Seismic wave Propagation and Imaging in Complex media: a European network

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Early Stage Researcher

Host Institution: University of Naples
Place of Origin: Dublin, Ireland
Appointment Time: January 2006

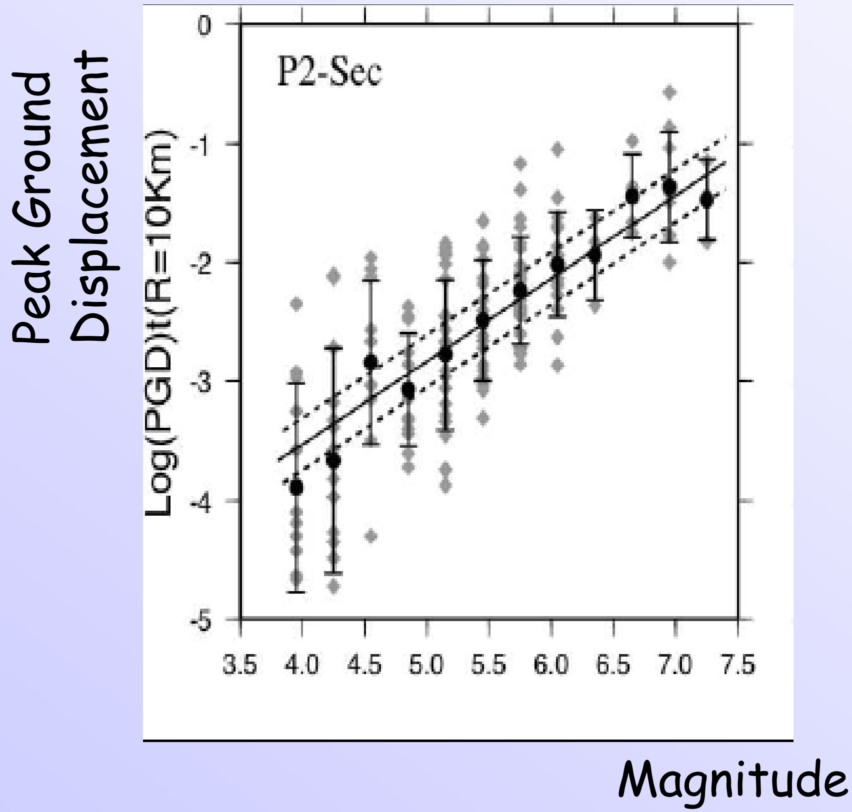
Project: How can initial ground motion scale with final rupture size?

Task Groups: Local Scale

Cooperation: INGV Roma

Early Magnitude Estimation

Scaling of Peak Displacement with Magnitude (Wu et al., GRL, 2006 and Zollo et al., GRL, 2006)



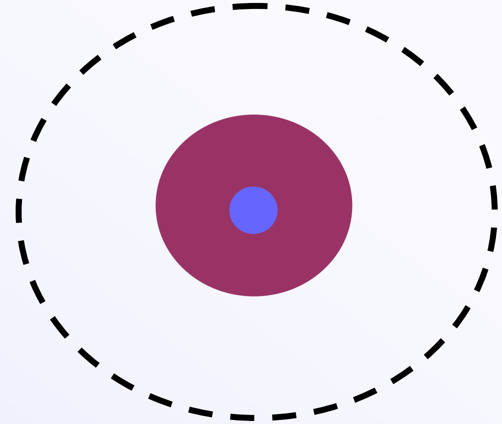
After: Zollo , Lancieri & Nielsen, GRL, 2006
Source: European Strong Motion Dataset (Ambraseys et al,. Geol. Teo. Appl., 2004)

