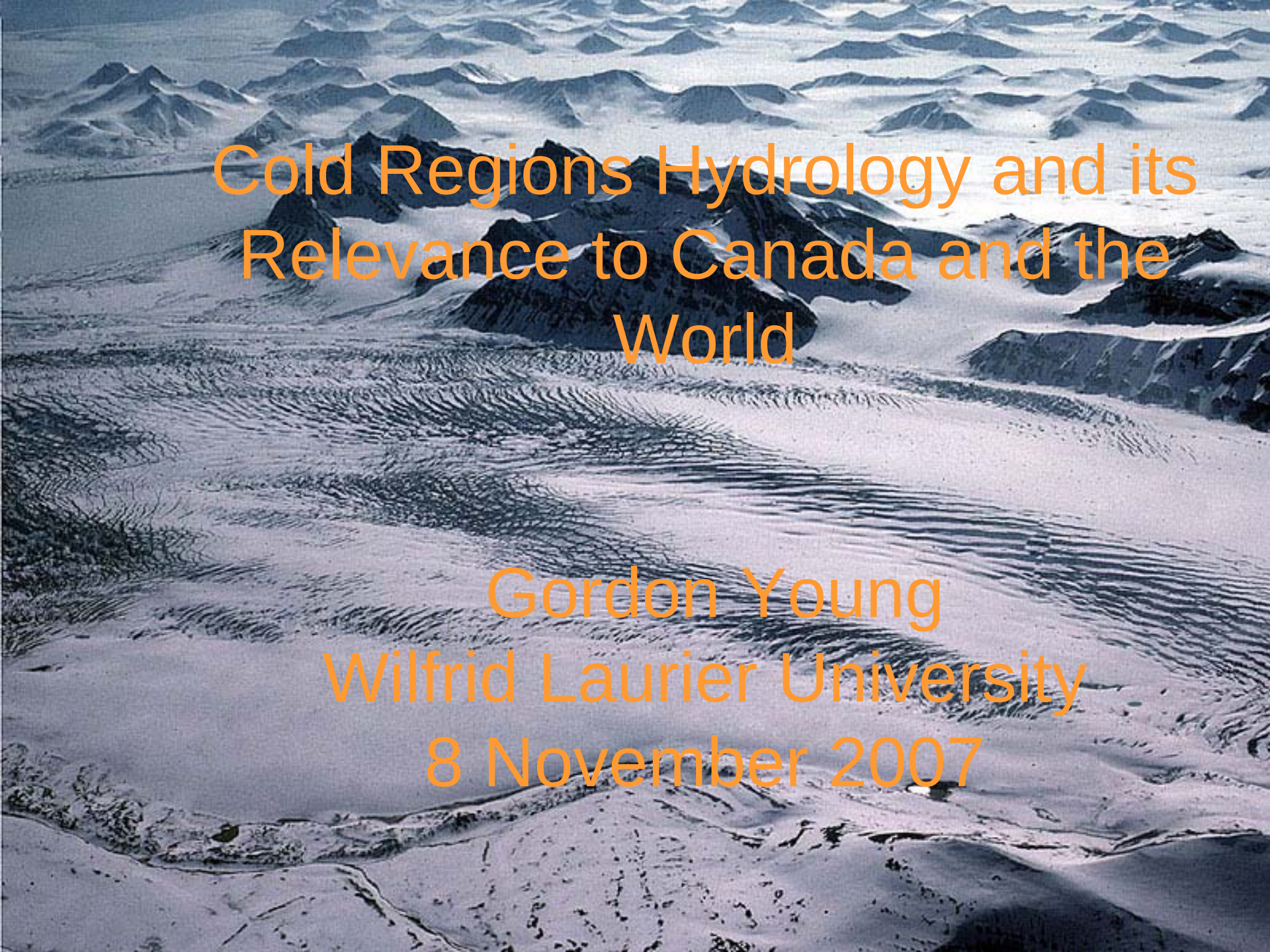


Cold Regions Hydrology and its Relevance to Canada and the World

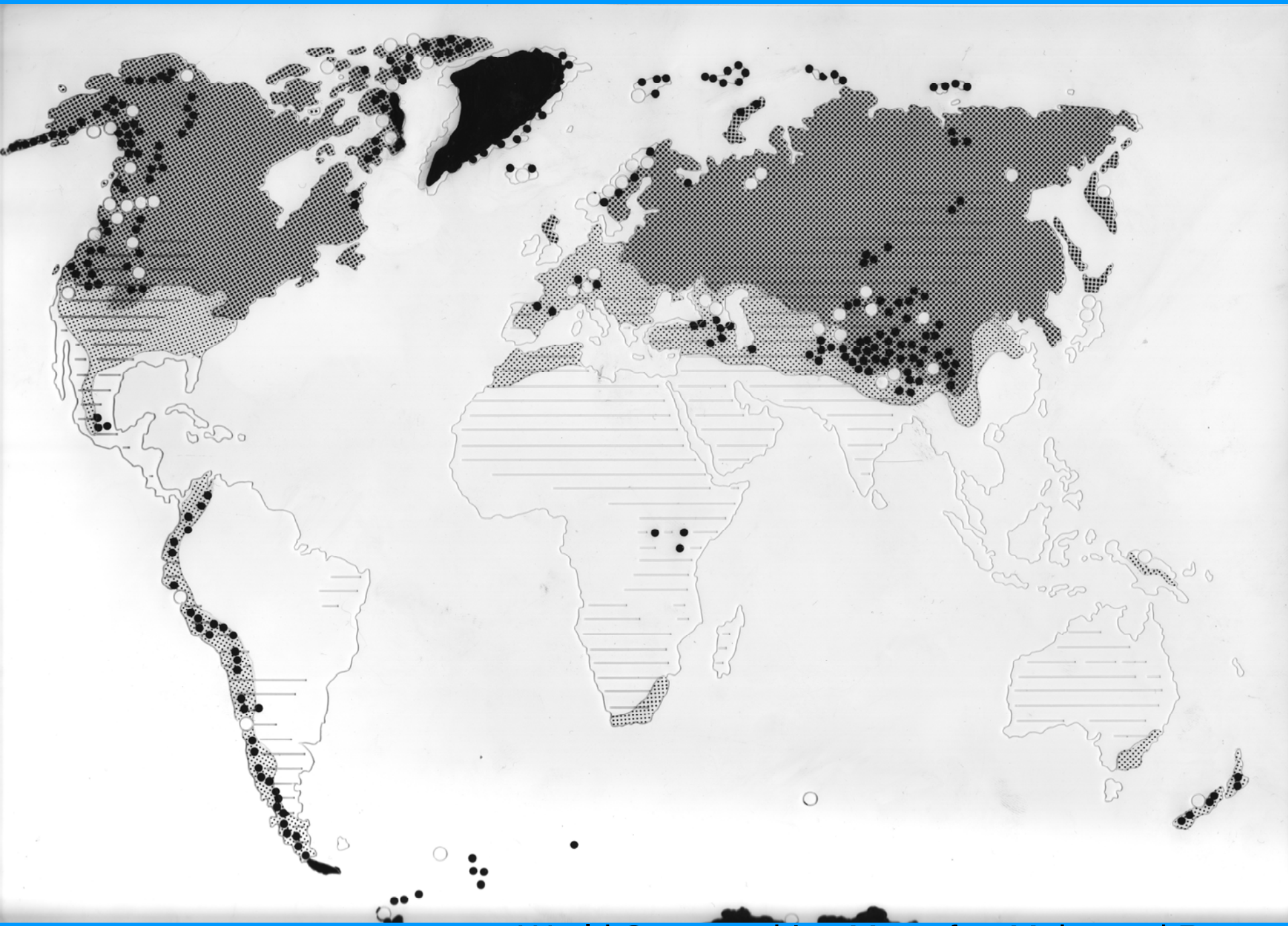
Gordon Young
Wilfrid Laurier University
8 November 2007

How to approach the subject:

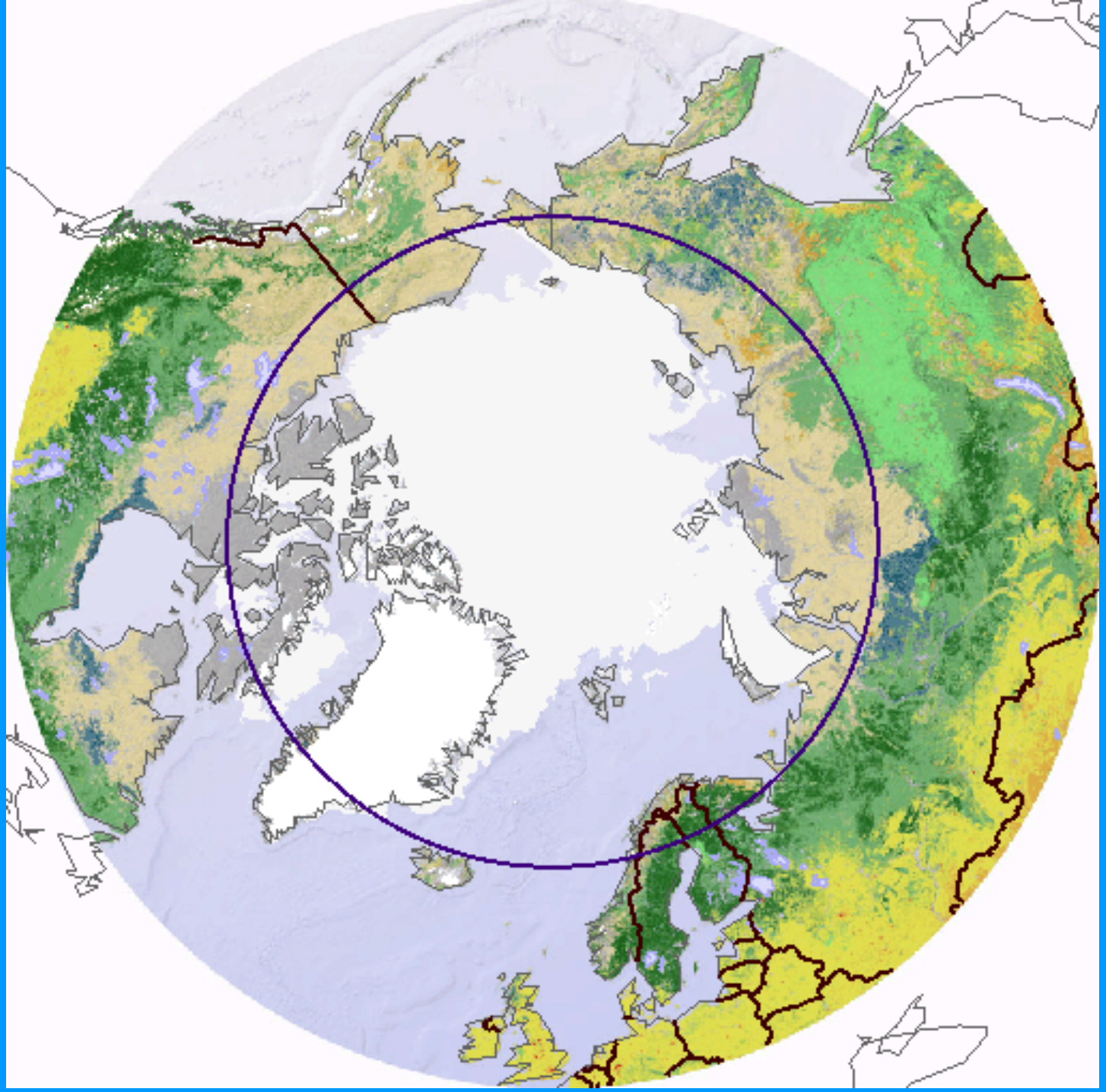
- Personal experiences
- The influence of Fritz Mueller on glaciology
- Historical perspective from 60’s on
- The influence of the International Hydrological Decade on Canadian hydrological research and on individuals
- Changes in technology:

