Olivine texture evolution under simple deformation: Comparing different numerical methods for calculating LPO and anisotropic viscosity

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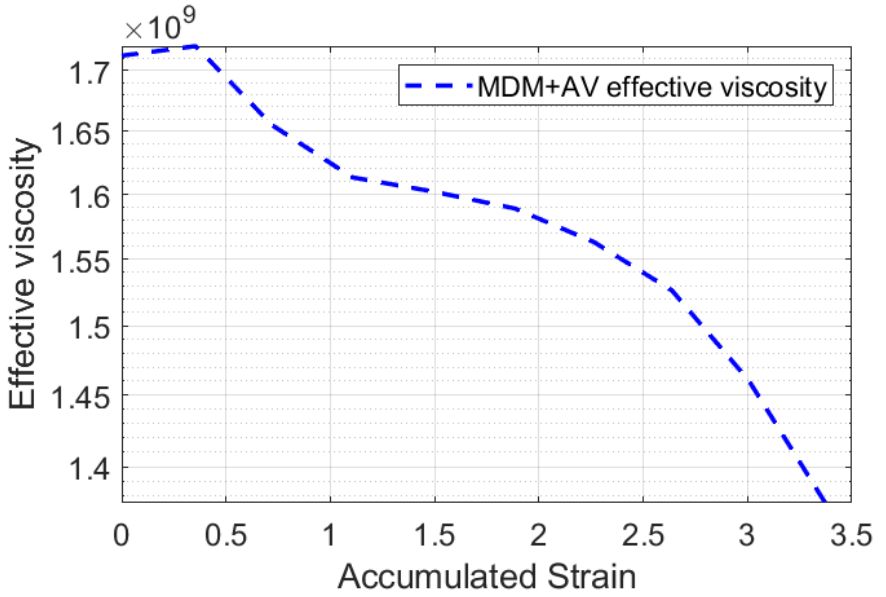
Method

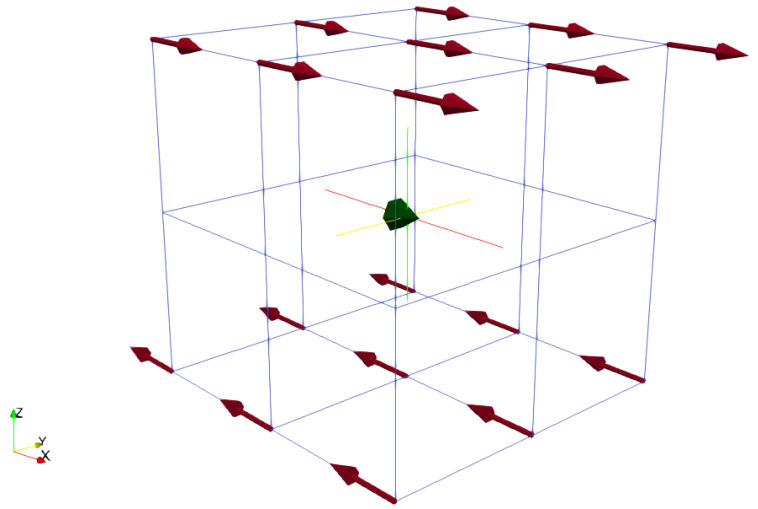
- Two methods that calculate anisotropic viscosity (AV) and lattice-preferred-orientation (LPO)
  - D-Rex[1] implemented in ASPECT[2]
  - Modified director method (MDM)[3] with and without a micromechanical model for AV implemented as Matlab scripts[4]
- Two 3D models[2]
  - Simple shearbox model
  - Subduction model

