

Glacial Record of Climate Change in the Pacific Northwest



Jon Riedel – North Cascades National Park
Johannes Koch – Brandon University

Glaciers are sensitive to climate change because temperature directly influences melt rate and amount of accumulation.



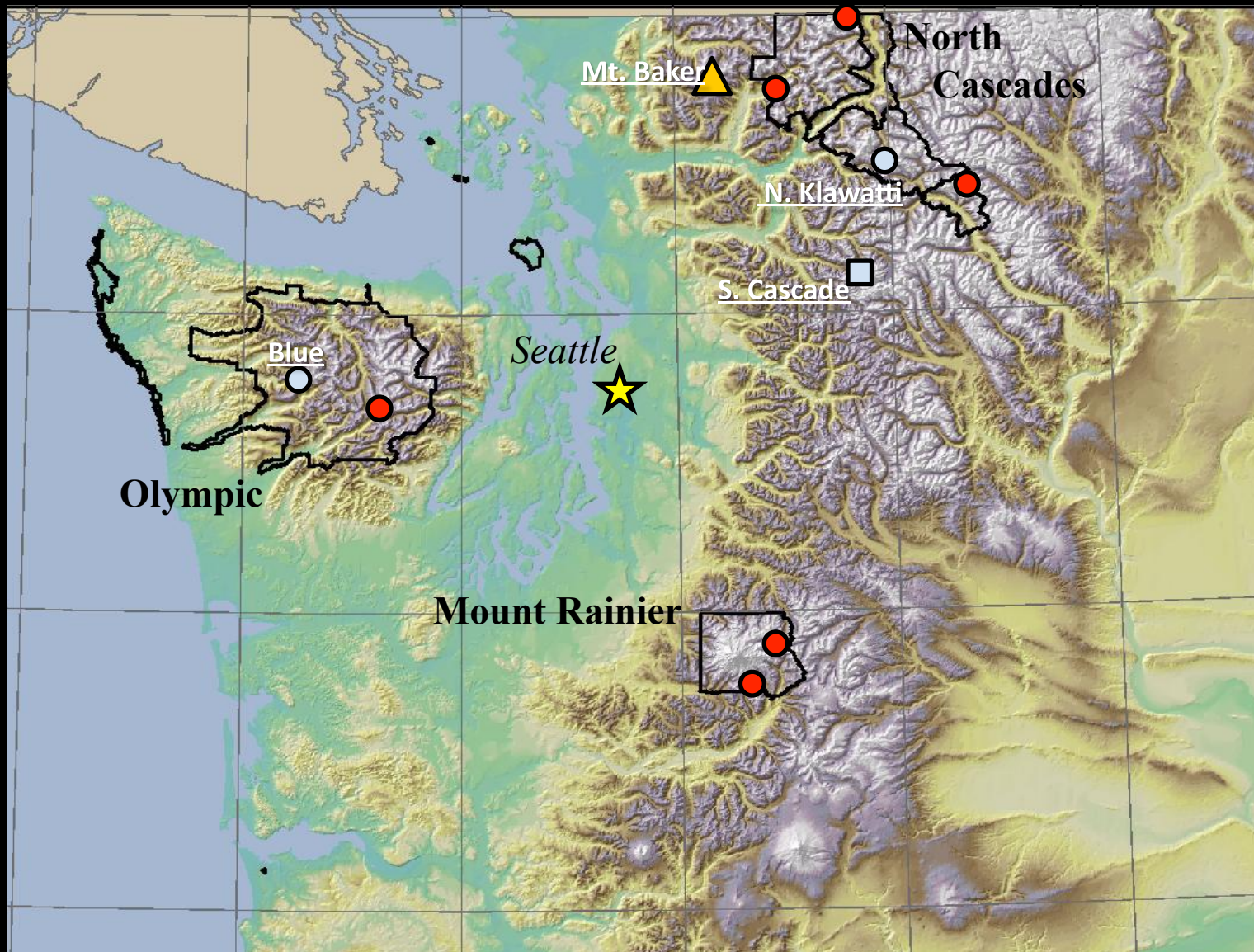
Glaciers leave clear records of climate change.



Elements of the Glacial Record

1. Mass balance measurements (50 years)
2. Map and photographic record (100 years)
3. Paleo reconstructions
 - a. Tree-ring based mass balance (1,000 years)
 - b. Moraines and buried forests (10,000 years)

