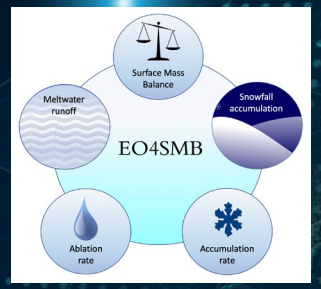
living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE



INCREASED VARIABILITY IN GREENLAND ICE SHEET RUNOFF DETECTED BY CRYOSAT-2 AS PART OF POLAR+ EO4SMB

Thomas Slater[1]*, Andrew Shepherd[1], Malcolm McMillan[2], Amber Leeson[2], Lin Gilbert[3], Alan Muir[3,4], Peter Kuipers Munneke[5], Brice Noël[5], Xavier Fettweis[6], Michiel van den Broeke[5], Kate Briggs[1], Marcus Engdahl[7]

[1]Centre for Polar Observation and Modelling, School of Earth and Environment, University of Leeds, Leeds, UK; [2]Lancaster Environment Centre, Lancaster University, Lancaster, UK; [3]Mullard Space Science Laboratory, Department of Space & Climate Physics, University College London, London, UK; [4]Centre for Polar Observation and Modelling, Department of Earth Sciences, University College London, London, UK; [5]Institute for Marine and Atmospheric research Utrecht, Utrecht University, Utrecht, the Netherlands; [6]SPHERES Research Unit, Department of Geography, University of Liège, Liège, Belgium; [7]Via Galileo Galilei, 1, 00044 Frascati RM, Italy

26/05/2022

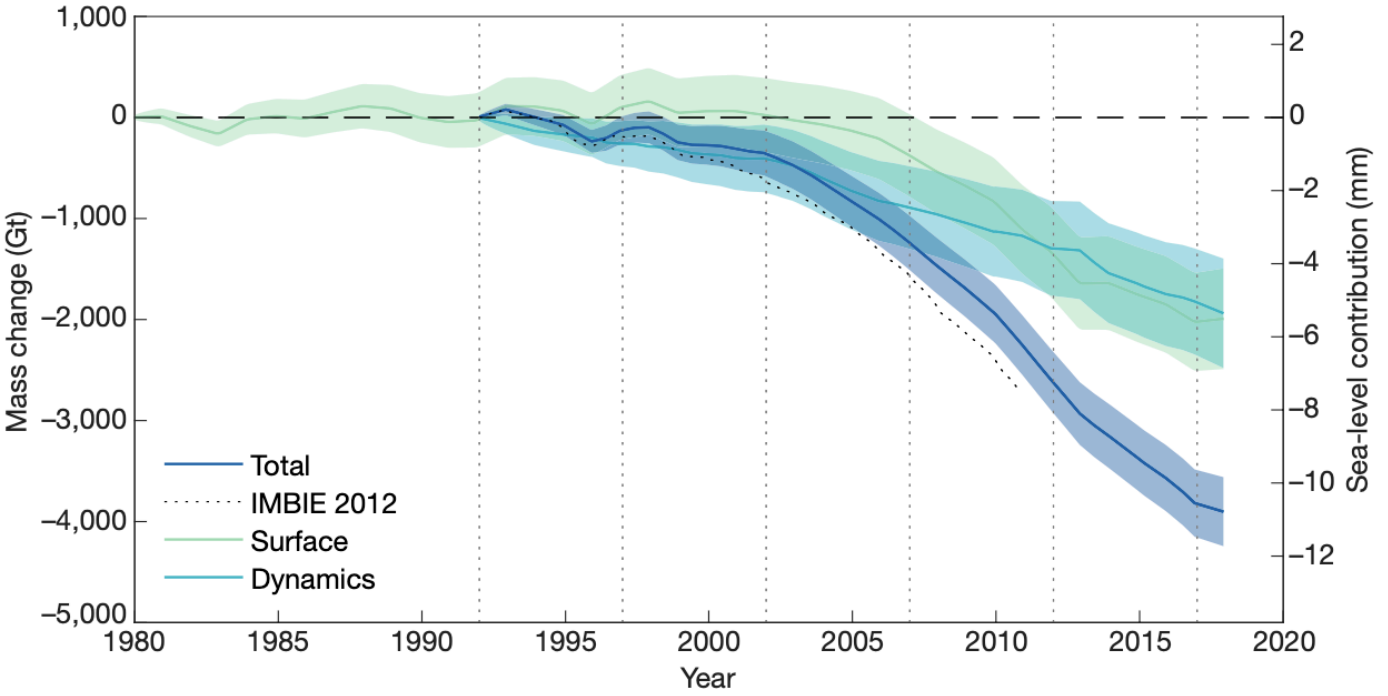
OUTLINE

- Introduction
- Partitioning CryoSat-2 elevation changes
- Seasonal cycle of melting and snowfall
- A CryoSat-2 record of Greenland runoff
- Increased variability in Greenland runoff from CryoSat-2 observations
- Key points

GREENLAND'S CONTEMPORARY MASS BALANCE

Greenland has contributed 11 mm to global sea level since 1992

Recent imbalance driven by decline in net surface mass balance (SMB) as regional climate has warmed



Cumulative Greenland mass anomalies. The IMBIE Team, 2020

GREENLAND'S SURFACE MASS BALANCE

Surface mass balance (SMB) net balance between gains (snowfall, rainfall) and losses (runoff, sublimation drifting snow erosion) at ice sheet surface…

