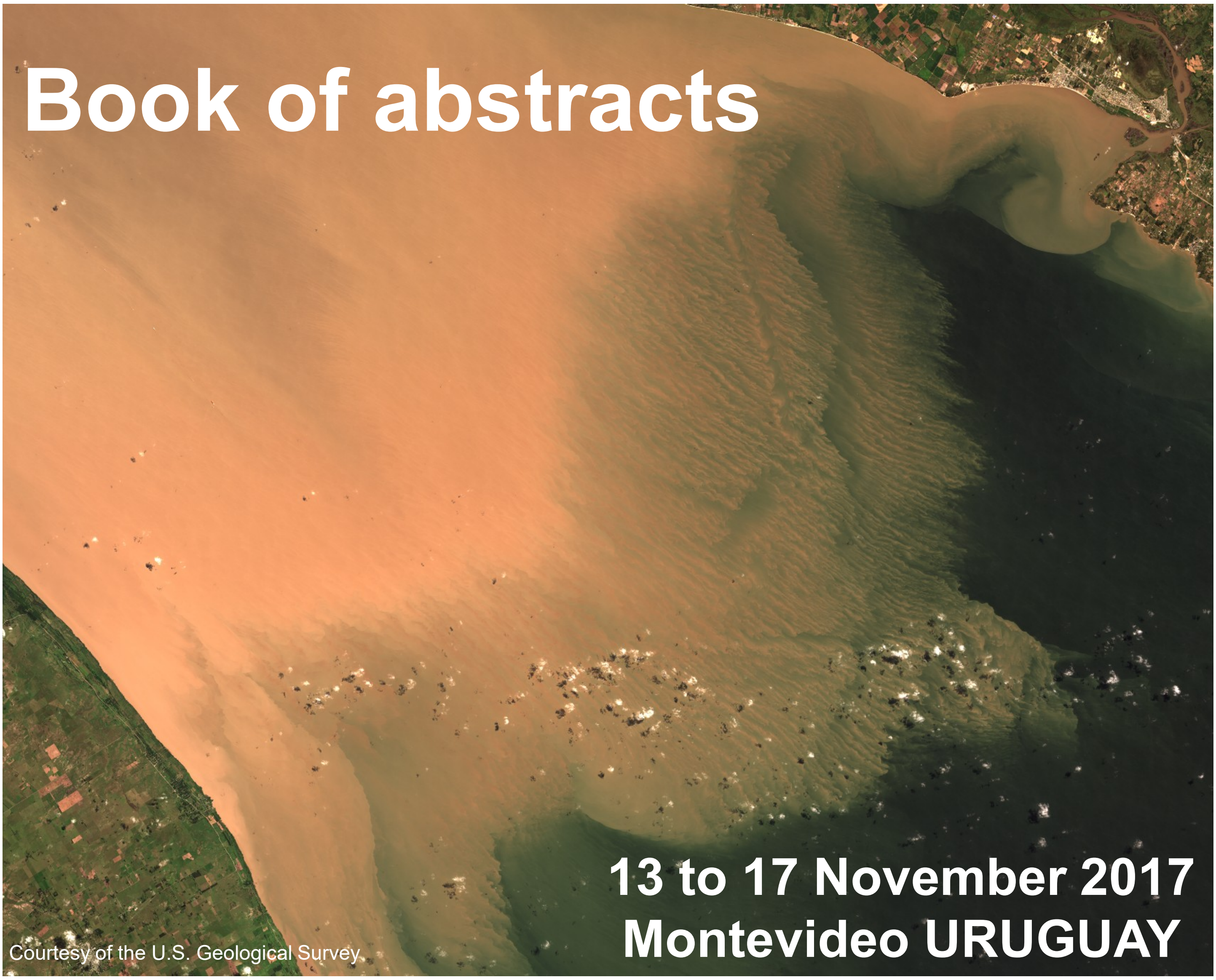
INTERCOH 2017
Montevideo - Uruguay
November 13 - 17

14th International Conference on Cohesive Sediment Transport Processes



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FACULTAD DE INGENIERIA

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Fundación Julio Ricaldoni
INGENIERÍA EN EL URUGUAY

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Book of abstracts

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INTERCOH 2017 - 14th International Conference on Cohesive Sediment Transport Processes is organized by the Instituto de Mecánica de los Fluidos e Ingeniería Ambiental (IMFIA), Facultad de Ingeniería, Universidad de la República.

