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A Methodology for Analyzing Climatological Data in the Western Mediterranean. Perspectives in Variational Inverse Modelling

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The knowledge of the dynamical structures associated with the general circulation in the Western Mediterranean is unceasingly growing as numerical models [Beckers, 1988] together with in situ observing systems become more and more sophisticated. The ultimate objective being the design of a 3-D realistic model, it is fundamental to confront the results stemming from numerical simulations with the extensive set of hydrographic data collected since the beginning of the century.

A variational inverse model, initially developed for the study of continental seas, has been tuned to phenomenons typical of the Mediterranean Basin. It allows to reconstruct, on the basis of local measurements (such as C.T.D. profiles carried out at pin-point hydrographic stations), continuous fields of the state variables representative of the general circulation and its evolution during the seasons. In this model, the 3-D structure of the Sea is reproduced by using a set of N layers, each of them being characterized by a density which is constant along the vertical and variable in the two horizontal directions. Although the vertical discretization may vary with the abundance and the spatial distribution of the data, three layers at least are necessary in order to reproduce adequately the Atlantic surface water, the Intermediate Levantine water and the dense water in the deep ocean. In each layer, the horizontal distribution of density (or any other scalar variable) is obtained by applying the weighted residual method to the equation

$$(\nabla^2\nabla^2\rho - \alpha\nabla^2\rho) + \sum_{k=1}^{N_d} \mu_k(\rho_k - d_k) + \gamma(\mathbf{u}.\nabla\rho - \tilde{\lambda}\nabla^2\rho) = 0$$

The first term is a smoothing operator equivalent to the variational principle [Brasseur, 1989]:

$$\operatorname{Min} J(\rho) = \int\int_D \left[\left(\frac{\partial^2\rho}{\partial x^2}\right)^2 + \left(\frac{\partial^2\rho}{\partial y^2}\right)^2 + 2\left(\frac{\partial^2\rho}{\partial x \partial y}\right)^2 + \alpha\left(\frac{\partial\rho}{\partial x}\right)^2 + \alpha\left(\frac{\partial\rho}{\partial y}\right)^2 \right] dx\,dy$$

where the "tension" parameter α has been introduced so as to take into account the frontal structures disclosed by physical, chemical and biological data. The second term is this by which the observations d_k, measured at (x_k, y_k), are assimilated into the continuous solution at $\rho_k = \rho(x_k, y_k)$. The weighting factors μ_k are fixed according to the confidence intervals associated with every data. They depend on the statistical quality of the measurements (systematic errors) as well as on the filtering required to cancel out processes representative of small scale motions. Moreover, the interpolation procedure is driven dynamically by an advection-diffusion relation with γ as a weighting factor. The velocity field $\mathbf{u}(x, y)$ is obtained by assuming that the flow within each layer is in geostrophic balance and satisfies the thermal wind equation, so that

$$\frac{\partial \mathbf{u}}{\partial x_3} = \frac{g}{\rho_0 f} \mathbf{e}_3 \Lambda \nabla\rho .$$

The turbulent diffusion coefficient $\tilde{\lambda}$ plays a role similar to the tension parameter α in the smoothness operator.

On the basis of climatological data collected in the Western Mediterranean, one can reconstruct typical 3-D configurations depicting the state of the Sea during the seasons by using the Variational Inverse Model. Of course, the above-mentioned equations concerning the reconstruction of buoyancy fields may be written for other kinds of data such as temperature, salinity, nutrients, phytoplankton, chemical tracers... The main objective is to describe, from the data, the standard patterns which recur from one year to another within the global system. Preliminary results show that the Variational Inverse Model makes up a practical tool for the understanding of fundamental questions as: what are the driving forces of the general circulation in the Northern part? what are the mechanisms responsible for the genesis and the cohesion of frontal structures?

In a subsequent stage, the reconstructed fields may be used as initial and boundary conditions in the framework of a general numerical model [Brasseur and Nihoul, 1990]. Indeed, the non-linear features of primitive equations models require the use of adequate auxiliary conditions to reproduce as much as possible realistic situations. The complementary nature between the direct approach based on evolution equations and the inverse method for the visualization of data will become essential for the understanding of the whole Mediterranean System.

