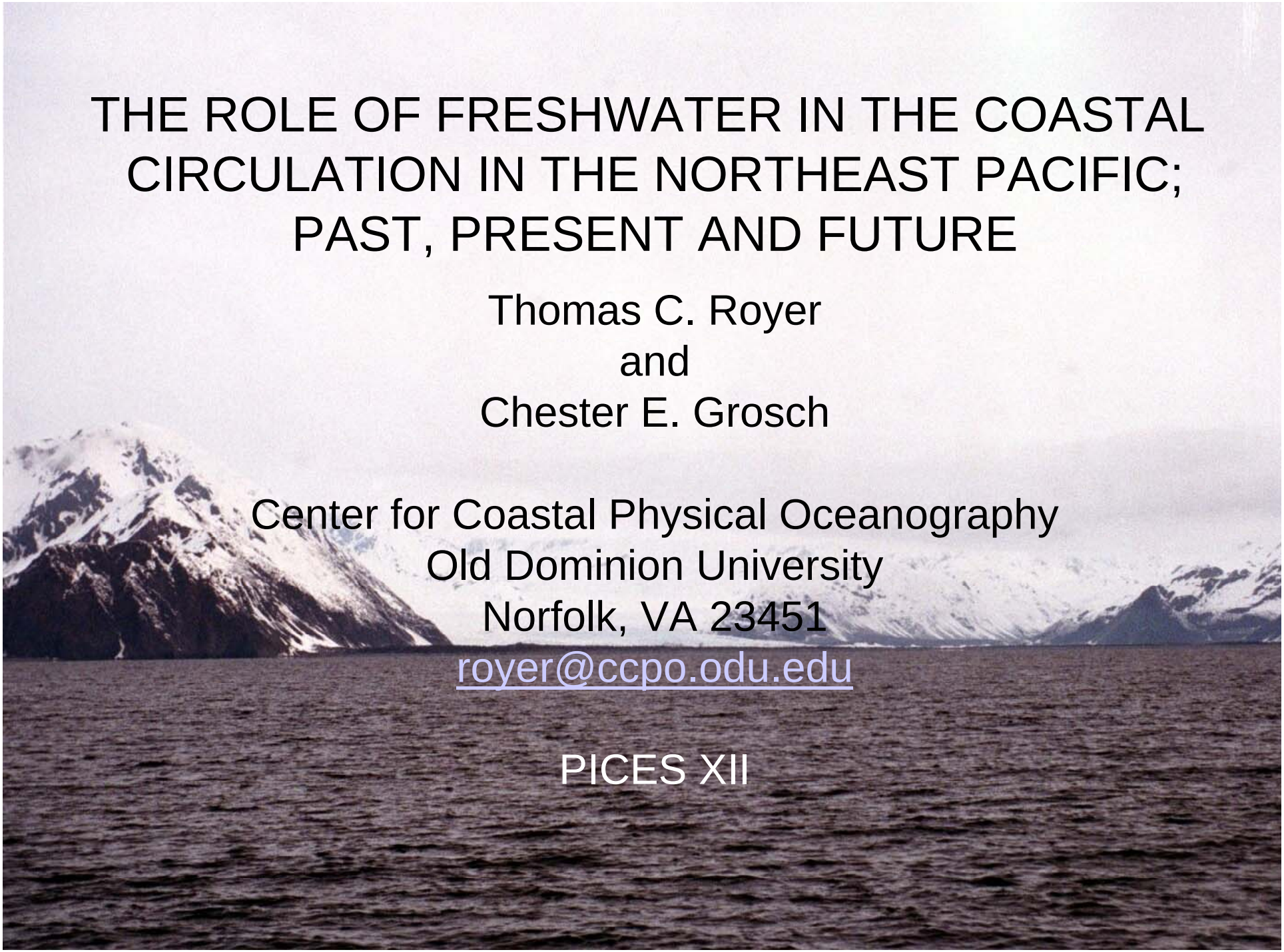


THE ROLE OF FRESHWATER IN THE COASTAL CIRCULATION IN THE NORTHEAST PACIFIC; PAST, PRESENT AND FUTURE

Thomas C. Royer
and
Chester E. Grosch

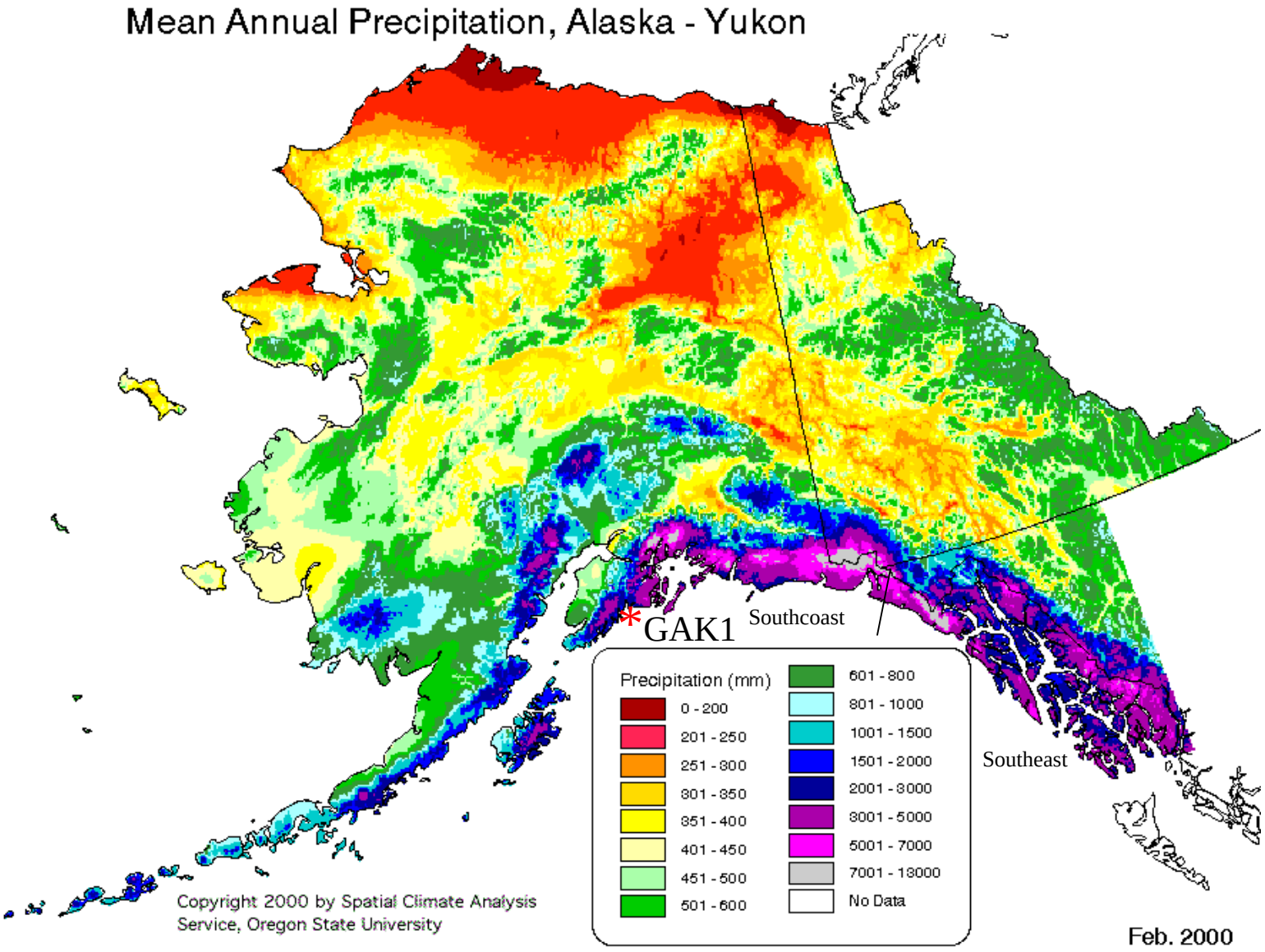
Center for Coastal Physical Oceanography
Old Dominion University
Norfolk, VA 23451
royer@ccpo.odu.edu

