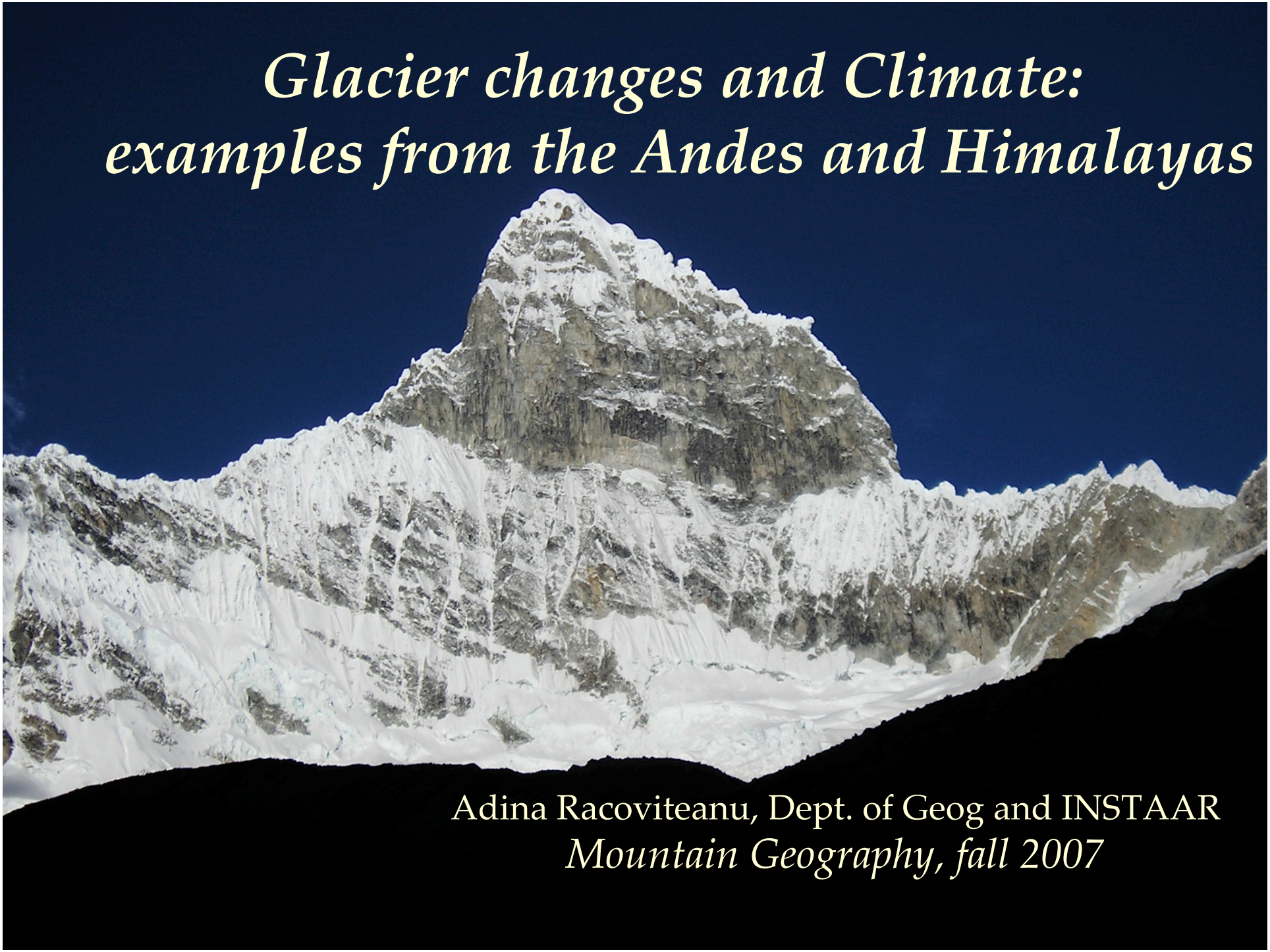
Glacier changes and Climate: examples from the Andes and Himalayas



Adina Racoviteanu, Dept. of Geog and INSTAAR

Mountain Geography, fall 2007

Sacred glaciers provide "medicinal" water Qoyllur Rit'I, Peru

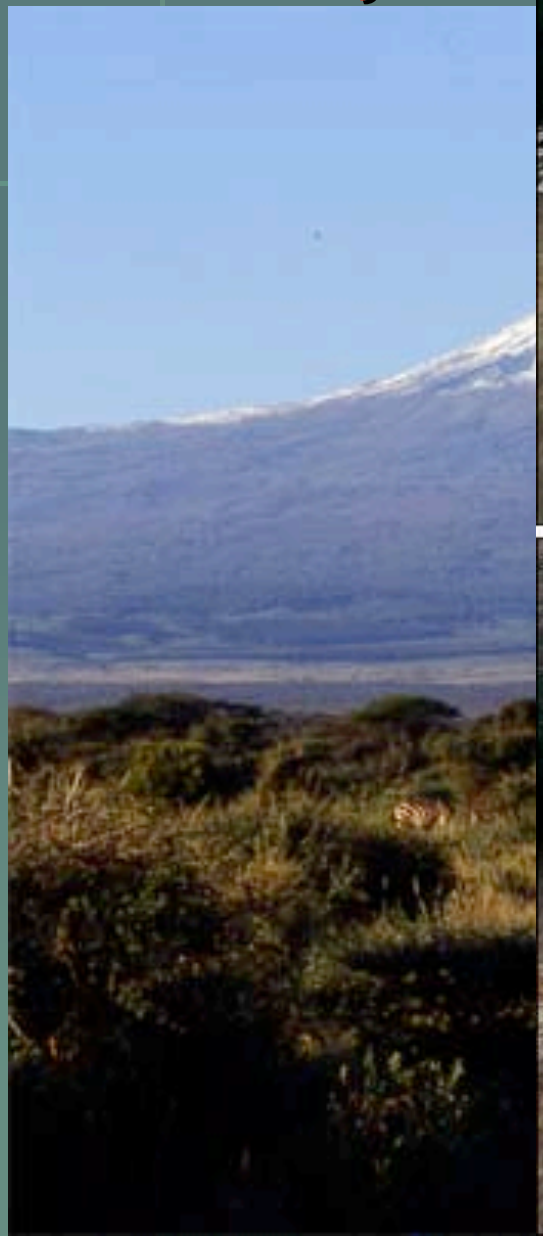
- *Andean glaciers: main source of water*
- *Glaciated mountains worshipped by the Incas (15-16th century) as "meteorological Gods"*
- *Human sacrifice rituals*

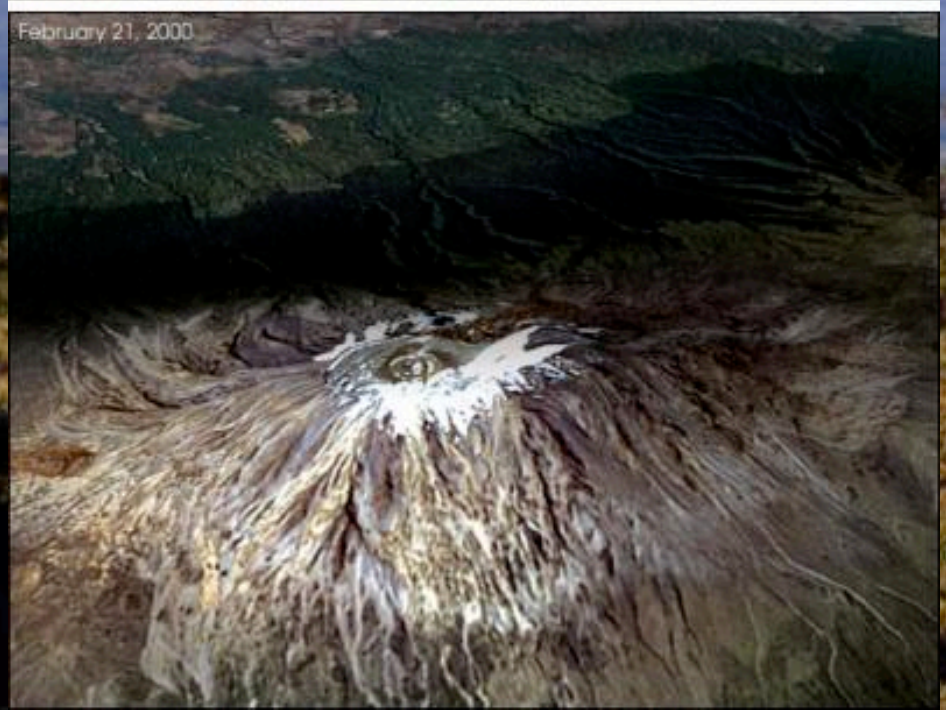
Indian Himalayas:

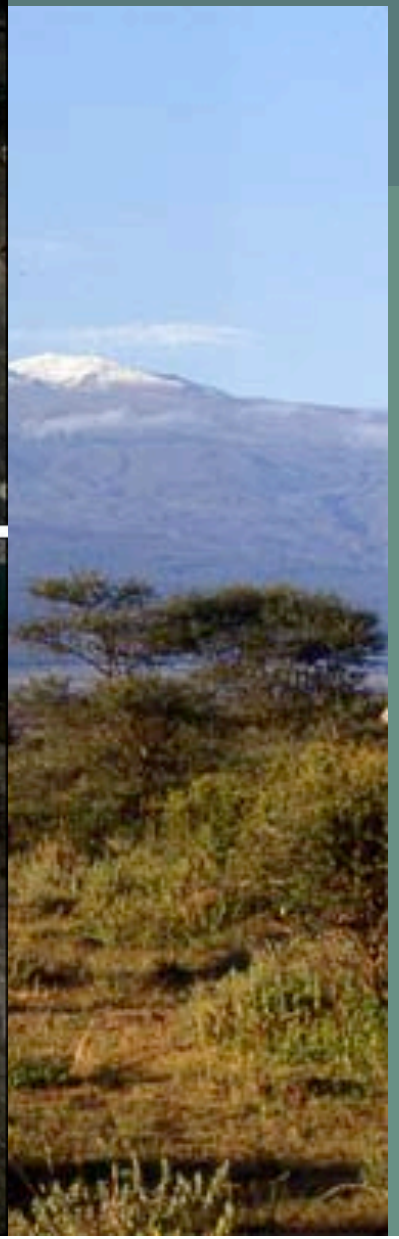
Glacier retreat at Gangotri, source of the holy Ganges

