



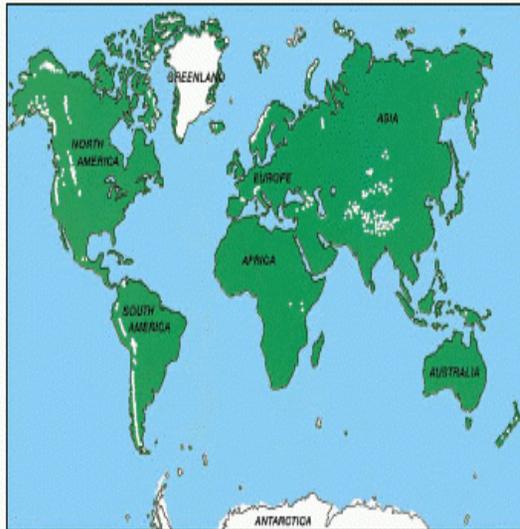
The Alaska Chapter of the *Satellite Image Atlas of Glaciers of the World*

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Satellite Image Atlas of Glaciers of the World



In 1978, the USGS began the preparation of the 11-chapter USGS Professional Paper 1386, "Satellite Image Atlas of Glaciers of the World." Between 1979 and 1981, optimum satellite images were distributed to a team of 70 scientists, representing 25 nations and 45 institutions, who agreed to author sections of the Professional Paper concerning either a geographic area (chapters B-K) or a glaciological topic (included in Chapter A). The scientists used Landsat 1, 2, and 3 multispectral scanner (MSS) images and Landsat 2 and 3 return beam vidicon (RBV) images to inventory the areal occurrence of glacier ice on our planet within the boundaries of the spacecrafts' coverage (between about 82° north and south latitudes). Some later contributors also used Landsat 4 and 5 MSS and Thematic Mapper, Landsat 7 Enhanced Thematic Mapper-Plus (ETM+), and other satellite images. In addition to analyzing images of a specific geographic area, each author was asked to summarize up-to-date information about the glaciers within each area and compare their present-day areal distribution with reliable historical information (from published maps, reports, and photographs) about their past extent. Because of the limitations of Landsat images for delineating or monitoring small glaciers in some geographic areas (the result of inadequate spatial resolution, lack of suitable seasonal coverage, or absence of coverage), some information on the areal distribution of small glaciers was derived from ancillary sources, including other satellite images. Completion of the atlas will provide an accurate regional inventory of the areal extent of glaciers on our planet during a relatively narrow time interval (1972-1981).

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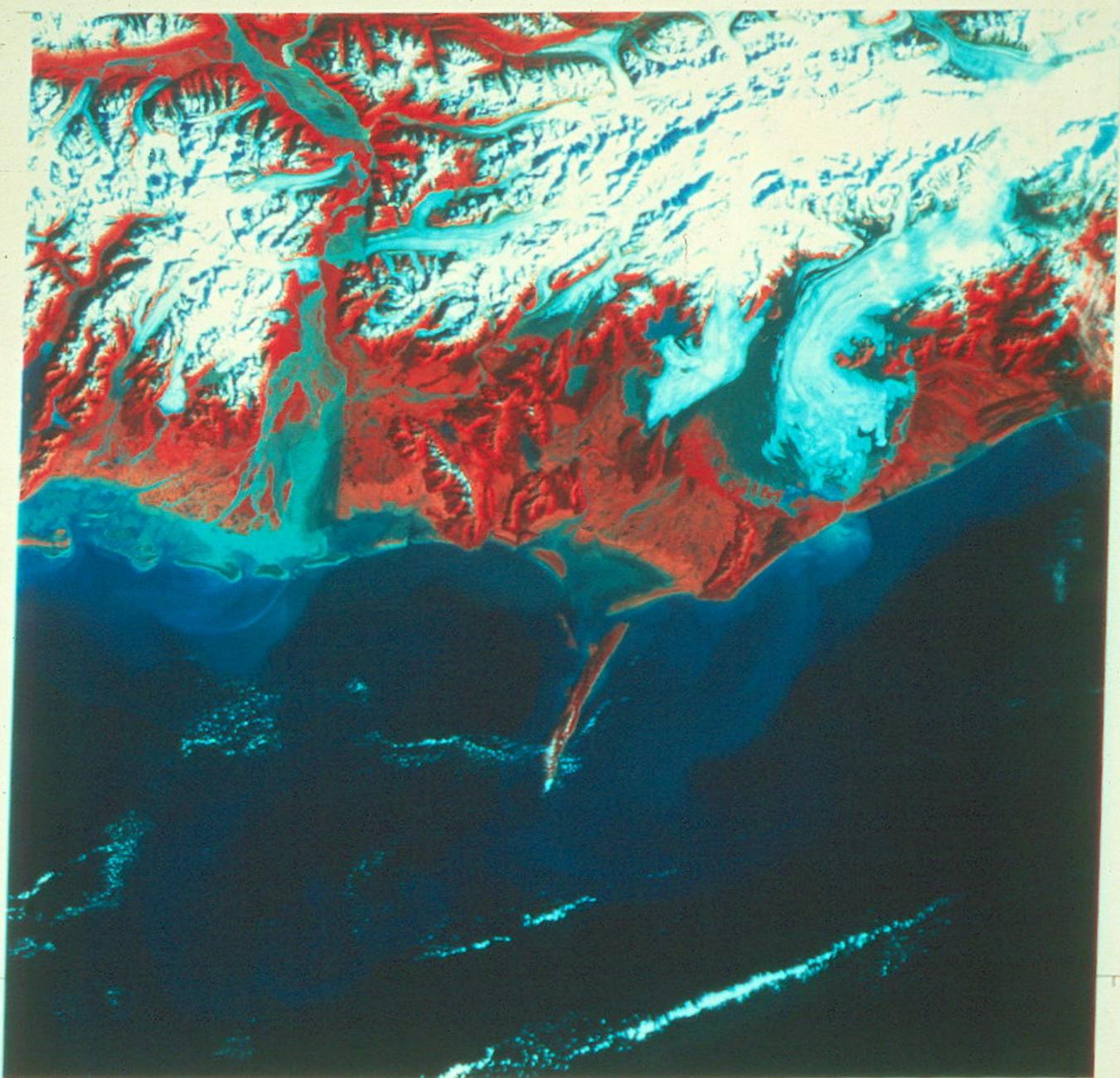
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The 11-chapter *Satellite Image Atlas of Glaciers of the World*, (USGS Professional Paper 1386 A-K), summarizes the behavior of Earth's glacier cover on a continental and sub-continental basis.

The primary data set used to establish a global baseline for determination of glacier terminus positions and changes is digital imagery collected by Landsat Multispectral Scanner (MSS) sensors on the Landsat 1, 2, and 3 satellites, during the first decade of the Landsat Program between 1972 and 1981.

The Alaska chapter, Chapter K, uses a set of 90 Landsat I and II color-composite images compiled by the author from the Landsat data holdings of the EROS Data Center, Sioux Falls, SD.

The data set consists of an individual color-composite Landsat image for each glacierized Alaskan path-row point.



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Chapter K also contains prospective and retrospective information, extending the descriptions of the behavior of individual glaciers from the Little Ice Age to the present.

The Alaska Chapter describes each of Alaska's 14 regions that currently support glaciers. In most areas analyzed, every glacier that descends below an elevation of ~ 1,500 m is currently retreating, thinning, or stagnating.



1. Coast Range
2. Saint Elias Range
3. Chugach Mountains
4. Kenai Mountains
5. Alaska Range
6. Talkeetna Mts
7. Wood River Mts
8. Kigluaik Mountains
9. Brooks Range
10. Aleutian Range
11. Wrangell Mountains
12. Alexander Archipelago
13. Aleutian Islands
14. Kodiak Island

ALASKAN GLACIER REGIONS

Most Alaskan glaciers have an uninterrupted history of continuous post-Little-Ice-Age retreat. In the Coast Mountains, St. Elias Mountains, and the Chugach Mountains more than a dozen large glaciers are currently advancing and thickening. Some have been expanding for more than a 100 years.

This presentation summarizes the findings of the Alaska Chapter and documents the complexities and natural variability of the response of Alaskan glaciers to changing regional climate.

Alaska has a glacier cover of ~ 75,000 km², with > 50,000 glaciers.

Only ~ 650 of these glaciers have been officially named.

Alaska's glaciers range in size from tiny cirque glaciers (< 1 km²) to massive piedmont glaciers such as Bering Glacier and Malaspina Glacier (each > 5,000 km²), each larger than the State of Rhode Island.

Data Sources

- **Published Descriptions of Glaciers** 1794 - present
- **Historic and Modern Maps** 1794 - present
- **Aerial Photography** 1926 - present
- **Ground-based Photography** 1883 - present
- **Airborne Radar** 1981 - 1991
- **Satellite Radar** 1978 - present
- **Space Photography** 1960 - present
- **Multi-Spectral Satellite Imagery** 1972 - present
- **Meteorological Data** 1947 –present
- **ASTER** 1999 - present
- **Proxy Data**