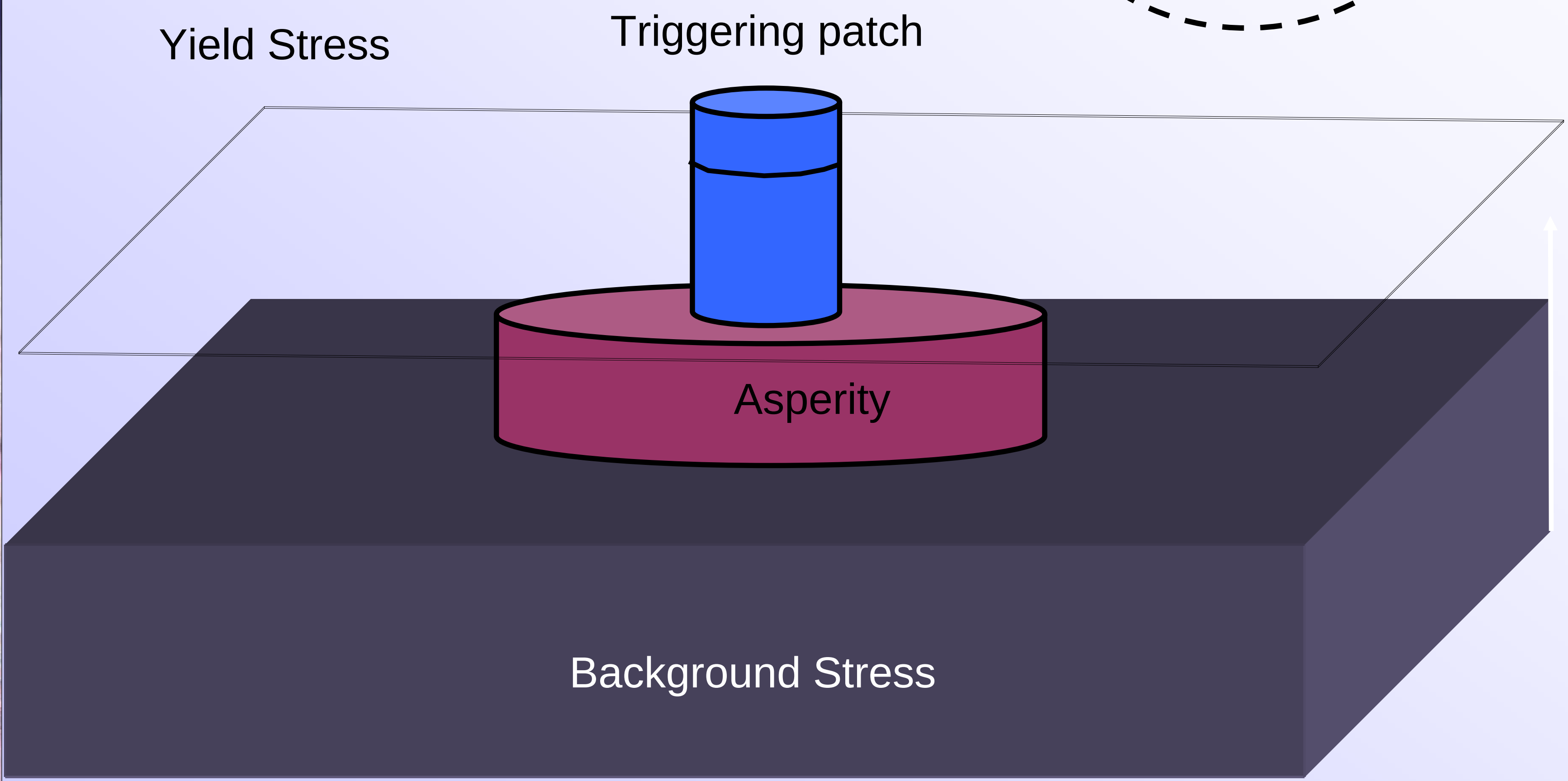
Explanation

- What physical model could explain this?
  - Breakout phase dynamically determines final earthquake size
  - Kinematic effects due to rupture and wave propagation

Dynamic Modeling

Model Setup

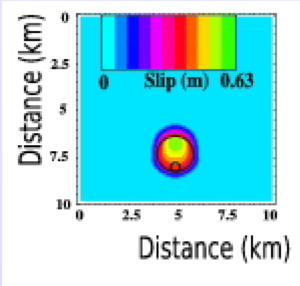


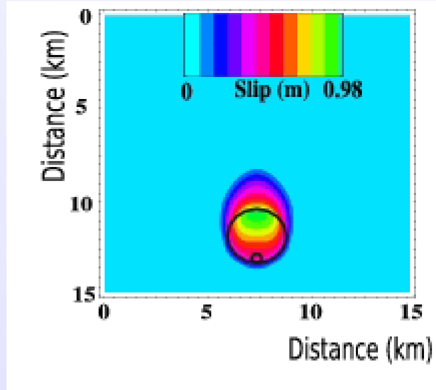


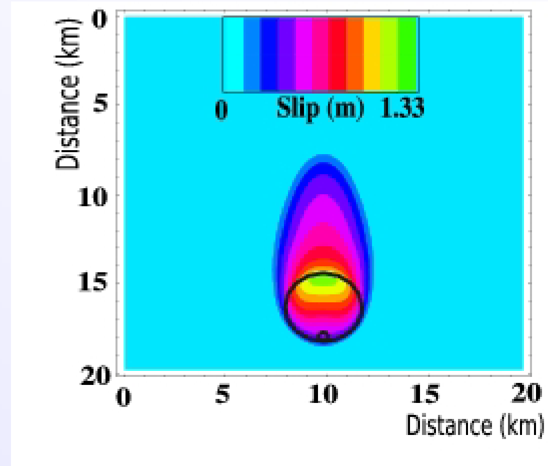
Yield Stress
Triggering patch
Asperity
Background Stress

