Characteristics of fresh water lenses in the equatorial Indian Ocean at 0 – 80.5E

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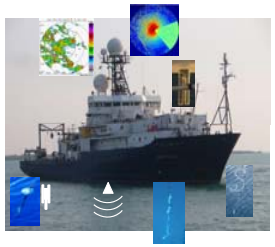
1- Abstract

The equatorial Indian Ocean is marked by strong insolation, generally weak winds and intermittent precipitation caused by atmospheric convection. Heavy downpours form cool, fresh lenses at the surface of an otherwise warm and salty upper ocean layer. We are investigating the thermohaline, turbulence and kinematic properties of 21 freshwater lenses observed over a 34 day period in October-November 2011, part of DYNAMO IOP.

- Data collected at 0N – 80.5E during Legs 2-3 of DYNAMO IOP
- 34-day time series from bow CT chain, Chameleon, ADCP, Flux Mast, X-Band radar
- A freshwater lens behaving as a gravity current is presented in Box 3
- Thermohaline and kinematic characteristics of all 21 rain patches are illustrated in Box 4

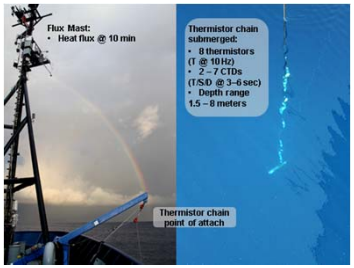
2 - Instrument set-up



R/V Roger Revelle

- CTD-chain on Bow
- Chameleon on Stern
- Sea Snake T
- Radiometer Skin T
- Flux Mast
- Meteorological data
- Optical Profiles
- ADCP
- C- & X-band radars

Instruments set-up on the Bow

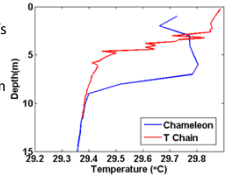


Benefits from the CT-Chain:

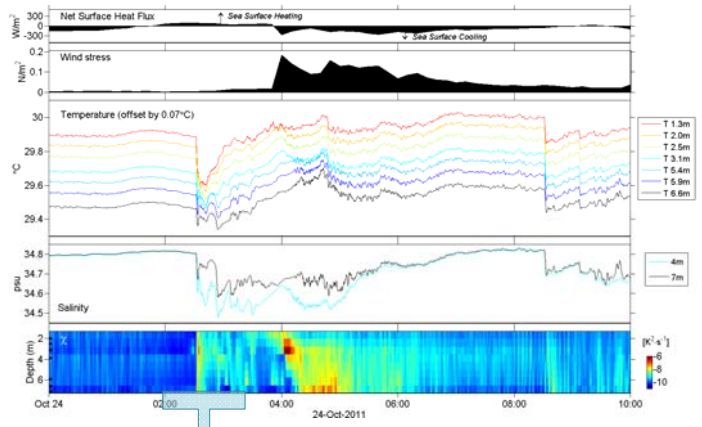
Coincident T profiles from T-chain and profiler in ship's wake.

Ship's wake mixes upper 5m

T-chain measures undisturbed fluid



3 - Example of freshwater lens: 24 October 2011



This example illustrates the sharp Temperature and Salinity anomalies pertaining to rain patches. This particular lens features a sharp leading front followed by a slow recovery of T and S to their initial levels or beyond. Water is fresher and cooler nearer the surface.

The bottom panel illustrates turbulent mixing. Two areas of intense mixing are noted:

- uniformly at the lens edge
- progressively deeper following an increase in wind stress at the surface

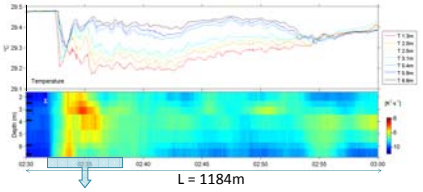
Mixing is higher overall inside the patch compared to outside.

Oscillations within the puddles could be internal waves at the bottom of the lens.

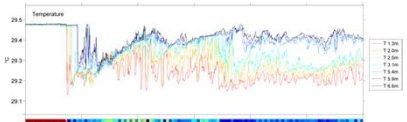
4- Details of the lens leading front

Sequentially zooming onto the front:

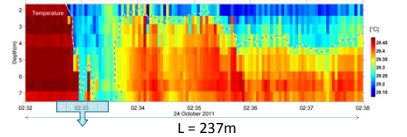
Intense mixing at the front edge



L = 1184m

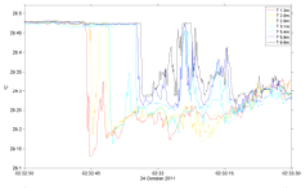


Turbulent head outlined by an isotherm



L = 237m

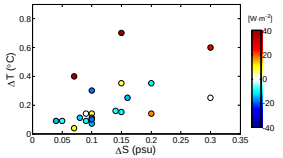
How sharp is this front?
T_t = 0.08°C/s
T_x = 0.05°C/m
S_t = 0.03 psu/s
S_x = 0.05 psu/m



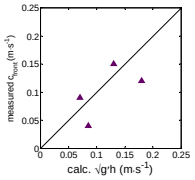
L = 20m

- Length: 4.62 km
- Volume: $42 \cdot 10^6$ m^3
- Estimated Rain volume needed: $0.3 \cdot 10^6$ m^3
- ΔT = -0.25°C; ΔS = -0.30 psu
- Jq0 = -70 W·m^2; Ih = -48 W·m^2; Jqh = 88 W·m^2;
- Time for turbulent heat flux Jqh to compensate ΔT: 6 hrs.
- Time for turbulent salt flux Js to compensate ΔS: 9 hrs.

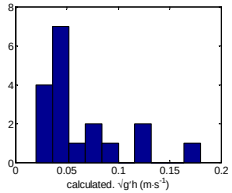
5- Characteristics of fresh water lenses



ΔT and ΔS were estimated across the leading edge of the lenses. Markers are color-coded using net surface heat flux accumulated over the two hours prior to the start of lens observation.



Trajectories of 4 freshwater lens fronts are tracked by averaging out surface waves on X-band radar. This leads to an estimate of the propagation speed of the lens front.
(X-band data credits: T. de Paolo)



Measured speeds compare reasonably well to a 2-layer gravity current speed,

$c_{front} = [g(\Delta\rho/\rho)D_{head}]^{1/2}$

6- Future directions

- Can we establish a momentum balance governing the spreading of freshwater lenses?
- Can we correlate the rain rate from precipitation maps to observed salinity anomalies in rain patches?
- Can we determine a patch age from a precipitation map and TS anomalies?
- Are barrier layers observed at the base of rain patches?
- Does heavy precipitation associated with MJOs create enough freshwater patches to affect the heat budget on a large spatial scale?