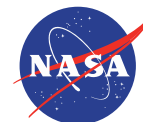




A Model for Earth's Surface Mass Transport: Integrating Polar Ice Sheets & Global Geodetic Observations

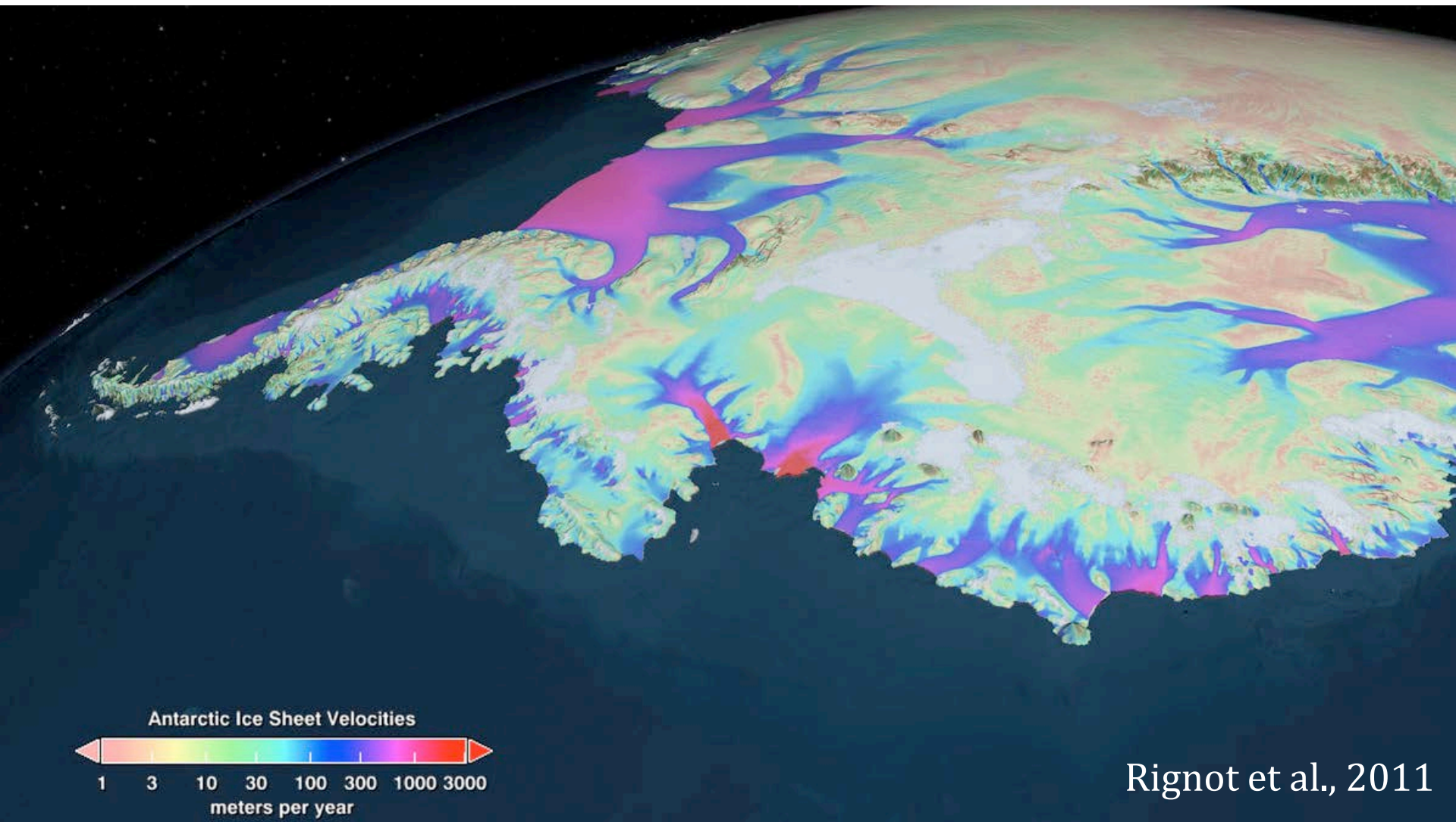
Surendra Adhikari, Erik R. Ivins, Eric Larour

February 9, 2016



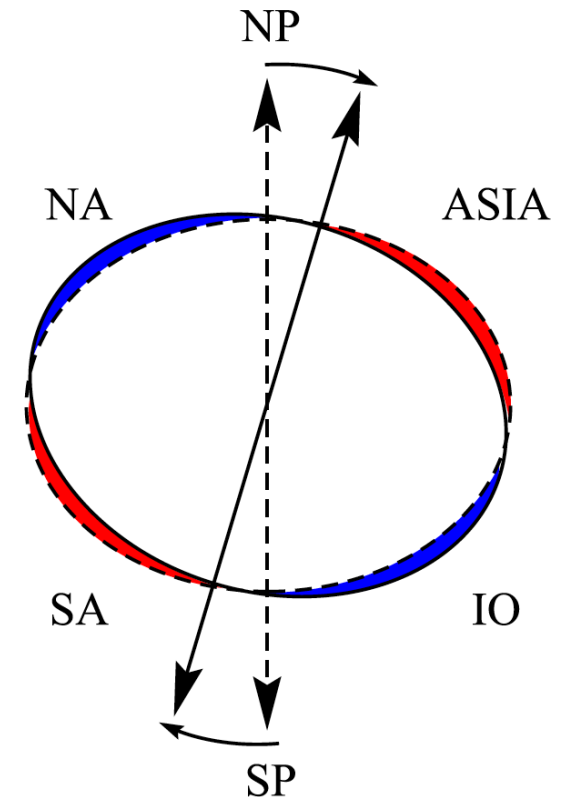
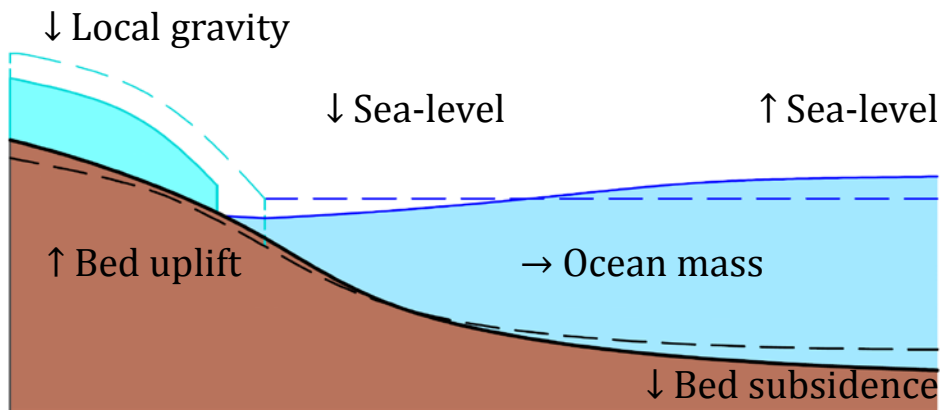
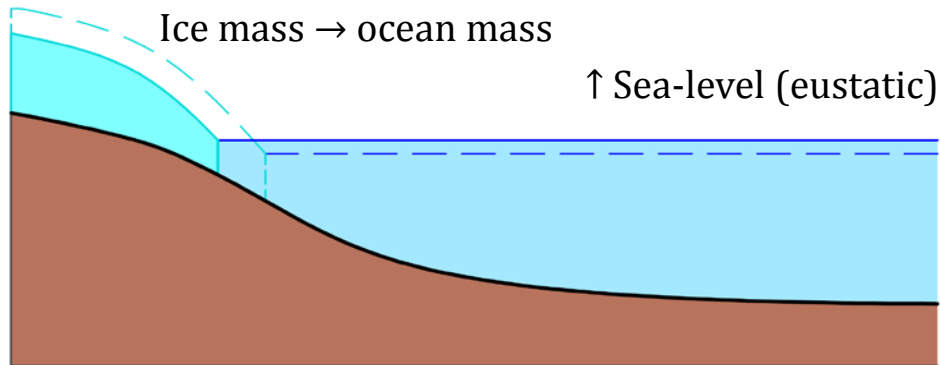
Jet Propulsion Laboratory
California Institute of Technology

