

Limited glaciations, glacier modeling, and paleoclimatic implications for the Tibetan Plateau

Jakob Heyman¹, Jon Harbor¹, Alun Hubbard², Arjen P. Stroeve³

¹ Department of Earth and Atmospheric Sciences, Purdue University, USA

² Institute of Geography and Earth Sciences, Aberystwyth University, UK

³ Department of Physical Geography and Quaternary Geology, Stockholm University, Sweden



Outline



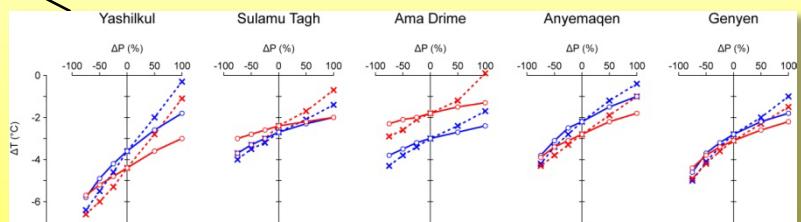
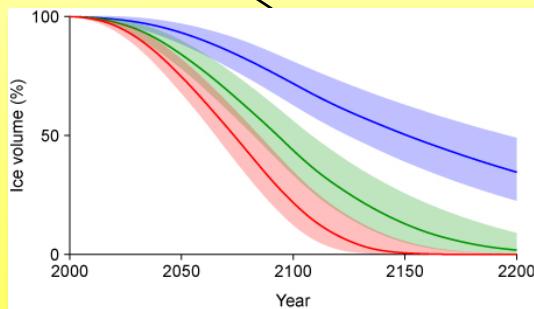
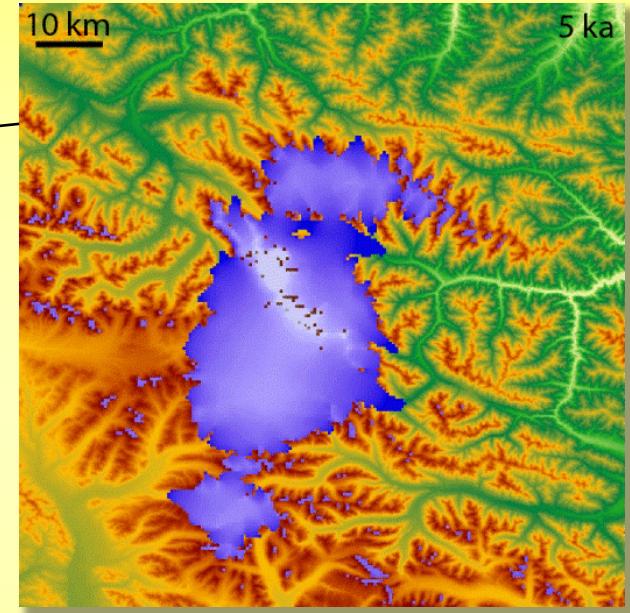
Introduction

Glacier model

Glacial paleoclimate

Projection

Conclusions



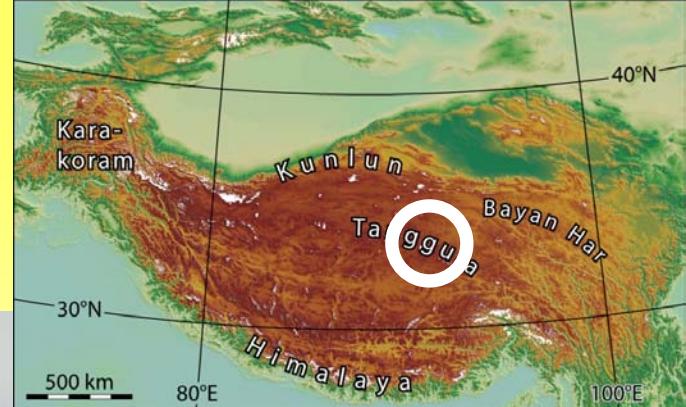
Limited glaciation of Tibet

Paleo-climate implications?

Exposure age data: Schäfer et al. (2002)

Owen et al. (2005)

Colgan et al. (2006)



77 ka

71 ka

66 ka

62 ka

47 ka Distance to

43 ka glacier: 7.8 km

34 ka Distance to glacier: 3.1 km

Glacial geology + glacial modeling

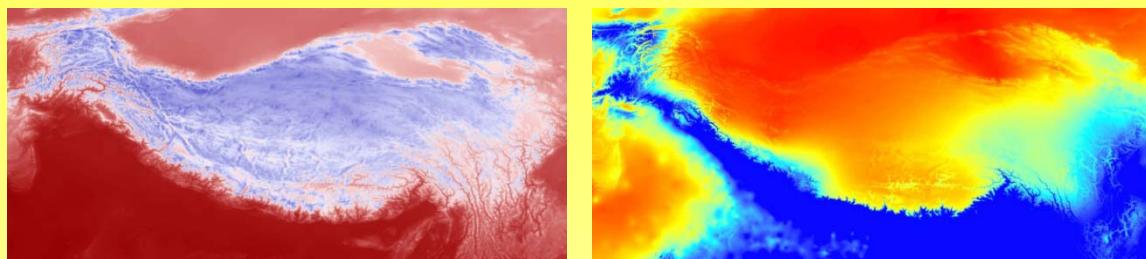
Glacier model

Input

Topography

Mean monthly temperature

Mean monthly precipitation



WorldClim climate data (Hijmans et al., 2005)

