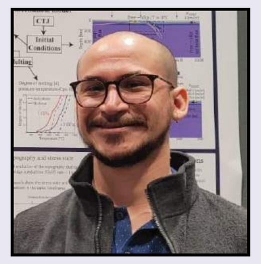
Slab window geodynamics: towards an integrated understanding of upper mantle dynamics and observations



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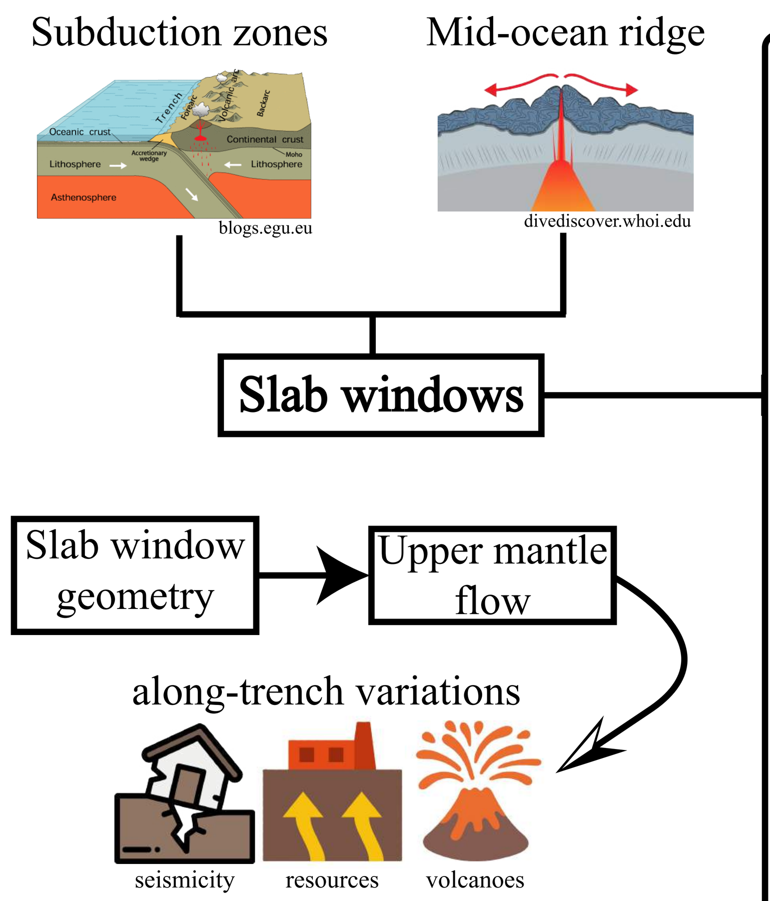
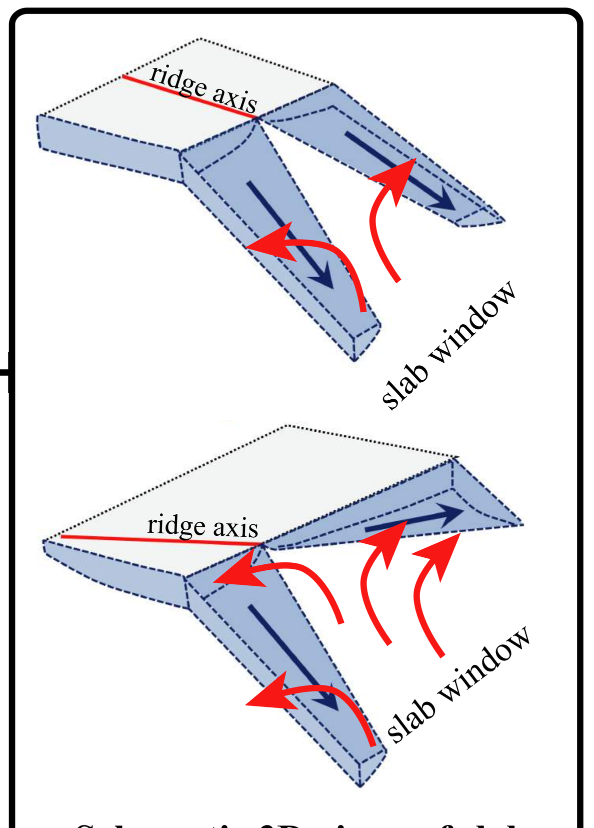
1. Motivation

