Lusi is a Sediment-Hosted Geothermal System (SHGS). These systems\textsuperscript{1}, characterized by carbon dioxide (CO\textsubscript{2}) of deep geothermal origin (thermometamorphic or mantle-derived), interact with CH\textsubscript{4}-rich fluids in shallower sedimentary rocks, leading to a hybrid CH\textsubscript{4}-CO\textsubscript{2} surface seepage system. SHGSs often feature muddy craters or bubbling pools and can be confused with, either mud volcanoes (sedimentary volcanism; \textsuperscript{2}) or mere geothermal/volcanic emissions. The methane vented at Lusi is mainly thermogenic (\(\delta^{13}\)C from -40 to -49 \%), although a possible mixing with shallower microbial gas (resulting in \(\delta^{13}\)C: -51.8 \%) was observed in the initial stages of Lusi’s activity\textsuperscript{3}. 

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1. Degassing modality

Lusi is a complex and multiple degassing system, with different components and modalities of gas release from the ground. The recognition of the degassing components was a prerequisite to design and perform gas flux measurements (Table 1).

The main degassing zone, which is object of the present work, covers an area of ~7 km$^2$, framed by a 12 m tall embankment (Fig. 1A, 2A). This surface can be divided in three main sectors.

(a) The central part (defined as crater zone) hosts two large active vents. These are characterized by constant gas and mud breccia release resulting in tens of meters tall plumes composed respectively of: 98% aqueous vapour, 1.5% CO$_2$ and 0.5% CH$_4$.$^{3,4}$

Drone thermal images showed the presence of two distinct hot zones that correspond precisely to the two active vents, where the most active bubbling occurs releasing deeper and hotter fluids.$^5$ A significant thermal effect around the main vent extends over a surface of 200 m$^2$, and about 80 m$^2$ for the secondary one. The main vent clearly defines a surface temperature pattern of concentric rings. The crater zone has the highest temperatures and is characterized by the constant activity of bursting bubbles that reach the size of several meters.

(b) A ~650 m diameter subcircular pond (>0.3 km$^2$) surrounds the active vents region. This pond, consisting of hot mud, is not accessible and hosts countless bubbling points, which vary in size from meters to decimetres scale and change position continuously together with the mud breccia flows that radially expand from the crater zone.

(c) The external region consists of dry walkable mud-breccia and is sheared by radial streams that flush the hot mud erupted from the vents. In this area three main degassing types could be identified: soil miniseepage, fractured zones, satellite seeps.

i) **Soil miniseepage**: a diffuse exhalation occurring throughout the walkable area inside the embankment, where no specific features are observed and mud appears to be generally undisturbed (Fig. 1A, 2C). It is analogous to “miniseepage” typically reported around seeps and mud volcanoes (e.g.;$^6$).

ii) **Fractured zones**: characterized by ten to hundred meter long fissures, centimetres to several meters wide and up to 3-5 meters deep (Fig. 1A, 2B, S2). They were mapped combining direct
field observations and high resolution satellite images as well as drone photogrammetry. The main fractured/faulted zones are NE-SW oriented (i.e. part of the Watukosek strike slip fault system) or coincide with the system of antithetic fracture zones (Siring fault system)\textsuperscript{7-10}.

iii) 

\textit{Satellite seeps:} active bubbling pools, broadly distributed throughout the entire region inside the embankment (Fig. 1A, 2D, S3). Seeps are circular depressions with an average diameter in the order of 20-30 cm, up to 1.5 m, and typically expel gas, water and, in some rare instances, mud, thus resulting in the formation of small gryphons. These seeps are part of an intricate subsurface plumbing system that continuously mutates in time as the fluids follow preferential pathways to reach the surface.

\textbf{Fig. S1.} (A-B) Normal probability plots for CH\textsubscript{4} and CO\textsubscript{2} to define the background values and the anomalous populations. Note logarithmic scale of ordinate (y) axis.
Fig. S2. Fractured zones inside the embankment area. A) Google Earth satellite image of the region around Lusi. Indicated are the main features (moving towards the NE: Penanggungan volcano of the Arjuno-Welirang volcanic complex, the fault outcrop of the Watukosek escarpment, the bent path of the Porong River and the intersection with Lusi); (B) High resolution Ikonos satellite image and details of the fractured and faulted area inside the Lusi embankment based on field and satellite observations. Grey shaded areas indicate the zones with high amount of fractures, dashed lines trace the direction of the main and the antithetic fractures on field; (C-D) elaboration maps of CH₄ and CO₂ flux from the faulted areas. This figure has been constructed using Surfer 12.0 (Golden Software).
Fig. S3. Satellite seeps inside the embankment area. A) Group of active seeps inside the embankment. (B) Superposed Ikonos satellite view and Kernel density; (C-D) Calculated CH$_4$ and CO$_2$ flux using IDW technique; (E-F) Combined Kernel and IDW technique for CH$_4$ and CO$_2$ fluxes. Basemap obtained using Statistica 10.0.
2. Total emission estimates

