Regionally Optimized GRACE Processing on Totten and Moscow University Glaciers

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GRACE Science Team Meeting 2017

http://phys.org/news/2012-03-gravity-climate-years-satellites.html

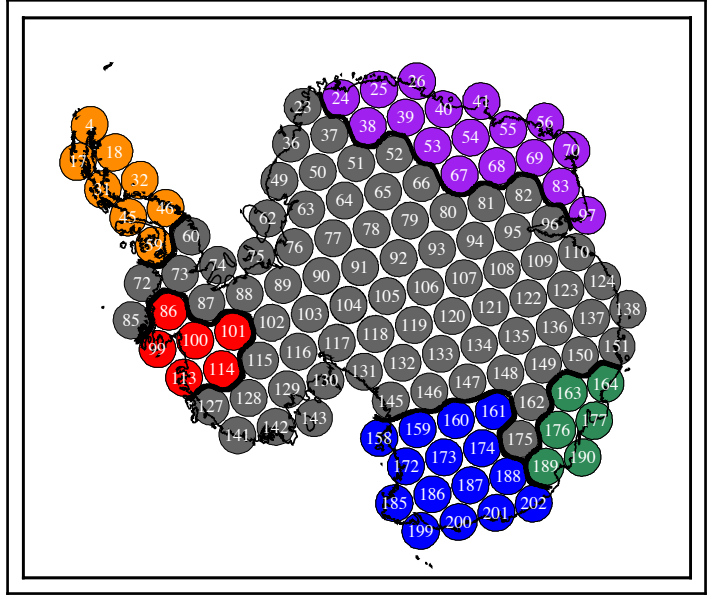
Overview / Science Goals

- Regionally-optimized processing of GRACE harmonics based on geophysical signal to evaluate glacier mass balance at a sub-basin level.
- Evaluate surface mass balance (SMB) from regional climate models and Mass Budget Method estimates
- Focus on Totten Glacier
  - Largest Discharge in East Antarctica - Grounding line flux of 71±3 Gt/yr in 2003-2008 [*Rignot et al.,* 2013]; 3.9m sea level rise potential [*Li et al.,* 2015]
  - Located in the marine-based sector of East Antarctica with most of basin below sea level, extending hundreds of kilometers inland [*Young et al.*, 2011].
- Preliminary work on the Getz ice shelf and SW Greenland (dominated by SMB)

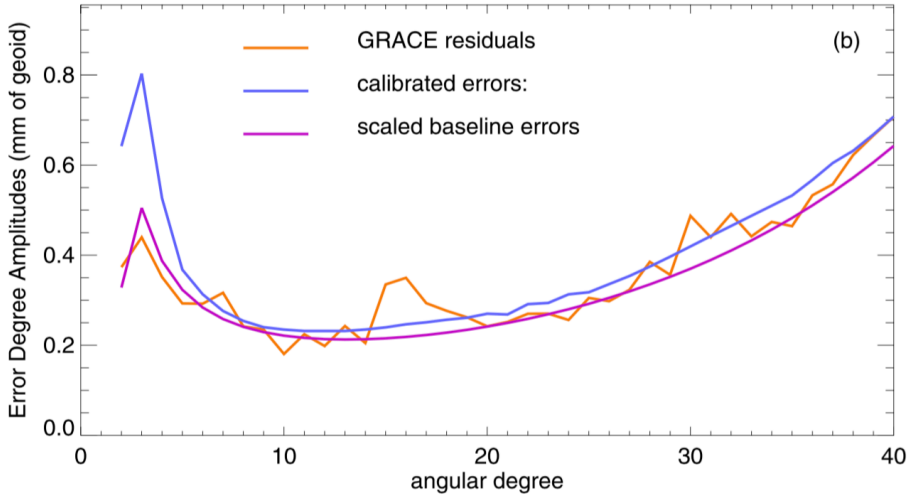
Optimized Harmonic Least-Squares Mascon Approach

- Spherical cap formalism [*Farrell*, 1972]:
  - *Sutterley et al.* [2014] and *Velicogna et al.* [2014]: 3-degree uniform-diameter spherical caps

- Optimization:
  - Size based on the signal to noise ratio (spatial resolution vs noisy higher harmonics)
  - Location and packing based on geophysical features to minimize leakage
    - Ideally uniform change in each cap, zero outside.

