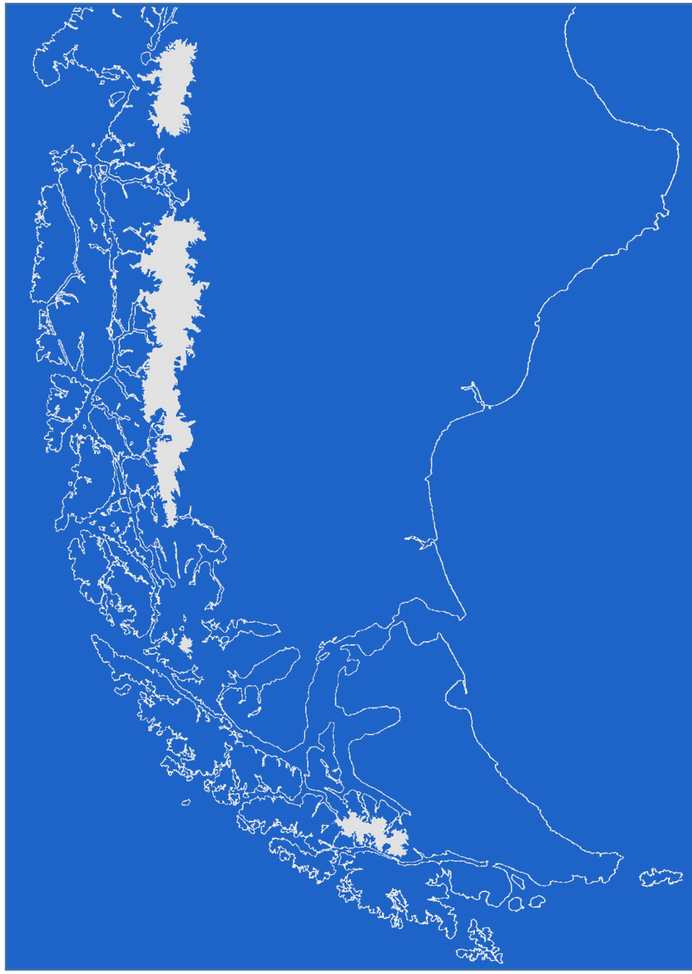
CESM 2024 Workshop



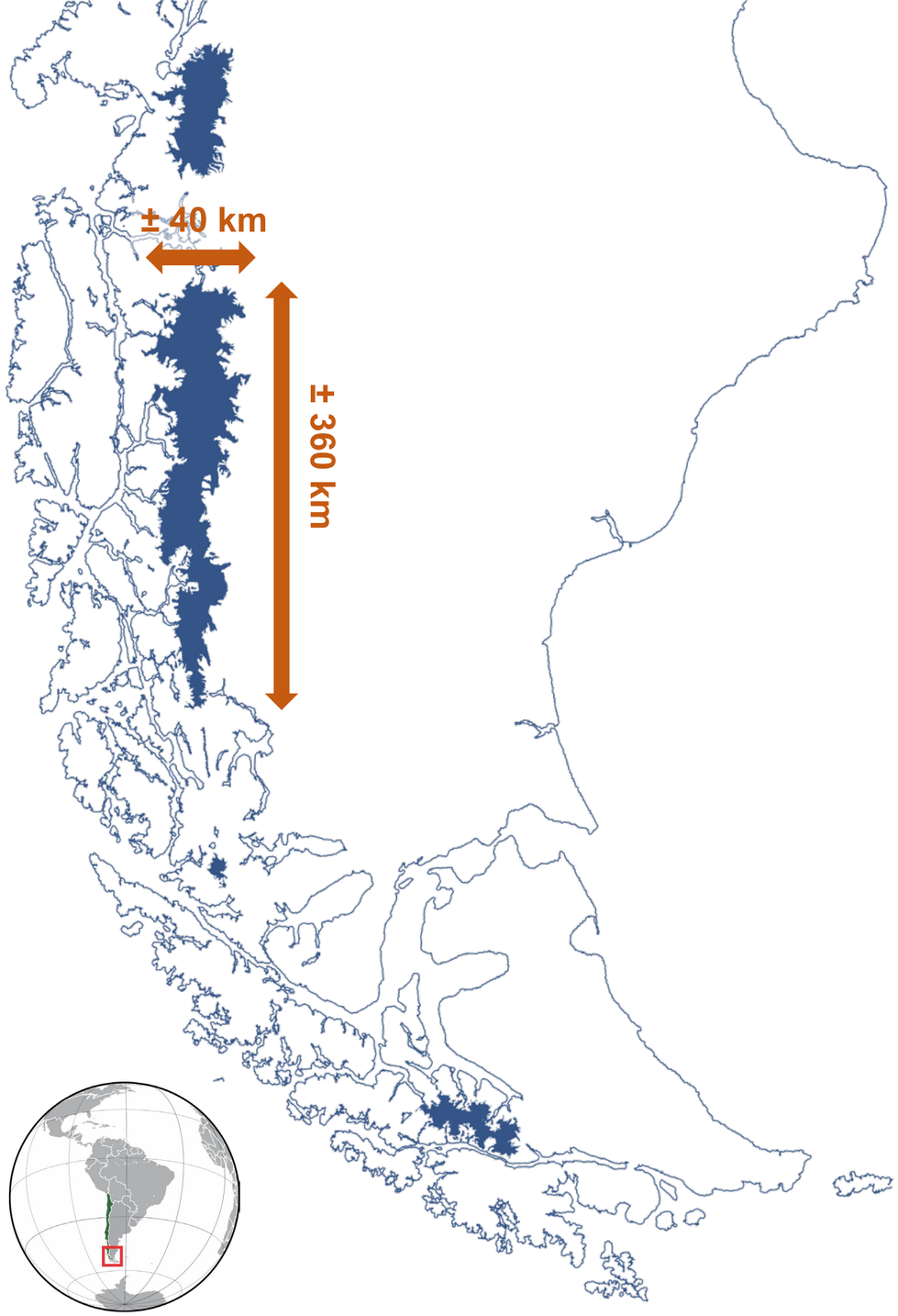
# Forecasting the future of the Southern Patagonian Icefield using the Community Ice Sheet Model

