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# On the projection of ADCP data associated to secondary currents driven by curvature on river bends

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Rivers dominate the landscapes, and the study of their morphology is relevant because they seldom form straight channels. Instead, they usually develop braids or meanders in response to sediment yield and bed slope at basin scale, and to bed and bank erosion processes at local scale. Therefore, the ability to simulate natural or artificial changes occurring along alluvial streams is the first step towards the design of most river management projects. Nevertheless, as the full understanding of all river morphodynamic aspects requires precise knowledge over a vast variety of spatial and temporal scales, separating scales constitutes an unavoidable short-cut in applied science. A process where flow and bank erosion time scales are uncoupled, albeit believed to be partially responsible for shaping the bed topography of river bends in the long term, is defined by the so-called helical flow.

Secondary currents represent a local process that scales with channel width (B) and water depth (H), and exhibits different behaviours depending on the aspect ratio $\beta$=B/H. These cross-stream circulations driven by centrifugal forces are important on their own right, despite the current belief that their role in shaping the bed topography has been over-emphasized over the years. Knowledge of the mechanics of three dimensional (3D) helical flow facilitates the prevention of silting, the location of navigation channels and water intakes, and the stabilisation of riverbanks. This helical motion indeed redistributes velocity, boundary shear stresses, and suspended matter across river bends, and alters the bedforms shape formed along meandering channels in flume experiments.

Although there exits a large body of experimental data on curved flows, there exits few field studies to date detailing the structure of helical flows driven by centrifugal forces. Today, ADCP (Acoustic Doppler Current Profiler) measurements have gained considerable acceptance because of their efficiency to compute river flow discharges from moving vessels across river transects, ruling out most of the inherent uncertainties associated with the use of other instruments. ADCP data are now routinely used to study 3D flows, and the trend is to repeat crossings along linear routes to resolve weak cross-stream velocities.

However, subtle aspects related to the classical method –the so-called Rozovskii method– used to detect this type of motion have not been accounted for in most studies of river bends and stream confluences. In this method, the motion at any measured point is decomposed into a cross-stream velocity with components oriented parallel and orthogonal to the depth-averaged velocity vector at each vertical. A limitation of this method is that it requires a continuity constraint for closure reasons, which yields one or more patterns of “apparent” circulation over the cross-section. The outcome of the Rozovskii method along any vertical profile should be seen as the excess (or deficit) of the radial velocity component relative to the respective depth-averaged value, contrary to the approach adopted here where the 3D absolute velocity relative to ground as captured by the ADCP is decomposed into tangential (along the cross-wise plane), normal (along the stream-wise plane), and up (along the vertical direction).

Different reaches of the alluvial system of the Paraná River, in Argentina, where selected to test the proposed methodology. It is therefore established that whenever centrifugal effects are up to the leading order (whose intensity seems to depend somehow on $\beta$), the secondary flow cell is always captured without the need to average repeated crossings, no matter if the cross-wise plane is not properly oriented (i.e. be strictly perpendicular to the primary flow plane). Additionally, the pattern of cross-circulation obtained is unique.