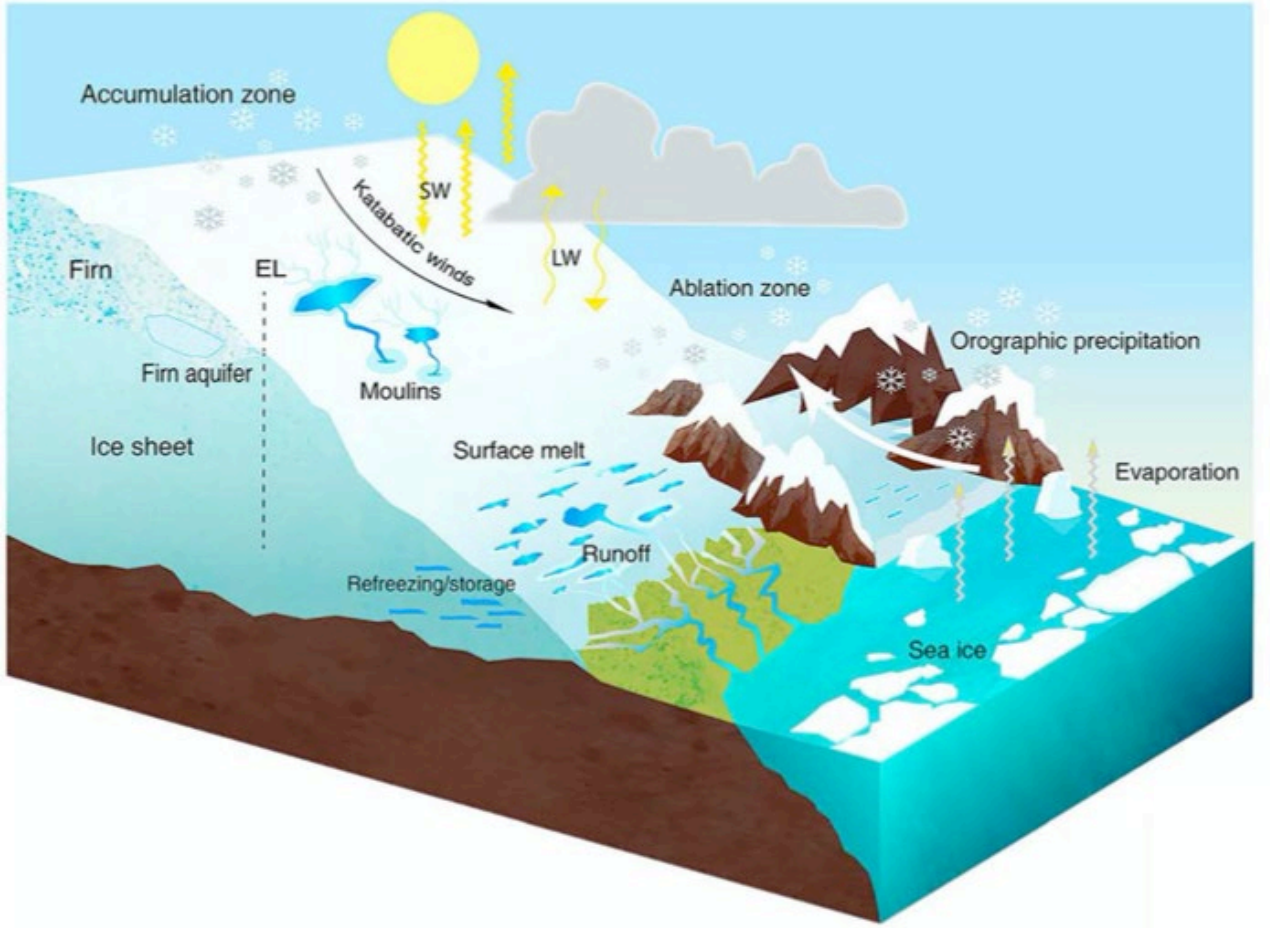
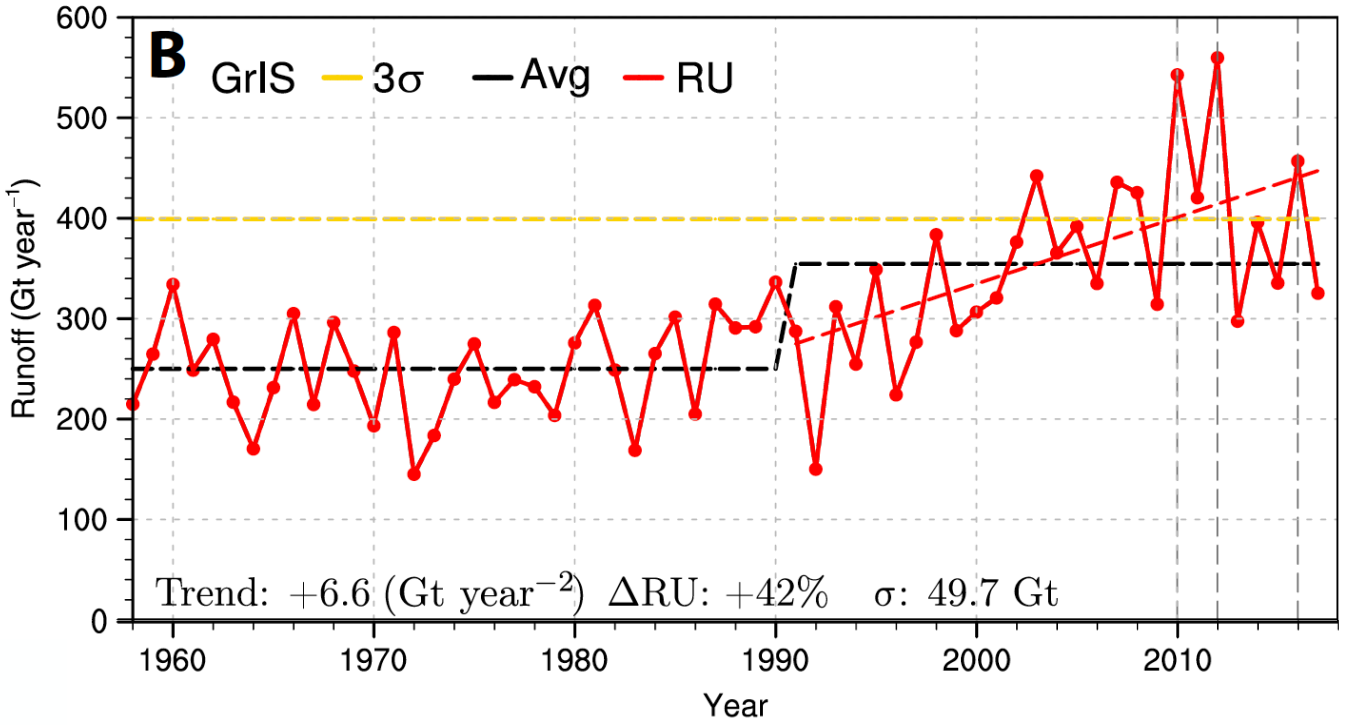


Illustration of processes contributing to Greenland SMB. Lenaerts et al., 2019

GREENLAND RUNOFF

Surface mass balance (SMB) net balance between gains (snowfall, rainfall) and losses (runoff, sublimation drifting snow erosion) at ice sheet surface…

… the recent decline has primarily been driven by increased runoff.