  - Computing capabilities

  - Surveying and Remote sensing

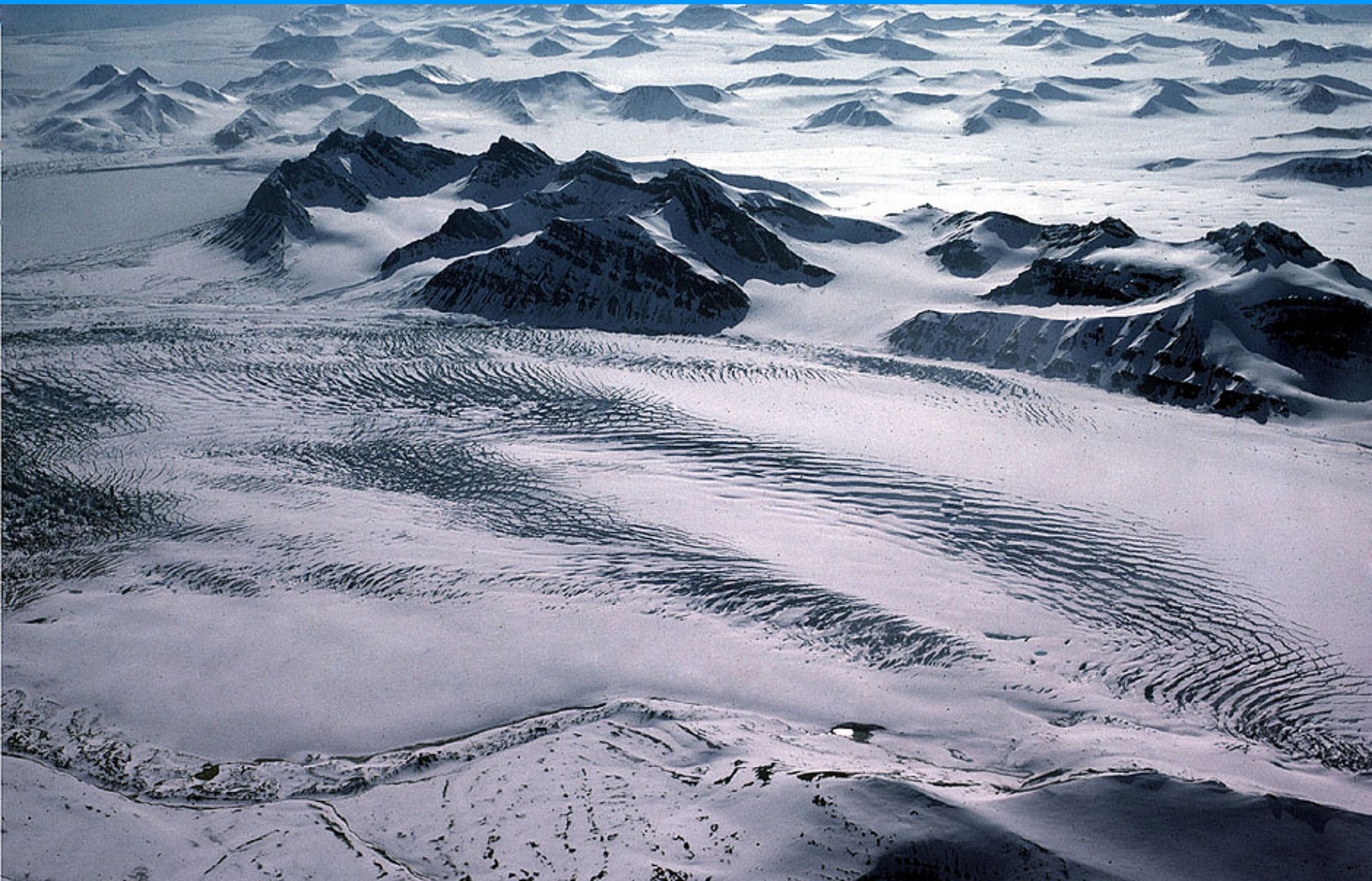


World Snow and Ice Map after Meier and Roots



Svalbard M Hambrey

Svalbard M Hambrey



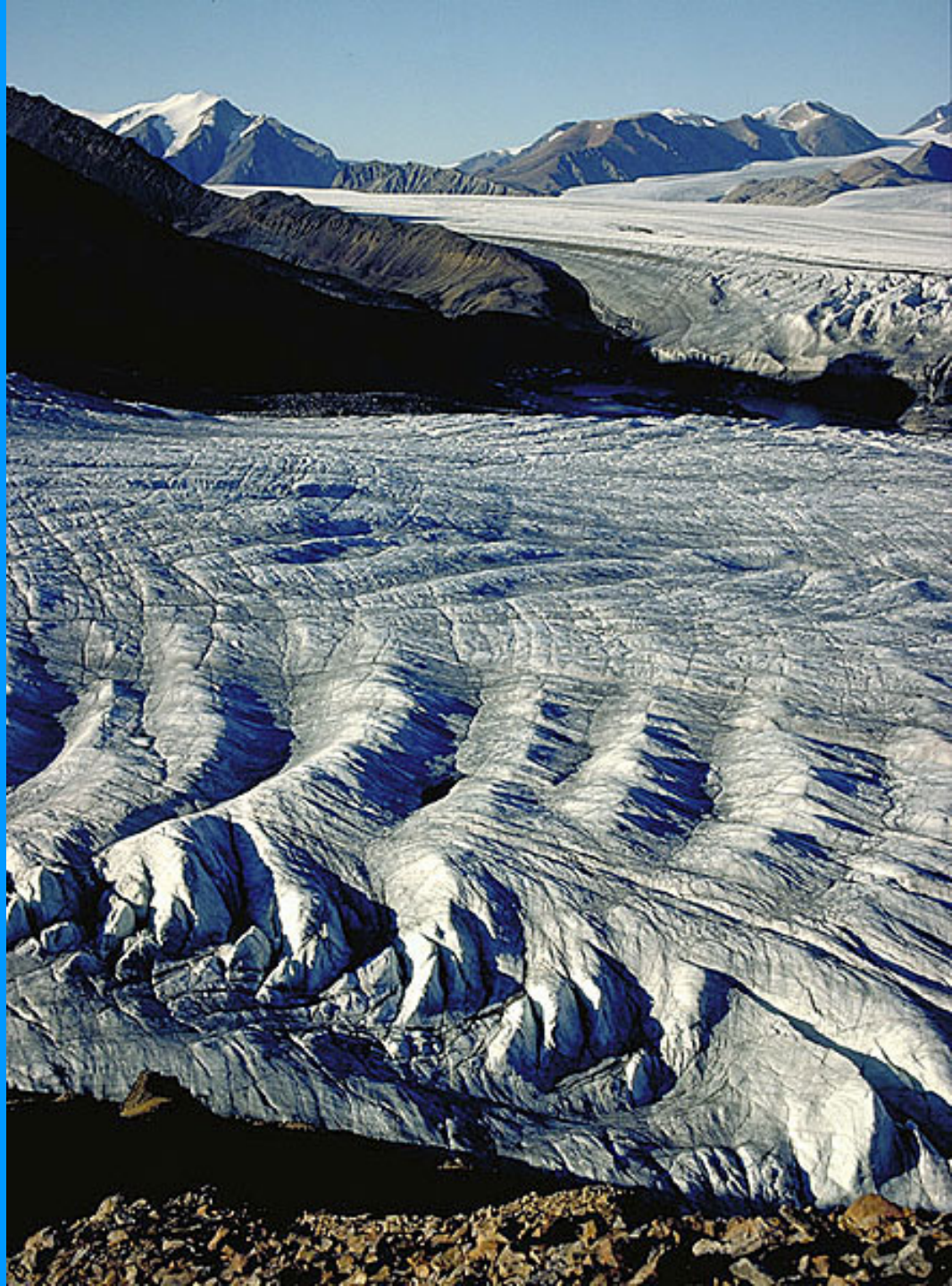
White Glacier Axel Heiberg M Hambrey

White and Thompson Glaciers Axel Heiberg J Alean

White and Thompson Glaciers

Axel Heiberg

J Alean

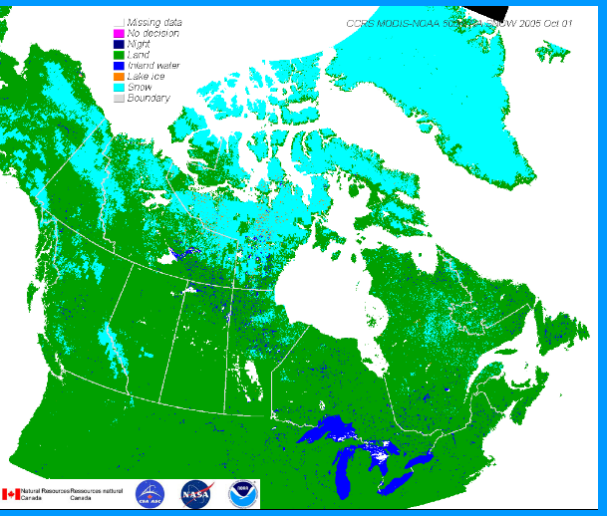


Between Lake, Axel Heiberg J Alean

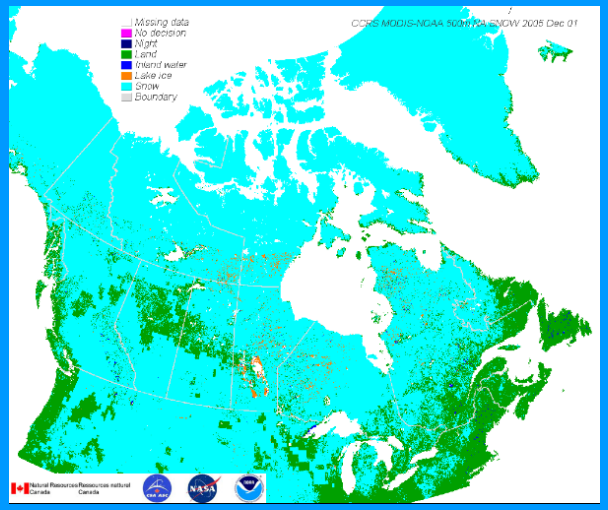
Between Lake, Axel Heiberg J Alean

Astro Lake, Axel Heiberg J Alean

Iceberg Glacier, Axel Heiberg



1 10 05



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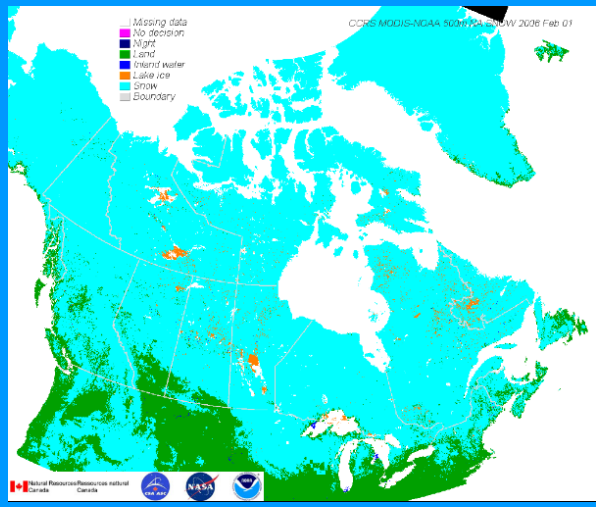

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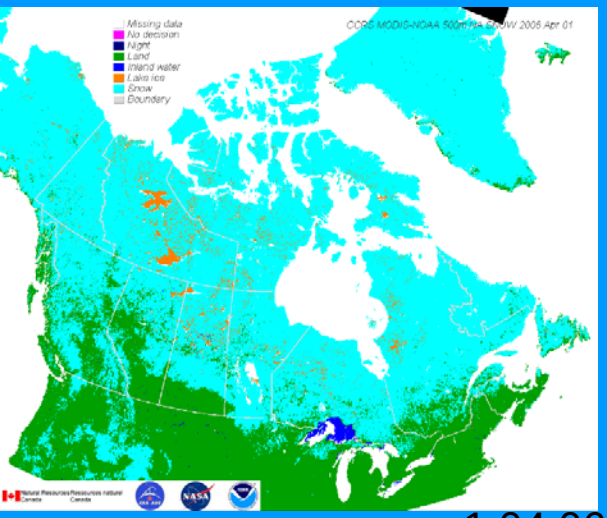

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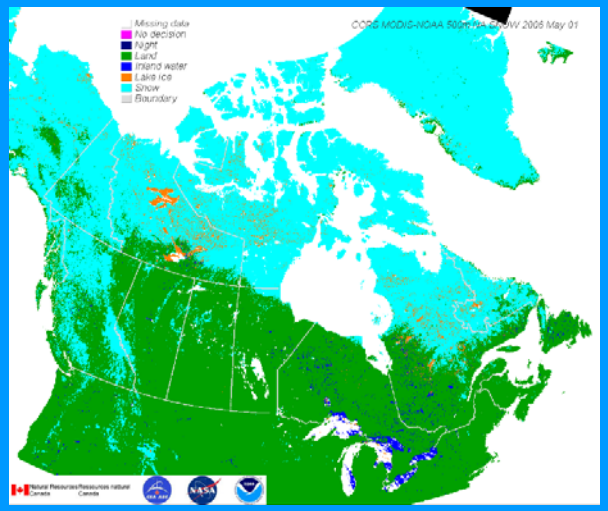
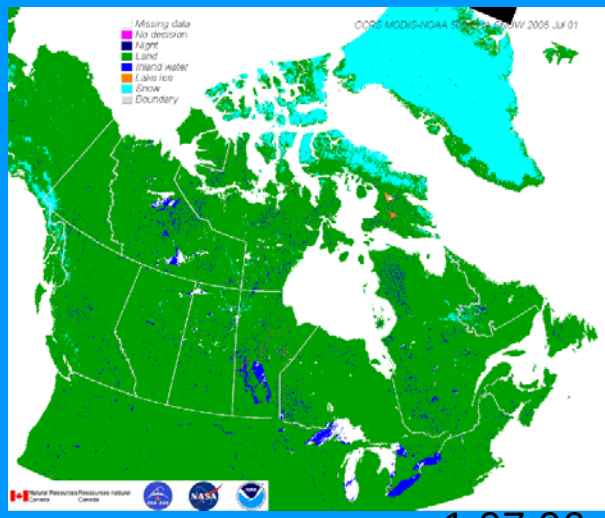


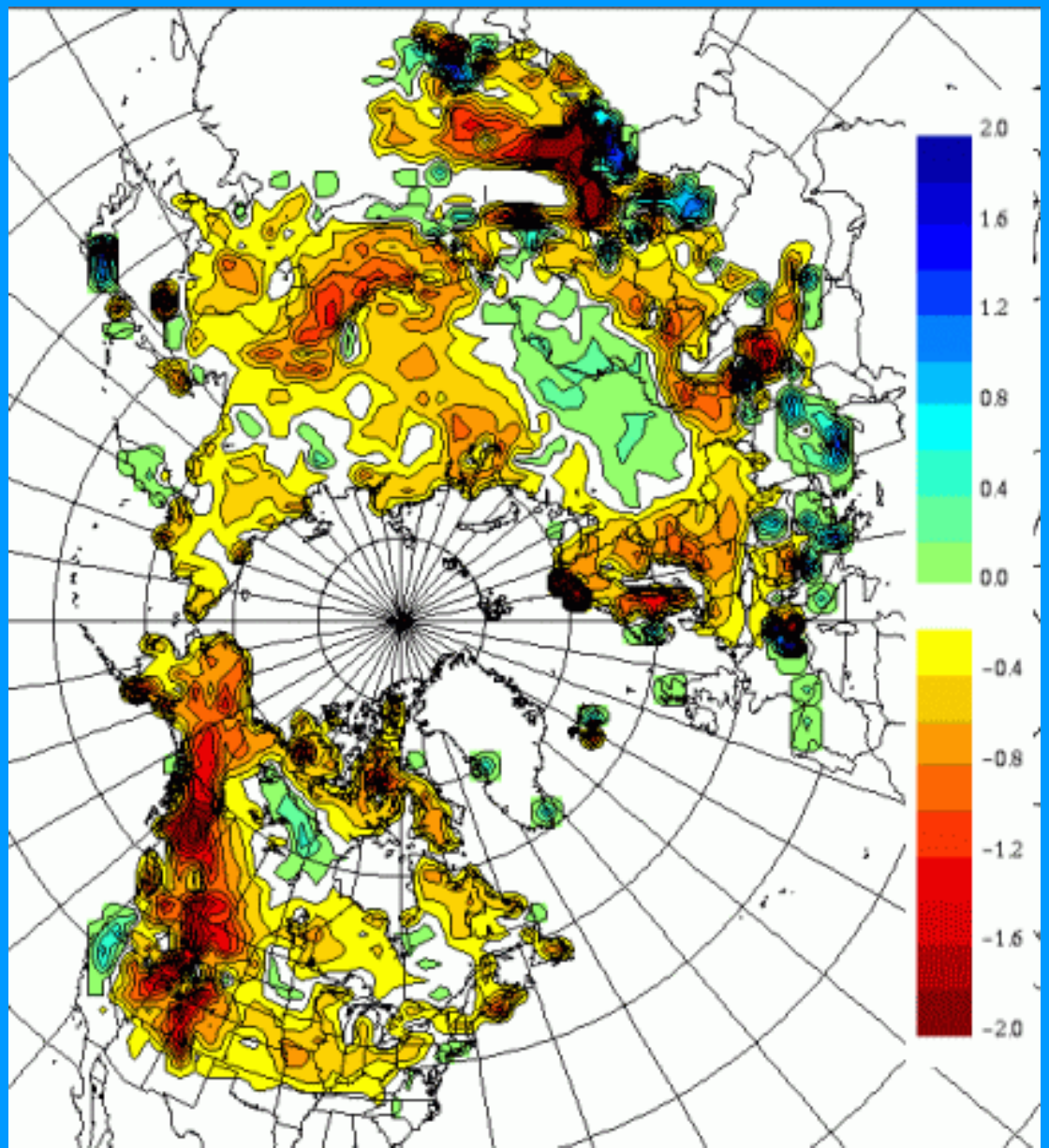
1 06 06



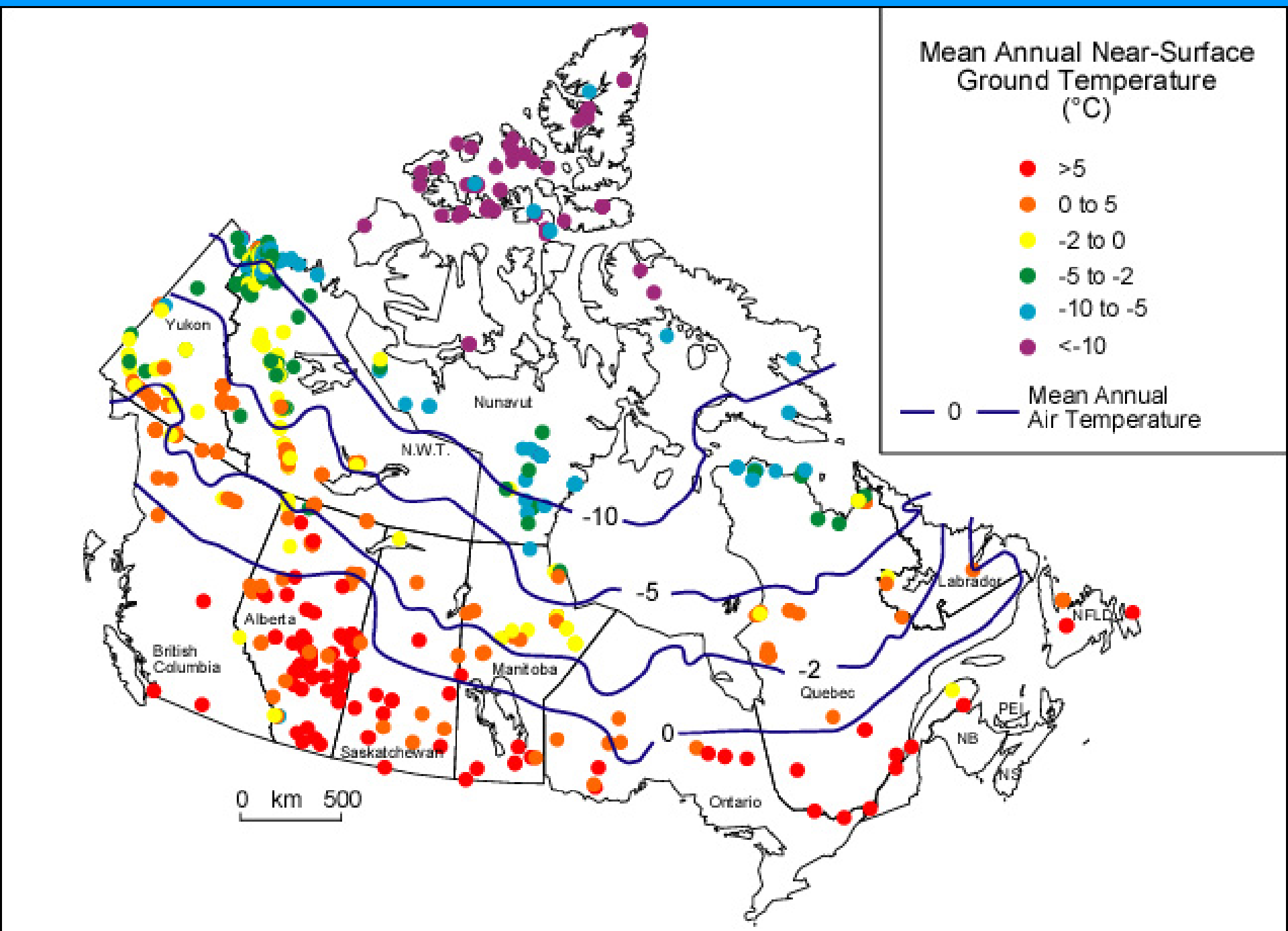
1 07 06

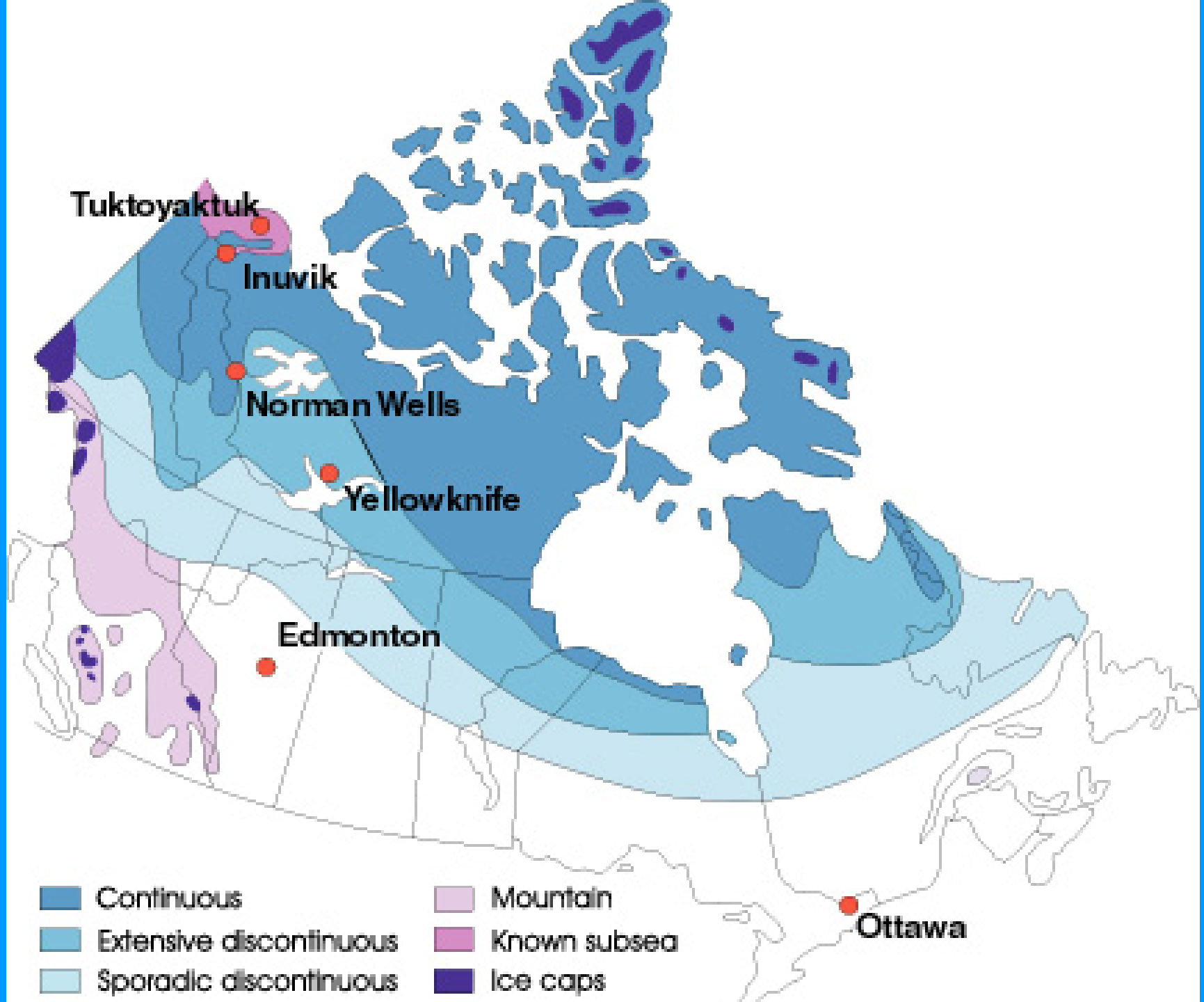
Lake ice break-up Churchill C Duguay

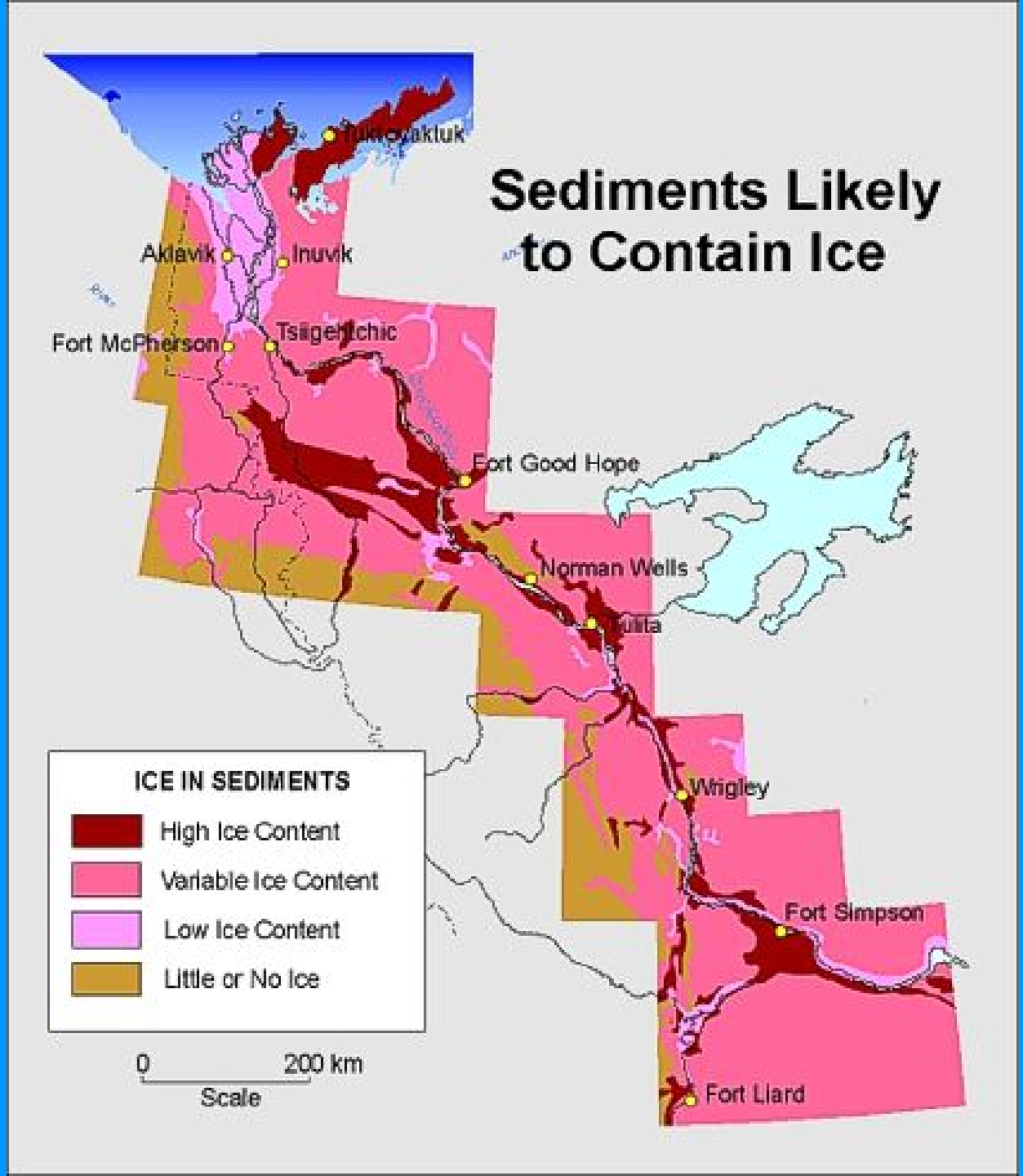
Average change (days/yr) in snow cover duration in the second half (Feb.-Jul.) of the snow year over the period 1972-2000. Derived from the NOAA weekly satellite snow cover dataset

