

Acceleration of ice sheet mass losses from GRACE: trends and uncertainties

Isabella Velicogna^{1,2}

1 -- University of California Irvine 2 -- JPL

Co-Authors:

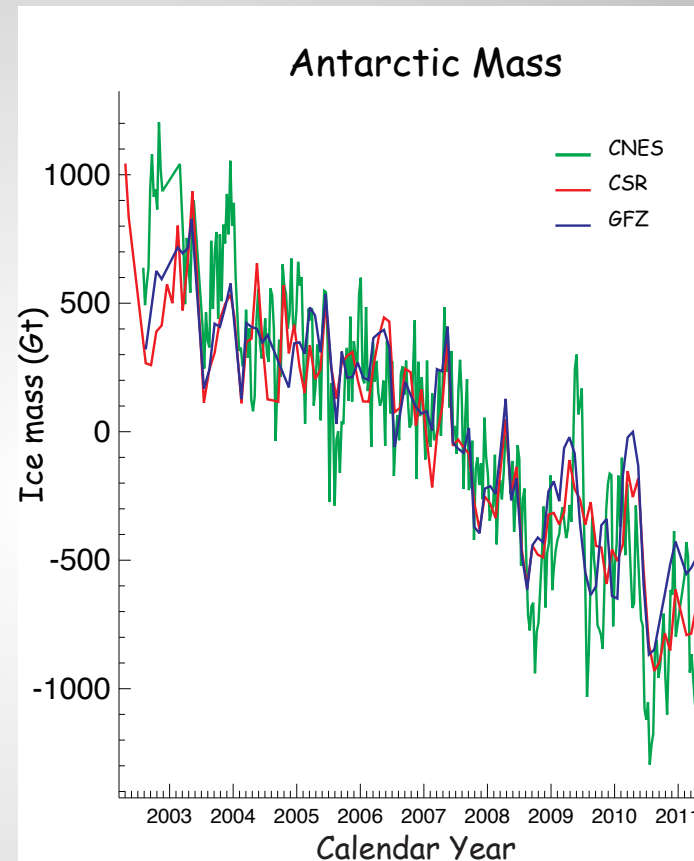
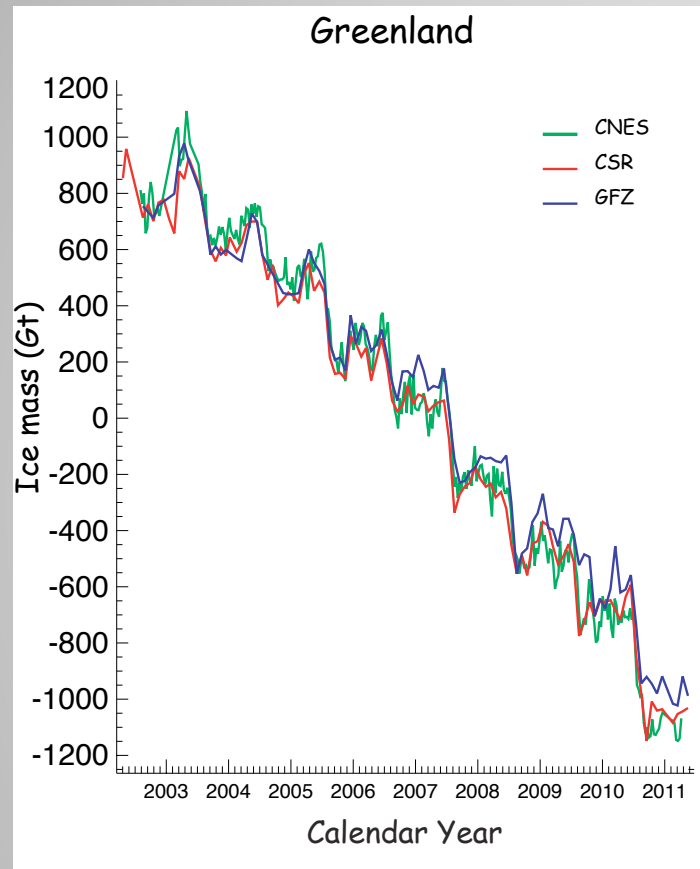
Tyler Sutterly, John Wahr, Michiel van den Broeke

Potential errors in GRACE mass balance estimates post processing errors

Table 2. Error Sources and Their Estimated Magnitudes^a

Error Source	AIS (Gt/yr)	GIS (Gt/yr)
Atmosphere	± 2	± 2
Ocean circulation	± 20	± 0.05
Scaling	± 3	± 29
GIA IJ05_R2	71 ± 39	-2 ± 21
GIA ICE5G	141 ± 72	9 ± 19
Omission of $l = 1$ terms	38	-9
Use of original C_{20} terms	40	8
GIC leakage	-	13 ± 2
Hydrology leakage	± 2	± 1
Omission of eustatic ocean	8	10
Measurement error	± 28	± 8

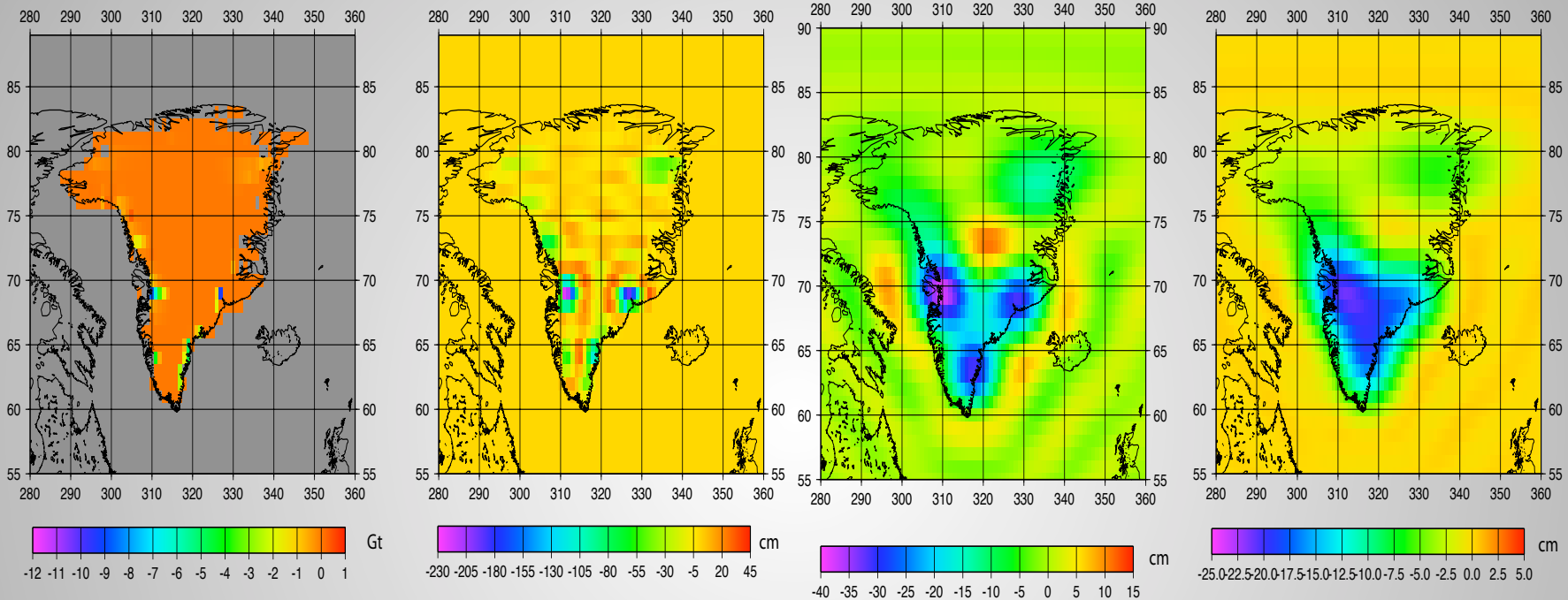
Comparison of solutions from different centers:



Overall different solutions agree within the error bars

Main difference with CNES-GRGS are determined by C20

Impact of truncation and smoothing total mass loss



Input signal :

$\lambda/2$: ~50 km

-263 Gt

lmax = 150

$\lambda/2$: ~130 km

Smoothing R=0

-211 Gt

Loss ~20%

lmax = 60

$\lambda/2$: ~330 km

Smoothing R=0

-180 Gt

loss ~32%

lmax = 60

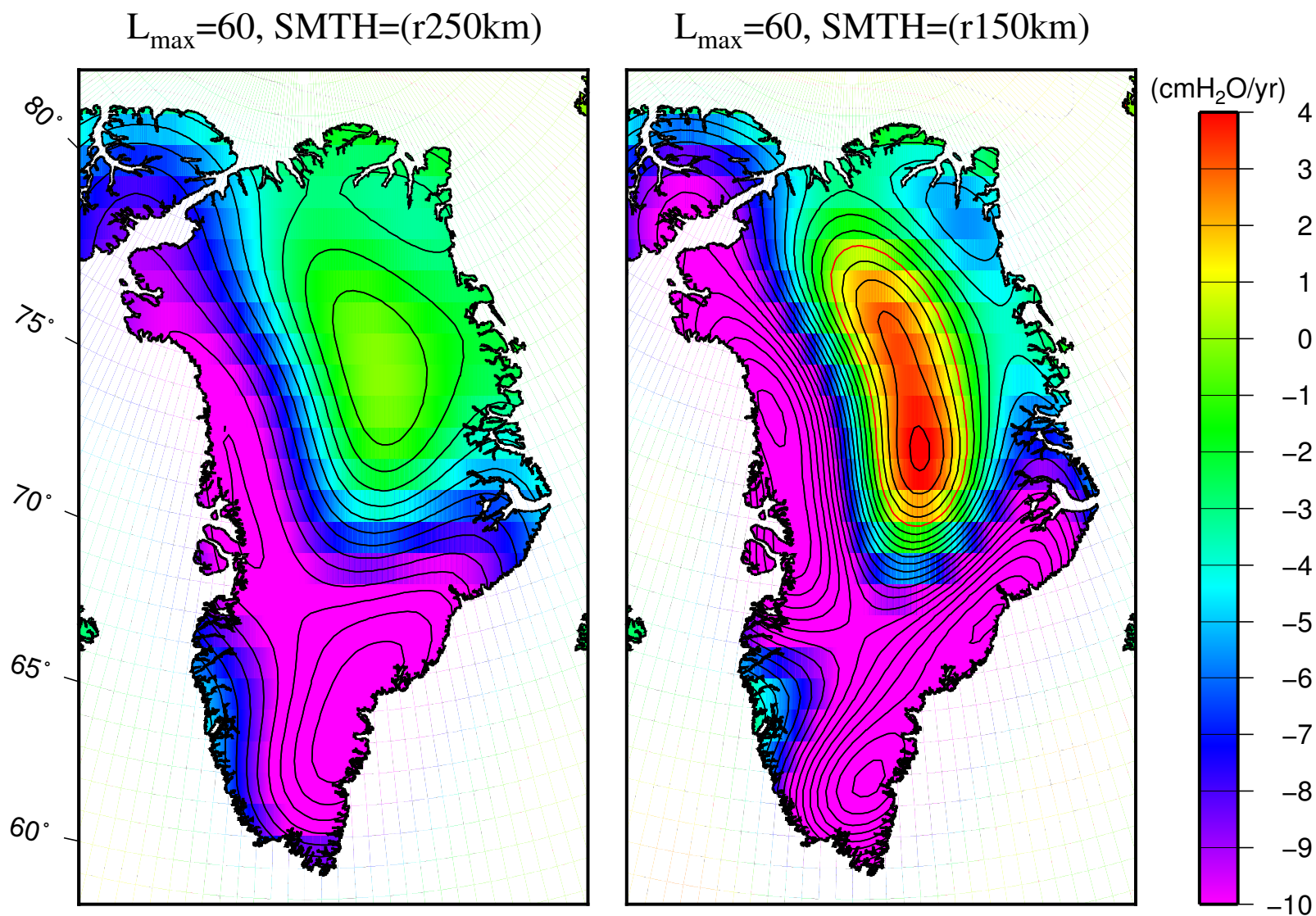
$\lambda/2$: ~330 km

Smoothing R=250

-153 Gt

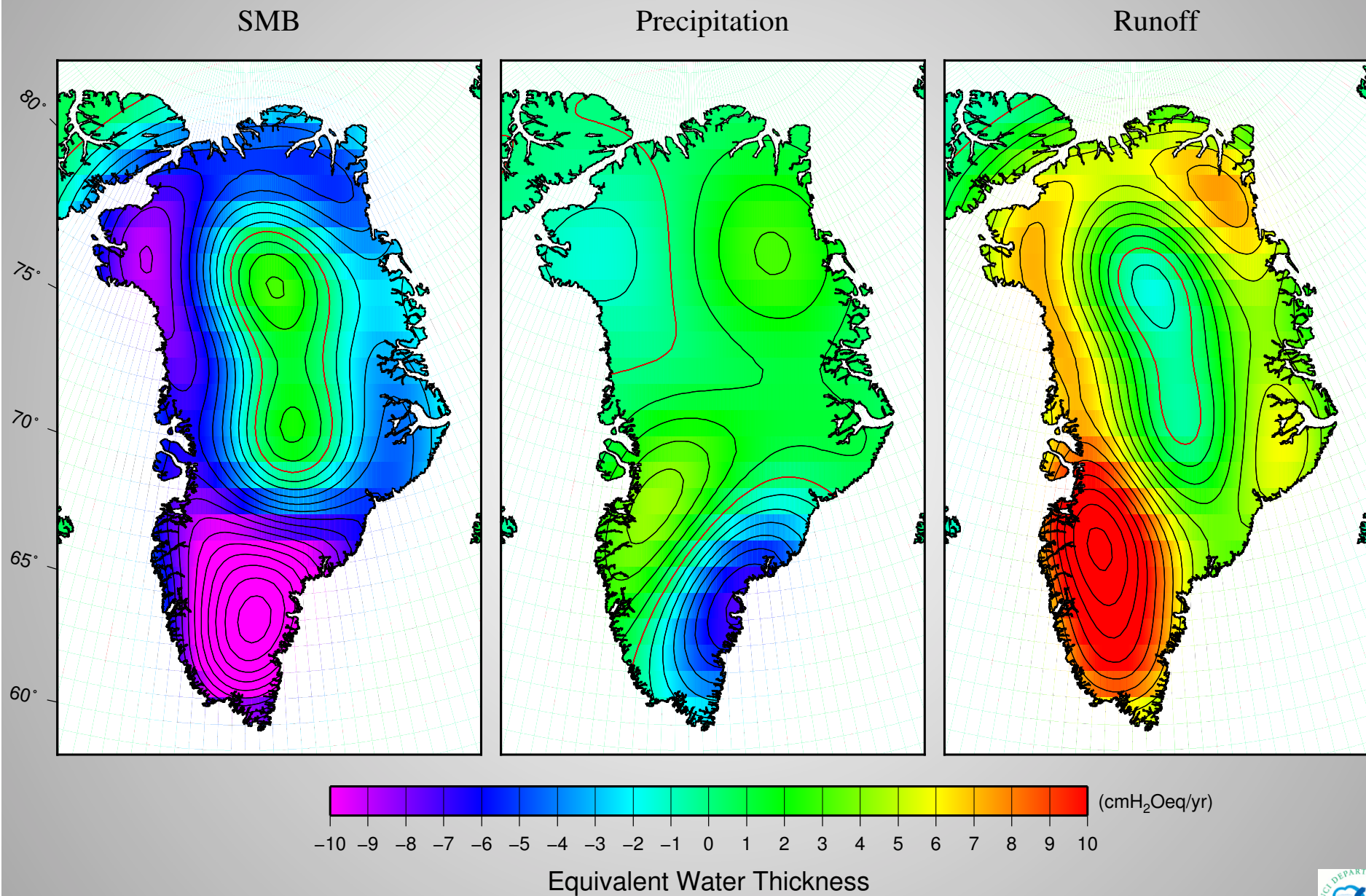
loss ~42%

GRACE ice mass trend 2003-2012

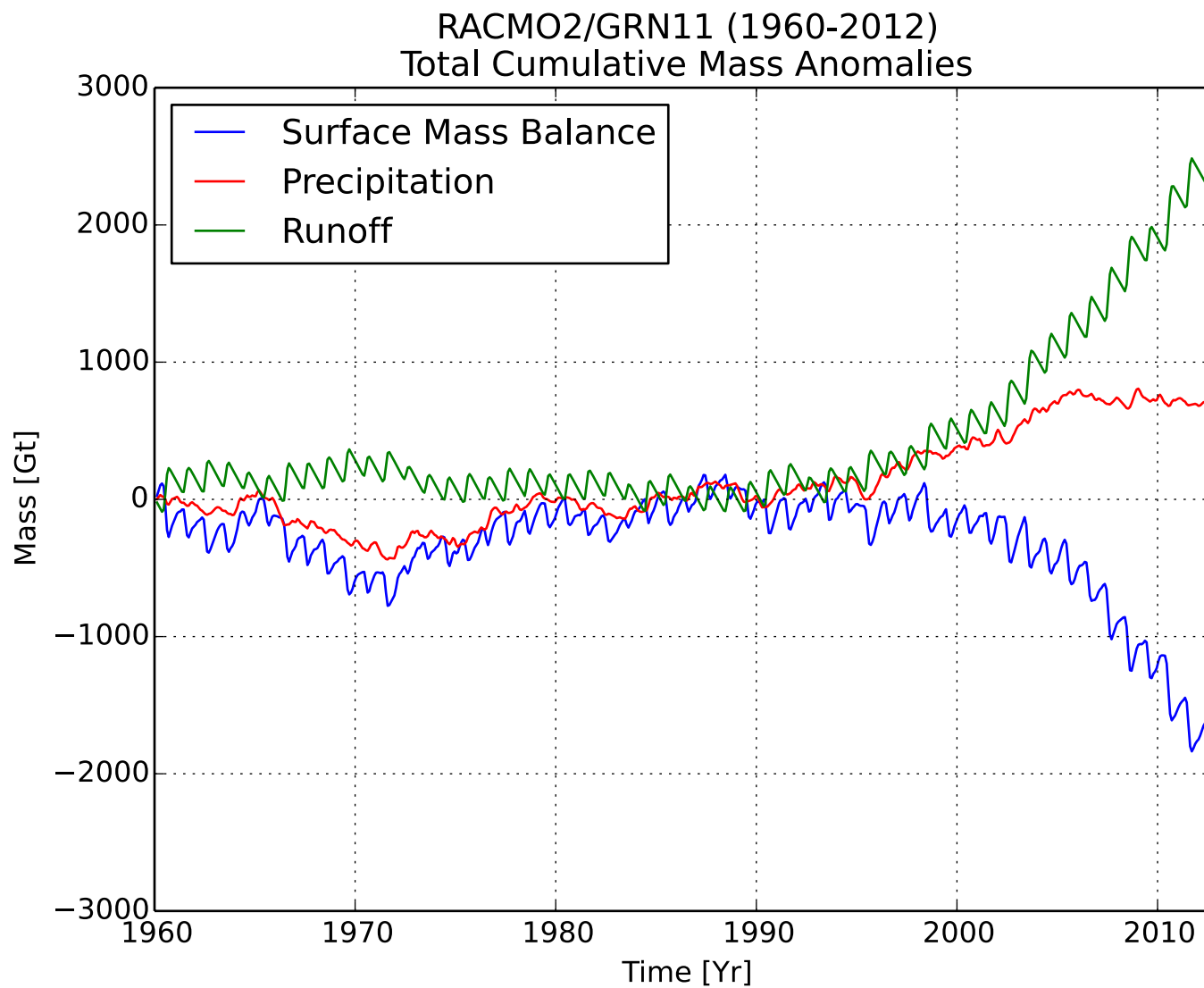


Figures corrected for GIA using Simpson–Milne (2009)

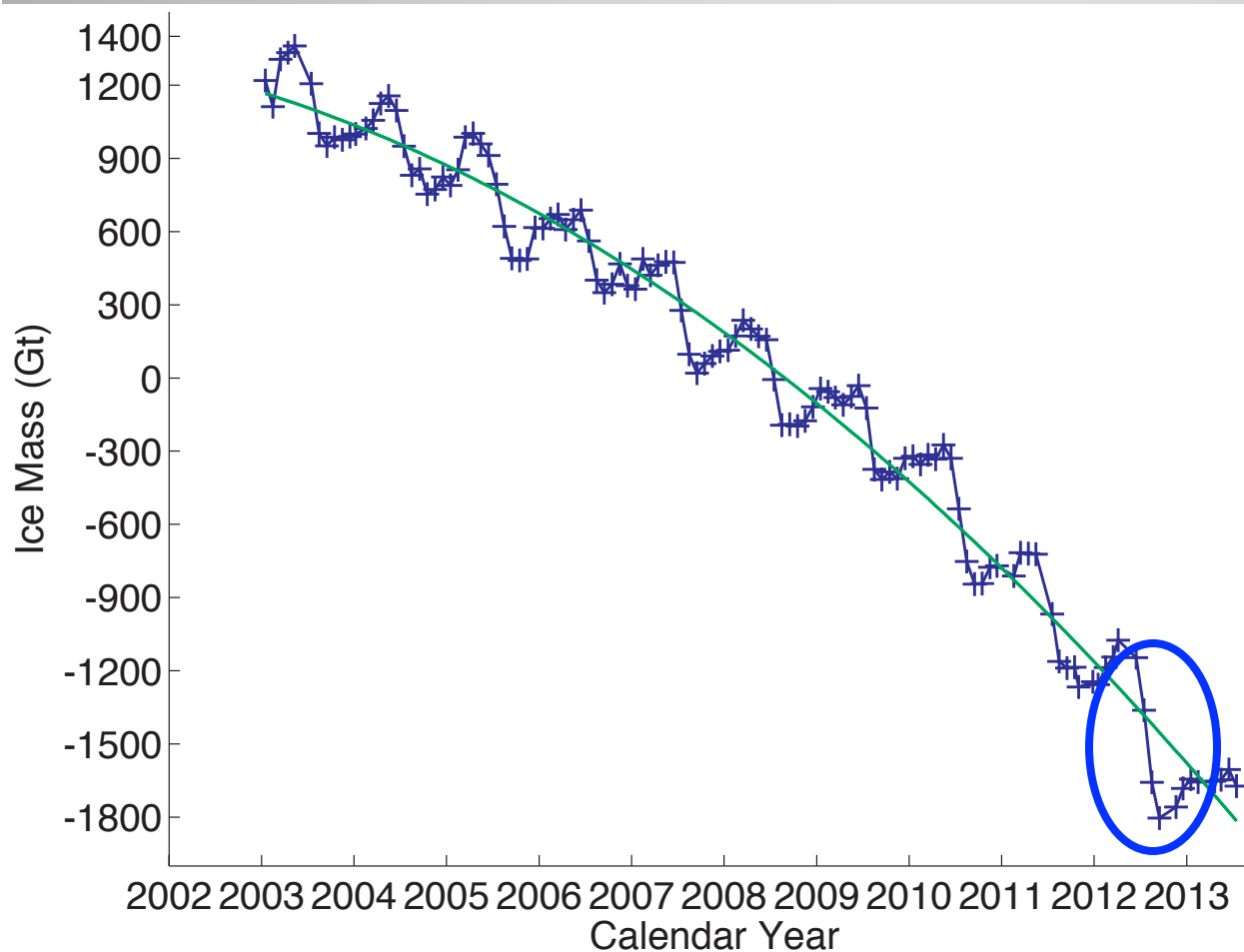
RACMO SMB ice mass trend 2003-2009 (R=150 km)



