

# Land ice mass evolution from the new GSFC mascon solution

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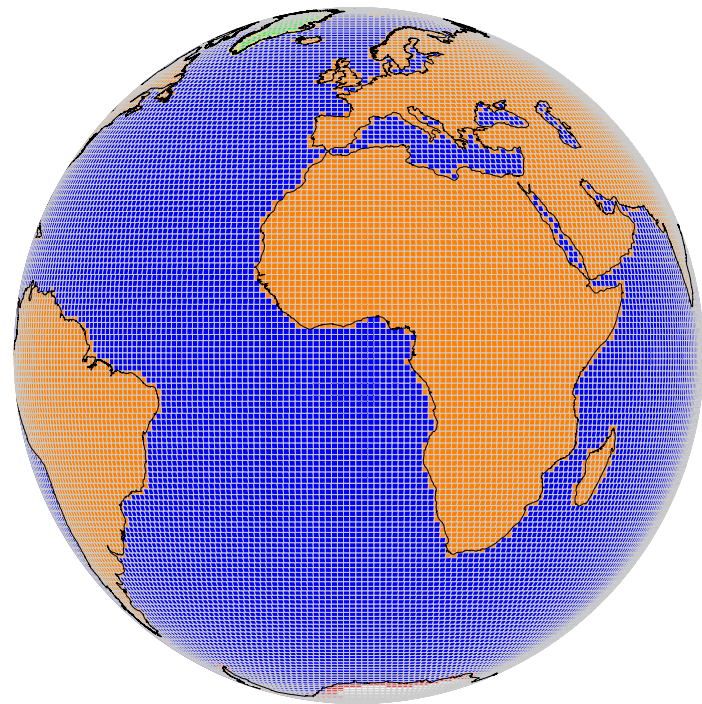
Luthcke, S.B., T.J. Sabaka, B.D. Loomis, A.A. Arendt, J.J. McCarthy, J. Camp (**2013**), Antarctica, Greenland and Gulf of Alaska land ice evolution from an iterated GRACE global mascon solution, *J. Glac.*, Vol. 59, No. 216, 613-631, doi:10.3189/2013JoG12j147.

Arendt, A., S. Luthcke, A. Gardner, S. O'Neel, D. Hill, G. Moholdt, W. Abdalati (**2013**), Analysis of a GRACE global mascon Solution for Gulf of Alaska Glaciers, *J. Glac.*, Vol. 59, No. 217, doi: 10.3189/2013JoG12J197.



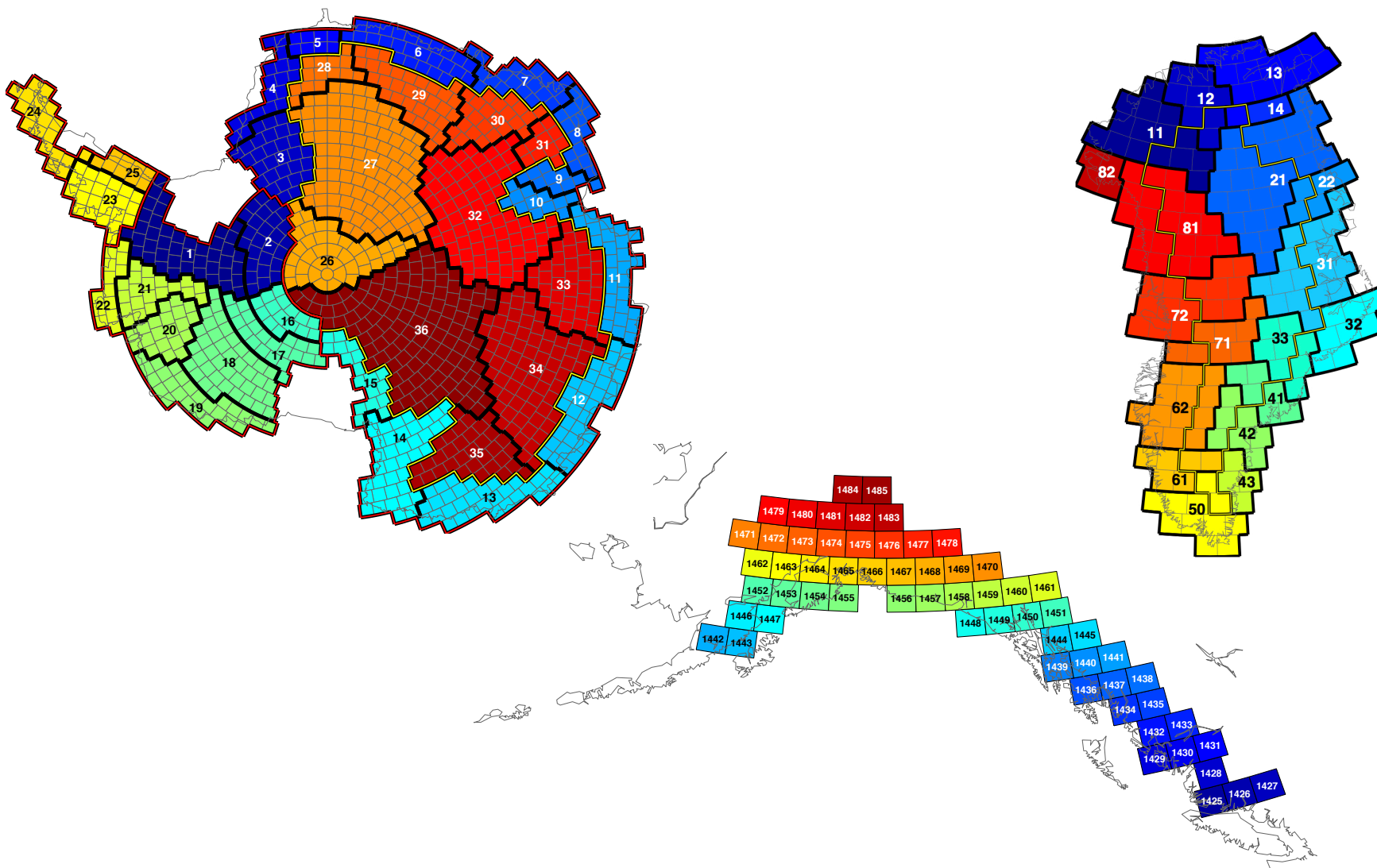
## Summary of GSFC global mascons

- 41,168 equal area 1-arc-degree mascons are directly estimated from GRACE KBRR L1B data with spatial and temporal exponential taper constraints applied; 10-day temporal resolution
- Spatial constraint: 100 km correlation distance
- Temporal constraint: 10-day correlation
- Most recent global solution has 7 separate constraint regions (mascons across constraint regions are uncorrelated):
  1. Greenland Ice Sheet  $> 2000$  m
  2. Greenland Ice Sheet  $< 2000$  m
  3. Antarctic Ice Sheet  $> 2000$  m
  4. Antarctic Ice Sheet  $< 2000$  m
  5. Gulf of Alaska glacier region
  6. Land (including all other ice regions)
  7. Ocean (including ice shelves)
- Solution is iterated to convergence





