BAKED ALASKA: Changing Climate – Changing Landscapes

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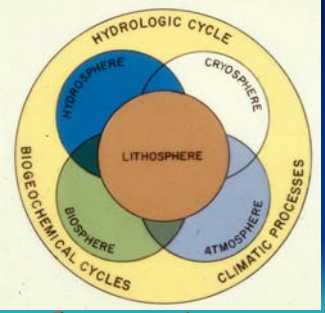
The purpose of this presentation is to provide an introduction to water on Earth, glaciers, and recent climate change. A region by region look at Alaskan glacier behavior and landscape evolution is also presented.

A logical starting point for a discussion about Alaskan glaciers is their primary ingredient –

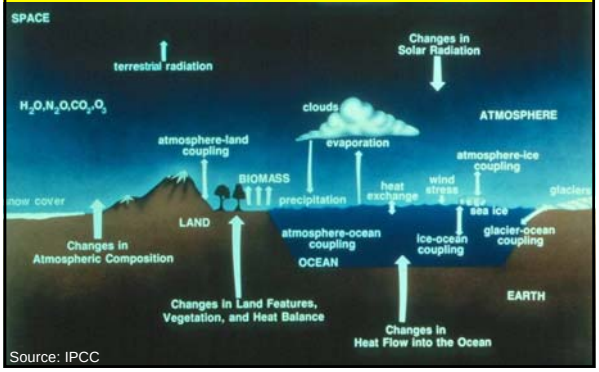
WATER.

Water is the central component of each the interrelated spheres, cycles, and processes of the Earth System.

THE EARTH SYSTEM



INTERACTIONS OF THE EARTH SYSTEM



Source: IPCC

97.2. % of all the water on Planet Earth is salt water.

Oceans and Inland Seas are the largest reservoir of water on Earth.

2.8 % of all the water on Planet Earth is fresh water.

Glacier ice is the second largest reservoir of water on Earth and the largest reservoir of fresh water on Earth!

3/4 of all fresh water on Earth is frozen in glacier ice.

Using the analogy that 1,000 drops of water represent all of the water on Planet Earth:

972 drops are in the oceans and inland seas

21 drops are in glaciers

6 drops are in ground water and soil moisture

< 1 drop is in the atmosphere

< 1 drop is in lakes and rivers

< 1 drop is in all living plants and animals

Water (H_2O) forms hexagonal crystals as it freezes and changes to its solid phase – ice.

Ice is a mineral with definite physical and chemical properties.

At a pressure of one atmosphere and a temperature of 0° C, liquid water has a density of 0.9998 g/cm³.

At a pressure of one atmosphere and a temperature of 0° C, ice has a density of 0.917 g/cm³.

Hence, ice at Earth's surface is ~ 8 % less dense than liquid water. Consequently, it floats with ~ 90 % of its volume submerged.

What is a GLACIER ?

Photos by Bruce F. Molnia

Glacier - A large, perennial accumulation of ice, snow, rock, sediment, and liquid water originating on land and moving down slope under the influence of its own weight and gravity; a dynamic river of ice. Glaciers are classified by their size, location, and thermal regime (i.e. polar vs. temperate).

Glaciers are sensitive indicators of changing climate.

0.7 % of Earth's glacier ice is located in temperate ice caps, icefields, and glaciers.

These are located in:

North America
South America
Africa
Irian Jaya
Asia
Europe
New Zealand

Using the analogy that 1,000 crystals of ice represent all of the glacier ice on Earth:

914 are in Antarctica

79 are in Greenland

~ 4 are in North America (~ 1 is in Alaska)

~ 2 are in Asia

< 1 is in South America, Europe, Africa, New Zealand and Irian Jaya

A temperate glacier is one in which during part or all of the year, liquid water coexists with ice.

Hence, a small change in temperature can have a major impact on glacier melting, area, volume, and sea level.

