DBCP 29
S&T Workshop

NEW OBSERVATIONS OF SUBSURFACE THERMAL SALINE AND CURRENT STRUCTURE FOR THE ARABIAN SEA FROM OMNI BUOYS

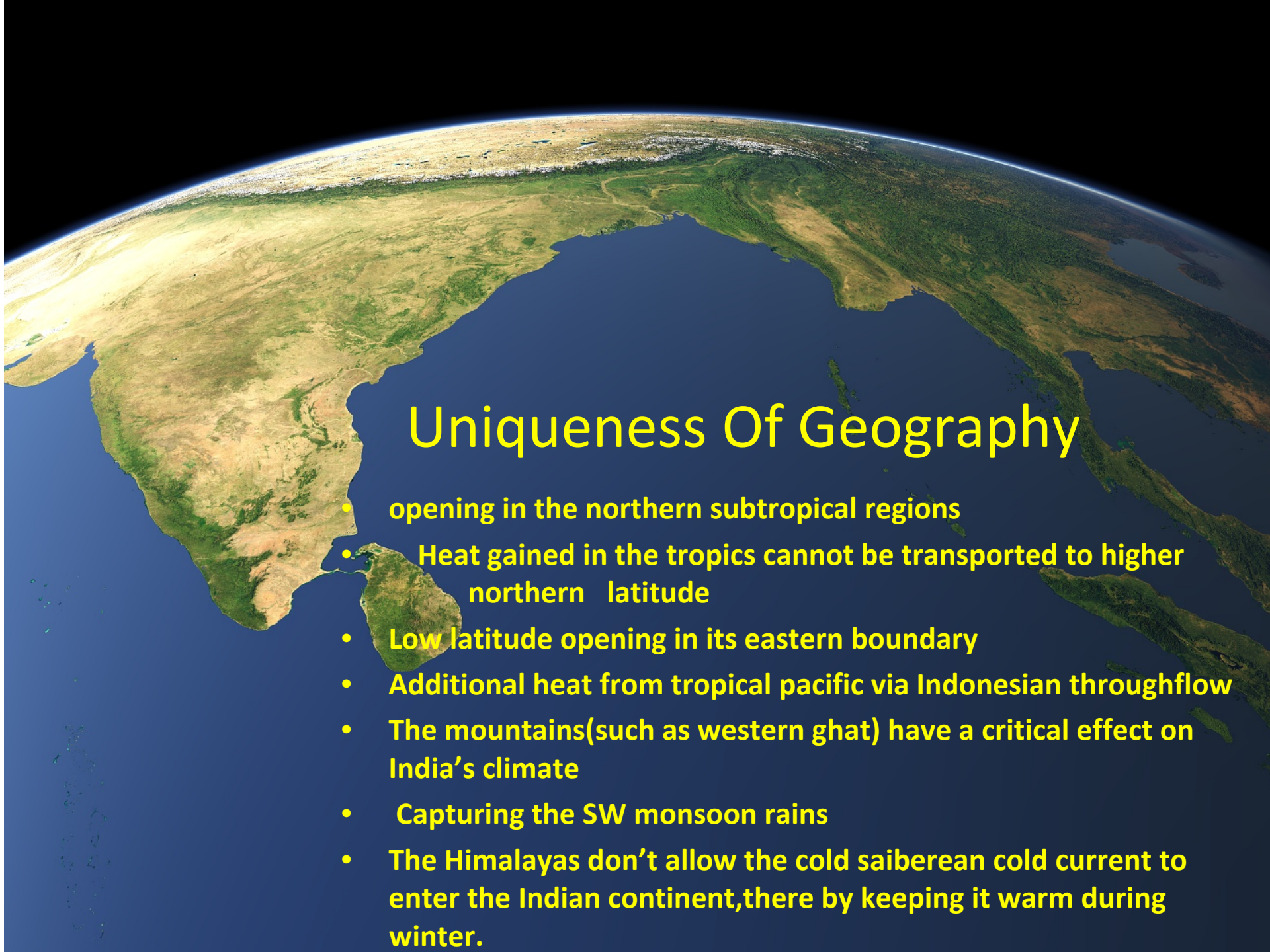
R. Venkatesan, Simi Mathew, Vimala J

ESSO - National Institute of Ocean Technology

Chennai

INDIA

23 September 2013



Uniqueness Of Geography

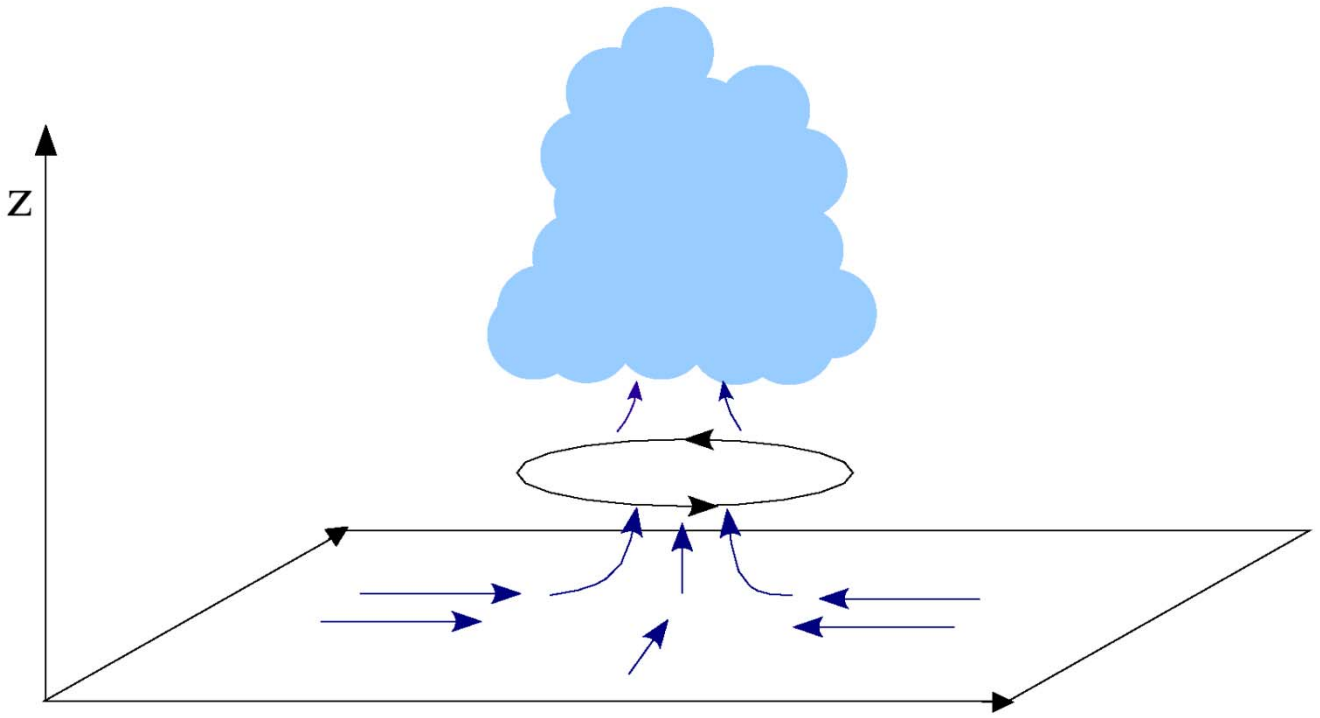
- opening in the northern subtropical regions
- Heat gained in the tropics cannot be transported to higher northern latitude
- Low latitude opening in its eastern boundary
- Additional heat from tropical pacific via Indonesian throughflow
- The mountains(such as western ghat) have a critical effect on India's climate
- Capturing the SW monsoon rains
- The Himalayas don't allow the cold saiberean cold current to enter the Indian continent,there by keeping it warm during winter.

