A Modeling Study of Interannual to Decadal Variability in Equatorial Pacific Biogeochemistry and Ecosystems

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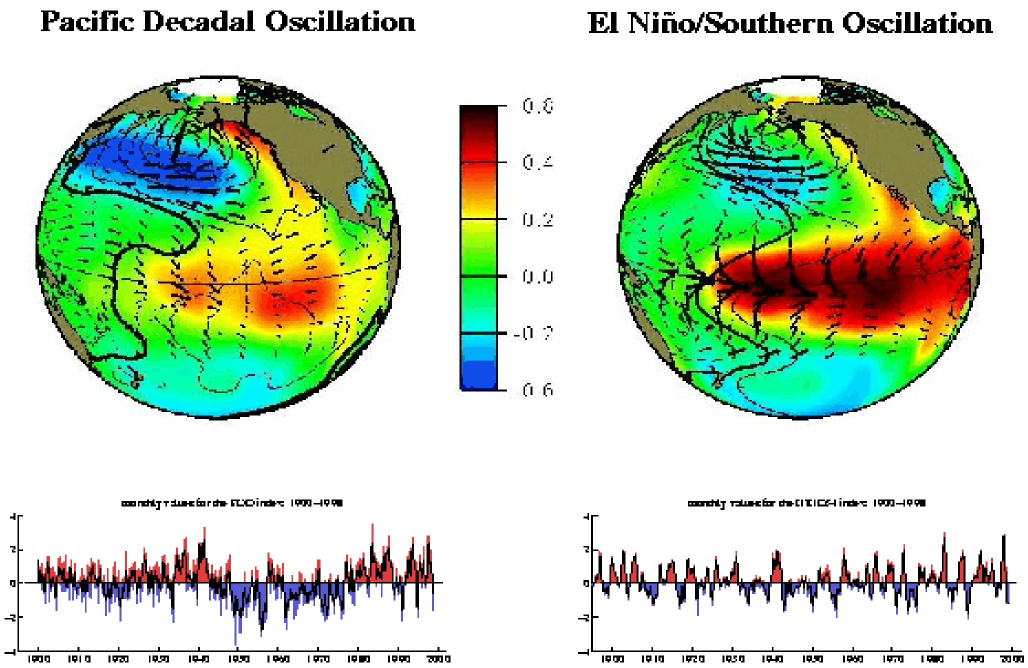
The Pacific Decadal Oscillation (PDO)

- Timeseries: construction by low-pass filtering. The PDO is often interpreted as a "slow mode" moving through system



Mantua et al. [1997]

- McPhaden and Zhang (2002) : Changes in overturning of "subtropical cells" (STCs) which link equatorial upwelling to extratropical subduction regions. Equatorial upwelling reduced by about 25%

General Question:

For model simulations, how do Equatorial Pacific biogeochemistry and ecosystems respond to wide range of timescales of variability contained in NCEP reanalysis fluxes?

Focus:

Decadal variability: Do the slowdown of the STCs and the resulting reduction in upwelling impact on equatorial biogeochemistry?

Is there a biogeochemical connection between extratropical and tropical basins through the ocean?

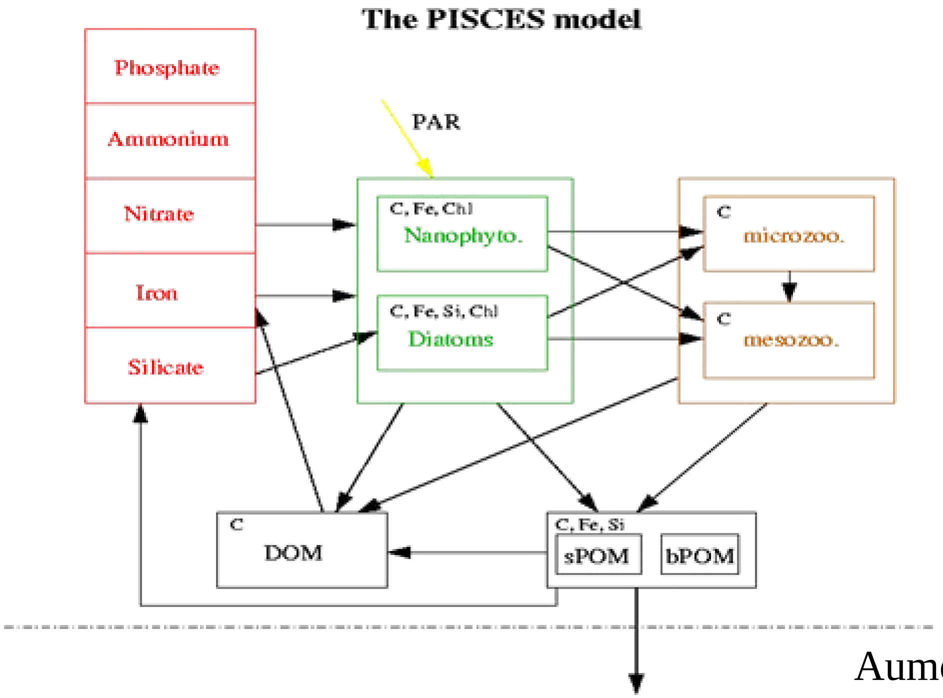
Rather than work with anomalies of tracer fields, consider full monthly mean tracer fields in order to identify relationship between different timescales

