RECONSTRUCTION OF THE PALEOCLIMATE ON DEDEGÖL MOUNTAIN WITH PALEOGLACIAL RECORDS AND NUMERICAL ICE FLOW MODELS

ESKİ BUZUL KAYITLARI VE SAYISAL BUZUL AKIŞ MODELLERİYLE DEDEGÖL DAĞI PALEOİKLİM REKONSTRÜKSÜYONU

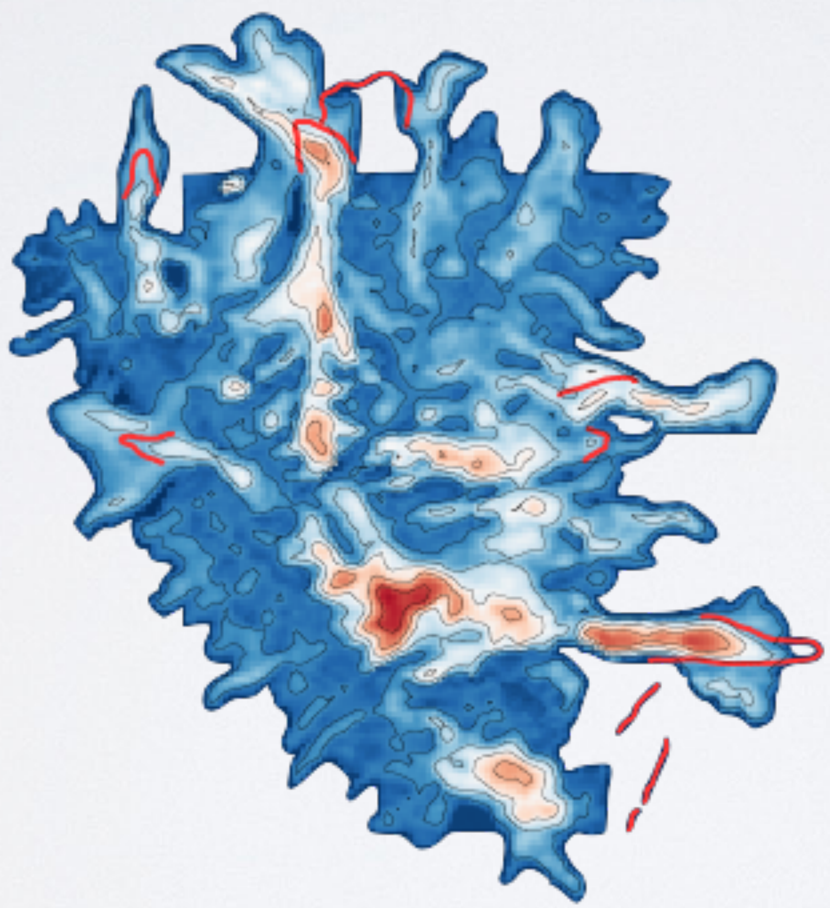

Image: Dedegöl Mountain
Paleoglacier Model
with PISM v0.7

-10°C degree colder
25% more precipitation

Adem Candaş

08.06.2017

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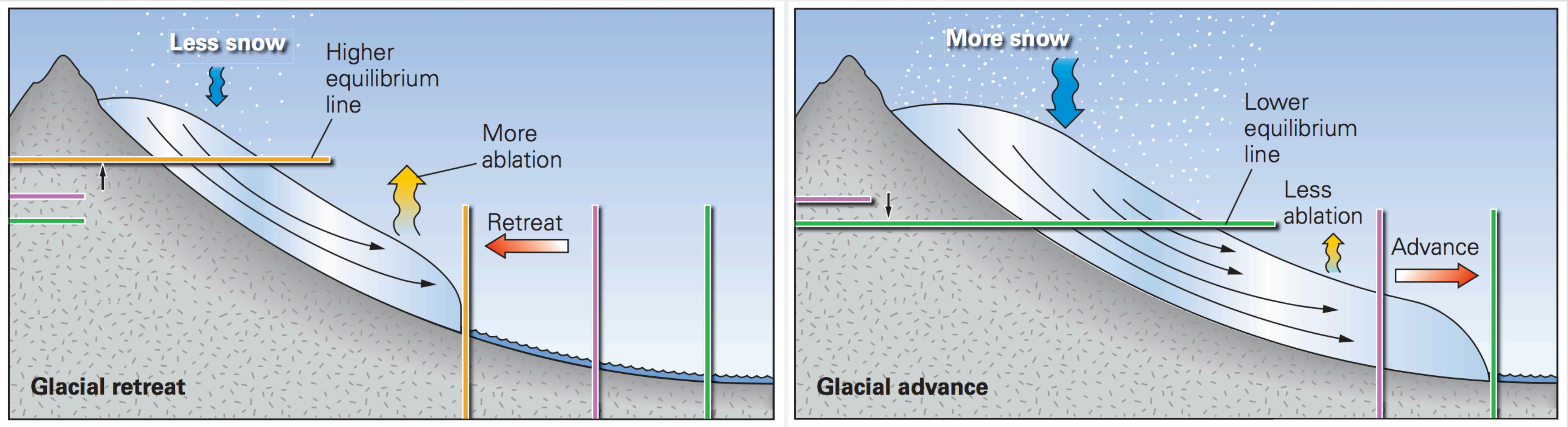
İSTANBUL TEKNİK ÜNİVERSİTESİ 1773

CONTENT

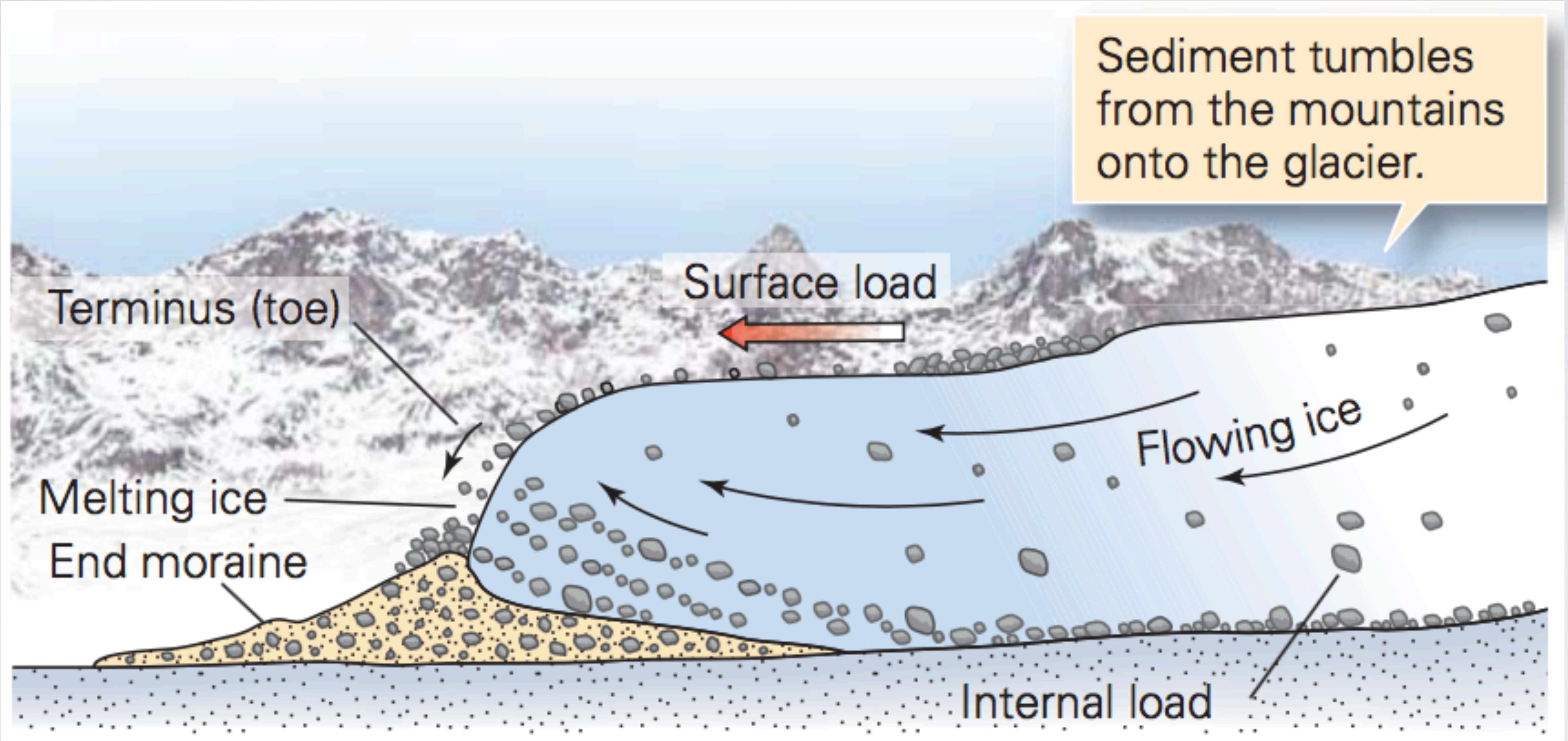
- Glaciers and Climate change
- How do they form?
- How do they move?
- Modeling and Reconstructions —> Paleoclimate
- Case Study: Dedegöl Mountain Paleoglaciers

GLACIER FLOW



Marshak, S. (2009). *Essentials of Geology, 4th Edition*, volume 17, WW Norton & Company.

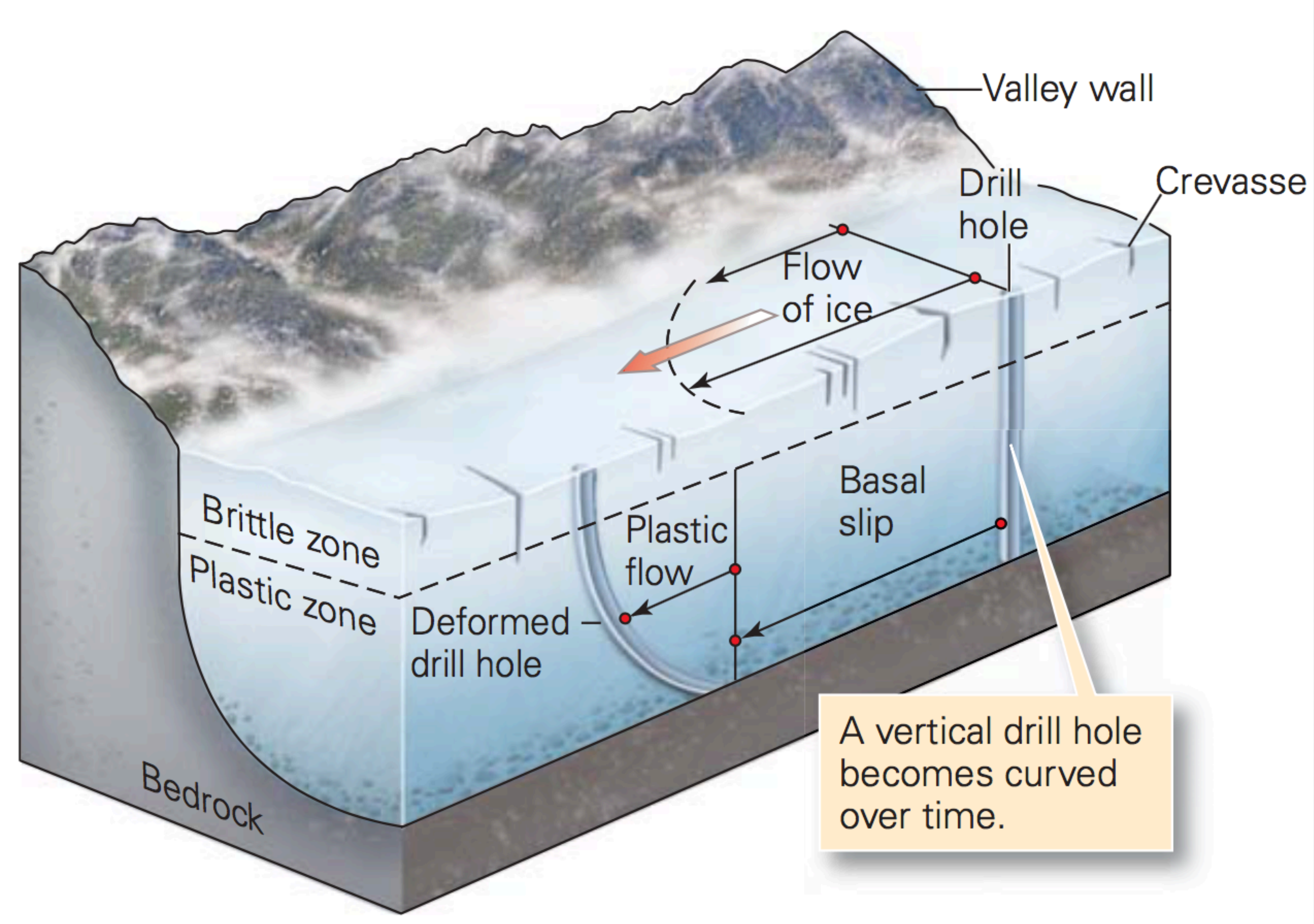
GLACIER FLOW



- Abrasive effect —> Transportation

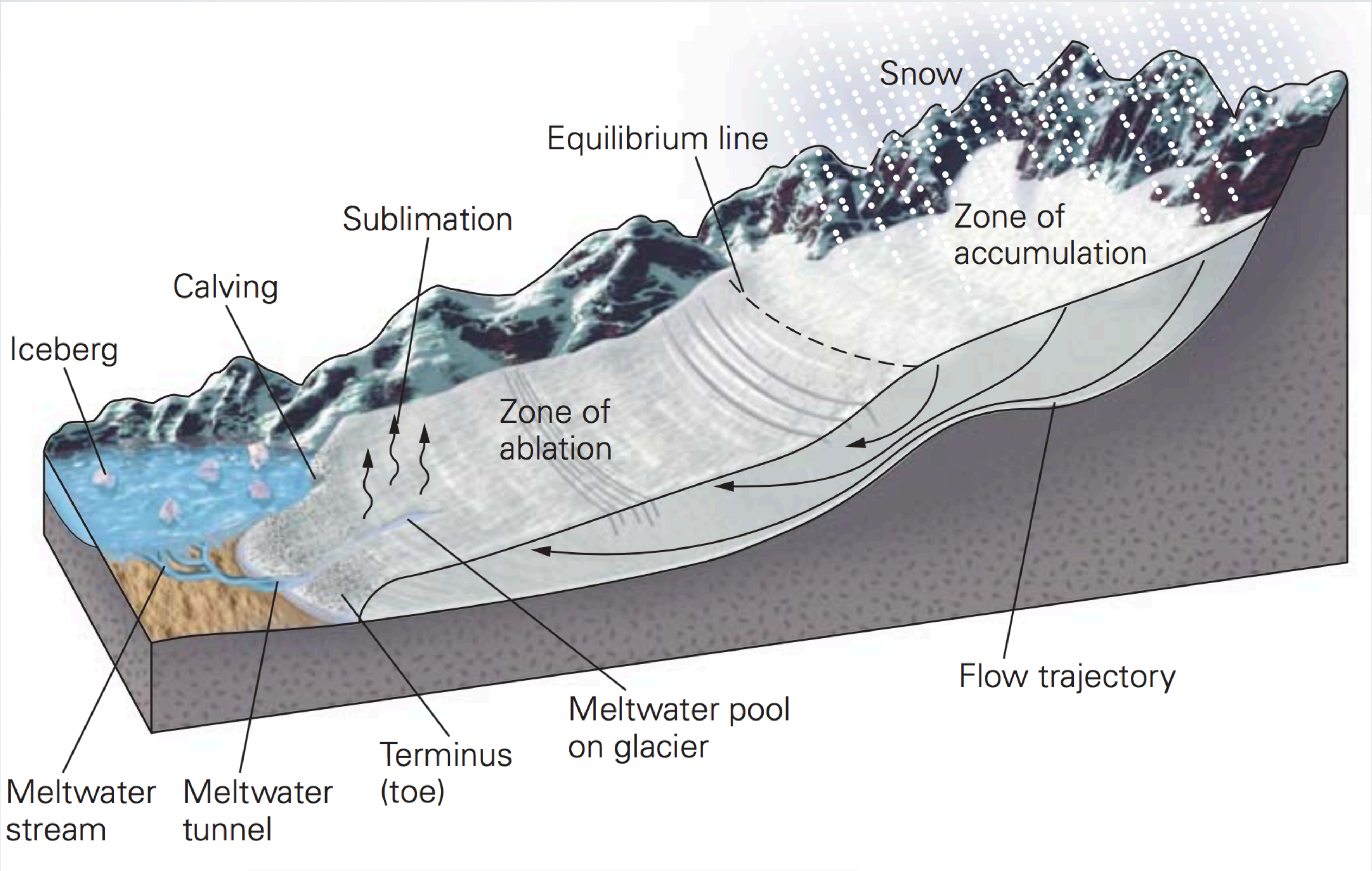
GLACIER FLOW

- Valley Glacier's Flow
- Flow Models



Marshak, S. (2009). *Essentials of Geology, 4th Edition*, volume 17, WW Norton & Company.

