Relationship between the mixed layer depth and surface chlorophyll in the Japan/East Sea

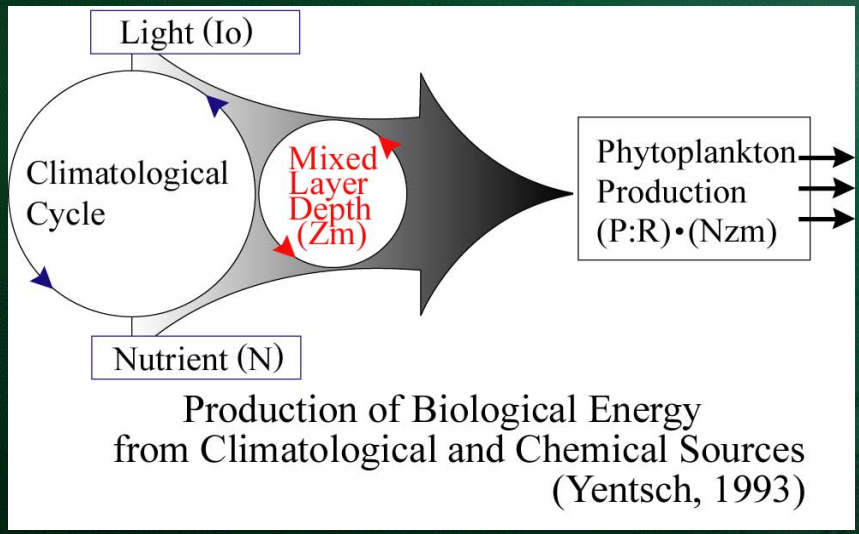
Hyun-cheol Kim[1,2], Sinjae Yoo[1]
Im Sang Oh[2]

1. Korea Ocean Research & Development Institute
2. . Seoul National University

Acknowledgements

- We thank NASA/DAAC, KODC and JODC for providing the data.
- Hyun-cheol Kim appreciate travel support from KOC and PICES.

Conceptual Model



Production of Biological Energy
from Climatological and Chemical Sources
(Yentsch, 1993)

- **The concentration of phytoplankton in a water mass is caused by several key factors.**
- **The growth processes and photosynthesis, are under the control of light and nutrients.**
- **The seasonal change in growth in temperate seas is linked with the seasonal change in the mixed layer depth.**
- **The mixed layer depth is regulated by meteorological processes such as wind stress, air-sea heat flux and change in solar radiation.**

Objectives

- To understand the role of mixed layer depth and current in determining the surface chlorophyll distribution in springs in ***the Japan/East Sea*** *using satellite-observed Ocean Color* and other data.

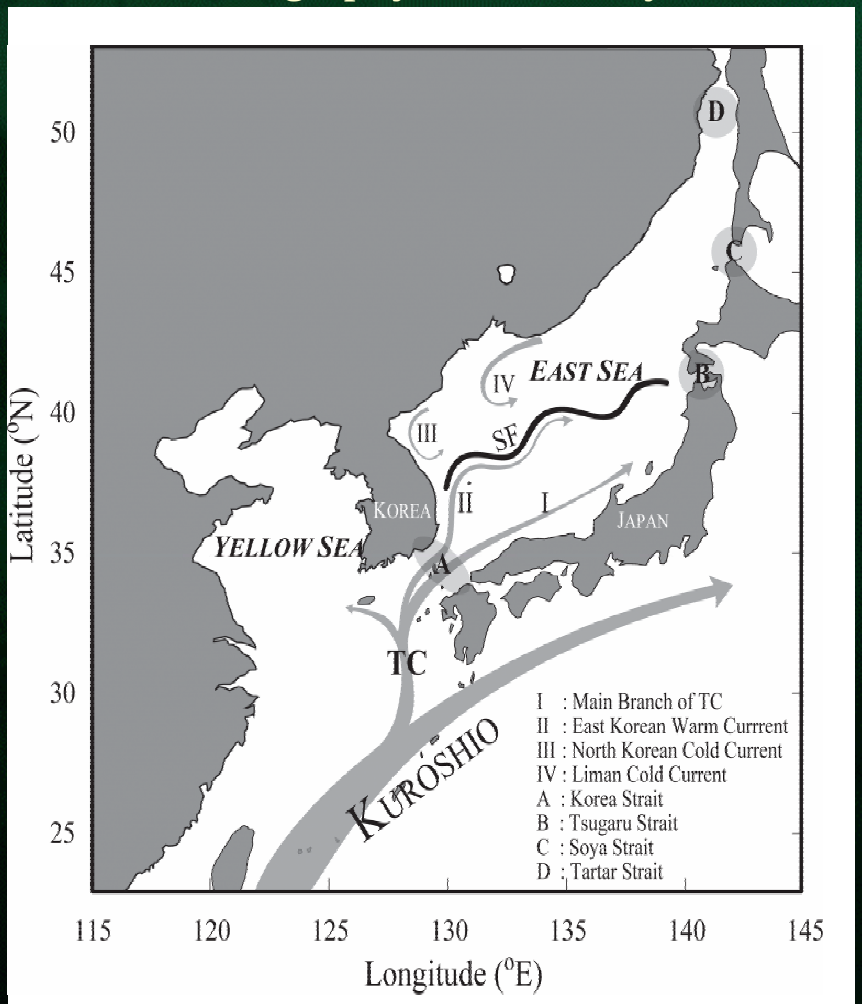
- Sub-topics

1. Seasonal variability & inter-annual variability of chlorophyll in the Japan/East Sea (JES).
2. Relationship between CHL and mixed layer depth at 4 sites
   - Phytoplankton bloom timing and mixed layer depth -