GREENLAND SMB



GREENLAND ICE MASS LOSS FROM GRACE



RL05

Trend Jan 2003-Jul2013:
 $-258 \pm 33 \text{ Gt/yr}$

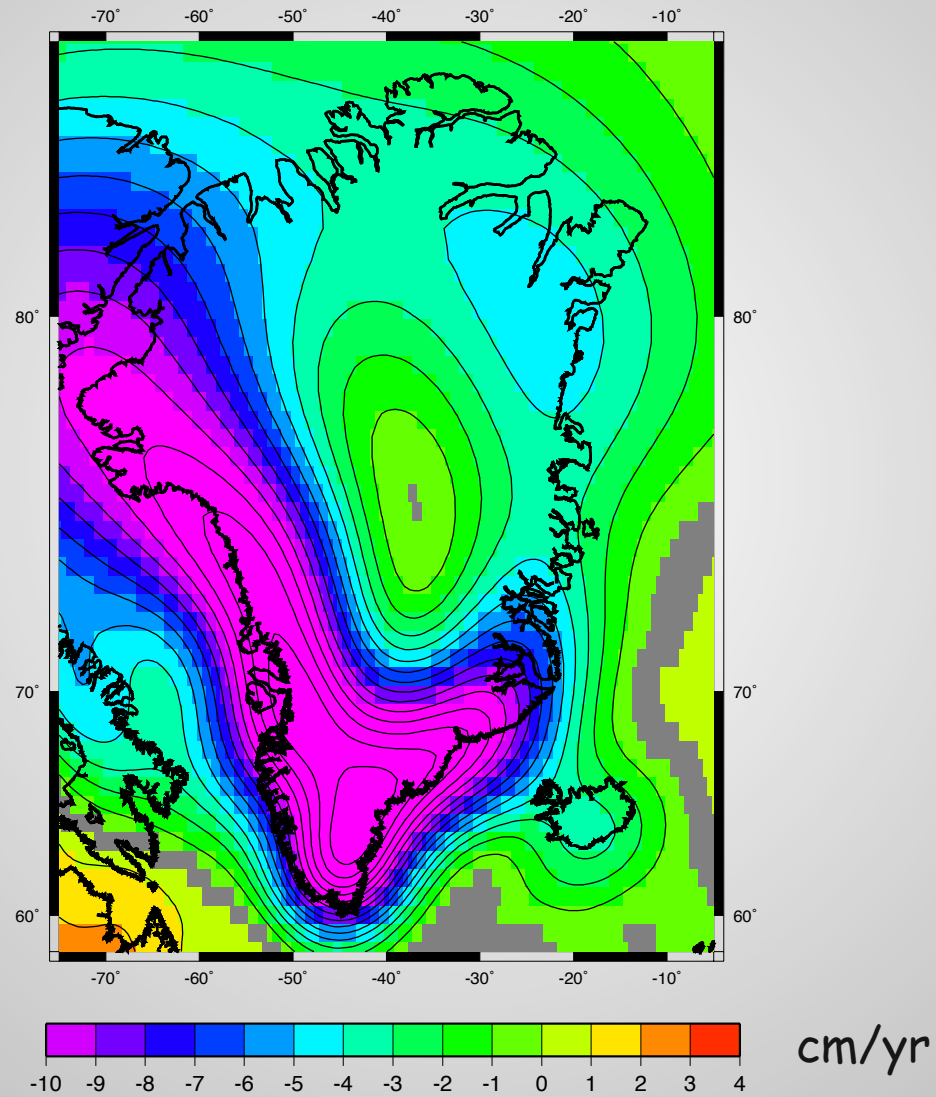
GIA: Simpson 2009

ACCELERATION: $-31 \pm 8 \text{ Gt/yr}^2$

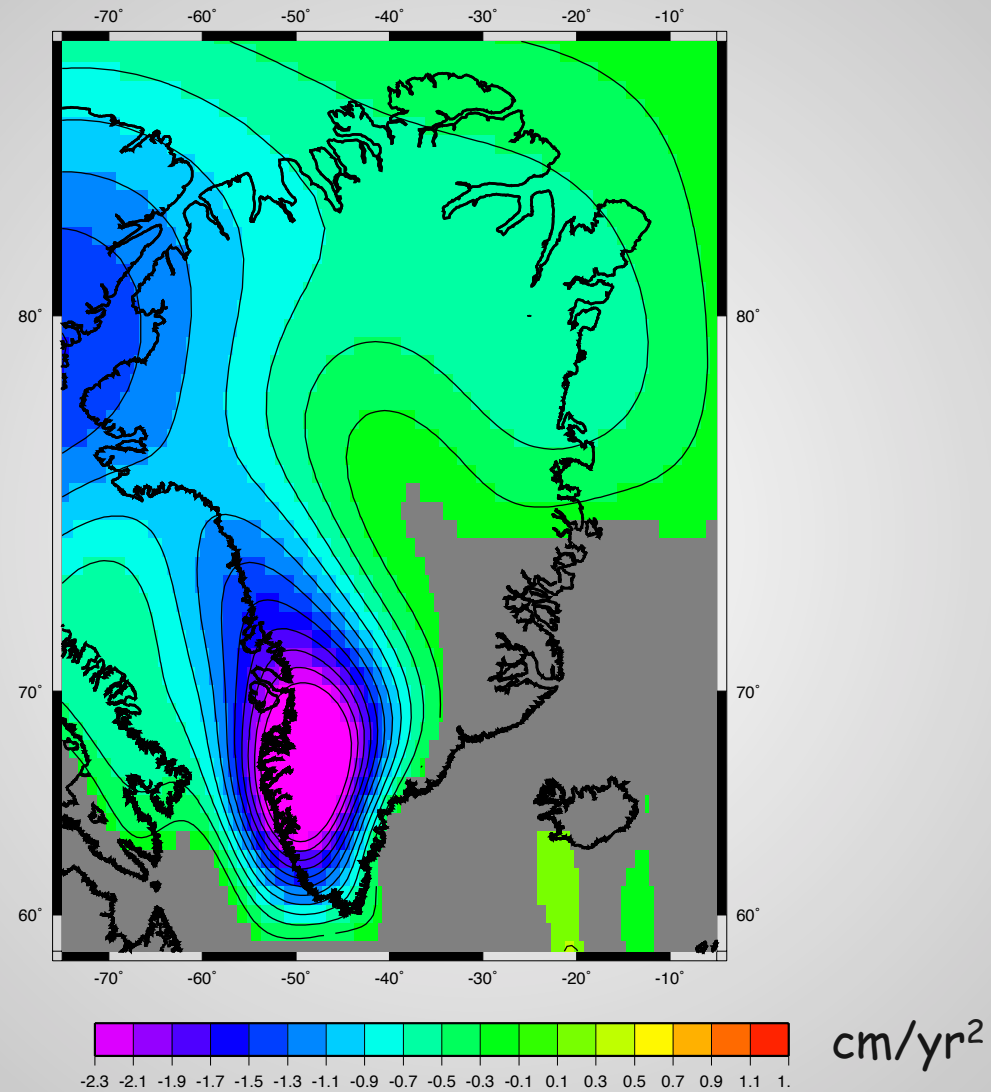
$R^2_{\text{adj}}(\text{quadratic})=0.99$