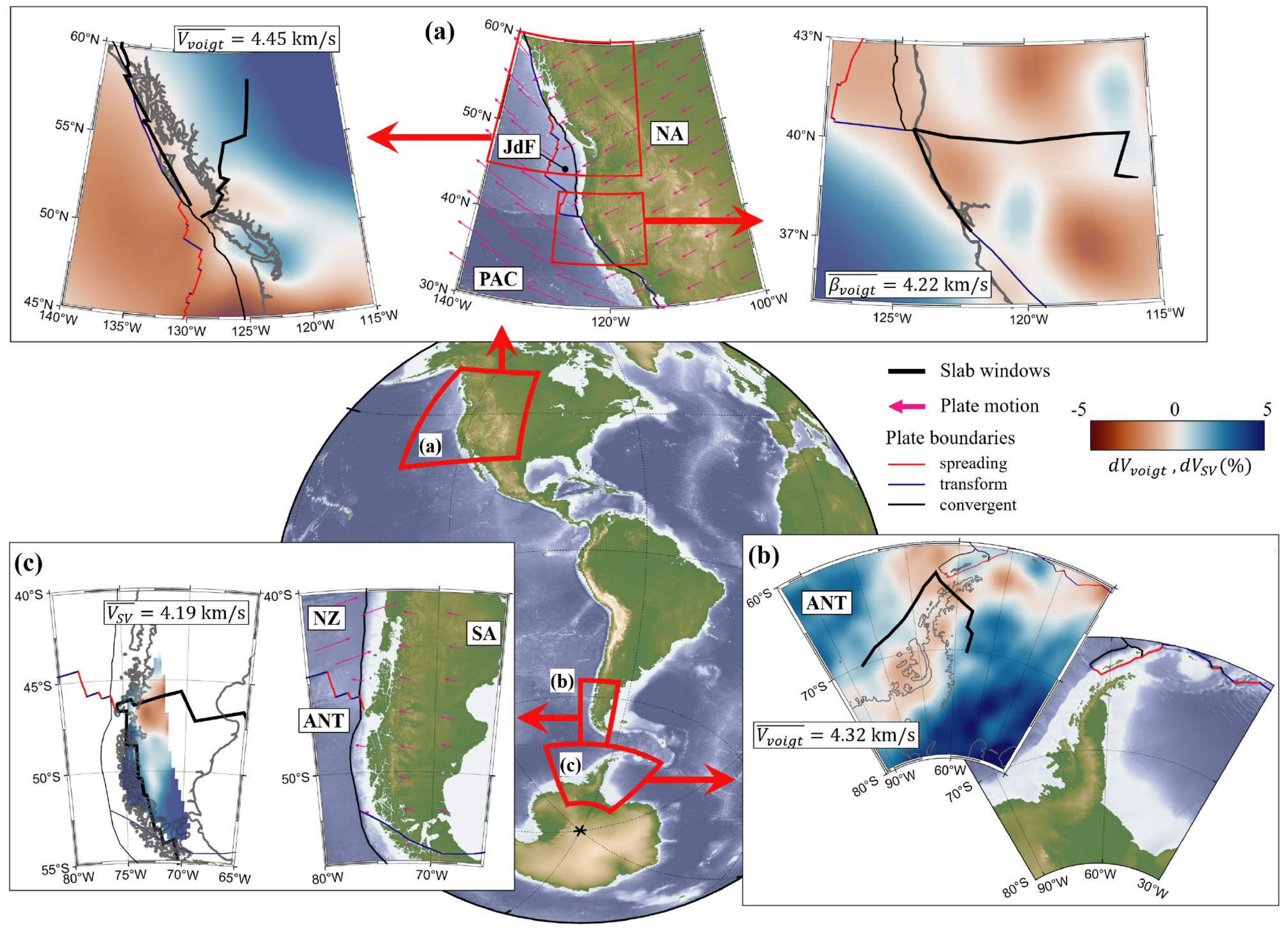




Schematic 3D views of slab windows and mantle flow due to a subducted mid-ocean ridge

What is the link between slab window geometries and upper mantle flow?