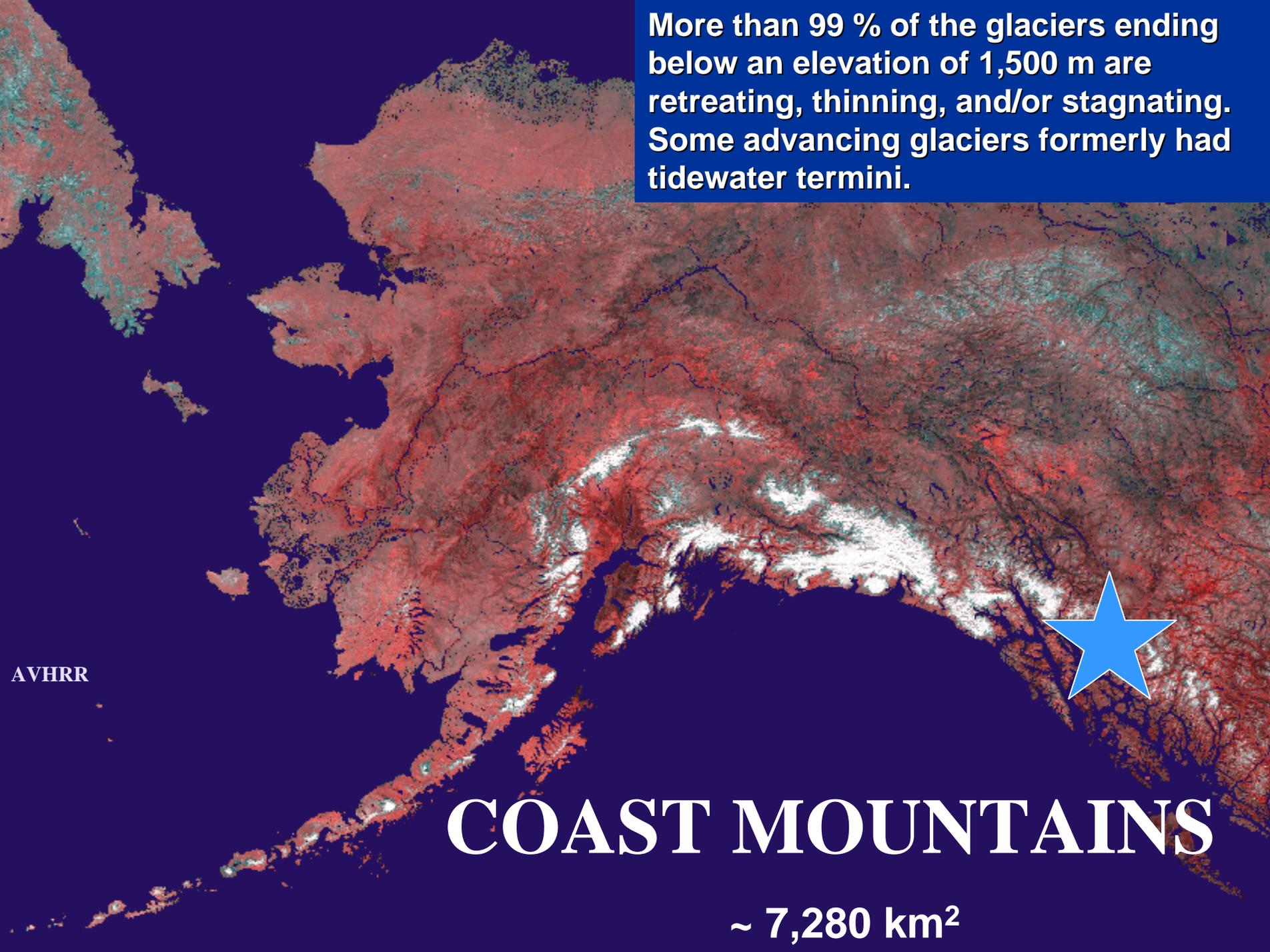
- **Author's Aerial and Field Observations** 1968 - present



1. Coast Range
2. Saint Elias Range
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ALASKAN GLACIER REGIONS

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

South Sawyer Glacier - Coast Mountains



2002

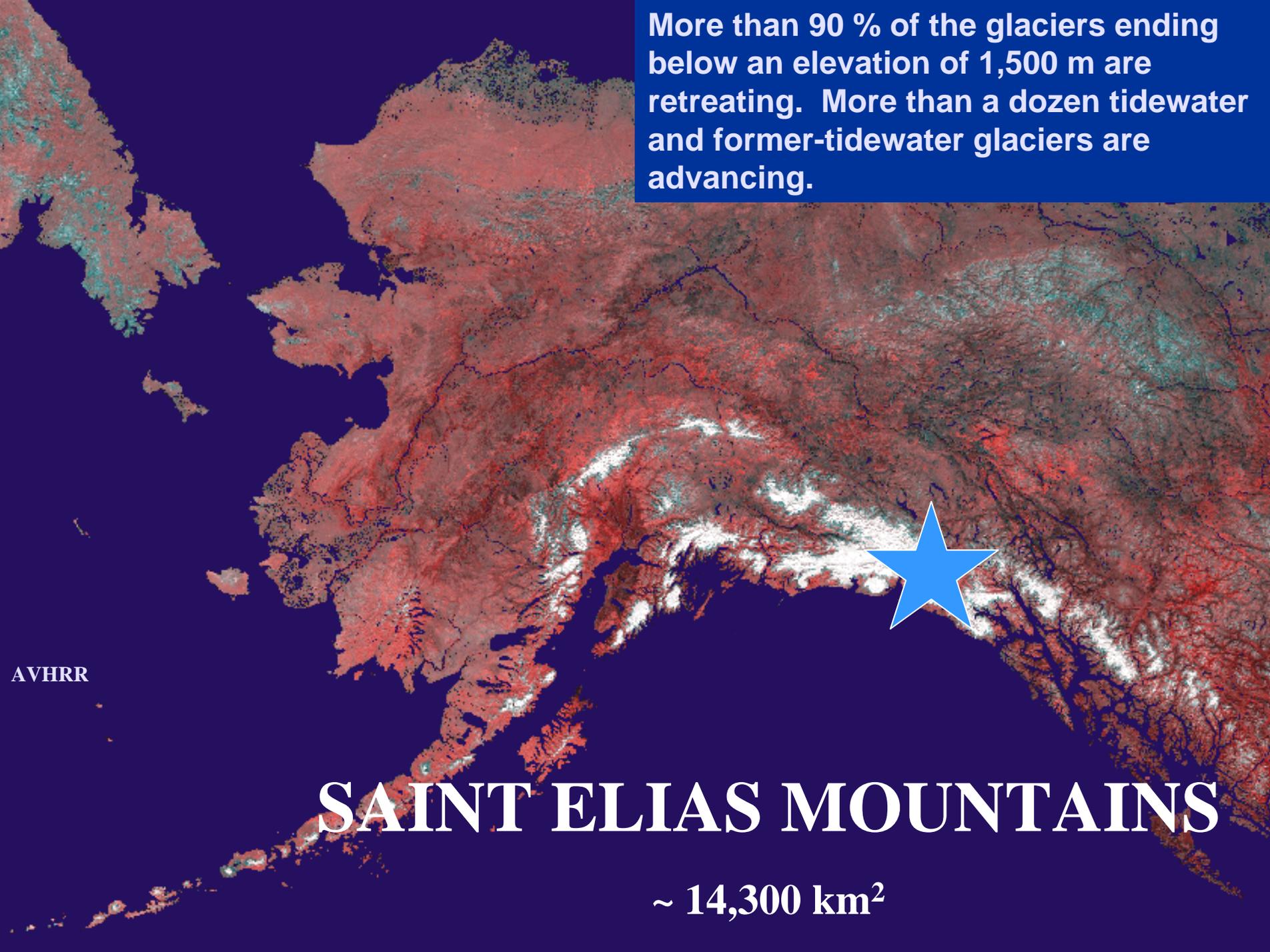
Taku and Norris Glaciers - Coast Mountains



2004



Mendenhall Glacier –Coast Mountains - 2004

A satellite map of the Saint Elias Mountains in Alaska, showing a complex network of glaciers. The map uses a color palette where white and light blue represent snow and ice, while darker colors represent land and water. A large blue star is positioned in the lower right quadrant of the mountain range, highlighting a specific area of interest. The text in the top right corner provides statistical information about glacier retreat and advance.

