IMPACT OF RUPTURE GEOMETRY UNCERTAINTY ON RAPID EARTHQUAKE IMPACT ASSESSMENT: A CASE STUDY

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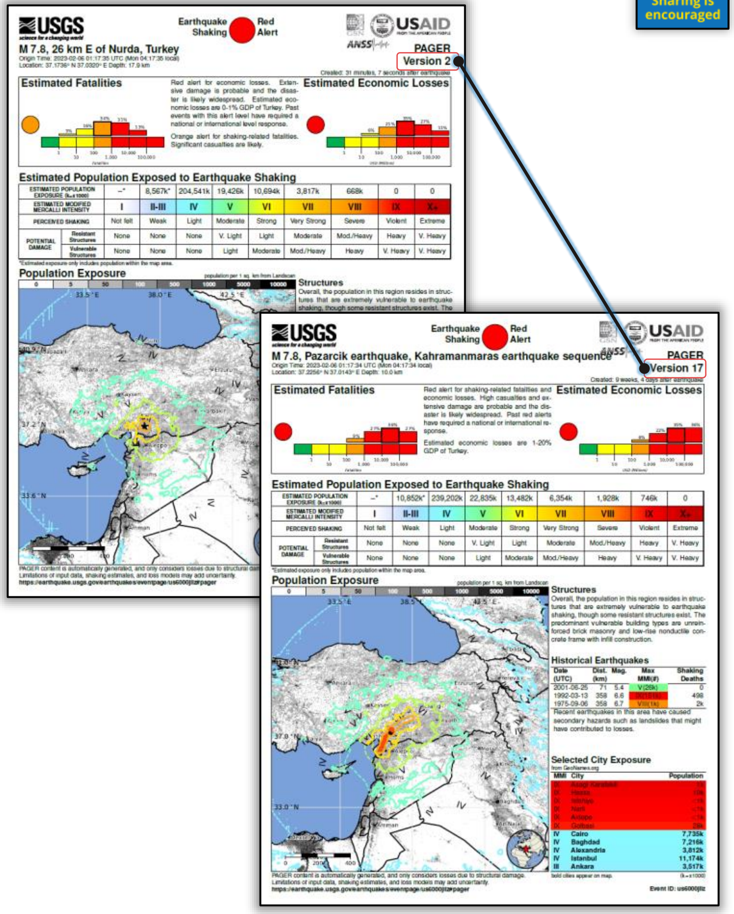
Problem Statement

- Many automatic systems that produce reports for the evaluation of the post-earthquake impact have proven their usefulness after devastating earthquakes.

- However, highly destructive earthquakes inevitably involve **“blind hours”** during which the impact cannot be effectively assessed. In such blind hours, predictions proceed through a series of approximations, simplifications, and corrections.

- For instance, the USGS PAGER system, undoubtedly the most well-known and mature platform for rapid impact assessment in the world, provides **several updates of their impact metrics** in the hours and days after destructive events.



Problem Statement (cont.)

- A rapid impact assessment procedure relies on conceptually **three main components** in the region of interest:
  1) Ground-shaking estimation
  2) Building exposure data
  3) Set of vulnerability functions