Bay Of Bengal and Arabian Sea:-

- The Indian subcontinent divides the north Indian Ocean into two tropical basins, namely the Arabian Sea and the Bay of Bengal.
- The Arabian Sea has high salinity whereas the salinity of the Bay of Bengal is much lower due to the contrast in freshwater forcing of the two basins.
- The freshwater received by the Bay in large amounts during the summer monsoon through river discharge is flushed out annually by ocean circulation.
- During the pre-monsoon months of February – April, a warm pool, known as the Arabian Sea Mini Warm Pool (ASMWP), which is distinctly warmer than the rest of the Indian Ocean, takes shape. In fact, this is the warmest region in the world oceans during this period.

Continued….

- More cyclones occur in the Bay of Bengal than the Arabian Sea and the ratio is approximately 4:1.
- An analysis of the frequency of cyclones on the east and west coasts of India between 1891 and 1990 shows that nearly 262 cyclones occurred (92 severe) in a 50 km wide strip on the east coast.
- Less severe cyclonic activity has been noticed on the west coast, with 33 cyclones occurring in the same period, out of which 19 of these were severe.
- REASON:- The Bay of Bengal is normally warmer than the Arabian Sea and thus contains more heat energy for Cyclones to grow and maintain themselves.

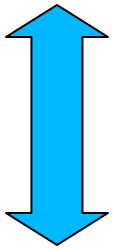


Cyclonic vorticity forced by the Himalayas ⇒ Frictional convergence in planetary boundary layer ⇒ lifting of moist air to the lifting condensation level ⇒ free convection

AIR-SEA INTERACTIONS:-

To Understand these interactions, we must understand;

How Ocean forces Atmospheric motion



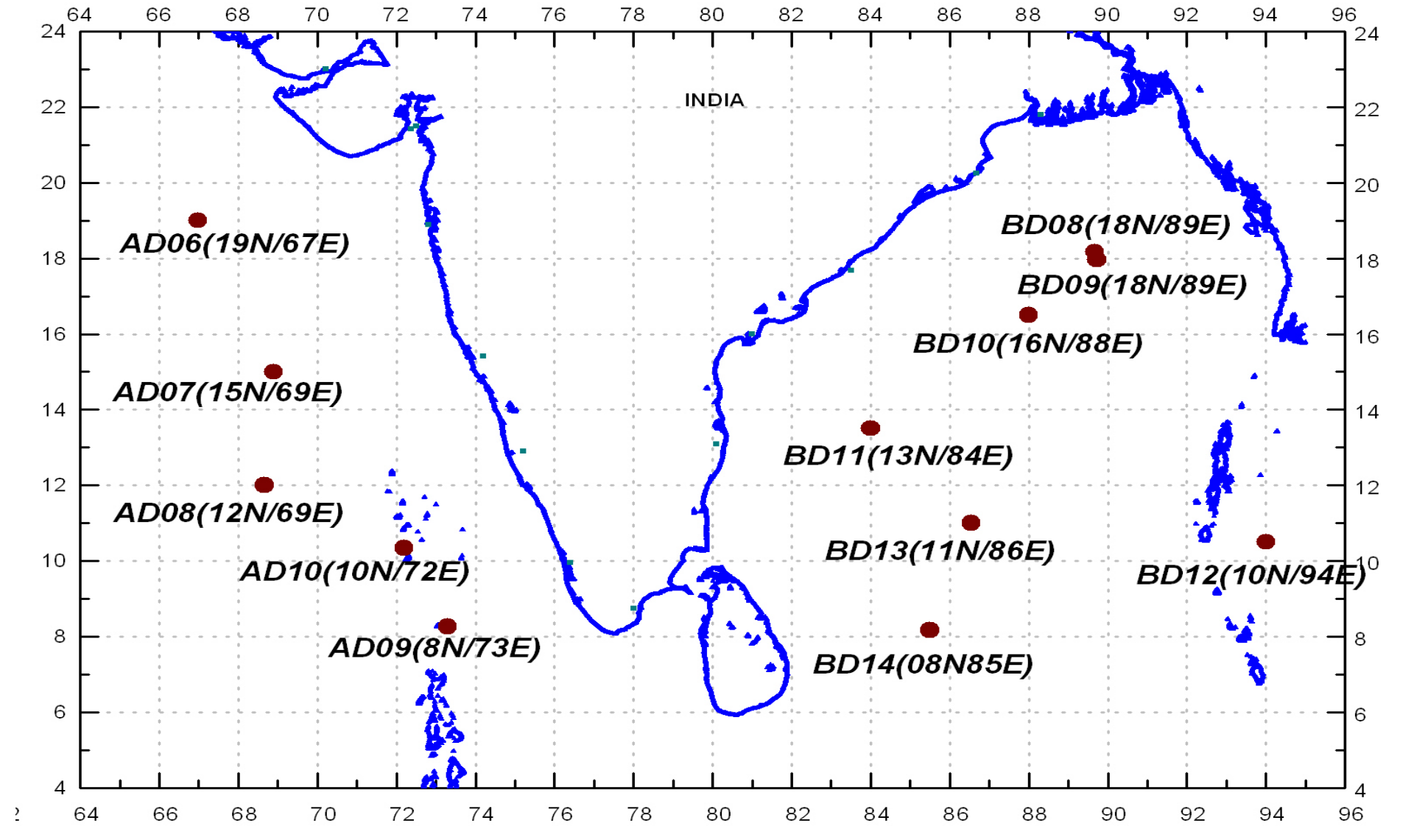
How Atmosphere forces Changes in SST distribution in Ocean

➢ Do we have similar air-sea interaction in the Indian Ocean-monsoon region?

➢a mode of variability in the Indian Ocean, known as the **‘Indian Ocean Dipole Mode’** that involves local air sea interaction similar to ENSO.

(Saji, Goswami, Vinayachandran and Yamagata, 1999, Nature,**401**, 360-363)

Moored Buoys
THE ARABIAN SEA AND BAY OF BENGAL



PARAMETERS

MET

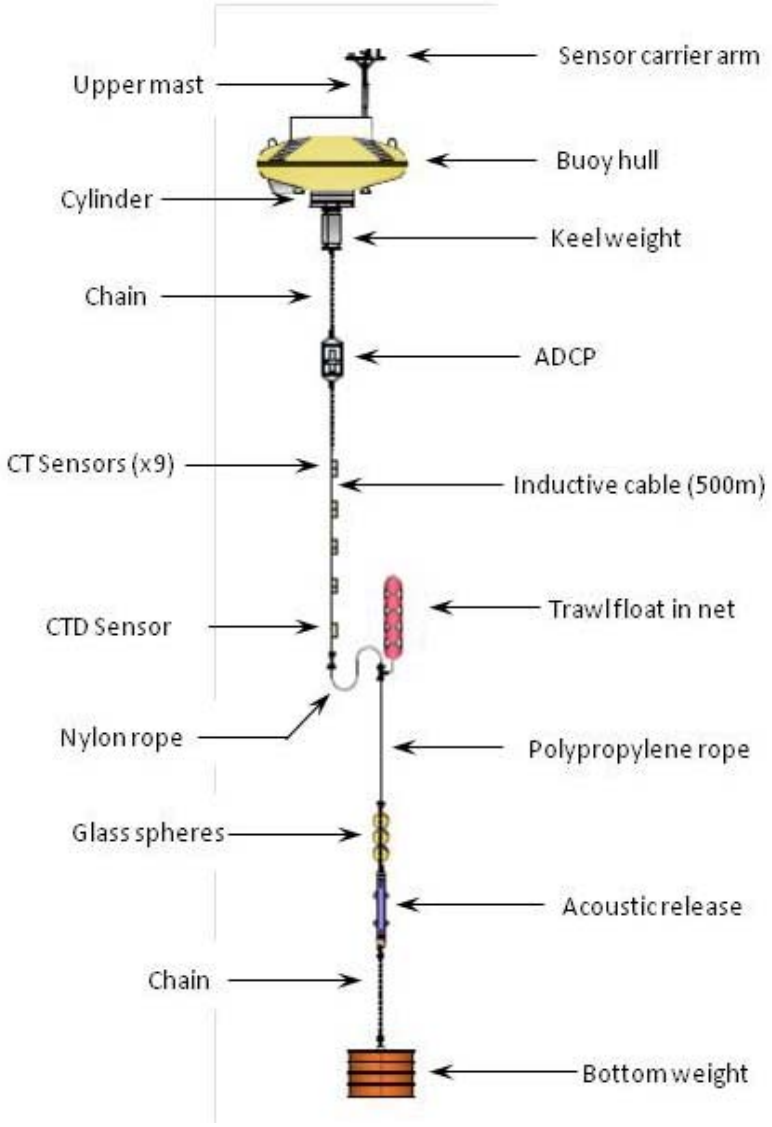
- **Air humidity, press. & temp., Incoming shortwave radiation, Down-welling long-wave radiation, Wind Speed, Gust & Direction**

