Bering Ecosystem Study (BEST) Workshop

March 17-19, 2003

Remote Sensing in the Bering Sea and the Effects of Processes in the Bering Sea Basin

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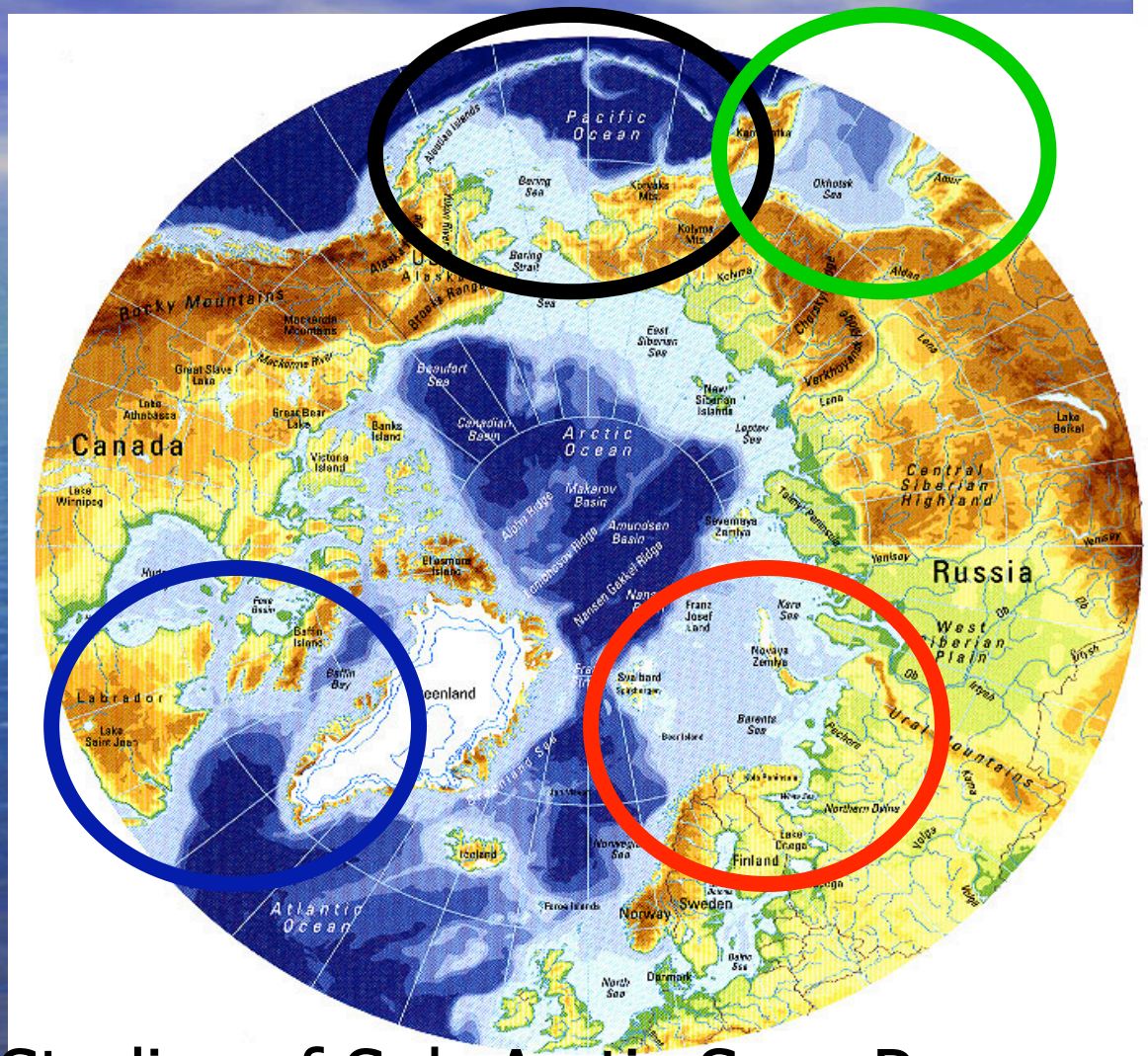
Oshoro-Maru at Pier 66 Seattle in summer 2001

Contents

- Background
- Two Topics
  - Coccolithophore Bloom dynamics during 1997-2002
  - Seasonal and interanual variability of Bering Sea Eddies along the green belt
- Future Application
- Some Suggestions

Background

OCEAN DEPTHS OF THE ARCTIC OCEAN AND ADJACENT SEAS

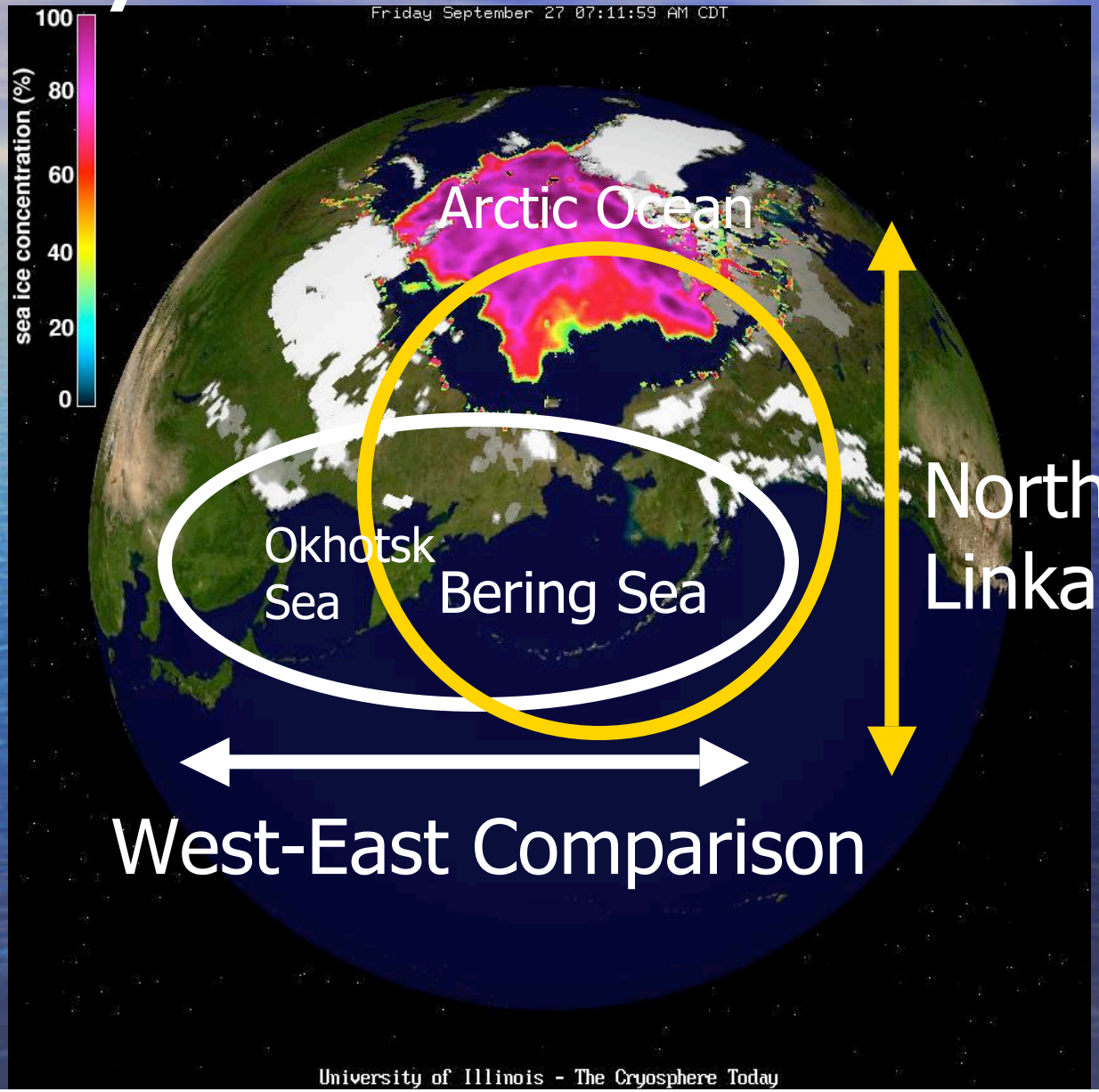


Max Depth

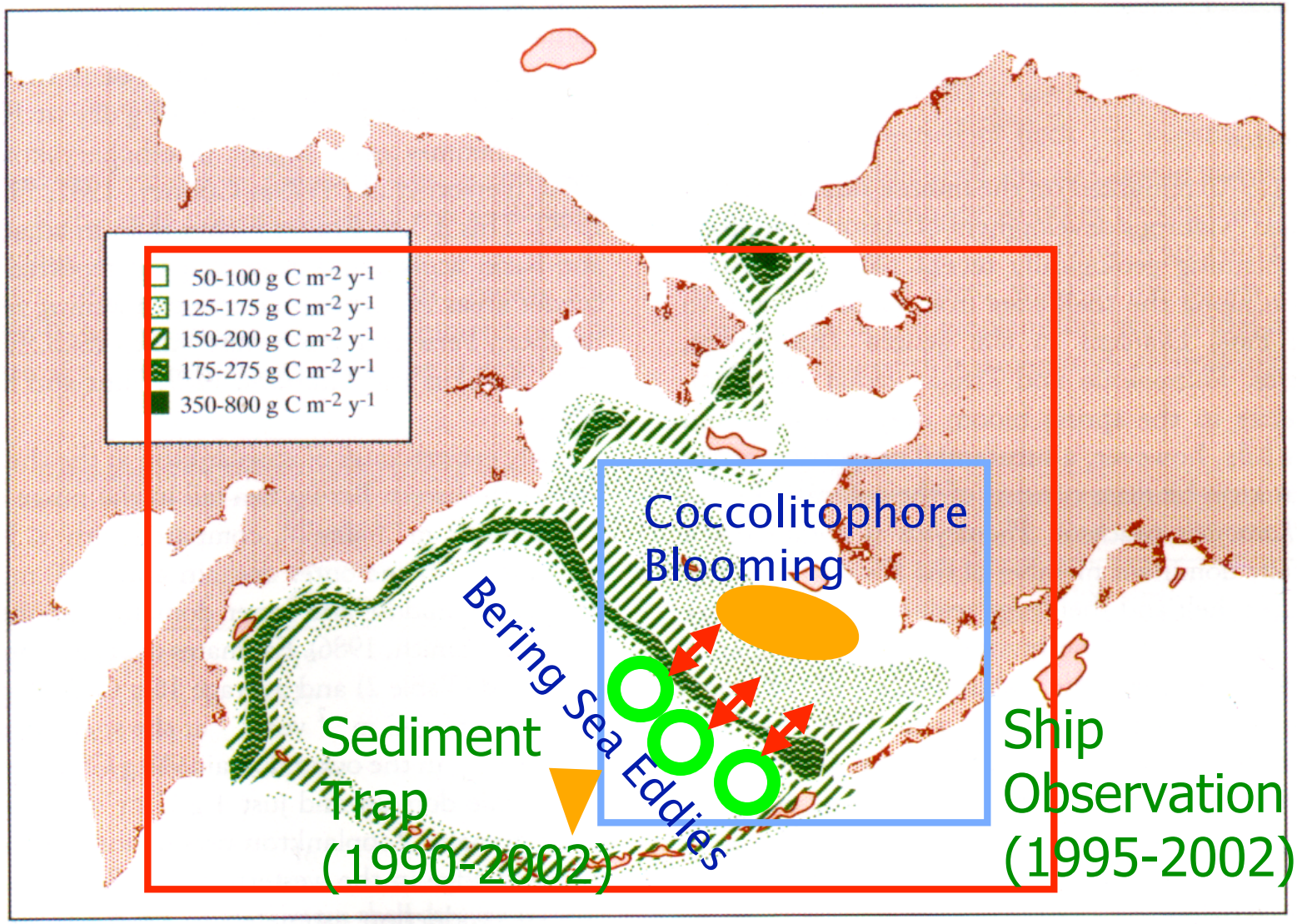
5450 m

Ecosystem Studies of Sub-Arctic Seas Program

Study Area


Friday September 27 07:11:59 AM CDT
sea ice concentration (%)
100
80
60
40
20
0
Arctic Ocean
Okhotsk Sea
Bering Sea
North-South Linkage
West-East Comparison
University of Illinois - The Cryosphere Today

