Exploring complex normal faulting systems through physics-based dynamic rupture modeling

10-12 min talk!

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ANR EQTIME Project

January 17, 2023

Outline

Motivation

Settings

Results

Conclusions

Motivation

Seismic Hazard in Central Italy

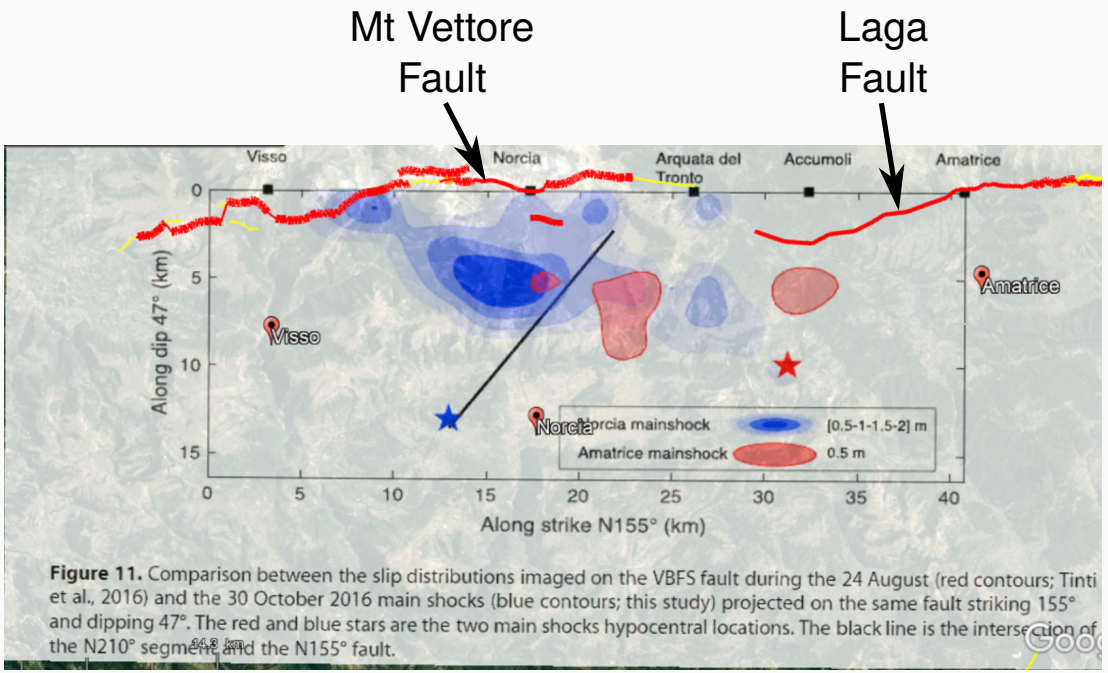

Figure 11. Comparison between the slip distributions imaged on the VBFS fault during the 24 August (red contours; Tinti et al., 2016) and the 30 October 2016 main shocks (blue contours; this study) projected on the same fault striking 155° and dipping 47°. The red and blue stars are the two main shocks hypocentral locations. The black line is the intersection of the N210° segment and the N155° fault.

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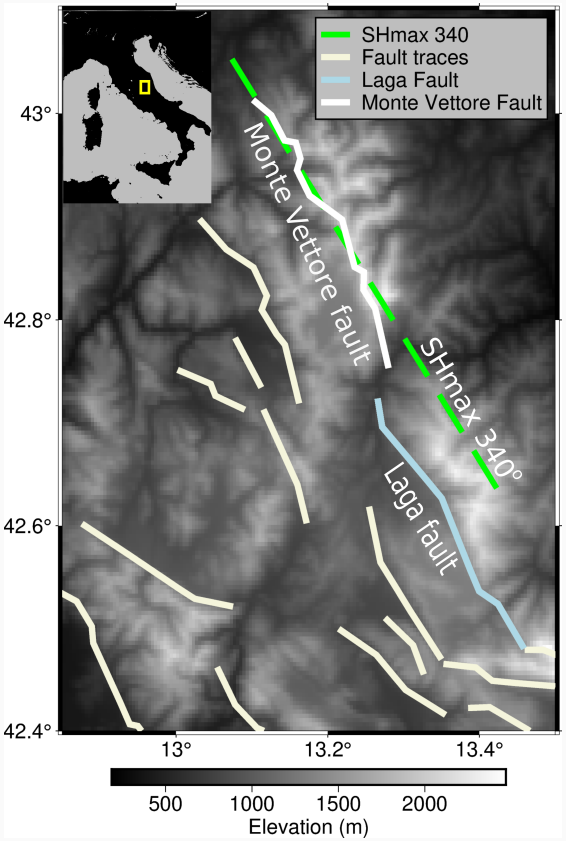

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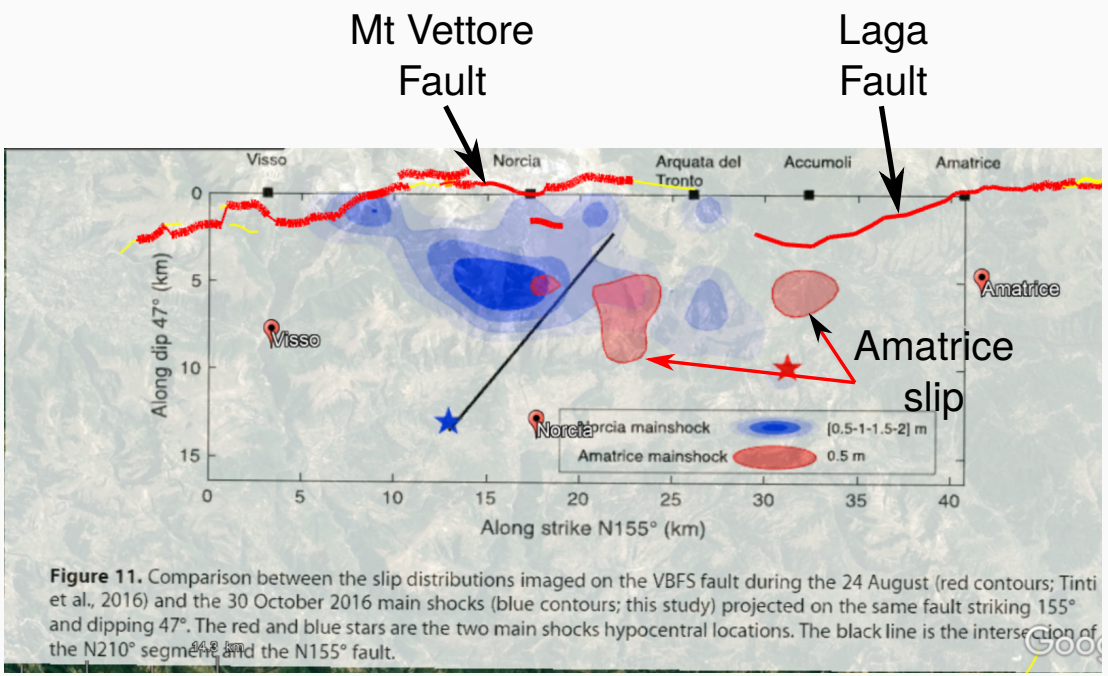

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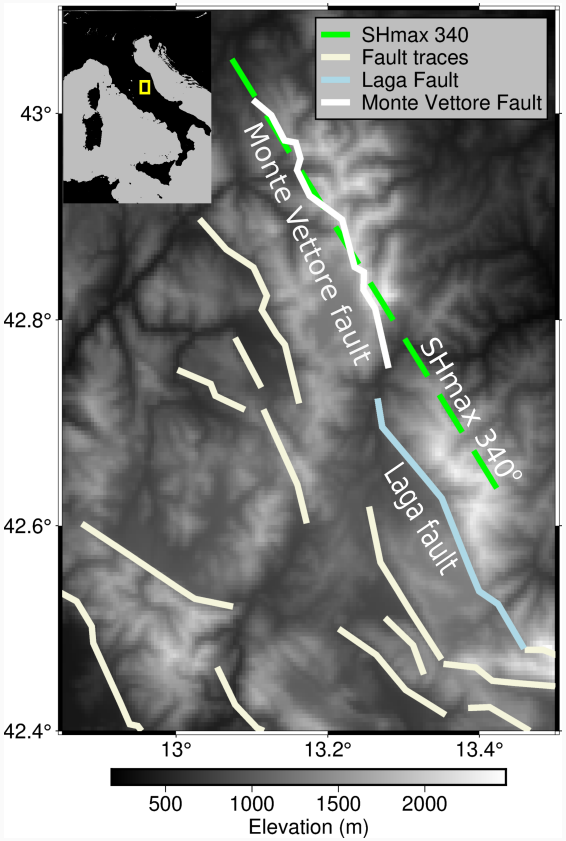

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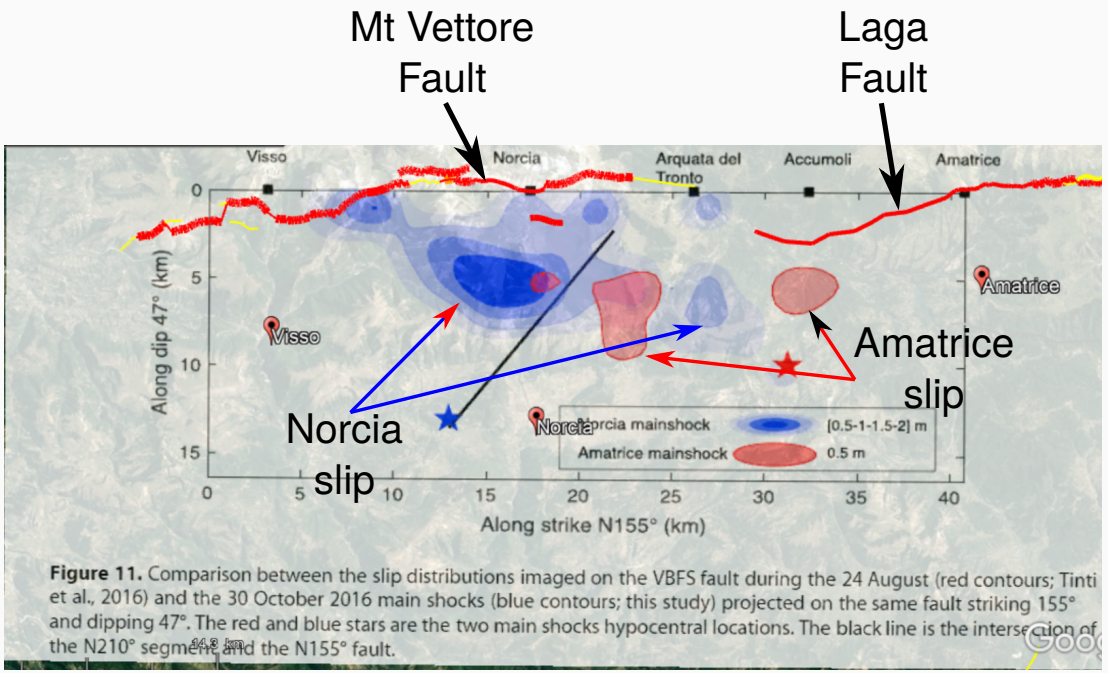

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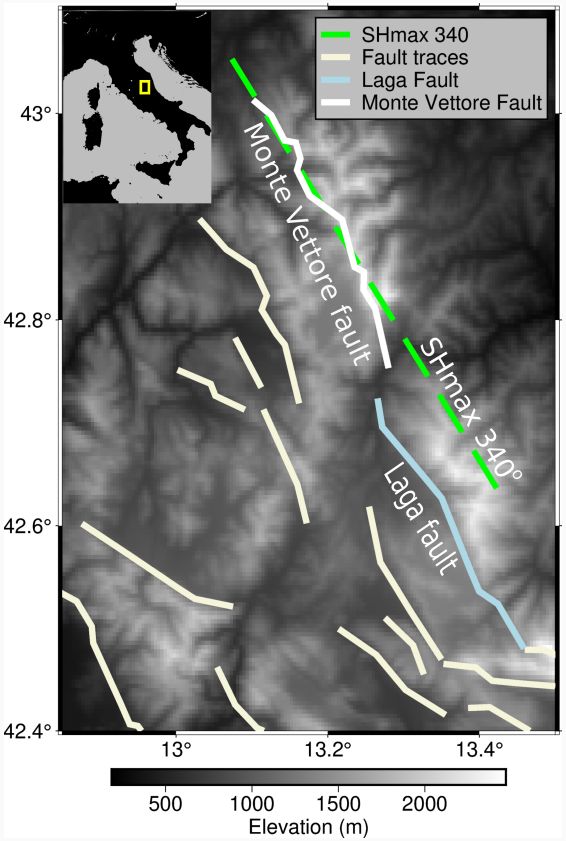

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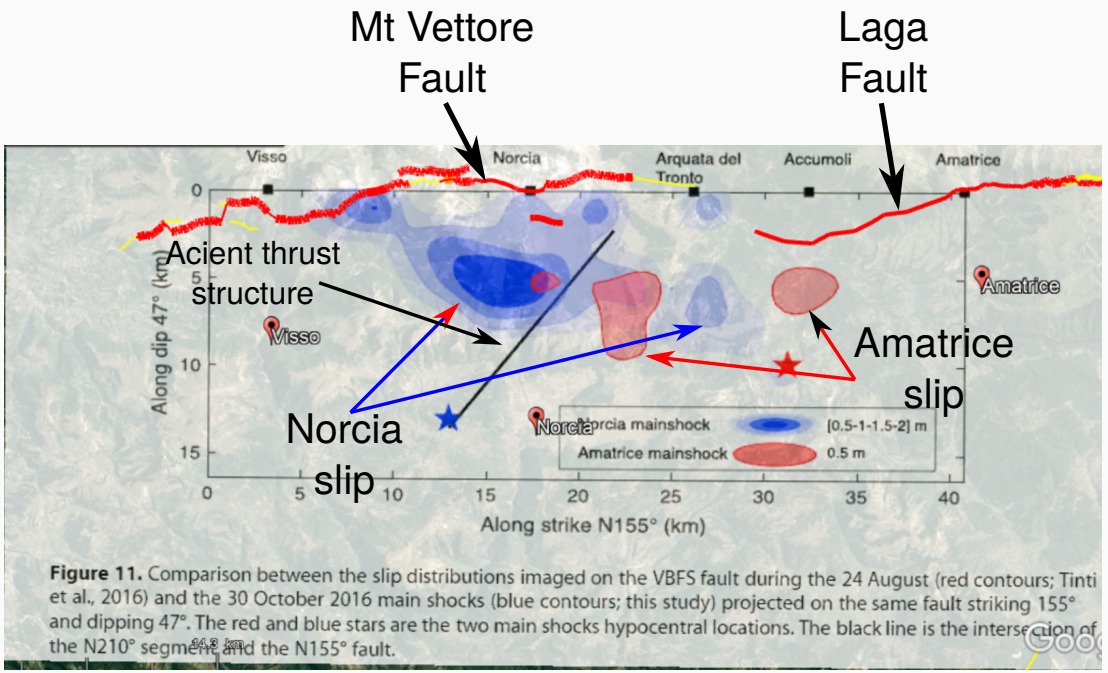

