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Applied Mathematical Modelling 31 (2007) 564–577
APPLIED MATHEMATICAL MODELLING
www.elsevier.com/locate/apm

Residual currents and corridor of flow in the Rio de la Plata

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Received 1 September 2004; received in revised form 1 February 2005; accepted 23 November 2005
Available online 15 February 2006

Abstract

The Rio de la Plata is a large and shallow water body that discharges onto the Atlantic Ocean. The main driving forces for the river flow are the bathymetry, tides, the outflow from the Paraná and Uruguay rivers and the winds. A numerical model covering the entire river was set up with the objective of increasing our understanding of the hydrographical features and morphological dynamics in the Estuary. The simulations revealed a counter-clockwise residual circulation in the Samborombón Bay and an eastward net flow near the Uruguayan coast. The residual flow is forced by both the tides and the bathymetry. The residence time for the entire river ranges from 40 to 80 days. However, residence times above 120 days was found in the Samborombón Bay. Three corridors of flow have been identified.

Keywords: Hydrodynamic modeling; Rio de la Plata; Residual currents; Corridor of flow

1. Introduction

The Rio de la Plata is exposed to extreme meteorological and hydrological conditions. Occasional cyclone surges in combination with tides have had devastating effects on the inner part of the river, causing livestock as well as property losses. We will focus on the residual flow during non-cyclonic conditions, since little research has been conducted in this area.

The results presented were obtained during the Project ''Environmental Protection of the Rio de la Plata and its Maritime Front'' (FREPLATA). The ultimate aim of the FREPLATA was to increase the physical understanding of the Rio de la Plata and to promote a sustainable development. Approximately 5 million people live in the area. Important questions have been raised about the fate of contaminants released from the city of Buenos Aires or about the feasibility of dredging for a seaport. Unfortunately, the available hydrodynamic data and knowledge necessary to help answer some of these questions remain inadequate. One objective was to increase our limited knowledge on the hydrographical features and the morphological development of the river.

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0307-904X/$ - see front matter
doi:10.1016/j.apm.2005.11.033

The outline of the residual circulation and its forcing helps us understand the transport of contaminants, the horizontal salinity distribution as well as the dynamic morphological conditions, in order to answer some of the important management questions.

The Rio de la Plata is a coastal plain estuary, which drains the Plata Basin towards the Atlantic Ocean (Fig. 1). The driving forces can be divided into topography, oceanographic conditions outside the Estuary (astronomical and meteorological tides), hydrology of the adjacent watershed (river discharge) and meteorological conditions (winds) in the river itself.

Moreover, the western South Atlantic, where the river discharges, is a distinctive region of the ocean where water masses produced in very distant regions merge. The confluence between the warm and salty Brazil Current and the cold and fresh Malvinas Current occurs at approximately 38 degree South, with the presence of a strong frontal region and very active dynamics.

From the hydrodynamic point of view the Rio de la Plata behaves as an estuary since water currents are controlled basically by the oceanic tides penetrating through its mouth. Though the tide amplitude is small (about 0.60 m between low and high tide), the large river width (minimum of 40 km) allows for a tidal prism which dominates the flow regime despite the significant discharge received from the tributaries (average of 22,000 $m^3 s^{-1}$). The base flow generated by this discharge is strong enough to prevent saline water penetration into the inner river, extending from its head to upstream the imaginary line traced along Punta Piedras (Argentina)—Montevideo (Uruguay). The Plata's denomination as a river, instead of as an estuary, arises precisely from this freshwater characteristic. Saline stratification can be detected in the outer region, though complete vertical mixing can occur for strong wind conditions [1]. Salinity structure and distribution and accompanying processes, like sedimentation, are modulated in such a way that they control, among other effects, spawning and fish recruitment.

The Rio de la Plata is divided in three regions: upper, intermediate and outer. The upper estuary is located upstream the Buenos Aires-Colonia line. The delta platform has a gently sloping fan with depths of 1–4 m.

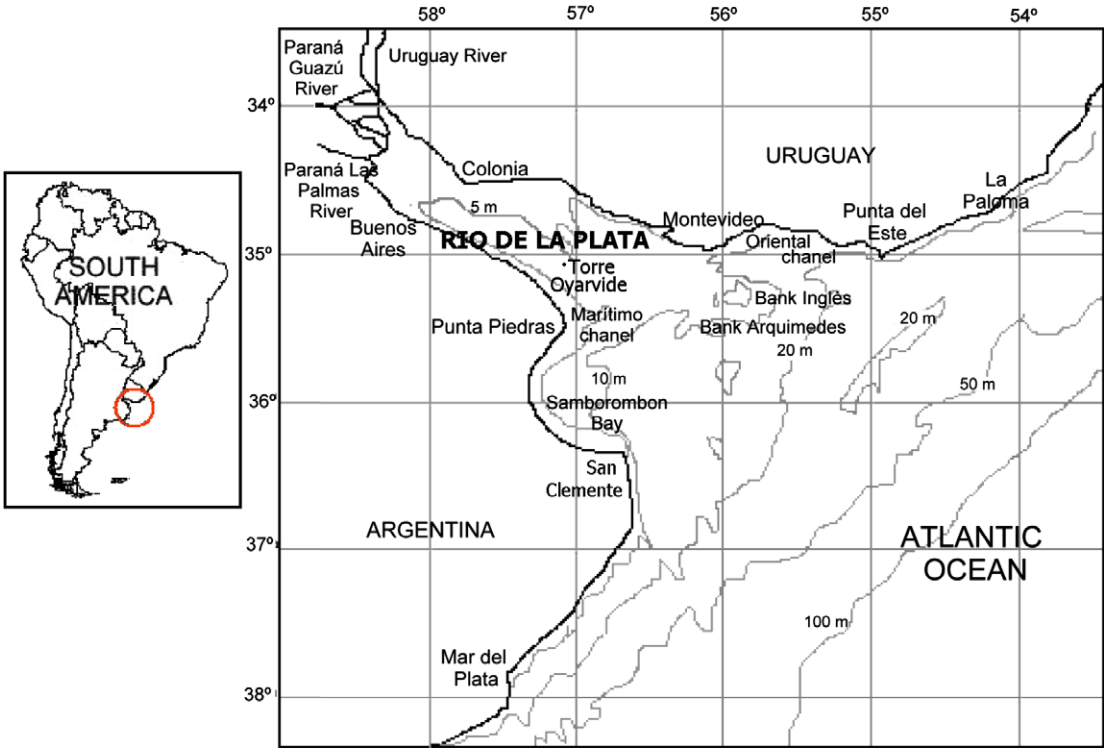

Fig. 1. The Rio de la Plata study area. Bathymetry in m below mean sea level.