Constraining the effects of topography and climate on climate change sensitivity of glaciers in Tibet

Research questions:

1. Which are the most important topographical and climatological drivers of glacier equilibrium line altitude (ELA)?
2. Can we explain ELA changes since the Little Ice Age with topographical and climatological variables?

Temperate glaciers in monsoon-affected southeastern Tibet are highly sensitive to climate change and exhibited the greatest mass losses in the whole of High Mountain Asia during the last decade. However, the drivers behind these observations are still lacking detailed investigation. This study will model glacier equilibrium line altitudes (ELA) and their changes since the Little Ice Age (dELA) as a function of topographical and climatological variables via multiple linear regression. The main challenges are the selection of model variables and the management of parameter collinearity. Various models may be compared.

The dataset provided includes the following variables at glacier level:

1. id: glacier ID
2. ELA: equilibrium line altitude in m
3. dELA: shift of ELA since the Little Ice Age in m
4. summit: summit height in m
5. debris\_cov: debris cover (0=no, 1=yes)
6. morph\_type: morphological type (6 classes)
7. orientation: geographical orientation (8 directions)
8. length: glacier length in m
9. area: glacier area in m2
10. P\_{01-12}\_mean: mean precipitation in month 1 to 12 in mm
11. P\_snow: mean annual snowfall in mm
12. P\_year: mean annual precipitation in mm
13. P\_monsoon: mean precipitation during monsoon in mm
14. P\_not\_monsoon: mean precipitation outside of monsoon season in mm
15. T\_MIN\_mean.{1-12}: average minimum temperature in month 1 to 12 in degC
16. T\_MIN\_mean\_monsoon: average minimum temperature during monsoon in degC
17. T\_MIN\_mean\_not\_monsoon: average minimum temperature outside of monsoon season in degC
18. T\_MAX\_mean.{1-12}: average maximum temperature in month 1 to 12 in degC
19. T\_MAX\_mean\_monsoon: average maximum temperature during monsoon in degC
20. T\_MAX\_mean\_not\_monsoon: average maximum temperature outside of monsoon season in degC
21. T\_mean\_mea.{1-12}: average mean temperature in month 1 to 12 in degC
22. T\_mean\_mea.yr: average annual mean temperature in degC
23. T\_mean\_monsoon: average mean temperature during monsoon in degC
24. T\_mean\_not\_monsoon: average mean temperature outside of monsoon season in degC
25. Slope\_min: minimum slope in deg
26. Slope\_max: maximum slope in deg
27. Slope\_mean: mean slope in deg
28. Elev\_min: minimum elevation in m
29. Elev\_max: maximum elevation in m
30. Elev\_mean: mean elevation in m

Literature:

1. Brun, F., Berthier, E., Wagnon, P., Kääb, A., Treichler, D., 2017. A spatially resolved estimate of High Mountain Asia glacier mass balances from 2000 to 2016. Nature Geosci advance online publication. doi:10.1038/ngeo2999
2. Karger, D.N., Conrad, O., Böhner, J., Kawohl, T., Kreft, H., Soria-Auza, R.W., Zimmermann, N.E., Linder, H.P., Kessler, M., 2017. Climatologies at high resolution for the earth’s land surface areas. Scientific Data 4, sdata2017122. doi:10.1038/sdata.2017.122
3. Loibl, D., Lehmkuhl, F., Grießinger, J., 2014. Reconstructing glacier retreat since the Little Ice Age in SE Tibet by glacier mapping and equilibrium line altitude calculation. Geomorphology 214, 22–39. doi:10.1016/j.geomorph.2014.03.018
4. Maussion, F., Scherer, D., Mölg, T., Collier, E., Curio, J., Finkelnburg, R., 2014. Precipitation seasonality and variability over the Tibetan Plateau as resolved by the High Asia Reanalysis. Journal of Climate 27, 1910–1927. doi:10.1175/JCLI-D-13-00282.1
5. Yao, T., Thompson, L., Yang, W., Yu, W., Gao, Y., Guo, X., Yang, X., Duan, K., Zhao, H., Xu, B., Pu, J., Lu, A., Xiang, Y., Kattel, D.B., Joswiak, D., 2012. Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings. Nature Climate Change 2, 663–667. doi:10.1038/nclimate1580