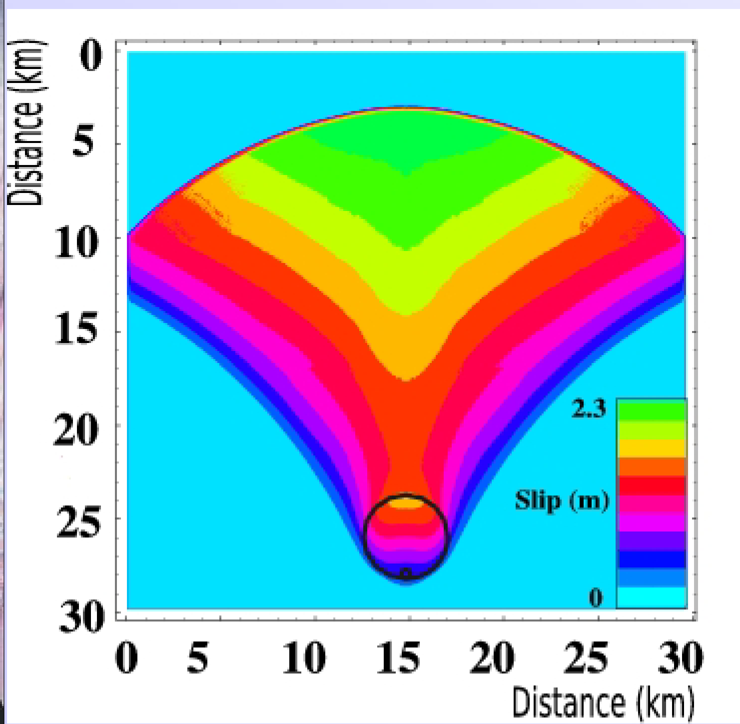
Dynamic Modelling Results -I

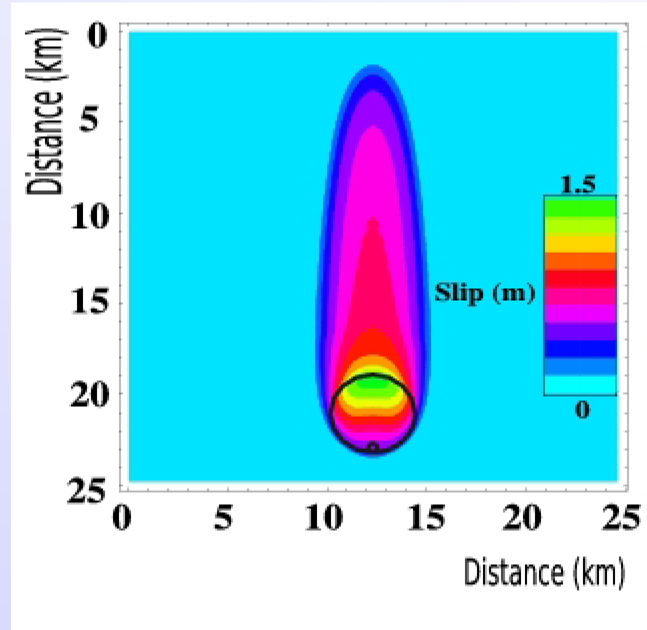
Total slip on the fault





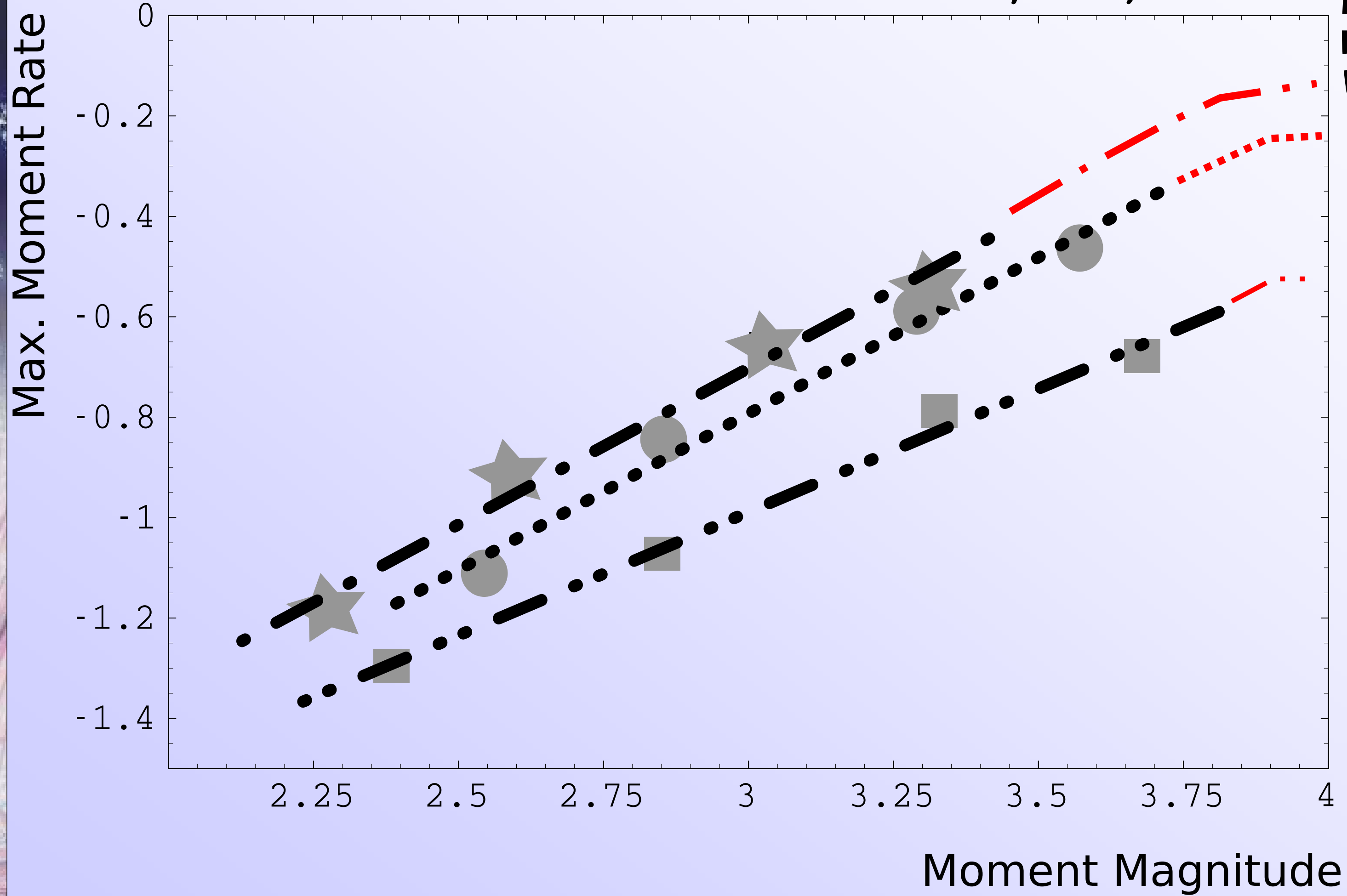


