The Active Fault Parameters for Time-Dependent Earthquake Hazard Assessment in Taiwan

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Taiwan is located at the boundary between the Philippine Sea Plate and the Eurasian Plate, with a convergence rate of ~ 80 mm/yr in a ~N118E direction. The plate motion is so active that earthquake is very frequent. In the Taiwan area, disaster-inducing earthquakes often result from active faults. For this reason, it’s an important subject to understand the activity and hazard of active faults.

The active faults in Taiwan are mainly located in the Western Foothills and the Eastern longitudinal valley. Active fault distribution map published by the Central Geological Survey (CGS) in 2010 shows that there are 31 active faults in the island of Taiwan and some of which are related to earthquake. Many researchers have investigated these active faults and continuously update new data and results, but few people have integrated them for time-dependent earthquake hazard assessment. In this study, we want to gather previous researches and field work results and then integrate these data as an active fault parameters table for time-dependent earthquake hazard assessment.

We are going to gather the seismic profiles or earthquake relocation of a fault and then combine the fault trace on land to establish the 3D fault geometry model in GIS system. We collect the researches of fault source scaling in Taiwan and estimate the maximum magnitude from fault length or fault area. We use the characteristic earthquake model to evaluate the active fault earthquake recurrence interval. In the other parameters, we will collect previous studies or historical references and complete our parameter table of active faults in Taiwan.

The WG08 have done the time-dependent earthquake hazard assessment of active faults in California. They established the fault models, deformation models, earthquake rate models, and probability models and then compute the probability of faults in California. Following these steps, we have the preliminary evaluated probability of earthquake-related hazards in certain faults in Taiwan.

By accomplishing active fault parameters table in Taiwan, we would apply it in time-dependent earthquake hazard assessment. The result can also give engineers a reference for design. Furthermore, it can be applied in the seismic hazard map to mitigate disasters.

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Abstract

The time-dependent earthquake hazard assessment of active faults has developed in U.S.A and Japan for many years. However, Taiwan still at the step of investigation and data collection for active faults. Few people have integrated them for time-dependent earthquake hazard assessment.

In this study, the active fault parameters from pervious researches are gathered and integrated for time-dependent earthquake hazard assessment in Taiwan. We focus on the fault model and try to exhibit the 3D fault geometry model in GIS system.

The active fault parameter data accomplished by this study can be applied it in time-dependent earthquake hazard assessment. Moreover, this parameters can also provide for engineers a reference for design and seismic hazard map to mitigate disaster.

Introduction

Taiwan is located at the boundary between the Philippine Sea Plate and the Eurasian Plate, with a convergence rate of ~ 80 mm/yr in a ~N118E direction (Figure 1). The plate motion is so active that earthquake is very frequent (Figure 2). In the Taiwan area, disaster-inducing earthquakes often result from active faults.

The active faults in Taiwan are mainly located in the Western Foothills and the Eastern longitudinal valley. Active fault map published by the Central Geological Survey (CGS) in 2010 shows that there are 33 active faults in Taiwan and some of which are related to earthquake (Figure 3). Many researchers have investigated these active faults and continuously update new data and results, but few people have integrated them for time-dependent earthquake hazard assessment.