1. Kaminski et al. 2004
2. Fraters and Billen 2021
3. Hansen et al. 2016
4. Kiraly et al. 2020

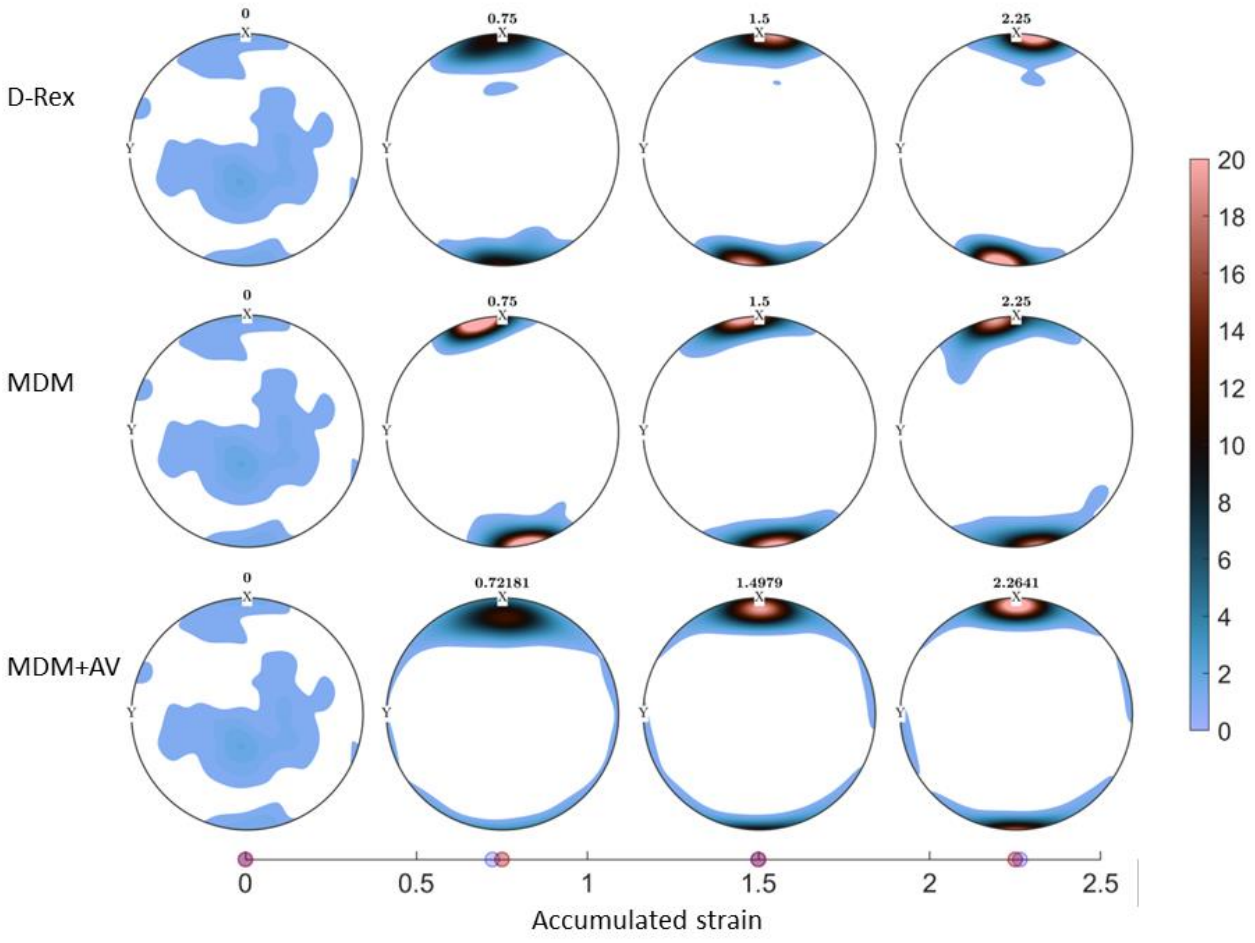
Simple shearbox model – setup

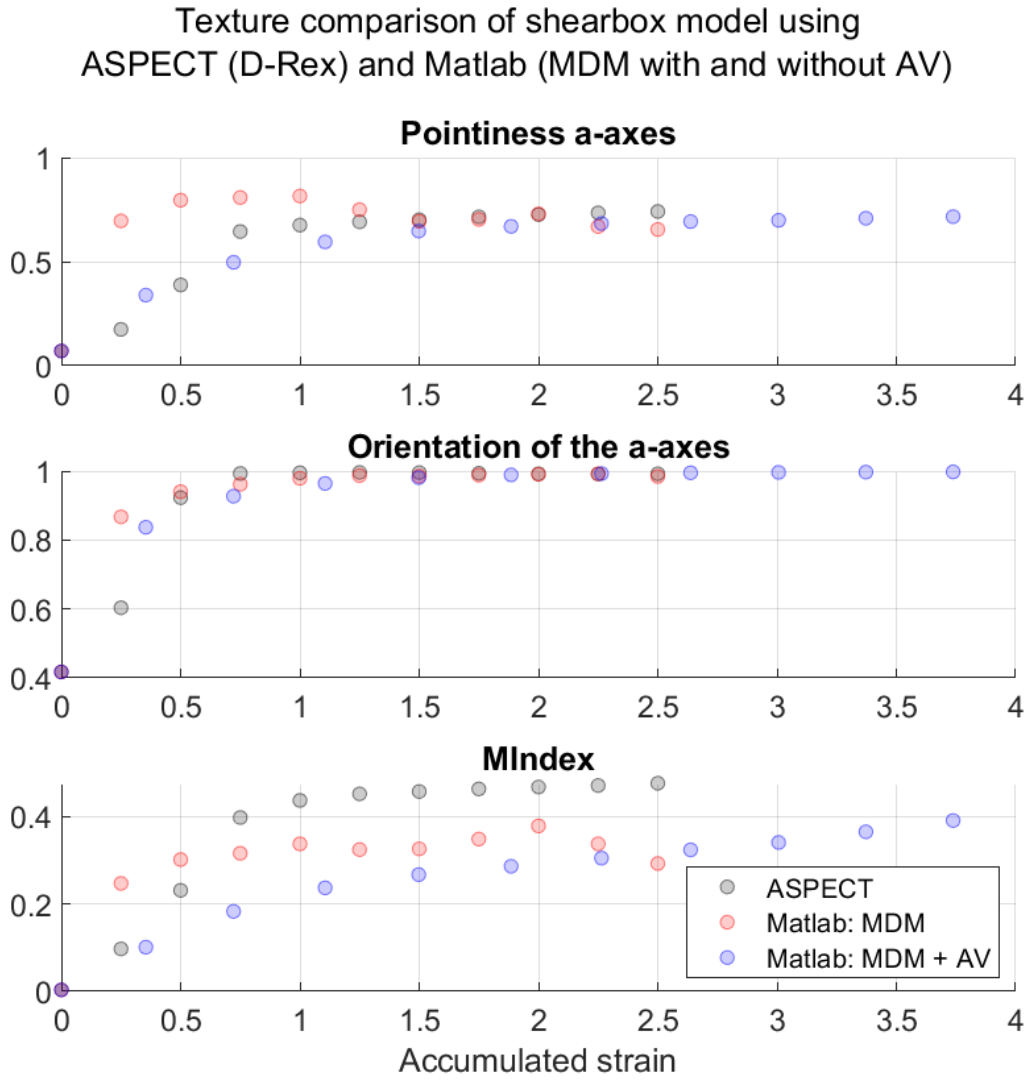
- Shear box: 1*1*1
- One particle at the center with 500 grains
- Applied velocity = z coordinates
- Run for 5 seconds
- D-Rex model with fixed viscosity and strain rate
- Viscosity drops by 17% in MDM model with AV implemented with accumulated strain of ~ 3.5





