

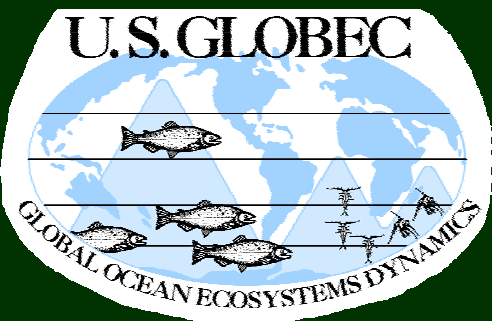
# Does phytoplankton biomass vary out-of-phase in the California Current and Gulf of Alaska on interannual time scales?

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3. NOAA, SFSC



2006 PICES Meeting, Honolulu



# Background

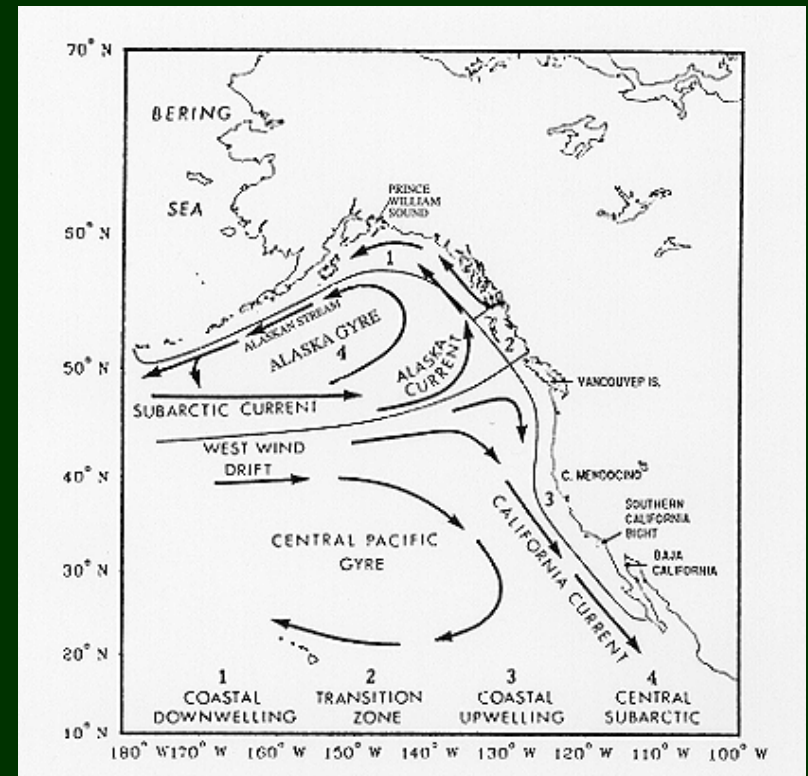
## U.S. GLOBEC Report # 17. 1996

**OVERALL GOAL:** To understand the effects of climate variability and climate change on the distribution, abundance and production of marine animals in the eastern North Pacific.

### Hypothesis I.

**Production regimes in the Coastal Gulf of Alaska and California Current System covary, and are coupled through atmospheric and ocean forcing.**

Figure 6. Report #17.  
from Ware and  
McFarlane 1989



# Outline

- quantify / compare seasonal variability
- compare interannual variability

## Data and Methods

- 8 years of daily SeaWiFS chlorophyll data
  - 1997 – 2005, 4km resolution, Ver.5 (circa 2005)
  - formed into monthly composites
    - EOF decompositions
- Temporally coincident time series
  - NCEP wind fields
  - Altimeter data
    - Aviso gridded SSH fields

## Acknowledgements

- NSF, NOAA: U.S. GLOBEC funding
- NASA GSFC Ocean Color Team



# Seasonal Variability

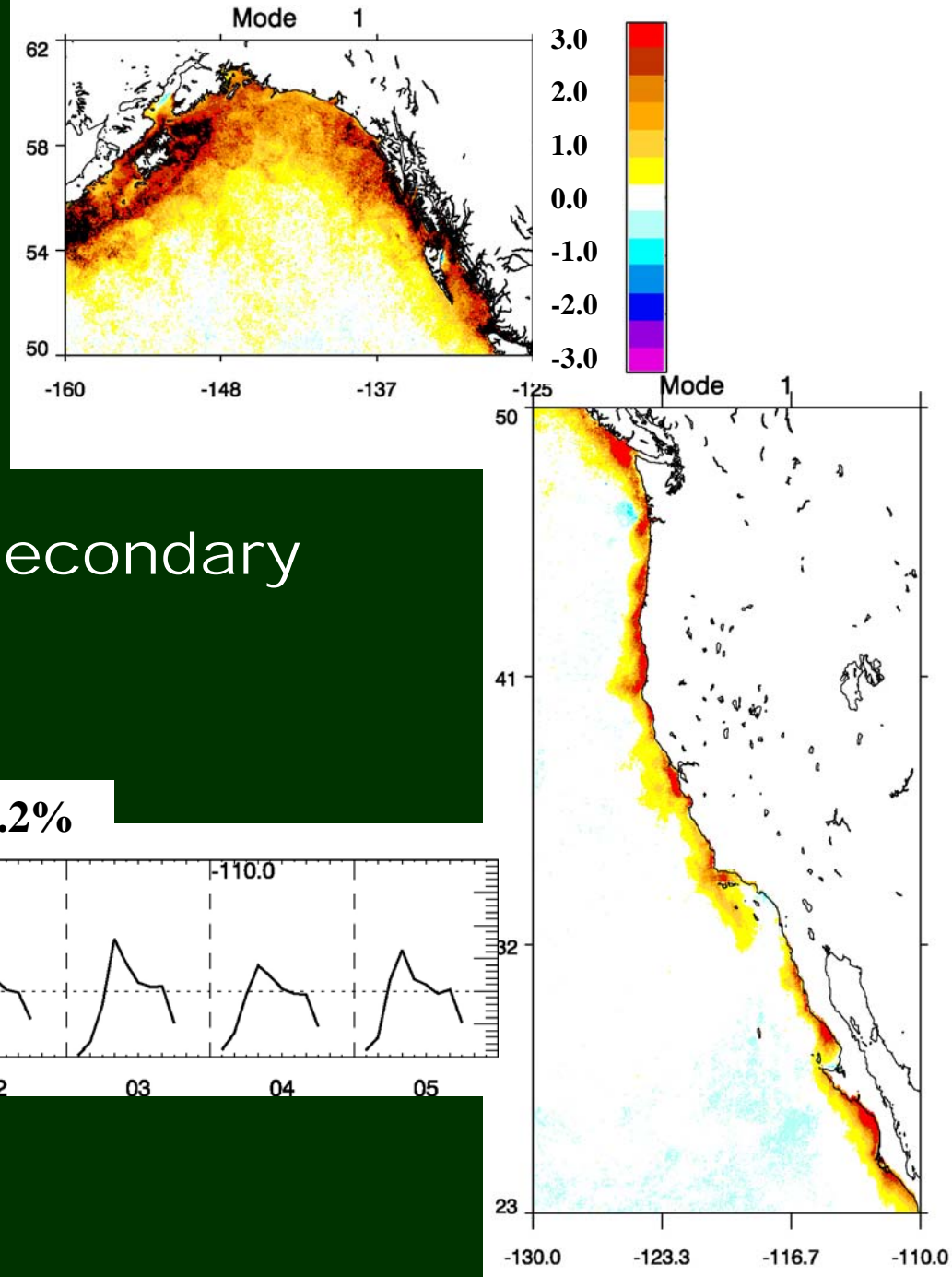
EOF decomposition of  
monthly [chl]