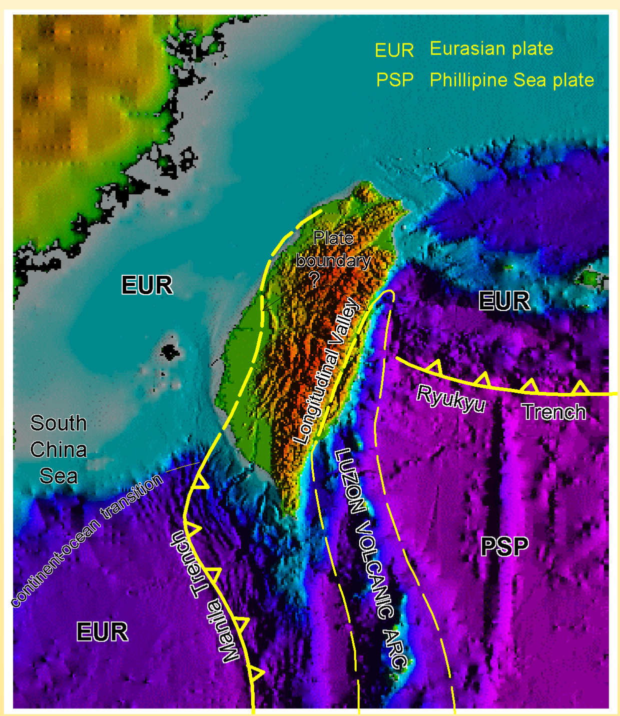


Figure 1 Location and Geological setting of Taiwan.

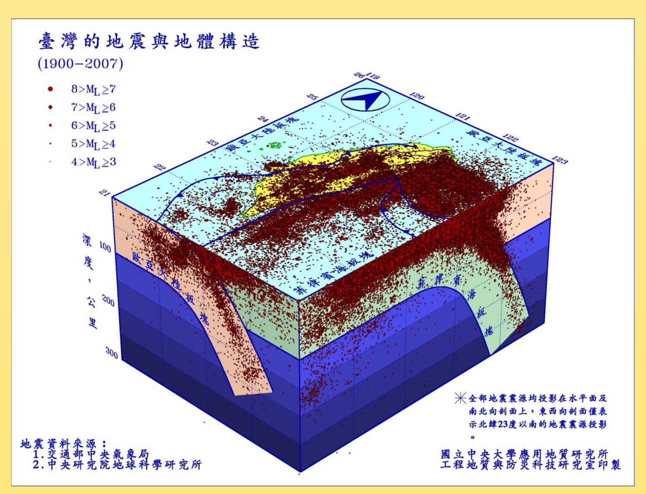


Figure 2 The plate structure and seismic distribution of Taiwan.