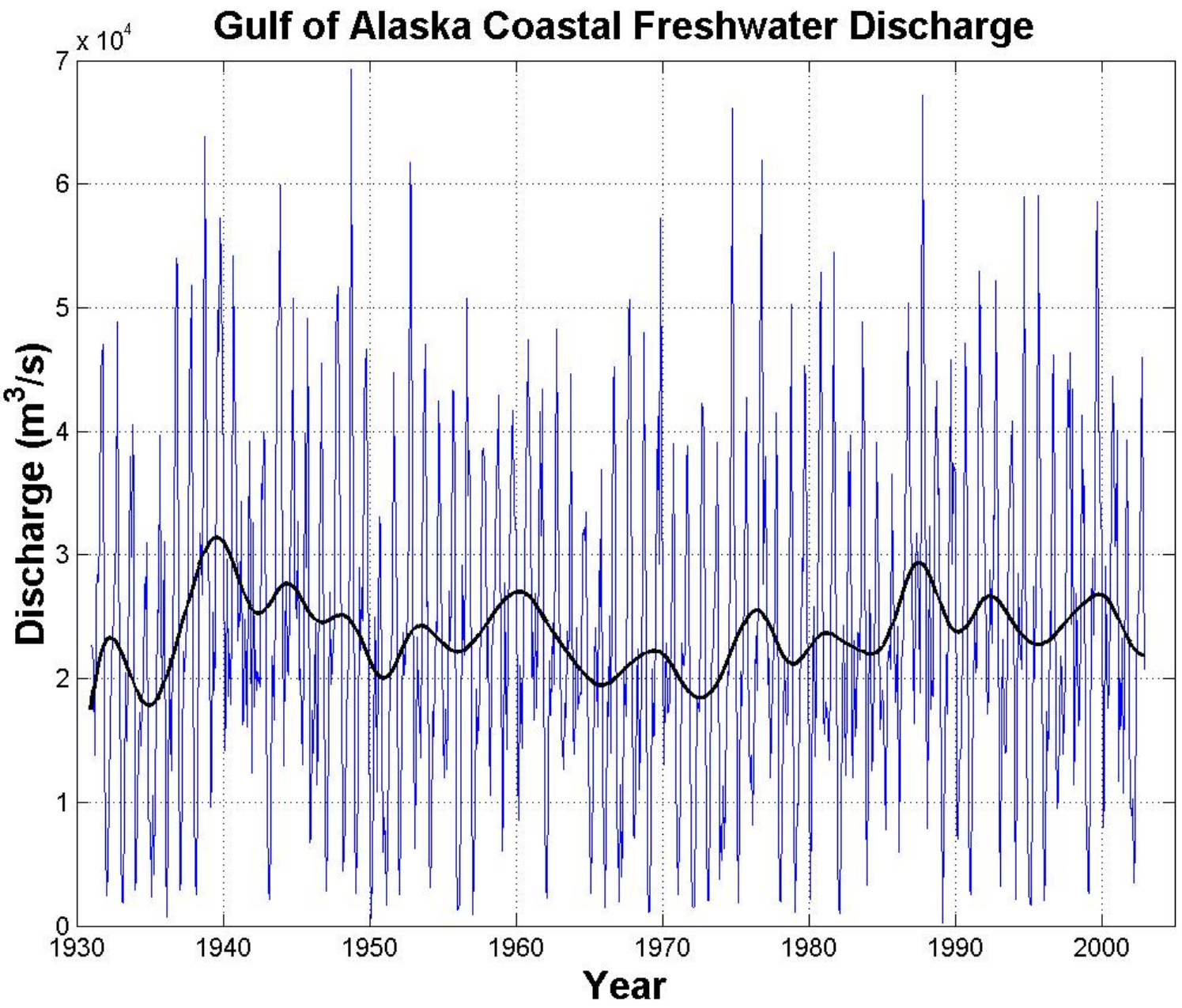
PICES XII

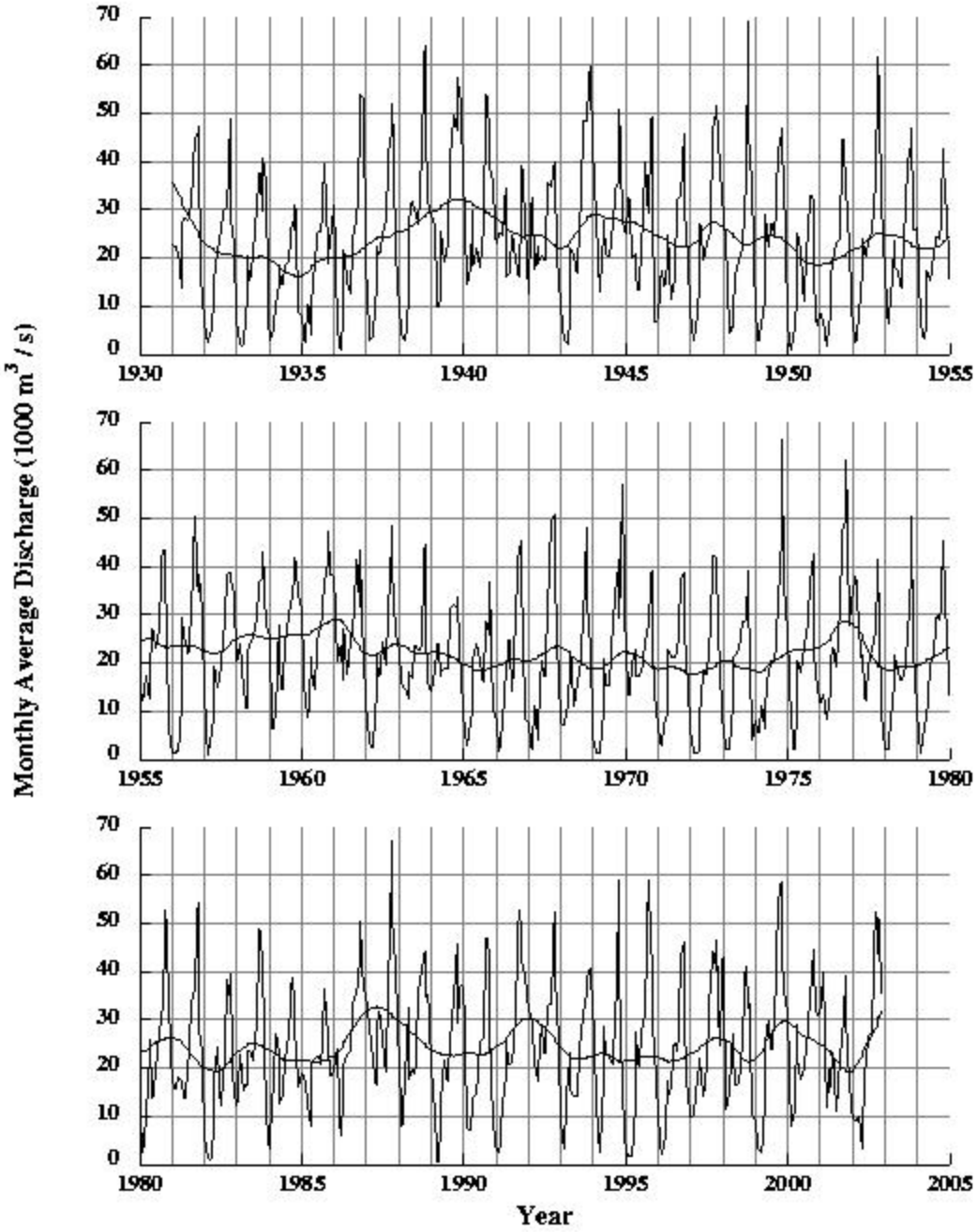
Development of a Hydrology Model for the Coastal Gulf of Alaska

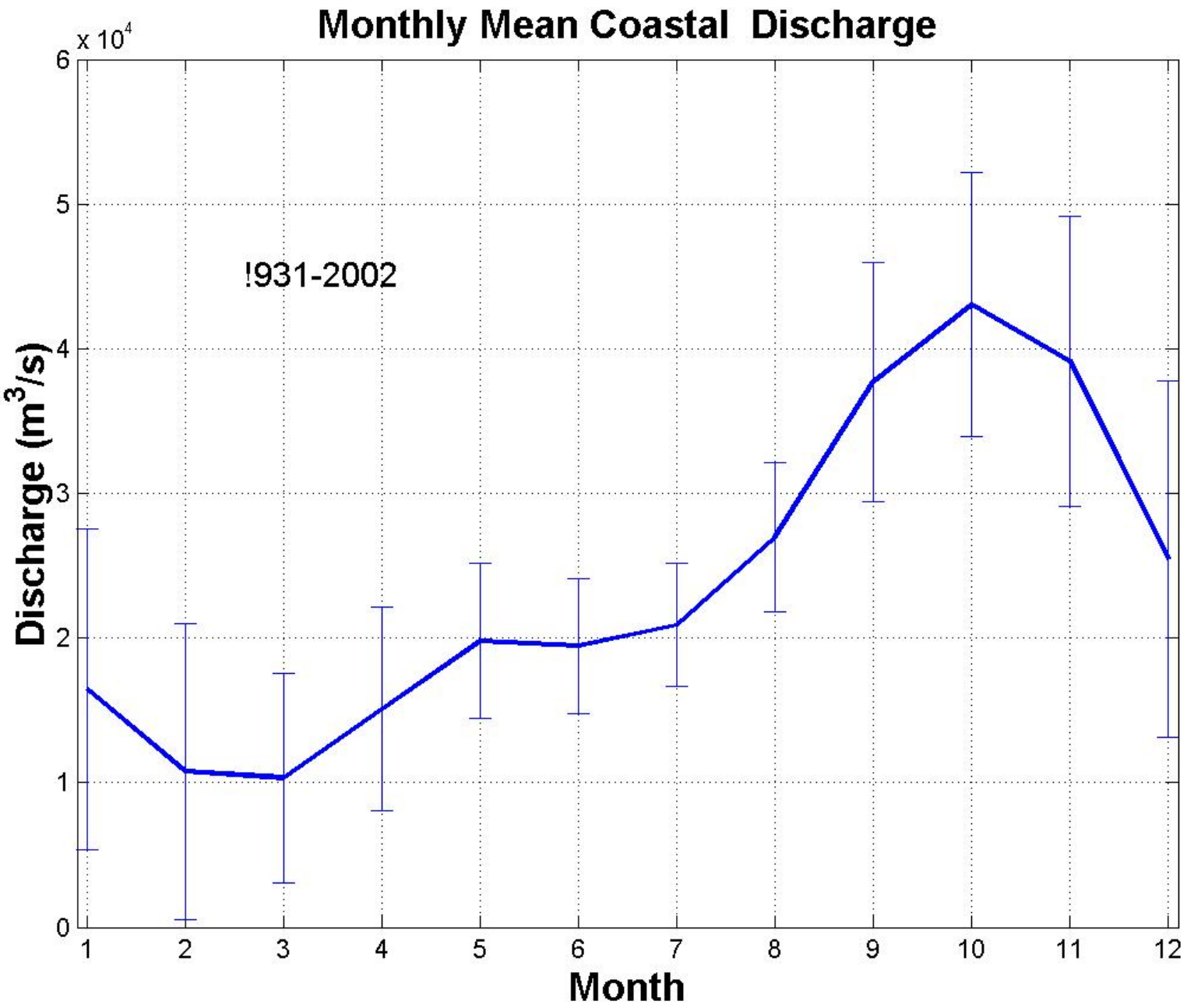
I. Reasons for the requirement of a model.
- Absence of river discharge measurements.
- High rates of precipitation.
- Glacial discharges/storage.