MODEL CONFIGURATION

- **Circulation**

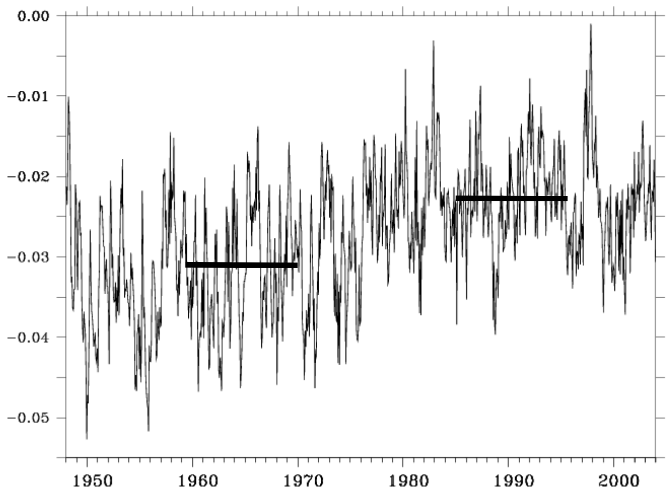
Forced experiments with ORCA2 configuration of OPA 8.2 model (Madec et al. 1998); model has 30 vertical layers, 2° resolution in extratropics, and 0.5° meridional resolution in the equatorial regions. Surface buoyancy fluxes are calculated using bulk formulas. Surface forcing from NCEP over 1948-2003.