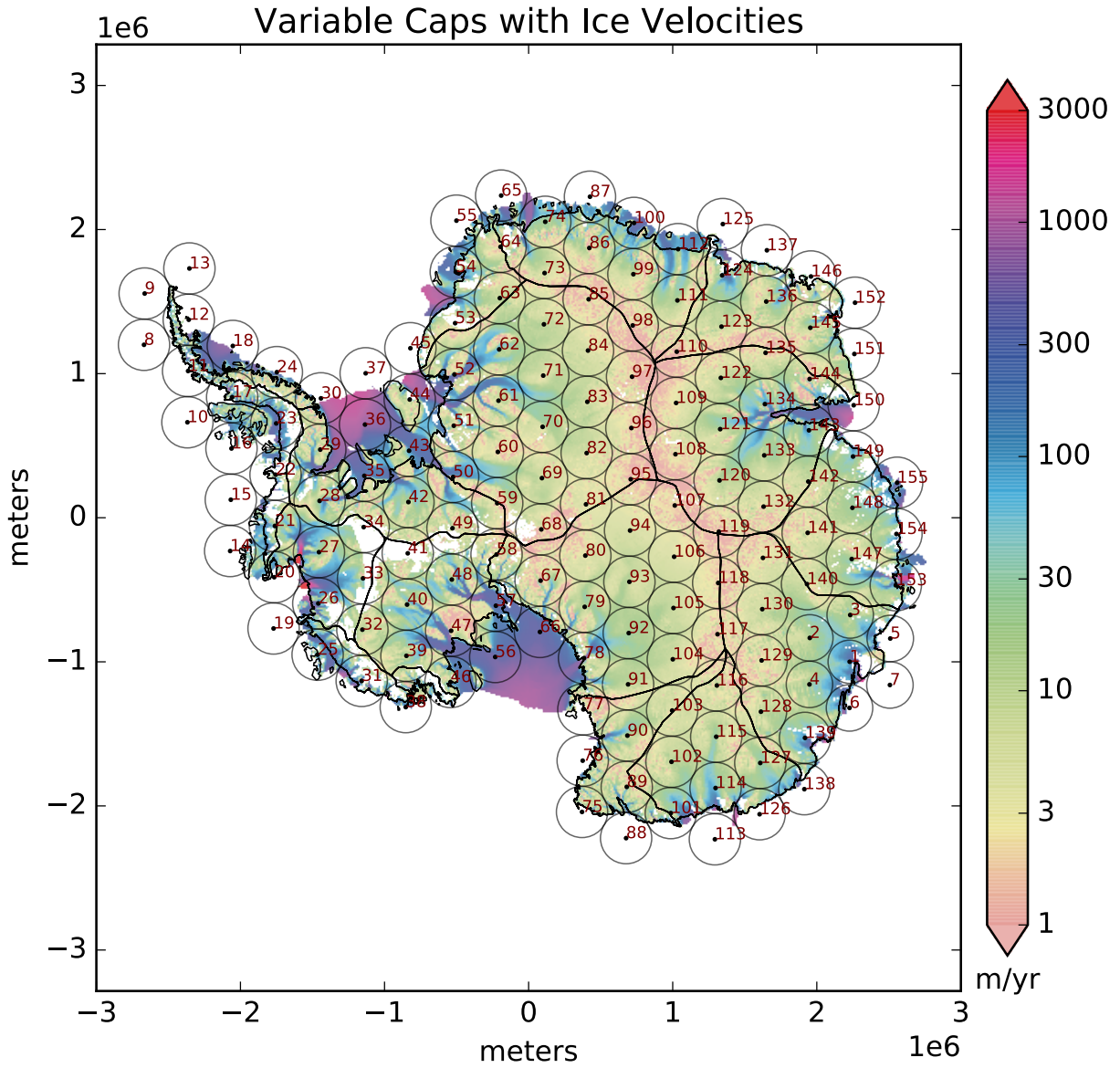


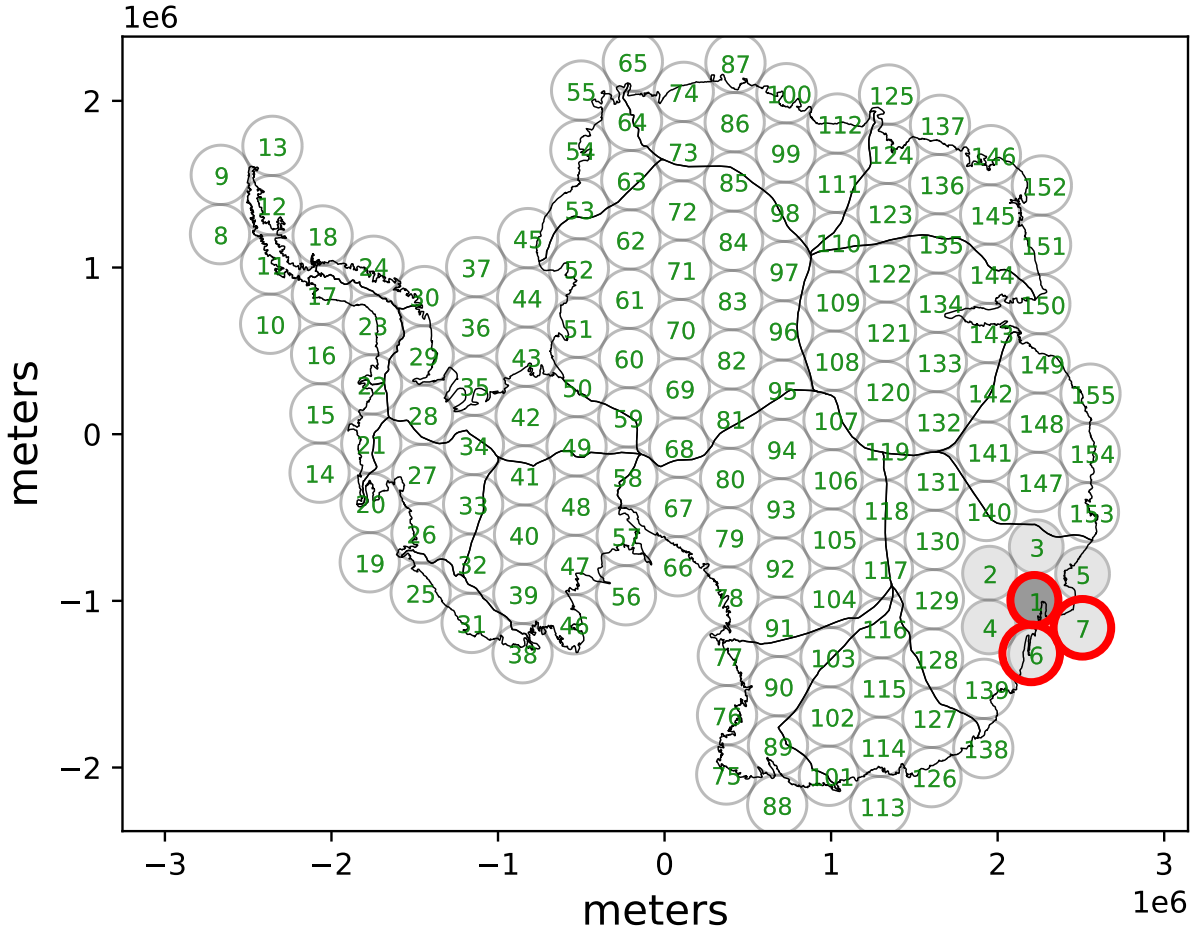
Velicogna et al. [2014] spherical caps for Antarctica



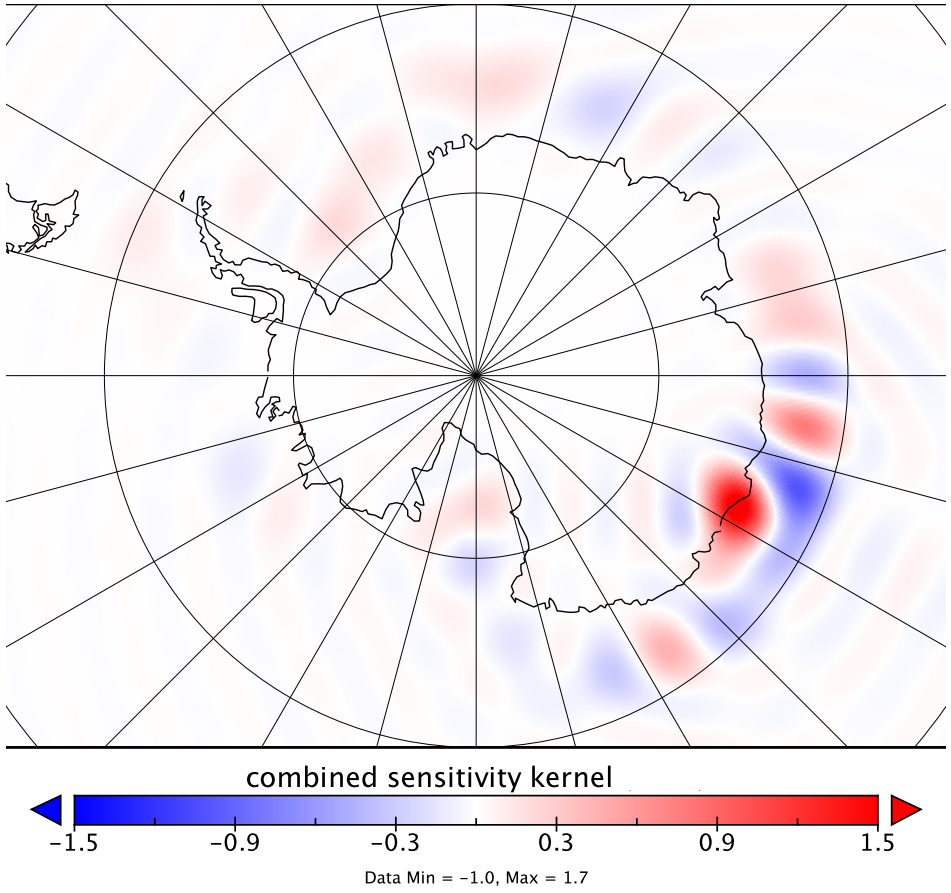
GRACE errors as a function of degree [*Wahr et al.*, 2006]