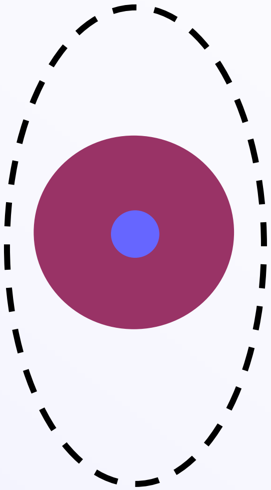




Dynamic Results -III

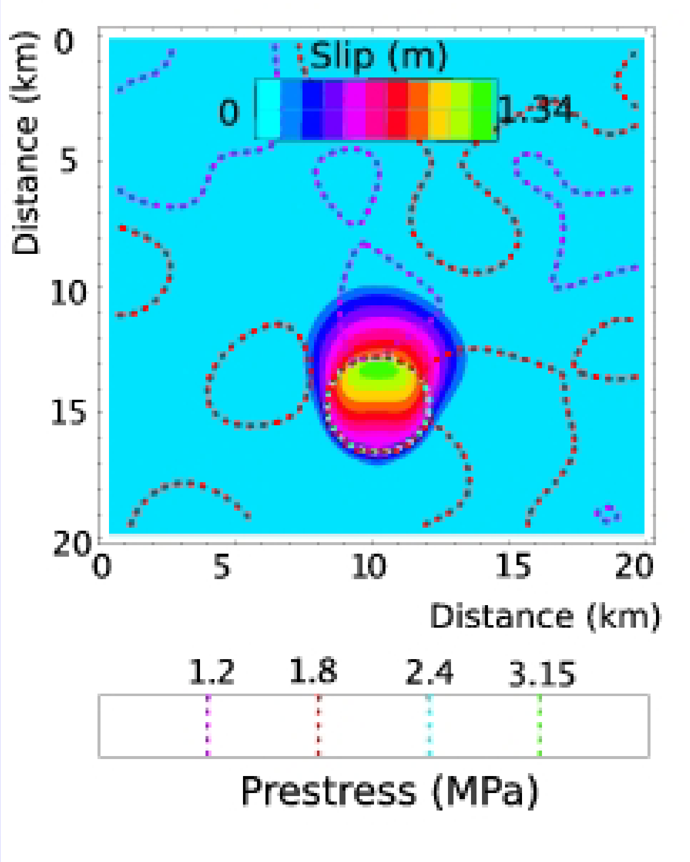
Max. Moment Rate Vs ML Outside of asperity

