Earth Surface Processes and Landforms

River, Coastal And Estuarine Morphodynamics: selected papers from the 10th anniversary of the RCEM Symposium

Journal:	*Earth Surface Processes and Landforms*
Manuscript ID	Draft
Wiley - Manuscript type:	ESEX commentary
Date Submitted by the Author:	n/a
Complete List of Authors:	Guido, Zolezzi; Universitá di Trento, Dipartimento di Ingegneria Civile, Ambientale e Meccanica Carniello, Luca; Universita degli Studi di Padova Dipartimento di Ingegneria Civile Edile e Ambientale, Department of Civil, Environmental and Architectural Engineering D'Alpaos, Andrea; University of Padova, Gesciences; University of Padova, Gesciences Lanzoni, Stefano; University of Padua, IMAGE Tubino, Marco; University of Trento, Department of Civil, Environmental and Mechanical Engineering
Keywords:	morphodynamics, discipline integration, river, coast, estuary
Abstract:	This Special Issue collects 17 selected contributions from participants to the 10th edition of the RCEM (River, Coastal and Estuarine Morphodynamics) Symposium, organized in Padova-Trento (Italy) in September 2017. The series of biennial RCEM Symposia has the key goal of enhancing interaction and promoting integration among the scientific communities focused on the morphological dynamics of river, coastal and estuarine environments, though various combinations of theoretical, observational, experimental and modelling approaches. The 17 contributions to this Special Issue contain 4 state of science reviews and overall offer a broad view of the cross-cutting perspective adopted when addressing morphodynamics. Such perspective accounts for the mutual interplay between morphology, fluid dynamics and other environmental factors, and has presently become a widespread paradigm to address landscape evolution.

Special Issue
River, Coastal and Estuarine Morphodynamics:
selected papers from the 10th anniversary of the RCEM Symposium

GUEST EDITORS
Guido Zolezzi, University of Trento, Italy – guido.zolezzi@unitn.it
Luca Carniello, University of Padova, Italy, luca.carniello@unipd.it
Andrea D'Alpaos, University of Padova, Italy, andrea.dalpaos@unipd.it
Stefano Lanzoni, University of Padova, Italy, stefano.lanzoni@unipd.it
Marco Tubino University of Trento, Italy – marco.tubino@unitn.it

ABSTRACT
This Special Issue collects 17 selected contributions from participants to the 10th edition of the RCEM (River, Coastal and Estuarine Morphodynamics) Symposium, organized in Padova-Trento (Italy) in September 2017. The series of biennial RCEM Symposia has the key goal of enhancing interaction and promoting integration among the scientific communities focused on the morphological dynamics of river, coastal and estuarine environments, though various combinations of theoretical, observational, experimental and modelling approaches. The 17 contributions to this Special Issue contain 4 state of science reviews and overall offer a broad view of the cross-cutting perspective adopted when addressing morphodynamics. Such perspective accounts for the mutual interplay between morphology, fluid dynamics and other environmental factors, and has presently become a widespread paradigm to address landscape evolution.

RCEM: 17 selected papers presenting a cross-cutting perspective on river, coastal and estuarine morphodynamics

EDITORIAL

RCEM (River, Coastal and Estuarine Morphodynamics) are a series of biennial symposia aiming at:

i) enhancing the interaction among the scientific communities involved in research on morphodynamics of river, coastal and estuarine environments;
ii) promoting integration among disciplines (hydraulic engineering, geomorphology, applied mathematics, ecology, sedimentology, forestry, remote sensing) and among approaches (theoretical, observational, experimental, modeling) adopted in the study of river, coastal and estuarine evolution processes.

The term "morphodynamics" started to be employed in very different research fields in the 1970s, from the morphological evolution of nervous tissues in biology (e.g. Jacobson and Gordon, 1976) to earth surface processes, initially in relation to the evolutionary dynamics of coasts (e.g. Wright, 1977). "Morphodynamics" has since then been increasingly used with reference to many other environments in the earth surface, and the "morphodynamics approach", which accounts for the mutual interplay between morphology and fluid dynamics, has become a widespread paradigm to address landscape evolution.

