Updated method of automatic assessment based on macroseismic data collected online at the Portuguese Seismological Service

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IPMA's web questionnaire 2006-2019

IPMA Web questionnaire purposes:

- The primary purpose of the macroseismic questionnaire and its automatic evaluation implementation is to provide macroseismic information to the civil protection authorities, immediately after felt earthquakes with impact on the population.

- Secondly, it is a efficient method to collect macroseismic information that will be deployed on catalogues, after revision.

For nearly 13 years, between 2006 and 2019, the Portuguese seismic service used a first web questionnaire to collected macroseismic information based on voluntary collaboration of Internet users that report their experiences after felt earthquakes.

During this period, thousands of responses (~17800) were received and analyzed, after the occurrence of almost five hundreds earthquakes that were felt in Azores archipelago, Madeira archipelago and Portugal mainland.

IPMA's web questionnaire 2006-2019

- The results of the questionnaire were fully integrated with the seismic processing routine of Portuguese seismological service, providing quantitative and qualitative information about seismic intensities.

- For that, an algorithm and a computer application written in C programming language was developed to analyze the reported effects and convert them into degrees of seismic intensity.

- Nevertheless some items of the entire process, needed to be corrected, expanded, and/or clarified.

- Although the good performance, the stability and the coherence with other methods (manual collection and ShakeMap), the process had some limitations, and some aspects had to be improved specially what concerns with hardware support, damages on buildings and indicators for intensities exceeding V.

At the end of 2019, after a revision of the questionnaire and the algorithm, a major upgrade of the method was implemented.

The new IPMA's web questionnaire

The new version of the questionnaire was created using LimeSurvey (GmbH, Hamburg, Germany, http://www.limesurvey.org), a free and open source survey tool.

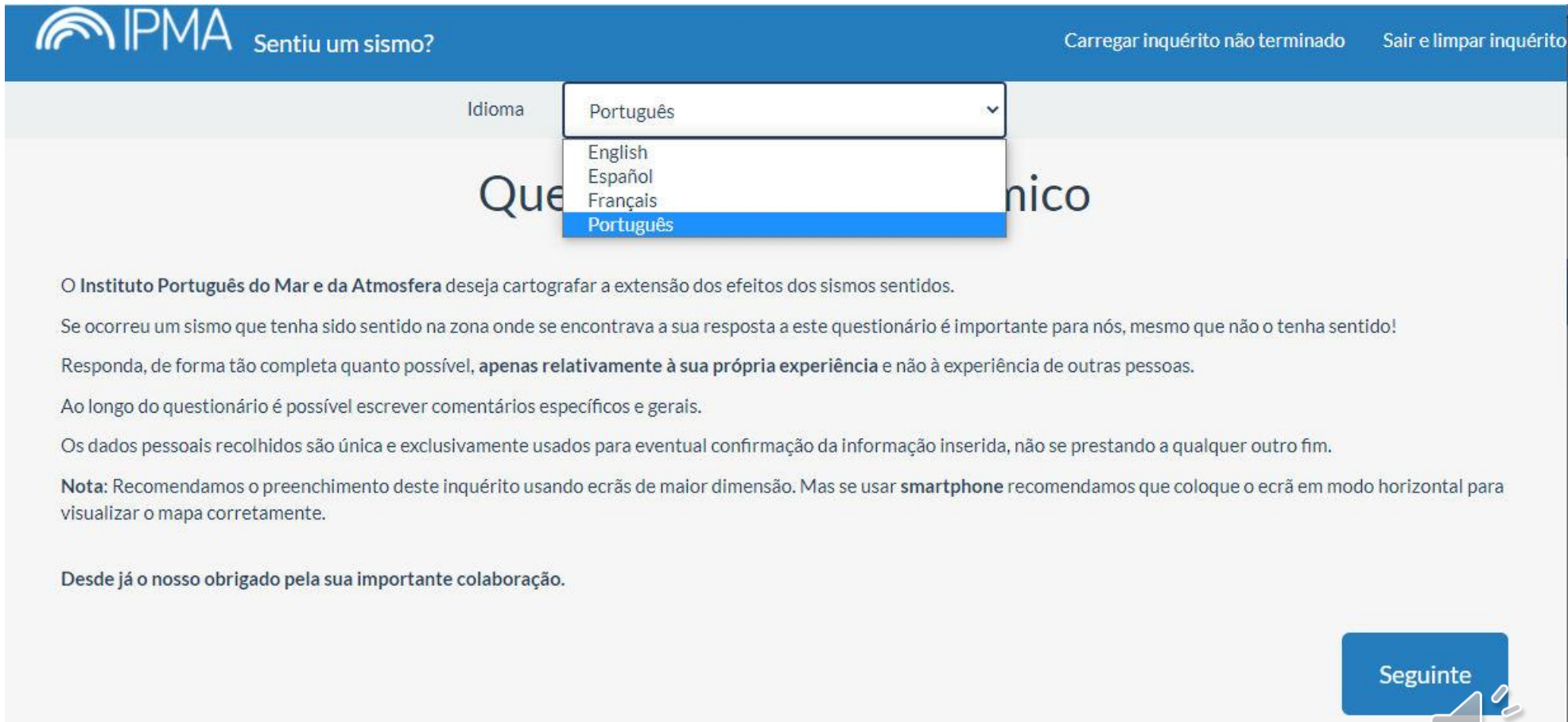The software LimeSurvey XAMPP package includes:

- Apache Server,

- MySQL database,

- interpreters for scripts written in the Hypertext Preprocessor (PHP) and Perl programming languages, and

- several other modules as OpenSSL and phpMyAdmin.