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

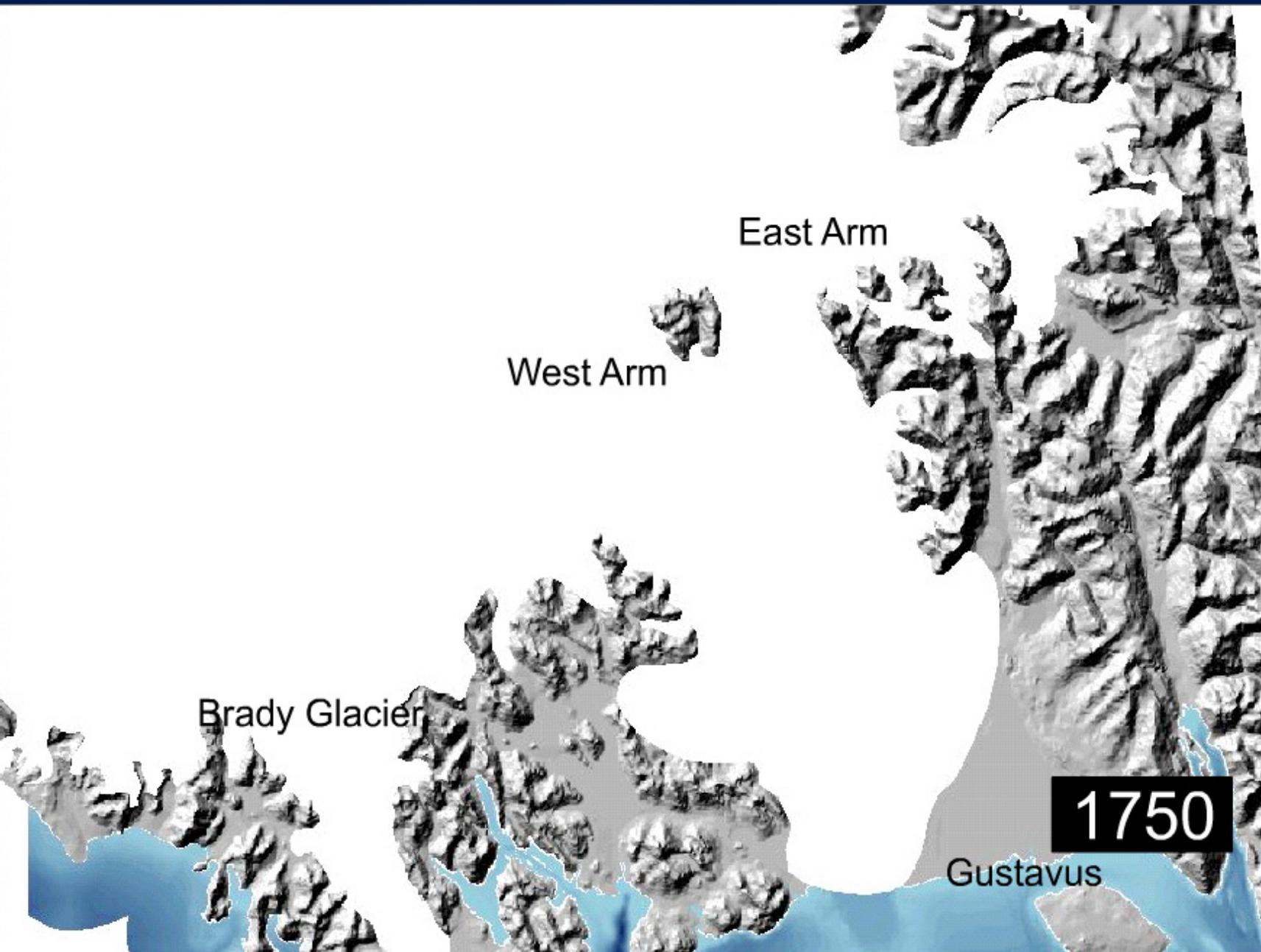
SAINT ELIAS MOUNTAINS

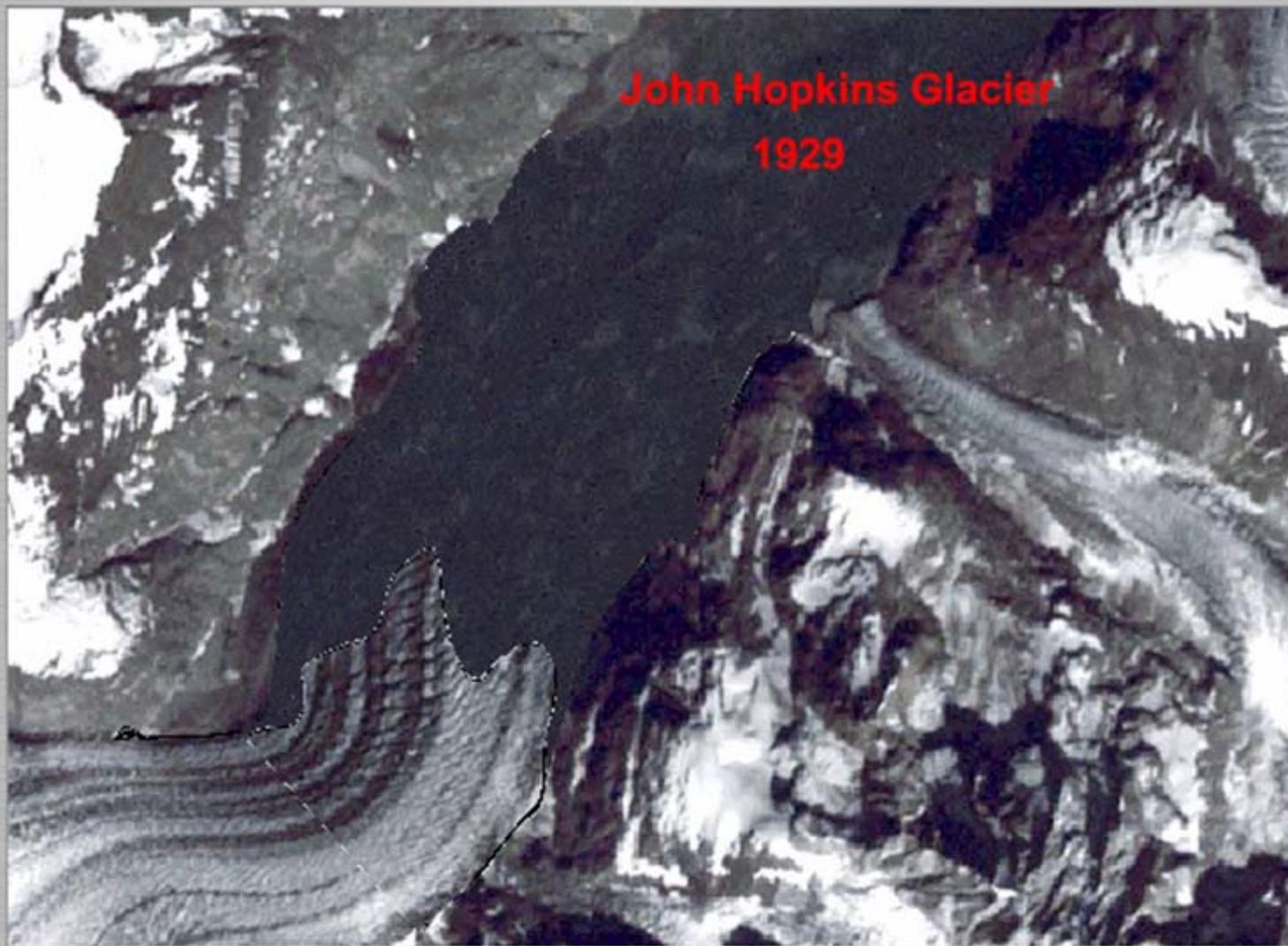
~ 14,300 km²

GLACIER BAY - August 2003



MODIS





00:00:00



AIR PHOTOGRAPHS







**Plateau Glacier
1961 – 2003**

LANDSAT 7
August 2000 – 2001

30 m pixel

2000

1980

1960

1940

M

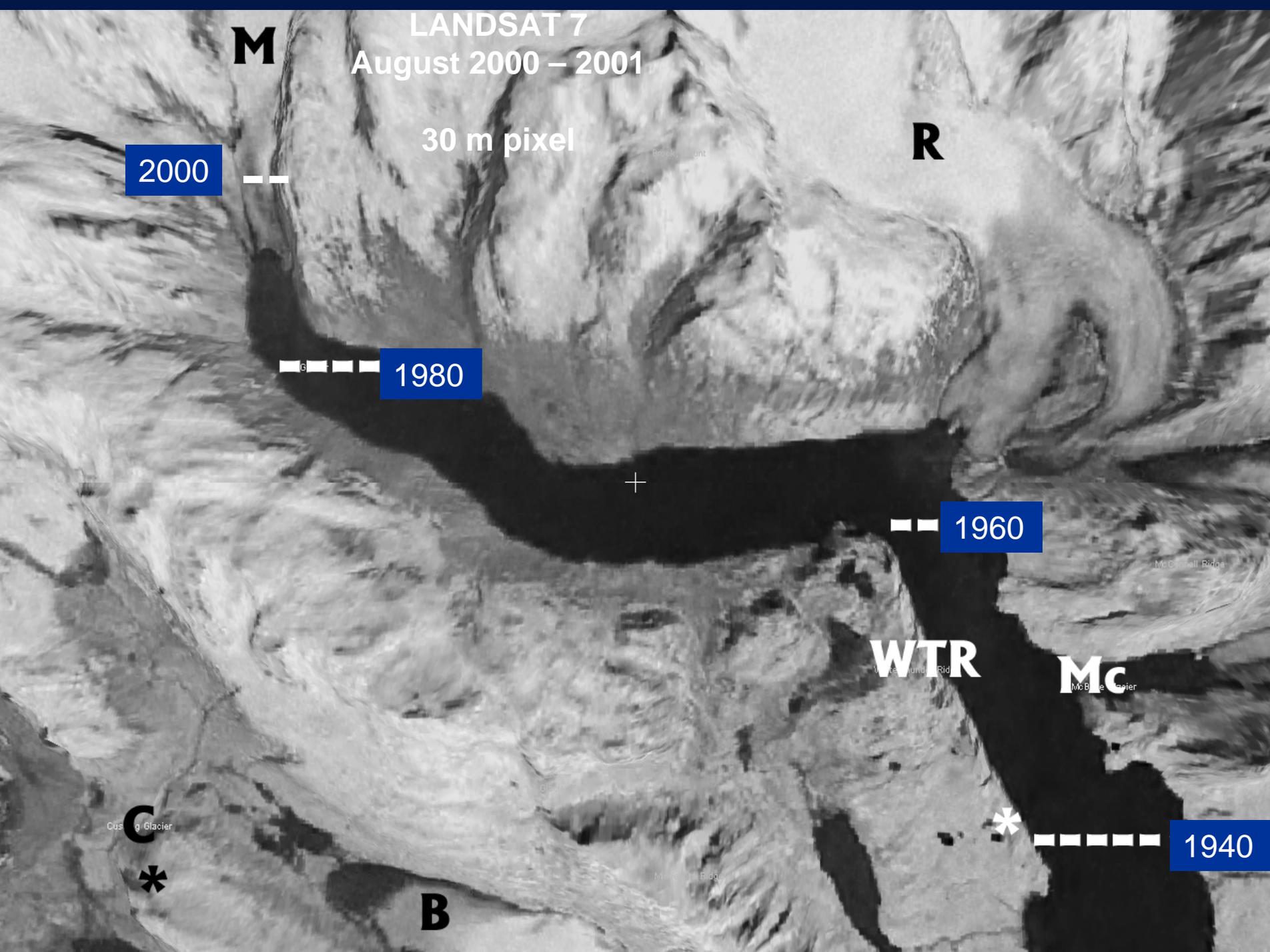
R

WTR

Mc

C

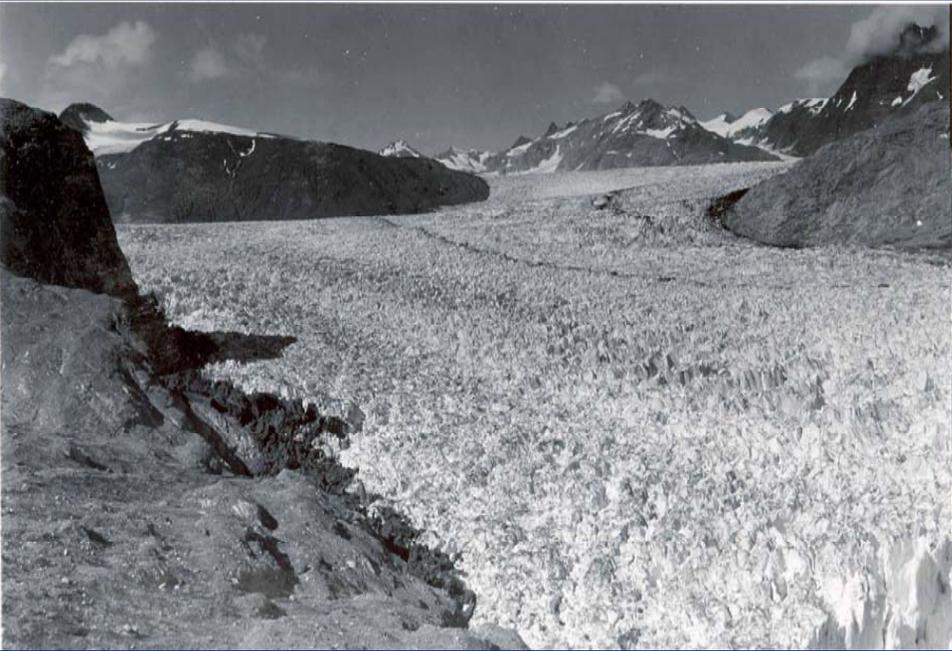
B



Muir Inlet & Glacier 1941 - W.O. Field







Muir Glacier and Inlet
