

# Climate Change Impact on Glaciers in the Langtang and Imja Sub-basins of Nepal

Glacier recession is one of the key indicators of climate change. Temperature change is an important factor in glacial retreat, advance, and change in surface area, although glacier mass may also be influenced by changes in precipitation, solar radiation, and the presence of surface matter. The glaciers in the Nepal Himalayas have shown signs of substantial recession in recent times. To investigate this further, studies were carried out in the Langtang (includes the Yala, Kimjung, and Lirung Glaciers) and Imja (includes Imja, Lhotse, and East Amadablam Glaciers) valleys on the relationship between average temperature and glacier surface area.

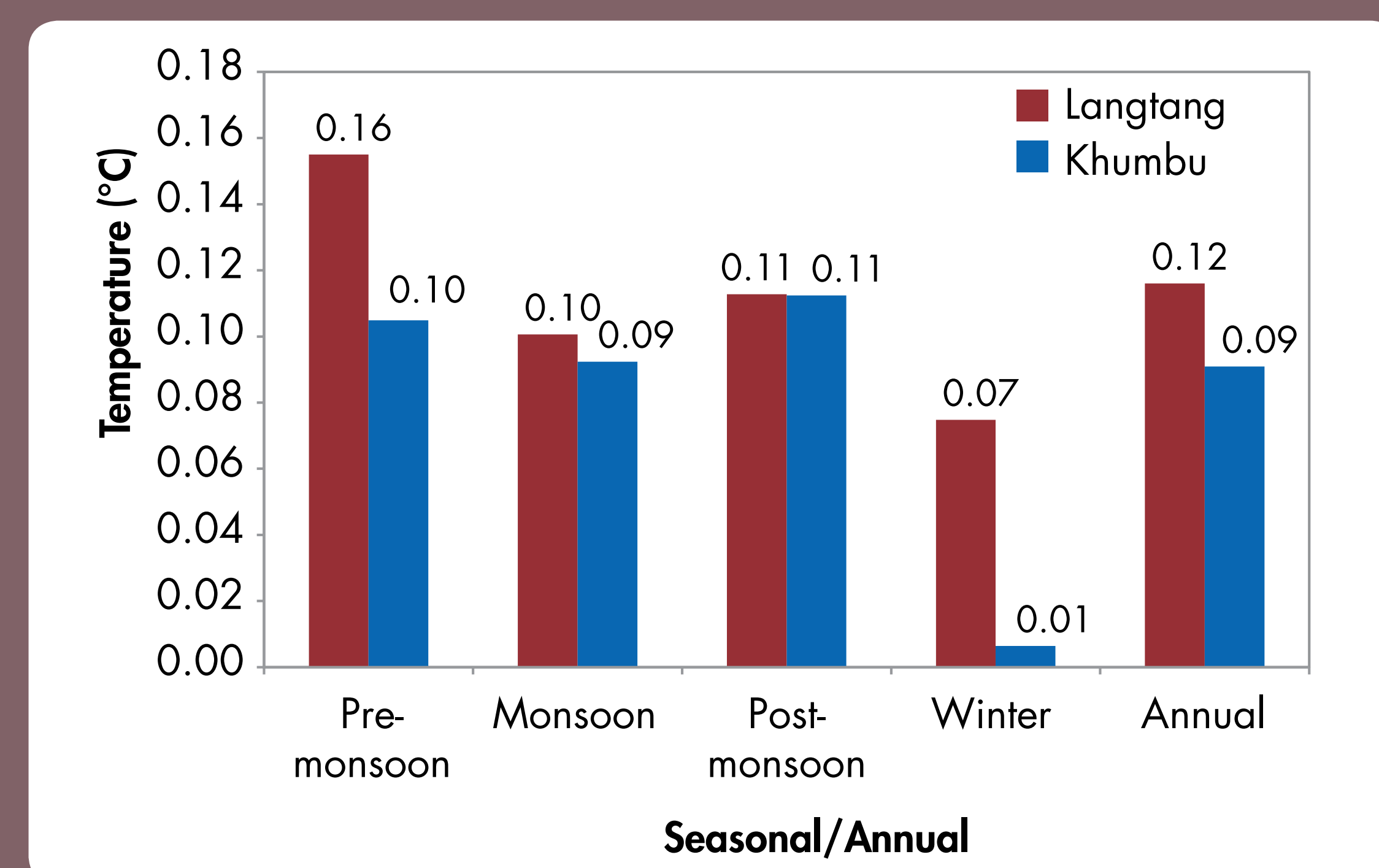
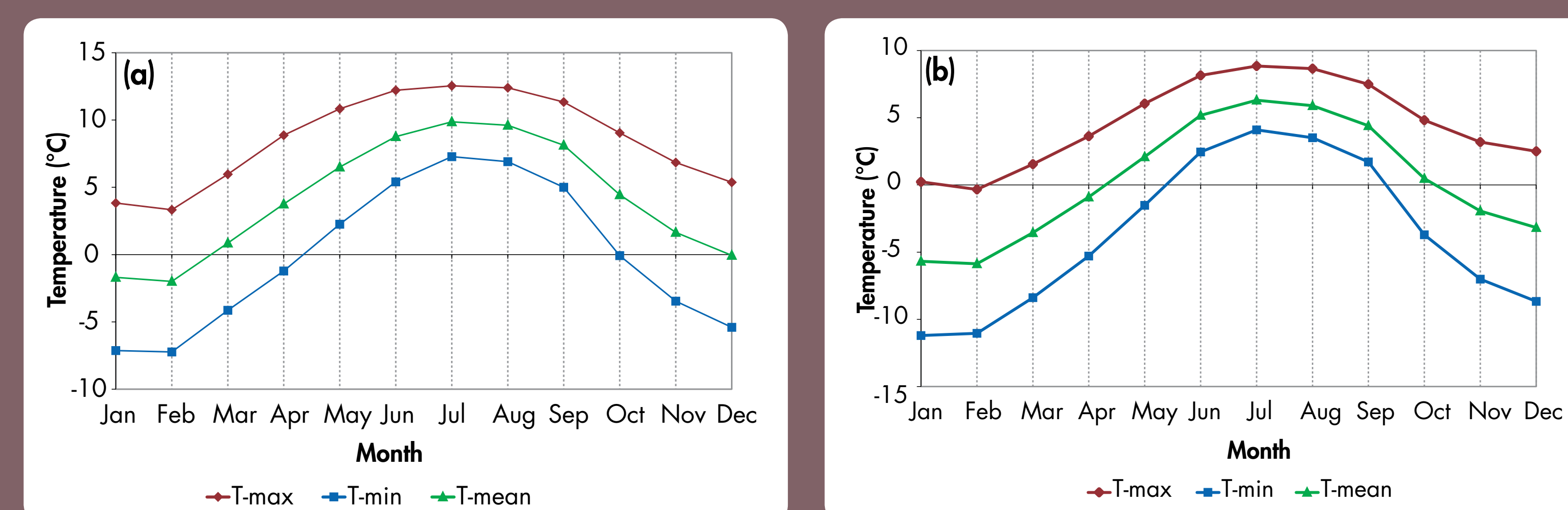
## Langtang valley