The new IPMA's web questionnaire

New features includes:

1) Multiple languages implemented (English, French, Portuguese and Spanish);

The new IPMA's web questionnaire

New features includes:

2) A list of last earthquakes that may have been felt in the Portugal region, that allows selection of the felt earthquake;

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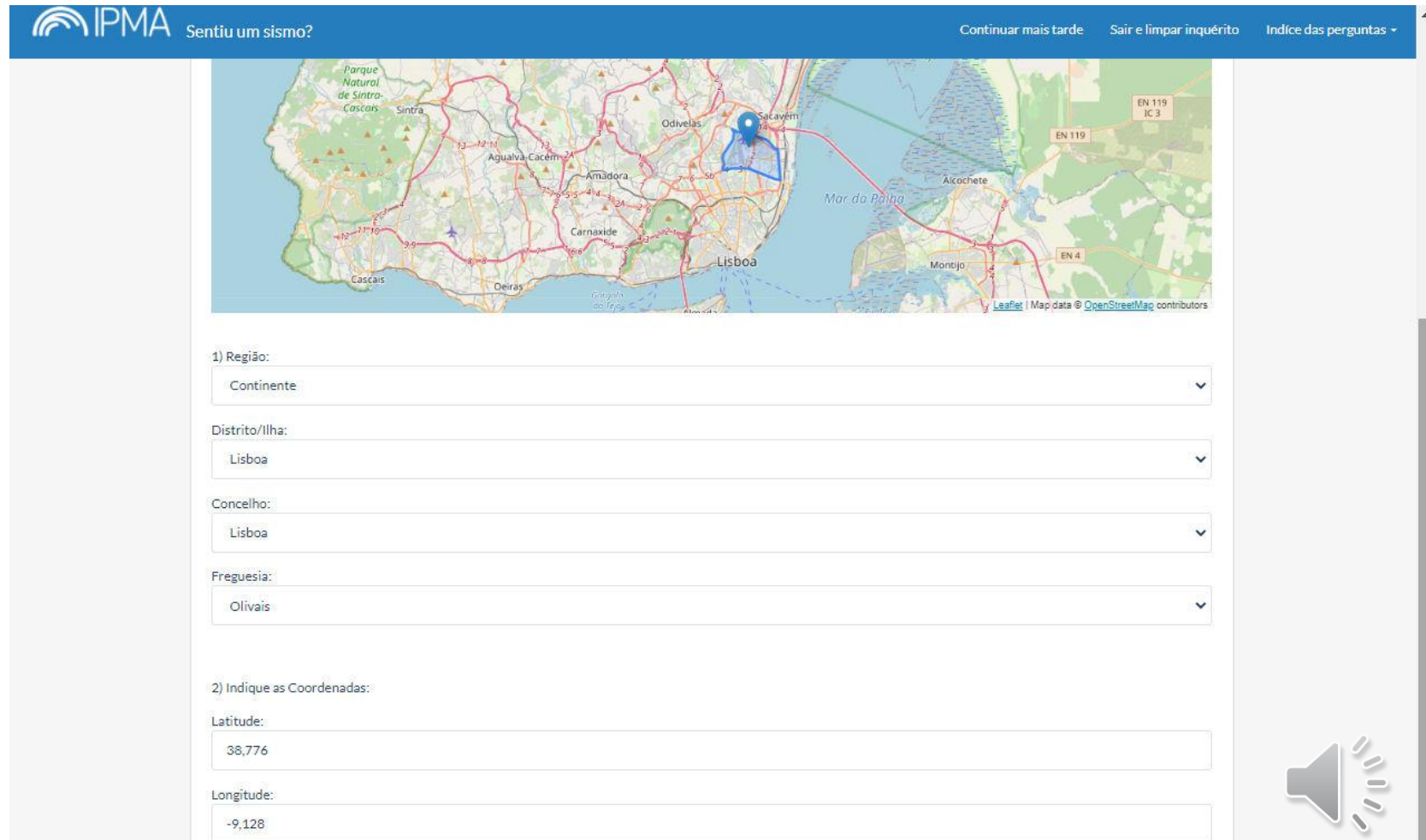
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The new IPMA's web questionnaire

New features includes:

3) A redesigned process to indicate the geographic location of the observer
- interactive map with zoom,
- a drop-down menu with the Portugal administrative regions (region, district, county and parish), or
- text boxes to fill with the coordinates;

The new IPMA's web questionnaire

New features includes:

4) A redesigned interactive schema of questions following the EMS-98 scale, using branch logic, with conditions implemented related to some questions and their answers, in order to display some questions if some conditions are met;

