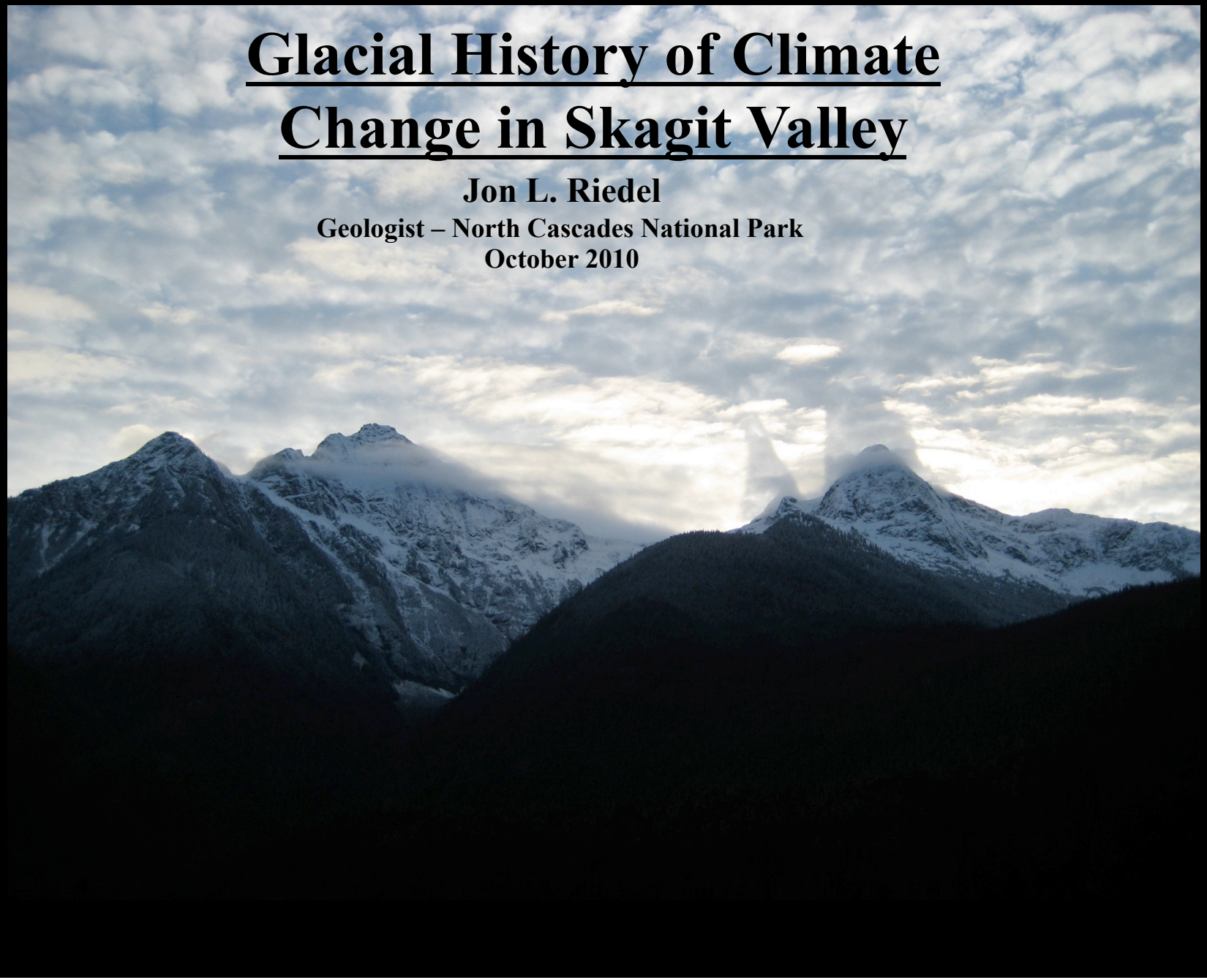
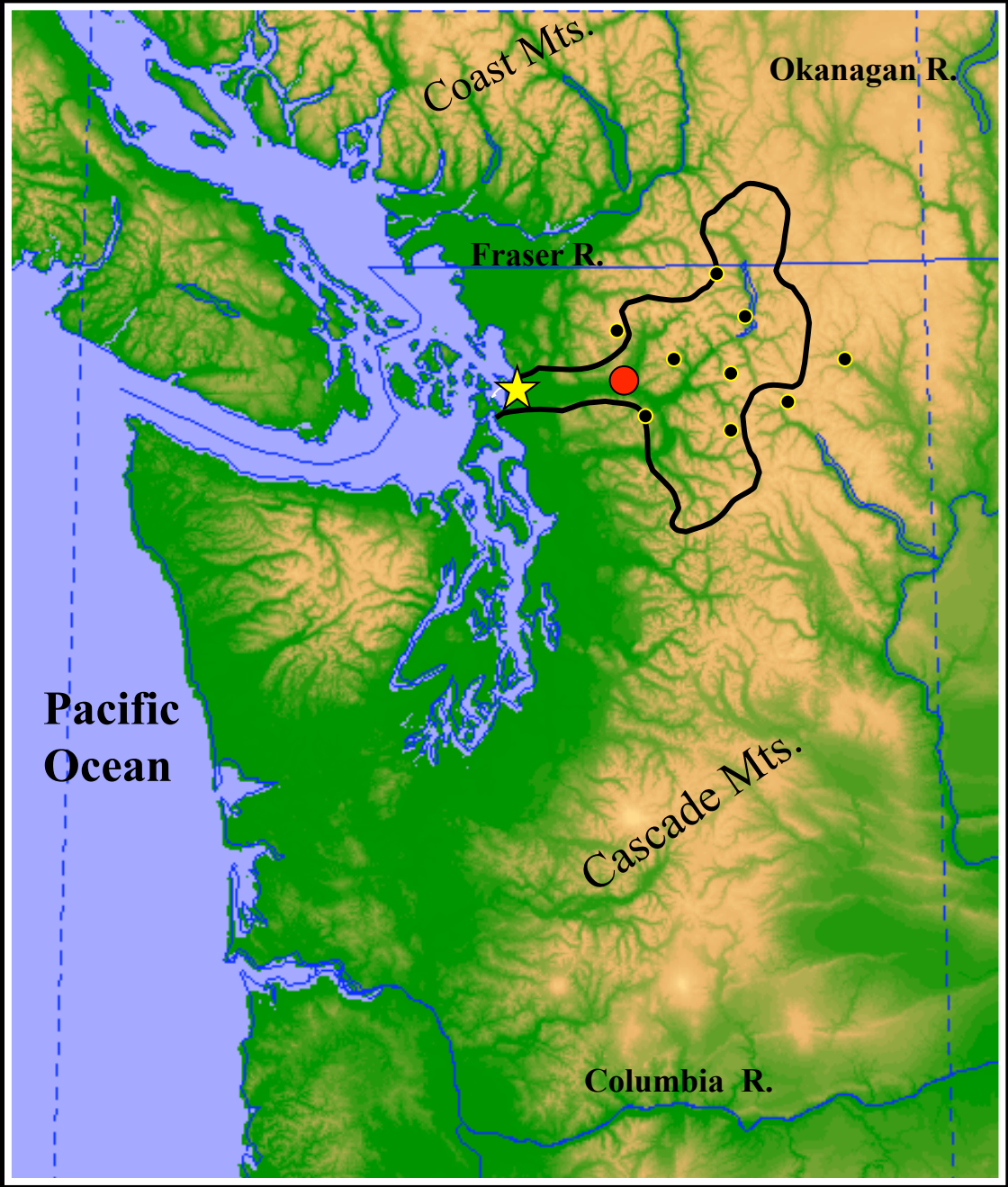
Glacial History of Climate Change in Skagit Valley

Jon L. Riedel
Geologist – North Cascades National Park
October 2010





49⁰

120⁰

Skagit Basin

Part One Outline:

I -Climate v. Weather

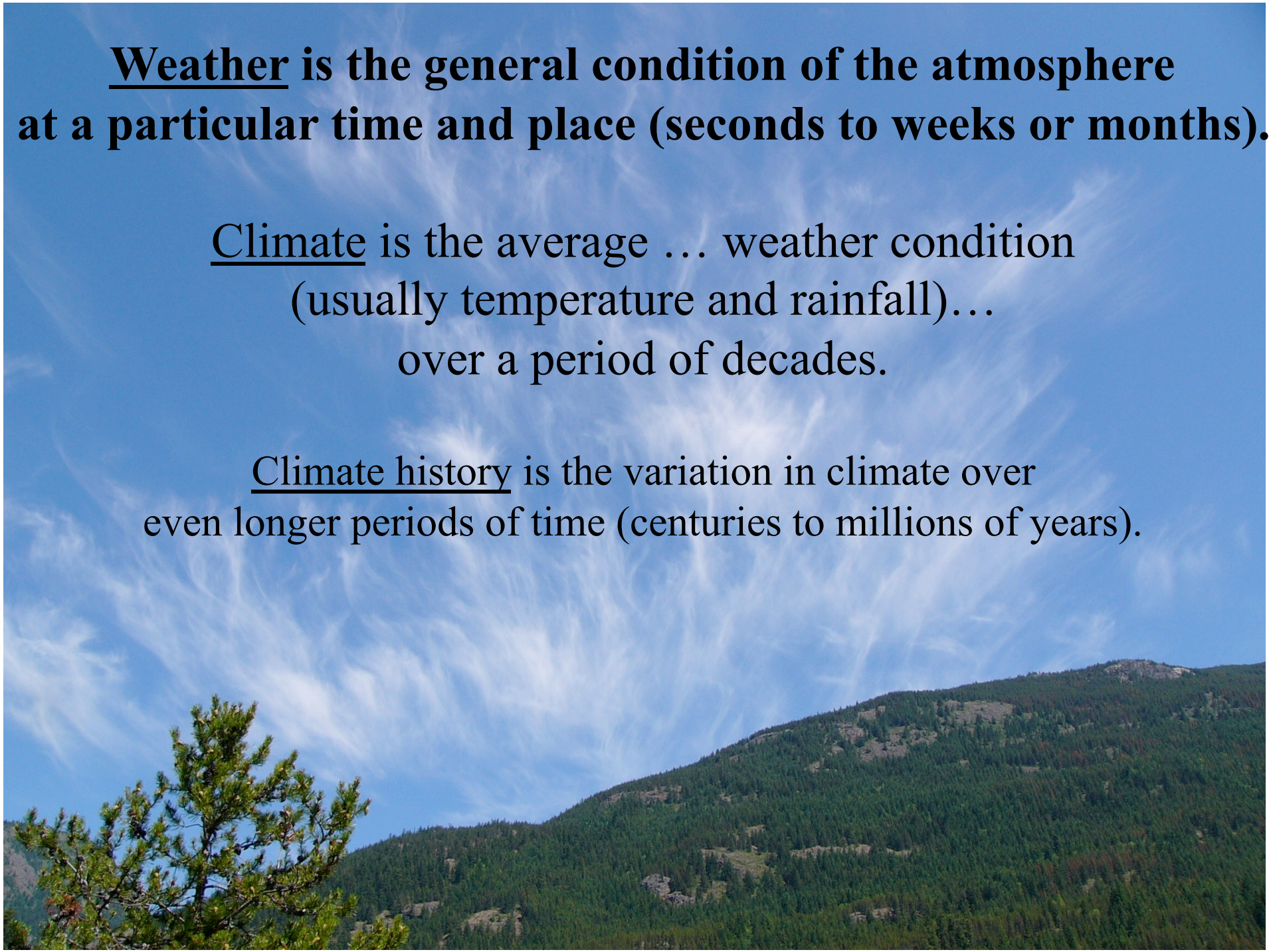
II-Climate of Concrete v. a Glacier

III-Climate Sensitivity

IV- Climate Change

VI- Glaciers

Part Two: Climate History

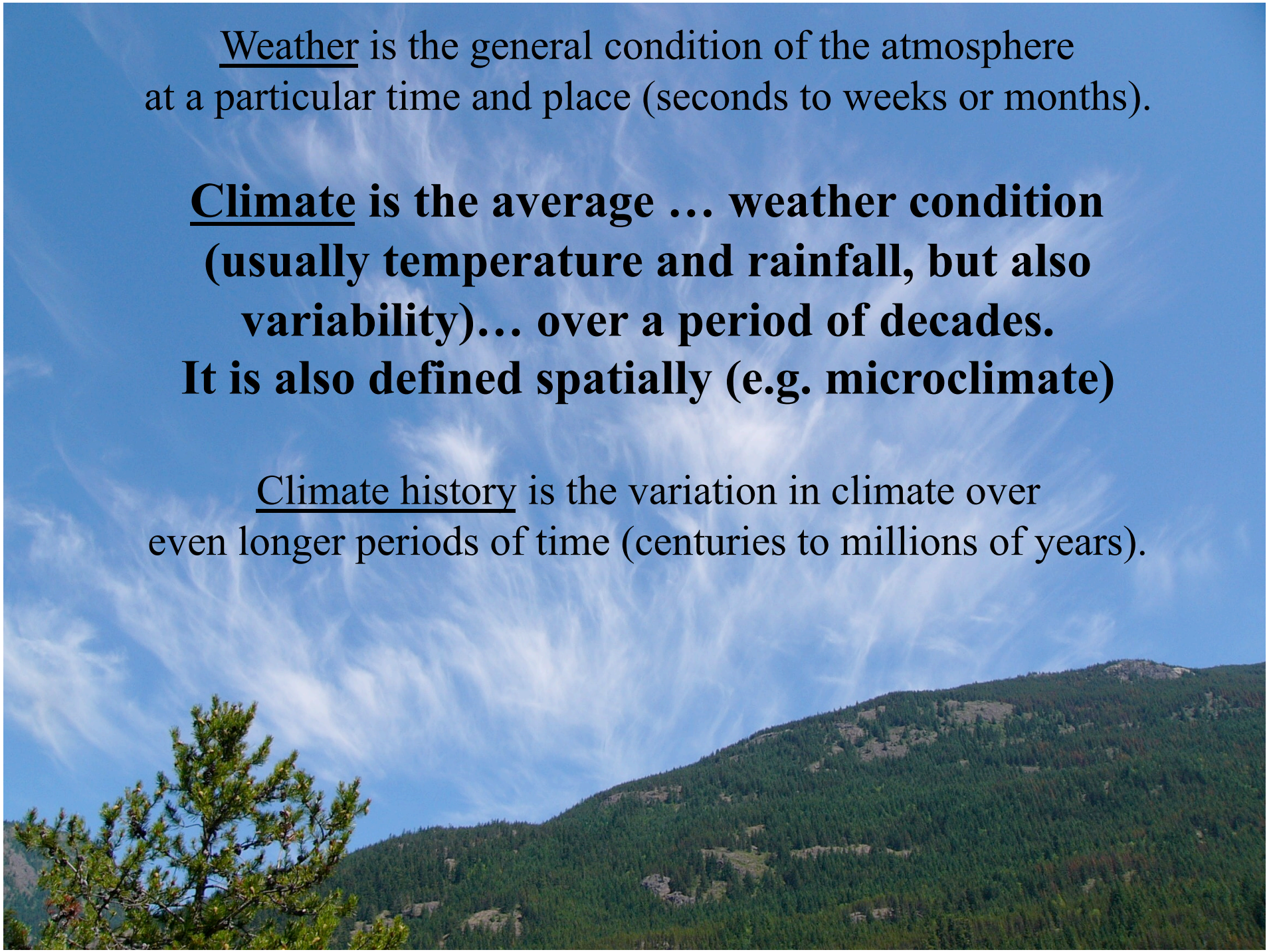


<u>Weather</u> is the general condition of the atmosphere at a particular time and place (seconds to weeks or months).

<u>Climate</u> is the average … weather condition (usually temperature and rainfall)… over a period of decades.

<u>Climate history</u> is the variation in climate over even longer periods of time (centuries to millions of years).

SUDOKU



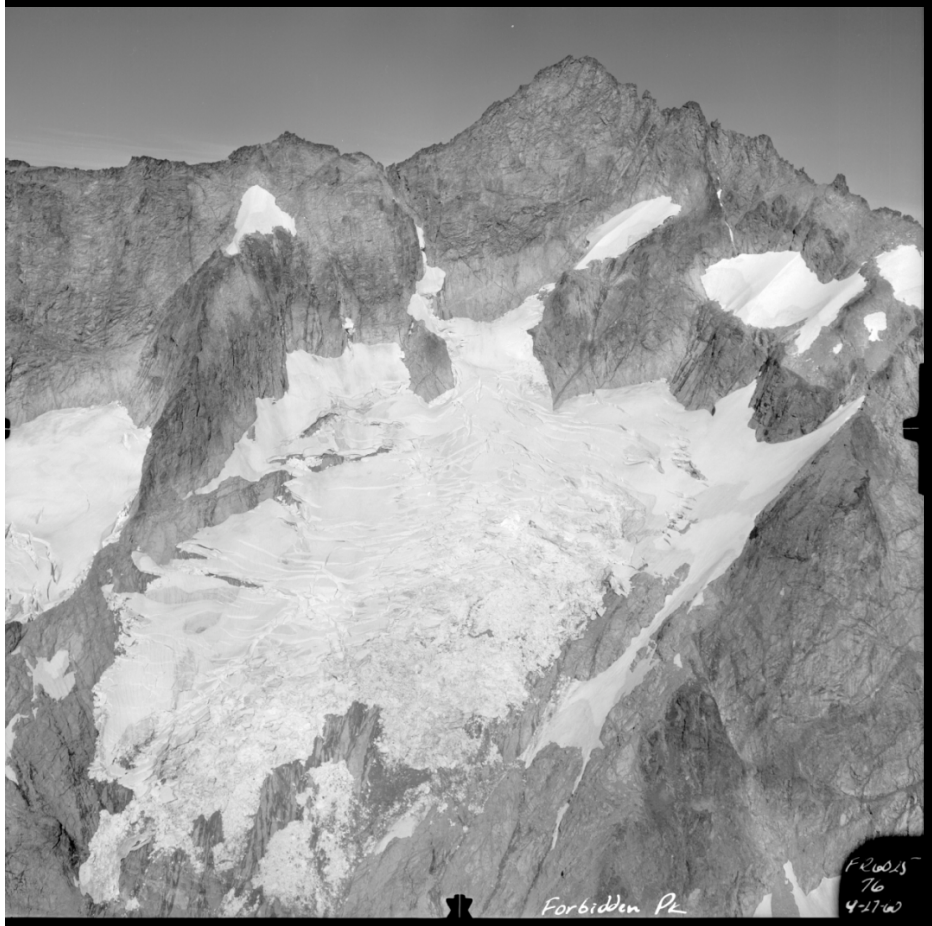
Weather is the general condition of the atmosphere at a particular time and place (seconds to weeks or months).

Climate is the average … weather condition (usually temperature and rainfall, but also variability)… over a period of decades. It is also defined spatially (e.g. microclimate)

Climate history is the variation in climate over even longer periods of time (centuries to millions of years).