- glacier terminus retreated by 3km

Kilimanjaro







NATIONAL GEOGRAPHIC NEWS
REPORTING YOUR WORLD DAILY

TODAY'S BEST NEWS PHOTO

Photo in the News: Seals, S
Satellites Help Map Ocean

News Front Page
15 Most Popular News Stories
Photos in the News
Videos in the News
Animals & Nature News
Archaeology & Paleontology News
Environment News
Health News
History & Culture News
Offbeat News
Science & Space News
Travel & Adventure News

NEWS FEEDS
XML RSS
Get our news delivered directly to your desktop—

News Front Page > Earth Pulse

"Artificial Glaciers" Aid Farmers in Himalayas

Pallava Bagla from Leh in Ladakh, India
for National Geographic News
September 4, 2001

Life is never easy for the hard-working Buddhist people of northern India's Ladakh region, which lies high in the inner Himalayas between China and Pakistan. The thin air of the high altitude takes its toll, and the landscape—known geographically as a cold desert—is barren and rocky. The biggest problem for villagers, however, is a perpetual shortage of water.

Less than seven centimeters of rain falls annually in Ladakh. Water is at a premium all year round, but the shortage is especially felt in March or April, when farmers must sow their crops.

Email to a Friend

Chewang Norphel, a retired civil engineer, wanted to find a way to help the peasants of Ladakh, where he grew up. His solution was the first known technique of its kind: creating "artificial glaciers" to capture and channel precious snowmelt that otherwise would be wasted.

The technology, basically a network of pipes, is simple and relatively cheap to build. So far Norphel has helped Ladakhi peasants construct five artificial glaciers to increase water supplies in their villages, especially for crop irrigation. Several

Global Warming Threatens Pakistan's Glaciers
"Breeding" glaciers

articles and analysis

Do You Take This Glacier to be Your Wife?

Dawn, By M. Ismail Khan, 28/07/2003

Hiking towards Biafo Glacier

Village elders, their heads together, intensely discuss and go on to decide arrangements for a unique marriage ceremony. The task at hand is to choose a male and a female piece of ice, setting in motion a series of rituals. Two chunks of ice, one each from a female and a male glacier, are then transported to an appropriate location. Doing so, porters carrying the pieces shall observe complete silence. Pieces of ice will then be placed side-by-side, close enough for both chunks to eventually produce 'offspring' in the shape of fresh water – a new source of irrigation and drinking water.

No, this is not an excerpt from the folklore of a primitive tribal society; this is, in fact, a water tradition being practiced even today in the 21st century, in small villages of the Karakuram in the Northern areas of Pakistan. Already there are many communities that have bred small glaciers in the Gilgit and Baltistan regions.

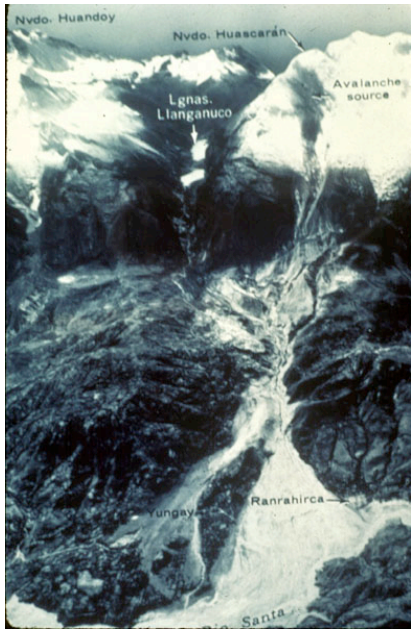
Breeding Glaciers in Ancient Times

As the stark reality of unpredictable water flow is dawning on the mountain communities of Pakistan, the age-old tradition of breeding glaciers is being revived with a fervor. Traditionally, village elders would gather to select a suitable site and large blocks of equal sizes of one male and one female block of ice were then taken from two different glaciers and carried on to the appointed location.

The gender of the glacier was determined by taking into consideration factors such as the characteristics of the people living in the nearby areas, where male glaciers were thought to produce a higher yield and fertility as well as a strong male population. Female glacier areas were said to have opposite characteristics, and were the home to a significant

Why do we care about glacier change?

- Water resources
- Sea-level rise
- Glacier-related hazards
- Sacred importance
- Tourism



GLACIERS AND CLIMATE

- Glacier mass balance basics
- Albedo feedbacks
- Glacier monitoring

What climatic conditions are needed for glaciers to form?

- cool summer temperatures in (< 0 deg. C)
- high winter precipitation

Why don't we have glaciers in Siberia or parts of Antarctica?

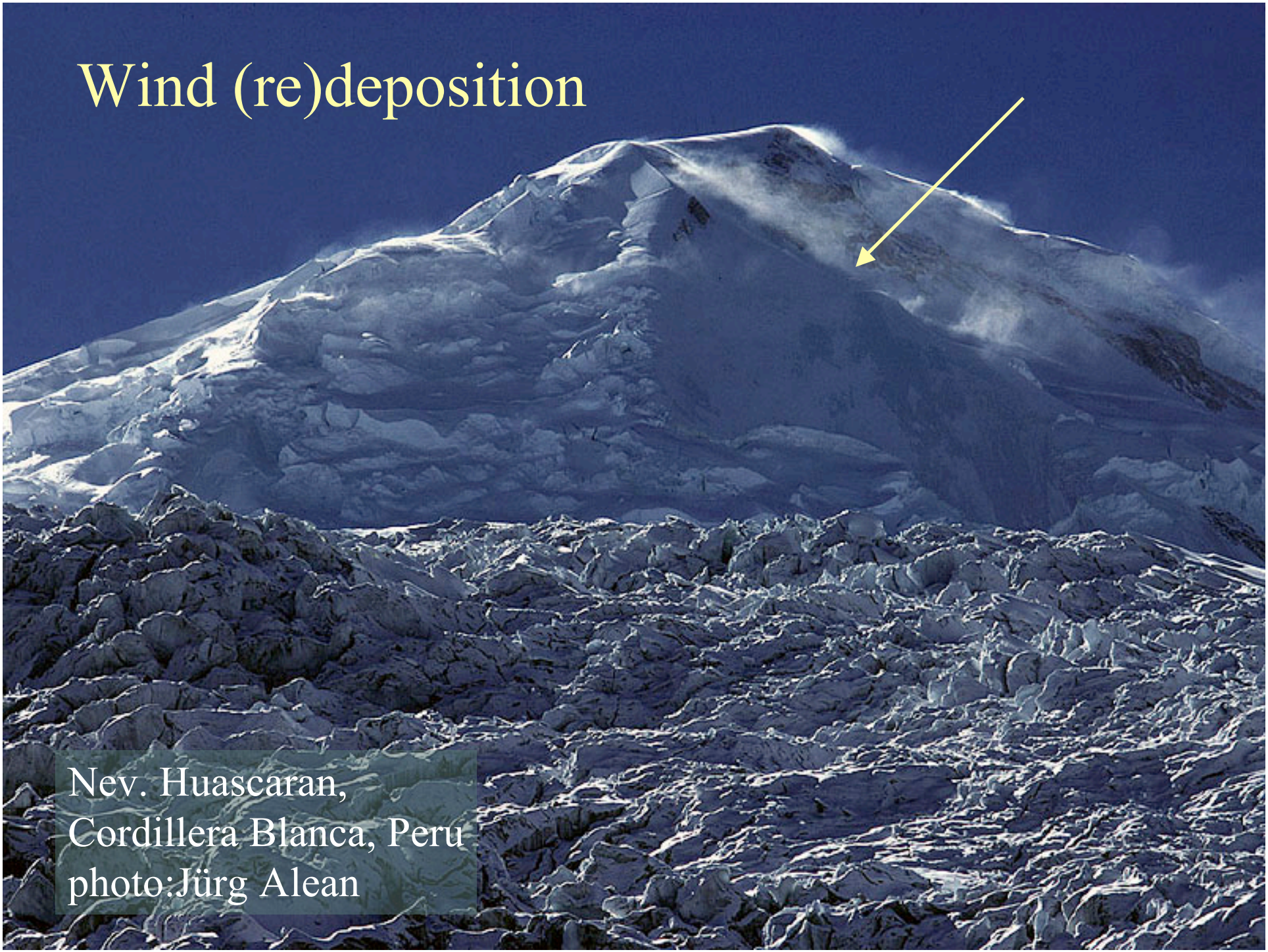
The glacier story:
1. glacier growth

Accumulation:

- snowfall
- avalanches : e.g. Karakoram, Andes
- wind re-deposition
- superimposed ice (rain freezing)