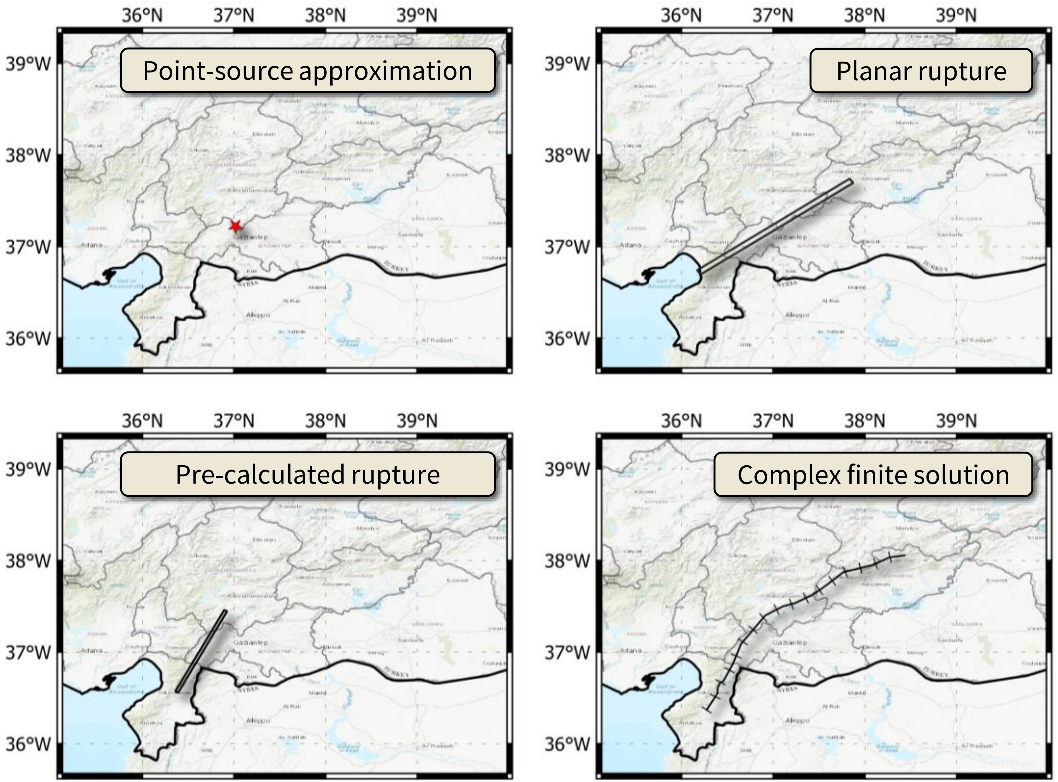
- While points 2 and 3 can be prepared in advance, **point 1** is quite difficult to clearly estimate with a best clarify after the earthquake.

- For a rapid and effective assessment in such clarity, **«the rupture geometry»** estimation is one of the major contributing parameters for UNCERTAINTY in both ground-shaking and, accordingly, impact assessment results.

