The INGV macroseismic photographic database (DFM): a structured photographic collection of earthquake effects in Italy

Tertulliani A., Graziani L., Locati M., Sbarra M., Castellano C., Berardi M.

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Answers to the Reviewer #1 Giacomo Buffarini

Comment 1: The purpose of the paper is very important supporting the research activity but also the training activity for new surveyor. The DFM here descripted is a powerful mean that collects a large amount of image from numerous seismic events very that can be used in future to better understand the macroseismic effect of an earthquake.

> **Answer**: We would like to thank the reviewer for appreciating our work and for emphasising the importance of DFM for research and training.

Comment 2: The rules at the basis of the DFM are sharable; it is important to state how to establish the vulnerability of the structure. This is important to guide the novel researcher, especially in case of reinforced concrete structures, because they can be more vulnerable if the evaluation doesn't take into account the rules and the legislation in force at the time they were realized.

> **Answer**: We thank the reviewer for highlighting this. The vulnerability assessment in DFM strictly adheres to the European Macroseismic Scale (EMS-98) guidelines. For reinforced concrete structures, the scale implicitly considers the level of earthquake resistance in the design. During field surveys and subsequent photo cataloguing, expert surveyors assess vulnerability classes, considering building typologies and inferring likely earthquake-resistant design levels. This level is estimated based on the construction period, primarily using field experience and preliminary reconnaissance of the building stock and the municipality's seismic classification history. This procedure enables the evaluators to take into account the building codes and legislative framework applicable when the structure was built, ensuring the classification is as reliable as possible, particularly for older reinforced concrete buildings that may not have been designed according to modern seismic standards. We will add a clarifying sentence to Section 3.2 to explicitly state how vulnerability is assessed according to EMS-98 principles, bearing in mind the building codes in force at the time of construction.

Comment 3: It could be useful to add, when possible, the image of the structure before the event. In many cases, using Google Street View, should be possible obtain the situation before the structure has been subjected to the earthquake. Sometimes, especially for heavy damaged building, it is important visualize the original defects that subsequently cause the damage.

> **Answer**: This is a very interesting and useful suggestion. The primary scope of DFM is to archive photographic documentation of the post-earthquake landscape, which is collected directly by QUEST. We agree that pre-event images are invaluable for accurately assessing seismic damage versus pre-existing defects. However, field operators performing rapid post-earthquake surveys in emergency conditions (e.g. in "red zones") often encounter infrastructural issues, such as a lack of internet connectivity, as well as severe time constraints, which prevent them from using online tools such as Google Street View on site. Furthermore, as we will clarify in the revised manuscript, DFM currently does not record the precise geolocation of individual buildings. Identifying the specific building, or even the exact location, of many historical photographs in our archive (dating back to the 1976 Friuli earthquake, for example) can be extremely challenging due to subsequent urban modifications and the lack of original GPS metadata. This makes the use of modern tools like Street View extremely difficult, if not impossible. For this reason,

operators are trained to assess the state of conservation and age of damage visually. DFM does not systematically store pre-event images from external platforms due to copyright restrictions, storage constraints and the time-consuming nature of adding such a feature. Nevertheless, during the subsequent internal assessment phase at the office, our experts routinely use such tools when applicable and available to evaluate the pre-existing conditions of buildings and resolve any uncertainties. We will add a note in Section 2 to mention this practice during the quality control phase and clarify the limitations regarding historical archives.

Comment 4: Fig.1 It is better to add in “Classification” also the term “Vulnerability”, otherwise “Typology” may appear as a synonymous of “Vulnerability” and we know that’s not true

Answer: We completely agree. We will update the flow chart in Figure 1 to include "Vulnerability" alongside “Typology & Damage Grading” to avoid any confusion.

Comment 5: Fig. 2 It has said that the data start from 1976 Friuli earthquake, but this event is not represented in this figure, why?

Answer: We apologise for the error. The database begins with the earthquake that occurred in 1980. We will amend the text accordingly.

Comment 6: Table 1 is missing; in the text they make reference to table 1 but there isn’t at all.

Answer: Mentioning Table 1 is due to a previous draft not being removed. We will correct this in the final revision.

Comment 7: LINE 48 the link is uncorrected because contain also “in Italian” that must be removed

Answer: Thank you for spotting this typo. We will amend the sentence to ensure that the URL is formatted correctly.