Avalanche-fed glaciers
Nev. Chacraraju,
Cordillera Blanca, Peru

Wind (re)deposition



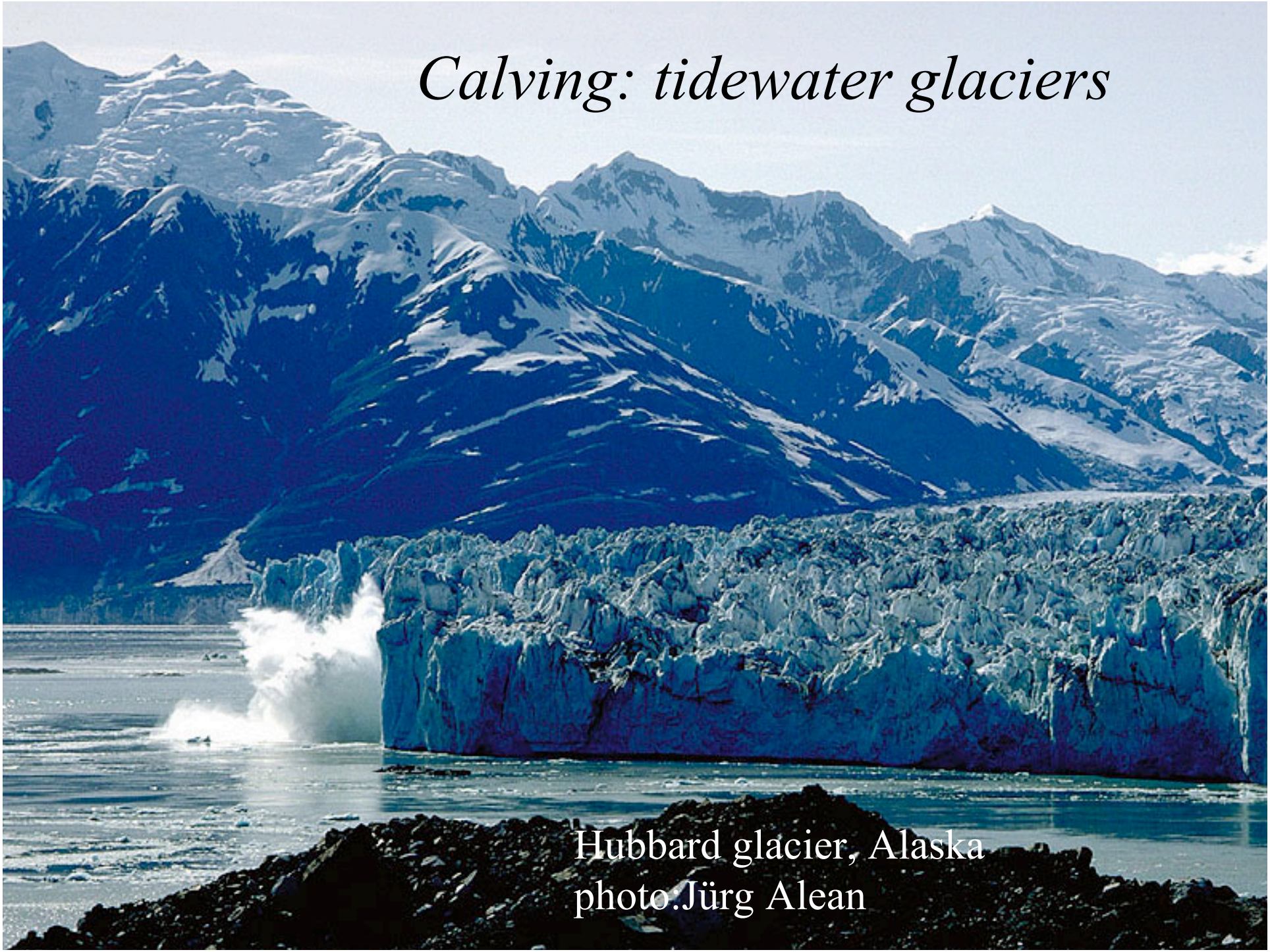
Nev. Huascaran,
Cordillera Blanca, Peru
photo:Jürg Alean

The glacier story (cont'd): 2. glacier decay

Ablation:

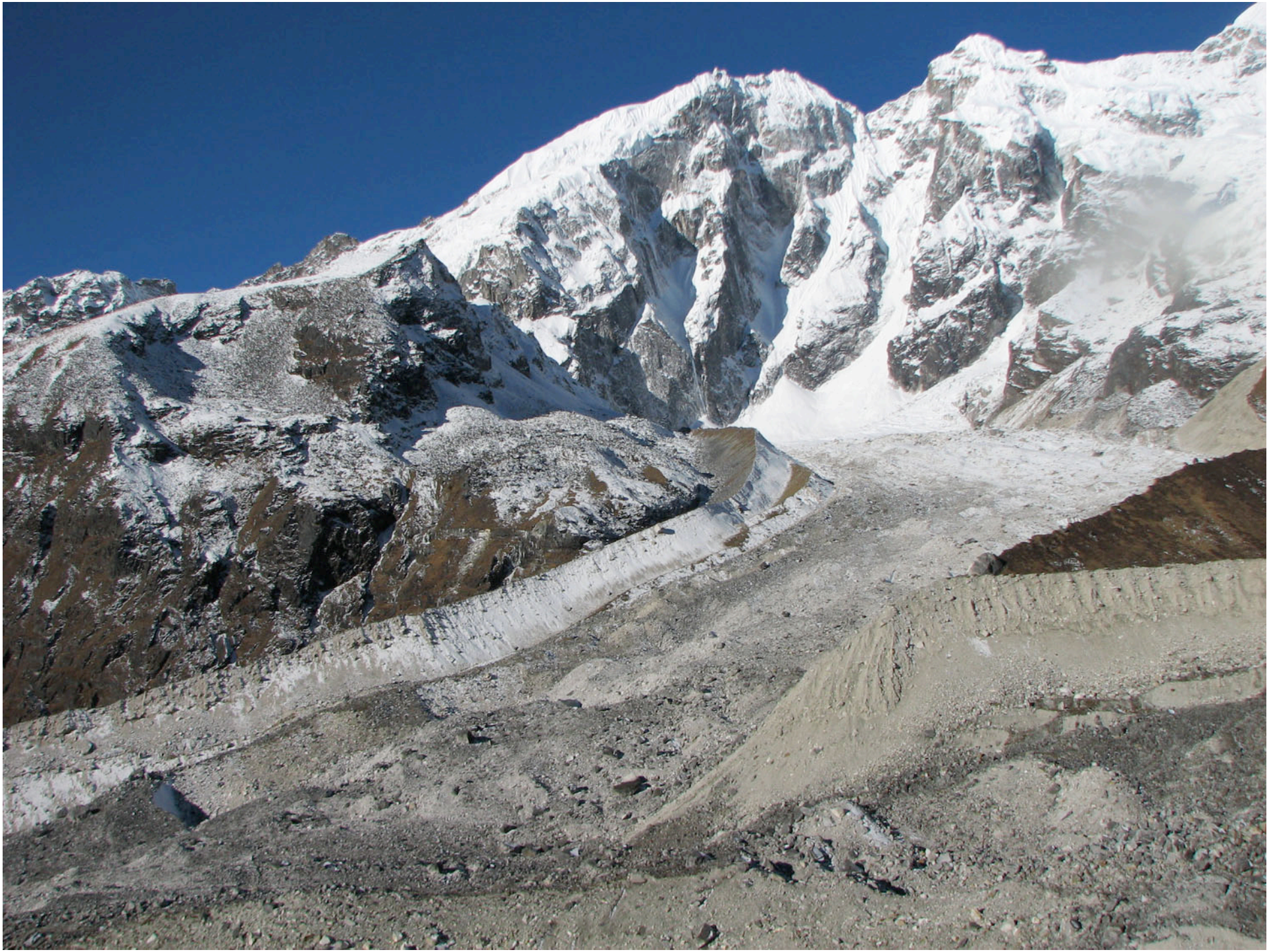
- melting
- evaporation/sublimation (only cold arid areas)
- calving
- wind erosion