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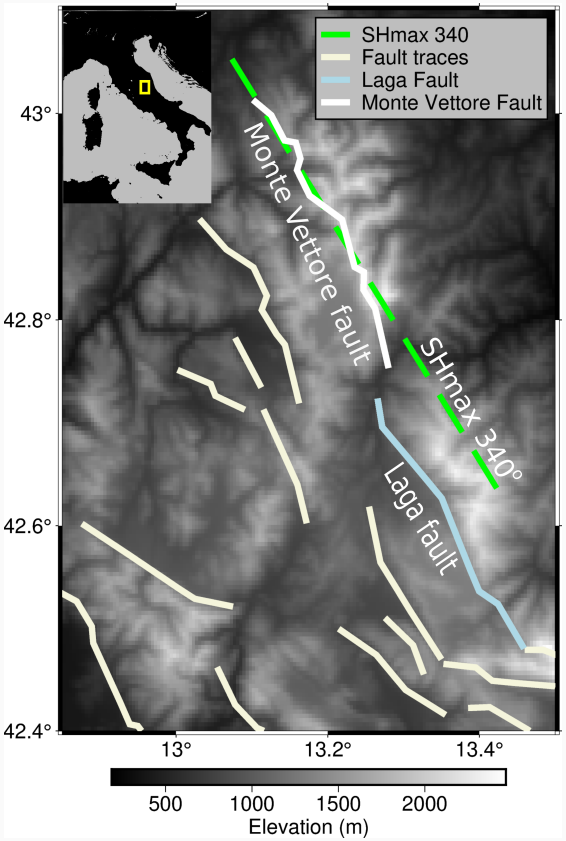

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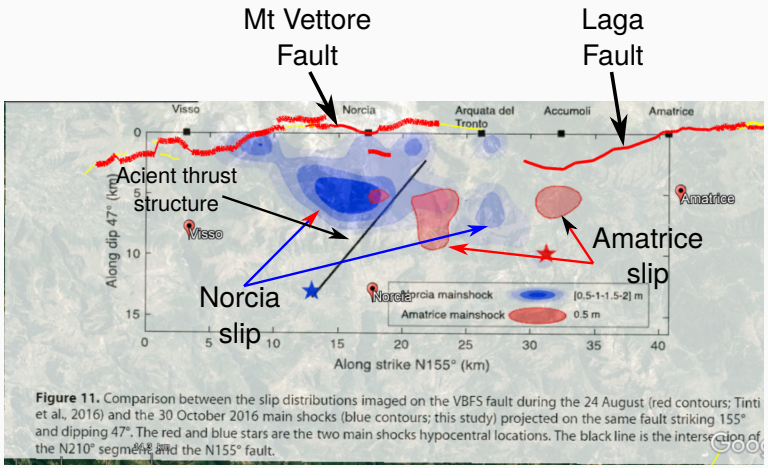

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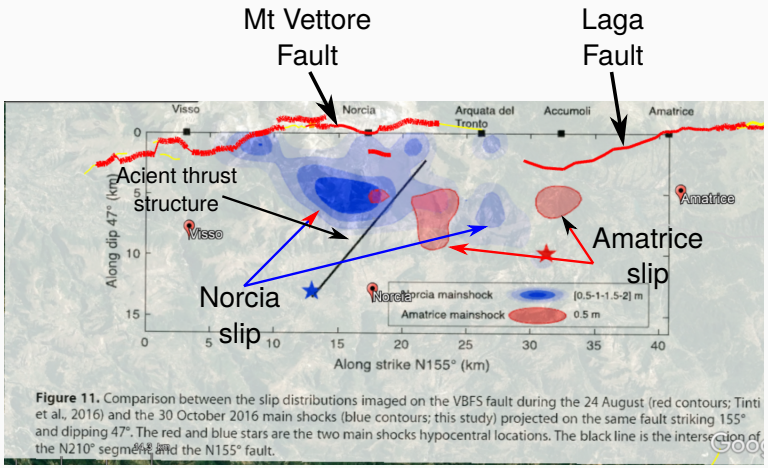

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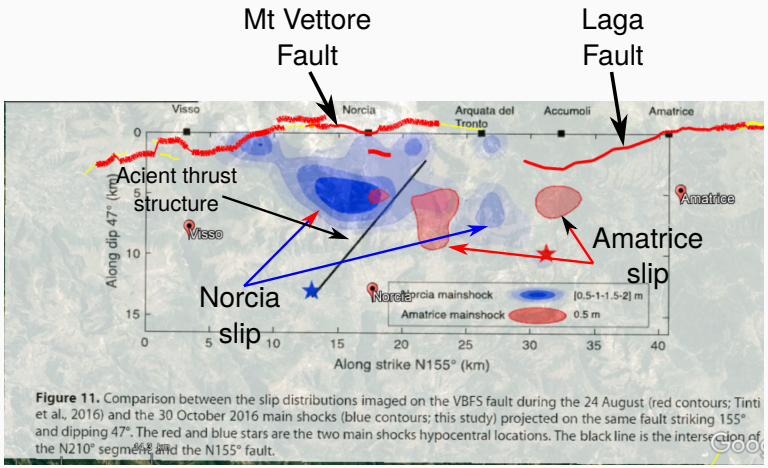

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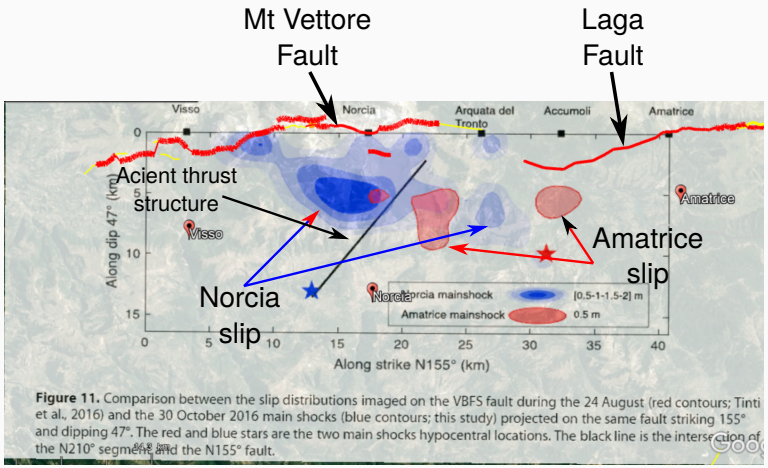

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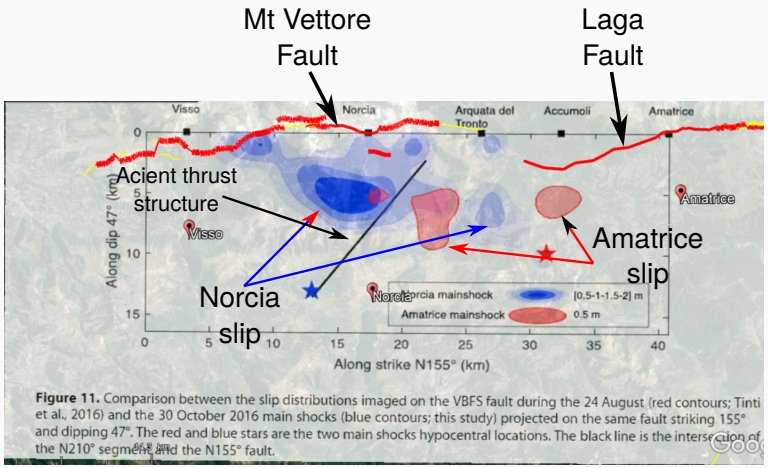

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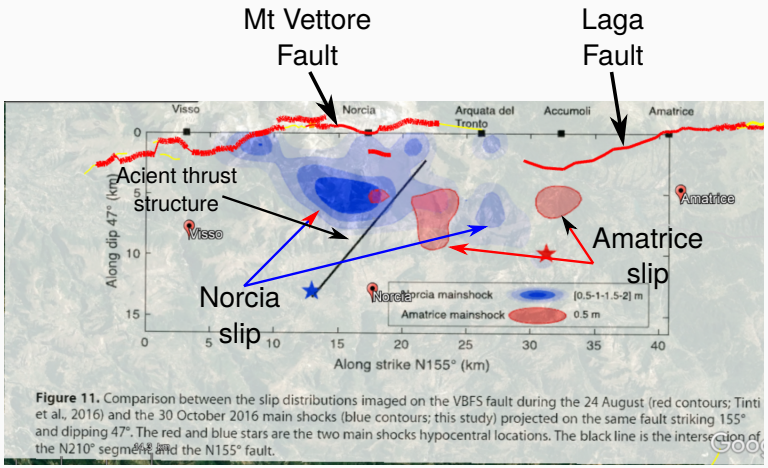

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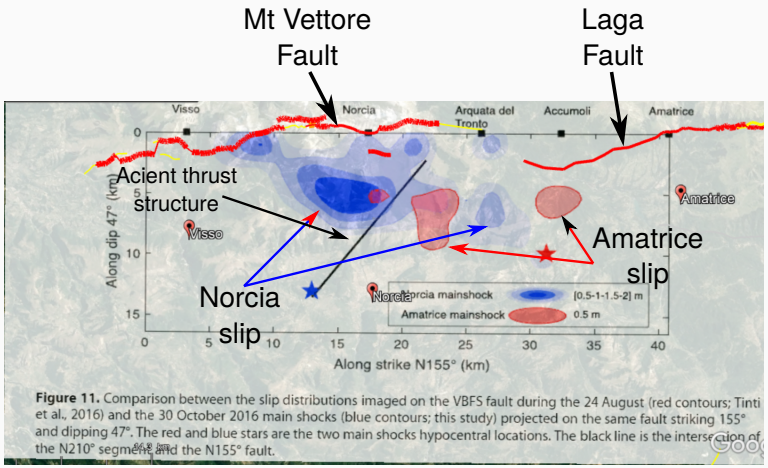

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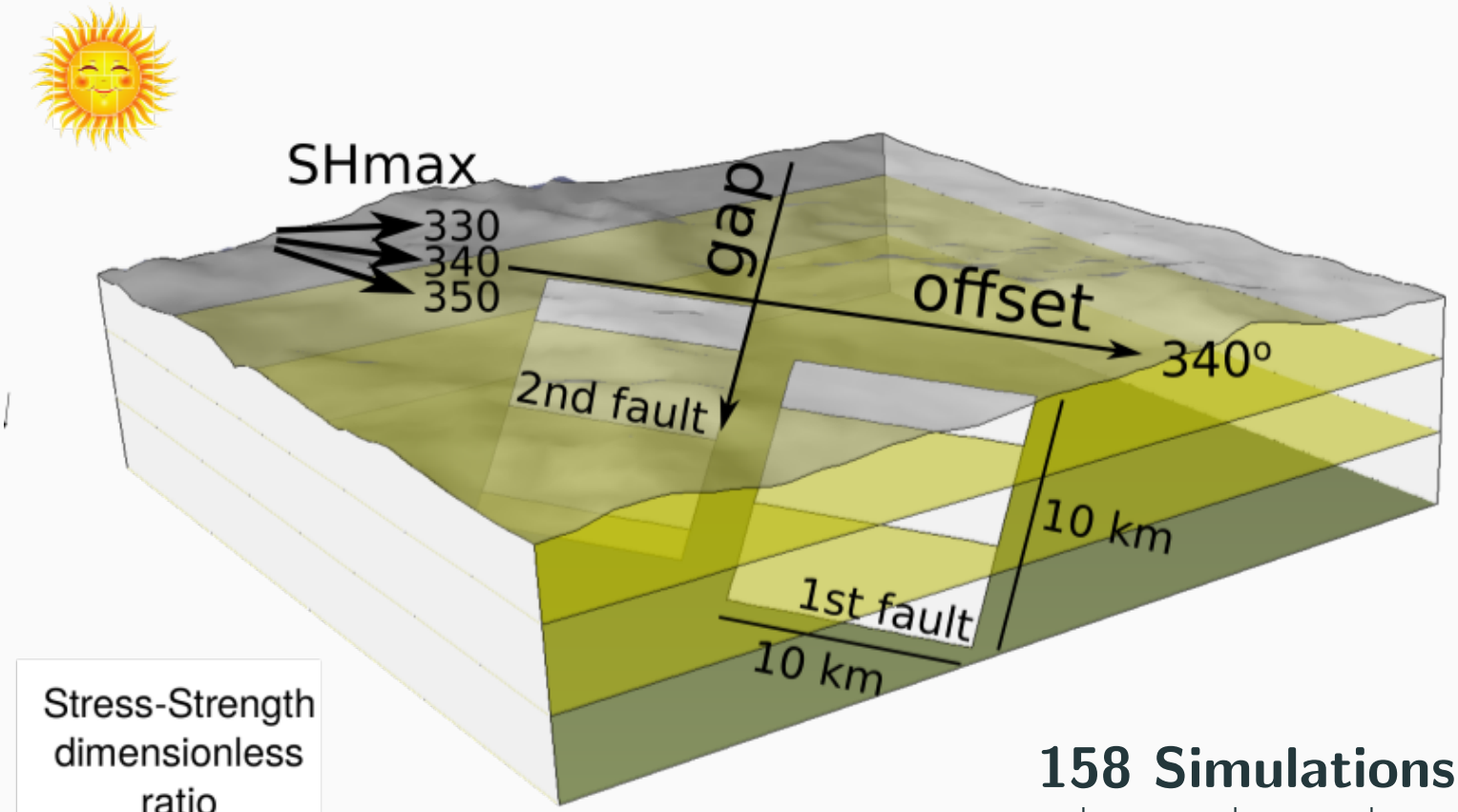
Investigate the physical conditons promoting rupture jumps across step overs regarding normal fault systems

