TSUMAPS-NEAM method: SPTHA

TSUMAPS-NEAM Objectives

The project will develop the first **homogeneous region-wide long-term Probabilistic earthquake-induced Tsunami Hazard Assessment (PTHA)** for the coastlines of the NEAM (North East Atlantic, the Mediterranean, and connected seas), and trigger a common tsunami-risk management strategy in the region.

These results will be achieved through:

- realization of **state-of-the-art PTHA** with full uncertainty treatment;
- review process with **international experts**;
- production of the PTHA *database and maps*;
- publicity of results through an *awareness raising and education phase*, and a capacity building phase. The PTHA products can serve as a basis for future national PTHA efforts and be the first step to include tsunamis in multi-hazard risk assessments.

MAIN FOCUS HERE:
→ *Development of **TSUMAPS methodology***
→ *Definition of a **multiple-expert process** with partecipatory review*

TSUMAPS METHODOLOGY

STEP 1: PROBABILISTIC EARTHQUAKE MODEL

- the definition of the parameters of all the possible representative seismic sources that may generate tsunamigenic earthquakes in the future;
- the quantification of their long-run frequency (mean annual rates).

STEP 2: TSUNAMI GENERATION & MODELLING IN DEEP WATER

- the simulation of the sea floor displacement;
- the simulation of the tsunami generation and propagation from the source to the target area, up to a given bathymetric depth

STEP 3: SHOALING AND INUNDATION

- the simulation of the last phases of the tsunami impact;
- the stochastic simulation of the associated uncertainty (including uncertainty deriving both from simplified source modelling and simplified tsunami modelling);
- the combination of the tsunami with the tides.

STEP 4: HAZARD AGGREGATION & UNCERTAINTY QUANTIFICATION

- the quantification of the hazard curves at the target sites;
- the disaggregation analyses.

TSUMAPS METHODOLOGY

Each STEP is organized in Levels:

- *Level 0 identifies potential input DB (including alternatives)*
- *Levels > 0 identifies different topics (to be treated through contional prob)*

In each Level, alternative implementations (epistemic uncertianty) are discussed

STEP 4 integrates STEPS 1 to 3 into the final assessment

All the steps, levels and method are documented:

- *4 general documents overviewing the method*
  - *Document #1: OVERVIEW ON THE WORKFLOW FOR THE ASSESSMENT (THIS DOCUMENT): HERE WE LIST ALL THE STEPS AND THE LOGIC WITHIN THE STEPS.*
  - *Document #2 (WHAT): MORE DETAILED EXPLANATION OF THE “LEVELS” WITHIN EACH STEP.*
  - *Document #3 (HOW): ALTERNATIVE MODELLING AT EACH STEP & LEVEL.*
  - *Document #4: SANITY CHECKS AND TESTS (e.g. sensitivity).*
- *1 technical document per level & STEP, describing the details of the implementation*

MULTIPLE-EXPERT PROCESS (1/6)

from SSHAC (1997)

ISSUE DEGREE	DECISION FACTORS	STUDY LEVEL
A Non-controversial; and/or insignificant to hazard	•Regulatory concern •Resources available •Public perception	**1** TI evaluates/weights models based on literature review and experience; estimates community distribution
B Significant uncertainty and diversity; controversial; and complex		**2** TI interacts with proponents & resource experts to identify issues and interpretations; estimates community distribution
C Highly contentious; significant to hazard; and highly complex		**3** TI brings together proponents & resource experts for debate and interaction; TI focuses debate and evaluates alternative interpretations estimates community distribution
		4 TFI organizes panel of experts to interpret and evaluate; focuses discussions; avoids inappropriate behavior on part of evaluators; draws picture of evaluators' estimate of the community's composite distribution; has ultimate responsibility for project

MULTIPLE-EXPERT PROCESS (1/6)

from SSHAC (1997)

ISSUE DEGREE	DECISION FACTORS	STUDY LEVEL
A		1

SSHAC levels define a multiple-expert process, specifying:

- How data/models/decisions are documented
- How to internally review the analysis
- The definition of roles and responsibility
- The interaction of the different groups
- ....

