Vertical column abundance and profile retrievals of Water Vapor above the Jungfraujoch

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(1) Institut d'Astrophysique - Université de Liège, B-4000 Liège, Belgium
(2) Institute of Applied Physics - University of Bern, CH-3012 Bern, Switzerland

Selected lines

Lines selected for water vapor retrievals, shown under dry and wet conditions :

Figure 1a : H_2O at 841.90 cm^{-1} (E'' = 52.9 cm^{-1}; S =2.63 x 10^{-24} cm/molec)
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Figure 1b : HDO at 2612.54 cm^{-1} (E'' = 490.4 cm^{-1}; S = 3.34 x 10^{-24} cm/molec)
SSG102 : 18 feb 1992, 0.07 mm HDO; SSK452 : 12 sep 1993, 4.2 mm HDO
Figure 1c : H_2O at 4580.07 cm^{-1} (H_2O; E'' = 224.8 cm^{-1};S = 1.03 x 10^{-24} cm/molec)
SSF262 : 22 nov 1991, 2.6 mm H_2O; SSF814 : 21 jan 1992, 0.25 mm H_2O

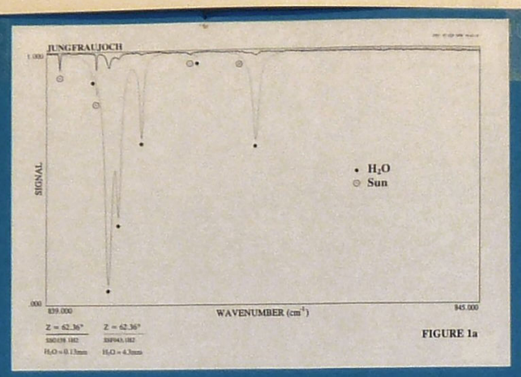

FIGURE 1a

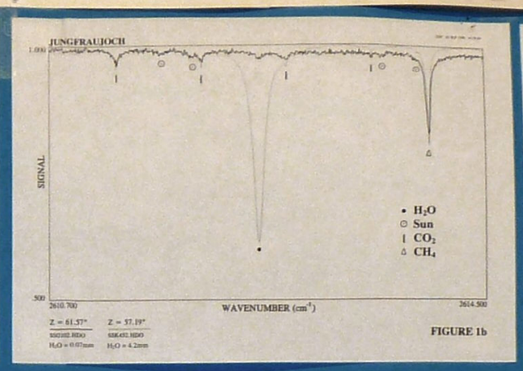

FIGURE 1b

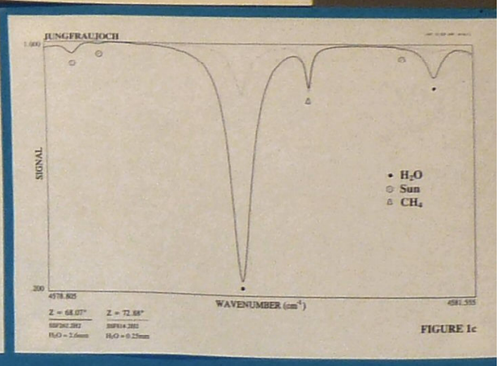

FIGURE 1c

FTS – SPM intercomparison

SPM = sun photometer SPM–2000
- operated by University of Bern
- 12 bands, from 370 to 1025 nm
- band width : 5 nm
- 1 measurement every 15 sec.
- 946 nm channel used for water retrieval

FTS = Fourier transform spectrometers
- 2 instruments, operated by University of Liège
- range : 1 to 15 μm
- very high resolution : 0.0010 to 0.0025 mK
- water lines used : 841.90, 2612.54 and 4580.07 cm^{-1}

Intercomparison campaigns :
- sept. – dec. 1993 (water amounts : 0.17 to 4.2 mm)
- june – july 1995 (water amounts : 0.72 to 5.0 mm)

Summary :

line	841.90 cm^{-1}		2612.54 cm^{-1}	
campaign	1993	1995	1993	1995
# coincident spectra	13	87	69	81
mean H2O (mm)	1.07	2.30	1.04	2.29
bias FTS–SPM (mm)	0.21	0.025	0.042	–0.046
stdev (mm)	0.21	0.111	0.095	0.207
rel. bias	20%	1%	4%	–2%
rel. stdev	20%	5%	9%	9%

Conclusion:
To obtain the same water column as the SPM (arbitrarily choosen as a reference), we have to divide the column obtained from the
841.90 cm^{-1} line by 1.108
2612.54 cm^{-1} line by 0.937
4580.07 cm^{-1} line by 1.53

Reference :
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Examples of H_2O fitting

Figure 4a : example of fitting the H_2O line at 841.90 cm^{-1}, giving a water vapor vertical column abundance of 5.60 x 10^{21} molec/cm^2 above Jungfraujoch. H_2O VMR profile used was MIXH2O.I (figure 5b).

Figure 4b : example of fitting the HDO line at 2612.54 cm^{-1}, giving a water vapor vertical column abundance of 2.57 x 10^{21} molec/cm^2 above Jungfraujoch. HDO VMR profile used was MIXH2O.8 (figure 5a).

