Glaciers and Climate Change at MORA

Jon L. Riedel

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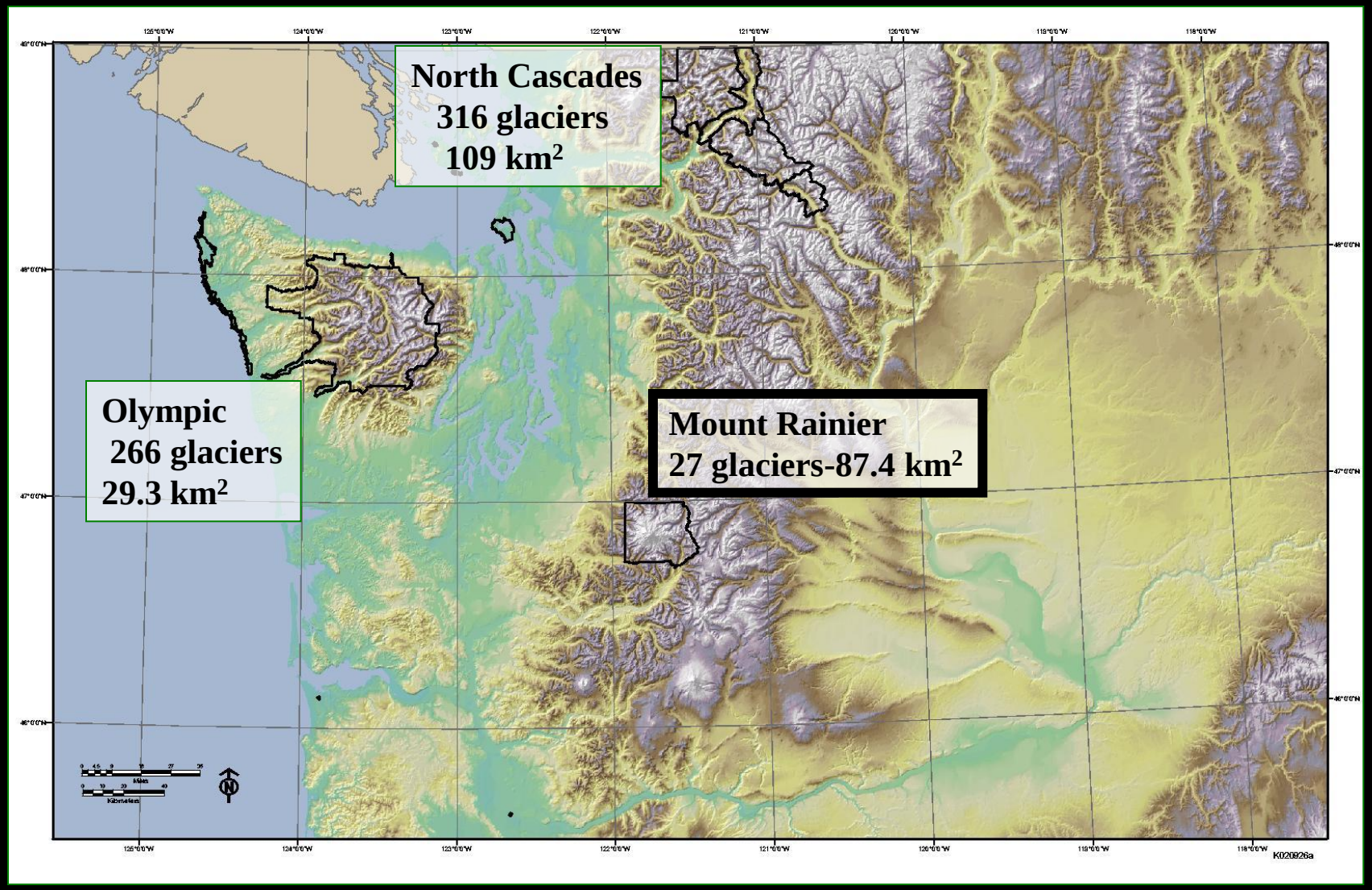
March 2, 2011

photos by John Scurlock

Washington's national parks hold more than 600 glaciers that cover 225 km^2.

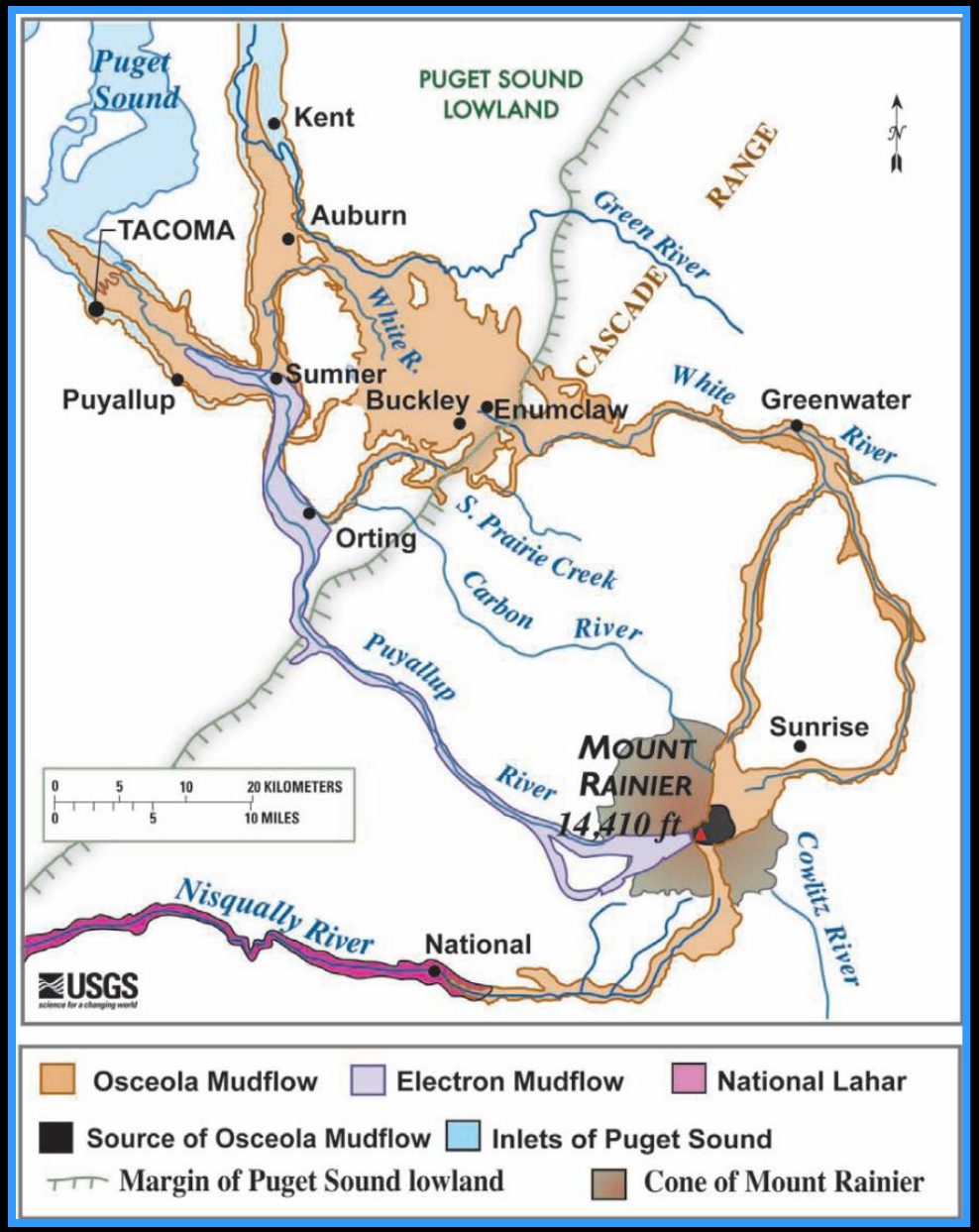


- **Glaciers are dramatic indicators of climate change because of their sensitivity to temperature and precipitation.**

- **Glaciers are powerful agents of landscape change, and have left a rich record of climate change in the form of glacial landforms and deposits.**

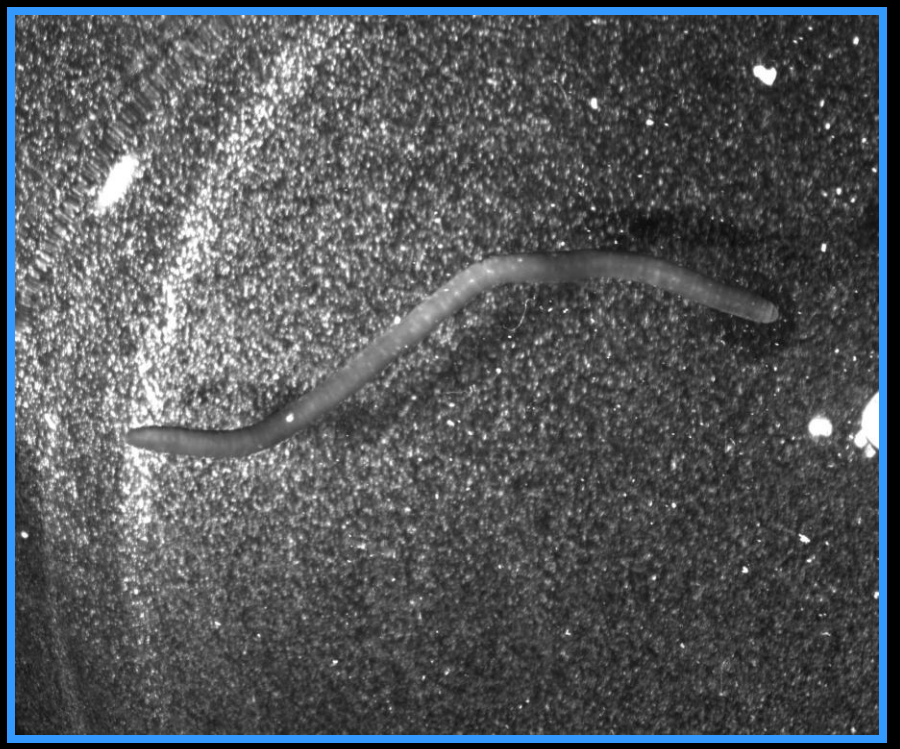
Dee Moleenar's 1947 Kautz Cr. lahar

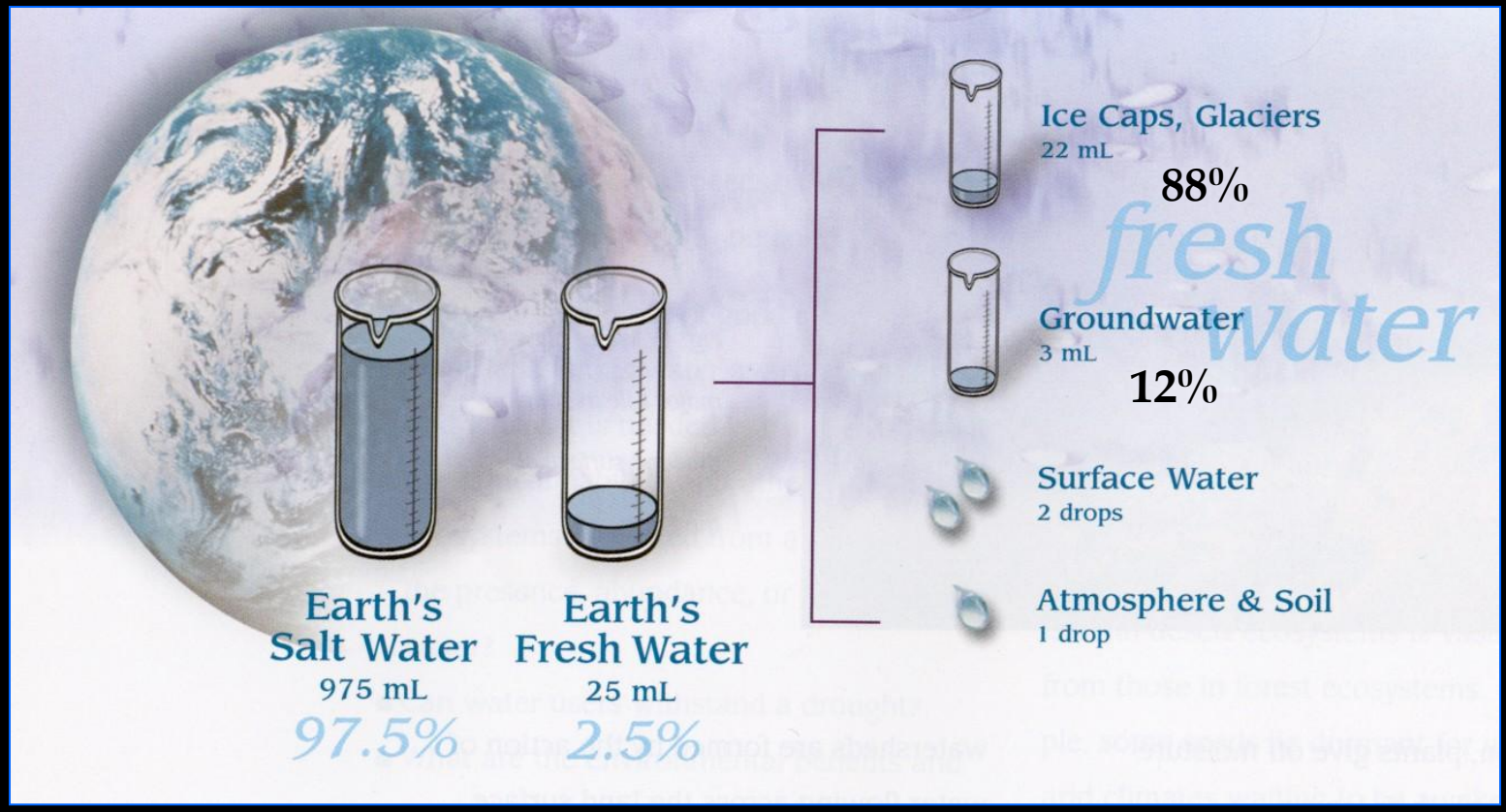
Austin Post May 1980 eruption of Mt. St. Helens