The goal is the quantification of the epistemic uncertainty in terms of «*the center, the body, and the range of technical interpretations that the* ***larger technical community*** *would have if they were to conduct the study.* »

→ ***Community Distribution***

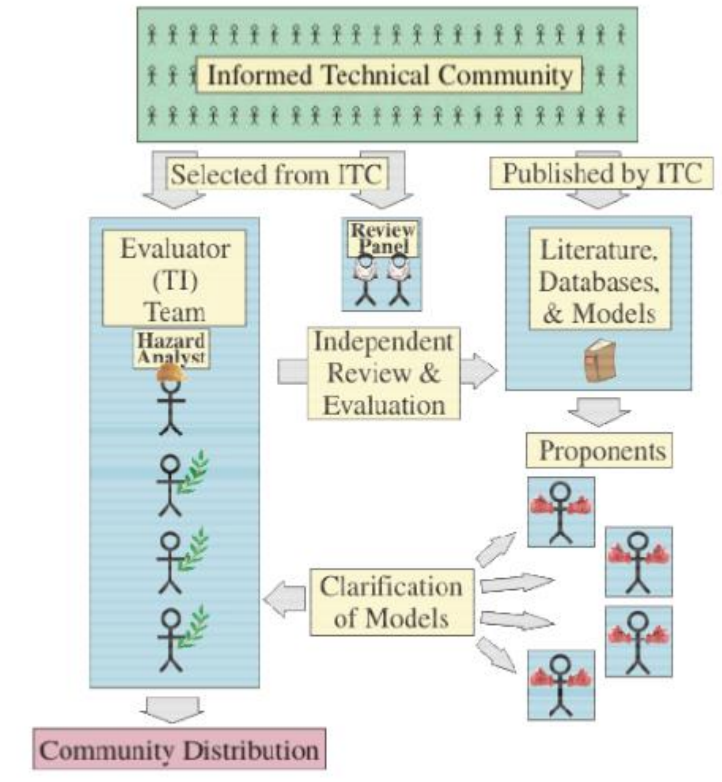
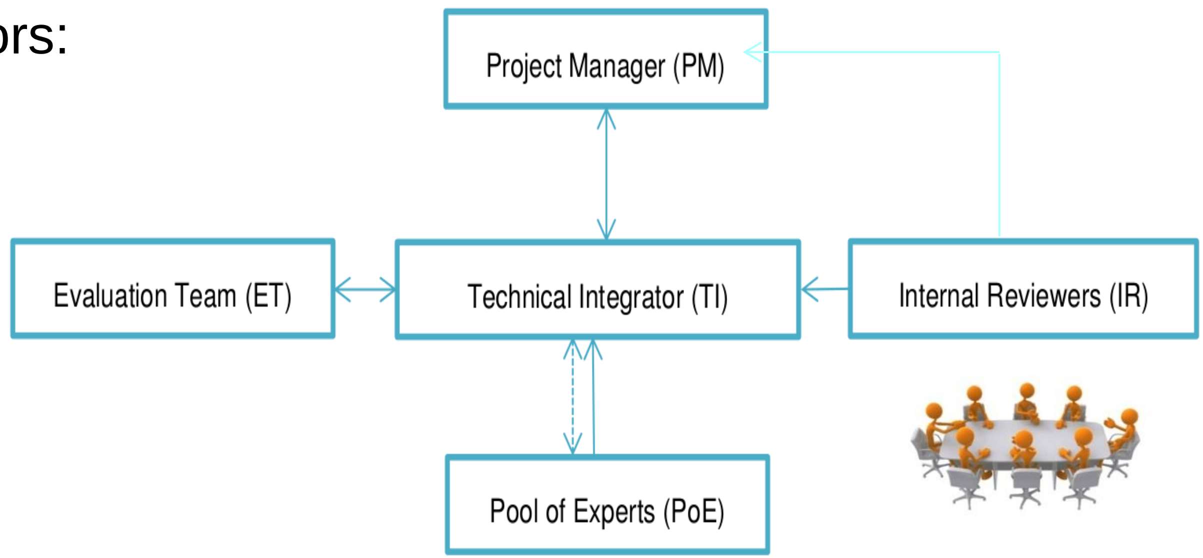


Figure 3. Expert interaction for SSHAC Level 2.

MULTIPLE-EXPERT PROCESS (2/6)

We apply a specific process (EU-P)

- EU-P is designed to guarantee (with limited budgets) the minimum level of robustness in **dealing with** and **quantifying** epistemic uncertainty (community distribution)
- EU-P is a multiple-expert process similar to SSHAC Levels 2/3 (with important differences, among which the use of classical elicitations…)
- EU-P with five core actors:



MULTIPLE-EXPERT PROCESS (3/6)

Project Manager (PM): Project manager is a stakeholder who owns the problem and is responsible and accountable for the successful development of the project.

Technical Integrator (TI): The technical integrator is an analyst responsible and accountable for the scientific management of the project.

Evaluation Team (ET): The Evaluation Team is a group of analysts that actually perform the hazard (and risk) assessments, under the guidelines provided by the TI.

