Reenvisioning the Ocean: The View from Space

A RESPONSE

Dave Siegel

University of California, Santa Barbara

6 12.011

C

Carbon

Remote Sensing Carbon

- Stocks
  - pCO_2, DIC, DOC, POC & PIC
- Components
  - Community structure, calcifiers, N_2 fixers, etc.
- Fluxes
  - Air-sea, export, net community production, etc.

Remote Sensing Carbon

- Ocean color is not perfect for this task

  Optical properties are not carbon species

    CDOM is not DOC, optical backscattering is not POC

- Need to think like paleo-oceanographers...

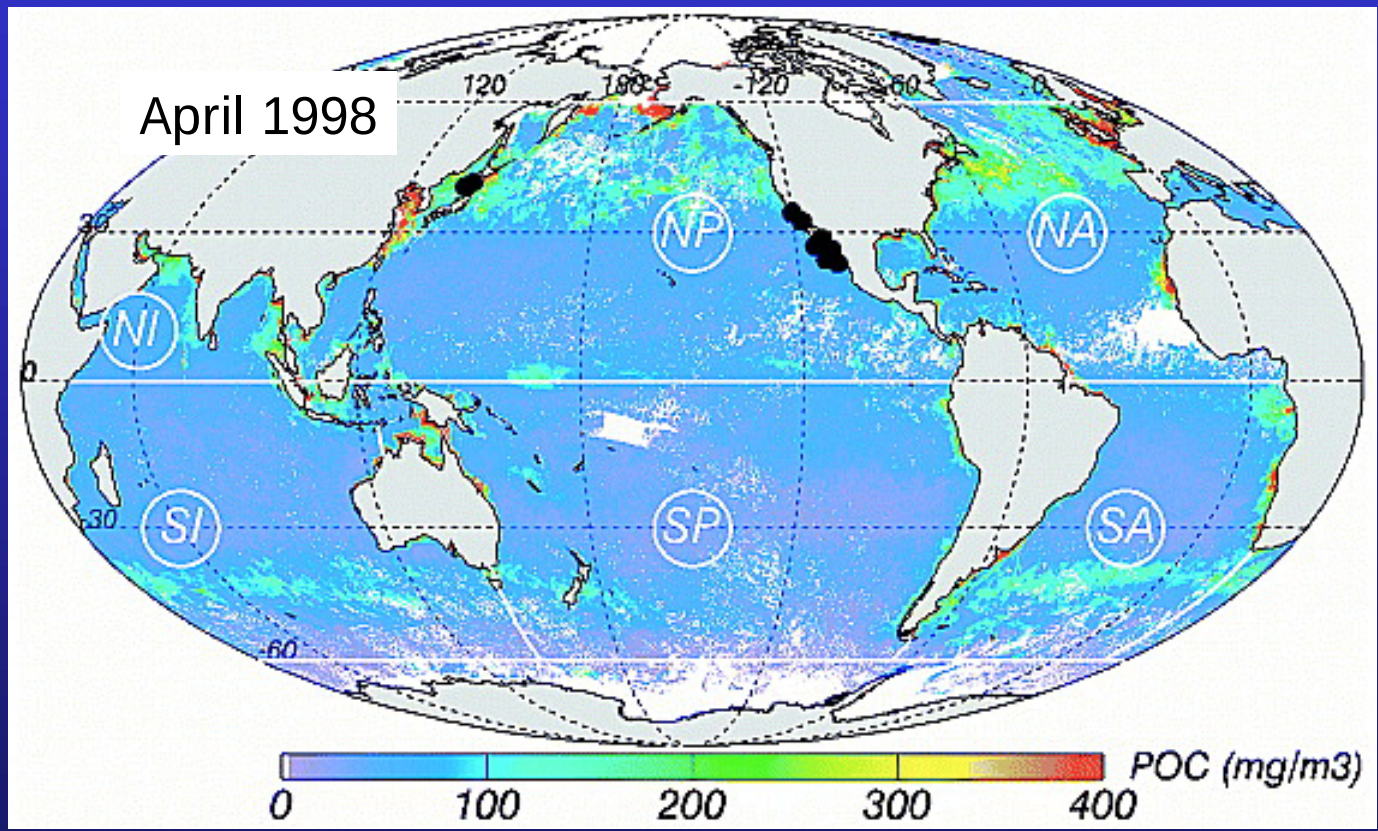
  Develop “quantitative proxies”

  But ... test them using real observations

Some Examples...

- Stocks
  - POC
  - pCO_2
  - CDOM (This is a shameless plug for our CDOM poster!!)
- Components
  - Calcifiers - coccolithophorid bloom occurrence
- Fluxes
  - Air-sea CO_2 fluxes

