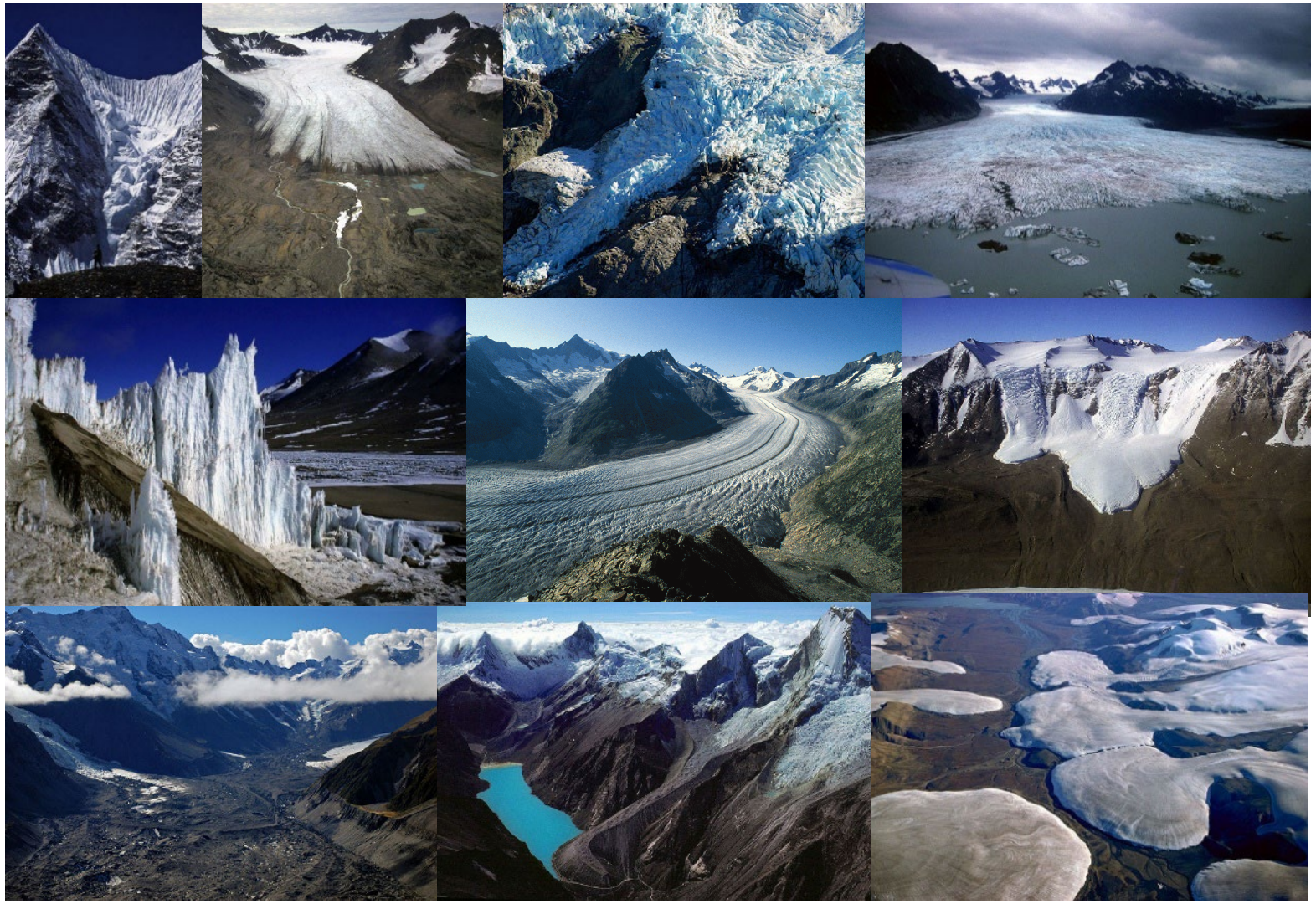
Regional comparisons of glacier mass changes from different methods

Michael Zemp (University of Zurich, CH), Noel Gourmelen (University of Edinburgh, UK), Livia Jakob (Earthwave, UK), Regine Hock (University of Oslo, NO), Etienne Berthier (LEGOS Toulouse, FR), Bert Wouters (Institute for Marine and Atmosphere Research and Delft University of Technology, NL), Alex Gardner (NASA Jet Propulsion Laboratory, USA), Geir Moholdt (Norwegian Polar Institute, NO), Fanny Brun (University Grenoble Alpes, FR), Matthias H. Braun (University of Erlangen-Nürnberg, DE)

IACS working group on Regional Assessments of Glacier Mass Change (RAGMAC)

RGI 6.0

Glaciers (distinct from Greenland and Antarctic ice sheets)



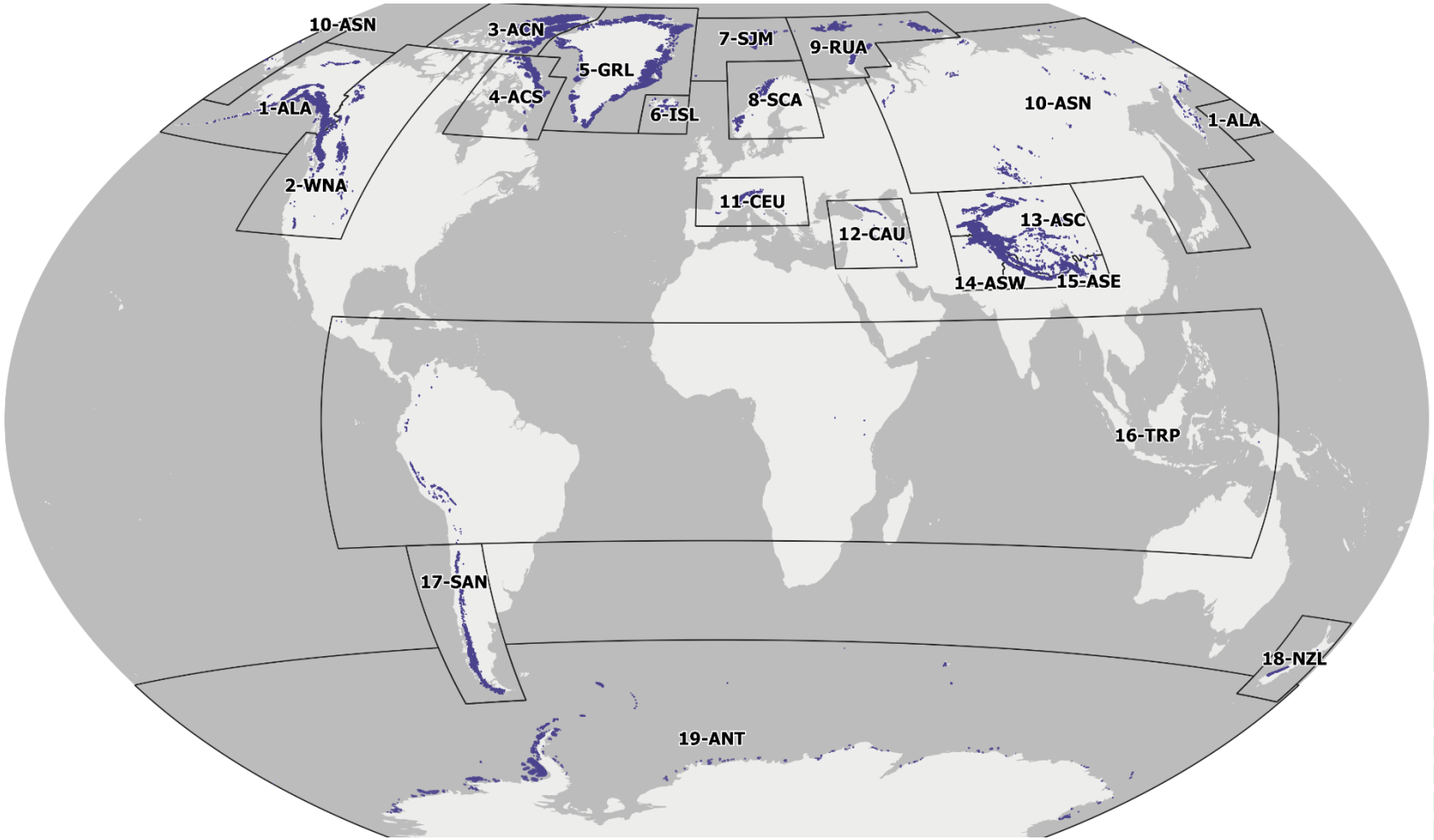
- >215,000
- ~700,000 km^2

  RGI Consortium (2017)
- ~160,000 km^3
- < 0.5 m potential SLE

  Farinotti et al. (2019)

