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Nearfield flow and transport of suspended sediments discharged by the Rhône River into Lake Geneva (France/Switzerland)

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Rivers bring nutrients and pollutants into lakes either dissolved or attached to solid particles. Inflow momentum, the density difference between river and lake water, lake currents, and stratification strength determine the fate of river discharge and the development of river plumes. Therefore, these parameters need to be measured in order to characterize the dynamics of lake-river plume interaction.
For Lake Geneva, the largest freshwater lake in Western Europe, the Rhône River is the principal source of water (75% on average over the period 1965-2013) and sediments. Most of the time, it enters the lake as an interflow detaching from the lakebed or as a turbidity current flowing through a canyon and carrying sediments, mainly as bed load, during occasional high discharge events.
In this study, the dynamics of the Rhône River interflow plume in Lake Geneva was investigated in detail by performing repeated transects in the nearfield over a distance of 2 km from the Rhone River mouth during several campaigns in 2018. Profiles of water temperature and conductivity, particle-size distribution and concentration of suspended sediments were collected simultaneously with continuous acoustic Doppler velocity profiling. Four particle size classes representative of the suspended sediments in the river were studied (fine silt, medium silt, coarse silt and fine sand). An automated data acquisition system on our boat was used to record the GPS coordinates of the measuring stations together with the scientific data and to track the sampling trajectory. Data were accessible in real time, allowing the on-site visualization of the spatio-temporal development of the plume parameters with high precision along its path and the optimization of the sampling strategy.
Our measurements show that the Rhône river plume develops as an interflow that is trapped in the metalimnion. With distance from the detachment point, the interflow entrains water and spreads mainly horizontally, progressively losing momentum and as a consequence, most of the larger sized particles. The depth and the direction of the interflow change with the seasonal evolution of the thermal stratification and with the varying water mass movement in the lake characterized by large scale along-shore flows perpendicular to the river mouth and by eddies of different size. The interflow also interacts with the shallow lake-floor relief near the mouth. It was found that the interflow could be treated as a negatively buoyant jet. This permits volumetric and momentum flow rates to be calculated across the transects and water entrainment, and energy loss to be estimated.
This data set, covering a wide range of spatio-temporal variability of the buoyant river discharge, was used to validate a three-dimensional coupled hydrodynamic and sediment transport model. The model will serve to identify the contribution of mixing and vertical settling in the observed diminution of the suspended sediment concentration along the river plume trajectory and to make predictions of the river plume dynamics for a wider range of river discharge and lake hydrodynamic and thermodynamic conditions.