OCEAN

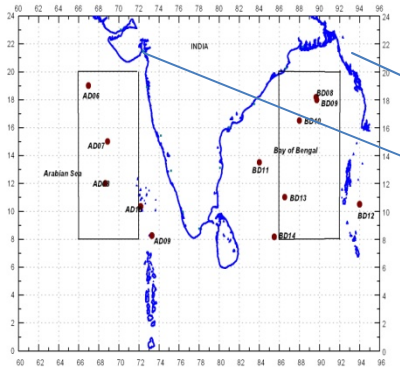
Temperature, Salinity upto 500m & Current (ADCP)

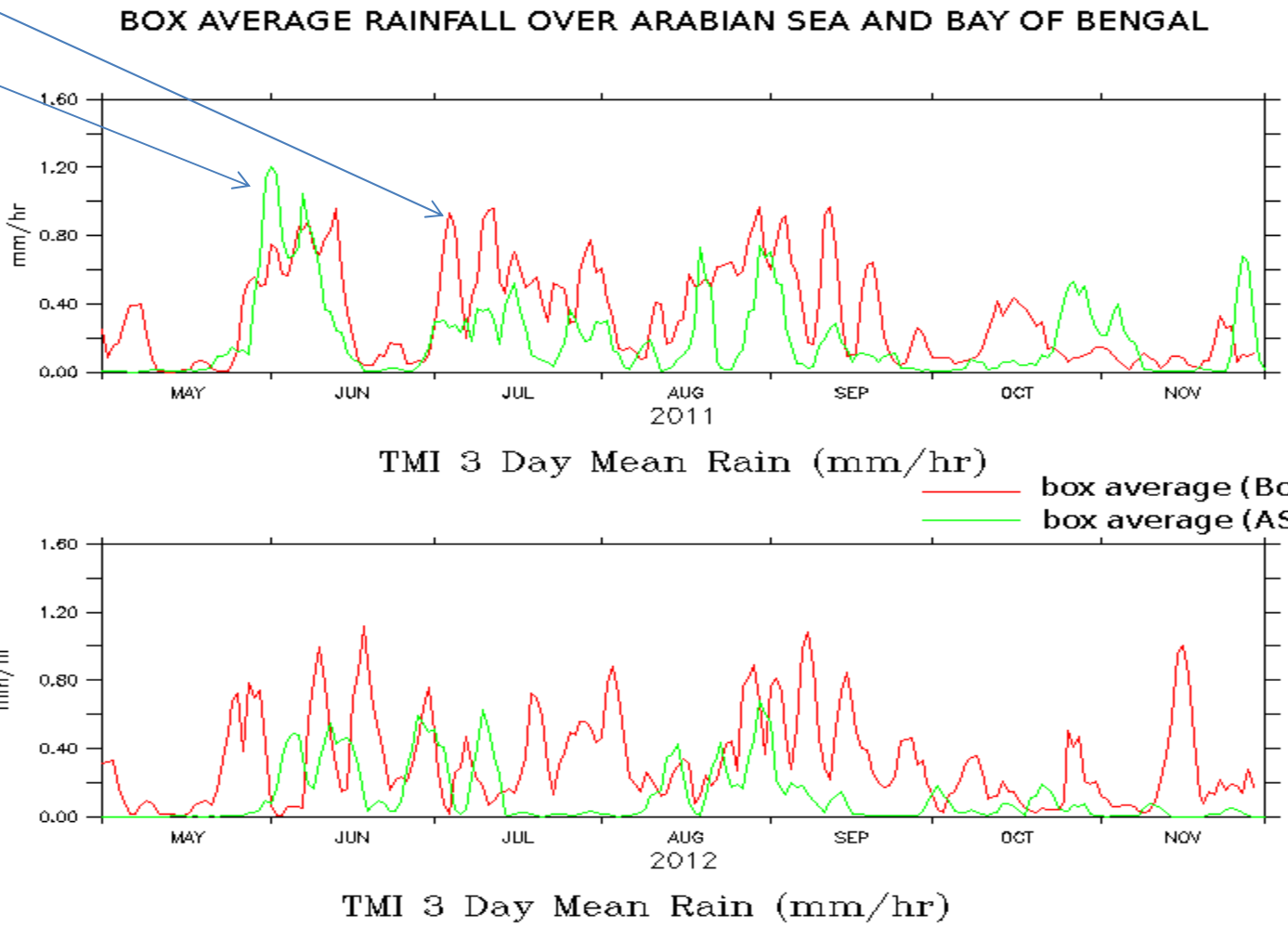
WAVE

Wave height and direction

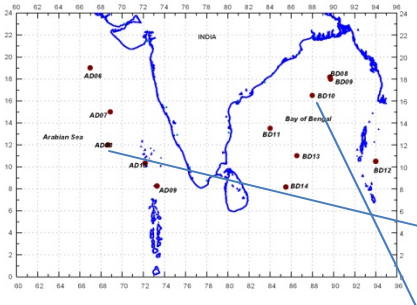


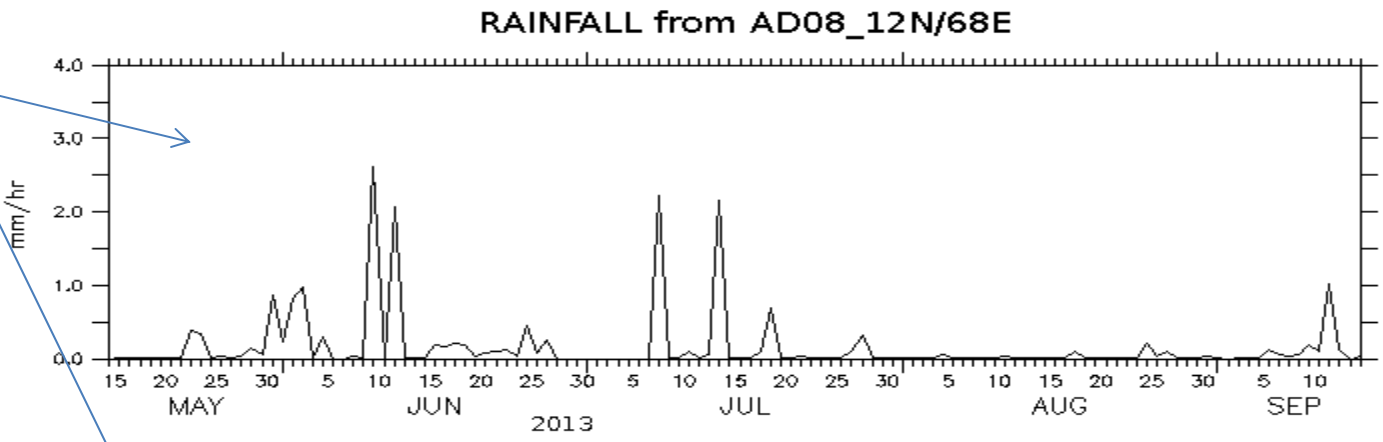
LESS RAINFALL RECEIVED OVER ARABIAN SEA WHEN COMPARED TO BAY OF BENGAL BASED ON 3DAY MEAN TMI DATA

