Atmosphere-Ocean Interactions in Equatorial and Northern Indian Ocean

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ASIRI-EBOB (Sri Lanka)

Sri Lanka

- NARA - National Aquatic Resources Research and Development Agency (VMP/CTD/ADCP)
- University of Sri Jayewardenepura through a (future cooperation)

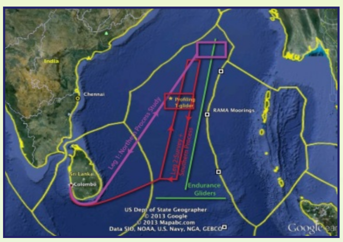
USA

- University of Notre Dame (VMP/CTD/ADCP)
- Naval Research Laboratory (ScanFish moorings)
- University of Washington (gliders)
- Scripps (drifters)

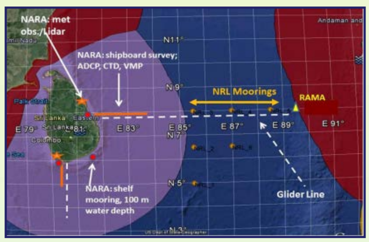
Abstract. The equatorial Indian Ocean is considered a hot spot of Earth's weather and climate variability. On the sub-seasonal scale, the active and break phases of South Asian monsoons trigger significant response in both the atmospheric and oceanic sides. It is hypothesized that episodic energetic small-scale atmospheric events (convection and turbulent entrainment) can be linked to larger scale phenomena such as the Madden Julian Oscillations and planetary (Kelvin-Rossby) waves. The smaller scale processes in turn have feedback on larger scale patterns of circulation through air-sea interaction. To study intra-seasonal phenomena, a measurement program has been initiated at eastern atolls of Seychelles, in Sri Lanka and Singapore, spanning time scales from minutes to months.

The aim is to (i) capture eastward and northeastward propagating disturbances over one year using profiles of moisture and velocity, (ii) observe entrainment of upper air into the marine boundary layer using LiDAR and ground (tower) based measurements, and (iii) delineate the role of small-scale atmospheric processes in determining air-sea property exchanges. Data of international observational networks as well as simulations of the WRF model will augment the analyses. This study, which is implemented under the ONR umbrella, is a part of a larger project Air Sea Interaction in the Northern Indian Ocean (ASIRI), the oceanographic part of which started in the Bay of Bengal and around Sri Lanka in 2013.

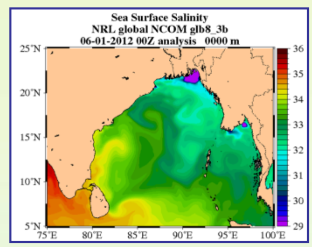
The first outcome related to ocean mixing and associated processes is presented. The project has an outreach component, wherein governmental and non-governmental organizations as well as universities from Sri Lanka, Seychelles and Singapore are participated in observations and analysis.

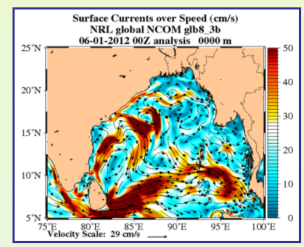


Process oriented surveys were taken in the central and northern BoB (eddies, frontal zones, plumes, filaments, internal waves, turbulence) in Fall of 2013 and Summer of 2014.



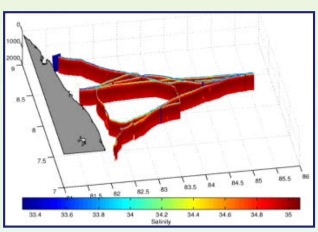
A year and a half (2013-2015) mooring measurements in the southern BoB plus mesoscale CTD/ADCP transects in the area and across the East-Indian Coastal Current (water exchange between the BoB and Arabian Sea, internal waves, mixing).



