

Evaluating next-generation and traditional intensity measures in regional seismic risk assessment

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Intensity measures in regional scale

Traditional IMs are known to under-perform next-generation ones:

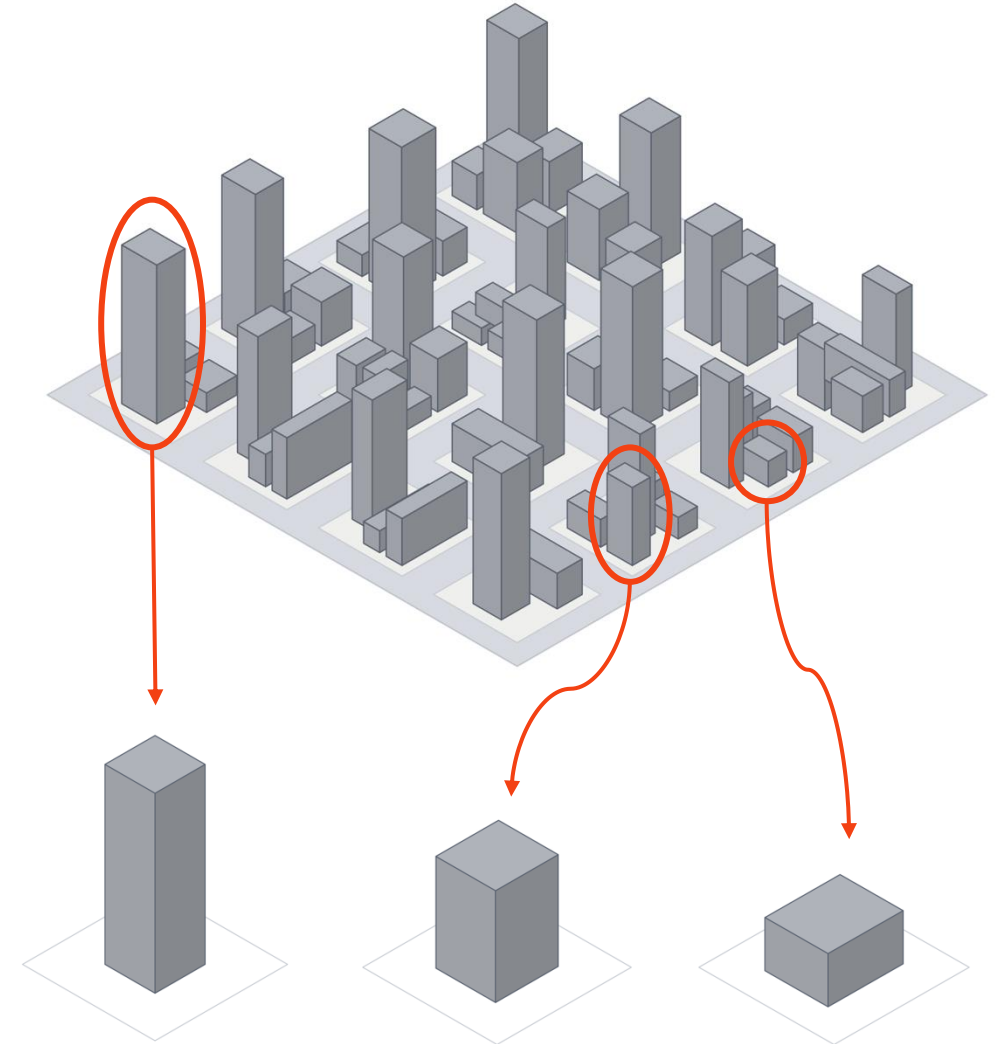
- Reduced efficiency
- Poor predictive capability
- Biased demand estimates

Which IM should we select to represent the building portfolio?

PGA , $Sa(T)$, $Sa_{avg}(T)$, $FIV3$, ...

Does that choice change the loss?

More than twenty years of work says the IM matters - at the building level.