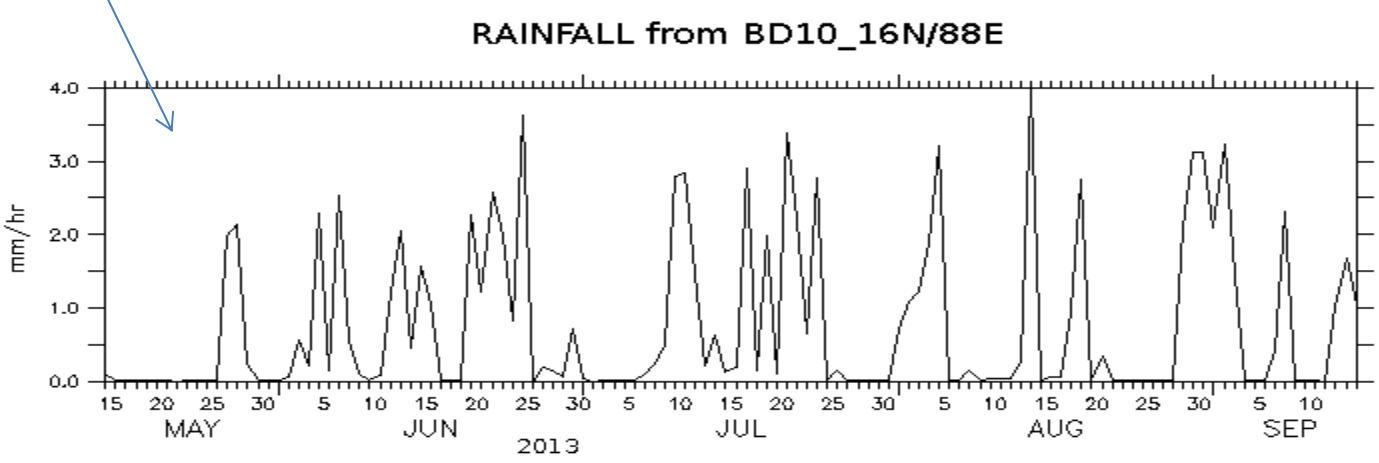




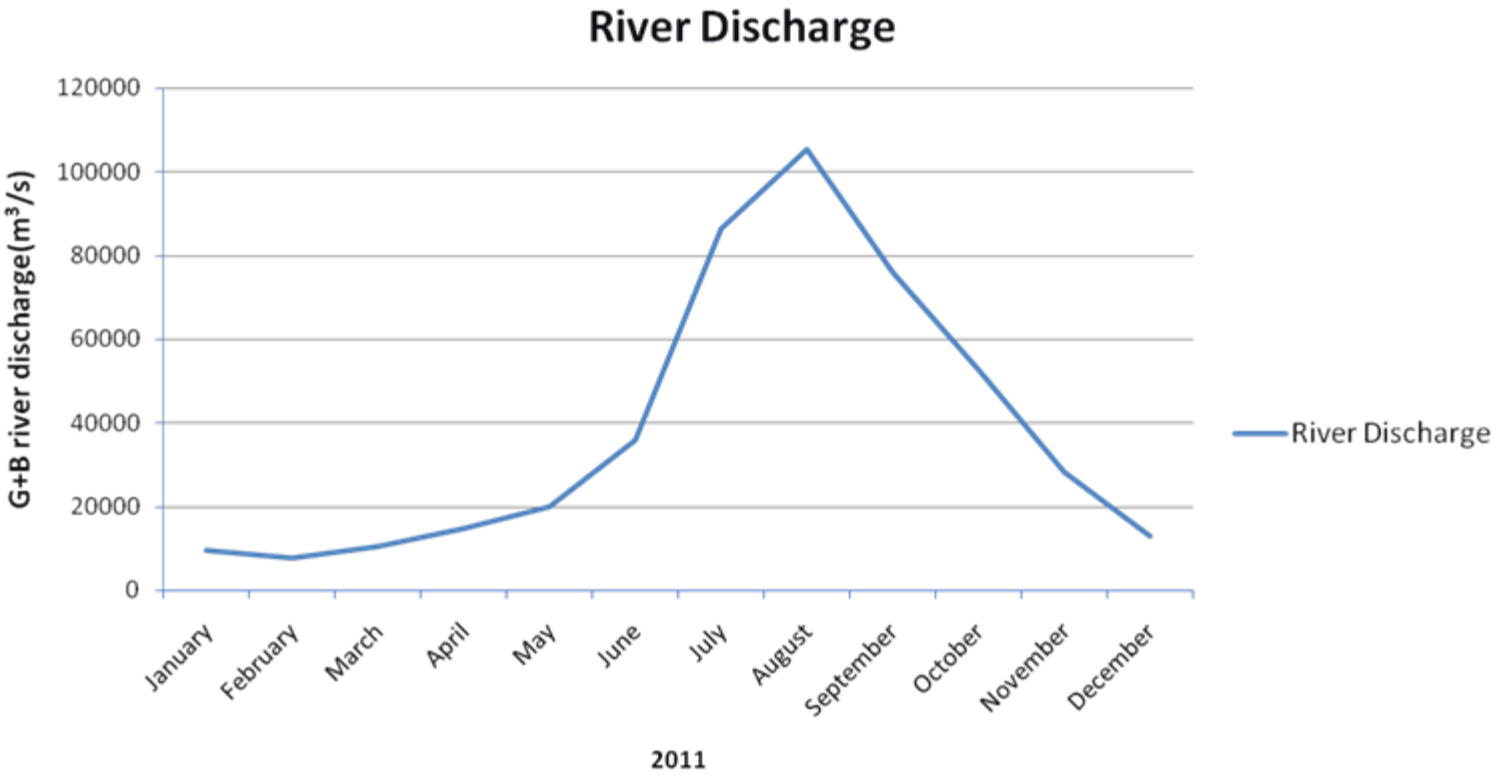
LESS RAINFALL OVER ARABIAN SEA COMPARED TO BAY OF BENGAL BASED ON OMNI BUOY RAINFALL DATA







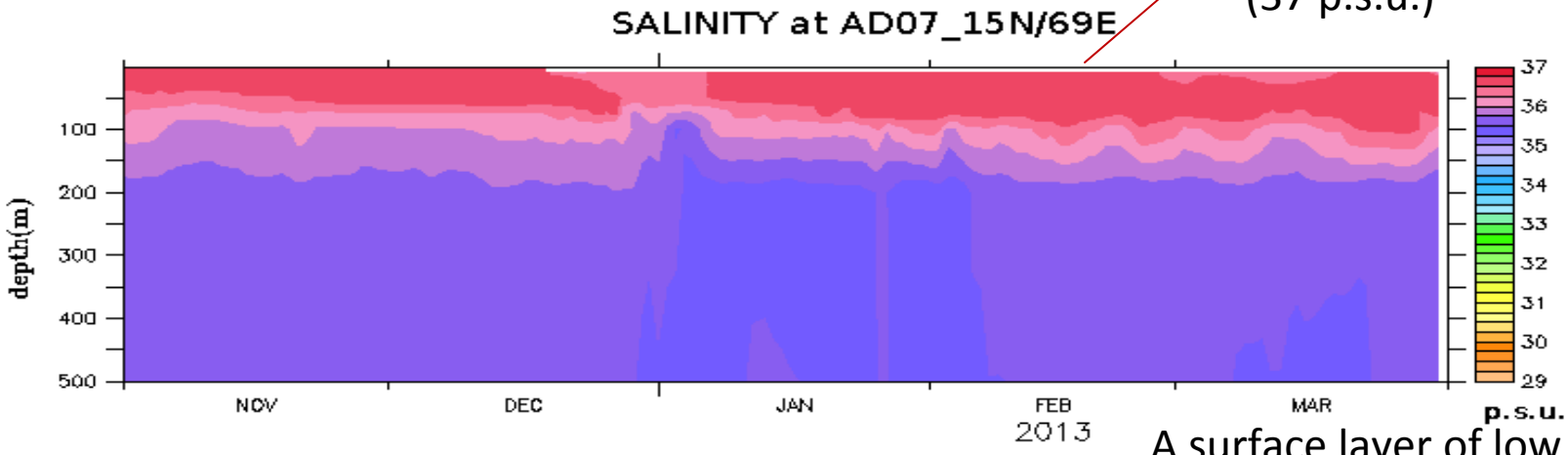
Ganges –Brahmaputra River the third largest freshwater discharge contribute ~25% of freshwater to the Bay of Bengal



