



# **Observation program for role of the Indian Ocean in the climate system**

**Gary Meyers**

**Co-Chair CLIVAR/GOOS**

**Indian Ocean Panel**

**With Contributions from IOP  
Members and Friends**

**Goa, 2-5 October 2006**



# **Outline**

**IOP history**

**Implementation of sustained  
observations—plan and reality**

**Climate research issues and overlap  
with SIBER interests**

**Upcoming process studies**

**Ocean re-analysis**

# **IOP History**

- ✓ **Established in 2004 after OceanObs(1999), SOCIO Workshop (2000) and IOGOOS conference (2002)**
- ✓ **Three meetings:**
  - **2004 Puna IITM (Joint with AAMP)**
  - **2005 Hobart CSIRO Marine**
  - **2006 Honolulu IPRC**
- ✓ **2007 in Africa, hopefully**

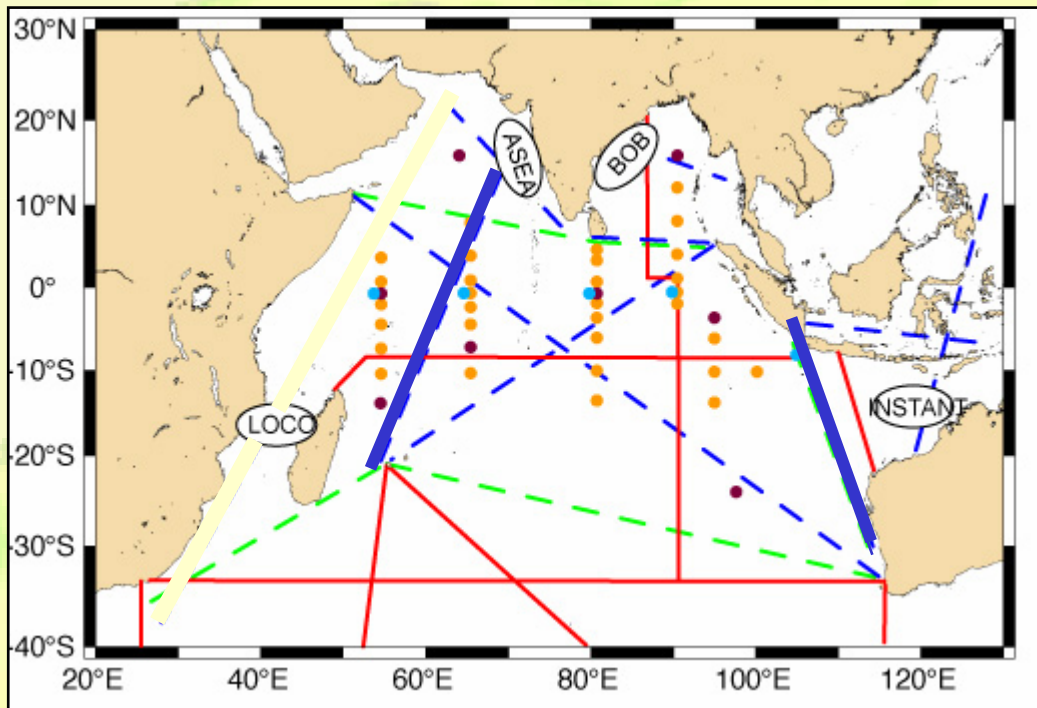
# **IOP Report 2006**

**The role of the Indian Ocean in the climate system—implementation plan for sustained observations**

**<http://eprints.soton.ac.uk/19645/>**

- Basin scale mooring array**
- Integrated approach to moorings, Argo floats, XBT lines, surface drifters, tide gauges**
- Alternative observational strategies assessed by observing system simulations**
- Research issues: review and key questions**

