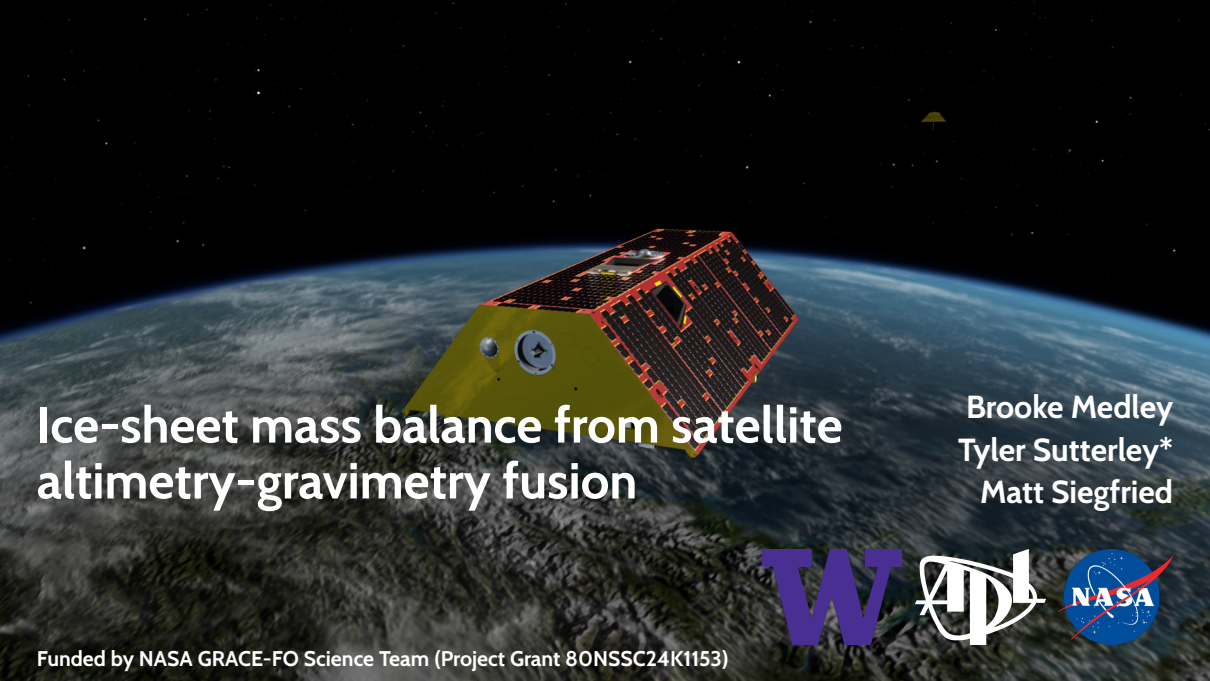

Ice-sheet mass balance from satellite altimetry-gravimetry fusion

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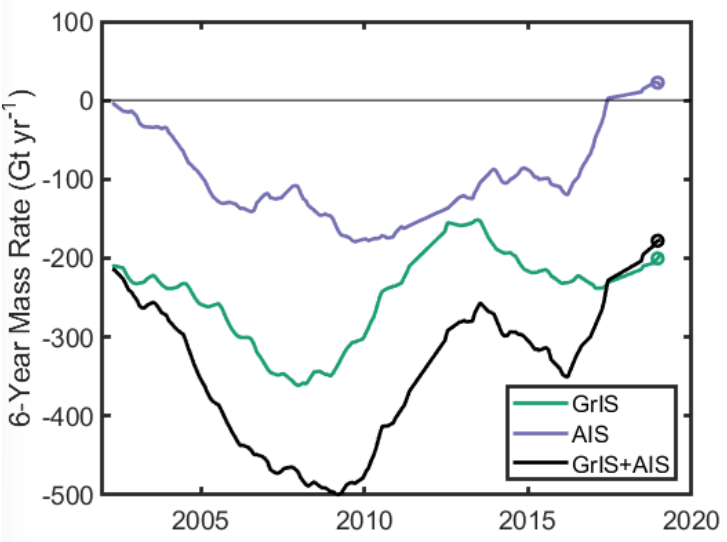
Tyler Sutterley*
Matt Siegfried