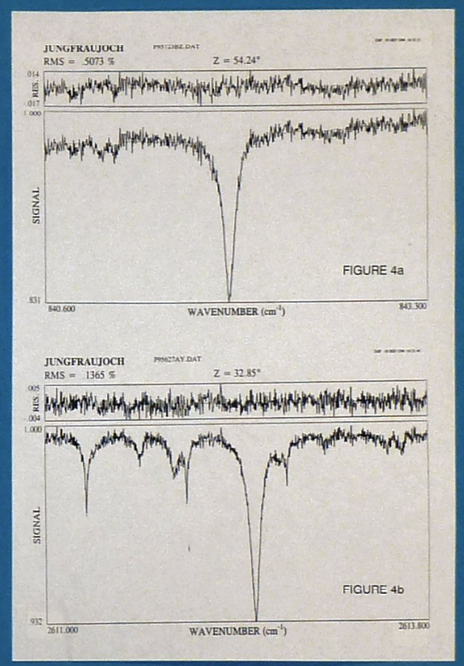

FIGURE 4a
FIGURE 4b

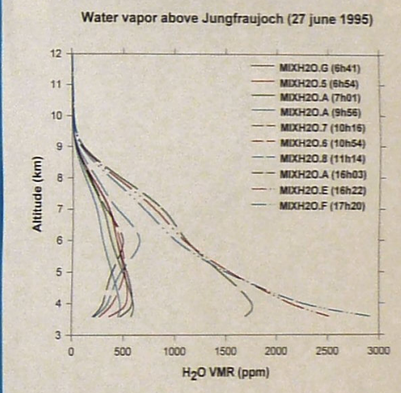

FIGURE 5a

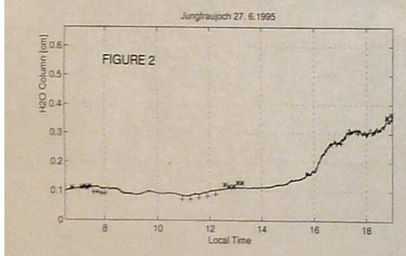

FIGURE 2

Example of water columns measured simultaneously by the SPM (continuous curve) and the FTS (* symbol for the line @ 841.90 cm^{-1}, + symbol for the line @ 2612.54 cm^{-1}) on June 27th,1995. For that particular day, mean difference between FTS and SPM was –7 % for the 841.90 cm^{-1} line and 5 % for the 2612.54 cm^{-1} line.

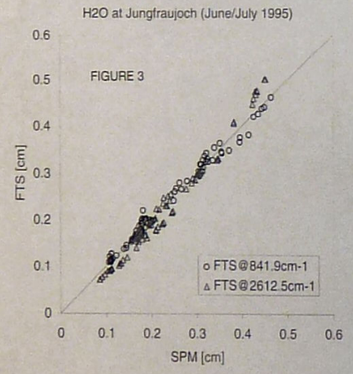

FIGURE 3

Comparison of the water columns retrieved during the 1995 campaign by the FTS and by the SPM.

Vertical profile tests

When fitting spectra with the SFIT program, the "effective apodization" parameter may be adjusted during the procedure. This parameter indicates how different the profile of a line in the observed spectrum is from the computed profile : an effective apodization greater than 1 means that the computed profile is too broad and a value less than 1 means that the computed profile is too narrow.

The parameter can be used to obtain a first approximation of the vertical distribution of H2O in the troposphere because, for the case of the water lines, it is very sensitive to the vertical distribution used, far more sensitive than the r.m.s of the fit.

Iterative method proposed :

1) from a typical "standard" H2O distribution, build a series of vertical distributions of H2O, decreasing more or less rapidly from the ground to the tropopause;those distributions have to be calibrated in some way, i.e. we have to know the change in effective apodization each curve produces.
2) fit the spectrum with the standard H2O distribution
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A few tests have be run, with spectra of June and July 1995, leading to acceptable fits of spectra (see Figures 4a and 4b). Samples of water vapor profiles obtained are reproduced in Figure 5a and 5b.

Important point to notice : water vertical columns change only a little (0–3%) when using a standard H2O distribution or a more realistic one, even if this one is very different from the standard one.

