

Water vapor isotopic abundance measurement in Tibetan Plateau based on portable laser heterodyne radiometer

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Abstract: Tibet Plateau is known as the third pole of the world, the environmental changing in this area profoundly impacts on east Asian or even global climate. HDO is the stable isotopes of water vapor and is the ideal tracer of water cycle, which has been applied to atmospheric circulation and climatic studies. For monitoring the water vapor isotopic abundance in Tibetan Plateau and provides reliable information for environmental and climatic studies, a portable laser heterodyne radiometer was operated at Golmud (Qinghai Province) in summer 2019. The radiometer adopted a narrow linewidth 3.66 μm DFB laser as the local oscillator and performed high resolution($\sim 0.009\text{ cm}^{-1}$) and high signal-to-noise ratio(~ 160). Furthermore, the absorption spectra of atmospheric HDO and H_2O were obtained and the retrieval algorithm of water vapor isotopic abundance based on LBLRTM was discussed. The optimal estimation method was chosen for retrieving, the ratio of HDO/ H_2O at Golmud is $185 \pm 7 \times 10^{-6}$ during the observation, the value is less than the Vienna Standard Mean Ocean Water (VSMOW, 311.5×10^{-6}) but larger than Standard Light Antarctic Precipitation (SLAP, 178.2×10^{-6}).

Introduction

- ◆ The abundance of the water isotopic composition are useful for the study of aspects of the hydrological cycle, as well as for monitoring global and regional climate change.
- ◆ The study of the isotopic composition of water vapor in the atmosphere can identify the source region and analyze climate change.
- ◆ The variation of the abundance also releases the degree of ocean pollutions, it is helpful to find the pollution sources.
- ◆ The laser heterodyne radiometer and the optimal estimation method are suitable for the measurement of HDO/ H_2O ratio.

Methods and Materials

Measurement Instrument

- (1) Laser Heterodyne Radiometer (LHR).
- (2) High sensitivity and resolution.
- (3) Little volume, easy operation and low cost.