The Green Belt (Springer *et al.*, 199



Two Topics

Bering Sea Ecosystem from Space

1. Coccolithophore Bloom dynamics during 1997-2002

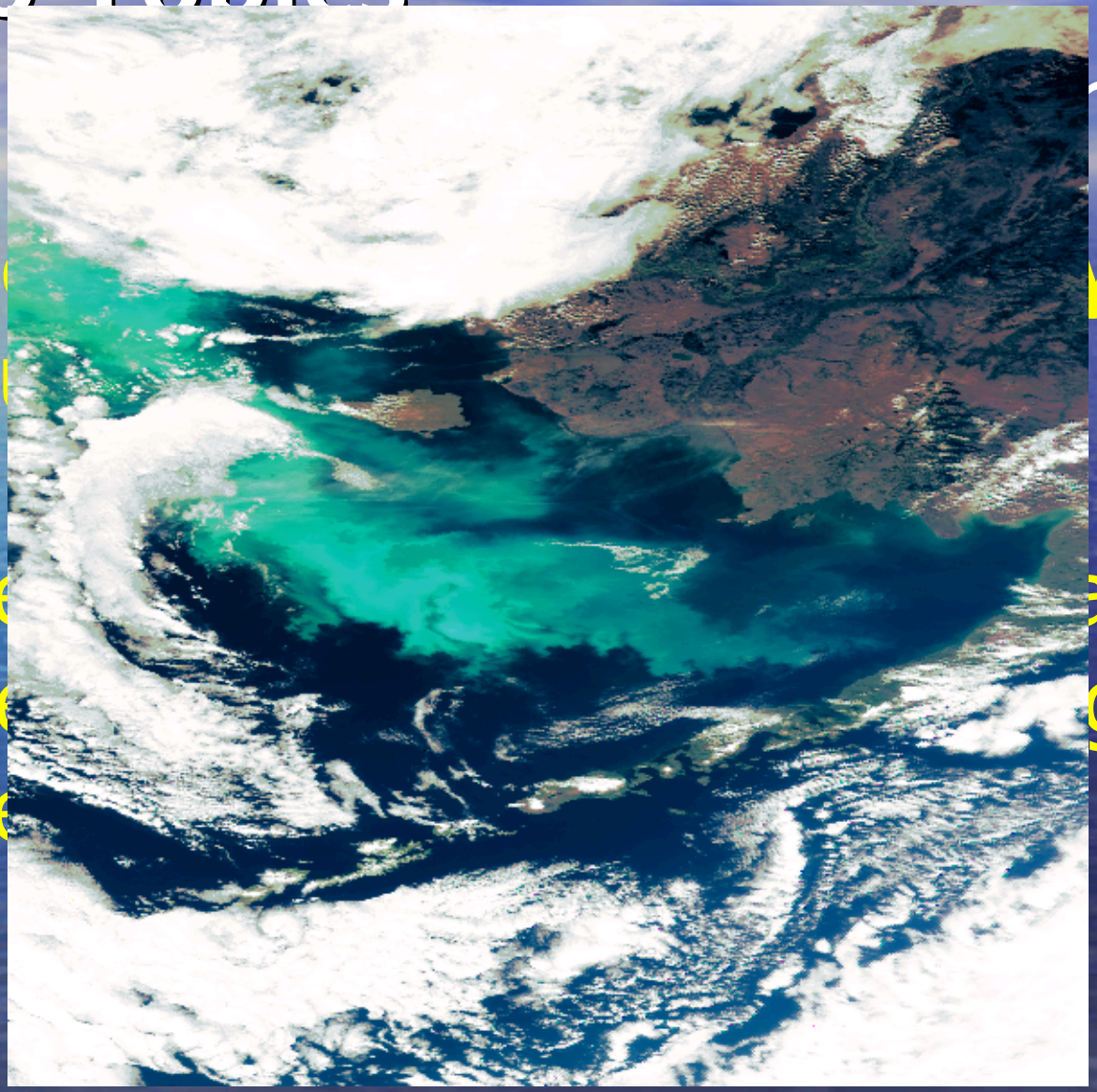
2. Seasonal and interanual variability of Bering Sea Eddies along the green belt

Two Topics

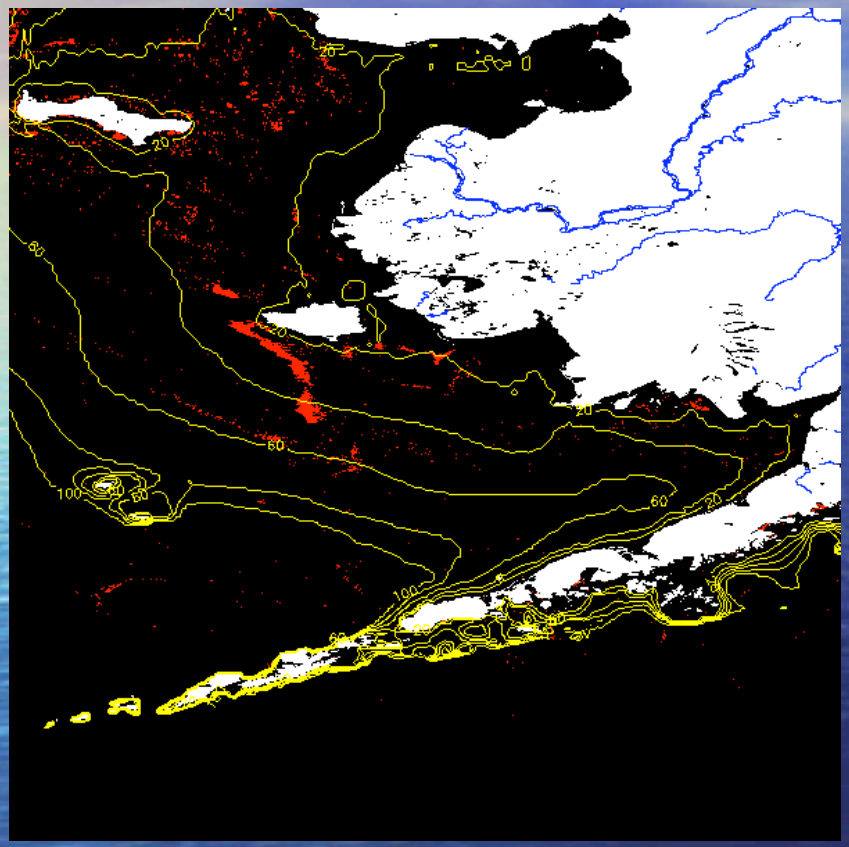
Beri n Space

1. C ynamics d

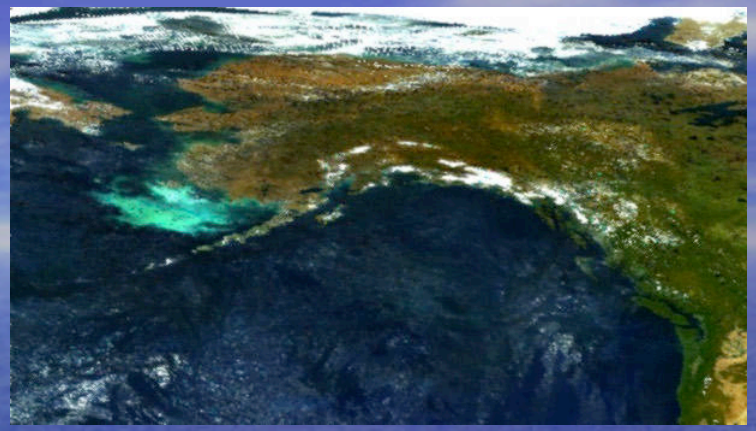
2. Se ability of Be green be



OCTS Coccolithophore mask image in 1997 spring



May 1997 OCTS Coccolithophore mask Image



SeaWiFS coccolithophore bloom
Image from Sep.19 to Oct.3

$nL_w(443) > 1.1$

$nL_w(565) > 0.8$

$0.64 < nL_w(443/565) < 1.55$

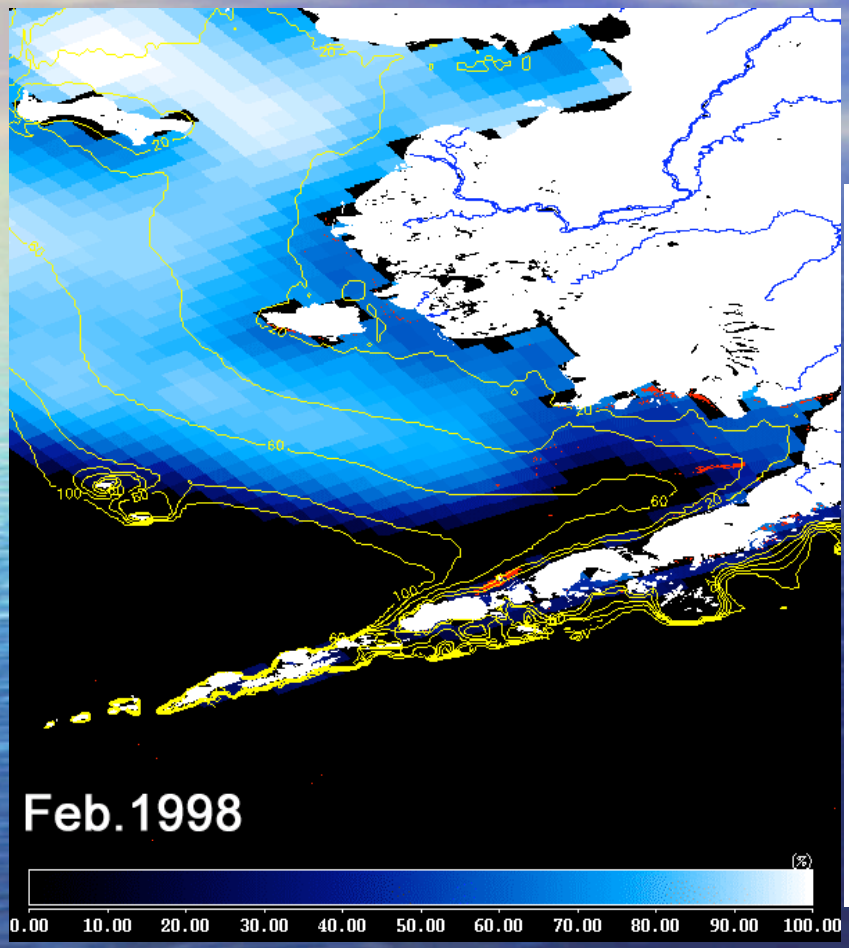
$0.7 < nL_w(443/520) < 1.0$

$0.93 < nL_w(520/565) < 1.6$

→OCTS found 1997 bloom!!

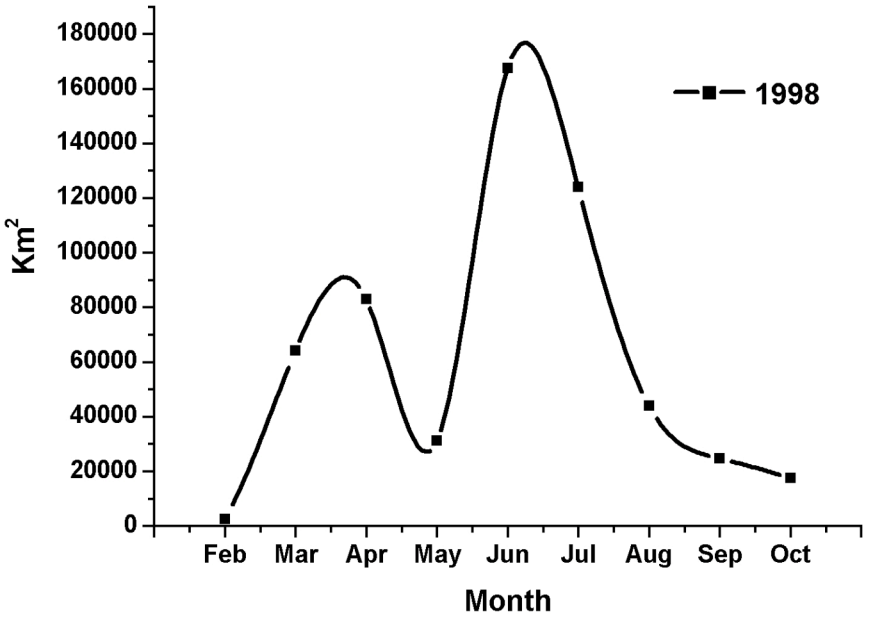
Iida et al. (2002)

