



# Evaluation of AOD1B RL06 over Greenland and Antarctica

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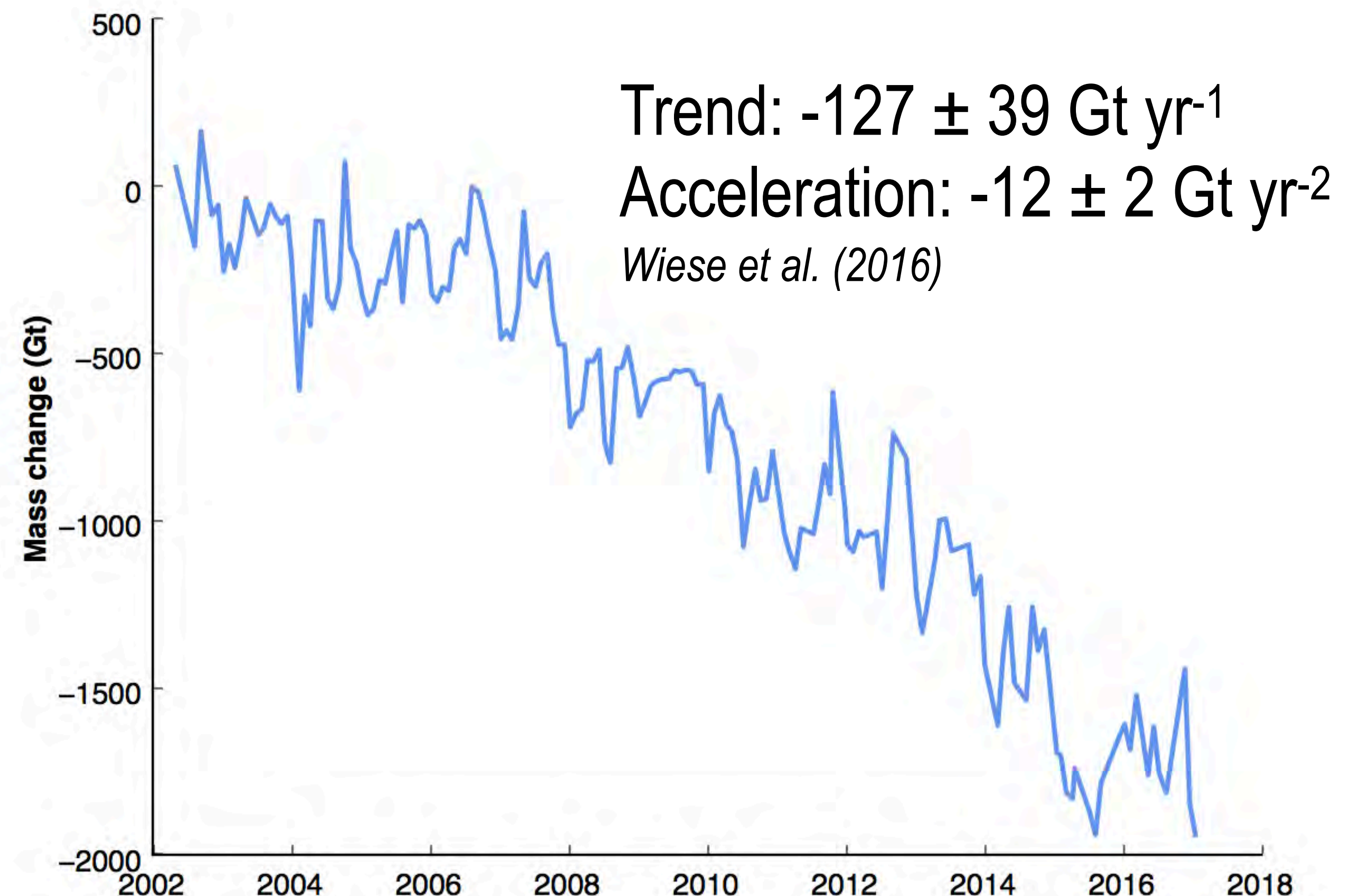
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# Overview

- GRACE senses the sum of atmospheric mass variations (surface pressure) and signals of interest on the ground, like ice mass loss, GIA, etc.
- Recovery of ground signals requires subtraction of a geophysical fluid model from GRACE observations, AOD1B
- The atmospheric component of AOD1B (GAA) uses the ECMWF Operational Analysis model
- Biases in this atmospheric model can create errors in estimates of ice mass loss
- AOD1B has been updated from RL05 to RL06. What are the effects of this update on future solutions?

## Antarctica



**How much of this signal is residual airmass?**



# Errors in AOD1B RL05



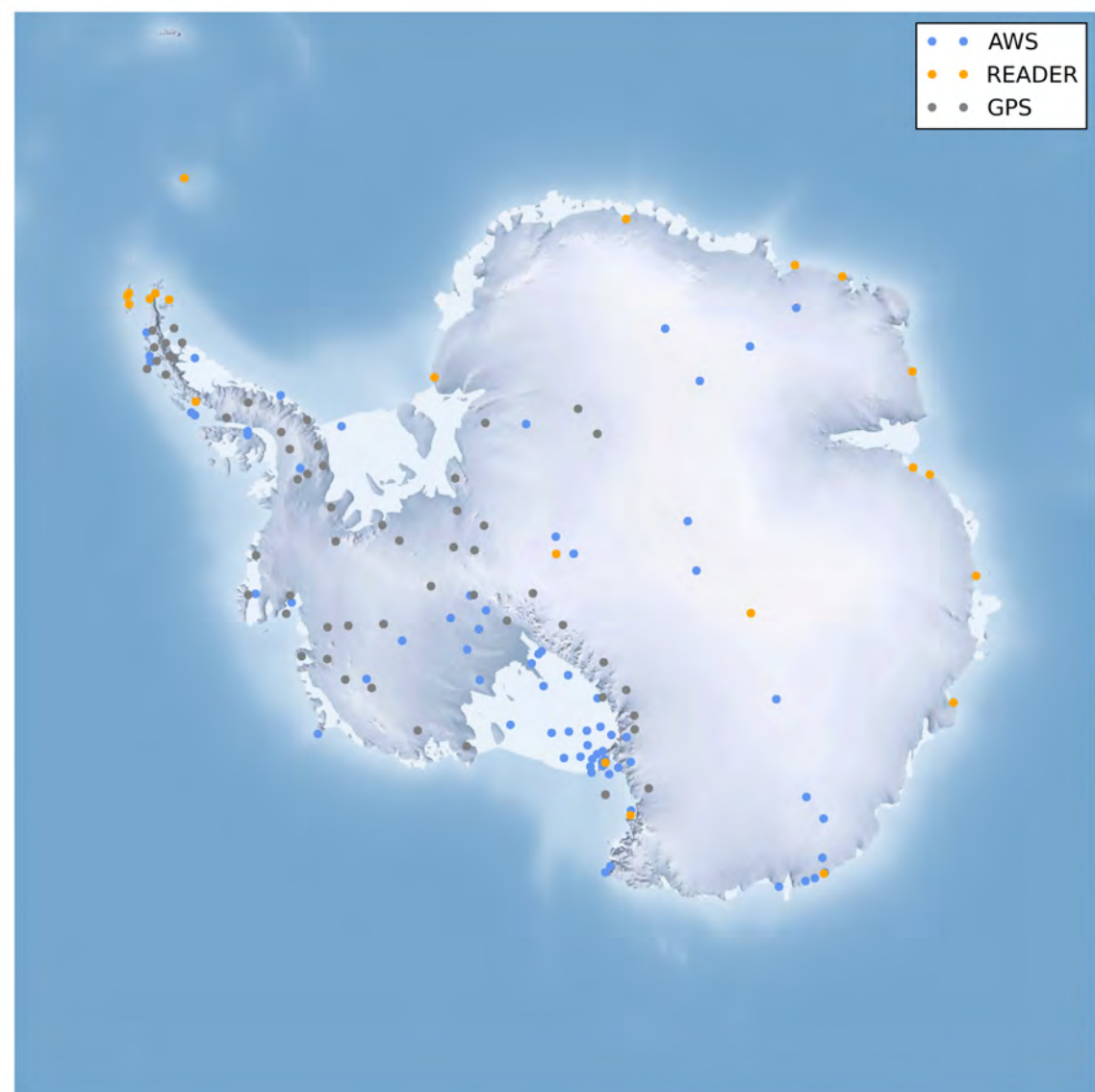
# Processing notes

- GAA is *subtracted* in all comparisons
- Posterior discontinuity corrections (GAE/GAF/GAG) have been removed from RL05
- RL05 evaluated at full resolution (d/o 100)
- All comparison data have been binned to same time period as GAA within JPL RL05.1M mascon months