Domain

200 x 200 pixels

1/240° resolution (<500 m)

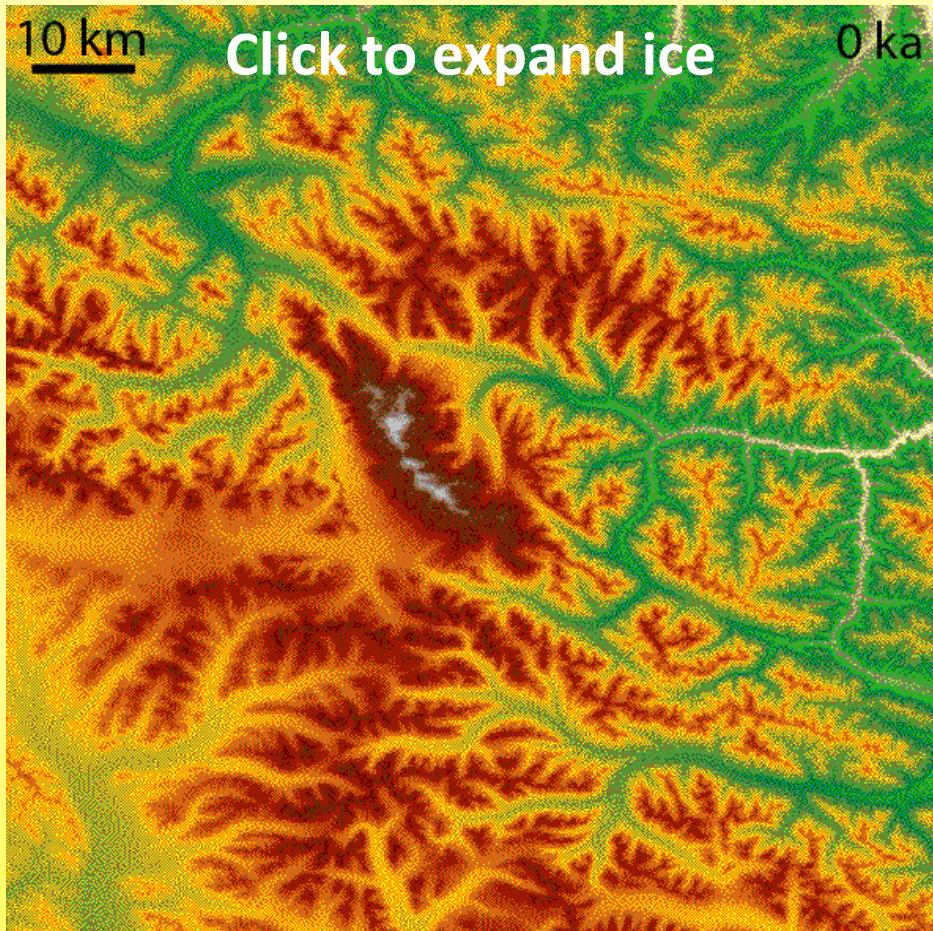
Degree day mass balance model

DDF-snow: 3 mm/°C/day

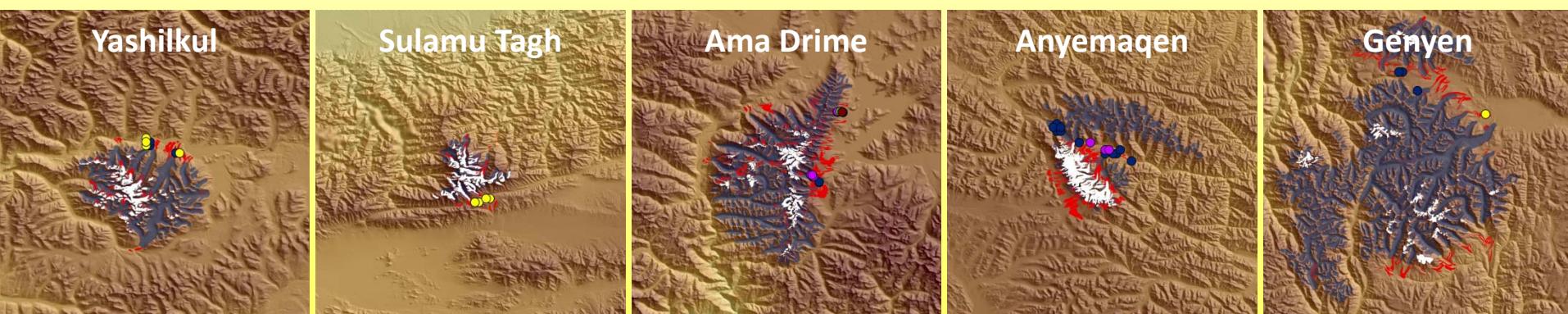