Matthias Troch, Gunter Leguy, Bill Lipscomb, Bob Anderson

INSTAAR University of Colorado Boulder

NSF

NCAR Operated by UCAR

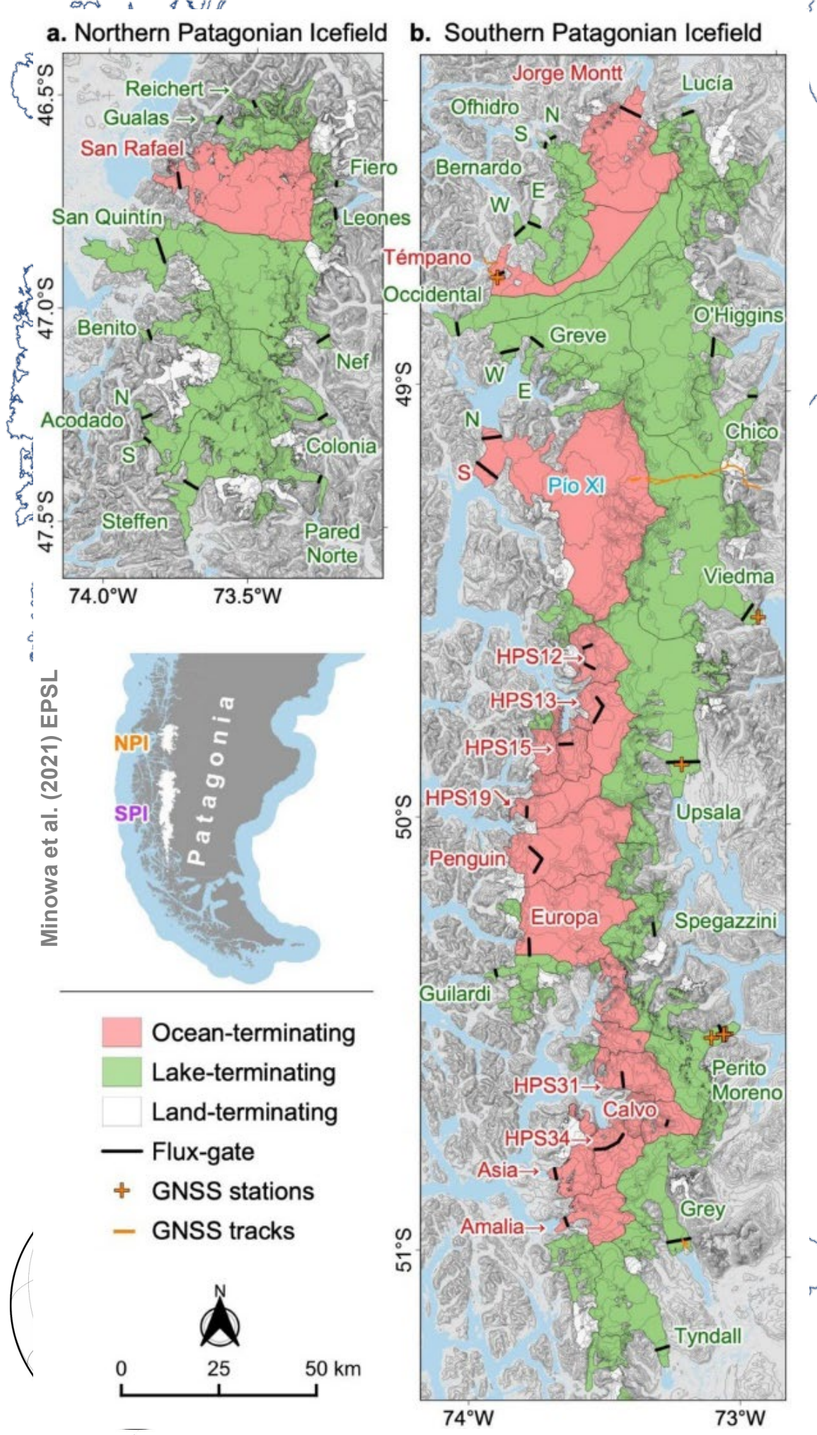



# Southern Patagonian Icefield

- Largest temperate icefield (*ca.* 12,000 km$^2$) in the Southern Hemisphere
- 2000 – 2016 CE: 0.02 – 0.04 mm/yr
- Some of the fastest-flowing glaciers in the world
- Extreme precipitation gradient
  - East: Dry continental climate
  - West: Hyperhumid maritime climate with annual precipitation >7 m/yr