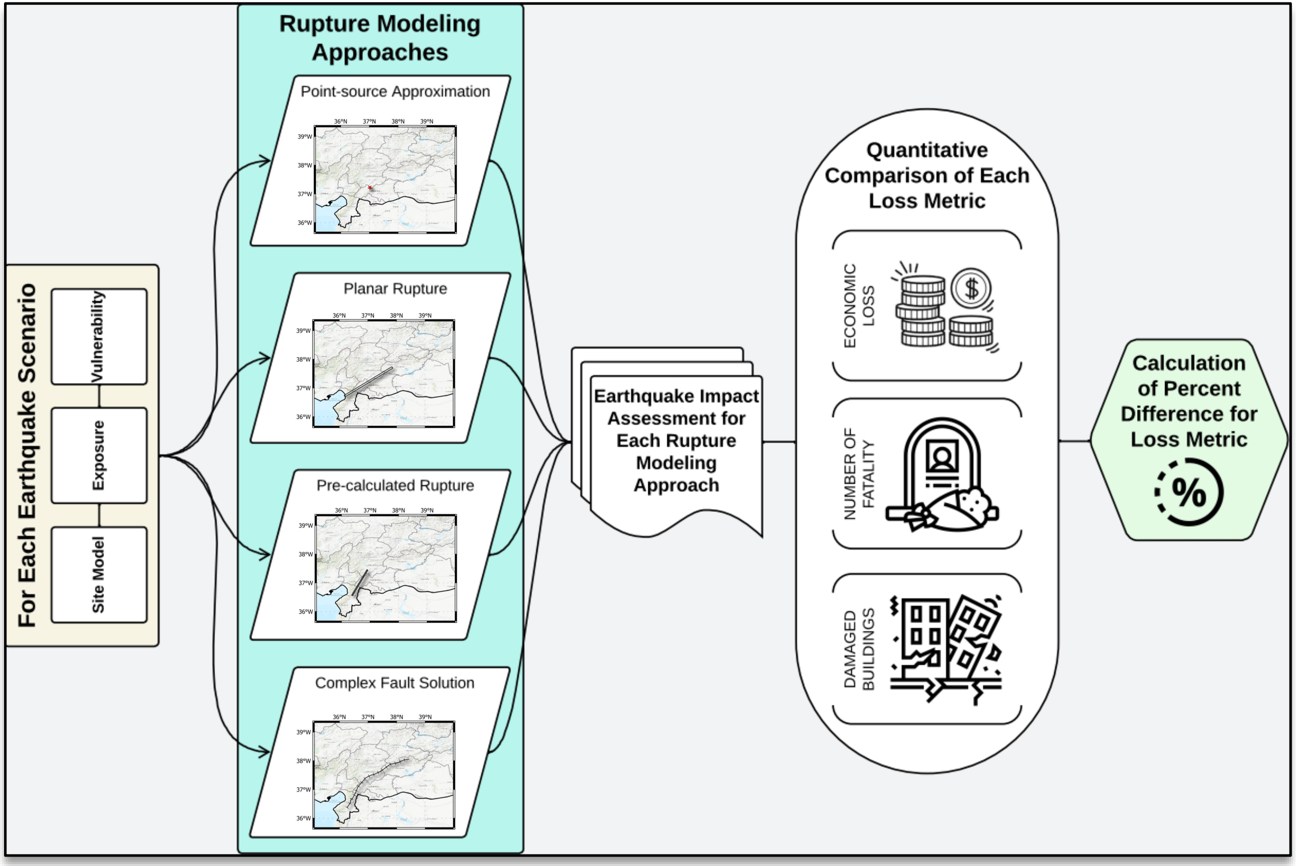
Aim

- This study investigates discrepancies arising from **rupture geometry uncertainty** and their potential **effect on ground shaking and impact estimates** in a very well-known M7.8 Kahramanmaras earthquake scenario.

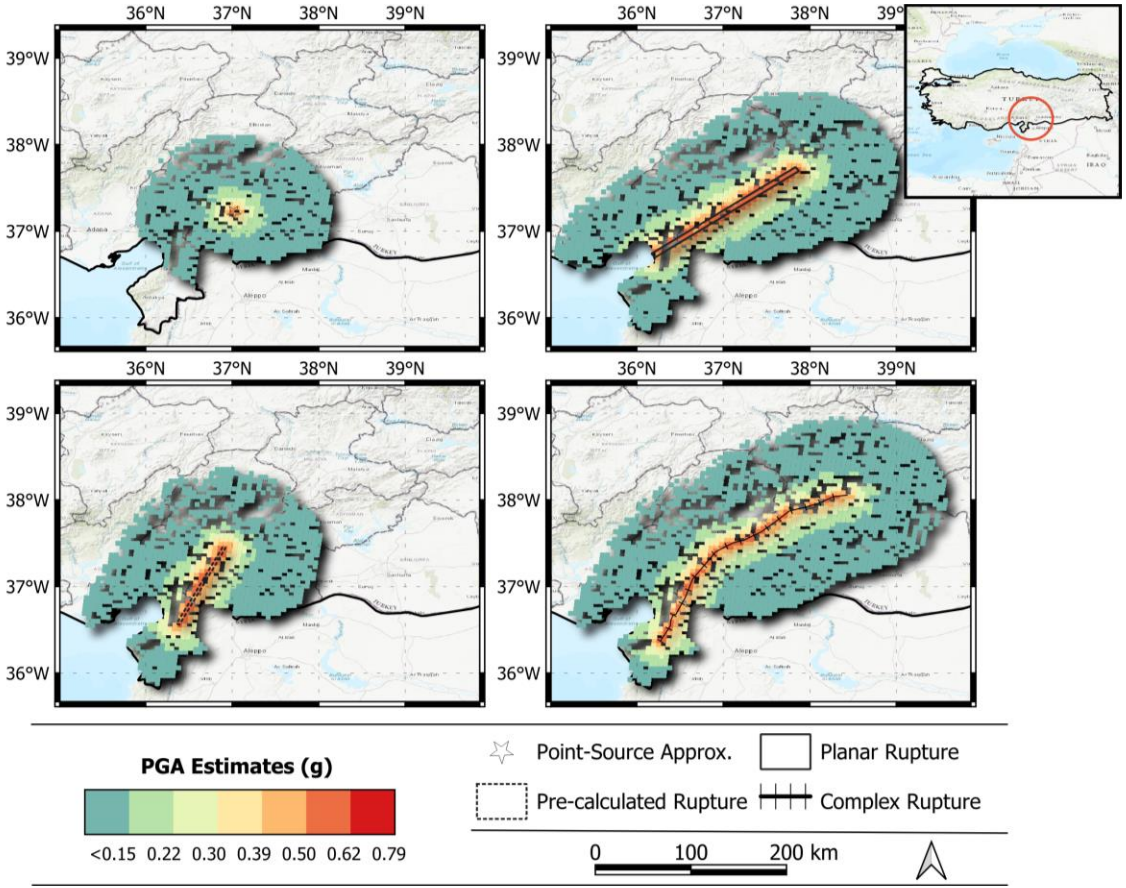
- To this end, we explore **different strategies to model rupture geometry**, ranging from point-source approximations to planar fault ruptures.