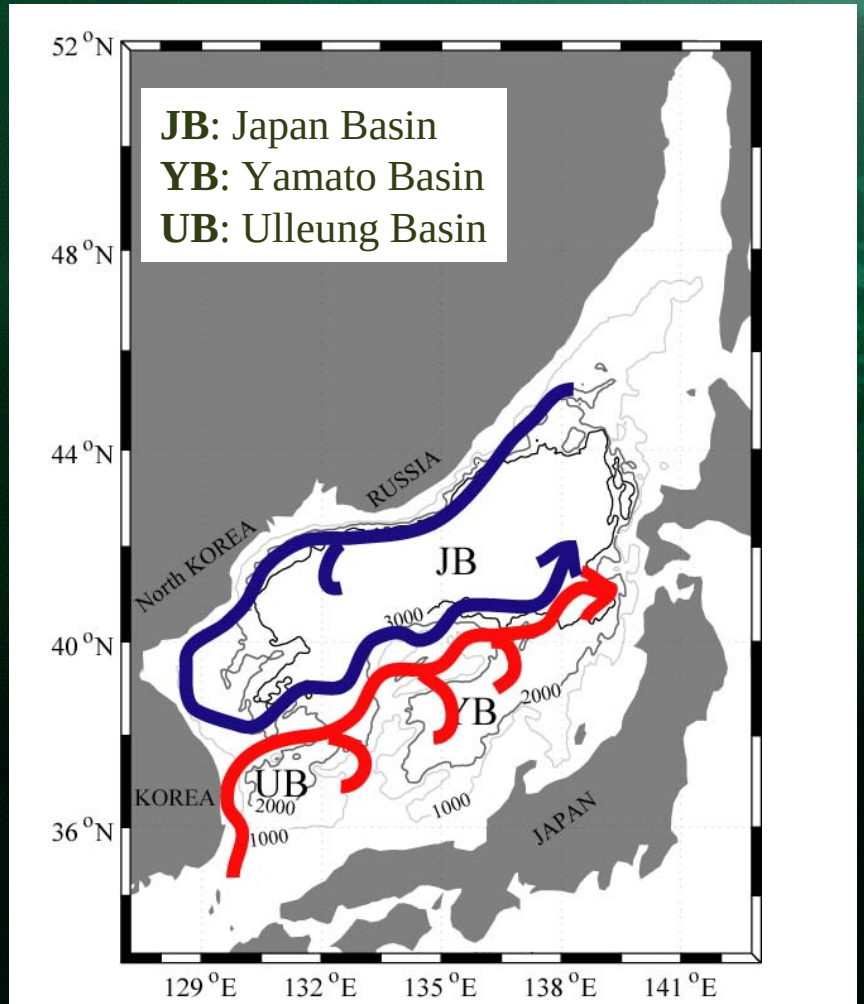
Study area

Japan/East Sea (JES) - "miniature ocean" (Ichiye, 1984)

