Covariability of Chlorophyll and Sea Surface Temperature at Global and Decadal Scales

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PSI
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Ocean color derived from satellite

Different calibrations and algorithms

Rebuilt fields by Antoine et al. (2005)
CZCS: [1979-1983]  
SeaWiFS: [1998-2002]

- Same algorithms
- Adapted calibration
- Increase of 20% in average

(Gregg et al., 2002: decrease of 6%)

Concomitant changes in Chl and SST?  
(2 drivers of the satellite Primary Production algorithms)
ERSST v3 difference:

SST-Chl relationship:
Inverse SST-Chl relationship over a large area

Chl ratio:

Relationships between 1999 to 2004

Behrenfeld et al. (2006)
Multivariate Empirical Orthogonal Function Analysis (MEOFs)

1. SeaWiFS era [1998-2005]
   Meofs, to set up the method (previous analysis)

   Meofs, to embrace the decadal scale

Reconstructed fields
Multivariate Empirical Orthogonal Function Analysis (MEOFs)

• Monthly

• 1°/1° (surface changes following latitudes are taken into account)

• Anomaly data fields: Signal - monthly climatology = Non seasonal signal

• (over the 2 time periods for the reconstructed fields)

• Normalized by standard deviation

• Same sampling between the 2 parameters
1) SeaWiFS [1998; 2005]

\[
\text{Chl} (x, y, t) = \sum_{i=1}^{N} a_i(t) \cdot c_i(x, y)
\]

\[
\text{SST} (x, y, t) = \sum_{i=1}^{N} a_i(t) \cdot b_i(x, y)
\]

MEOF1: 12% variance

- Associate \textbf{temporal AND spatial signal}
- SST & Chl \textbf{COVARIABILITY}
- Decompose in modes
1) SeaWiFS [1998; 2005]

Relationships between 1999 to 2004

Behrenfeld et al. (2006)

MEI = Multivariate ENSO index
SST spatial signature of the: Pacific Decadal Oscillation (PDO)

Consider PDO index

MEI=Multivariate ENSO index
PDO= Pacific Decadal Oscillation
1) SeaWiFS [1998; 2005]

How does the global analysis is influenced by the Pacific?

Basin Analyses
1) SeaWiFS [1998; 2005]

a. Using MEOFs, we have consistent results with previous analyses

b. Decadal indices (as PDO) have to be considered

c. Analyses have to be performed separately for each basin
Part II: Decadal changes

CZCS-SeaWiFS [1979;1983]-[1998; 2002]
2) CZCS-SeaWiFS [1979;1983]-[1998; 2002]

Meofs spatial variability

Similar structures & evolution

Ratio
2) CZCS-SeaWiFS [1979;1983]-[1998; 2002]

AMO regime shift: COLD → WARM

SST spatial signature of the:
Atlantic Multidecadal Oscillation (AMO)

MEI = Multivariate ENSO index

PC

MEOF1 (9%)
2) CZCS-SeaWiFS [1979;1983]-[1998; 2002]

MEI=Multivariate ENSO index
PDO= Pacific Decadal Oscillation

Regime shift

MEI=Multivariate ENSO index
PDO= Pacific Decadal Oscillation
2) CZCS-SeaWiFS [1979;1983]-[1998; 2002]

MEOF1 (14%)
PC
MEI
PDO

SST spatial signature of the:
Pacific Decadal
Oscillation (PDO)

PDO regime shift: WARM → COLD

Pacific Decadal Oscillation

SST-Chl relationship


AMO

Atlantic Multidecadal Oscillation

1999-2004

Behrenfeld et al. (2006)
Conclusions

- Chl changes observed over the SeaWiFS or the CZCS-SeaWiFS era seem related to natural basin-scale oscillations in the physical environment (i.e., PDO, AMO...)
- It’s unclear whether those decadal regime shifts can alternately emphasize or offset the possible effects of longer-term climate variability.
- The understanding of these decadal regimes, and their representation into global ocean models, are primordial if one aims at predicting the impact of climate change on ecosystems in the next decades.
- This study also emphasizes the critical importance of reanalysing historical data sets and of maintaining satellite time series in the next decades.
Why is it noteworthy for the Pacific?

✓ Impact on ecosystems:
  - Salmon  (Mantua et al., 1997; Hare et al., 1999…..)
  - Anchovies and sardines  (Chavez et al., 2003)
  - Pacific sea birds  (Vandenbosh, 2000)
  - ..........

✓ Impact on sea level pressure

Mantua and Hare, 2002