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Seismic Hazard Harmonization in Europe

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THEME 6: Environment

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D5.2 – Structure of the logic tree to be used in seismic hazard computation

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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)	

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1. Introduction

The goal of the current document is, for the SHARE project, to present a structure for the logic tree on the level of the source model as well as on the level of single source zones. All details are not intended to be presented but rather the principles along which the logic tree will be constructed in SHARE.

WP5, or the representatives of this workpackage, see their role as a moderator to reflect the SHARE description of work (DOW) (SHARE, 2009), views and decisions within the SHARE project as expressed in the SHARE preparatory meeting as well the WP3 Rome September meeting 2009, the SHARE annual meeting 2010, the WP5/WP6 workshop April 2009 and the SHARE WP5 model building workshop October 2010. Inputs to the logic tree structure come from WP3 with the deliverables of the source model, activity rates and Mmax, and from WP4 with the deliverable ground-motion prediction equations (GMPEs).

The use of logic-tree in seismic hazard has become a common tool in probabilistic seismic hazard assessment (PSHA) (e.g., see Budnitz et al., 2007, Stepp et al., 2001, Coppersmith et al., 2009) for representing epistemic uncertainties, i.e., the uncertainties related to incomplete knowledge of the input model. An example from the SHARE region performed, is the PEGASOS project. This project sampled the epistemic uncertainty at a high level by using four different research groups, who, for the same area derived different source models leading to different hazard results (Coppersmith et al., 2009, Burkhard and Grünthal, 2009, Musson et al., 2009, Schmid et al., 2009, Wiemer et al., 2009).

The applied input models for probabilistic hazard assessment (PSHA) within the SHARE project, an areal source zone model, a source model with faults combined with background areal sources, and a diffuse seismicity based model, were decided upon in the SHARE preparatory meeting and DOW. For further description of these models see D5.1. The motivation for the different input source models are that we currently do not know the seismotectonic properties of the SHARE area to high enough detail to suggest a best model. Even though small parts of the SHARE area are well understood, uncertainties exist both as to the construction of areal sources as well as to completeness and reliability of fault source information. Therefore the use of the different model components, areal sources, fault sources, and diffuse seismicity sources (see D5.1), resulting in a source model logic tree, is reflecting the current epistemic uncertainties as understood within SHARE.

Apart from branching made at the source model level the SHARE logic tree will be also be built at the source zone level. At the source zone level seismicity parameters and GMPEs will be branched. A description follows below.

2. Logic tree for the source model

According to the SHARE input specification document (Sørensen et al., 2009) and D5.1, four source typologies can be implemented with the SHARE seismic hazard engine (SHE). These are smoothed/zoneless seismicity, areal source zones, fault sources, and subduction sources. It is not expected that all typologies will be applied in all areas of the model. From these sources three main branches of the logic tree for the source model will be constructed (Figure 1):

- Areal source model. A zone based model containing one branch of areal sources.
- Hybrid source model, for parts of the area where fault sources exist, a branch will be built of a hybrid source zone model consisting of background areal sources and fault sources.
- A smoothed/zoneless seismicity model branch.

The zone based areal source model will cover the whole area. This type of model has been constructed by T3.4 in eight regional workshops, email discussions and phone conferences during the first part of the SHARE project. The model is a so-called consensus model meaning that agreement has been reached by the participating experts in the various regions. Areal source models are in frequent use throughout the area (e.g., Grünthal et al., 1999a, 1999b, Jimenez et al., 2003) and often in an advanced stage (e.g., Grünthal et al., 2009, Meletti, 2008, Musson, 2007, Papaiouannou and Papazachos, 2000, Wiemer et al., 2009a). If several models are provided for a subarea then this part can be branched accordingly to number of models provided. This has however, so far not been provided by any of the SHARE sub-regions.

The hybrid model, consisting of fault sources in combination with areal background sources, will only cover a part of the area. The fault sources are being provided by from T3.2. The fault sources are also called seismogenic sources (Basili et al., 2009)

Smoothed seismicity model/zoneless approaches are described in more detail in D5.1. It should be mentioned that in the PEGASOS project, a SSHAC level 4 project, the branching of the input hazard model into both areal sources and gridded seismicity model/zoneless was approved and applied (Burkhard and Grünthal, 2009, Wiemer et al, 2009b).

