

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

# Climate Change Impact on Water Resources.



By

**Manzoor Ahmad Malik**  
**Director**

Pakistan Council of Research in Water Resources  
Peshawar

# Climate Change Impact on Water Resources

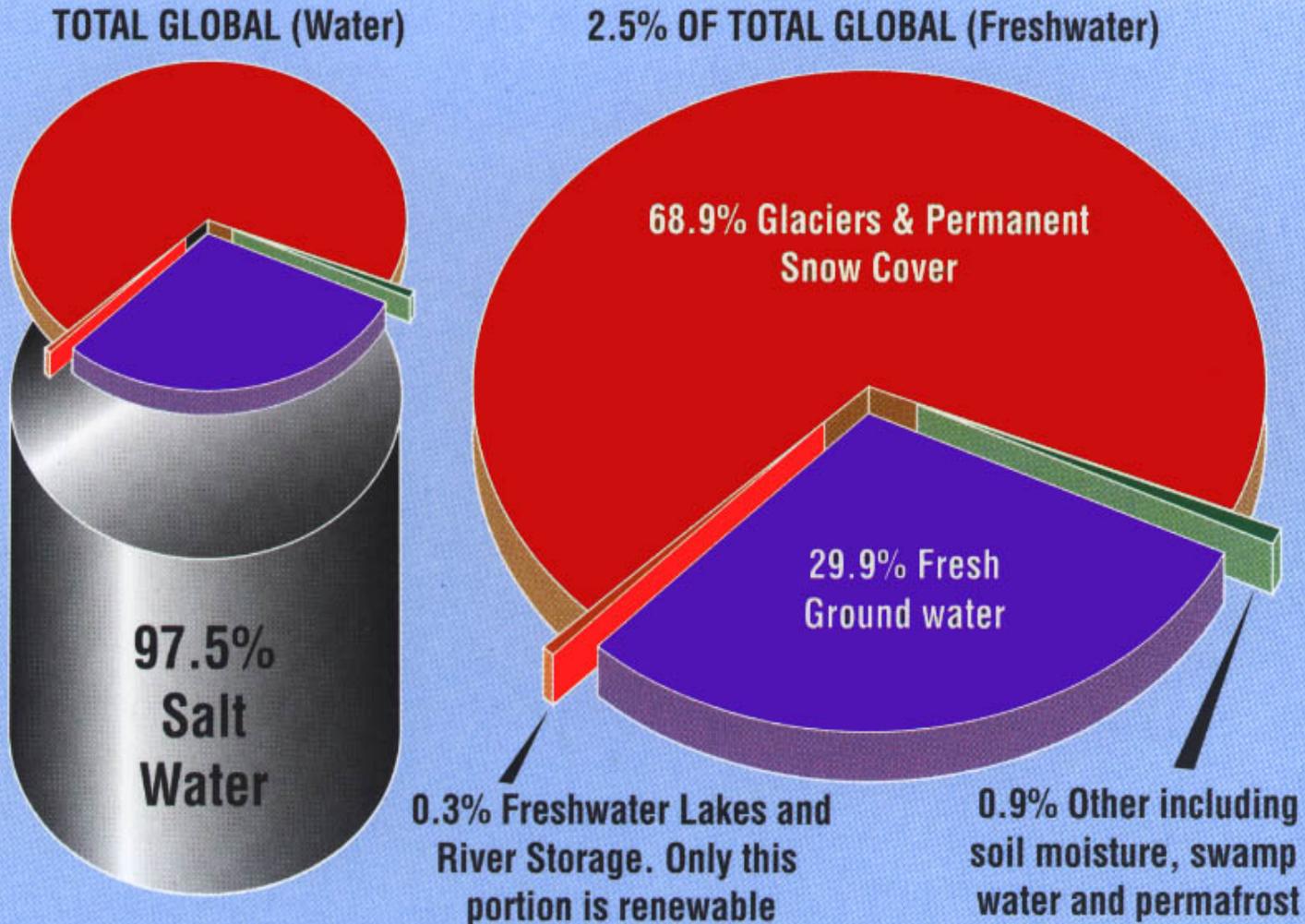
## Structure of Presentation

1. **Background**
2. **Major findings of IPCC.**
3. **Some Climate Extreme**
4. **Impact on Pakistan**
5. **Climate Change VS Glacier and snow**
6. **Himalayan Glaciers**
7. **Glaciers in Pakistan**
8. **Climate Change Impact on Glaciers; Implication for Pakistan water resources.**
9. **Adaptive Measures.**

# Hydrosphere

- Water: 1386 million km<sup>3</sup> on earth
  - in which: 97.5% saline water
  - 2.5% freshwater
- Freshwater:
  - 68.9% : ice, snow in the Antarctic, the Arctic and the mountains
  - 0.3% : lakes, reservoirs and river systems
  - 29.9%+0.9%: groundwater + others
- Accessible freshwater: 13 % of freshwater / 0.4 percent of total water

# Water distribution on the earth

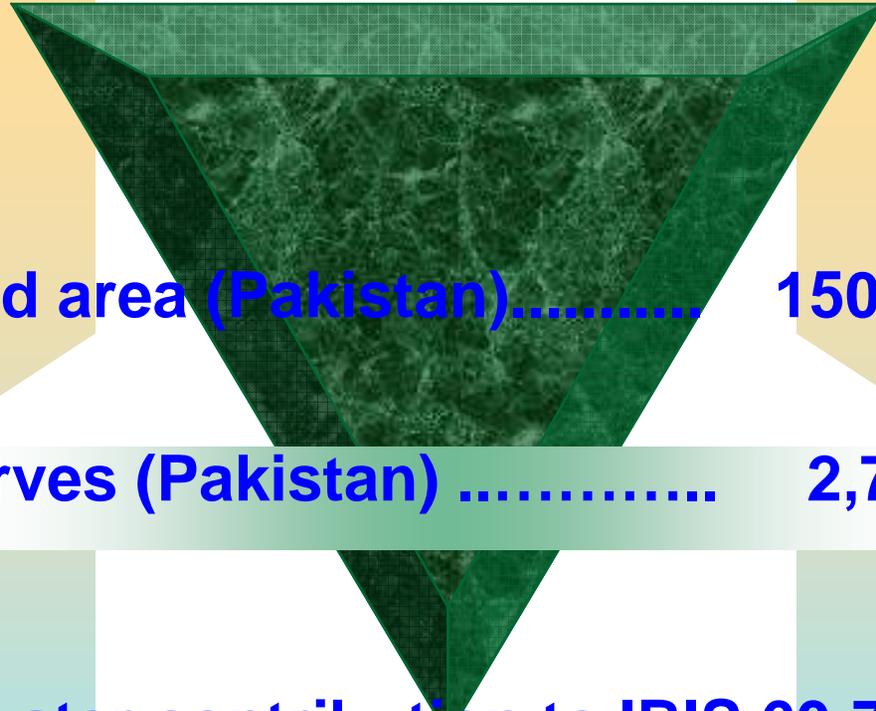


# Global distribution of glaciared area (after UNEP, 1992)

Region	Surface area (km <sup>2</sup> )
Antarctica	13,586,310
Greenland	1,726,400
Asia	185,211
Europe	53,967
North America	276,100
South America	25,908
Newzealand	7,860
Total	15,861,766