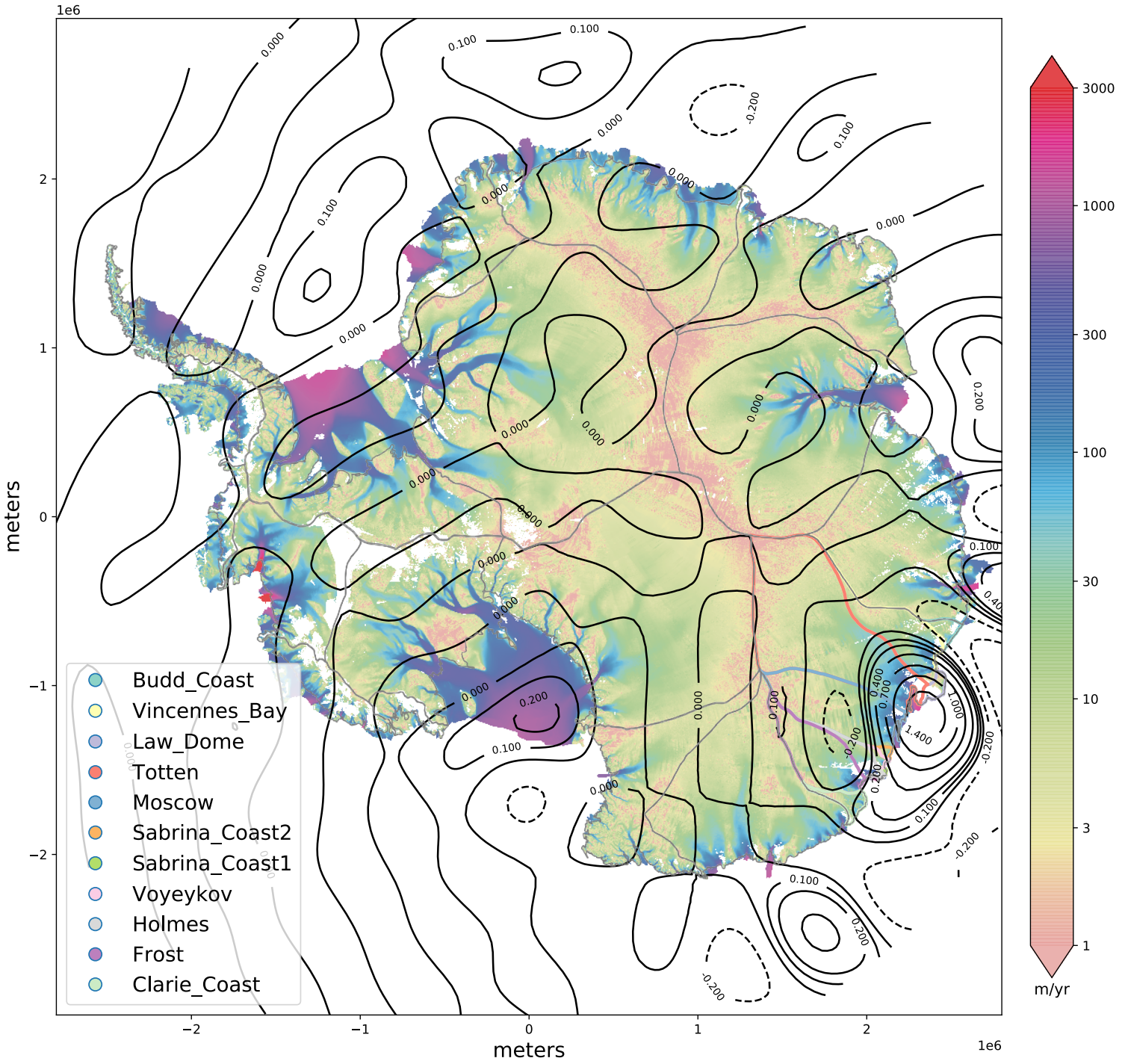
Three-layer hexagonal grid:
Diameters: 2.7° (dark gray), 2.9° (light gray) , 3.2° (white)





Sensitivity kernel





Quantifying Leakage:

- Divide synthetic field into spherical caps
- Fit each cap to all mascons in harmonic domain (“island solution”), also fit all the complementary caps to the mascons (“hole solution”)
- Recovered/Actual Mass for Totten: 100.7%

GIA, land-ocean leakage, and statistical errors:

- GIA fitted to masons and the range for different models used as error.
- Sea level fingerprint fitted to mascons and scaled by total change; assume 100% error.
- Fit error takes residual autocorrelation into account.

Results: Trends and Combined Errors

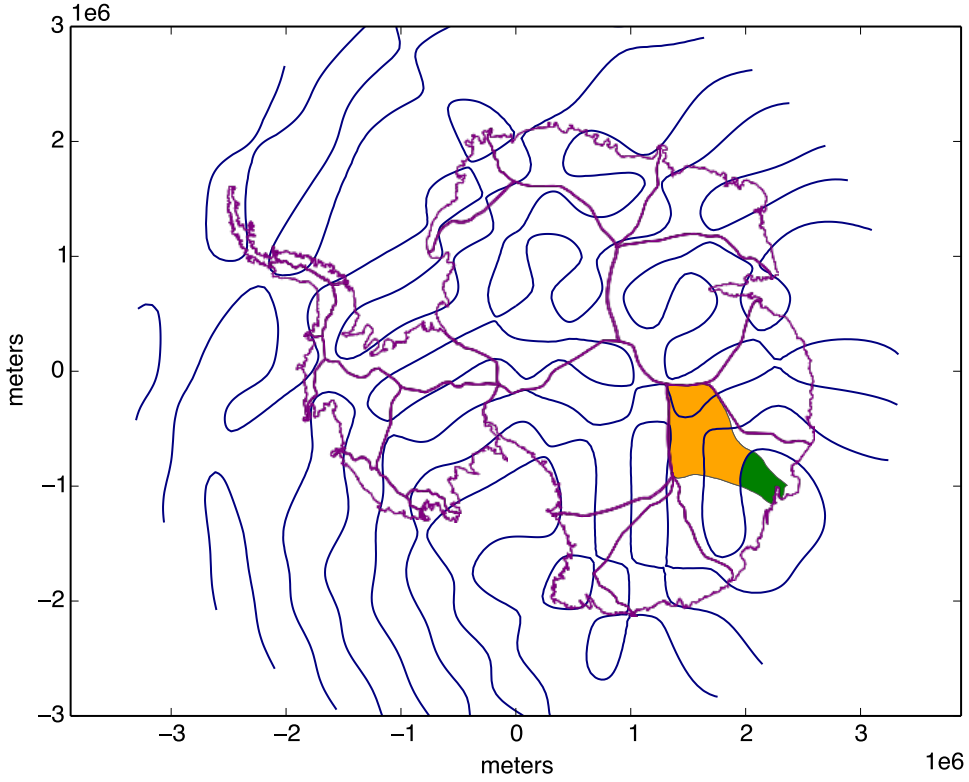
Months 004– 176 (April 2002 - August 2016)

		Coefficient	Total Error	Leakage Error	Fit Error	GIA error
IJ05 Trend	[Gt/yr]	-14.66	3.47	2.26	2.48	0.87
AW13 Trend	[Gt/yr]	-14.55	3.37	2.23	2.48	0.49
W12a Trend	[Gt/yr]	-17.54	3.36	2.13	2.28	0.79