Liquid water may be on (pools, supraglacial streams), in (moulins, conduit systems, englacial streams), or under (subglacial lakes, subglacial streams), a glacier.

Alaska has a glacier cover of ~ 75,000 km^2, with > 50,000 glaciers.

Only ~ 650 of these glaciers have been officially named.

Alaska's glaciers range in size from tiny cirque glaciers (< 1 km^2) to massive piedmont glaciers such as Bering Glacier and Malaspina Glacier (each > 5,000 km^2), each larger than the State of Rhode Island.

The Area of Alaska's Glaciers is:

~ 1/3 the glacier area of Canada

~ 1/2 the glacier area of Asia

~ the same glacier area as Russia

~ 2.5 times the glacier area of China and Tibet

~ 3 times the glacier area of South America

~ 6 times the glacier area of Iceland

~ 12 times the glacier area of Europe

~ 75 times the glacier area of New Zealand

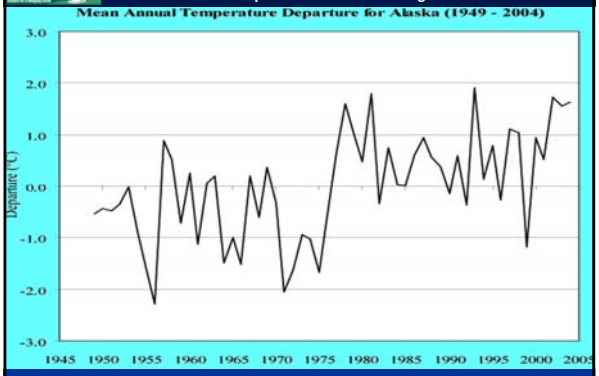
> 100 times the glacier area of the rest of the US

> 1,000 times the glacier area of Africa

Almost All Alaskan glaciers that are below ~ 1.5 km in elevation are temperate.

Photo by Bruce F. Molnia

Alaskan Temperatures are Increasing



Source: Alaska Climate Research Center, Geophysical Institute, University of Alaska Fairbanks

Less than 20,000 years ago, during the last phase of the Pleistocene, the Last Glacial Maximum (LGM), glaciers covered:

- ~ 8 % of Earth's surface
- ~ 25 % of Earth's land area
- ~ 1/3 of Alaska.

During the LGM, global sea level was >100m lower than it is today.

Following the LGM (beginning ~ 15,000 yr B.P.), continental glaciers retreated and sea level began to rise.

By ~ 6,000 yr B.P. sea level reached its current height. It has fluctuated ever since.

Today, glaciers cover:

- ~ 3.1 % of Earth's surface,
- ~ 10.7 % of Earth's land area
- ~ 5 % of Alaska.

Glaciers and Global Sea Level

If all of Alaska's glaciers melted, sea level would rise ~ 0.05 m.

If all of Earth's temperate glaciers melted, sea level would rise ~ 0.3 m.

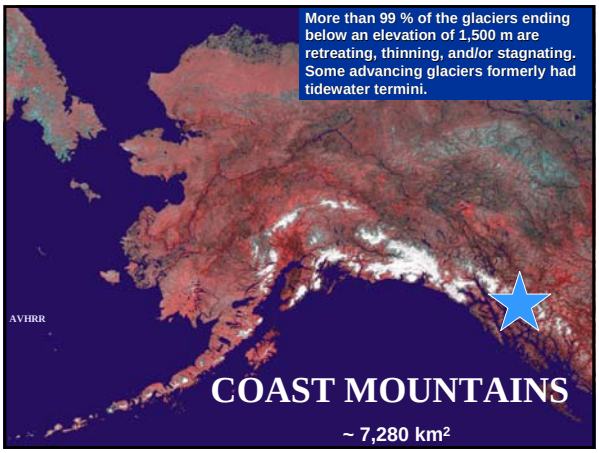
If all of Greenland's glaciers melted, sea level would rise ~ 6 m.