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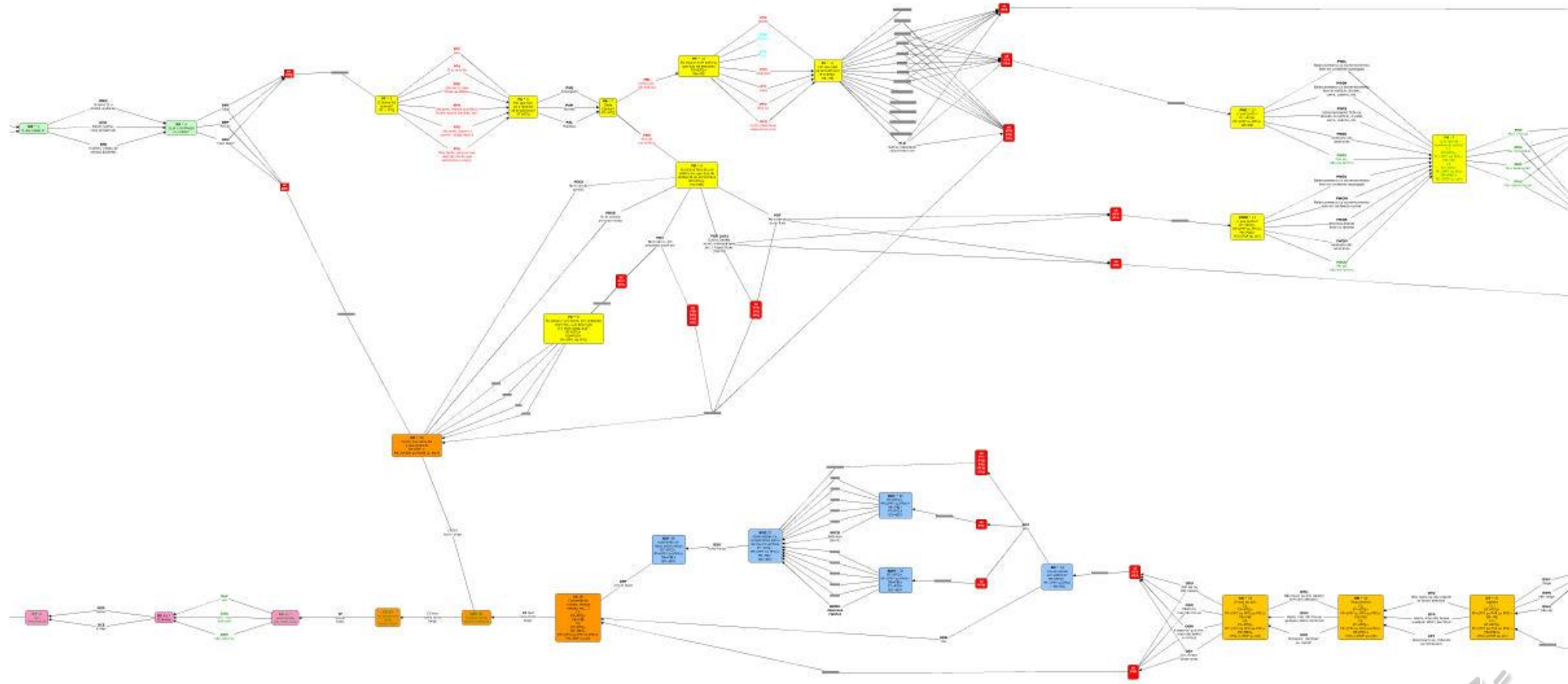
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The new IPMA's web questionnaire