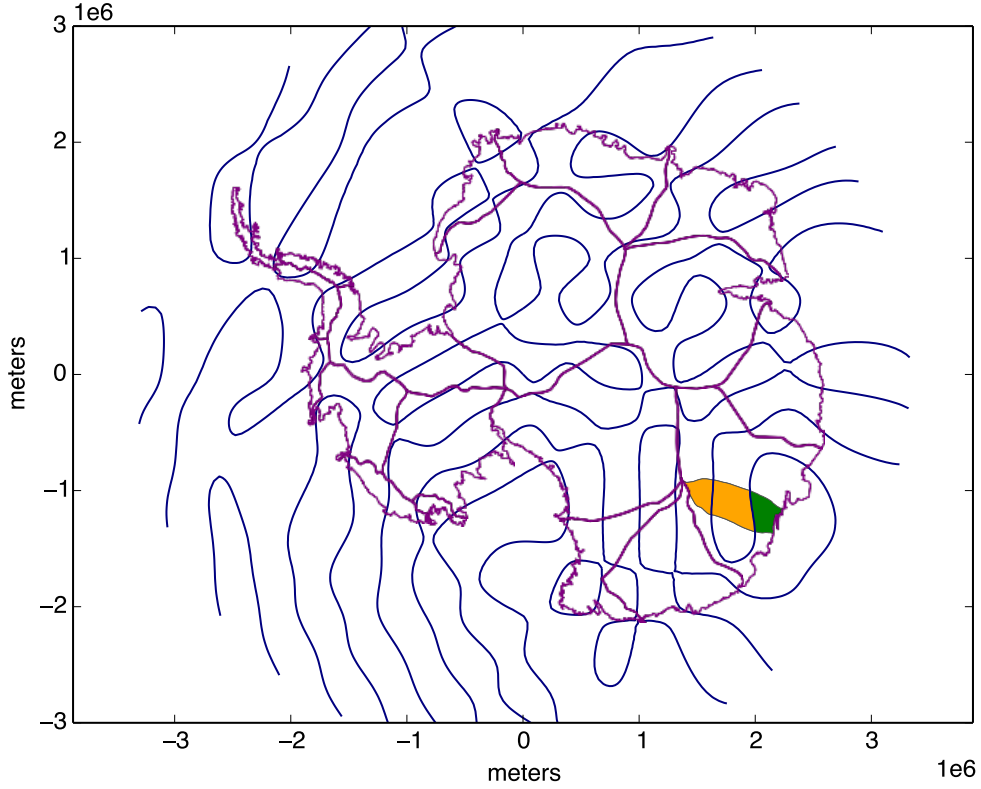
All errors added in quadrature. Model selection based on AICc and BIC citeria.

Comparison with Mass Budget Estimates: Evaluate SMB within Kernel

Totten Basin

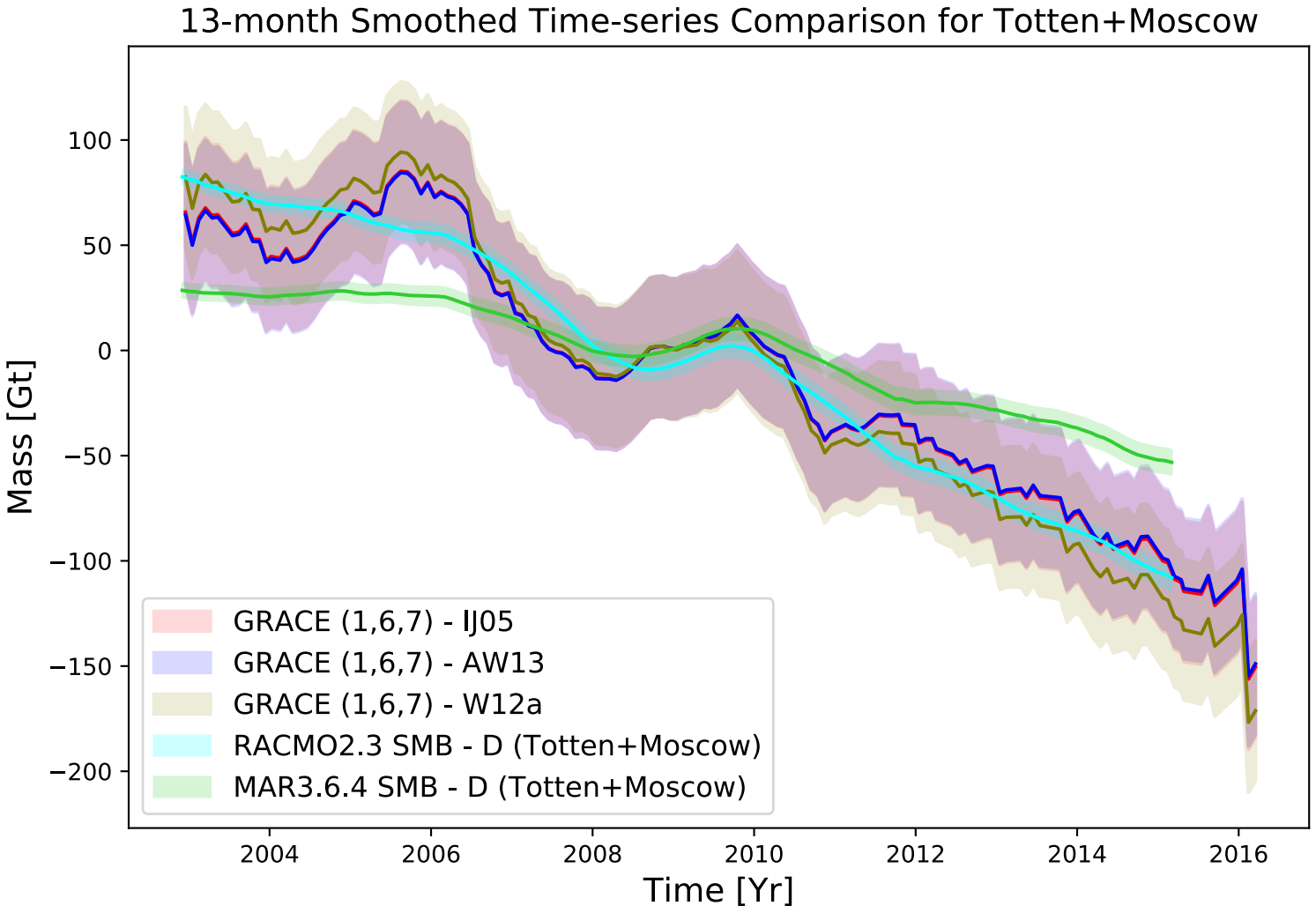


Moscow Basin



Remove portions of the drainage basins that are outside of the 0-contour.