Ice sheets: Need for high-resolution observation & modeling.

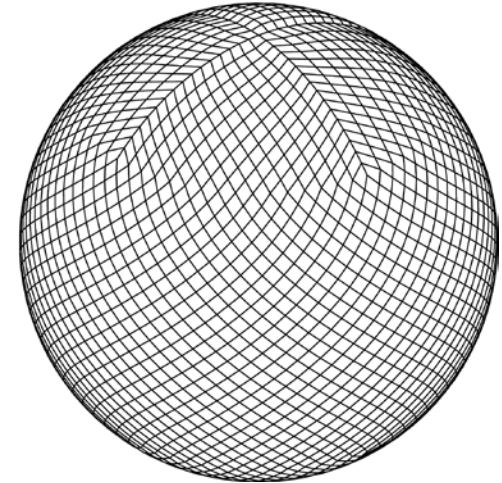


Relative sea level: For a self-gravitating, rotating Earth.

$$\Delta S(\theta, \lambda, t) = -\frac{m_i(t)}{\rho_o A_o} + \frac{1}{g} \Phi(\theta, \lambda, t) + \frac{1}{g} \Lambda(\theta, \lambda, t) + C(t)$$

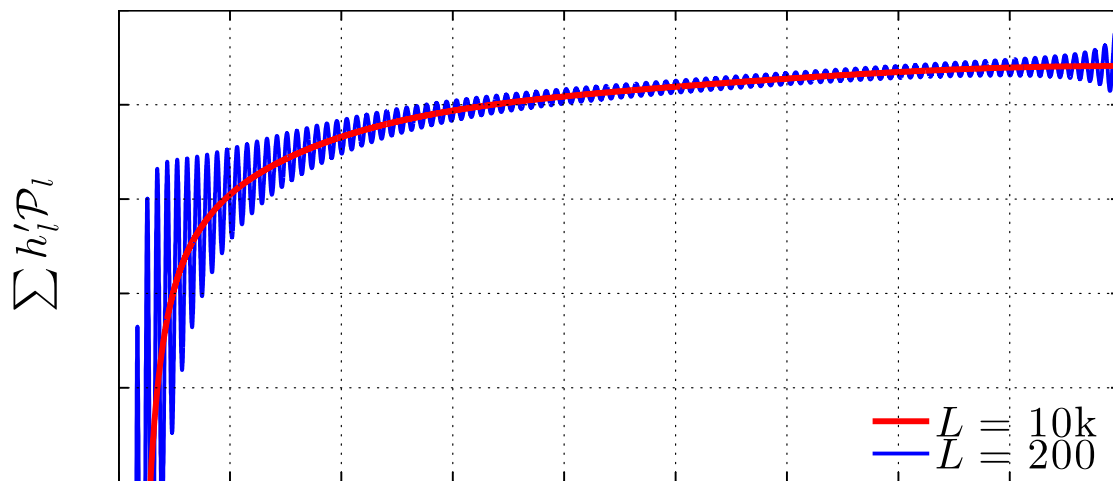


Spectral methods: Mitrovica & Peltier, 1991.



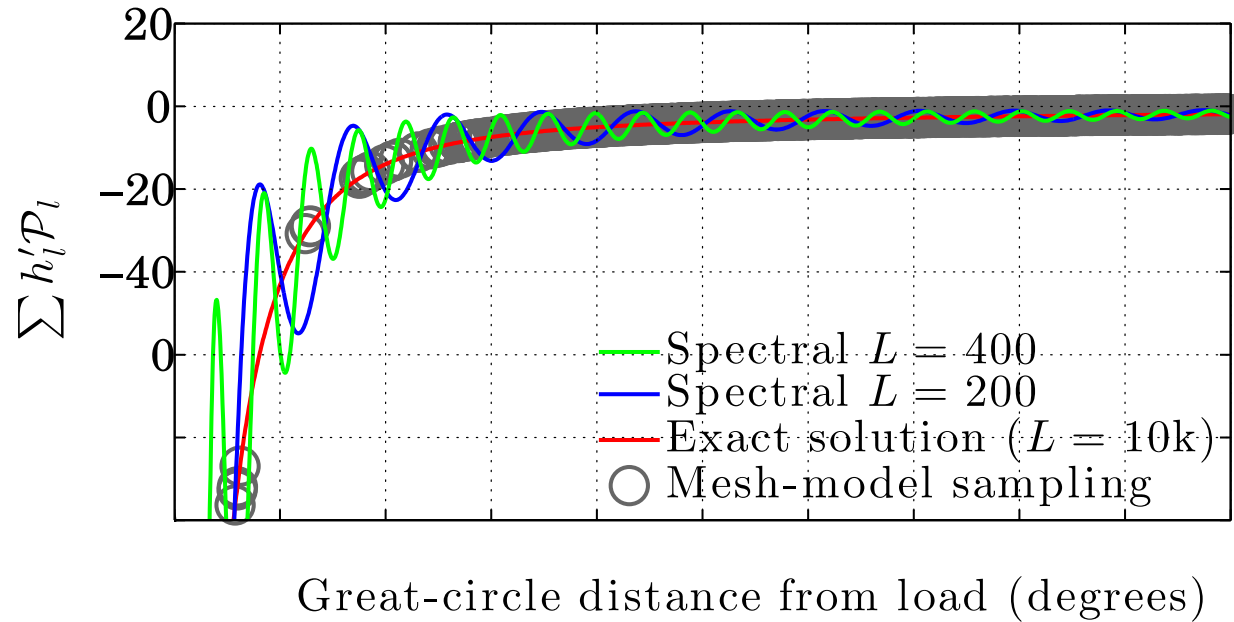
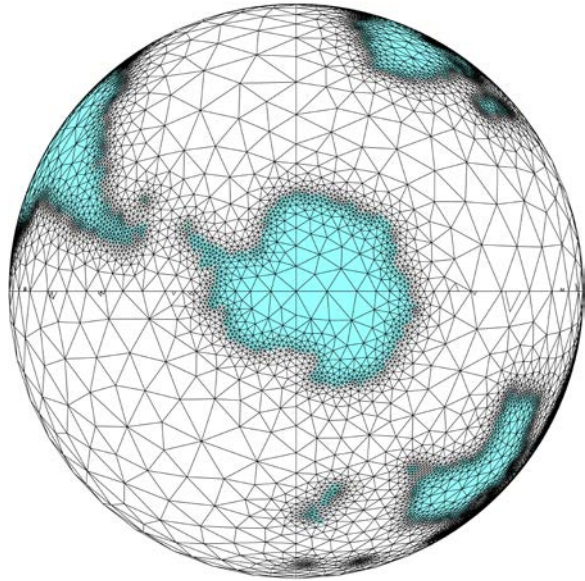
$$\Delta S(\theta, \lambda, t) = \sum_{l=0}^{\infty} \sum_{m=-l}^l \Delta S_{lm}(t) \mathcal{Y}_{lm}(\theta, \lambda)$$