The series of RCEM Symposia was particularly focused on the action of water flow in different environments (river, estuaries, tidal and delta regions, coasts) and the first edition (Genova, Italy,

1999) took its inspiration from the many similarities among the (bio)physical processes responsible for bedform, planform and in general landform pattern dynamics across these environments.

The spirit of the symposium did not change over time until its tenth edition, increasing the sense of belonging to the RCEM international community that expanded form the 118 contributed abstracts participants to the first edition to the 272 abstracts contributed to the 10th edition (Figure 1B). Such increase parallels the general growth of the scientific community in the field, with a strong increase in the number of indexed publications (Scopus database) having "morphodynamics" either in their title, abstract or keywords (grey bars in Figure 1A). These trends likely reflect a more general growing trend in the number of scientific publications in all fields of knowledge, estimated in the average between 8% and 9% every year by Bornmann and Mutz (2015). The yearly increase in the number of morphodynamics-related records has been even higher than such average rate (see black symbols in Figure 1A), showing a large scatter and an average yearly increase rate that slightly reduces when considering the most recent years, from 23% (1977 – 2019) to 15% (2000 – 2019) and 5% (2010 – 2019).

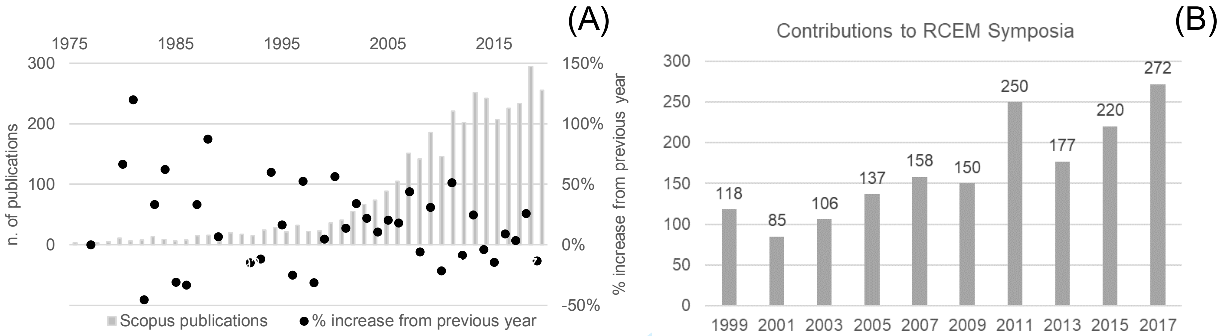

Figure 1. (A) Number of Scopus publications having the word "morphodynamics" either in their title, abstract or keywords and percentage increase of the number of publications compared to the previous year. Only records belonging to journals relevant to earth surface processes have been included. (B) Number of accepted abstracts for the first ten RCEM Symposia.

This Special Issue draws from the 10th anniversary of the RCEM Symposium, held in Padova-Trento (Italy) in September 2017. It provides a few examples of the cross-cutting perspective adopted to address the morphodynamic of fluvial, coastal and estuarine environments within the RCEM community. The collected 17 contributions include four State of Art papers concerning the most recent advances in computational morphodynamic modeling of coupled flow-bed-sediment systems (Shimizu et al., 2019), a critical analysis of existing data on vegetation-flow-sediment interactions obtained through both laboratory experiments and field campaigns (Tinoco et al. 2019), a review of existing moving-boundary theories of shorelines with two extensions to allow inclusion of first-order effects of waves and tides (Voller et al., 2019), and an overall assessment of the role played by wave forcing on the hydro-morphodynamics in shallow nearshore areas and at river mouths (Brocchini, 2019). The other 13 papers cover different topics about morphodynamics, spanning multiple environments, tackling concepts and processes with the aid of refined theoretical and numerical tools (Redolfi et al., 2019; Tambroni et al., 2019), grounding the results on laboratory data (Finotello et al., 2019; Geng et al., 2019; Matoušek et al., 2019, Porcile et al., 2020) and field observations (Fogarin et al. 2019, Tommasini et al. 2019), and making use of interdisciplinary approaches (Calvani et al. 2019; Cheng et al., 2019, Pivato et al. 2019, Van der Vijesel et al., 2020) also to develop new conceptualizations (Schlömer et al., 2020).