Annual runoff modelled by RACMO. Noël et al., 2019

GREENLAND RUNOFF

Video Credit: UCLA; Smith et al., 2014

GREENLAND RUNOFF

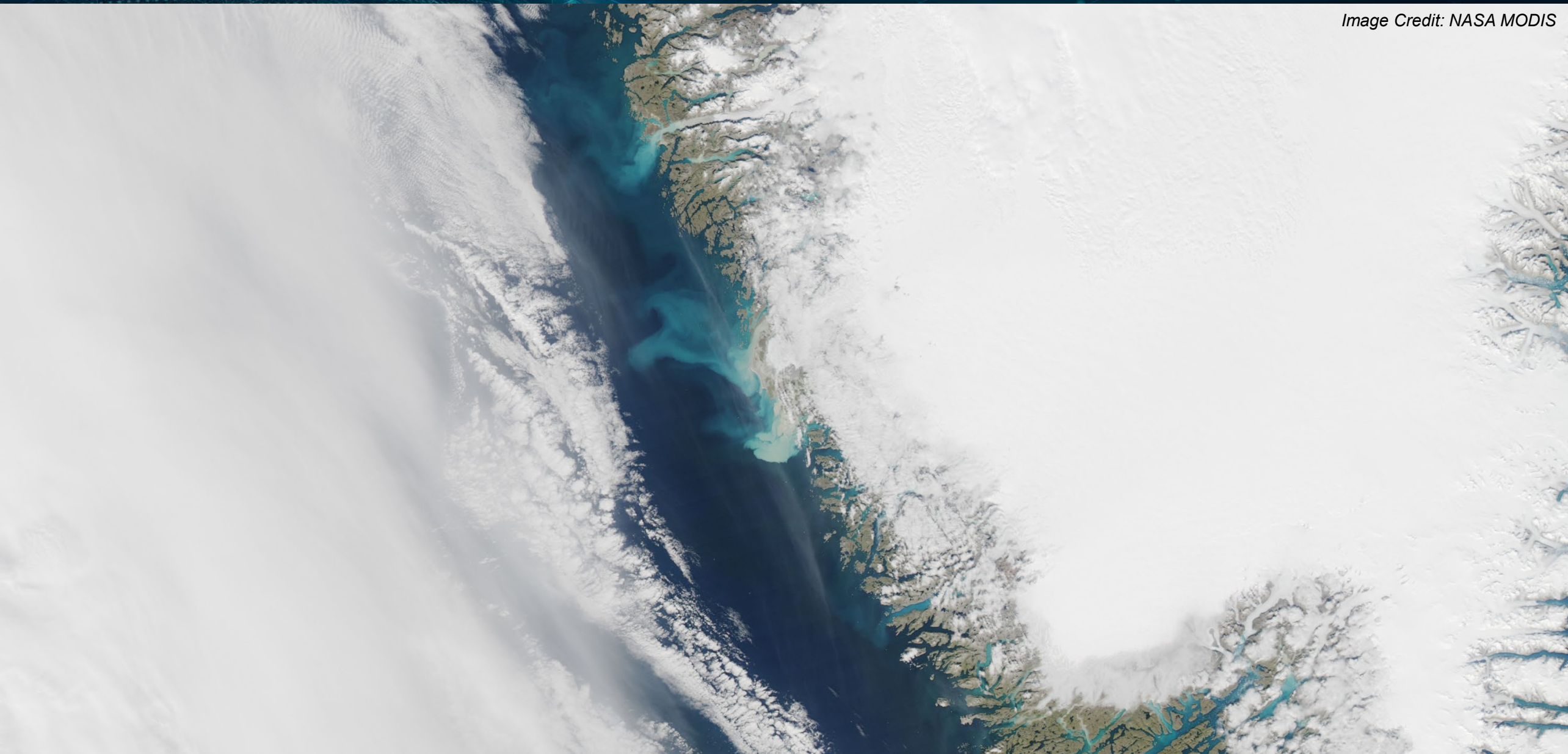
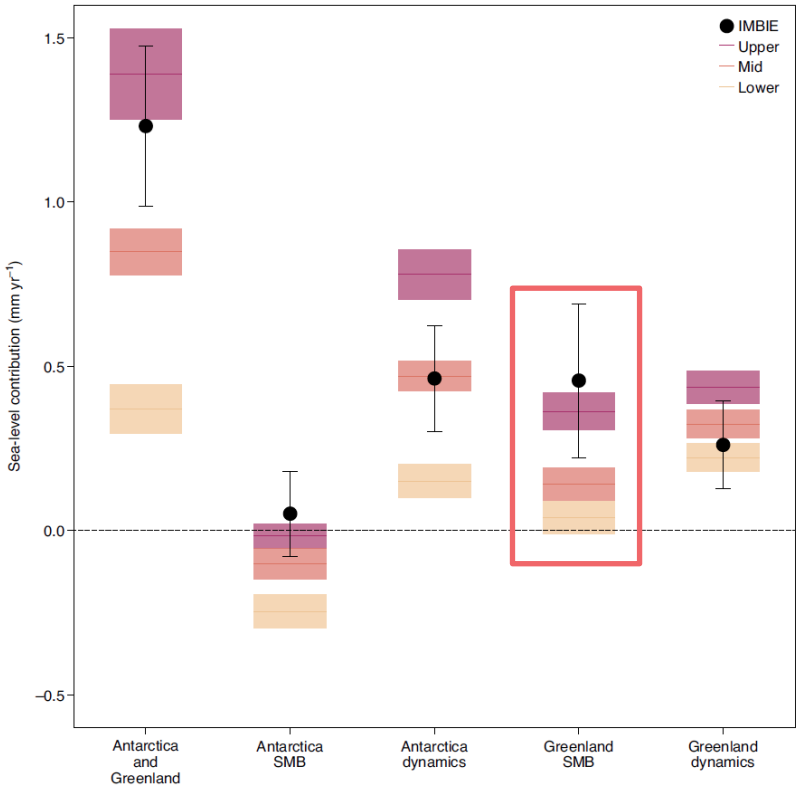