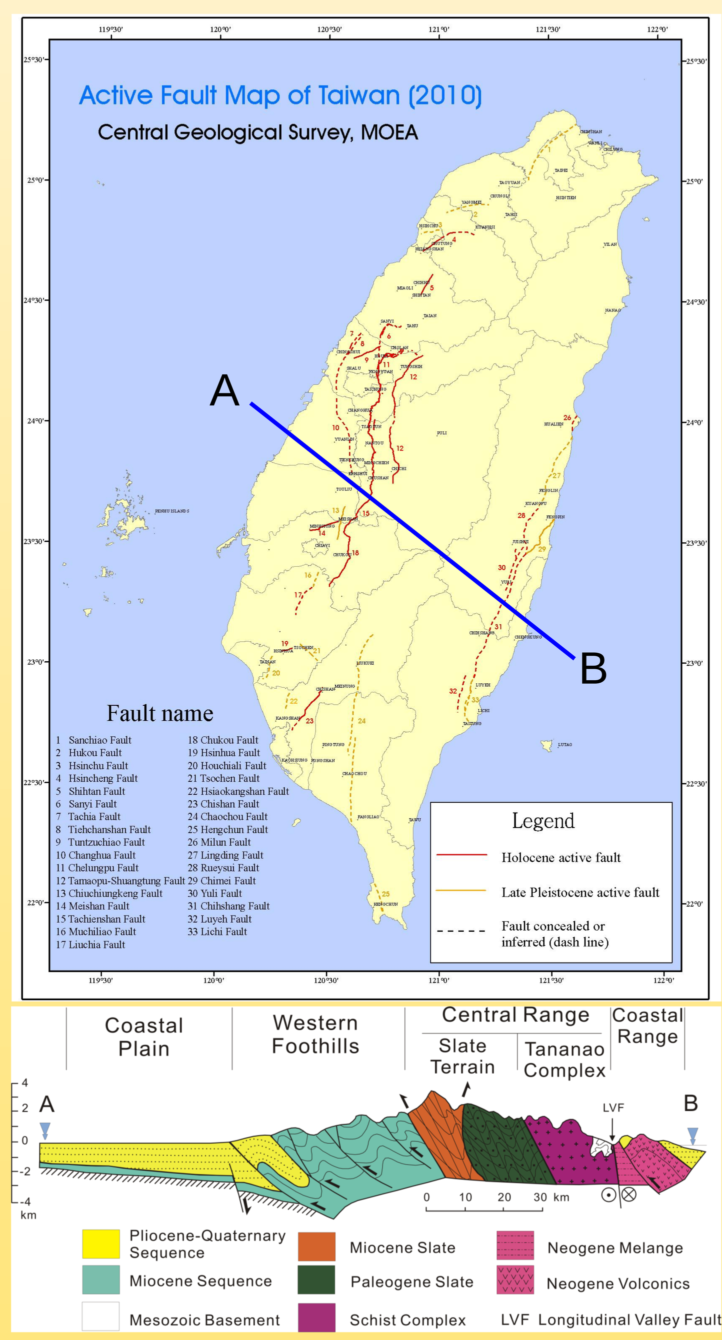


Figure 3 Active fault of Taiwan (2010) and structure profile of AB line. (excerpt from Hu et al., 1997)

Fault Parameters

This study collected the fault source scaling in Taiwan (Wells and Coppersmith, 1994; Yen and Ma, 2011) and estimate the characteristic magnitude by fault length or area. The characteristic earthquake model will be used to evaluate the recurrence interval. The fault parameters table example of northern Taiwan shows in Table 1.

Table1 Active Fault parameters of Northern Taiwan

ID	Name	Segment	Length (km)	Depth (km) Top	Depth (km) Bottom	Area (km^2)	Mechanism	Dip (degree/orientation)	Slip rate (mm/yr)	Recurrence interval (yr)	The last event	Characteristic earthquake (Mw)
1	Sanchiao	N	37	0	15	612.4	Normal	>60/E	0.69(1)		<11,000yr	6.97(0.5) 7.10(0.5)
		S	13	0	15	215.2			1.2(0.5) 1.8(0.5)			
2	Hukou		22	0	12	410.7	Reverse	~40/S	0.9(0.2) 1.7(0.6) 2.5(0.2)		＜70,000yr	6.50(0.5) 6.64(0.5)
3	Hsinchu		9	0	12	141.0	Oblique reverse	~50/S	1.0(0.5) 1.2(0.5)		Late Pleistocene	5.98(0.5) 6.16(0.5)
4	Hsincheng		28	0	12	672.0	Reverse	~30/S	1.0(0.5) 1.6(0.5)		＜300yr	6.64(0.5) 6.77(0.5)
5	Shihtan		12	0	12	158.8	Reverse	>60/W	1.3(0.2) 2.5(0.6) 3.8(0.2)		A.D.1935	6.15(0.5) 6.32(0.5)

P.S.: The parameters of active faults consider Central Geological Survey Special Publication NO.19, NO.20, NO.21, NO.23, Chang(2002), Chen et al.(2010) and other Journal papers.

Fault Model

According to the fault parameters and the C.G.S. active fault map, this study established the 3D fault geometries in GIS system. Figure 5~9 show the active fault geometries of Taiwan which can be used as a preliminary fault model.