Analytical modelling has been at the core of theoretical morphodynamics well before the beginning of the RCEM symposia, especially when computational tools did not allow powerful numerical simulations of the governing differential equations of fluid flow over movable boundaries. Despite massive improvements in computational power, analytical approaches are still essential to capture the key physical processes and controlling parameters of several morphodynamic problems, as exemplified in the papers by Redolfi et al. (2019) and Tambroni et al. (2019) for fluvial and tidal environments, respectively. Redolfi et al. (2019) present a theoretical analytical framework that clarifies the intrinsic "free" instability and the role of external forcings that control the dynamics of river bifurcations, based on morphodynamic influence. As confirmed by comparison with experimental data, under super-resonant conditions of the upcoming flow, fluvial bifurcations are found to invariably evolve towards unbalanced configurations of the downstream branches, independently of the external forcing (e.g., bed effects, slope advantage), which instead control the bifurcation stability under sub-resonant conditions. Tambroni et al. (2019) use analytical and numerical tools to investigate the basic mechanism that governs the evolution of topographic expansions and explore the instability of the bottom topography under conditions of steady, spatially expanding flow. The bar pattern emerging from numerical simulations is found to have consistent features with those observed in the field, suggesting that, in general, expansion acts to reduce bar development relative to an equivalent rectilinear flow.

The contributions by Finotello et al. (2019), Geng et al., (2019) Matoušek et al. (2019), Porcile et al. (2020) show how laboratory experiments can be used to unravel physical processes at quite different spatial and temporal scales and in different environments. Matoušek et al. (2019) explore experimentally the internal structure of intense collisional bedload transport, applying various measuring techniques (stereoscopic imaging techniques, Ultrasonic Doppler Velocimetry) to get a robust validation of the acquired dataset. Eventually, the collected data are used to assess how relations involving global quantities (discharge, friction factor, bed slope, flow depth), commonly used in hydraulic practice, perform in the presence of intense sediment transport rates. The dynamics of supply-limited bedforms in rivers is the subject of the work by Porcile et al. (2020), who performed three sets of laboratory experiments varying the initial thickness of the layer of alluvial sediment, a proxy for the sediment supply limitation. Increasing supply limitation results in longer and more complex bedform patterns, as revealed by Fourier spectral analysis of the bed morphology. At a much larger spatial scale, Geng et al. (2019) use a schematic lagoon to study the initiation and evolution of tidal channel networks. The dynamics and configurations of the synthetic networks show that ebb currents have a higher capability to initiate and shape tidal networks than flood currents. Overall, flood-dominated tides favor the formation of small-scale channel branches in the upper basin zone, while long lasting ebb-dominated tides result in more complex, wider and deeper tidal networks. The formation of tidal channel networks in depositional, fluvio-deltaic settings was investigated by Finotello et al. (2019) who address the morphological response of tide-influenced deltas subject to relative sea-level rise. They demonstrate that the action of tidal forcing can create composite deltas where distinct land-forming processes dominate different areas of the delta plain, shaping characteristic morphological features such as funneled distributary channels and branching networks of tidal channels. Tides effectively act to maintain distributary channels flushed and remove fluvial deposits from the delta topset, reducing avulsion frequency and resulting in greater shoreline transgression compared to identical, purely fluvial, deltaic systems.