Internal Reviewers (IR): One expert or a group of experts on subject matter under review that independently peer reviews (participatory) and evaluates the work done by the TI and the ET.

Pool of Experts (PoE: optional, only for high-level analyses**):** This pool has the goal of representing the larger technical community within the process. The pool is selected by PM and TI. The PoE supports the TI in making the most critical choices.

MULTIPLE-EXPERT PROCESS (3/6)

External (to TSUMAPS) experts are present in 2 groups: PoE and IR

→ ***The PoE provides input to the process***

→ ***The IR reviews the method, including the «fairness» in traslating and implementing PoE quantifications in the final results***

Project Manager (PM): Project ma[...] and is responsible and accountable [...]

Technical Integrator (TI): The tech[...] accountable for the scientific manag[...]

Evaluation Team (ET): The Evaluation Team is a group of analysts that actually perform the hazard (and risk) assessments, under the guidelines provided by the TI.

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MULTIPLE-EXPERT PROCESS (4/6)

Key features of EU-P:

- **Transparency:** Data, models and methods choices are documented;

- **Independence:** Project Manager (PM), Technical Integrator (TI) and Internal Reviewers (IR) are independent;

- **Responsibility:**
  - → PM holds the responsibility of the project and about all "political choices";
  - → TI holds the intellectual ownership of the process and is responsible for all "scientific choices" in the project and for the results.
  - → ET is responsible for performing the analysis following the TI requests.
  - → IR is responsible for the conformance between the scientific development of the project, the EU-P guidelines and the scientific up-to-date capabilities.

- **Consensus:** PM, TI and IR formally agree on the final products, holding the responsibility of them in their specific roles. Consensus should be reached on both procedural and technical aspects, including <u>conformance between PoE feedbacks and TI/PM choices.</u>

MULTIPLE-EXPERT PROCESS (5/6)

Main steps of the process through thephases

Phase 1 (pre-assessment): Data, models and methods are defined;

- PM defines the PoE
- TI+ET defines a list of alternative models and data to be used (on paper)
- *PoE interview #1 (expert elicitation): prioritization of levels for alternatives*
- *IR review Phase 1*
- PM and TI take decisions about how to proceed

Phases 2 (assessment): Models are implemented and results produced

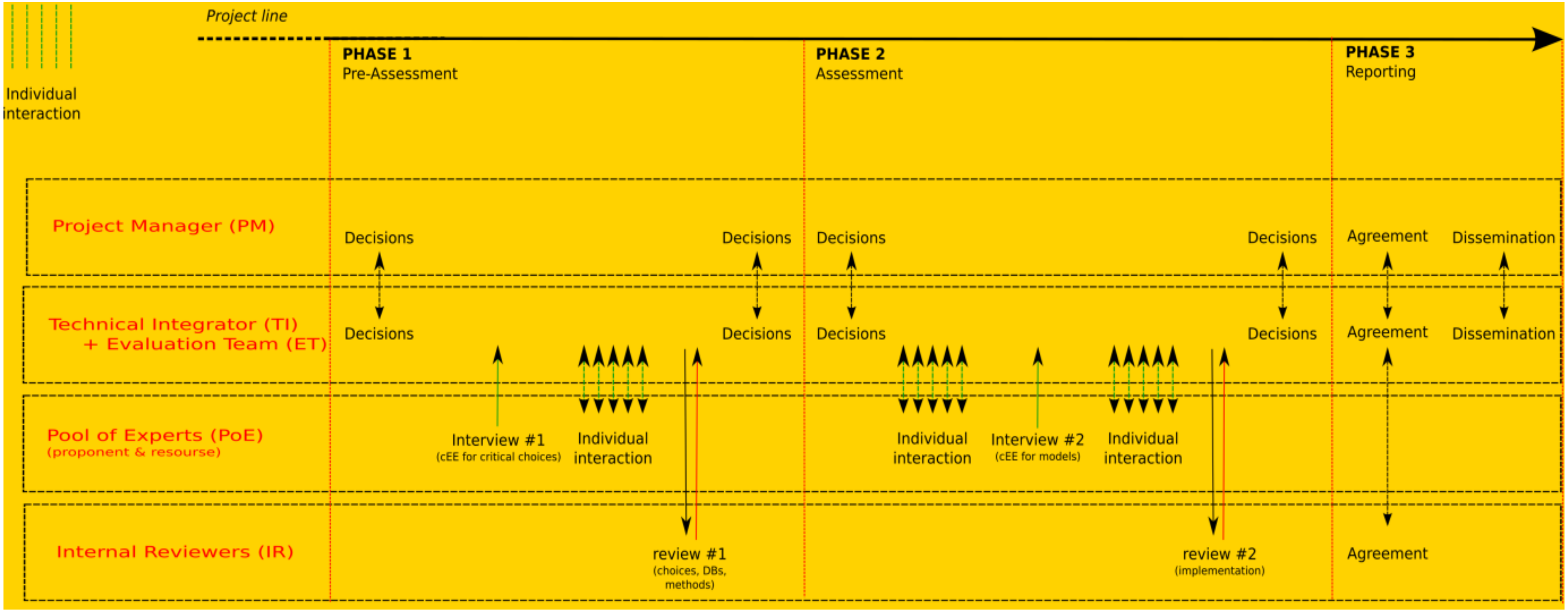
- TI+ET implement the selected models based on selected data;
- TI+ET implement the scheduled sanity checks and tests;
- *PoE interview #2 (expert elicitation): quantification of weights of alternatives*
- TI + ET produces preliminary results
- *IR review Phases 2*
- PM and TI set final implementation
- *PM + TI + IR reach an **agreement** of the results*