# Comparison with In Situ Data



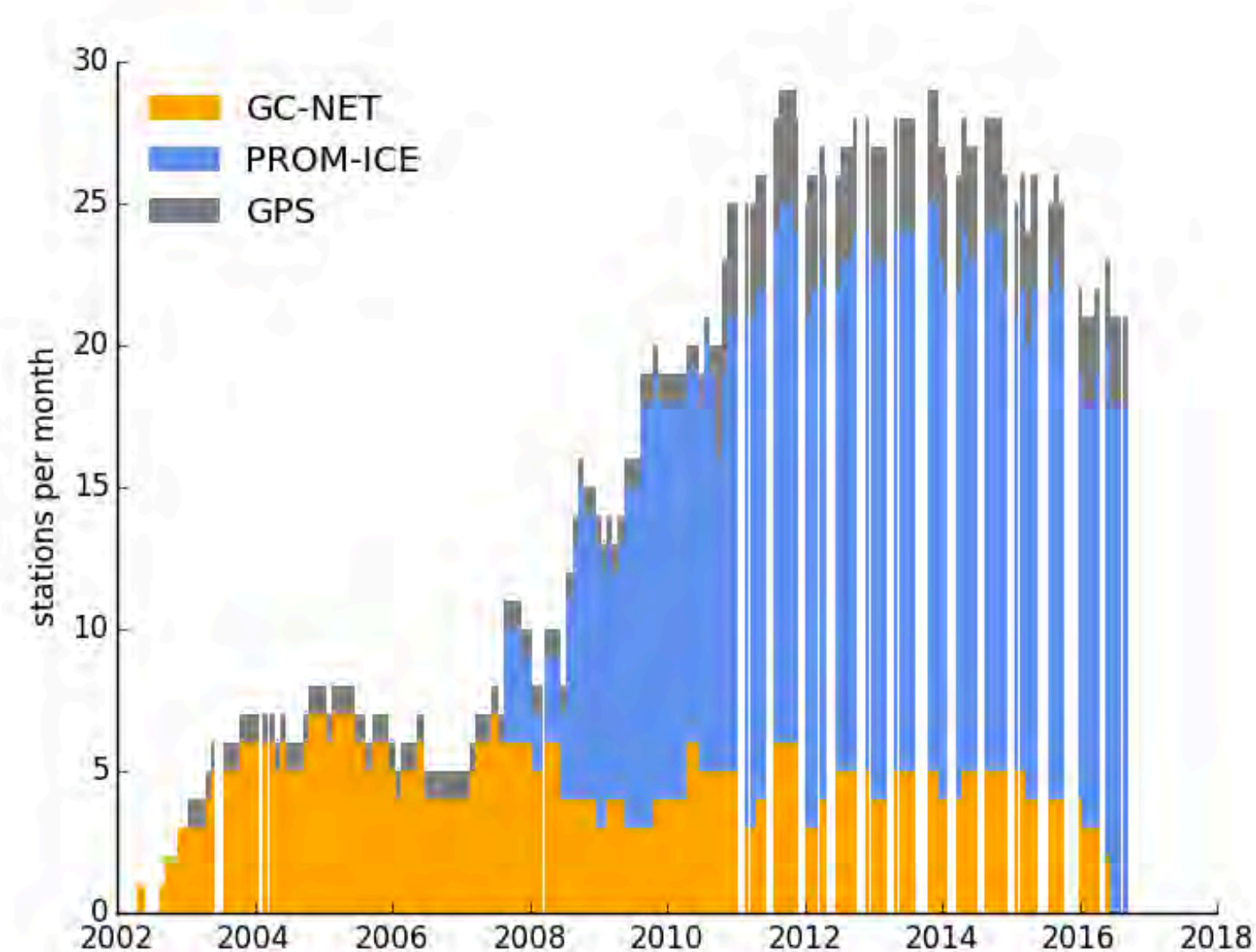
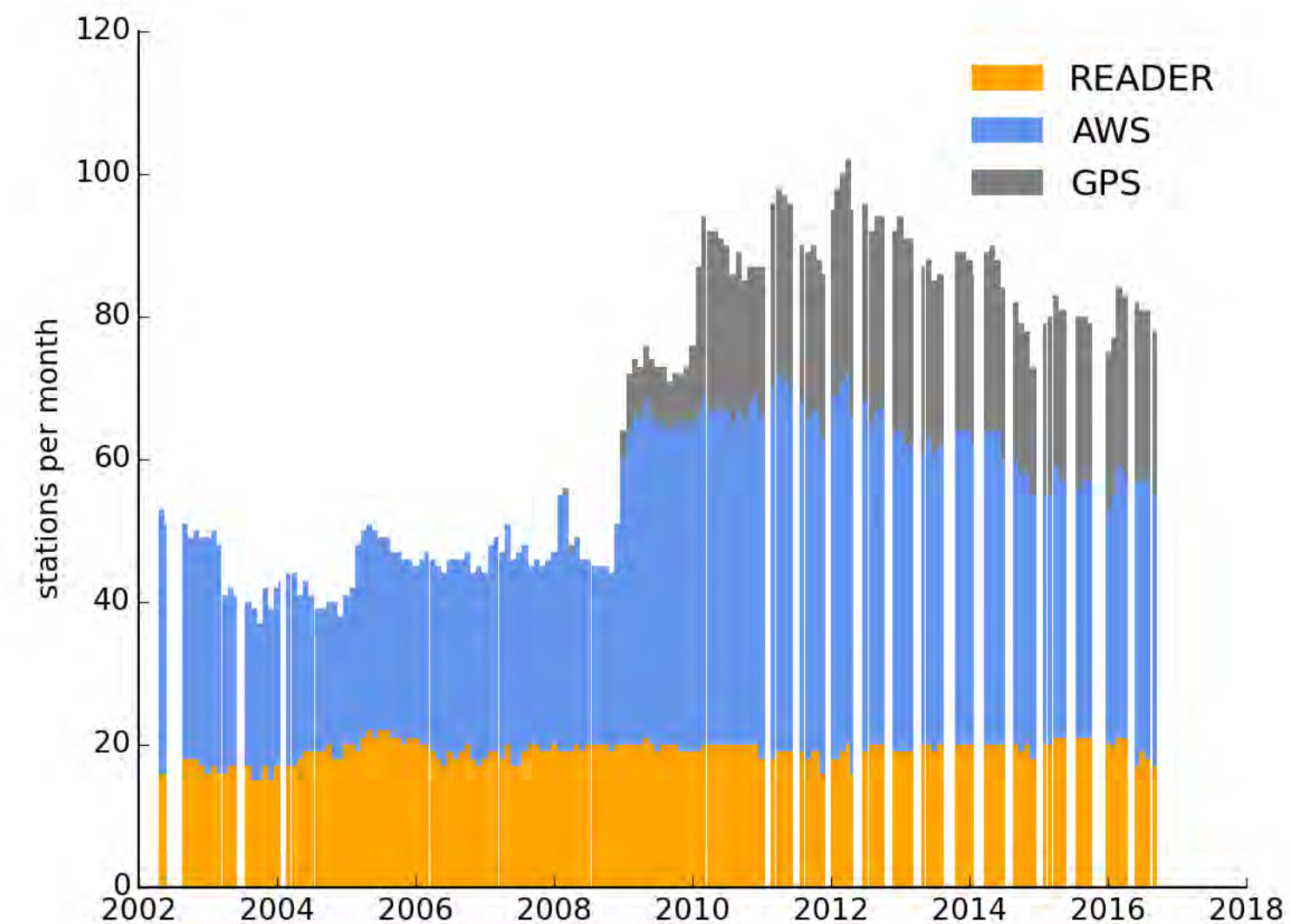
## Antarctica

<b>AWS</b>	61 stations
<b>READER</b>	22 stations
<b>GPS</b>	31 stations
<b>Total</b>	114 stations



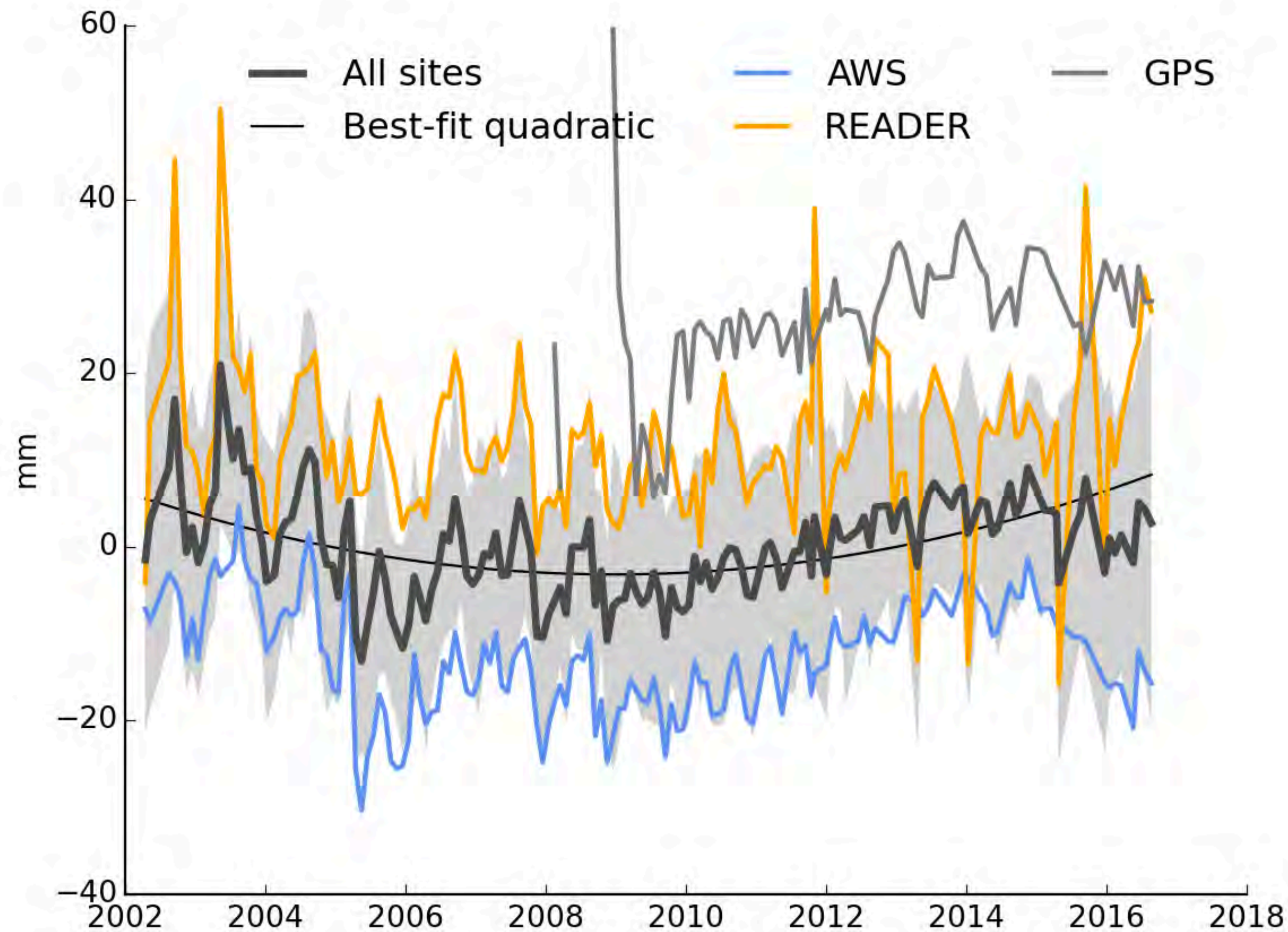
## Greenland

<b>PROM-ICE</b>	20 stations
<b>GC-NET</b>	7 stations
<b>GPS</b>	4 stations
<b>Total</b>	157 stations