Settings

Geometry and parameters explored



Stress-Strength dimensionless ratio

$$S = \frac{\tau_p - \tau_0}{\tau_0 - \tau_r}$$

158 Simulations

Parameter	min	Δ	max

Simulations using: www.seissol.org

linear slip weakening law

(e.g., Wollherr et al., 2018; Ulrich et al., 2019)

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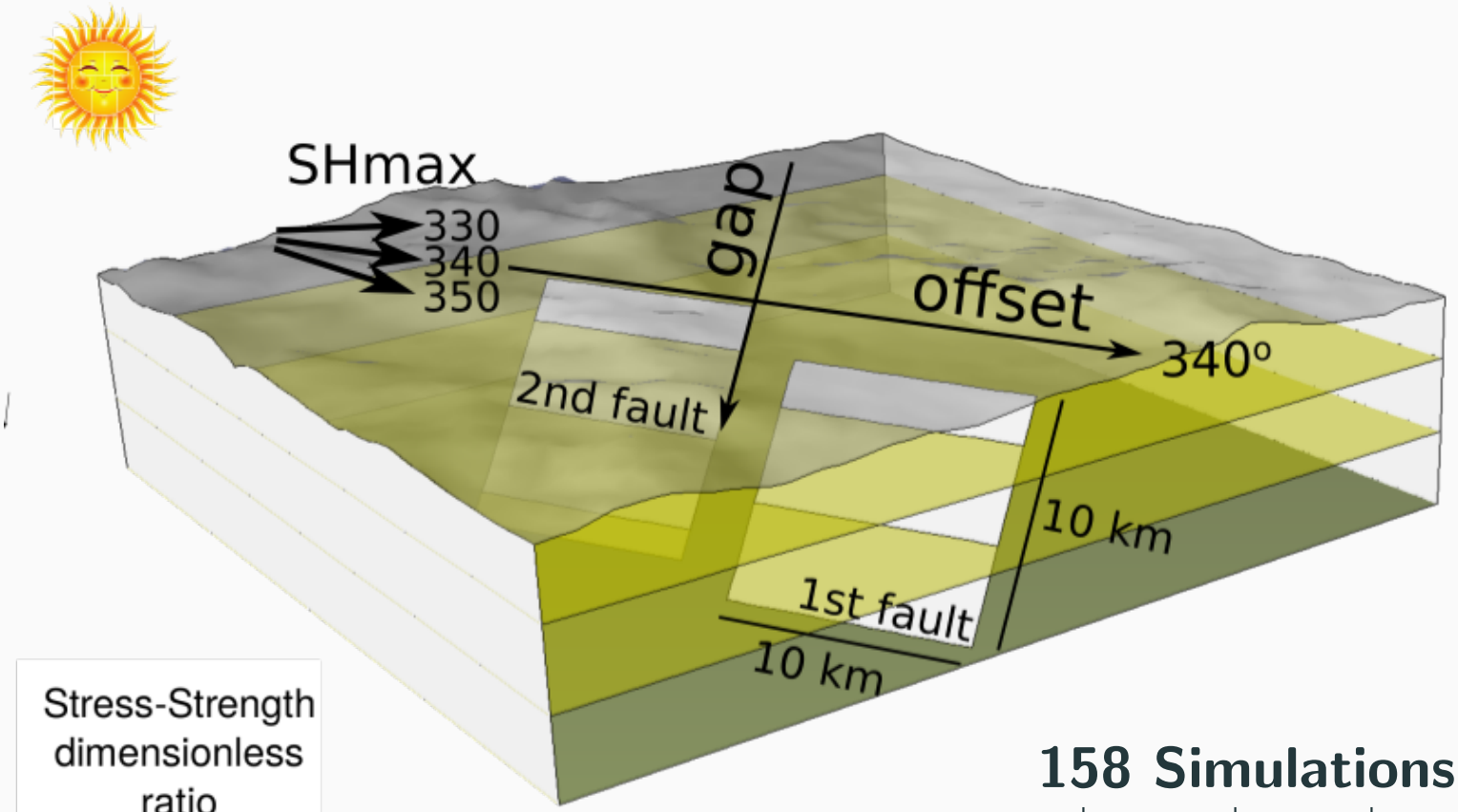

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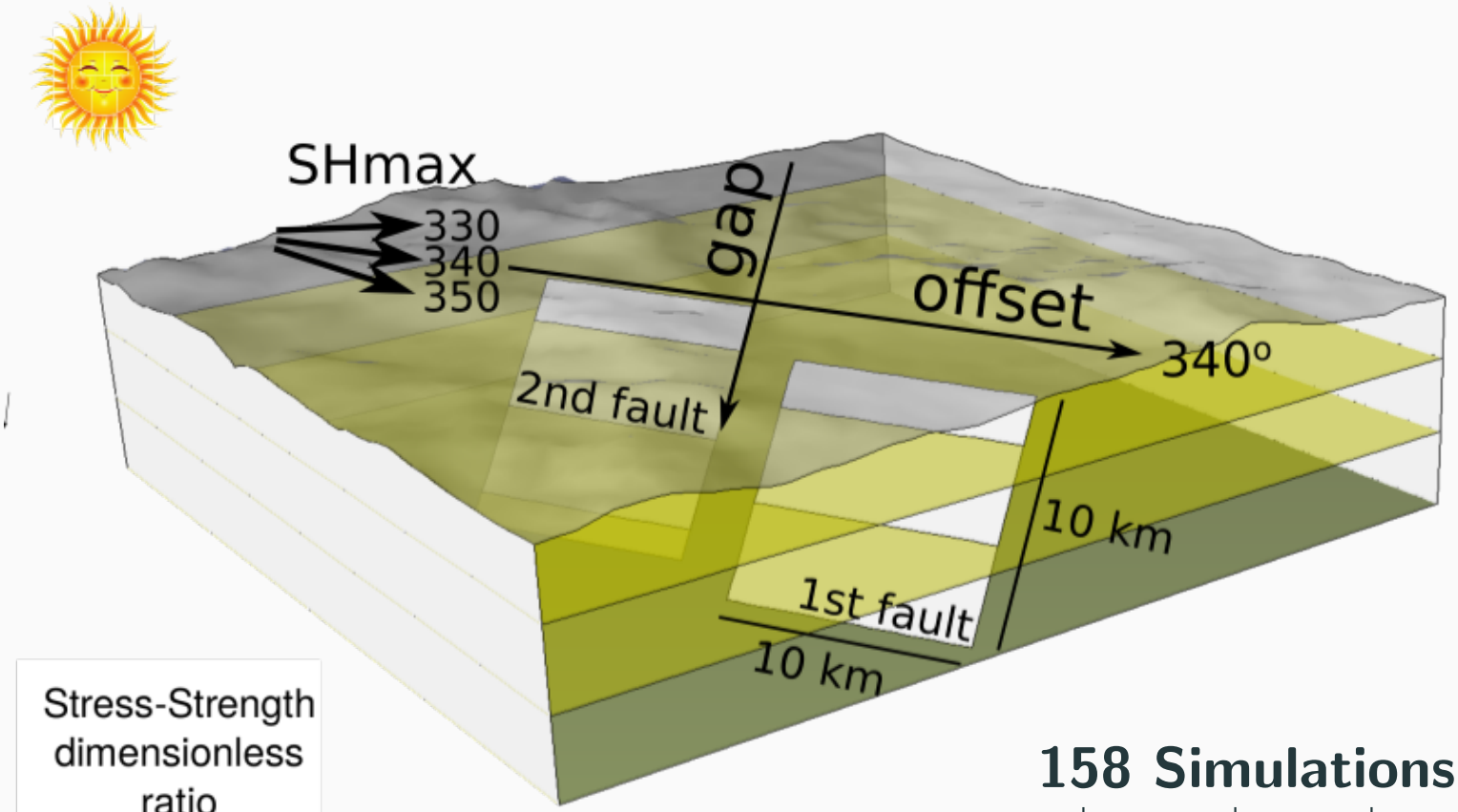

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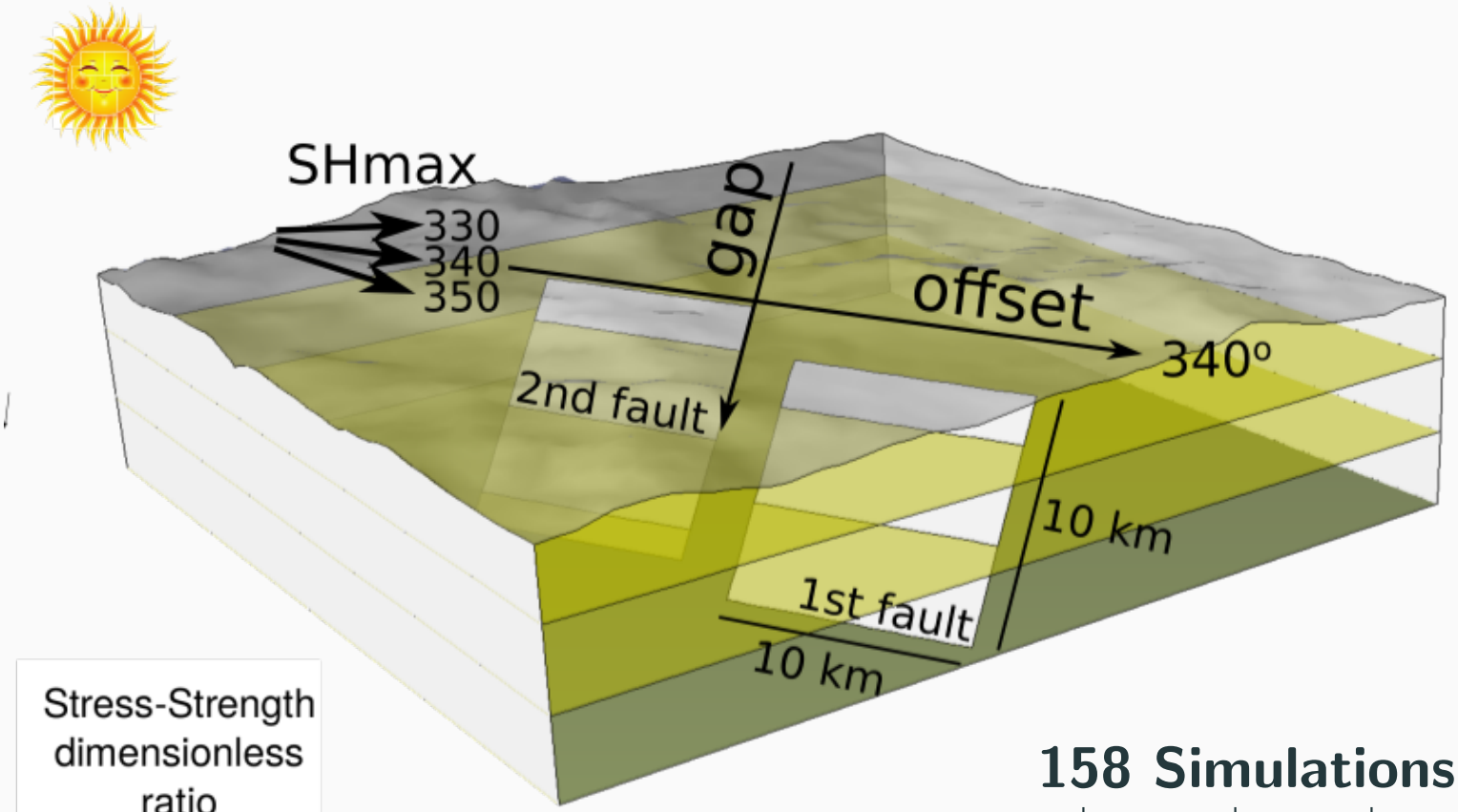