Phase 3 (reporting): Results are divulgated outside the project

MULTIPLE-EXPERT PROCESS (6/6)

Epistemic Uncertainty Process (EU-P, Selva et al., in prep) formulates a specific process (from SSHAC 1997) for the management of critical and subjective choices within a project targeted to (multi-) hazard and/or risk analyses.

EU-P foresees a project in 3 phases, with 5 interacting actors:



Role of Pool of Expert (PoE) in TSUMAPS-NEAM

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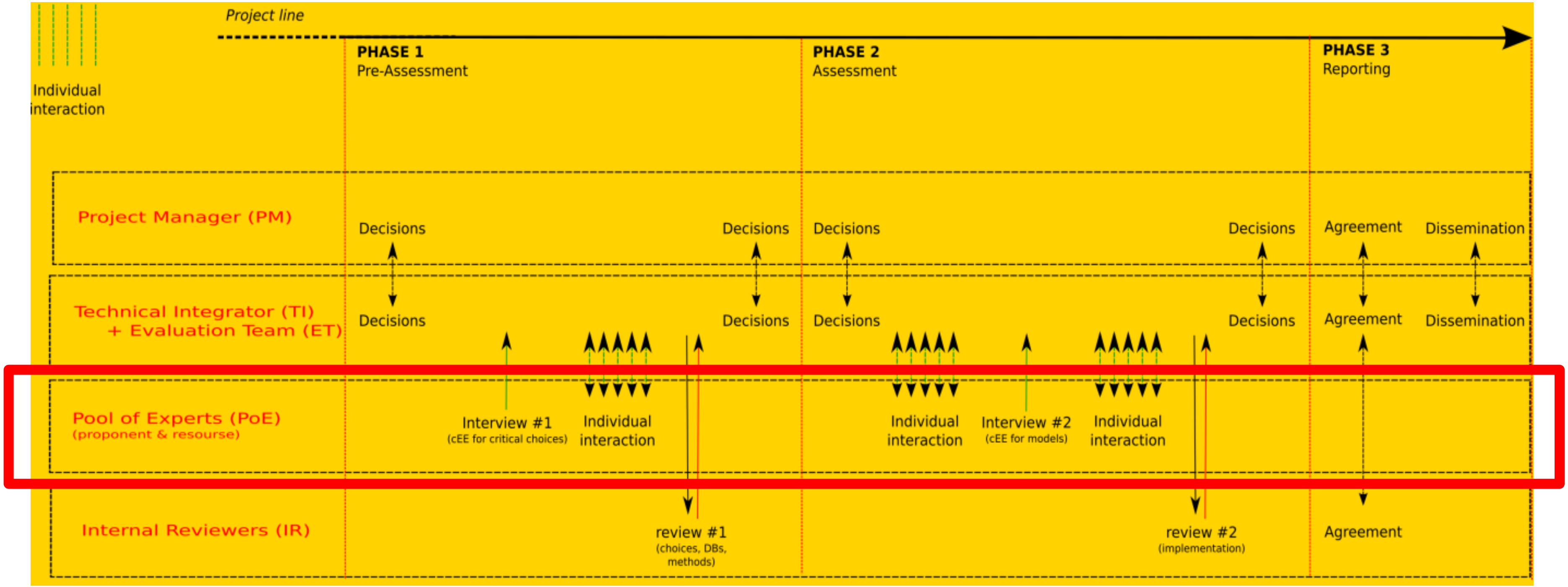
EU-Process & Panel of Experts (PoE)

