Impact of Horizontal Salinity Gradients on the Bay of Bengal Circulation & Mesoscale Variability

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Related talks by Akhil V P (Jerome Vialard, 6th 16.00) & A V S Chaitanya (8th 15.30)
Bay of Bengal (BoB) – One of the freshest region in the tropical Ocean.
Seasonally reversing monsoon drives the climate of the northern Indian Ocean.

**Summer Monsoon**
- Strong southwesterly winds.
- Heavy rainfall.

**Winter Monsoon**
- Cold dry northeasterly winds.
- Less rainfall.
Introduction

Monsoon (Shenoi et al., 2002)
Cyclones (Sengupta et al., 2008)
Productivity (Prasannakumar et al., 2002)

Strong surface freshening
Stable stratification
inhibits vertical mixing

Rainfall and runoffs during monsoon

[taken from Chaitanya et al., 2014]
Previous studies described the effect of salinity on vertical mixing.

But not its potential effect on pressure gradient.
Seasonally reversing monsoon winds force seasonally reversing circulation.

- **Major current in BoB**: East Indian Coastal Current (EICC)
- **EICC** – seasonally reversing western boundary current
  - **Pre Monsson**: EICC flows northward.
  - **Post Monsoon**: EICC flows southward.
Ganges freshwater input

- Coastally trapped
- Flows southward during post monsoon
- Carries Ganges fresh water southward
- Drives strong salinity gradients (e.g. Chaitanya et al. 2014; Akhil et al. 2014)
Strong salinity gradients (e.g. Chaitanya et al. 2014; Akhil et al. 2014)
Introduction

- Observational study revealed a narrow (50-100 km wide) freshening along the coast of India – ‘river in the sea’– in agreement with the model result.

- Strong salinity gradients (e.g. Chaitanya et al. 2014; Akhil et al. 2014)
Question: Contribution of horizontal salinity gradient to the EICC?

- Strong salinity gradients (e.g. Chaitanya et al. 2014; Akhil et al. 2014)
Data & Methods

Model: NEMO OGCM

(1/4°) regional BoB configuration
Interannual rain (GPCP) & satellite-derived runoffs (following Papa et al. [2012])
No relaxation to SSS climatology.

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<th>Exp</th>
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<td>REF</td>
<td>Control Experiment</td>
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<td>NOS</td>
<td>No salinity effect in pressure gradient</td>
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REF-NOS = Effect of salinity on pressure gradient

Observations:

SMOS : SSS climatology
GECKO : SL & surface current climatology
Captures EICC seasonality (southward during post monsoon – OND; Northward in pre-monsoon – FMA)

Captures surface salinity seasonality (expands southward along east coast of India during post monsoon-OND; salty during pre-monsoon-FMA)
Freshening occurs simultaneously with EICC reversal to southward current

- Model accurately represents the seasonal reversal of both SSS & surface current
Surface current & SSS along the east coast of India

Model Validation

- EICC largely geostrophic
Results

Effect of horizontal salinity gradient on EICC

Salinity gradients contribute significantly to southward EICC in boreal fall (post-monsoon)

Figure: map of SL anomaly (color) & surface currents (vectors) during OND.
Salinity-induced gradients reduce the EICC intensity by up to 10–20 cm/s, i.e. ≈40% during Oct–Dec
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Results

- Salinity-induced gradients reduce the EICC intensity by up to 10–20 cm/s, i.e. ≈40% during Oct-Dec

- EICC decrease is largely geostrophic (i.e. associated with salinity-driven pressure force)
Results

Impact of horizontal salinity gradient on EICC

- Salinity gradients contribute to ~40% of the EICC intensity.
Impact of horizontal salinity gradient on Eddies

- Large number of Eddies in BoB (Chelton et al., 2011)
- Maximum eddy variability is along the western BoB (Chelton et al., 2011)

- Observation (Gecko – SL) also shows similar result
Impact of horizontal salinity gradient on Eddies

Generating mechanisms of eddies

- Barotropic instability (favoured by strong horizontal shear)
- Baroclinic instability (favoured by strong baroclinic pressure gradients)

Salinity:
- River in the sea strongly stratified: strong baroclinicity
- Salinity contributes to eddies amplitude?
Results

Impact of horizontal salinity gradient on Eddies

Figure: STD of SL anomalies

- Model reproduces (underestimates) eddy variability in the western BoB (near the EICC)

- Neglecting salinity gradients drive a \( \approx 30\% \) reduction in eddy variability in this region

- Mechanism: reduction of baroclinic instabilities associated with the near-surface salinity gradient at the EICC / river in the sea edge?
Horizontal salinity gradients contribute to up to $\approx 40\%$ of EICC intensity after the summer monsoon.

Salinity gradients enhance mesoscale variability by up to 30% in the western BoB.

Robust results in a similar 1/12° experiment.
Positive Feedback Loop

EICC forms the ‘river in the sea’ (Akhil et al 2014; Chaitanya et al., 2014)

‘river in the sea’ strengthens EICC (keerthi et al 2018, in preparation)
Thank You