Riggs Glacier
1941-2004









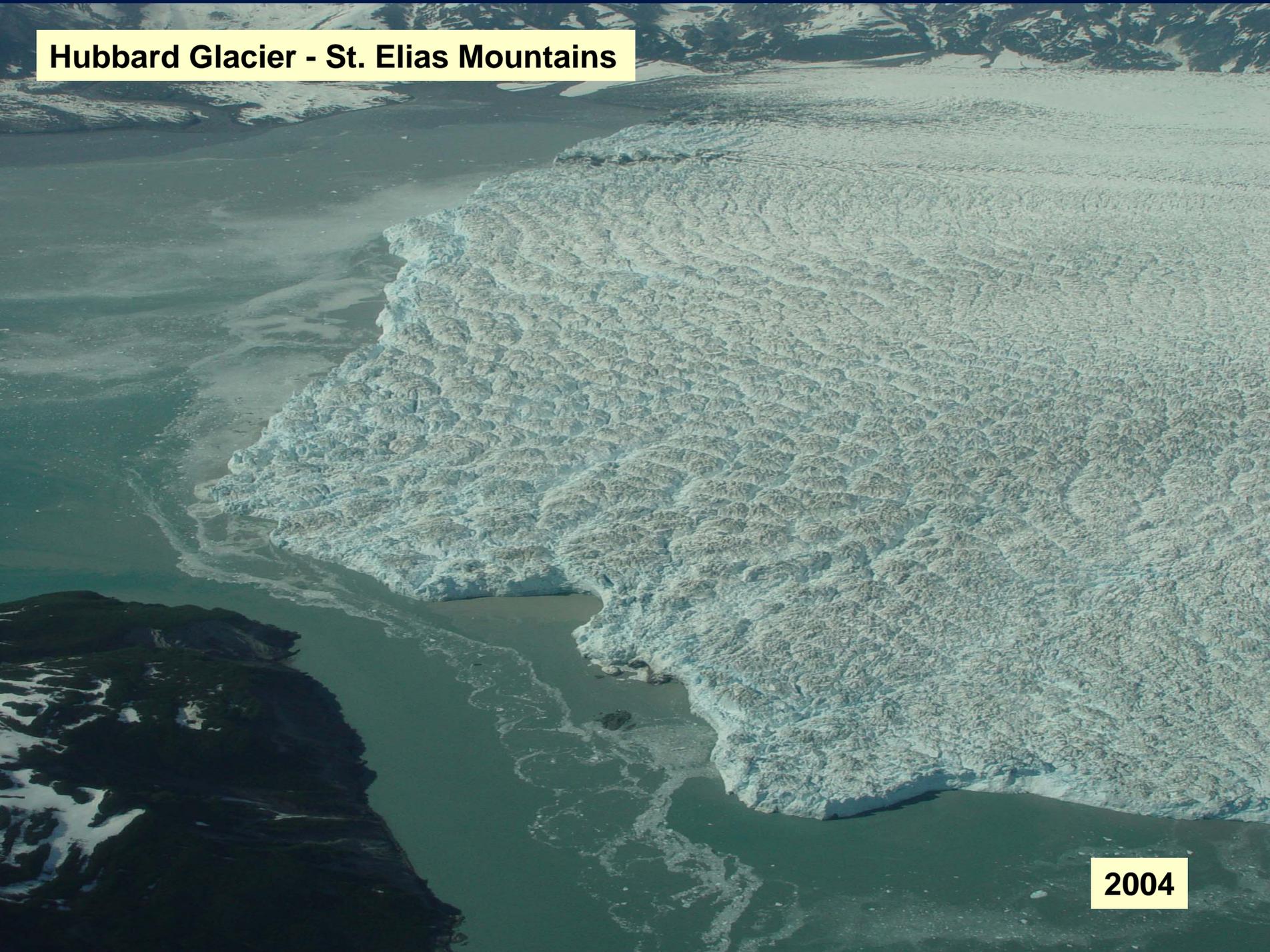
Muir Glacier
1976 – 2003





Yakutat Glacier – July 2005

Hubbard Glacier - St. Elias Mountains



2004

Malaspina Glacier - St. Elias Mountains



2004

Icy Bay

ASTER

June 6, 2001

15 m pixel

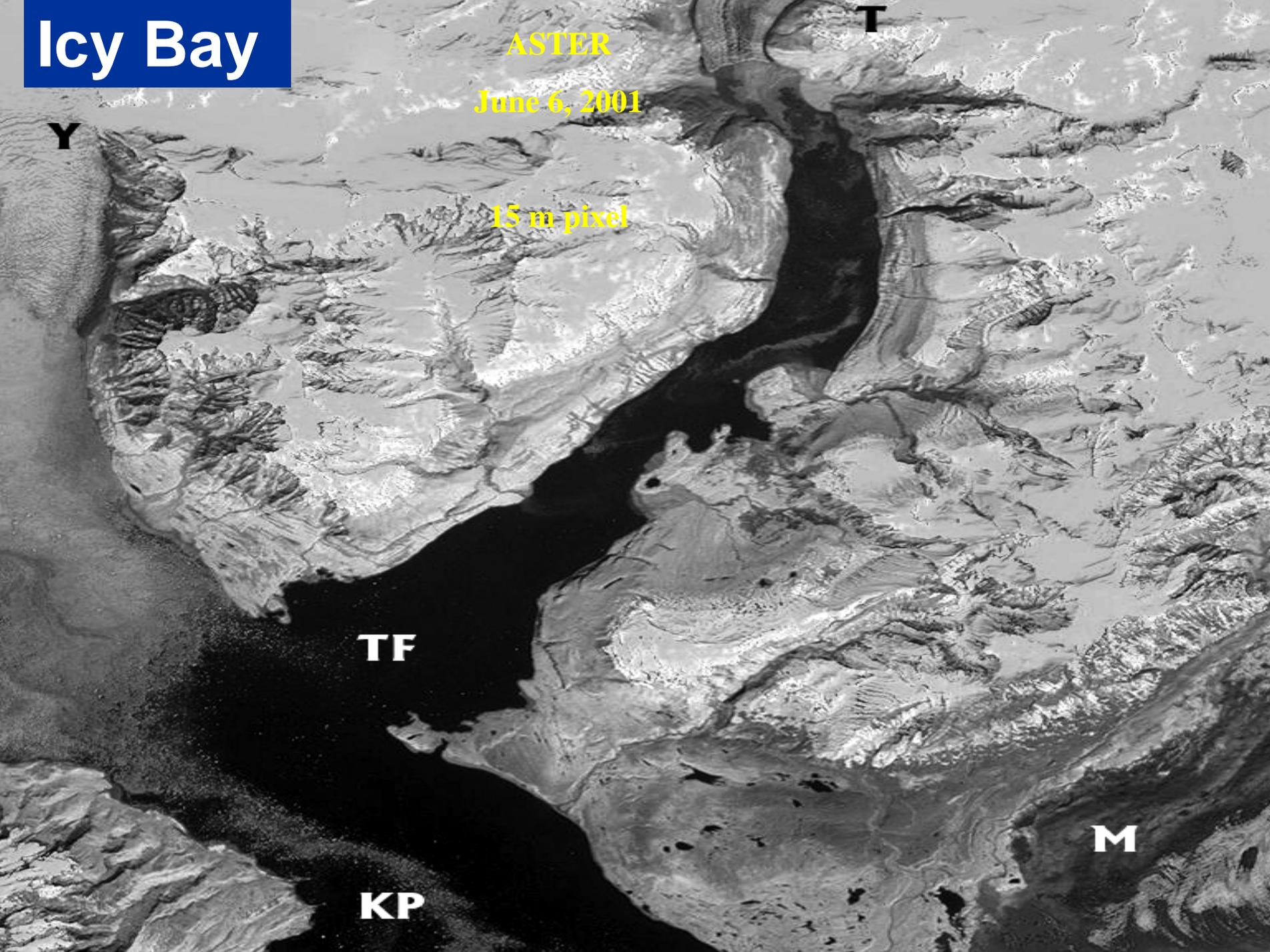
Y

T

TF

M

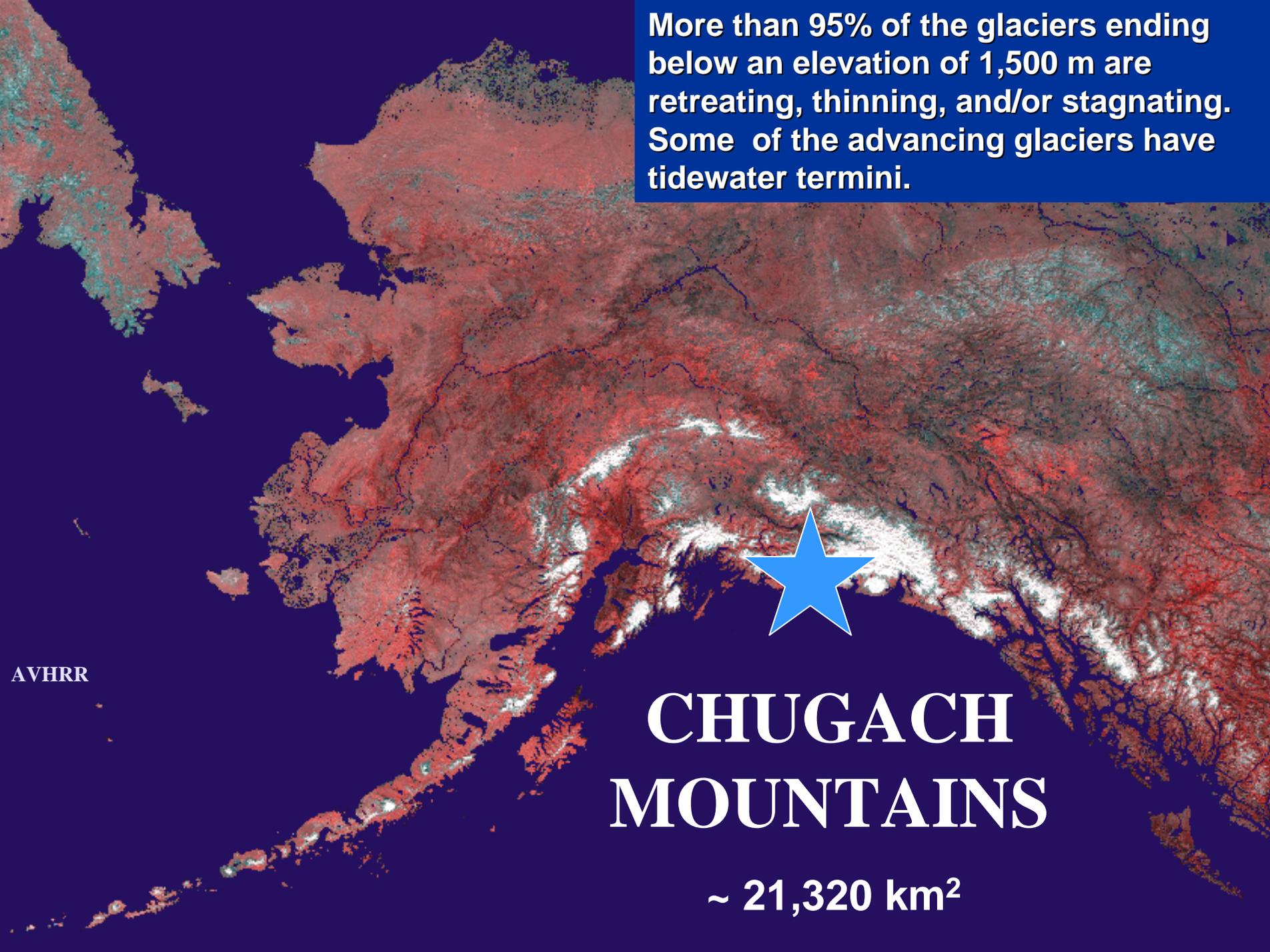
KP



Granite Range - NW St. Elias Mountains



2002



More than 95% of the glaciers ending below an elevation of 1,500 m are retreating, thinning, and/or stagnating. Some of the advancing glaciers have tidewater termini.