# 1-arcdeg equal area global mascons: Land ice regions





## Linearized mascon error decomposition

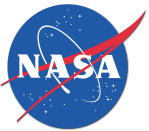
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$$\begin{aligned}\Delta m &= \tilde{m} - m, \\ &= \left( L^T A^T W A L + u P \right)^{-1} L^T A^T W d - m \\ &= \left( L^T A^T W A L + u P \right)^{-1} L^T A^T W (A L m + v) - m \\ &= \left[ \left( N + u P \right)^{-1} N - I \right] m + \text{Leakage} \\ &\quad \left( N + u P \right)^{-1} L^T A^T W v \quad \text{Noise} \\ &= \left( R - I \right) m + \text{Leakage} \\ &\quad \left( N + u P \right)^{-1} L^T A^T W v \quad \text{Noise}\end{aligned}$$

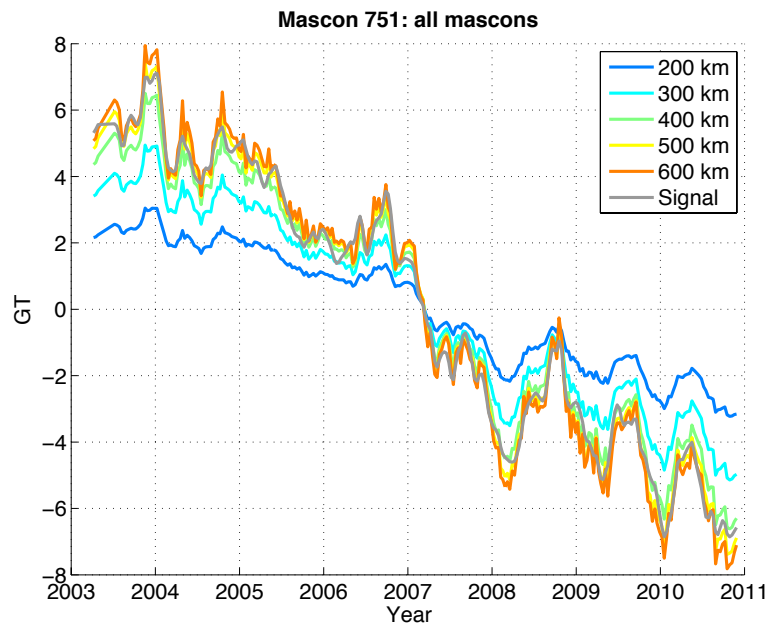
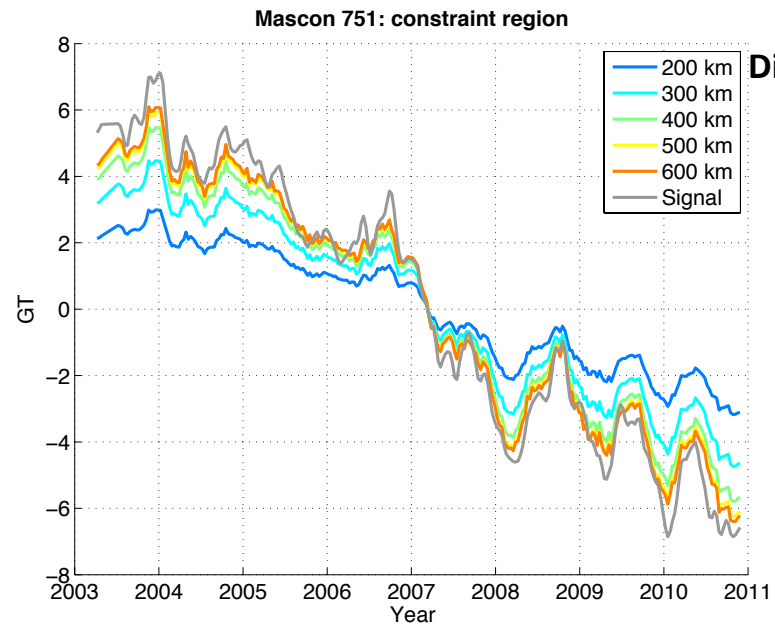
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$A$	=	C/S Jacobian	$N$	=	Mascon Normal matrix
$L$	=	Shape function	$R$	=	Resolution matrix
$W$	=	Data weight matrix	$v$	=	Data noise vector
$P$	=	Mascon regularization matrix	$m$	=	True mascon state
$d$	=	Data vector	$\tilde{m}$	=	Estimated mascon state

