Global glacier changes from radar altimetry

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Noel Gourmelen,
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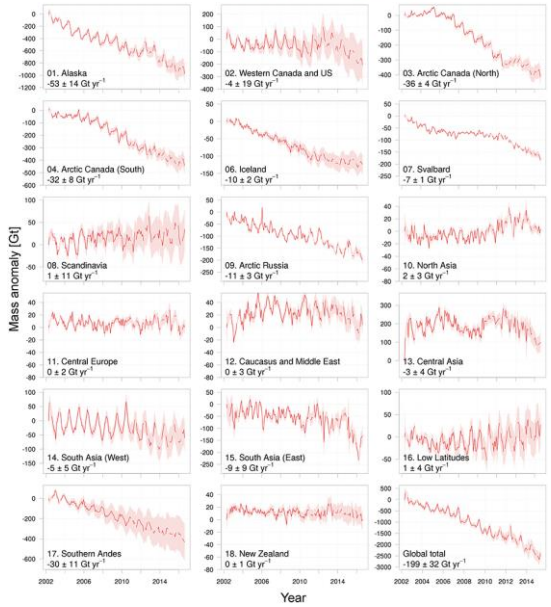
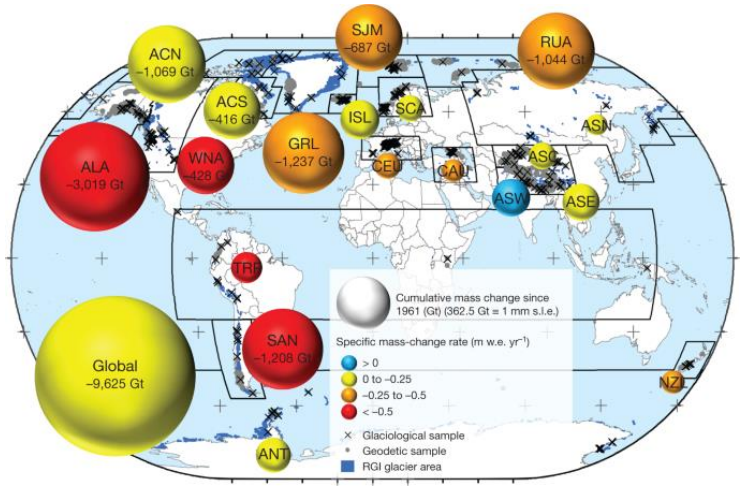
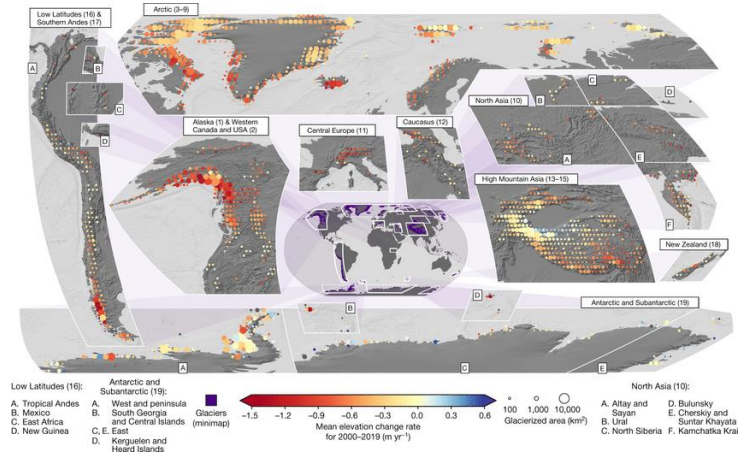
Global glacier changes



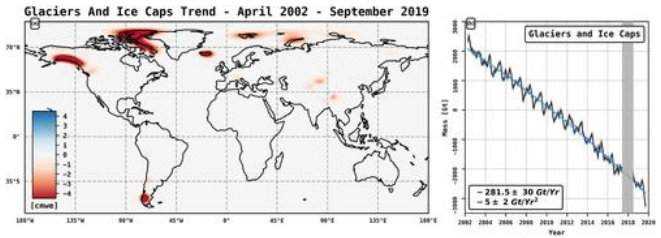
Wouters et al. (2019)