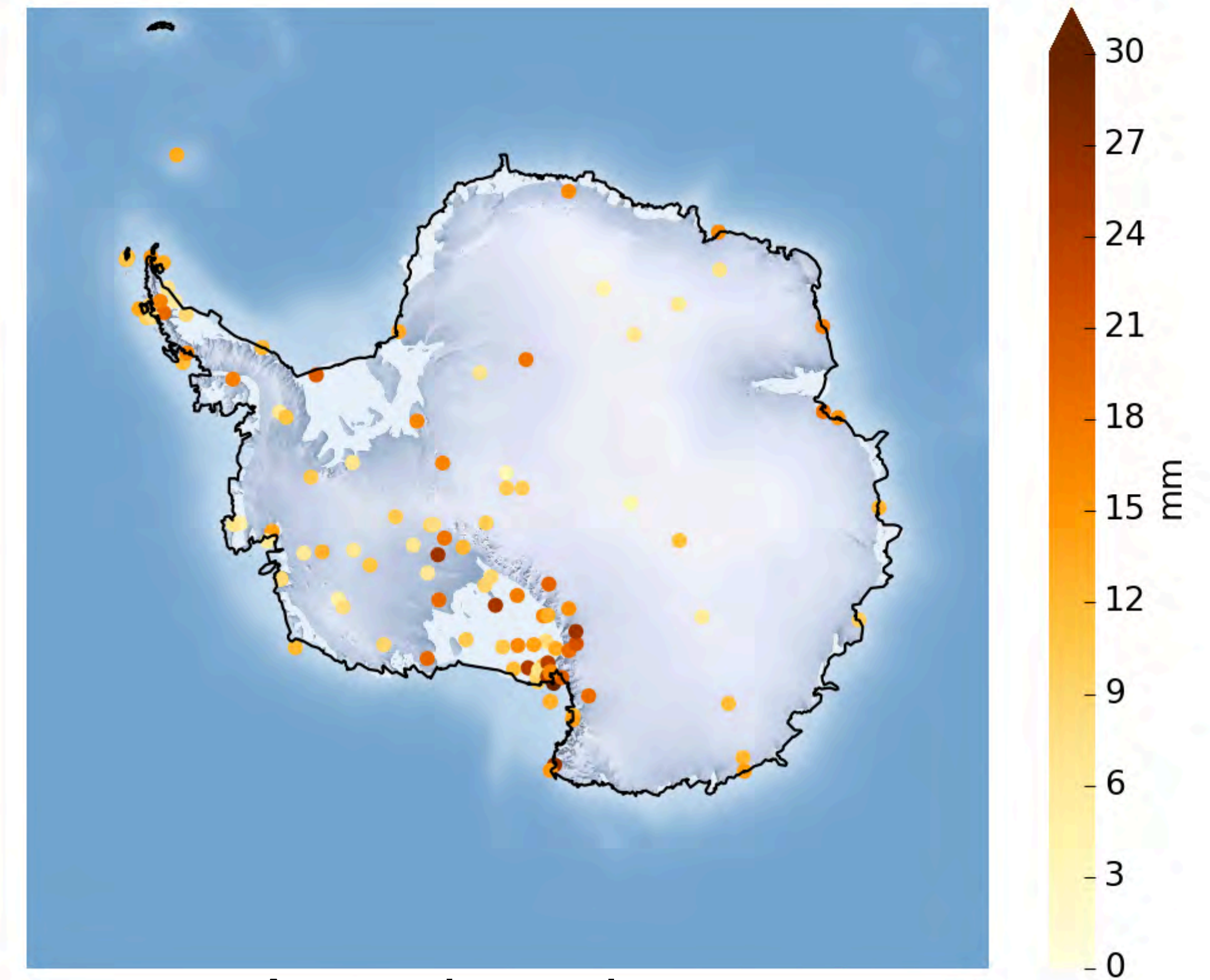


# Comparison with In Situ Data



(Model minus GAA RL05)

RMS Error: 14.1 mm

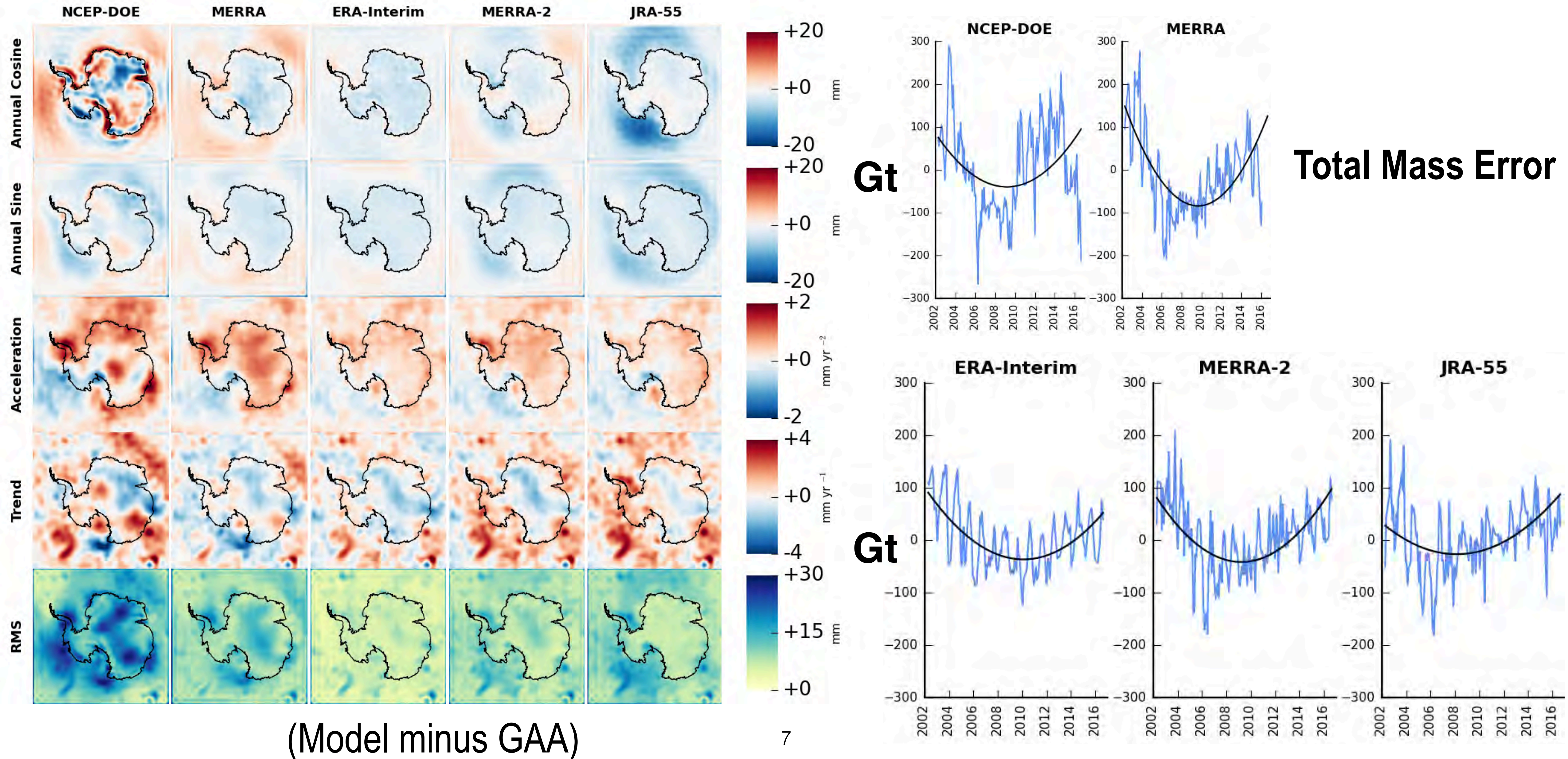


Acceleration:  
 $0.39 \pm 0.05 \text{ mm yr}^{-2}$   
 $4.7 \pm 0.6 \text{ Gt yr}^{-2}$