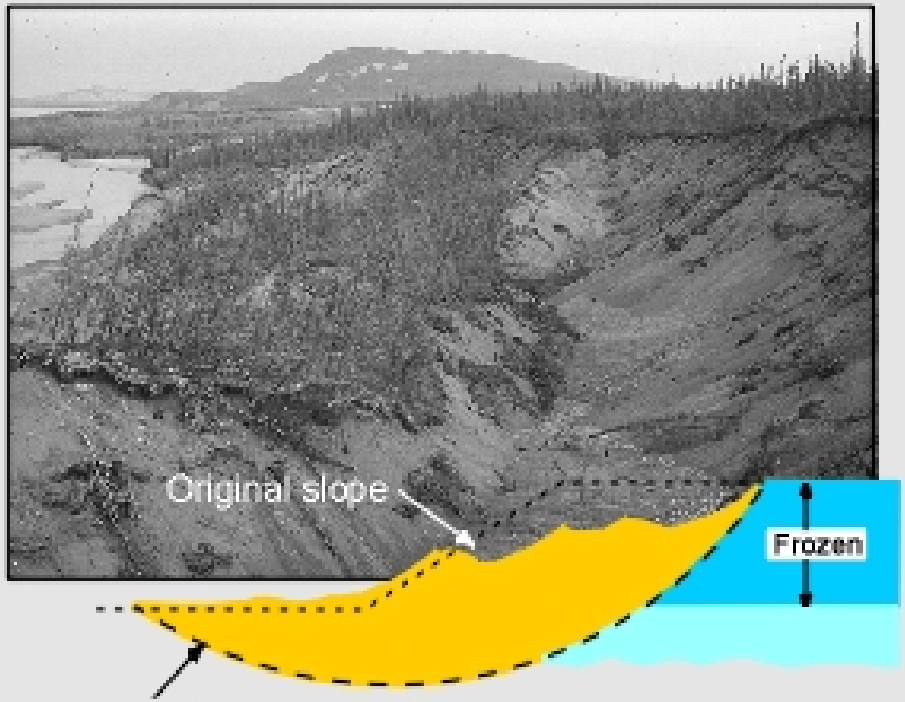


River ice jams; New Brunswick


Mean Annual Near-Surface Ground Temperature (°C)
>5
0 to 5
-2 to 0
-5 to -2
-10 to -5
<-10
0
Mean Annual Air Temperature
Yukon
Nunavut
N.W.T.
-10
-5
-2
0
Alberta
British Columbia
Saskatchewan
Manitoba
Ontario
Quebec
Labrador
NFLD
PEI
NB
NS
0 km 500

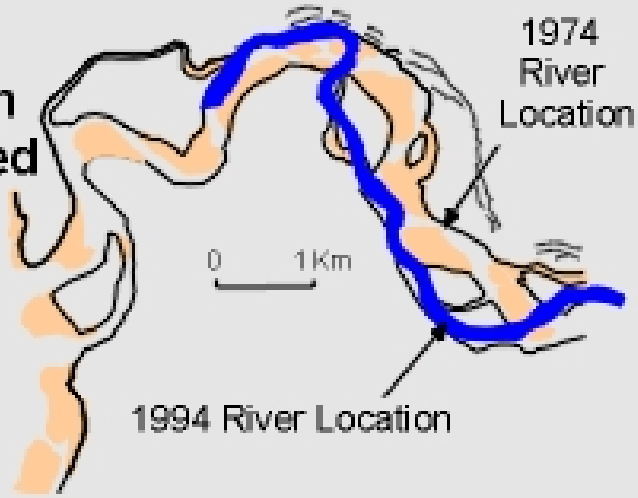

Tuktoyaktuk
Inuvik
Norman Wells
Yellowknife
Edmonton
Ottawa
Continuous
Extensive discontinuous
Sporadic discontinuous
Mountain
Known subsea
Ice caps


Sediments Likely to Contain Ice
Aklavik
Inuvik
Fort McPherson
Tsiigehtchic
Fort Good Hope
Norman Wells
Wrigley
Fort Simpson
Fort Liard
ICE IN SEDIMENTS
High Ice Content
Variable Ice Content
Low Ice Content
Little or No Ice
0
200 km
Scale



Circular failure surface defined by head scarp and toe

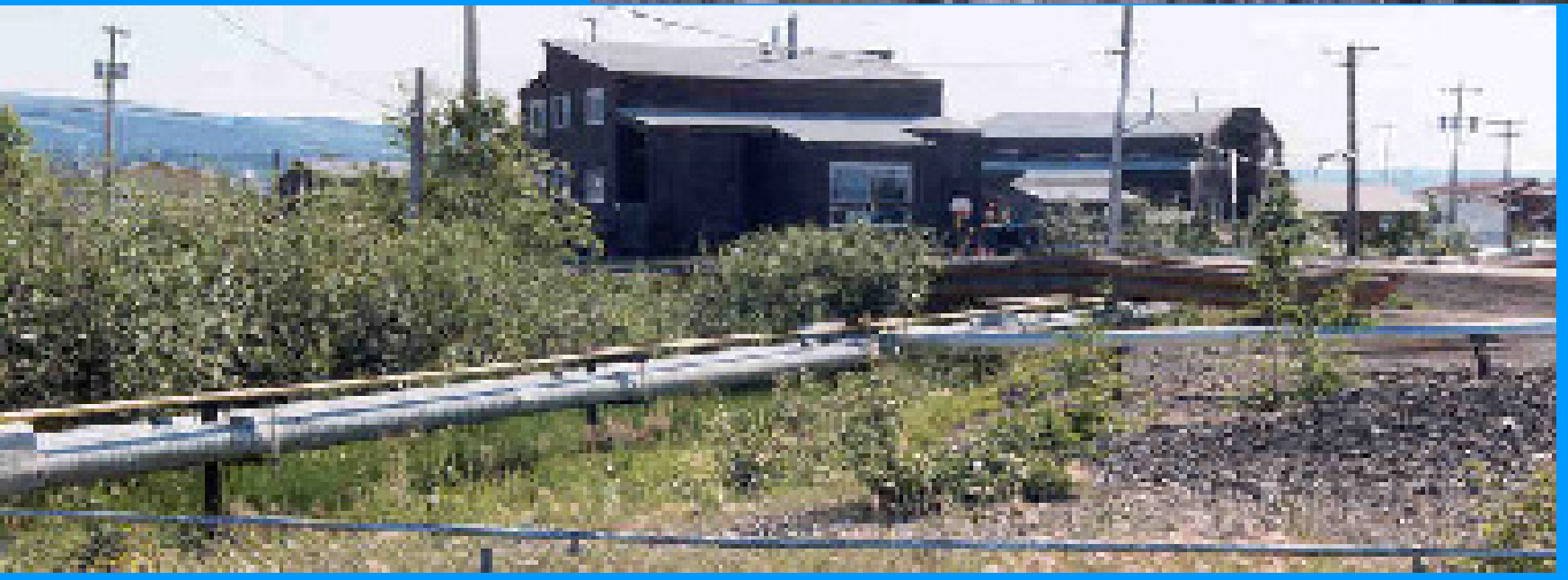
Failure of frozen sediments caused by river undercutting



MacKenzie River

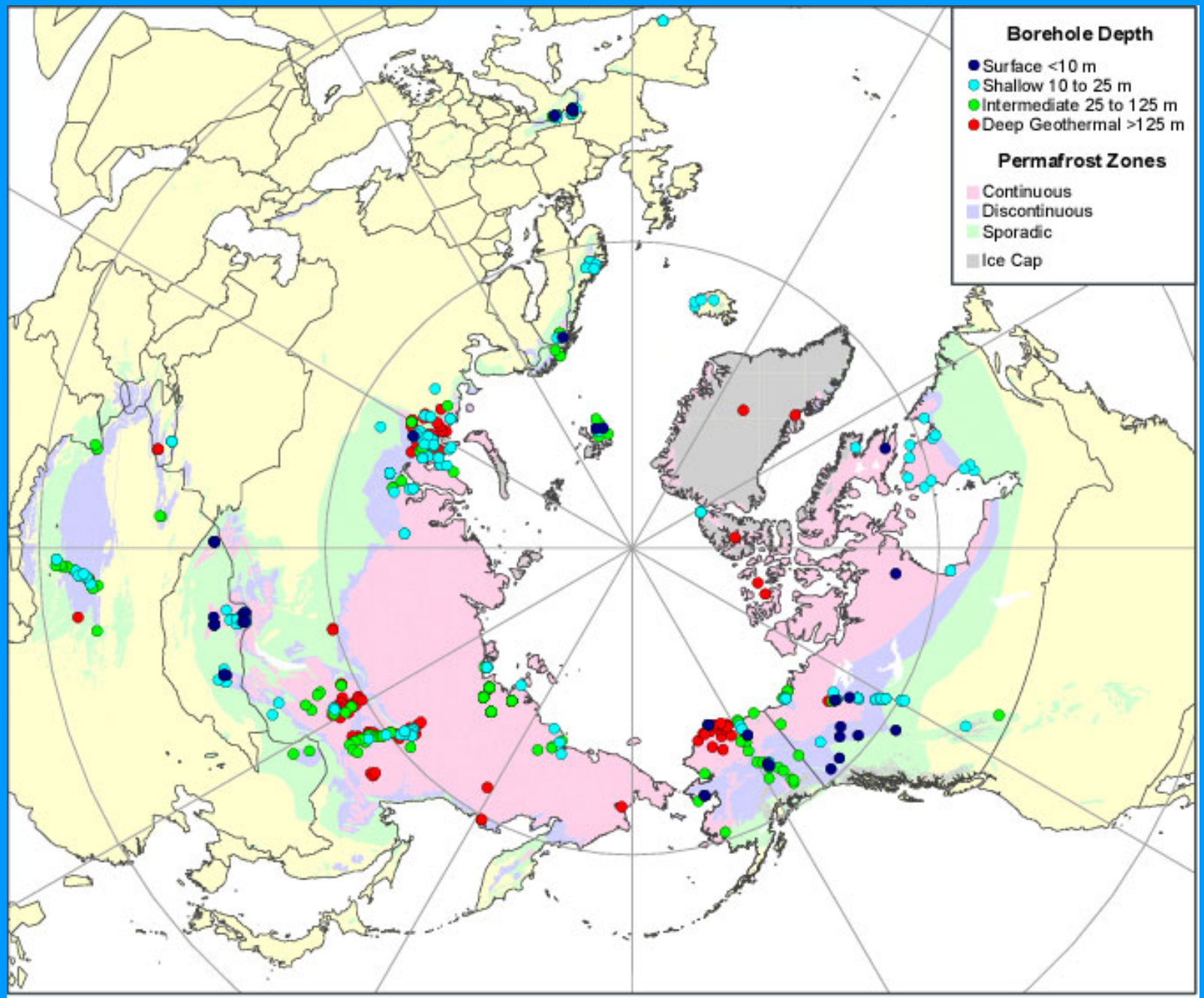
Bank slumping MacKenzie River

Permafrost melt: effects on structures



Upheaval of buried pipeline, Norman Wells 1997

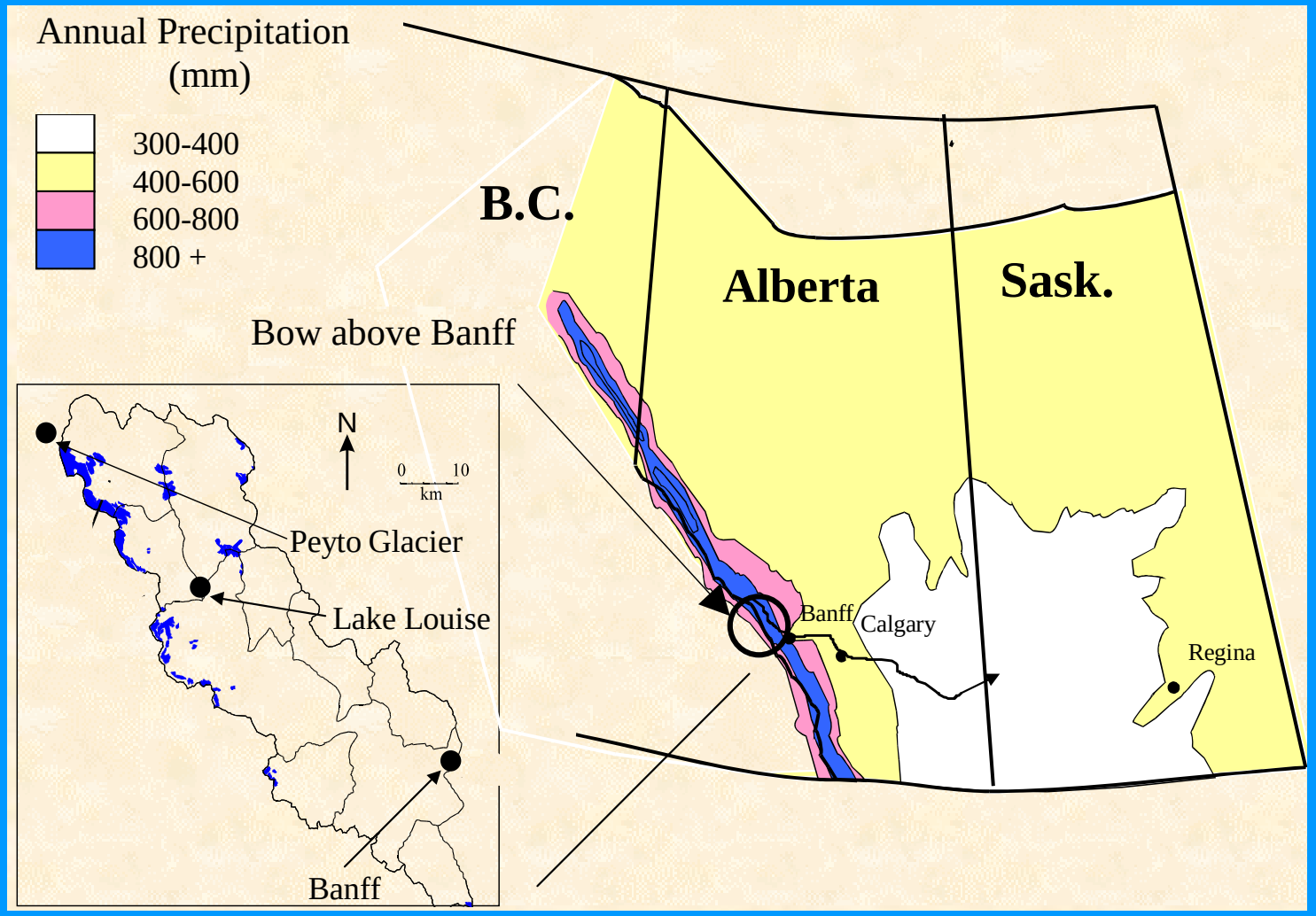
Location of Candidate Sites for Permafrost Thermal Monitoring