Comparing with Mass Budget time-series (with 1x1km linear interpolation)

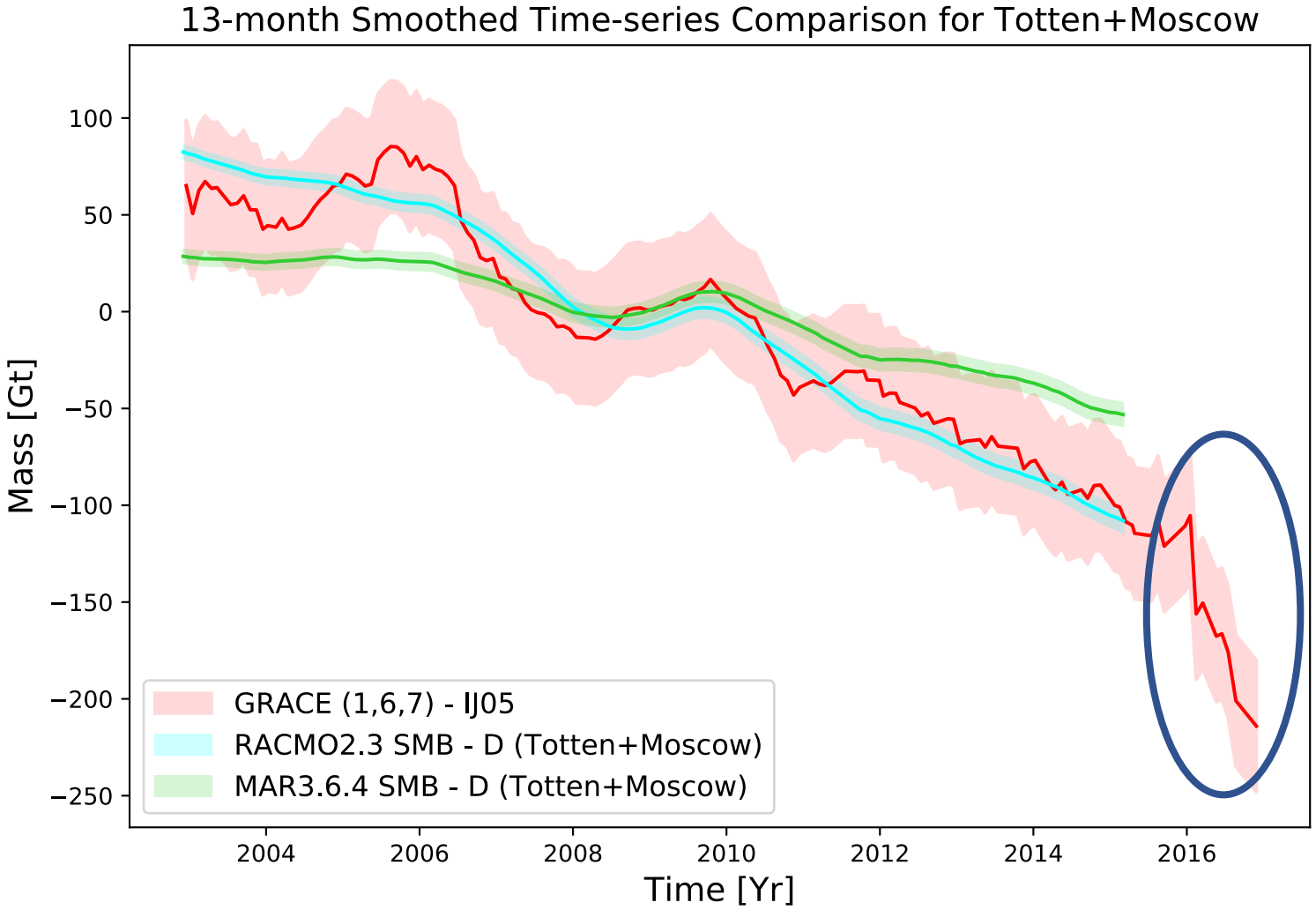


SMB outside of the 0 kernel contour is removed from SMB – D time-series.
The mean SMB of the *whole* basin is removed from discharge since we assume discharge = SMB in long term for the whole basin.

Comparison of GRACE and MBM time-series from April 2002 to December 2015

	Trend (Gt/yr)	Regression Error (Gt/yr)
GRACE (IJ05)	-14.89	2.70
GRACE (AW13)	-14.68	2.70
GRACE (W12a)	-17.71	2.70
MBM (MAR3.6.4)	-6.75	1.54
MBM (RACMO2.3)	-15.58	1.83

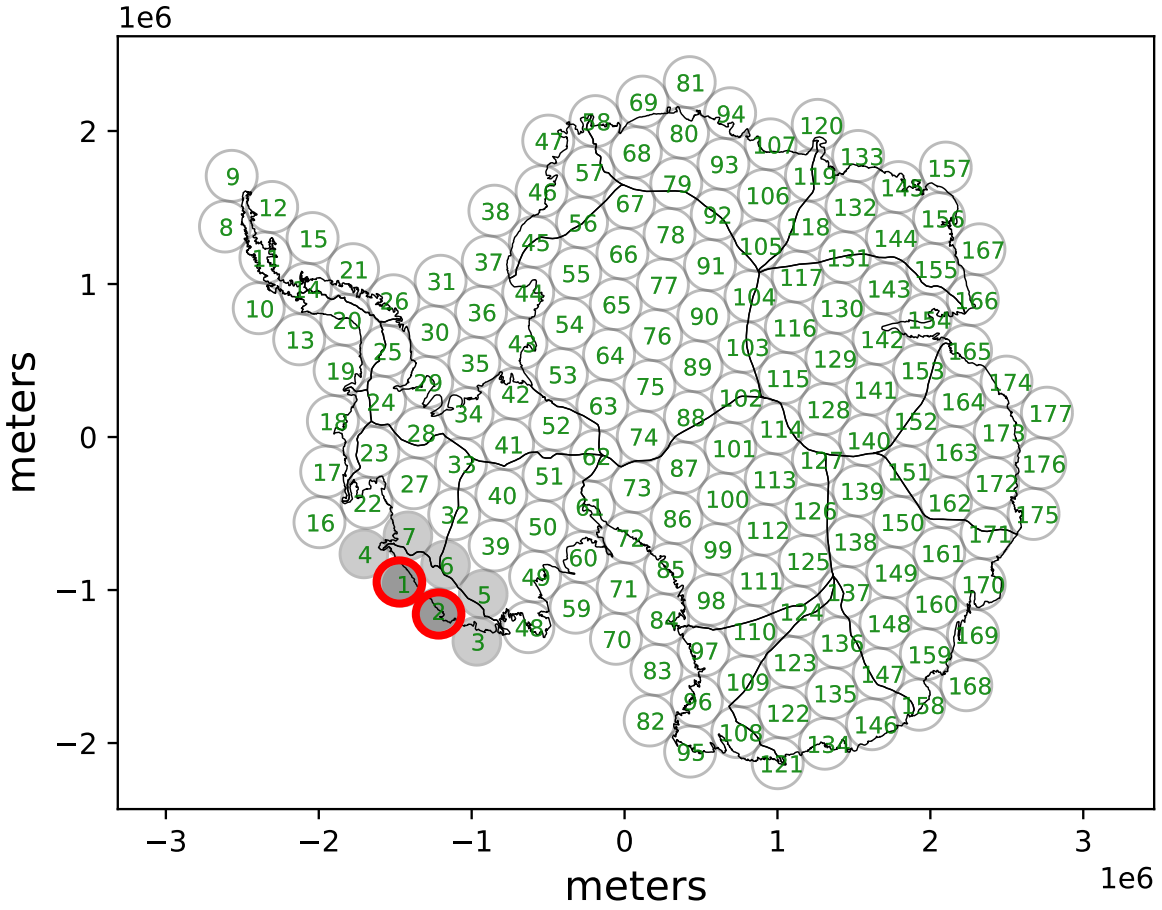
Note about the continuation of time-series to the end of GRACE period