Mode 1:

seasonal cycle in phase

May max, late-summer secondary

Variance = 14.2%



# Seasonal Variability

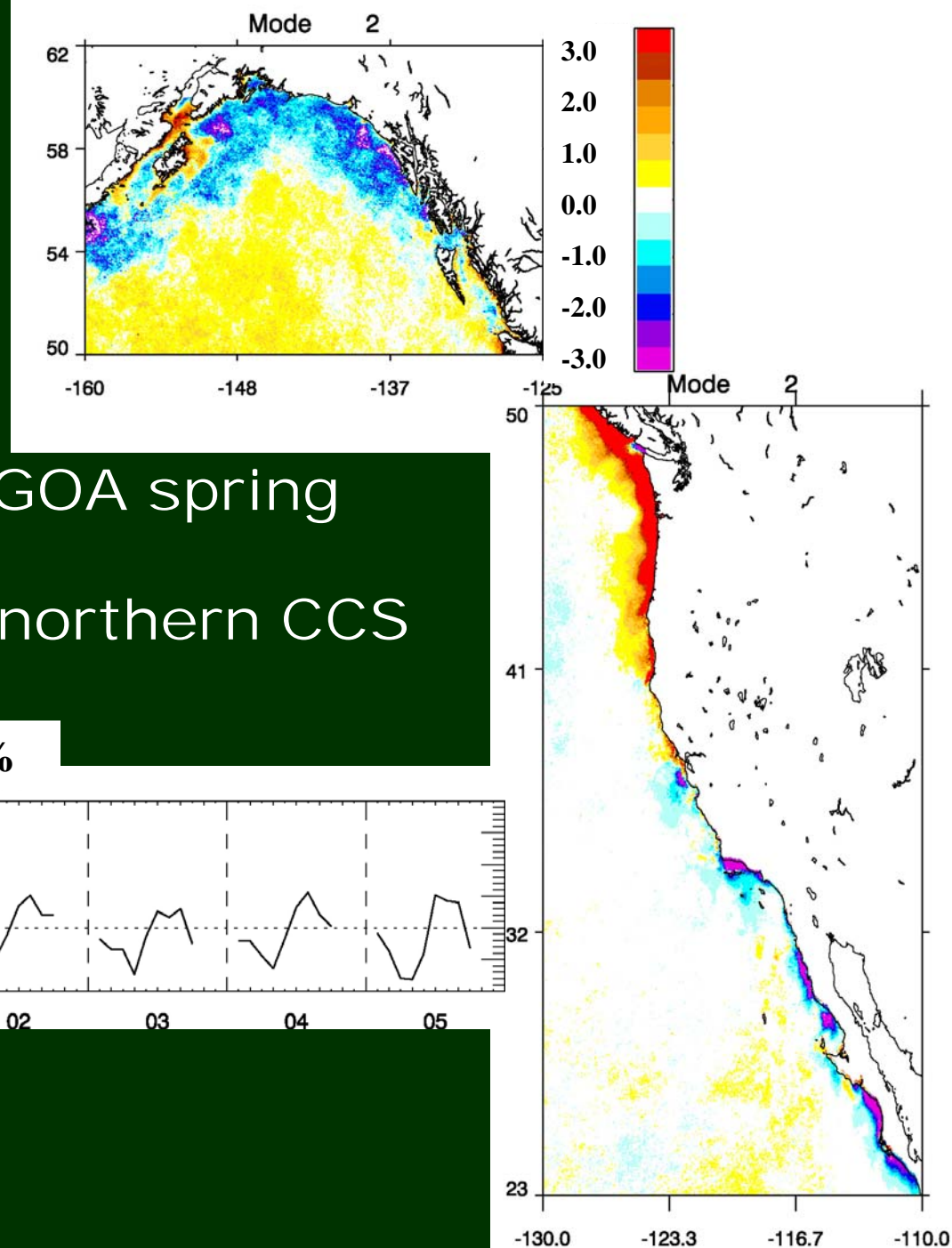
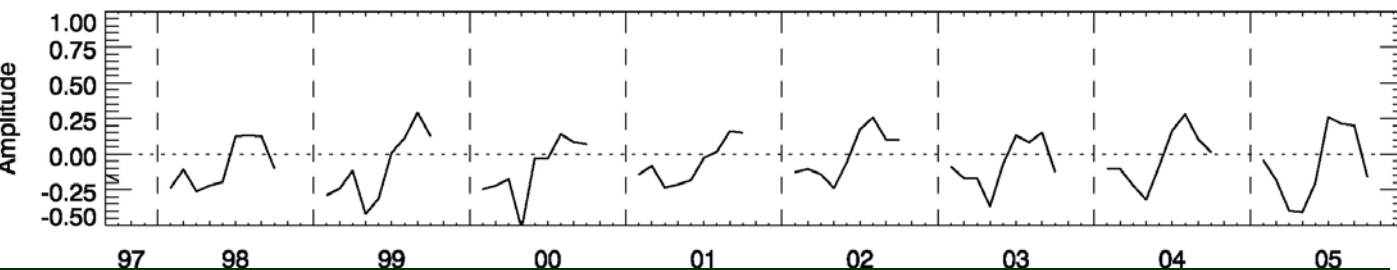
EOF decomposition of  
monthly [chl]