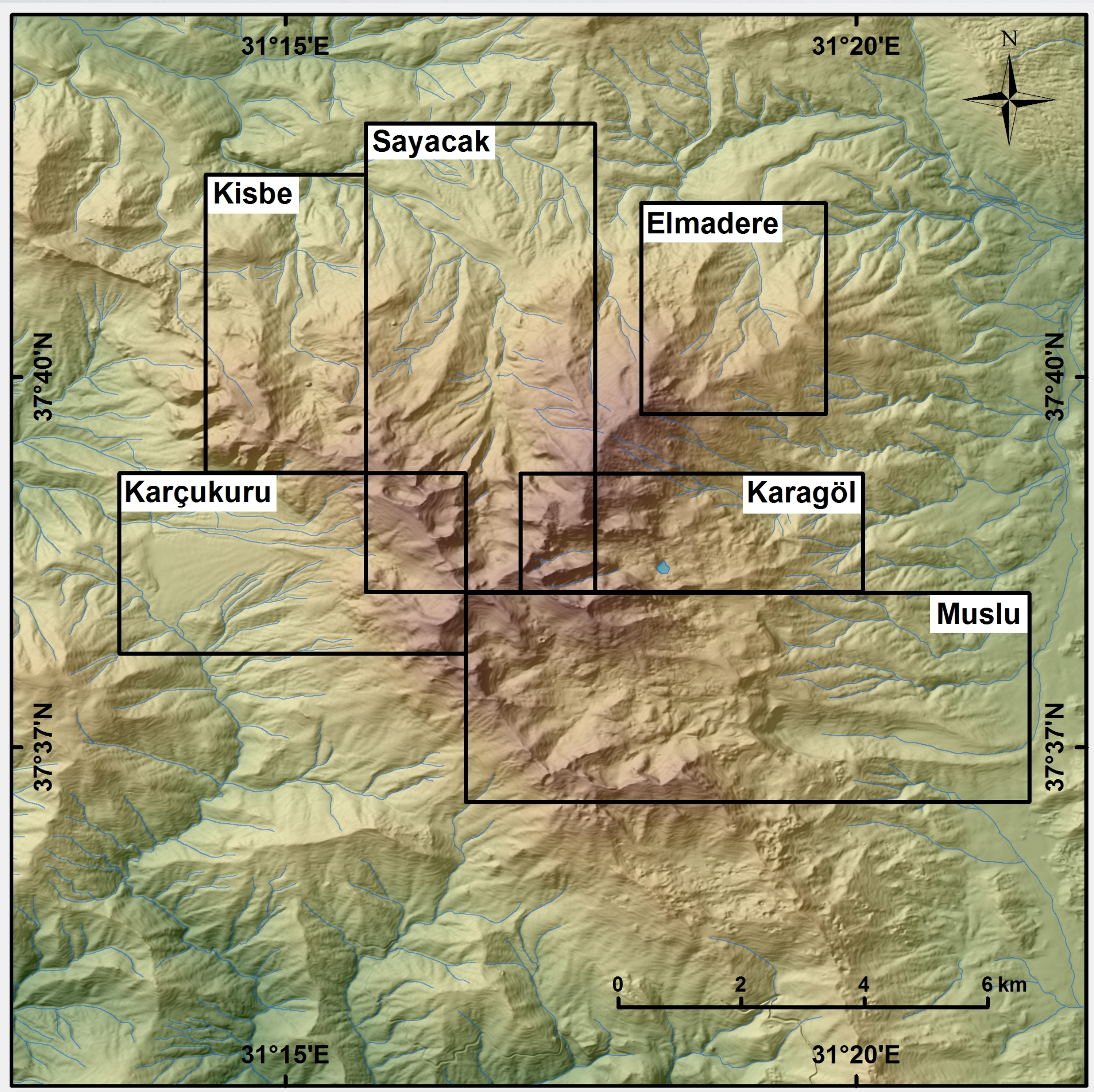
GLACIER FLOW



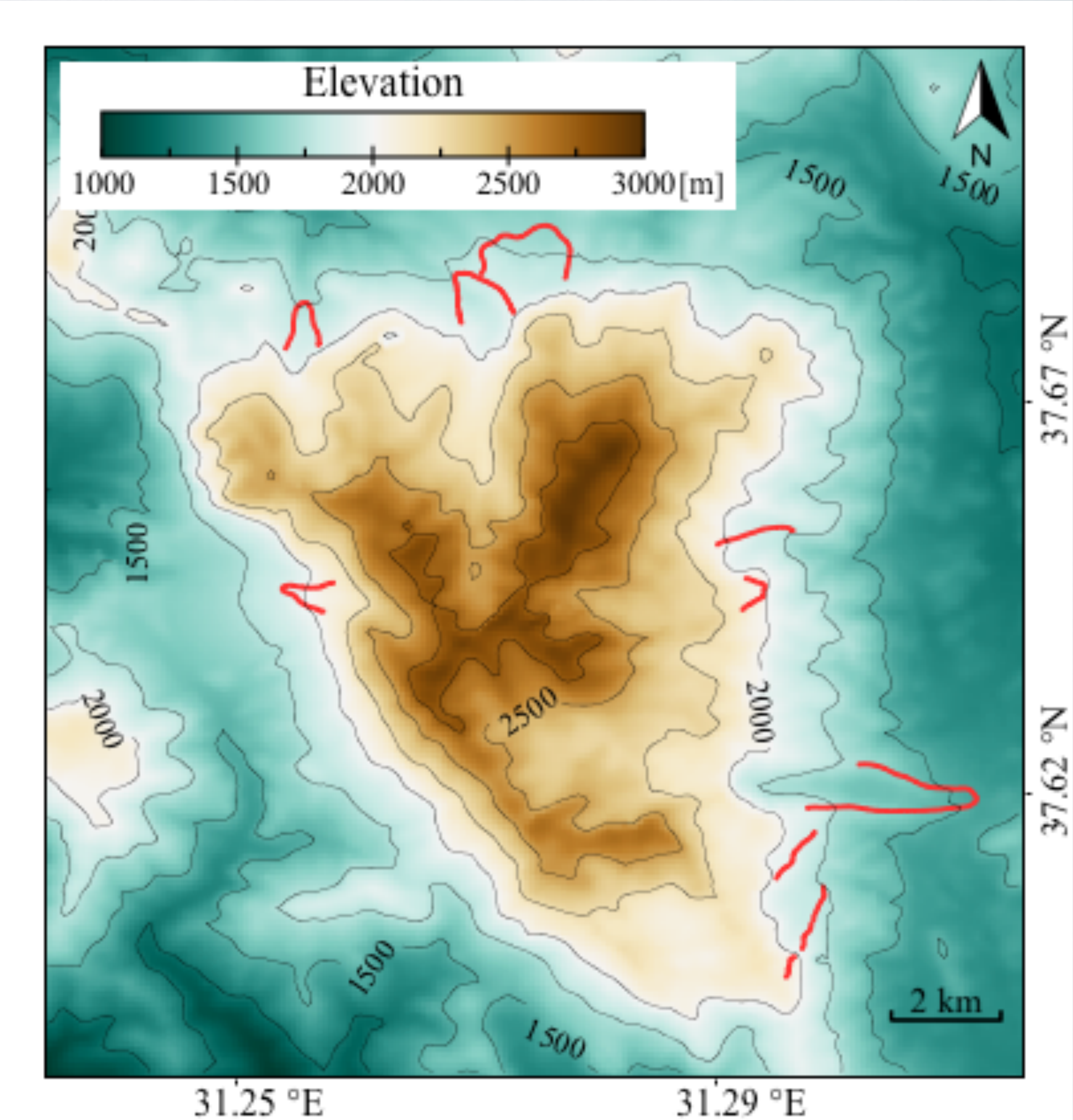
Marshak, S. (2009). *Essentials of Geology, 4th Edition*, volume 17, WW Norton & Company.

- What are the inputs?

CASE: DEDEGÖL MOUNTAIN

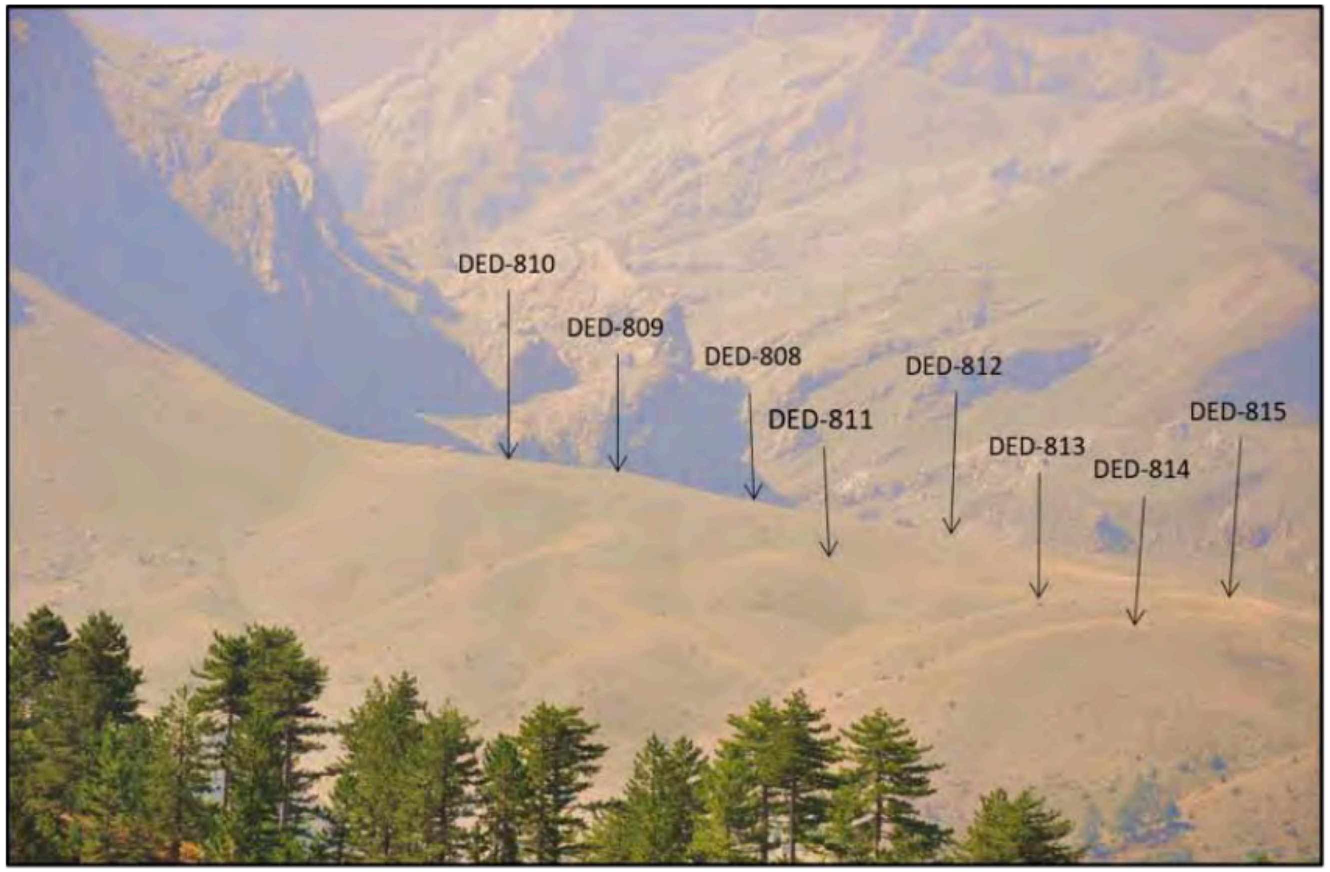


Köse, O. (2017). Late Quaternary glaciations and ^{36}Cl geochronology of the Mount Dedegöl, *M.Sc. Thesis*, Istanbul Technical University, Istanbul, Turkey.



