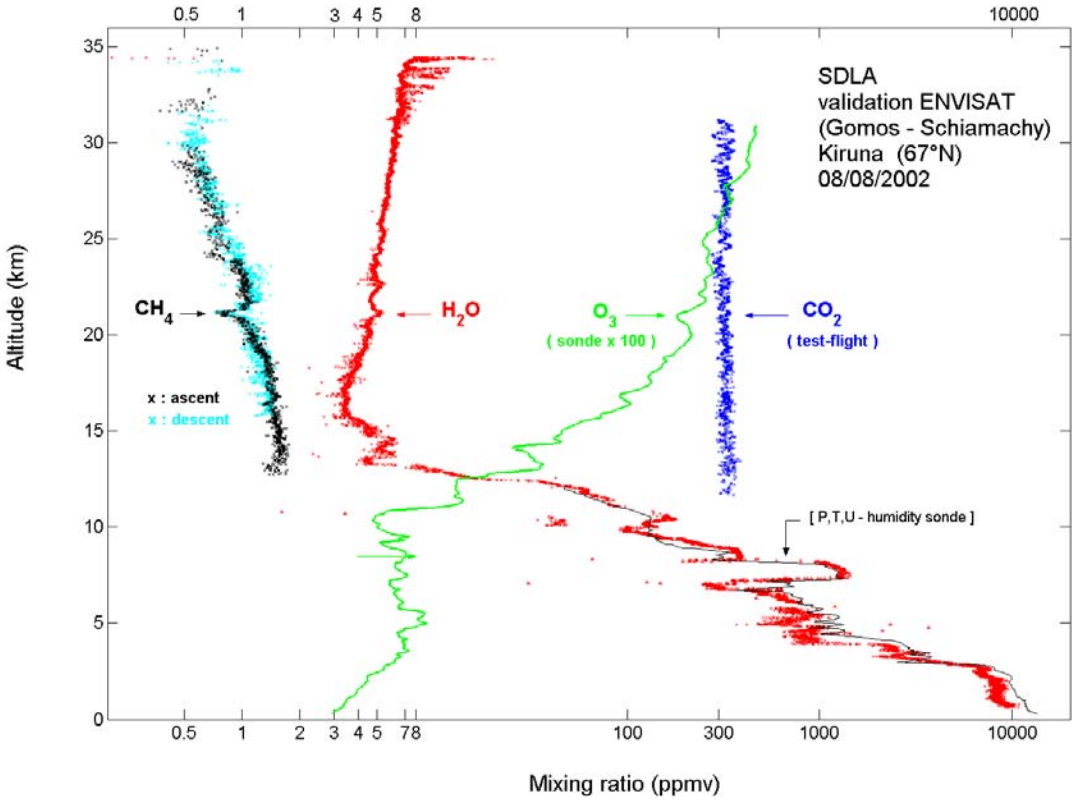

Fig.3. In situ measurements of H_2O, CH_4 and CO_2 yielded by the SDLA in Kiruna on 8 August 2002. See text for more details.

Fig.4 shows a zoom on the stratospheric data in Fig.3. The total hydrogen budget is found equal to $[H_2O]+2[CH_4]$ = 7 ppmv+/-0.2 ppmv which is consistent with previous measurements a high latitudes. The CH_4 data were scaled to $-2[CH_4]+7$ and added to Fig.4.

