# Temporal and spatial changes of Environmental Lapse Rate distribution over the pan-Arctic

Zelu Zhang[1], Jonathan Bamber[1,2]& Adam Igneczi[1]

## Background and Introduction

The Environmental Lapse Rate (ELR) characterizes the relationship between temperature and altitude near the ground, and can be used to downscale near-surface temperatures. A more precise Environmental Lapse Rate (ELR) can be used directly to improve the statistical downscaling of near-surface temperatures, which is critical for researching Ice sheet SMB (surface mass balance).
In this study, we calculated ELR using ERA5 reanalysis data across the Pan-Arctic and comprehensively investigated the temporal and spatial variations of ELR distribution in this area. Our findings provide a clearer picture of the vertical temperature variability across the Arctic region and can offer valuable guidance for future studies on near-surface temperature and inversion phenomena in various regions.

**Keywords:** Environmental lapse rate, Near-surface temperature, Greenland, Arctic.

## Data & Methods

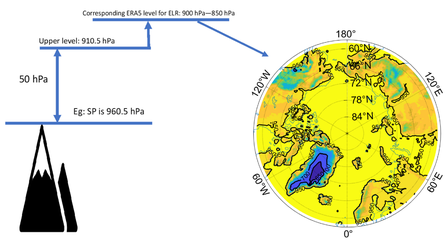
The following data were required to complete the research:

- ECMWF atmospheric reanalysis ERA5 hourly and monthly averaged data on pressure levels from 1979 to present
- Surface pressure data from ERA5 hourly data on single levels from 1959 to present
- Integrated Global Radiosonde Archive (IGRA) from NCEI

We calculate the ELR based on this equation

$$\Gamma = \frac{\Delta T}{\Delta z} \qquad (1)$$

Where  is a grid point's lapse rate (K/km), $\Delta z$ is the vertical distance between two selected pressure level pairs and $\Delta T$ is the temperature difference between these selected pressure levels.




## Inversions of pan-Arctic

The extensive inversions over the pan-Arctic area in winter are probably due to the combined effect of the cold and dry atmosphere, relatively few clouds, and the cold snow surface.

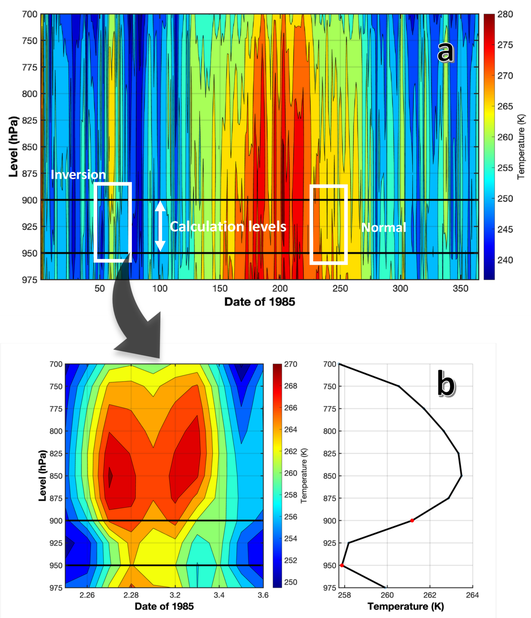



**Figure 3:** When inversion happens: a The multi-level and daily temperature of the grid point 81°N,16°W in 1985; b Enlarged "inversion box" in a.

We included inversions in our averaged results instead of discarding positive values as previous studies tended to do. The areas where inversions occurred most frequently and strongly were also the areas with the most frequent occurrences of positive ELR values.