Variability of coccolithophore bloom and Sea Ice

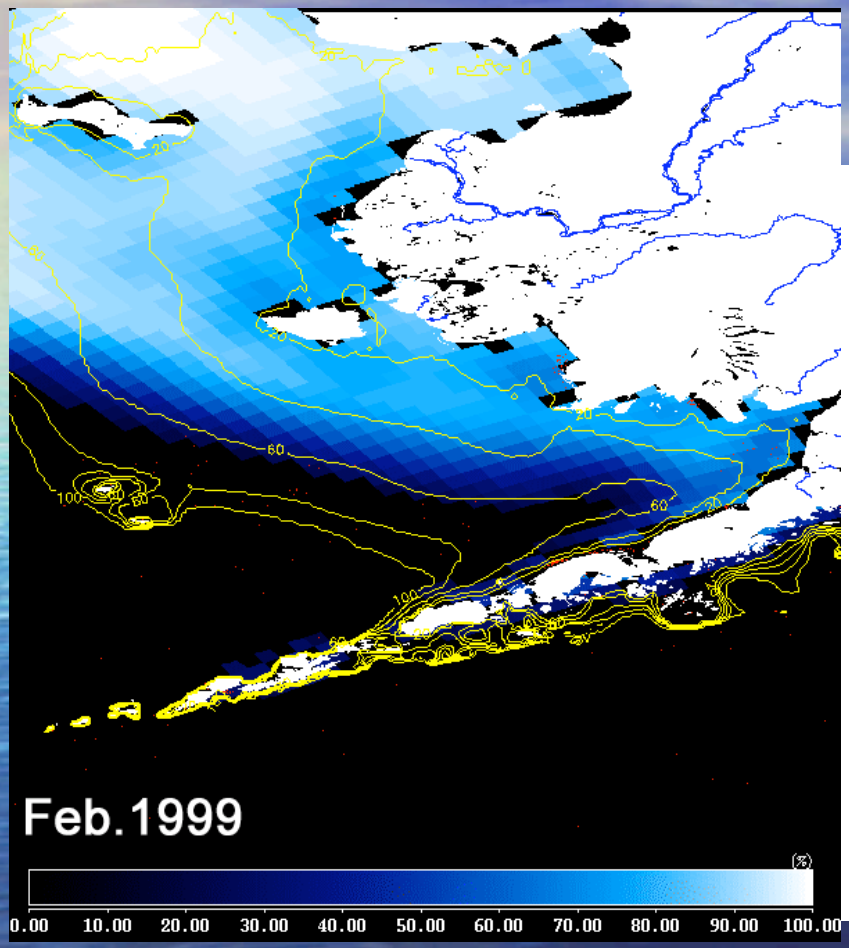


Composite Monthly Sea ice and Coccolithophore Mask Image

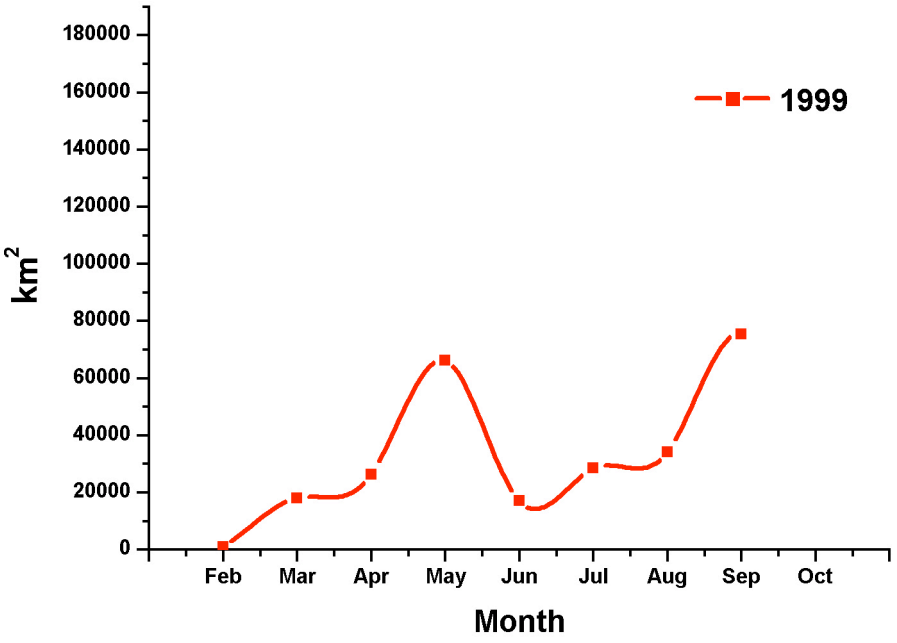
Coccolithophore bloom area



Variability of coccolithophore bloom and Sea Ice

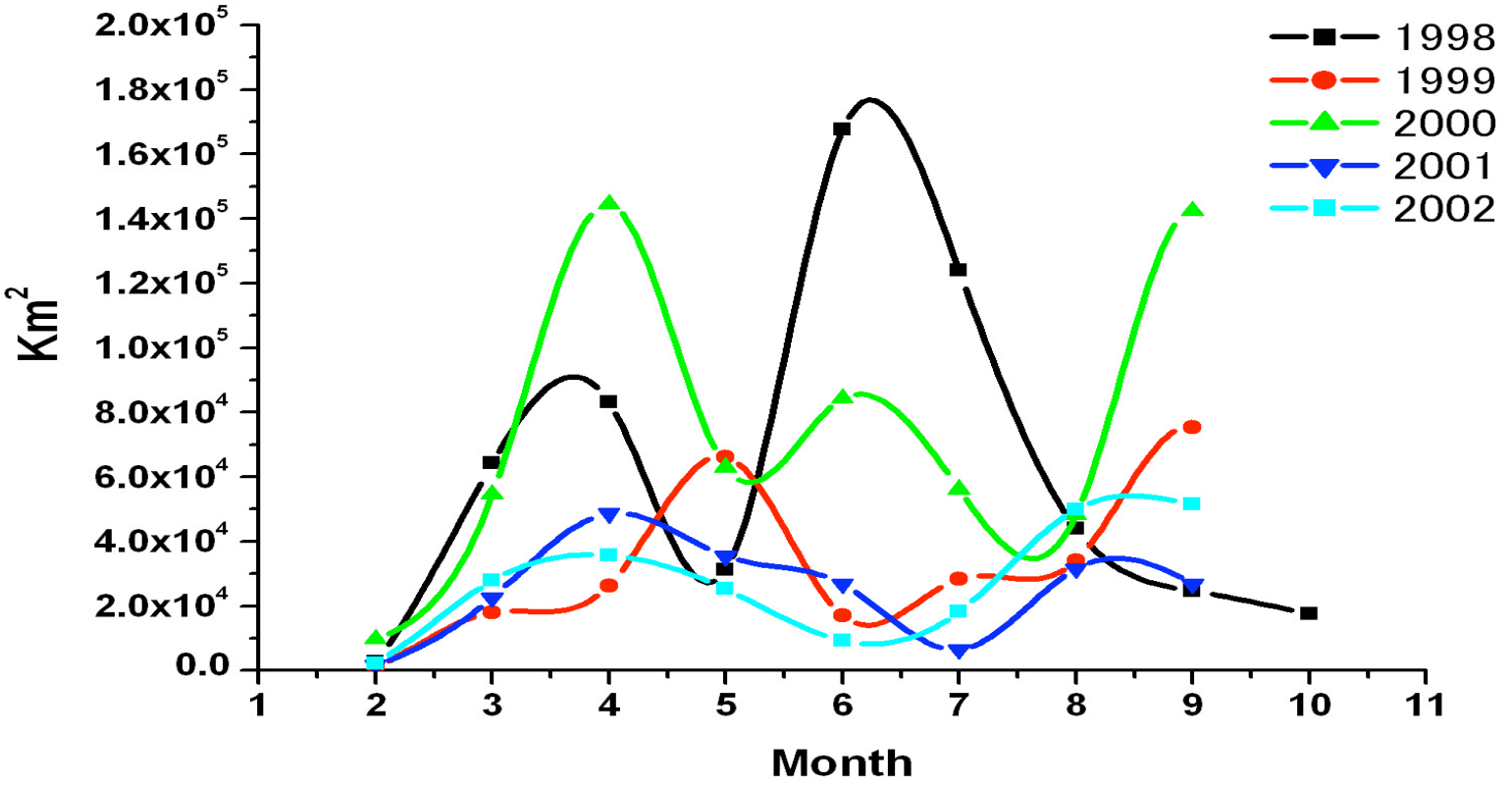


Coccolithophore bloom area



Composite Monthly Sea ice and Coccolithophore Mask Image

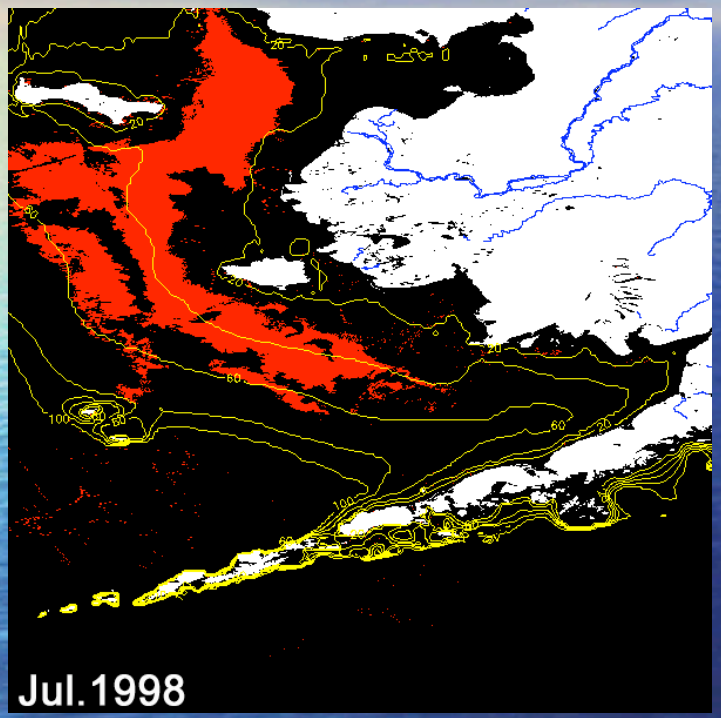
5 years Variability of coccolithophore bloom area

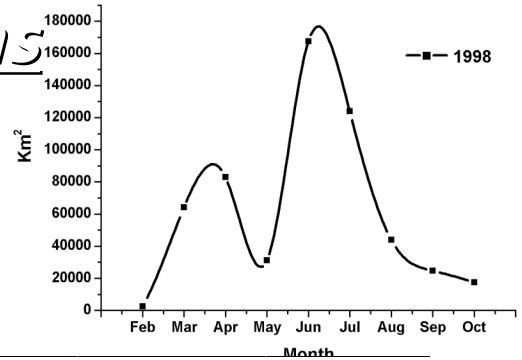


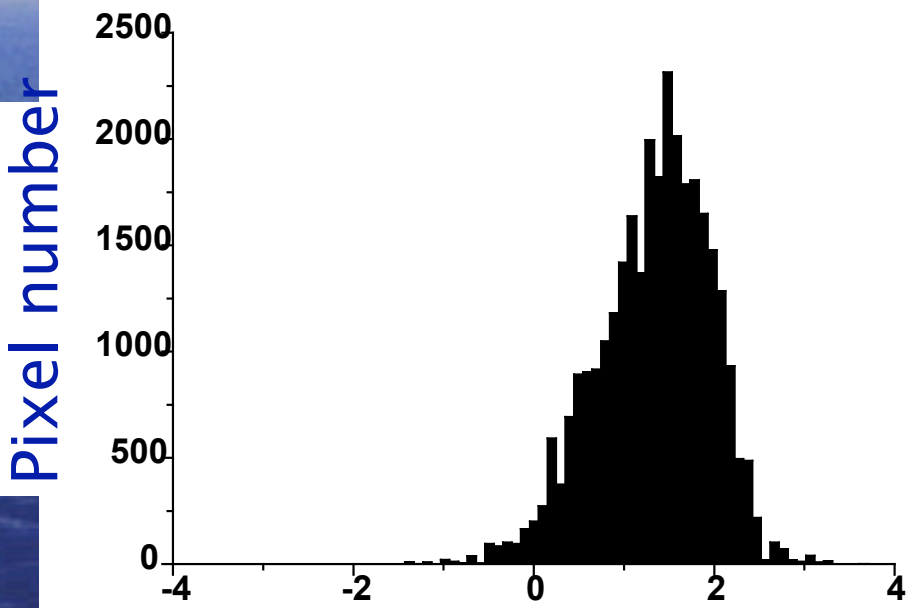
- 1998
  → massive summer bloom
- 1999
  → weak spring and fall bloom
- 2000
  → massive bloom(Apr.Jun.Sep.)
- 2001
  → low sea ice concentration
  weak bloom
- 2002
  → weak bloom

SST anomaly and coccolithophore blooms

1998 Summer





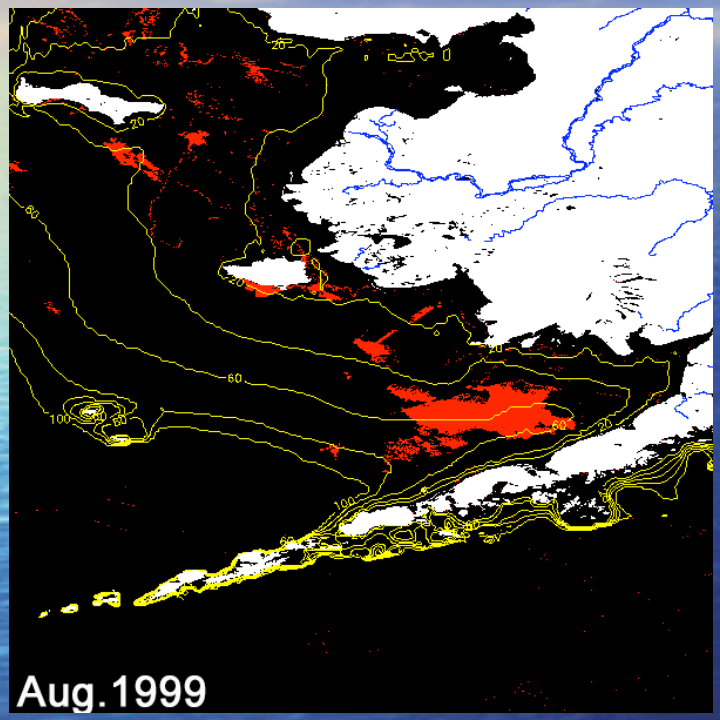


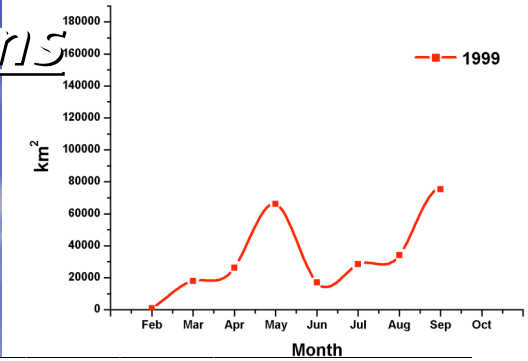
in cocco bloom area

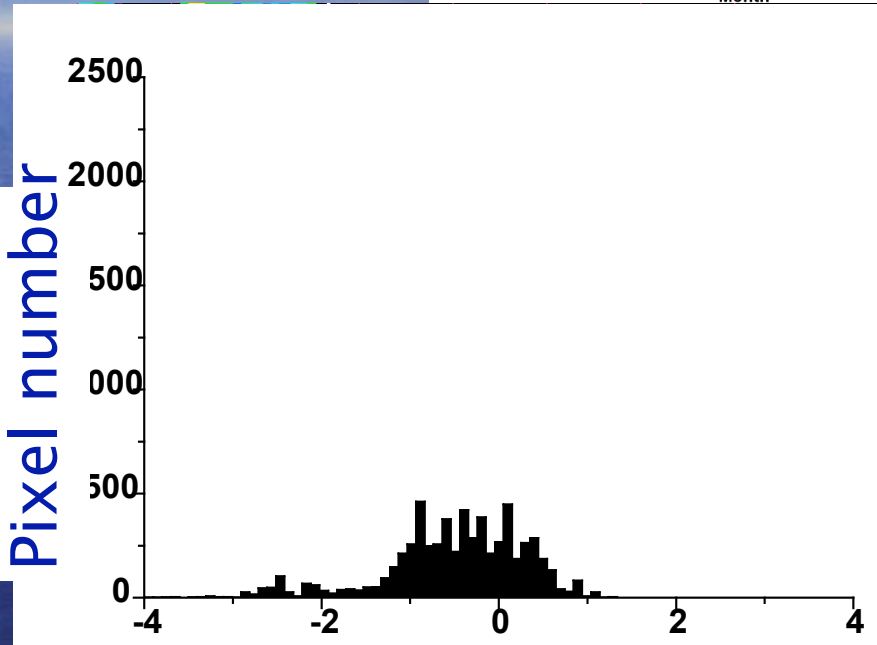
Positive SST Anomaly!!

SST anomaly and coccolithophore blooms

1999 Summer







in cocco bloom area

Negative SST Anomaly!!

Conclusions

Coccolithophore Blooms

- We found coccolithophore bloom using OCTS image in spring, before observation by SeaWiFS image in autumn 1997.

