# *The Effect of Global Warming on Himalayan Glaciers: Position Paper*

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I am conducting a research project about the effects of global warming on Himalayan glaciers. During my talk, I explained what is happening in that region and a peculiar effect that my group and I discovered. First of all, a brief introduction to the current situation. Figure 1 is taken from the IPCC report of 2023 [1] which tells us that the global mean temperature has increased by 1.1 degrees since the pre-industrial level. Perhaps 1.1°C does not seem like much, but in reality, a slight change in the global mean temperature has a big impact on the regional scale.

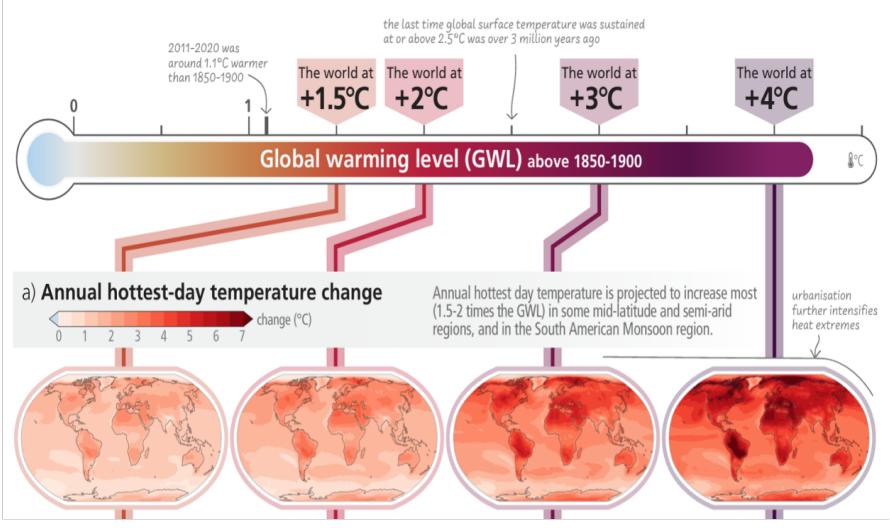


Figure 1: IPCC, 2023: Climate Change 2023: Synthesis Report [1].

We are at a critical juncture where regional variations in climate response become essential for accurate predictions and adaptation strategies. The question is: how do different regions, particularly high-elevation environments, respond to climate change?

Glaciers are a crucial component of the Earth system, as they represent one of the most visible and sensitive indicators of global warming, allowing their widespread shrinkage to be observed worldwide. The accelerating loss of glacier mass highlights the urgency of understanding not only the global trend, but also the mechanisms driving regional differences in glacier response. My research focuses in particular on the impacts of climate change on mountain glaciers.

The first thing that I can say about them is that mountains act as global climate amplifiers.

What does that mean? It means that even a modest change in global warming has a strong impact, producing stronger changes at high elevations. This comes about through an effect that we call elevation-dependent warming (EDW). So, compared to low elevation areas, high elevations have a stronger impact from global warming. This is due to different mechanisms, like a difference in the solar radiation, or a difference in the atmosphere. For example, the atmosphere is thinner at higher elevations. All these mechanisms together accelerate the rate of change of the mountain ecosystem.

The Himalaya region, also called the Third Pole, is the mountain ecosystem I focused my study on. We call it the Third Pole because, apart from the Arctic and Antarctic regions, this area of the world has the highest number of glaciers, and it is of critical importance for all the nations in that area, being a source of water for billions of people. The map in Figure 2 shows the mass loss of the glaciers in the Himalaya region [2].

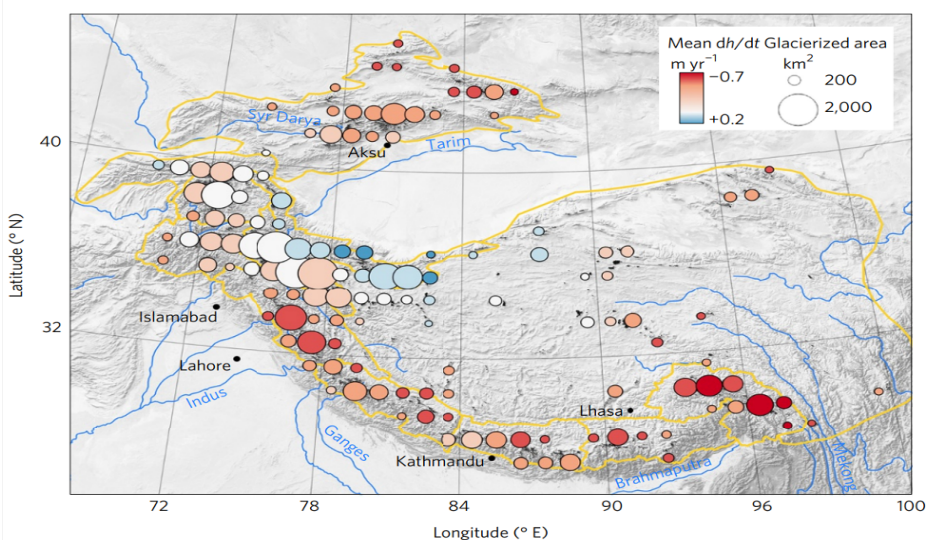

Figure 2: Glacier elevation changes for High Mountain Asia (2000–2016) [2]

At first glance, the glaciers are losing mass, like everywhere else in the world. But as you can see in the top left corner, there are some glaciers that behave in a peculiar manner. In the Karakoram region we found that the glaciers are more or less stable or even growing slightly despite global warming. We call this phenomenon the Karakoram anomaly. Notably, this behavior is not confined to the Karakoram only; similar glacier-stability signals have been detected in several other subregions of the Himalayan arc.