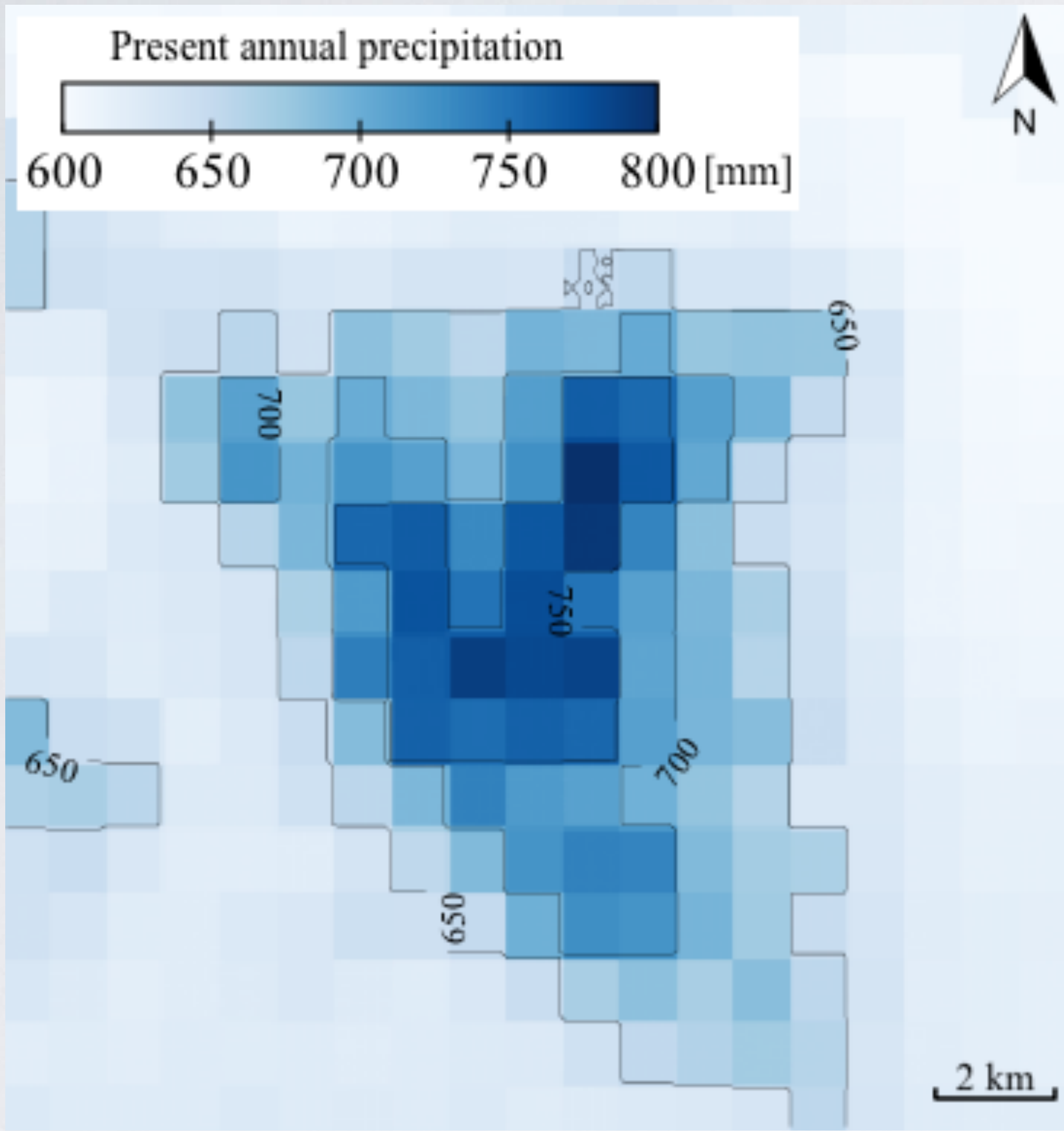
ASTER GDEM 30 m resolution

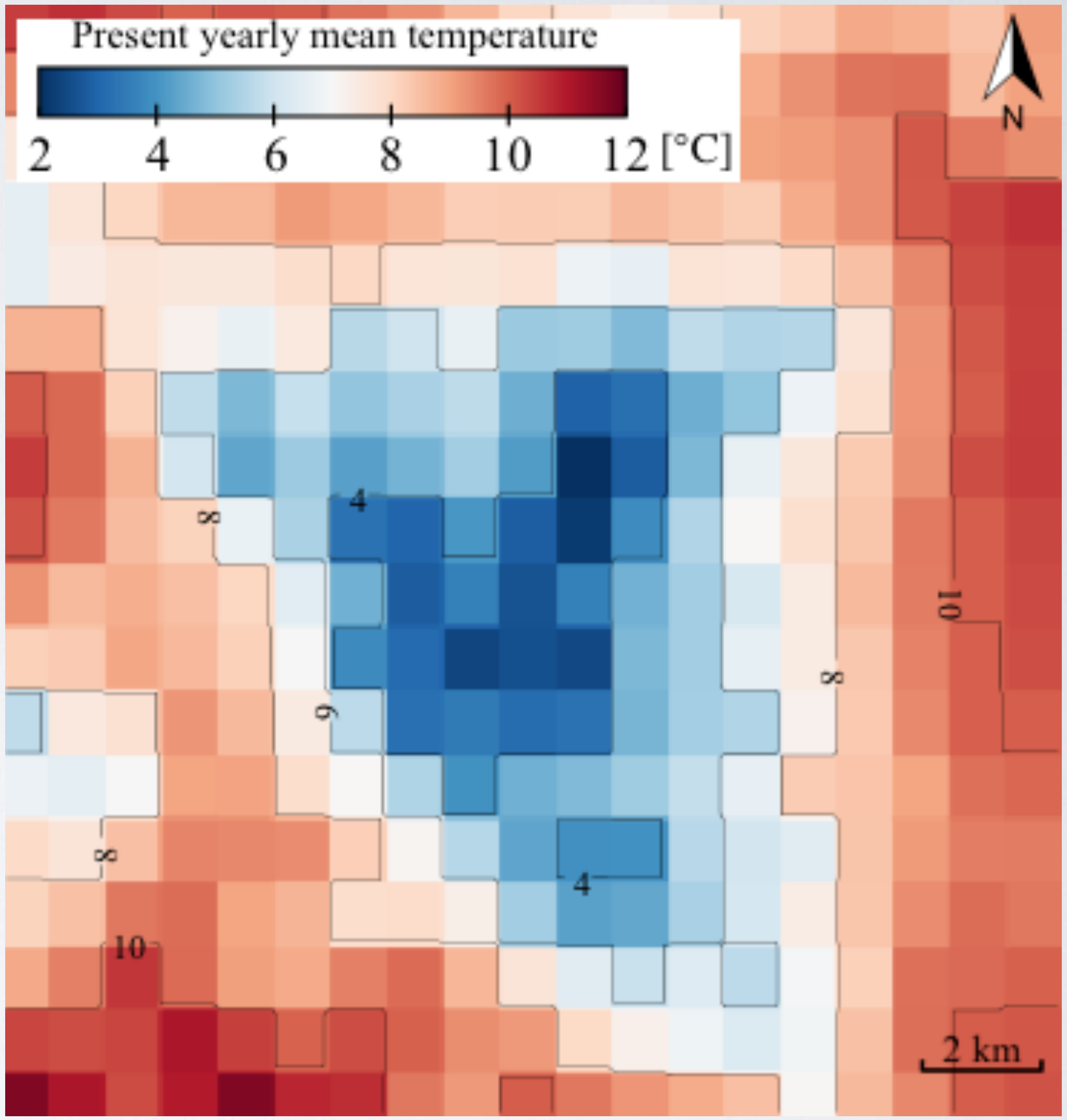
FIELD STUDY



August, 2015 & July, 2016

PRESENT CLIMATE





646 mm annual precipitation

42% falls in winter months

~1 km resolution

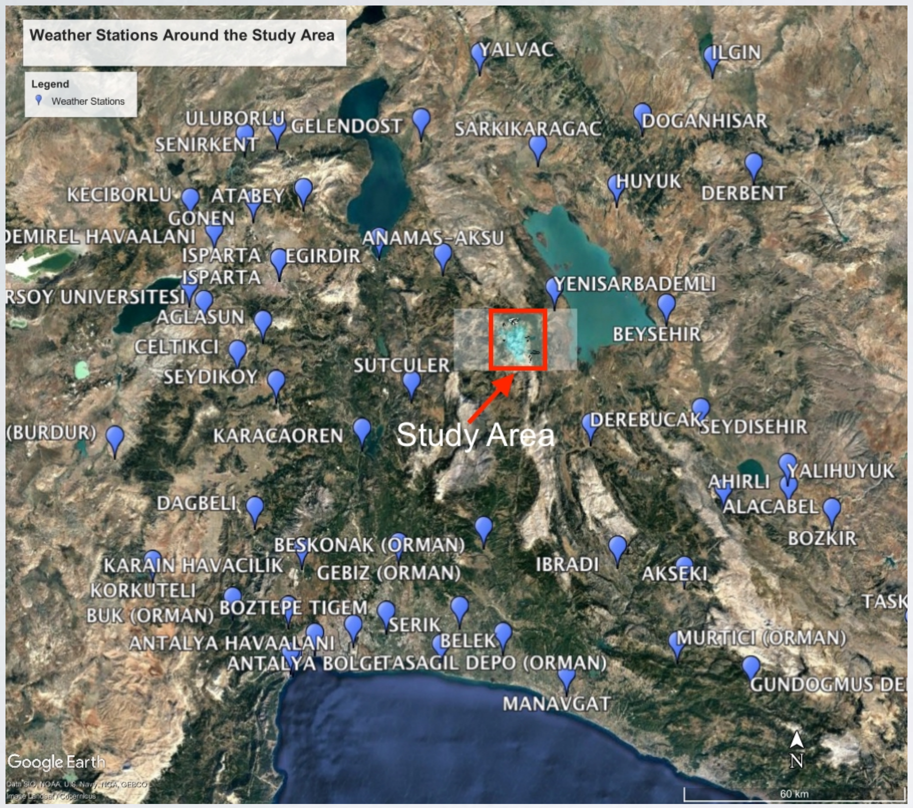
average summer temperature is 17.6°C

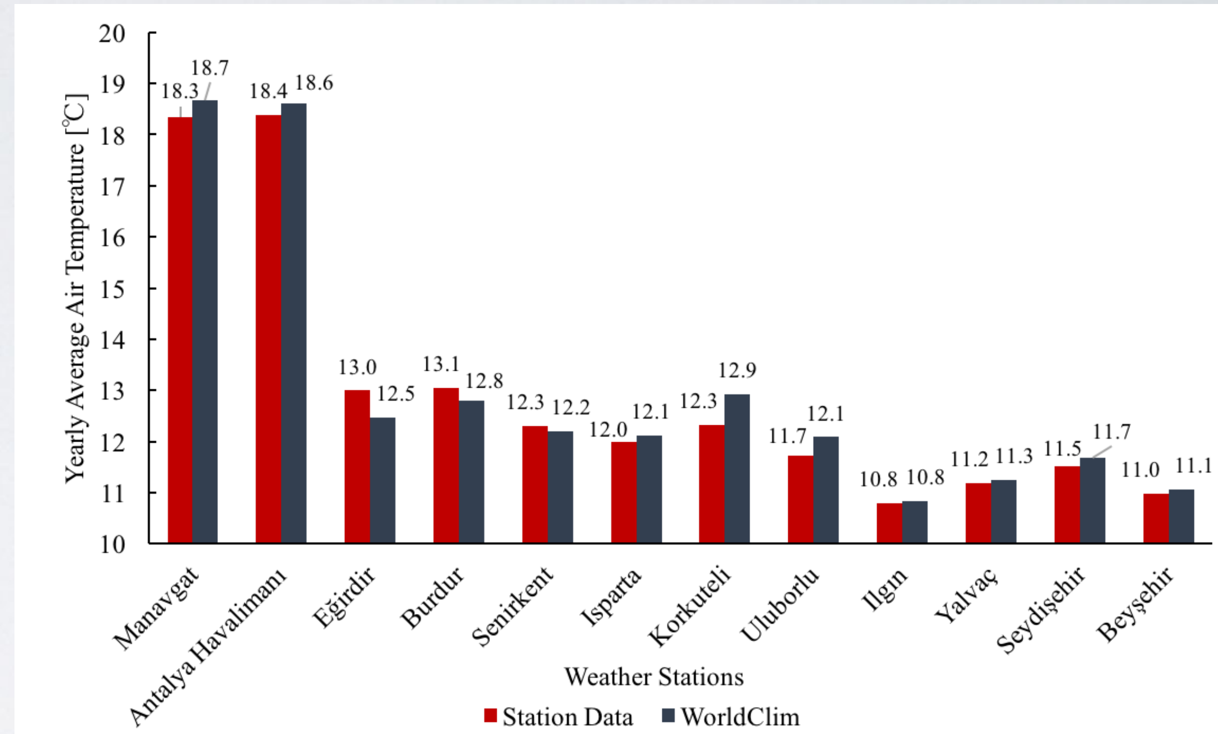
average winter temperature is -1.2°C

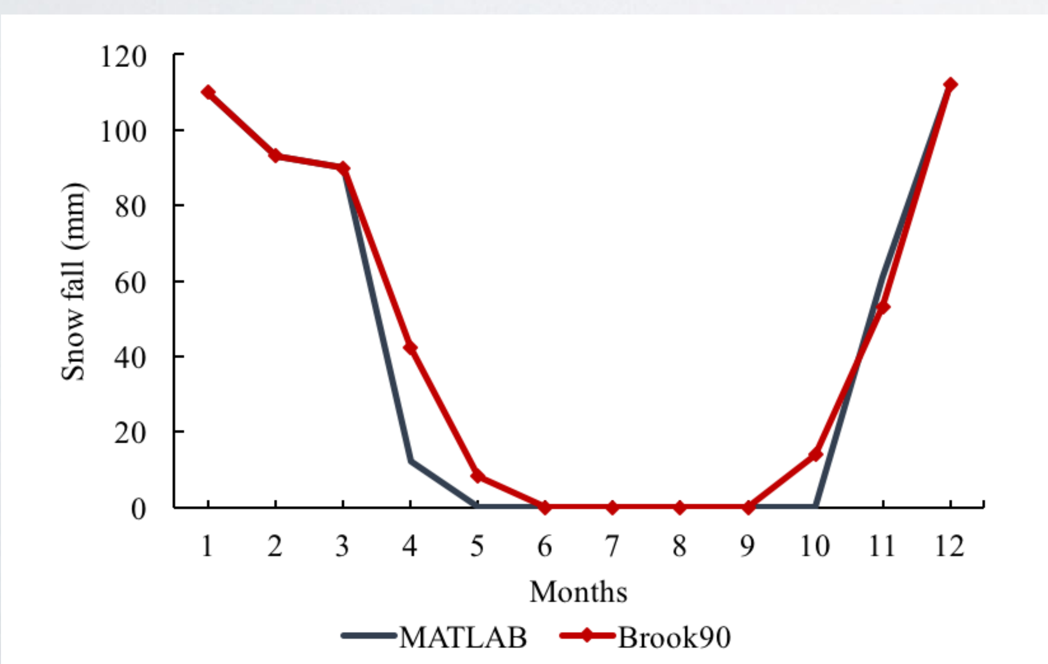
yearly temp. average ~8.2°C

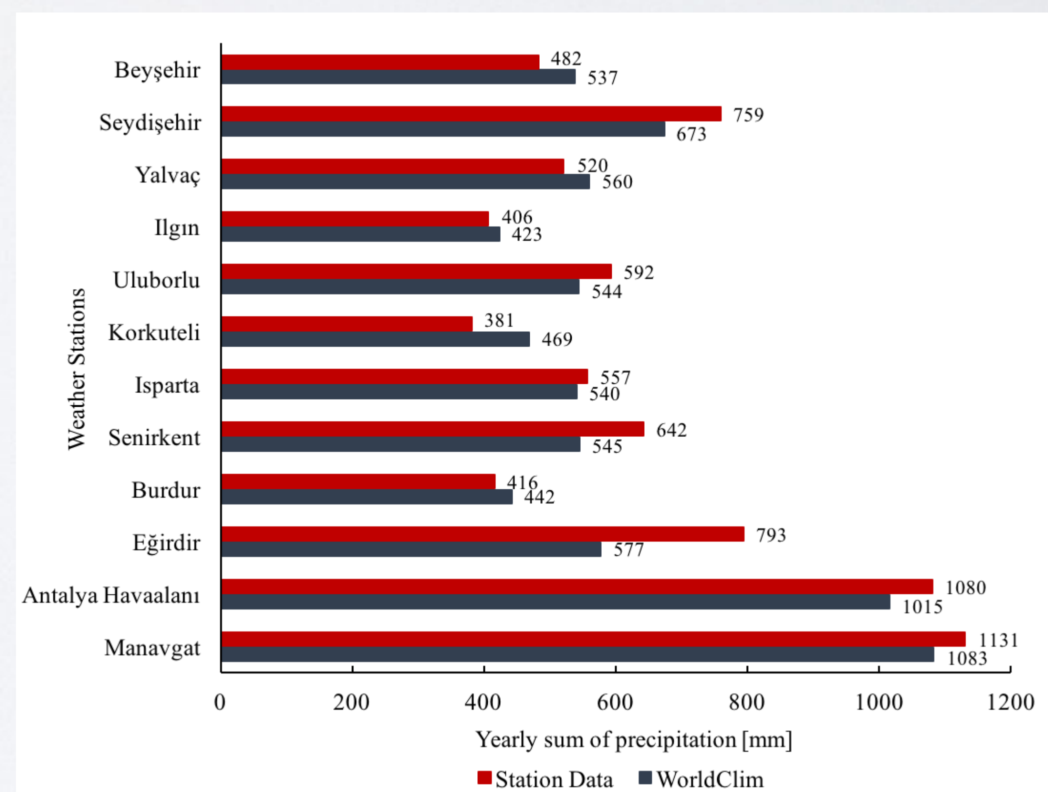
www.worldclim.org

WORLDCLIM VS WEATHER STATIONS









PALEOCLIMATE MODELING

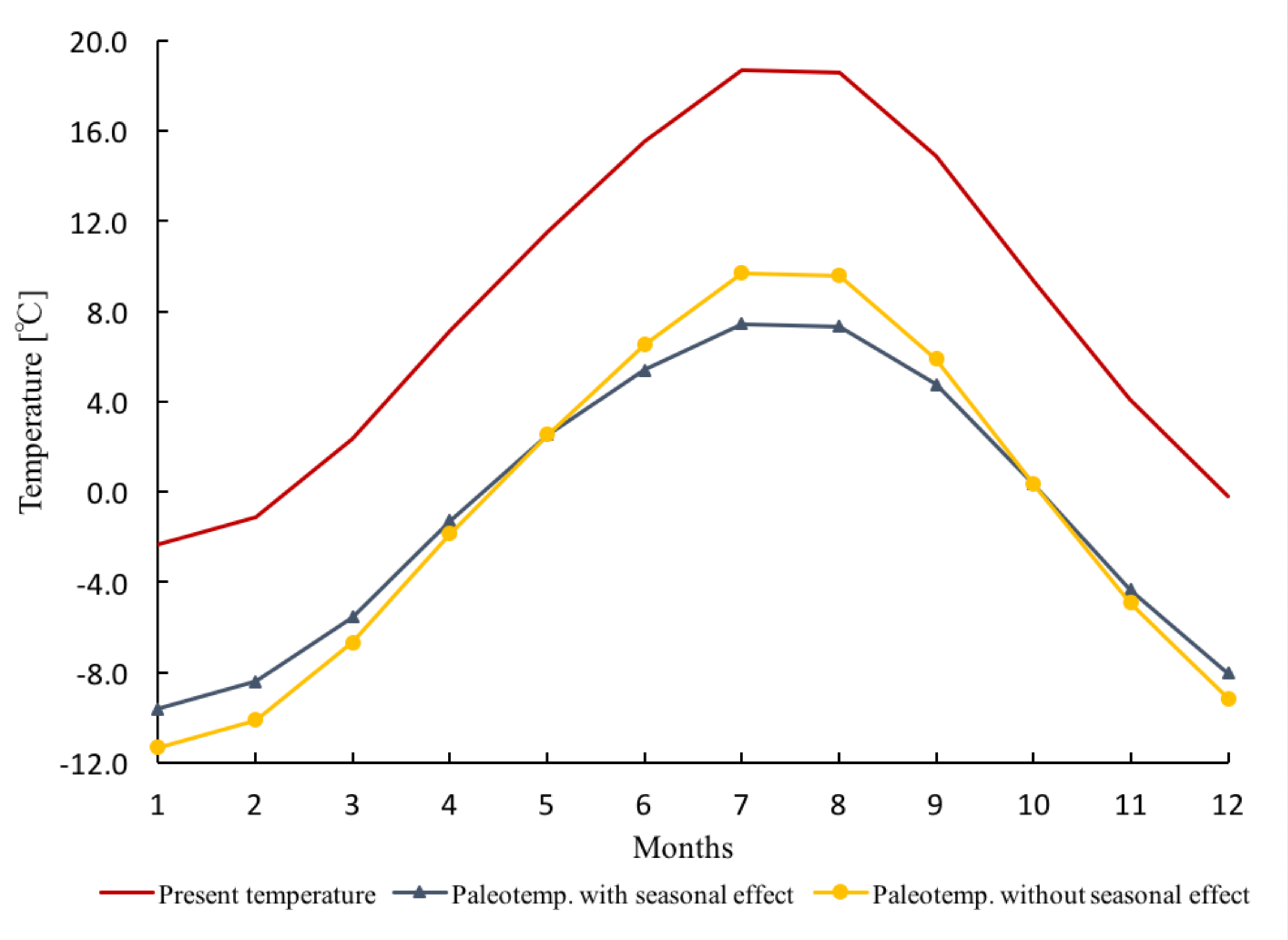
Table 2.1 : The coefficients used to offset temperature depending on seasonal effect. The default ΔT =-9°C degree.

Months	1	2	3	4	5	6	7	8	9	10	11	12
Coefficients	0.65	0.65	0.7	0.75	0.8	0.9	1	1	0.9	0.8	0.75	0.7
ΔT^{new} [°C]	-7.3	-7.3	-7.9	-8.4	-9.0	-10.1	-11.3	-11.3	-10.1	-9.0	-8.4	-7.9

$$\Delta T^{new}(m) = \frac{\Delta T^{default} \times 12}{\sum_{n=1}^{12} coeff_n} \times coeff^m, \quad m = 1...12$$

where, $\Delta T^{default}$ is the default offset value

PALEOCLIMATE MODELING



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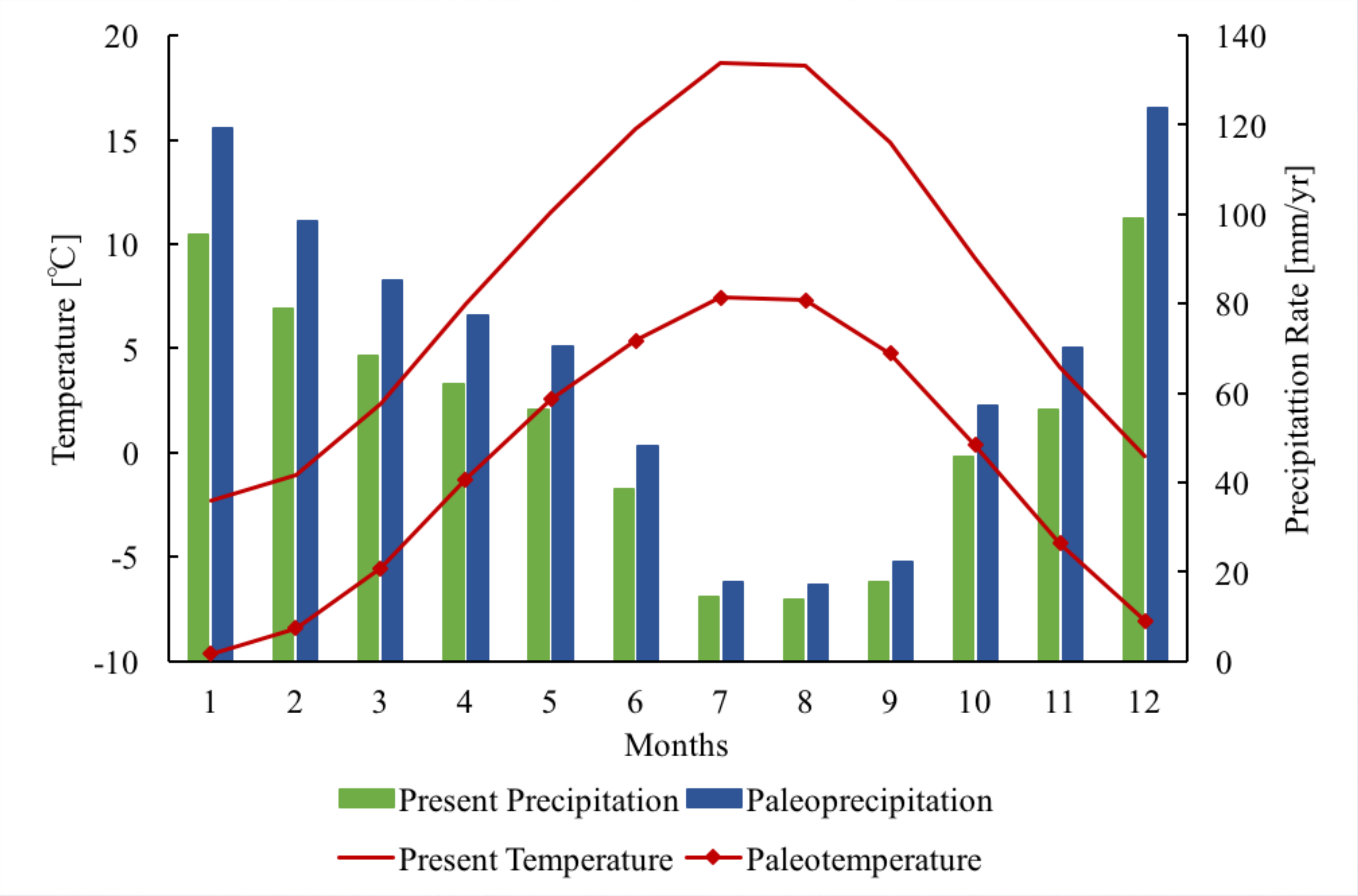
CLIMATE INPUTS



-9°C degree colder and 25% more precipitation values.

Accumulation:

if T <0
Accumulation = Ice equivalent precipitation

elseif 0<T<2
Accumulation linearly dependent to prec.

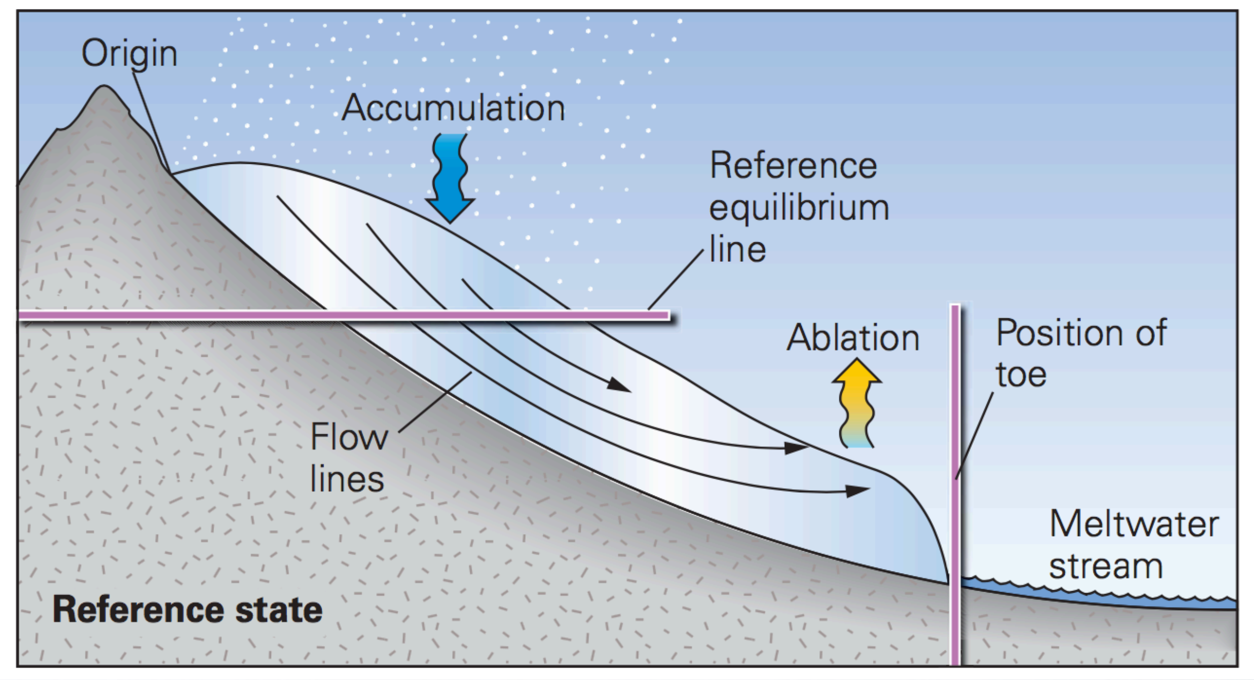