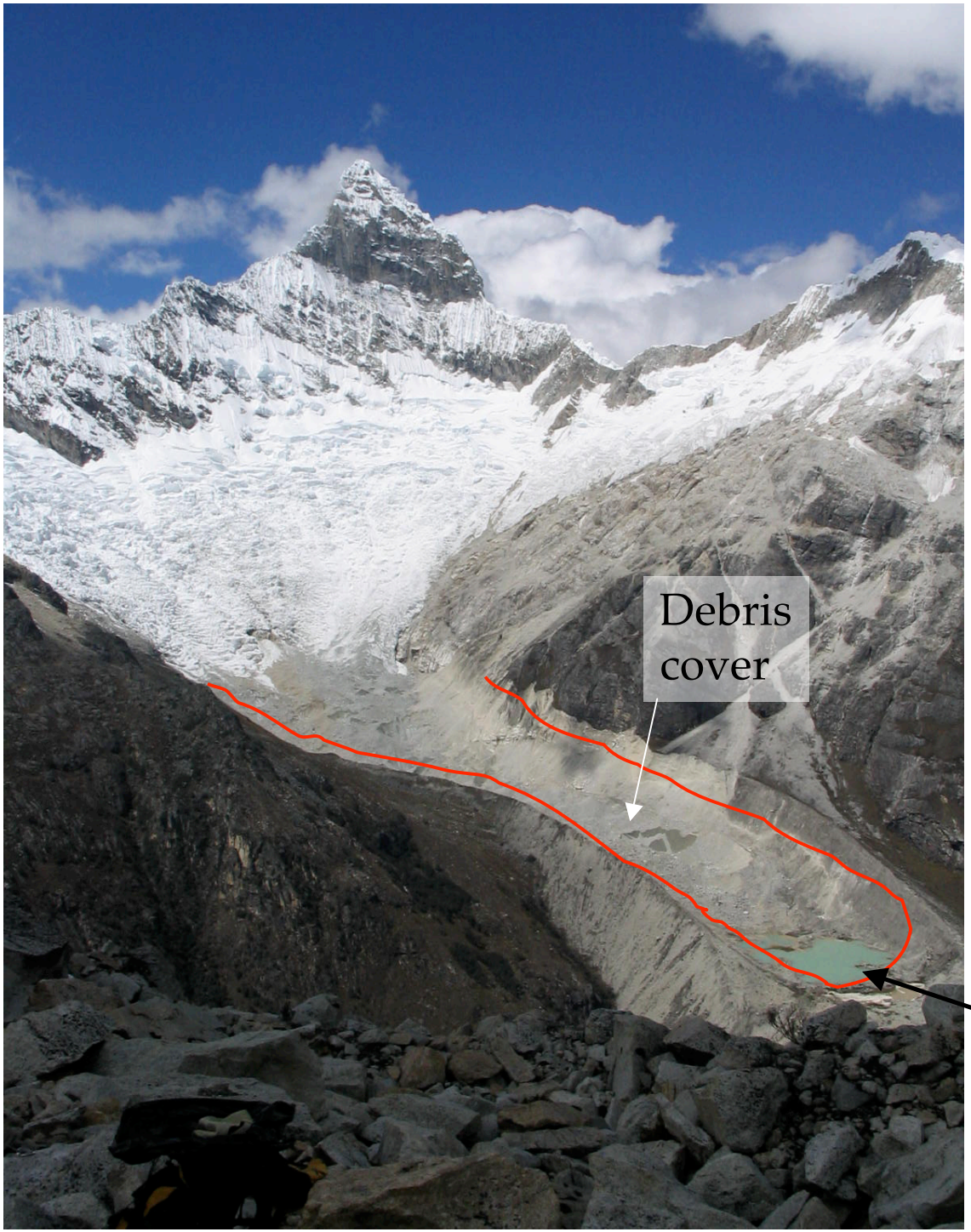
Calving: tidewater glaciers



Hubbard glacier, Alaska
photo:Jürg Alean

Glacier retreat- Qori Kalis glacier, Peru

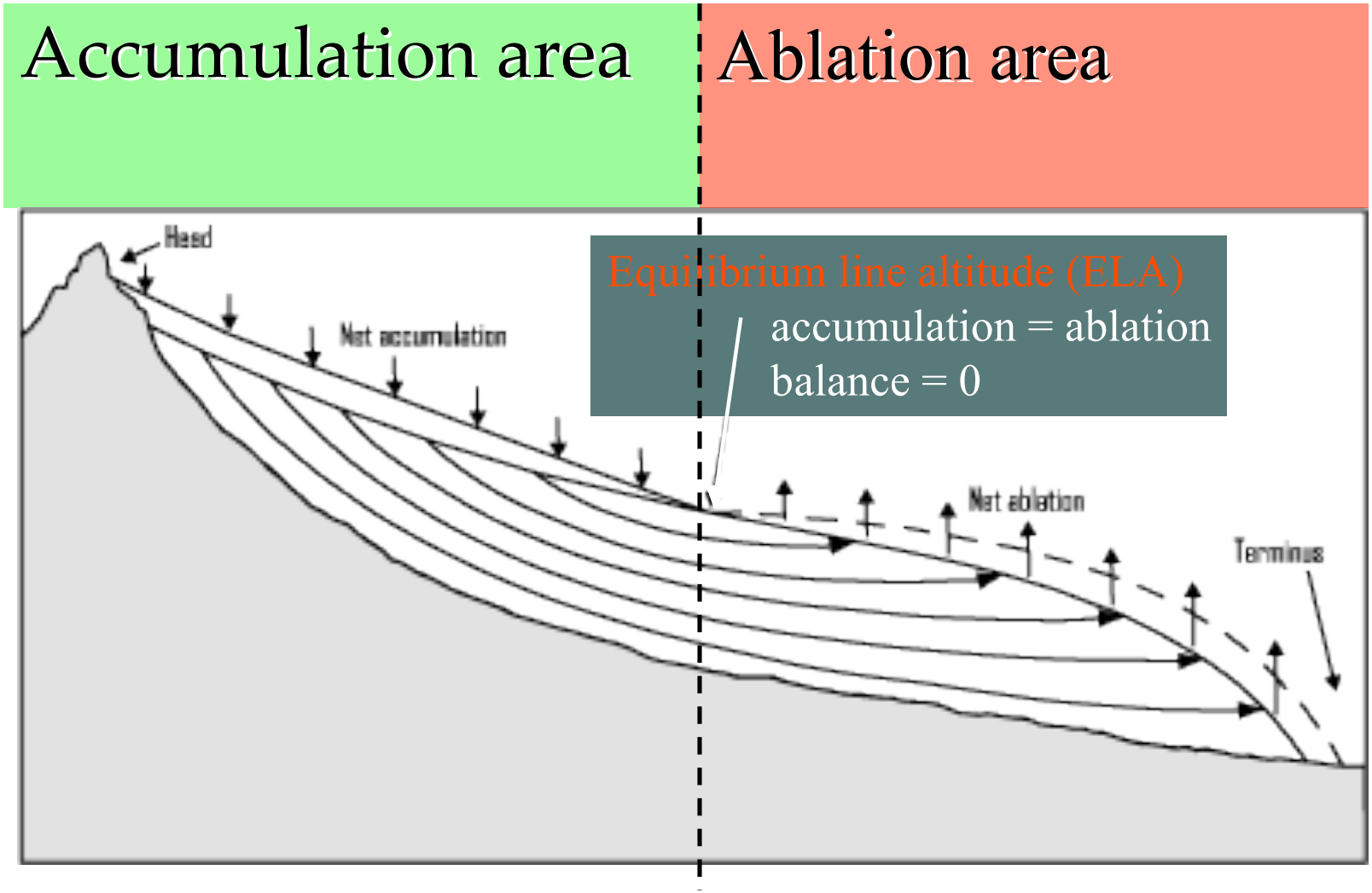




Effect of debris cover on ablation Rate ?

- **Thin debris**:
  - ➢ lower albedo
  - ➢ increased ablation
- **Thick debris**
  - ➢Sheltering effect
  - ➢Decreases ablation

Glacier Mass Balance



Glacier mass balance

=difference between accumulation and ablation

= most sensitive climate indicator of the health of a glacier

- Net balance (Bn): Bn = bw + bs
  - winter balance (bw) measured in April /May and
  - summer balance (bs) measured in September or early October.

- Annual balance: measured between 2 fixed dates each year

  Units: [m water equivalent /year]

Mass balance and climate

- NEGATIVE: glacier losses mass →in the long term, it *retreats*
- POSITIVE: glacier gains mass → in the long term, it *advances*
- ZERO MASS BALANCE:
  - Terminus is stationary
  - no change in glacier mass, volume
  - Glacier is in equilibrium

BUT ICE STILL MOVING FORWARD!!!

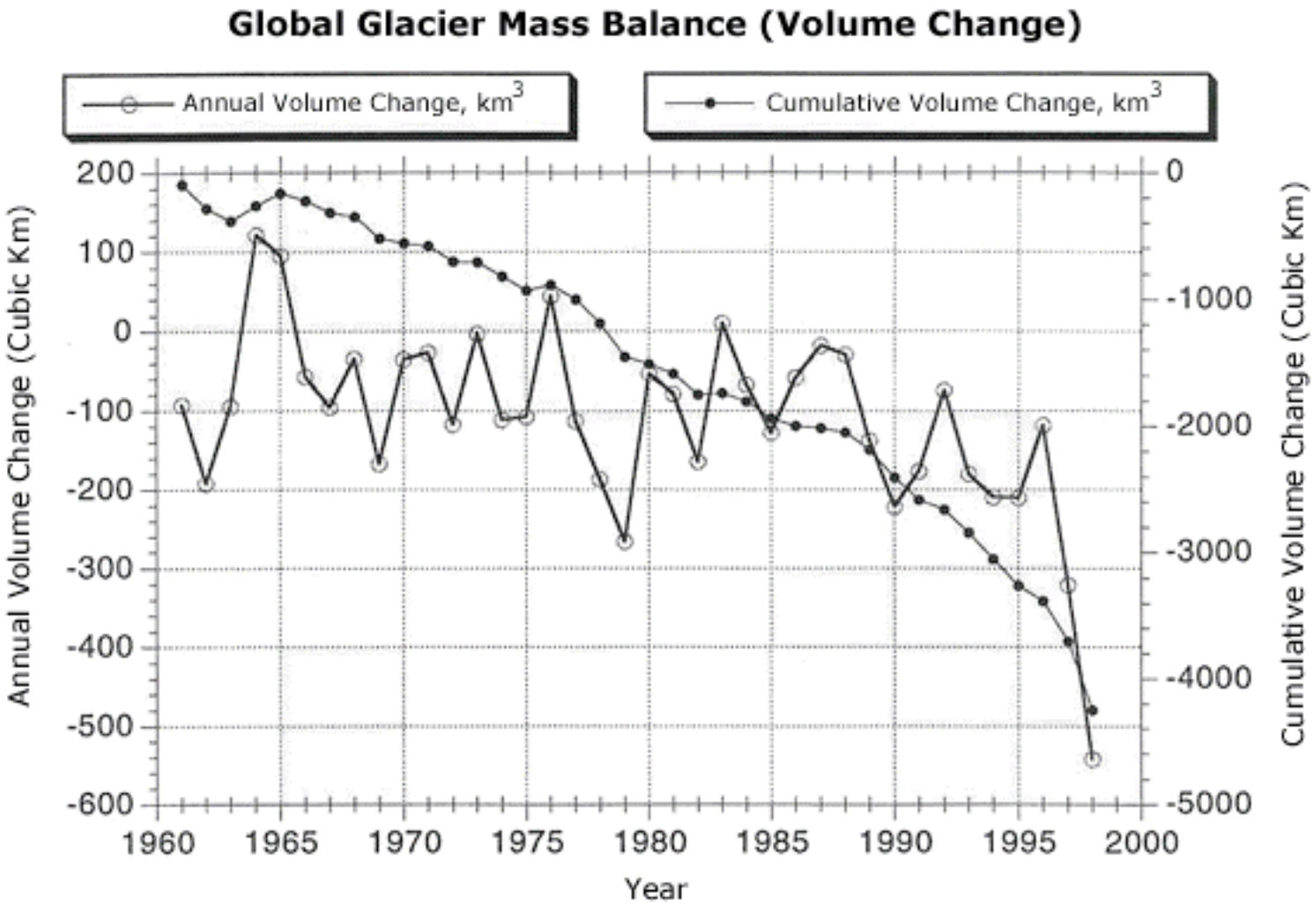
Mass balance – climate relationship

Mass balance is a function of:

- Summer Temperature and solar radiation:
  - Higher temperatures can cause glaciers to melt but the relationship is not straightforward
- Winter Precipitation and temperature:
  - Amount/type of moisture
  - Timing of snowfall

<u>Antarctica example:</u>

- higher temperature-->more evaporation from ocean
- warmer air ->air holds more water vapor ->
  more snowfall --> glaciers will grow!!!!