Photos from www.swisseduc.ch/glaciers/

Key questions of international glacier monitoring



Randolph Glacier Inventory 6.0

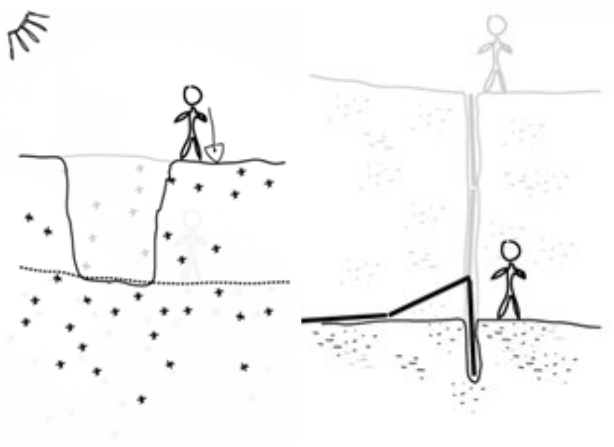
How much glacier ice is out there?

How (fast) do glaciers change?

Different methods to measure glacier changes in elevation, volume, and mass

GLACIOLOGICAL METHOD

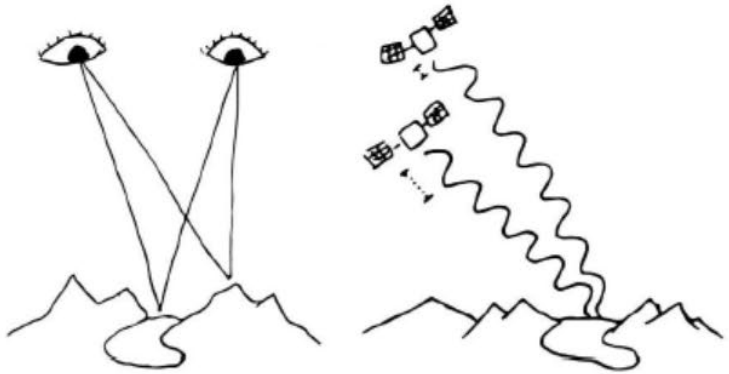
accumulation ablation



GEODETIC METHODS

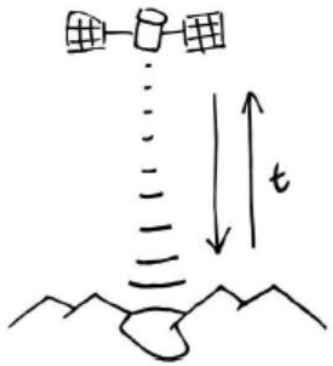
DEM differencing

stereo-images SAR interferometry



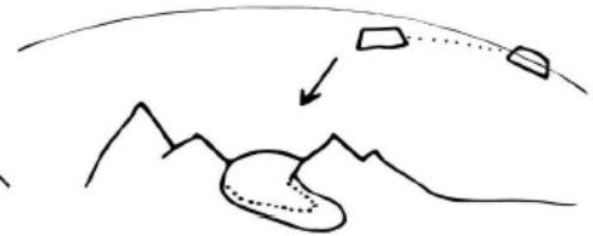
Altimetry

laser, radar



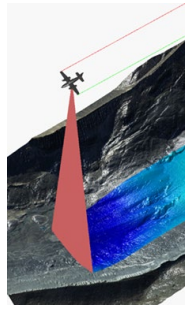
Gravimetry

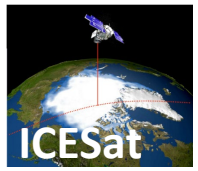
GRACE
GRACE Follow-On



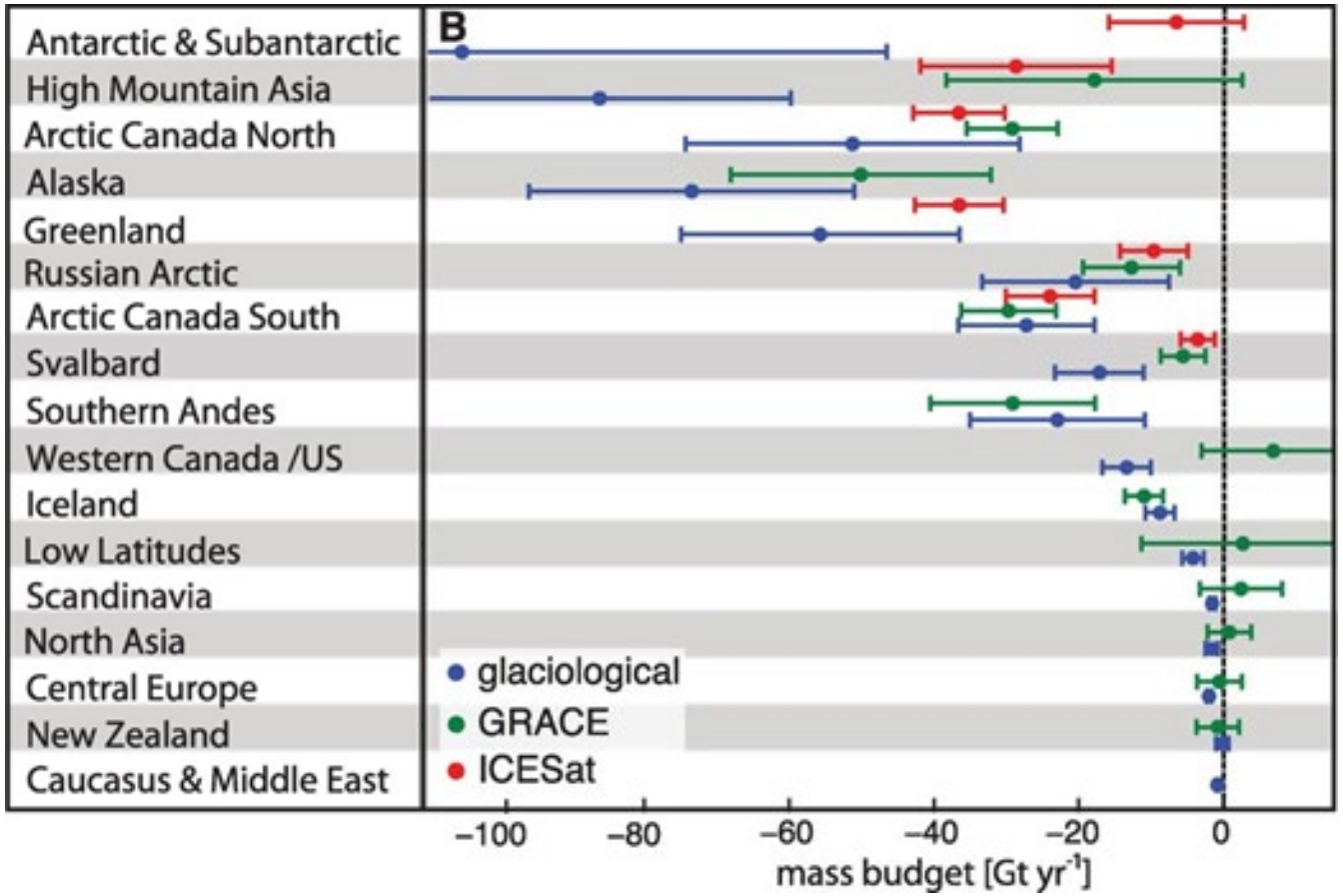
Figures by H. Machguth and D. Treichler

Observational baseline for IPCC AR5





