Air-sea Interaction Regional Initiative in the Northern Indian Ocean
1.5 billion people depend on the Monsoon water, food, economy

The world’s largest populations lie astride the Bay of Bengal

Source: Twisted sifter
- Seasonal wind reversal changes circulation
- Extremely fresh
- Highly stratified, poorly ventilated
- Warm surface - SST responds quickly
- Air-sea fluxes <-> FW runoff
- Oxygen minimum zone

Bay of Bengal - anomalous ocean

Surface salinity from the Aquarius satellite - Jan 2012

Temperature- mooring 18N. courtesy D. Sengupta

Salinity
A challenge for prediction

Climate models (dry bias)

Monsoon ISV - “active-break”

Ocean models - Surface too cool
Intra-seasonal variability
Large uncertainty in air-sea fluxes - differences amongst flux products

Mean net surface heat flux (1988-2000)
Improve monsoonal prediction on sub-seasonal time scales through a better understanding of the upper ocean structure, processes, and ocean-atmosphere exchange.
Building a Partnership

Starting with a steering committee - 2010 August, white paper, Exploratory meetings with Indian & Sri Lankan Institutions / Ministries


Cruises:
- Nov-Dec 2013 R/V Roger Revelle - 2 Legs from Colombo, Sri Lanka
- Dec 2013 Sagar Nidhi from Chennai
- June 2014 R/V Revelle - from Chennai
- August 2014 Sagar Nidhi
- Oct/Nov 2014 Sagar Nidhi - mooring deployment

Summer school in India
- 2014 July

Institutions
- IITM Pune
- INCOIS Hyderabad
- IISc Bangalore
- NIOT Chennai
- NIO Goa
- ISRO Ahmedabad
- NARA- Colombo

National Monsoon Mission

Indian Ministry of Earth Sciences

ASIRI

Sri Lanka

Building a Partnership

Indian Ministry of Earth Sciences

National Monsoon Mission

ASIRI

Sri Lanka
What sort of program?

Improve monsoonal prediction on sub-seasonal time scales

Modeling and Prediction
- Coupled models
- Assimilation

Improve representation of
- Boundary layers
- Air-sea fluxes
- Subgrid processes

Parameterize processes and fluxes

Observations
- Buoys, floats, gliders, drifters, optics, satellite
- Measurements - structure, fluxes, phenomena

Process Studies
- Modeling and analysis
- Interpret observations
- Explore parameter dependence

ASIRI
Questions

Air-sea fluxes of heat, moisture and momentum
Quantify, test and refine parameterizations

Controls on surface temperature
Responds rapidly to incoming solar radiation.

Upper ocean stratification, freshwater, its dispersal
How is surface freshwater entering the northern bay get dispersed?

Autonomous assets
- gliders, floats, drifters

Satellite products
- SSH, SSS, SST, wind, fluxes

Research cruises
- uCTD, wire-walkers, optics, radiometry

Modeling
- regional and process models

Moored Observatory
- Air-sea fluxes & ocean structure time series
Surface Salinity (Aquarius)

Challenges
- Salinity controls surface density - influenced by FW discharge
- Country EEZs
- Access
- Sharing of data

NCOM simulated
Surface Salinity (30 Oct 2009)
from Tommy Jensen, NRL
Research Cruises

R/V Roger Revelle 83.5m, 3180 tons

R/V Sagar Nidhi 103.6m, GRT 4862 Mt

- UCTD survey
- ADCP
- Turbulence glider
- Temperature microstructure
- Gliders
- Radiometry/ IOP
- Wire walker
Salinity as measured in November 2013
Process Study Ocean Model shows submesoscale eddies and filaments that contribute to lateral and vertical dispersal of fresh water.
Surface meteorology every minute.

Direct covariance flux.

Bay of Bengal - Air sea flux

Controls on SST: Solar input

Measure: Light, attenuation, properties
- Spectrally-resolved radiometry
- Inherent optical properties of water - Absorption, scattering
- Constituents of water - dissolved, particulate organic matter

Improve estimates of A-S flux
Test bulk formulae

Surface meteorology every minute
Direct covariance flux.
Expected Outcomes

Long term observatory

- Air-sea flux measurements + solar input
- Test bulk formulae, improve models
- Upper ocean vertical structure

Measure mixing rates

- Relate to air-sea fluxes and stratification
- Test and improve parametrizations
- Improve upper ocean vertical structure in models

Process modeling

- Understand freshwater dispersal mechanisms
- Understand mixing processes
- Estimate advection - test for seasonal variations
Expected Outcomes

Partnership

Training and Education

• New generation of oceanographers in India
• Use of new instrumentation
• Building a sustainable observation program

• Scientific collaboration  > 10 years
• Cooperation on instrumenting the ocean
• Bay of Bengal observatory
Summary

Monsoons an ocean-atmosphere climate phenomenon of high societal relevance. Needing our community’s attention.

Large uncertainty in forecast — variability on sub-seasonal time scales and regional spatial scales not captured by models.

Northern Indian Ocean - unique region - strong freshwater influence, poorly ventilated to the north.

Specific questions being addressed through ASIRI:

• Atmospheric convection occurs over the ocean - Strong air-sea interaction - air-sea fluxes?
• Controls on SST?
• Surface freshwater dispersal and stratification?

Objective: Improve understanding and forecasting of the monsoons.