Resolution R	# nodes $4\pi a^2/R^2$	Max degree $\pi a/R$	# coefficients $(\pi a/R + 1)^2$
100 km	51,000	200	40,400
2 km	127,516,000	10,000	100,020,000



Great-circle distance from load (degrees)

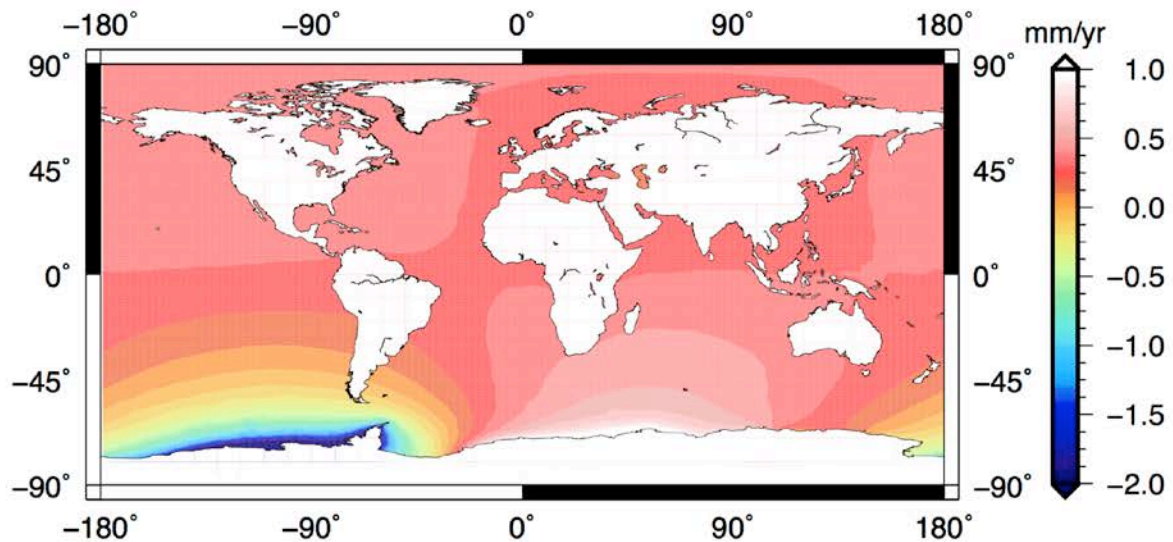
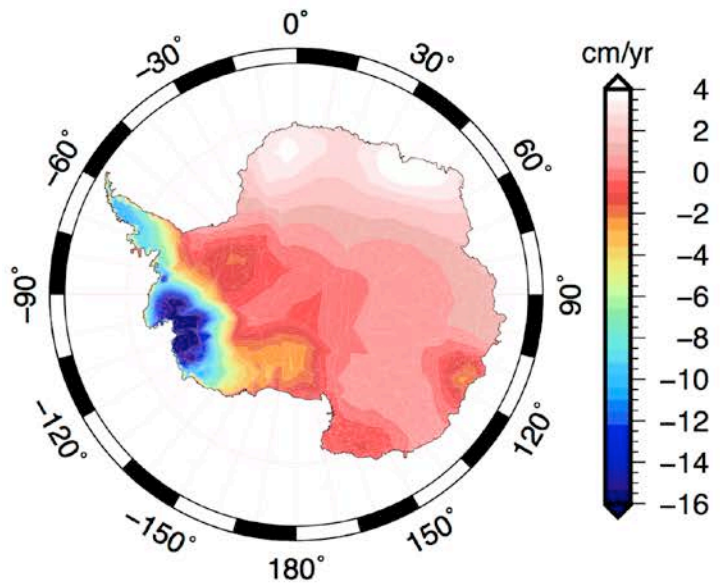
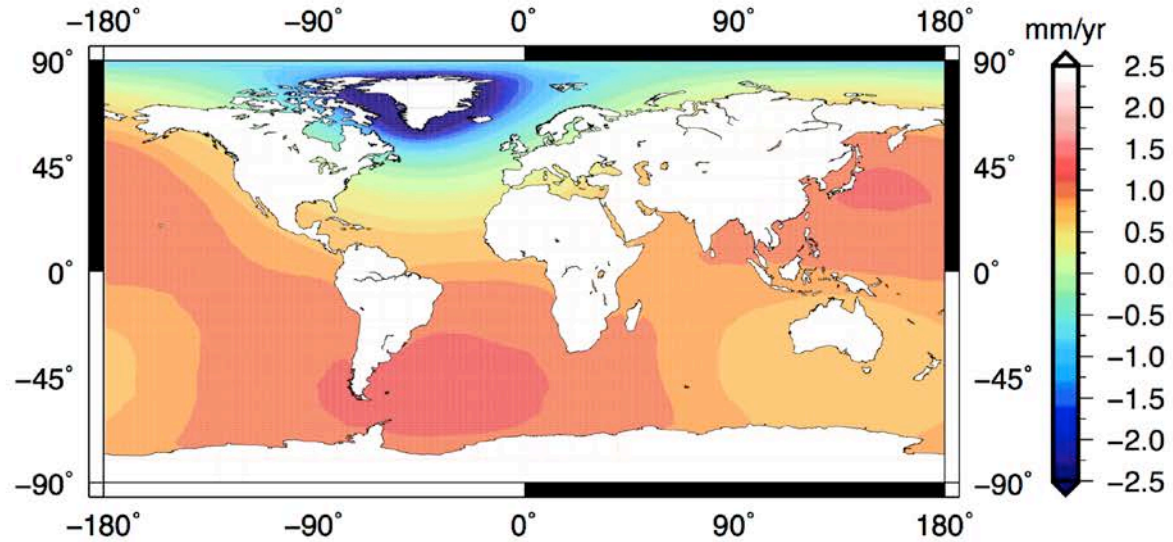
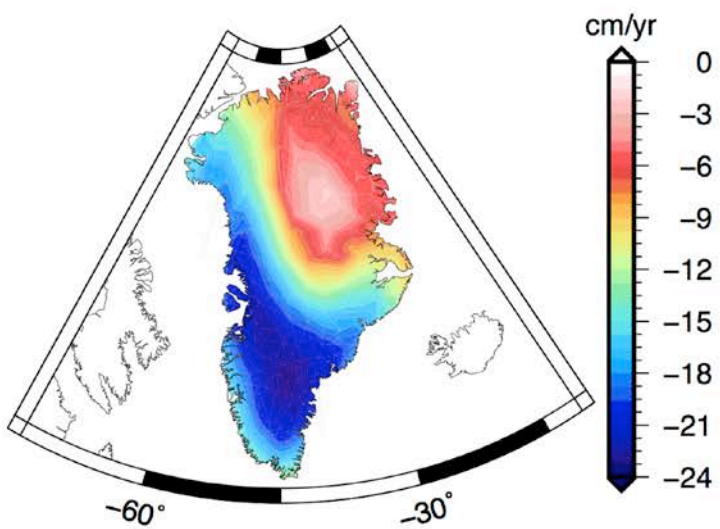
A mesh-based approach.