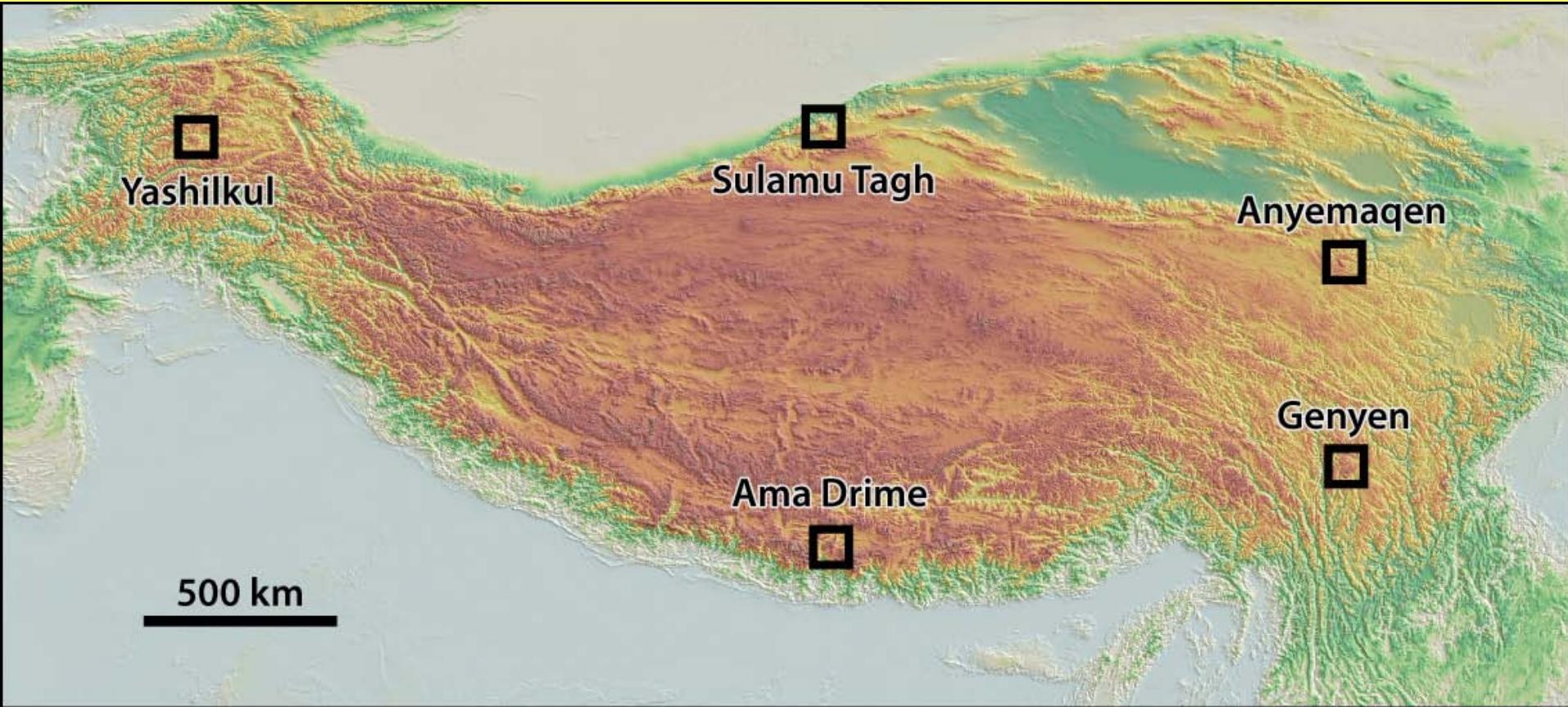
DDF-ice: 8 mm/°C/day

Higher order 3D ice flow model

Run with basal sliding on and
basal sliding off (frozen bed)