Mode 2: out of phase

Early peak (April-May): GOA spring  
bloom, southern CCS

Later peak (July-Sept): northern CCS  
upwelling

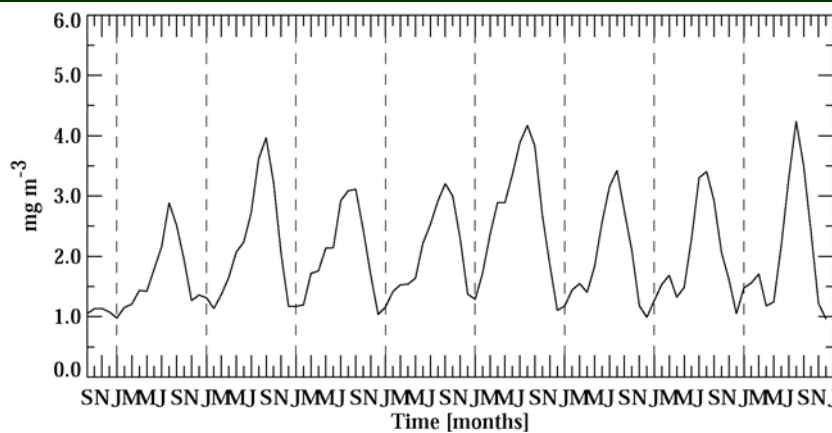
**Variance = 8.2%**



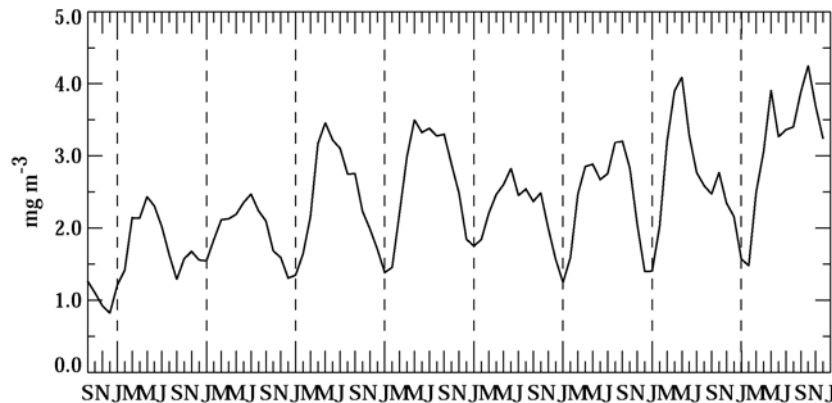
# Seasonal Chlorophyll Variability

## California CS

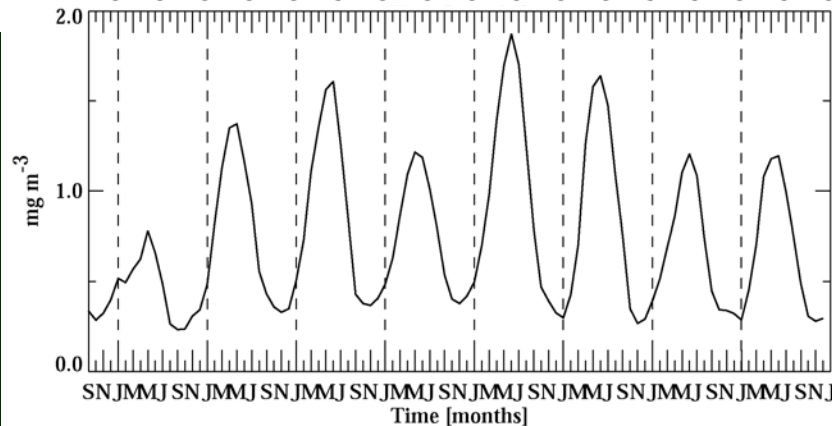
44°N



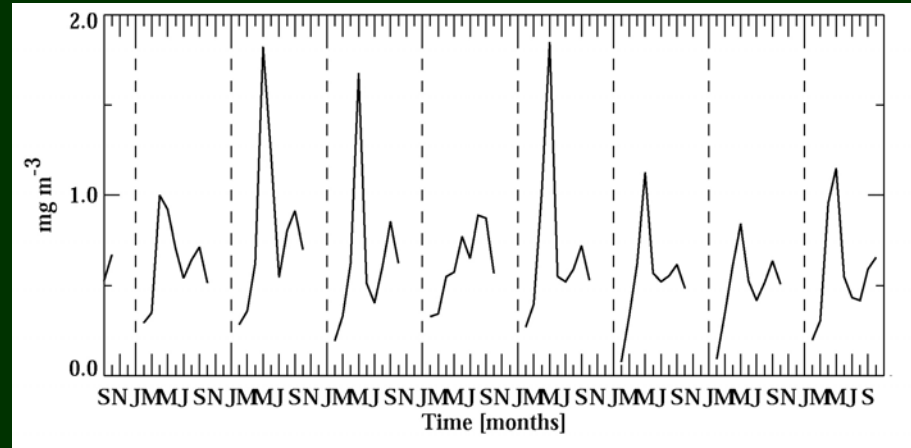
37°N



28°N



## Gulf of Alaska – eddy corridor

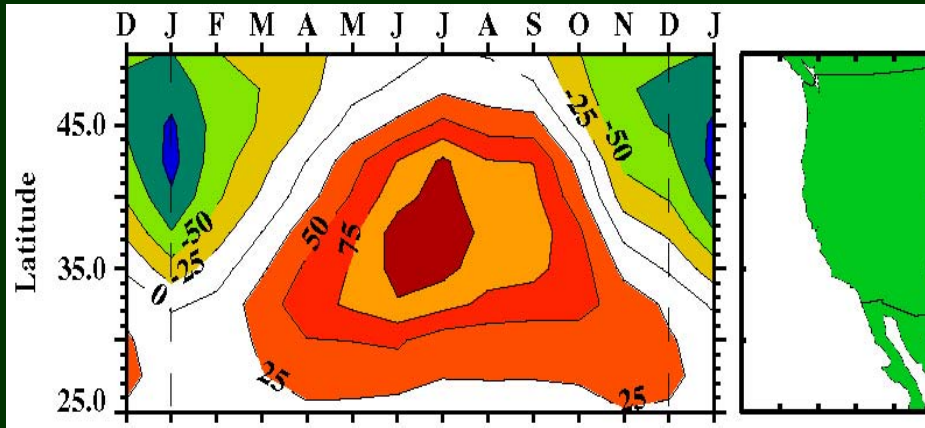




# Seasonal Forcing

In the CCS:

Wind  $\Rightarrow$  offshore Ekman transport  
+ curl  $\Rightarrow$  upwelling



Latitudinal phase differences

In the GOA:

Light availability

Winter: dark, stormy  
& cloudy

Summer: light, stormy  
& cloudy (but less so)

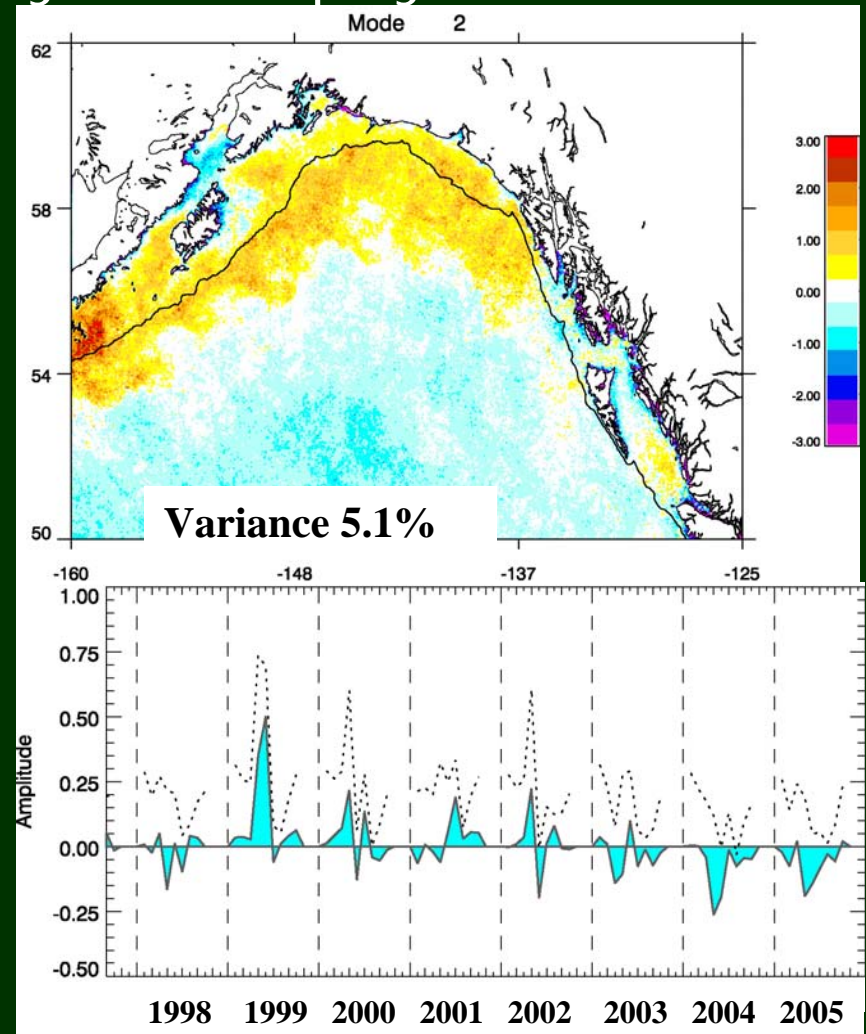
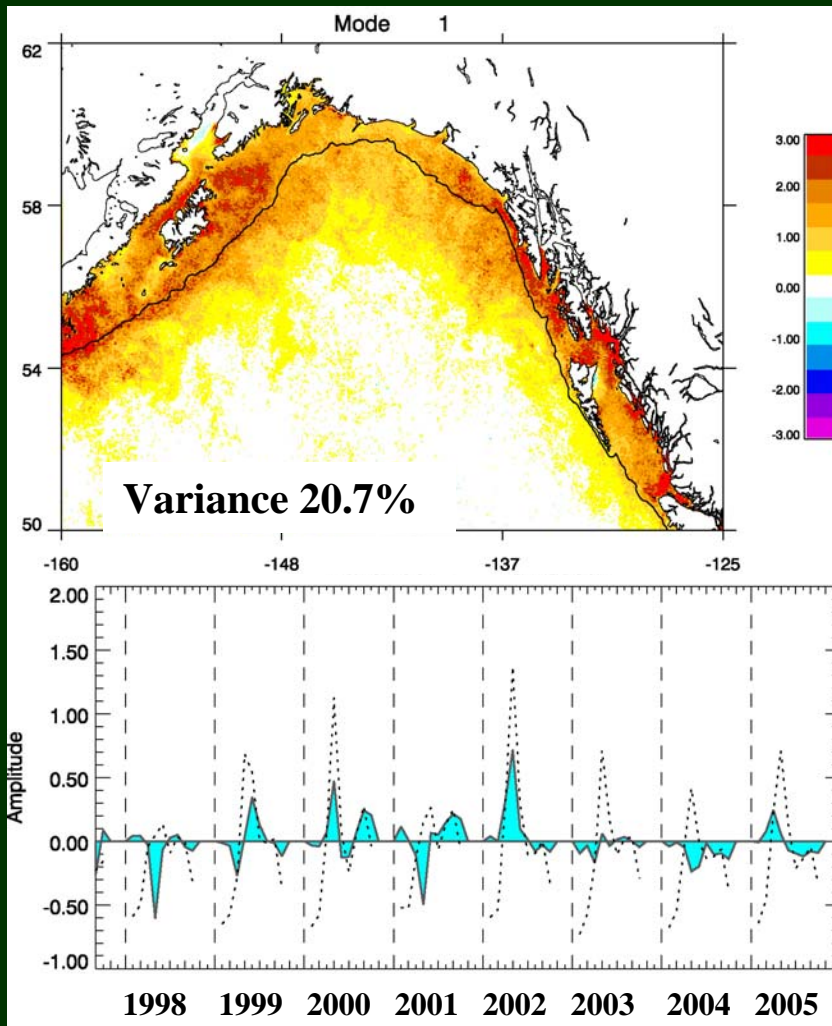
~ similar phasing in  
coastal margin region