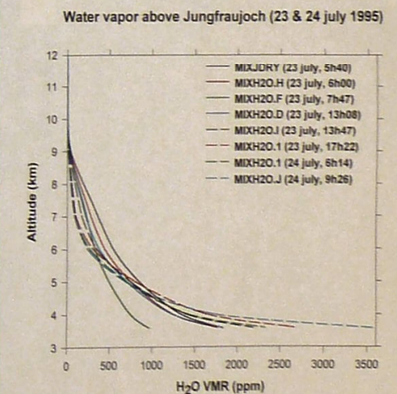

FIGURE 5b

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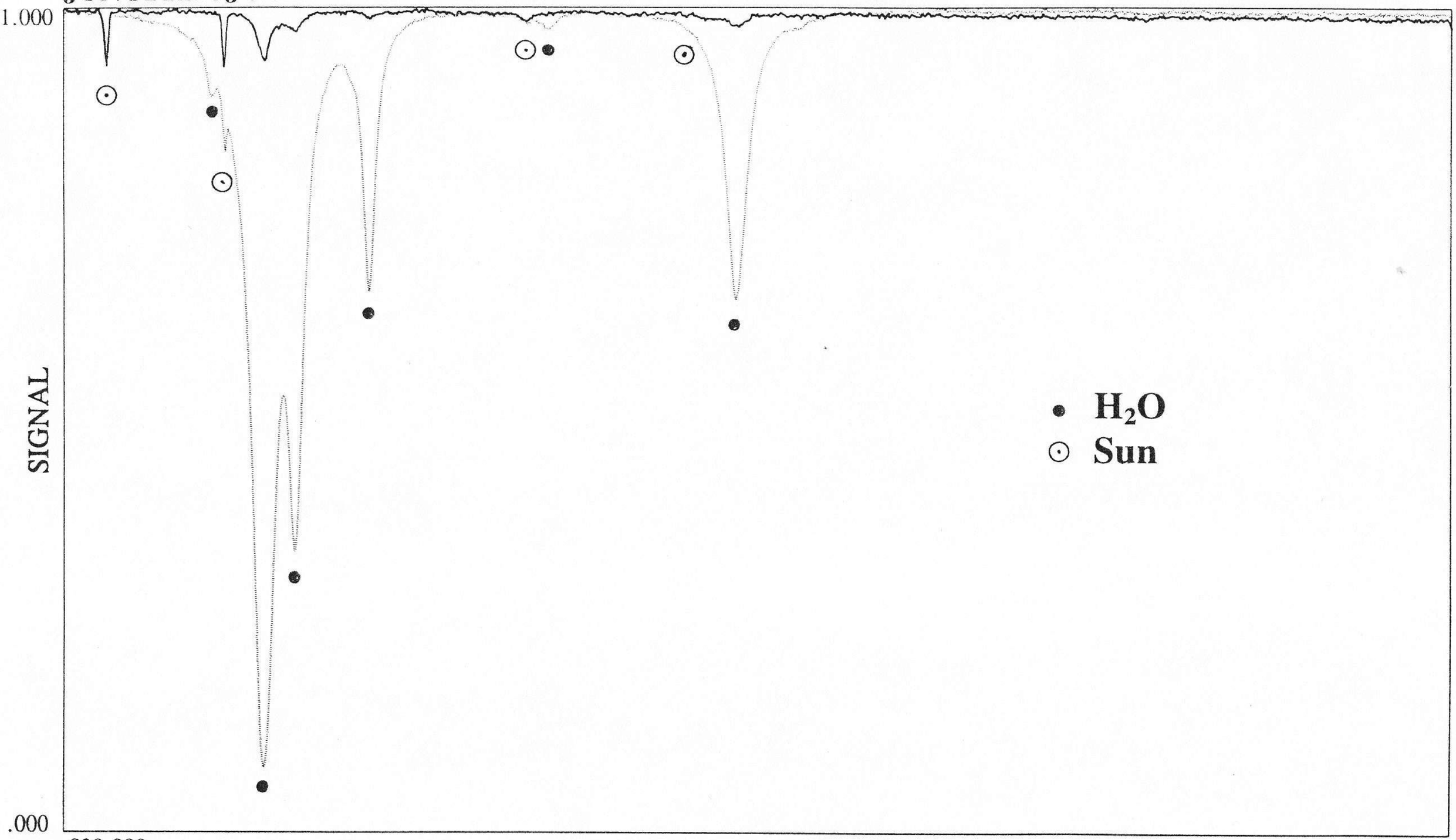
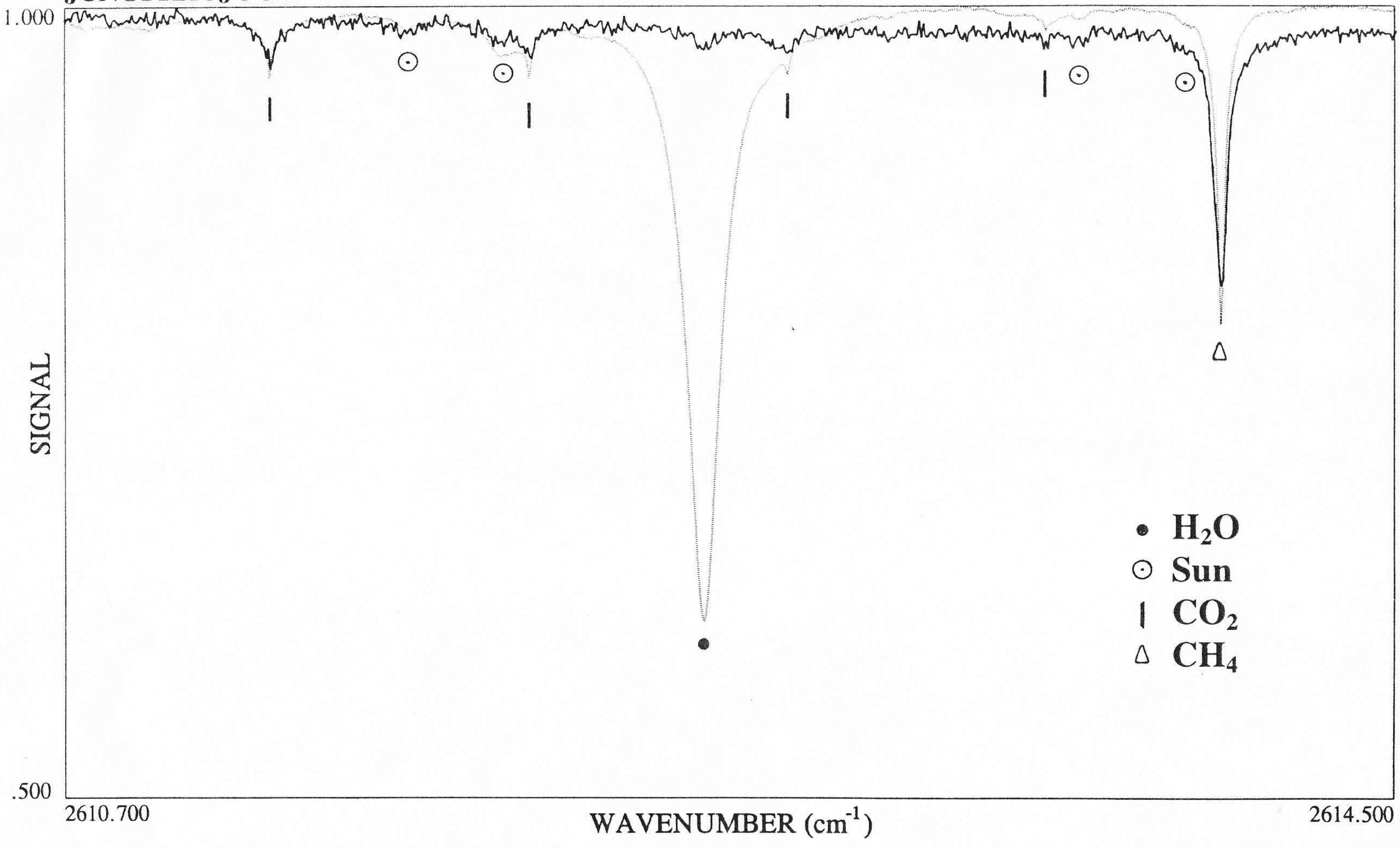