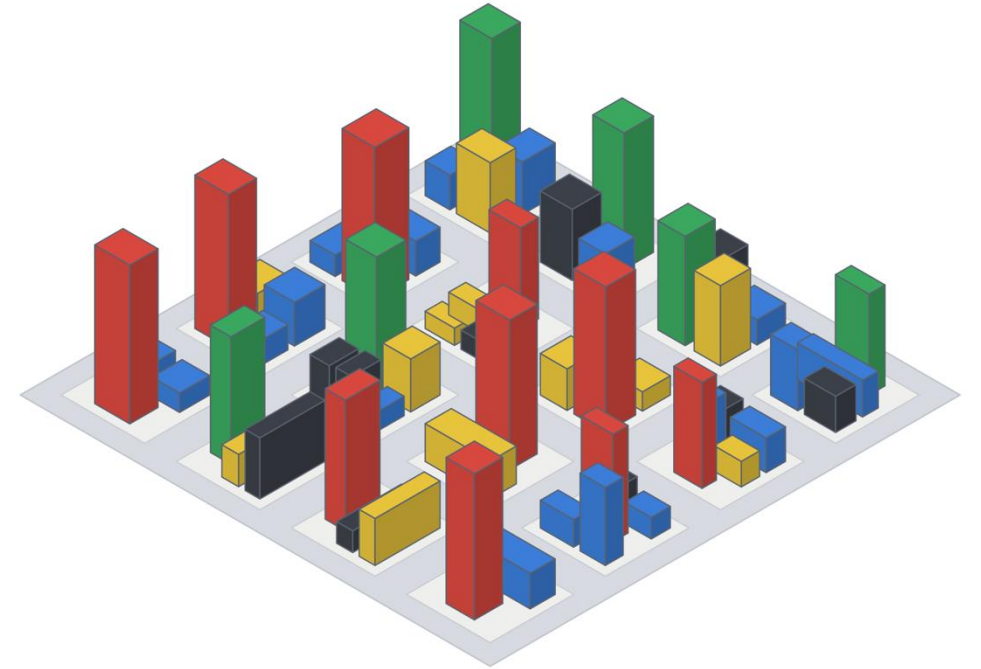
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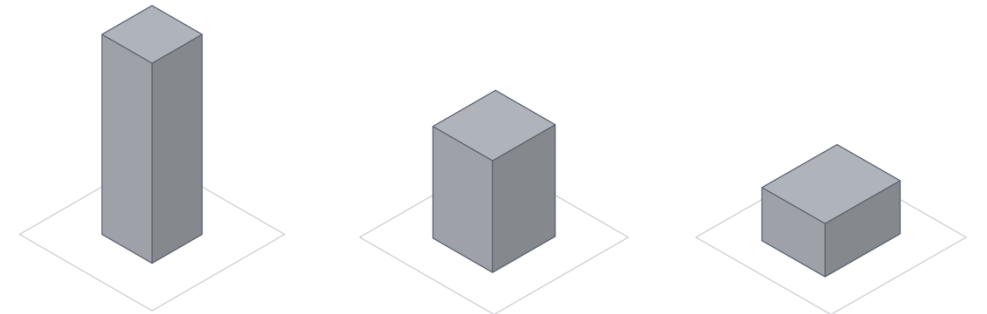
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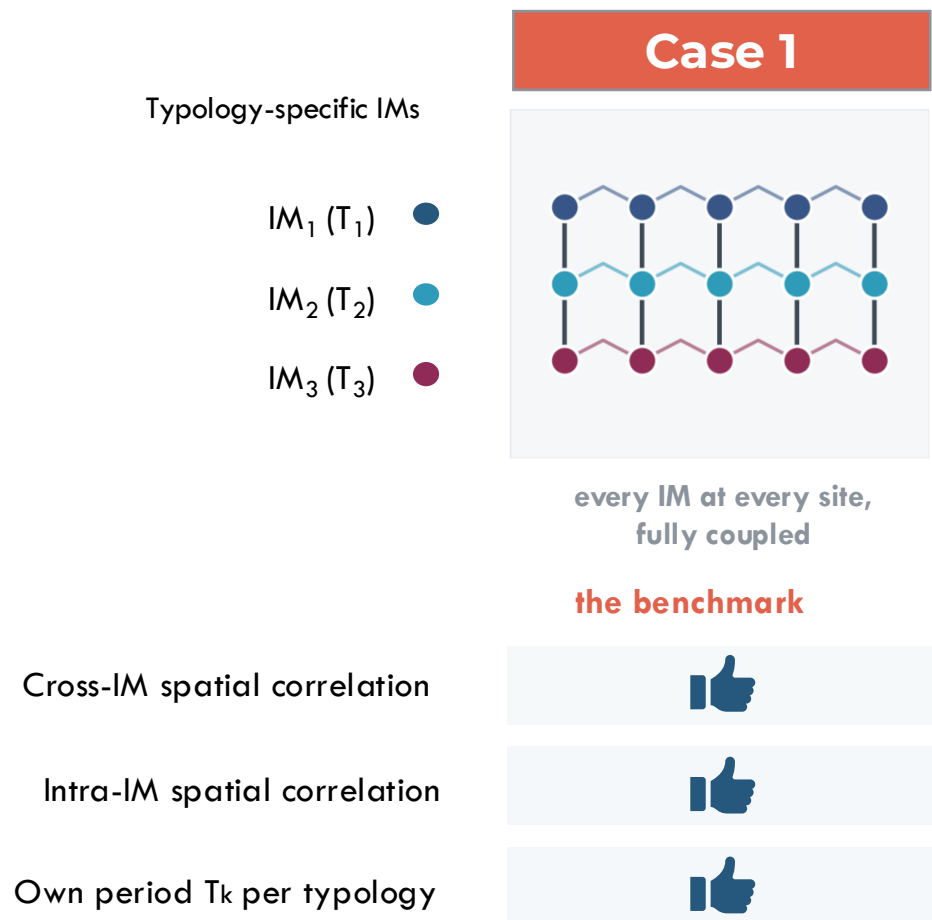