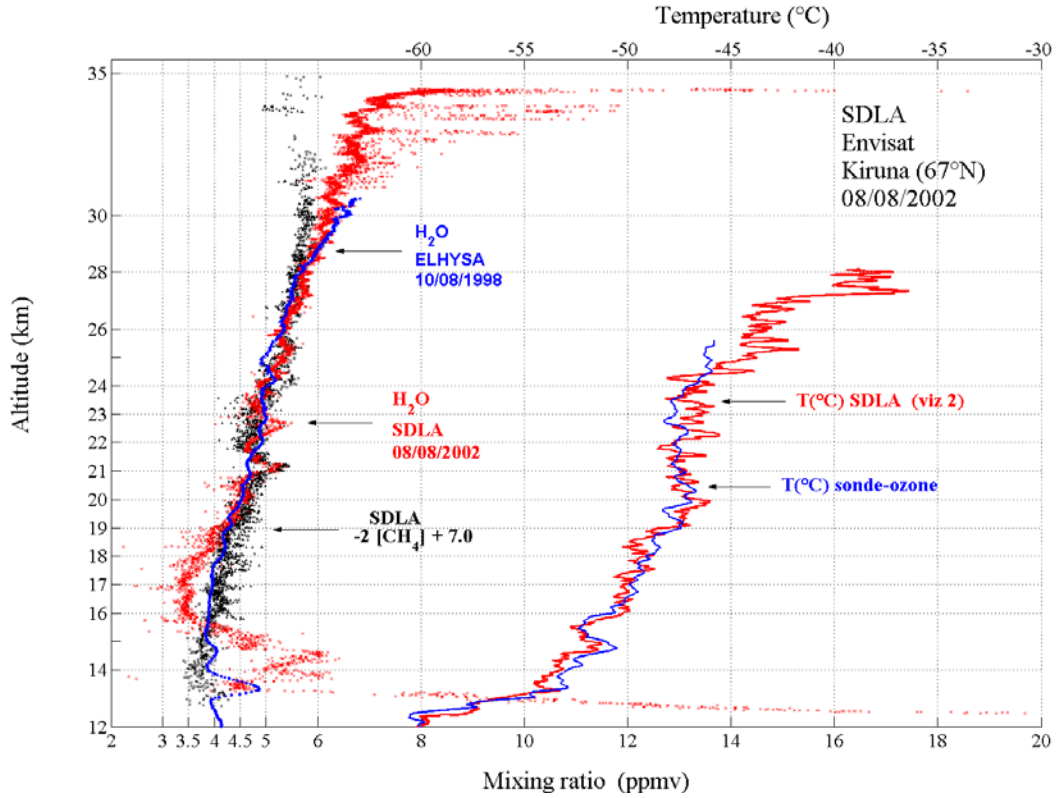

Fig.4. A zoom on the stratospheric measurements in Fig.3. See text for more details.

As can be seen in Fig.4, in the altitude region ranging from 15km to 19km, the SDLA measured low H_2O concentration values; this slight dehydration could be due to the presence of aerosols at the time and place of the flight, which were also detected by lidar soundings from Kiruna. In Fig.4, we have also added the H_2O profile yielded by the ELHYSA hygrometer at the same place and time but four years ago; it is of interest to see the agreement between both profiles despite the four-years lag time.

On September the 16th, the micro-SDLA was flown from Aire sur l'Adour in good agreement with GOMOS overpasses. The achieved H_2O and CH_4 data are made available for the validation of ENVISAT. Fig.5 shows H_2O profile yielded by the micro-SDLA which is superimposed to the H_2O achieved one month before by the SDLA in Kiruna.

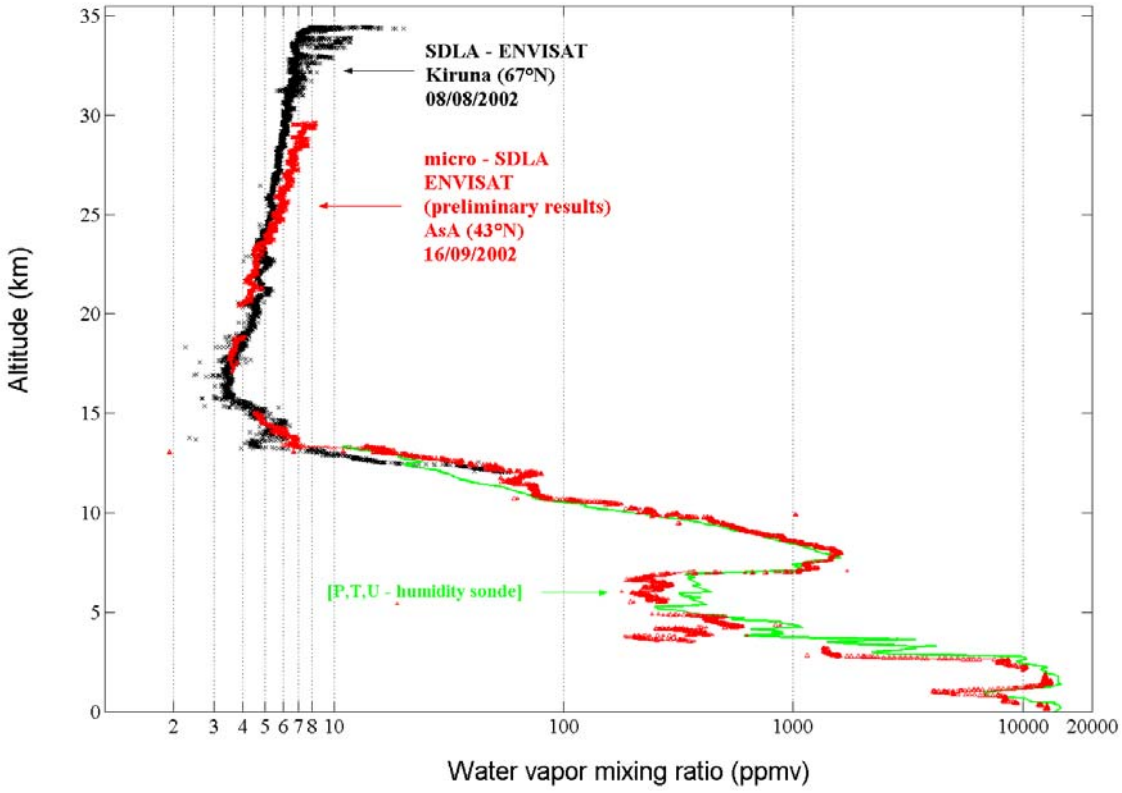

Fig.5. In situ measurement of H_2O yielded by the micro-SDLA laser sensor on September the 16th from Aire sur l'Adour.