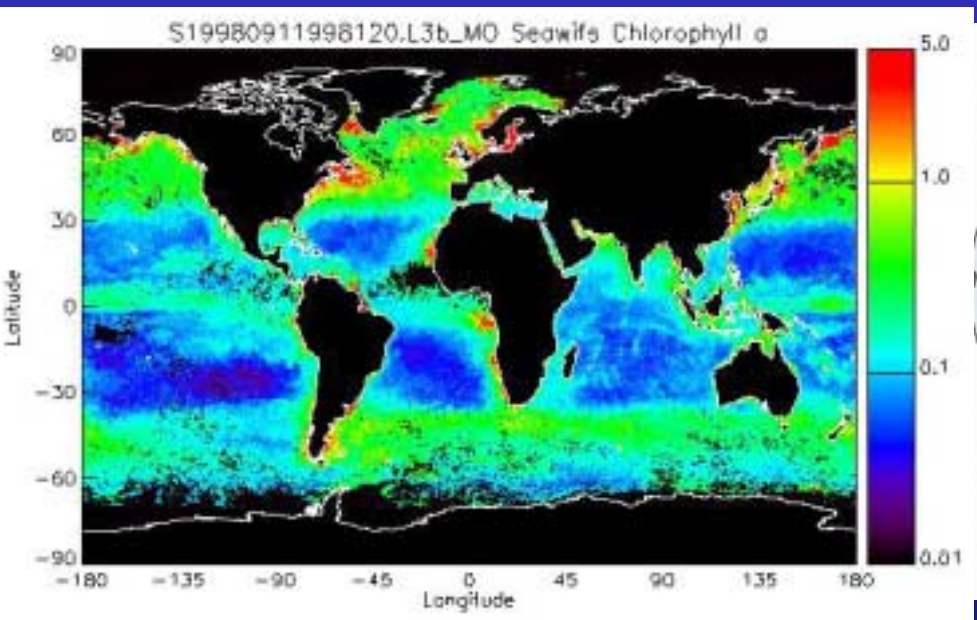
Remote Sensing of POC



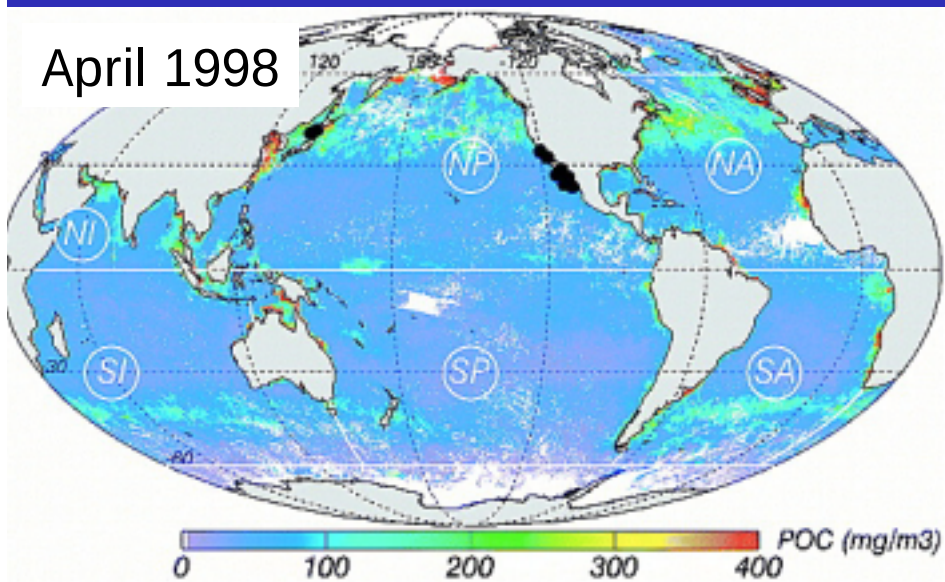
Relate POC to estimates of optical backscattering by particle