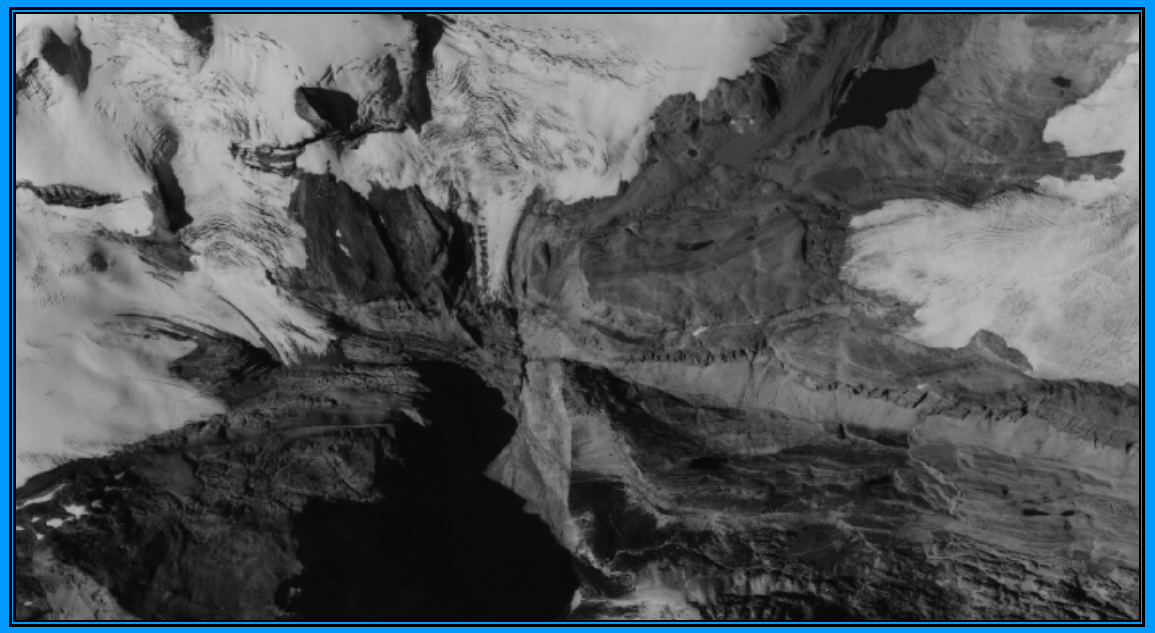
Peyto 1966 W Henoch

Athabasca D Latimer

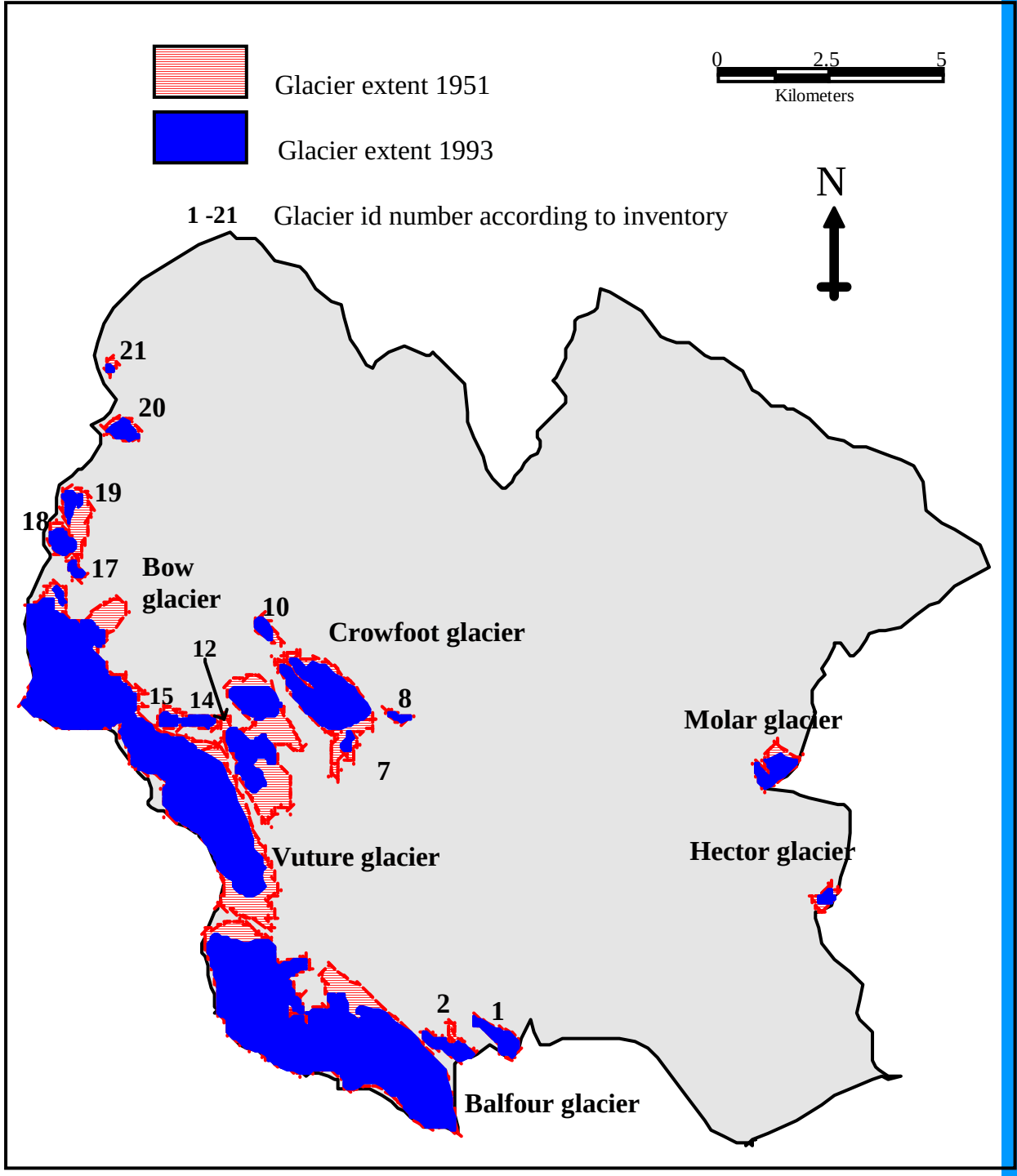
Snow dome D Latimer


Annual Precipitation
(mm)
300-400
400-600
600-800
800 +
B.C.
Alberta
Sask.
Bow above Banff
N
0
10
km
Peyto Glacier
Lake Louise
Banff
Banff
Calgary
Regina

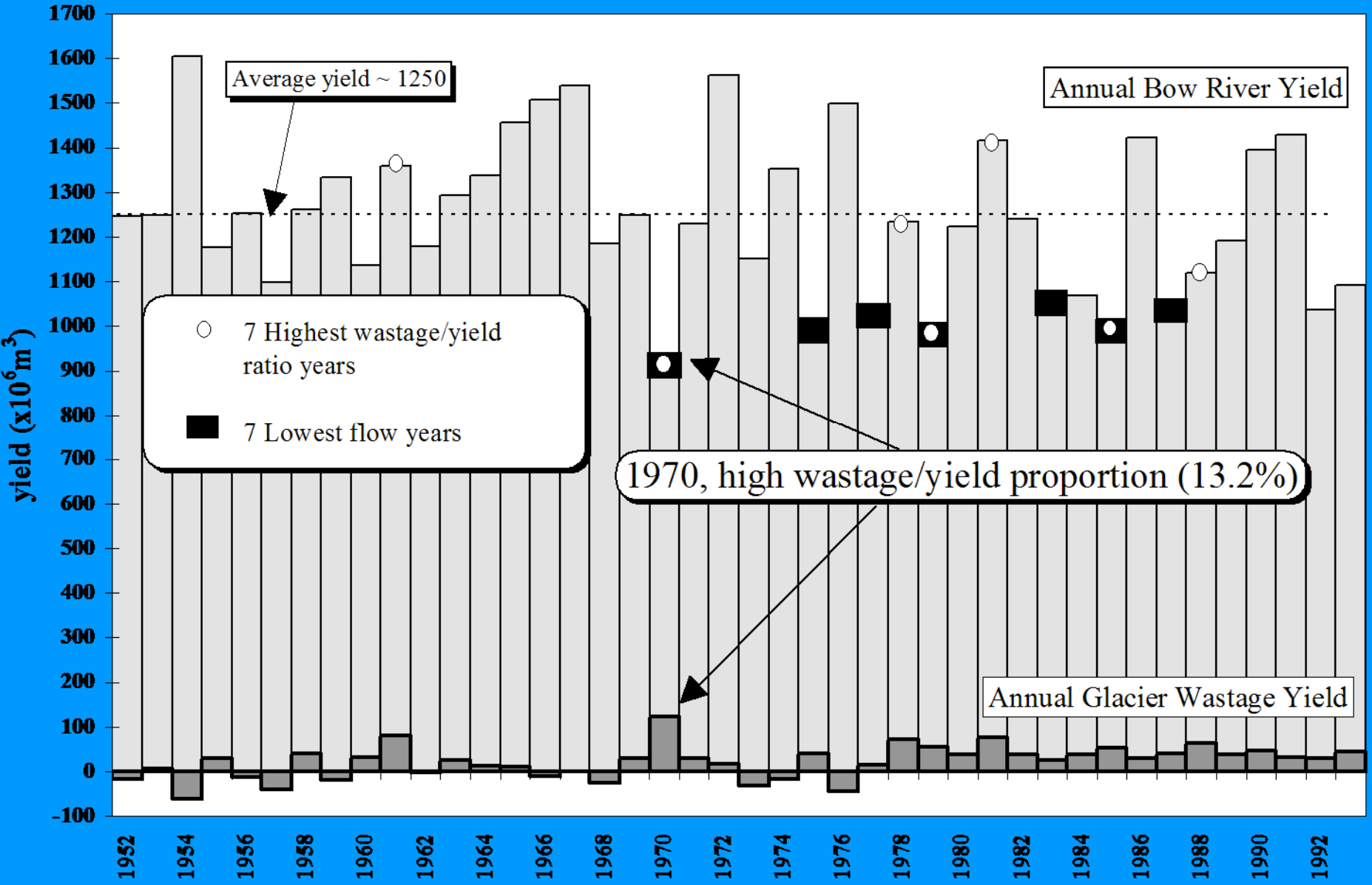
- Partial aerial photograph coverage of glaciers in the Waputik Mountains upstream of Hector Lake in 1951 (top) and 1993 (bottom)



- Glacier extents in Hector Lake Basin, 1951-1993

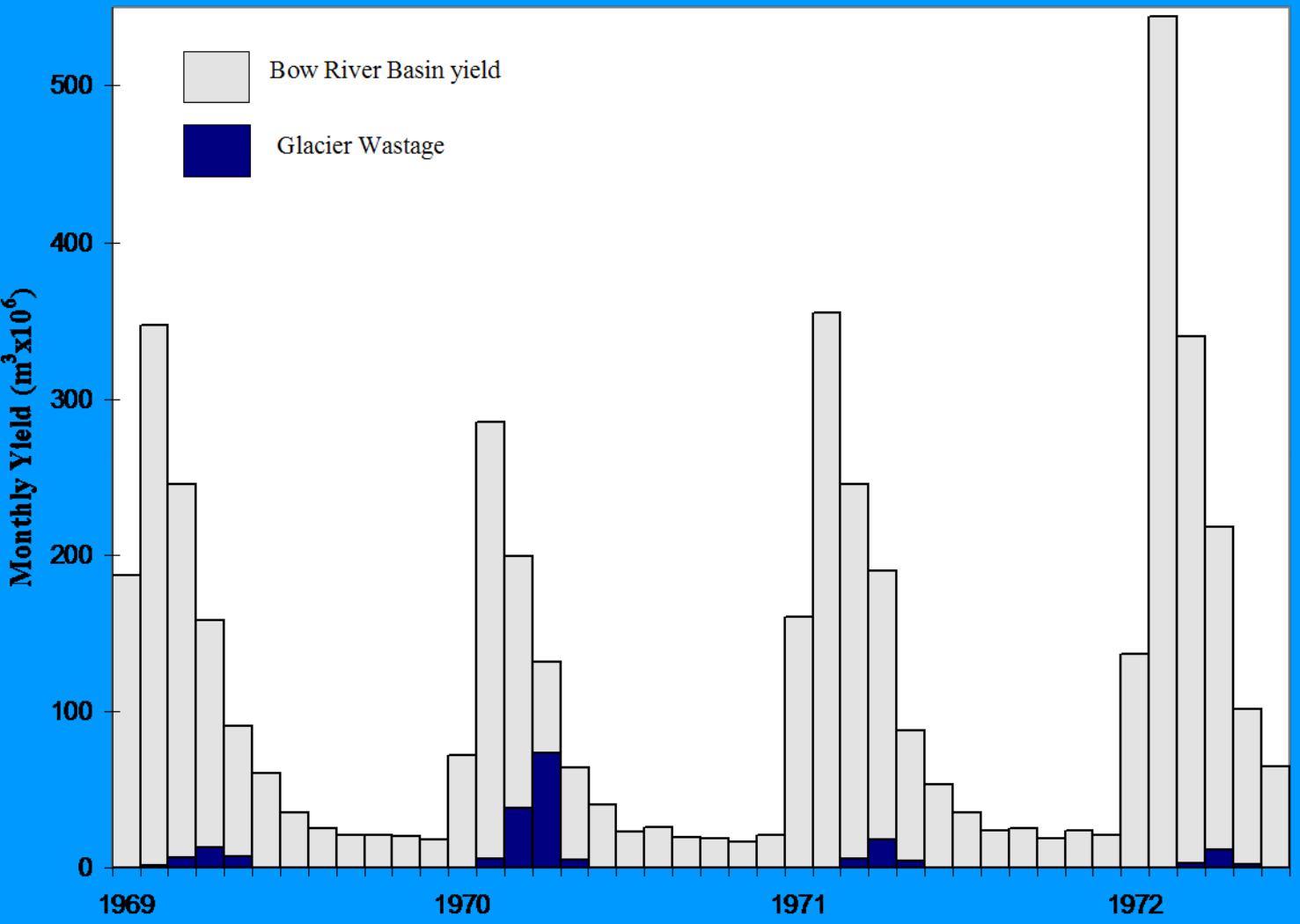


Annual Bow River Basin yield with glacier wastage and storage super-imposed



- **Observed monthly hydrograph for Bow River above Banff 1969-1972**

with modelled wastage flow super-imposed



1930

Photo: Mittelholzer,
Kilimanjaro Flug

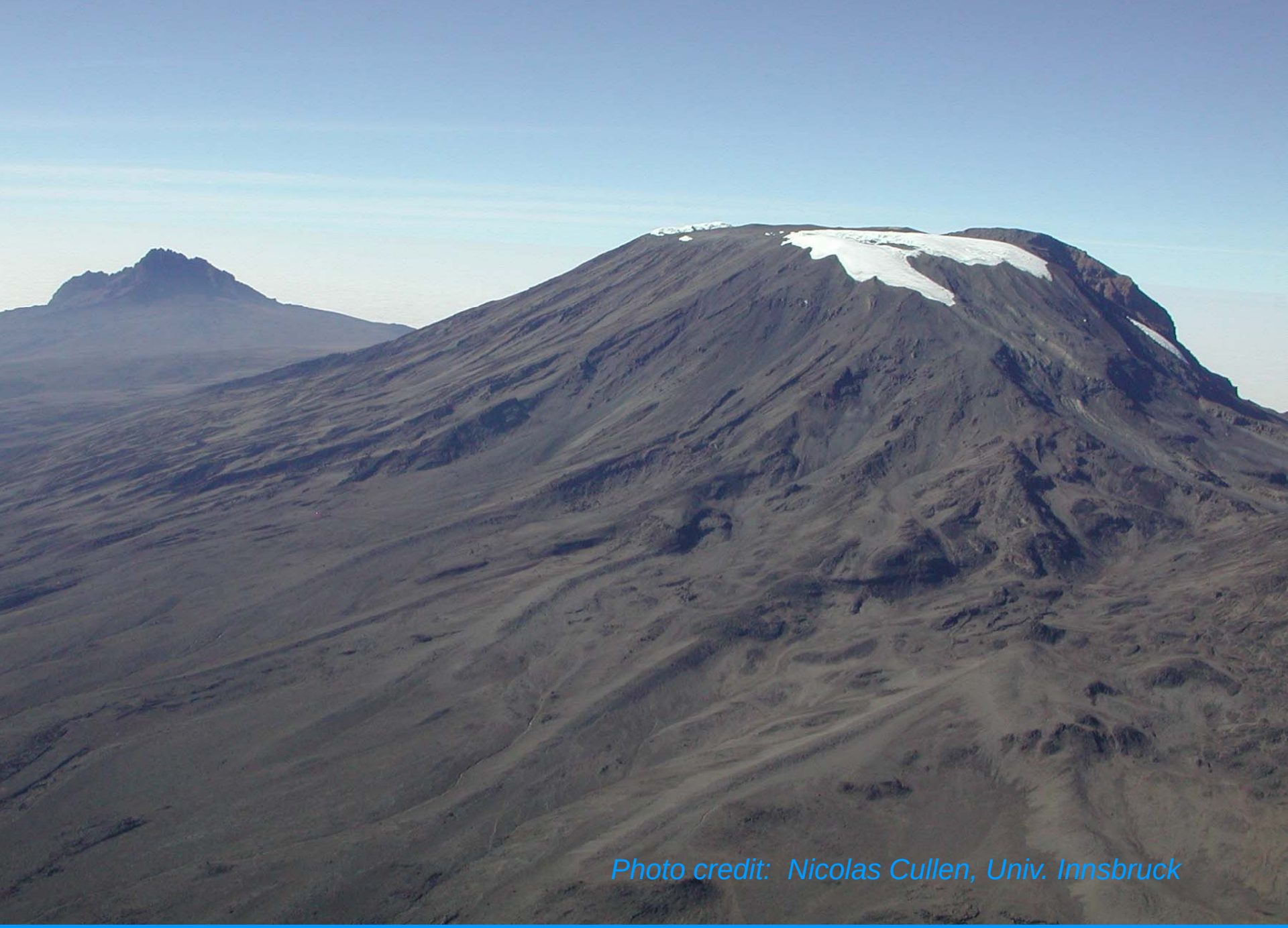
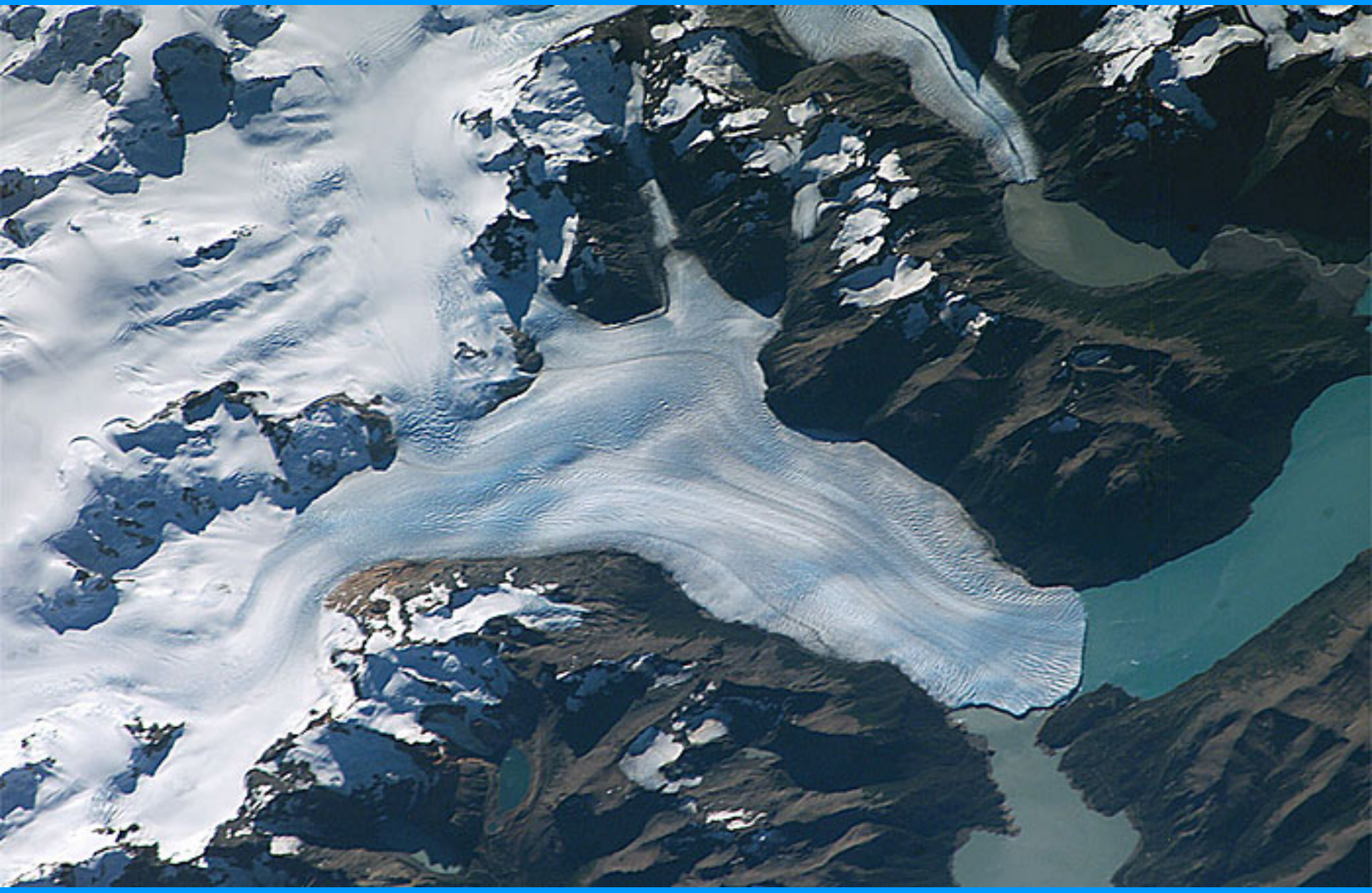


