Using biogeochemical models to optimize sampling design for biogeochemical profiling float arrays

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Australia-India Joint Indian Ocean Bio-Argo Project

“Characterising the changing Indian Ocean’s biogeochemistry and ecology using revolutionary new robotic tools”

• Collaboration between:
  • CSIRO (Australia): Hardman-Mountford, Trull, Wijffels
  • CSIR-NIO and INCOIS (India): Naqvi, Ravichandran

• Aims:
  • Coordinated bio-float deployments (2014-15)
  • Joint protocol development for deployments and data (with international Bio-Argo community)
  • Facilitate wider collaboration towards Indian Ocean Bio-Argo network
What are Bio-Argo Floats?

The new Bio Argo floats are equipped with different technology to their predecessors. They feature sensors for:

- dissolved oxygen
- dissolved organic matter
- nitrate
- chlorophyll
- particle scattering

1. Research ships drop the float in the ocean
2. The float descends to 1000 metres and takes readings
3. The float descends again to 2000 metres and takes more readings
4. After staying submerged for around 9 days, the float surfaces
5. Once at the surface, all the data is transmitted to a satellite
6. Once the data is received it is sent to the closest research station for analysis
What are Bio-Argo Floats?

Float specs:
BGC: CTD, DO₂, Chl F, CDOM F*, backscatter (532*, 700 nm), UV NO₃*
Val: as BGC + radiometry (Lu/Ed, 4 wavelengths), transmissometer (650 nm), backscatter (470 nm)

* options – not on all floats

http://www.seabird.com/products/spec_sheets/NAVISBGCindex.htm
How do Bio-Argo Floats work?

- How to optimise Bio-Float sampling?
  - Profile frequency?
  - Profile depth?
  - Park depth?
  - Float lifespan?
  - Sensors?
- Variable dependent on features of interest
  ➔ Modelling
Why the Indian Ocean?

• Key region for coastal populations
• Ocean biogeochemistry links climate and food security issues

Key Biogeochemical Features
• Low oxygen waters: Arabian Sea & Bay of Bengal
• Productive anticyclonic eddies in SE Indian Ocean
• Upwelling (Java-Sumatra)
• Carbon export hotspots (e.g. Kerguelen, Heard Island)
• ...
Challenges of using floats to sample AC eddies

• Fundamental questions:
  • Can floats be retained in eddies? ✔
  • Can floats adequately sample eddy structure?

Courtesy of Pete Strutton, UTAS
Can floats adequately sample AC eddy structure?

- **Model (OFAM):** Mean eddy
  - Ocean Forecast Assimilation Model (OFAM): global eddy-resolving 10km resolution GCM
- **Observations (Argo):** Float-sampled eddy
  - ‘Argo floats’ capture eddy structure

Observations compared with model results:
- Symmetrical
- Depth (m)
- Radius
- Centre
Challenges of using floats to sample AC eddies

• Fundamental:
  • Can floats be retained in eddies? ✓
  • Can floats adequately sample eddy structure? ✓

▶ Sampling strategy: Optimizing retention
  a) Eddy type – forming vs. mature
  b) Float location – centre vs. perimeter
  c) Profile timing
  d) Park depth
Sampling strategy: Eddy Type and float location

- Forming coastal eddies have high loss rate of particles
- Particles close to centre of eddy no more likely to be retained
- Mature offshore eddies have very high retention rate of particles
- Particles in centre have higher rate of retention
Sampling strategy: Profile timing

Initial position

- Floats trapped at surface disperse rapidly
- Extended time at park depth improves retention

Position after 30 days

(a) Trapped at surface

(b) 6 hrs between surfacing

(c) 12 hrs between surfacing
Sampling strategy: park depth

Park depth is critical

Distribution after 60 days

Park depth 300 m

Park depth 500 m
**Preliminary conclusions**

- Prolonged retention of floats in eddies is possible
- Float sampling can adequately represent eddy physical structure
- Forming (coastal) eddies are relatively unstable and have low rate of retention
- Mature offshore eddies have very high rate of retention and represent the ‘safest bet’ for float deployments in eddies
- In regions of strong horizontal velocities, profile timing makes a difference to retention
- Adjustment of park depth may improve retention in forming eddies
- Some sort of compromise may be needed in the choice of profiling period and park depth to keep floats on the necessary path
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