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# Quantifying Uncertainties for earthquakes' Magnitude and Depth

Ludmila Provost, Oona Scotti

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## INTRODUCTION

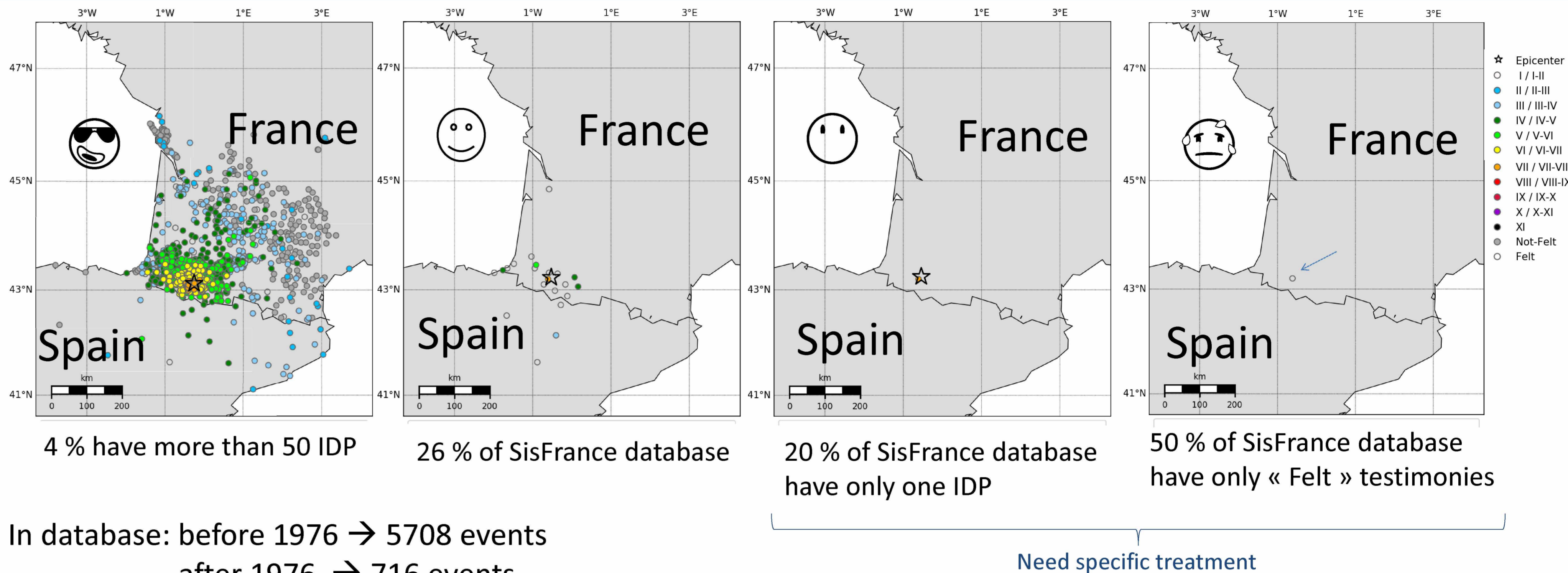
We develop a methodology that quantify uncertainties for earthquakes' (M, H) by giving a space of possible (M,H) solutions based on intensity data uncertainties as well as on IPE epistemic uncertainties: the QUake-MD methodology.

The only data available on historical earthquake are the information provided by historical sources. This information can be translated into intensity through the use of intensity scale.

Magnitude and depth (M, H) can be estimated from macroseismic intensity by using empirical intensity prediction equations (IPE).

However both intensity data and the IPE are marred of uncertainties. Intensity data of one earthquake can be very sparse and their attributed intensity value are often based on one historical source, which can be a secondary source. Calibration of IPE is a challenging task. Indeed IPEs are sensitive to the choice of calibration earthquake, to the (M, H) instrumental parameter values and associated uncertainties, regional heterogeneities of attenuation, etc.

M, H estimates from macroseismic intensity are thus uncertain. The application of one IPE on macroseismic data gives one couple of (M, H) solution, with eventually an associated uncertainty but is it enough?