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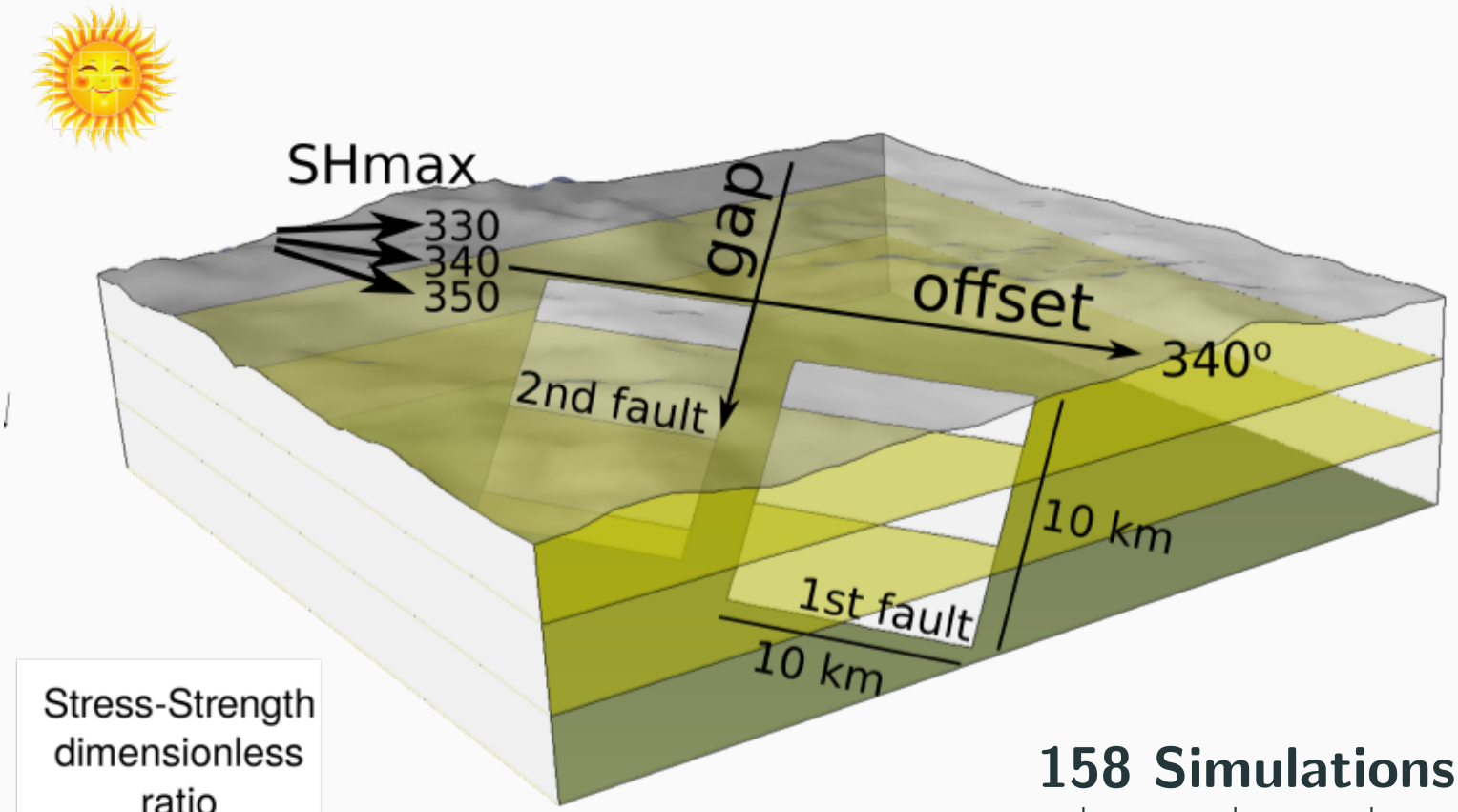

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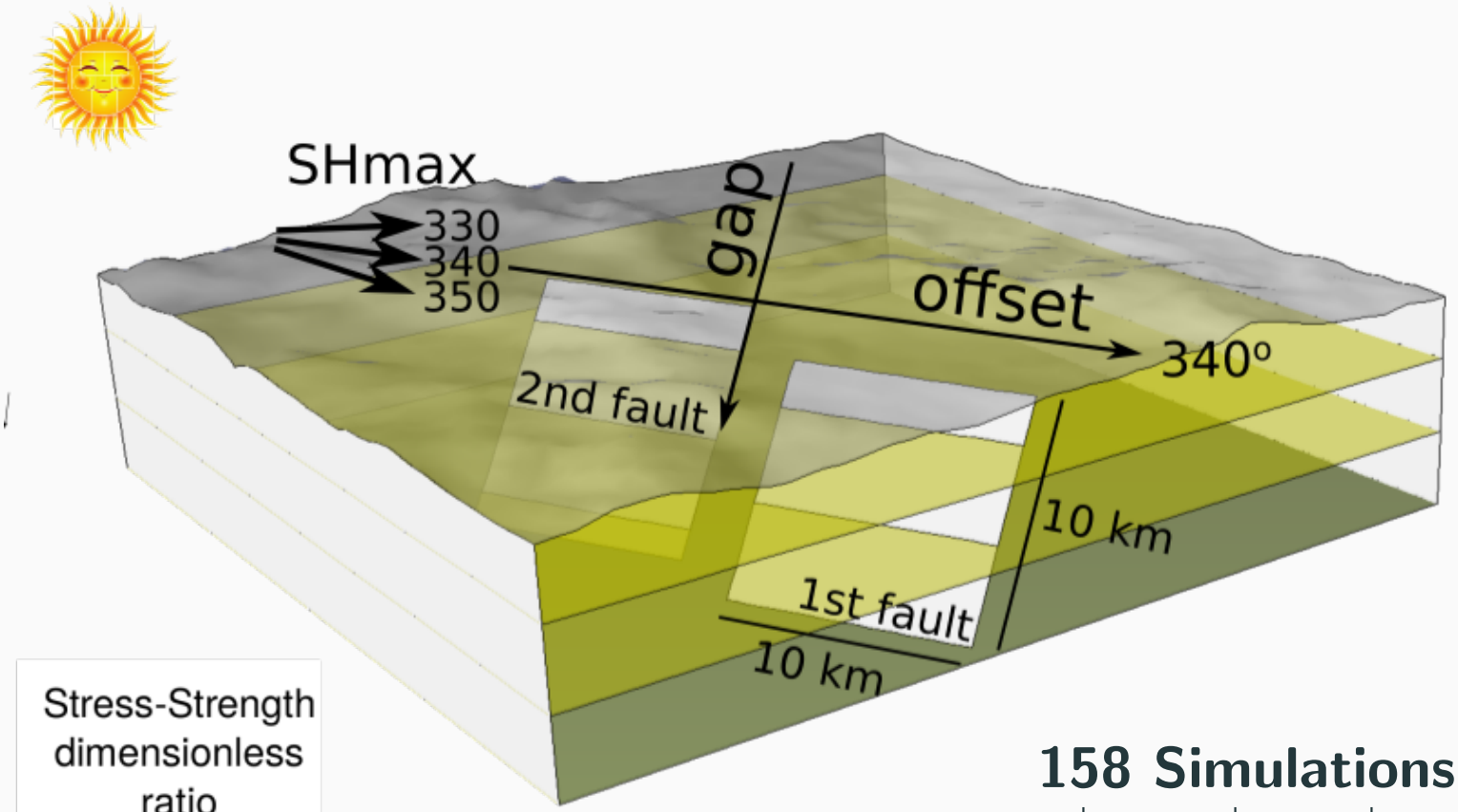

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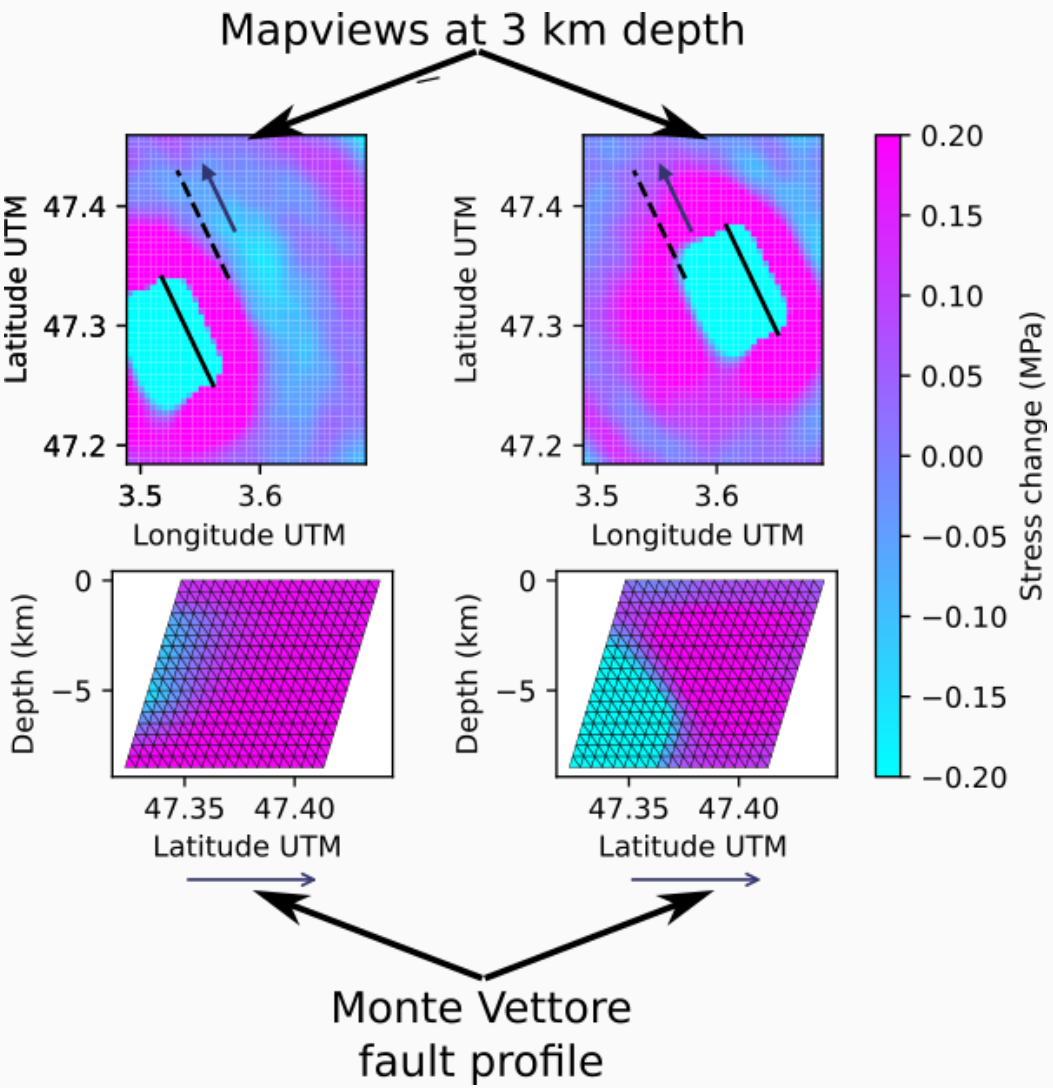
Static analysis ... jump? break-away?

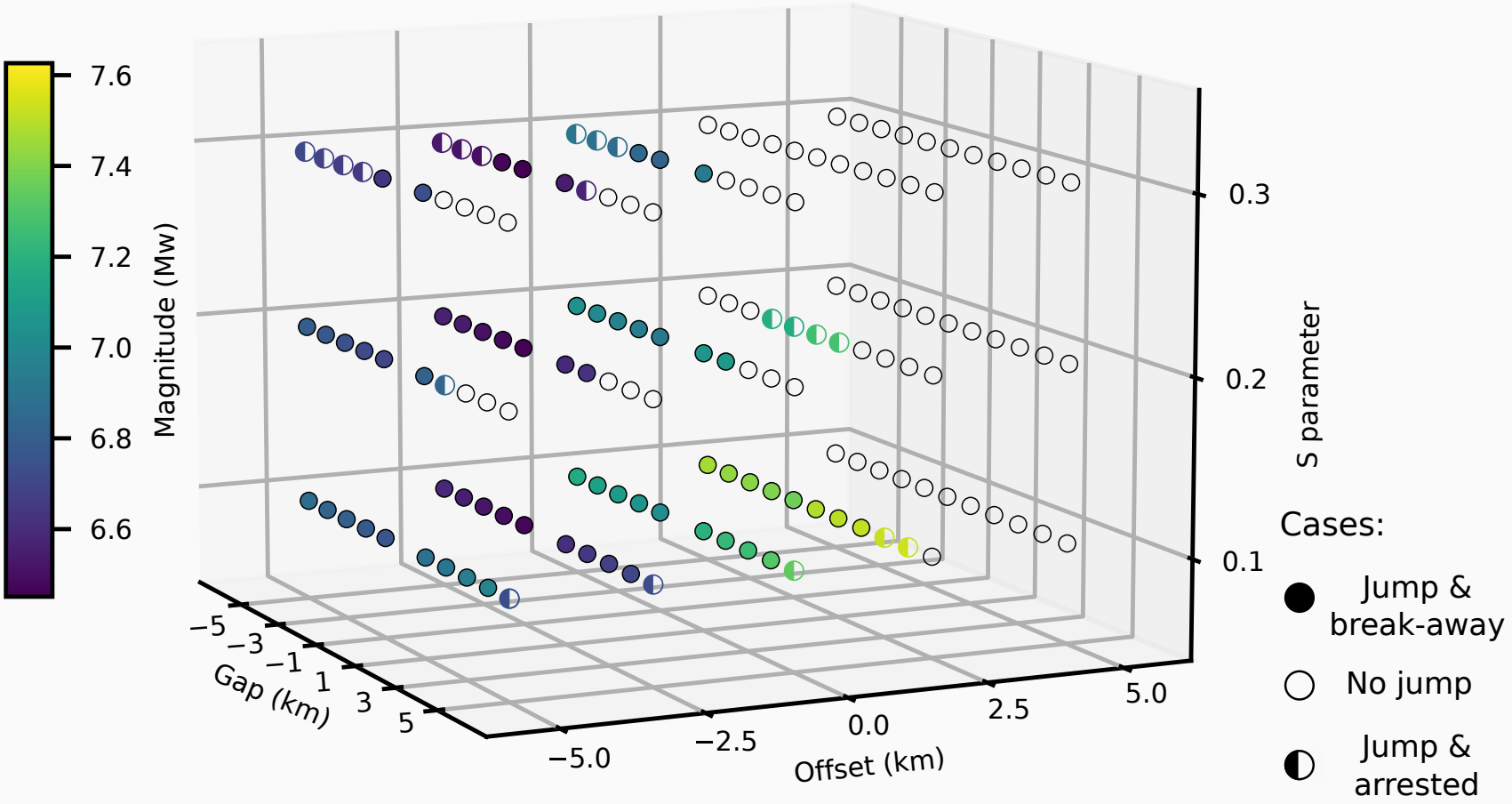


Are jumps and breakaway behavior prone to happen in both cases?

Is a static analysis enough to determine such behaviors?