N.P.S. Glacier Monitoring in Washington



North Klawatti Glacier

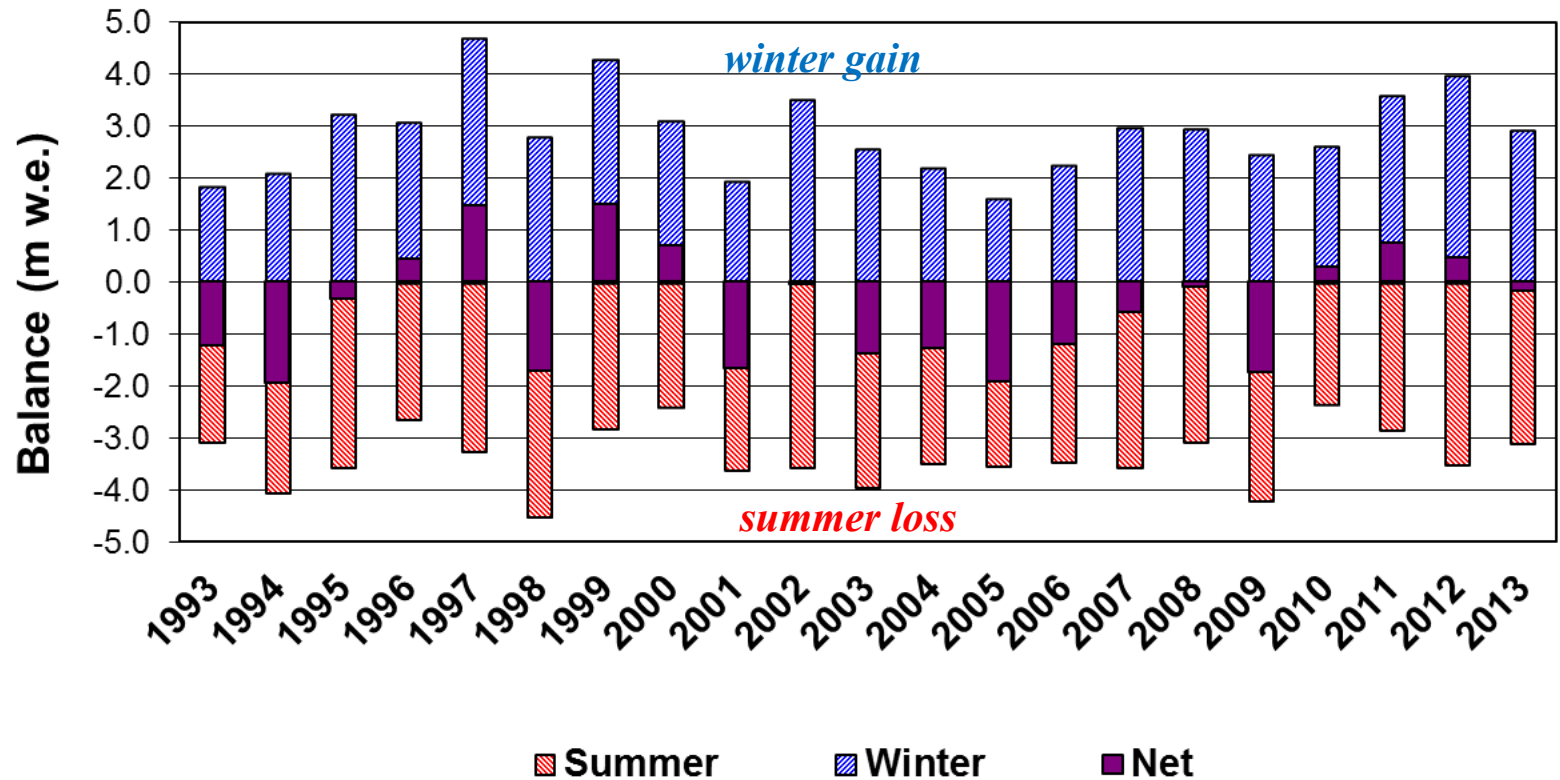
Spring



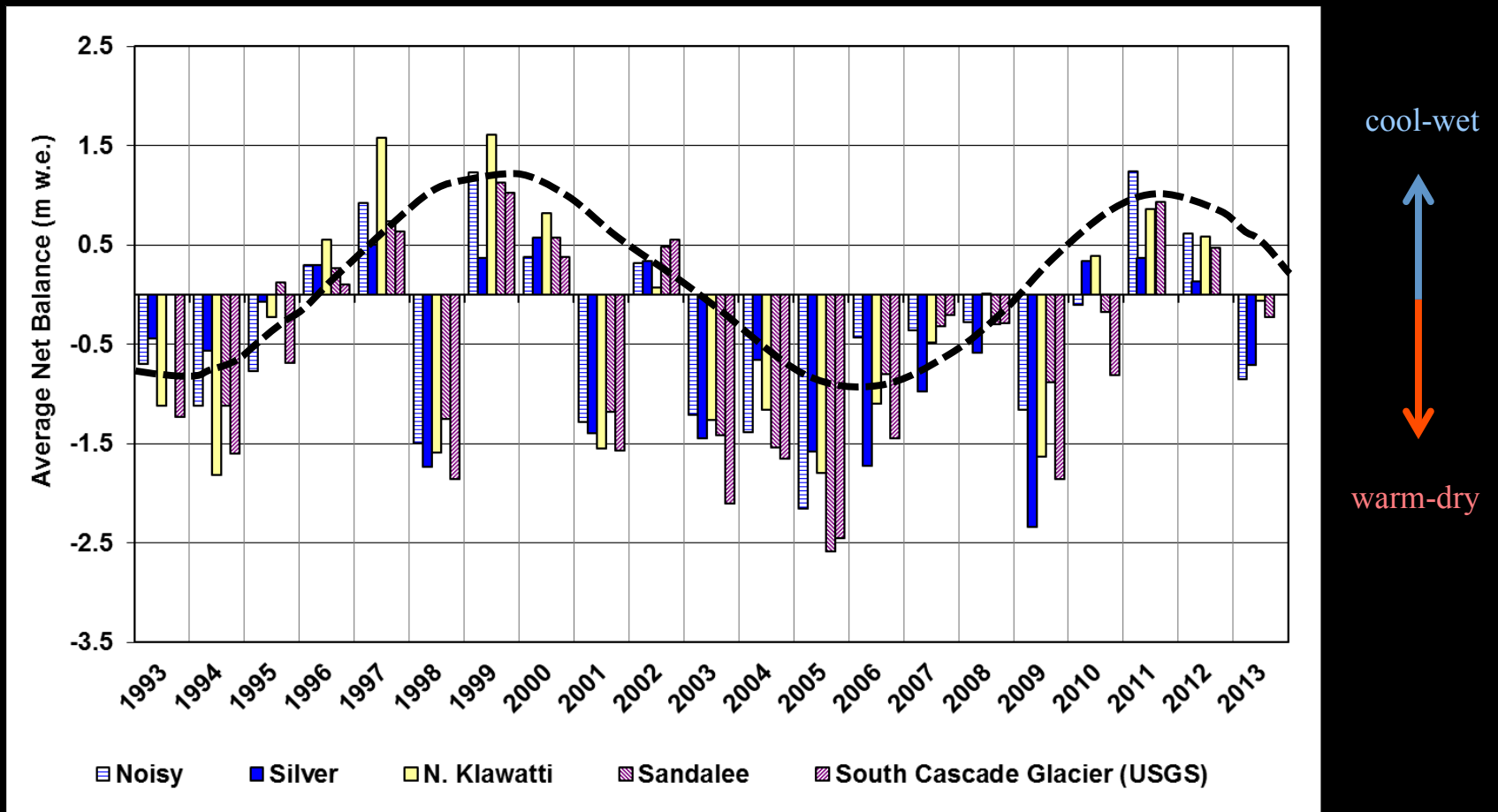
Fall



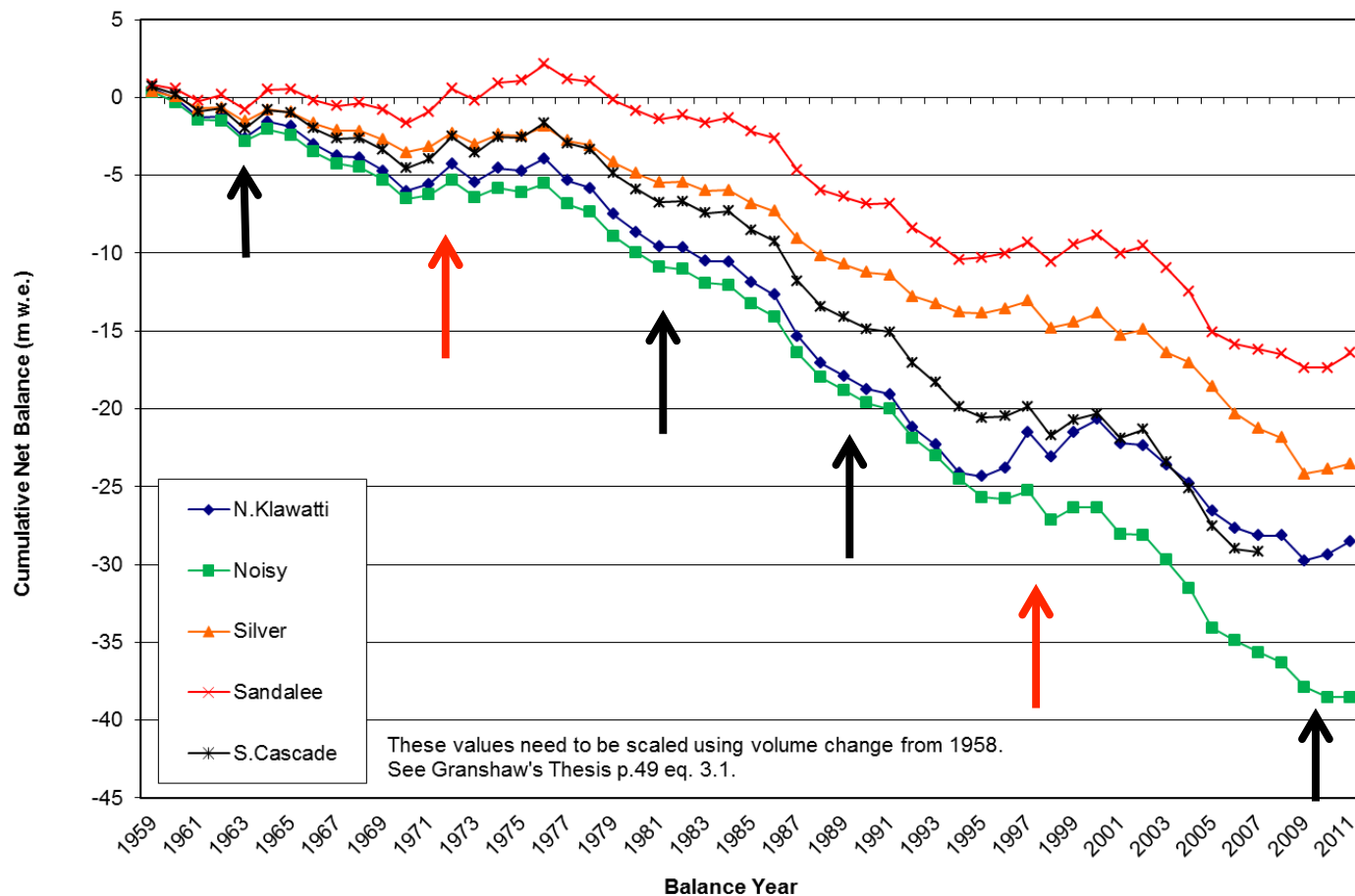
North Klawatti Glacier Balance



Net Mass Balance of North Cascade Glaciers

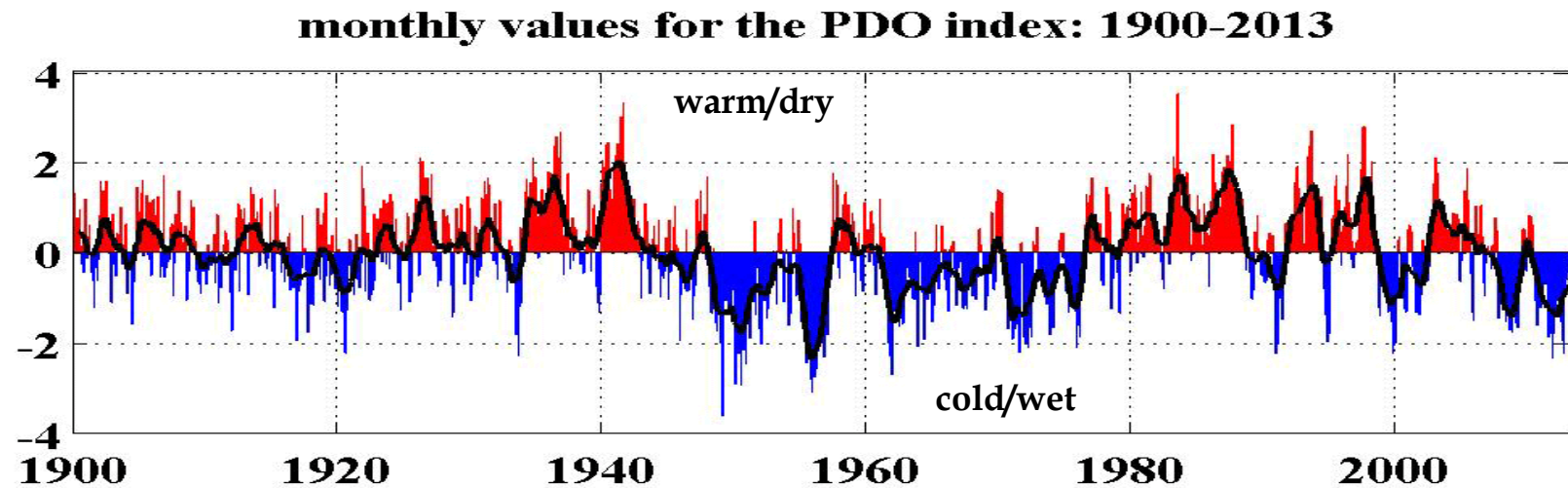


Trend in glacier volume is strongly negative, but is punctuated by periods of relatively wet, cool weather every ~10 years with a stronger response every 20-40 years.



