SHARE

SEVENTH FRAMEWORK PROGRAMME

Grant Agreement no. 226967

Seismic Hazard Harmonization in Europe

Project Acronym: SHARE

SP 1-Cooperation

Collaborative project: Small or medium-scale focused research project

THEME 6: Environment

Call: ENV.2008.1.3.1.1 Development of a common methodology and tools to evaluate earthquake hazard in Europe

D5.4 – First-round regional seismic hazard assessment including de-aggregation and validation

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GFZ German Research Center for Geosciences (GFZ)
G. Grünthal

Revision: 1

Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Table of Contents

Overview of the feedback process

Internal and external evaluation of probabilistic seismic hazard assessment (PSHA) projects, its computational and procedural implementation, the model philosophy and applied approaches as well as preliminary and final hazard results are essential components of each PSHA. This is particularly important for a regional scale project that aims to harmonize the hazard assessment across national boundaries. The SHARE modelling team is strongly depending on reviews of experts with various different expertise. Only with their feedback, the hazard modellers are able to develop a model that reflects to a satisfying level the state-of the art knowledge for an appropriate PSHA of the target region.

SHARE planned the feedback procedure in its document of work (D1.1) and the SHARE management implemented the procedure more extensively than assumed therein. Representatives of the SHARE consortium convened for two workshops on March 12/13, and September 3/4, 2012. Both workshops included about 35 experts representing multiple disciplines (geology, seismology, tectonics, statistics, earthquake engineering) and roles within the project: the different roles can be categorized in data supplier, local/national/regional expert for data or hazard expertise, expert in hazard modelling, expert in engineering seismology and earthquake engineers.

The SHARE management invited external experts (see Table 1) to these meetings to obtain feedback from the community not fully involved in the SHARE process: this is an essential procedure to understand whether the model is acceptable for the larger community that did not have the possibility to participate directly within the project.

Name of External Expert	Institution / Country	Workshop Attended
Oona Scotti		March
Laura Peruzza		March
Ezio Faccioli		March
Carlos Sousa Oliveira		September
Thomas Wenk		September
Dario Sleijko		September

Table 1: Experts attending the review meetings of SHARE.

In addition to the feedback meetings in 2012, the SHARE consortium convened for its annual meetings in Rome (1st Annual Meeting, June 15/16, 2010) and in Oslo (2nd Annual Meeting, June 15-17, 2011). In both meetings the hazard model, the input data, engineering requirements and approaches were discussed in detail within the consortium. In both meetings, members of the SHARE scientific advisory board (J. Zschau, M. Koller, A. Pinto, P. Pinto) attended the meeting. Additional experts where invited to share their expertise: during the 2nd Annual Meeting we hosted E. Carvalho Cansado, J. Bommer, F. Scherbaum and N. TheodolidisE. Faccioli, L; during the final meeting we hosted E. Faccioli and L. Gülen.

Feedback documents where provided by scientists listed in Table 2. The documents re attached to the document in the Archive *FeedbackDocumentsShare.zip*.

Name	AS-model	FSBG-model	Smoothed Seismicity Models	GMPEs	
Oona Scotti	x	x			
Laura Peruzza	x	x			
Ezio Faccioli	x			x	
Dario Sleijko	x	x	x	x	
Carlos Sousa Oliveira					No written feedback
Thomas Wenk					No written feedback
M. Stucchi / A. Rovida	x				
T. Camelbeeck	x				
K. Vanneste	x	x			
G. Grünthal	x				
M. Erdik **K. Sesetyan** **M. Demircioglu**	x				
J. Mayordomo	x			x	And general comments

C. Lindholm **H. Bungum**	x				
S. Vilanova **J. Fonseca**	x	x		x	
P. Y. Bard **F. Cotton**	x	x		x	And general comments
S. Akkar				X	
R. Basili		x			

Table 2: Scientists that provided feedback in written form or that were contacted via phone or skype.

Goals of the Model Review Workshops

Both review workshops served multiple goals for the hazard modelling team of WP5 / WP6:

1. Discussion of the hazard model, its computational implementation and preliminary hazard results,
2. Define model revisions and additional model tests,
3. Define a roadmap for the implementation of the revisions.

Prior to the workshops documentation on the data and the hazard model generation was provided to the participants. This material was then presented during the workshops with the intent to bring all participants to the same level of information. Presenting the data, philosophy of the hazard model component, the approaches used for the derivation of parameters such as activity rates and its computational implementation during the workshop was essential to fully describe the complexity of the task and the challenges associated with the approaches and the data at hand.

Results of the Review Meetings

The outcomes of the review meetings are summarized in the minutes of each meeting. The minutes include tentative schedules for the revision of the models. These are available with this deliverable. Attached are also all feedback documents we received during the process.

Implementation of the Community Feedback

Based on the feedback documents and the results of the review meetings, the WP5/WP6 hazard modelling team at ETH implemented the suggested revisions after checking for consistency with the overall model philosophy. In this process, the hazard team reviewed the suggestions and consulted the regional and / or national specialists for clarifications.

Appendix

Feedback documents follow from here on.

Dear Jochen, Laurentiu, Domenico,

we have reviewed the material you sent (excellent by the way), with special reference to the AS one. Here some comments for the Italian sources; general comments follow.

A) You require revision for some AS. In our opinion most, if not all, problems come from two issues: zones and activity rates assessment.

ITAS286. The fit is clearly wrong, probably driven by low Mw data points below the suggested threshold (4.6). A proper fit will give a higher, more reasonable b value
ITAS292. The fit is clearly wrong, probably for the same reasons as above. Same solution
ITAS293. The fit is clearly wrong, probably for the same reasons as above. Same solution
ITAS302. The zone has too few events. However, it is offshore and not very active
ITAS306. The zone has few events. The fit might be slightly improved
ITAS326. The fit is clearly wrong. A proper fit will give lower, more reasonable b value (the one you propose?).
ITAS313. The fit is clearly wrong. A proper fit will give lower, more reasonable b value (the one you propose).

B) Now some general comments.

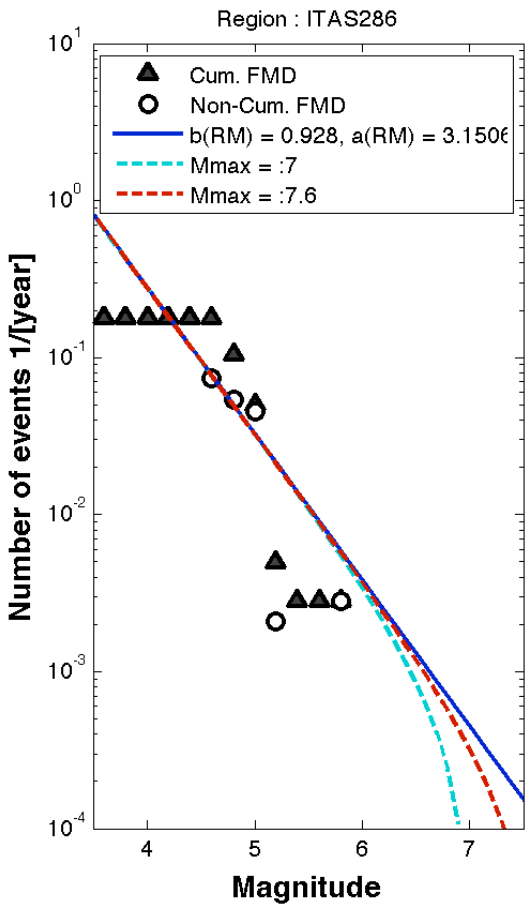
1. <u>Completeness</u>. We tried to give it a homogeneous solution – although for sure not the "exact" one – which is not local and neither based on "visual inspection" only. It mostly referred to medium-large events and was discussed and share with the partners, some of them appear to have changed their mind. It was then changed for smaller Mws, and the establishment of low thresholds was agreed to reduce the influence of low Mw bins; now they are back. The completeness assessment was performed on superzones (as agreed) because it simply cannot be assessed on small zones. Of course, one can accept small, local deviations; not large ones. What appears now is that you are inserting different estimates from varied origins, including the one adopted for GEM1 (we did not know them when discussing the problem and nobody put them forward; by the way, they refer to "superzones", too). Nothing against them, in principle; but two branches would be better than a patchwork.

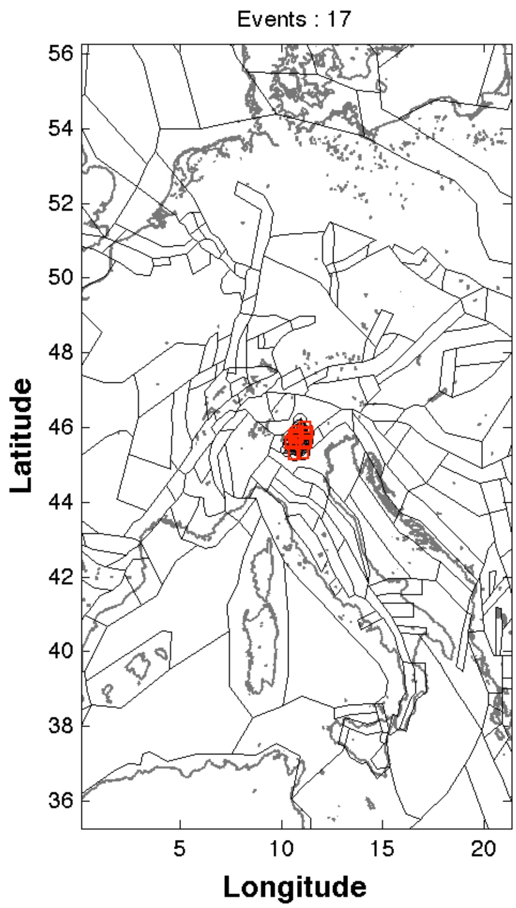
2. <u>Activity rates</u>. Most problems come from the methodology (already said, we know; but this is the problem !). The story was initially constrained by the issue that b should be not very different from 1. This caused evident gaps between data and fit. Now it seems that low b values can be acceptable somewhere, such as in Basel, South Valais, GRAS370, ITAS313

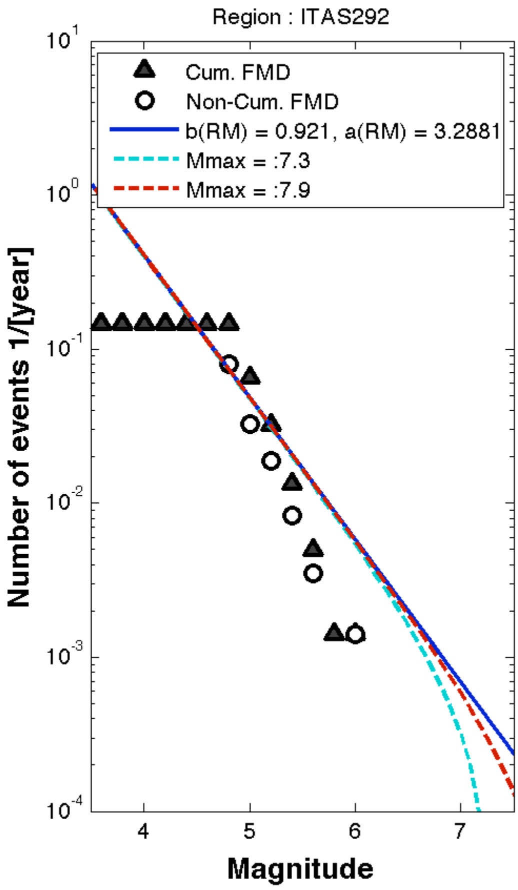
(finally!). Eastern Sicily is even more striking: the proposed fit does not even consider Mmax. In conclusion, to try and solve activity rates problems changing the completeness, may seems easier, but it is just to go around the problem. The problem remains the fit, although we must admit that the situation has improved,

3. Adjusting. We perfectly understand the need for some adjustments when you come close to the final release. You are now trying to put together and adjust pieces which were not completely designed in a coherent way. This is due, and good luck! We know this phase of the work and we fell near to you. However, we see many risks in performing such adjustments introducing changes because local experts (may be including you for Switzerland...) are not “happy” with some results (you mention “underestimate rates and hazard”, “underestimate rates and hazard in Northern Europe”: with respect to what?). This may open a huge flow of changes (see messages by Faccioli, Garcia M. etc.) and, basically, challenge the homogeneity of the work. You mention that the SHARE consortium must agree; this should not be, in our opinion, the main criterion. We are convinced that WPs and Tasks should have the final word on it.

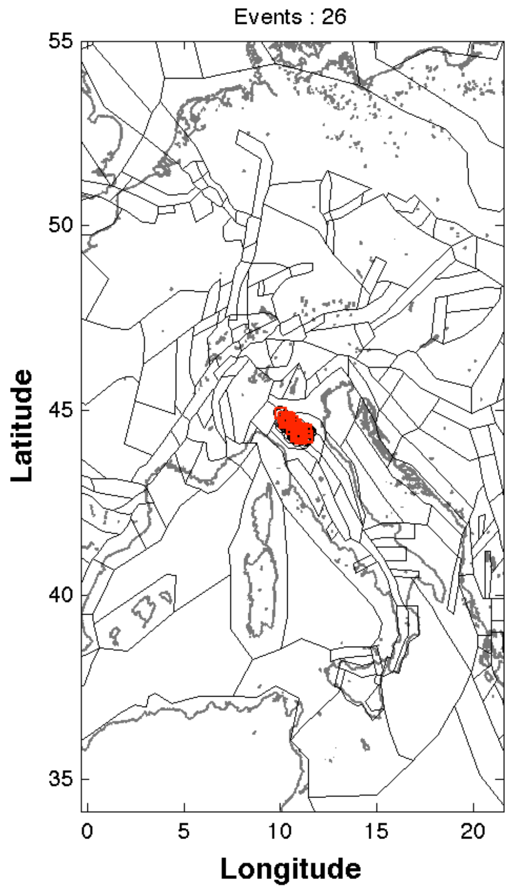
Milano, Pisa, September 2, 2012-09-02 Max, Andrea, Carlo



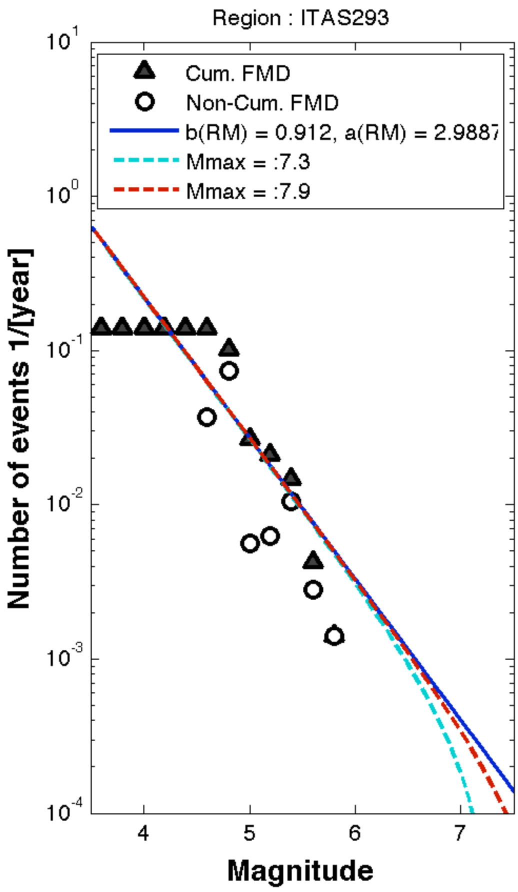




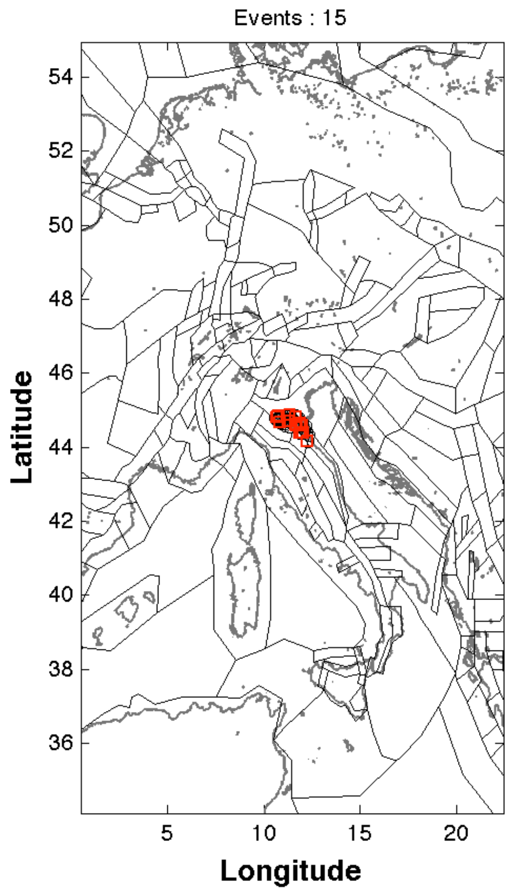
Region : ITAS292
Cum. FMD
Non-Cum. FMD
b(RM) = 0.921, a(RM) = 3.2881
Mmax = :7.3
Mmax = :7.9
Number of events 1/[year]
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
4
5
6
7
Magnitude



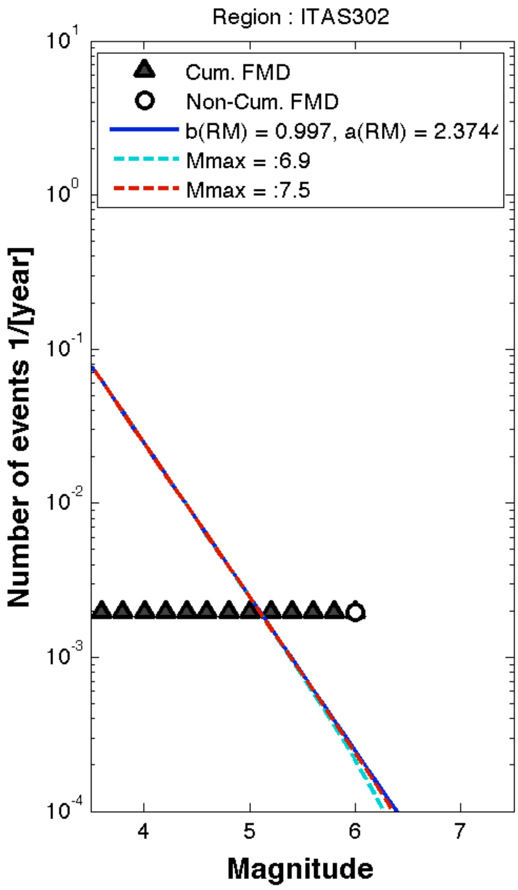
Events : 26
Latitude
55
50
45
40
35
0
5
10
15
20
Longitude

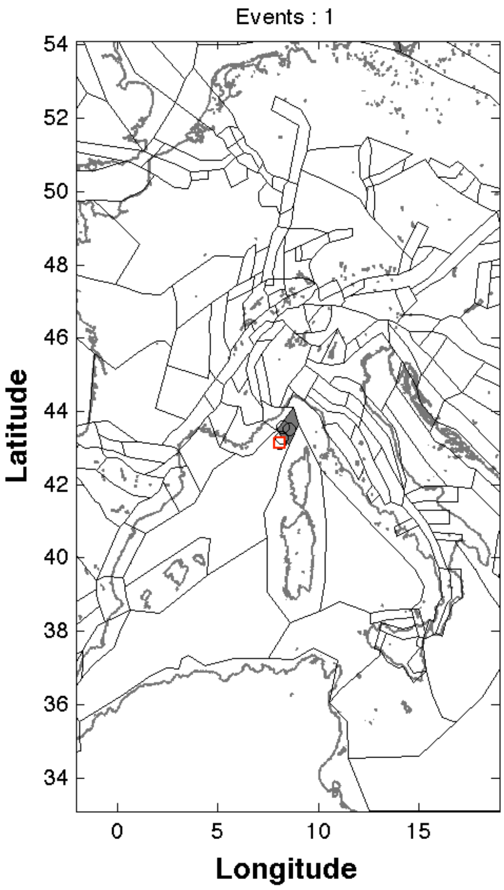


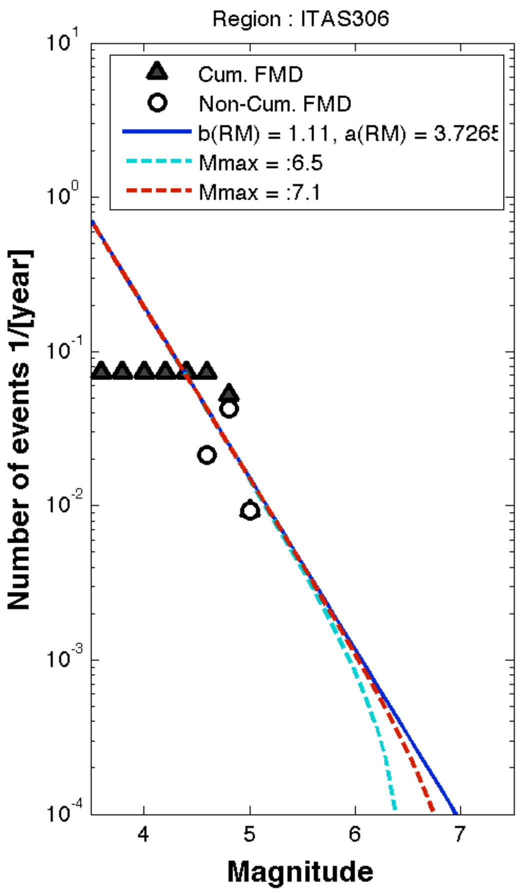
Region : ITAS293
Cum. FMD
Non-Cum. FMD
b(RM) = 0.912, a(RM) = 2.9887
Mmax = :7.3
Mmax = :7.9
Number of events 1/[year]
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
4
5
6
7
Magnitude

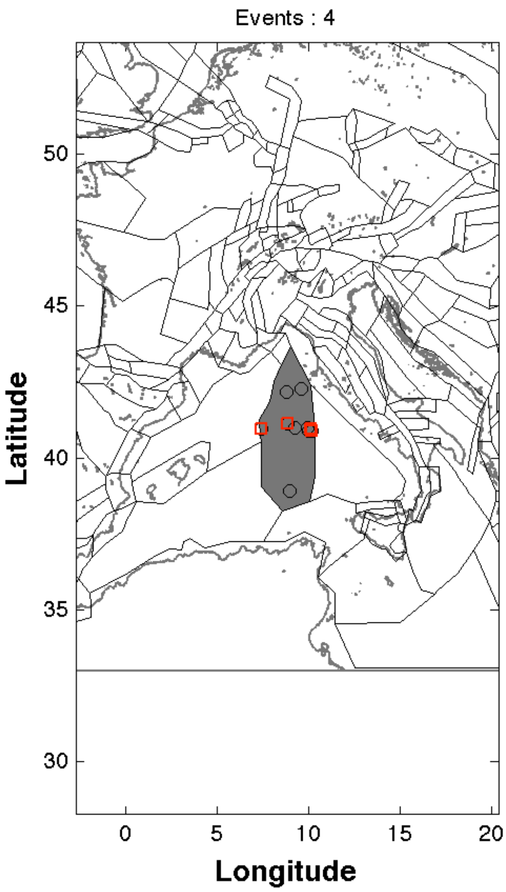


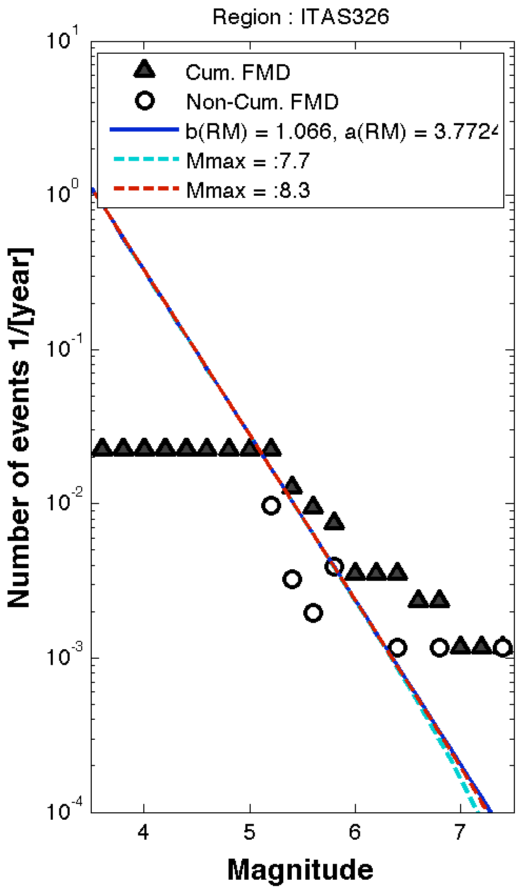
Events : 15
Latitude
54
52
50
48
46
44
42
40
38
36
5
10
15
20
Longitude

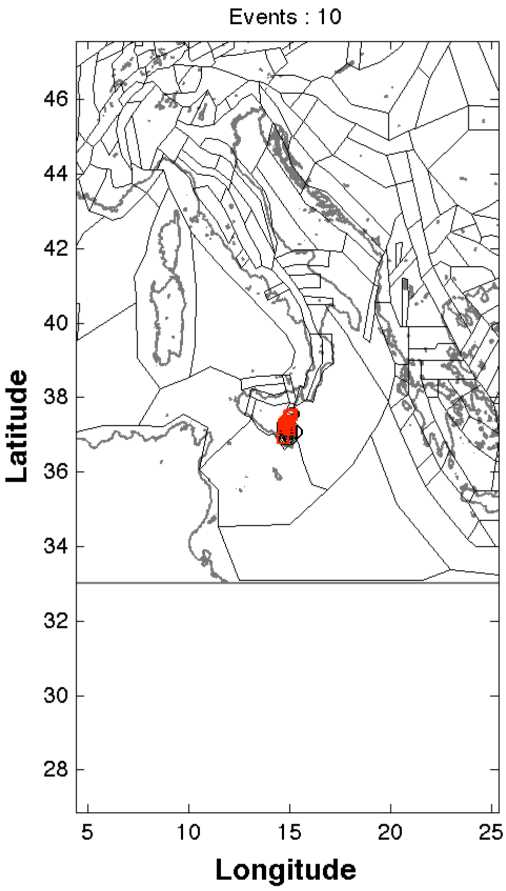

Region : ITAS302
Cum. FMD
Non-Cum. FMD
b(RM) = 0.997, a(RM) = 2.3744
Mmax = :6.9
Mmax = :7.5
Number of events 1/[year]
Magnitude

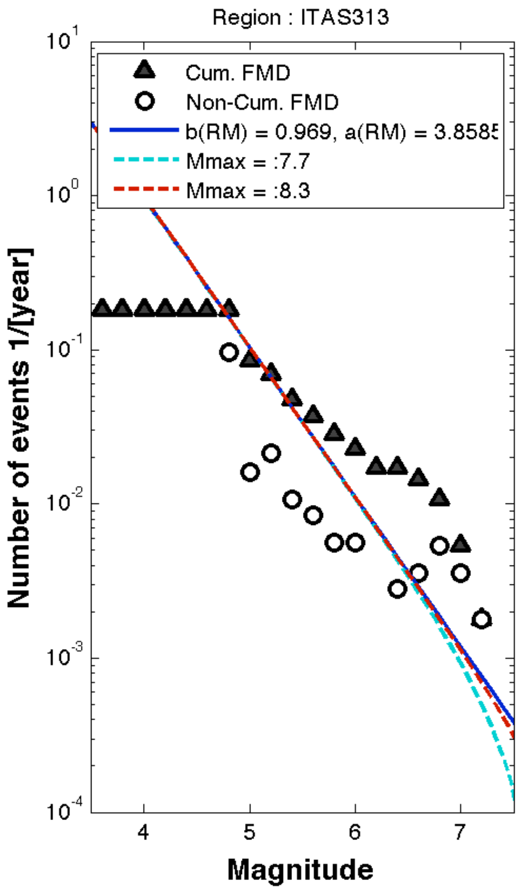

Events : 1
Latitude
Longitude

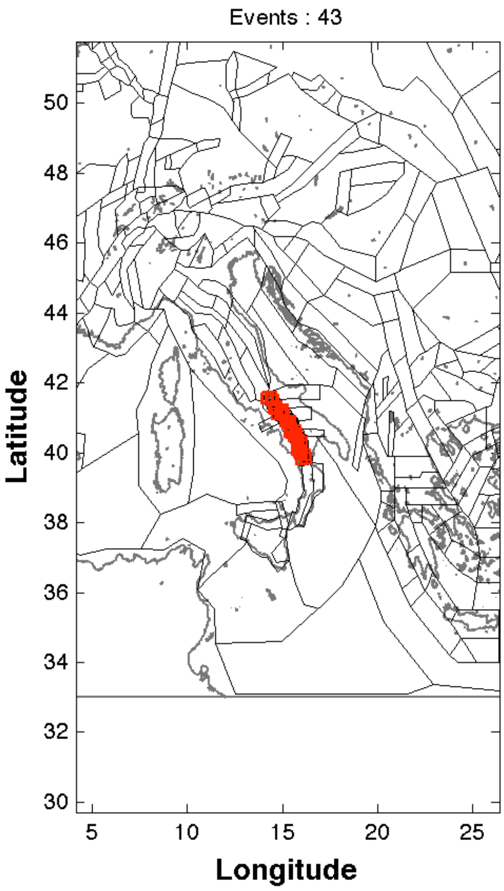

Region : ITAS306
Cum. FMD
Non-Cum. FMD
b(RM) = 1.11, a(RM) = 3.7265
Mmax = :6.5
Mmax = :7.1
Number of events 1/[year]
Magnitude


Events : 4
Latitude
Longitude


Region : ITAS326
Cum. FMD
Non-Cum. FMD
b(RM) = 1.066, a(RM) = 3.772
Mmax = :7.7
Mmax = :8.3
Number of events 1/[year]
Magnitude


Events : 10
Latitude
Longitude


Region : ITAS313
Cum. FMD
Non-Cum. FMD
b(RM) = 0.969, a(RM) = 3.858
Mmax = :7.7
Mmax = :8.3
Number of events 1/[year]
Magnitude


Events : 43
Latitude
Longitude

From: Thierry Camelbeeck <Thierry.Camelbeeck@oma.be>
Subject: Fwd: earthquake on 1953 September 15 23h55m
Date: September 11, 2012 8:56:32 AM GMT+02:00
To: Wössner Jochen <jochen.woessner@sed.ethz.ch>, <massimiliano.stucchi@mi.ingv.it>, "Dr. G. Grünthal" <ggrue@gfz-potsdam.de>
Cc: Kris Vanneste <kris.vanneste@oma.be>

Dear Gottfried, Jochen and Max,

My colleague Kris Vanneste reviewed the hazard results for Belgium and surrounding areas. He did a comparison with our recent computations [even if it is not easy because the zones are not defined in the same way]. He will send his short report today, with different remarks on how to improve the computations. Of course, we know that in the frame of SHARE, most of the remarks are difficult to be taken in consideration due to scale of the study [for example: completeness evaluated on large areas far greater than the Belgian territory].

Nevertheless, there is **one data that we would like to see modified in the earthquake catalogue** because it is incorrect and contribute to an excessive hazard in the Hainaut zone. This modification concerns the 1953 September 15 earthquake. It is evaluated at a magnitude 5.0 [because an intensity VII has been published]. In our catalogue, there is no indicated magnitude, because we consider the earthquake as a small event [It has been felt at a local scale]. During the last years, I did work on the 20th century earthquakes and unfortunately up to now, my work only concerns the period 1900-1950. Yesterday, I had a look on the available data for the earthquake, and it is evident that his magnitude is far less than 5.0. Looking at the seismograms of the Uccle Wiechert vertical seismograph, I can evaluate the maximal displacement to more or less 2 micrometers [at a distance of 60 km]. It corresponds a local magnitude of 3.6, which is very likely a surestimation, because the visible signal corresponds surely to surface waves and not S-waves [because the earthquake is probably superficial].

In attachment, you will find the information about this earthquake in the seismic bulletin of Uccle (event 351). This is the origin of intensity VII. There is an evident surevaluation of the intensity. Two formulaires of the macroseismic inquiry are also in the pdf file. They concern two of the rare localities where the earthquake has been felt. In Quaregnon, the locality where damage have been noticed, only two chimneys have been damaged. This should correspond to intensity V - VI (at the maximum).

Thank you for your cooperation

Best wishes

Thierry

France

- PYB and FC. The distribution of hazard is a little bit different from AFS2006 and MEDD2002, with relatively higher hazard (compared to the average value) in Tricastin (or even west of Tricastin/ west of Rhône river / difficult to see at such a scale) and in Jura south of the Vosges, and lower values in western France. Does it come from the geometry of zone sources, from the magnitude conversion or from the GMPEs ?
- PYB. I anticipate the smaller values as compared to MEDD2002 to be related to the GMPEs and to the magnitude conversion. We will have to make this clear.
- PYB. I feel uncomfortable with the large difference between Western and Eastern Pyrenees, even at long return period. PYB
- PYB. All this make me wonder whether the key control of this map is not the recent seismic activity (over the last 50-100 years), that constrains the a and b value, much more than the historical seismicity or tectonic considerations ? – But may be I am wrong.

Other areas

- PYB. I wonder whether the usual GMPES even for subduction zones are applicable to the Vrancea area ? Have they been tested with the few available Romanian data ?

- PYB. I am surprised not to see any signature from very large size events offshore Portugal/Spain/Morocco at large periods and long return periods ? (I could not find the disaggregation results for Lisbon ?). Same thing for the Levant fault system : although it is on the border of the mapped area, it does not seem to affect so much the hazard in southern Turkey ?

- PYB. Is there a reason for the UHS spectra to have a rather small "Sa_{max}/pga" ratio (around 2 only for a number of sites : Basel-Bucharest-Istanbul-Rhodes-Thessaloniki-Wien, I would expect a somewhat larger value, exceeding 2.5) ?

Displaying the hazard results

- PYB and FC. It seems VERY important to us to show not only the map of mean hazard values, but also the associated uncertainties : maps of fractiles 16% / 84% or 20% / 80%, and also to directly map the uncertainty by mapping the ratio pga84% / pga16% [and same thing for Sa(0.2s) and Sa (1.0s)]

- PYB. Colour scale : I would
  a) take a logarithmic scale on pga and spectral values (with identical colors within values a_i – a_{i+1}, and $a_{i+1} = 2^{0.5} . a_i$ (example scale : 0.025-0.0.0353-0.05-0.0706-0.10-0.1414-0.20-0.283 – 0.4 – 0.566 – 0.8 – 1.13 – 1.6). May be it is too coarse, and a better ratio would be $a_{i+1} = 2^{0.25}$, leading to twice more zones and colors
  b) adapt the color scale to each considered period (in order in shift the "red" color to lower values for long period) . The basic "reference spectrum" to adapt the color scale to the period could be the EC8 Type I spectra.

Releasing the SHARE results

- FC and PYB. The 2 months delay for discussion before the final publication seems very short and dangerous for the credibility of the SHARE results (and of the probabilistic approach also). we would recommend to use a little bit of the GEM funding to go on for the discussions and feedbacks on the SHARE maps for several months after the official end of the project, in order to ensure that the final maps – that will be de facto the new reference for the Euromed area – are well accepted.

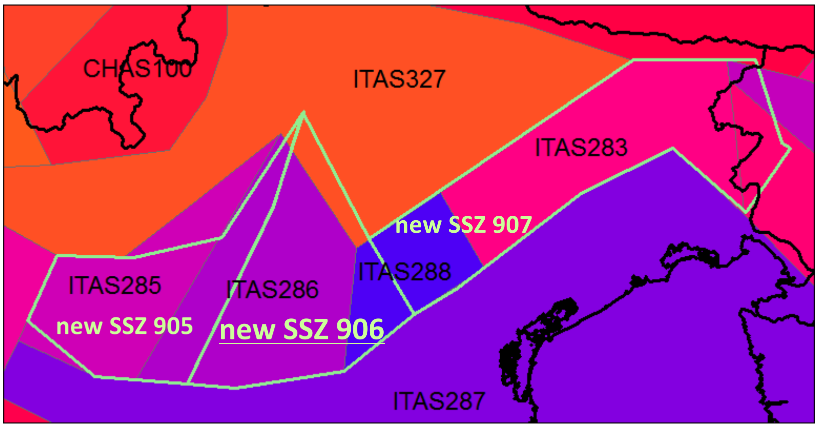
Feedback on the AS-model

by Ezio Faccioli (with the assistance of Manuela Vanini, PoliMi, and F. Galadini, INGV)

Source ITAS286

Geometry change

We suggest a different geometry, as shown in the figure (zones labelled "new SSZ") and specified in the table.



Latitude [°]	Longitude [°]
45.291803	10.398314
45.981253	10.89851
46.071093	10.94334
46.348278	11.082326
45.844157	11.435145
45.541637	11.671069
45.32724	11.269327
45.273041	10.661901
45.291803	10.398314

This new geometry reflects changes we suggested for Italian SSZs that include the central and the eastern Southern Alps ('original' SSZs 905 to 907 of ZS9, i. e. the original model of ASs for Italy from which the ITAS zones were mostly taken).

In order to draw these seismogenic zones, three different tectonic domains have been considered:

i) the long Venetian-Friulian Prealpine belt characterised by active thrust systems responsible for the strongest earthquakes of the region (Galadini et al., 2005; Burrato et al., 2008);
ii) the complicated transfer zone dominated by the NW-SE faults paralleling the "Schio-Vicenza line" Auct. (e.g. Zanferrari et al., 1982) and structuring the Lessini Mts. and Lake Garda sectors (Scardia et al., 2011);
iii) the NNE-SSW trending thrust systems of the "Giudicarie domain" at the western margin of Lake Garda, completing the transfer of the displacement from the eastern Southern Alps and linked southward to the thrust systems of the central Alps (particularly active in the Brescia sector).

For the Venetian-Friulian Prealpine belt, we preferred to merge the easternmost sector of SSZ 906 with SSZ 905. In this way, we obtained a single zone encompassing all the frontal thrusts which are the expression of the present tectonics of the eastern Southern Alps. The previous separation had insufficient geological justifications; moreover the border between SSZs 905 and 906 was located over the surficial expression of the Bassano-Cornuda seismogenic source, responsible for the 1695 earthquake. As to SSZ 906, we decided to enlarge it towards the N and to shift its western margin to the E. Indeed, this zone includes the complicated structural domain which transfers the displacements from the eastern to the central Southern Alps. This transfer zone includes the Schio-Vicenza, Verona and Nogara faults (Scardia et al., 2011). The necessity to encompass the former and minor associated faults has suggested the enlargement of the zone to the North. Moreover, the evidence of a main role of the Verona and Nogara faults and of their associated structures in the expression of the present tectonic regime of Lake Garda suggested to assign this sector to the SSZ encompassing the Lessini domain, i.e. to the new SSZ 906.

Activity rate parameter change

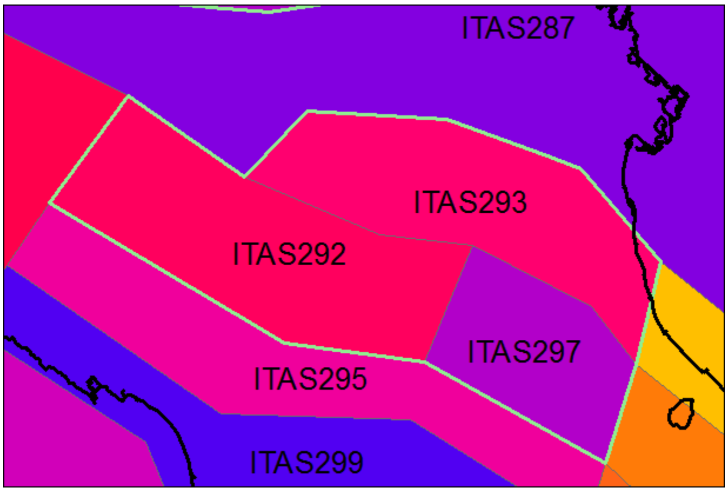
a =3.19424

b = 0.97870

Sources ITAS292 and ITAS293

For these sources, we recommend merging together the original SSZs (912, 913 and 914, corresponding to ITAS 292, 293 and 297), of ZS9, including the Ferrara arc and the Pedeapenninic Thrust Front.