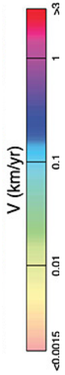
# Southern Patagonian Icefield

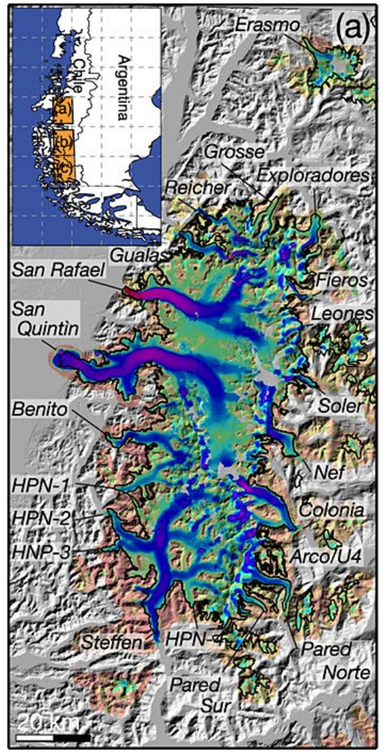
- Largest temperate icefield (*ca.* 12,000 km$^2$) in the Southern Hemisphere
- 2000 – 2016 CE: 0.02 – 0.04 mm/yr
- Some of the fastest-flowing glaciers in the world
- Extreme precipitation gradient
  - East: Dry continental climate
  - West: Hyperhumid maritime climate with annual precipitation >7 m/yr

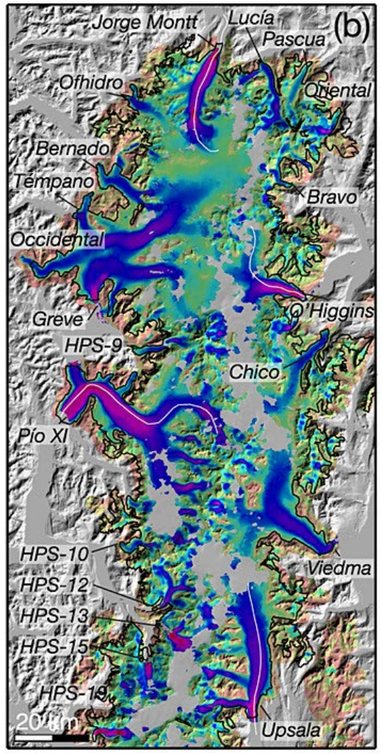


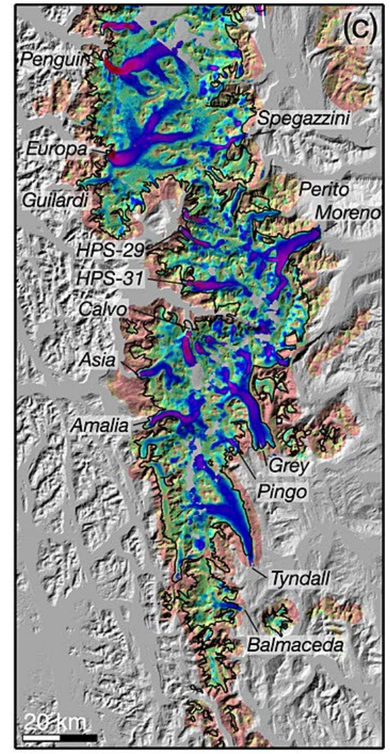

"In the southern part of SPI, we find some of the fastest-flowing glaciers in the world with velocities up to **10.3 km/yr** for **Glacier Penguin** (28 m/d), 8.8 km/yr for Glacier Europa (24 m/d), 6.0 km/yr for HPS-19 (16 m/d)"

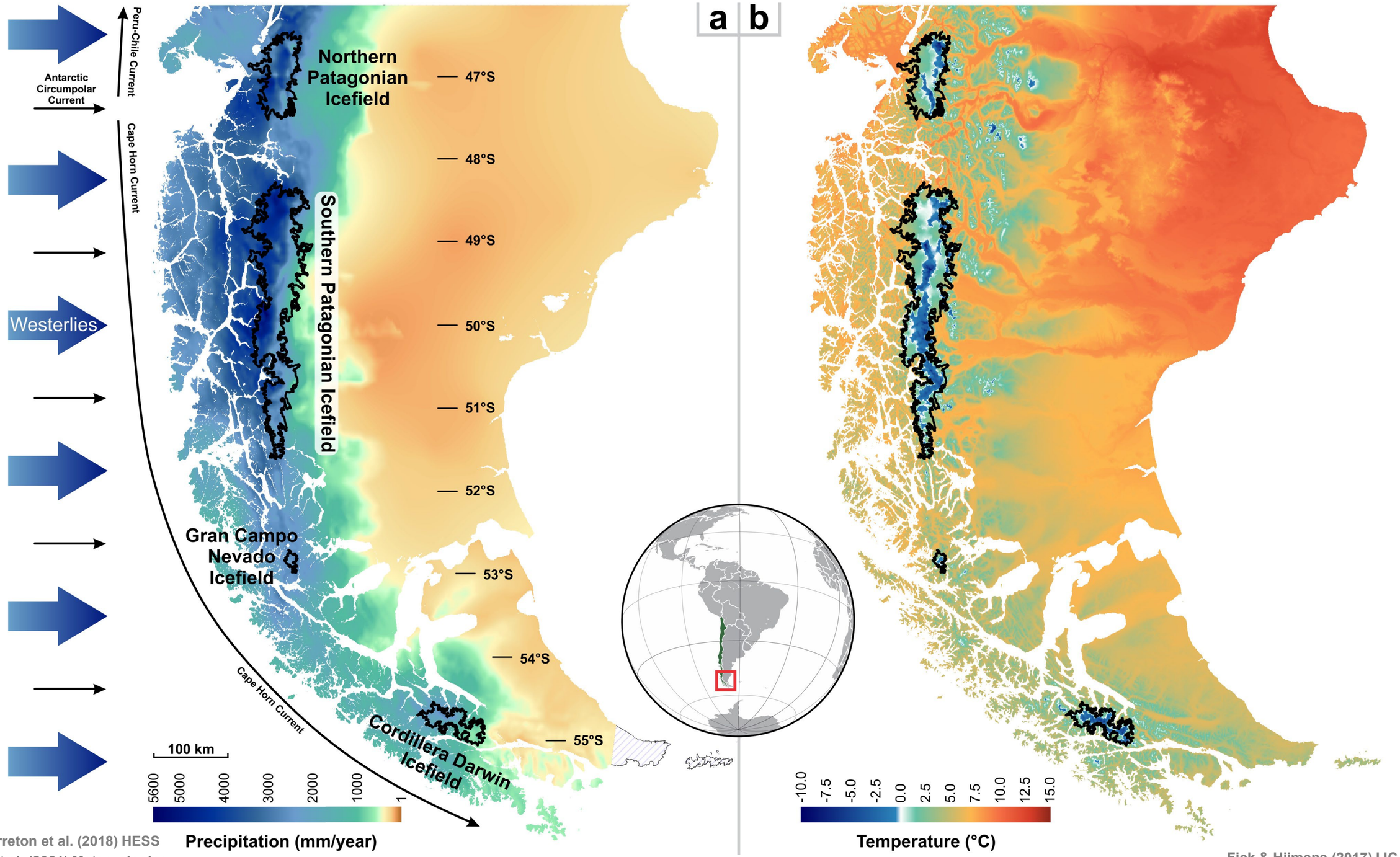
Mouginot & Rignot (2015)
Geophysical Research Letters



