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Precursory diffuse CO_2 emission signature of the 2011 El Hierro submarine eruption, Canary Islands

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El Hierro is the youngest and southernmost island of the Canarian archipelago and represents the summit of a volcanic shield elevating from the surrounding seafloor at depth of 4000 m to up to 1501 m above sea level. The island is believed to be near the present hotspot location in the Canaries with the oldest subaerial rocks dated at 1.12 Ma. The subaerial parts of the El Hierro rift zones (NE, NW and S Ridges) are characterized by tightly aligned dyke complexes with clusters of cinder cones as their surface expressions. Since 16 July, an anomalous seismicity at El Hierro Island was recorded by IGN seismic network. Volcanic tremor started at 05:15 on 10 October, followed on the afternoon of 12 October by a green discolouration of seawater, strong bubbling and degassing, and abundant bombs on a decimetre scale found floating on the ocean surface offshore, southwest of La Restinga village, indicating the occurrence of a submarine volcanic eruption at approximately 2 km far the coast line of La Restinga. Further episodes have occurred during November, December 2011 and January 2012, with turbulent water, foam rings, and volcanic material again reaching the sea surface.

In order to improve the volcanic surveillance program of El Hierro Island and to provide a multidisciplinary approach, a continuous geochemical station to measure CO_2 efflux was installed on September 2003 in Llanos de Guillen, the interception center of the three volcanic-rift zones of the island, with the aim of detecting changes in the diffuse emission of CO_2 related to the seismic or volcanic activity. The station measures on an hourly basis the CO_2 and H2S efflux, the CO_2 and H2S air concentrations, the soil water content and temperature and the atmospheric parameters: wind speed and direction, air temperature and humidity and barometric pressure. The meteorological parameters together with the air CO_2 concentration are measured 1 m above the ground and the soil water content and soil temperature are measured 40-cm deep, and recorded contemporaneously with CO_2 efflux. Although time series of CO_2 efflux showed background (4-5 g m-2 d-1) values before the July 16, when the seismic unrest started, and still August 30, some significant increases up to 10 g m-2 d-1 was measured prior the occurrence of peaks on the seismic energy release. Since the end of August, coinciding with a migration of the hypocenters of the seismic activity toward the south part of the island, the CO_2 efflux time series started a relatively constant increase during 1 month, reaching a maximum of 19 g m-2 d-1 one week before the occurrence of the submarine volcanic eruption. Since October 5 till present, including the whole eruptive period, the CO_2 efflux time series have shown a general decrease trend but with some significant emission peaks prior the occurrence of important seismic energy release episodes. This station has revealed as an important observation point to evaluate the volcanic activity of El Hierro Island since diffuse degassing of carbon dioxide seems to be associated with fluid pressure fluctuations in the volcanic system. These results demonstrated the potential of applying continuous monitoring of soil CO_2 efflux to improve and optimize the detection of early warning signals of future volcanic unrest episodes at El Hierro.