Schematic map
Geography & current system



Topography
& Three Basins

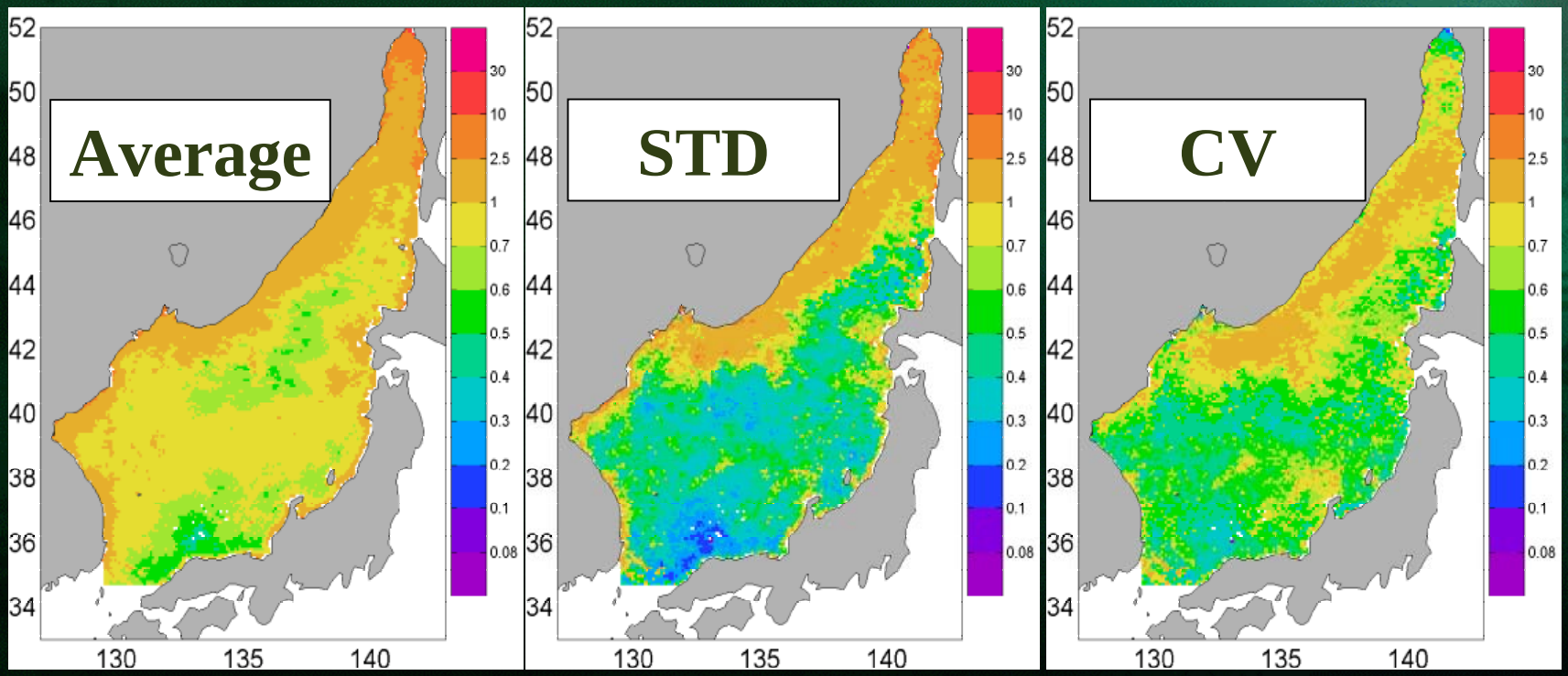


Data

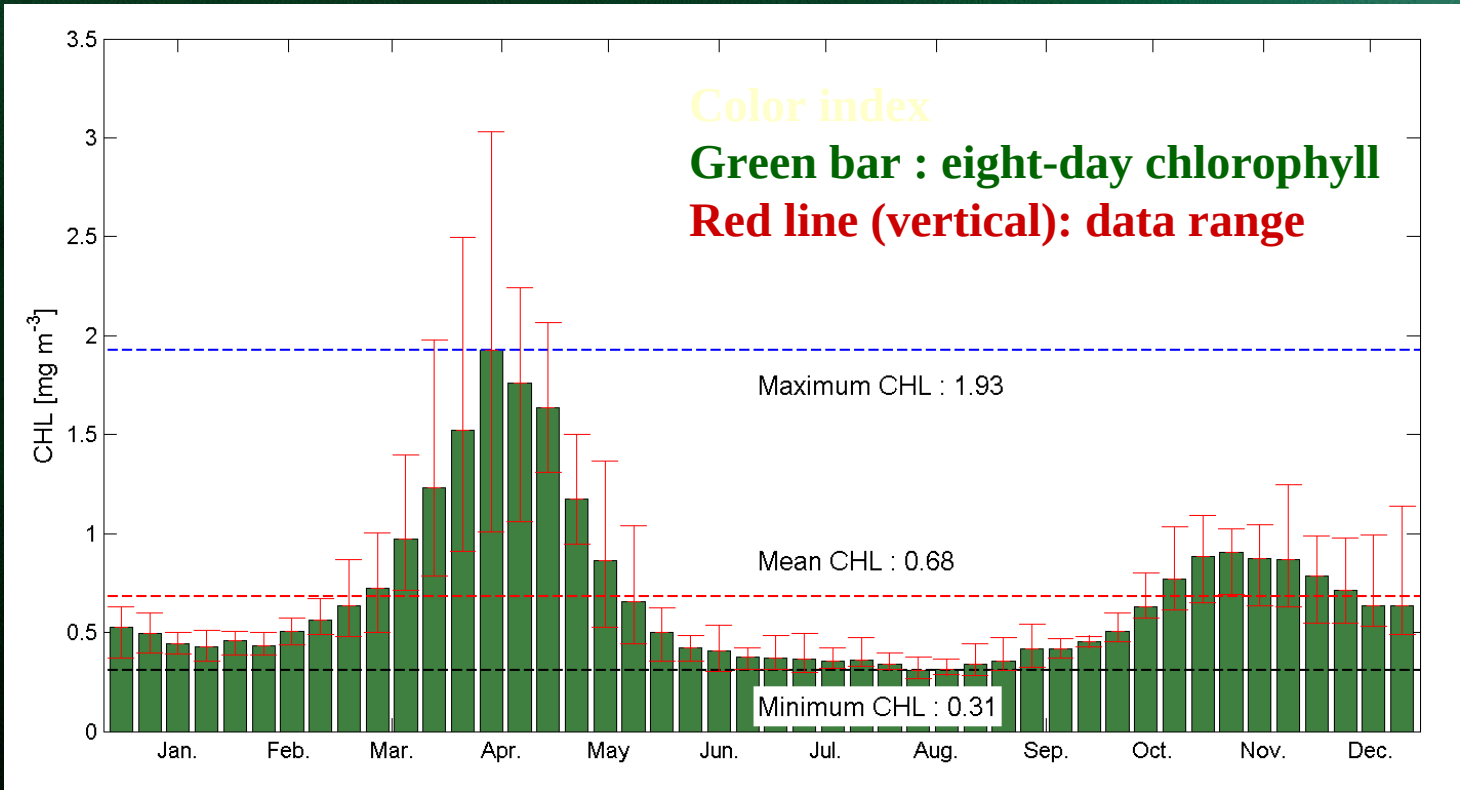
- Ocean Color (Chlorophyll) :
  SeaWiFS (1997.9~2005.6)
- PAR :
  SeaWiFS (1997.9~2005.6)
- SST :
  AVHRR (1997.1~2004.12)
- MLD :
  FNMOC Model results (by Kara et al., 2003)
- Temperature profile
  KODC (1997~2004), JODC (1997~2002)