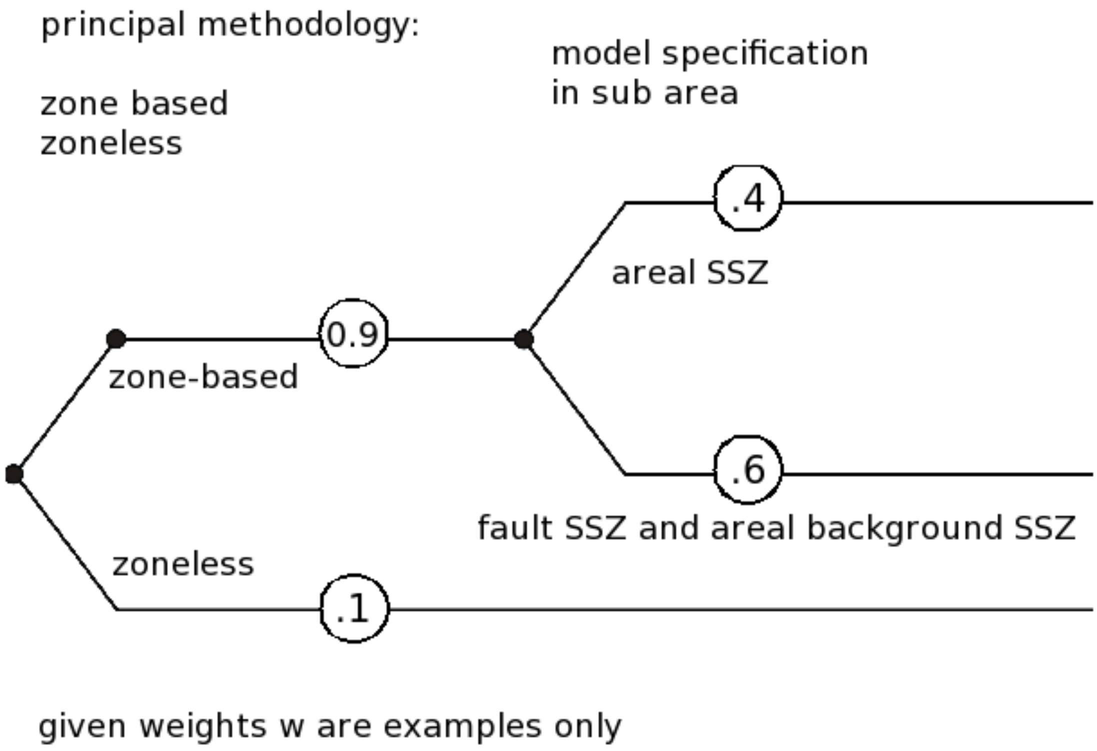

Figure 1. Example of the principal source model logic tree.

3. Logic tree of earthquake parameters and GMPEs for source zones

For each source, be it a smoothed seismicity model, a source zone or a fault source, epistemic uncertainties in the associated parameters can be branched out in the logic tree. Parameters to be branched are:

- Activity parameters
- M_{max}
- GMPEs

At this stage the details of the branching at the source zone level has not been made wherefore we present this part of the tree schematically (Figure 2). Other parameters, used in the source zones, like focal depth distribution and faulting style, are considered aleatoric and are not being part of the logic tree.

Activity parameters can be in either a and b pairs or ν_0-β pairs, and will be determined using a maximum likelihood methodology following Wiechert (1980). Further, the intention of T3.6 is to use a method taking into account location of events. The joint distribution of activity parameters will be captured by a sufficient number of parameter sets, e.g., 25 pairs (Figure 2). For fault sources the activity parameters can be determined either from the surrounding seismicity or fault slip information.

M_{max} can be determined from several different methodologies like the EPRI (Coppersmith., 1994) used in stable continental areas (SCR). The EPRI methodology allows for a discrete distribution of M_{max} values and are commonly used in SCR (e.g., see NORSAR & NGI, 1998, Wahlström & Grünthal 2001, Grünthal & Wahlström 2006, Burkhard & Grünthal 2009, Wiemer et al., 2009b) with the subdivision of extended and non-extended crust. It is expected that Mmax determination shouldnot always be determined for all single source zone, due to limited amount of seismicity, but sometimes need to be made for larger areas of similar properties in order to achieve more stable results.

In active regions M_{max} is often determined from observed maximum value (e.g., see Papiouannou & Papazachos, 2000, Rebez & Slejko 2004,) or observed maximum value and a safety margin (e.g., see Slejko et al. 1998).

GMPEs are usually adopted to specific tectonic regimes like stable continental areas, active regions, subduction zones, volcanic areas etc. (e.g., see Douglas et al., 2009). In SHARE each source will be characterized by WP3 and WP4 as belonging to a particular tectonic regime. The GMPEs will thus be delivered by WP4 as a suite of relations for corresponding tectonic regimes. It is expected that for some or all regions several equally valid GMPEs will be employed.