else T>2
Accumulation = 0

Ablation:

Positive Degree Day

$$EPDD = \sigma \int_0^{12} 30.4 \left[0.3989 \exp\left(-1.58 \left| \frac{T_{mon}}{\sigma} \right|^{1.1372} \right) + \max\left(0, \frac{T_{mon}}{\sigma}\right) \right] dt.$$

Braithwaite, R.J. ,1995



Marshak, S. (2009). *Essentials of Geology, 4th Edition*, volume 17, WW Norton & Company.

Mass Balance = Accumulation - Ablation

GLACIER MODEL

- www.pism-docs.org

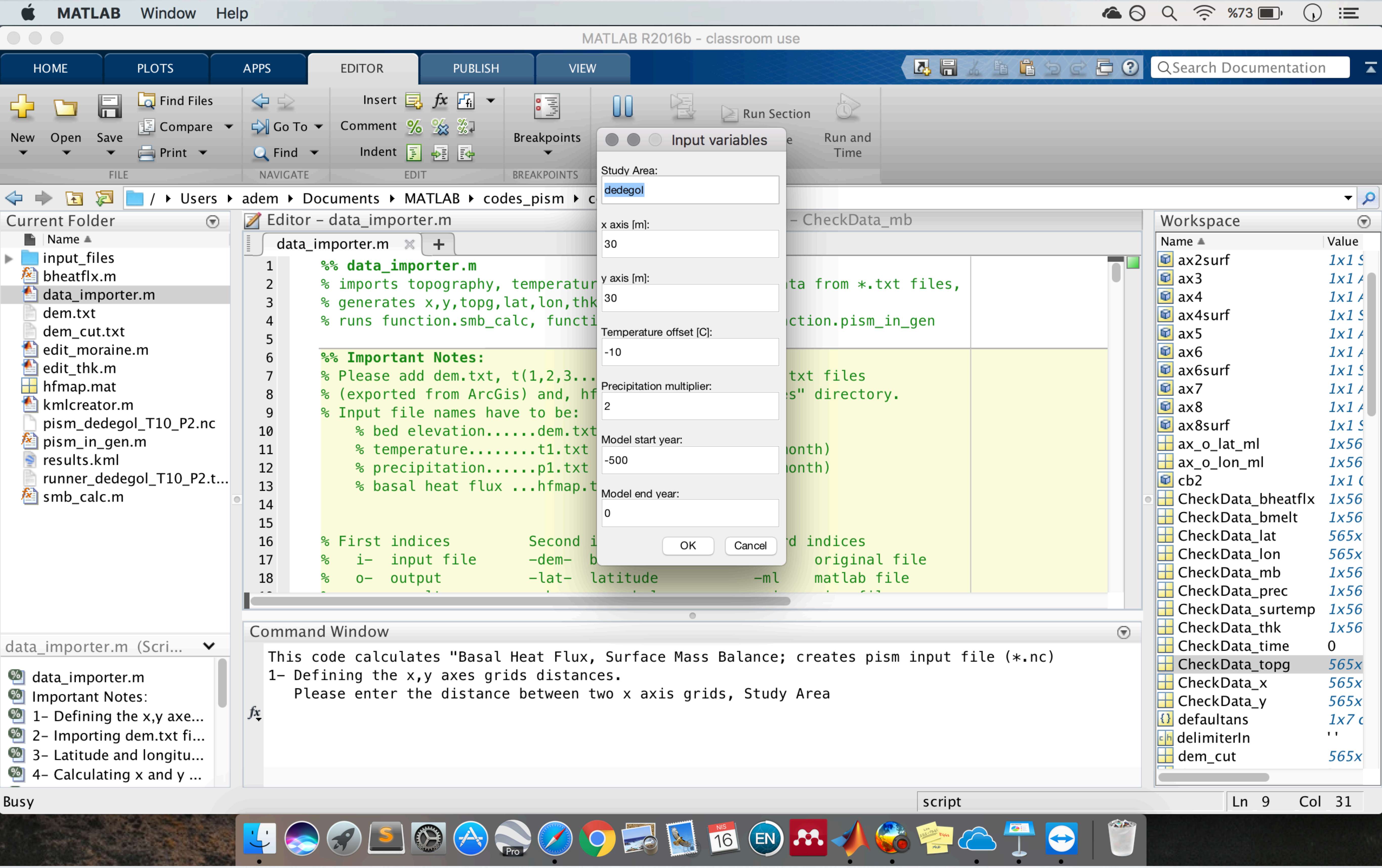
Parallel Ice Sheet Model

Name	Long Name	Type
pism_dedegol...	pism_dedegol_T1...	Local File
bheatflx	Basal Heat Flux	Geo2D
bmelt	Ice Basal Melt Rate	Geo2D
climatic_m...	Surface Mass Balan...	Geo2D
ice_surface...	Annual Mean Air T...	Geo2D
lat	Latitude	Geo2D
lon	Longitude	Geo2D
mapping	mapping	—
precipitation	Present Precipitation	Geo2D
thk	Ice Thickness	Geo2D
time	Time	—
topg	Bedrock Topography	Geo2D
x	Cartesian x-coordi...	1D
y	Cartesian y-coordi...	1D

```
      :_FillValue = NaNf; // float

    float thk(x=565, y=565, time=1);
      :reference = "Initial. Cond.";
      :grid_mapping = "mapping";
      :long_name = "Ice Thickness";
      :standard_name = "land_ice_thickness";
      :units = "meters";
      :coordinates = "lat lon";
      :_FillValue = NaNf; // float

  // global attributes:
  :Title = "Pism input Data Set";
  :Comments = "Created at EIES, Istanbul Technical University";
  :input_code_example = "mpiexec -n 4 pismr -i pism_{location}_T
}
```