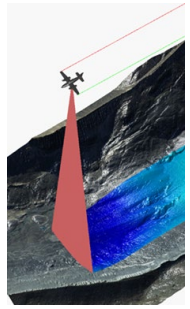
Regional glacier mass-change estimates 2003-2009

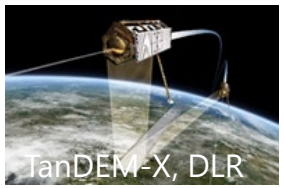


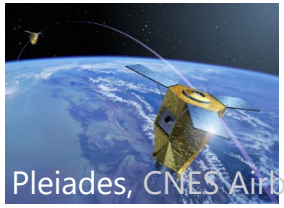
Gardner et al. (2013)

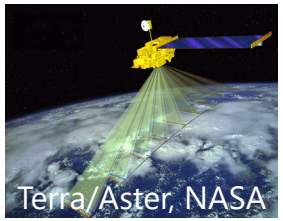
Glaciological: ~500 glaciers
Geodetic (DEM diff.): ~500 glaciers
GRACE: regional estimates
ICESat: regional estimates

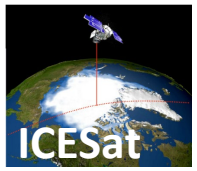
Observational baseline for IPCC SROCC



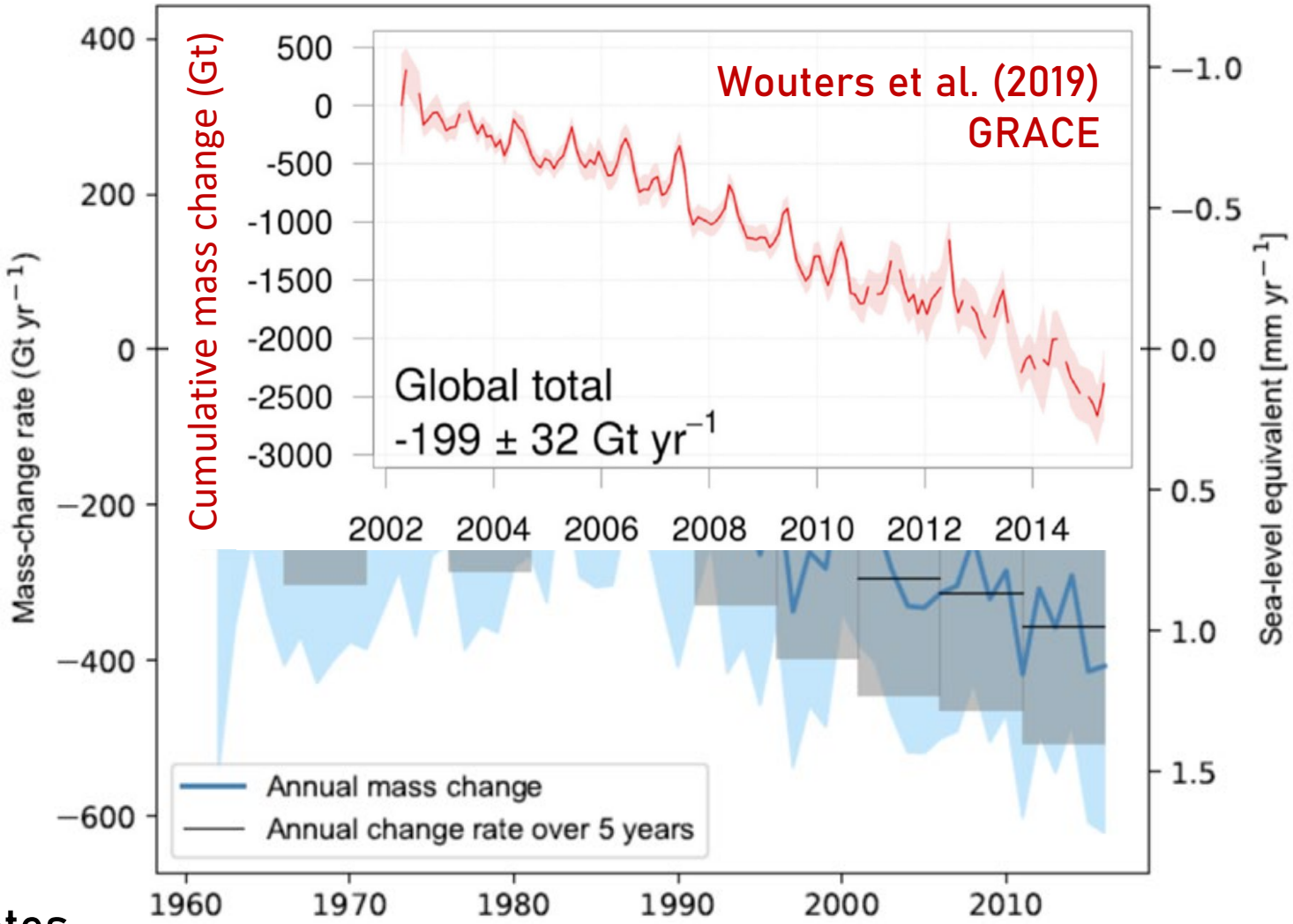






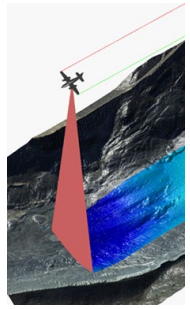


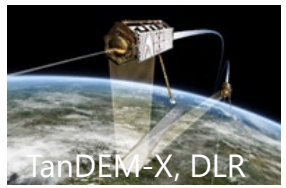
Glaciological: ~500 glaciers
Geodetic (DEM diff.): >19,000 glaciers
GRACE: regional estimates
ICESat: regional estimates

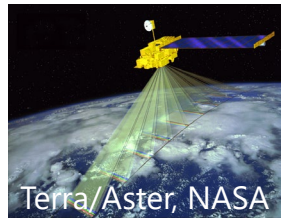


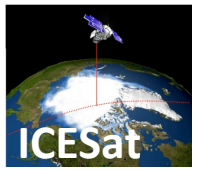
Zemp et al. (2019), glaciological & geodetic