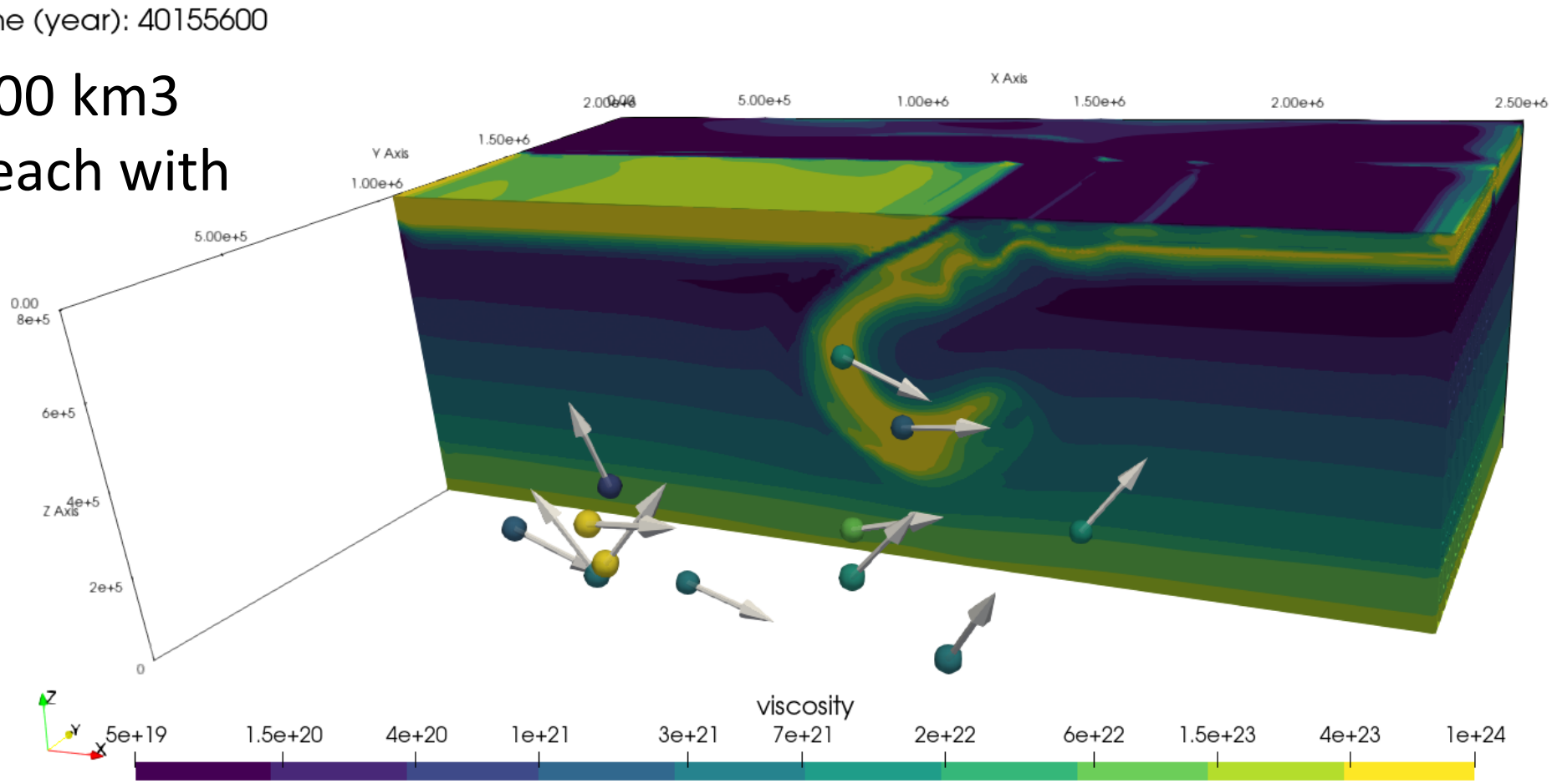
Simple shearbox model – texture





3D subduction model – setup

- 2500*2000*800 km3
- 100 particles each with 1000 grains
- 41 myr



Take home points

- Adding anisotropic viscosity to the texture models will change the deformation rates and texture
- Accumulated strain in MDM with AV is more than twice of the no-AV D-Rex model within a shearbox model
- AV effect is more complex in subduction setting and needs more investigation

References

Bangerth, W., Dannberg, J., Gassmoeller, R., & Heister, T. (2020). Aspect v2.2.0. Zenodo. https://doi.org/10.5281/zenodo.3924604

Fraters, M.R.T., and Billen, M.I., 2021, On the Implementation and Usability of Crystal Preferred Orientation Evolution in Geodynamic Modeling: Geochemistry, Geophysics, Geosystems, v. 22,doi:10.1029/2021GC009846.

Hansen, L., Conrad, C., Boneh, Y., Skemer, P., Warren, J., & Kohlstedt, D. (2016a). Viscous anisotropy of textured olivine aggregates: 2. Micromechanical model. Journal of Geophysical Research-Solid Earth, 121(10), 7137-7160. doi:10.1002/2016JB013240Kaminski, E., Ribe, N., & Browaeys, J. (2004).