- Loss in total amount: Lirung Glacier (greatest) and Kimjung Glacier (least)
- Percentage of glacier area loss: Yala Glacier (51%, from 5.0 km<sup>2</sup> in 1976 to 2.4 km<sup>2</sup> in 2009); Lirung Glacier (47%, 10.0 km<sup>2</sup> to 5.3 km<sup>2</sup>); Kimjung Glacier (18.9%, 5.0 km<sup>2</sup> to 4.1 km<sup>2</sup>).

## Imja valley

- Loss in total amount: Lhotse Glacier (greatest) and East Amadablam Glacier (least).
- Percentage of glacier area loss: Lhotse Glacier (31%, from 14.7 km<sup>2</sup> in 1979 to 10.2 km<sup>2</sup> in 2010); East Amadablam Glacier (19%, 2.4 km<sup>2</sup> to 1.9 km<sup>2</sup>); Imja Glacier (16%, 21.0 km<sup>2</sup> to 17.6 km<sup>2</sup>).

Average monthly temperature in (a) Langtang and (b) Khumbu (1988–2008)



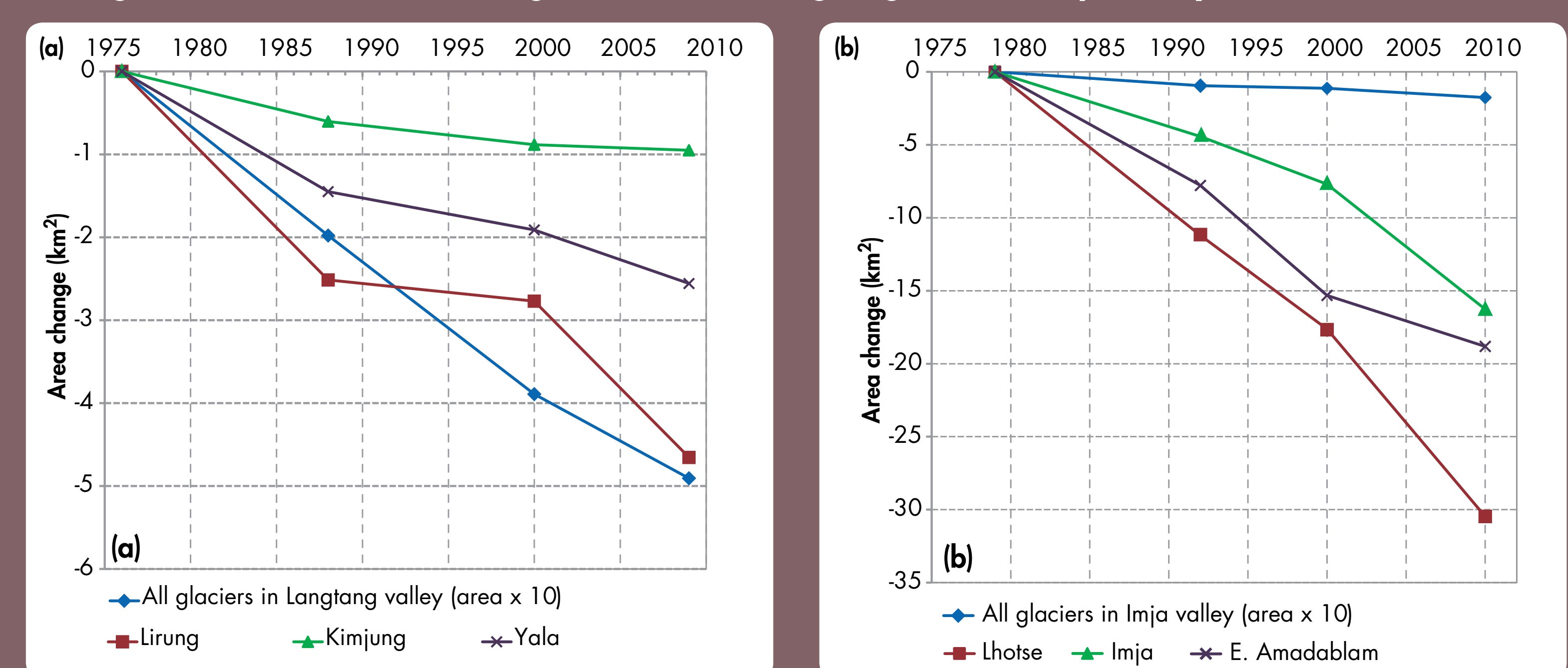
Rate of change in average seasonal and annual mean temperatures in (a) Langtang, (b) Khumbu (1988–2008)

Average annual temperature change in Langtang and Khumbu between 1988 and 2008 (°C/yr)