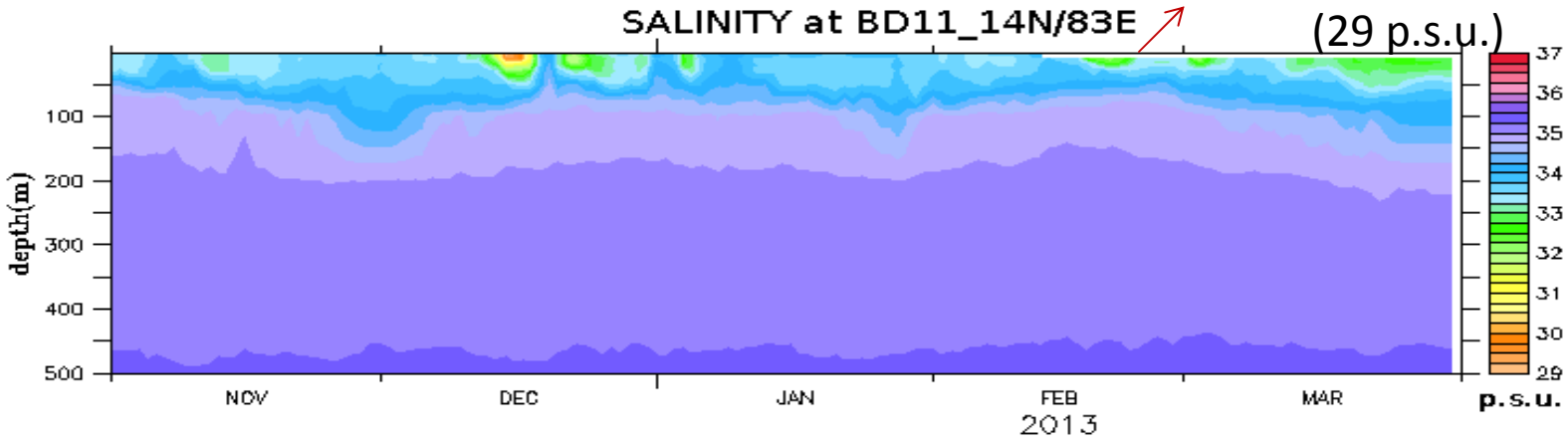
Reference : Fabien Durand et. al. , JGR, Vol. 117, 2012. Ganga-Brahmaputra river discharge from Jason-2 radar altimetry: An update to the long-term satellite-derived estimates of continental freshwater forcing flux into the Bay of Bengal

SALINITY STRUCTURE DIFFERENCE IN THE ARABIAN SEA AND BAY OF BENGAL

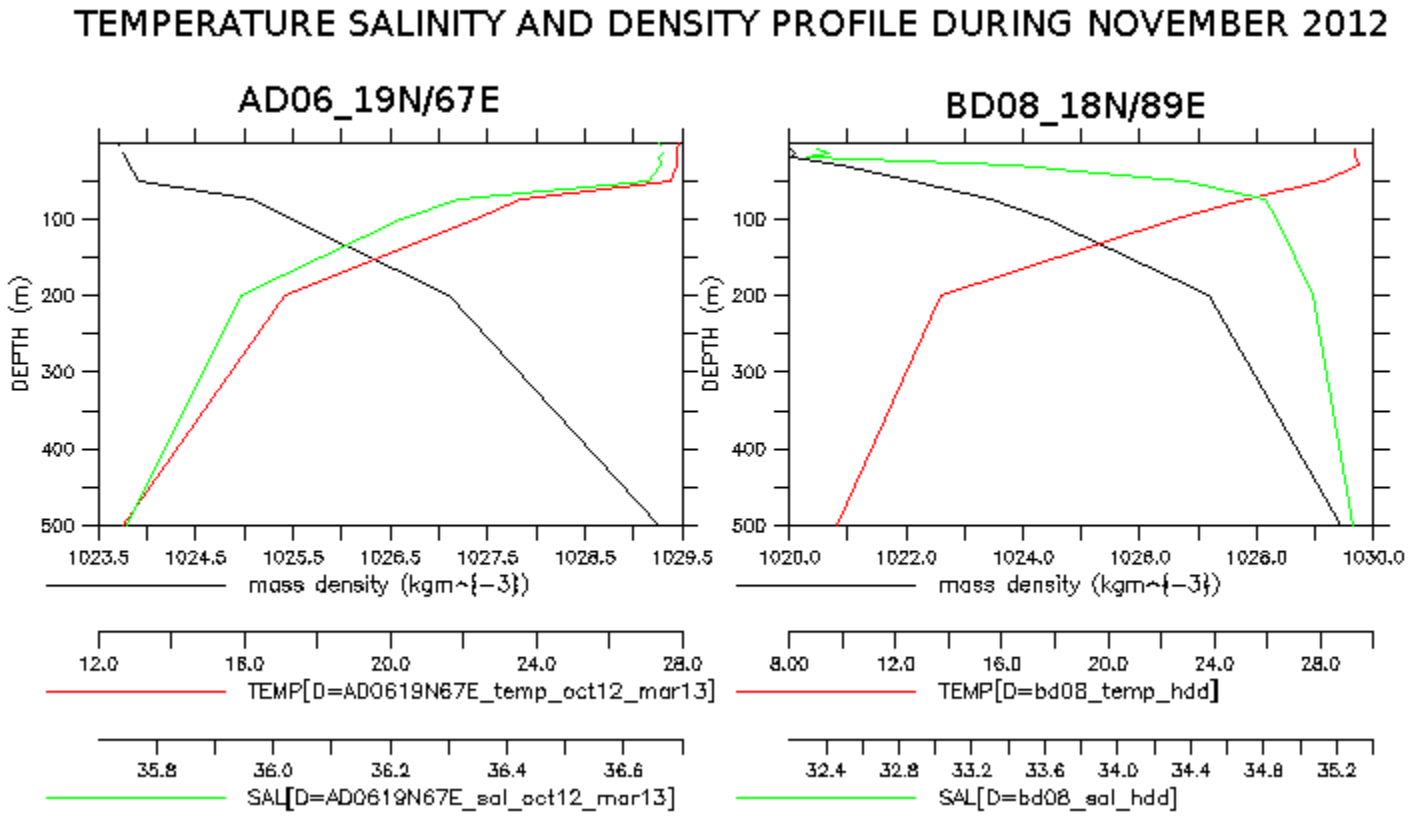
A surface layer of high Salinity in the Arabian Sea (37 p.s.u.)