# Himalayan glaciers

- ✔ Himalayan region winter snow and ice cover: 80%
- ✔ Himalayan region summer snow and ice cover: 10%
- ✔ Glaciers in Himalayan region are: 5218
- ✔ Out of those in Northern Pakistan: 1214
- ✔ Dominant glaciers in Northern Pakistan are: 202

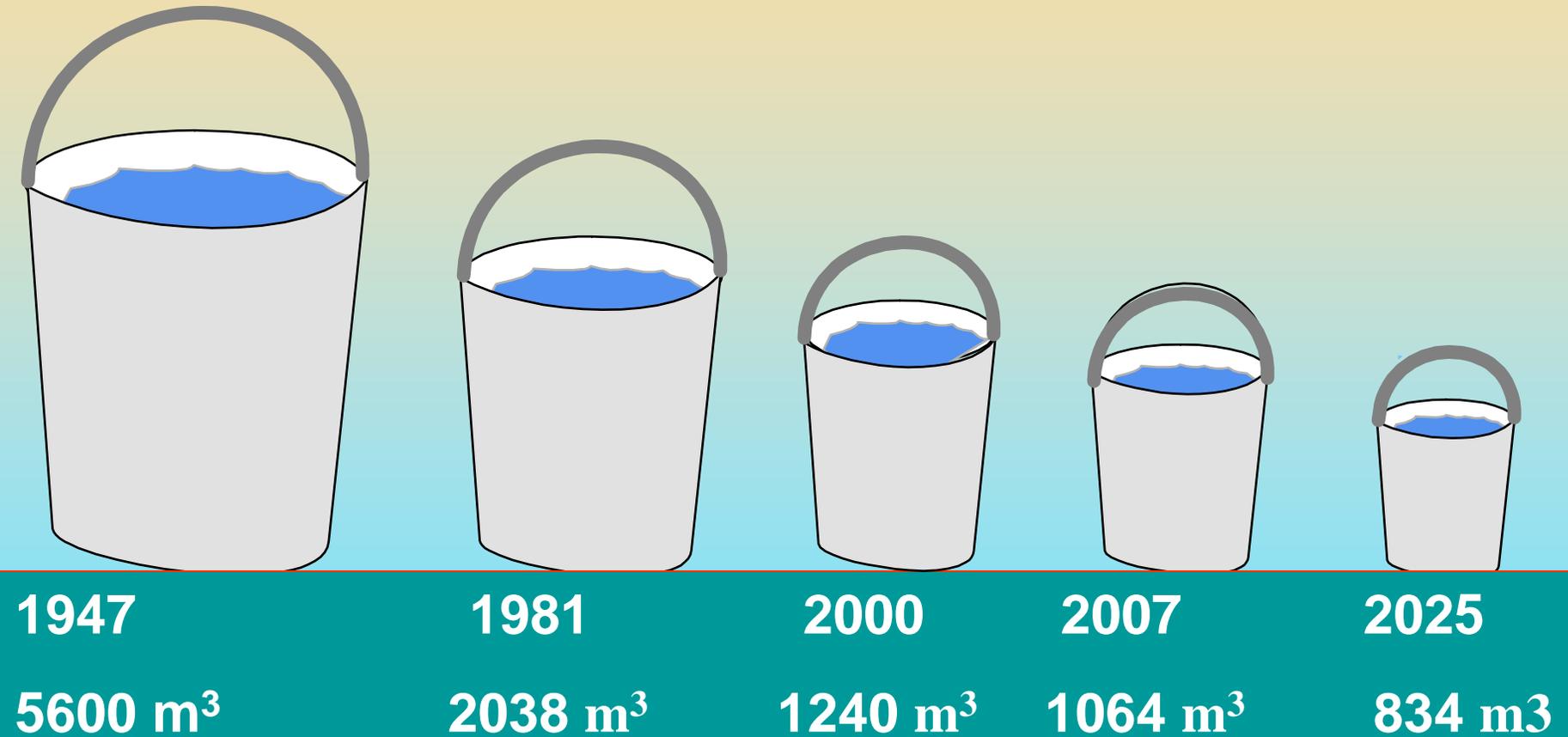


❖ **Total glaciated area (Pakistan)..... 15041 Km<sup>2</sup>**

❖ **Est. Ice Reserves (Pakistan) ..... 2,738 Km<sup>3</sup>**

❖ **Glacial melt water contribution to IBIS 60-70%**

# Freshwater availability per capita 1947- 2025 in Pakistan

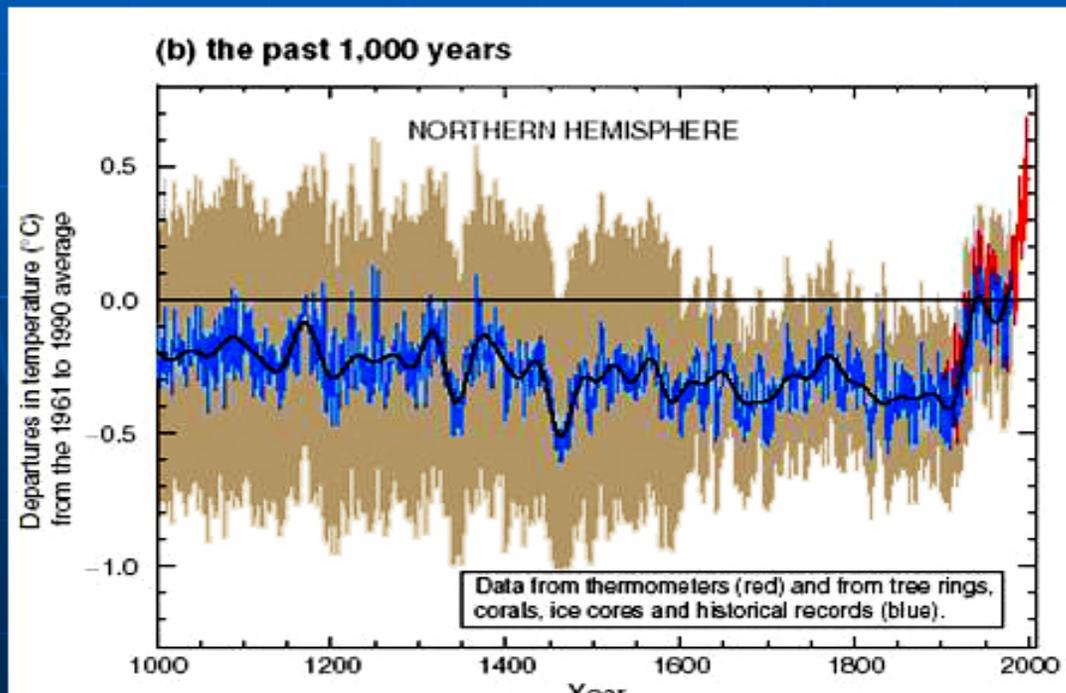
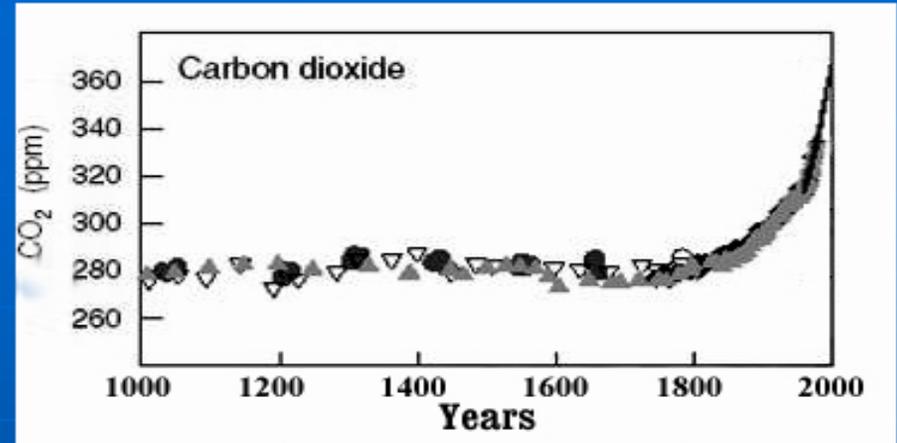
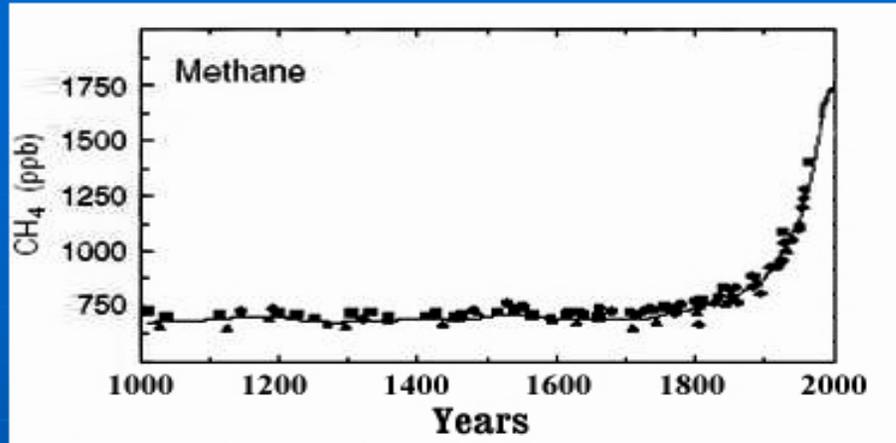


Pakistan was categorized in 2003 as country under water stress; surpassing only Ethiopia and on par with African countries such as Libya and Algeria

# Climate Change and Water Resources

- ✔ **Climate change is *the greatest challenge facing the world at the beginning of the century***
- ✔ ***Its direct impact will be on water resources***

# Past 1000 Year Changes in Temperature and CO<sub>2</sub> & CH<sub>4</sub> Concentrations



# Major Findings of IPCC Third and Fourth Assessment Reports

- Global Atmospheric concentration of carbon dioxide increased from the

pre-industrial (18<sup>th</sup> Century) value of 280 ppm to 379 ppm in 2005;

- Average global temperature increased during the last century by  $0.6^{\circ}\text{C}$

mainly due to increase in GHG levels; the updated 100 year (1906-2005) increase is  $0.74^{\circ}\text{C}$ ; 11 of the last 12 years were the warmest during the last 150 years;

➤ Some major changes associated with this temperature increase are:

- Significant changes in precipitation in different world regions
- Increase in frequency and intensity of climate extremes (storms, floods, droughts)
