EARTH 270 – DISASTERS AND NATURAL HAZARDS (v. 2018)

Kensennuma City, Miyagi Prefecture , Japan, March 2011

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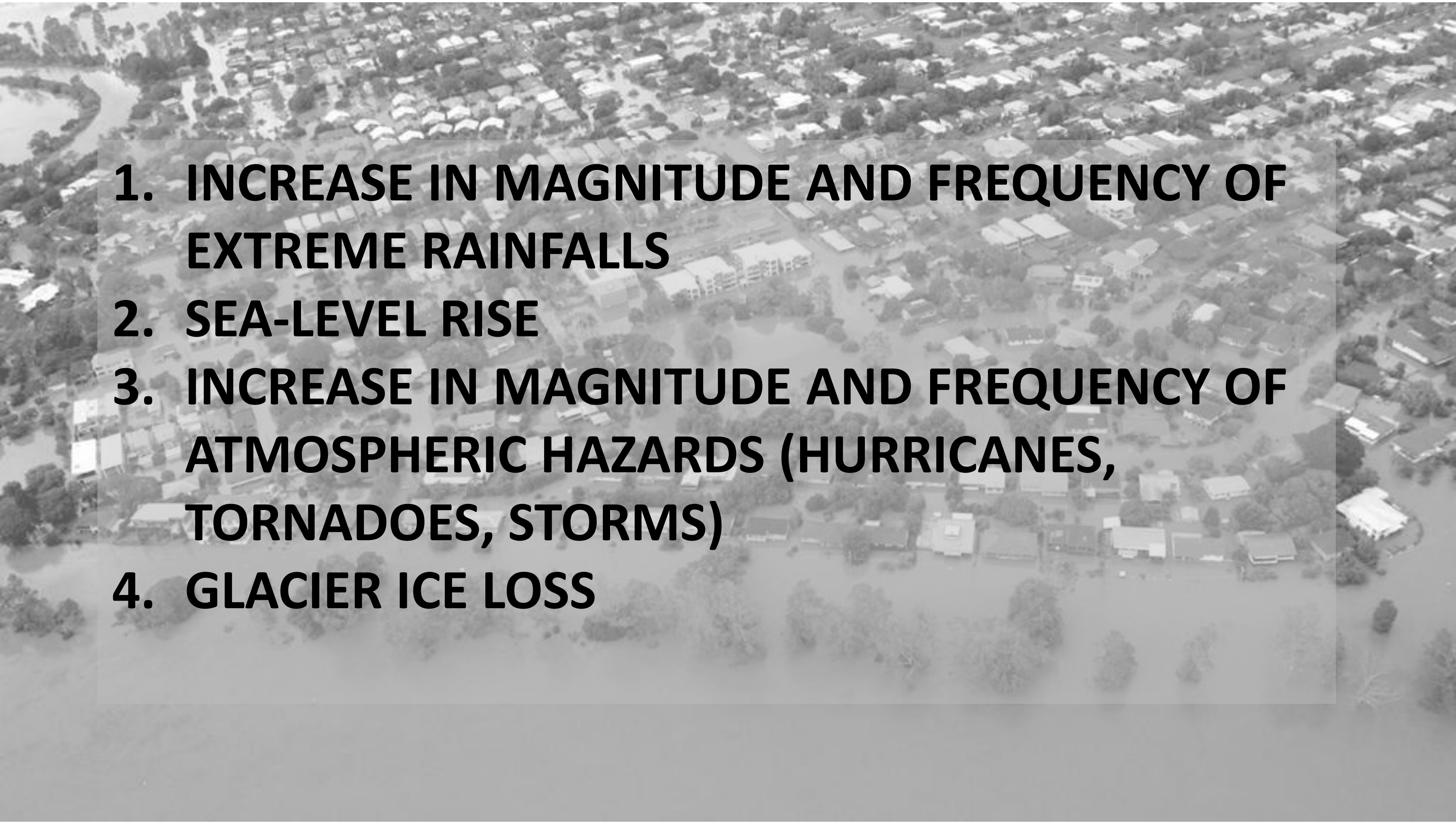
UNIVERSITY OF WATERLOO

NATURAL HAZARDS AND CLIMATE CHANGE



1. INCREASE IN MAGNITUDE AND FREQUENCY OF EXTREME RAINFALLS
2. SEA-LEVEL RISE
3. INCREASE IN MAGNITUDE AND FREQUENCY OF ATMOSPHERIC HAZARDS (HURRICANES, TORNADOES, STORMS)
4. GLACIER ICE LOSS

1. INCREASE IN MAGNITUDE AND FREQUENCY OF EXTREME RAINFALLS

INCREASE IN FLOODS, DEBRIS FLOODS, AND LANDSLIDES ?

DEBRIS FLOOD IN CANMORE, ALBERTA (2013)

DEBRIS FLOOD IN CANMORE, ALBERTA (2013)

KYUSHU RAINFALL-INDUCED LANDSLIDES (2012)

2. SEA-LEVEL RISE

Malé – capital of Maldives

Figure TS.18. *Annual averages of the global mean sea level based on reconstructed sea level fields since 1870 (red), tide gauge measurements since 1950 (blue) and satellite altimetry since 1992 (black). Units are in mm relative to the average for 1961 to 1990. Error bars are 90% confidence intervals. {Figure 5.13}*

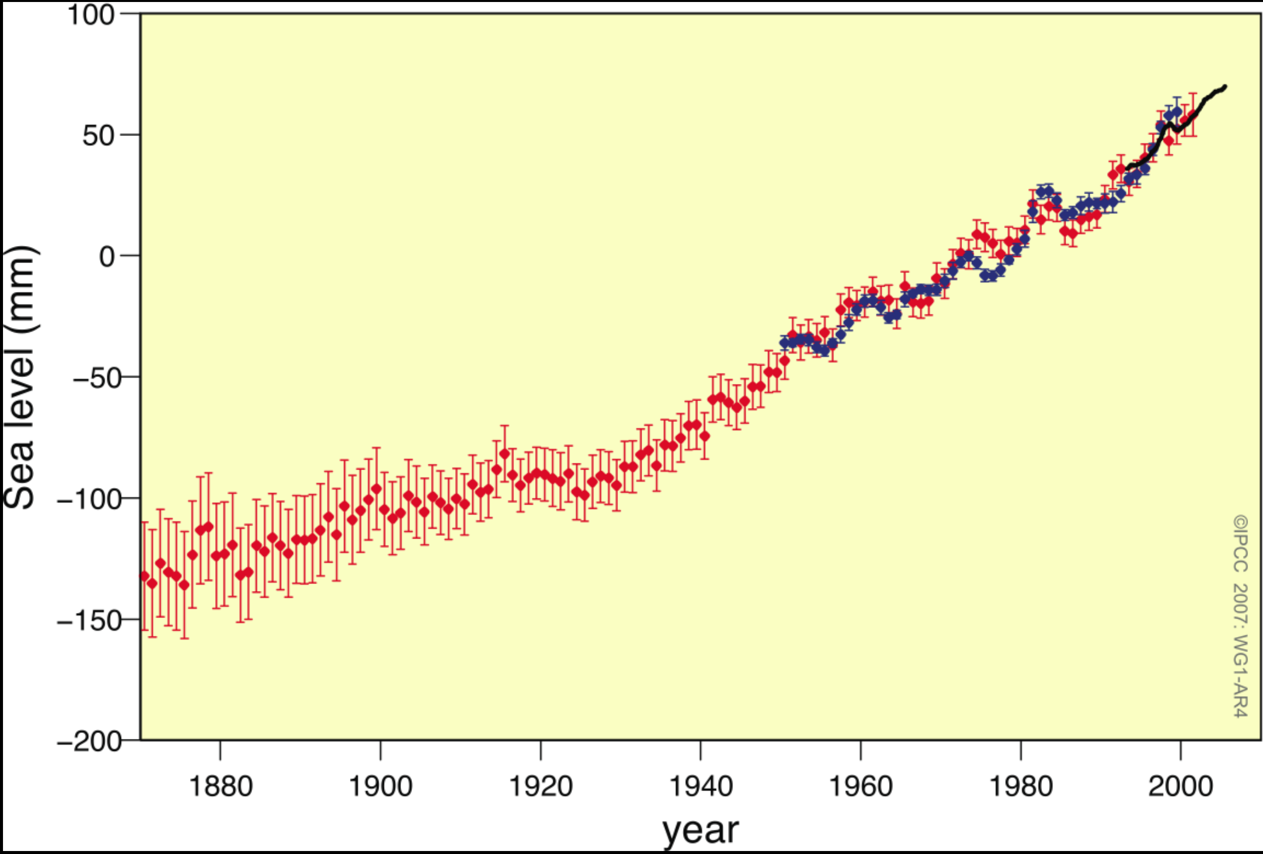
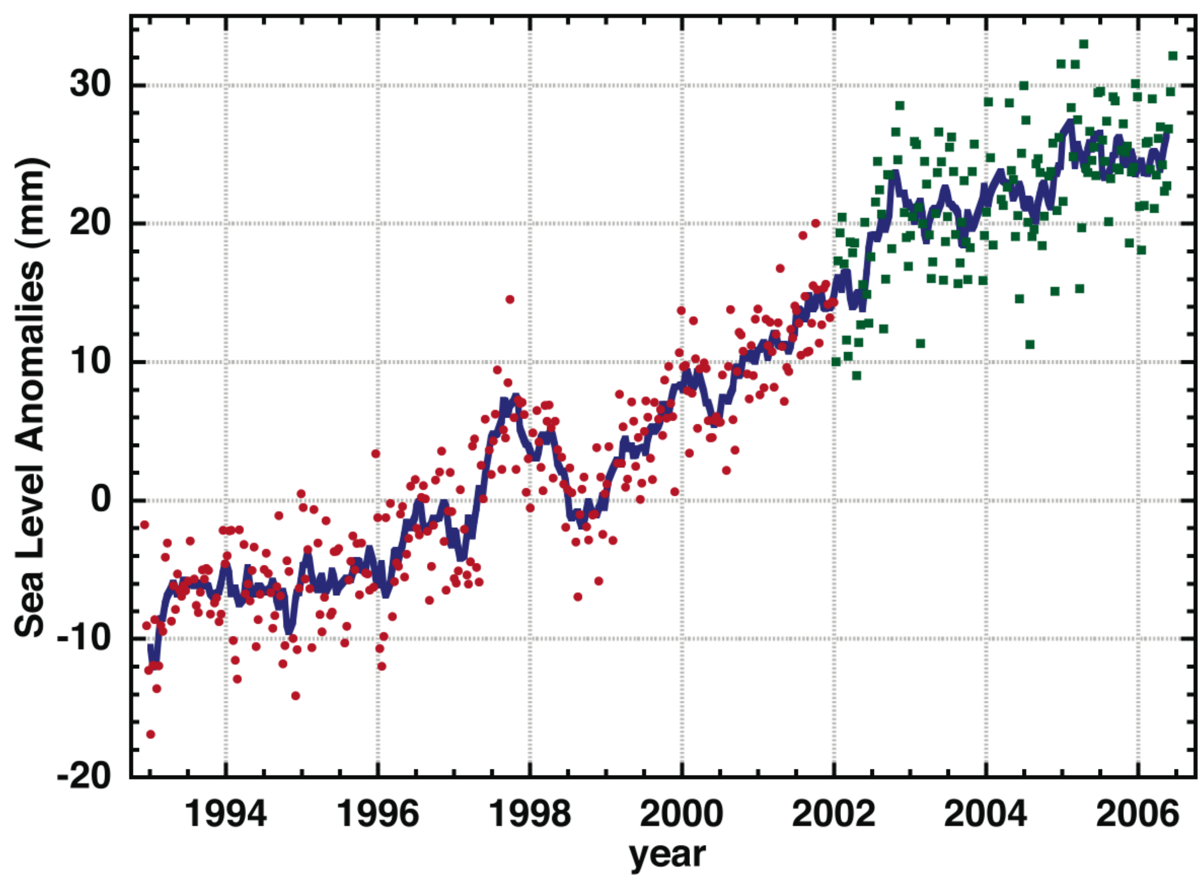


Figure 5.14.

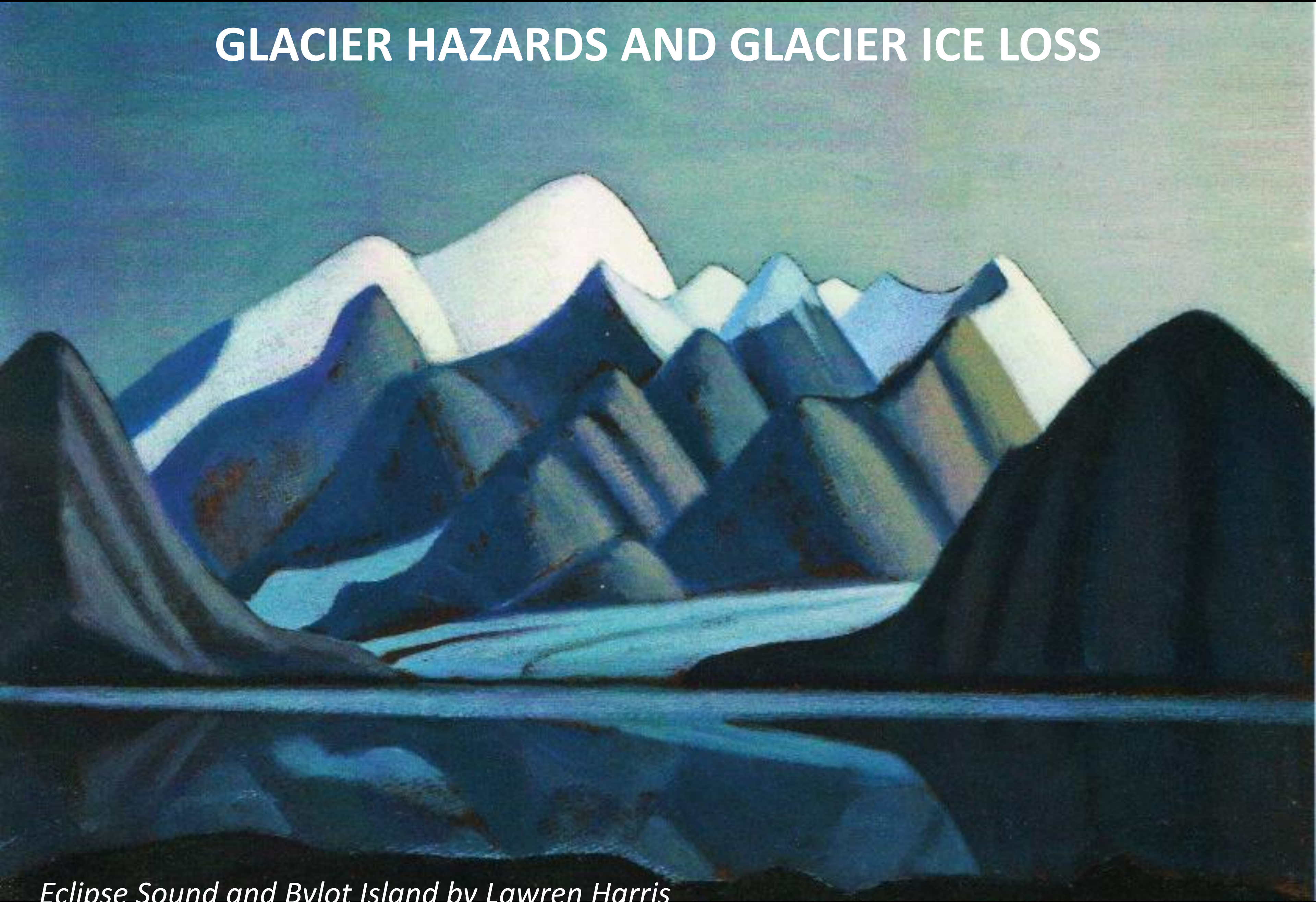
Variations in global mean sea level (difference to the mean 1993 to mid-2001) computed from satellite altimetry from January 1993 to October 2005, averaged over 65°S to 65°N. Dots are 10-day estimates (from the TOPEX/Poseidon satellite in red and from the Jason satellite in green). The blue solid curve corresponds to 60-day smoothing. Updated from Cazenave and Nerem (2004) and Leuliette et al. (2004).