Crater zone: The largest active vent (Vent 1) was monitored during its regular activity (i.e. excluding the powerful geysering events that characterize about half of the activity at Lusi; 11). Between 2015-2019, a total of 205 replicated measurements were completed during low (< 1 m s⁻¹) wind conditions using a theodolite (Topcon AT-G2) positioned in the observatory tower located in the SE of the embankment zone (Fig. 1A, 2A). It was then measured the time required for a beamed point of the vapour plume of the main vent to move from a given height A to another height B. This large database shows that the speed of the rising plume ranges from 0.4 to 1.5 m/s (Fig. S4A). The resulting average speed of the plume is 0.86 m s⁻¹ (± 0.19 m/s standard deviation).

Based on comparative satellite and drone images we estimated that the main vent has a diameter of ~100 m. However, observations show that during the regular Lusi activity a) the plume does not occupy the full width of the vent but rather its central area (width of ~50 m, Fig. 1C) and b) the plume density is not homogeneous throughout its volume and contains air pockets. Our conservative estimates consider that the plume has air content ranging between 70-80% (Fig. S4B).

Monitoring of the smaller vent (Vent 2) shows that its behaviour is similar to that of the larger one. A diameter of 35 m was selected with the same parameters used for the main vent. These conservative parameters (i.e. 50 and 35 m wide plumes, 20-30% gas volume, regular vent activity) were then used for calculations. The crater gas composition was calculated from a large sample suite that we collected directly from the crater since 2006 in agreement with the values measured by Vanderkluysen et al. 4. We know that 98 vol.% of Lusi plume is composed by aqueous vapour, while the remaining ~2 vol.% consists of CO₂ (respectively 1.49 vol.%) and CH₄ (0.51 vol.%).³,⁴

The total amount of gas released inside the gas plume has been estimated as follow:

\[ G_i = \rho_i \left[ \alpha_i (v \cdot S) \right] \]

Where \( G_i \) is the mass flux of a specific gas \( i \) (CO₂ or CH₄); \( \rho_i \) is the density of the gas; \( \alpha_i \) is the concentration of this gas in the total volume flux of the plume; \( v \) is the velocity in the plume (0.86±0.19 m/s) of cross-sectional area \( S \) (1962 m² for main vent and 1017 m² for smaller vent). The gas density can be estimated using molar volume of the ideal gas at 1 atm and 40º C (\( V_m=25.696 \text{ l/mol} \)) and molar mass (\( M_{CO2}=44 \text{ g/mol} \) and \( M_{CH4}=16 \text{ g/mol} \)) as \( \rho_i = M_i/V_m \). The gas
concentration $\alpha_i$ is the product of gas concentration from the crater (0.01492 for CO$_2$ and 0.00508 for CH$_4$) and the concentration of crater gas within the air-polluted plume (0.25 ± 0.05). Using this method we estimate a total flux from the main vent of ~42 ktonnes CH$_4$ yr$^{-1}$, and ~339.5 ktonnes CO$_2$ yr$^{-1}$ while the second vent emits ~21.8 ktonnes CH$_4$ yr$^{-1}$, and ~176 ktonnes CO$_2$ yr$^{-1}$.

Miniseepage and fracture zones: The data treatment of flux measurements on miniseepage and fractured zones involved the calculation of standard statistical parameters. The Sinclair method$^{12}$ was applied to define background values by means of normal probability plot (NPP). As suggested by Fig. S1A, the probability plots of $\phi$CH$_4$ (logarithmic positive values) confirm that flux values have a log-normal distribution and highlight the presence of two different populations both for miniseepage and fractured zones. Differently, most $\phi$CO$_2$ variations (Fig. S1B) can be ascribed to a single population, with the exception of the background value (30 g m$^{-2}$ day$^{-1}$) and some outliers with $\phi$CO$_2$ $\geq$ 200 g m$^{-2}$ day$^{-1}$, likely related to the occurrence of fractures causing an increased soil permeability at a local scale.

