

Fault Steppers:

Small Input Details Affect Large-Scale Behaviors

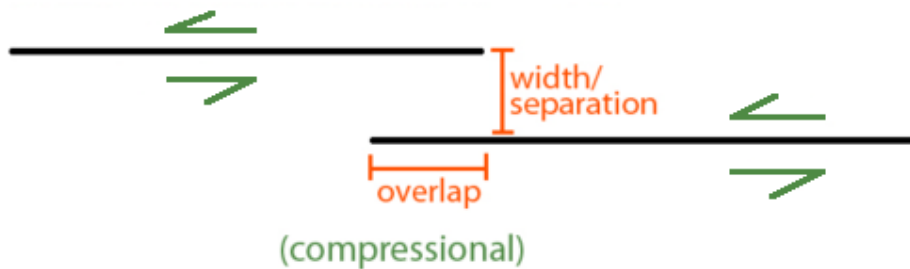
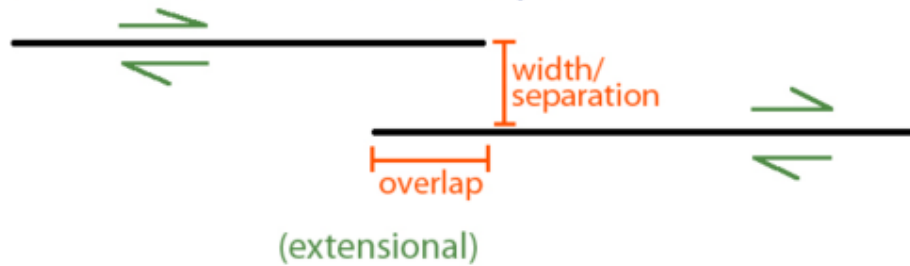


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SCEC CODE VALIDATION WORKSHOP
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To Jump or Not To Jump?

- That is the question.

Unlinked/Disconnected Stepover



Linked/Connected Stepover



Factors that Affect Jumping



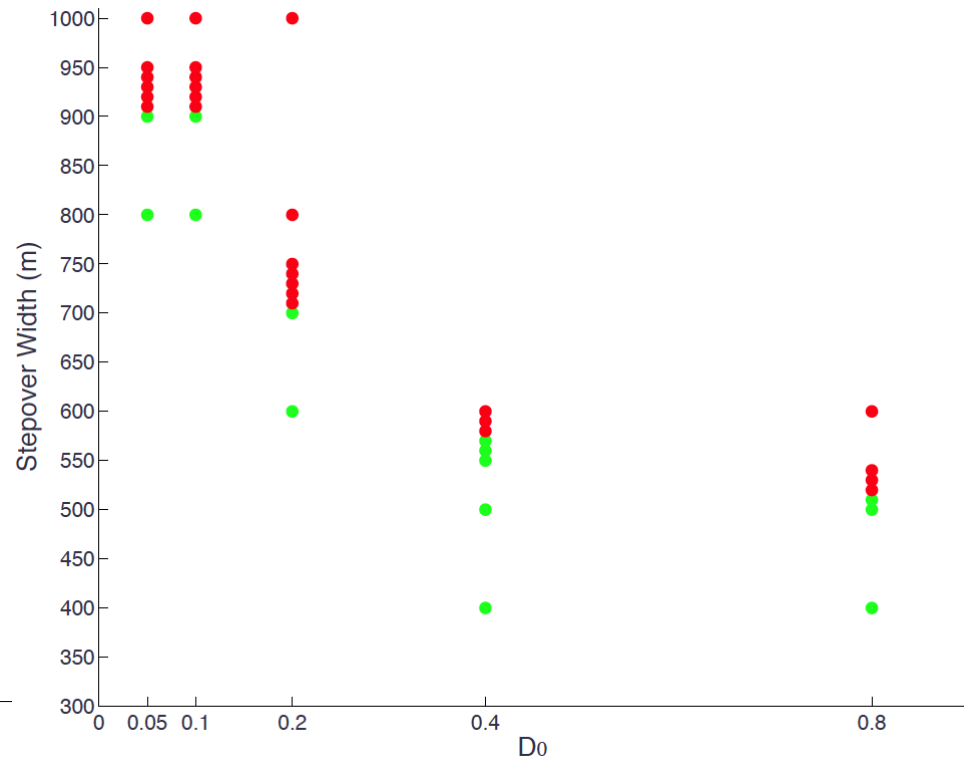
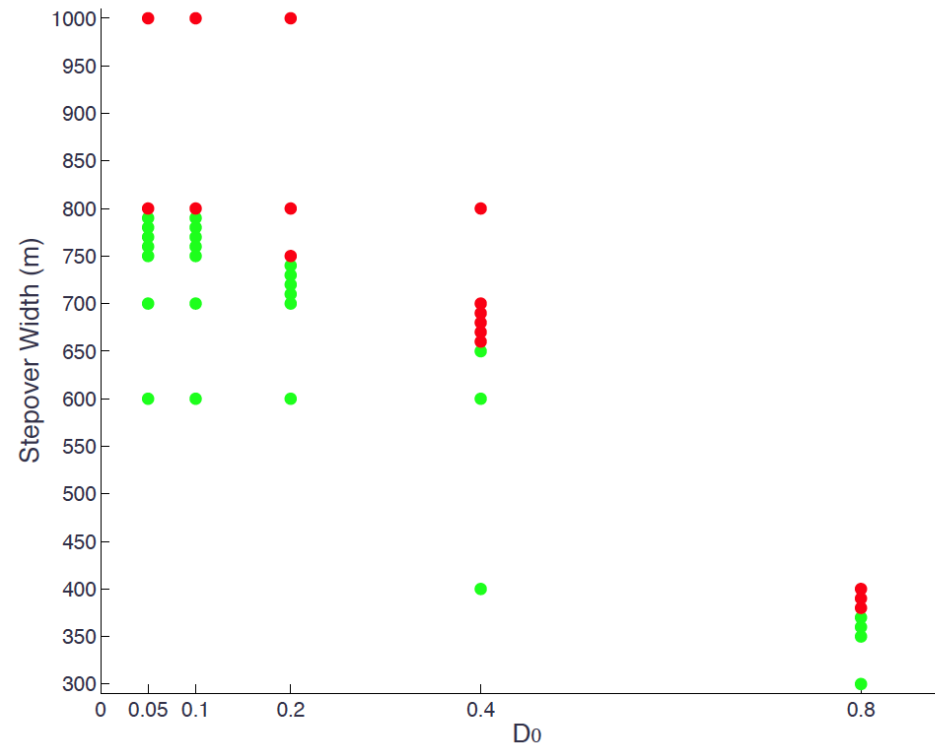
- Separation between faults
- Extensional vs. compressional
- Stress drop
 - Rupture velocity
- Slip-weakening parameter
- What's between the two main faults
 - Length/angle of linking segment
 - Length/position of parallel intermediate segment