Funded by NASA GRACE-FO Science Team (Project Grant 80NSSC24K1153)

Ice sheet mass balance: 20+ years of change



In the last six years:

Antarctica: +19 Gt/yr

Greenland: -196 Gt/yr

Combined: -177 Gt/yr

We launch two missions and Antarctica decides to go all screwy…

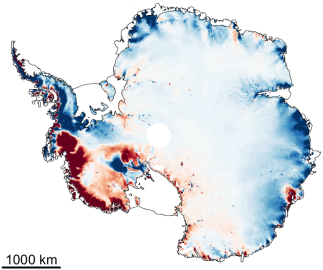
Where is this variability coming from???

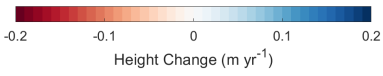
So what do we want to do here?

- Estimate mass change at ICESat-2 resolution with large-scale change constrained by GRACE-FO
- Compare and reconcile SMB/FDM models (JPL-GEMB, GSFC-fdm, IMAU-RACMO)
- Decompose observed mass change into driving processes (SMB and dynamics)

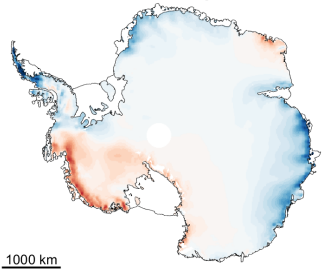
Traditional altimetry processing for mass change