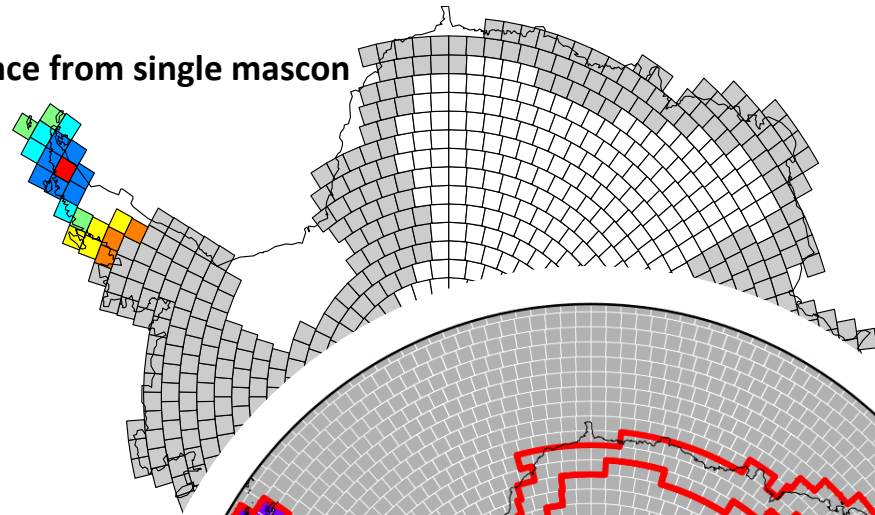




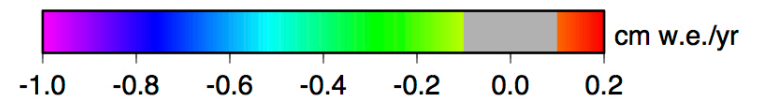
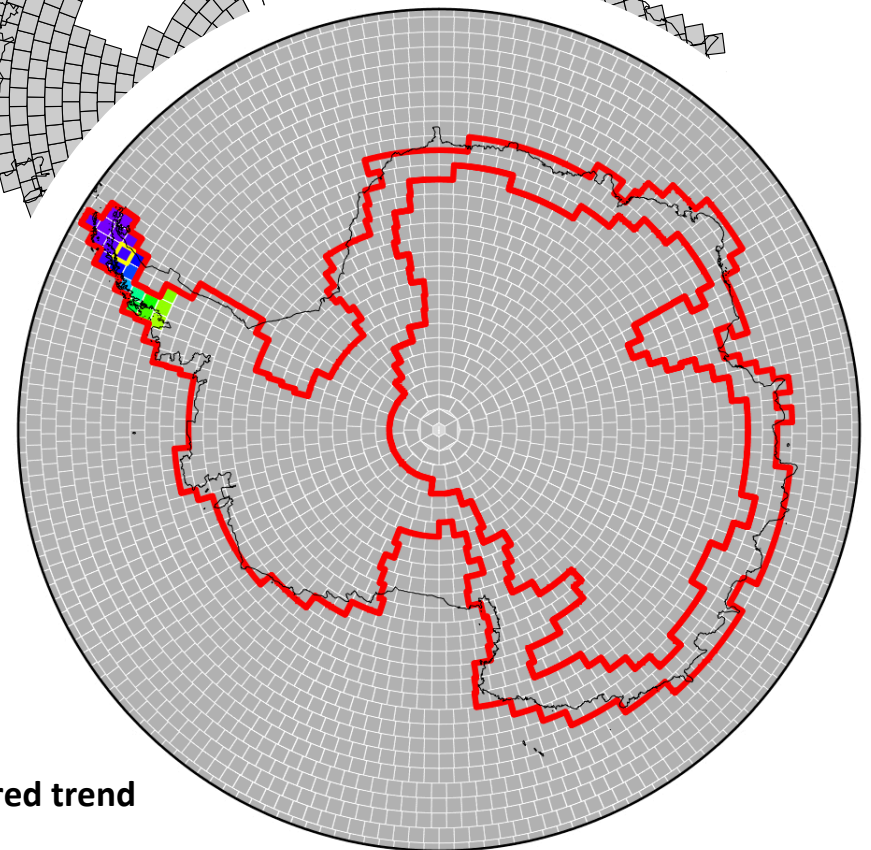
# Spatial resolution of mascon solutions



Distance from single mascon



Recovered trend





# Mascon solution summary (2003.12 to 2010.12)

## Trends

GIS =  $-230 \pm 12 \text{ Gt a}^{-1}$

GIS<2000 m =  $-224 \pm 20 \text{ Gt a}^{-1}$

AIS =  $-81 \pm 26 \text{ Gt a}^{-1}$

WAIS =  $-106 \pm 16 \text{ Gt a}^{-1}$

EAIS =  $63 \pm 28 \text{ Gt a}^{-1}$

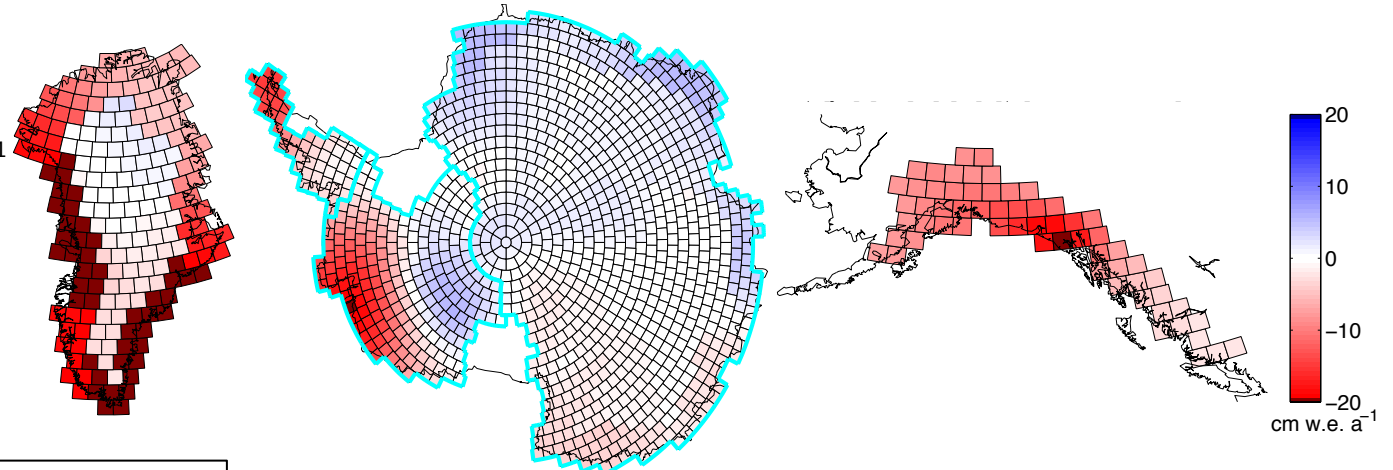
AISSPen =  $-38 \pm 14 \text{ Gt a}^{-1}$

