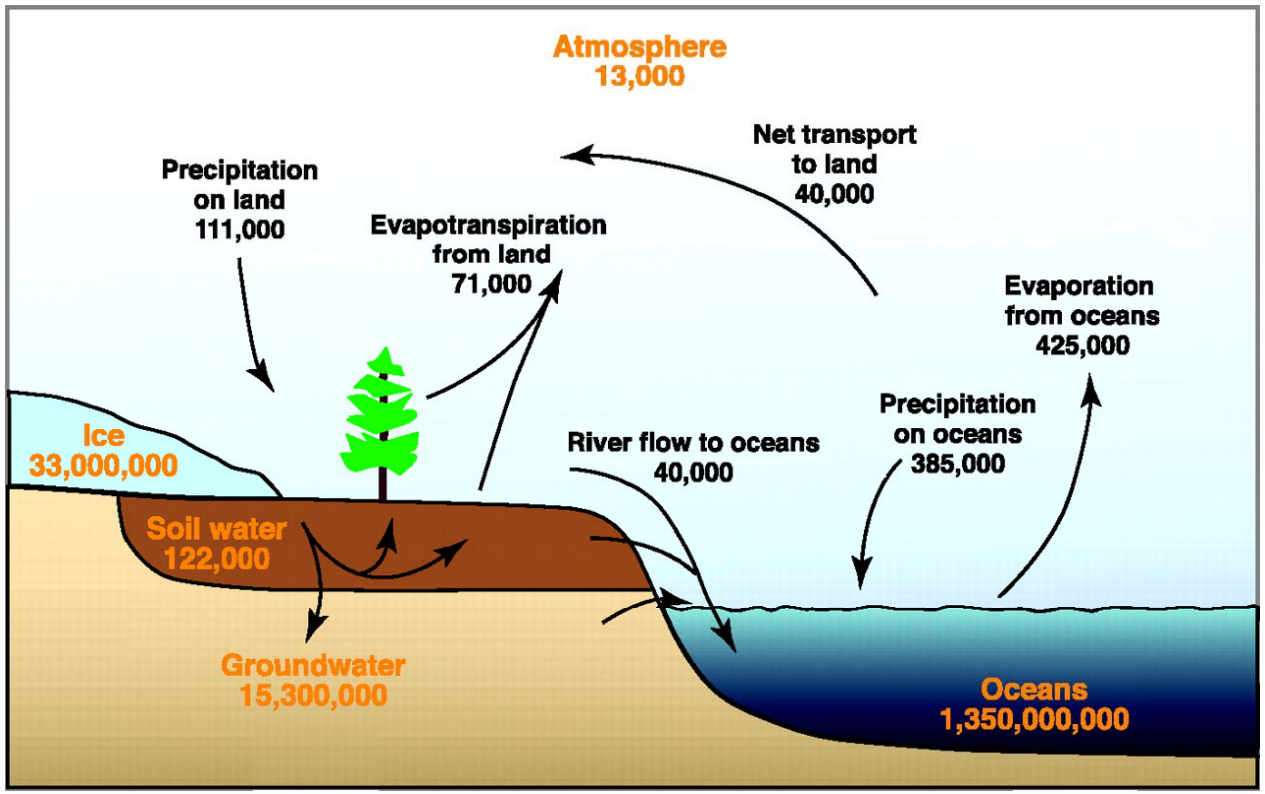
Between a rocky planet and a watery place

The problem of observing the solid Earth and hydrosphere together

Peter Clarke

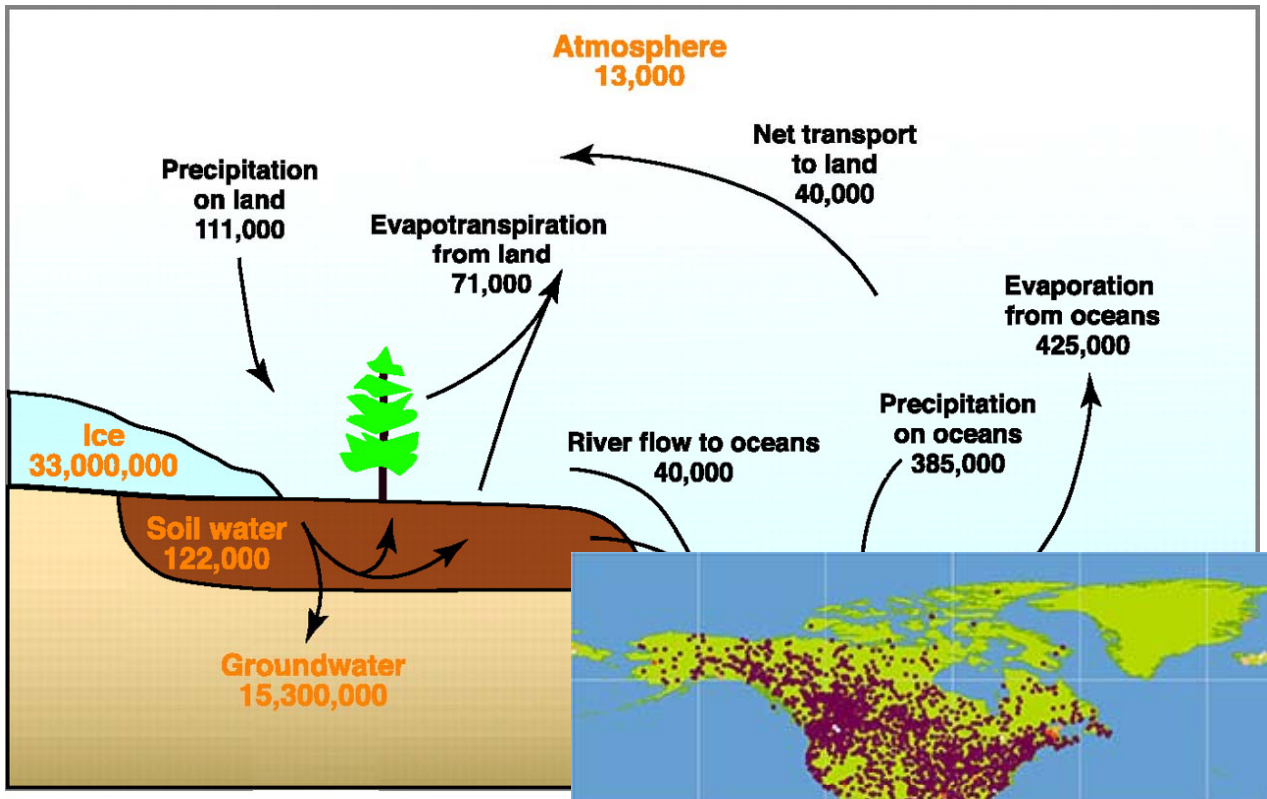
Newcastle University

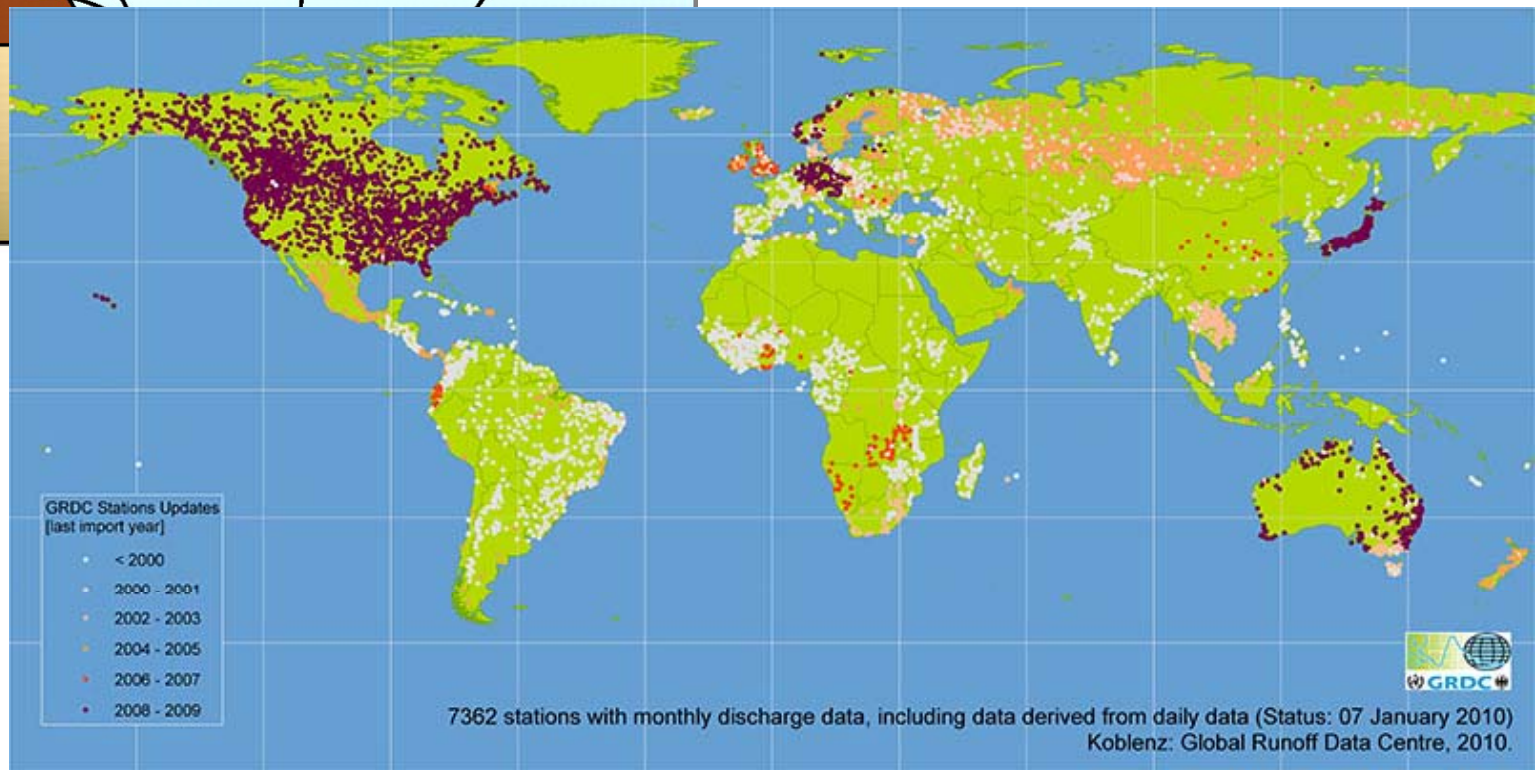
Challenges of measuring the water cycle



Alley *et al.* (2002), *Science*

Challenges of measuring the water cycle





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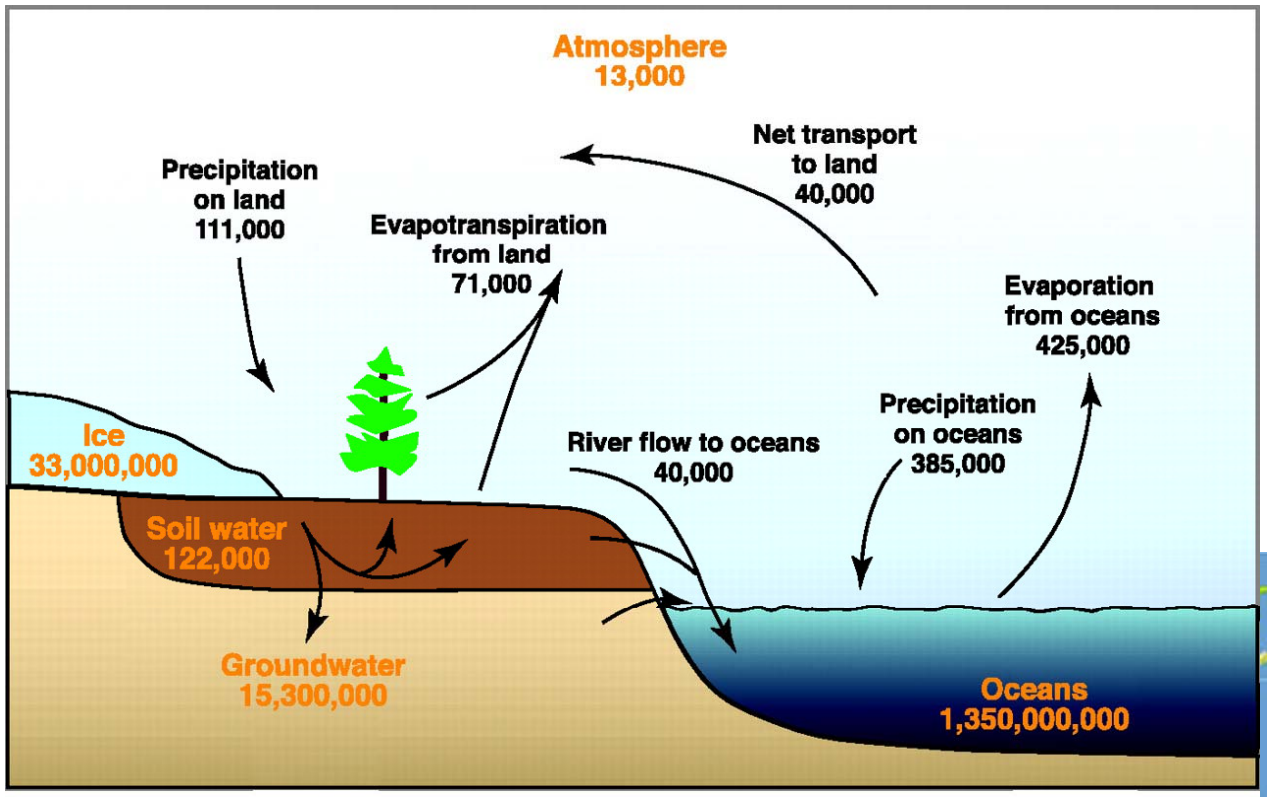
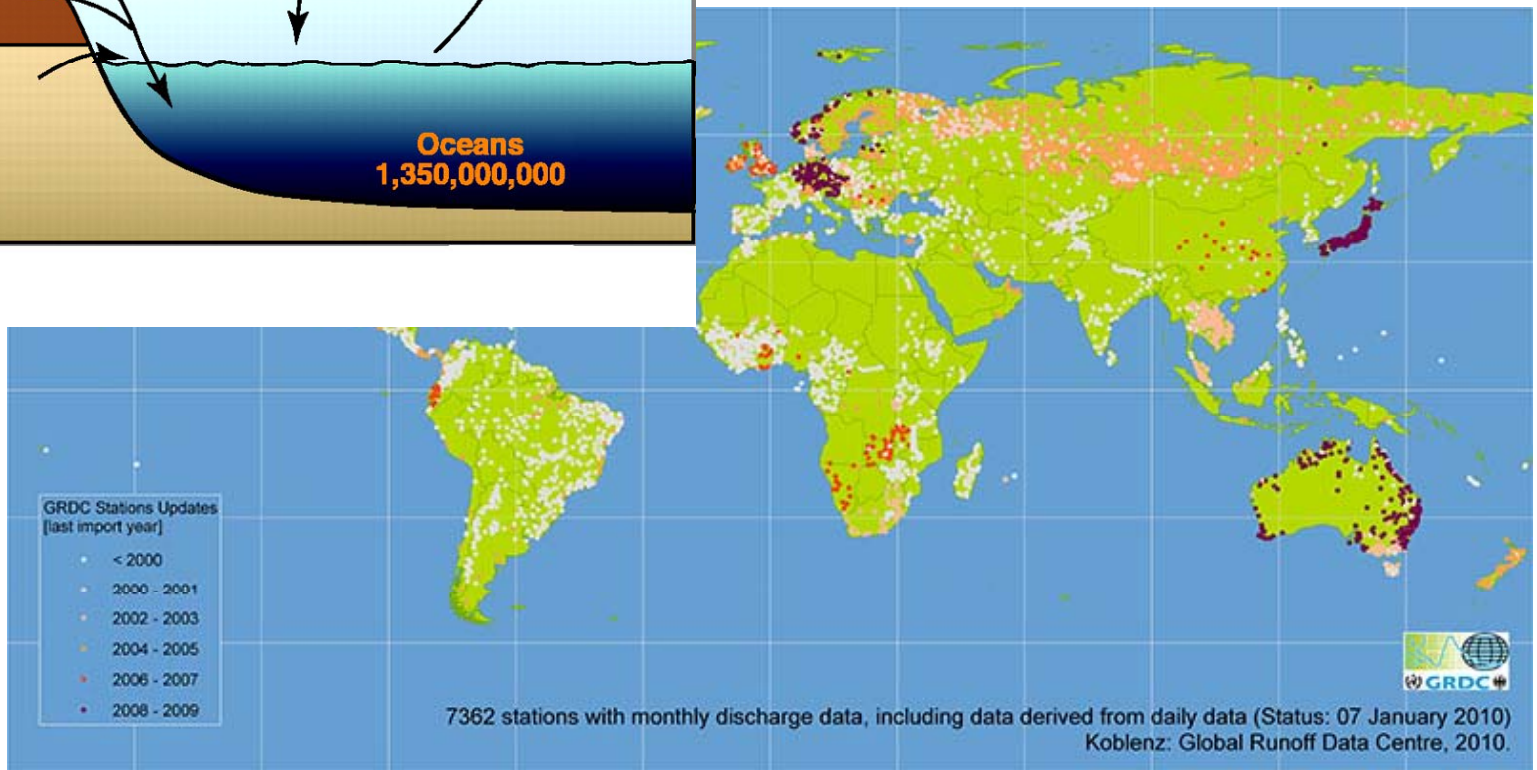
Challenges of measuring the water cycle