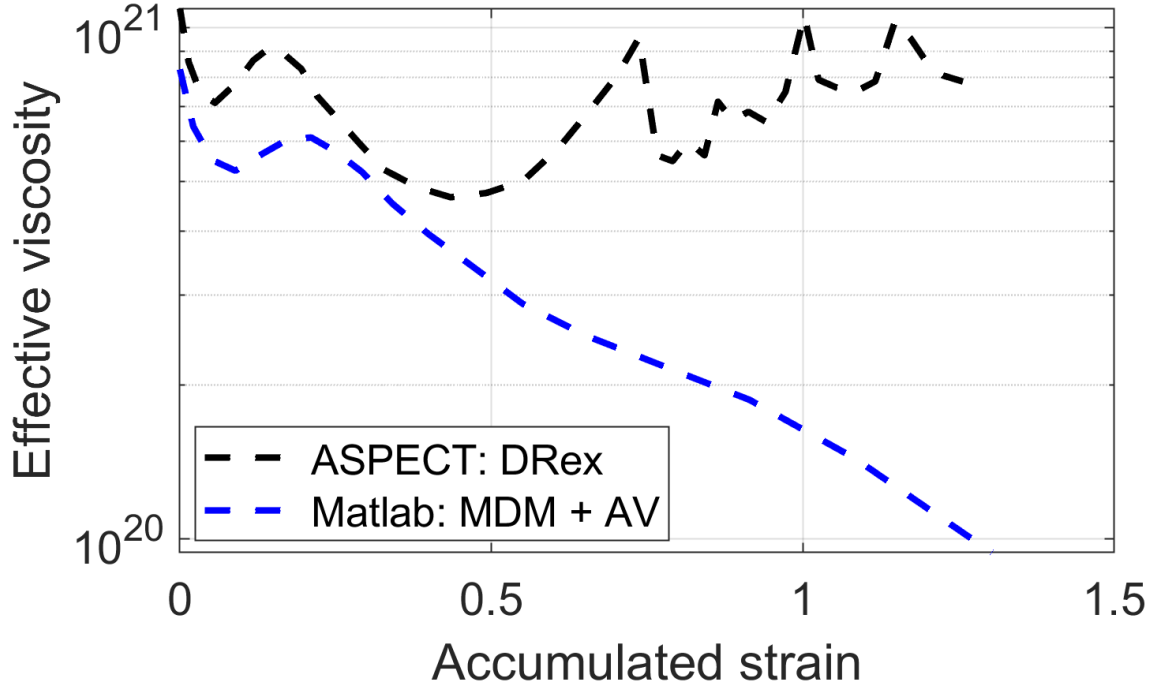
D-Rex, a program for calculation of seismic anisotropy due to crystal lattice preferred orientation in the convective upper mantle. Geophysical Journal International, 158(2), 744-752. doi:10.1111/j.1365-246X.2004.02308.x

Király, A., Conrad, C., & Hansen, L. (2020). Evolving Viscous Anisotropy in the Upper Mantle and Its Geodynamic Implications. Geochemistry Geophysics Geosystems, 21(10). doi:10.1029/2020GC009159