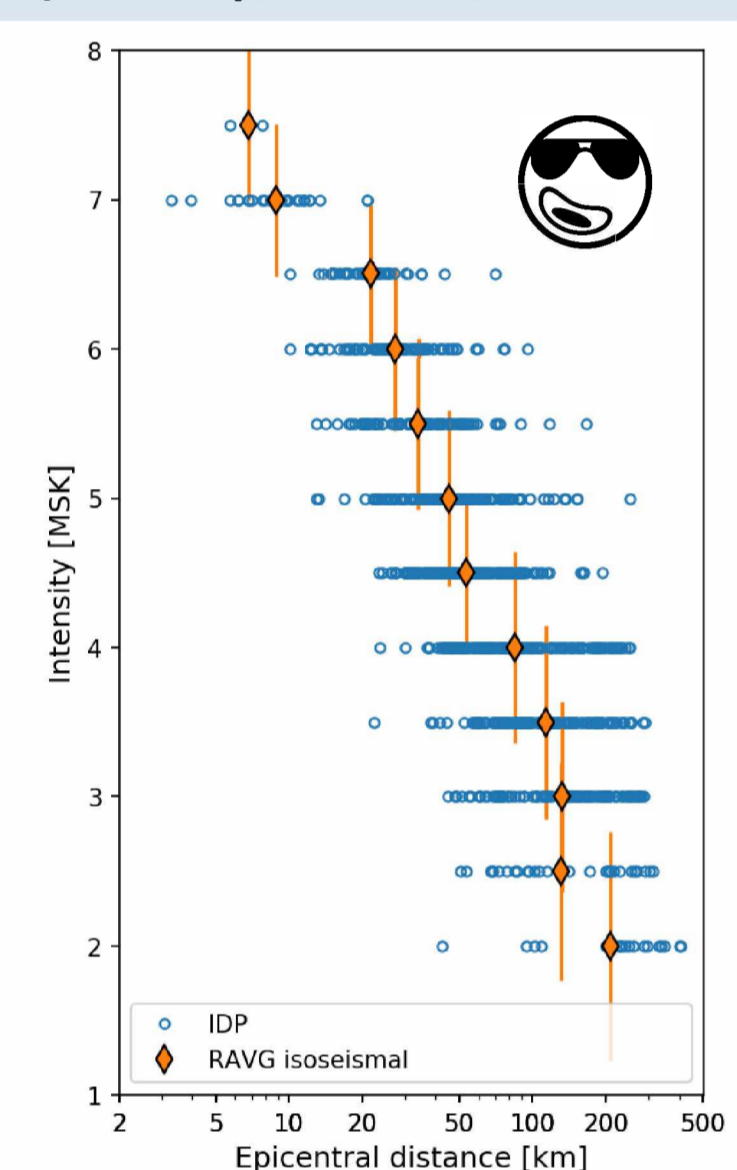


Database used for the poster: SisFrance ([www.sisfrance.net](http://www.sisfrance.net), consortium BRGM, EDF, IRSN)

## QUake-MD : QUantifying Uncertainties for earthquakes' Magnitude and Depth

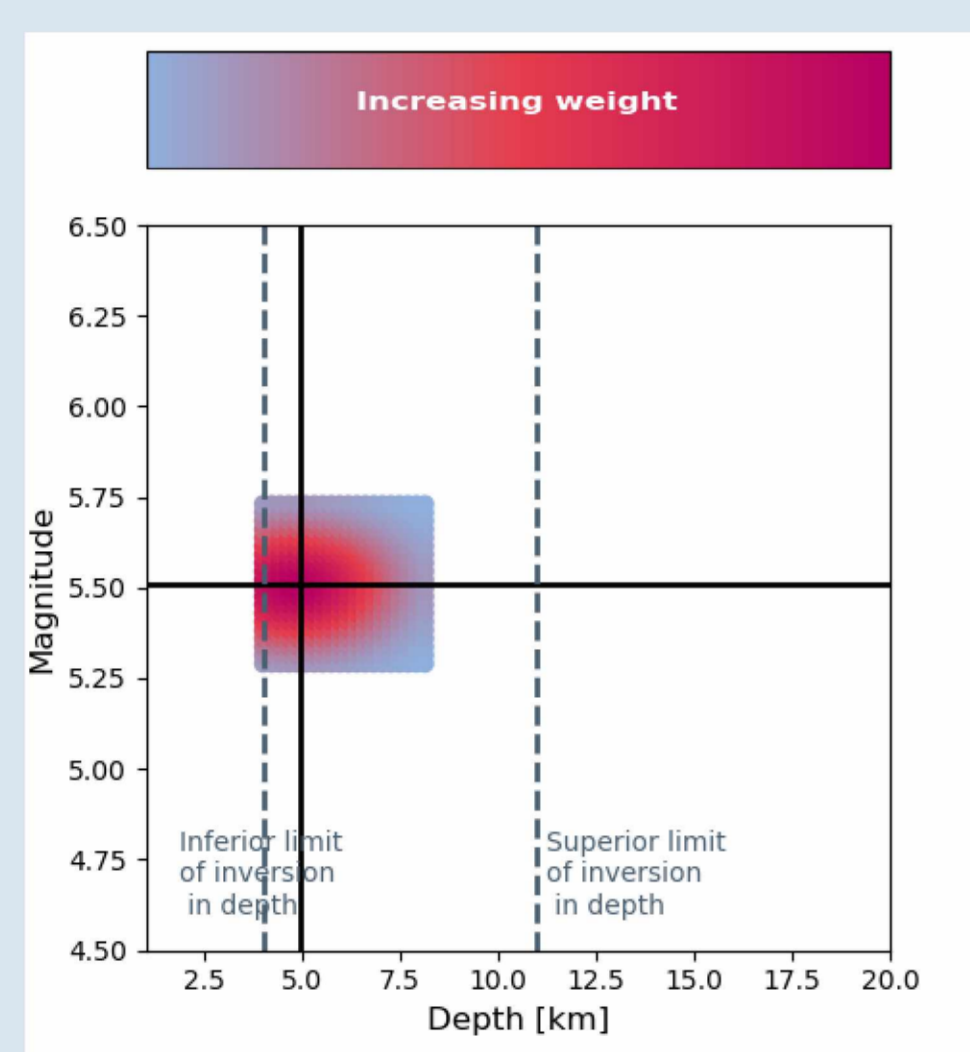
### Quantifying intensity data uncertainties