If all of Antarctica's glaciers melted, sea level would rise ~ 73 m.

Eustacy refers to the change in global sea level.

If all of the glacier ice on Earth were to melt, sea level would rise ~ 80 m, flooding every coastal city on the planet.

The volume of water that is estimated to be present in Alaskan glaciers is ~ 45,000 km^3 .


More than 99 % of the glaciers ending below an elevation of 1,500 m are retreating, thinning, and/or stagnating. Some advancing glaciers formerly had tidewater termini.
AVHRR
COAST MOUNTAINS
~ 7,280 km²

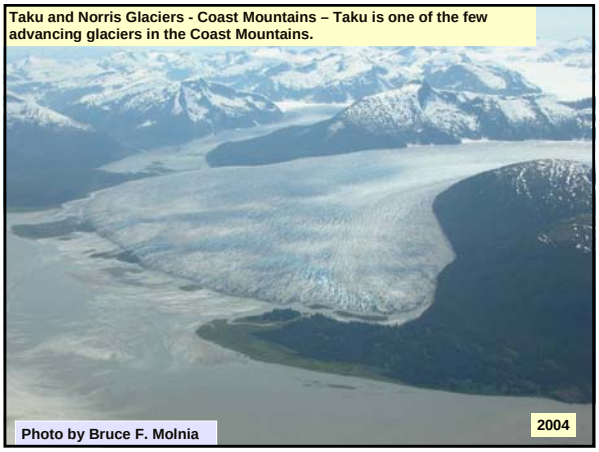
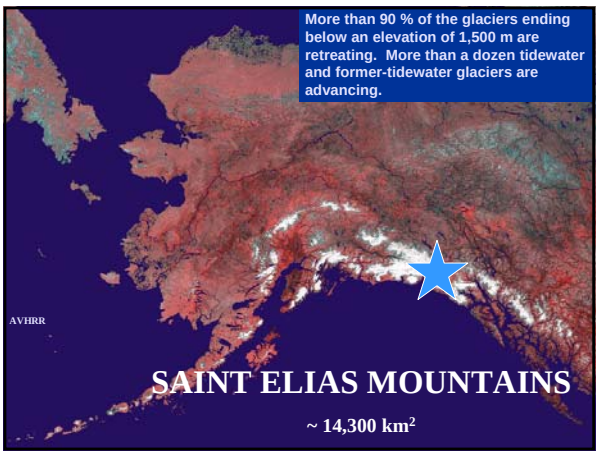
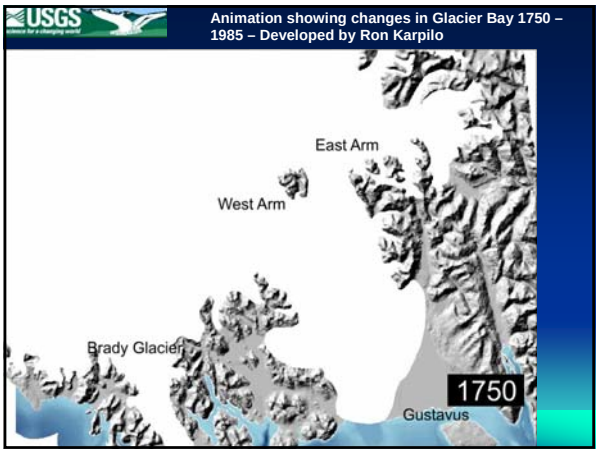

Taku and Norris Glaciers - Coast Mountains – Taku is one of the few advancing glaciers in the Coast Mountains.
Photo by Bruce F. Molnia
2004


Photo by Bruce F. Molnia
Mendenhall Glacier –Coast Mountains – 2004 – Retreat began ~1750.