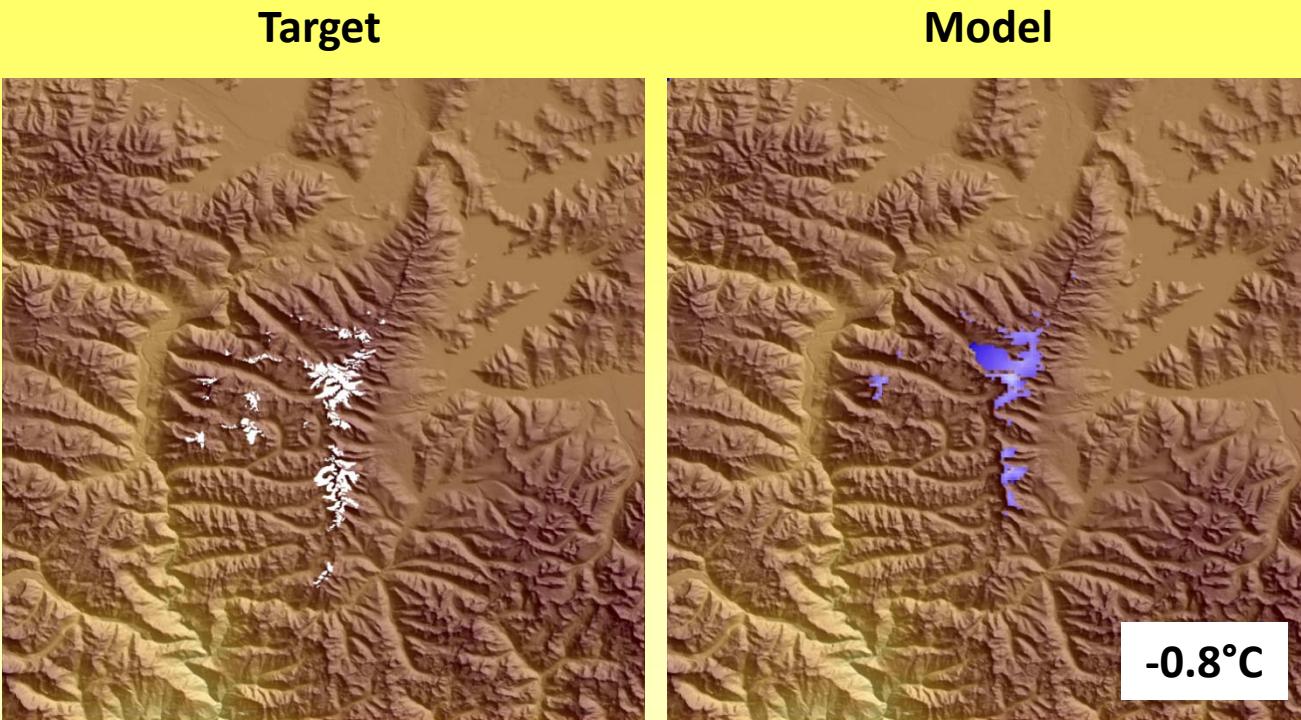
Glacier model domains



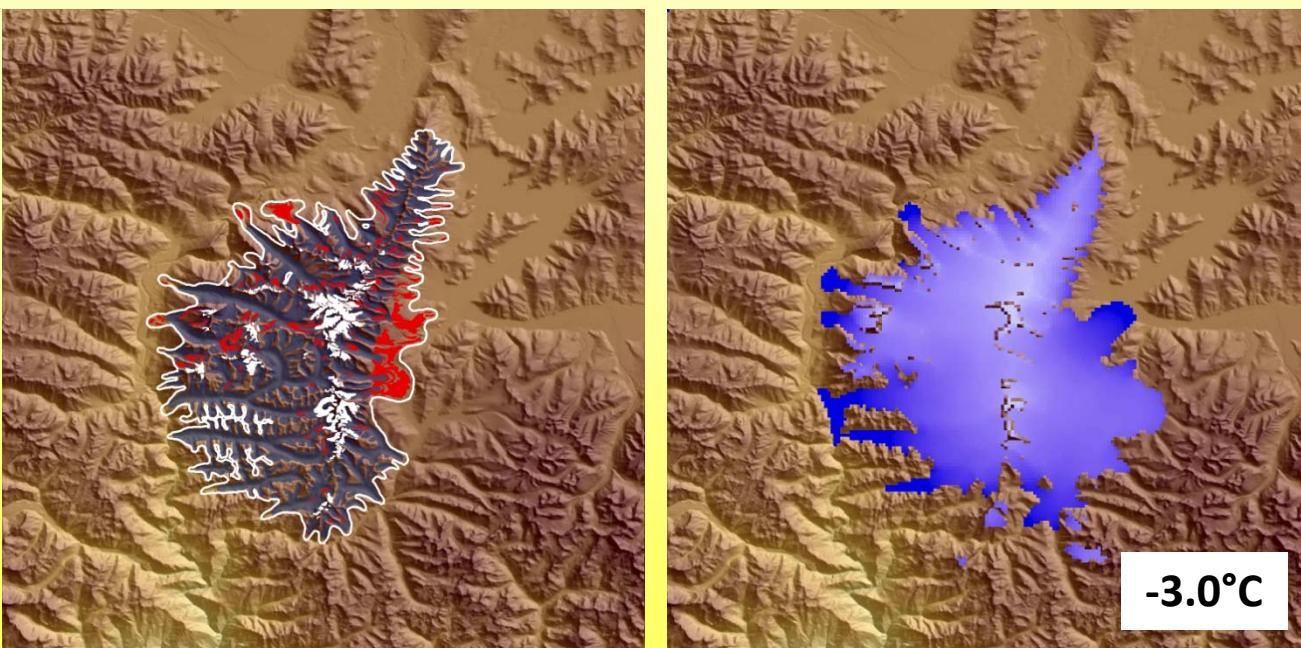
Exposure ages: ● 10-25 ka ● 25-50 ka ○ 50-100 ka ● >200 ka