1. Seasonal and inter-annual variability of chlorophyll in Japan/East Sea

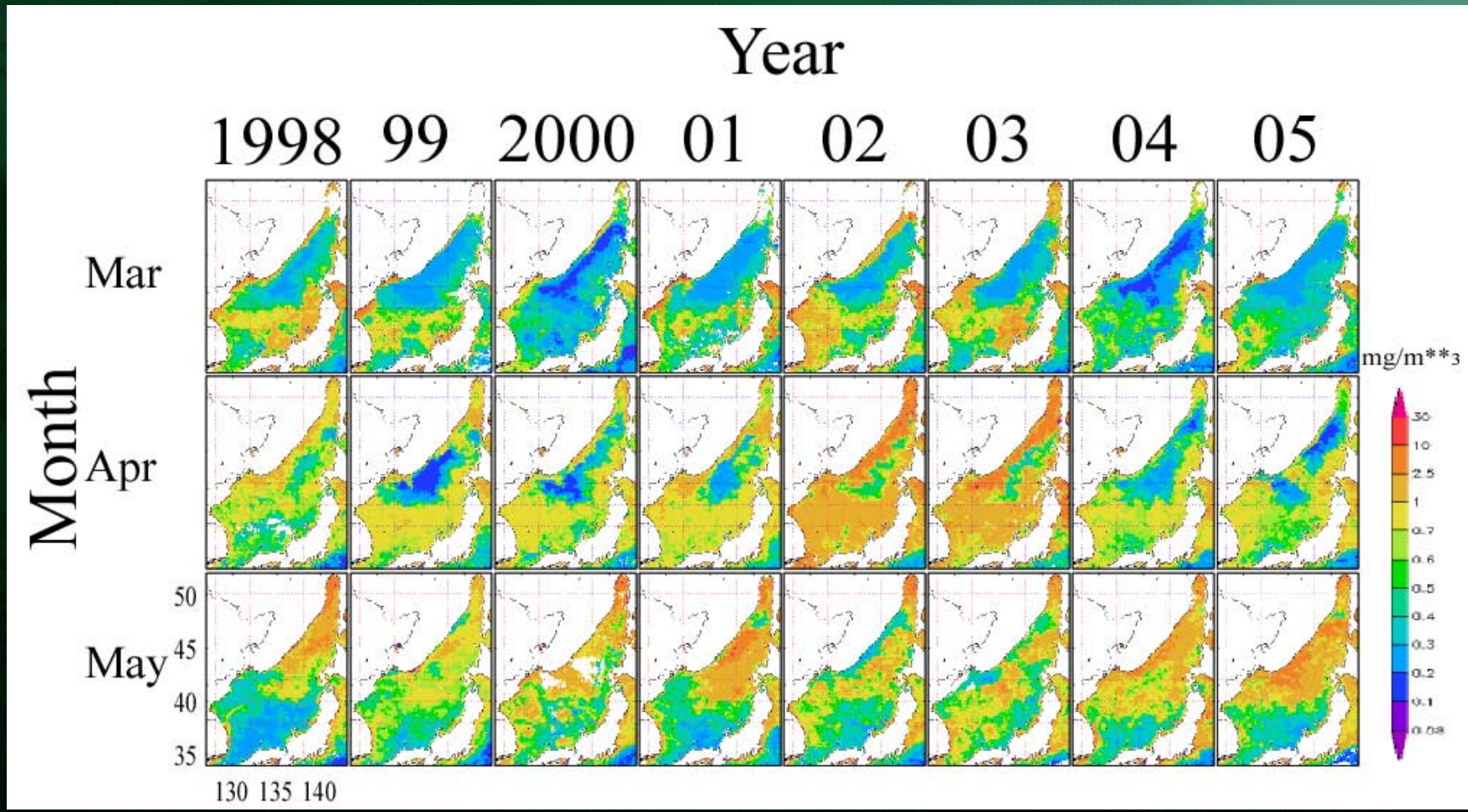
Statistics of CHL in springs (1998~2005)