Mendenhall Glacier – 2004 - Coast Mountains
Photo by Bruce F. Molnia


Herbert Glacier - Coast Mountains – 2004 - Arrow marks 1968 terminus position.
Photo by Bruce F. Molnia


More than 90 % of the glaciers ending below an elevation of 1,500 m are retreating. More than a dozen tidewater and former-tidewater glaciers are advancing.
AVHRR
SAINT ELIAS MOUNTAINS
~ 14,300 km²

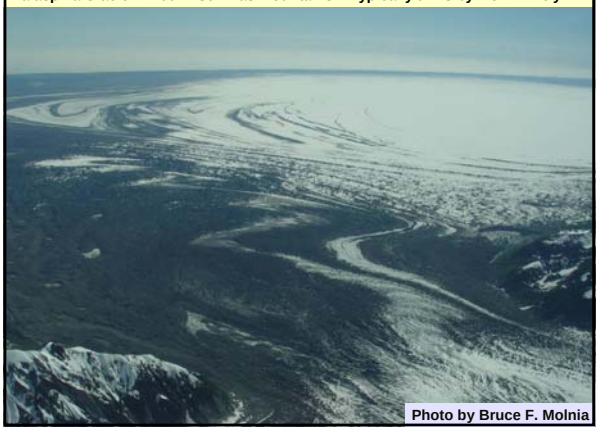

USGS
Animation showing changes in Glacier Bay 1750 – 1985 – Developed by Ron Karpilo
East Arm
West Arm
Brady Glacier
1750
Gustavus


USGS
1941 Photo by W.O. Field
2005 Photo by Bruce F. Molnia
Muir Glacier and Inlet
1941-2004


USGS
1980 Photo by Bruce F. Molnia
2003 Photo by Bruce F. Molnia
McBride Glacier
1980 – 2003

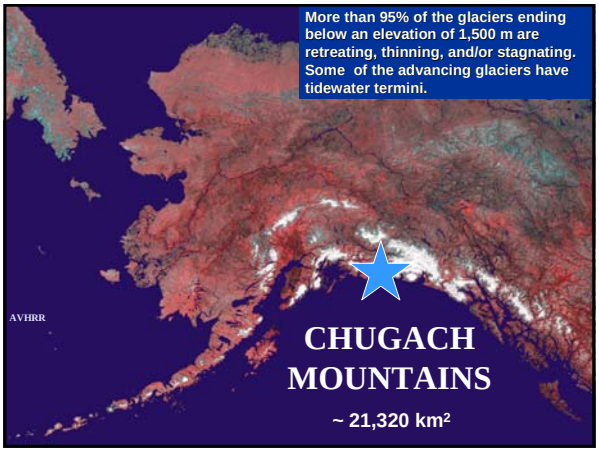
Hubbard Glacier – 2004 - St. Elias Mountains - One of the fastest growing glaciers in Alaska

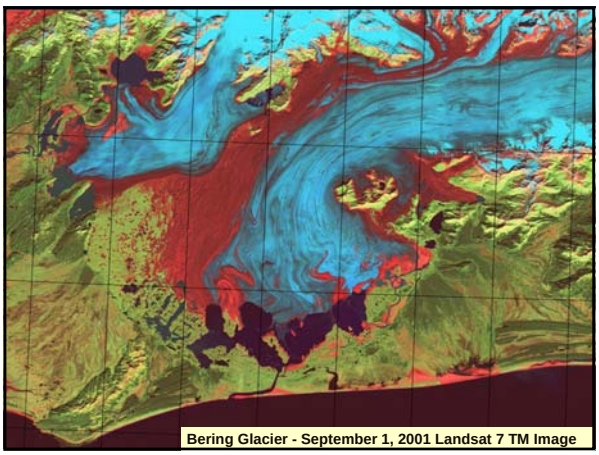
Malaspina Glacier – 2004 - St. Elias Mountains – Typically thins by 1.5 – 2 m / yr.



Granite Range - NW St. Elias Mountains - 2002 - This unnamed glacier is rapidly thinning and retreating. It is typical of most of the glaciers in this region.