# Interannual Variability

EOFs of each region separately

Consider anomalies from the mean seasonal cycles

Gulf of Alaska: monthly chlorophyll fields



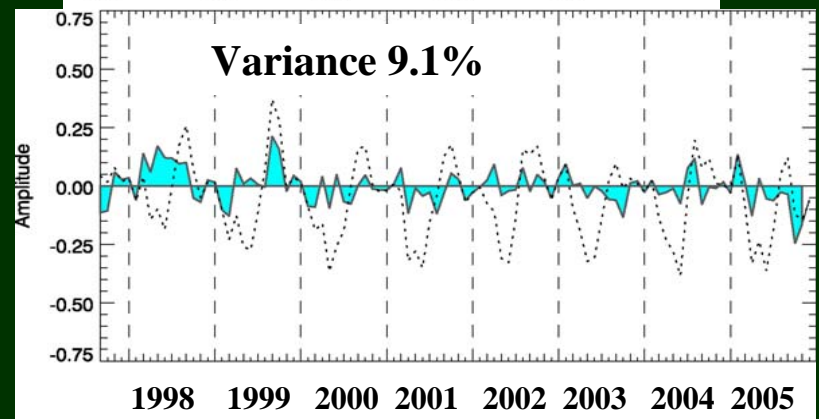
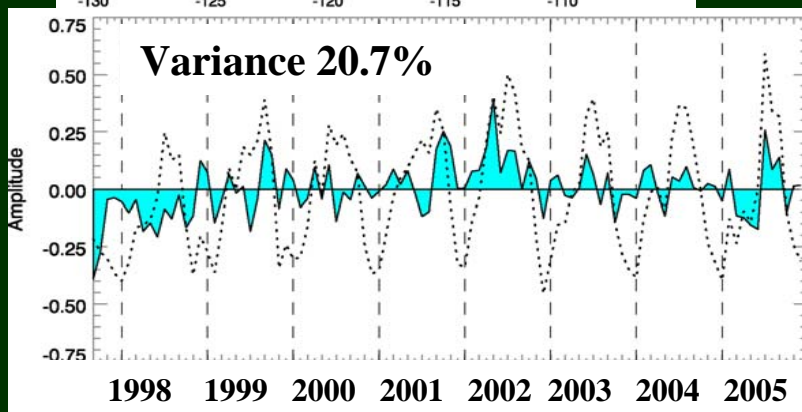
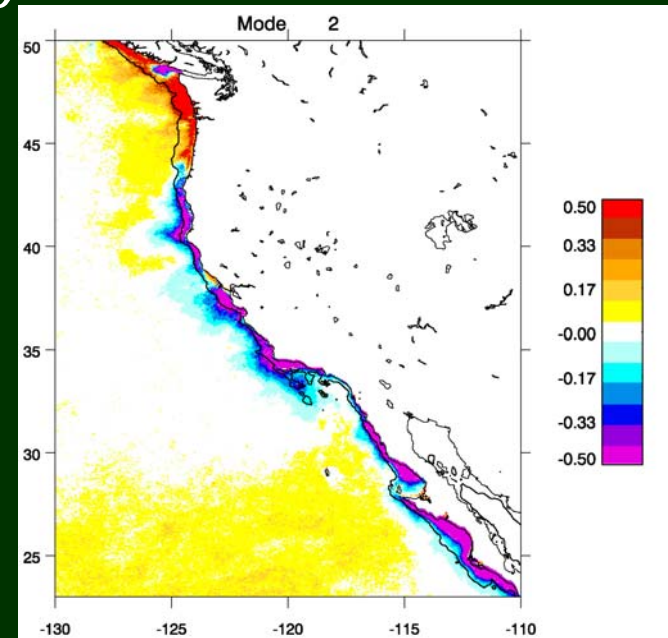
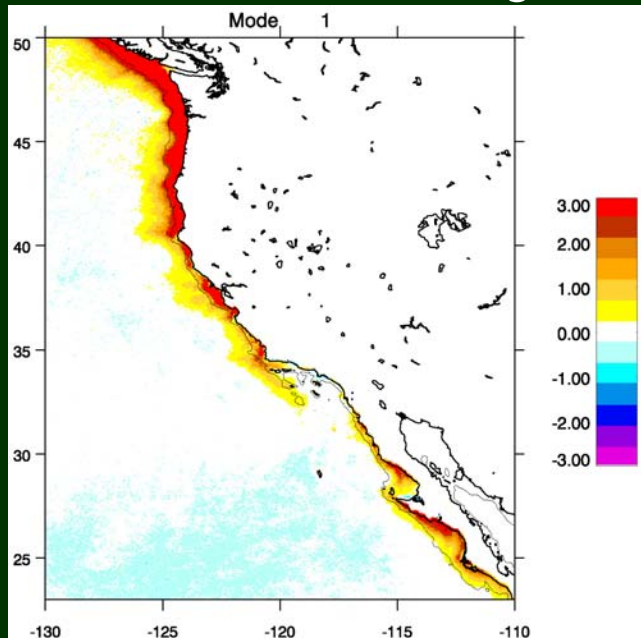