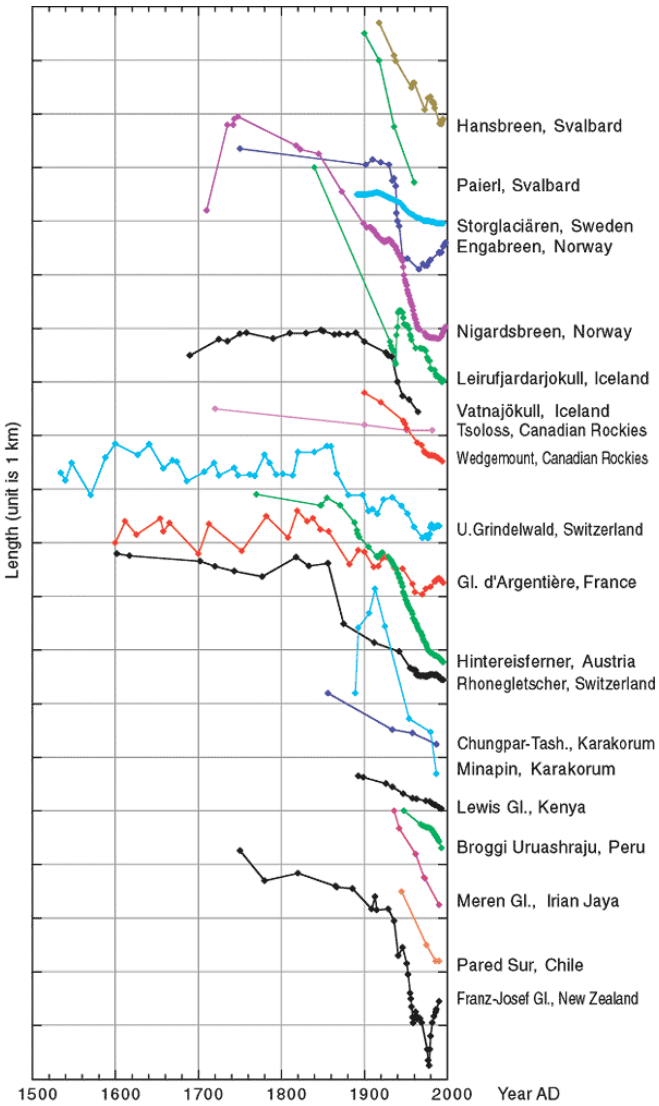

Global Glacier Mass Balance (Volume Change)
Annual Volume Change, km3
Cumulative Volume Change, km3
Annual Volume Change (Cubic Km)
Cumulative Volume Change (Cubic Km)
200
100
0
-100
-200
-300
-400
-500
-600
0
-1000
-2000
-3000
-4000
-5000
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

Equilibrium line altitude

Where is the ELA?

ELA response to climate

- Positive Mass Balance -- ELA lower
  - Glacier gets bigger or advances
- Negative Mass Balance -- ELA higher
  - Glacier gets smaller or retreats



Glacier terminus behavior

- General retreat since 1900's
- Signal is synchronous worldwide
- Response times of glacier lengths:
  10 - 100 years (mountain glaciers)
  1,000 – 10,000 years (ice sheets)
- Smaller glaciers respond faster to changes in climate → more sensitive

IPCC (1990)

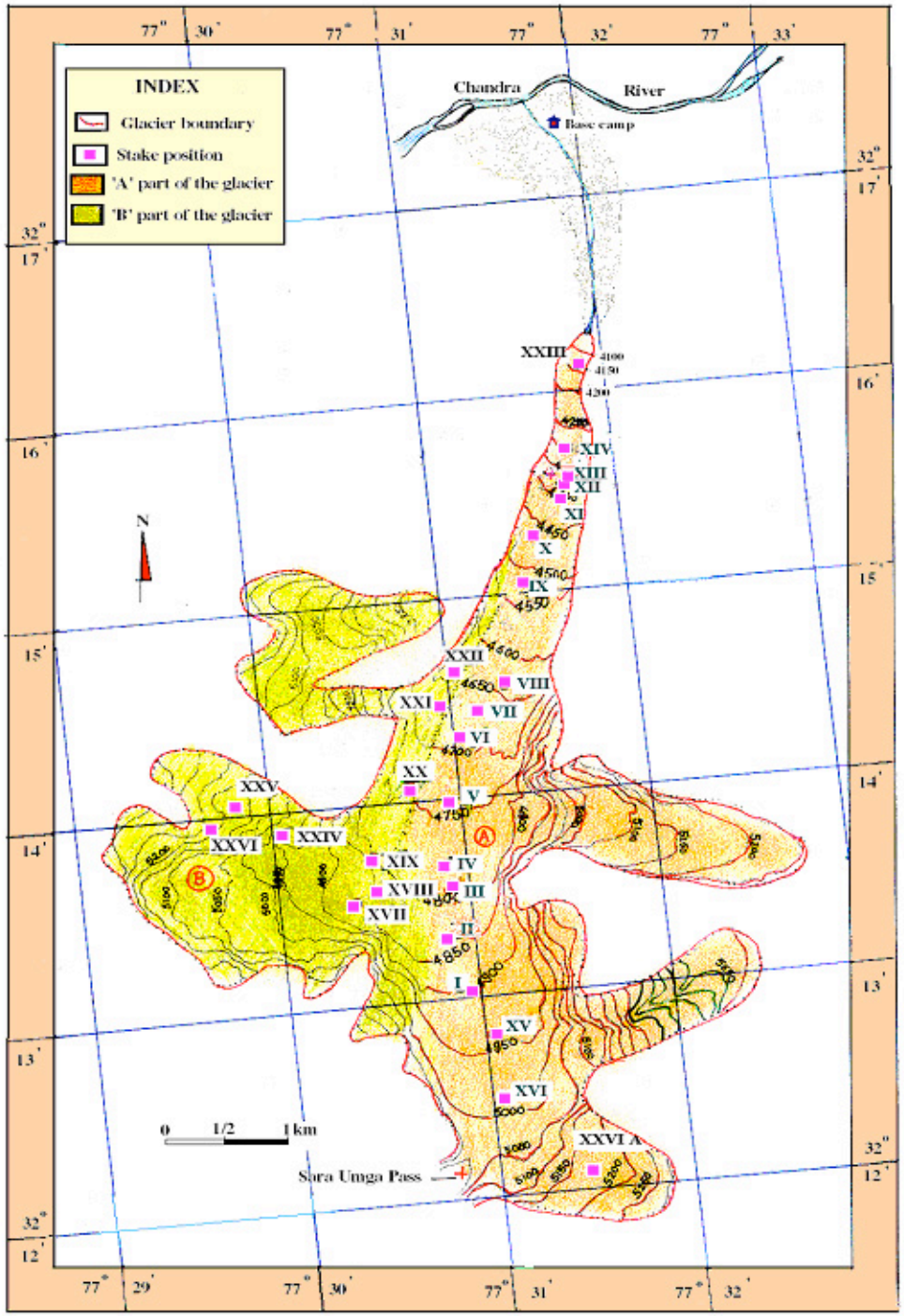
Glacier response -summary

- Most alpine glaciers and ice caps expected to retreat under global warming scenarios

- NOTE: Antarctica glaciers expected to grow due to possible increase in precipitation

Glacier mass-balance monitoring methods:

- Hydrologic
- Glaciologic (field-based)
- Geodetic (remote sensing)



1) Traditional glaciologic method

- *"stakes and pits"*
- limited application in remote areas
- Data from Hindu-Kush and Himalayas missing from long-term records