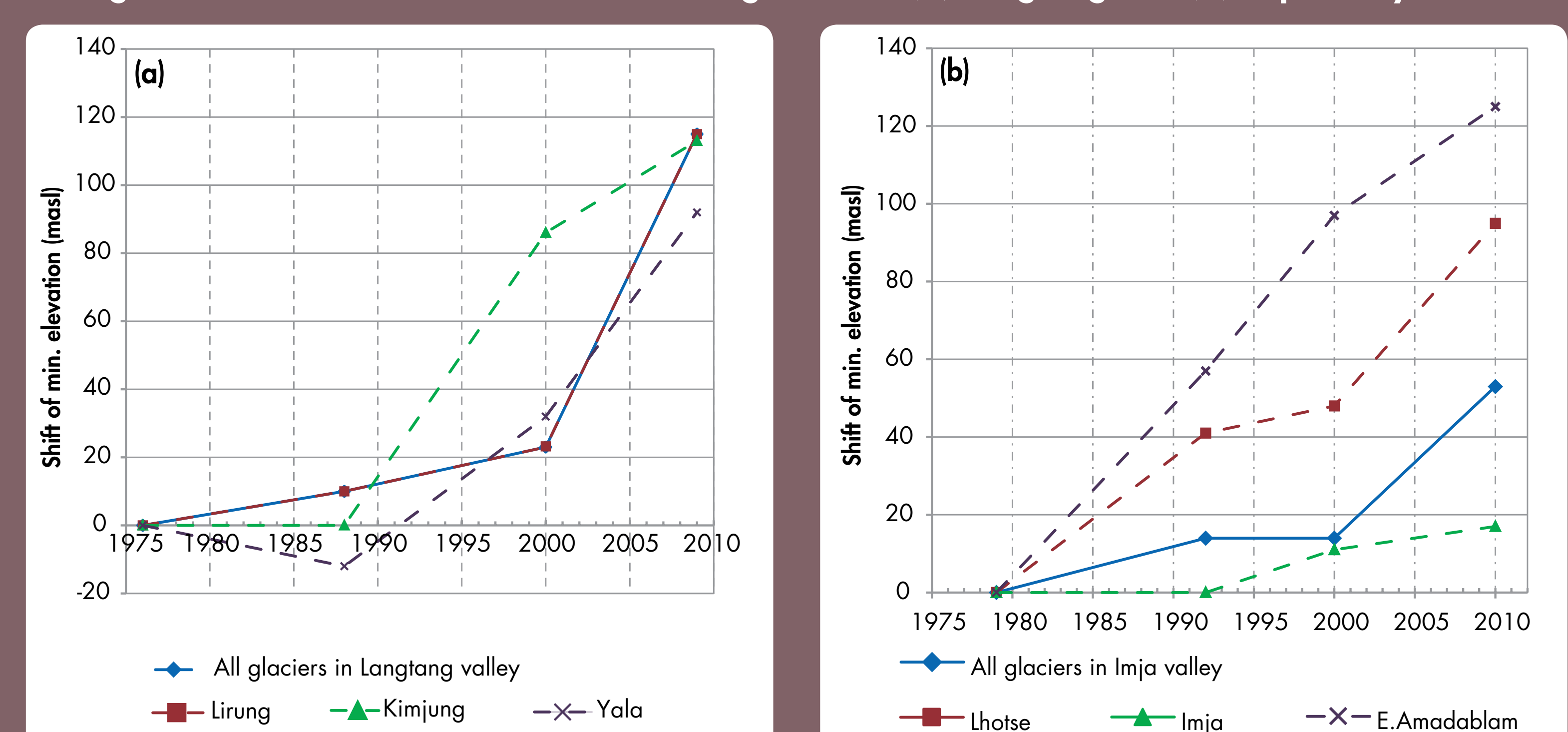
Station	Maximum	Minimum	Mean
Langtang	0.128	0.124	0.116
Khumbu	0.093	0.139	0.091

- The average monthly maximum temperature is below 13°C in Langtang and 9°C in Khumbu, and the average monthly minimum temperature is about -2.0°C in Langtang and -6.0°C in Khumbu.
- The average annual mean temperature increased by 0.12°C/year at the Langtang station and 0.09°C/year at the Khumbu station. The increase was observed in all seasons, but was highest in the pre-monsoon season in Langtang and post-monsoon season in Khumbu.
- In Langtang the maximum and minimum temperatures increased at almost the same rate, whereas in Khumbu the minimum temperature increased slightly faster than the maximum temperature.
- The differences in temperature change in the two decades, 1988–1997 and 1998–2007, showed that warming was greater in 1998–2007 than in 1988–1997 in both locations and in all seasons, with the greatest differences observed in the pre-monsoon season and the least in the winter seasons.
- The decadal mean temperature increased from 3.3 to 5.0°C in Langtang and from -0.3 to 0.7°C in Khumbu between the decades 1988–1997 and 1998–2007.
- Analysis of 5 and 10-year moving averages indicated that although both the maximum and minimum temperatures showed a rising tendency, only the increase in minimum temperature was significant.