AVHRR

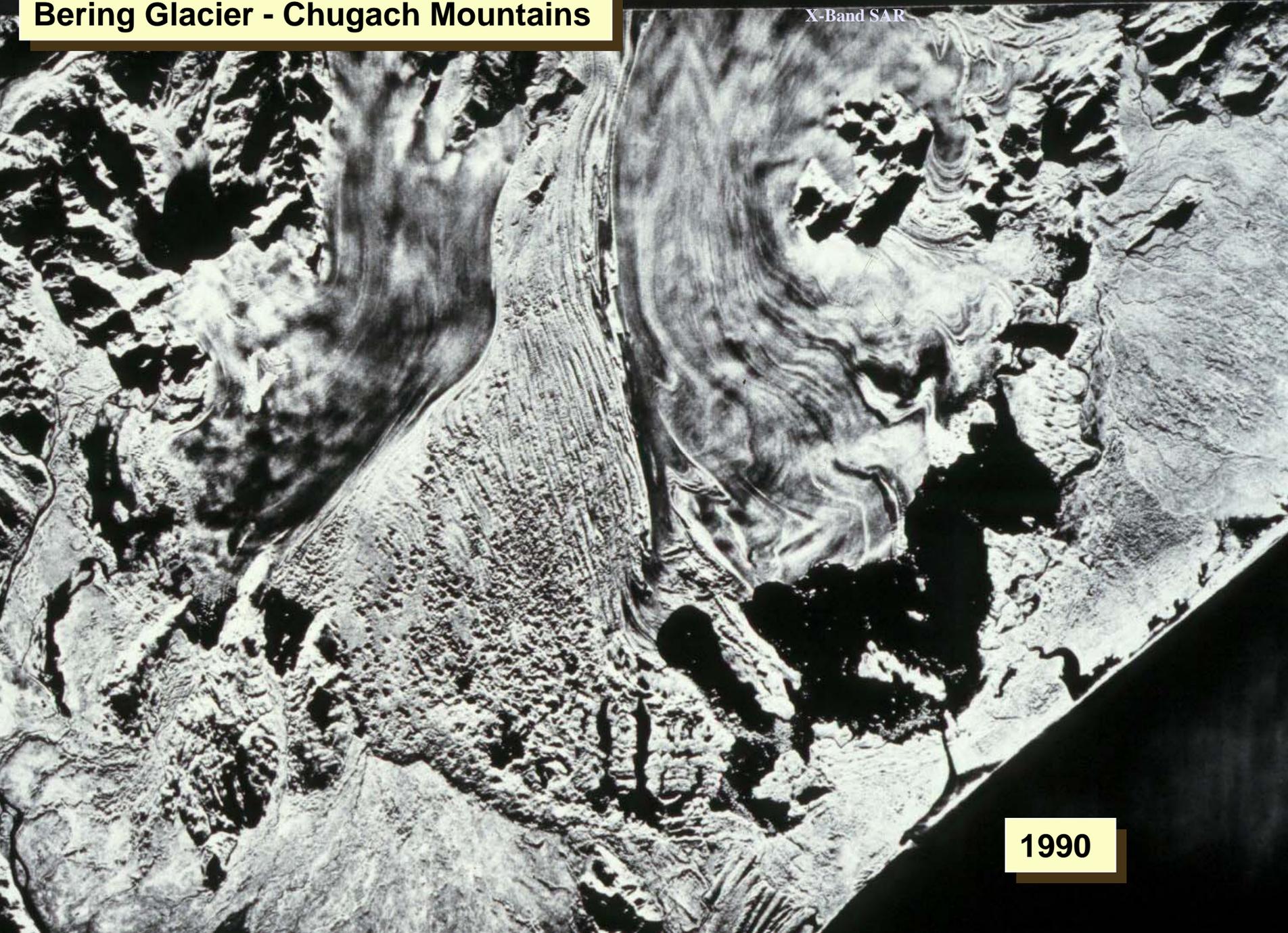


CHUGACH MOUNTAINS

~ 21,320 km²

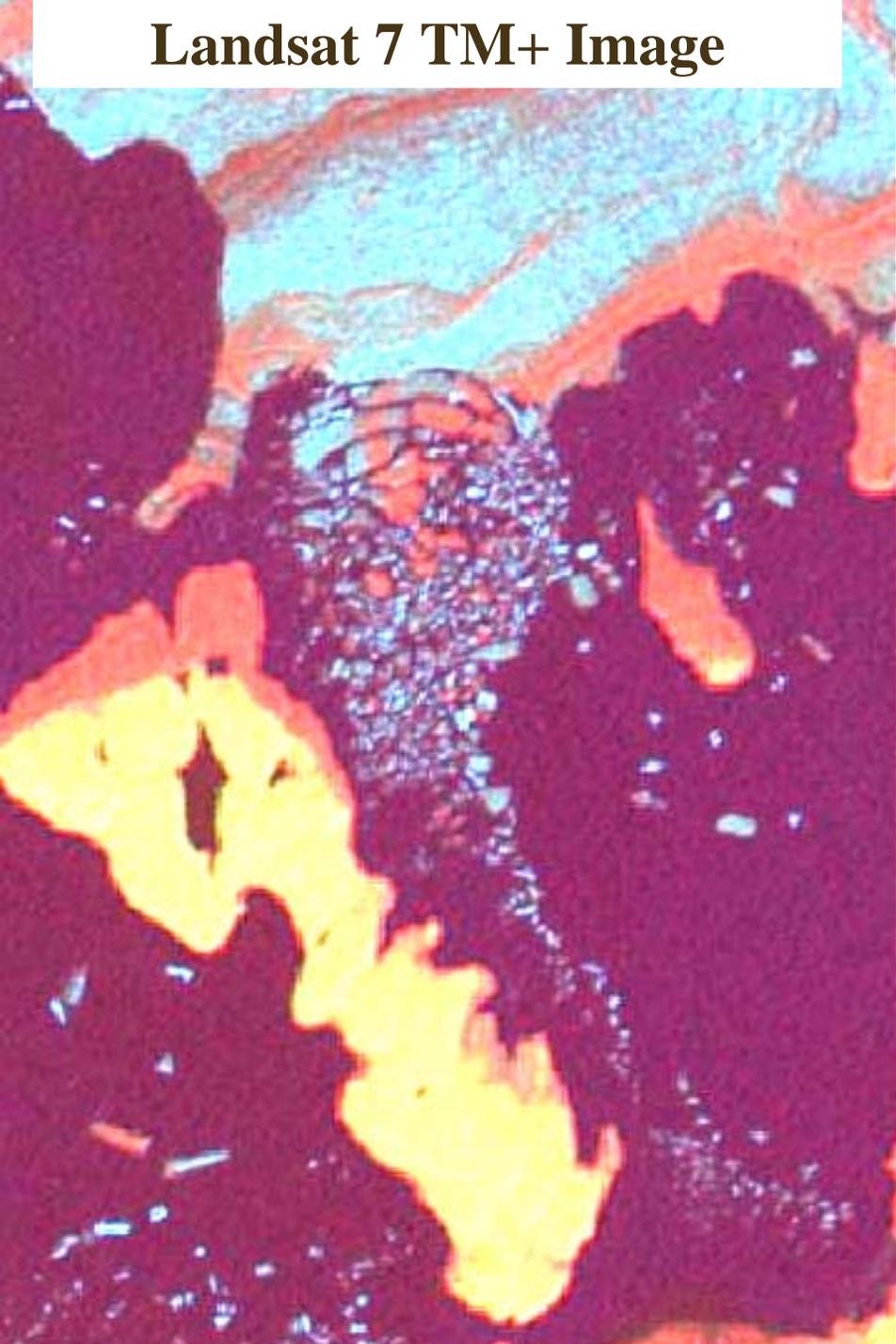
Bering Glacier - Chugach Mountains

X-Band SAR



1990

Landsat 7 TM+ Image



Disarticulation is a process in which a number of very large, generally tabular pieces of a glacier (icebergs) are passively separated from its terminus or lateral margin regions, often simultaneously, usually without the release of large quantities of energy.

