
Mantle
Lithosphere

Dynamic Feedbacks Between Mantle Flow and Global Tectonics

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AUGURY
Reconstructing Earth's mantle convection

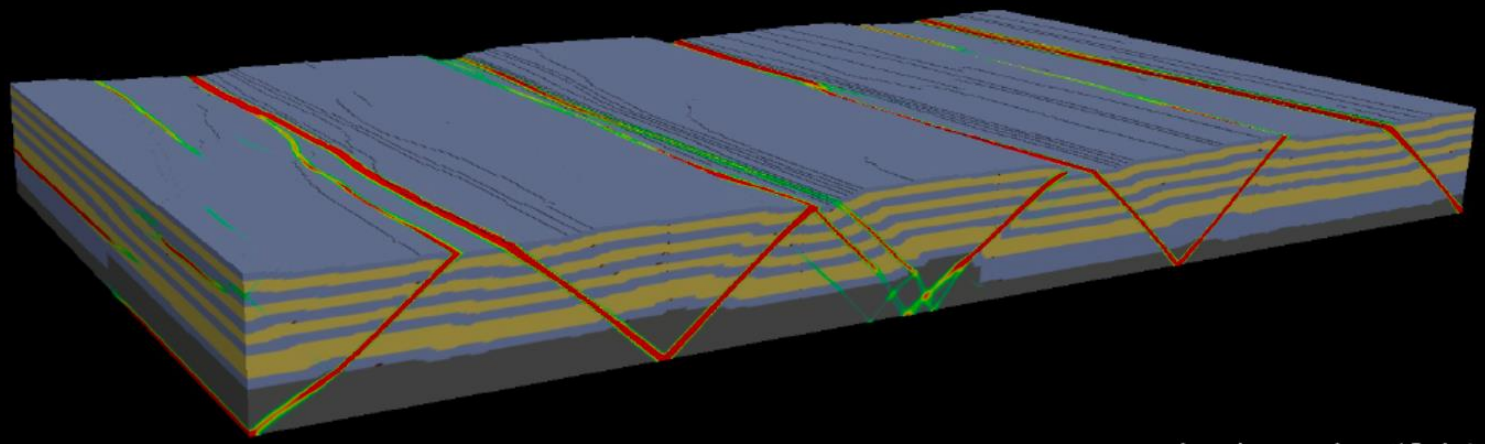
European Research Council
Established by the European Commission

EarthBYTE
Building a Virtual Earth

Laboratoire de Géologie de Lyon
Terre Planètes Environnement

ETH zürich

Hypothesis: use the same physics for lithosphere and convecting mantle



strain rate (1/s)

2e-15 4e-15 6e-15 8e-15

1e-17 1e-14

3.110 Myrs

Image by B. Kaus


Strength > Stress

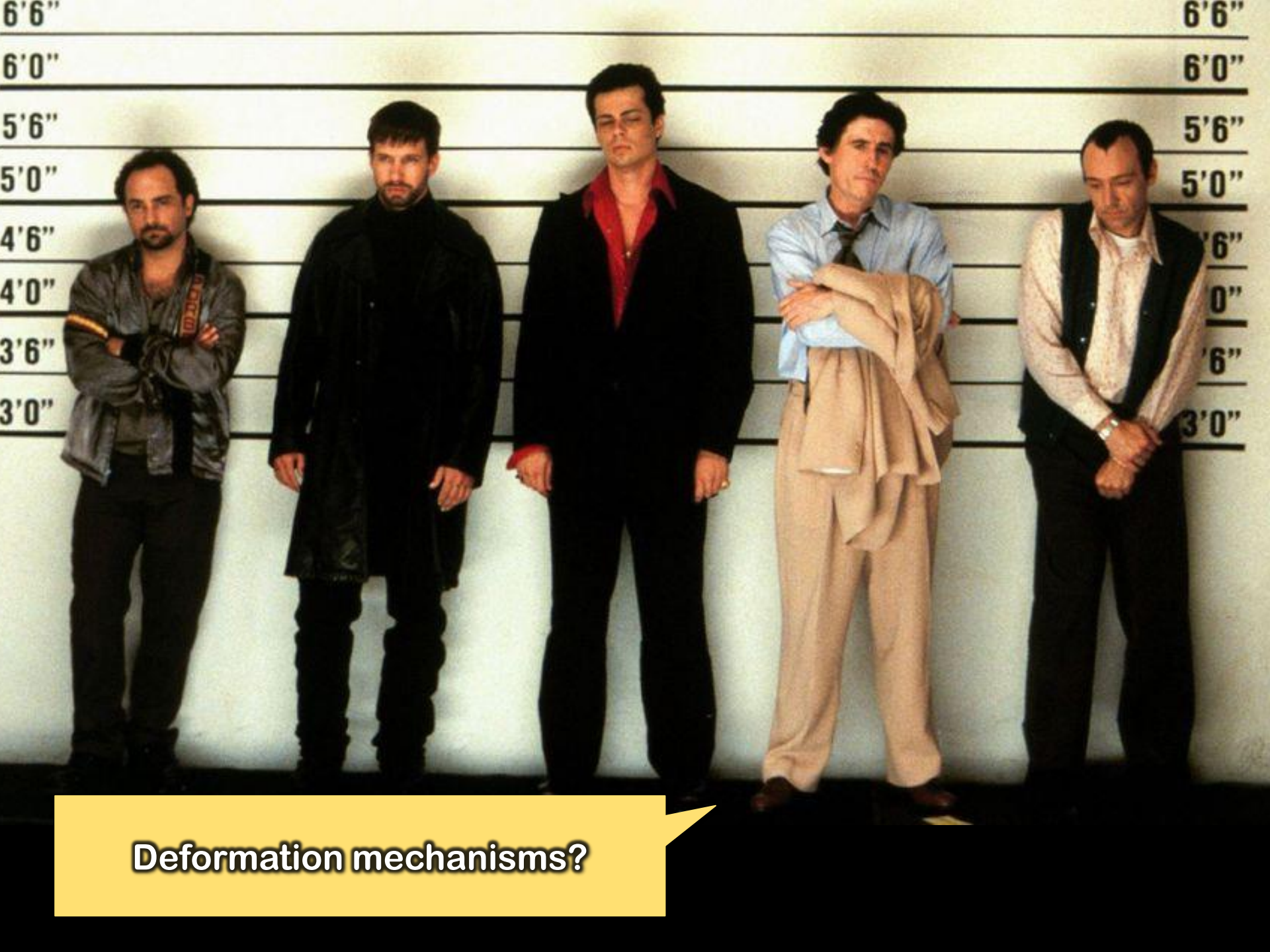

Strength < Stress

$$\vec{\nabla} \cdot \vec{u} = 0$$

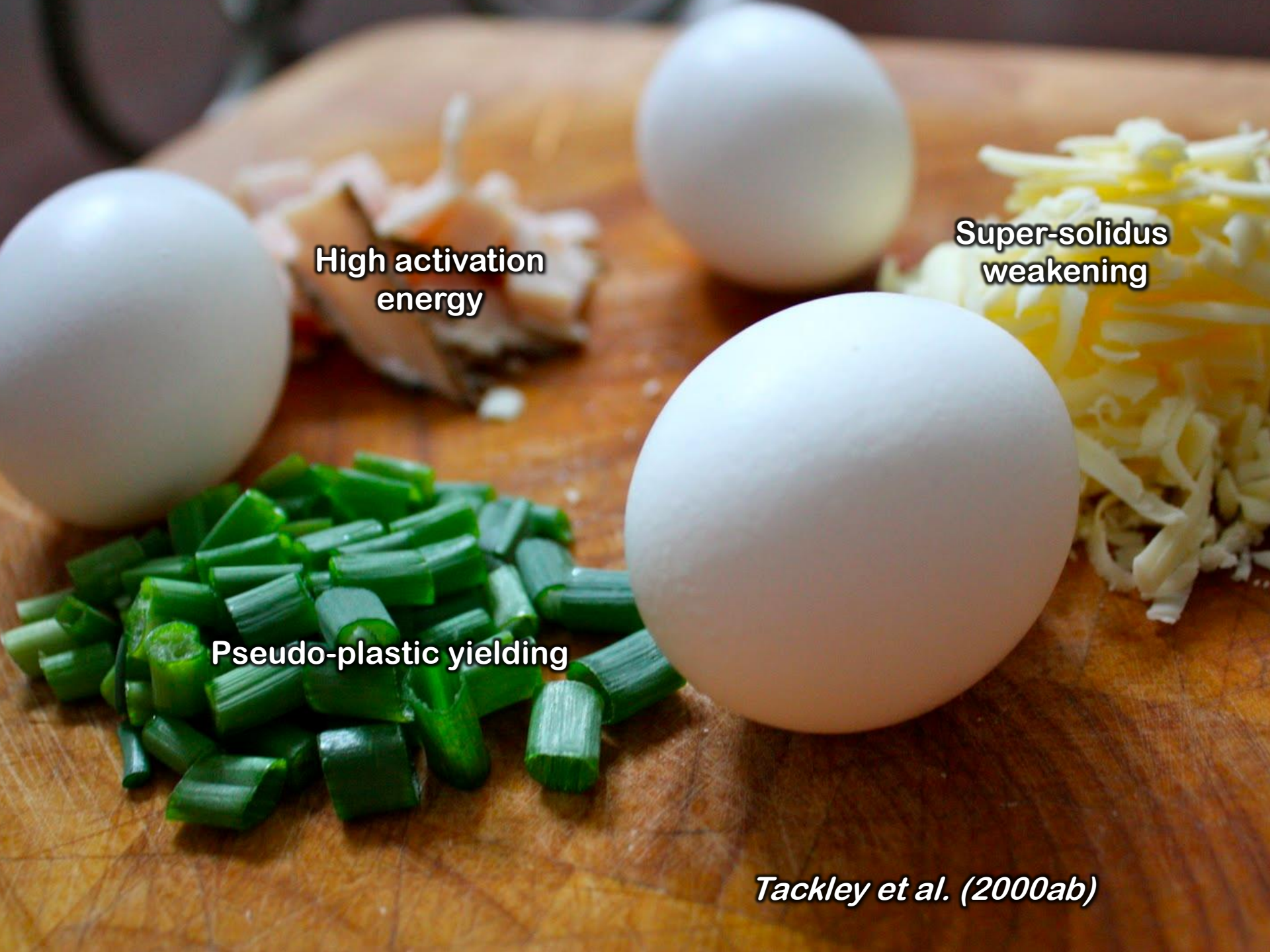
$$-\vec{\nabla} P + \vec{\nabla} \cdot \left[\eta\left(\partial_i u_j + \partial_j u_i\right)\right] = Ra(T - RC)\vec{e}_r$$