This merging has been essentially conditioned by kinematic reasons. Indeed, the three zones are characterised by thrusts having comparable seismogenic potential and characterised by effective depths of the seismic activity having limited differences from zone to zone.



Latitude [°]	Longitude [°]
44.669632	9.656718
45.011757	10.015694
44.745728	10.537289
44.951595	10.824336
44.916168	11.457679
44.781052	11.919618
44.74168	12.052342
44.434109	12.395358
44.106453	12.270123
43.793972	12.116509
44.136684	11.32331
44.208866	10.699876
44.669632	9.656718

<u>Activity rate parameter change</u>

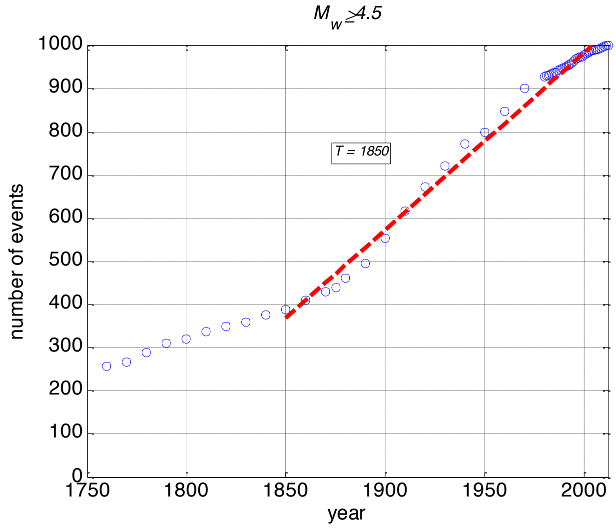
a (for the whole macrozone) = 4.28208

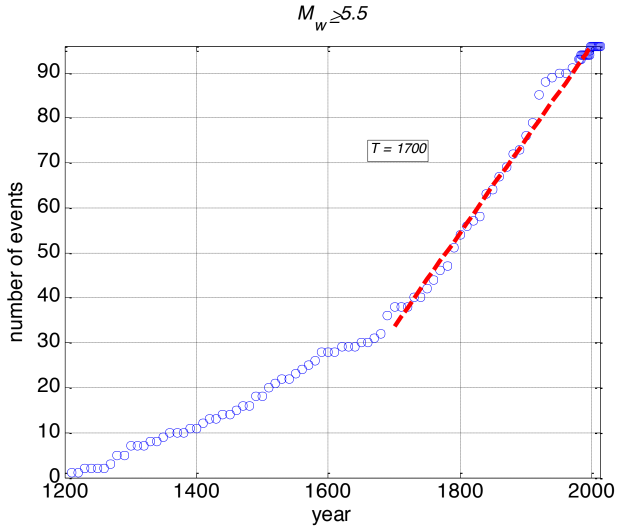
b (for the whole macrozone) = 1.05027

Completeness period changes

We suggest different completeness periods, computed through the visual-cumulative criterion, using an ad hoc compiled catalogue, including CPTI11 as a basis. Results obtained for this working catalogue at the magnitude thresholds $M_w \geq 4.5$ and $M_w \geq 5.5$ are shown.

M_w	Year
2.5	2000
3	1985
3.5	1981
4	1875
4.5	1850
5	1850
5.5	1700
6	1550
6.5	1200





References

Burrato P., Poli M.E., Vannoli P., Zanferrari A., Basili R., Galadini F., 2008. Sources of Mw 5+ earthquakes in Northeastern Italy and western Slovenia: an updated view based on geological and seismological evidence. Tectonophysics, 453, 157-176.

Galadini, F., Poli, M.E., Zanferrari, A., 2005. Seismogenic sources potentially responsible for earthquakes with M≥6 in the eastern Southern Alps (Thiene-Udine sector, NE Italy). Geophysical Journal International, 161, 739-762.

Scardia G., Rogledi S., Monegato G., Galadini F., 2011. L'assetto strutturale ed il modello cinematico. In: E. Castellaccio, R. Zorzin (eds.), Acque calde e geotermia della provincia di Verona, aspetti geologici ed applicazioni , Memorie del Museo Civico di Storia Naturale di Verona, 3a Serie, Sezione Scienze della Terra, 8, 102-110.

Zanferrari A., Bollettinari G., Carobene L., Carton A., Carulli G.B., Castaldini D., Cavallin A., Panizza M., Pellegrini G.B., Pianetti F., Sauro U., 1982. Evoluzione neotettonica dell'Italia nord-orientale. Mem. di Sc. Geol., 35, 355-376.

From: "Dr. G. Grünthal" <ggrue@gfz-potsdam.de>
Subject: Re: SHARE: Area Source Model Feedback - Reply by August 7!
Date: August 7, 2012 4:24:26 PM GMT+02:00
To: Jochen Woessner <j.woessner@sed.ethz.ch>

Dear Jochen,

following is our response to your request from July 27:

Completeness:
One of our large concerns is about the SHEEC completeness superzones and the corresponding results. This point has adequately been addressed in your report, which lead to a clear improvement (although not yet perfect). You refer in this respect to our GEM1 report (Grünthal et al., 2010), but when quoting it one should keep in mind that it was a seven-weeks-project (December 2009 - January 2010, when we had to deliver the data).

Vrancea - deep source:
We would not enlarge the zone. Capture the deep seismicity by using a larger zone, but use the original small zone for the PSHA. Background for this are assumed localization errors. What concerns the GR-parameters we want to refer to our results in our GEM1 report (Grünthal et al., 2010; p. 19, Fig. 13). We could calculate a well constrained b=0.657±0.092 for Mw≥5.75 and a somewhat smaller one for lower Mw.

Source zone in SW-Germany DEAS141(Südschwarzwald, southern Black Forest):
We have checked the data according our full catalogue for Germany. We receive an a-value of 2.197 for a given b=1 on the basis of 73 earthquakes with Mw>=2. This means that we would rather confirm the old values and cannot expect larger a-values.
In your graphs for the AS you show the completeness, where we interpret one event with 4.6 above the red line, while in the heading there are given "3 events" in the complete part. Are the remaining 2 in the time span since 1940, which is not depicted (like the eq in 2004)? The GR graph we interpret in the way that it has 2 events with 4.6 and one with 4.4, but in the completeness graph we cannot see the 4.4 event above the red line - at least not in the depicted part.

Best wishes,
Gottfried

„
Am 24.07.2012 11:34, schrieb Wössner Jochen:

> Dear colleague
>
> with some delay we are now ready to start the feedback process on the AS-model as indicated in the RoadMap that we developed in the 1st review meeting.
>
> We have prepared the data and a short documentation on what we did and are now asking you for your feedback on the activity rates of the single Area Sources in the AS-Model Version 4. Since it is quite some information, I do not use milliarium but rather our webserver.
>
> Please surf to
> http://mercalli.ethz.ch/~jowoe/share/ModelEvaluation/
> ans download the zip-file. When you uncompress, you will be asked for a password (SHARE12!!) and then unfolds.
>
> Open document (v1.v1.FeedbackActivityRates.pdf or the docx). This document explains in some detail what we did and what we expect from the feedback, also what the files are that are otherwise contained in the folders you have created by unzipping. The folder ASZ_activity contains plots that give you a good impression of the activity rate fit, this I recommend to go through in as a second step.
>
> >From the feedback we expect your expert opinion in case you would like changes of the activity rates to a single area source. The document shows you examples how we implemented this for some sources already. In case you have question, please send an email to me and Laurentiu!
>
> Feedback implementation:
> We are currently computing the hazard for the AS-Model Version 4. Given your feedback, we will implement them and hope to have then the next version ready (hopefully) for the September meeting. However, we are still also computing the other branches of the model and thus it is very tight in terms of computation time and preparation for the 2nd feedback meeting. So, we ask you to provide feedback as soon as possible, but latest August 7!
>
> We now this is tight and we know it is summer and vacation time.....
>
> FOR WP2 members (Helen and Kyriazis):
> At this stage, I think you could use this model for initial computations of the loss scenario calculations for Deliverable D2.5. In case you need more information, please let us know.
>
> In case you have questions, please let us know - me and Laurentiu!
> Best regards
> Jochen
> ----------------------
> Dr. Jochen Woessner
> ETH Zürich, Swiss Seismological Service
> Sonneggstrasse 5, 8092 Zürich
> +41-44-633-7591
> j.woessner@sed.ethz.ch<mailto:j.woessner@sed.ethz.ch>

Suggestions for Parameter Modification in the AS Model for Turkey

1.) We have realized some inconsistencies in the mechanism percentages (Ss, Nf, and Tf) assigned to the source zones, such as 50, 40, and 10 for NAF. Using the fault mechanism database of KOERI, we suggest modifications in the percentages given in the columns Ss, Nf, and Tf for some of the sources in the ASmodel shape file (Figure 1, provided in the attached shape file).

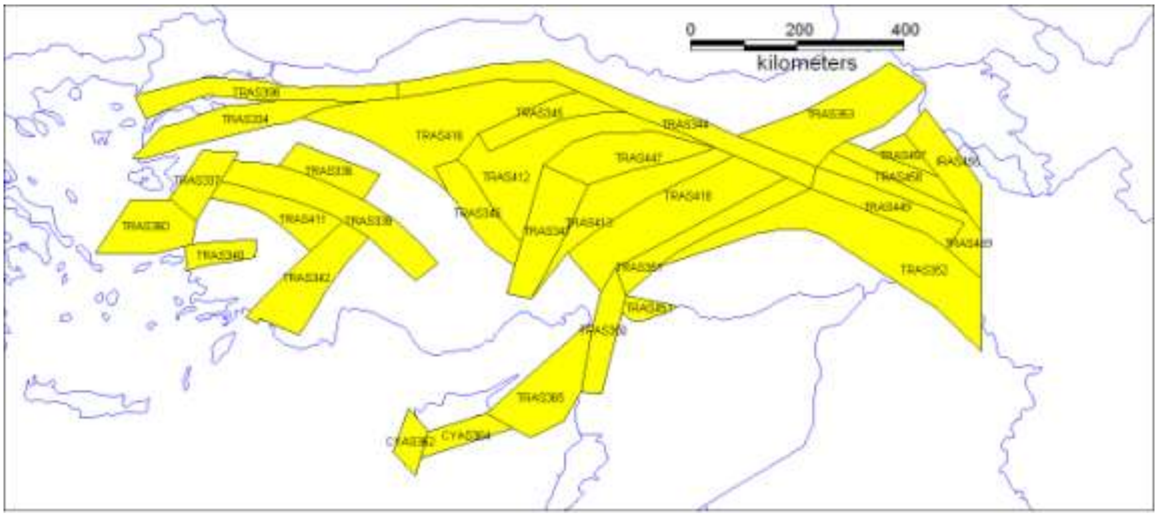


Figure **1**. Source zones for which new percentages of Ss, Nf, and Tf are suggested.

2.) Completeness: We may suggest to take year 2000 for the completeness of Magnitude >=4.4 in the Eastern Anatolian region, except for the source zones TRAS353, TRAS454, TRAS457, TRAS458, TRAS459 (far eastern Turkey).

3.) The recurrence parameters (a and b) of the following source zones need to be modified as they fall below the cumulative occurrence rates:

Most importantly (primary fault zones)

- **TRAS396 (NAF Marmara)**
- **TRAS334 (NAF Marmara, Southern branch)**
- **TRAS350 (Hatay)**
- TRAS340 (Gediz graben)
- TRAS360 (Izmir)

Secondly (secondary fault zones or background zones)

- TRAS356
- TRAS395
- TRAS415
- TRAS336
- TRAS365

4.) The recurrence parameters of **TRAS344 (NAF)** and **TRAS351 (EAF)** in the latest version are not provided. But they might also need a modification as above.

5.) The recurrence parameters (a and b) of source zone **TRAS348 (Adana)** may be lowered as it falls above the cumulative occurrence rates.

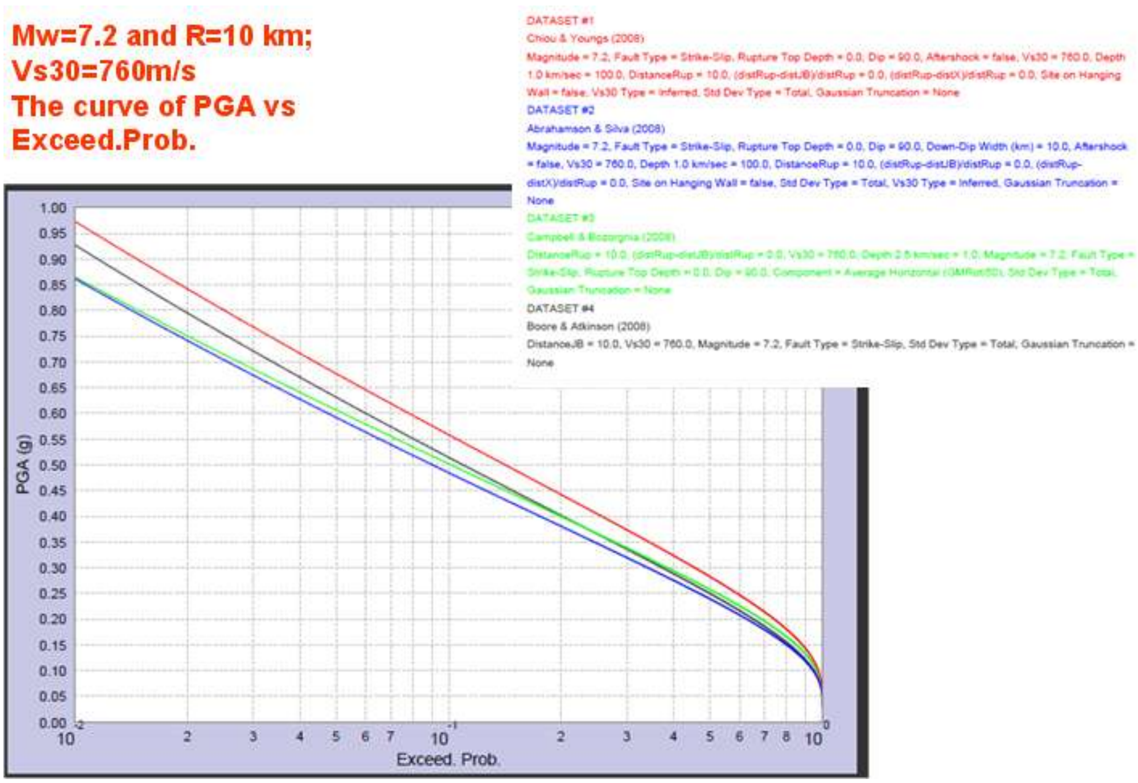
FsFb Model

1) Fb source zone in the Marmara region cut in the middle of the Marmara Sea, which seemed peculiar to us.
2) The minimum slip rate assigned to TRCS003 needs to be corrected and taken similar to the other segments of NAF (around 19mm/yr instead of 1mm/yr).

General Comments on the As Source Model Results

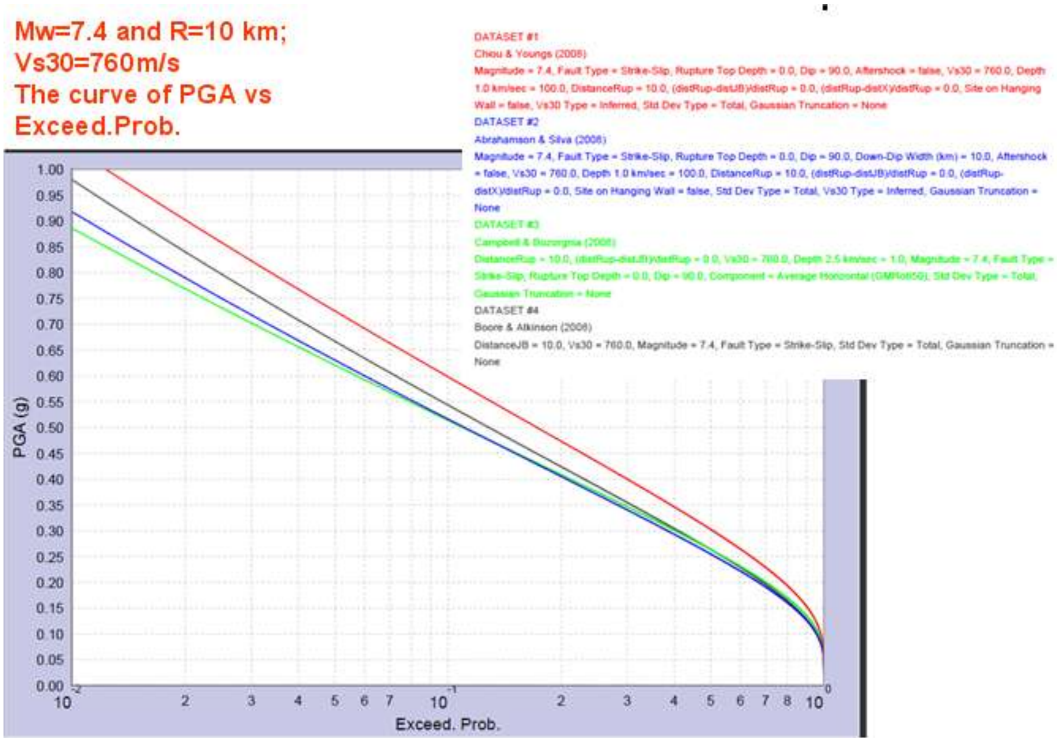
As it was discussed during the meeting, the hazard values for the NAF region and especially for the NAF region in Marmara (Istanbul) are lower than expected. To quantify the hazard in Marmara, we can perform a simple calculation for an earthquake of magnitude Mw7.2 or Mw7.4 on the main branch of the NAF in the Marmara Sea, with a distance to Istanbul of 10 to 20 km. The average return period of this event can be taken as 250 years.

- RP=250 yrs
- Annual Probability = 1/250=0.004

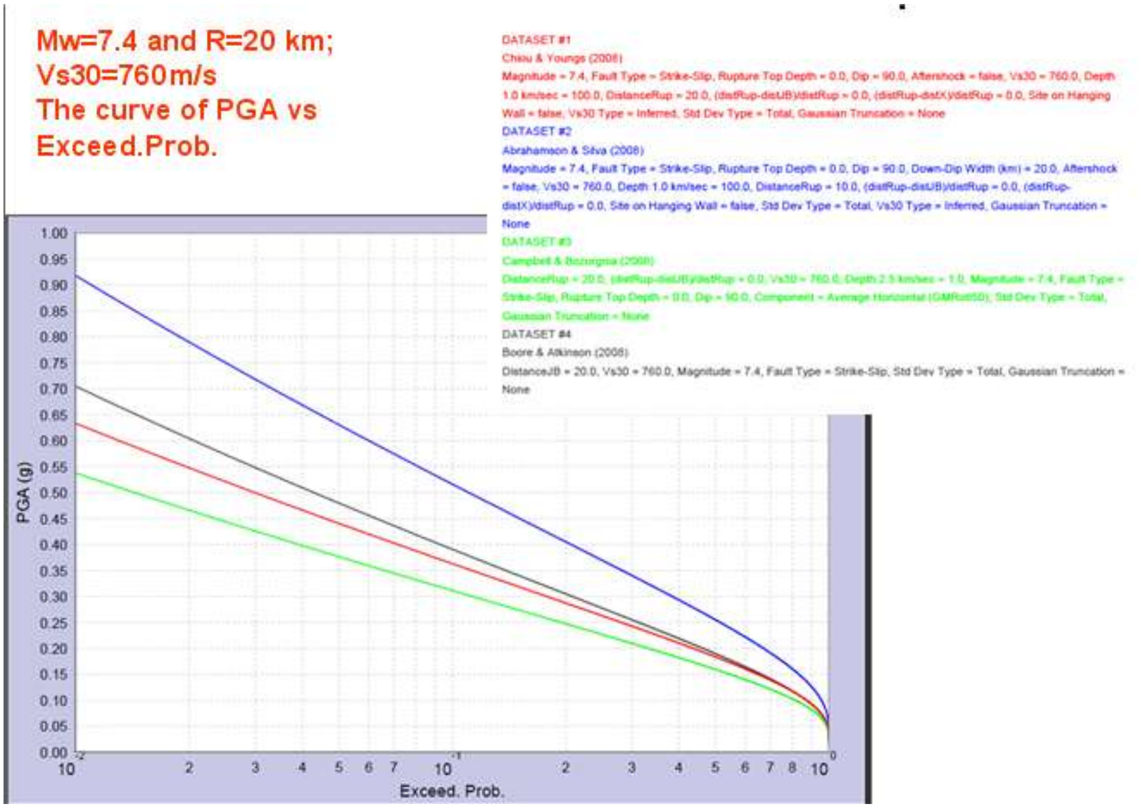


The curve of PGA vs Exceedance Probability for the scenario with magnitude 7.2 and 10 km distance

The curve of PGA vs Exceedance Probability for the scenario with magnitude 7.2 and 20 km distance



The curve of PGA vs Exceedence Probability for the scenario with magnitude 7.4 and 10 km distance



The curve of PGA vs Exceedence Probability for the scenario with magnitude 7.4 and 20 km distancee

In the above figures:

- 0.5 exceedence probability => 0.5 * 0.004 = 0.002 => corresponds to a return period of 500 yrs
- 0.1 exceeding probability => 0.1 * 0.004 = 0.0004 => corresponds to a return period of 2500 yrs
- 0.025 exceeding probability => 0.025 * 0.004 = 0.0001 => corresponds to a return period of 10,000 yrs

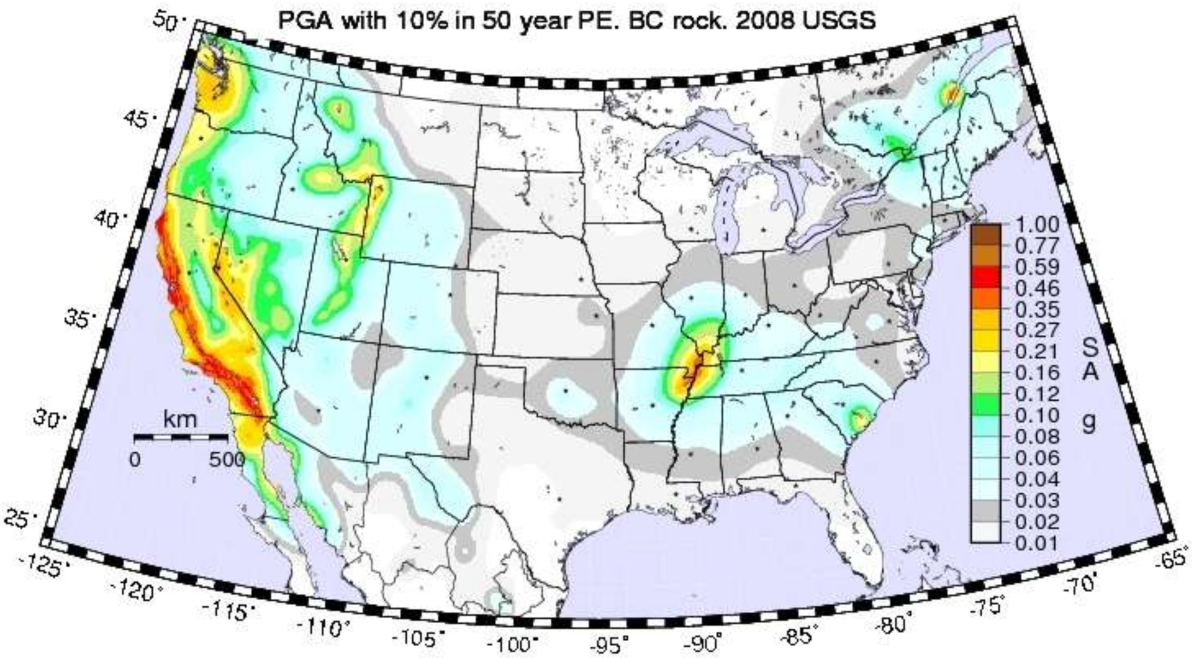
For Mw=7.4 and distance between 10km and 20km , the average PGA values are 0.20g-0.27g, 0.40g-0.54g and 0.57g-0.74g for the return periods of 500, 2500, and 10000 yrs, respectively.

For Mw=7.2 and distance between 10km and 20km , The averege PGA values are 0.16g-0.25g,, 0.32g-0.52g and 0.47g-0.73g for the return periods of 500, 2500, and 10000 yrs, respectively.

We think that the results for Mw7.2 should represent the lower bound for the probabilistic hazard for Istanbul (and generally along NAF) (approximately 0.2g, 0.4g and 0.6 g lower bound).

2.) The tectonic structure, geometric condition, slip rates, fault type are similar along SAF in USA and NAF in Turkey. For that reason, we can compare the results obtained

from PSHA for SAF and NAF, the PGA with 10% PE in 50 years being in the range of 0.35-0.59g around SAF in the figure below.
in



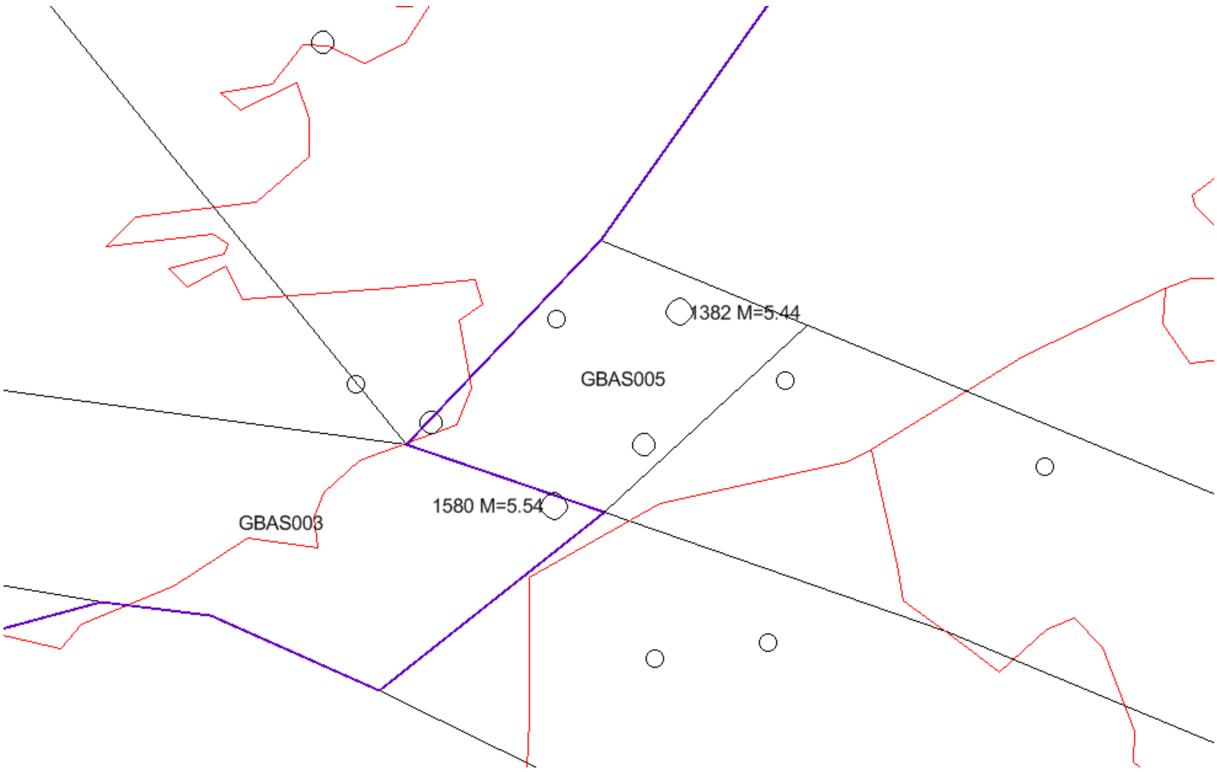
http://earthquake.usgs.gov/hazards/products/conterminous/2008/maps/

Feedback to SHARE AS model by Royal Observatory of Belgium

Source geometry

To my knowledge, zone GBAS005 was meant to contain the historical seismicity in the southern North Sea. In the present implementation, the 1580 earthquake is situated in zone GBAS003. I'm not sure this is intentional or a result of imprecise drawing of zone boundaries.

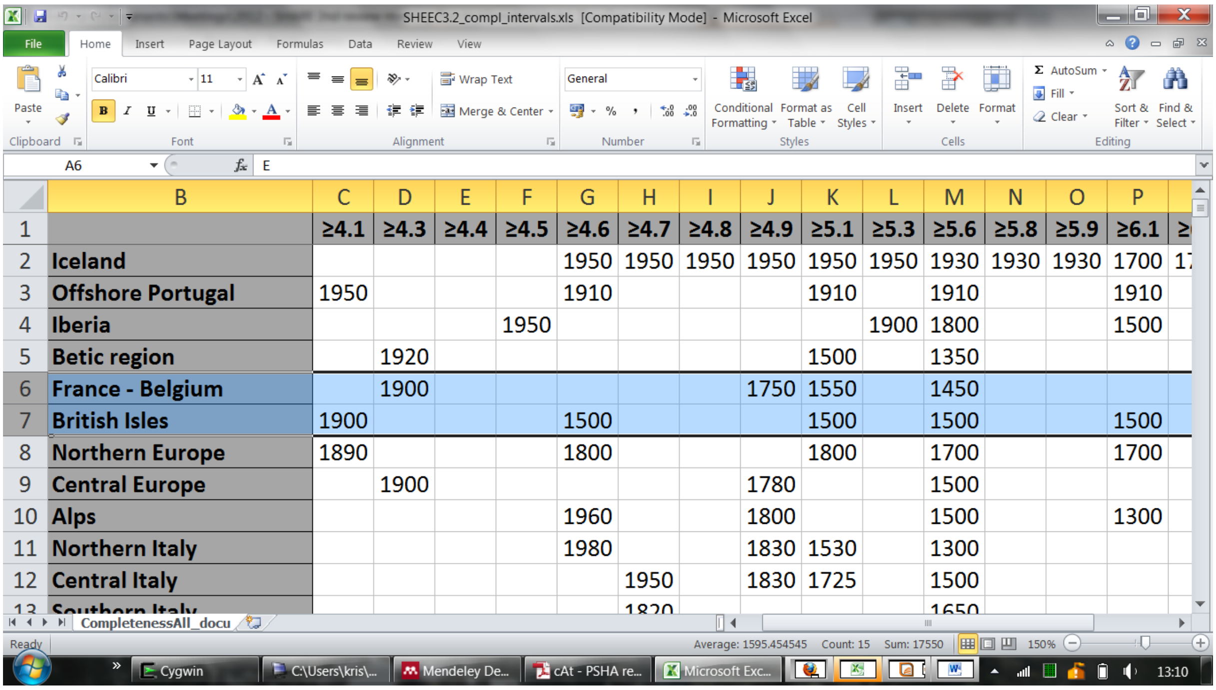
To be discussed with Roger Musson.



Catalogue completeness

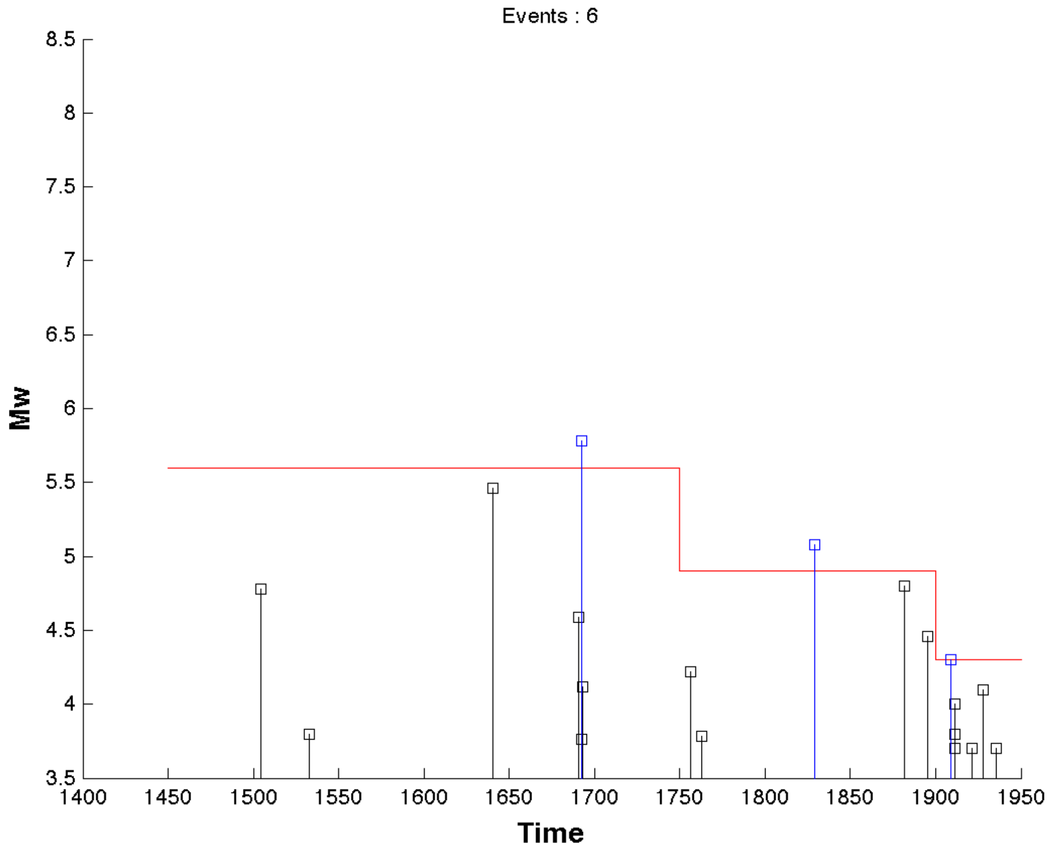
There is potentially a problem with the way the completeness levels are implemented.

According to the table in SHEEC3.2_compl_intervals.xls, most sources in and around Belgium are in completeness zone "France-Belgium", with the exception of GBAS003 (containing the 1580 earthquake), which is in completeness zone "British Isles".



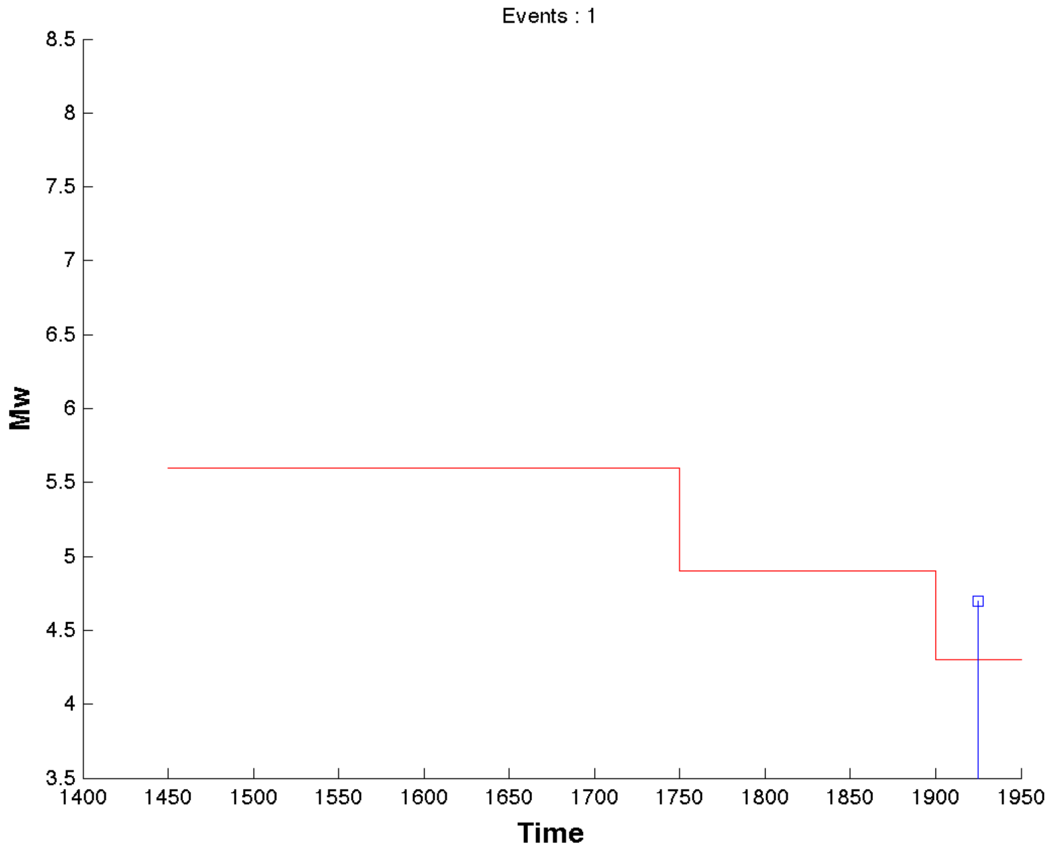
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
1		≥4.1	≥4.3	≥4.4	≥4.5	≥4.6	≥4.7	≥4.8	≥4.9	≥5.1	≥5.3	≥5.6	≥5.8	≥5.9	≥6.1	≥
2	**Iceland**					1950	1950	1950	1950	1950	1950	1930	1930	1930	1700	17
3	**Offshore Portugal**	1950				1910				1910		1910			1910	
4	**Iberia**				1950						1900	1800			1500	
5	**Betic region**		1920							1500		1350				
6	**France - Belgium**		1900						1750	1550		1450				
7	**British Isles**	1900				1500				1500		1500			1500	
8	**Northern Europe**	1890				1800				1800		1700			1700	
9	**Central Europe**		1900						1780			1500				
10	**Alps**					1960			1800			1500			1300	
11	**Northern Italy**					1980			1830	1530		1300				
12	**Central Italy**						1950		1830	1725		1500				
13	**Southern Italy**						1820					1650				

The completeness plots for AS in Belgium are not in agreement with the table above. In particular, the interval 1550-1750 should have a magnitude of completeness of 5.1, whereas the plots show a magnitude of completeness of 5.6 for the entire interval 1450-1750. In the plot below for zone BEAS158, this results in an event around 1640 not being selected (at least according to the plot).



Again according to the completeness table, zones in the British Isles are complete for M=4.6 from 1500 onward. (It is also possible that there is a problem with the table, as 1500 is listed for different magnitudes). The completeness plot for e.g., GBAS004 is clearly not in agreement with the table: the interval 1750-1900 has completeness magnitude ~4.9, and the interval 1450-1750 ~M 5.6.

As there is no plot for GBAS003, I assume there is no earthquake complying with the completeness criteria. However, if the table is correct, the Mw=5.54 1580 earthquake should have been selected. The end result is that not a single earthquake from the important historical activity in the southern North Sea is selected in the final analysis.



