Unraveling the Climate Effects of Eco-morphodynamic Carbon Cycling in Meandering Rivers

(Proposer: Alvise Finotello)

Meandering rivers represent some of the most dynamic geomorphological features on Earth, boasting sinuous channels shaped by continuous erosion and deposition along their inner and outer banks, respectively. This ongoing process of sediment movement across river plains leads to the gradual joining of channel bends, a phenomenon known as meander cutoff, which isolates segments of the channel. The interplay between channel migration and meander cutoff plays a pivotal role in determining the distribution of floodplain sediments' ages, with significant implications for understanding global terrestrial organic-carbon fluxes and related impacts on Earth's climate (Ielpi et al., 2023; Salerno et al., 2023; Torres et al., 2017)
However, these processes unfold over timescales far exceeding human lifespans, necessitating the use of long-term simulations conducted through numerical morphodynamic models to study meandering river dynamics (Bogoni et al., 2017; Camporeale et al., 2005; Ielpi et al., 2023). These models often assume that meandering rivers possess boundlessly expansive floodplains (i.e., they lack lateral constraints) and can migrate freely within them. Yet, lateral confinement, such as by terraces or valley flanks, has been shown to exert control over meander dynamics, affecting their downstream migration and lateral expansion capacity. This, in turn, influences their ability to form meander cutoffs and can shorten the characteristic timescales for sediment storage, with direct impacts on eco-morphodynamic carbon storage and pumping (*sensu* Salerno et al., 2023).

This research project aims to explore the degree to which rivers can freely meander and understand the impacts of valley lateral confinement on the morphodynamic evolution of meandering rivers, as well as the resulting distribution of floodplain ages and carbon fluxes. The PhD candidate will conduct numerical simulations using various meander-centerline-migration models to determine the extent to which the assumption of freely migrating meandering rivers holds true. Critical model parameters such as valley width (relative to river size), erodibility of floodplain soil and valley flanks, river width-depth ratio, and sediment physical properties will be systematically varied to identify potential thresholds in river morphodynamic behavior.
The modeling results will then be compared with a comprehensive compilation of natural river systems, using remotely sensed river and floodplain morphologies derived from freely available, h-resolution digital topographic data. This compiled archive of natural river systems will be utilized to constrain floodplain age distribution and estimate carbon fluxes in meandering rivers globally, via integration with numerically modelled co-evolution of river morphology and floodplain organic carbon stocks and fluxes.

Collaborations: Alessandro Ielpi (University of British Columbia, Canada); Daniele Viero (University of Padova, Italy); Mathieu Lapotre (University of Stanford, USA); Eli D. Lazarus (University of Southampton, UK).

Related funding: DOR – Finotello.

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