Sources: Granshaw 2001; Riedel and Larrabee, in press

Sea surface temperature index of the Pacific Decadal Oscillation



Source: JISAO

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South Cascade Glacier

1928 (USGS)



2003 (Scurlock)



Olympic Mountains – Lillian Glacier



1905 (NPS)



2010 (McClean)

Regional decline of glacier area in the past century:

- North Cascades -53% (~1900-1998; NPS)
- Olympic Mountains -52% (~1900-2009; Spicer, 1986; NPS)
- Garibaldi -44% (~1900-2005; Koch, 2006)
- Mount Rainier -22% (1913-2000; Nysten, 2002)
- Mount Baker -30% (~1900-2006, Brown, 2010)
- Mount Adams -49% (~1900-2007; Sitts et al. 2010)



Recent Loss of Glacier Area:

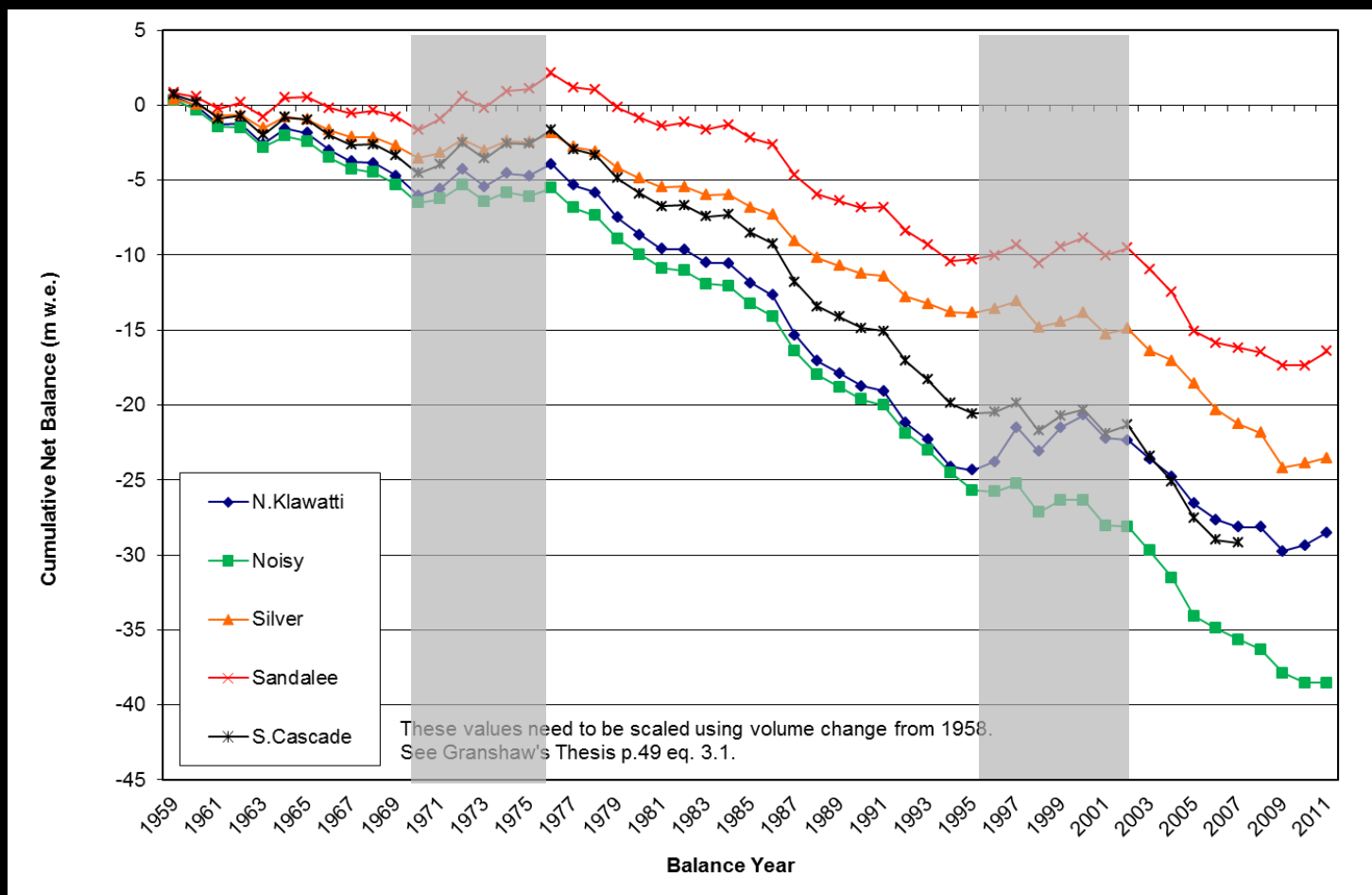
- Olympic Mountains -34% (1982-2009; Riedel et al., in review)
- Vancouver Island -20% (1985-2005; Lewis and Smith, 2004)
- Southern Coast Mountains -10% (1985-2005; Bloch et al., 2010)
- North Cascades -20% (1959-2009; Dicks, 2013)



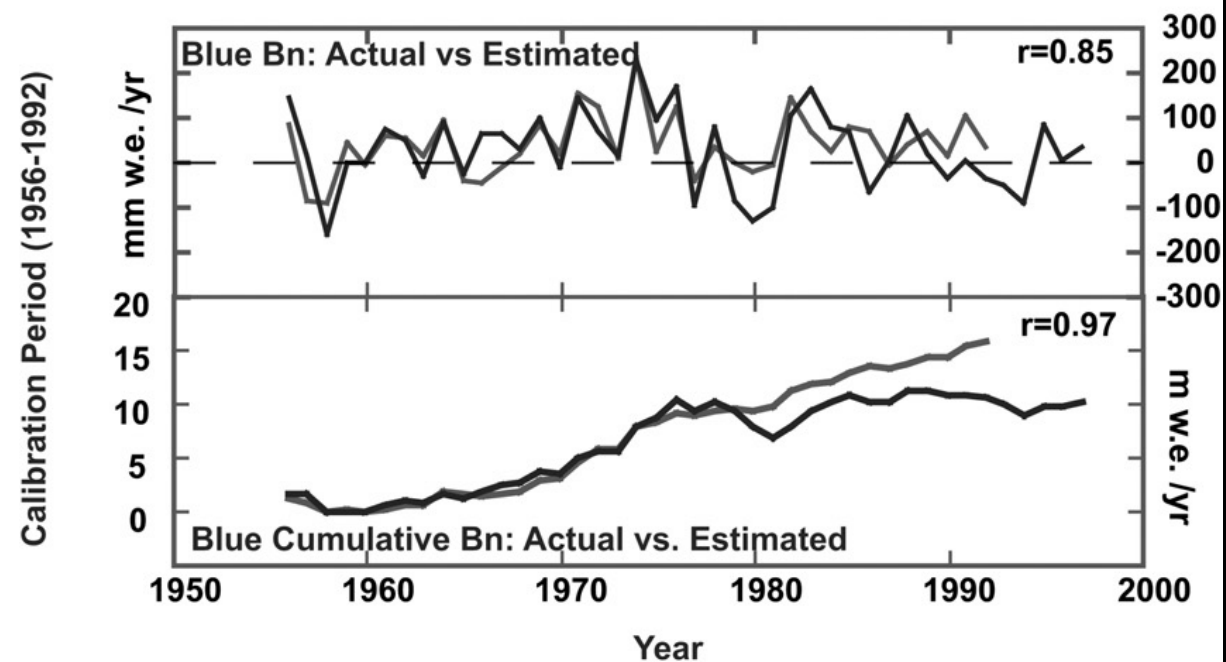
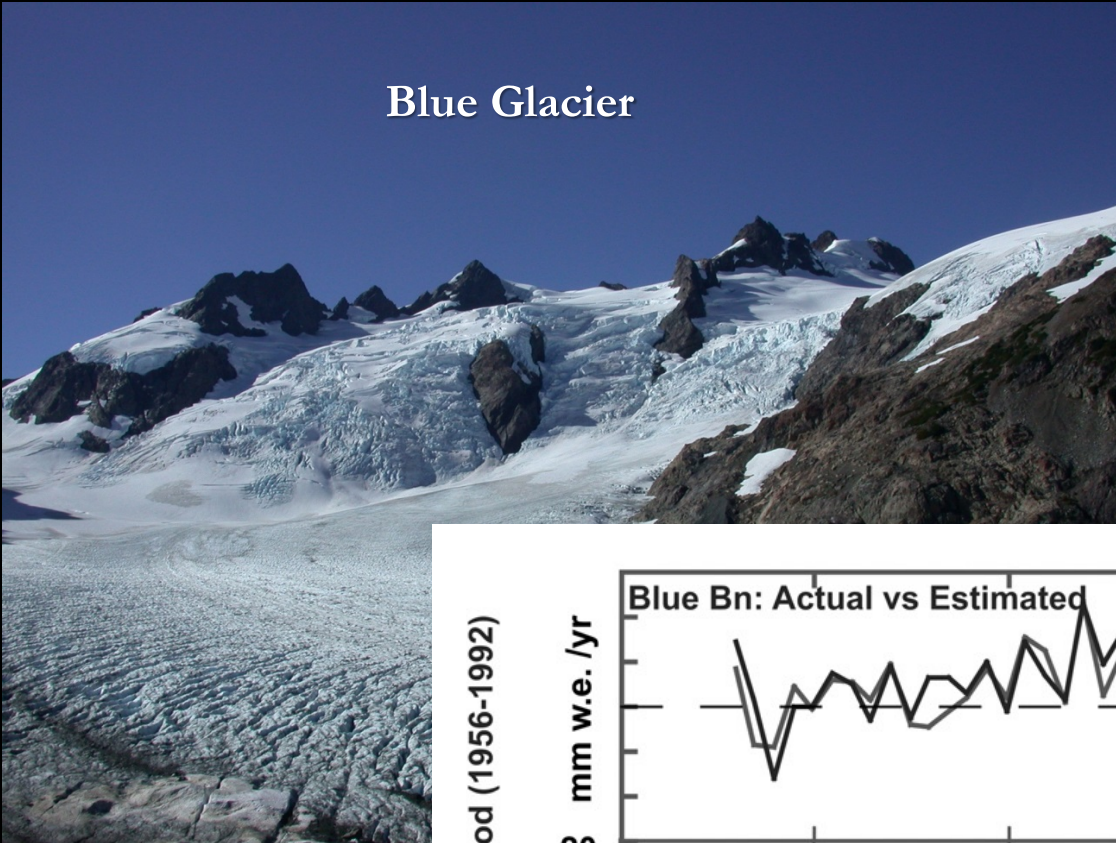
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Cumulative Mass Balance of Five North Cascade Glaciers 1959-2011

