THE OMEGA PROJECT: OBSERVATIONS AND MODELLING OF EDDY SCALE GEOSTROPHIC AND AGEOSTROPHIC CIRCULATION

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Abstract

The OMEGA project is an interdisciplinary physically based initiative aimed to provide the scientific community with a new tool for computation of vertical velocity from routine CTD and ADCP data. The field studies were completed during October (BIO *Hespérides*) and December (RRS *Discovery*) 1996. Preliminary analysis of the data show the existence of significant variability at scales of the order of the internal Rossby radius and also indirect evidences of vertical motions. The data are being analyzed and used to compute the associated three-dimensional circulation through methods and models of different complexity.

Key-words: mesoscale phenomena, fronts, surface waters, Alboran Sea

Introduction

OMEGA, a research project of the European Union MAST programme, has three main objectives: to determine the three-dimensional ageostrophic circulation at mesoscale (10-100 km) fronts and eddies and quantitatively estimate the vertical velocity, to evaluate the impact of the ageostrophic vertical motion on the biogeochemical properties in the upper 400 m, and to provide the scientific community with a standardised tool for the computation of vertical motions from routine CTD and ADCP data.

The results of high resolution modelling of frontogenesis (1) showed that vertical velocities up to 100 m/day could be expected at Rossby deformation radius scale meanders due to frontal baroclinic instability. Several studies by members of the OMEGA group (2, 3) have diagnosed high vertical velocities in frontal eddies, also in the Alboran Sea (4). Other authors have recently investigated this phenomena (5, 6). Vertical motion couples the deep ocean with the near surface layers, providing an enhanced transport route for heat, nutrients and biomass. The distribution of primary production patchiness is driven by mesoscale physics (7, 8). At these scales, successful research requires interdisciplinary observational strategies.

OMEGA is a comprehensive proposal combining an observational strategy of remote sensing and *in situ* high resolution physical, chemical, biological and meteorological measurement with a numerical modelling/data assimilation strategy to quantify the errors involved in the diagnostic analysis of the observational data, and make prognostic simulations of mesoscale features. Mesoscale eddies are ubiquitous in the ocean and the conclusions from OMEGA will be relevant to all ocean regions.

OMEGA Cruises

The OMEGA experimental work concentrates on two specific frontal zones of the western Mediterranean: the northern edge of the western gyre in the Alboran Sea and the Almeria-Oran front. Both are regions of strong vertical shear and intense mesoscale circulation, and are usualy identified by strong gradients in satellite infrared imagery (fig. 1). Two cruises were carried out during autumn 1996: in October the Spanish BIO *Hésperides* sampled the western Alboran gyre (OMEGA-1) and in December the UK RRS *Discovery*, the Almeria-Oran frontal region (OMEGA-2). In both cruises, data obtained in 3-4 consecutive samplings of the same area included Seasoar (undulating CTD + optical sensors), ADCP, fluorescence, multibeam acoustic backscatter, nutrients, flow-cytometry, etc., in conjunction with differential and 3D GPS navigation, as well as meteorological information. The deployment of neutrally buoyant Lagrangian floats in OMEGA-1, at the depth where maximum vertical motion was expected (100 m), provides direct estimates of the vertical velocity. The floats, able to record vertical water motion, were tracked by 6 acoustic receivers previously moored in the area, and recovered 50 days after the deployment.

During OMEGA-2 some ship tracks (fig. 2) were aligned along ERS-2 and Topex-Poseidon satellite tracks so that the combination of altimeter data and in situ SeaSoar and ADCP vertical profiling can be used to derive the along track geoid. Knowledge of the geoid will allow long term monitoring of the cross-track surface geostrophic currents and their temporal variations over the lifetime of the ERS satellites.

An aircraft made meteorological and radiometric measurements during this second cruise.

Determination of mesoscale circulation

The different sensors and sampling methodologies used during the OMEGA cruises have highlighted the presence of active frontal zones in both study areas. Preliminary analysis of the data show the existence of significant variability at scales of the order of the internal Rossby Radius and also indirect evidences of vertical motions.

The combined *in situ* and remotely sensed datasets have enabled a detailed description of the surface water types, the fronts that separate them, the bio-optical properties, and the associated changes around the time of the cruises. Shipborne measurements indicate that the surface signatures visible from remote sensed data are indicative of circulation to a depth of more than one hundred metres. The results of the merging and interpretation of such a comprehensive dataset show the potential and capabilities of the combined satellite/*in situ* approach in rendering a picture of the relationship between the physics of frontal zones and bio-optical variability at the mesoscale with an unprecedented degree of accuracy. Particular attention is given to the relationship of the observed biological variability to the 3-D circulation at the front and to assessing the influence of sub-surface patchiness in the interpretation of ocean colour data from satellites.

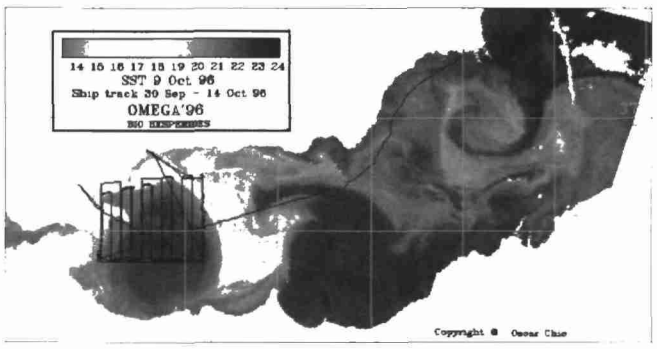

Figure 1: The western Alboran gyre (left) and Almeria-Oran front (right) observed in a NOAA/AVHRR infrared image recorded on board the BIO *Hespérides* on 9 October 1996, with the ship tracks for OMEGA-1 cruise overlaid.

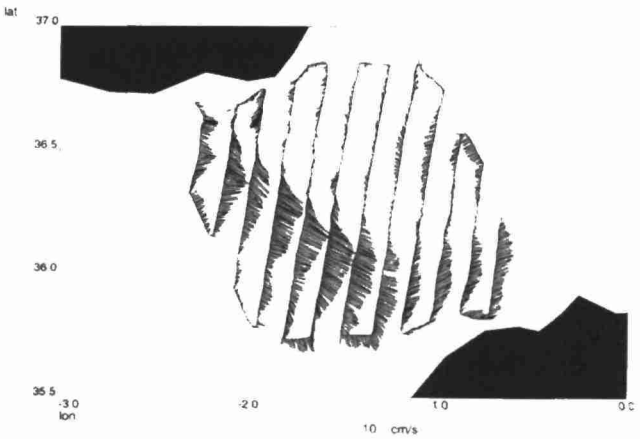

Figure 2: The Almeria-Oran frontal jet at 46 m depth, as measured by combining ADCP profiles and precise navigation data recorded on board the RRS *Discovery* in December 1996. Two of the parallel ship tracks coincide with ERS-2 altimeter groundtracks