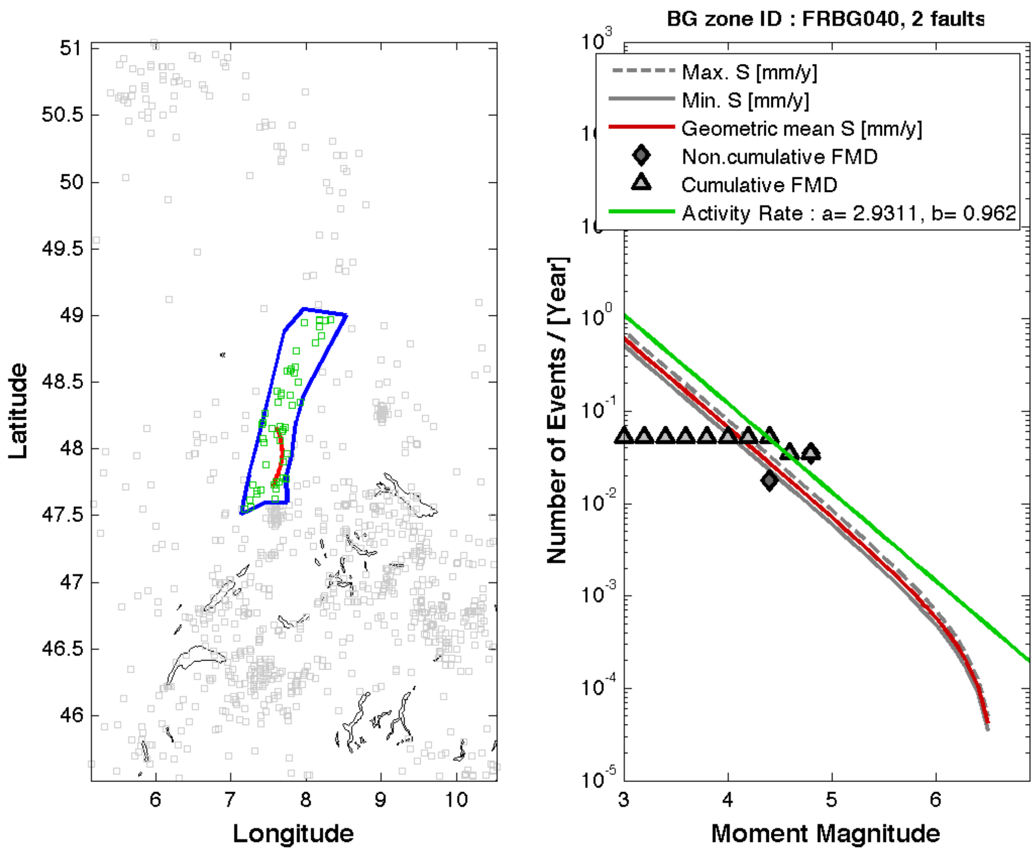
Source Parameters

Is there a table showing the magnitude-depth distributions adopted for all area sources in the OQ computations?

FSBG Model

There do not seem to be major problems with the Lower Rhine Graben, although if possible, we would like to suggest to confine the northern limit of the background zone (NLBG018) to the northernmost extension of faults, instead of continuing this zone into the North Sea, which might upset our Dutch colleagues.

When examining the activity-rate plots of the fault sources, I discovered a potential problem which may explain the low hazard of certain fault sources (not those in Italy).). The problem is under-representation of fault sources in their background zone. Consider the Upper Rhine Graben (FRBG040Only one fault has been identified in this zone, but it is clear from the seismicity that this fault cannot explain all the seismic activity in this zone. As a result, the activity rate of this fault computed with the Anderson-Luco model is clearly below the activity computed from the catalog.



There are several other background zones exhibiting this problem, a.o.:

(BABG006), (BGBG010), DEB017 (I can't even see the fault here), (ESBG023), (ESBG024), (ESBG026), ESBG028, ESBG03, ESBG036, FRB040, HRBG059, ITBG068, ITBG075, (ITBG076), ITBG079, and PTBG084.

Zones between parentheses are less clear.

Criteria to discern background zones where faults are underrepresented could be based on:

- Judgment from local experts
- Comparison of the total fault area with the area of background source

Possible solutions:

- Make smaller background zones for those cases
- Specify full MFD for BG source extending beyond M=5.5, obtained by subtracting the fault activity rate from the catalog activity rate.

This problem does not explain why the hazard predicted by the FSBG model in Italy and Greece is lower than that predicted by the AS model. Looking at the activity plots for Italy, it seems that in most background zones the combined activity of the faults is close to the catalog activity, except for the above-mentioned zones where faults seem to be under-represented. In zone ITBG074, the combined activity rate of all fault sources is less than the catalog activity rate, which could explain the lower hazard. However, in zone ITBG069, the activity rates are similar, whereas the hazard predicted by the FSBG model is clearly lower, so some other effect may play here.

Possible reasons why hazard is less for faults than for area sources, when activity rates are more or less the same:

- Smaller hypocentral depths considered for the area sources: check if minimum and maximum depth of fault sources is comparable to that of corresponding area sources.
- Focal mechanism: if the faults are normal faults, and all rakes are considered in the area sources, then hazard for faults might be less (e.g., AkB2010 GMPE predicts smallest hazard for normal faults)
- Smaller Mmax for fault sources than for the corresponding area sources. This has also been put forward by Roberto Basili. Don't know how this could be solved:
    - o maybe allow larger magnitudes by simultaneous rupture of two or more faults, but I don't see how this can be done in OQfor t
    - o allow larger earthquakes to happen in the BG zone, by constructing a MFD that accounts for the missing activity of large earthquakes

Other observations:

- The reason why fault sources seem to "work well" in Turkey is likely due to the fact that the majority of fault sources in Turkey have higher activity rates than the catalog activity.
- In SE Spain, the relative hazard of fault sources versus area sources seems to correspond well with the relative activity rates, except for ESBG033, which has clearly higher activity rates for the fault sources, but smaller hazard over most of the area (except very close to the faults). This is probably a Mmax effect (Mmax of fault sources is only ~6.5).
- In Greece, most fault sources have activity rates similar to or higher than the catalog activity. If we compare GRBG052, the hazard (PGA at 475-yr return period) predicted by the FSBG model is significantly smaller than that predicted by the AS model, despite higher activity rates. The same is true for GRBG055. This is hard to understand.

- Source SKBG100 (Austria/Slovakia) seems to produce lower hazard at 475-yr return period than the corresponding area sources, but at 2475-yr return period, the hazard seems more or less the same to me.

COMMENTS ON THE INFORMATION FURNISHED TO EXTERNAL EXPERTS FOR THE 2ND REVIEW SHARE WORKSHOP (3-4 September, 2012, ETH Zurich).

Author: Julián García Mayordomo (from Instituto Geológico y Minero de España, IGME)

The opinions expressed in this document belong solely to the author and do not represent the oficial point of view of IGME or any other Spanish institution.

General comment

I believe activity rates are under estimated because of the characteristics of the SHEEC catalogue, the declustering process followed, and the completeness intervals considered. The SHEEC catalogue contains less events and with smaller magnitudes than the IGN catalogue. The declustering windows used are, in my opinion, too wide and so they filter too much of the catalogue. Additionally, the time completeness intervals are in general too short (i.e starting years of completeness are in general too young), leaving behind many events.

In the following pages I explain better these problematic issues and suggest possible ways to amend them.

I will also say something about the “Source Zones and Tectonic Regimes” and the “Hazard Results “.

ACTIVITY RATES: Earthquake Catalogue and Declustering

* Earthquake catalogue: SHEEC vs. IGN

I have been looking at the catalogue provided (SHEECv3.2.shp) and comparing it to the already-declustered and homogenized-to-Mw catalogue that IGN has prepared for the SH calculations for the new map of Spain. I noticed that the IGN catalogue is much larger, even though it has been declustered, than the SHEEC catalogue (which I think corresponds to a un-declustered version). 1884 events Mw≥4.0 compare to 684 from SHEEC.

Furthermore, I have looked at a few particular main events and noticed that systematically Mw reported in the IGN catalogue for the main historical earthquakes is larger than Mw from SHEECv3.2.shp. There are also noticeable differences in the epicentral location of some major events.

Here I list few cases (but there are many more):

EVENT	YEAR	INTENSITY (IGN)	Mw (IGN)	Mw (SHEEC)
Amer	1427	VIII-IX	5.9	5.6
Olot	1427/5/15	VIII-IX	5.8	5.5
Almería	1487	VIII	6.0	5.9
Vera	1518	VIII-IX	6.2	5.97
Muro de Alcoy	1644	VIII	6.1	5.3
Almería	1657	VIII	6.0	5.7

Estubeny	1748	IX	6.2	5.9
Torrevieja	1829	IX-X	6.6	6.5
Arenas del Rey	1884	IX-X	6.5	6.3

The effect of using a less populated catalogue and with lower Mw values is obtaining lower hazard results. I understand that this is not the time for making changes in catalogues, even more when this IGN catalogue has not yet been officially released. But I think it is important to keep this in mind, as the different activity rates that come from the use of one or other catalogue would affect importantly the hazard results. Hence, this is one of the reasons the SHARE hazard results are going to be "lower" than the new Spanish national SH results.

*** Declustering**

In the document SHARE_DeclusteringSHEEC_ver5.pdf is explained the process followed for declustering the catalogue. There is this graphic illustrating the time/space windows used as function of Mw:

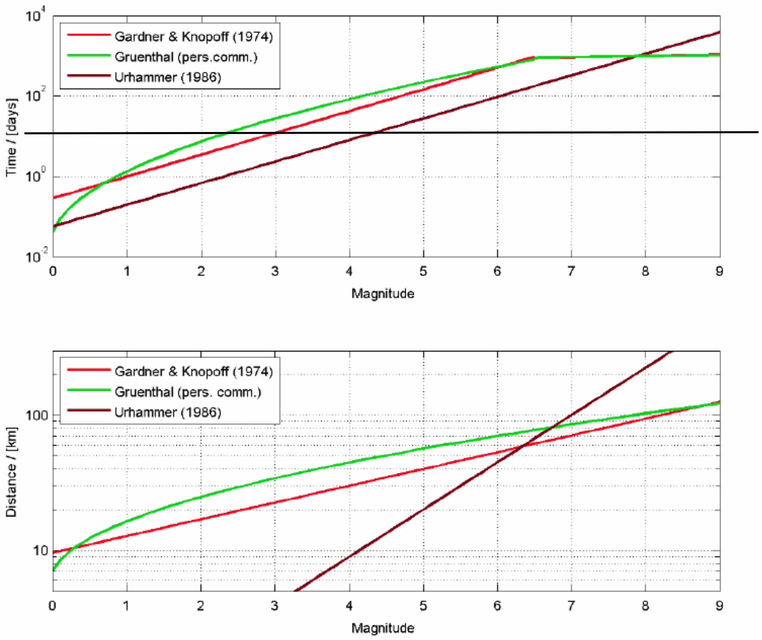


Figure 3: Window size for time and space as a function of magnitude. The green line indicates the window sizes used here.

As it can be deduced, a Mw 5.0 implies a time/space window of approx. *100 days/ 40km*. In my opinion this is too "aggressive", in particular the value 40 km, in the sense that it would over-filter the catalogue in the Mw range 4-5 (and that would lead in obtaining lower activity rates). Additionally, following this approach approx. 50% of the SHEEC catalogue is filtered away, which I think it is quite a lot, when more "normal" values in SH works in Spain are around 30%.

I consider a reference Mw 5.0 because this is the common main shock we expect in most of Spain for a 500-yr return period (see for instance Gaspar-Escribano et al., 2008, *Bulletin Earthquake Eng, 6:179–196*). Additionally, the last damaging (and thoroughly recorded) earthquakes in Spain (in 1999, 2002, 2005, 2011) have been in the Mw range 4.5-5.2, so a Mw 5.0 is good for comparison to these seismic series. As well, a Mw 5.0

can be regarded to a Intensity VII event, which are the most common in the historical catalogue.

Álvarez-Gómez et al (2005, *Computers and geosciences, 31(4):521–525*) consider that a 10 day/10 km window is a good standard value for declustering the Spanish catalogue. This window has been used in few SH works in Spain (e.g., García-Mayordomo and Insua-Arévalo, 2011, *Soil Dyn. & E.E.*, *31:1051–1063* ; García-Mayordomo et al., 2007, *Journal of Seismology, 11(4):453–71*), where it has been shown it works fine for declustering earthquake swarms and series of Mw<5.5). Additionally, a Mw 5.0 event means a subsurface rupture length of approx. 1-5km (e.g., Wells and Coppersmith, 1994; Stirling et al., 2002; …)

So, **I would prefer to declustering the catalogue following Urhammer (1986)** because is closer to what I think (from Urhammer curve in the graphs above for a Mw 5.0 a 20 days/20km aprox. is obtained). For the new SH map of Spain the declustering time/space window used for a Mw 5.0 is aprox. 300 days/25 km.

COMPLETENESS: super zones and completeness time intervals

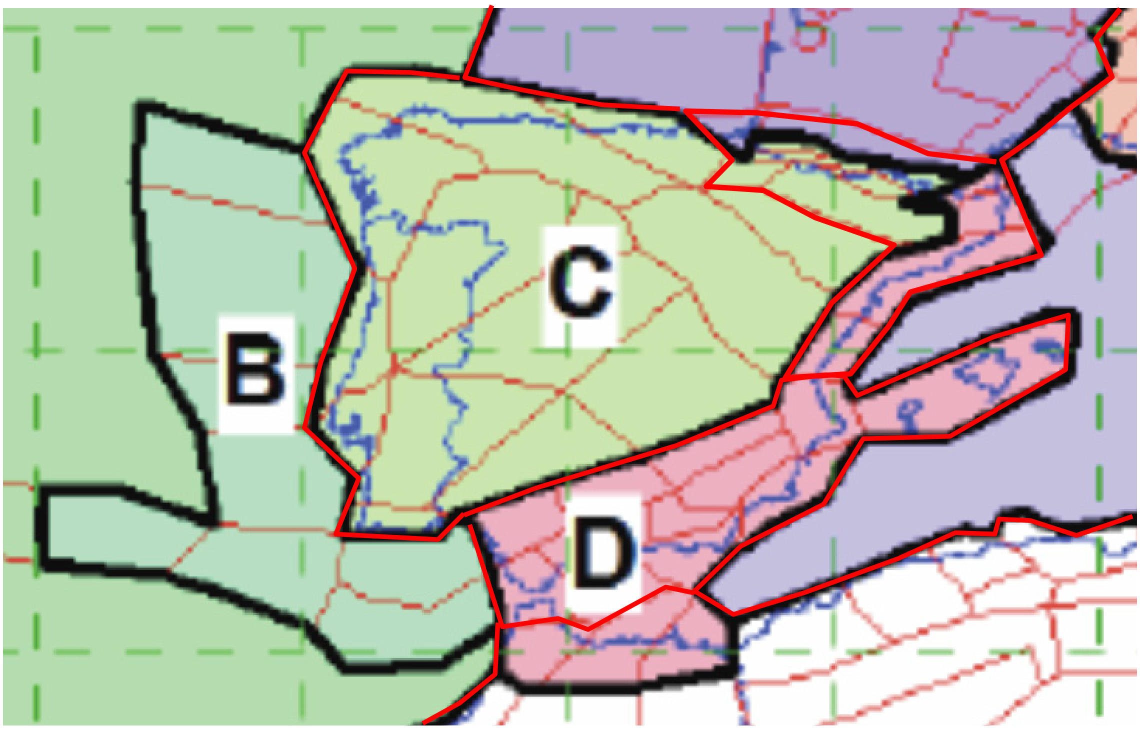
***Changes in super zones geometry**

I propose to change super zone C and super zone D and add two new zones, one to cover the Pyrenees and Catalan Coastal Ranges and other for the North of Africa (Morocco).

The most seismically active areas of the Pyrenees are in the French side, and they have a seismic network older and wider than the Spanish one. So, the Pyrenees should be included in zone E (France), or became an independent zone. I prefer this last option.

Additionally, I think that the Coastal Catalonian Ranges should be an independent zone or be included in the Pyrenees zone, rather than in Iberia (C) or Betics (D).

Finally, the seismic record of the north of Africa is clearly more incomplete than the one in South of Spain. I suggest separating this area from zone D (South Spain). It might happen that you think it does not worth the trouble (as other seismic zones in the rest of Africa (Argelia, Tunis,…) have not been included in the calculations.



***Changes in completeness time intervals**

The reference years of completeness for each of the super zones detailed above follow, indicating the literature source from which they come.

Please note that there is a problem very difficult to cope with related to the magnitude values, as each literature source has produced their own conversions to Mw from Intensity/magnitude. This may lead to mismatches between the magnitude range and completeness periods when comparing from one source to SHARE. I have noticed that the IGN'12 source produces larger Mw than SHEEC catalogue, (around 0.2-0.3 larger). I don't know if this is primarily due to the conversion equation used or to differences in the Intensity value assigned originally to the earthquake in the catalogue.

Pyrenees and Catalonian Coastal Ranges

Two main sources of information, one proposal

Table 2
Starting years of completeness for different ranges of homogenised moment magnitude (Mw_h). The equivalent MSK-intensity for each magnitude range is shown in brackets.

Mw_h	(I_{MSK})	Starting year
2.2–2.9	(II)	1986
3.0–3.4	(III)	1965
3.5–3.9	(IV)	1885
4.0–4.4	(V)	1830
4.5–4.9	(VI)	1740
5.0–5.4	(VII)	1650
≥ 5.5	(≥ VIII)	1150

Source: García-Mayordomo and Insua-Arévalo (2011), *Soil Dyn & E E*, 31:1051-1063.

Table 3 Completeness date used for the best fittings of the GR relations

Magnitude (M_L)	Initial date
3.0–3.2	1977
3.3	1970
3.4–3.9	1965
4.0–4.5	1880
4.6–4.9	1830
5.0–5.4	1750
5.5–5.9	1420
6.0–6.5	1000

Source: Secanell et al (2008). Probabilistic seismic hazard assessment of the Pyrenean region. Journal of seismology, DOI 10.1007/s10950-008-9094-2

PROPOSAL for Pyreness

Mw	Year
3.0-3.4	1965
3.5-3.9	1885
4.0-4.4	1830
4.5-4.9	1740
5.0-5.4	1650
5.5-5.9	1420
6.0-6.4	1152
≥6.5	1152

Iberia (new Zone C)

One main source of information

Mw	Year
3.0-3.4	1985
3.5-3.9	1980
4.0-4.4	1933
4.5-4.9	1910
5.0-5.4	1800
5.5-5.9	1720
6.0-6.4	1152
≥6.5	1152

Source: IGN (2012). Mapa de Peligrosidad Sísmica de España. Catálogo Sísmico de Proyecto. Preparación y Homogenización. Informe técnico IGN: PSE.CS.F02.

Betic Range (aka South Spain) (new Zone D)

Three sources of data, one proposal

Mw	*GM'07*	*IGN'12*	*SHARE*	PROPOSAL
3.0-3.4		*1978*		**1978**
3.5-3.9	*1850*	*1975*		**1975**
4.0-4.4	*1850*	*1908*	*1920*	**1908**
4.5-4.9	*1750*	*1883*		**1800**
5.0-5.4	*1725*	*1800*	*1500*	**1700**
5.5-5.9	*1475*	*1520*	*1350*	**1475**
6.0-6.4	*1200*	*1048*		**1048**
≥6.5	*1000*	*1048*	*1200*	**1048**

Sources:

J. García-Mayordomo & J. M. Gaspar-Escribano & B. Benito (2007). Seismic hazard assessment of the Province of Murcia (SE Spain): analysis of source contribution to hazard. *Journal of Seismology*, 11(4):453–71.

IGN (2012). Mapa de Peligrosidad Sísmica de España. Catálogo Sísmico de Proyecto. Preparación y Homogenización. Informe técnico IGN: PSE.CS.F02

sheec3.2_compl_intervals.xls (info provided by Jochen for the 2nd review meeting)

North of Africa (Morocco)
One main source of information

Mw	Year
3.0-3.4	1987
3.5-3.9	1987
4.0-4.4	1950
4.5-4.9	1930
5.0-5.4	1910
5.5-5.9	1845
6.0-6.4	1578
≥6.5	1578

Source: IGN (2012). Mapa de Peligrosidad Sísmica de España. Catálogo Sísmico de Proyecto. Preparación y Homogenización. Informe técnico IGN: PSE.CS.F02

COMMENTS on “Spanish source zones to be reviewed”

In the document provided (v1.SHARE_ASmodel.pdf) there is table: List of Area Sources to be Reviewed, where Spanish zones appear:

ESASXXX	Many of the historical events have MW=5.1 in the period 1700-1900, but they are excluded by completeness – may need a change here
ESAS472	Events in 1400 century fully exclude, check completeness

Comments:

ESASXXX: Hopefully, if you change the completeness intervals as detailed above most of the source zones would have now a representative sample for fitting a,b values (or at least better than the one that can be seen in the plots provided).

For the new SH map of Spain, earthquakes as low as Mw 3.5 are considered in the fit. This means, in general, obtaining better fits rather than using Mw>4.0 as in SHARE.

ESAS472: With the new intervals proposed for the Pyrenees the 1427 Amer and Olot events will be included in the GR fit.

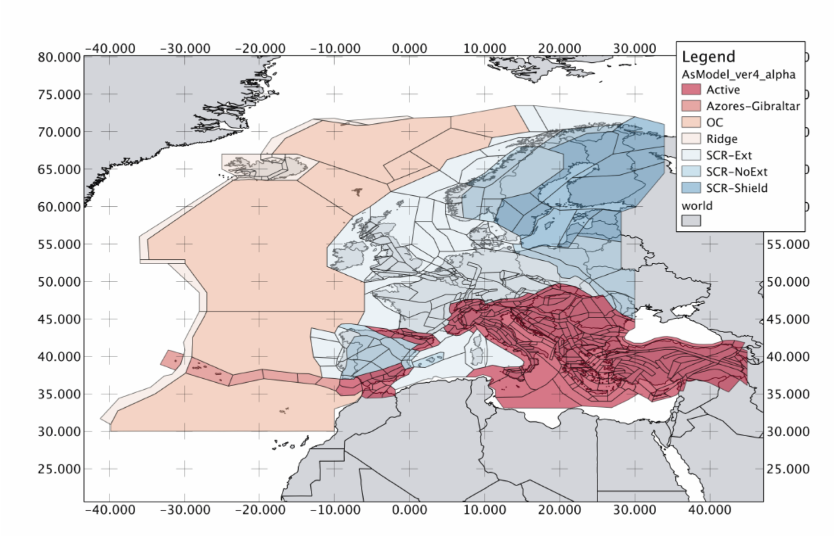
SOURCE ZONES GEOMETRY

I see that you have implemented the changes in the Pyrenees agreed with IRSN-France (S. Baize) that we talked about in the last meeting. Thanks. The rest of the zones are fine and they correspond to the model IGME-Spain (myself) and LNEG-Portugal (Vilanova) agreed. Just for the record I inform you that that model has been further changed to be incorporated in the hazard calculations performed for the new national SH map of Spain, an initiative led by IGN (Instituto Geográfico Nacional). The Iberian-SHARE model was modified based on the criteria of the experts belonging to the commission formed to follow the creation of the map. The differences between both models are, in general, minor, and I think they are not crucial for the results for most of the country.

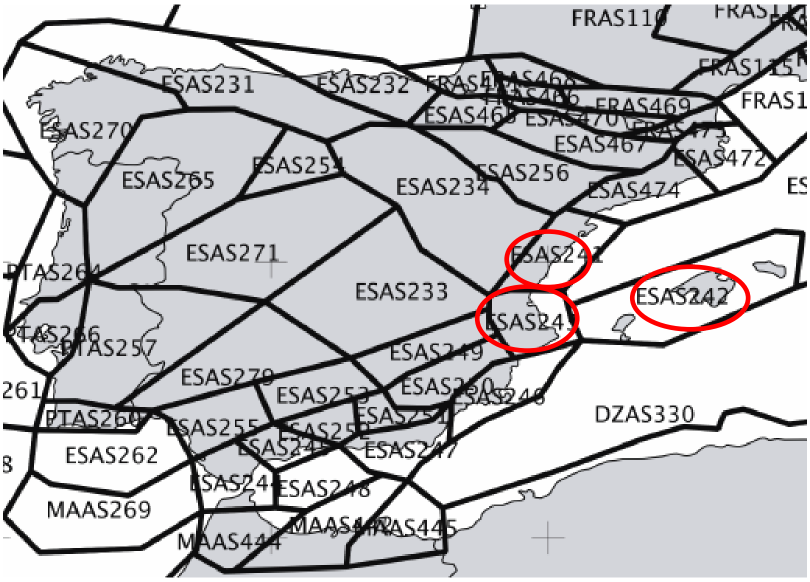
* Tectonic Regime

Following the figure (included in SHARE_ASmodel4_Maps.pdf):

Tectonic Regimes



I would make the following changes:
Spanish zones ESA241, ESA242 and ESA243 (see figure below) should be classified as "Active" (and so have a red colour in the picture above).


FRAS110
ESAS231
ESAS232
ESAS270
ESAS265
ESAS254
ESAS234
ESAS256
ESAS467
ESAS472
ESAS474
FRAS469
ESAS271
ESAS233
ESAS241
ESAS242
ESAS243
ESAS249
ESAS279
ESAS253
ESAS255
ESAS262
MAAS269
DZAS330
ESAS247
ESAS248
MAAS444
MAAS445
PTAS264
PTAS257

Data received: 29/08/2012 Paris, 31 August, 2012

FaultModel: Comments on the fly, given the short time before your meeting.

Congratulations on structuring the datafiles, it's been easy to consult but I have very little time and I have some important questions.

- The heterogeneity in the definition of the BG zones of faults across the region studied is tremendous. Some BG regions just don't make much sense and the comparisons between seismicity rates and geological rates seem meaningless.

- Pretending to have identified all faults that can produce M>=5.5 at the European scale in most of these BG zones is not realistic, especially in those zones where the background region is 99% devoid of faults. A more realistic representation of knowledge at the European scale should be considered (maybe M>=6.5?).

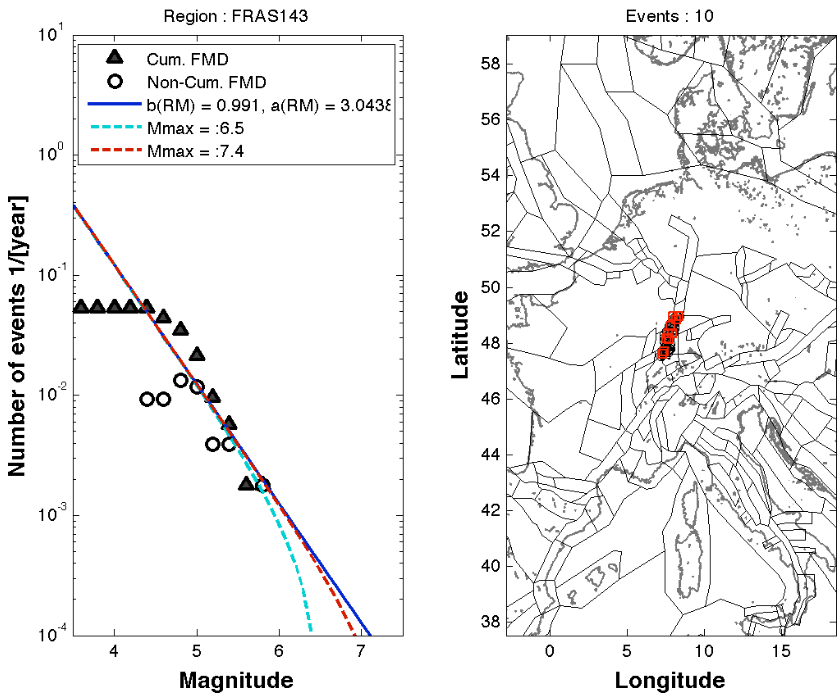
- Why is only the Anderson and Luco model considered? Clearly in many regions this model does not capture the observed seismicity rates of M>6. In many countries, it is recognized that knowledge of how seismicity occurs on faults is still a matter of debate, other models should be considered before implementing this approach.

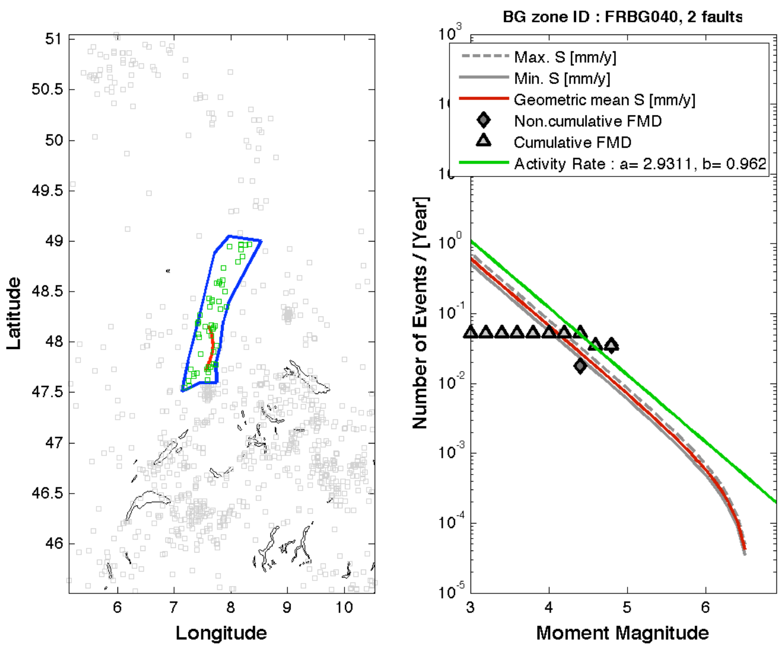
- For a number of faults (Ligurian Basin, Corinth rift, for example) I was not able to appreciate the level of knowledge that is used to characterize the faults …could you please indicate to me the version of DISS that corresponds to the calculations performed?

I have many more question and comments but time is short, just two examples to illustrate my concern.

1 Question:

It is not very easy to follow how the FSBG model has been parameterized. Consider the Example of the FRAS143 = FRBG040. The zones are identical in the two models but a and b values are different.





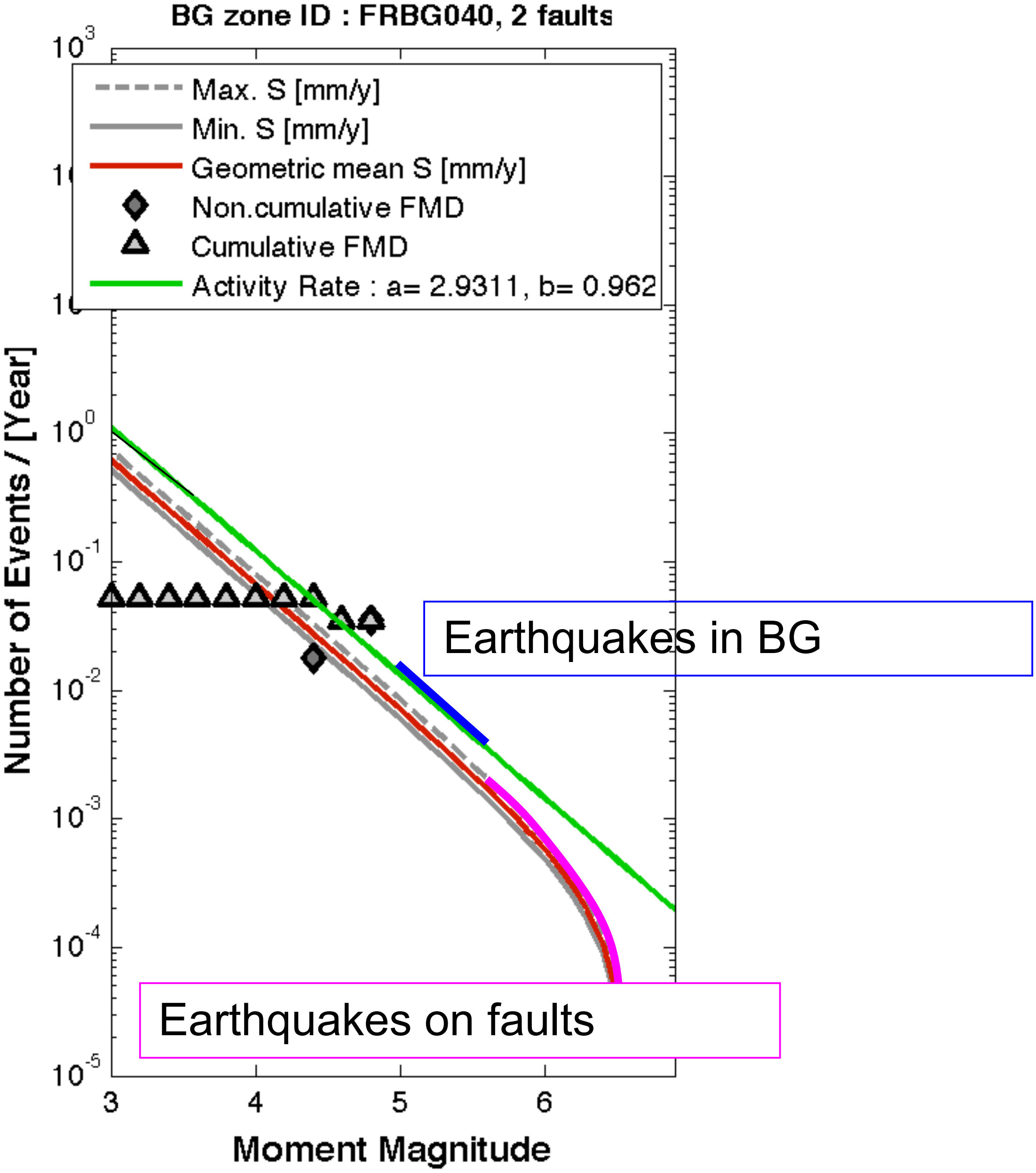
We are in Case 3 (> 1 fault)…in theory no earthquakes have been associated to specific faults, so why are the a and b values different?

Comment

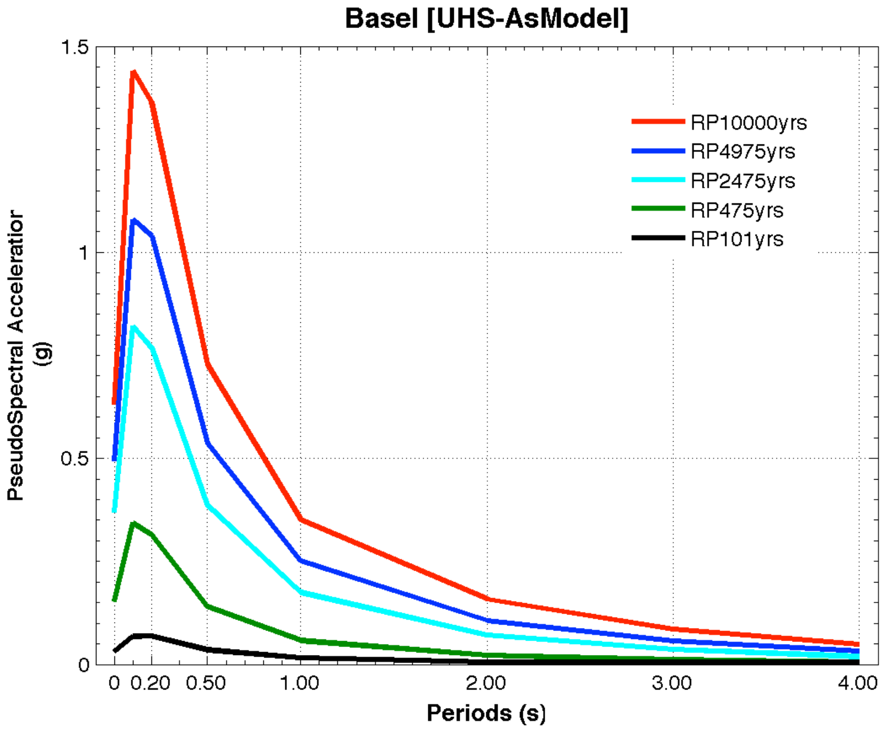
In the PSHA calculation of activity rates for faults what is exactly done?

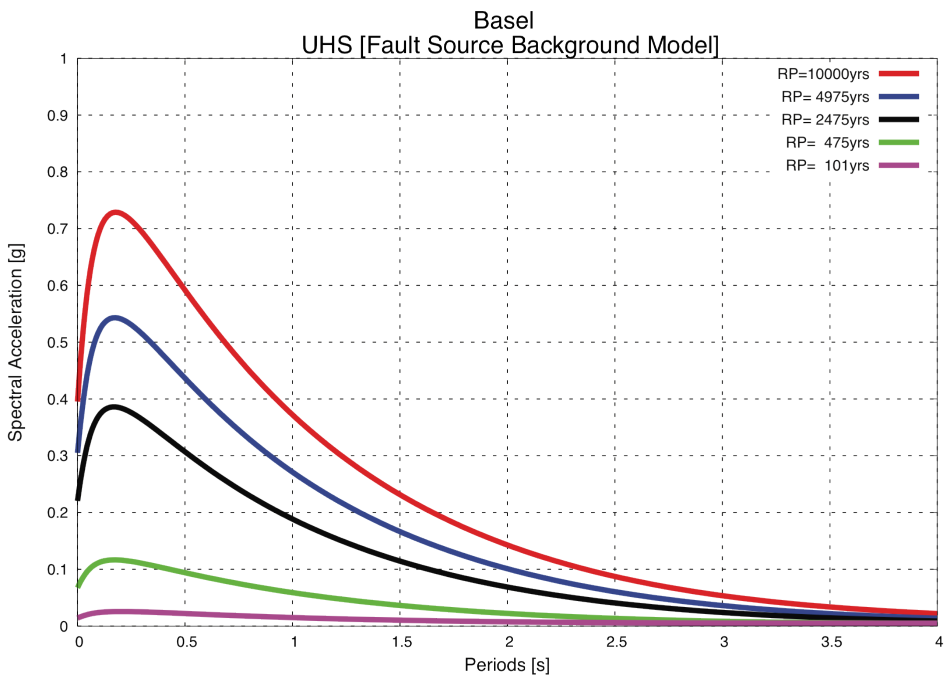
You only consider M>=5.0?5.0>M<5.5 earthquake in the background and M>=5.5 on the faults?

Therefore for this particular zone..is the following representation correct?

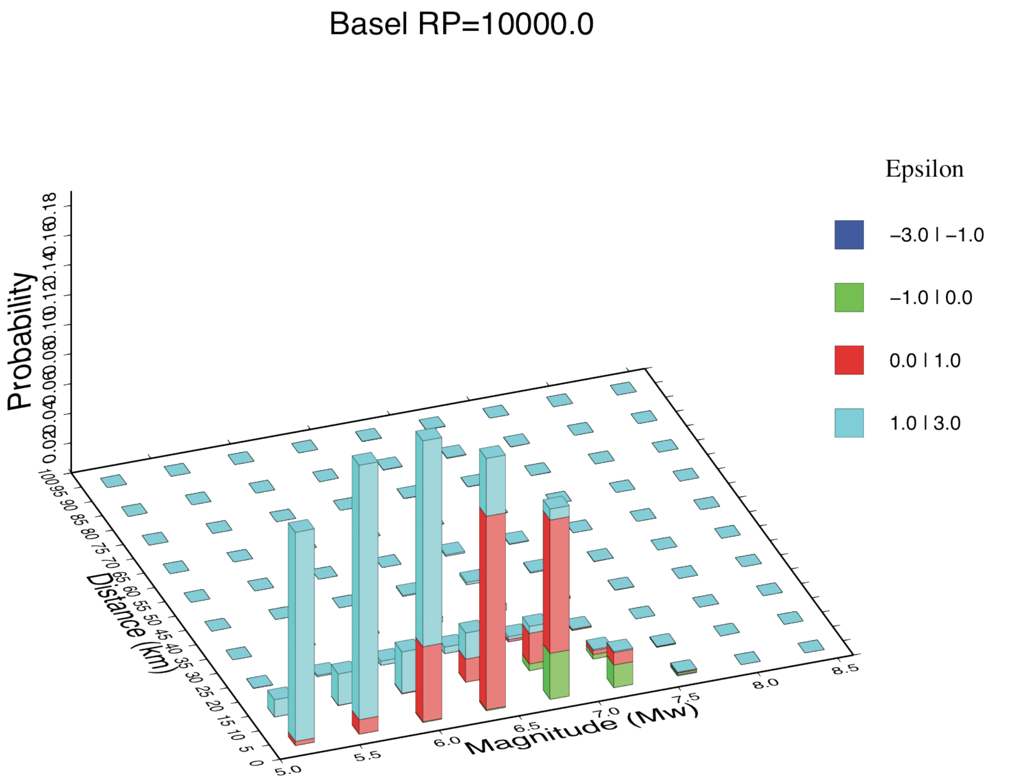


I'm sure your answer will help understand why there is such a difference between the two models for the predicted UHS at Basel, even for 10000 years return period ➔ removing the contribution of M>=5.5 earthquake from the BG of zones with faults has major consequences that affect the neighbouring zone without faults at all return periods!! Hence my first comment above.

