Indian Ocean modeling: successes, problems and prospects

IO Modeling Workshop

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Successes

What phenomena are current IO models able to simulate?

Problems and prospects

What phenomena can (should) still be studied with existing models?

What are existing models not able to do?
What phenomena are current IO models able to simulate?

Mean, seasonal, and intraseasonal currents

Interannual variability
  Indonesian throughflow?
  ENSO and IODZM?

Mixed-layer processes
Mean and seasonal currents: wind forcing

Seasonally reversing monsoon winds

Reversing cross-equatorial winds

Equatorial zonal winds

Rather steady Southeast Trades
Mean and seasonal currents: phenomena

- Somali Current
- Indian coastal currents
- Equatorial phenomena
- Thermocline ridge
- Indonesian Throughflow
- Shallow overturning circulations
- Leeuwin and Eastern Gyral Currents
Interannual variability: IOD

Saji (2004, priv. comm.)
The IOD is a mode of climate variability involving organized changes of winds, atmospheric convection, SST, and thermocline depth ($h$), reminiscent of a La Niña event in the Pacific. The IOD exhibits close links to, as well as independence from, ENSO.
Mixed-layer processes

Hood et al. (2003)
What phenomena still need to be modeled?
What cannot be studied with existing models?

Mean and seasonal cycle
  Eastern Gyral Current, Leeuwin Current

Interannual variability
  Indonesian Throughflow
  Sumatra/Java upwelling

Intraseasonal oscillations

Mixed-layer processes
  Thin, fresh, surface layers
  Rainfall and river runoff
Thin, fresh, surface layers

(b) Phase II: Star 2
- Temperature
- Salinity

(c) Phase III: Triangle
- Temperature
- Salinity

Webster et al. (2002)
Precipitation ($P$) is a key atmospheric variable, among other things indicating where the atmosphere is driven by convection. The accuracy of precipitation products over open oceans, however, remains problematic due to the lack of *in situ* measurements. Three satellite-based precipitation products are shown on the left. They differ in both their spatial patterns and magnitudes.

Yu and McCreary (2004; JGR) evaluated various $P$ products using an ocean model to “convert” $P$ to sea-surface salinity (SSS). Since freshwater runoff into the ocean must be considered but is unavailable, they parameterized runoff by nudging model surface salinity ($S_1$) toward observed SSS only at basin boundaries and whenever $S_1 > SSS$. They then compared the $S_1$ field forced by a particular $P$ product to observed SSS.
The panels show differences between modeled $S_1$ forced by the three $P$ products and observed SSS. The difference is the smallest for CMAP, a merged product based on rain-gauge data and several satellite measurements. The result from GPCP, another merged product, can be improved by adjusting its amplitude, supporting the notion that merged products give reliable spatial patterns but not necessarily correct magnitudes. The bias from the University of Arizona product, based only on satellite measurements, however, cannot be improved via simply adjusting its magnitude.
Runoff

Surface salinity is affected by river runoff, as well as rainfall. The figure shows sea-surface salinity ($S_1$) fields in solutions to an Indian Ocean model forced by COADS precipitation, with different parameterizations of runoff: no runoff (top), runoff only in the Bay of Bengal (middle), and all runoff (bottom).
What phenomena still need to be modeled?

What cannot be studied with existing models?

- Mean and seasonal cycle
  - Eastern Gyral Current, Leeuwin Current
- Interannual variability
  - Indonesian Throughflow
  - Sumatra/Java upwelling
- Intraseasonal oscillations
- Mixed-layer processes
  - Thin, fresh, surface layers
  - Rainfall and river runoff