Loisel et al. [2002] GRL

Remote Sensing of POC

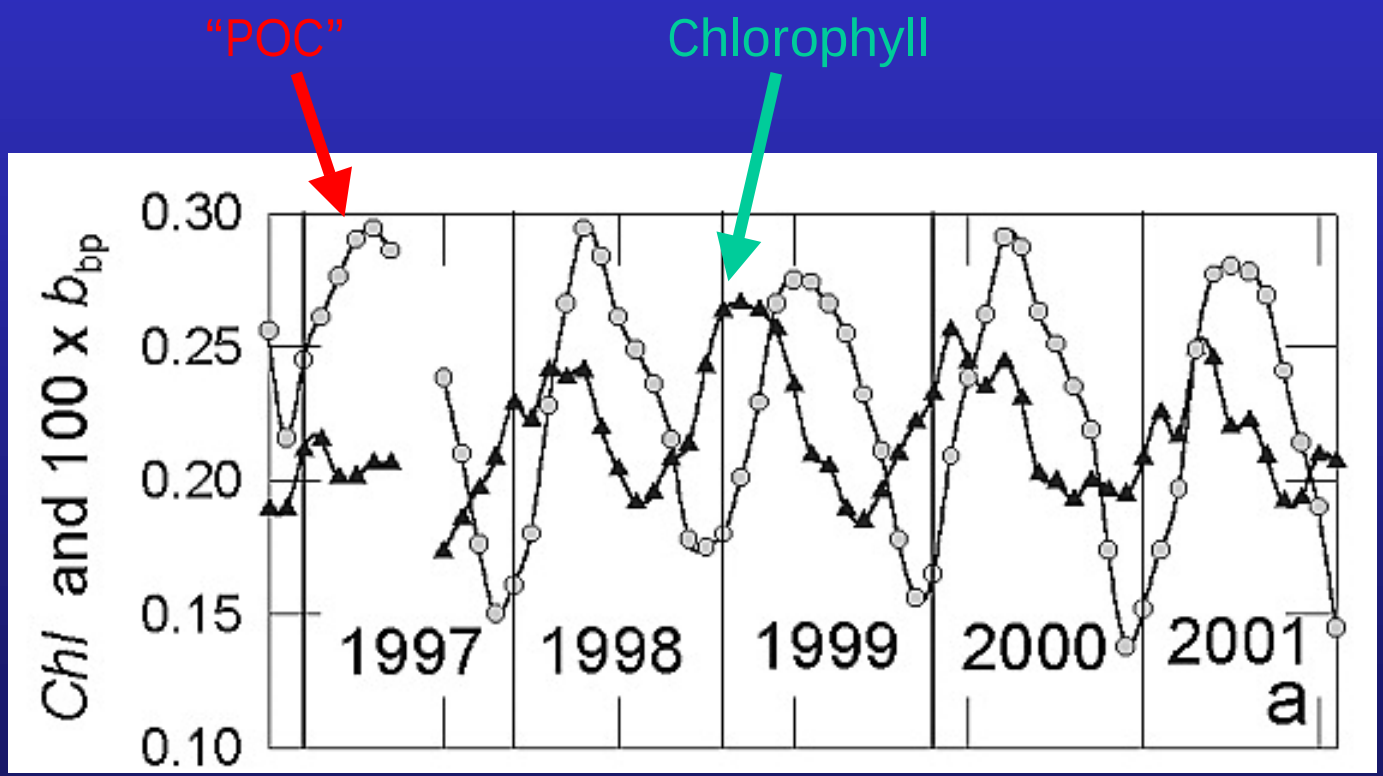


SeaWiFS chlorophyll concentration



SeaWiFS POC

Remote Sensing of POC

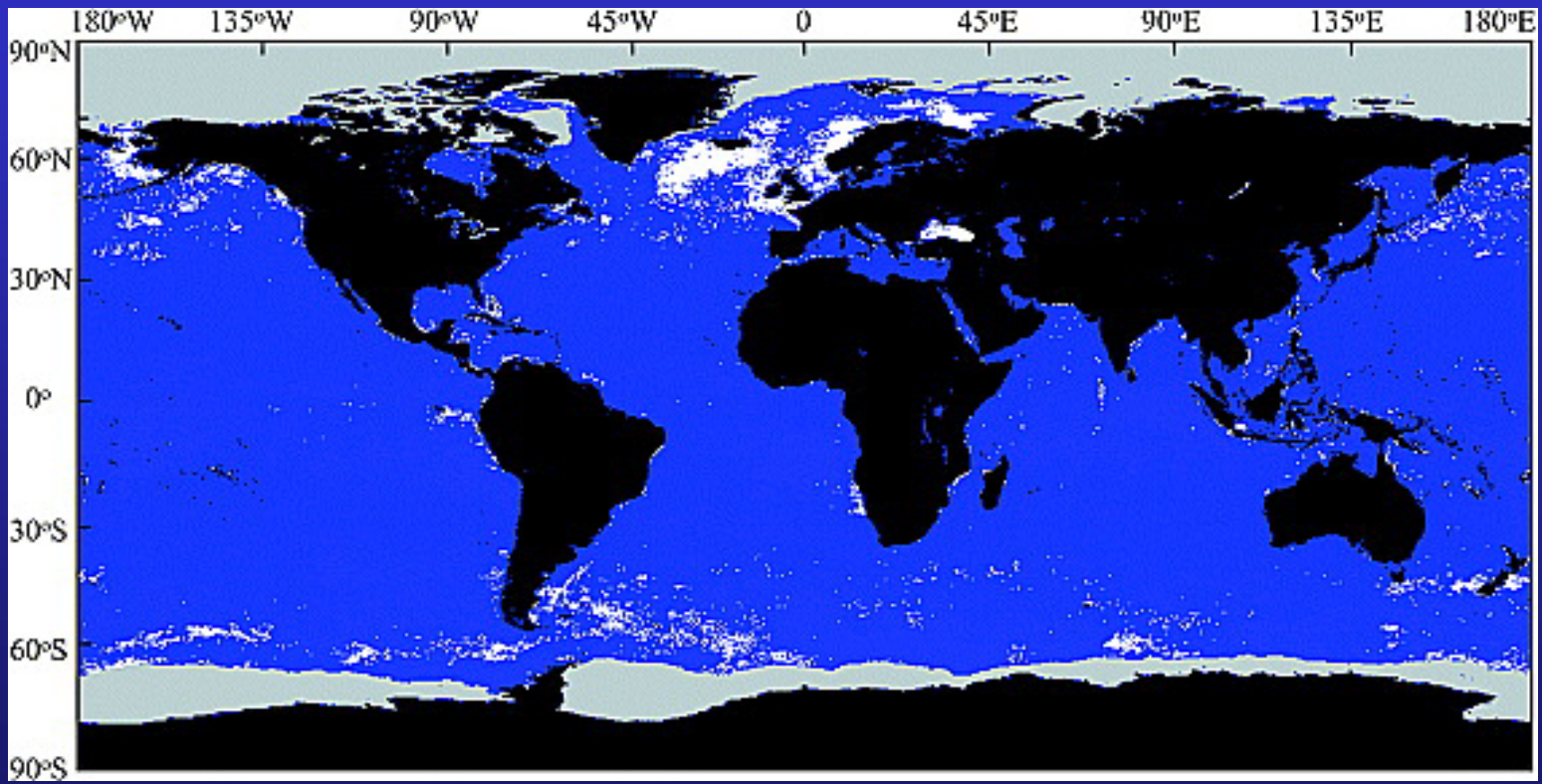


Average for the North Atlantic (0 to 60^{o}N)

Remote Sensing of POC

- POC patterns are very different from chlorophyll
- Validation at BATS & HOT is OK, but not great
  - Ratios of satellite to field POC are 1.22 (± 0.37) @ BATS & 0.94 (±0.27) @ HOT
- Enables POC budgets to be assessed
  - Mean POC = 54 mg C m^{-3}
- Large uncertainty in conversion from optics to POC
  - Estimated to be ~40% - Improvements are underway