- **Biogeochemistry**



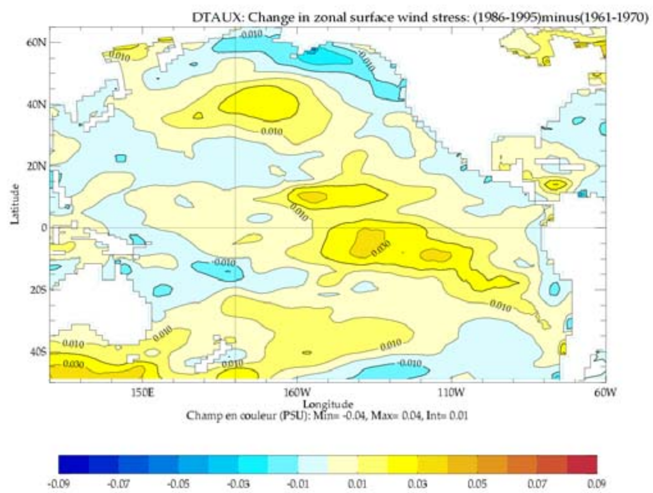
Aumont and Bopp 2006

Decadal changes in NCEP wind stresses



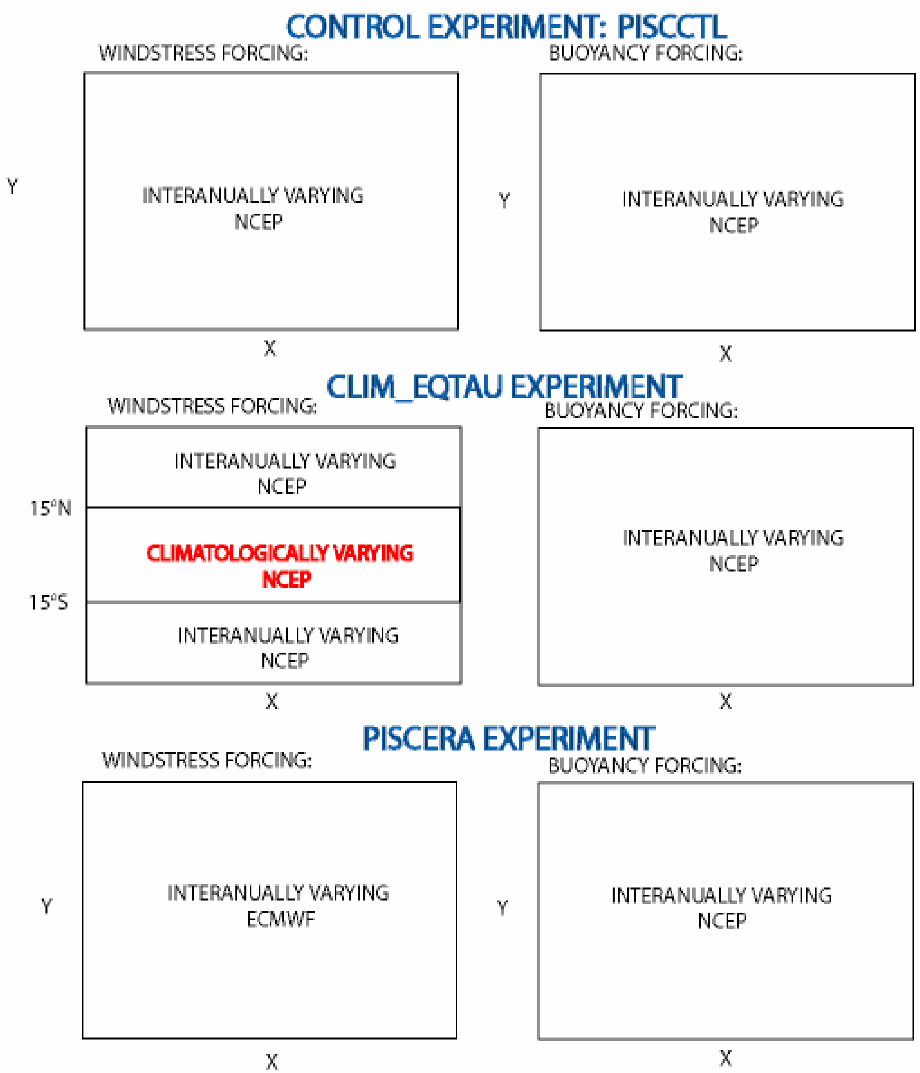
NCEP τ_x (zonal wind stress component) averaged over 4°N-4°S,120°E-270°E,. This quantity is 34% larger in NCEP over the period 1961-1970 than 1986-1995.

NCEP: despite some problems, best climate reconstruction that we have. How realistic is the 1976/77 “shift”, and to what extent is it an artifact of assimilation of satellite data? Sigfried Schubert (NASA):shift not due to data assimilation



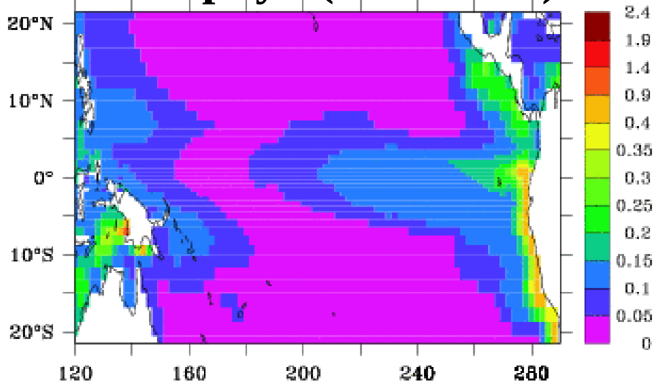
Difference in surface wind stress pattern: Mean(1986-1995)-Mean(1961-1970) Positive values indicate that wind stresses were weaker for the later period.

PHYSICAL FORCING FOR 3 EXPERIMENTS

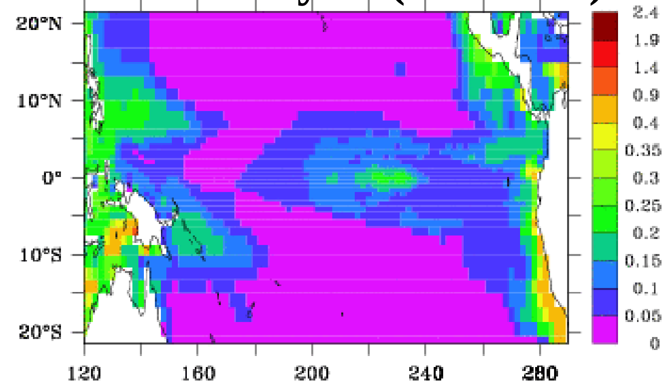


MODEL/DATA COMPARISON FOR SURFACE CHLOROPHYLL:

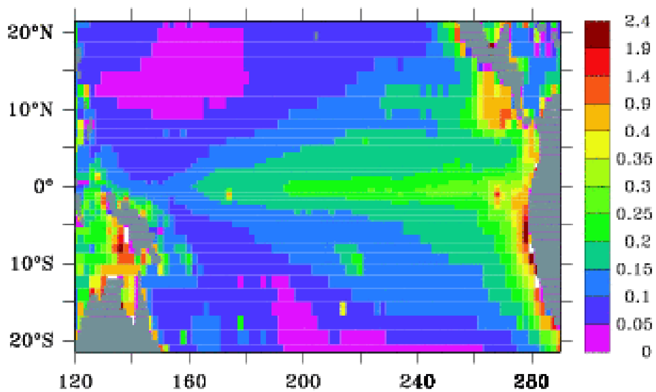
Mean ORCA2-PISCES chlorophyll (1998-2002)