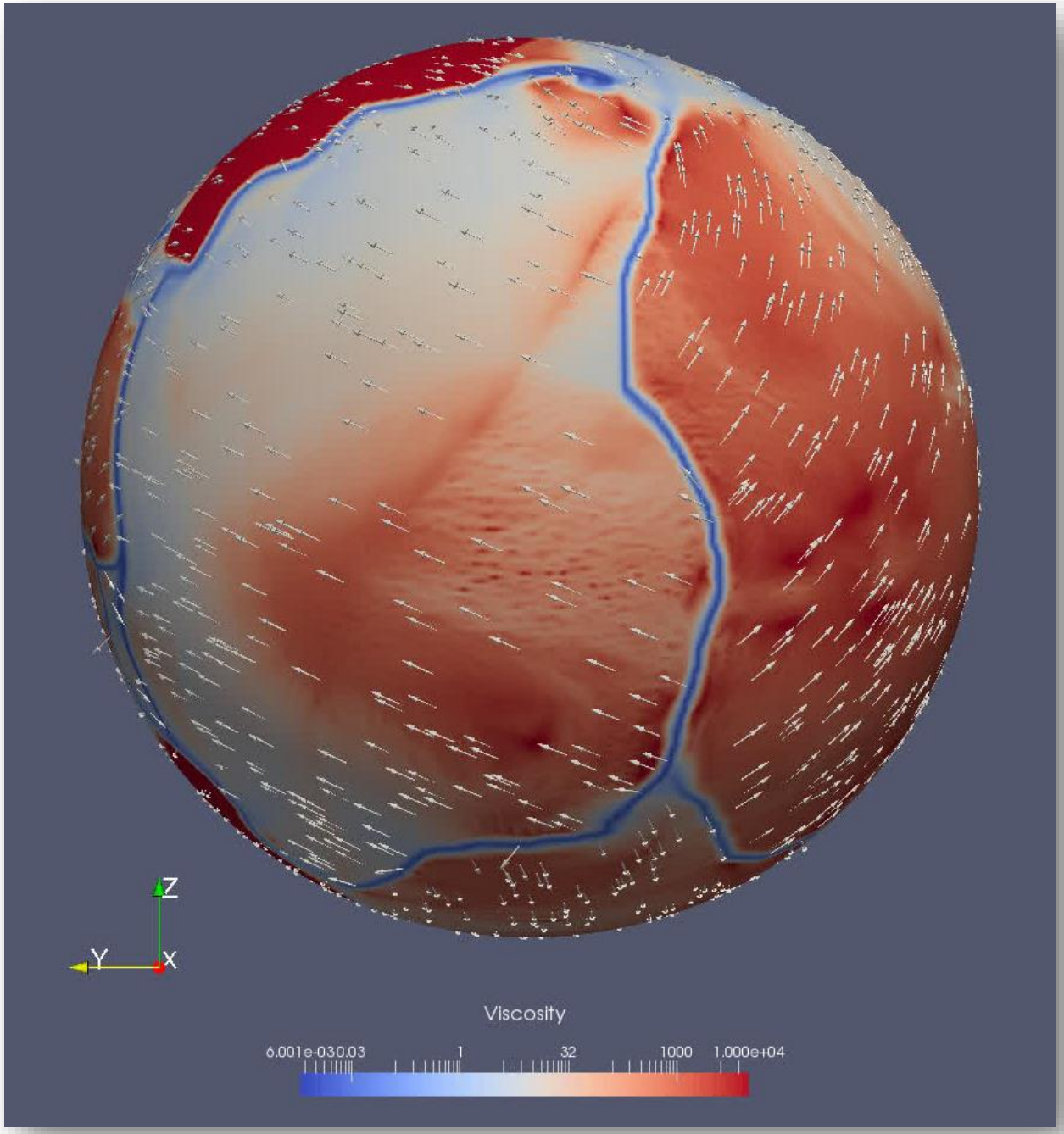
$$\partial_t T + \vec{u} \cdot \vec{\nabla} T = \nabla^2 T + Q,$$

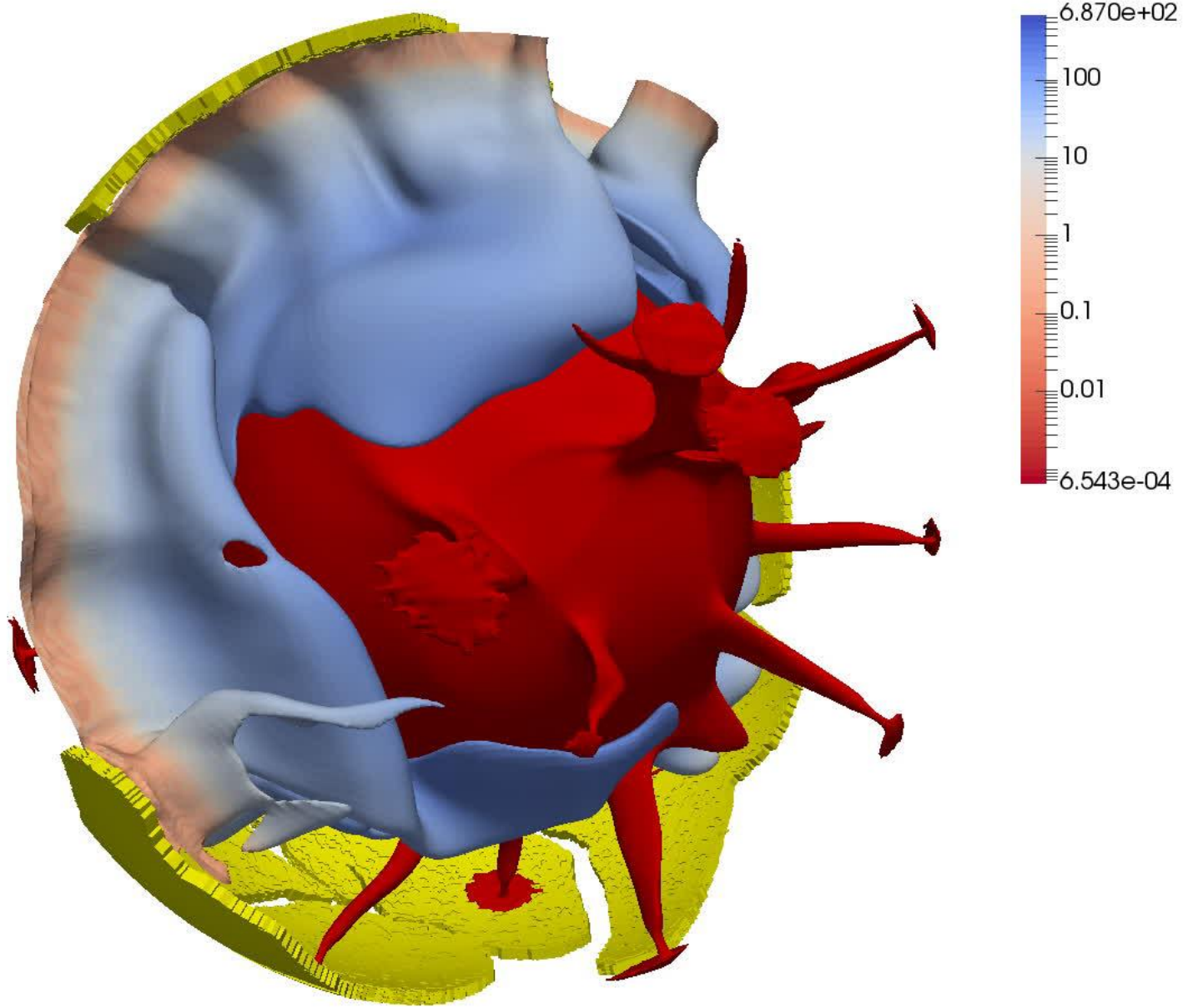
$$\frac{\partial C}{\partial t} + (\mathbf{u} \cdot \nabla) C = 0.$$