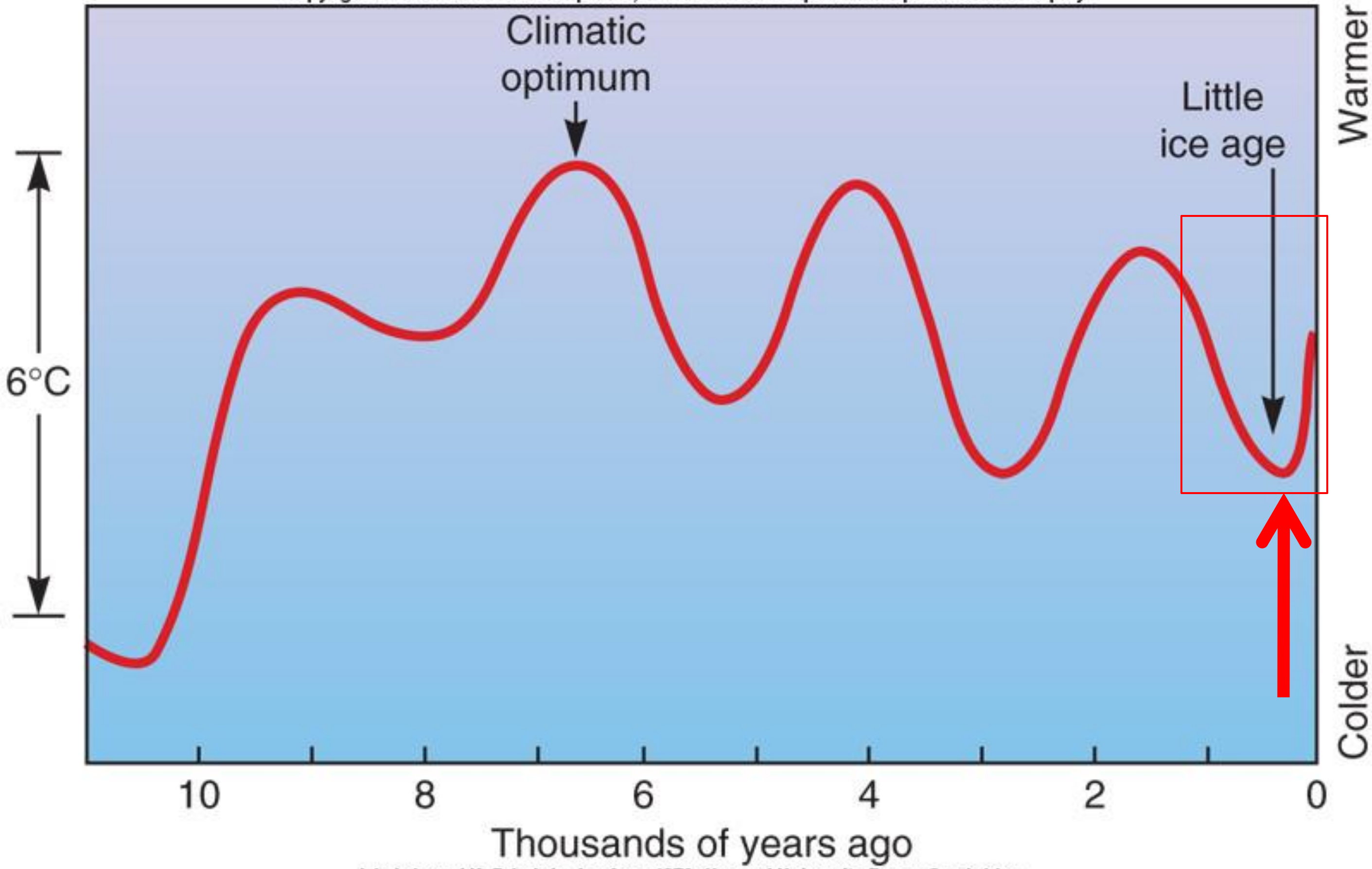
3. INCREASE IN MAGNITUDE AND FREQUENCY OF ATMOSPHERIC HAZARDS (HURRICANES, TORNADOES, STORMS)

4. GLACIER ICE LOSS

GLACIER HAZARDS AND GLACIER ICE LOSS

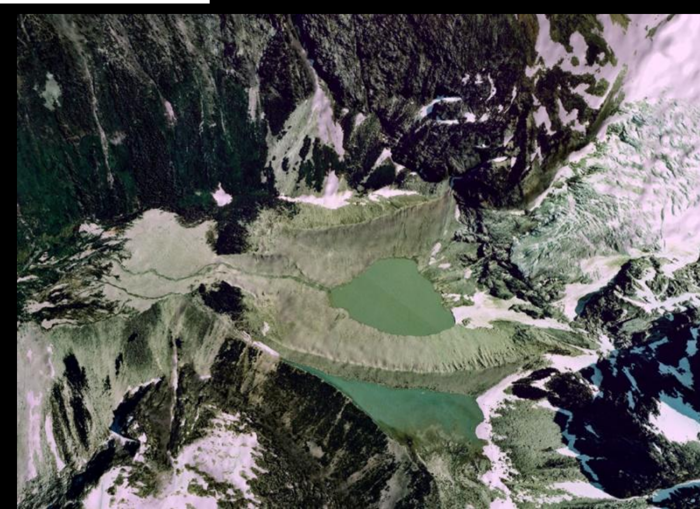


Eclipse Sound and Bylot Island by Lawren Harris

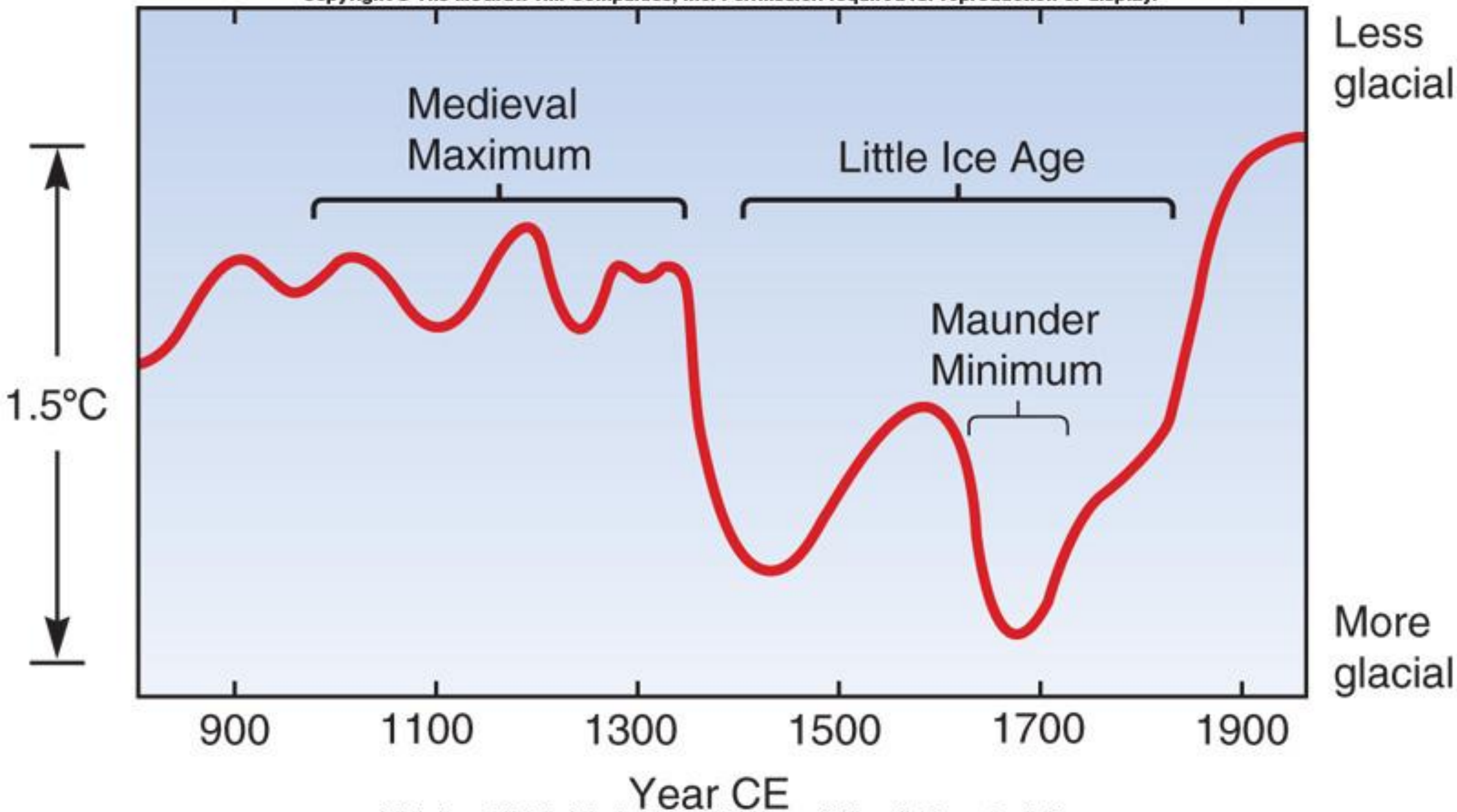


J. Imbrie and K. P. Imbrie, *Ice Ages*,1979; Harvard University Press, Cambridge

NATURAL HAZARDS AND CLIMATE CHANGE IN THE LAST 1,000 YEARS



CLIMATE CHANGE IN THE LAST 1,000 YEARS



J. Imbrie, and K. P. Imbrie, *Ice Ages*,1979; Harvard University Press, Cambridge

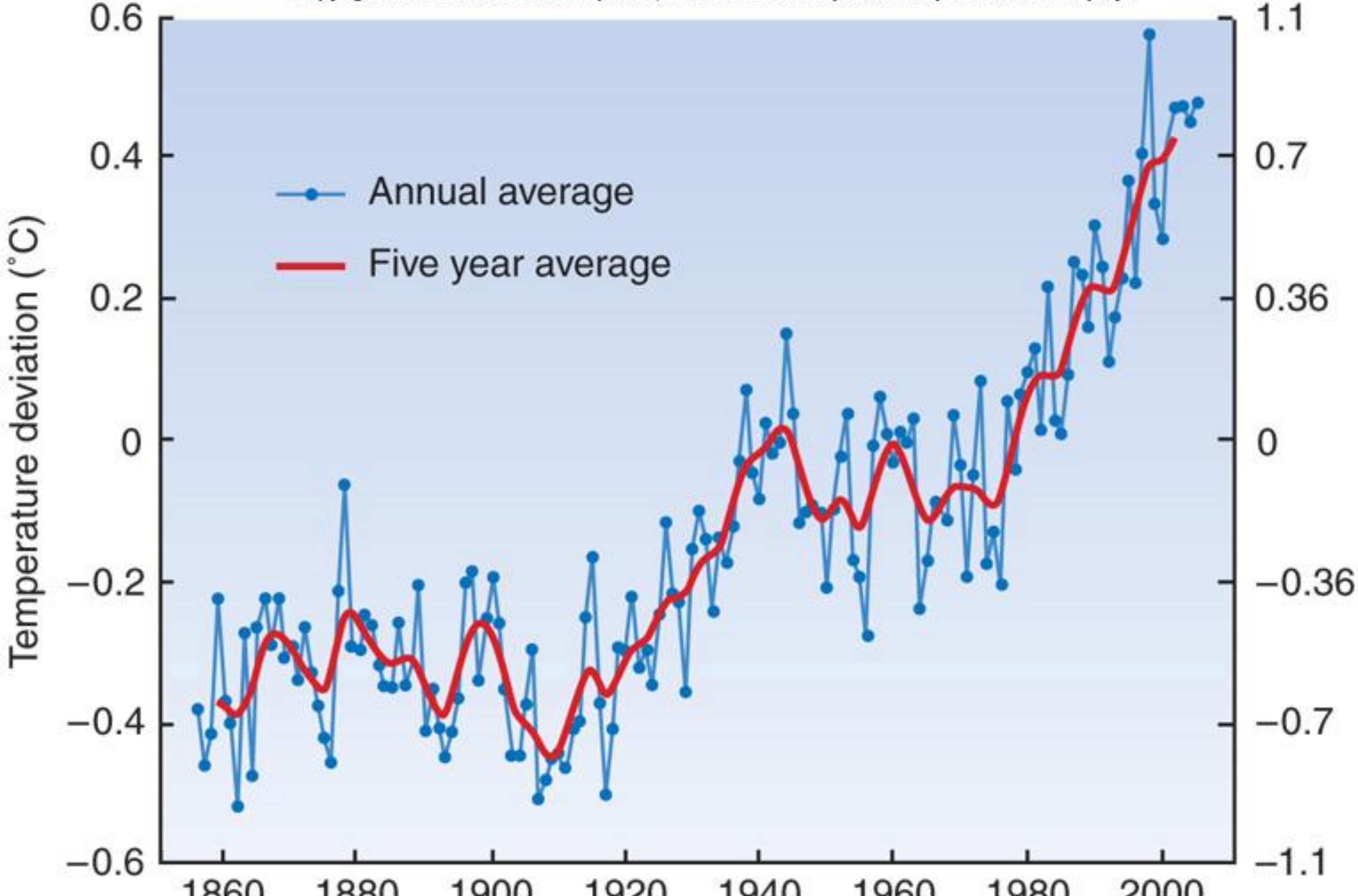
THE LITTLE ICE AGE

HOW CLIMATE MADE HISTORY
1300–1850

BRIAN FAGAN

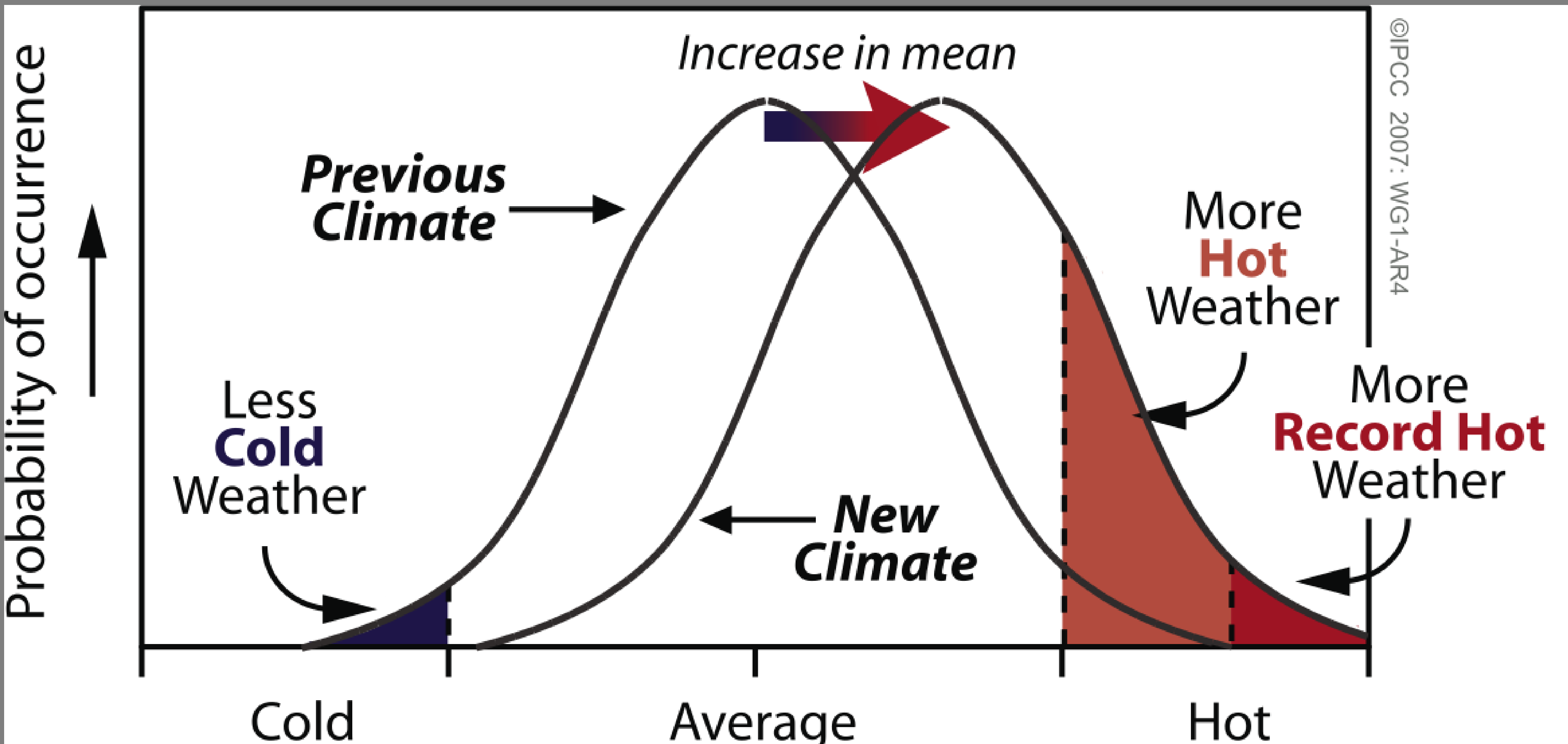
AUTHOR OF
Floods, Famines and Emperors

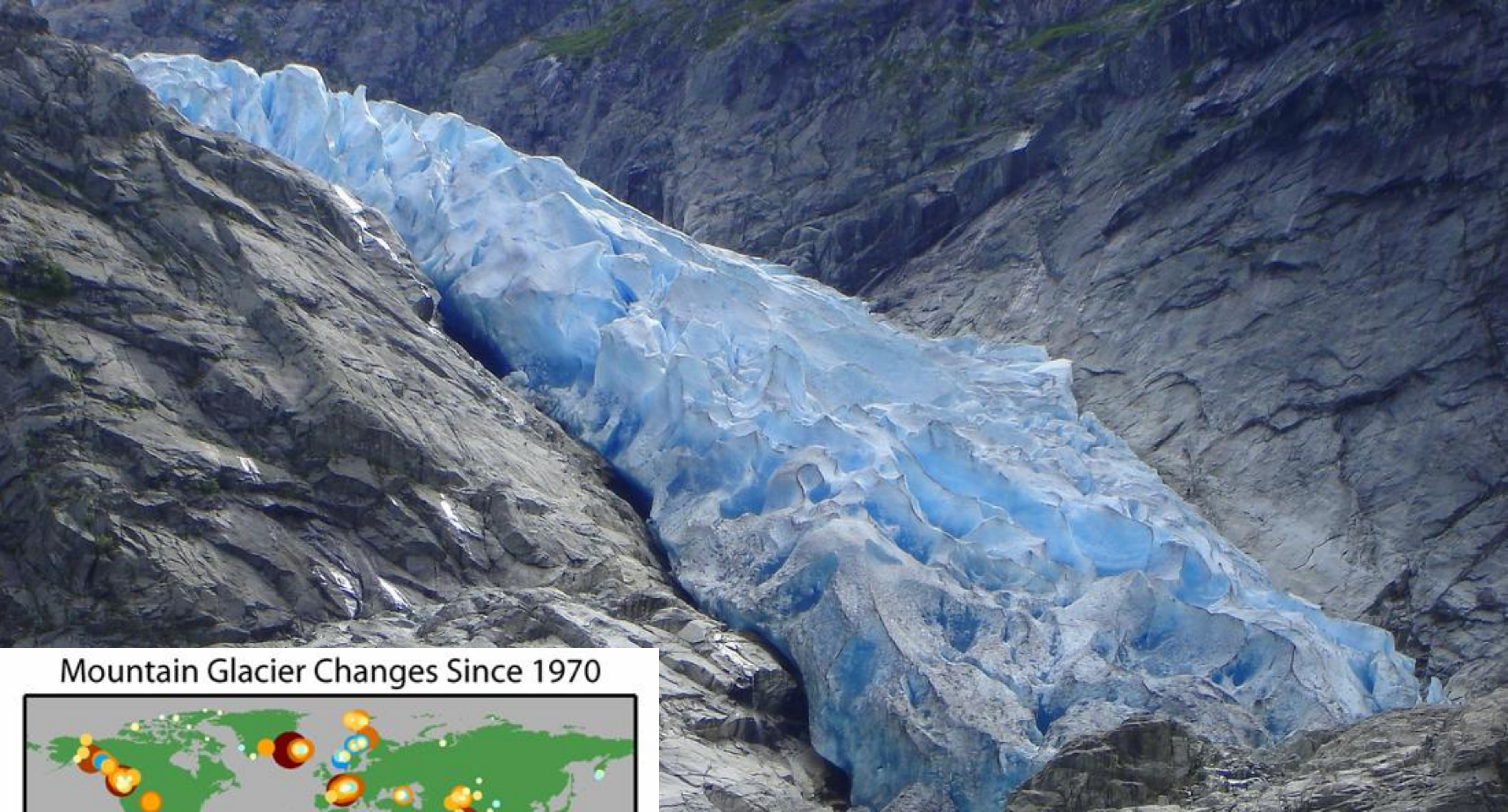
CLIMATE CHANGE IN THE LAST CENTURY OR SO; WHAT IS THE MOST VISIBLE RESULT AND WHAT HAZARDS HAVE INCREASED IN MAGNITUDE AND FREQUENCY?