Slip-Weakening Parameter



Extensional

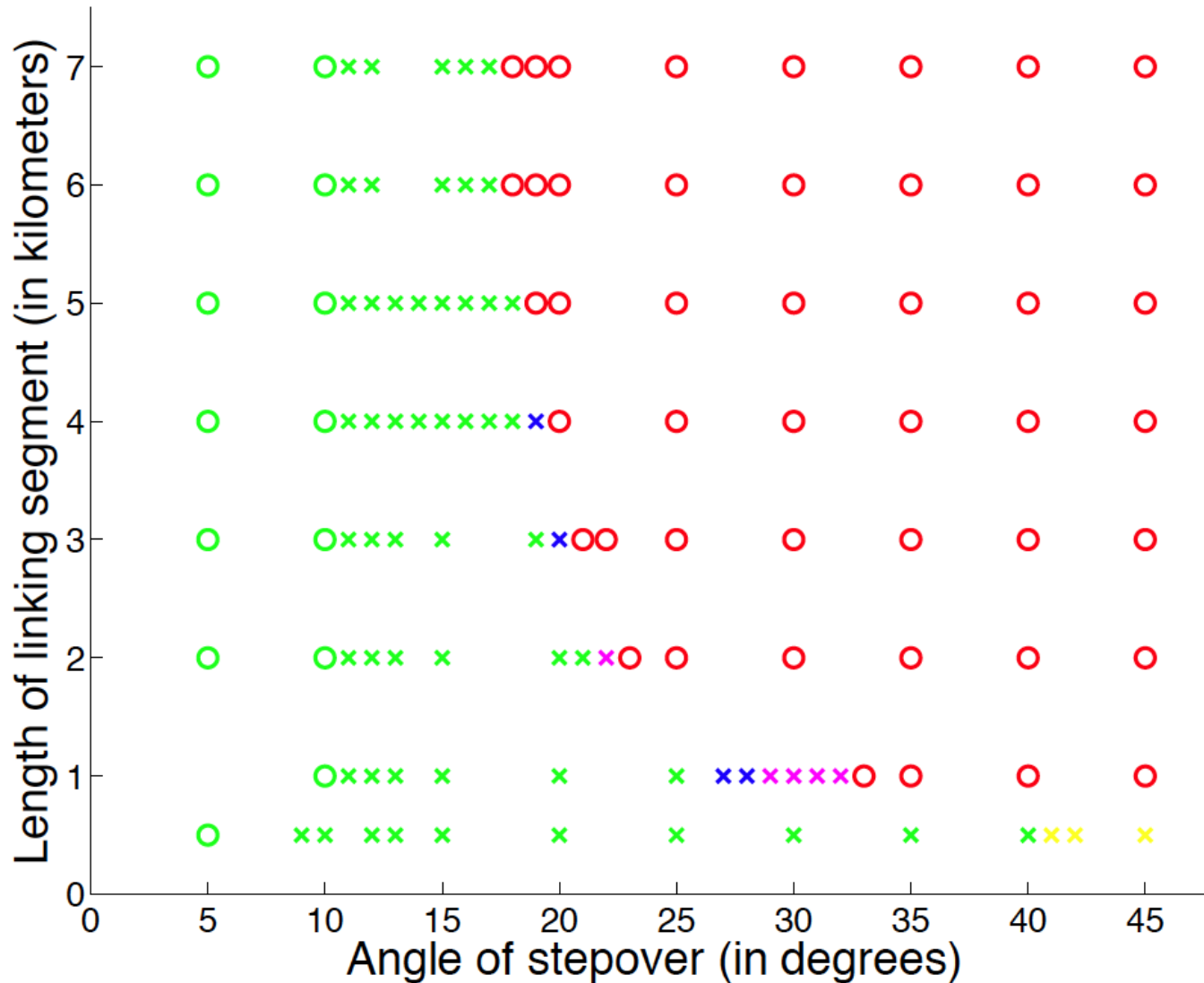
Compressional



Linking Segment



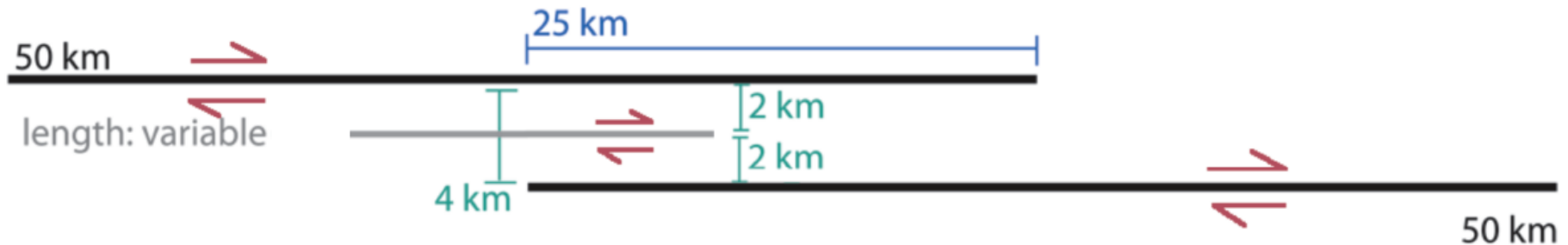
Compressional Stepovers



Parallel Intermediate Segment



Extensional Stepover



Compressional Stepover



Nucleation: 3 km from right end of right segment, 8 km deep
Intermediate segment depths modeled: 16 km and 8 km

Physical and Numerical Parameters



P-wave velocity	5000 m/s
S-wave velocity	3100 m/s
Density	2675 kg/m ³
Static frictional coefficient	0.75
Dynamic frictional coefficient	0.3
Slip weakening parameter	0.4
Element size	200 m
Forced nucleation radius	3000 m