MATLAB Window Help
MATLAB R2016b - classroom use
HOME PLOTS APPS EDITOR PUBLISH VIEW
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Go To Find
Insert Comment Indent
Breakpoints
Run Section
Run and Time
FILE NAVIGATE EDIT BREAKPOINTS
/ Users adem Documents MATLAB codes_pism
Current Folder
Name
input_files
bheatflx.m
data_importer.m
dem.txt
dem_cut.txt
edit_moraine.m
edit_thk.m
hfmap.mat
kmlcreator.m
pism_dedegol_T10_P2.nc
pism_in_gen.m
results.kml
runner_dedegol_T10_P2.t...
smb_calc.m
Editor - data_importer.m
data_importer.m
%% data_importer.m
% imports topography, temperatur
% generates x,y,topg,lat,lon,thk
% runs function.smb_calc, functi
%% Important Notes:
% Please add dem.txt, t(1,2,3...
% (exported from ArcGis) and, hf
% Input file names have to be:
% bed elevation......dem.txt
% temperature........t1.txt
% precipitation......p1.txt
% basal heat flux ...hfmap.t
% First indices Second i
% i- input file -dem- b
% o- output -lat- latitude
- CheckData_mb
ta from *.txt files,
ction.pism_in_gen
txt files
s" directory.
onth)
onth)
d indices
original file
-ml matlab file
Input variables
Study Area:
dedegol
x axis [m]:
30
y axis [m]:
30
Temperature offset [C]:
-10
Precipitation multiplier:
2
Model start year:
-500
Model end year:
0
OK Cancel
Workspace
Name Value
ax2surf
ax3
ax4
ax4surf
ax5
ax6
ax6surf
ax7
ax8
ax8surf
ax_o_lat_ml
ax_o_lon_ml
cb2
CheckData_bheatflx
CheckData_bmelt
CheckData_lat
CheckData_lon
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CheckData_surtemp
CheckData_thk
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CheckData_topg
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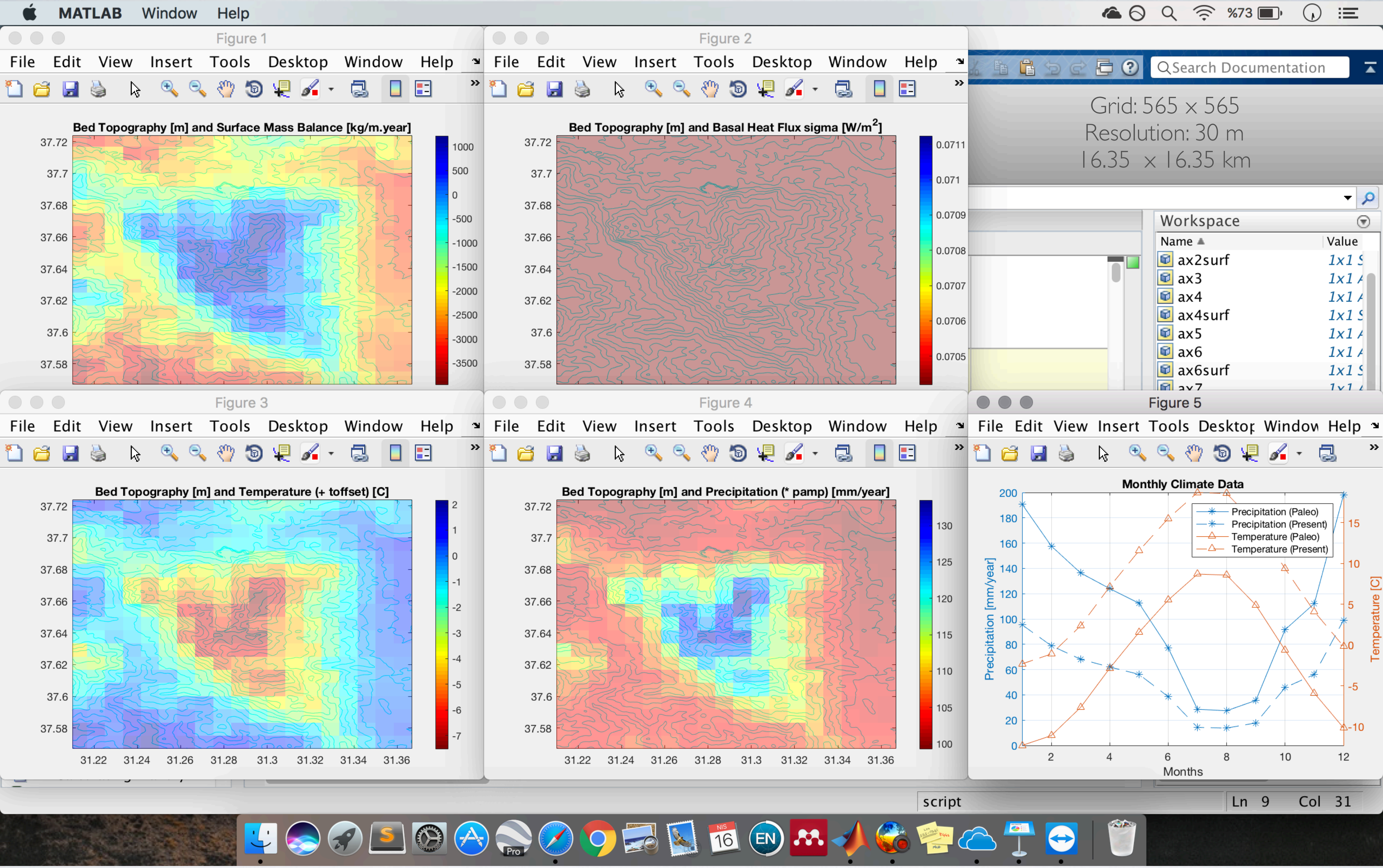
data_importer.m
Important Notes:
1- Defining the x,y axe...
2- Importing dem.txt fi...
3- Latitude and longitu...
4- Calculating x and y ...
Command Window
This code calculates "Basal Heat Flux, Surface Mass Balance; creates pism input file (*.nc)
1- Defining the x,y axes grids distances.
Please enter the distance between two x axis grids, Study Area
Busy
script
Ln 9 Col 31



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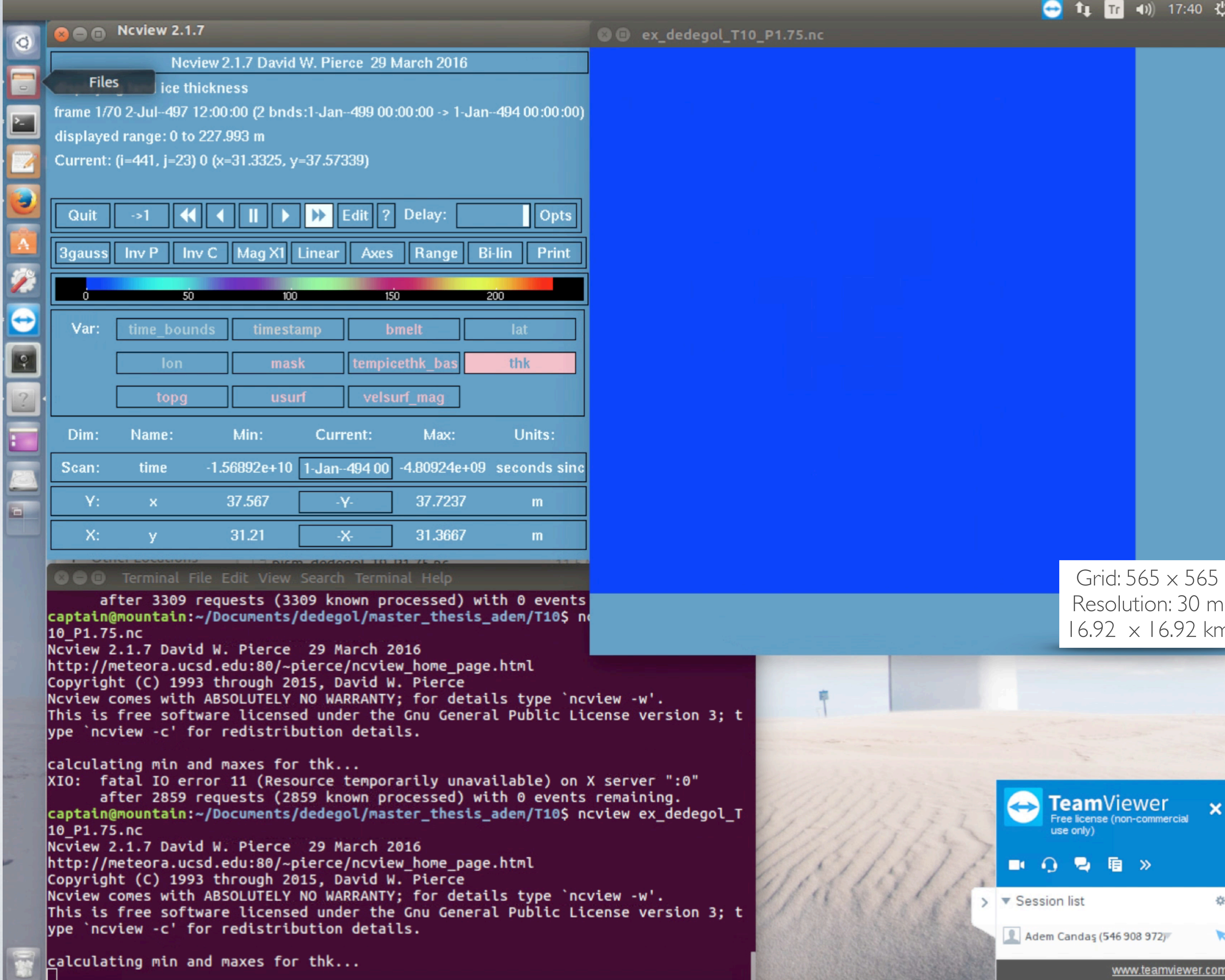


Grid: 565 x 565
Resolution: 30 m
16.92 x 16.92 km

PALEOCLIMATE CASES - DEDEGÖL MOUNTAIN

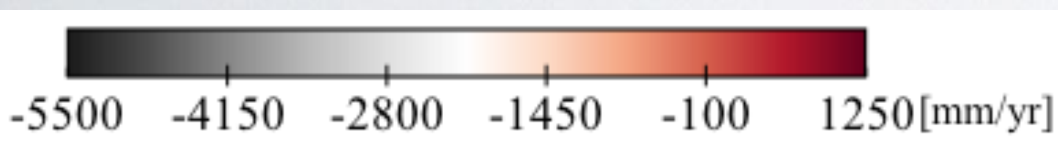
Table 4.1 : Paleoclimatic surface mass balance maximum and minimum (in parenthesis) values in mm/yr

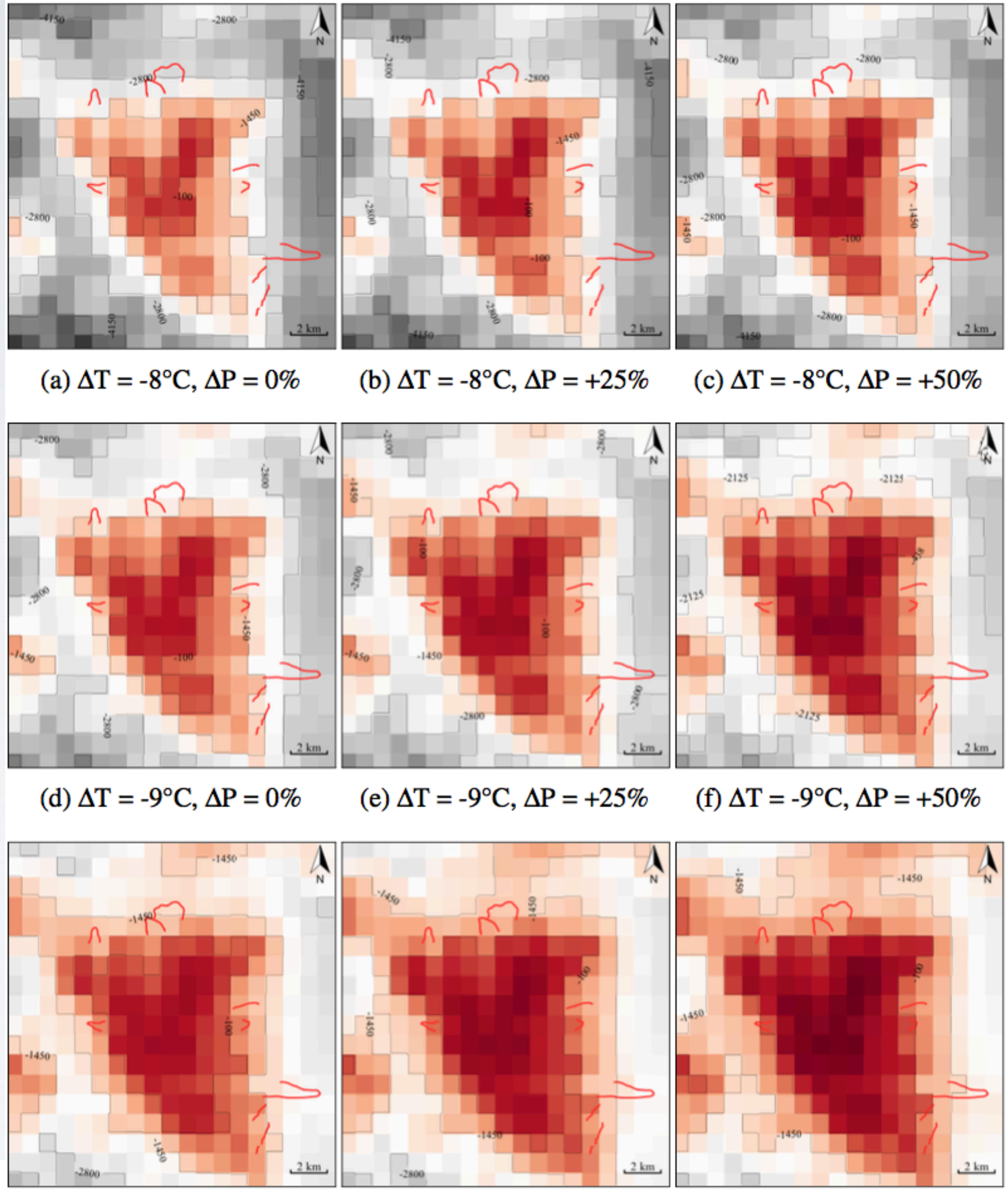
ΔT	ΔP		
	unchanged	+ %25	+ %50
-8°C	504 (-5352)	705 (-5168)	906 (-4984)
-9°C	664 (-4488)	874 (-4293)	1084 (-4098)
-10°C	782 (-3686)	999 (-3486)	1217 (-3286)

SURFACE MASS BALANCE

in mm/yr

Grid: 565 x 565
Resolution: 30 m
16.92 x 16.92 km





(a) ΔT = -8°C, ΔP = 0%
(b) ΔT = -8°C, ΔP = +25%
(c) ΔT = -8°C, ΔP = +50%
(d) ΔT = -9°C, ΔP = 0%
(e) ΔT = -9°C, ΔP = +25%
(f) ΔT = -9°C, ΔP = +50%
(g) ΔT = -10°C, ΔP = 0%
(h) ΔT = -10°C, ΔP = +25%
(i) ΔT = -10°C, ΔP = +50%

RESULTS

Table 4.2 : Dedegöl Mountain paleoclimatic reconstruction. Maximum and Minimum Mass Balance (in parenthesis) (M) [mm/yr], Equilibrium Line Altitude (ELA) [m], Ice volume (ivol) [km^3], Ice area (iarea) [km^2], Maximum ice thickness (H) [m] were shown for each simulations.

