ANALYSING PALAEO CIRQUE GLACIER EQUILIBRIUM ALTITUDES AS INDICATORS OF PALAEOCLIMATE ACROSS SCANDINAVIA

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PROJECT AIMS

To use a high density of palaeo cirque ELAs and the relationship to climate to analyse for subdivisions within a single region

The use of palaeo equilibrium line altitudes (ELAs) estimates could potentially be used to hone in on different palaeo climates and give some reference to the conditions in the alpine environment

Cirque ELA & Climate

At the equilibrium line altitude, Ohmura (1992) and Ohmura and Boettcher (2018) established a quantitative relationship

$$P = a+bT+cT^2$$

P = Precipitation @ ELA

T= Temperature @ ELA

a =966, b=230, and c = 5.87

This relationship is used readily in reconstructing palaeoclimates based on the ELA of a glacier

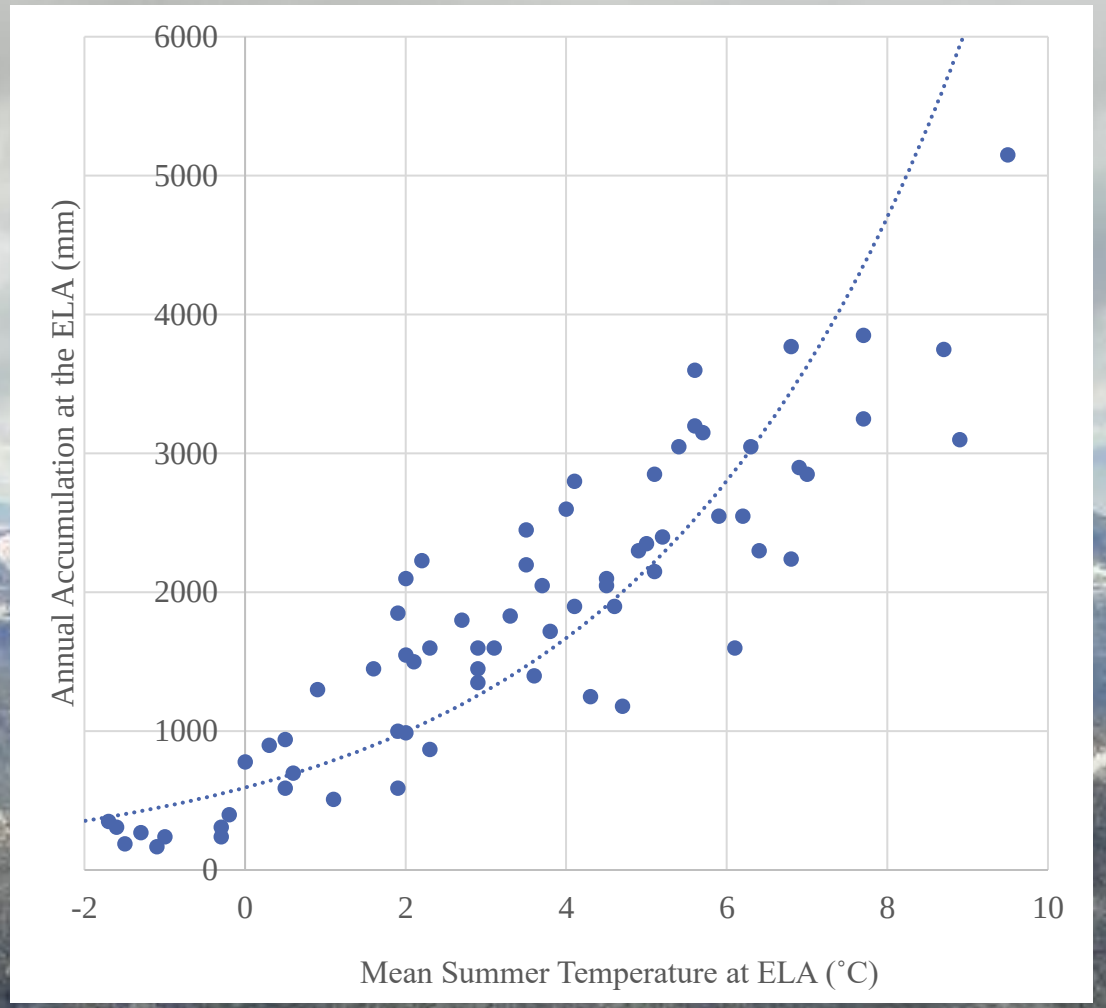


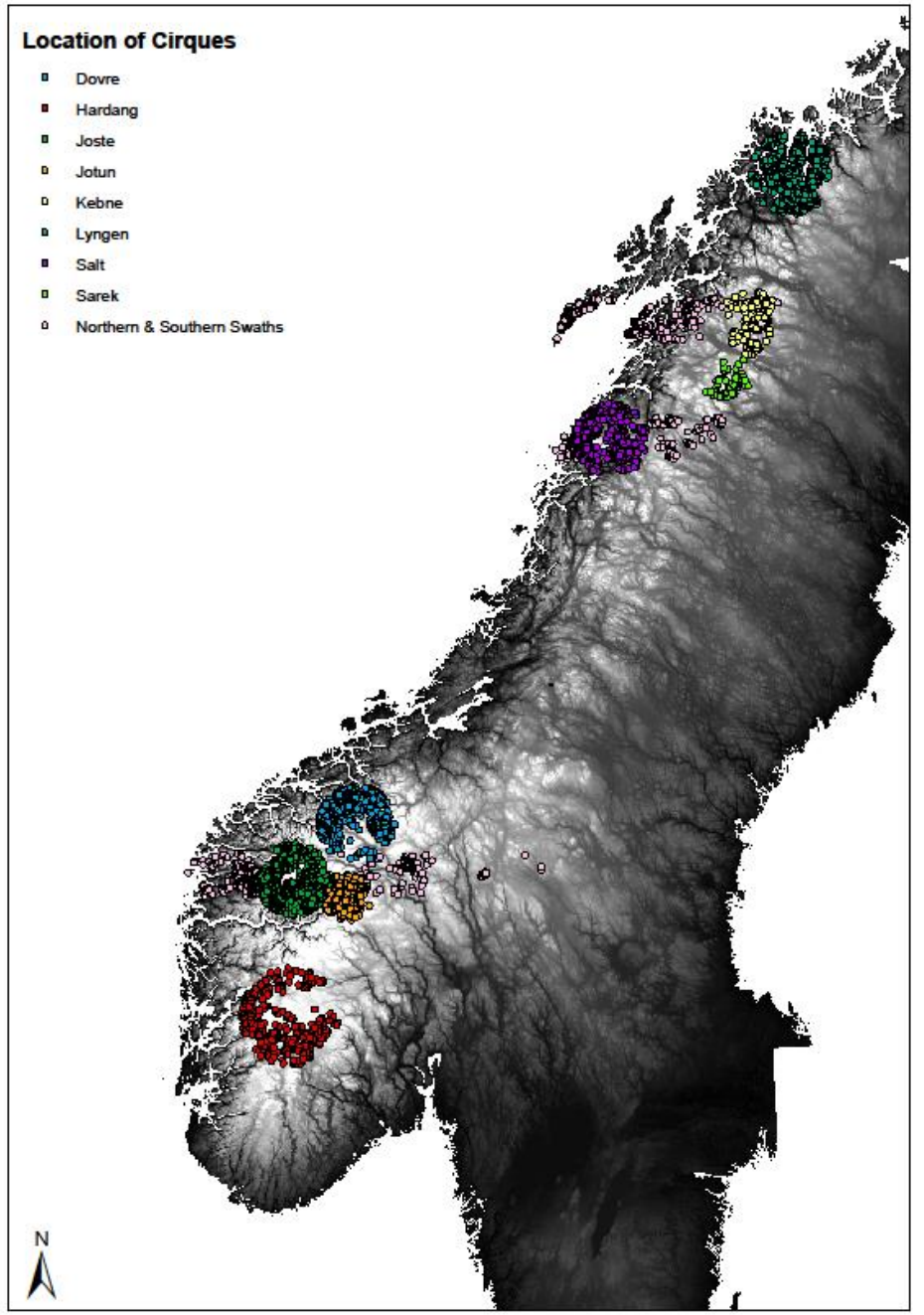
Figure is reconstructed from the data used to establish the Ohmura equation

METHODS

- 3784 cirques were mapped by John Jansen's team
- Locations are provided on the map
- A GIS tool for Automated Cirque metric extraction (ACME) by Spagnolo et al., 2017 was used to discover all the physical properties of the cirques