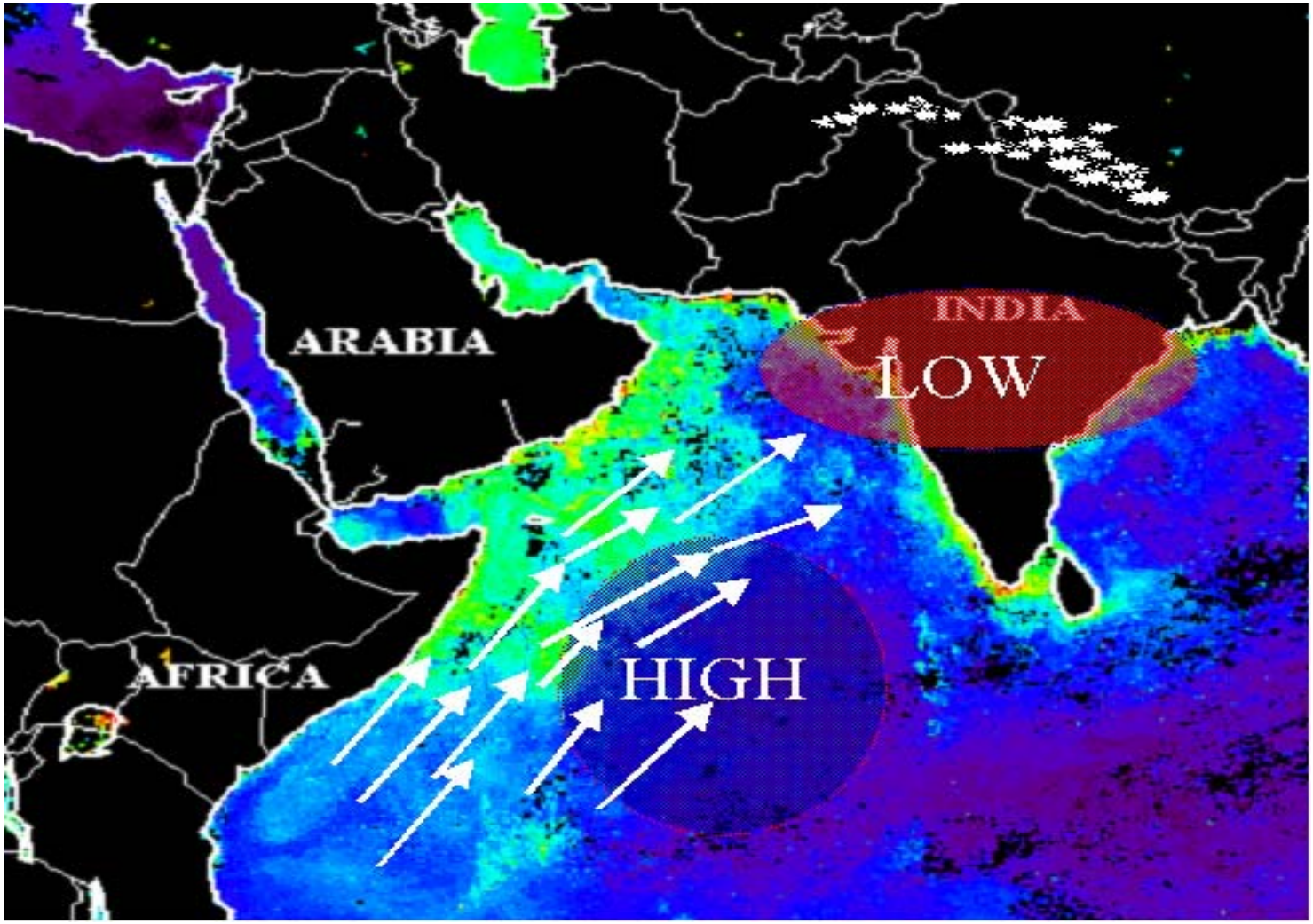
A surface layer of low Salinity in the Bay of Bengal (29 p.s.u.)

