TACE: Equatorial Upwelling Rates inferred from Helium Isotope Data

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Upwelling is one of the key processes to maintain the Tropical Atlantic cold tongue. Direct measurements of the upwelling have been hampered by the small speeds involved. Instead, vertical motion has to be estimated by indirect methods. Klein and Rhein (2004) propose a novel approach to infer equatorial upwelling velocities by exploiting the helium isotope disequilibrium between atmosphere and equatorial oceanic mixed layer. Although the vertical and horizontal resolution of the existing helium data in the upper tropical oceans was too poor to support a detailed study, it was sufficient to show the potential of the method.
The advantage of the helium isotope method is that the equatorial helium disequilibrium between mixed layer and atmosphere can only be maintained by vertical motions, since horizontal advection in the mixed layer would import equilibrated water and thus erode the signal. Assuming moderate levels of turbulence at the base of the mixed layer the vertical diffusion turned out to be much smaller than the air-sea gas exchange, which has then to be balanced by upwelling from below.
For an accurate determination of the helium balance in the mixed layer it would be advisable to perform concurrent turbulence measurements during future experiments. Temporal as well as zonal gradients were ignored by Klein and Rhein (2004) due to lack of sufficient tracer data. The time scale of the gas transfer (order of 10 days) determines the validity of a helium-derived estimate of w. To detect small changes in δ^3He repeated measurements will be necessary to decrease the error margins of the individual measurements. At present, the major uncertainty of w is caused by the insufficient number of helium data in space and time.

Objectives

- to estimate upwelling rates from the distribution of Helium isotopes in the equatorial Atlantic
- to infer the temporal variability of the upwelling in the eastern tropical Atlantic by a time series of Helium distribution and the spatial variability by sampling along crossequatorial sections at different longitudes (23°W, 10°W, 10°E)

Methods and field work

- analyse Helium samples from zonal sections crossing the equator in spring 2006 (RV METEOR cruise)
- in order to obtain a time serie, analyse Helium samples from three French cruises in the eastern tropical Atlantic in fall 2005, spring 2006 and fall 2006 (IFREMER, coordinator B. Bourles), and on the RV Ron Brown (NOAA, coordinator Bob Molinari).
- the Helium distribution will be combined with the profiles of vertical turbulence (P. Brandt, IFM-Geomar) and with meteorological data (winds, buoyancy fluxes) to optimize the estimate of the upwelling rate, using a dedicated mixed layer model.

Literature:

Klein, B., und M. Rhein, Equatorial Upwelling Rates inferred from helium isotope data: a novel approach. Geophys. Res. Lett. 31, L23308, doi: 10.1029/2004GL021262, 2004