Pools are in cubic kilometers

Fluxes are in cubic kilometers per year



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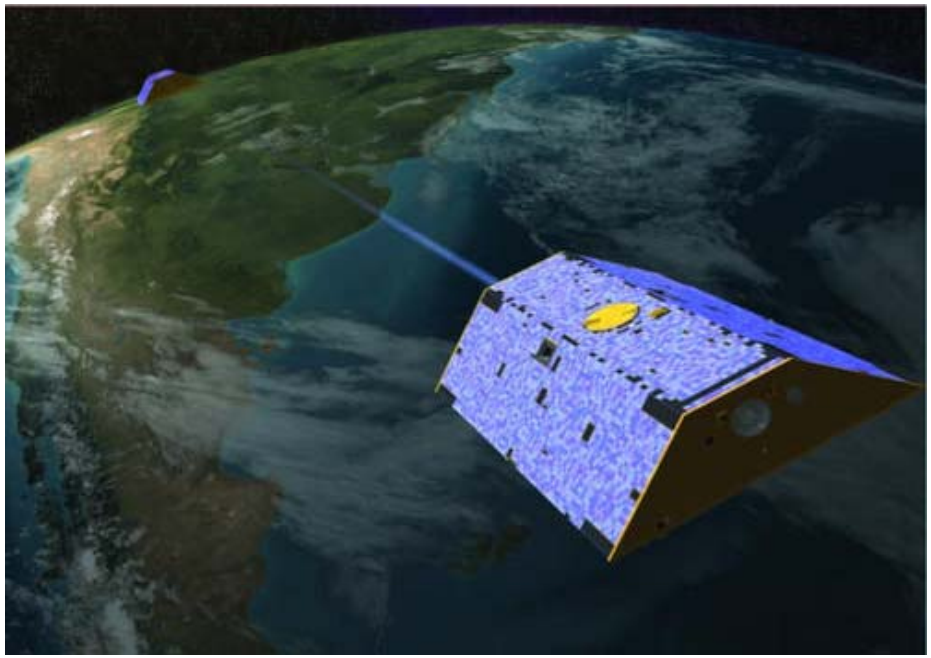
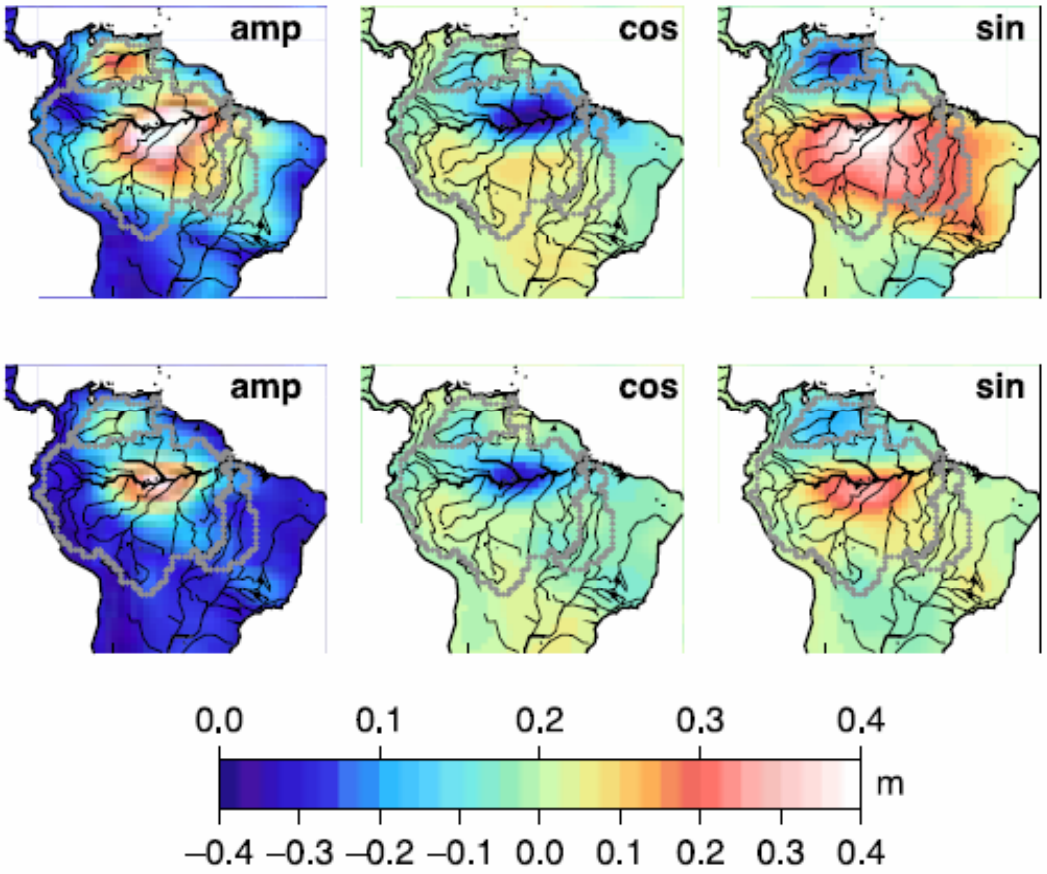
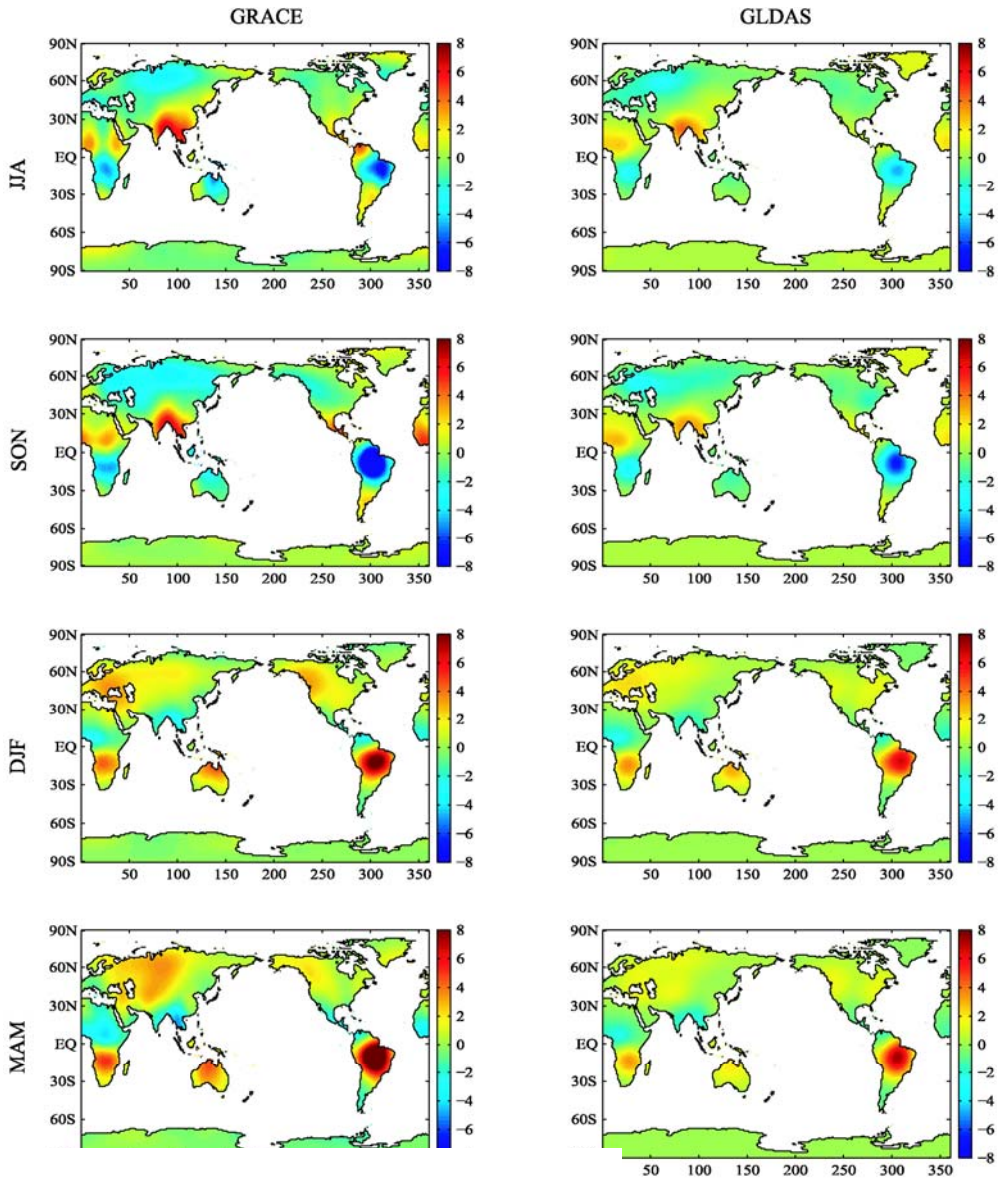
Fluid influences on the solid Earth
(1) Gravity