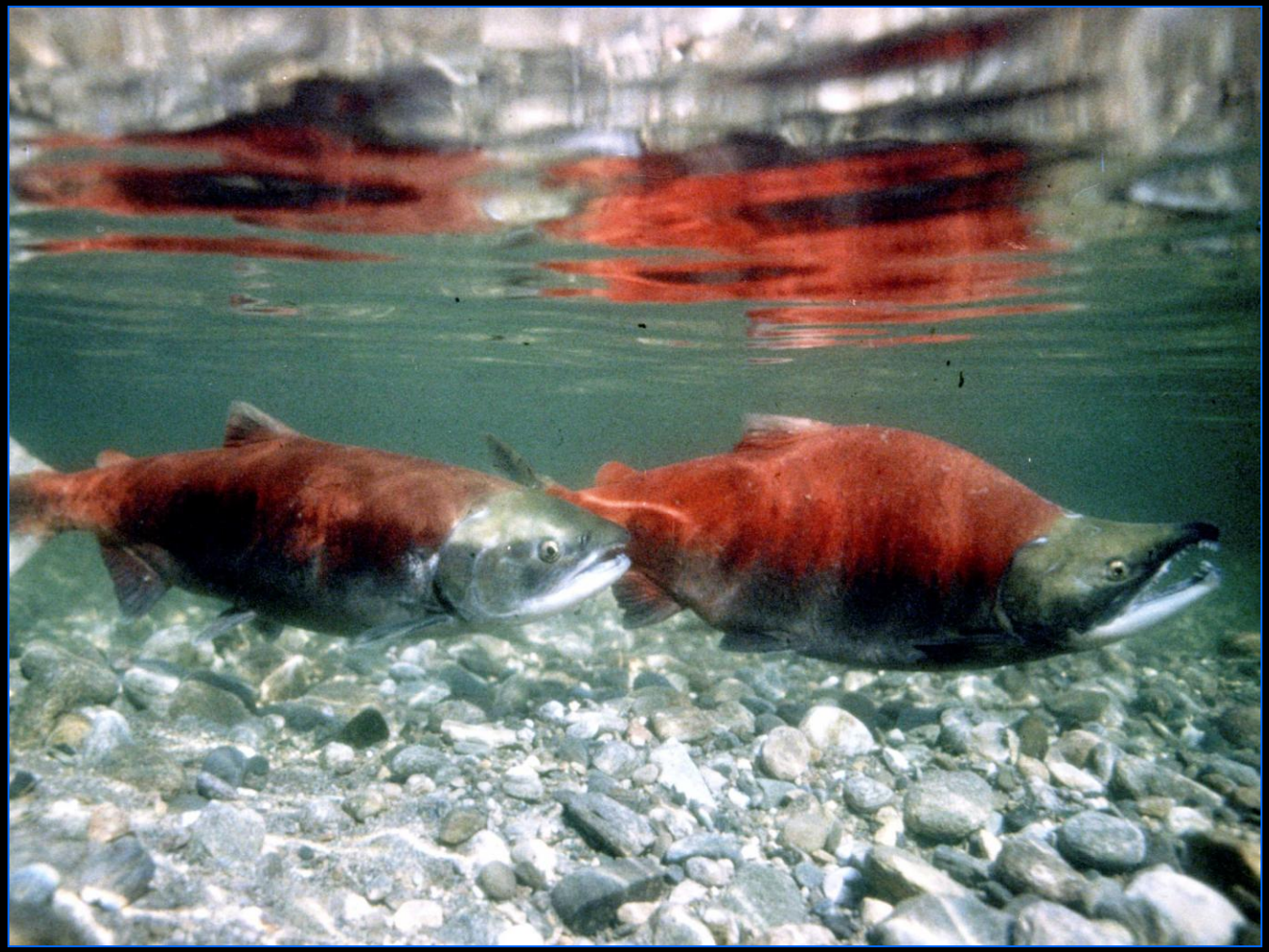

Puget Sound
PUGET SOUND LOWLAND
Kent
Auburn
TACOMA
RANGE
Green River
CASCADE
White R.
Sumner
Puyallup
Buckley
Enumclaw
White River
Greenwater
S. Prairie Creek
Orting
Carbon River
Puyallup River
Sunrise
MOUNT RAINIER
14,410 ft
0 5 10 20 KILOMETERS
0 5 10 MILES
Nisqually River
National
Cowlitz River
USGS
science for a changing world
Osceola Mudflow
Electron Mudflow
National Lahar
Source of Osceola Mudflow
Inlets of Puget Sound
Margin of Puget Sound lowland
Cone of Mount Rainier

Ice Worm (*Mesenchytraeus solifugus*)
photos courtesy of Paula Hartzell

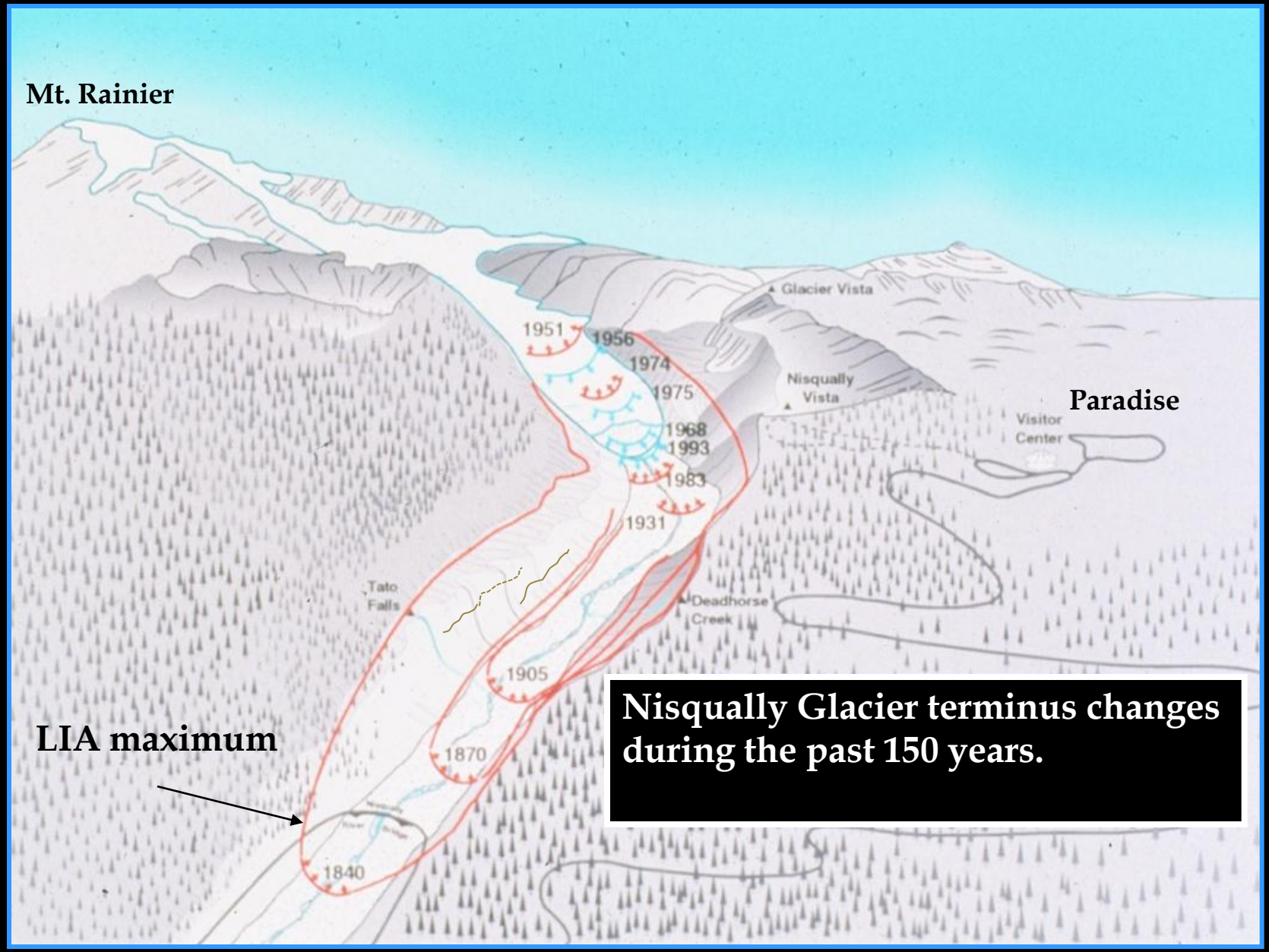
Rosy Finch




Earth's
Salt Water
975 mL
97.5%
Earth's
Fresh Water
25 mL
2.5%
Ice Caps, Glaciers
22 mL
88%
fresh
water
Groundwater
3 mL
12%
Surface Water
2 drops
Atmosphere & Soil
1 drop



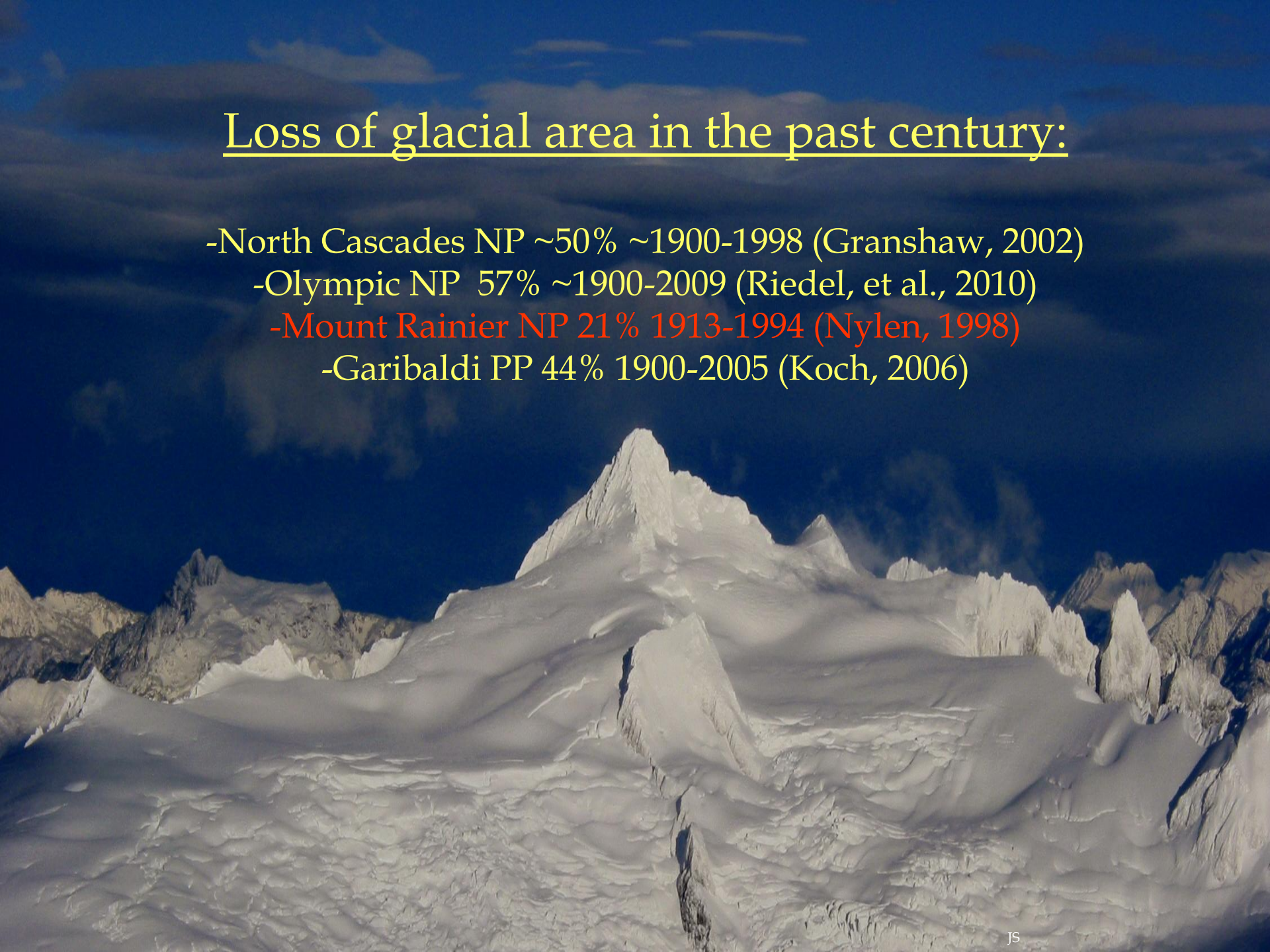
1914 photo 30965 Washington State Historical Society

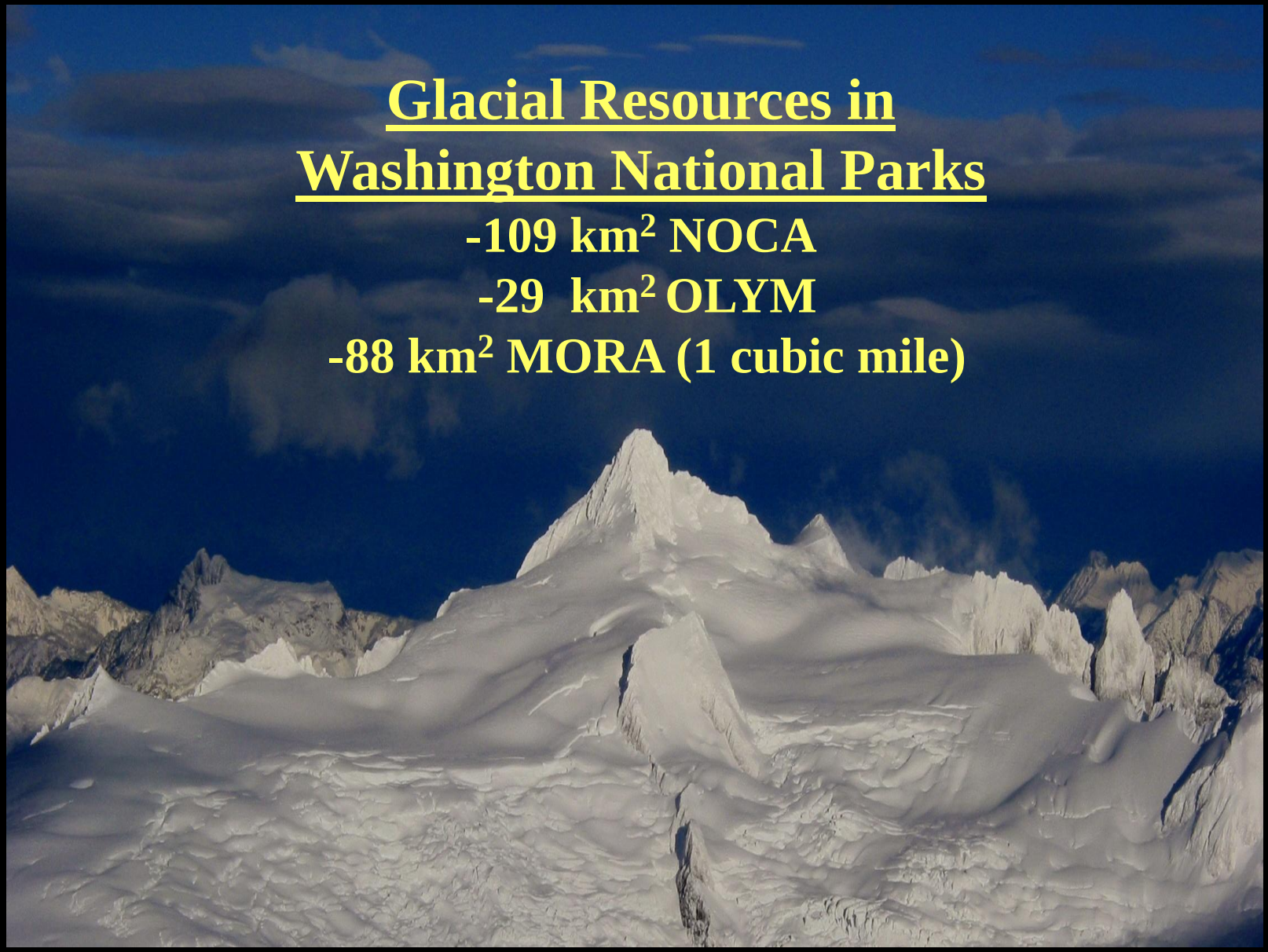

Mt. Rainier
Glacier Vista
1951
1956
1974
1975
1968
1993
1983
1931
Nisqually Vista
Paradise
Visitor Center
Tato Falls
Deadhorse Creek
1905
1870
1840
LIA maximum
Nisqually Glacier terminus changes during the past 150 years.