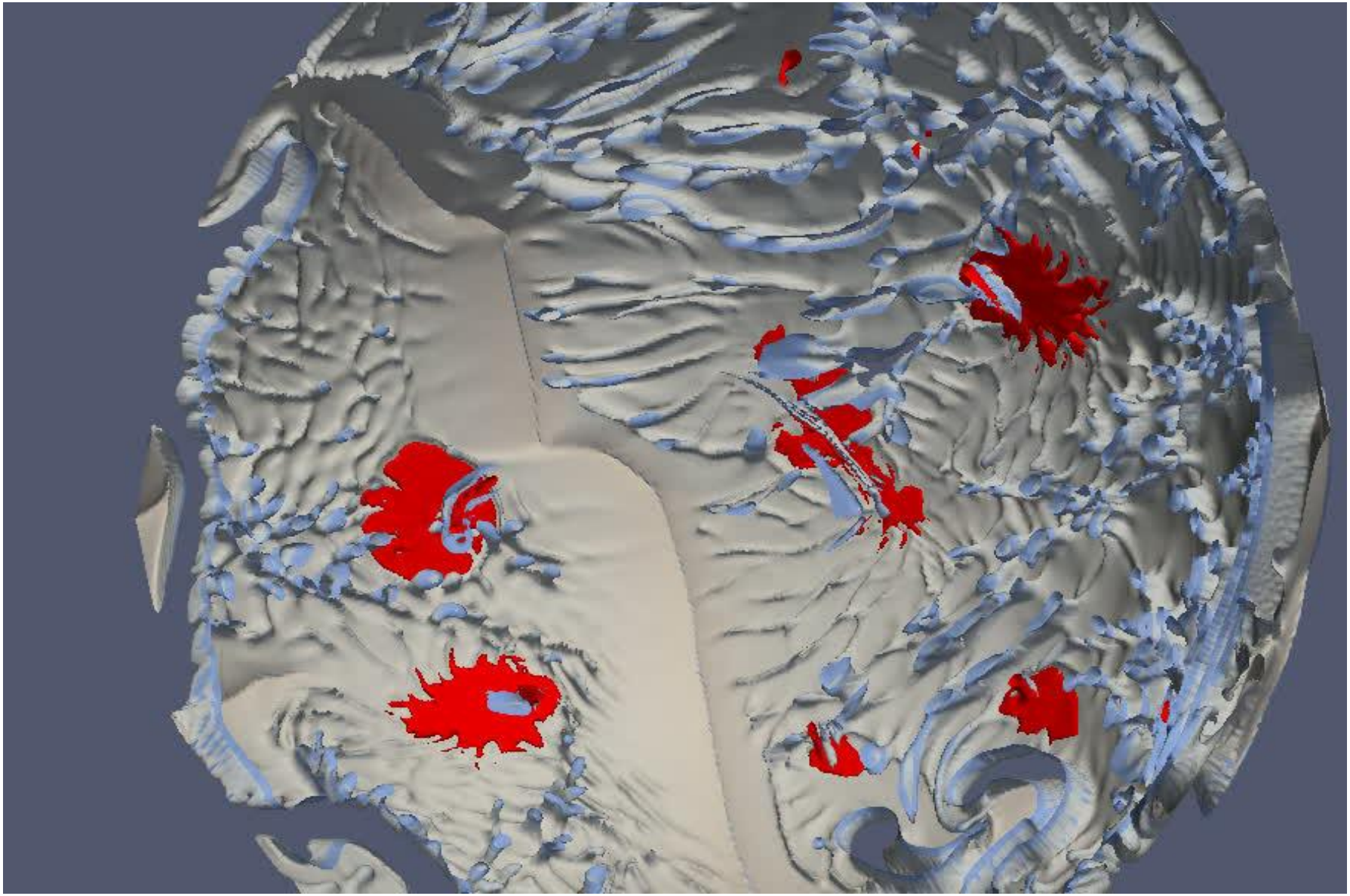

6'6"
6'0"
5'6"
5'0"
4'6"
4'0"
3'6"
3'0"
Deformation mechanisms?


Plan A
Plan B

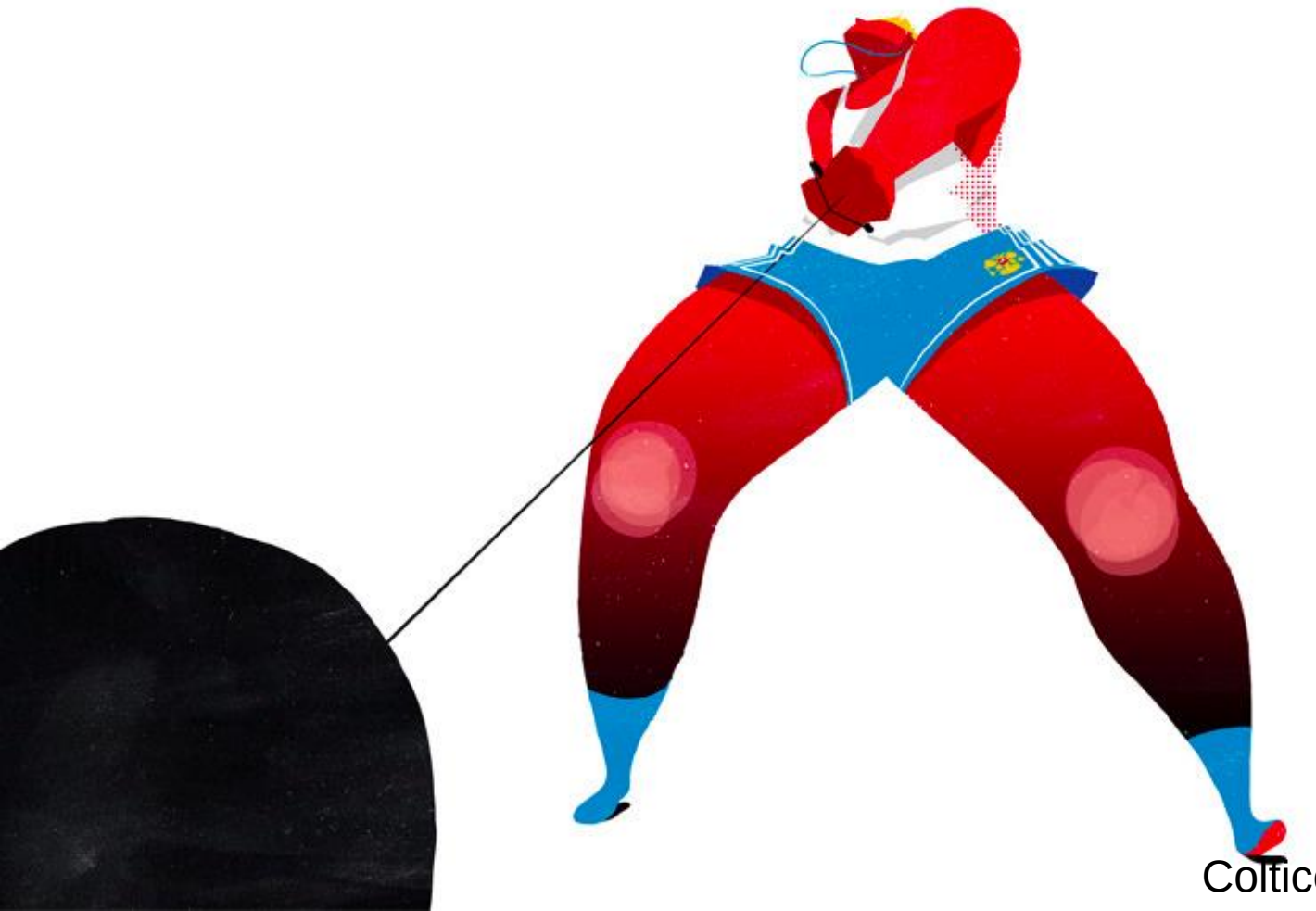

High activation energy
Super-solidus weakening
Pseudo-plastic yielding
Tackley et al. (2000ab)