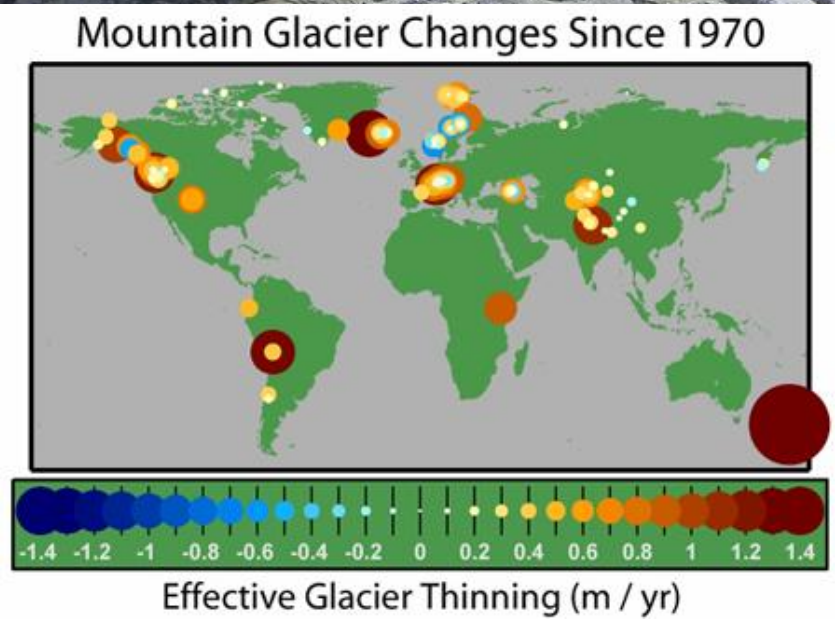


University of East Anglia and the Hadley Centre of the United Kingdom

GLOBAL WARMING



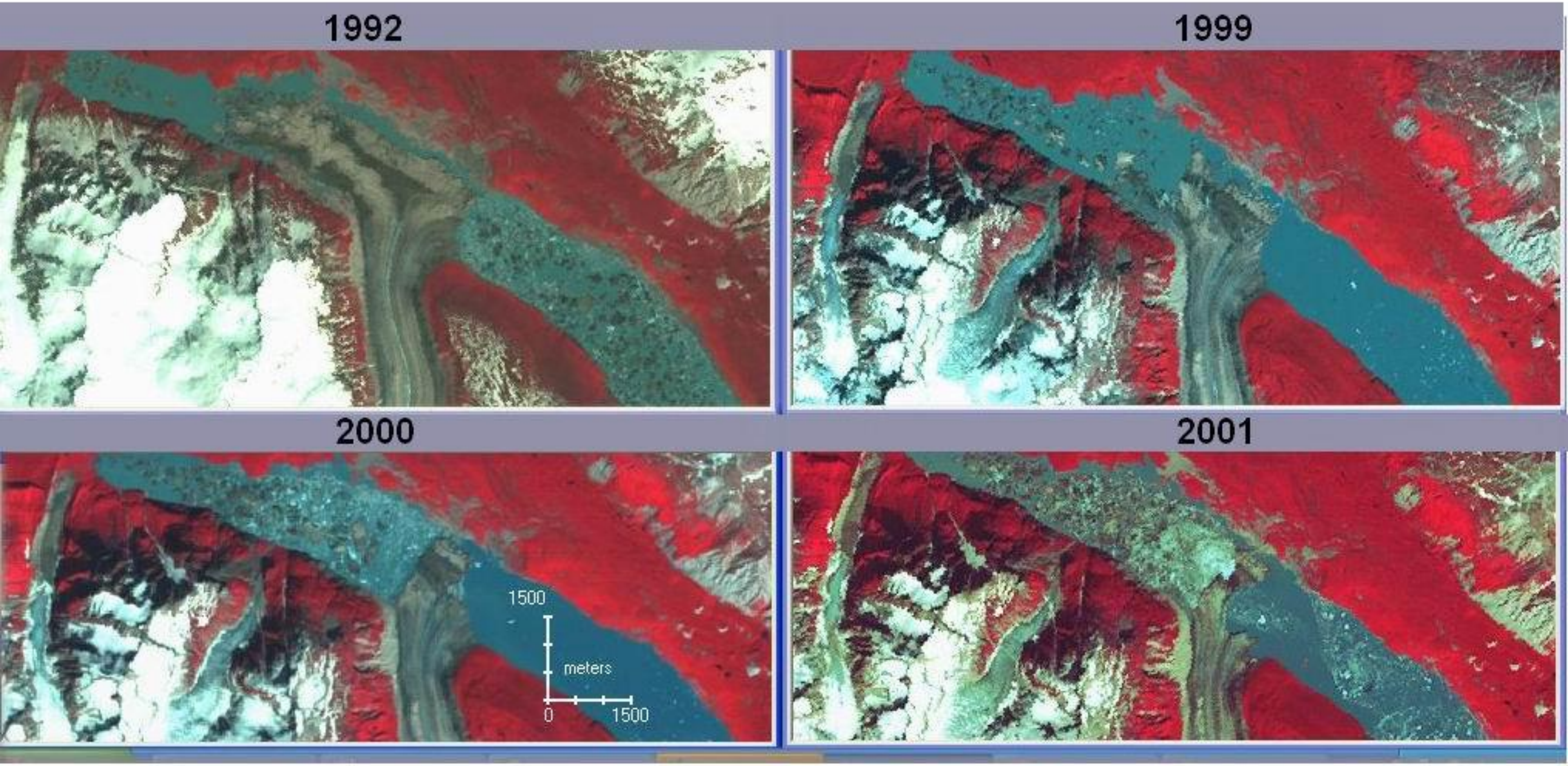


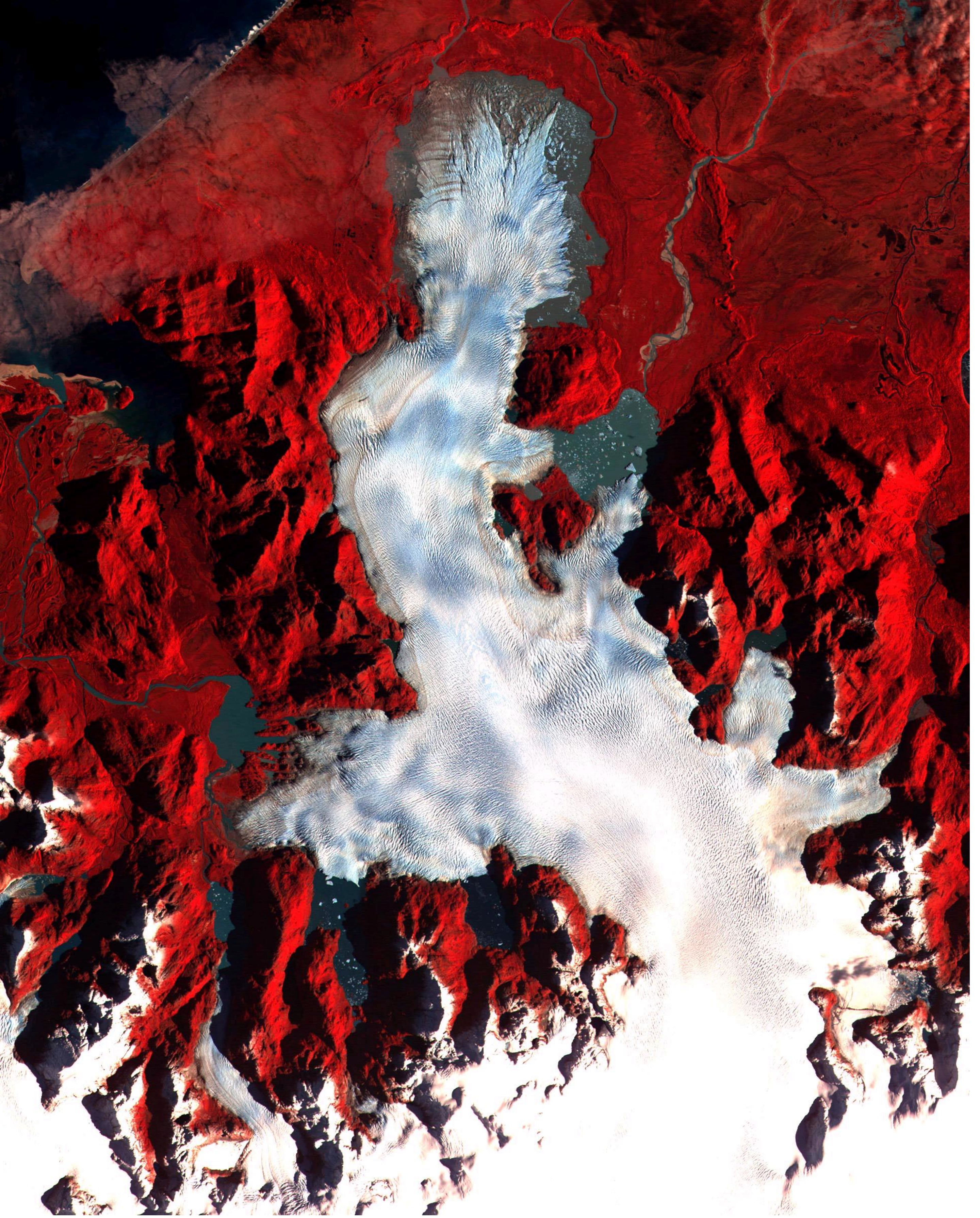


GLACIERS AND GLACIER ICE LOSS

GLACIERS – THERMOMETERS FOR CLIMATE CHANGE

Glacier retreat in Lake Melbern area as recorded in Landsat TM/ETM+ satellite imagery, 1992-2002