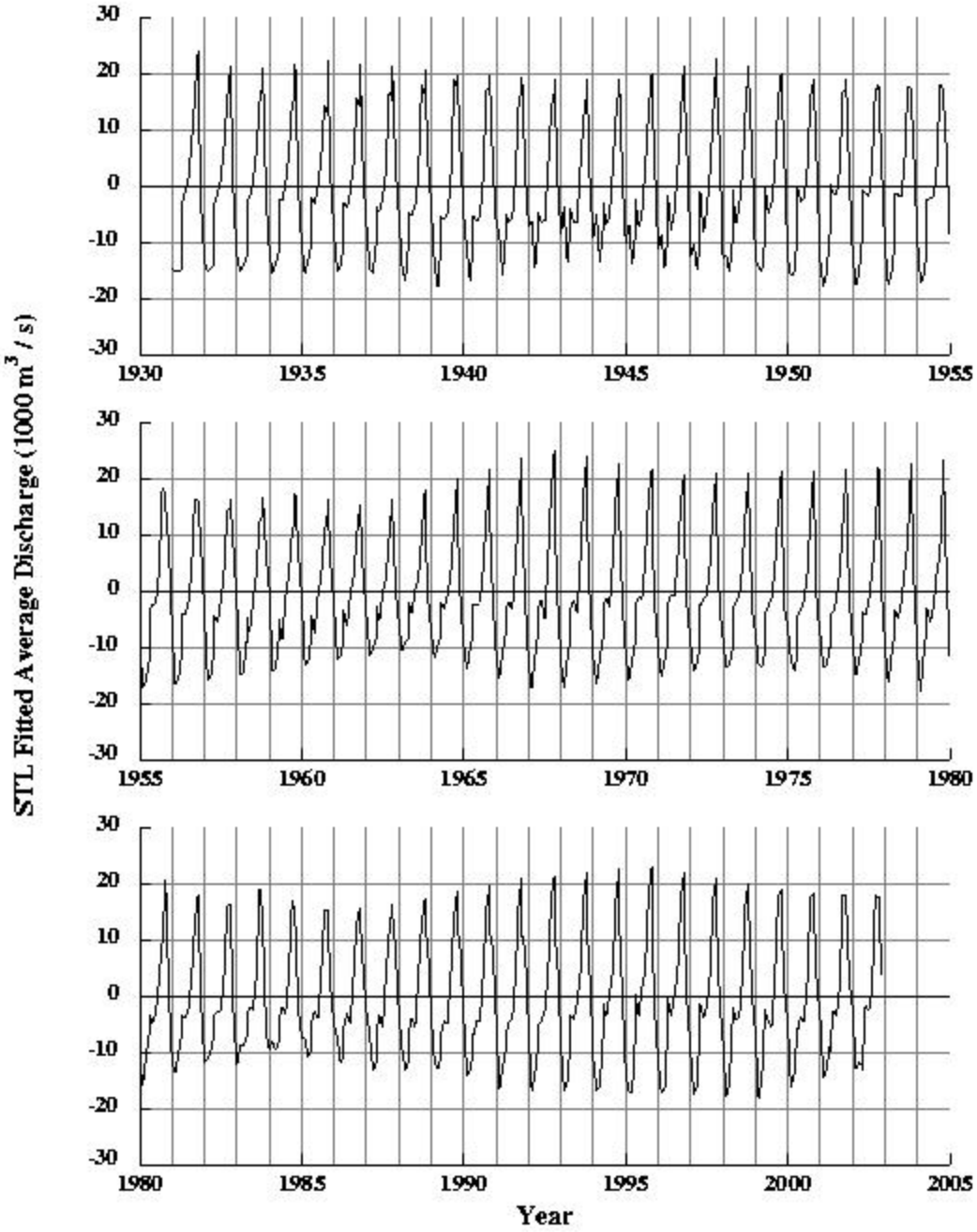
II. Assumptions
- Major river discharges here are relatively small.
- Use divisional averaged precipitation over
  - Southeast and Southcoast Alaska.
- Adjust seasonal and interannual water storage
  - according to air temperatures but no net change
  - in water storage from 1931-1980.
- Exclude upstream (Canadian) sources.

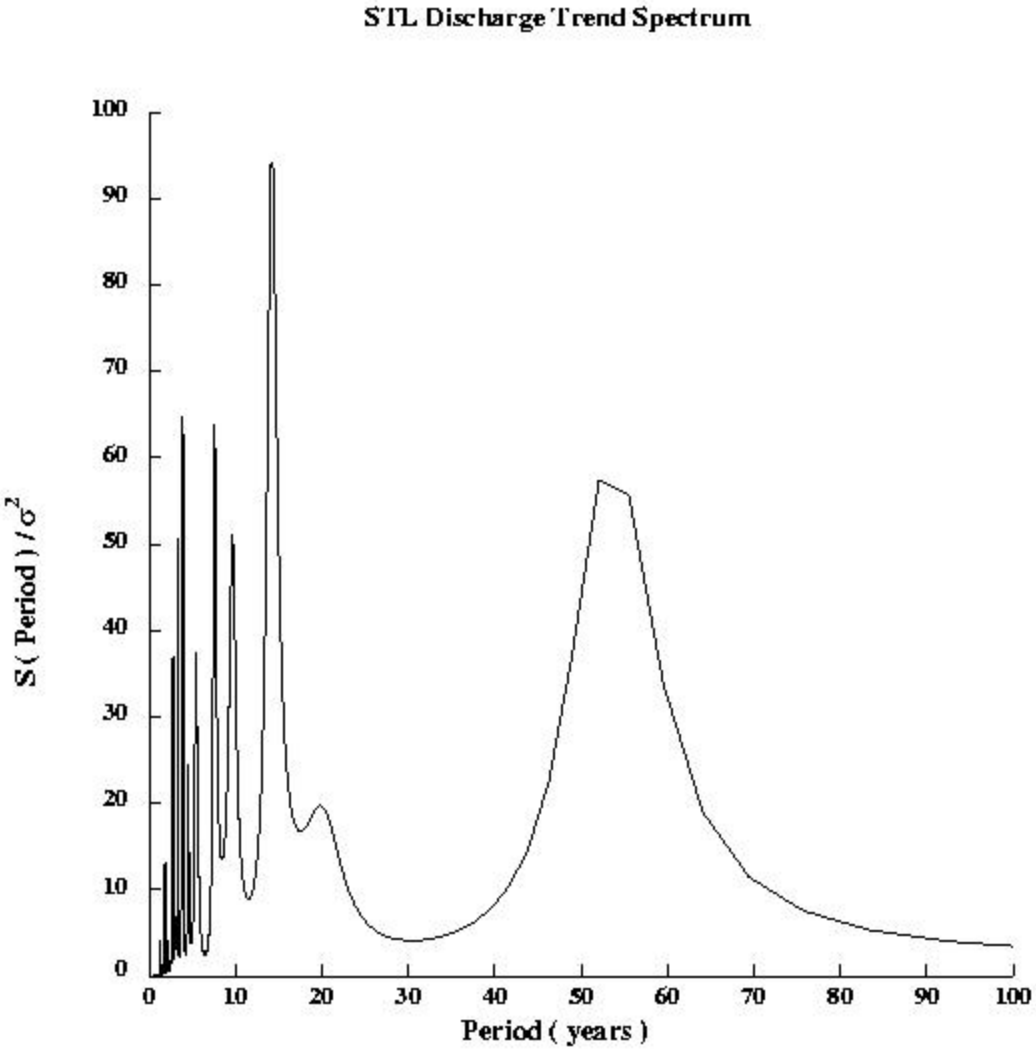

Mean Annual Precipitation, Alaska - Yukon
GAK1
Southcoast
Southeast
Precipitation (mm)
0 - 200
201 - 250
251 - 300
301 - 350
351 - 400
401 - 450
451 - 500
501 - 600
601 - 800
801 - 1000
1001 - 1500
1501 - 2000
2001 - 3000
3001 - 5000
5001 - 7000
7001 - 13000
No Data
Copyright 2000 by Spatial Climate Analysis Service, Oregon State University
Feb. 2000

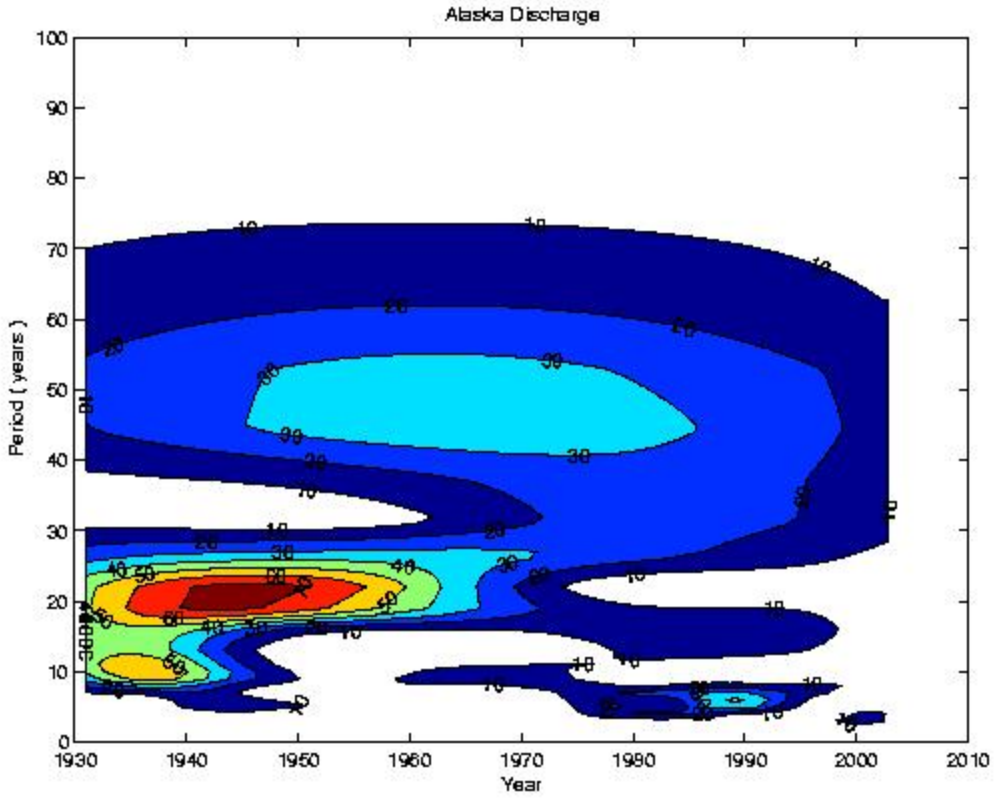

Gulf of Alaska Coastal Freshwater Discharge
x 10^4
7
6
5
4
3
2
1
0
Discharge (m^3/s)
1930
1940
1950
1960
1970
1980
1990
2000
Year