Photo credit: Nicolas Cullen, Univ. Innsbruck

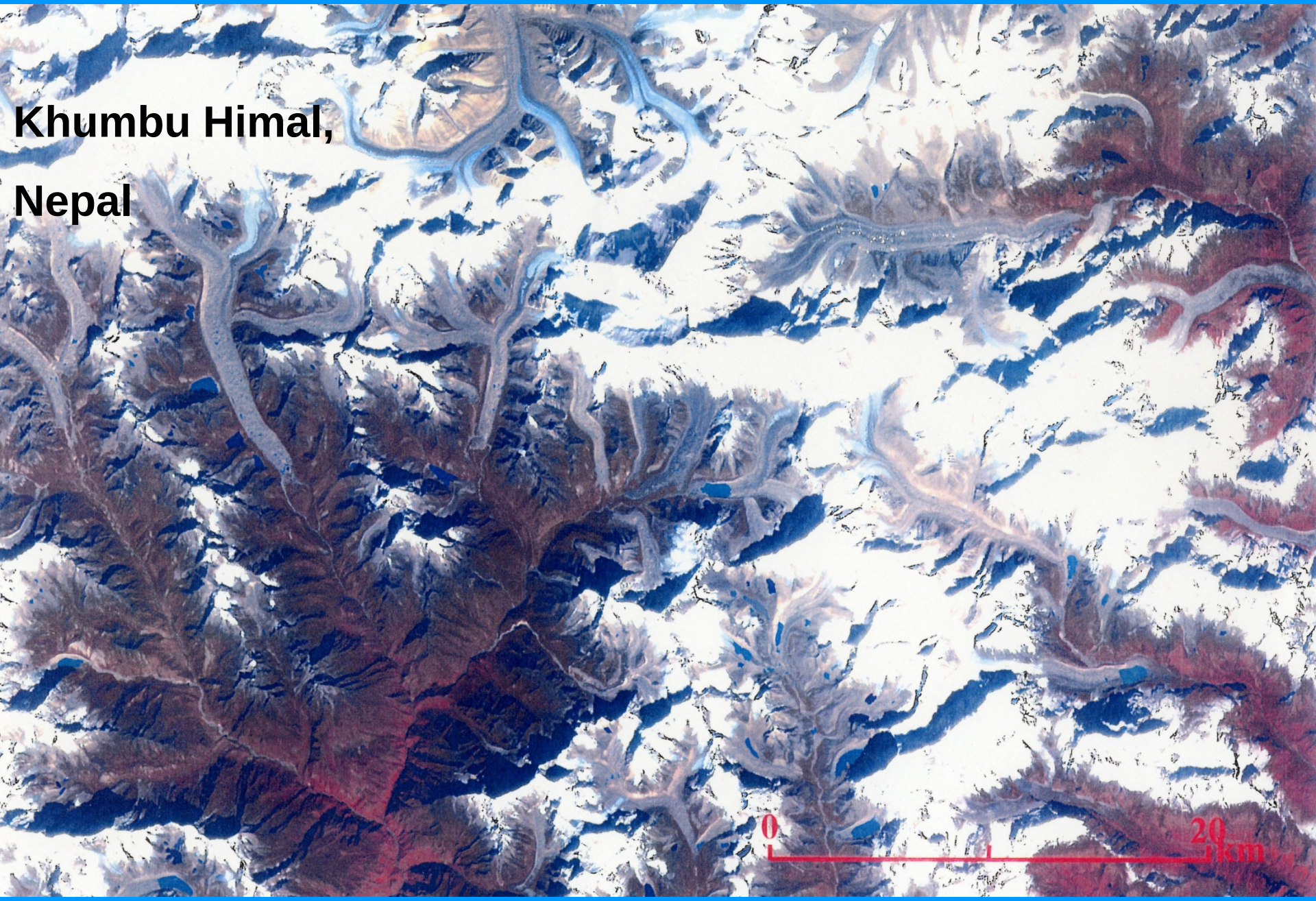
Satellite image of the glacial lakes and the Southern Patagonian Icefield (black: border CL-AR). TERRA, MODIS 28.3.2003

Tele photo from ISS (ISS010-E-18312) 19.2.2005. Water in Brazo Rico is turbid due to higher sediment content than in Lago Argentino

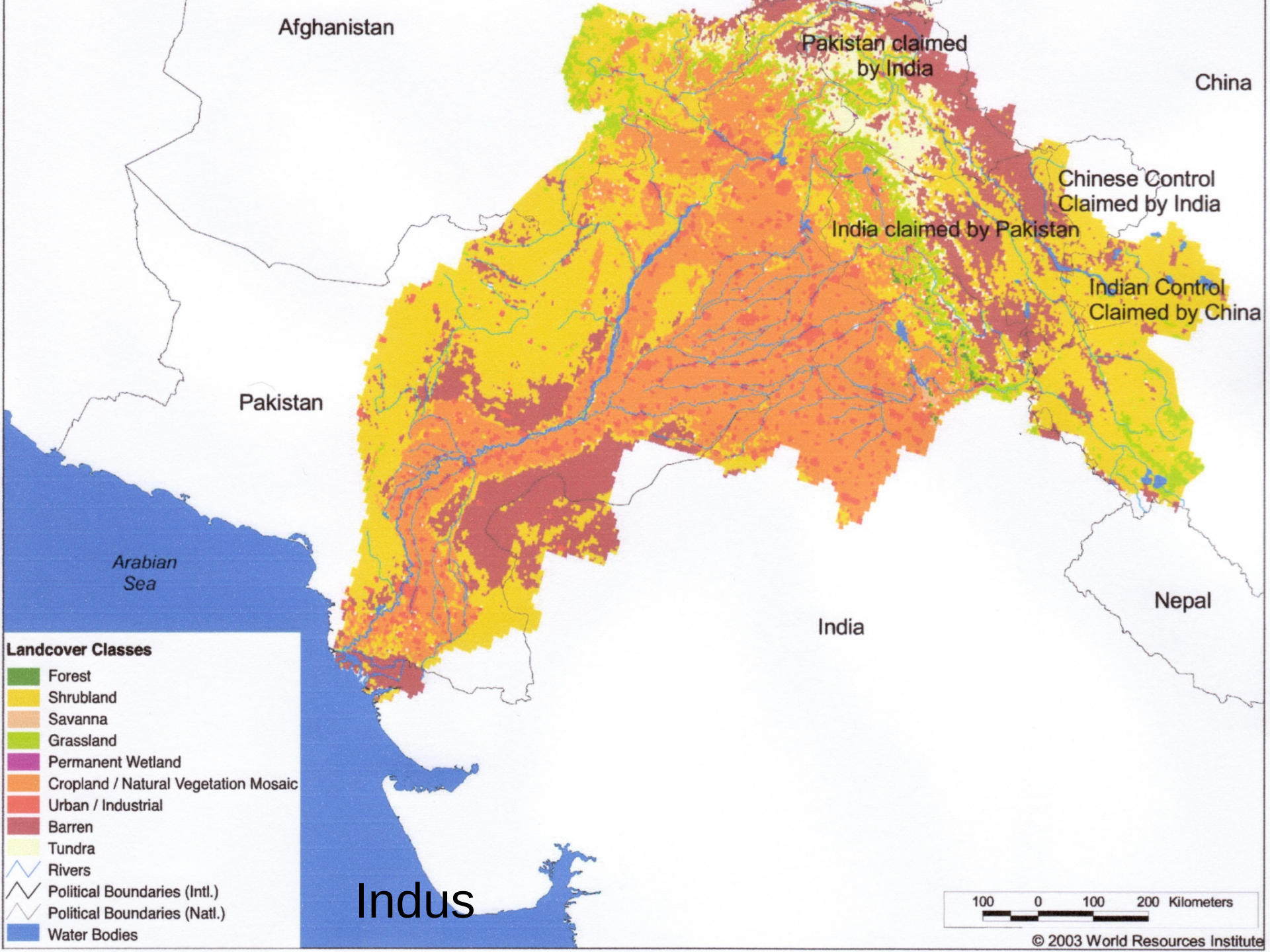


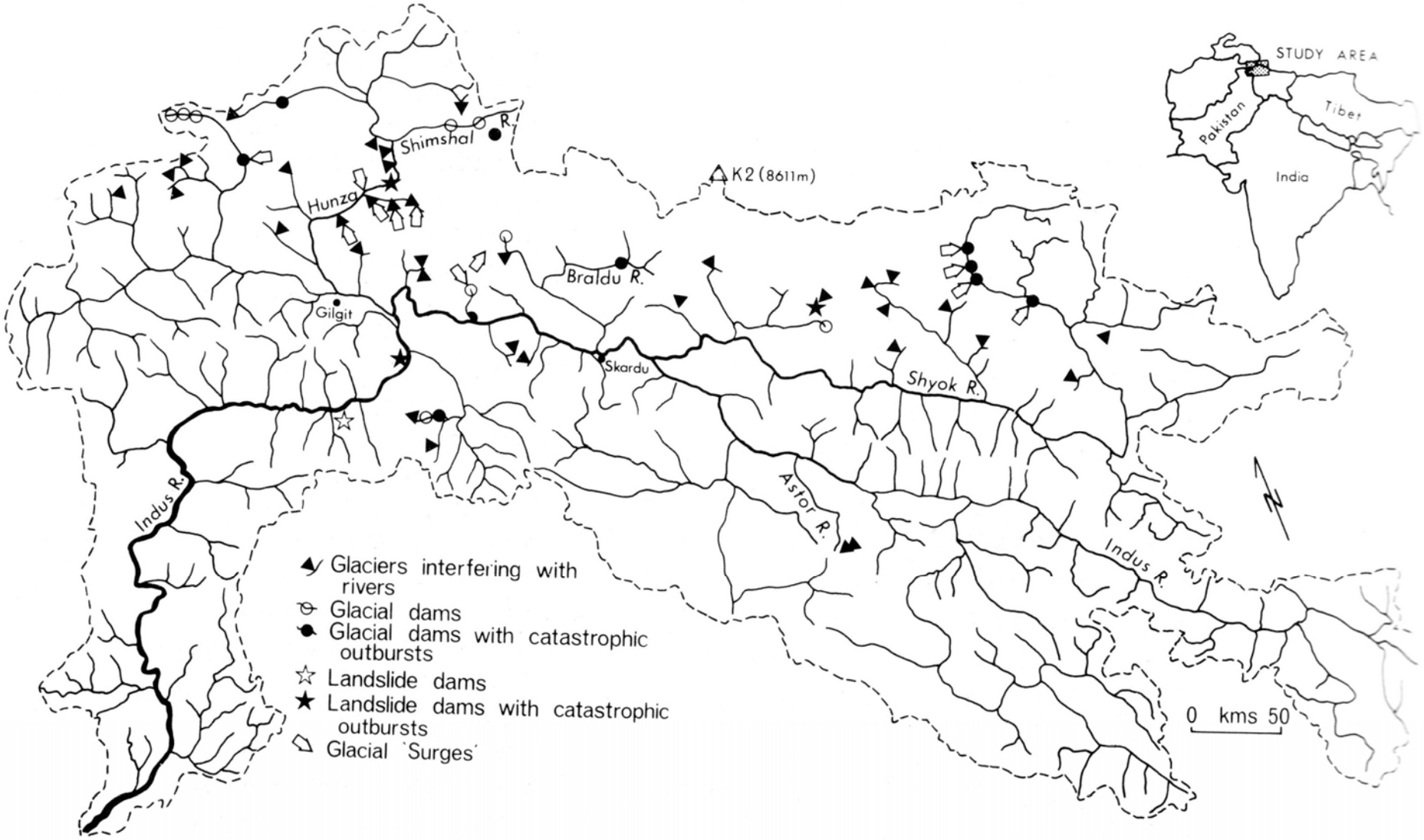
Channel between the peninsula and Glaciar Perito Moreno

Central Asia


Khumbu Himal,
Nepal
0
20
km

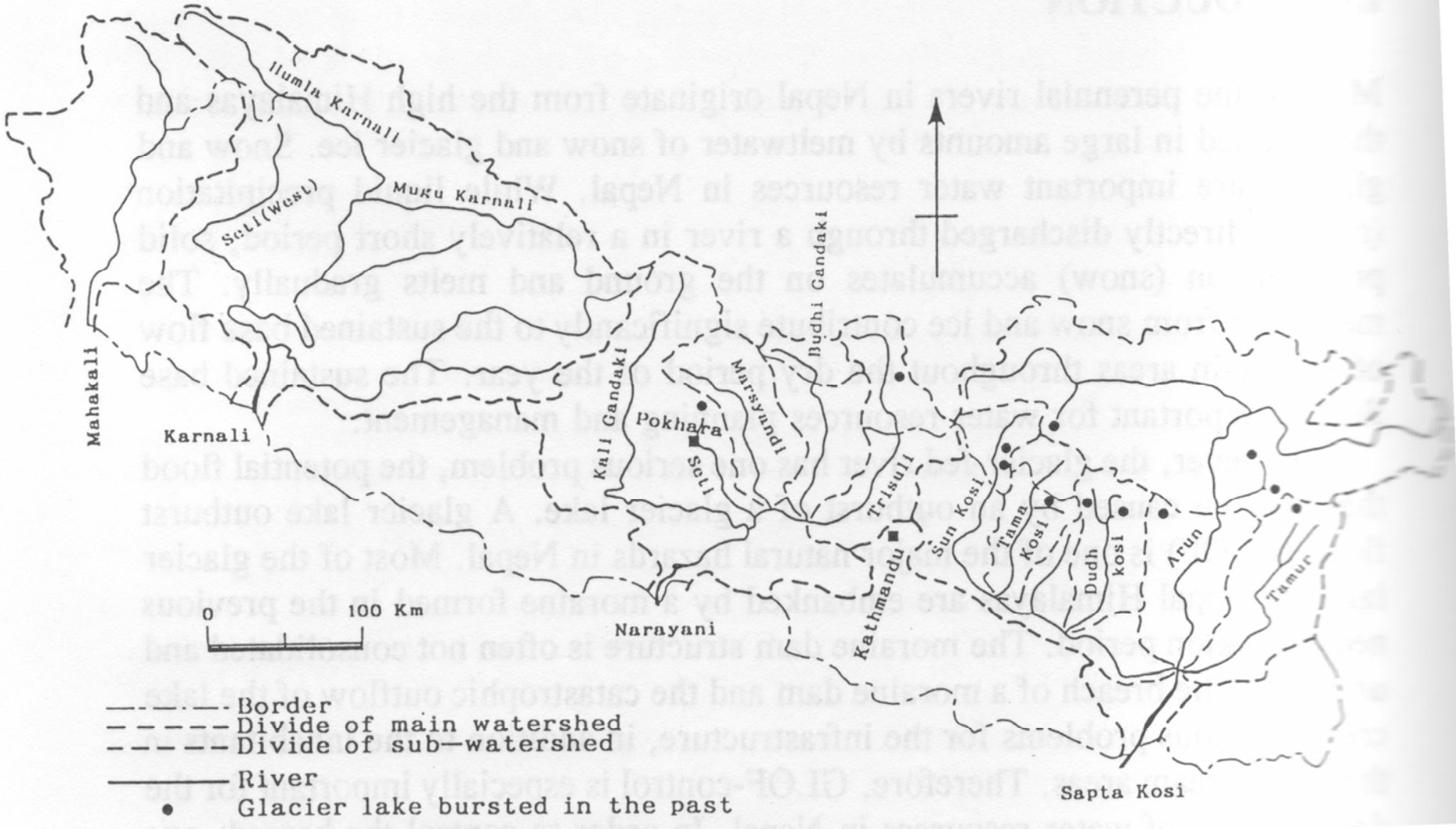

NAKAWO, Masayoshi Research Institute for Humanity and Nature





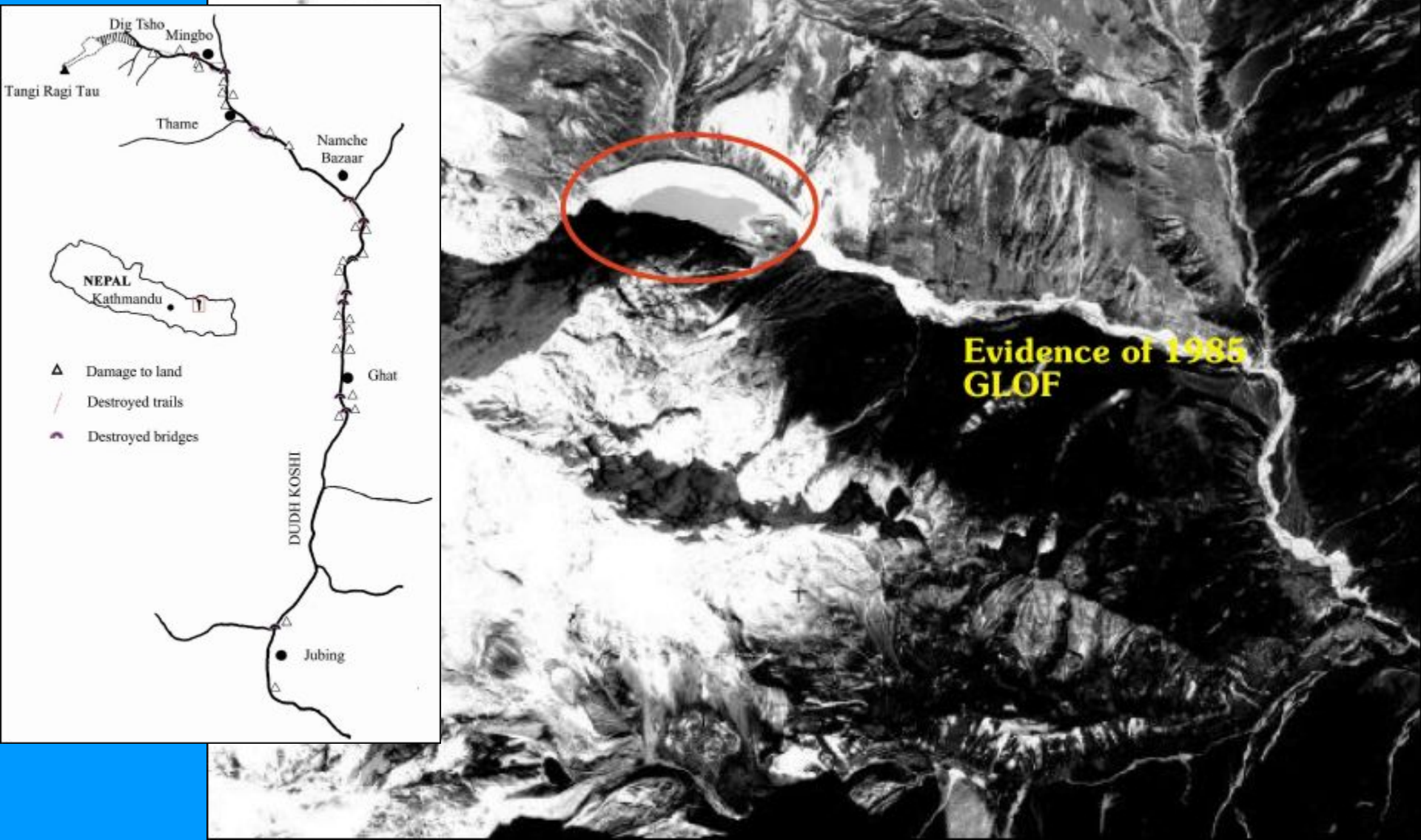
Indus River: glacier dams and related events (after Hewitt 1982)