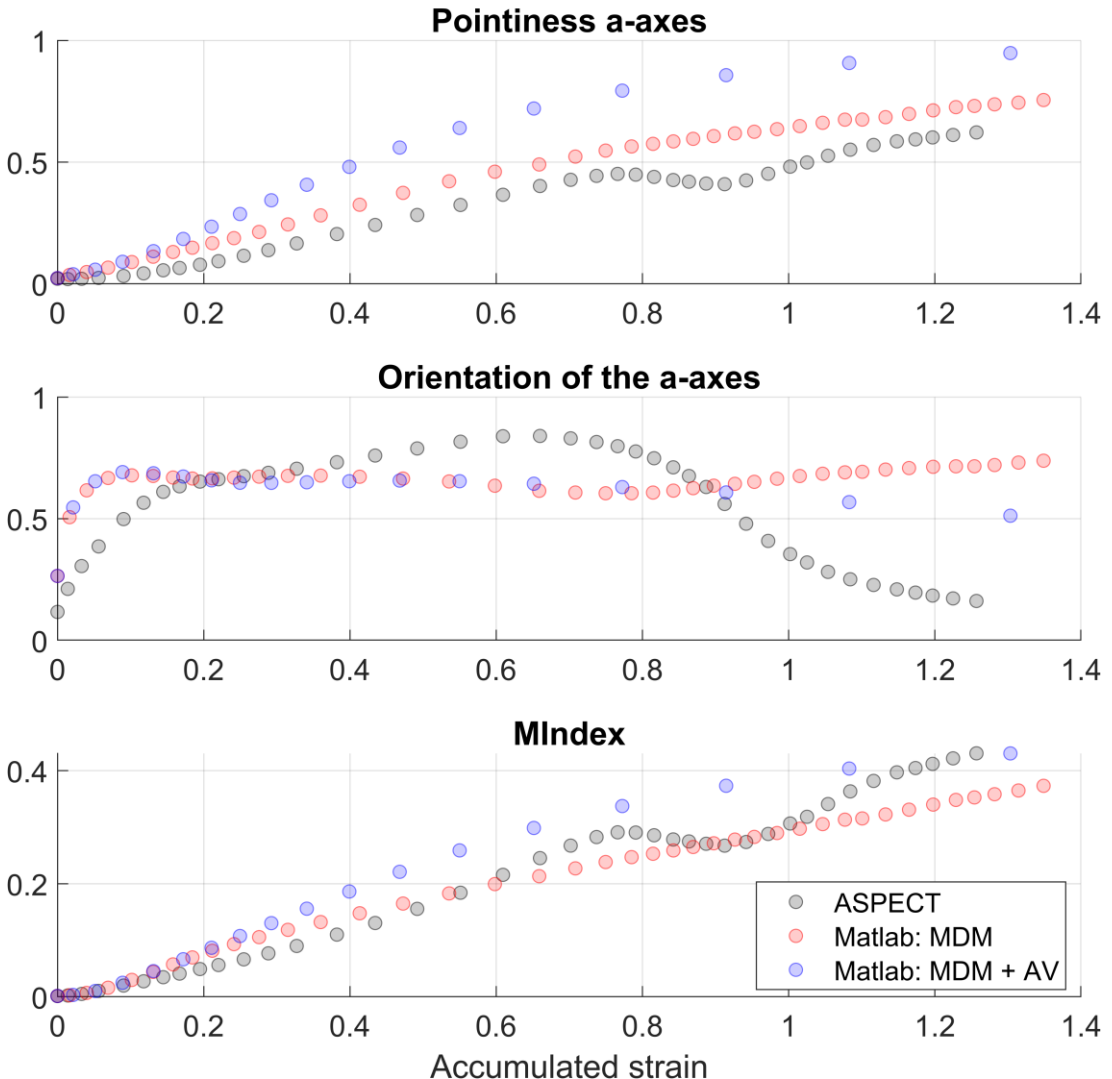
Thanks for listening!

3D subduction model – results

- Selected 1 particle for analysis each time: e.g. particle id 41



Texture comparison 3D subduction models using ASPECT (D-Rex) and Matlab (MDM with and without AV) in the mantle wedge region