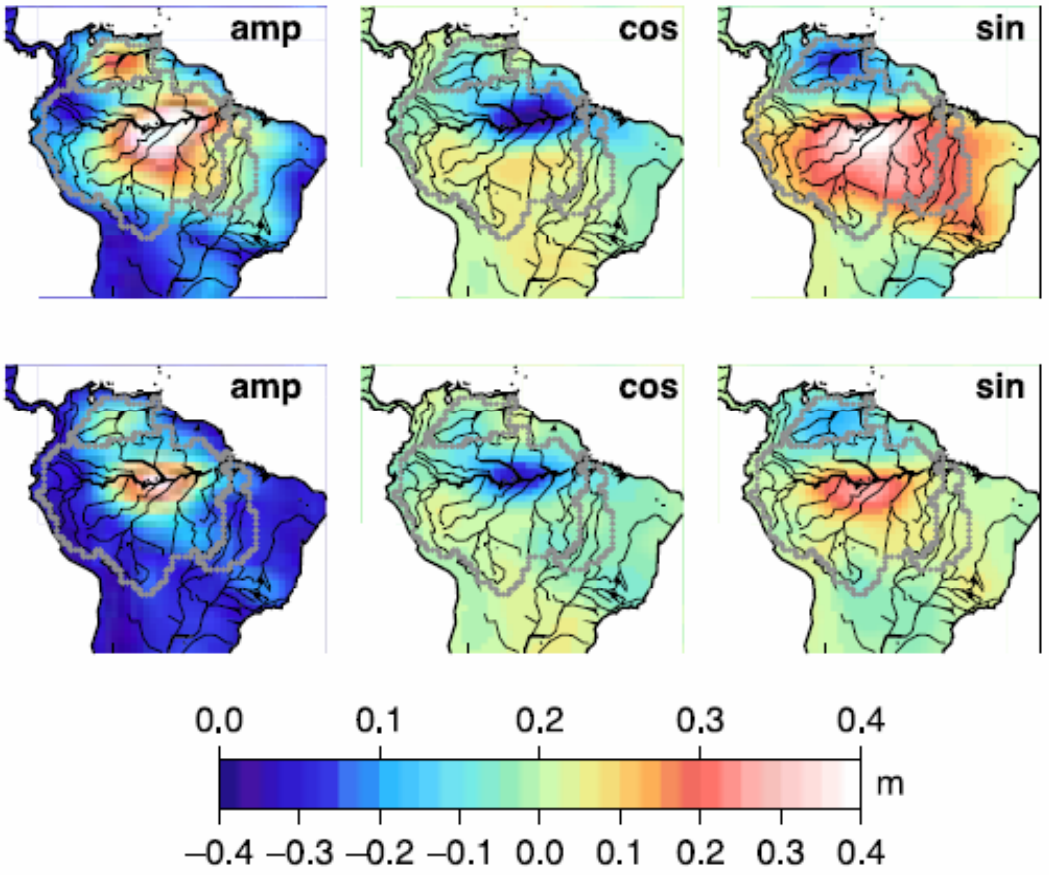


Han *et al.* (2010), *G*^{3}

Fluid influences on the solid Earth
(1) Gravity

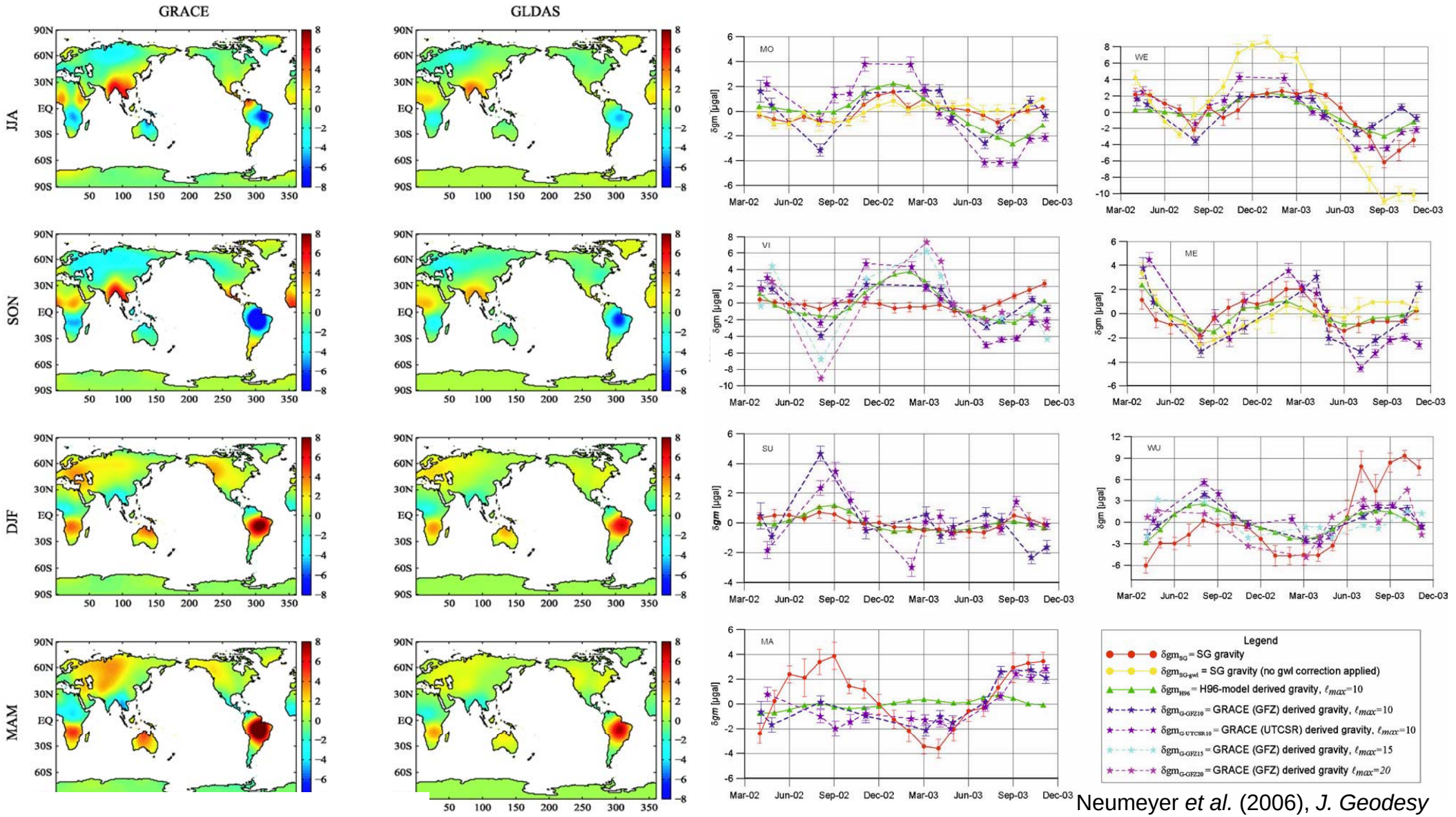


Syed *et al.* (2008), *WRR*



Han *et al.* (2010), *G*^{3}

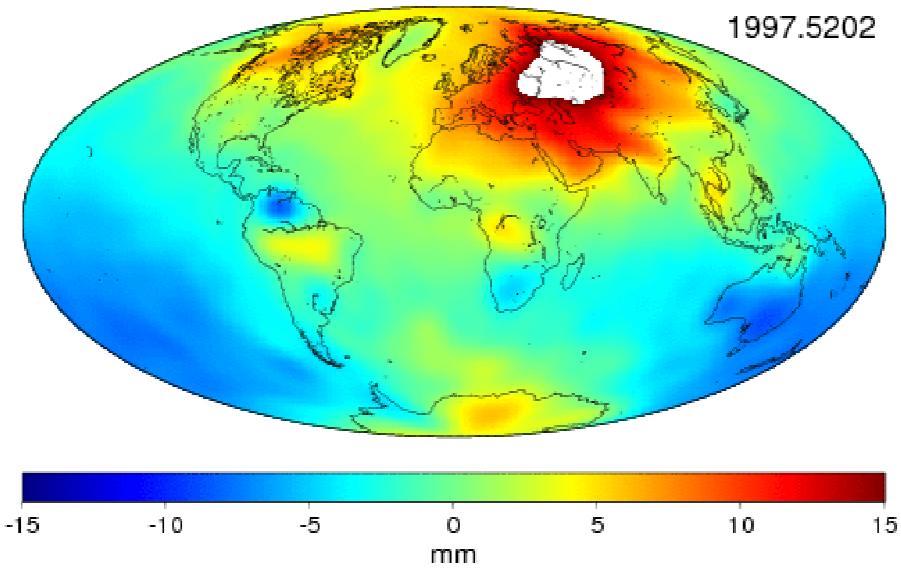
Fluid influences on the solid Earth
(1) Gravity



Syed *et al.* (2008), *WRR*

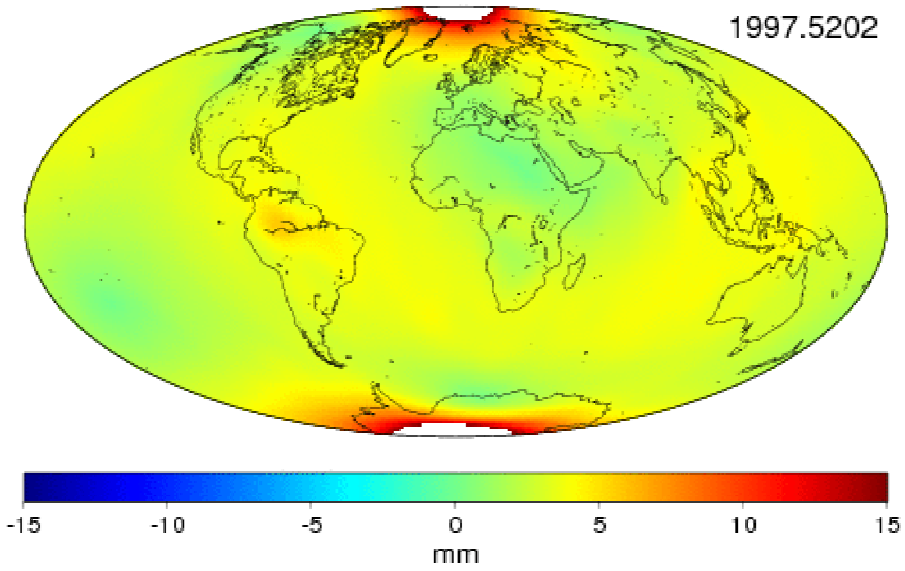
Neumeyer *et al.* (2006), *J. Geodesy*

Fluid influences on the solid Earth
(2) Deformation



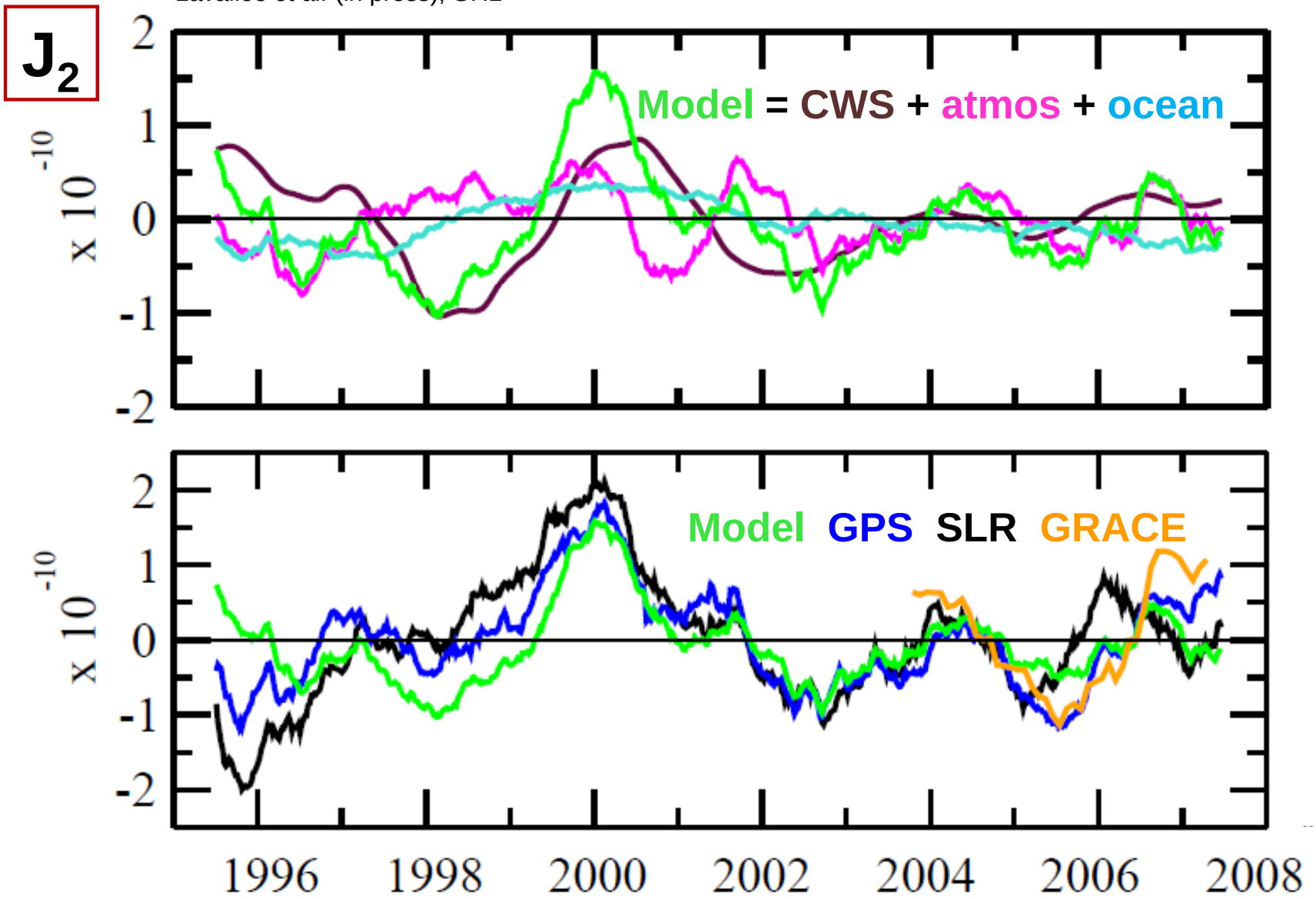
Vertical

Lateral



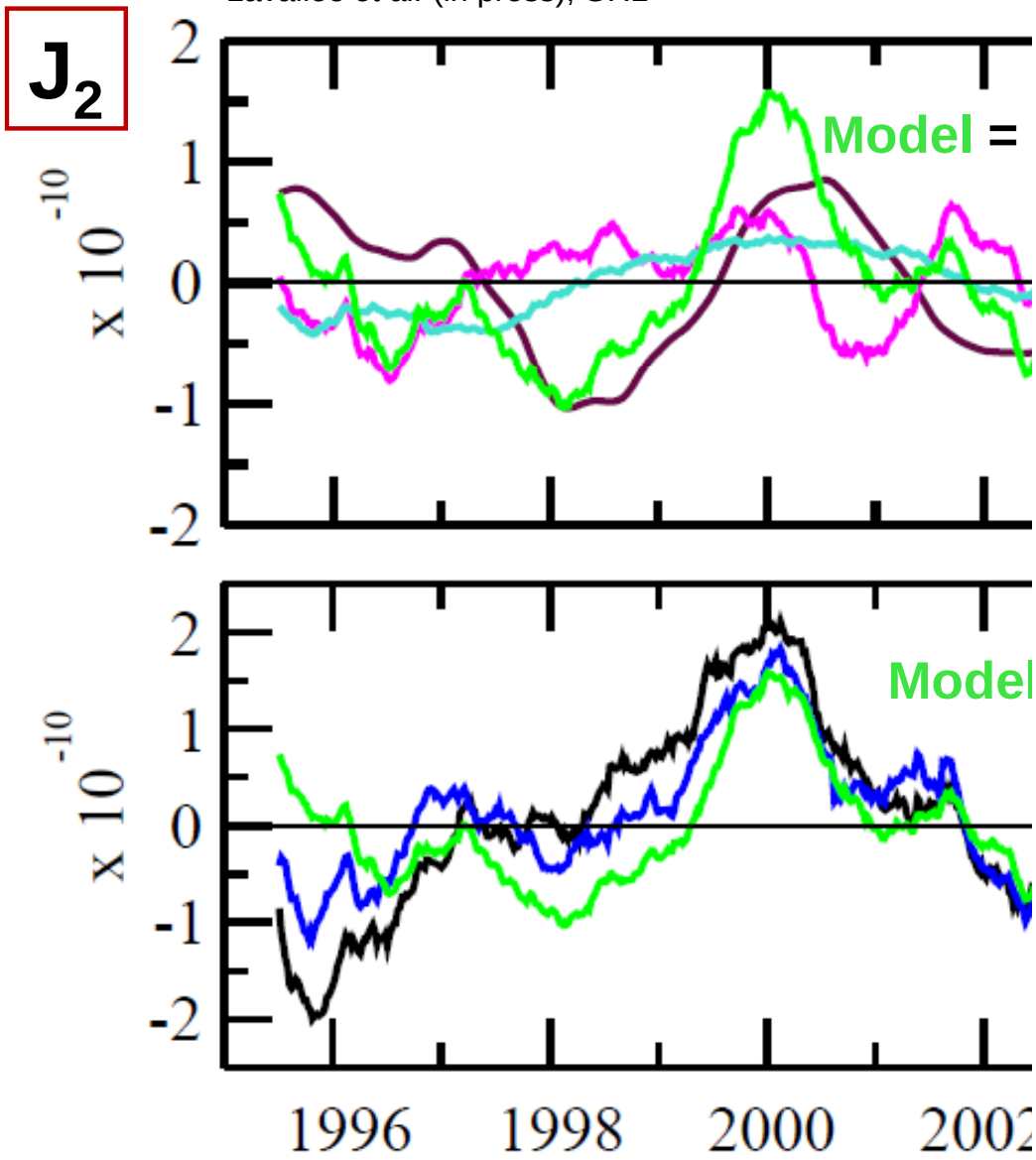
Fluid influences on the solid Earth
(2) Deformation