- Melting of glaciers and polar ice and shrinkage of snow line and permafrost
- Rise in global average sea level as much as 0.17 m, during the 20<sup>th</sup> century

➤ Future change in global average temperature is expected in the range 1.8 °C – 4.0 °C over the 21<sup>st</sup> Century;

➤ These will be accompanied by much increased impacts on global precipitation, extreme events, melting of glaciers, sea level rise etc.

# Some Climate Extremes Recently Experienced in South Asia

<b><u>Year</u></b>	<b><u>Events</u></b>
<b>1991</b>	A catastrophic cyclonic storm in Bangladesh left 100,000 people dead.
<b>1992</b>	Last decade's worst flood in Jhelum river in Pakistan.
<b>1998</b>	Two-thirds of the Bangladesh area was inundated by flood waters and forced more than 20 million people to evacuate their homes.
<b>1999</b>	Severe Cyclonic Storm hit the coastal areas of Pakistan and India.

# Some Climate Extremes Recently Experienced in South Asia (Contd.)

<u>Year</u>	<u>Events</u>
<b>1998-2001</b>	History's worst drought in Pakistan.
<b>2001</b>	621 mm rainfall in Islamabad during 10 hours in the month of July.
<b>2005</b>	Heavy winter rains in parts of Pakistan and Afghanistan in March caused severe flash flooding in Balochistan province.
<b>2005</b>	Unusual high temperatures in northern mountains during the month of June; accelerated snow melt caused heavy flooding of Kabul, Swat, Shahlam, Kunar and Chitral rivers.

# Some Climate Extremes Recently Experienced in other Regions

## Year

## Events

**2003**

Heavy rains in the holy city of Makkah, Saudi Arabia on November 10; caused widespread flooding of the city.

**2004**

Snowfall in the al-Jiys mountain range in UAE, the first ever in historical record.