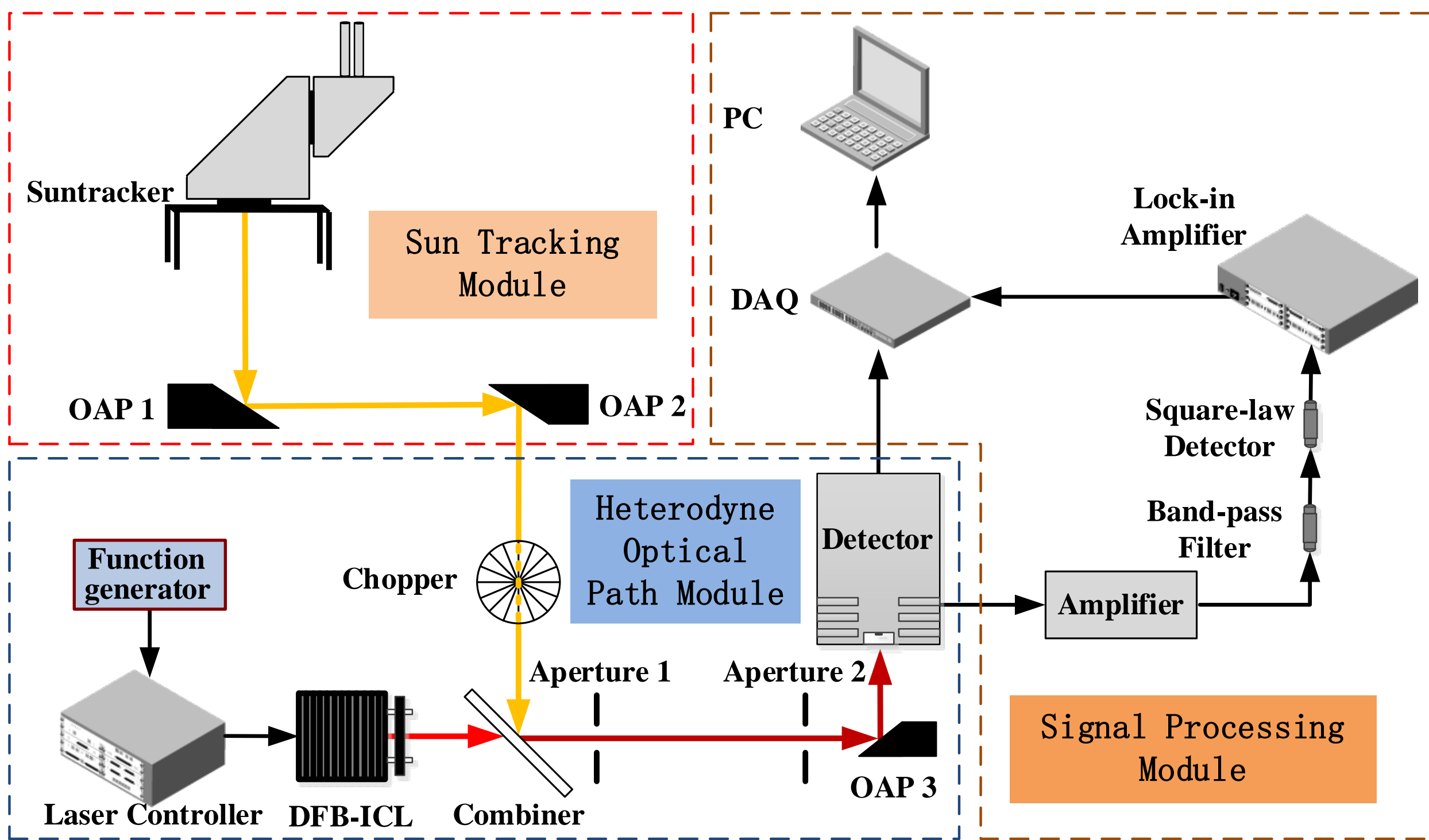


Figure 1. Schematic figure of LHR

Parameter	During Measurements
Frequency coverage	2730.4~2732.8 cm^{-1}
SNR	~ 160
Spectral resolution	$\sim 0.009\text{ cm}^{-1}$
Target species	H_2O , HDO
Interfering species	CO_2 , O_3 , CH_4

Table 1. Specifications of the Laser Heterodyne Radiometer

Retrieval Algorithm

- (1) Optimal Estimation Methods (OEM).
- (2) The *priori* from ECMWF (European Centre for Medium-Range Weather Forecasts).
- (3) Forward model is LBLRTM (Line-By-Line Radiative Transfer Model).