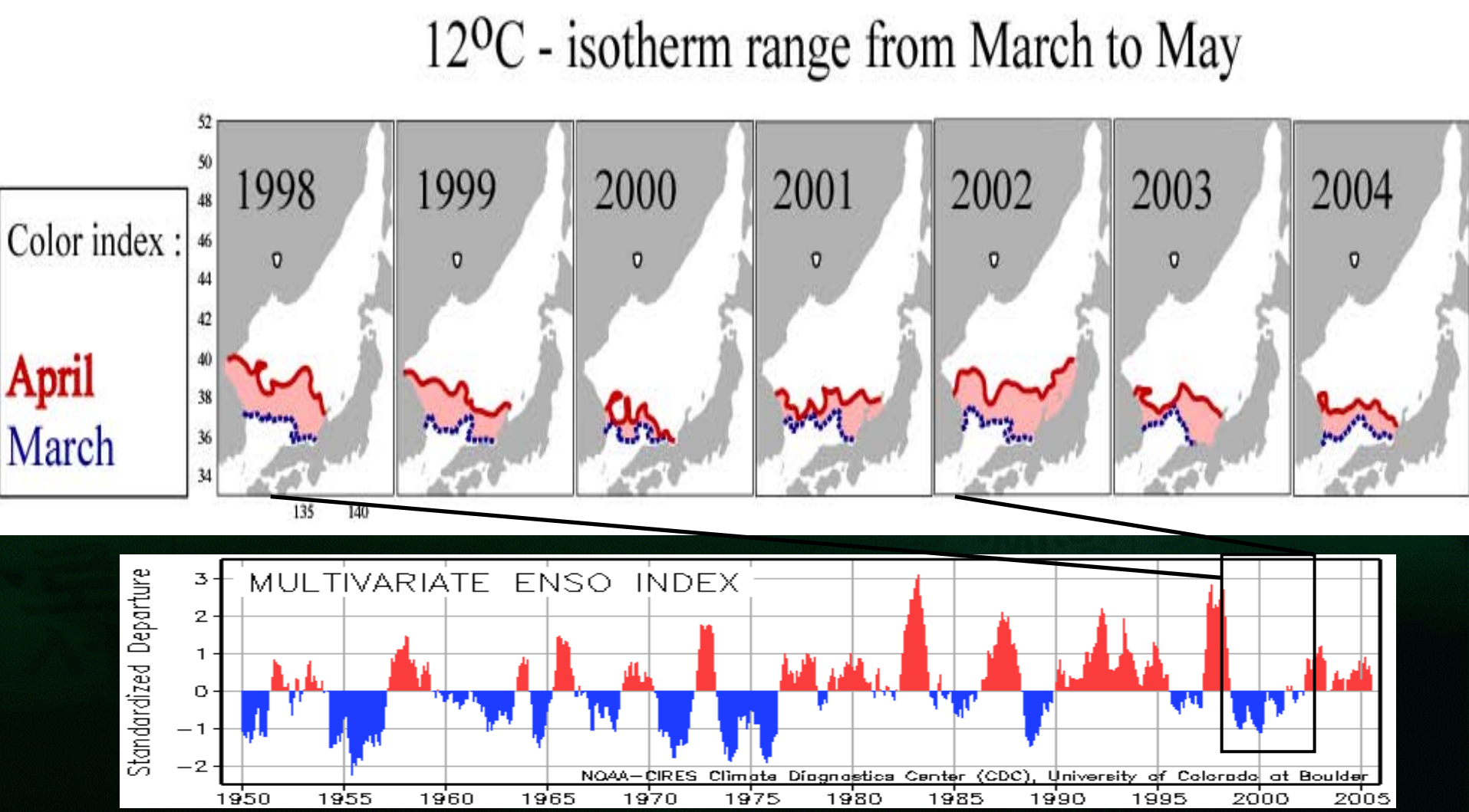
Mean seasonal CHL concentration cycle over the eight years (1997~2004) in the JES



CHL distribution in springs



12 ℃ isothermal range (MAR→APR) in springs vs. ENSO Index



Summary 1.

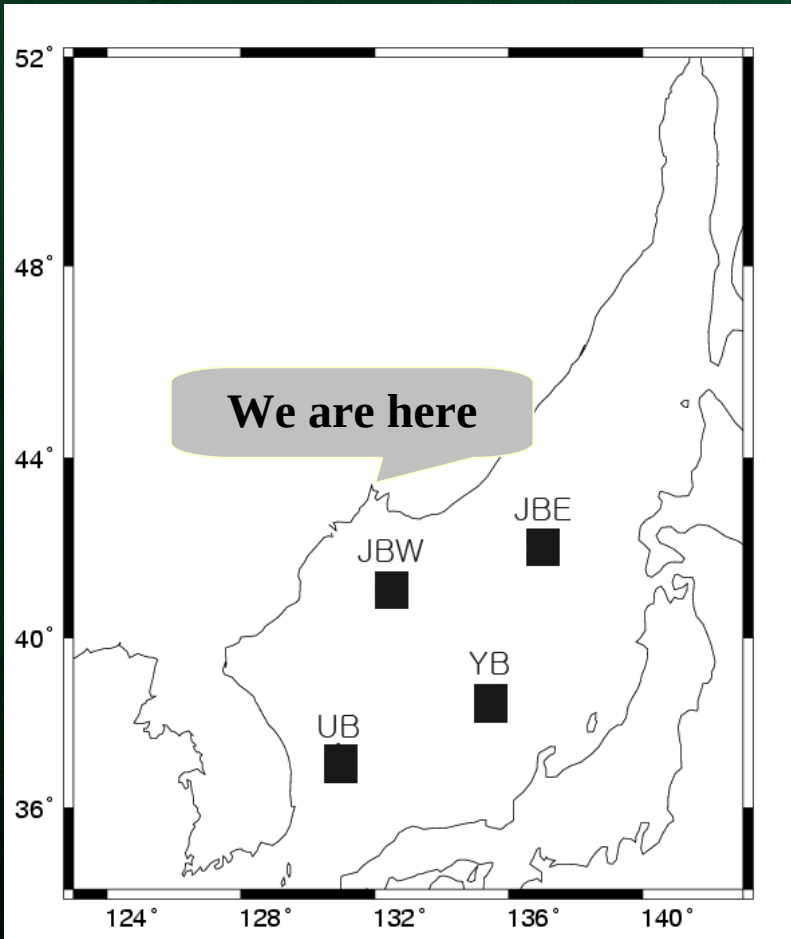
- **Average CHL is higher in coast region and sub-polar front than those in the Japan Basin (north) and the south-eastern JES.**
- **Average CHL in Primorye coast showed high inter-annual variation.**
- **Seasonal CHL cycle is bimodal in the JES.**
- **Spring blooms in the sub-polar front region is earlier than those in the Japan Basin by one month.**
- **In El Niño years (1998, 2002), 12℃-isotherm moved northward further from March to April, and the bloom occurred earlier.**
- **These two features seem related.**

