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Portable near-infrared heterodyne spectroradiometer for atmospheric CO_2 precision measurements.

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We present a portable, lightweight, and low-cost near-infrared laser heterodyne spectroradiometer (LHS) with a high spectral resolution of 0.0003 cm-1. Due to advanced capabilities provided by its ultra-high spectral resolution, such an instrument may be included into ground-based networks for monitoring greenhouse gases. Sample spectra of the atmospheric CO_2 absorption lines obtained by direct Sun observations have allowed us to measure CO_2 column abundance with a precision of 0.5% and to retrieve its vertical profiles.
The previous version of the LHS described in Rodin et al. (2014) has demonstrated capabilities of methane vertical profiling. Further modification of the LHS is characterized by the upgraded system of laser frequency stabilization, digital intermediate frequency (IF) signal processing, and the automated solar tracking system. Highly stabilized DFB laser coupled with a single mode optical fiber is used as a local oscillator (LO), which emits at the wavelength $\lambda \approx 1.6$ μm. LO frequency is modulated by a ramping law using an integrated-cavity multiple pass cell filled with CO_2 at 150 mbar as a reference. We employ a single mode optical fiber coupler to mix solar radiation transmitted through the Earth atmosphere with the LO radiation and to pass the mixed radiation to the InGaAs photodiode. The beat signal from the photomixer is analyzed by the IF receiver within the bandpass of $\sim$ 20 MHz. The Rohde & Schwartz RTO 1012 oscilloscope with self-developed LabView software were used to get absorption spectra on the PC.
CO_2 measurements were made in Moscow suburb near the industrial zone. 10 min of signal integration are chosen as an operation mode of the LHS, which lets to achieve SNR $\sim$ 100. The inverse problem solution algorithm based on the principle of maximal entropy results in the evaluation of the CO_2 atmospheric column with the accuracy comparable with the measurements of high resolution FTIR spectrometers. Due to the extreme spectral resolution, additional capabilities are appearing, including vertical profiling of greenhouse gas concentration and winds.

References:
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