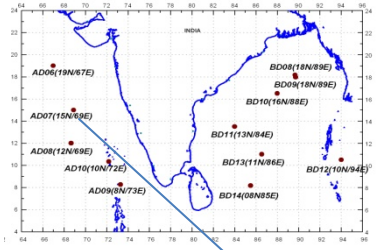


DENSITY OF BAY OF BENGAL WATERS ARE DETERMINED MANILY BY THE SALINITY

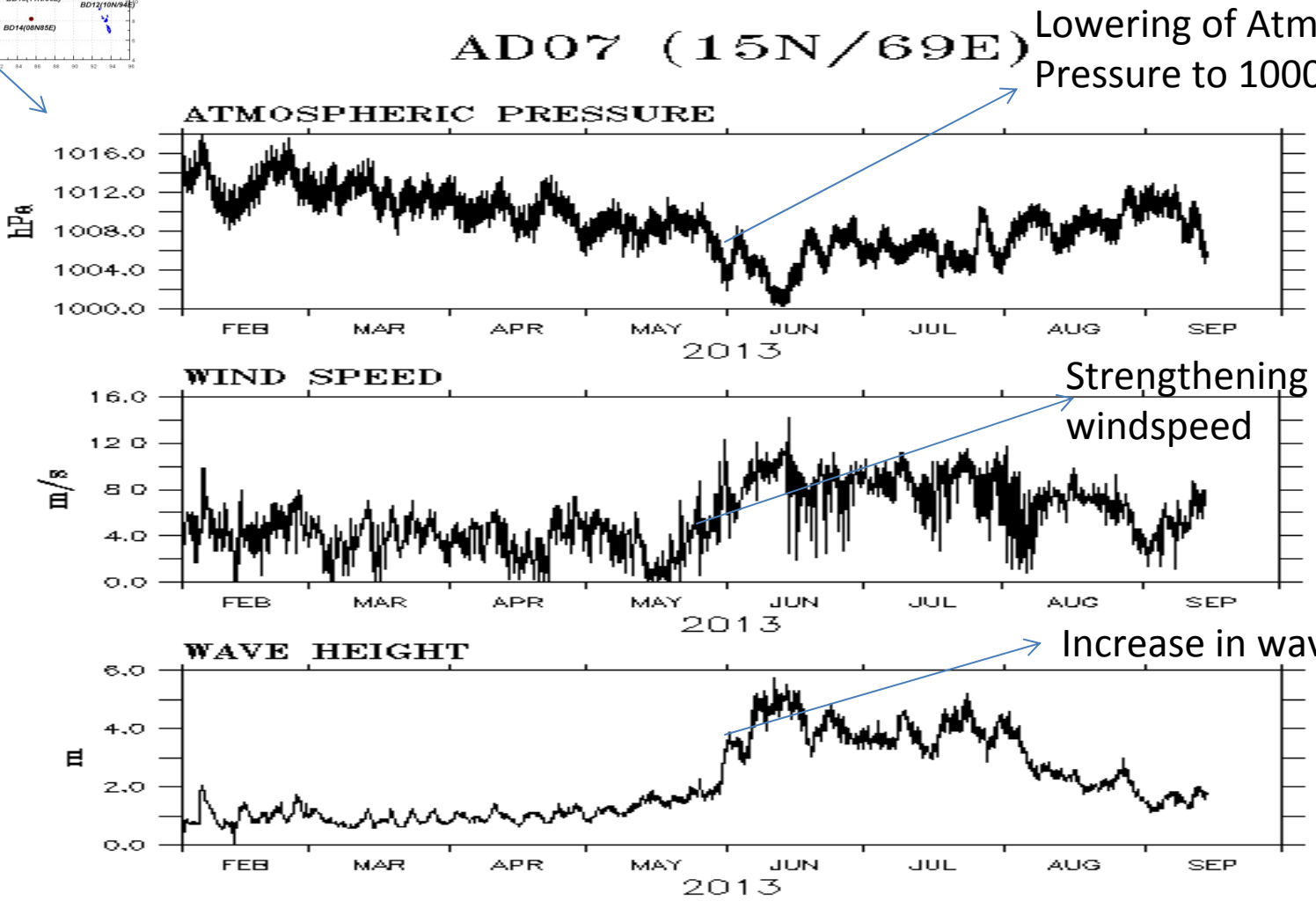


ONSET OF SOUTHWEST MONSOON WITH THE LOW PRESSURE PREVAILING OVER THE NORTHERN INDIA





MONSOON ONSET IN THE ARABAIN SEA

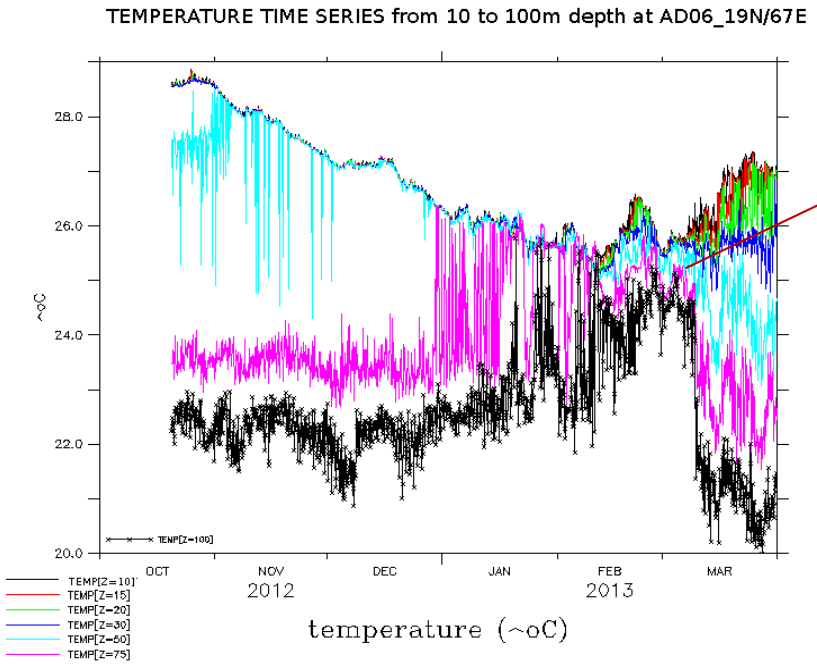


Lowering of Atmospheric Pressure to 1000hPa

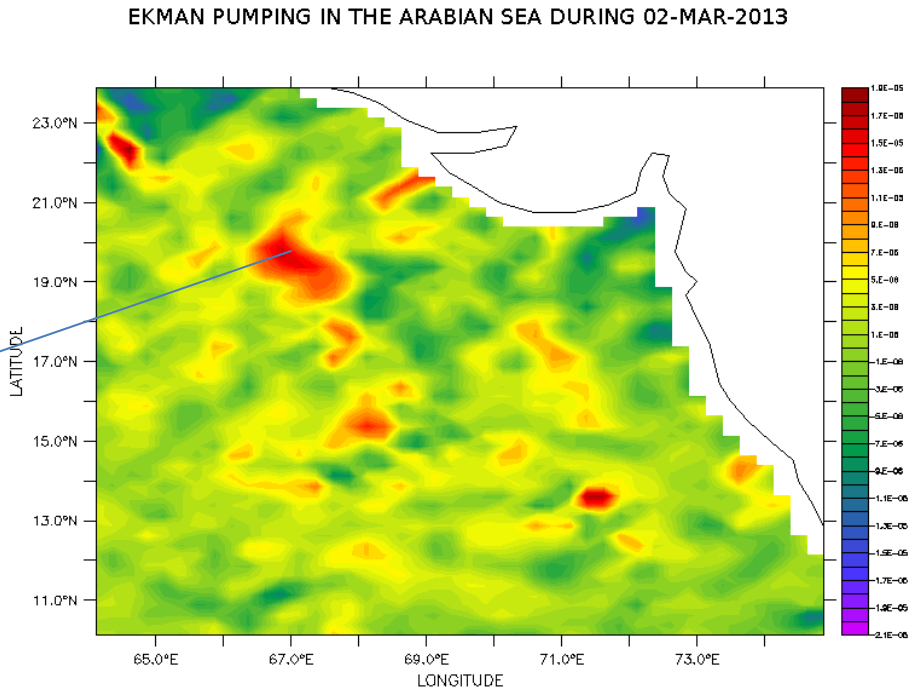
Strengthening of the windspeed

Increase in waveheight

STRONG MIXING IN THE OPEN OCEAN DUE TO WIND DRIVEN UPWELLING IN THE ARABIAN SEA



Strong mixing upto 100m depth which raises the temperature at 100m depth to the surface value.



Strong positive Ekman pumping driven by the divergence in the open ocean.

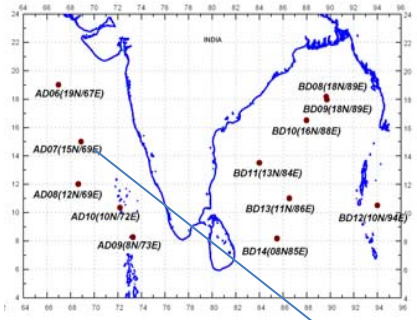
$W_E = 1/\rho f^* (\partial\tau_y/\partial x - \partial\tau_x/\partial y)$

τ is the wind stress term

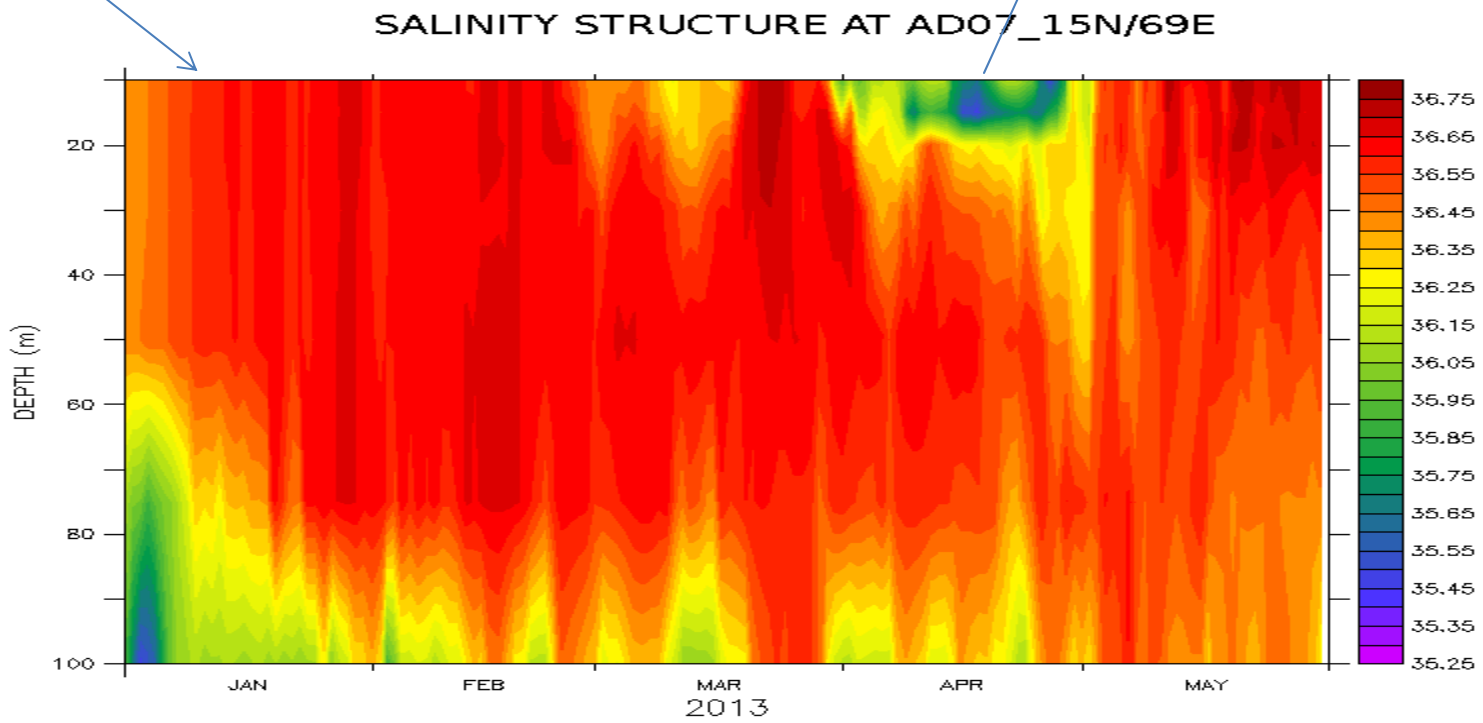
ρ is the density of the sea water

f is the Coriolis parameter

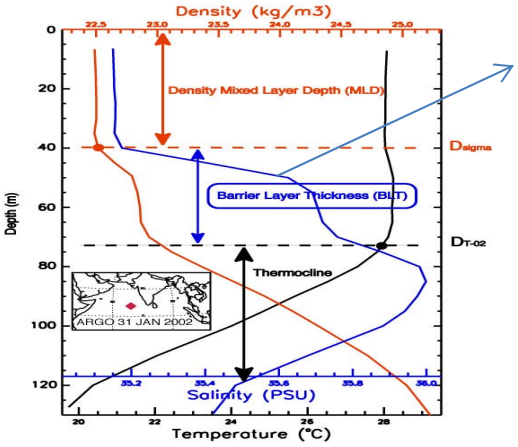
POCKETS OF LOW SALINE WATERS ARE OBSERVED IN THE ARABIAN SEA DURING THE MONTH OF APRIL-2013