Resolution	Max degree	# nodes	# coefficients	OS X 10.9.5
~2 km	10,000	Variable (16,553)	-	~5 mins
100 km	200	49,152	40,401	~30 mins
50 km	400	196,608	160,801	~6 hours
		>127 M	>100 M	

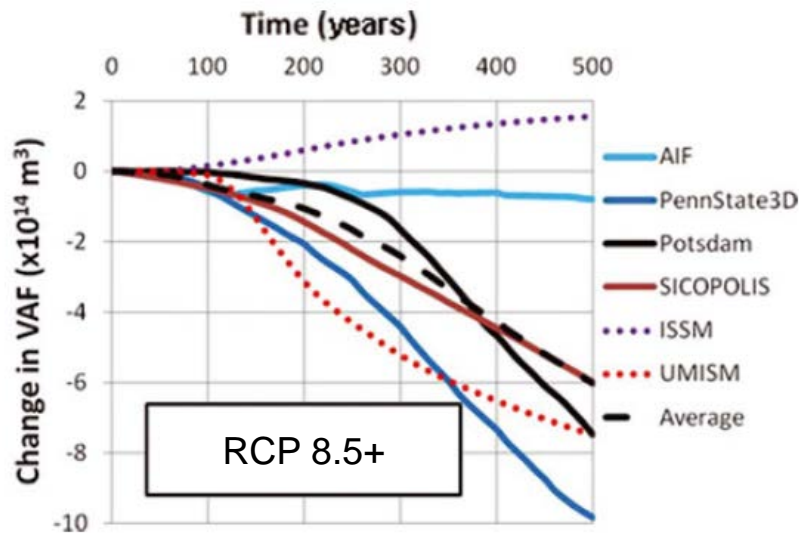
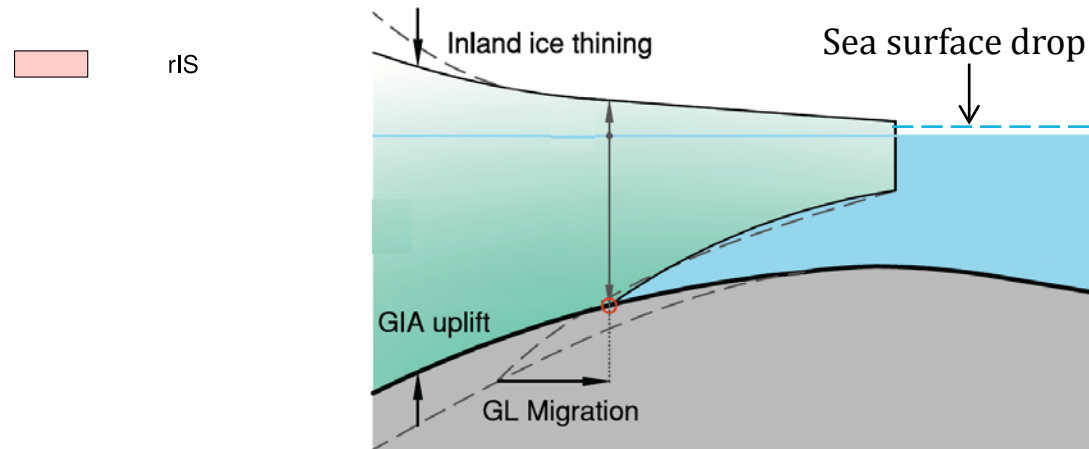
Sea-level fingerprints of ice sheets: 2003-2015.

GRACE CSR Release-05 Level-2 GSM monthly gravity fields.