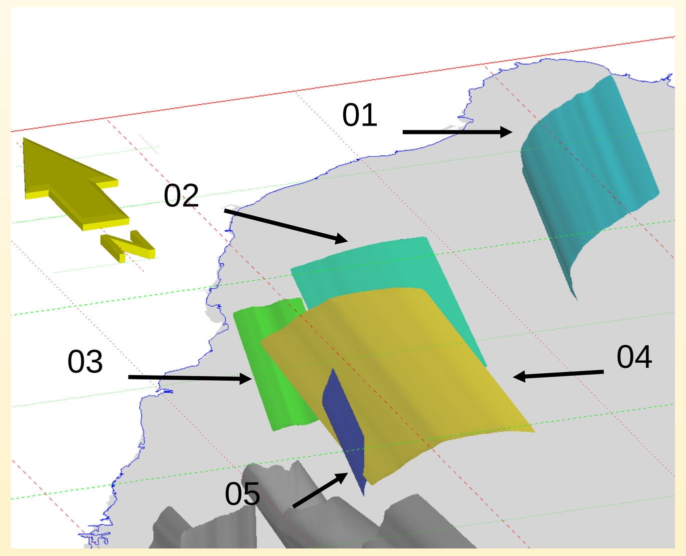


Figure 5 Fault Geometry in Northern Taiwan.

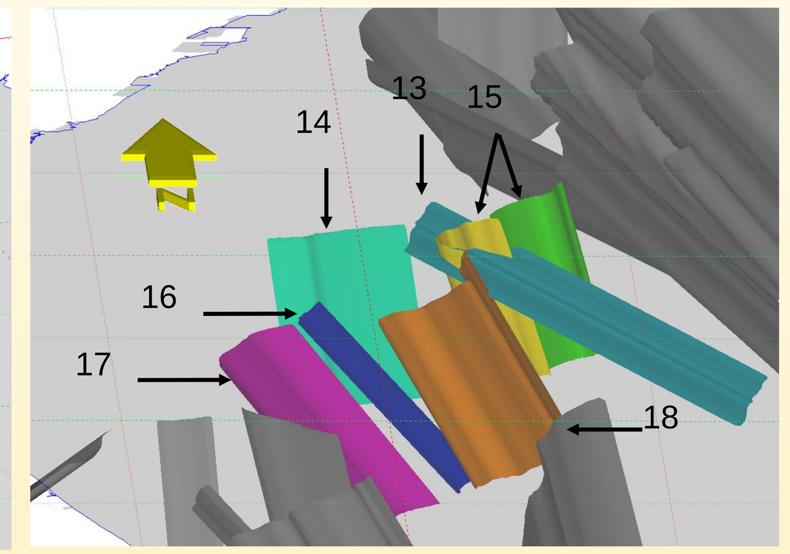


Figure 7 Fault Geometry in South-Western Taiwan.