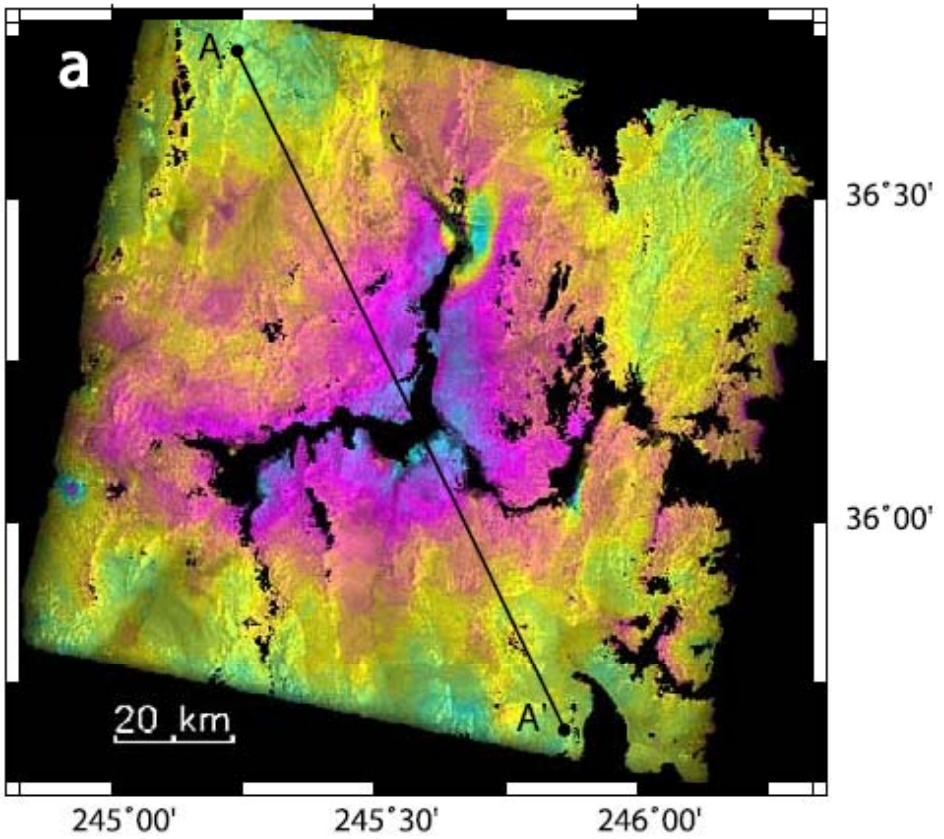
Lavallée *et al.* (in press), *GRL*



Fluid influences on the solid Earth
(2) Deformation

Lavallée *et al.* (in press), *GRL*





Cavalie *et al.* (2007), *JGR*

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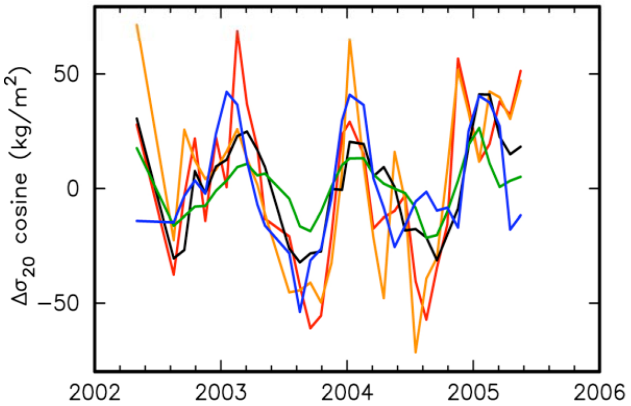
Fluid influences on the solid Earth
(3) Rotation

- Length of day

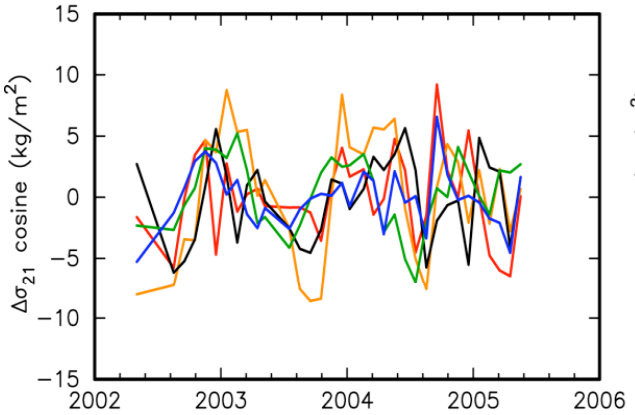
$$LOD \propto \Delta\sigma_{20}$$

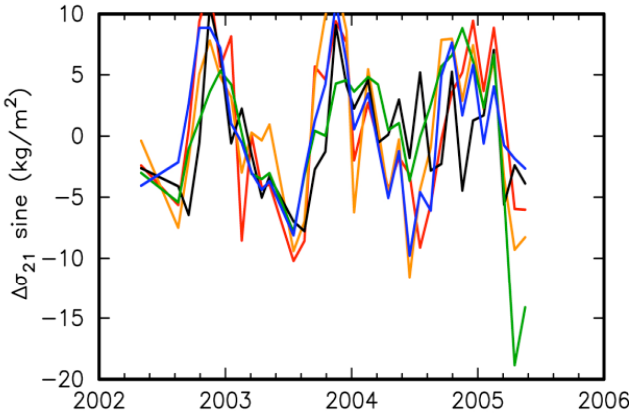


SLR measurement
GRACE (UTCSR RL04)
GRACE (UTCSR RL01)
GPS measurement
EOP measurement

- Polar motion

$$(x_p, y_p) \propto (\Delta\sigma_{21}^S, \Delta\sigma_{21}^C)$$





(excluding momentum terms)

Gross *et al.* (2008), *IGCP565 Workshop 1*

Confounding factors:
(1) Tectonics

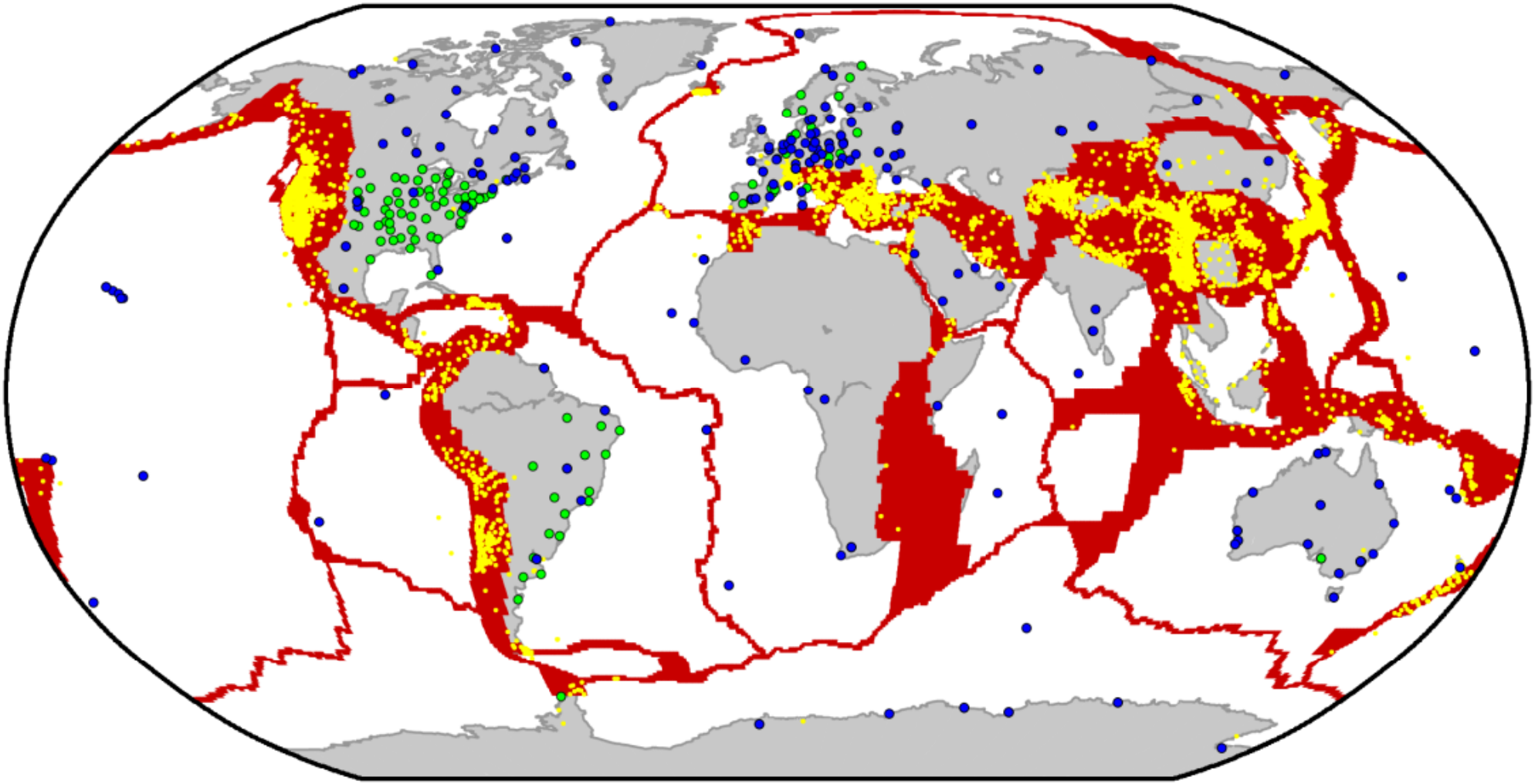
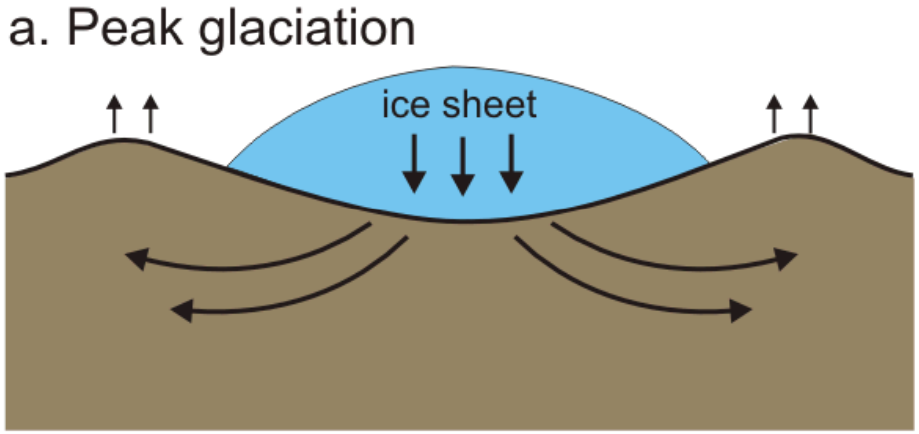


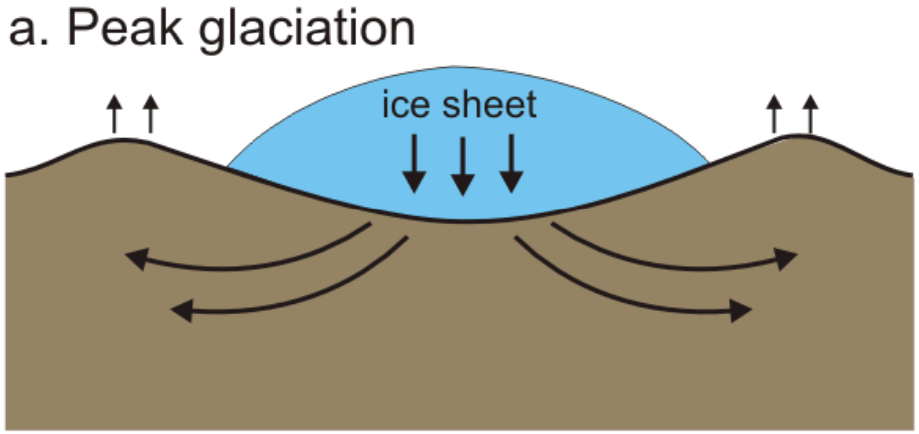
image: David Lavallée, after Kreemer *et al.* (2006), *GRL*

Confounding factors:
(2) Glacio-isostatic adjustment

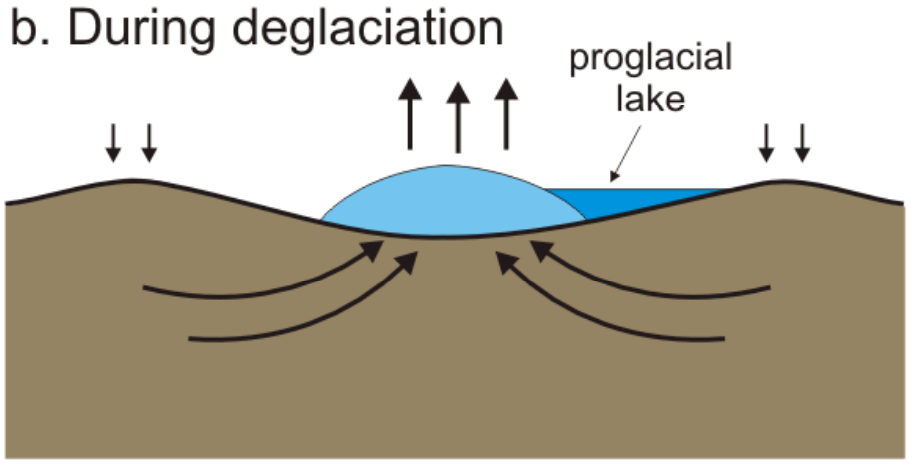


images: Matt King

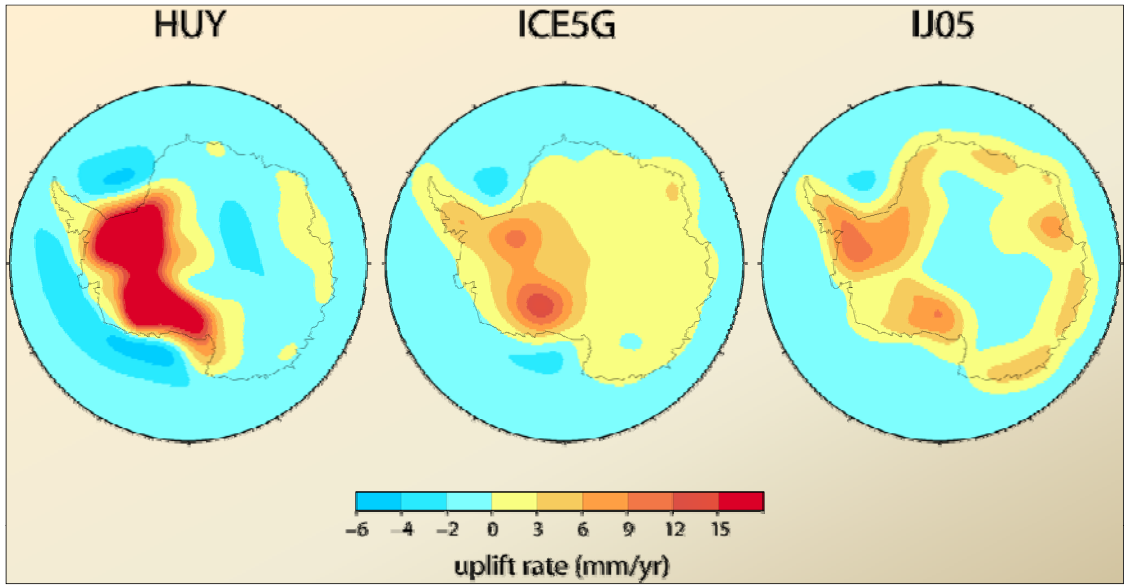
Confounding factors:
(2) Glacio-isostatic adjustment