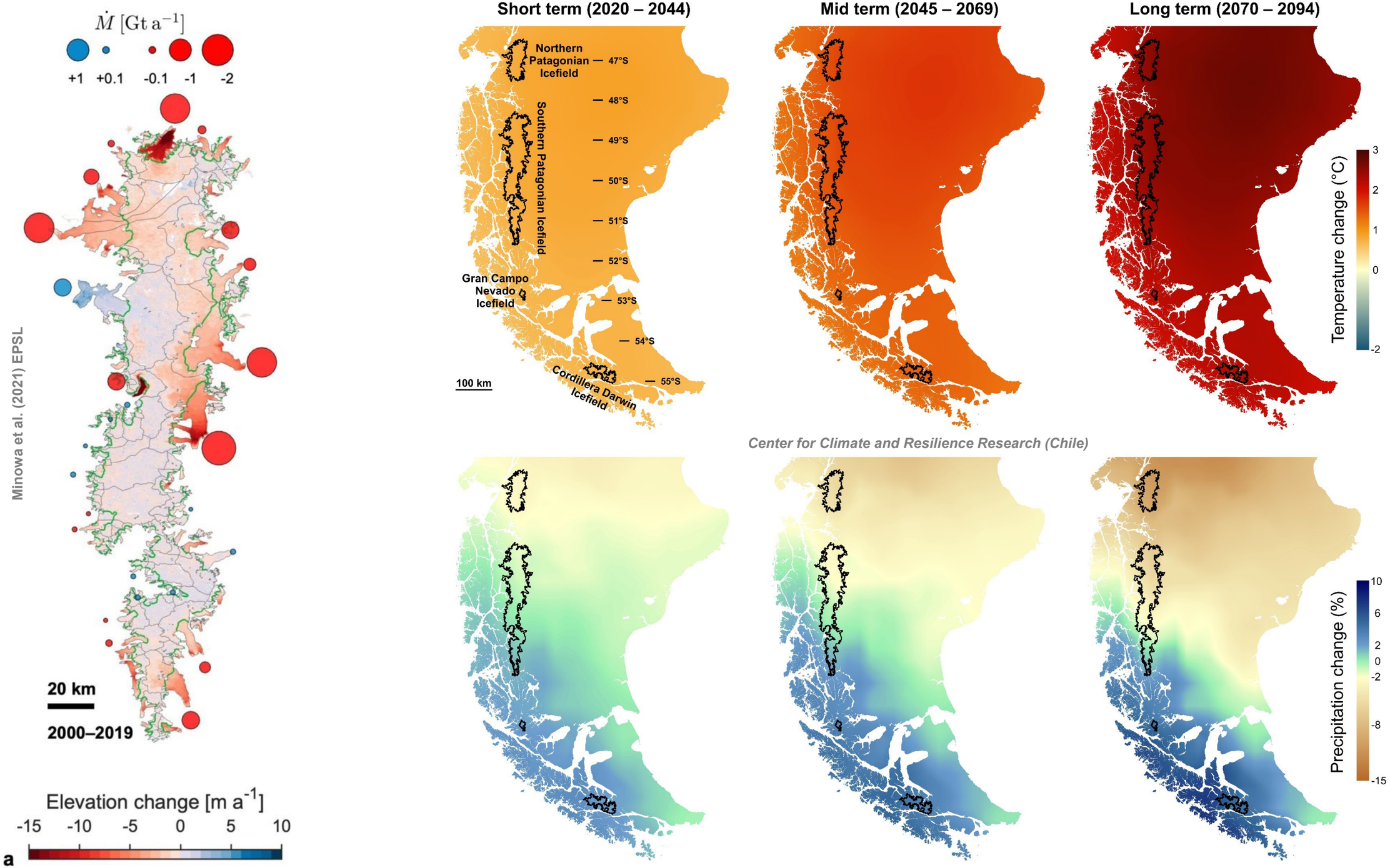






Alvarez-Garreton et al. (2018) HESS
Almonacid et al. (2021) Meteorologica

Fick & Hijmans (2017) IJC


$\dot{M}$ [Gt a$^{-1}$]
+1 +0.1 -0.1 -1 -2
Minowa et al. (2021) EPSL
20 km
2000–2019
Elevation change [m a$^{-1}$]
-15 -10 -5 0 5 10
a
Short term (2020 – 2044)
Mid term (2045 – 2069)
Long term (2070 – 2094)
Northern Patagonian Icefield
Southern Patagonian Icefield
Gran Campo Nevado Icefield
Cordillera Darwin Icefield
47°S
48°S
49°S
50°S
51°S
52°S
53°S
54°S
55°S
100 km
Temperature change (°C)
3 2 1 0 -2
Center for Climate and Resilience Research (Chile)
Precipitation change (%)
10 6 2 0 -2 -8 -15

# Research objectives

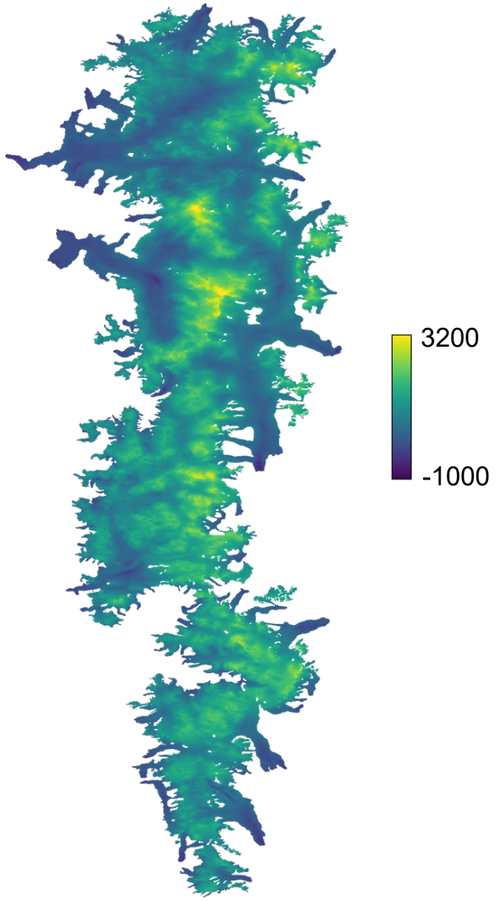
Estimate the net mass change of the Southern Patagonian Icefield by 2100 CE