FIGURE 1a

DSP 02 SEP 1996 16:58:09

JUNGFRAUJOCH

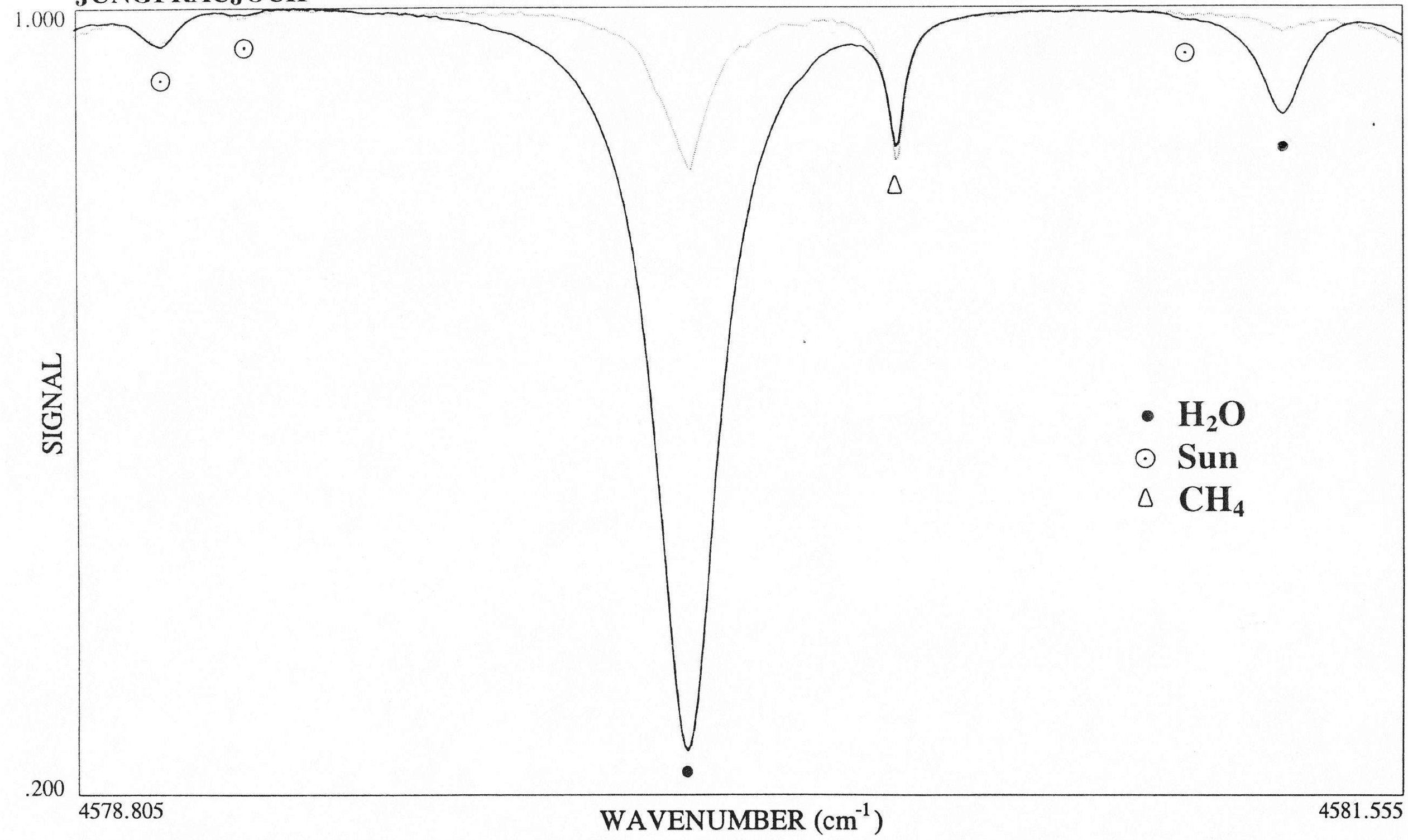


Z = 61.57° — SSG102.HDO — H_2O = 0.07mm

Z = 57.19° — SSK452.HDO — H_2O = 4.2mm

FIGURE 1b

DSP 02 SEP 1996 16:36:12