USGS

Loss of glacial area in the past century:

-North Cascades NP ~50% ~1900-1998 (Granshaw, 2002)
-Olympic NP 57% ~1900-2009 (Riedel, et al., 2010)
-Mount Rainier NP 21% 1913-1994 (Nylen, 1998)
-Garibaldi PP 44% 1900-2005 (Koch, 2006)



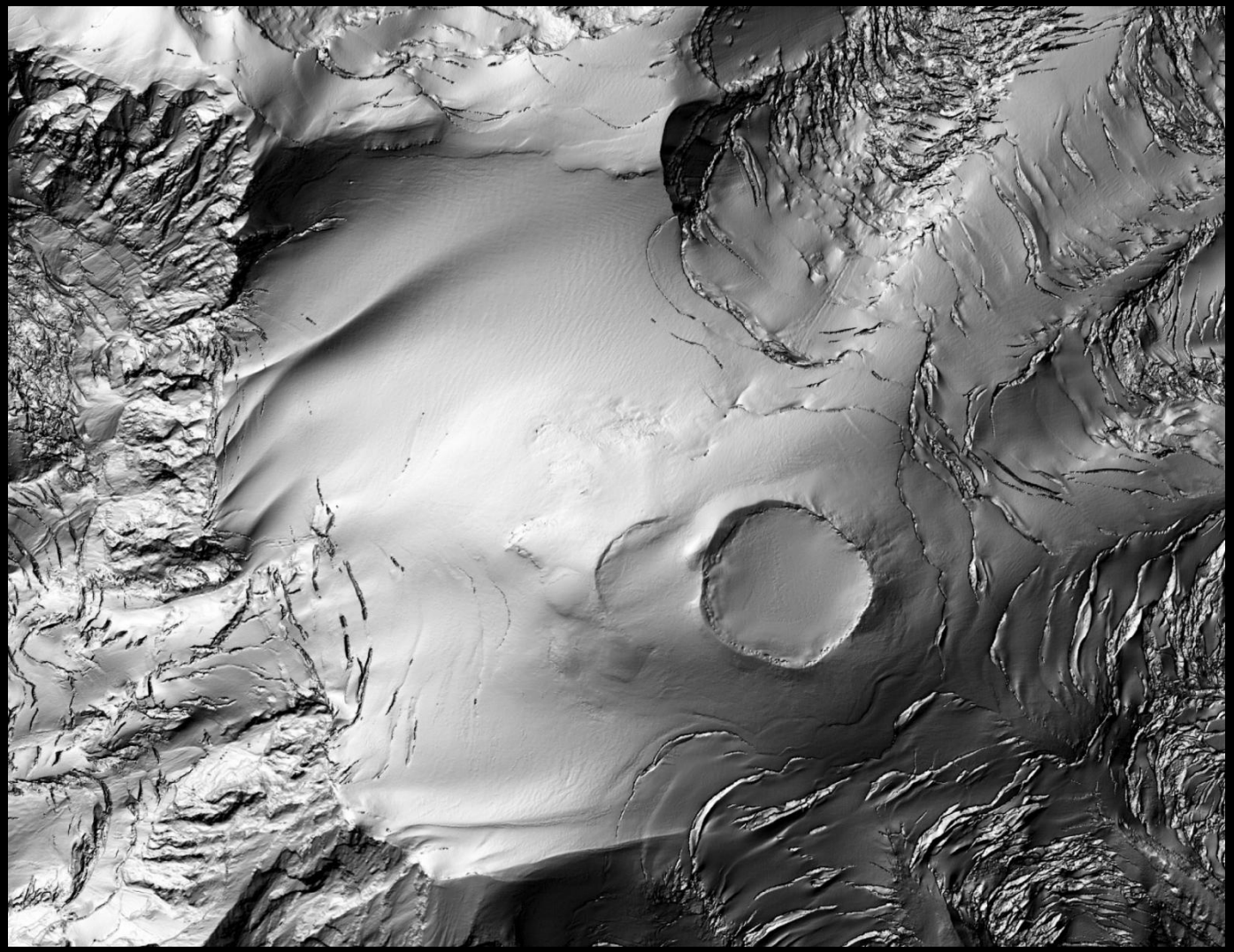

Glacial Resources in
Washington National Parks
-109 km2 NOCA
-29 km2 OLYM
-88 km2 MORA (1 cubic mile)

Mount Rainier Glacier Monitoring 2003-2010

Problems monitoring glaciers at Mt. Rainier:

-substantial debris cover slows melting;
-high ice flow velocity (30-40 ft/ year);
-difficult surface access with ice falls and unstable slopes;
-mountain creates its own weather;
-wide elevation range (1500-4300m); and
-possible geothermal melting.

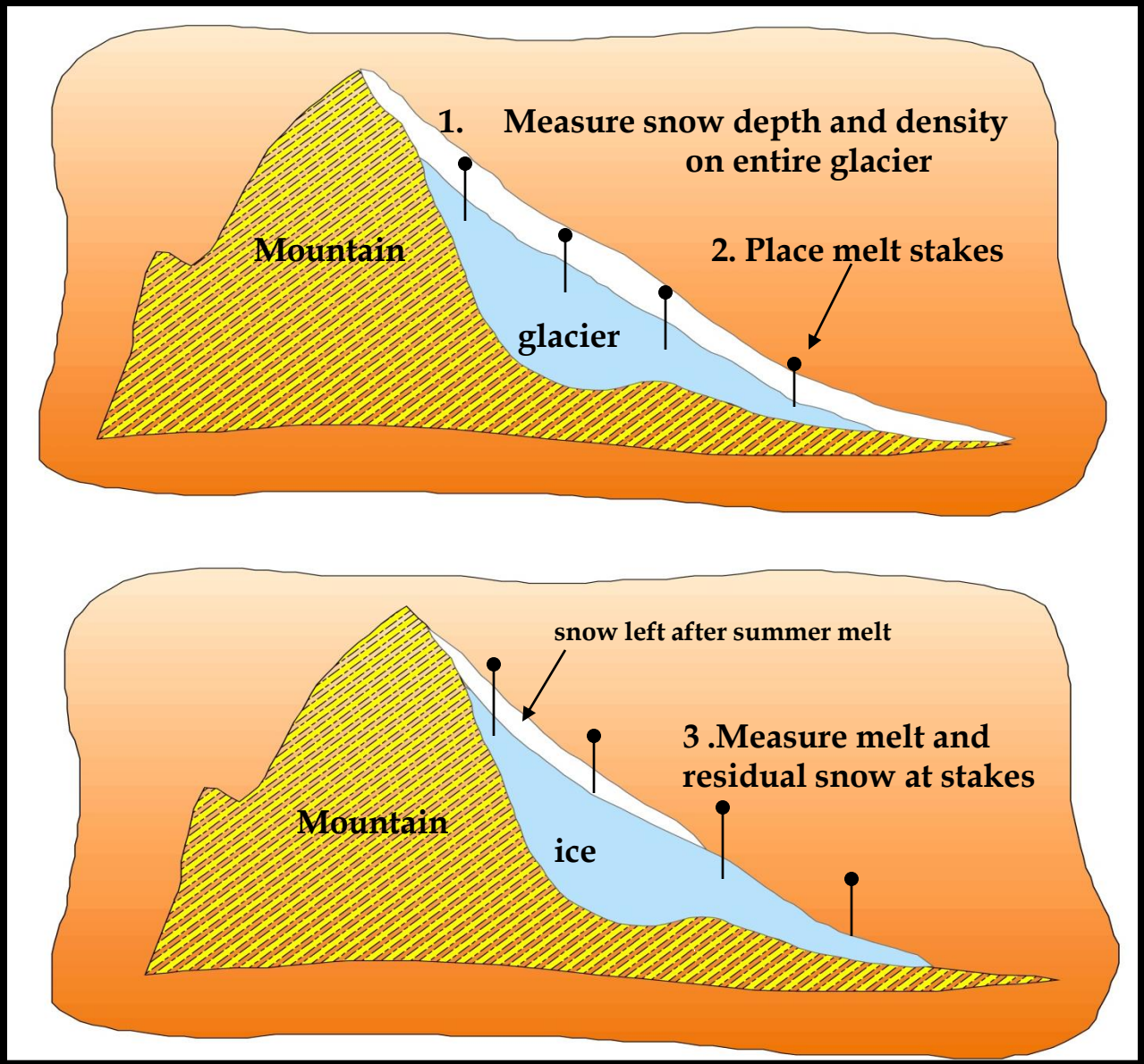
LiDAR image of Mount Rainier summit



We measure change on the glacier surface at two key times each year.

Spring Visit

Fall Visit



Emmons Glacier

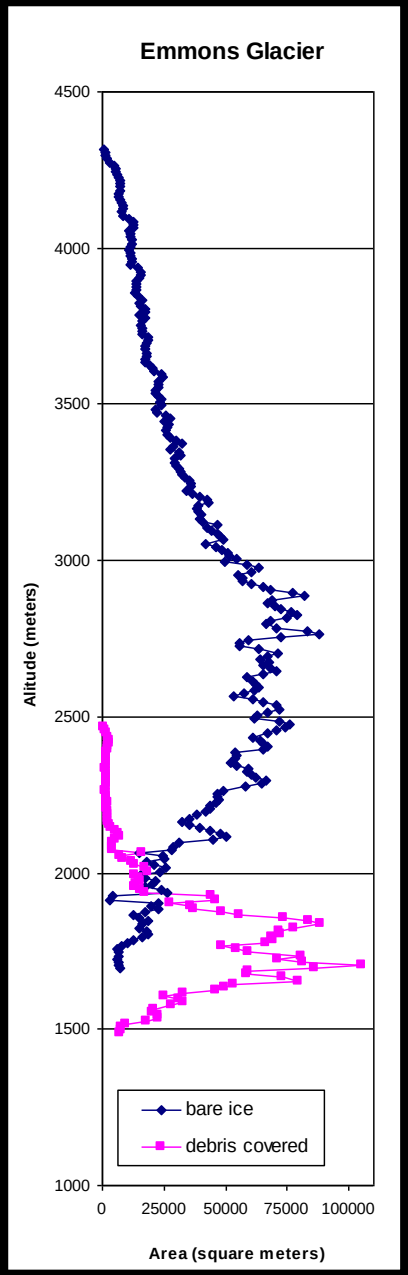
Nisqually Glacier

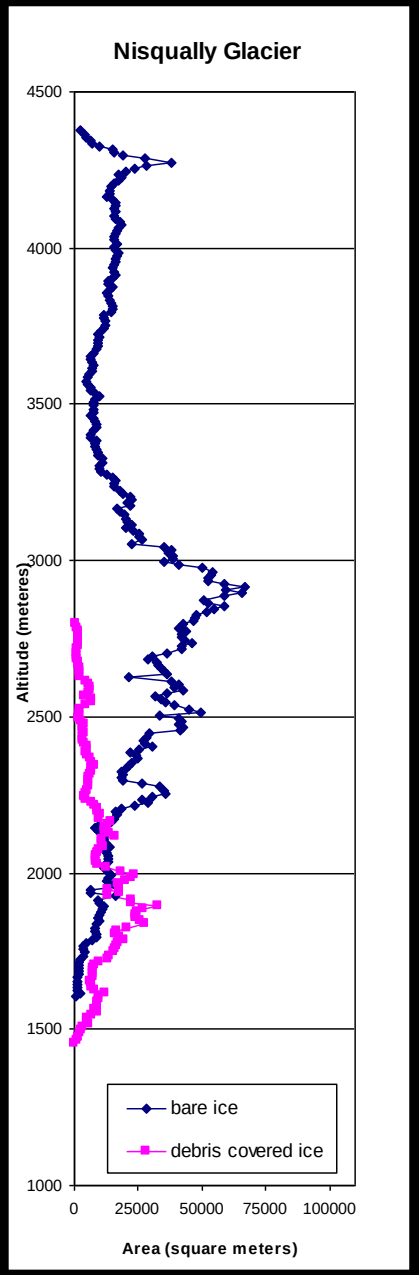
*A steam drill mounted on a backpack frame is used to melt holes in glaciers for stakes.

*Stakes serve as a reference point for measuring summer melt.