Descriptive Statistics

	N	Minimum	Maximum	Mean	Variance	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Area_2D	3784	21281	9026956	650307.33	5.013E+11	3.435	.040
area_3D	3784	11160	10177360	649483.36	5.675E+11	3.492	.040
Area (m^2)	3784	18407.29	9026956.15	650302.5751	5.013E+11	3.435	.040
Aspect (°)	3784	0	359	176.02	11097.527	.057	.040
Circular	3784	1.01	1.52	1.0812	.002	1.919	.040
Distance to Coast (km)	3784	.92	251.73	82.2396	2314.209	.286	.040
HI	3784	.17	.98	.4317	.008	-.153	.040
hypso_max	3784	3	2033	1014.10	161821.549	-.382	.040
L	3784	141	3994	831.01	179436.953	1.760	.040
L_W	3784	.40	3.35	1.0989	.108	1.139	.040
Perimeter	3784	549	12581	2793.82	1803094.221	1.477	.040
Plan_clos	3784	0	329	138.48	4995.590	.214	.040
Slope_mean	3784	2	67	25.09	77.871	.354	.040
THAR ELA (m)	3784	66.0	2067.5	1077.423	150629.099	-.345	.040
W	3784	166	3304	788.48	152044.086	1.357	.040
Longitude (°E)	3784	4.74	21.05	12.1088	25.423	.409	.040
Latitude (°N)	3784	59.64	69.92	64.6970	11.778	.162	.040
Z_max	3784	109	2397	1236.21	148562.351	-.365	.040
Z_mean	3784	34	2067	1052.86	152685.122	-.361	.040
Cirque Floor Altitude (m)	3784	-2	1953	918.64	167088.777	-.305	.040
Z_range	3784	26	1149	317.57	28785.861	.999	.040
Valid N (listwise)	3784						



- Comparison With GLaRE tool

- GLaRE is a semi-automated tool for calculating ELAs, flow lines need to be hand drawn, thus the tool takes 10-20min per glacier
- With 3800 examples, it was impractical to analyse each glacier with GLaRE
- GLaRE creates a reconstructed palaeo glacier surface which then can be used to calculate the ELA (Pellitero et al., 2015; Pellitero et al., 2016)
- Instead, we used cirque floor altitudes (CFAs) as a proxy for ELA as recommended (Barr & Spagnolo, 2015)

