frontiers in Earth Science

TYPE Correction
PUBLISHED 06 October 2026
DOI 10.3389/feart.2026.1995506

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
Zhangdong Jin,
Chinese Academy of Sciences (CAS), China

*CORRESPONDENCE
Claudio Ventura Bordenca,
claudio.ventura@ingv.it

RECEIVED 11 September 2026
ACCEPTED 21 September 2026
PUBLISHED 06 October 2026

CITATION
Ventura Bordenca C, Massa M, Rizzo AL, Ferrari E, Carra N, Barberio MD, Piersanti A and Sciarra A (2026) Correction: A global dataset of fluid-based pre-seismic anomalies in crustal environments. *Front. Earth Sci.* 14:1995506. doi: 10.3389/feart.2026.1995506

COPYRIGHT
© 2026 Ventura Bordenca, Massa, Rizzo, Ferrari, Carra, Barberio, Piersanti and Sciarra. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Correction: A global dataset of fluid-based pre-seismic anomalies in crustal environments

Claudio Ventura Bordenca[1]*, Marco Massa[1], Andrea Luca Rizzo[1,2], Elisa Ferrari[1], Nicolò Carra[1], Marino Domenico Barberio[3], Antonio Piersanti[3] and Alessandra Sciarra[3]

[1]Istituto Nazionale di Geofisica e Vulcanologia (INGV), Sezione di Milano, Milano, Italy, [2]Department of Earth and Environmental Sciences, Università degli Studi di Milano-Bicocca, Milan, Italy, [3]Istituto Nazionale di Geofisica e Vulcanologia (INGV), Sezione di Roma, Rome, Italy

KEYWORDS
crustal fluids, earthquake precursors, gas-hydrogeochemistry, integrated database, pre-seismic anomalies

A Correction on
A global dataset of fluid-based pre-seismic anomalies in crustal environments

by Ventura Bordenca C, Massa M, Rizzo AL, Ferrari E, Carra N, Barberio MD, Piersanti A and Sciarra A (2026). Front. Earth Sci. 14:1868566. doi: 10.3389/feart.2026.1868566

There was a mistake in Figure 1 as published. The geographical distribution of the pre-seismic anomalies was incomplete because the anomalies identified in the Kamchatka Peninsula were not included. The corrected Figure 1 appears below.

There was a mistake in Figure 2 as published. Following the inclusion of the Kamchatka Peninsula entries, the statistical distributions and percentages shown in the histograms (Figures 2A,B) needed to be updated. The corrected Figure 2 appears below.

There was a mistake in the caption of Figure 1 as published. The spatial description for Figure 1C in the caption was incomplete and did not cover the full geographical extent of the updated dataset. The corrected caption of Figure 1 appears below.

Following the inclusion of additional data from the Kamchatka region, the total number of compiled anomalous signals in the dataset increased from more than 900 to more than 1,000. A correction has been made to **Section 3 Dataset description**, paragraph 1:

"We have systematically reviewed pre-seismic anomalous variations reported in crustal environments across 28 countries worldwide (Figure 1). The compiled dataset comprises data extracted from over 300 time-series and approximately 160 peer-reviewed publications spanning the period from 1978 to 2025. These studies report chemical or physical fluid-related signals interpreted as occurring prior to selected seismic events. The dataset includes more than 1,000 anomalous signals