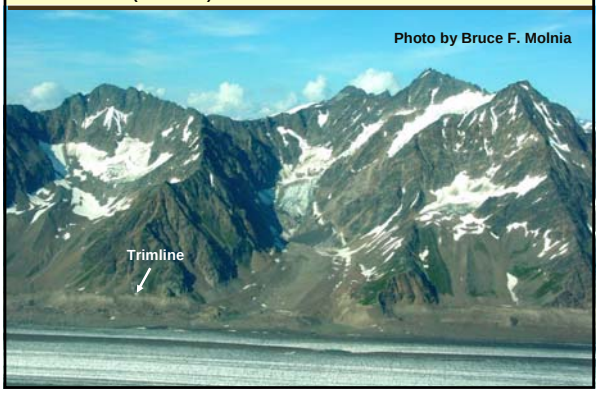
Photo by Bruce F. Molnia



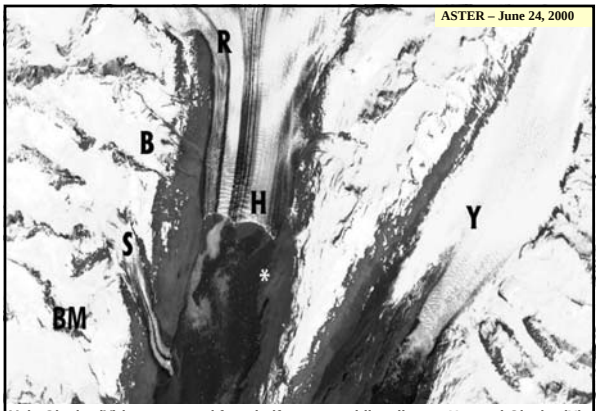


Bering Glacier - September 1, 2001 Landsat 7 TM Image

Unnamed Cirque Glaciers - Chugach Mountains - 2001– These retreating glaciers no longer reach the large valley glacier at the bottom of the photograph. Note the dramatic trimline (see arrow)



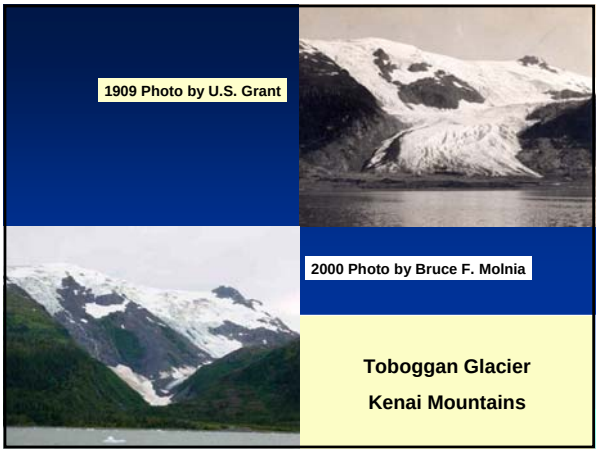
Tana Glacier - Chugach Mountains – 2000 – So much of Tana Glacier has melted away that its terminus is composed of isolated masses of debris-covered stagnant ice, separated by large, water-filed open areas



Yale Glacier (Y) has retreated for a half century while adjacent Harvard Glacier (H) has advanced more than 1 km.


Yale Glacier - Chugach Mountains
Photo by Bruce F. Molnia
2001


1909 Photo by U.S. Grant
2000 Photo by Bruce F. Molnia
Harvard Glacier
Chugach Mountains


1909 Photo by U.S. Grant
2000 Photo by Bruce F. Molnia
Toboggan Glacier
Kenai Mountains


Every glacier ending below an elevation of 1,500 m is retreating, thinning, and/or stagnating.
AVHRR
KENAI MOUNTAINS
~ 4,810 km²