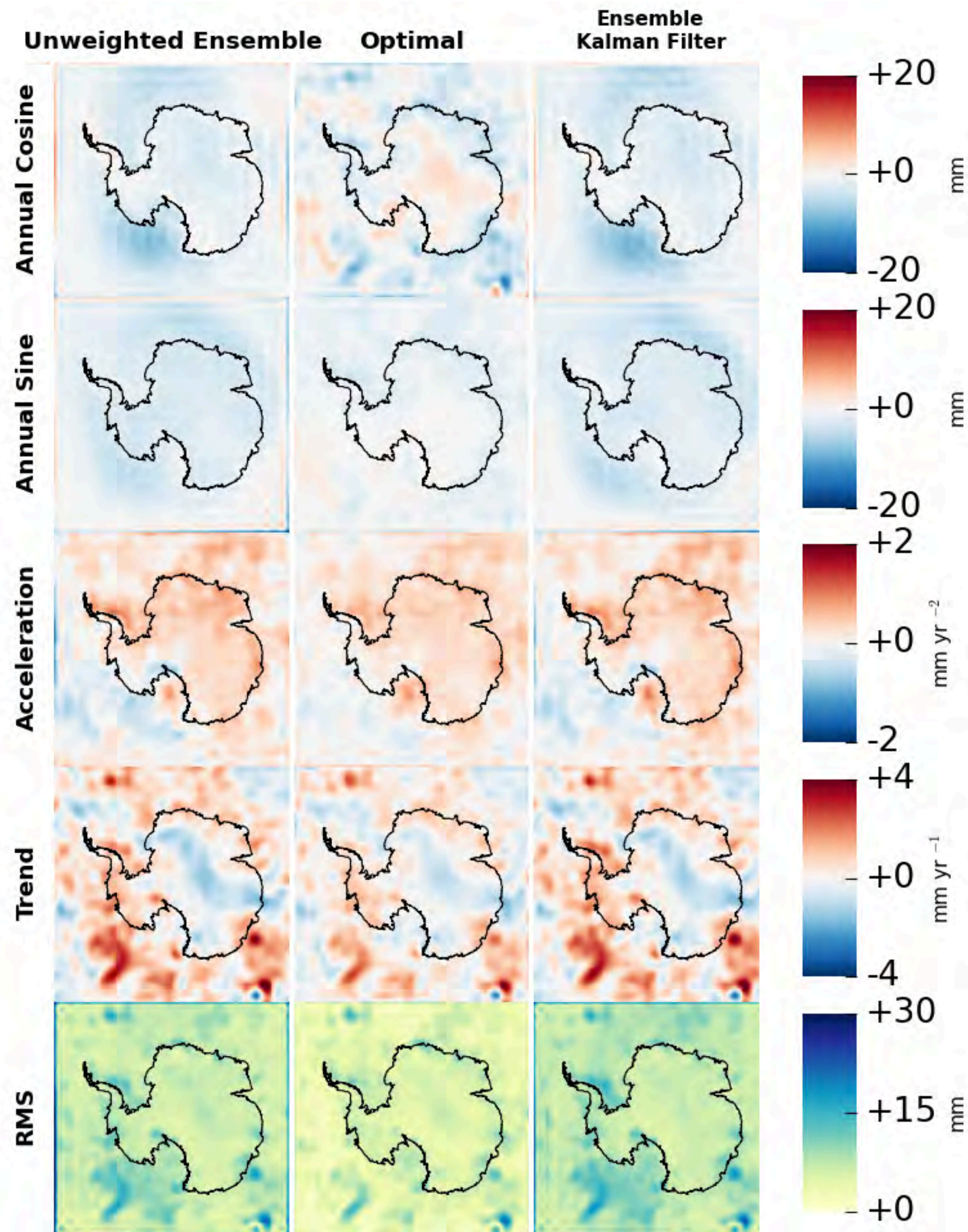
# Comparison with Alternative Models







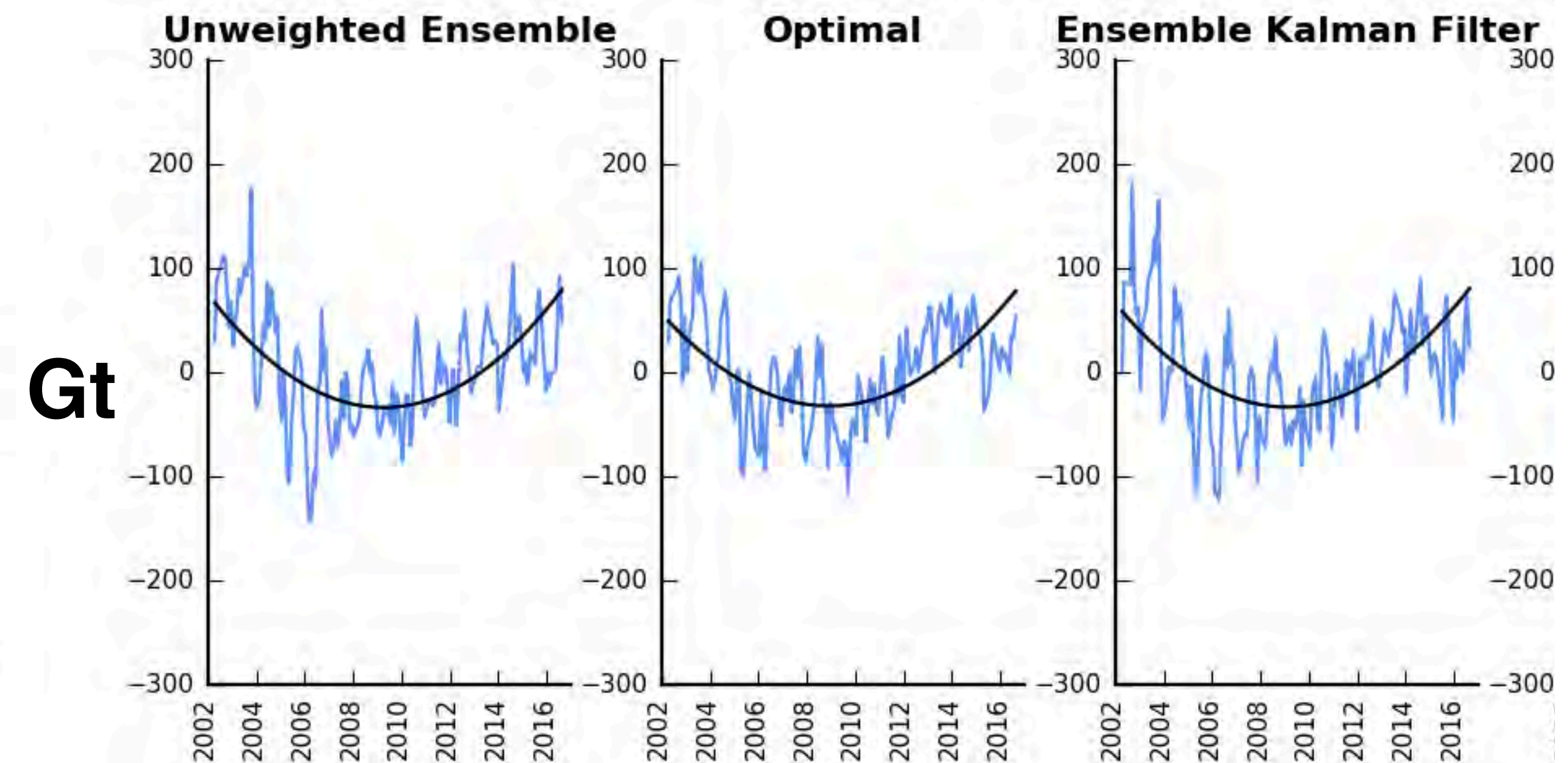
# Comparison with Combined Models



**Unweighted Ensemble** — Simple average of ERA-Interim, MERRA-2, and JRA-55 at each month

**Optimal Interpolation** — Collocation of in situ instrument data constrained with ERA-Interim covariance

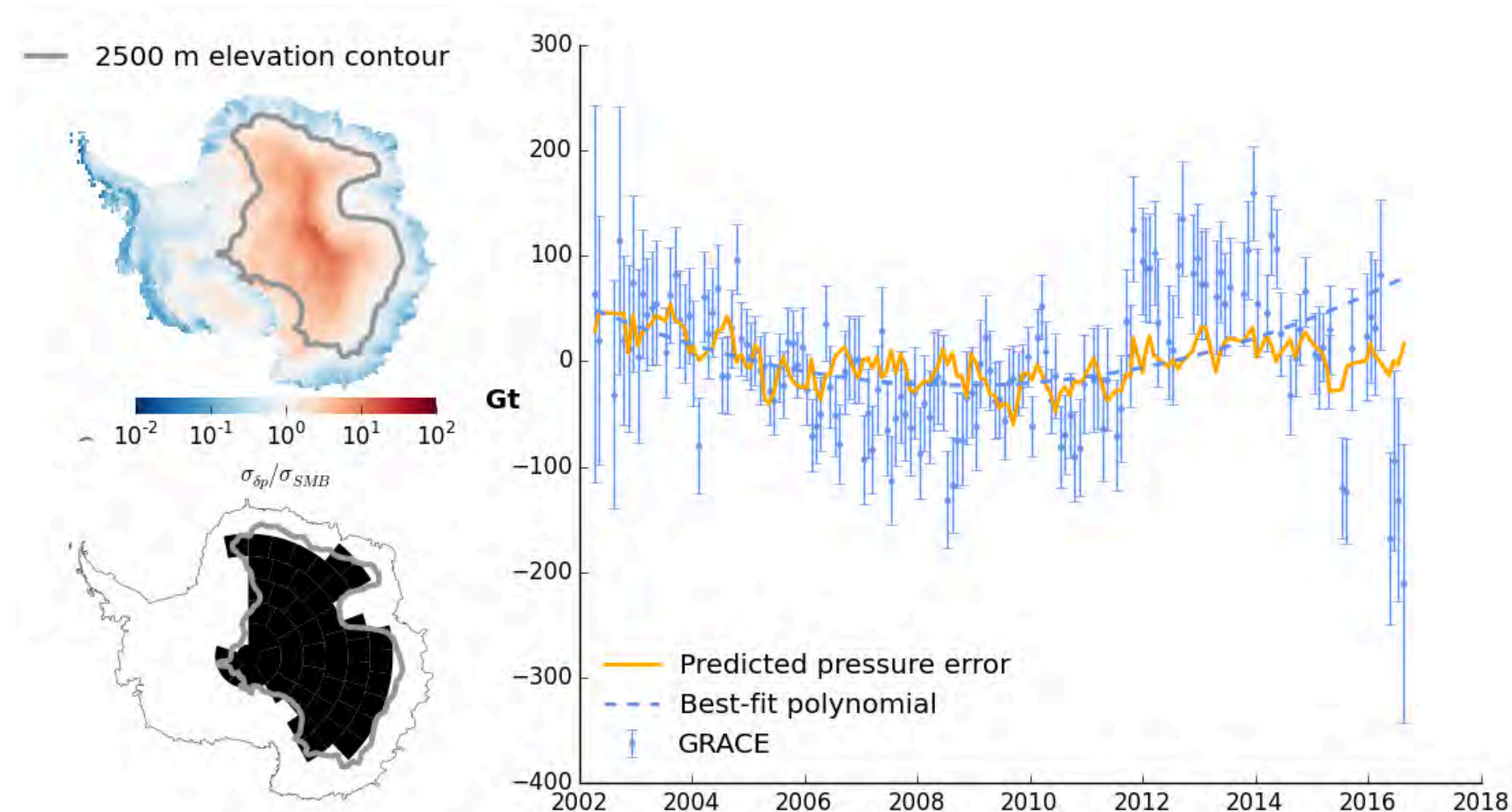
**Ensemble Kalman Filter** — Collocation of in situ instrument data constrained with sample covariance of ERA-Interim, MERRA-2, and JRA-55 at each month