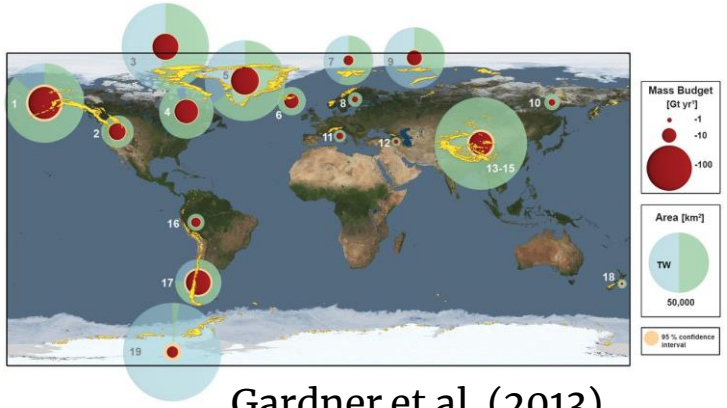
Zemp et al. (2019)



Hugonnet et al. (2021)



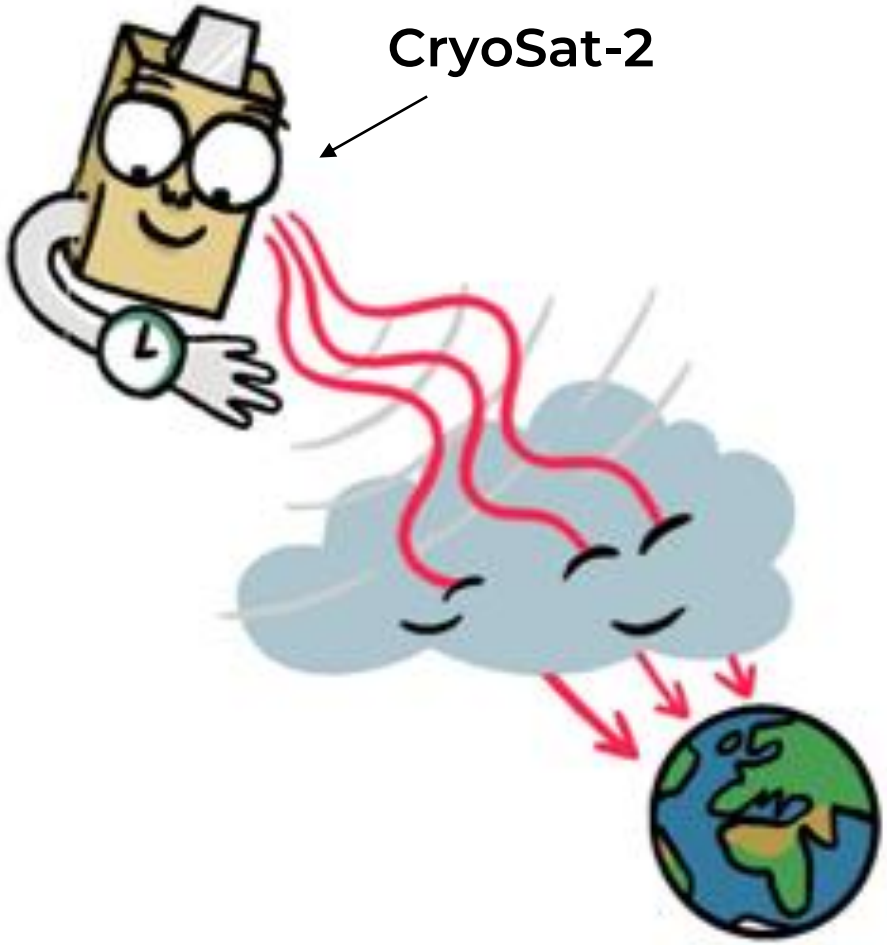
Ciracì et al. (2020)



Gardner et al. (2013)