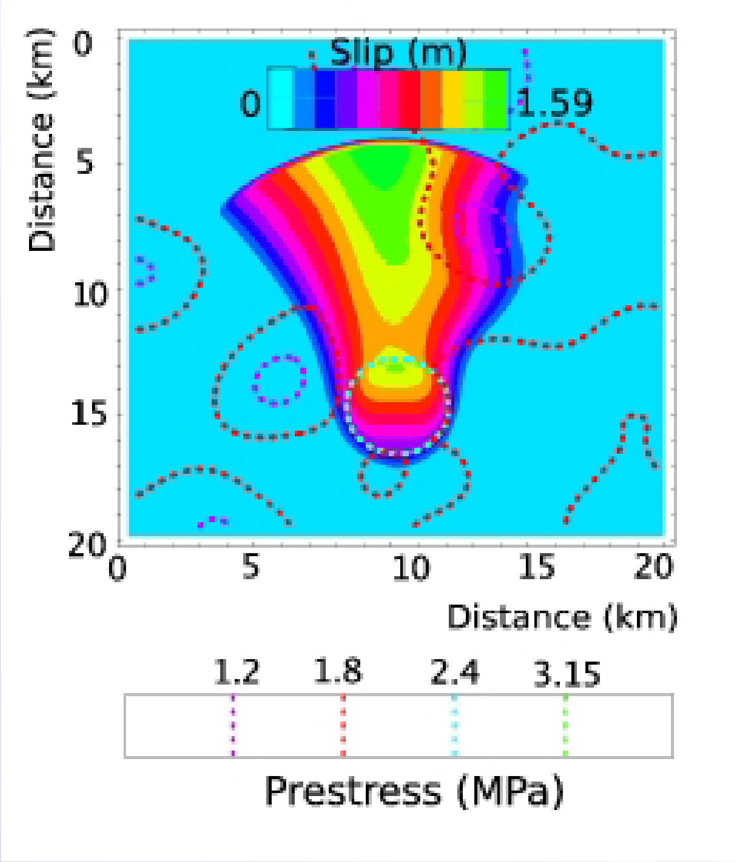




Cascade Feature of Rupture

Application of heterogeneous pre-stress



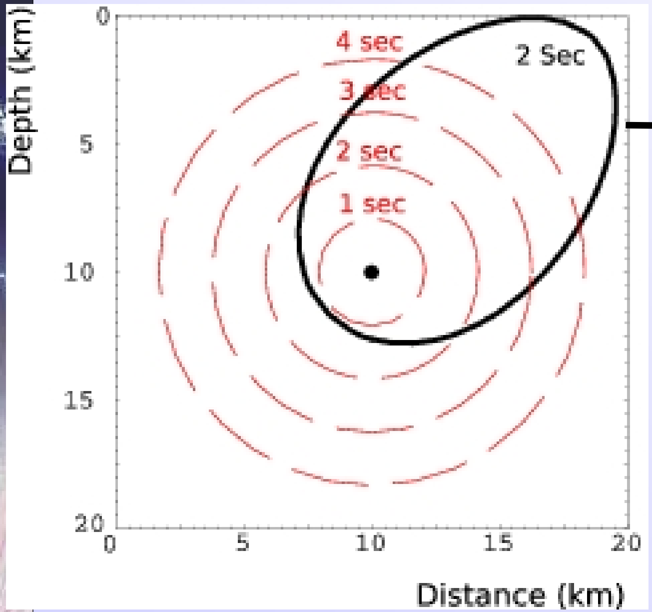


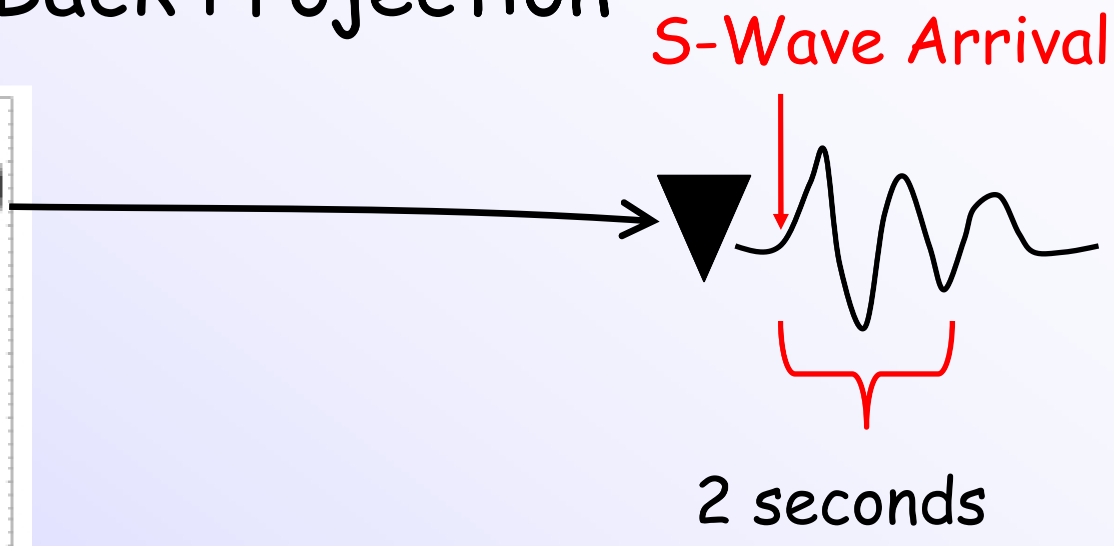
Dynamic Conclusions

- *Dynamic Rupture is Deterministic over a very short scale*
- *The stopping of earthquakes is predominantly a cascade in nature*
- *Scaling only works for a particular class of rupture models (self healing pulses)*