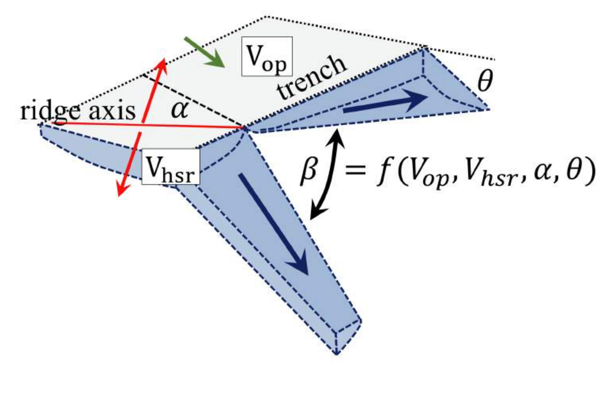
2. Slab windows in the eastern Pacific [1]



Tectonic setting and shear wave seismic tomography of modern slab windows along the eastern Pacific

3. Analytical treatment and numerical modeling

Analytical [2]



Governing equations

$$\frac{\partial v_i}{\partial x_i} = 0 \qquad -\frac{\partial P_i}{\partial x_i} + \frac{\partial \sigma_{ij}}{\partial x_i} = -\rho g$$

$$\rho C_{p,eff} \frac{DT}{Dt} = \frac{\partial}{\partial x_i}\left(k \frac{\partial T}{\partial x_i}\right) + H_r + H_s + H_a$$

Rheology

$$\eta_{diff} = \frac{1}{2} A_D^{-1} \sigma_{crit}^{1-n} \exp\left(\frac{PV_a + E}{RT}\right) \quad \text{Diffusion creep}$$

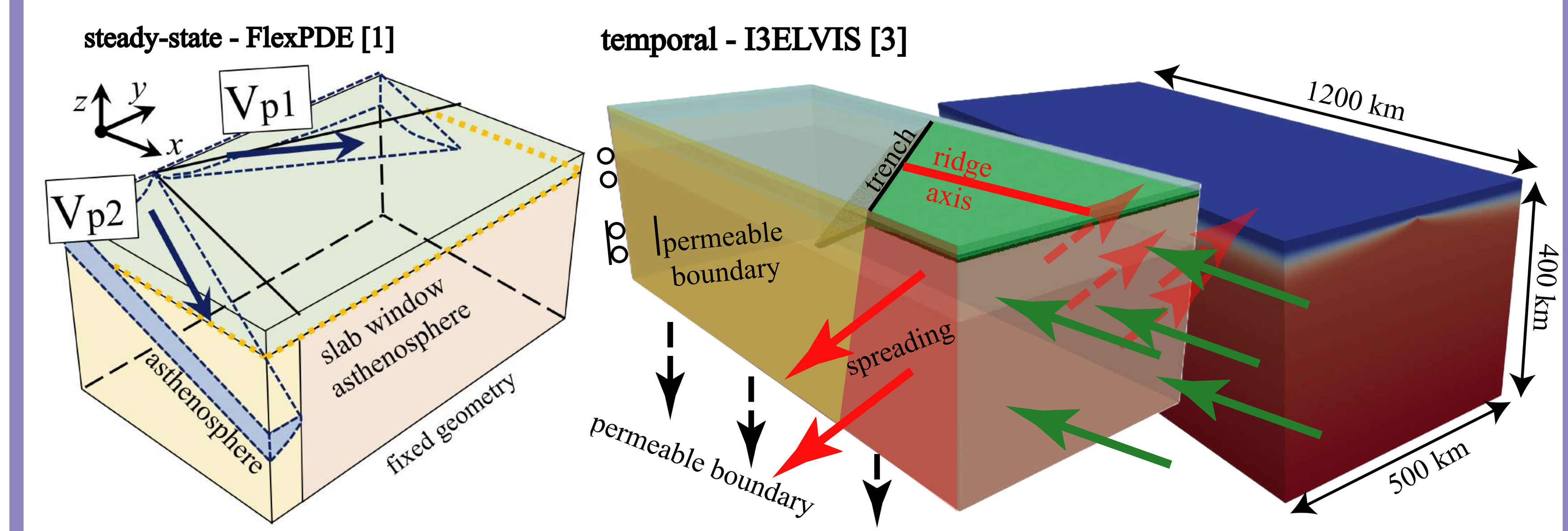
$$\eta_{disl} = \frac{1}{2} A_D^{1/n} \dot{\varepsilon}_{II}^{(1-n)/n} \exp\left(\frac{PV_a + E}{nRT}\right) \quad \text{Dislocation creep}$$