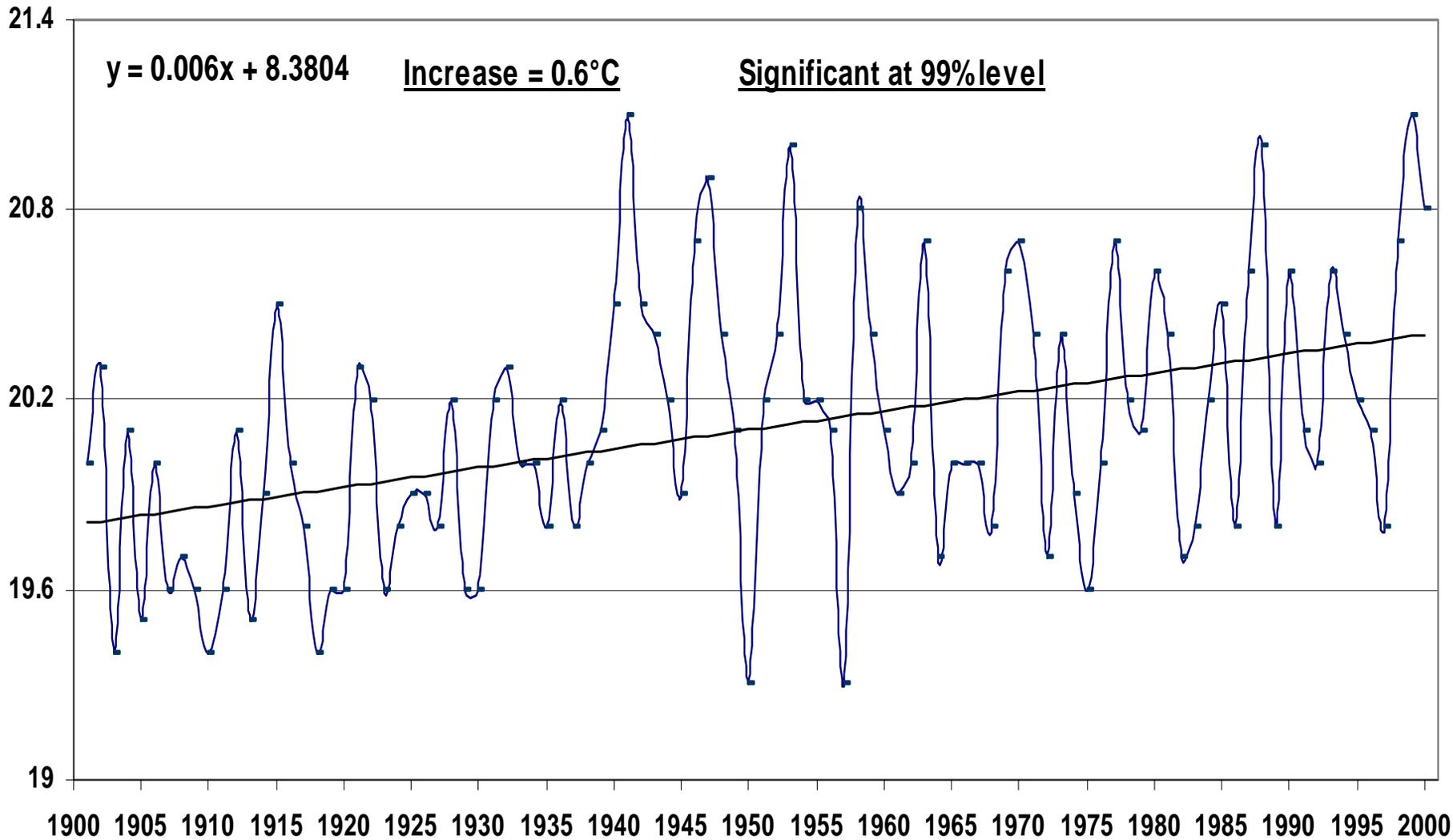
**2005**

Heavy rains in Saudi Arabia caused severe flooding in the city of Medina.

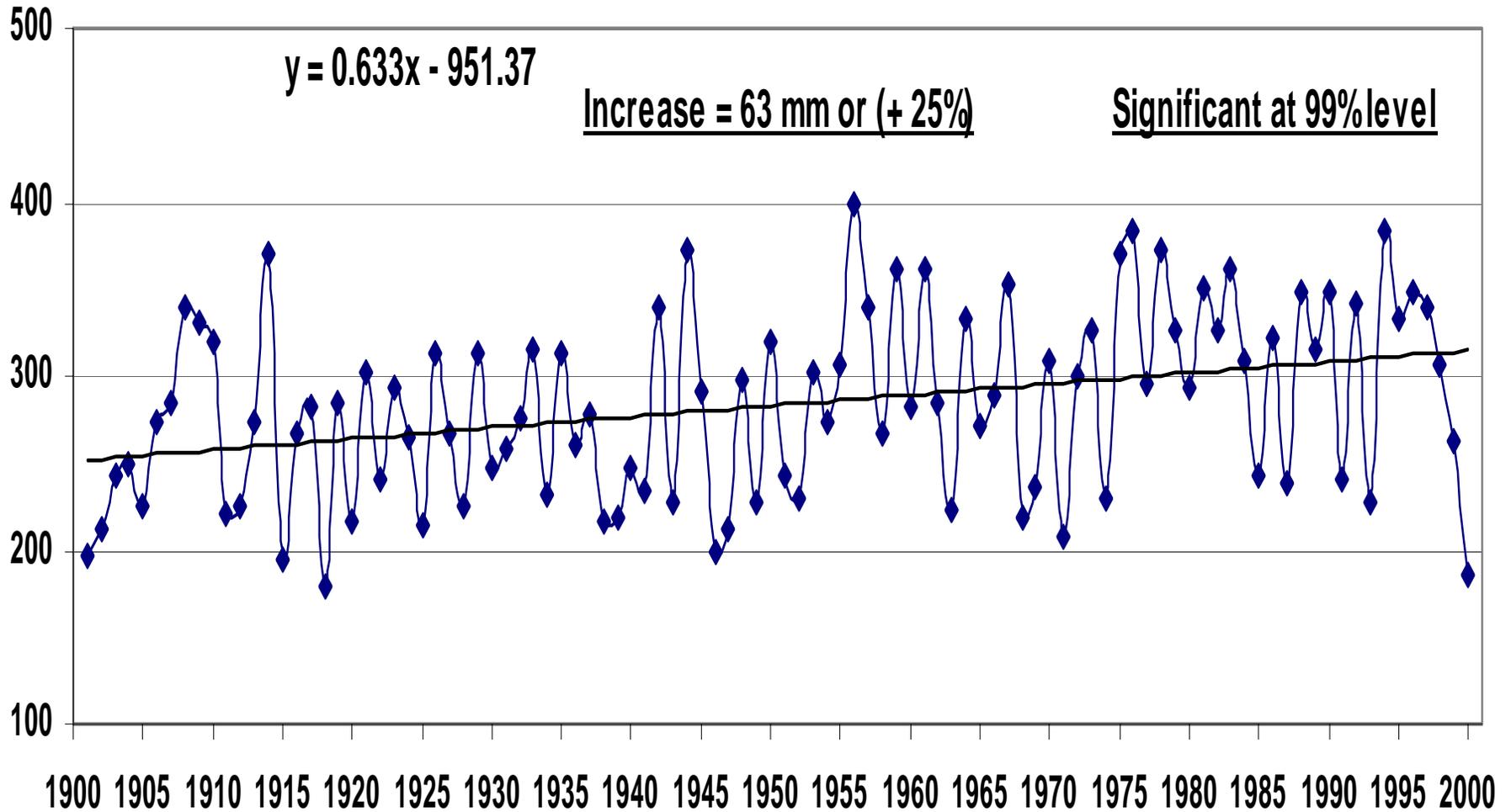
**2005**

Two large hurricanes, Katrina and Rita developed in the Gulf of Mexico and hit the coastal cities of America in August and September i.e. within a period of one month, which is very unusual.