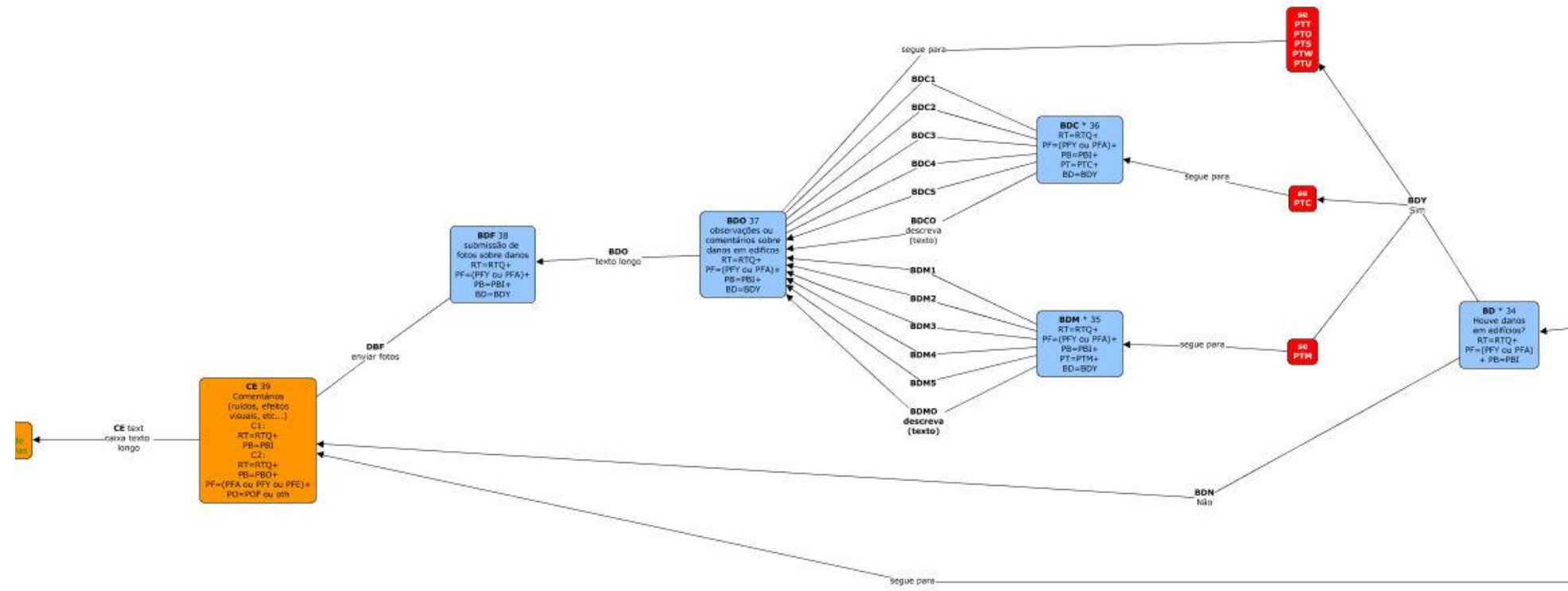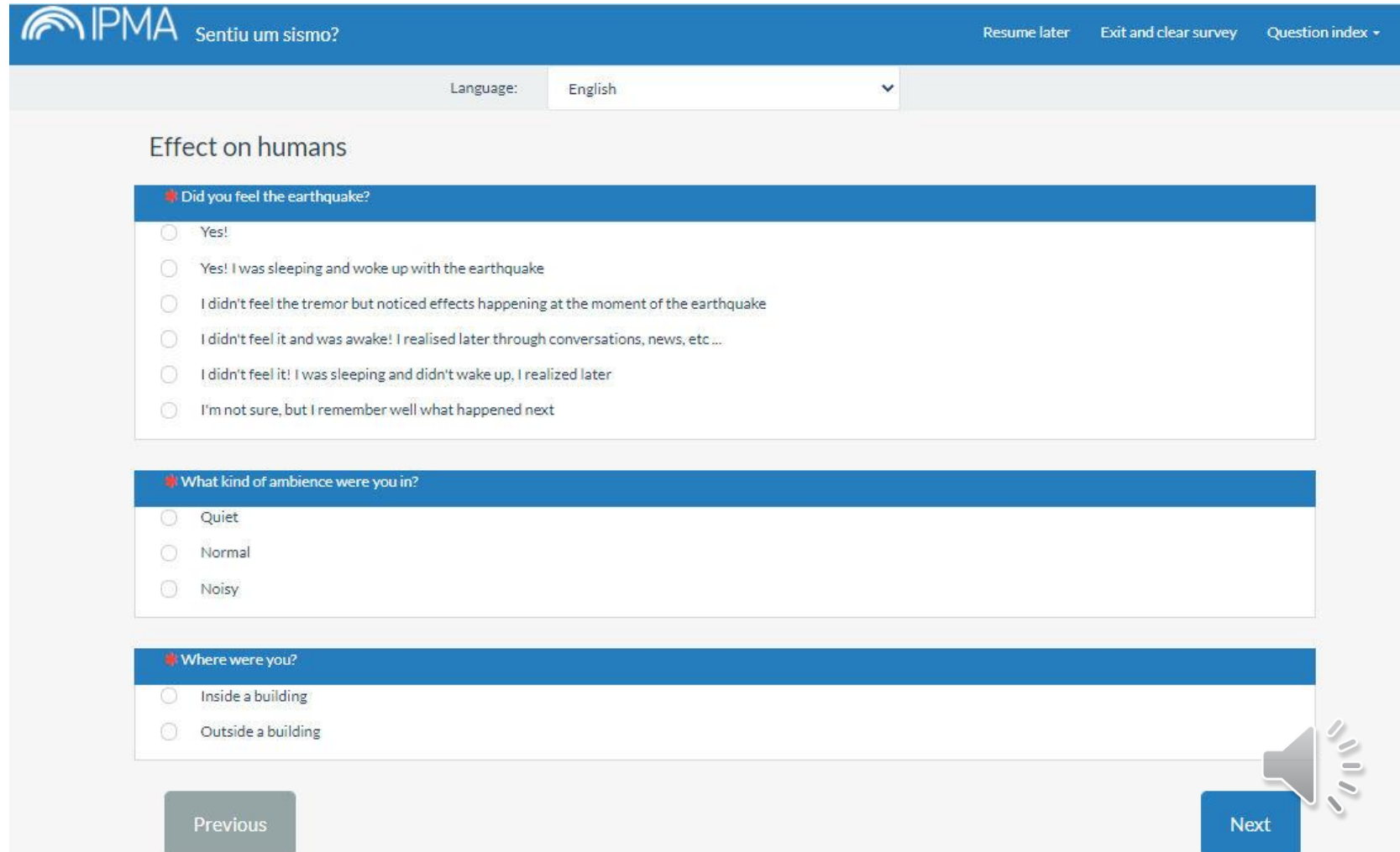
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Effect on objects and nature