~ 700 Gt

Ice mass Trend (Jan 2003-Jul 2013)

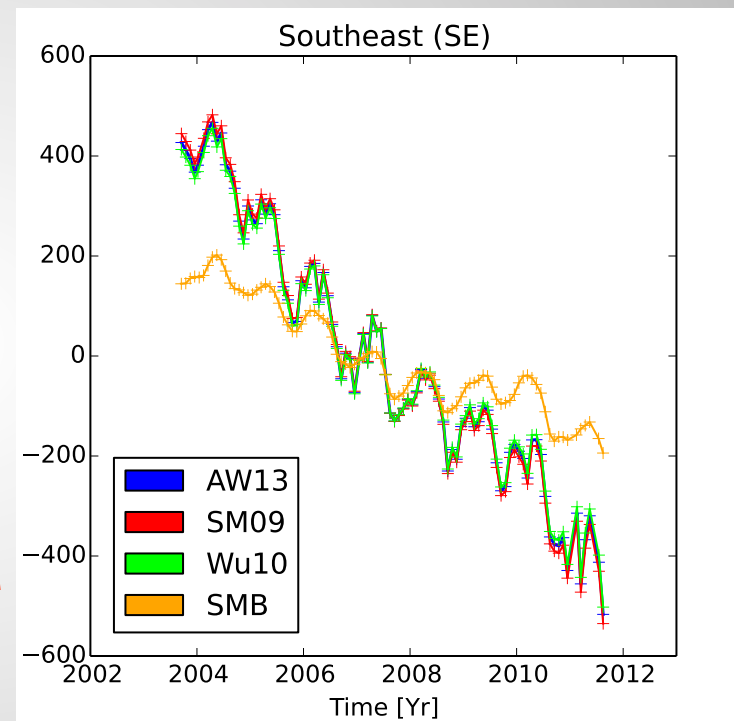
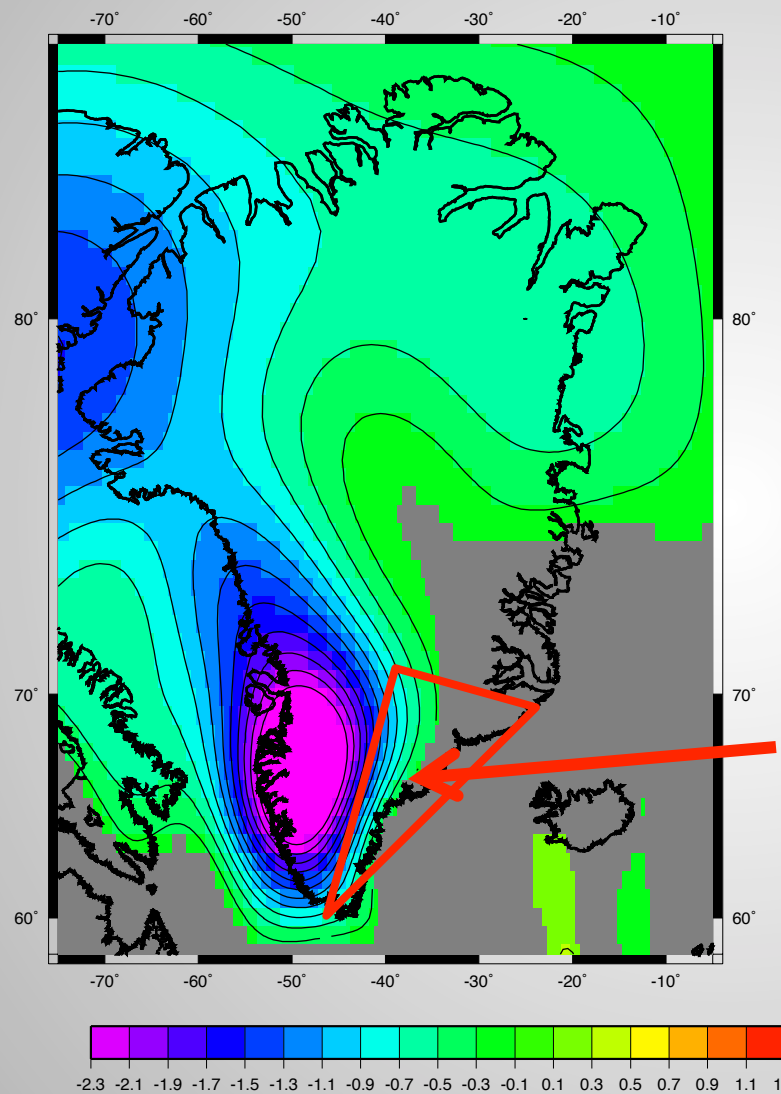


Acceleration (Jan 03-Jul 13)