Modeling approach

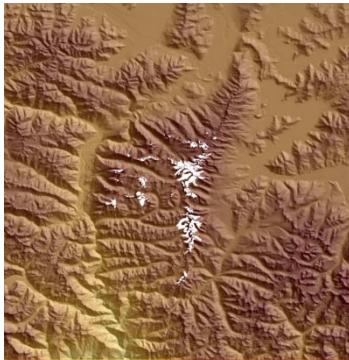
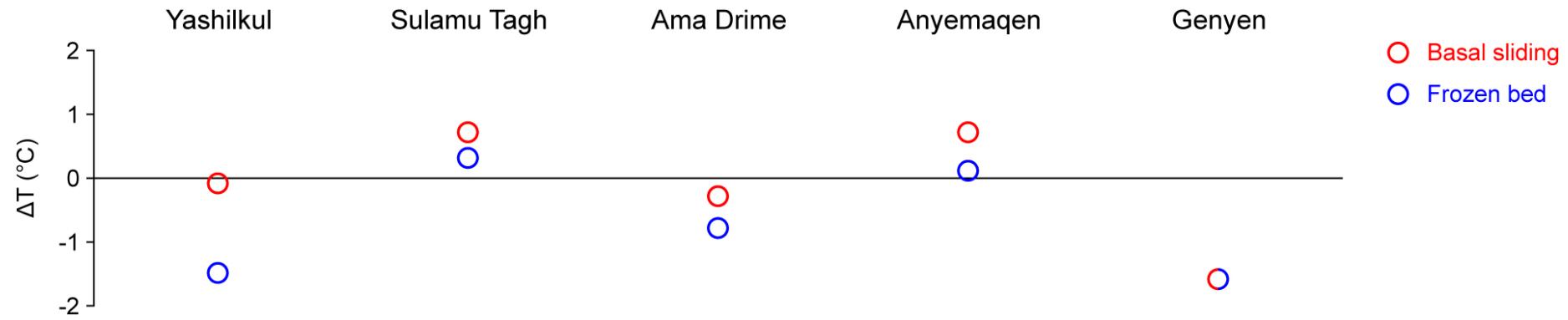
Present-day
glacier



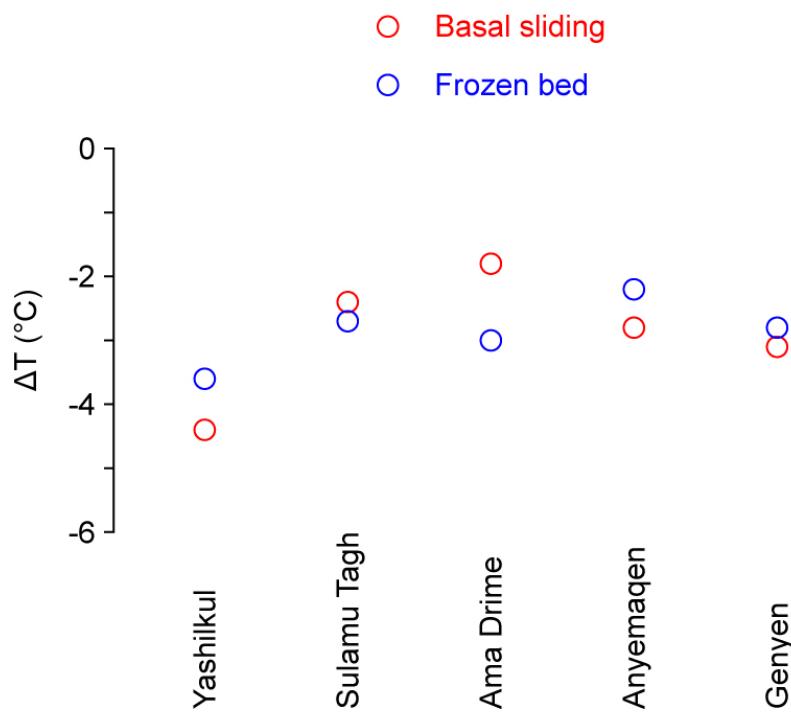
Paleo-glacier



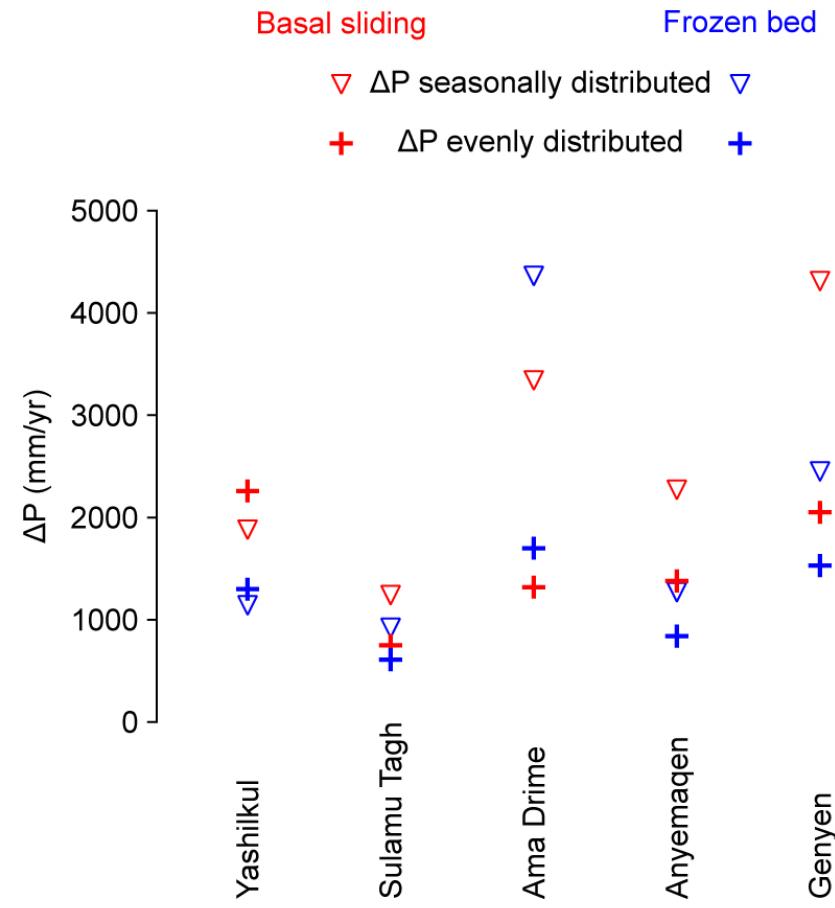
Temperature perturbations to reproduce present-day glaciers