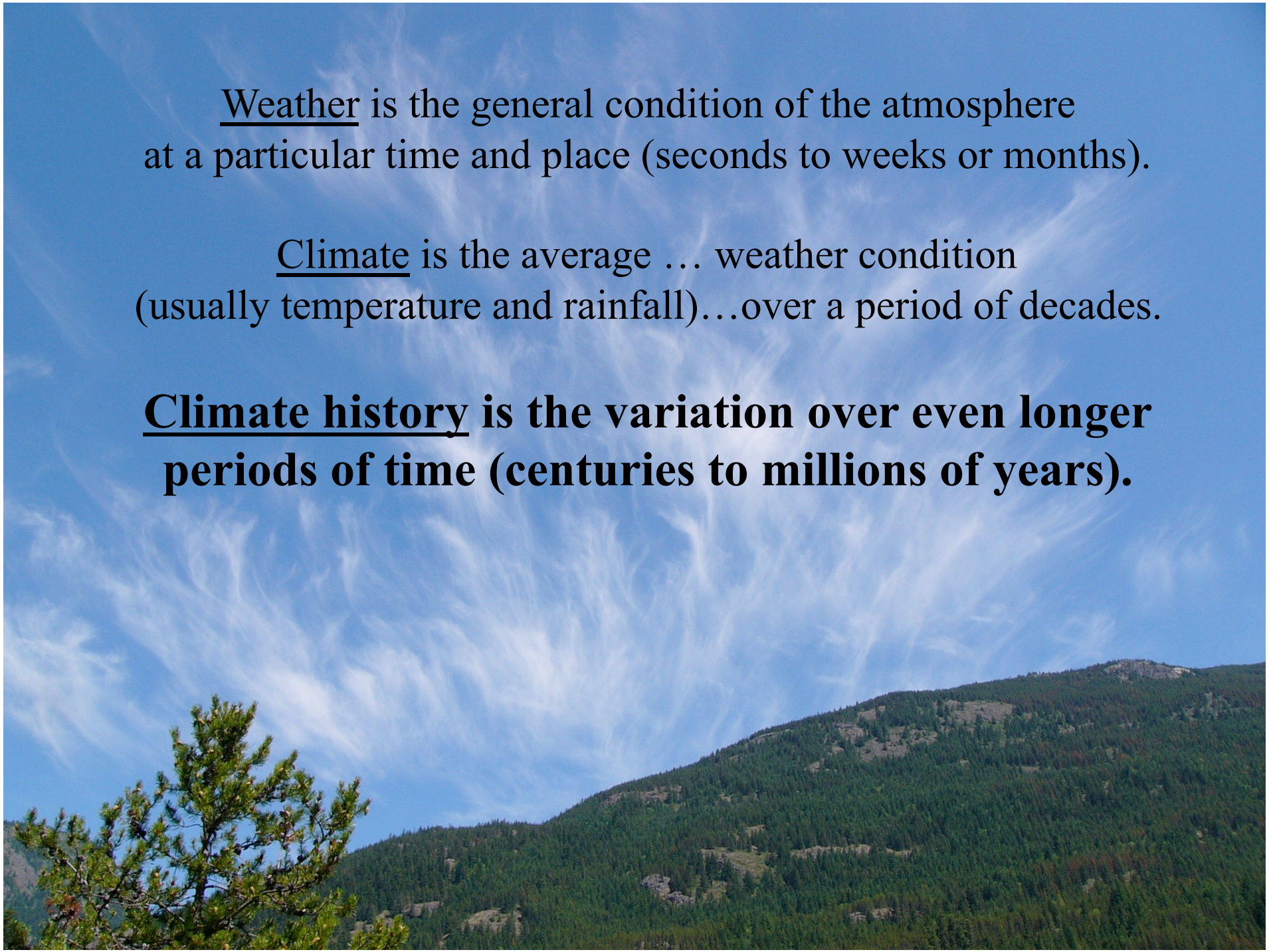
Forbidden Peak

9-27-1960 Austin Post



9-21-2005 John Scurlock

Looking west down Skagit Gorge, a path that climate change cut through the crystalline core of the North Cascades (photo by Scurlock).



Weather is the general condition of the atmosphere at a particular time and place (seconds to weeks or months).

Climate is the average … weather condition (usually temperature and rainfall)…over a period of decades.

Climate history is the variation over even longer periods of time (centuries to millions of years).

Later I will present geologic evidence from ancient lakes and glaciers of climate change during the past 30,000 years.

Part One Outline:

I -Climate v. Weather

II-Climate of Concrete

III-Climate Sensitivity

IV-Climate Change

VI- Glaciers

Part Two: Climate History

Climate of Concrete, Washington (elevation 300 ft.)

Average annual temperature 50.9 ˚F (10 °C)

Annual temperature range 0 to102 ˚F

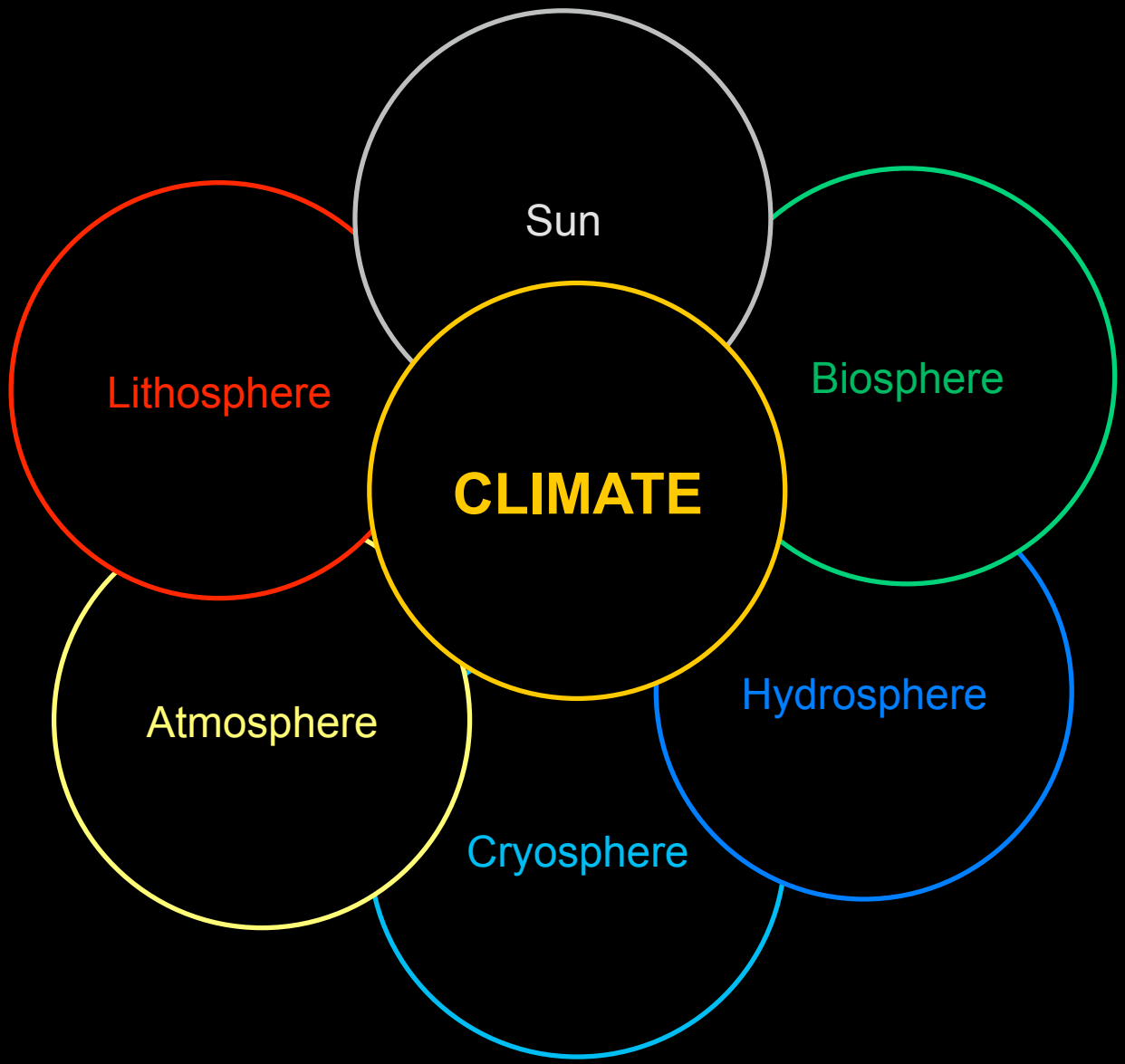
Average annual precipitation 68” (24” snow)

Climate of Noisy Glacier, Washington (elevation 5700 ft)

Average annual temperature ~32˚F (0 °C)

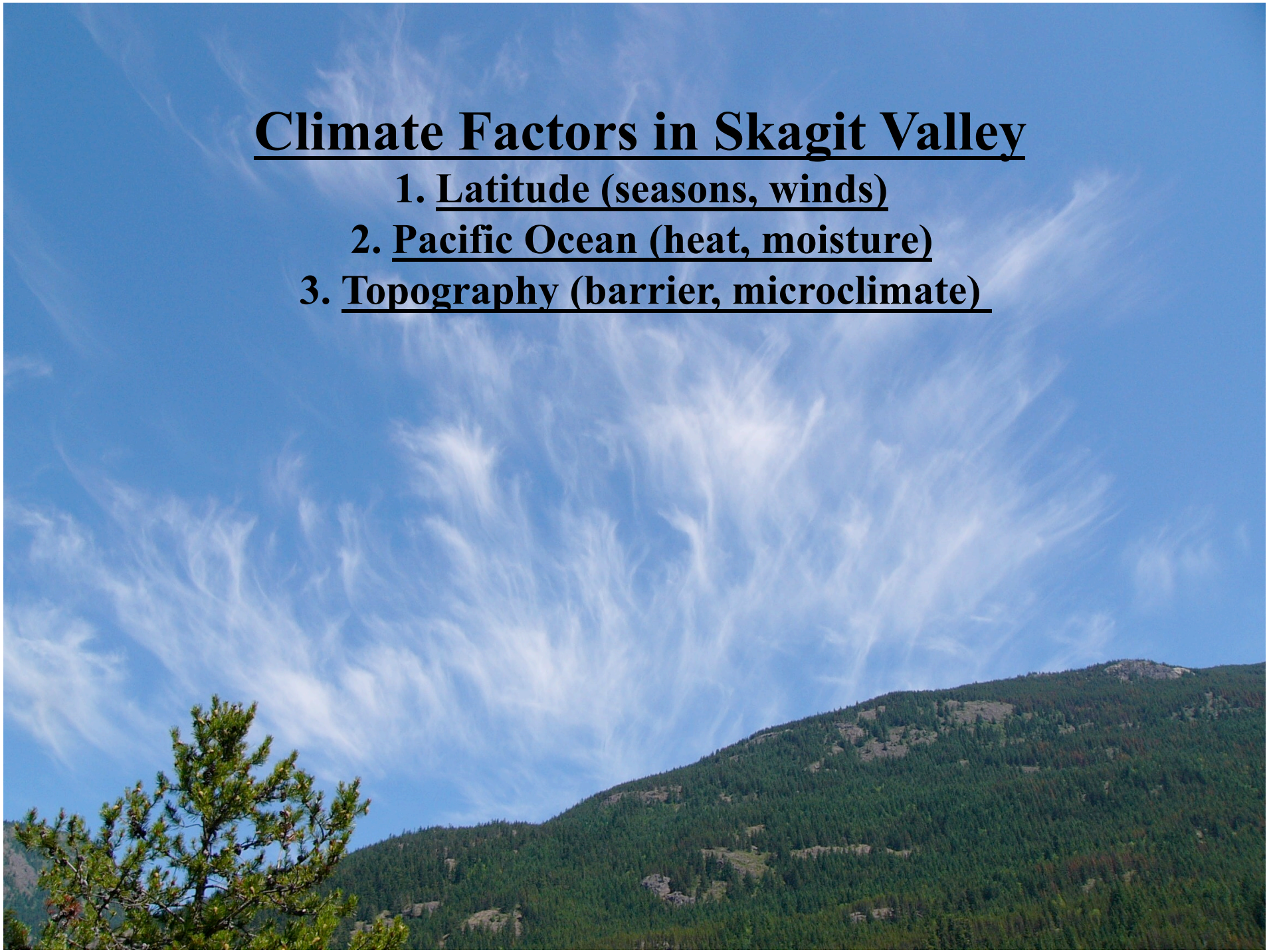
Annual temperature range ?

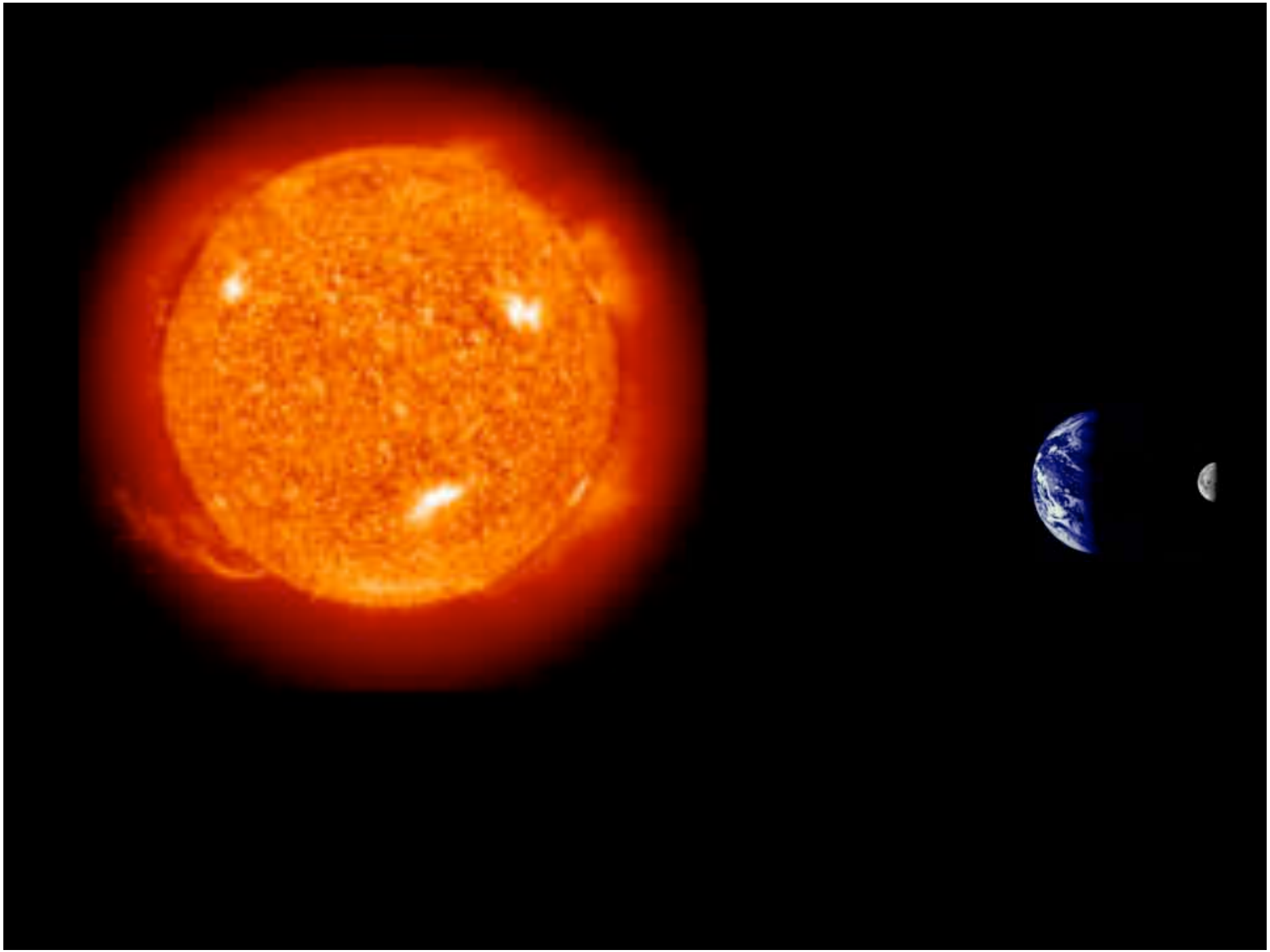
Average annual precipitation 120” (20-30 ft snow)


