Pathways of Arabian Sea coastal upwelled water in the northern Indian Ocean using Tracers in a numerical model

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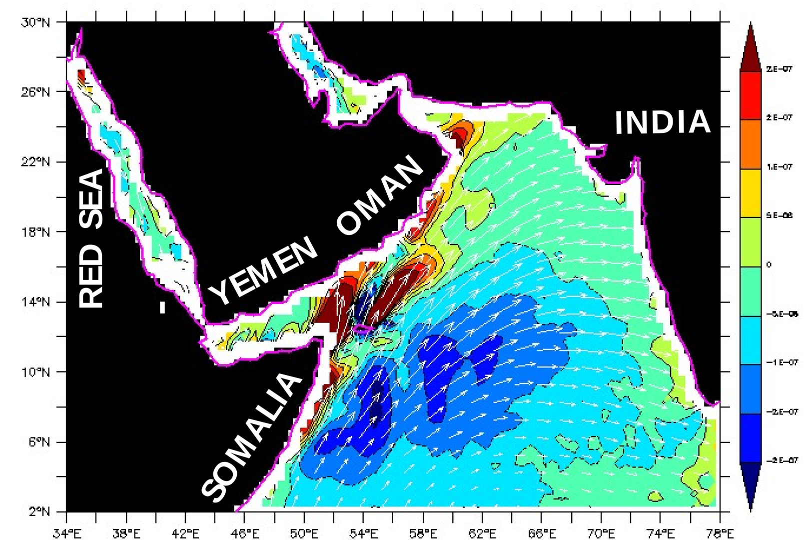
1 Abstract:

A non-linear 2.5 layer wind driven ocean model coupled with a 1.5 layer analytical model for upwelling is used to identify the spreading pathways of the upwelled water from various regions of the western Arabian Sea. The analytical estimates of coastal upwelling yield a good quantitative measure of total upwelling in consistence with the observations.

A 65±5% of Somali upwelling water intrudes the central Arabian sea and circulates anticyclonic to the south and advects to the east across the northern Indian Ocean, while a 30±5% intrudes the northern part of the Arabian sea where it shares with a 70±5% of Arabian coastal upwelled water. The remaining water intrudes into the Gulf of Aden with a 10±5% of Arabian coastal upwelled water. At any part of the year the central north equatorial Indian Ocean is occupied with 70±5% of Somali upwelled water and a 20±5% of Arabian Sea coastal upwelled water showing that the former spreads faster than the later. The longer residence time of upwelled water in the northern Arabian Sea may attest to the high biological productivity there.

2 Charaectersitcs of Arabian Sea Upwelling

1. Maximum upwelling during southwest monsoon (June-September).
2. Upwells high nutrient water.
3. Reason for high Biological productivity and Fish catch.



3 Objectives:

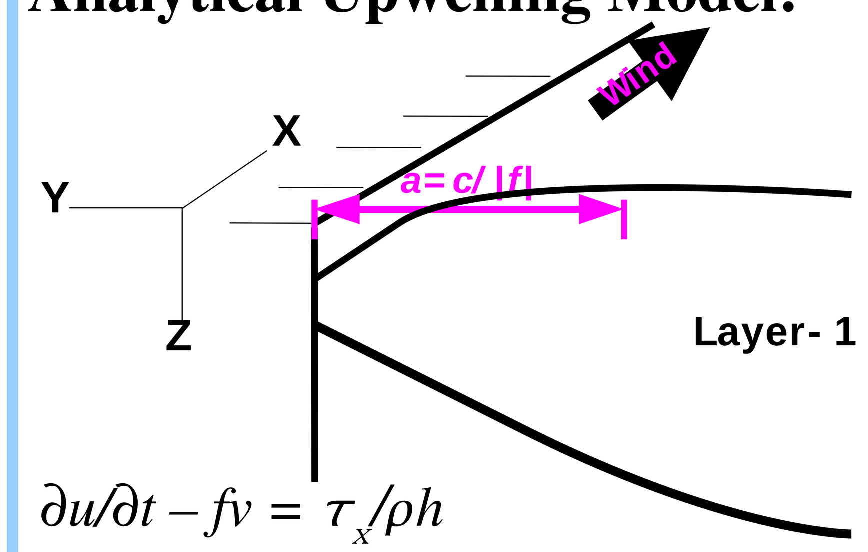
1. Where does this upwelling water go?
2. How long does this water exist in the vicinity of the upwelling region?
3. What are the pathways of this water?
4. Does its spreading pathway has any significance on Biological productivity there?