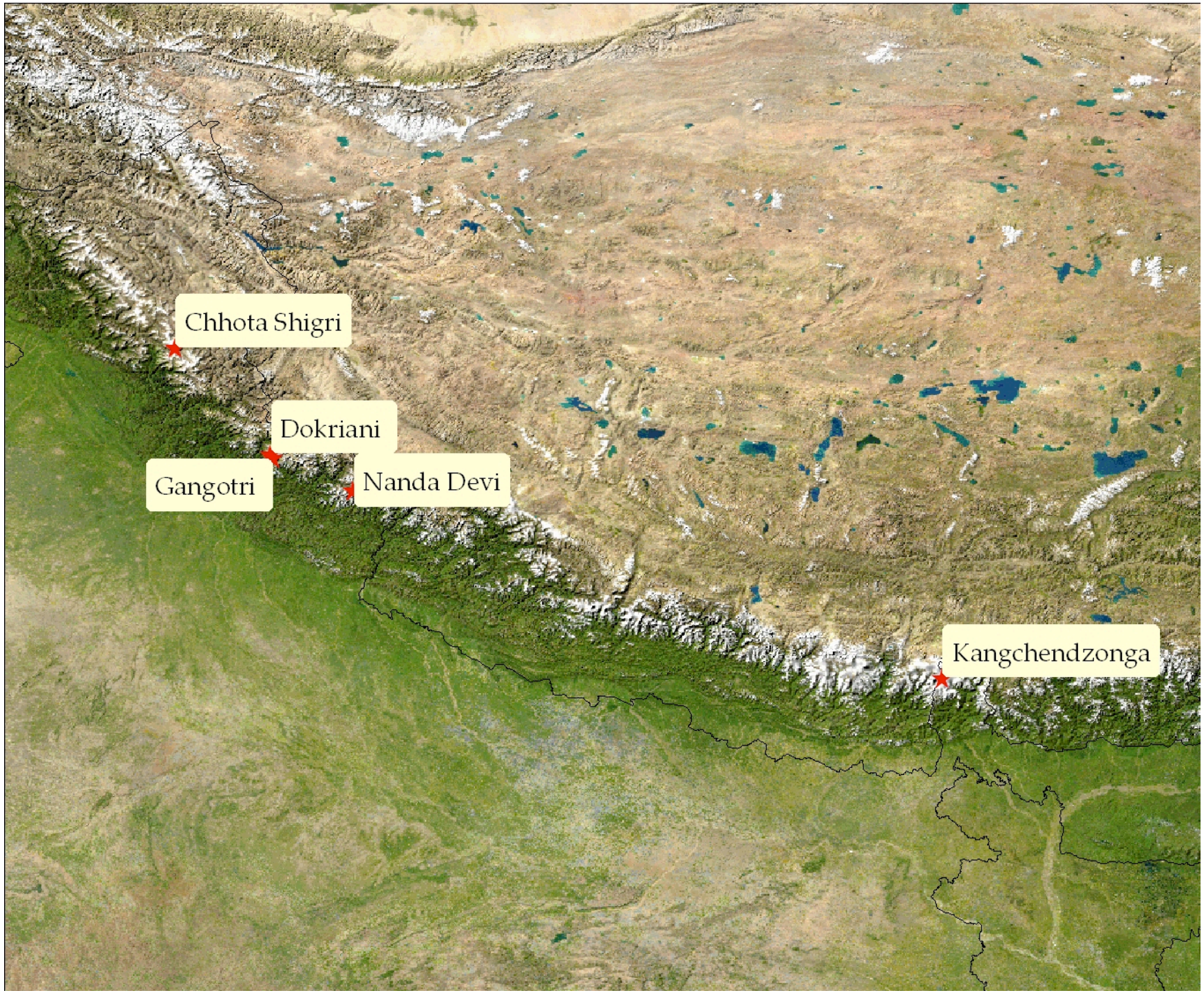
Chhota Shigri, India

Meteorological stations installed on glacier

Artesonraju glacier (Peru)
meteorological station, june 2004

- air temperature
- radiation
- wind


Chhota Shigri mass-balance
expedition, Sept. 23 – Oct 1st
IRD France, UR GREAT ICE