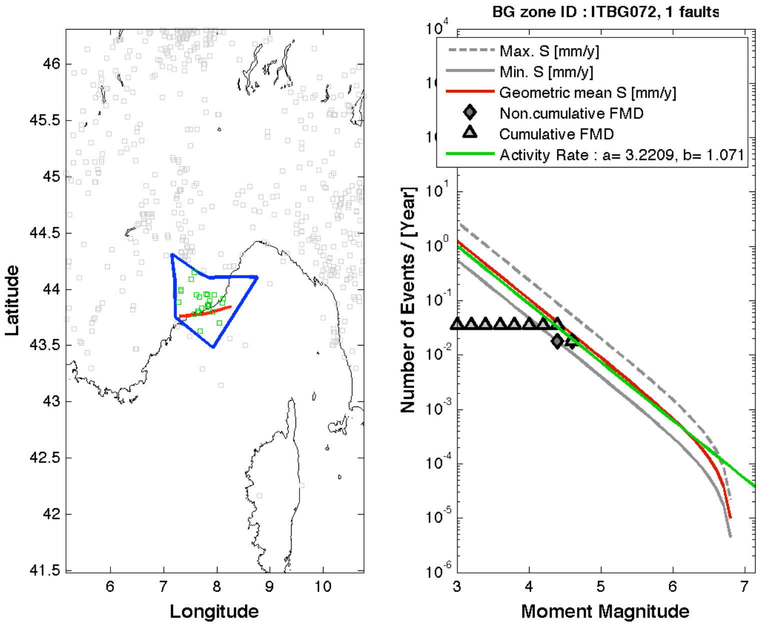




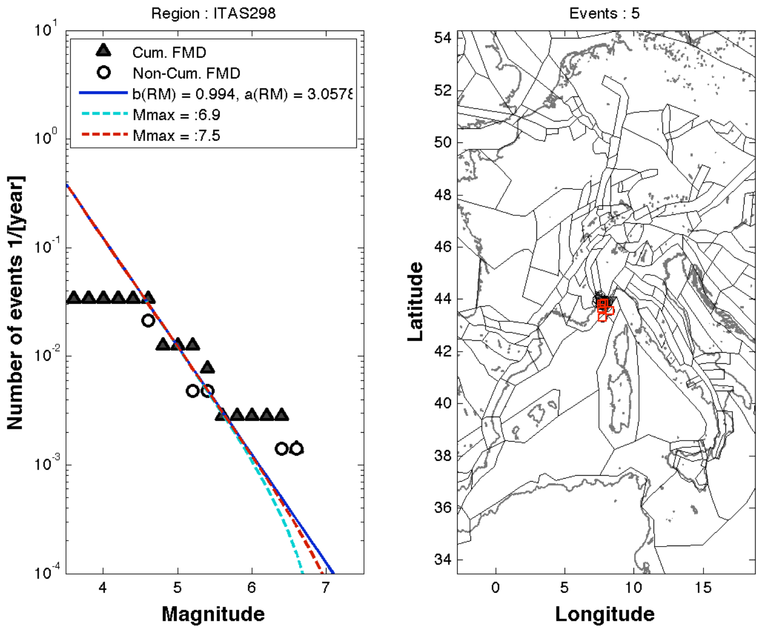
Coul you provide disaggregation for the AS model for Basel to compare to the one below, which I found in the : FSBGmodel\FSBGmodel\HazardResults\DisaggregationPlots



Other Example of difference between a and b value from one model to the other..what does this BG represent with respect to the fault and what is the evidence for such a fault ?



so when we are comparing AS and FSBG models what are we really comparing?

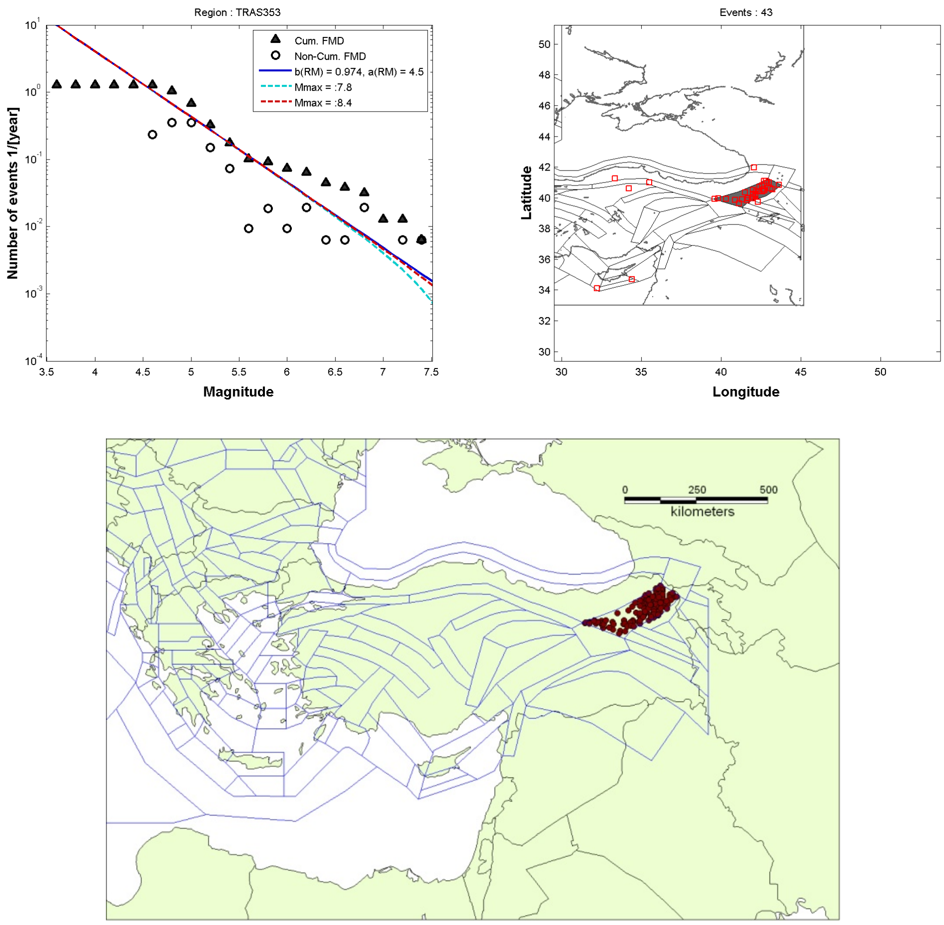


Bon courage for your meeting on Monday!!

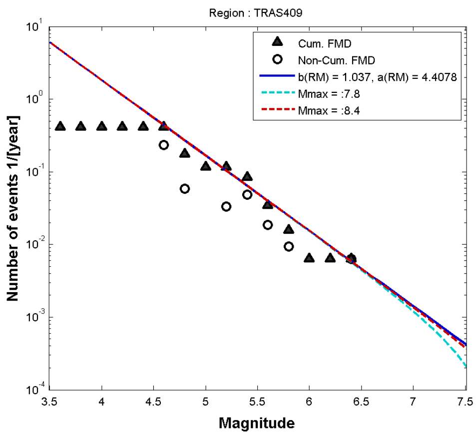
Greetings
Oona

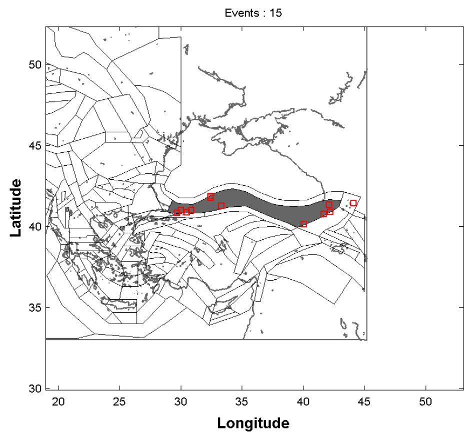
When we plot the events associated with ASR= TRAS353, TRAS409, TRAS416, TRAS447, TRAS448, TRAS449, TRAS454, TRAS457, TRAS459, GEAS343, GEAS452, CYAS362 and IRAS456 source zones using the catalogue “SHEEC3.2_EMME_NW_append” with the query of model=1 (main shocks), we obtain the green figures presented below. As you can see, there are NOT any earthquakes associated with the source zones other than those they fall in. So could it be a display error or id errors occurred during the conversion to zmap software?

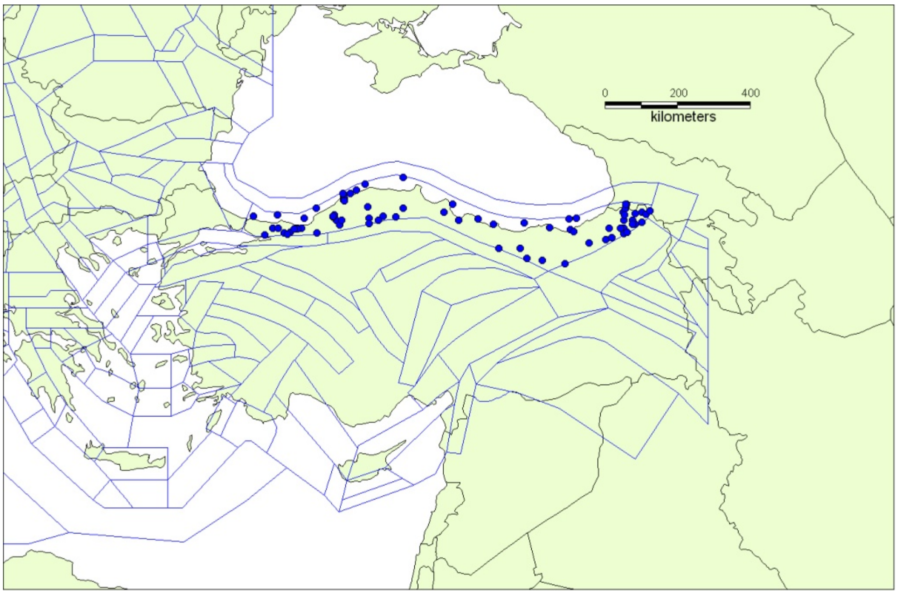
TRAS353



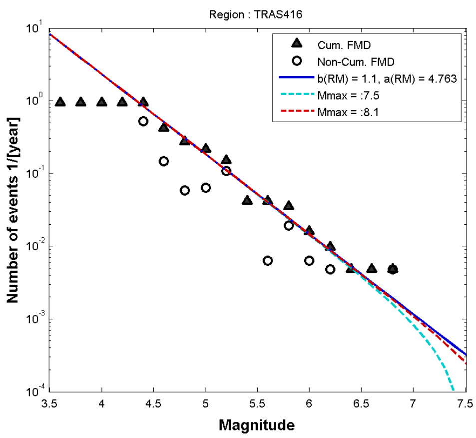
TRAS409

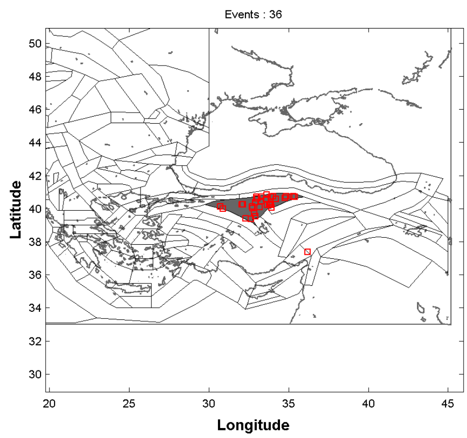

Region : TRAS409
Cum. FMD
Non-Cum. FMD
b(RM) = 1.037, a(RM) = 4.4078
Mmax = :7.8
Mmax = :8.4
Number of events 1/[year]
Magnitude

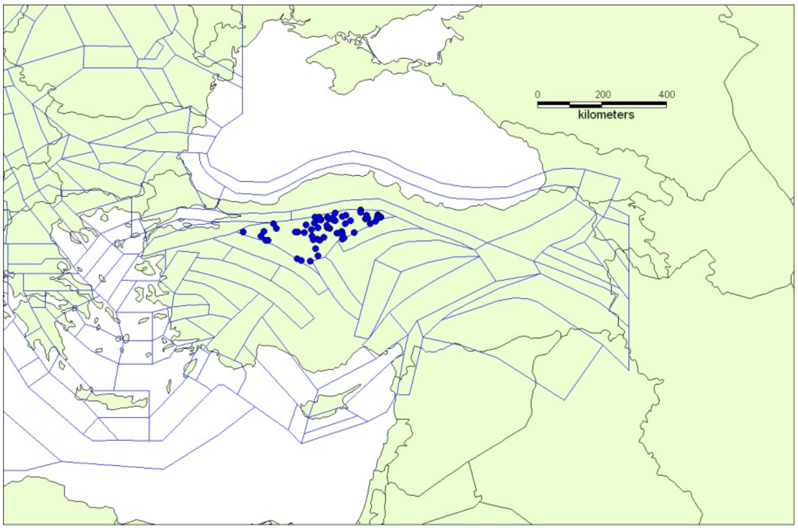

Events : 15
Latitude
Longitude


0
200
400
kilometers

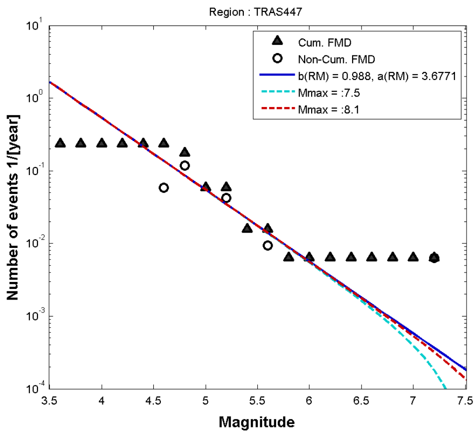
TRAS416

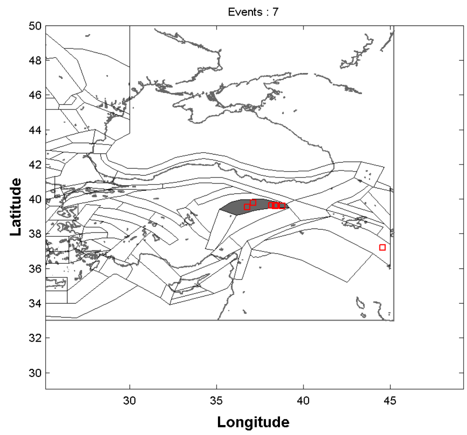

Region : TRAS416
Cum. FMD
Non-Cum. FMD
b(RM) = 1.1, a(RM) = 4.763
Mmax = :7.5
Mmax = :8.1
Number of events 1/[year]
Magnitude

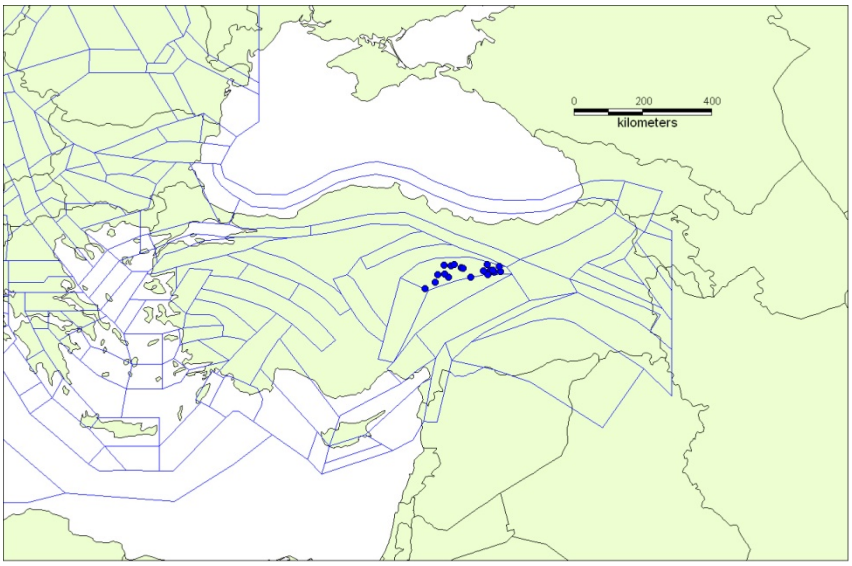

Events : 36
Latitude
Longitude


0
200
400
kilometers

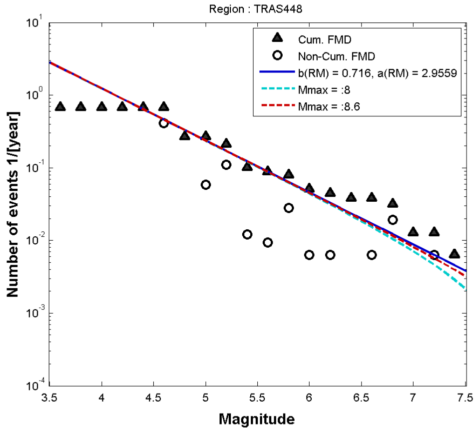
TRAS447

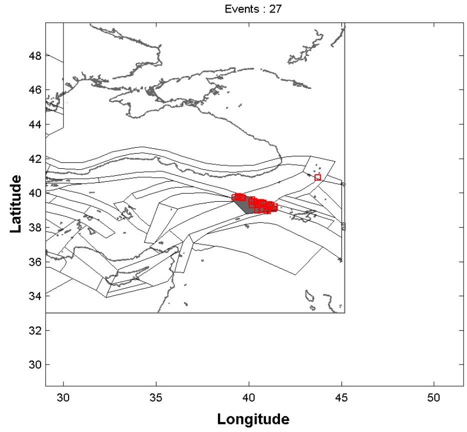

Region : TRAS447
Cum. FMD
Non-Cum. FMD
b(RM) = 0.988, a(RM) = 3.6771
Mmax = :7.5
Mmax = :8.1
Number of events 1/[year]
Magnitude

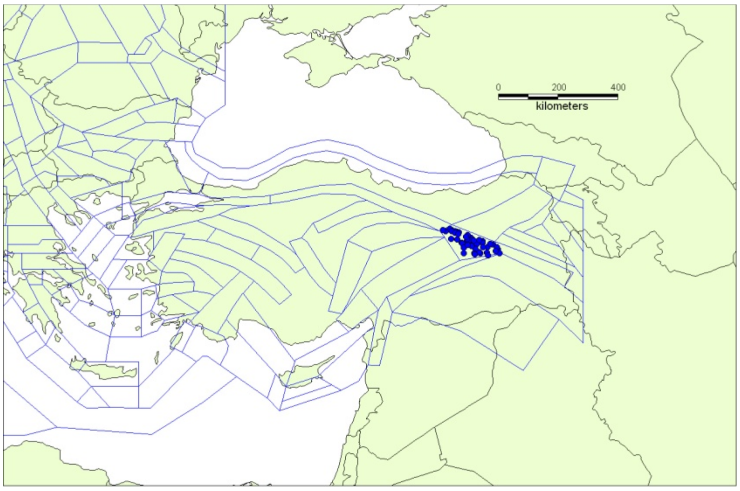

Events : 7
Latitude
Longitude


0
200
400
kilometers

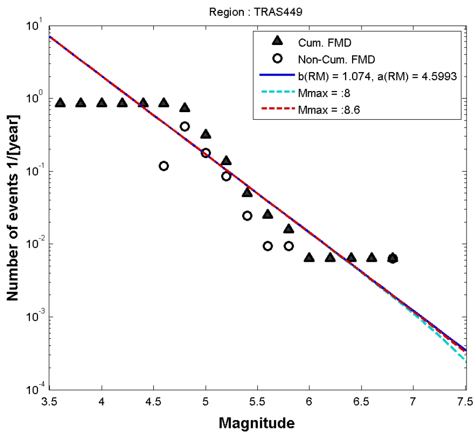
TRAS448

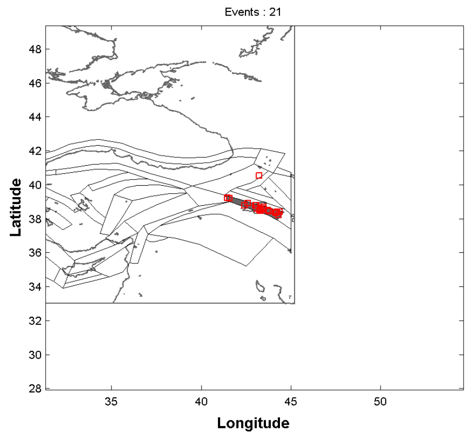


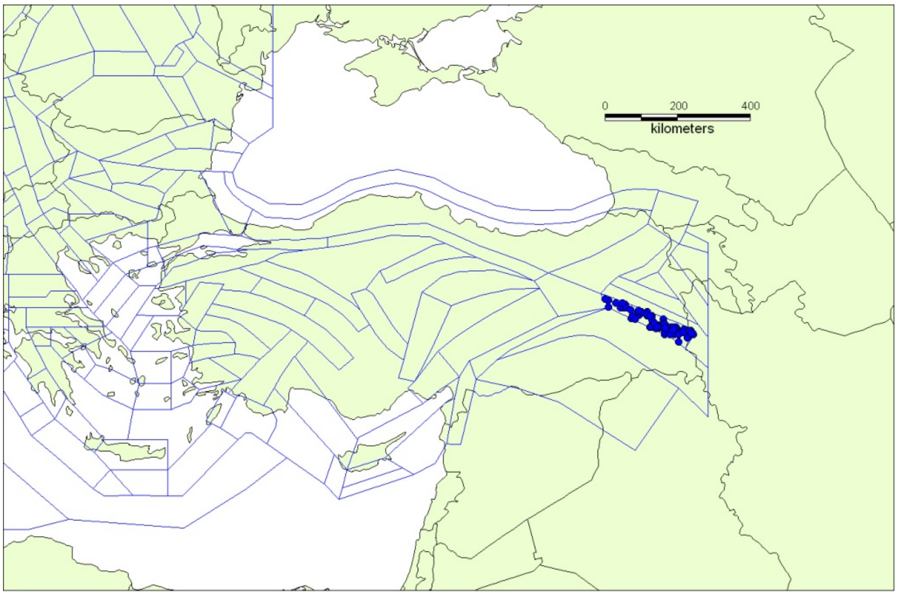




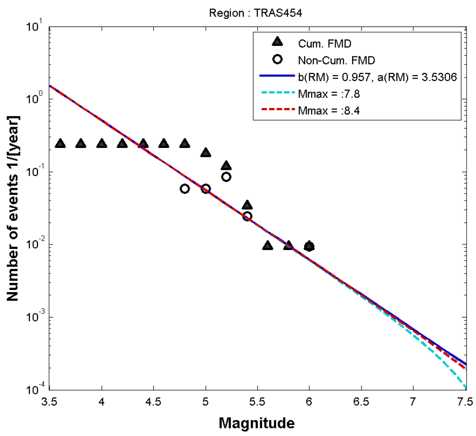
TRAS449

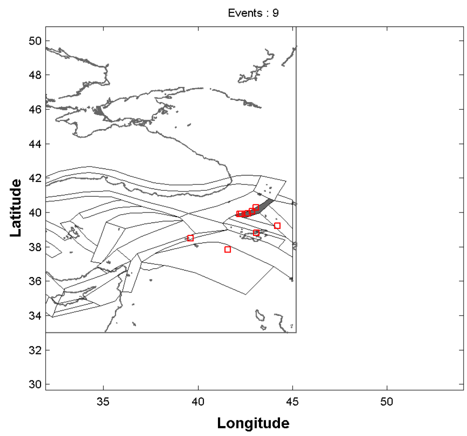


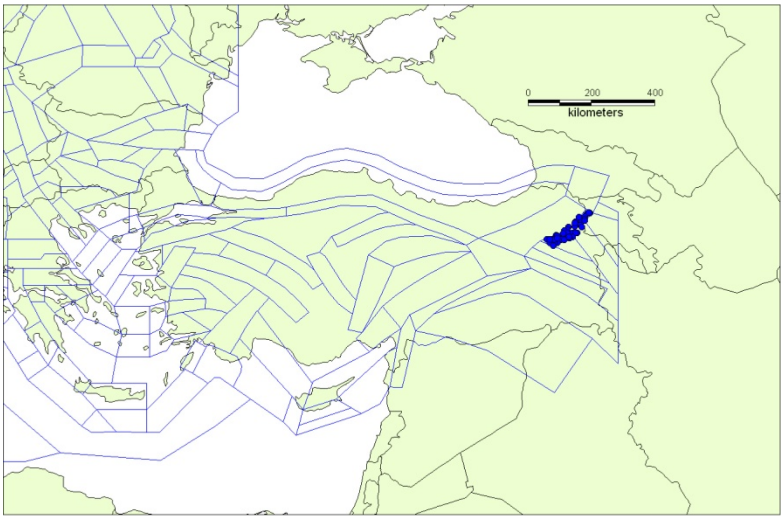



0
200
400
kilometers

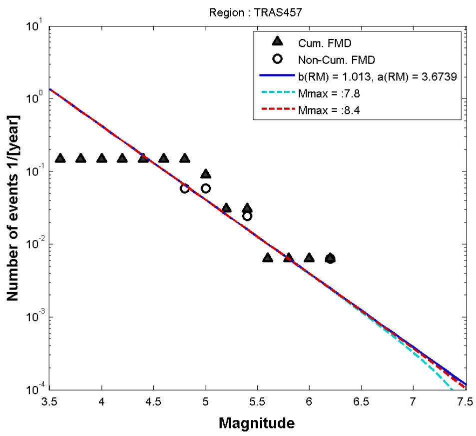
TRAS454

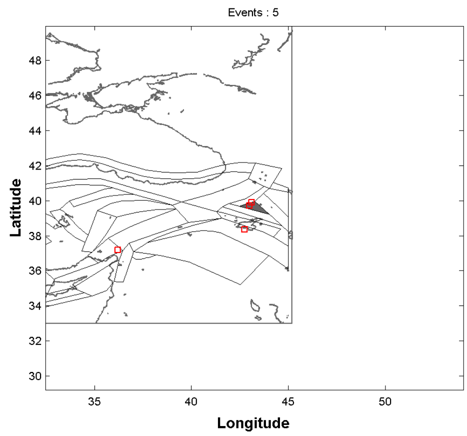

Region : TRAS454
Cum. FMD
Non-Cum. FMD
b(RM) = 0.957, a(RM) = 3.5306
Mmax = :7.8
Mmax = :8.4
Number of events 1/[year]
Magnitude

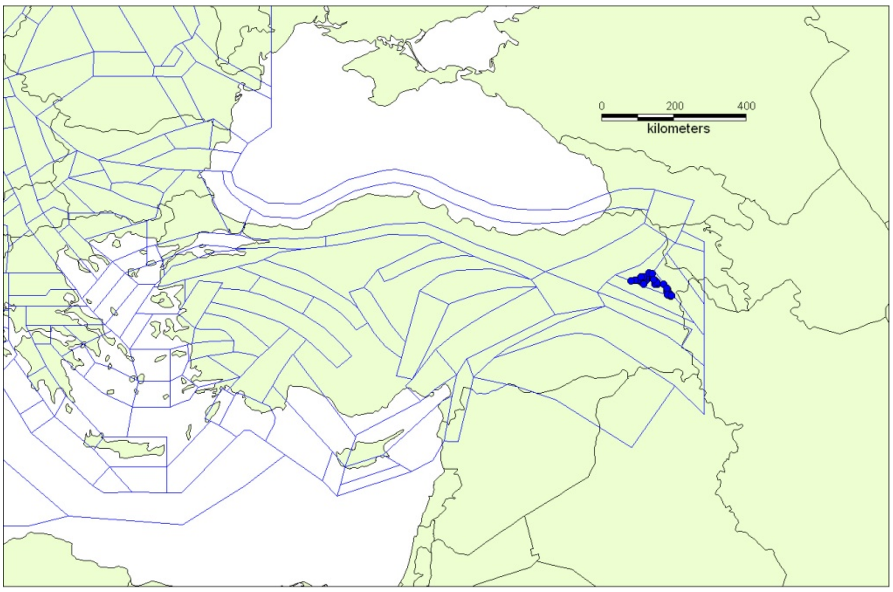

Events : 9
Latitude
Longitude



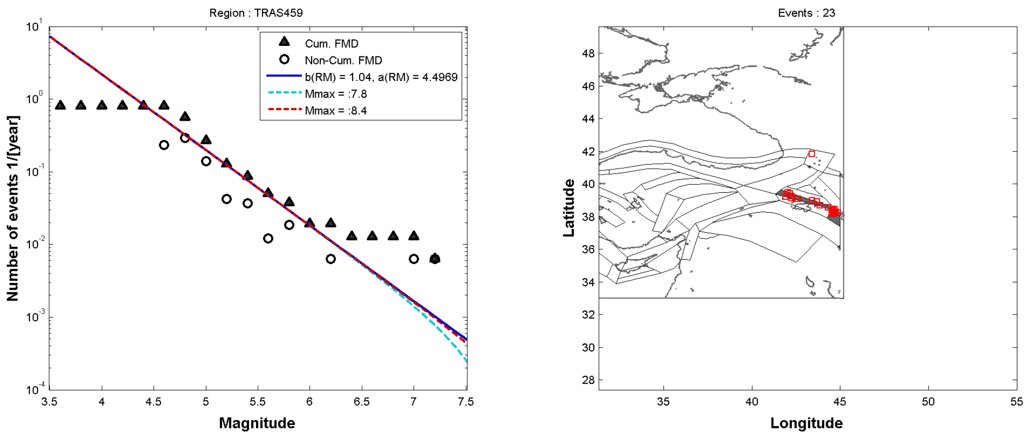
TRAS457

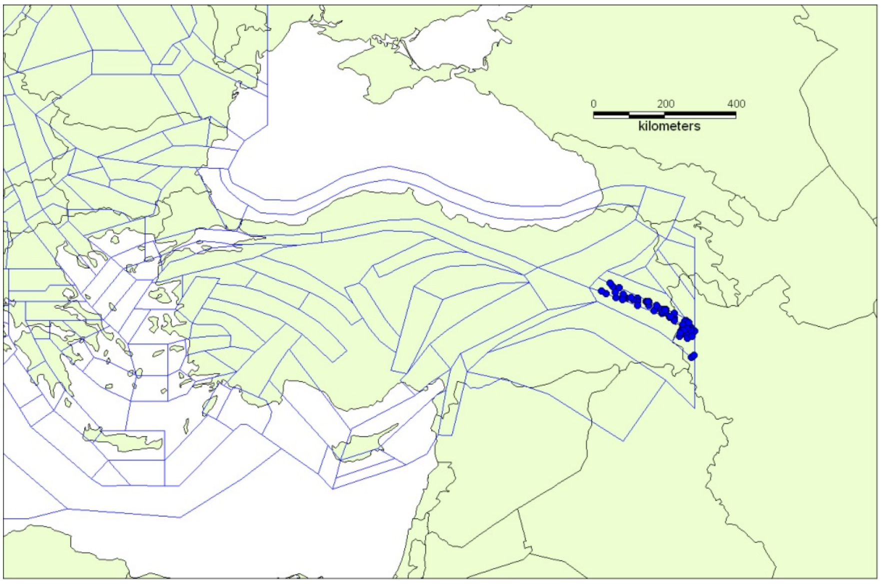




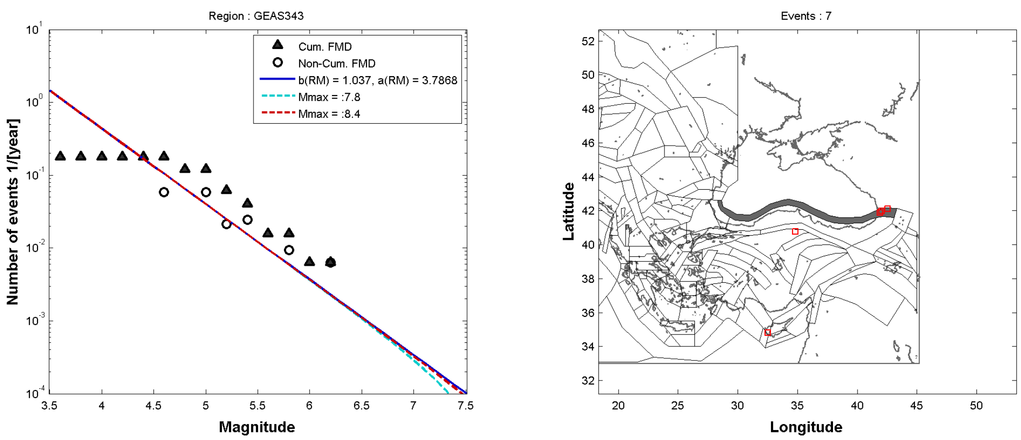


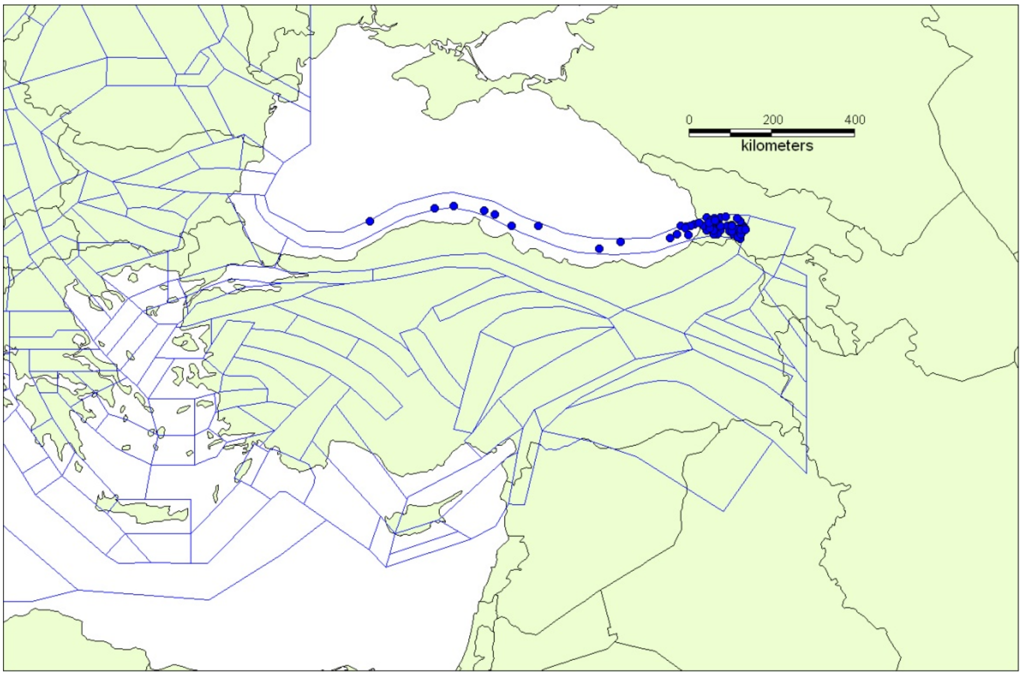
TRAS459


Region : TRAS459
Cum. FMD
Non-Cum. FMD
b(RM) = 1.04, a(RM) = 4.4969
Mmax = :7.8
Mmax = :8.4
Number of events 1/[year]
Magnitude
Events : 23
Latitude
Longitude

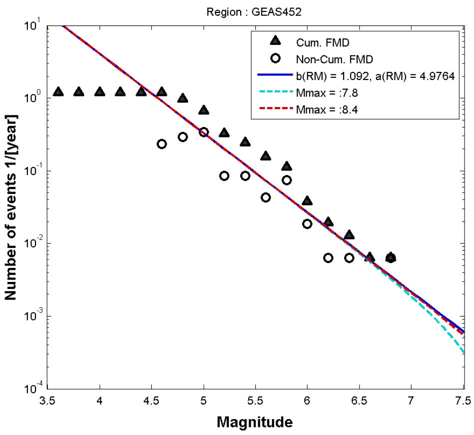

0
200
400
kilometers

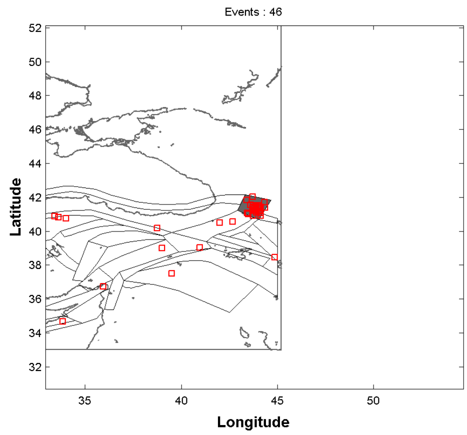
GEAS343

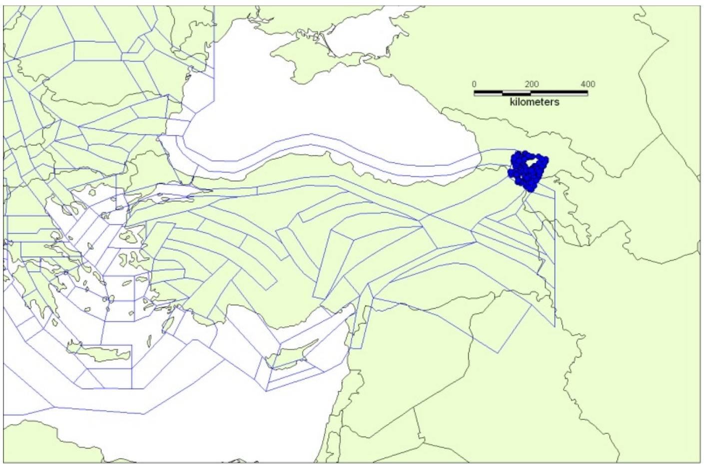

Region : GEAS343
Cum. FMD
Non-Cum. FMD
b(RM) = 1.037, a(RM) = 3.7868
Mmax = :7.8
Mmax = :8.4
Number of events 1/[year]
Magnitude
Events : 7
Latitude
Longitude



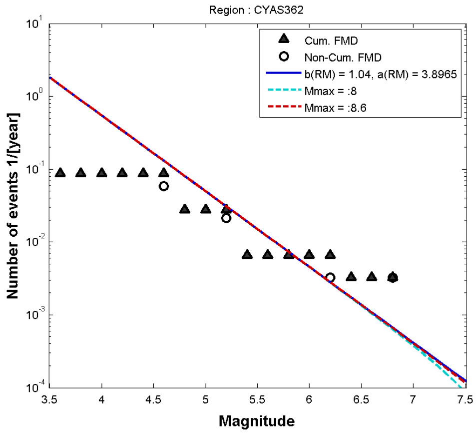
GEAS452

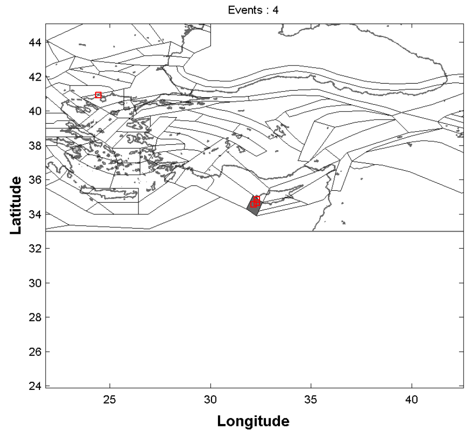


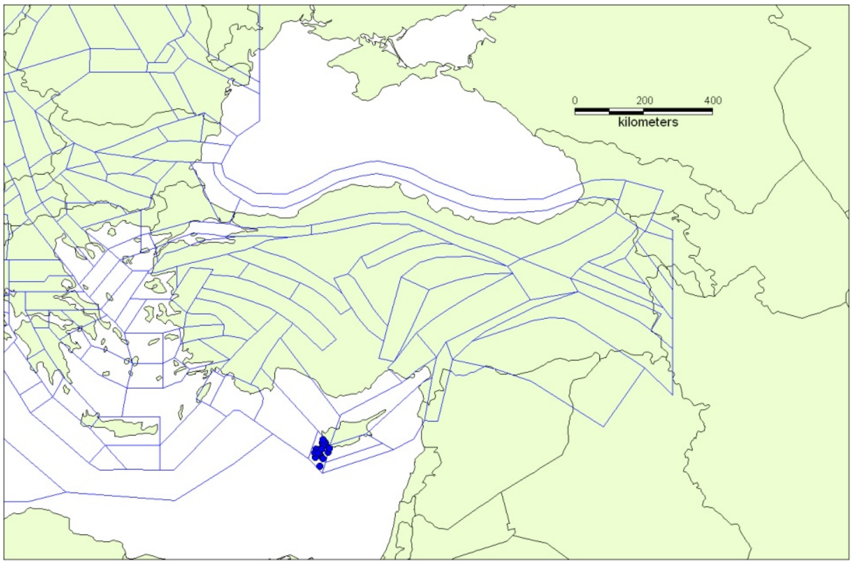




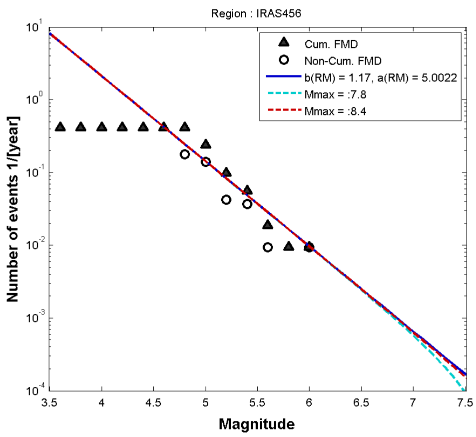
CYAS362

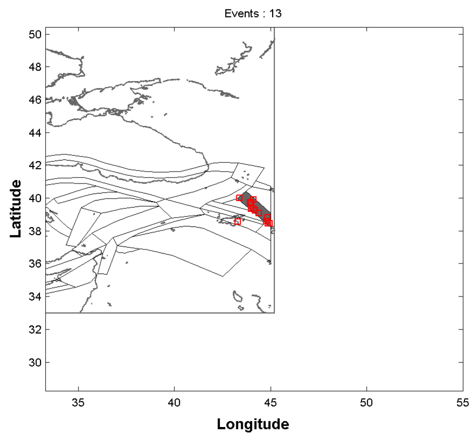

Region : CYAS362
Cum. FMD
Non-Cum. FMD
b(RM) = 1.04, a(RM) = 3.8965
Mmax = :8
Mmax = :8.6
Number of events 1/[year]
Magnitude

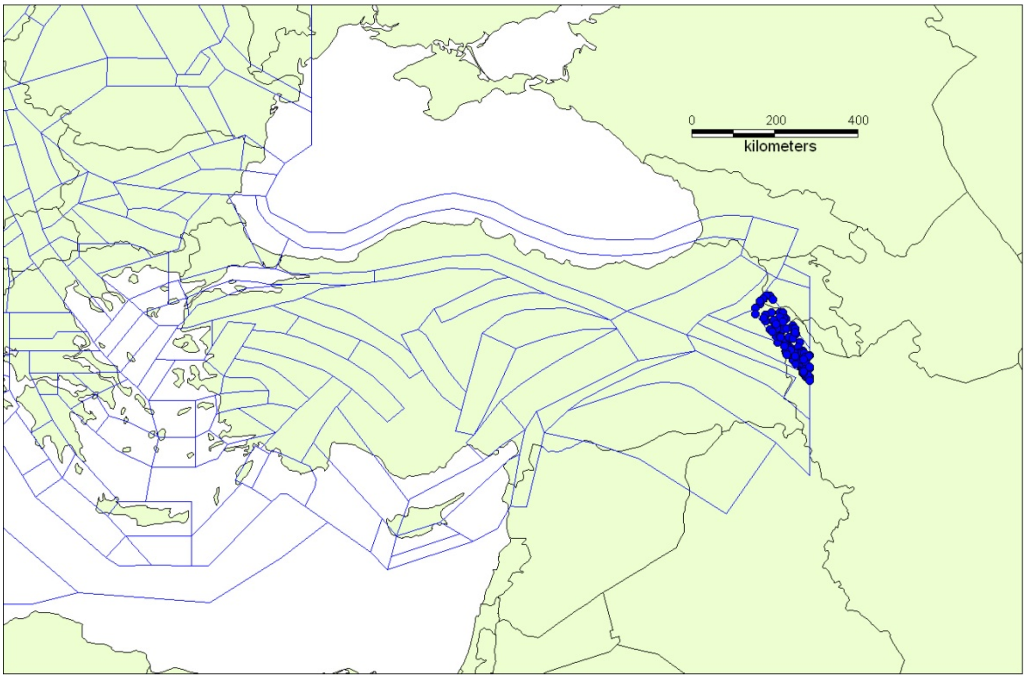

Events : 4
Latitude
Longitude


0
200
400
kilometers

IRAS456


Region : IRAS456
Cum. FMD
Non-Cum. FMD
b(RM) = 1.17, a(RM) = 5.0022
Mmax = :7.8
Mmax = :8.4
Number of events 1/[year]
Magnitude


Events : 13
Latitude
Longitude


0
200
400
kilometers

ROADMAP

Achieved	Expected	Due	Task / Data	Responsible	Comment
		Sept. 7	Feedback from Expert	All SHARE members and experts	
		Sept 7	Completeness update	INGV Milan ETH	
		Sept 7	Merge sources / Assign events in catalog accoringly	ETH / INGV	
		Set. 7	Mmax Uncertainty faults / Adjust to AS model	ETH / INGV / NORSAR / BGS	
		Sept. 11	Sigma for the Vrancea GMPE	METU / LGIT	
		Sept 12	Activity Rate Update / Plots to be send	ETH / INGV / NORSAR / BGS	
		Sept 12	AS model calculation start	ETH	
		Sept 18	Activity Rate FSBG	ETH / INGV / NORSAR / BGS	
		Sept 22	As model results	ETH	
		Sept. 26	WCEE Presentation	Giardini	
		?	WCEE Presentation	Wössner	
		Oct 2	Start FSBG calculations	ETH	
		Oct 15	FSBG model calculation complete	ETH	
		Oct 31	PostProcessing AS + FSBG finished	ETH	
		Nov. 5	Weighting of Models	ETH / GFZ / INGV	
		Nov. 18	Suggestion for D2.7		
		Nov. 19/20	Final Meeting in Istanbul		

25. April 2012

Seismic Hazard Harmonization in Europe

Model Review Meeting

Minutes

Summary for Day 1 and Day 2

During the intense 2.5 day workshop all issues considering the SHARE model building process, the status of the model, model adjustments and preliminary results as well as the harmonization issues between SHARE and EMME were discussed.