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Preface

INTERCOH2017 is the 14th edition of the biannual meeting that gathers the international community of scientists and engineers, who have chosen to embrace the challenge of study, work, and find engineering solutions in fluvial, estuarine, and marine environments where cohesive sediments dominate the sediment dynamics in a close relation with the hydrodynamics, chemistry, and biology. More information on the past and future meetings and the activities of the cohesive sediment research community can be found on www.intercoh.org.

When I had just graduated as an hydraulic and environmental engineer, and was starting to look at flocculation dynamics, an officemate told me the following story: a well know engineer that was visiting Uruguay was asked if, having worked and researched extensively on sediment transport, he had not considered studding cohesive sediments, to what he replied "I like to see the result of my research during my lifetime". I kept that phrase in my mind and recall it every time I feel that the progress we are making is not successful or fast enough. For some of us that live in front of one of the largest estuaries of the world staying clean was not an option and we happily decided to dive ourselves into the "mud" and the study of the wonderful complexity of cohesive sediment dynamics.

This is the second time that the INTERCOH Meeting comes to South America; the previous time was in 2009 in the cities of Rio de Janeiro and Paraty, Brazil. The need of engineering solutions in the Rio de la Plata and the Montevideo Bay made that the study of cohesive sediments started early. The Montevideo Port is literally build on mud and dredging and building in the area required the study of the cohesive sediments in the area as early as 1871. The "recent" study of cohesive sediments in the Universidad de la República, started with the experiences of Oscar Maggiolo in the late 60s and early 70s. The research on cohesive sediments stopped, as most of the research in the country, during the 11 years of dictatorship, during which most of the research team that worked with Maggiolo was expelled from the University and several had to leave the country. You can still see the gap for those years in the Journal of Fluid Mechanics collection at our library. With the return of the democracy, the cohesive sediment research at the University also returned in the newly created Instituto de Mecánica de los Fluidos e Ingeniería Ambiental (IMFIA), and the work on cohesive sediments has continued for the last 30 years.

The abstracts on this book summarize the current activity of research groups across the globe, covering the topics of: Mud rheology and fluid mud; Suspended matter and flocculation; Bed shear, erosion and bed exchange; Sediment characterization; Siltation, Dredging and plumes; Biological and ecological controls; Coastal and estuarine hydrodynamics; Coastal and estuarine morphodynamics; and Wetlands dynamics. The review of the abstracts was in charge of the INTERCOH Steering Committee, while the Local Committee was in charge of the editorial duties, with the help of Susana Vinzón and Carl Friedrichs. We expect that the complete works will be submitted to an Special Issue in the Topical Collection of the Ocean Dynamics journal.

This current edition of INTECOH is possible thanks to the work and help of several people. First, thanks to the Steering Committee, Ashish Mehta and Han Winterwerp for trusting us the organization of the meeting. Also thanks to Susana Vinzón and Carl Friedrichs for their help during the review process, to Erik Toorman and Larry Sanford for their advice and tips for the organization of the meeting. Thanks to the Local Committee; Dominique who was in charge of the secretary; Gonzalo Rodriguez, who was in charge of the webpage and the informatics; the School of Engineering Accountant Office, which managed the founds; the School of Engineering Dean, María Simon, and the School Board for their support and allowing us to use the school facilities for the meeting. Finally, thanks to my Colleagues: Christian Chreties, Sebastián Solari, and Rodrigo Alonso; and the Students: Michael Jackson, Daniela Martinez, Guillermo Echavarría, Manuel Teixeira, and María Ballesteros; for their support and help during the event.

Finally thanks for the support of the Sponsors: Delegación Uruguaya a la Comisión Técnico Mixta de Salto Grande, Intendencia de Montevideo, Hidrovía S.A., Delegación Uruguaya a la Comisión Administradora del Río de la Plata, ANCAP, Saceem S.A. Your support is truly appreciated.

Welcome to Montevideo.