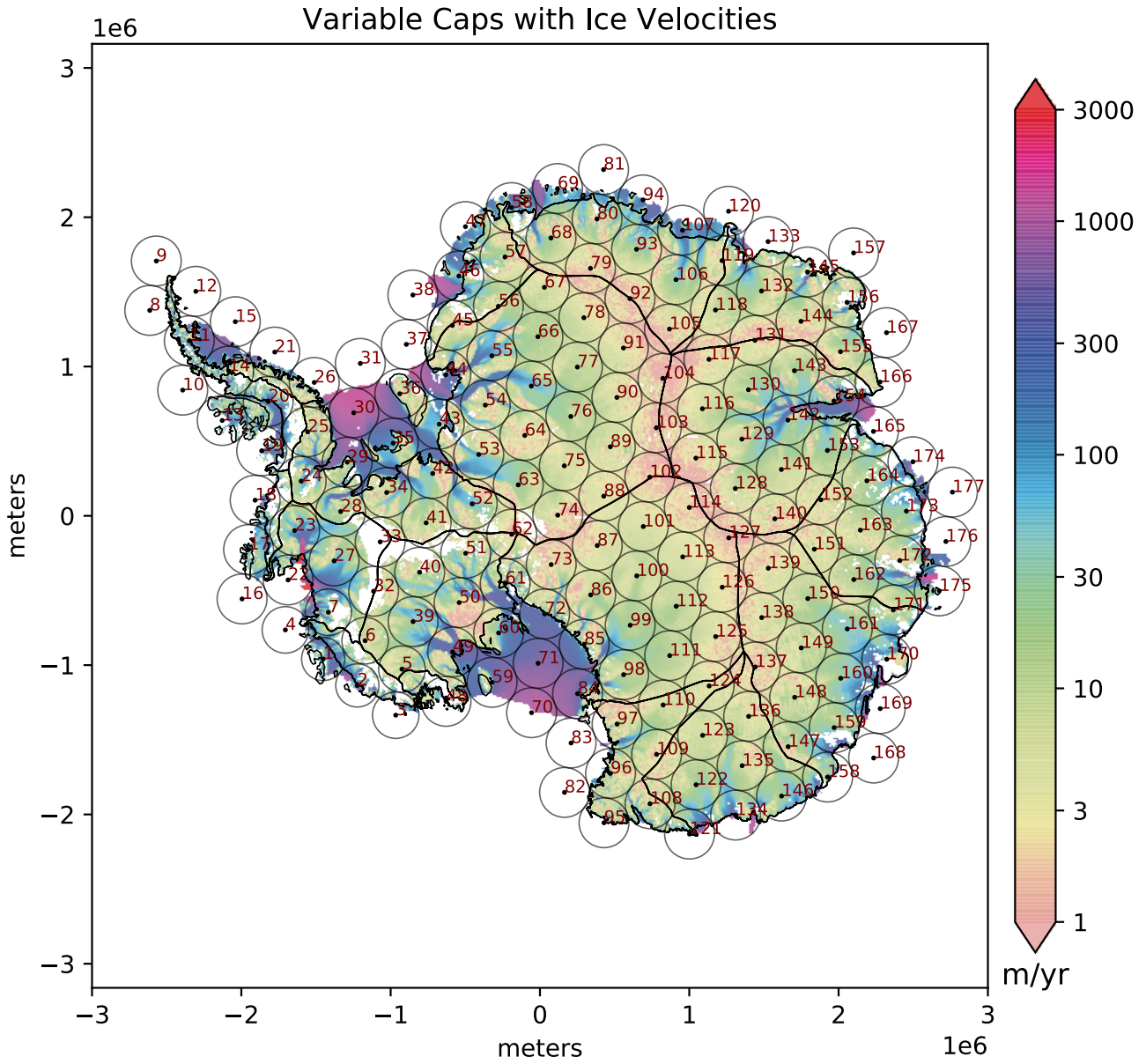


	Coefficient	Total Error	Leakage Error	Fit Error	GIA error
Trend (IJ05) [Gt/yr]	-16.13	3.72	2.27	2.81	0.87
Acceleration [Gt/yr^2]	-1.51	1.44	0.38	1.39	--