Following the discussions, the participants come to the following **main conclusions**:

1. The SHARE model is yet too preliminary and needs revision in all parts of the principle methods used as source models (ASZ, FS+BG, Kernel-smoothed approaches). Note that at the meeting results were still based on the SHEEC version 2 which excluded data east of 32E.
2. The hazard engine needs to be further checked to ensure correct calculations. Sensitivity tests have to be performed for various choices in the input model, e.g. the inclusion of magnitude uncertainties in the activity rate calculation or effects of declustering.
3. The current final date (May 31st, 2012) does not leave enough time for all tests / checks. Thus we seek an extension of the project by 5 months until October 31st, 2012.
4. SHARE and EMME harmonization can be managed by solving the differences in the GMPE selection and weighting of the source model branches. A solution has been discussed and will be suggested at the next EMME General Assembly in Istanbul, March 27-29, 2012, for confirmation.

On the following pages, a summary of the issues discussed and a roadmap to finish SHARE given the 5 months extension is proposed.

Details on open issues within share and the roadmap proposed are found following the summary of Day 3.

Day 3: Minutes on SHARE – EMME Harmonization

Provided by S. Akkar

Karin Sesetyan presented the current status of source modeling for the EMME region. She noted that the zone-based approach seems to be the best option for EMME. In her presentation she also pointed that the project still misses the relevant seismological parameters for modeling of faults and made it clear to the audience that the EMME source logic-tree will be a simplified version of the corresponding one in SHARE. Roberto Basili will help the EMME source modeling of Caucuses region.

Sinan Akkar was the second speaker in the joint SHARE-EMME seismic hazard meeting. He presented the initial results of the EMME GMPEs logic-tree studies. He explained the methodology followed in EMME. EMME GMPEs working group uses analytical testing and ranking methods while deciding on the GMPEs logic-tree application. SHARE GMPEs work package considered the expert opinion as well as analytical testing and ranking methods for selecting and weighting GMPEs that are used in the hazard computation of SHARE. The results presented by Sinan Akkar indicate that both approaches result in practically the same GMPEs for active shallow crustal regions (ASCR). The only difference between EMME and SHARE ASCR GMPEs is the Akkar and Cagnan (2010) model that replaces the Cauzzi and Faccioli (2008) GMPE selected for the SHARE project. EMME studies give equal weights to the selected GMPEs whereas SHARE assigns different logic-tree weights that are primarily based on expert opinion. Sinan Akkar also showed preliminary hazard results for the EMME-SHARE border region by comparing the hazard contours of TR = 475, 2475 and 10,000 years calculated from EMME and SHARE methodologies. The results suggest a slight conservatism of EMME approach. After this presentation Fabrice Cotton suggested Sinan Akkar to send this presentation to the SHARE GMPEs group for their opinion on the methodology followed in EMME as well as the GMPEs selected in the context of EMME project. This suggestion was accepted by Sinan Akkar. He indcated that the better performance of Akkar and Cagnan (2010) can be the abundant Turkish data in the EMME SM database. Sinan Akkar's response to this comment was the significant contribution of Iranian database in EMME strong-motion database. Ezio Faccioli raised his concerns about the performance of Akkar and Cagnan (2010) model as this model is developed from a local (Turkish) dataset. He also questioned the reliability of the Iranian data used by the EMME GMPEs group for testing and ranking the candidate GMPEs. Sinan Akkar responded these comments that are summarized in the following bullets:

- There is no global predictive models because such models are also derived from datasets that are dominated by a few countries. For example NGA models are derived from data recorded in California (WNA) and Taiwan (mainly the 1999 Chi-Chi earthquake) and Cauzzi and Faccioli (2008) almost exclusively made use of Japanese data.
- EMME strong-motion databank is a product of intensive 2-year work and Iranian data are reliable as they are the final results of both local and international experts. The metadata information of the Iranian data is gathered from international and local seismological agencies under the consensus of EMME GMPEs group.

The discussions of SHARE-EMME joint meeting ended with a conclusion that EMME and SHARE project groups will collaborate as much as possible to reduce the regional hazard differences along the EMME-SHARE border region. EMME will try speeding up the hazard computations to compare the border region hazard results during the final SHARE meeting. Sinan Akkar offered the METU help in this respect.

16. September 2012

SHARE

SEVENTH FRAMEWORK PROGRAMME

Seismic Hazard Harmonization in Europe

2nd Model Review Meeting

Minutes

Summary

The main conclusions drawn from the discussions at the 2nd Review Meeting are:

1. SHARE members are convinced to revise the model within the given time and thus target to produce the final hazard by early November 2012.
2. The Area Source Model and the Fault Source and Background Model need both revisions. For the revisions a detailed roadmap has been defined during the meeting, the roadmap is attached to this document. In case algorithm driven parameter determination does not lead to a satisfying result, expert judgement will be used considering the regional input.
3. Presentations of the hazard results for the revised Area Source model shall be presented at the 15th World Conference of Earthquake Engineering (Lisbon)
4. Dissemination of the printed version (D5.6) is targeted the month December 2012 / January 2013.
5. The generation of a European reference seismic hazard zonation map (Deliverable 2.7) is critical but debated as noted in during the 2nd Annual SHARE meeting in Oslo. The deliverable shall contain suggestions on how the EC8 committee may revise this for future revisions of the EC8-code which may not be based anymore on the zonation concept.
6. Additional feedback will be accepted until September 10. Afterwards the ETH modeling team will implement what is available.
7. We change the hazard integration to start from M_W=4.5 instead of M_W=5. This means that GMPEs need to be checked for this range and need to be likely adjusted.
8. Dissemination of results: The uncertainties of the model output should be clearly communicated when disseminating the hazard results. Feasible ways are to include maps showing the quantiles.

Comments on the initiated feedback process

Members of the SHARE consortium and external experts complimented on feedback process and on the provided material in preparation of the workshop. The material was taken to be very useful to get familiar with the work done and the problems within the calculation of the hazard model.

Important Revisions for source models

- **Catalog completeness** needs to be revisited which will affect all source model types. INGV Milan will provide a suggestion upon which new activity rates will be computed.
- Consistency checks between the activity rates of the AS- and the FSBG-model need to be performed not to have different rates for AS-sources that are also valid in the FSBG-model.
- Activity Rate Calculation for zones with 1 event left needs to be clearly explained

Particular updates / checks for the AS-model:

1. Adjust geometry for some of the source with none /very few events, i.e. remove some of the sources.
2. Vrancea region: Revise the area sources and implement GMPEs following Sokolov (2008). An urgent decision here is to develop a constraint on the uncertainty of the relationship.
3. Check the data for single event sources after completeness
4. Activity rate parameter adjustment based on expert knowledge will be used to revise algorithm driven parameters

Particular updates for the FS+BG model:

1. The discrepancy between the larger Mmax in the AS-model and the FS+BG model will be addressed by including the uncertainty of the Mmax determination from the scaling relations into the modeling. A logic-tree to estimate the activity rates using the Anderson & Luco model is suggested that considers Mmax of each individual fault sources as well as its uncertainty.
2. Adjust parameters for the Area Sources remaining in the FS+BG model according to the AS-model; more technically, this means the same IDAS need to have the same activity parameters.
3. For some of the fault slip rates, e.g. some in Turkey, fix the minimum slip rates.

Comments on UHS / Disaggregation results

- Disaggregation: Use finer differentiation for Epsilon, use 1 unit steps.
- Plot ratios of the UHS spectra for different return periods to understand whether this is physically possible

Comments on the Hazard Results (general)

1. Vrancea region: Hazard is too high, shape is not according to the state of knowledge. Approach

by Sokolov (2008) will be implemented for testing.

2. Swabian Alp: Hazard too high from the area source model in relation to adjacent regions, FSBG-model too low. Possibly leave no weight on this there.
3. Eastern Turkey: Hazard seems high and is not including sources from eastern countries such as Iran, Armenia, Georgia. Needs to be included from EMME.
4. South-Eastern Turkey: Pattern is doubtful and not correct as large variations occur. Input from EMME necessary.
5. Pyrenees: The change from the larger hazard values in the Western Pyrenees to the lower values in the Eastern Pyrenees is distinct. Reasons might be found in the geometry of the sources and or the computed activity rates. This may also be a reason of completeness.
6. Western margin of Portugal: Values seem to be to low and not considering correctly the distant sources. Suggestions for changing the tectonic regime were given. Feedback is expected from Vilanova and Fonseca.
7. Albania: Hazard in southern Albania seems very high compared to what the results of the NATO Balkan Project is.

16. September 2012

Final Agenda

Location: Zurich, ETH, Sonneggstrasse 5, D45
Date: 3./4. September 2012
Organizers:
J. Woessner (ETH Zürich, j.woessner@sed.ethz.ch), M. Bolliger (ETH Zürich, m.bolliger@sed.ethz.ch)

Participants: SHARE scientists, External experts

Goals of the meeting:

- Presentation and discussion of the hazard model and results
- Define model adjustments and implementation
- Define schedule to Final Model and Deliverable Output

Summary:

Day 1: The focus is on the Area Source Model and Fault Source - Background-model. We discuss the model, its implementation in OpenQuake, and the mapped hazard results. Shortcomings and possible updates are pointed out.
Day 2:
Morning:
We start with the presentation of Kernel Smoothed Seismicity models and their implementation.
We then discuss site-specific hazard results for the selected regions (Deaggregation and Spectra).

Afternoon:
We first focus on engineering input and feedback and then discuss the final schedule for SHARE.

Day 1: Sept. 3, Morning session

Time	Title	Presenter / Moderator
12:45	Welcome and Workshop Introduction	D. Giardini
13.00	Source Model Overview: Current state and changes to 1st model	J. Wössner
13:20	GMPE overview and Sensitivity	L. Danciu
13:35	OpenQuake Implementation	L. Danciu
14:00	Area Source Model: Quality check and updates Feedback from Regional Experts on the model Implementation	 J. Wössner L. Danciu
14:45	Hazard Results: Area Source Model	L. Danciu / J. Woessner
15:30	Coffee	
16:45	Discussion: Hazard Results and Model	
20:30	Dinner	

Day 2: Sept. 4, Morning session:

Time	Title	Presenter / Moderator
8:30	Recap from Discussion on AS-model	
9:00	FS-BG Model: Quality Checks and Sensitivity Implementation	J. Wössner
9:45	Hazard Results: FSBG-Model	L. Danciu
10:00	Coffee	
10:30	Detailed hazard results for selected cities UHS and Deaggregation	L. Danciu
11:00	WP2 needs	H. Crowley
11:30	Discussion: Towards the Final Model	D. Giardini
12:40	Lunch	

Day 2: Sept. 4, Afternoon session:

Time	Title	Moderator
14:00	Smoothed Seismicity Model Branch: Overview Stochastic Earthquake Forecast Model Hybrid Smoothed Seismicity Model	J. Woessner G. Grünthal
15.00	Model dissemination (Prel. Poster)	J. Wössner
15:15	Coffee	
16:00	Adjourn	

SHARE

Area Source Model Feedback from NORSAR

for

Scandinavia and surrounding areas

by

Louise W. Bjerrum, Hilmar Bungum and Conrad Lindholm

NORSAR, POB 53, N-2027 Kjeller

August 7, 2012

Updated October 3, 2012

Introduction

This document is provided in response to the SHARE delivery of preliminary area source (AS) delivery from the project manager on 24 July 2012, consisting of recurrence computations with underlying files and documentation.

This feedback consists of a combination of comments and specific recommendations for changes. We kindly request that you use the a- and b-values indicated in Table 2 for the final hazard computation.

In September 2012 we received an updated model (v5) and we have now amended this document to give feedback on this model as well. The original document is kept unchanged (in black) and the new comments are all in red.

General comments

The completeness of the documentation provided is much appreciated and has made it possible to review the results in an efficient way. We would like to start with a few general comments:

We are not sure exactly which parameters which have been used in the AtticIvy (ML) computations, in particular with respect to the priors and their weights. The default rules used (in the program) for zones with few or no earthquakes could also have been spelled out more clearly since these affect several zones in the north.

The b-values are generally varying between 0.8 and 1.2, which is a larger variation than what some people who subscribe to regional b-value stability often are willing to accept. The b-value variability is of course depends on the b-priors and their weights.

Since the completeness model for northern Europe is common for a large super-zone we assume that many of the problems that we have seen with specific zones could have been corrected by introducing zone-specific completeness models. The problems with this are that this would have created a lot of follow-up work, it could have created regional inconsistencies, and not the least, it would not be possible for us to know the effects of the recommended changes until the next feedback. So instead of suggesting changes to the completeness model we have chosen to work with the given super-zone model and rather recommend specific changes to the regressional a- and b-values, properly justified in each case.

Some of the completeness plots for individual zones seem to be missing some of the newest events. There may be comments on this also under individual zones. We suggest using the same x-axis (timespan) on all completeness plots. Data in the completeness plots seem to be missing in the catalogue and vice versa, i.e. the plots are not always reliable and/or understandable.

Specific events in the catalogue

In the following we provide comments on specific events where the present review has revealed particular problems with the underlying SHARE/SHEEC v3.2 catalogue, which used an updated FENCAT catalogue (Uski et al., 1992) for Fennoscandia. We refer also to the earlier SHARE report by Bungum et al. (2010) which updated locations and magnitudes for some important historical earthquakes in Fennoscandia, already accepted and included. We regret that that report was not complete in the sense that we in the present review have found even more events that needed to be updated (we just assumed that FENCAT/SHEEC was better updated), but we think that it is still important to report on these, justified in each particular case, usually by reference to publications. We have, however, limited our comments to cases which are hazard significant. The specific events are covered in Table 1.

Table 1: Specific events in the SHEEC v.3.2 catalogue for which we have comments.

Event	Zone	Comment	Reference
1834 3/9; Mw 5.0	NOAS054	This magnitude refers back to the seminal re-evaluation work by Muir Wood and Woo (1987) and as such has to be used and accepted. We note, however, that this is a single large event in a region where similar magnitudes are never reported.	Muir Wood and Woo (1987) but not re-evaluated later.
1953 6/3; Mw 4.4	NOAS057	This event is important since it is the largest one in the Oslo region since the large M_S 5.4 earthquake in 1904 (Bungum et al., 2009). We don't know where the Mw 3.6 comes from in the SHEEC catalogue, but Muir Wood and Woo (1987) had M_S 4.0, later re-evaluated to 4.4 by NORSAR and GRØNER AS (1996).	Re-assessed to M_S 4.4 by NORSAR and GRØNER AS (1996).
1986 5/2; Mw 4.7	NOAS049	This event is noted with Mw 4.3 in the SHEEC catalogue. The event is well studied and should have Mw 4.7 according to Hansen et al. (1989).	Hansen et al. (1989)
1988 8/8; Mw 5.3	NOAS049	This important earthquake in the Møre Basin event is noted with Mw 4.5 in the SHEEC catalogue. The event should have Mw 5.3 according to Hansen et al. (1989).	Hansen et al. (1989)
2004 21/9; Mw 5.0 and 5.2	LVAS035	These are the two important Kaliningrad events where our position is that both should both be used in the regression, thereby invoking an exception to the declustering procedure in this	Gregersen et al. (2007)

		case. Please also use the magnitudes reported by Gregersen et al. (2007).	
2008 16/12; Mw 4.6	SEAS030	This event should be kept in mind for this work, although the timespan for the catalogue ends in 2006. This event is important when considering the seismic hazard in the region.	Voss et al. (2009)

We notice that the proposed corrections to the catalogue are still not implemented in the ASmodelv5 of September 2012. Some of these changes are significant, affecting larger and regionally important earthquakes.

Specific comments on individual zones

See Table 2 in the end of the section for a complete list of the new a- and b-values.

Zones with plots

NOAS039: Northern Viking Graben. This is an aborted rift zone which in the context of Stable Continental Regions (Johnston et al., 1994) is a type of geology which is particularly prone to large earthquakes. The graben is well defined both in terms of crustal thickness variations and microseismicity, and for this reason a return period of 1270 for Mw 5.5 events is considered much too long. Inspecting the regression plot, we have therefore moved the line to the right by changing the b-value to 1 (from 1.005) and the a-value to a + 0.3 = 2.7255, which results in a doubling of the activity and a reduction by a factor of two of the return period for Mw 5.5, to 600 years.

The new regression from September 2012 is only slightly different from the July one and we suggest to maintain the correction proposed on August 7.

NOAS041: Vøring Shelf (Trøndelag Platform). This is essentially an aseismic area (Byrkjeland et al., 2000), and the return period seems ok (presumably determined by the default rules for aseismic zones).

We suggest to use the new regression, which gives a return period for Mw 5.5 of about 4000 years.

NOAS042: Vøring Basin. The b-value is low in this case (0.799), but the resulting return period still seems ok.

In the new regression the b-value is even lower than in the regressions from July (0.684 vs. 0.799). We suggest therefore to keep the earlier (July) values for a and b.

NOAS043: Lofoten Islands. This also seems ok.

We suggest to use the a- and b-values from the new regression.

NOAS045: Lofoten Basin. This region is special since it is a highly active region in oceanic crust (discussed in detail by Byrkjeland et al., 2000). The b-value is a bit high (1.186) but the return period seems reasonable.

The b-value is lowered slightly in the new regression. We suggest that this will be used.

NOAS048: Barents Sea Margin. This zone which also includes the Senja Fracture Zone is also quite active, but in the completeness plot there is a Mw 5.8 event around 1915 which we do not find in the catalogue. This should be checked.

We suggest to use the new regression also here, with a return period of about 900 years for a Mw 5.5 event.

NOAS049: Møre Margin. In this zone two events are given with incorrect magnitude. This is the 08 August 1988 event, which should have Mw 5.3 (given Mw 4.5) and the 05 February 1986, which should have Mw 4.7 (given Mw 4.3) (Hansen et al., 1989). This will change the regression. We do not suggest changing a- and b-values manually, but rather use new values from a new regression.

This active zone clearly suffers from the magnitude errors documented on August 7. Given that this will not be corrected we need to change the a- and b-values to increase the activity of the zone. The new regression yields a- and b-values of 2.4119 and 0.896, respectively, corresponding to return periods of 330 years and 15 years for Mw 5.5 and Mw 4.0. We suggest to change the a-value = a + 0.3, giving a return period of Mw 5.5 of 165 years.

NOAS051: Rogaland. An active zone, seems ok.

We suggest using the new a- and b-values here.

NOAS053: Hordaland. Also an active zone, and the results are consistent with our understanding of the area. There are three Mw~5.2 events over a 100 year period (1886; 1955; 1989) which is consistent with the suggested return periods of 250 years and 4 years for events of Mw 5.5 and 4.0, respectively.

We suggest using the new a- and b-values here.

NOAS054: Telemark. Seems ok. The magnitude of the Mw 5.0, 3 September 1834 event in this area (see Table 1) is reported by both Kijko and Sellevoll (1990) and Muir Wood et al. (1988) as M 5.1 and 5.0, respectively. Like noted in Table 1 this is a one-of-a-kind event in this part of the country, but it is well covered by historical reports in the Scandinavian Earthquake Archive (SEA).

We suggest using the new a- and b-values here.

NOAS055: Skagerak. An active zone; seems ok.

We suggest using the new a- and b-values here.

NOAS057: Oslo Graben. Like for the Viking Graben (zone NOAS039) this is an aborted rift zone, with recognized earthquake potentials, and in this case we had a large earthquake here in 1904, with M_W 5.4 (Bungum et al., 2009, see also Bungum and Fyen, 1979). The 06 Mar 1953 event is reported in the catalogue with an incorrect magnitude (Mw 3.6) and this should be changed to Mw 4.4 (see also Table 1), which will change the regression. We suggest to set the b-value to 1 (from 0.943) and change the a-value to a + 0.9 = 2.5887. This will change the return period for Mw 5.5 events from 3150 years to 815 years (the return period for Mw 4.0 events is then 26 years). This is consistent with the microseismicity of the area and moreover gives the 1904 M_W 5.4 earthquake a return period of about 800 years.

The 1953 event has not been changed in the catalogue. We suggest to use the new regression but with a correction to the a-value = a + 0.45, giving a return period of 830 years for a Mw 5.5 event.

NOAS058: Møre and Romsdal, Trøndelag and Nordland. This is an active zone which includes the largest historical earthquake in Scandinavia, M_W 5.8 in 1819. Seems ok.

We suggest using the new regression here.

NOAS078: This zone should be wider in order to include the entire mid-oceanic ridge. With the current zonation many events falls in NOAS079, giving that zone a higher activity than it should have, and the activity of NOAS078 becomes too low. We suggest reconsidering the zone boundary between the two zones, and therefore redoing the regression analysis for this area and for NOAS079.

We suggest using the new regression here.

NOAS079: As stated above the zone has a wrong geometry and includes many of the events which occur on the mid-oceanic ridge. Therefore, the calculated recurrence period of 40 years for Mw 5.5 events will not be correct. We suggest reconsidering the zone boundary between the two zones, and therefore redoing the regression analysis for this area, like for NOAS078.

This zone should be less active, and the high activity comes up due to a cluster of events close to the zone GLAS079, which should be considered to be broadened in order to remove the seismicity from this zone. If the zonation is not changed we suggest to manually change the a-value to a – 0.9 = 3.4668, yielding a Mw 5.5 return time to about 300 years.

SEAS028: Northern Sweden and Finland. The earthquake activity reported in the catalogue for events with Mw ≥ 4.0, suggests a higher activity rate. The regression curve should therefore be moved, and we suggest to change the a-value to a + 0.3 = 2.7055, which gives return periods of 620 years and 20 year for Mw 5.5 and 4.0, respectively.

For reasons given earlier we suggest to use the new regression but with corrections to the a-value = a + 0.3 and the b-value = 1. This gives a return period of 630 years for Mw 5.5.

SEAS030: Kattegat and Southern Sweden. This is the region of the important M 5.6 1759 earthquake (Muir Wood, 1989), which is not seen in the completeness plot. Also, since the earthquake catalogue runs only to 2006, the Mw 4.6 16 Dec 2008 event (Voss et al., 2009) is not included. Also, as recent as on 06 Aug 2012 there was another event here, with m_b 4.4 (EMSC and USGS)! We are aware that these events cannot be included in the catalogue due to the chosen timespan, but the events should anyhow be kept in mind when evaluating the a- and b-values. We suggest to set the b-value to 1 (from 0.9) and change the a-value to a + 0.9 = 2.4039, resulting in return periods of 1250 years and 40 years for Mw 5.5 and 4.0 events, respectively (from 2790 years for Mw 5.5). These values are in better agreement with the geology (large variations in crustal thickness) and with both historical seismicity and the microseismicity of the area.

We suggest using the new regression with corrections to the a-value = a + 0.6 and b-value = 1. This gives a return period of 1200 years for Mw 5.5 events.

SEAS033: Central Sweden. The return period for this region also seems a bit long. However, with our limited knowledge of the area we cannot justify alternative values here.

We cannot judge if one regression is better than the other in this case.

RUAS025: Northern Norway, Finland and Russia. In the completeness diagram there is noted an earthquake of Mw 5.8 around 1925. This event is not used in the regression, which is based on only three events: 1990 Mw 4.4; 1991 Mw 3.3 and 2001 Mw 4.4. Several other events in this region also do not seem to be included. We suggest a recalculation of the regression of this area, including the missing events.

Again we hope that this can be corrected. However, the new regression yields shorter return periods, and we therefore suggest to use these, if there is not done new regressions based on a catalogue including the mentioned events.

FIAS026: Central Finland. The event cluster in the north-eastern corner of this zone is likely to include induced tectonic events from the mining activity in Kola, which presumably should not be contributing to the seismic hazard. To resolve this would take more time, however, but could be done by contacting Institute of Seismology in Helsinki.

We suggest using the new a- and b-values here.

FIAS032: Southern Finland. The area is large, and the return period appears to be on the high side. However, we do not have enough knowledge about this area to evaluate this further.

We suggest using the new a- and b-values here.

LVAS024: Estonia and Latvia. We do not possess enough knowledge about the geology and seismicity of this area to justify if the a- and b-values are reasonable values or not.

We cannot judge if one regression is better than the other in this case.

LVAS035: *C*oastal Baltic. The two Kaliningrad events (21 September 2004) are in the catalogue set to only include the second of these events in the regression. This is due to the current declustering analysis, where they fall too close in time and space. Although these earthquakes clearly are dependent on one another, we think that there in this case should be made an exception from the general declustering rule, since these events should not been seen as fore- and after-shocks but more as two main events. Furthermore, the magnitudes given for these two event in the catalogue (Mw 4.6 and 4.7) are not correct and should be changed to Mw 5.0 and 5.2 for the first and the second event, respectively (Gregersen et al., 2007).

We still hope that the magnitudes of the mentioned events can be changed, as well as including the two 2004 Kaliningrad events as sister events.

BYAS036: Poland-Belarus. We do not possess enough knowledge about the geology and seismicity of this area to justify if this is a reasonable value or not.

We cannot judge if one regression is better than the other in this case.

DKAS031*:* Jutland. We do not possess enough knowledge about the geology and seismicity of this area to justify if this is a reasonable value or not.

We cannot judge if one regression is better than the other in this case.

Zones without plots

NOAS027: Finmark. The activity here seems too low with return periods calculated to 12470 for Mw 5.5 events. We change the a-value to a + 0.6 = 2.0042. The return periods are then changed to 3100 years and 100 years for Mw 5.5 and 4.0 events, respectively. This is more consistent with the events reported by Bungum and Lindholm (1996). Most of the important post-glacial Masi fault zone (where microseismicity has been documented) is not included in this zone, but is located in SEAS028.

NOAS040: North of Finmark. The region borders to the coast (zone NOAS027) where there are some small earthquakes. Seems ok.

NOAS046: Large aseismic zone with two small events in one corner. Seems ok.

NOAS047: This is a narrow aseismic zone, but surrounded by higher activity (NOAS043 and NOAS045). Even so, the calculated return period of approximately 28,000 years seems to be on the high side.

NOAS050: Also an aseismic zone and therefore determined by the special rules for such zones.

NOAS056: Horda Platform, known to be essentially aseismic (Bungum et al., 1991); geologically comparable to the Trøndelag Platform (NOAS041).

We suggest to use the new regression with a correction to the a-value = a – 0.3, yielding return periods of 4600 years for a Mw 5.5 event, which is more comparable with NOAS041.

SEAS023: Two events (including M_W 5.1 from 1540), otherwise aseismic. Seems ok.

SEAS029: Two relatively large (M_W 4.5) events, otherwise aseismic. We do not, however, have any additional information here that could help us to evaluate this zone.

SEAS034: Vänern region, with well documented seismicity. The calculated return period of 10500 years for Mw 5.5 events seems very large, especially compared to the seismic activity in the catalogue (see Table 3 for an extract, only covering this area). There are 14 events in the catalogue with 3.5 < M < 4.5 between 1697 and 1986, which suggest a higher activity. The a-value is therefore changed to a + 0.9 = 2.3086, which gives return periods of 1320 years and 42 years for events of Mw 5.5 and 4.0, respectively.

DKAS022: Southern Denmark. This is also an aseismic zone where presumably the return period is determined by the default rules (resulting in 15000 years for Mw 5.5).

*Table 2. The corrected a- and b-values for all the zones. The zones marked with * are those where a- and possible also b-values values have been changed.*

IDAS	EVENTS	A	B
NOAS027 *	0	2.0042	1
NOAS039 *	3	2.7255	1
NOAS040	0	1.7094	1
NOAS041	1	1.9284	1
NOAS042	10	2.0753	0.799
NOAS043	13	3.6863	1.153
NOAS045	12	4.8638	1.186
NOAS046	0	1.8479	1
NOAS047	0	1.0534	1
NOAS048	3	2.4055	1
NOAS049	8	2.8315	1
NOAS050	0	1.2933	1
NOAS051	15	4.0164	1.217
NOAS053	25	4.0463	1.171
NOAS054	3	2.5958	1.045
NOAS055	9	3.6353	1.179
NOAS056	0	1.3236	1
NOAS057 *	1	2.5887	1

IDAS	Events	A	B
NOAS058	12	3.4456	1.104
NOAS078	49	5.2988	1.148
NOAS079	11	4.2930	1
SEAS023	0	1.8647	1
SEAS028 *	3	2.7055	1
SEAS029	0	1.5524	1
SEAS030 *	1	2.4039	1
SEAS033	1	1.9284	1
SEAS034 *	0	2.3806	1
SEAS038	0	2.0279	1
RUAS025	3	2.4055	1
FIAS026	6	3.0472	1.081
FIAS032	1	1.9284	1
LVAS024	5	2.3996	0.946
LVAS035	4	2.3403	0.955
BYAS036	3	2.4255	1.005
DKAS022	0	1.323	1
DKAS031	1	1.9284	1

Table 3. List of earthquake in the catalogue for the zone SEAS034 (Vänern).

Mw	Year
4.46	1697
3.8	1708
3.8	1798
3.8	1896
3.7	1901
4	1907
3.6	1908

Mw	Year
3.7	1920
3.8	1922
3.8	1929
3.6	1933
3.6	1973
3.8	1986
3.5	1986

*Table 4. Updated values for the zones after the new regressions from September 2012. Fields marked with "?" indicate that we do not feel comfortable choosing between the two regressions. The zones marked with * are those where a- and possible also b-values values have been changed from the regression (either the one from July or September 2012).*

IDAS	A	B
NOAS027*	2.0042	1
NOAS039*	2.4154	0.942
NOAS040	1.7094	1
NOAS041*	1.7863	0.98
NOAS042	2.0753	0.799
NOAS043	2.4827	0.857
NOAS045	4.6149	1.121
NOAS046	1.8479	1
NOAS047	1.0534	1
NOAS048*	2.8573	1.056
NOAS049*	2.7119	0.896
NOAS050	1.2933	1
NOAS051	2.7886	0.915
NOAS053	3.2464	0.986
NOAS054	2.1055	0.955
NOAS055	2.5891	0.919
NOAS056	1.8318	1
NOAS057*	2.6925	1.02

IDAS	A	B
NOAS058	3.047	1.023
NOAS078	4.9443	1.073
NOAS079*	3.1668	1.024
SEAS023	1.8647	1
SEAS028*	2.6992	1
SEAS029	1.5524	1
SEAS030*	2.4078	1
SEAS033	?	?
SEAS034*	2.3806	1
SEAS038	2.1318	1
RUAS025	2.4339	1
FIAS026	2.6433	0.969
FIAS032	2.8203	1.092
LVAS024	?	?
LVAS035	1.7457	0.833
BYAS036	?	?
DKAS022	1.323	1
DKAS031	1.8863	0.98

Closing comments

With regard to the SHEEC catalogue we have observed that several events are reported with a magnitude different from published values. Often the magnitudes given are too low, and needs to be corrected. Also, for some cases events are missing from the catalogue. Due to the sheer size of the catalogues and the large geographical area, we have most likely not found everything. This is especially relevant for areas outside the Norwegian territory.

From the present review of the SHARE AS delivery we also find that there are several shortcomings in the completeness analysis. It is problematic that not all completeness analyses have been shown, and also that the timespan for the different completeness analyses seems inconsistent. Also, some events appear with correct magnitude on the completeness plots, but still do not seem to be used in the regression for the a- and b-values, and vice versa.

In areas where we have found that the a- and b-values in the SHARE AS delivery are not sufficiently well supported, we have adjusted the a- and b-values accordingly (see Table 2). The new values are supported by previous studies and by our understanding of the seismotectonics of the area, and the new values are therefore better justified. We expect therefore that the values for the zones marked with an * in Table 2 will be used in the further analysis, which also should include another feedback phase.

In some areas we have suggested to include new events and/or update event magnitudes, but we emphasize that this has only been done in cases of important (hazard significant) events. Only in one case, on the mid-Atlantic ridge, have we suggested to change the zone boundaries, affecting two zones. We are aware of the required workload with redoing the regression for these zones, but since we have asked for this only in important cases we hope that it can still be done.

We emphasize again that important (and documented) errors in the catalogue should be corrected when discovered, so that such errors are not propagated into present and future studies based on the catalogue. This is not in conflict with publishing the catalogue, which refers to the version of the catalogue at a particular date.

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SHARE

Area Source Model Feedback from NORSAR

for

Scandinavia and surrounding areas

by

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August 7, 2012

Introduction

This document is provided in response to the SHARE delivery of preliminary area source (AS) delivery from the project manager on 24 July 2012, consisting of recurrence computations with underlying files and documentation.

This feedback consists of a combination of comments and specific recommendations for changes. We kindly request that you use the a- and b-values indicated in Table 2 for the final hazard computation.

General comments

The completeness of the documentation provided is much appreciated and has made it possible to review the results in an efficient way. We would like to start with a few general comments:

We are not sure exactly which parameters which have been used in the AtticIvy (ML) computations, in particular with respect to the priors and their weights. The default rules used (in the program) for zones with few or no earthquakes could also have been spelled out more clearly since these affect several zones in the north.

The b-values are generally varying between 0.8 and 1.2, which is a larger variation than what some people who subscribe to regional b-value stability often are willing to accept. The b-value variability is of course depends on the b-priors and their weights.

Since the completeness model for northern Europe is common for a large super-zone we assume that many of the problems that we have seen with specific zones could have been corrected by introducing zone-specific completeness models. The problems with this are that this would have created a lot of follow-up work, it could have created regional inconsistencies, and not the least, it would not be possible for us to know the effects of the recommended changes until the next feedback. So instead of suggesting changes to the completeness model we have chosen to work with the given super-zone model and rather recommend specific changes to the regressional a- and b-values, properly justified in each case.

Some of the completeness plots for individual zones seem to be missing some of the newest events. There may be comments on this also under individual zones. We suggest using the same x-axis (timespan) on all completeness plots. Data in the completeness plots seem to be missing in the catalogue and vice versa, i.e. the plots are not always reliable and/or understandable.

Specific events in the catalogue

In the following we provide comments on specific events where the present review has revealed particular problems with the underlying SHARE/SHEEC v3.2 catalogue, which used an updated FENCAT catalogue (Uski et al., 1992) for Fennoscandia. We refer also to the earlier SHARE report by Bungum et al. (2010) which updated locations and magnitudes for some important historical earthquakes in Fennoscandia, already accepted and included. We regret that that report was not complete in the sense that we in the present review have found even more events that needed to be updated (we just assumed that FENCAT/SHEEC was better updated), but we think that it is still important to report on these, justified in each particular case, usually by reference to publications. We have, however, limited our comments to cases which are hazard significant. The specific events are covered in Table 1.