REFERENCES

BECKERS J.M. 1988. Modélisation Mathématique et Numérique de la Mediterranée occidentale, Thèse de fin d'études d'Ingénieur Civil en Mécanique-Physique, Juin 1988, Université de Liège.

BRASSEUR P., 1989. Analyse de données océanographiques par le modèle variationnel inverse, Thèse de fin d'études d'Ingénieur Civil en Mécanique-Physique, Juin 1989, Université de Liège.

BRASSEUR P. and NIHOUL J.C.J, 1990. Data processing and initialization scheme in the Northern Bering Sea by Variational Inverse Models. AGU Ocean Sciences Meeting, New Orleans.

O-IV3

Observations of Currents and Temperature on the Adriatic Shelf in Summer

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Current and temperature data were collected between 12 August and 10 September 1989 at three stations near the north-eastern Adriatic coast, in the framework of Adriatic Scientific COoperation Programme (ASCOP). Time series have been low-pass filtered in order to remove inertial and tidal oscillations. The low-passed data provide information about residual and wind-driven dynamics of the North Adriatic in summer.

The main feature of the current time series is variability at time scale of about ten days. Therefore, the analysed one-month period has been divided into three nearly equal subintervals with almost constant direction of current vectors. For each subinterval residual currents have been calculated and are presented in Figure 1. They indicate the existence of cyclonic gyre in the northernmost part of the Adriatic Sea. In the southern part of the measurement polygon anticyclonic gyre is observed at the beginning of the experiment, whereas cyclonic gyre is found there at the end of the experiment.The latter circulation pattern, consisting of two cyclonic gyres that dominate the open Adriatic waters, is typical for the summer period (Orlić, 1989). Present current records suggest shifting of the gyres at the time scale of about ten days. A similar phenomenon has been observed by Italian researchers in the north-western part of the Adriatic Sea. Some evidence for such a current variability in the summer 1979 is presented by Michelato (1983) and analysed in a modelling framework by Malanotte-Rizzoli and Bergamasco (1983). Accerboni et al. (1989) have reported on the similar current variations in the summers of 1983 and 1984.

During the analysed measurement interval only two wind episodes have been recorded (each lasting for about a day). Consequently, measured variations in circulation pattern may be attributed to thermohaline forcing, as was also pointed out by Malanotte-Rizzoli and Bergamasco (1983) for the summer 1979. Alternatively, such a variability can be interpreted in terms of baroclinic waves propagating through the North Adriatic.

The two wind episodes have generated response which has considerably changed current field for a short period of time. Temperature records at three analysed locations have shown that both wind episodes induced vertical mixing and appreciable decrease of surface water temperature.

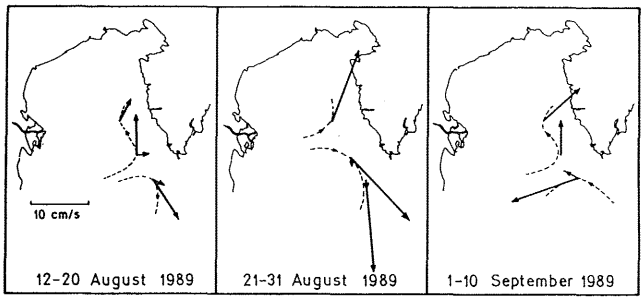

Figure 1. Surface (——) and bottom (——) residual currents and schematic representation of streamlines (---) in the North Adriatic during the summer 1989.

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ACCERBONI, E., MICHELATO, A., SCARAZZATO, P., VIEZZOLI, D., 1989. Caratteristiche dinamiche e termoaline dell'Adriatico centro-settentrionale nel periodo primavera - estate. Bollettino di Oceanologia Teorica ed Applicata, Numero speciale : 19-39.

MALANOTTE-RIZZOLI, P., BERGAMASCO, A., 1983. The dynamics of the coastal region of the northern Adriatic Sea. Journal of Physical Oceanography, 13 : 1105-1130.

MICHELATO, A., 1983. Caratteristiche della circolazione delle acque costiere dell'Emilia-Romagna. Eutrofizzazione dell'Adriatico - Ricerche e linee d'intervento, Bologna: 149-168.

ORLIć, M., 1989. Salinity of the North Adriatic: a fresh look at some old data. Bollettino di Oceanologia Teorica ed Applicata, 7 : 219-227.