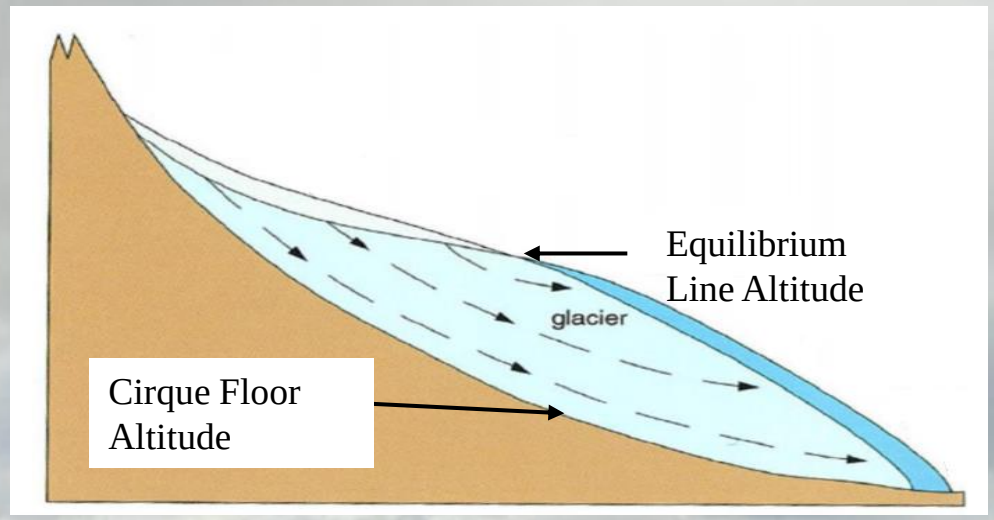
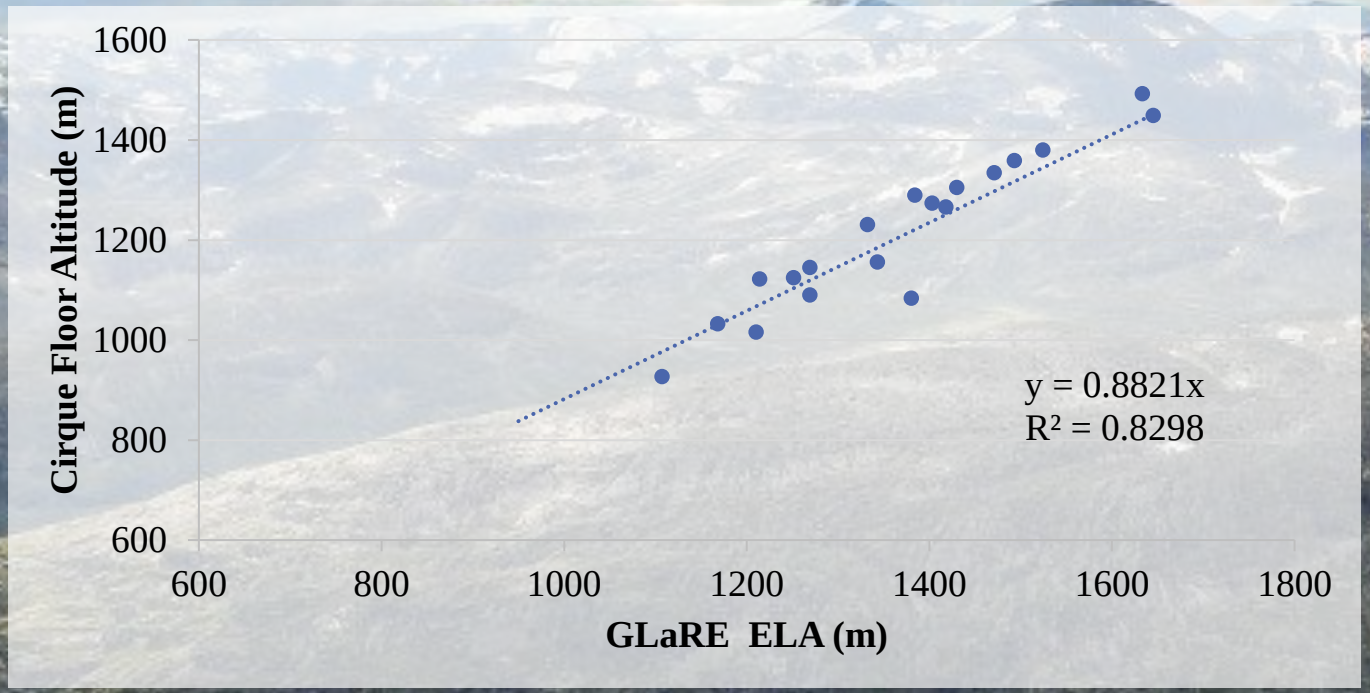