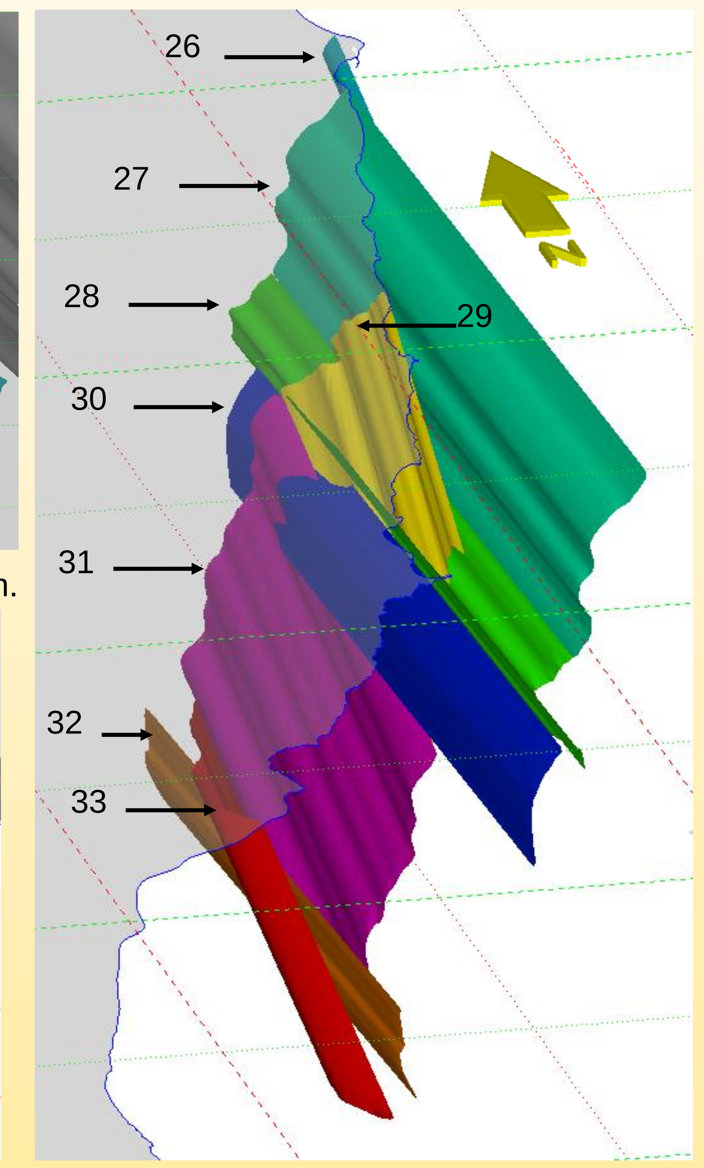


Figure 9 Fault Geometry in Eastern Taiwan.

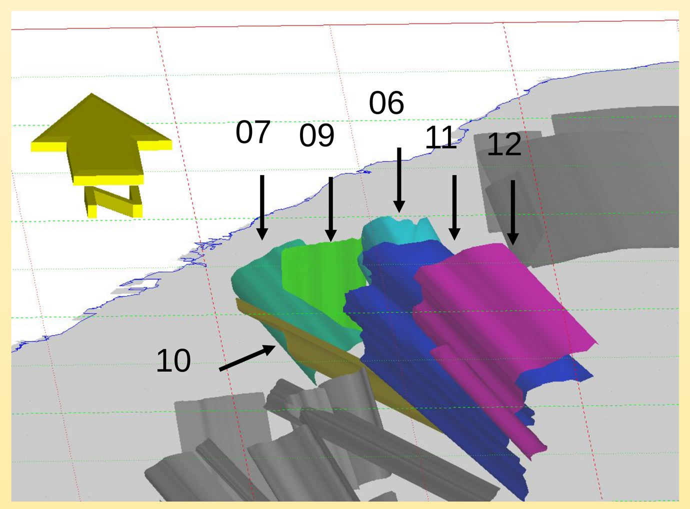


Figure 6 Fault Geometry in Central Taiwan.