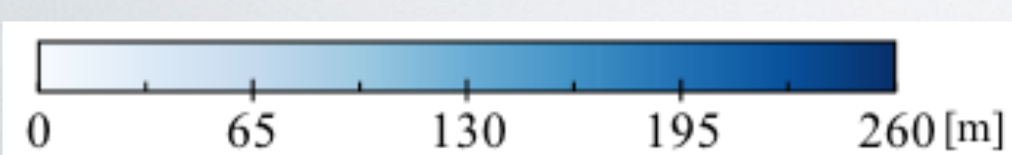
ΔT		**ΔP** unchanged	+ %25	+ %50
-8°C	M	504 (-5352)	705 (-5168)	906 (-4984)
	ELA	2642±132	2552±130	2444±126
	ivol	0.63	1.51	2.44
	iarea	15.85	27.08	42.51
	H	119	197	225
-9°C	M	664 (-4488)	874 (-4293)	1084 (-4098)
	ELA	2475±131	2343±115	2278±
	ivol	2.19	3.37	4.70
	iarea	37.98	55.56	72.56
	H	214	228	244
-10°C	M	782 (-3686)	999 (-3486)	1217 (-3286)
	ELA	2283±130	2133±113	2066±136
	ivol	4.40	6.14	8.06
	iarea	69.27	94.44	115.09
	H	234	239	255

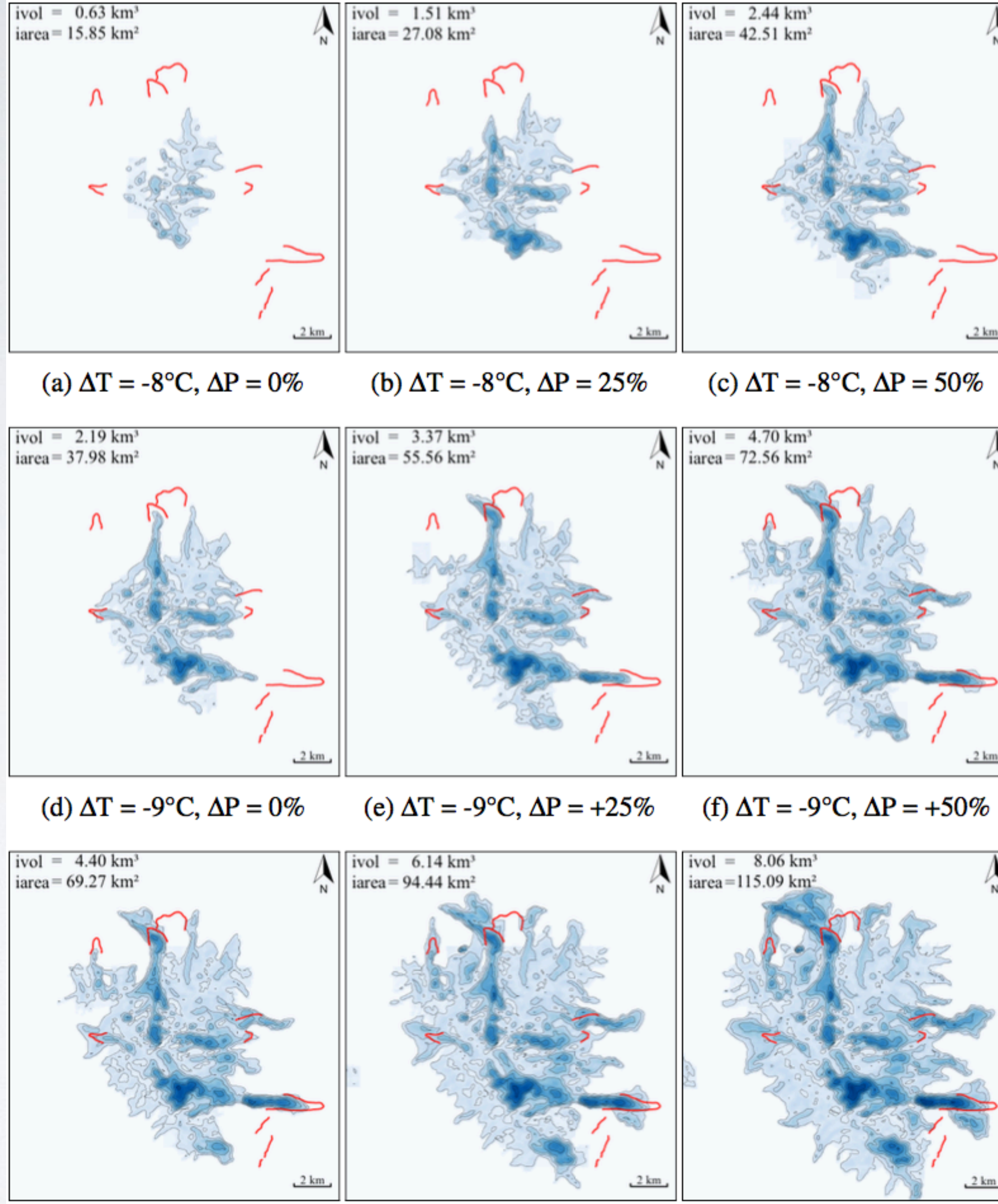
GLACIER THICKNESS

in meters

The red continues lines indicate the moraine crests.

Grid: 565 × 565
Resolution: 30 m
16.92 × 16.92 km





(a) ΔT = -8°C, ΔP = 0% (b) ΔT = -8°C, ΔP = 25% (c) ΔT = -8°C, ΔP = 50%

(d) ΔT = -9°C, ΔP = 0% (e) ΔT = -9°C, ΔP = +25% (f) ΔT = -9°C, ΔP = +50%

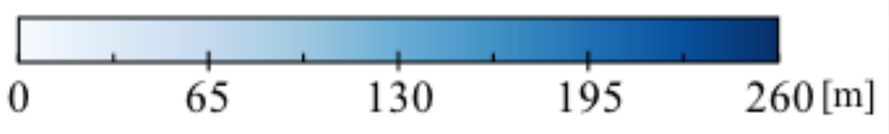
(g) ΔT = -10°C, ΔP = 0% (h) ΔT = -10°C, ΔP = +25% (i) ΔT = -10°C, ΔP = +50%

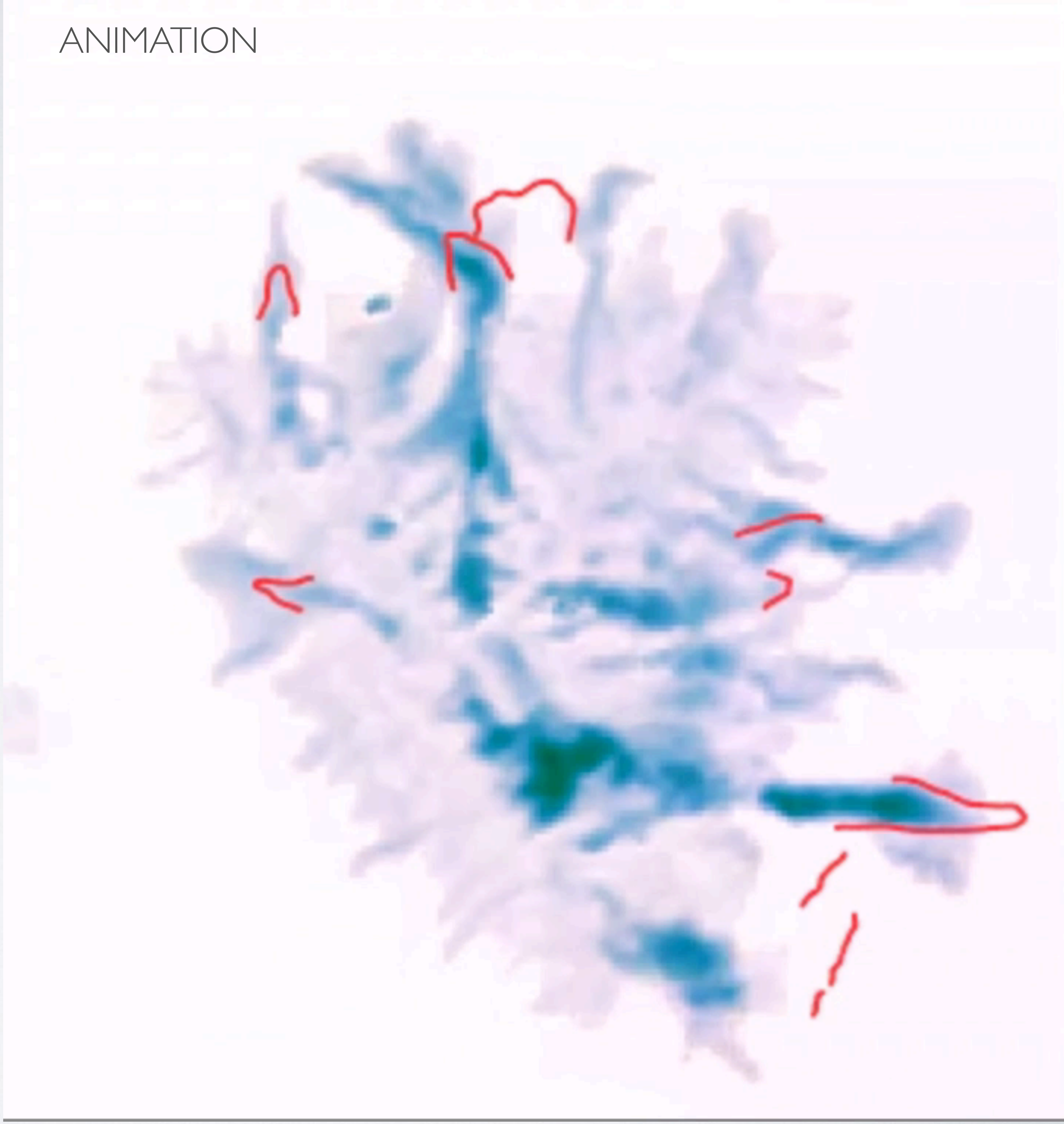
DEDEGÖL MOUNTAIN

ICE THICKNESS

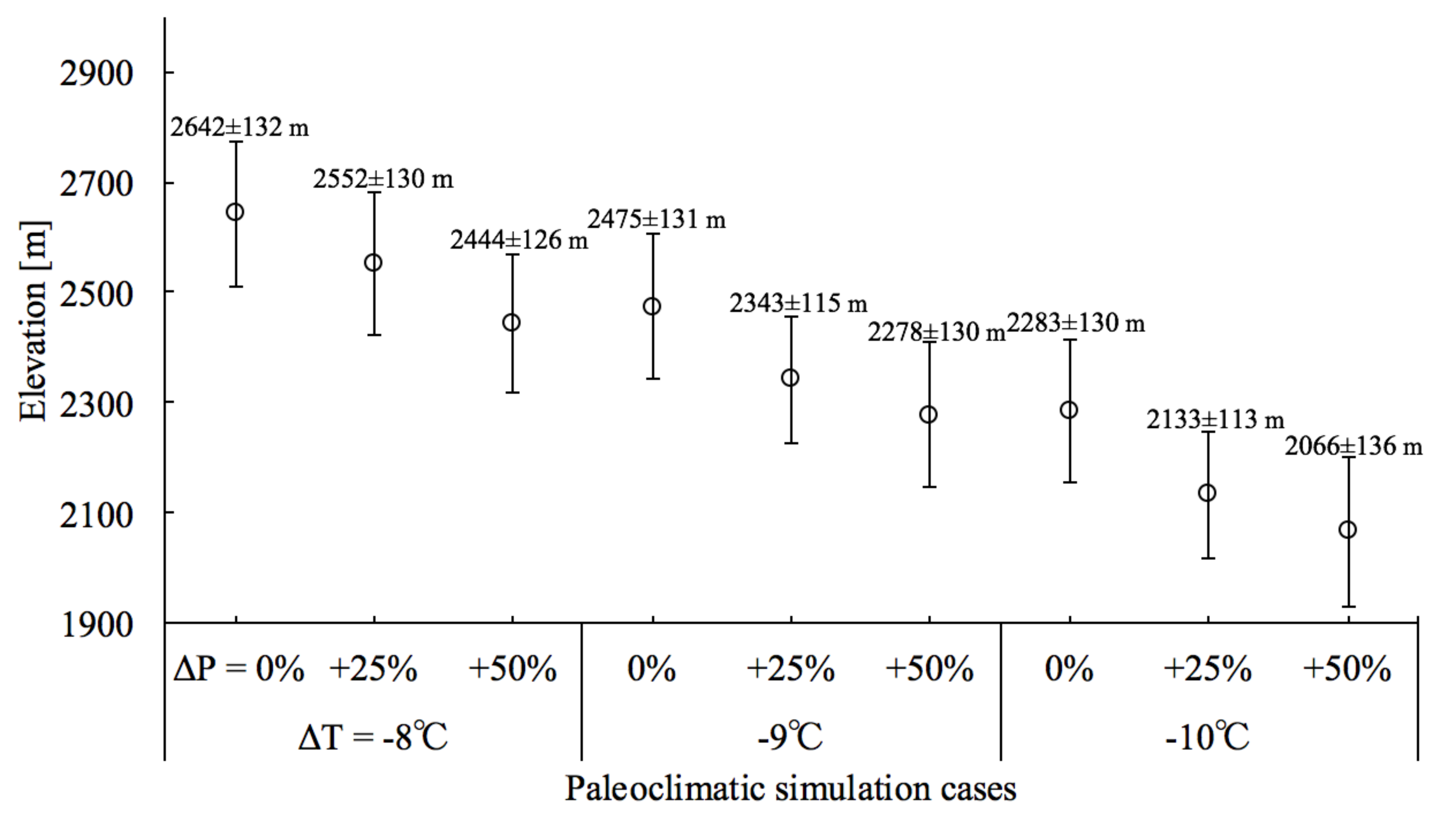
-10°C degree colder
25% more precipitation