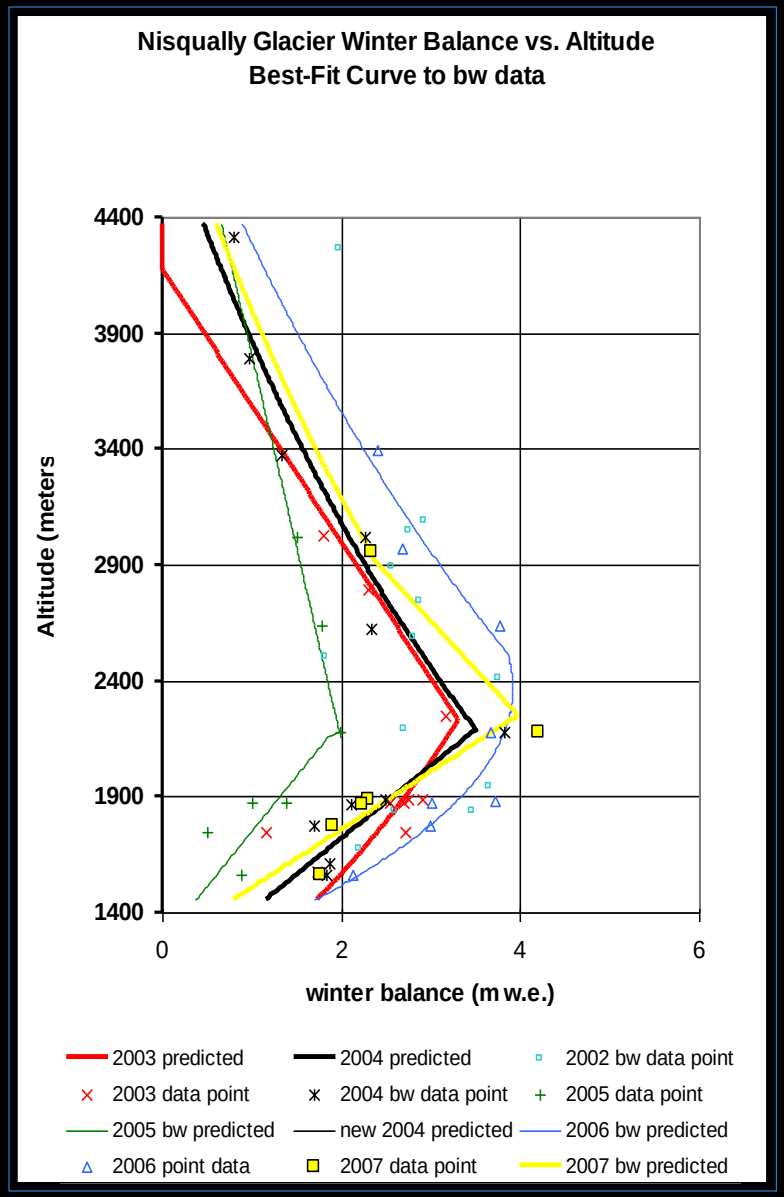
*Summer melt can exceed 12m (~40 feet).

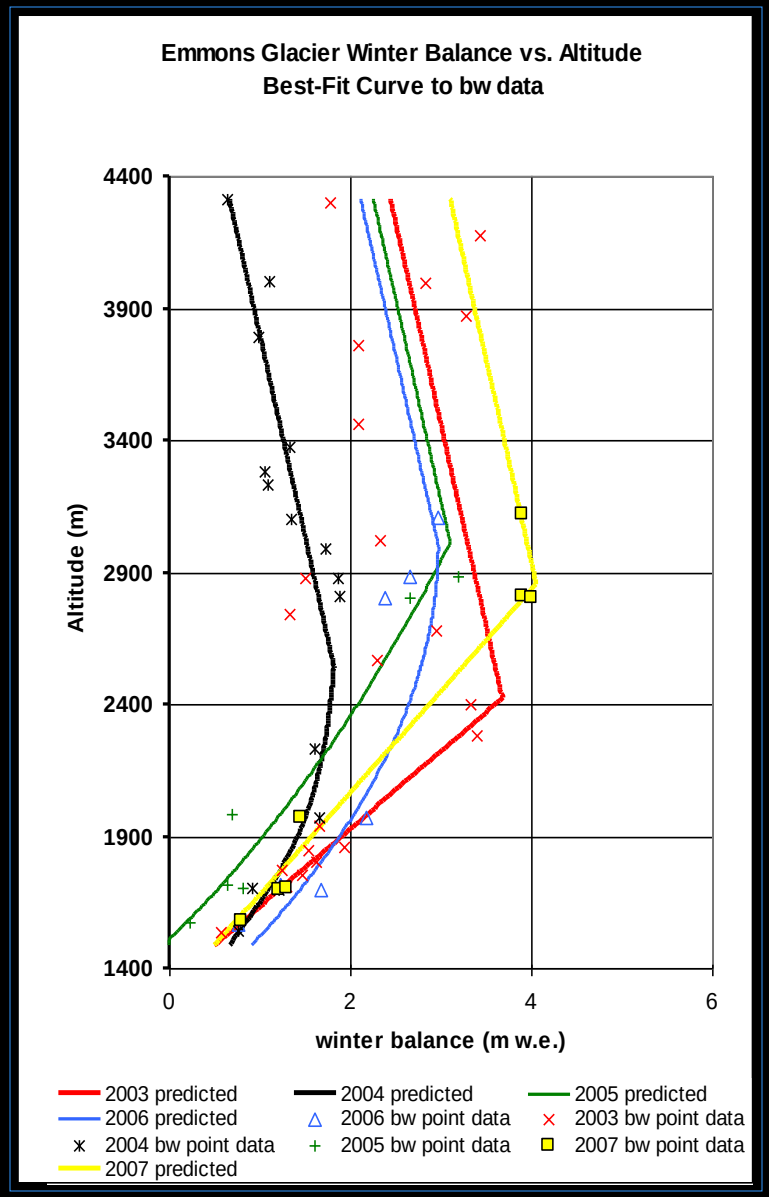
Area-Altitude Distribution

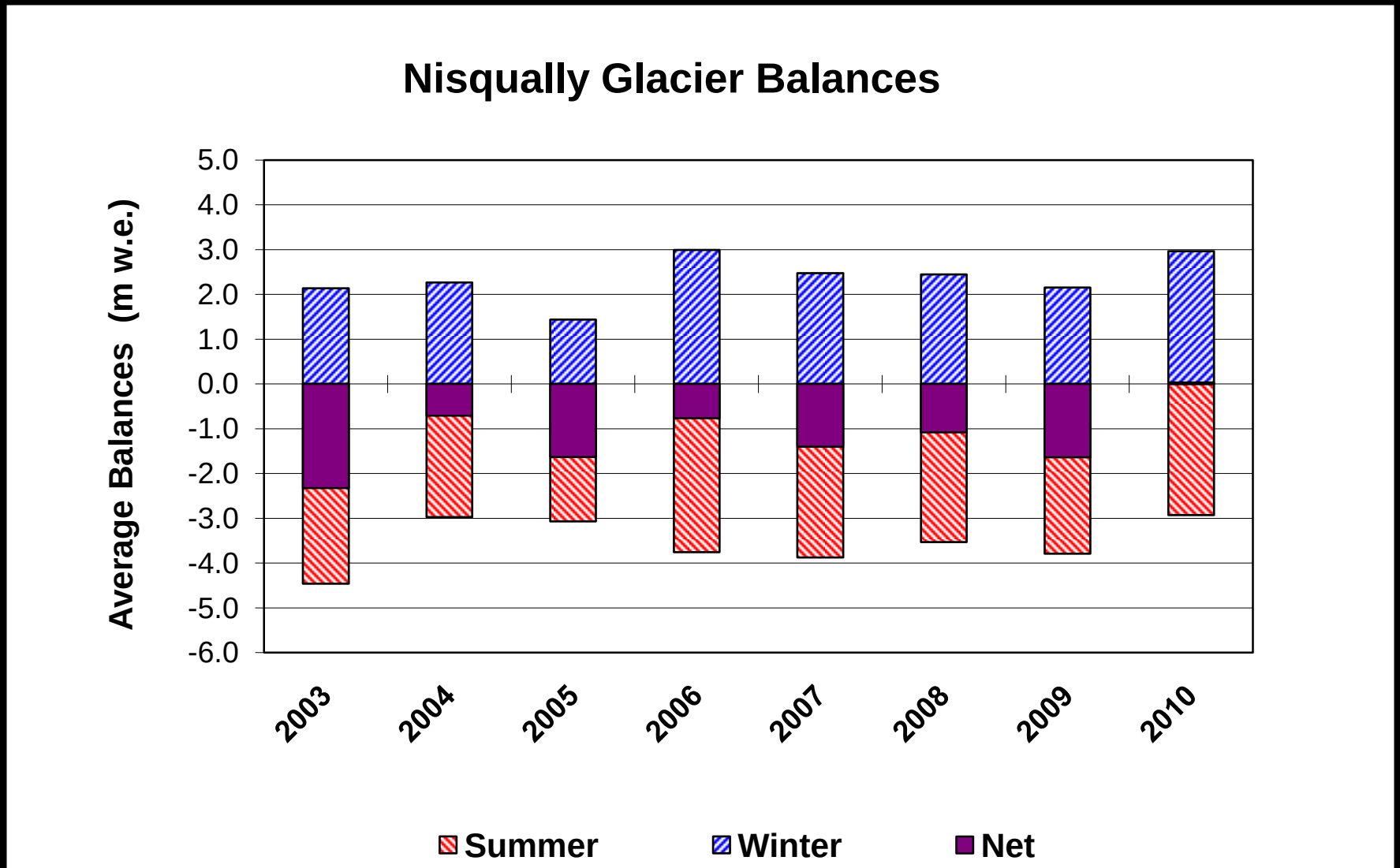


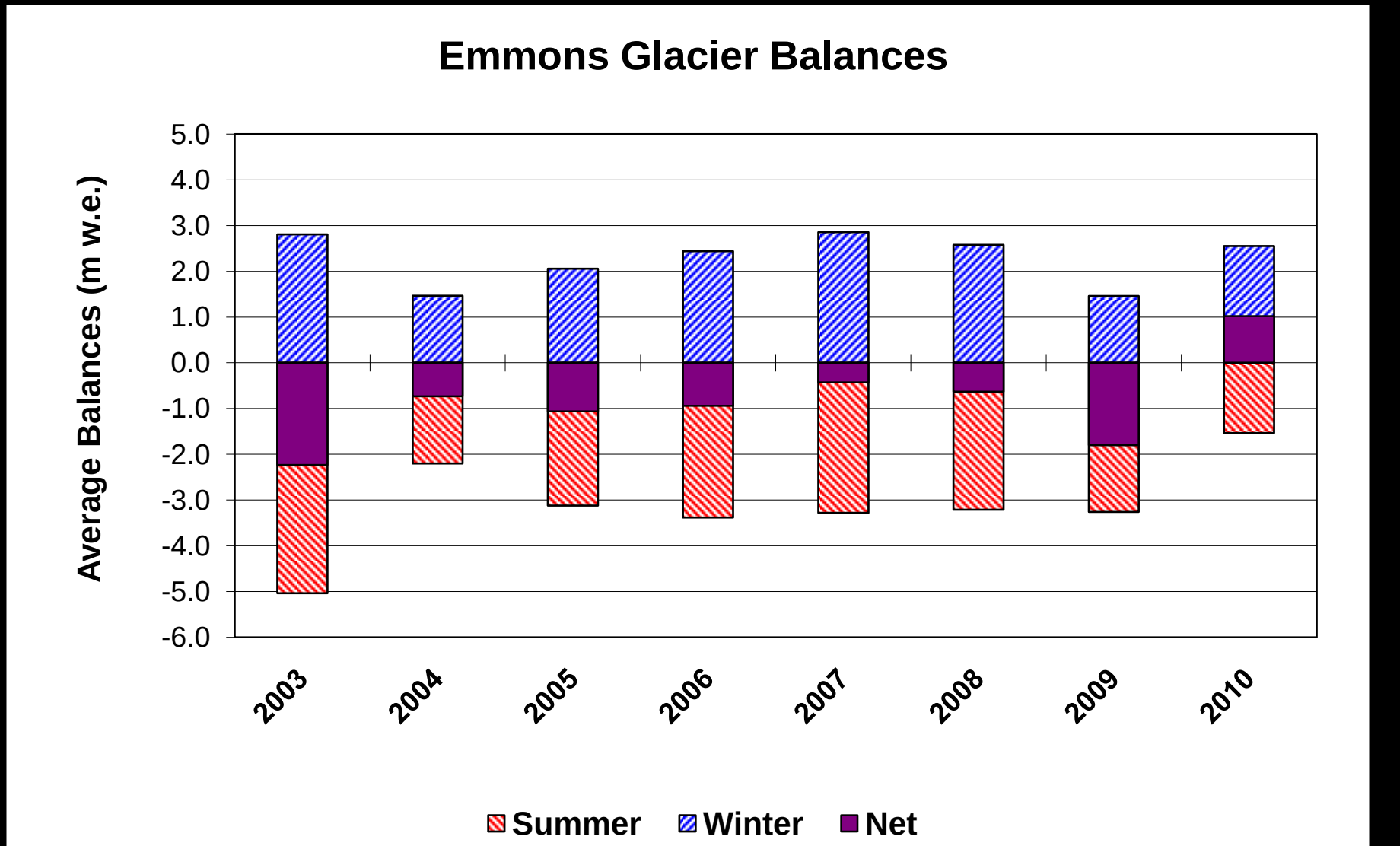


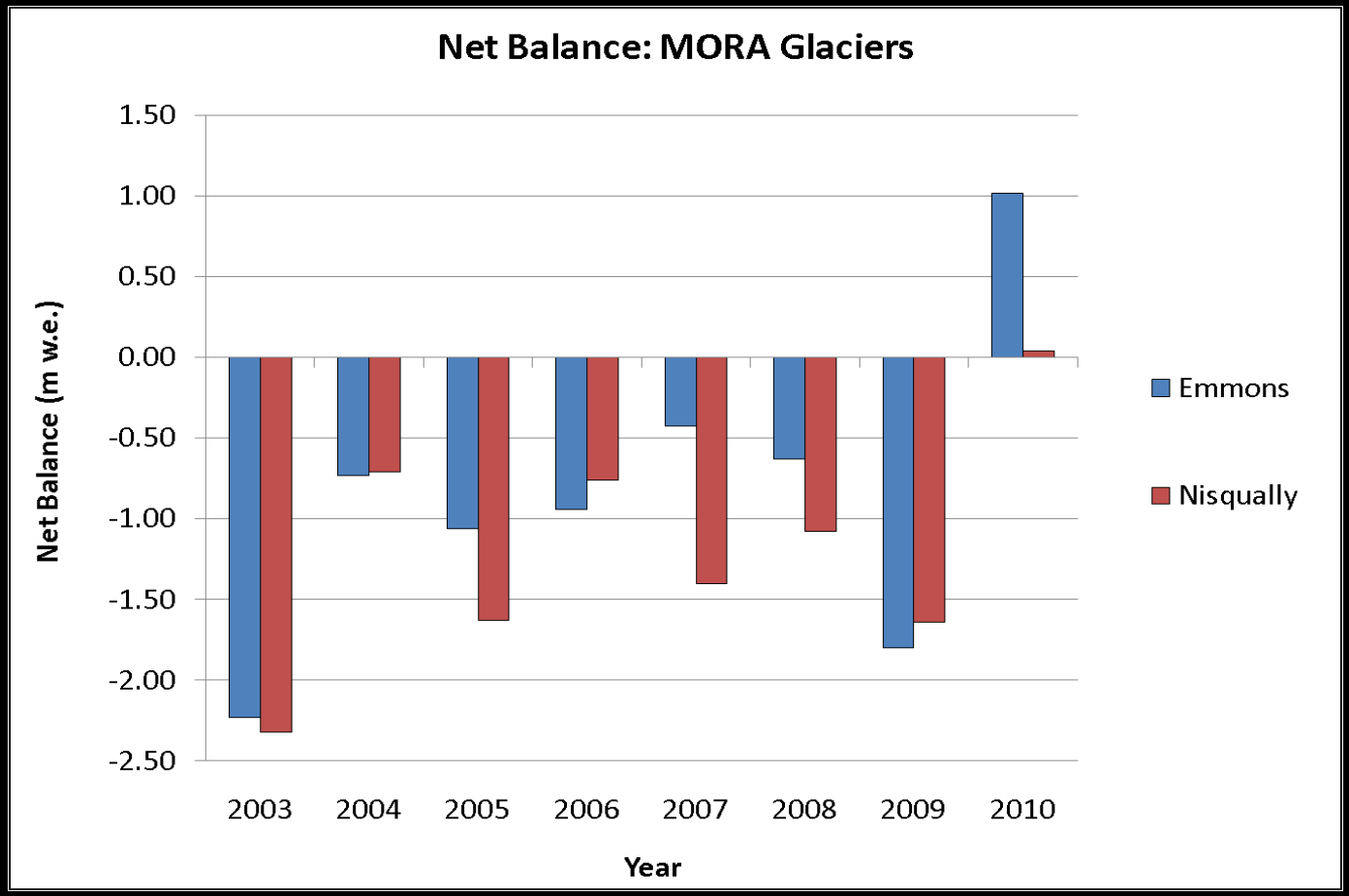
On both glaciers we observe a decrease in winter accumulation and increase in variability of accumulation above a certain elevation (~2400 m on Nisqually and ~2800 m on Emmons).