images: Matt King

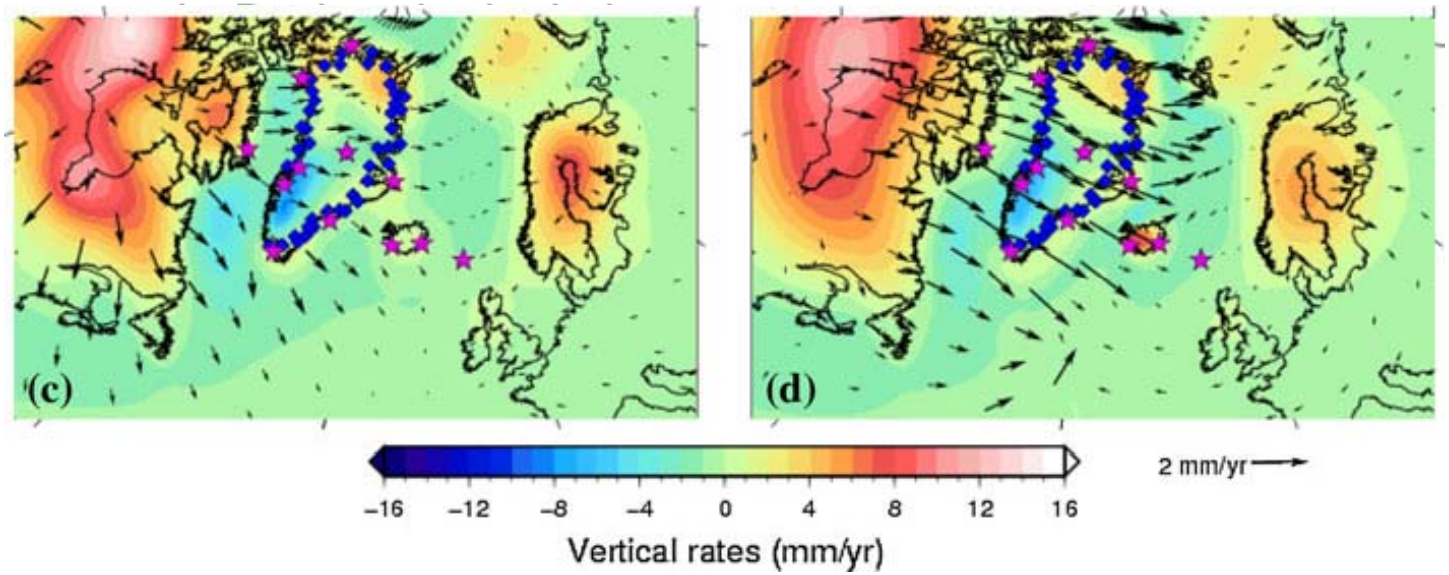


Confounding factors:
(2) Glacio-isostatic adjustment

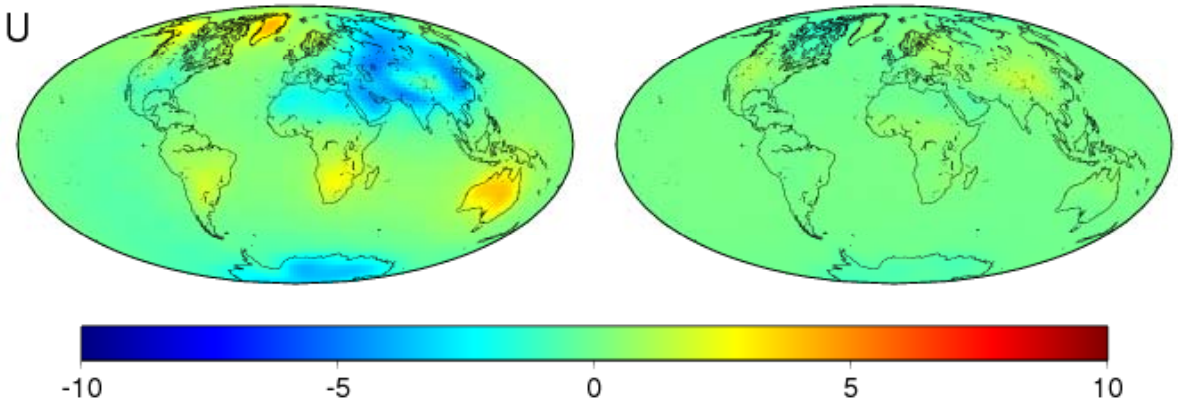


King *et al.* (2010), *Surv. Geophys.*

images: Matt King



Confounding factors:
(3) Atmosphere & Oceans



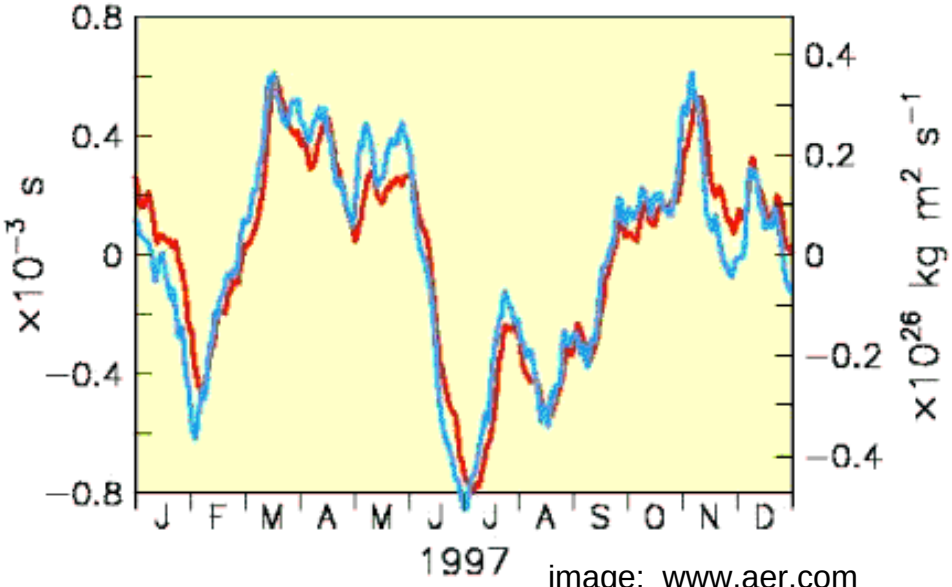
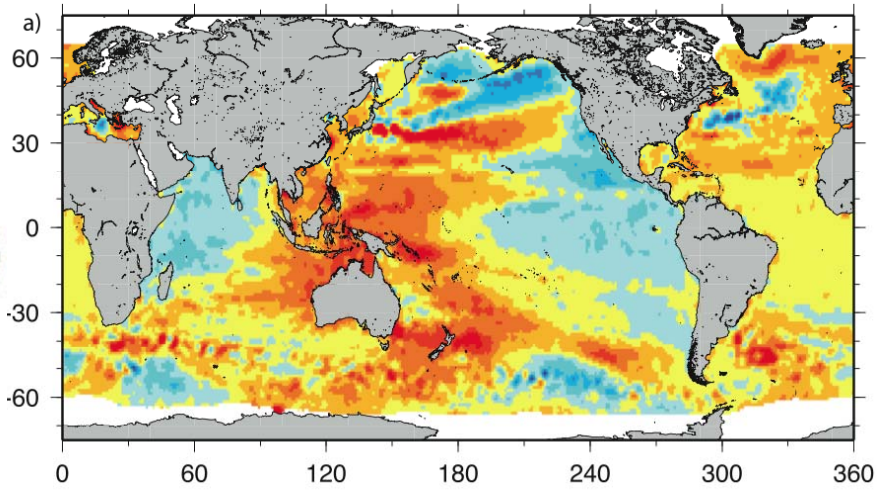
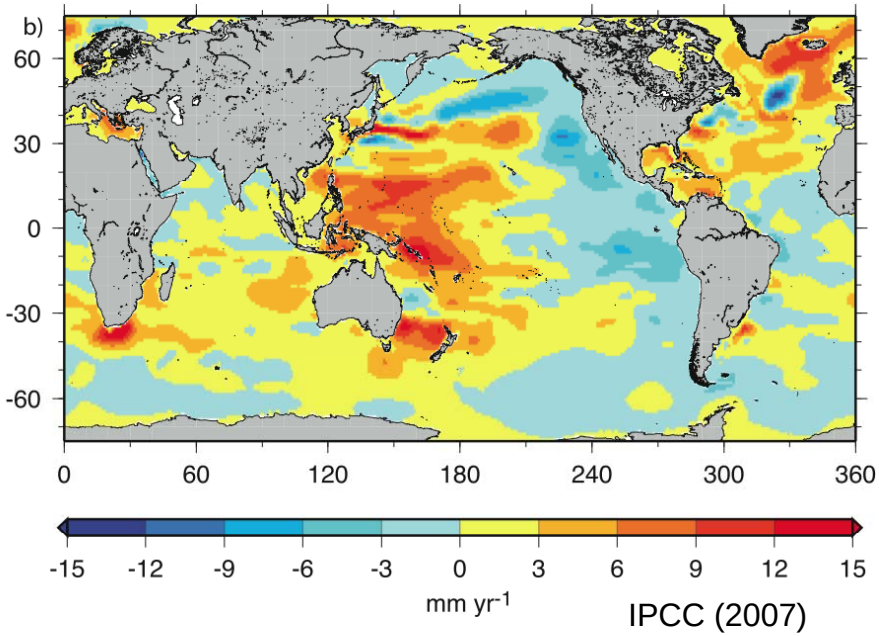