**Hypothesis**

The latitudinal gradient in precipitation change might drive a heterogeneous response of the icefield's glaciers to future climate change, with accelerated retreat in the north and potential stabilization in the south.

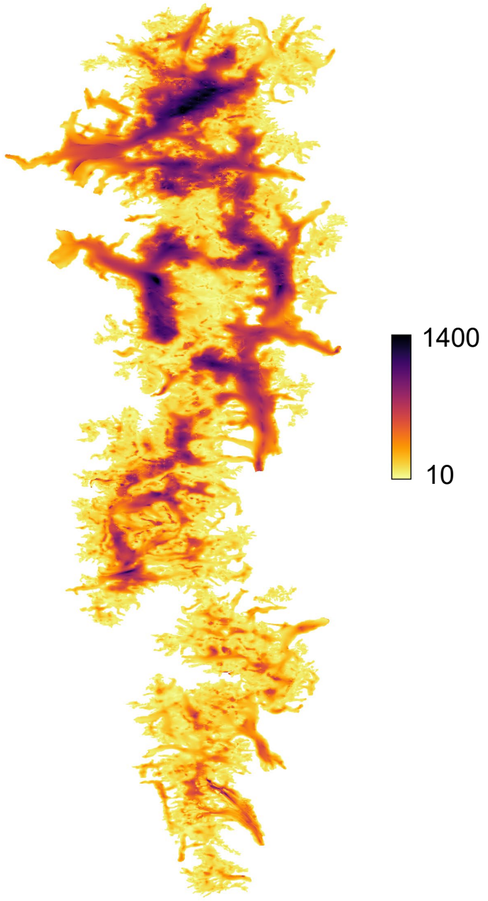
# Glacier thickness and velocity

**Subglacial bed elevation (m)**



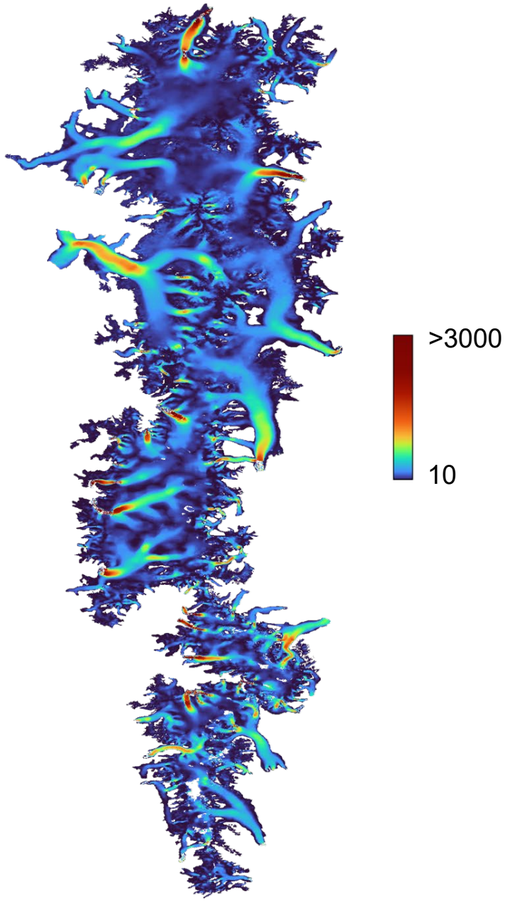

Fürst et al. (2024) Communications Earth & Environment

**Glacial thickness (m)**




Fürst et al. (2024) Communications Earth & Environment

**Ice-flow velocity (m/year)**




Millan et al. (2022) Nature Geoscience

# Climate forcing

- **Model initialization**

CR2MET: Precipitation & min/max near-surface temperature
*Center for Climate and Resilience Research Meteorological dataset*
0.05° grid
1960 – 2021