Z
Y
X
Viscosity
6.001e-03
0.03
1
32
1000
1.000e+04


Viscosity
6.870e+02
100
10
1
0.1
0.01
6.543e-04

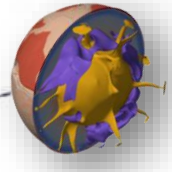


A forecast experiment

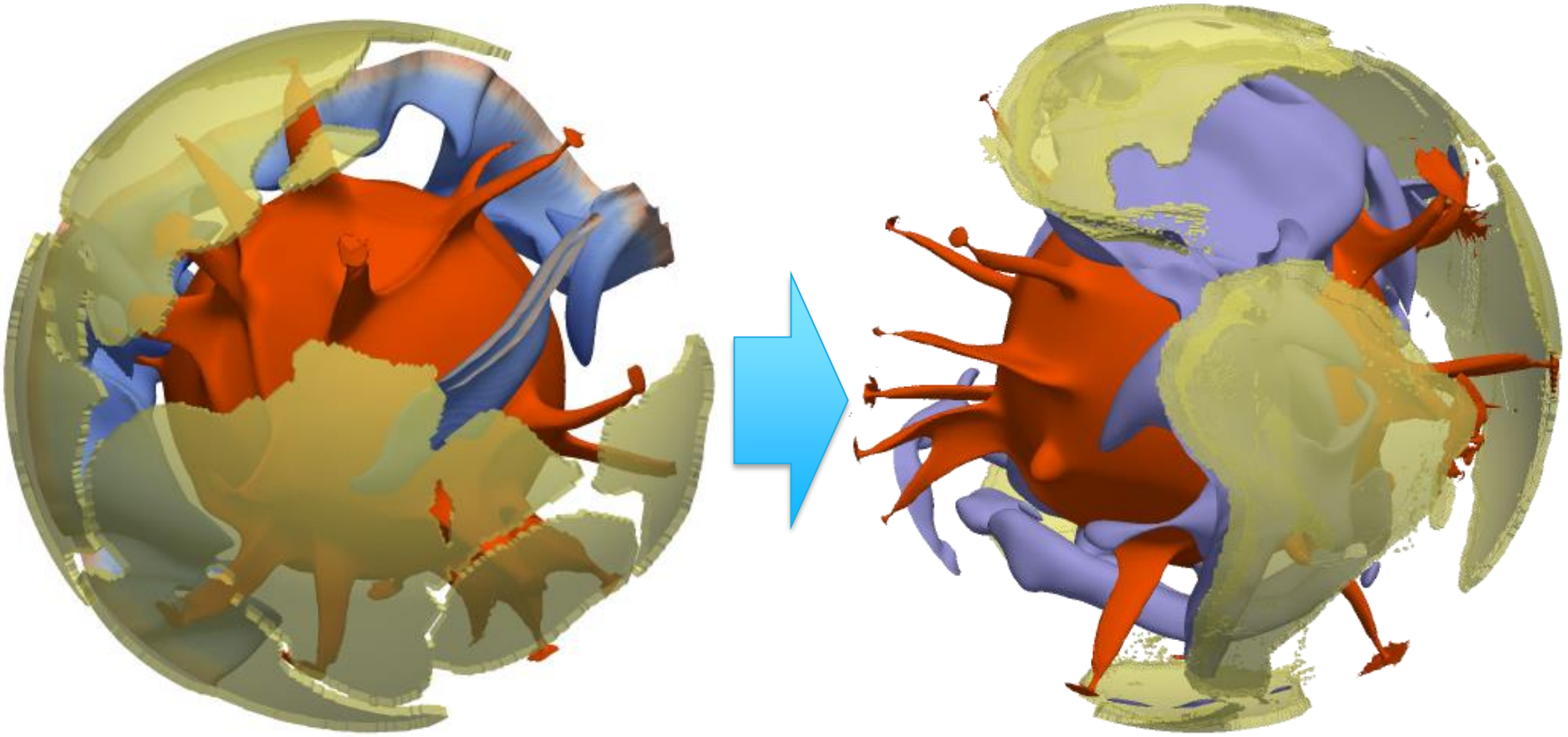


Coltice, submitted to *PLOS O*

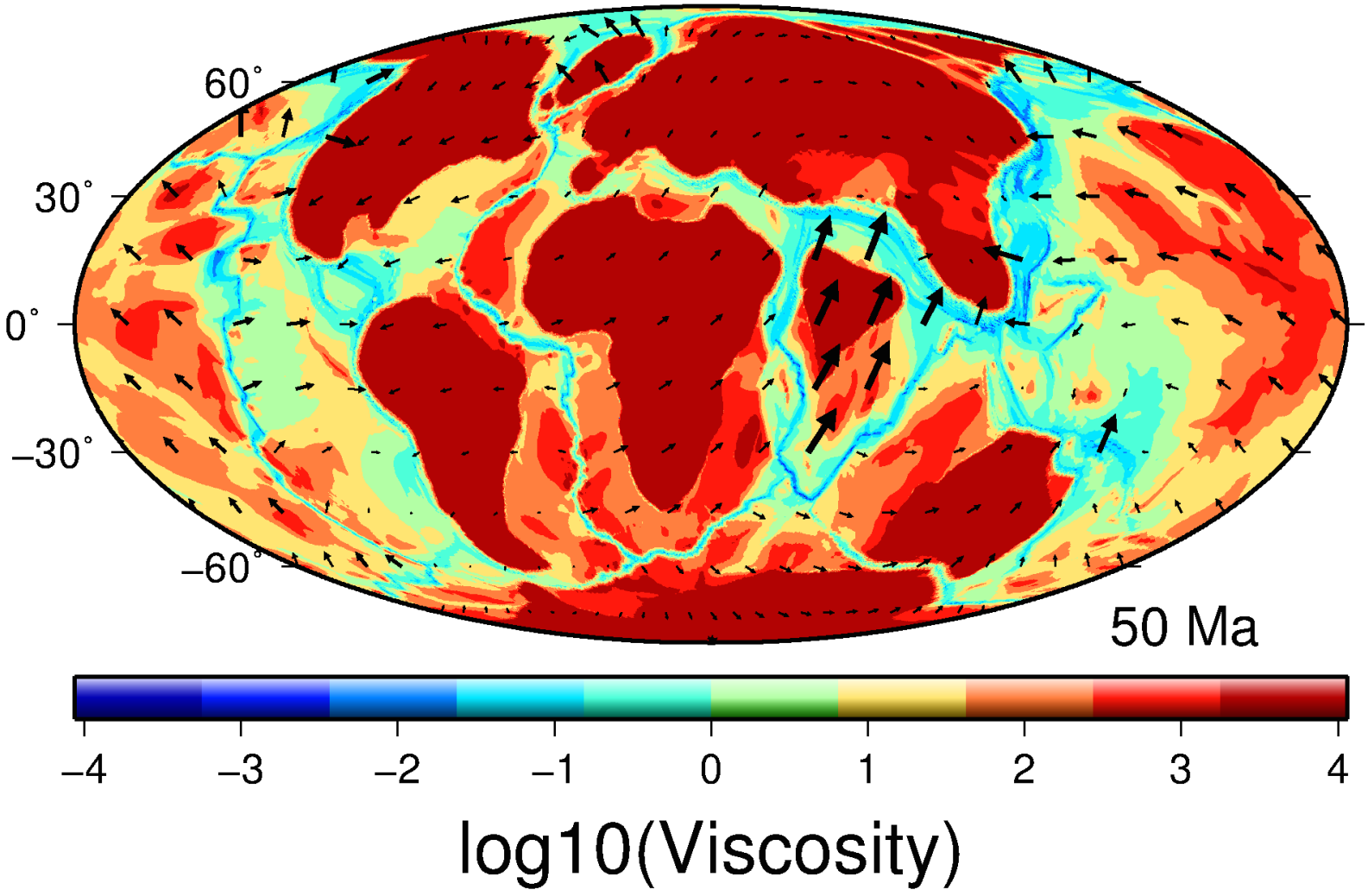
Swinging and turning:
Impose plates since
200Ma until 50 Ma