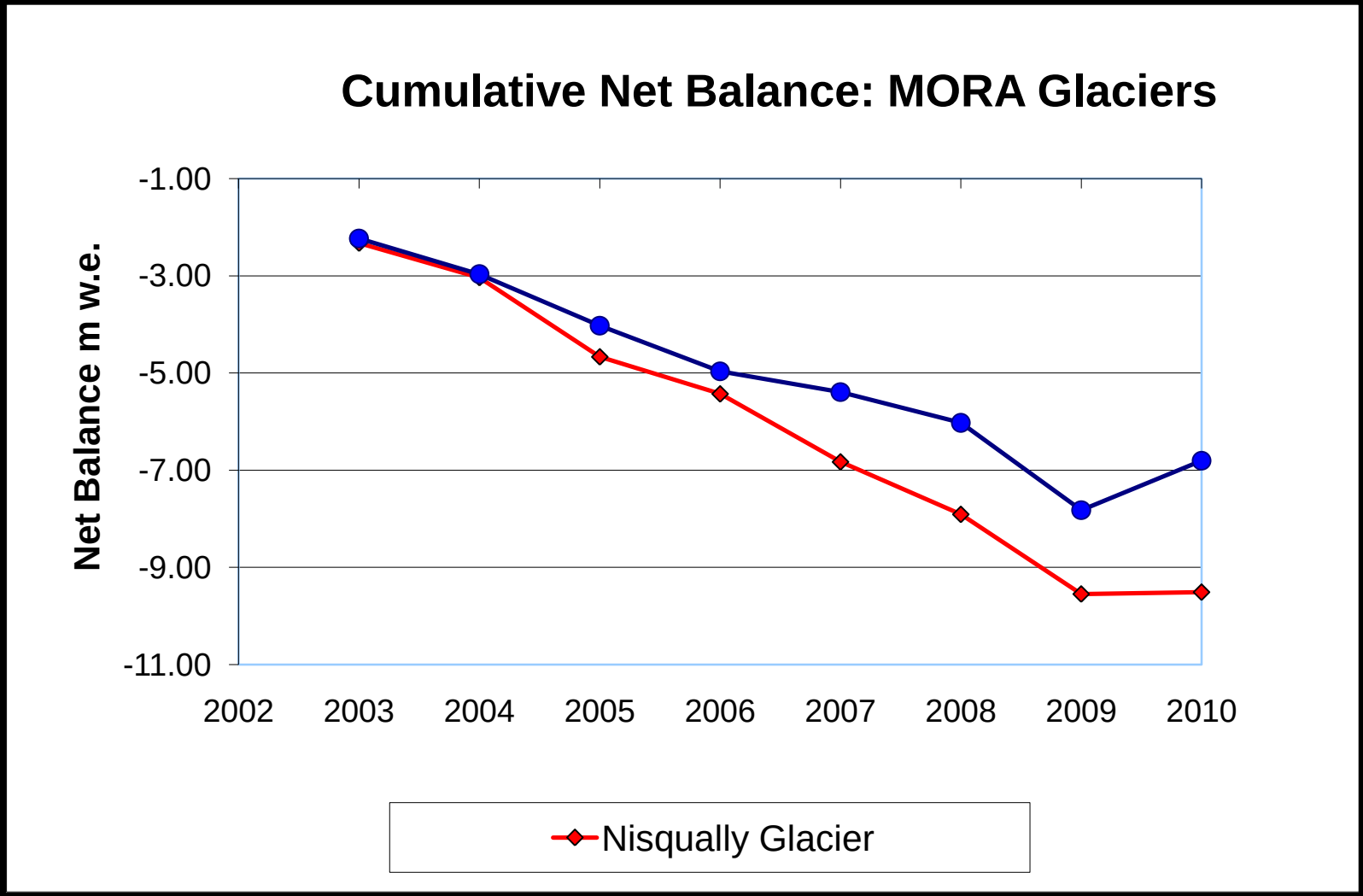


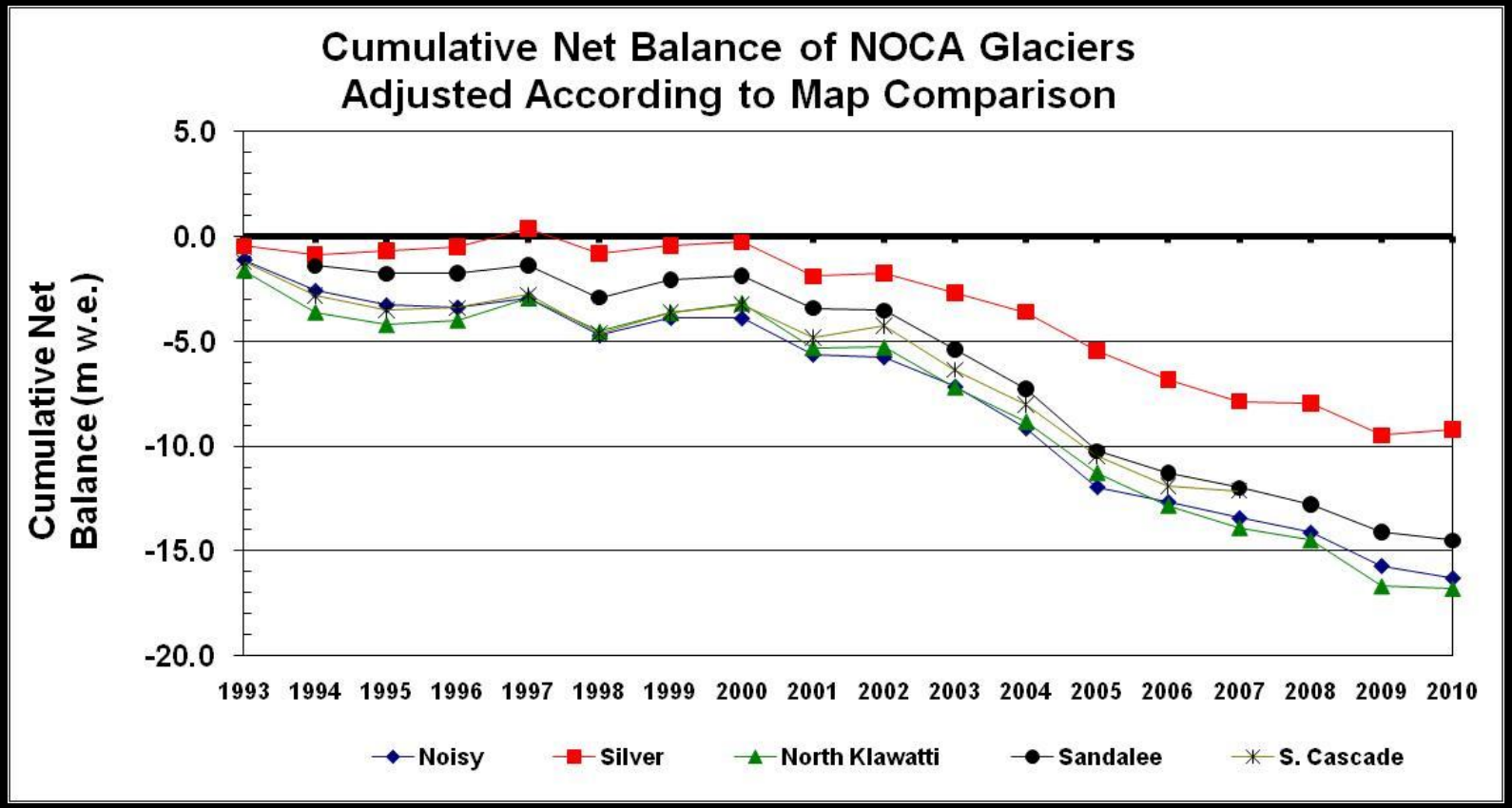


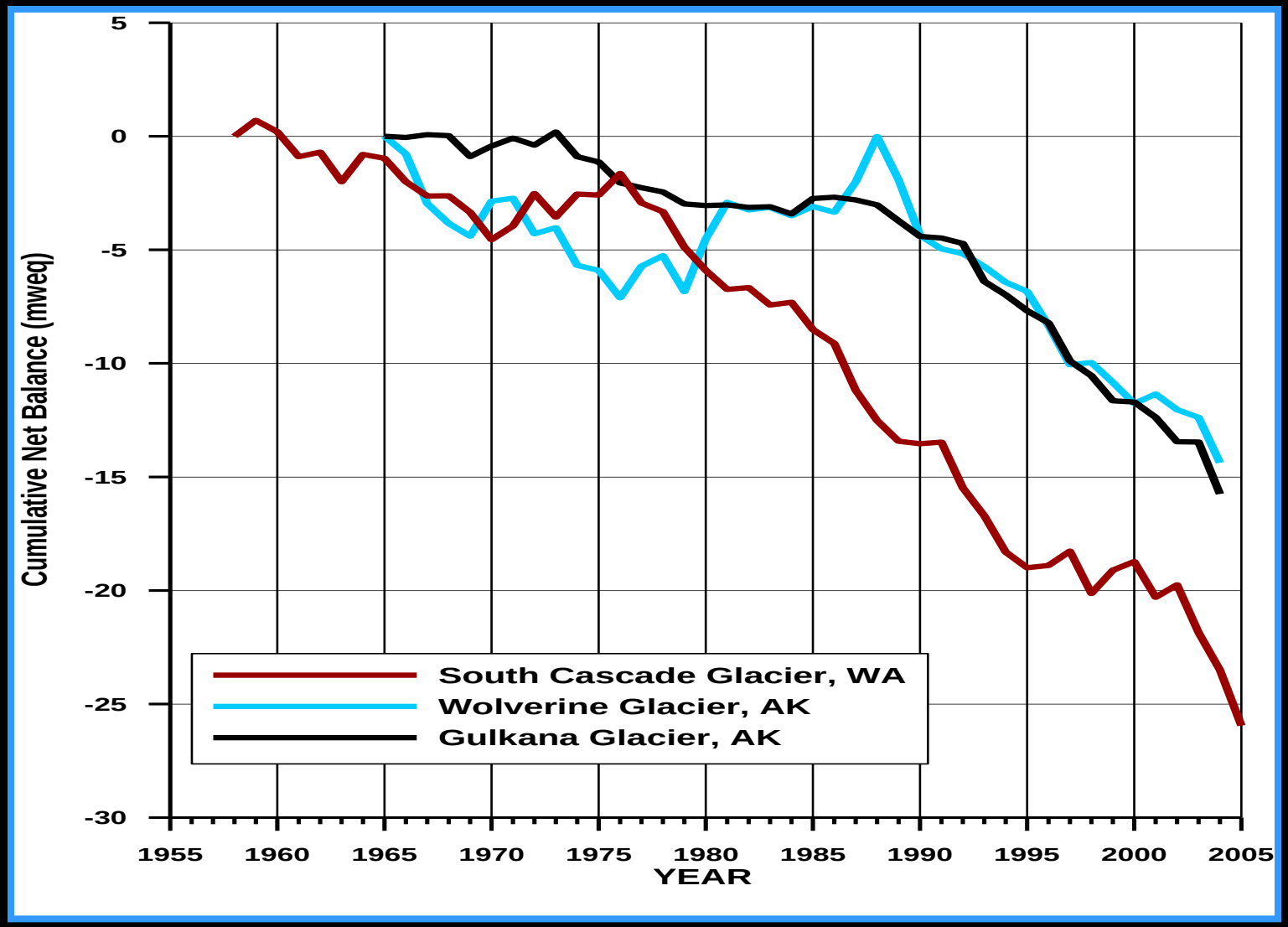

Nisqually Glacier Balances
Average Balances (m w.e.)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
2003
2004
2005
2006
2007
2008
2009
2010
Summer
Winter
Net


Emmons Glacier Balances
Average Balances (m w.e.)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
2003
2004
2005
2006
2007
2008
2009
2010
Summer
Winter
Net

