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# Hydrodynamics and mixing at the confluence of Rio Negro and Rio Solimões, Manaus, Brazil

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Confluences are a common feature of riverine systems, where are located converging flow streamlines and potential mixing of separate flows. It is generally acknowledged that the hydrodynamics and morphodynamics within the confluence hydrodynamic zone (CHZ) are influenced by (1) the planform of the confluence; junction angle of confluence, (2) momentum flux ratio of merging streams ($M_R$) and (3) the level of concordance between channel beds at the confluence entrance. Further any differences in the water characteristics (e.g. temperature, conductivity, suspended sediment concentration) between the incoming tributary flows and subsequent possible stratification may also impact on the local processes about the confluence.
Most studies about confluences have focused either on laboratory confluences or on small natural confluences, with only a limited number of studies conducted about large river confluences (e.g. channel width >100 m). The confluence of the Negro and Solimões Rivers near Manaus ranks among the largest on Earth and its study may provide some general insights into large confluence dynamics and processes. As part of the CLIM-Amazon Project (a joint European and Brazilian Research Project funded by the EU about climate and sedimentary processes of the Amazon River Basin) an investigation was conducted about that confluence in both low (October 2014 – $Q_N$=24900 $m^3$/s, $Q_S$=63500 $m^3$/s) and high (April/May 2015 – $Q_N$=32400 $m^3$/s, $Q_S$=106800 $m^3$/s) flow conditions. In these field trips, acoustic Doppler velocity profiling (ADCP) and high-resolution seismic methods, such as echo-sounding and sub-bottom profiling, were used as well as water sampling for the measurement of several water chemistry parameters (temperature, conductivity, pH, turbidity, oxygen isotopes) and suspended sediments concentration.
The main findings from these field studies were: (1) the differences in tributary water characteristics created lateral stratification about mixing interface and a rapid lateral change in velocity about mixing interface seemed to indicate that even the velocity shear had significant role in mixing processes. Furthermore even the lateral forces from converging flows have significant impact on confluence dynamics. During the field studies the width of the mixing interface (based on backscatter data) was initially in the order of hundred meters and ten meters in the low flow and high flow conditions, respectively. After all, the flow exhibited characteristics of both shear flows and gravity currents, but had complex dynamics due to strong interactions between the turbulent features of each; (2) common hydrodynamic and morphodynamic features noted in previous confluence studies, such as stagnation zone, velocity deflection and re-alignment zone, separation region with recirculation, secondary currents, scour hole and deposition areas, were observed; (3) an initial comparison to previous studies collected in smaller natural and laboratory confluences seemed to indicate some differences in the observed flow properties and structures within the initial portion of the downstream channel between laboratory and natural confluences, these differences could be related to the difference in tributary water characteristics observed in natural confluences; (4) a comparison between the data collected in the two field trips highlighted larger flow velocities (up to 3.2 m/s), water depth and, more generally, a larger CHZ in high flow conditions as well as mixing conditions different from those in low conditions.