# Retrieval of Pressure Signals in GRACE Data

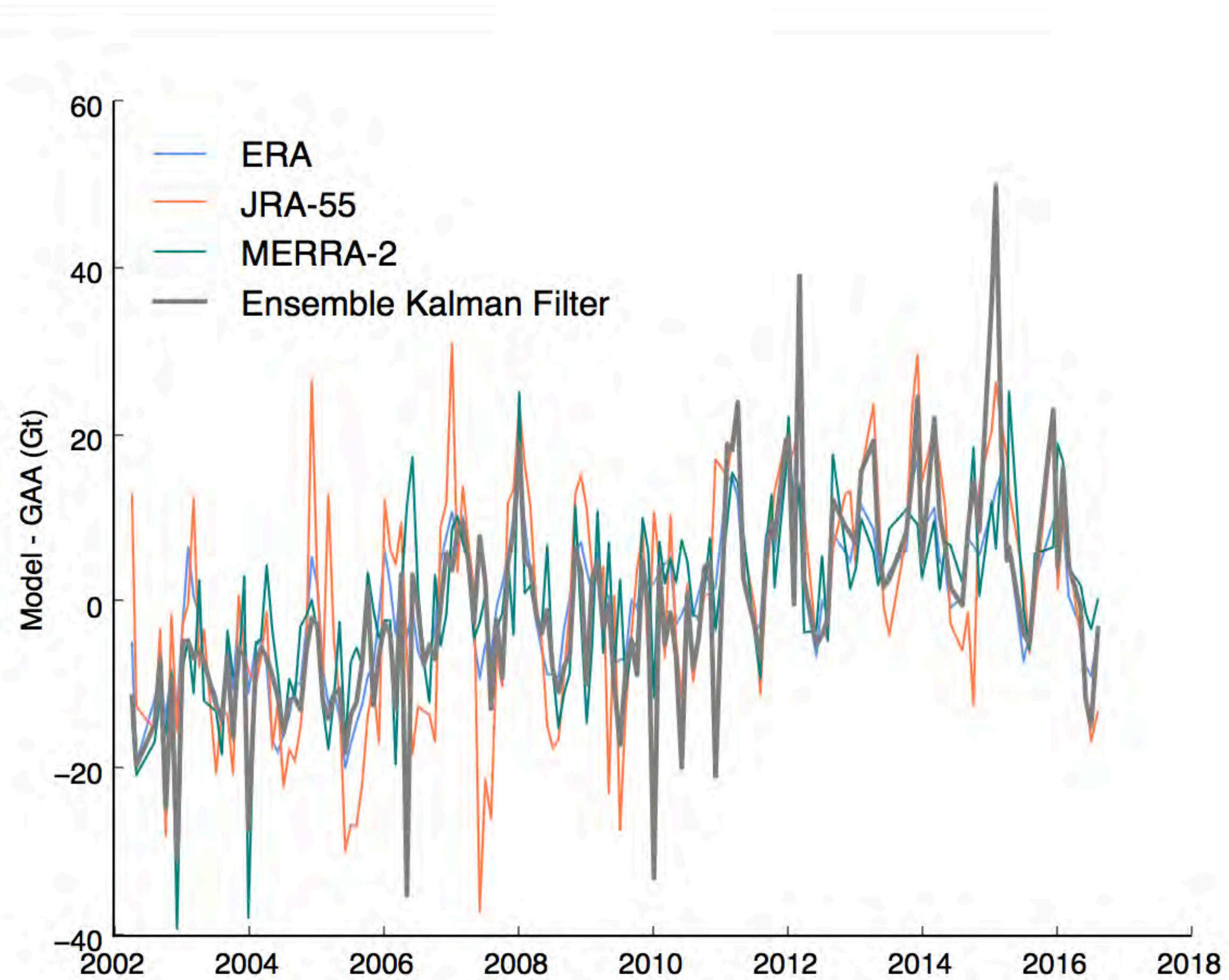
- Start with JPL RL05.1M mascons
- Isolate quiet High Antarctic Plateau, where pressure error RMS is high relative to SMB variability
- Detrend data to remove accumulation, GIA, ice dynamics, etc.
- Remaining signal is neatly predicted by modeled surface pressure errors and matches acceleration characteristics



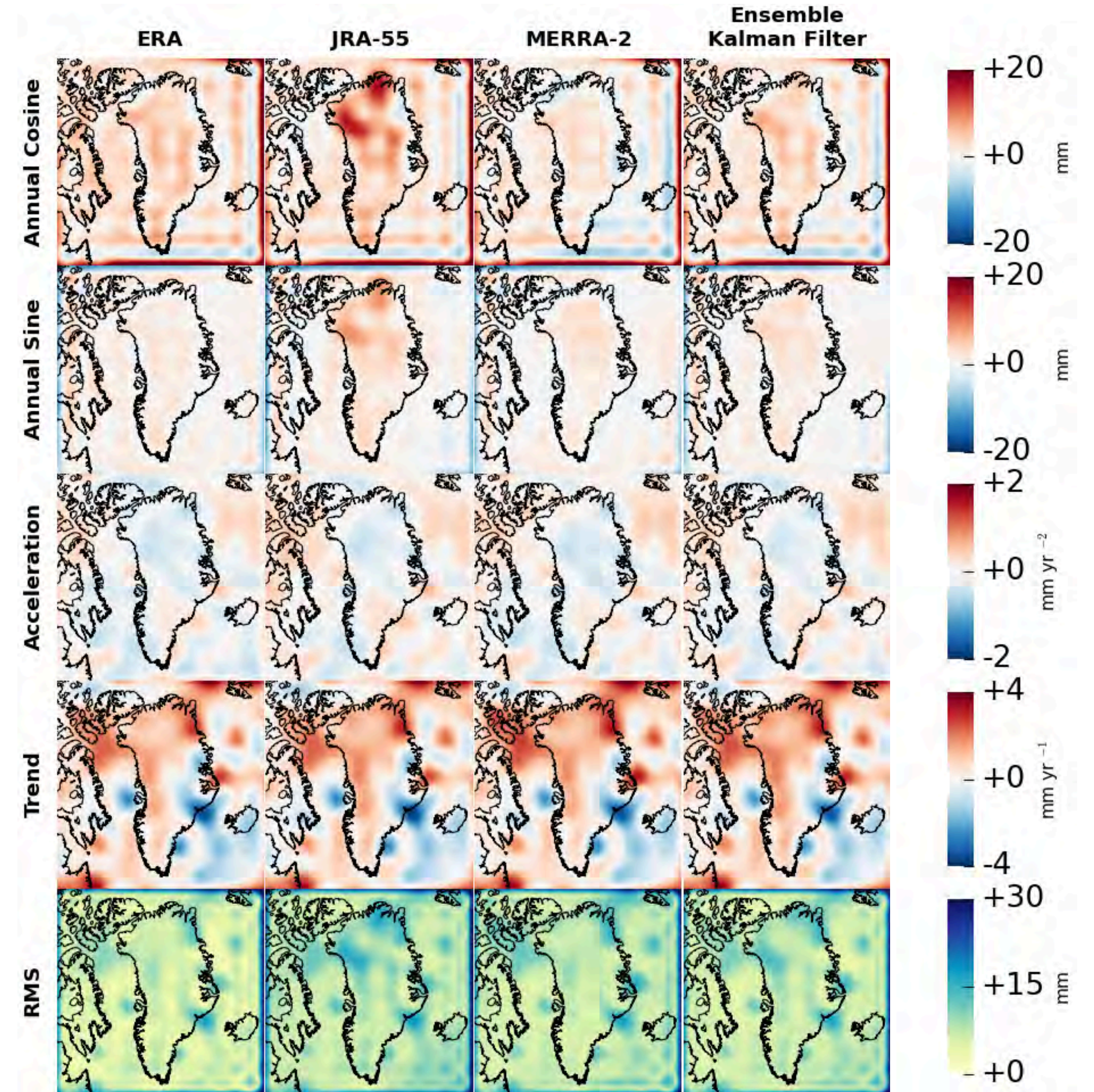




# Greenland



Trend errors of 1.2-1.8 Gt yr<sup>-1</sup>







# Conclusions for AOD1B RL05

- GAA is less accurate than reanalyses when compared with instruments over both Greenland and Antarctica
- Typical  $4 \pm 1$  Gt yr<sup>-2</sup> acceleration error over Antarctica in 2002—2016 timespan
- Pressure errors are large enough to retrieve from GRACE data over Antarctica
- Errors introduce small trend over Greenland (1—2 Gt yr<sup>-1</sup>) and episodic departures up to 40 Gt