Sun
Lithosphere
Biosphere
CLIMATE
Atmosphere
Hydrosphere
Cryosphere

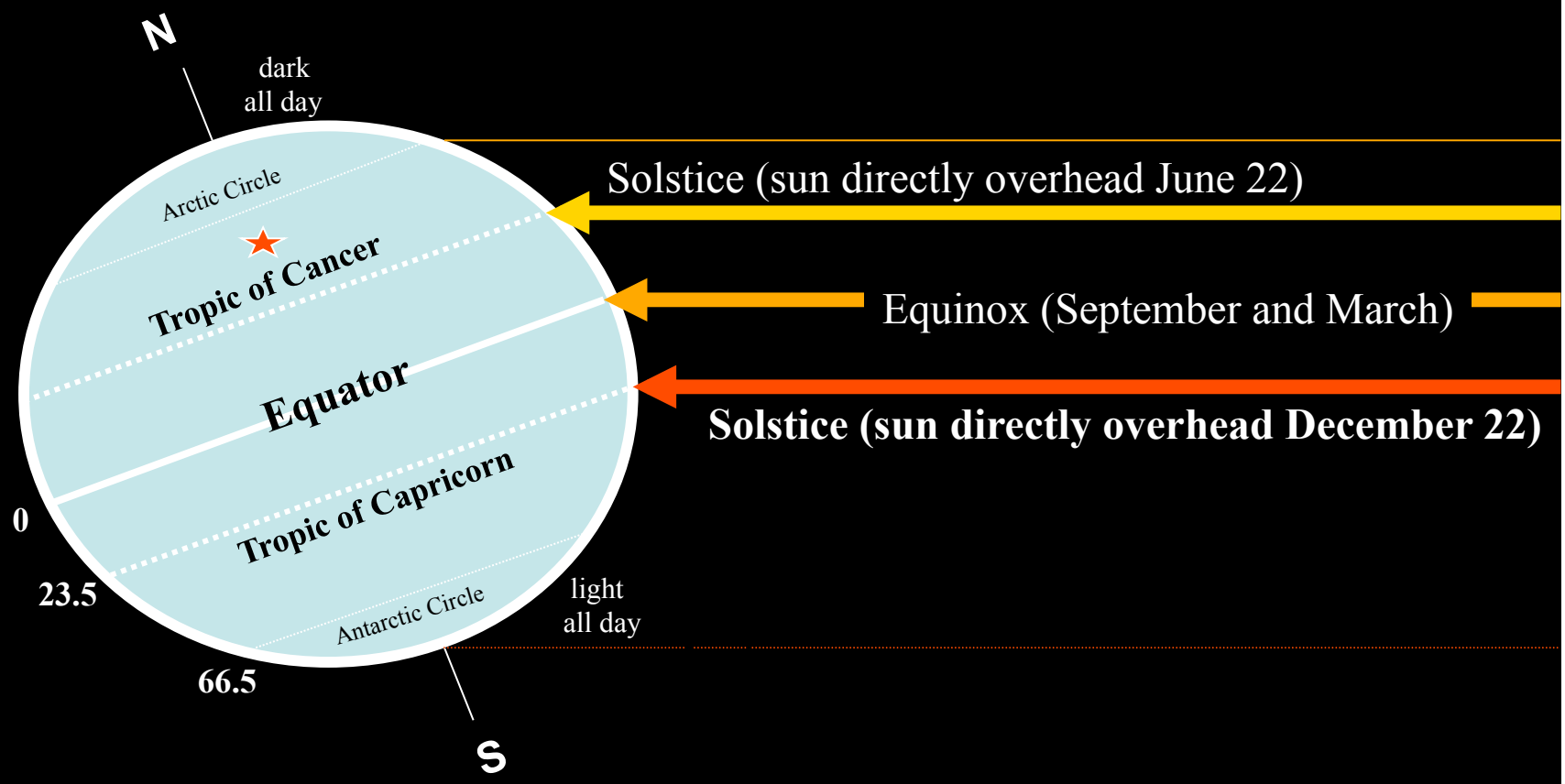
Climate Factors in Skagit Valley

1. Latitude (seasons, winds)
2. Pacific Ocean (heat, moisture)
3. Topography (barrier, microclimate)



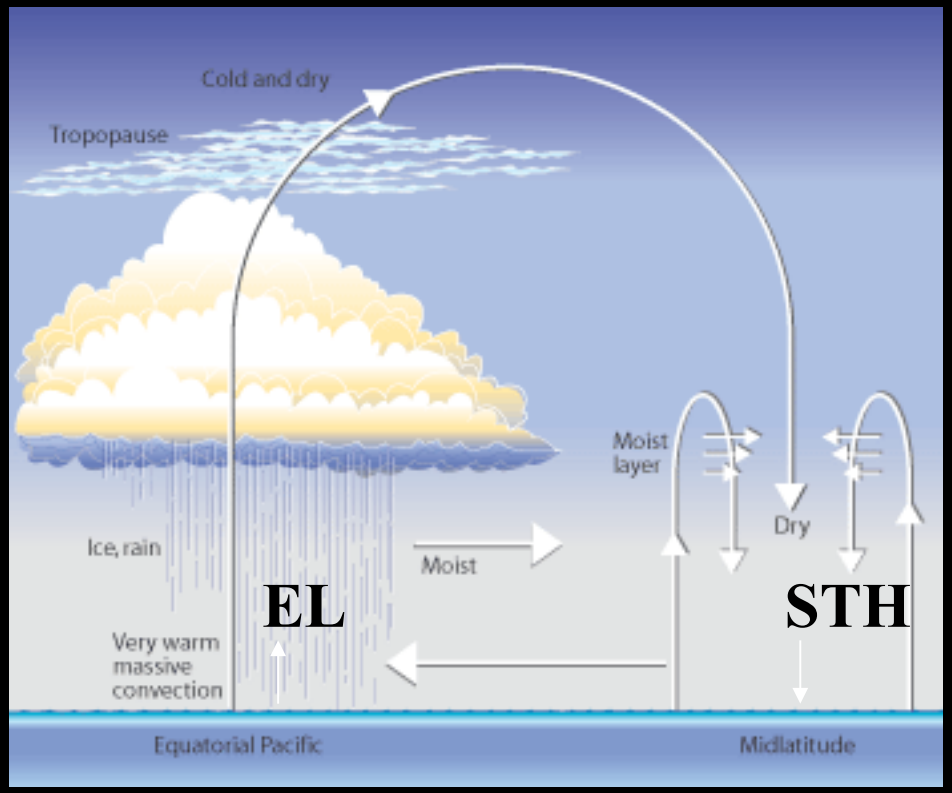


Northern Winter Solstice

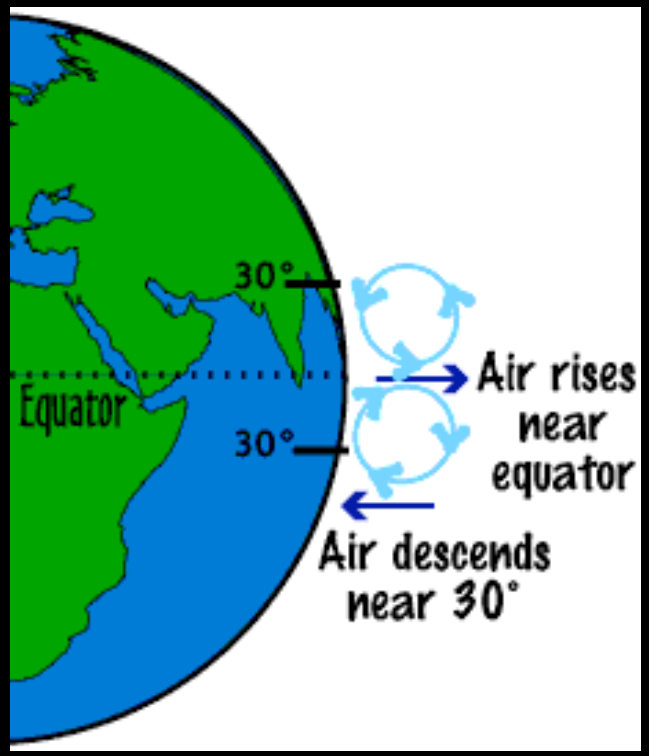


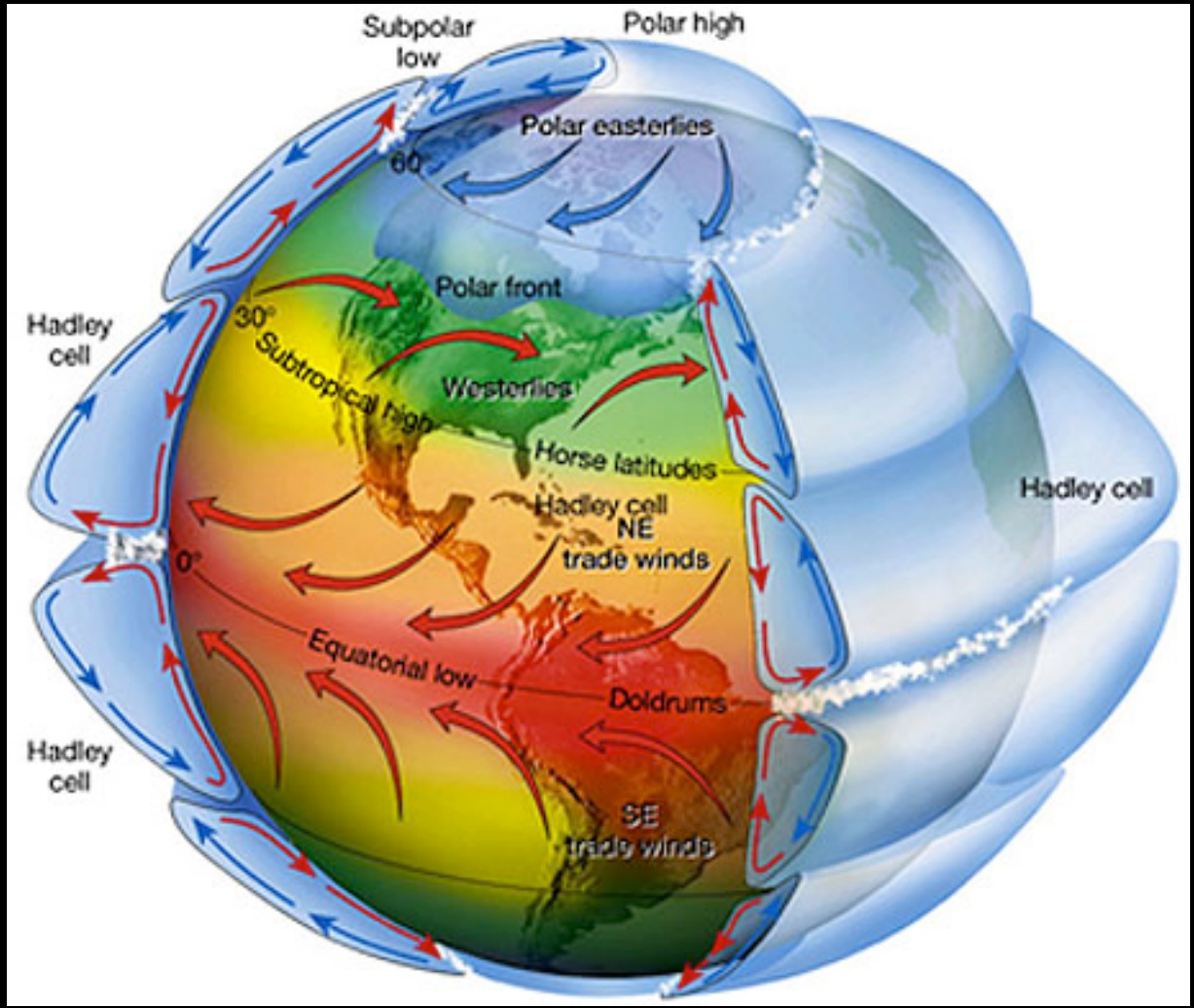
Hadley Circulation

-drives westerly winds(jet stream)

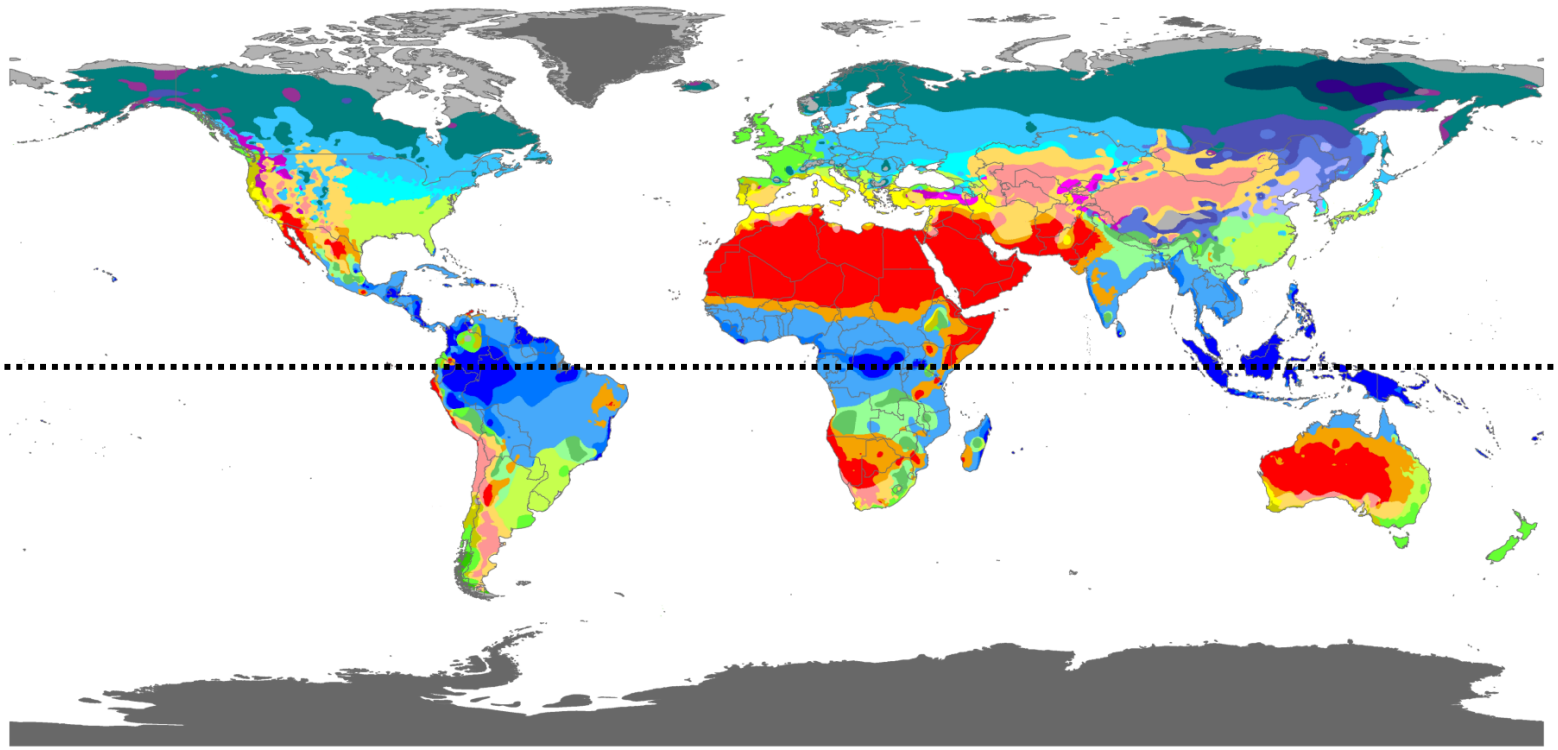


North-south transect




Subpolar low
Polar high
Polar easterlies
60°
Polar front
Hadley cell
30°
Subtropical high
Westerlies
Horse latitudes
Hadley cell
NE trade winds
Hadley cell
0°
Equatorial low
Doldrums
Hadley cell
SE trade winds

World map of Köppen-Geiger climate classification



Af	BWh	Csa	Cwa	Cfa	Dsa	Dwa	Dfa	ET
Am	BWk	Csb	Cwb	Cfb	Dsb	Dwb	Dfb	EF
Aw	BSh		Cwc	Cfc	Dsc	Dwc	Dfc	
	BSk				Dsd	Dwd	Dfd	

THE UNIVERSITY OF MELBOURNE

Contact : Murray C. Peel (mpeel@unimelb.edu.au) for further information

DATA SOURCE : GHCN v2.0 station data
Temperature (N = 4,844) and
Precipitation (N = 12,396)

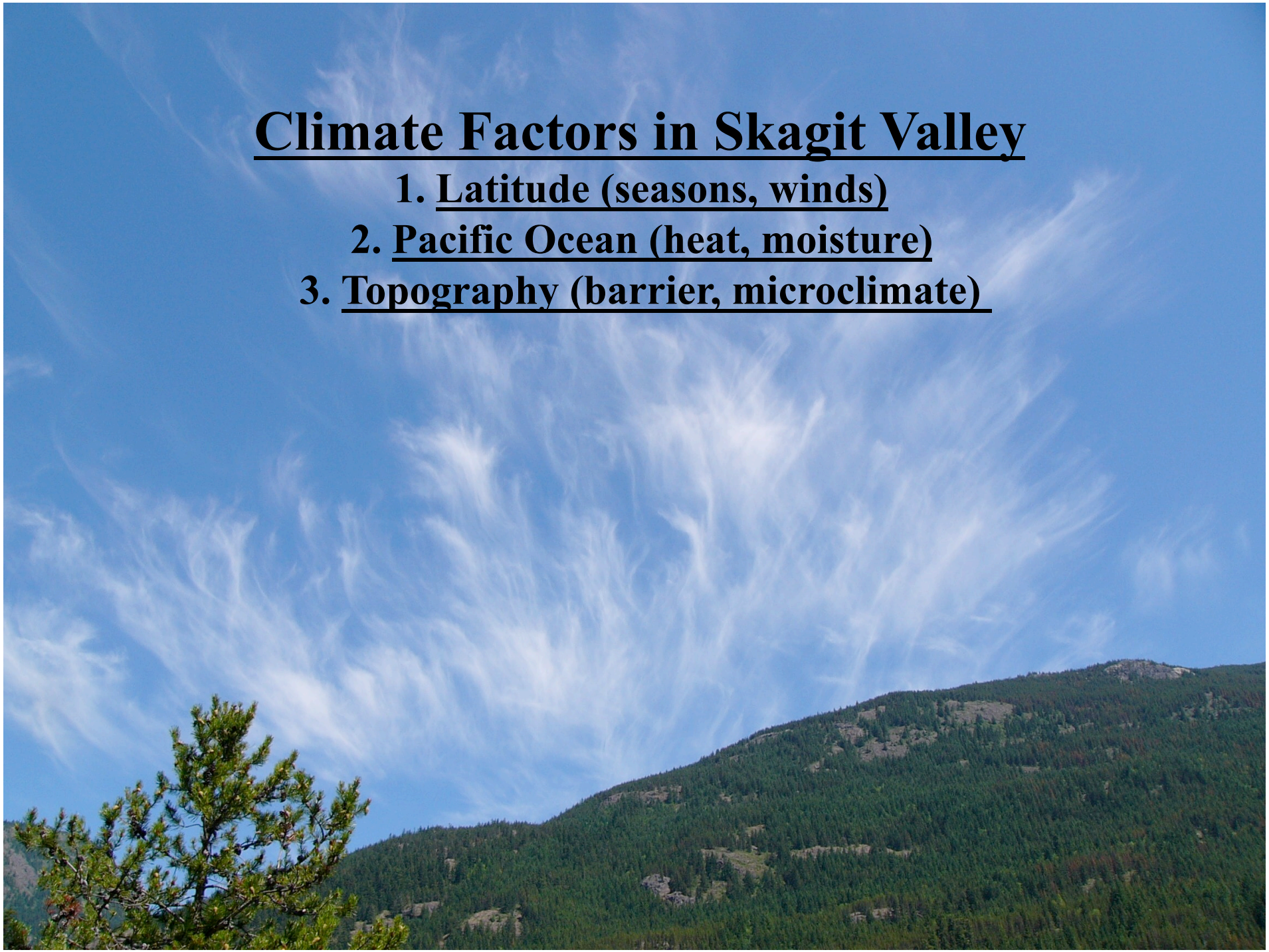
PERIOD OF RECORD : All available

MIN LENGTH : ≥30 for each month.

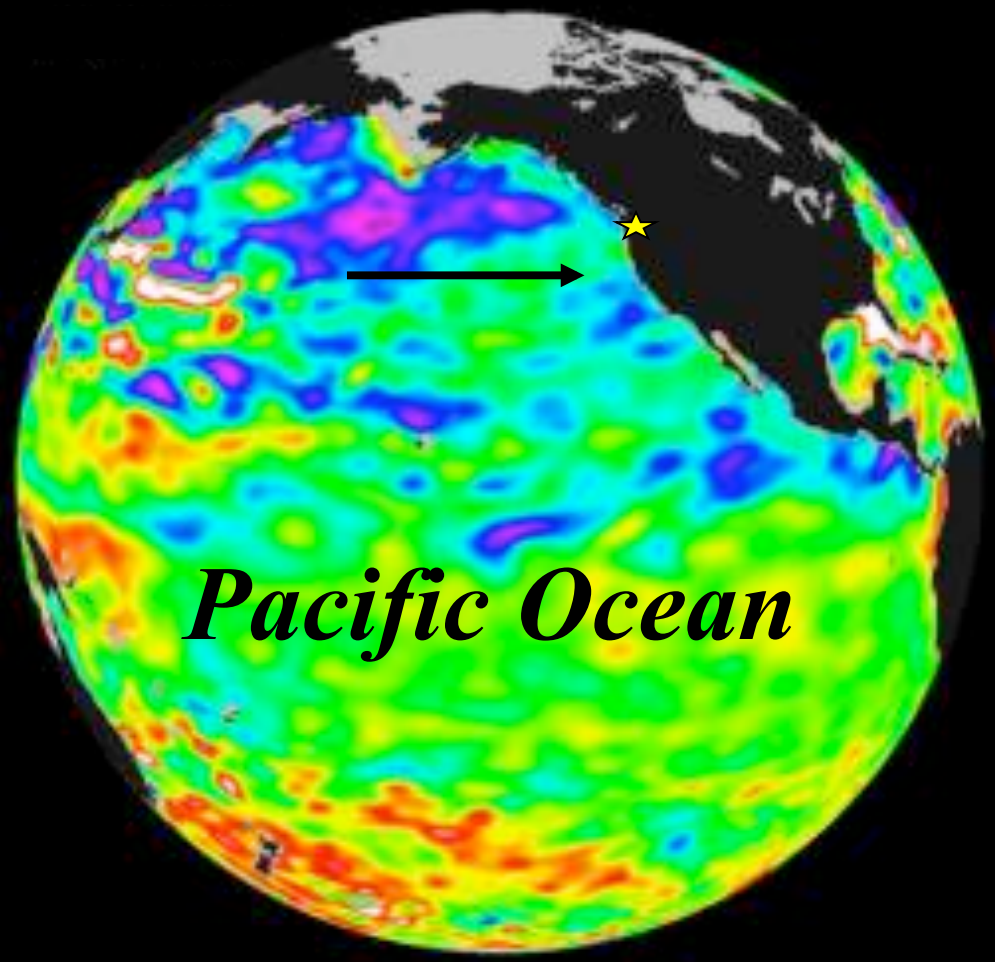
RESOLUTION : 0.1 degree lat/long

Climate Factors in Skagit Valley

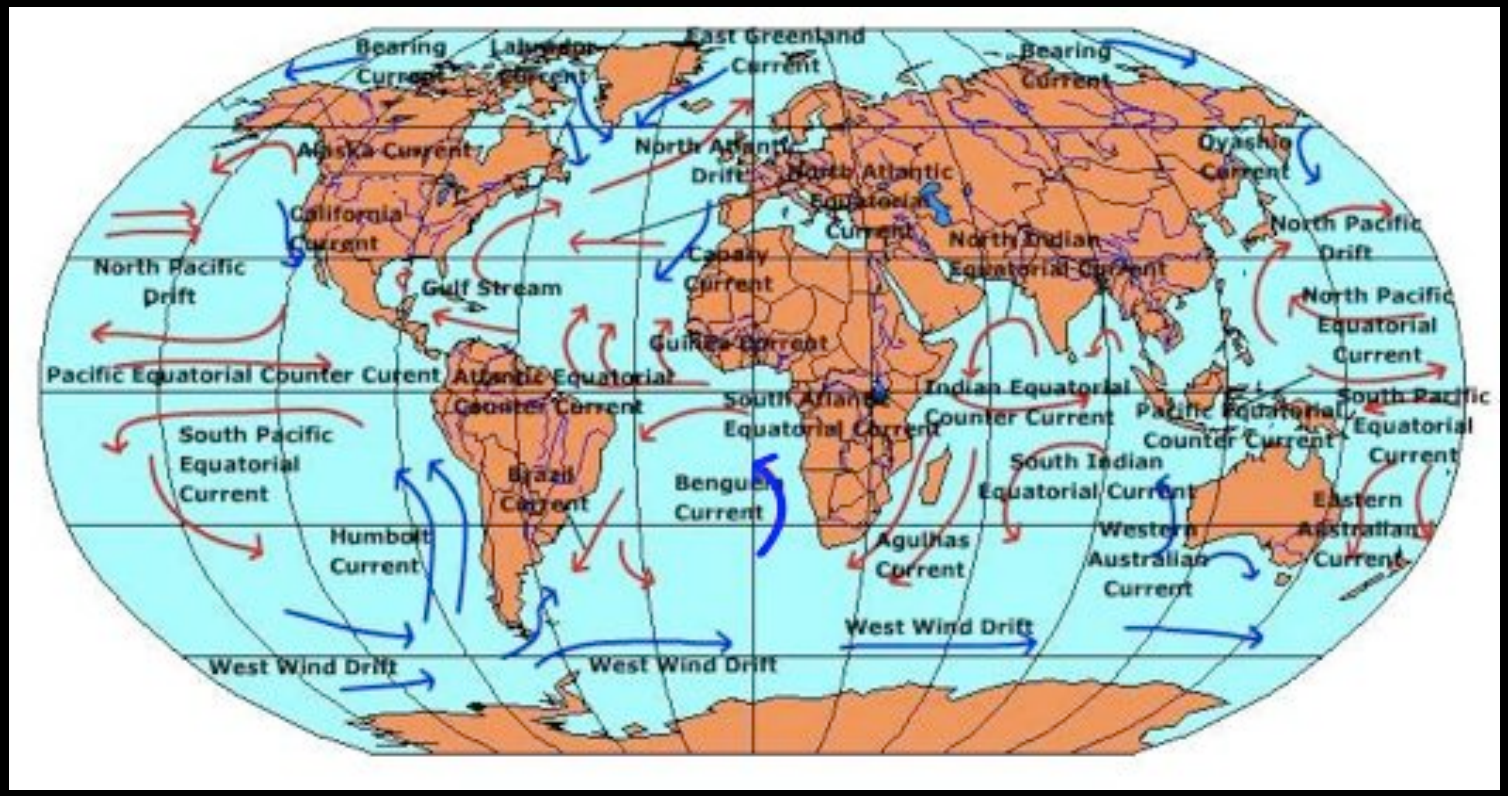
1. Latitude (seasons, winds)
2. Pacific Ocean (heat, moisture)
3. Topography (barrier, microclimate)



