High curvatures drive river meandering

A. Finotello1*, A. D’Alpaos1, E.D. Lazarus2, and S. Lanzoni3

1 Dipartimento di Geoscienze, Università di Padova, 35131 Padua, Italy
2 School of Geography & Environmental Science, University of Southampton, Southampton SO17 1BJ, UK
3 Dipartimento di Ingegneria Civile, Edile e Ambientale (ICEA), Università di Padova, 35131 Padua, Italy
E-mail: alvise.finotello@unipd.it

Sylvester et al. (2019) challenge the concept in fluvial geomorphology that meander migration rates ($\zeta$) tend to decrease in bends of high curvature ($\mathcal{C}$) beyond a critical threshold $\mathcal{C}^* = CW > 0.25–0.5$, where $W$ represents the width of the river (Hooke, 2013). Analyzing several meandering rivers in the Amazon basin, and accounting for the spatial lag ($\Delta \mathcal{C}_T$) between the respective maxima in migration rate and curvature within meander bends, Sylvester et al. find significant correlation between field data and modeled migration rates computed in two different ways—as a function of the local channel curvature, and as the weighted aggregate of the upstream curvature—suggesting a monotonic relationship between migration rates and curvature that is not limited by a critical threshold in channel curvature, as previously thought. Here, we use the authors’ published data for rivers in the Amazon Basin (GSA Data Repository item 2019095) to offer that Sylvester et al. do not necessarily overturn the paradigm that migration rates reduce at high-curvature bends.

To align our analysis with the approach by Sylvester et al., we compute meander migration rates with a dynamic time-warping algorithm (https://github.com/mlt/QGIS-Processing-tools) corrected by the average spatial lag between maxima in migration rate and curvature ($\Delta \mathcal{C}_T$) in each individual channel reach. We show that the median binned values of migration rates ($\overline{\zeta} = \zeta/W$) consistently plateau at width-adjusted curvatures $\mathcal{C}^* > 0.25–0.30$ in all cases except the Jutai River (Fig. 1), suggesting saturation of $\zeta^*$ beyond a critical curvature threshold. The reaches Mamoré, Purus, and Purus2 even show a subtle decrease of $\zeta^*$ beyond $\mathcal{C}^* = 0.25–0.50$, indicating a peak in $\zeta$ over this critical range of $\mathcal{C}^*$. This peak in $\zeta^*$, however, is typically observed from the maximum values of the $\zeta^*$ distribution in $[\mathcal{C}^*; \mathcal{C}]$ space, rather than the distribution’s central tendency (see Hooke, 2013, and references therein). Analysis of the 95th percentiles of the $\zeta^*$ distribution reinforces evidence that bends where $\mathcal{C}^* < 0.50$–0.50 also reflect the highest $\zeta^*$, even with the spatial lag factored in (Fig. 1).

Realistic meandering patterns arise from fluvial models in which, much as Sylvester et al. describe, channel migration rate is a function of the weighted aggregate of local and non-local curvature, and the curvature-migration lag ($\Delta \mathcal{C}_T$) is implicitly embedded in the phase-lag between channel curvature and near-bank excess velocity, to which migration rates hold a direct proportionality (e.g., Frascati and Lanzoni, 2009). However, the morphologic characteristics of these simulated patterns show statistically meaningful deviations from natural meander-