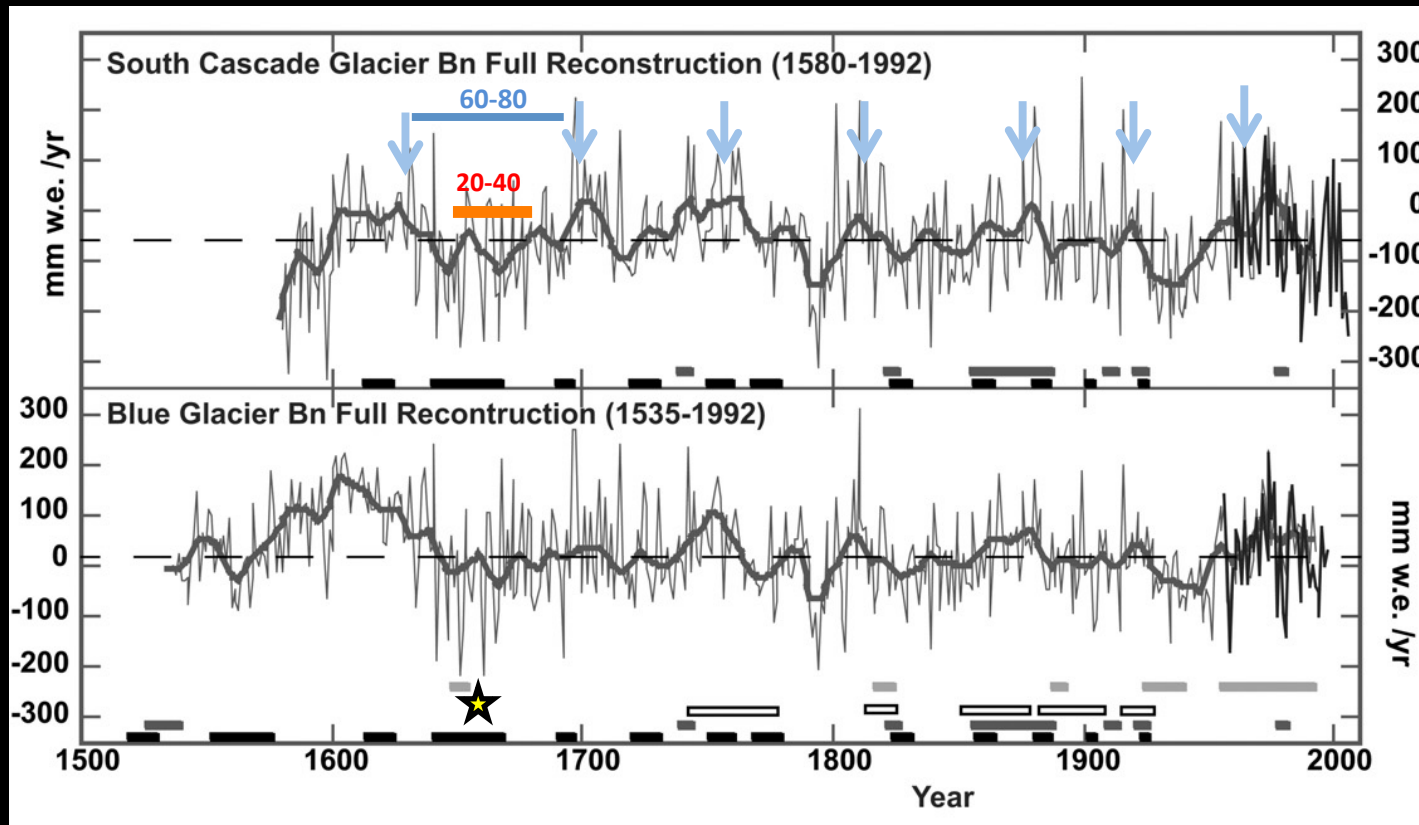


Blue Glacier



Malcomb and Wiles, 2013

Glacial Mass Balance Reconstructed from Tree Ring Width

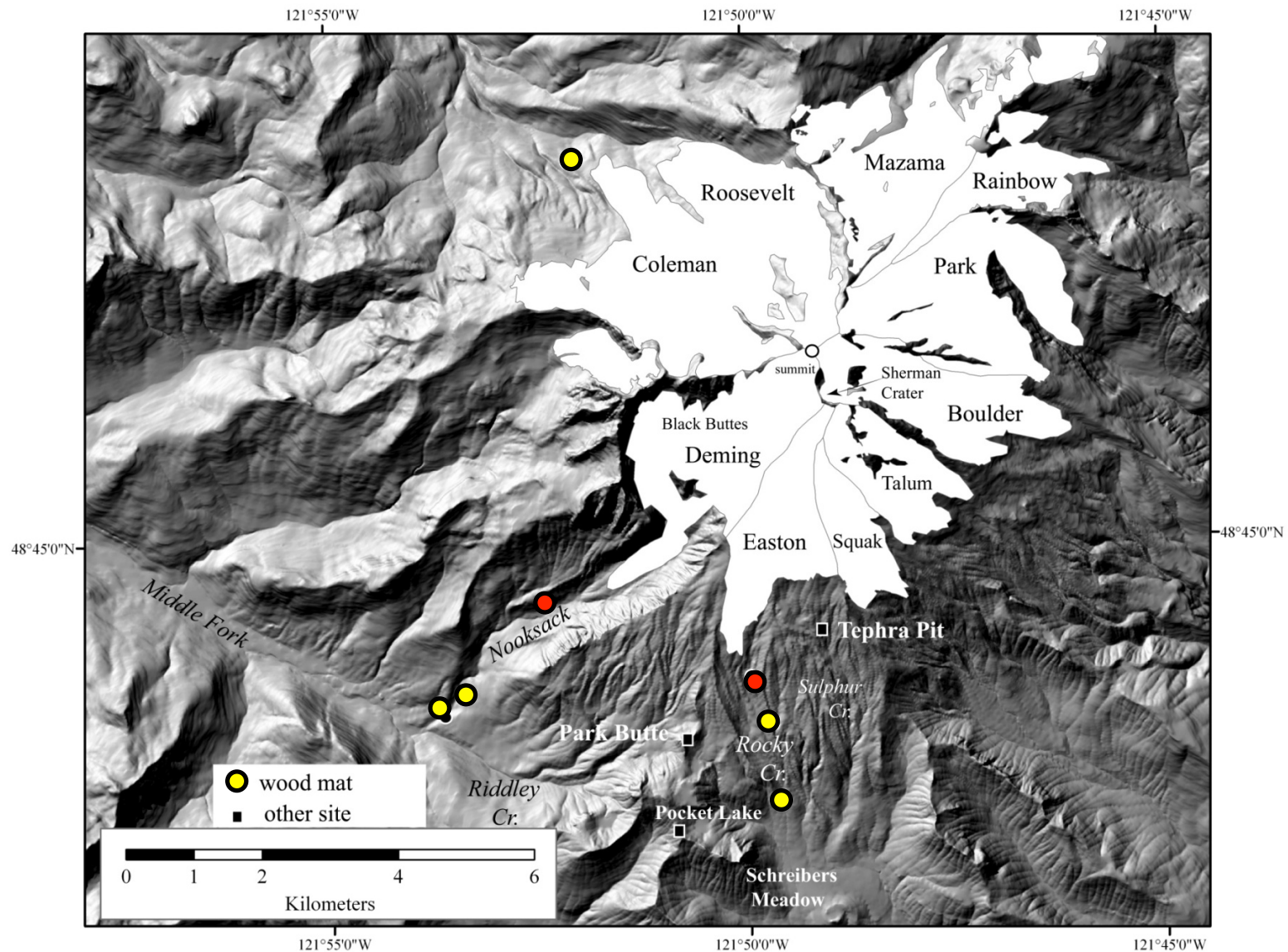


Source: Malcomb and Wiles, 2013





Mount Baker Glacier History Study Sites