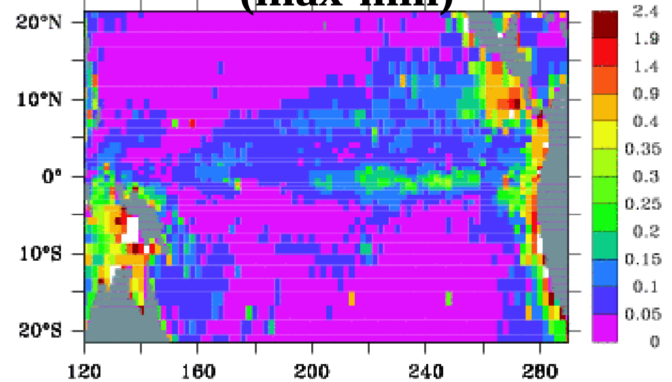
ORCA2-PISCES seasonal cycle (max-min)



Mean SEAWIFS chlorophyll



SEAWIFS seasonal cycle (max-min)



(Units of μmol/L)

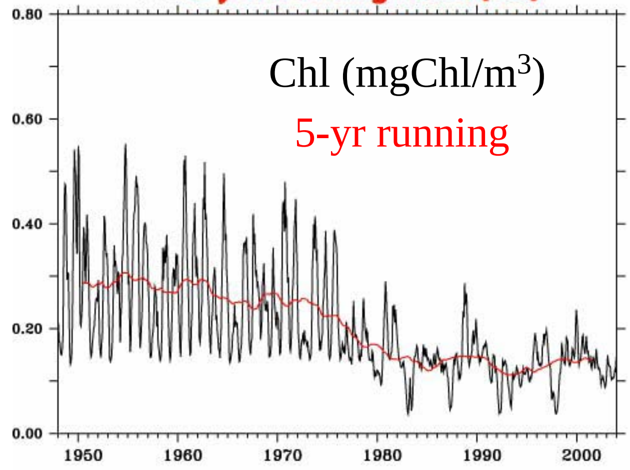
Monthly Chlorophyll Concentration averaged over 90W-150W,2N-2S (1948-2003)

61-70 vs. 86-95

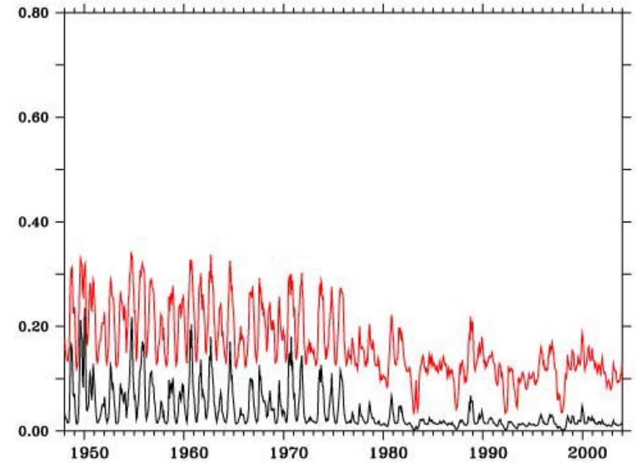
Annual: 80% higher

Seasonal: 120% higher

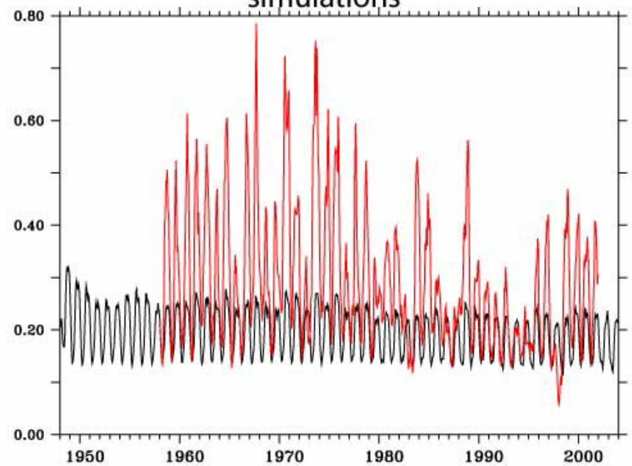
NCEP forcing: Monthly mean (black) and **5-year running mean (red)**