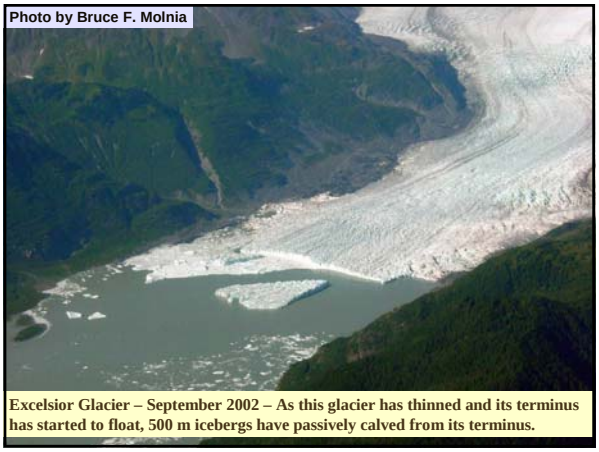
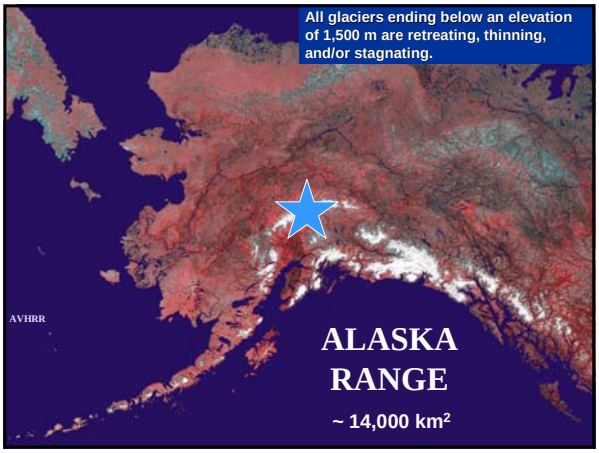


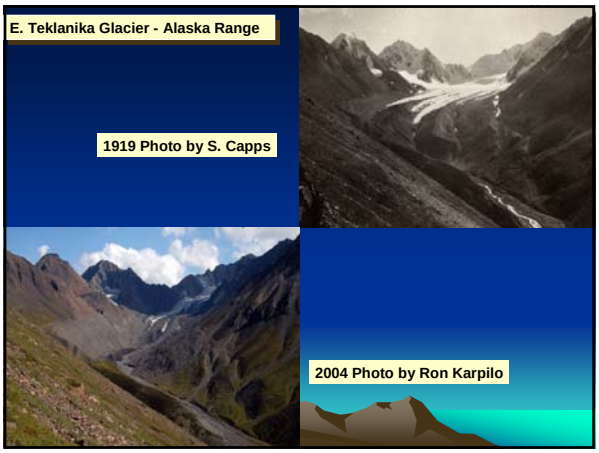
Photo by Bruce F. Molnia
Excelsior Glacier – September 2002 – As this glacier has thinned and its terminus has started to float, 500 m icebergs have passively calved from its terminus.


Unknown Photographer ~ 1920
2005 Photo by Bruce F. Molnia
Bear Glacier
1920 - 2005


Photos by Bruce F. Molnia
Bear Glacier –
September 2002 - August 2005
In less than 3 years, the terminus of Bear Glacier retreated more than 2 km


1909 Photo by U.S. Grant
2004 Photo by Bruce F. Molnia
McCarty Glacier
Kenai Mountains

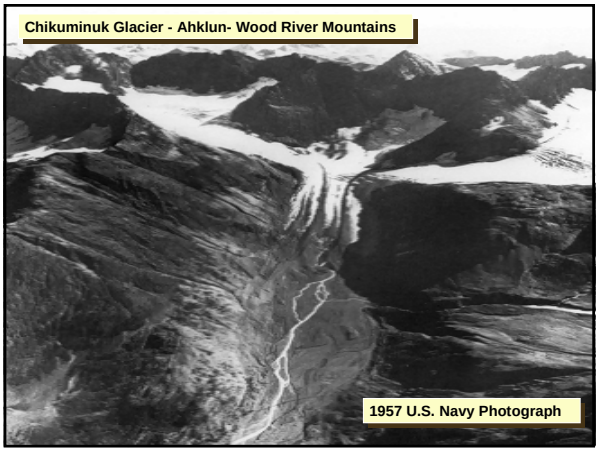

All glaciers ending below an elevation of 1,500 m are retreating, thinning, and/or stagnating.
AVHRR
ALASKA RANGE
~ 14,000 km2