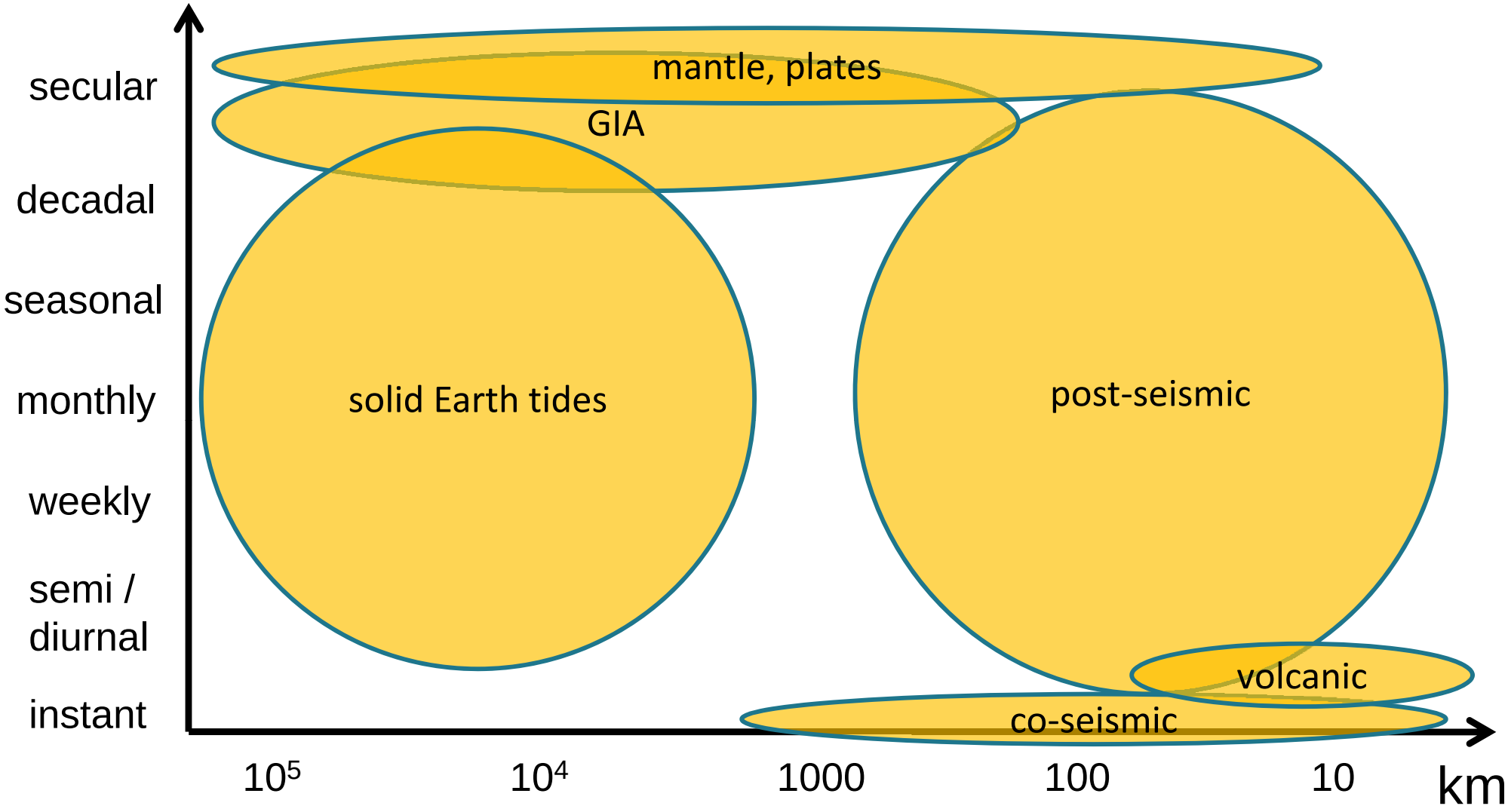
image: www.aer.com





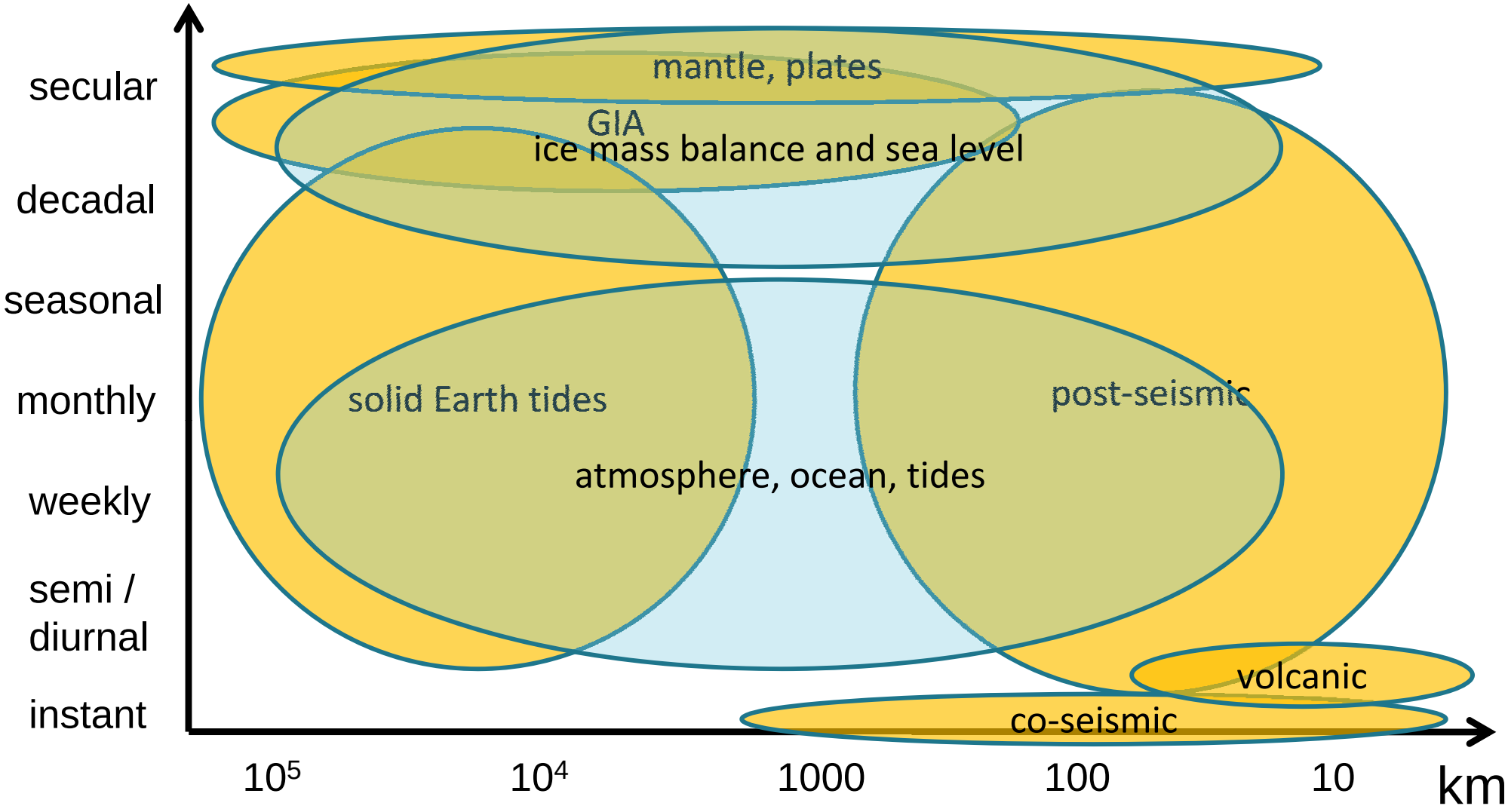
IPCC (2007)

Spatial and temporal scales of change



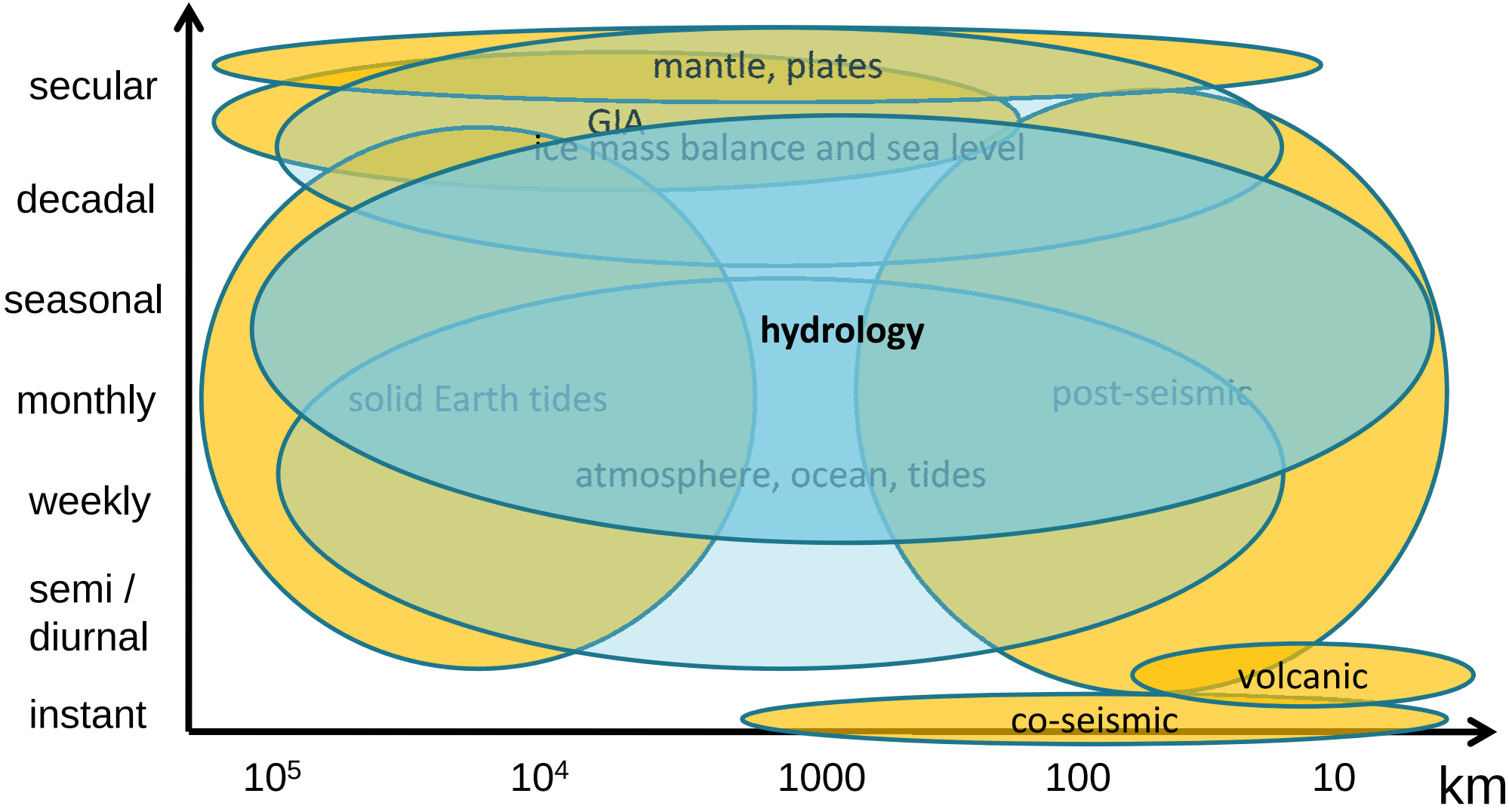
after Ilk *et al*. (2005)

Spatial and temporal scales of change



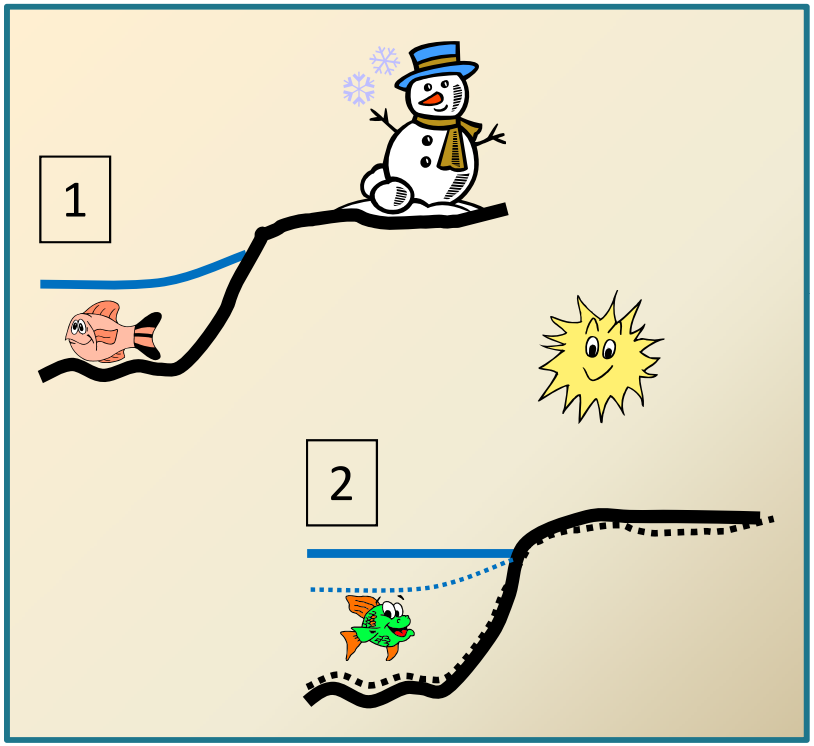
after Ilk *et al*. (2005)

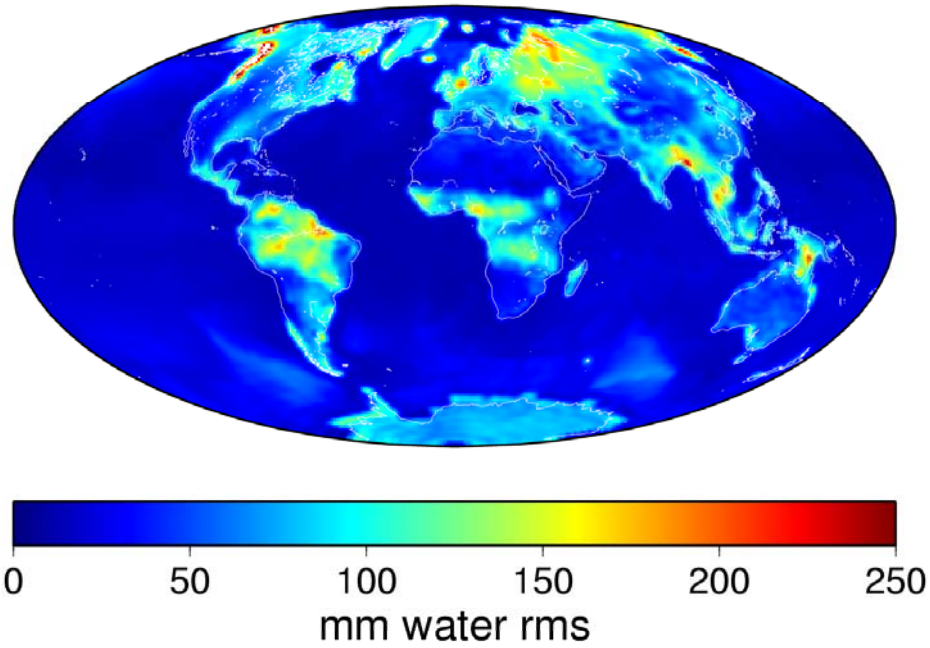
Spatial and temporal scales of change



after Ilk *et al*. (2005)