# Interannual Variability

EOFs of each region separately

Consider anomalies from the mean seasonal cycles

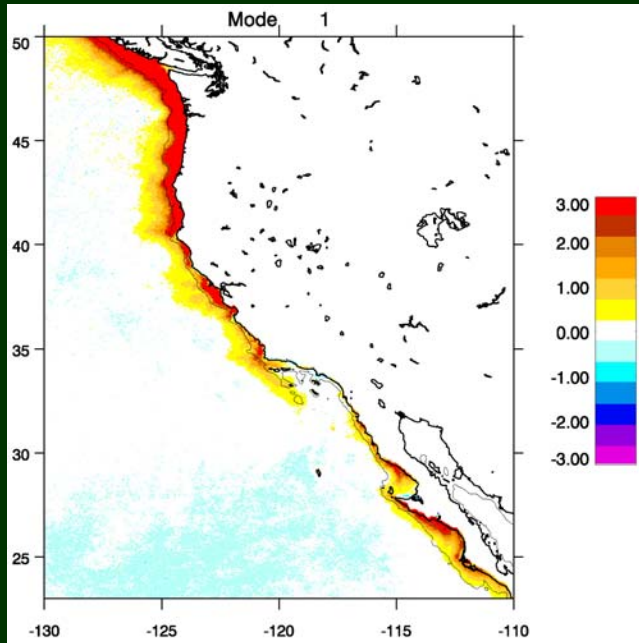
CCS: monthly chlorophyll fields



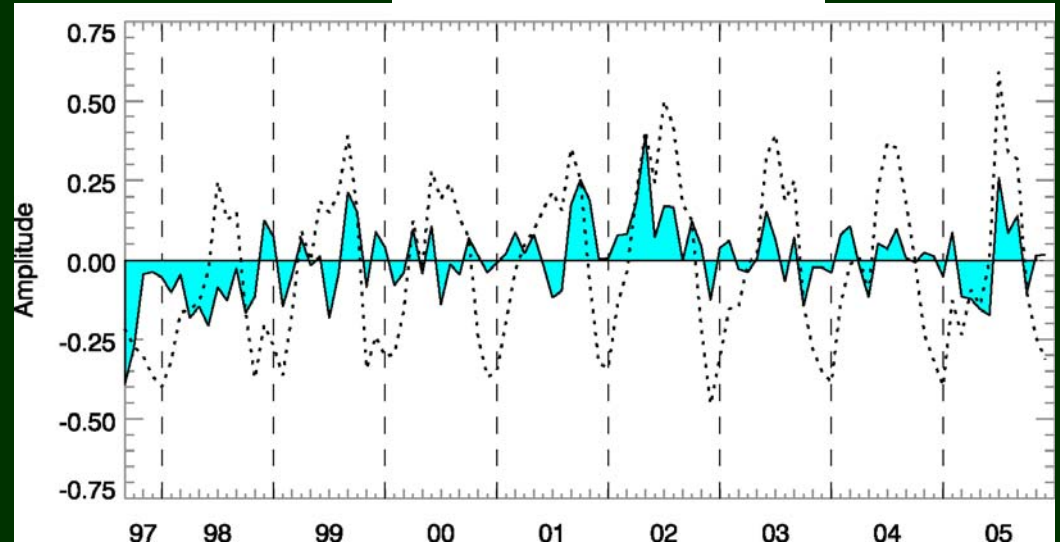
# Interannual Chlorophyll Variability: In Phase?