Image Credit: NASA MODIS

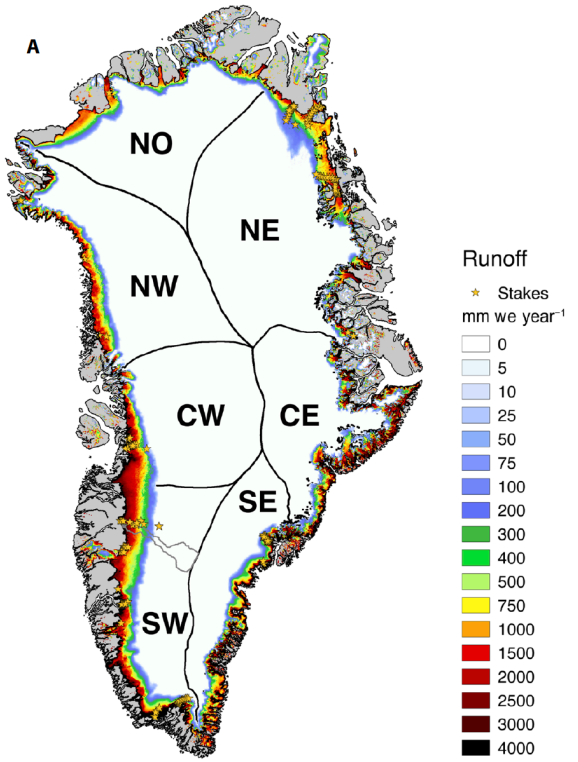
GREENLAND RUNOFF

Video Credit: NASA

THE NEED FOR EARTH OBSERVATION OF SMB



Comparison of IMBIE (black) and AR5 projections, Slater et al., 2020

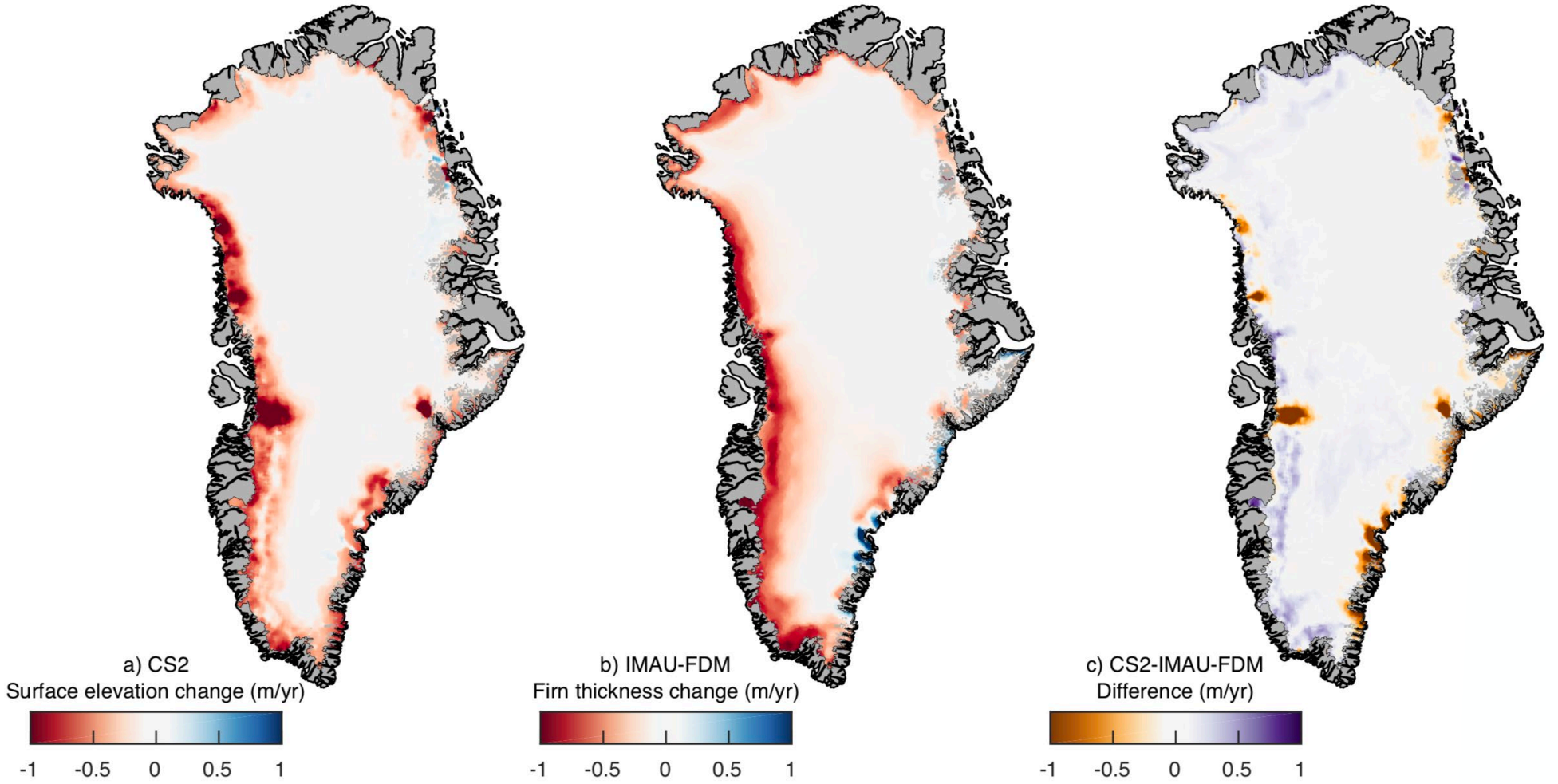


Average annual runoff (1958-2017) modelled by RACMO. Noël et al., 2019

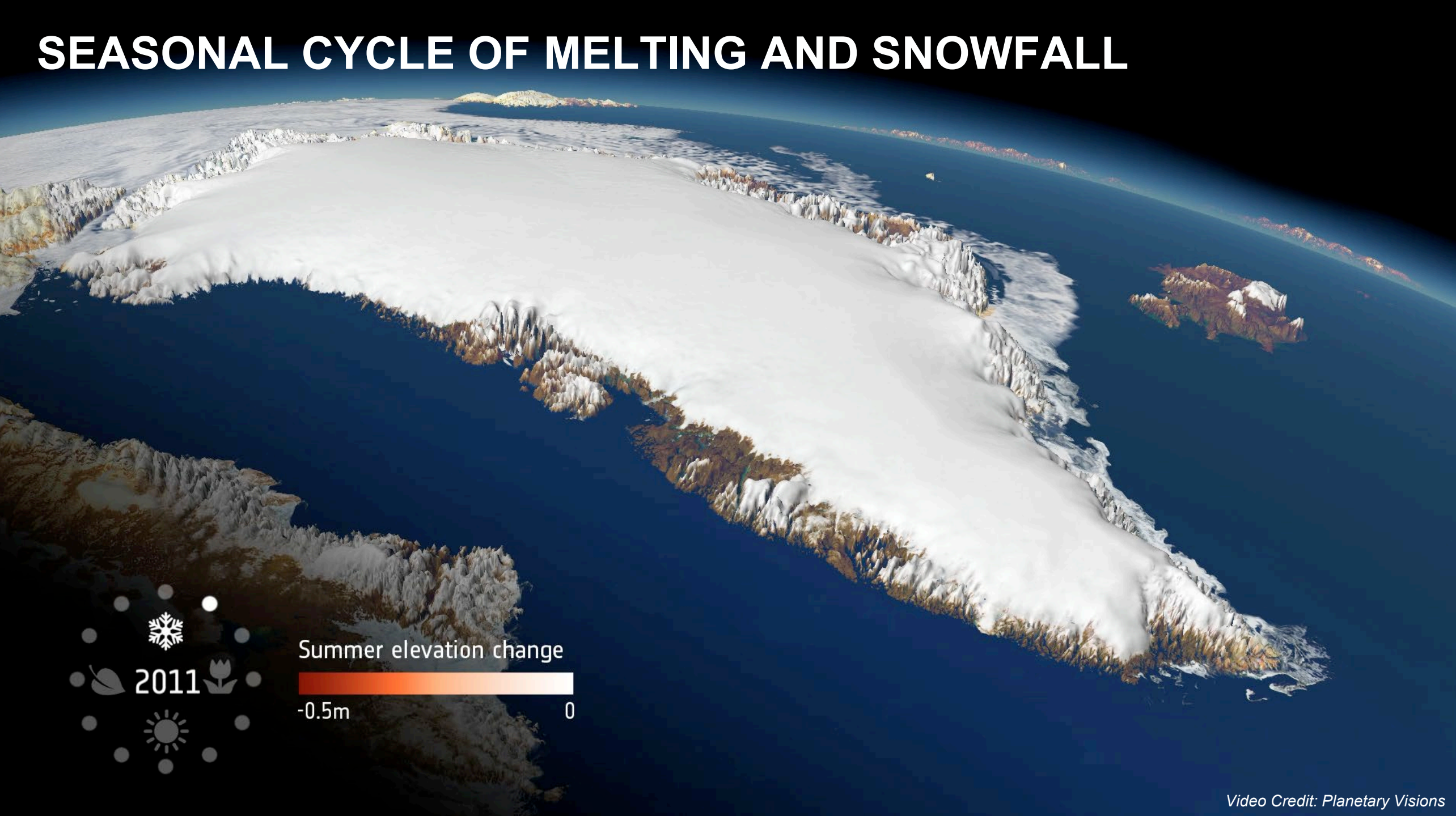
Global climate models historically used in sea level projections have not captured recent interannual variability in SMB and underestimated Greenland's sea level contribution