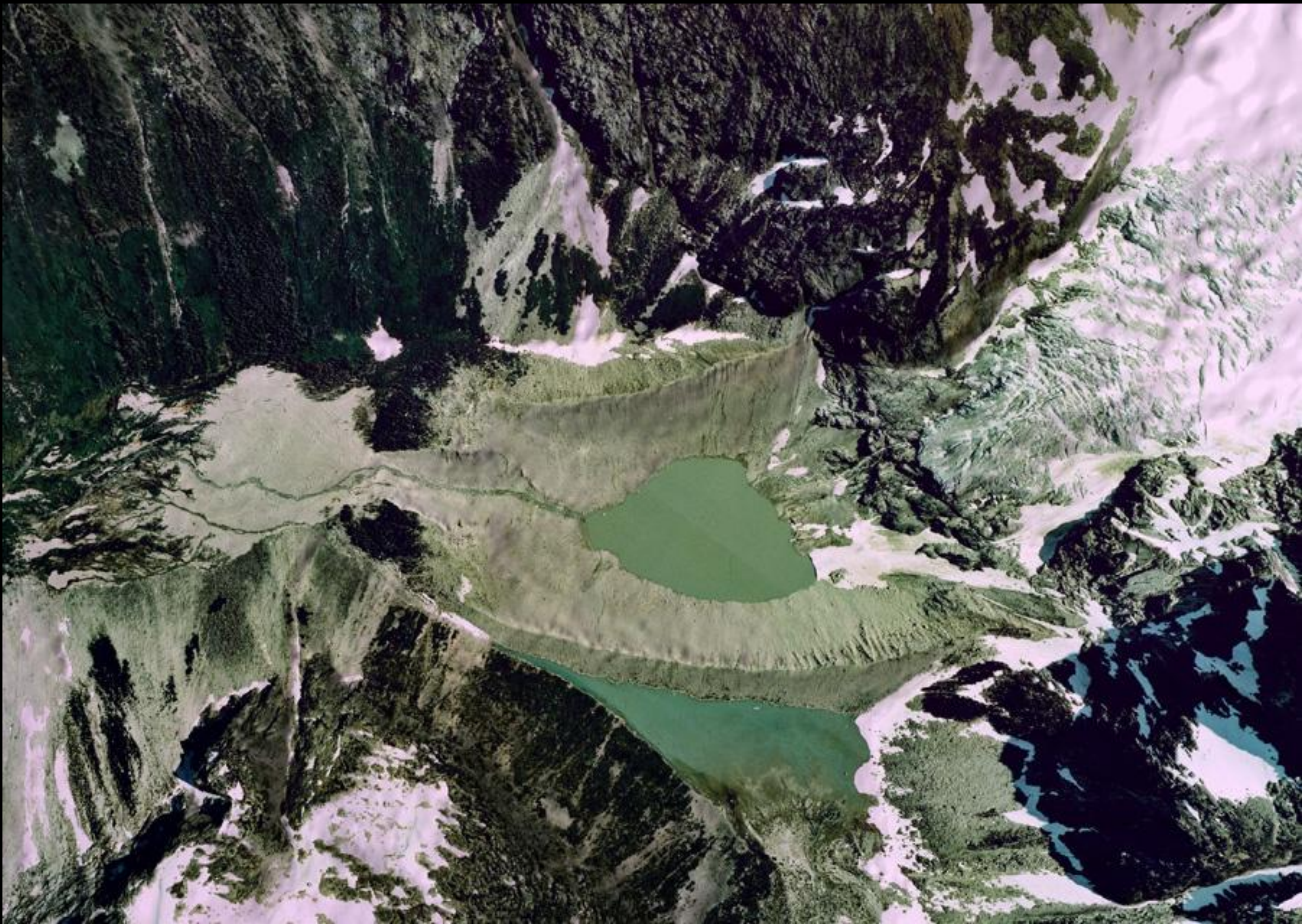


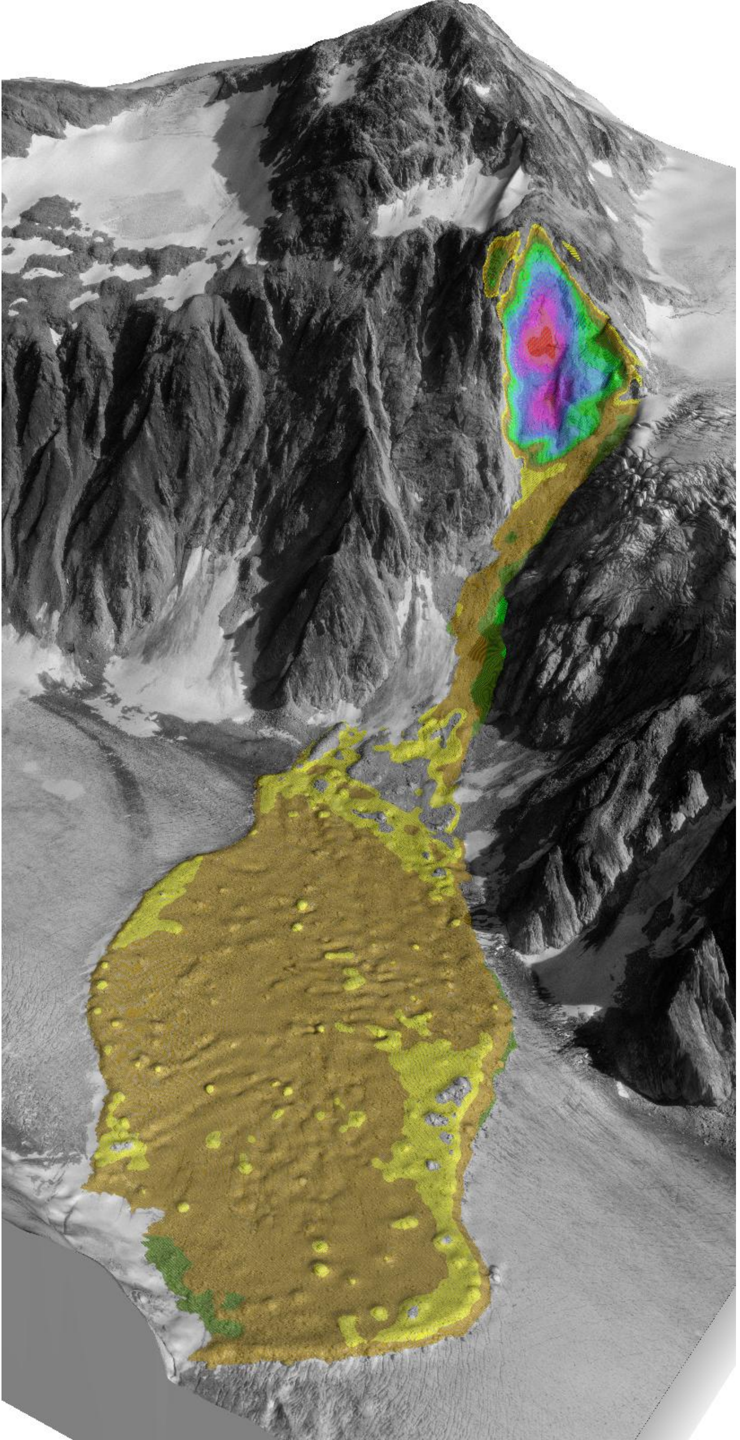


RETREATING GLACIERS IN PATAGONIA

GLACIERS RETREATING IN BHUTAN HIMALAYA CREATING GLACIAL LAKES

GEOMORPHIC HAZARDS RELATED TO CATASTROPHIC GLACIER ICE LOSS





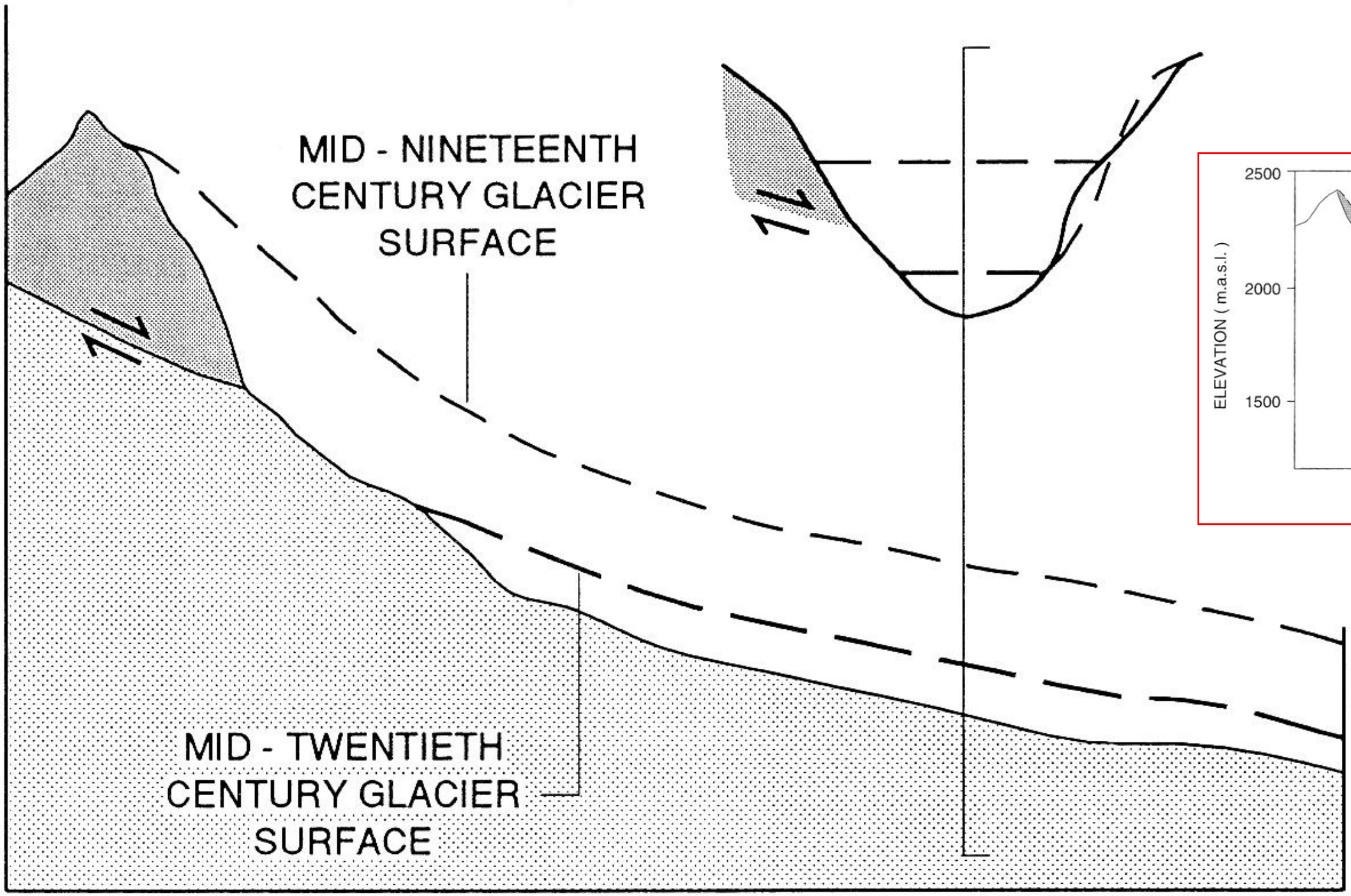
ICE LOSS IN THREE DIMENSIONS

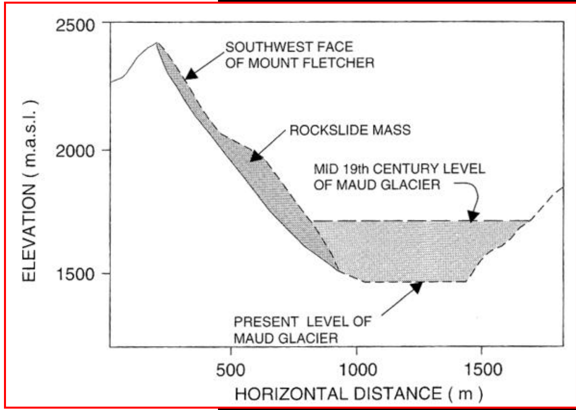
TIME, AREAL EXTENT (GLACIAL RETREAT), AND VERTICAL DIMENSION (GLACIER DOWNWASTING)

GEOMORPHIC HAZARDS ASSOCIATED WITH ICE LOSS

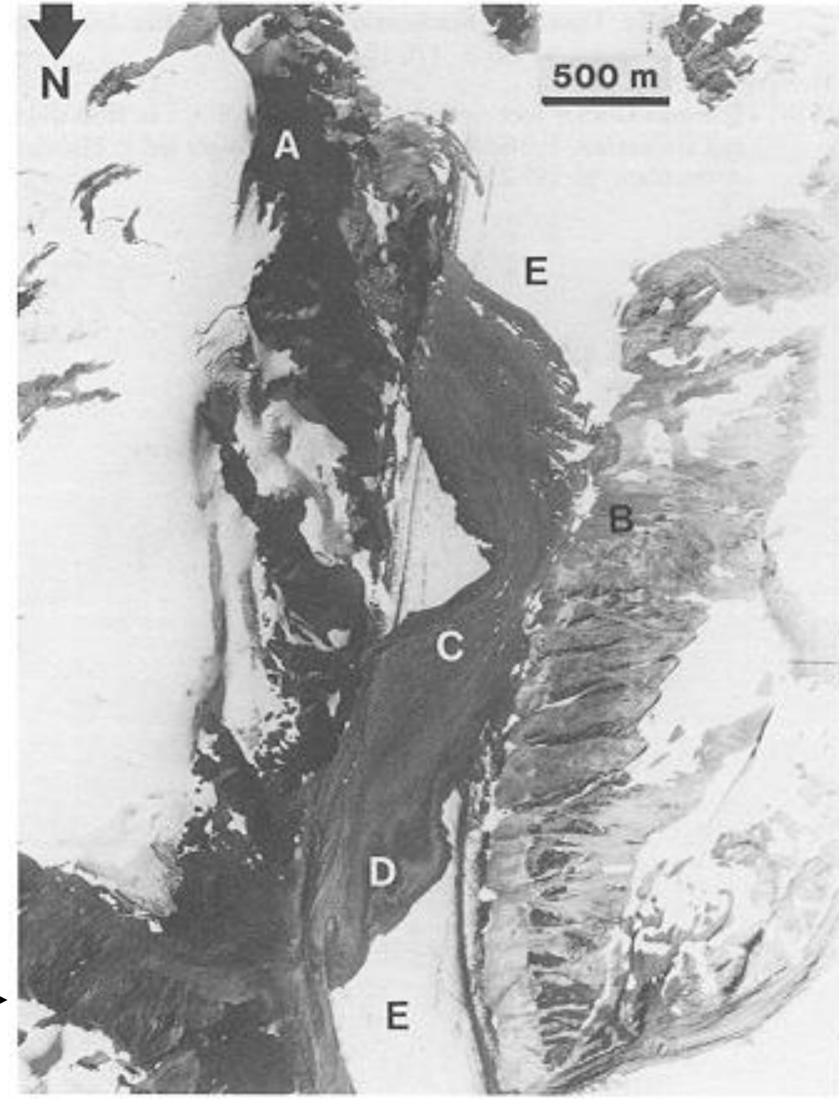
1. LANDSLIDES
2. DEBRIS FLOWS
3. GLACIER AVALANCHES
4. FORMATION AND FAILURE OF MORAINE-DAMMED LAKES
5. FORMATION AND FAILURE OF GLACIER-DAMMED LAKES

GLACIER THINNING AND RETREAT AND LANDSLIDES





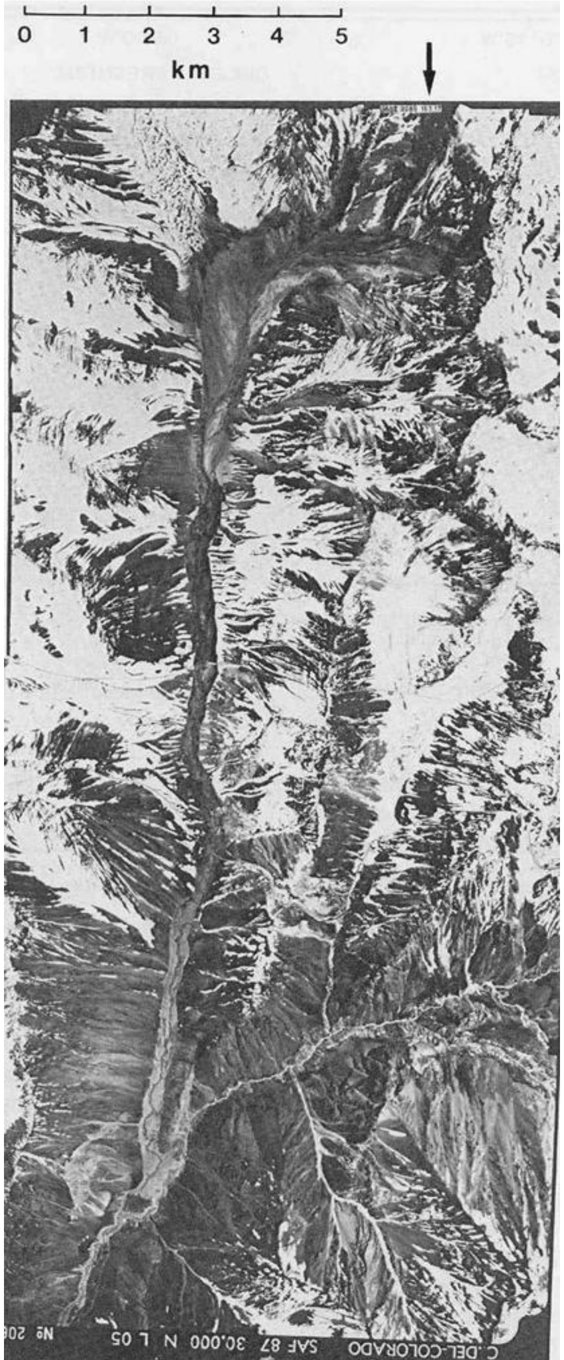
ROCK AVALANCHES, WITH VOLUMES IN EXCESS OF 1 M m^3, HAVE OCCURRED IN THE COAST MOUNTAINS OF BRITISH COLUMBIA EVERY 3.5 YEARS 1955-1999.



1956 Tim Williams Glacier rock avalanche (3 M m^3)

1997 Mount Munday rock avalanche (3.2 M m^3)

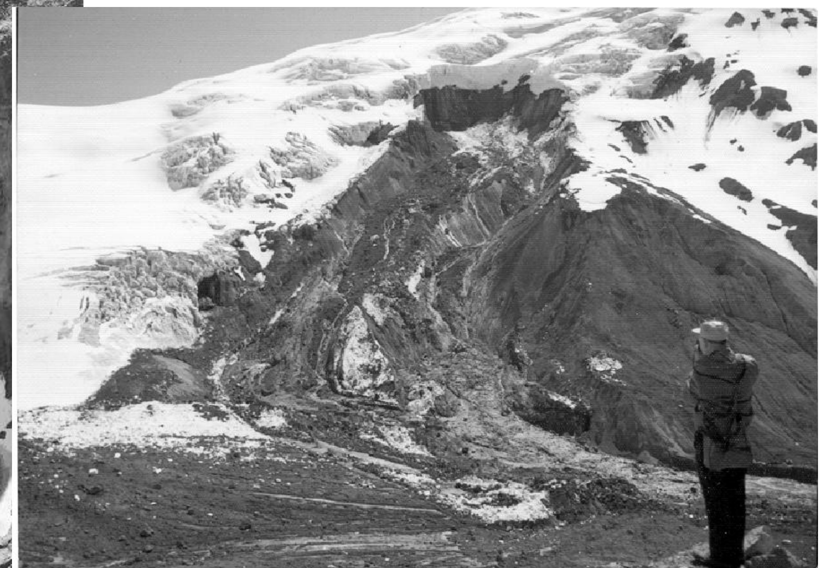
1987 Parraguirre rock avalanche-debris flow, Chilean Andes



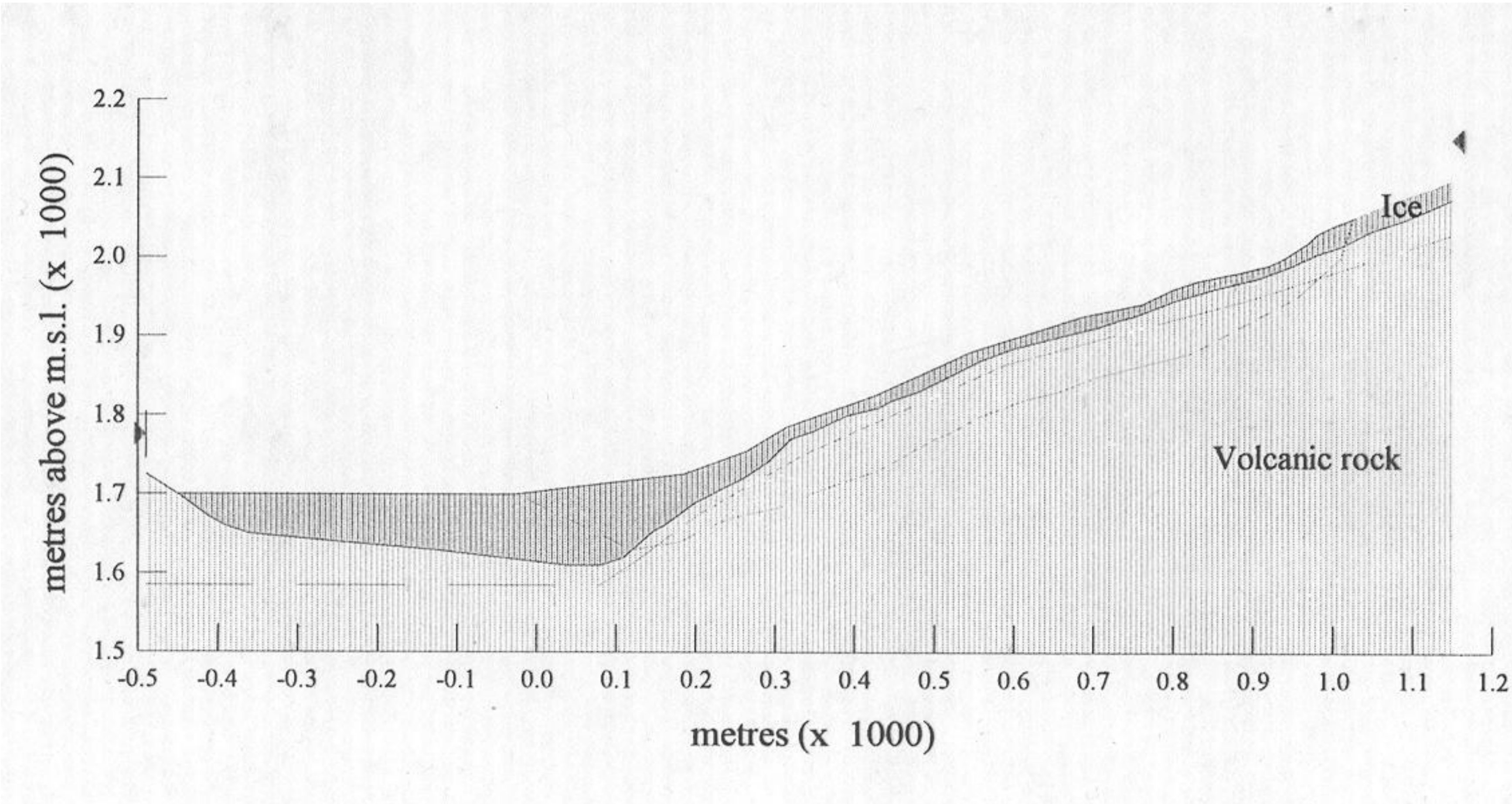
1959 Pandemonium Creek rock avalanche, Coast Mountains, B.C.