$$\frac{1}{\eta_{eff}} = \frac{1}{\eta_{diff}} + \frac{1}{\eta_{disl}} \quad \text{Effective rheology}$$

$$\eta_{eff} \le \frac{\sigma_{yield}}{2\dot{\varepsilon}} = \frac{C_0 + P\sin(\varphi)}{2\dot{\varepsilon}} \quad \text{Brittle rheology}$$

Numerical

steady-state - FlexPDE [1] | temporal - I3ELVIS [3]

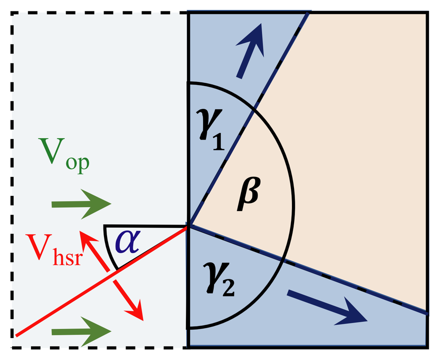


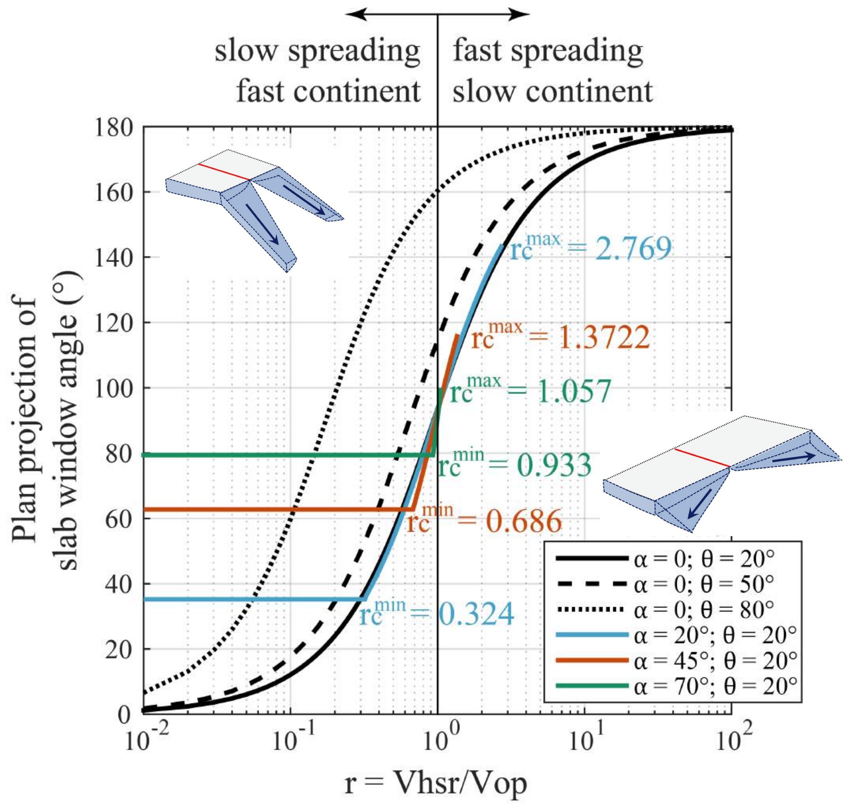
Geometry, boundary and initial conditions for steady-state and temporal numerical models