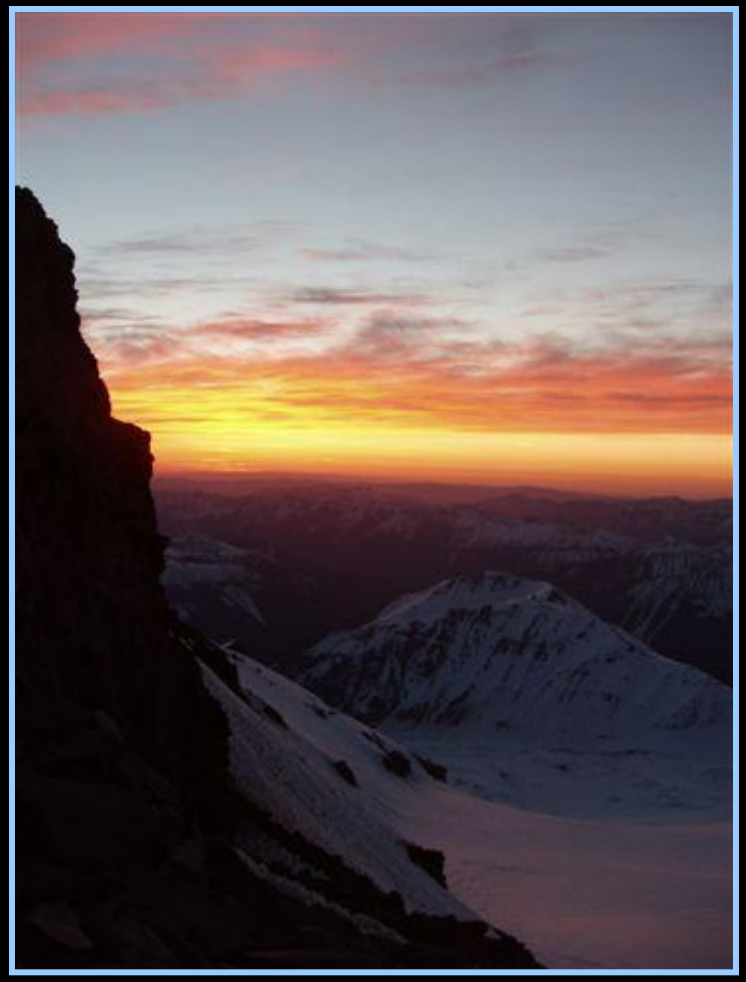

Net Balance: MORA Glaciers
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
Net Balance (m w.e.)
2003
2004
2005
2006
2007
2008
2009
2010
Year
Emmons
Nisqually


Cumulative Net Balance: MORA Glaciers
Net Balance m w.e.
-1.00
-3.00
-5.00
-7.00
-9.00
-11.00
2002
2003
2004
2005
2006
2007
2008
2009
2010
Nisqually Glacier


Cumulative Net Balance of NOCA Glaciers
Adjusted According to Map Comparison
Cumulative Net Balance (m w.e.)
5.0
0.0
-5.0
-10.0
-15.0
-20.0
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Noisy
Silver
North Klawatti
Sandalee
S. Cascade


Cumulative Net Balance (mweq)
5
0
-5
-10
-15
-20
-25
-30
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
YEAR
South Cascade Glacier, WA
Wolverine Glacier, AK
Gulkana Glacier, AK

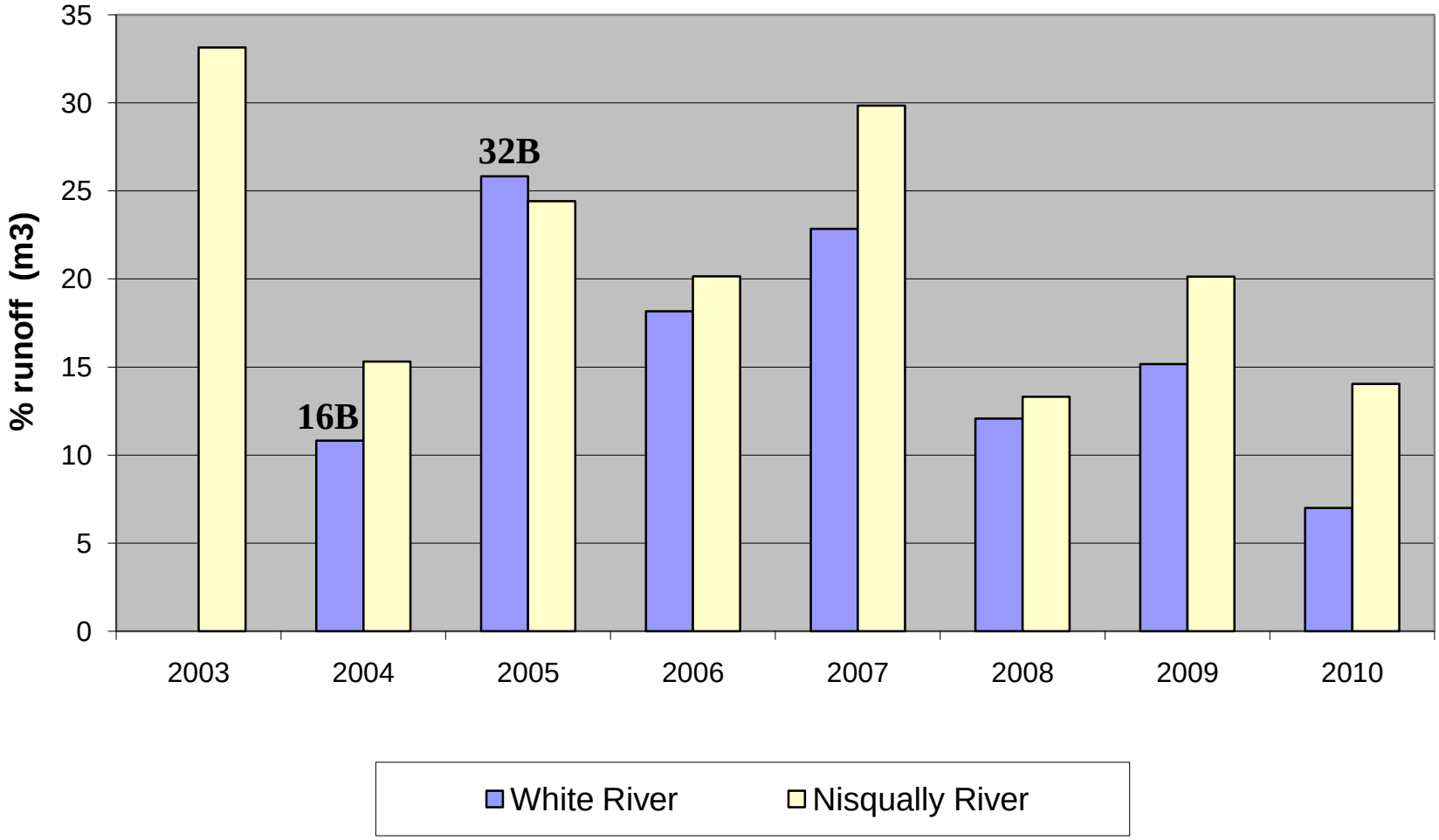
Source USGS



Total net loss of water from MORA glaciers 2003-2009 ~ 200B gallons

Primary mode of retreat of MORA glaciers is by down-wasting, not by frontal retreat up the mountain.

Percent Glacier Contribution to Total Runoff (May-September)



Glaciers and Climate Change at MORA

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Geologist, North Cascades N.P.