GOA =  $-69 \pm 11 \text{ Gt a}^{-1}$

ICE5G Paulson GIA for GIS and GoA

Larsen LIA for GoA

IJ05\_R2 GIA for AIS



## Accelerations

GIS =  $-10 \pm 6 \text{ Gt a}^{-2}$

GIS<2000 m =  $-11 \pm 7 \text{ Gt a}^{-2}$

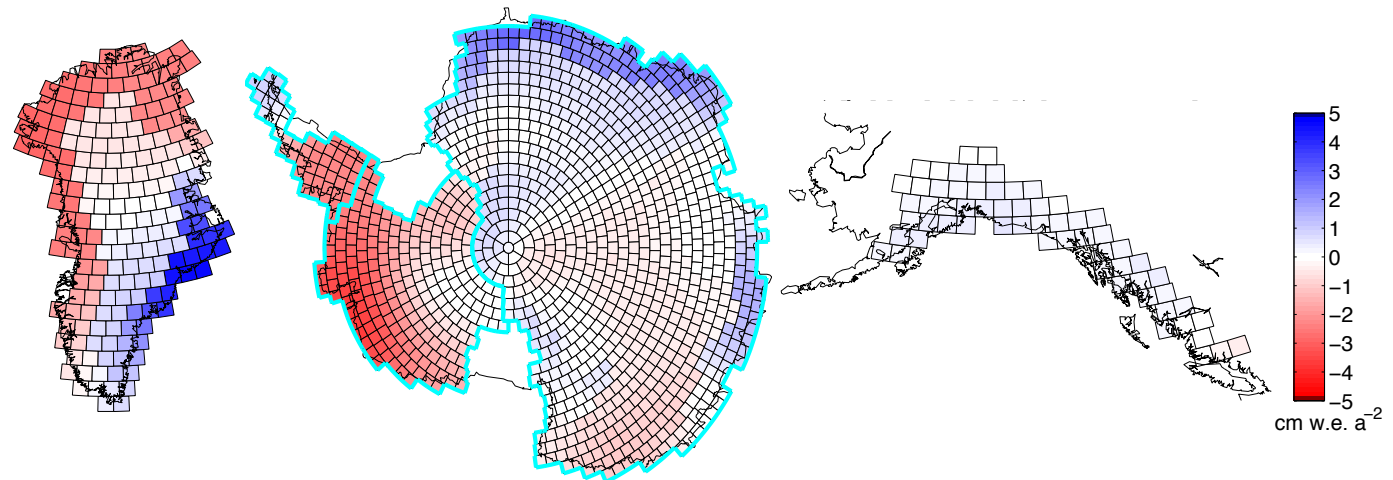
AIS =  $-33 \pm 26 \text{ Gt a}^{-2}$

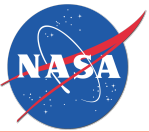
WAIS =  $-46 \pm 6 \text{ Gt a}^{-2}$

EAIS =  $22 \pm 22 \text{ Gt a}^{-2}$

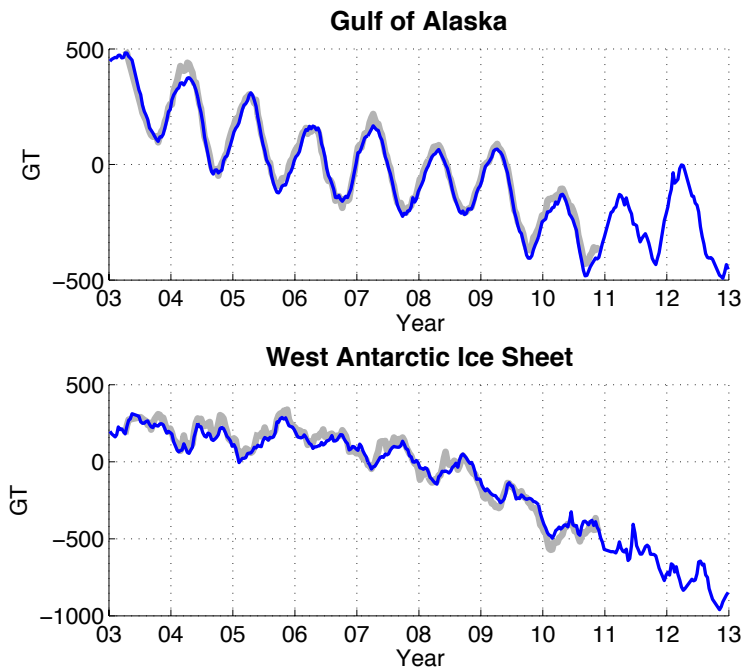
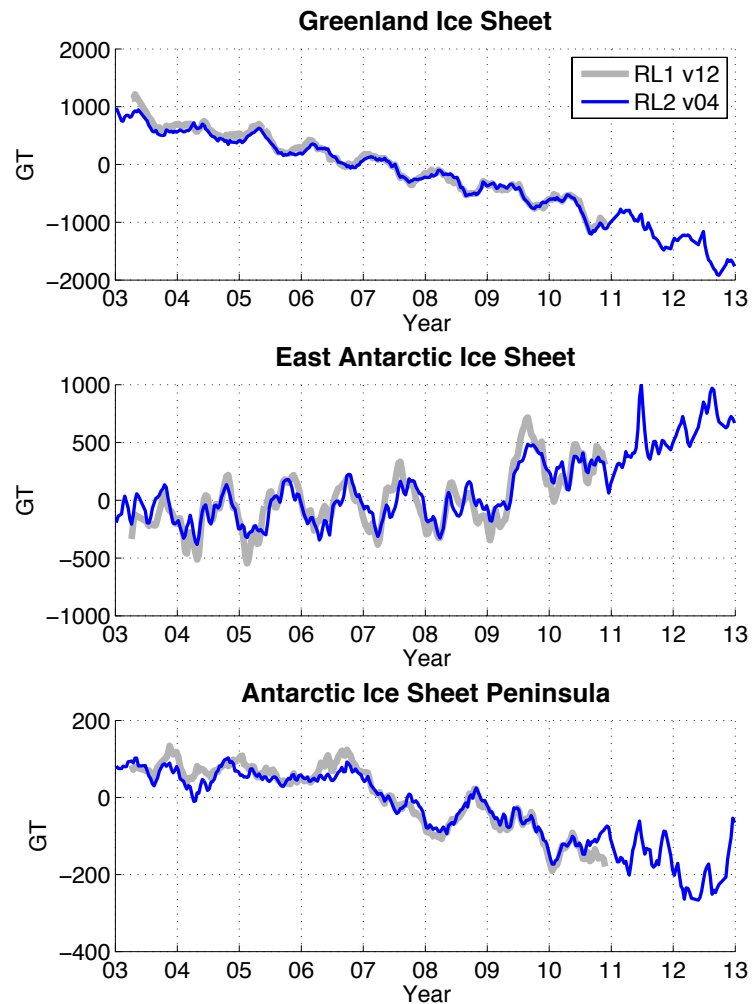
AISSPen =  $-9 \pm 5 \text{ Gt a}^{-2}$