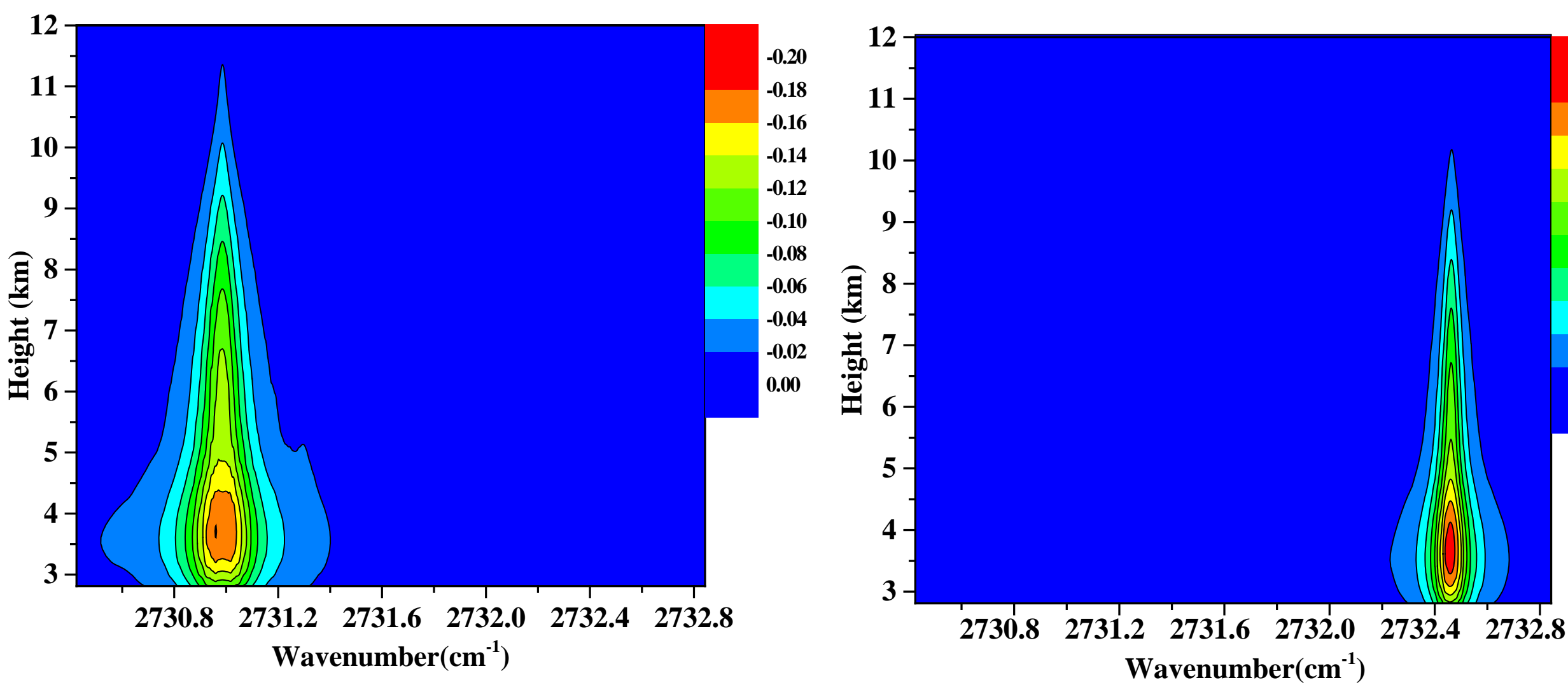


Figure 2. Jacobian value of HDO (left) and H_2O (right)

