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Seismic signatures of trench rupturing megathrust earthquakes: structural effects of accretionary-wedge and subducting oceanic crust

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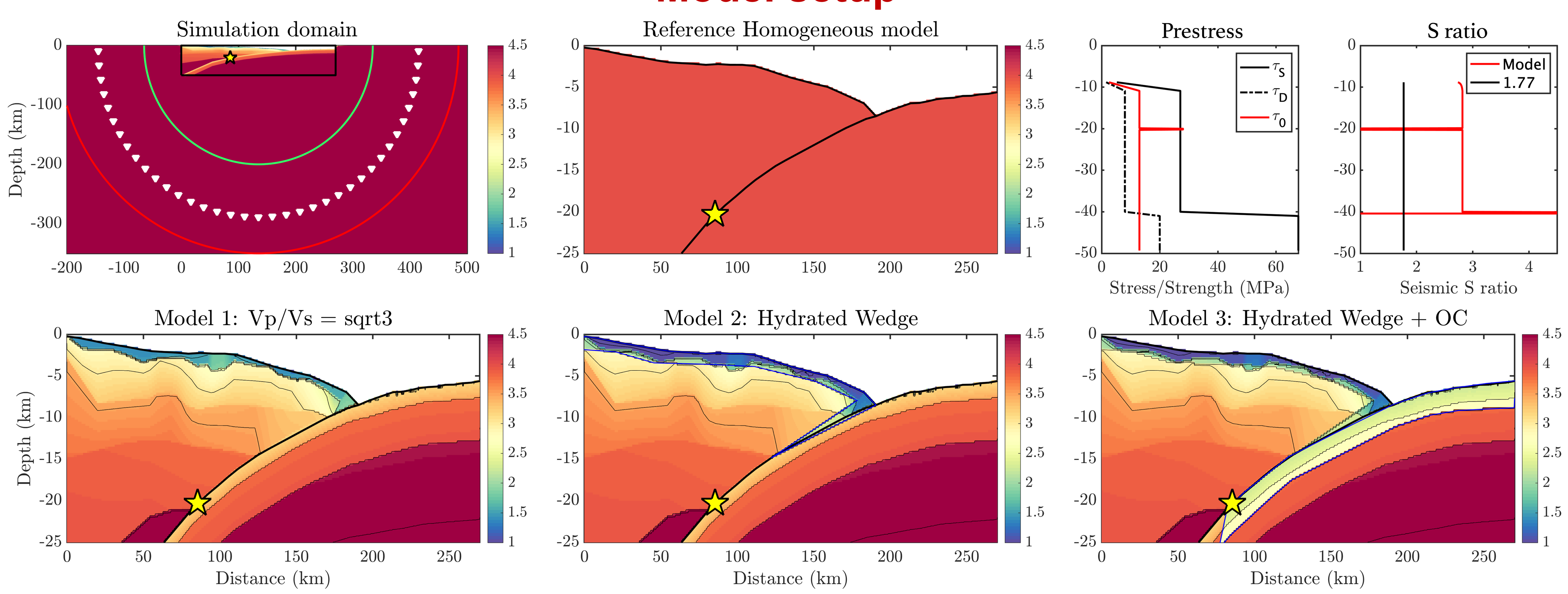
1-min summary

1. **We build dynamic megathrust rupture models with realistic seismic velocity structures**
2. **Seismic velocity structure, especially the S wave velocity has great effects on the dynamic rupture of megathrust earthquakes**
3. **High frequency seismic data at certain takeoff angle can potentially help to constrain the structures.**