GOA =  $2 \pm 7 \text{ Gt a}^{-2}$





## GSFC mascon time series: RL01 v12 vs. RL02 v04

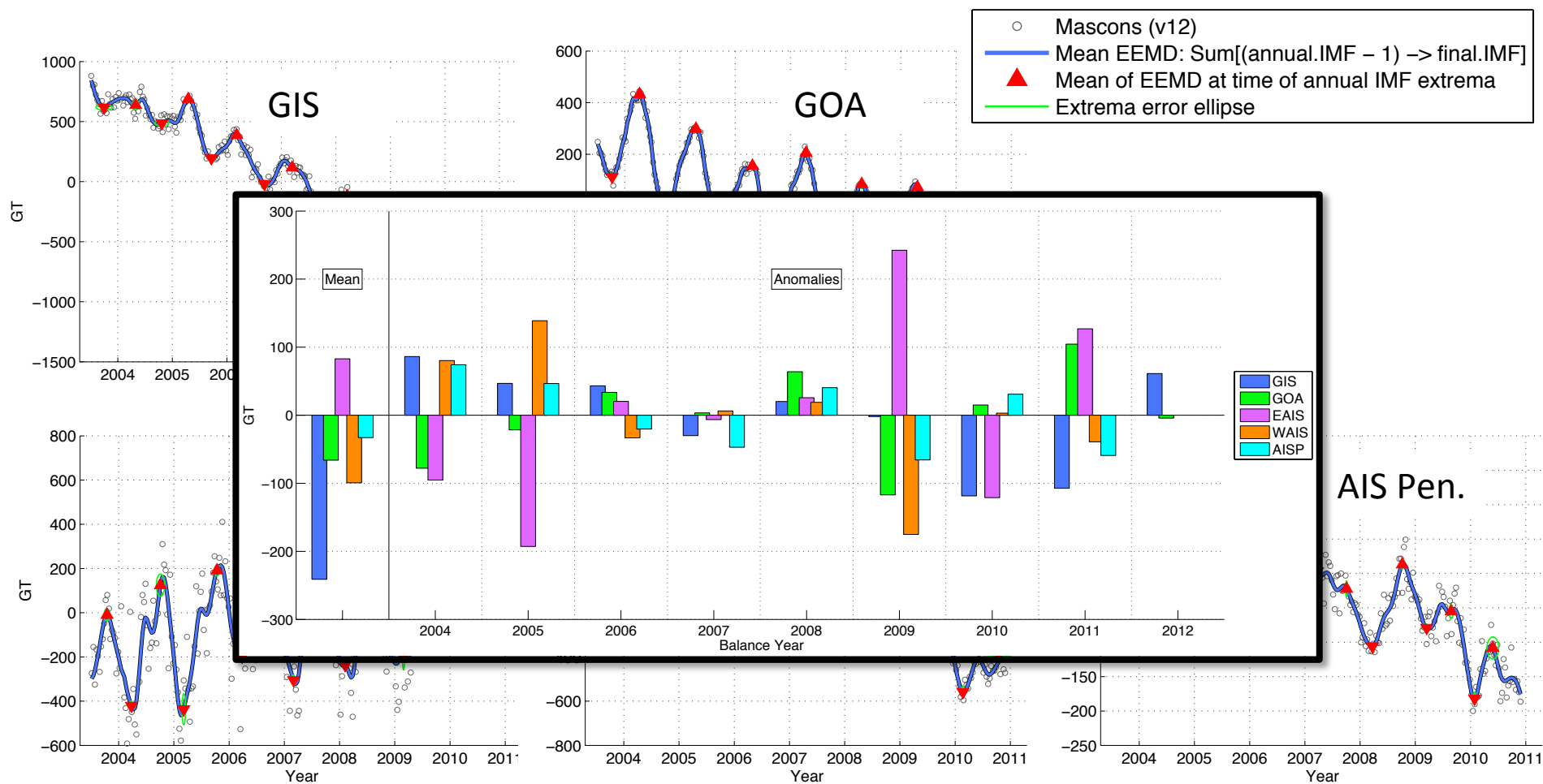


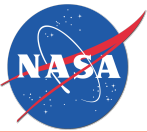
Paulson  
ICE-5G GIA

IJ05\_R2 GIA

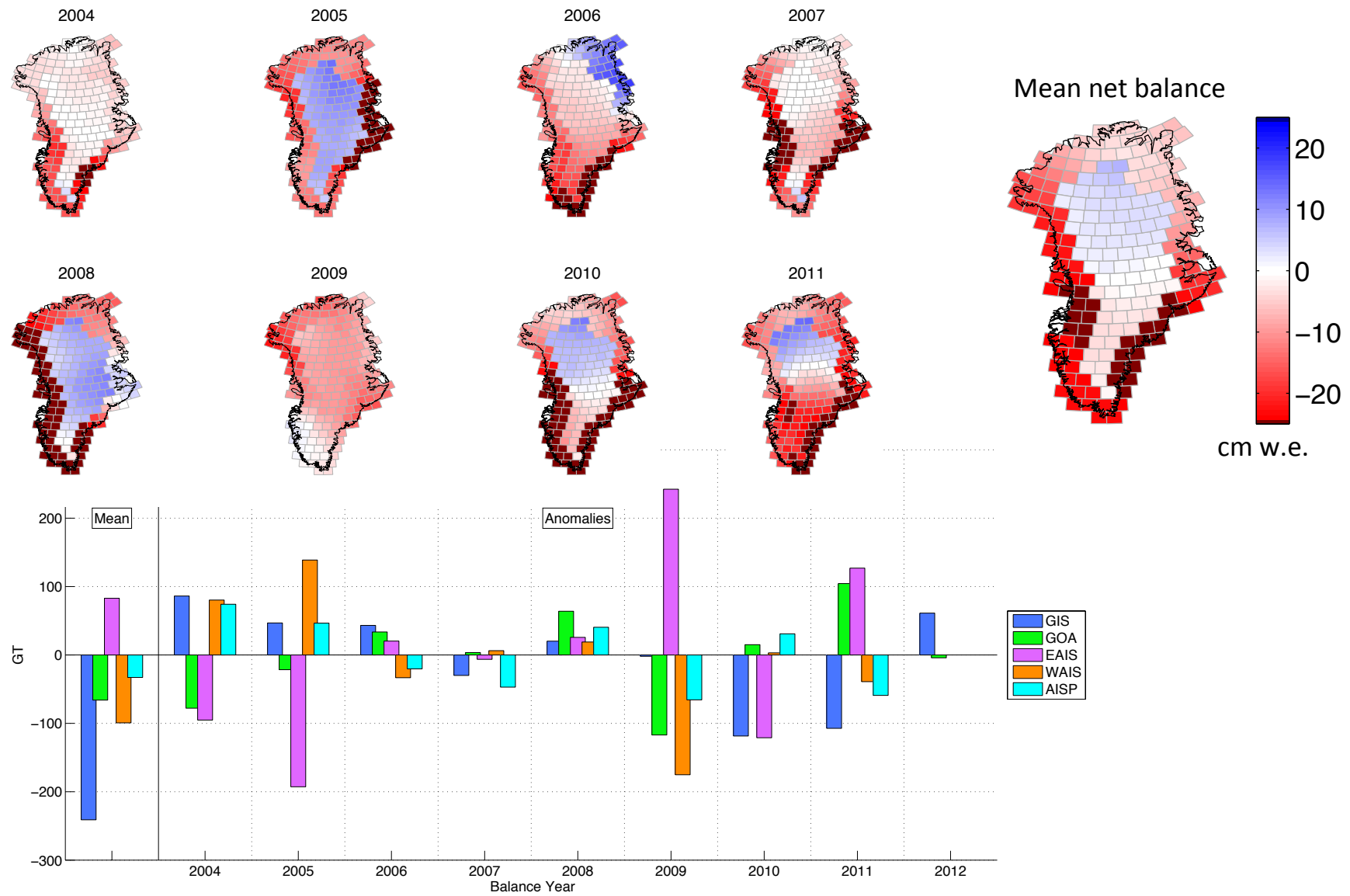