Kinematic Modeling

Isochrone Back Projection





$$u(x,y,z,t) = \Delta u \frac{\mu R^c}{4\pi \rho \alpha^3 r} \int_s dS$$

Slip $\propto$ Length of Fault

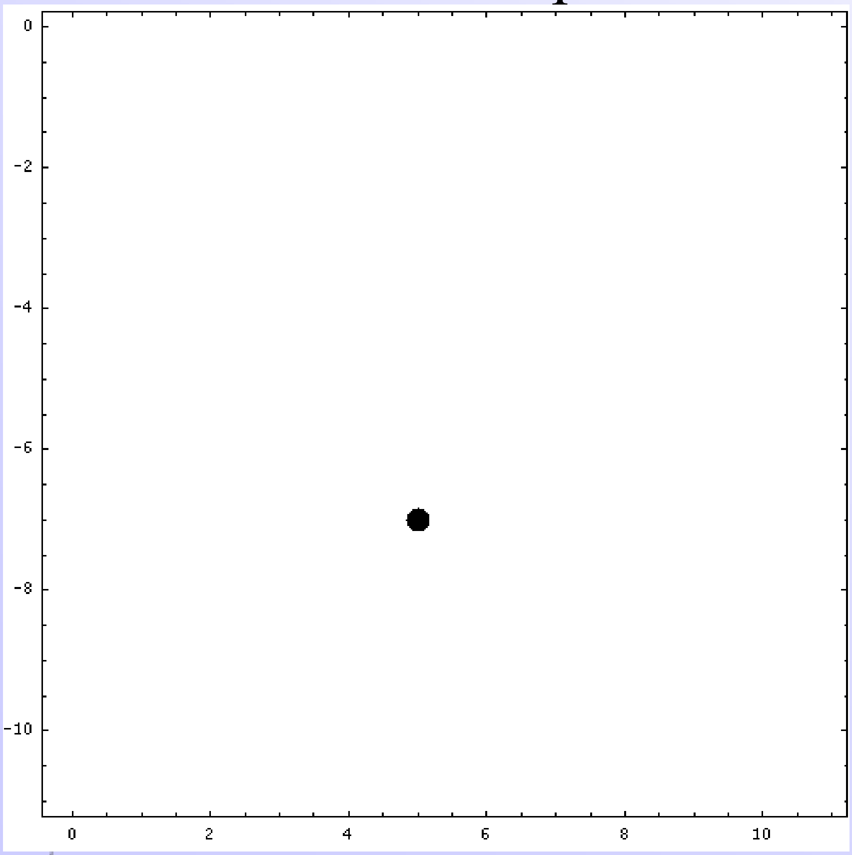
After: Bernard & Madariaga,1984

Isochrone back-projection

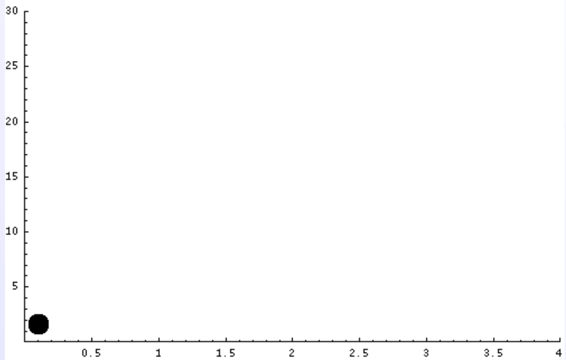
Station Distance: 30km
Rupture Velocity: 2.5km/s
Hypocentre Depth: 7km

P-wave Velocity: 4km/s
Azimuthal Angle: 45 degrees
Fault Size: 10km x 10km => 5-6.5ML