Prof. Francisco Pedocchi
Chairman INTERCOH2017

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Modelling unsteady flow and sediment deposition in large lowlands rivers: An application to the Paraná River

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Abstract

In this work a quasi-2D model suitable for the simulation of time-dependent water flow and fine sediment transport processes in large lowland river-floodplain systems is presented. This rivers formed by main channel-floodplain involve large exchanges of water and sediments within the system, as well as nutrients and biota. Floodplains play an important role in river flood attenuation, it is important to understand floodplain inundation dynamics in order to make decisions on flood risk management. The deposit of fine sediments is the process responsible for the long-term modification of the floodplain. Moreover, it can become a reservoir of contaminated sediments. Large lowland river-floodplain systems have very complex morphology with a network of permanent channels, interconnected lagoons, natural levees. The sediments are transported mainly as wash load. These systems have flooding duration on the order of several months, with a gradual and fairly slow floodplain filling due to overbank flows from the main stream and secondary floodplain channels. Quasi-2D models can capture the fundamental characteristics of water flow and sediment dynamics in these areas. These slow dynamics are compatible with the hypothesis on which quasi-2D models are based allowing for an effective compromise between computational costs and process representation. In this contribution, the application of a quasi-2D unsteady flow and sediment transport model in a large lowland river system is presented. The study area comprises a reach 208 km long of the Paraná River (between Diamante-Ramallo, Argentina) representing total a river-floodplain area of 8,100km^2. The model was already calibrated and validated in previous work. In this paper, the model results corresponding to simulations of water and sediment dynamics during a recent five-year period are presented.

CTSS8-FLUSED model

Water flow is simulated with the CTSS8 hydrodynamic model (Riccardi, 2000). The governing equations for the quasi two-dimensional horizontal time-depending flow field are represented by the well-known approach of interconnected cells (Cunge, 1975). Water continuity for each link between cells is used. Different discharge laws between cells can be used. Fluvial type links can be specified by means of kinematic, diffusive, quasi-dynamic and dynamic discharge laws derived from the Saint Venant momentum equation. In order to deal with special features of fluvial systems, weir-like discharge laws representing natural sills, levees, road embankments, etc., are included in the model. The spatial distribution of model parameters and hydrodynamic variables is done through the subdivision of model domain in irregular cells.

The sediment module FLUSED (Basile *et al.*, 2007) incorporated into the CTSS8 model simulates transport of fine sediments and deposition processes by solving the quasi-2D continuity equation of suspended sediment, which for the j-th cell reads (neglecting horizontal diffusion):

$$A_{s\,j}\frac{\partial(hC_s)_j}{\partial t} = (A_s\,\phi_s)_j + \sum_{k=1}^{N}(QC_s)_{j,k} \qquad (1)$$

where h is the water depth in the cell, Cs is the volumetric sediment concentration and ϕ_s is the downward vertical flux of fine sediments (deposition rate), expressed as: $\phi_s = P_d\; w_s\, C_s$, where Pd is the probability of deposition; w_s is the fall velocity of suspended sediment particle. The probability Pd of particle remaining deposited is given by:

$$P_d = 1-(U/U_{cd})^2,\; if\;\; U < U_{cd} \qquad (2)$$

where U is the mean flow velocity and Ucd is the critical mean flow velocity for deposition. Water flow and sediment equations are solved using a finite difference numerical scheme. Water levels in each computational cell are determined by an implicit algorithm and water discharges are successively obtained by applying the discharge laws between cells. Using an implicit algorithm, suspended sediment concentration, horizontal and vertical sediment fluxes are determined. Additionally, mean and total cumulative daily, monthly and annual sediment deposition (volume and weight) as well as bed level changes are computed for each cell. The initial conditions are represented by the water levels, discharges and sediment concentrations at each computational cell of the simulated domain. Boundary conditions for water flow are represented by the hydrographs at the upstream end of the reach and by water depth-discharge relations at the downstream boundary. The incoming suspended sediment transport at the upstream end is specified.