CryoSat-2 swath altimetry to measure glaciers

Radar altimetry



All weather system

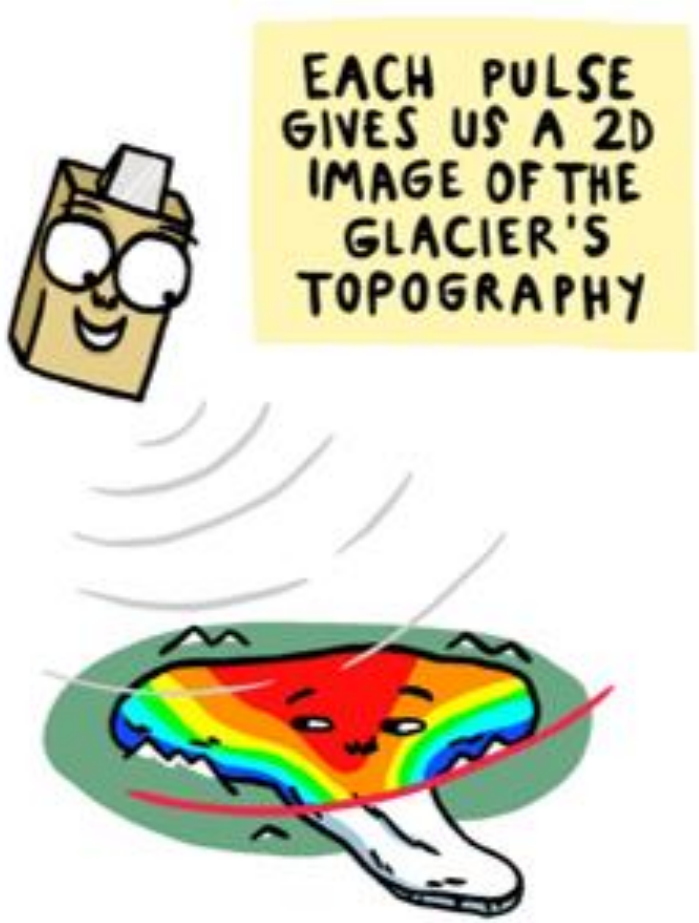
CryoSat-2: first SAR altimeter

Drawings by Agathe Monnot

Interferometry

CryoSat-2 is the first interferometric radar altimeter

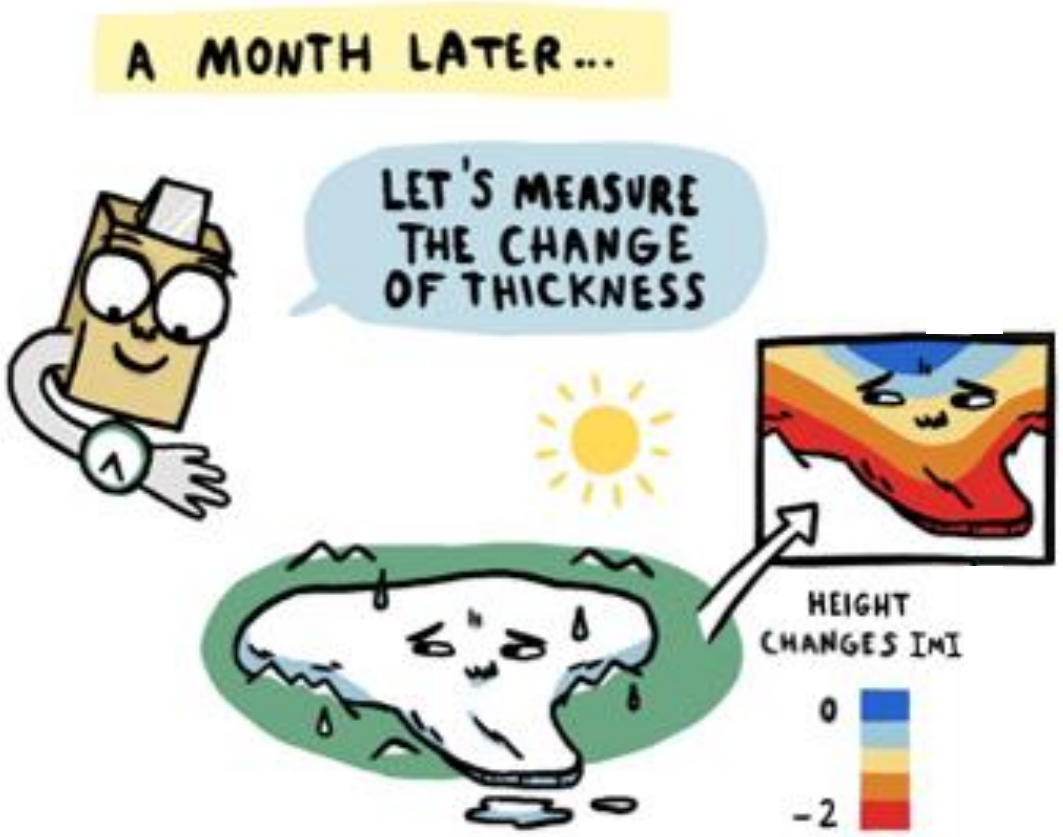
Swath processing algorithm



Novel technique “swath processing”