Example of QUake-MD application on one calibration earthquake (Arudy, 1980, instrumental Mw=5.1)

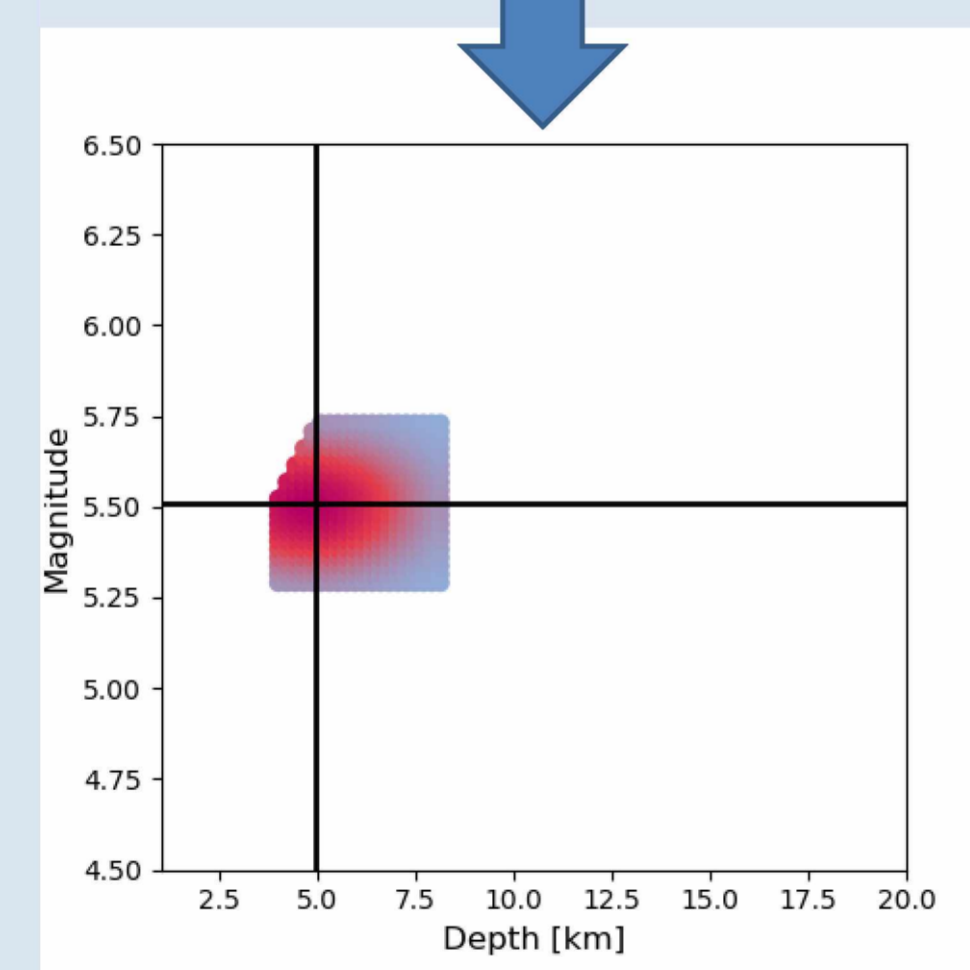


Least square inversion with constraints for depth on data with one IPE  
 Intensity data weighted by their quality factor