✱ Hanging objects?

- ● There were none or I did not notice if they were affected
- ○ There were, but there was no noticeable effect
- ○ Swing slightly
- ○ Swing moderately
- ○ Swing considerably

✱ Liquides?

- ● Il n'y avait pas ou je n'ai pas regardé si ont été affectés
- ○ Il y avait, mais il n'y avait pas d´effets visibles
- ○ Ils ont oscillé et dans certains cas projetés hors des récipients
- ○ Les récipients, les réservoirs et les piscines se sont débordés.

✱ ¿Vajilla (platos, vasos, tazas, copas, etc...)?

- ○ No había o no me di cuenta si fueron afectados
- ○ Había, pero no hubo ningún efecto perceptible
- ◉ Tintinearon
- ○ Hicieron ruido apreciable
- ○ Alguna vajilla se rompió
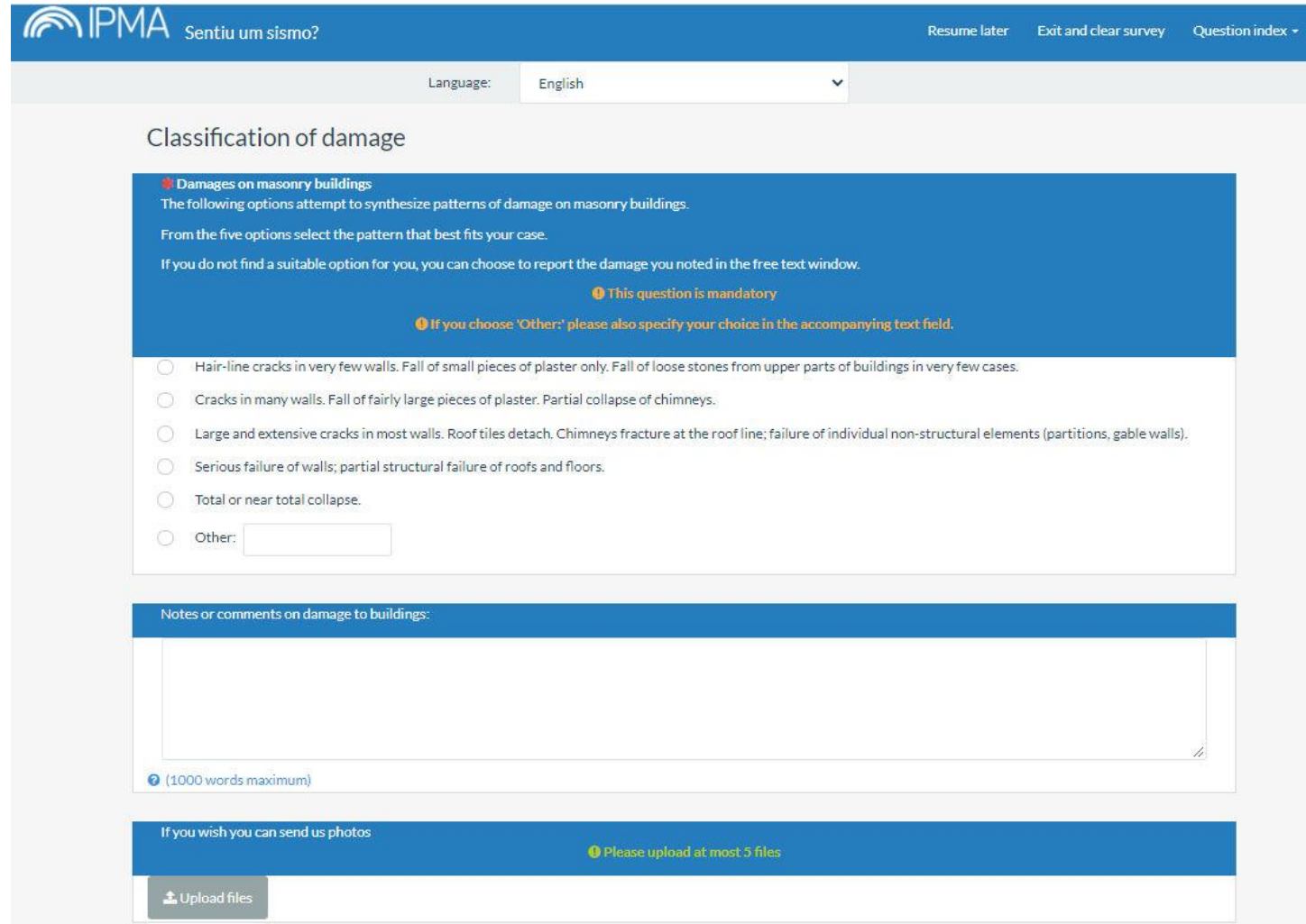- ○ Mucha vajilla se rompió
- ○ Casi toda la vajilla se rompió

The new IPMA's web questionnaire

New features includes:

5) More questions and details were included, including:

- a completely new group of questions related to damages on buildings,
- questions related to effects felt in offshore boats, and
- possibility to send photos;

The new IPMA's web questionnaire

New features includes:

5) A code was incorporated to convert the questions and answers into another form that is the same in the different languages;

Examples of codification about **P**eople:

PFelt PFYes PFNo PFBut
PBuilding PBInside PBOutside
PType of building PTMasonery PTConcrete PTWood PTSteel + C
PWhat was felt **I**nside PWILight PWIModerate PWIStrong PWIDifferent
PWhat was felt **O**utise PWOLight PWOModerate PWOStrong PWODifferent
PDuration Comments on duration (### in seconds)
PReaction PRNo fright (almost) PRSome fright PRModerate fright
          PRBig fright PRX-treme fright + C
PSleep PSConscient PSAwake PSSleep
PAmbience PAQuiet PANormal PALoud

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Examples of codification about **O**bjects and Nature:

OSuspended OSDon't know OSNo effect OSLight 3 OSModerate 4 OSX-treme 5
OChina OCDon't know OCNo effect OCRattle – tilintar 4 OCClatter – chocalhar 5
        OCBreak – few may break 6 OCMany break 7 OCX-treme, most break >=8
ODoors and Windows ODDon't know ODNo effect ODRattle (estremeceram 4
        ODSwing panes open and shut 5 ODWindows panes break - few 5
        ODXtreme windows panes break - many >=6
OObjects OODon't know OONo effect OOTop heavy and small objects may fall or shift 5
        OOStable objects may fall 6 OOFall from shelves in large numbers 7
        OOBig objects fall to the ground 8
OLiquids OLDon't know OLNo effect OLOscillate and may spill 5
        OLSplash from containers, tanks, pools 7
OFurniture OFDon't know OFNo effect OFShakeFew 4 OFShakeMany 5
        OFMoveFew (shift) 6 OFMoveMany (shift) 7
        OFTop heavy, may be overturned 7 OFOverturned 8

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Examples of codification about **B**uildings:

BDamages BDNo BDYes
BDMasonry (with figure) BDM1 BDM2 BDM3 BDM4 BDM5
BDConcrete (with figure) BDC1 BDC2 BDC3 BDC4 BDC5
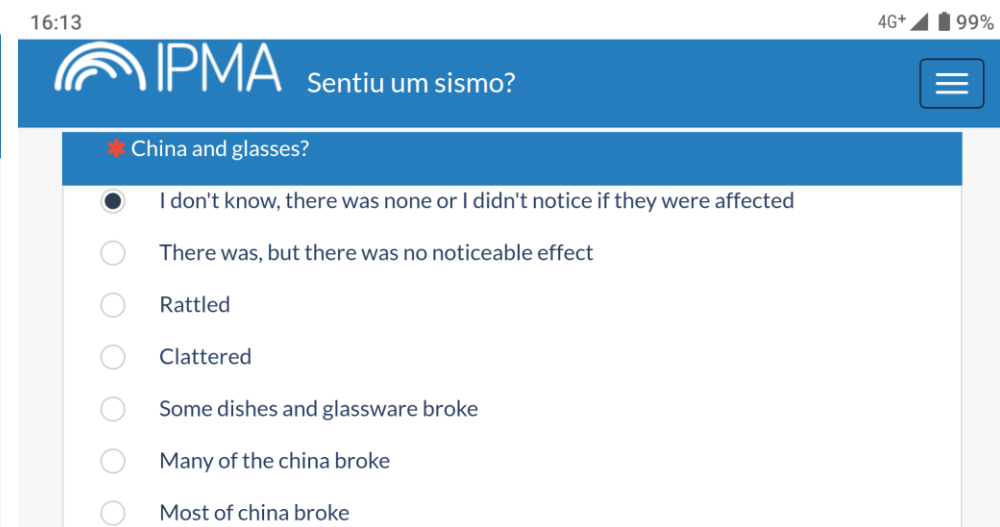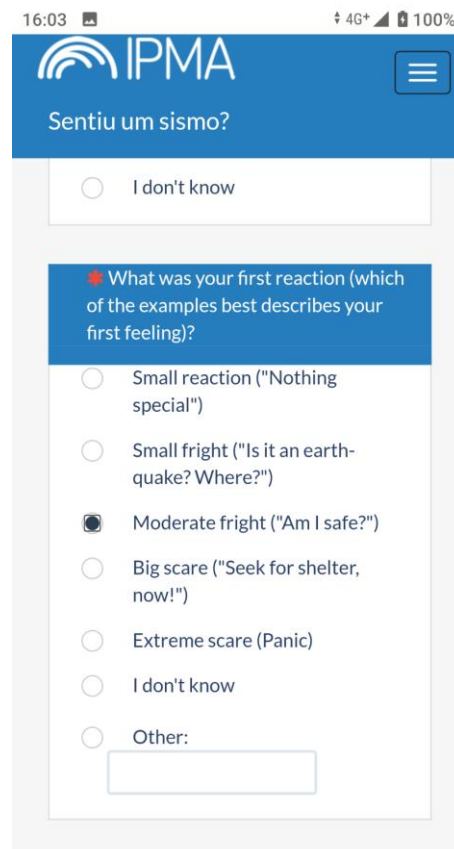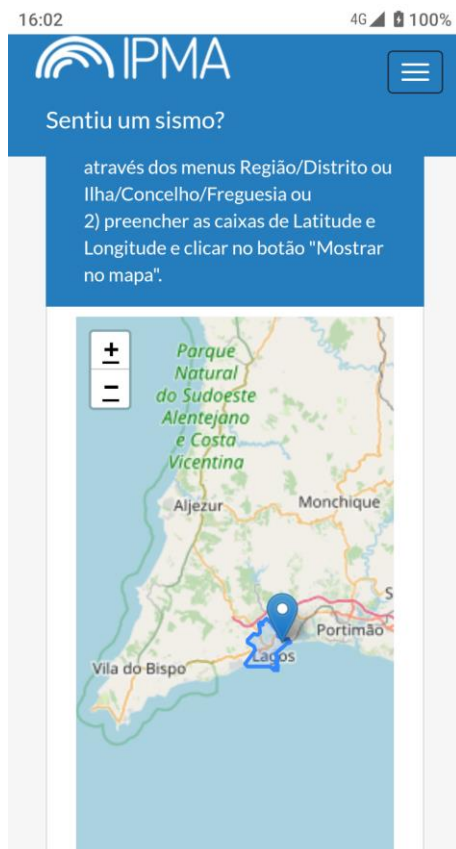**BDO**thers **C**omments on others

The new IPMA's web questionnaire

New features includes:

5) Possibility to be displayed in PC or/and mobile devices (smartphones and tablets) regardless of the operating system.

The new IPMA's web questionnaire

The questionnaire has now 5 main groups of questions related to:
- time and date of observation,
- geographic location of observer,
- effects on people,
- effects on objects and nature,
- building damages and
- has the possibility to collect some different kinds of comments on the earthquake, in free text.

The algorithm and the WebMInt program were adapted and upgraded according to the new features of the questionnaire and some other improvements were made. For instance, analyses question by question the responses associated with the same location (still in test), some quality control strategies implemented were refined, and several results according to different statistical approaches are obtained to gather information for further discussion.