Grid: 565 x 565
Resolution: 30 m
16.92 x 16.92 km

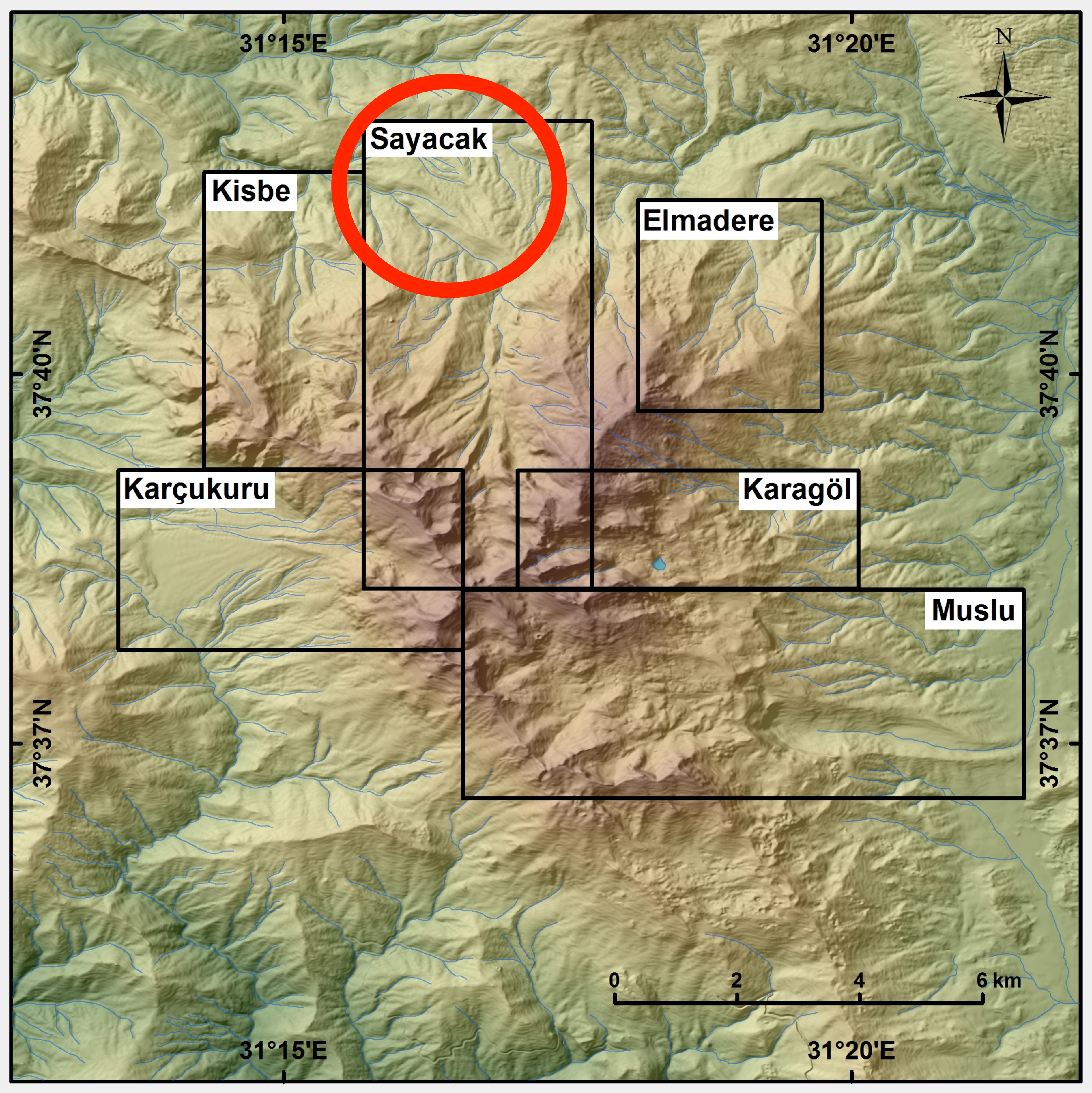




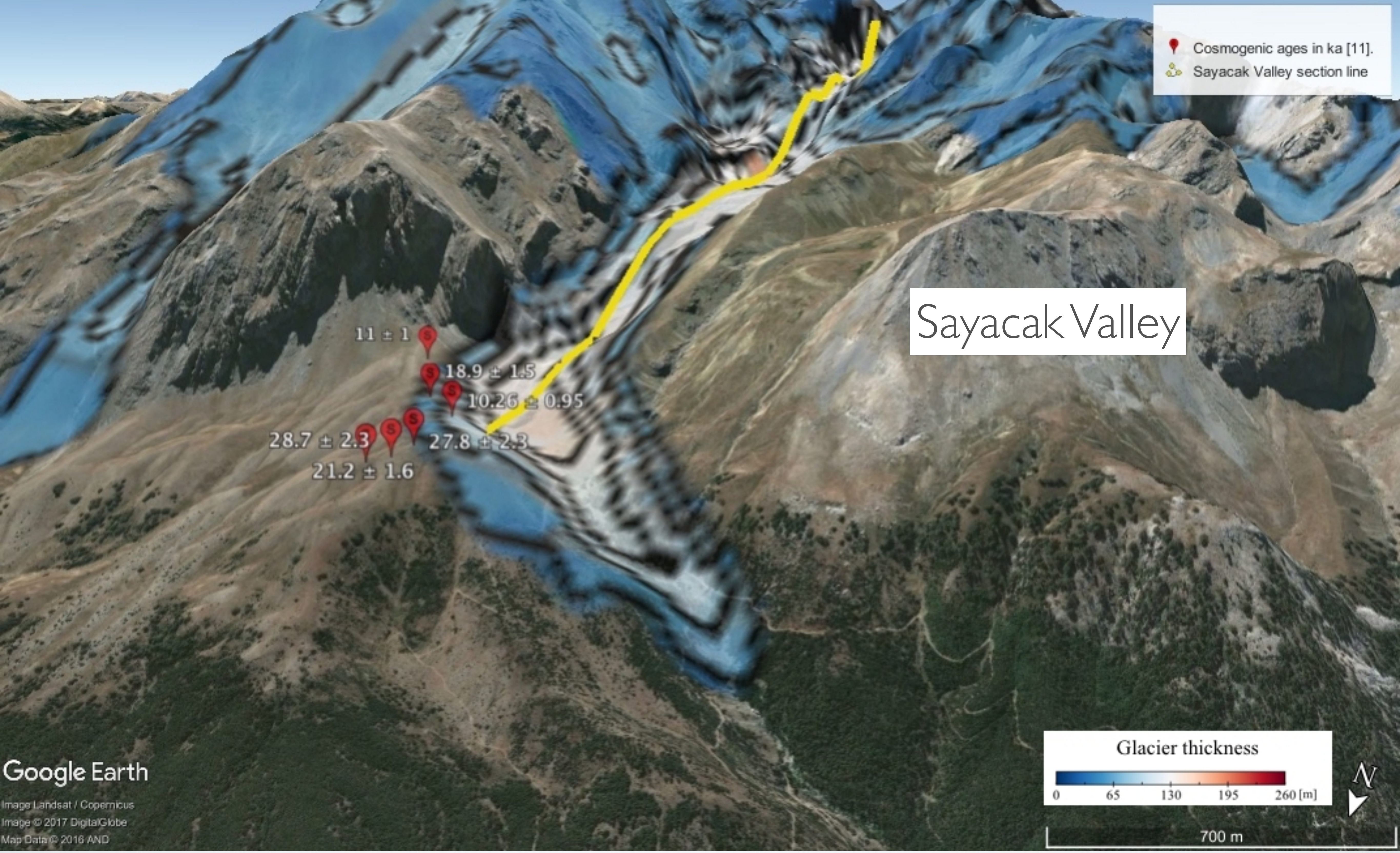
EQUILIBRIUM LINE ALTITUDE



Paleoglacial ELAs with ±1σ



Sayacak Valley - PISM

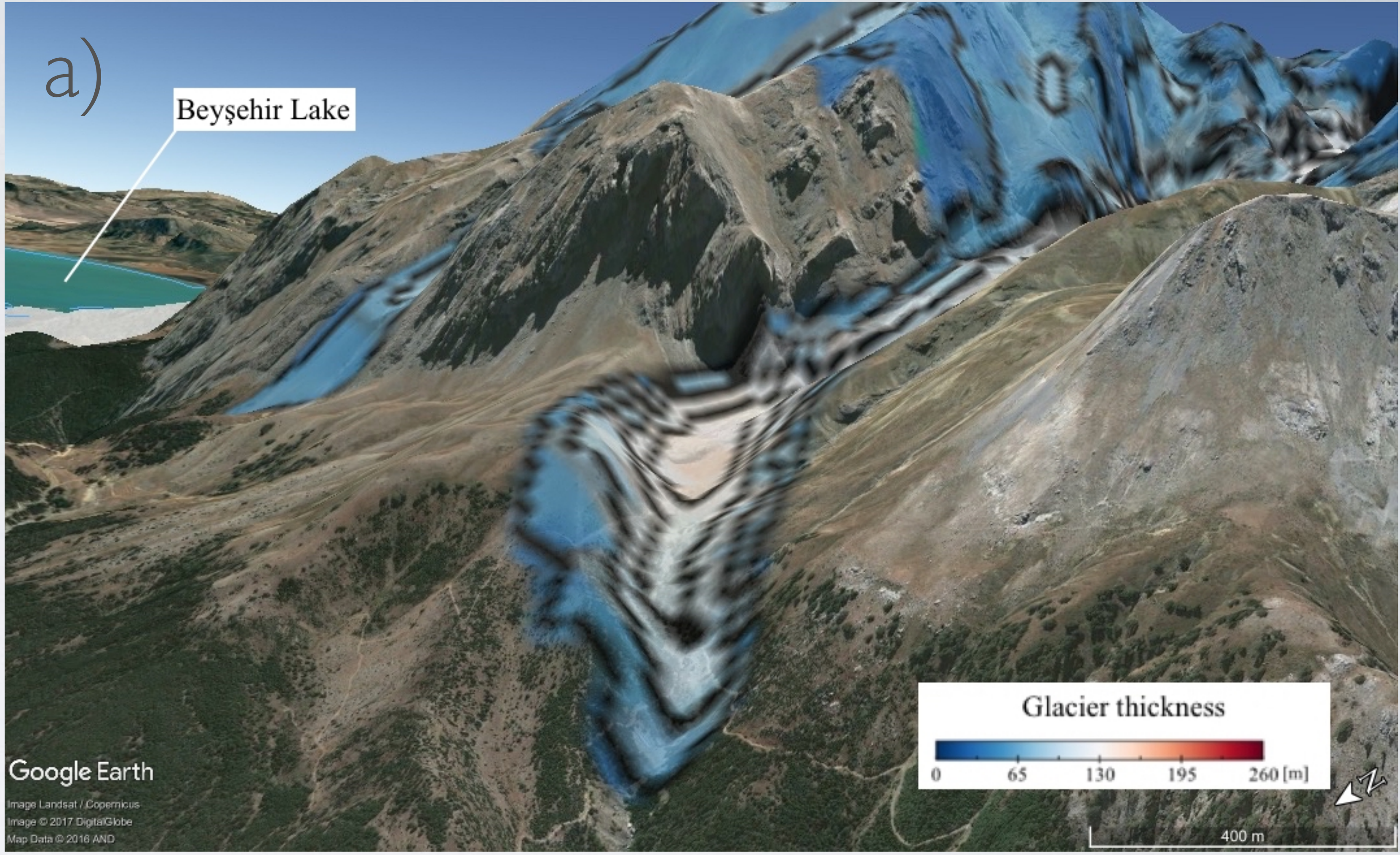


-9°C degree colder
25% more precipitation

SAYACAK VALLEY

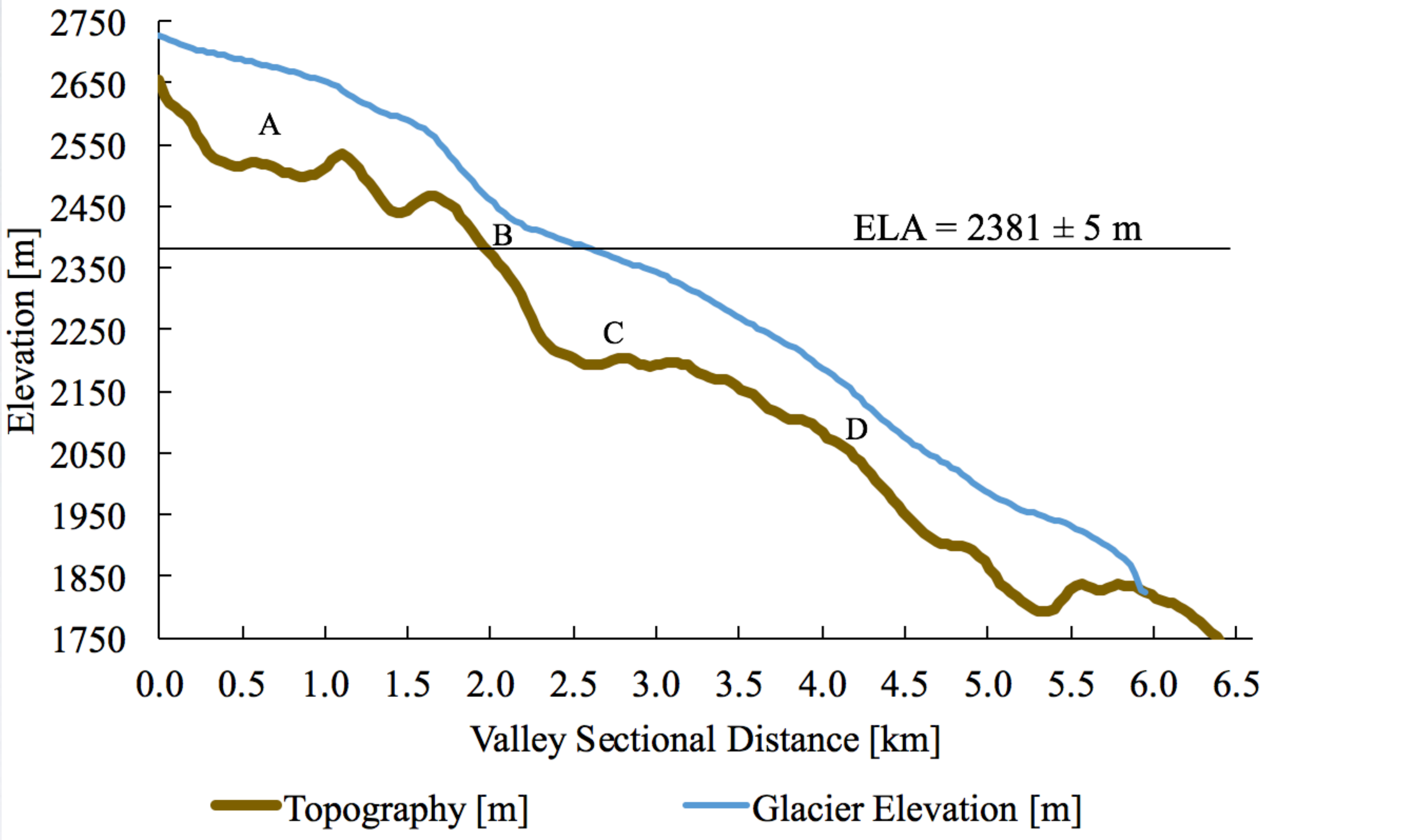
a) Google Earth Image (May 2017)