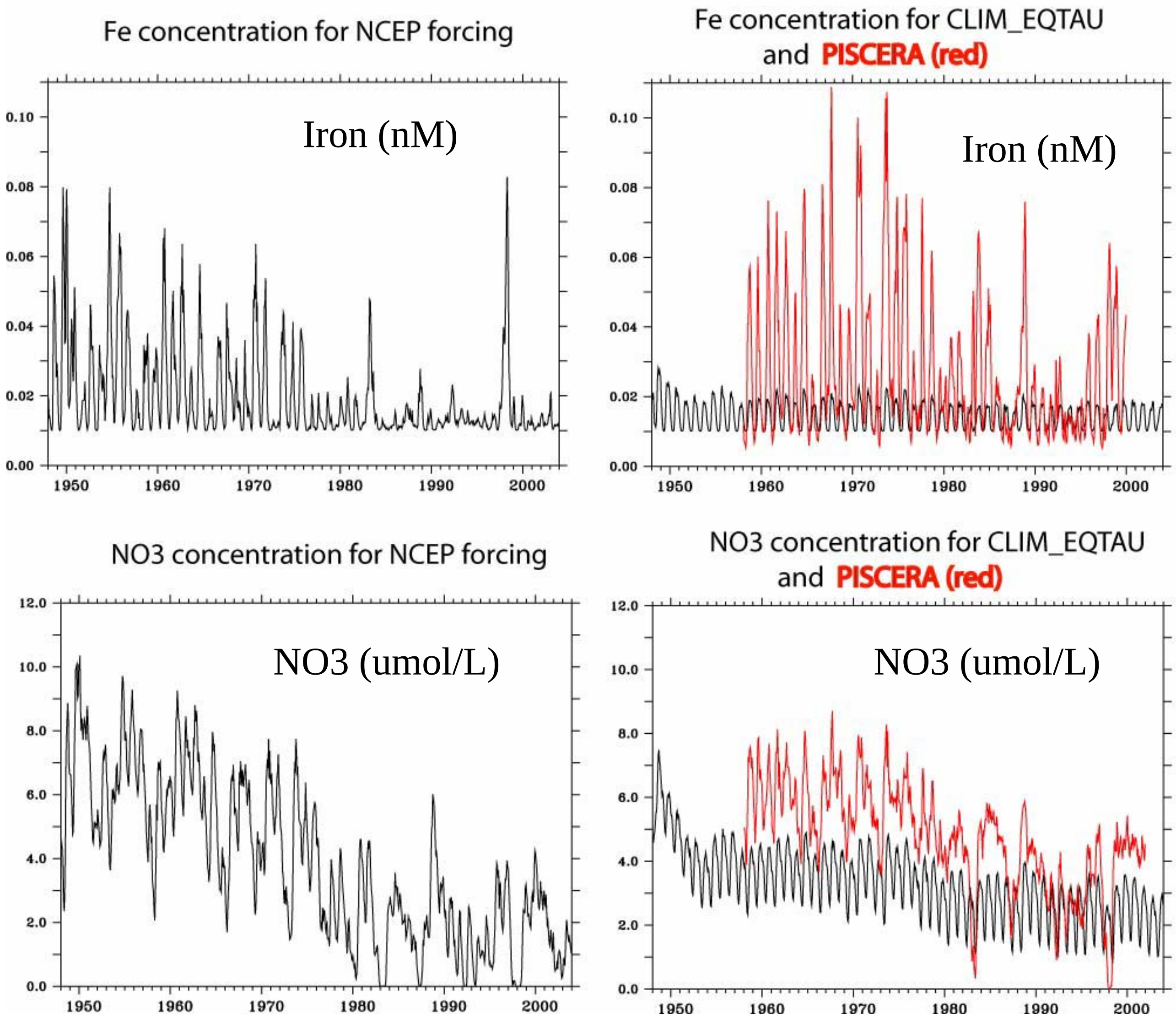
NCEP forcing: diatom (black) and **nanophytopankton (red)** components



CLIM_EQTAU (black) and **PISCERA (red)** simulations



Monthly Fe and NO3 concentrations averaged over 90W-150W,2N-2S (1948-2003)