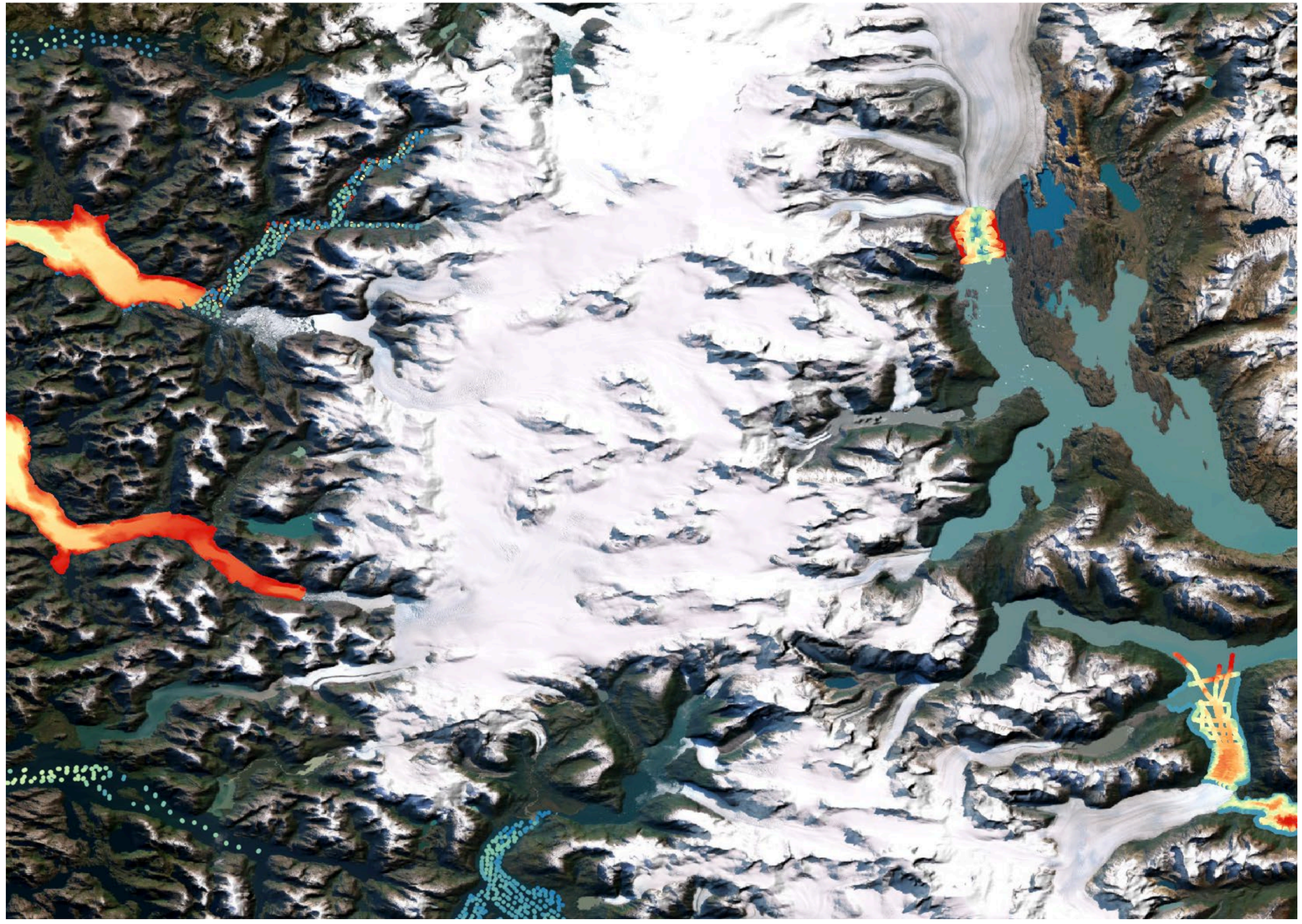
Statistical downscaling
ECMWF reanalysis ERA5
MODIS land-surface temperature