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Four ways to shake a portfolio



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	Case 1	Case 2
Typology-specific IMs		
$IM_1(T_1)$		
	every IM at every site, fully coupled	every IM, but each field simulated on its own
	the benchmark	operational models
Cross-IM spatial correlation		
Intra-IM spatial correlation		
Own period T_k per typology		

Four ways to shake a portfolio

	Case 1	Case 2	Case 3
Typology-specific IMs			
$IM_1(T_1)$			
	every IM at every site, fully coupled	every IM, but each field simulated on its own	one IM at T^* for the whole building stock
	the benchmark	operational models	standard practice
Cross-IM spatial correlation			
Intra-IM spatial correlation			
Own period T_k per typology			

Four ways to shake a portfolio

	Case 1	Case 2	Case 3	Case 4
Typology-specific IMs				
IM ₁ (T ₁)				
	every IM at every site, fully coupled	every IM, but each field simulated on its own	one IM at T* for the whole building stock	one IM at T*, sites treated as independent
	the benchmark	operational models	standard practice	cheapest shortcut
Cross-IM spatial correlation				
Intra-IM spatial correlation				
Own period T _k per typology				

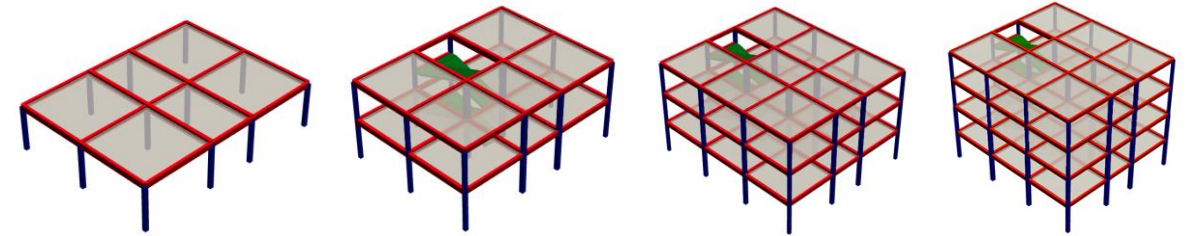
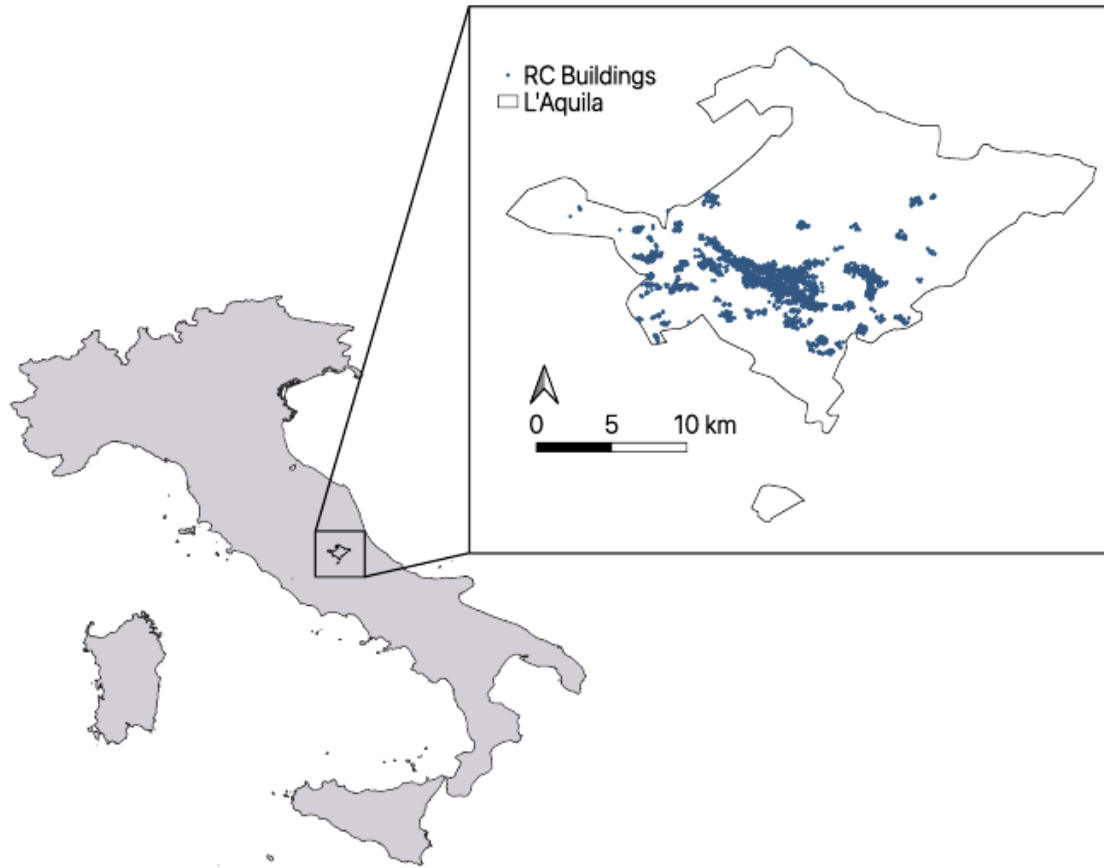
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Case 1 is not the expensive one. A PCA formulation of the cross-IM field costs $\frac{1}{3}KM^3$ against LMC or MT's $\frac{1}{3}(NM)^3$. Here 114× faster: 10 min → 5.3 s per field.