Regional climate models have been principal source of ice-sheet wide estimates of SMB parameters; available *in situ* data is sparse

PARTITIONING CRYOSAT-2 ELEVATION CHANGES



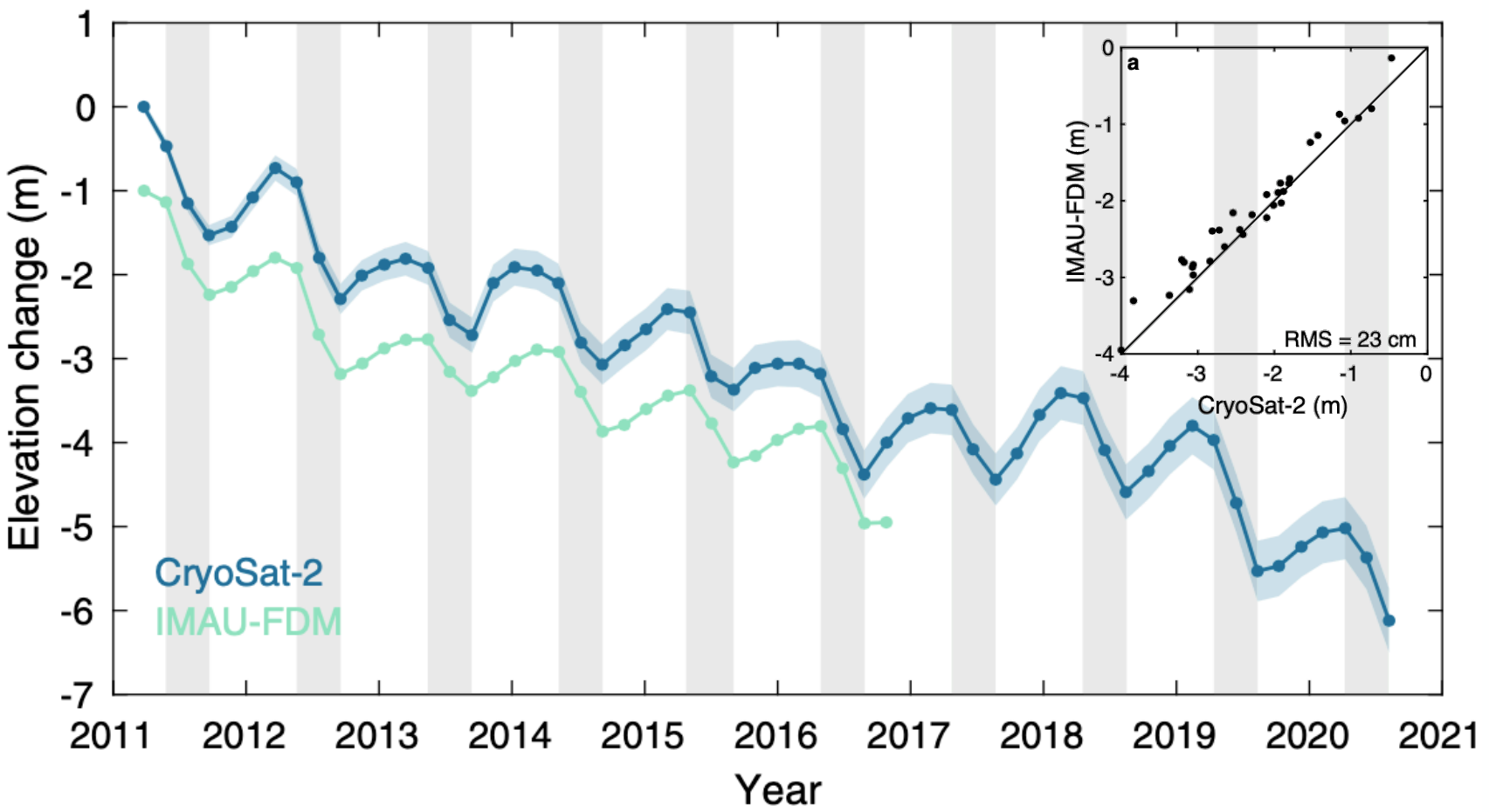
SEASONAL CYCLE OF MELTING AND SNOWFALL

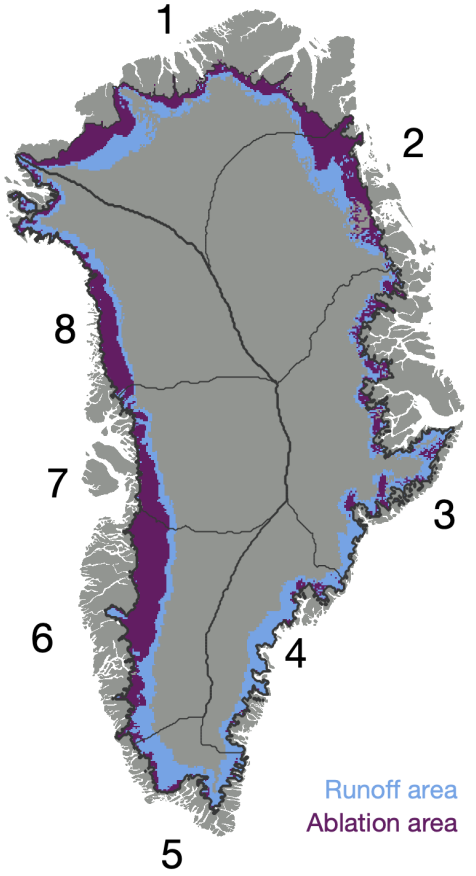


Video Credit: Planetary Visions

SEASONAL CYCLE OF MELTING AND SNOWFALL

Ablation zone time series



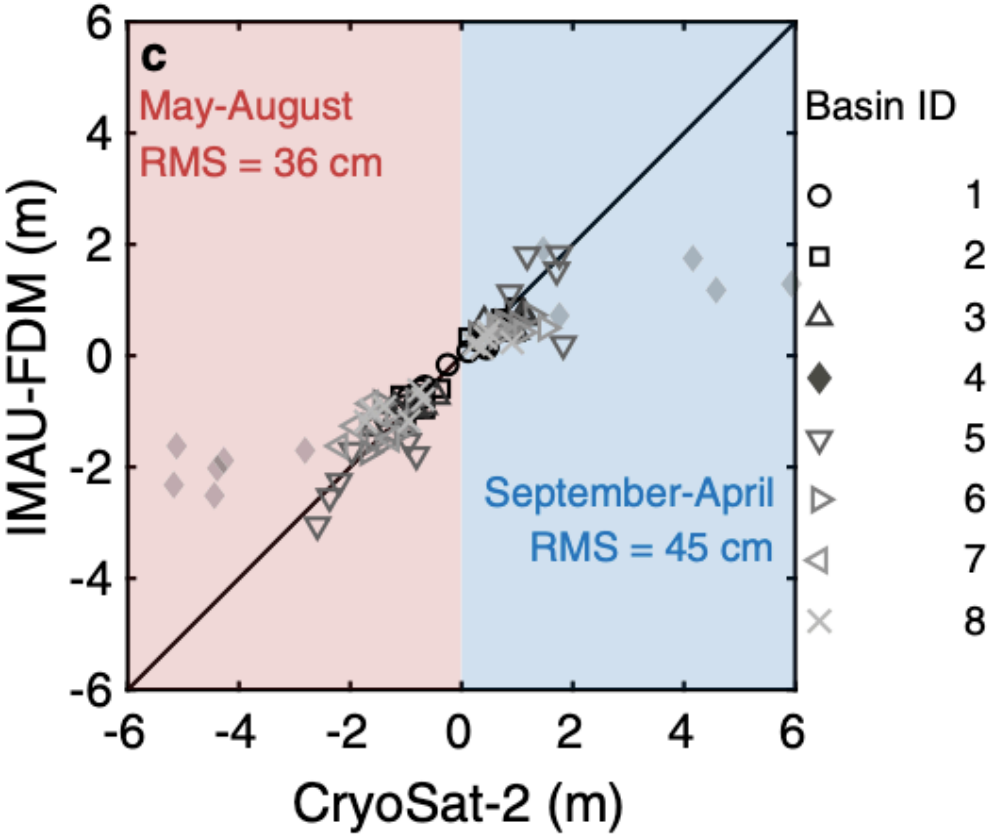


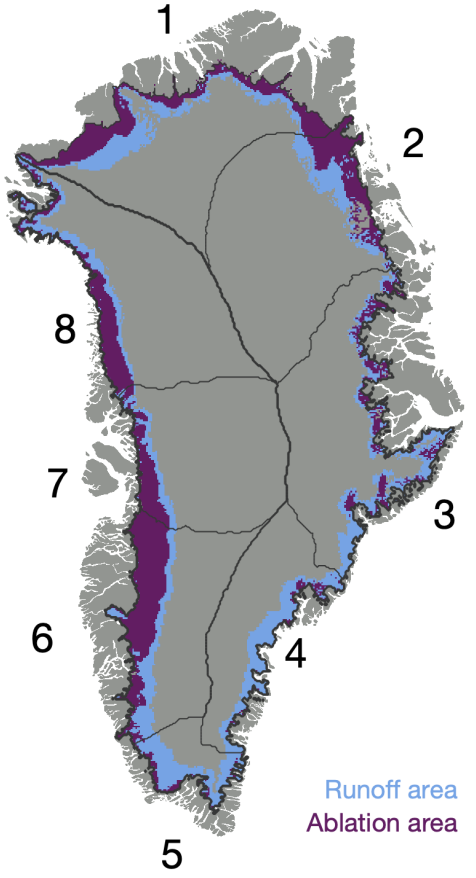