- Coccolithophore bloom of *Emiliania huxleyi* began spring and distributed at the surface layer from 20m to 100m in depth in the southeastern Bering Sea Shelf.

- Large bloom in 1998 and 2000, weak bloom in 1999 2001 and 2002. Positive sea surface temperature(SST) anomaly was corresponding to occurrence of massive coccolithophore blooms,

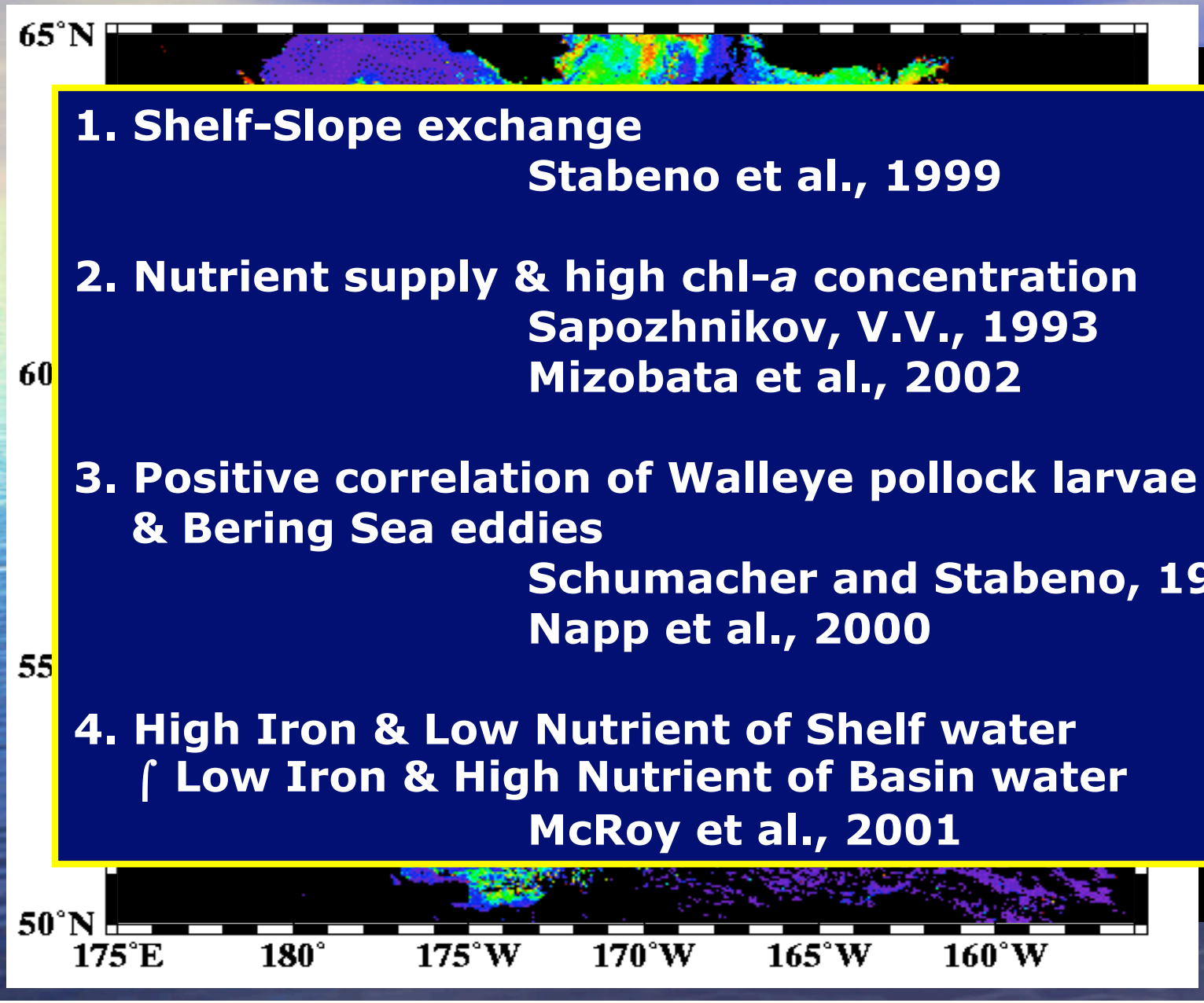
Two Topics

Bering Sea Ecosystem from Space

1. Coccolithophore Bloom dynamics during 1997-2002

2. **Seasonal and interanual variability of Bering Sea Eddies along the green belt**

Background



1. Shelf-Slope exchange
   Stabeno et al., 1999

2. Nutrient supply & high chl-*a* concentration
   Sapozhnikov, V.V., 1993
   Mizobata et al., 2002

3. Positive correlation of Walleye pollock larvae & Bering Sea eddies
   Schumacher and Stabeno, 1994
   Napp et al., 2000

4. High Iron & Low Nutrient of Shelf water
   ∫ Low Iron & High Nutrient of Basin water
   McRoy et al., 2001

Questions

Little are known about the horizontal distribution of mesoscale eddies along the shelf edge….

How many eddies are there along the shelf edge?

How much impacts does it affect on phytoplankton distribution and primary production along the "Green Belt"?

Data and Method

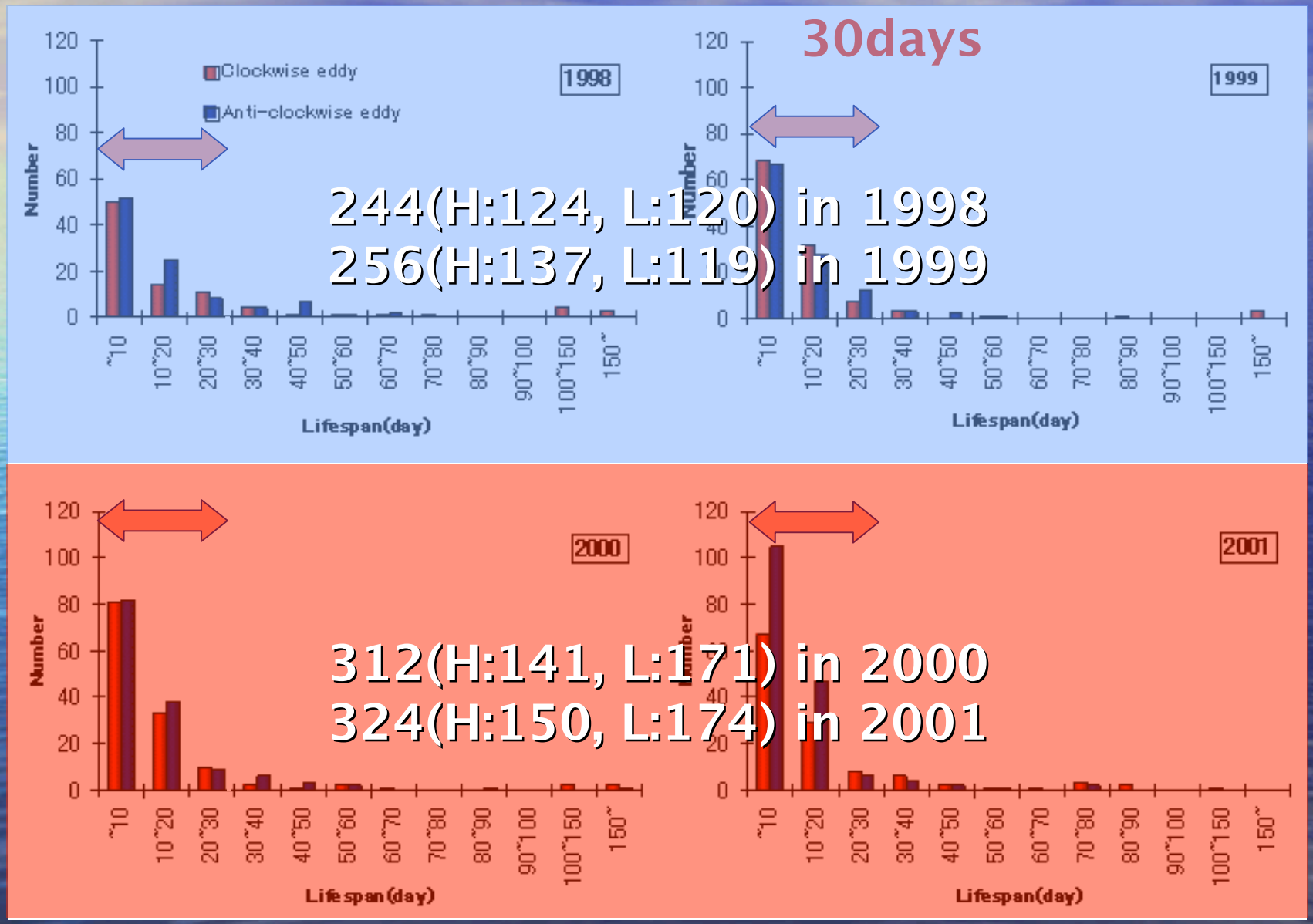
1. **TOPEX/ERS-2 daily Sea Surface Height Anomaly (SSHA) image 1998 Jan.1. ~ 2001 Dec.30**
   (http://www-ccar.colorado.edu/research/topex/html/topex.html)

2. **TOPEX/Poseidon 10days cycle SSHA**
   1997 Jan. ~ 2001 Dec (cycle 158 ~ 342)

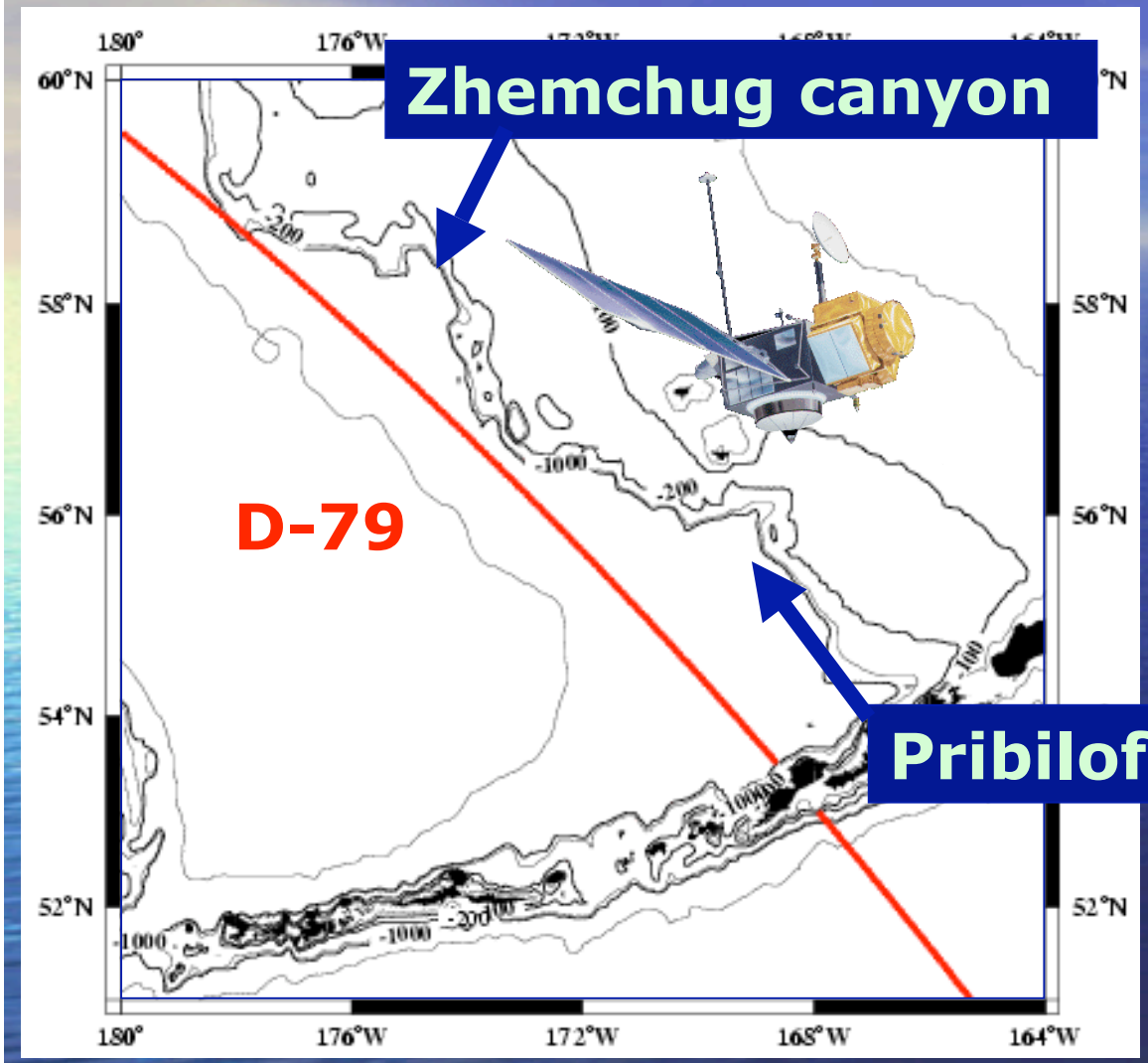
3. **Orbview2/SeaWiFS L3 chl-*a* concentration**
   1997 October. ~ 2001 May

4. **Primary production**
   calculated from SeaWiFS chl-*a*, PAR and NOAA/ AVHRR sea surface temperature using Kameda and Ishizaka model [advanced VGPM model]
   1997 October. ~ 2001 May