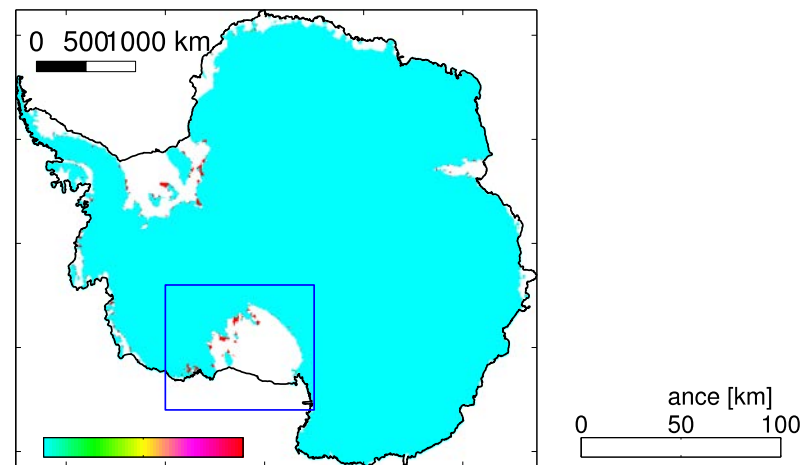


Implications for ice sheet modeling

Pine Island Glacier

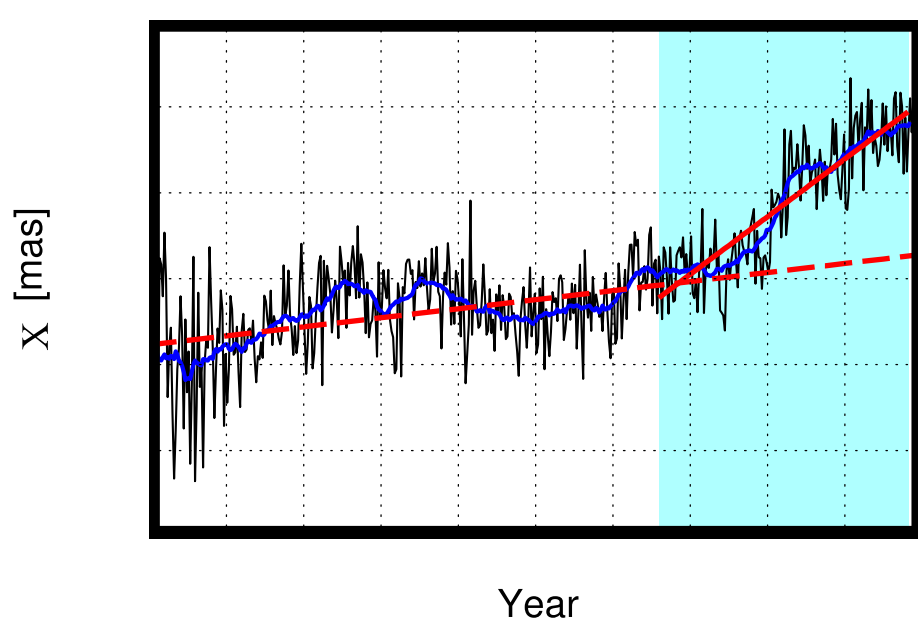
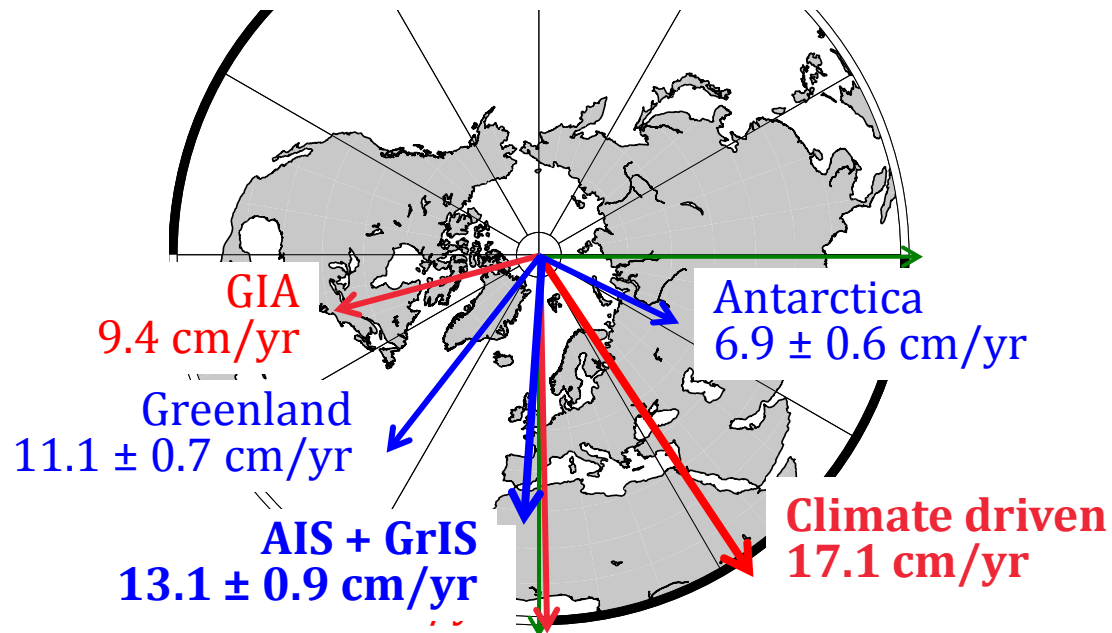


Bindschadler et al., 2013



Adhikari et al., 2014

Implications for space geodesy



Summary

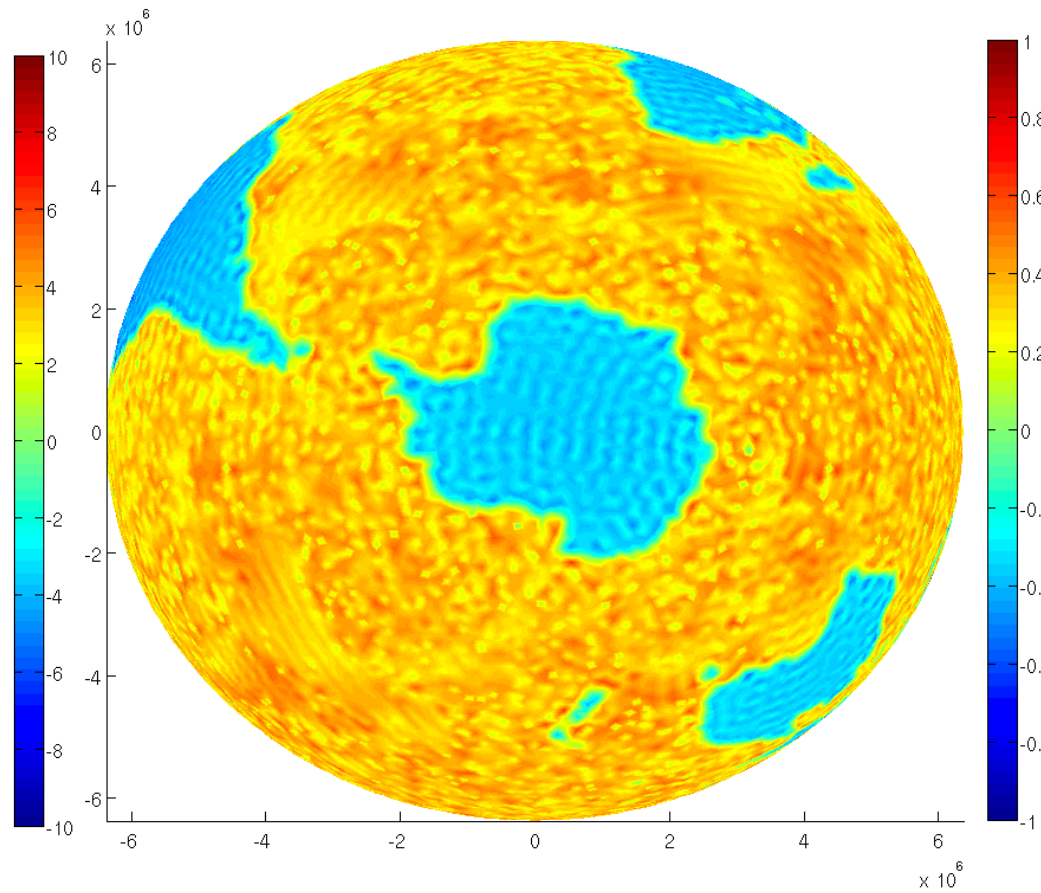
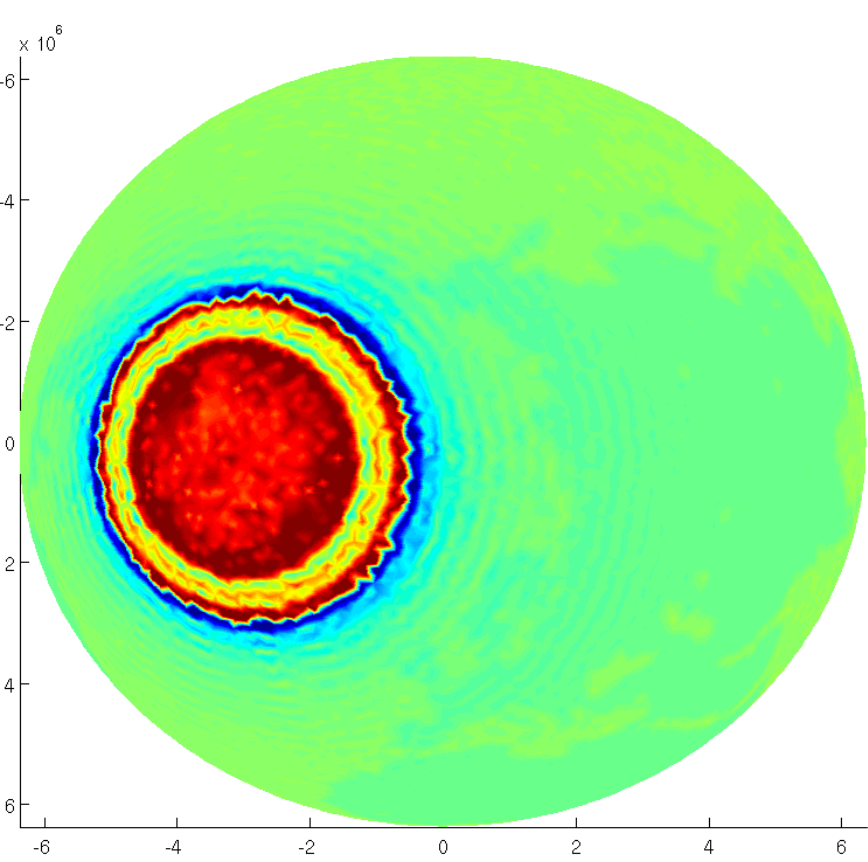