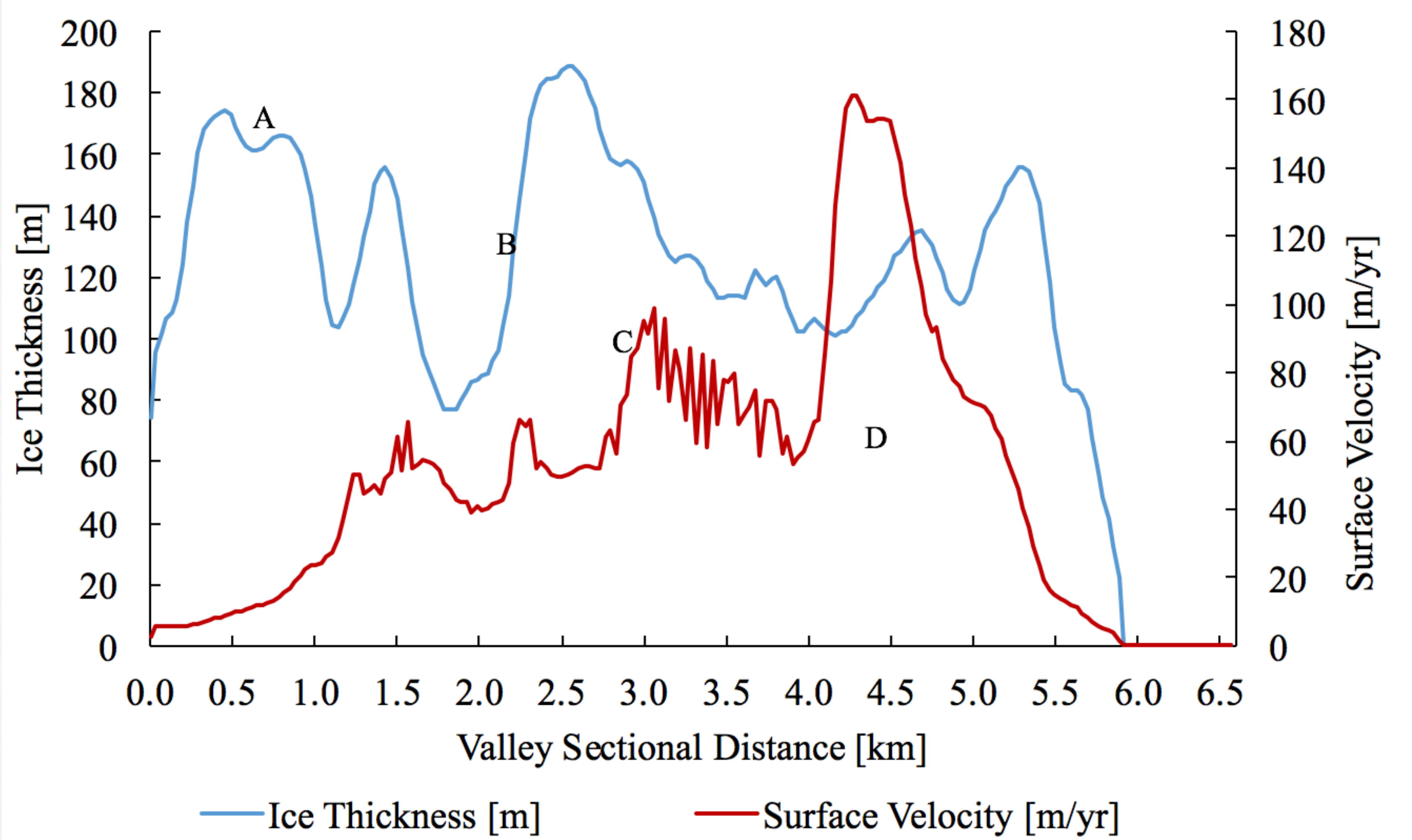
b) Drone Image (June 2016)



SAYACAK VALLEY SECTIONAL VIEW

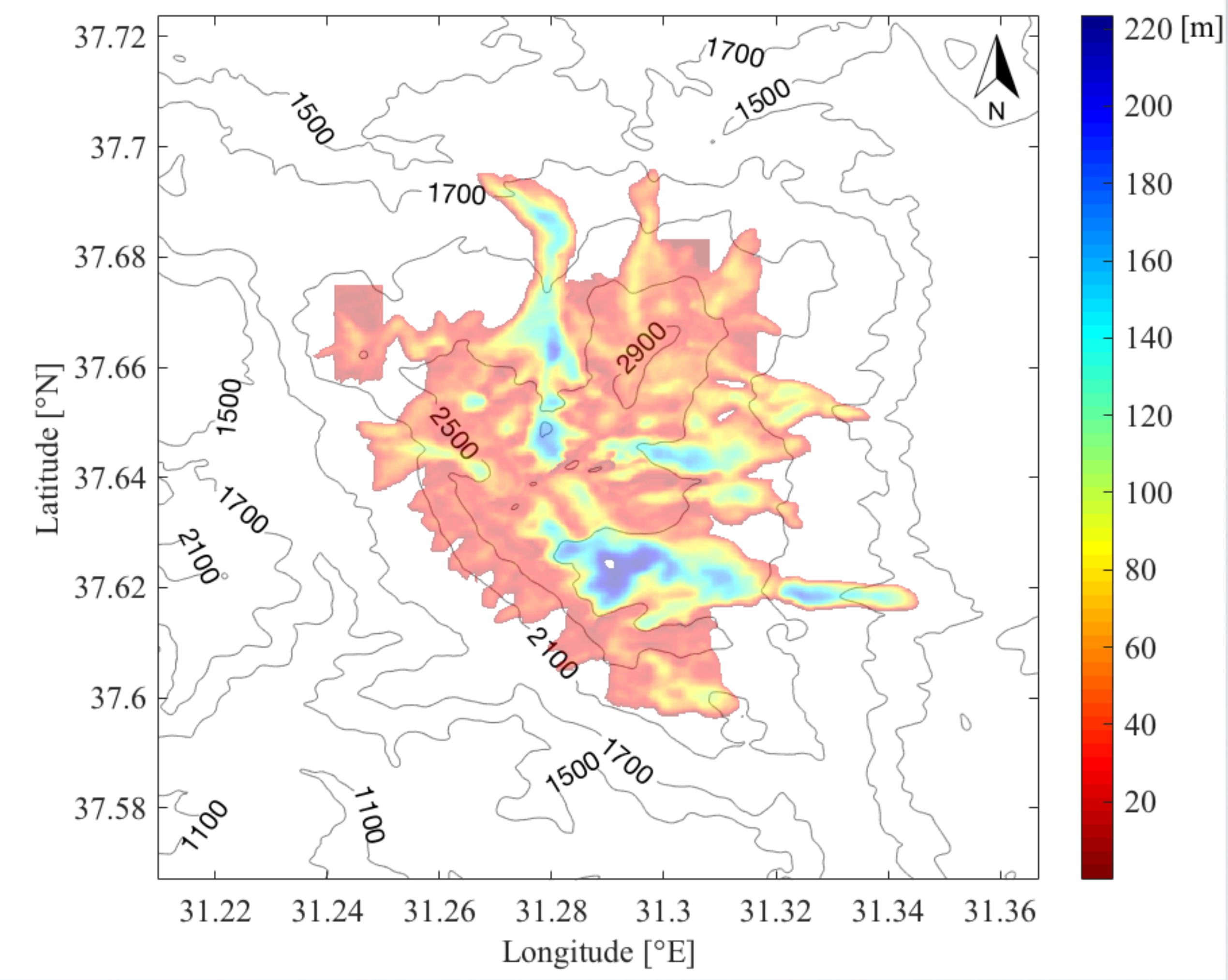
-9°C degree colder
25% more precipitation

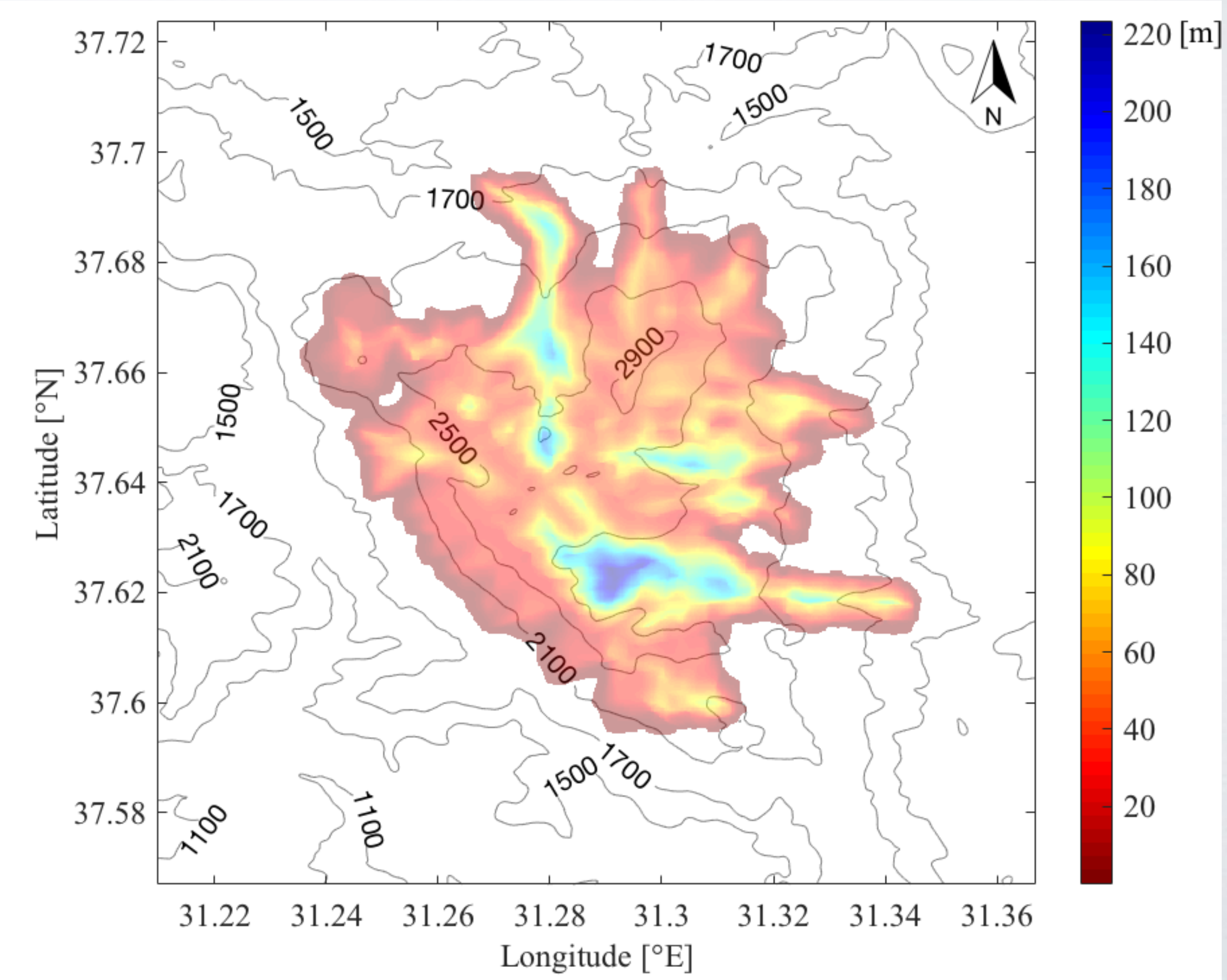




PISM AND 2-D GLACIER FLOW MODEL RESULTS

-9°C degree colder
25% more precipitation





CONCLUSION

1. Parallel Ice Sheet Model is suitable for use in modeling of relatively low resolution mountain glaciers,

2. Temperature depression of 9 to 10°C degree, accompanied by a 25% precipitation increase, is required for the remodeling of paleoglaciers existed during from the LGM to Early Holocene,

   Early Holocene
   $\Delta T = -9°C$, $\Delta P = +25\%$
   LGM
   $\Delta T = -10°C$, $\Delta P = +25\%$

3. Using the current digital elevation model can lead to some deterioration in the results due to the moraines blocking the glacier flow,

4. The simulation of different temperature and precipitation input values are matched with the moraine deposits in different valleys. This indicates that there has been more than one glaciation time in Dedegöl Mountain since the LGM.

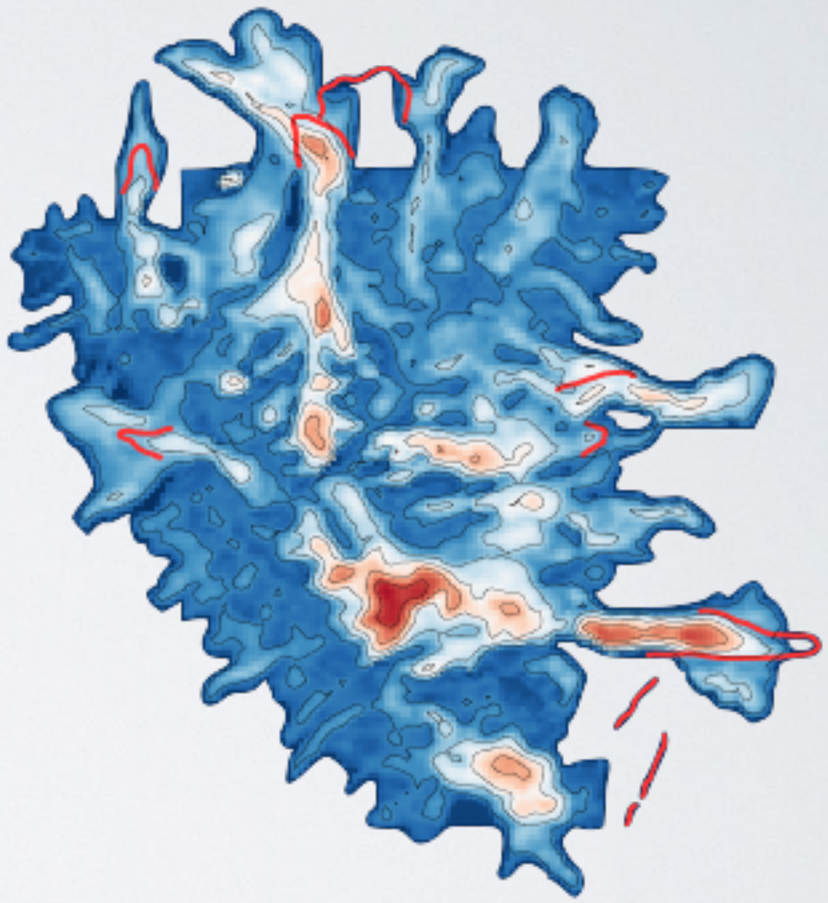


Image: Dedegöl Mountain Paleoglacier Model with PISM v0.7
-10°C degree colder
25% more precipitation

- Parallel Ice Sheet Modeling - PISM: jointly developed at the University of Alaska, Fairbanks the Potsdam Institute for Climate Impact Research: www.pism-docs.org

- Supported by Tübitak 114Y548 Project

- e-mail: candas@itu.edu.tr