March 2, 2011

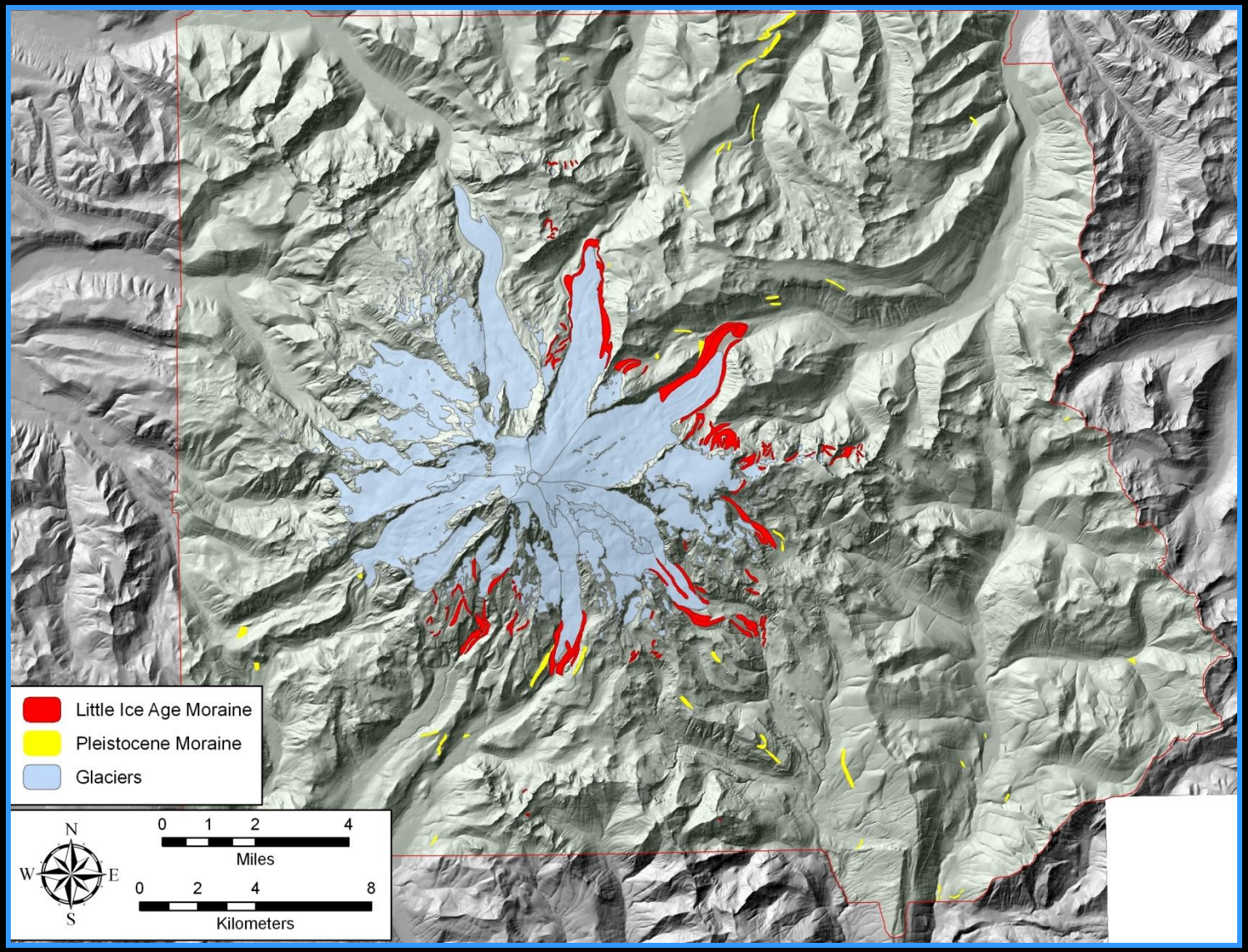
Outline

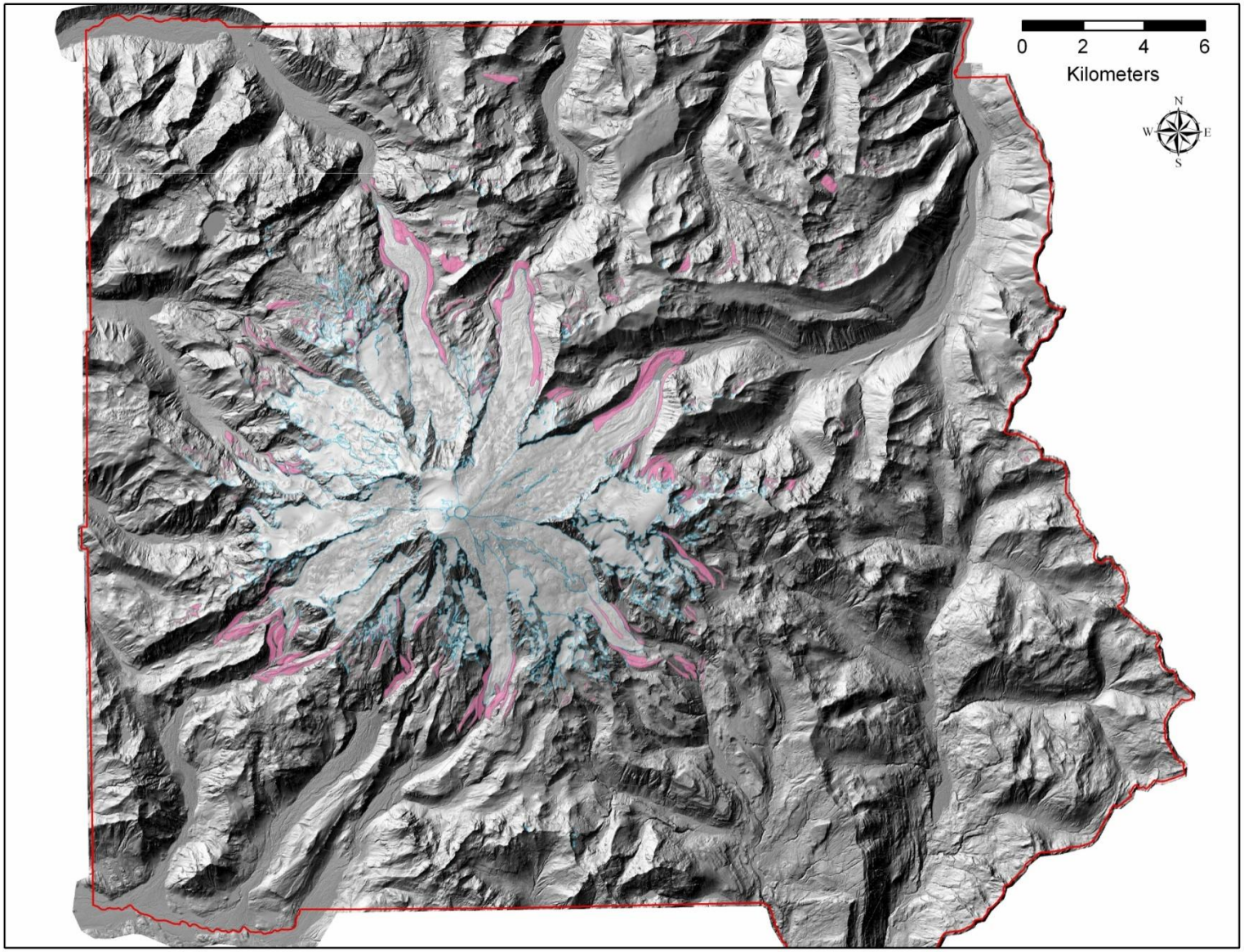
I- Glacier Change Since 2,500 BC

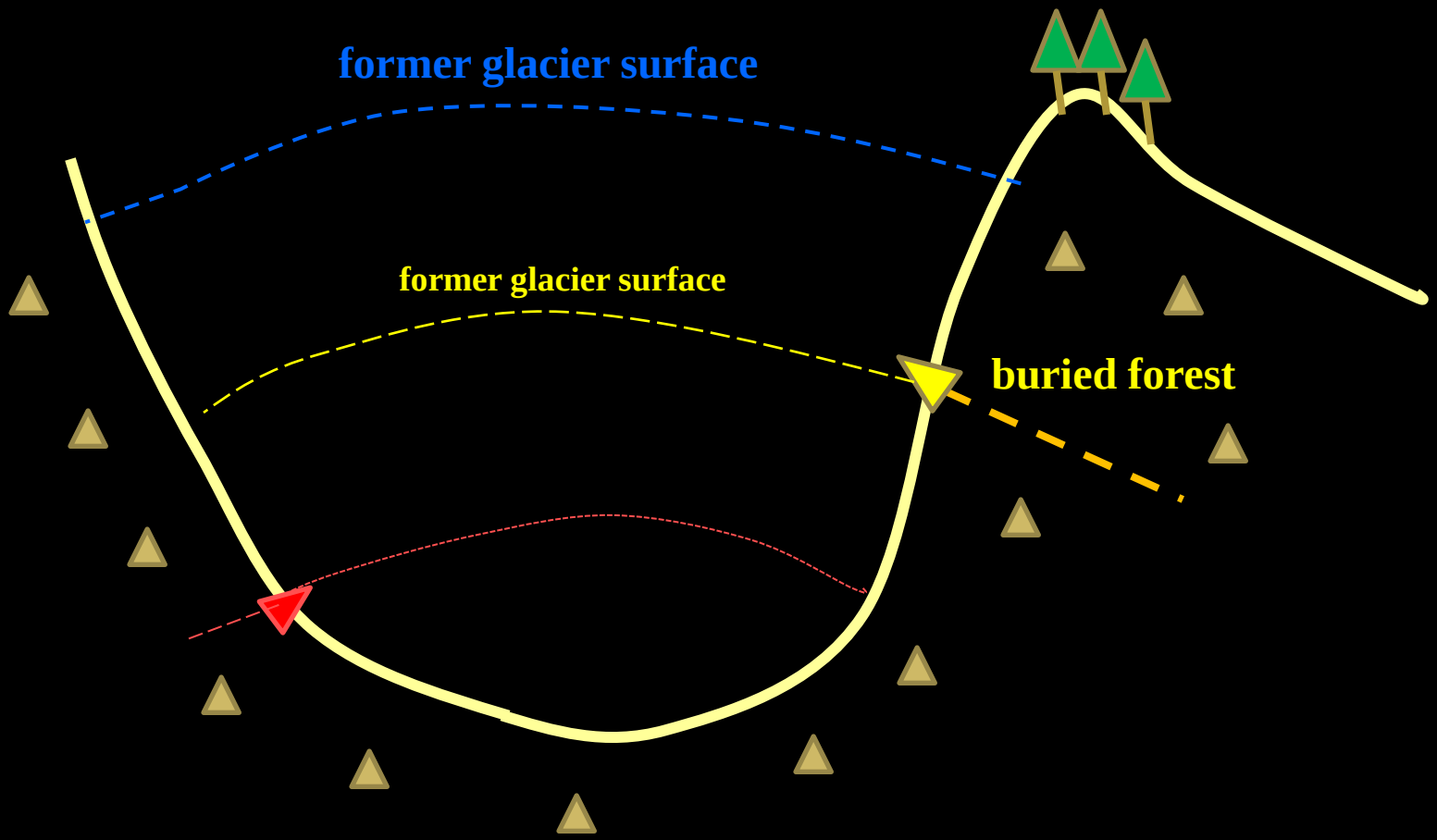
II - Glacier Change Since 1900

III- Glacier Change Since 2003

Photos by R. Lofgren

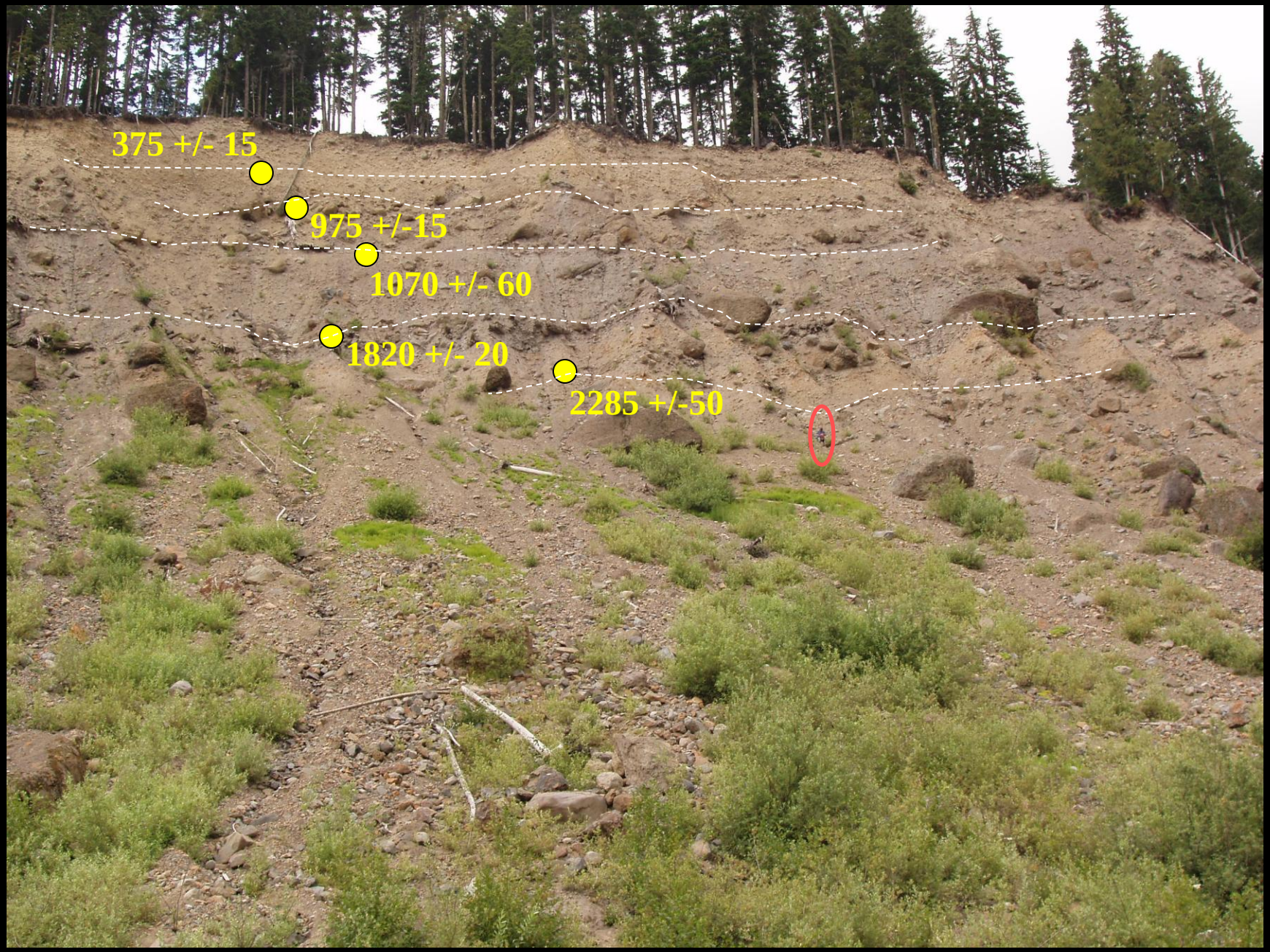

Little Ice Age Moraine
Pleistocene Moraine
Glaciers
N
W
E
S
0 1 2 4
Miles
0 2 4 8
Kilometers


0 2 4 6
Kilometers
N
W
E
S


former glacier surface
former glacier surface
buried forest

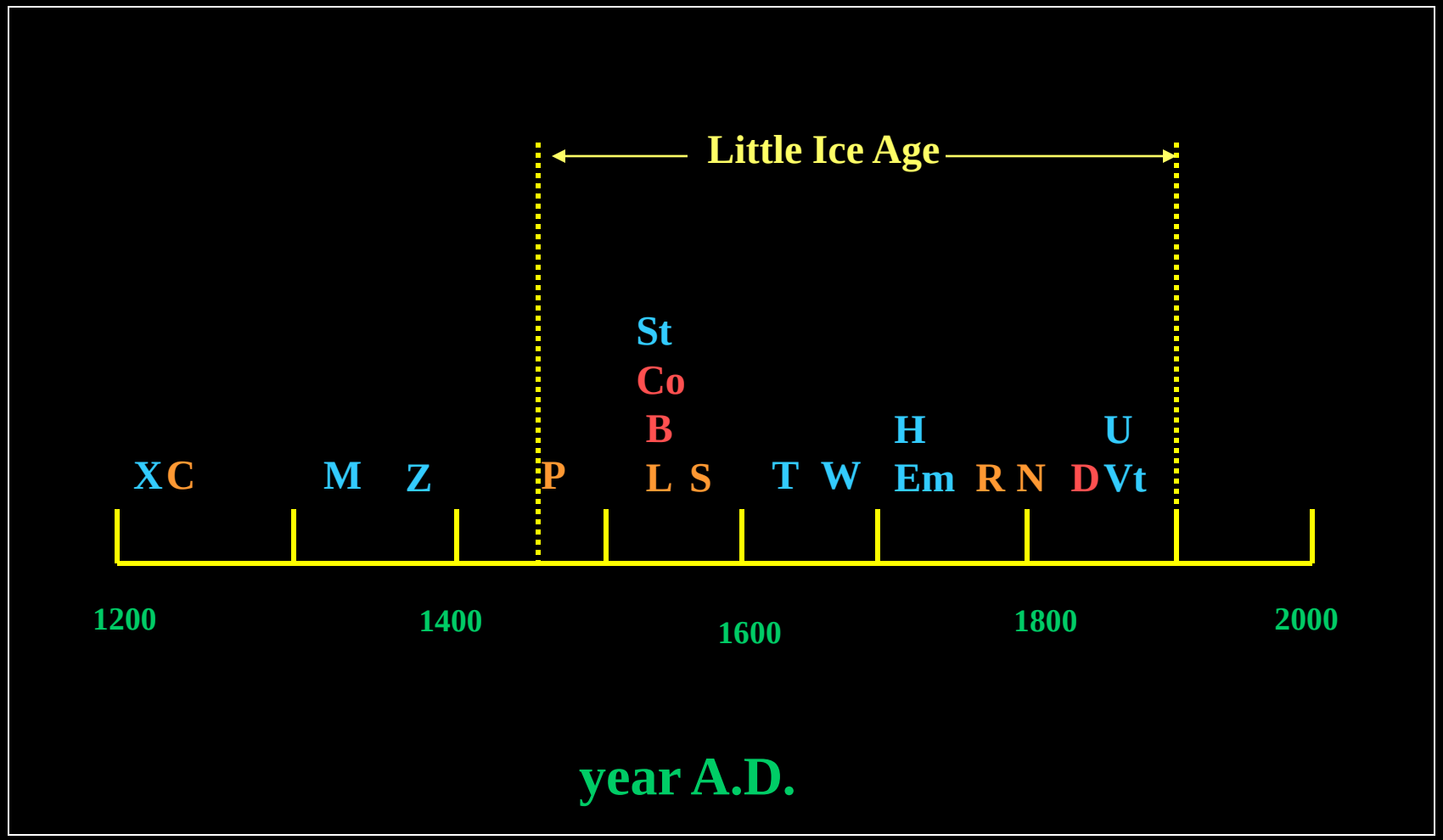

Black Diamond

Source: Samolcyzk et al., (2010)

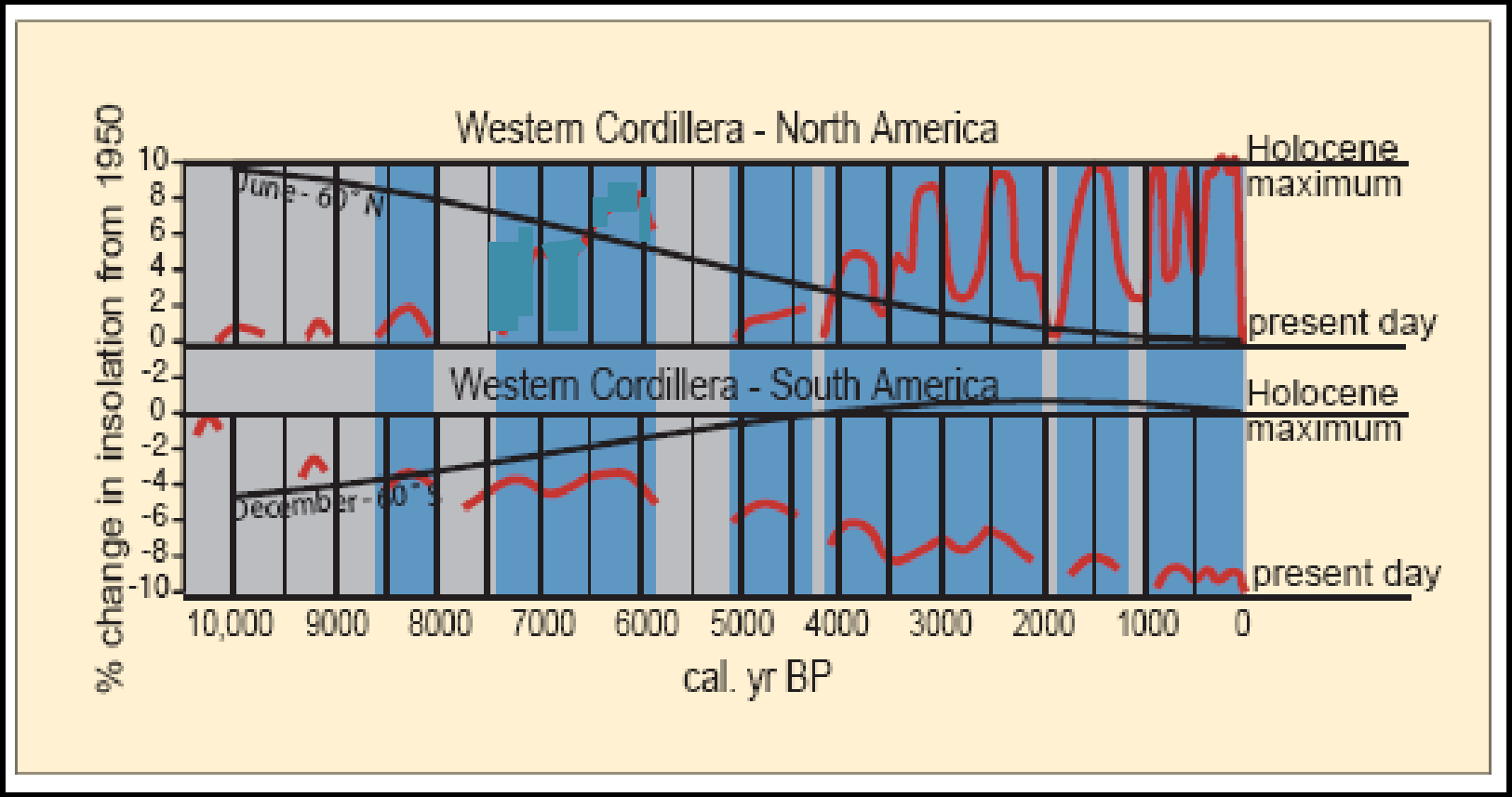

375 +/- 15
975 +/-15
1070 +/- 60
1820 +/- 20
2285 +/-50

Timing of post ice age maximum extent for 19 Cascade glaciers.

