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Volcanic gases in the SWIR-MWIR spectral range: simulations of CO_2 absorption band at 4.81 micron

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The measurements of gases concentration in atmosphere and in volcanic plumes and clouds with the identification of their spatial distribution are recently developed thanks to availability of the gases absorbing spectral channels in the space sensors. In particular, measuring the volcanic source of Carbon Dioxide from space represents a challenge, due to the high interest in knowing the distribution of this greenhouse gas and quantifying the natural source as volcanoes represent. The aim of the present study is to understand the capability of the spectral channel at 4.81 μm to detect and measure the CO_2 concentration in the atmosphere and in a degassing volcanic plume. The performance of this channel was investigated by using the MODTRAN (MODerate resolution atmospheric TRANsmission) radiative transfer model. The TOA (Top Of Atmosphere) radiance simulations have been operated with realistic input data to reproduce scenarios in the Mt. Etna volcanic area: vertical atmospheric profiles of pressure, temperature and humidity are obtained from probe balloons launched from Trapani (Sicily region). Several simulations were carried out to analyse the sensitivity of the channel to the CO_2 concentration, considering in particular the presence of the water vapour whose absorption influences the 4.81 μm band. Furthermore, to evaluate the response of a real satellite sensor to incoming radiances, typical response functions of operational sensors were used. In particular, the response function of the MASTER (Modis ASTER) airborne simulator is considered and adapted, maintaining the same shape and enlarging the FMHW (Full Width at Half Maximum) to 0.30 μm. The simulations show the impact of the water on CO_2 absorption band, leading to a radiance decrease (at the sensor) of about 0.15 W/m2*str*μm. A correct evaluation of the water concentration in the atmosphere is necessary to remove this contribution in radiance. Moreover, the sensitivity studies indicate that a doubling of the CO_2 concentration (i.e. from 400 to 800 ppm) determine a decrease in radiance of about 0.07 W/m2*str*μm; these simulations provide preliminary indications on the signal/noise ratio necessary to appreciate the carbon dioxide variations and then retrieving its concentration.