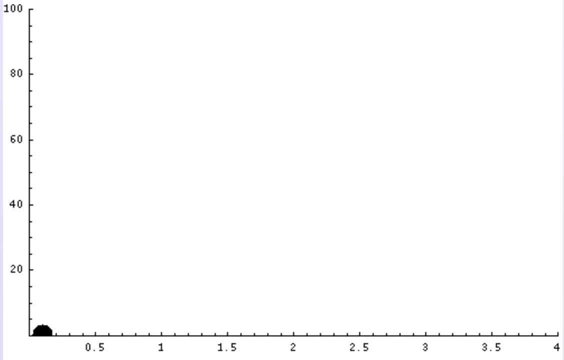
Isochrone Shape



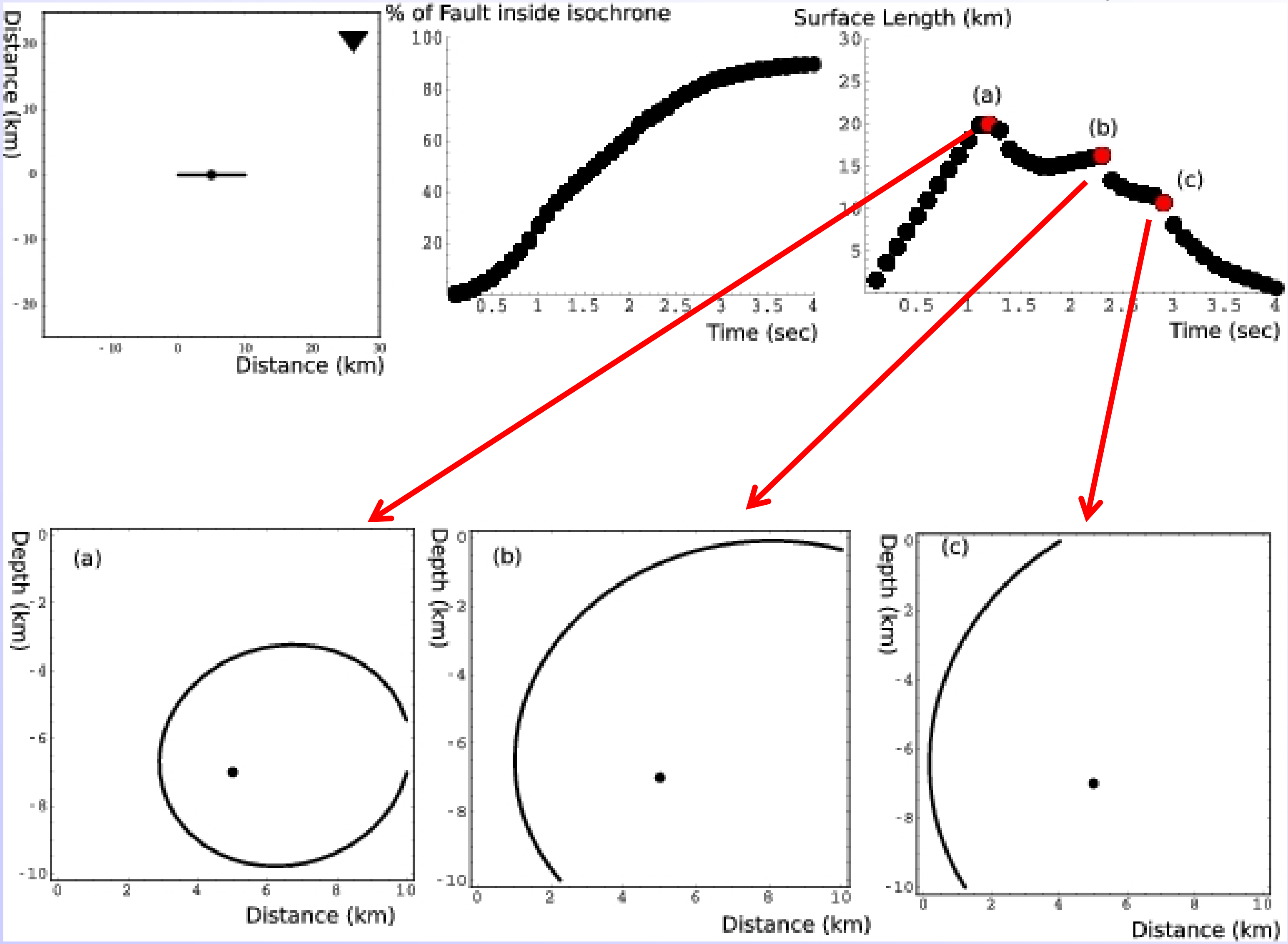
Isochrone Length



% of Total Fault Area

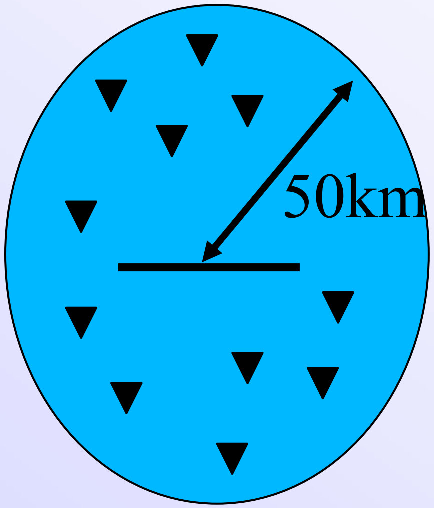


Isochrone evolution over time



Model Set up

Station Distribution: Random Distribution



Two velocity Profiles: (a) vp=4.5km/s (b) vs= 2.6km/s

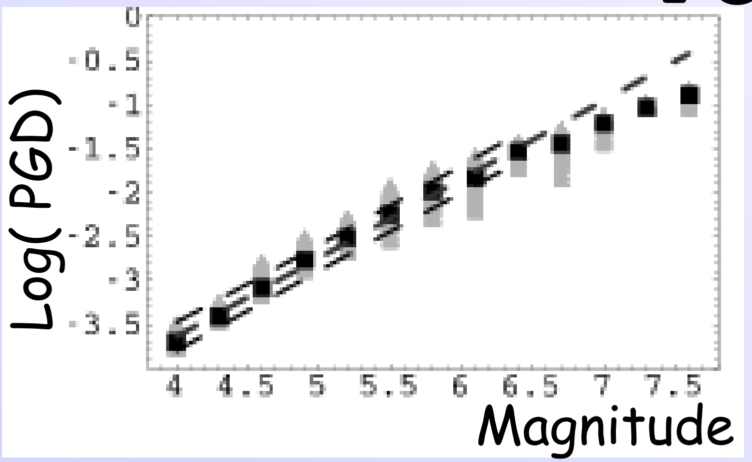
Hypocentre Location: Randomly distributed below 10km

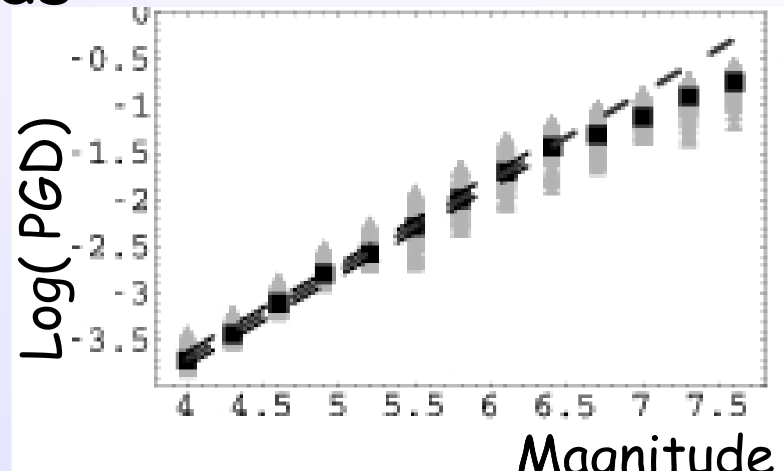
Fault Length for Square Fault: 0.94km - 59.5km