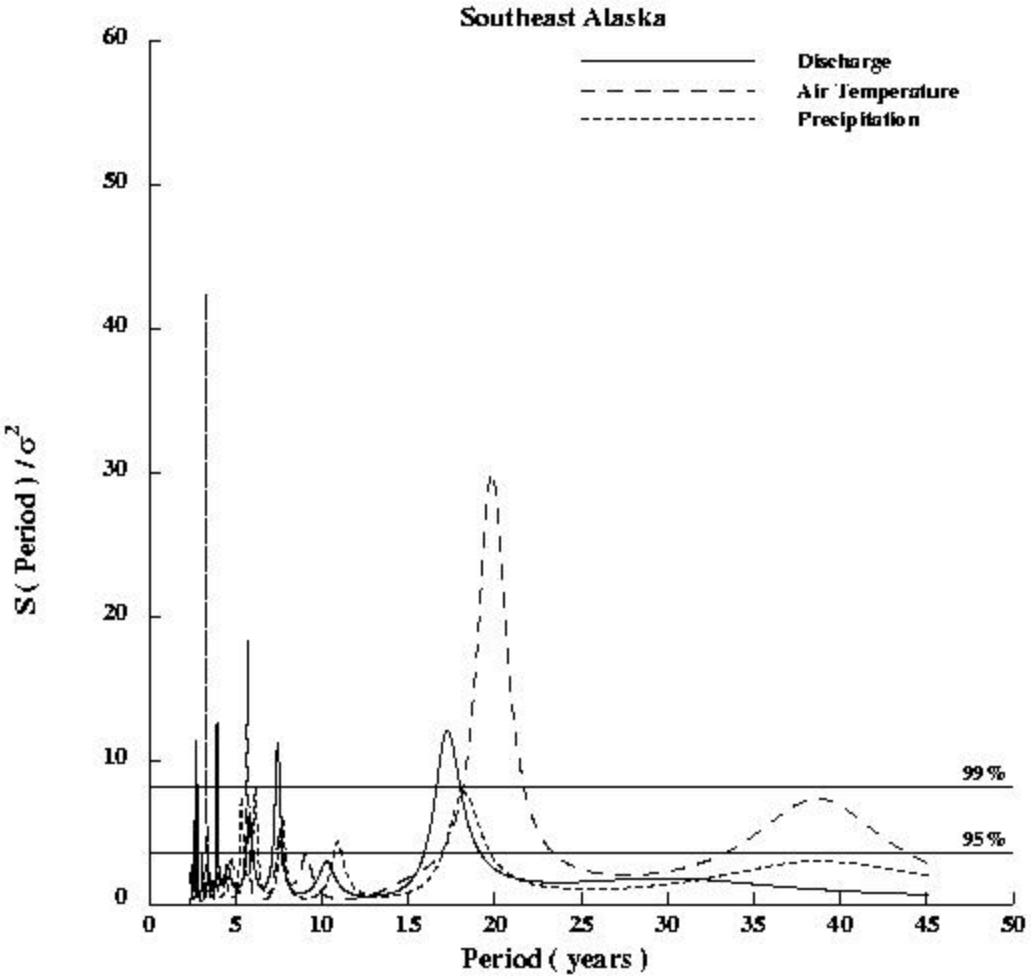

Monthly Average Discharge (1000 m3 / s)
70
60
50
40
30
20
10
0
1930
1935
1940
1945
1950
1955
1955
1960
1965
1970
1975
1980
1980
1985
1990
1995
2000
2005
Year

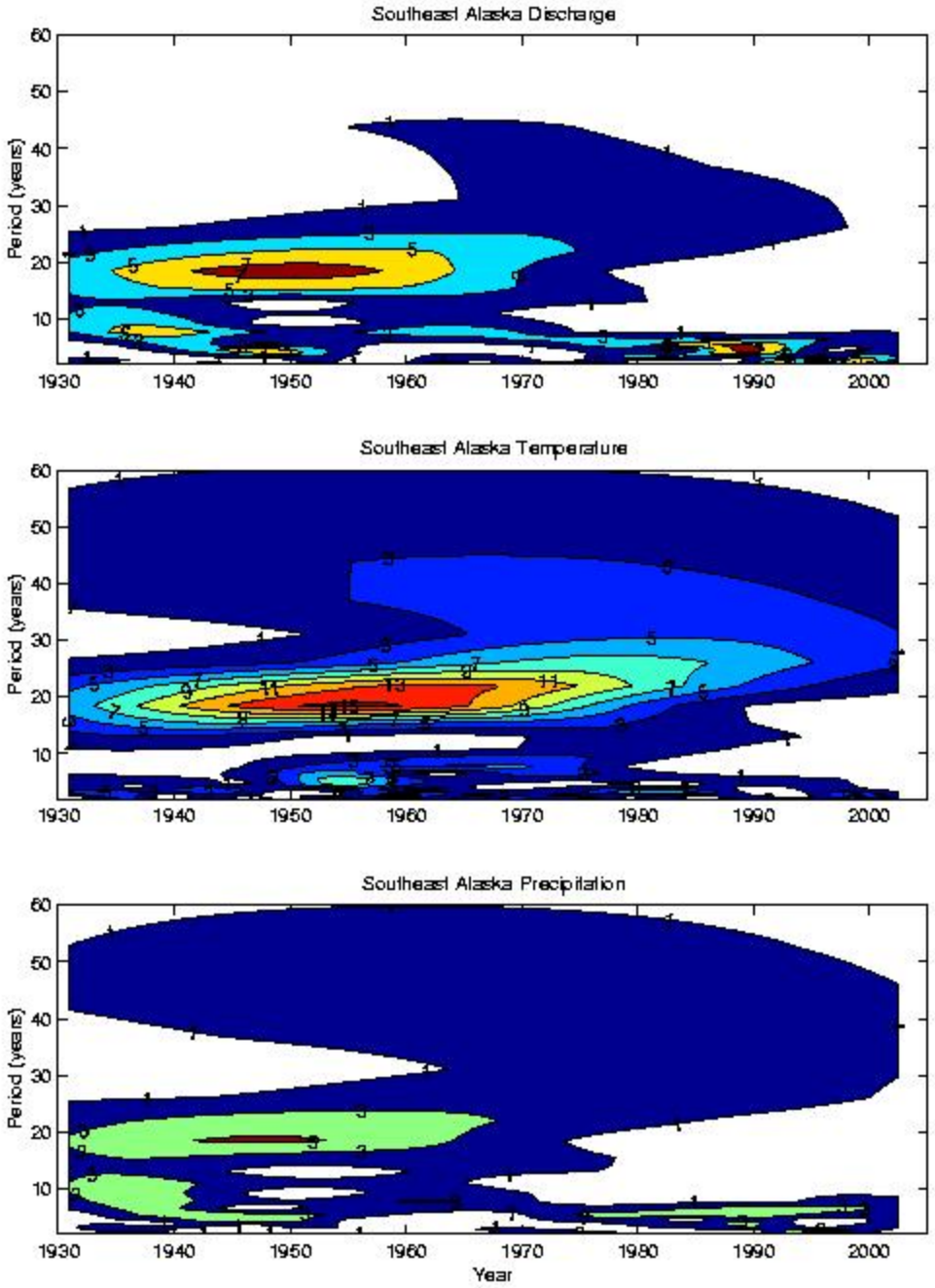

Monthly Mean Coastal Discharge
x 10^4
6
5
4
3
2
1
0
!931-2002
Discharge (m^3/s)
1
2
3
4
5
6
7
8
9
10
11
12
Month

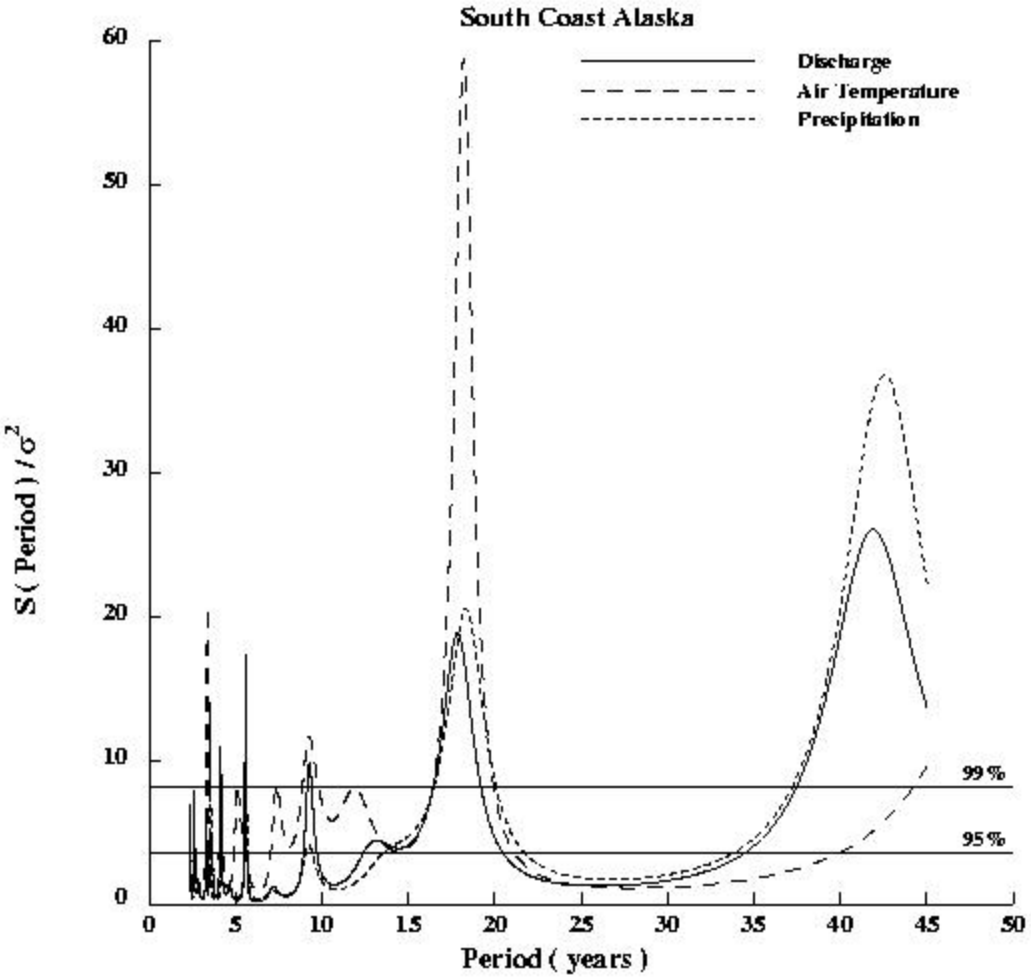

STL Fitted Average Discharge (1000 m3 / s)
30
20
10
0
-10
-20
-30
1930
1935
1940
1945
1950
1955
1955
1960
1965
1970
1975
1980
1980
1985
1990
1995
2000
2005
Year

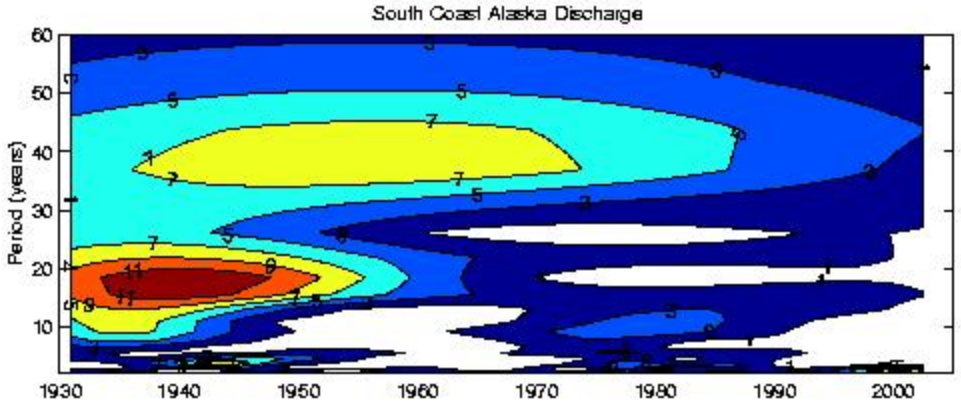

STL Discharge Trend Spectrum
S (Period) / σ²
Period (years)
0
10
20
30
40
50
60
70
80
90
100