Nepal: glacier lake outburst floods (after Yamada and Sharma, 1993)



Nepal Imja Lake

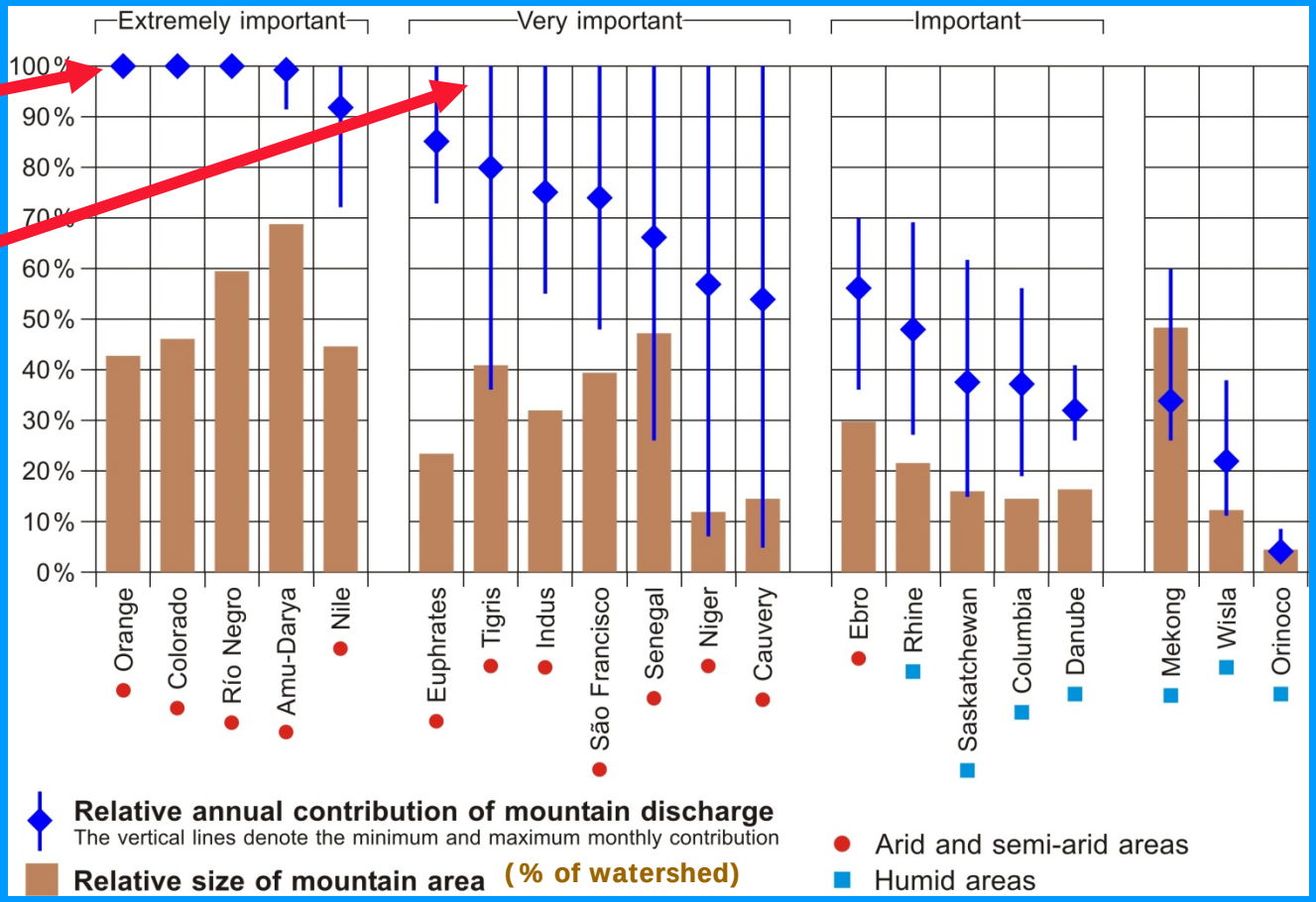
Nepal Dig Tsho 1985



Central Asia

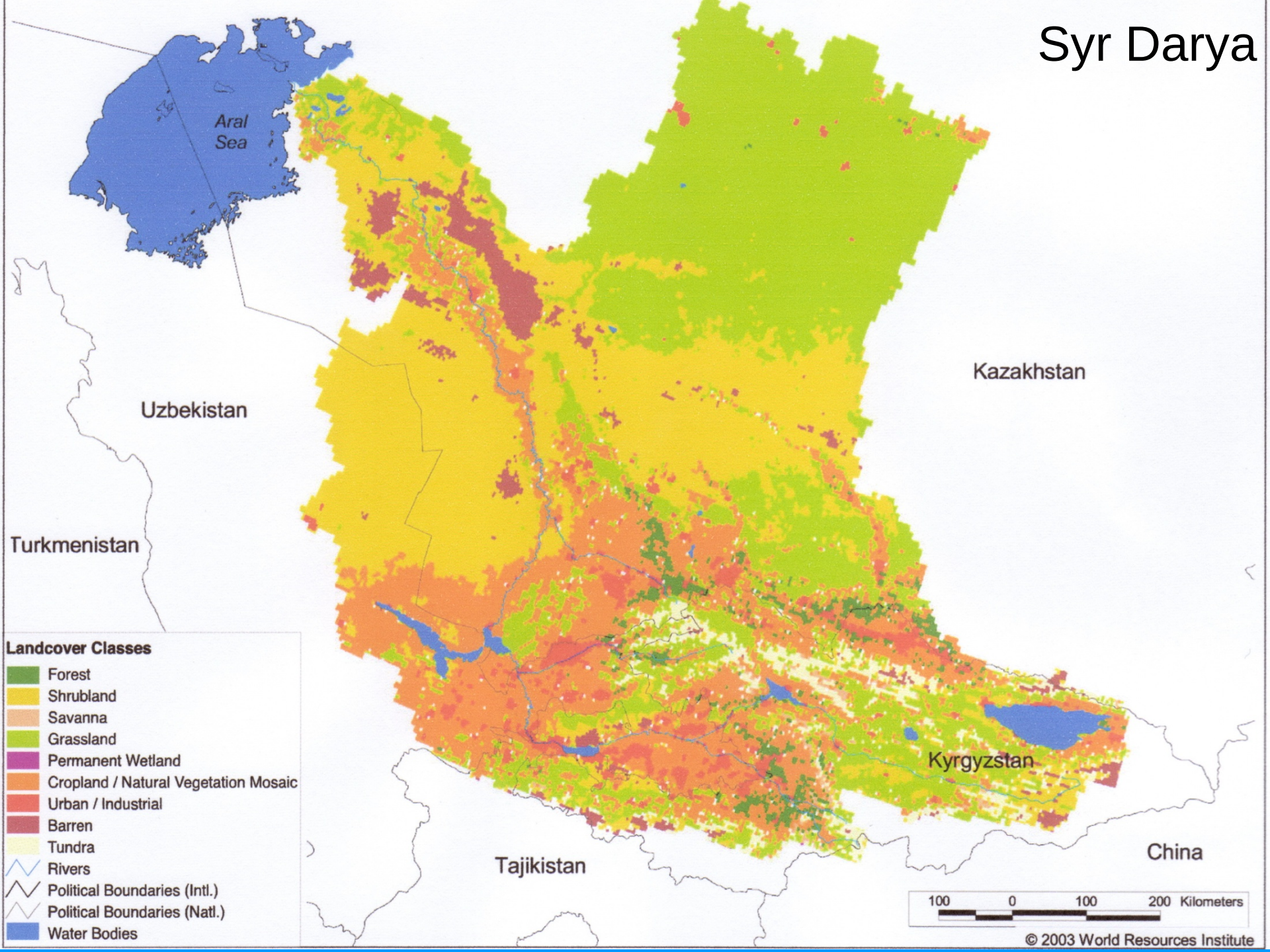
Mountains are important for water supply

- ALL flow is from mountains
- Seasonal low flow is all from mountain regions

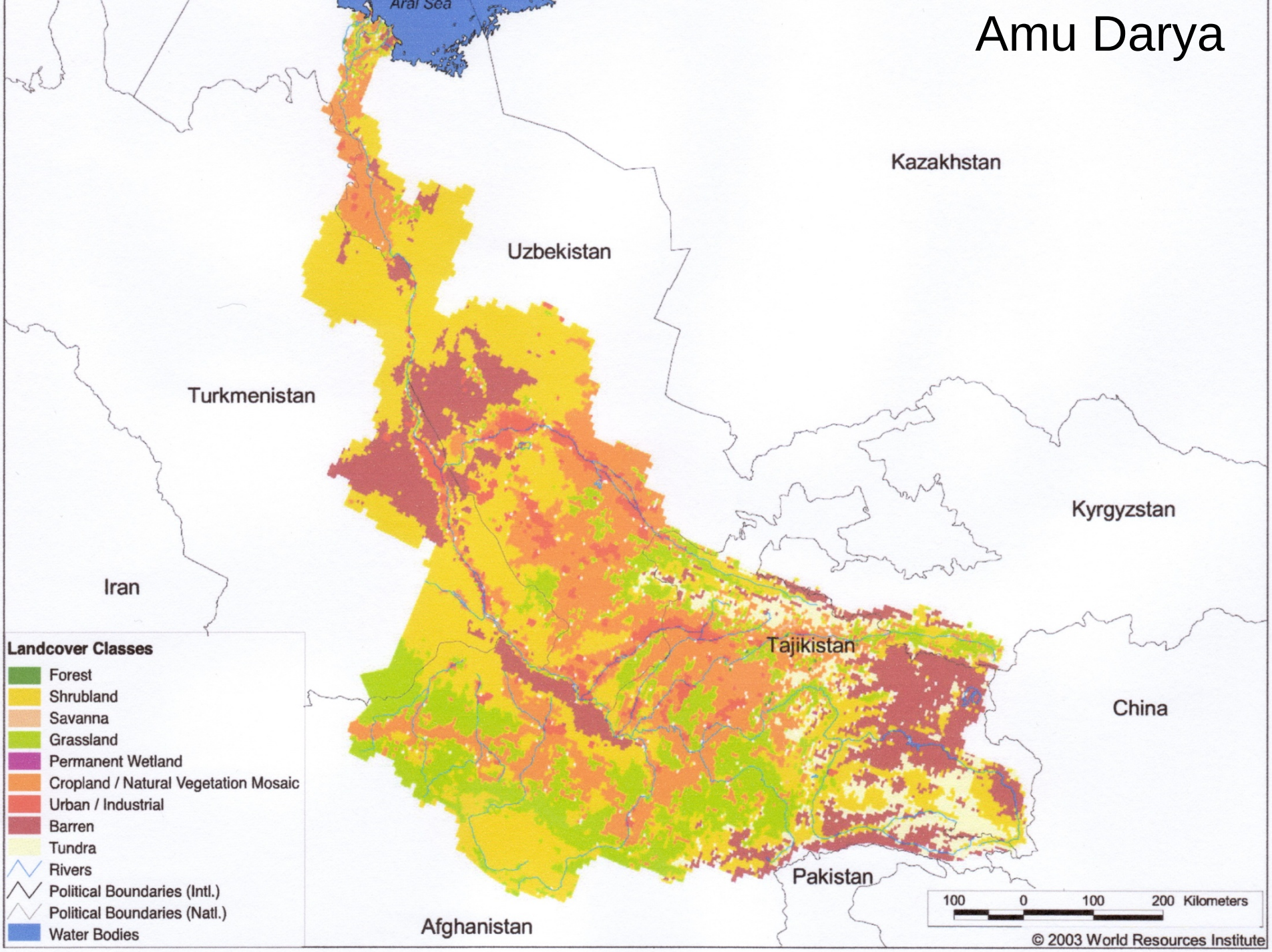


Outside of the tropics, mountains cover 24% of the surface, but yield 46% of the runoff.

Syr Darya



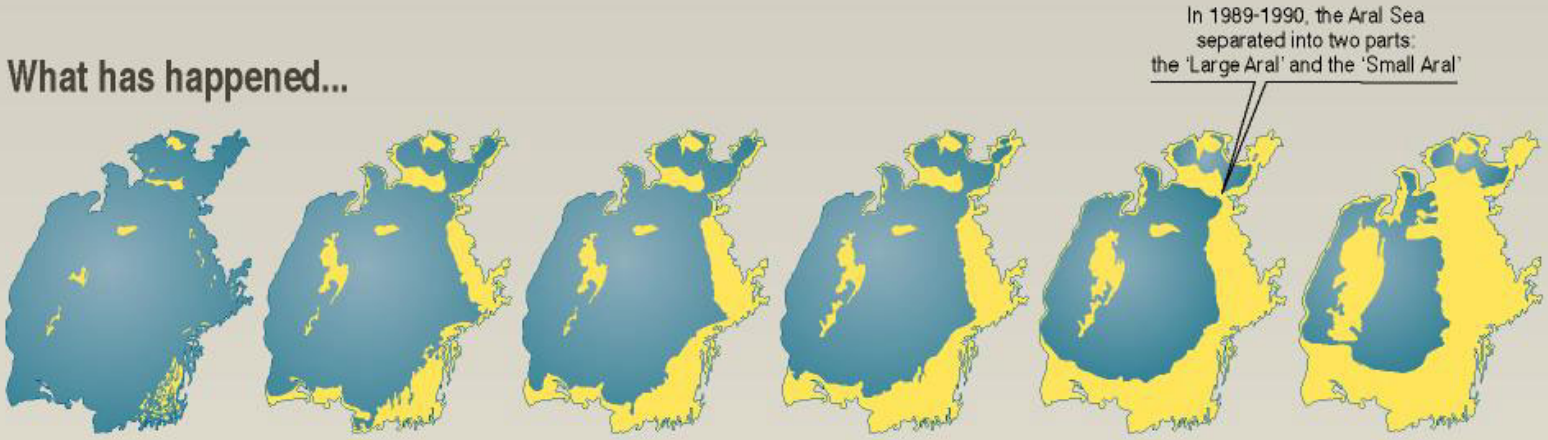
Amu Darya



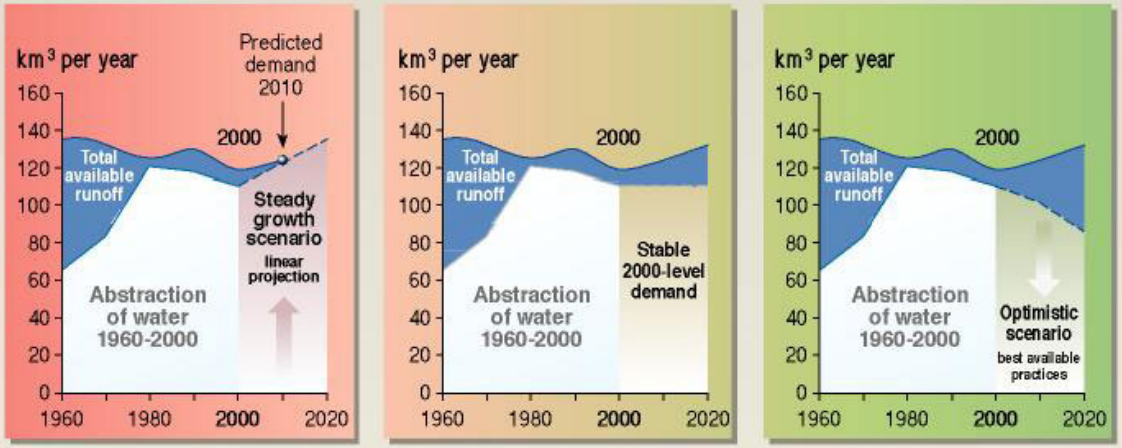
Will the Aral Sea Disappear Forever?

The last 40 Years and Alternative Future Scenarios

What has happened...



What could happen...



UNEP

PHILIPPE REKACEWICZ
MARCH 2002

Sources: Nikolaï Denisov, GRID-Arendal, Norway; Scientific Information Center of International Coordination Water Commission (SIC ICWC); International Fund for Saving the Aral Sea (IFAS); The World Bank; National Astronautics ans Space Administration (NASA); United States Geological Survey (USGS), *Earthshots : Satellite images of environmental change*, United States Department of the Interior, 2000.