Climate perturbations for paleo-glaciation targets

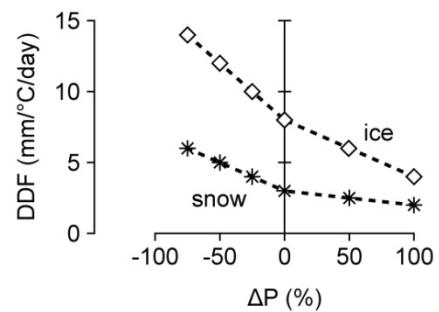
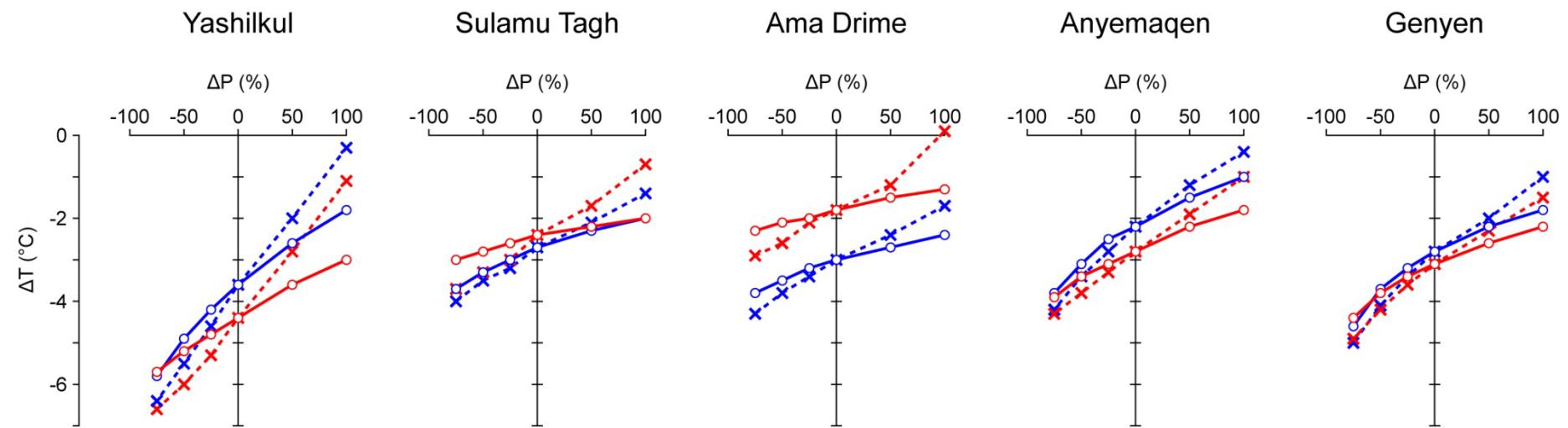