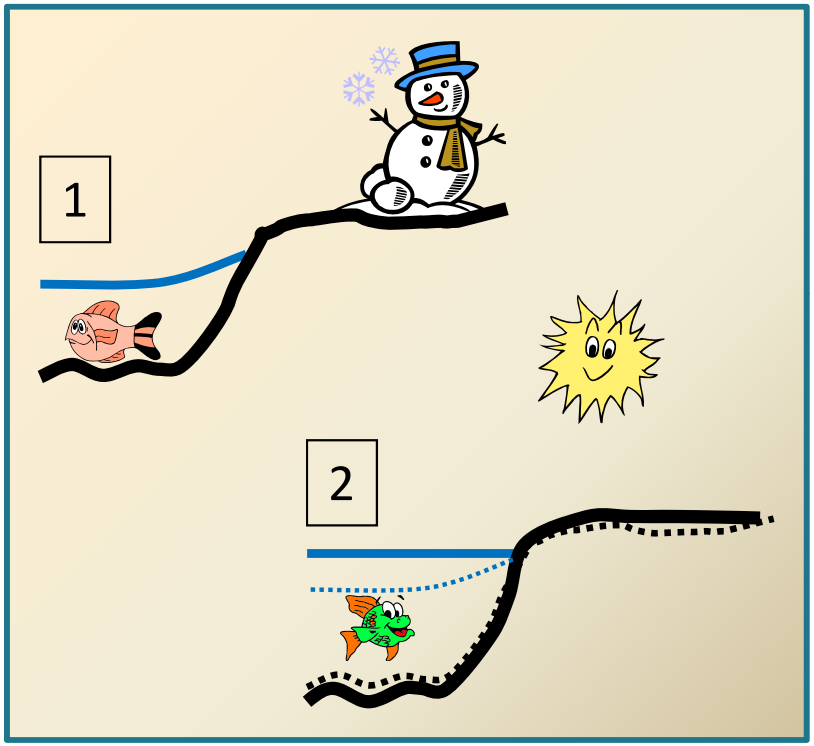
Spatial “fingerprints” and consistency

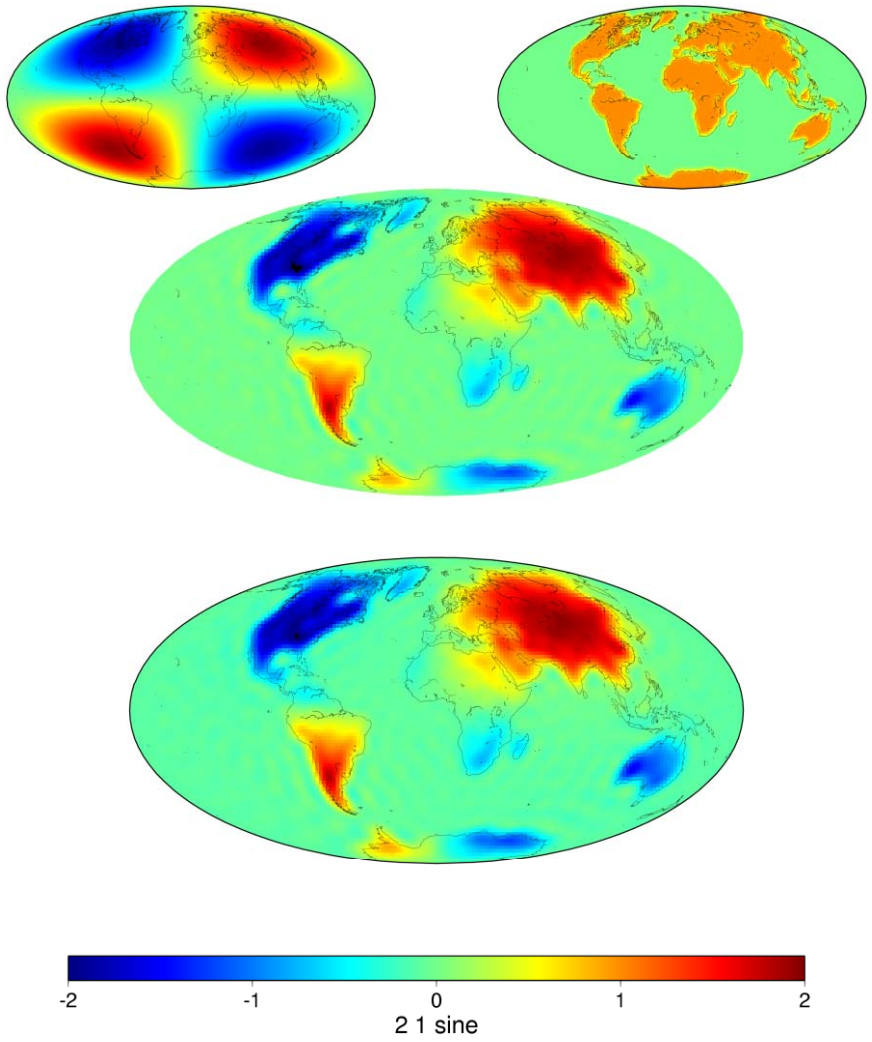




after Clarke *et al*. (2007), *GJI*

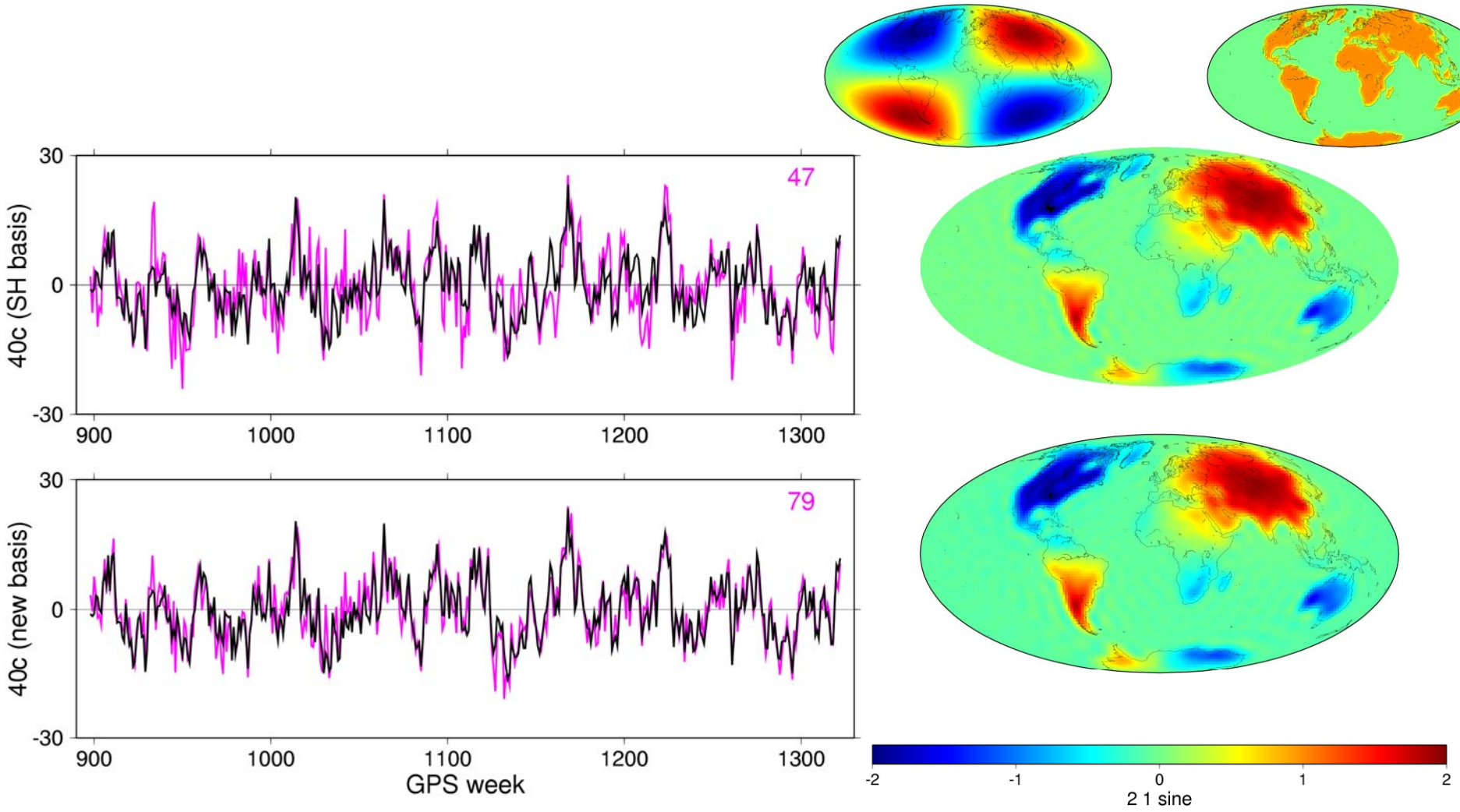
Spatial “fingerprints” and consistency





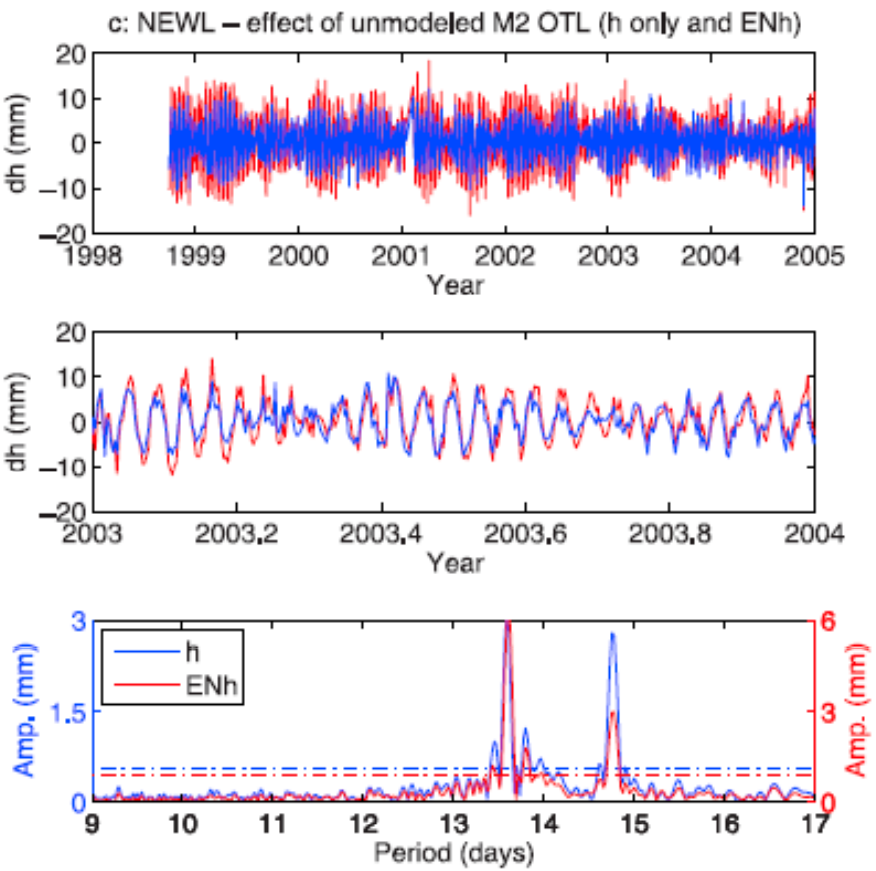
after Clarke *et al*. (2007), *GJI*

Spatial “fingerprints” and consistency

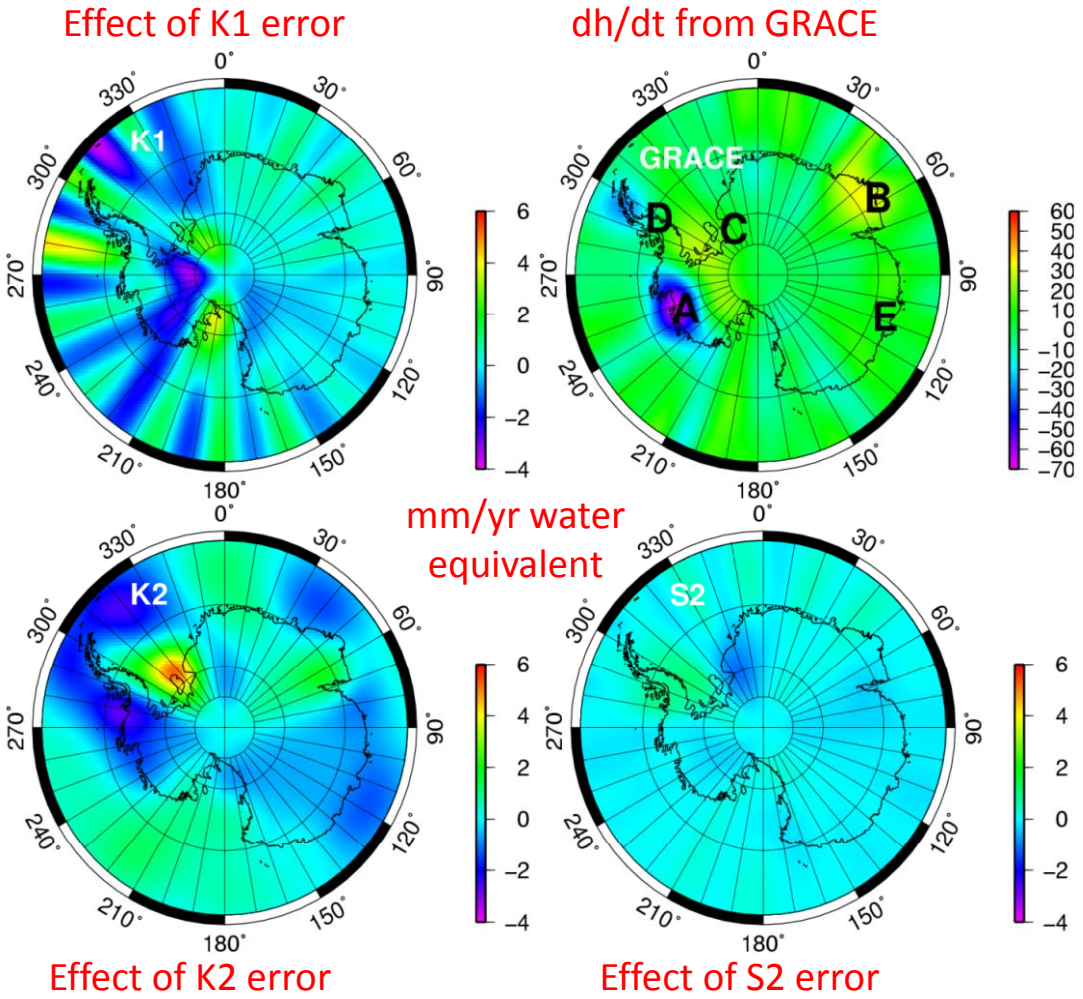


after Clarke *et al*. (2007), *GJI*

Geodetic challenges: (1) Aliasing and noise

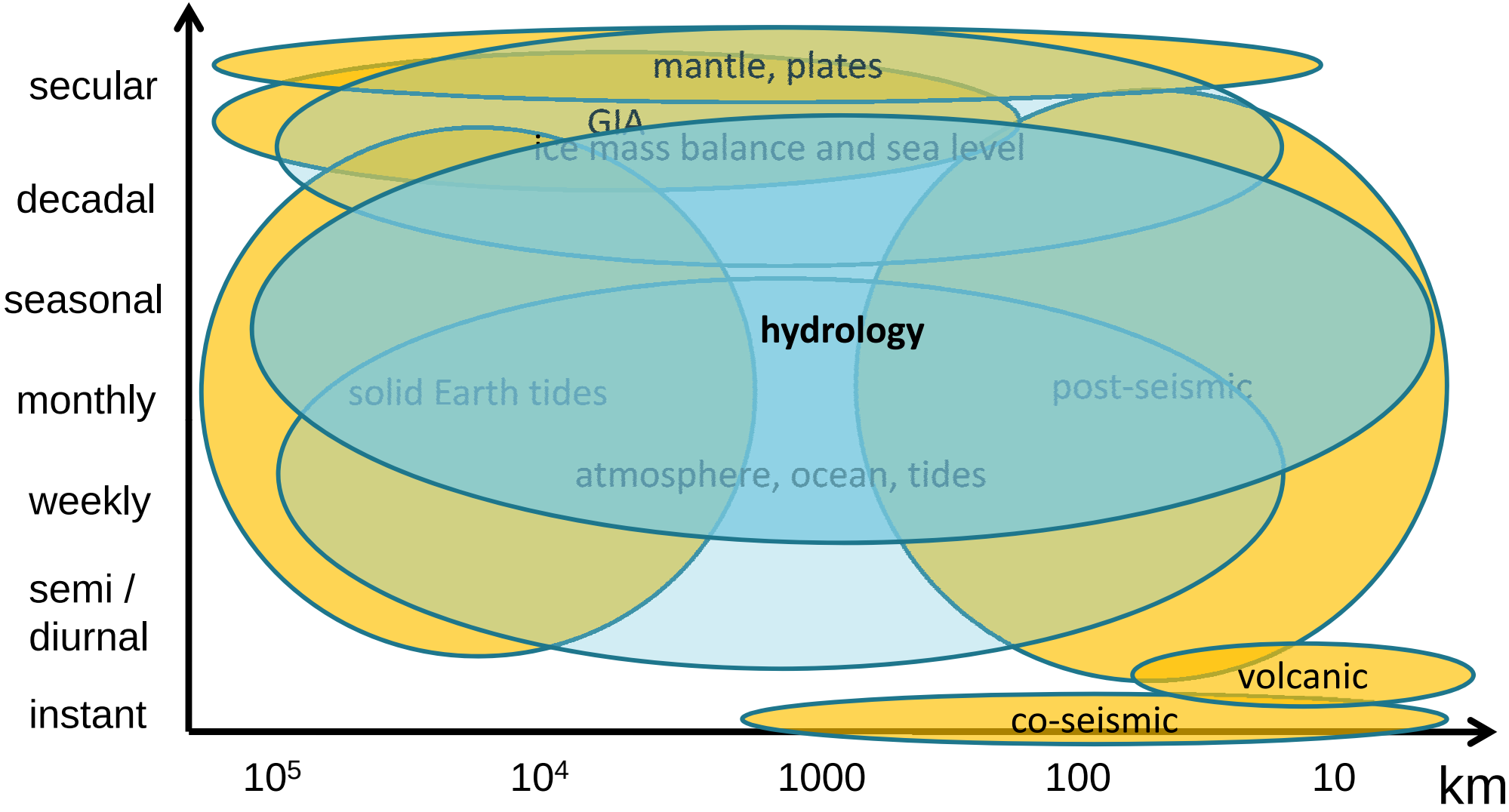


Penna *et al.* (2007), *JGR*



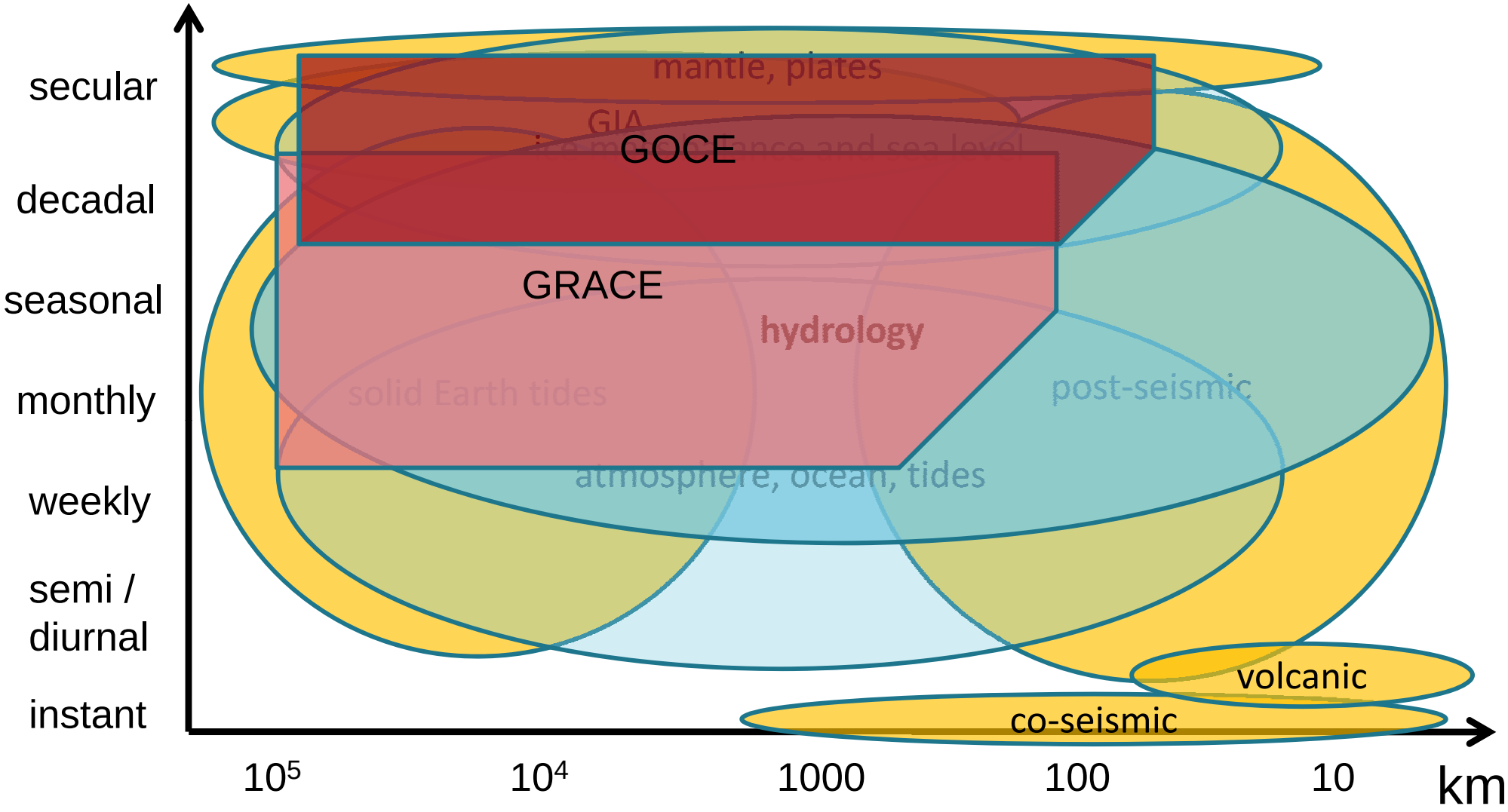
Moore & King (2008), *JGR*

Geodetic challenges: (2) Sampling



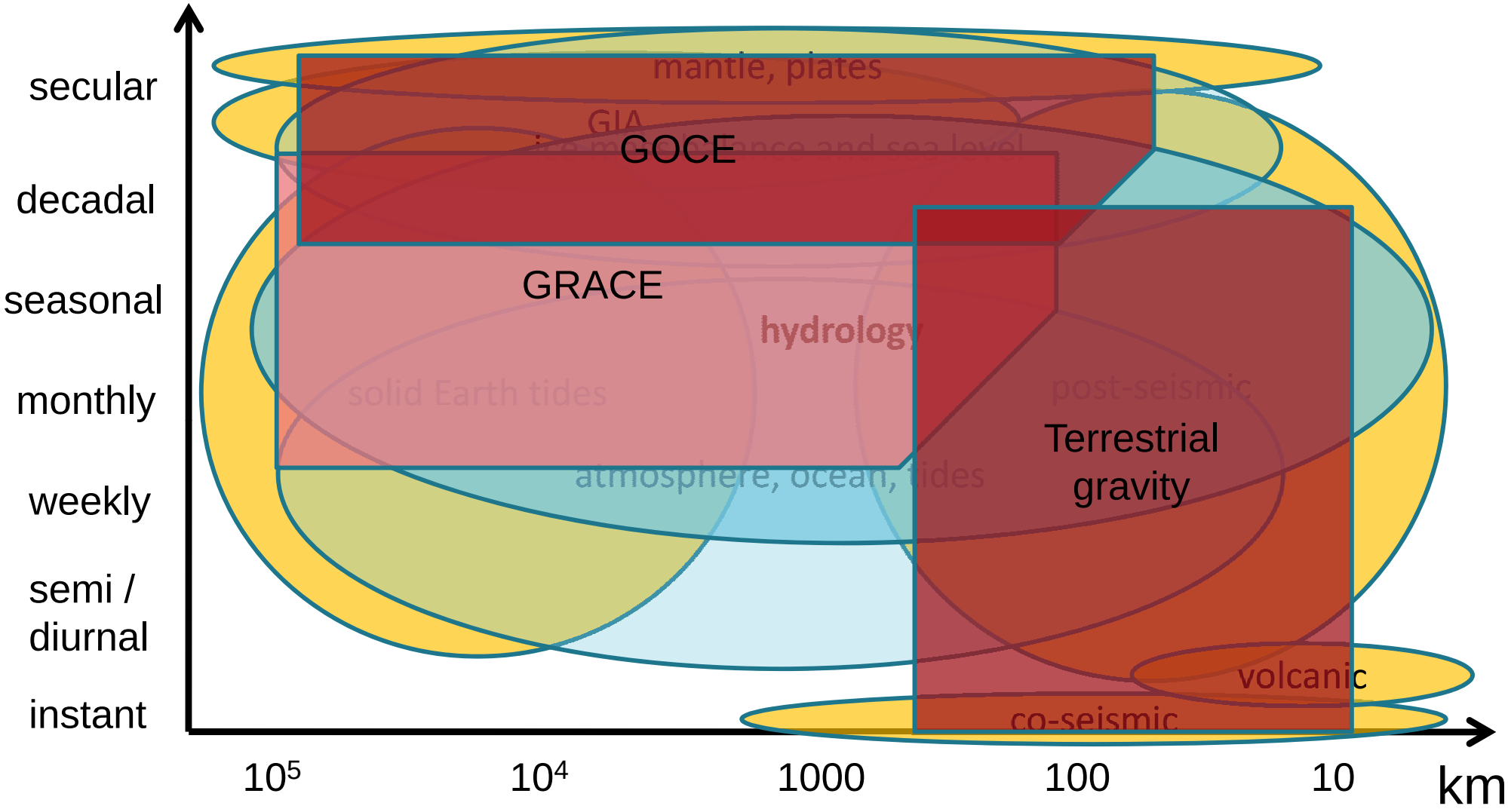