# Mean Temperature (°C) Trend 1901-2000 for Pakistan

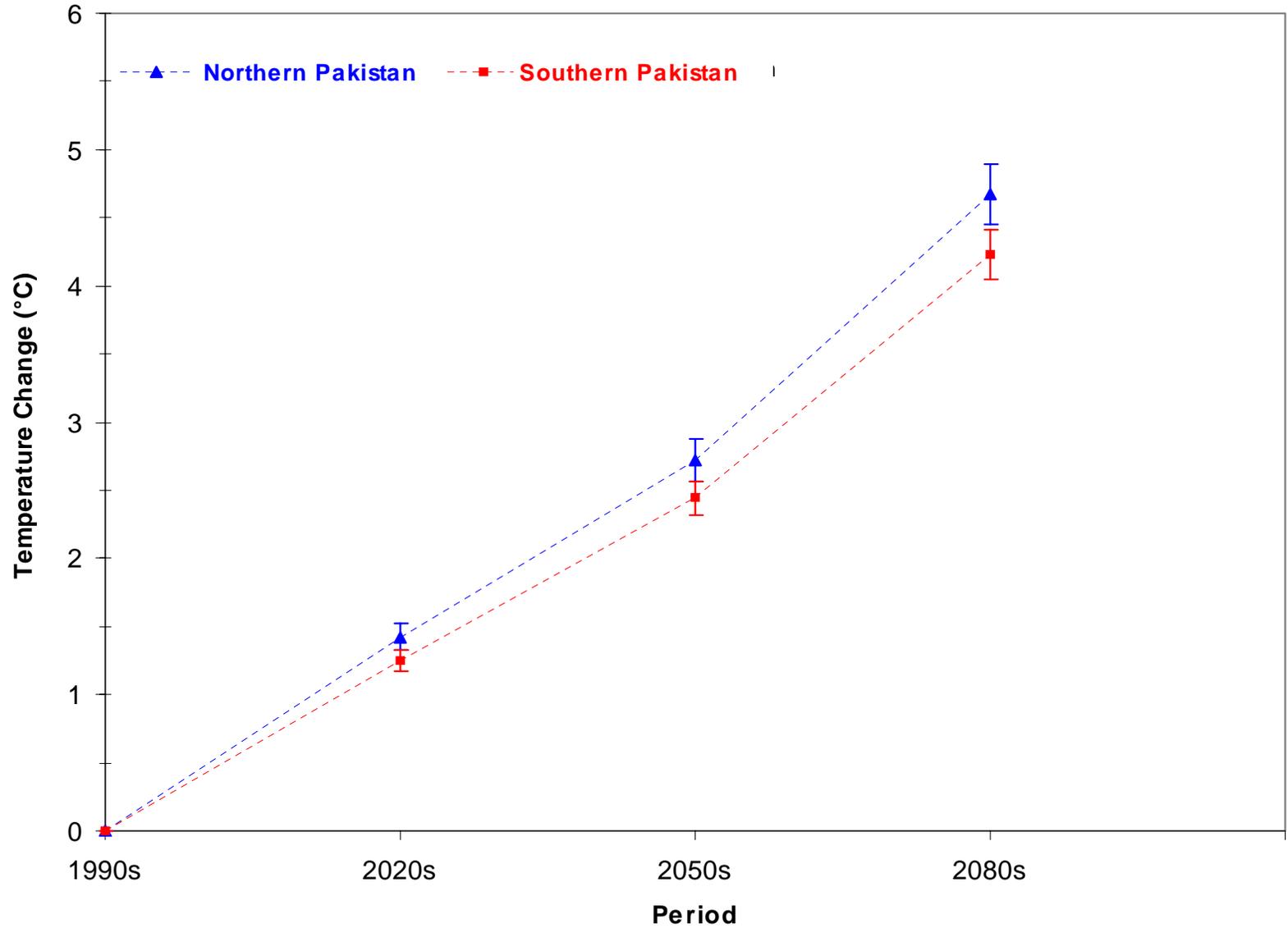


# Annual Precipitation (mm) Trend 1901-2000 for Pakistan

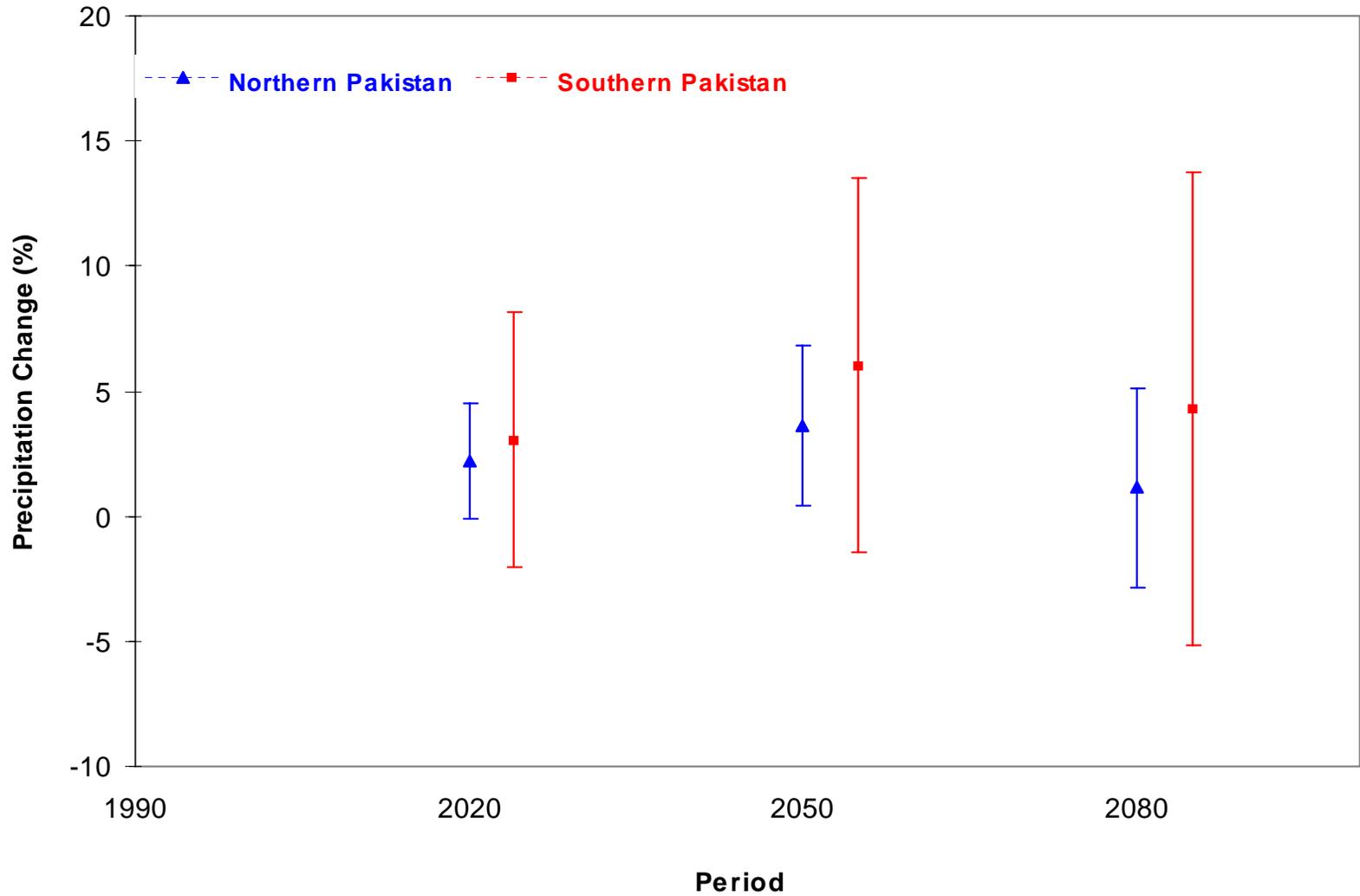


# Projected Changes in Average Temperature of Northern and Southern Pakistan

(Corresponding to IPCC A2 Scenario )