Results

Results ... summary from 158 simulations



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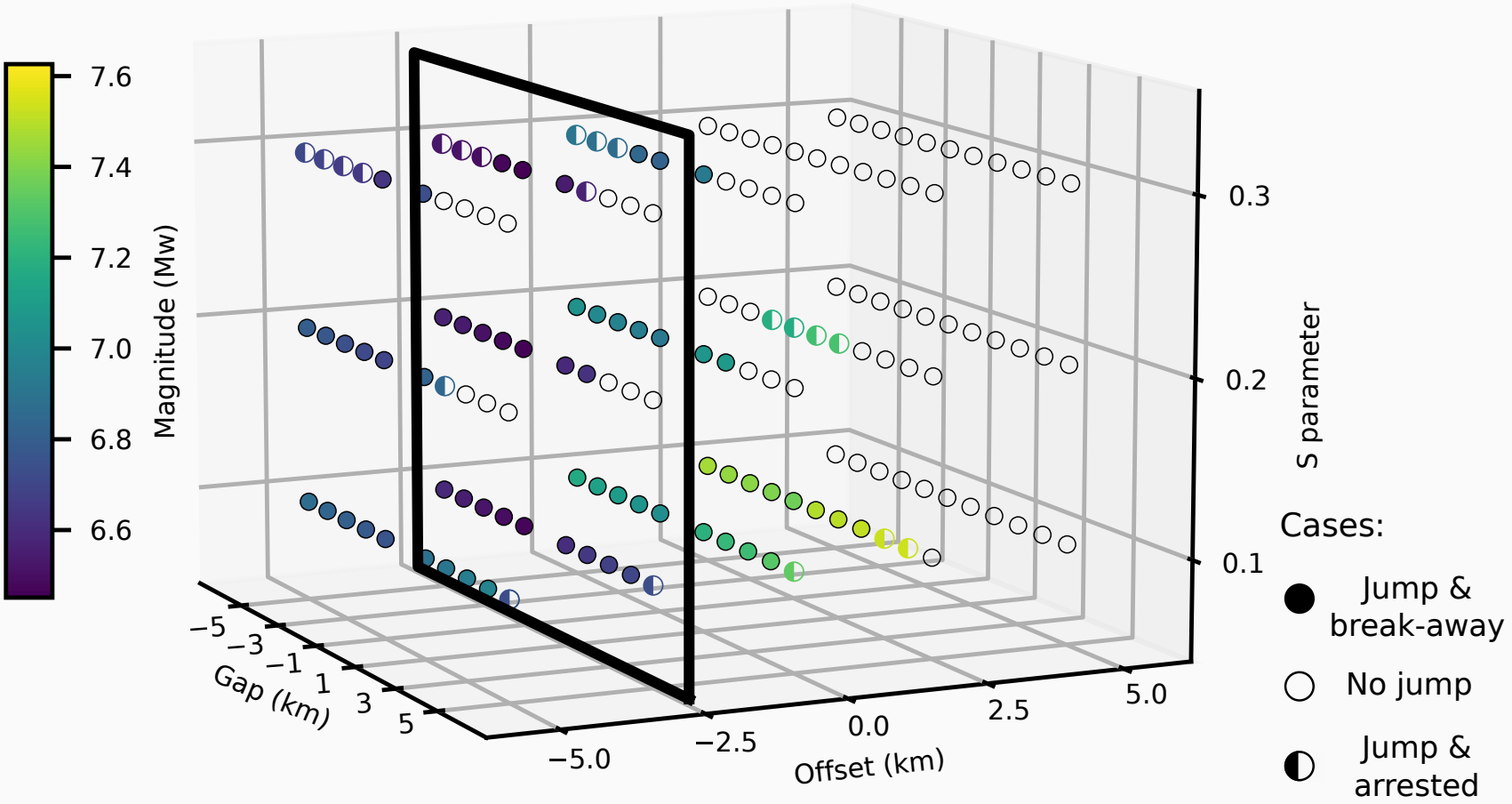
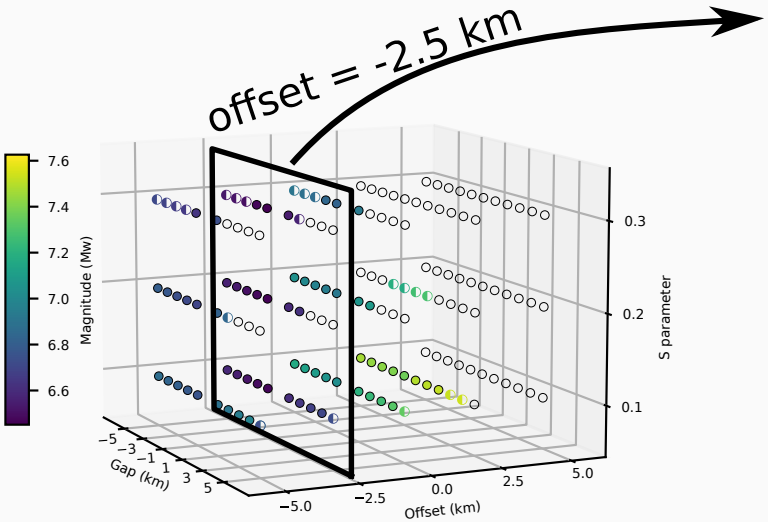


Let's see in detail some results at

a given offset ... at offset $= -2.5$ km ($\frac{1}{4}$ overlaped)

Results: Hangig/foot wall Asymmetric behavior



Cases:

● jump & break-away

○ jump & arrested

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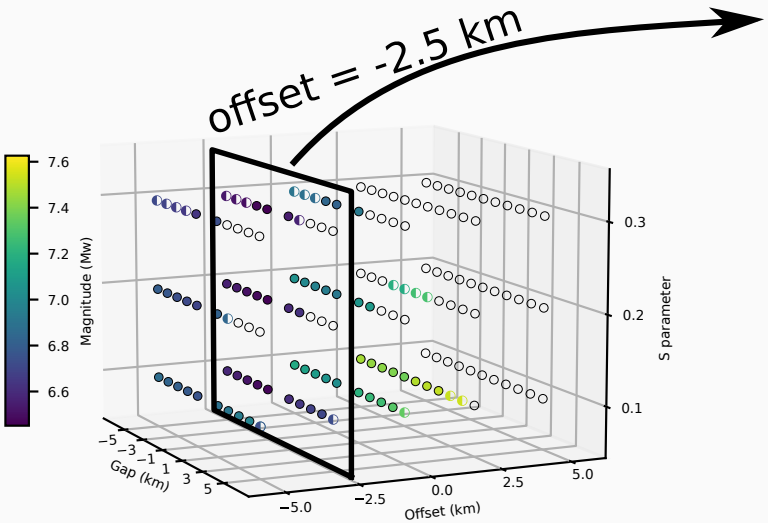

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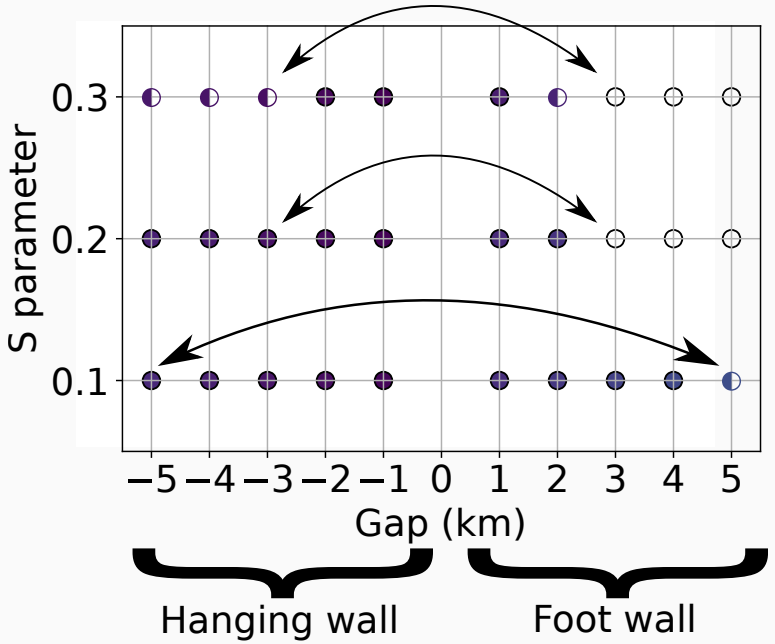
Compressive/Extensive Asymmetry



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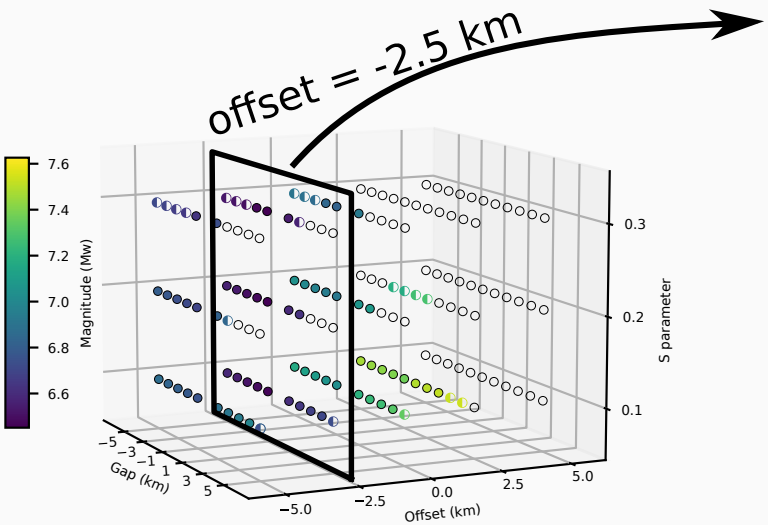

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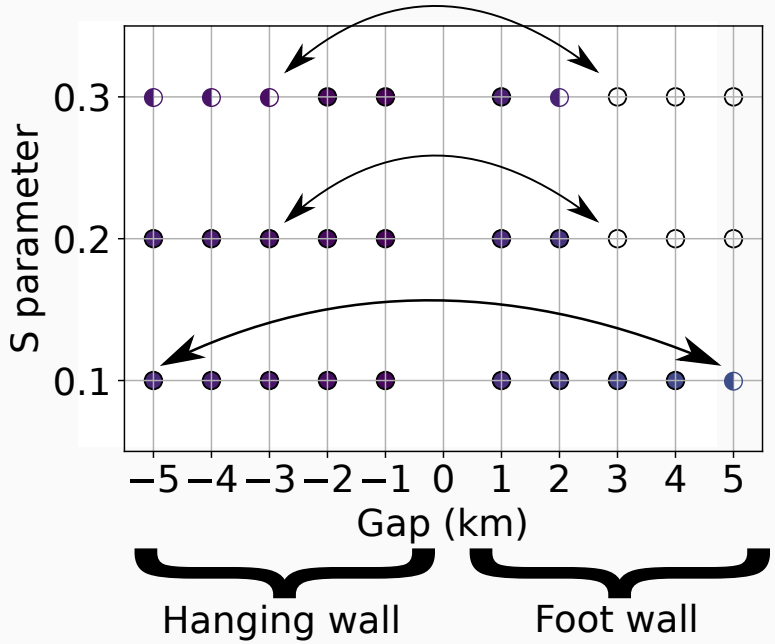
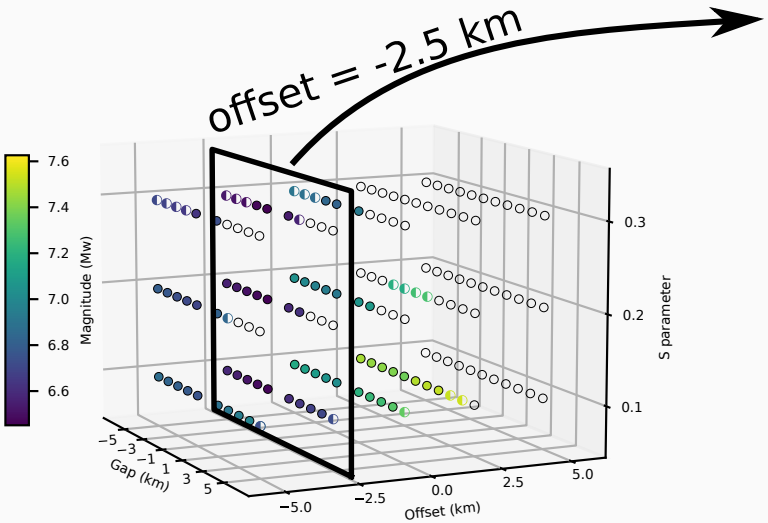


☞ **Hanging/foot wall asymmetry:**

When the 2nd fault is on the hanging wall (Gap < 0), the rupture is more likely to

- be triggered
- be sustained

Results: Stress shadow ☞ expected magnitudes



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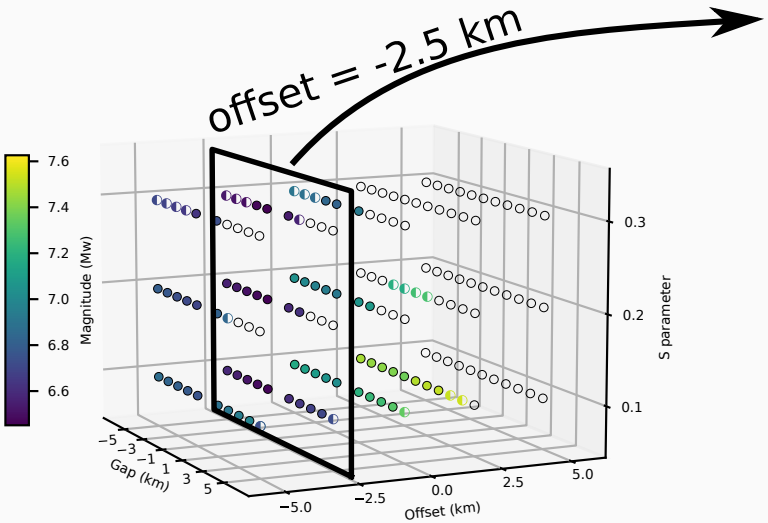

