Why don't rivers straighten out over time?

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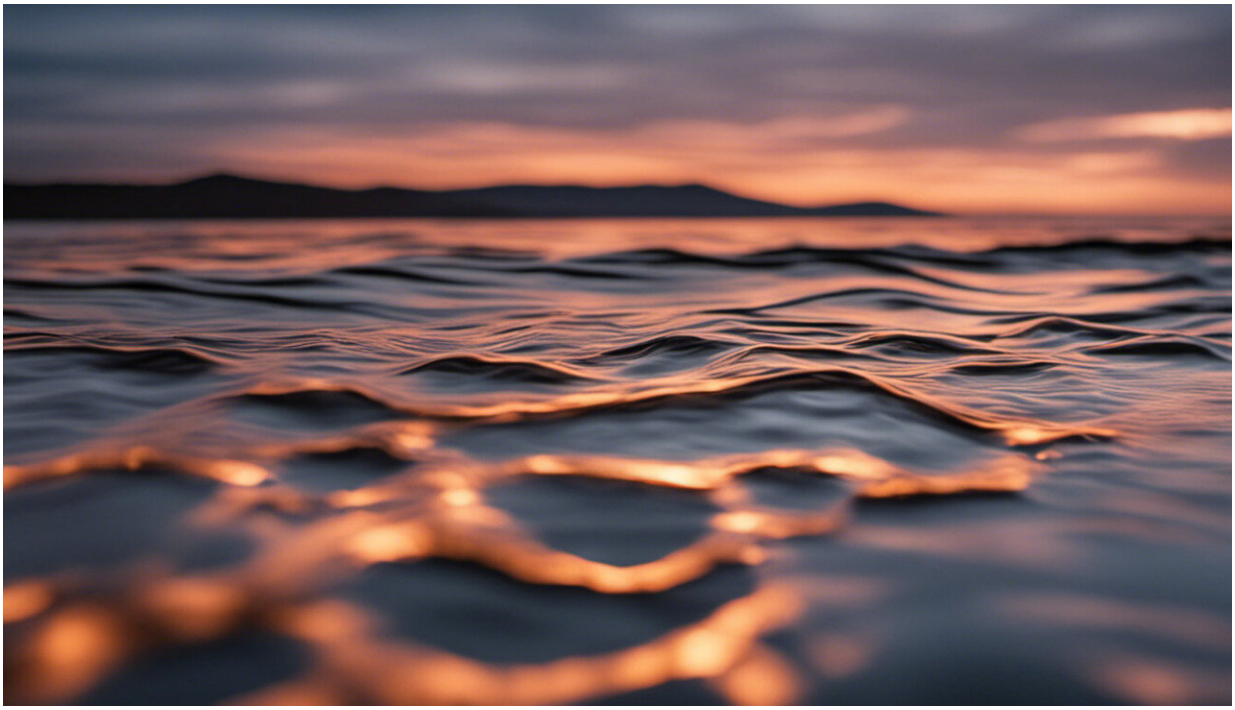

Credit: AI-generated image (disclaimer)

Seen from above, the world's greatest rivers can be recognized by their serpentine curves. But how do these shapes form, do they alter over time and does this matter? We turned to our river system expert, Carmelo Juez.

Water flows downhill, and as it does, follows the path of least resistance. And over time, the flow of a river can carve its way through mountains

in pursuit of this downward trajectory. So it seems counter-intuitive that they often get longer and more winding over time, rather than straighter.

But according to Juez, it's a misconception that rivers should follow a straight path from hillslopes to lowlands. Rivers develop bends and meanders, increasing resistance and reducing channel gradients, to manage the water energy as they cross floodplains.

"The geometry of these minimizes energy expenditure at each river section. Think about walking down a mountain, you could walk straight down but it takes less effort to zigzag down," Juez explains. As a river flows, it carries sediment with it, eroding some banks and reinforcing others.

"The only rivers with a uniform and regular geometry are man-made. These are rivers which have been channeled for civil infrastructure, such as flood protection, or to gain agricultural land," summarizes Juez.

A long and winding path

So what specifically determines the shape of a river, and how can that change over time? The path of a river is mainly influenced two key factors known as "regimes": flow and sediment.

The flow regime is about the rate and timing of water flow, as influenced by climate variables such as precipitation and air temperature. Whereas, the amount, type and timing of sediment deposit, as well as local topography, also influence the river's route, as does the interaction between sediment and water.

Juez's previous work in the SEDILAND project, which was supported by the Marie Skłodowska-Curie Actions program, evidenced how these dynamic processes are sensitive to land use and land cover changes.

Analyzing 15 years' worth of hydrological and sediment records from four catchment areas of the Spanish Pyrenees with similar geophysical characteristics, Juez's analysis suggested that land use and land cover determine the timescales of changes to sediment regimes.

As SEDILAND also highlighted, land cover and use changes can either help or hinder resistance to climate change which can alter streamflow and sediment deposition.

"Climate change varies the timing of seasonal rainfall, snow melt or glacier basin melting, causing flooding which can erode banks. It can also affect sediment production—with drier basins, more extreme thermodynamic actions, changes in icing and melting cycles—all altering the sediment delivery in river systems," Juez adds. "If these events become more frequent and prolonged they will alter the shape and path of rivers."

But this is not a linear process, since land use changes, sometimes as climate mitigation actions, can themselves have unforeseen consequences. For example, one study reported that a river catchment forest expansion in the Spanish Pyrenees abruptly depleted the riverbed of sediment.

High-tech river systems forecasting

Previously, riverbed morphology and sediment regime characteristics were investigated along river sections of varying lengths, with sites selected based on land cover changes, such as afforestation or grazing.

"Being site-specific, data was limited. Nowadays, unmanned aerial vehicles combined with machine learning algorithms can link the causes and consequences of localized river system changes to long-term global disturbances. I expect that probabilistic modeling will soon give us an

even more accurate and holistic view," concludes Juez.

So the complex twists and turns of a river tell the story of the surrounding landscape and the climate—and where the river might wind next.

Provided by CORDIS

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