The main steps of the algorithm are:
- read and filter data,
- conversion of answers to numbers,
- analysis of answers,
- summary by Macroseismic Data Point (MDP), and
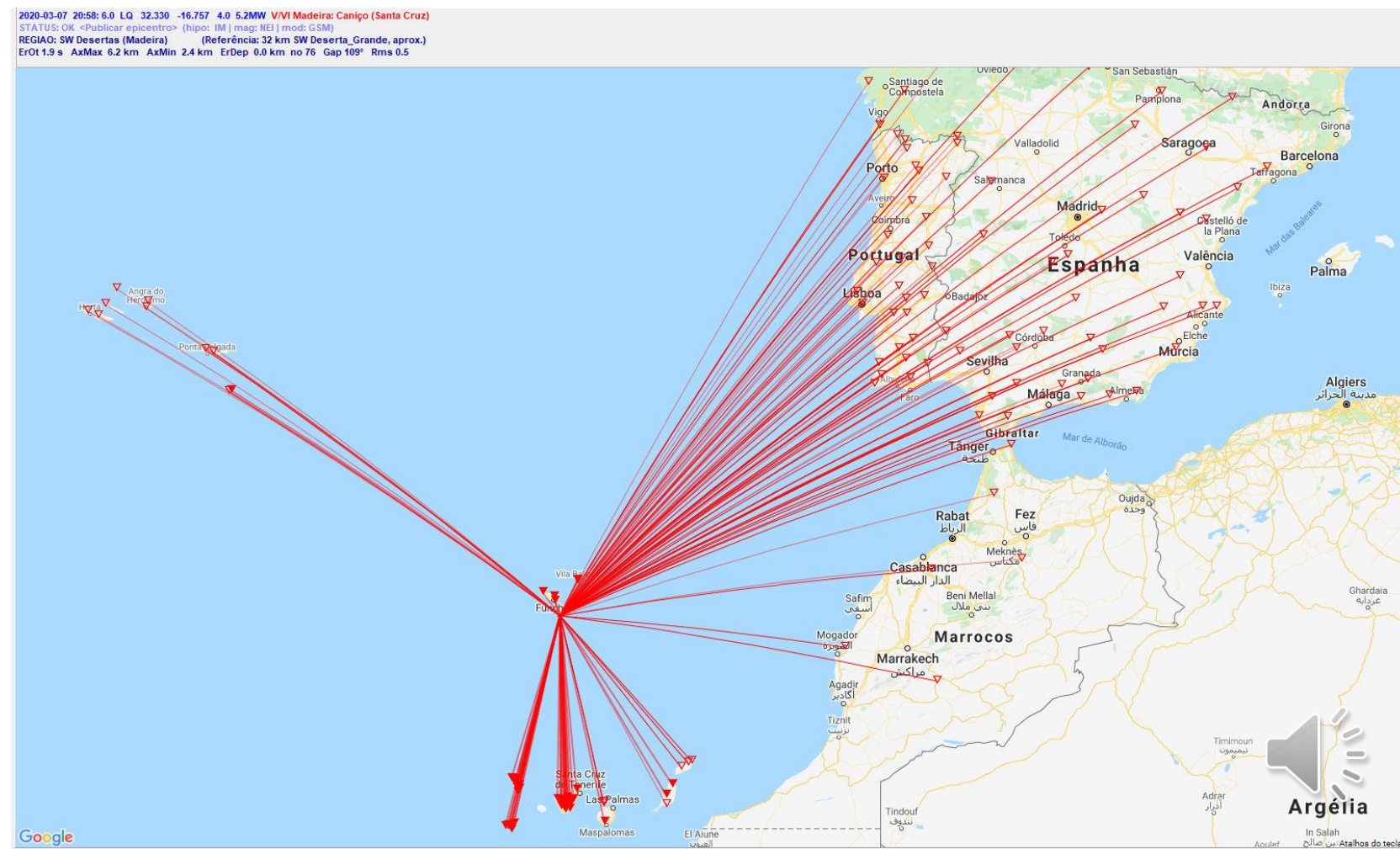- writing results.

The new IPMA's web questionnaire

The WebMInt program interacts with other tools of the operational seismic center (figure 1), in particular with:

- the earthquake analysis software SEISAN (Havskov J., and Ottemoler L., 2005),
- the program W_Emap (Carrilho F., 2005), and
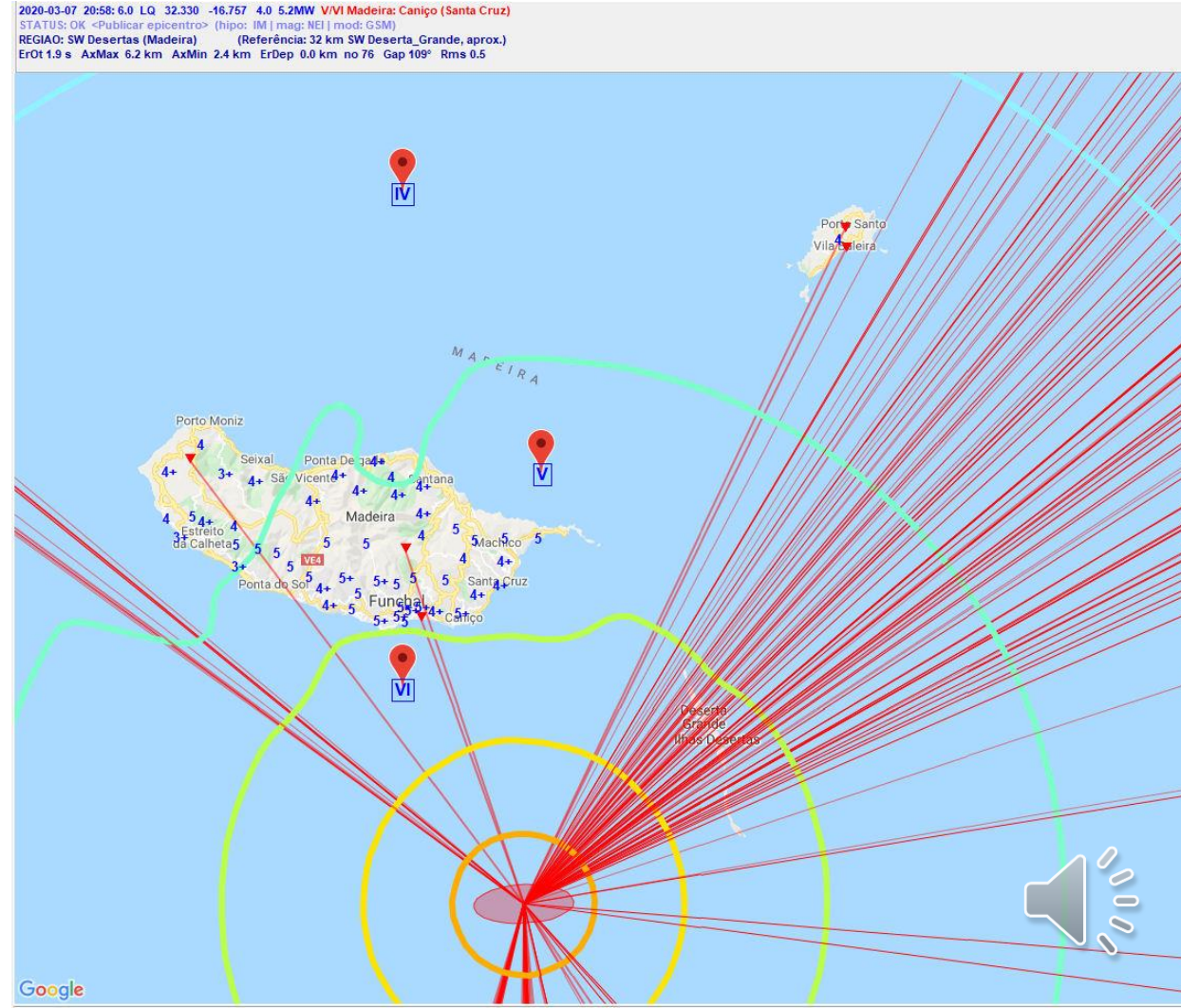- the software ShakeMap (Wald et al., 2005).