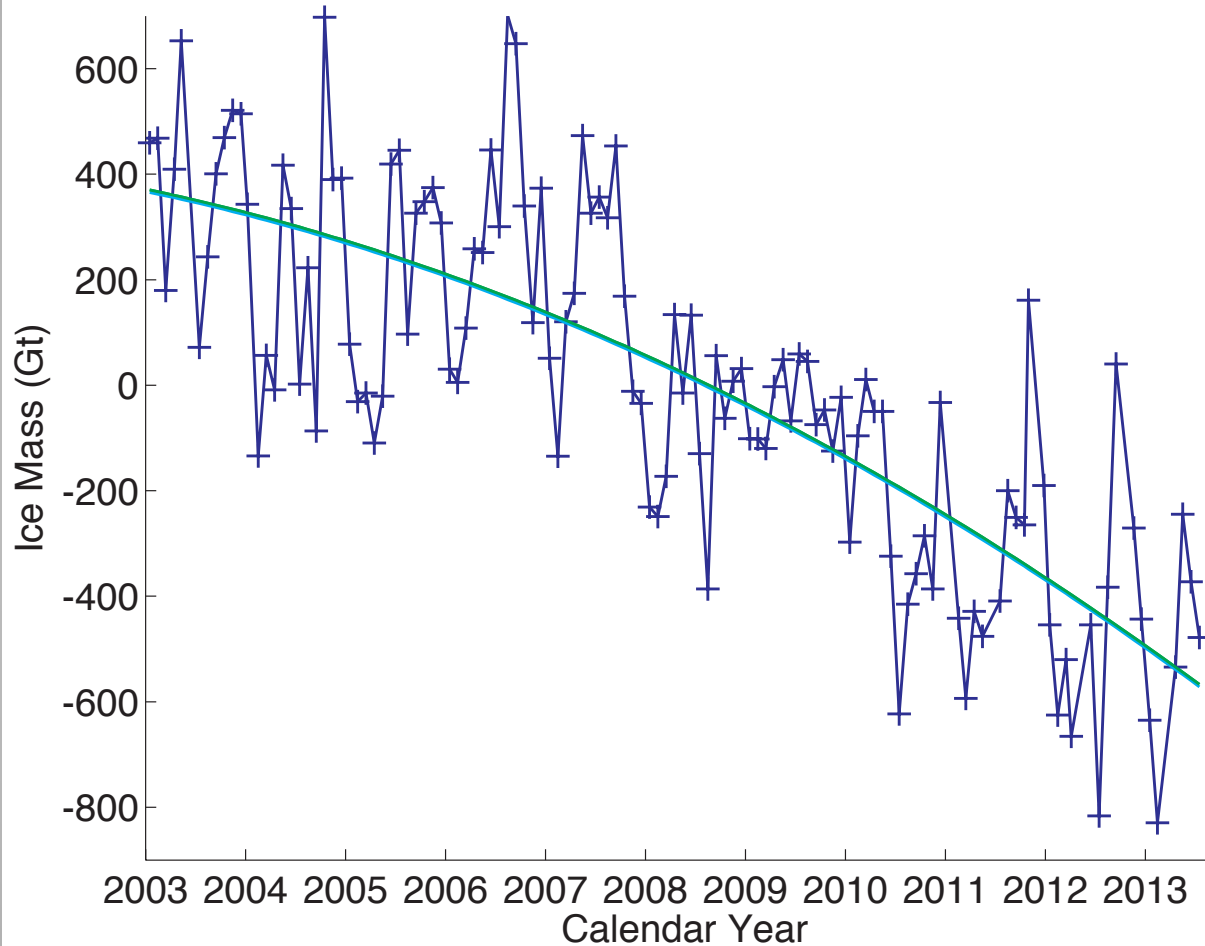
Velicogna et al. 2013

Acceleration



Velicogna et al. 2013

ANTARCTICA



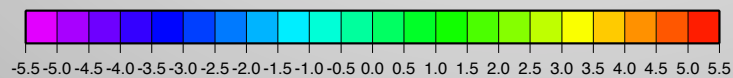
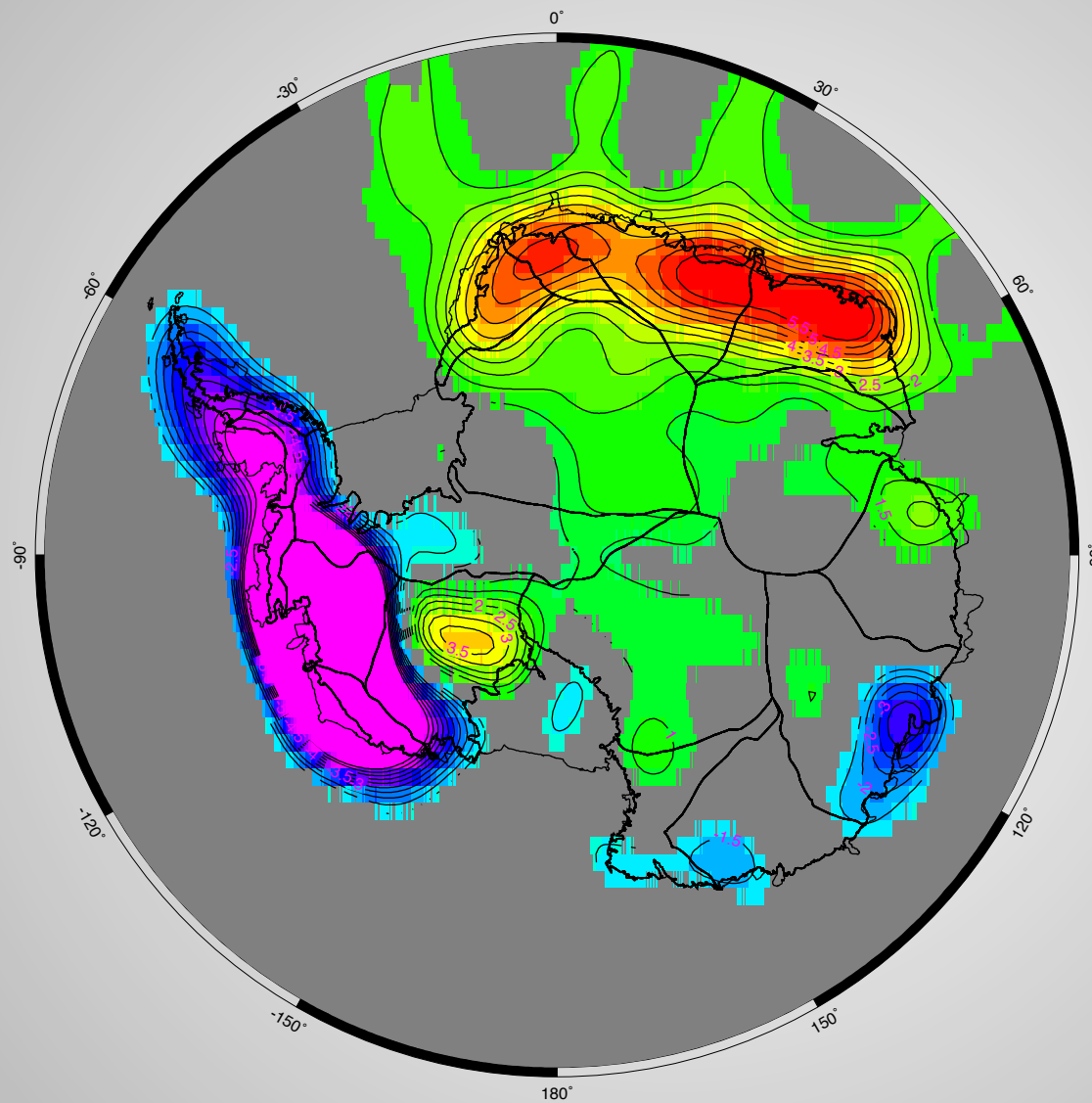
RL05