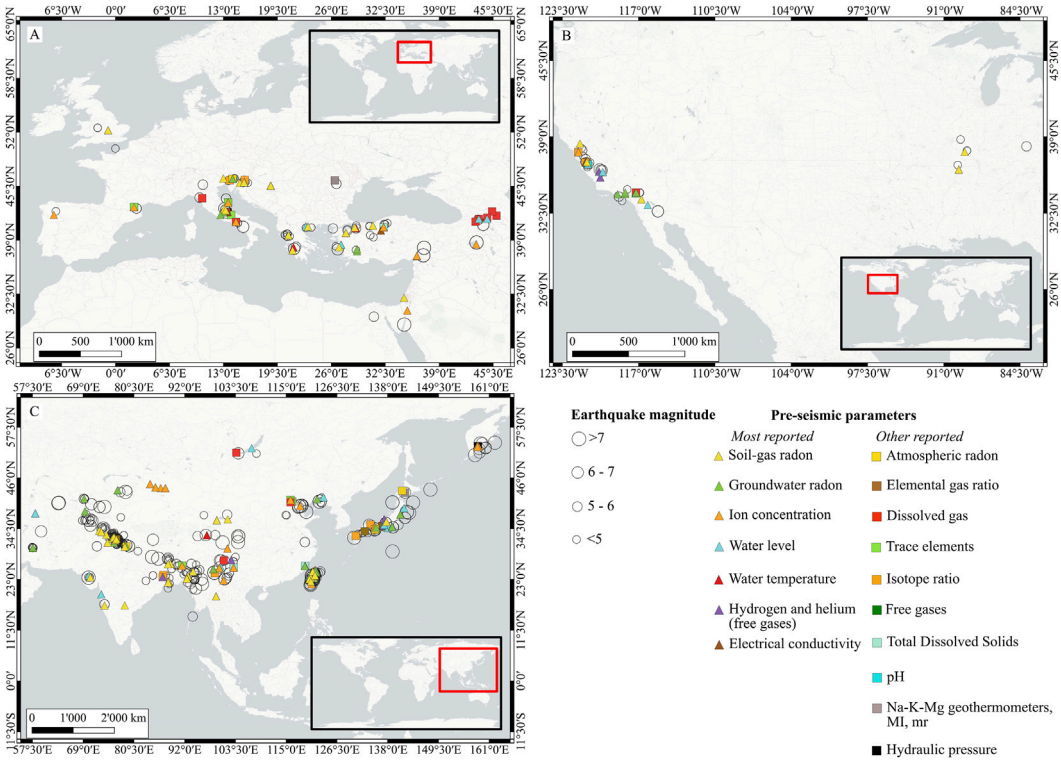


FIGURE 1
Global distribution maps ((**A**) European area; **(B)** North America area; **(C)** Central and Eastern Eurasia) of pre-seismic anomalous variations of fluid parameters in crustal environments, as reported in the scientific literature. Each colored symbol (triangle or square) indicates a monitoring site where an anomaly was detected. Where multiple types of anomalies were recorded at the same monitoring site (e.g., Zatolmin in Slovenia, Ayran springwater in Turkey,...) symbols may appear overlapped. Open circles indicate earthquakes related to the reported pre-seismic anomalies. MI = Maturity Index; mr = molar ratios.

temporally associated with over 500 earthquakes with magnitudes up to 9, for which focal depths and epicentral distances were compiled from the scientific literature. Earthquakes in the dataset include focal depths of up to 452 km and epicentral distances of up to ~1800 km from the monitoring sites where the anomalies were detected."

Following the inclusion of the anomalies from Kamchatka, the total signal count and country distribution statistics presented in **Section 3** required updating. A correction has been made to **Section 3 Dataset description**, paragraph 2:

"As depicted in Figure 2A, the dataset is dominated by earthquakes of intermediate magnitude ($4 < M < 6$), which represent the most frequent class, while lower ($M < 4$) and higher magnitudes ($M > 6$) are less common. Similarly, the majority of events are associated with shallow focal depths (<20 km), with a marked decrease in frequency at greater depths. A comparable pattern is observed for epicentral distance, with most anomalies occurring within 100 km of the monitoring site and progressively fewer events at larger distances. About 60% of all reported anomalies is derived from just three countries: India (~30%), China (~20%), Taiwan (~10%). These are followed by Russia (~8%), Japan (~7%), United States (~6%), Turkey (~5%), and Italy (~4%), collectively accounting for an additional 30% of the total. All remaining countries each contribute fewer than 3% of the recorded anomalies."