# Mass time series and balance season timing from EEMD application to mascon solution: RL01 V12



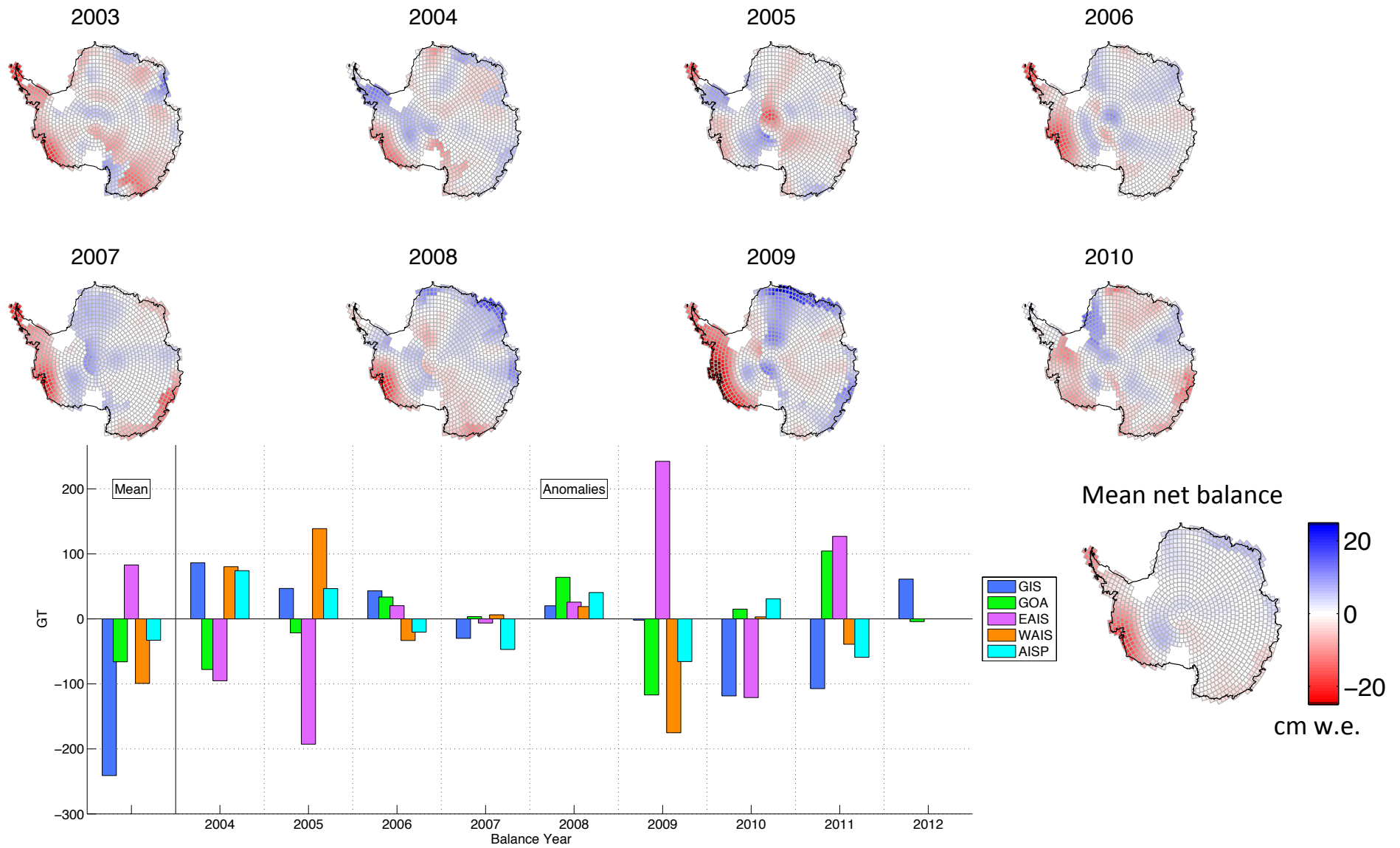


# Greenland Ice Sheet RL02 v04 net balances (Paulson ICE-5G GIA applied)





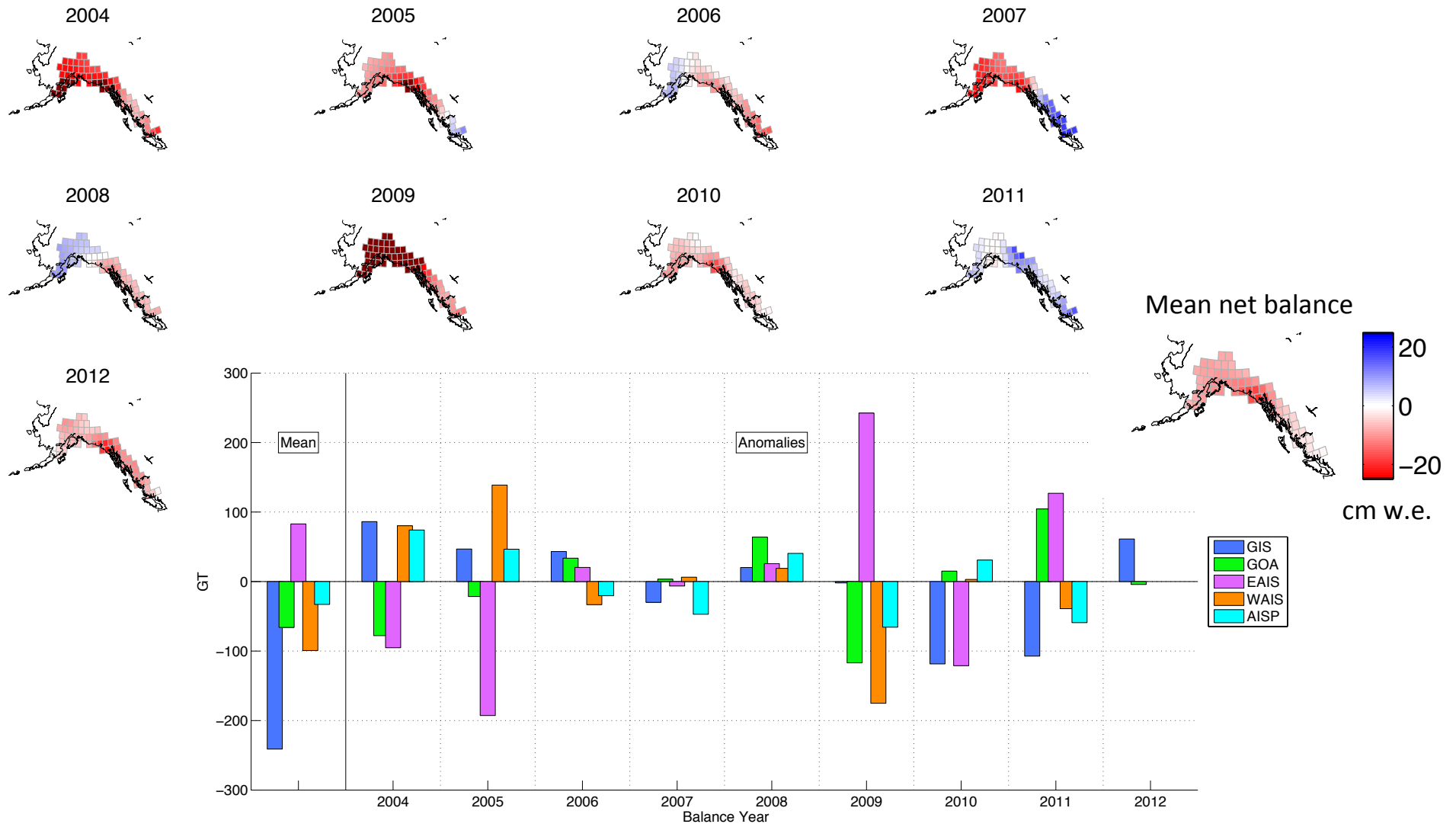