Results - 1 : Lifetime of eddies



Results - 2 : Bering Sea eddy field

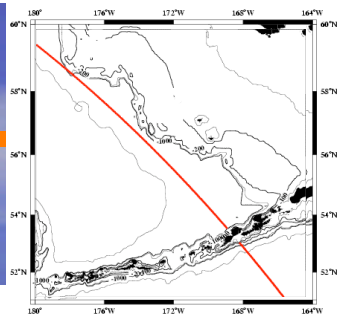


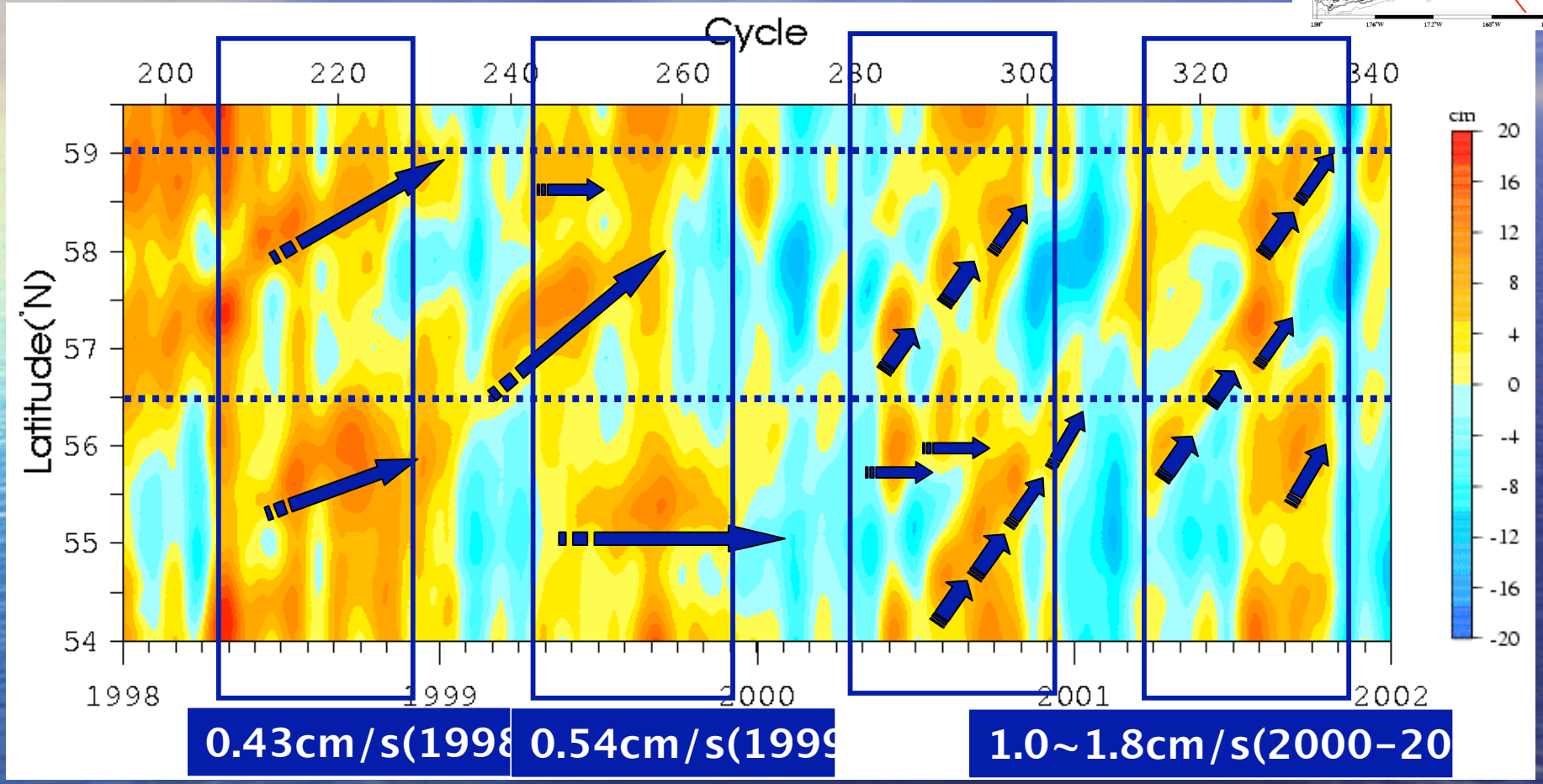
10 days cycle data

along the shelf break of the Bering Sea

SSHAs calculated from
Merged Geophysical Data Record – B[JPL] (Benada,1997)

Results - 2 : Bering Sea eddy field

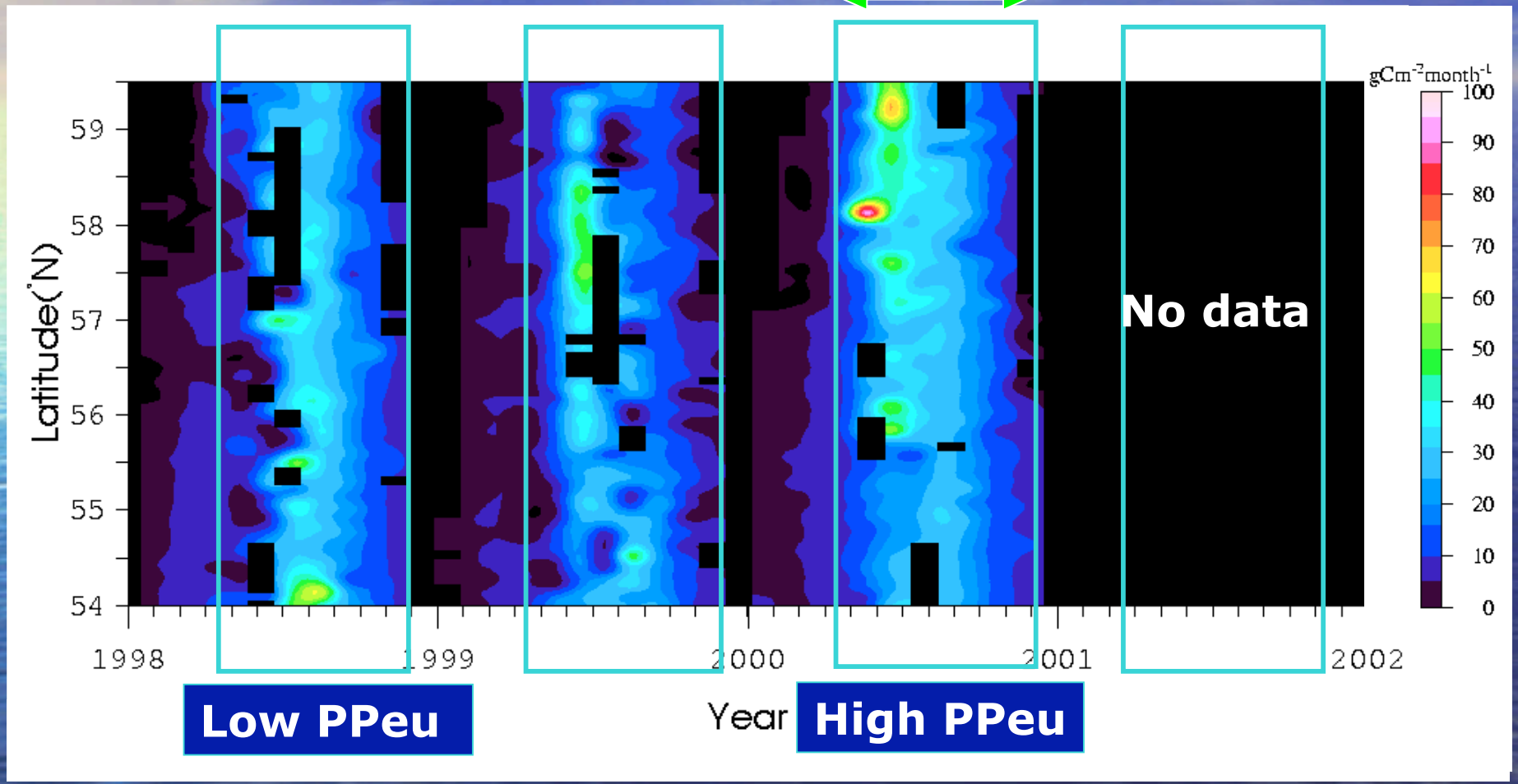




Time-latitude isopleths of T/P SSHAs

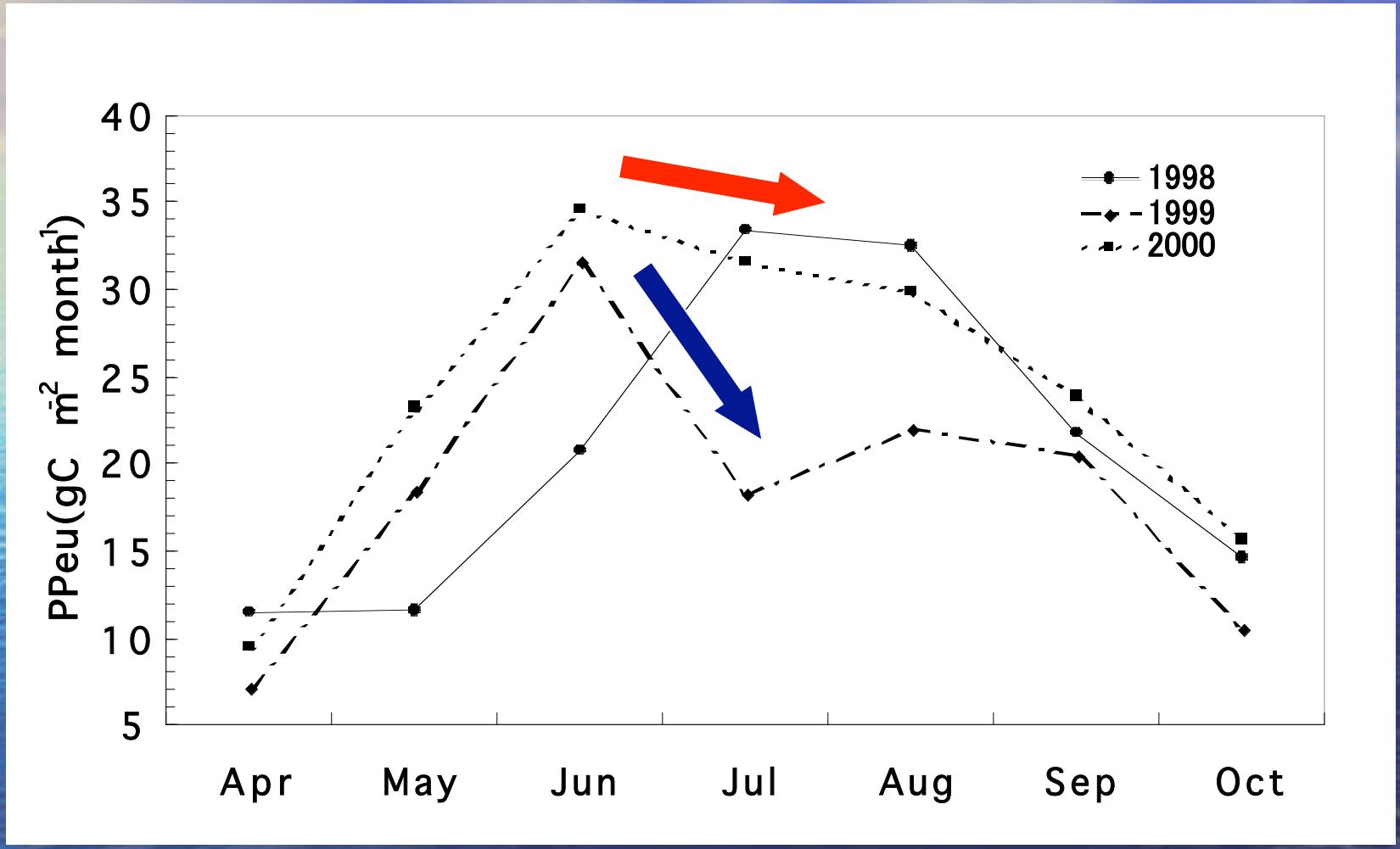
Results - 3 : Biological conditions(PPeu)

About 6months



Time-latitude isopleths of primary production estimated using Kameda and Ishizaka model(2002)

Results - 3 : Biological conditions(PPeu)



Averaged primary production along the shelf break

Conclusions

Bering Sea eddies and primary production

Satellite Remote sensing revealed,

1. **The interannual variability of Bering Sea eddy field affected by the BSC transport. (From 2000, there was an increase in Bering Sea eddy field.)**

2. **Difference in Propagation and distribution characteristics between cyclonic and anti-cyclonic eddy**

3. **An importance of Bering Sea eddy field for maintaining the productivity.**

Future Application
Bering Sea Ecosystem from Space

New method of sea ice thickness estimation using passive microwave radiometers

Tateyama et al. (2002)

- amount of sea ice production interannual
- variability of sea ice thickness

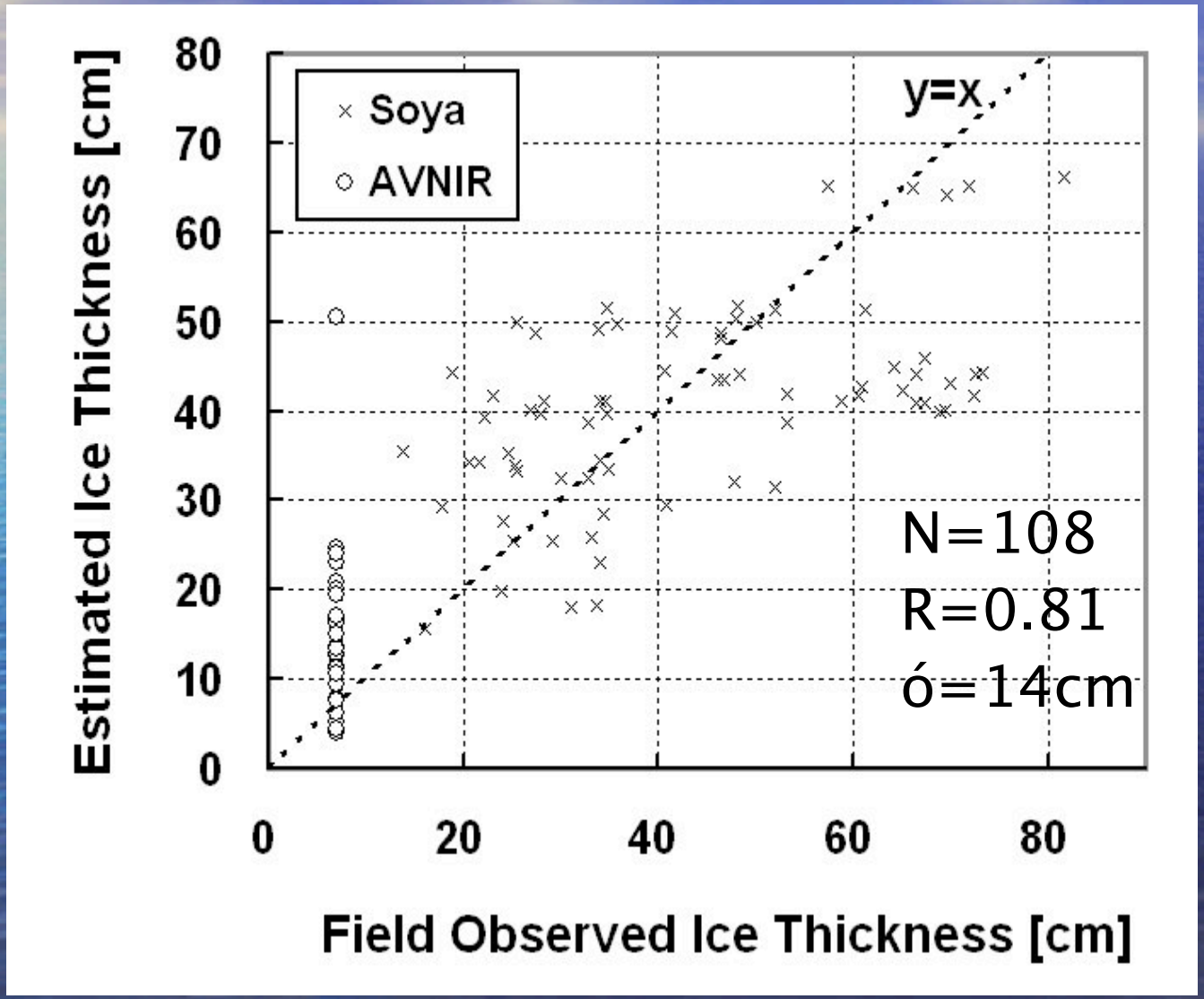
New ocean color data sets and Multi-sensor

SeaWiFS, two MODISs (from Aqua and Terra) and GLI (from ADEOS-II)

The frequency of shutter chances is increasing and hyper-spectral data sets are available.