1975 DEVASTATION GLACIER LANDSLIDE, COAST MOUNTAINS, BRITISH COLUMBIA

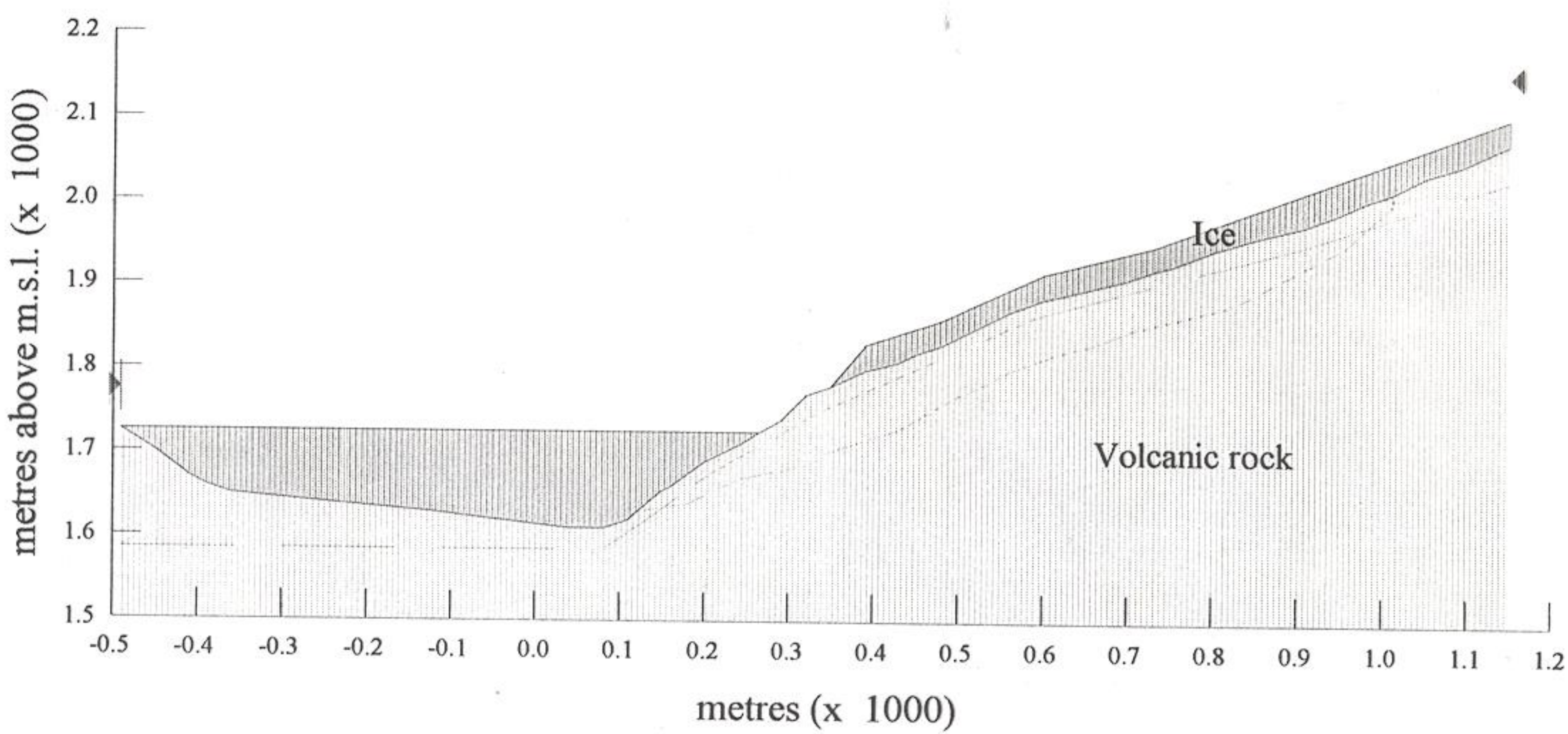
SOURCE AREA OF 1975 DEVASTATION LANDSLIDE



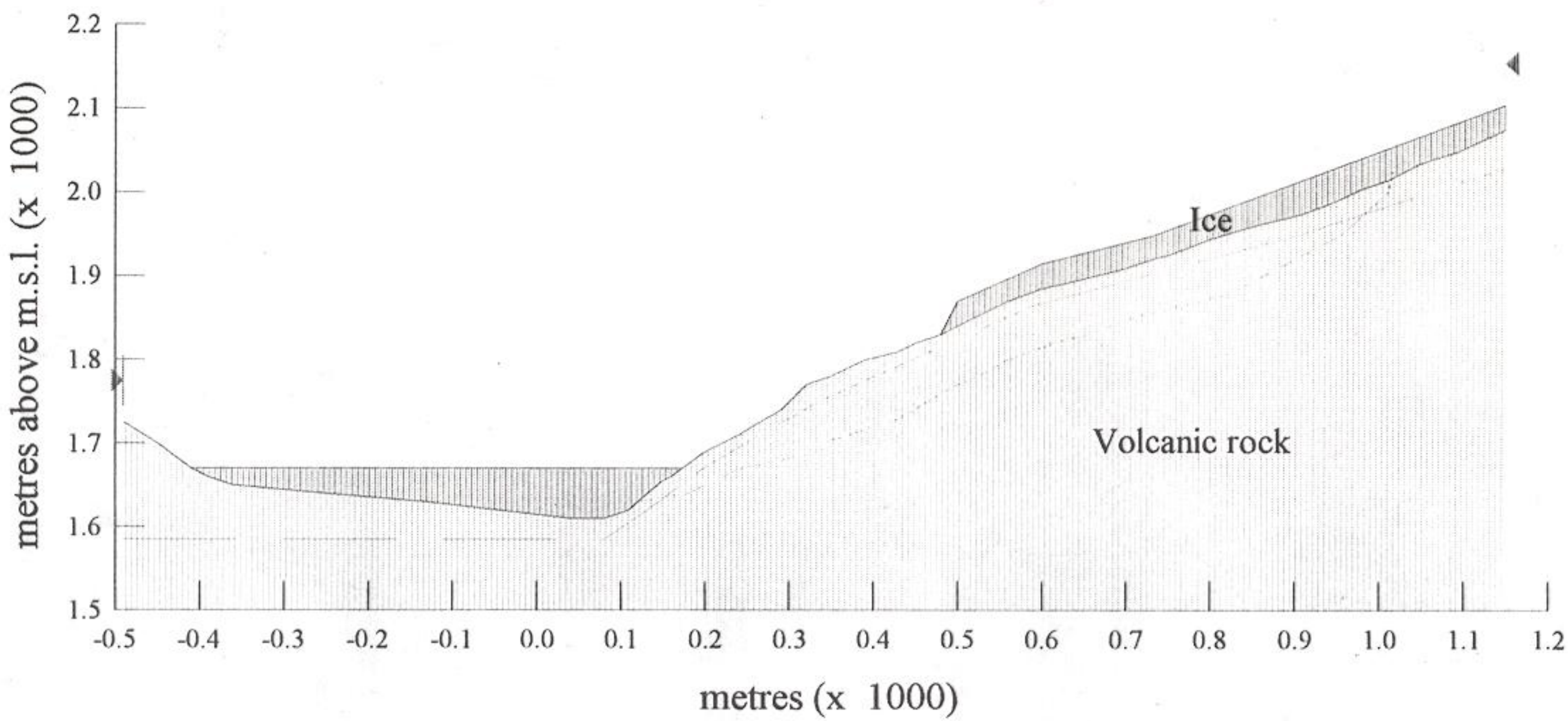
STABILITY ANALYSIS OF GLACIER DOWNWASTING AND ICE RETREAT AT DEVASTATION GLACIER (1)



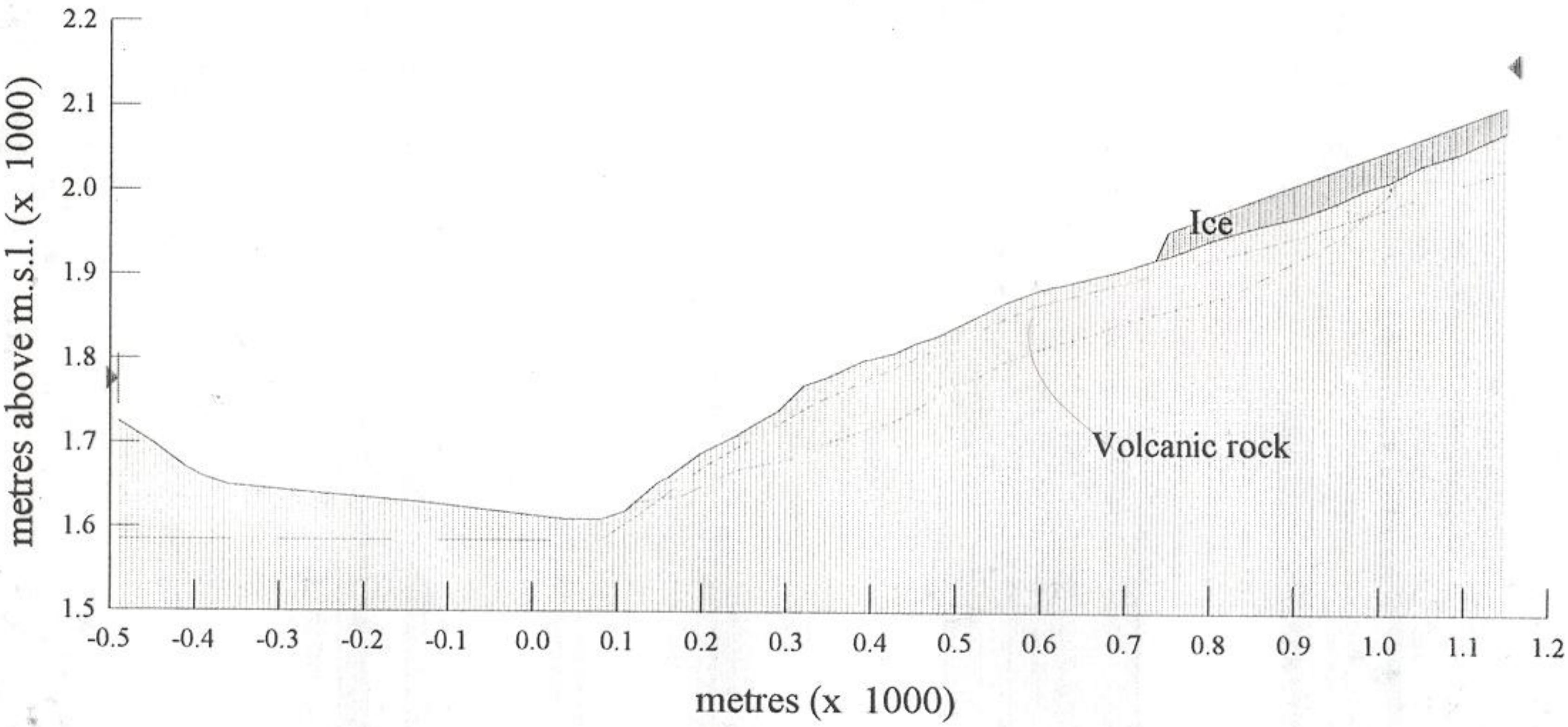
T1 – FULL NEOGLACIAL EXTENT; SLOPE UNDERCUT BEGINNING OF ICE LOSS



T2 – CONTINUED ICE LOSS; SEPARATION OF DEVASTATION GLACIER AND CREST GLACIER

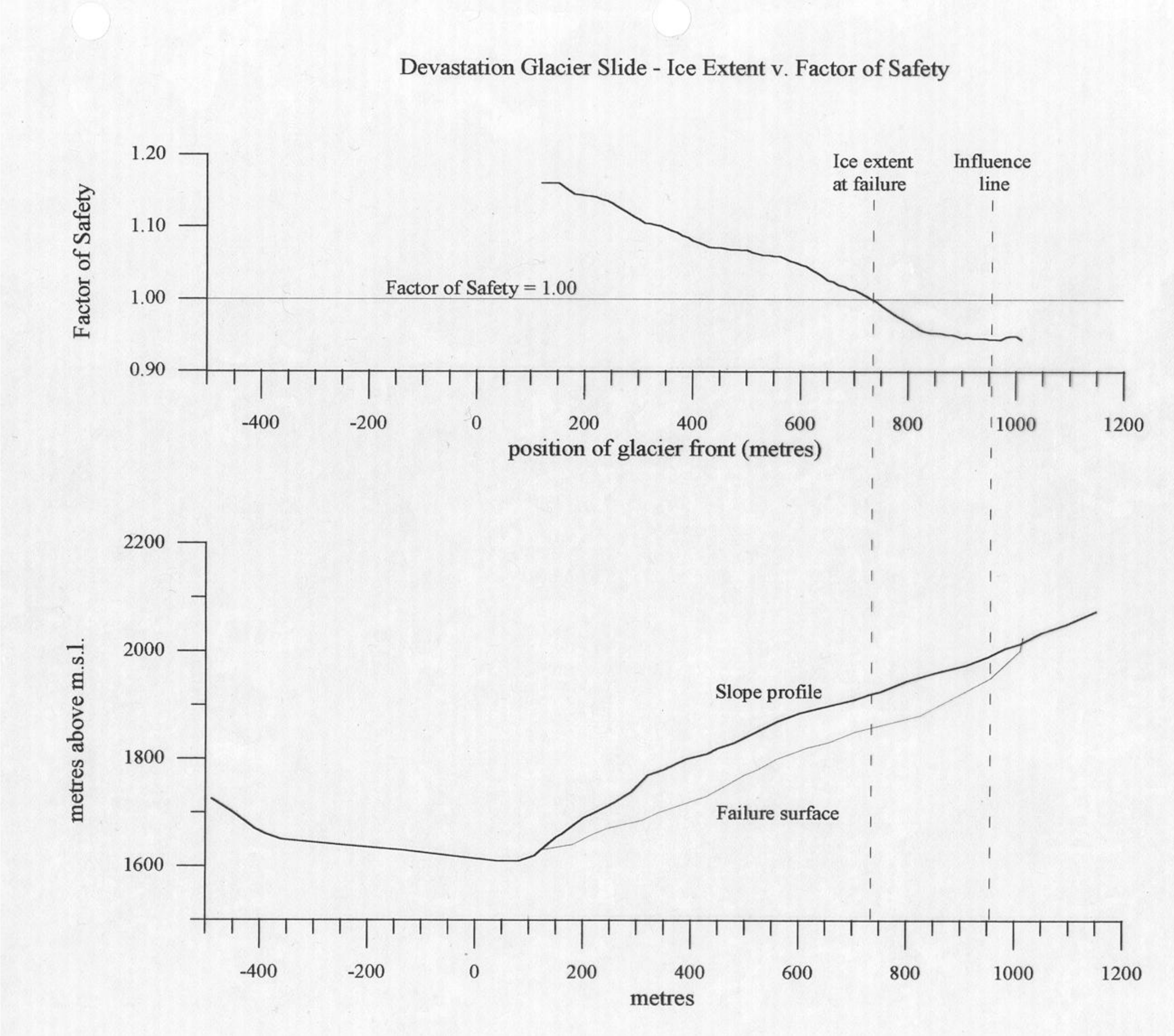


T3 – CONTINUED ICE LOSS; DEBUTRESSING OF TOE AND RETREAT OF CREST GLACIER UPSLOPE



T4-FAILURE CONDITIONS IN 1975; COMPLETE TOE DEBUTRESSING AND RETREAT OF CREST GLACIER TO HEAD OF 1975 SLIDE

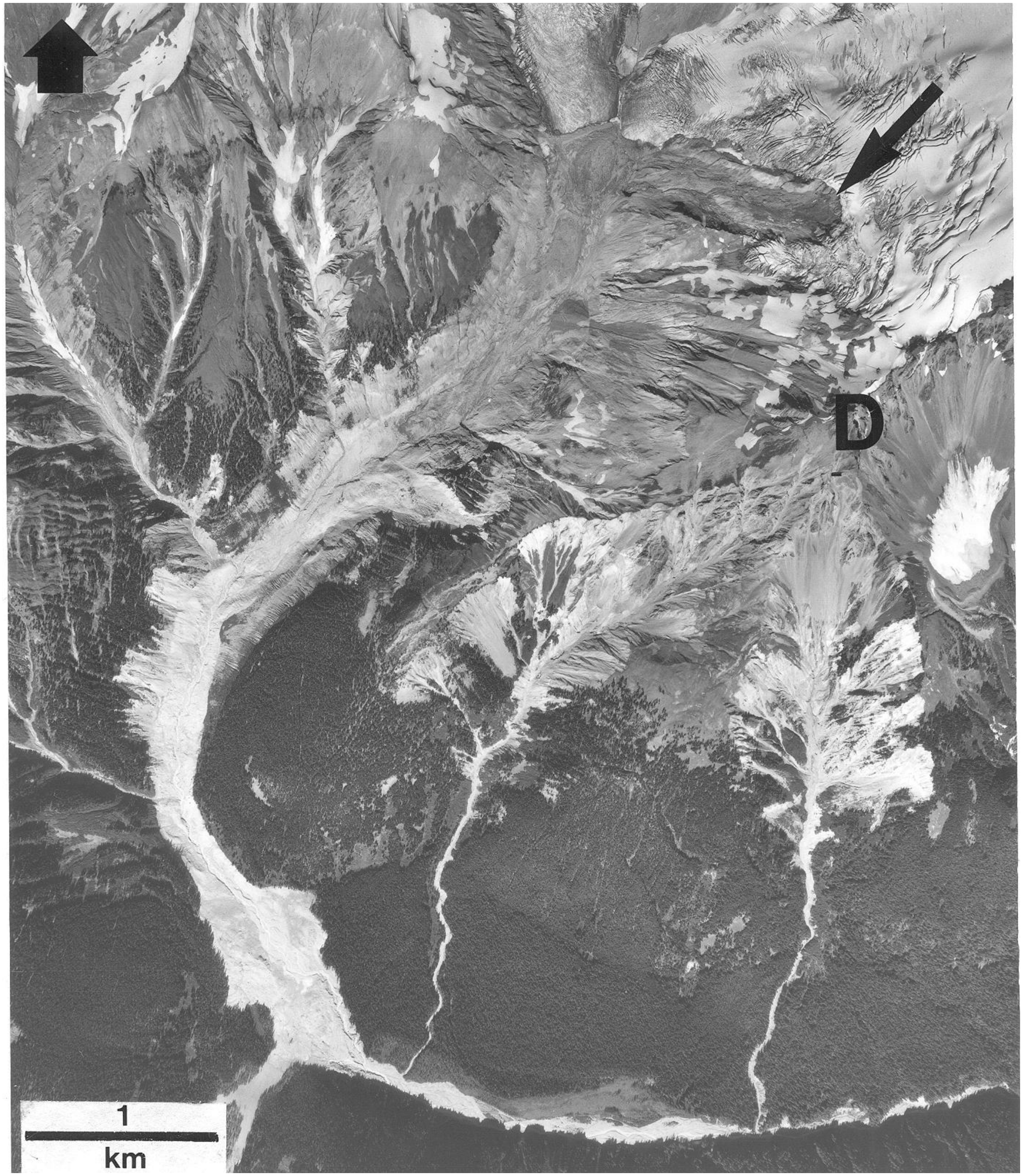
STABILITY ANALYSIS OF GLACIER DOWNWASTING AND ICE RETREAT AT DEVASTATION GLACIER (2) ; ICE EXTENT REFERS TO RETREAT OF CREST GLACIER AFTER SEPARATION