4 Tracer Modeling:

Physical Model:

2&½ Layer non-linear reduced gravity model.
20km x 20km spatial resolution.
Forced with Quickscat windstress for yr. 2000.

Analytical Upwelling Model:



$\partial u/\partial t - fv = \tau_x/\rho h$

$\partial v/\partial t + fu = -g'\partial \eta/\partial y$

$\partial \eta/\partial t + h\partial v/\partial y = 0$

Solution; $\eta = \tau_x/\rho c(e^{-y/a})t$; $a = c/|f|$

Tracer injection:

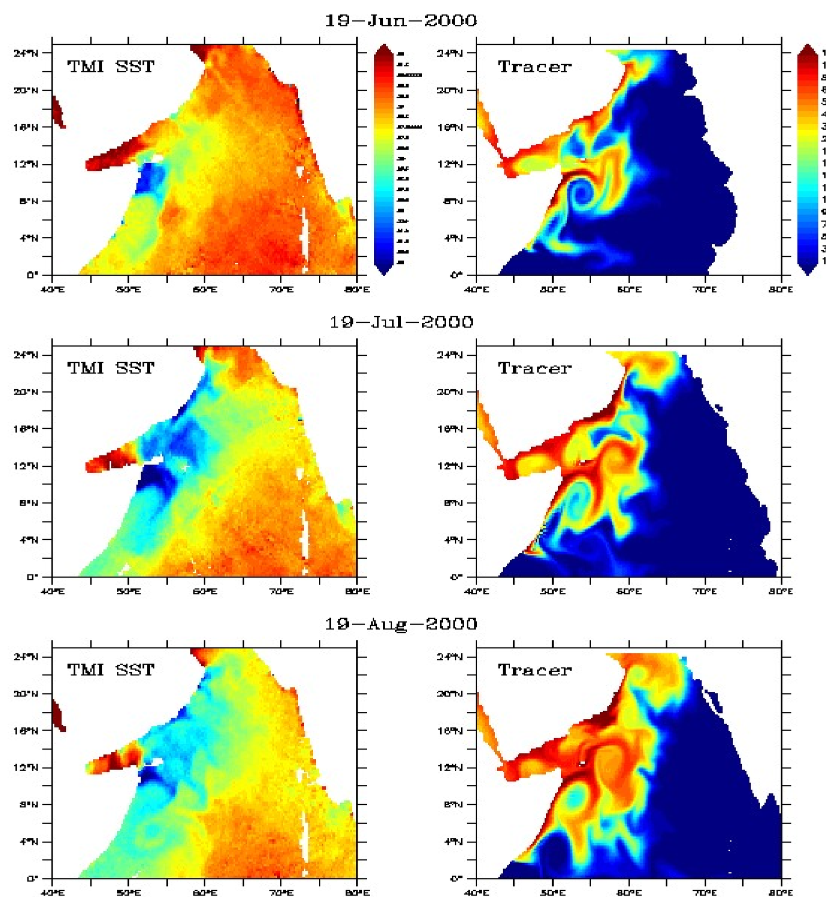
$w_e = \partial \eta/\partial t = (\tau_x/\rho)(e^{-y/a})$

Tracer evolution:

$\partial C/\partial t + U.\nabla C - \nabla \bullet Ac\, \nabla C = \kappa\ \tau_x/\rho)(e^{-y/a})$