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Answers to the Reviewer #2 Massimiliano Pittore

Comment 1: The paper describes a FAIR-compliant dataset created by INGV to archive photographic documentation of earthquake effects in Italy since the late 1970s. Compiled mainly by the QUEST team during post-event surveys, it preserves both digitized analogue photos and more recent digital images, each including metadata and damage classifications based on EMS-98. The database structure and technical features are described clearly and in enough details to allow for its use, and it is clearly a potentially valuable resource for research in engineering and historical seismology, also since it is interoperable with the INGV seismic databases.

> **Answer**: We thank the reviewer for their positive and encouraging comments.

Comment 2: From the technical perspective the interface of the database is well described, however the first earthquake listed in the platform is the 1980 Irpinia one, not the 1976 Friuli as indicated. Please check.

> **Answer**: We thank the reviewer for noting this, DFM starts from the earthquake that occurred in 1980, we will correct the text accordingly.

Comment 3: The date and time of the captured photo are not indicated in the database interface. Is this information available? If so, could be useful to show it, in particular to better place the picture in the context of multiple events or aftershocks.

> **Answer**: We agree that this information is crucial, especially for tracking damage progression. However, it's important to note that for many historical photos in our archive, this level of detailed information is unfortunately unavailable. Furthermore, while the time elapsed since the mainshock is typically short, the duration of a macroseismic survey can span several days, particularly in large urban areas. We updated the web interface to make the available date and time information prominently visible to users; the information might be available for future events. We will mention this improvement in Section 5 (Future developments) and clarify the limitations regarding historical data.

Comment 4: There is no specific indication of the ID of the object the picture refer to. Is this even recorded? From the schema and figures is not clear but it would be very useful considering that multiple pictures refer to the same objects from different perspective and distances.

> **Answer**: Yes, this is a fundamental aspect of our database design. Behind the scenes, multiple pictures of the same building from different angles can be linked together by a unique “Subject ID”. However, as photos come from different physical archives, we are in the process of manually revising them to identify photos of the same building. We realise that this may not be immediately obvious from the current public interface. We will improve the description in Section 3.2 to clarify the existence of this Subject ID and explain how it groups photos. We will also consider making this grouping more evident in future releases of the web portal.

Comment 5: In the map placing the localities with pictures, an overlay describing the estimated macroseismic intensity (e.g. from shake-map) could be provided, and the icons indicated the locality might have variable dimension depending on the number of surveyed objects.

> **Answer**: These are interesting suggestions that would significantly enhance the analytical capabilities of the web portal. We will consider including features such as adding ShakeMap overlays and scaling icons based on the number of surveyed objects per locality in our development roadmap, subject to the availability of resources for this best-effort initiative.

Comment 6: why is important to blurry any personal information in the pictures, it is not clear why the geolocalization of the pictures is not indicated, since it is a public information (e.g., google street view shows both buildings and their locations). Also, often the pictures refer to small details of the buildings and is missing an overview of the building itself, which could be useful to review the assessment or as base information for subsequent assessments (e.g. in case of multiple events).

> **Answer**: We thank the reviewer for highlighting the geolocation issue, as this enables us to correct a misleading statement in the original manuscript. The lack of precise coordinates for individual buildings on the public portal is not just a matter of privacy; the DFM database does not currently record the precise geolocation of individual buildings, even for recent events. Given the available resources, grouping photos at the locality level was the most feasible approach. We will amend Section 3.2 to accurately reflect this technical limitation. With regard to the blurring of information, strict compliance with the GDPR still requires us to minimise the exposure of any personal data captured incidentally (e.g. licence plates or recognisable faces of bystanders). We completely agree on the importance of overviews. The more recent QUEST standard protocol requires a general overview of the building to be taken before detailed photos of the damage are taken. In DFM, a subject ID typically includes an overview photo alongside more detailed ones. If some are missing, this is often due to challenging field conditions (e.g. narrow streets or debris) or the limitations of older analogue archives. Section 2 will clarify that the protocol explicitly includes taking overview photos.

Comment 7: Since some information is not published, is there a plan to provide interested researchers with a more detailed set of information, or a qualified entry point to the full set of information? Since the database is clearly science and research-oriented, a partial disclosure of the collected information would make it much less useful since there is no obvious use for e.g., communication purposes.