# IndOOS: Multi-platform System around a basin-scale mooring array



Key new element—  
mooring array: ocean  
obs + meteorology

Argo floats  $3^\circ \times 3^\circ$   
Drifters  $5^\circ \times 5^\circ$

~20 real-time tide  
gauges

— Carbon/hydro cruise

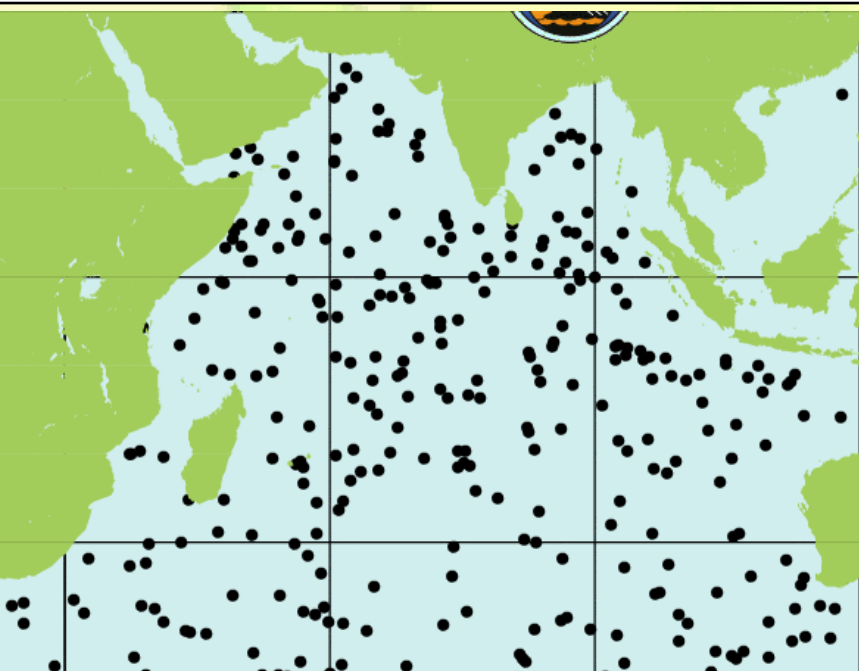
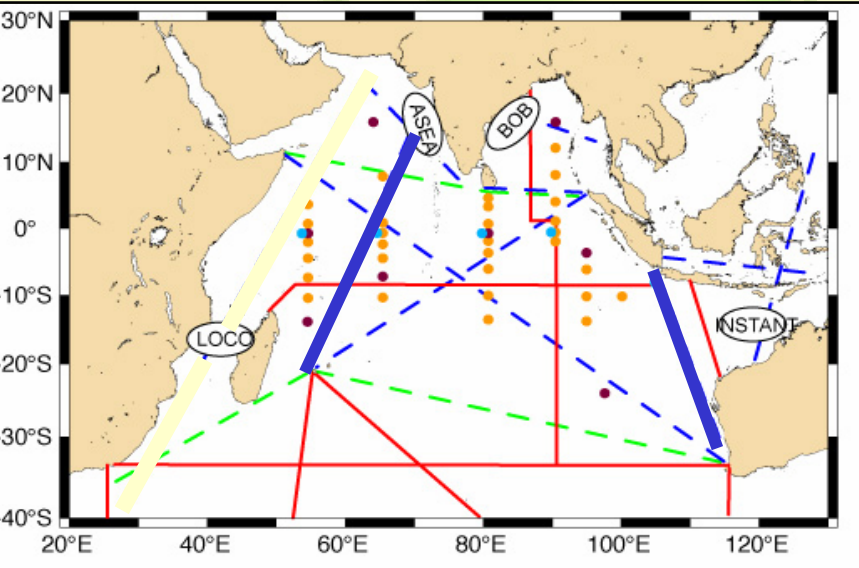
- - - High density XBT

- - - Frequently repeated XBT

— Enhanced XBT lines to monitor  
Indonesian Throughflow, inflow to  
western boundary, Java upwelling and  
 $10^\circ\text{S}$  thermocline ridge

○ Regional mooring arrays

# IndOOS Plan & Reality



Basin scale array—McPhaden's talk

Argo floats 390/480, full implementation likely—**note subtropics; O- sensors S Riser**

XBT lines full implementation likely, except IX10—**note BGC enhancements**

Tide gauges—IOTWS

Regional arrays—now and future

Hydro-lines

# IndOOS Goal

**Support improved description, understanding and ability to predict:**

- **Seasonal monsoon variability—the oceans role**
- **Intraseasonal variability (e.g. MJO)—interactions and feedbacks with upper ocean**
- **Monsoon ↔ ENSO interactions**
- **Indian Ocean Dipole ↔ ENSO interactions**
- **Decadal variability**
- **Warming trends since the 1970s.**