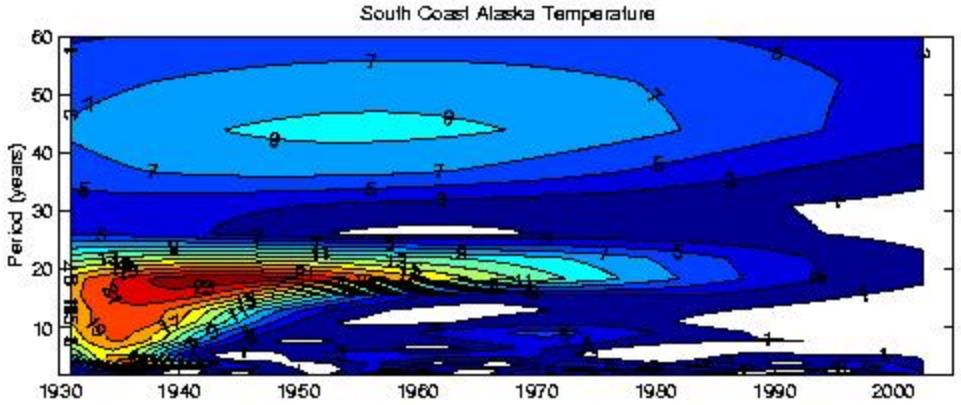

Alaska Discharge
Period (years)
Year
100
90
80
70
60
50
40
30
20
10
0
1930
1940
1950
1960
1970
1980
1990
2000
2010

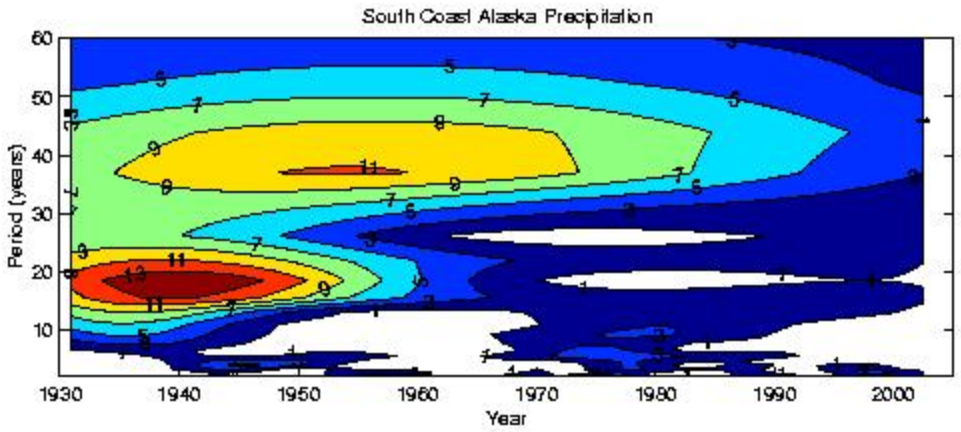

Southeast Alaska
Discharge
Air Temperature
Precipitation
99%
95%
S(Period) / σ²
Period (years)
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
40
45
50

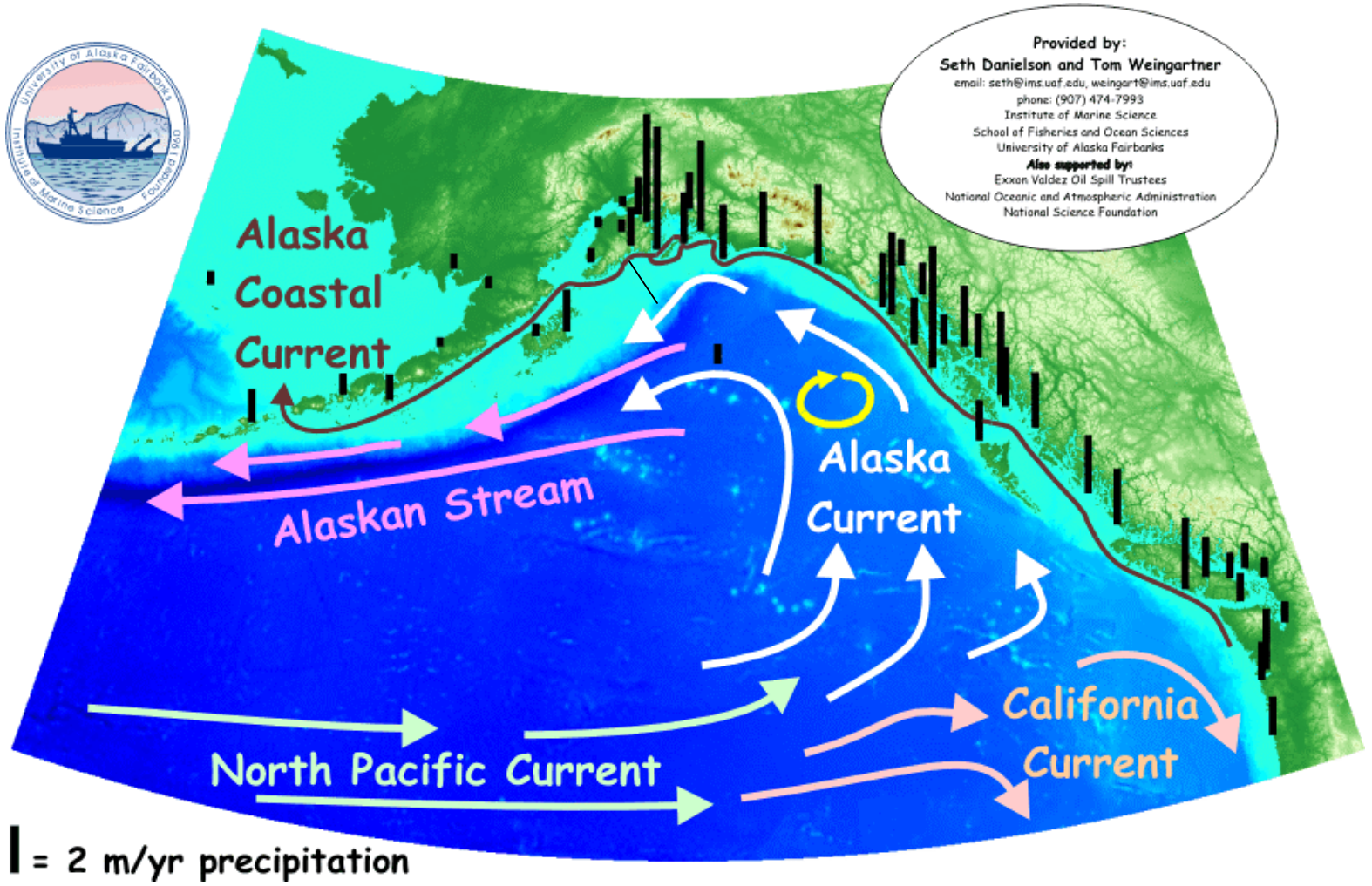

Southeast Alaska Discharge
Southeast Alaska Temperature
Southeast Alaska Precipitation
Period (years)
Year
60
50
40
30
20
10
1930
1940
1950
1960
1970
1980
1990
2000


South Coast Alaska
Discharge
Air Temperature
Precipitation
99%
95%
S(Period) / σ²
Period (years)
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
40
45
50


South Coast Alaska Discharge
Period (years)
60
50
40
30
20
10
1930
1940
1950
1960
1970
1980
1990
2000

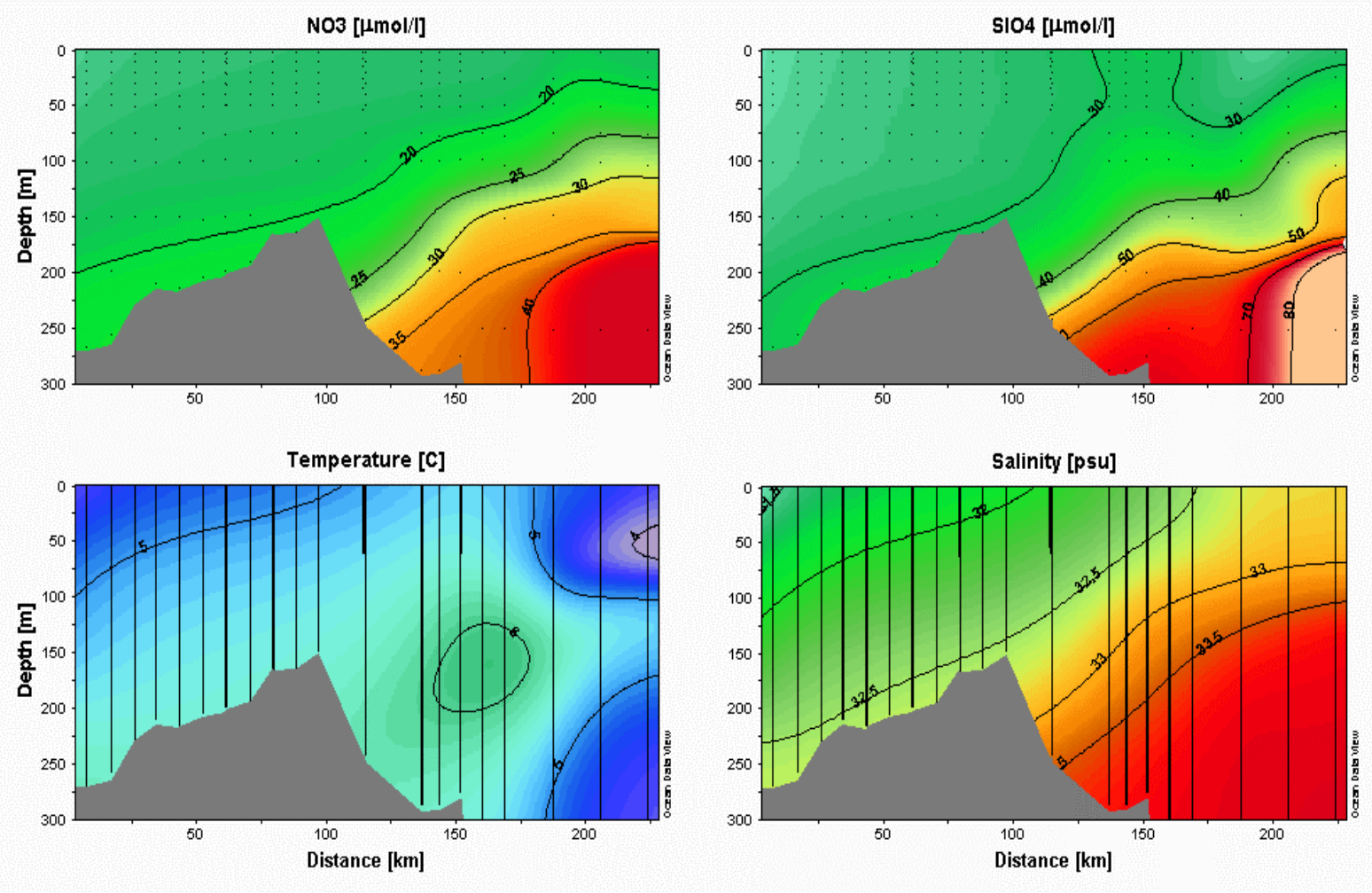

South Coast Alaska Temperature
Period (years)
60
50
40
30
20
10
1930
1940
1950
1960
1970
1980
1990
2000