Moreover, in order to estimate a background value of the regional flux and its expected gradual decrease furthering from the crater zone, several profiles have been extended up to 2.7 km outside the embankment zone (Fig. 2A). The CO$_2$ weighted average was calculated taking into account only the measurements above the background values (30 g m$^{-2}$ day$^{-1}$), likely dominated by biological soil respiration, while for CH$_4$ all positive measured values were considered (Fig. S1A-B).

Miniseepage and fractured zones statistical elaboration allows to estimate the gas emission rates (expressed in tonnes day$^{-1}$) by Natural Neighbour interpolation and volume method. In particular, a total of 175 flux measurements were carried out to estimate the miniseepage emission type. At any of these localities flux of CO$_2$ and CH$_4$ was detected resulting in mean values of 13.07 g m$^{-2}$ day$^{-1}$ ($\phi$CO$_2$) and 361 mg m$^{-2}$ day$^{-1}$ ($\phi$CH$_4$). This value has been applied for all the area framed by the embankment interested by miniseepage (5.91 km$^2$) resulting in a total average flux of 2.01 (from 1.3 to 4.8 lower and upper quartile, respectively) tonnes day$^{-1}$ of CO$_2$ and 2.12 (from 0.9 to 5.6 lower and upper quartile, respectively) tonnes day$^{-1}$ of CH$_4$.

The 129 flux measurements completed in the fractured regions (Fig. S2) revealed a CO$_2$-dominated seeping gas and have significantly higher soil temperatures and flux rates compared with the
surrounding undisturbed sediments. The calculated mean values are 35.75 g m\(^{-2}\) day\(^{-1}\) and 3.22 mg m\(^{-2}\) day\(^{-1}\) for \(\phi\)CO\(_2\) and \(\phi\)CH\(_4\), respectively. These values have been applied for the mapped fractured zones (1.34 km\(^2\)) resulting in a total average flux of 47.90 (from 15 to 100 lower and upper quartile, respectively) tonnes day\(^{-1}\) of CO\(_2\) and 4.31 (from 0.04 to 19 lower and upper quartile, respectively) tonnes day\(^{-1}\) of CH\(_4\). Fractured zones also show high concentration of active seeps confirming a greater amount of fluids release at these localities.

**Satellite seeps:** The average calculated flux rate among the 351 measured seeps is 71.68 g m\(^{-2}\) day\(^{-1}\) of CO\(_2\) and 218.31 g m\(^{-2}\) day\(^{-1}\) of CH\(_4\). The amount of CH\(_4\) and CO\(_2\) released by the satellite seeps was obtained by adding together the individual contribution of each measured seep.

Since the amount of satellite seeps occurring inside the embankment largely exceed the amount of those measured, the position of all the seeps was digitized based on high resolution satellite images. Their location can be easily recognized due to the colour contrast between the dry and the water-saturated sediments (Fig. S3A). Normal probability plots were used to calculate the population classes of the measured fluxes. The emission factor for CO\(_2\) and CH\(_4\) is the result of the weighted average for every single population class and the mean of the weighted averages of all the identified classes. These emission factors were applied for the number of seeps (total of 16,148) that have been mapped from the high resolution satellite images (Fig. 1A). Moreover, an additional statistical procedure was then applied in order to estimate the amount of CO\(_2\) and CH\(_4\) outgassing from these digitized seeps (i.e. defined as “points” in the following) but not measured in situ. The procedure combines the following statistical processing: i) Natural Neighbour that interpolates a raster surface from points using a natural neighbour technique; ii) IDW that interpolates a raster surface from points using an inverse distance weighted (IDW) technique; iii) Kernel Density that calculates a magnitude per unit area from point or polyline features using a Kernel function to fit a smoothly tapered surface to each point or polyline; iv) Raster Calculator that builds and executes a single Map Algebra expression using Python syntax in a calculator-like interface.