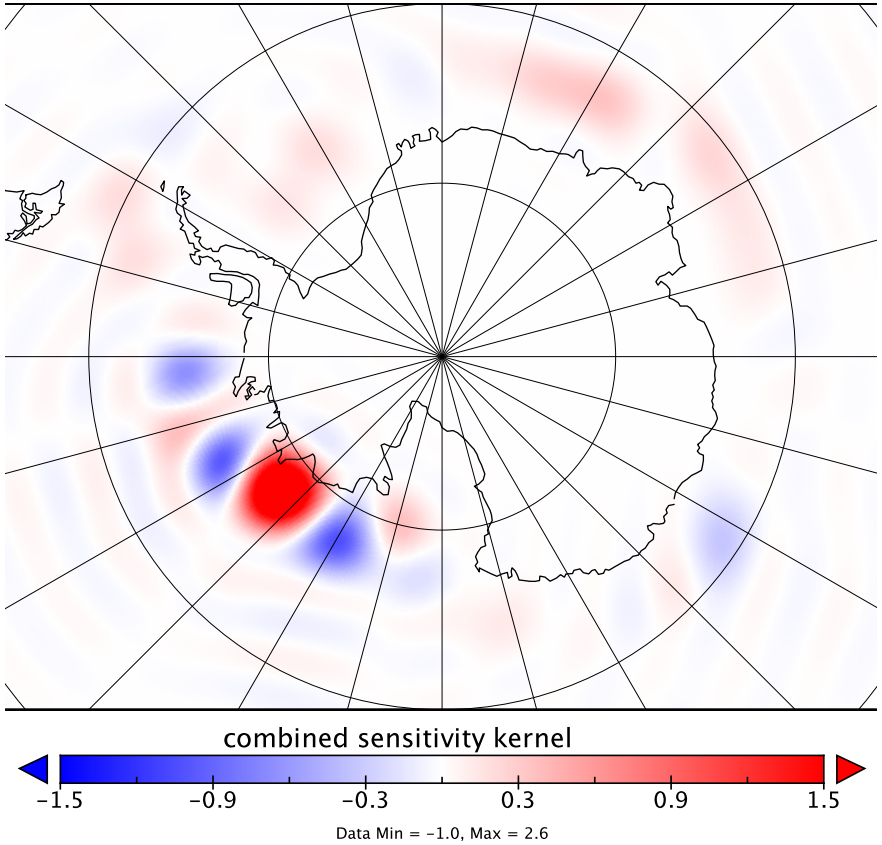
Other examples: Getz ice-shelf

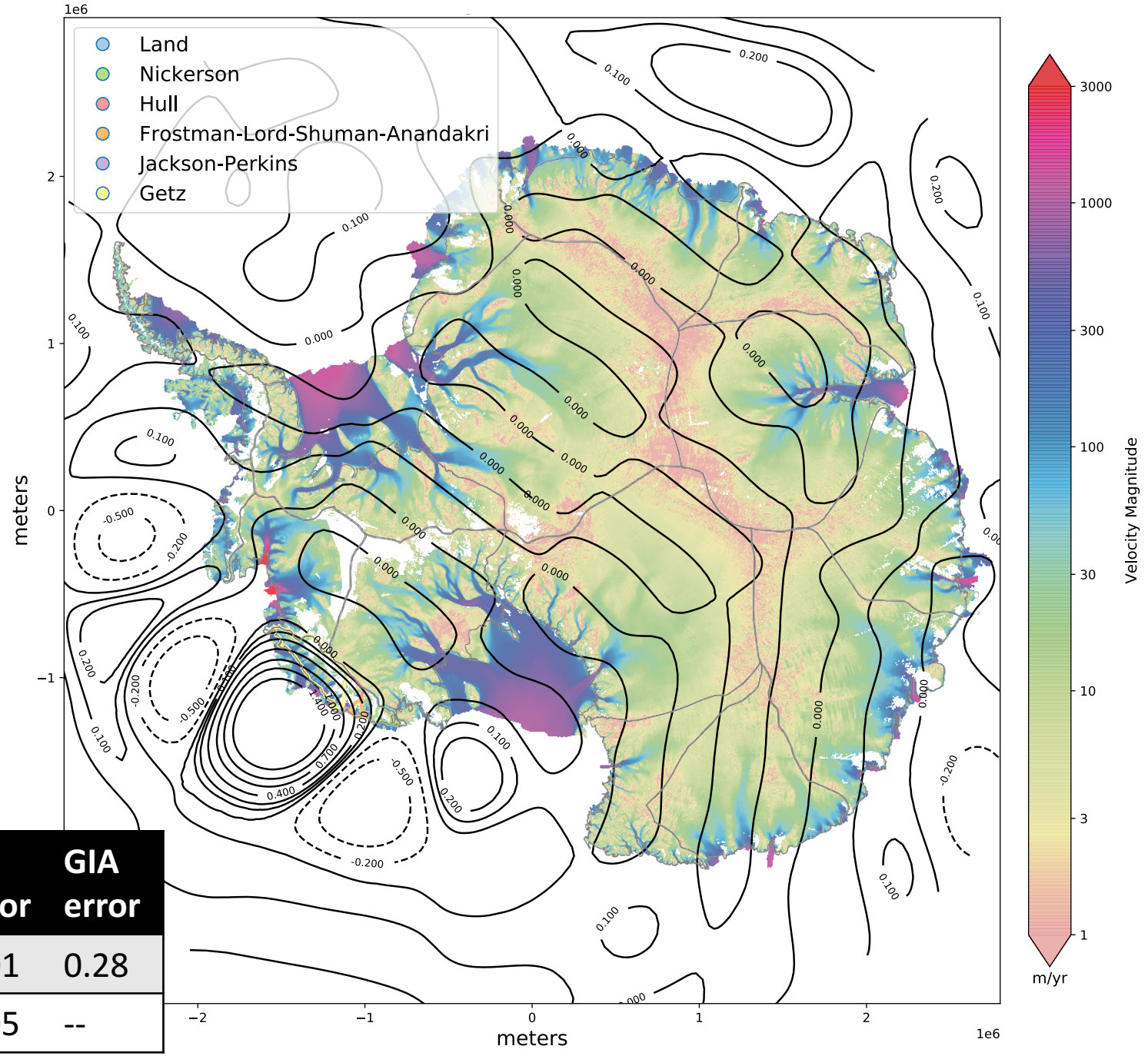
3-layer hexagonal grid:
Cap Diameters: 2.6° (dark grey),
2.8° (light grey), 3.0° (white)