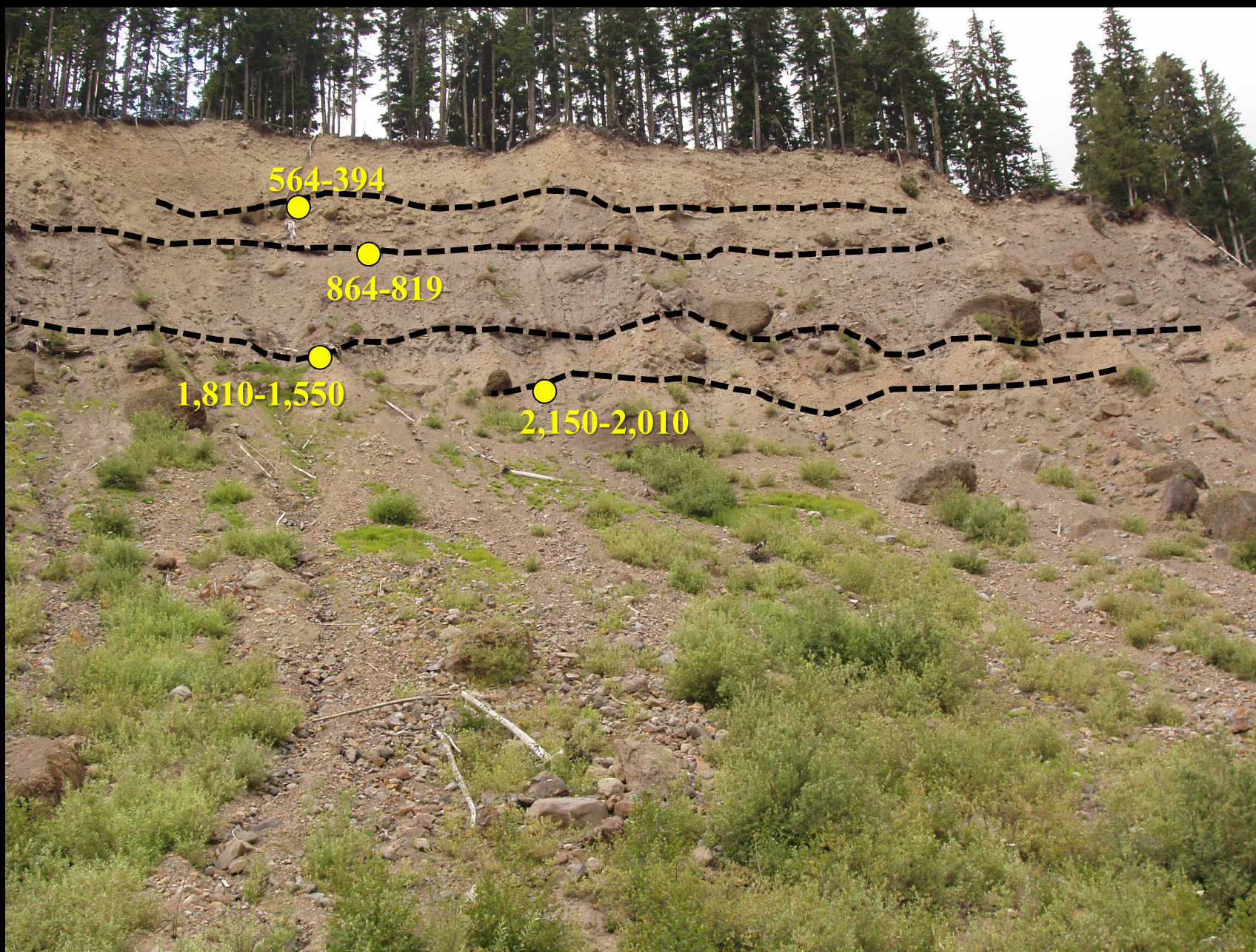




6,260 -5,910 cal. yr BP

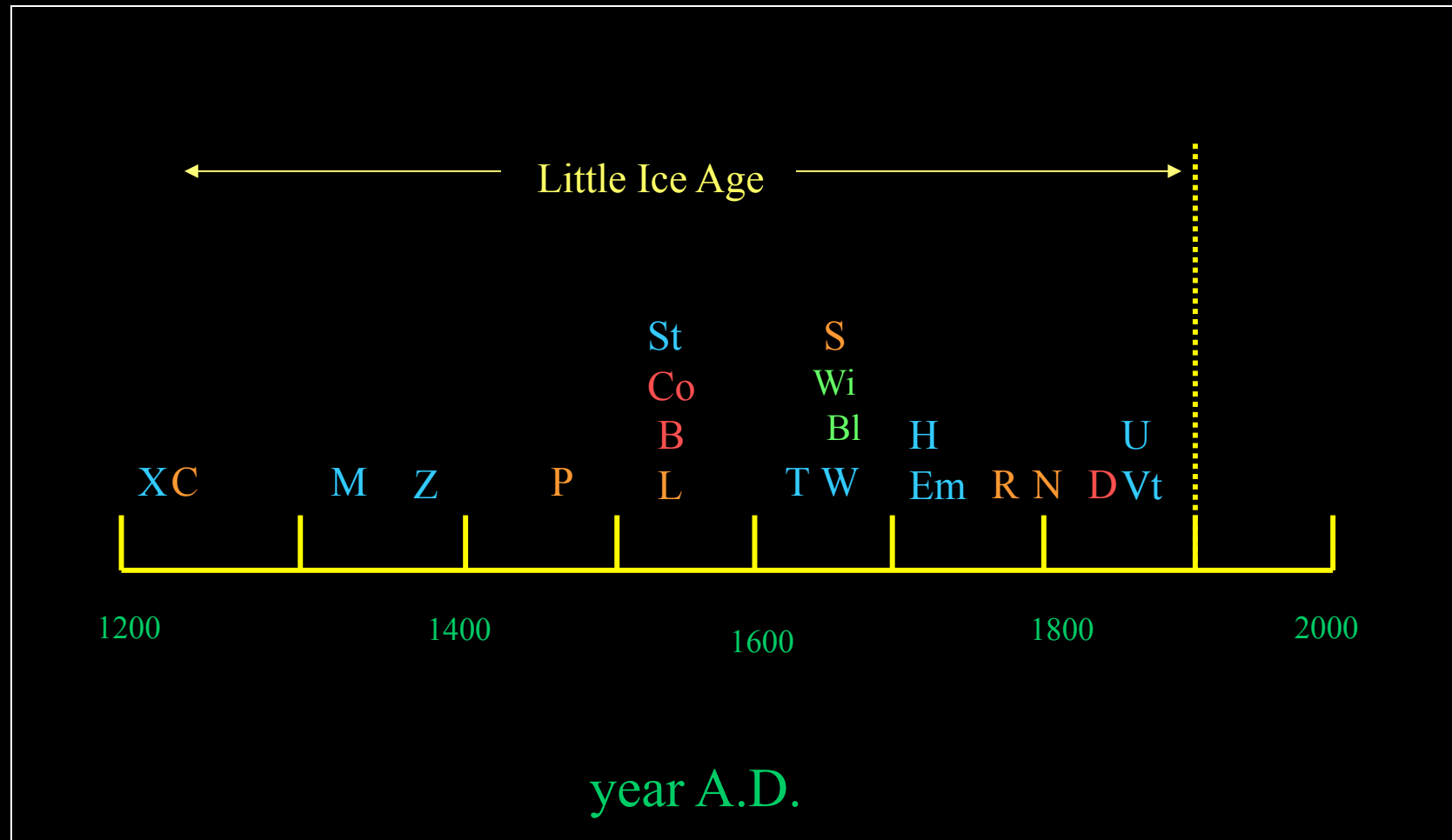




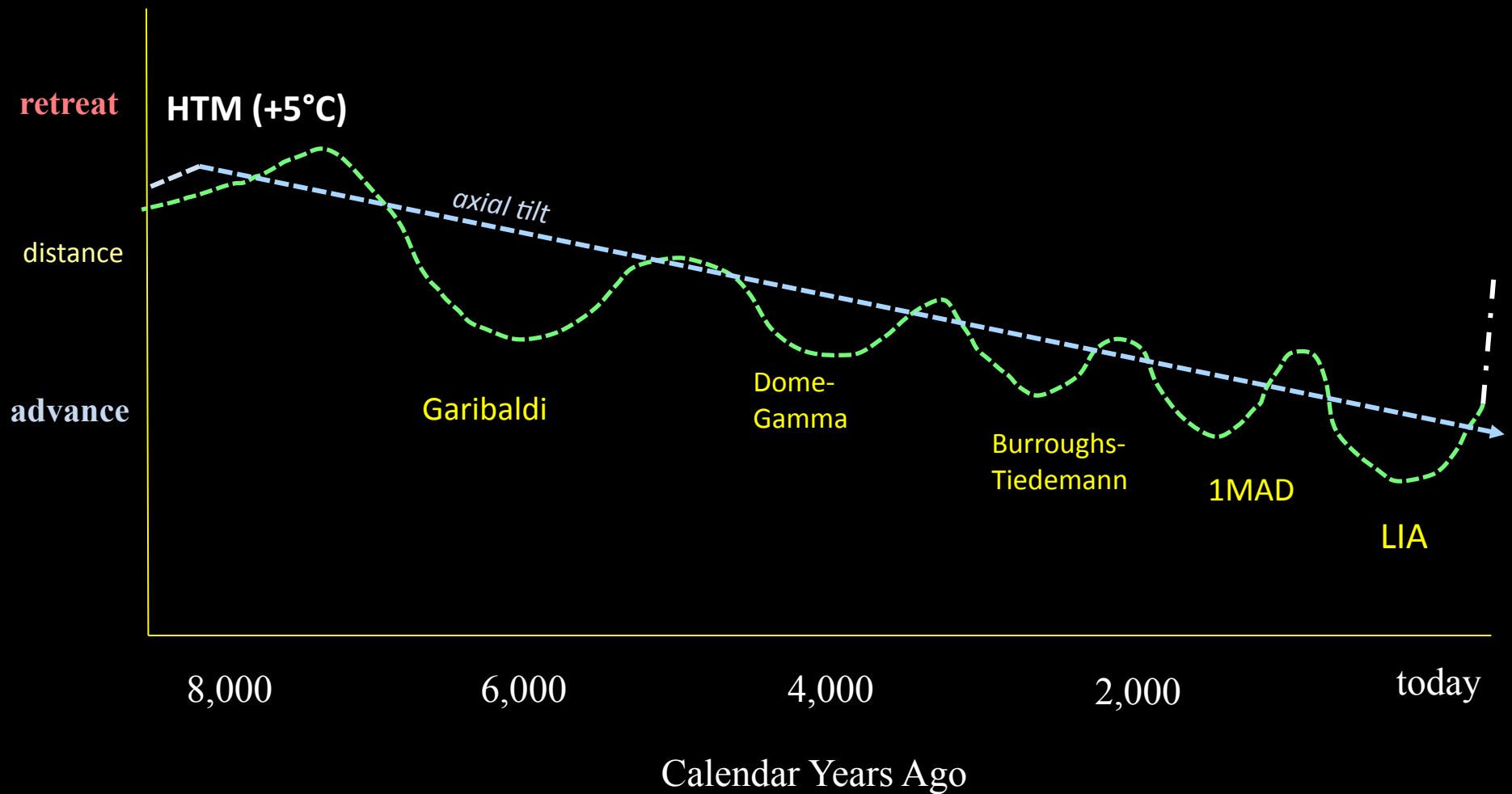


Timing of maximum extent in past 8,000 years for 21 PNW glaciers

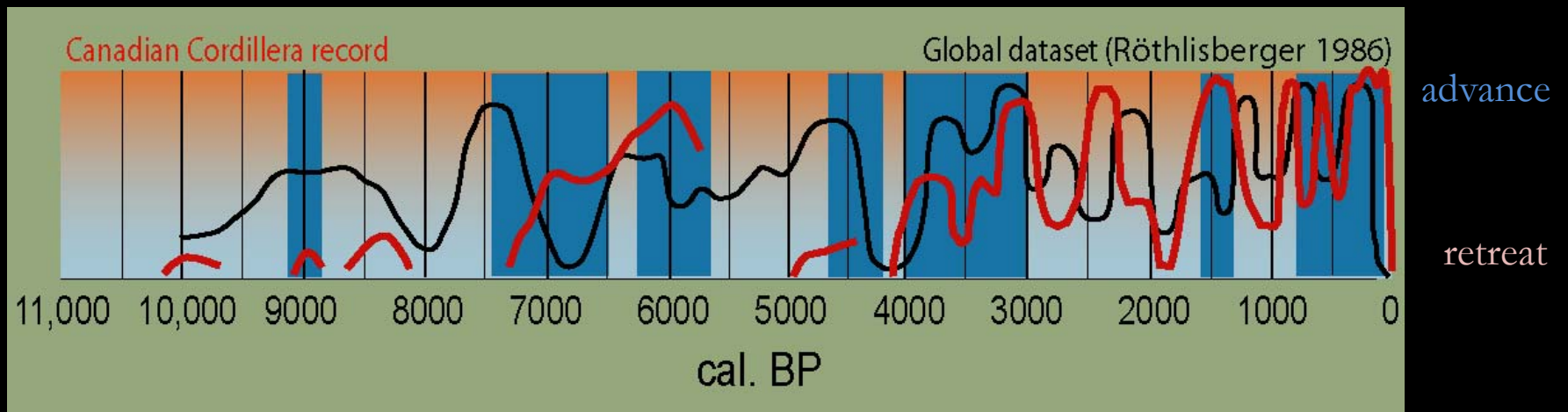
(Mt. Baker, Mount Rainier, North Cascades, Olympics)



