ET-AL FACTSHEET

Morphodynamic Modeling

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THE ISSUE Braided rivers are dynamic systems with a continually-shifting network of channels responding to water and sediment supply. Our understanding of how these channels will evolve over decades to centuries, and how they will respond to alterations in water or sediment supply resulting from climate or land use change, remains unclear, and current computational models are inadequate for answering these questions.

KEY QUESTIONS:

- How do variations in sediment supply influence braided river morphology?
- How will decadal to centennial-scale changes in river morphology impact in-channel habitat?

BACKGROUND: Given the sensitivity of braided rivers to floods, which may completely rearrange channel form in a matter of hours to days, it's reasonable to wonder what effect human factors (such as climate change and land use), which can alter flood size and frequency and/or the amount of sediment delivered to these streams, might have on the form of these streams and their associated habitat. In cases like this, we can turn to field work to document the effect of numerous floods and infer the different mechanisms by which they alter channel form. But given that flood/sediment influencing factors, such as climate change, might take decades to centuries to manifest, it would take many years of field work to understand these mechanisms of change.

In such instances, we can turn to modeling as a tool with which to predict the form of braided rivers in response to shifting water and sediment inputs. Unfortunately such long-term predictions (10's-100's of years) that document channel change can be taxing on even powerful computers, given that they need to track indivual grains of sediment as they move through the system, and perform a great deal of accounting to compute channel bed change through time (a concept we refer to as morphodynamics).

Figure 1. The River Feshie study reach.

OUR APPROACH: One way to deal with the inherent complexity of modeling braided rivers is to experiment with novel ways for computing sediment transport. Rather than tracking each particle as it moves downstream, we are developing morphodynamic models based on sediment 'path-lengths,' which are distributions of how far particles are moving once they are eroded in a flood. They can be theoretical or empirical in nature, and may take a variety of forms - the existence of path-lengths during floods means that the time step of our model isn't a second/minute/hour, but rather is one flood. We intend to undertake tracer experiments on study streams in the UK and the US which have potential to provide field-calibrated path-length distributions. These distributions have been found by numerous researchers in flume and field work, but have not been widely incorporated into models. We intend to use these models as scenario-based tools to answer fundamental braided river questions over relevant time scales.

EXAMPLE APPLICATION & VERIFICATION: Figure 2 shows an early version of the morphodynamic model on the River Feshie, a braided stream in the Scottish Highlands for which repeat topographic surveys have been completed (2000-2007 and 2013). Our initial modeling efforts highlight the ability of the algorithm to repoduce process zones, such as confluence pool scour and subsequent local deposition, along with scour of the outside of channel bends. They emphasize the need for discrete inclusion of certain processes, particularly bank erosion. Ongoing research includes validation of hydraulic modeling components, development of a bank erosion algorithm, and exploration of process representation with regard to mechanisms which promote braiding.

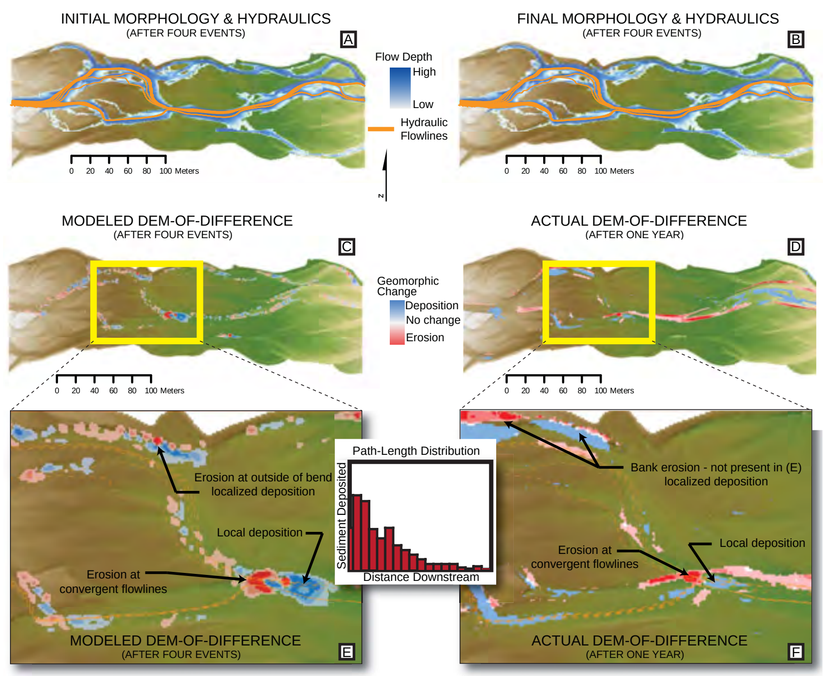

Figure 2: Results of a simple proof-of-concept morphodynamic model are shown for a portion of the River Feshie (UK) study reach. Initial hydraulics and channel morphology are shown in (A), with model results after four flood events shown in (B). DEMs-of-Difference (DoDs) computed by subtracting final surface from initial surveyed surface shown for model results in (C) and actual field surveys in (D), with close-ups in (E) and (F). Note the correspondence between areas of net deposition, but differences resulting from not including bank erosion in the morphodynamic model's process representation.

TAKE AWAY

- Our model allows for the exploration of bar-scale morphodynamics over decadal and centennial timescales, which were impossible using previous morphodynamic models.
- The model agrees well with field data but requires additional development with regard to particular braiding mechanisms
- The model will be used to explore channel change under scenarios of altered sediment and water delivery

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Available at: http://etal.joewheaton.org

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