4. Slab window geometry [1]

$$r = \frac{V_{hsr}}{V_{op}}$$

Ridge obliquity, α



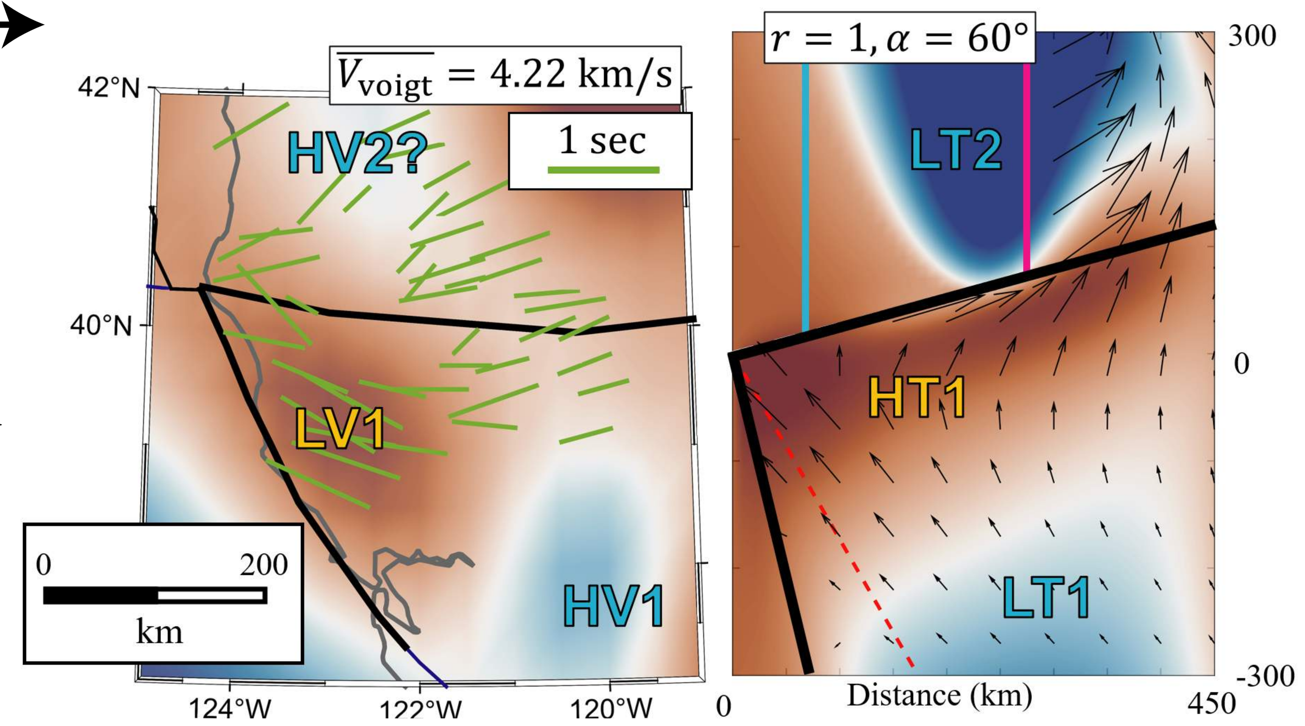


