A new attempt of 2-D numerical ice flow model to reconstruct paleoclimate from mountain glaciers

Adem Candaş and Mehmet Akif Sarıkaya

Istanbul Technical University, Eurasia Institute of Earth Science, 34469, Ayazağa, Istanbul, Turkey

Introduction

The aim of this study is to model paleo-glaciers in Dedegöl Mountain (SW Turkey) and simulate the paleo-climatic conditions.

The first method, two-dimensional (2-D) model based on the shallow ice approximation (SIA) (Plummer and Phillips, 2003; Eaves et. al., 2016), is used to compare the simulated and field observed ice extent of paleo-glaciers:

$$\frac{\partial h(x,y,t)}{\partial t} = M(x,y) - \nabla q(x,y)$$

A MATLAB code is generated and finite difference method is used to solve this non-linear equation. On the other hand, Parallel Ice Sheet Model (PISM) (the PISM authors, 2016) is used to regenerate paleo-glaciers in the same area.

The annual mass balance is calculated by the difference of the net accumulation and ablation of snow and (or) ice. Also, Positive Degree Day Factor is used to calculate ablation (Zweck, 2005).

Ice Thickness & Moraine Ages

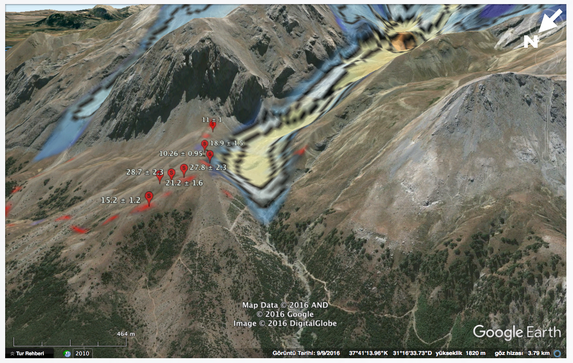

Figure 1. PISM simulation of paleo ice thickness in Sayacak Valley. Conditions T: -9°C; P:x2 (from present). Ages [ka]

Results - Ice area with PISM

Comparison of moraine proxies formed by paleo-glaciers, obtained from field studies and PISM models under different climatic conditions.

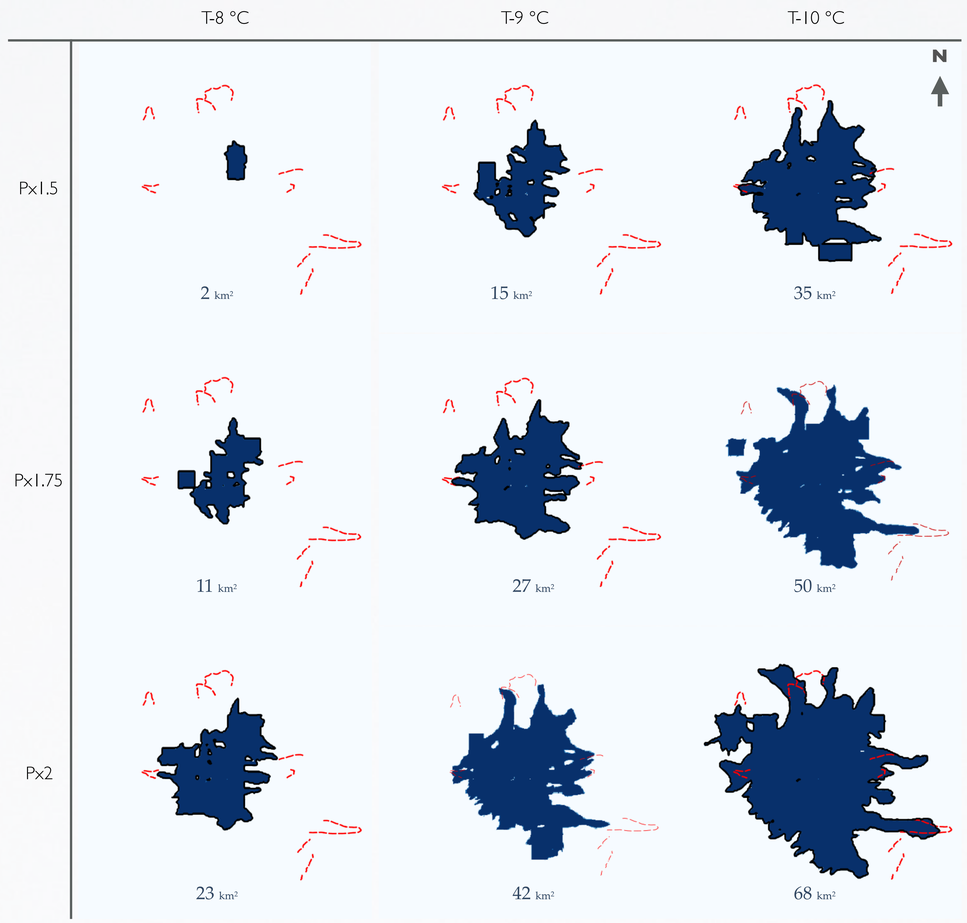

Figure 2. Simulation of paleoglacier area at Dedegöl Mountain. T: Temperature offset; P: Precipitation multiplier (from Present) Grid: 565x565; Resolution: 30m; Total Area: 286.29 km2

Results - 2D flow model vs PISM

The study on two-dimensional (2-D) model based on the shallow ice approximation (SIA) is an ongoing project.

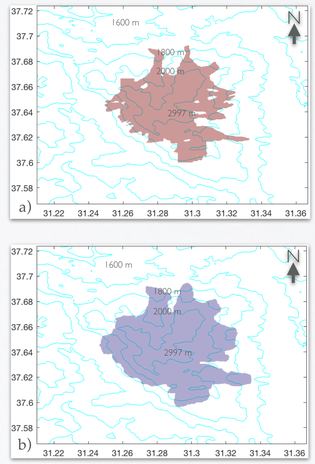

Figure 3. a) Parallel Ice Sheet Model Dedegöl Mountain Glacier Mask under paleo-climatic conditions; temperature 9 °C colder and precipitation doubled. b) The two-dimensional shallow ice approximation model shows similar profile in the same area.

Conclusions

- Even if PISM is developed for ice sheets, using it with the 2D ice-flow model provides significant simulations for a mountain glacier.
- Simulations of nine conditions with PISM show that local air temperatures were depressed by 8-10 °C relative to present during the Last Glacial Maximum. Also, increasing of precipitation up to 1.5-2.0 times from present can be observed.

Acknowledgments

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