Limited cooling enough

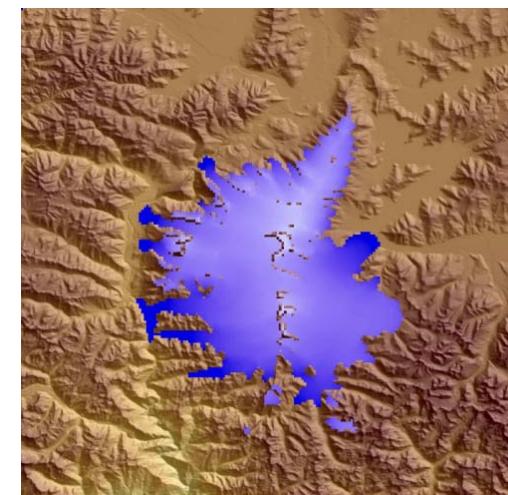


Significant precipitation increase required

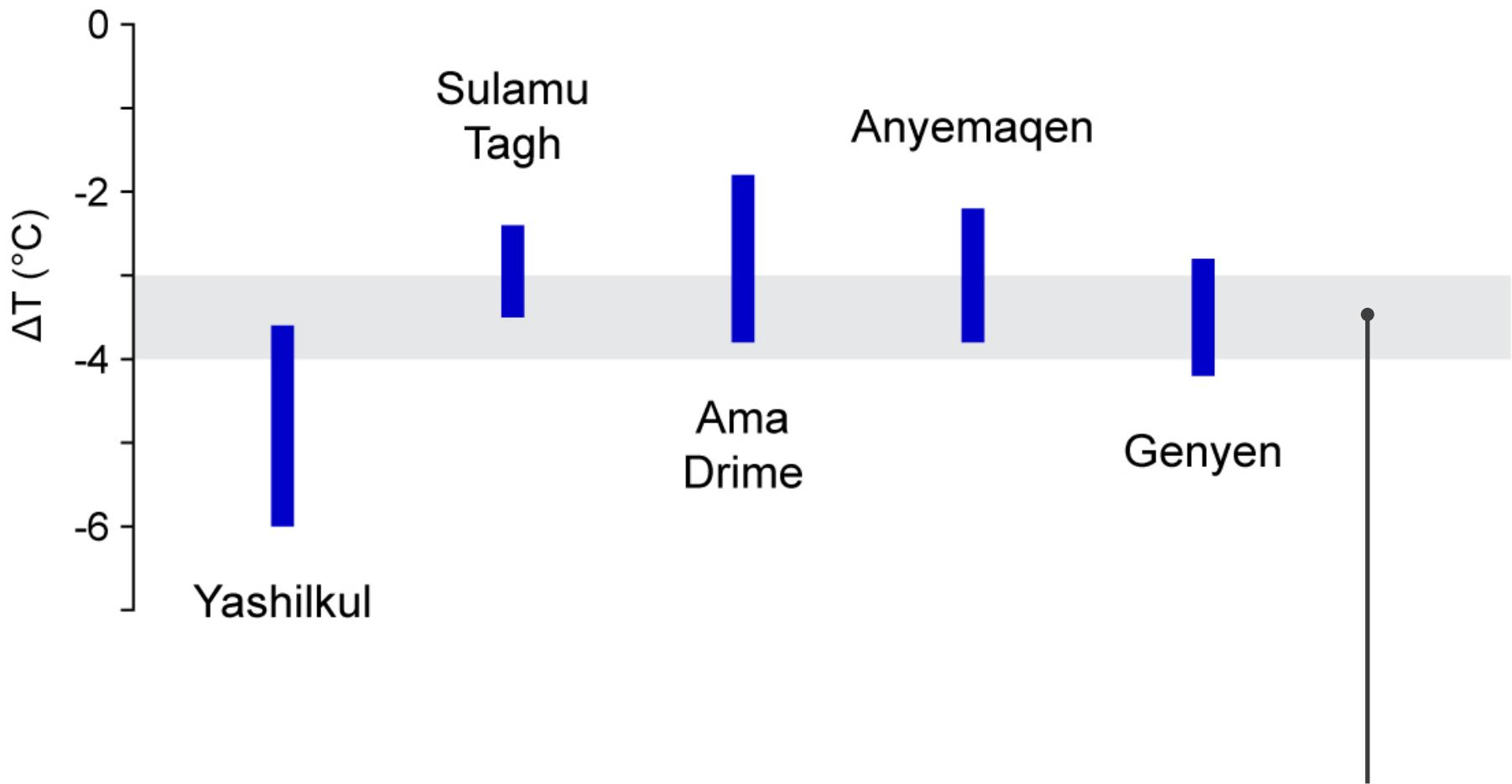
Climate perturbations for paleo-glaciation targets