More details and references about these processing procedures are provided below. Natural Neighbour technique is a common and robust interpolation method that produces a conservative and artifice-free result. This approach aims to find, among the samples, the closest subset to each interpolation point and then applies weighted averages on them based on proportionate areas to
interpolate a value. The interpolated surface is tightly controlled by the original data points and has the advantage of not having to specify parameters such as radius, number of neighbours or weights. The use of this method is most appropriate where sample data points are distributed with uneven density. The Inverse Distance Weighted (IDW) technique is an interpolation method usually applied to highly variable data assuming that each input point (i.e., digitized filtrations) has a local influence that decreases with distance. The use of this method assumes that the closer points have a greater weight than those further away and therefore their influence decreases with the distance from their sampled position. Kernel density estimation is a statistical tool that allows to create a smooth curve given a set of data and to visualize the “shape” of some data, as a kind of continuous replacement for the discrete histogram. Conceptually, a smoothly curved surface is fitted over each point. The surface value is highest at the location of an analysed point and diminishes with increasing distance ultimately reaching zero at the search radius distance (defined as 2 m based on concentric measurements conducted around a set of reference seeps) from the point. The digitalized seeps were analyzed and integrated using Raster Calculator to estimate and map their distribution in the study area. The final product results from the merged Kernel and IDW maps (Fig.S3 B-F). A total flux of 14.59 and 98.52 tonnes day$^{-1}$ of CO$_2$ and CH$_4$, respectively, was therefore calculated for all the seeps within the embankment.
Fig. S4. (A) Measured plume velocities since May 2015-March 2019. Indicated with the red line the average value calculated from the 205 measurements; shaded area indicates the standard deviation used for calculations. (B) Plot of daily CO$_2$ and CH$_4$ discharge from a 50 m wide plume during its regular activity. Considering a conservative gas content in the plume (i.e. between 20-30%) the daily flux is estimated to vary between 583-1358 tonnes day$^{-1}$ of CO$_2$ and 72-168 tonnes day$^{-1}$ of CH$_4$. (C) Mud flow rate measured since Lusi inception.
3. Mud flow rate

Since the Lusi inception in May 2006, different approaches have been used to estimate the mud flow rate (Fig. S4C). Some of these methods are linked to the continuously mutating field conditions, the size of the eruption site, and the contingency procedures required to mitigate potential hazardous situations. These field operations were either combined or modified through time and had to be all taken into account in order to obtain the total flow rate (see more details in 29). During the initial phases, the mud flow extension was monitored using satellite images and a portion of the erupted mud was scooped and loaded into large trucks so it could be removed, treated, and dumped at selected locations. In parallel several framed ponds were built around the crater zone to protect the settlements and control the spreading of the mudflows. The surface of these ponds was calculated using multiple IKONOS satellite images as well as measuring their empty volume. The flow rate within these ponds was then monitored using calibrated sticks. Since 2006 the region has been constantly monitored by a dense GPS network in order to measure potential subsidence in the area, and the flow rate estimates were compensated with recorded vertical movements29. Since October 2006, the erupted mud was treated and discharged, through a system of pumps, to the Porong River located to the south and later, in much lesser volumes, also to the stream located to the north of Lusi. Since March 2009 the active vent remained isolated at the centre of the large embankment zone and the erupted mud was forced towards the south to optimize the flushing into the Prong River. In order to implement the removal of clasts and fine-grained sediments deposited in the outskirts of the embankment zone, a “circular” pumping system strategy was applied when needed. First, water from the Porong River was pumped inside the outermost sectors of the embankment area; these newly created pools were then dredged in order to stir up in suspension the solid particles and ultimately pump all the sediment-enriched mixture out into the Porong River. The flow rate calculations were compensated with the amount of fresh water pumped inside these pools. All the estimates were compensated by the measured precipitations. Considering the significant amount of water evaporation that occurs directly at the crater site, in the surrounding large pond, and in the remaining area inside the embankment, the flow estimates might represent a lower value than the one reported herein.
4. TROPOMI - Emission quantification using the source pixel method

The TROPOMI instrument onboard the European Space Agency’s Sentinel-5P satellite was launched in October 2017. The satellite is in a sun-synchronous orbit with a local overpass time of 13:30 hours. It has a wide swath of 2600 km and provides column averaged CH₄ mixing ratios (XCH₄), among other species, at ~7×7 km² ground pixel resolution at nadir and near daily global coverage. We analyzed data collected between May 2018 and July 2019 for local enhancements in XCH₄ over Lusi to provide an independent quantification of methane emissions and compare it with the estimates derived from in-situ measurements.