after Ilk *et al*. (2005)

Geodetic challenges: (2) Sampling



after Ilk *et al*. (2005)

Geodetic challenges: (2) Sampling



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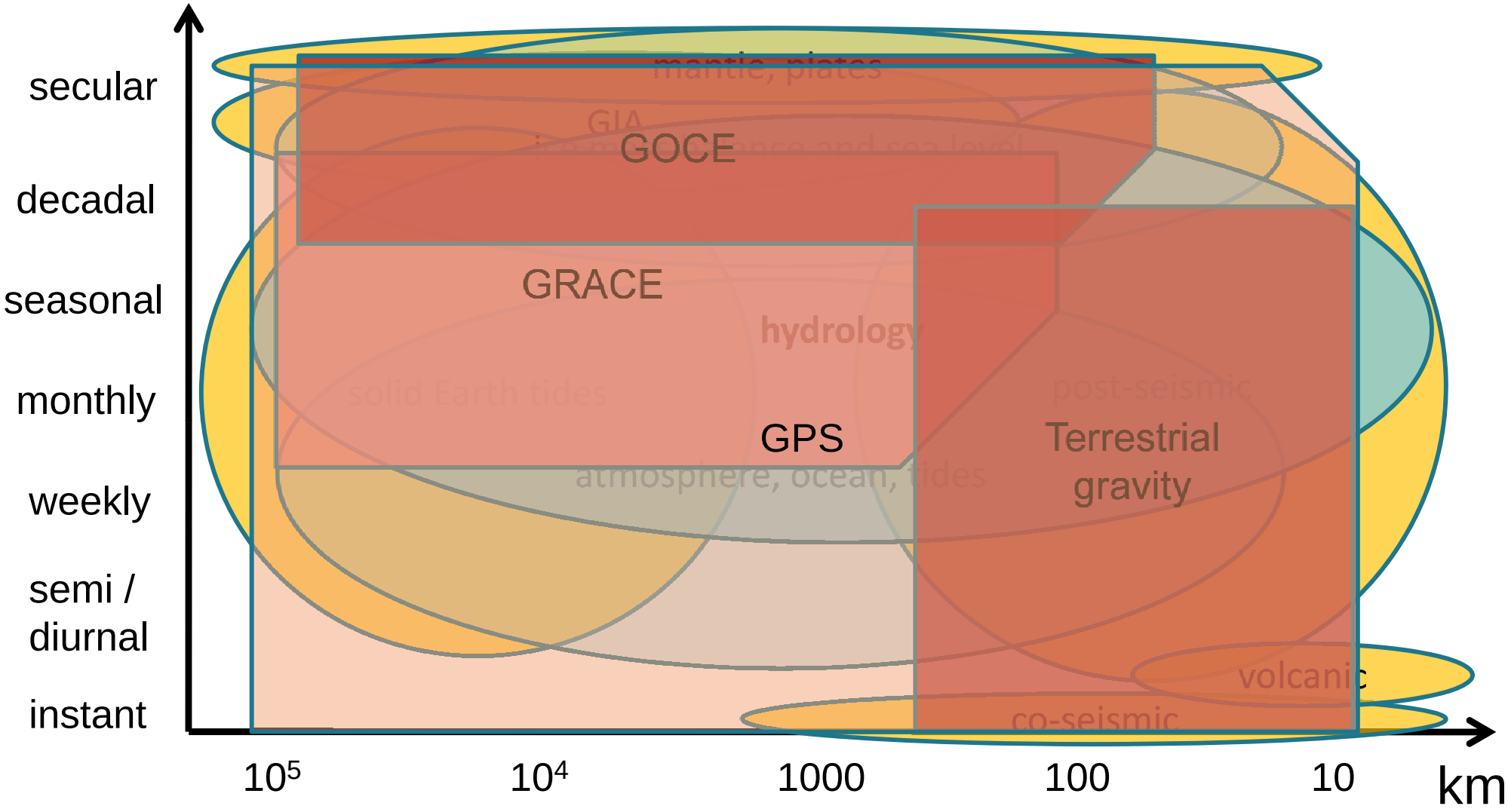
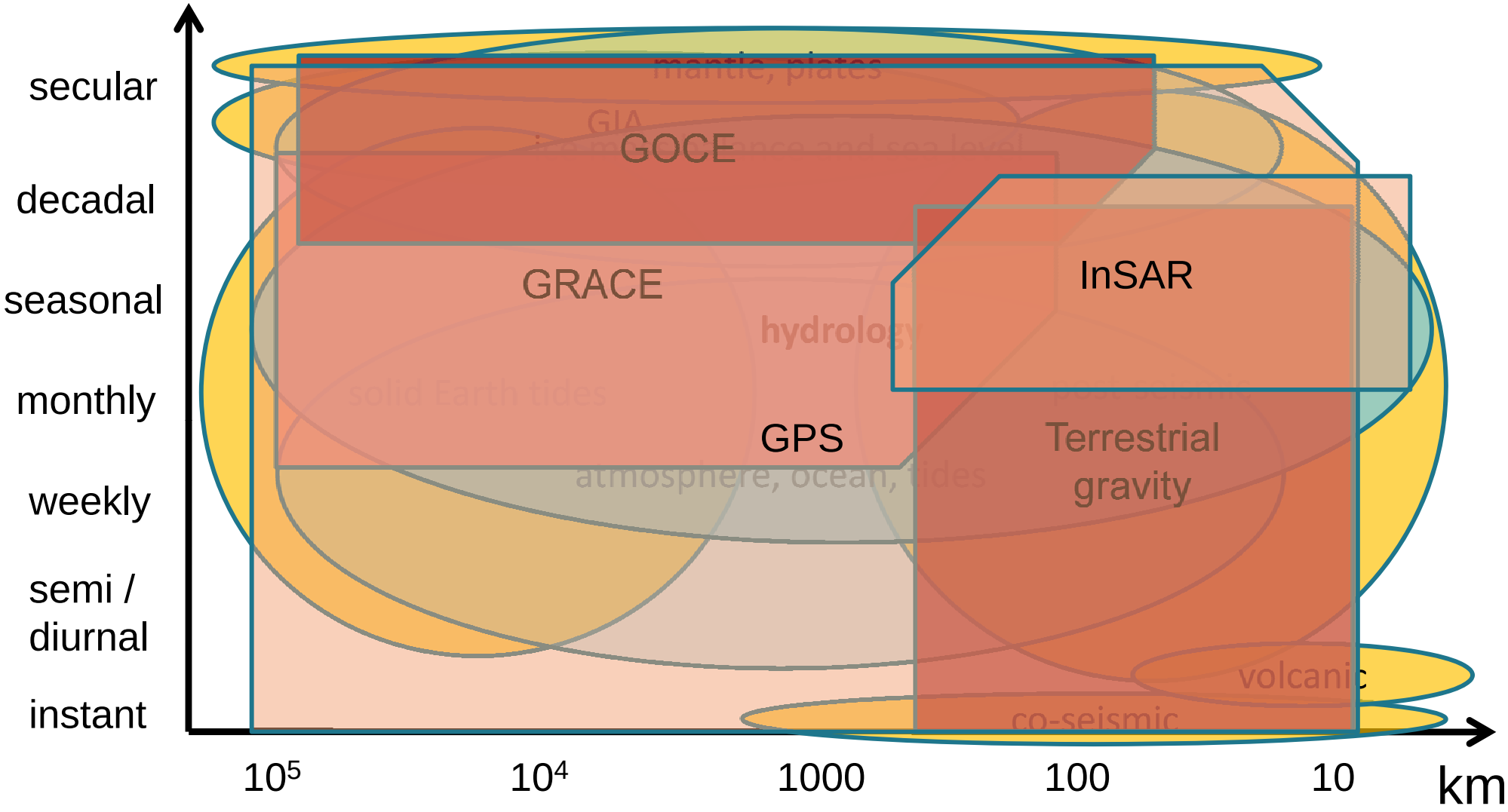
Geodetic challenges: (2) Sampling



after Ilk *et al*. (2005)

Geodetic challenges: (2) Sampling



after Ilk *et al*. (2005)

Workshop questions

- How can we bridge the gap in spatial scales between regional/global and point/catchment measurements?
- How can we isolate long-term hydrological change from secular effects due to tectonics, GIA, etc?
- How can we improve measurement accuracy and robustness to seasonal and other artefacts?