One city, 2,962 buildings



one 3D nonlinear MDOF archetype per typology, 1 to 4 storeys

Mw 6.3

2009 L'Aquila scenario

2,962

RC infilled frames

8

typologies, $T_k = 0.14 - 0.45$ s

16

conditioning IMs

40 × 11

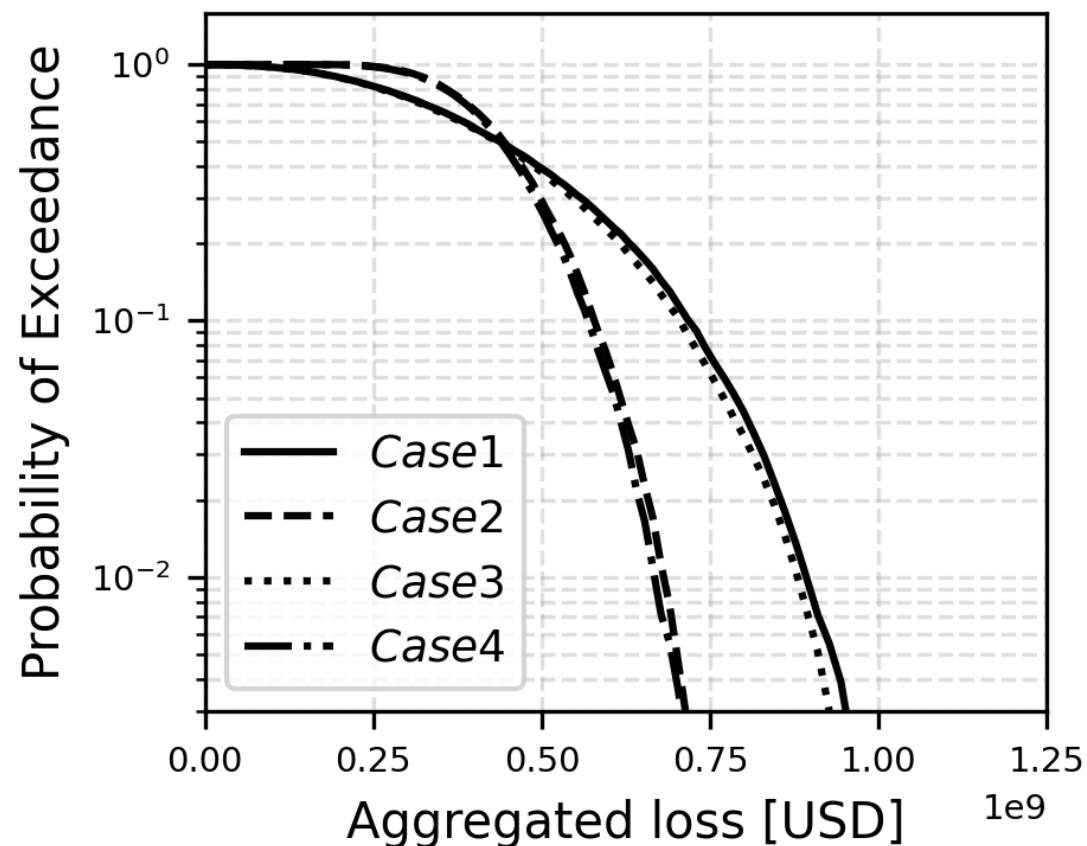
record pairs × return periods

10,000

field simulations per case

