Applied Geochemistry 85 (2017) 73–85

Contents lists available at ScienceDirect

Applied Geochemistry

journal homepage: www.elsevier.com/locate/apgeochem

A reliable and effective methodology to monitor CO_2 flux from soil: The case of Lipari Island (Sicily, Italy)

M. Lelli*, B. Raco

Institute of Geoscience and Earth Resources, CNR, Via G. Moruzzi, 1, Pisa, Italy

ARTICLE INFO

Article history:
Received 20 March 2017
Received in revised form
15 August 2017
Accepted 23 August 2017
Available online 31 August 2017

Handling Editor: Prof. M. Kersten.

Keywords:
Accumulation chamber
CO_2 flux from soil
Time series analyses
Lipari Island
Meteorological influence

ABSTRACT

A new unit for continuous monitoring of CO_2 flux diffused from soil was developed and preliminary tested in the field at Lipari Island (Sicily, Italy). The developed device (CO_2-S-POT), based on the accumulation chamber method, is an assembled unit easy to install and to manage. Both dimensions ($104 \times 61 \times 75$ cm) and weight (32 Kg) of CO_2-S-POT are lower than the equipment which are commonly used for continuous monitoring of diffused CO_2 flux. Besides CO_2 flux measurements, it is able to measure several environmental parameters [air temperature, soil temperature, atmospheric pressure, Volumetric Water Content (soil VWC%) and soil conductivity]. Laboratory tests showed a very good performance of the assembled system in terms of detection limit (0.1 mol $m^{-2} \cdot day^{-1}$), reproducibility (RSD better than 3.5%) and linearity (up to 4 order of magnitude). Field tests (3 months) were performed at Lipari Island (Sicily, Italy), where no continuous monitoring of diffuse CO_2 flux using the accumulation chamber method is ongoing. During field tests, the CO_2-S-POT performed flux measurements every hour, together with monitoring of the environmental parameters. During field tests, no ordinary or extraordinary maintenance was necessary and no missing data were detected. The soil CO_2 flux showed strong influence operated by air pressure, air temperature, soil temperature, soil conductivity, Volumetric Water Content and rain. Statistical methods based on Time Series Fourier analysis (TSFA), Principal Component Analysis (PCA) and also Multiple Linear Regression Analysis (MLRA) are used in order to filter the influence of the environmental parameters on the flux data, and, at the same time, to highlight the contribution which could be due from deep system. Raw flux data (in ppm $\cdot sec^{-1}$) are used in time series analysis, since these represent the real physical variable measured in the field, without transformations. In fact, the conversion from ppm $\cdot sec^{-1}$ to another dimension (i.e. mol $\cdot m^{-2} \cdot day^{-1}$) affects the correlation between the measured parameters (i.e. CO_2 flux and environmental parameters).

The results of the statistical procedure showed that 1) the oscillation at low period (hours and days) are due to variations of environmental parameters and 2) the soil CO_2 flux measured at Lipari is characterized also by long period variations (compared to the previous ones, i.e. weeks), difficult to explain just in terms of environmental parameters. The applied methodology, based on multivariate statistical techniques, has allowed to identify residual anomalies, following a suitable procedure to handle the multicollinearity. In the period from August 20 to August 23, 2014, when there were not both significant air pressure variations and rain events, anomalous positive residuals were identified. These residual anomalies are those interesting from volcanic surveillance point of view. However, to assess whether the residual anomalies are effectively controlled by variations induced by the deep system (i.e. seismic and/or volcanic activity) others parameters, such as wind speed and wind direction, and more time of observation should be taken into consideration.

* Corresponding author.
E-mail address: m.lelli@igg.cnr.it (M. Lelli).

http://dx.doi.org/10.1016/j.apgeochem.2017.08.004
0883-2927/