Generates more measurements

Measuring glacier changes



Unique combination of high temporal (monthly) and high spatial resolution

Radar altimetry & mountain glaciers

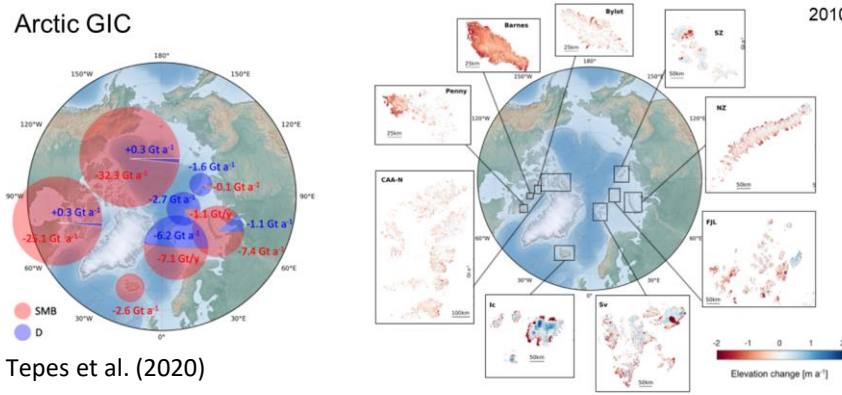
Alaska

2010-2019

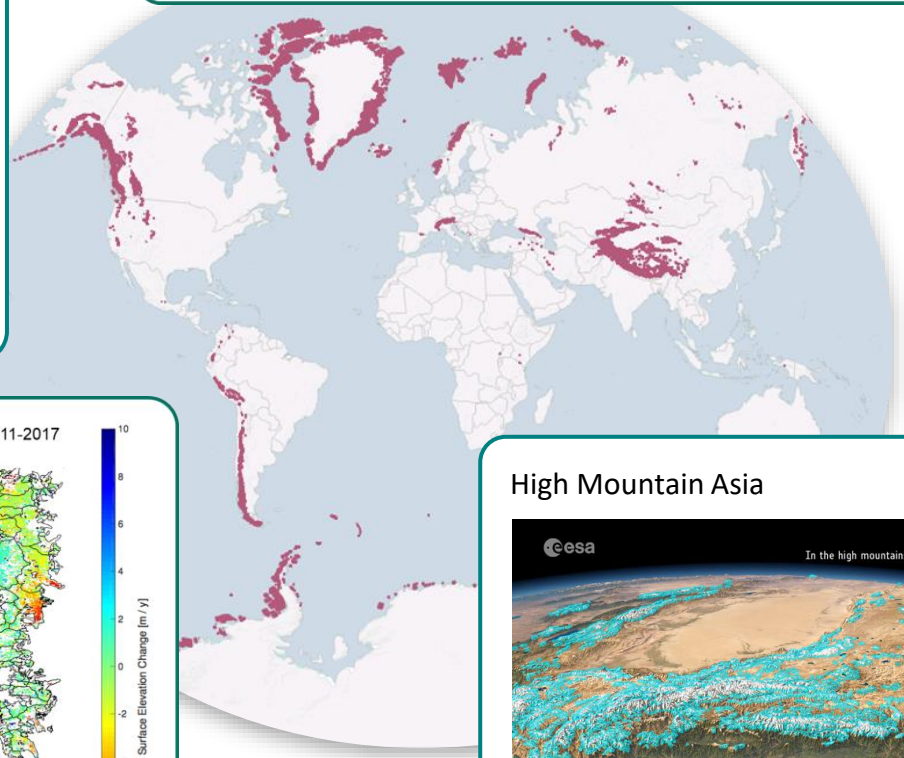
Jakob et al. (2021)