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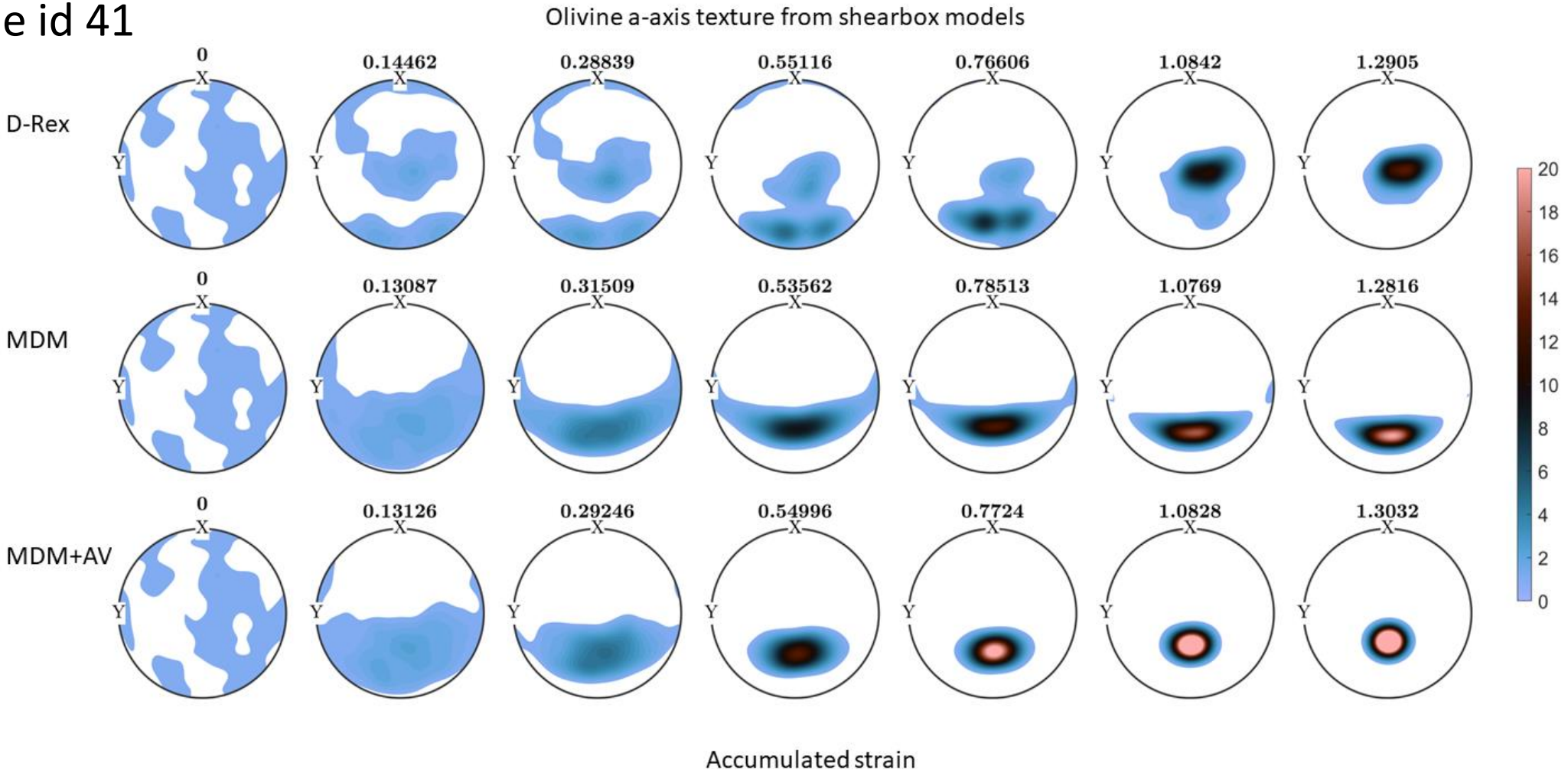
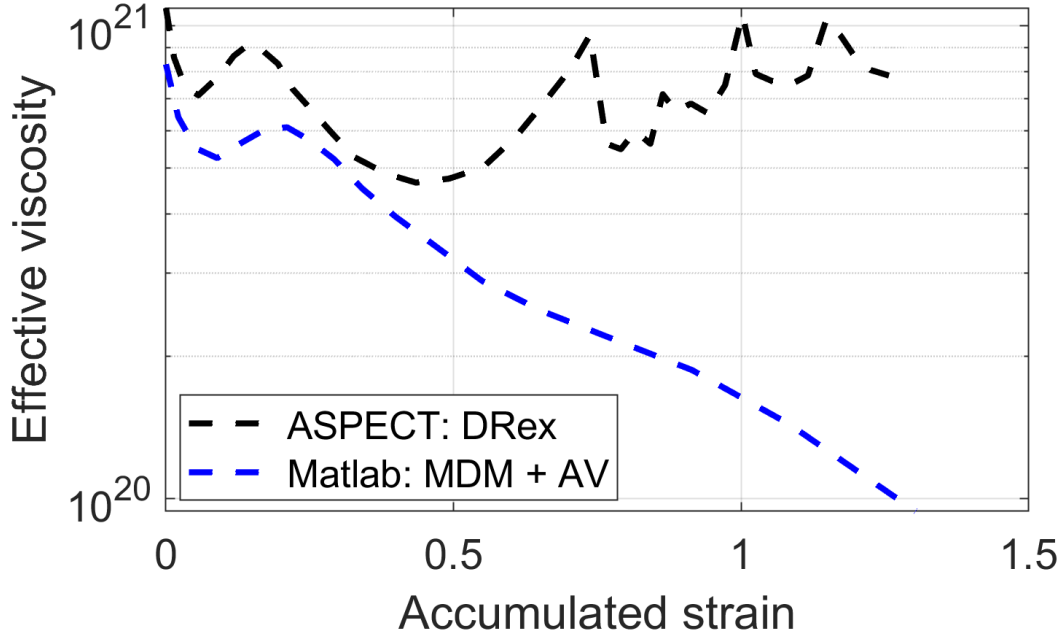


3D subduction model – results

- At half of the model run time, the predicted strain rate for the MDM models grows to 1000 times of D-Rex strain rate, which might be because our current fluidity tensor is not fully recovered correctly.



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