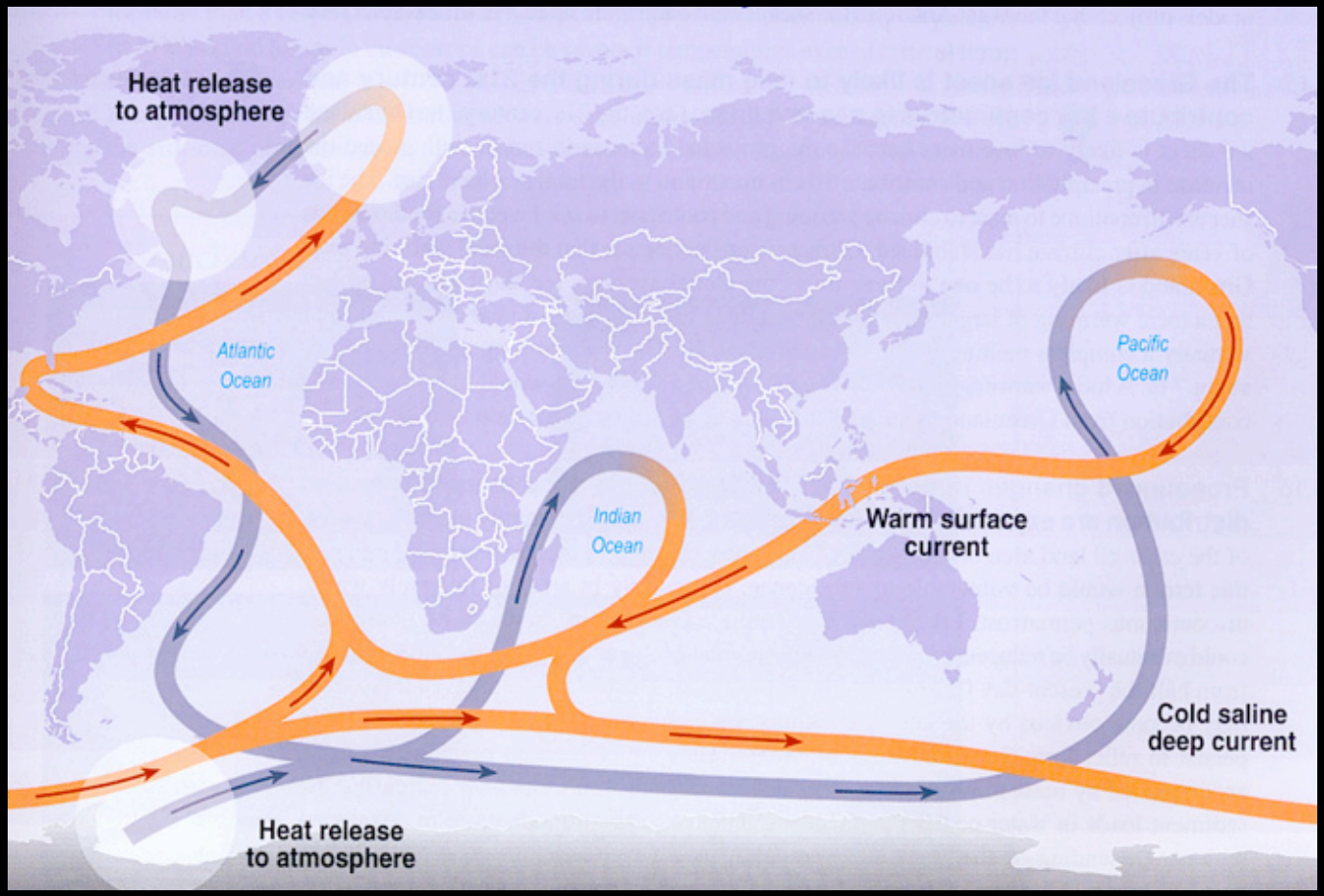
The Pacific Ocean integrates, amplifies, and remembers.



Ocean currents redistribute warm water from the equator to cold polar regions (red), and cold water from polar to tropics (blue).

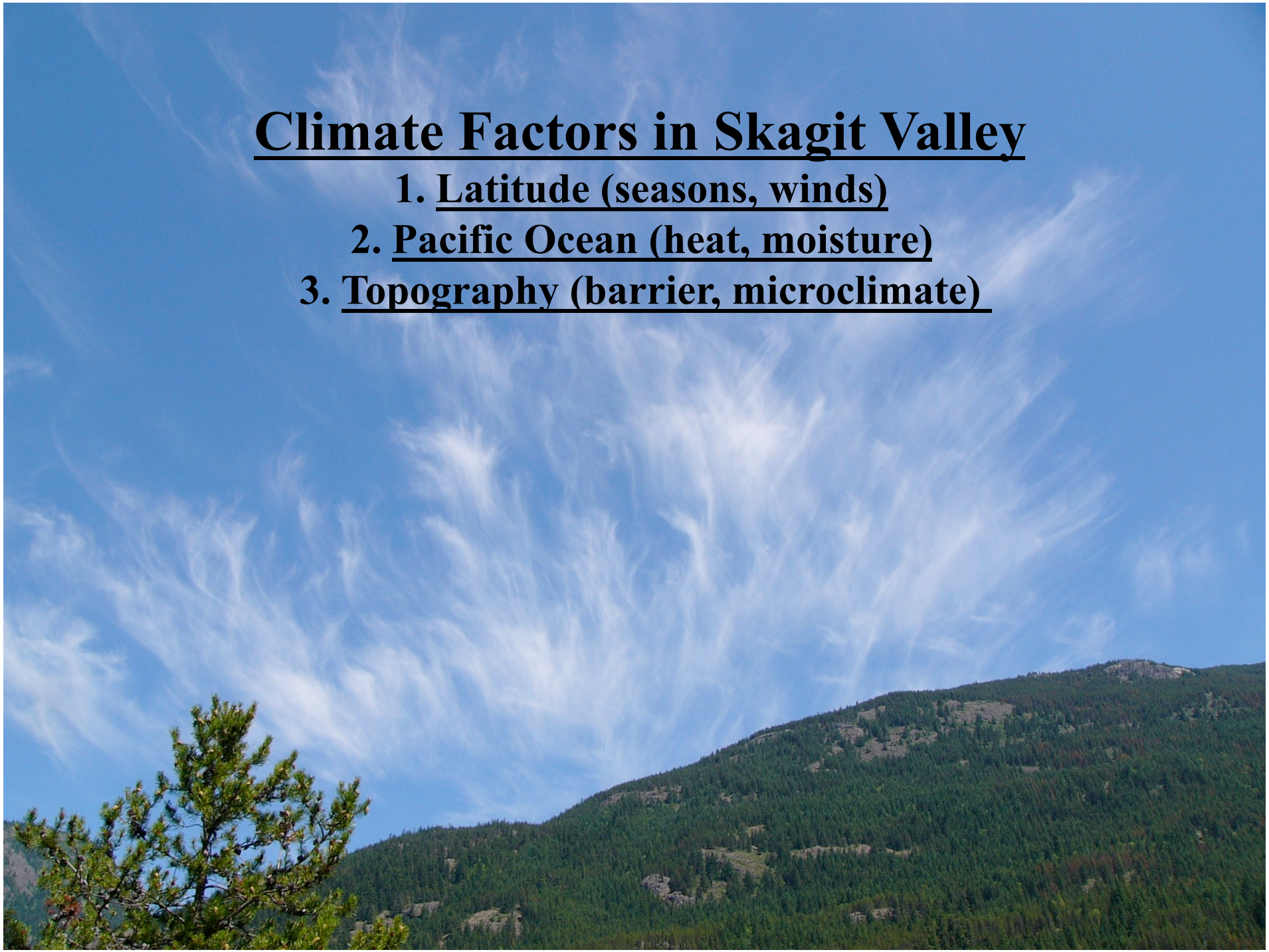


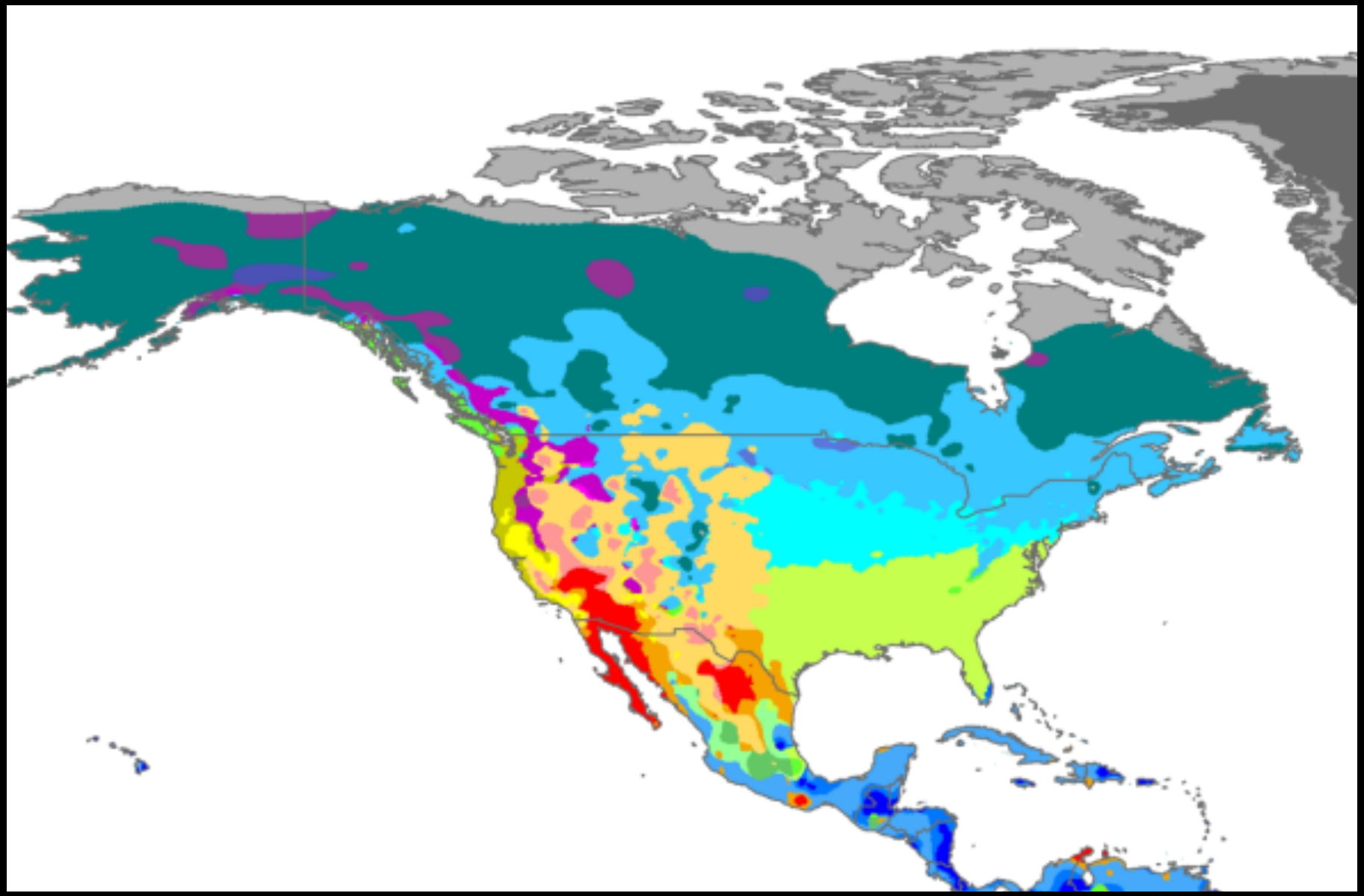
Cold ocean currents are typically on the east side of the ocean basins, while warm currents are on the west side.


Heat release
to atmosphere
Atlantic
Ocean
Pacific
Ocean
Indian
Ocean
Warm surface
current
Cold saline
deep current
Heat release
to atmosphere

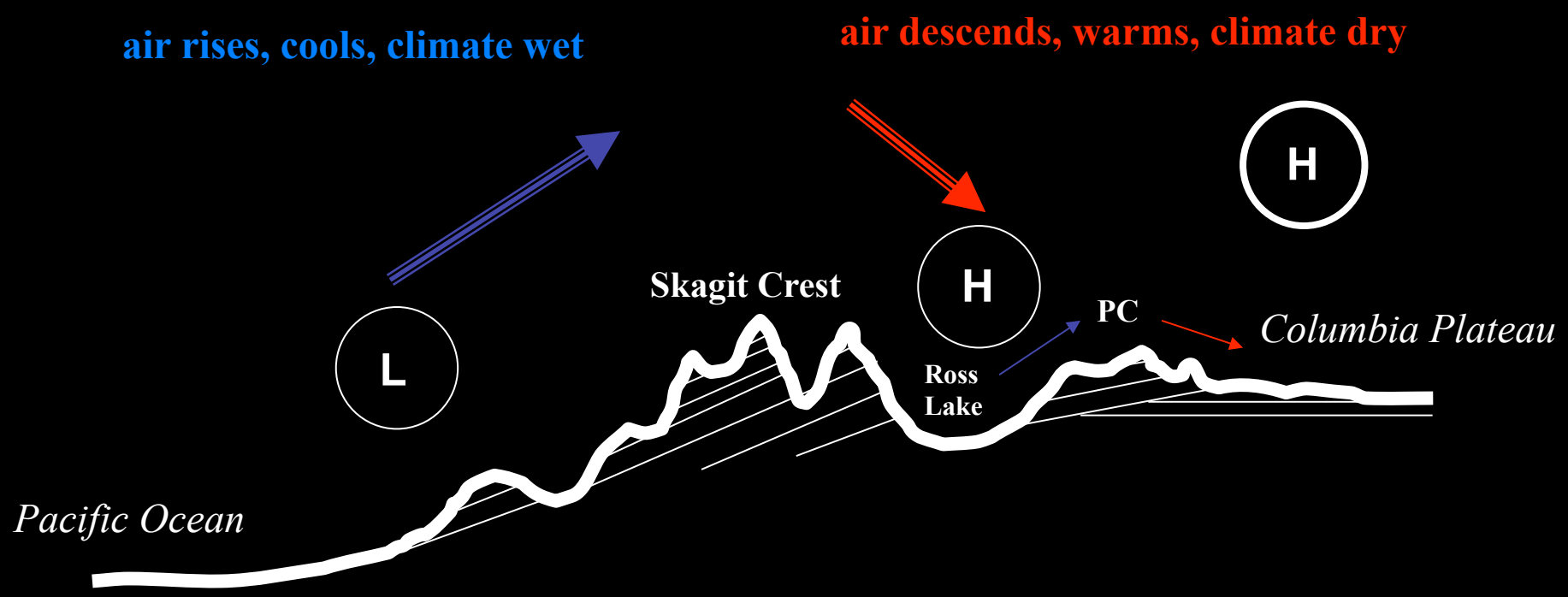
Climate Factors in Skagit Valley

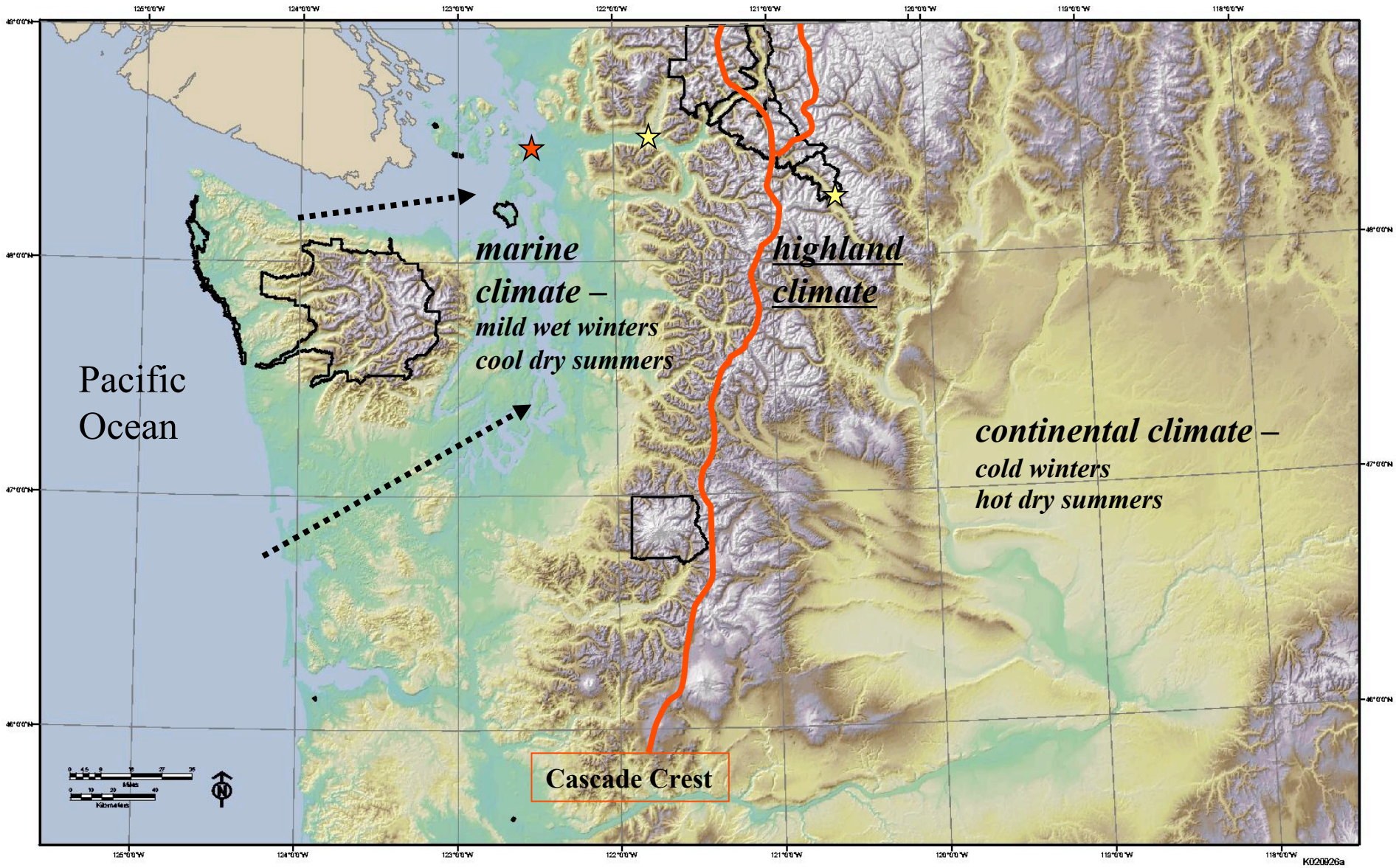
1. Latitude (seasons, winds)
2. Pacific Ocean (heat, moisture)
3. Topography (barrier, microclimate)





Air flow over the North Cascades




Pacific Ocean
marine climate –
mild wet winters
cool dry summers
highland climate
continental climate –
cold winters
hot dry summers
Cascade Crest
K020926a

Climate of Concrete, Washington (elevation 300 ft.)