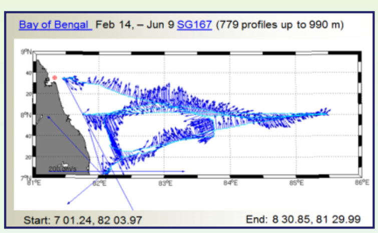


Simulation of the mesoscale dynamics in the Bay of Bengal affected by monsoon circulation (Tommy Jensen, NRL).

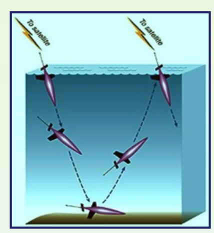
Examples of the Seaglider sections
(Craig Lee, University of Washington)



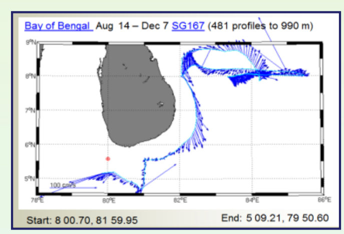
Salinity



Currents



Operation



Currents

Small-Scale Dynamics in the BoB

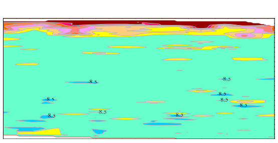
Under moderate (11 - 12 m/s) winds, well-mixed turbulent surface layer (SL), was effectively detached from the underlying thermohalocline due to very strong salinity stratification. The dissipation rate in the SL, $\varepsilon = 10^{-6} - 10^{-8}$ W/kg, gradually decreased from the sea surface. Below the SL, the dissipation rate sharply dropped to less than ~10^{-9} W/kg, remaining approximately constant downward. The horizontal/ temporal differences of *T*, *S* and σ_T in the middle of SL were as high as *dT* ~ 0.25 C, *dS* ~ 0.4 psu, and $d\sigma_T$ ~ 0.22 over a distance of ~ 2 km (*left panel*)

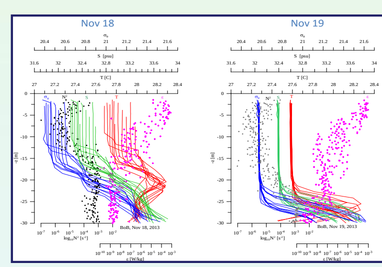
Under higher winds (16 - 18 m/s), the SL deepened only slightly, being nominally decoupled from the pycnocline. Several short periods of the intensification of wind stress from ~ 0.15 to ~ 0.5 N/m^2, led to an increase of ε to $10^{-6} - 10^{-7}$ W/kg in the lower part of the mixing layer presumably due to shear-induced turbulence. The enhanced turbulence not only produced vertical mixing, but also initiated horizontal stirring, thus dramatically reducing thermohaline differences in the mixed SL down to *dT* ~ 0.017C, *dS* ~ 0.02 psu, and $d\sigma_T$ ~ 0.008, respectively. However, very strong stratification in the pycnocline suppressed the wind-induced vertical mixing, which did not penetrate below *z* ~ 22 - 25 m (*right panel*).

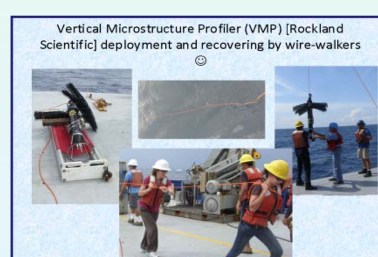
Near-surface turbulence of this genre, which produces weakly-penetrative vertical mixing but effective horizontal stirring could be a characteristic feature of the BoB dynamics in the regions away from strong local frontal zones.

No internal sources of turbulence were evident in the water interior. Internal wave radiation and internal wave breaking below the pycnocline appear to be mostly damped by local dynamics. Rare patches of low Richardson number were detected.

It is likely that under mild or even relatively strong but short-sustained winds small-scale dynamics of the SL and that of the pycnocline do not interact with each other.







The VMP profiling and a "wire-walkers" recovery ☺

Acknowledgement

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