Remote Sensing of Calcifiers



Coccolithophorid bloom classification

Iglesias-Rodríguez et al. [2002] GBC

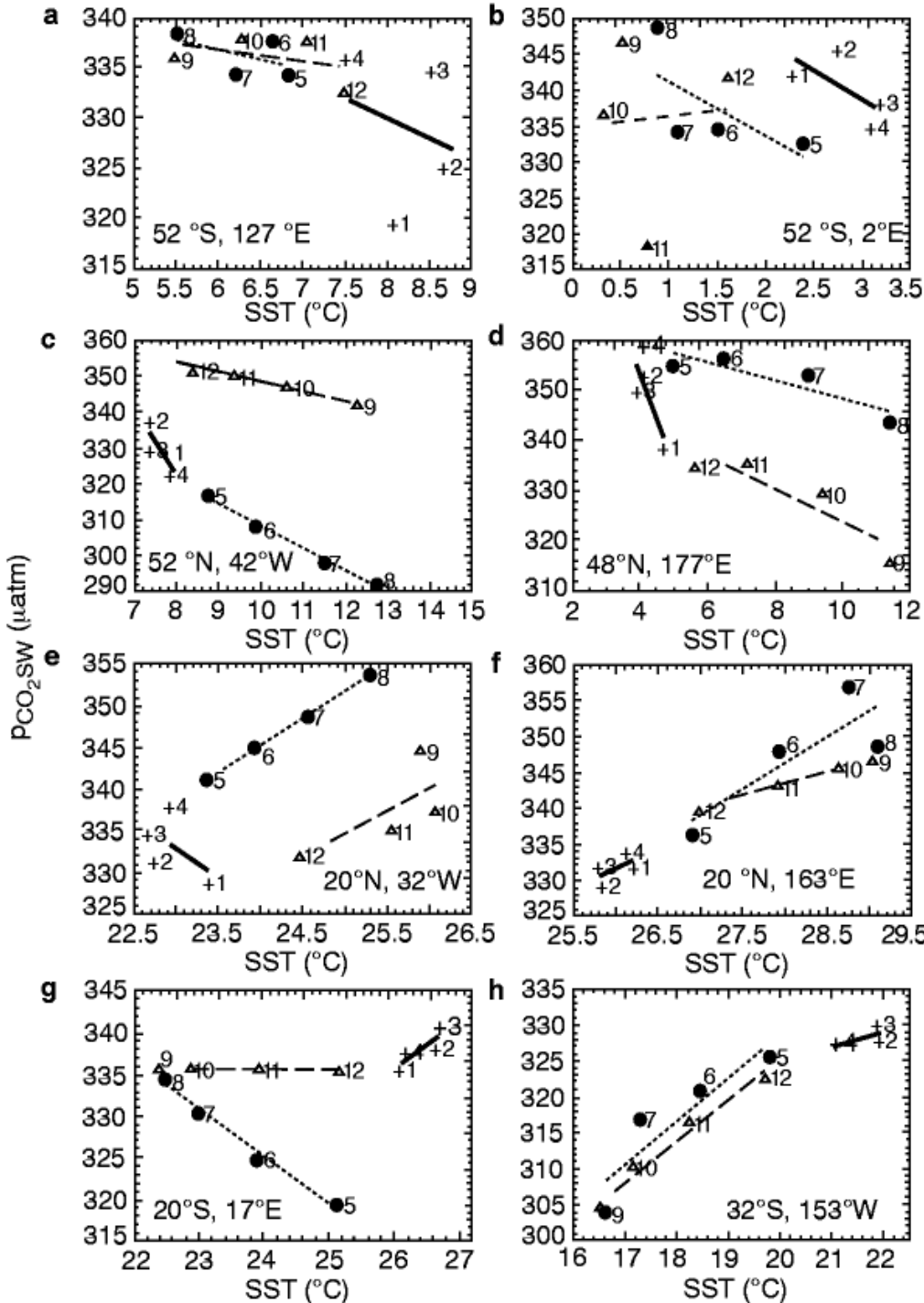
Remotely Sensing of Calcifiers

- Classification analysis based on observations of coccolithophorid blooms
- Enables space/time characteristics of coccolithophorid blooms to be assessed
- First (& probably easiest) step towards determining phytoplankton community structure remotely

