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Editorial: River plumes and estuaries

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Editorial on the Research Topic
River plumes and estuaries

River runoff is an important driver of many physical, biological, and geochemical processes in coastal and shelf sea areas. The river-estuary-sea continuum represents a variety of complex interactions between the terrestrial freshwater discharge and ocean water. River estuaries are areas where freshwater discharge initially interacts with seawater. The related estuarine mixing processes define the source properties for river plumes, which in turn determine the plume's structure and govern its subsequent dynamics on the shelf. The intensity of estuarine mixing varies from negligible, when mostly undiluted freshwater discharge inflows directly into a coastal sea, to dominant, which results in significant dilution of river discharge in well-mixed semi-enclosed basins by the time it enters the shelf.

River plumes generally occupy wide, but shallow sea surface layer bounded by sharp density gradient. The area of a river plume is 3-5 orders of magnitude greater than its depth, therefore, even small rivers with discharge rates ~1–10 m^3/s form river plumes with horizontal spatial extents ~10–100 m. Areas of river plumes formed by the largest World rivers are ~100–1000 km^2. Despite relatively small volume of total freshwater runoff to the World Ocean, river plumes occupy up to 1/5 of shelf areas of the World Ocean and substantially influence global fluxes of buoyancy, heat, terrigenous sediments, nutrients, and anthropogenic pollutants, which are discharged into the coastal sea with continental runoff. River plumes are characterized by strong spatial inhomogeneity and high temporal variability caused by external forcing and mixing processes. Regional features (delta/estuary, enclosed bay/open sea, shoreline, bathymetry, etc.) also affect the morphology and behavior of river plumes. As a result, dynamics and variability of river plumes are key factors for understanding mechanisms of spreading, transformation, and redistribution of continental discharge and river-borne constituents in the coastal sea and their influence on the adjacent continental shelf.

Estuarine processes and river plumes received much attention during the last decades. Previous research provided general concepts of transport and mixing processes in estuaries (e.g., MacCready and Geyer, 2010; Geyer and MacCready, 2014; Burchard et al., 2018) and in river plumes (e.g., Yankovsky and Chapman, 1997; Lentz and Fewings, 2012; Horner-Devine et al., 2015). However, progress in observational sampling methods and in numerical model capabilities have brought new challenges in understanding the structure, dynamics, and variability of estuaries and river plumes, as well as the influence of freshwater discharge on processes in the coastal sea. This was the main motivation to organize this Research Topic.

A collection of 16 papers authored by 69 researchers in total were published in this Research Topic. The majority of these articles were focused on various aspects of the river plume dynamics. The influence of wind and tidal forcing on different river plumes was studied by Osadchiev et al., Yankovsky et al., and Whitney et al. Yankovsky et al. and McPherson et al. demonstrated that tidally-induced internal waves can strongly affect spreading patterns of river plumes. Zavialov described a new mechanism of oscillations of surface level of a small plume. Other related works analyzed the mechanisms that drives lateral spreading of river plumes (McPherson et al.) and mixing across the plume-sea interface (Ayouche et al.; Jiang et al.). Several works described variability of structure of specific river plumes on various temporal scales: synoptic variability of the Yukon plume (Clark and Mannino) synoptic and seasonal variability of the Pearl river plume (Zhi et al.), seasonal variability of the Red river plume (Nguyen-Duy et al.), seasonal and inter-annual variability of the Lena plume (Osadchiev et al.), as well as broad spectrum of meso- and submesoscale processes associated with the Gironde River plume (Ayouche et al,). Estuarine processes addressed in this Research Topic included ocean-estuarine exchange for the Gulf of Ob (Osadchiev et al.) and the Patos Lagoon (Bortolin et al.). Several works studied the influence of river plumes on estuarine and coastal ecosystems: sediment processes in the Rhine plume (Safar et al.) and the Patos Lagoon (Bortolin et al.), algal blooms near the Changjiang Delta (He et al.), distribution and grazing of zooplankton at the Laptev Sea shelf (Pasternak et al.).

Studies of river plumes and estuarine processes are mostly based on *in situ* measurements, remote sensing and numerical modeling. *In situ* measurements represent ground truth for studies of estuaries and river plumes. Generally, they provide discrete data with relatively low spatial and/or temporal resolution. As a result, studies based only on *in situ* measurements often have the inherent spatial or temporal limitations. Satellite and other remotely sensed data, on the other hand, provide sufficient spatial coverage of estuaries and river plumes. However, remote sensing is limited to surface processes and requires validation of sampled characteristics against *in situ* measurements. Numerical modeling reproduces the three-dimensional plume structure with relatively high spatial and temporal resolution. Albeit in many cases it is still not sufficient for many processes including submesoscale dynamics, internal waves, etc. Numerical studies also require thorough validation against *in situ* data, which is often lacking.

The methodology applied in manuscripts published in this Research Topic was either analysis of *in situ* data sets (McPherson et al.; Osadchiev et al.; Osadchiev et al.; Pasternak et al.; Safar et al.; Yankovsky et al.; Zavialov) or numerical modeling (Ayouche et al.; Clark and Mannino; He et al., Jiang et al.; Nguyen-Duy et al.; Whitney et al.; Zhi et al.). Several papers combined remotely sensed data with *in situ* measurements including Osadchiev et al. and Yankovsky et al. who used novel techniques of aerial remote sensing to measure surface currents within river plumes and Bortolin et al. who used satellite data to evaluate turbidity in the Patos Lagoon.

River plumes and estuaries have wide variety of regional features; therefore, it is important to study them in different geographical regions. It was the case of the Research Topic, which papers addressed river plumes and estuaries in the Arctic Ocean (Clark and Mannino; Osadchiev et al.; Osadchiev et al.; Pasternak et al.), in mid-latitudes in Northern (Ayouche et al.; Osadchiev et al.; Safar et al.; Whitney et al.; Zavialov) and Southern (McPherson et al.) hemispheres, in tropical coastal areas in the Eastern Asia (He et al.; Jiang et al.; Nguyen-Duy et al.; Zhi et al.), North America (Yankovsky et al.) and South America (Bortolin et al.).

Recent studies demonstrated that many processes are significantly different for small and large river plumes. Therefore, it is necessary to consider different spatial and temporal scales of transformation of river runoff in the sea and distinguish the obtained regional results for specific river plumes in context of these scales. The papers in the Research Topic covered all spatial scales of river plumes from the largest World rivers (Clark and Mannino; He et al.; Jiang et al.; Osadchiev et al.; Osadchiev et al.; Pasternak et al.; Zhi et al.) to medium-size (Ayouche et al.; Bortolin et al.; Nguyen-Duy et al.; Safar et al.; Yankovsky et al.) and small river plumes (McPherson et al.; Osadchiev et al.; Whitney et al.; Zavialov).

Author contributions

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Conflict of interest

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