2. Relationship between CHL and mixed layer depth at 4 sites

- Bloom timing and mixed layer depth-

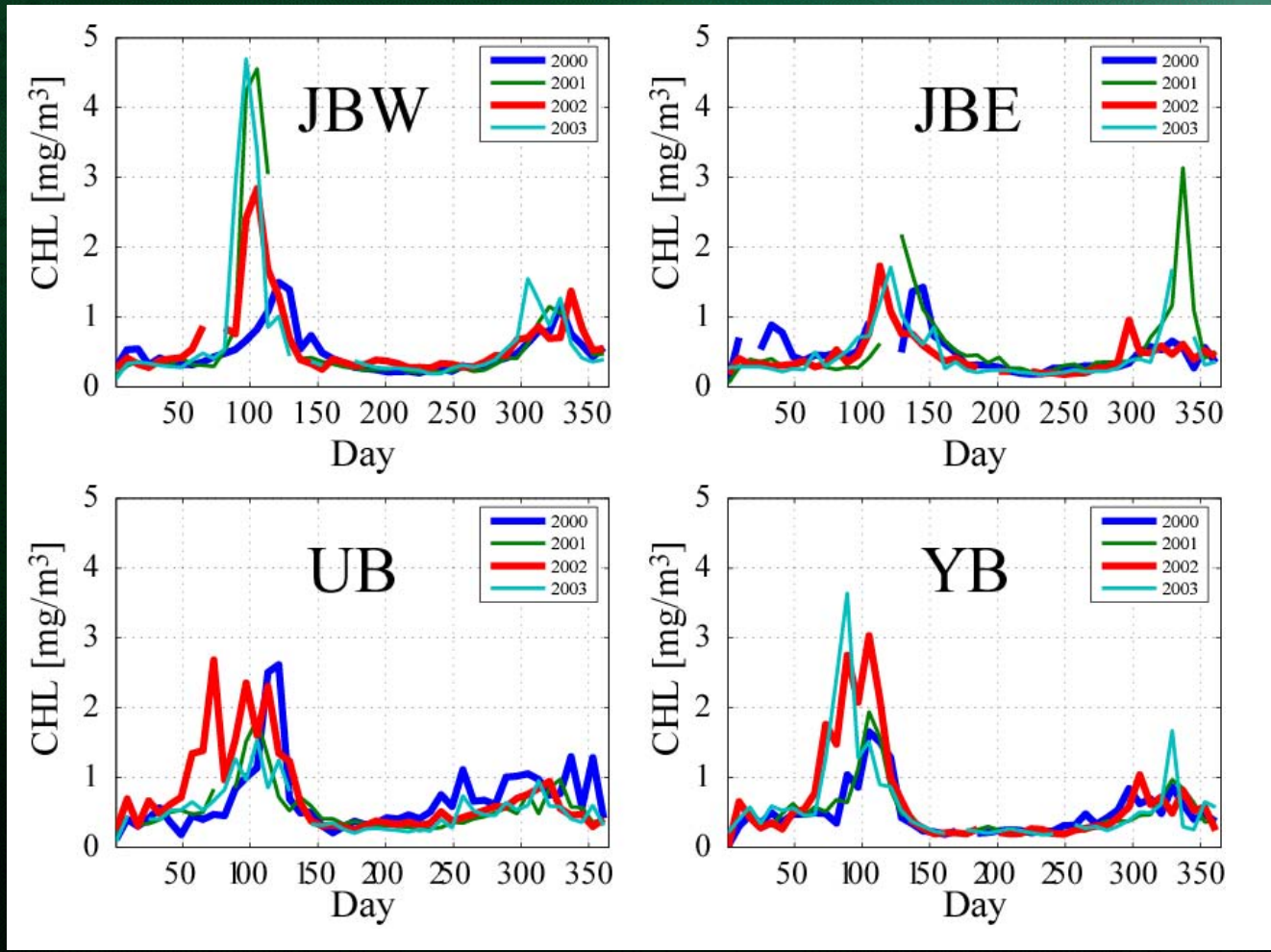
CHL data with matching MLD data were used (2000~2003)

Sampling sites

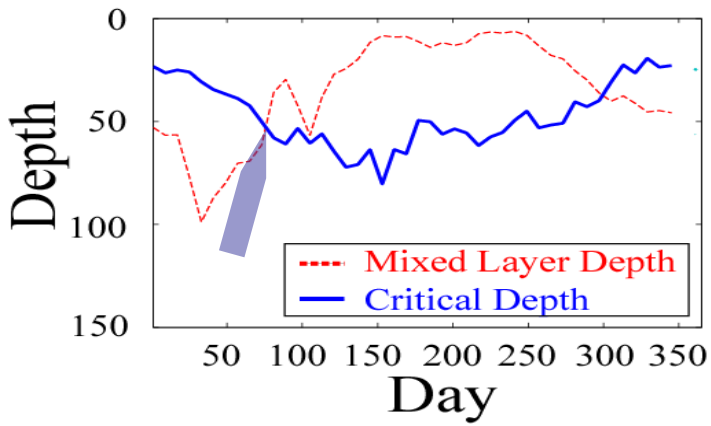


- **UB** (Ulleung Basin)
  - ⇔ 130.5°E ~ 131.5°E
  - ⇕ 36.5°N ~ 37.5°N
- **YB** (Yamato Basin)
  - ⇔ 135.0°E ~ 136.0°E
  - ⇕ 38.0°N ~ 39.0°N
- **JBW** (western part of Japan Basin)
  - ⇔ 132.0°E ~ 133.0°E
  - ⇕ 40.5°N ~ 41.5°N
- **JBE** (eastern part of Japan Basin)
  - ⇔ 136.5°E ~ 137.5°E
  - ⇕ 41.5°N ~ 42.5°N