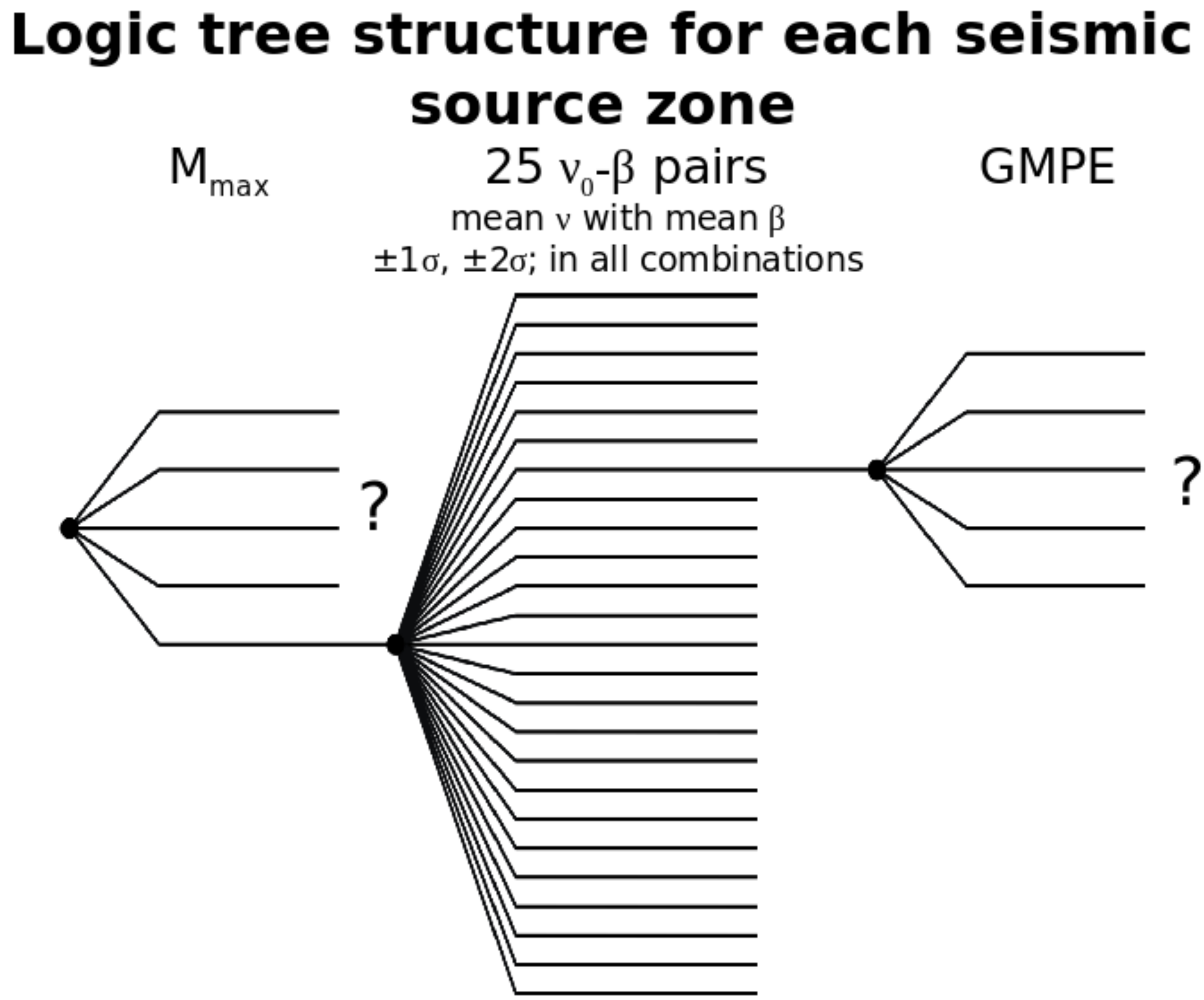

Figure 2. An example of logic tree structure for a single source zone. The branching details on M_{max} and GMPEs have not yet been fixed in this project.

4. Assignment of weights

The weight assigned to a logic tree branch should represent the likelihood of that branch being the true model. In most cases, however, weights will be assigned by the experts deriving the input data for the logic tree, based on their judgement of the likelihood of the competing models. Weights can also be derived from e.g. a Bayesian scheme as suggested by F. Scherbaum during the SHARE 1st annual meeting in June 2010.

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