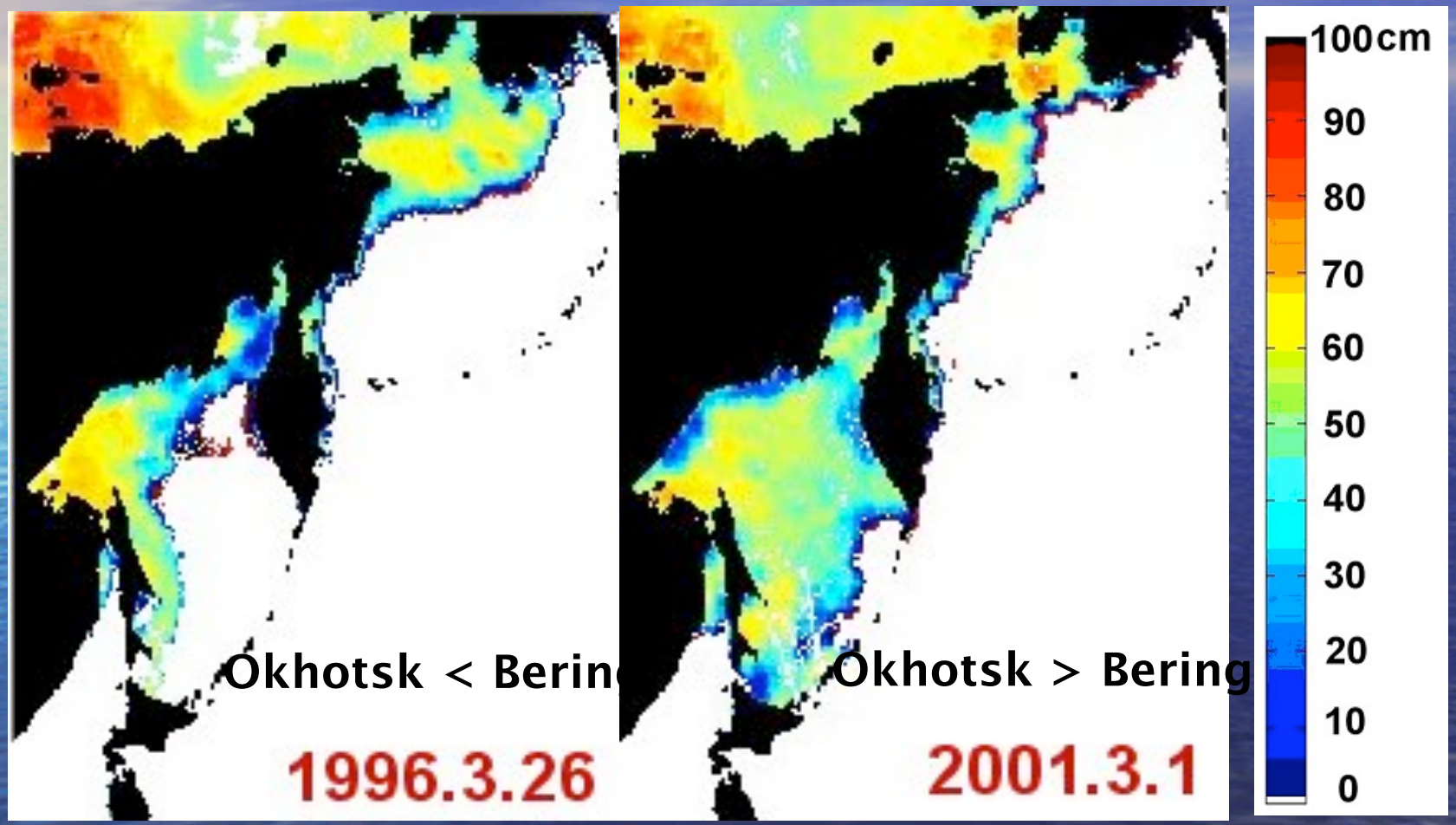
New method of sea ice thickness estimation

$$H(\mathrm{cm}) = -537.33 \cdot PR + 83.88 \cdot R_{37V/85V} - 6.91$$



Tateyama et al. (2002)

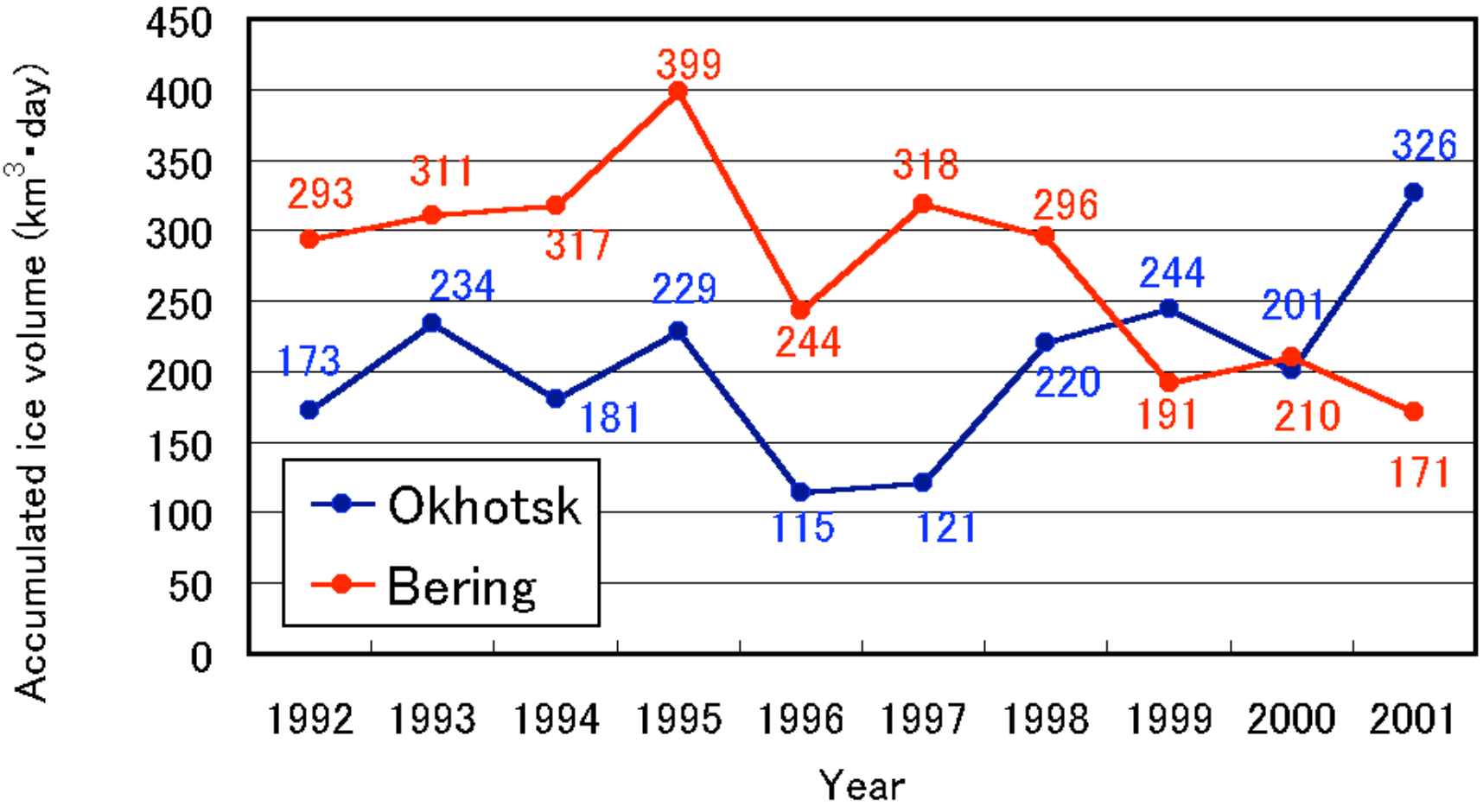
Inter-seasonal out-of-phase response in the Okhotsk Sea and the Bering Sea



Tateyama et al. (2002)

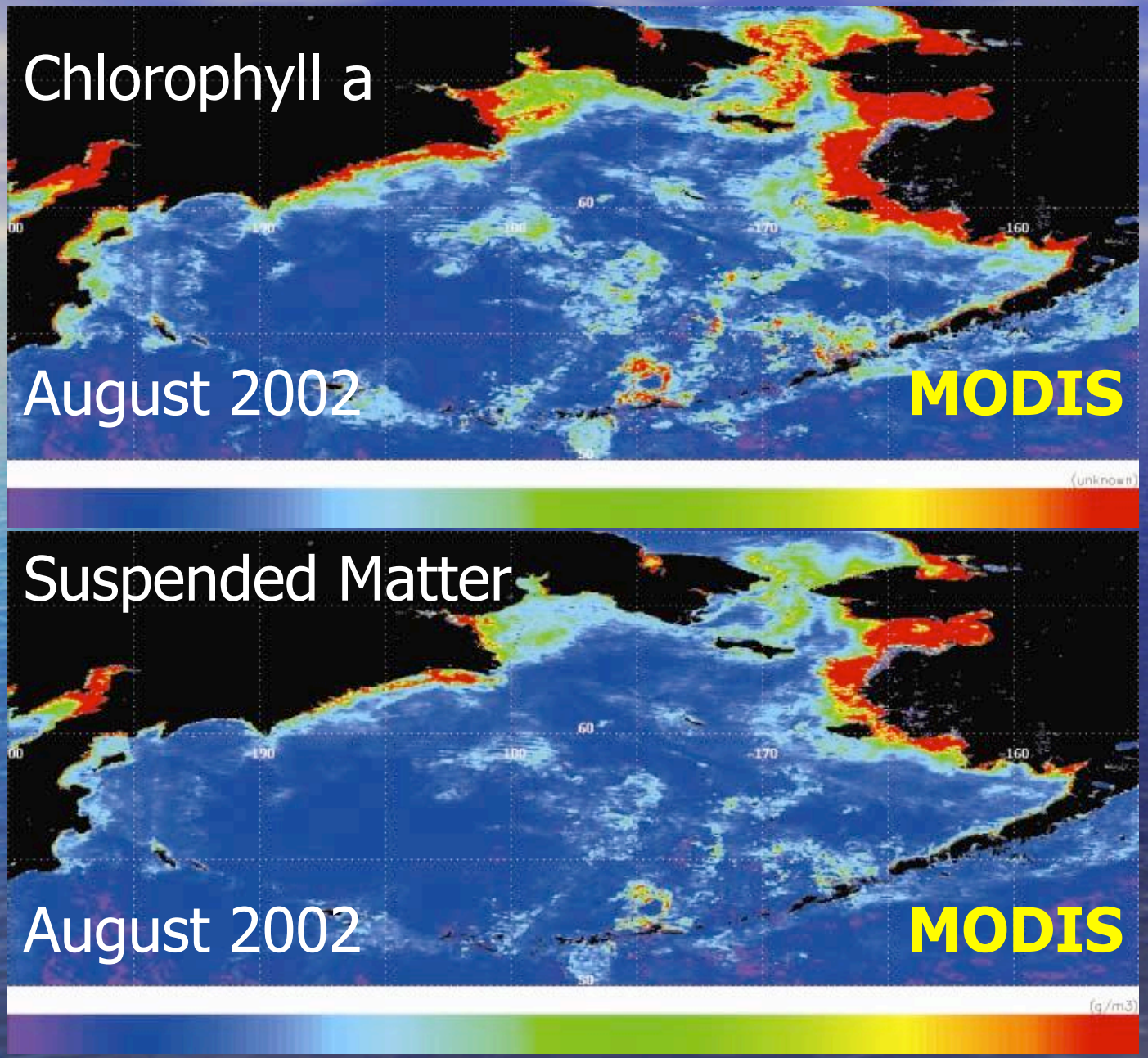
New method of sea ice thickness estimation

