# CO2 dynamics in volcanic lakes from hydroacoustic and complementary measurements

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Echosounding surveys have been performed on Indonesian (Rinjani, Kelud, Kawah Ijen, Galunggung) and Philippian (Taal) volcanic lakes with a SIMRAD ES60 single beam, dual frequency (50 and 200 kHz) echosounder, since 2007. CO2 gas bubbles are strong scatterers of incident acoustic waves. Echosounding methods might therefore be helpful for mapping gas emissions at the floor of volcanic lakes and to quantify fluxes of CO2 emitted through the lake. We focus on the analysis of echo sounding profiles recorded in Kelud volcanic lake where gas bubbles were found to mostly contain CO2.

In November 2007, the extrusion of a new lava dome evaporated Kelud volcanic lake in Java, Indonesia. 4 months before a detailed echo sounding survey of the volcanic lake coupled to floating accumulation chamber measurements detected abnormally high carbon dioxide emissions. It constituted the earliest sign of the volcanic unrest; well before any other monitored parameter. CO2 flux is quantified using an empirical equation based on the volume of bubbles backscattered in the water column. Its comparison with the fluxes retrieved from the floating chamber method better constrain carbon dioxide dynamics in the volcanic lake. It reveals that 70 % of the carbon dioxide enters the lake in a dissolved form, while the remaining 30 % is supplied to the lake on a gaseous state. Almost three-quarter of the ascending bubbles dissolve in the water column leaving the majority of the 330 Tons/day of carbon dioxide diffusing at the air-water interface.

Some recent results from Taal volcano (2011-2012) will also be discussed.

As echo sounding lakes/caldera is fast and non invasive, this method could thus provide useful information on degassing processes especially when coupled with complementary methods.