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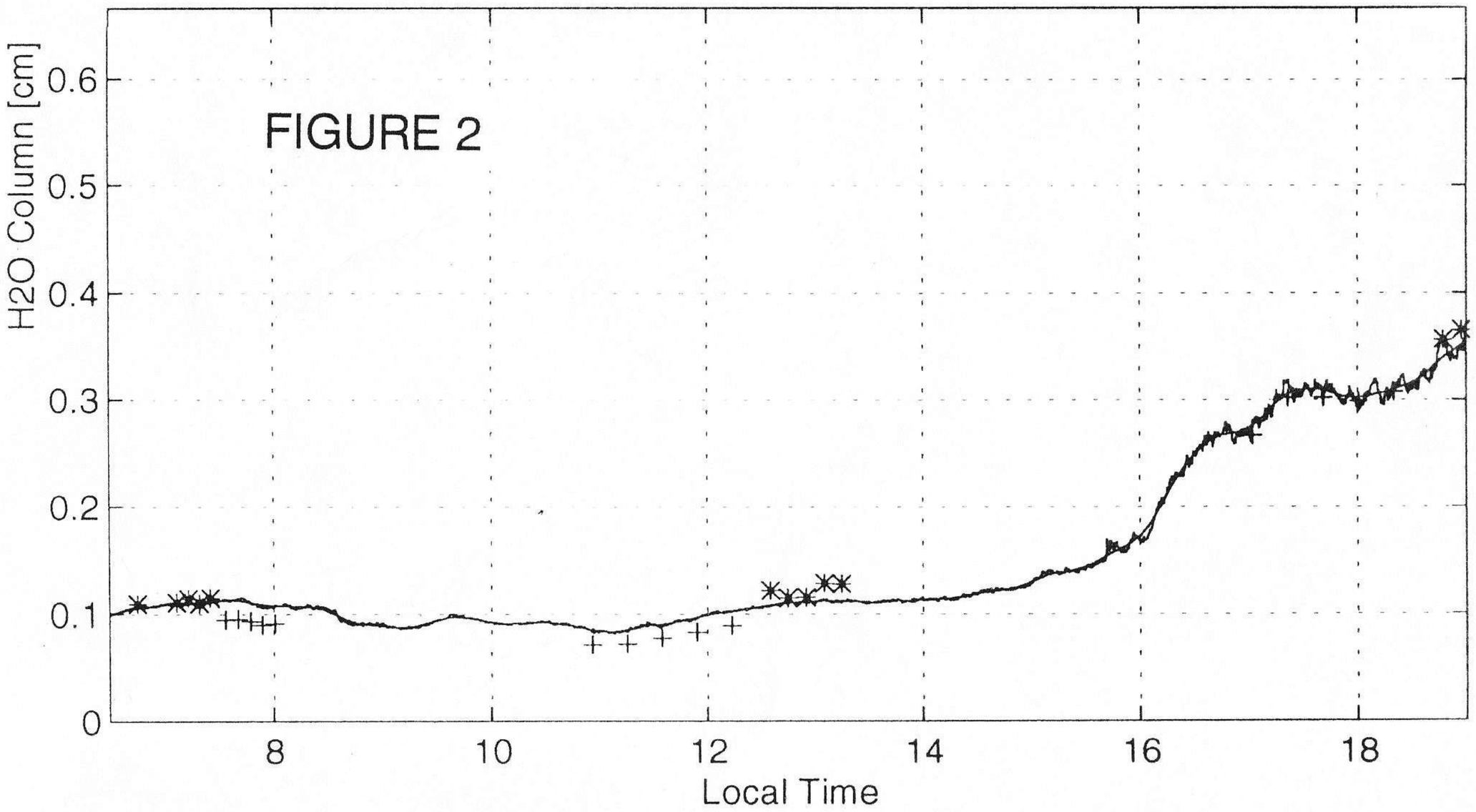

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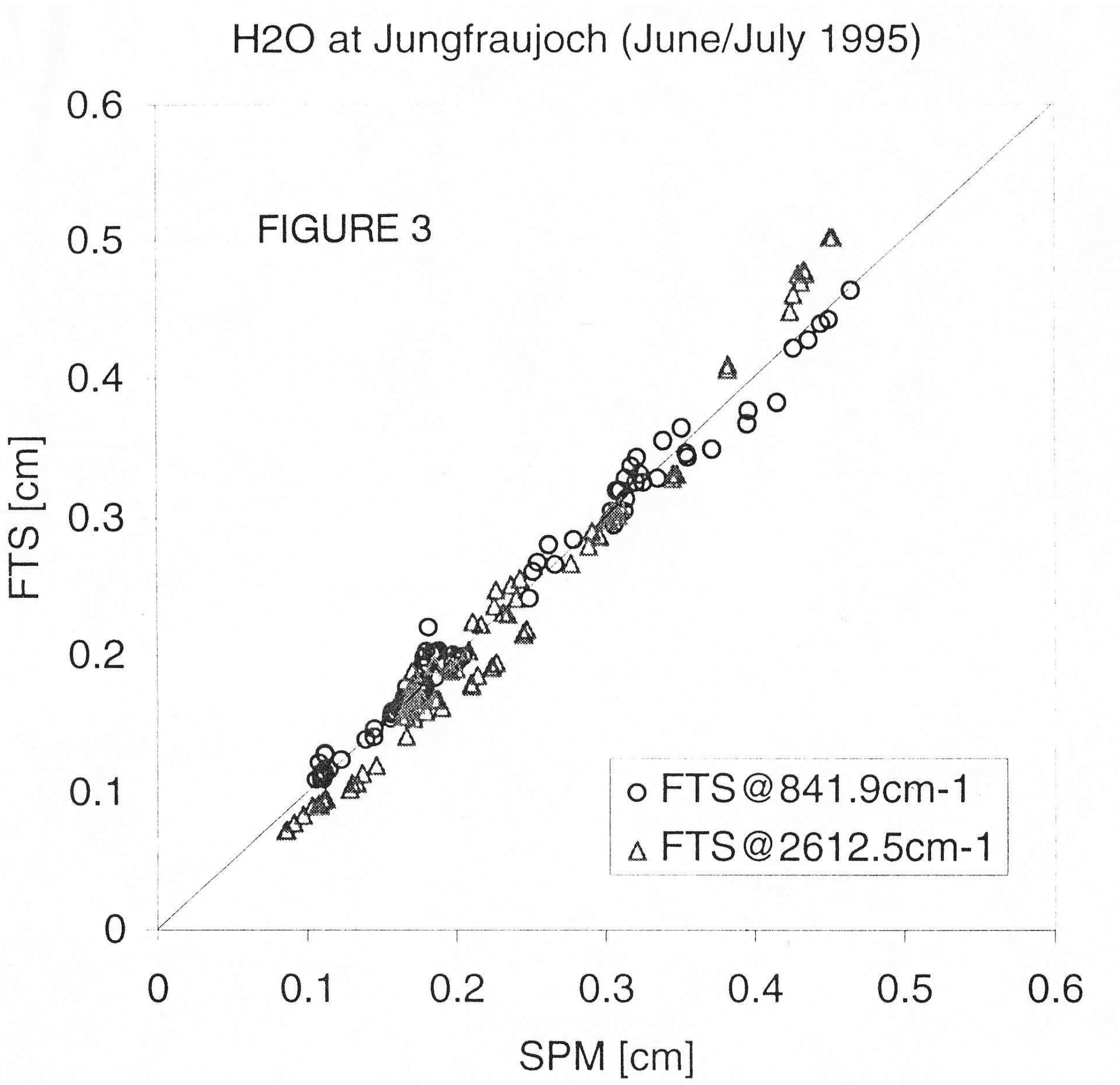