Figure modified from Hambrey & Alean, 2004



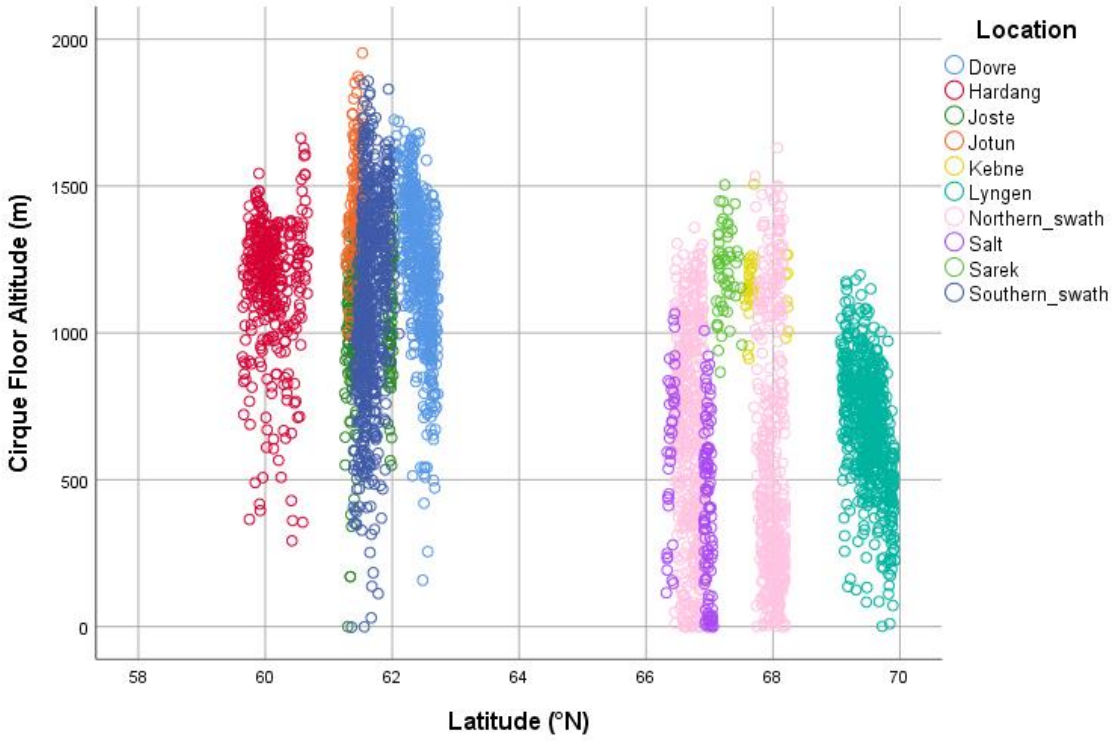
Accuracy of GLaRE vs. CFAs

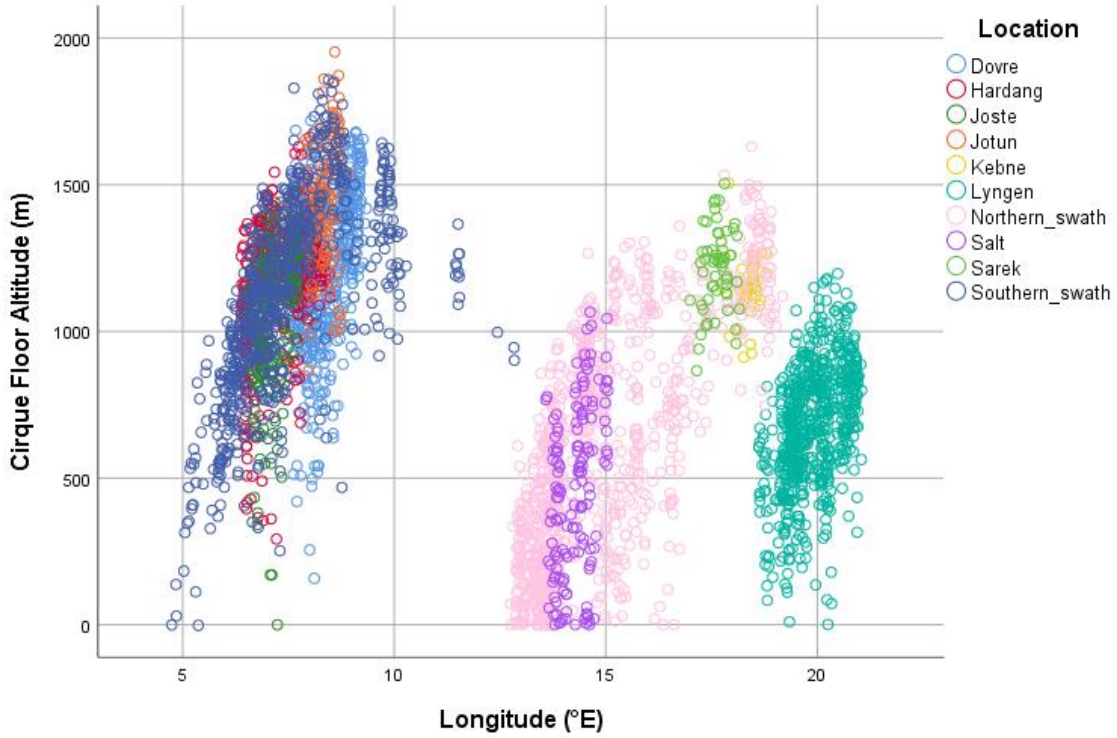
-Example of 20 cirques from the Dovre region