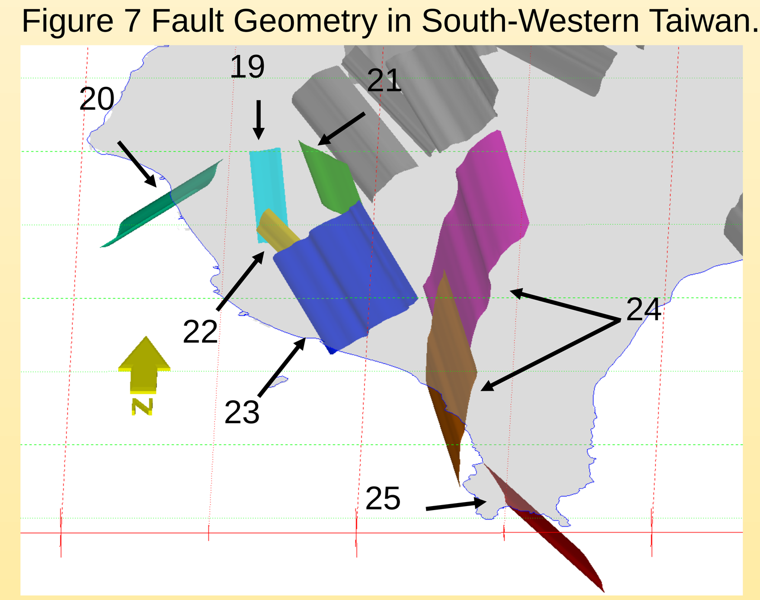
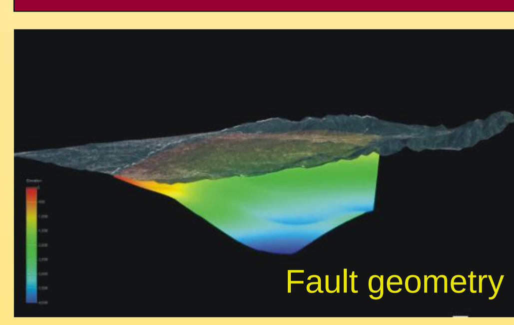
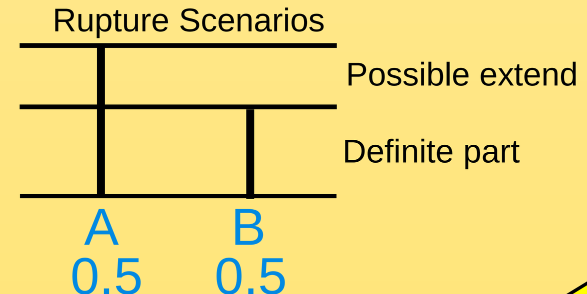


Figure 8 Fault Geometry in Southern Taiwan.