The use of field data to develop useful tools for the monitoring and management of tidal environments and coastal infrastructures is illustrated by Fogarin et al. (2019). Adopting a multidisciplinary approach (multibeam backscatter data, sediment samples, underwater images) Fogarin et al. (2019) obtain detailed maps of the seafloor morphology, sediment distribution and benthic habitats at one of the tidal inlets of the Venice Lagoon. This high-resolution map is then be used to classify different benthic habitats, reflecting the spatial variability in hydrodynamics and sediment transport pathways, on the basis of a multidisciplinary approach that involves geomorphology, fluid dynamics and ecology. By combining observational evidence from the Venice Lagoon in the last four centuries and the results of numerical simulations, Tommasini et al. (2019) address the mechanisms controlling marsh edge erosion in shallow tidal systems. By analyzing the effects of the impinging wind waves on the retreat of salt-marsh boundaries, and how the temporal evolution of wind-wave fields over the last centuries affects erosional dynamics, they highlight that relating salt-marsh lateral erosion rates to mean wave-power densities provides a valuable tool to address long-term tidal morphodynamics. The study of Van der Vijesel et al. (2020) reveals a striking similarity between present-day sedimentary patterns in ridges and sedimentary patterns found in ancient stromatolites and Precambrian microbialite strata. Their laboratory study shows that biofilm sediment trapping and stabilization in ridges of present-day intertidal flats is found to be characterized by indicators of self-organization, suggesting an intriguing hypothesis whereby self-organization dynamics might have been captured in fossil microbialites, a notion that may be important for paleoenvironmental reconstruction.

Finally, the papers by Calvani et al. (2019) Cheng et al. (2019), Pivato et al. (2019) and Schlömer et al. (2020) focus on the complex interactions between morphodynamics and biological processes, reflecting the interdisciplinary spirit invoked in RCEM Symposia. Calvani et al. (2019) analyse the interactions between river morphodynamics and vegetation properties at the reach scale by using field observations and theoretical modelling. The study derives general scaling laws to capture how the hydrodynamic-induced vegetation mortality, and hence the flood regime of a river, can lead to vegetation zonation in convergent streams. The results provide observational evidence to test a previously developed theoretical model, reinforcing the importance of accounting for vegetation dynamics in river morphodynamics. Cheng et al. (2019) examine experimentally the effects of single and repeated-cycles of high and low bed shear stress on the stability of newly developed bio-sedimentary beds. The study shows that biofilm mediated intertidal sediments exhibit more complex erosional behavior than abiotic systems. Repeated cycles of shear stress, mimicking cyclic disturbance due to tidal flows and other episodic events, do not degrade the system stability but seem to enhance bio-stabilization. The study emphasizes the importance of the interplay between sedimentology, benthic biology, and hydrodynamics that control the behavior of coastal sediments. The bio-stabilizing effect of microalgae (microphytobenthos) on bed sediments is also the topic of the contribution by Pivato et al. (2019). Assuming that microalgae photosynthetic growth is mainly driven by bed sediment surface temperature and light availability, Pivato et al. (2019) developed a 1D model describing the vertical energy transfer and the temperature dynamics of the sediment-water continuum in shallow water conditions to estimate the local microalgae growth and the related stabilizing effect. Using this model Pivato et al. (2019) highlight the crucial role of bio-stabilization on the morphological evolution of shallow tidal systems and the related strong seasonal variations. Finally, Schlömer et al. (2020) propose a unifying hierarchical theoretical framework for "obstacle marks", sedimentary bedforms, created by the interaction between an obstruction exposed to a current. The framework identifies the boundary conditions and parameters controlling the major process dynamics of obstacle mark formation, and is illustrated with reference to laboratory experiments.