An R-squared of 0.73 is fairly high but that results is a median differenceof 138 m between the two measurements, which is still fairly substantial

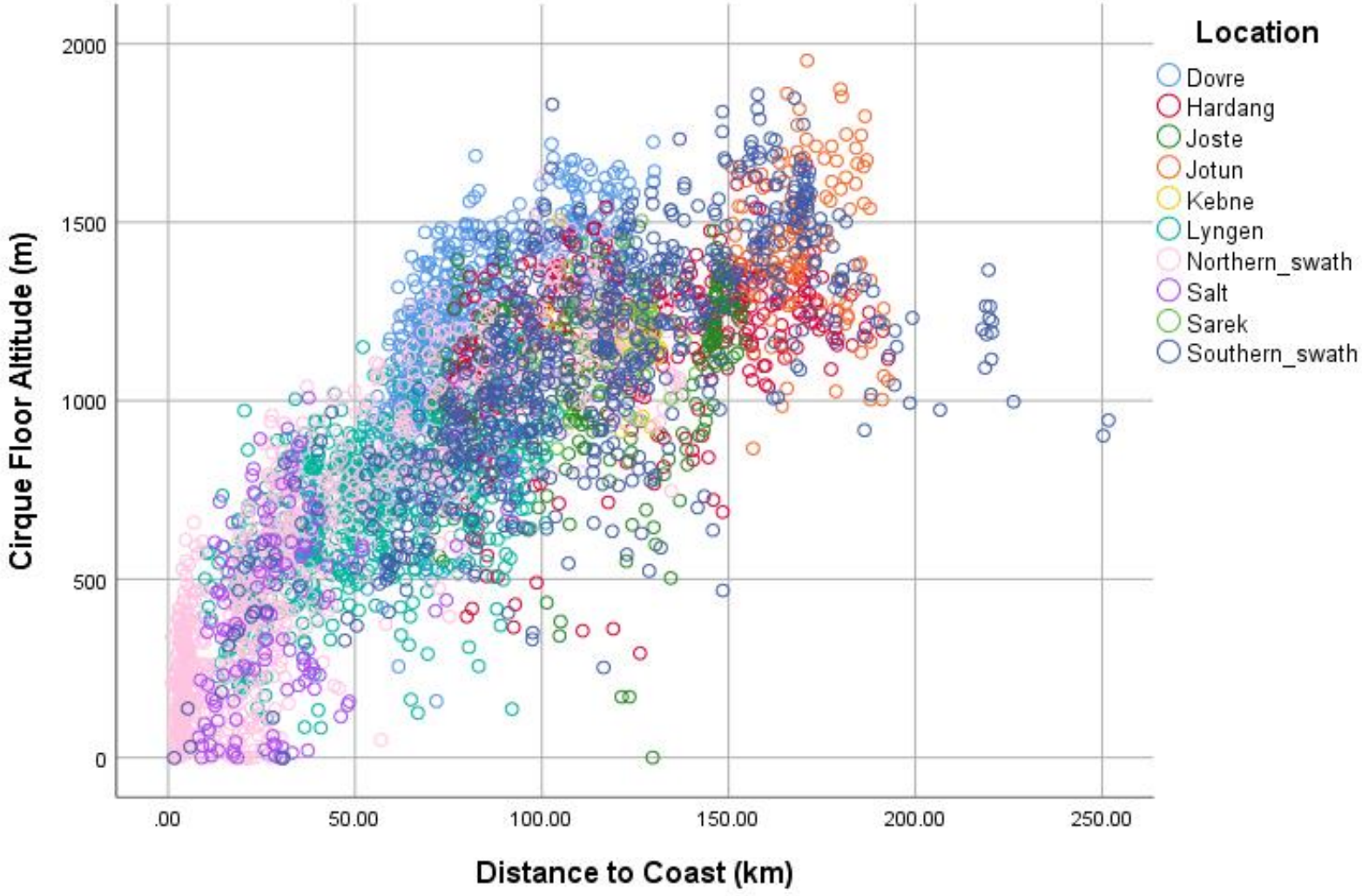
PRELIMINARY RESULTS

- Here, we investigate patterns with different sub-regions, to see if there is any sort of pattern within the overall dataset.
- To understand the controls on CFAs and thus the proxy for ELA