SEASONAL CYCLE OF MELTING AND SNOWFALL

Seasonal changes between CryoSat-2 and firn modelling also agree well in ablation zone – indicates that SMB processes are the primary driver

Interannual variations in e.g. ice-sheet wide summer elevation changes reflect variations in atmospheric forcing – summer thinning ~40% lower on average 2013-2015 (1.2 ± 0.4 m) than 2012 and 2019 (1.9 ± 0.5 m)

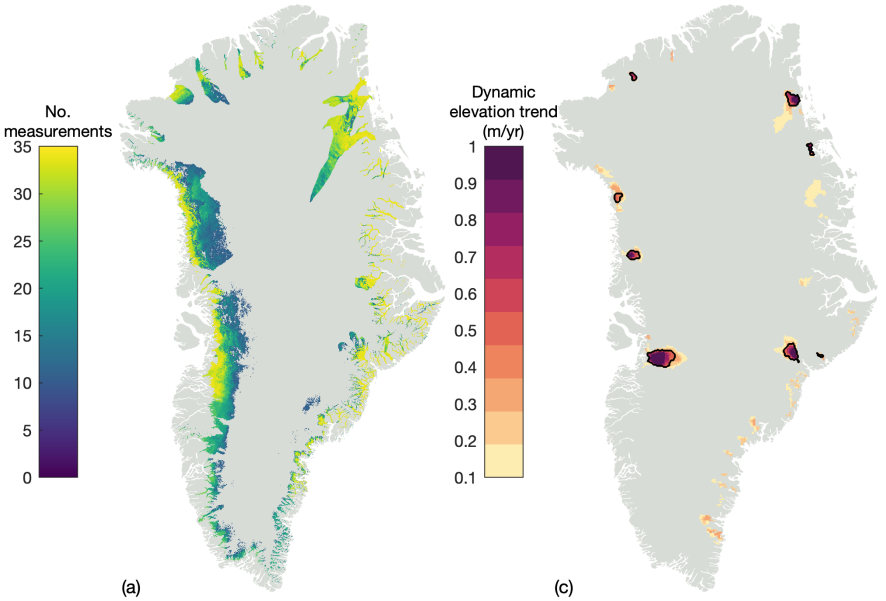
Seasonal elevation changes in ablation zone in summer (red) and winter (blue)