Observational baseline for IPCC AR6

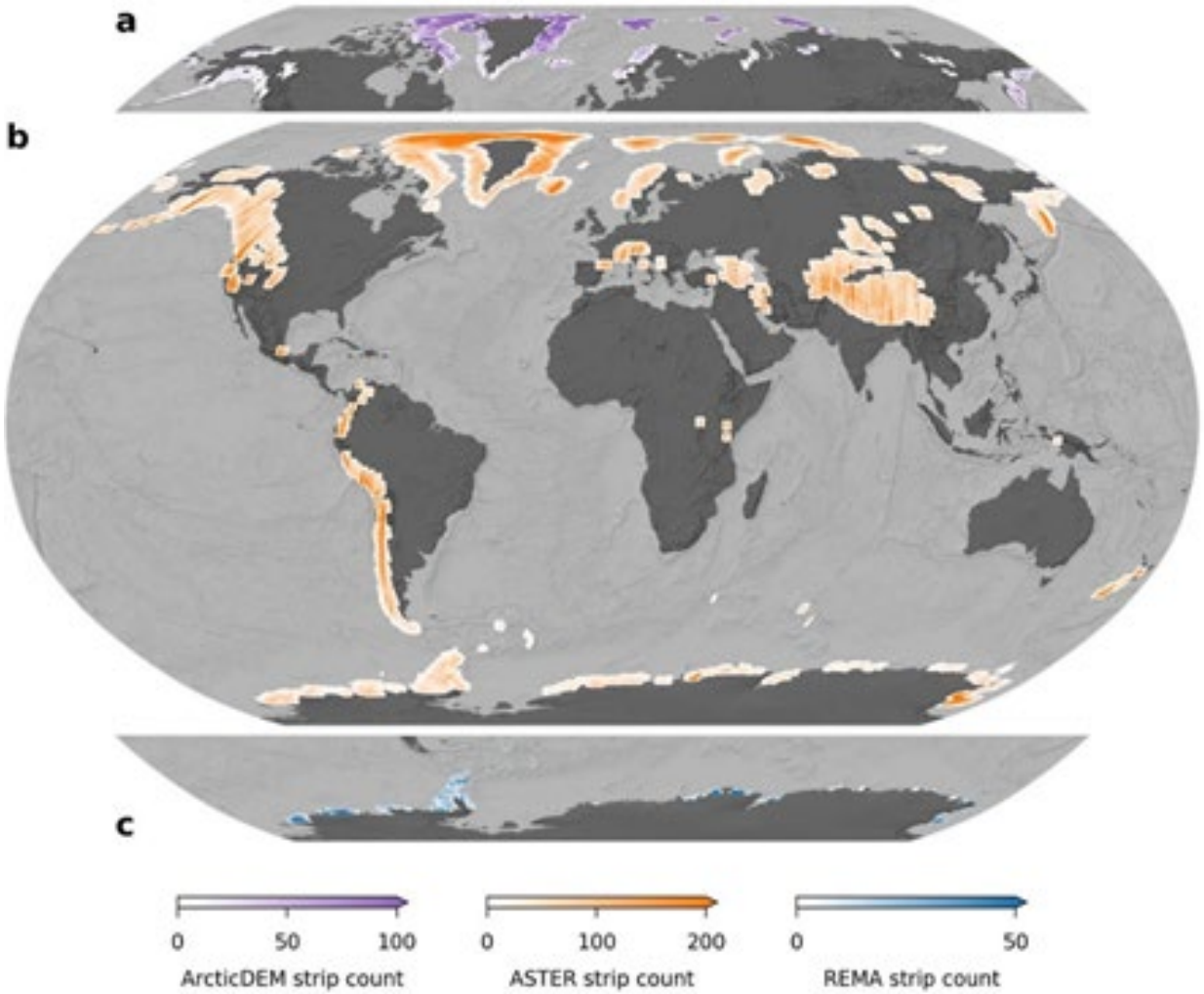






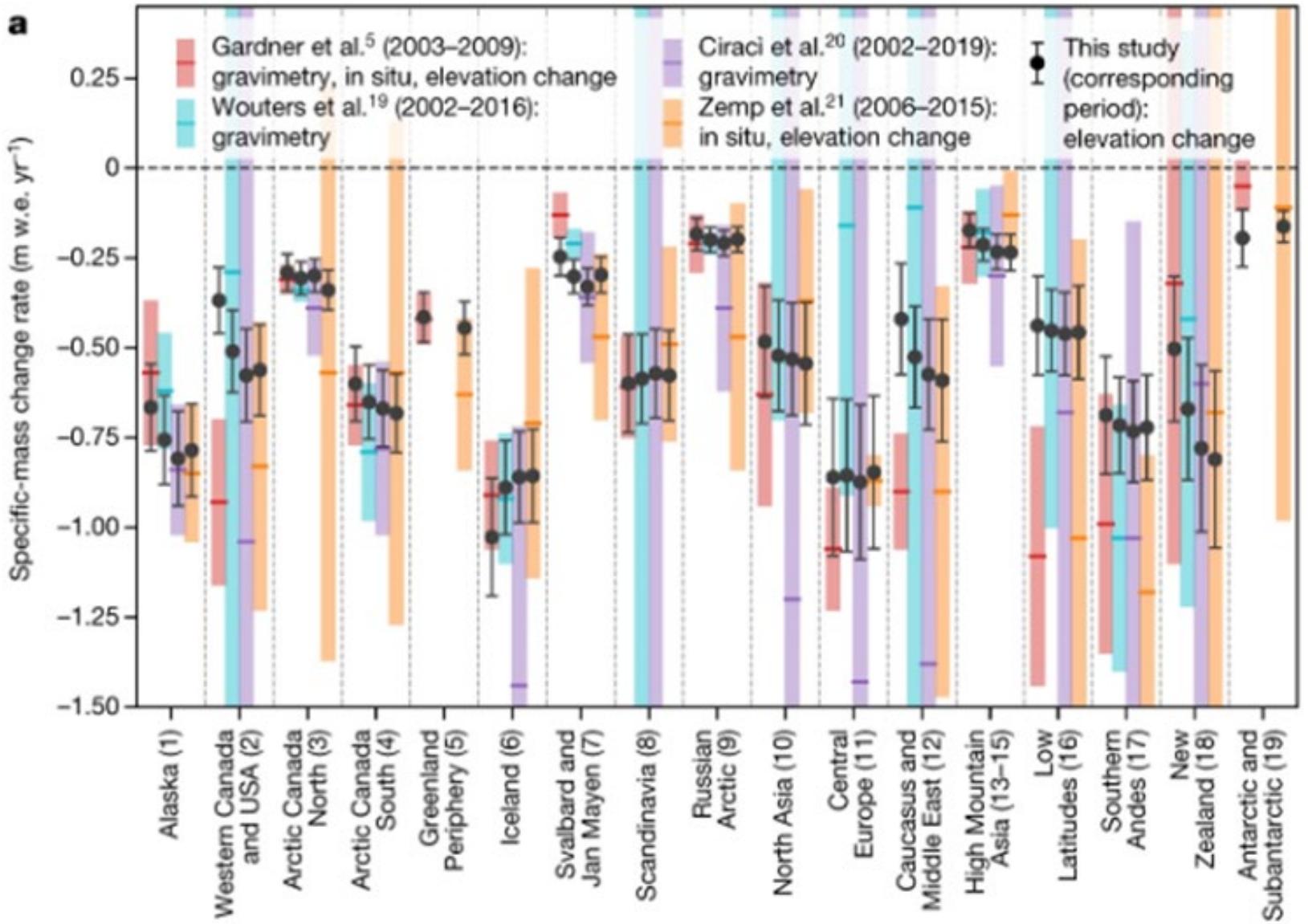


Glaciological: ~500 glaciers
Geodetic (DEM diff.): >200,000 glaciers
GRACE: regional estimates
ICESat: regional estimates



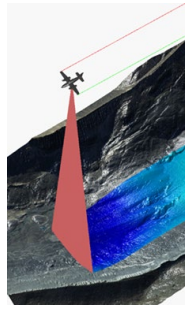
Hugonnet et al. (2021)