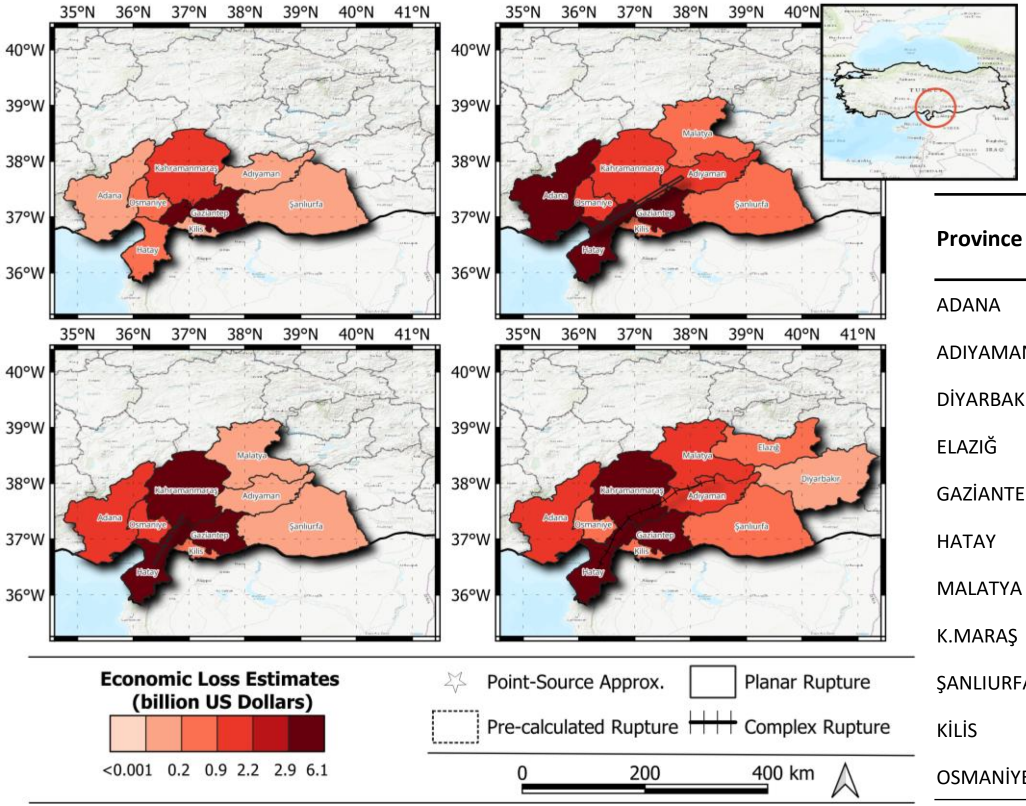
Methodology



Ground Shaking Estimates

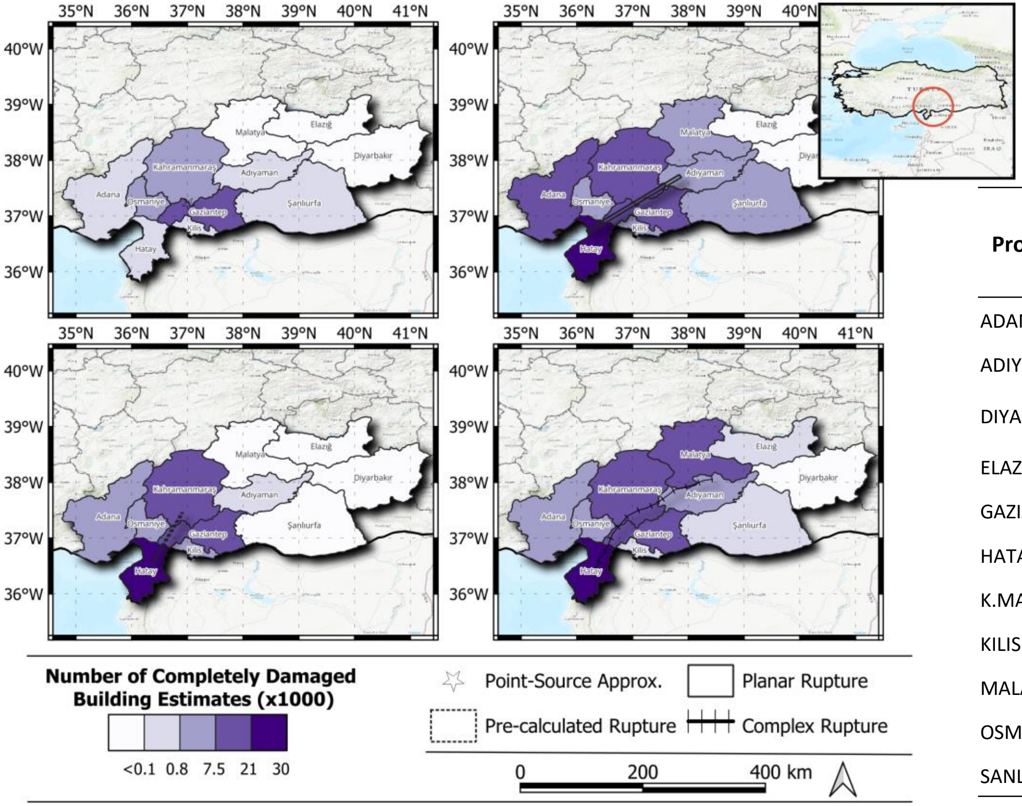


Economic Loss Estimates



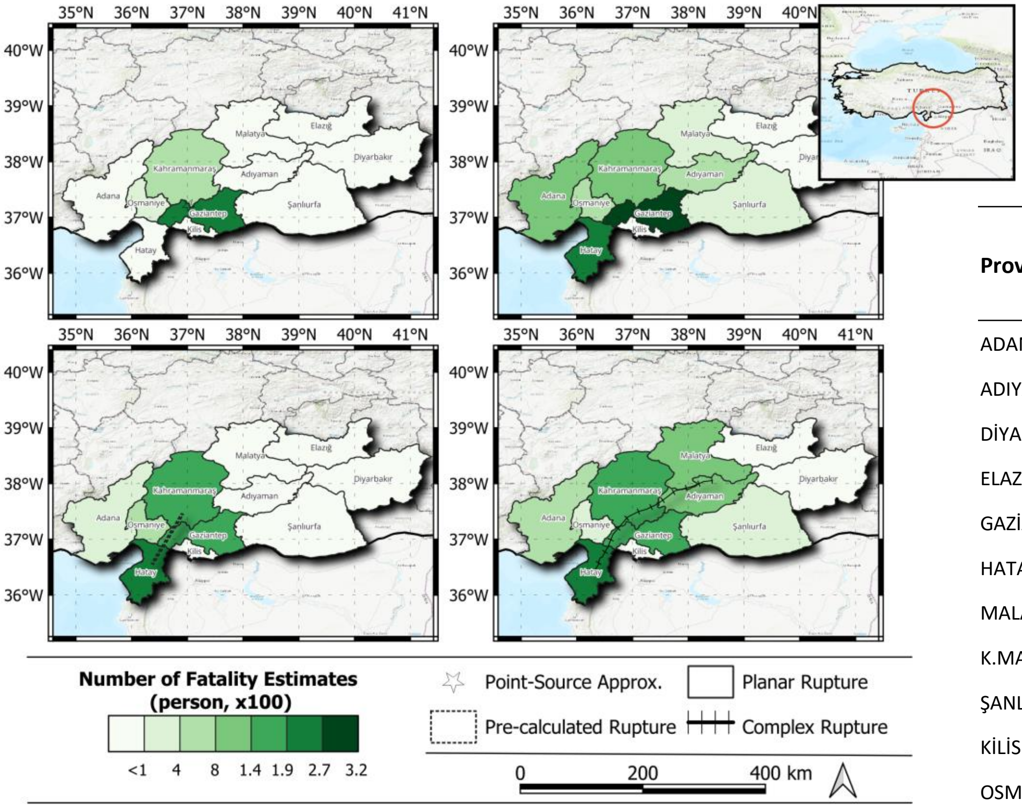
Province	Estimated Economic Loss for Each Rupture Modeling Approach (US Dollars)			
	Point-Source	Planar	Pre-Calculated	Complex Finite
ADANA	16.8 million (99%)	3,603.1 million (195%)	1,093.0 million (10%)	1,220.7 million
ADIYAMAN	64.7 million (96%)	1,139.5 million (22%)	74.2 million (95%)	1,457.3 million
DİYARBAKIR	-	-	-	19.4 million
ELAZIĞ	-	-	-	295.0 million
GAZİANTEP	4,781.8 million (28%)	6,070.3 million (62%)	3,476.0 million (7%)	3,742.9 million
HATAY	229.8 million (95%)	4,176.4 million (14%)	4,350.0 million (10%)	4,855.4 million
MALATYA	0.2 million (100%)	676.4 million (65%)	1.5 million (100%)	1,907.5 million
K.MARAŞ	1,529.9 million (62%)	1,992.1 million (51%)	3,680.0 million (9%)	4,050.2 million
ŞANLIURFA	43.5 million (85%)	304.7 million (8%)	10.6 million (96%)	282.5 million
KİLİS	149.8 million (10%)	195.1 million (17%)	171.5 million (3%)	166.5 million
OSMANİYE	472.3 million (43%)	1,070.8 million (30%)	1,075.0 million (31%)	822.5 million
TOTAL	**7,288.8 million (61%)**	**19,228.4 million (2%)**	**13,931.8 million (26%)**	**18,819.8 million**