Bering Glacier - Chugach Mountains



2002

Unnamed Cirque Glaciers - Chugach Mountains

2001





Head of the Landslide - Photograph by Ruedi Homberger)

Tana Glacier - Chugach Mountains

2000





R

B

S

BM

H

Y

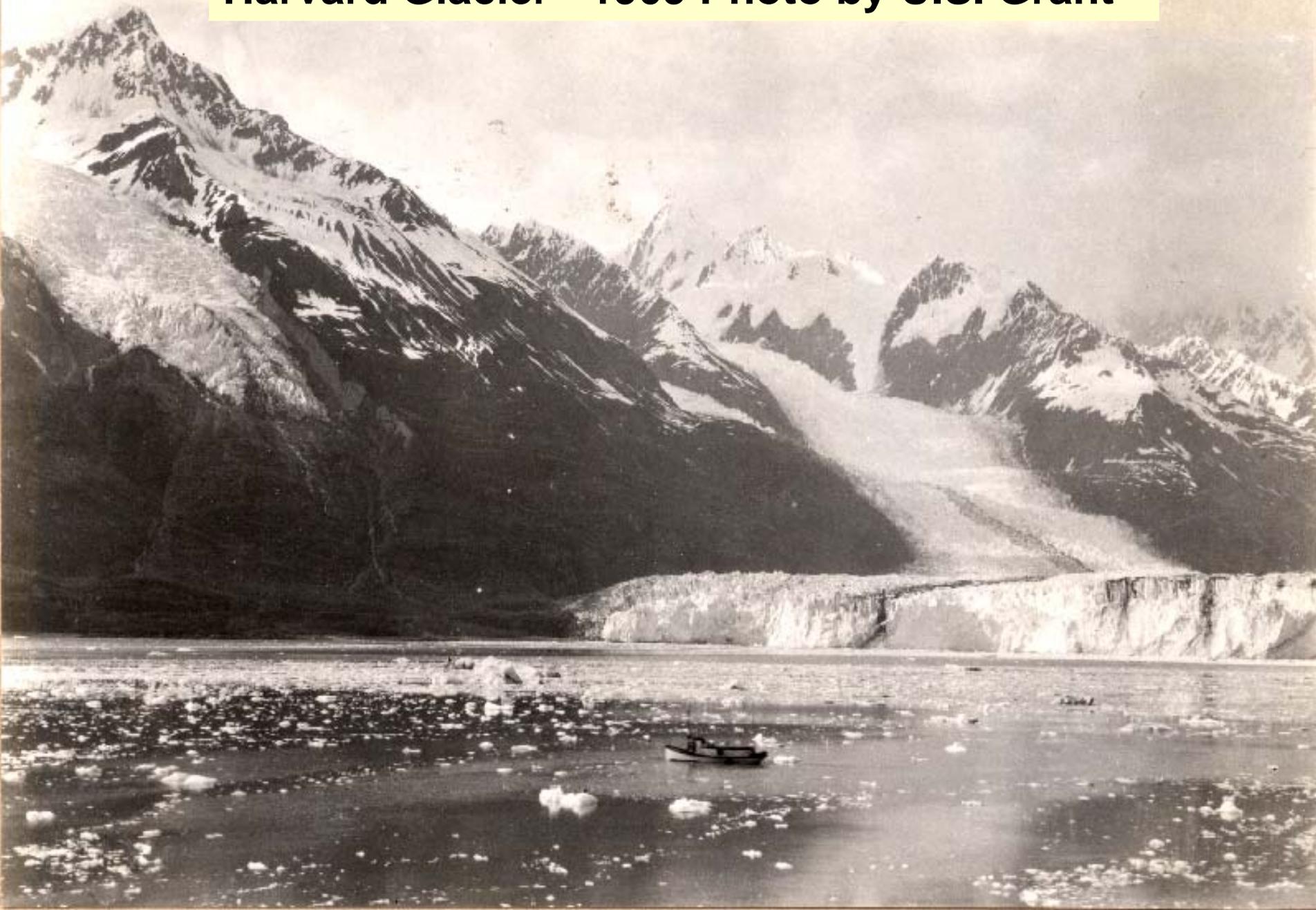
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Yale Glacier - Chugach Mountains