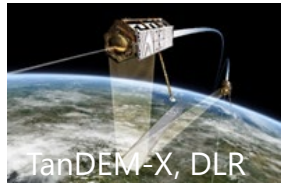
Need for an intercomparison exercise

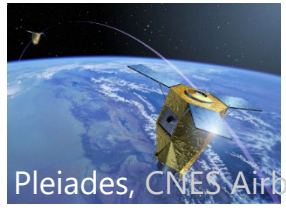


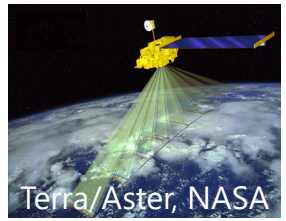
Hugonnet et al. (2021)

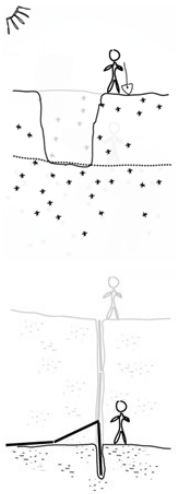
Towards next IPCC report

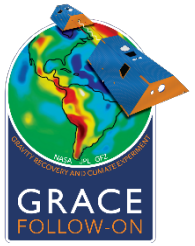


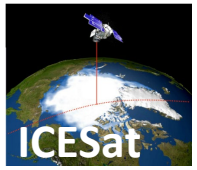












Glaciological:	~500 glaciers
Geodetic (DEM diff.):	>200,000 glaciers
GRACE:	regional estimates
ICESat:	regional estimates

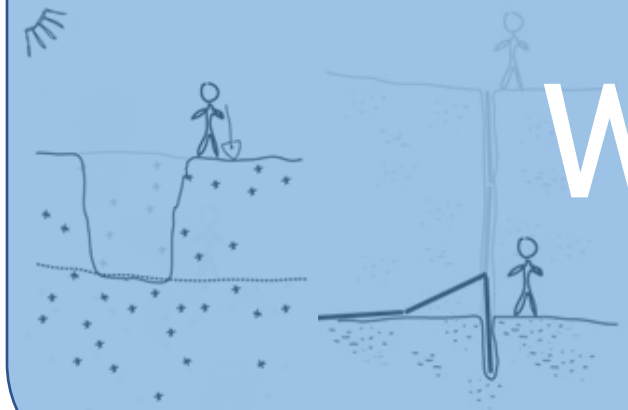
- Towards global geodetic coverage
- Towards monthly temporal resolution
- From TOO LITTLE to
  TOO MUCH & TOO DIFFERENT
- New challenges related to
  - processing chains
  - intercomparison of results
  - uncertainty estimates
- Towards data centric approach

IACS WG Regional Assessment of Glacier Mass Changes (RAGMAC)