E. Teklanika Glacier - Alaska Range
1919 Photo by S. Capps
2004 Photo by Ron Karpilo


Every glacier is retreating. Many glaciers disappeared during the 20th century.
AVHRR
TALKEETNA MOUNTAINS
~ 1,000 km²


Talkeetna Glacier - Talkeetna Mountains – 2000 – All glaciers in this region are rapidly retreating
Photo by Bruce F. Molnia

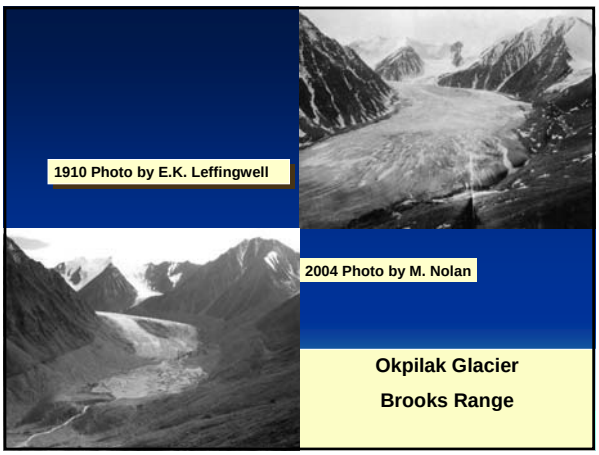

Every glacier is retreating. Some glaciers disappeared during the 20th century.
AVHRR
WOOD RIVER MOUNTAINS
~ 60 km²

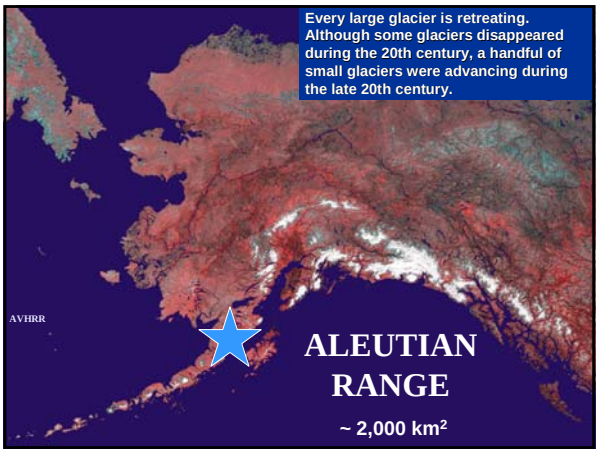

Chikuminuk Glacier - Ahklun- Wood River Mountains
1957 U.S. Navy Photograph


Every glacier is retreating. Some glaciers disappeared during the 20th century.
AVHRR
KIGLUAIK MOUNTAINS
< 1 km²