DEBRIS FLOW-DISTAL
DEBRIS CHARACTERISTICS

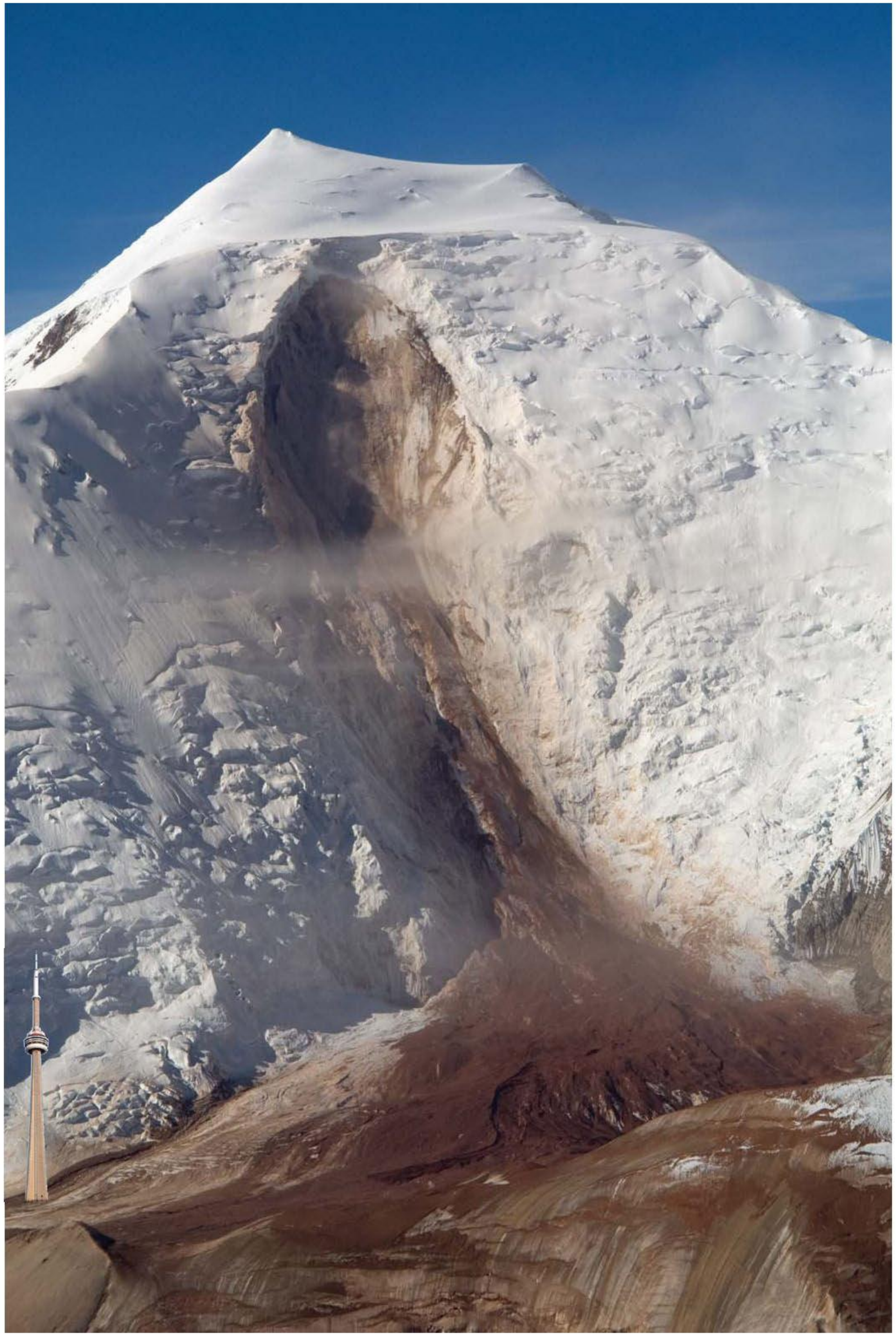
- Highly saturated fluid like debris
- Super-elevation up to 100 m
- V_{max} ~ 36m/s
- Contains blocks of melting ice
- Blocked Meager Creek forming lake

1975 DEVASTATION GLACIER ROCKSLIDE/DEBRIS FLOW



OVERVIEW OF LANDSLIDE PATH

- Initial failure volume = 13 M m^3
- Height of path (H) = 1220 m
- Length of path (L) = 7 km
- Travel angle = arctan H/L = 10°



2007 MOUNT STEELE ROCK AVALANCHE, ST ELIAS MOUNTAINS, YUKON

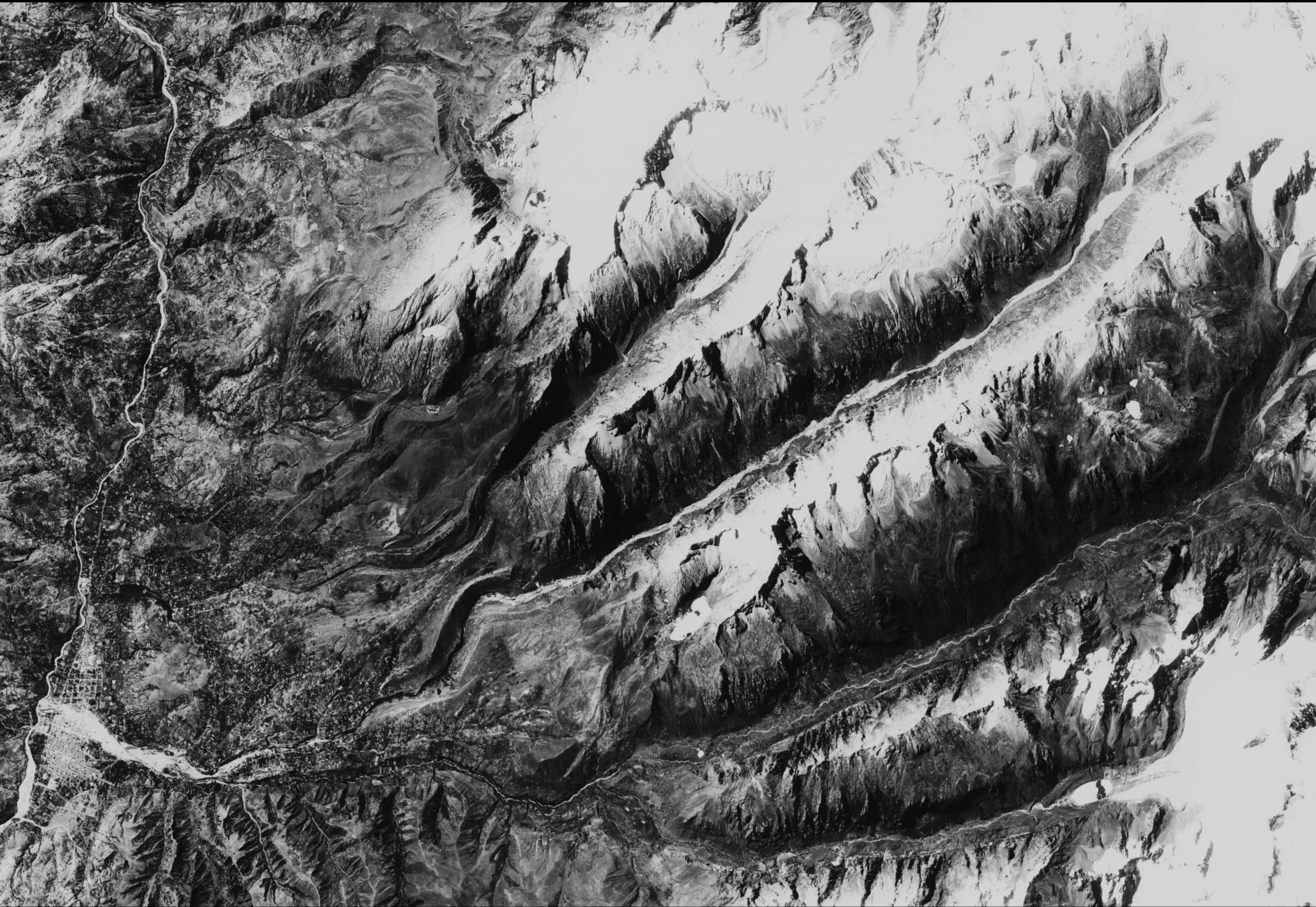
H = 2164 m; L = 5760 m; Velocity ~ 59 m/s ; Volume ~ 75 Mm^3

LAKE PALCACOCHA IN 1940 PHOTOGRAPHED BY KINZL AND SCHNEIDER

48. Die am 13. XII. 1941 ausgebrochene Laguna Cohup, die einen Teil der Stadt Huaras wegriß (7. IX. 1947).

51. Die von der Sturzflut der Laguna Cohup teilweise zerstörte Stadt Huaras. Flugbild von Westen (24. VI. 1947).

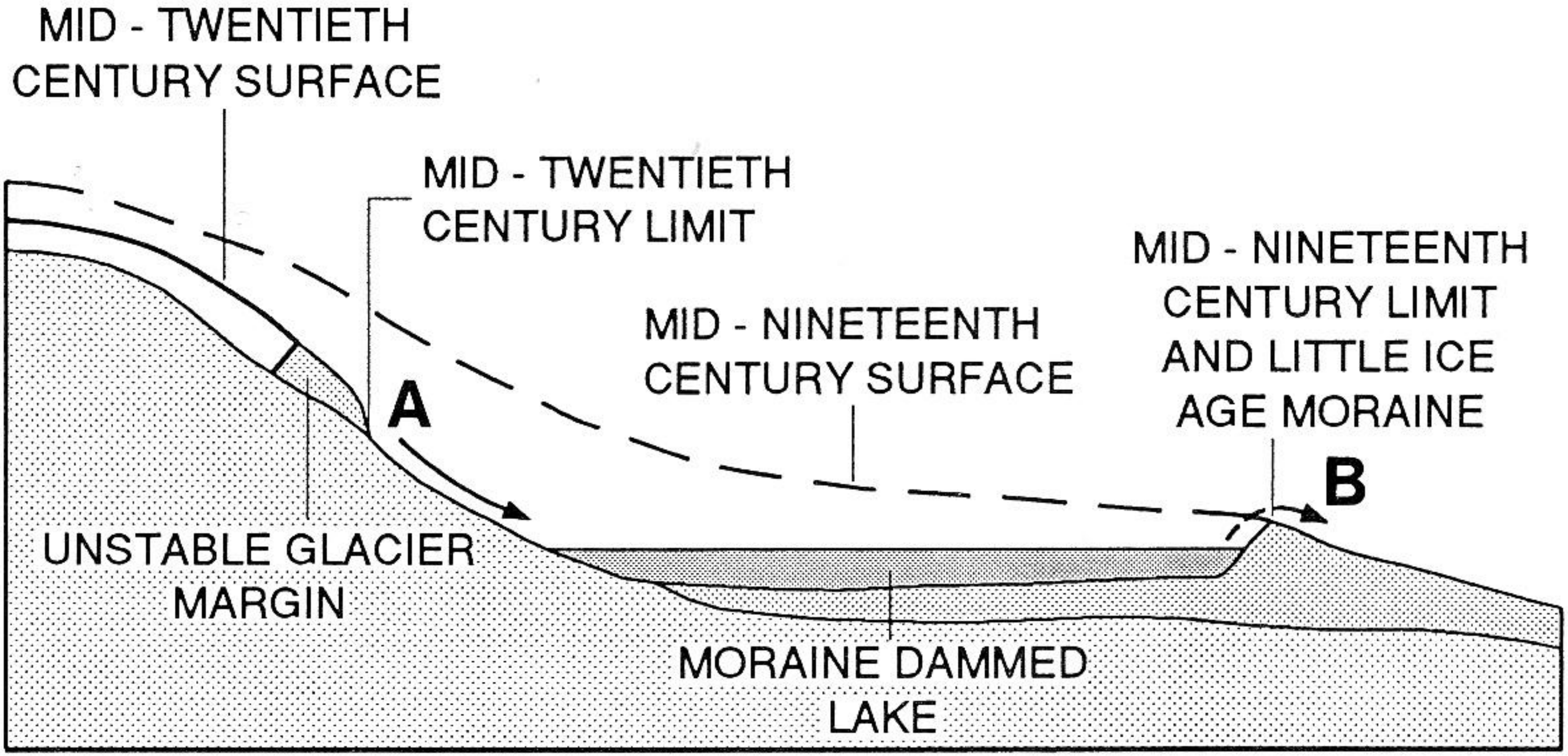
52. Der größte Granitblock in der Sturzflut von Huaras, rund 3 km oberhalb der Landstraße. Im Hintergrund Eukalyptuswald (18. VIII. 1947).



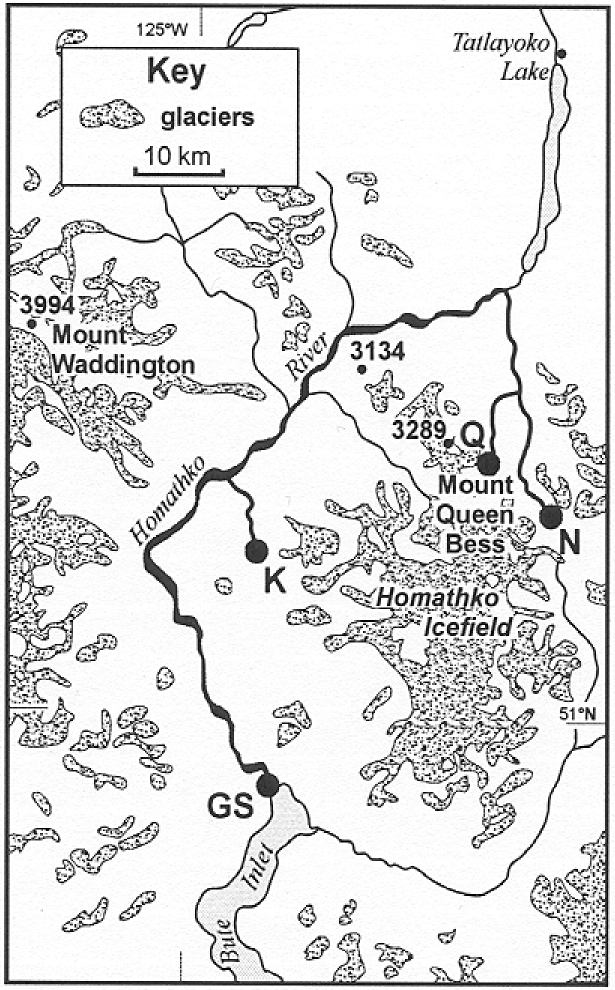
Corona spy satellite image 1962


LAKE PALCACOCHA (2017)