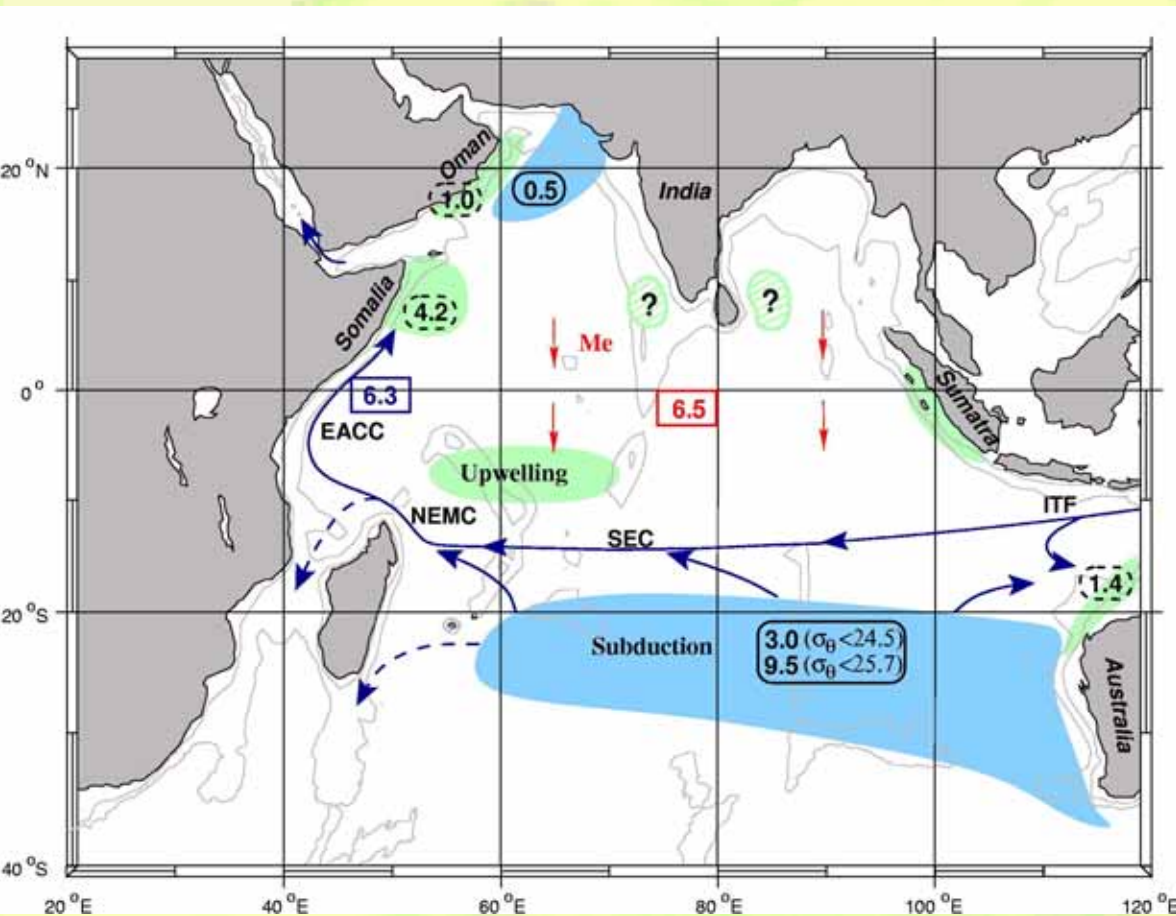
# **SIBER**

- **Broaden integration of observations—biology, chemistry and physics**
- **Why and how should we add biogeochemical sensors to the system?**

# Monsoon upwelling zones

Rates of upwelling & subduction known to some extent, needs improvement

What is the relevant rate of biological fluxes?