Quality factor	Weight
A	4
B	3
C	2



$I_0$  + uncertainties filtering

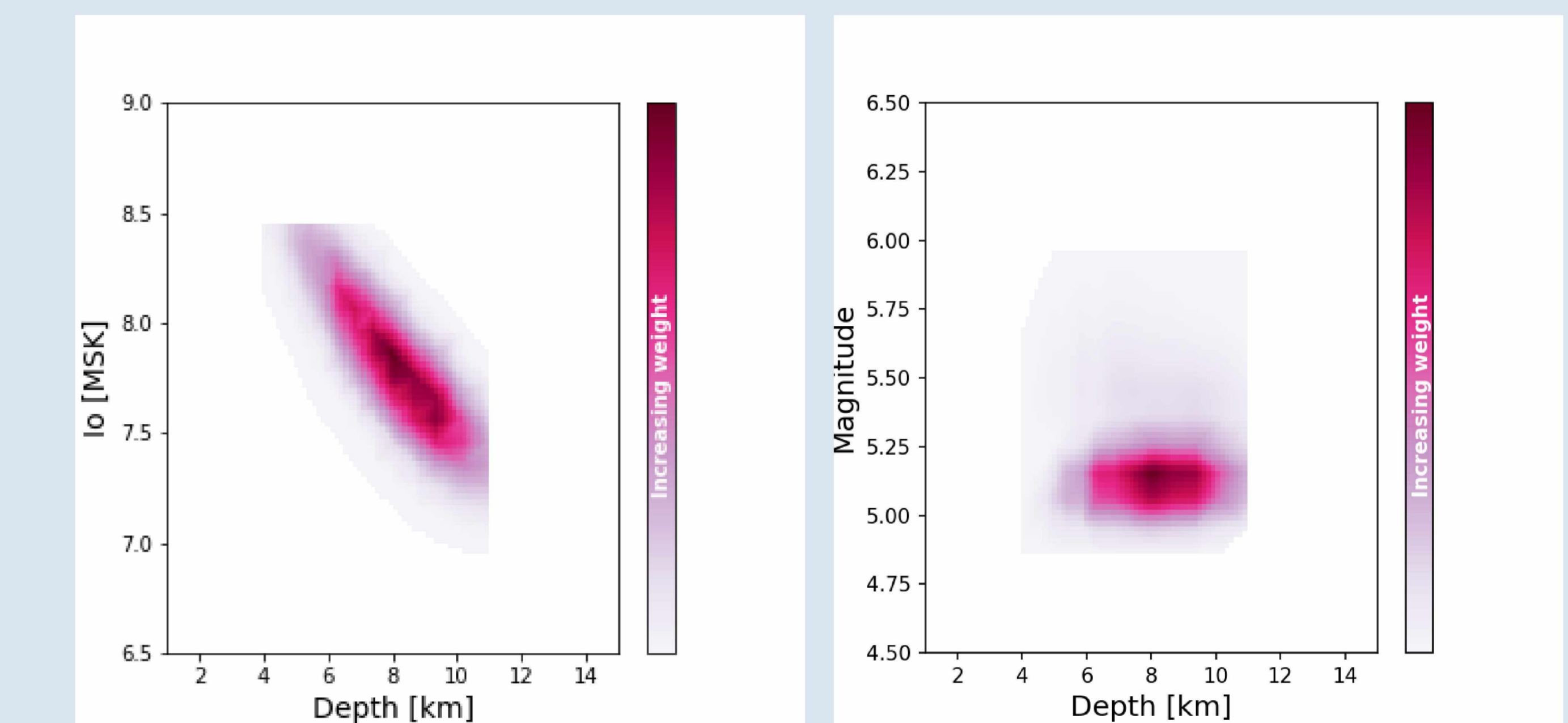
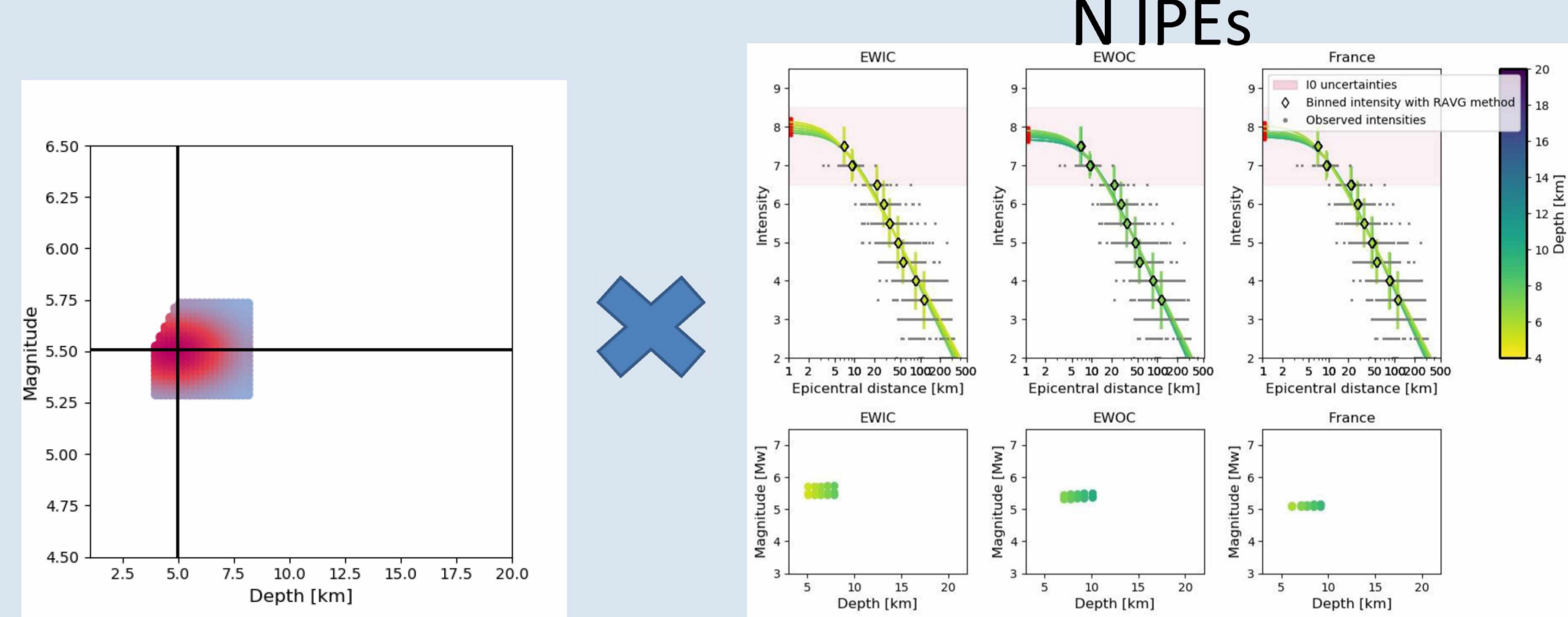