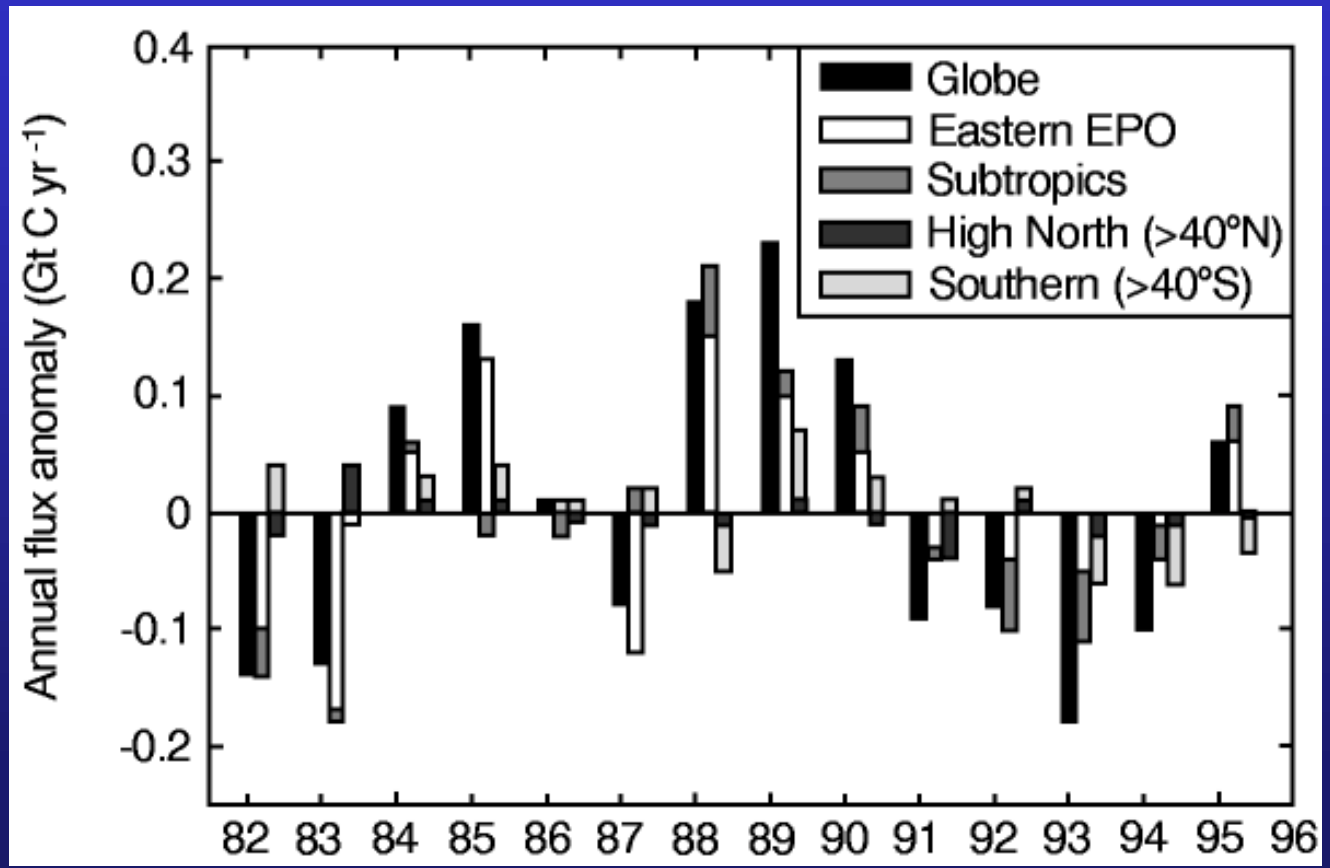
Air-Sea CO_2 Fluxes

- Relate observations of pCO_2 to SST
- Satellite SST to map pCO_2
- Highly variable relationship

Lee et al. [1998] *Nature*



Air-Sea CO_2 Fluxes



Incorporating winds enables air-sea CO_2 fluxes to be estimated

Air-Sea CO_2 Fluxes

- Used regional relationships for pCO_2 as f(SST)
- Drive with remote estimates of wind & SST
- Approach has promise, but we need a better way to predict pCO_2

- What if climate change, alters pCO_2 =f(SST)??

6 12.011

C

Carbon

Remote Sensing Carbon

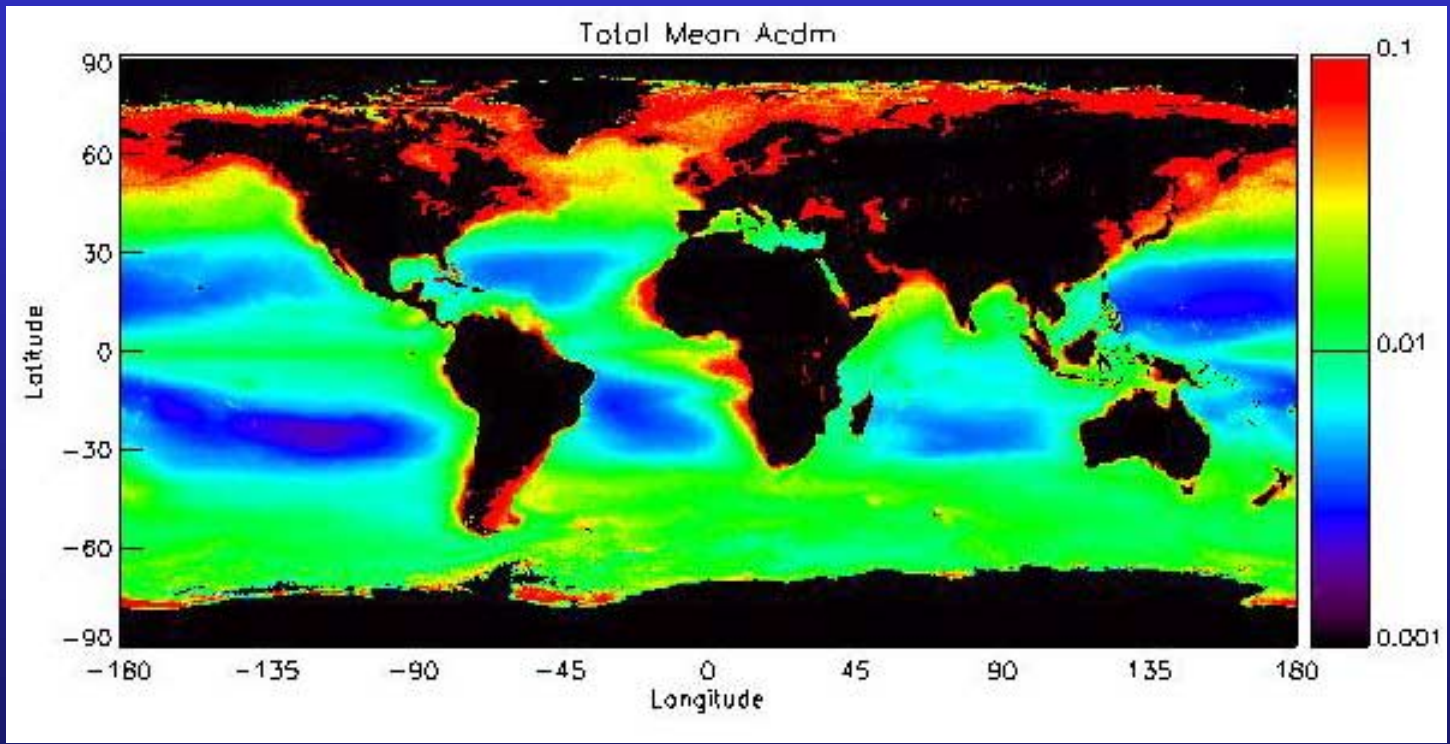
- Ocean color is not easily related to carbon
  - Chlorophyll is not carbon
- Key is using “real” observations to build simple models
  - Global data are finally available – more in future
  - The JGOFS legacy is its open data access
  - We are really just at the beginning of this work

The Future is Remotely Sensible

- There are many applications under consideration
  - Primary production & export fluxes
  - Photochemical rxn rates (CO, CO_2, COS, etc.)
  - DMSP/DMS cycling & air-sea DMS fluxes
  - *Trichodesmium* distributions
  - Physiological status from fluorescence
  - and many more ...