5 Model tracer and data Comparison:

TMI SST   Model Tracer

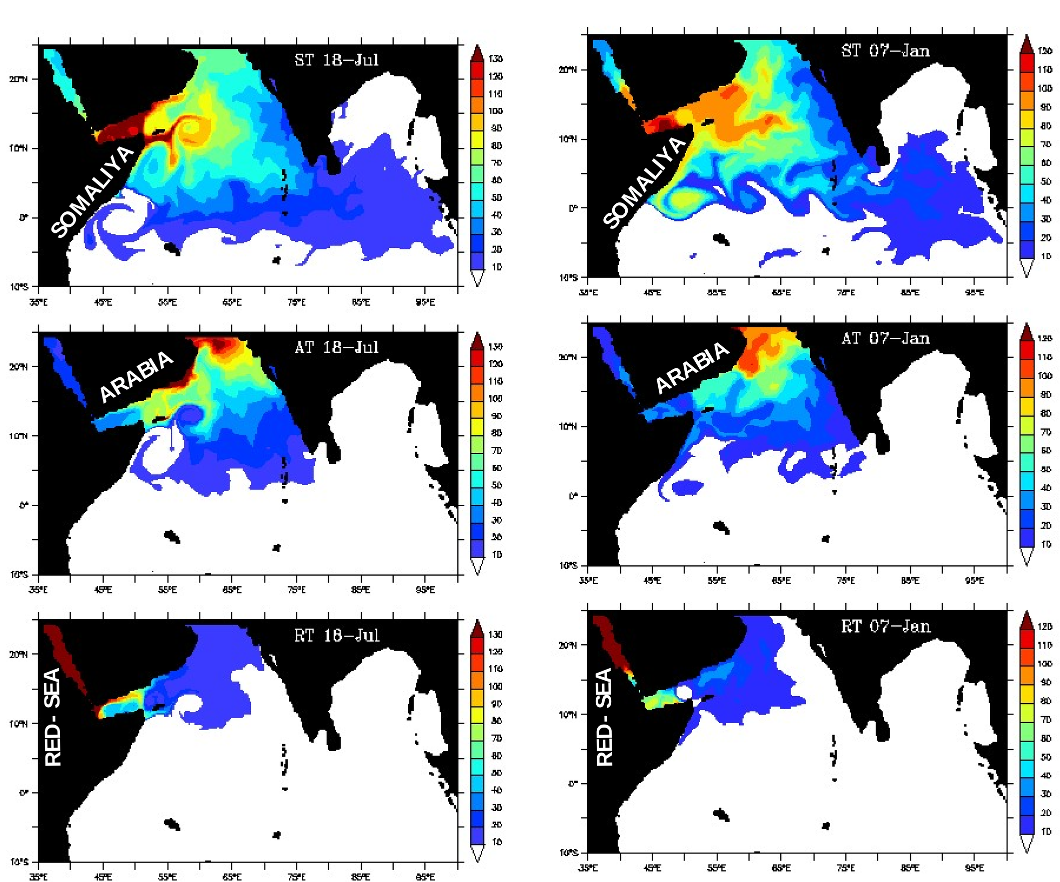


Summation of Somali, Arabian coast and Red sea tracers.

Upwelling induced cold SST is coincided with model tracer.