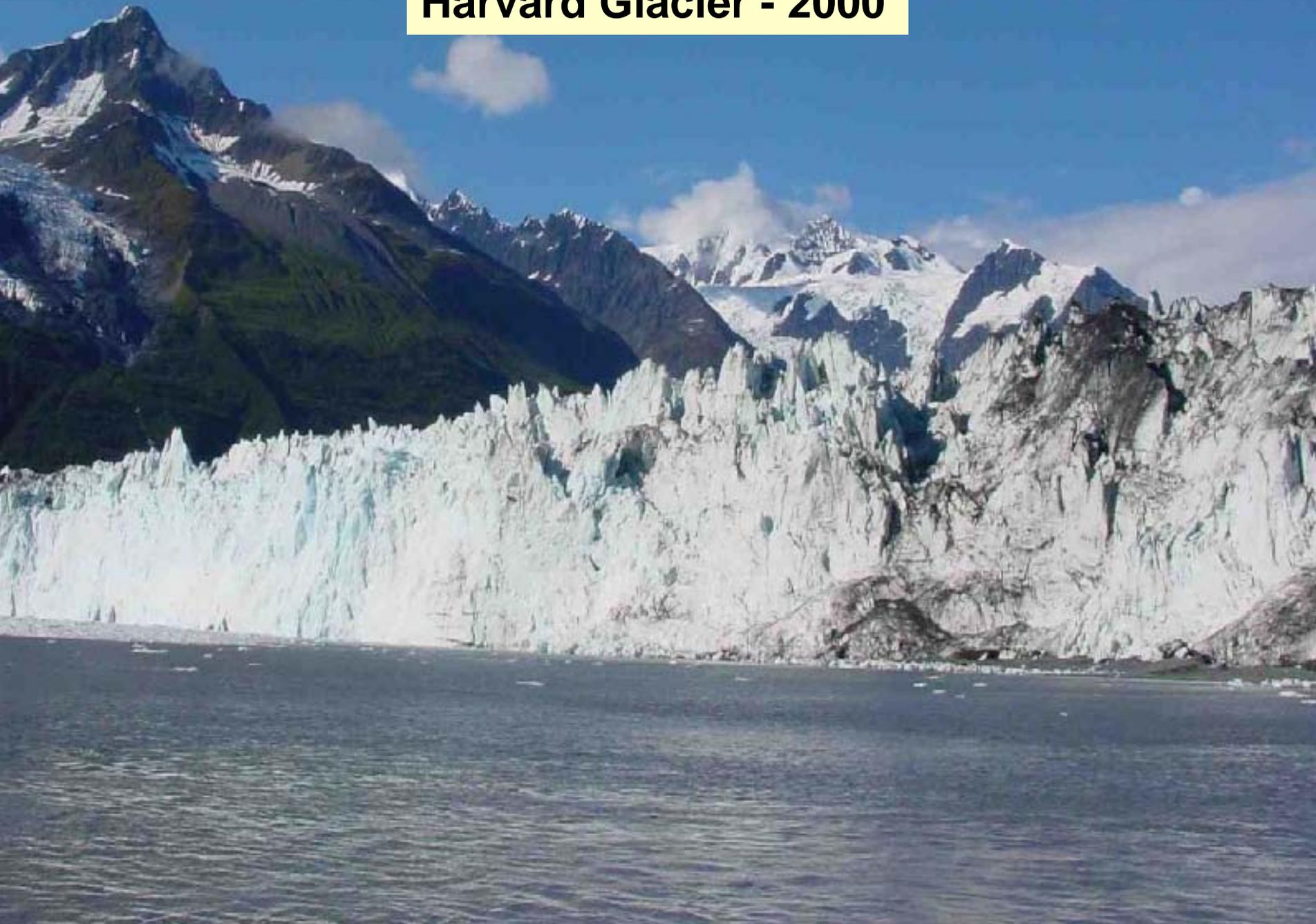


2001

Harvard Glacier - 1909 Photo by U.S. Grant



Harvard Glacier - 2000



1909 Photo by U.S. Grant



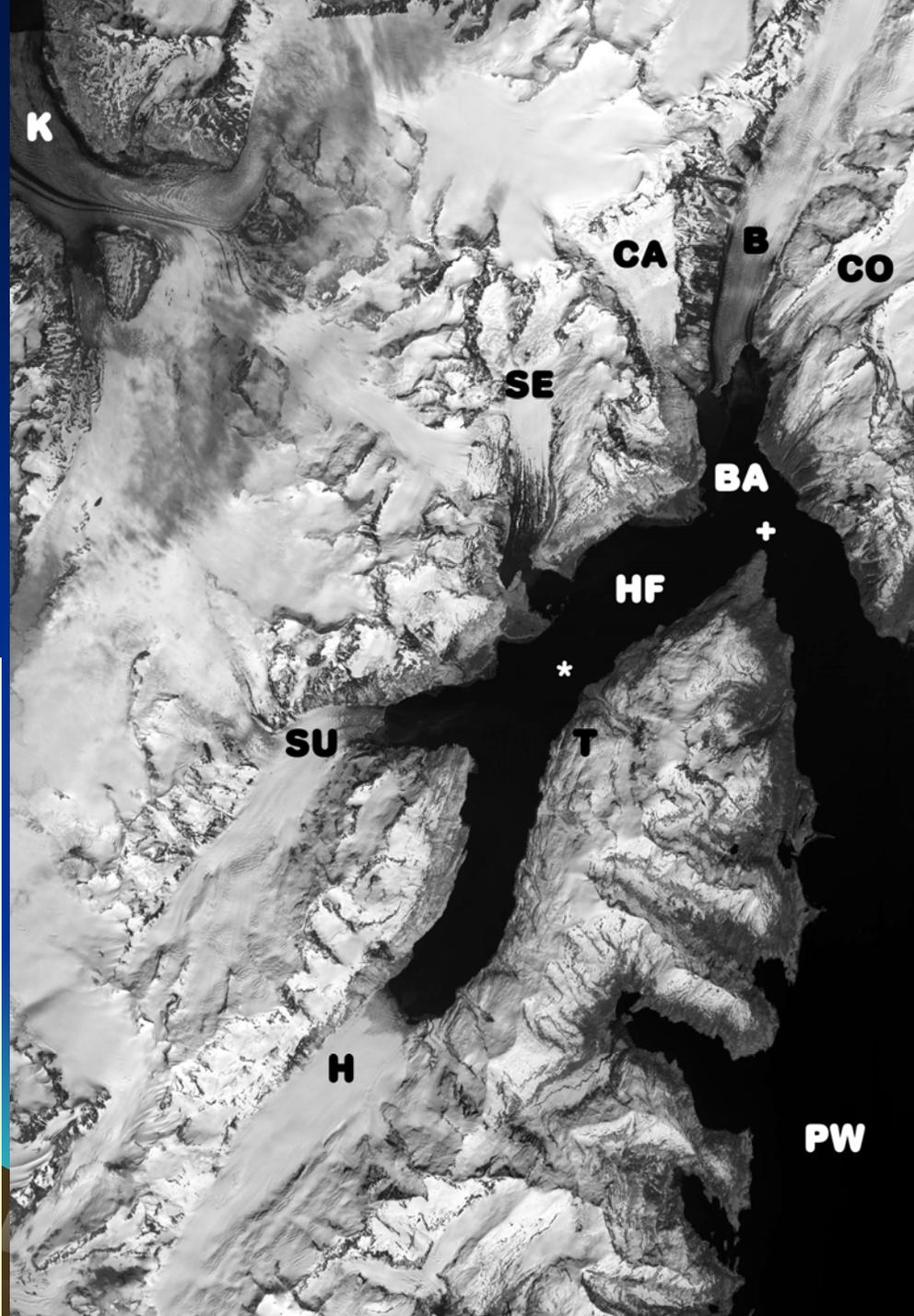
2000



**Harvard Glacier
Chugach Mountains**

HARRIMAN FIORD

ASTER – June 24, 2000



Toboggan Glacier - 1909 Photo by U.S. Grant



Toboggan Glacier - 2000



1909 Photo by U.S. Grant



2000



**Toboggan Glacier
Kenai Mountains**

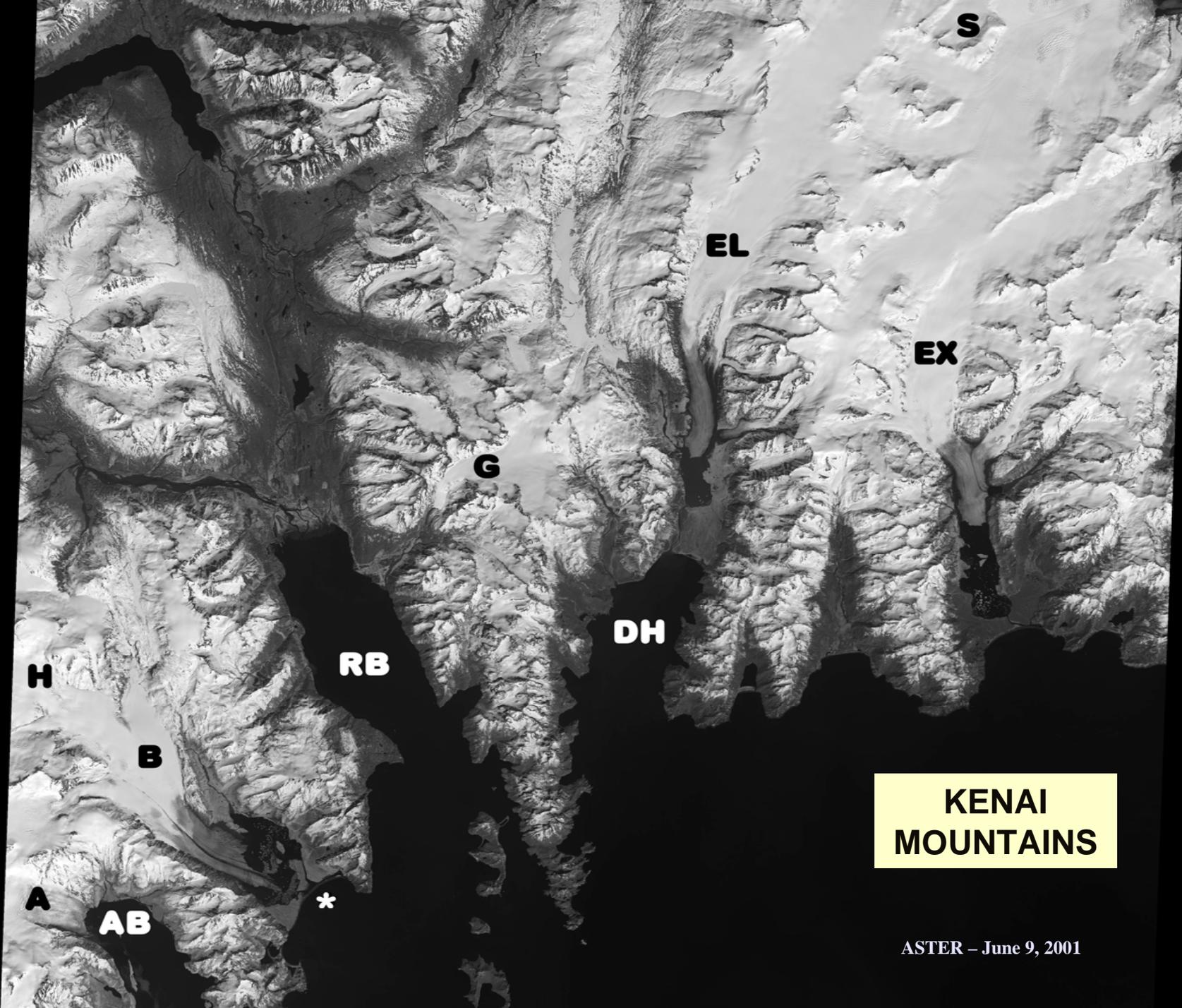
Every glacier ending below an elevation of 1,500 m is retreating, thinning, and/or stagnating.



AVHRR

KENAI MOUNTAINS

~ 4,810 km²



**KENAI
MOUNTAINS**

ASTER - June 9, 2001



Excelsior Glacier – September 2002

Bear Glacier - 1909-2005



AB

Bear Glacier

ASTER – June 9, 2001



RB



Bear Glacier – September 2002



Bear Glacier –August 2005



**Bear Glacier –
September 2002 - August 2005**



McCarty Glacier - 1909 Photo by U.S. Grant



McCarty Fiord - 2004



1909 Photo by U.S. Grant



2004



**McCarty Glacier
Kenai Mountains**

Holgate Glacier, 1909 - 2005



Northwestern Glacier, 1909 - 2004



All glaciers ending below an elevation of 1,500 m are retreating, thinning, and/or stagnating.



AVHRR

**ALASKA
RANGE**

~ 14,000 km²

1919 Photo by S. Capps



2004 Photo by R. Karpilo



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.



TALKEETNA MOUNTAINS

~ 1,000 km²

AVHRR

Talkeetna Glacier - Talkeetna Mountains



2000

Every glacier is retreating. Some glaciers disappeared during the 20th century.

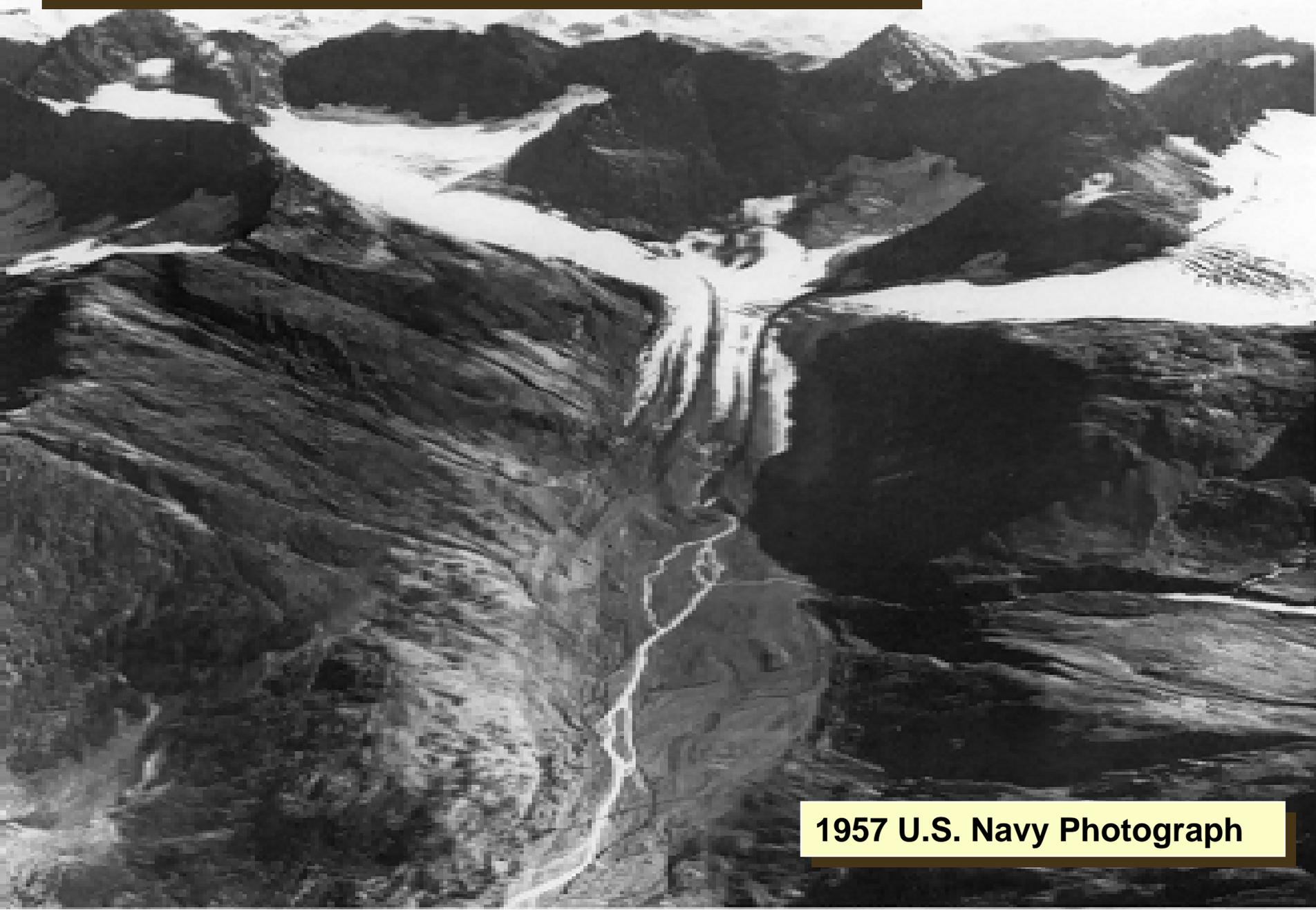


AVHRR

WOOD RIVER MOUNTAINS

~ 60 km²

Chikuminuk Glacier - Ahklun- Wood River Mountains



1957 U.S. Navy Photograph

Every glacier is retreating. Some glacier disappeared during the 20th century.