## Temporal and spatial variability in ELR of Greenland

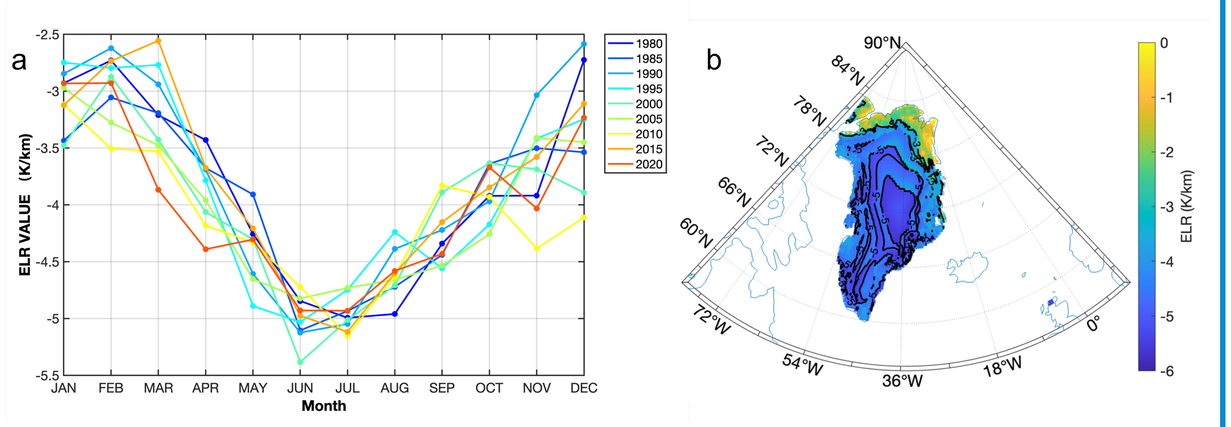



**Figure 1:** a: Annual cycle of Greenland's monthly averaged ELR; b: Multi-year mean Greenland ELR

Most of Greenland's multi-year mean ELR falls into the value range of -3 to -6 K/km. The ELR (absolute) values over Greenland decrease with latitude in most months, excluding June and July.

## Temporal and spatial variability of ELR in NA and NE

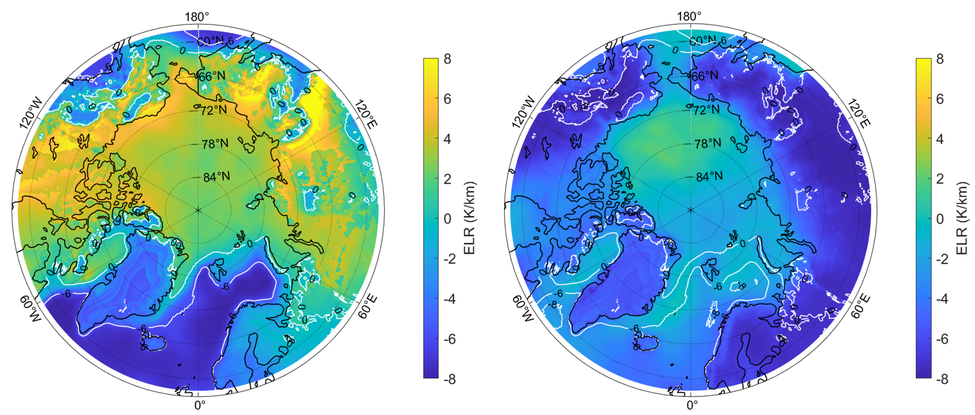



**Figure 2:** Multi-year average pan-Arctic ELR in Winter/Jan (left) and Summer/Jun (right)

The monthly ELR patterns in North America (NA) and Northern Eurasia (NE) exhibit similar annual cycles of ELR in Greenland. The large ELR (absolute) value is close to -6 K/km in summer. During winter, the pan-Arctic region displays extensive positive ELR values, whether over ocean or land; yet this phenomenon persists longer in NA than NE.

## References

[1] L. Gao, M. Bernhardt, and K. Schulz. Elevation correction of era-interim temperature data in complex terrain. *Hydrology and Earth System Sciences*, 16(12), 2012.

## Future Research

Correcting a bias between the ECMWF data set and station observation. To investigate the lapse rate and inversion surface-type dependence to verify our current results

## Contact Information

1 School of Geographical Sciences, University of Bristol
2 Technical University Munich

Email ci21923@bristol.ac.uk
Tel +44 7421726420