WP 3 – reconciled estimate

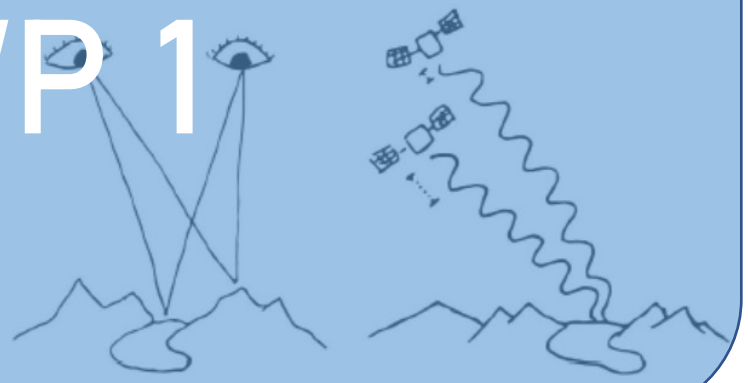
GLACIOLOGICAL METHOD

accumulation ablation



DEM differencing

stereo-images SAR interferometry



WP 1

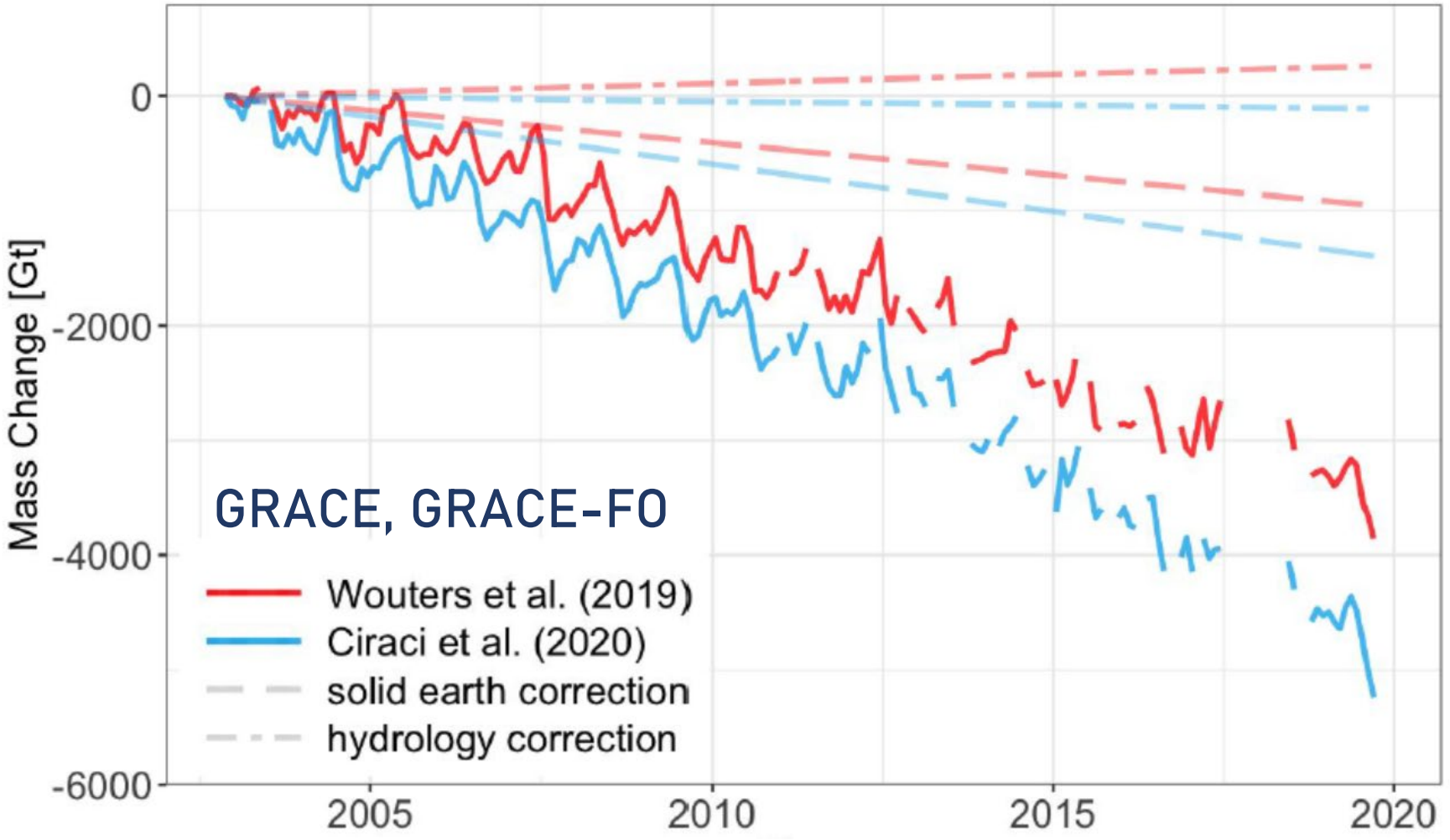
GEODETIC METHODS

Altimetry Gravimetry

laser, radar GRACE GRACE Follow-On

WP 2

RAGMAC WP1 – altimetry and gravimetry

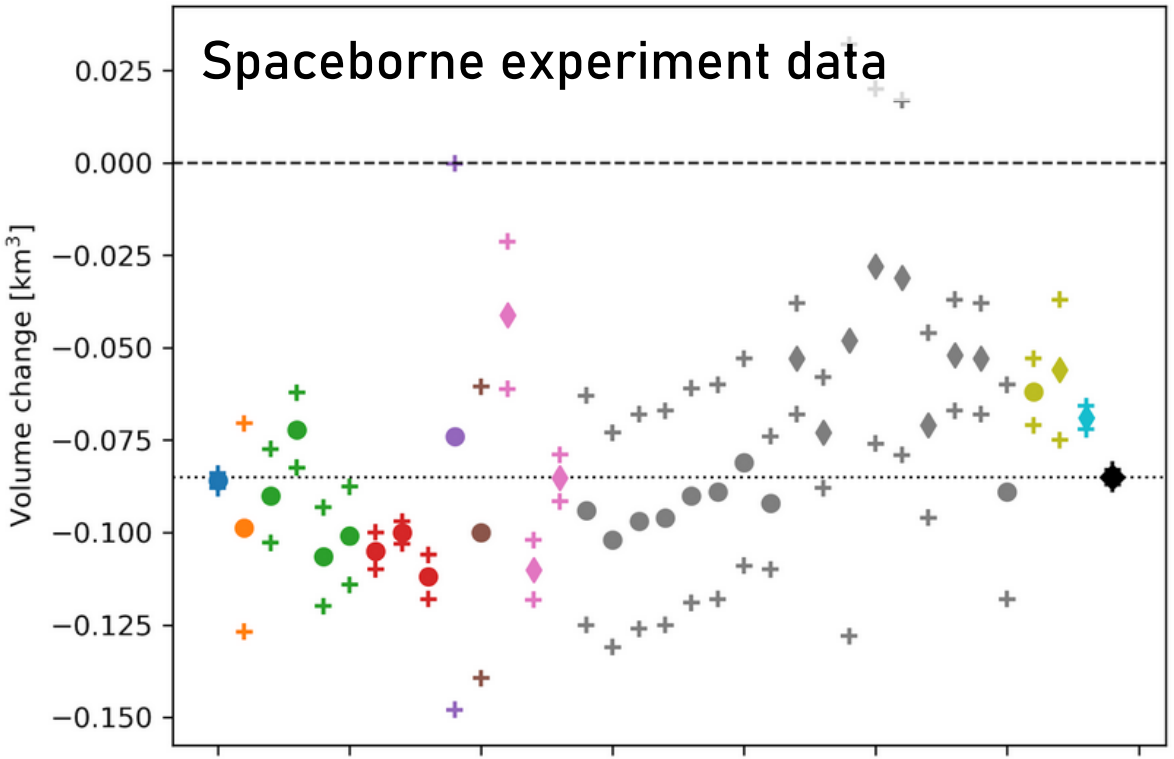


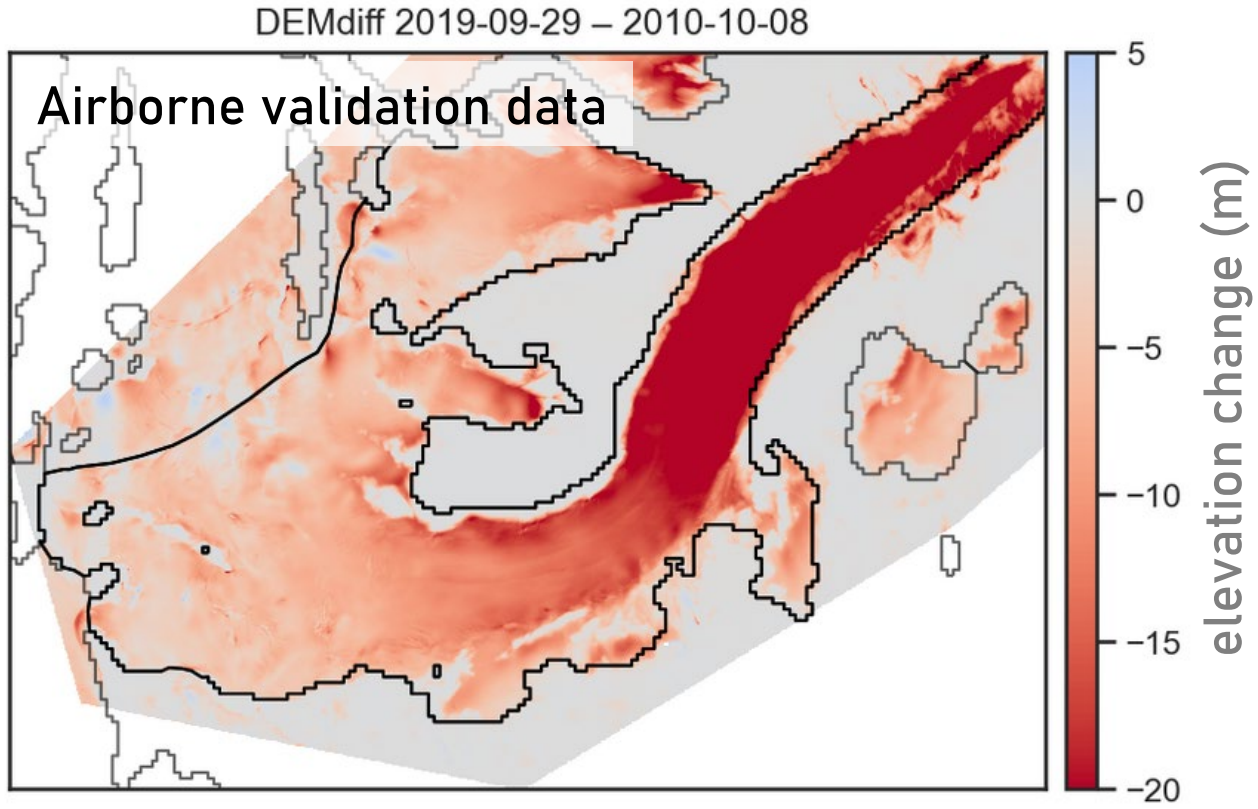
Berthier et al. (in review)

A large part of differences in gravimetric estimates can be explained by different correction (e.g., solid earth, hydrology).