KIGLUAIK MOUNTAINS

< 1 km²

AVHRR

Grand Union Glacier - Kigluaik Mountains



1985 Photo by D. Kaufman

Every glacier is retreating. Some glacier disappeared during the 20th century.



AVHRR

**BROOKS
RANGE**

< 1,000 km²

1910 Photo by E.K. Leffingwell

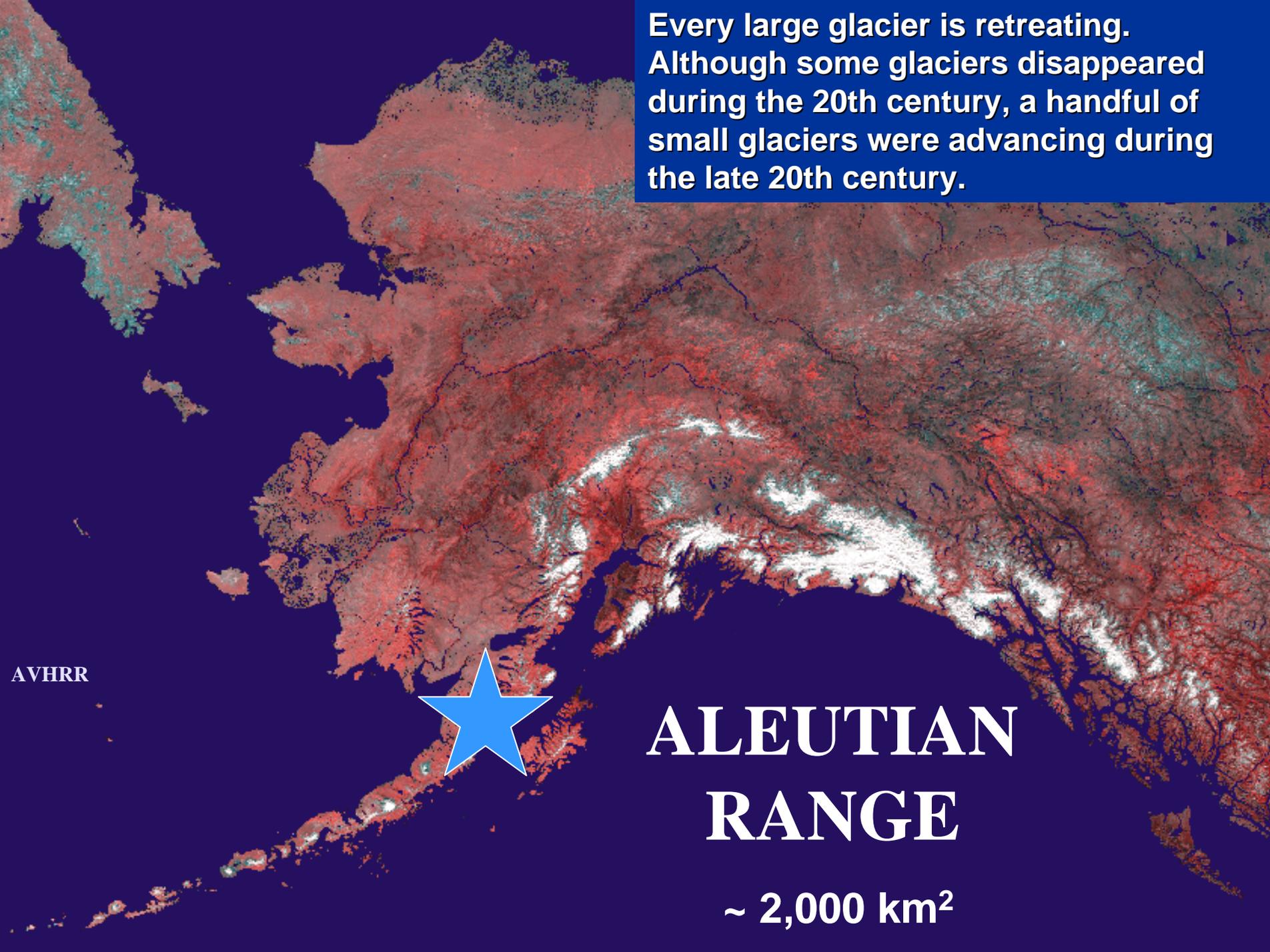


2004 Photo by M. Nolan



**Okpilak Glacier
Brooks Range**

Every large glacier is retreating. Although some glaciers disappeared during the 20th century, a handful of small glaciers were advancing during the late 20th century.



AVHRR

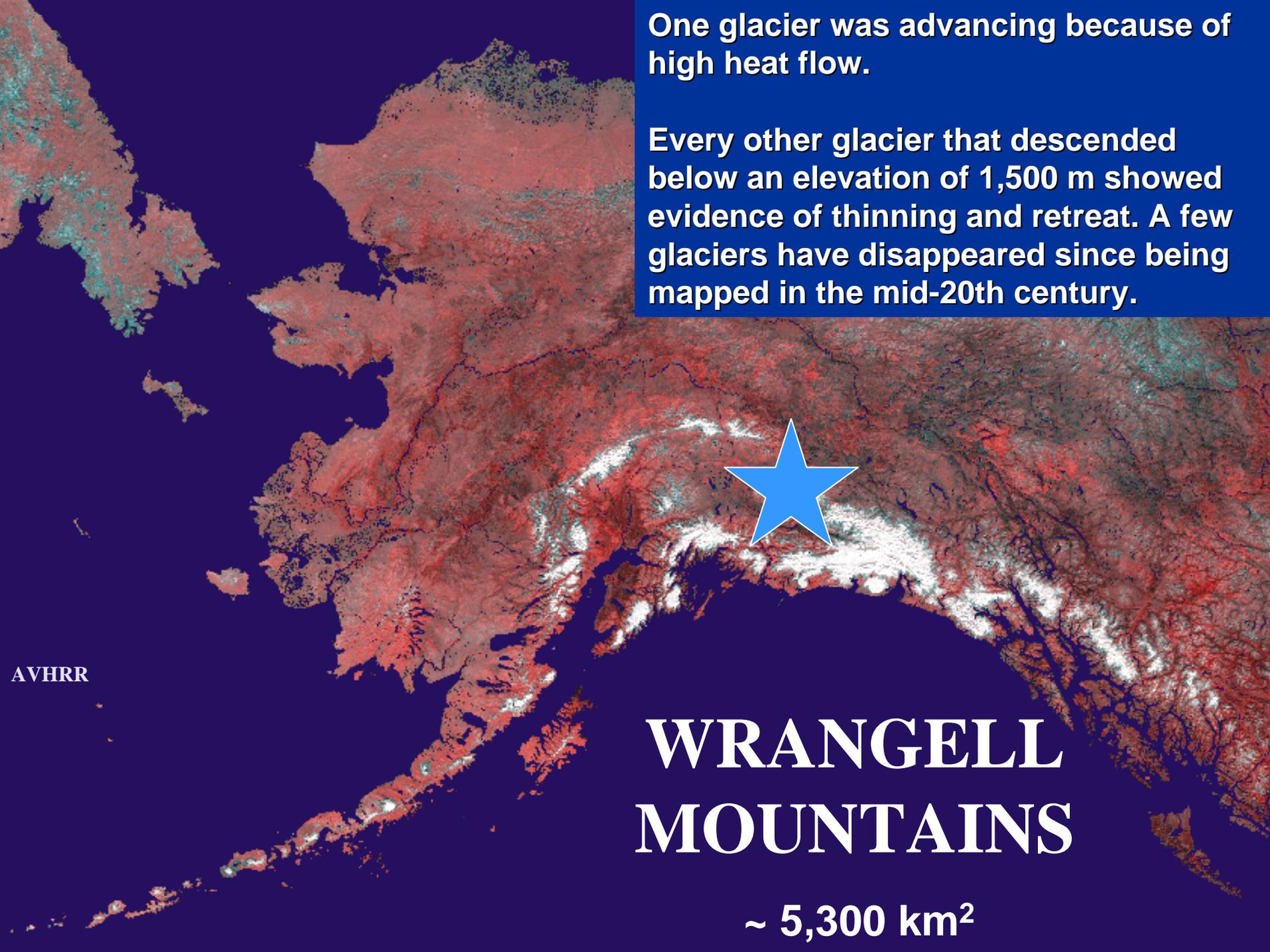


**ALEUTIAN
RANGE**

~ 2,000 km²

Aleutian Range

GF



One glacier was advancing because of high heat flow.

Every other glacier that descended below an elevation of 1,500 m showed evidence of thinning and retreat. A few glaciers have disappeared since being mapped in the mid-20th century.



**WRANGELL
MOUNTAINS**

~ 5,300 km²

AVHRR

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



- The Alaska Chapter of the *Satellite Image Atlas of Glaciers of the World*, (USGS Professional Paper 1386 A-K), will be published later this year.
- It will present a summary of glacier behavior in every mountain range and island group in Alaska.

- **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.**