Trend Jan 2003-Jul2013:
 $-83 \pm 49 \text{ Gt/yr}$

GIA: IJ05-R2

ACCELERATION: $-10 \pm 8 \text{ Gt/yr}^2$

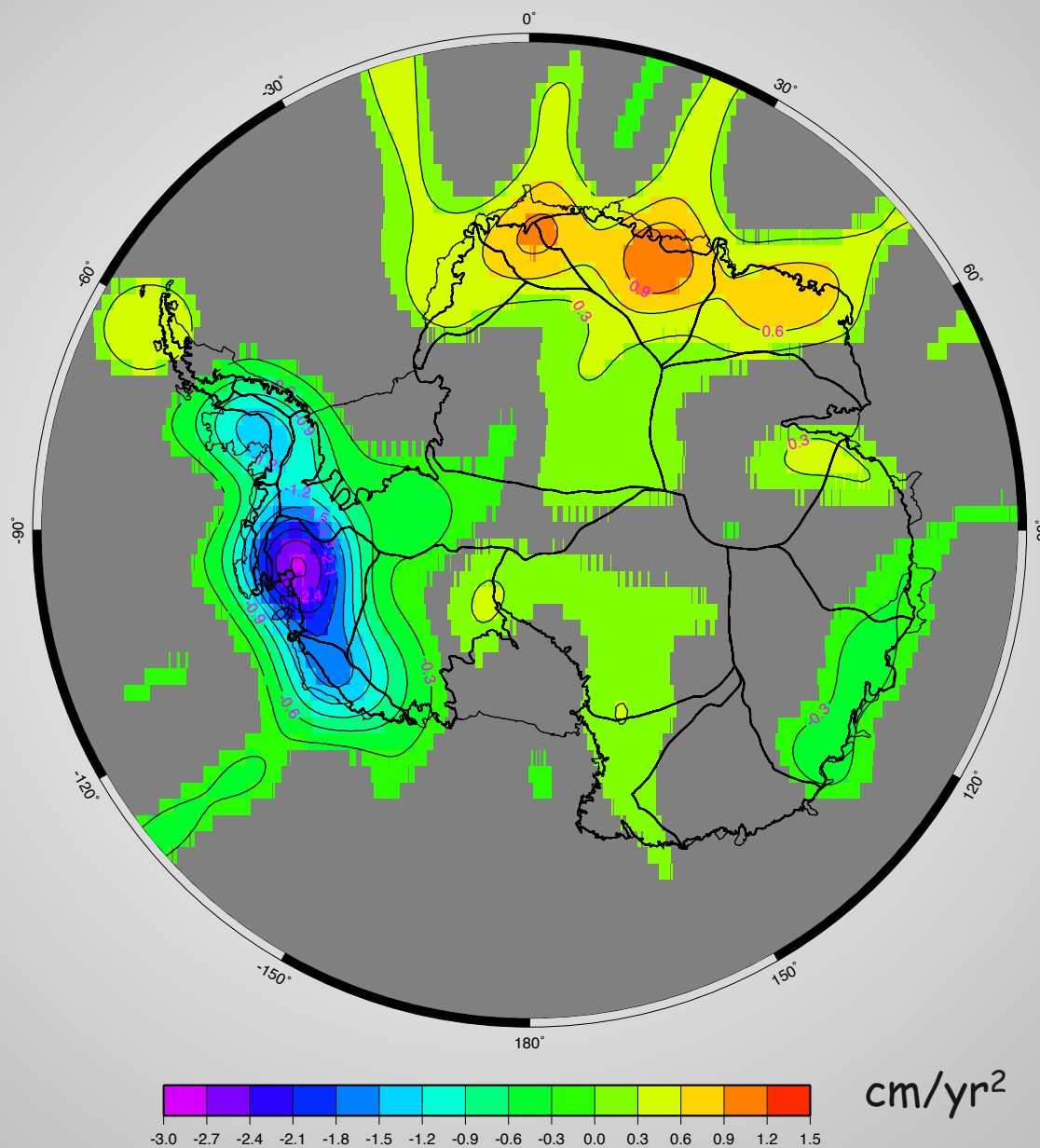
Ice mass Trend (Jan 2003-Jul 2013)