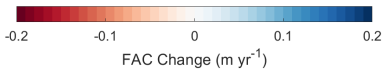
Height change
altimetry observation



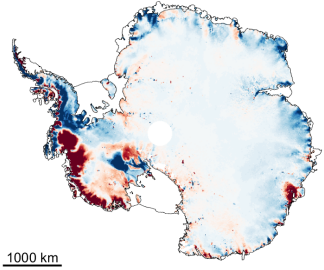


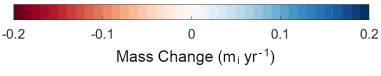
Firn-air content change
model output



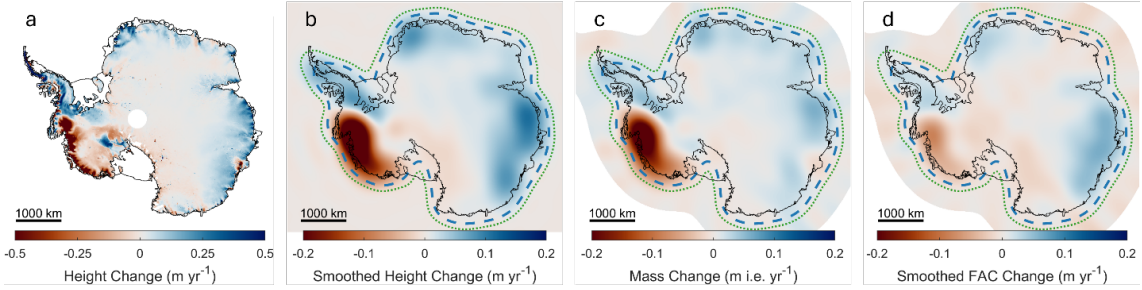


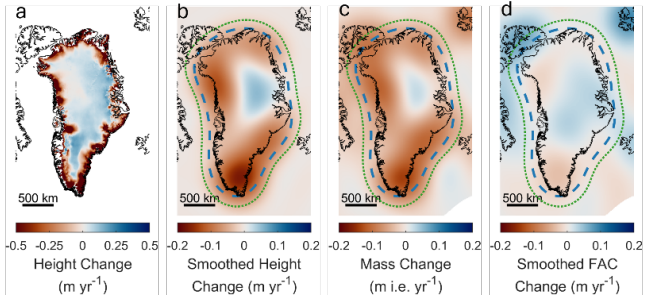
Mass change
obs/model residual





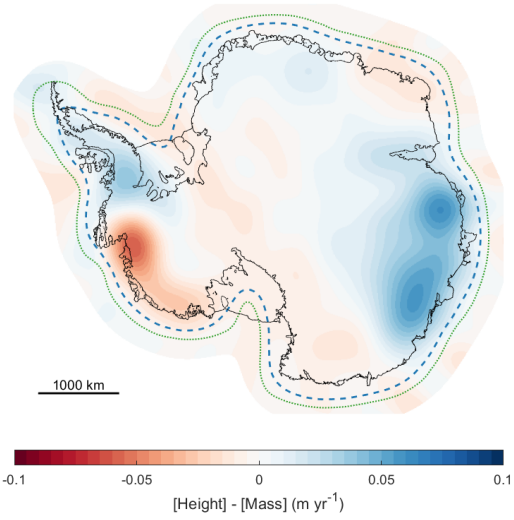
GRACE-FO and ICESat-2 for measuring firn-air content





oops! we've ruined our spatial resolution!

Leveraging firn-air content patterns from models



Assuming spatial structure from model is correct:

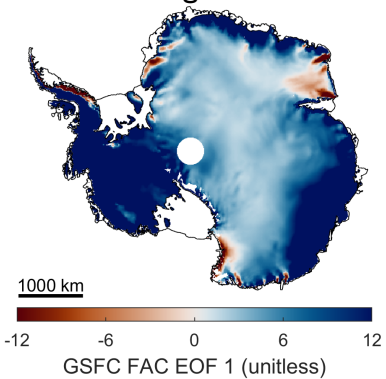
- Perform EOF analysis to estimate dominant spatial modes

$$\Delta\mathrm{FAC}(x, y, t) = \sum_{k=1}^{N} \mathrm{PC}(t) \cdot \mathrm{EOF}_k(x, y)$$

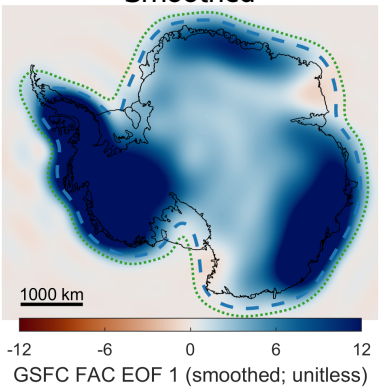
- Apply "GRACE-like" processing to our EOFs
- Infer for EOF presence in our observations by treating as an inverse problem
- Can then use the *original* EOFs to reconstruct high-resolution estimates of FAC variability