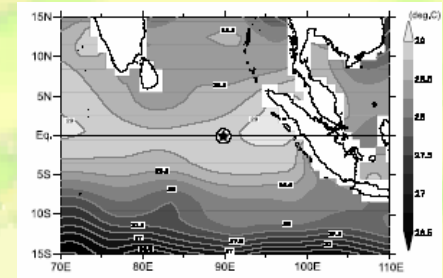
Schott and McC 2003

# Intraseasonal var'n

Masumoto et al 2005

Zonal wind/u,v current

90E mooring  
2000 to present

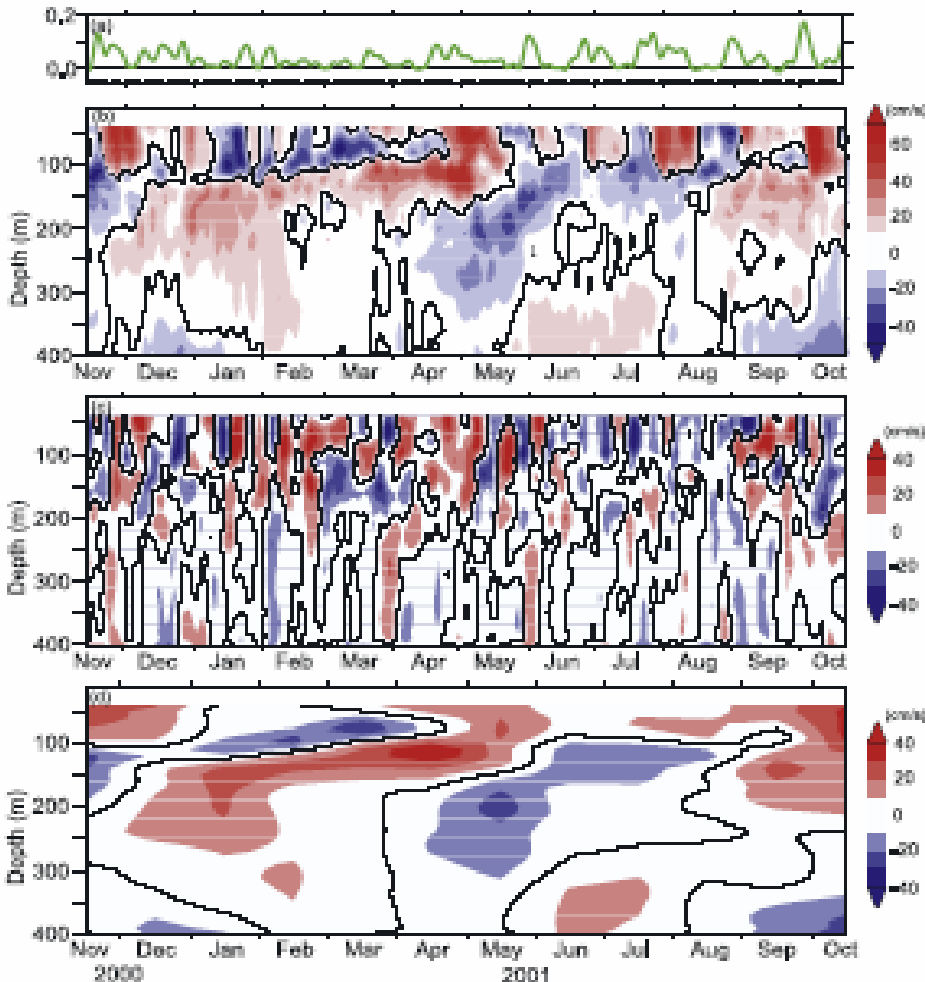


Key to monsoon, IOD prediction

Strong intraseasonal variation in mixed layer, barrier layer, currents and thermocline

What are the consequences for nutrient fluxes, PP, etc.?

Role of deeper variation: e.g. upward propagation of semiannual Wyrтки Jet



# ENSO-IOD relationship

	NEGATIVE IOD	NO EVENT	POSITIVE IOD
<b>EL NINO</b>	1930	1877 1888 1899 1911 1914 1918 1925 1940 1941 1965 1986 1987	1896 1902 1905 1923 1957 1963 1972 1982 1991 1997
<b>NO EVENT</b>	1880 1956 1958 1968 1974 1980 1985 1989 1992	1881 1882 1883 1884 1890 1895 1898 1900 1901 1904 1907 1908 1912 1913 1915 1920 1921 1927 1929 1931 1932 1934 1936 1937 1939 1943 1947 1948 1951 1952 1953 1959 1960 1962 1966 1969 1971 1976 1979 1990 1993 1995	1885 1887 1891 1894 1919 1926 1935 1944 1945 1946 1961 1967 1977 1983 1994
<b>LA NINA</b>	1906 1909 1910 1916 1917 1928 1933 1942 1950 1975 1981	1878 1879 1886 1889 1892 1893 1897 1903 1922 1924 1938 1949 1954 1955 1964 1970 1973 1978 1984 1988 1996 1998	