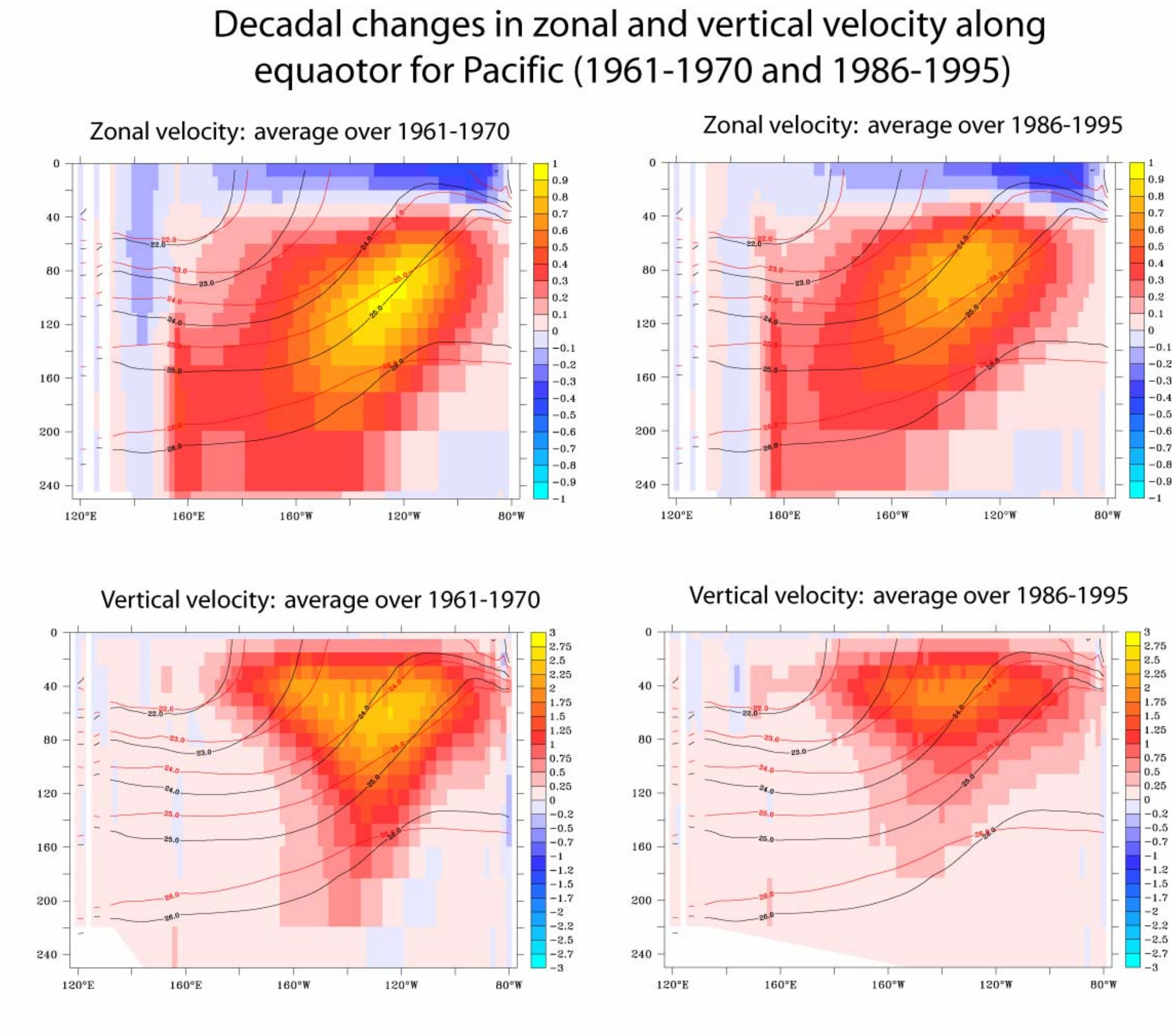
Potential mechanisms

- Change in upwelling rate (volume/time)

- Change in depth (or isopycnal horizon) from which upwelling occurs, with iron concentration remaining roughly constant on isopycnal surfaces

- Ferricline/pycnocline decoupling (change in iron concentration on isopycnal surfaces)