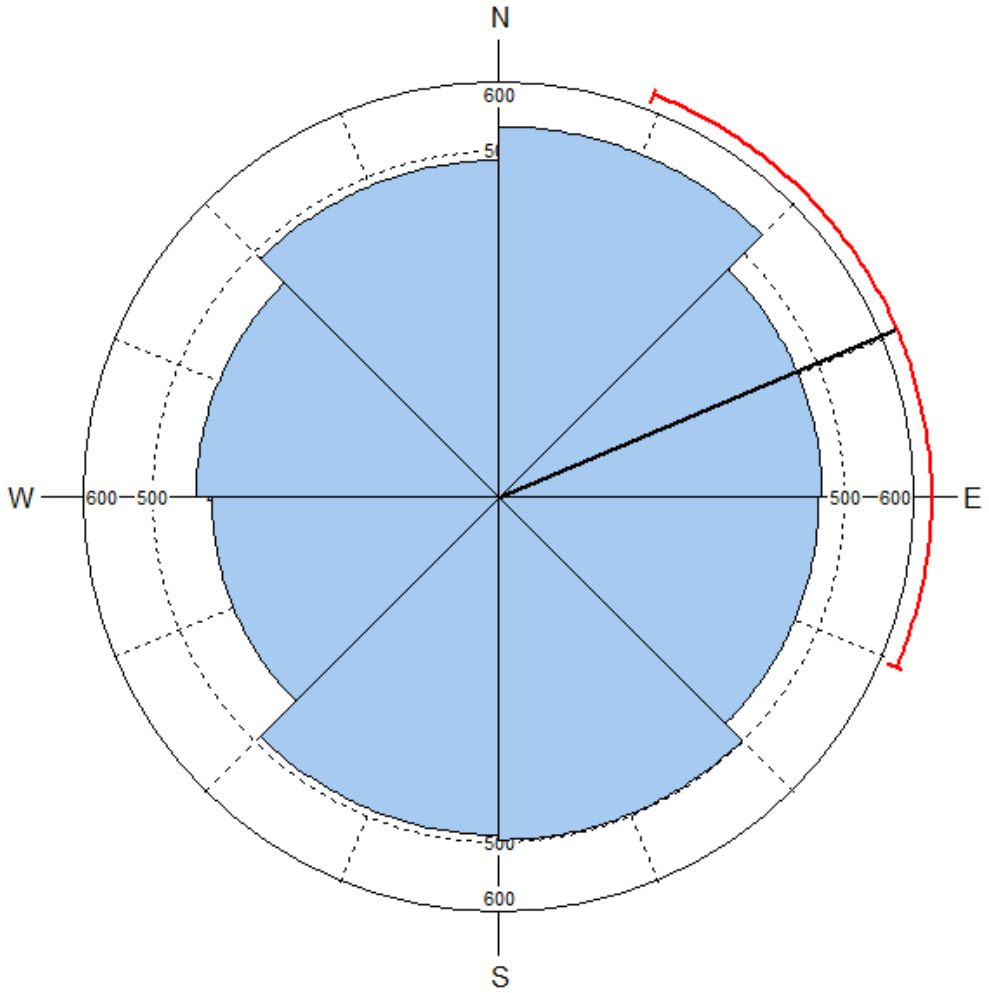
RESULTS- DISTANCE FROM THE COAST



The CFAs reflect the typical pattern of increasing with distance from the coast

This is a result of topographic availability, distance to the moisture source and moisture availability

RESULTS - ASPECT



The mean vector is 67˚ (thick black line) but the vector strength is very low

This uncharacteristic pattern for the northern hemisphere, could be a result of sampling bias during the mapping of the cirques

It could also reflect the lack of glacier occupied cirques – this analysis only includes cirques without any ice present

WHAT IS NEXT?

- Since this is all fairly new data, we plan on taking time to expand testing of the GLaRE tool precision versus CFAs to other regions to see if there is any relationship
- We plan on comparing the rock type to the aspect results
- We plan on adding in a dataset of modern cirque glaciers to see if that adjusts the mean aspect
- More testing by elevation to look for signatures within the dataset
- Skewness & Kurtosis tests need to be completed to use the median instead of the mean
- A palaeo sea level needs to be implemented as some of the cirques are ‘at modern sea level’
- Expanding some of the high density areas to cover more of E/W Swaths

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Questions: please contact Rachel Oien
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