- **Future forcing**

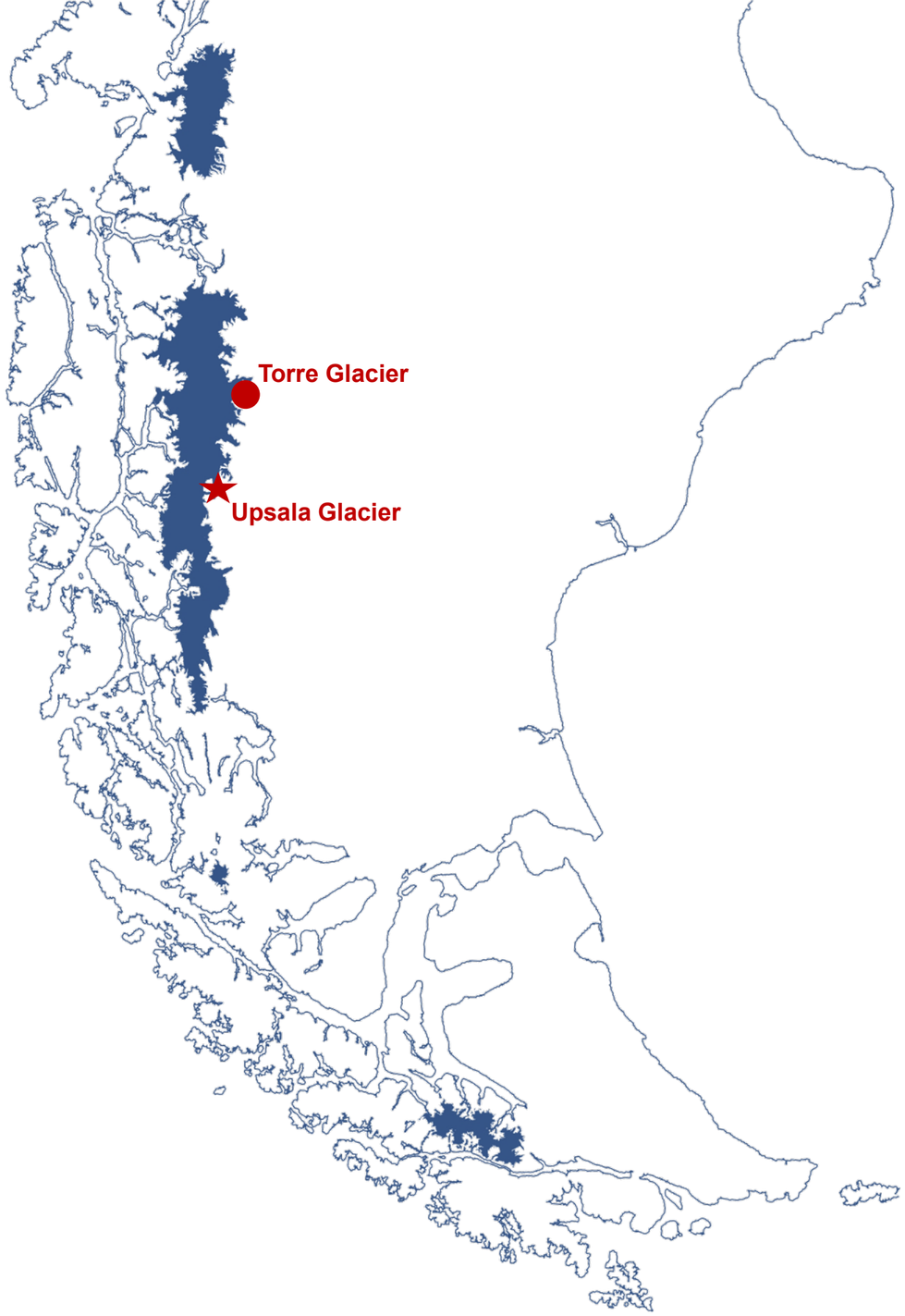
CR2: CMIP5 + CORDEX + CR2-RegCM4
Short term (2020 – 2044), mid term (2045 – 2069), long term (2070 – 2094)