Average annual temperature 50.9 ˚F (10 °C)

Annual temperature range 0 to102 ˚F

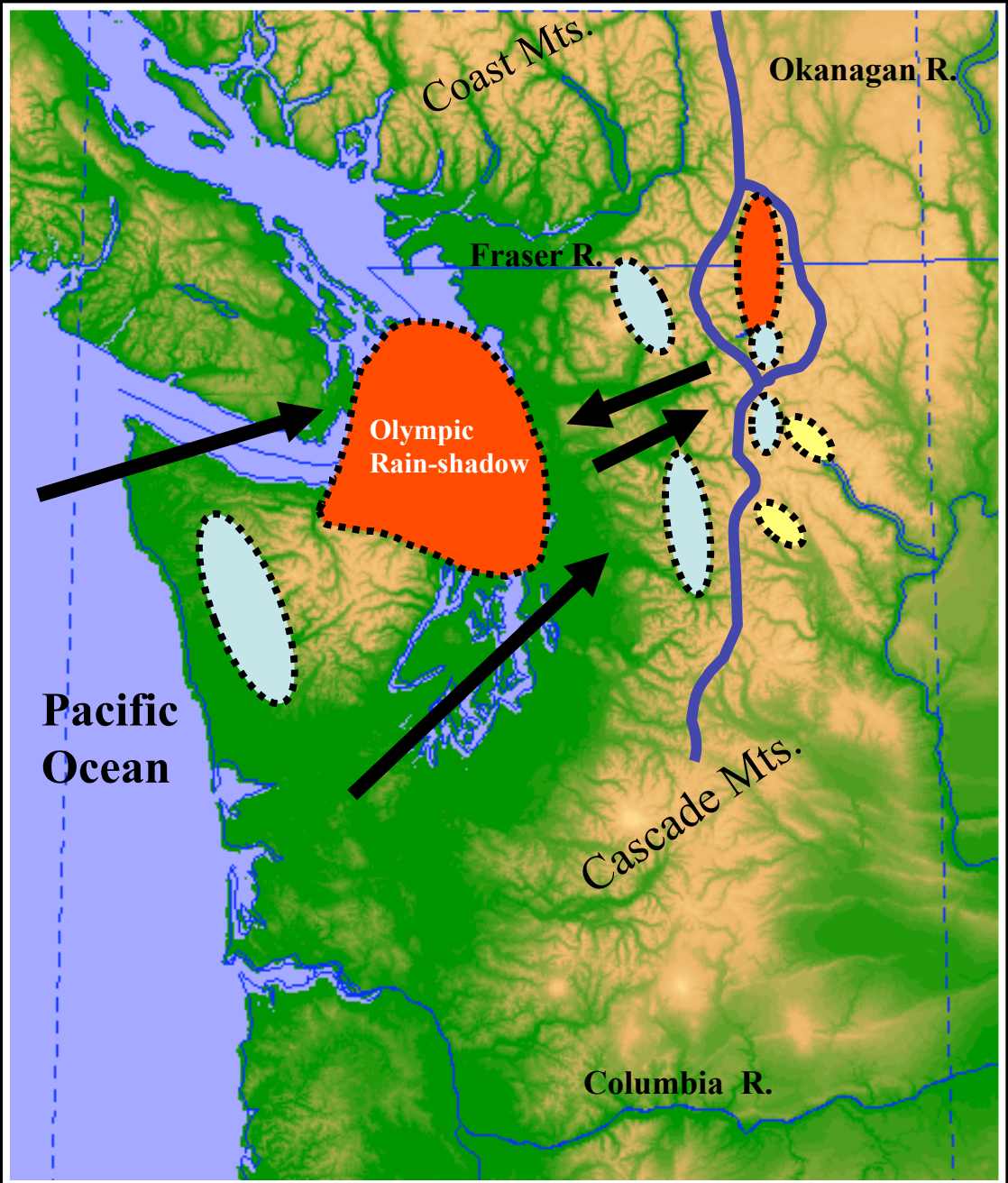
Average annual precipitation 68” (24” snow)

Climate of Stehekin, Washington (elevation 1200 ft)

Average annual temperature 47.6 ˚F (9 °C)

Annual temperature range -21 to 107 ˚F

Average annual precipitation 35” (124” snow)



49⁰

120⁰

Mesooclimates of the Skagit Region

Skagit Valley Floor Precipitation Changes

Delta = 25”
Sedro Woolley = 46”
Concrete = 67”
Marblemount = 84”
Diablo = 74”
Hozomeen = 40”

Part One Outline:

I -Climate v. Weather

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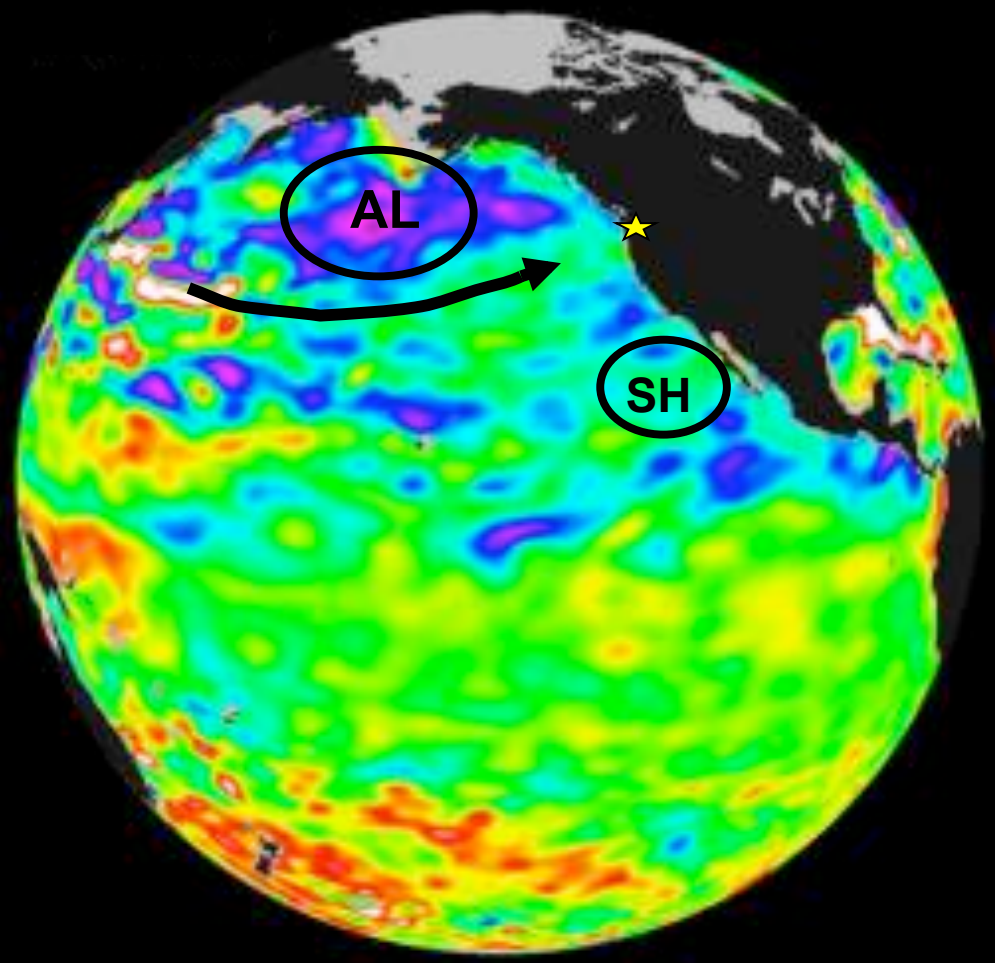
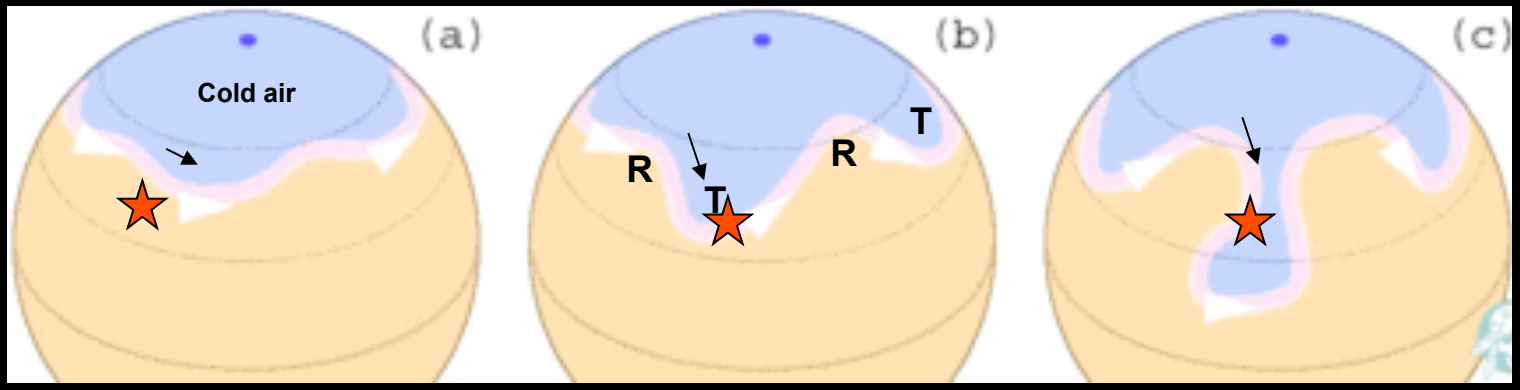
Part Two: Climate History

The atmosphere and oceans are closely coupled. Changes in the state of the oceans can quickly and directly influence the state of the atmosphere through the position of the jet stream and air mass boundaries.



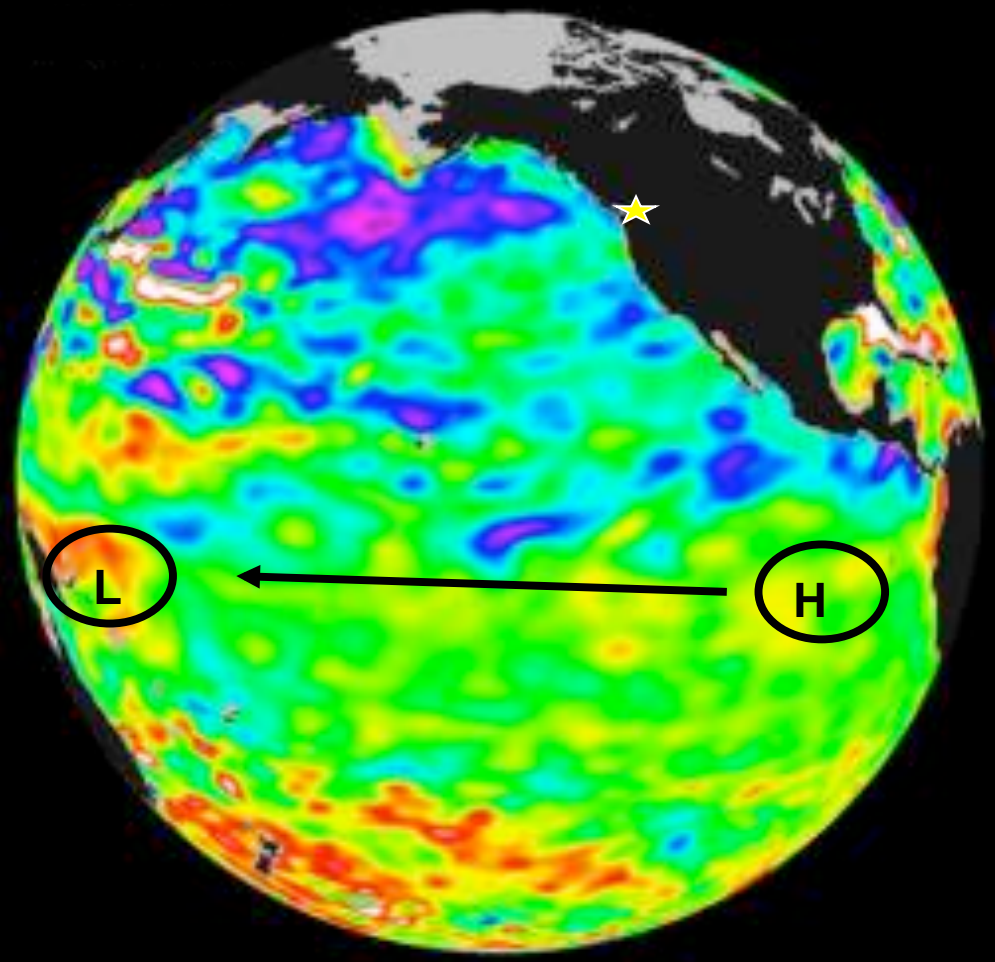
Breakdown of the polar front and development of Rossby waves.



Zonal -stable Meridional-stormy

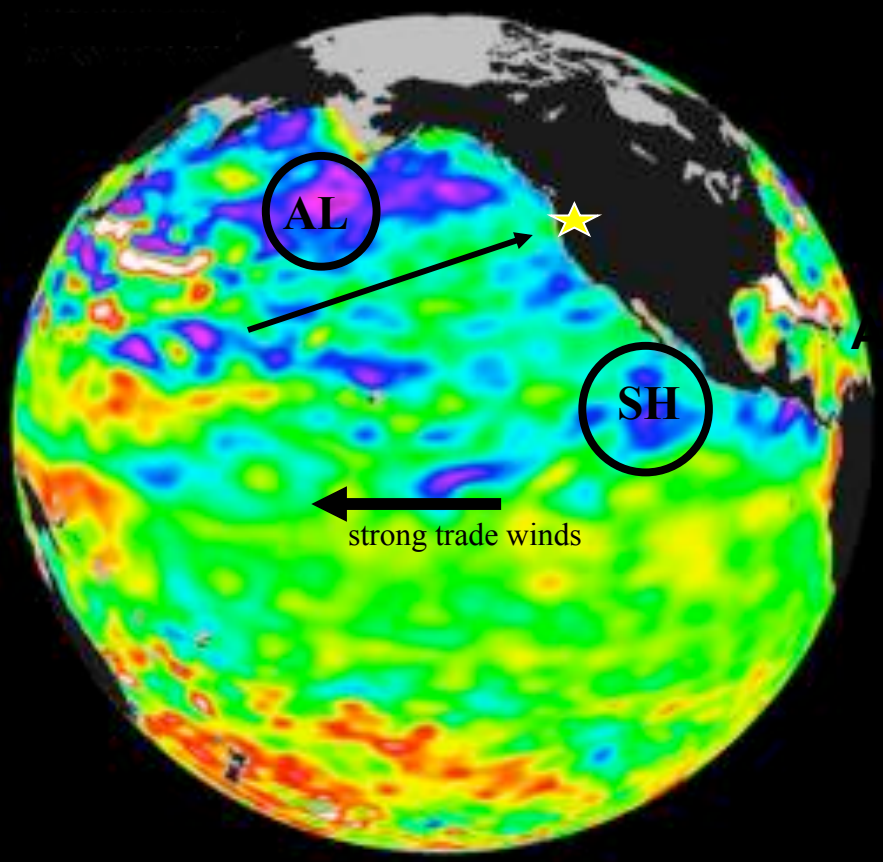
In the North Cascades polar outbreaks are known as northeasters, which bring strong, cold/dry winds and subfreezing temperatures to western Washington.

Walker Circulation over the equatorial Pacific.