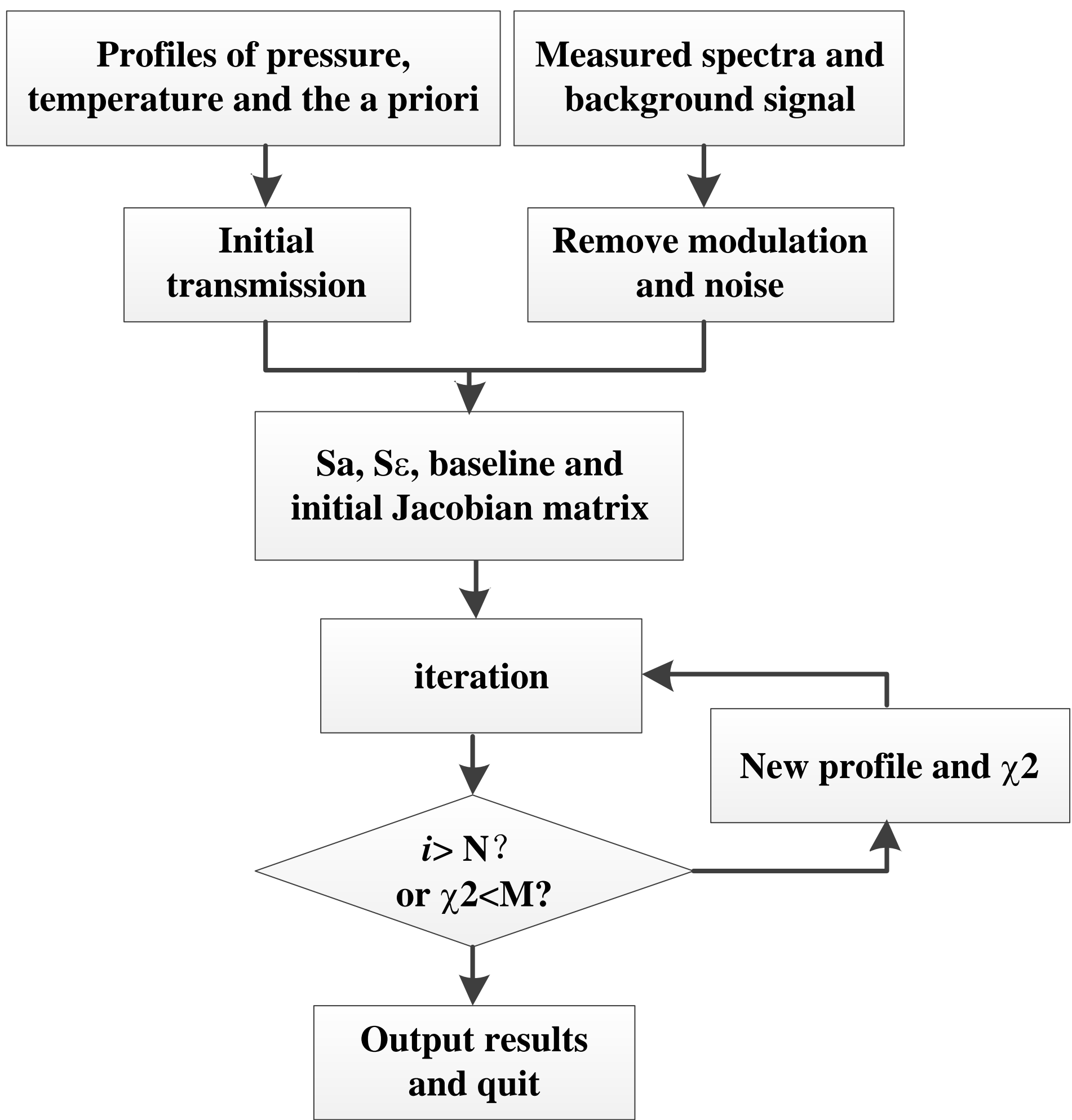


Figure 3. Flow chart of retrieval method

Results

1. The absorption spectra of HDO and H_2O in 3.66 μm at Golmud have been obtained.
2. The residuals of retrieval fitting are less than 0.1.
3. The ratio of HDO/ H_2O is $185 \pm 7 \times 10^{-6}$ at Golmud during the observation.

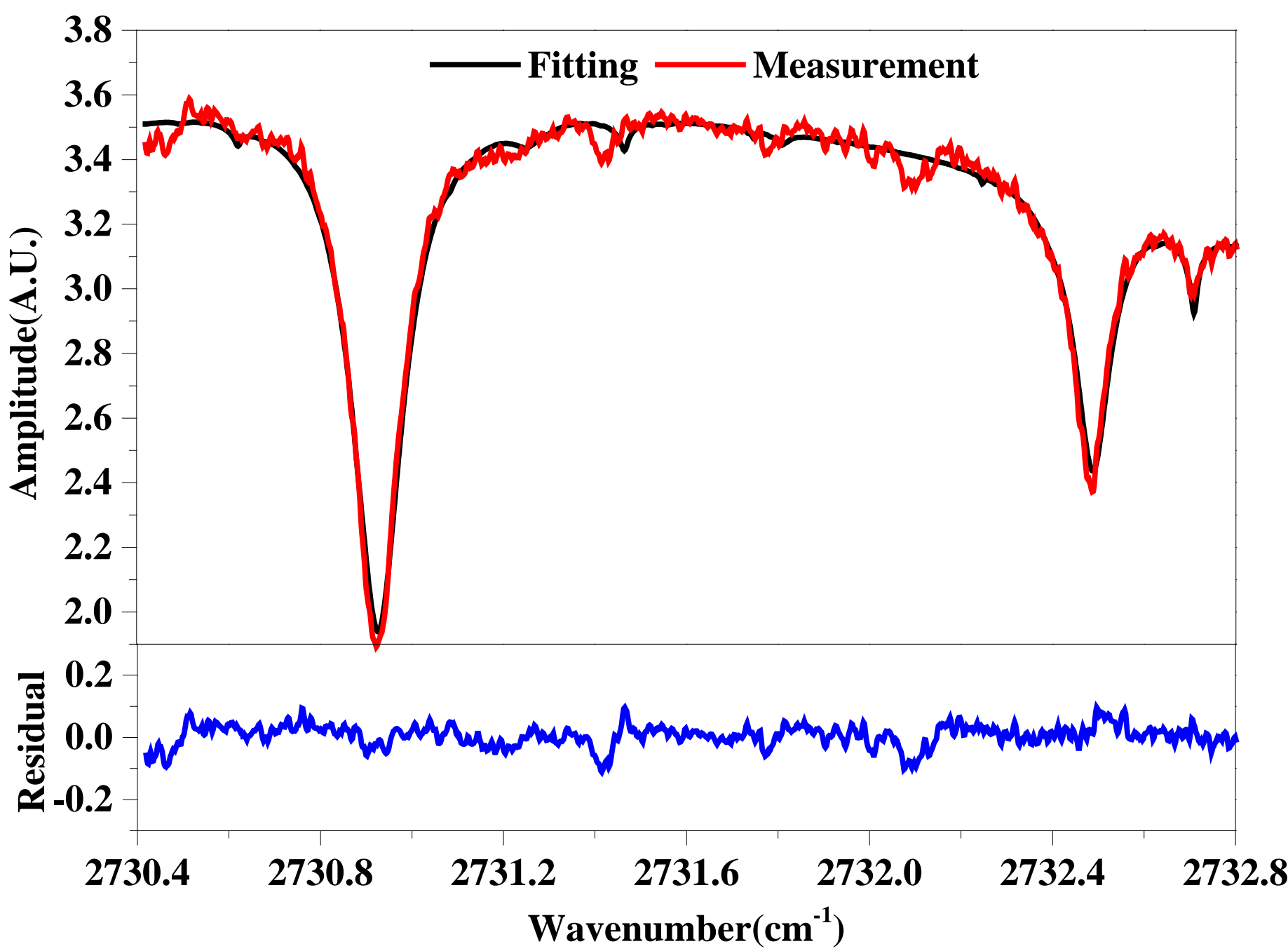


Figure 4. The measured spectra (black line) and the fitting (red line)