Arctic GIC

2010-2017

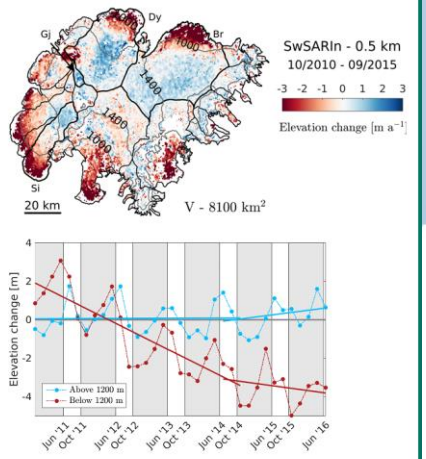


Tepes et al. (2020)



Icelandic Ice Caps

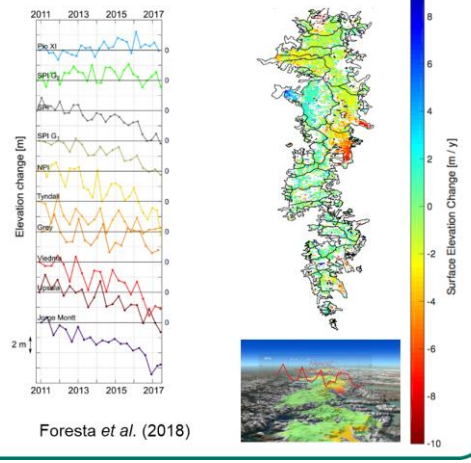
2010-2015



Foresta *et al.* (2016)

Patagonia

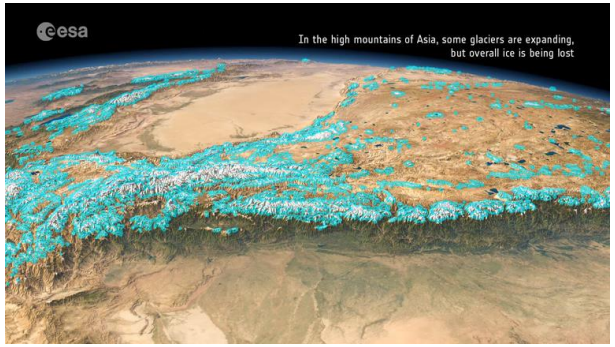
2011-2017



Foresta *et al.* (2018)

High Mountain Asia

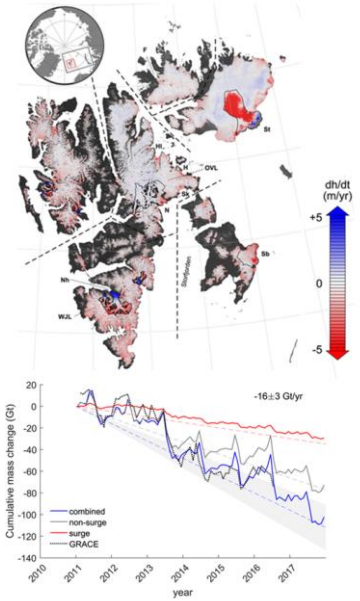
2010-2019



Jakob et al. (2021)

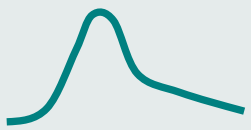
Svalbard

2011-2017



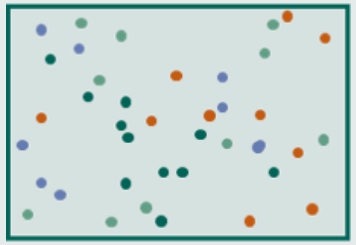
Morris *et al.* (2020)