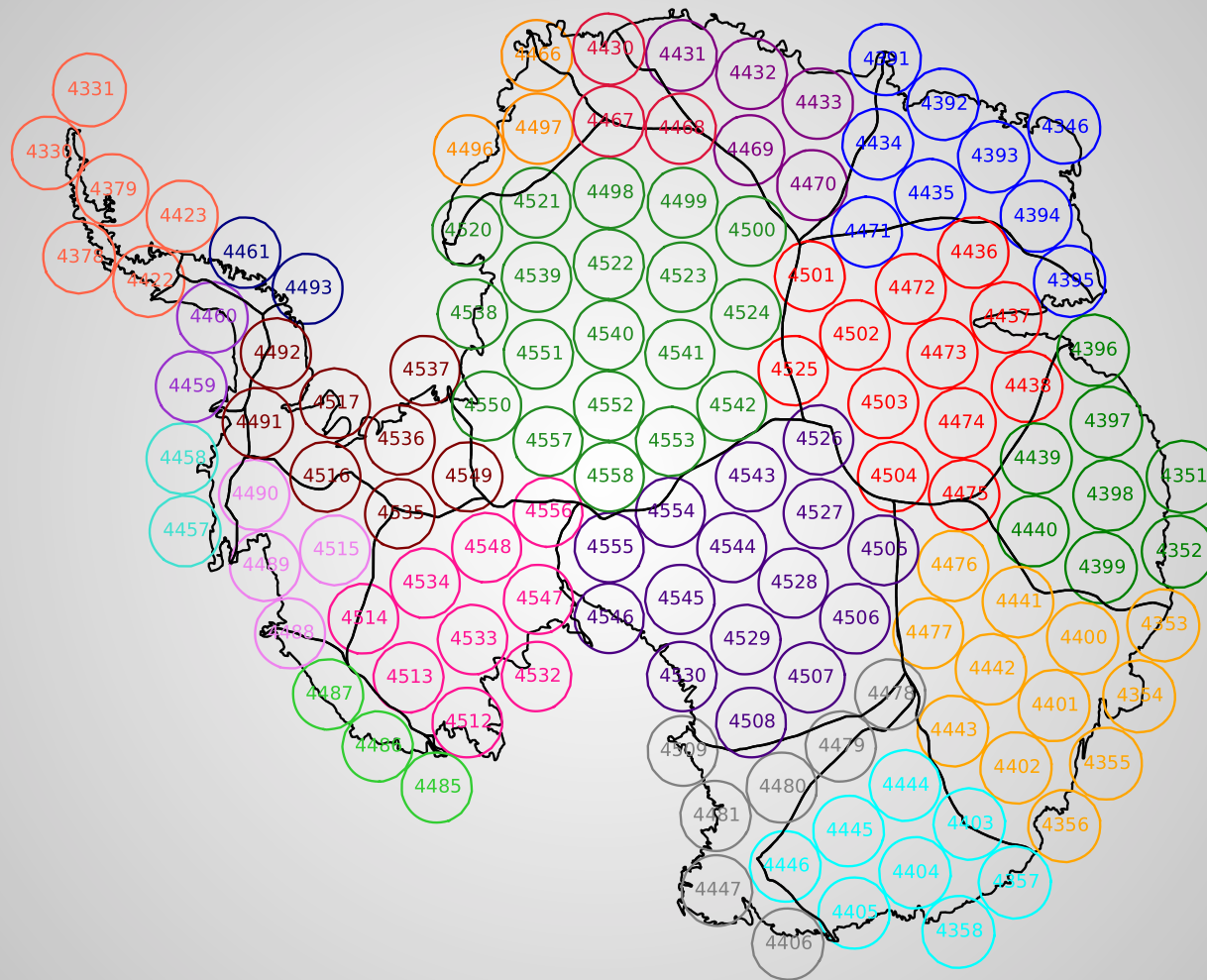
cm/yr

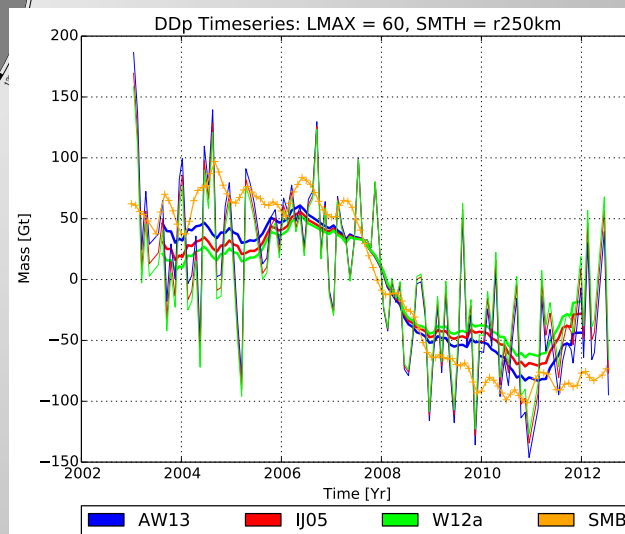
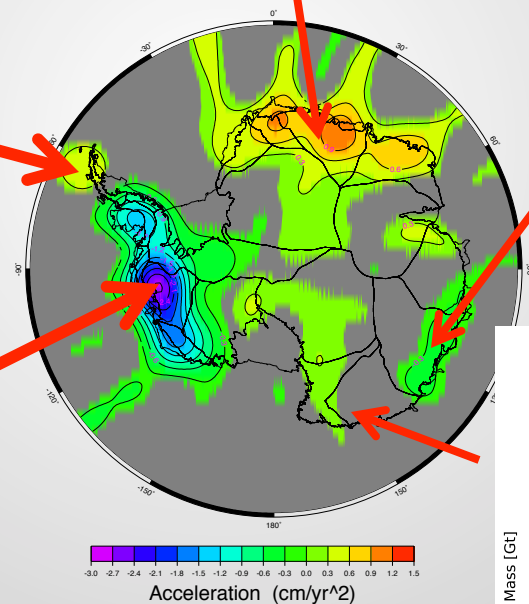
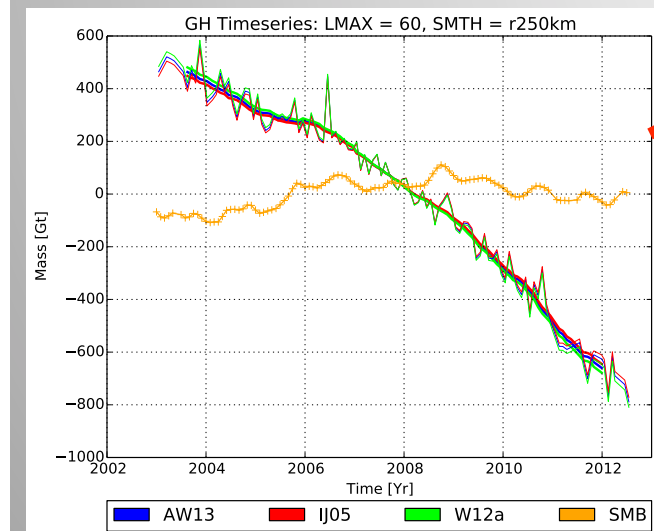
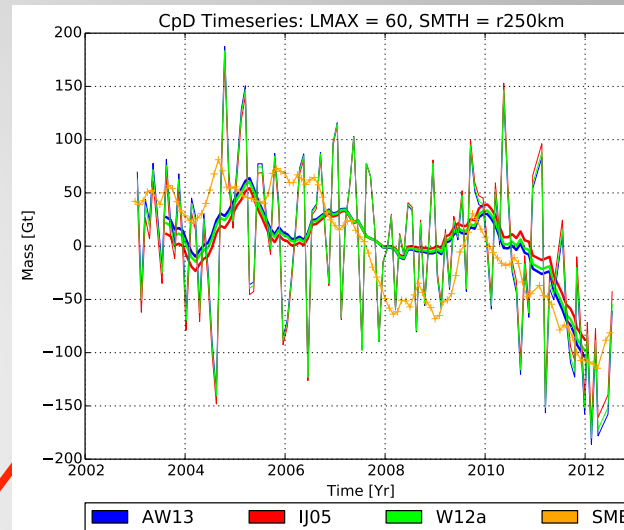
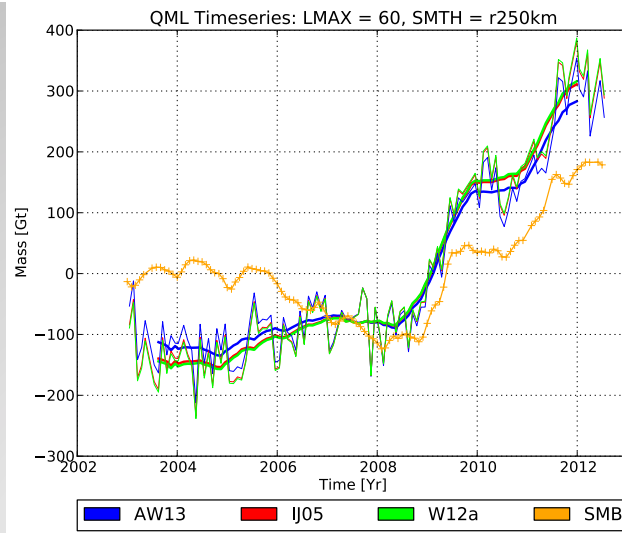
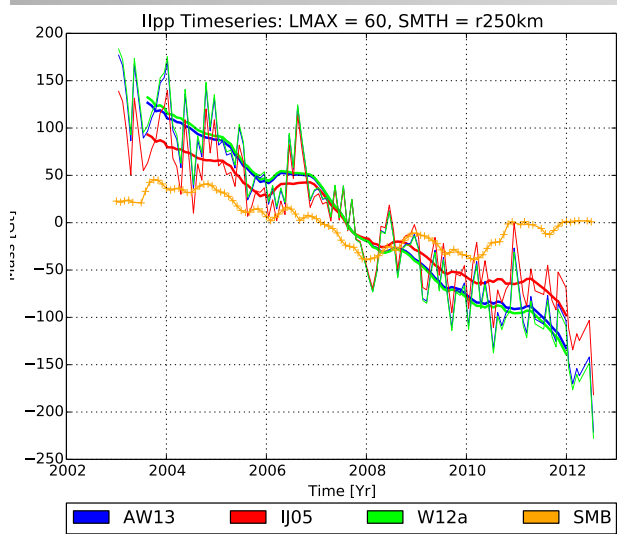
Velicogna et al. 2013

Acceleration (Jan 03-Jul 13)



Antarctica Spherical Cap





CONCLUSIONS

We made progress in estimating error budget for GRACE ice mass balance estimates.

We are now getting regional detail in ice mass losses using the mascon approach.

We find excellent agreement between different center solutions.
CNES-GRGS C20 generates differences for the GRGS estimates

It is very important to interpret our GRACE results in light of observations of the critical processes such as ice discharge and surface mass balance, and of independent observations.

We are able to detect statistically significant areas of acceleration in mass change, e.g. Pine Island Glacier, Queen Maud Land, NW Greenland, SW Greenland error on those estimates will decrease with longer time series.

In Antarctica, we detect ongoing, increasing dynamic losses in the Amundsen Sea, enhanced SMB in Queen Maud Land, and a temporal variability in SMB in Cook Ice Shelf area. and in the Totten region