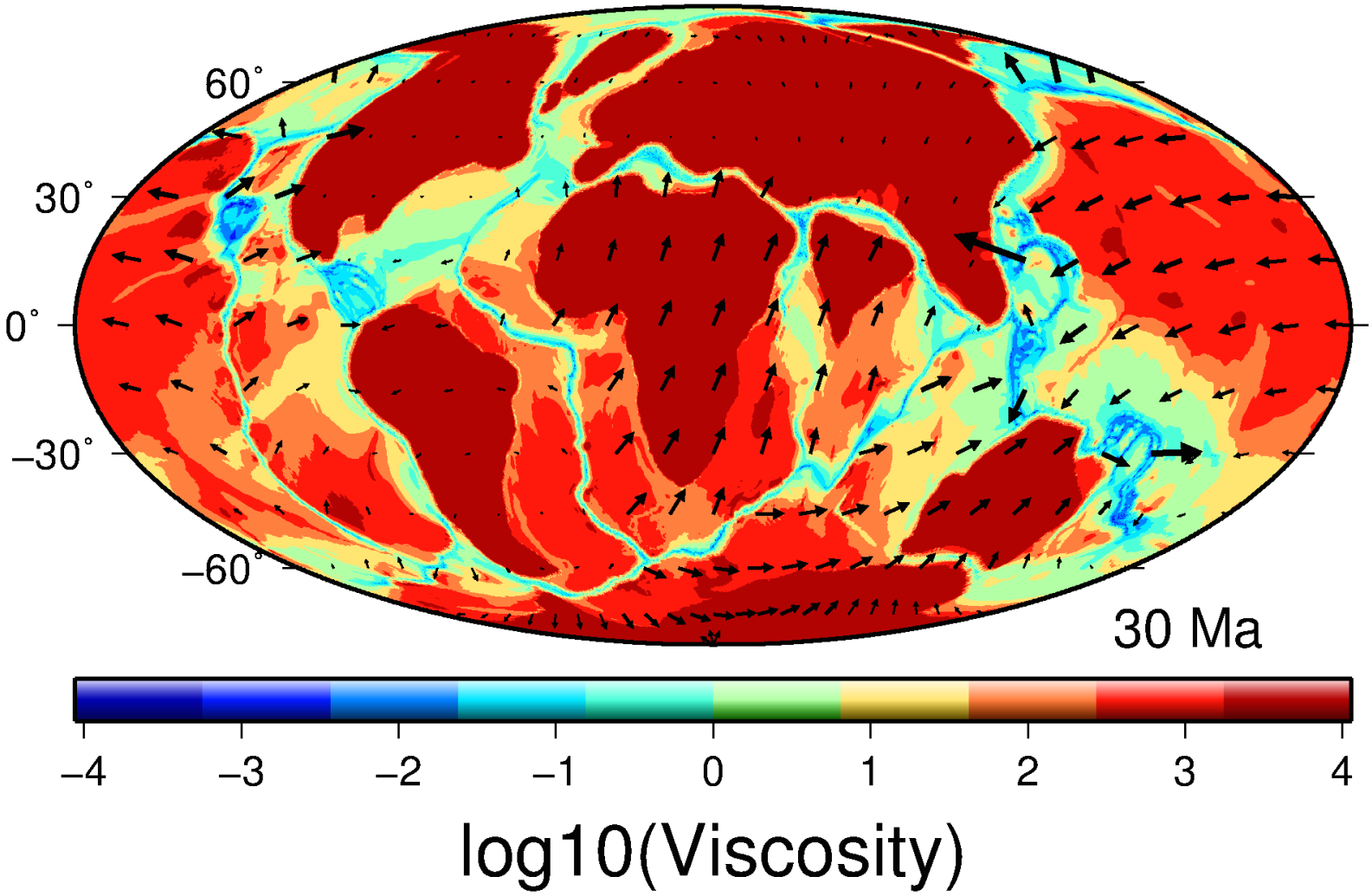


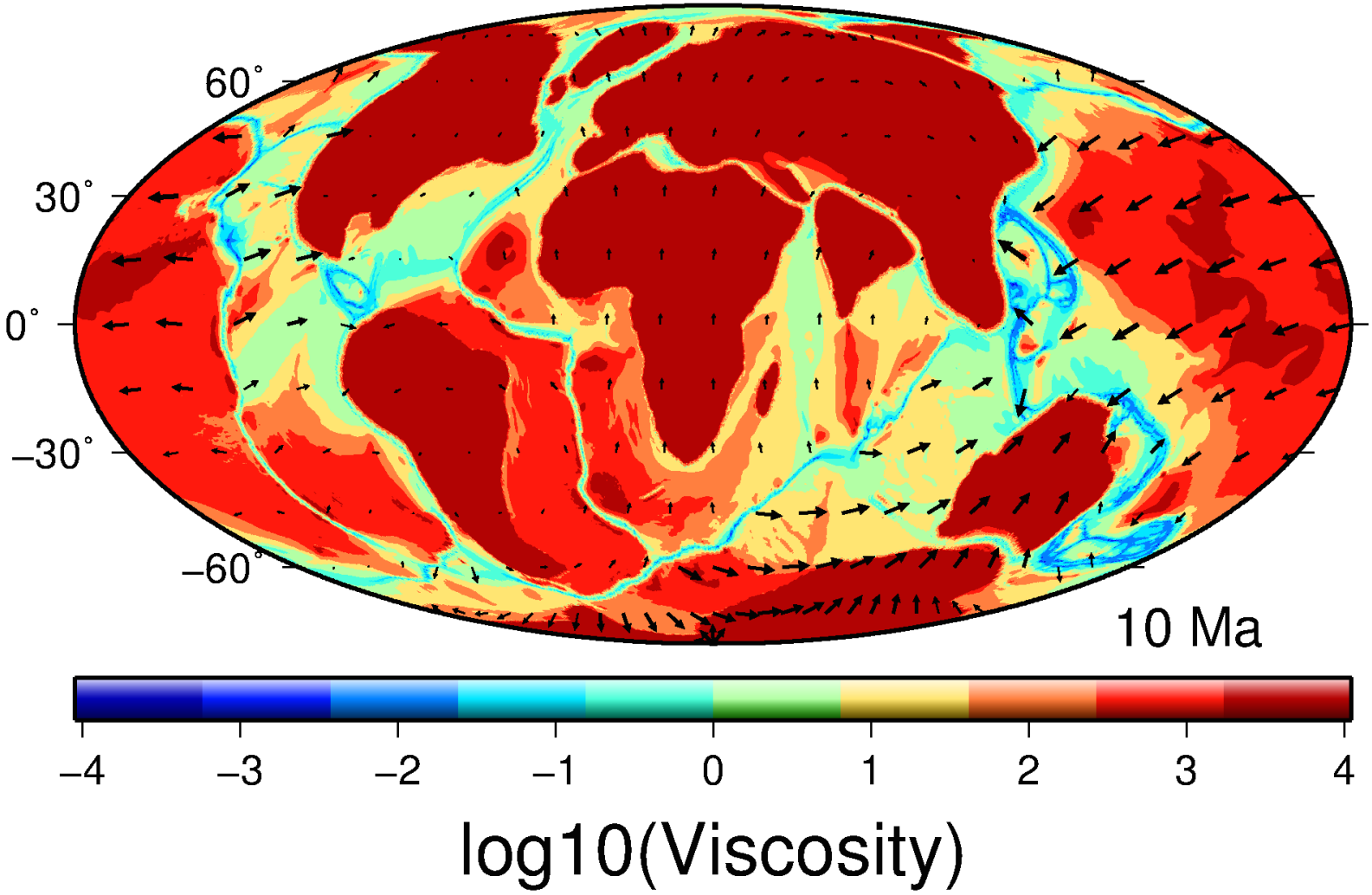
See Bello et al., EPSL 2015

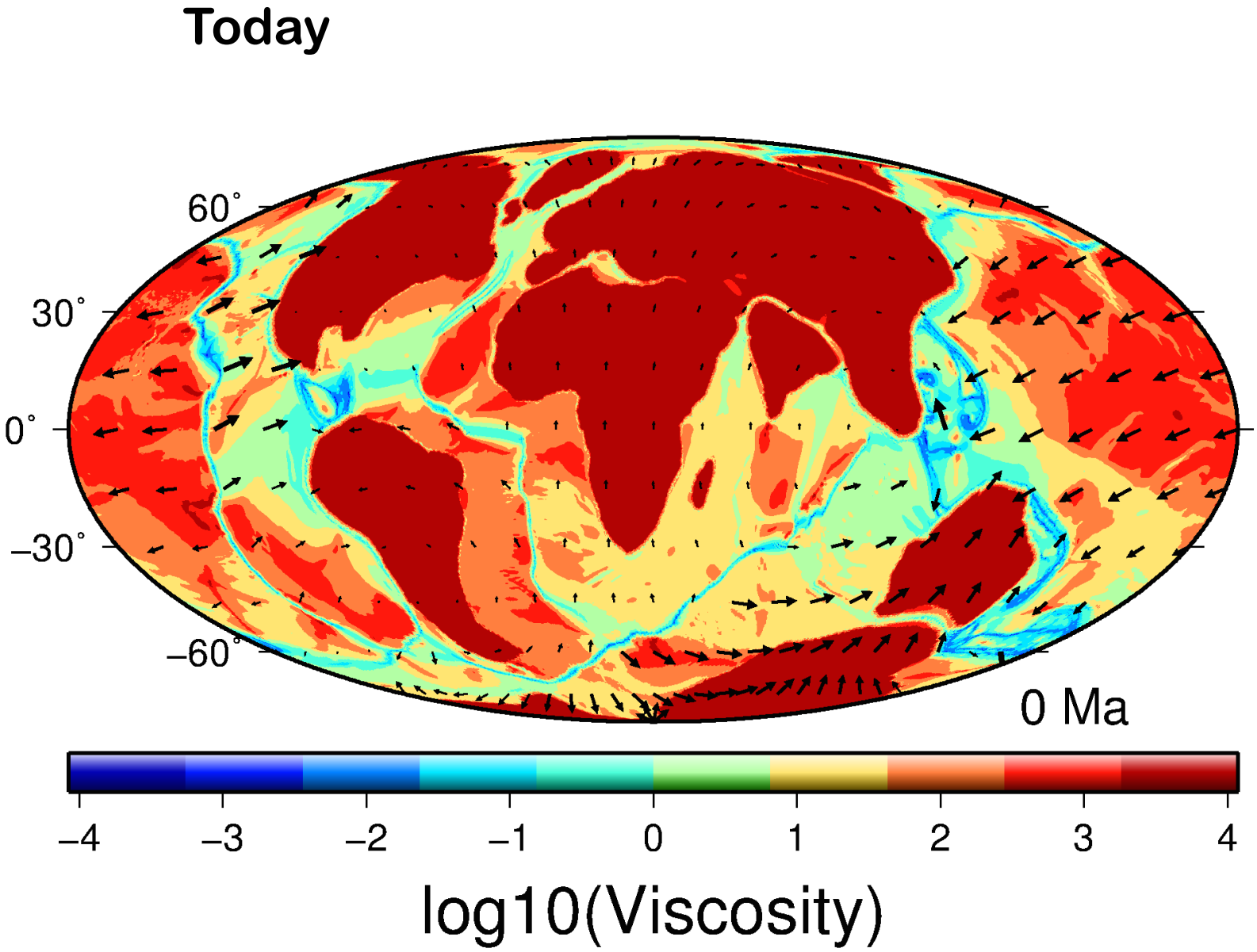


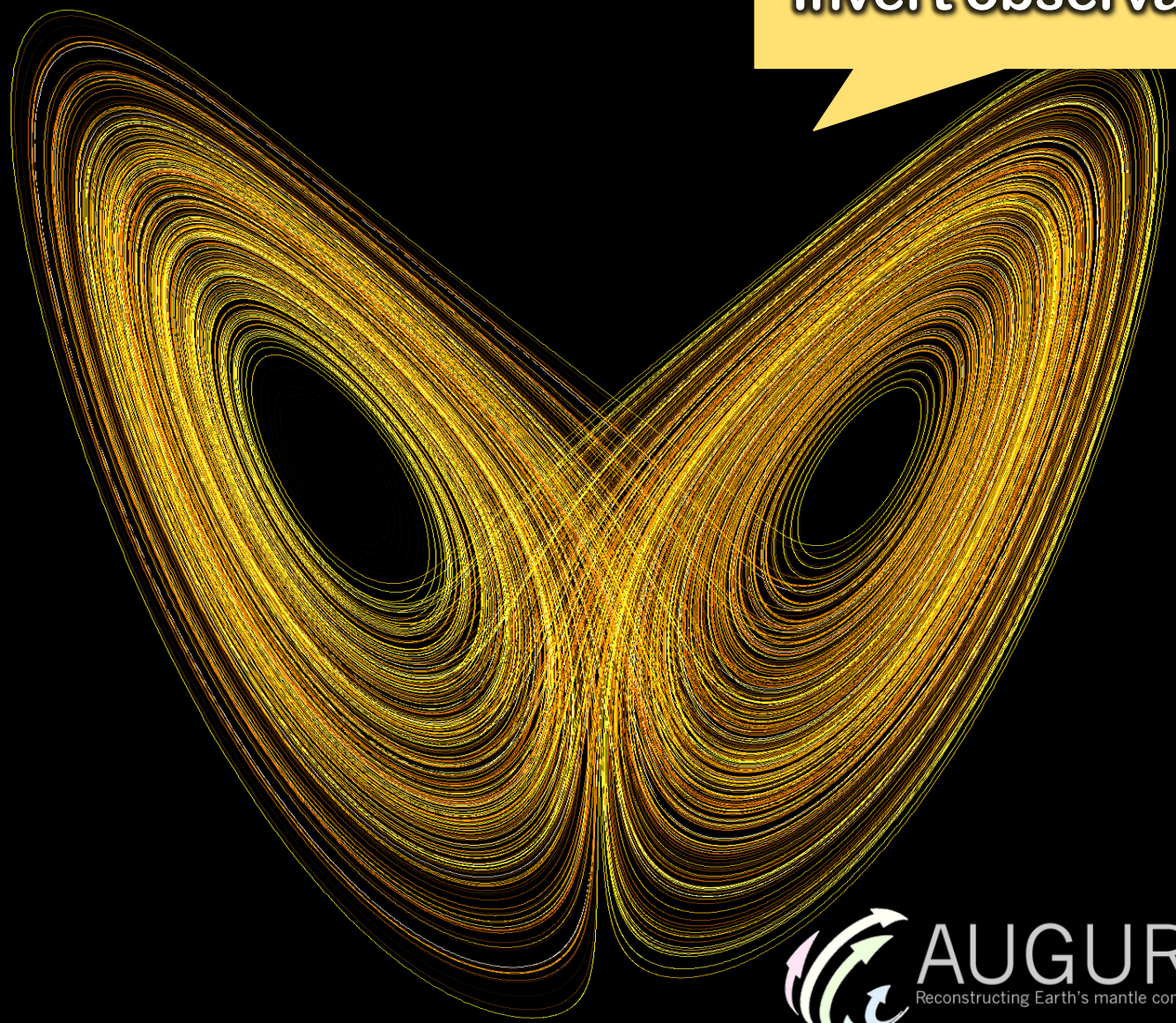

Free flight until 0Ma
2155


60˚
30˚
0˚
–30˚
–60˚
50 Ma
–4
–3
–2
–1
0
1
2
3
4
log10(Viscosity)


60˚
30˚
0˚
–30˚
–60˚
30 Ma
–4
–3
–2
–1
0
1
2
3
4
log10(Viscosity)


60˚
30˚
0˚
–30˚
–60˚
10 Ma
–4
–3
–2
–1
0
1
2
3
4
log10(Viscosity)


Today
60˚
30˚
0˚
–30˚
–60˚
0 Ma
–4
–3
–2
–1
0
1
2
3
4
log10(Viscosity)