Methods



CryoSat-2 waveforms

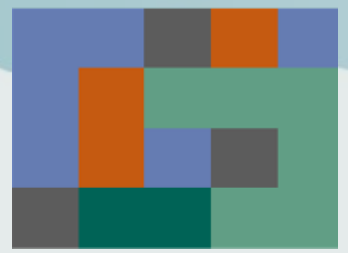
Swath processing



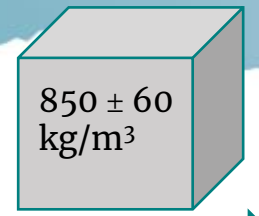
Swath elevation measurements

dh/dt

Plane fit approach



Maps of elevation changes

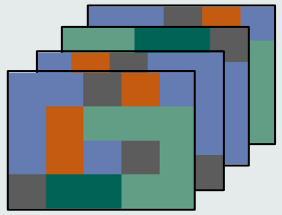


Huss (2013) Bulk density

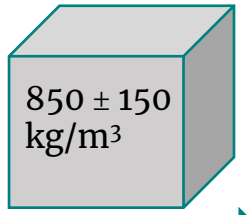
Linear mass change

timeseries

Remove topography & average



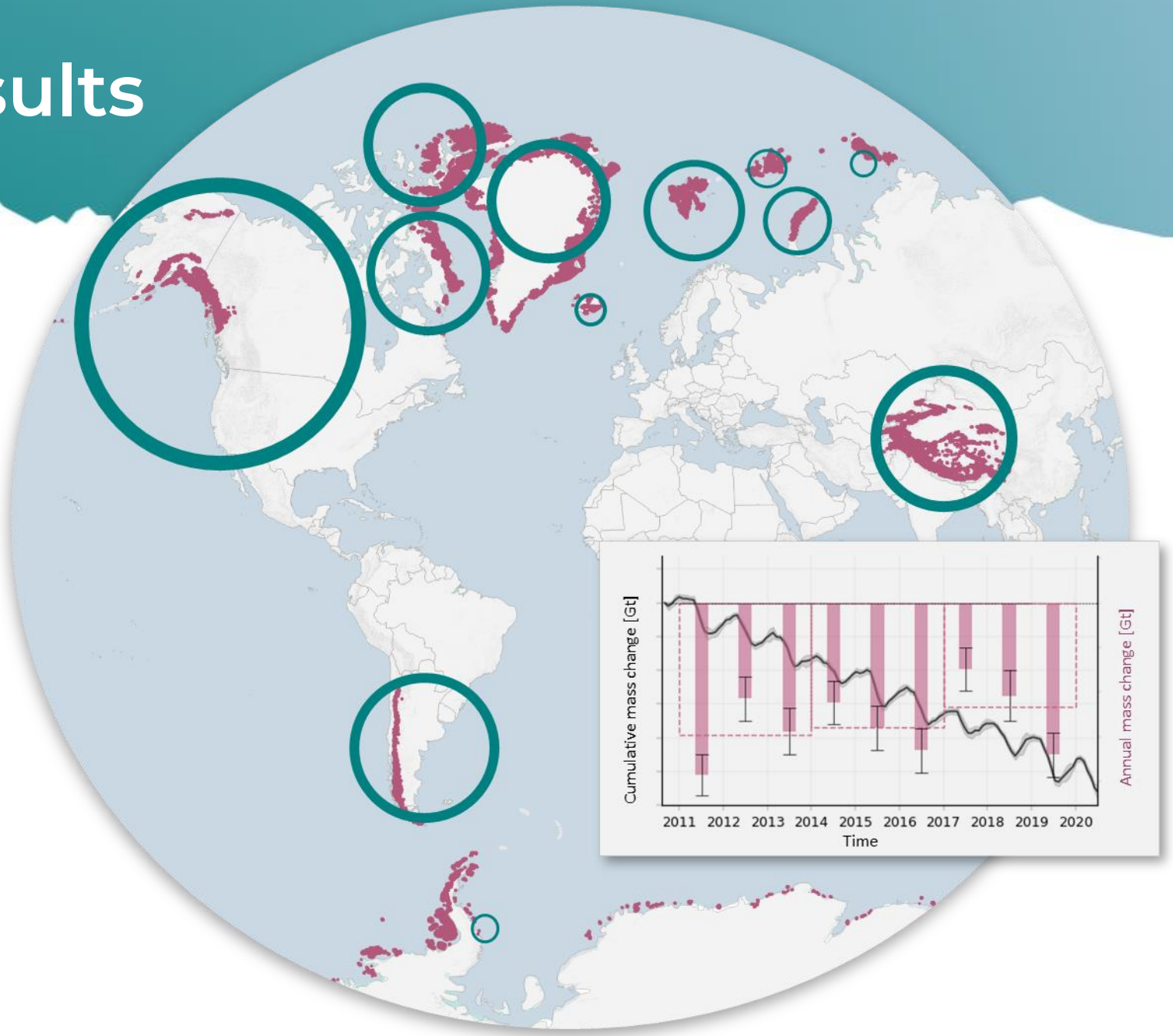
Monthly maps of elevation changes



Timeseries of mass change

(e.g. inter-annual variability)