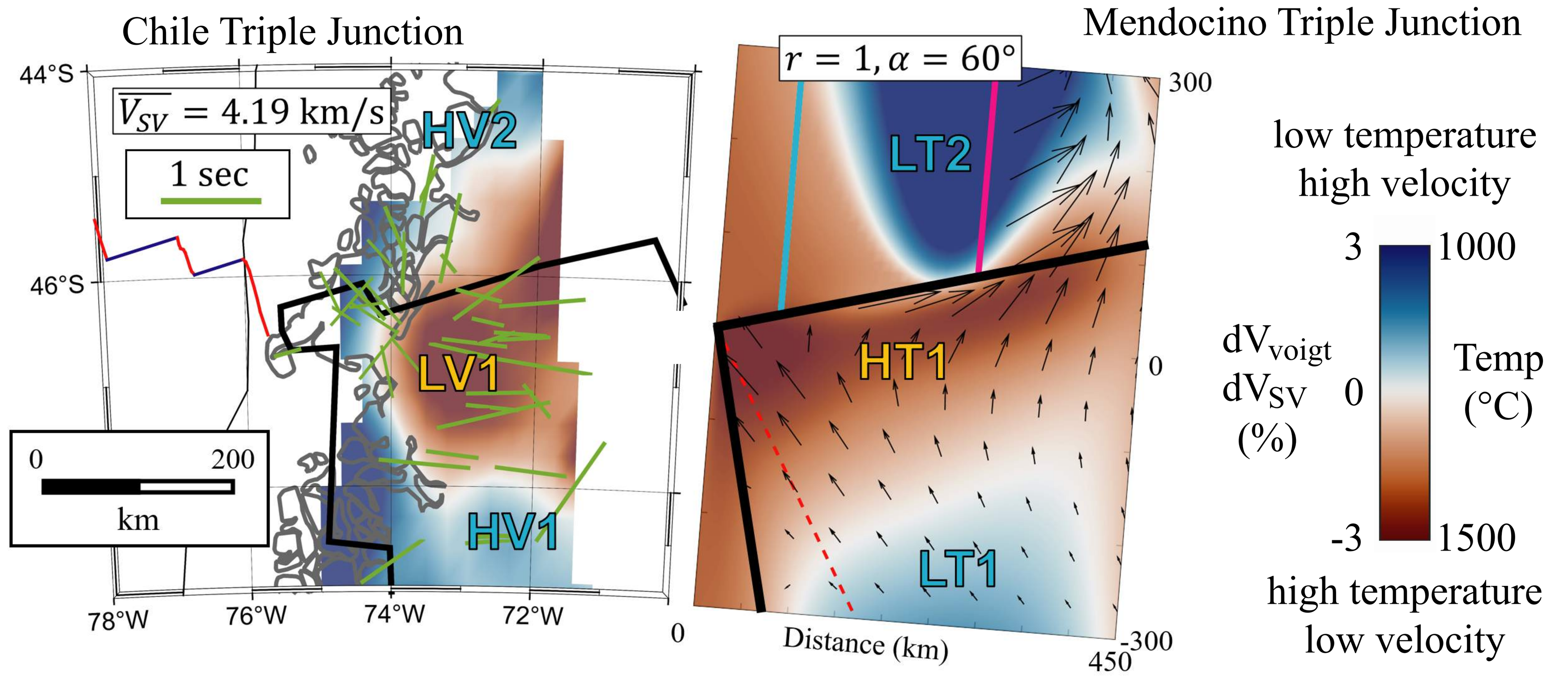
Projection of the slab window angle as a function of the tectonic setting

