A MULTI-SENSOR APPROACH TOWARDS COASTAL OCEAN PROCESSES MONITORING

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ABSTRACT

The coastal ocean is of crucial societal importance. A quantitative understanding of the physical processes impacting the coastal region is necessary to determine how the sea level and current variability will affect coastal systems. Dynamics along the continental slopes are difficult to observe given the wide spectrum of temporal and spatial variability of physical processes which occur. Thus, studying such complex dynamics requires the development of synergic approaches through the combined use of modeling and observing systems at several spatial/temporal sampling level requirements. The objective of this work is to develop coastal operational oceanography on the basis of combined observing systems.

1. INTRODUCTION

New monitoring technologies are being progressively implemented in coastal ocean observatories. As an example, autonomous underwater vehicles are new platforms which allow high resolution sampling, showing the existence of new features, such as sub-mesoscale eddies with intense vertical motions that significantly affect upper ocean biogeochemical exchanges. The new observatories are discovering new insights of coastal oceans variability which will in turn trigger new theoretical developments, increasing our understanding of coastal and nearshore processes and contributing towards a more science based and sustainable management of the coastal area.

The objective of this work is to develop coastal oceanography on the basis of adequate observing systems. Specifically, it is intended:

(1) To validate, intercalibrate and improve observing data dedicated to coastal ocean studies. The first step consists in implementing the technological existent advances in satellite altimetry in the coastal area. This is part of an ongoing work carried out by several groups from Europe which includes applying improved altimeter corrections and reviewing the data recovery near the coast. In a second step, improved altimetry measurements will be compared with independent observing system at several time-space sampling. In this respect, we hold the view that the so far unexploited possibilities from the potential merging of existing in situ (glider, tide gauges, drifters) data sources with remote sensing data (SST, altimetry) has to be developed in a calibration-validation purpose. Thus, the understanding of the physical contents of each sensor has to be deeply investigated.

(2) To improve our scientific knowledge of the coastal ocean by exploiting a multi-sensor approach. In particular, we examine the possibility of using a combination of different sensors to compute an accurate surface velocity field of the ocean currents.

2. SYNERGY BETWEEN GLIDER AND ALTIMETRY DATA

We present the results of an intensive observational programme conducted at IMEDEA combining altimetry and glider data, which consisted in running glider missions along selected altimeter tracks (Envisat, Jason-1/2). The goal of this experiment is twofold: i) to investigate the limitations and potential improvements of altimetry data in the coastal area ii) to test the feasibility of new technologies to study coastal dynamics. In the period comprised between July 2007 and July 2009, 9 glider missions have been performed, with a total of 6000 full CTD casts from the surface down to 180 m collected. Figure 1 shows some results of a particular mission (April 2008) revealing the appearance of an anomalous anticyclonic eddy detected by altimetry, glider and SST data. New methodologies have been developed and applied in order to combine surface glider geostrophic velocities with integrated currents estimated by the glider (GPS locations every 6 hours). This approach proves to be very efficient for reducing the differences between altimetry and glider data. Further, we have also used high frequency (20 Hz) altimetry data which in some particular cases, after a dedicated processing, also improves the comparison between altimetry and glider velocities (Figure 1).