RAGMAC WP2 – DEM differencing (optical, radar)

Volume change intercomparison experiment at Hintereisferner, AT





Circles = ASTER, Diamonds = TDX, Square = both
Colors = different data contributors; black = valdiation

=> Talk by Sommer et al. (2022), ESA LPS A9.05
=> Poster by Brun et al. (2022), ESA LPS A9.05

RAGMAC WP3: Glacier Mass Balance Intercomparison Exercise

Community effort to reconcile measurements of glacier mass balance

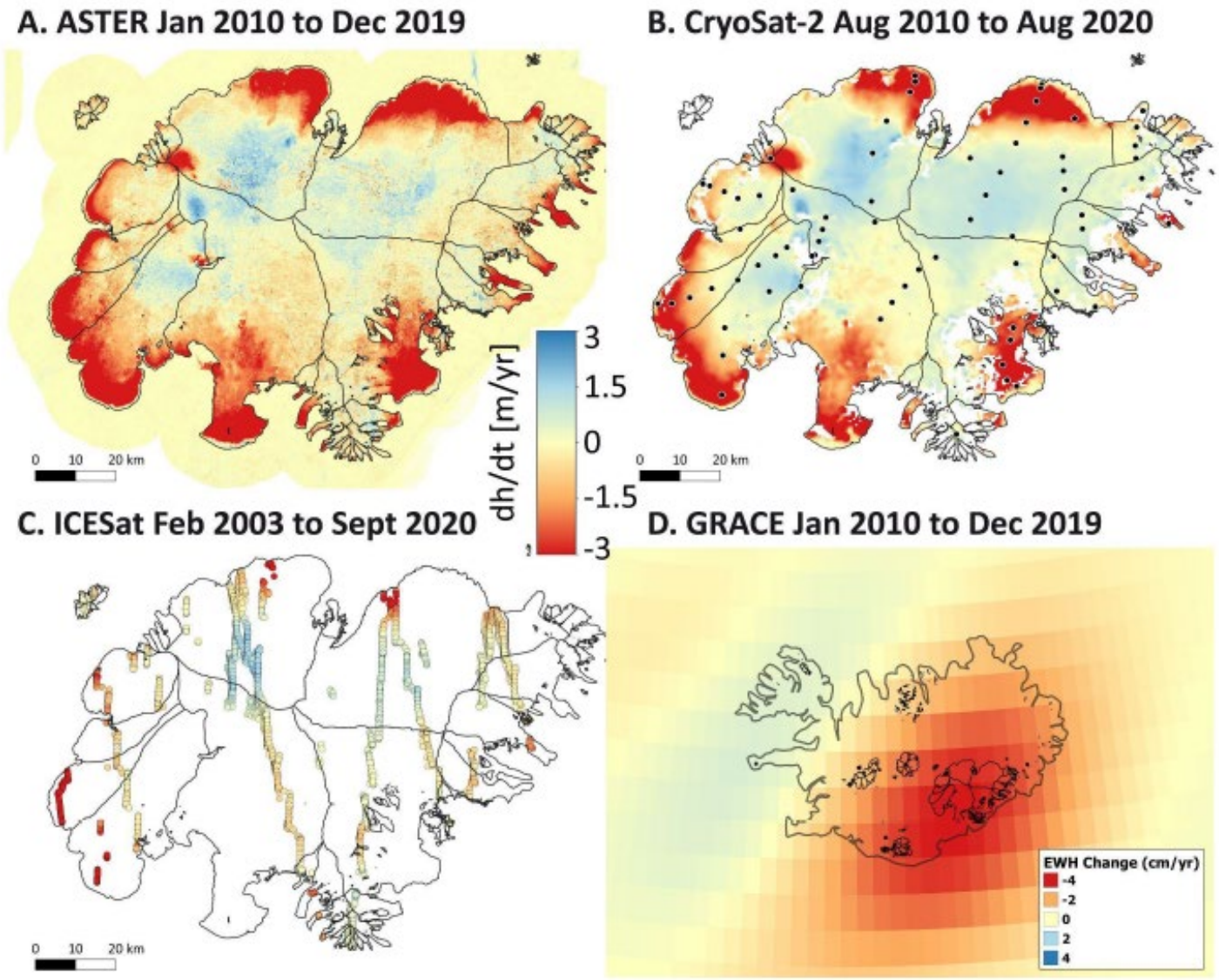
IACS

Building on existing activities and network of RAGMAC (Regional Assessments of Glacier Mass Change)