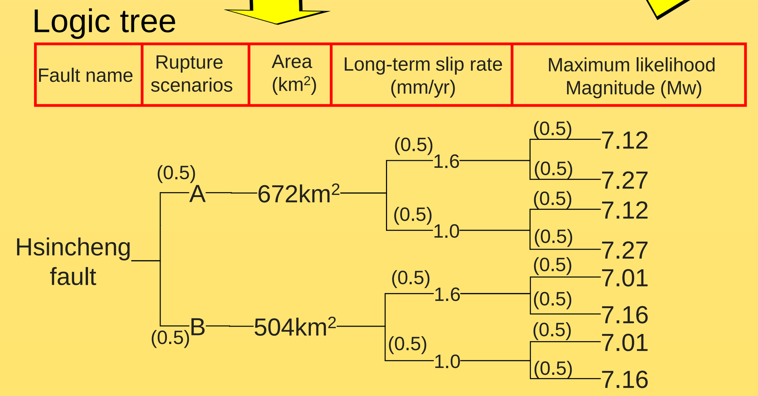
Assessment Example – Hsincheng fault



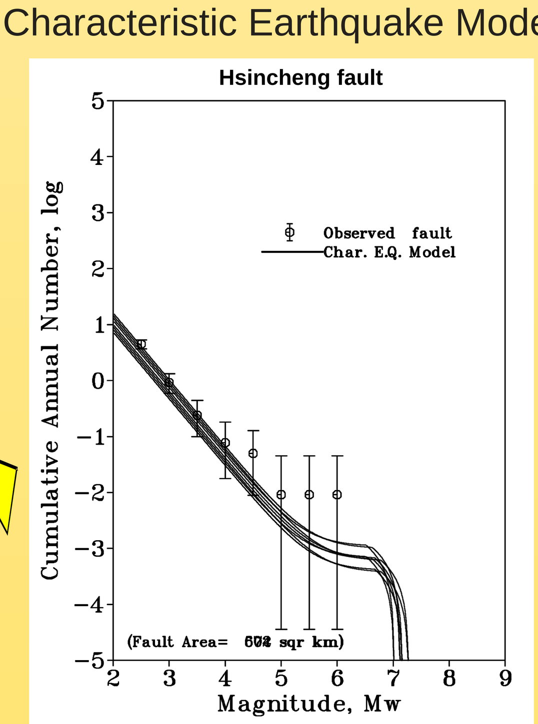
Rupture Scenarios



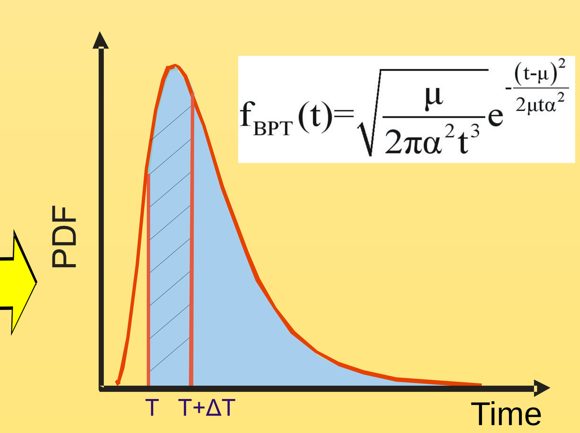
Logic tree



Characteristic Earthquake Model



Calculate conditional probability by Probability Models



$$f_{BPT}(t)=\sqrt{\frac{\mu}{2\pi\alpha^2 t^3}}\,e^{-\frac{(t-\mu)^2}{2\mu\alpha^2 t}}$$

	Mw	P of 30yr	P of 50yr	P of 100yr
P	Mw≧6.5	0.79%	1.43%	3.38%

Assessment Procedure

The WG08 (Working Group 2008) have finished the time-dependent earthquake hazard assessment in California (UCERF 2). The model framework includes the fault models, the deformation models, the earthquake rate models and the probability models (Figure 10).

For probability models, we will consider Japan's experience to adopt different probability models to evaluate the active fault probability, the conceptual process is shown in Figure 11.

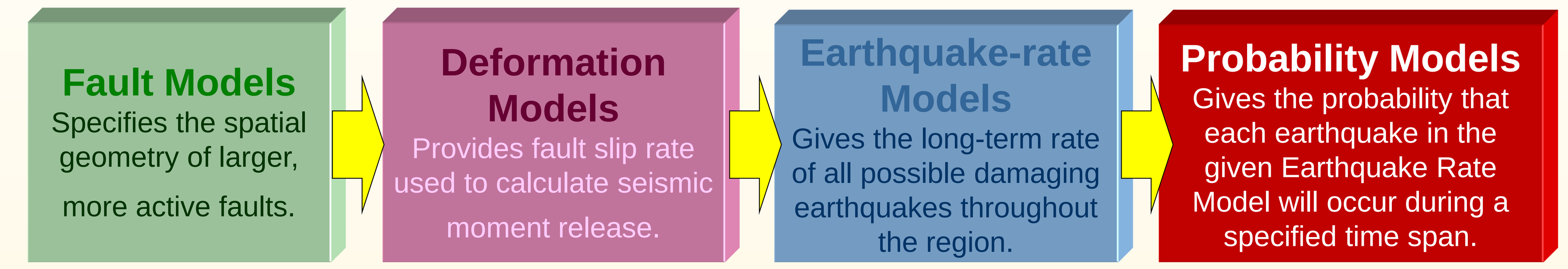


Figure 10 The four basic components of the UCERF 2 model.(From WG08,2007)