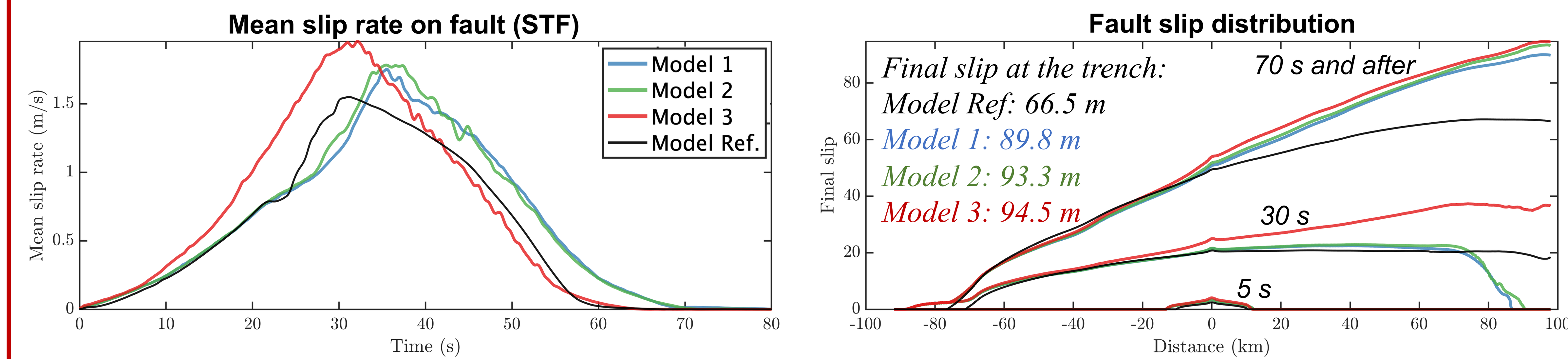
Model setup

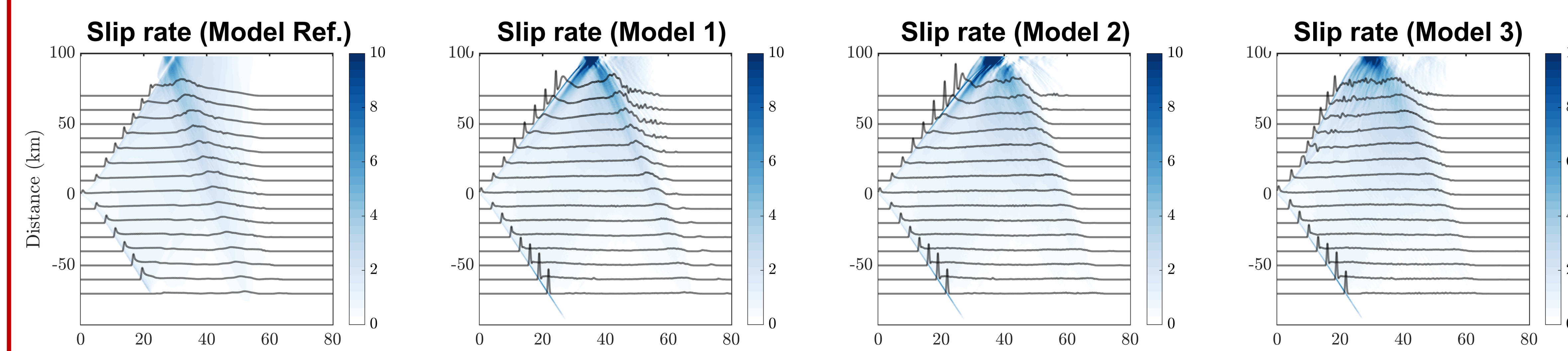


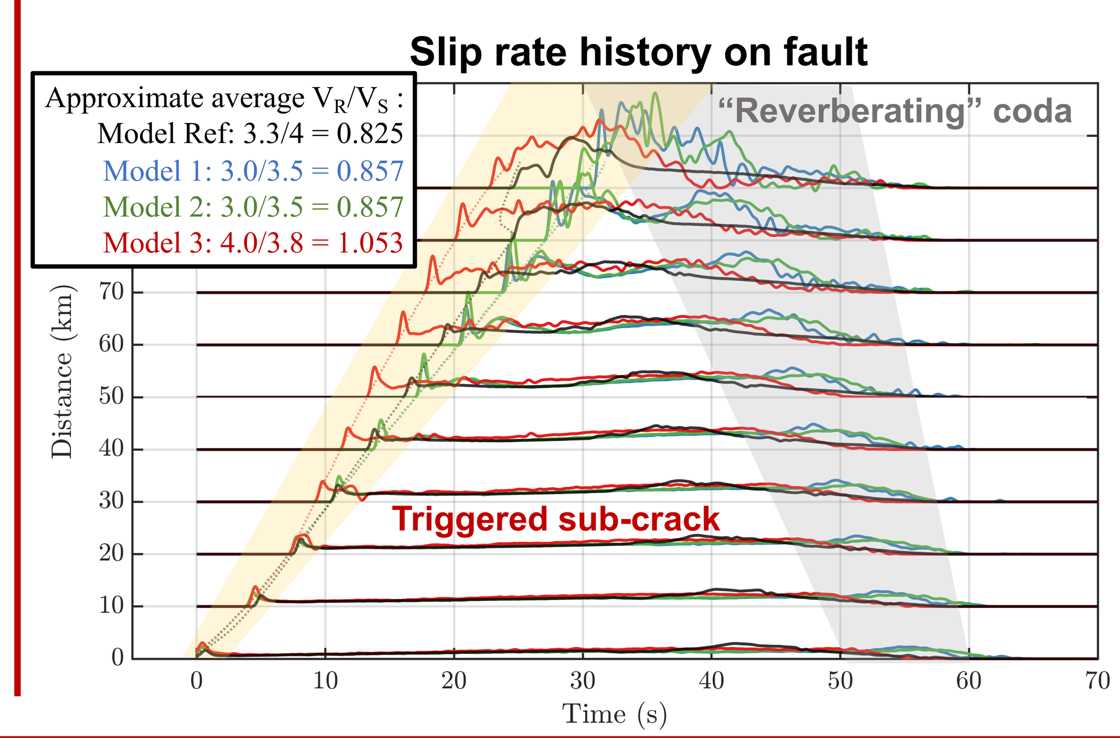
We test 4 types of typical velocity models with the dynamic parameters:

- **Model Ref. : Homogeneous velocity model (Vs = 4km/s);**
- **Model 1: Realistic velocity model with constant Vp/Vs = $\sqrt{3}$;**
- **Model 2: Realistic velocity model with hydrated (high Vp/Vs = 2.45) shallow layer;**
- **Model 3: Realistic velocity model with hydrated shallow layer and subducting oceanic crust.**

Dynamic rupture on fault (simulated by SEM2DPACK)