CHL time-series at 4 sites



Matching time of MLD and CRD and starting time of blooming define



◆**Mixed Layer Depth (MLD):**
Model running result from FNMOC

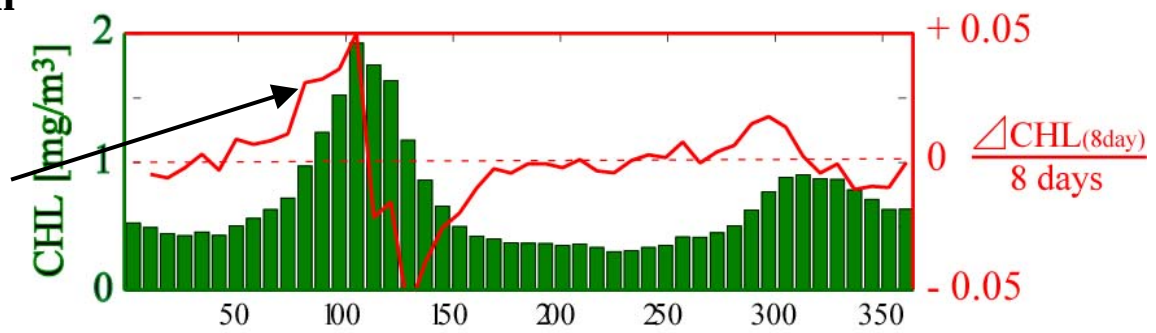
◆**Critical Depth (CRD):**
Calculated using
Nelson & Smith (1991) formulation

$$CRD = 0.18\,\bar{I}_0 / KI_c$$

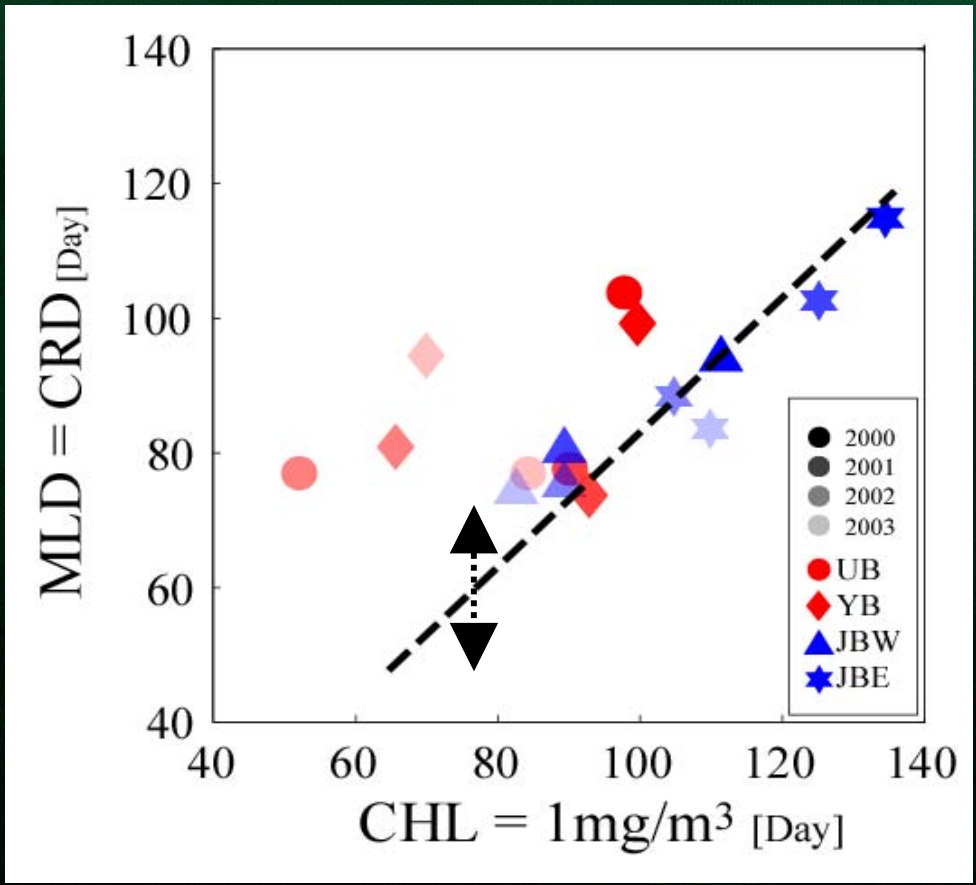
Define:

Starting time of bloom

$$\frac{\Delta CHL_{(8days)}}{8\,days} = 0.03$$



Relationship between starting time of blooming (CHL=1mg/m^3) and matching time of MLD and CRD