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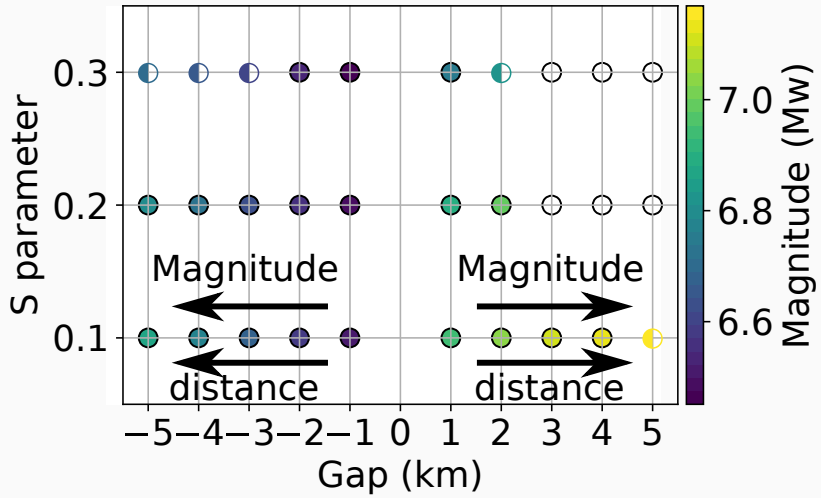

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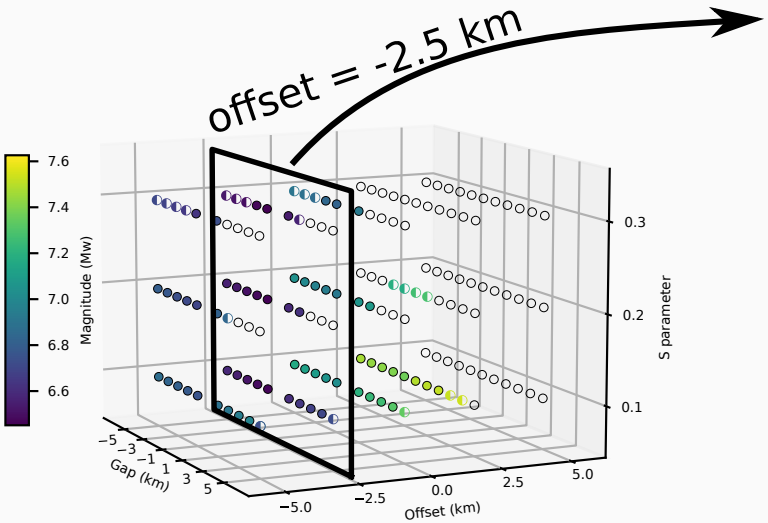

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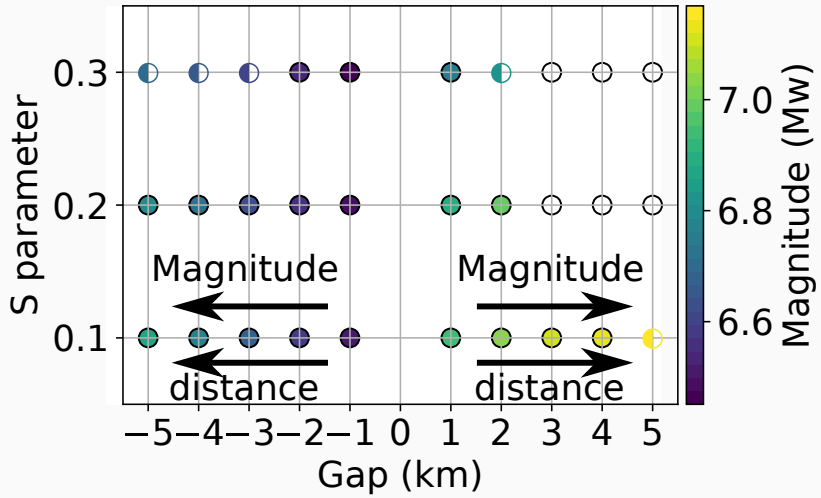

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The final energy released (M_w proxy) increases/decreases according to the distance between faults.

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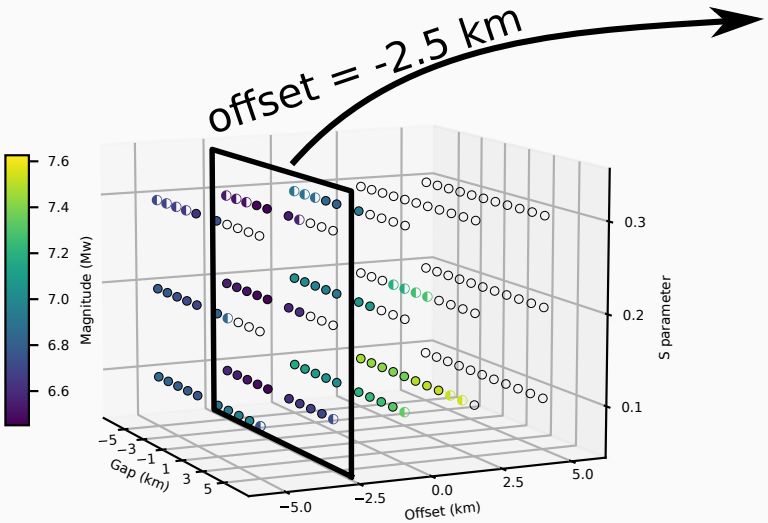

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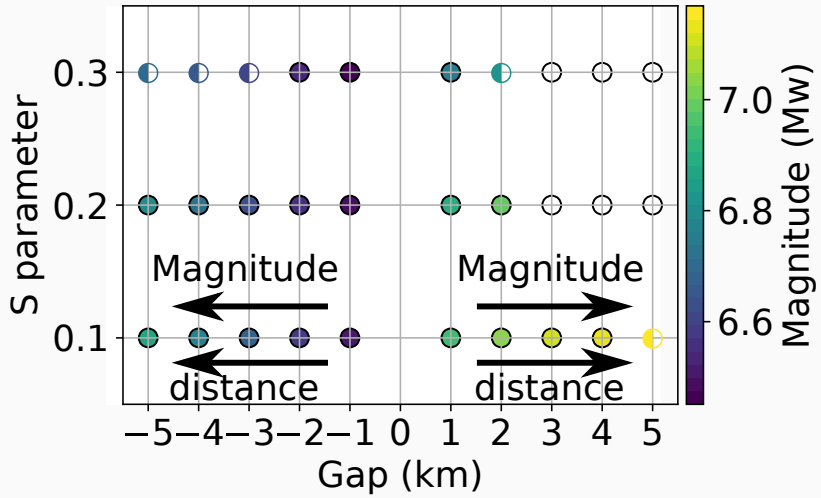

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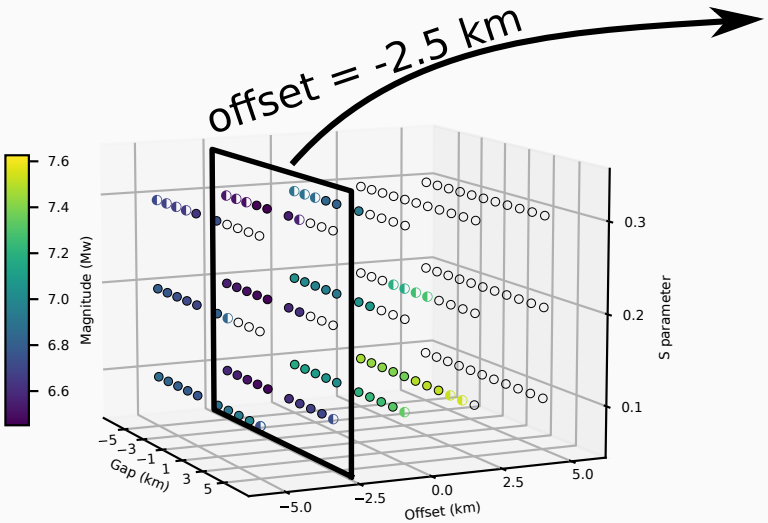
The closer $\longrightarrow$ rupture jump

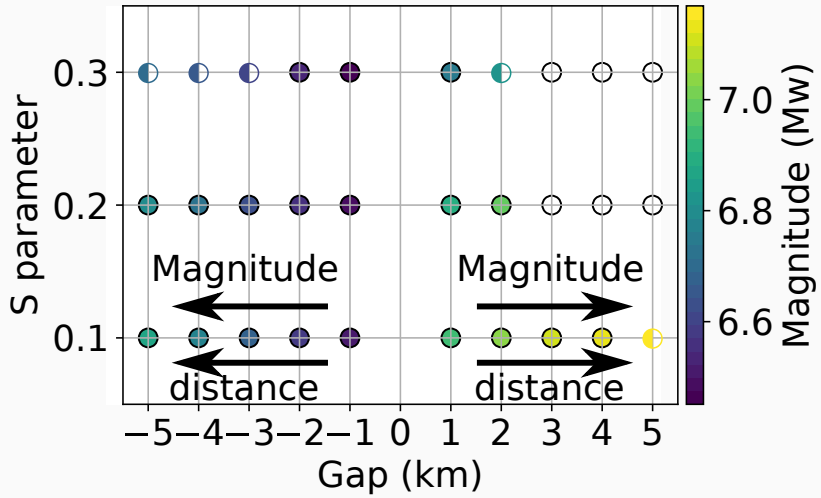
Results: Stress shadow ☞ expected magnitudes



Cases:

- ● jump & break-away
- ○ jump & arrested
- ◐ no jump

Proximity VS magnitude



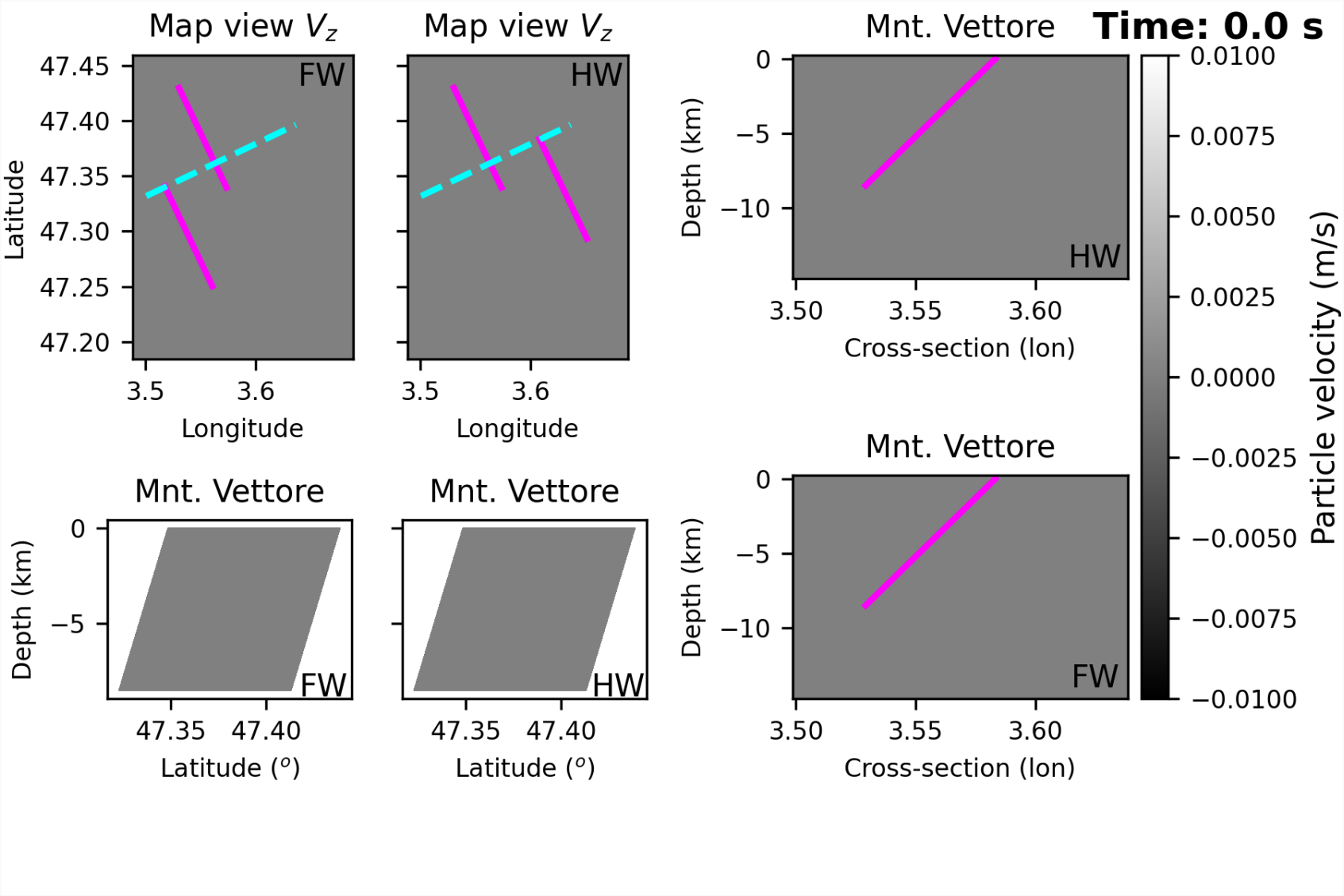
☞ **Stress shadow:**

The final energy released (M_w proxy) increases/decreases according to the distance between faults.