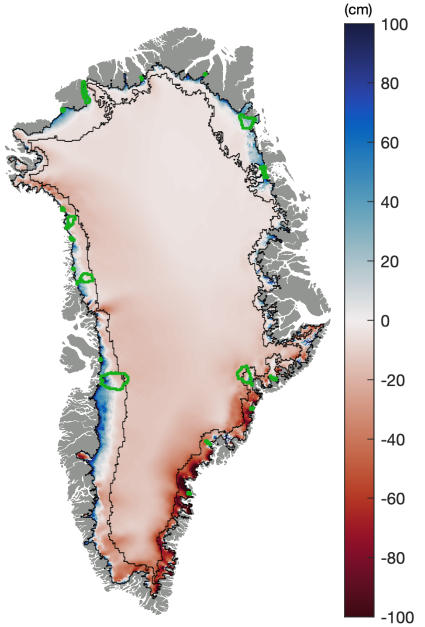


A CRYOSAT-2 RECORD OF GREENLAND RUNOFF

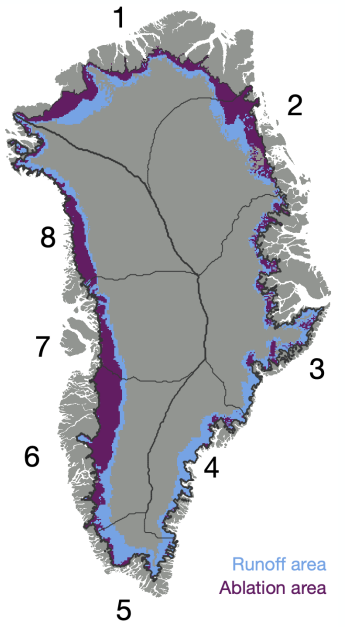
Because observed seasonal changes are driven by SMB, and dominant process in summer is melting, we use CryoSat-2 elevation measurements to estimate ice-sheet runoff



Identify and remove areas of dynamic imbalance using velocity data and dynamic elevation trends from CryoSat-2

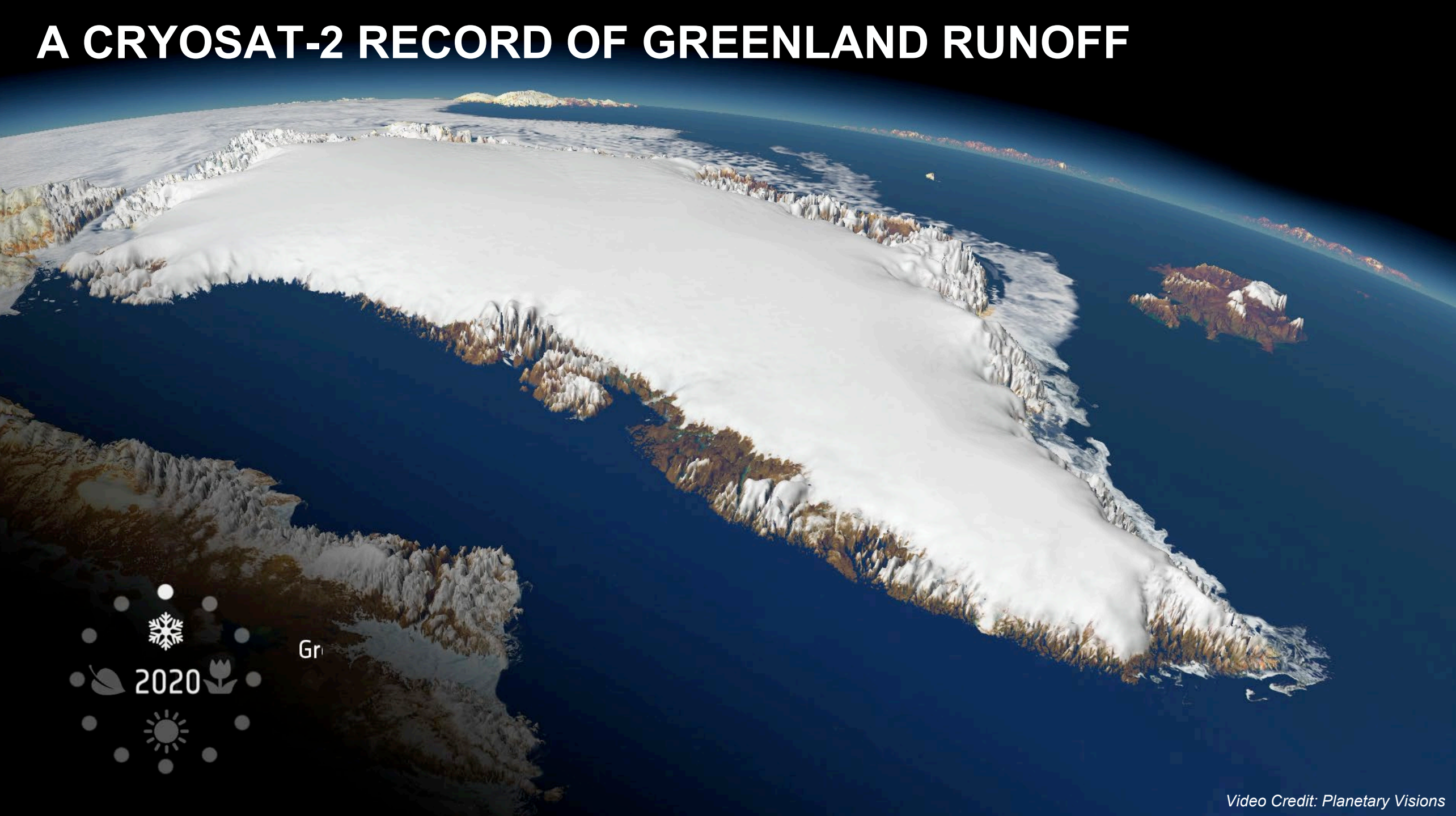


Account for elevation signal associated with steady-state divergence of ice to isolate contribution due to SMB anomalies