- Our global-scale computational tool, developed within the JPL's **Ice Sheet System Model (ISSM)**, allows for solving km-scale ice mechanics and global geodetic observables simultaneously.
- Geodetic observables can be utilized to constrain ice sheet models.
- Possibility of simulating both the polar ice sheets simultaneously.
- Paper in revision for *Geoscientific Model Development*.

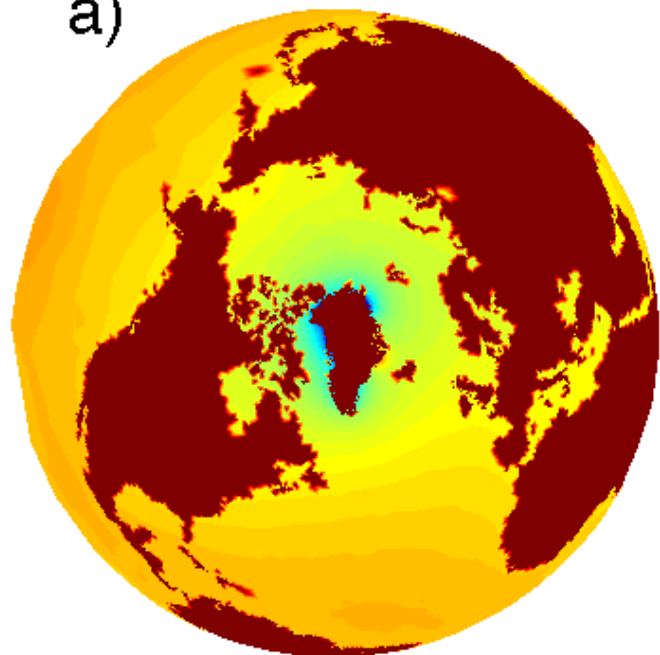
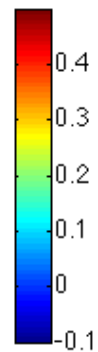


NASA Postdoctoral Program

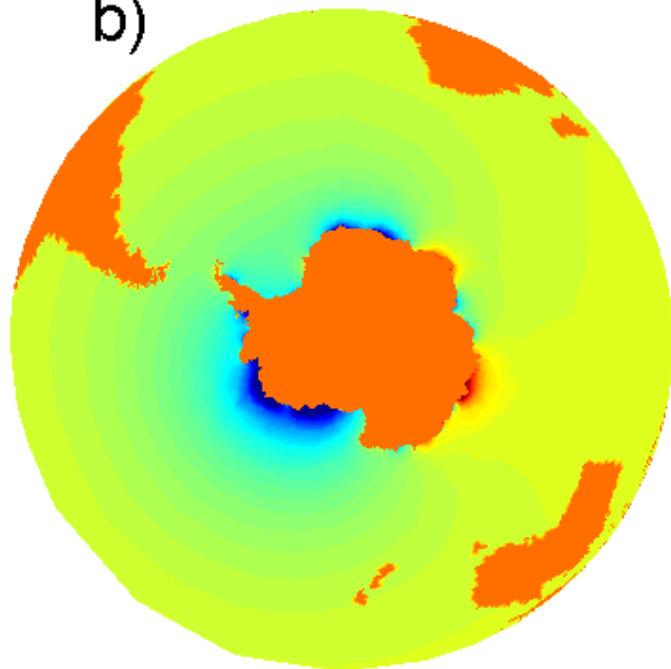
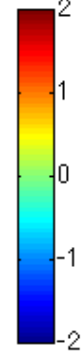




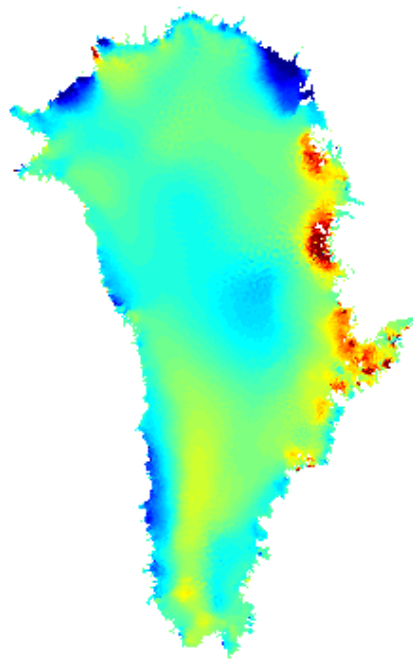
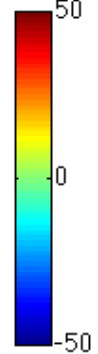
a)