One space of solution for one IPE

### Required

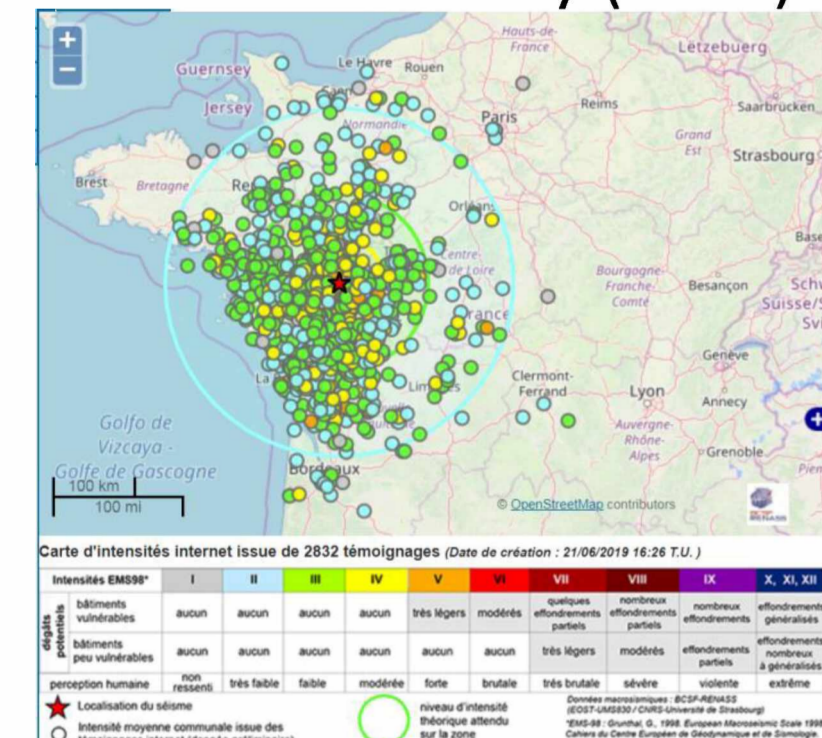
- An IPE with the following mathematical formulation:  
 $I = C1 + C2M + \beta \log(D_{hypo}) + \gamma D_{hypo}$
- Quality factor associated to each intensity data points
- Epicentral intensity  $I_0$  with associated uncertainties or  $I_{0\min}$  and  $I_{0\max}$
- Depth limit  $H_{min}$  and  $H_{max}$  for the application of the IPE to estimate (M, H)