REFERENCES

1. Brocchini, M. (2019). Wave-forced dynamics in the nearshore river mouths, and swash zones. Earth Surface Processes and Landforms. https://doi.org/10.1002/esp.46999.
2. Bornmann, L., & Mutz, R. (2015). Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. Journal of the Association for Information Science and Technology, 66(11), 2215-2222.
3. Calvani, G., Perona, P., Schick, C., & Solari, L. (2019) Biomorphological scaling laws from convectively accelerated streams. Earth Surface Processes and Landforms. https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4735
4. Chen, X., Zhang, C., Paterson, D. M., Townend, I. H., Jin, C., Zhou, Z., ... & Feng, Q. (2019). The effect of cyclic variation of shear stress on non-cohesive sediment stabilization by microbial biofilms: the role of 'biofilm precursors'. Earth Surface Processes and Landforms, 44(7), 1471-1481. https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4573
5. Finotello, A., Lentsch, N., & Paola, C. (2019). Experimental delta evolution in tidal environments: Morphologic response to relative sea-level rise and net deposition. Earth Surface Processes and Landforms, 44(10), 2000-2015. https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4627
6. Fogarin, S., Madricardo, F., Zaggia, L., Sigovini, M., Montereale-Gavazzi, G., Kruss, A., & Trincardi, F. (2019). Tidal inlets in the Anthropocene: geomorphology and benthic habitats of the Chioggia inlet, Venice Lagoon (Italy). Earth Surface Processes and Landforms, 44(11), 2297-2315. https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4642
7. Geng, L., Gong, Z., Zhou, Z., Lanzoni, S., & D'Alpaos, A. (2019). Assessing the relative contributions of the flood tide and the ebb tide to tidal channel network dynamics. Earth Surface Processes and Landforms. https://doi.org/10.1002/esp.4727
8. Jacobson, A. G., & Gordon, R. (1976). Changes in the shape of the developing vertebrate nervous system analyzed experimentally, mathematically and by computer simulation. Journal of Experimental Zoology, 197(2), 191-246.
9. Matoušek, V., Zrostlík, Š., Fraccarollo, L., Prati, A., & Larcher, M. (2019). Internal structure of intense collisional bedload transport. Earth Surface Processes and Landforms, 44(11), 2285-2296. https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4641
10. Pivato, M., Carniello, L., Moro, I., & D'Odorico, P. (2019). On the feedback between water turbidity and microphytobenthos growth in shallow tidal environments. Earth Surface Processes and Landforms, 44(5), 1192-1206. https://doi.org/10.1002/esp.4567
11. Porcile, G., Blondeaux, P., & Colombini, M. (2020) Starved versus alluvial river bedforms: an experimental investigation. Earth Surface Processes and Landforms. https://doi.org/10.1002/esp.4800

12. Redolfi, M., Zolezzi, G., & Tubino, M. (2019). Free and forced morphodynamics of river bifurcations. Earth Surface Processes and Landforms, 44(4), 973-987. https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4561
13. Schlömer, O., Herget, J., Euler, T. (2020) Boundary condition control of fluvial obstacle mark formation – a framework from geoscientific perspective. Earth Surface Processes and Landforms. Accepted
14. Shimizu, Y., Nelson, J., Arnez Ferrel, K., Asahi, K., Giri, S., Inoue, T., ... & Kyuka, T. (2019). Advances in Computational Morphodynamics Using the International River Interface Cooperative (iRIC) Software. Earth Surface Processes and Landforms. https://doi.org/10.1002/esp.4653
15. Tambroni, N., Seminara, G., & Paola, C. (2019). On the incipient formation of bars and channels on alluvial fans. Earth Surface Processes and Landforms, 44(12), 2479-2493. https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4676
16. Tinoco, R. O., San Juan, J. E., and Mullarney, J. C. (2019) Simplification Bias: Lessons from Laboratory and Field Experiments on Flow through Aquatic Vegetation. Earth Surf. Process. Landforms, https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4743.
17. Tommasini, L., L. Carniello, M. Ghinassi, M. Roner, A. D'Alpaos (2019). Changes in the wind-wave field and related salt-marsh lateral erosion: inferences from the evolution of the Venice Lagoon in the last four centuries, Earth Surface Processes and Landforms, 44, 1633-1646. https://doi.org/10.1002/esp.4599.
18. Voller, V. R., Swenson, J. B., & Paola, C. (2019). The thin blue line: A review of shoreline dynamics across time scales and environments. Earth Surface Processes and Landforms. https://doi-org.ezp.biblio.unitn.it/10.1002/esp.4705
19. van de Vijsel, R. C., van Belzen, J., Bouma, T. J., van der Wal, D., Cusseddu, V., Purkis, S. J., Rietkerk M., van de Koppel, J. (2020) Estuarine biofilm patterns: Modern analogues for Precambrian self-organization. Earth Surface Processes and Landforms. https://doi.org/10.1002/esp.4783
20. Wright, L.D. (1977). Morphodynamics of a wave dominated river mouth. In: Proc. Fifteenth Coastal Eng. Conf. (Hawaii Univ., USA, Jul.11-17,1976), 2. American Soc.Civ. Engng., pp. 1721-1737.