Nat. Hazards Earth Syst. Sci. Discuss., 1, C1056–C1061, 2013
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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Temporary seismic monitoring of the Sulmona area (Abruzzo, Italy): quality study of microearthquake locations" *by* M. A. Romano et al.

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Received and published: 3 September 2013

REVISION OF THE MANUSCRIPT "TEMPORARY SEISMIC MONITORING OF THE SULMONA AREA (ABRUZZO, ITALY): QUALITY STUDY OF MICROEARTHQUAKE LOCATIONS"

Dear Editor,

We considered all the comments and suggestions received from the three referees and we found them very helpful. So we accepted all the hints and we did our best to properly modify the manuscript and to improve the paper. The structure of the article

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remains substantially the same, even if some adjustments to the text, the figures and the tables were made. Parts of the original text are now kept on a separate appendix (Appendix A). The following notes summarise all changes, together with a detailed answer to the issues raised by the reviewers. We hope we have answered to all the comments and that the new manuscript is now suitable for publication in NHESS. Best Regards

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REFEREE #1: Dario Albarello

We agree with Albarello's observation on Fig. 11d, according to whom the actual slope of the G-R relationship is more than 0.7 for events with magnitudes lower than 2.3. So we reformulated the sentence as indicated on the attached doc file (page 16, line 27).

REFEREE #2: Elena Eva

Following the suggestions of the reviewer, we improved the readability of the paragraph 3.2 (1), we pointed out the total improvement between the preliminary and final locations (2), we added some explanation about the derivation of the velocity model 'e' (3), we inserted the date of last access at ISIDE and OASIS website also in the text (4) and updated the bibliography (5). In detail:

1) We substantially reduced Sect. 3.2 moving, in the Appendix A, the analysis of phase reading uncertainties, the Table 2 (now Table A1) and Fig. 5 (now Fig. A1). As written at the end of the appendix (page 20, line 5), we decided to retain this detailed section giving a rationale.

2) At the bottom of Fig. 2 (representing the map of preliminary locations) and of Fig. 10 (now Fig. 9, representing the map of final locations) we inserted two tables which summarized some characteristics (number of events, GAP, RMS, ErrH and ErrZ) of located earthquakes, in order to show their different quality. We choose this form to visualize differences because located earthquakes in the initial and final steps were

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not exactly the same (see page 9, line 3 for explanation).

3) We explained how the model 'e' was derived from model 'd' and why we used it to calculate the local velocity model for the Sulmona area (page 10, line 9 and page 11, line 14)

4) We changed the citation of ISIDE and OASIS websites, but we do expect eventual editorial staff's adjustments.

5) We inserted the reference to the paper of Elter et al. 2012 (page 5, line 7 and page 22, line 25).

REFEREE #3: Anonymous

Accepting all reviewer's proposals, we simplified Sect. 3.2 (1), modified Fig. 9c and Fig. 9d (now Fig. 8c and Fig. 8d) (2) and commented the choice of using RSNC phase readings, even if their actual uncertainties are unknown (3). In detail:

1) See the answer given to Referee #2 at point (1).

2) We redrew the histograms related to standard horizontal and vertical errors of Fig. 9 (now Fig. 8) by using a bin of 0.2 km instead of 1 km, for showing their distribution adequately.

3) As far as it concerns the homogeneity of the uncertainty associated to each phase reading, we agree with the reviewer. As matter of fact, the integration of our dataset with further arrival times of the RSNC and RSA (national and regional permanent networks respectively) was a necessary step because the earthquakes located using only STN data suffer of GAP and too high horizontal/vertical errors (see the summary table inserted on the bottom of Fig. 2). As described in the paper, the 68% (or $\sim$ 70% if we consider the effectively used phases after applying the distance weighting) of phase readings have manually assigned wheights, while only the remaining 32% (or $\sim$ 30% after applying the distance weighting) remain unchecked. In order to illustrate how the 32% of the unchecked weights could influence the solutions we performed some

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sensitivity tests varying the weight codes of INGV phases and/or the Hypoellipse location code (Lahr, 1980) weighting scheme. We did not add these tests in the revised manuscript, but we only mention them in the appendix 3.2 (page19, line 23-30), because we do not believe they are of general interest. As further check, we compared our manual readings (and weights) and the ones (and weights) released by INGV in the Italian Seismic Bulletin for INTR and LPEL permanent stations and verified that such differences fall within the uncertainty interval of the adopted weighting scheme of our final location.