Constraining firn-air content variability

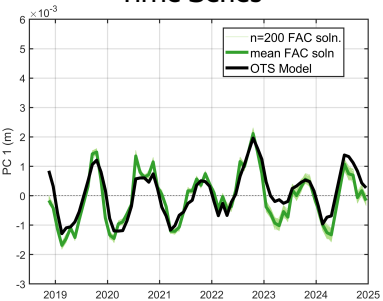
GSFC-fdm FAC EOF_1
Original



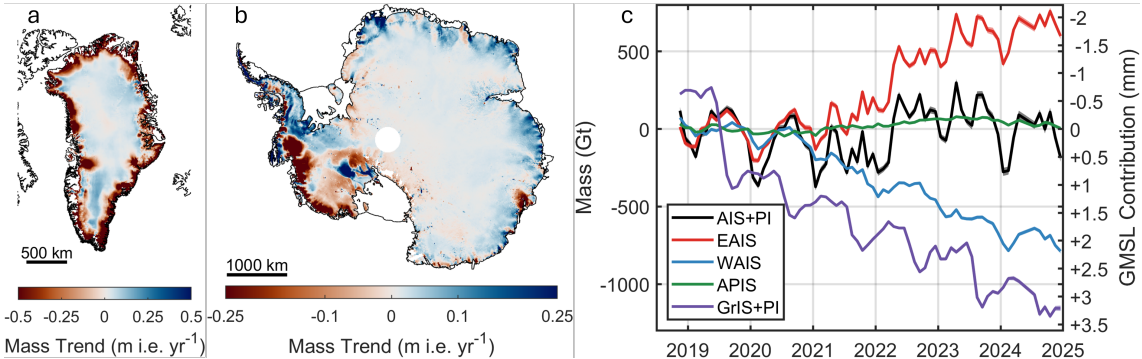
GSFC-fdm FAC EOF_1
Smoothed



Principle Component 1
Time Series



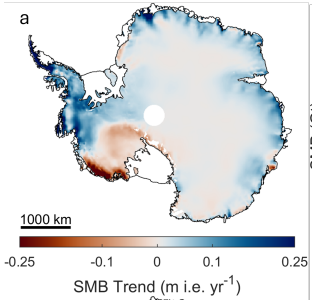
High-resolution estimates of mass change (Nov. 2018 – Dec. 2024)

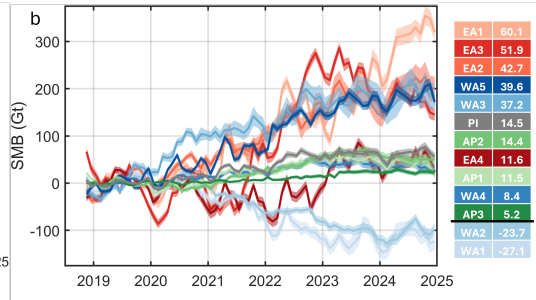


Monthly ice-sheet mass balance and global mean sea level (GMSL) contributions for Greenland and Antarctica

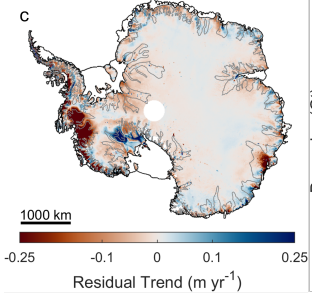
Dominant processes driving mass change (Nov. 2018 – Dec. 2024)

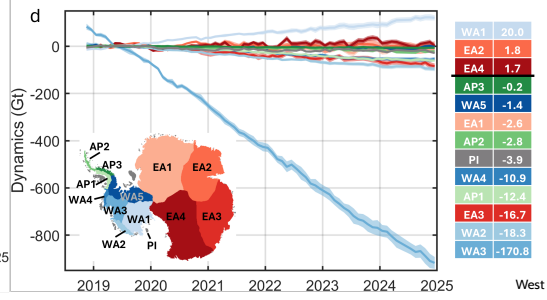
That's a whole lotta snow…





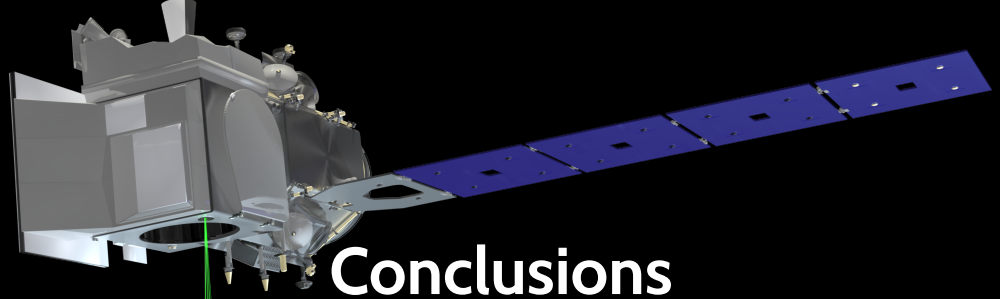
EA1	60.1
EA3	51.9
EA2	42.7
WA5	39.6
WA3	37.2
PI	14.5
AP2	14.4
EA4	11.6
AP1	11.5
WA4	8.4
AP3	5.2
WA2	-23.7
WA1	-27.1





WA1	20.0
EA2	1.8
EA4	1.7
AP3	-0.2
WA5	-1.4
EA1	-2.6
AP2	-2.8
PI	-3.9
WA4	-10.9
AP1	-12.4
EA3	-16.7
WA2	-18.3
WA3	-170.8

West Antarctica is still doing its thing…



Conclusions

- ICESat-2 + GRACE-FO make a winning combination!
- Novel observational constraint on SMB vs. Dynamics
- Need to keep these time series moving into the future…