We use the mass balance method, described in Buchwitz et al.³⁰, to quantify the methane emission from Lusi. The mass balance method has the advantage that it is a quick method and does not require an atmospheric transport model. However, the method makes simplistic assumptions about the CH₄ emission distribution and atmospheric transport. In this method, the source flux $Q$ [Gg y⁻¹] is calculated by multiplying the $\Delta XCH₄$ enhancement ($XCH₄$ source – $XCH₄$ background) with a conversion factor $CF$ shown below:

$$Q = \Delta XCH₄ \times CF$$

$$CF = L \times V \times M_{exp} \times M \times C$$

where $L$ [km] is the effective length of the source area through which the air parcel carrying methane is ventilated (computed as square root of the source region), $V$ [km h⁻¹] is the effective wind speed, $M_{exp}$ is the ratio of average surface pressure in the source box and standard surface pressure of 1013.25 hPa, $M$ is a constant to convert concentration to mass change per area [5.345 kg CH₄ km⁻² ppb⁻¹] in standard atmospheric conditions and $C$ is a dimensionless factor chosen to be 2.0, derived by Buchwitz et al.³⁰, based on the concentration difference of the air parcel before and after entering the source area.

The domain of the TROPOMI analysis ranges from 6.027 to 9.027 °S latitude and 111.211 to 114.211 °E longitude (Fig. S5).

The source box 1 (see Fig. S5) covers a rectangular area of ~20×20 km² centered around the Lusi eruption site located at 112.711 °E, 7.527 °S. To calculate the XCH₄ enhancement in the source box, the local background mixing ratio in the upwind direction of the source pixels is subtracted. The local background region is chosen in upwind direction of the source box, with the dimension equal to the length of the source box, which lies to the East and South-East of Lusi given the
dominant wind direction during the analyzed period (see Fig S6A). The spatial distribution of $\text{XCH}_4$ is corrected for the influence of variations in surface elevation by adding 7 ppb/km relative to mean sea level$^{30}$. Boundary layer averaged wind fields from ECMWF ERA5 are used, representing the 06:00 UTC overpass time of TROPOMI (C3S, 2017). Figure S6B shows the wind speed and direction for each grid pixel of ECMWF ERA5 winds over the domain from all the considerable days of the screened orbits. Since the selected source box is larger than the area of Lusi ($\sim 7$ km$^2$), other sources may be present. To account for their contribution, anthropogenic emissions from EDGAR v5.0 for 2015$^{31}$, biomass burning emissions from the GFED4.1s emission inventory for 2018$^{32}$ and wetland emissions from WetCHARTs version 1.0$^{33}$ for 2015 were subtracted. Emissions were quantified for boxes 1-6 (Fig. S5), with varying contributions from anthropogenic emissions to test the robustness of the emission estimate for Lusi.
**Fig. S5.** An oversampled ($0.01° × 0.01°$) map of TROPOMI data averaged over the study domain from May 2018 till July 2019. The location of Lusi is indicated by a triangle and the squares denotes the multiple source boxes considered for emission quantification. Units in ppb. Map generated using Python 2.7.13 version.

**Case for sensitivity: Data averaging and bias correction**

A total of 50 orbits were screened for data availability, in the period May 2018 – July 2019 requiring > 100 pixels per orbit, to have sufficient spatial coverage over the domain. Figure S6C show the temporal spread of screened orbits across the analysis period. The data in these orbits
were regridded and averaged at a resolution of 0.1° × 0.1°. The selected orbits show a significant correlation between XCH₄ and aerosol optical thickness (AOT) varying from -0.13 to -0.86, with a correlation of -0.68 averaged over all data. The averaged data were corrected to remove this correlation by linear regression between XCH₄ and AOT (Fig. S6D), yielding a slope of -364 ppb per unit of AOT. As a sensitivity test, emissions were quantified using TROPOMI data including and excluding this additional bias correction.
Fig. S6. Mass balance method defining regions, bias correction and final estimates for TROPOMI. (A) Local background region (red polygon) as defined in the upwind direction of source box (black polygon) for TROPOMI measurements. The dominant wind direction is arrowed. (B) Windrose diagram showing dominant wind speed and wind direction from all the grids of considered orbits (domain: 112.711 ± 0.525, -7.527 ± 0.525). (C) Screened orbits considered for the analysis spread across different months in 2018-2019. On the x-axis we have the temporal scale and each vertical line along y-axis represents screened orbit considered for the analysis. (D) The relation between TROPOMI $\text{XCH}_4$ and AOT before (left panel) and after (right panel) correction using linear regression. (E) Methane emissions quantified from TROPOMI data using source boxes increasing in size (see Fig. S5 for the definition of box 1-6). Total emissions include emissions from Lusi, EDGARv5.0 anthropogenic, GFED4.1s biomass burning and wetlands. All images were generated using Python 2.7.13 version.