General Pattern of Glacial Activity (Climate) in the Past 10,000 years

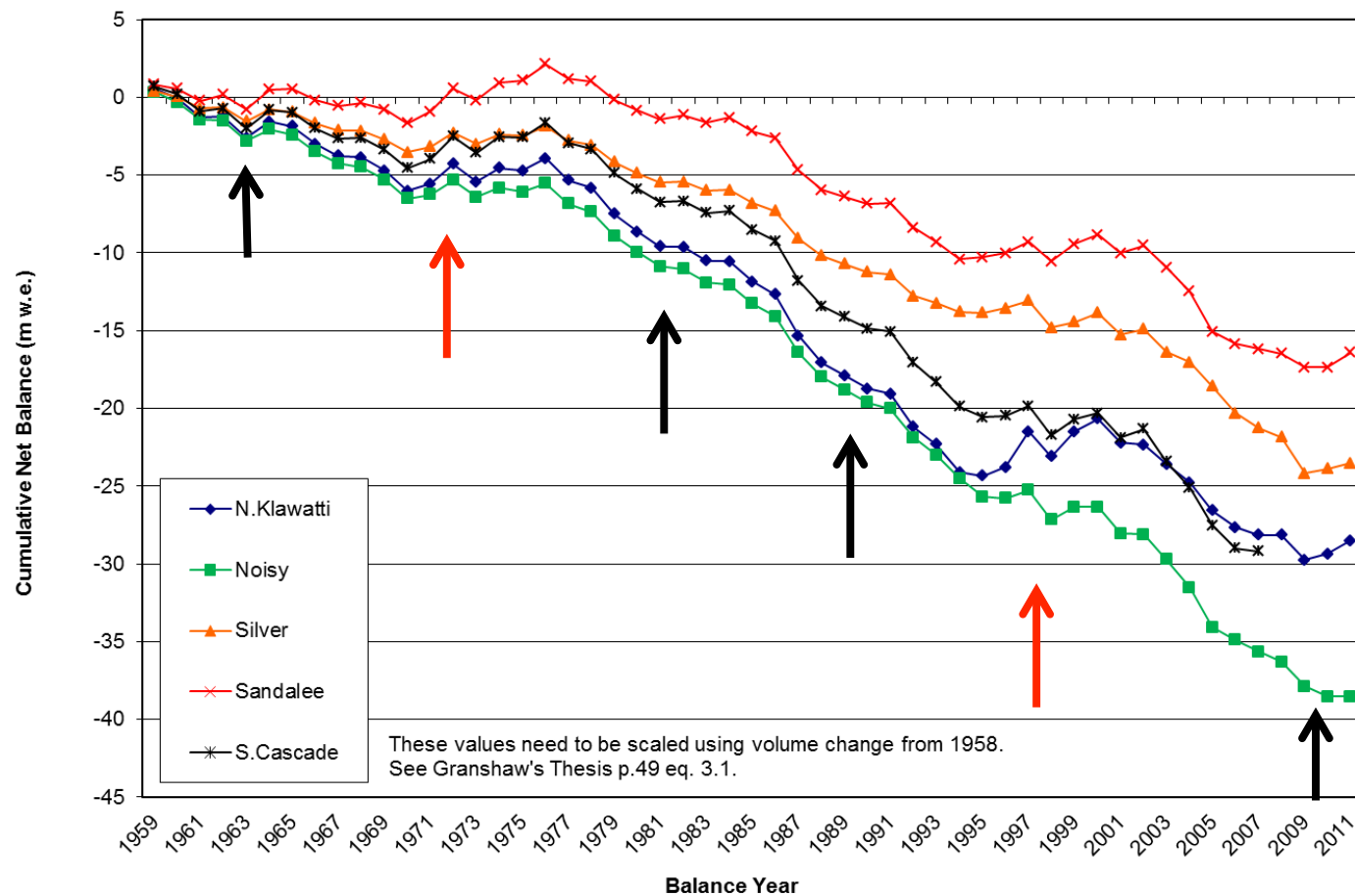


Moraine Record of Holocene Glacier Fluctuations



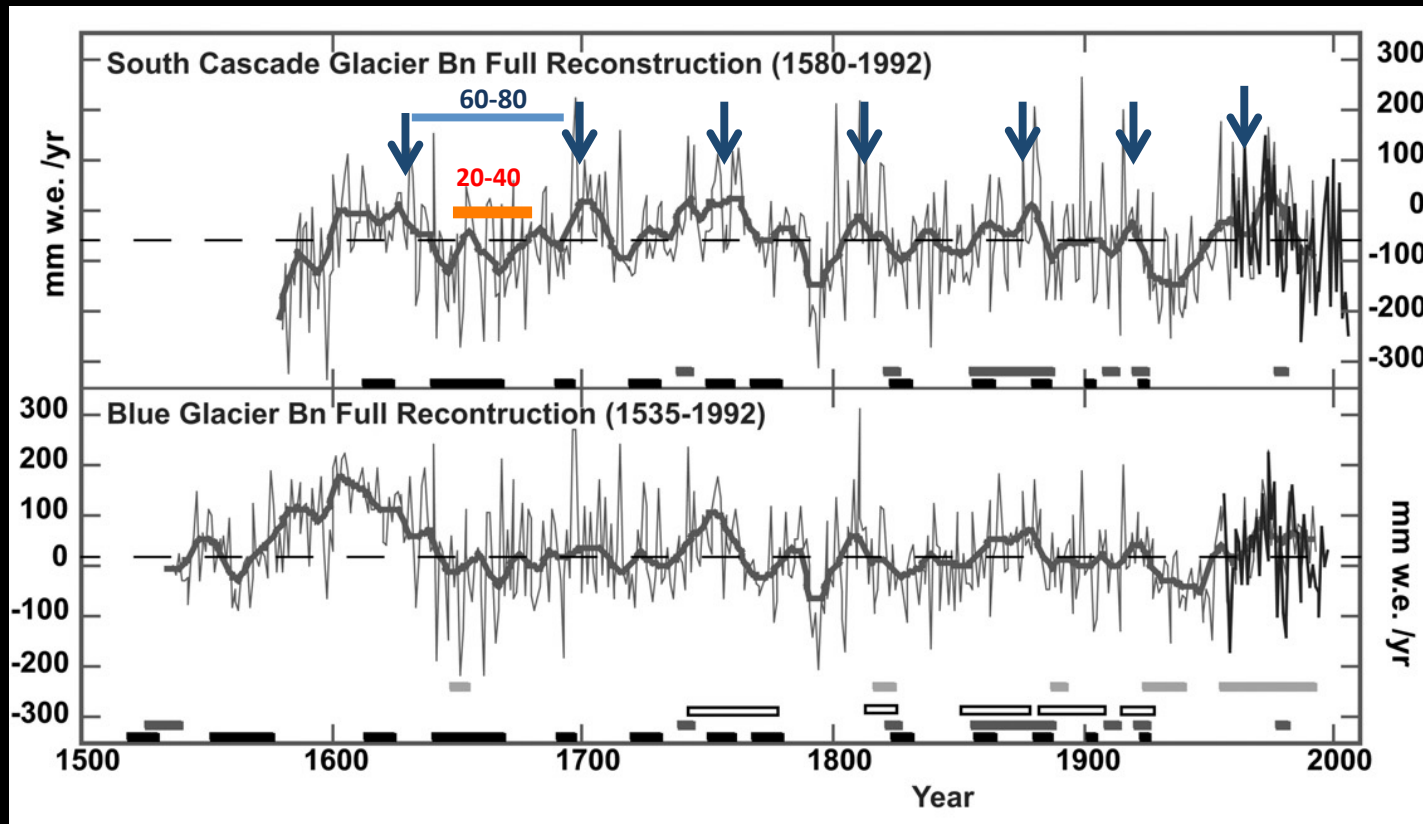
Summary of Glacial History of Climate Change