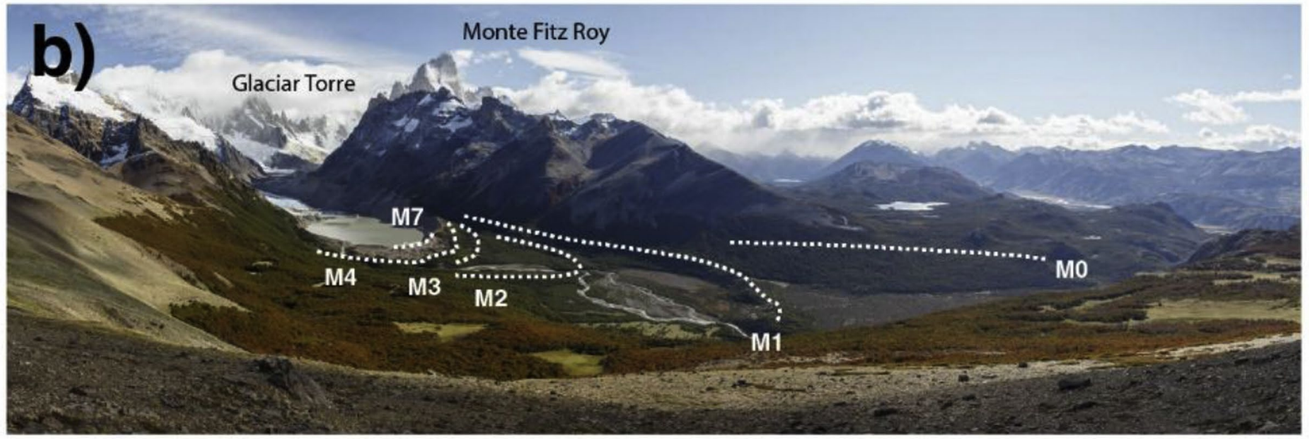
Present day
RCP2.6
RCP8.5

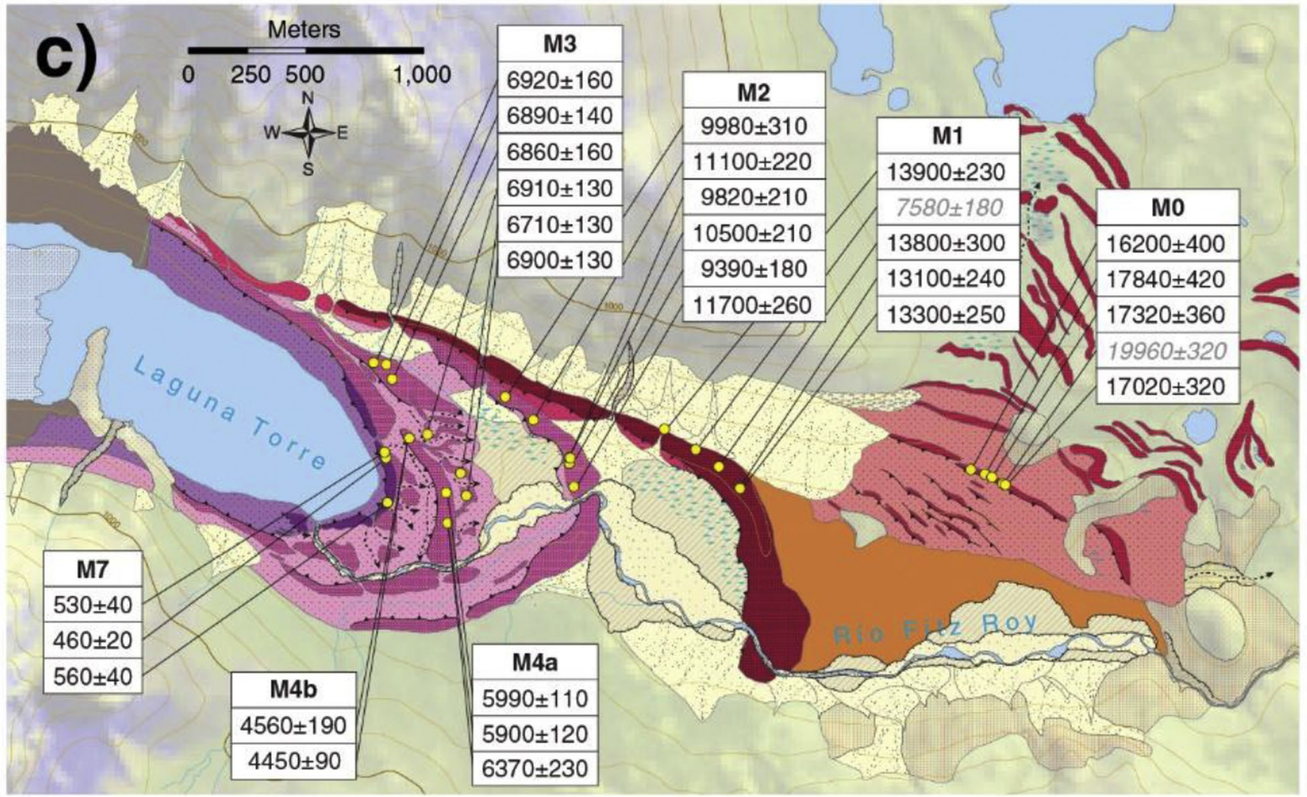
# Some remaining challenges



# Paleo case studies

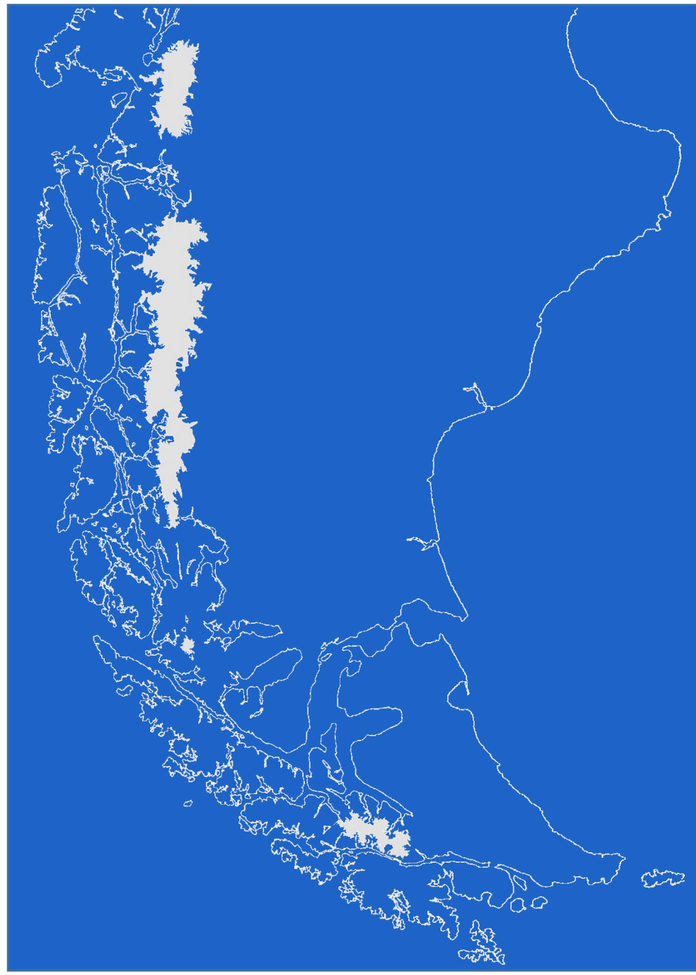



Reynhout et al. (2019) QSR

# CESM 2024 Workshop



matthias.troch@colorado.edu