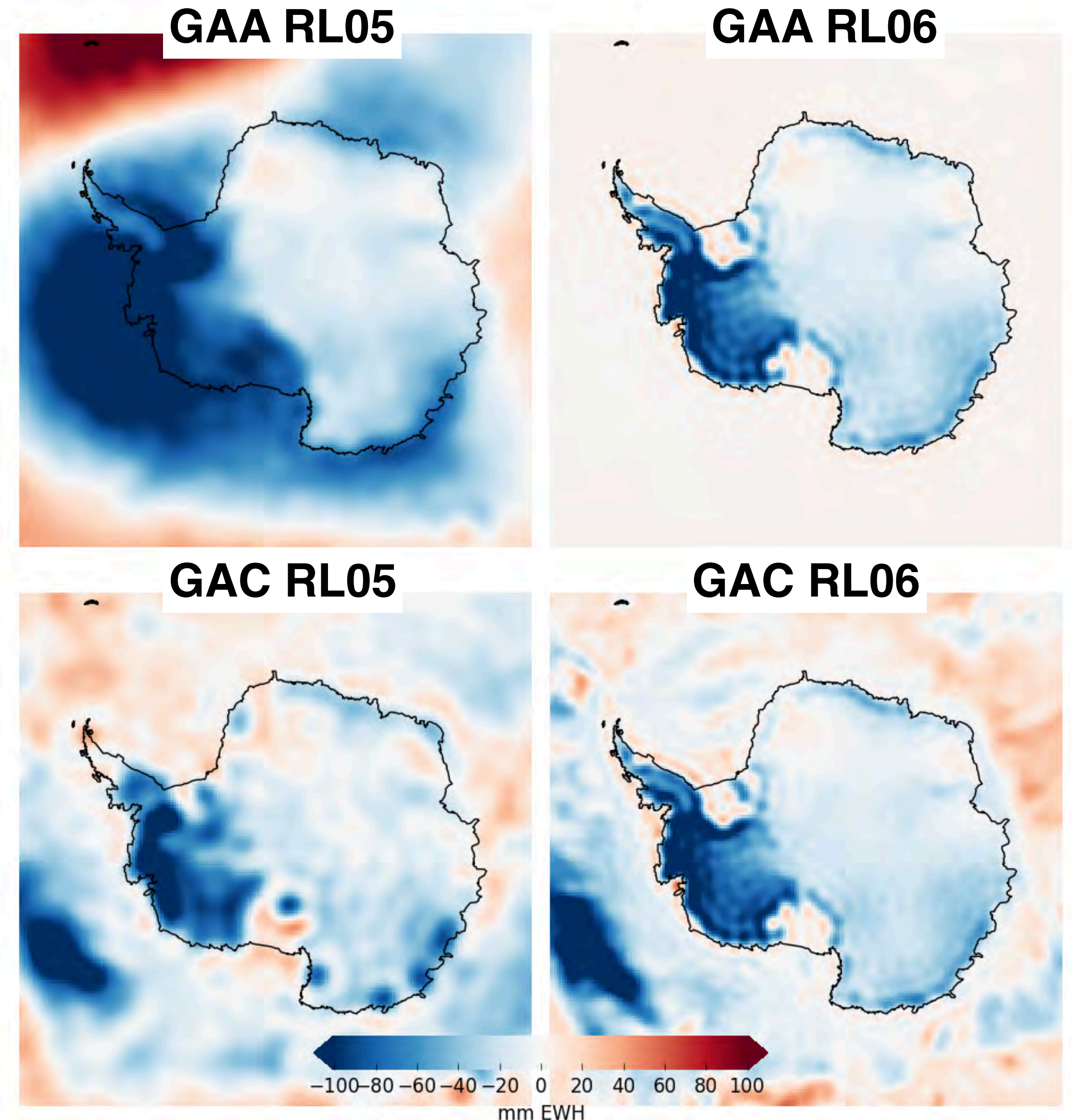


# Errors in AOD1B RL06



# AOD1B RL06

- Released early 2017
- Key Differences
  - Uses ERA-Interim prior to 2007; ECMWF Operational Analysis thereafter
  - Higher resolution — evaluated at degree and order 180 instead of 100
  - Better handling of model discontinuities
  - Definition of GAA/atm (atmosphere) and GAB/ocn (ocean) changed over oceans to include IB correction. GAA cannot be compared with surface pressure data over oceans.







# Comparison of AOD1B RL06 with AOD1B RL05

## Approach

- Compute unofficial GAA, GAB, GAC, and GAD products by averaging respective AOD1B RL06 products within GRACE solution months for JPL RL05.1M mascons
- Evaluate accuracy of model by comparison with surface pressure measurements
- Evaluate effects on overall mass change by comparing GAC (atmosphere plus ocean) instead of GAA between versions

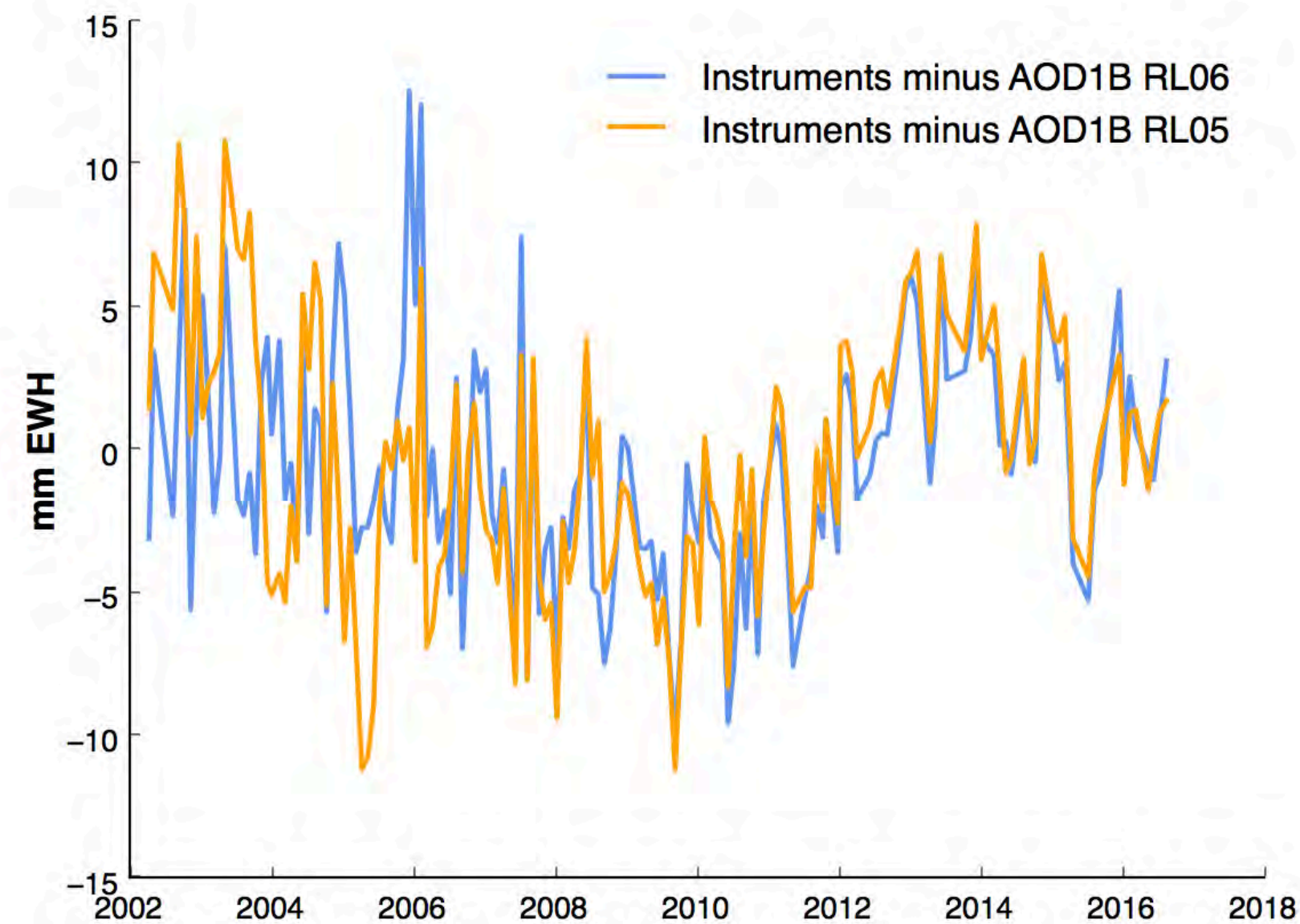




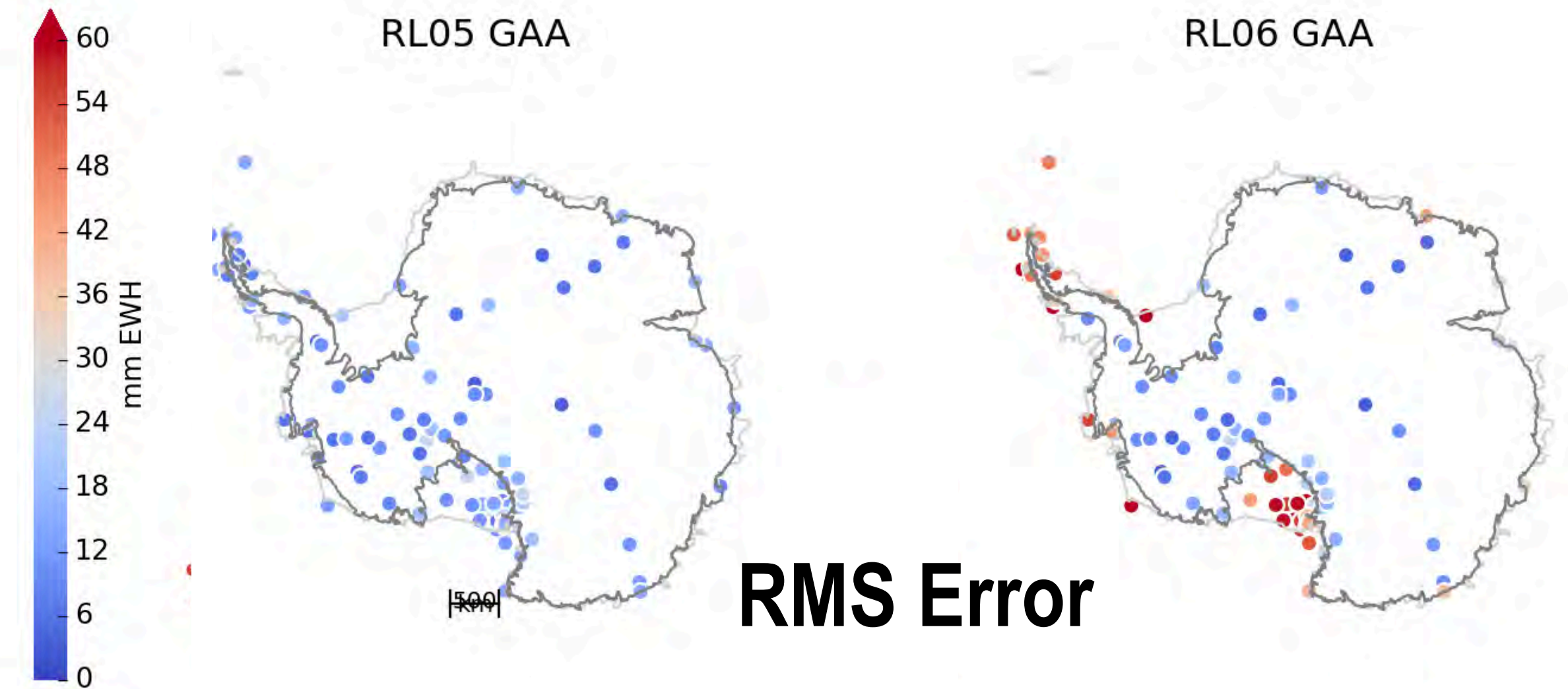
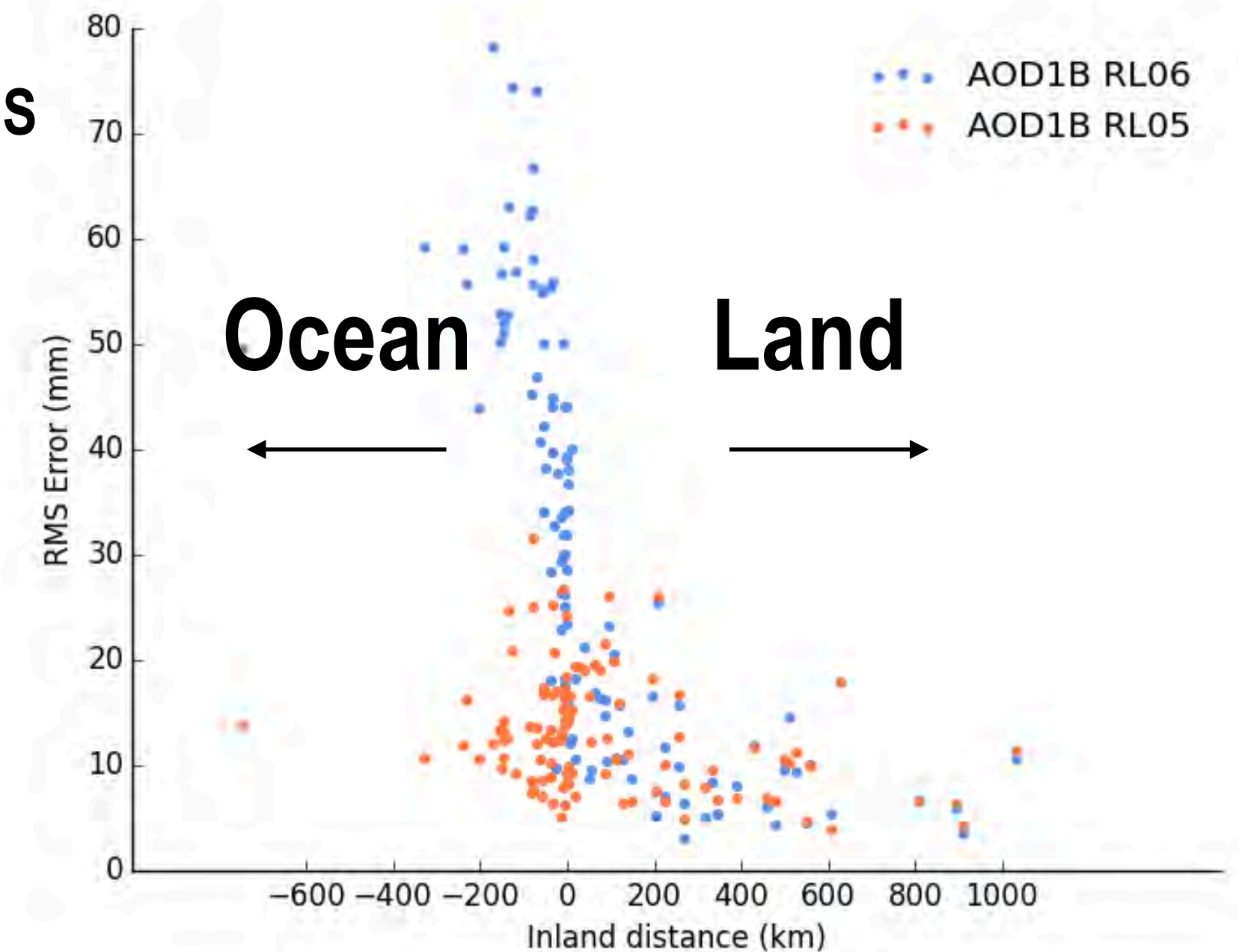
# Accuracy of AOD1B RL06 over Antarctica