# Cold anomaly and upwelling in the IOD eastern pole

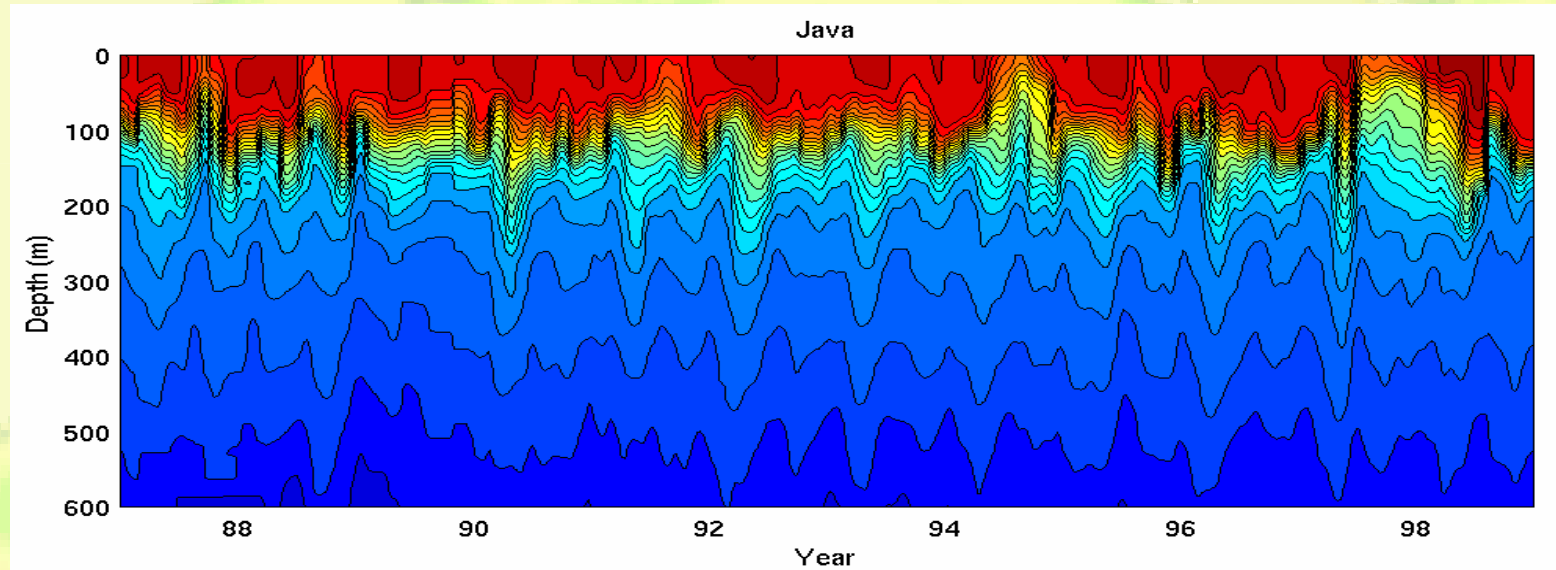
Upwelling events

1988

1991

1994

1997

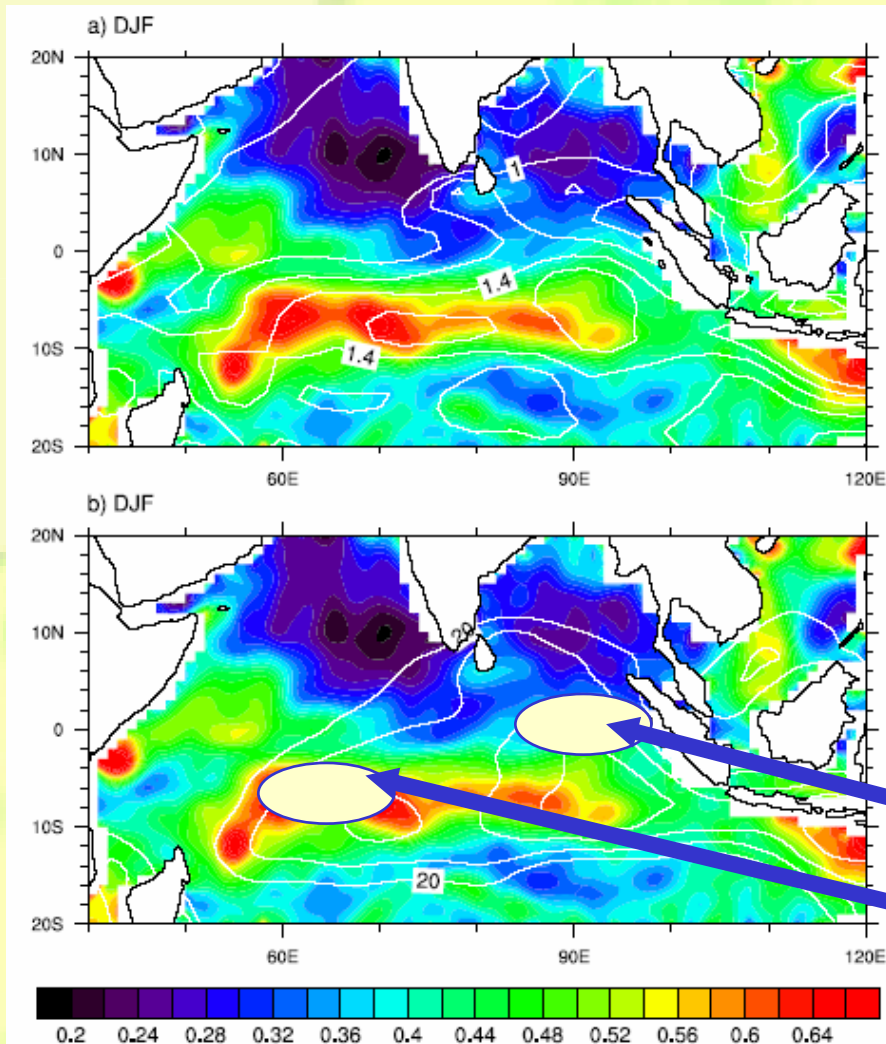


IOP: Analysis of surface layer heat budget. When is cool SST due to evaporation, or upwelling or cool advection?

SIBER: What is the biological system in different phases of the IOD ENSO relationship?? Remember Raghu's warning!

# Intraseasonal (e.g. MJO Variations)

## Two process studies



Standard deviation DJF

TOP: SST (color), wind speed (m/s)

BOT: SST (color), OLR ( $W/m^2$ )