 $S(m)$ 

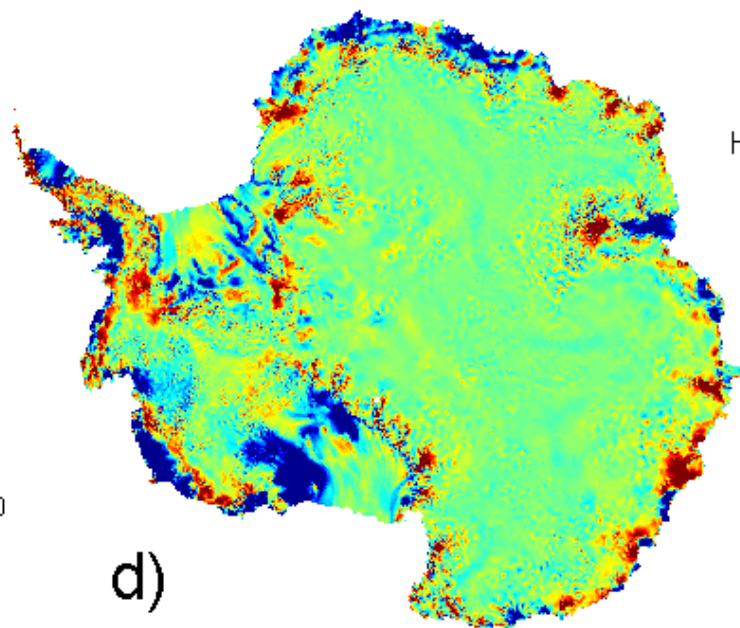
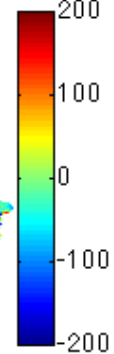
b)

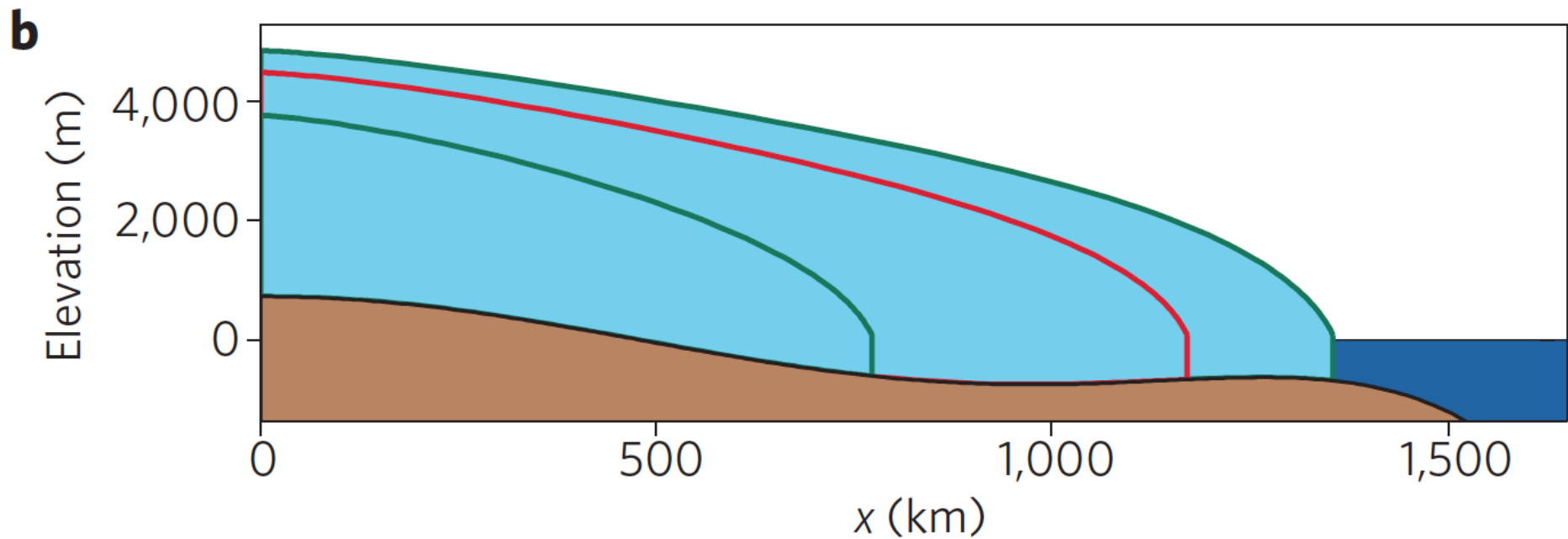
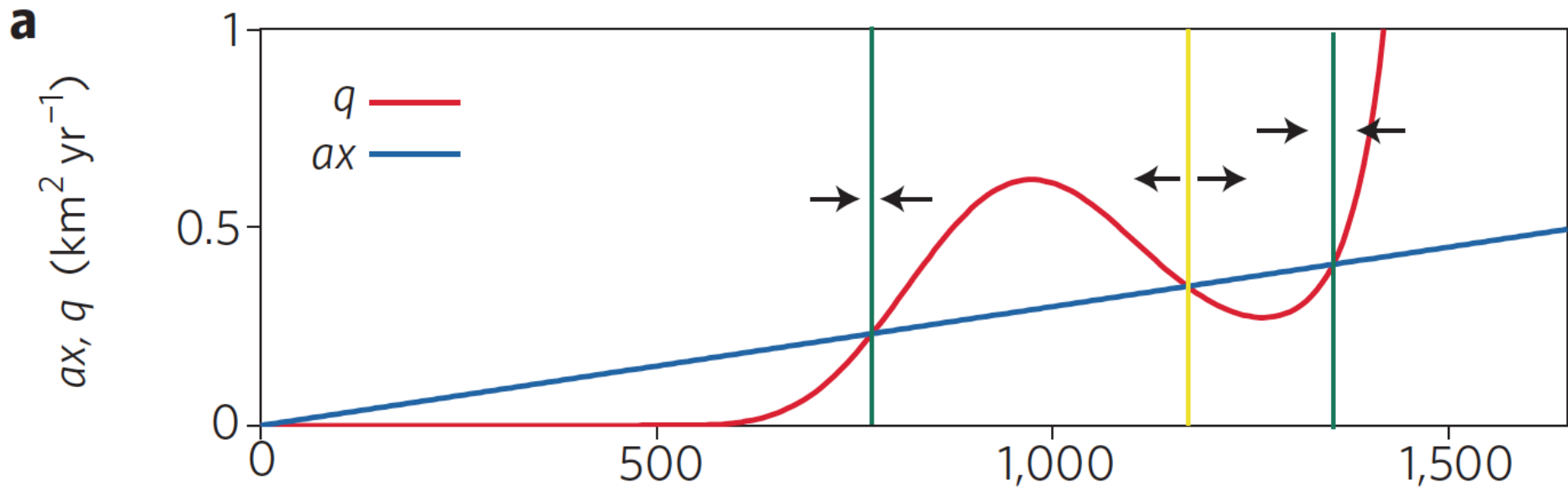
 $S(m)$ 

c)