Analytical solution → Numerical modeling →

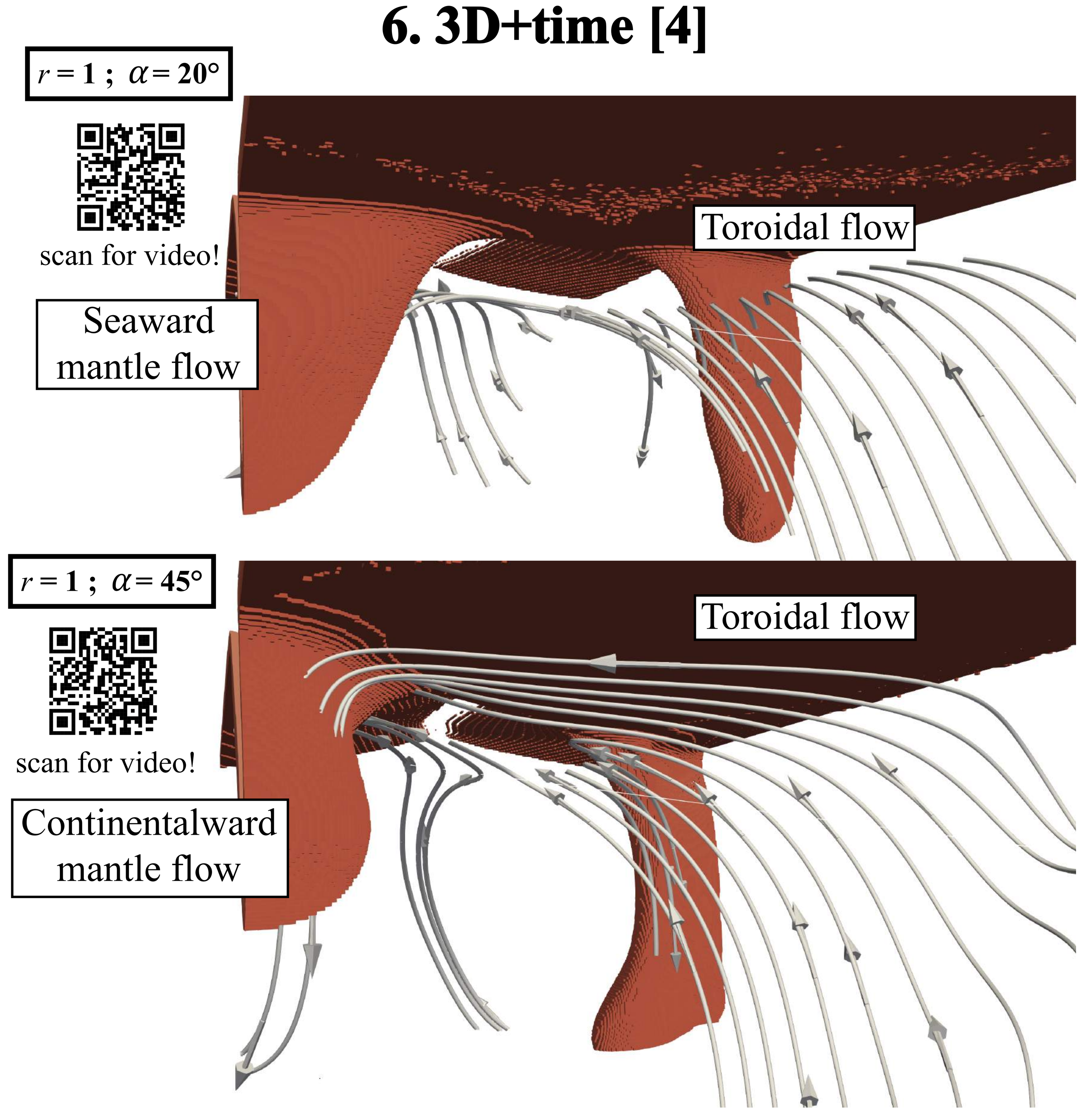
5. 3D steady-state [1]

3D steady-state models, shear wave seismic tomography and splitting





6. 3D+time [4]

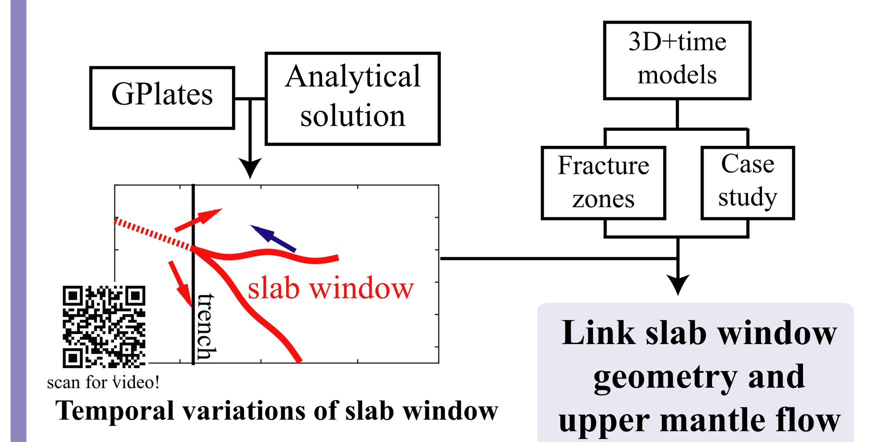


3D mantle flow through the slab window and around slab edges

7. Conclusions

- Both 3D models develop **upwelling and seaward mantle flow** near the triple junction and **toroidal flow** around slab edges.
- Temporal models develop both **seaward and continentalward upper mantle flow** on each subducted slab.

8. Outlook



References

[1] Sanhueza et al. (2023). EPSL, 623, 1-10
[2] Thorkelson (1996). Tecto, 225(1-2), 47-63
[3] Gerya & Yuen (2007). PEPI, 165(1-4), 83-105
[4] Sanhueza et al. (2024). In-prep.

Acknowledgments

· ANID PhD Scholarship 21210747
· Swiss Government Excellence Scholarship