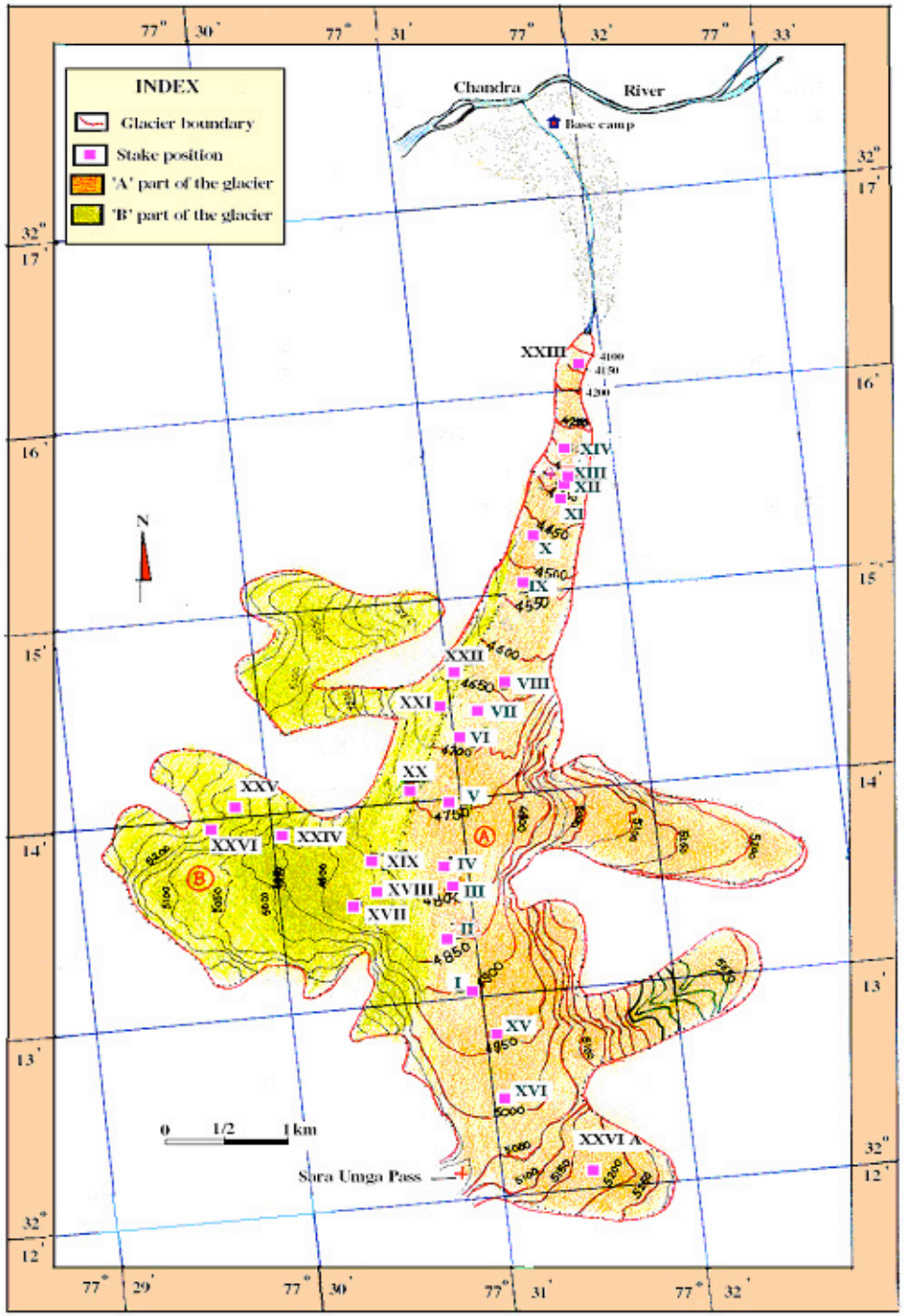

Chhota Shigri
Dokriani
Gangotri
Nanda Devi
Kangchendzonga


Choudharys
DL 7CC 6474

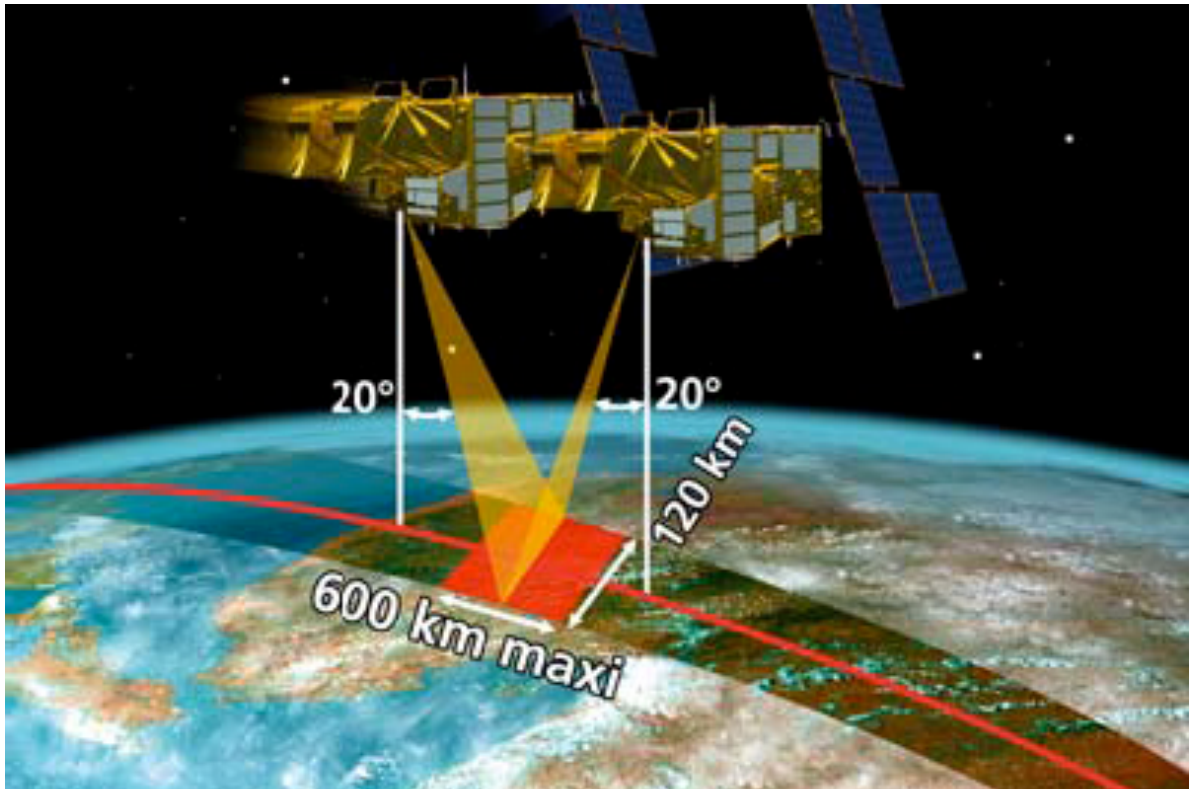

Steam driller


Bamboo stakes


SFS - LYS
CATBUS

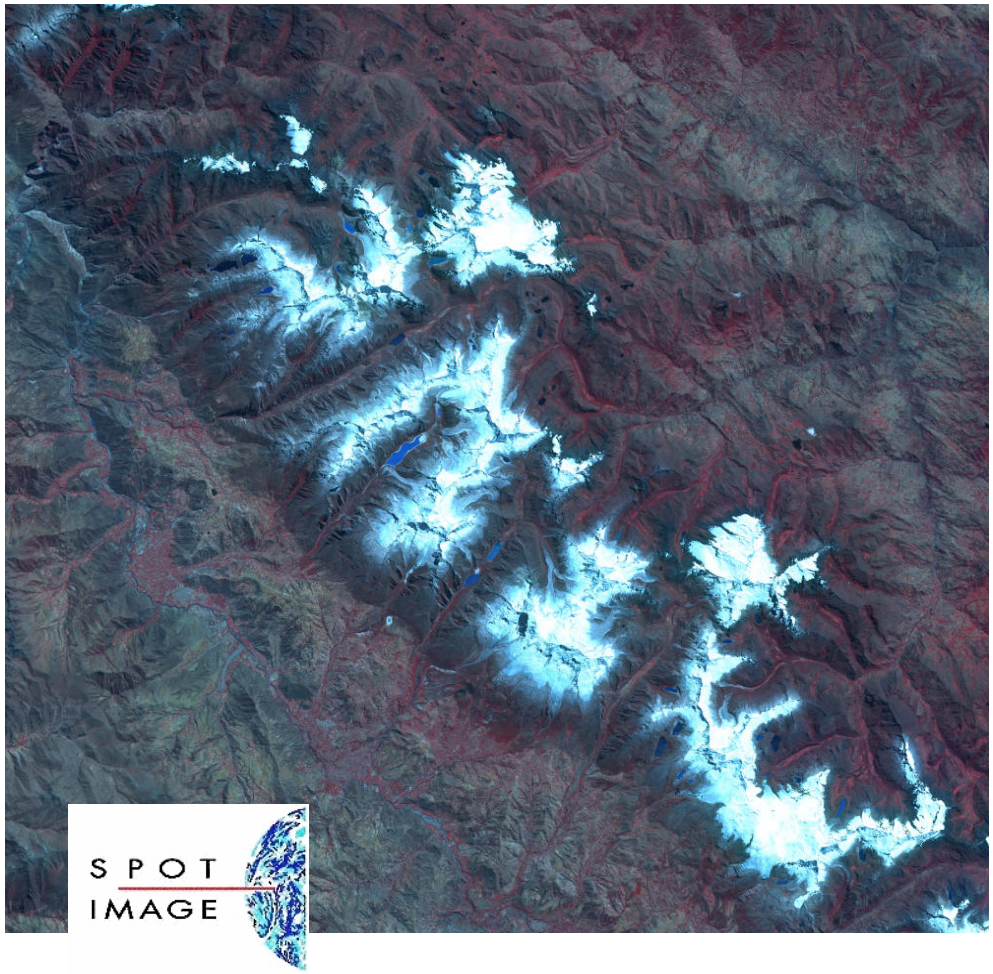

INDEX
Glacier boundary
Stake position
'A' part of the glacier
'B' part of the glacier
Chandra River
Base camp
N
0 1/2 1 km
Sura Umga Pass
77° 30' 77° 31' 77° 32' 77° 33'
32° 17'
32° 16'
32° 15'
32° 14'
32° 13'
32° 12'
77° 29' 77° 30' 77° 31' 77° 32'
XXIII
XIV
XIII
XII
XI
X
IX
XXII
VIII
XXI
VII
VI
XX
V
XXV
XXVI
XXIV
XIX
IV
XVIII
III
XVII
II
I
XV
XVI
XXVI A
A
B

2. Geodetic methods: New tools for mass-balance monitoring



HRS (High Resolution Stereoscopic) instrument has the capability to acquire two images simultaneously

Advantages of remote sensing techniques



- glacier mapping over larger, inaccessible areas
- Elevation data derived from stereo imagery
- high spatial resolution (10 - 25 m)
- fast, inexpensive

Glacier parameters that can be measured from space

- Area
- Length
- Hypsometry
- Mass – balance (indirectly)
- Equilibrium line altitude (ELA) - estimated

Edit View Favorites Tools Help

ack Search Favorites Media

ess http://www.glims.org/ Go

GLIMS: Global Land Ice Measurements from Space

Using the World's Glaciers to Monitor Climate Change

- HOME
- ABOUT GLIMS
- HAZARDS
- MONITORING
- GLOBAL CHANGE
- OTHER APPLICATIONS
- MAPS & DOCS
- NEWS
- SOFTWARE

Search

Search

Help

GLIMS*(Global Land Ice Measurements from Space)* is a project designed to monitor the world's glaciers primarily using data from the ASTER (Advanced Spaceborne Thermal Emission and reflection Radiometer) instrument aboard the EOS Terra spacecraft, launched in December, 1999.

"Glim" is an archaic Scottish term that means "a passing look; a glimpse; as much as is seen at a glance." In a future historical perspective, we may well look back on GLIMS and other early-21st Century remote-sensing of Earth's glaciers as a glim of a passing or changing phenomenon.

We are continuing to acquire an annual image (clouds permitting) of all the world's glaciers and to build the infrastructure for GLIMS:

- a set of software tools that we can apply to the tracking of glaciers'
  - areal extent