FORMATION AND DESTRUCTION OF MORAINE - DAMMED LAKES

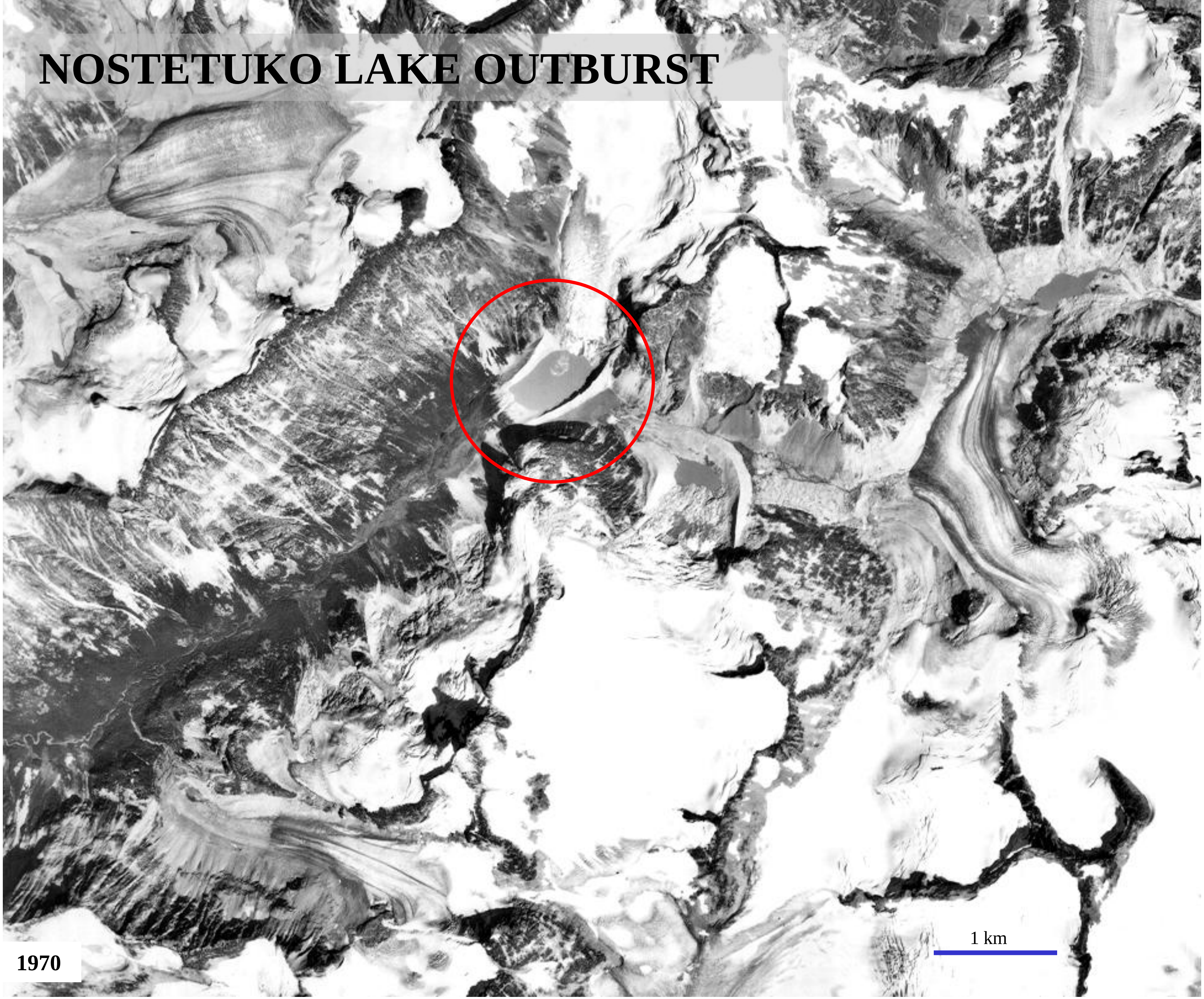


Moraine-dammed Queen Bess Lake, Coast Mountains, BC



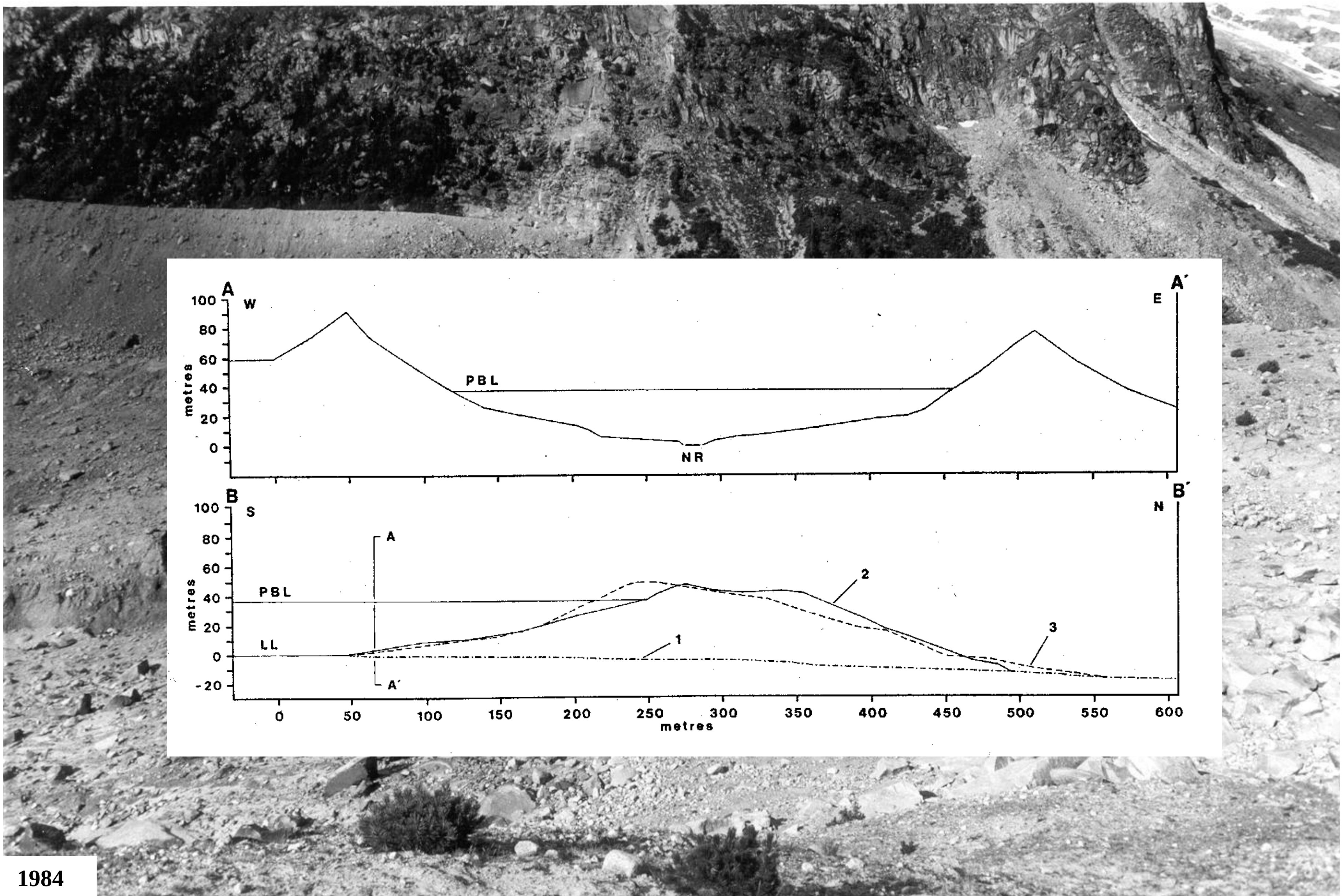
K : Klattasine (ca. 1971)
N : Nostetuko Lake (1983)
Q : Queen Bess (1997)
GS : Gauging Station at mouth of Homathko

NOSTETUKO LAKE OUTBURST




1984


1970

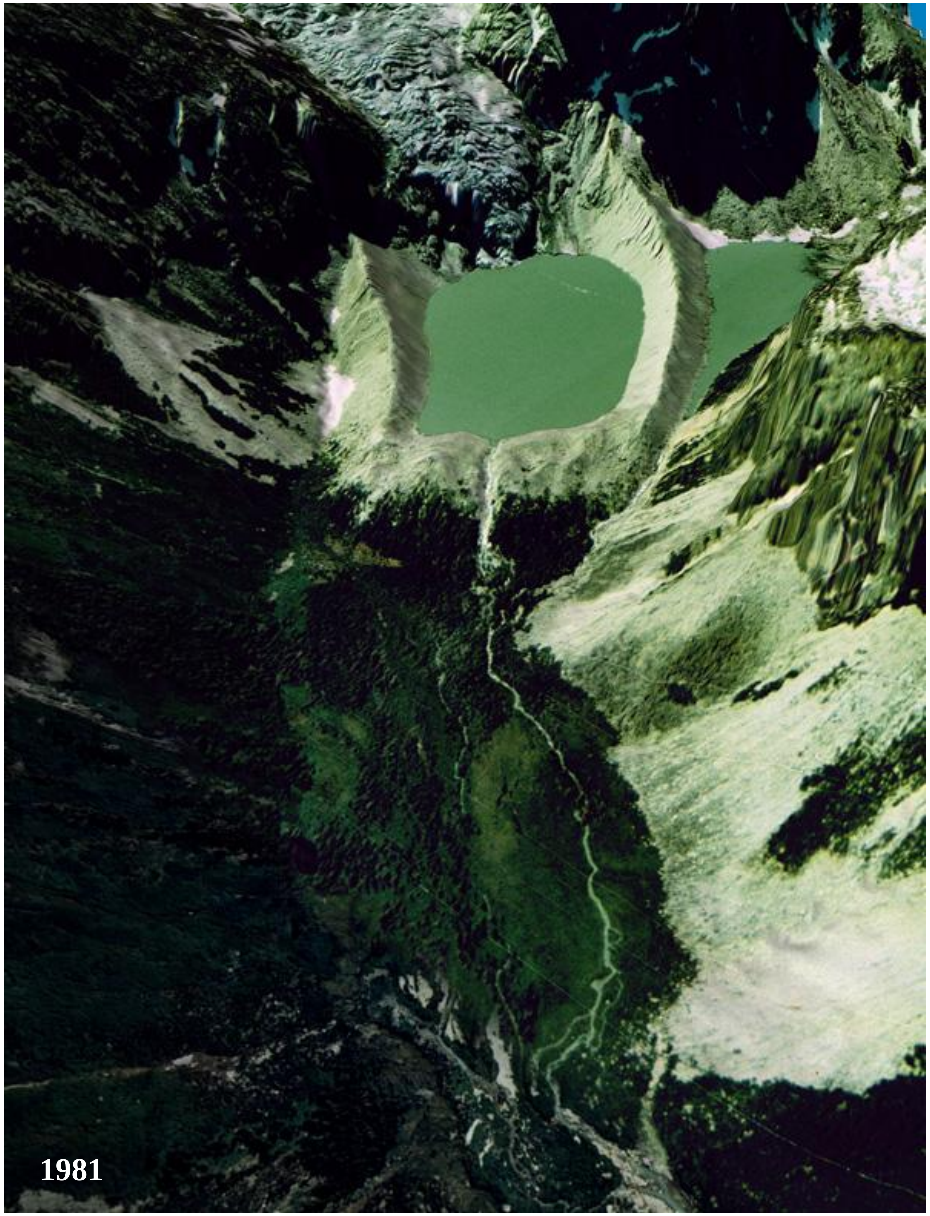


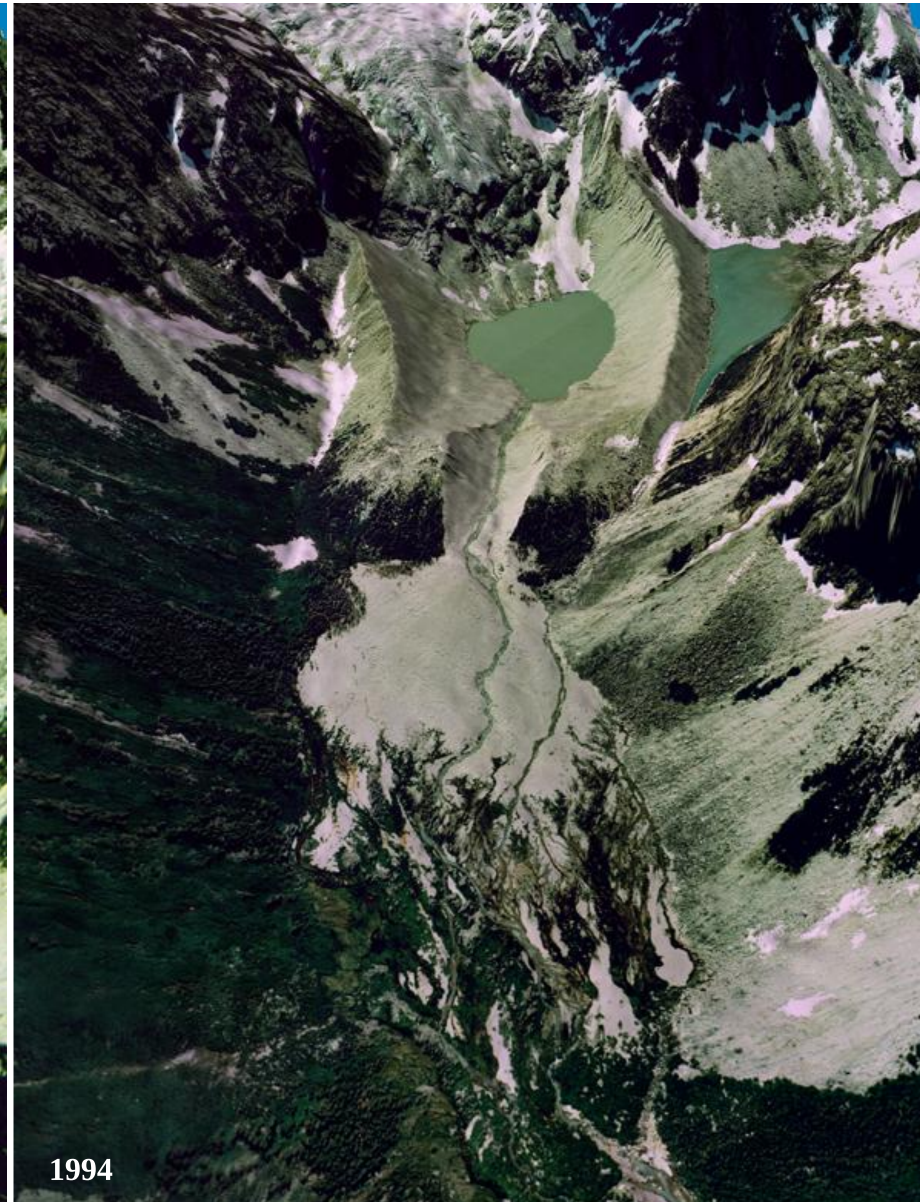
A
W
A′
E
PBL
NR
metres
B
S
B′
N
PBL
LL
A
A′
1
2
3
metres
0
50
100
150
200
250
300
350
400
450
500
550
600
1984

