ABSTRACT

The effects of obstacles, such as, mountains and plateaus, on heat transfer and fluid flow in the earth's atmosphere have always been a subject of research due to their economic and environmental importance in shaping food production and the world's climate. They are one of the most stunning features of the landscape and play a major role in affecting the climatology of a particular location and thus determining its natural habitat. The flow of air, structure of clouds, surface evaporation, transport of heat and moisture through the atmosphere are all steered by their orographic effects. Mechanically, the surface orography acts as a flow barrier that forces the air to deflect, rise and cool, generate waves, and sometimes cause temperature inversion. Thermodynamically, these elevated terrains during summers act as the heat sources and cause instability due to surface heating. These thermo-mechanical effects of the orography influence the general circulation and energy transport in the planet.

Paleoclimate evidence suggests that the earth's orography has constantly been changing over a long-time scale. But in the present era, with the rapid changes in climate and global warming becoming more apparent worldwide, orographic changes due to ice melting and glaciers loss, especially over the polar regions, have accelerated. The Antarctic continent has undergone complex changes in the past few decades due to the human intervention, which raises concerns regarding the future of the largest cryosphere reserve on the planet. Despite this fact, the consequences of orographic change over the Antarctic have received little attention partly due to its long geographic isolation and non-decreasing sea ice trend compared to its northern counterpart. Under the projected trajectory of the greenhouse emissions, the climate of the continent is projected to become wetter, warmer, and more prone to ice sheet meltdown and sea ice loss. Consequently, the orography and ice cover are expected to fluctuate drastically in the future due to warming, which will exert feedback on the atmospheric circulation (mean flow and eddies). Detangling the effects of these changes on climate systems from other changes accompanied due to warming is required for a better understanding of their impact on the Polar climate. Therefore, the overreaching aim of the present thesis is to examine the influence of the large-scale Antarctic orography and ice sheets on the atmospheric circulation and energy transfer on the planet, using comprehensive climate models.

In the first half of the thesis, we use the atmospheric general circulation model to evaluate the role of Antarctic orography in the general circulation and energy transport on the planet. First, the impact of Antarctic orographic suppression is presented to highlight the *importance of its orography on the global climate. It is demonstrated that the reduction in Antarctic orography would enhance the poleward energy transport by causing changes in the mean atmospheric circulation and enhancement in the eddy motions over the Southern Hemisphere. Simulations performed by altering the orography further suggest that a reduction from the current orographic configuration will influence its local climate by changing the seasonal precipitation, causing tropospheric and surface warming, changes in winds, stationary waves, and energy transport over the region. Orographic enhancement is noted to cause the opposite response. These results suggest that although the Antarctic continent is geographically isolated from the rest of the world, it exerts climatic influence, which is experienced locally and globally through the changes in the stationary eddies, energy transport, and general circulation.*

In the second half of the thesis, we use coupled atmosphere-ocean climate models to investigate the remote impact of Antarctic orography and its sea-ice extent on the global climate. Specifically, we study the teleconnections of the Antarctic ice sheet with the South Asian monsoon system, influencing the energy transport over the monsoon domain through atmosphere-ocean coupling. We examine the impact of Antarctic ice sheet reduction on monsoon circulation, precipitation, and energy transport. We demonstrate that the monsoon system is significantly strengthened by the Antarctic orographic reduction, specifically over the Southern Hemisphere, and this strengthening partly compensates for the excess poleward energy demand. Further, through the coupled sea-ice reduction modelling simulations, we examine the global influence of the projected sea ice loss and the associated mechanism on the climate system. The results indicate that, like the Antarctic orographic height, its sea ice cover also strongly influences the atmospheric circulation and energy transport on the planet. A reduction in its sea ice cover in the future will lead to a mini global warming signal and cause significant changes in the mean flow and eddies over the Southern Hemisphere, thereby reducing the poleward energy transport. These results highlight the intimate coupling of the Antarctic orography and its sea ice cover with the global climate and demonstrate the importance of its orographic presence besides its direct contribution to the rising sea levels.