Circulation Changes

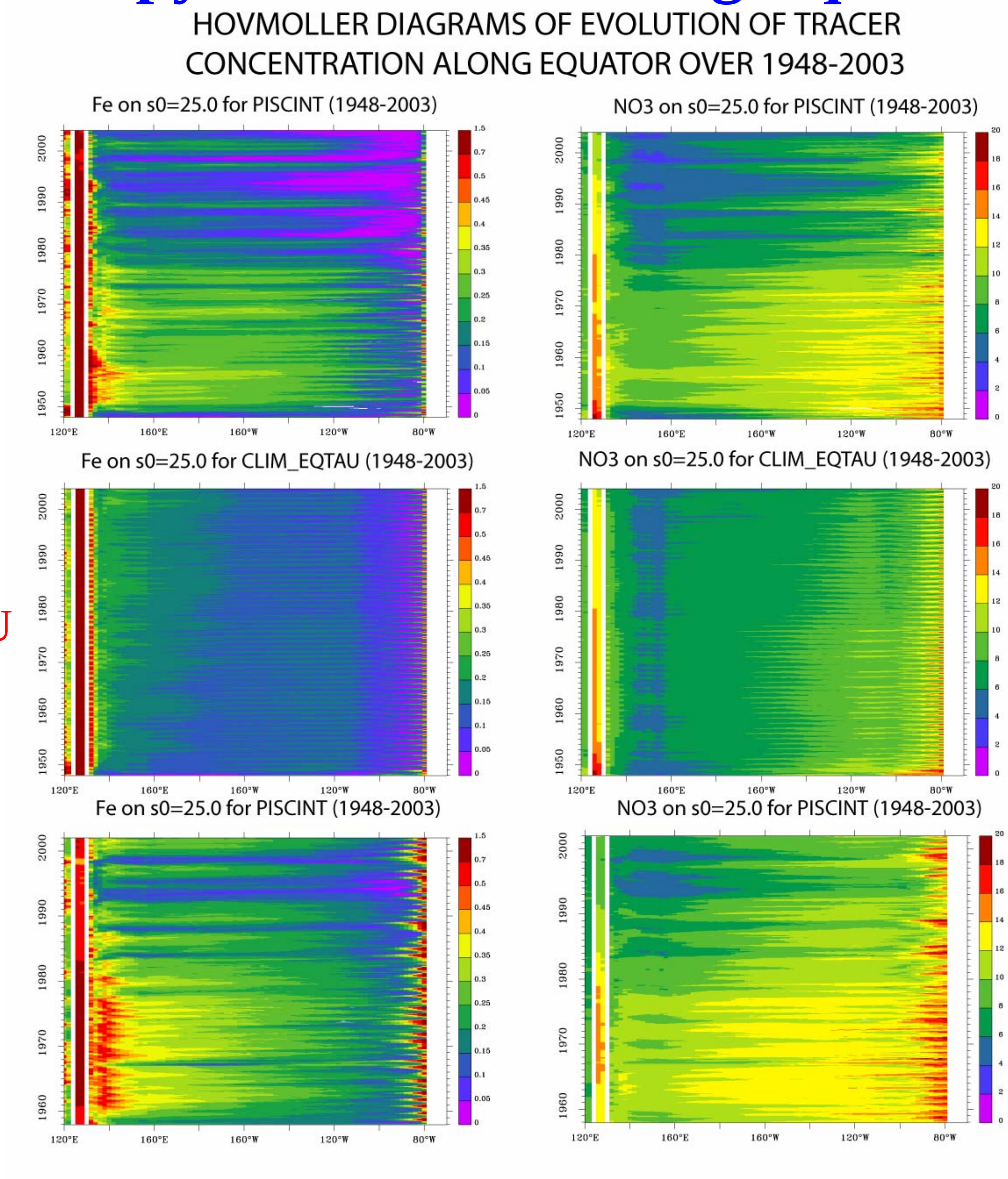


Tracers on isopycnal surfaces along Equator (1948-2003)