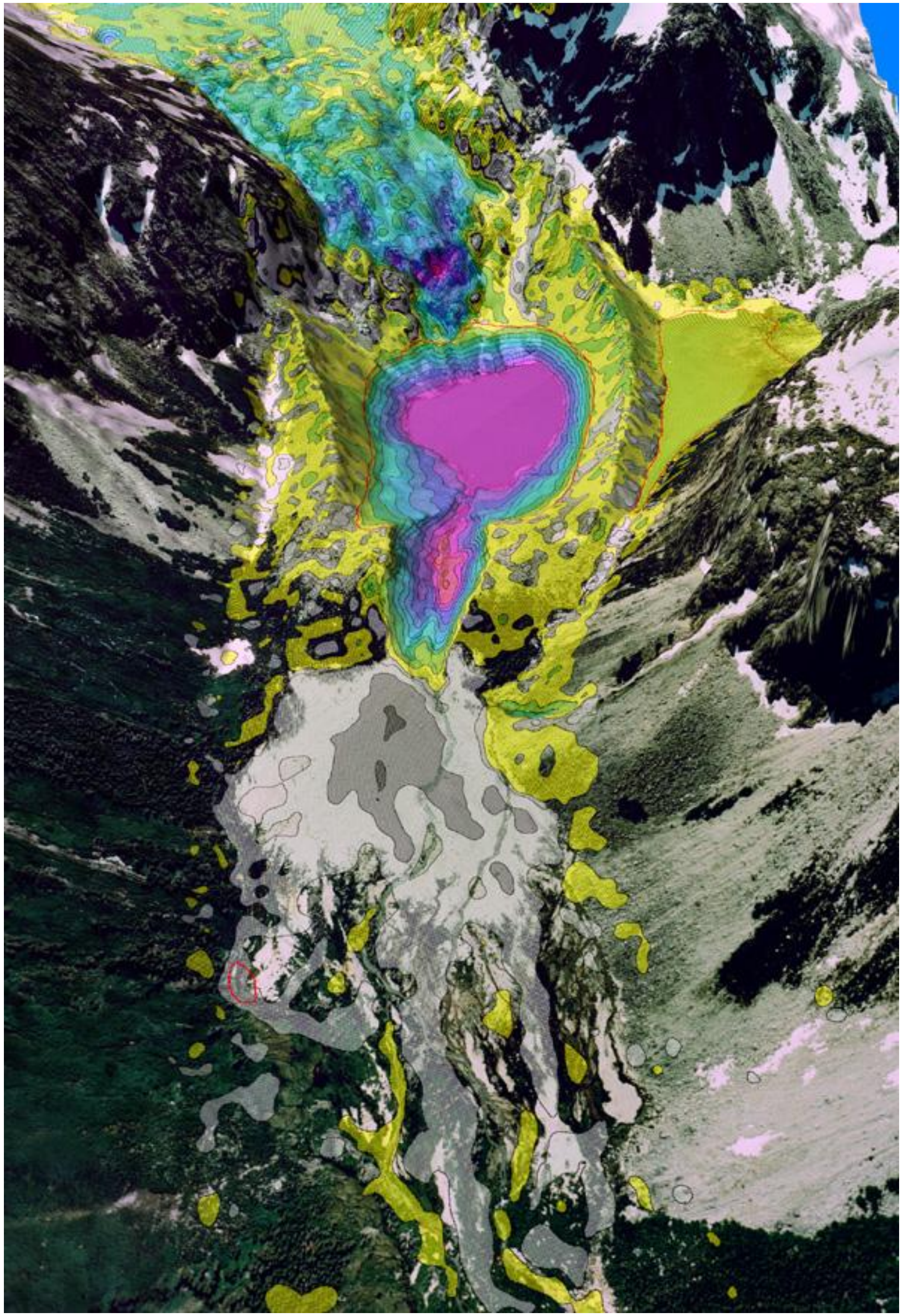
1984


NOSTETUKO LAKE JULY 1981
500 m


NOSTETUKO LAKE JULY 1994
500 m


1981


1994



NOSTETUKO LAKE OUTBURST SUMMARY

Date: July 19, 1983

Outburst Volume: 6.5 M m^3

Breach Loss Volume: 1.6 M m^3

Max. Discharge: ca. 10,000 m^3/s

Max. Wave Run-Up: 11.7 m

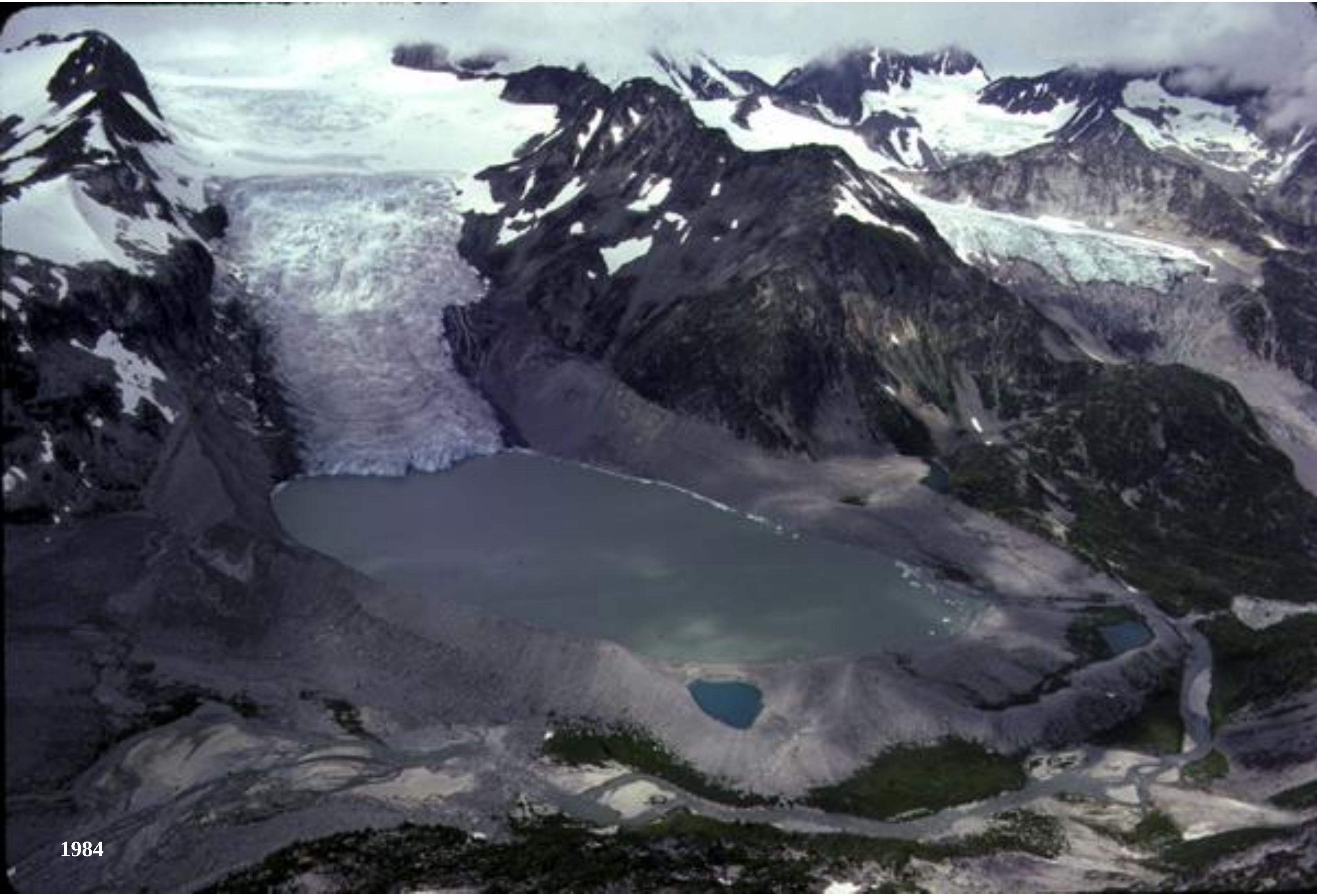
Wave Velocity:15 m/s

Drawdown: 38 m

Cause: glacier avalanche

Volume of Glacier Avalanche: ca. 1.5 M m^3

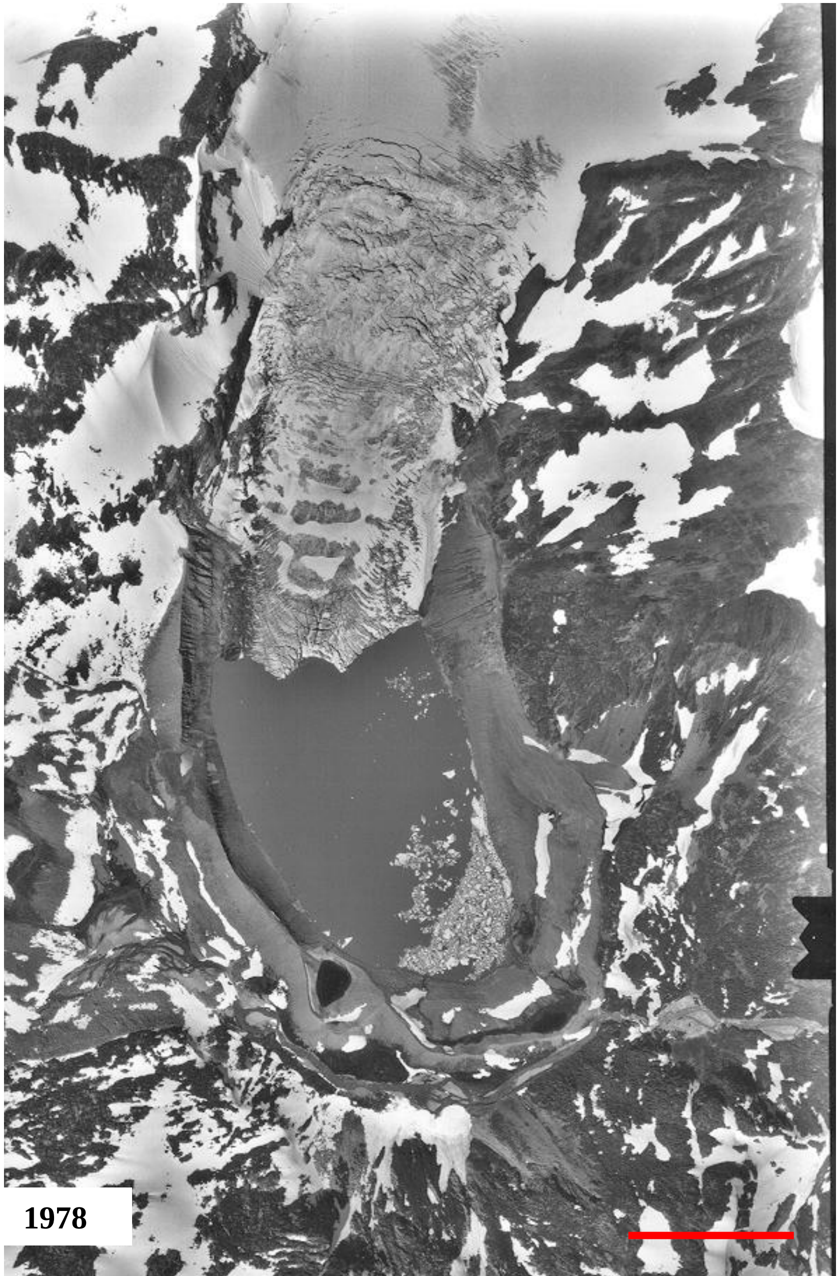

QUEEN BESS LAKE OUTBURST
1987


1984

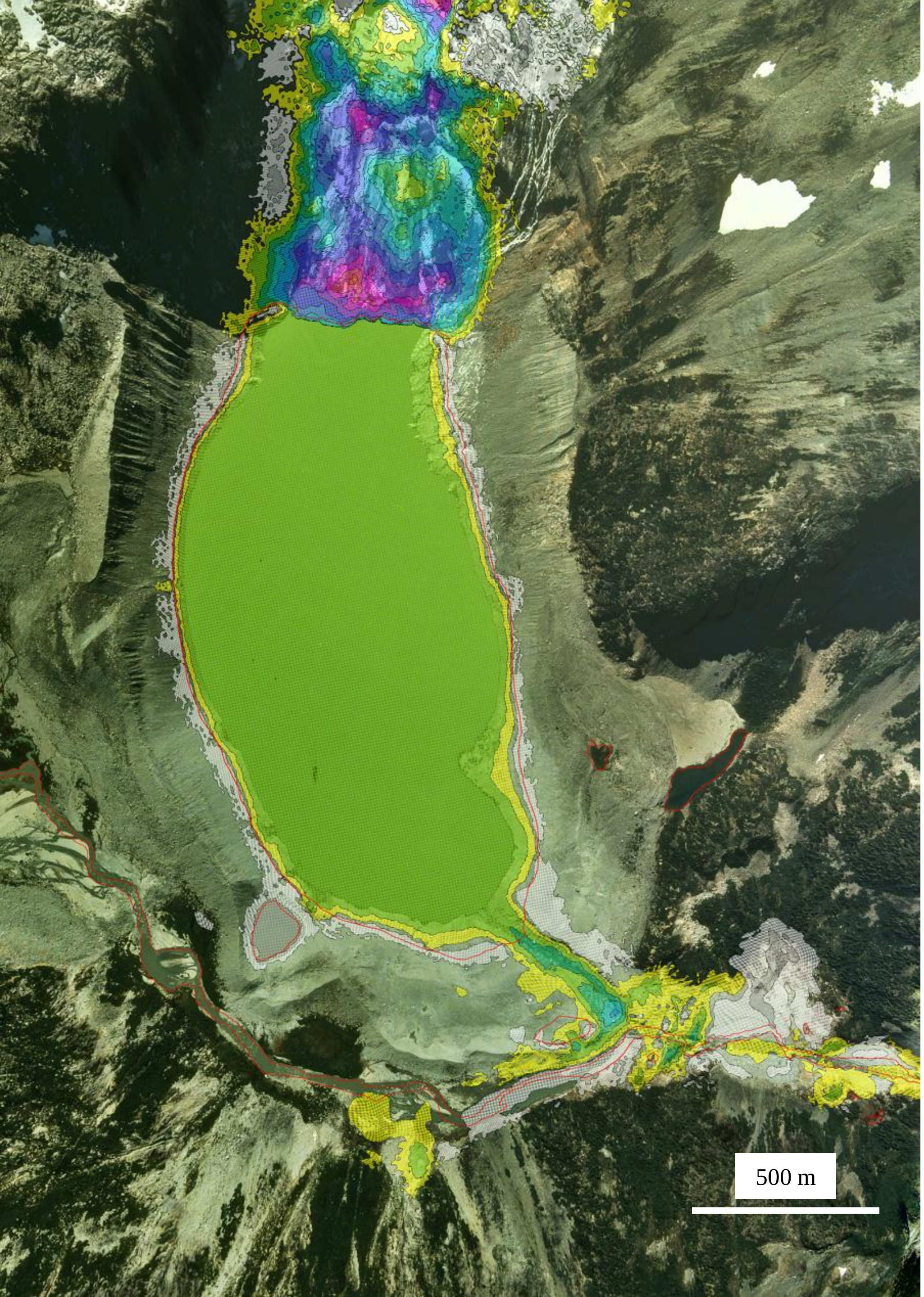

1987


1997


500 m
1998


1978


1997



QUEEN BESS LAKE OUTBURST SUMMARY

Date: August 12, 1997

Outburst Volume: 6.5 M m^3

Breach Loss Volume: 280,000 m^3

Max. Discharge: ca. 300,000 m^3/s

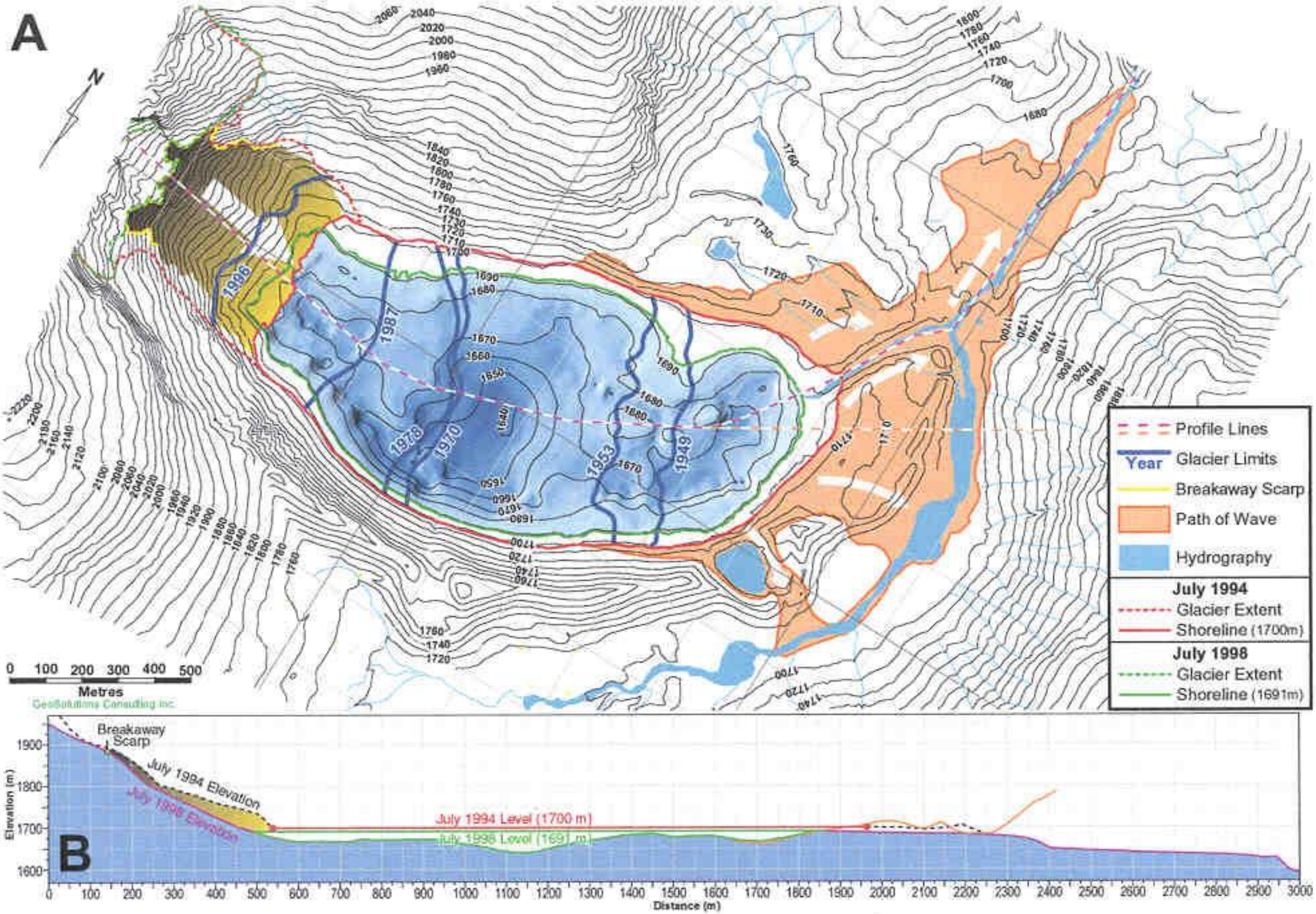
Max. Wave run-up: 35 m

Wave Velocity: ca. 25 m/s

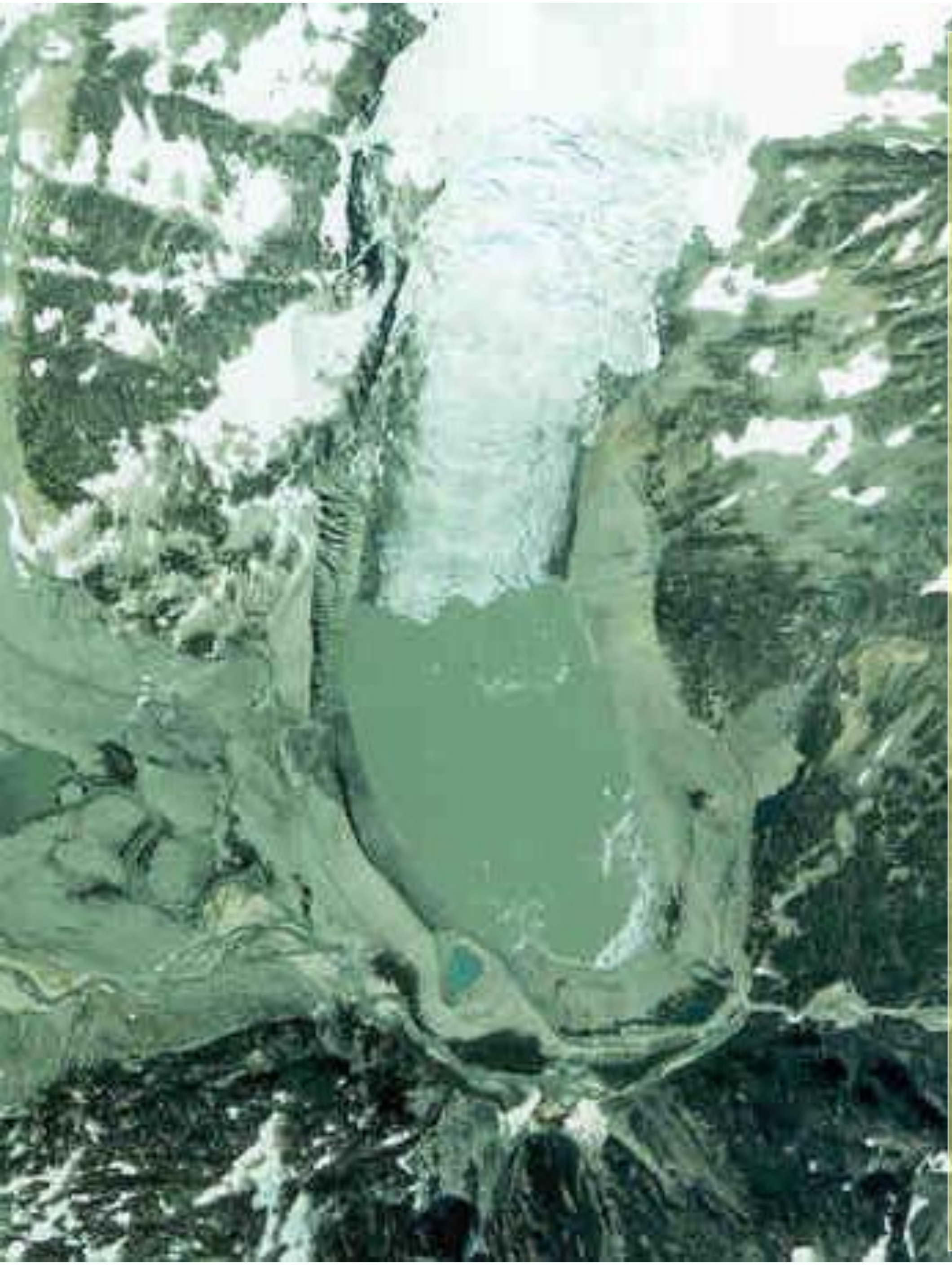
Drawdown: 8 m

Cause: glacier avalanche

Volume of Glacier Avalanche: ca. 2.3 M m^3



A
N
1996
1987
1978
1970
1953
1949
Profile Lines
Year Glacier Limits
Breakaway Scarp
Path of Wave
Hydrography
July 1994
Glacier Extent
Shoreline (1700m)
July 1998
Glacier Extent
Shoreline (1691m)
0 100 200 300 400 500
Metres
GeoSolutions Consulting Inc.
B
Breakaway Scarp
July 1994 Elevation
July 1998 Elevation
July 1994 Level (1700 m)
July 1998 Level (1691 m)
Elevation (m)
Distance (m)



SOME ELEMENTS OF A SIMPLE BREACHING SYSTEM

1. Events preconditioned by dramatic late twentieth-century glacier retreat

2. Breaches resulted from wave train generated by glacier avalanches

3. Glacier avalanches occurred as glacier toe encountered steep rock slopes above lake

4. Triggered by above average (but not exceptional) summer warm spells

5.Nostetuko-style breach characterised by deep breach incision initiated by high discharges in spillway associated with wave (evidence of previous overtopping)

6. Queen Bess-style characterised by massive overtopping wave over a wide crest width followed by breach incision (no evidence of previous overtopping)

7. Two styles reflect differing breach thresholds