 $H(m)$ 

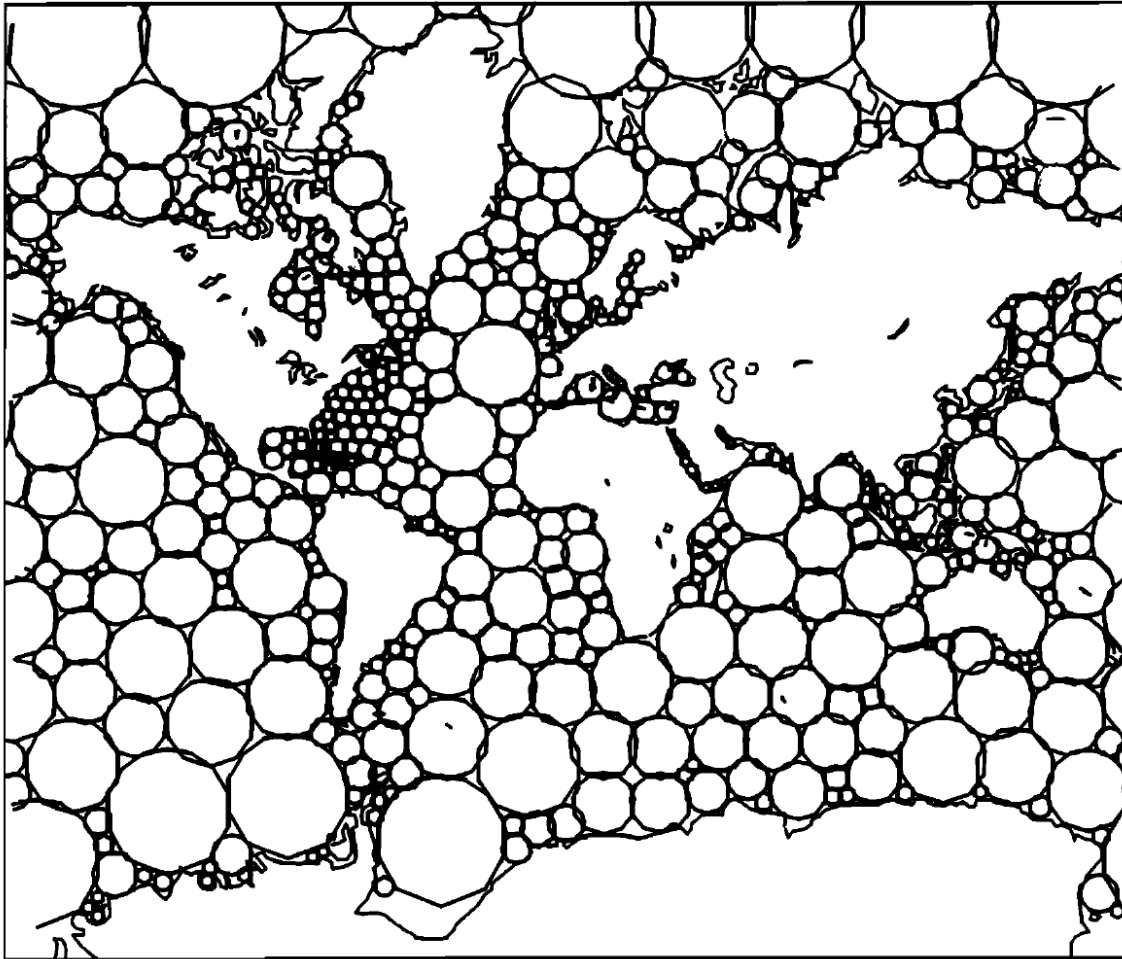
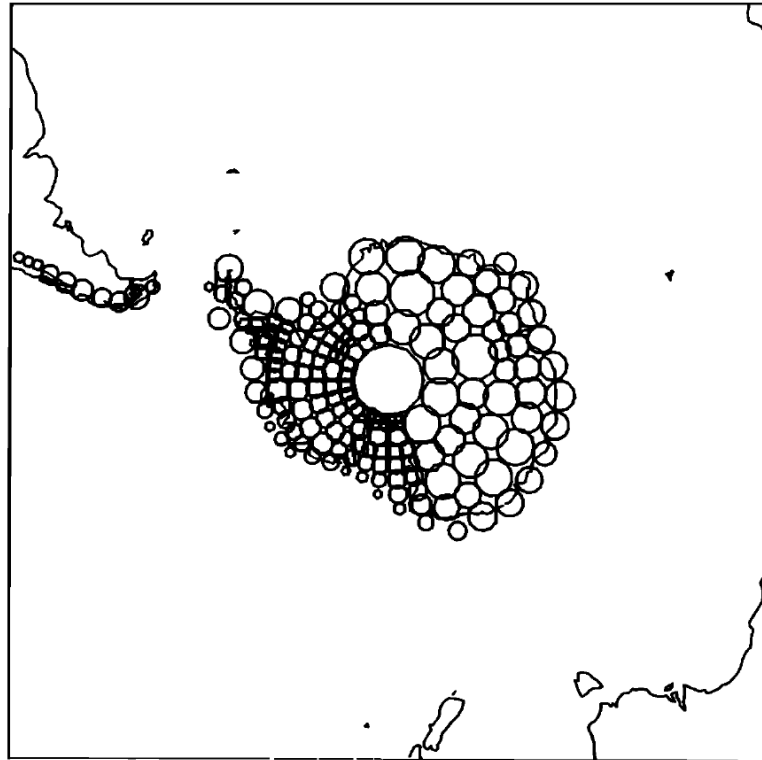
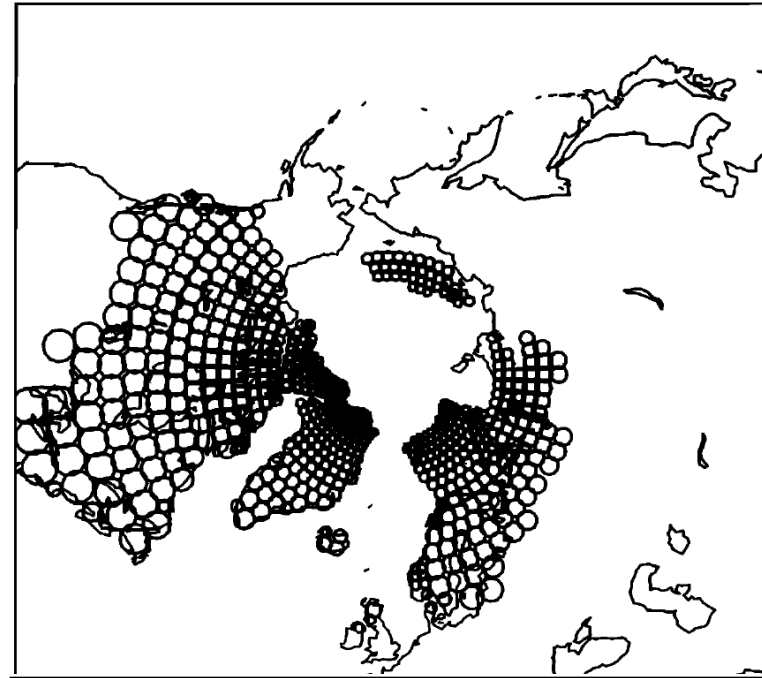
d)

 $H(m)$ 



Discrete methods:

Works of Clark, Peltier, & others.



Tushingham & Peltier, 1991