Accumulated ice volume

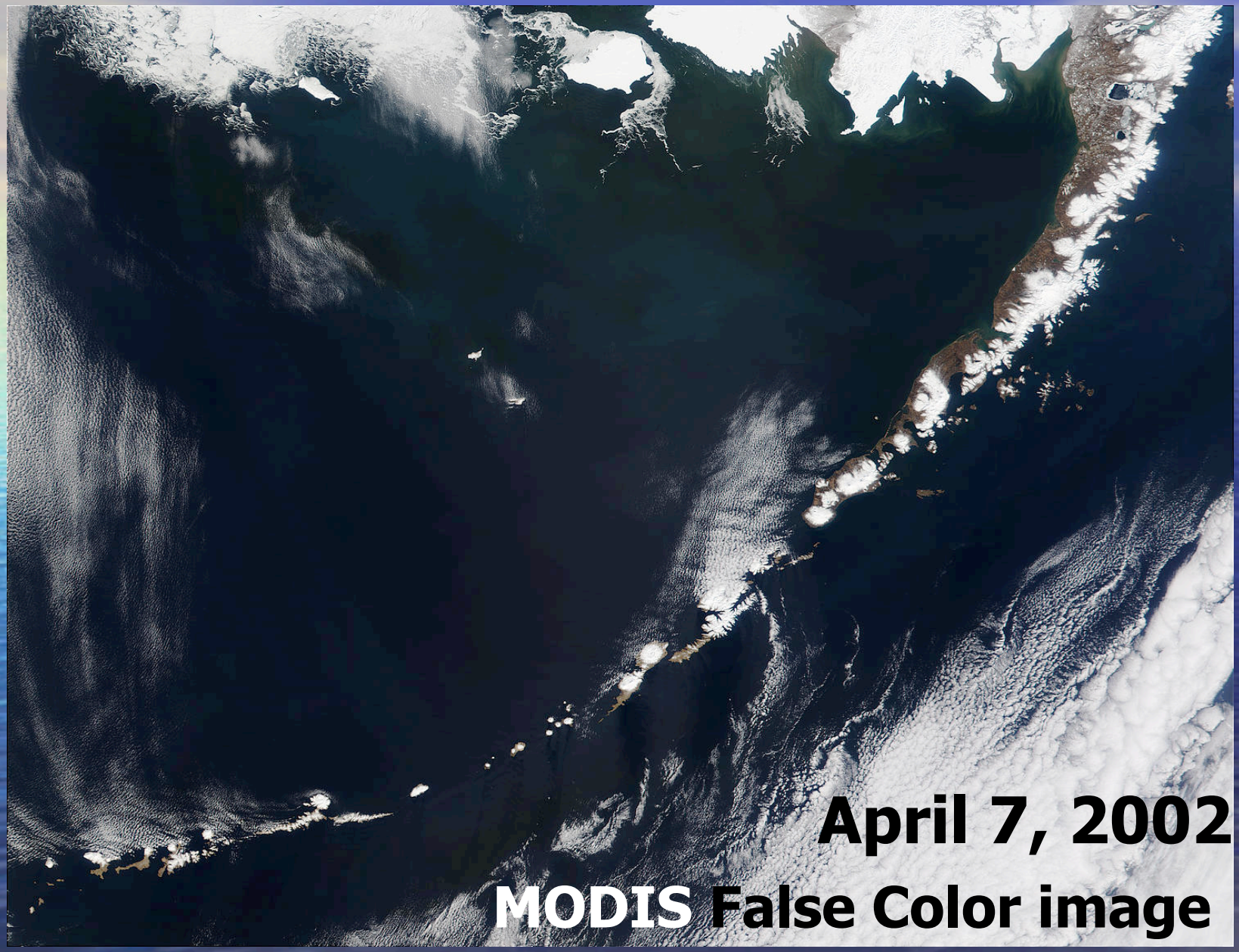


Tateyama et al. (2003), unpublished

New ocean color data sets and Multi-sensor

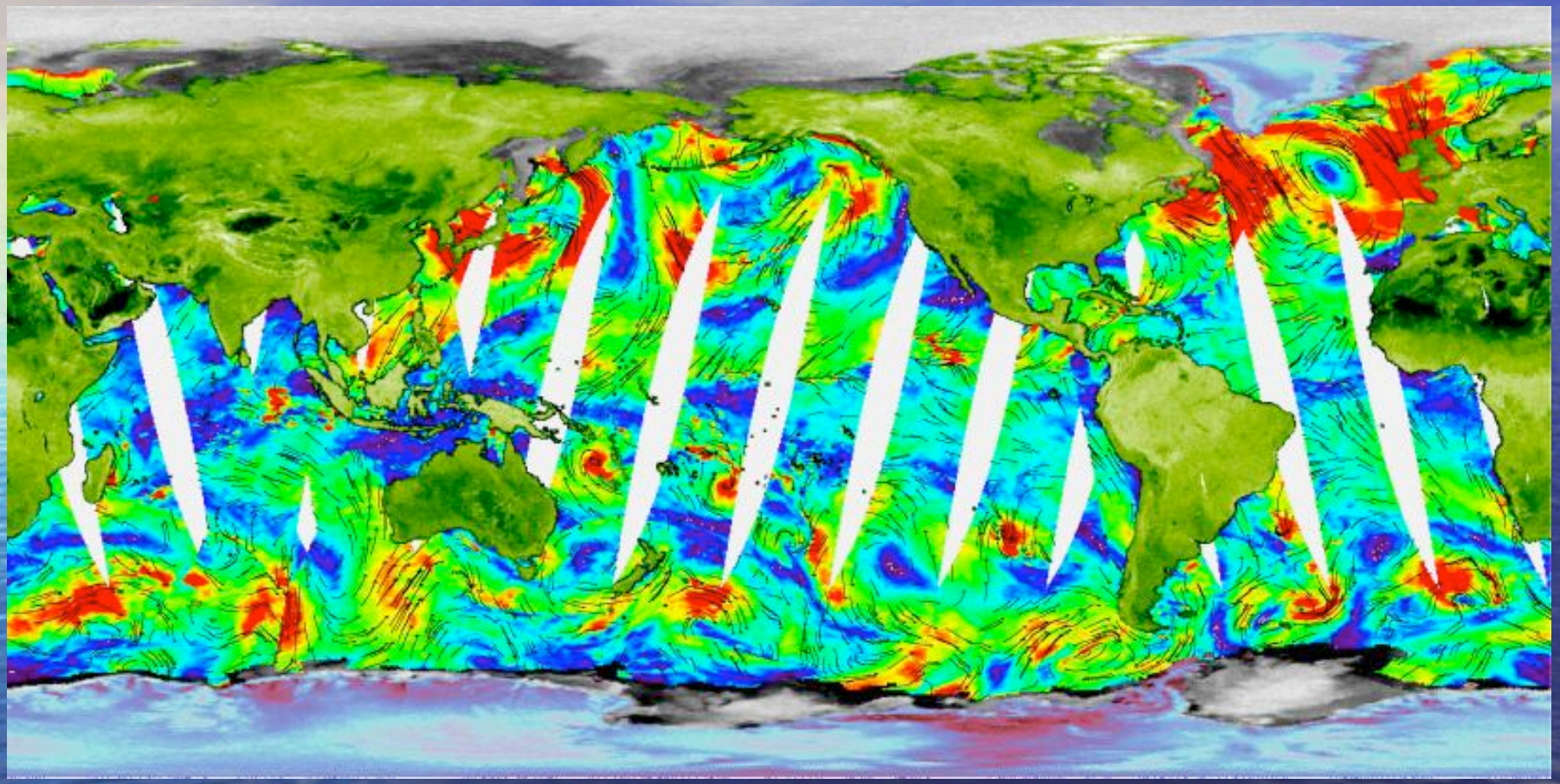


New ocean color data sets and Multi-sensor



New ocean color data sets and Multi-sensor

ADEOS-II SeaWinds (Microwave)



Four days composite(Jan. 28- Jan. 31, 2003)

Some Suggestions

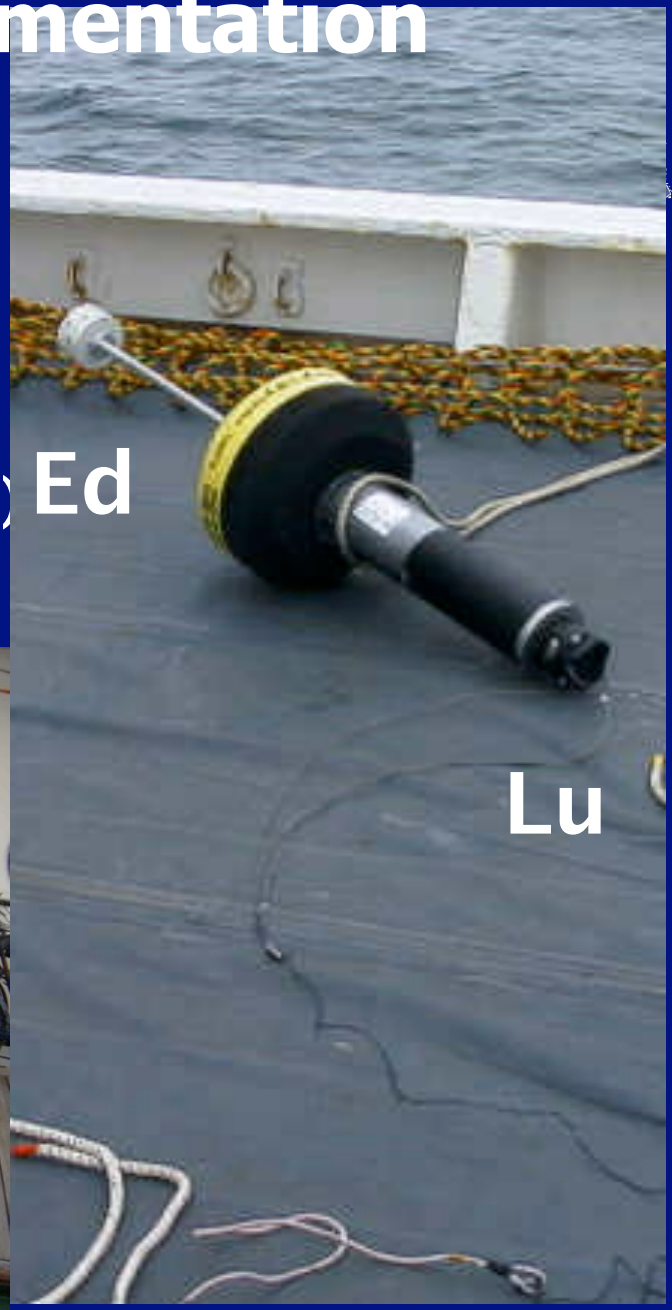
- **Bio-optical drifting buoy (TOGA-TAO type)** to study time-series primary production and biogeochemical process
- **ARGO-type bio-optical buoy system** (such as K-SOLO) to study vertical structure of biological processes in the basin region of the Bering Sea

Some suggestions: Instrumentation

Bio-optical Drifting Buoy

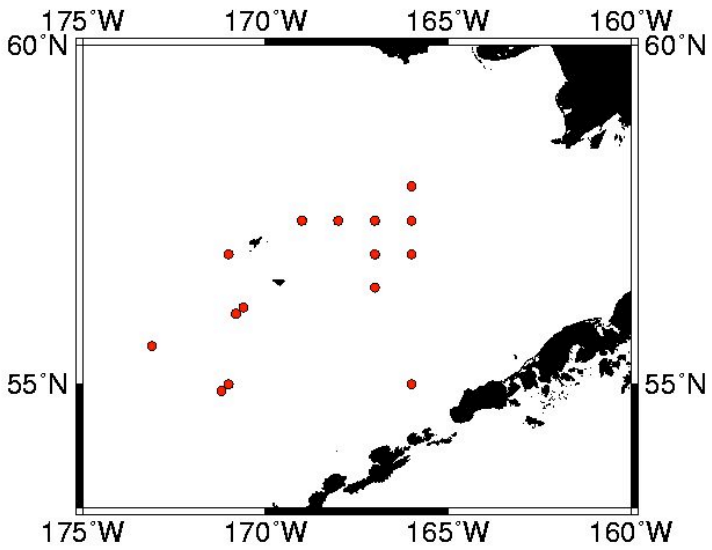
Sensors

1.Barometer (Ba)
2.Sea Surface Temperature(SST)
3.Air Temperature(AT)
4.Lu(683nm)
5.Lu(670nm)
6.Lu(555nm)
7.Lu(510nm)
8.Lu(490nm)
9.Lu(443nm)
10.Lu(412nm)
11.Ed(490nm)



