Sensitivity studies of the 4.8 micron carbon dioxide absorption band for high temperature events

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Measuring the sources of carbon dioxide is of high interest in order to know the distribution of this greenhouse gas and quantify the natural/anthropogenic emissions. The aim of the present study is to understand the capability of the absorption band at 4.8 µm to detect and measure the CO$_2$ emissions from different HTEs (High Temperature Events) like degassing plumes from active volcanic sources, fires and industrial emissions. The performance of this channel was investigated by using the MODTRAN (MODerate resolution atmospheric TRANsmission) radiative transfer model. Simulations of the TOA (Top Of Atmosphere) radiance have been performed by using real input data to reproduce realistic scenarios on a volcanic high elevation point source (>2 km). The sensitivity of the channel has been analysed varying CO$_2$ concentrations (in the range 0-1000 ppm) and surface temperatures from standard (300 K) to high temperature (1000 K). Moreover, typical response functions of imaging sensors carried on aircraft and operating in the Middle Wave InfraRed (MWIR) spectral region were used: the channel width values of 0.15 µm and 0.30 µm were tested. Simulations provide results about the sensitivity necessary to appreciate carbon dioxide concentration changes considering a target variation of 10 ppm in the gas column concentration. The results show the strong dependence of at-sensor radiance on the surface temperature: radiances sharply increase, from 1 Wm$^{-2}$sr$^{-1}$µm$^{-1}$ (in the standard condition) to >1200 Wm$^{-2}$sr$^{-1}$µm$^{-1}$ (in the warmest case). The highest sensitivity has been obtained considering the channel width equal to 0.15 µm with noise equivalent delta temperature (NEDT) values in the range from 0.045 to 0.560 K at surface temperatures ranging from 300 to 1000 K. Furthermore, data acquired by the multispectral MASTER (Modis ASTER) airborne simulator on Kilauea volcano (Hawaii), during the January/February 2018 campaign, were considered. The aim is to estimate lava flow/lake temperatures and to test the channel at 4.8 µm for retrieving CO$_2$ emissions on volcanic craters.