Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

AAS21-P07 Room:Convention Hall Time:May 27 18:15-19:30

Measurement of stable isotope ratios of atmospheric carbon dioxide by wavelength modulation absorption spectroscopy with

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Since the industrial revolution, the concentration of carbon dioxide, a greenhouse gas is increasing every year, it has become a cause of global warming. Carbon dioxide is released from various emission sources and is absorbed to different sinks. Carbon dioxide is circulated among the atmosphere, hydrosphere, and geosphere. For suppression global warming, there is a need to accurately grasp the emissions and removals of carbon dioxide between these reservoirs. Measurement of concentration and stable isotope ratio of carbon dioxide provide us useful information in order to elucidate the carbon cycle. Therefore, we focus on the approach to use the stable isotope as an index. Carbon dioxide has stable isotopes, $^{12}CO_2$, $^{13}CO_2$, and $^{12}C^{18}O^{16}O$, it is known that these isotope ratios are different for each emission source.

As one of conventional measurement techniques of isotope ratios which has been used, there is isotope ratio mass spectrometry (IRMS) technique. Although this technique has a very high measurement precision (0.01-0.1 ‰), it cannot be measured outside the laboratory because the device is a large. Therefore, a laser absorption spectroscopy in recent years has been attracting attention. This technique is excellent in portability since the device can be made compact. Also, because suitable selection of absorption lines prevents interference from other species, the sample can be introduced directly to the device. Therefore, the device can be carried to the location where we want to measure the stable isotope ratio of carbon dioxide, it is possible to perform real-time measurements at high time resolution.

In this study, we constructed a high-precision measuring device of atmospheric carbon dioxide stable isotope ratios, using wavelength modulation absorption spectroscopy with a newly developed 2.8 μm DFB laser and a Heriot type multi-pass reflection cell. In the measurement, absorption lines are selected in terms of being continuous of $^{12}CO_2$, $^{13}CO_2$ and $^{12}C^{18}O^{16}O$ and small interference from water around 2.8 μm. Wavelength modulation absorption spectroscopy allows improved sensitivity and zero background measurement by modulating wavelengths at a high frequency and performing heterodyne detection.

Keywords: carbon dioxide, stable isotope, near-infrared absorption spectroscopy