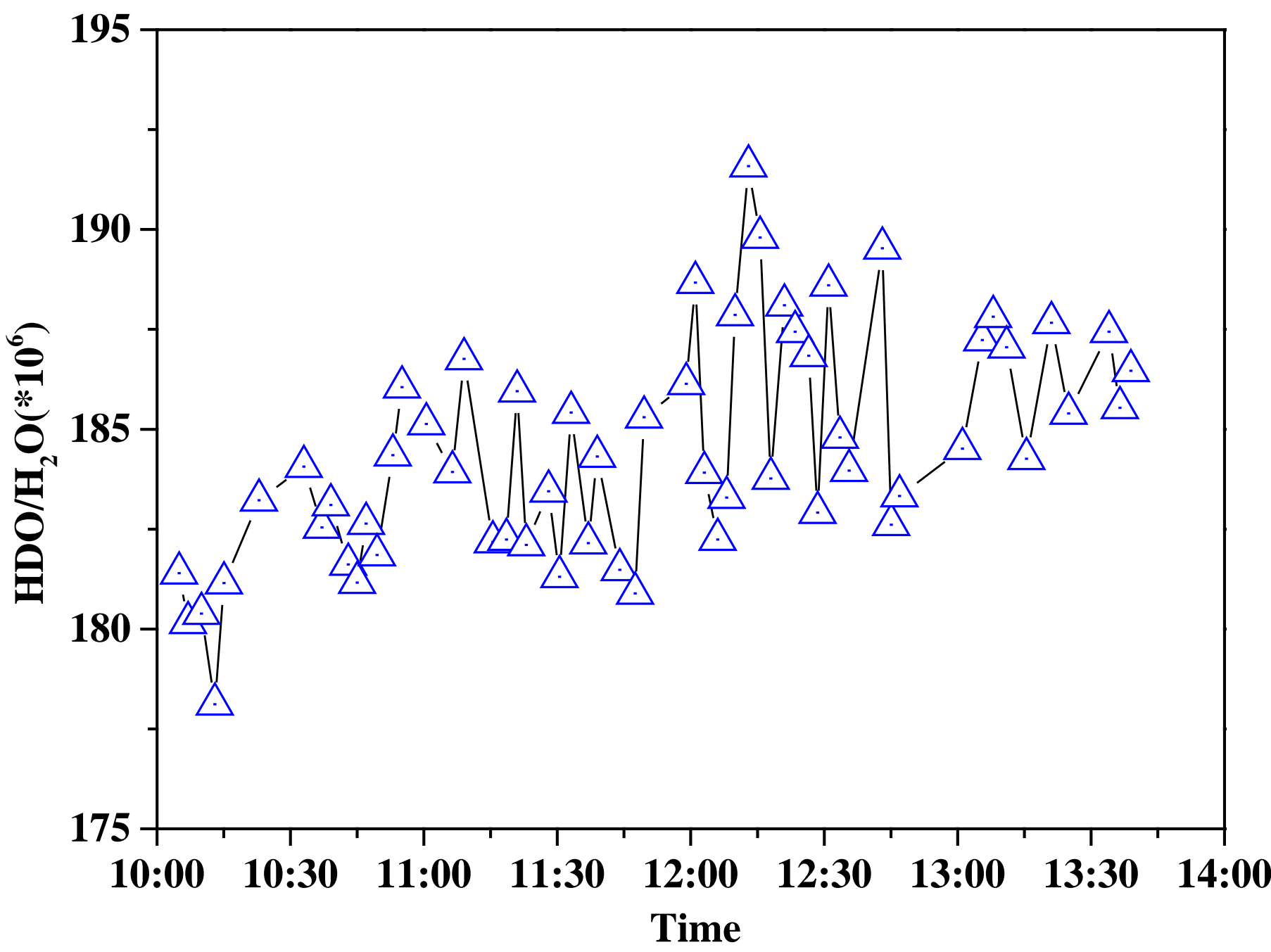


Figure 5. The ratio of HDO/ H_2O at Golmud on August 2nd

Conclusions

1. LHR is the powerful instrument for obtaining solar spectra transmitted the total atmosphere.
2. The optimal estimation method is suitable for the study of greenhouse gases and isotopic abundance.
3. The ratio of HDO/ H_2O at Golmud is much smaller than the coastal areas.