Number of Completely Damaged Buildings Estimates



Province	Estimated Number of Completely Damaged Buildings for Each Rupture Modeling Approach			
	Point-Source	Planar	Pre-Calculated	Complex Finite
ADANA	81.6 (98%)	12,412.1 (188%)	3,975.4 (8%)	4,303.2
ADIYAMAN	203.6 (97%)	5,722.9 (23%)	245.0 (97%)	7,438.6
DIYARBAKIR	-	-	-	68.2
ELAZIG	-	-	-	736.2
GAZIANTEP	13,663.8 (28%)	19,735.1 (84%)	9,997.5 (7%)	10,711.8
HATAY	832.8 (97%)	23,498.3 (20%)	24,603.2 (16%)	29,242.7
K.MARAS	6,445.4 (69%)	9,213.7 (56%)	18,324.3 (13%)	20,984.3
KILIS	724.5 (15%)	1,066.0 (26%)	890.2 (5%)	847.7
MALATYA	1.3 (100%)	2,795.1 (73%)	7.1 (100%)	10,318.9
OSMANIYE	2,305.5 (56%)	6,804.4 (31%)	7,008.3 (35%)	5,183.9
SANLIURFA	127.2 (84%)	1,010.4 (27%)	33.6 (96%)	796.3
TOTAL	**24,385.5 (73%)**	**82,257.9 (9%)**	**65,084.5 (28%)**	**90,631.8**

Number of Fatality Estimates



Province	Estimated Number of Fatality for Each Rupture Modeling Approach			
	Point-Source	Planar	Pre-Calculated	Complex Finite
ADANA	6 (99%)	1,392 (197%)	407 (13%)	469
ADIYAMAN	32 (97%)	770 (21%)	37 (96%)	971
DİYARBAKIR	-	-	-	9
ELAZIĞ	-	-	-	85
GAZİANTEP	2,402 (32%)	3,223 (77%)	1,690 (7%)	1,816
HATAY	101 (96%)	2,145 (21%)	2,300 (15%)	2,702
MALATYA	0 (100%)	358 (71%)	1 (100%)	1,225
K.MARAŞ	609 (68%)	870 (55%)	1,630 (16%)	1,931
ŞANLIURFA	49 (81%)	338 (33%)	10 (96%)	254
KİLİS	83 (15%)	117 (21%)	100 (3%)	97
OSMANİYE	233 (47%)	596 (35%)	619 (41%)	440
TOTAL	**3,516 (65%)**	**9,809 (2%)**	**6,794 (32%)**	**10,001**

Results and Conclusions

- **Point-source approximation** demonstrates significant limitations, introducing substantial discrepancies (61–73% in loss estimates at the aggregated level) in each impact metric, thereby compromising rapid impact assessment reliability.
- In contrast, the **planar rupture model** provided compatibility compared to the benchmark results (2–9% differences), while the **pre-calculated rupture** resulted in differences at the order of 26–32% at the aggregated level.
- Critically, **aggregate-level estimates masked provincial disparities**, and therefore, inferences on a provincial basis are needed to avoid insufficient and possibly misleading interpretations.
- For instance, the difference rates of the number of completely damaged buildings estimates obtained using the point-source approximation for Kahramanmaras, Hatay and Gaziantep provinces are **64%, 98%, and 5%,** respectively, while these error rates are **13%, 16%, and 7%,** respectively, in the case of using the pre-calculated rupture model.
- The pre-calculated rupture model offers an alternative solution to the approximated rupture models, improving rapid loss assessment accuracy in cases where data constraining the rupture geometry are not available after a destructive earthquake.

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