Stress Case	Normal Stress	Shear Stress	S
Jumps without segment	166.5 bars	100 bars	0.49
No jump without segment (extensional)	178 bars	103.4 bars	0.60
No jump without segment (compressional)	200.2 bars	110.1 bars	0.80

Results: Compressional



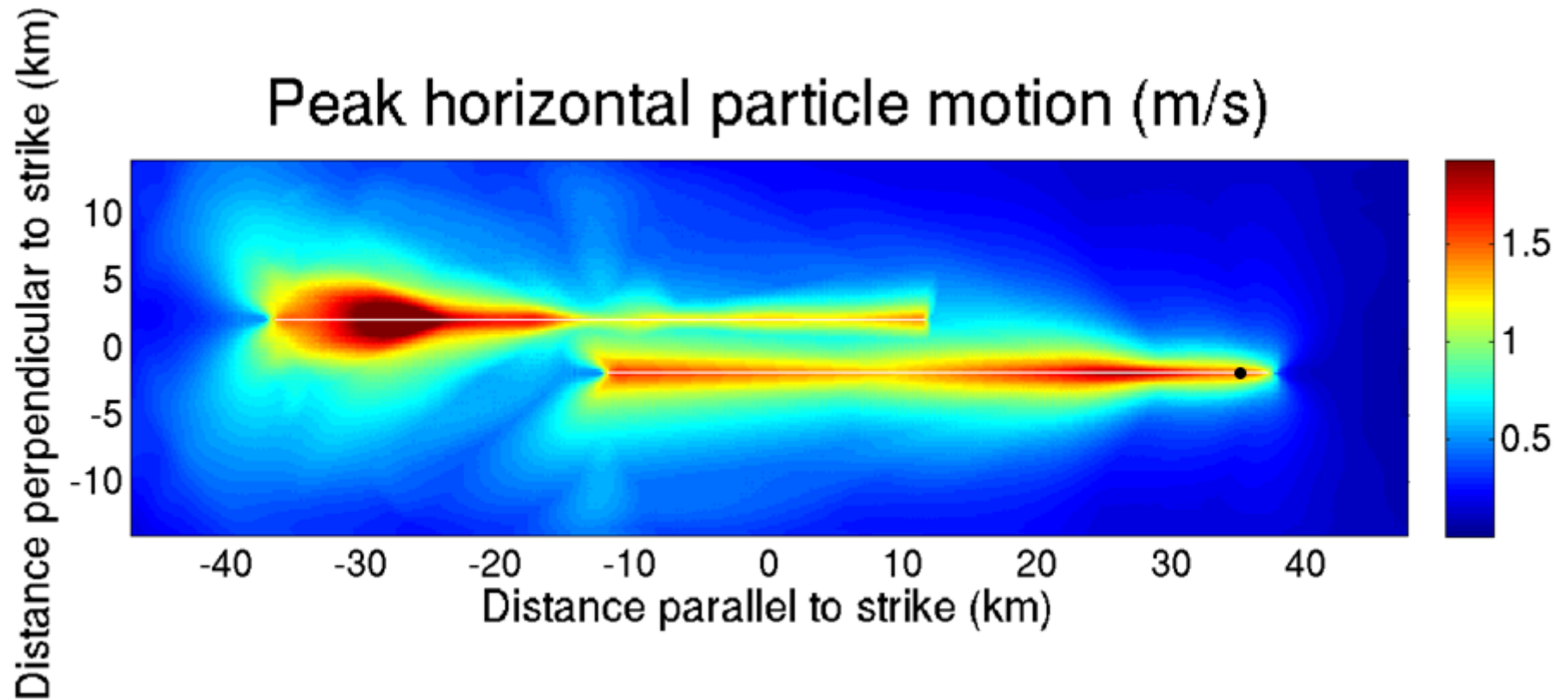
	3 km segment	5 km segment	7 km segment	10 km segment	15 km segment
Jumps without segment; Segment 16 km deep	Jump	Jump	Jump	Jump	Jump
Jumps without segment; Segment 8 km deep	Jump	Jump	Jump	Jump	Jump
No jump without segment; Segment 16 km deep	No jump	No jump	Jump	Jump	Jump
No jump without segment; Segment 8 km deep	No jump	No jump	Jump	Jump	Jump