Fragilities from multiple-stripe analysis on hazard-consistent (conditional-spectrum) records, per IM and per period.

The modelling strategy matters



-20 %

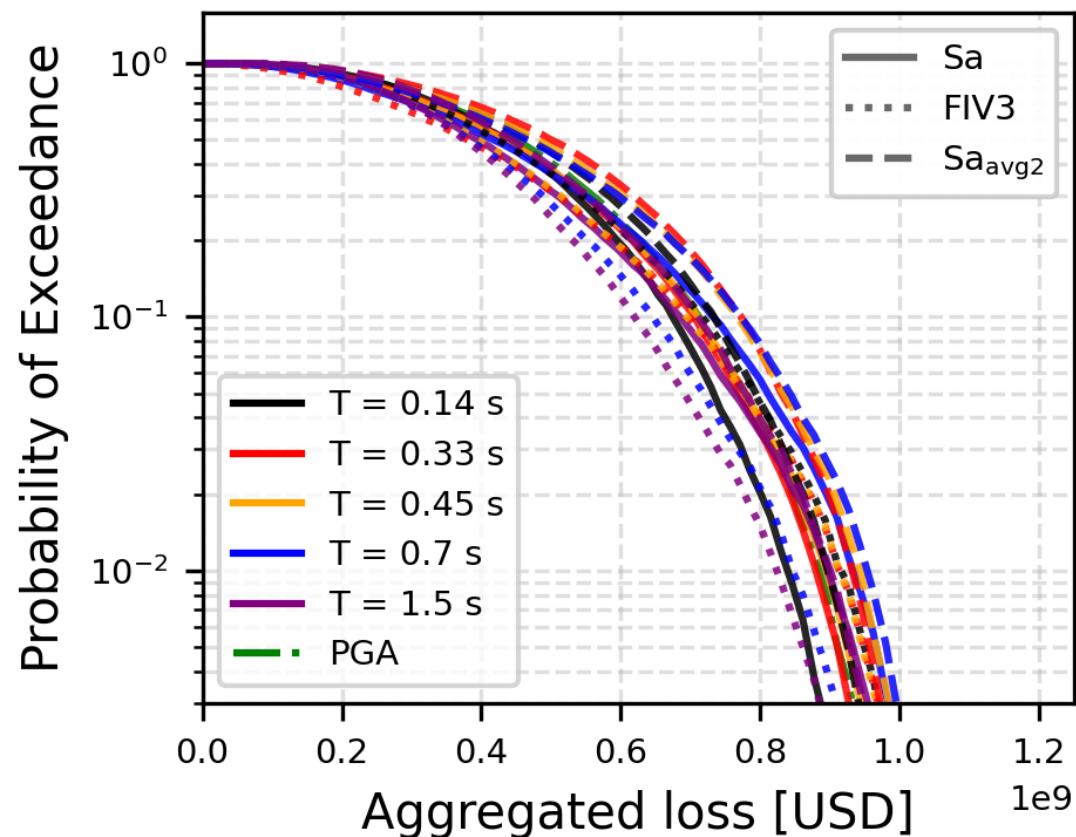
under-estimated aggregate loss at the 10 % exceedance level —
about US\$ 135 M for this portfolio

Case 2 typology-specific IMs, but each field simulated on its own — the cross-IM dependence is lost.