Change in area of the selected glaciers in (a) Langtang and (b) Imja valley



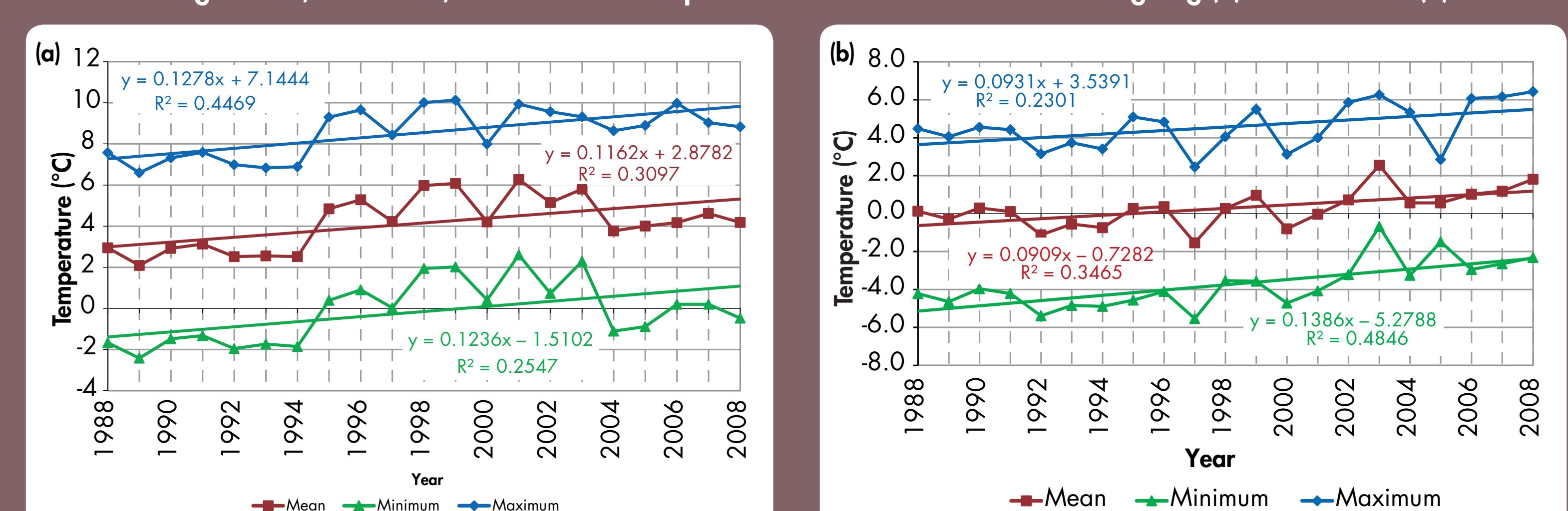
Change in minimum elevation of the selected glaciers in (a) Langtang and (b) Imja valley



Average monthly maximum, minimum, and mean temperatures in Langtang and Khumbu (1988–2008)

Temperature (°C)	Winter		Premonsoon		Monsoon		Postmonsoon		Winter	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
<b>Langtang</b>										
Tmax	3.8	3.3	6	8.9	10.8	12.2	12.5	12.4	11.3	9
Tmin	-7.1	-7.2	-4.1	-1.2	2.3	5.4	7.3	6.9	5	-0.1
Tmean	-1.7	-2	0.9	3.8	6.5	8.8	9.9	9.6	8.1	4.5
<b>Khumbu</b>										
Tmax	0.2	-0.3	1.5	3.6	6	8.1	8.8	8.7	7.5	4.8
Tmin	-11.2	-11	-8.4	-5.3	-1.5	2.4	4.1	3.5	1.7	-3.7
Tmean	-5.7	-5.9	-3.6	-0.9	2.1	5.2	6.3	5.9	4.4	0.5

Annual average mean, maximum, and minimum temperatures from 1988 to 2008 in Langtang (a) and Khumbu (b)



Average decadal and annual mean temperature in (a) Langtang and (b) Khumbu