> **Answer**: We thank the reviewer for raising this important point. As we explained in our response to Comment 6, the DFM database does not currently hold the precise geolocation of individual buildings. Everything in our archive is already publicly accessible and the CC BY 4.0 licence allows anyone to use the photos for any purpose, provided they cite the source correctly. The database is maintained on a best-effort basis by researchers who balance this project with their primary institutional duties. Unfortunately, there is no dedicated staff exclusively assigned to DFM management. However, we recognise the scientific value of providing a more detailed set of information to interested researchers.

Comment 8: While the Mw 6.29 2009 "L'Aquila" earthquake lists 944 pictures, 56% of the entire database, in case of other recent and major earthquakes (e.g., the Mw 6.18 2016 -August- earthquake lists only 11 pictures) there is only an handful of localities with pictures of damaged buildings. Also in the case of 2023 Umbria earthquake there is only one locality with two pictures of two buildings. The 2023 Tuscany M5.1 earthquake is not present, etc. The authors acknowledged that "The population of the DFM is a recent and ongoing long-term effort, and the dataset is expected to grow substantially in the coming years [...]" but is not clear what roadmap does it have with respect to adding further data to the database and based on which prioritisation scheme. Also, an indication of the percentage of considered objects with respect to available data would be useful to estimate coverage and completeness of the

database. This is an important aspect that should be addressed more carefully, also to highlight the long-term sustainability of the database. Also, is there in place a protocol/workflow to integrate the database in all future QUEST missions, so that a minor delay can be expected before this information is made available?

> **Answer**: The reviewer correctly identifies an imbalance. The 2009 L'Aquila earthquake involved a massive and prolonged survey effort, resulting in a disproportionate number of photographs being made available online compared to other events. The DFM population is an ongoing effort, primarily carried out on a best-effort basis by researchers alongside their other institutional duties. Our prioritisation scheme generally follows three steps: 1) new events (to make data available quickly); 2) major historical events (digitising analogue archives, such as the 1980 Irpinia earthquake); and 3) progressively filling gaps for other recent events. Regarding future field surveys, QUEST has recently updated its operational protocol. In the near future, we will experiment with using a dedicated mobile application (QUEST-DATA). Among its features, it can feed photos and preliminary classifications directly into a centralised repository. We will include a reference to this in the final revision of the article. Although mapping these to precise public coordinates is still being evaluated due to the aforementioned resource constraints, this digital workflow will significantly reduce the delay between field surveys and data becoming available in DFM. We will add a paragraph to Section 2 to explain this new workflow, as well as adding a paragraph to Section 3.3 to explain the prioritisation roadmap.

Comment 9: Would be interesting for the authors to comment on the possibility to integrate rapid damage mapping approaches such as the one described in Pittore et al. (2018) to complement the database and provide a web-based interface for EMS-98 damage mapping and semi-automated evaluation of macroseismic intensity. This would also highly enrich the scientific and operational value of the database.

> **Answer**: The photos collected in the field for the DFM project are intended to preserve the most relevant information available for learning purposes. These photos are not intended for assessing macroseismic intensity, and there are insufficient quantities to enable this using the methodology described by Pittore et al. (2018). As mentioned in Section 5, however, these photos are valuable for machine learning. This section will be expanded to include Pittore et al. (2018) as an example.

Comment 10: This database could be linked or integrated with the IDEA and DADO from Eurocentre. The latter for instance provide building-by-building damage data for hundreds of thousands of objects. The authors could comment on the potential for integrating these different sources.

> **Answer**: We strongly agree that interoperability with other databases, such as IDEA and Da.D.O., is highly desirable. Although DFM focuses on the macroseismic perspective (EMS-98) and Da.D.O. is more engineering-oriented (based on AeDES forms), linking the two via event IDs or locality names could offer a more complete picture by combining seismological and structural engineering data. However, it should be noted that direct cross-referencing on a building-by-building basis would currently be limited, as precise building coordinates are unavailable in DFM. Furthermore, although the IDEA image dataset is freely available in an open-access repository (accessed via a DOI pointing to zip files rather than an interactive portal), the Da.D.O. platform requires users to register in order to access its data. This means that any direct web link from DFM to Da.D.O. would not provide immediate open access for all users. We will add a comment in Section 5 about exploring future interoperability with engineering databases such as Da.D.O. and IDEA, bearing in mind these technical and access-related constraints.