Case 4 no spatial correlation at all — a different shortcut, almost the same error.

Cases 1 and 3 fully coupled and single-IM land on top of each other.

The intensity measure does not



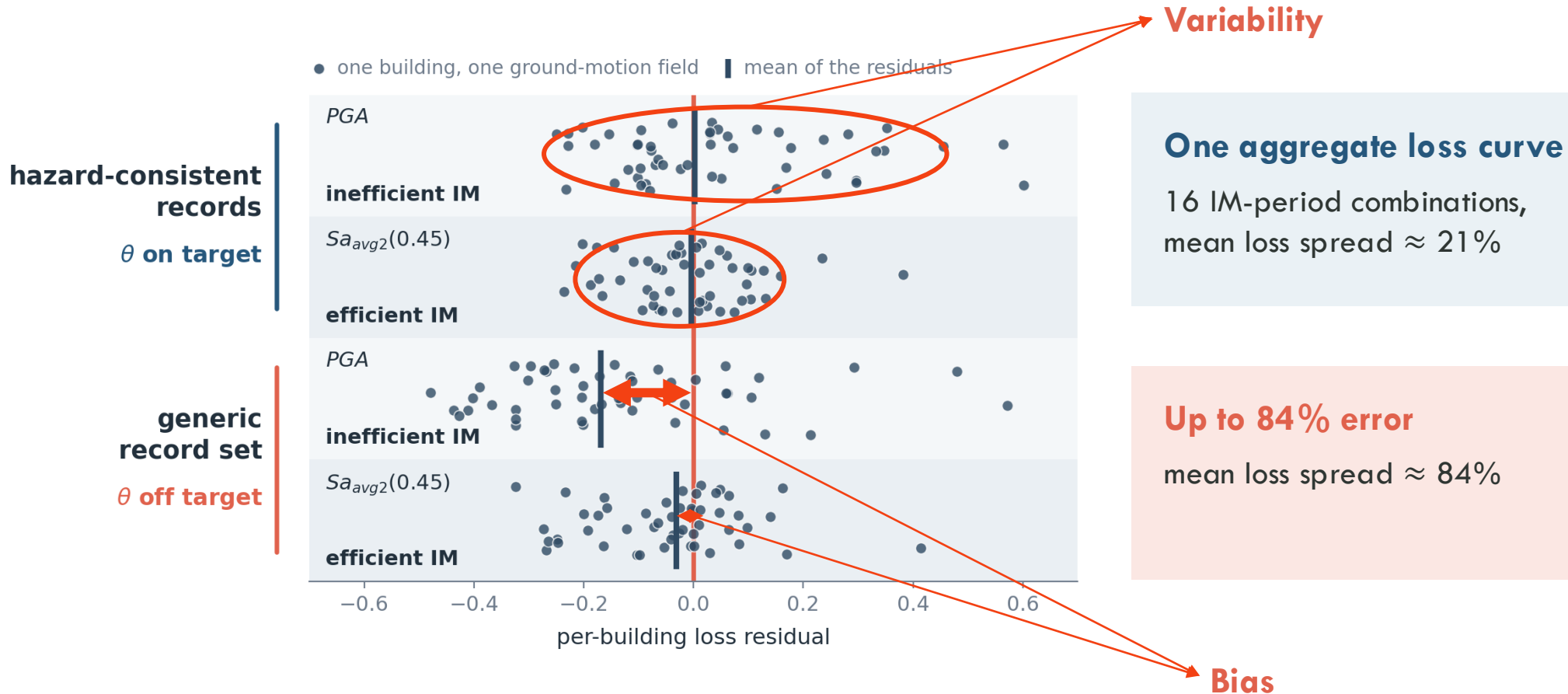
21 %

total spread in mean aggregate loss across all 16 IM-period combinations

Period independence is known for single buildings. This is it surviving aggregation over a spatially distributed, heterogeneous stock.

So the conclusion was "IMs don't matter". No one in the room believes that. Neither did we.