1. Clear evidence in mass balance data of decadal and multi-decadal punctuated warming;



Summary of Glacial History of Climate Change

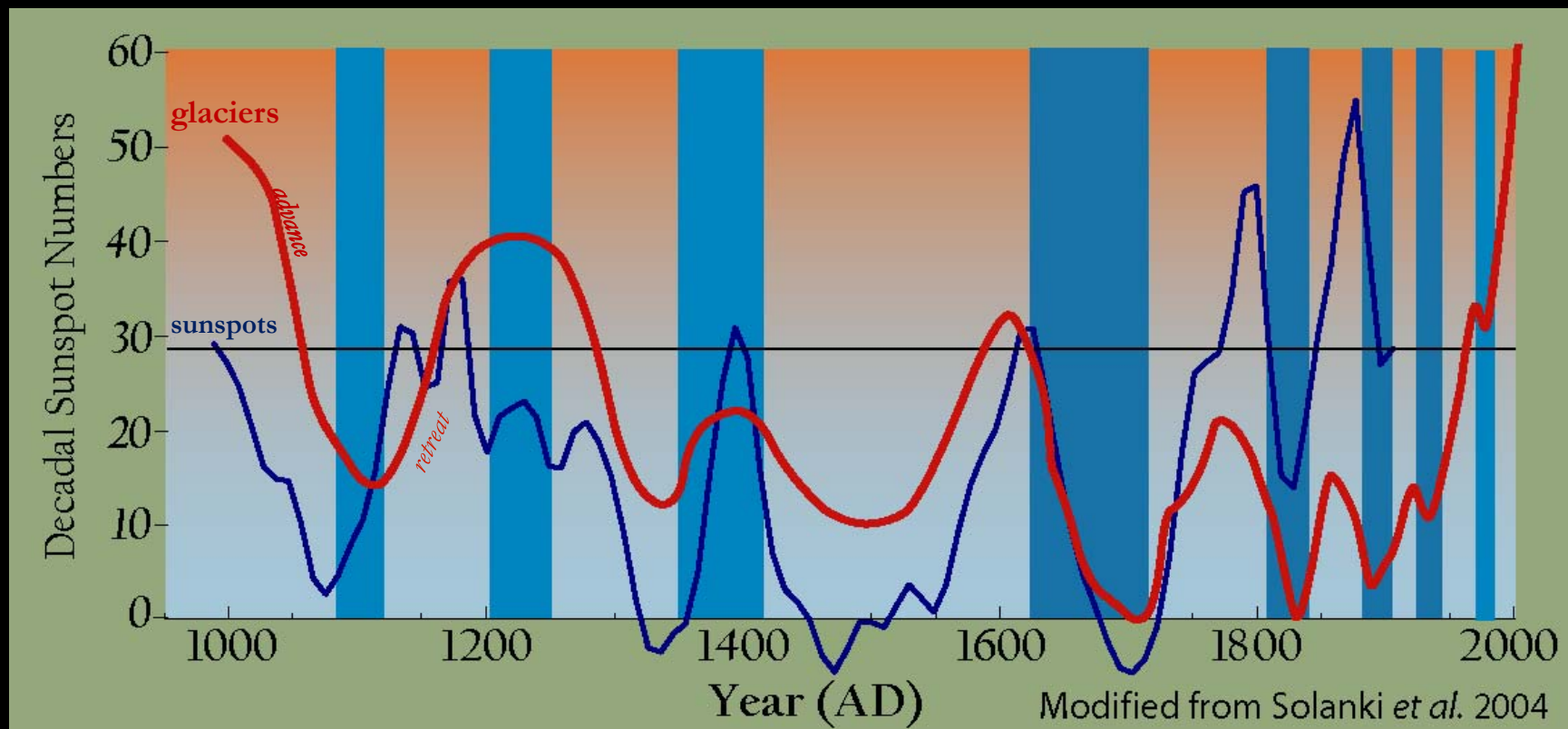
2. Glacier mass balance reconstructions show clear multi-decadal climate cycle (PDO @ 30-40 & 60-80 years);



Malcomb and Wiles, 2013

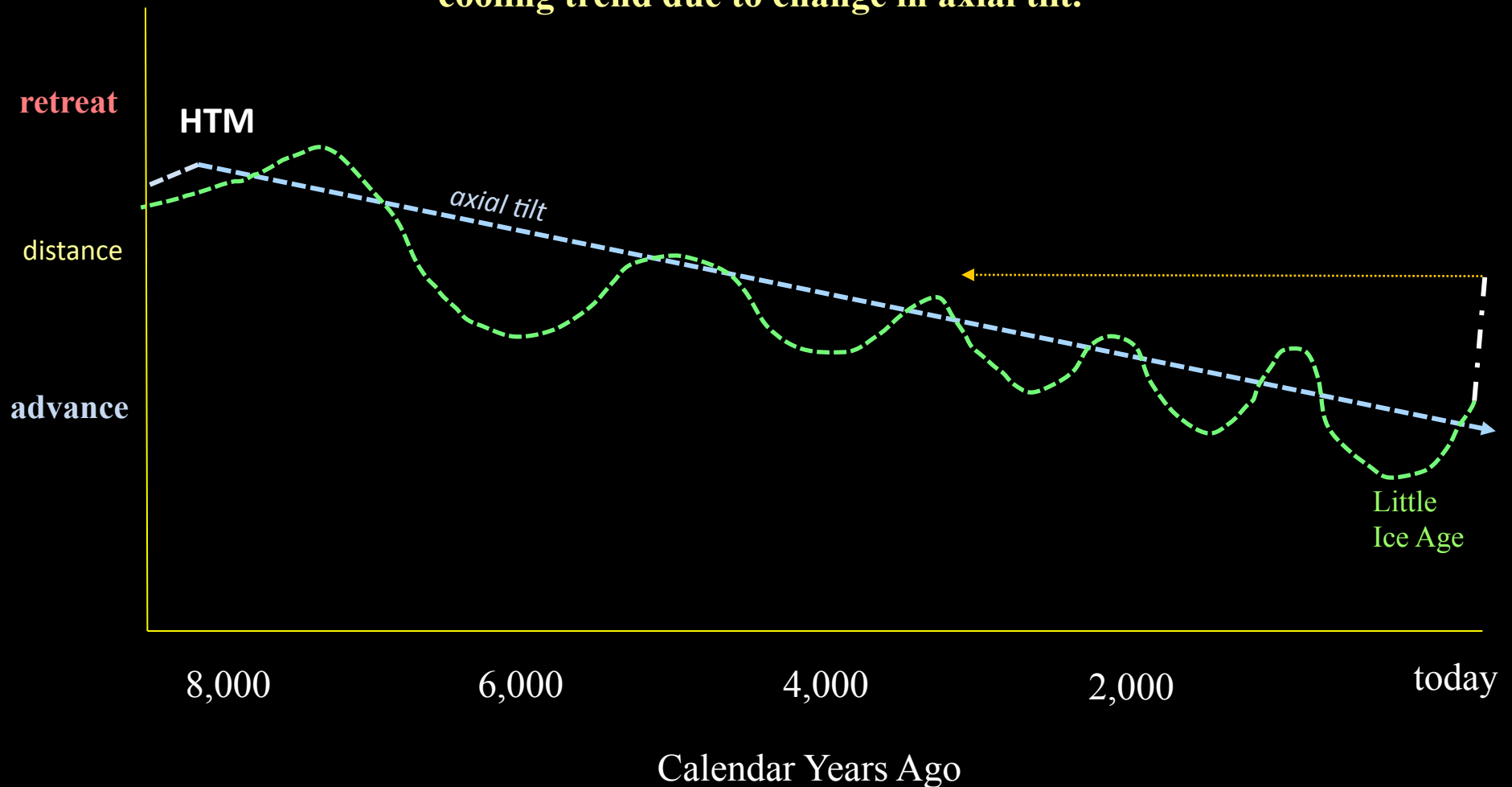
Summary of Glacial History of Climate Change

3. Cyclic changes in the Pacific Ocean at multi-decadal scales do not explain longer term glacial record; need to understand climate forcing at longer time scales; and



