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Nine years of monitoring diffuse CO_2 degassing from Taal volcanic crater lake, Phillippines

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Taal volcano is one of the most active volcanoes in the Philippines and has produced some of its most powerful historical eruptions. Located on the southwestern part of Luzon Island in the Philippines Archipelago, the volcano consists of a 15-22-km prehistoric caldera, occupied by Lake Taal, the active vent complex of Volcano Island and the Crater Lake (TCL), 1.9 km in diameter. Six of 24 known eruptions at Taal since 1572 have caused many fatalities, and several million people live within a 20-km radius of Taal's caldera rim, making the volcano the largest threat to the Philippine population. An alarming increase in seismicity, gas emission, deformation and temperature of the TCL, from March 2011 was interpreted as the result of a new magma intrusion beneath TCL (Arpa et al., 2013). Between 2008 and 2014, ITER/INVOLCAN has collaborated with PHIVOLCS and from 2015 at to present with the University of the Philippines, also counting with the support of the Spanish Aid International Agency (ACECID), to perform diffuse CO_2 efflux surveys at the surface of TCL. In total, 17 surveys have been undertaken at TCL since 2008. Last three surveys were performed in March, May and November 2017, with 152 sites distributed homogenously along the surface of TCL. Together with diffuse CO_2 efflux measurements, at each sampling site, water temperature, pH and conductivity have also been measured. The CO_2 measurements were carried out following the accumulation chamber method (Parkinson, 1981) by means of a portable LICOR soil CO_2 efflux instrument. To estimate the total CO_2 output, sequential Gaussian simulations (sGs) was used. Surface TCL CO_2 efflux values ranged from 39 to 5,284 g m^{-2} d^{-1}, 52 to 2,053 g m^{-2} d^{-1} and 342 to 12,296 g m^{-2} d^{-1}, for March, May and November surveys, respectively. Main CO_2contributions were always observed at those areas where bubbling activity occurs. The estimated diffuse CO_2 emission released from TCL during 2017 surveys were 1,763 $\pm$ 237 t d^{-1}, 442 $\pm$ 18 t d^{-1} and 1,501 $\pm$ 62 t d^{-1}, for March, May and November survey, respectively. March and November values were relatively high if they are compared with the rest of the time series except for the period 2010-2011, when magma intrusion beneath TCL occurred. These results reveal significant variations from 2008 to 2017 and do not seem to be masked by external variations, showing a temporal correlation with the onsets of high frequency seismic events recorded by PHIVOLCS at Taal. The above observations suggest subsurface magma movement as the cause for the observed changes in the total output of diffuse CO_2 emission at TCL, and CO_2 efflux surveys become an effective volcanic surveillance tool for Taal volcano.