Depth of intermediate segment has no first-order effect on jumping rupture.

Extensional: Jumps Without Segment



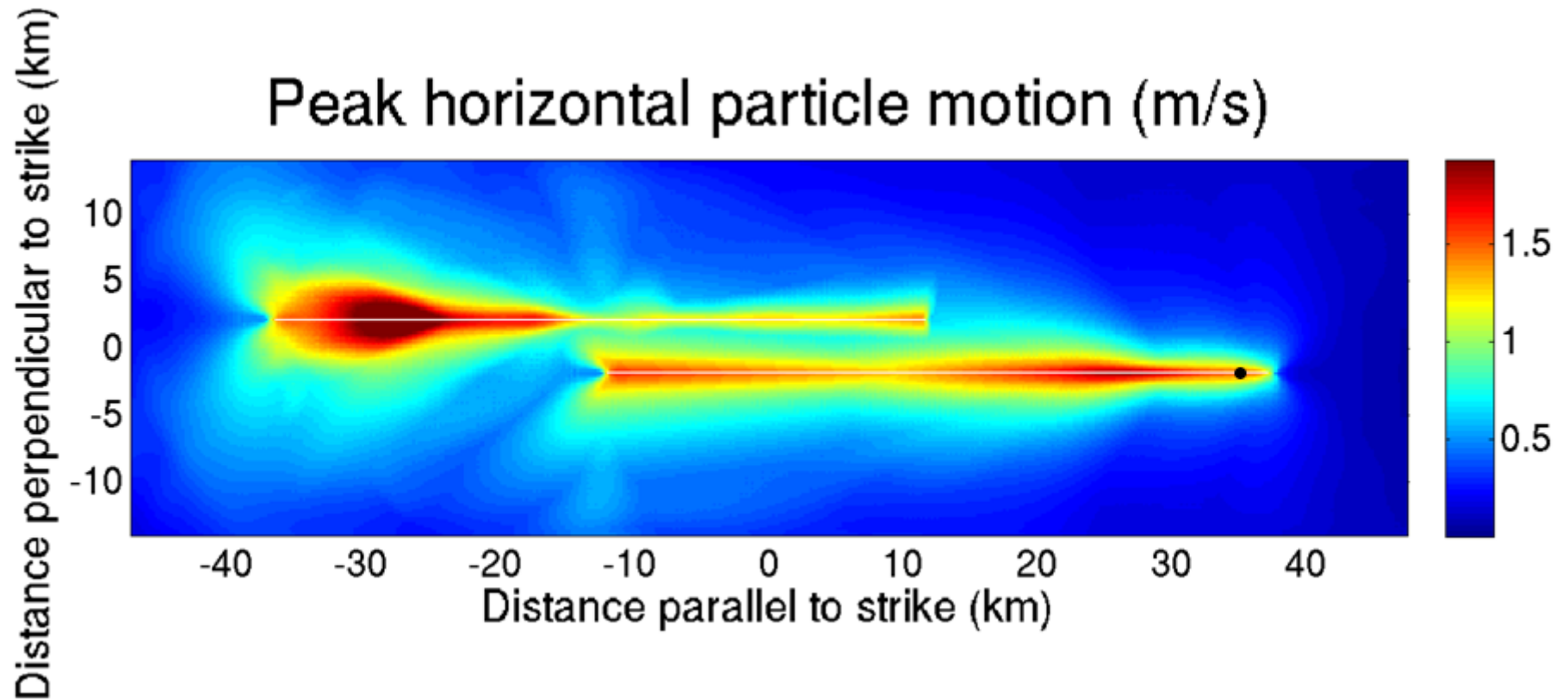
No intermediate segment



Extensional: Jumps Without Segment



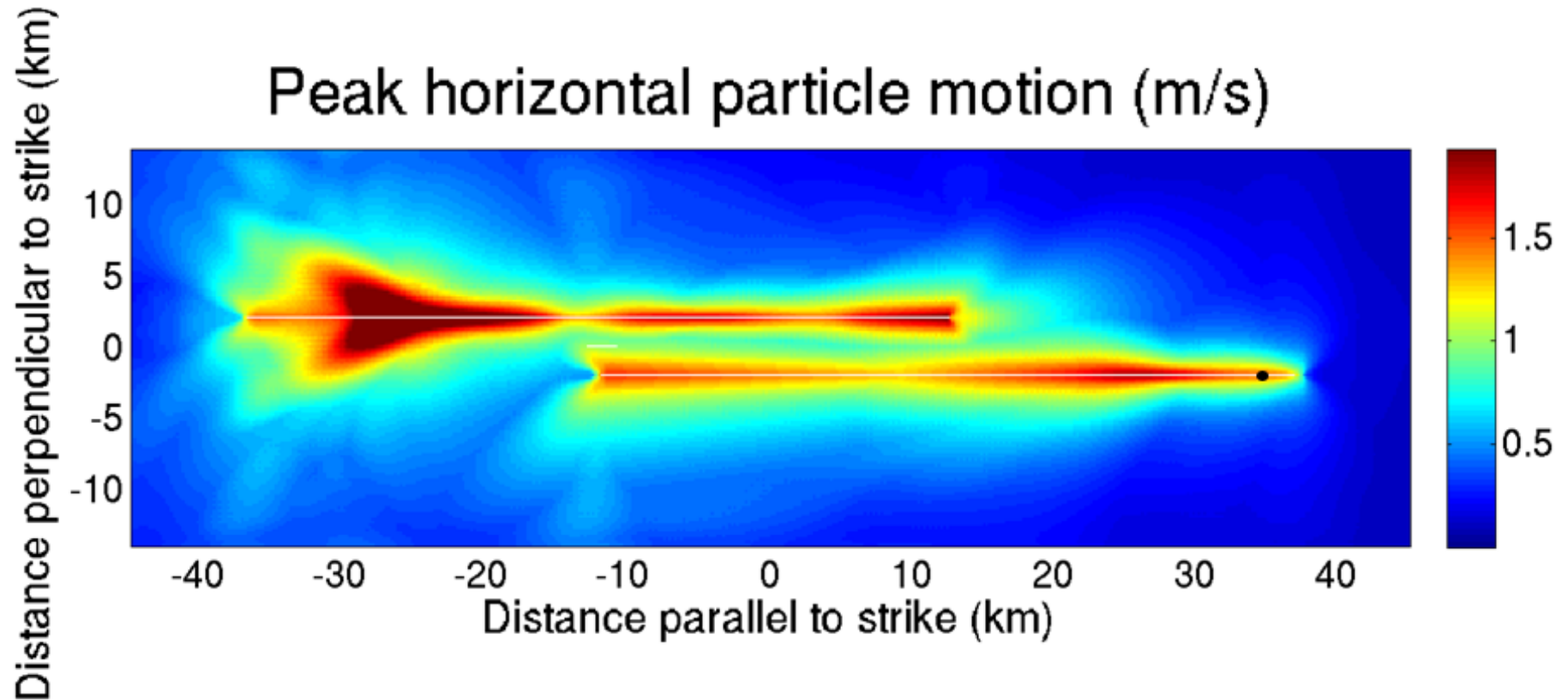
No intermediate segment



Extensional: Jumps Without Segment



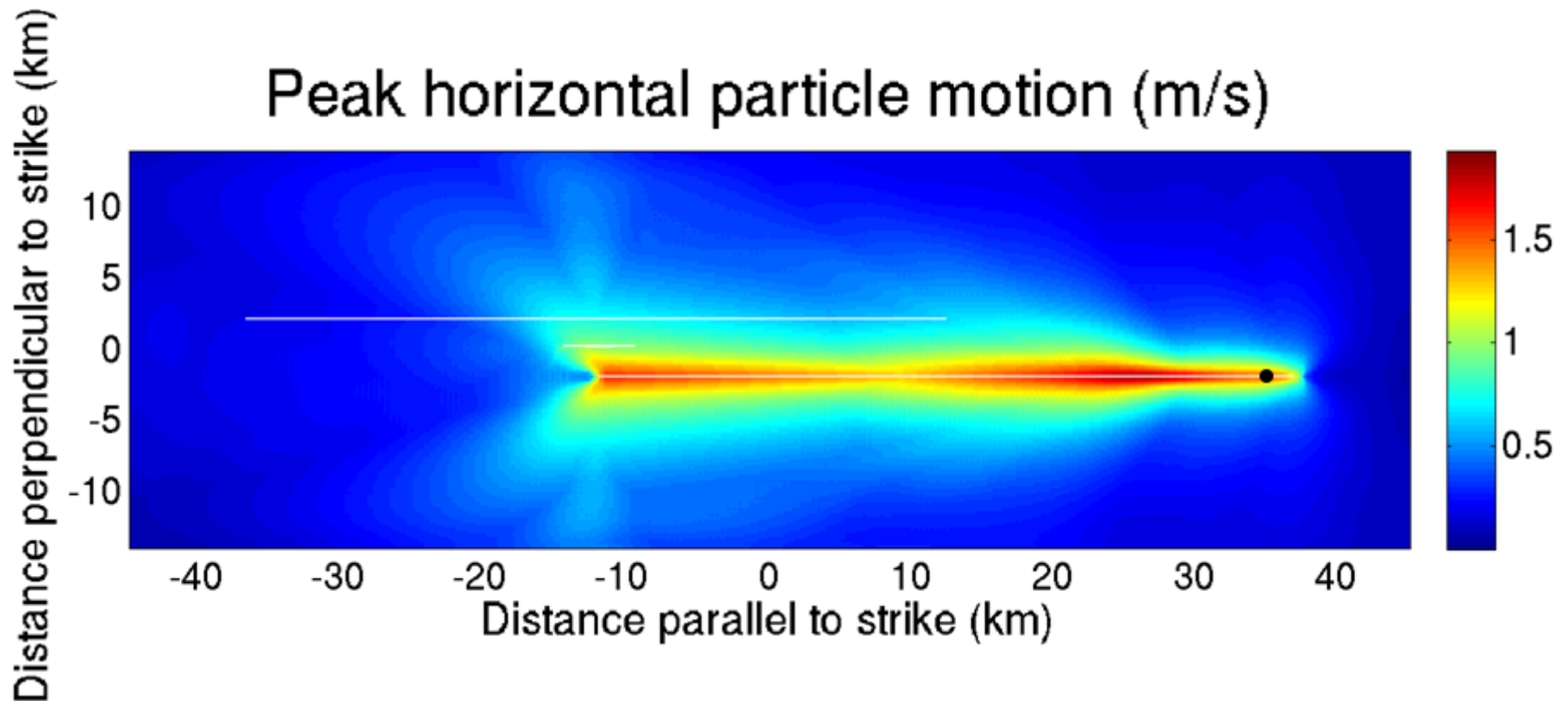
3 km intermediate segment



Extensional: Jumps Without Segment