- Only 37 out 114 stations more than 220 km inland to compare with GAA (RL06)
- RMS error of 9.1 mm EWH with RL06 vs. 9.5 mm EWH with RL05
- Mean instrument errors practically identical after 2007

**Mean Instrumental Error**



**Inland Distance vs. RMS Error**

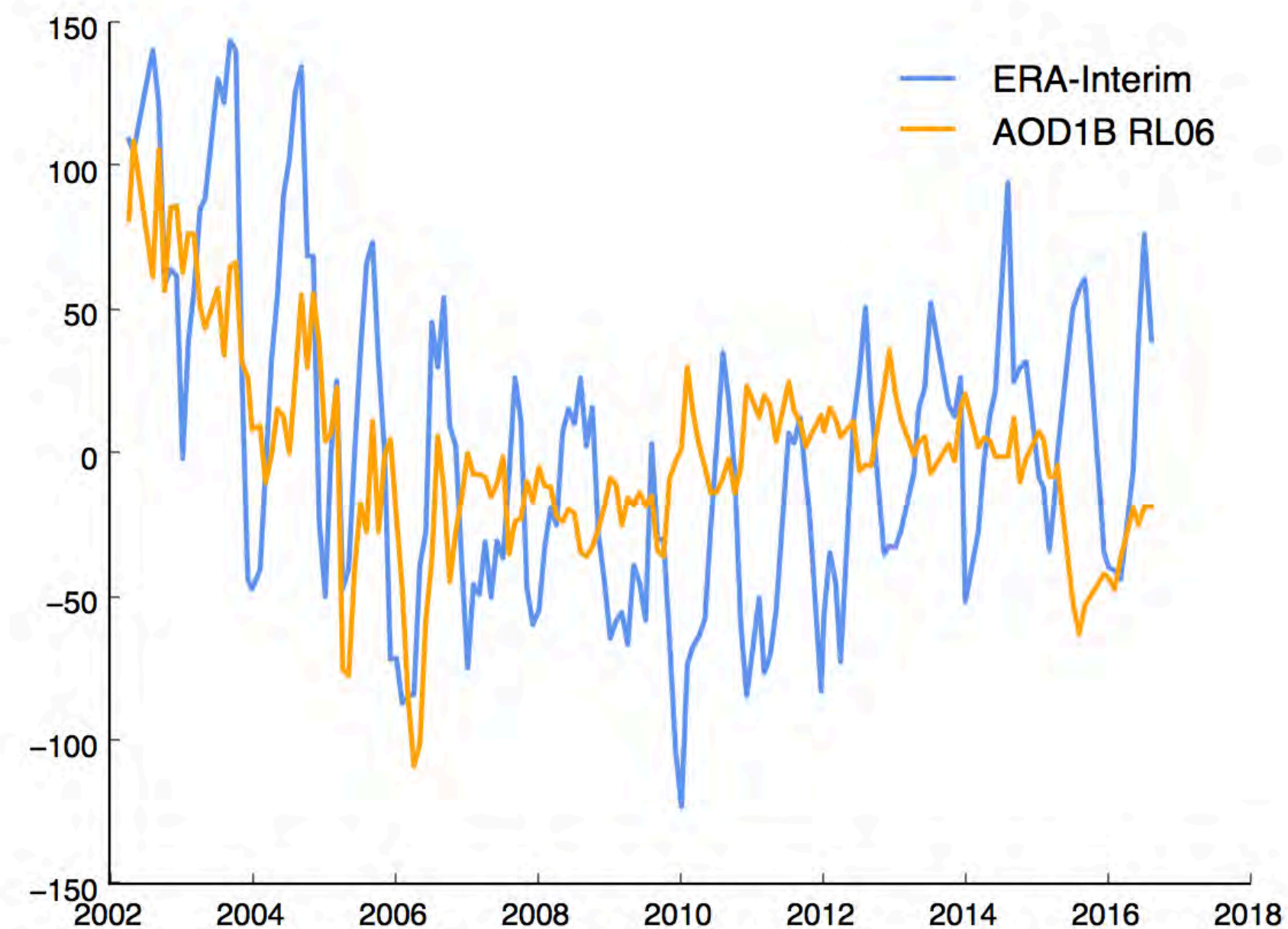




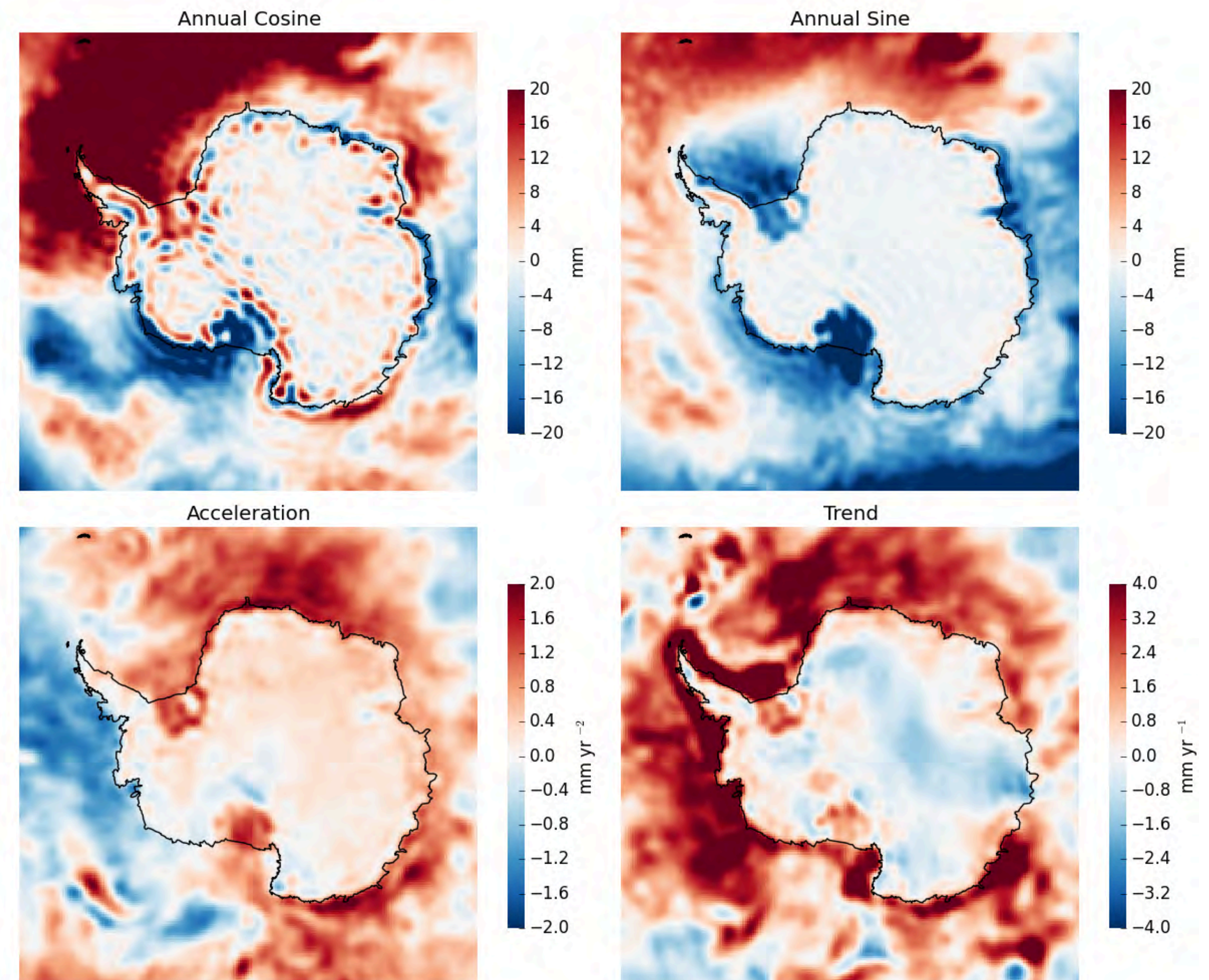


# Effect of AOD1B RL06 over Antarctica

- AOD1B RL06 captures 2002—2007 drift well
- 2007—2016 drift not evident
- Acceleration difference:  $1.7 \pm 0.3$  Gt yr<sup>-2</sup> (out of anticipated 4 Gt yr<sup>-2</sup>)
- Trend difference:  $-3 \pm 0.6$  Gt yr<sup>-1</sup>



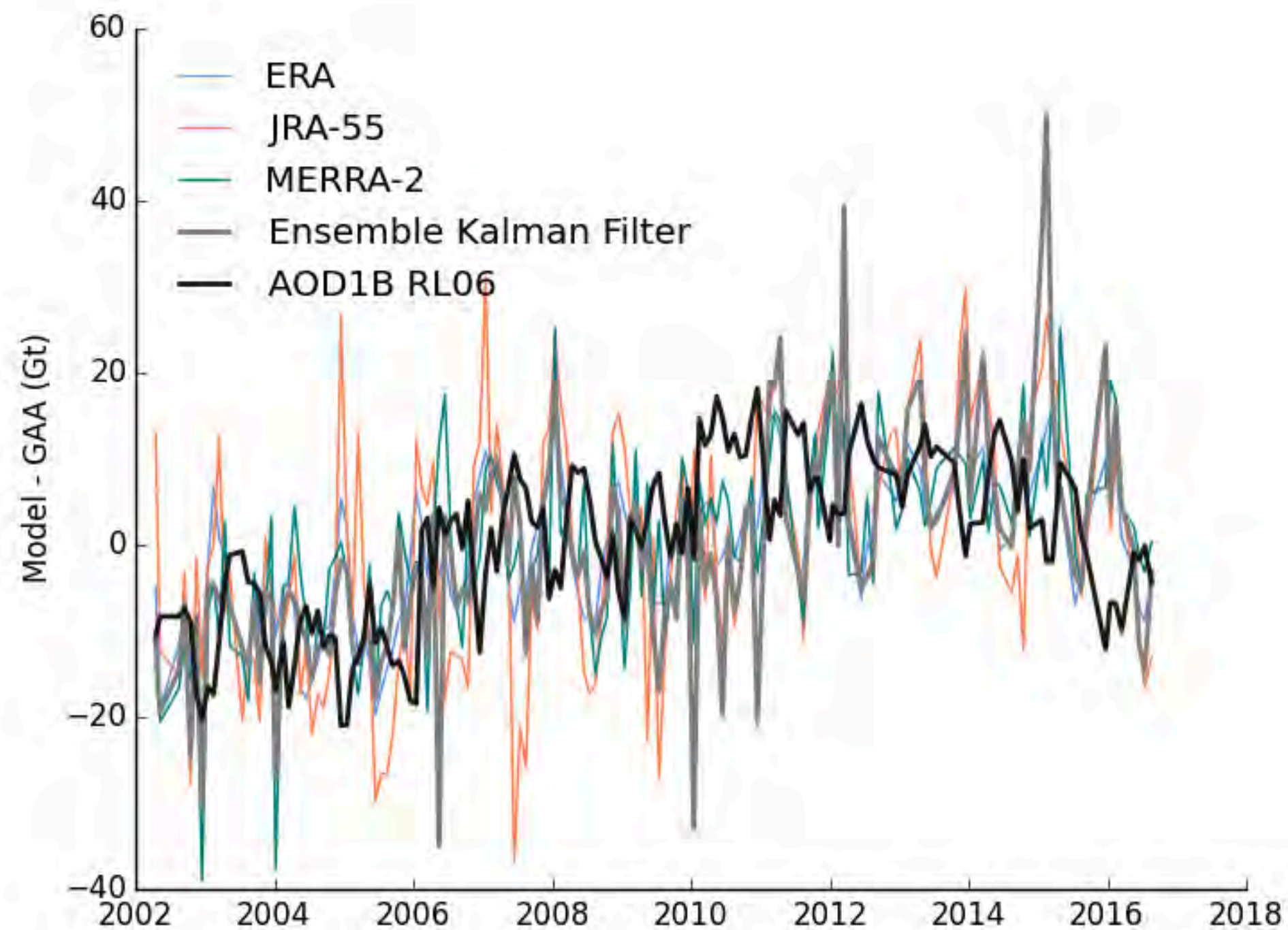
## AOD1B RL06 minus AOD1B RL05



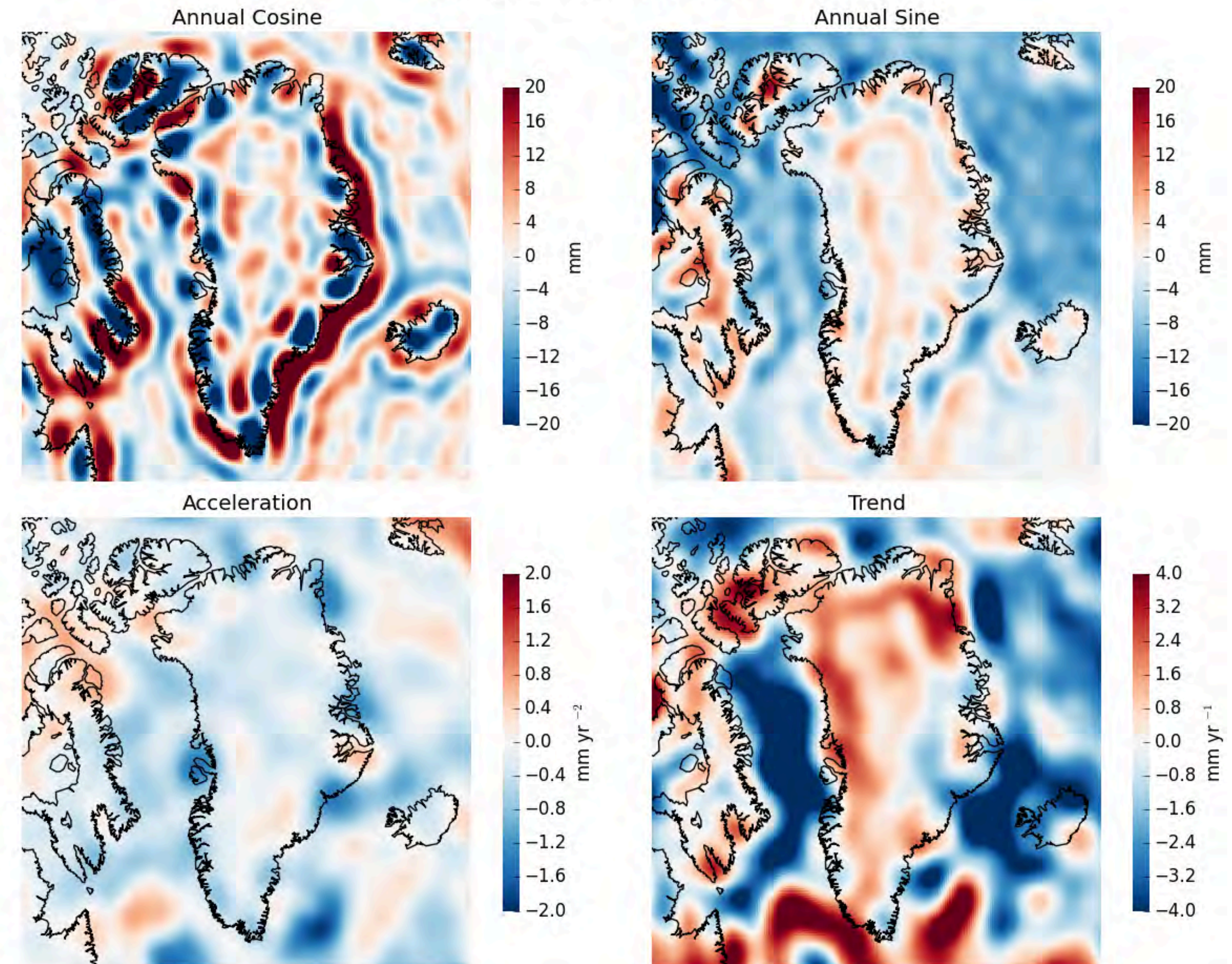


# AOD1B RL06 over Greenland

- Insufficient number of inland observation sites to evaluate accuracy with surface pressure measurements



## AOD1B RL06 minus AOD1B RL05







# Conclusions

## AOD1B RL05

- Errors hide significant acceleration in Antarctic mass loss ( $\sim 4 \text{ Gt yr}^{-2}$  more negative) and episodic errors in Greenland mass loss
- Pressure error signals can be recovered from GRACE data over Antarctica

## AOD1B RL06

- Alleviates model drift between 2002 and 2007 and is comparably accurate with RL05 over Antarctica
- Reduces half of acceleration errors over Antarctica introduced by RL05
- Captures trends over Greenland, but not episodic excursions

**More Information:** Hardy et al. (2017, JGR:SE, *in press*)