South Coast Alaska Precipitation
Period (years)
60
50
40
30
20
10
1930
1940
1950
1960
1970
1980
1990
2000
Year



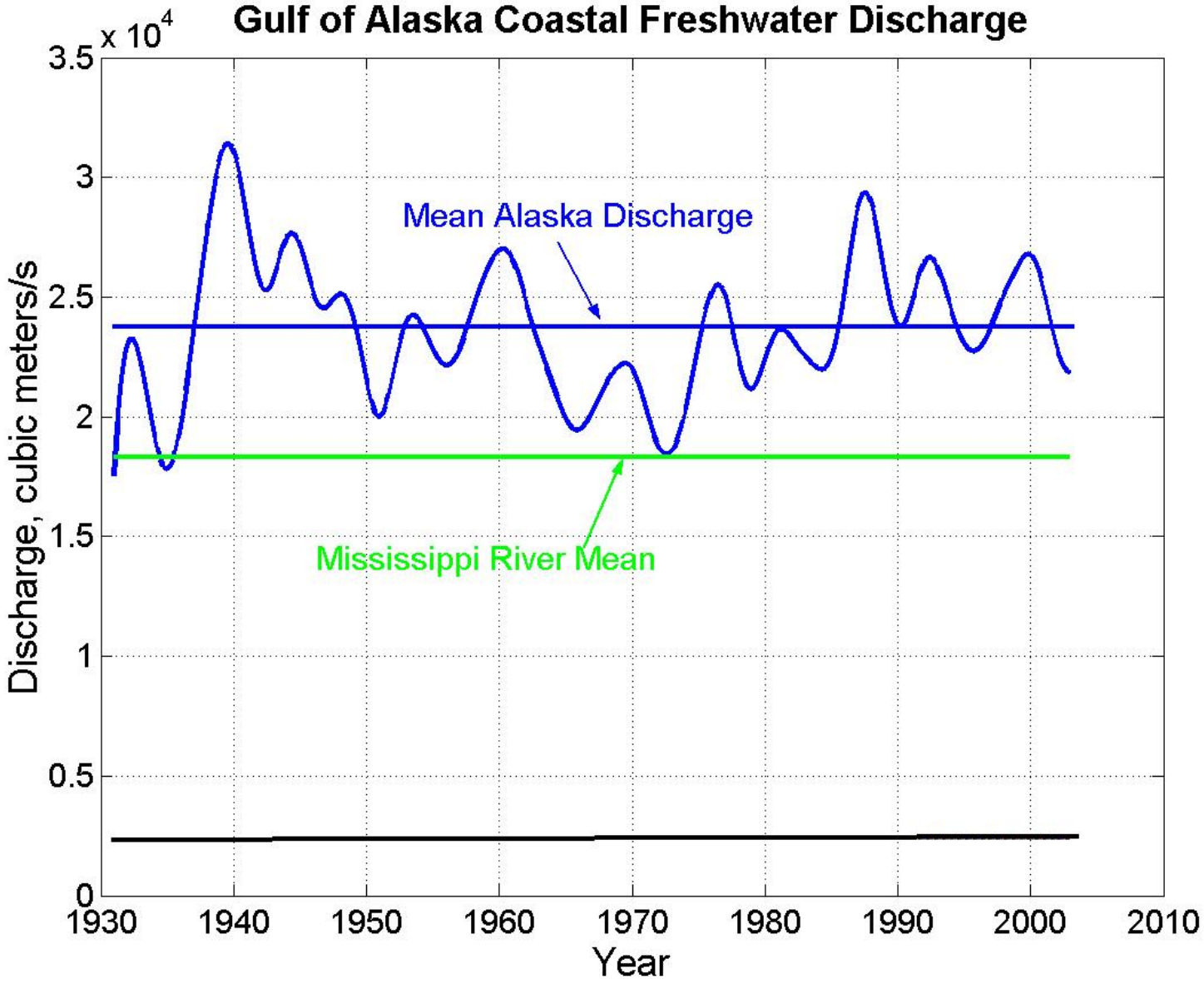
Provided by:
Seth Danielson and Tom Weingartner
email: seth@ims.uaf.edu, weingart@ims.uaf.edu
phone: (907) 474-7993
Institute of Marine Science
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
Also supported by:
Exxon Valdez Oil Spill Trustees
National Oceanic and Atmospheric Administration
National Science Foundation

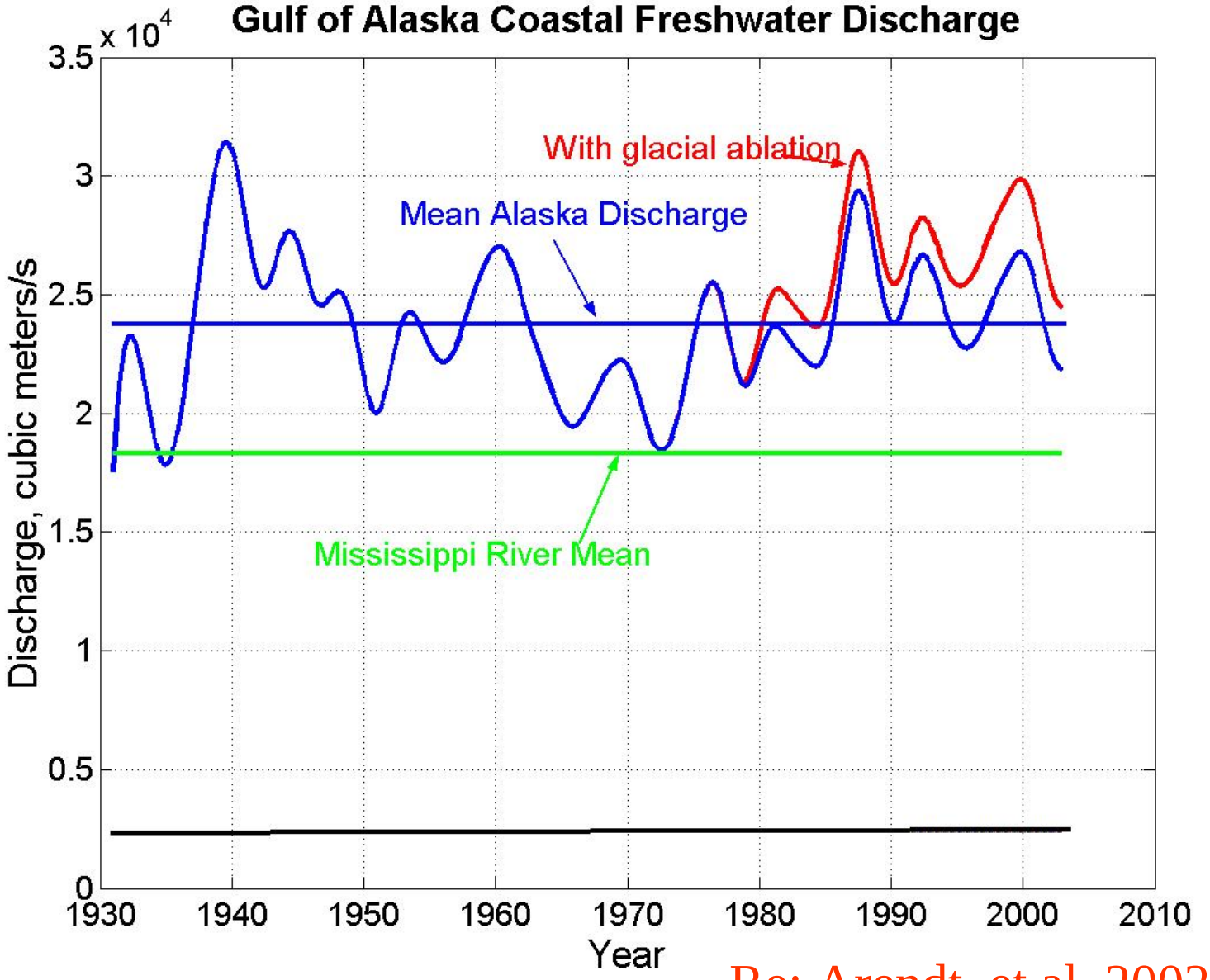
March 2000 (late winter)