Basal sliding Frozen bed
Varying DDF Varying DDF



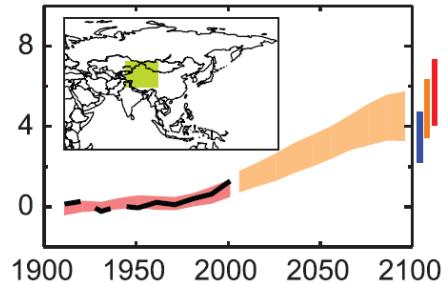
Assuming 0 to -50% ΔP



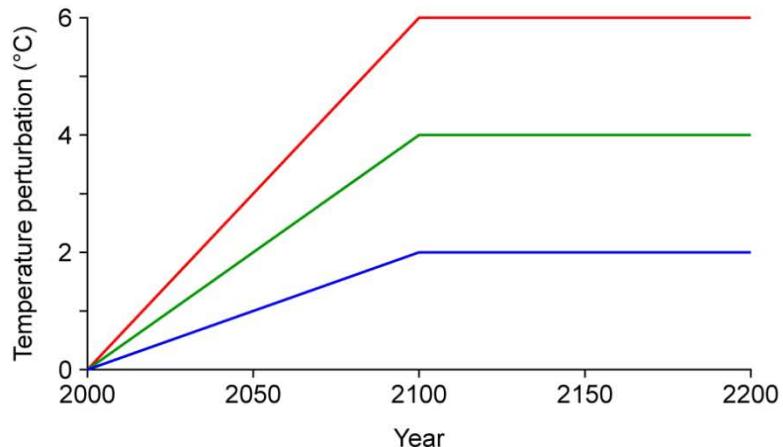
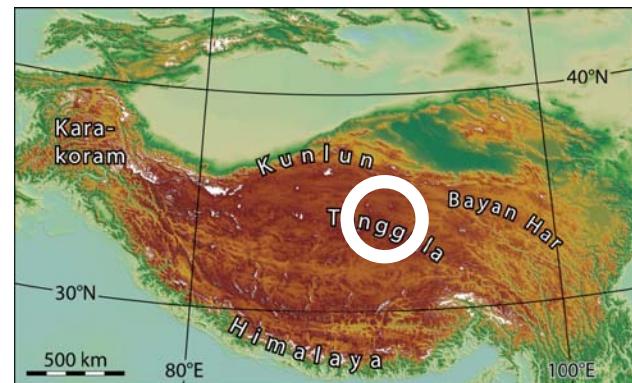
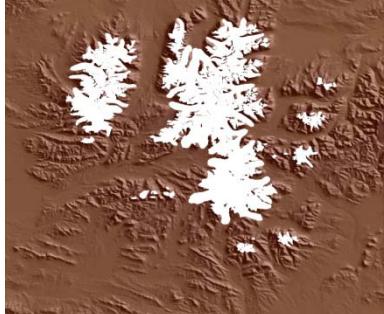
Max LGM summer cooling: 3-4°C
Schmidt et al. (2011): QSR
Miehe et al. (2011): QR

Glacier projection

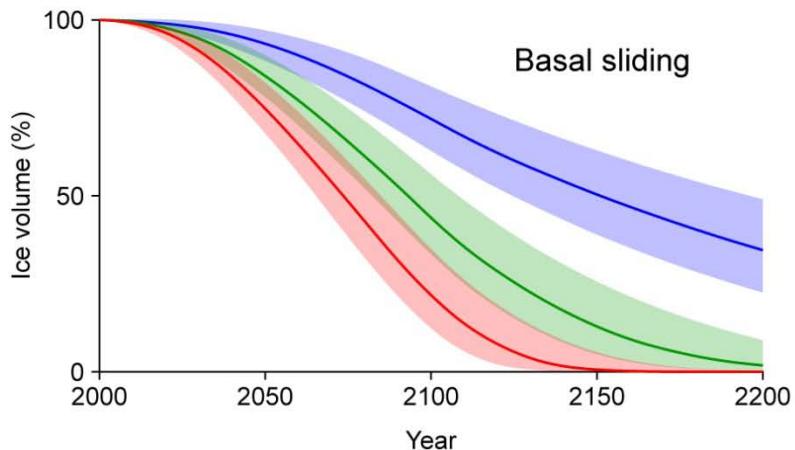
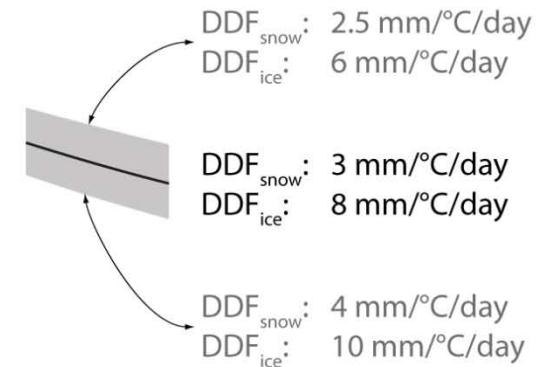
IPCC (2007) regional projection



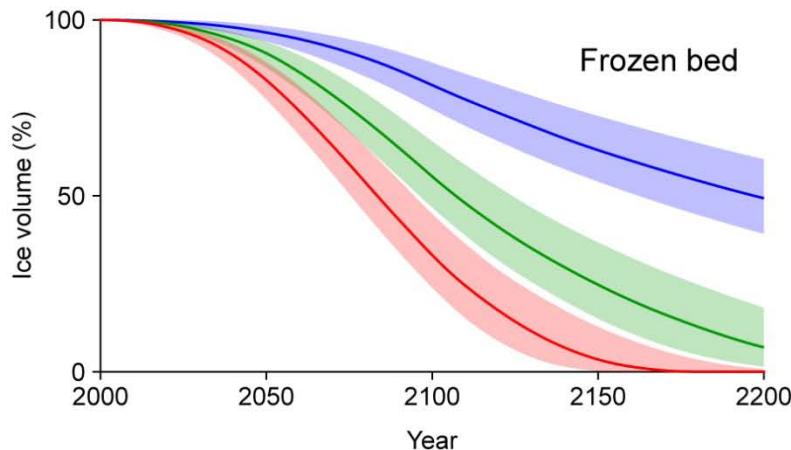
Geladandong ice-field



Precipitation
increase: **20%**



Basal sliding



Frozen bed

Conclusions

- Tibetan glaciers appear more sensitive to temperature than to precipitation perturbations
- Limited cooling (2-5°C) is enough to expand Tibetan glaciers beyond their LGM extent
- Future warming of projected IPCC magnitude would likely lead to extensive glacier reduction on the Tibetan Plateau



Thank you!