Table 1: Specific events in the SHEEC v.3.2 catalogue for which we have comments.

Event	Zone	Comment	Reference
1834 3/9; Mw 5.0	NOAS054	This magnitude refers back to the seminal re-evaluation work by Muir Wood and Woo (1987) and as such has to be used and accepted. We note, however, that this is a single large event in a region where similar magnitudes are never reported.	Muir Wood and Woo (1987) but not re-evaluated later.
1953 6/3; Mw 4.4	NOAS057	This event is important since it is the largest one in the Oslo region since the large M_S 5.4 earthquake in 1904 (Bungum et al., 2009). We don't know where the Mw 3.6 comes from in the SHEEC catalogue, but Muir Wood and Woo (1987) had M_S 4.0, later re-evaluated to 4.4 by NORSAR and GRØNER AS (1996).	Re-assessed to M_S 4.4 by NORSAR and GRØNER AS (1996).
1986 5/2; Mw 4.7	NOAS049	This event is noted with Mw 4.3 in the SHEEC catalogue. The event is well studied and should have Mw 4.7 according to Hansen et al. (1989).	Hansen et al. (1989)
1988 8/8; Mw 5.3	NOAS049	This important earthquake in the Møre Basin event is noted with Mw 4.5 in the SHEEC catalogue. The event should have Mw 5.3 according to Hansen et al. (1989).	Hansen et al. (1989)
2004 21/9; Mw 5.0 and 5.2	LVAS035	These are the two important Kaliningrad events where our position is that both should both be used in the regression, thereby invoking an exception to the declustering procedure in this case. Please also use the magnitudes reported by Gregersen et al. (2007).	Gregersen et al. (2007)
2008 16/12; Mw 4.6	SEAS030	This event should be kept in mind for this work, although the timespan for the catalogue ends in 2006. This event is important when considering the seismic hazard in the region.	Voss et al. (2009)

Specific comments on individual zones

See Table 2 in the end of the section for a complete list of the new a- and b-values.

Zones with plots

NOAS039: Northern Viking Graben. This is an aborted rift zone which in the context of Stable Continental Regions (Johnston et al., 1994) is a type of geology which is particularly prone to large earthquakes. The graben is well defined both in terms of crustal thickness variations and microseismicity, and for this reason a return period of 1270 for Mw 5.5 events is considered much too long. Inspecting the regression plot, we have therefore moved the line to the right by changing the b-value to 1 (from 1.005) and the a-value to a + 0.3 = 2.7255, which results in a doubling of the activity and a reduction by a factor of two of the return period for Mw 5.5, to 600 years.

NOAS041: Vøring Shelf (Trøndelag Platform). This is essentially an aseismic area (Byrkjeland et al., 2000), and the return period seems ok (presumably determined by the default rules for aseismic zones).

NOAS042: Vøring Basin. The b-value is low in this case (0.799), but the resulting return period still seems ok.

NOAS043: Lofoten Islands. This also seems ok.

NOAS045: Lofoten Basin. This region is special since it is a highly active region in oceanic crust (discussed in detail by Byrkjeland et al., 2000). The b-value is a bit high (1.186) but the return period seems reasonable.

NOAS048: Barents Sea Margin. This zone which also includes the Senja Fracture Zone is also quite active, but in the completeness plot there is a Mw 5.8 event around 1915 which we do not find in the catalogue. This should be checked.

NOAS049: Møre Margin. In this zone two events are given with incorrect magnitude. This is the 08 August 1988 event, which should have Mw 5.3 (given Mw 4.5) and the 05 February 1986, which should have Mw 4.7 (given Mw 4.3) (Hansen et al., 1989). This will change the regression. We do not suggest changing a- and b-values manually, but rather use new values from a new regression.

NOAS051: Rogaland. An active zone, seems ok.

NOAS053: Hordaland. Also an active zone, and the results are consistent with our understanding of the area. There are three Mw~5.2 events over a 100 year period (1886; 1955; 1989) which is consistent with the suggested return periods of 250 years and 4 years for events of Mw 5.5 and 4.0, respectively.

NOAS054: Telemark. Seems ok. The magnitude of the Mw 5.0, 3 September 1834 event in this area (see Table 1) is reported by both Kijko and Sellevoll (1990) and Muir Wood et al. (1988) as M 5.1 and 5.0, respectively. Like noted in Table 1 this is a one-of-a-kind event in this part of the country, but it is well covered by historical reports in the Scandinavian Earthquake Archive (SEA).

NOAS055: Skagerak. An active zone; seems ok.

NOAS057: Oslo Graben. Like for the Viking Graben (zone NOAS039) this is an aborted rift zone, with recognized earthquake potentials, and in this case we had a large earthquake here in 1904, with M_W 5.4 (Bungum et al., 2009, see also Bungum and Fyen, 1979). The 06 Mar 1953 event is reported in the catalogue with an incorrect magnitude (Mw 3.6) and this should be changed to Mw 4.4 (see also Table 1), which will change the regression. We suggest to set the b-value to 1 (from 0.943) and change the a-value to a + 0.9 = 2.5887. This will change the return period for Mw 5.5 events from 3150 years to 815 years (the return period for Mw 4.0 events is then 26 years). This is consistent with the microseismicity of the area and moreover gives the 1904 M_W 5.4 earthquake a return period of about 800 years.

NOAS058: Møre and Romsdal, Trøndelag and Nordland. This is an active zone which includes the largest historical earthquake in Scandinavia, M_W 5.8 in 1819. Seems ok.

NOAS078: This zone should be wider in order to include the entire mid-oceanic ridge. With the current zonation many events falls in NOAS079, giving that zone a higher activity than it should have, and the activity of NOAS078 becomes too low. We suggest reconsidering the zone boundary between the two zones, and therefore redoing the regression analysis for this area and for NOAS079.

NOAS079: As stated above the zone has a wrong geometry and includes many of the events which occur on the mid-oceanic ridge. Therefore, the calculated recurrence period of 40 years for Mw 5.5 events will not be correct. We suggest reconsidering the zone boundary between the two zones, and therefore redoing the regression analysis for this area, like for NOAS078.

SEAS028: Northern Sweden and Finland. The earthquake activity reported in the catalogue for events with Mw ≥ 4.0, suggests a higher activity rate. The regression curve should therefore be moved, and we suggest to change the a-value to a + 0.3 = 2.7055, which gives return periods of 620 years and 20 year for Mw 5.5 and 4.0, respectively.

SEAS030: Kattegat and Southern Sweden. This is the region of the important M 5.6 1759 earthquake (Muir Wood, 1989), which is not seen in the completeness plot. Also, since the earthquake catalogue runs only to 2006, the Mw 4.6 16 Dec 2008 event (Voss et al., 2009) is not included. Also, as recent as on 06 Aug 2012 there was another event here, with m_b 4.4 (EMSC and USGS)! We are aware that these events cannot be included in the catalogue due to the chosen timespan, but the events should anyhow be kept in mind when evaluating the a- and b-values. We suggest to set the b-value to 1 (from 0.9) and change the a-value to a + 0.9 = 2.4039, resulting in return periods of 1250 years and 40 years for Mw 5.5 and 4.0 events, respectively (from 2790 years for Mw 5.5). These values are in better agreement with the geology (large variations in crustal thickness) and with both historical seismicity and the microseismicity of the area.

SEAS033: Central Sweden. The return period for this region also seems a bit long. However, with our limited knowledge of the area we cannot justify alternative values here.

RUAS025: Northern Norway, Finland and Russia. In the completeness diagram there is noted an earthquake of Mw 5.8 around 1925. This event is not used in the regression, which is based on only three events: 1990 Mw 4.4; 1991 Mw 3.3 and 2001 Mw 4.4. Several other events in this region also do not seem to be included. We suggest a recalculation of the regression of this area, including the missing events.

FIAS026: Central Finland. The event cluster in the north-eastern corner of this zone is likely to include induced tectonic events from the mining activity in Kola, which presumably should not be contributing to the seismic hazard. To resolve this would take more time, however, but could be done by contacting Institute of Seismology in Helsinki.

FIAS032: Southern Finland. The area is large, and the return period appears to be on the high side. However, we do not have enough knowledge about this area to evaluate this further.

LVAS024: Estonia and Latvia. We do not possess enough knowledge about the geology and seismicity of this area to justify if the a- and b-values are reasonable values or not.

LVAS035: *C*oastal Baltic. The two Kaliningrad events (21 September 2004) are in the catalogue set to only include the second of these events in the regression. This is due to the current declustering analysis, where they fall too close in time and space. Although these earthquakes clearly are dependent on one another, we think that there in this case should be made an exception from the general declustering rule, since these events should not been seen as fore- and after-shocks but more as two main events. Furthermore, the magnitudes given for these two event in the catalogue (Mw 4.6 and 4.7) are not correct and should be changed to Mw 5.0 and 5.2 for the first and the second event, respectively (Gregersen et al., 2007).

BYAS036: Poland-Belarus. We do not possess enough knowledge about the geology and seismicity of this area to justify if this is a reasonable value or not.

DKAS031*:* Jutland. We do not possess enough knowledge about the geology and seismicity of this area to justify if this is a reasonable value or not.

Zones without plots

NOAS027: Finmark. The activity here seems too low with return periods calculated to 12470 for Mw 5.5 events. We change the a-value to a + 0.6 = 2.0042. The return periods are then changed to 3100 years and 100 years for Mw 5.5 and 4.0 events, respectively. This is more consistent with the events reported by Bungum and Lindholm (1996). Most of the important post-glacial Masi fault zone (where microseismicity has been documented) is not included in this zone, but is located in SEAS028.

NOAS040: North of Finmark. The region borders to the coast (zone NOAS027) where there are some small earthquakes. Seems ok.

NOAS046: Large aseismic zone with two small events in one corner. Seems ok.

NOAS047: This is a narrow aseismic zone, but surrounded by higher activity (NOAS043 and NOAS045). Even so, the calculated return period of approximately 28,000 years seems to be on the high side.

NOAS050: Also an aseismic zone and therefore determined by the special rules for such zones.

NOAS056: Horda Platform, known to be essentially aseismic (Bungum et al., 1991); geologically comparable to the Trøndelag Platform (NOAS041).

SEAS023: Two events (including M_W 5.1 from 1540), otherwise aseismic. Seems ok.

SEAS029: Two relatively large (M_W 4.5) events, otherwise aseismic. We do not, however, have any additional information here that could help us to evaluate this zone.

SEAS034: Vänern region, with well documented seismicity. The calculated return period of 10500 years for Mw 5.5 events seems very large, especially compared to the seismic activity in the catalogue (see Table 3 for an extract, only covering this area). There are 14 events in the catalogue with $3.5 < M < 4.5$ between 1697 and 1986, which suggest a higher activity. The a-value is therefore changed to $a + 0.9 = 2.3086$, which gives return periods of 1320 years and 42 years for events of Mw 5.5 and 4.0, respectively.

DKAS022: Southern Denmark. This is also an aseismic zone where presumably the return period is determined by the default rules (resulting in 15000 years for Mw 5.5).

*Table 2. The corrected a- and b-values for all the zones. The zones marked with * are those where a- and possible also b-values values have been changed.*

IDAS	EVENTS	A	B
NOAS027 *	0	2.0042	1
NOAS039 *	3	2.7255	1
NOAS040	0	1.7094	1
NOAS041	1	1.9284	1
NOAS042	10	2.0753	0.799
NOAS043	13	3.6863	1.153
NOAS045	12	4.8638	1.186
NOAS046	0	1.8479	1
NOAS047	0	1.0534	1
NOAS048	3	2.4055	1
NOAS049	8	2.8315	1
NOAS050	0	1.2933	1
NOAS051	15	4.0164	1.217
NOAS053	25	4.0463	1.171
NOAS054	3	2.5958	1.045
NOAS055	9	3.6353	1.179
NOAS056	0	1.3236	1
NOAS057 *	1	2.5887	1

IDAS	Events	A	B
NOAS058	12	3.4456	1.104
NOAS078	49	5.2988	1.148
NOAS079	11	4.2930	1
SEAS023	0	1.8647	1
SEAS028 *	3	2.7055	1
SEAS029	0	1.5524	1
SEAS030 *	1	2.4039	1
SEAS033	1	1.9284	1
SEAS034 *	0	2.3806	1
SEAS038	0	2.0279	1
RUAS025	3	2.4055	1
FIAS026	6	3.0472	1.081
FIAS032	1	1.9284	1
LVAS024	5	2.3996	0.946
LVAS035	4	2.3403	0.955
BYAS036	3	2.4255	1.005
DKAS022	0	1.323	1
DKAS031	1	1.9284	1

Table 3. List of earthquake in the catalogue for the zone SEAS034 (Vänern).

Mw	Year
4.46	1697
3.8	1708
3.8	1798
3.8	1896
3.7	1901
4	1907
3.6	1908

Mw	Year
3.7	1920
3.8	1922
3.8	1929
3.6	1933
3.6	1973
3.8	1986
3.5	1986

Closing comments

With regard to the SHEEC catalogue we have observed that several events are reported with a magnitude different from published values. Often the magnitudes given are too low, and needs to be corrected. Also, for some cases events are missing from the catalogue. Due to the sheer size of the catalogues and the large geographical area, we have most likely not found everything. This is especially relevant for areas outside the Norwegian territory.

From the present review of the SHARE AS delivery we also find that there are several shortcomings in the completeness analysis. It is problematic that not all completeness analyses have been shown, and also that the timespan for the different completeness analyses seems inconsistent. Also, some events appear with correct magnitude on the completeness plots, but still do not seem to be used in the regression for the a- and b-values, and vice versa.

In areas where we have found that the a- and b-values in the SHARE AS delivery are not sufficiently well supported, we have adjusted the a- and b-values accordingly (see Table 2). The new values are supported by previous studies and by our understanding of the seismotectonics of the area, and the new values are therefore better justified. We expect therefore that the values for the zones marked with an * in Table 2 will be used in the further analysis, which also should include another feedback phase.

In some areas we have suggested to include new events and/or update event magnitudes, but we emphasize that this has only been done in cases of important (hazard significant) events. Only in one case, on the mid-Atlantic ridge, have we suggested to change the zone boundaries, affecting two zones. We are aware of the required workload with redoing the regression for these zones, but since we have asked for this only in important cases we hope that it can still be done.

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ASZ- Feedback for Iberia
Key aspects, obvious errors and misfits

Susana P. Vilanova, September 5, 2012

Summary & Recommendations:

I performed few analyses using the declustered version of the SHEEC catalogue for the completeness zones OFFP and IBER. I concluded that the completeness periods were probably switched between both zones for the lower magnitude thresholds used (M4.0-4.1 and M4.5-4.6), possibly due to a compilation error. For instance, while my completeness analyses for magnitudes M>=4.1 for IBER led to a starting year around 1910, 1907 is the value used by SHARE for M>=4.0, but for region OFFP (for region IBER is the values used by SHARE is 1950).

This error has dramatic implications for most of the offshore sources zones. Since the completeness period considered in the GR calculations is around two times longer than what it should be (half of the catalogue has no events at all) the calculated rates drop to ½ of their values. Regarding the onshore region, the completeness period considered is too short for the corresponding magnitude thresholds. Subsequently, the activity rates for the onshore sources are inconstant and erratic.

I strongly recommend the activity rates to be recalculated using corrected completeness periods. This correction only will probably raise the hazard to the ground motion levels expected for the region.

I focused my analysis only on IBER and OFFP completeness zones (and source zones within) but this problem is probably affecting other regions. In short, I suggest that all the completeness periods should be carefully crosschecked and scrutinized, and the recurrence relationships recalculated.

In the following sections I detail my observations and present few tables and figures comparing the impact of correcting the completeness periods for the area sources enclosed by both completeness regions OFFP and IBER.

Completeness analysis for completeness regions OFFP and IBER

I performed completeness analysis using the declustered SHEEC catalogue using the Stepp (1972) method and checking the stability of the activity rate. The results are presented in Figure 1 and Figure 2 and are summarized in Table 1.

		This analysis	SHARE
OFFP	M>=4.1	Date= 2002 DT=5 λ=14.8 y^{-1}	Date=1950 DT=57 λ=2.5 y^{-1}
OFFP	M>=4.6	Date=1952 DT=55 λ=0.8 y^{-1}	Date=1910 DT=97 λ=0.4 y^{-1}
IBER	M>=4.0	Date=1947 DT=57 λ=1.0 y^{-1}	Not performed
IBER	M>=4.5	Date= 1907 DT=100 λ=0.71	Date=1950 DT=97 λ=0.35 y^{-1}

Table 1- Comparison of the completeness results and corresponding activity rates resulting from this study with the proposed by SHARE.

It seems that there was an error associating the completeness analysis performed in SHARE to the corresponding completeness zones. Table 2 presents the corrected completeness times for the ASZs analyzed, using the analysis performed by SHARE.

OFFP	M>=4.0	2002 ?
OFFP	M>=4.5	1950
IBER	M>=4.1	1950
IBER	M>=4.6	1910

Table 2 - Corrected completeness periods.

The consequences of this error are dramatic for the offshore areas because using the completeness date presented by SHARE, a significant part of the period associated with the corresponding magnitude had no earthquakes. The rates using the corrected completeness period almost double for the offshore area sources.

For the onshore area sources the changes are not as dramatic because the considered completeness period was shorter than the corrected one. This means that while the rates are probably not increasing systematically, the robustness of the activity rate analysis increases using the corrected completeness periods (because a large number of data excluded by a too short completeness period is now included). For some IBER source zones the increase in the activity rate is also dramatic.

Regarding the completeness periods for the larger magnitudes, I think that 1700 for M6.5, for such an extensive offshore area, is a very optimistic estimate. However, I don't think it will affect the rates significantly.

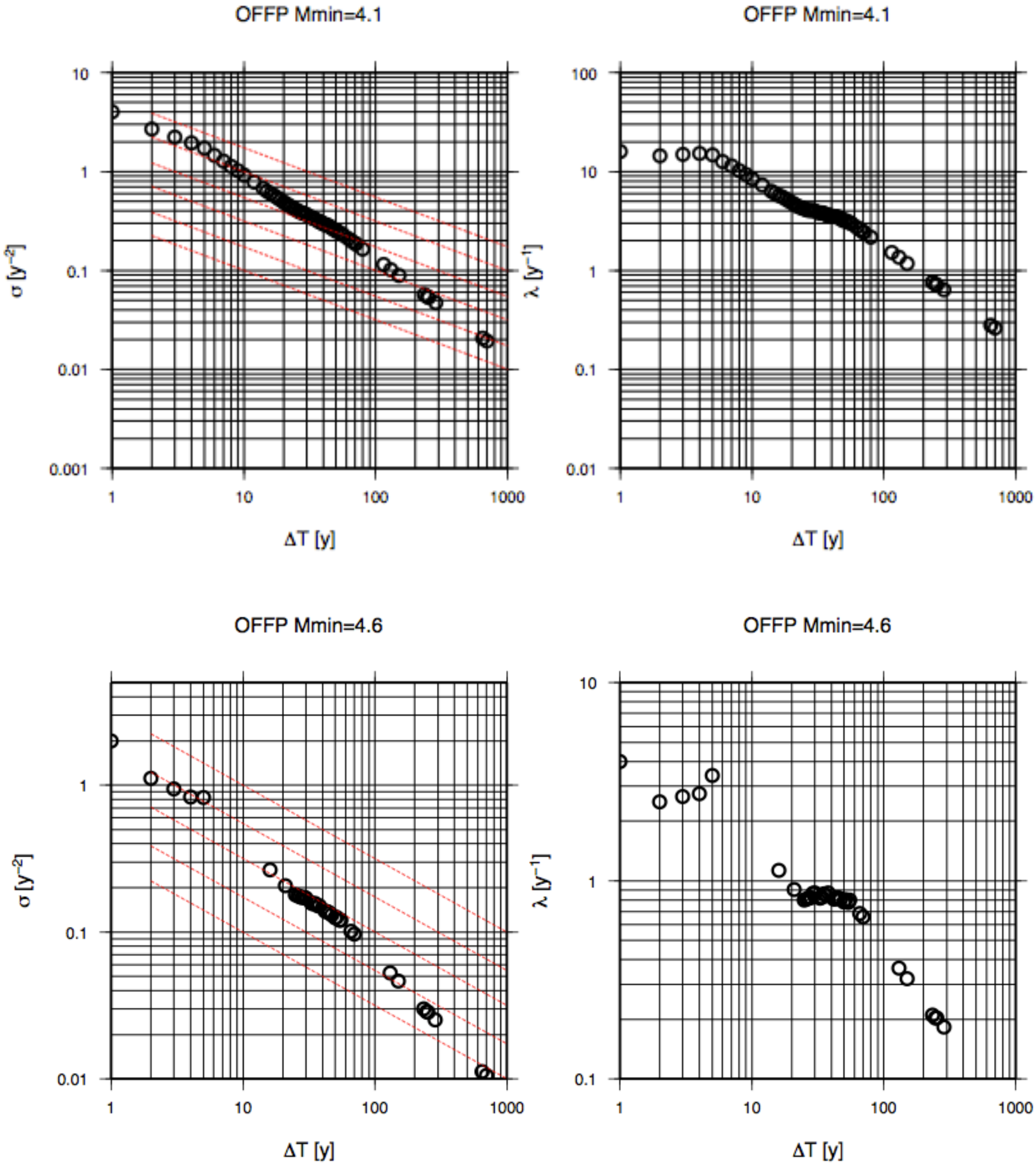


Figure 1 - Completeness analysis for large zone OFFP for Mw>=4.1 and Mw>=4.6. The left plots illustrate the Stepp (1972) methodology and the right plots the variation of seismicity rates with completeness time. DT is the time window considered, starting from the end of the SHEEC catalogue. The complete catalogue should display a slope parallel to the Stepp function (red dashed line) and the activity rates should be stable with time (horizontal). For short periods there is large statistical instability due to limited amount of data.

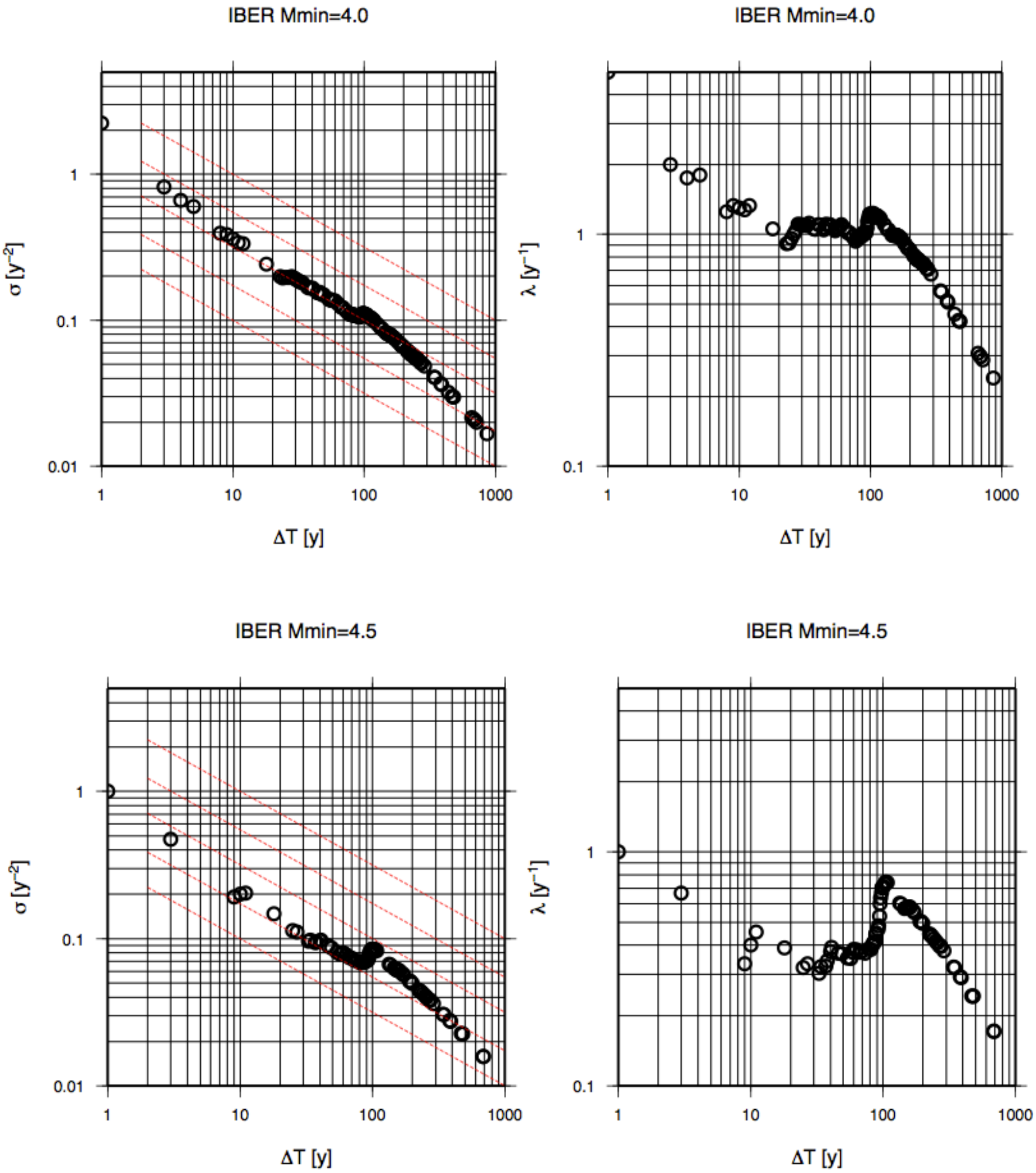


Figure 2 - Completeness analysis for large zone IBER for Mw>=4.0 and Mw>=4.5. The left plots illustrate the Stepp (1972) methodology and the right plots the variation of seismicity rates with completeness time. DT is the time window considered, starting from the end of the SHEEC catalogue. The complete catalogue should display a slope parallel to the Stepp function (red dashed line) and the activity rates should be stable with time (horizontal). For very short periods there is large statistical instability due to limited amount of data. Note that the seismicity in IBER is affected by a strong non-poissonian behavior around DT=100.

Consequences for the activity rates of the individual area sources

I computed the activity rates for some of the source zones to understand the impact of changing the completeness period. Table 3 presents the rates computed for several source zones within completeness regions OFFP and IBER. As expected, the changes are dramatic for some regions.

Completeness zone	Magnitude threshold	Corrected completeness year	AS	Corrected rate	SHARE rate
OFFS	4.5	1950	258	0	-
			259	0.03	0.03
			261	0.05	0.02
			262	0.33	0.12
			263	0.18	0.10
			268	0.45	0.02
			269	0.05	0.03
			278	0.07	0.01
IBER	4.1	1950	257	0.10	0.06
			260	0.03	0.02
			264	0.07	0.02
			265	0.14	0.04
			266	0.09	0.04
			270	0.09	0.04
			271	0 .02	0.02

Table 3 – Comparison of the activity rates for individual source zones using the corrected completeness periods with those proposed by SHARE. The last were estimated visually from the recurrence plots supplied.

ASZ- Feedback for Iberia
On the revised completeness periods for Iberia

Susana P. Vilanova, September 19, 2012

Summary & Recommendations:

In this document I update the analysis performed on previous feedback document in order to take into account the revised completeness periods proposed for Iberia by Max Stucchi and work-team. I also briefly comment on the standardization and homogenization strategy followed by project SHARE and on the general purpose of regional feedback.

The main conclusions are that the most important identified source of bias, which concerned the completeness region offshore Portugal (OFFP), has been corrected for the magnitude threshold M4.5. However, it still remains an issue for the magnitude threshold M4.1. Of course, this will only affect the rates (and the hazard) if such magnitudes will be used in the recurrence fitting procedure.

Regarding the onshore region (IBER) the revised completeness periods improve to some extend the issues raised in my previous document. While, in my opinion, the completeness periods could be longer for M>=4.5, this issue will probably not have a dramatic effect on the rates. However, it limits the amount of data available for the individual source recurrence analysis.

In the following sections I discuss and justify my observations with more detail.

Completeness analysis for the offshore region OFFP and corresponding activity rates

The extension of the completeness period for M4.5 from 1900 to 1960 seems appropriate, and is corroborated by the alternative analysis performed in my feedback document of September 7, 2012. Figure 1 shows the consequences of this correction for the activity rates for a source zone within the completeness region OFFP.

For lower magnitude thresholds I think that the activity rates clearly indicate that the SHEEC catalogue is not complete except for a very short period. The activity rates steadily decrease with the duration of the completeness period as can be seen in Figure 2, which is not the expected behavior for a complete catalogue. I would recommend magnitudes lower than M4.5 not to be used in the recurrence analysis.

I notice that I had a compilation error in Table 3 of the feedback document of September 7, 2012. The SHARE rate for zone 268 was $0.2y^{-1}$ instead of $0.02\ y^{-1}$.

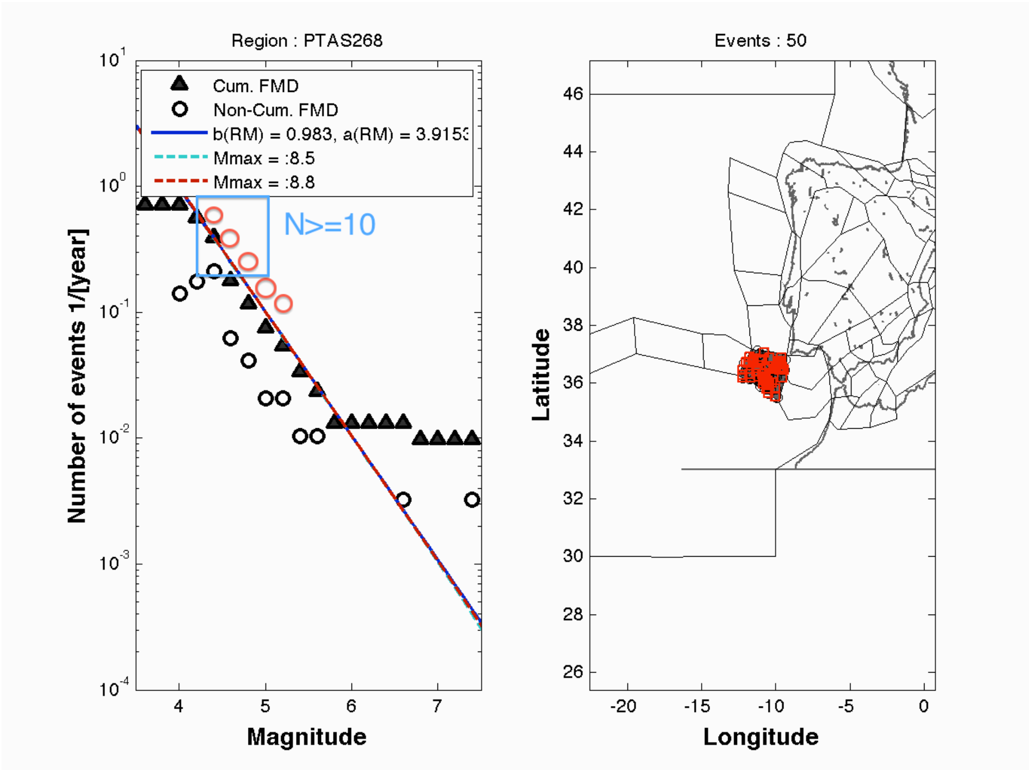


Figure 1 – Approximate changes on cumulative activity rates using the revised completeness periods for 4.4<=M<=5 (red circles) for OFFP source 268. Since the vertical axis is logarithmic the changes are indeed significant.

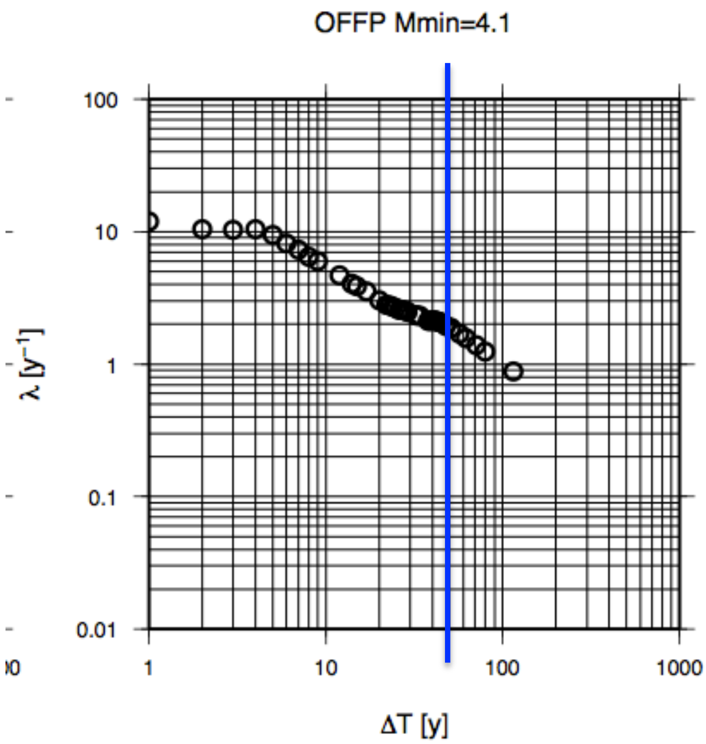


Figure 2 - Activity rates for 4.1<=M<4.5 for the OFFP region. The rates decrease with increasing period of completeness for all but very short completeness periods. The blue line represents the newly proposed SHARE completeness period.

Completeness analysis for the region IBER and corresponding activity rates

I don't understand the grounds for Lisbon to have a different completeness period than that for rest of the onshore region, in particular in what concerns low magnitudes (M4.0 and M4.5). I would recommend that any kind of special treatment (as that being discussed with Laurentiu for the offshore region regarding the distance and type of GMPES) should be well justified.

The new completeness period chosen for M4.1 is in agreement with my alternative completeness analysis. However, the activity rate plots I performed show that, in general, the rates for IBER are stable since around 1900 for M4.6 (1930 if one chooses to exclude the period displaying non-poissonian behavior; see Figure 3). While it is not in general misleading to use completeness periods shorter than what they could potentially be, in regions of low seismicity (as is the case) this choice may lead to a very limited number of events to play with when calculating the recurrence parameters.

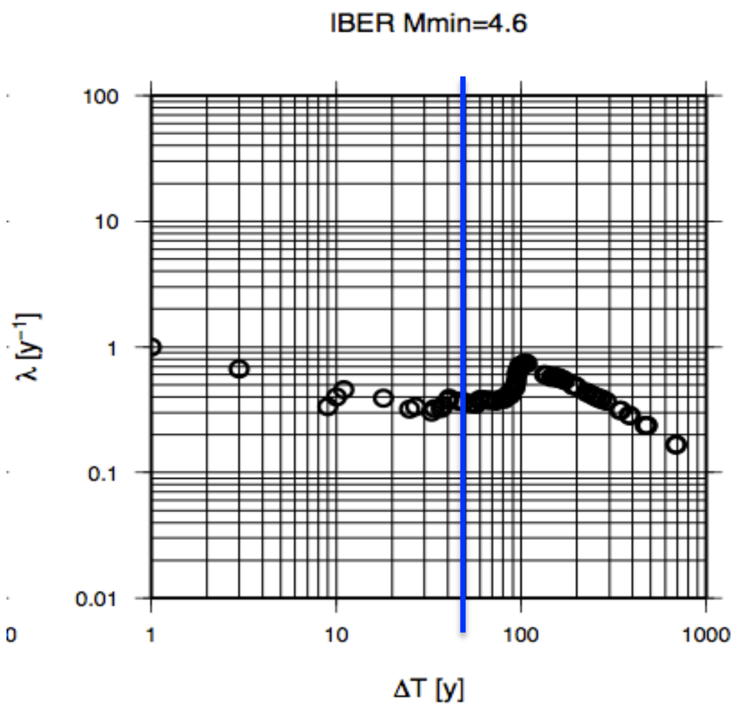


Figure 3 - Activity rates for M>=4.6 for the IBER region. The blue line represents the newly proposed SHARE completeness period. The activity rates are stable for another couple of decades (still excluding the non-poissonian behavior).

I think that a completeness period starting from 1500 for M>6.1 is reasonable. Statistical analyses are not robust for large magnitudes due to the very limited number of events. I wouldn't prefer the completeness period for M>=6.0 to start from 1850 instead of 1500. The activity rates for these larger magnitudes are statistically meaningless and that's why I'd rather rely on lower magnitudes to estimate the activity rates (and that's exactly what maximum likelihood fitting does). I don't think that changing the completeness period for this magnitude will influence the hazard at all (except if using the least squares fit to the GR plots, or a by-eye fit).

Comment on the standardization and homogenization strategy of project SHARE and the role of regional feedback

In this last section I would like to clarify that, in my opinion, the role of regional feedback is not to replace the work performed by the workgroups. I do not endorse an approach in which each region would be choosing their activity rates or completeness periods. In my view, my role as a regional expert may be useful only to detect and point out possible sources of bias (errors, misfits, region-specific issues) that are necessarily involved in a project of such dimensions. I performed alternative analysis not as a replacement for the workgroup analysis, but as a sanity check procedure, as Joao explained in his email.

At any rate, the important thing is that the completeness periods were improved and that the activity rates will better represent the seismicity levels that affect the region.

Completion report following the SHARE meeting
Zurich, 12-14 March 2012

Prepared by: Oona Scotti & Laura Peruzza

Introduction

This document has been prepared after the end of the SHARE meeting, held in Zurich in March 2012 but initially scheduled in Nov 2011, and intended to be a final review of PSHA results. OS and LP were invited to attend the meeting to follow the developments of SHARE, with some misunderstandings about their role (GEM WG, or European external experts); the ambiguity has been solved during the meeting, motivating this report.
This document provides our comments on the status quo of the project, choices, solutions adopted and some still open points, plus our suggestions focussed on the project closure; they all are elements to evaluate the exportability of SHARE experience to the wider objectives of GEM Regional Programmes. For these reasons, the document is an effort bounced back to the SHARE Project leaders, and forwarded with informal minutes to WG members who were not present.

From the Meeting Agenda

Goals:

- *Presentation and discussion of the 1st hazard model and results*
- *Prepare a plan for model adjustments and their implementation*
- *Define further modelling procedure and timeline*
- *Discuss schedule and extension of project*

Summary:

Day 1: *Model presentation*

The workshop focuses at first on the essential ideas of the source model branches and their specific details, followed by a presentation on the GMPE logic tree essentials. The presenters should point out model features, assumptions, uncertainties, and limits. This is intended to reach a common understanding of the model assumptions. Then implementation issues will be discussed. Then we discuss the hazard results for the Area Source Model branch followed with some comparison to national hazard maps.

Day 2: *Model presentation and discussion of model adjustment*

The morning of the second day is dedicated to further discuss hazard results of the Fault Source + Background Model and the smoothed seismicity approaches followed by a discussion on model adjustments. The goal of the day is to propose a schedule for preparation and implementation of the next model version, including initial ideas on weighting the models in different tectonic regions.

Day 3: *Harmonization SHARE – EMME*

Due to slightly different parameterization and approaches used in the two projects, we dedicate a morning to harmonize the efforts in EMME and SHARE.

Status quo of SHARE

The SHARE project has been and is presently running into computational problems and has decided to ask for an extension to the EC, in order to ensure that the necessary simplifications

dictated by OpenQuake comply with the different modelling approaches proposed and also to allow for a complete testing of the different model components before delivering/accepting the final preferred "mean" model.
The SHARE deliverables being very wide, the logic tree structure quite complex and the OpenQuake code still under development are posing a serious problem to the project. Model simplifications are presently being considered and concern every numerical integration parameter that can be relaxed with negligible impact on hazard mapping: some examples are the step of magnitude bins in the Gutenber-Richter integration, the reduction of ground motion levels to be computed, the rarefaction of calculus grid points (set ordinarily to 0.1 degrees) in regions where there are no cities and offshore, a basic sampling of source depth distribution (by now only 3 depths have been taken in consideration) etc. In the end, **SHARE** results will be a **balance** between the **PSHA model (source models and GMPEs)**, SHARE **Output Requirements** and **ITInfrastructure** (Hardware + Software) performance.