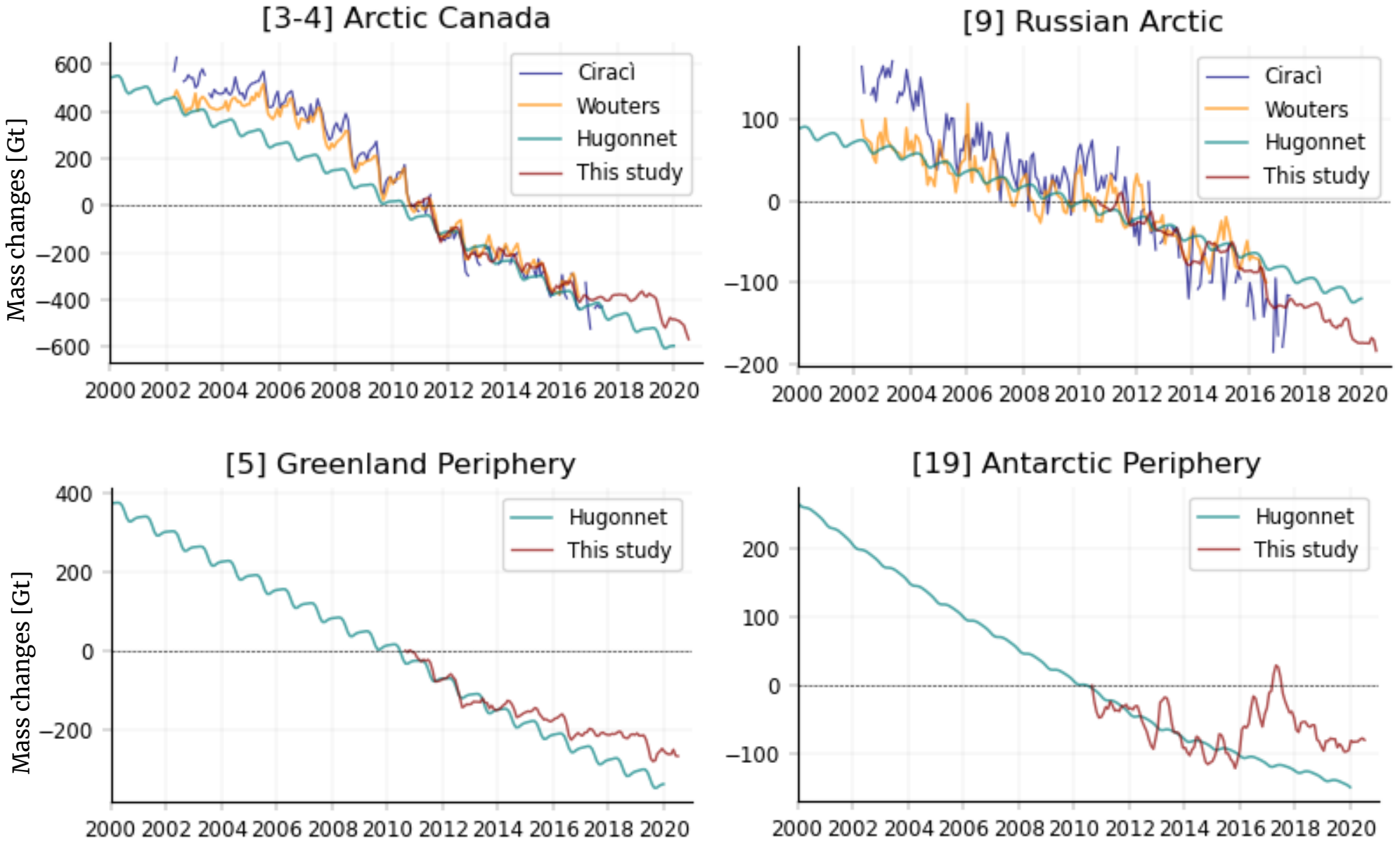
Results



Global glacier change 2010–2020

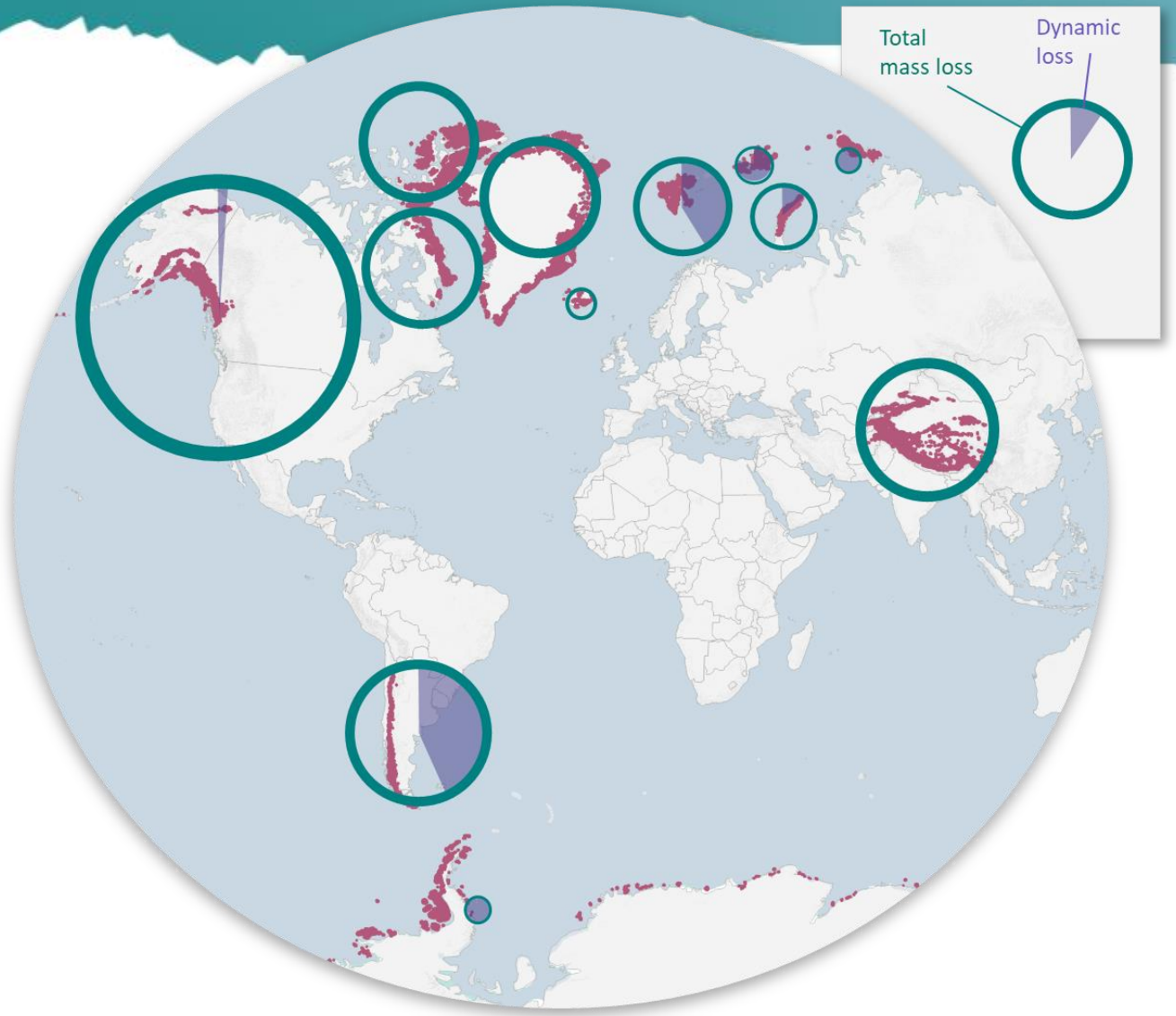
- 7.5 ± 0.3 mm SLE per decade
- 25% of sea-level budget
- 2.3% of global glacier ice volume lost per decade

Comparison with other studies



Mass Balance Partitioning

Partitioning SMB and Dynamic loss



- **89 %** of global glacier mass loss driven by SMB anomaly, **11%** by dynamic imbalance
- Dynamic imbalance is a major source of mass loss in **Patagonia, Antarctica, Svalbard, Russian Arctic**
- First global glacier mass balance partitioning

Take Home

- Radar altimetry has proven itself as a tool to measure glacier changes on a global scale
- CRISTAL mission: Measuring glaciers is one of the primary objectives
- First global glacier mass balance partitioning