(Mt. Baker, Mount Rainier, North Cascades)

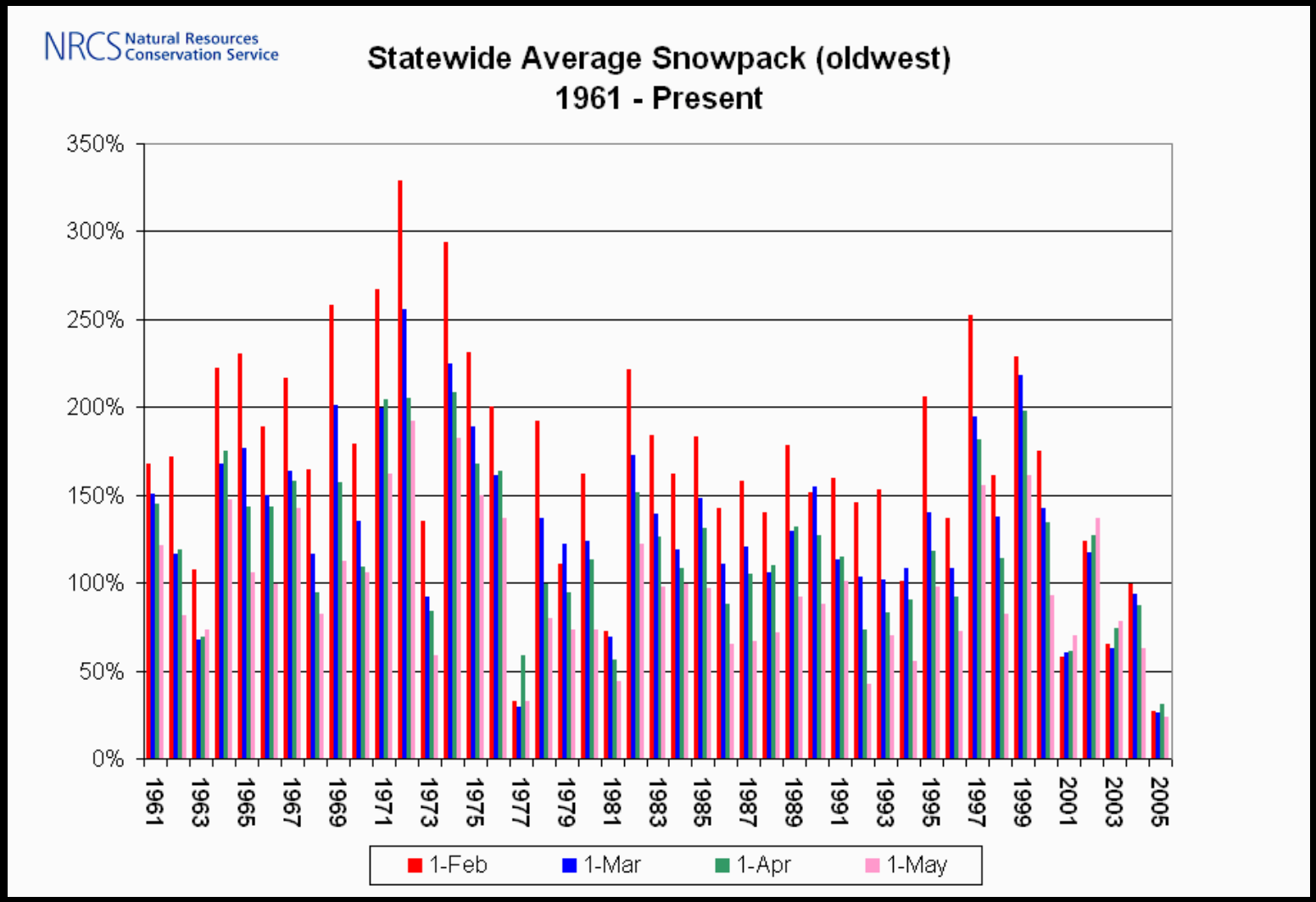


➢contrasting north and south hemisphere glacial records

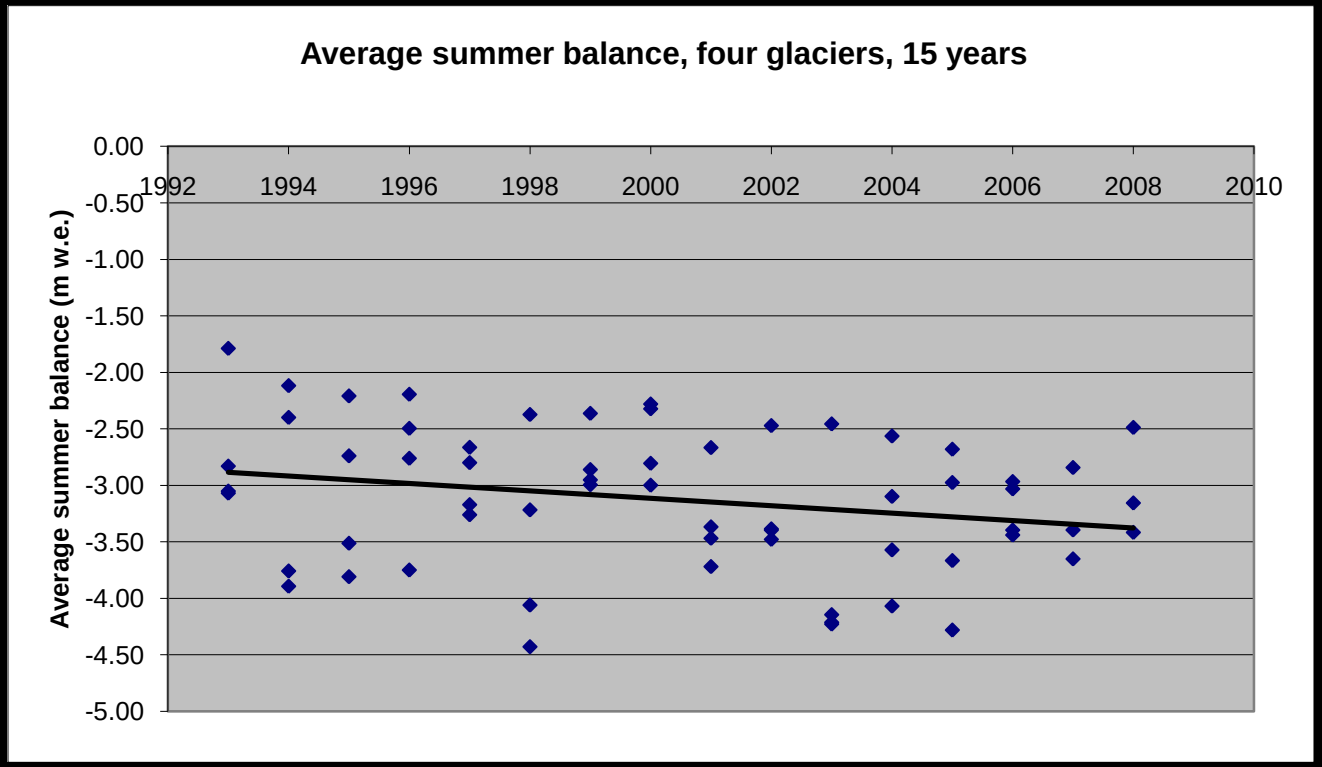


-sources: Koch and Clague (2006) and Bradley et al. (2002).

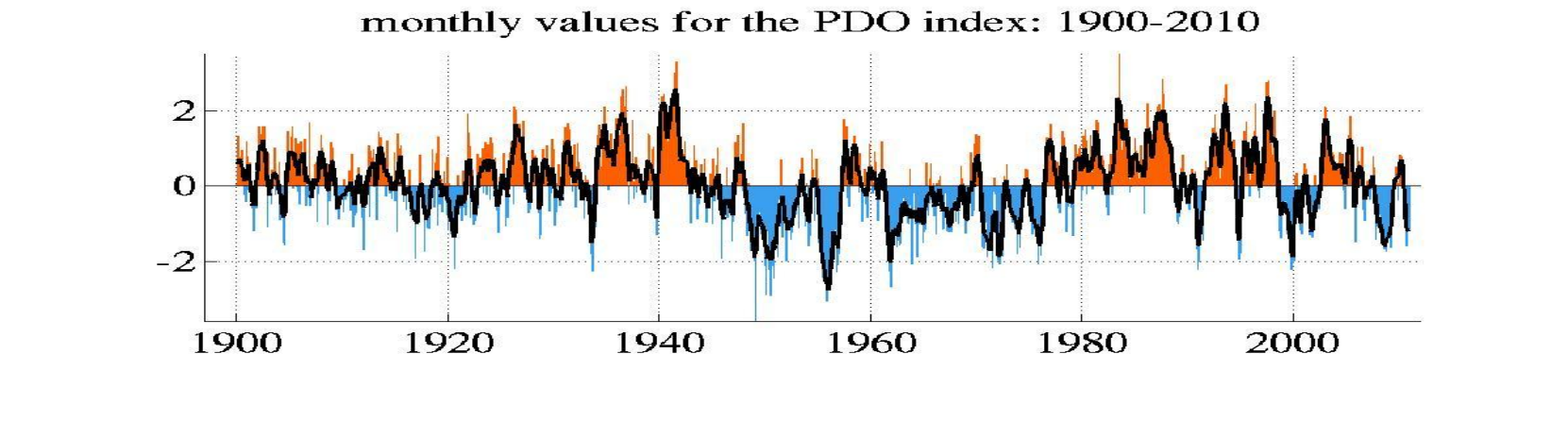
Washington State snow-pack has declined ~25% in the last 54 years, while annual precipitation has increased slightly.



Summer melt at NOCA glaciers



The Pacific Decadal Oscillation Index



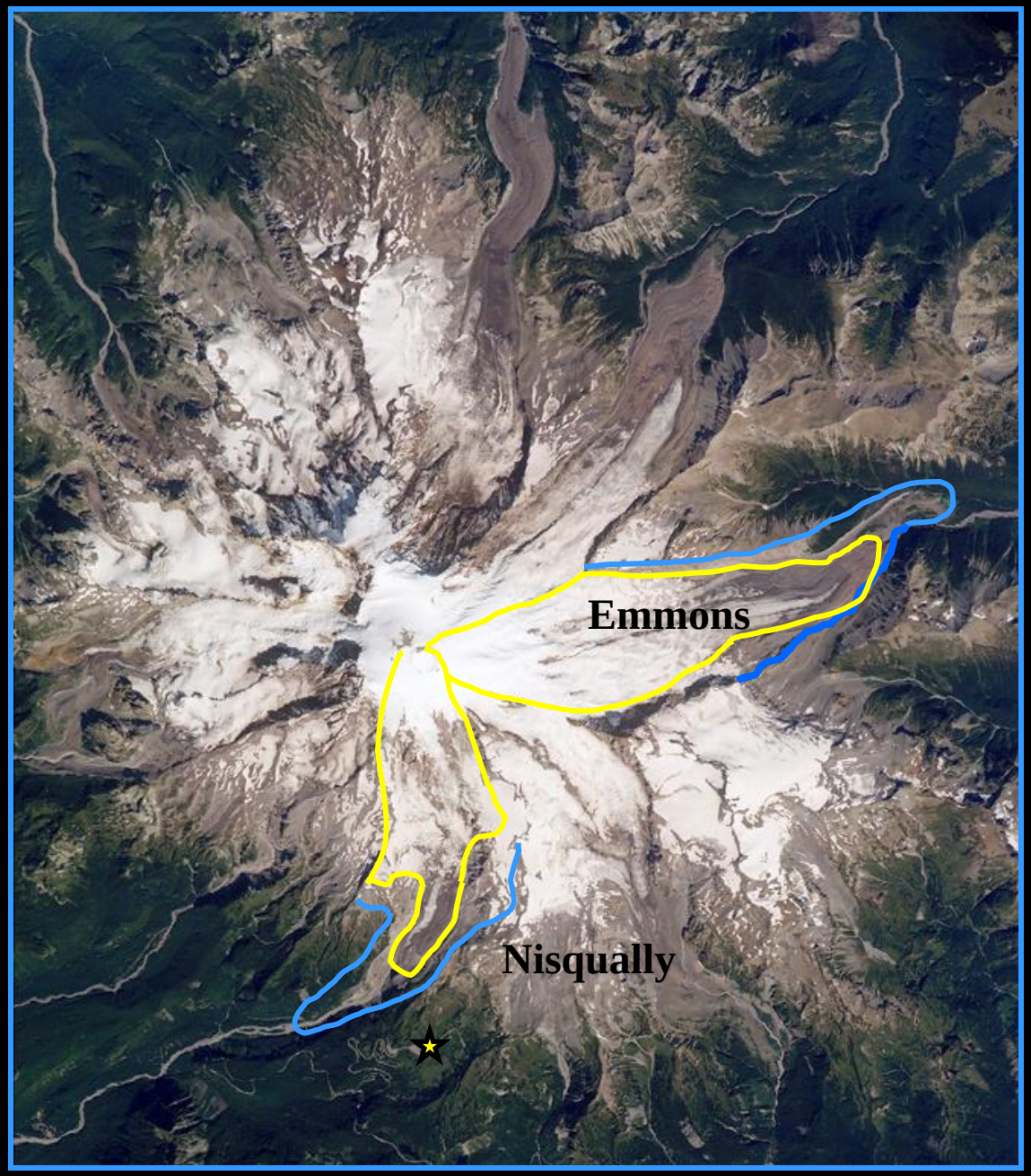
Source JISAO

Preliminary Results OLYM Glacier Inventory

-1900 area = 66.6 km^2

-1982 (Spicer) area = 45.9 km^2

-2009 (Riedel et al.) area = 29.1 km^2


Emmons
Nisqually