**MJO Process Studies**

**MISMO (Japan) Oct-Dec 2006**

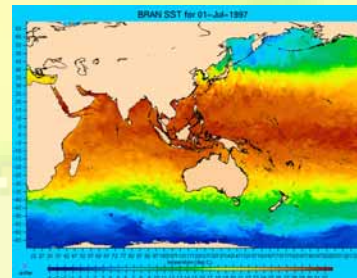
**CIRENE (France) Jan 2007**

# **Ocean state estimation (re-analysis and prediction)**

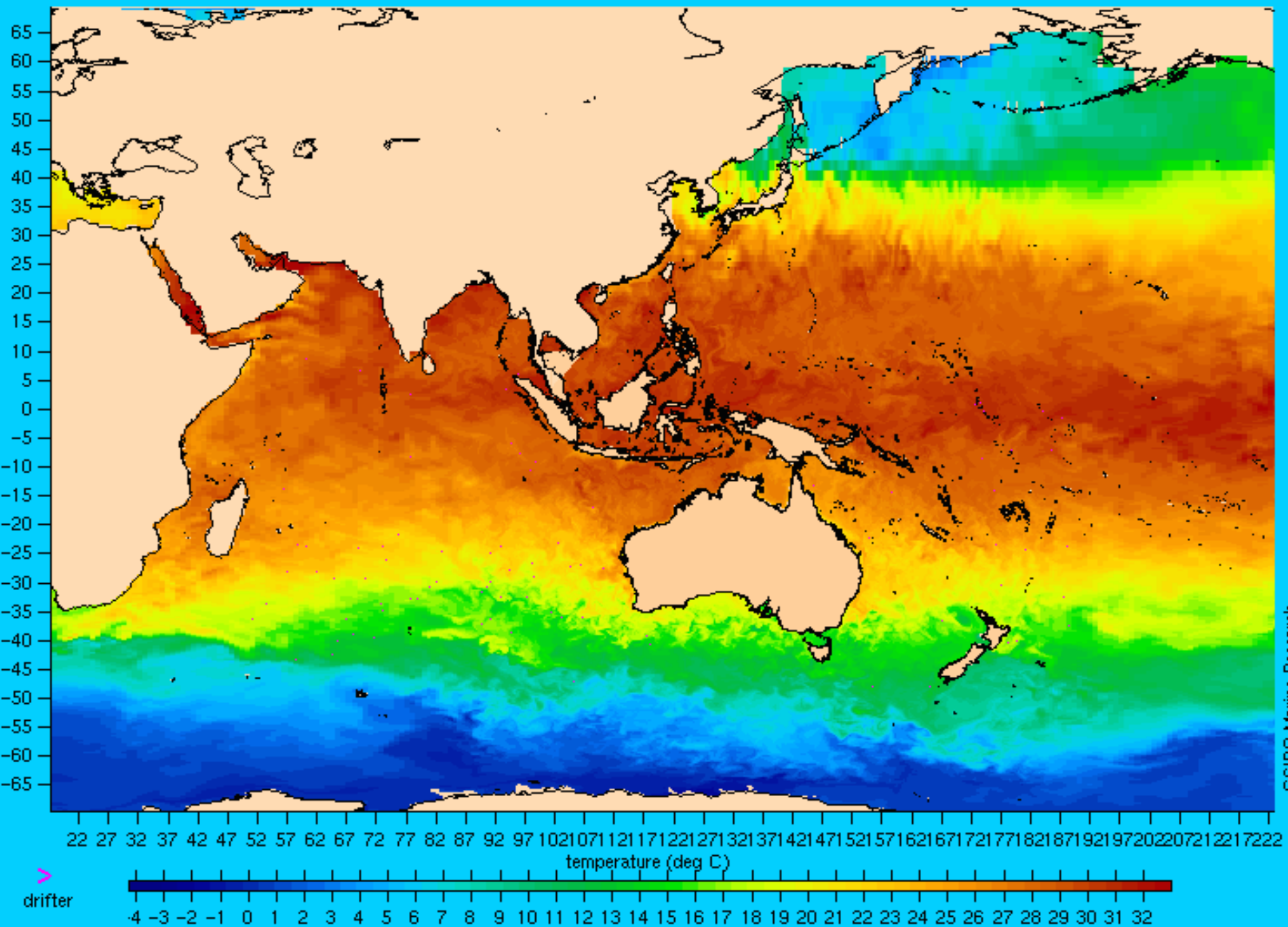
**Strategy for integration and application  
of the diverse data streams**

**Global Ocean Data Assimilation  
Experiment (GODAE)**

- **BlueLink**
- **Simple Ocean Data Assimilation (SODA)**
- **Estimation of Circulation and Climate in the Oceans (ECCO)**



# BRAN SST for 01-Jul-1997



# Summary

**There is an opportunity to enhance IndOOS with biogeochemical measurements**

**Need to know the research issues and develop a detailed implementation plan**

**Some research issues that engage IOP**

- **Intraseasonal—biophysical interactions in mixed layer**
- **Seasonal—role of upwelling and subduction in shallow overturning cells**
- **Interannual—joint impact of ENSO and IOD on biological systems**