# Antarctic Ice Sheet RL02 v04 net balances (IJ05\_R2 GIA applied)



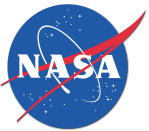




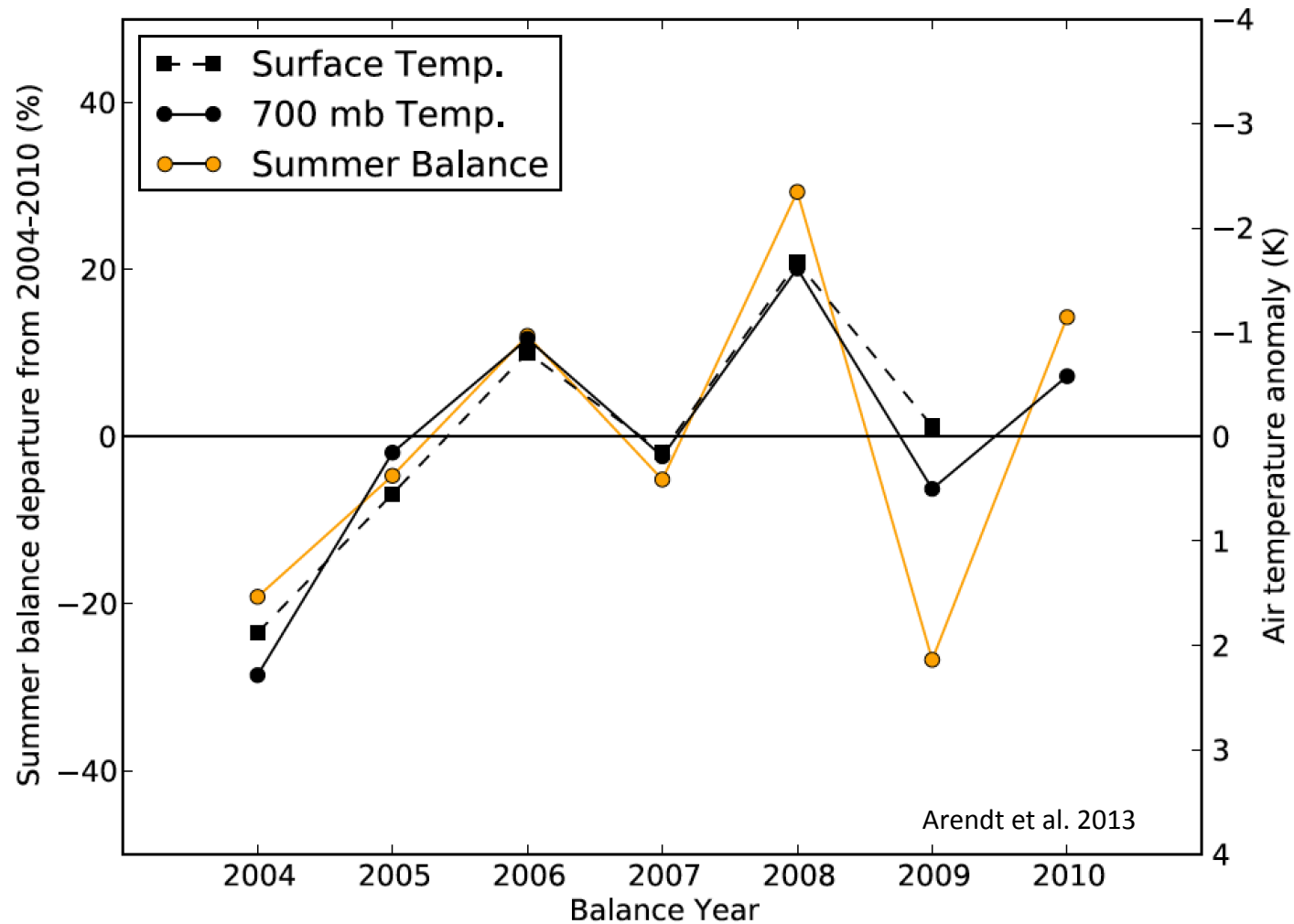
# Gulf of Alaska RL02 v04 net balances (Paulson ICE-5G GIA and Larson LIA applied)