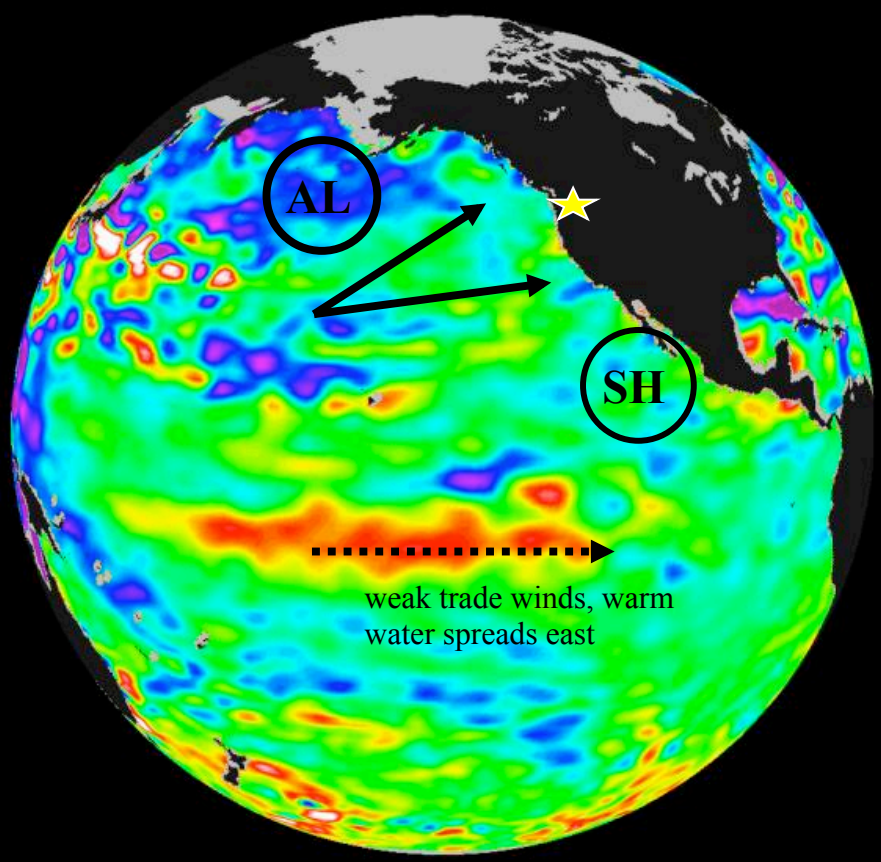


Pacific Ocean Winter Temperature Extremes

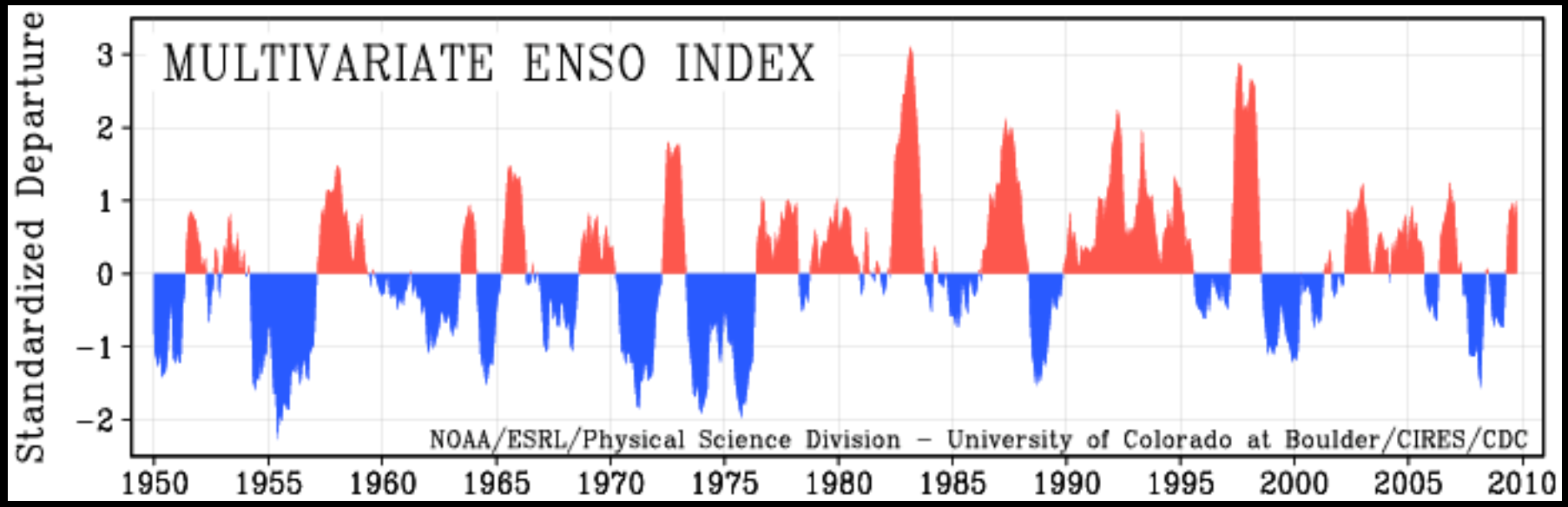
La Nina – cool/wet winter



El Nino – warm/dry winter

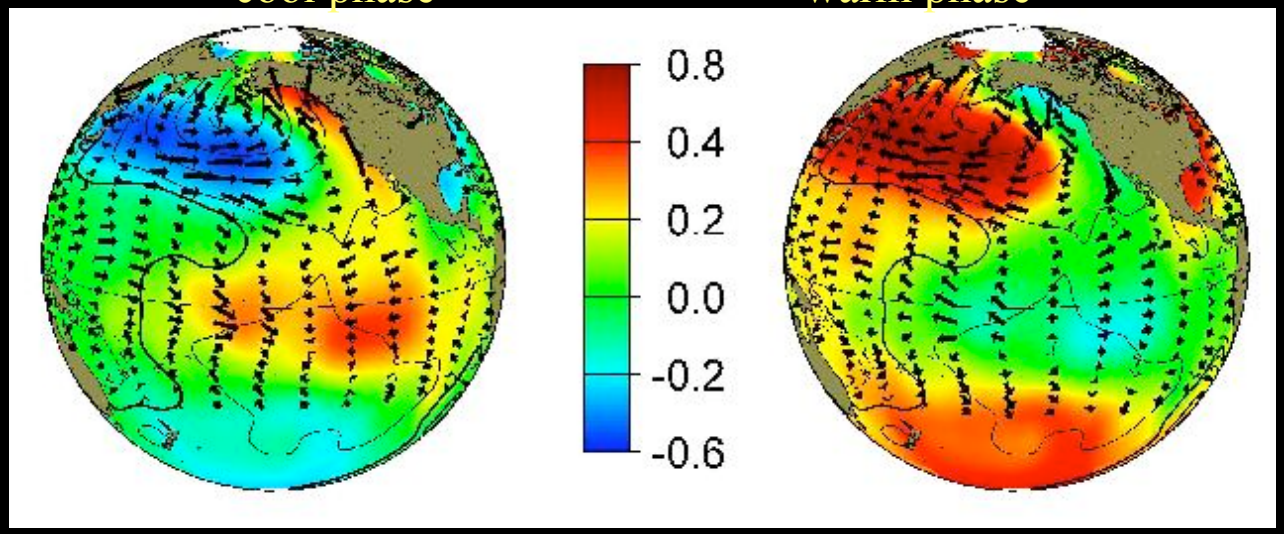


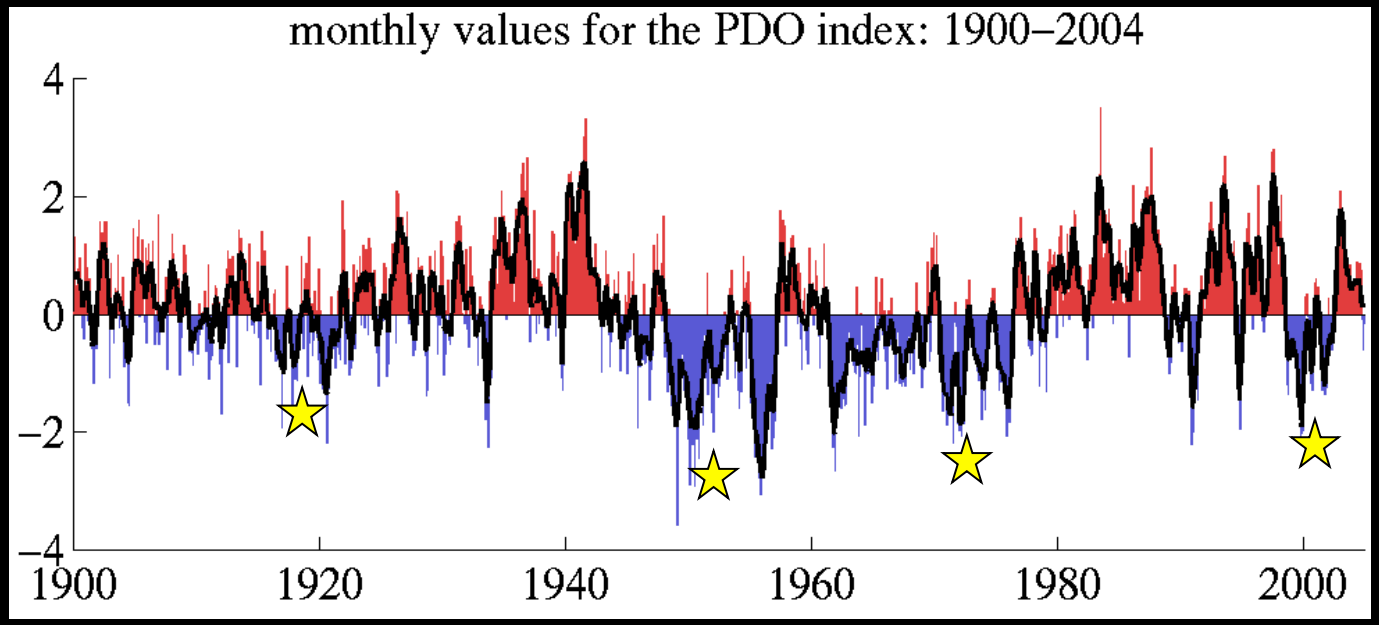
Time Series of El Nino-Southern Oscillation



Pacific Decadal Oscillation

cool phase warm phase





Part One Outline:

I -Climate v. Weather

II-Climate of Concrete v. a Glacier

III-Climate Sensitivity

IV-Climate Change

VI- Glaciers and Climate History

Part Two: Climate History

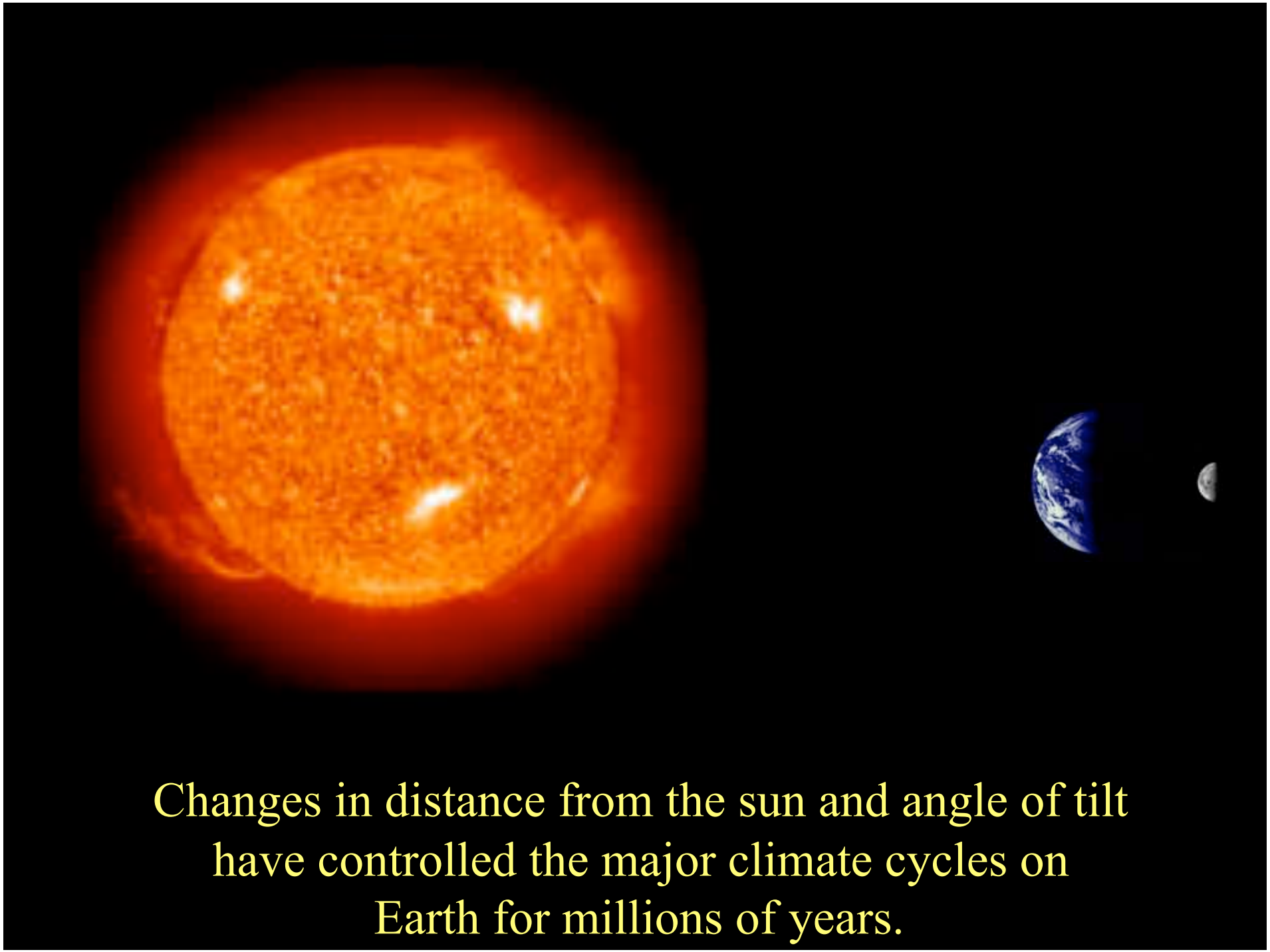
Natural Climate Change Drivers and Cycles

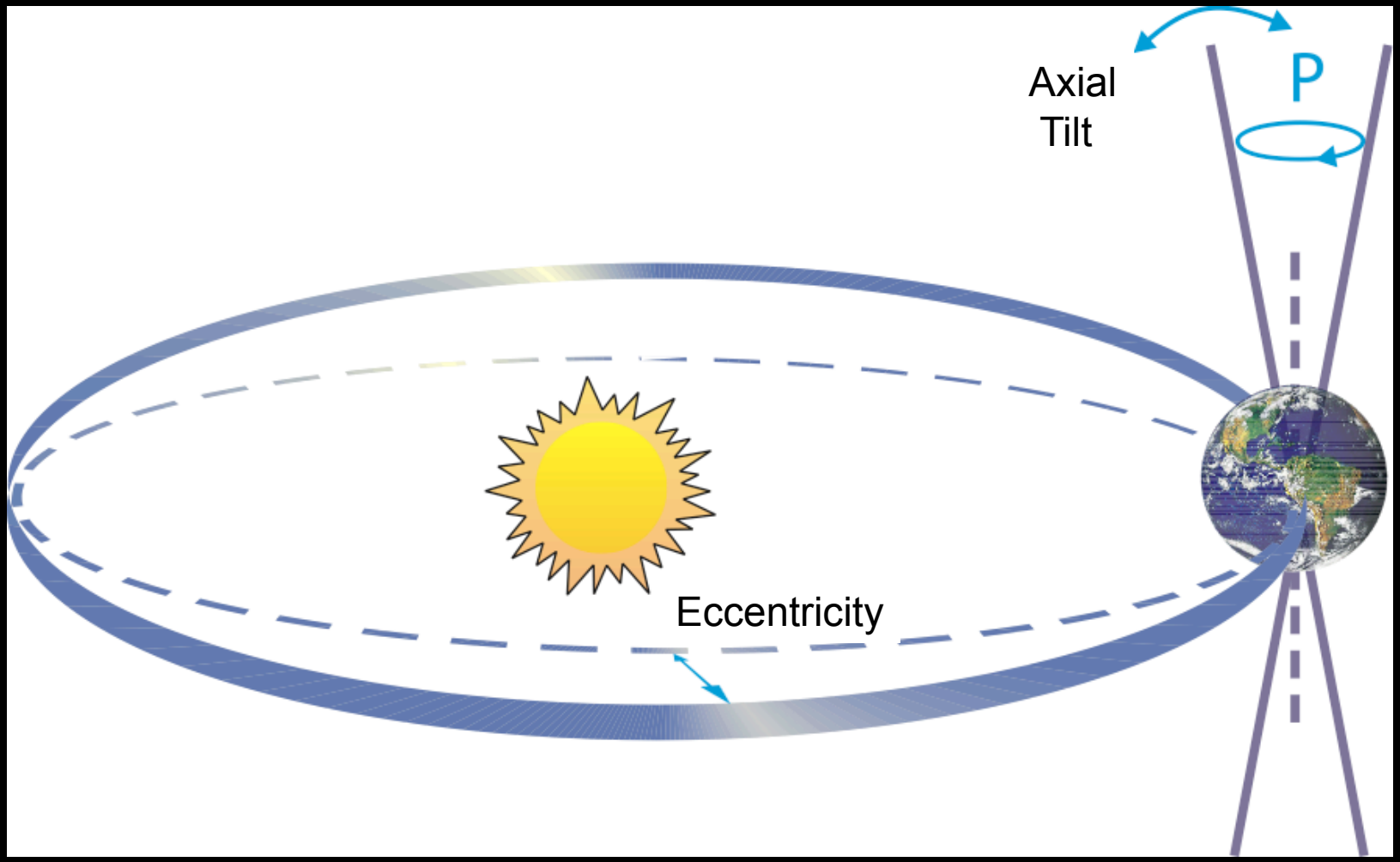
- **External**
  - Earth–Sun relations (26,000, 41,000 and 100,000 year cycles)
  - Solar variability (11-~200-1,000? year cycles)
  - Asteroid or comet

- **Internal**
  - Ocean temperature (hundreds of years)
  - Composition of atmosphere (1-200 years)
  - Glaciers (thousands to tend of thousands of years)
  - Land-Ocean distribution (millions of years)

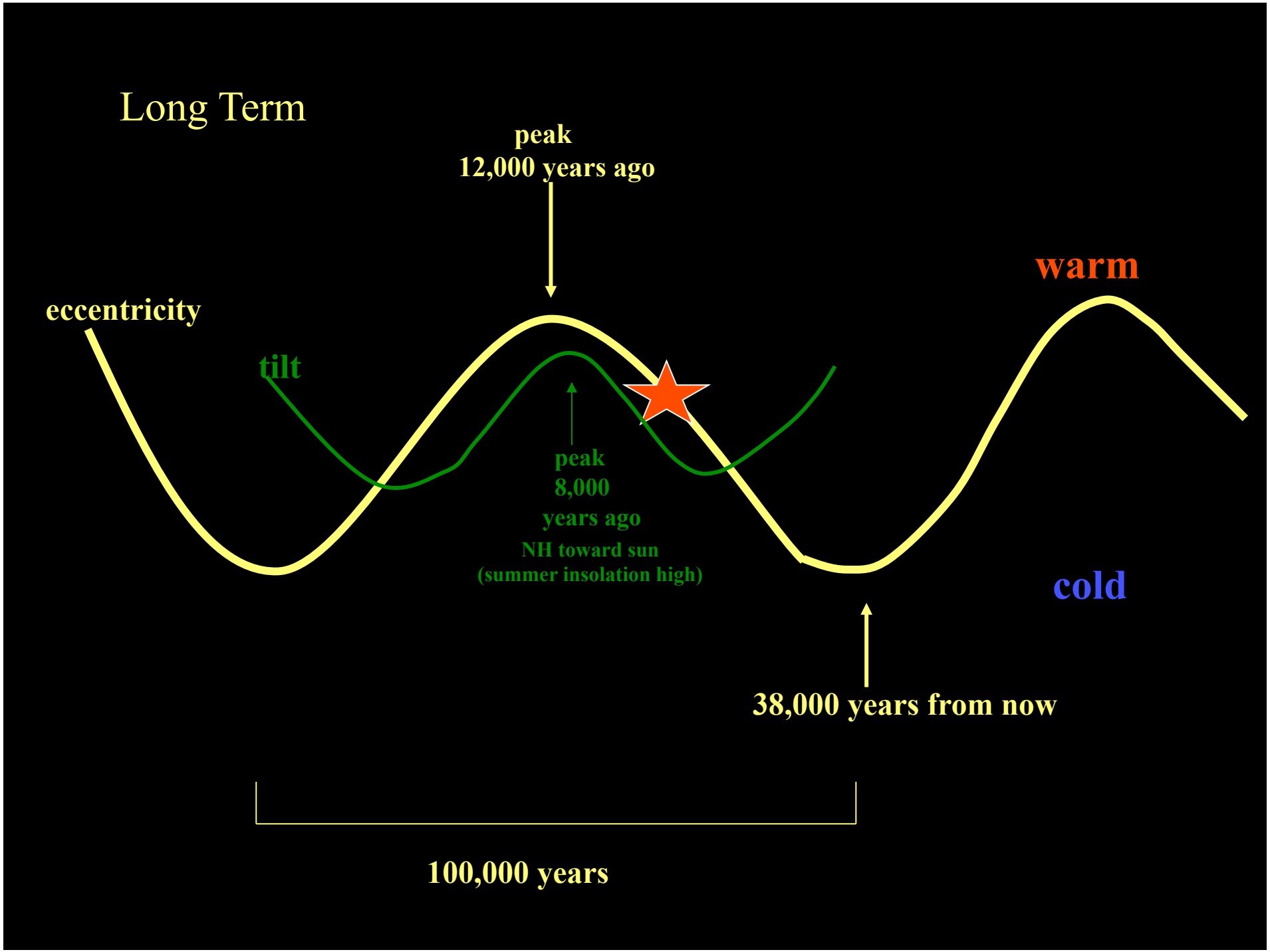
Impacts from comets and asteroids, like air pollution and volcanoes, produce sunlight-blocking dust and cool climate.

As we know, some resulting climate changes caused by these events are devastating (e.g. dinosaurs).

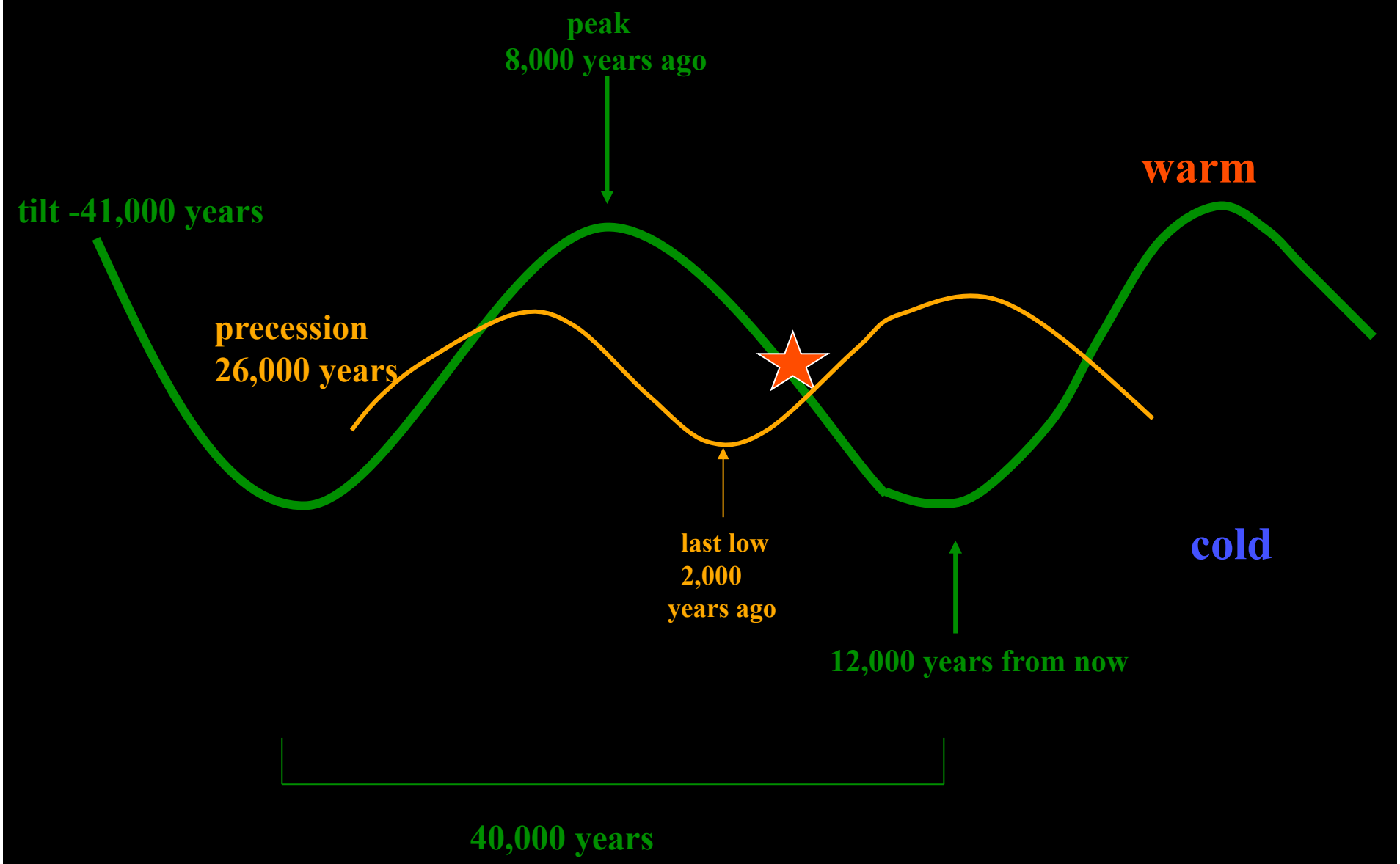

Changes in distance from the sun and angle of tilt
have controlled the major climate cycles on
Earth for millions of years.