PISCTL

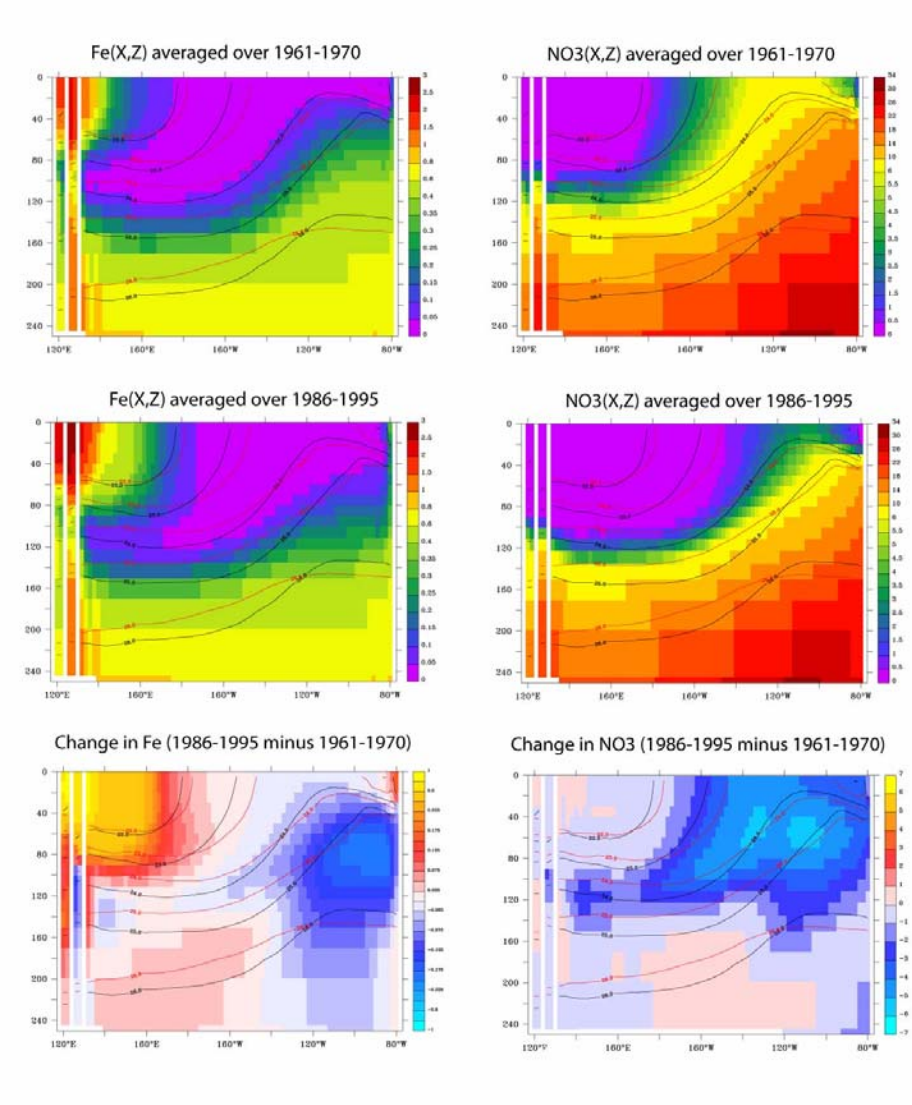
CLIM_EQTAU

PISCERA



Fe (nmol/kg) NO3 (µmol/kg)

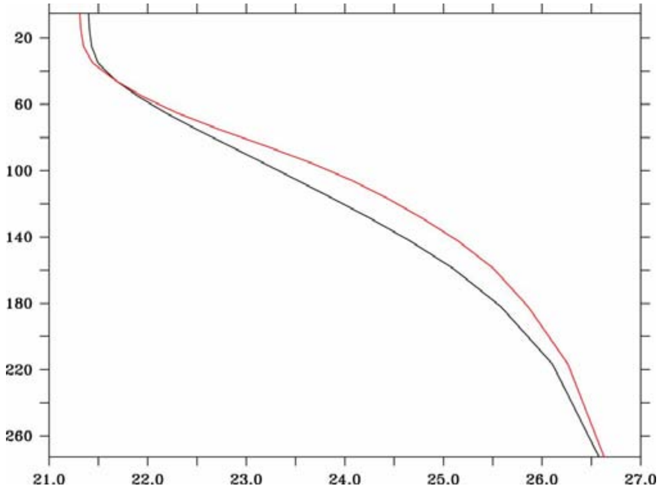
Decadal change in tracer concentrations along Equator (1961-1970 and 1986-1995)



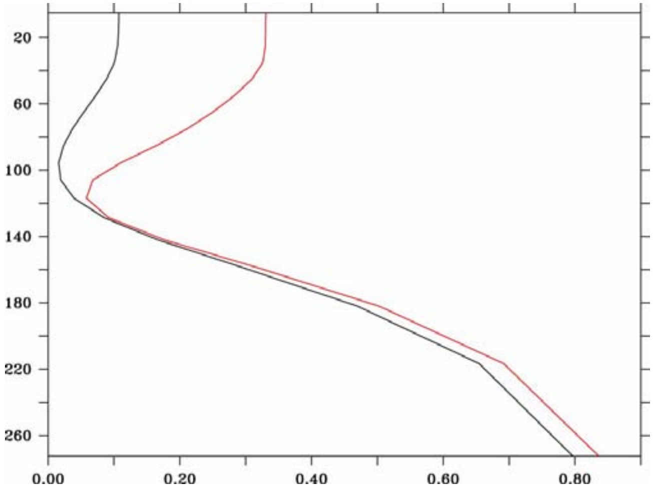
VERTICAL PROFILES OF DENSITY AND DISSOLVED IRON CONCENTRATION UNDER THE WARM POOL

(Average over 155E-165E, 1N-1S)

Potential density



Iron concentration



Decade 1961-1970

Decade 1986-1995

Conclusions

- Large decadal changes in seasonality of surface iron and chlorophyll
- Surface Chlorophyll response strongly nonlinear (amplification here)
- Decoupling of ferricline and pycnocline on decadal timescales

Is it realistic ?

- We don't know. Very few data before 1976 for Chl and NO3
- Strong blooms possible (La Nina 98). Decadal changes possible (Antoine et al., 2005, ...)
- Main conclusions:

  Equatorial Pacific may not be stable (low Chl, low Seasonality)

  Biogeochemical responses are non-linear

  Important of not overfiltering the data (seasonality)