Does a damaged-fault zone mitigate the near-field impact of supershear earthquakes?

Application to the 2018 M 7.5 Palu earthquake

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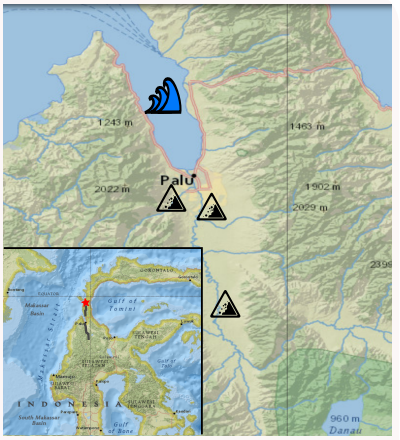
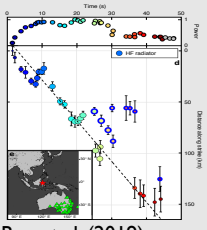
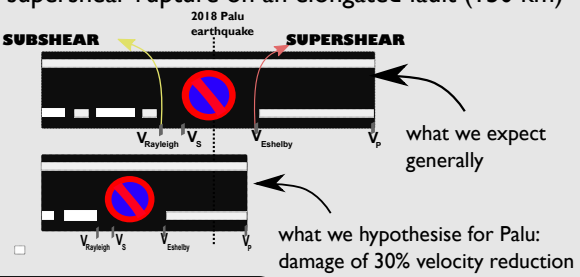


What was striking about Palu?

- The 2018 Palu event was a supershear earthquake running at an unexpectedly low speed (sub-Eshelby speed)
- Early and persistent supershear rupture on an elongated fault (150 km)



Bao et al. (2019)



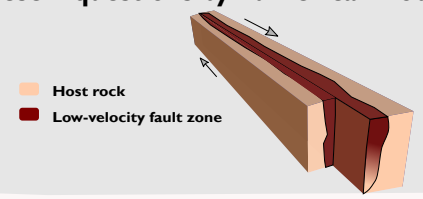
what we expect generally

what we hypothesise for Palu: damage of 30% velocity reduction

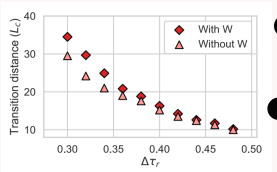
- Devastating coseismic landslides -inland and submarine- were reported in near field (< 10 km off-fault distance)

Question II Does a slow supershear within damage mitigate/aggravate the near-field ground motion and consequent landslide susceptibility ?

We address these 2 questions by numerical modelling



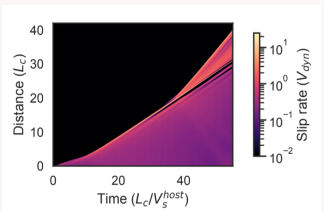
Question I Is the slow supershear rupture the result of the presence of a damaged-fault zone ?



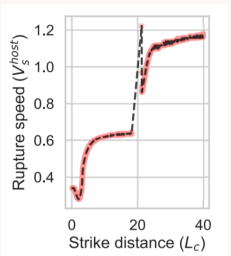
- Earlier supershear transition for a higher background stress; slight delay due to W
- Computed distance btw 4-15 km: consistent with observation (considering back-projection uncertainties)

Lc: half-length of nucleation zone
$\Delta\tau_r$: initial background stress

The case of $\Delta\tau_r = 0.37$



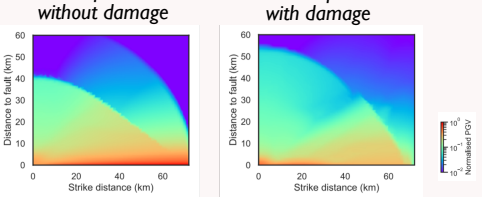
- initial subshear rupture becomes supershear at 8 km

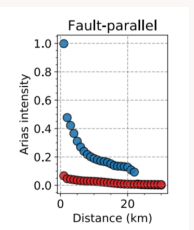


- rupture speed stabilises at 1.2Vs ~4.17 km/s (observed speed)

Q1:: Damage can explain the slow supershear in Palu earthquake

Fast supershear without damage | *Slow supershear with damage*



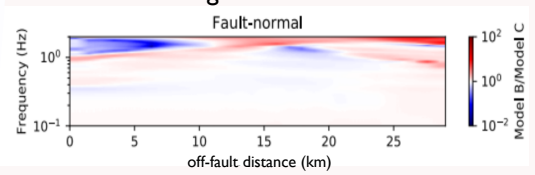


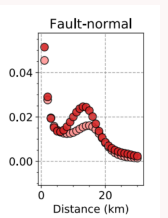
- significant attenuation of ground motion due to slow rupture speed

Mitigated landslide-triggering impact during slow supershear

Comparison of two slow supershear models with/out damage

- enhanced high-frequency energy (> 0.5 Hz) due to damage





Aggravated landslide-triggering impact because of damage

Q2:: Despite slow supershear, damage could have aggravated near-field ground motion and landslide risk in Palu

Discussion

- Better interpretation of past/future supershear events (ex: The 1999 Izmit, the 2002 Denali earthquakes)
- Challenges/need of adopting damage properties for further hazard studies

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