Summary of Glacial History of Climate Change

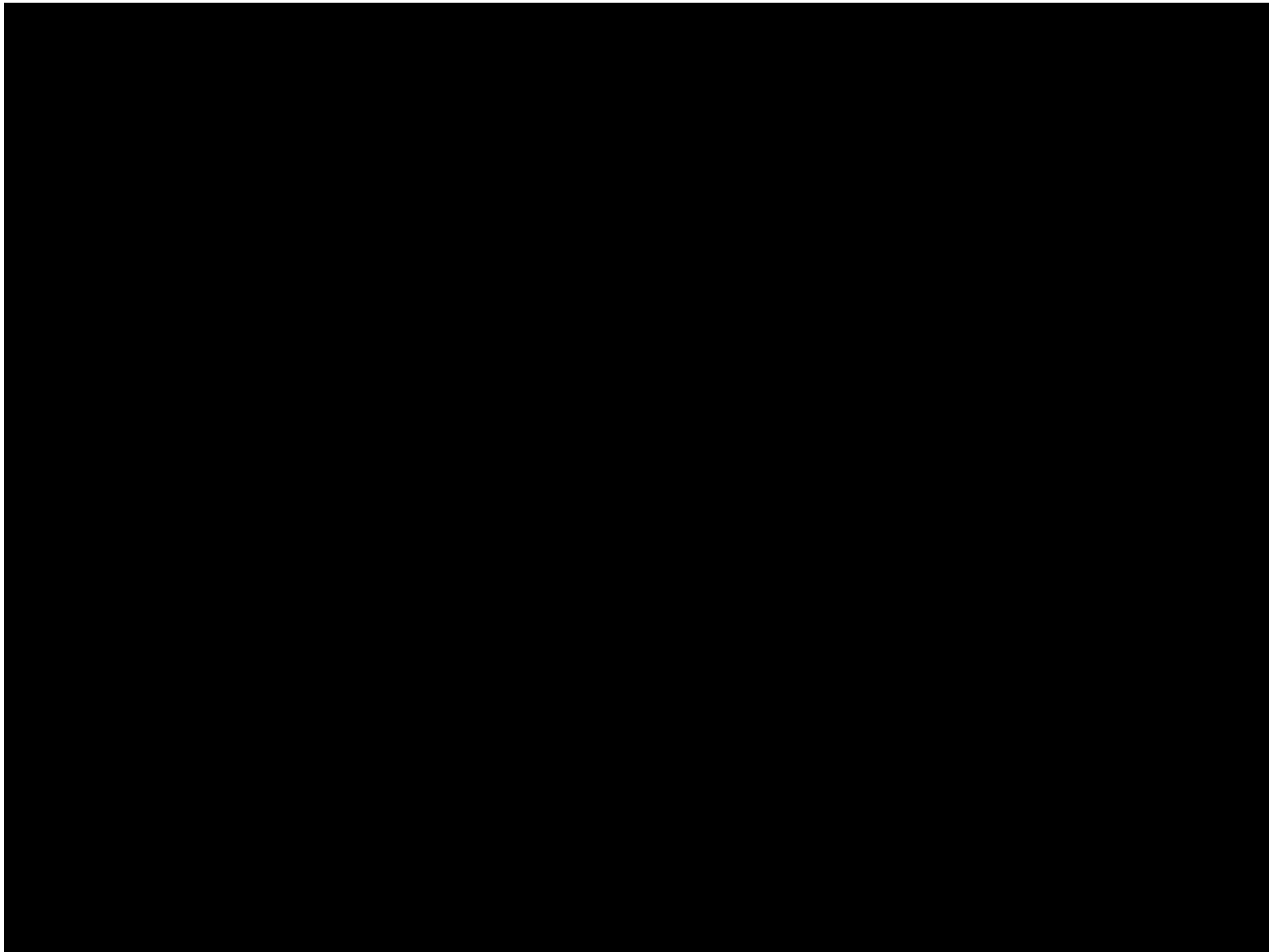
4. Recent rapid glacier recession is uncovering terrain that has not been exposed for thousands of years-opposite a long-term cooling trend due to change in axial tilt.



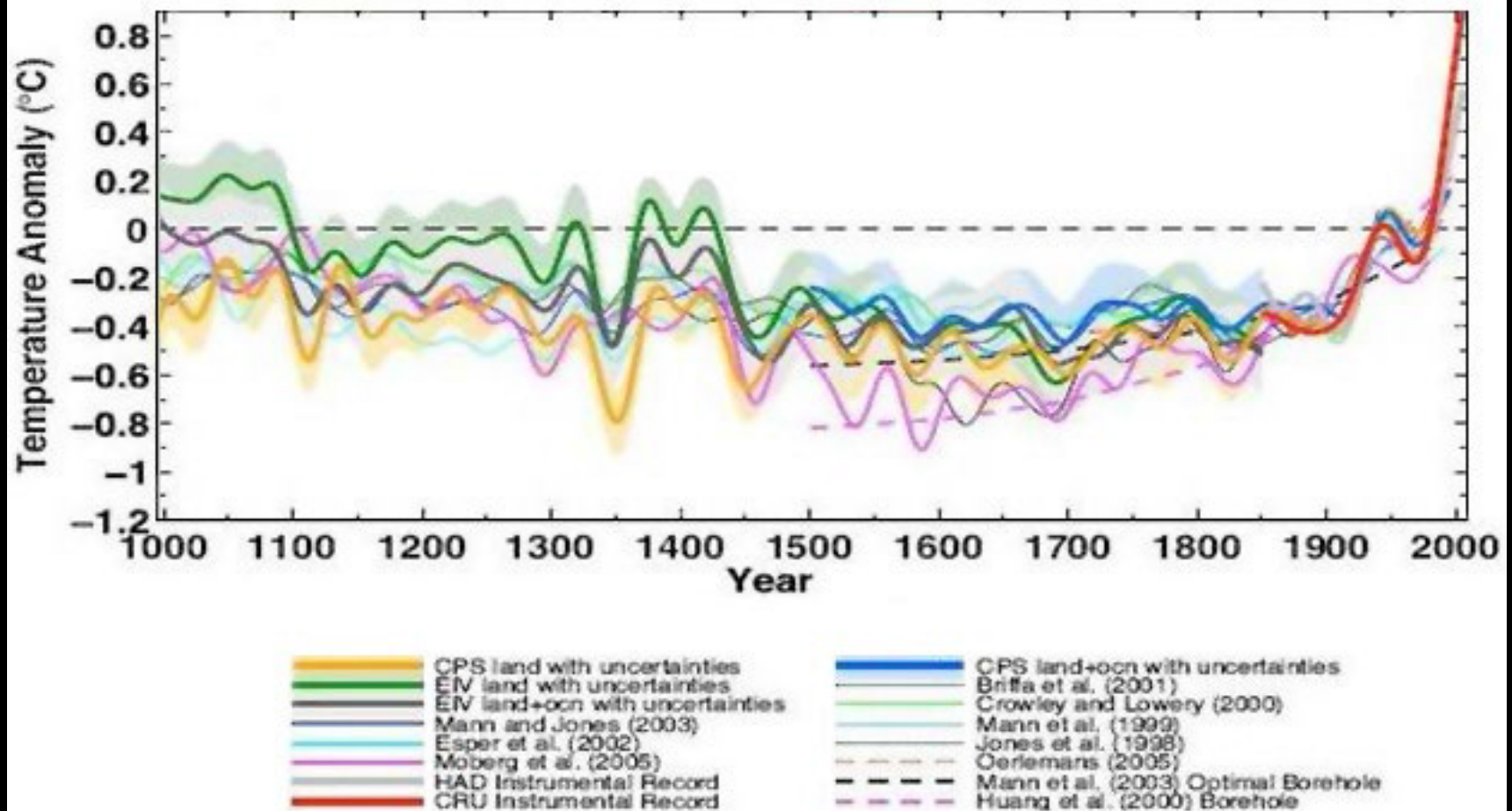
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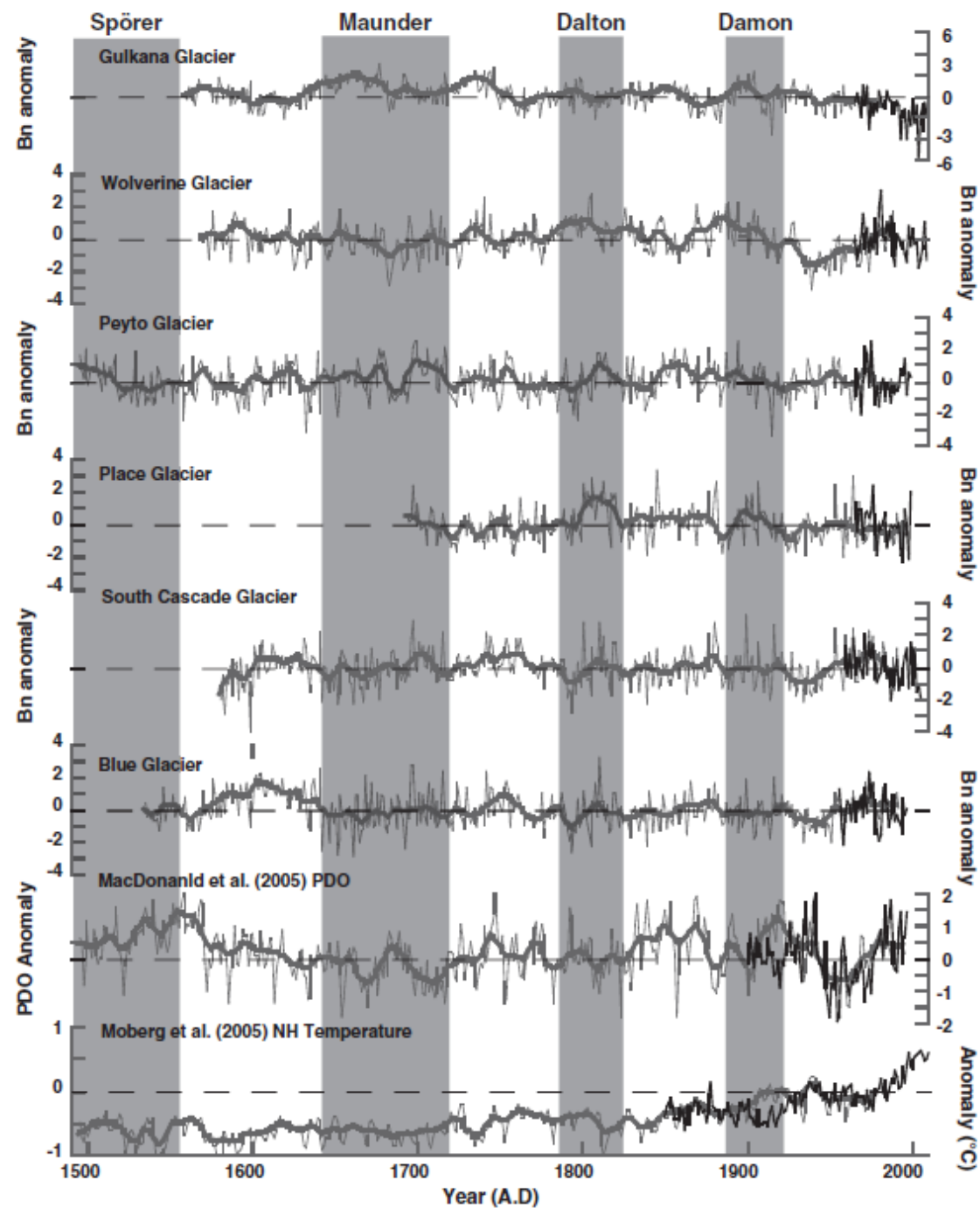
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Northern Hemisphere



Source Mann et al., 2009



Long Term Earth-Sun Relations