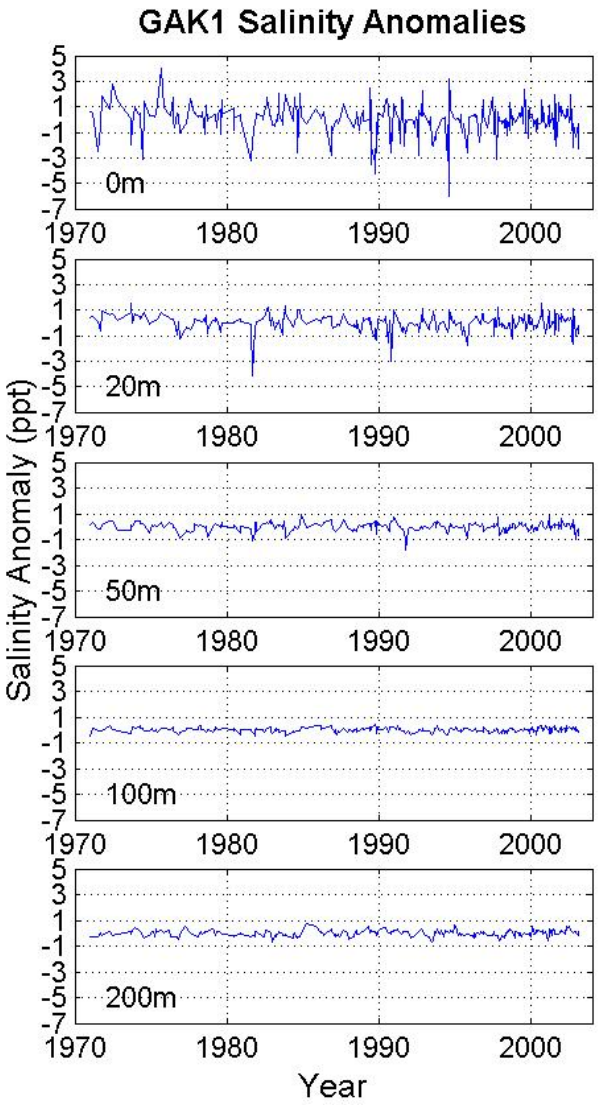
Seward Line

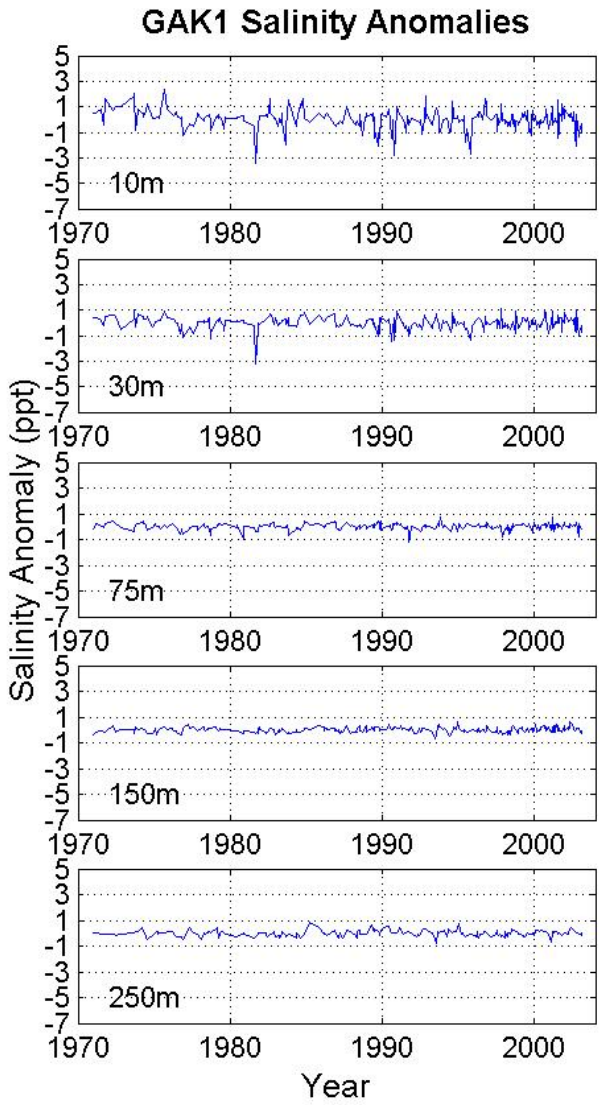
Childers, et al, 2002.

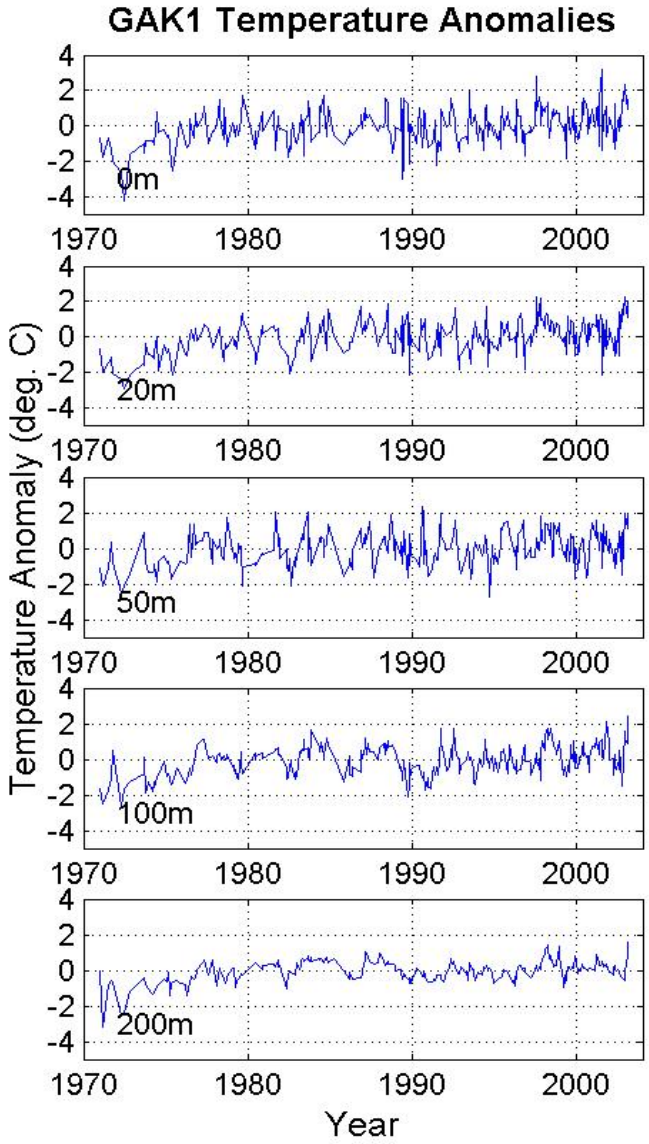

Gulf of Alaska Coastal Freshwater Discharge
x 10^4
3.5
3
2.5
2
1.5
1
0.5
0
Discharge, cubic meters/s
Mean Alaska Discharge
Mississippi River Mean
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

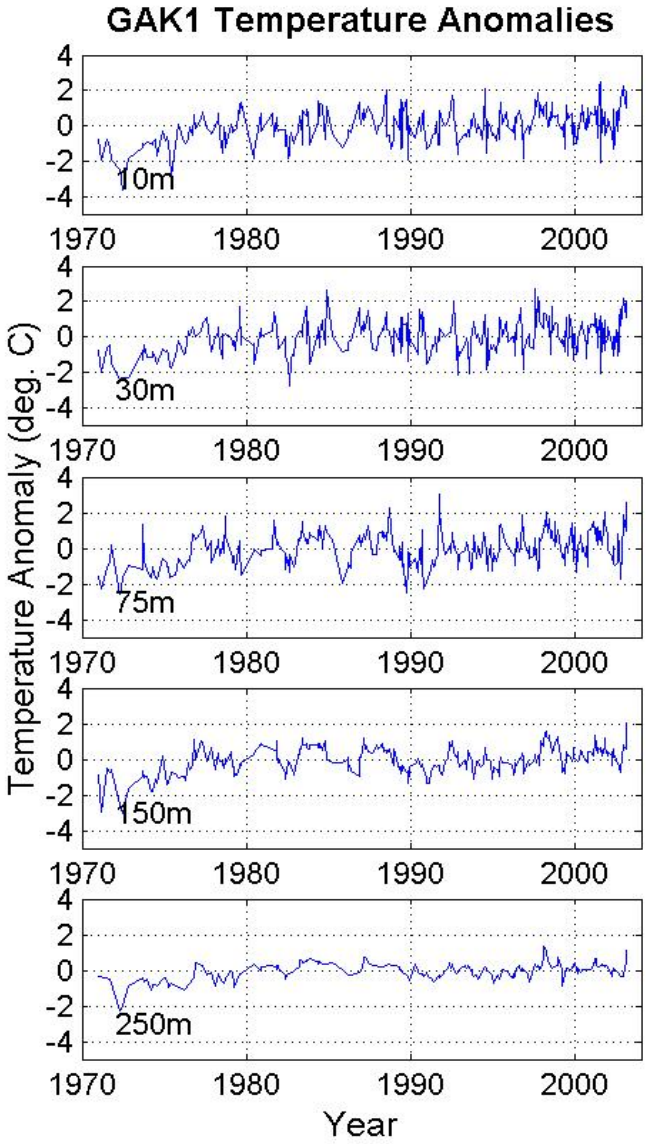


Re: Arendt, et al, 2002


GAK1 Salinity Anomalies
Salinity Anomaly (ppt)
0m
20m
50m
100m
200m
1970
1980
1990
2000
Year


GAK1 Salinity Anomalies
Salinity Anomaly (ppt)
10m
30m
75m
150m
250m
1970
1980
1990
2000
Year


GAK1 Temperature Anomalies
Temperature Anomaly (deg. C)
0m
20m
50m
100m
200m
4
2
0
-2
-4
1970
1980
1990
2000
Year


GAK1 Temperature Anomalies
Temperature Anomaly (deg. C)
10m
30m
75m
150m
250m
4
2
0
-2
-4
1970
1980
1990
2000
Year

Effects of Increased Coastal Freshwater Discharge

- Increased stratification throughout the Northeast Pacific.
  Salinity decrease at GAK1 for 0-100 m (-0.0022 /year, since 1970).
  Salinity increase for 100-250m (+0.0013 /year), possibly from estuarine circulation.

- Increased strength of the northward Alaska Coastal Current surface flows (formerly 0.25-1.8 m/s).

- Increased temperatures throughout the water column from increased advection from the south (+0.03 C/year).

- Changes in the seasonal signal of stratification will affect the upward mixing of nutrients into the euphotic zone and the timing of the blooms of productivity.

Effects of Decreased Coastal Freshwater Discharge

- Decreased stratification throughout the Northeast Pacific.
- Decreased strength of the northward Alaska Coastal Current surface flows.
- Decreased temperatures throughout the water column from decreased advection from the south.
- How and when might a decrease occur?

Effects of Decreased Coastal Freshwater Discharge

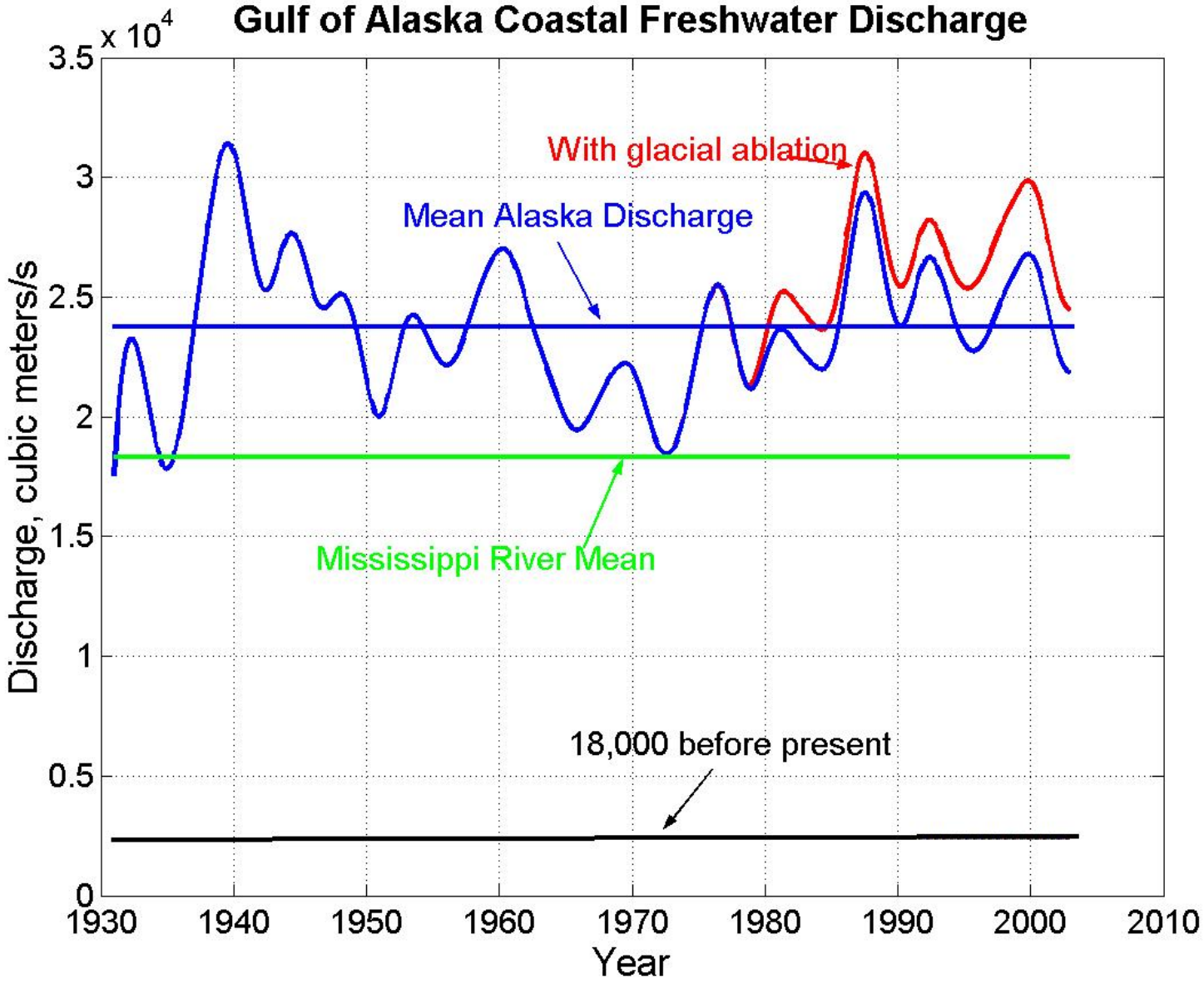
- Decreased stratification throughout the Northeast Pacific.