Thank you!!

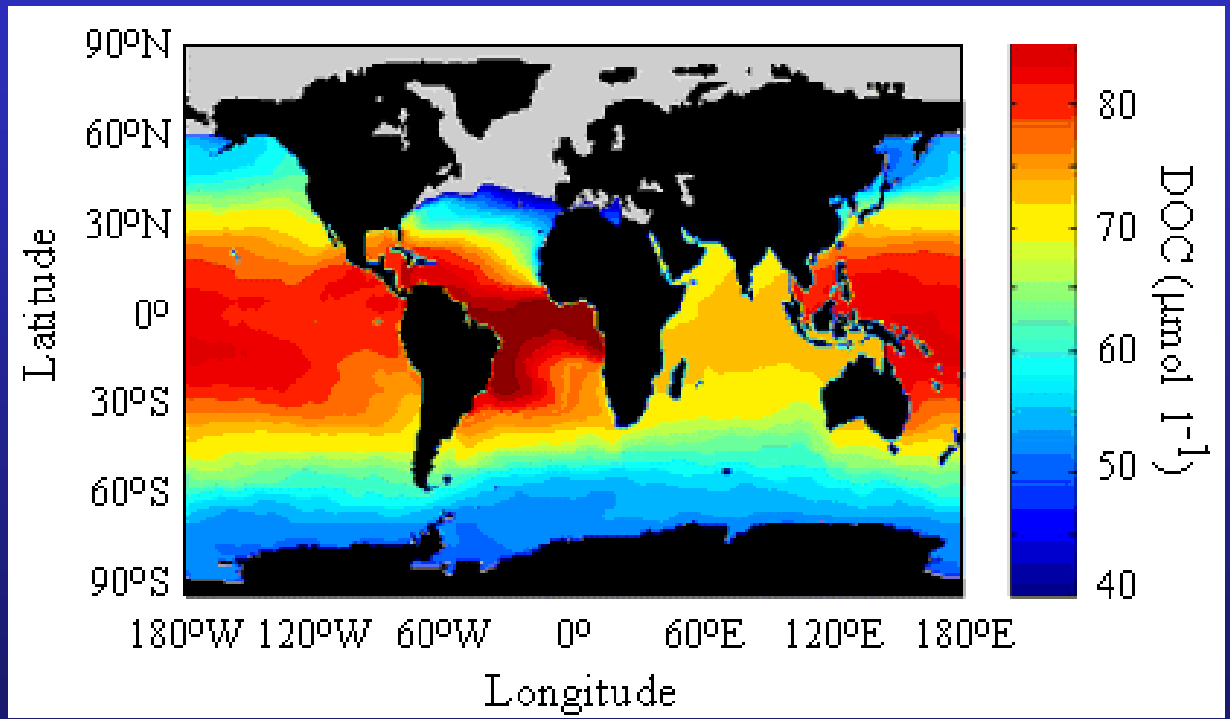
Remote Sensing of DOC



Colored Detrital & Dissolved Organic Material Absorption

Siegel et al. [2002] JGR

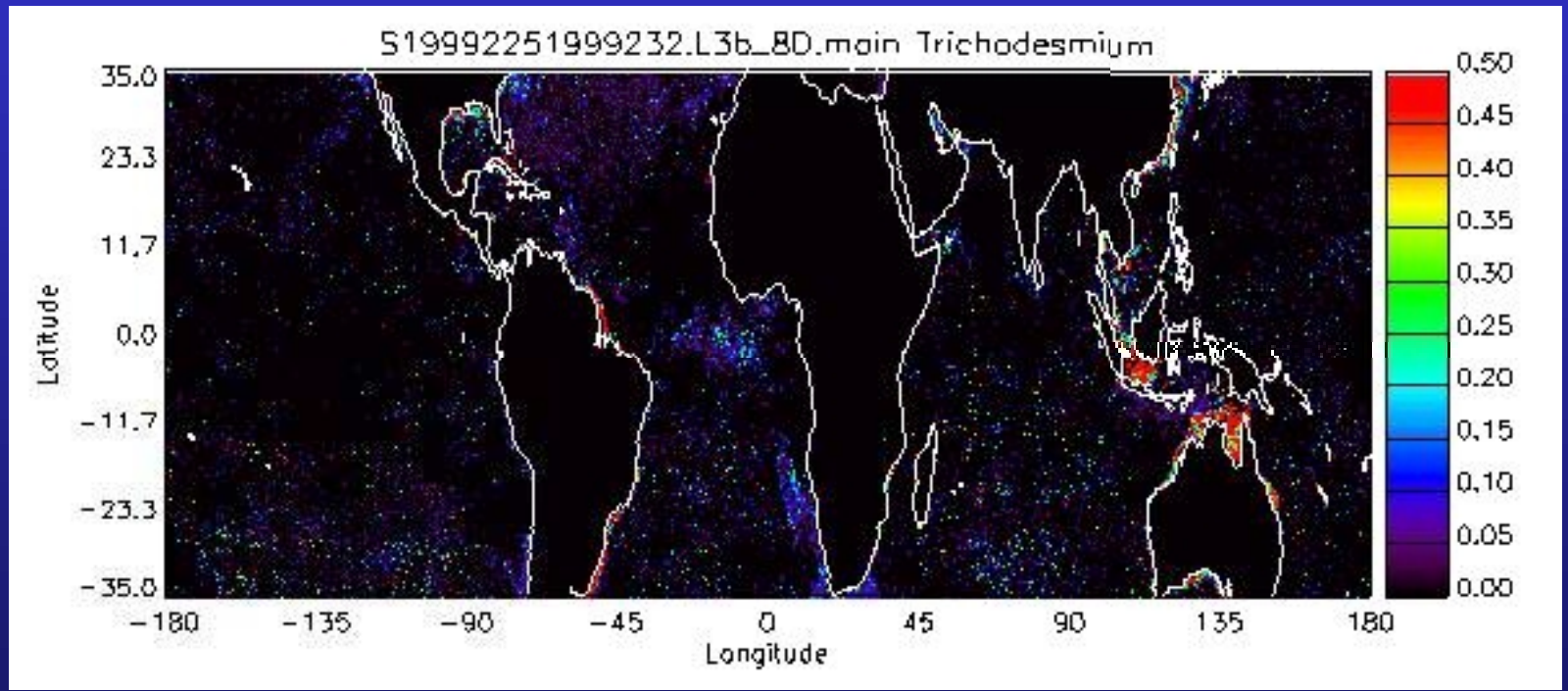
Remote Sensing of DOC



NH Winter DOC Distribution

Siegel et al. [2002] JGR

Remote Sensing of *Trichodesmium*