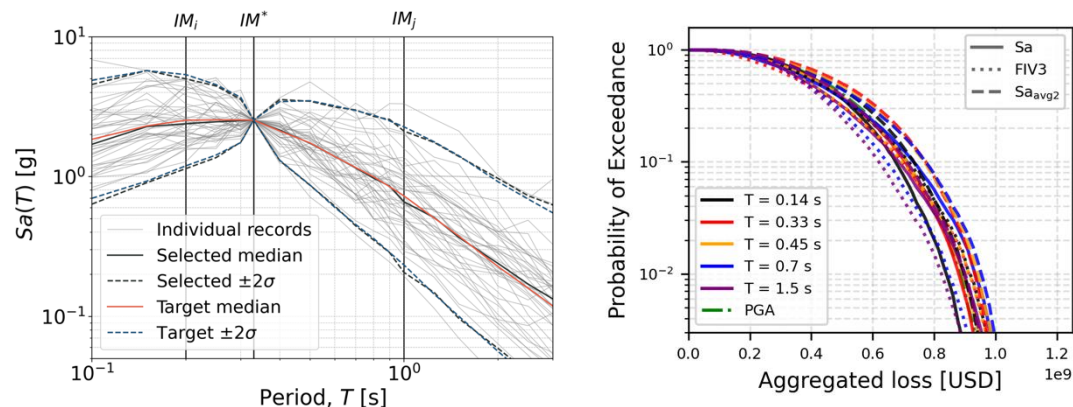
Bias and variability



Take the hazard consistency away

Same GMM, same portfolio, same target amplitude at every return period — only the spectral shape differs.

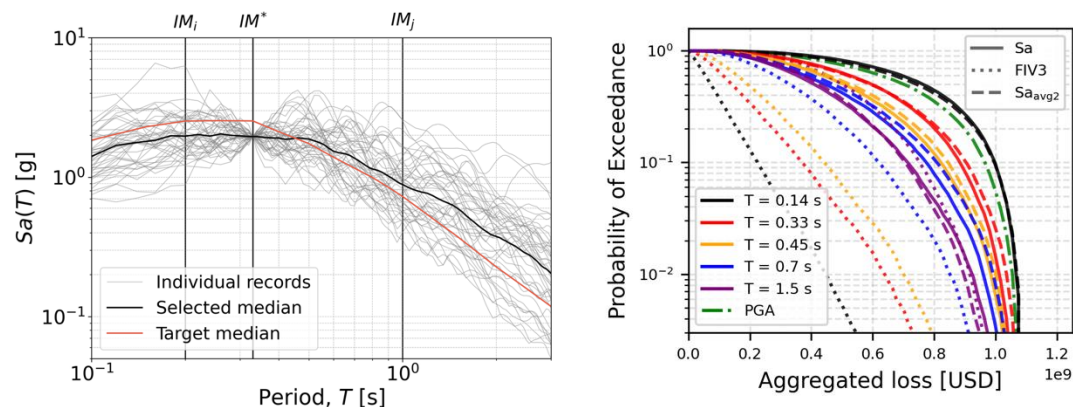
Conditional spectrum — hazard-consistent



21 %

spread in mean aggregate loss.
The sixteen curves lie on top of each other.

FEMA-P695 far field — generic



84 %

spread in mean aggregated loss.
Over half of the bias is the fragility median, not its dispersion.

Conclusions

- **Hazard consistency is the decisive step.** With it, the aggregate loss curve is invariant to the conditioning IM: 21 % spread against 84 % for a generic set.
- **Get the joint dependence right.** Dropping cross-IM correlation underestimates the loss by about 20 % (US\$ 135 M)
- **The IM still matters.** Per realisation at the building level, in the collapse tail, and above all whenever hazard consistency cannot be enforced.
- **If you must commit to one:** S_{avg} anchored at or just above the dominant elastic period (0.45 - 0.7 s here). Avoid short-period S_a , PGA and FIV3 with generic records.

Choose your records before you choose your IM.

With V. Ozsarac, D. Shahnazaryan and G. J. O'Reilly · models and fragility parameters: github.com/vitorazevedomonteiro/Regional-assessment-laquila



Monteiro, Vítor A., & O'Reilly, Gerard J. (2026) "Evaluating next-generation and traditional intensity measures in regional seismic risk assessment", 18th European Conference on Earthquake Engineering, Berlin Germany.