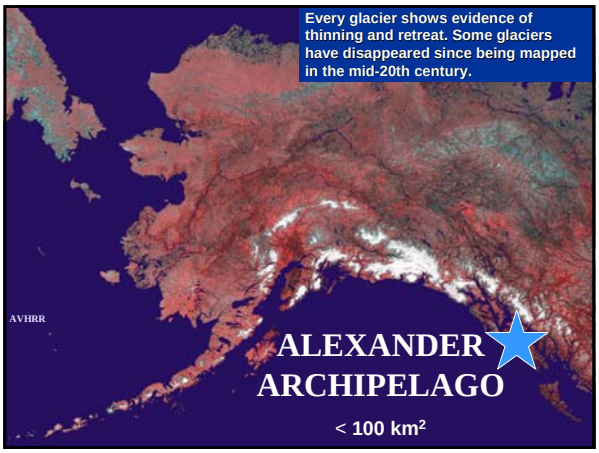

Grand Union Glacier - Kigluaik Mountains
1985 Photo by D. Kaufman

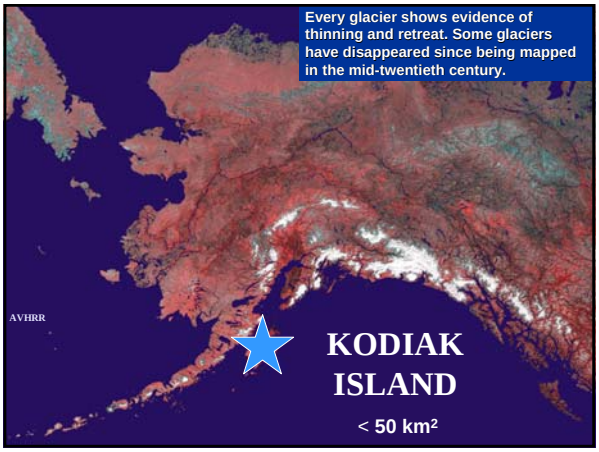

Every glacier is retreating. Some glaciers disappeared during the 20th century.
AVHRR
BROOKS RANGE
< 1,000 km²

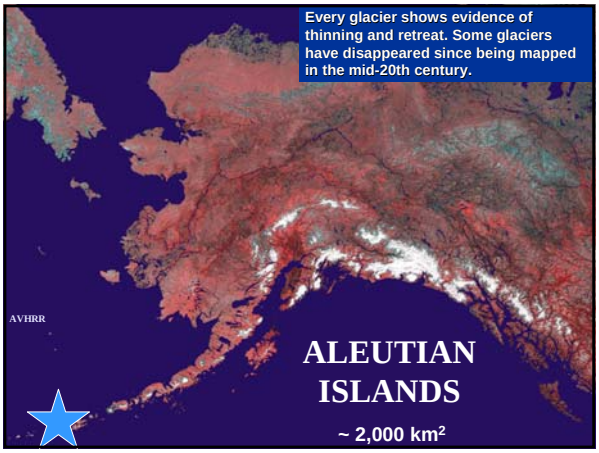

1910 Photo by E.K. Leffingwell
2004 Photo by M. Nolan
Okpilak Glacier
Brooks Range



While the larger glaciers in the Aleutian Range are shrinking, many small glaciers have been advancing.


Every glacier shows evidence of thinning and retreat. Some glaciers have disappeared since being mapped in the mid-20th century.
AVHRR
ALEXANDER ARCHIPELAGO
< 100 km²


Every glacier shows evidence of thinning and retreat. Some glaciers have disappeared since being mapped in the mid-twentieth century.
AVHRR
KODIAK ISLAND
< 50 km²


Every glacier shows evidence of thinning and retreat. Some glaciers have disappeared since being mapped in the mid-20th century.
AVHRR
ALEUTIAN ISLANDS
~ 2,000 km²

CONCLUSIONS

- Every Alaskan mountain range and island group is characterized by significant glacier retreat, thinning, and/or stagnation, especially at lower elevations.
- All but a few glaciers that descent below an elevation of 1,500 m are thinning, stagnating, and/or retreating.
- At some locations, observed glaciers have completely disappeared during the 20th and early 21st century.

- In some areas, retreat that started as early as the early eighteenth century, is continuing into the twenty-first century.
- At some locations, retreat is resulting in the number of glaciers actually increasing, but the volume and area of ice decreasing.
- Glaciers at higher elevations show little or no change.
- Of the nearly 700 named Alaskan glaciers, approximately a dozen are currently advancing.