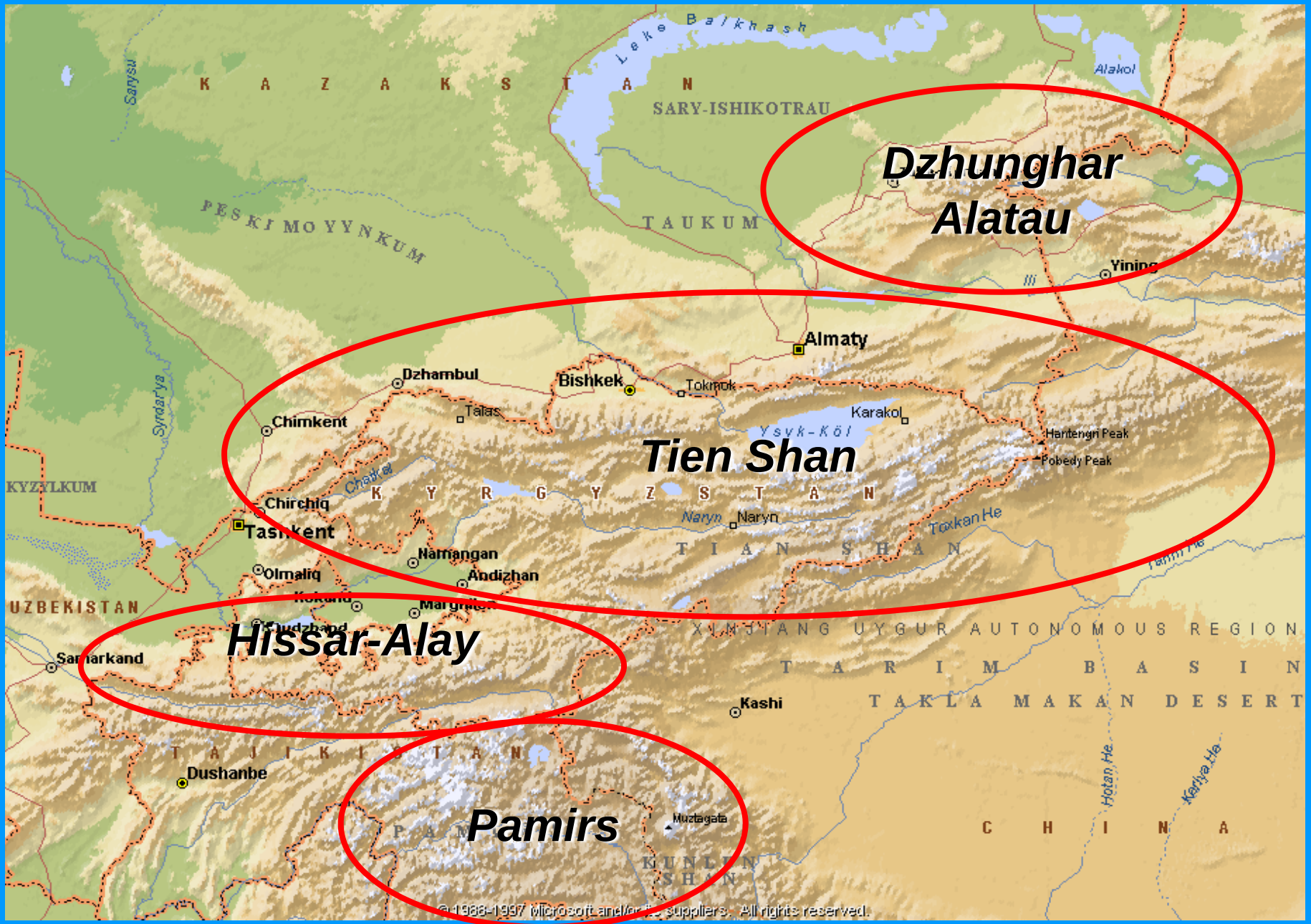
MAJOR IRRIGATION COMPLEXES IN THE ARAL SEA BASIN

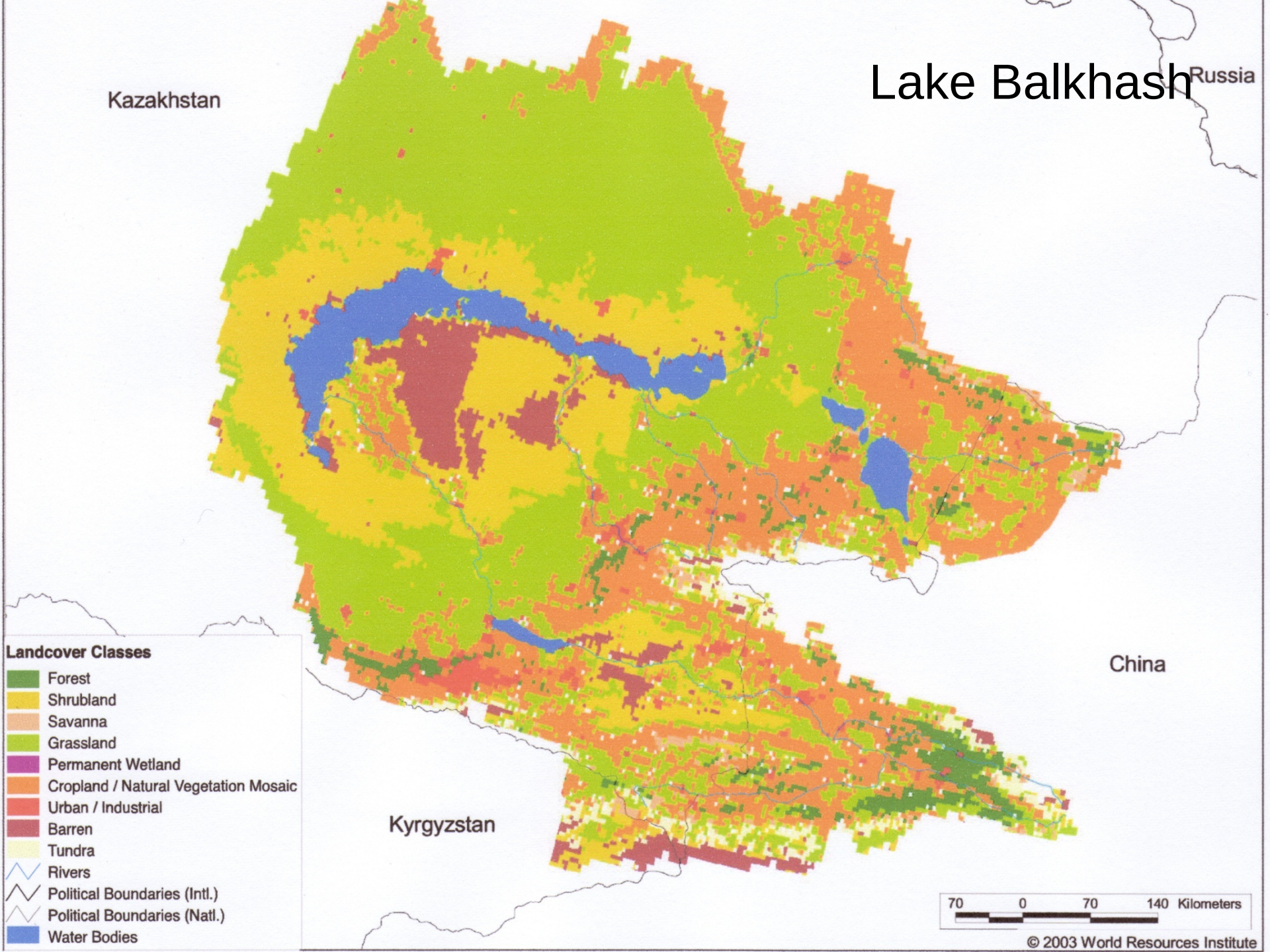
Main irrigation zones in the Aral Sea Basin

Proposed Siberia-Aral Sea Canal

1. Kara-Kum Canal
2. Amu Dar'ya Delta
3. Amu-Bukhara Canal
4. Zeravshan Valley
5. Karshi Steppe
6. Middle Amur Dar'ya
7. Surkhandar'ya Valley
8. Golodnaya Steppe
9. Fergana Valley
10. Middle Syr Dar'ya
11. Kzyl-Orda Canal
12. Syr Dar'ya Delta

Tien Shan, Dzhunghar Alatau, Pamirs

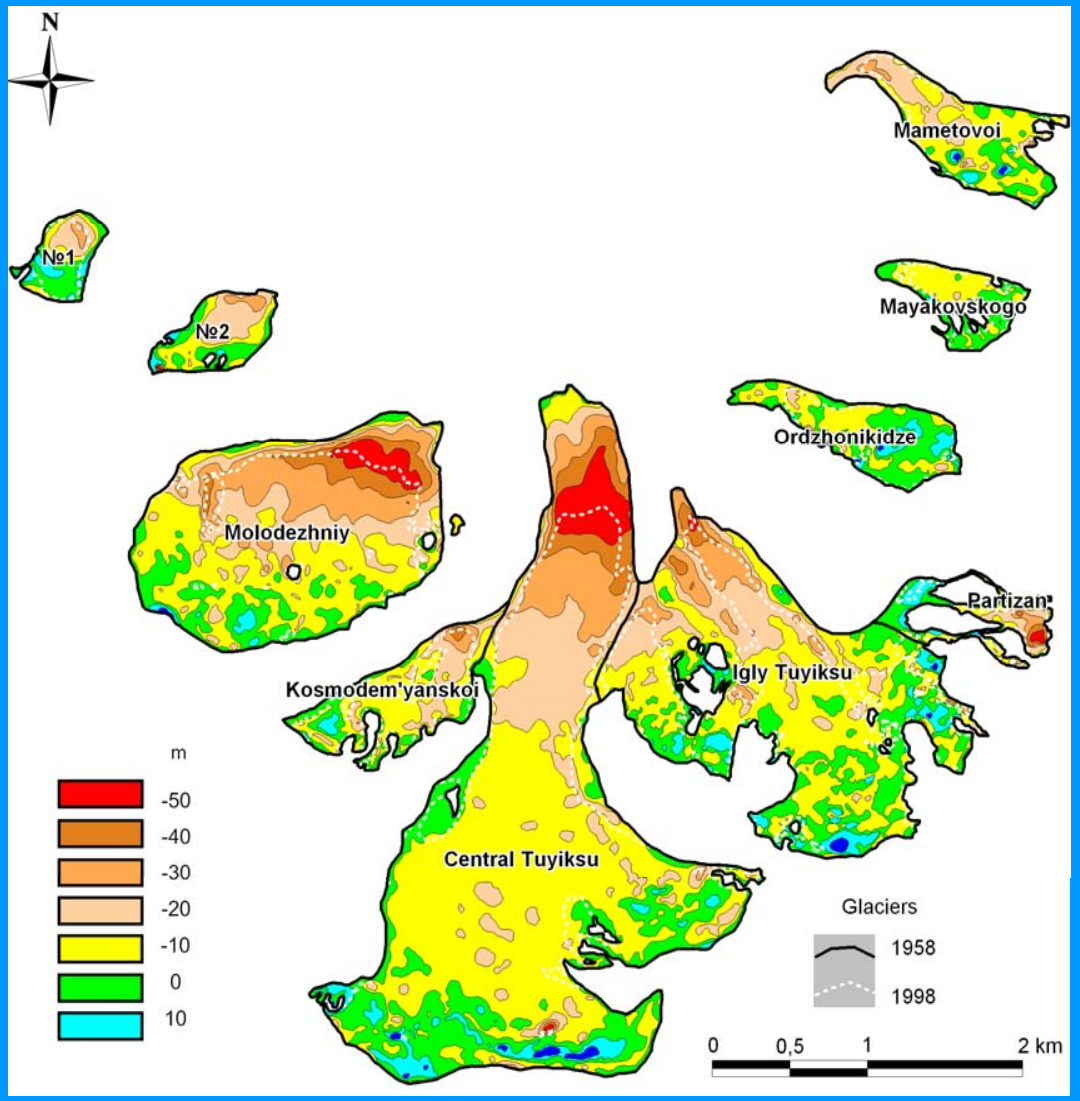



Lake Balkhash
Kazakhstan
Russia
China
Kyrgyzstan
Landcover Classes
Forest
Shrubland
Savanna
Grassland
Permanent Wetland
Cropland / Natural Vegetation Mosaic
Urban / Industrial
Barren
Tundra
Rivers
Political Boundaries (Intl.)
Political Boundaries (Natl.)
Water Bodies
70 0 70 140 Kilometers
© 2003 World Resources Institute

Tuyuksu glacier

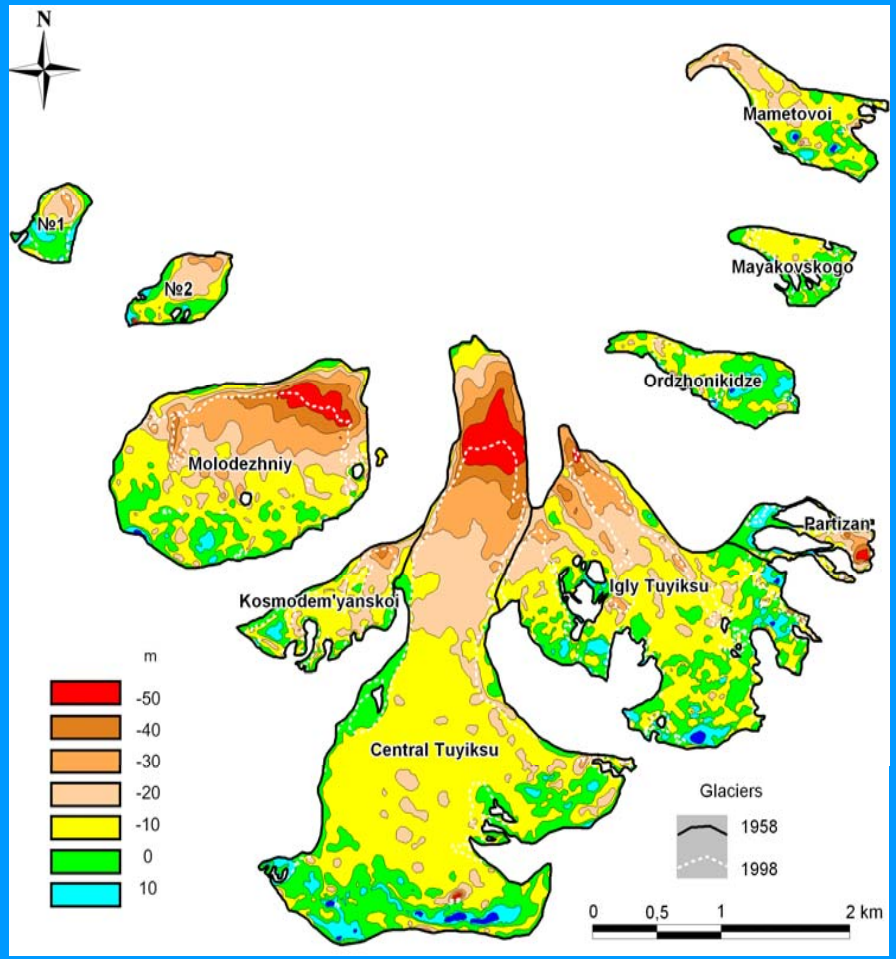
Surface height changes of the open part of the Tuyuksu glaciers (1958-1998)

•During the 40 years Tuyuksu glacier has receded 1 km and had lost 41 million m3 of ice. Total reduction of thickness of ice at the end of the tongue of the glacier has exceeded 45 m (marked in red). On the most part of the glacier the loss of thickness of ice was from 5 up to 15 m (orange, yellow).

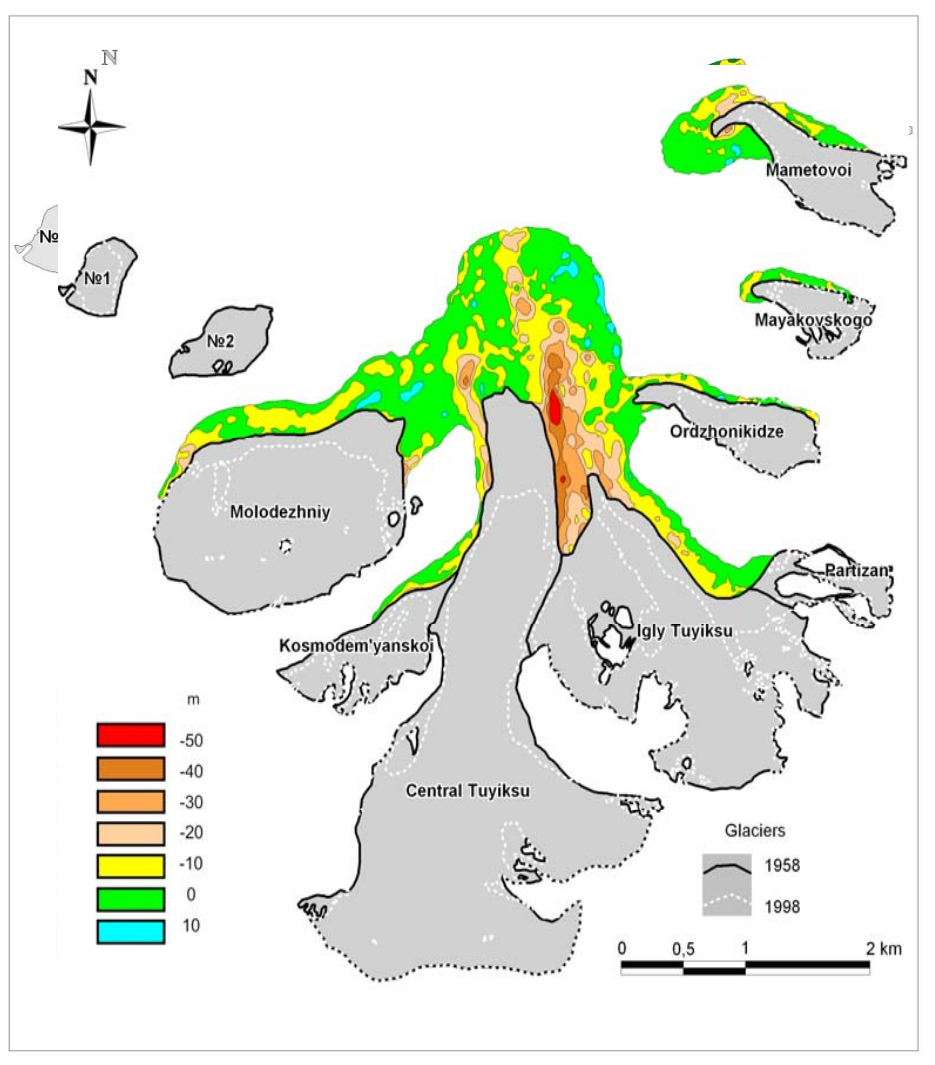


Surface height changes of the open part of the Tuyuksu glaciers (1958-1998)

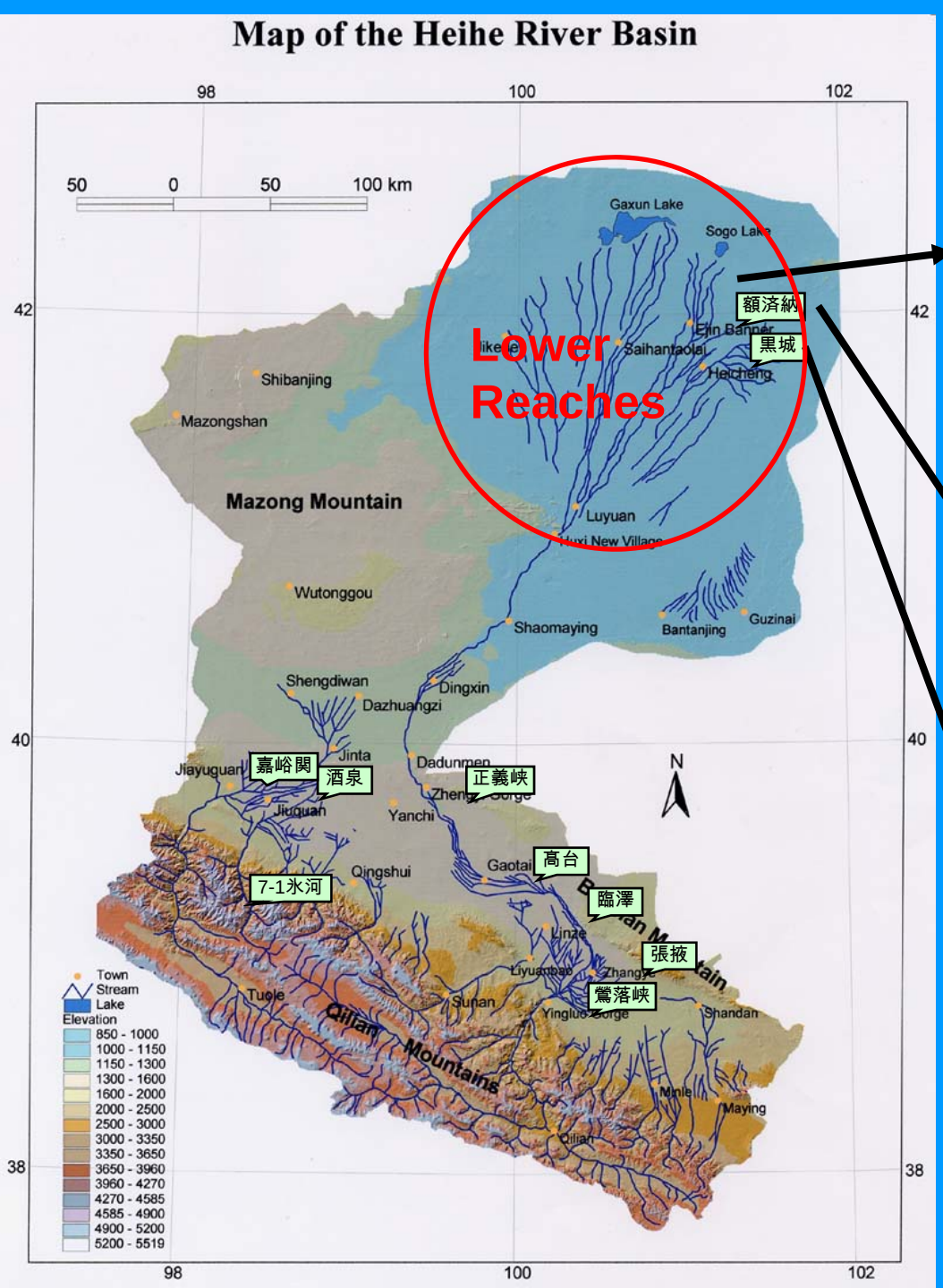
•At the same time, in a considerable part of the accumulation zone the mass balance was positive. The thickness of new accumulation layer was from 5 to 25 m.