- PoE interacts with Tis
- 2 formal feedbacks through ***expert elicitation***
- ***Individual interactions***, when required



EU-P within TSUMAPS-NEAM

Roles:

Project Manager (PM):	Steering Commitee
Technical Integrator (TI):	J. Selva, R. Omira, S. Lorito, H.K. Thio
Evaluation Team (ET):	TSUMAPS-NEAM Task B
Internal Review (IR):	@@
Panel of Experts (PoE)	@@

- *PoE is a mix of external & internal experts (not in TI and PM groups)*
- *Experties varies from Probabilistic Seismic Hazard Analyses, to source modelling and tsunami generation and propagation*
- ***PoE represents the extended technical community** (SSHAC 1997) within TSUMAPS-NEAM*
- ***PoE provides specific input** to the TSUMAPS-NEAM, regarding the management of epistemic uncertainty (critical choices, alternative models, etc.)*

→ classical Expert Elicitation (cEE)

classical Expert Elicitation

What cEE is?

- *Expert Judgement has always played a large role in science and engineering;*
- *Elicitations are conducted to quantify uncertainties (especially, when this is impossible from models/data);*
- *cEE is a structured process with 3 main stages:*
    - *Preparation: formulation of the problem, selecion of the panel, definition of target, query and performance variables, ...*
    - *Elicitation: collection of opinions through questionnaires*
    - *Post-processing: aggregation of opinons, discrepancy analysis, documentation, ...*

classical Expert Elicitation

Based on formal questinnaires: *they depend on*

→ *Goal of the assessment*

→ *Aggregation process (the method adopted, see below)*

→ *Selected process to seek 'consensus'*

Different classes of methods exist for cEE:

- *Mathematical VS Behavioral (with interactions)*
- *Bayesian (with prior) VS not Bayesian*
- *Direct VS undirect*
- *....*

Our selection: *Mathematical, not Bayesian, Direct*

→ *No iteration, no priors, and we ask what we want to know!*

Consensus

Rational consensus:

1. ***Reproducibility:*** *All results must be <u>reproducible</u>, with calculation models and data being clearly specified and made available.*
2. ***Accountability:*** *The <u>source of data</u> (name and institution) must be identified, and data must correspond to the exact source from which the data are elicited.*
3. ***Empirical Control:*** *Experts' assessments must be, in principle, physically observable (testable in future).*
4. ***Neutrality:*** *The elicitation process must ensure that the <u>actual beliefs of experts</u> be collected (e.g. no punishment or rewords through a self-rating system).*
5. ***Fairness:*** *All experts <u>must be regarded equally before the aggregation process</u>.*

Consensus

Seeking consensus

It is often facilitated by weighing experts into the aggregation phase:

- ***Equal weights:*** *all experts are equals*
- ***Self-scoring:*** *experts judge their own expertise (used with highly heterogeneous groups)*
- ***Performance based:*** *measuring the 'subjective' view about uncertainty*
- ***Acknowledgement based:*** *measuring the influence over the group*
- *...*

We compare 3 different strategies:

→ *Equal, Performance-based, Acknowledgement-based*

Performance based weighting scheme

GOAL:

Try to measure the capability of the expert in judging his/her own uncertainty

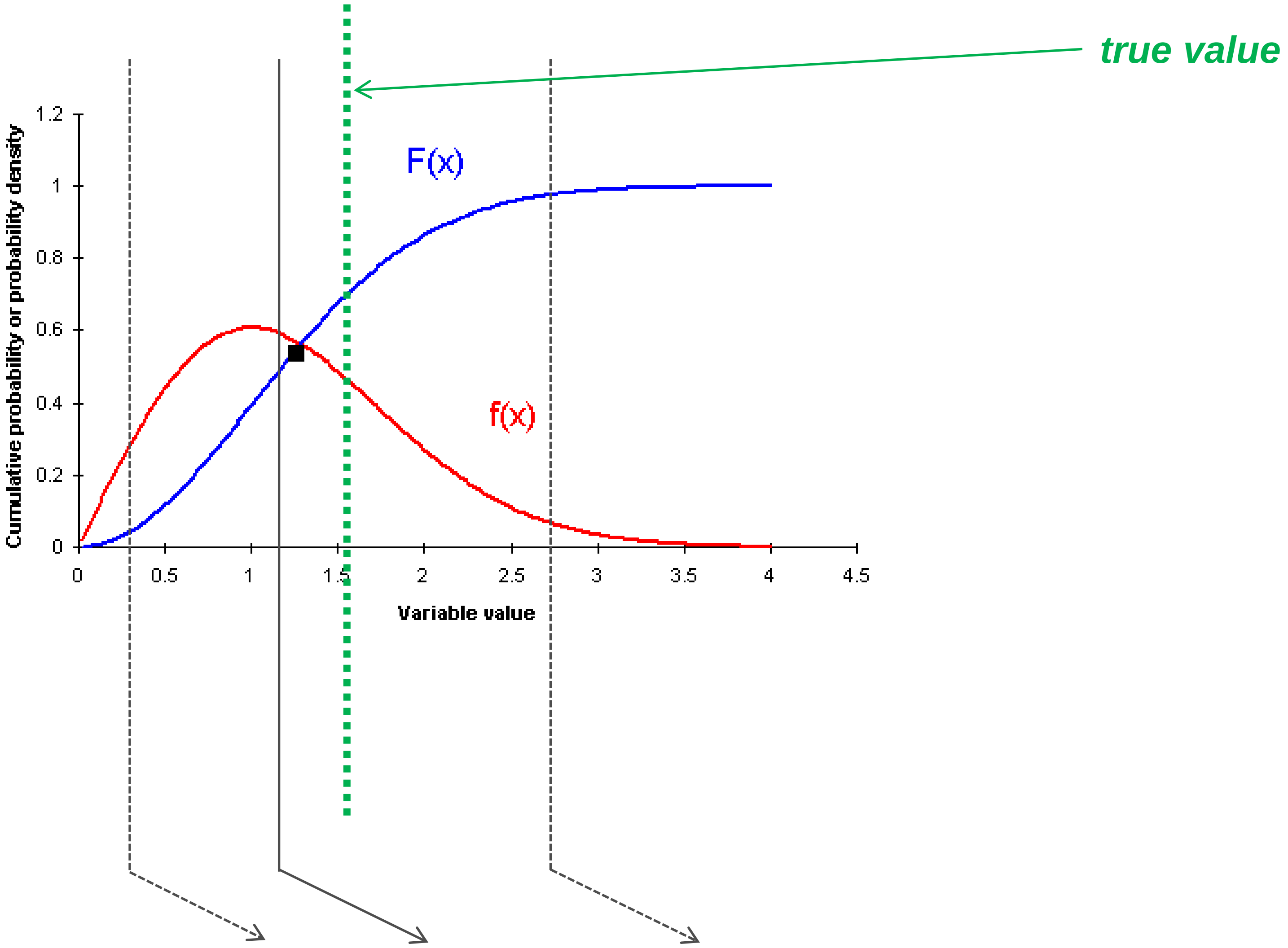
METHOD:

The performance is made on *seed* questions to which the elicitator knows the answer, but experts don't.

→ *the expert is not supposed to know the answers (but the opposite), the point is to measure how he/she deals with his/her uncertainty*

- Based on 'Calibration' and 'Information':
  → Calibration measures if the expert is biased
  → Information measures if the expert is informative