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JUNGFRAUJOCH P95723BZ.DAT

RMS = .5073 % Z = 54.24°

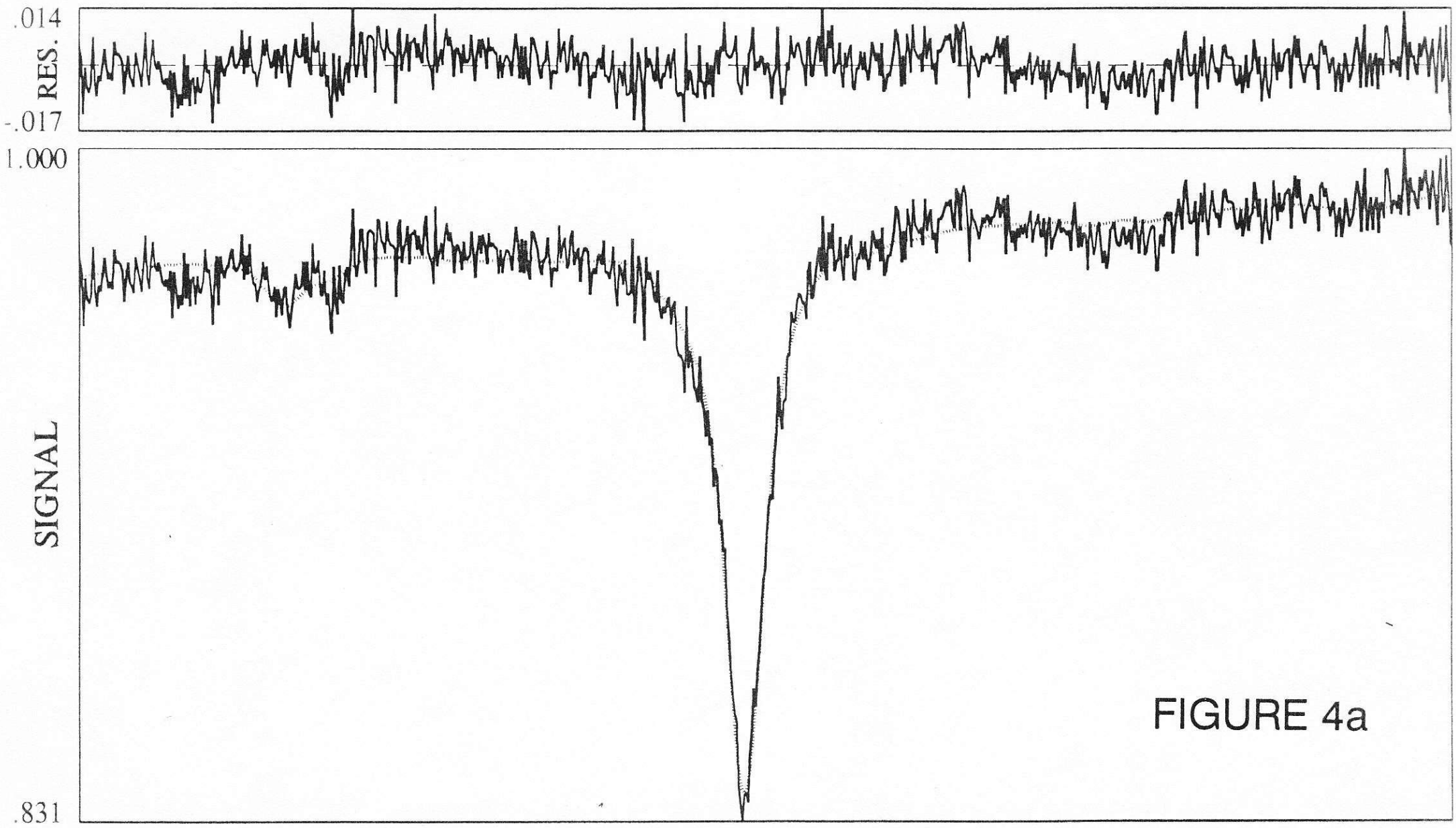

FIGURE 4a

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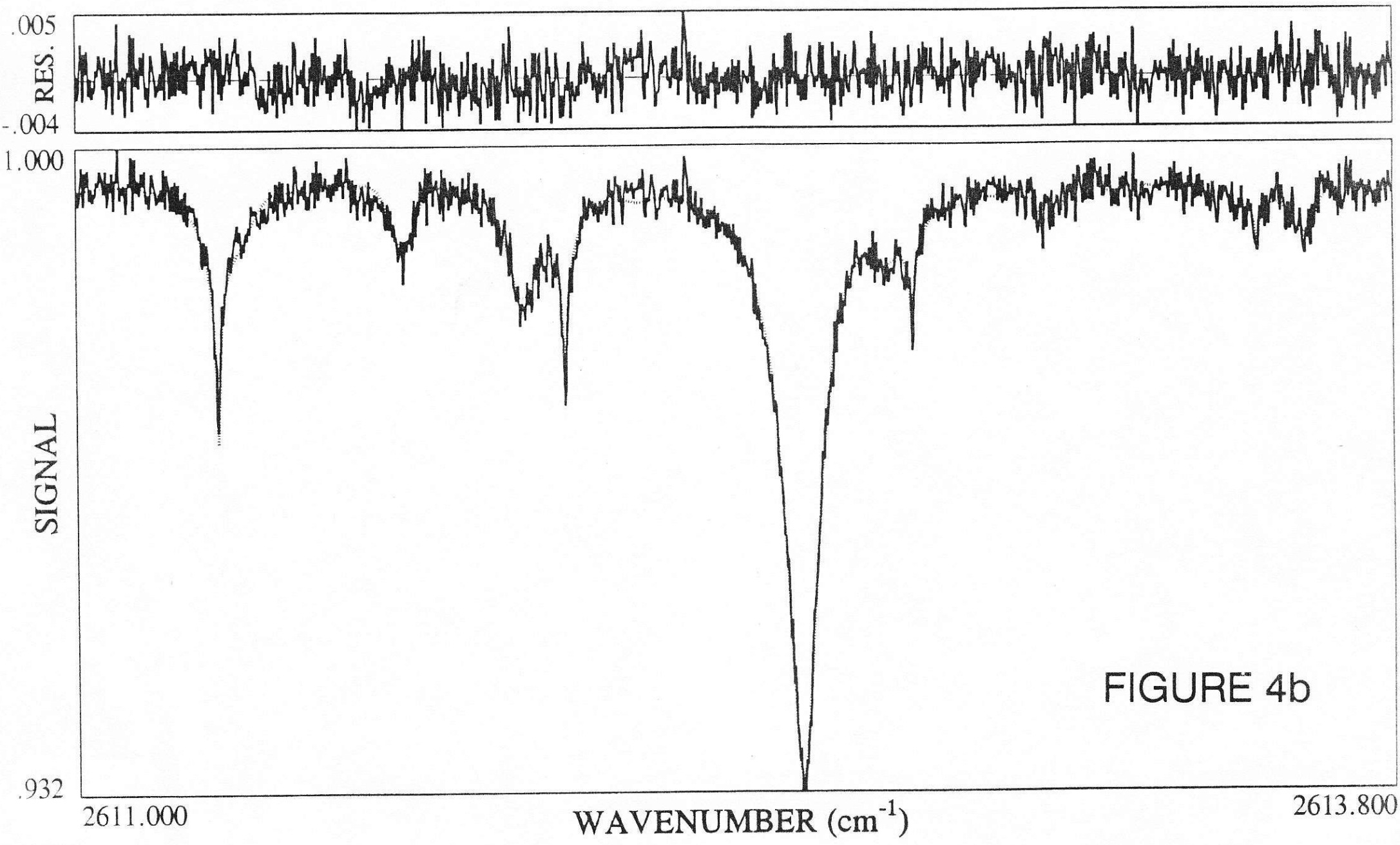
JUNGFRAUJOCH P95627AY.DAT

RMS = .1365 % Z = 32.85°