The percentage values for precursor types in **Section 3** were inaccurate as they did not reflect the updated statistical distributions following the inclusion of the Kamchatka dataset. A correction has been made to the **Section 3 Dataset description**, paragraph 5:

"This dual criterion, combining the type of parameter with its frequency of documentation, provides a consistent framework for comparative analysis and helps to emphasize the relative significance of each anomaly type within the broader context of earthquake precursor research. The inclusion of each anomaly was guided by strict criteria. We considered only those signals with a clear temporal correlation to a specific seismic event and documented in peer-reviewed scientific publications. In particular, in order to enable spatial relationship between the earthquake and associated anomalies we only included those for which detailed metadata of the seismic events were available (e.g., epicentral distance and/or geographical coordinates of the monitoring site). One or more anomalies can be associated with a single earthquake event. As shown in Figure 2B, radon constitutes the most frequently

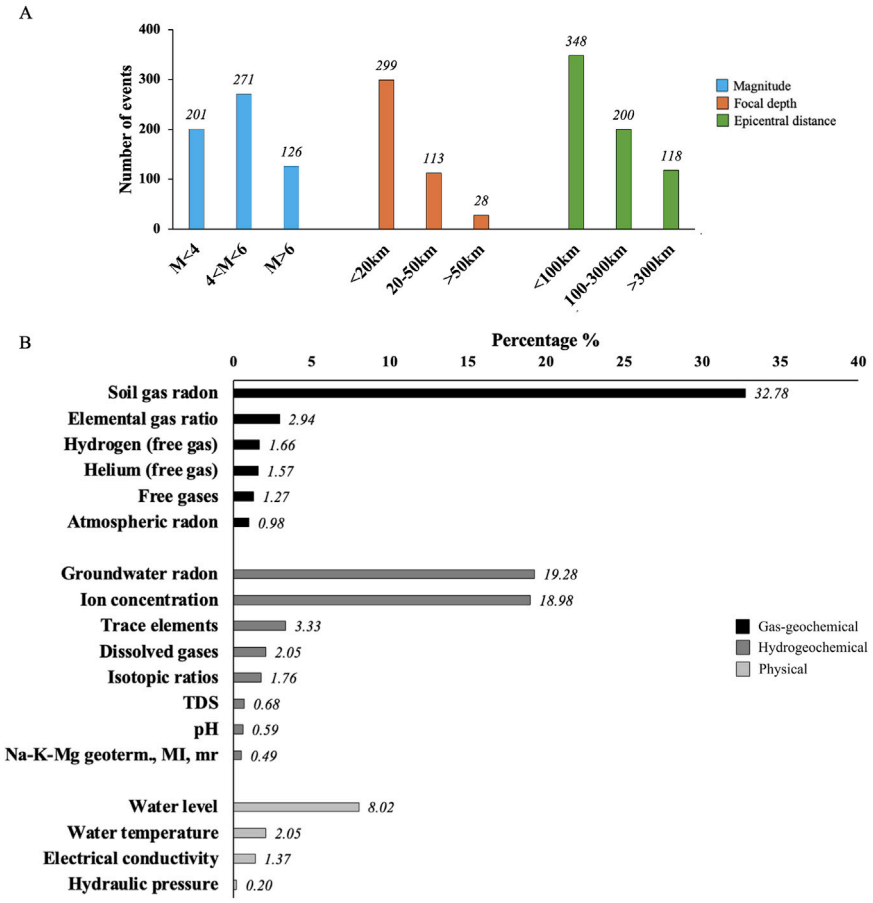


FIGURE 2
(A) Histograms showing the distribution of earthquake magnitudes, focal depths and epicentral distances. **(B)** Histograms showing the percentage of anomalous cases per category, further grouped as gas-geochemical (black), hydrogeochemical (dark gray) and physical (light gray), over the total amount of reported anomalies. MI = Maturity Index; mr = molar ratios; TDS = Total Dissolved Solids.

reported precursor among gas-hydrogeochemical signals (~33% in soil gas and ~20% in groundwater), while major ion concentrations and water-level changes also represent a relevant class of precursors accounting for ~19% and ~8% of reports, respectively."

The original version of this article has been updated.

Generative AI statement

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.