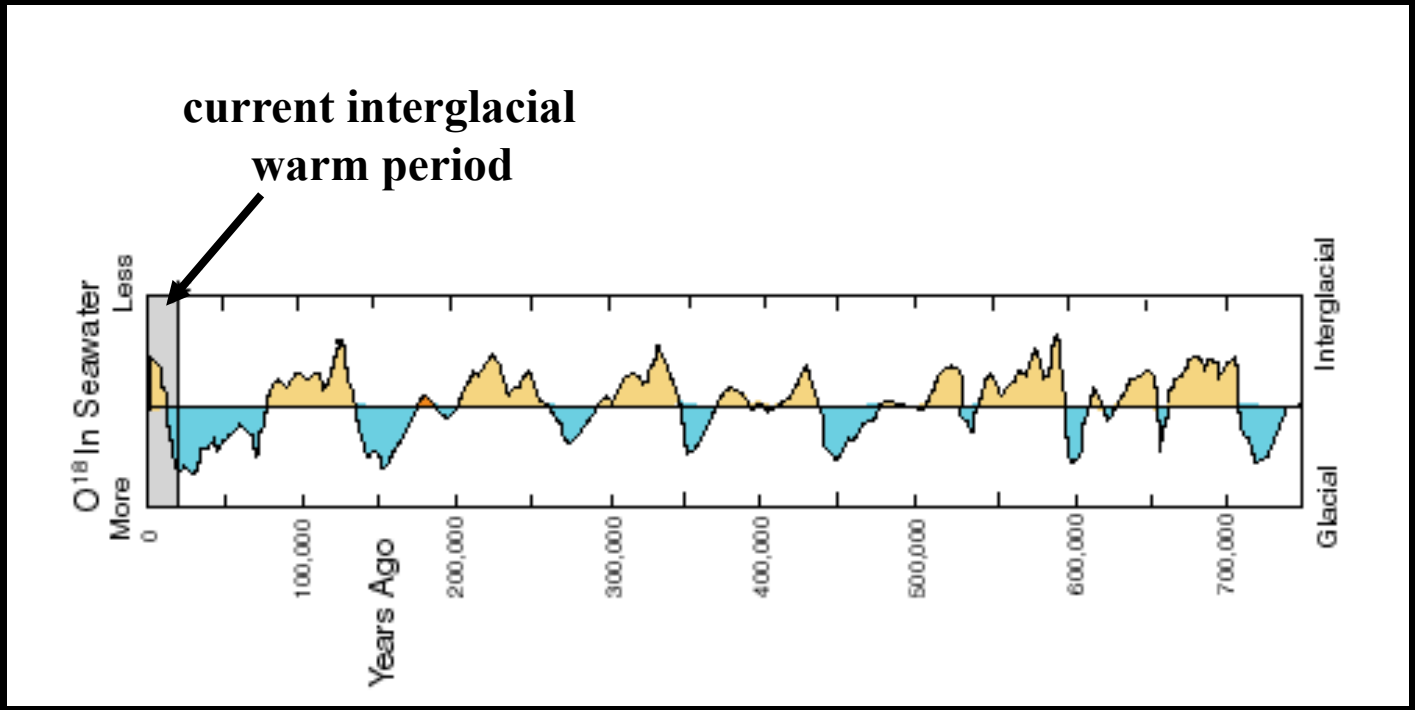


Schematic diagram of Earth's orbital changes that pace the ice age climate cycles.

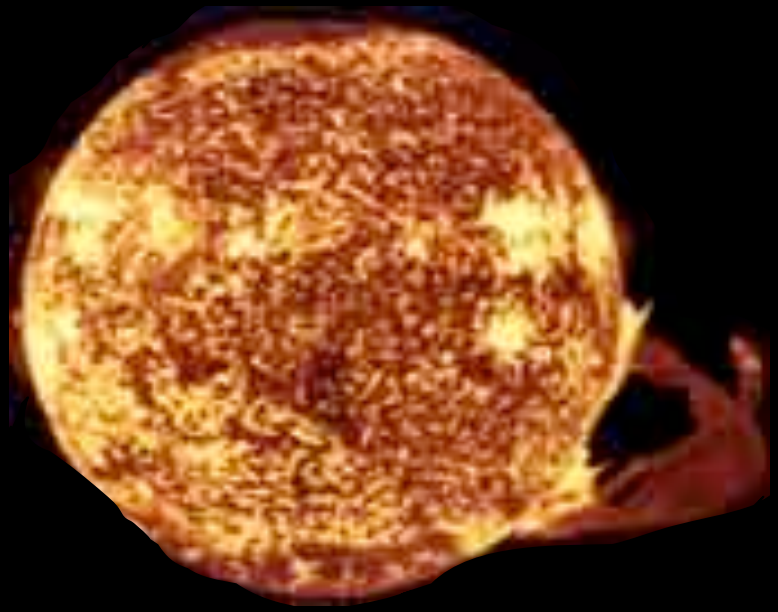

Long Term
peak
12,000 years ago
warm
eccentricity
tilt
peak
8,000
years ago
NH toward sun
(summer insolation high)
cold
38,000 years from now
100,000 years

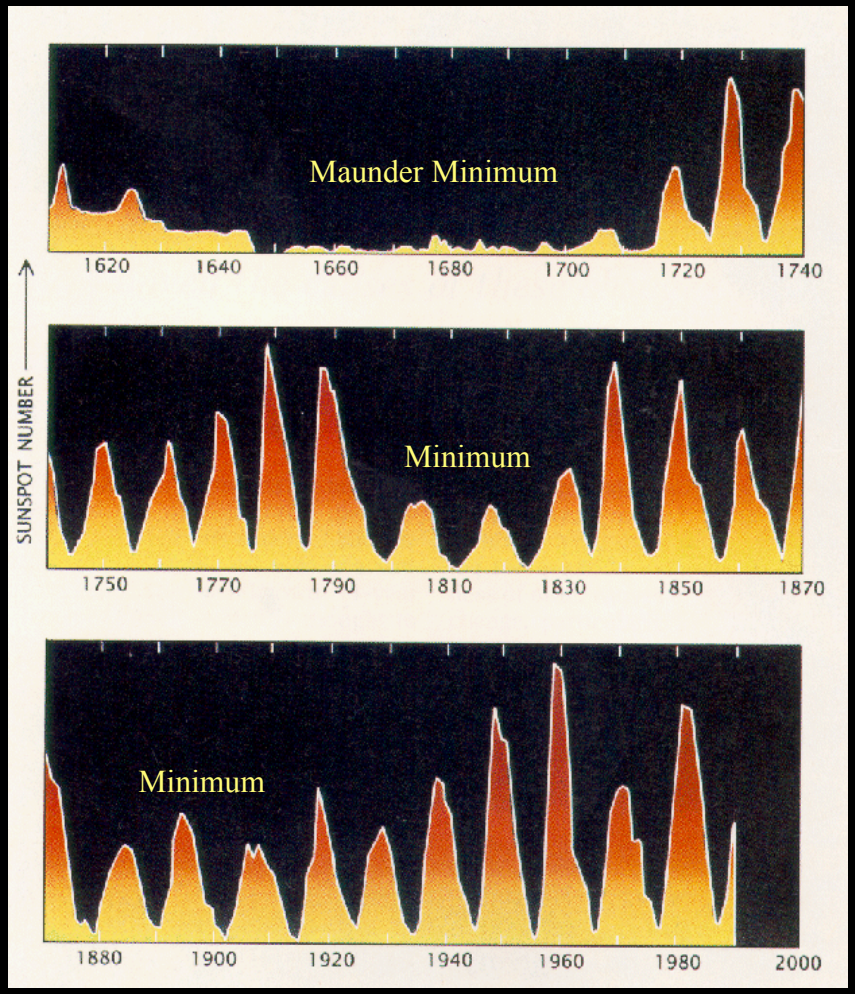
Long Term Earth-Sun Climate Relations



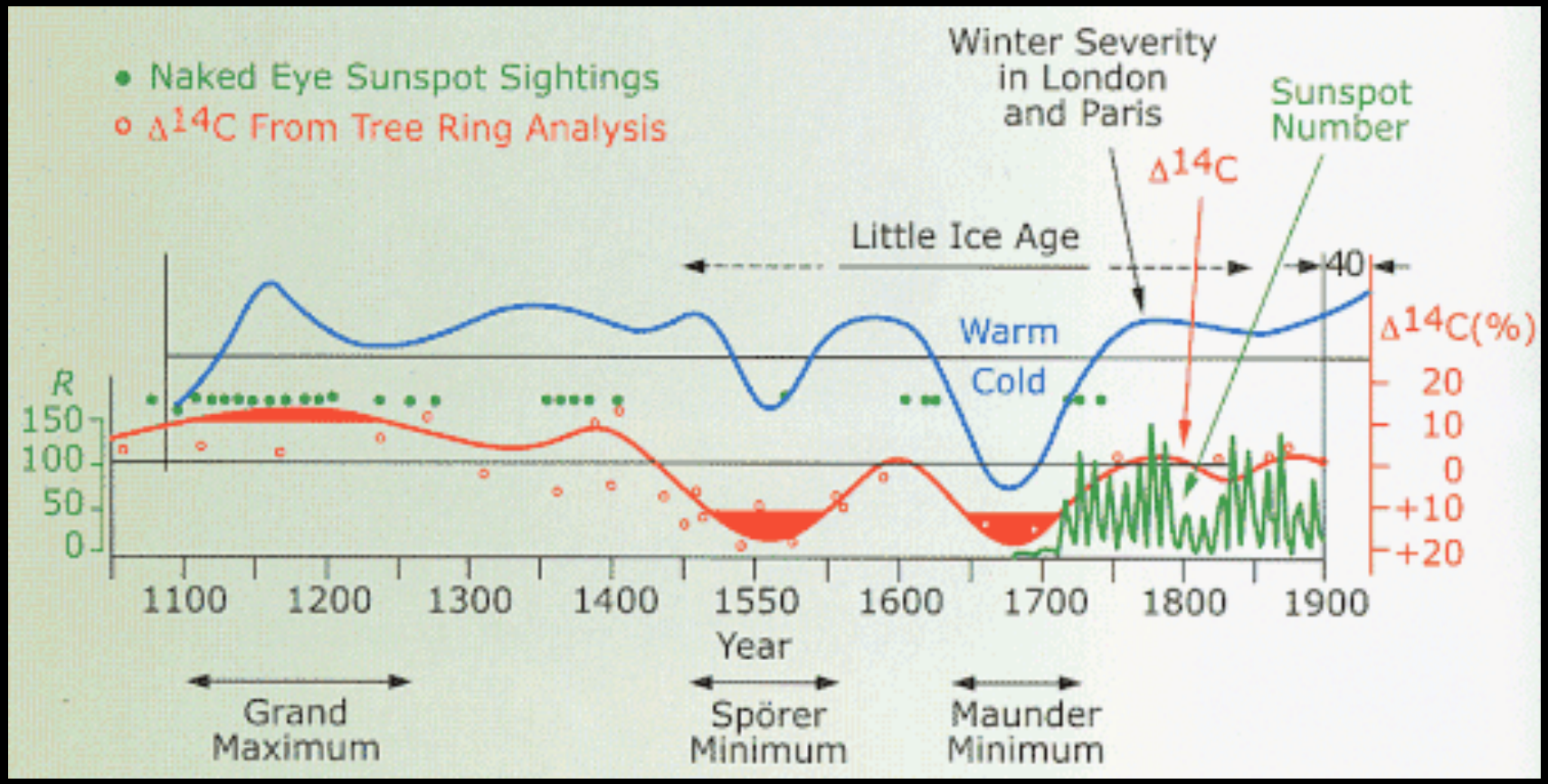


Ocean floor sediment core record of ice age climate cycles spanning >700,000 years.





Output from the sun varies on several time scales, including 11 , ~200, and possibly 1,000 years.


Naked Eye Sunspot Sightings
Δ14C From Tree Ring Analysis
Winter Severity in London and Paris
Sunspot Number
Δ14C
Little Ice Age
40
Warm
Cold
R
150
100
50
0
Δ14C(%)
20
10
0
+10
+20
1100
1200
1300
1400
1550
1600
1700
1800
1900
Year
Grand Maximum
Spörer Minimum
Maunder Minimum

Earth's Major Tectonic Plates

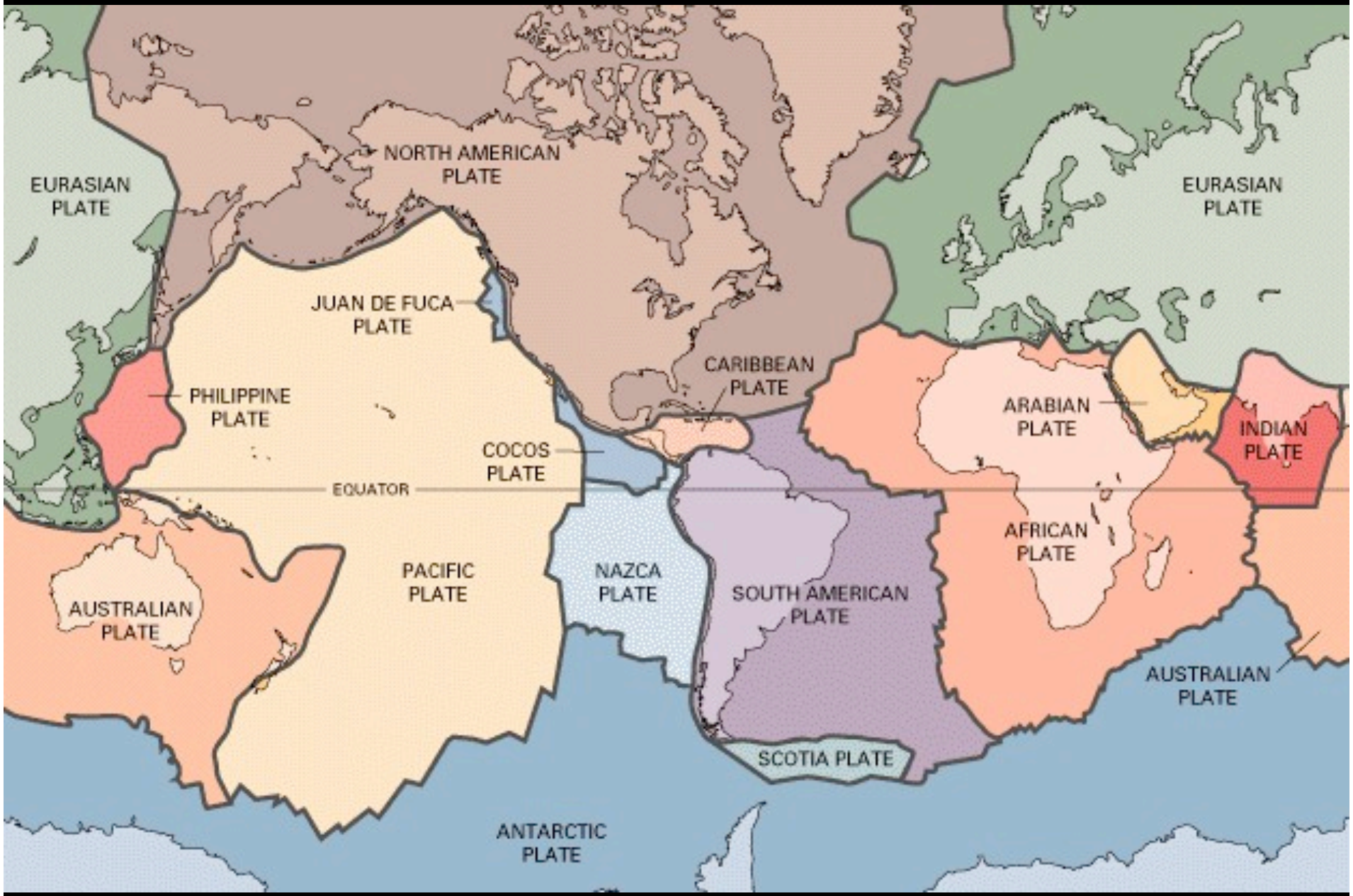
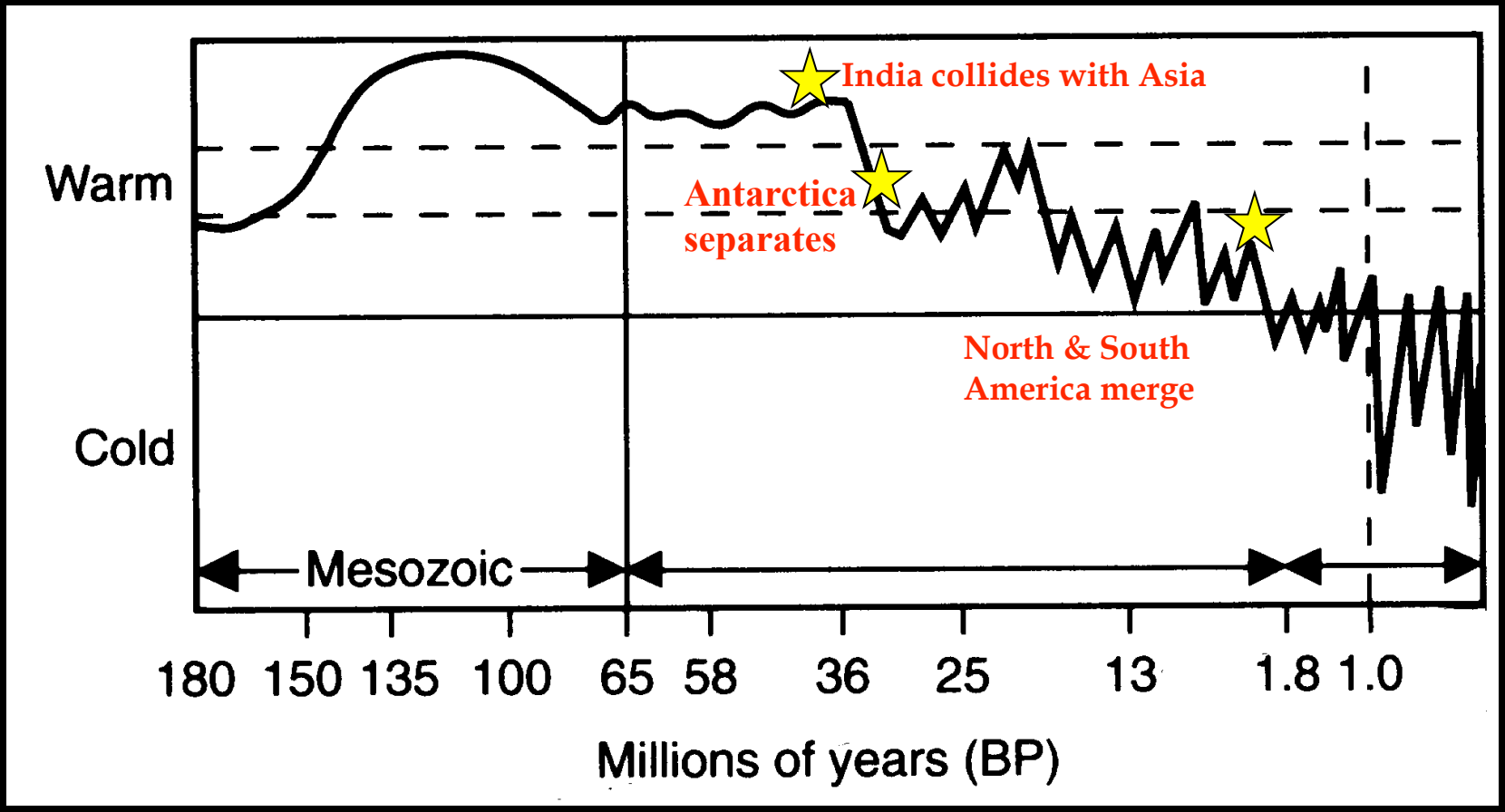
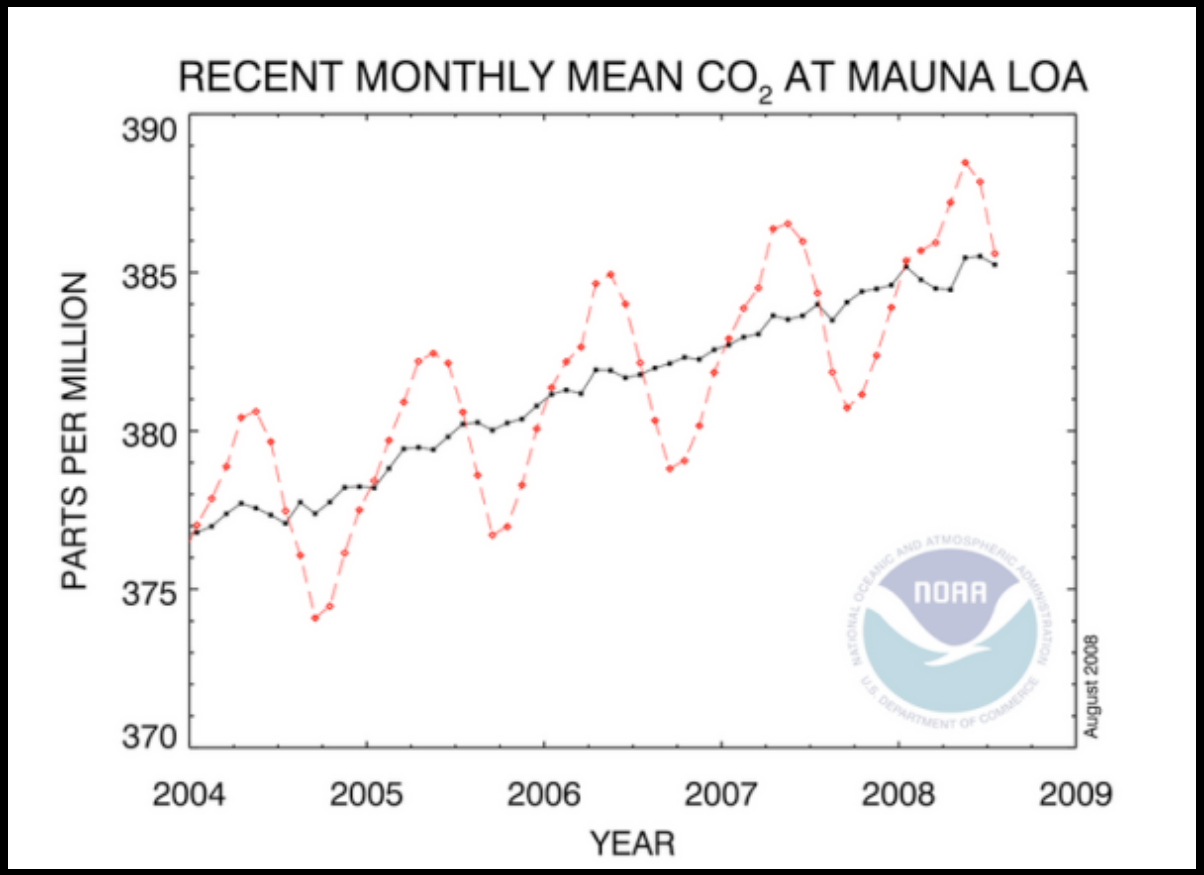
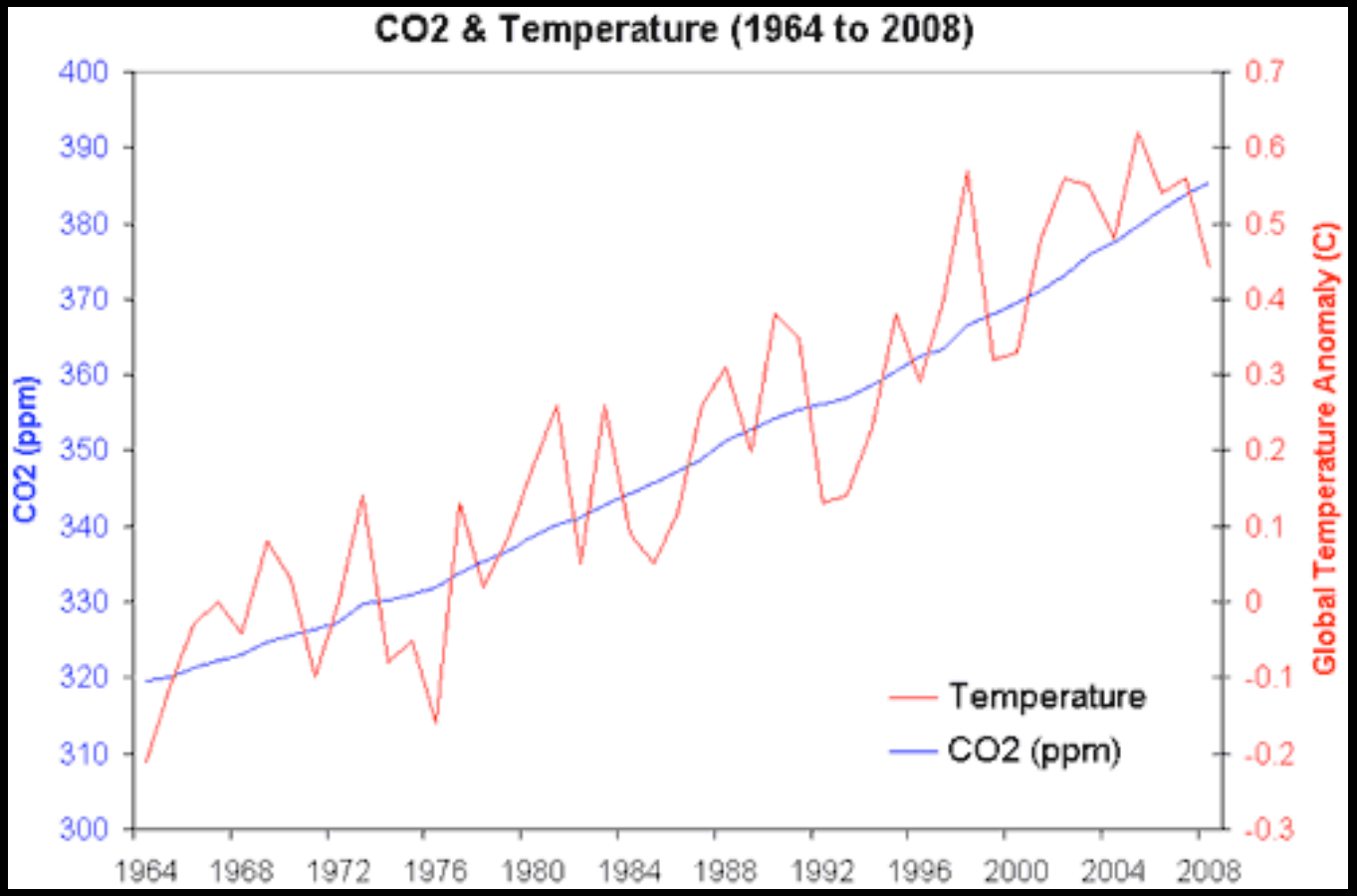