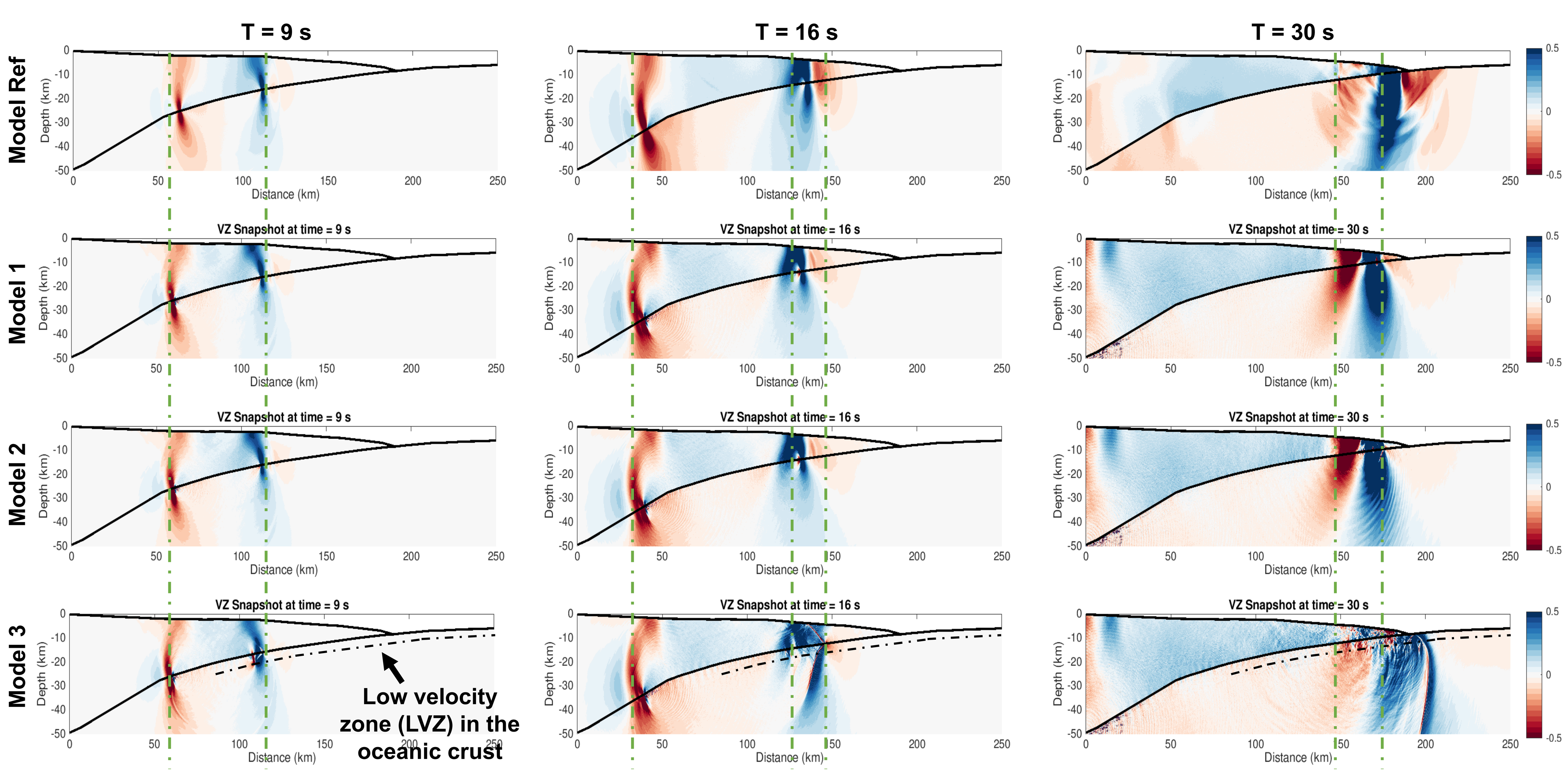


❖ **Final slip can be amplified due to the low velocity structures (compared to the model Ref. with homogeneous velocity).**

❖ **The near-source scattering of seismic waves due to complex structure interacts with dynamic triggering of slip on the fault at the trench, yielding high frequency radiation.**

❖ **We find splitting rupture front at certain point (8-9s) for the model with hydrated oceanic crust (Model 3).**