Example: March 7, 2020 Mw 5.2 Madeira Is. Earthquake

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Example: March 7, 2020 Mw 5.2 Madeira Is. earthquake

The IPMA's seismic operational program W_Emap plots MDP's intensities, as well, theoretical and observed isoseismals.

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The new IPMA's web questionnaire

Example: March 7, 2020 Mw 5.2 Madeira Is. earthquake

The IPMA's seismic operational program W_Emap allows interactions with MPD's data and manual validation.

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Example: March 7, 2020 Mw 5.2
Madeira Is. earthquake

The ShakeMap program incorporate also MDP's data (see report stationlist.txt)

Portugal – IPMA ShakeMap : SW Desertas (Madeira)
MAR 7 2020 08:58:06 PM GMT   M 5.2   N32.33 W16.76   Depth: 4.0km   ID:2020030720580502

```
# Earthquake 2020030720580502: 03/07/2020 20:58:06 GMT, M=5.2, Lat: 32.3300,
Lon: -16.7570, Depth: 4km, Bias: mmi=0.00 pga=0.00 pgv=0.00
# Columns: Station Code, latitude, longitude, regression dist (km),
intensity, network code, Channel 1 Code, PGV (cm/sec), PGA (%g), PSA 0.3 sec
(%g), PSA 1.0 sec (%g), PSA 3.0 sec (%g), Channel 2 Code, PGV (cm/sec), PGA
(%g), PSA 0.3 sec (%g), PSA 1.0 sec (%g), PSA 3.0 sec (%g), Channel 3 Code,
PGV (cm/sec), PGA (%g), PSA 0.3 sec (%g), PSA 1.0 sec (%g), PSA 3.0 sec (%g)

PMAR, 32.7237, -16.9137, 45.4, 4.7, IMP, HH1, 1.8800, 3.6122, , , , HH2,
1.0700, 2.3286, , , ,
PMOZ, 32.8230, -17.1972, 67.7, 4.2, IMP, HHE, 1.1900, 2.0500, , , , HHN,
0.9905, 1.8429, , , ,
PMPS, 33.0570, -16.3330, 89.2, 2.8, IMP, EHE, 0.0000, 0.3888, , , , EHN,
0.0000, 0.3265, , , ,
PMPST, 33.0788, -16.3333, 91.3, 3.3, IMP, HHE, 0.1618, 0.6510, , , , HHN,
0.2365, 0.7235, , , ,
I310101, 32.7317, -17.1366, 56.6, 5.0, MMI, DERIVED, nan, nan, nan, nan, nan
I310102, 32.7521, -17.1397, 58.6, 4.0, MMI, DERIVED, nan, nan, nan, nan, nan
I310103, 32.7568, -17.1760, 61.1, 4.5, MMI, DERIVED, nan, nan, nan, nan, nan
I310105, 32.7395, -17.2099, 61.8, 3.5, MMI, DERIVED, nan, nan, nan, nan, nan
I310106, 32.7596, -17.2284, 64.6, 4.0, MMI, DERIVED, nan, nan, nan, nan, nan
I310107, 32.8115, -17.2251, 68.7, 4.5, MMI, DERIVED, nan, nan, nan, nan, nan
I310108, 32.7624, -17.1941, 62.7, 5.0, MMI, DERIVED, nan, nan, nan, nan, nan
```

VIBRAÇÃO PERCETIVEL	N/ sent	Fraco	Moderado	Forte	Bast/ Forte	Mto Forte	Ruinoso	Desastroso	Extremo
DANOS POTENTIAIS	n/a	n/a	n/a	Mto ligeiro	Ligeiro	Moderado	Mod./Forte	Forte	Mto Forte
PGA(%g)	<0.05	0.3	1.6	5.0	8.8	15	27	47	>83
PGV(cm/s)	<0.07	0.4	1.9	5.8	11	22	43	83	>160
INTENSIDADE INSTRUMENTAL	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon IM–(Atkinson & Kaka; 2007) & (Wald, et al.; 1999)

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The new IPMA's web questionnaire

Since October 16, 2019, there were more than 20,000 hits that resulted in 7200 validated responses. During this period there were 35 earthquakes felt on the mainland, 2 in the Madeira archipelago and 76 in the Azores archipelago.

Next steps:
- all aspects concerning quality must be reviewed in detail,
- the MDP assessment of seismic intensity by questions needs to be further tested,
- the use of orthogonal grids should be introduced as well as other approaches that can overcome the limitations of the DCF concept as they are MDP's based on administrative criteria that vary in time, and
- there is a lack of secure criteria for quantifying the terms "few", "many" and "most" of the EMS-98.

The new IPMA's web questionnaire

This entire process, always evolving, as it is in use, responds efficiently, on the one hand, to operational emergencies and, on the other, to the volume of data that is collected.

However, it remains necessary to stay focused on the basic concepts of seismic intensity as they are applied in EMS-98 and ensure that these are well translated into the algorithms and that the best tools of mathematics and statistics are used since data scarcity and geographical sparsity of observations are significant problems when dealing with macroseismic studies.