Index for *Trichodesmium* occurrence

Toby Westberry [work in progress]

Remote Sensing of DIC & pCO_2

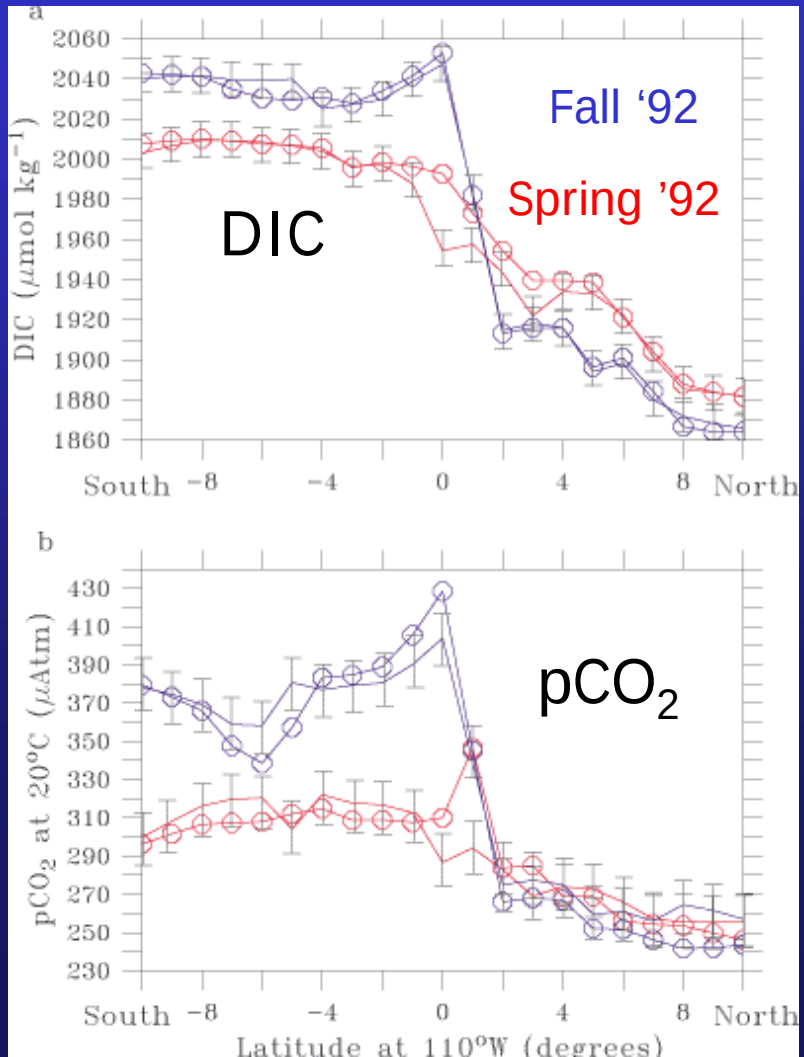
- Empirical approach for the Tropical Pacific

- Model ...

  DIC = f(SST,SSS)

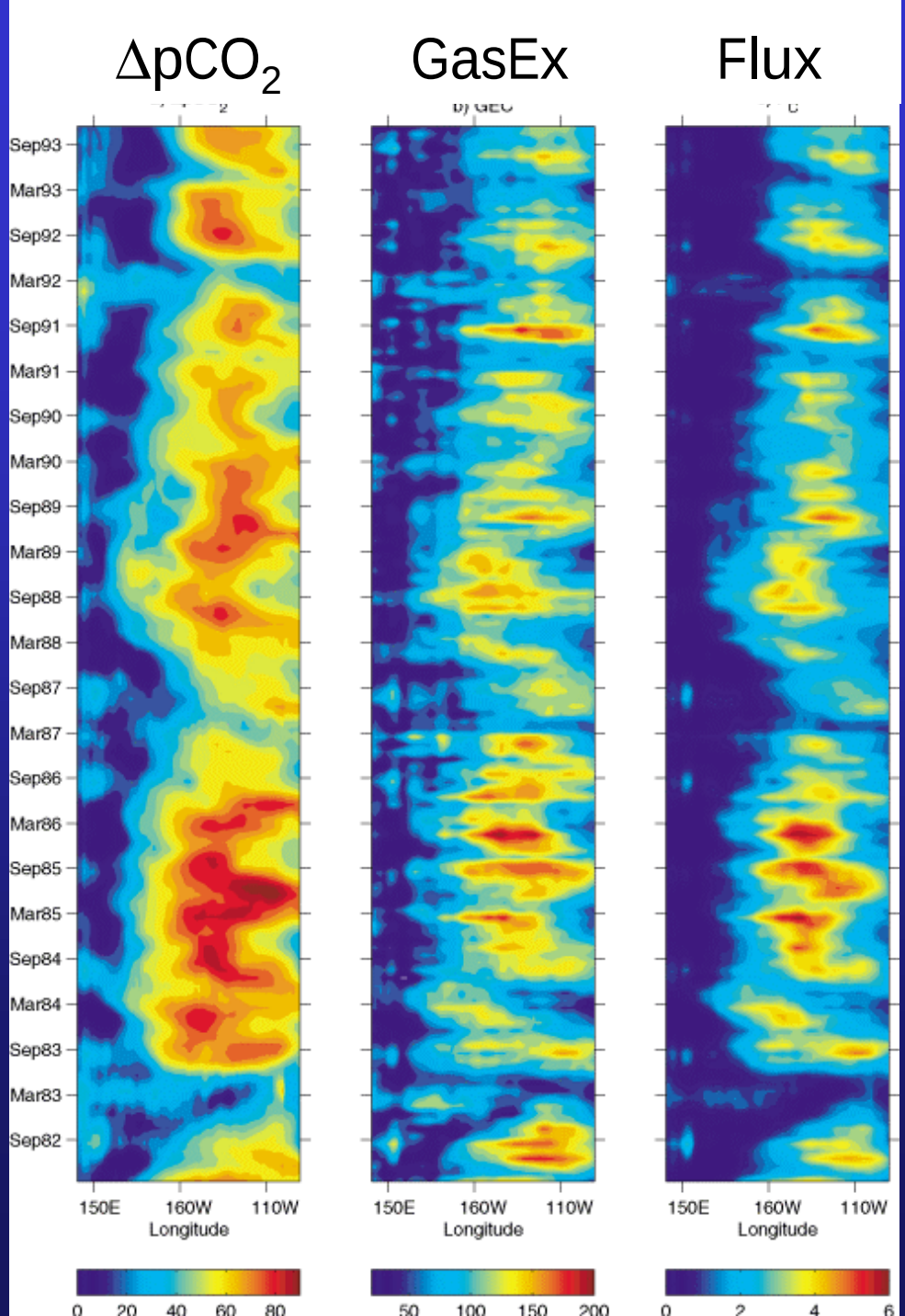
  TA = f(SST,SSS)