### Quantifying IPE epistemic uncertainties



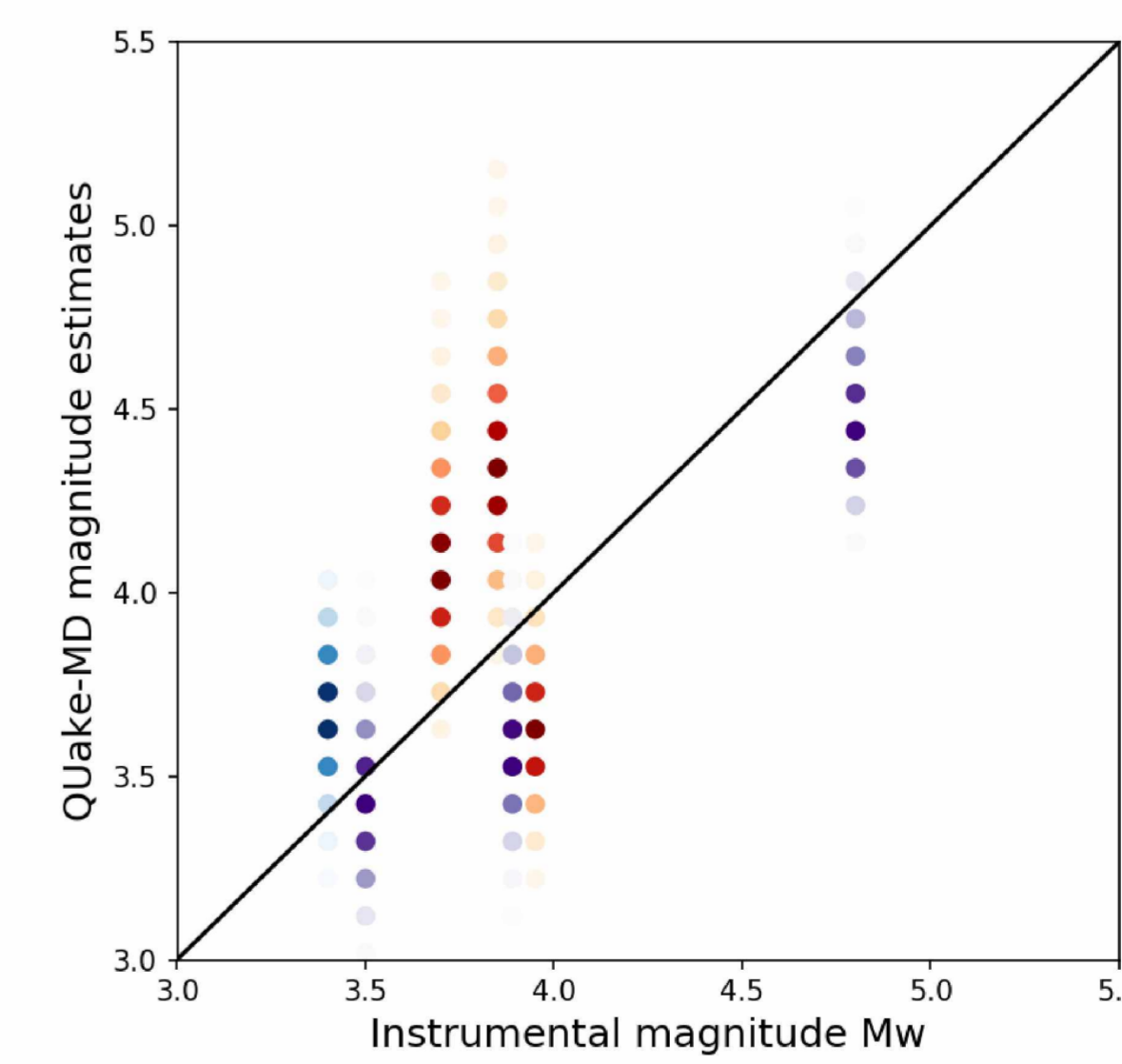
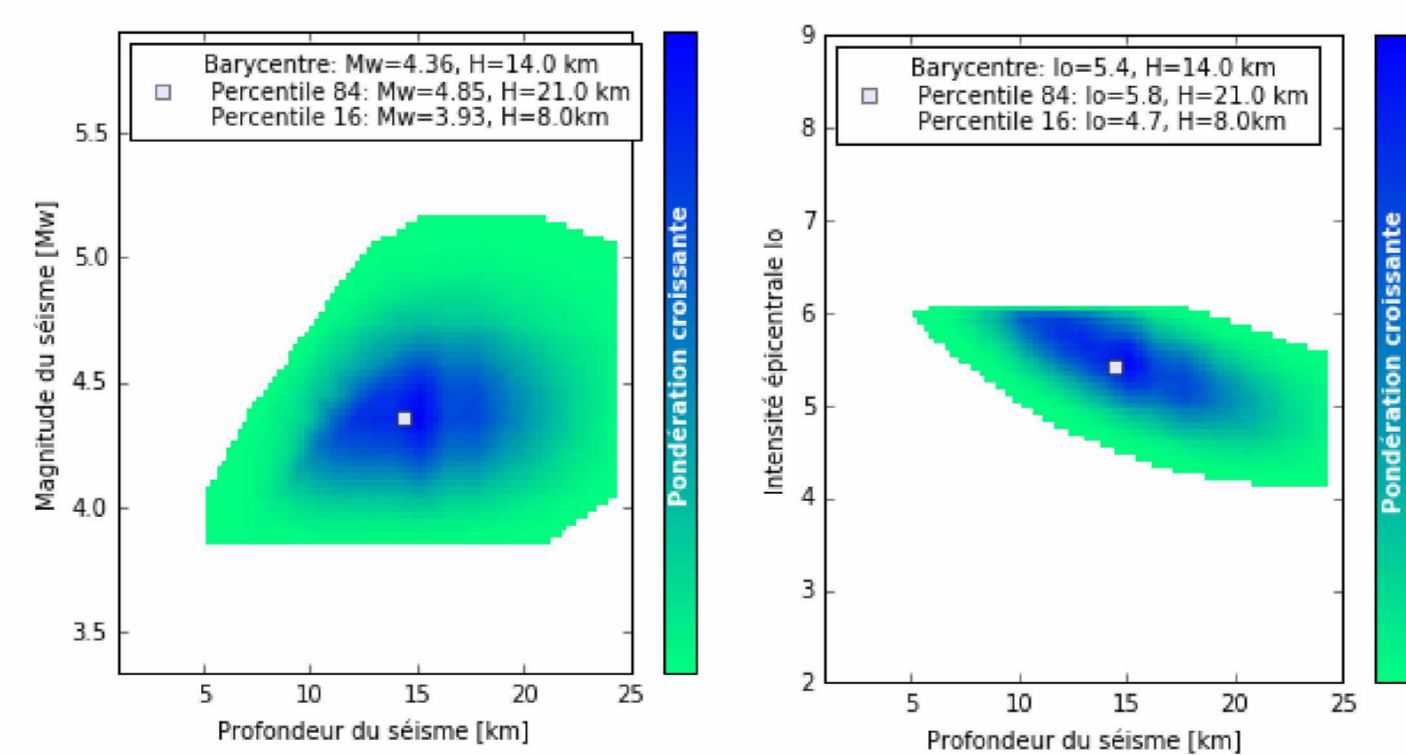
## Testing QUake-MD on recent earthquakes using internet intensities

Internet intensity (BCSF) from the 06/21/19, 06:50 pm



Latitude: 47.1505°N  
 Longitude: 0.3367°W  
 Date : 21/06/2019  
 Local time: 09h50  
 Local magnitude MI(source Renass): 4.8  
 Local magnitude MI(source LDG): 5.2  
 Magnitude Mw: 3.9 (Satriano)