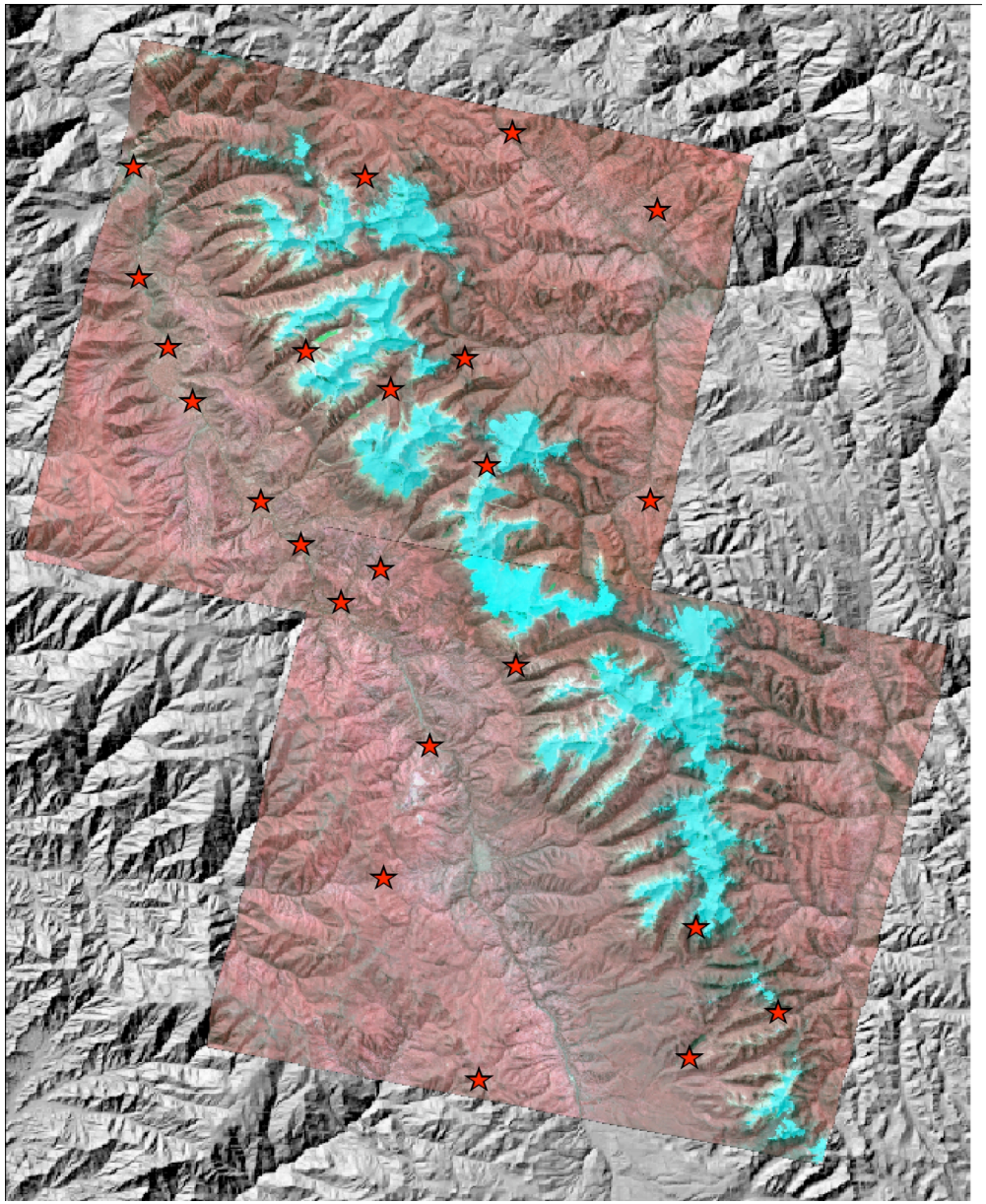
GANGOTRI GLACIER

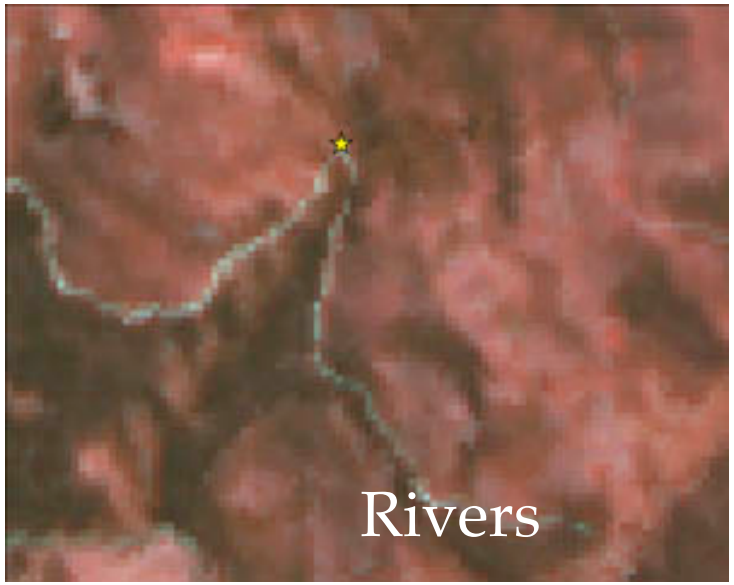
This composite ASTER image shows how the Gangotri Glacier terminus has retracted since 1780. Contour lines are approximate. (Image by Jesse Allen, Earth Observatory; based on data provided by the ASTER Science Team; glacier retreat boundaries courtesy the Land Processes Distributed Active Archive Center)

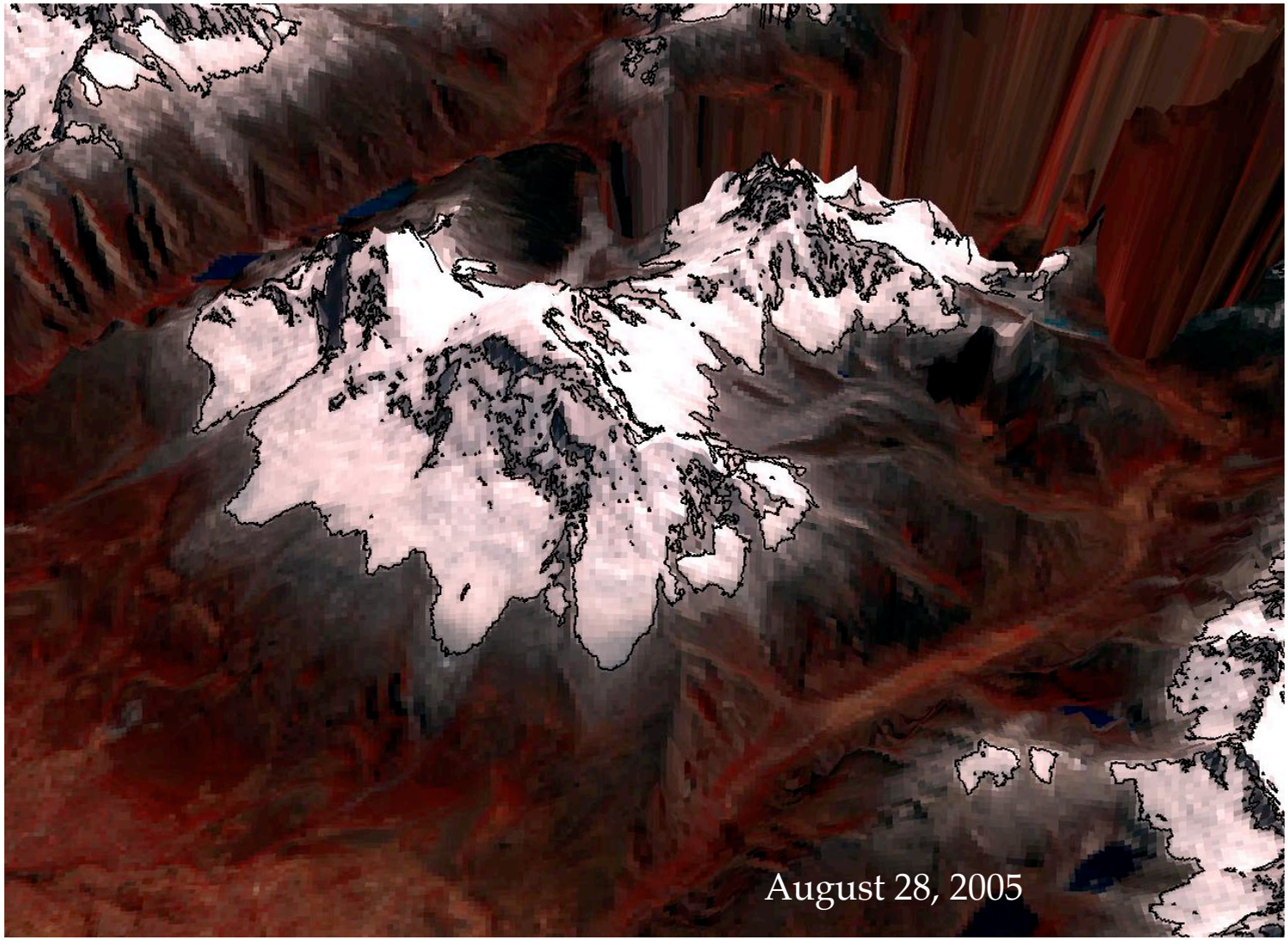
350 x 263, 53

tp://www.glims.org/GlobalChange/ Internet

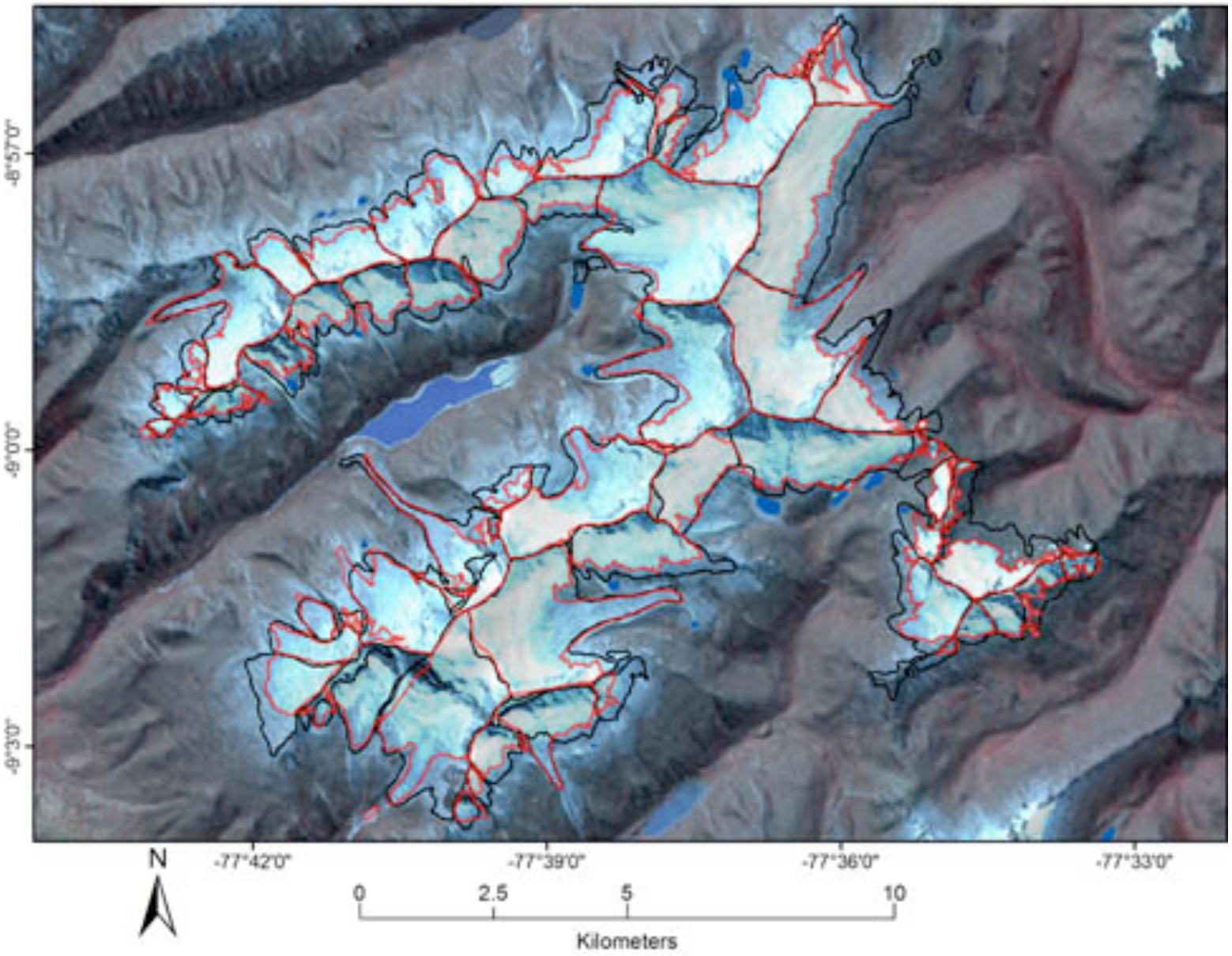
Ground Control Points (GCPs) collection






August 28, 2005

Glacier inventorying




Field validation