EOF Mode 1 of each

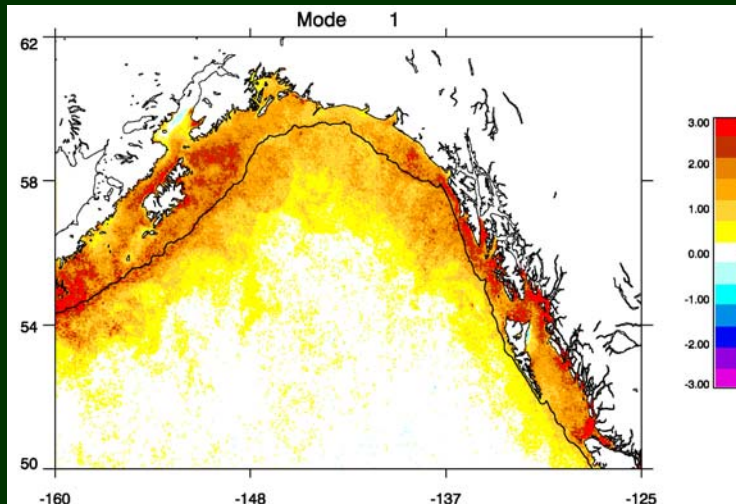
California Current



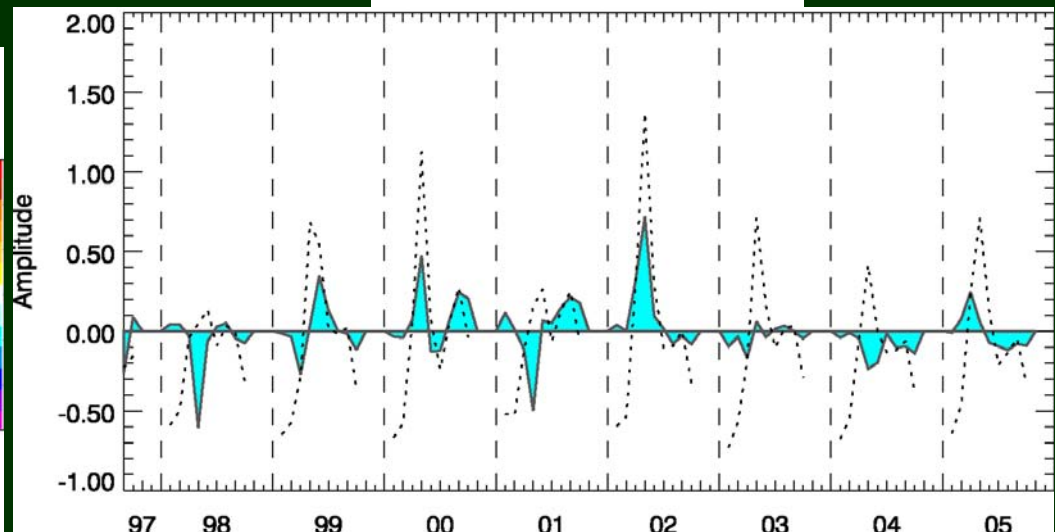
Variance 20.8%



Gulf of Alaska



Variance 20.7%





# Mean Coastal Chlorophyll

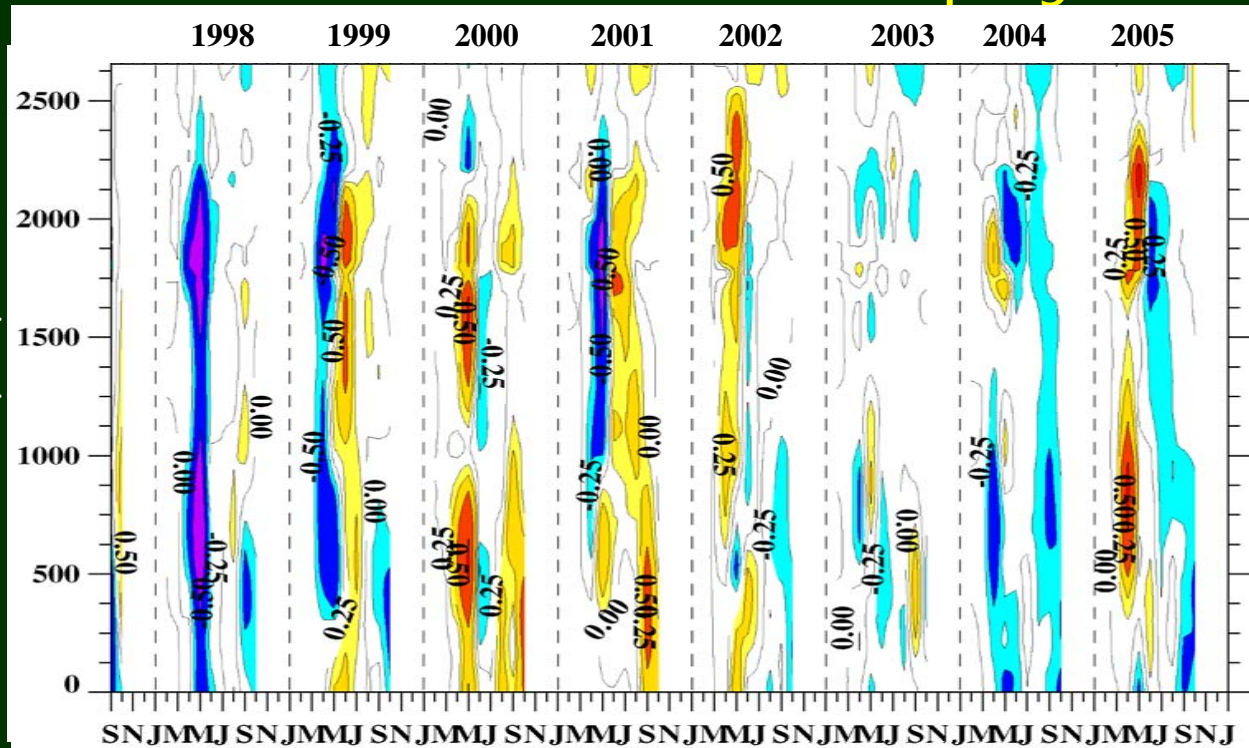
*Q. Charl. Isl.*

Gulf of Alaska  
150km mean

*Seward Ln.*

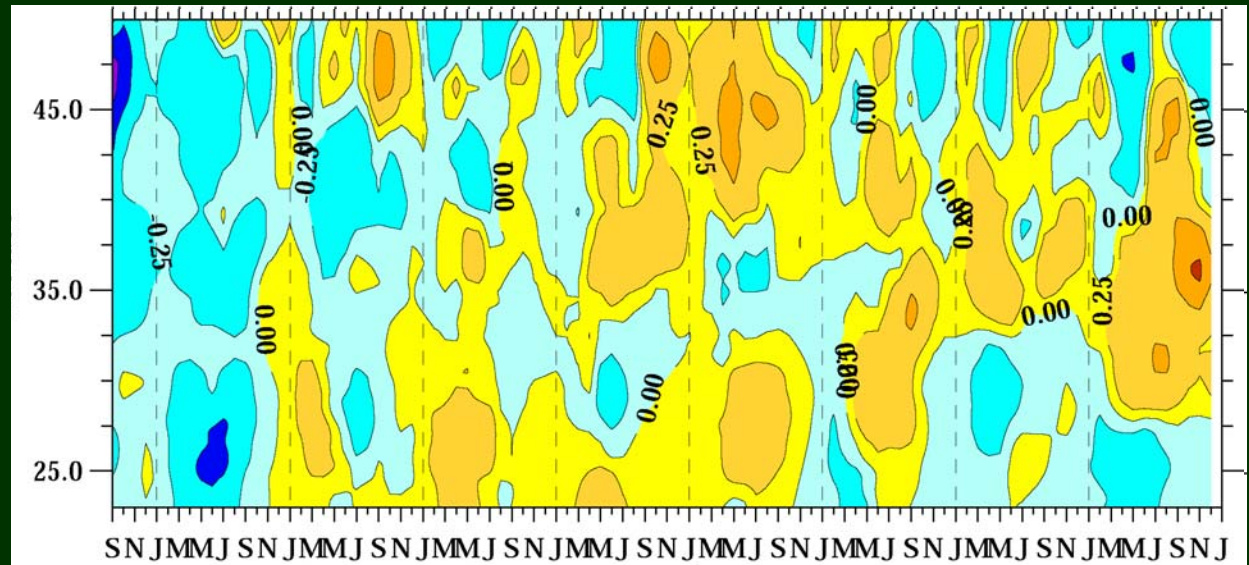
*Kodiak Isl.*

Distance (km) W - E



California Current  
100km mean

Latitude

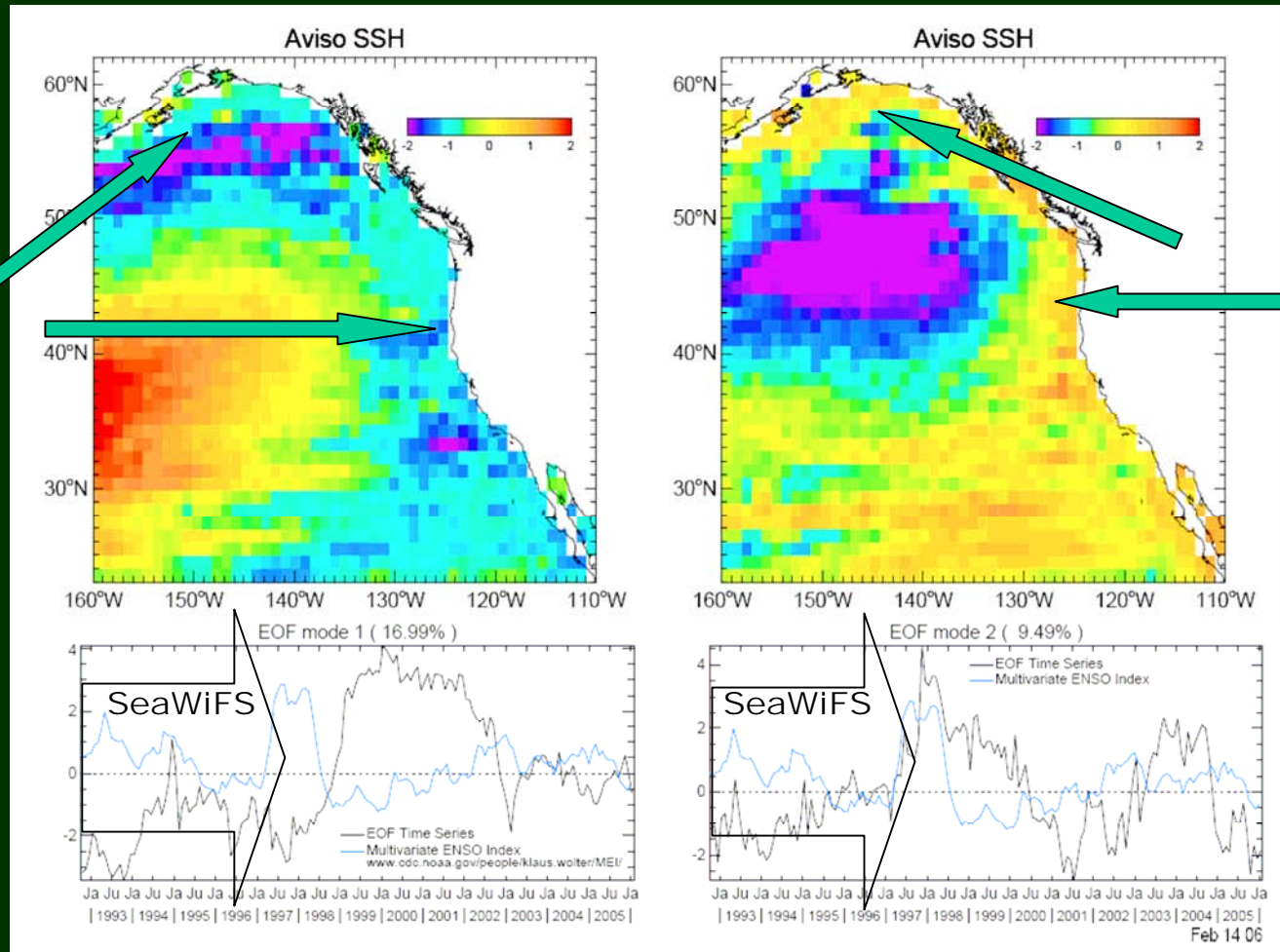


# Altimeter-derived SSH fields (1993-2005)

1<sup>st</sup> 3 EOF modes: over whole basin

Seasonal cycles removed

In Phase



Out of Phase

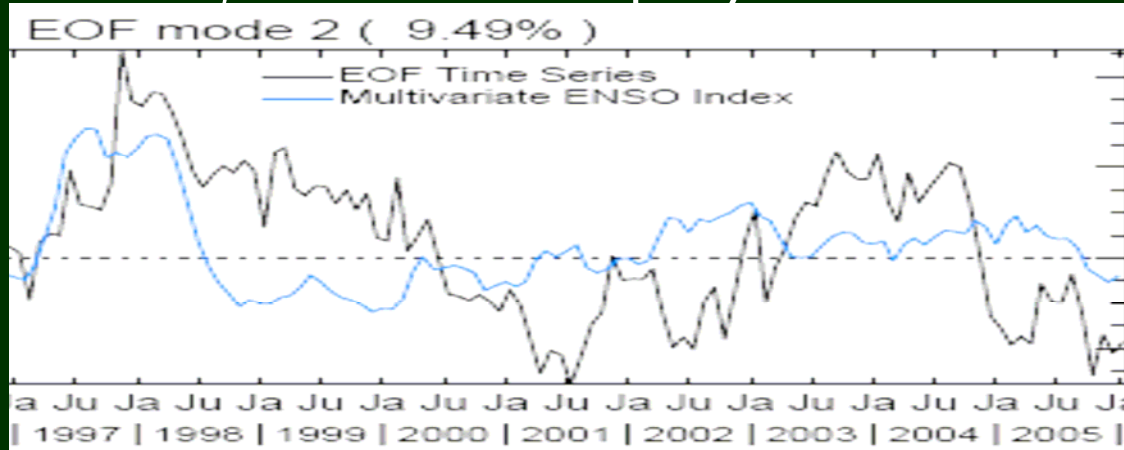
Black: SSH EOF time series

Blue: Multivariate ENSO Index