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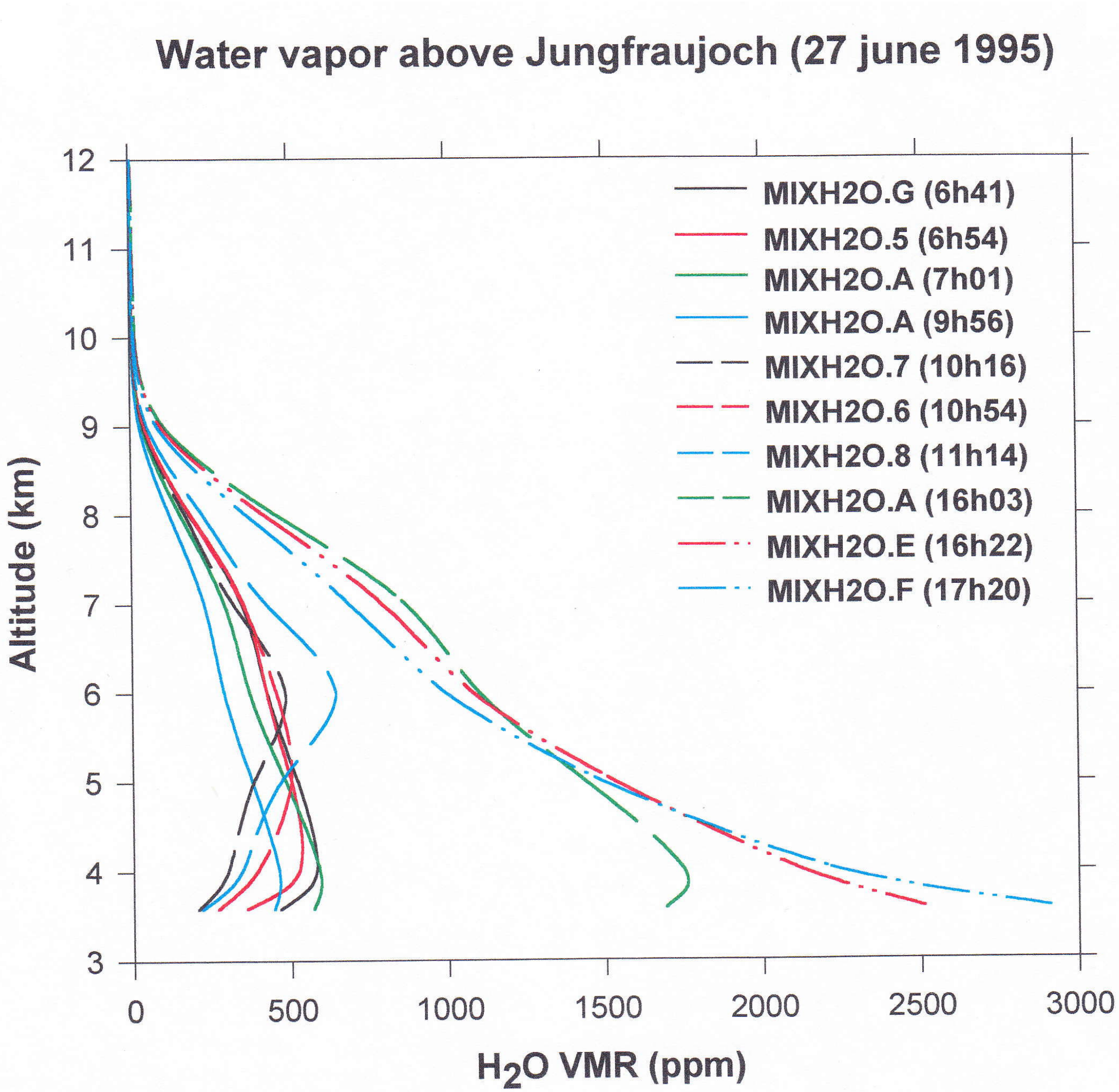
Water vapor above Jungfraujoch (27 june 1995)
MIXH2O.G (6h41)
MIXH2O.5 (6h54)
MIXH2O.A (7h01)
MIXH2O.A (9h56)
MIXH2O.7 (10h16)
MIXH2O.6 (10h54)
MIXH2O.8 (11h14)
MIXH2O.A (16h03)
MIXH2O.E (16h22)
MIXH2O.F (17h20)
Altitude (km)
12
11
10
9
8
7
6
5
4
3
0
500
1000
1500
2000
2500
3000
H2O VMR (ppm)