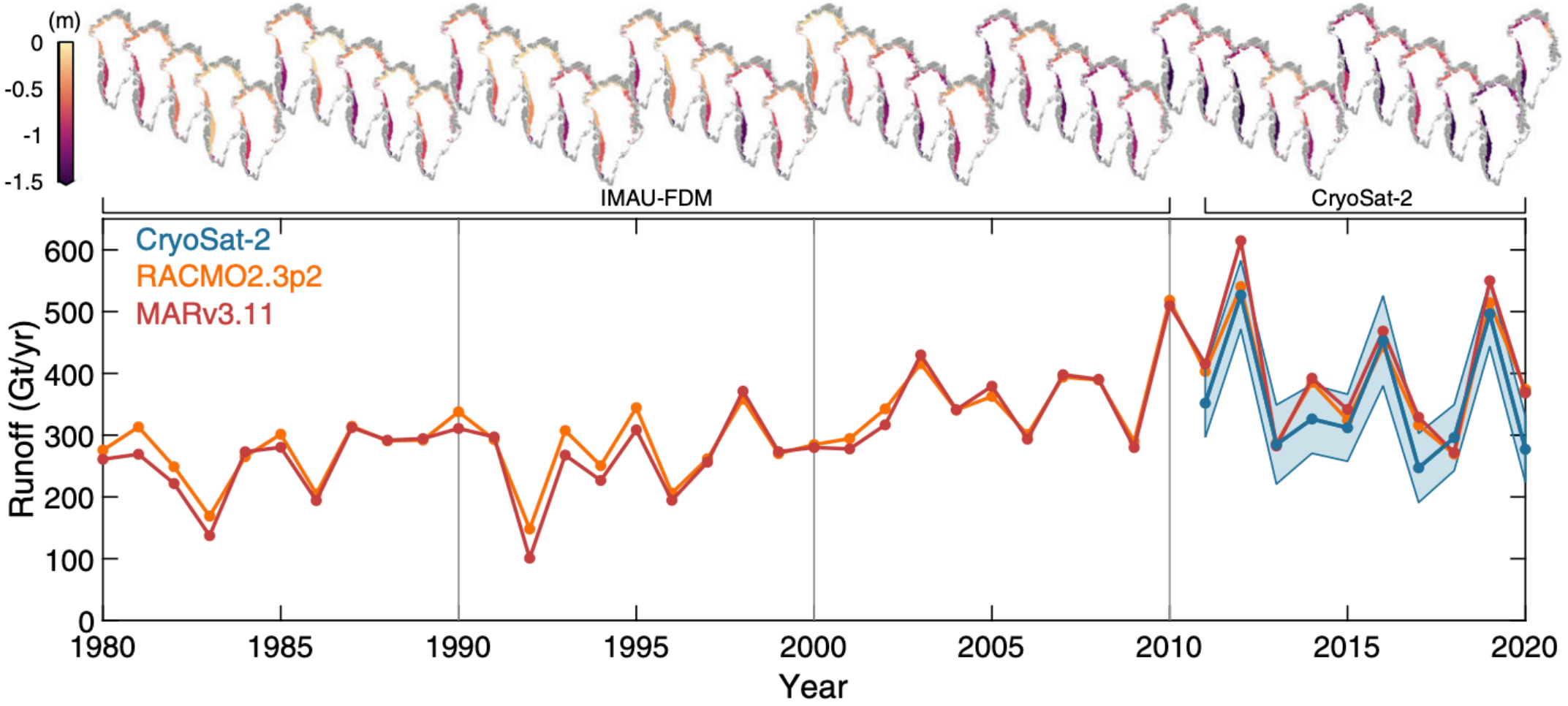
Convert elevation changes to mass assuming constant densities

A CRYOSAT-2 RECORD OF GREENLAND RUNOFF

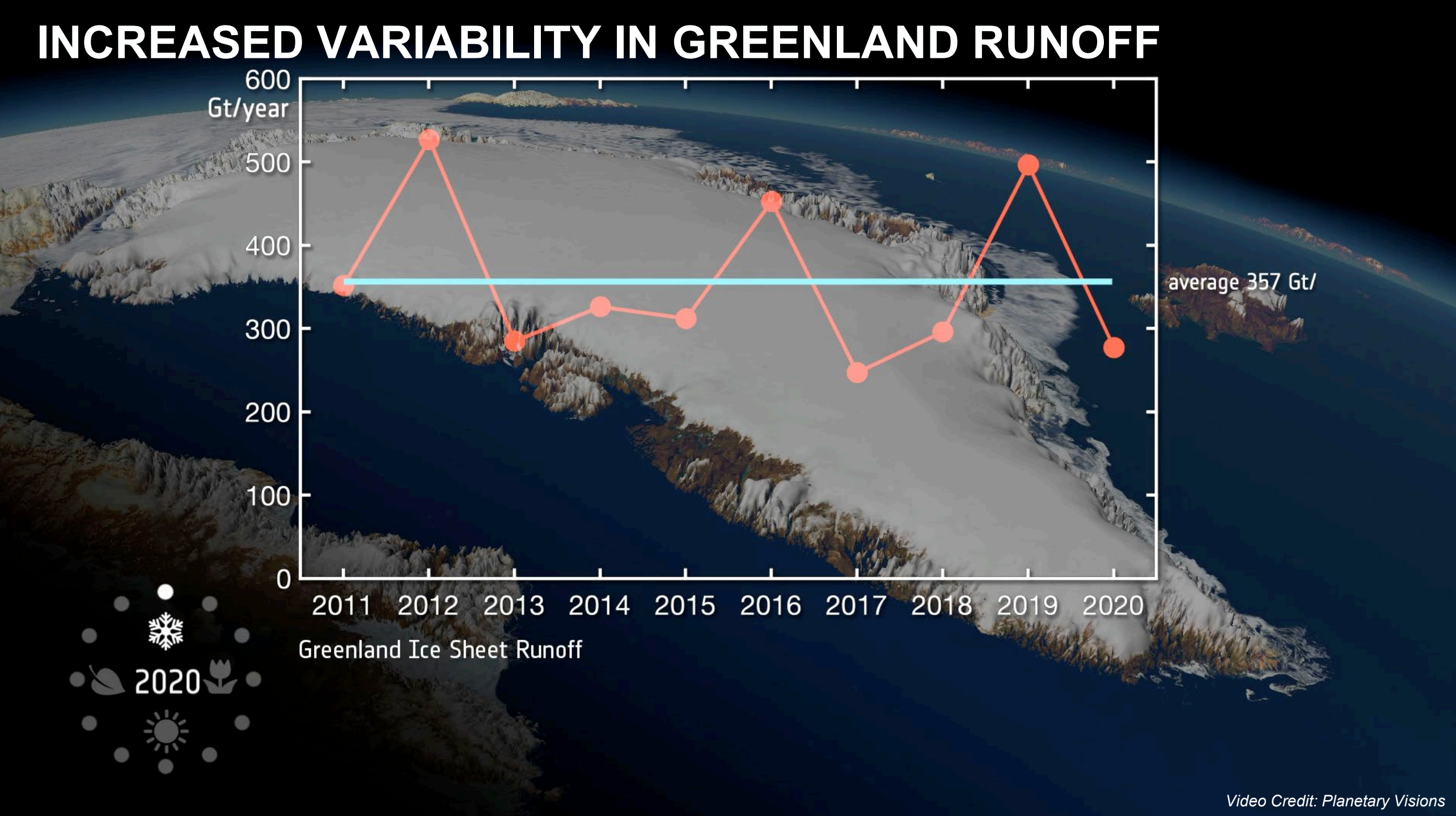


Video Credit: Planetary Visions

A CRYOSAT-2 RECORD OF GREENLAND RUNOFF



INCREASED VARIABILITY IN GREENLAND RUNOFF



Video Credit: Planetary Visions

KEY POINTS

- CryoSat-2 can detect Greenland ice-sheet and regional scale seasonal elevation changes.
- Close agreement with firn modelling suggests these changes are driven by SMB…
- … CryoSat-2 can provide observational and satellite-based estimate of ice sheet runoff at scale.
- Runoff estimated by CryoSat-2 between 2011-2020 21% higher and 60% more variable than previous three decades.
- Observational approach allows runoff to be measured in near real-time, and support improvements in model capability.
- Work … owfall variab

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Investigating the Applications of Singular Spectrum Analysis for Satellite Altimetry Derived Surface Elevation Change Time Series over Ice Sheets

Poster | A9.04 Mass Balance of the Cryosphere

R. Wassink Speaker

Lancaster University