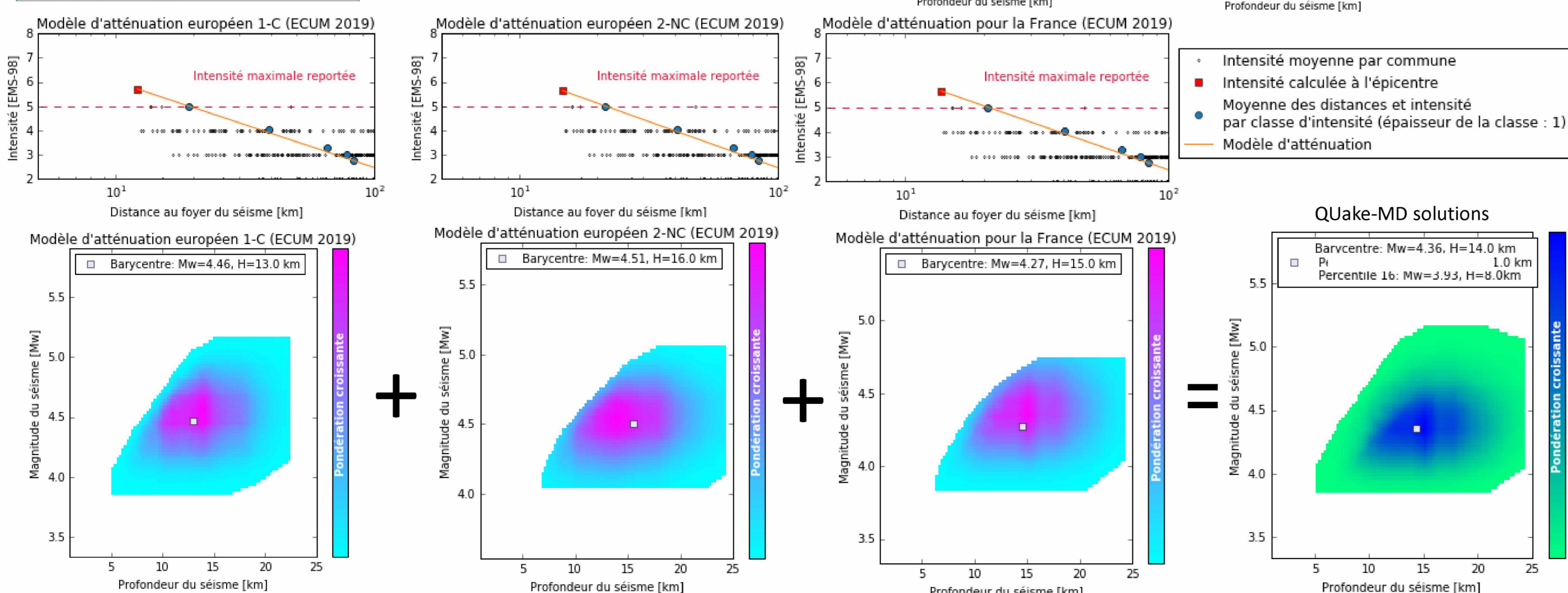
### QUake-MD solutions



West France  
 East France  
 SE France

8 recent earthquakes with available instrumental Mw compared.

Source of the instrumental Mw: C. Satriano and B. Delouis



Name of the earthquake	Date	Inst. Mw	Mmin - Mmax Quake-MD	H Quake-MD barycenter	Macroseismic field quality
Barcelonnette (SE France)	07/04/2014	4.7-4.8	4.2-5.1	9 km	A
Barcelonnette (SE France)	06/11/2015	3.9	3.2-4.2	11 km	C
La Rochelle (W France)	28/04/2016	3.8-3.9	3.7-4.9	12 km	A
Digne-les-Bains (SE France)	10/11/2016	3.5	3-4	9 km	C
Saint-Hilaire-de-Voust (W France)	12/02/2018	3.9-4	3.2-4.1	4 km	C
Bourg-en-Bresse (E France)	21/11/2018	3.4	3.2-4	12 km	B
Montendre (W France)	20/03/2019	3.7	3.6-4.9	9 km	B
Layon (W France)	21/06/2019	3.9	3.9-5.1	14 km	A

➔ Need for accurate estimates of instrumental Mw and depth to test QUake-MD