# Projected Changes in Average Precipitation of Northern and Southern Pakistan (Corresponding to IPCC A2 Scenario )



# Climate Change vs. Glaciers, Snow and Ice

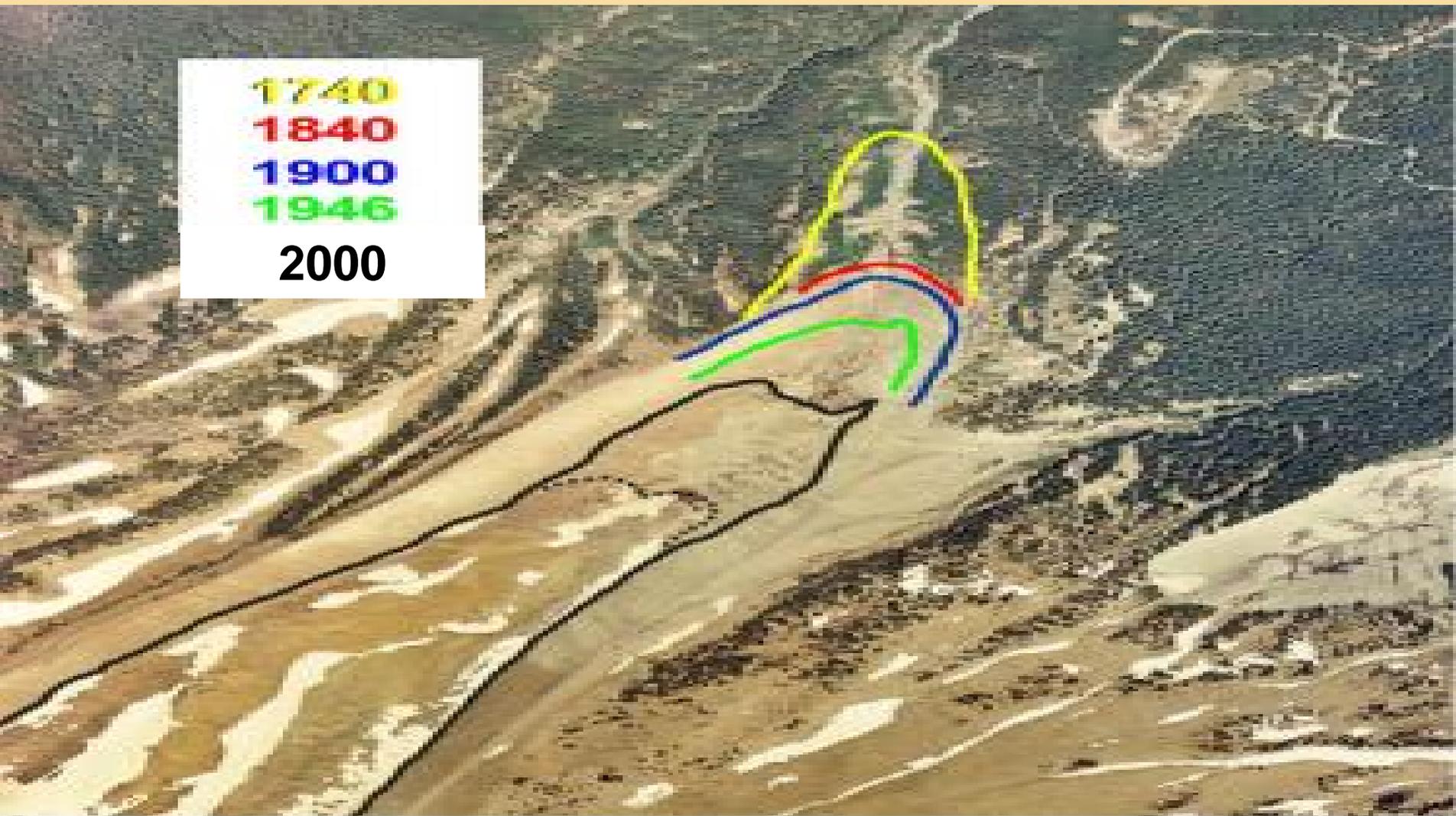
- ✔ Glaciers, snow and ice are considered to be the most sensitive indicators of climate change
- ✔ At the same time, snow and ice-mass distribution have a profound effect on the climate system
- ✔ A remarkable effect of global warming has been the shrinking of the ice-cap on the north pole; it has shrunk by more than 10% since late 1960s.

# Climate Change: Worldwide Glacier Melt

- ✔ Mountain Glaciers worldwide are generally reported to be receding over the last 100 years.
- ✔ According to World Glacier Monitoring Service (WGMS), the measurements taken over the last century “clearly reveal a general shrinkage of mountain glaciers on a global scale”
- ✔ The IPCC in its second Assessment report (1996) forecast that up to a quarter of global mountain glacier mass could disappear by 2050 and up to half could be lost by 2100