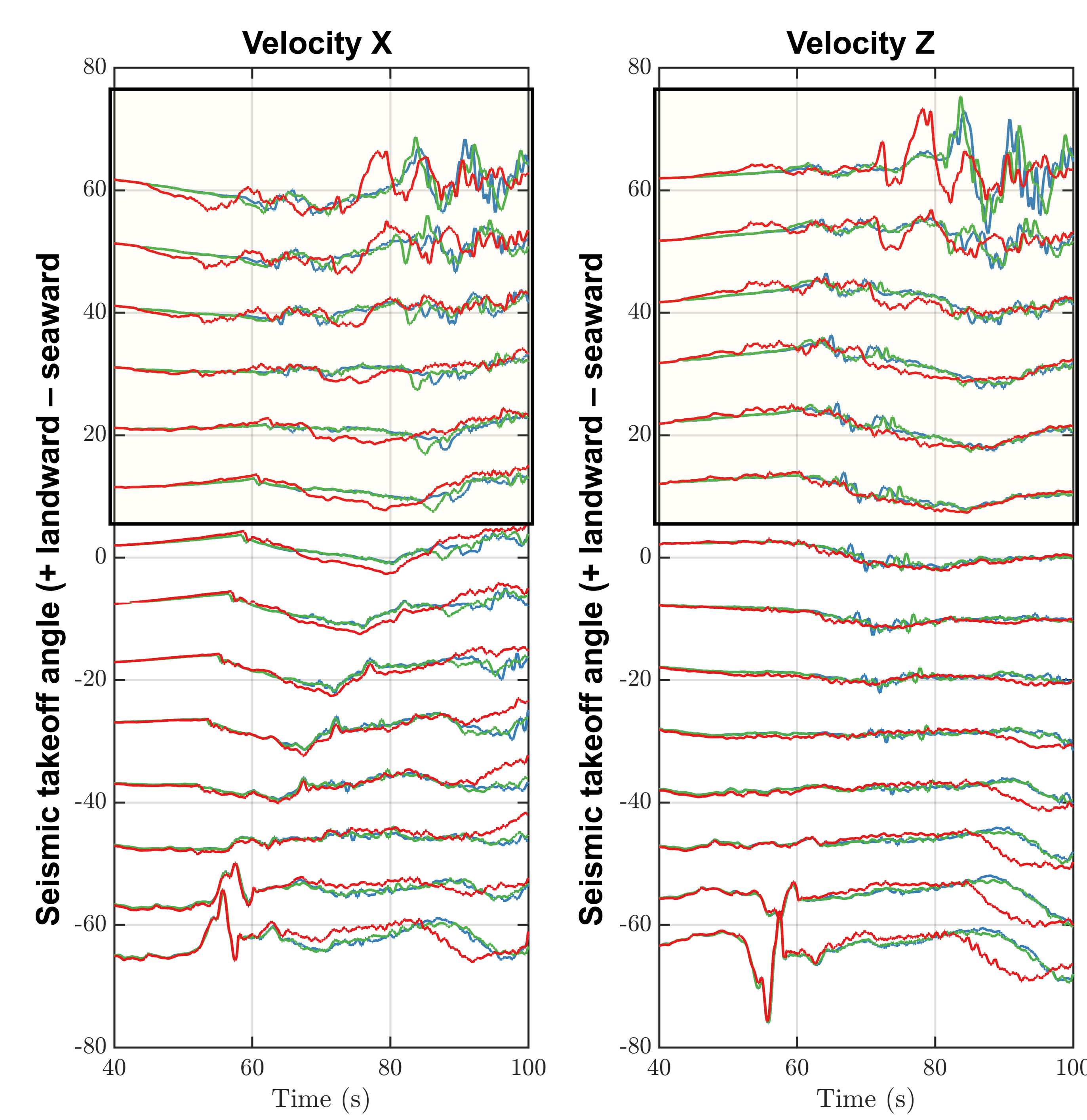
Wavefield snapshots (velocity v_z field)



❖ **The low velocity oceanic crust can trap the waves and dynamically trigger secondary crack in front of the main rupture front (potential for super-shear rupture).**

❖ **Shallower low velocity wedge has similar effects and can cause complex high frequency radiation in the seismic wave field.**

Seismograms from simulations (Model 1, 2, 3)



❖ **Recorded velocity seismograms indicate obvious waveform discrepancy within certain range of takeoff angle on the seaward sides**

Discussion

❖ **Realistic velocity structure is very important for the dynamics of earthquake rupture and seismic hazard assessment. Therefore it should be better constrained and included in the case-specific numerical simulations.**

❖ **The dynamic effects of trapped waves can potentially trigger secondary crack, which is able to form super-shear rupture. But the inelastic and poroelastic effects can then become the primary mechanisms at very high stress concentration.**

❖ **High frequency features of the seismic waves in certain range of takeoff angle can potentially help to constrain the velocity structure of shallow megathrust.**

Miura, Seiichi, et al. "Structural characteristics off Miyagi forearc region, the Japan Trench seismogenic zone, deduced from a wide-angle reflection and refraction study." *Tectonophysics* 407.3-4 (2005): 165-188.