Individual deliverables of the project have been reached, in general, but "data" exchange is not trivial, in terms of factual procedures or in hidden, underacting, strategical choices. Conversely, the results presented at the meeting were produced in a relatively short period of time after the deliver of "freezed" ingredients, and could not be fully checked for consistency. This will be corrected before the next meeting, by going back to the original files and checking the input, and by asking feedback to national representatives. The **quality assurance** is therefore **expected to increase in the final products**, by solving communication problems and by raising the common perception and acceptance of all the working hypotheses.

Given the complex nature of the SHARE project covering numerous countries with extremely different seismogenic and anthropic factors, the **homogenization of standards and procedures is a result itself**. It was impossible to develop everywhere all the branches for the hazard calculation; the problem of weighting scheme of source model branches and representativeness of different source approaches have not been faced, yet. But the project forces the European community to abandon a unique seismogenic source zoning scheme, to discuss and look for a rationale to difficult or ill-posed questions (such as Mmax, for example, or regionalization of historical magnitudes vs globalization of GMPE) and strives for transparency in data gathering, public availability of metadata, rigorous replicability and testing procedures. We do expect **positive cascade effects**, once these aspects will be fully understood and accepted, and **new tools will be freely available** (software, database, documentation).
Following a scheme similar to the one adopted in previous reports, we enter now in the details of individual model components.

Choices, solutions, open issues

- <u>For the SSZ, three approaches are proposed:</u>
  - (i) Classical: areal source zones (ASZ), based predominantly on consensual models developed in each country. At the meeting, the SSZ was updated to account for a consensual zoning scheme that was discussed between France and Spain. Such consensual discussion could not unfortunately take place for all border regions. There is space for improvement in future projects.
  - (ii) Geological: Composite Fault Source Zones (CFSZ) based on estimates of geometry and slip rates along a collection of predominantly blind/hypothetical

active fault sources described in the DIS3D database and embedded in a background seismicity. Data taken from literature or previous projects are very heterogeneous, but they have been assembled and homogenized by a unique team. Future initiatives should pursue the goal of a wider European inventory of individual seismogenic faults, on which basic field observations are kept separate from the source zone model (consensual or not).

(iii) Zoneless: two smoothed seismicity methods**.** The main difference between them is that one smooths observed seismicity density and only models observed smoothed seismicity rates, whereas the second approach combines modelled smoothed seismicity based on GR behaviour. In the second approach CFSZ are also considered with GR FMD.

Open issues:

(i) Should the three approaches be merged into a single logic tree? The discussion did not conclude on this issue because of time constraints. A general feeling emerged, that the Geological approach needs to be pursued but it may not be mature enough to be considered for the final "mean" model. It should however be used as a sensitivity test. The smoothed seismicity models are highly debated, too. Although they provide an alternative concept that allows expressing the degree of stationarity of seismicity in space, one completely ignores the geological information and the other one only considers the CFSZ as relevant geological information. Moreover, one of the smoothed seismicity models does not integrate beyond the observed maximum Magnitude. Such a model may not be appropriate for longer return periods. Finally, the isotropic kernel used for faults may not be the best representation for CFSZ.

(ii) The representation of sources does not completely fix ambiguities between the physical characteristics and the modelling simplifications. Some example: the subduction zones are modelled in the ASZ branch as areal source volumes, no interface surface/zone; ruptures are allowed to go beyond the source boundaries; by treating of top of rupture versus hypocentral depth for extended sources there is the need to define the distribution of top of rupture for different magnitudes – faults are line surfaces – need to assume 3 km depth?; depth distribution in thickened crust (e.g. Fennoscandinian area) should decrease the impact of already low seismicity.

- <u>The SHEEC catalogue is twofold:</u>

(i) the "historical" segment is compiled by INGV group (Stucchi coord.). Concerning the construction of the historical earthquake catalogue (1000-1899), the SHARE project decided to concentrate the efforts into producing a **single** reference record, where only one homogeneous Mw (but PROXI) magnitude for Europe and an associated uncertainty is provided for each historical event. In some cases the evaluation represents a weighted average of the SHARE determinations from macroseismic data points (MDPs) available for Europe and the value determined by national catalogues. It is important to note that the macroseismic determinations were calibrated **regionally (8 zones)** using different approaches depending on the offshore/onshore location of the event, with the exception of the UK where a third approach is implemented.

(ii) the "instrumental" part (1900-2006) is compiled by GFZ team (Grunthal coord.) by merging national reference catalogues. It is also important to note that the post-1900 earthquake catalogue was constructed using another procedure. Mw is still the standard value given, and one location/magnitude is assigned to each earthquake.

In spite of the heterogeneous nature of the procedure, the deliverable of this project represents an important milestone in the building of a common and shared European earthquake database. The earthquake data file contains non-conventional fields, identifying declustered events (main or not), source zone assignment (not strictly based on eq. location), tectonic regionalization. A useful column that should be added to the SHARE datafile available in Millarium repository is the complete/uncomplete assignment for each event.

Open issues:

(i) Future projects will need to focus on improving the quantification of the real uncertainty of location, magnitude and depth estimates. Indeed, the choice of a single reference macroseismic study for each event and the choice of a single modelling procedure for the computation of location and magnitude may be underestimating the true uncertainty of location and magnitude for many of the earthquakes.

(ii) Future projects should better address the apparent contradiction between GMPE which have a tendency to rely on global calibration data sets, and macroseismic Magnitudes which are established predominantly on regional calibration data sets.

- Completeness is evaluated with different philosophies:

(i) by means of historiographic considerations on the availability of "observers" (written sources, seismographic stations); this approach, even if disputable as largely influenced by experts opinions, is expected to blend decades of misleading common practice, using the statistical approach only;

(ii) by classical, purely statistical methods based on the stationarity of the process.

As final result, 24 superzones, areas of similar levels of completeness were defined: time window of completeness becomes an attribute to each record of the catalogue.

Open issues:

(i) Completeness issues discard a huge amount of earthquake records (e.g. all the events collected from 1000 to 1200, in all the SHARE regions except "superzone" M – Sicily); as the declustering algorithm does not adjust the magnitude of the main event to an equivalent moment-budget magnitude of the sequence, the effort done in data collection is partially vanished; some issues to overcome stationarity issues, for hazard purposes, should be developed in future projects.

- GMPE selection and LT:

The most elaborate exploration of epistemic uncertainty was performed for the GMPE. The approach taken in this part of the project lead to the elaboration of logic trees that favoured GMPE calibrated on **global** rather than regional data sets, and different logic trees are proposed depending on tectonic regionalization (the active/stable/subduction subdivisions etc.). An accepted limitation is that the GMPE LT remains an attribute assigned to the source, nor to the path, neither to the receiver.

Open issues still remain as:

(i) the extrapolation to the same periods of different GMPE (by now only common frequencies are treated), computer-time limits for acceptable shape in spectra; extrapolation to longer period (>2 s);
(ii) it will be necessary to extrapolate existing GMPE for modelling distant high magnitude earthquakes (e.g. Lisbon-like eqs);
(iii) global attenuation properties are invoked, but strong regionalization in attenuation of intensity is known: this aspect, even if not considered in SHARE, should impact back to the homogeneity in MW computation from MDP;
(iv) some border issue with EMME, described later on.

- <u>PSHA calculations:</u>
Problems of performances of OpenQuake, with month-to-years of expected computer time to respect the initial choices. Some sensitivity studies were shown, to justify broader samplings. Computational boxes have been set, following the GMPE LT, and they require great care to check and to fix inconsistencies in adjacent region.
Open issues partially discussed at the meeting:
    (i) In the SHARE project seismic hazard is integrated only up to 3 sigmas of each GMPE. This has important implications if return periods longer than 2000 years are considered in the deliverables.
    (ii) The minimum magnitude considered is Mw=5.0. This is an important decision that will impact the results especially in regions of low seismicity.
    (iii) Mean e median: some checks are required as results are opposite to the expectations.

- <u>Seismicity rate assumptions considered in the ASZ-branch:</u>
An issue that was raised during the meeting concerns the fact that the completeness magnitude is very high (Mw=4.0). This is due to the fact that in some countries no data is provided below this threshold. It was proposed to allow lower completeness magnitudes, at least down to M3, where the data is available. This is an important issue for regions of low seismicity. Another issue that was not discussed concerned the choice of declustering.
(i) At present within the SHARE areal sources (how many?) where no M>=4.0 events exist, the choice is to assume an apriori activity rate of 0.05 events per year per 10^6 sq km and a b-value of 1.
(ii) Some a-priori values (b=0.96-1.12) are introduced in the methodology; for small samples b-prior is 1.0;
(iii) The second modelling choice that was made concerns the declustering scheme. Only one scheme is implemented: the Grünthal, 1985 version of the Gardner and Knopoff, 1974 method which uses fixed magnitude dependent time and distance windows. The influence of this choice of declustering on the the GR-modeling results should be quantified (especially for regions where earthquakes with M<4.0 are going to be considered).
(iv) Finally, an adjusted magnitude is introduced for use in the maximum likelihood recurrence calculations. The choice made in SHARE-ASZ branch is to apply the Tinti and Mulargia (1985) corrections factor. This choice should reduce the activity rate estimates by up to 50 percent depending on the mean uncertainty of the local catalogues.
Open issues:

Each one of these decisions needs to be clearly addressed and sensitivity test should be performed. The preliminary results presented at the meeting showed much lower hazard levels compared to previous PSHA calculations performed in each country. The discussion was not conclusive as it was not possible to appreciate during the meeting which was the choice or the collection of choices that led to such lower hazard values.

- Seismicity parameters for Smoothed seismicity-branch:
  The smoothed seismicity branch has been very marginally tackled during the meeting: it is not clear whether the pre-processing performed (declustering and magnitude corrections and method for computing activity rates) in the ASZ branch is also performed here.

- Seismicity parameters for CFSZ-branch:
  This part of the project is still under development. In SHARE project, the Anderson and Luco (1983) model-2 is used to compute activity rates from geological slip rates (on preliminary, unchecked fault model), given a Mmax and with b-GR taken from background sources: then rates for M=>5.5 are assigned to the "fault", below 5.5 to BK. As a matter of fact, seismic moment rate budgeting, relying on the "fault" dimensions often based on interpretations and highly speculative slip rates assigned to the sources, is an expert opinion. It is not clear, by now, how far from the fault geometry the "background" is extended, and if and how the FS+BK branch (which results were shown, by putting huge emphasis on their "preliminary, still unchecked" character) includes areal sources too. The main issue that was discussed concerned whether only the GR FMD should be considered for CFSZ or whether also characteristic FMD should be explored. Again, computational constraints will not allow this question to be resolved within the SHARE project. However sensitivity tests should be performed for different return periods and different spectral frequencies and for slow versus faster slipping CFSZ. This approach needs a more in-depth analysis, as it seemed to lead to incoherent results.
  Open issues:
  (i) There are great inconsistencies between activity rates of the background zone and those deduced from CFSZ on the basis of slip rate, the latter predicting several orders of activity more than the one expected from catalogue statistics; sanity checks are still in progress.
  (ii) No aseismic factor is considered; modellers introduced strain drop D/L factors (1.0e-04) and scaling relationships with different choices than the ones adopted by fault compilers (to fix Mmax, for example); comments on that should be done only when the final fault model will be treated.
  (iii) Activity rates deduced from the CFSZ are distributed between a buffer zone around the CFSZ and the CFSZ itself based on a threshold magnitude. The value for this threshold magnitude was debated but no conclusive decision was taken.
  (iv) Moment balancing on CFSZ+ background source zones BSZ must follow a rationale.

- Mmax
  For ASZ:
  the issue raised for this parameter are:

(i) The need to define macrozones.
(ii) Mmax based on the earthquake catalogue should be derived by assuming M(catalogue) + Uncertainty(catalogue).
(iii) In certain regions the Mmax derived on the basis of CSFZ are lower than the Mmax based on the earthquake catalogue.

For CFSZ:
estimates are based on a variety of scaling laws (Mmax estimated for all faults WC94, KA02, HB02, LE10). Each scaling law is only considered in its range of application. The concept of aspect ratio is used as proxy to segmentation, so very long fault have many short segments. Different scaling laws depending on the tectonic regime.
Open issues:
(i) No sanity checks have been implemented for verifying that small sources (ASZ) tolerate the Mmax assigned in their superzone;
(ii) Similarly, the scaling relationships applied to CFSZ should be compatible with observations (e.g. 7.8 Mmax assigned to N-Anatolian fault, versus higher observed values).

Lessons learned, and suggestions

This was a very instructive workshop for everybody present with heated discussions on important issues.

The most important issue, that could not be discussed but it is definitely a lesson learned, is that the degree of refinement and detail that should go into developing seismic hazard models for large scale regional objectives should be commensurate with the computational capacity of the algorithm that will be used to implement the model. It is quite simple to fit the knowledge we have in a region onto a well known computer code, it's relatively simple to adapt some algorithms to model some well known peculiarities we want to use in a specific region, but if nor the fuel, and neither the car are established, it is difficult to predict how far we should go.
As the OpenQuake release that will be used for the SHARE final computations (and in theory, distributed with SHARE results) should be different from the "current" one available to other Regional Project, we do suggest a **full documentation of all the pre-post processing phases and settings**, to favour potential transitions to other PSHA releases/platforms. The dissemination of intermediate results (such as Mmax, depth distribution, activity rates and moment rate maps) is an added value to the Project.

It is important that all the project partners are at the same time data providers and controllers of intermediate steps in calculation; visual representations of earthquake records discarded for completeness/declustering issues should help local (national) experts to judge the effect of filtering. **This check should turn out to be a lesson for future eqs/fault catalogue compilation, too.** The same macro-check should be extended to the seismicity parameters (GR, Mmax) used in the model versus observations.

Moment budget on "faults" and on area sources has to be at least visually compared, and discussed with national representatives, too. **Homogenization** of "composite" sources and faults as gathered by the **Global GEM component** is a future issue.

Sensitivity tests should allow appreciating whether modelling choices are maximizing or minimizing hazard compared to other plausible choices. Theses tests **should be exhaustive enough to be able to appreciate the impact of the different choices for shorter and longer return period**. Deterministic scenarios should also be performed to check locally the results. Example: In the present project, epistemic uncertainty in predicted activity rates based on seismicity can be appreciated through the ASZ and zoneless modelling approaches. However, it will be difficult to interpret the differences because the three approaches (one ASZ and two zoneless approaches) are based on different catalogue pre-processing schemes).

Homogenization issues between EMME and SHARE are important, but they cannot jeopardize independent choices of the regional projects. As Turkey will be in the delicate position of having two different “reference” maps, we believe the differences should be explained and justified by means of the logic tree architecture; the architecture of main branches (zone, fault, zoneless) are by far the most difficult element to be set homogeneously, between Regional Project (in particular, it is not exportable from SHARE to EMME projects).

Conclusion

In conclusion, the SHARE project represents definitely a step forward from the GSHAP initiative in as much as it provides, in its final deliverables, common European databases necessary for a homogeneous PSHA calculation across Europe. The project will also deliver the open source program used for the computations (OpenQuake release xx). Therefore, in theory, the results should be reproducible.
It must be stressed however, that shared and common databases delivered by SHARE are the fruit of several decisions that were made by the people in charge of the different work packages. As such they cannot be considered as being “consensual” or “approved” by each European country. National representatives will not be able to “validate” the SHARE PSHA model, but should be invited to take a look at the parameterization of the model in order to identify obvious mistakes, if any, and at the same time become aware of what this new seismic hazard map of Europe is based upon and what are the range of applications for which it may be useful as well as those for which it should not be used.

Paris, 24 August, 2012

Personal comments on the activity rates proposed in the SHARE project concerning the French territory

Oona Scotti

Version 1

Following a request by Jochen Wössner (see mail below), this document presents a very brief comment on the activity rates proposed in France, in view of a discussion that will take place on the 2nd-3rd September 2012 for the second review meeting of the SHARE project.

Needless to say, I have no official "French" role in this review process. The comments contained in this document do not engage anybody else beside me.The comment concern ONLY the activity rates, no comments are provided on the depth, the Mmax, the earthquake catalogue or the validity of the SHARE source zone definitions.

In order to "check" the activity rates I followed two strategies:

> 1/ I made a rough comparison of activity rates of M>=5 as predicted by the Geoter study* and the SHARE project for the whole of the French territory. Activity rates were normalized by the surface of each source zone and gridded in 0.20°x0.20°.
> ***Used for the official seismic zonation map of France (http://www.planseisme.fr/Zonage-sismique-de-la-France.html).**
>
> 2/ I made a second comparison of GR predictions for those source zones that have the same geometry (or almost) between SHARE and the Geoter study.

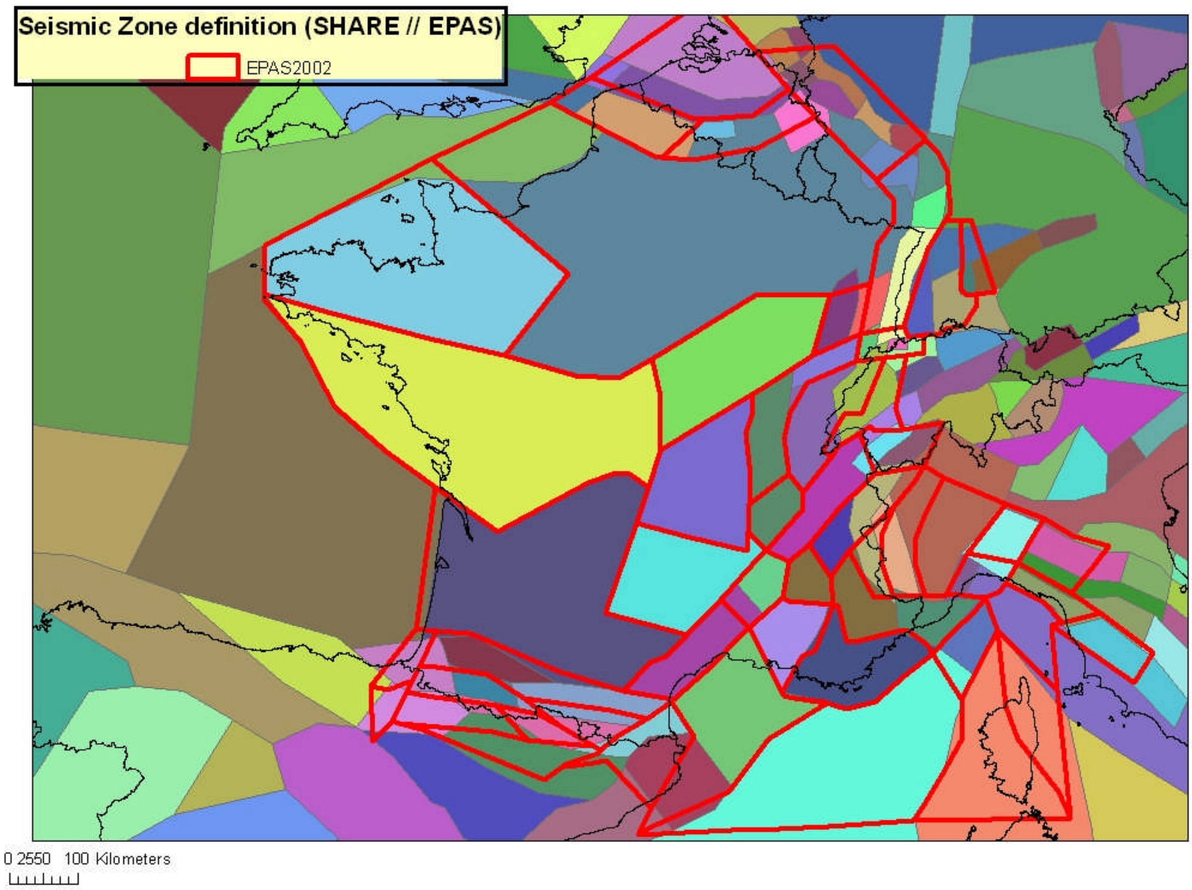
I make no suggestions for changes in activity rates. However, there are clearly some source areas for which verification is warranted. In particular, the SHARE project should clarify the manner in which source areas for which there is very little or no data have been treated (most of the French regions are affected by this problem).

Preamble

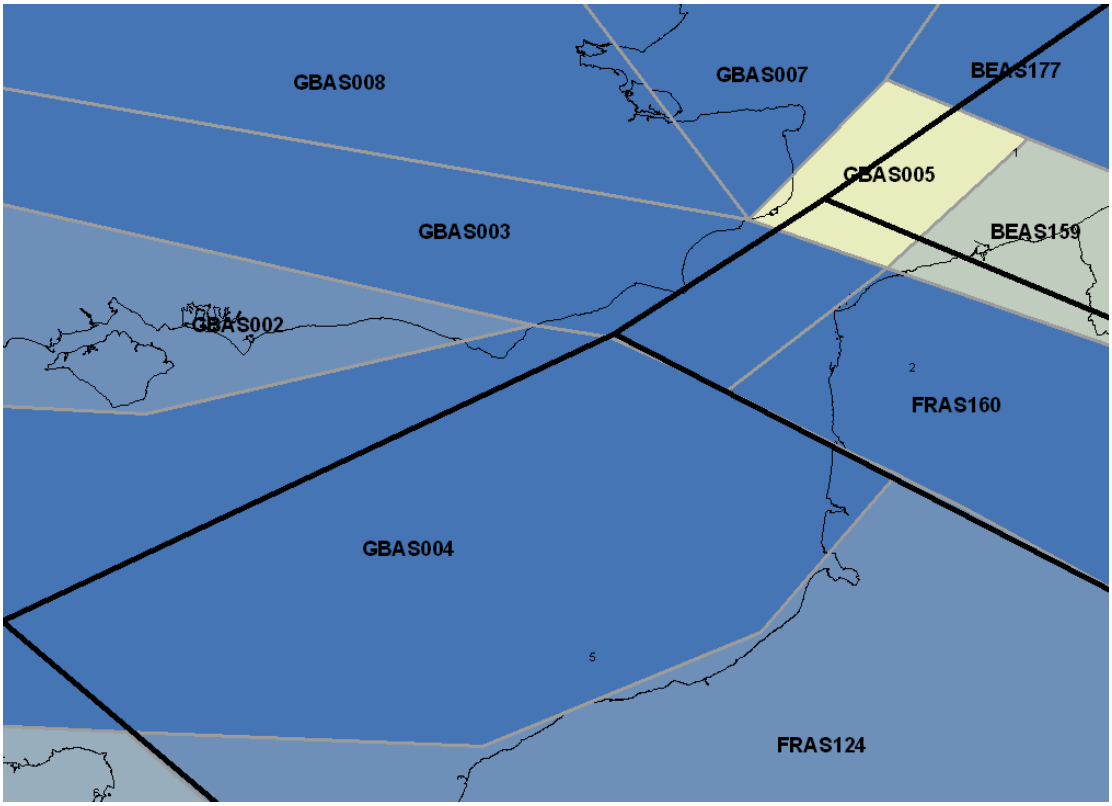
Stéphane Baize provided the EPAS areal source zone definition to the SHARE project, because SHARE requested the most recent “consensual” French version of the source zones. The SHARE project has adopted the EPAS source zone definition for most of the source zones that fall within the French territory. However, for some zone within the territory and for all zones that concern neighbouring countries the geometries of the source zones have changed.

Only one neighbouring country, Spain, officially contacted Stéphane Baize for an exchange of ideas concerning the redefinition of source zones proposed in SHARE.

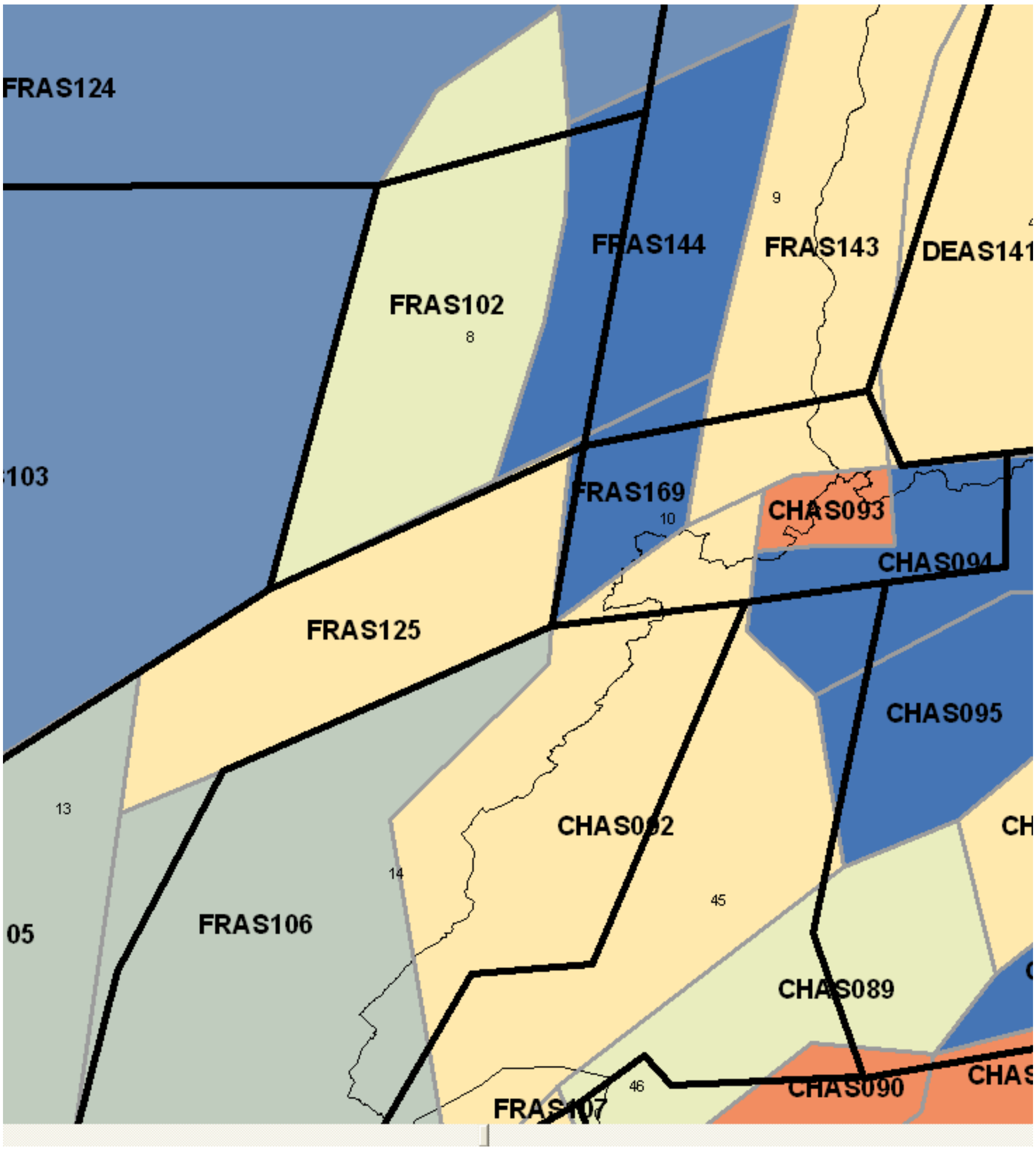
SHARE partners’s point of view (Italy, Switzerland, Germany, Belgium and England) seems to have prevailed without any discussion with Stephane Baize or any other French geologist (to the extent of my knowledge).



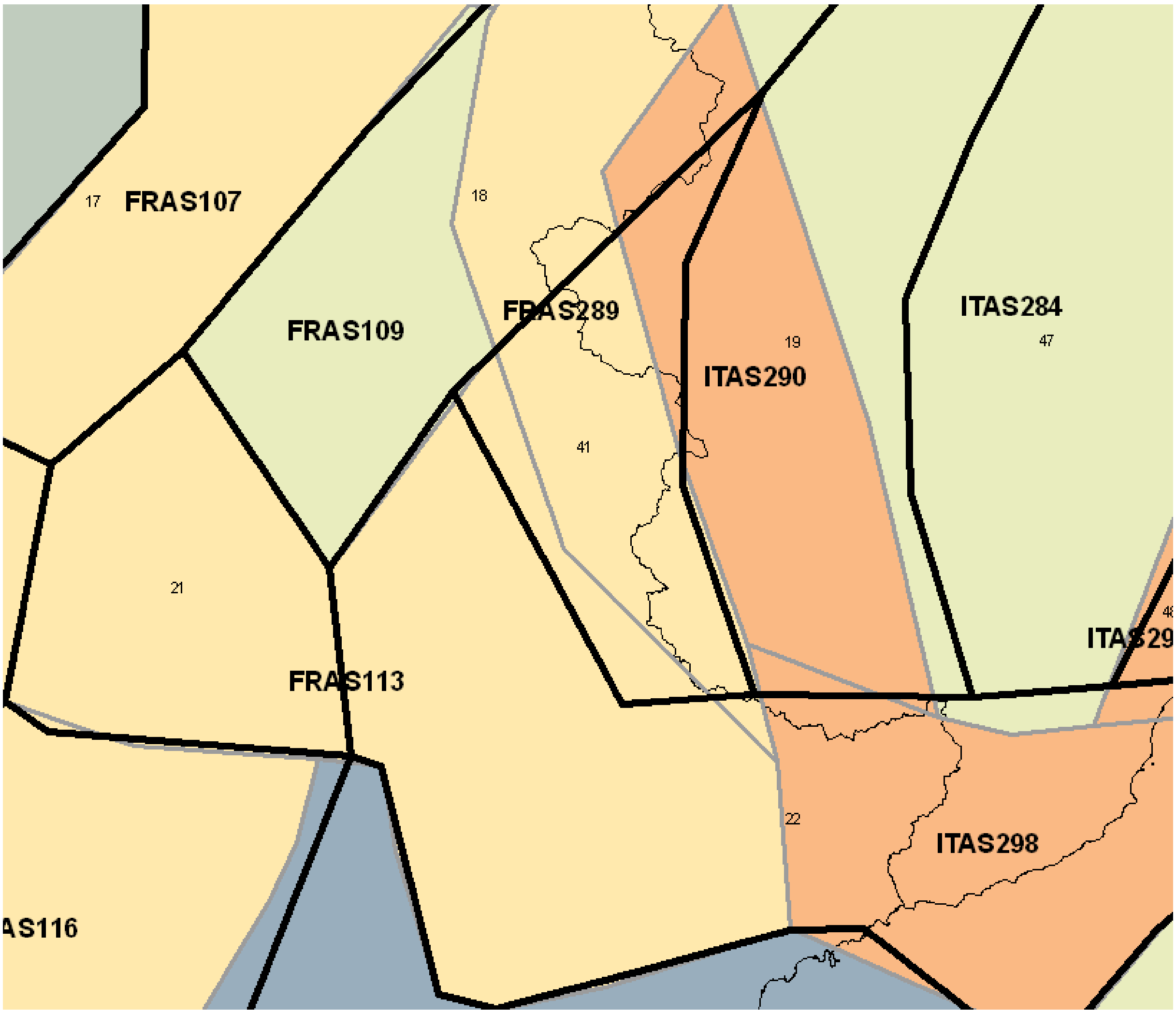
SHARE zones in colour scheme. EPAS zones traced with a red outline.



The English view of France (grey limits = SHARE, black limits = EPAS)



The german-swiss view of France (grey limits = SHARE, black limits = EPAS)

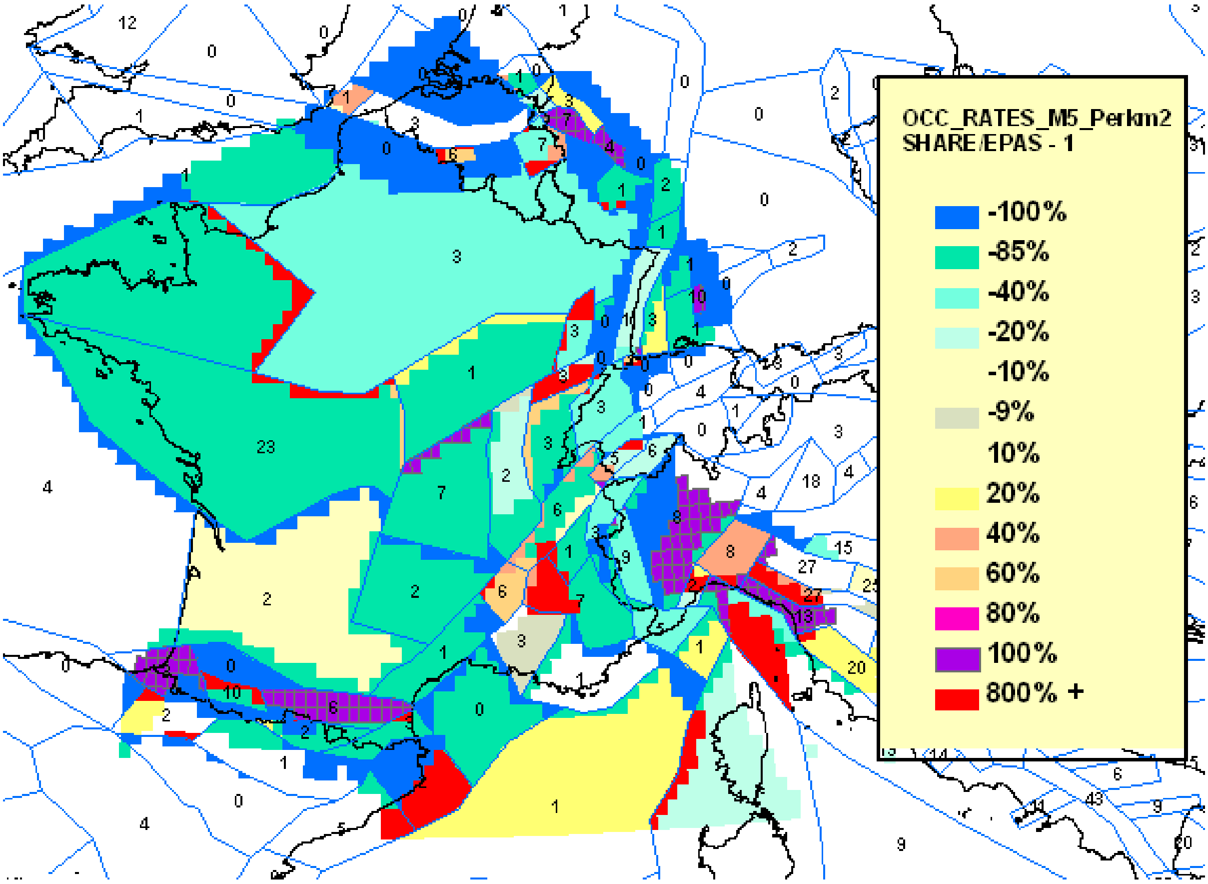


The Italian view of France (grey limits = SHARE, black limits = EPAS)

Earthquake activity rates for France

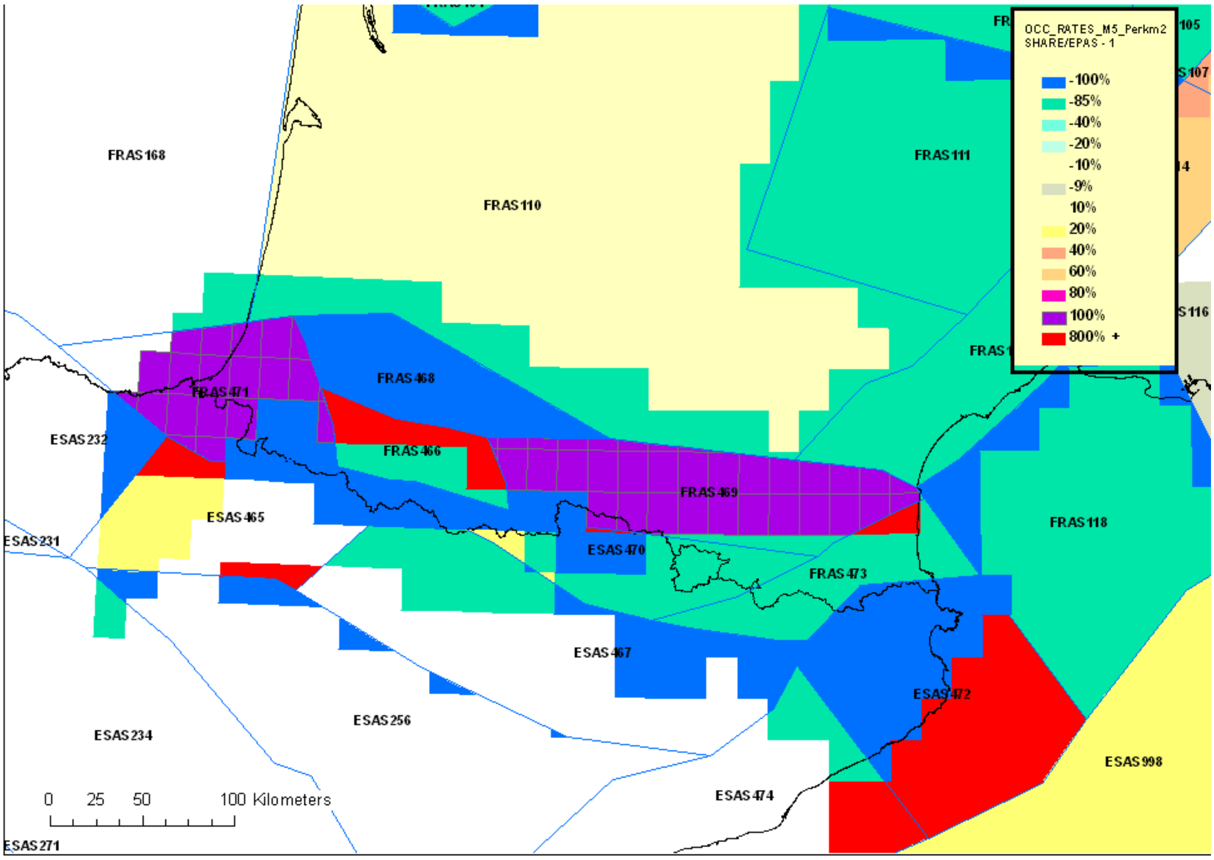
1/ Comparison of predicted activity rates for M>=5 for the whole of the French territory, normalized to the surface and gridded in 0.20°x0.20° grid (the grid is rough – please ignore the border effects). In this step I assume that the shapefile provided by Jochen is more or less valid, since I use the `OCC_RATESN` field provided therein. It is a rough calculation to identify possible “anomalies”.

NB Geoter study is based on an “Mldg=Ms”” magnitude scale earthquake catalogue whereas the SHARE catalogue is based on the Mw scale.