# EOF Anomaly Time Series:

Basin Heights, ENSO, and chlorophyllII

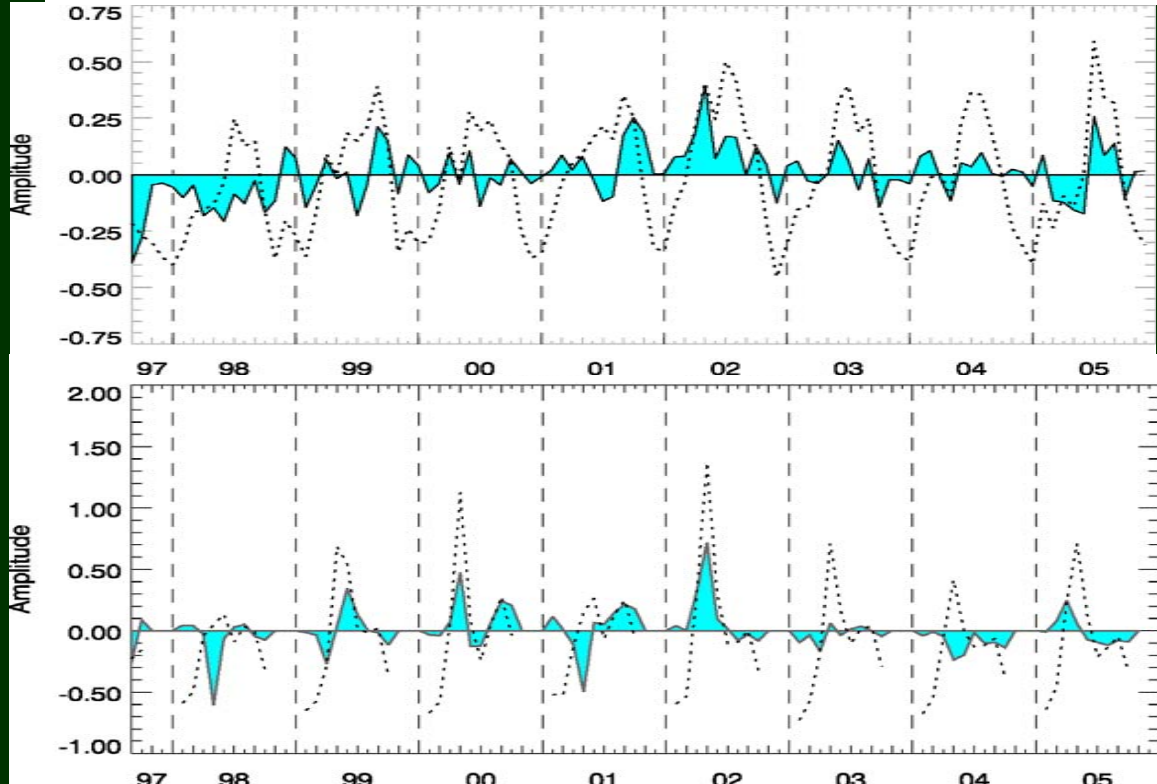
SSH heights  
& ENSO



California  
chlorophyllII

*blue  
shaded  
anomalies*

G of Alaska  
chlorophyllII

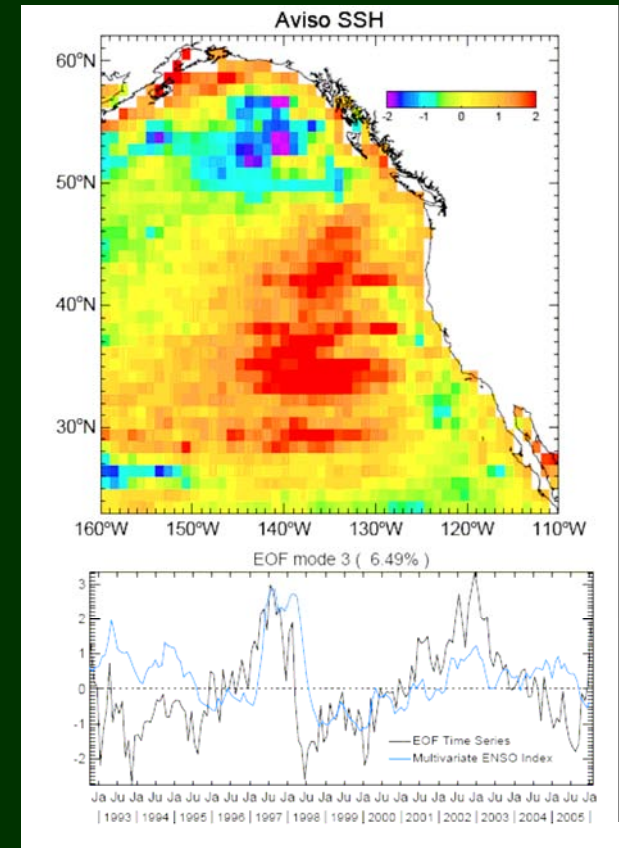
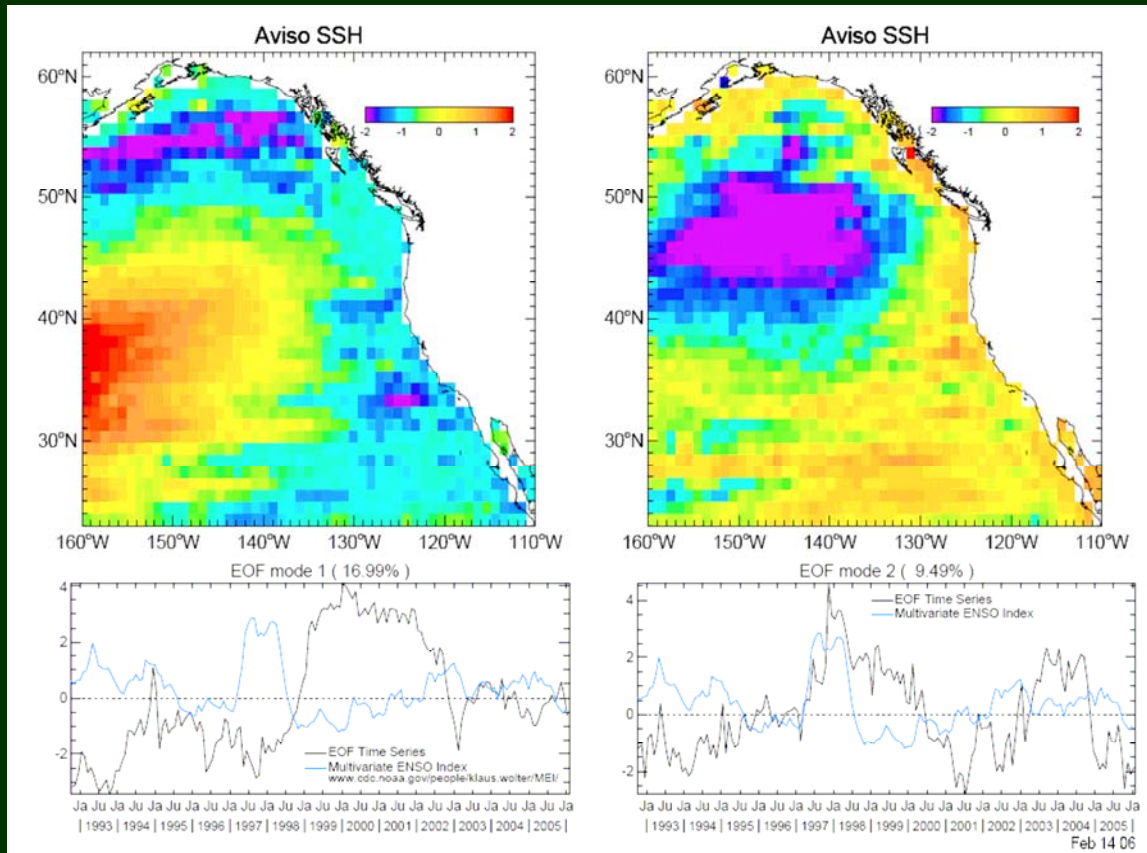




# Altimeter-derived SSH fields (1997-2005)

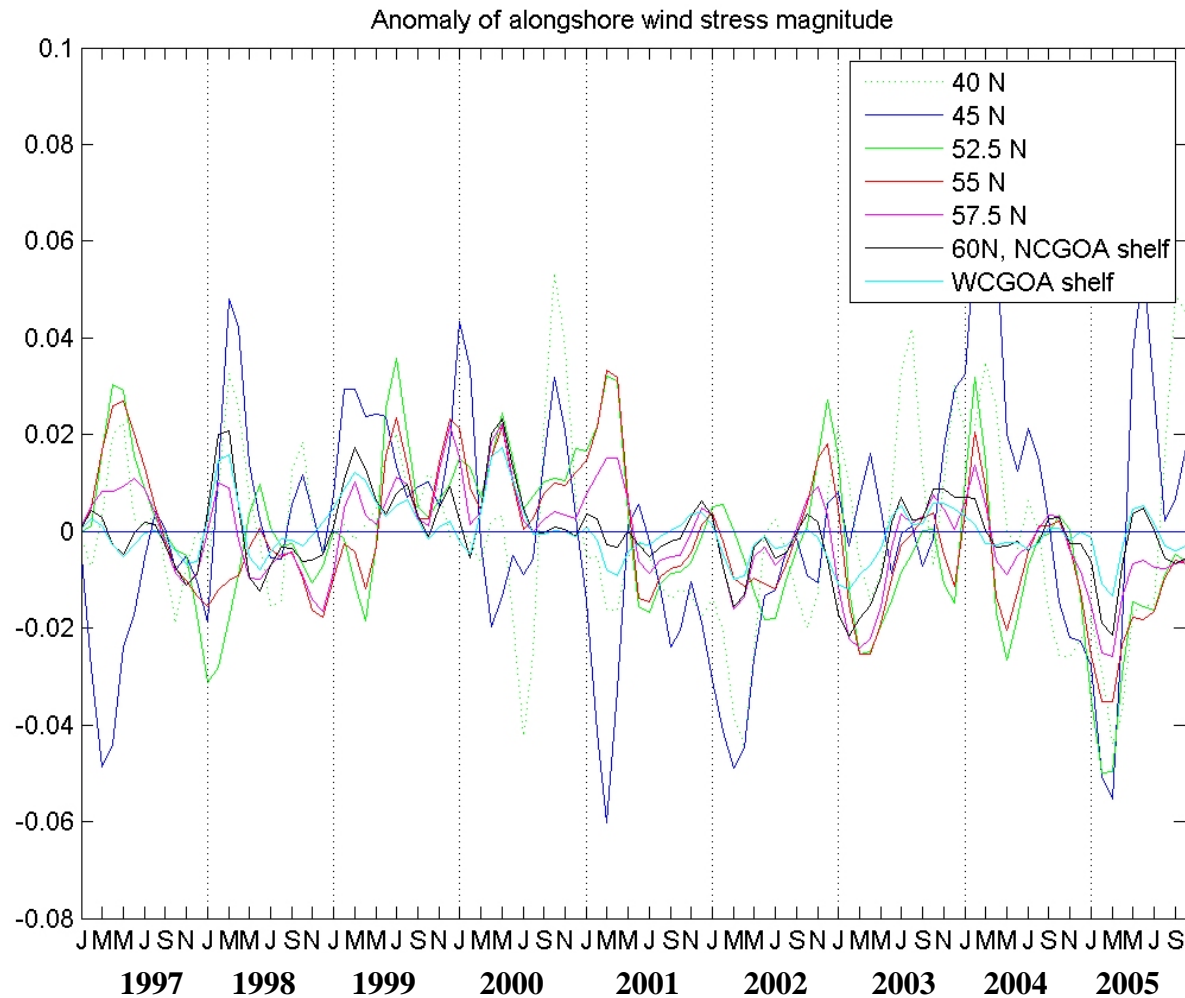
## 1<sup>st</sup> 3 EOF modes: over whole basin

### Seasonal cycles removed



# Wind Forcing

## Anomalies of total alongshore wind stress



# Summary

## Chlorophyll Variability in the Gulf of Alaska and California Current

- Seasonal Cycles:
- weak in phase signal (early summer maximum)
  - GOA in phase with southern CCS
  - out of phase with late max in northern CCS
  - phased wind forcing (CCS), light (GOA)

Interannual Variability:

- strongest signals **in phase** over early record
  - 1997 – 2003 (El Nino, 2002 event)
- **out of phase** recently (2004 – 2005)
- consistent with:
  - basin-scale SSH anomalies & implied circulation
  - some aspects of wind forcing, similar switch?

# Summary

## Chlorophyll Variability in the Gulf of Alaska and California Current

In phase variability: El Nino / 2002 event

- increased (decreased) vertical nutrient flux in CCS
- increased (decreased) light availability in GoA

Out of phase: recent 12-24 months

- decreased vertical nutrient flux in CCS
- increased light availability in GoA