2-year project supported by ESA

https://glambie.org

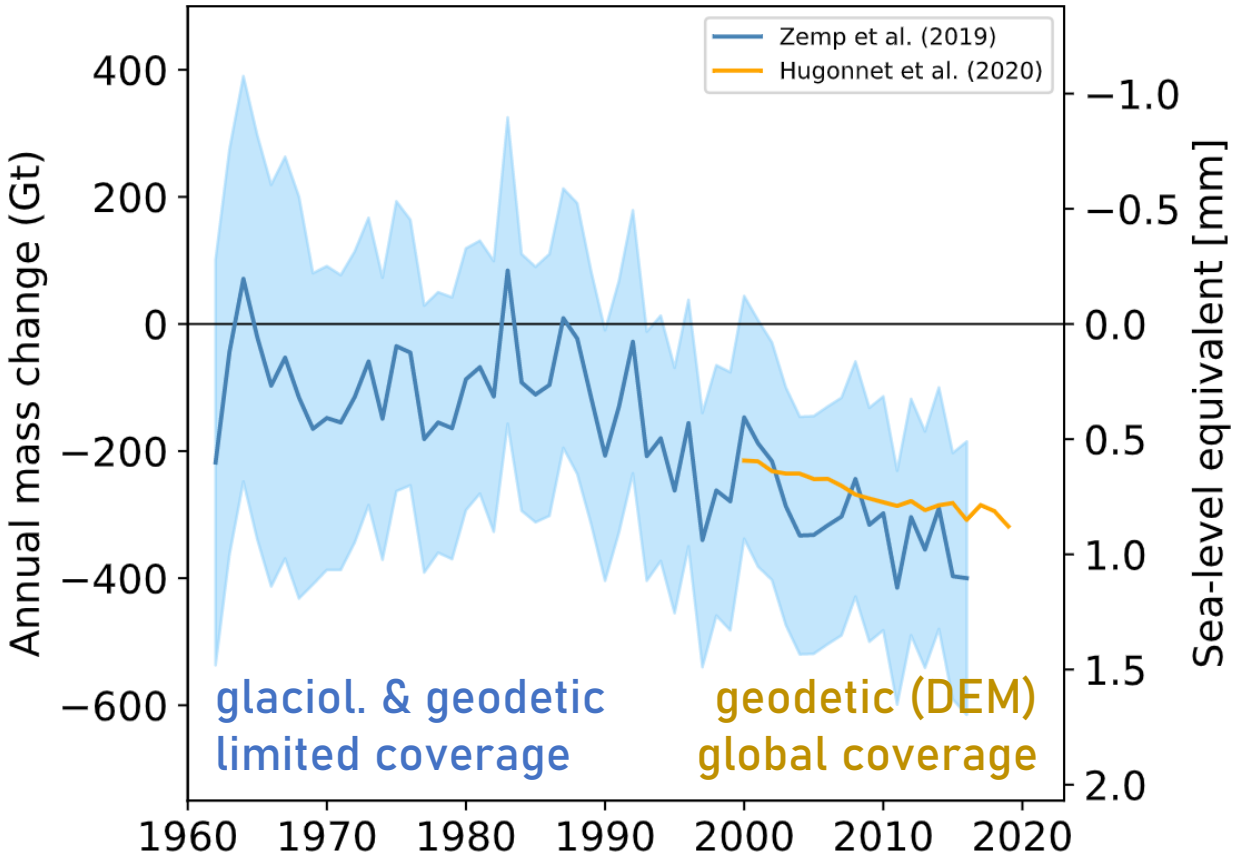
Towards reconciled regional estimates

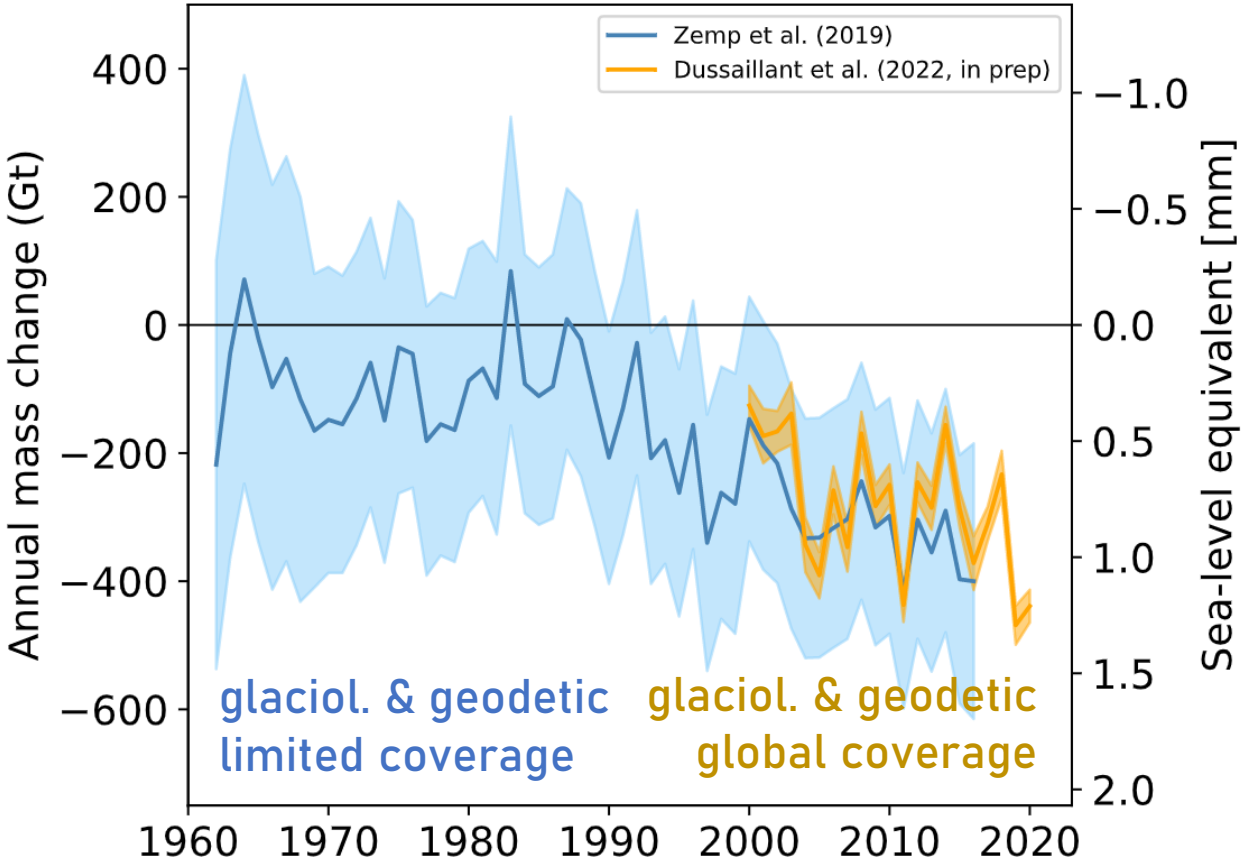


Volume & mass changes of Vatnajökull, IS

Berthier et al. (in review)

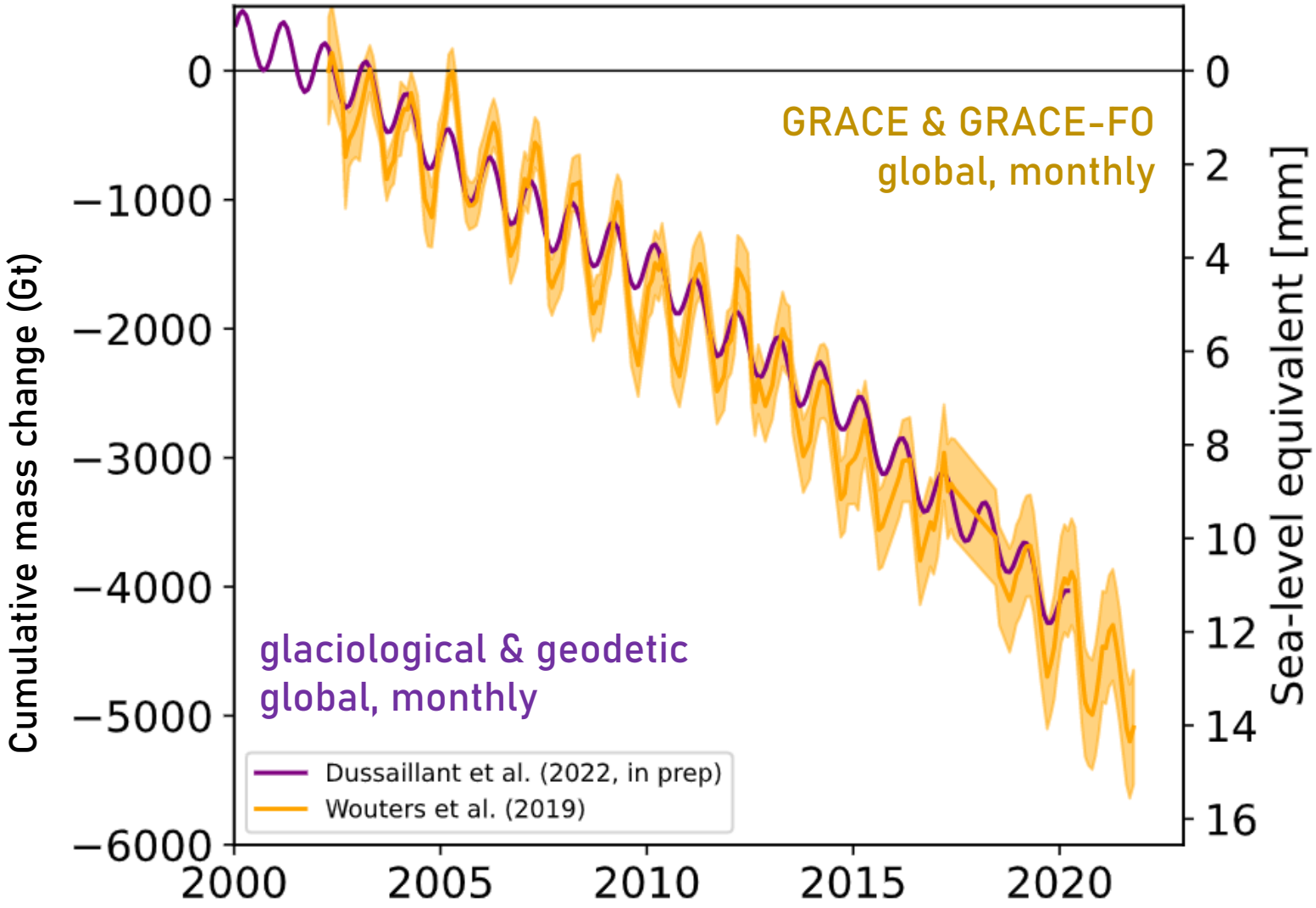
Outlook on global estimates – super preliminary, of course! ☺





Inter-annual variability from glaciological
Spatial coverage and decadal mean from geodetic (DEM differencing)

Outlook on global estimates - super preliminary, of course! ☺



Towards seasonal and monthly estimates

Intercomparison with gravimetry & altimetry

Conclusions

Community efforts towards new reconciled estimate of regional and global glacier mass changes from different sources

Supported by ESA as contribution to International Association of Cryospheric Sciences

Combining the best from all sources:

- data-centric approach
- temporal variability from glaciological, gravimetry, altimetry
- spatial coverage & resolution from geodetic (DEM differencing)

RGI 6.0

Join the ESA GlaMBIE Networking Event
Thu 17:30-18:30 in Room H-1-07
https://glambie.org

glambie