Surface height changes of the buried part of Tuyuksu glaciers (1958-1998)



- Total loss of ice volume of the buried part of the glaciers is equivalent to 20 % of the total loss of ice of the open part of the Tuyuksu glaciers.



Lowering of ground water level

Dry up of many wells

Lakes disappeared

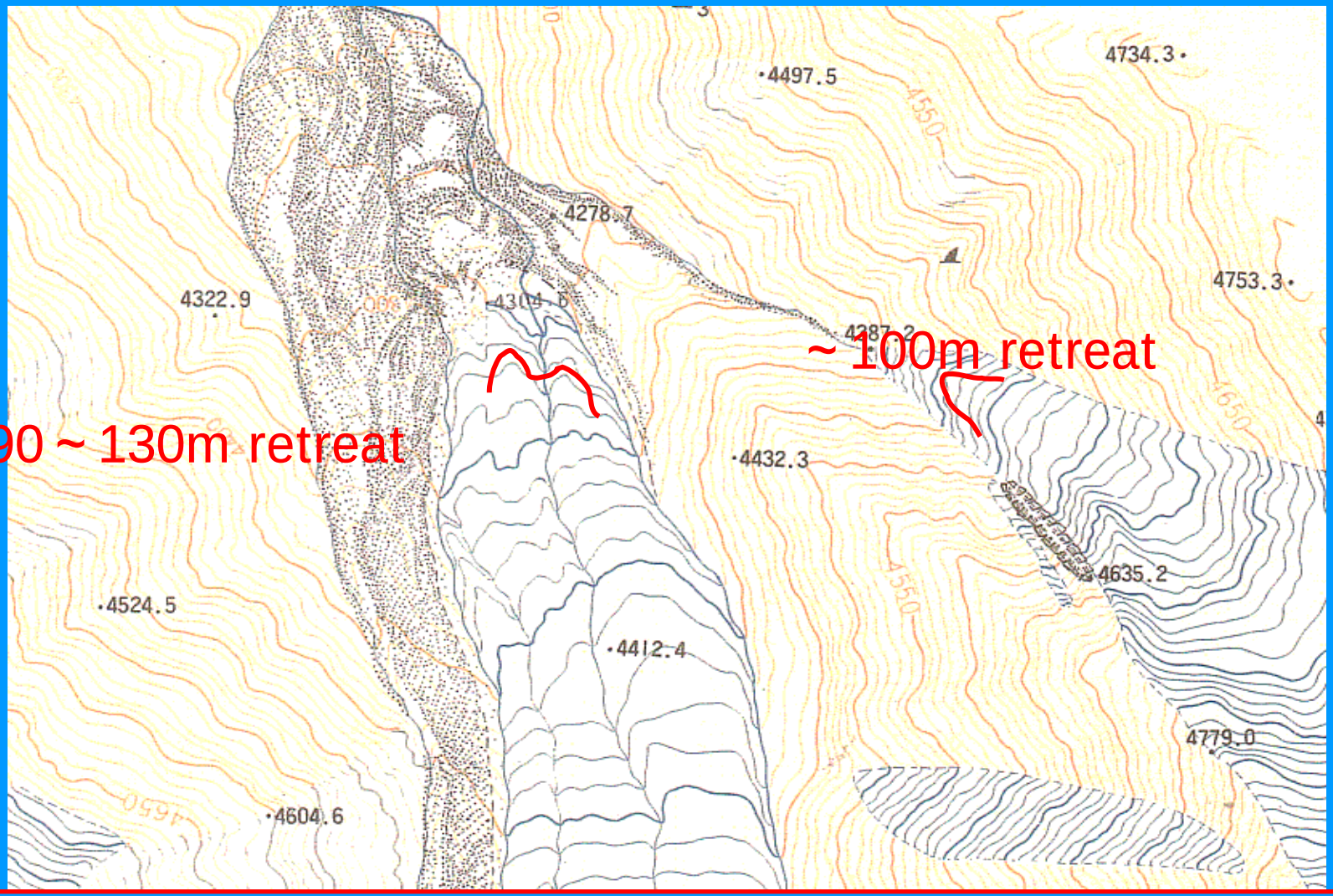
Deterioration of ecosystem

Heihe River

2 0
0 2

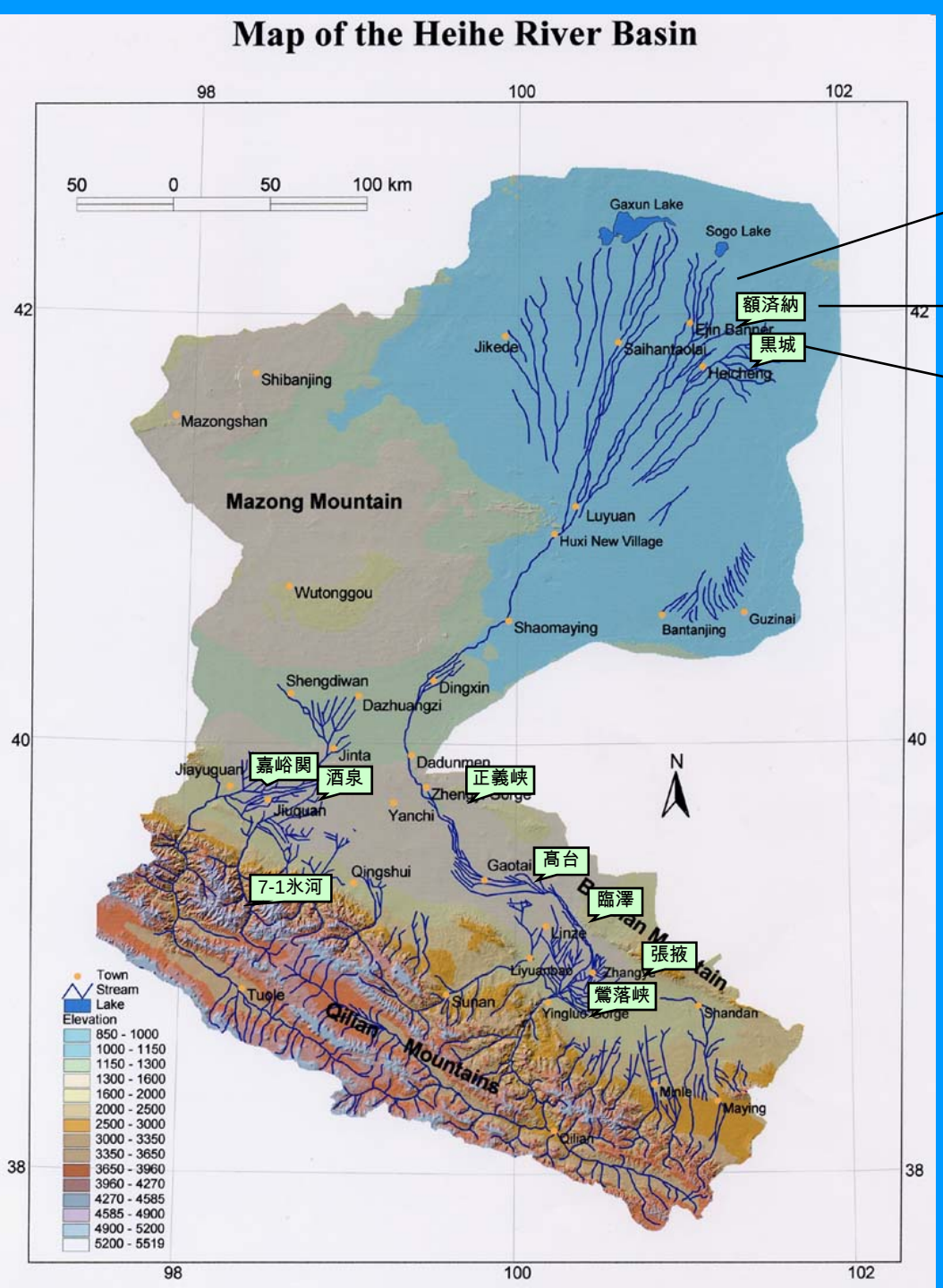
7-1 Glacier, Qilian Mountains, western China

1 9 7 5 - 2 0 0 3



One tenth of ice has been lost in 28 years

M) 氷川儲量 (KM)³ 1：12000



Lowering of ground water level

Dry up of many wells

Lakes disappeared

Deterioration of ecosystem

The shortage of water

The measures taken, were

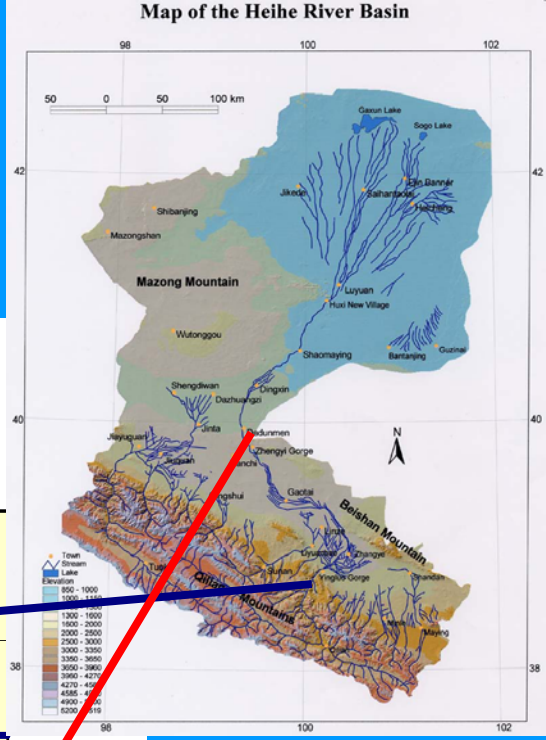
Ecological migration

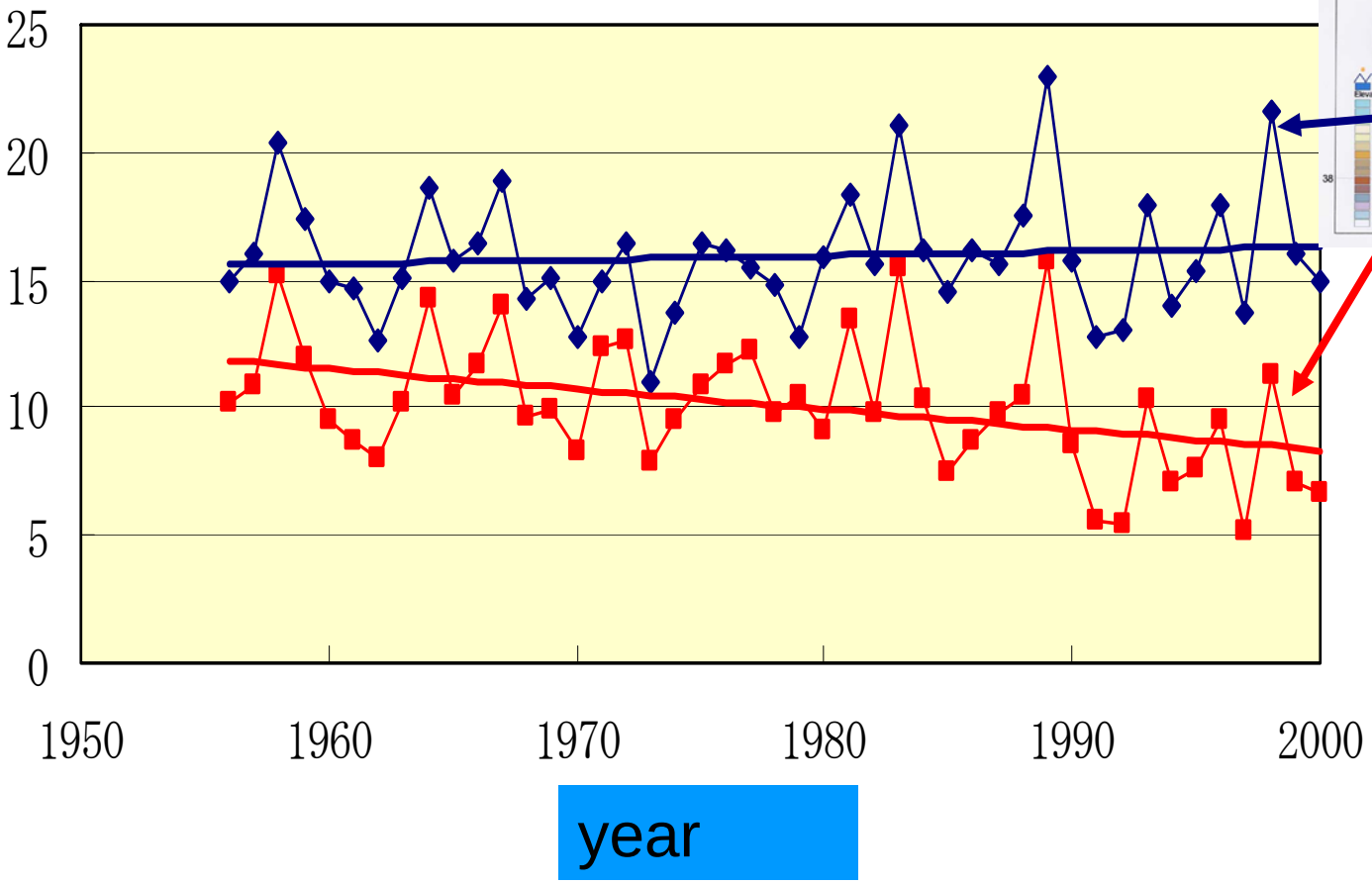
(Forced relocation of people for preserving ecosystem)

Afforestation

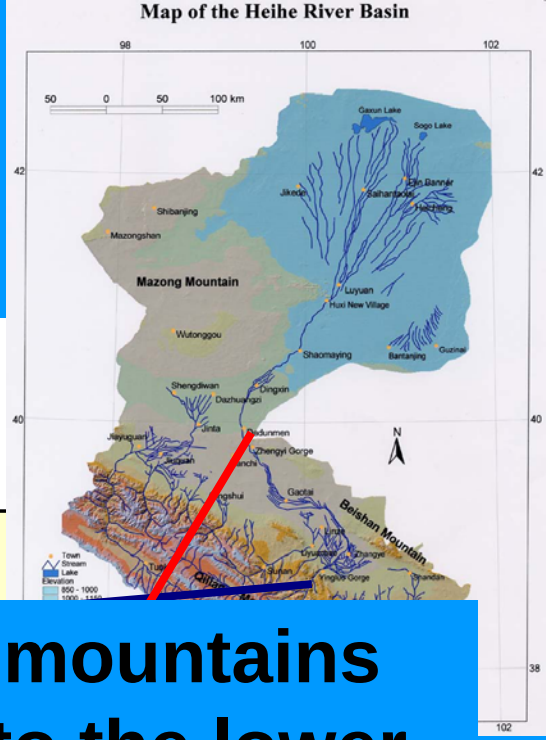
A regulation to limit the water use in the middle stream

River discharge, t / a





River discharge, t / a



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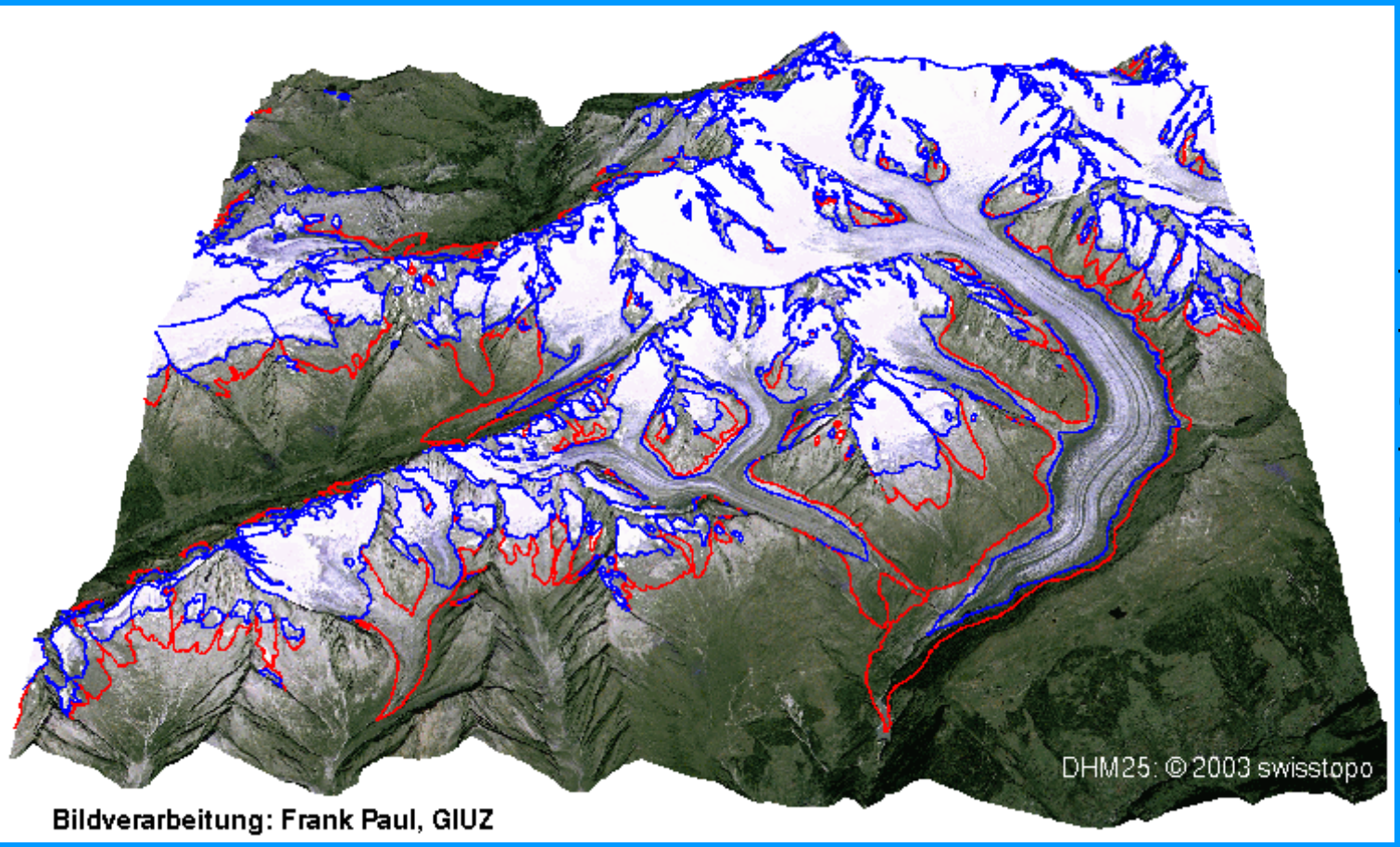
Although the river discharge from the mountains has been rather stable, the discharge to the lower reaches has rapidly decreased. The major cause for the water shortage in the lower reaches is the large water consumption in the middle reaches.

The glacier studies, therefore, are to be combined with studies on human activities downstream, in order to seek for better human life.

Aletsch Glacier J Alean

Climate change in mountains affects hydropower production capacity



Glacier recession leads to change in timing of water delivery such that small changes in precipitation may lead to larger changes in performance.

Findeln glacier (left) and Gorner glacier (right) J Alean