Study area

The model was implemented along a 208-km reach of the Paraná River, Argentina, between Diamante and Ramallo and involving a river-floodplain area of 8,100km^2. The floodplain is morphologically complex, due to past episodes of sea-level rise and climate change. A well developed network of surface-floodplain channels, oxbow lakes, lagoons, permanent pond areas, and different types of vegetation can be observed. The floodplain width in the study area varies between 30 and 60km, while the width of the main channel varies from 0.5 to 3km. The mean annual water discharge at station Rosario is 17,000m^3/s, while during the extraordinary floods of 1983 the maximum water discharge was approximately 60,000m^3/s with almost 30,000m^3/s flowing in the main stream, and the floodplain was completely inundated. The minimum water discharge observed at Rosario was 6,700m^3/s, in 1970. The ratio between maximum and minimum water discharges is 9, a rather low value as in other large rivers of the world. A 56-km long road embankment connecting Rosario and Victoria (RV) crosses the entire floodplain.

The annual average total sediment transport entering the system is approximately 150×10^6t/yr, of which 83% is composed of silt and clay transported in suspension as wash load. Sediment load entering the system is the main driver of changes in floodplain levels over long time periods. In general, suspended sediment concentrations vary seasonally, from 50 to 60mg/l up to 500 or 600mg/l (that occurs between March and April) in the main stream. Annual mean values are approximately within the range of 150 to 250mg/l. The few available measurements in the floodplain indicate lower values, typically below 100mg/l.

Application of the model

The topological discretisation was carried out by selecting river cells and valley cells, and by defining the different type of links between cells to represent special topographic features (natural levees, road embankments, bridges, etc.). Currently, the model has 1413 stream cells that represent the main stream, secondary surface-floodplain channels and the Coronda river tributary and 140 floodplain cells representing the alluvial valley and islands, with 4248 links between the different cells. Calibration (for low, medium, and high water stages) and validation results were very satisfactory, with the average error in calibration lower than 10% at all stations and most Nash-Sutcliffe coefficients were above 0.8 (Garcia *et al.*, 2015). The different water stages (specially medium and high) are well reproduced by the model. In this work a recent hydrological five-year were simulated (Sep 2010-Ago 2015), with incoming discharges derived from available records in upstream stations.

Sediment transport and deposition simulations were performed by using synthetics sedigraphs (determined from available historic suspended sediment concentrations and water discharges) and sedimentological parameters (sediment fall velocity for a range between coarse clay (3.35μm) to medium silt (21.2μm), critical mean flow velocity for deposition of the 0.15m/s, sediment porosity 0.42).

Model results

The obtained results of hydrodynamic simulations of observed floods are very satisfactory, with an average error between calculated and observed daily water levels and discharges lower than of 15% in all stations. Moreover, the Nash-Sutcliffe coefficients obtained (0.86 to 0.92 in the principal registration stations, and 0.56 to 0.61 in others stations) indicate an adequate model performance.

From the results of the analyzed periods, it can be indicated that the higher deposits were observed in cells corresponding to lagoon areas in which the flow velocity was very low, and also in cells where the floodplain widened. Practically no deposition occurred in the main stream. The simulation results for all observed floods show that average annual incoming sediment load were 76.7×10^6t/yr. The annual average deposition over the entire domain (floodplain-channel system) varied from 10.2×10^6 to 17.5×10^6t/yr and, thus, the entire domain retained between 13% and 23% of the incoming sediments. The amount of sediment deposited on the floodplain varied from 3.4×10^6 to 4.4×10^6t/yr, representing a retention of 4.5% to 5.7%. Such deposits induces an increase in floodplain bed levels of the order of 0.3 to 0.4mm/yr. The present results constitute an important advance in the knowledge of sedimentation processes in the reach.

References

Basile, P.A., Riccardi, G.A., Garcia, M.L., and Stenta, H.R. (2007). Quasi-2D modeling of hydro-sedimentological processes in large lowland river-floodplain systems. Workshop on Morphodynamics Processes in Large Lowland Rivers, National Center for Earth-Surface Dynamics (USA) and National University of Litoral, Cayastá, 3 p. Santa Fe, Argentina.

Garcia, M.L., Basile, P.A. and Riccardi, G.A. (2015). Modelling extraordinary floods and sedimentological processes in a large channel-floodplain system of the Lower Paraná River (Argentina). International Journal of Sediment Research, 30 (2): 150–159.

Riccardi, G.A. (2000). A quasi-2D hydrologic-hydraulic multilayer simulation system for rural and urban environments. Doctoral thesis, Faculty of Exact, Physical and Natural Sciences, National University of Córdoba, Argentina (in Spanish).