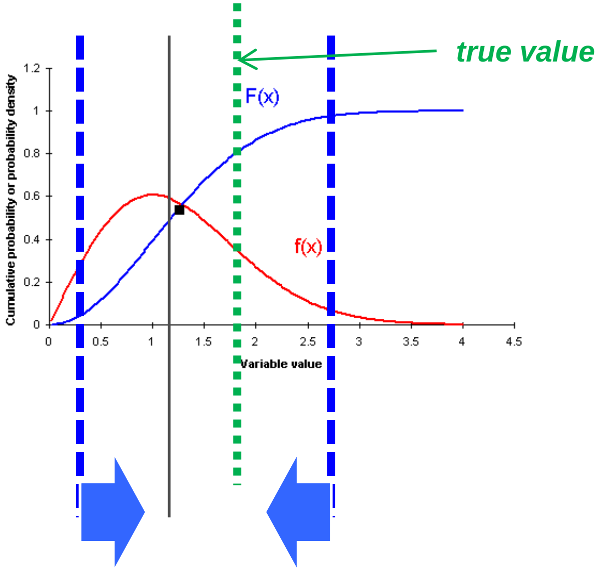
Performance based weighting scheme



We ask you 3 values: min, best guess, max

5-th perc median, 95-th perc

Performance based weighting scheme

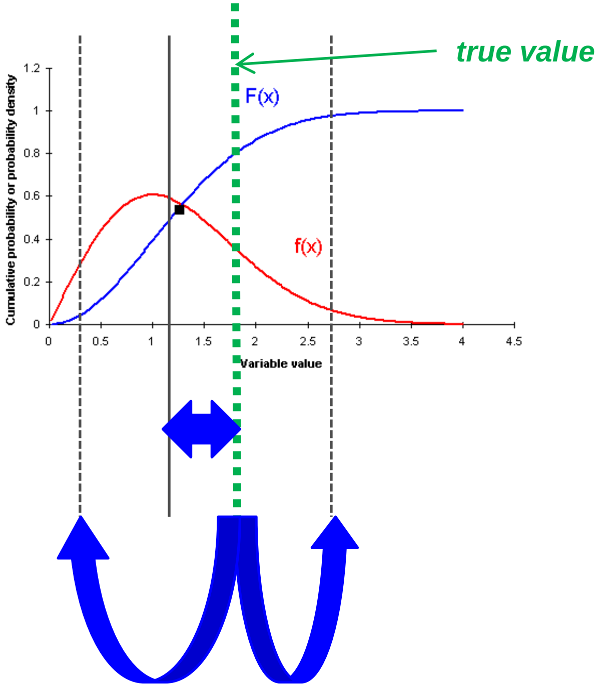


Information:

The weight increase if the distance between min and max diminishes:

Uncertainty ↓ ➔ ↑ Weight

Performance based weighting scheme



Information:

The weight increase if the distance between min and max diminishes:

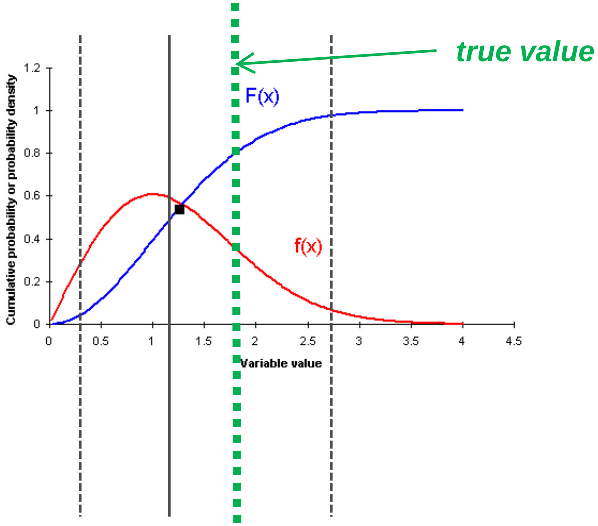
Uncertainty ↓ ➔ ↑ *Weight*

Calibration:

The weight decrease if the true value is close to best guess, and at least between min and max:

Precision ↑ ➔ ↑ ***Weight***

Performance based weighting scheme



Information:
The weight increase if the distance between min and max diminuisced

Uncertainty ↓ ➔ ↑ *Weight*

Calibration:
The weight decrease if the true value is close to best guess, and at least between min and max

Precision ↑ ➔ ↑ *Weight*

→ If your **uncertainty is too small**: ↑ **information** ↓ **calibration**

→ If your **uncertainty is too big**: ↓ **information** ↑ **calibration**

There are no magic rules... just try be 'honest' in judging your level of knowledge in each issue...

It is perfectly normal that you perform bad in more than 1 question...

Acknowlidgement based weighting scheme

GOAL:

Try to measure the representativeness of the opinion within the technical community

METHOD:

Mutual blind voting procedure. Each expert votes the 2 other experts, identifying who you would prefer to make quantifications *(if this is not you!!)*

- *You must vote for yourself (to avoid temptations, if selfvoting is forbitten...)*
- *You must select two collegues, scoring*
  - *1 collegue with weight 2 (higher confidence)*
  - *1 collegue with weight 1*

Post-processing

- ***Results are computed with equal, performance & acknowledgement weights***

  → *check of consistency & identification of controversies*

  Potential controversies will be openly discussed, to see if there was

  a problem in the formulation, or it was a real controversial issue...

- ***Weighted results will be used****, since typically more stable and with smaller uncertainties.*

classical Expert Elicitation

- *We will send you the **results** of the analysis*

- *Weights and votes of experts will **never be disclosed**!!*

  → *Results will be discussed either in an aggregated form, or in an anonymous way.*

*"We note that poor performance as a subjective probability assessor does not indicate a lack of substantive expert knowledge. Rather, it indicates **unfamiliarity with quantifying subjective uncertainty** in terms of subjective probability distributions" (Willy Aspinall)*

Expert Elicitation Methods

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Formal feedbacks

Pre-assessment phase: Feedback #1 (max Sept. 2016)

Goal: Trimming the alternative tree

Accopaining material*: general documents overviewing the methodology, technical documents regarding input methods*

Assessment phase: Feedback #2 (max Dec. 2016)

Goal: Weights of alternative models (e.g., like in a Logic Tree)

Accopaining material*: general documents overviewing the methodology, technical documents regarding implementations, results of sanity checks and tests*

Other (?)