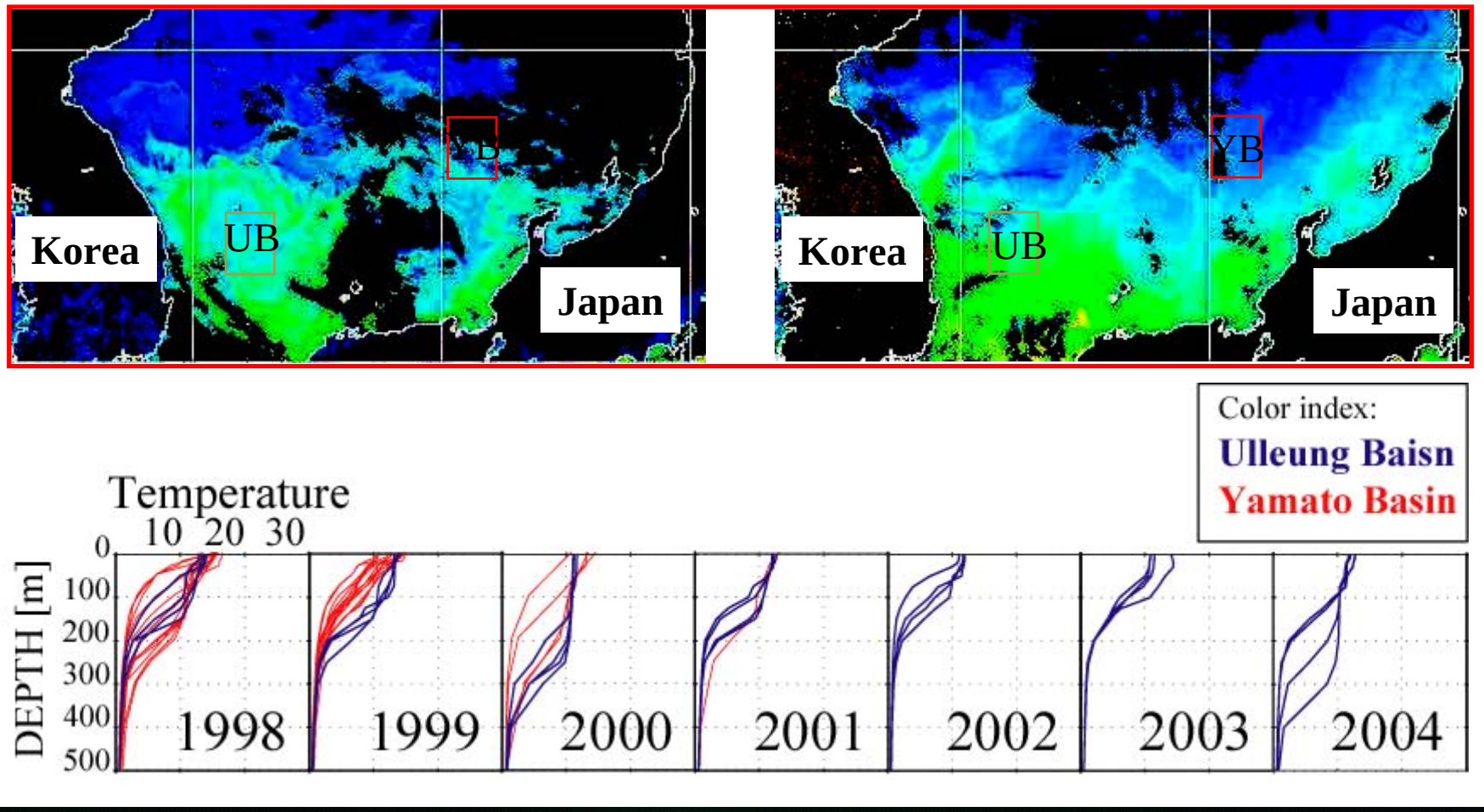


◆**The spring blooms occurred later than expected by CRD model in the UB and YB (southern gyre).**

◆**In JBE and JBW (northern gyre), linear trend indicates that local stratification is the major driver in determining the bloom timing.**

◆**On the contrary, in the UB and YB, larger scatter indicates that spring bloom mechanisms are more complicated.**

SST images & temperature profiles



Summary 2.

- **The spring blooms in 2002 are earlier than those in 2000 at all sites.**
- **Spring blooms in southern part of JES are earlier than those in northern part of JES**
- **Spring blooms in western part of JES is earlier than those in eastern part.**
- **The shallower the mixed layer depth, the earlier spring bloom started (2002).**
- **The deeper the mixed layer depth, the later spring bloom started (2000).**
- **The spring blooms occurred later than expected by CRD model in the UB and YB.**

Conclusions

1. Seasonal and inter-annual variability of CHL in the JES.

- **Seasonal CHL cycle is bimodal**
- **Spring blooms around the sub-polar front is earlier than those in Japan Basin by one month.**
- **In El Niño years (1998, 2002), 12℃−isotherm moved northward faster from March to April, and the bloom occurred earlier.**

2. Bloom timing and mixed layer depth

- **The shallower the mixed layer depth, the earlier spring bloom started (2002).**
- **The deeper the mixed layer depth, the later spring bloom started (2000).**
- **Northern basin, such as JBE and JBW, showed a linear relationship between the starting time of bloom and matching time of MLD and CRD, whereas southern basin, such as UB and YB, showed a large deviation between them.**
- **We interpret this as that local stratification process determined the plant growth conditions in the northern basin, while in the southern basin, plant growth condition was determined in more complex ways.**
- **Presumably, Tsushima Current and eddies in the southern part seemed to make light-nutrient conditions for plant growth more complex.**

Thanks…