FIGURE 5a

Water vapor above Jungfraujoch (23 & 24 july 1995)

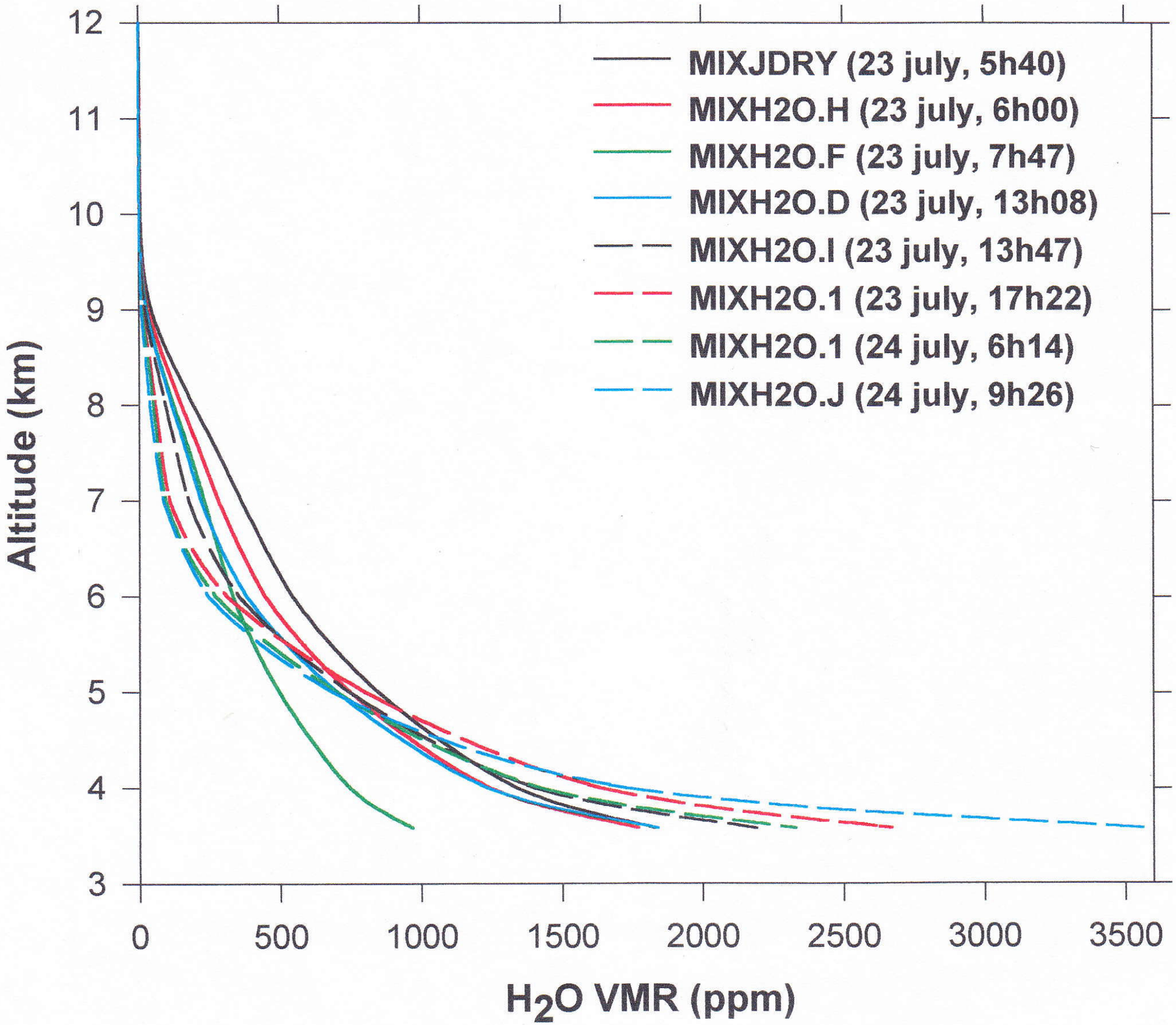

FIGURE 5b