Plate Tectonic Events that Altered Earth's Climate

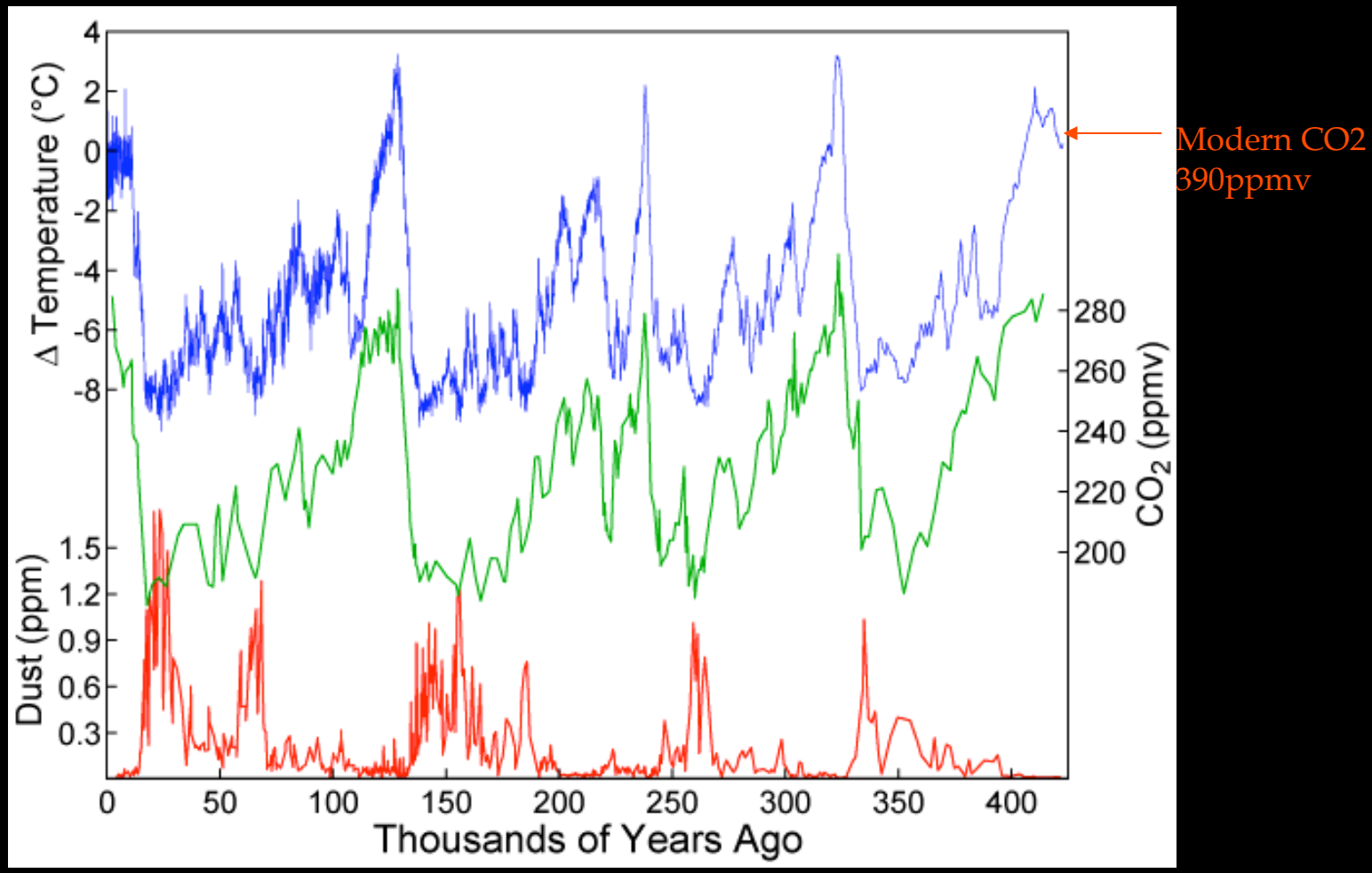


The Earth's atmosphere is a thin layer of gas (78% nitrogen, 21% oxygen) that provides a relatively warm climate given our distance from the sun. It also provided a stable climate and protects life from ultraviolet radiation.

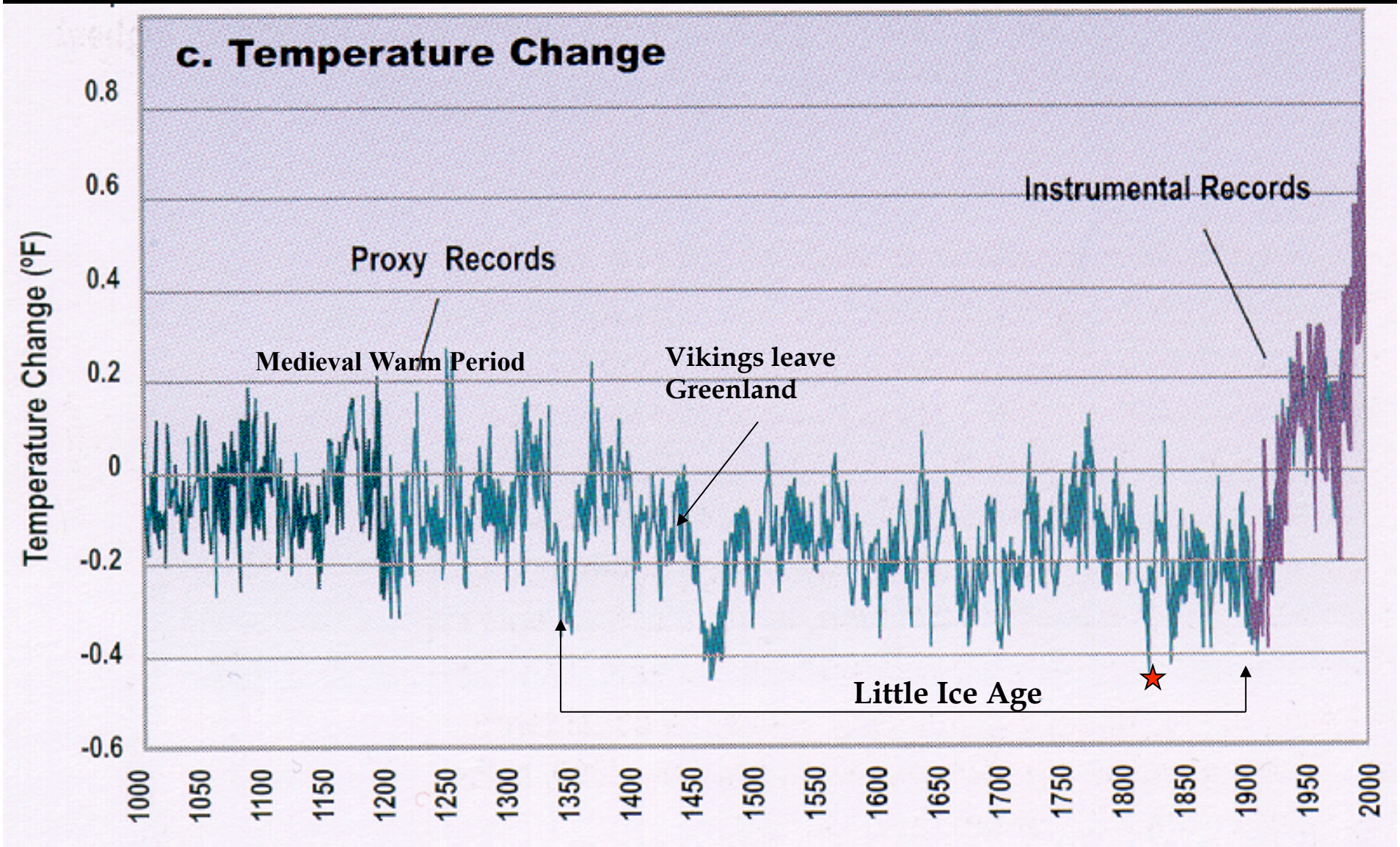

RECENT MONTHLY MEAN CO_2 AT MAUNA LOA
PARTS PER MILLION
390
385
380
375
370
2004
2005
2006
2007
2008
2009
YEAR
August 2008
NOAA


CO2 & Temperature (1964 to 2008)
CO2 (ppm)
Global Temperature Anomaly (C)
400
390
380
370
360
350
340
330
320
310
300
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
2008
Temperature
CO2 (ppm)

Long-term climate variations from Vostok Ice Core, Antarctica (Rothman, 2001).



For most of the past 1,000 years earth's climate was cooling gradually (data from Jones and Britta, 1992).



Part One Outline:

I -Climate v. Weather

II-Climate Factors

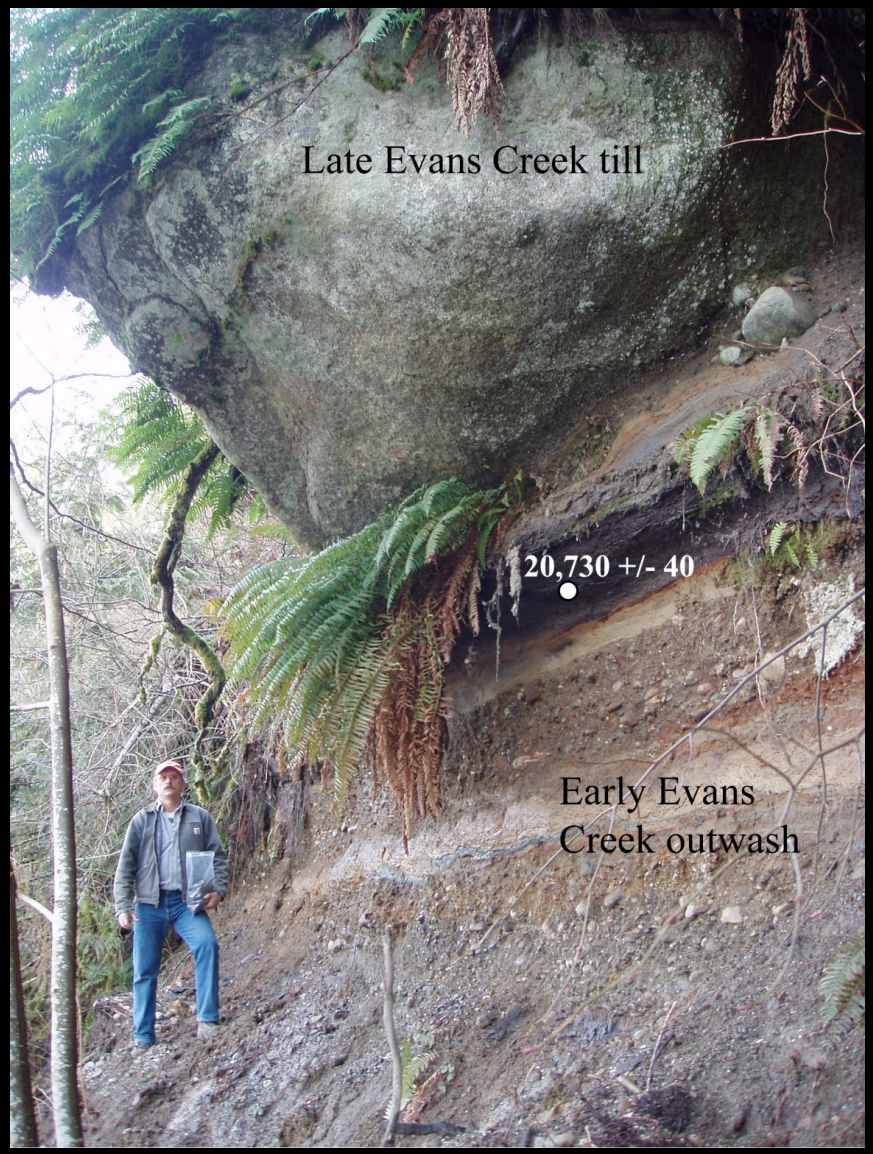
III-Climate Sensitivity

IV-Natural Climate Change Drivers

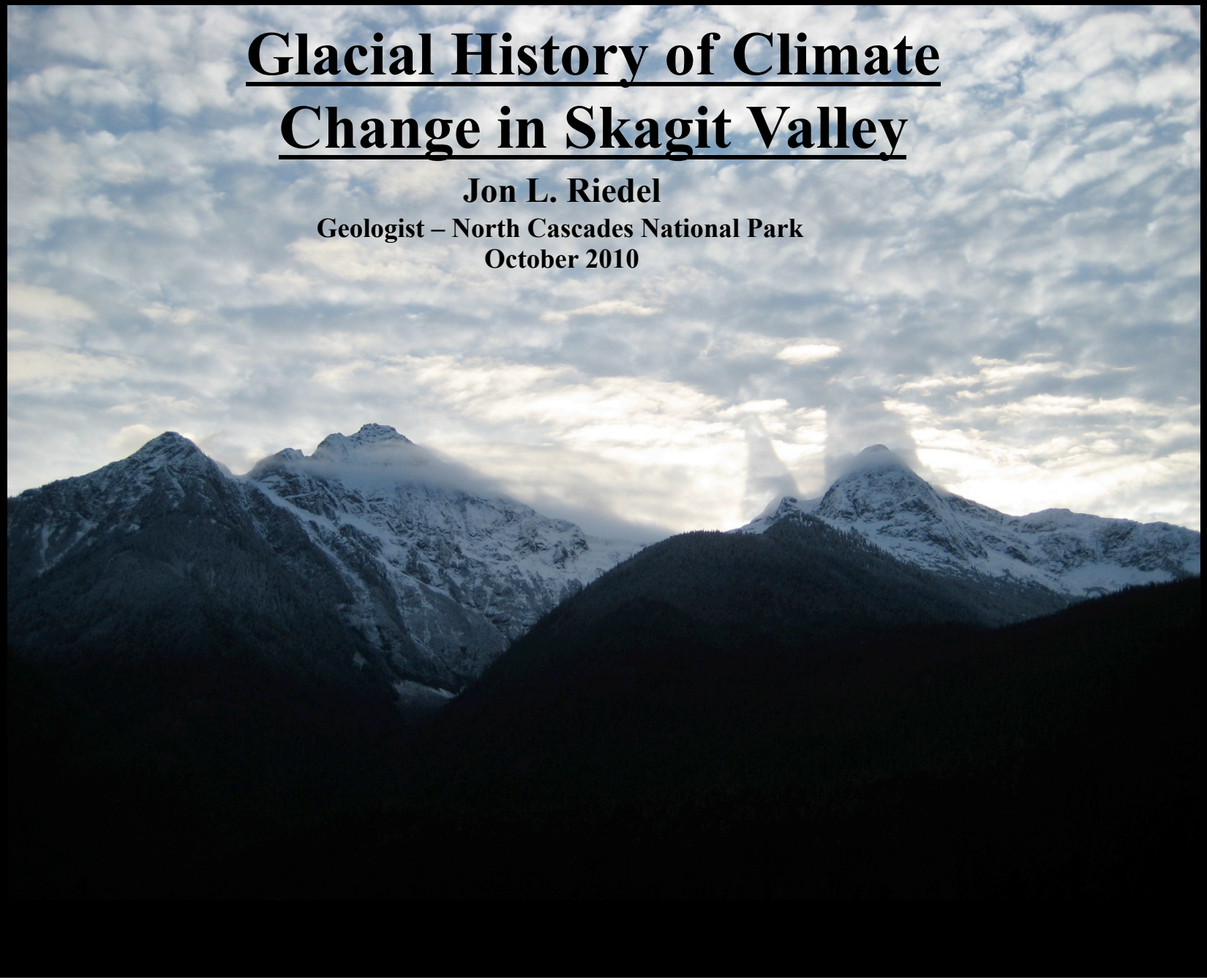
VI- Glaciers and climate history

Part Two: Climate History

- Glaciers are dramatic indicators of climate change because of their sensitivity to both winter and summer weather.



Glaciers ability to shape the landscape has left a rich record of climate change in our region in the form of glacial landforms and deposits.

Glacial History of Climate Change in Skagit Valley

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October 2010