- Tests performed by using different weight options and weight codes

Except for the regional stations (RSA), for which we retrieved and analysed the useful waveforms, we used the revised P and S arrival times released by INGV in the Italian Seismic Bulletin. Our final locations (presented in the paper) were obtained by using RSNC weight codes handled as STN weight codes and optimized weight options. We performed some sensitivity tests varying the weight codes of INGV phases and/or the weighting scheme of Hypoellipse. So we re-located earthquakes:

1 - using 'worsened' RSNC weight codes (considering 0=1, 1=2, 2=3, 3=4) and optimized weight options (test 1);

2 - using 'worsened' RSNC weight codes (considering 0=1, 1=2, 2=3, 3=4) and Hypoellipse standard weight options (test 2);

3 - using 'worsened' RSNC weight codes (considering 0=2, 1=3, 2=4) and optimized weight options (test 3);

4 - using 'worsened' RSNC weight codes (considering 0=2, 1=3, 2=4) and Hypoellipse standard weight options (test 4).

The histograms of the differences in terms of hypocentral depth between our final locations and the test 1, test 2, test 3, test 4 were plotted (Fig. 1), together with the curve of cumulative number of events. Note that in all cases about 90% of differences are less

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than 1 km, i.e. within the uncertainty of our best locations.

Caption Figure 1

Fig. 1 Hypocentral depth differences between the final locations and the relocated earthquakes considering Test1-Test4.

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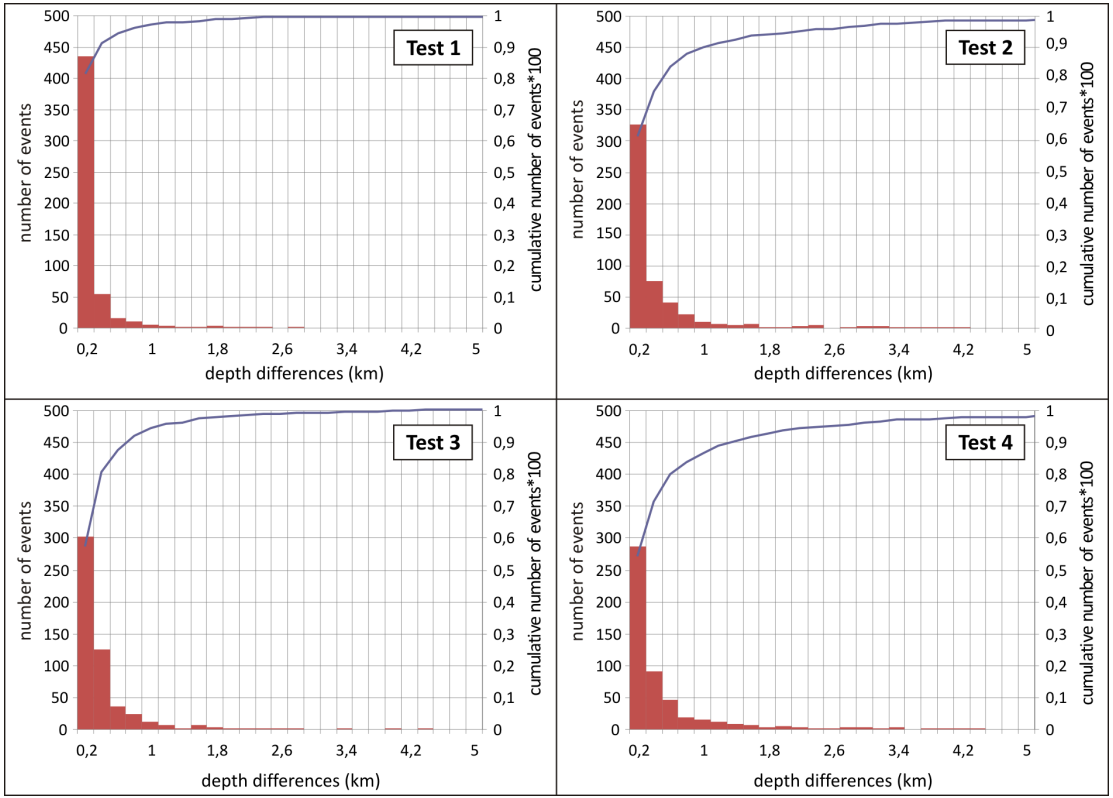

Fig. 1.

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