Abstract View

Volume 18, Issue 4 (April 1988)

Journal of Physical Oceanography
Article: pp. 565–583 | Abstract | PDF (3.51M)

The Sinking of Warm-Core Rings

Rick Chapman and Doron Nof

Department of Oceanography, Florida State University, Tallahassee, Florida 32306

(Manuscript received April 17, 1987, in final form October 26, 1987)

DOI: 10.1175/1520-0485(1988)018<0565:TSOWCR>2.0.CO;2

ABSTRACT

Intense cooling of a warm-core ring or warming of the fluids surrounding a ring can increase the density of that ring relative to the surrounding fluids. This increase in density can cause the ring to sink under the surrounding fluids. A simple model of this process in a two and one-half layer (two active and one passive layer) ocean consisting of an inviscid Boussinesq fluid on an f-plane is presented. The model assumes that the cooling or heating occurs in such a way as to maintain a uniform density throughout each of the active layers. This special form of the heat flux allows the results for various relative ring densities to be connected through the conservation of potential vorticity. Analytic solutions are constructed and their structure helps to establish the physical processes accompanying the sinking of a ring.

Results show that warm-care rings can sink in a matter of weeks when exposed to typical cold-air outbreaks of -1000 W m^{-2} surface heat flux. The model predicts that when the ring sinks it is overwashed completely, but this overwashing layer is very thin near the center of the ring. It is suggested that the convective mixing associated with continued cooling will act to suppress any surface signature of the overwashing. Applying the same model to the process of differential warming of the surrounding layer, leads to similar results, except that any surface signatures of overwashing will be visible due to the lack of convective mixing. The main difference between cooling the ring and warming the environmental fluid is that, in the former case, the model breaks down when the ring is capped whereas, in the latter case, the ring continues to sink as the warming continues. It is proposed that the above mechanism can lead to the formation of streamers when one portion of the overwashing fluid has been passively marked with a visible tracer such as temperature or chlorophyll.

It is shown that the fluid that initially overwashes the ring originates under the ring, and not from outside the ring. When the ring sinks, this fluid is pushed out to the edge of the ring and spun up in the process. The theory further provides a mechanism for the entrainment of shelf-water organisms that are observed in warm-core rings.

top