  Loukos et al [2000] GRL

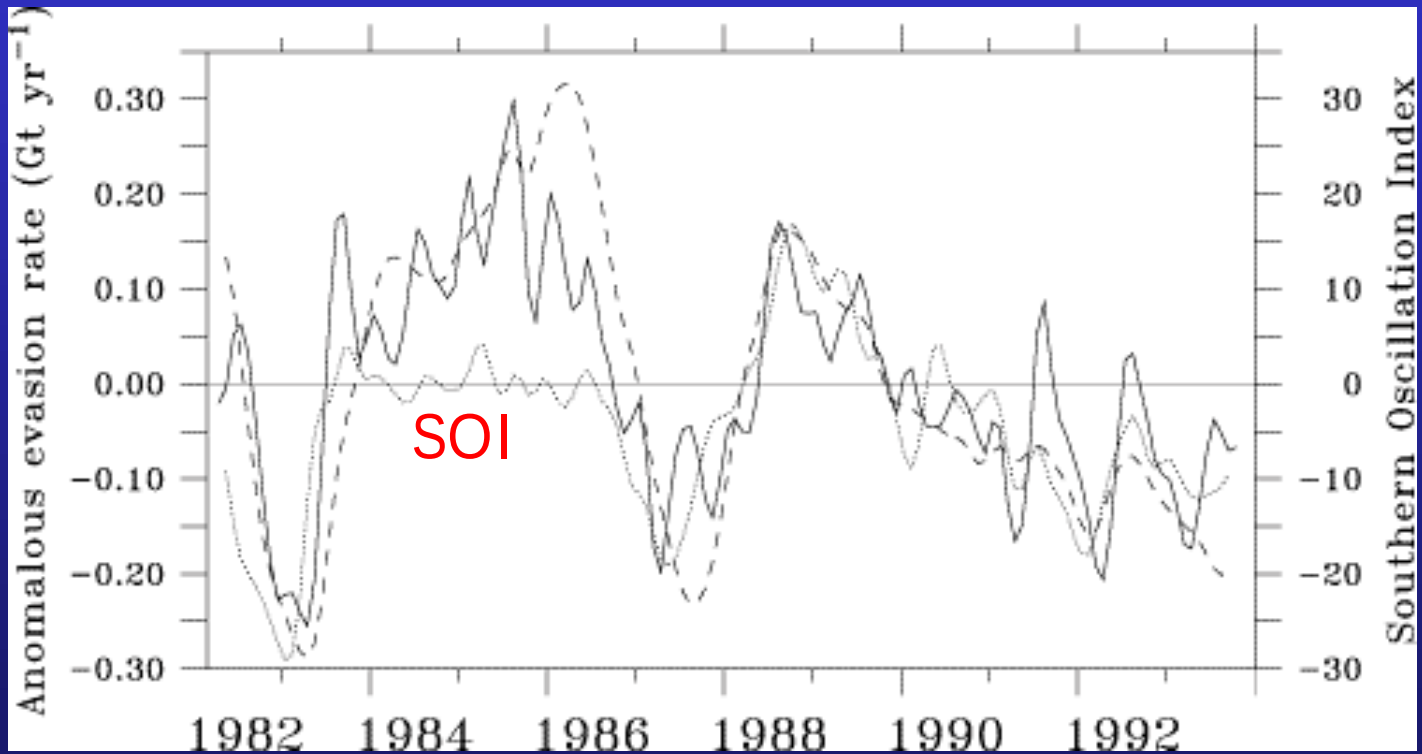


Remote Sensing of DIC & pCO_2

- Average from 5°S to 10°N
- 1982 to 1994
- SST, SSS & wind products used



Remote Sensing of DIC & pCO_2



Anomalous evasion is well related to SOI

Remote Sensing of DIC & pCO_2

- Empirically model DIC & TA for Tropical Pacific
- Drive this with remote sensing (& other) data
- Find relationship between CO_2 evasion & SOI
- BUT, evasion flux uncertainties are ~50%
- More field observations should help
- So would the remote sensing of sea surface salinity