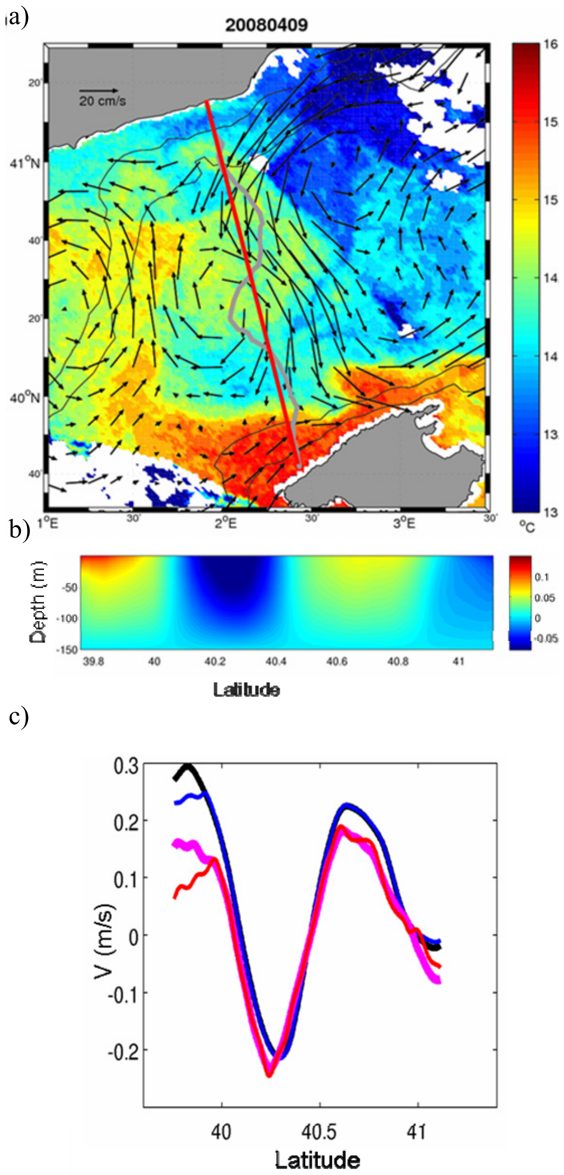


Figure 1. Results of a glider mission (April 2008) along an ENVISAT track in the Balearic Sea. a) Synoptic view from remote sensing data. Vectors correspond to absolute geostrophic currents from merged altimeter gridded fields (source: AVISO) and the background color field is a SST image (source: ICM). The red line is the ENVISAT 773 track and the grey line corresponds to the trajectory followed by the glider, which was deviated from the nominal track due to the presence of strong currents (anticyclonic eddy). Isobaths are 500 and 1000 m. b) Vertical section of geostrophic velocity from glider data. Dynamic height is obtained from the glider P, T, and S profiles with a reference level of 180 m. Positive values indicate currents towards NE. Three main patterns are identified: the Balearic current close to the Balearic slope (left in the image), the anticyclonic eddy in the center of the transect and the Northern current flowing south-westwards at the northern edge of the domain (right of the image). c) Along track geostrophic velocity from altimetry (red & pink lines) and glider (blue & black lines).

3. ESTIMATING SURFACE OCEAN CURRENTS USING A MULTI SENSOR APPROACH

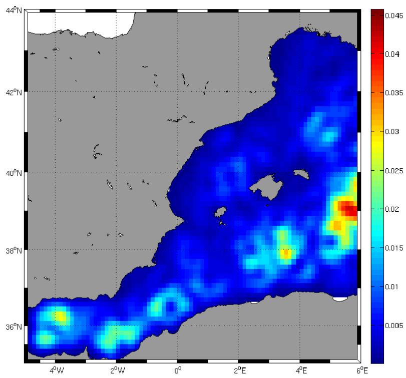
A technique is developed with the aim of providing accurate estimates of surface ocean currents. The method consists in the combination of large scale (order of 100 km) geostrophic currents from altimetry with small scale dynamics derived from Sea Surface Temperature (SST) images. The method is based on the assumption that dynamic height (or sea surface height derived from altimetry) and SST are linearly correlated. This assumption is justified from CTD data. An Ekman component is also added in order to include ageostrophic wind effects.

The method is tested in the Balearic Sea, in the framework of the SINOCOP Experiment in which several drifters were deployed and CTD (Conductivity Temperature Salinity) profiles were collected. The results show a significant improvement in both the correlation (35%) and RMS Difference (40%) between the actual velocity of the drifters and our multi-sensor dataset or altimetry alone. The multi-sensor dataset provides higher eddy kinetic energy fields than altimetry with better continuity of mesoscale and subme-soscale features such as eddies and jets (Figure 2).

4. PERSPECTIVES

These studies are in line with the new OceanBIT Coastal Observing and Forecasting System, a new facility that will address scientific and technological coastal ocean international priorities. The System will be based in the Balearic Islands but will have a more general Mediterranean / Global Ocean interest (the Mediterranean as an ideal, small scale ocean). On a long term, with this kind multi-approach experiments, our vision is to advance on the understanding of physical and multidisciplinary processes and their non linear interactions, to detect and quantify changes in coastal systems, to understand the mechanism that regulate them and to forecast their evolution and or adaptation under, for example, different IPCC scenarios.

a)



b)

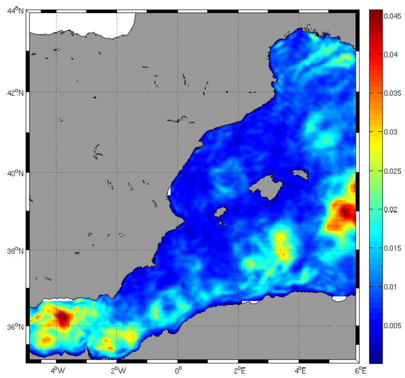


Figure 2: Mean Eddy Kinetic Energy averaged over the period of April to July 2009. a) Velocity from altimetry product. b) Velocity from a multi-sensor (altimetry + SST) product. Units are m2/s2.