# Elliot glacier Mount Hood Oregon USA

1740-2000



# Qori Kalis Glacier, Quelccaya Ice Cap, Peru,

**a** 1978

**1978**



**b** 2002

**2002**



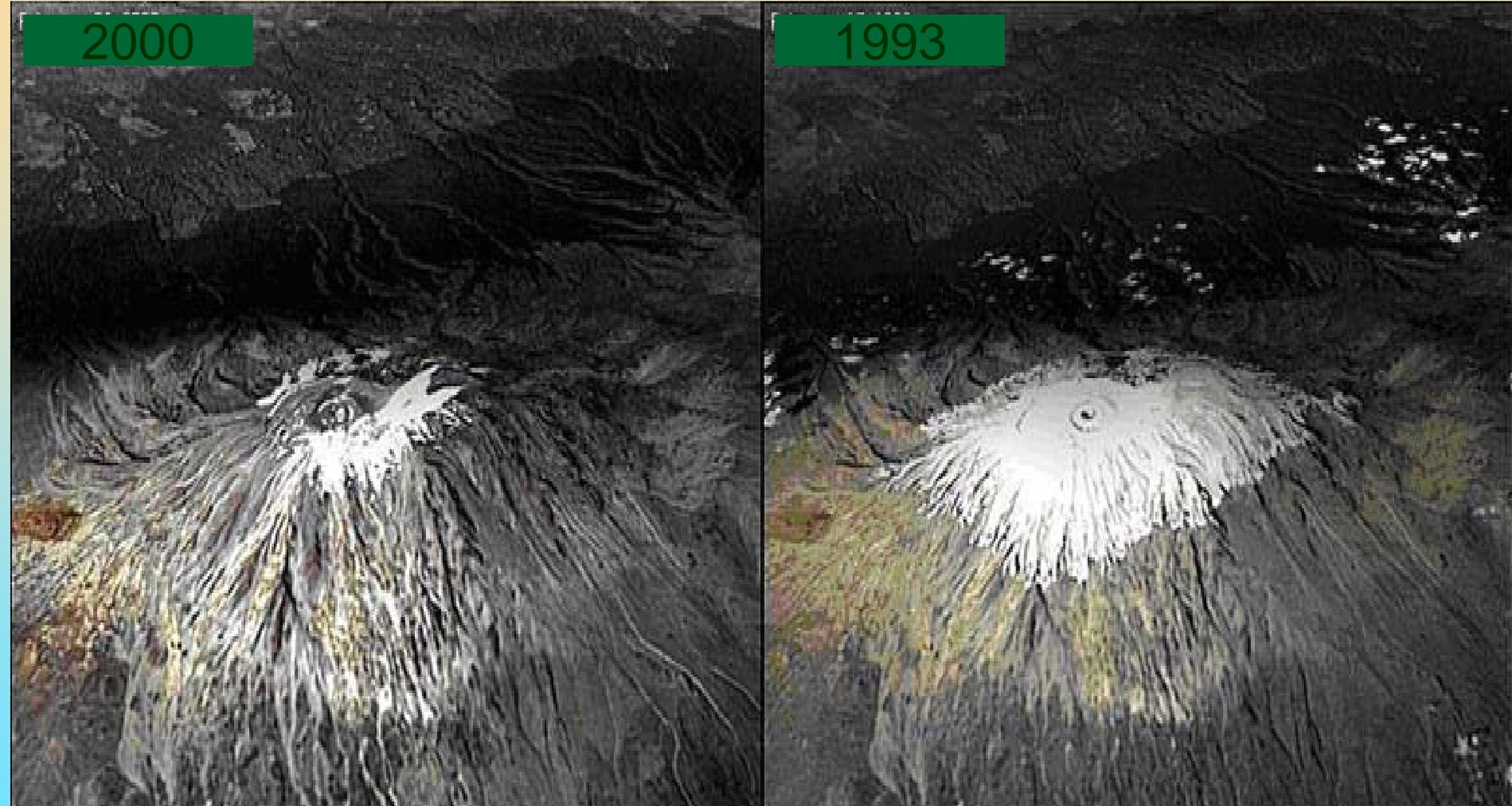


**The Pasterze, Austria's longest glacier**, was about 2 kilometers longer in the 19th C. but is now completely out of sight from this overlook on the Grossglockner High Road.

# Mount Kiliminjaro, Africa

2000

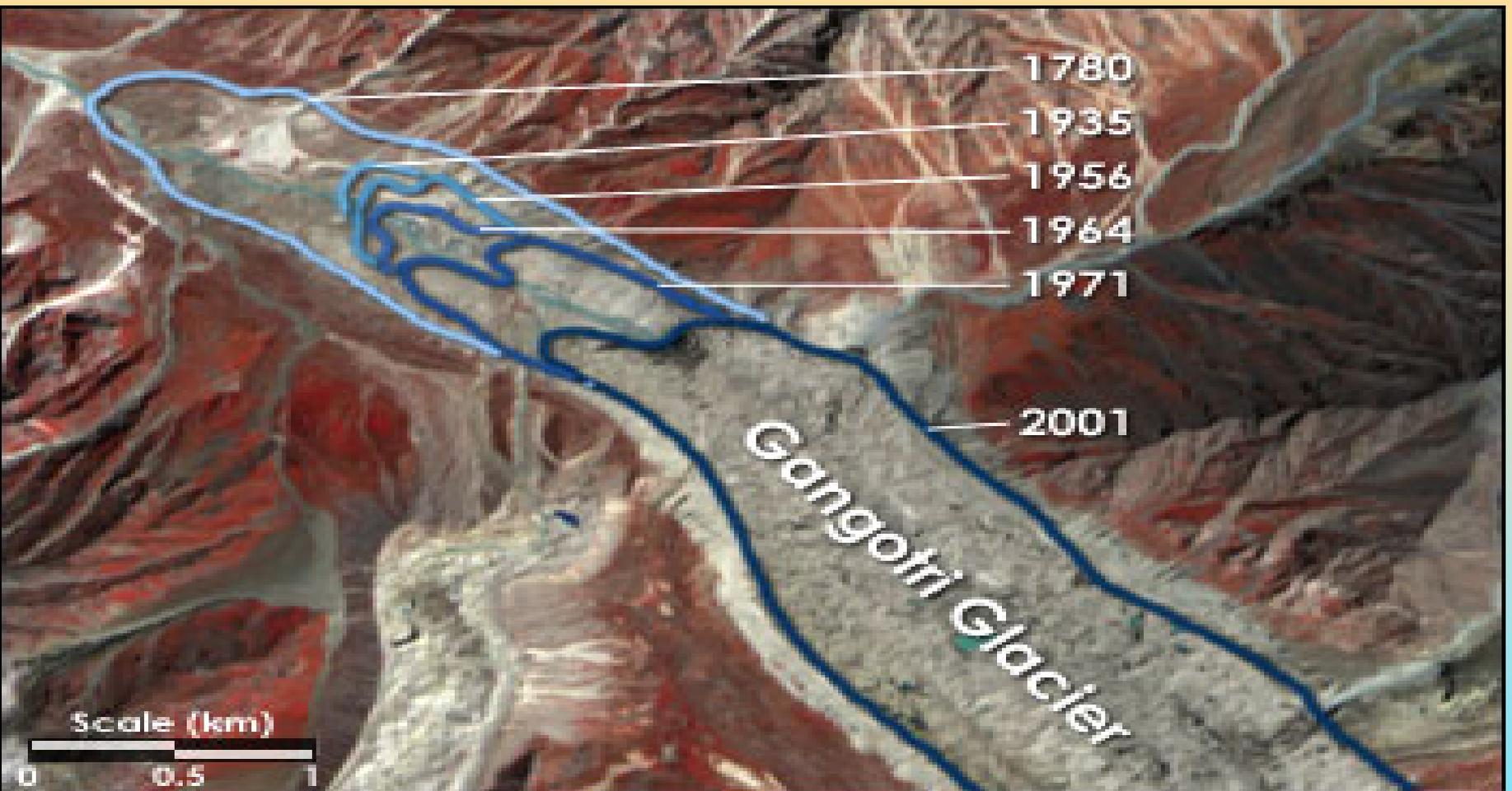
1993



# Himalayan Glaciers

- ❖ Glaciers in Himalayas have generally been retreating since AD 1850 and recent publications confirm that, for many, the rate of retreat is accelerating.
- ❖ In India, one of the largest glaciers in the Himalayas, the Gangotri glacier that feeds the river Ganges, has retreated about the 2 km in the last 200 years of which about 1 half is in the last 30 years.
- ❖ In 1999, a report by the Working Group on Himalayan Glaciology (WGHG) of the International Commission for Snow and Ice (ICSI) stated :  
“glaciers in the Himalayas are receding faster than in any other part of the world and, if the present rate continues, the likelihood of them disappearing by the year 2035 is very high.”
- ❖ A recent study has reported conflicting findings. According to it, in the late 1990s widespread evidence of glacier expansion was found in the Central Karakoram.