Results for Simplistic Peak Ground Motion

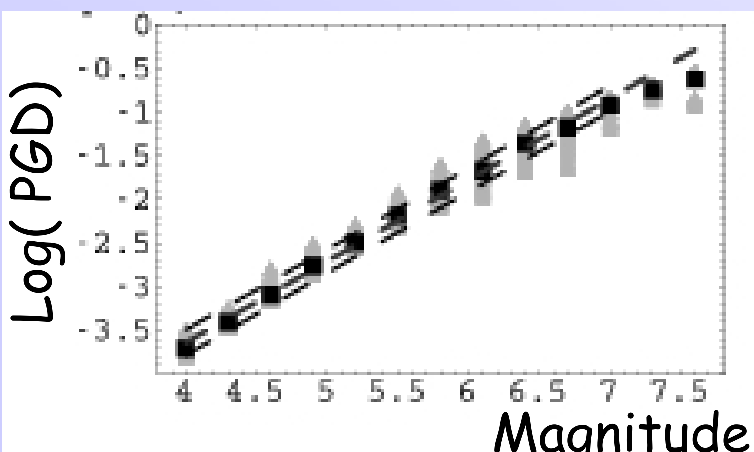
P-wave:4.5km/s S-wave:2.6km/s

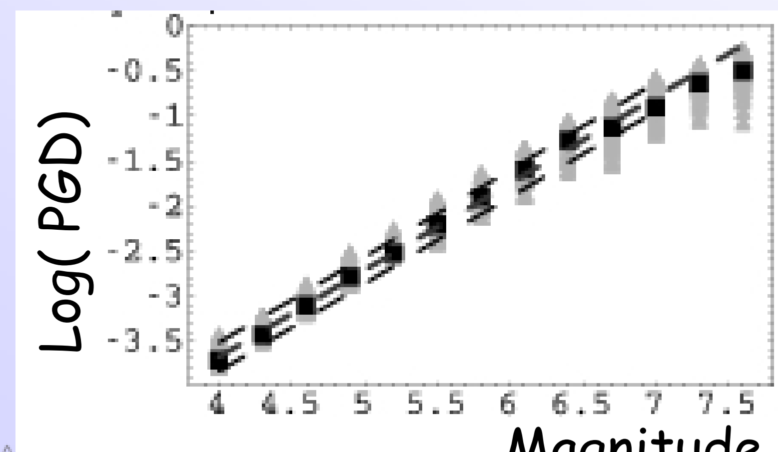
1 Seconds





2 Seconds

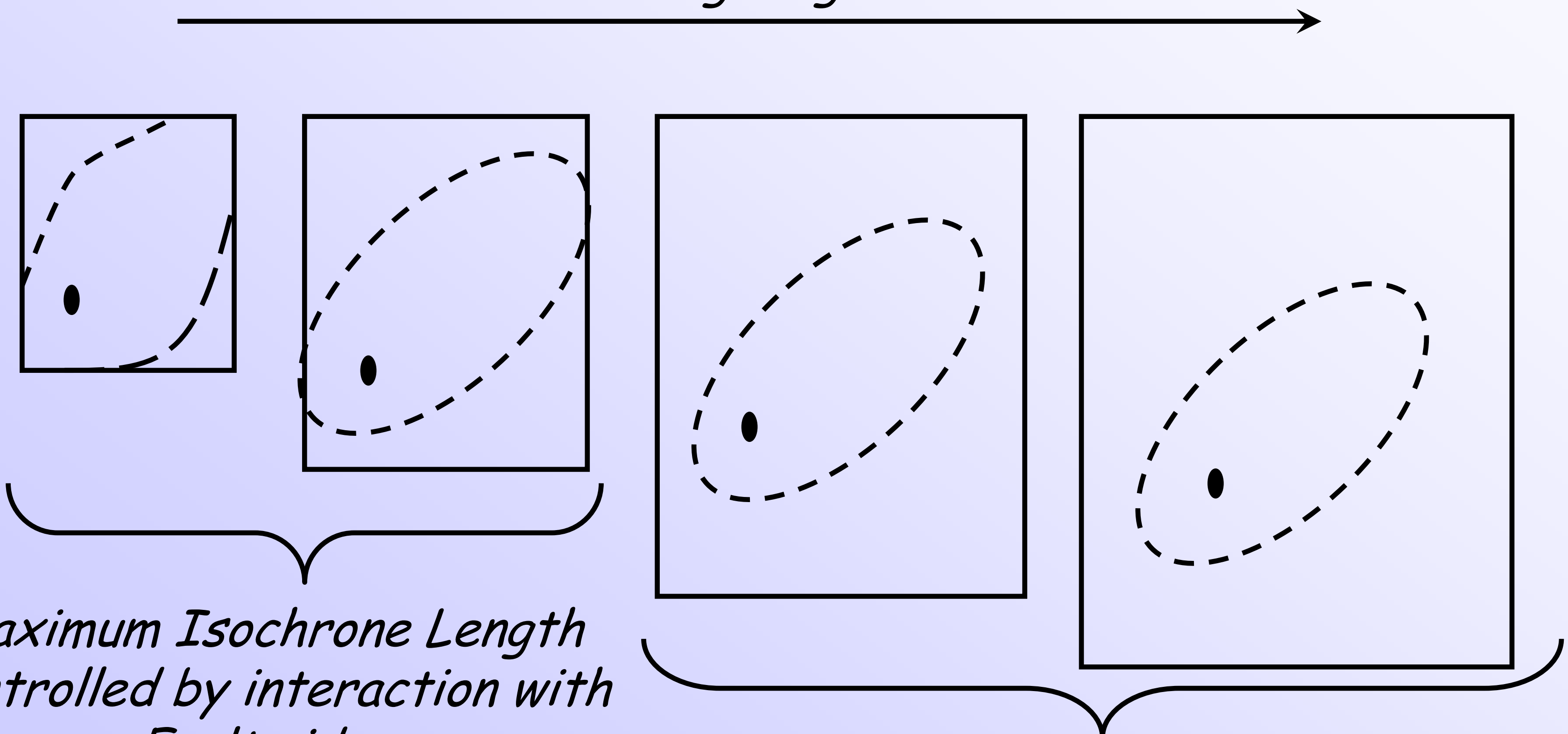




Why does the isochrone length become constant?

- *Isochrone =2 secs in all cases*

Increasing Magnitude



Maximum Isochrone Length Controlled by interaction with Fault sides

Isochrones are no longer touching fault sides at 2 sec period

Kinematic Conclusion

- Earthquake magnitude estimation is highly dependant on fault kinematics

- Measuring Isochrone length produces similar features seen in peak displacement for early magnitude estimations

Final Conclusion

- Kinematic rather than dynamic would appear to influence early magnitude estimation

The End