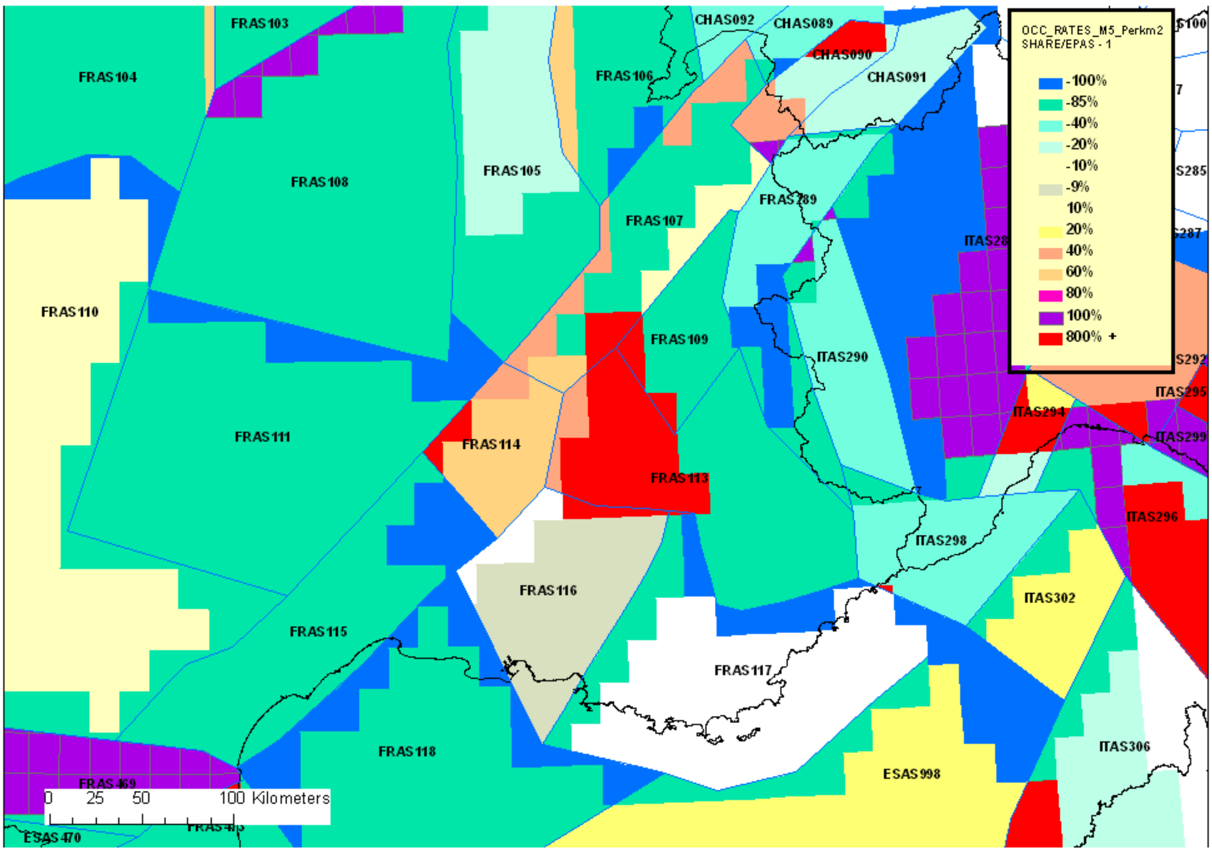


Share predicts between 40 and 80 % less activity rates for most of the source zones in France. However, in some regions (Pyrenees and Eastern France) SHARE predicts in a few source zones much higher activity rates. **The map above shows that locally the rates can very much exceed 100% compared to EPAS**. These source areas are newly defined in SHARE and I have no suggestion as to how to check their validity, it sure seems like a big increase and given the small number of data available, just make sure that something spurious did not slip in. The numbers shown in the Figure are taken from Jochen shapefile and correspond to the NEVENTS (apriori events used to compute GR???)

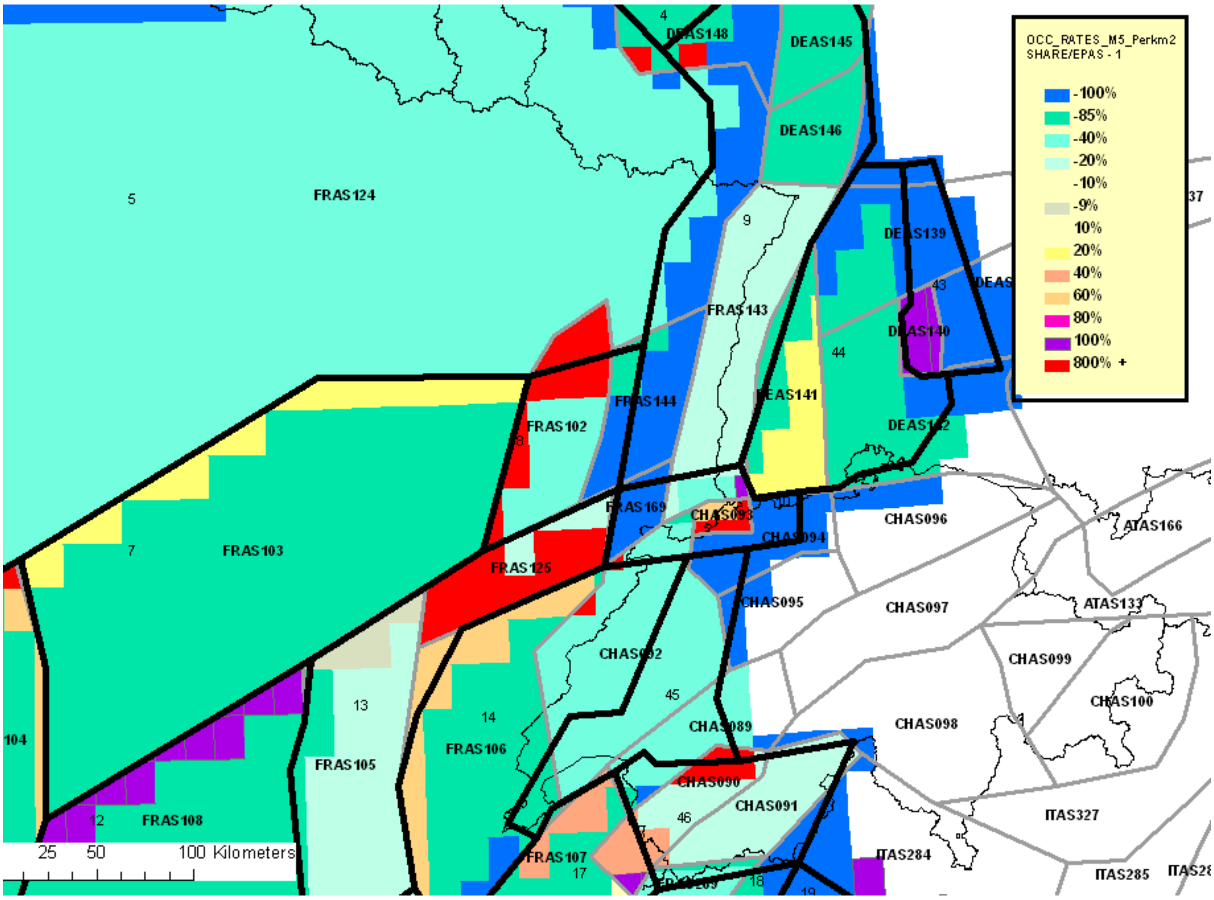
I zoom on these regions below.



Zoom on the Pyrenees: FRAS471, 469, 472.



Zoom in SE France:: FRAS113



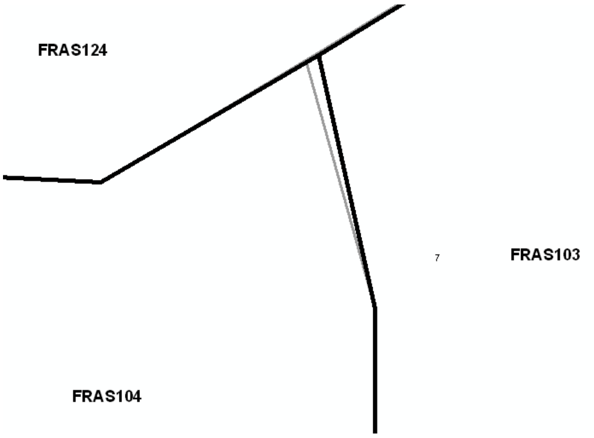
Zoom in SE France:: FRAS125

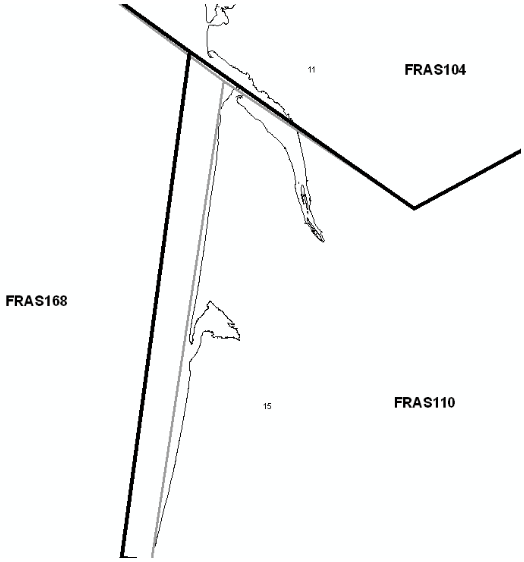
2/ GR comparison for 8 source zones **that share the same geometry (or almost) between SHARE and the Geoter study**

* remember that Geoter study is based on an “Mldg=Ms”” magnitude scale earthquake catalogue whereas the SHARE catalogue is based on the Mw scale.

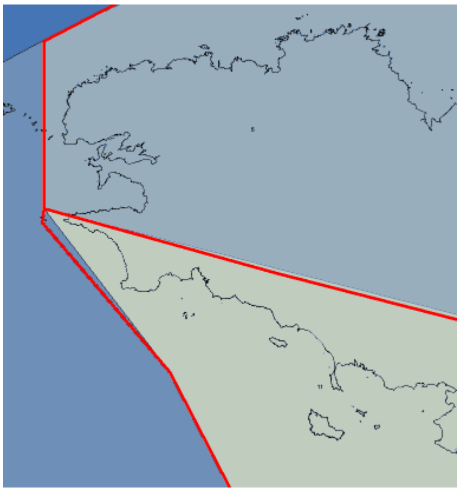
Given that only 8 out of the original 52 EPAS zones are retained in SHARE, I will only be able to restrict the more rigorous comparison to these 8 zones, for all that it is worth.

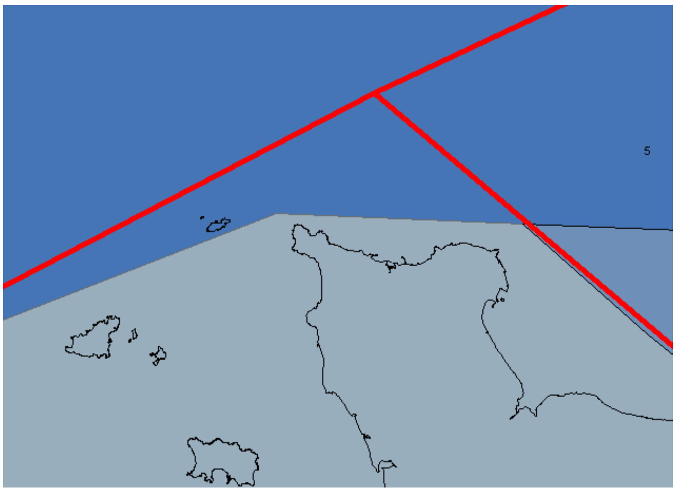
NB From the shapefiles I received, it seems that there are slight differences in the drawing of polygons even for those source zones that appear to be the same as EPAS. Which shapefile did you use in SHARE?





Ex:



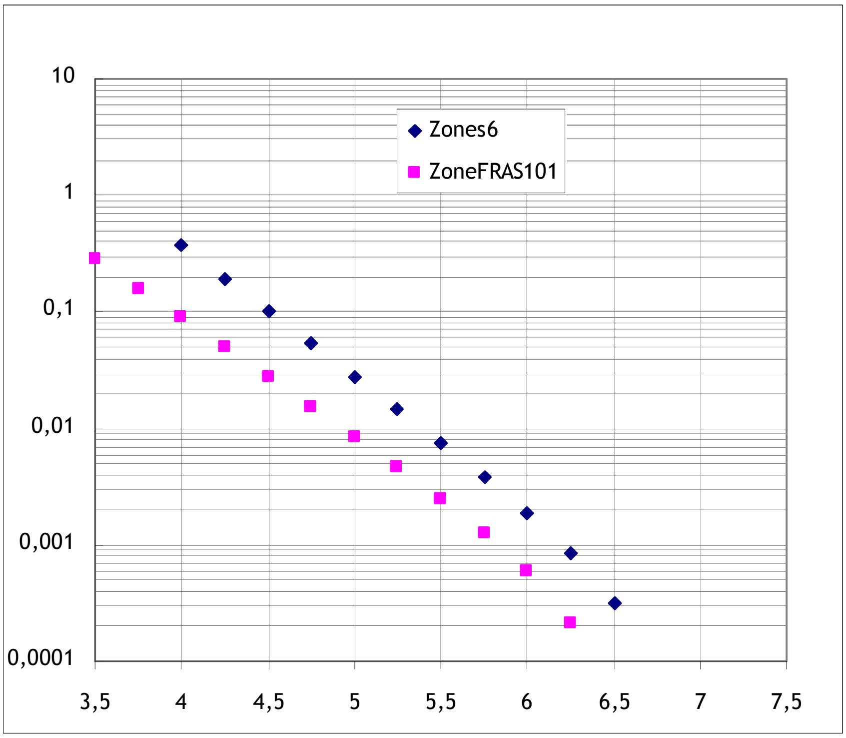


IDAS	TECREG	a-value	b-value	EVENTS in Zone	MAXMAG01
FRAS101	**SCR-Ext**	**2,9646**	**1,004**	**8**	**6,5**
FRAS102	SCR-Ext	2,5258	1,001	3	6,5
FRAS103	**SCR-Ext**	**1,9308**	**0,976**	**1**	**6,5**
FRAS104	**SCR-Ext**	**3,4451**	**1,009**	**23**	**6,5**
FRAS105	SCR-Ext	2,3506	1,001	2	6,5
FRAS106	Active	2,5274	1,002	3	6,9
FRAS107	Active	3,2249	1,012	6	6,9
FRAS108	**SCR-Ext**	**2,3982**	**0,894**	**7**	**6,5**
FRAS109	Active	2,3744	0,997	1	6,9
FRAS110	**SCR-Ext**	**2,2495**	**0,979**	**2**	**6,5**
FRAS111	**SCR-Ext**	**2,4229**	**1,017**	**2**	**6,5**
FRAS113	Active	3,249	1,003	7	6,9
FRAS114	SCR-Ext	3,3096	1,107	6	6,5
FRAS115	SCR-Ext	2,0428	1	1	6,5
FRAS116	**Active**	**2,906**	**1,008**	**3**	**6,9**
FRAS117	**Active**	**2,4962**	**1,022**	**1**	**6,9**
FRAS118	**SCR-Ext**	**1,0497**	**1**	**0**	**6,5**
FRAS124	SCR-Ext	2,8831	1,079	3	6,5
FRAS125	SCR-Ext	2,8831	1,079	3	6,5
FRAS143	SCR-Ext	3,0438	0,991	11	6,5
FRAS144	SCR-Ext	0,2174	1	0	6,5
FRAS160	SCR-Ext	0,6763	1	0	6,5
FRAS168	SCR-Ext	2,6449	1	4	6,5
FRAS169	SCR-Ext	-0,2875	1	0	6,5
FRAS289	Active	2,8698	1,001	3	6,6
FRAS466	Active	3,4473	0,992	10	6,8
FRAS468	Active	0,4694	1	0	6,8
FRAS469	Active	2,8411	1,005	6	6,8
FRAS471	Active	2,5422	1,005	3	6,8
FRAS473	Active	2,5347	0,993	3	6,8
Weight mmax					0,5

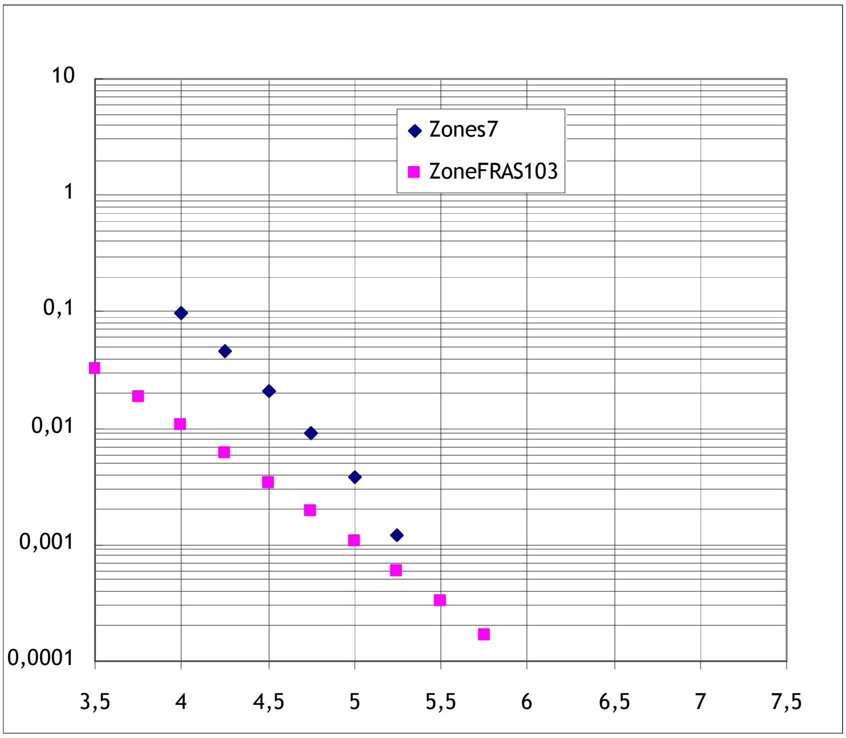
SHARE table provided by Jochen and used for comparison with Geoter.

GR comparison between Geoter (blue) and SHARE (pink) studies for area sources zones whose geometry is the same in EPAS and SHARE.

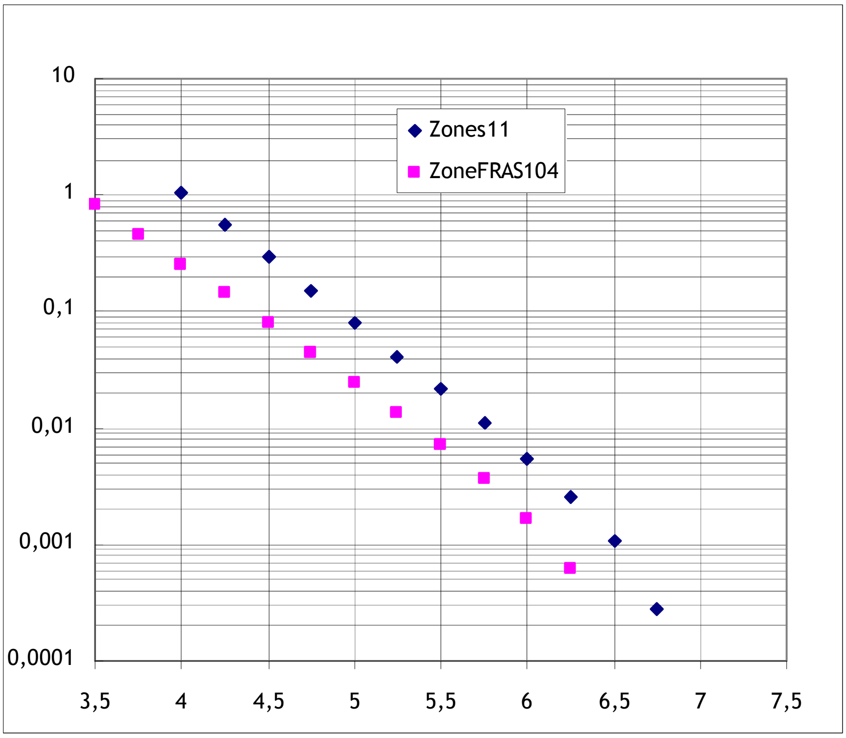
FRAS101	**SCR-Ext**	**2,9646**	**1,004**	**8**	**6,5**	**6,7**	**6,9**	**7,1**



FRAS103	**SCR-Ext**	**1,9308**	**0,976**	**1**	**6,5**	**6,7**	**6,9**	**7,1**



FRAS104 SCR-Ext 3,4451 1,009 23 6,5 6,7 6,9 7,1



This is the only zone for which the data allows a reasonable calibration of the GR

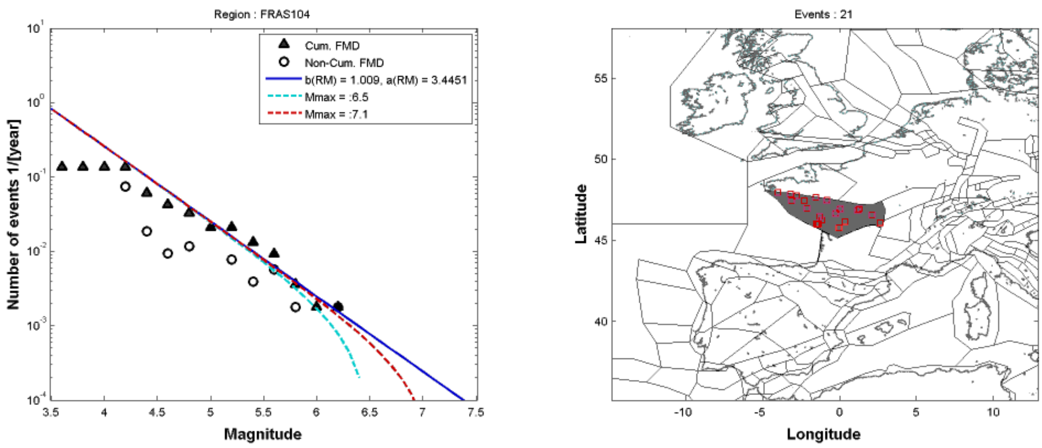
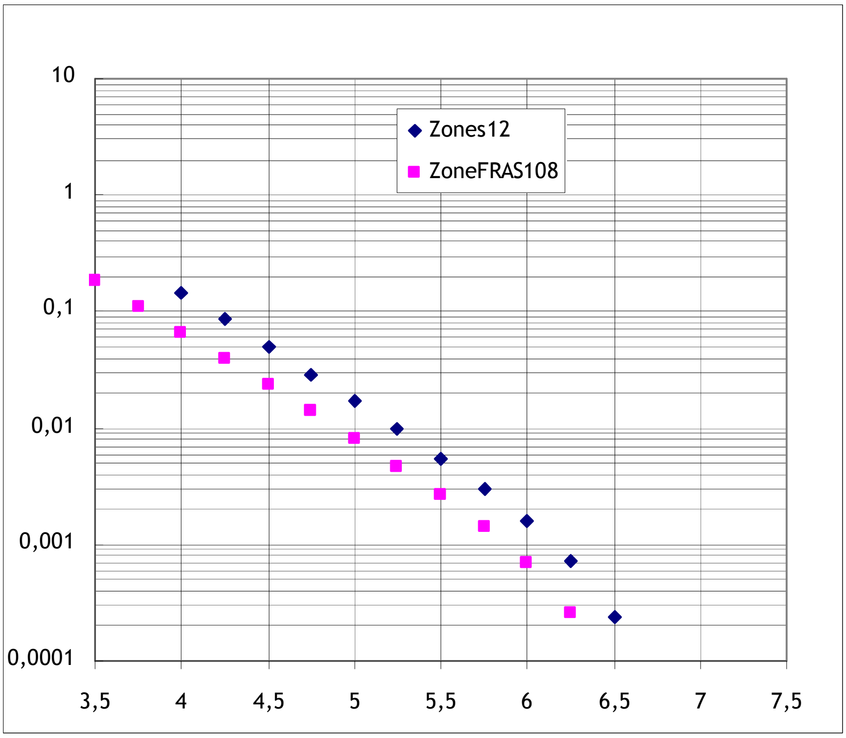
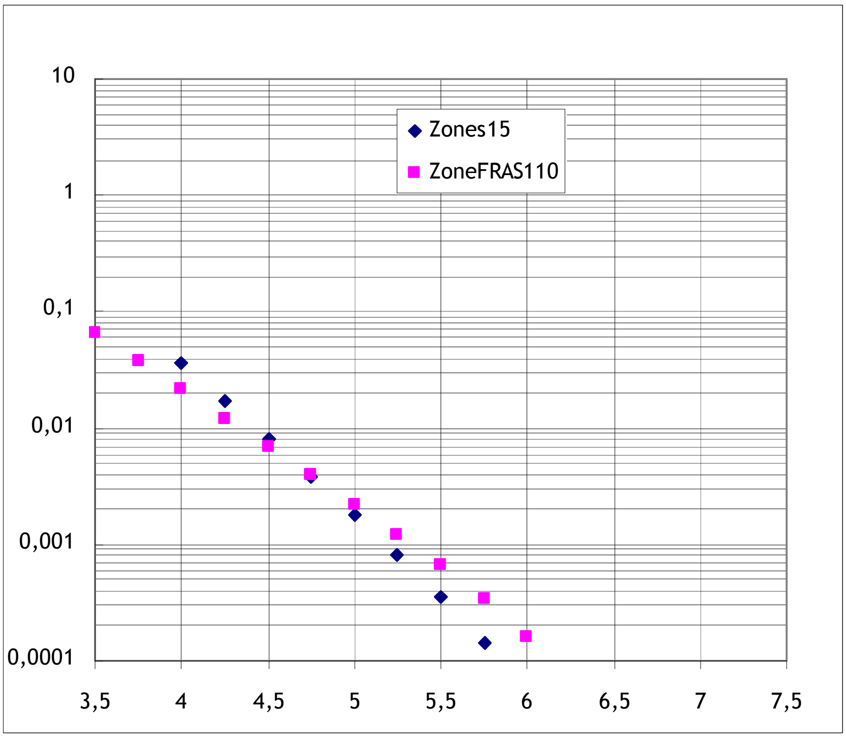


Figure from Jochen files.

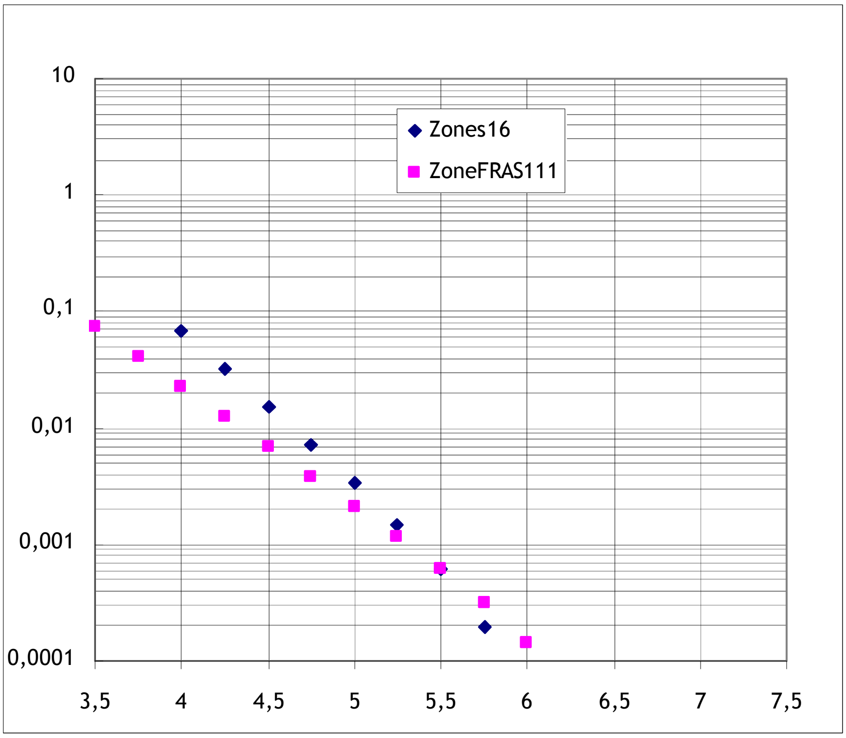
FRAS108 SCR-Ext 2,3982 0,894 7 6,5 6,7 6,9 7,1



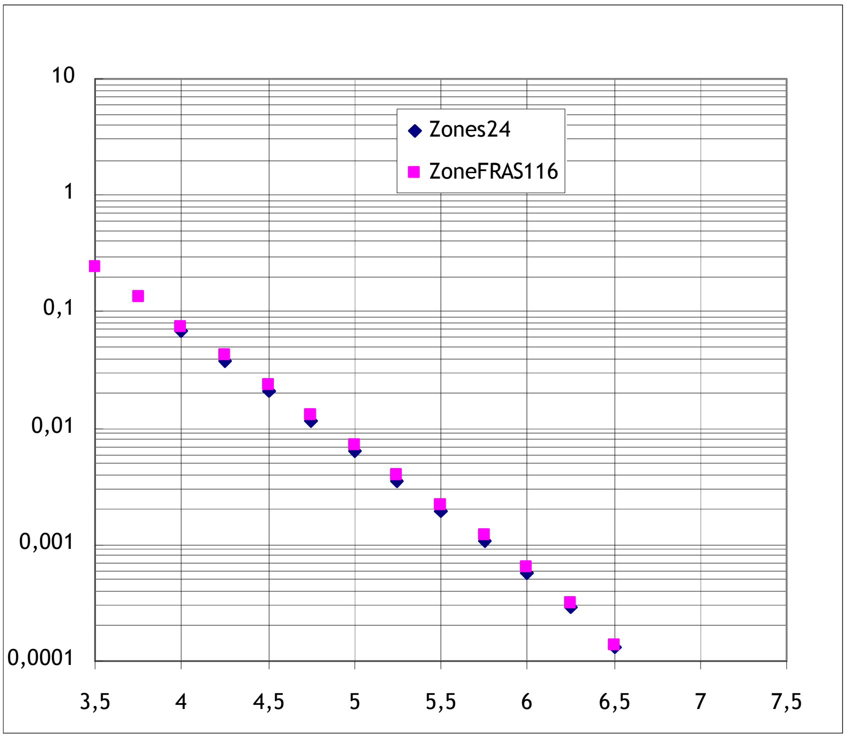
FRAS110 SCR-Ext 2,2495 0,979 2 6,5 6,7 6,9 7,1



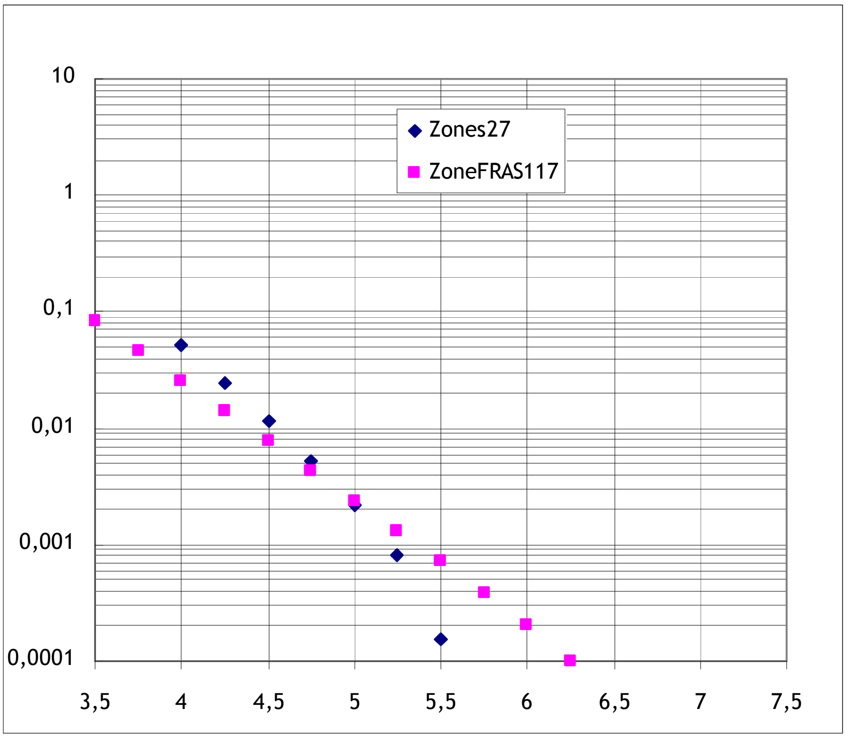
FRAS111 SCR-Ext 2,4229 1,017 2 6,5 6,7 6,9 7,1



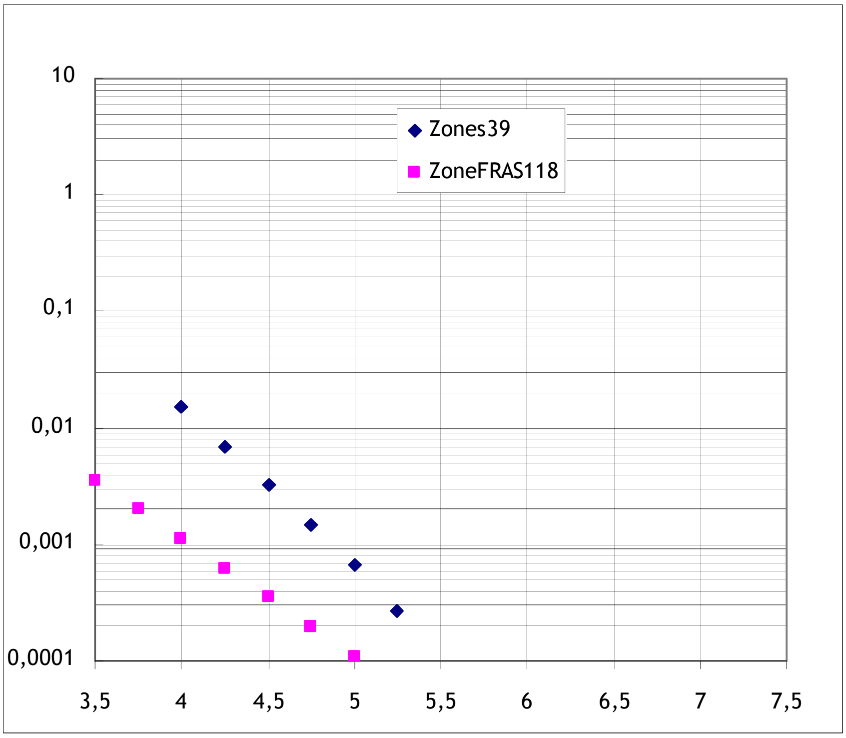
FRAS116 Active 2,906 1,008 3 6,9 7,1 7,3 7,5



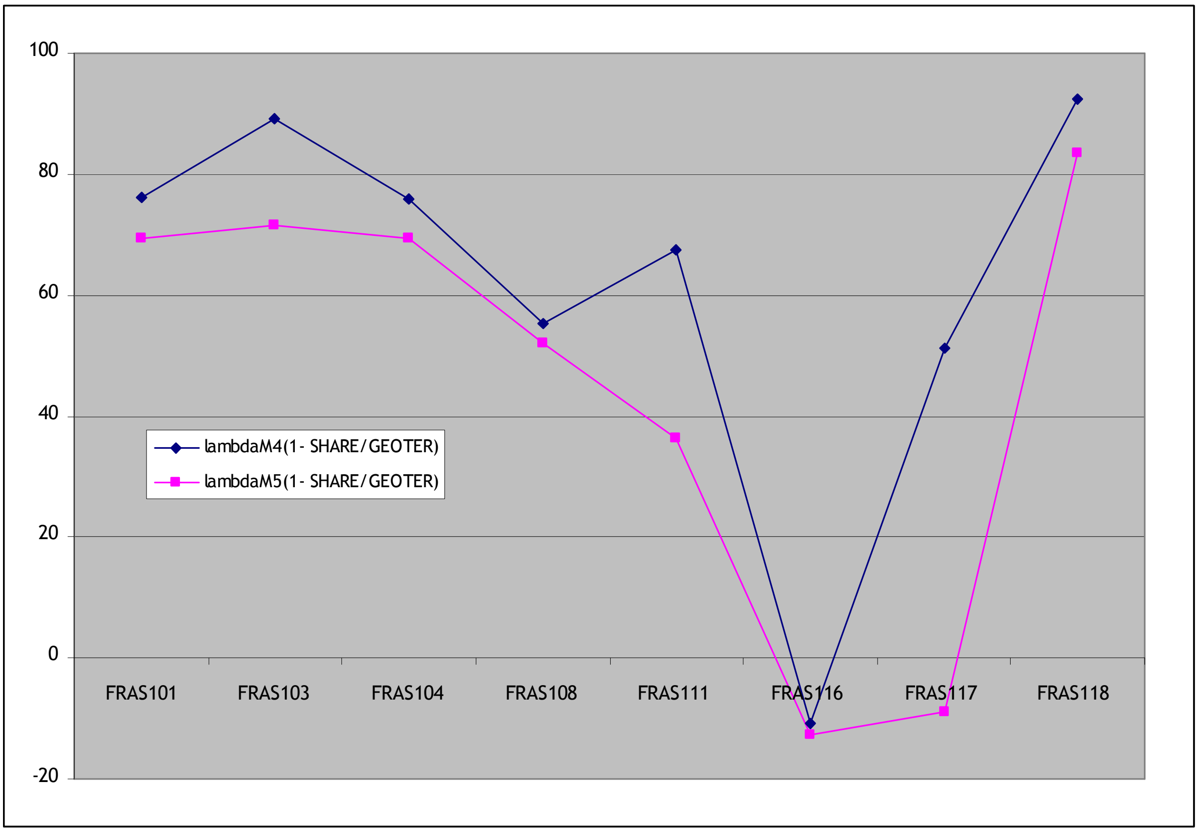
FRAS117 Active 2,4962 1,022 1 6,9 7,1 7,3 7,5



FRAS118 SCR-Ext 1,0497 1 0 6,5 6,7 6,9 7,1



What to say?



Based on the 8 out of 52 EPAS zones that I analyzed, I can partially confirm the conclusions of the first rough analysis:
for source zones FRAS101, 103, 104, 108, 118 activity rates will decrease by 50 to 90% for M>=4 and a bit less for M>=5.
For FRAS116 shows activity rate estimates similar to those of the GEOTER study.
For FRAS117 shows similar activity rates to the Geoter study but only for M>=5,

The most surprising result is the very heterogeneous differences between the activity rate estimates of the two studies.

1/ Magnitude conversions schemes, magnitude correction factors declustering schemes applied, Mmax estimates between the SHARE and Geoter study are quite different, ➔ may affect the resulting activity rates in an heterogeneously manner.

2/ Since most of the zones I compared here, with the exception of FRS104, have very little data, the criteria used in SHARE for attributing activity rates to areal zones that have only a few data points may also be a source of such an heterogeneous impact.

Conclusions

I make no suggestions for changes in activity rates.

Suggestions: the SHARE project should clarify the manner in which you treated source areas for which there is very little data (most of the French regions are affected by this problem). Some source area show tremendous increases in predicted activity rates of M>=5; these should be verified.

Appendix

EMAIL sent on the 27/07/2012 to:
Giardini Domenico; Conrad Lindholm; Hilmar Bungum; Ezio Faccioli; SCOTTI Oona; Corinne Stutz; Andrea Rovida; Roger M.W. Musson; G. Grünthal; Dr. Dietrich Stromeyer; Konstantinos Makropoulos; Mine B. Demircioglu; Karin Sesetyan; Erdik Mustafa; Pitilakis, Kyriasis; Helen Crowley; Laura Peruzza; Fäh Donat; Stefan Wiemer; Thierry Cameelbeck; Susana Vilanova; Joao Fonseca; Branislav Glavatovic; Mircea Radulian; Marco Pagani; Céline Beauval; Fabrice Cotton; Gianluca Valensise

Dear colleague

with some delay we are now ready to start the feedback process on the AS-model as indicated in the RoadMap that we developed in the 1st review meeting.

We have prepared the data and a short documentation on what we did and are now asking you for your feedback on the activity rates of the single Area Sources in the AS-Model Version 4. Since it is quite some information, I do not use milliarium but rather our webserver.

Please surf to
http://mercalli.ethz.ch/~jowoe/share/ModelEvaluation/
ans download the zip-file.

Open document (v1.v1.FeedbackActivityRates.pdf or the docx). This document explains in some detail what we did and what we expect from the feedback, also what the files are that are otherwise contained in the folders you have created by unzipping. The folder ASZ_activity contains plots that give you a good impression of the activity rate fit, this I recommend to go through in as a second step.

From the feedback we expect your expert opinion in case you would like changes of the activity rates to a single area source. The document shows you examples how we implemented this for some sources already. In case you have question, please send an email to me and Laurentiu!

Feedback implementation:
We are currently computing the hazard for the AS-Model Version 4. Given your feedback, we will implement them and hope to have then the next version ready (hopefully) for the September meeting. However, we are still also computing the other branches of the model and thus it is very tight in terms of computation time and preparation for the 2nd feedback meeting. So, we ask you to provide feedback as soon as possible, but latest August 7!

We now this is tight and we know it is summer and vacation time.....

FOR WP2 members (Helen and Kyriazis):
At this stage, I think you could use this model for initial computations of the loss scenario calculations for Deliverable D2.5. In case you need more information, please let us know.

In case you have questions, please let us know - me and Laurentiu!
Best regards
Jochen

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j.woessner@sed.ethz.ch<mailto:j.woessner@sed.ethz.ch>