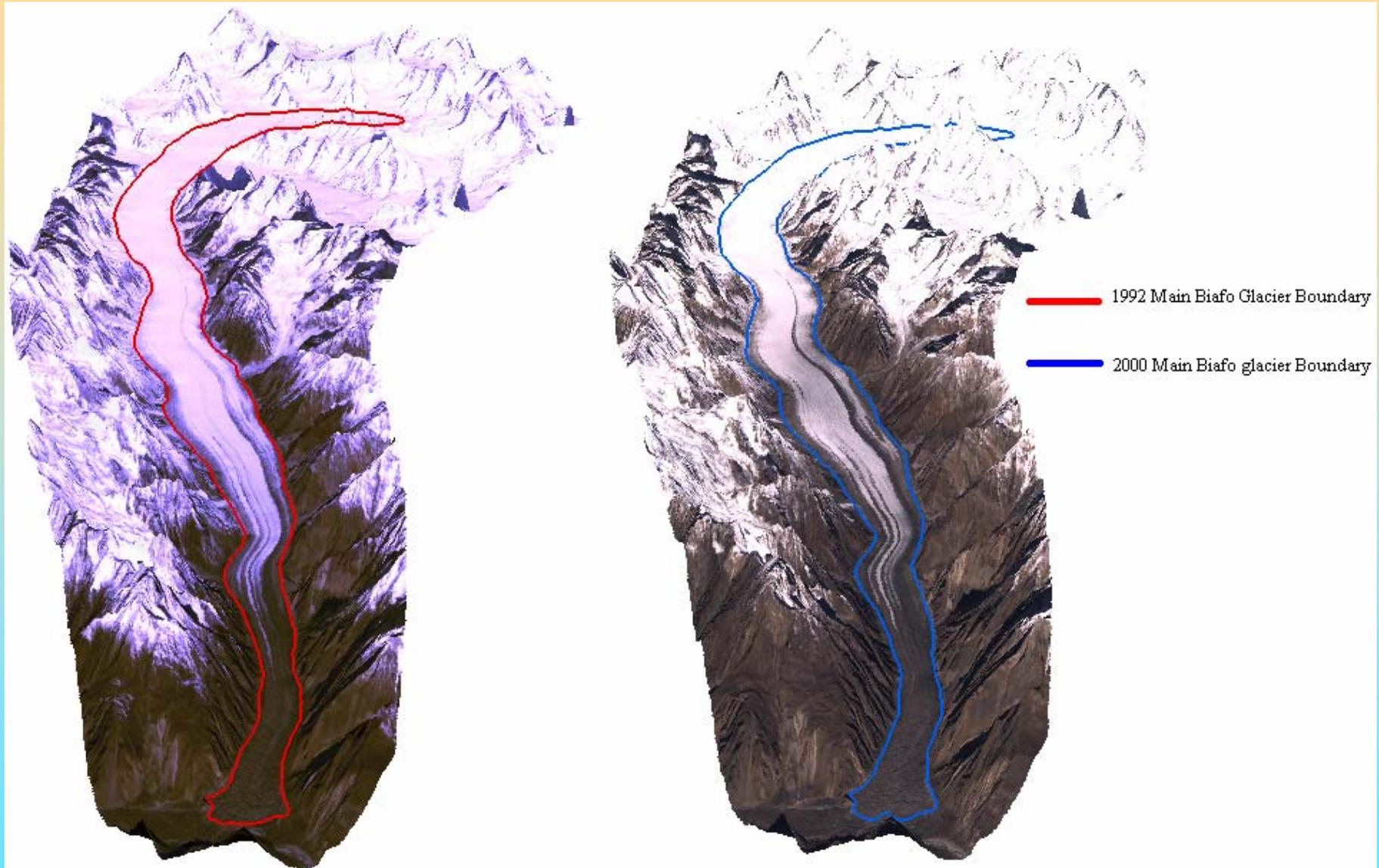
## Changes in Gangotri Glacier, Indian Himalaya



**This composite ASTER image shows how the Gangotri Glacier terminus has retracted since 1780. Contour lines are approximate. (Image by Jesse Allen, Earth Observatory; based on data provided by the ASTER Science Team; glacier retreat boundaries courtesy the La2828nd Processes Distributed Active Archive Center)**

# Temporal Change Detection In Biafo Glacier, Karakoram, Pakistan.

Landsat image; Resolution 30m



**3d view of Main Biafo Glacier (Shigar River Basin) with overlaid digitized boundary of the glacier showing the changes in the main glacier stream.**

# Climate Change Impact on Glaciers: Implications for Pakistan's Water Resources

- ✔ More Water may be available in first few decades but the flows would decrease thereafter due to reduced glacier volume
- ✔ Change in the Intra-Annual pattern of river flows
- ✔ Increased frequency and intensity of floods and droughts due to reduction of natural reservoirs
- ✔ Floods resulting from outbursts of glacial lakes (GLOF) may cause severe damages downstream
- ✔ Drying up of mountain springs and glacial streams

# Water sector issues/deficiencies

- ✔ **Water supply short fall to meet the growing demand**
- ✔ **Lack of proper maintenance of exiting irrigation infrastructure**
- ✔ **Over exploitation of groundwater**
- ✔ **Low productivity of water**
- ✔ **Conveyance losses**
- ✔ **Capacity building of stakeholders and concerned departments**
- ✔ **Water quality**
- ✔ **Need for enhanced coordination of water sector institutions**

# Keys to water crisis

- ✓ Water conservation
- ✓ Construction of new reservoirs
- ✓ Canal lining to avoid losses
- ✓ High efficiency irrigation such as sprinkler and trickle irrigation
- ✓ Water recycling
- ✓ Rainwater harvesting
- ✓ Drought contingency plan
- ✓ Population control
- ✓ Pollution control

# PCRWR Projects for Northern Areas

- ✓ Improved water conservation practices for NWFP and Northern Areas
  - Construction of farm level water reservoirs
  - Construction of farm level storage tanks
  - Construction of diversion channels
  - Installation of trickle irrigation
  - Establishment of Sub-office at Gilgit
  
- ✓ Result oriented short term research studies to improve water resources of mountainous areas
  - Development of rainwater harvesting techniques
  - Grafting and monitoring of grafted glaciers for exploring viability of the technique in collaboration with AKRSP
  - Monitoring glacial movement such as Korumber glacier
  - Hydrological study of snow melt stream flow

# PCRWR Projects for Northern Areas (continued....)

- ✔ Provision of safe drinking water
  - Water quality laboratory at Gilgit
  - Assessment survey of water supply schemes
  - Capacity building of water supply managers and technicians
  
- ✔ Participatory integrated water management programme
  - Demonstration of irrigation technologies for mountainous areas such as sprinkler and trickle irrigation
  - Demonstration of innovative water lifting devices such as hydra-ram pumps
  
- ✔ Clean drinking water for all
  - Water quality and feasibility survey for installation of filtration plants

*Thank you*