Furthermore, the ELHYSA hygrometer was flown twice recently from Kiruna on December the 4th and the 7th within the framework of the CIPA project devoted to the study of Polar Stratospheric Clouds; the achieved H_2O measurements will be available for the ENVISAT validation.

Regarding the GOMOS H_2O data corresponding to the flights of the SDLA and the micro-SDLA at the very beginning of the campaign, presently the profiles feature large discrepancies and inconsistent values. The improvement of the H_2O retrieval algorithm is under way and the comparisons with the in situ data reported in this paper will be carried out as soon as the new H_2O measurements are made available.

3. FUTURE BALLOON ACTIVITIES RELATED TO ENVISAT

Two flights of the SDLA and ELHYSA instruments are scheduled in January 2003 from Kiruna with the purpose of validating the GOMOS H_2O data.

Furthermore, we have proposed a balloon campaign from Aire sur Adour on October 2003 (or on May 2004) to study subtropical intrusions into mid-latitudes (see Fig.6) and its impact on stratospheric O_3 and H_2O using *in situ* data (SDLA, ELHYSA, ionic anemometers, …), satellite measurements (GOMOS, …) and high-resolution advection and trajectory models (MIMOSA, FLEXPART-ST). This program is proposed by the Service d'Aéronomie (SA) and the Laboratoire de Météorologie Dynamique (LMD) to the Programme National de Chimie Atmosphérique (PNCA) and involves a large team of both laboratories. The science evaluation is under way. A joint contribution from ESA and CNES to the flight program is to be considered.

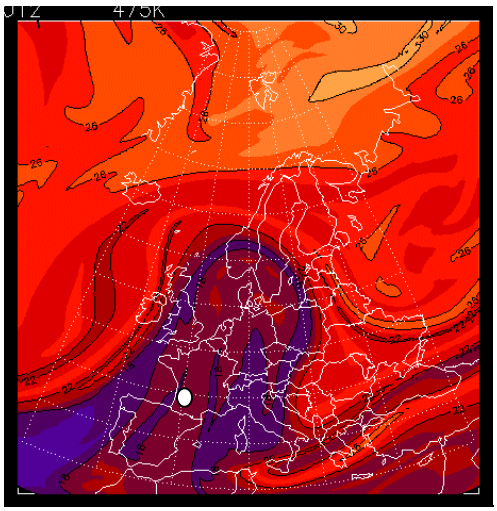

Fig.6. A 475K high-resolution PV-integration obtained with the MIMOSA model (developed by A. Hauchecorne) on 16 October 2001, during the ODIN validation campaign at mid-latitudes (see results in Fig.2). An intrusion of low-PV tropical air is observed. A large dehydration and a depletion of ozone were detected in the lower stratosphere by the SDLA and ELHYSA instruments at the same period; the location of the balloon flights is marked with a white circle [6].

4. REFERENCES

1. Durry G. and G. Megie. Atmospheric CH_4 and H_2O monitoring with near-infrared InGaAs laser diodes by the SDLA, a balloonborne spectrometer for tropospheric and stratospheric in situ measurements , *Appl. Opt.*, Vol. 38, pp 7342-7354, 1999.

2. Durry G. and I. Pouchet. A Near-Infrared Diode Laser Spectrometer for the In Situ Measurements of CH_4 and H_2O from Stratospheric Balloons, *J. Atmos. Ocean. Tech*., 18, 1485-1494, 2001.

3. Pruvost P., J. Ovarlez, J. Lenoble and W.P. Chu. Comparison of Stratospheric Aerosol and Gas Experiment and Balloon-Borne Stratospheric Water Vapor Measurement, *J. Geophys. Res.,* 98, D3, 4889-4896, 1993.

4. Ovarlez Joelle and Henri Ovarlez, Stratospheric water vapor content evolution during EASOE, *Geophys. Res. Lett*., 21, 13, 1235-1238, 1994

5. H. Kanzawa, C. Schiller, J. Ovarlez, C. Camy-Peyret, S. Payan, P. Jeseck, H. Oelhaf, M. Stowasser, W.A. Traub, K.W. Jucks, D.G. Johnson, G.C. Toon, B. Sen, J.-F. Blavier, J.H. Park, G.E. Bodeker, L.L. Pan, T. Sugita,H. Nakajima, T. Yokota, M. Suzuki, M. Shiotani, Y. Sasano , Validation and data characteristics of water vapor profiles observed by the Improved Limb Atmospheric Spectrometer (ILAS) and processed with Version 5.20 algorithm, In press, *J. Geophys. Res*., 2002.

6. Durry G., Hauchecorne A., Ovarlez J., Ovarlez H., Pouchet I., Zeninari V. and Parvitte B. In situ measurement of H_2O and CH_4 with telecommunication laser diodes in the lower stratosphere: dehydration and indication of a tropical air intrusion at mid-latitudes, *J. Atmos. Chem,* 43, 175-194, 2002.