The closer $\longrightarrow$ rupture jump

The closer $\longrightarrow$ less magnitude

Special case: offset −2.5 km, gap ±5.0 km



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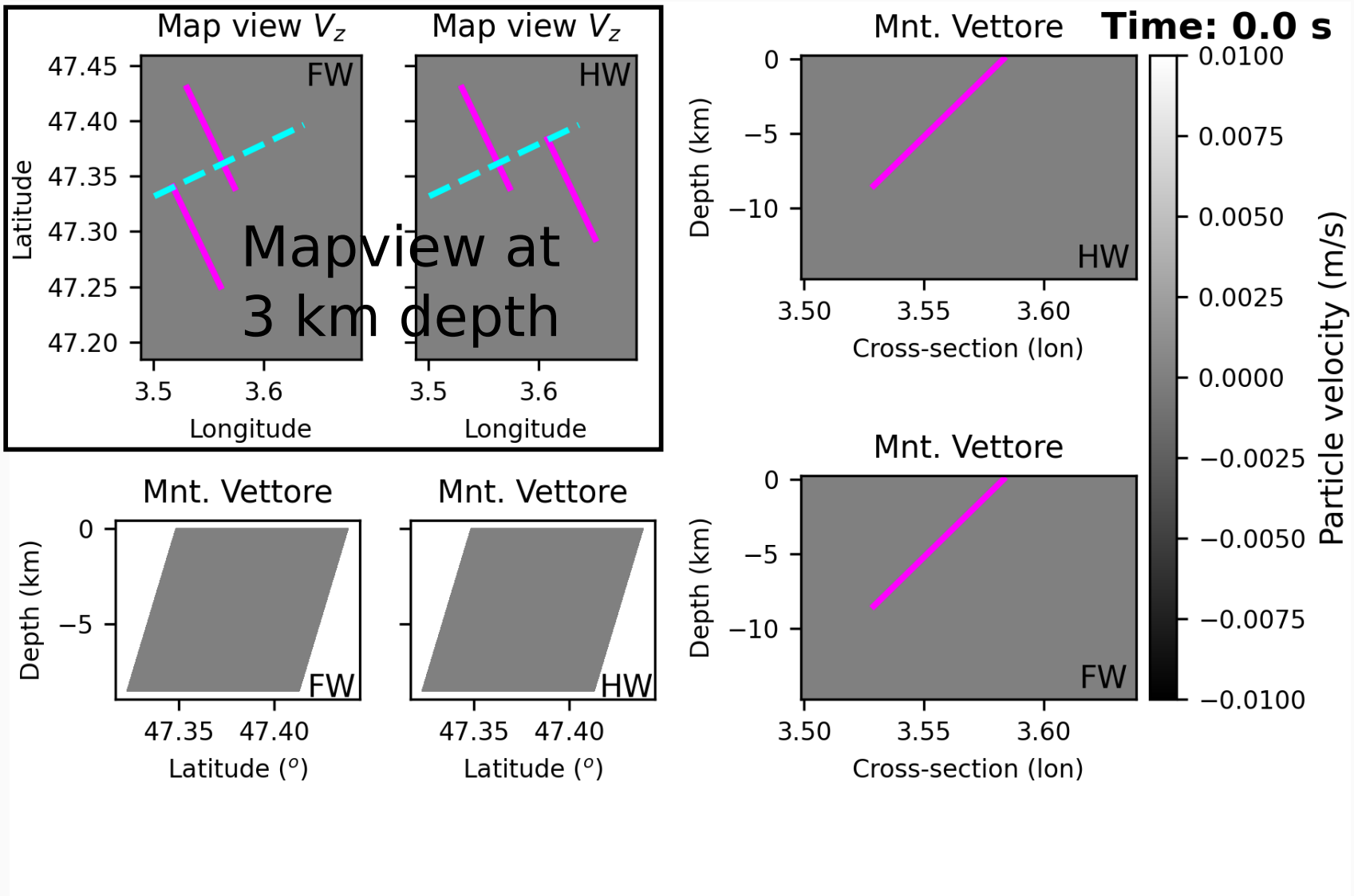

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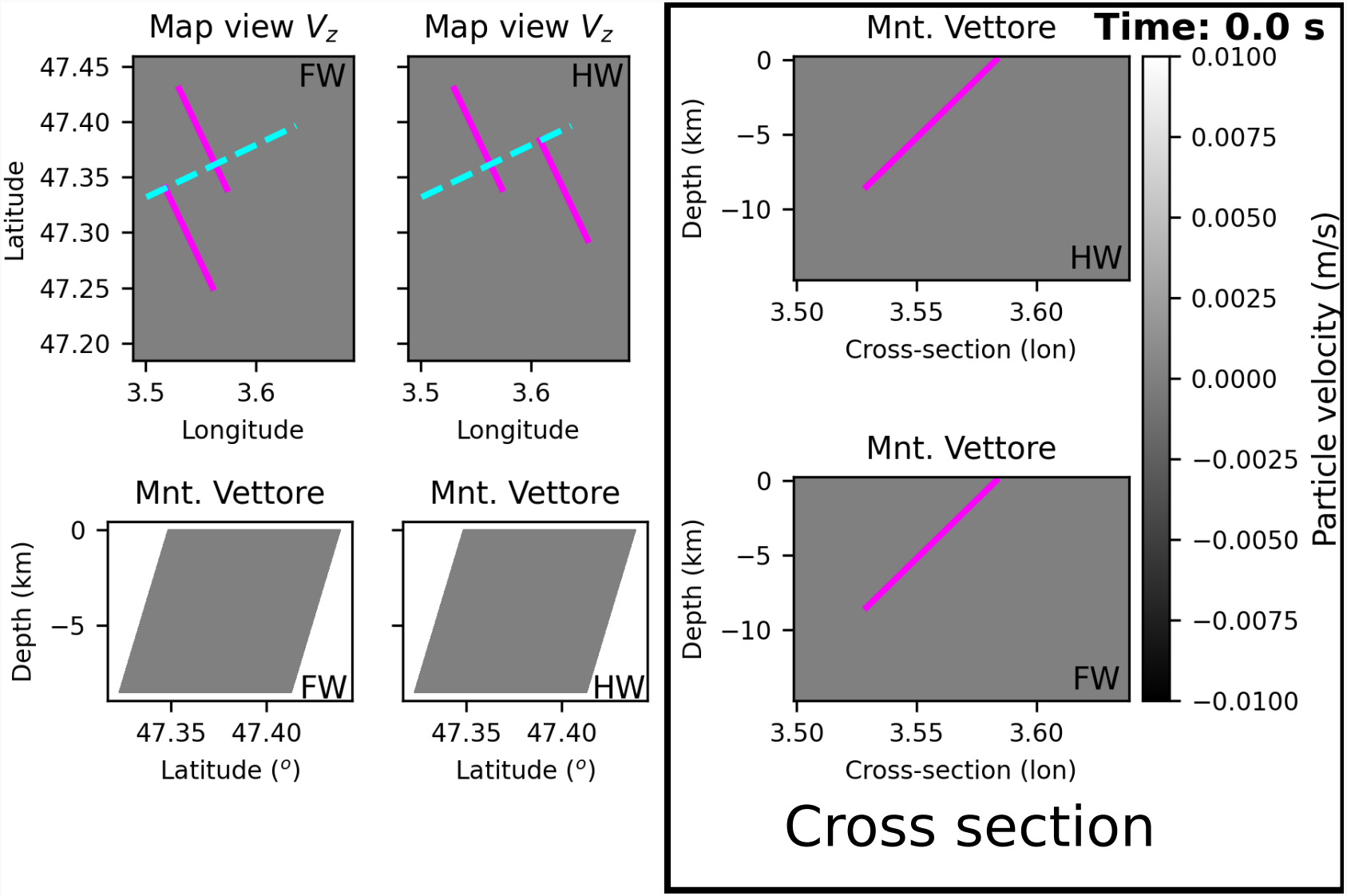

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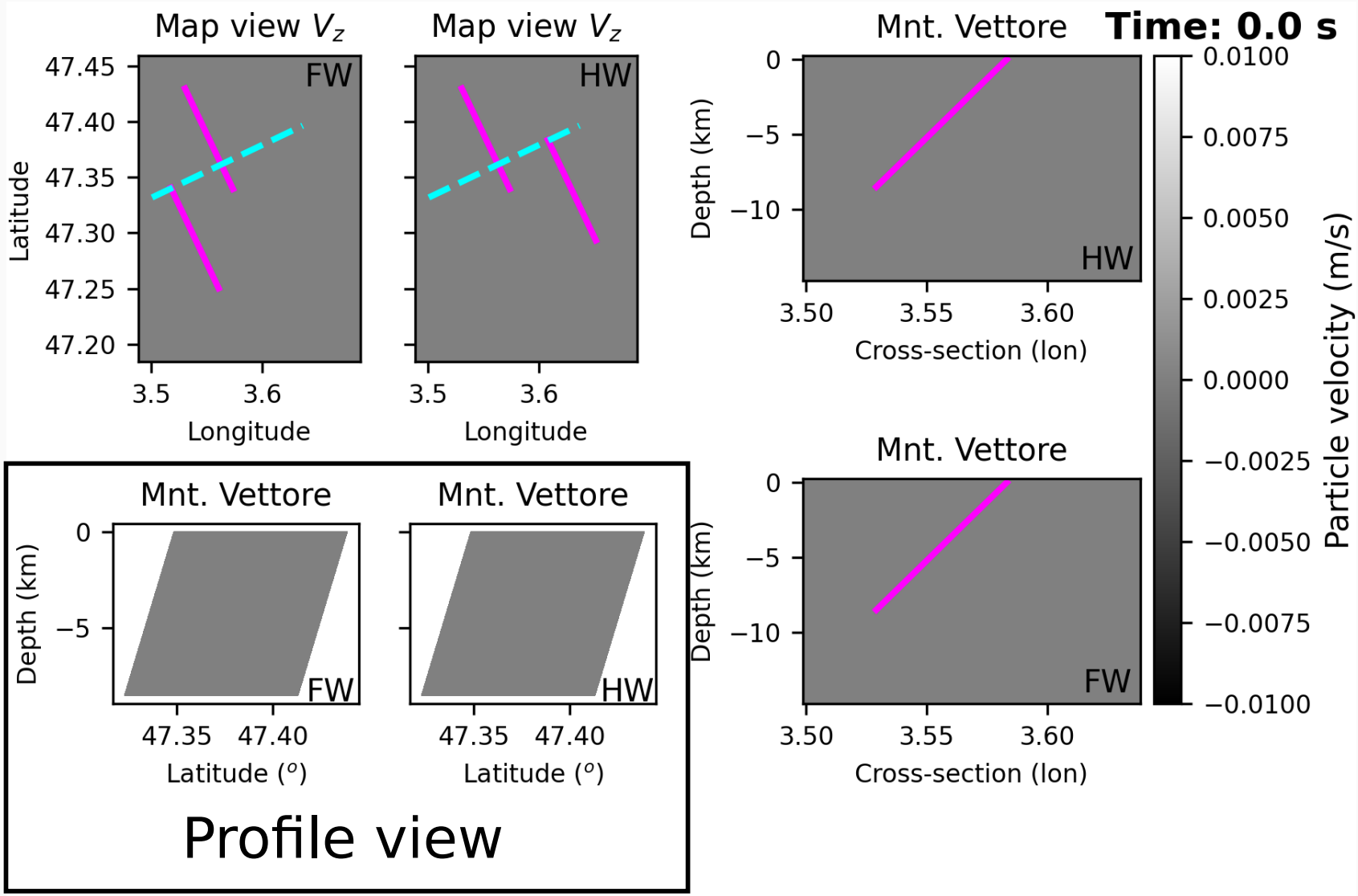

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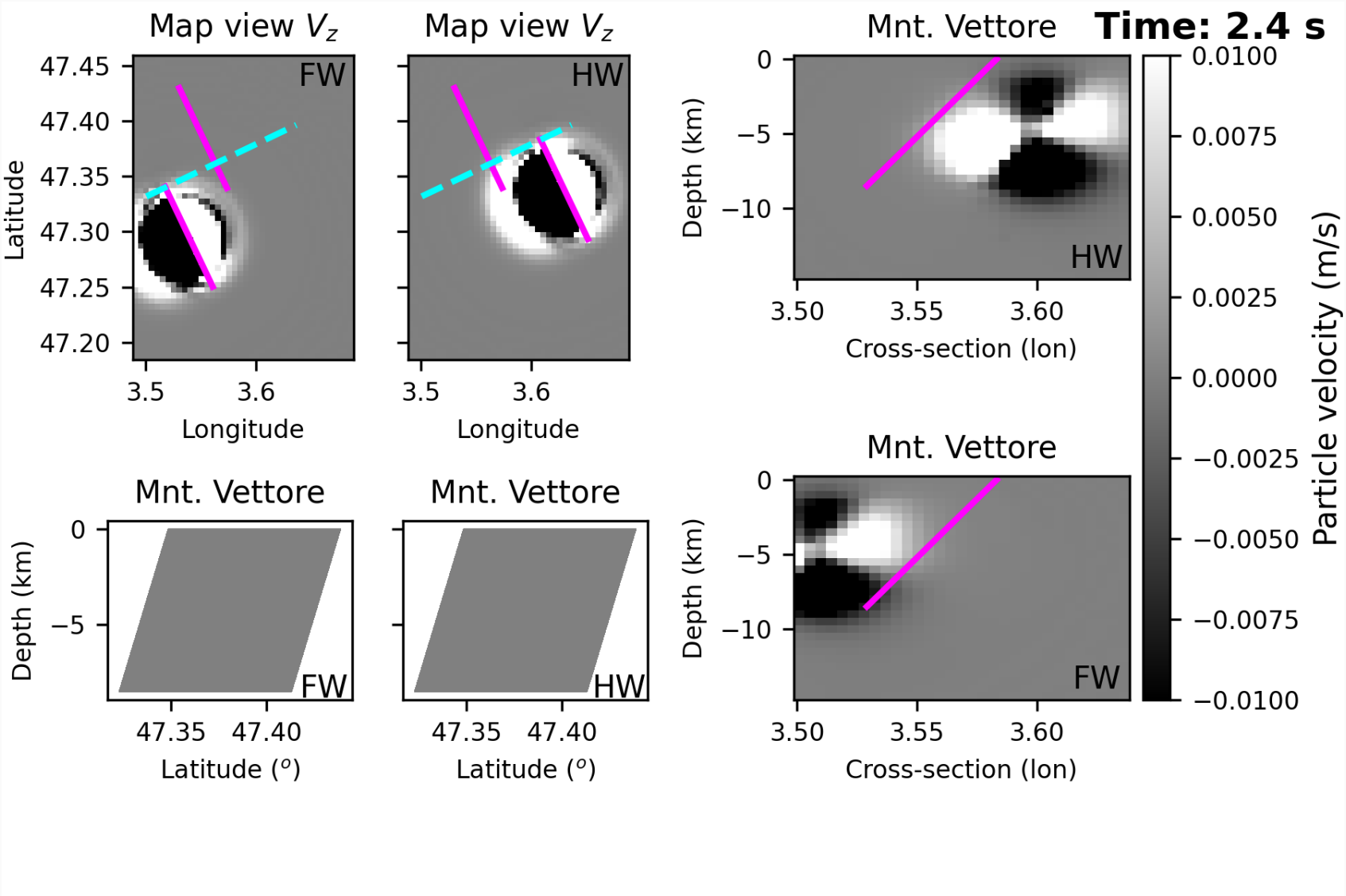