Invert observations
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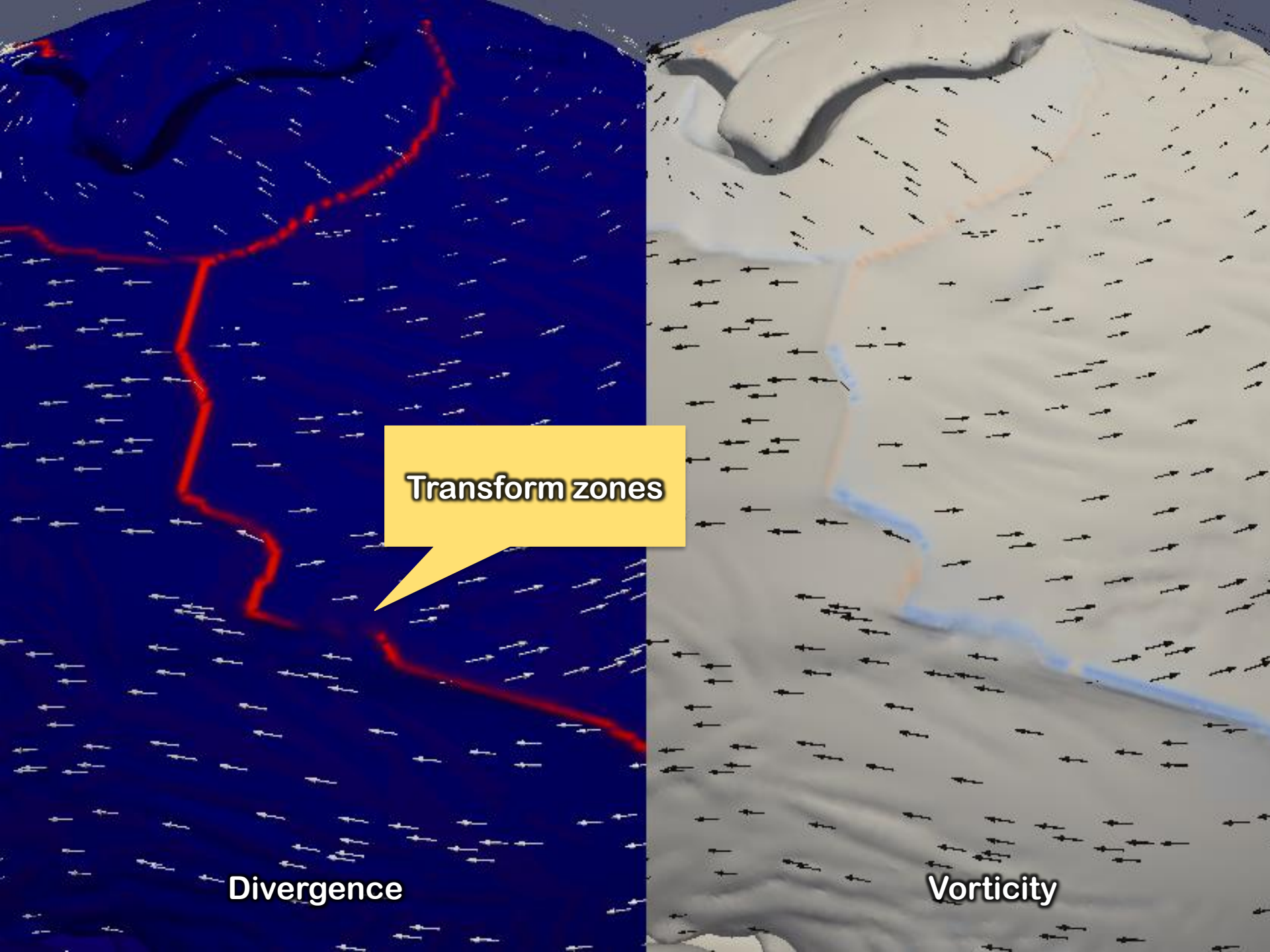
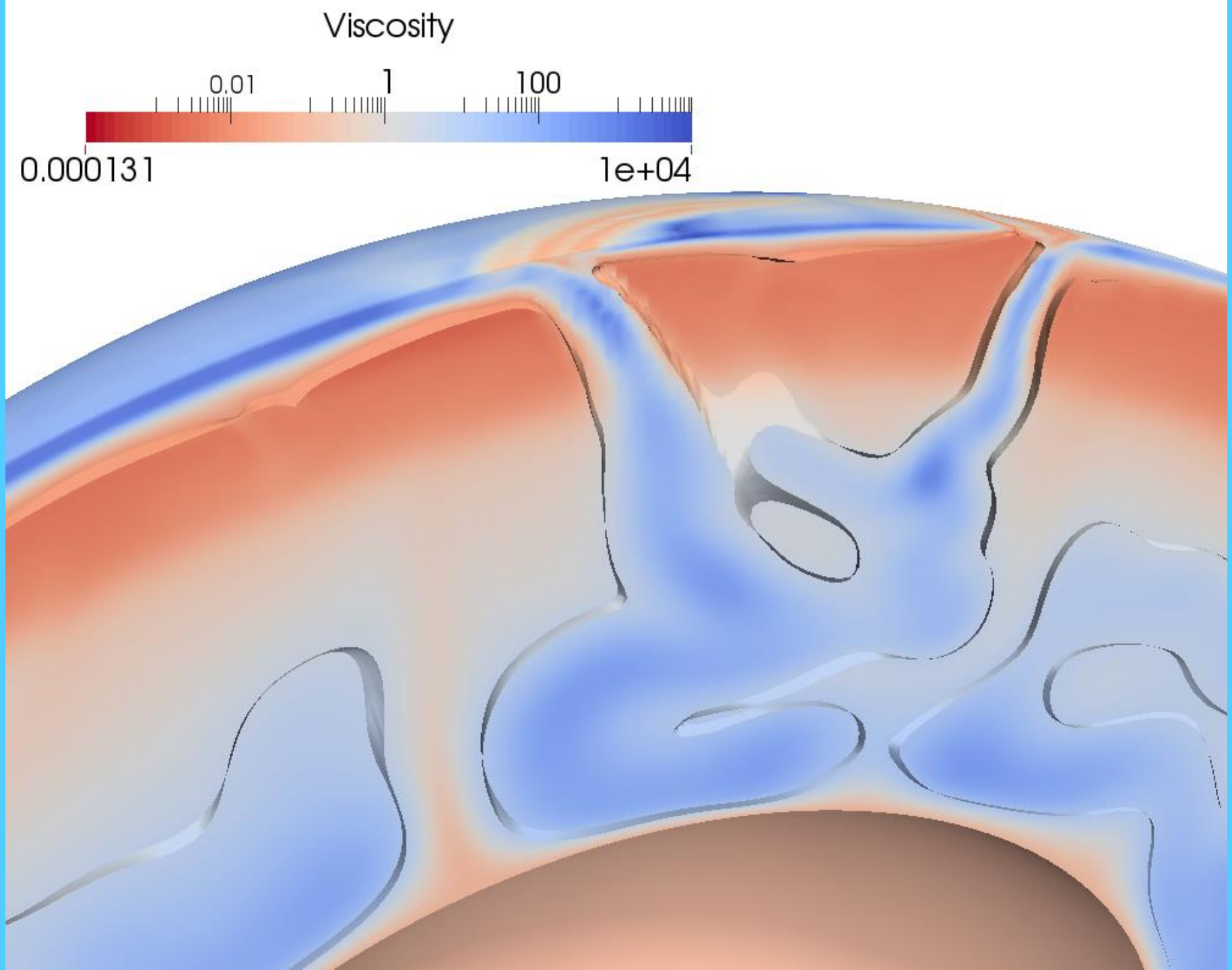
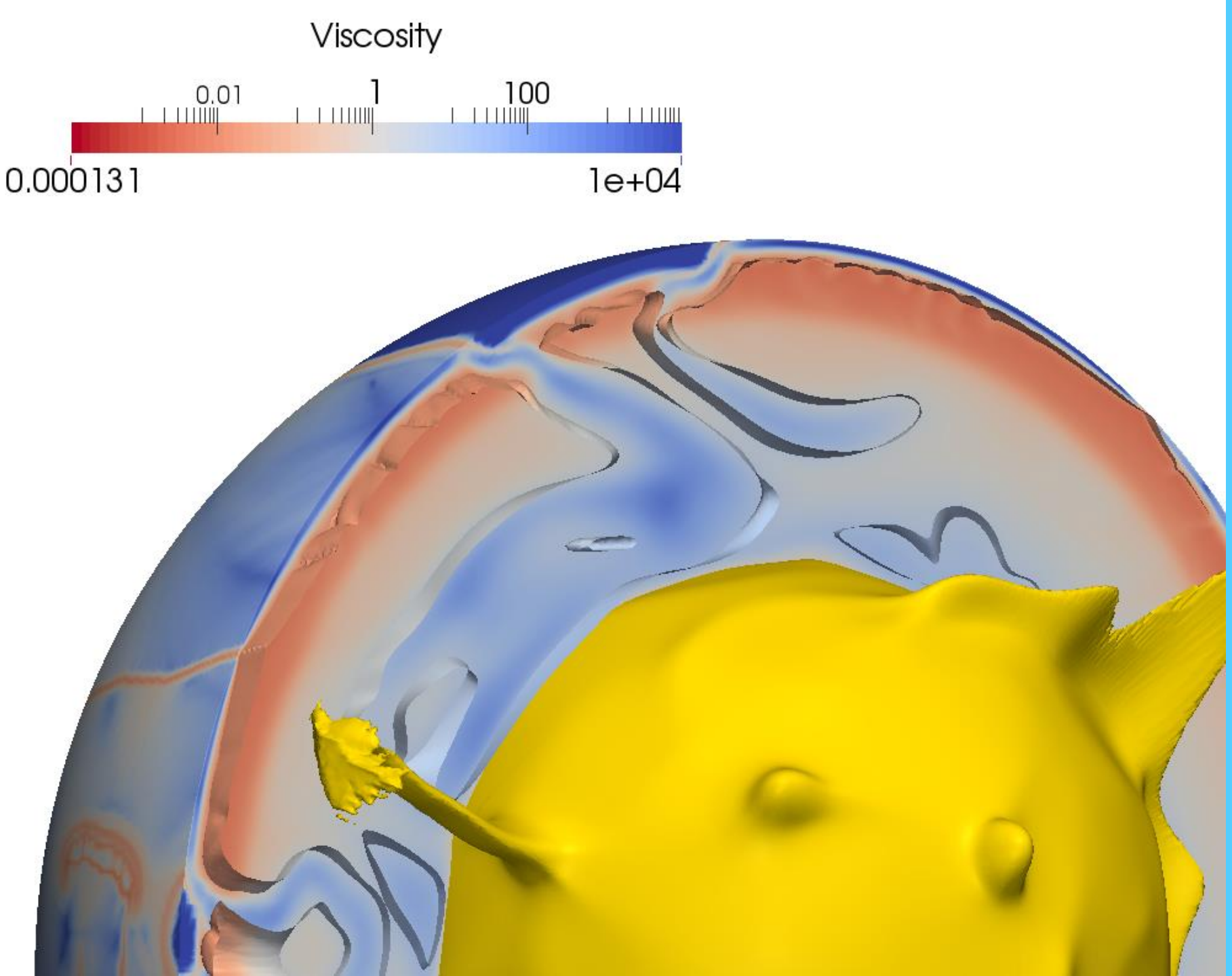
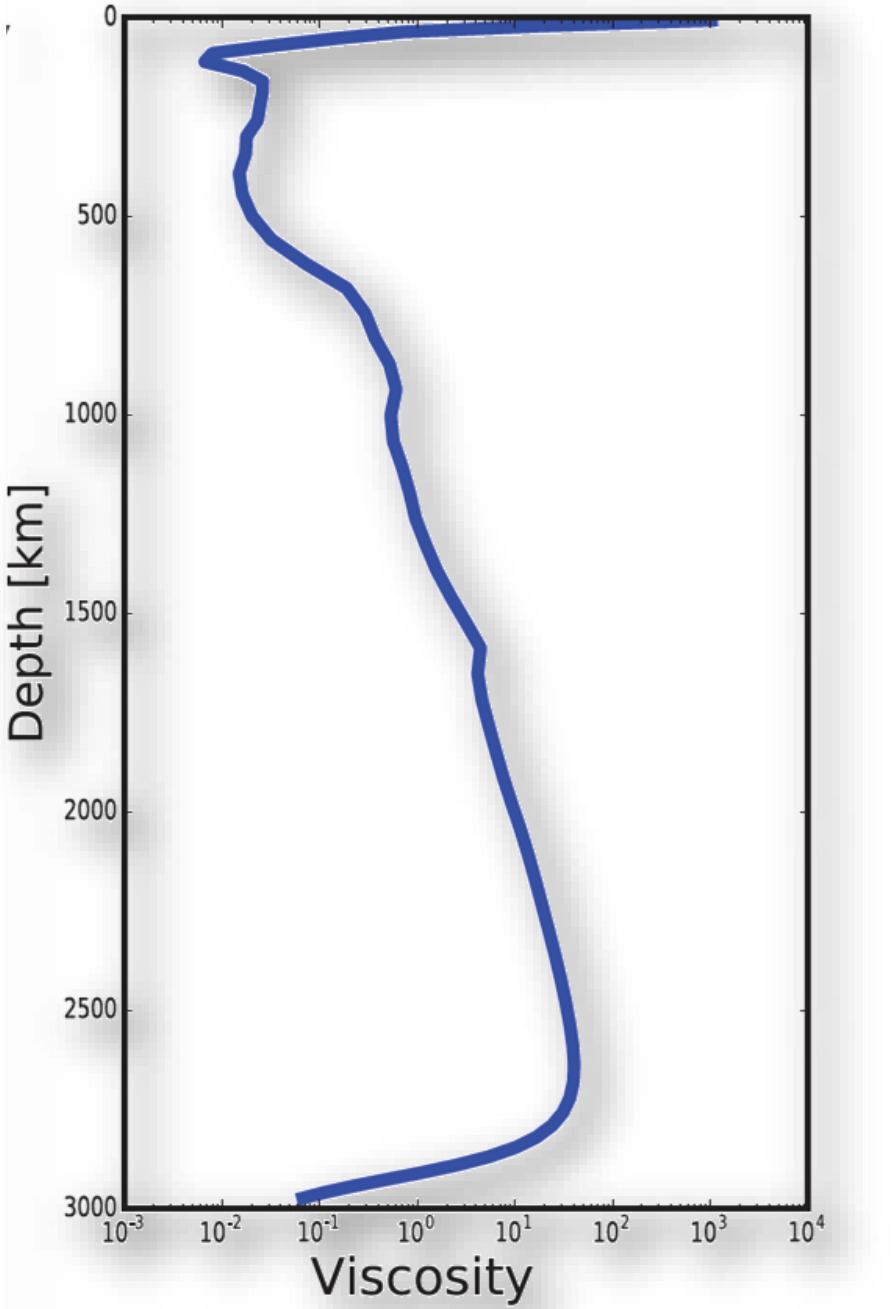
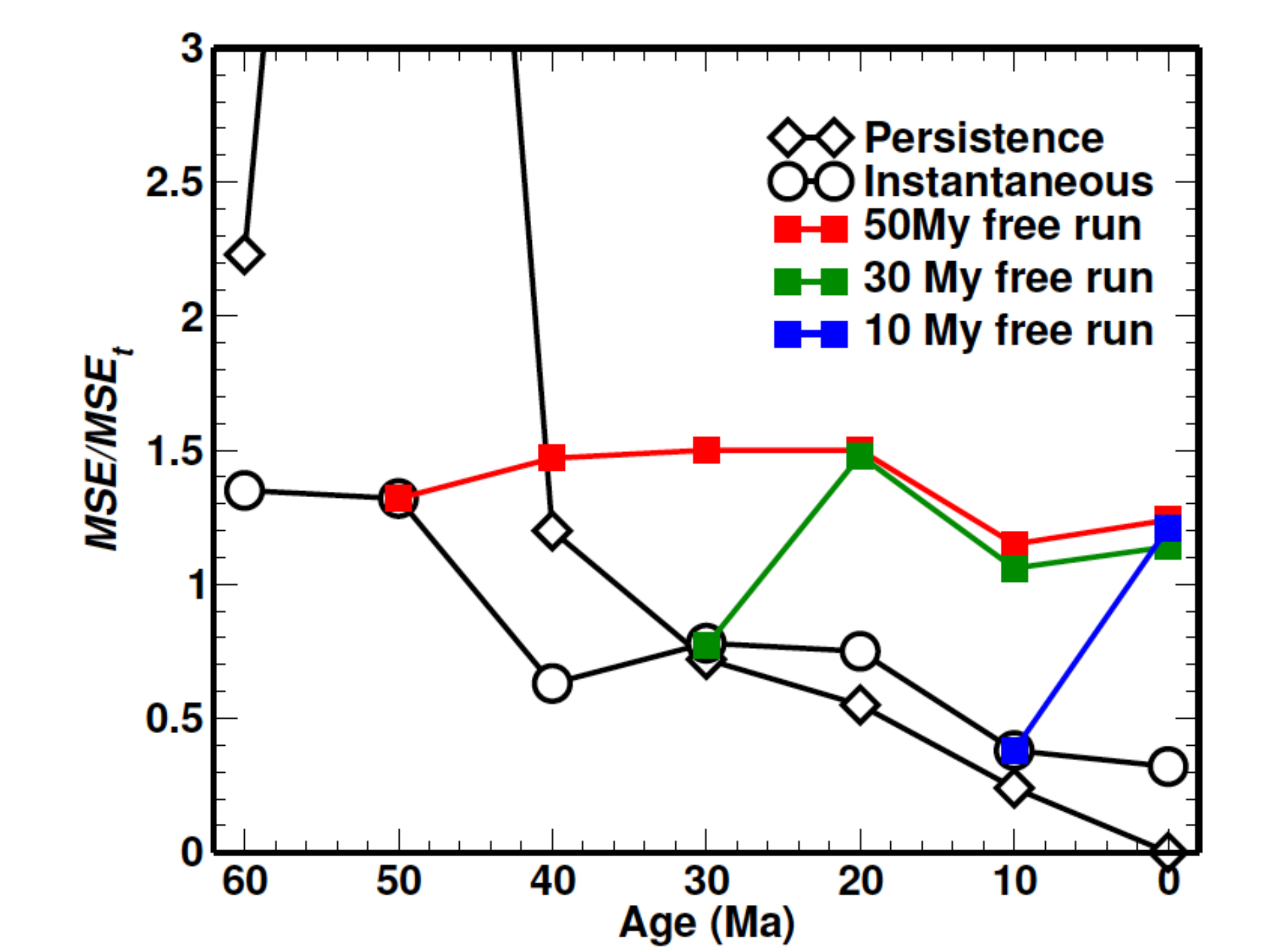

Transform zones
Divergence
Vorticity


Viscosity
0.01
1
100
0.000131
1e+04


Viscosity
0.01
1
100
0.000131
1e+04


0
500
1000
1500
2000
2500
3000
Depth [km]
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Viscosity


Persistence
Instantaneous
50My free run
30 My free run
10 My free run
MSE/MSE$_t$
Age (Ma)
0
0.5
1
1.5
2
2.5
3
60
50
40
30
20
10
0