- Decreased strength of the northward Alaska Coastal Current surface flows.

- Decreased temperatures throughout the water column from decreased advection from the south.

- How and when might a decrease occur?

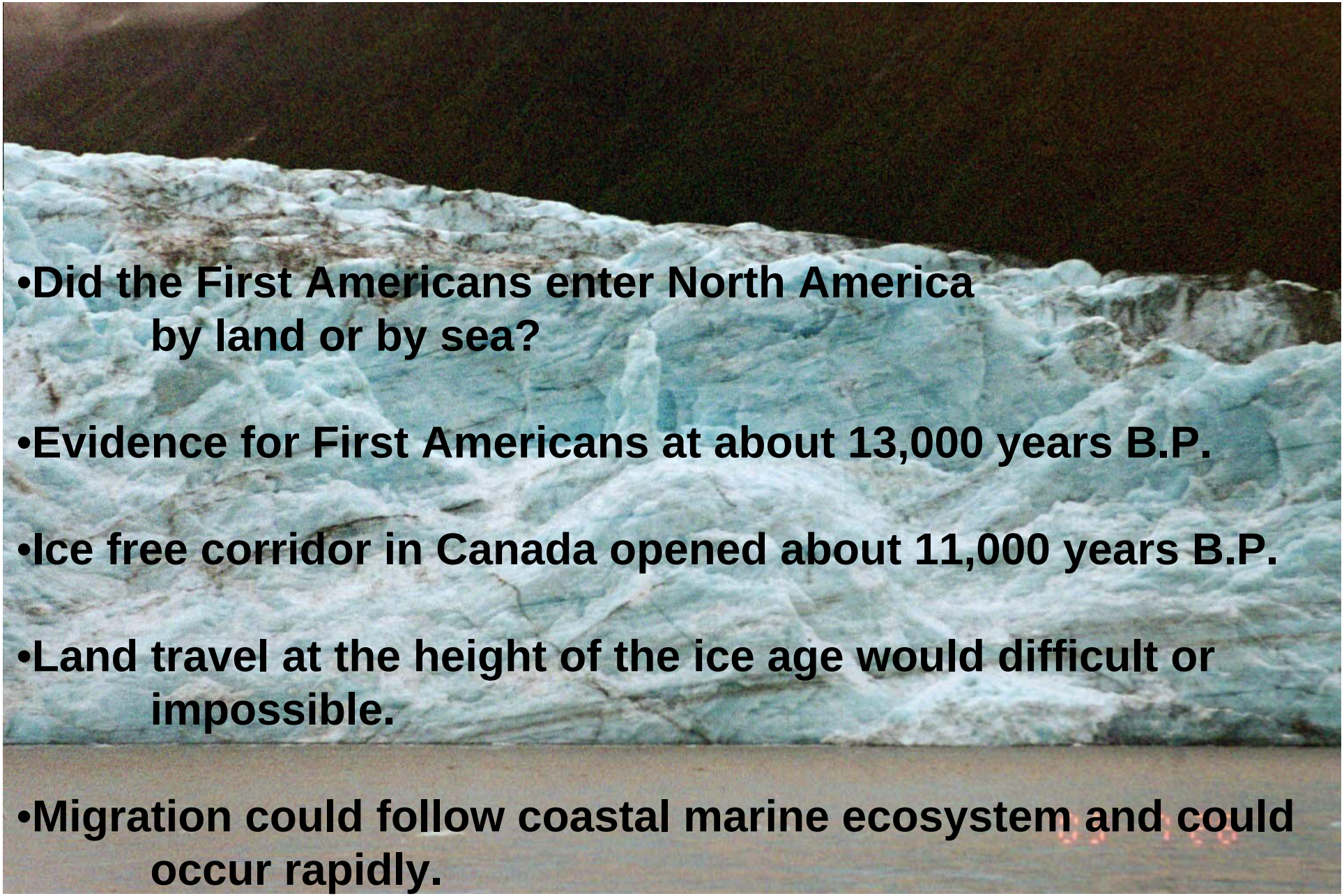
  During the ice ages when most precipitation is locked up in glacial fields, possibly reduced by 90%.


Gulf of Alaska Coastal Freshwater Discharge
x 10^4
3.5
3
2.5
2
1.5
1
0.5
0
Discharge, cubic meters/s
With glacial ablation
Mean Alaska Discharge
Mississippi River Mean
18,000 before present
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

Additional Effects of decreased freshwater discharge

- The subpolar, cyclonic circulation of the North Pacific Ocean could be reduced or absent.
- Sea level was lower by about 120 meters.
- Southward marine travel near the coast would be enhanced.

- **Did the First Americans enter North America by land or by sea?**
- **Evidence for First Americans at about 13,000 years B.P.**
- **Ice free corridor in Canada opened about 11,000 years B.P.**



Childs Glacier with the Copper River, Cordova, Alaska

From Dixon, 2002

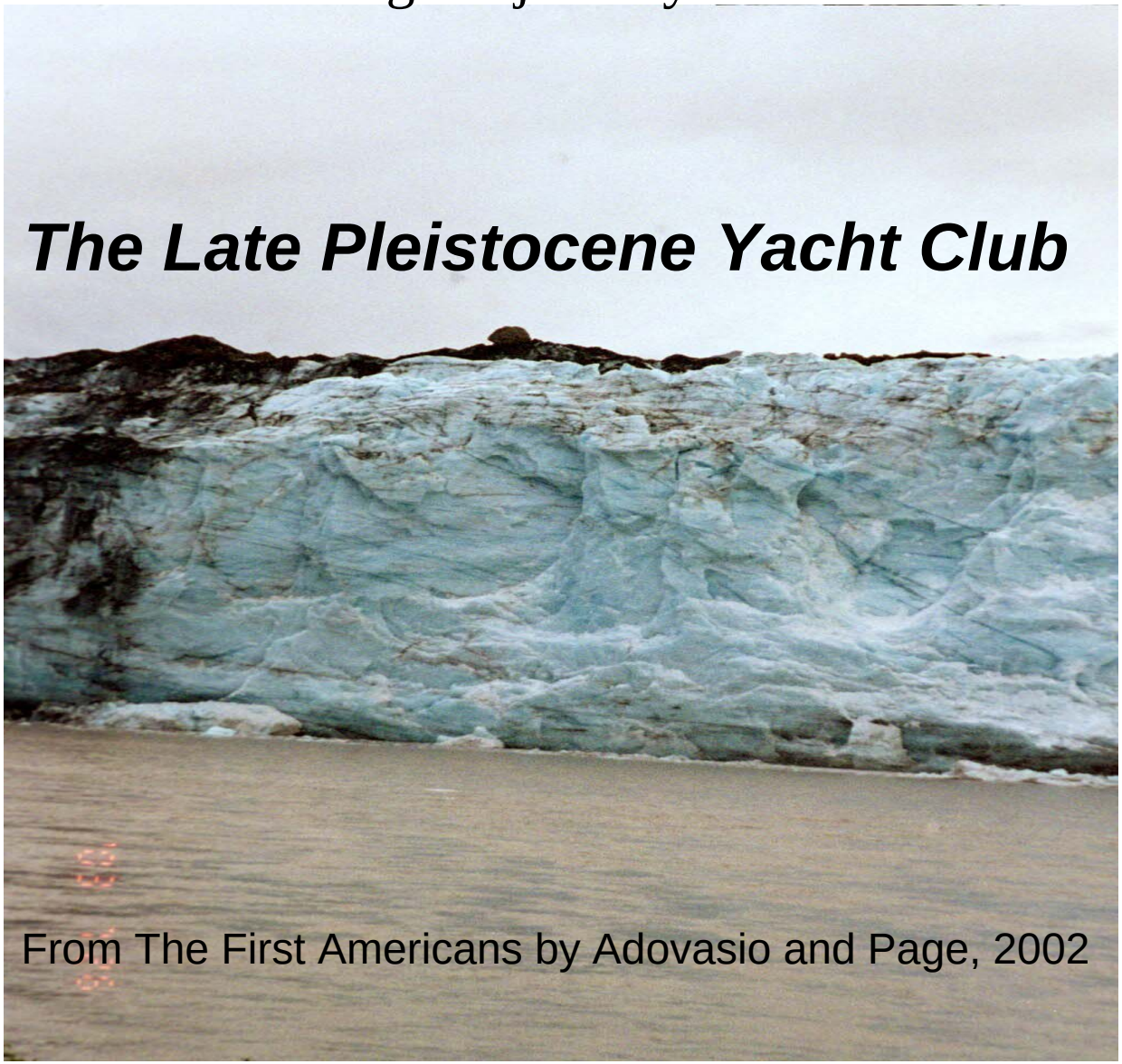
North America about 16,250 Years Before Present

Summary

- Enhanced Alaska Coastal Current with Climate Change
- Diminished Upper Layer Salinity
- Increased Lower Layer Salinity
- Increased Water Temperatures

Possible Route for First Americans

A possible view during the journey from Asia to America



From The First Americans by Adovasio and Page, 2002