Sensitivity Kernel



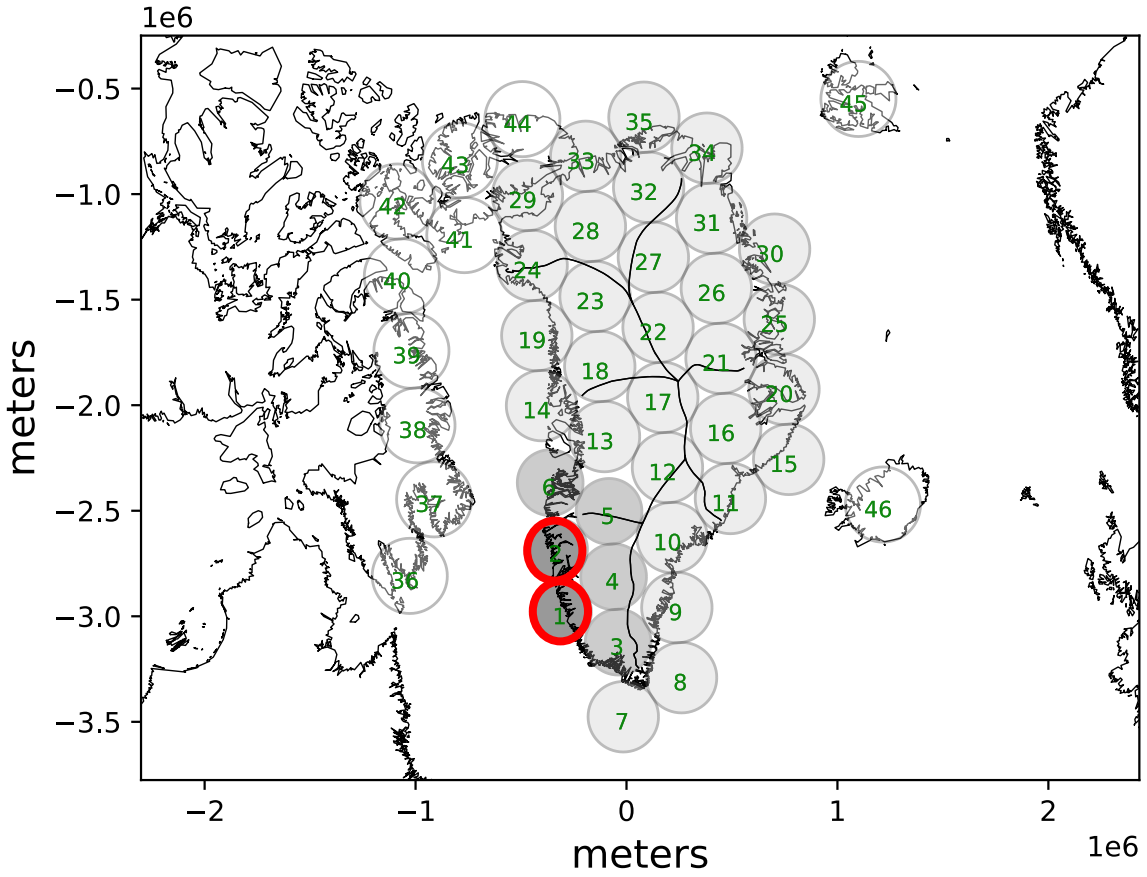


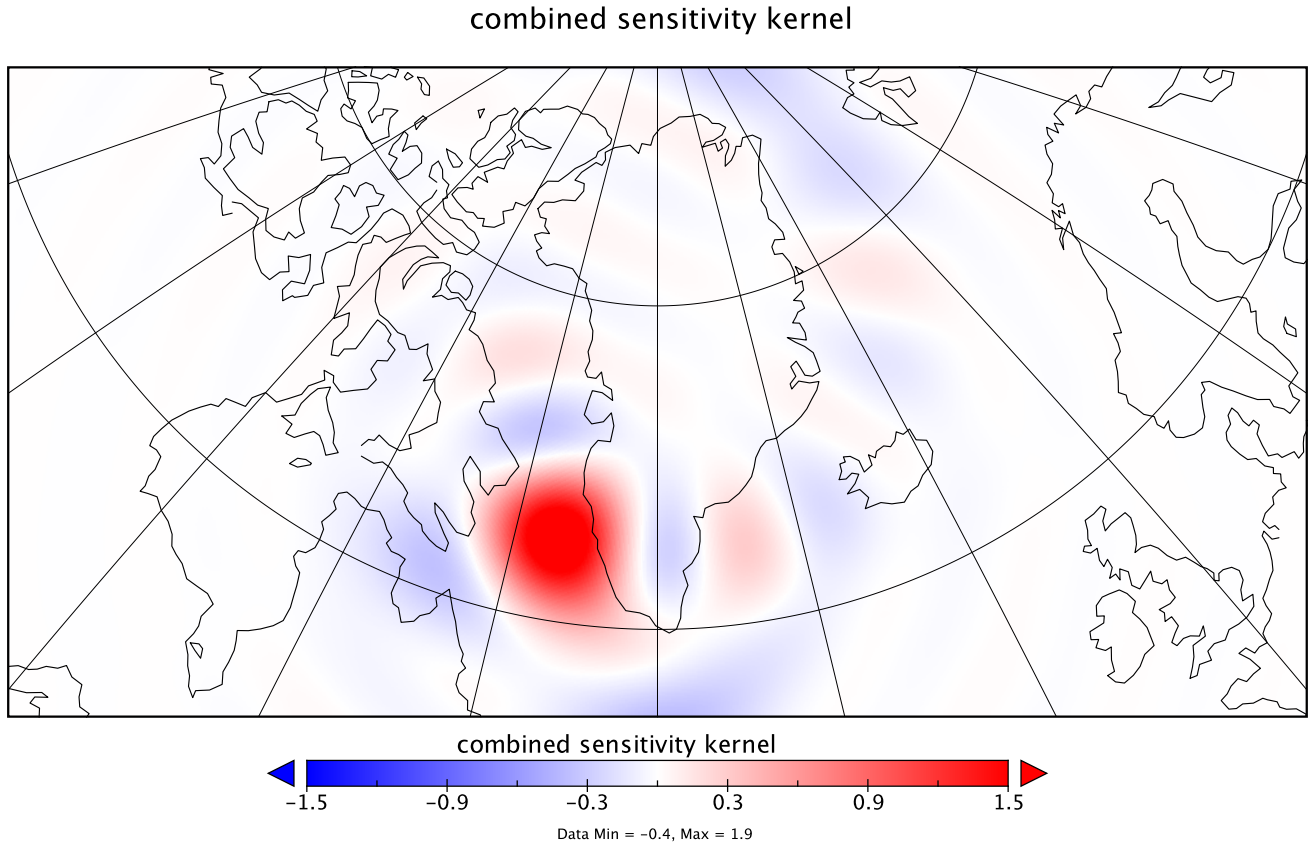
Months 004-176 – Using IJ05:

	Coefficient	Total Error	Leakage Error	Fit Error	GIA error
Trend [Gt/yr]	-19.97	6.16	5.80	2.01	0.28
Acc. [Gt/yr²]	-1.70	2.12	1.83	1.05	--

SW Greenland

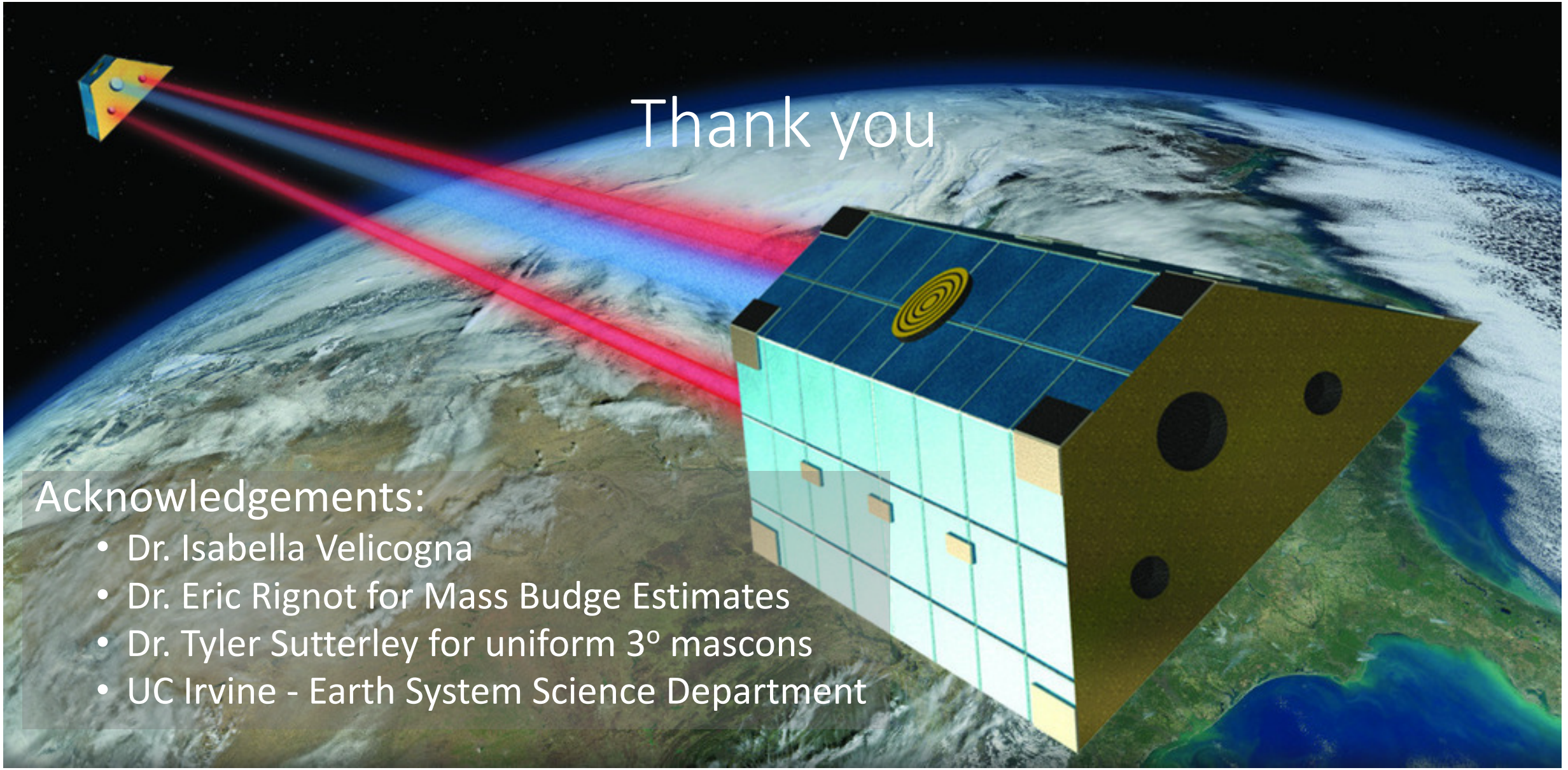
4-layer hexagonal grid:
Cap Diameters: 2.6° (black), 2.8° (dark grey), 3.0° (light gray), 3.2° (white)





Conclusions

- Regionally-optimized variable caps produce reasonable sub-basin estimates
- Our Totten+Moscow estimates agree well with Mass Budget estimates, not too strongly dependent on choice of GIA
  - Better temporal resolution and not dependent on SMB models.
- Allows for the evaluation of SMB from regional climate models at a sub-basin level
  - In Totten and Moscow RACMO2.3 agrees with our estimates while MAR3.6.4 underestimates the loss
- The agreement between GRACE and Mass Budget estimates in this region also allows for future evaluation with GRACE-FO



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