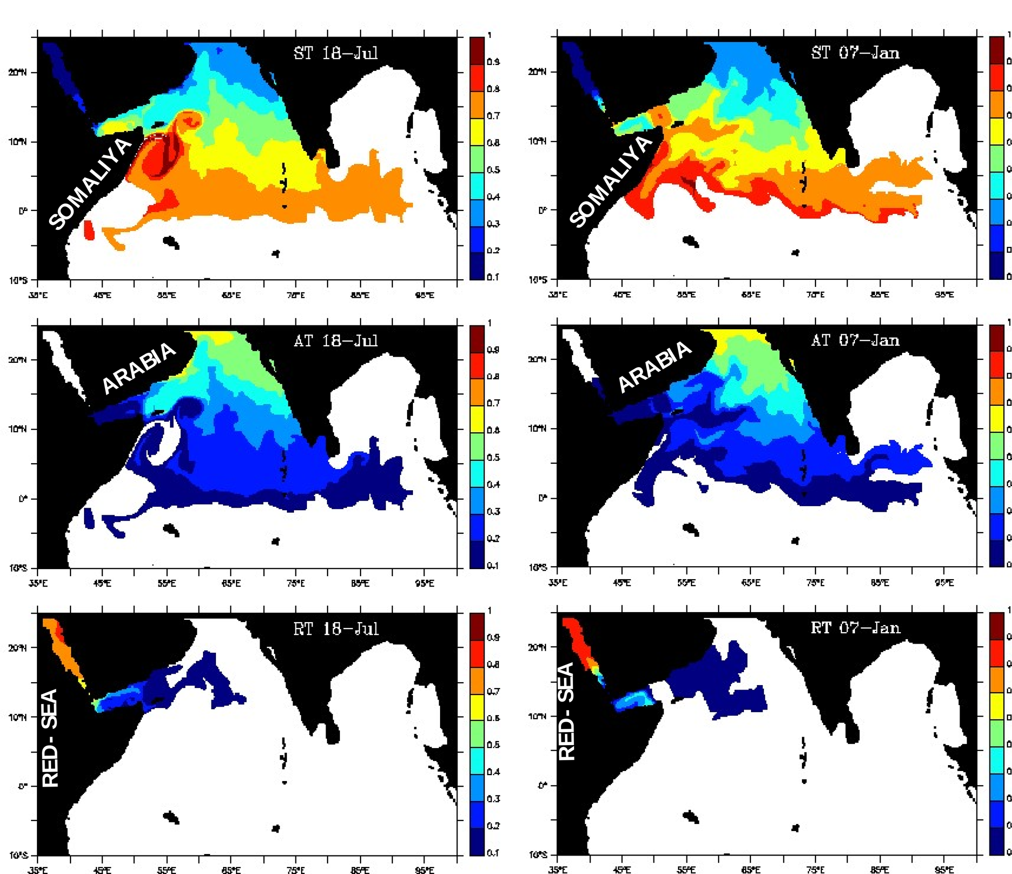
6 Spreading of Upwelling water:

Tracer spreading after 5-year of integration



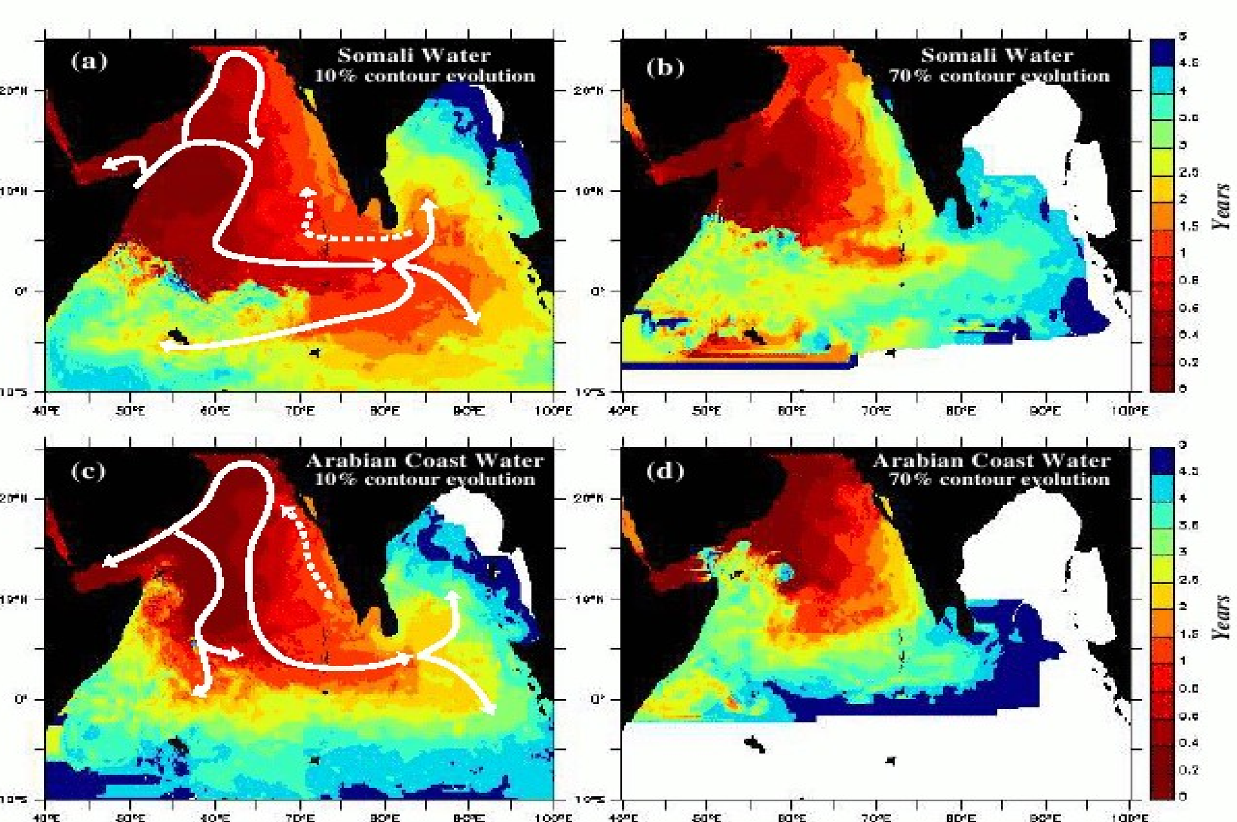
7 Relative occupation of upwelling water:

(Units are in x 100%)



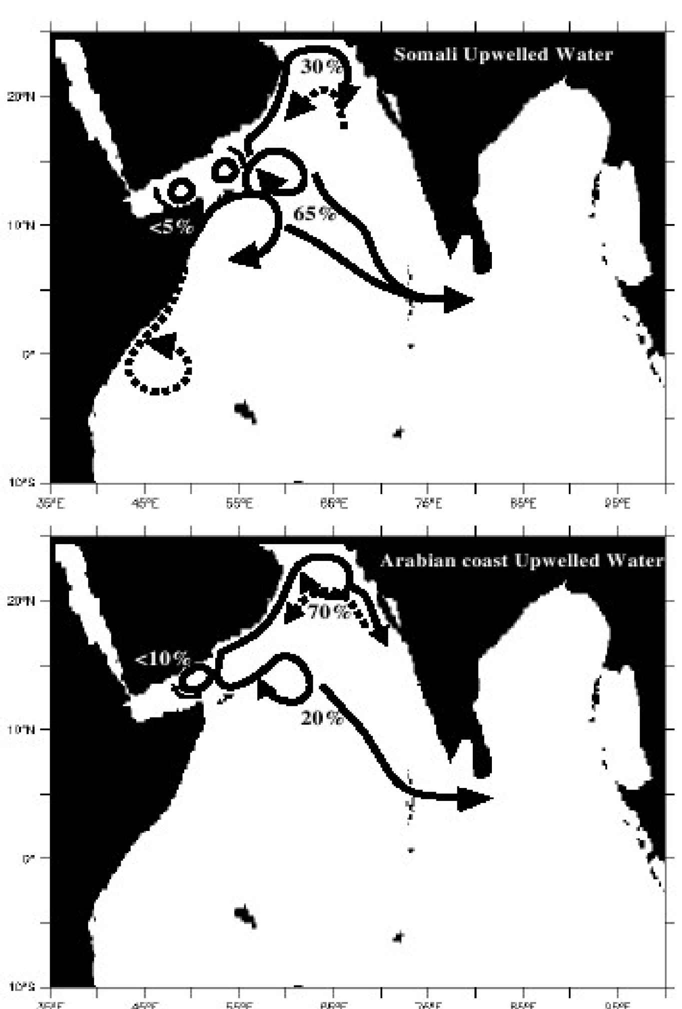
8 Age of upwelling water:

Time evolution of 10% and 70% concentration fronts (Units are in years)



9 Results:

Individual spreading pathways of Upwelling water from various coasts of Arabian Sea are investigated using numerical tracers in a high-resolution reduced gravity model. Following conclusions are reached.



1) 65±5% of Somali water spreads in southern Arabian Sea.
2) 30±5% of Somali water spreads in northern Arabian Sea.
3) 5±5% of Somali water intrudes into the Gulf of Aden.
4) 70±5% of Arabian coast water spreads in northern Arabian Sea.
5) 20±5% of Arabian coast water spreads in southern Arabian Sea.
6) 10±5% of Arabian coast water intrudes into the Gulf of Aden.

Impacts: The relatively longer residence time of high nutrient upwelled water in the surface ocean of Arabian sea may have influence on the local Biogeochemical processes.