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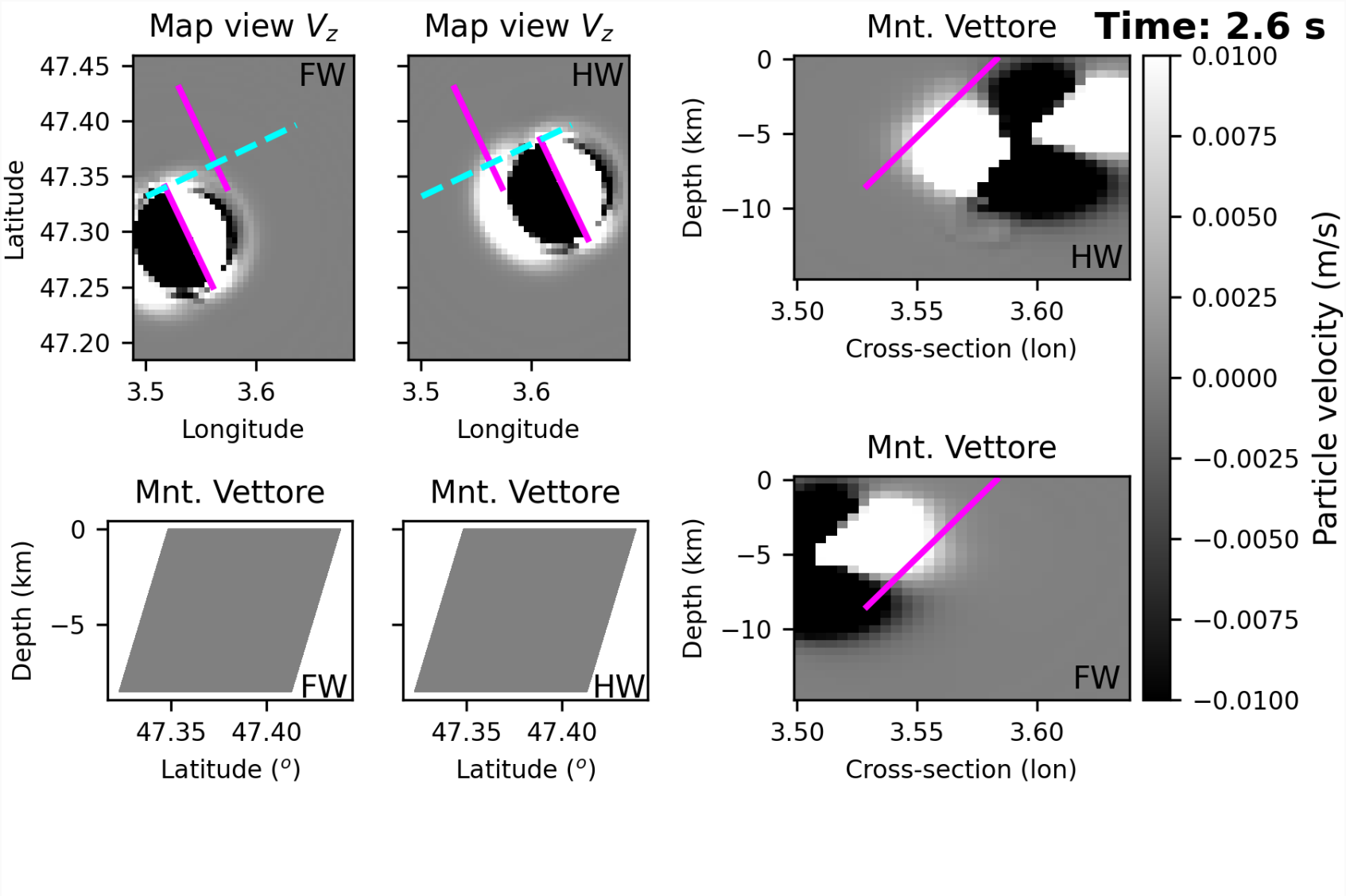
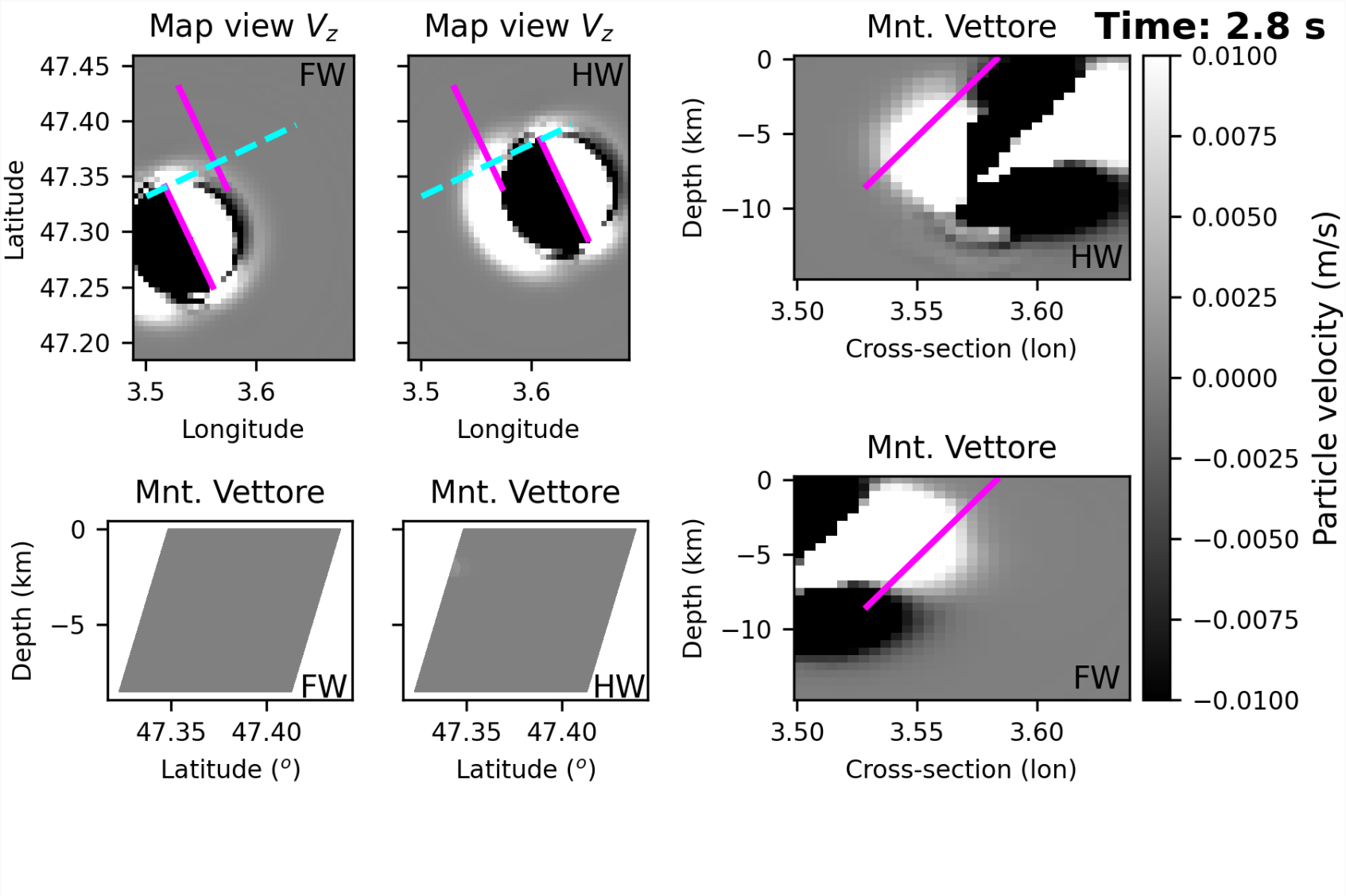
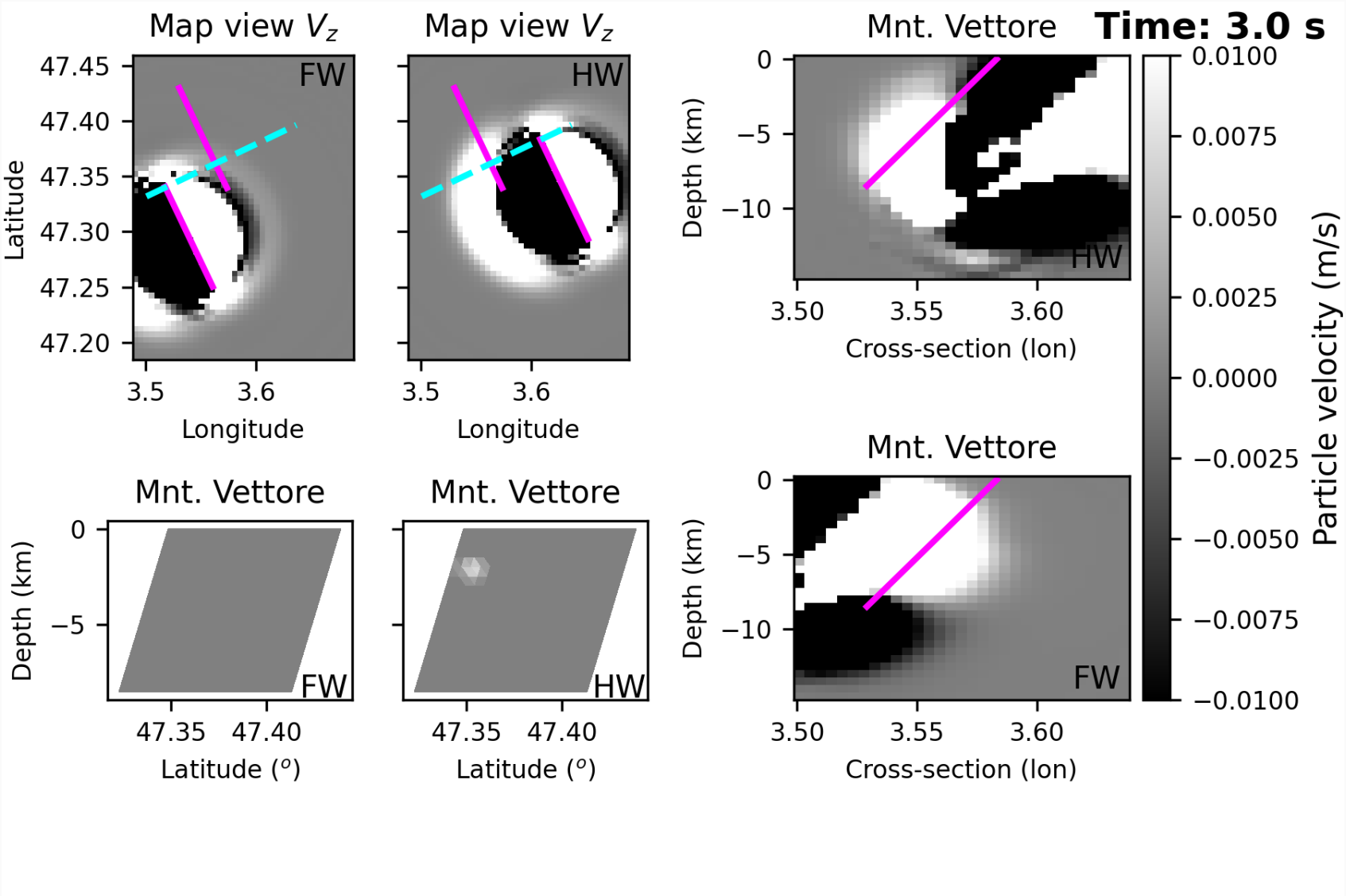


Special case: offset -2.5 km, gap ± 5.0 km



Special case: offset -2.5 km, gap ± 5.0 km



Conclusions

Conclusion & discusion

To sum up:

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- ☞ Static analyses seem to be insufficient to precisely determine a rupture jump and beak-away behaviors.

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- ☞ It is necessary to have an enough large area where ΔCFF$>$0 to ensure a sustained rupture after it jumped across the step-over.

To sum up:

- ☞ Static analyses seem to be insufficient to precisely determine a rupture jump and beak-away behaviors.
- ☞ It is necessary to have an enough large area where ΔCFF$>$0 to ensure a sustained rupture after it jumped across the step-over.
- ☞ Behaviors such as “stress shadow” and ”asymmetric response” were observed as for strike-slip faults.

To sum up:

- ☞ Static analyses seem to be insufficient to precisely determine a rupture jump and beak-away behaviors.
- ☞ It is necessary to have an enough large area where ΔCFF$>$0 to ensure a sustained rupture after it jumped across the step-over.
- ☞ Behaviors such as “stress shadow” and ”asymmetric response” were observed as for strike-slip faults.
- ☞ The 2nd fault rupture seems to be dynamically triggered by the strong stopping phase arriving from behind.

To sum up:

- ☞ Static analyses seem to be insufficient to precisely determine a rupture jump and beak-away behaviors.
- ☞ It is necessary to have an enough large area where ΔCFF$>$0 to ensure a sustained rupture after it jumped across the step-over.
- ☞ Behaviors such as "stress shadow" and "asymmetric response" were observed as for strike-slip faults.
- ☞ The 2nd fault rupture seems to be dynamically triggered by the strong stopping phase arriving from behind.
- ☞ 5 km seems to be the largest distance that the rupture can jump (considering very high stress levels).

Thank you for listening!

Questions?

References

References

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