**Can SIBER use re-analysis products? How?**

# IOP members—2004-2006

G. Meyers (chair)	CSIRO, Hobart, Australia
P. Hacker	University of Hawaii, Honolulu, USA
Y. Kuroda	JAMSTEC, Yokosuka, Japan
Y. Masumoto	FORSGC, University of Tokyo, Japan
M. McPhaden	NOAA, PMEL, Seattle, USA
R. Molcard	LODYC, Paris, France
M. Ravichandran	INCOIS, Hyderabad, India
F. Schott	IMR, University of Kiel, Germany
S. Shetye	NIO, GOA, India
L. Yu	WHOI, USA
TBN	Indonesia
J. McCreary ( <u>AAMP</u> )	University of Hawaii, Honolulu, USA
C. Reason (VACS)	University of Capetown
B. Tilbrook ( <u>IOCCP</u> )	CSIRO, Hobart, Australia
P. Webster ( <u>AAMP</u> )	GIT, Atlanta, USA

# **New members—2007-2009**

<b>Weidong Yu</b>	<b>FIO, China</b>
<b>Jerome Vialard</b>	<b>LOCEAN, France</b>
<b>VSN Murty</b>	<b>NIO, India</b>
<b>Gabe Vecchi</b>	<b>GFDL, USA</b>
<b>Tony Lee</b>	<b>JPL, USA</b>

**Biogeochemistry link TBN**

**Indonesia rep TBN**