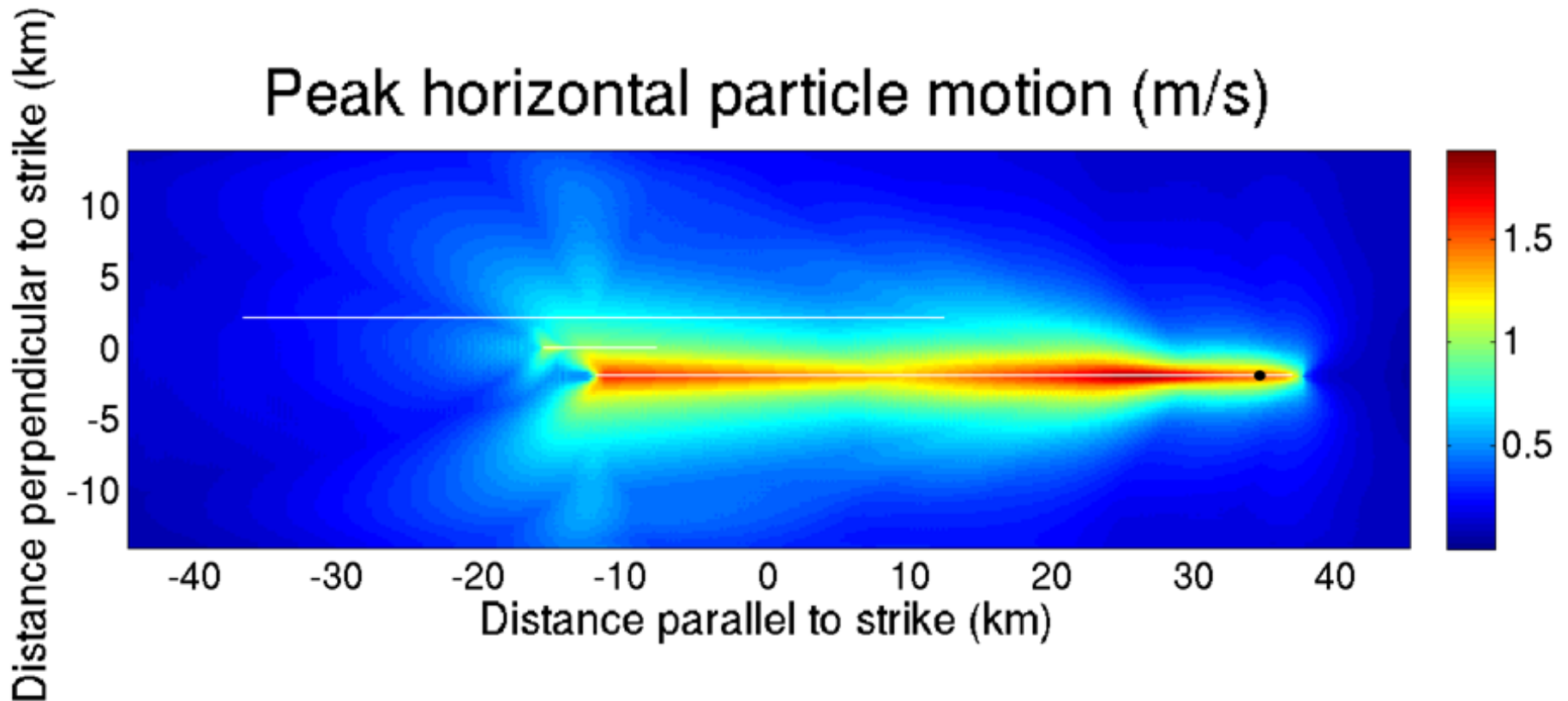
5 km intermediate segment



Extensional: Jumps Without Segment



7 km intermediate segment

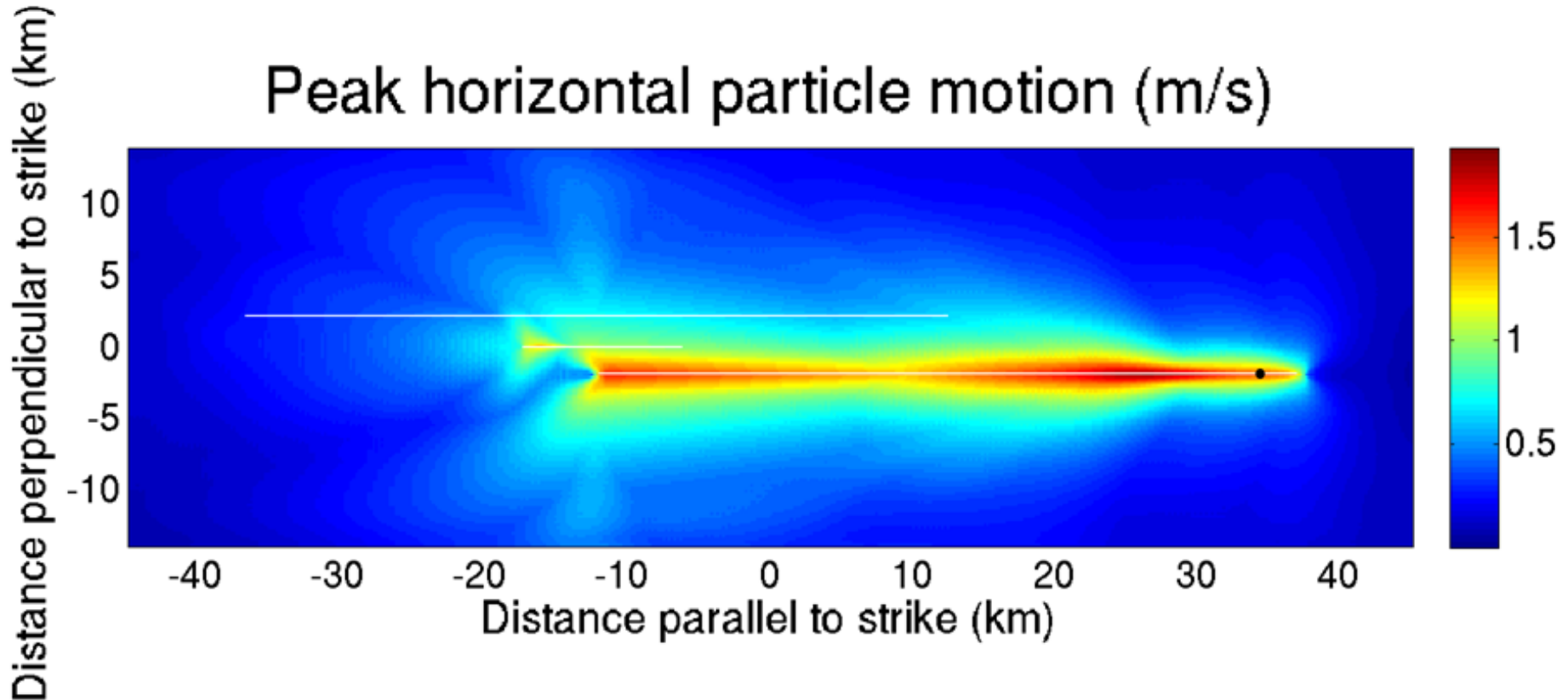


Extensional: Jumps Without Segment



10 km intermediate segment

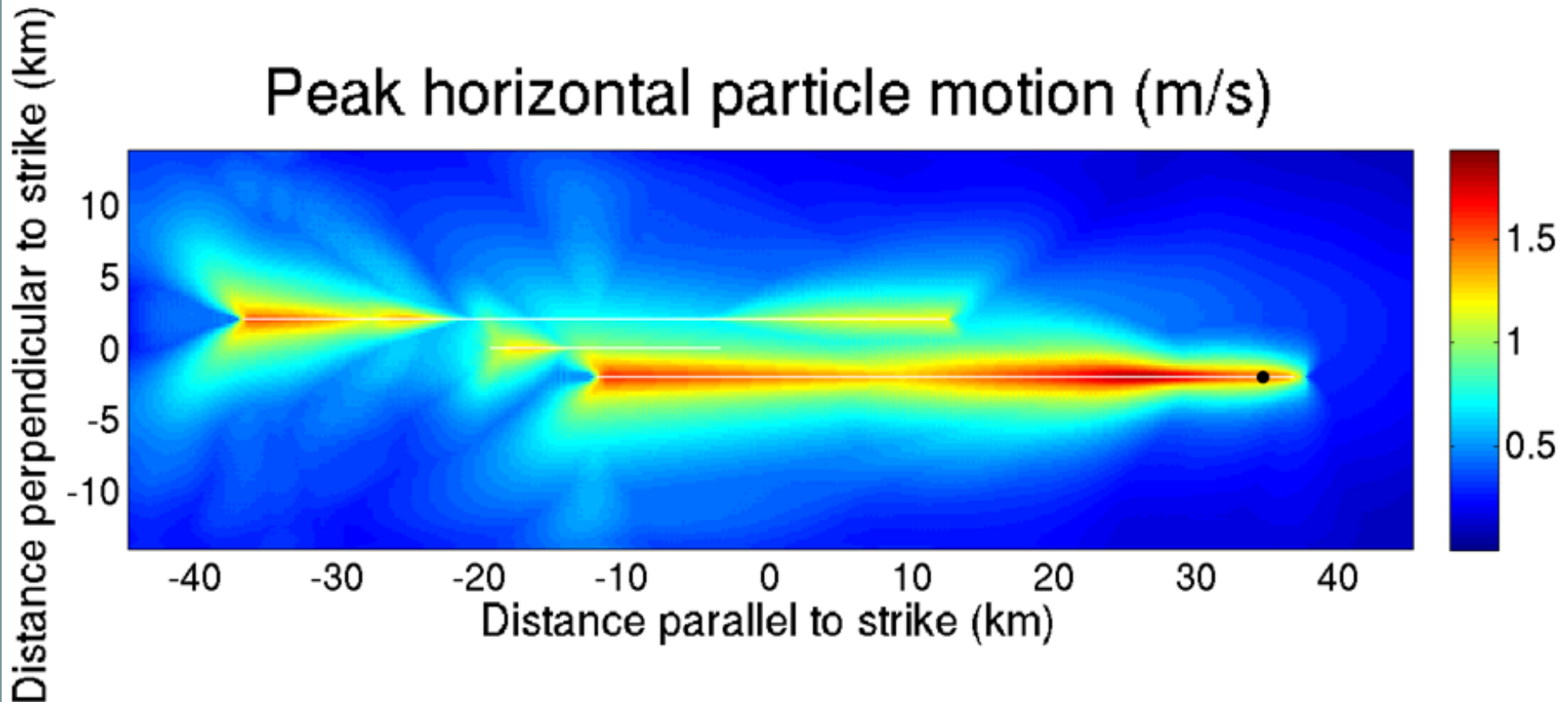
Peak horizontal particle motion (m/s)



Extensional: Jumps Without Segment



15 km intermediate segment



Results: Extensional



	3 km segment	5 km segment	7 km segment	10 km segment	15 km segment
Jumps without segment; Segment 16 km deep	Jump	No jump	No jump	No jump	Jump
Jumps without segment; Segment 8 km deep	Jump	Jump	Jump	Jump	Jump
No jump without segment; Segment 16 km deep	No jump	No jump	No jump	No jump	No jump
No jump without segment; Segment 8 km deep	No jump	No jump	Jump	Jump	Jump

Depth of intermediate segment does affect ability of rupture to jump.

Conclusions



- The presence of an intermediate fault segment does alter rupture behavior and ground motion.
 - It is always an aid to rupture in compressional stepovers.
 - It may be a barrier or an aid in extensional stepovers, depending on its length.
- Longer intermediate segments are more likely to aid in rupture propagation through the stepover.
- The basal depth of the intermediate segment makes no first-order difference in compressional stepovers, but does alter rupture behavior in extensional ones.
- These effects are caused by the interaction of stress shadowing and directivity.

Conclusions



- Faults between or connecting the two primary segments can have a considerable effect on rupture behavior.
 - Understanding fault structure within stepovers is important.
 - Simplify model geometry at your own risk!
- Specific choice of physical/computational parameters can also strongly affect the ability of rupture to jump the stepover.