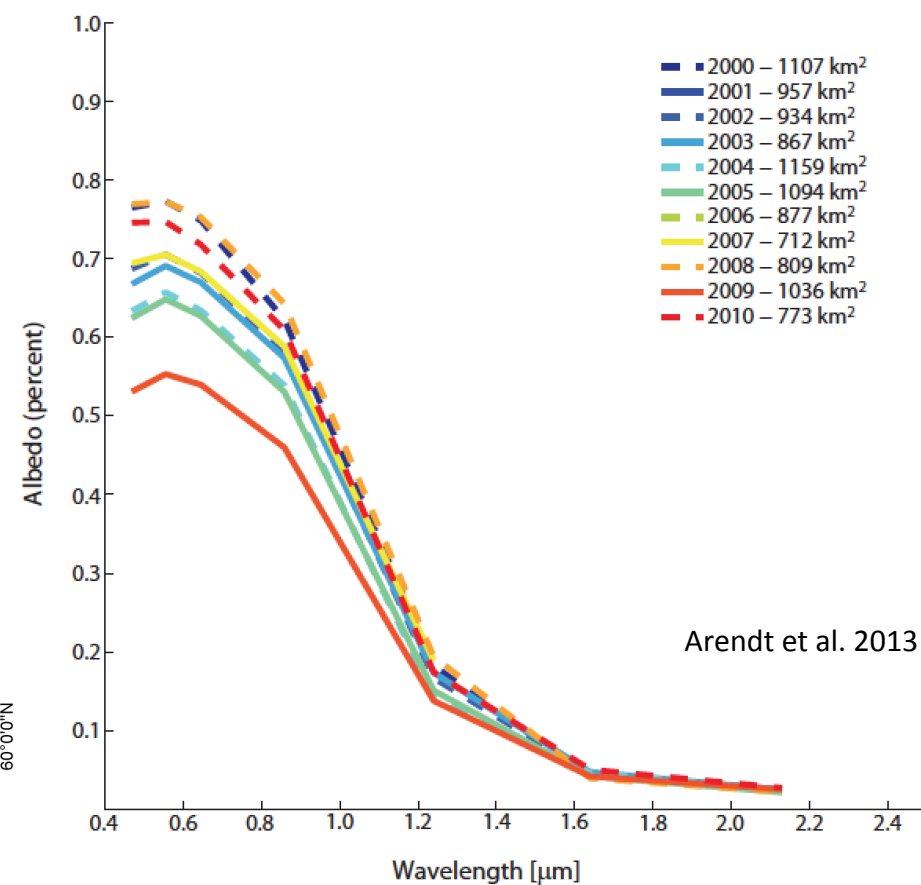
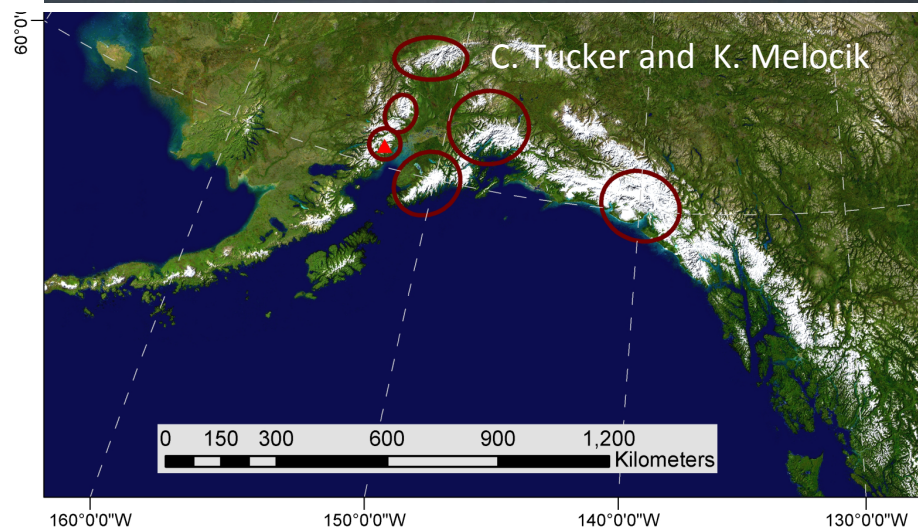


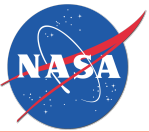
## GoA mascon summer balance anomaly vs. air temp. anomaly





## Mount Redoubt eruption; Mar. 22 – Apr. 4, 2009





## GOA area-averaged mass balances from GRACE and ICESat