CH$_4$ emission from Lusi

In this study, we use the official TROPOMI operational two-band retrieval product. It uses the O$_2$A band at 0.79 $\mu$m and the CH$_4$ band at 2.3 $\mu$m in respectively the NIR and SWIR spectral bands of TROPOMI. XCH$_4$ is retrieved using the full-physics RemoTeC algorithm, accounting for light path perturbations due to scattering on aerosol and cirrus cloud particles in the atmosphere$^{34,35}$. Butz et al.,$^{35}$ showed that XCH$_4$ from the full-physics retrieval algorithm used for TROPOMI data can have large errors over dark surfaces. This can affect our emissions estimates. Therefore, we filter out TROPOMI pixels with SWIR albedo of less than 0.02 (ATBD$^{36}$). Using the mass balance approach outlined above, the CH$_4$ emission from Lusi was estimated at $140 \pm 87$ ktonnes yr$^{-1}$. This number is consistent with the independent estimate that is obtained from surface data, albeit that uncertainty margins are large. The sensitivity test using corrected data gave an estimate of 70 ktonnes yr$^{-1}$, which lies within the high uncertainty range of our estimate. Using the ensemble of estimates due to varying background, source box and regridding resolution we calculate an uncertainty of 60% around the quantified mean emission. For the wind speed, we estimate an uncertainty of 18% (around the mean) which is similar to that found in measurements i.e. 22% (0.19/0.86 m s$^{-1}$) (Figure S4A). Moreover, the surface data are expected to lead to a lower emission rate due to a low mud flow rate during the 2014-2016 in situ survey period (Fig S4C). The TROPOMI measurements where conducted for the period 2018-2019. During this time interval
mud flow rates were higher, with likely increased fluxes of water vapor, CO₂ and CH₄ (Fig. S4C). The high uncertainty in the TROPOMI-derived estimate is mainly due to the sensitivity to the choice of the background and source boxes. The anthropogenic emission from EDGARv5.0 varies between 10 ktonnes yr⁻¹ and 184 ktonnes yr⁻¹ while that of GFED4.1s varies between 0.09 to 0.41 ktonnes yr⁻¹ and wetland varies from 0.04 to 1.65 ktonnes yr⁻¹ going from ~20×20 km² to ~70×70 km², and therefore become significant at larger source box sizes. Further details about the estimates and other parameters are tabulated in Table S1. Our emission quantification method cannot clearly distinguish all sources of emissions in the vast region around Lusi. These could include unusually high anthropogenic sources (not identified so far on the basis of the information we got from maps and local authorities) and additional natural geological emissions such as the seepage activity that has been reported in the region (e.g. ³⁷ and refs therein). In any case, the TROPOMI estimates are consistent with a significant source from Lusi for any choice of region (Fig. S6E).

| Source region | Size (deg) | Dimension (Lat-Long) (deg) | Wind Speed (m/s) | Total mass balance (Gg/y) | EDGAR v5.0 (Gg/y) | GFED v4.1s (Gg/y) | Wetland (LPJ) (Gg/y) | Lusi (Gg/y) |
|---------------|------------|----------------------------|------------------|---------------------------|------------------|------------------|----------------------|-------------|
| Box 0         | 0.2° × 0.2° | (-7.427 : -7.627) (112.611 : 112.811) | 1.36 ± 0.12 | 86 | 10.02 | 0.09 | 0.04 | 76 ± 24 |
| Box 1         | 0.3° × 0.3° | (-7.327 : -7.627) (112.511 : 112.811) | 1.52 ± 0.15 | 135 | 31.09 | 0.19 | 0.13 | 104 ± 30 |
| Box 2         | 0.4° × 0.4° | (-7.227 : -7.627) (112.411 : 112.811) | 1.42 ± 0.13 | 178 | 61.58 | 0.27 | 0.17 | 116 ± 33 |
| Box 3         | 0.5° × 0.5° | (-7.127 : -7.627) (112.311 : 112.811) | 1.76 ± 0.08 | 267 | 99.54 | 0.33 | 0.45 | 167 ± 61 |
| Box 4         | 0.6° × 0.6° | (-6.977 : -7.627) (112.211 : 112.811) | 1.56 ± 0.05 | 310 | 140.98 | 0.37 | 0.98 | 168 ± 56 |
| Box 5         | 0.7° × 0.7° | (-6.927 : -7.627) (112.111 : 112.811) | 1.87 ± 0.08 | 390 | 184.15 | 0.41 | 1.65 | 204 ± 68 |

Table S1: Input parameters used to calculate methane emissions at Lusi eruption site for different source input.
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