Some suggestions: Instrumentation

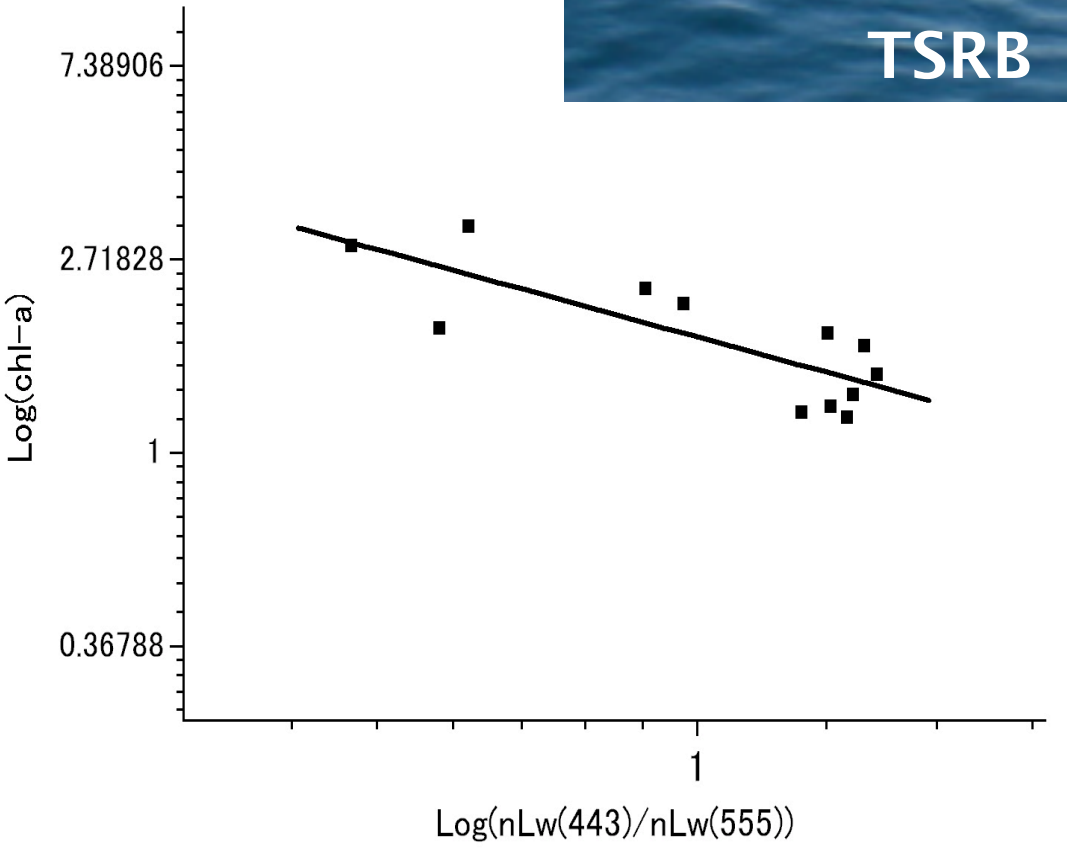
Bio-optical Drifting Buoy



TSRB Obs. map

↓

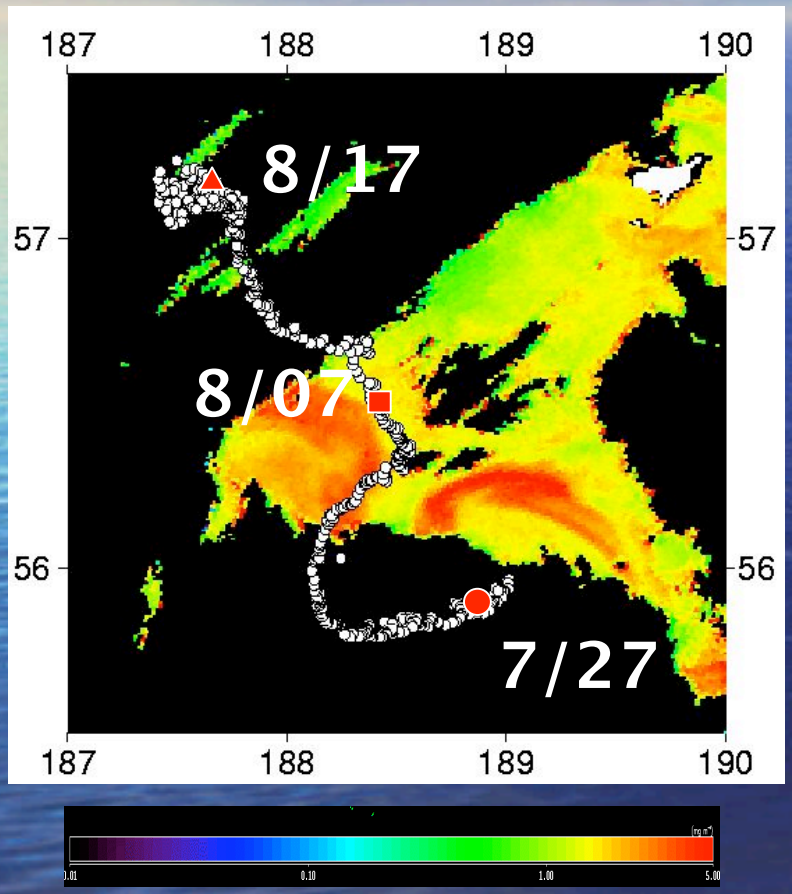
Mooring optical buoy

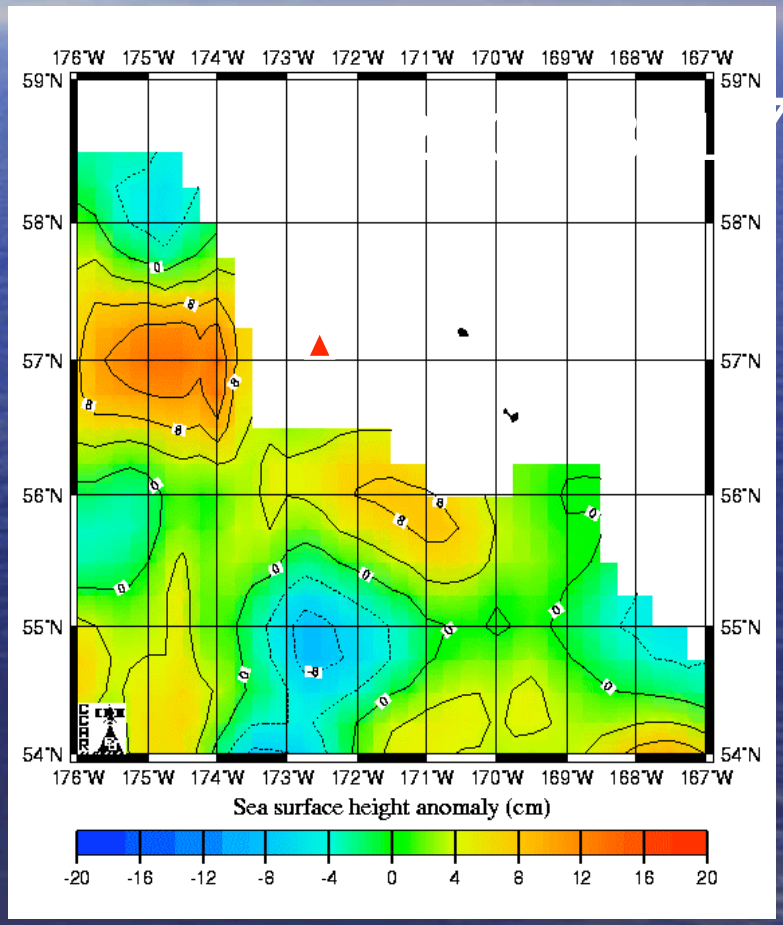


$$Chl = 0.59807 * (Lu443/Lu555)^{-1.04598}$$

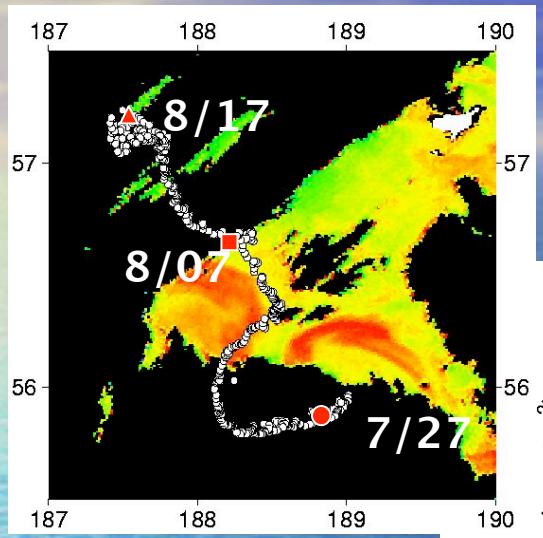
Comparison trajectory with TOPEX and SeaWiFS d

2001





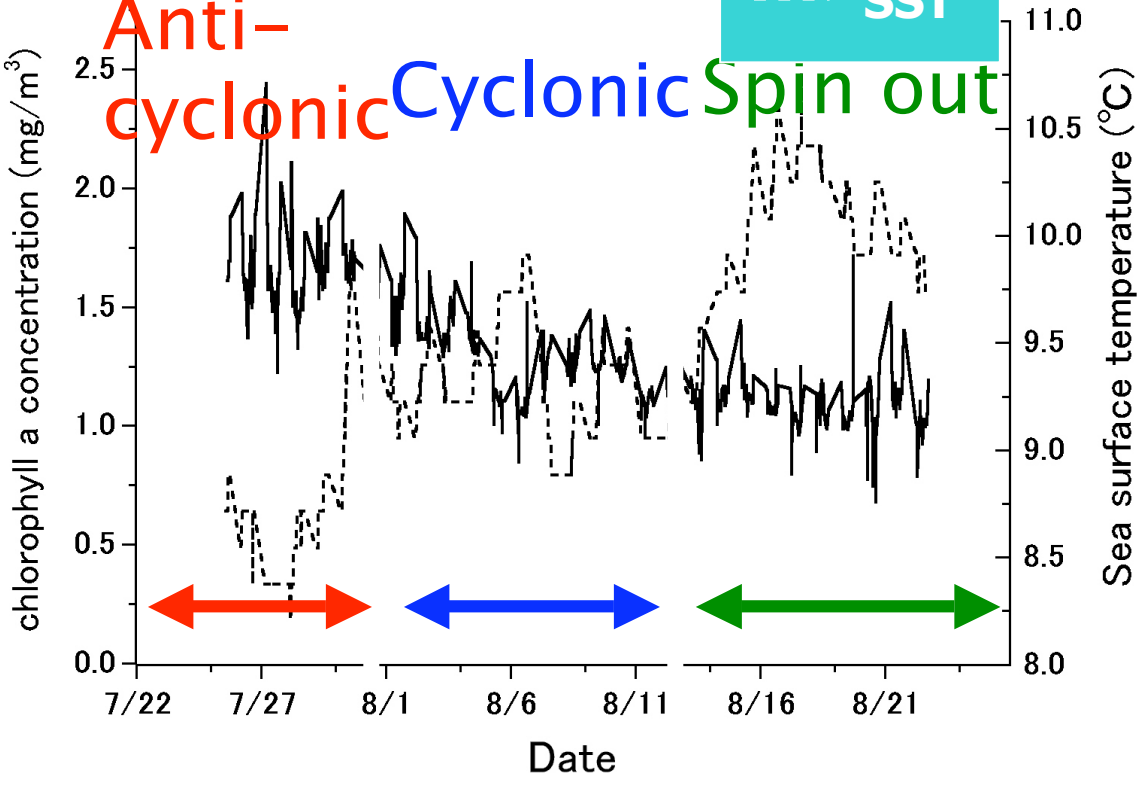
Variability of SST and chl-a field in 2001



Anti-cyclonic

Cyclonic

Spin out



Some suggestions: Instrumentation

Bio-optical Drifting Buoy

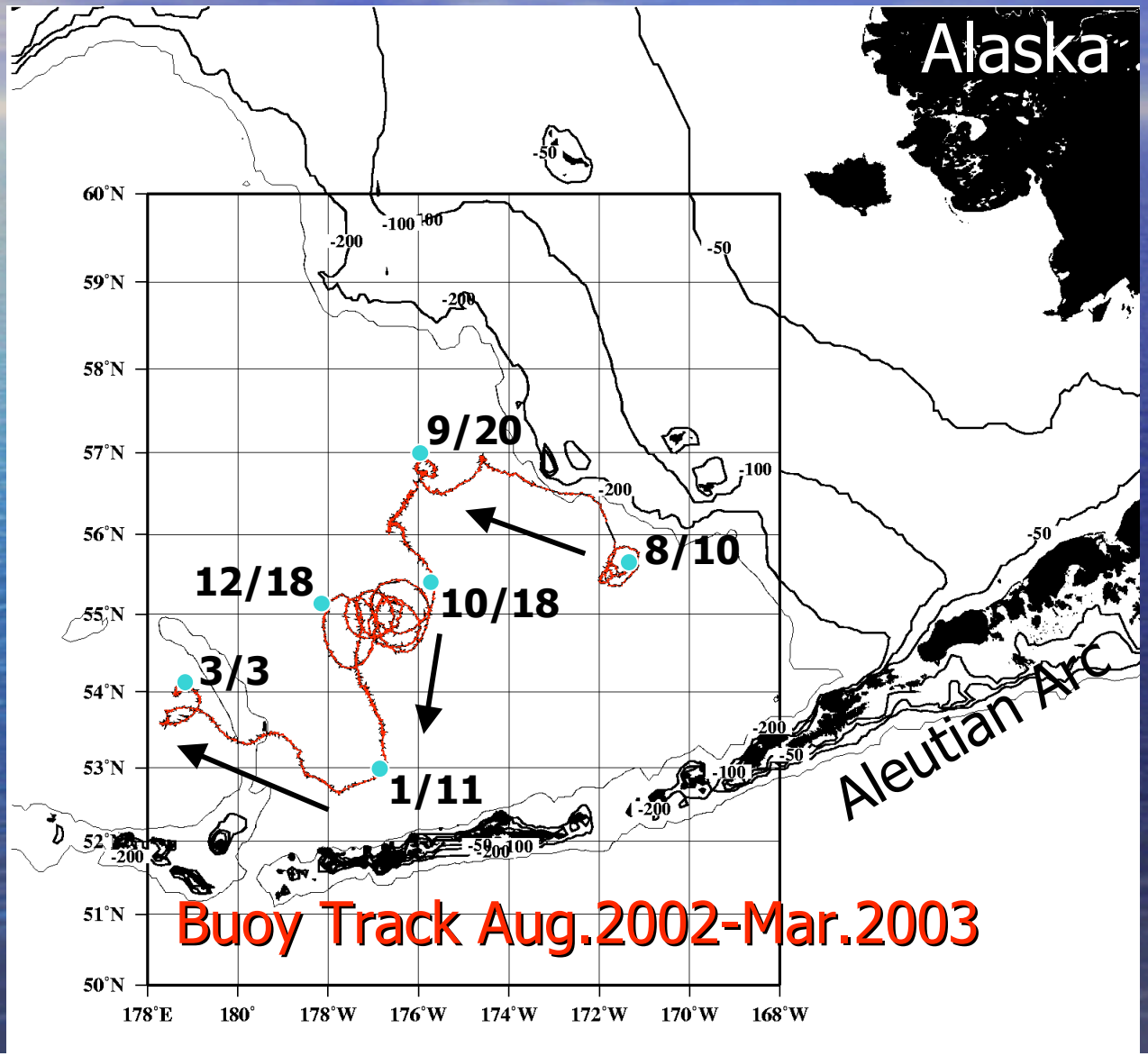


Photo by Sei-ichi Saitoh
Baby Island, Aleutian Islands
in Summer, 1975