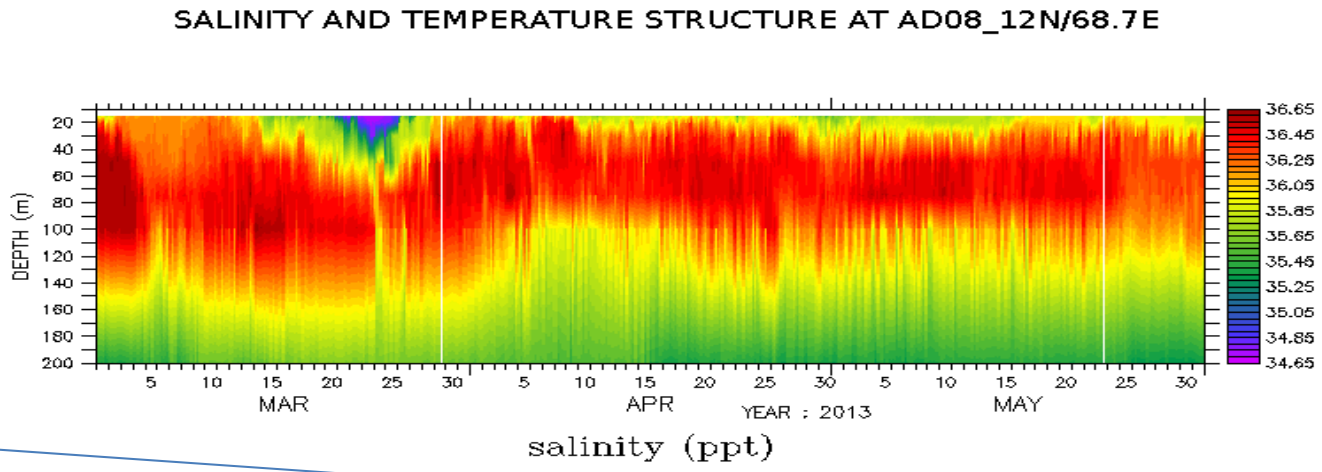
LOW SURFACE SALINE WATERS OF 35.5 p.s.u. OBSERVED IN THE CENTRAL ARABIAN SEA



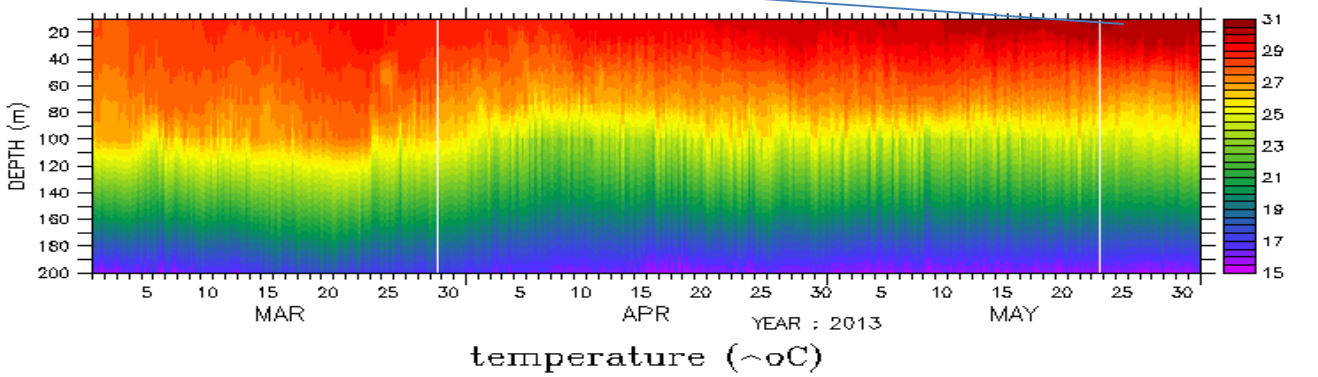
BARRIER LAYER FORMATION DURING THE SUMMER TRANSITION PERIOD (APRIL-MAY) - HIGH SUB-SURFACE SALINE WATERS INDUCED WARMING OF THE SURFACE



Barrier layer - formed by the high sub-surface salinity



Surface temperature Increased upto 31°C



Cyclone Observation by Moored Data Buoys

1.BANGLADESH SEVERE CYCLONE – September 1997
Buoys observed this phenomenon : DS3, DS4, DS5

2. ARABIAN SEA CYCLONE – June 1998
Buoys observed this phenomenon : DS1, DS2, SW1

3. ARABIAN SEA CYCLONE – October 1998
Buoys observed this phenomenon : DS1, SW1

4. BANGLADESH SEVERE CYCLONE – October 1998
Buoys observed this phenomenon : DS3, DS4, DS5

5. Bay of Bengal Cyclone – November 1998
Buoys observed this phenomenon : DS3, DS4, DS5

6. Arabian Sea Cyclone – December 1998
Buoys observed this phenomenon : DS1

7. ARABIAN SEA CYCLONE – May 1999
Buoys observed this phenomenon : DS1, SW1

8. ARABIAN SEA CYCLONE – September 1999
Buoys observed this phenomenon : DS1, SW1

9. ORISSA SUPER CYCLONE – October 1999
Buoys observed this phenomenon : DS3, DS4

10. CYCLONE OVER CENTRAL BAY – October 2000
Buoys observed this phenomenon : DS3, DS4, DS5

11. CYCLONE IN ARABIAN SEA - May 2000
Buoy observed this phenomenon : DS1

12. Bay of Bengal Cyclone – October 2000
Buoys observed this phenomenon : DS3, DS4, DS5

13. CYCLONE IN ARABIAN SEA - May 2001
Buoy observed this phenomenon : DS1

14. BAY OF BENGAL CYCLONE – October 2002
Buoys observed this phenomenon : DS3, DS5

15. BAY OF BENGAL CYCLONE – May 2003
Buoys observed this phenomenon : OB8, MB11, MB12, DS3, DS5

16. BAY OF BENGAL CYCLONE – October 2003
Buoys observed this phenomenon : OB8, MB11, MB12, DS3, DS4,DS5

17. Bay of Bengal Cyclone – December 2003
Buoys observed this phenomenon : OB8, MB11, MB12, DS3, DS4,DS5

18. CYCLONE IN ARABIAN SEA - May 2004
Buoy observed this phenomenon :
DS1,DS2,DS7,OB3,SW2,SW3,SW4,MB1

19. Bay of Bengal Cyclone – April 2006
Buoys observed this phenomenon : MB10, MB12, OB8,DS5

20. Bay of Bengal Cyclone – May 2007
Buoys observed this phenomenon : MB12, DS4,DS5

21. Bay of Bengal Cyclone – November 2007
Buoys observed this phenomenon : DS4,DS5

22. Bay of Bengal Cyclone – May 2009
Buoys observed this phenomenon : OB10,OB12

23. Bay of Bengal Cyclone – November 2010
Buoys observed this phenomenon : BD06, BD13,BD14

24. Bay of Bengal Cyclone – December 2011
Buoys observed this phenomenon :BD02, BD08, BD10, BD11, BD13

25. Bay of Bengal Cyclone – May 2013
Buoys observed this phenomenon : BD08, BD09, BD10, BD11, BD13, BD14

CONCLUDING REMARKS

- The uninterrupted sea truth data from moored Buoys from the Arabian Sea is very helpful to study the onset of monsoon.
- The strong wind forced mixing which induces strong mixing in the open ocean helps to mix the waters deep upto 100m depth.
- Pockets of low saline waters is also observed in the Arabian Sea during the pre-monsoon period.