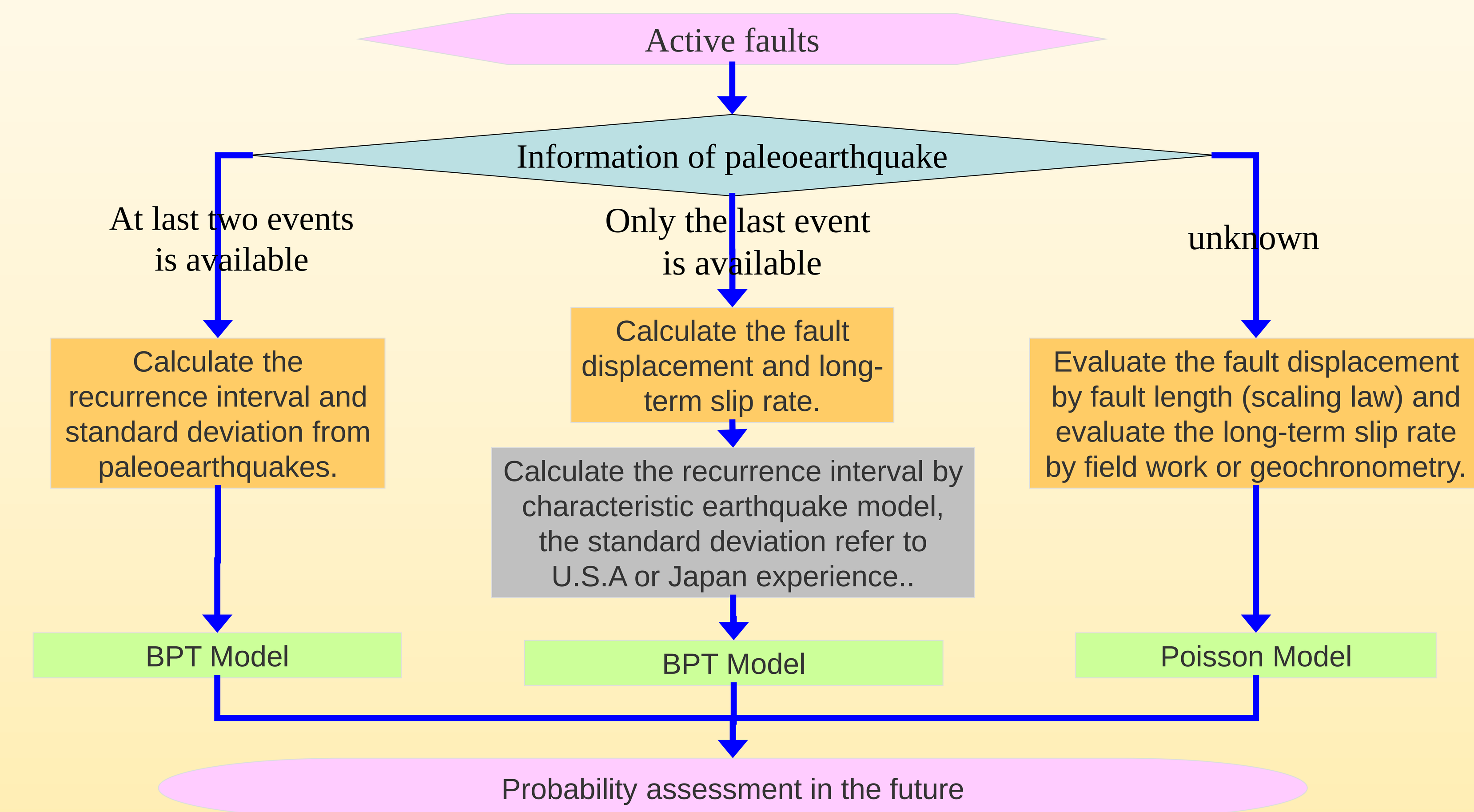


Figure 11 The conceptual flow chat of probability assessment.

Future work

By accomplishing active fault parameters table in Taiwan, we will apply it in time-dependent earthquake hazard assessment. The results can be exhibited in a map which includes the distribution of active faults, the characteristic earthquake magnitude and the conditional probability in the next 30 or 50 years.

Consider the exhibition of Japan (Figure 12), this study will produce our results like that. The assessment results can give engineers a reference for design. Furthermore, it can be applied in the seismic hazard map to mitigate disasters.

Figure 12 The active fault and probabilities during the next 30 years in Japan (extract from Japan National Seismic Hazard Map, 2010).

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