What is happening in the Himalaya region?
We started our study in the area of Mt. Everest where there is an Italian meteorological laboratory in Nepal, The Pyramid Station, shown in Figure 3. It is situated at more or less 5,000 meters above sea level, which is where we took the meteorological data.

Figure 3: Pyramid Station (Mt. Everest).

We also use reanalysis data to study the daytime temperature trends (Figure 4). The map represents the area near the Pyramid Station; we can see that there are some blue areas, which is the region where the glaciers are and the temperatures are colder than what they should be if only the EDW theory is taken into consideration. We begin to observe local cooling near the glacier masses. The black lines represent the glaciers, and the blue spots indicate the cooling, as we can see this is all around the border of the glacier. We call this phenomena the Glacier cooling effect (Figure 4). Wherever we have significant glacier masses we can observe consistent local cooling despite global warming.

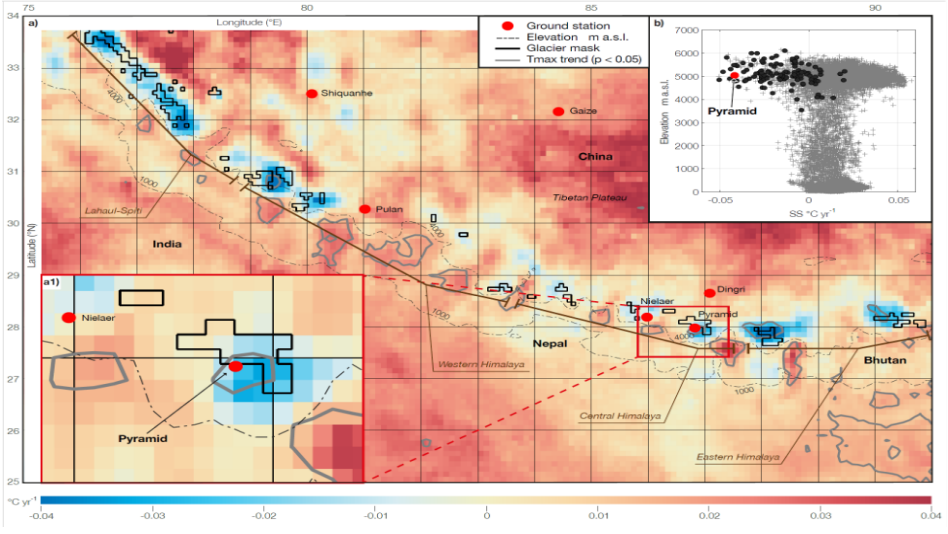


Figure 4: 2 m Max Temperature Trend near the Pyramid station from ERA5-land data (1990-2020)[3].

The cooling effect is a sensible heat exchange between the air masses above the glacier and the surface of the glacier itself. This develops daytime Katabatic winds that draw cold air from the top of the glacier to the bottom, creating localized cooling at the bottom of the glacier [3] (Figure 5). This fundamental effect helps preserve the glacier from melting despite global warming.

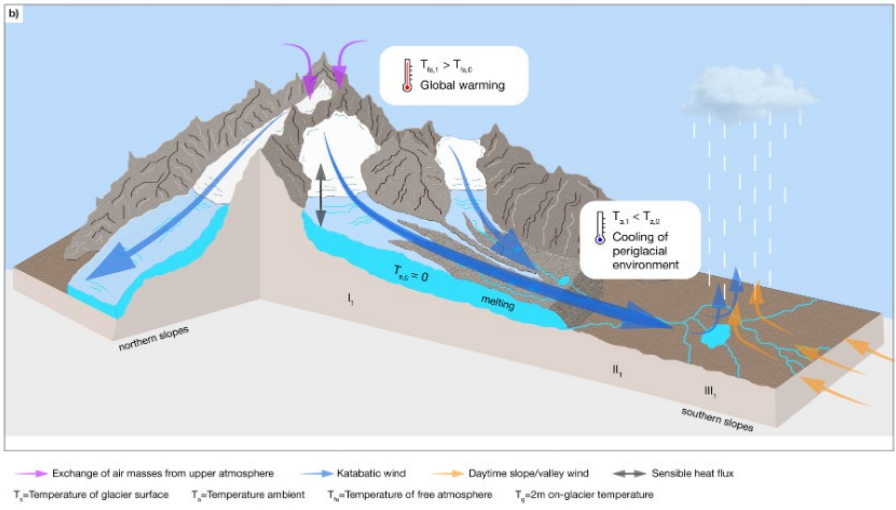


Figure 5: Glacier Cooling Effect - Schematic diagram explaining the air cooling observed in the surroundings of Himalayan glaciers during Global Warming [3].

The cooling effect is a good starting point to explain the peculiar behavior of some of the glaciers in the Himalaya region. It tells us that for regional climate dynamics, it is crucial to try to understand the effect of global warming at a regional level.

To conclude, we cannot deny global warming and glacier shrinkage, but in the Himalaya region there is a complex response due to different regional climate dynamics. In particular, we found that the glacier cooling effect helps preserve the glaciers from melting, and it develops from the very presence of those glaciers. Glacier-climate interaction is very complex and difficult to study but understanding it is the key to predicting our future.

Thank you.

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