Overview

Method: Analytic Hierarchy Process (AHP)

→ Prioritization of levels

→ Ranking (weighting) of alternative models

...same method, but different level of complexity is expected!!

Other cEE methods (e.g., the Cooke's classical method) may be used for other quantifications, if required...

Analytic Hierarchy Process (AHP)

To assign weights on alternative models used in hazard/tsunami hazard assessment

Analytic Hierarchy Process (Task B):

- More than 5000 applications
- Organizes and analyzes a decision problem in a structured way
- Decompose the problem into a hierarchy
- Evaluate the various nodes in hierarchy using pairwise comparisons
- Compares experts' judgments in pairs on a verbal scale (1-7)
- Converts the evaluations to numerical values
- Numerical values on alternatives -> required results

Analytic Hierarchy Process (AHP)

Three main steps:

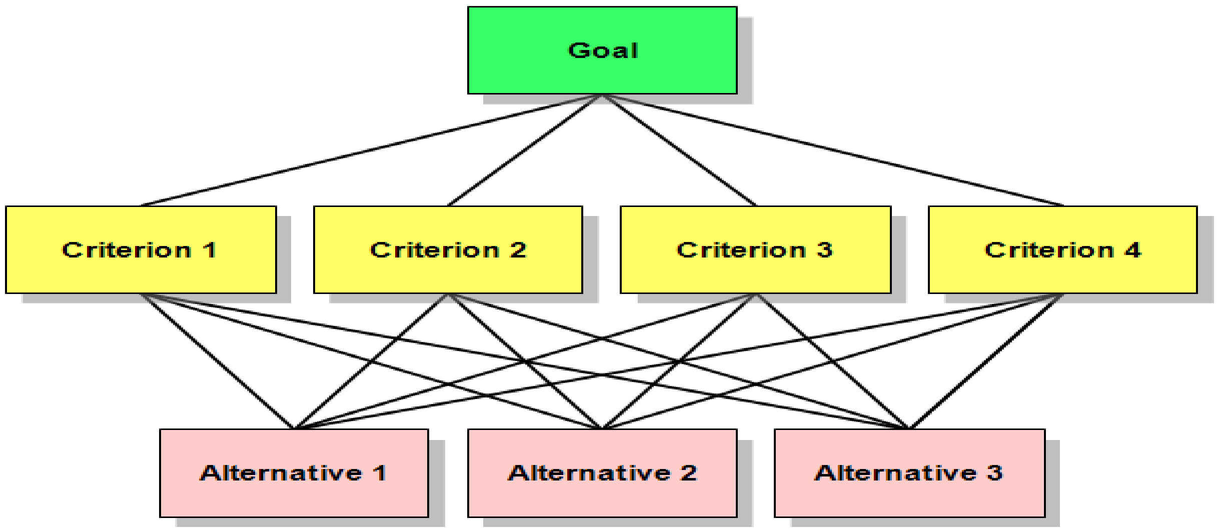
Objective: Weighting of alterative models

Criteria: Criterion (C1), Criterion (C2), Criterion (C3)

(e.g., personal confidence, applicability, validation, independence)

Alternatives: Model (M1), Model (M2), Model (M3)

(e.g., truncated pareto, tapered pareto, etc.)



Analytic Hierarchy Process (AHP)

Three steps:

1. Pairwise comparsions among criteria
2. Pairwise comparisons among models, with respect to each criterion
3. Synthesis of outcome and results

Example Questions

In your opinion: (<u>find in letter's attachment</u>)

STEP 1

What is the relative importance of C1 over C2?

What is the relative importance of C1 over C3?

STEP 2

What is the relative importance of C2 over C3?

...

What is the relative importance of M1 over M2, following C1?

What is the relative importance of M1 over M3, following C1?

...

Analytic Hierarchy Process (AHP)

Scale:	1-Equal important	3-Moderate important	5-Strong important	7-Very strong important	9-Extreme important
C1/C2 or M1/M2					
C1/C3 or M1/M3					
C2/C3 or M2/M3					

Your judgments

Alternative	**M1**	**M2**	**M3**
M1	1	7	1/3
M1	1/7	1	5
M2	3	1/5	1

Matrix forms

Models	**M1**	**M2**	**M3**
Weights	0.25	0.55	0.20

Our Objective

Thank you