PhD announcement:
Aix-Marseille University (AMU), CEREGE UMR 7330, Aix – en – Provence, France

Title:
Relationship amongst hydrology, sediment transport, and morphological evolution on an alpine gravel-bed braided river (the Buech River, SE France)

Key words:
sediment transport, alluvial river morphodynamics, quantitative fluvial geomorphology

Qualifications:

- Applicants must have been younger than 30 on March 11, 2016
- Applicants must have earned a Masters degree in Earth Sciences, Engineering, Geography, or closely related fields by the end of August
- Preference will be given to candidates with experience in sediment transport, river morphodynamics, and quantitative fluvial geomorphology, and with strong skills in GIS and programming
- Fluency in French is not mandatory to apply, however preference will be given to applicants with at least a basic level in reading, writing, and speaking.
- A French or international drivers license is mandatory by the start of the contract

Details about the contract :
The PhD will be funded through a fellowship awarded by the Provence-Alpes-Côte d'Azur (PACA) Region and co-funded by the French Water Agency (award pending). The contract is expected to begin on October 1, 2016 for a fixed duration of 3 years. The gross monthly salary is 1709.06 Euros. The PhD student will be based at the CEREGE laboratory (UMR 7330) and co-supervised by Michal TAL (Assist. Prof AMU) and Edward ANTHONY (Prof. AMU) and will work in close collaboration with a technical committee composed of scientists (University/CNRS), industry researchers (EDF), river managers and applied researchers (SMIGIBA, ONEMA, etc...) who are affiliated with the project and/or are recognized experts in the field.

CEREGE is located in the commune of Aix-en-Provence and 30 km from Marseille. It is possible to live in either city and commute by car or bus to the lab. It is also possible to live in one of the many small villages in the area.

Application procedure :
Interested candidates should send:

- a statement of motivation (3 pages max) that explicitly describes the candidates interest in the project and demonstrates their understanding of the research objectives, as well as outlines their qualifications and readiness to carry out the work proposed.
- a CV
- a transcript from the Masters program
- a PDF of the Masters thesis and any resulting publications
- contact information for 2 persons that can provide references

The deadline for submitting applications is ***September 2.***

Contact for applications and inquiries :
Michal Tal: tal@cerege.fr

Description of the research project :
The Buech River is situated in the western Alps in SE France. This alpine gravel-bed braided river is approximately 120 km long from its source in the Massif du Dévoluy (altitude 2700 m) to its confluence with the Durance River (altitude 400 m), and drains a watershed approximately 1490 km2. The basin is located within the subalpine chains, the foreland fold-and-thrust belt, formed during the Late Miocene by propagation of the orogenic front onto the European foreland, composed of a folded Mesozoic sequence of marly and calcareous sediments deposited on the former European passive margin. The Buech is characterised by an alpine climate in the north (19% of the basin is above 1500 m altitude and is covered in snow in january and february) that gives way to a mediterranean climate in the south, resulting in cold winters and dry summers and a snow-rain regime with 2 maxima : in spring due to snowmelt and abundant rain and autumn due to heavy rain. The combination of altitude, strong precipitation associated with a mediterranean climate, and high slopes (average slope ~ 0.5% with up to 10% slopes in the upper reaches) leads to a system that is torrential in nature with sudden and violent floods. Anthropogenic modifications of the Buech river since the 18th century include the construction of widespread dikes and levees and gravel mining. In 1992, the Saint Sauveur dam ~ 35 km upstream of the mouth, was put into operation, trapping the bedload arriving from upstream. It is commonly agreed that the combination of bank protection installations, gravel extractions, and the reduction in sediment delivery to the downstream have rendered the riverbed more vulnerable to incision. The Buech is home to a rich diversity of fauna and flora both within the main channel and its network of secondary channels. Six of its 17 fish species are protected of which 2 species, Mediterranean barbel (Barbus meridionalis) and Souffia (Telestes souffia) are classified as rare, and 1 species, the apron (Zingel asper), is endangered.

A study started in 2013 by researchers based at the CEREGE laboratory has focused on a 10 km reach at the downstream of the Buech immediately upstream of the confluence with the Durance. This confluence is situated within the backwater zone of the St Lazare dam on the Durance immediately upstream of the town of Sisteron. In order to reduce sediment accumulation and the risk of high water levels in this urbanised zone, in 2010 EDF, the French electric company operating the dam, dredged a zone spanning the full width of the active braidplain of the Buech River along approximately 1 kilometer and to an average depth of approximately 4 m. This excavated zone, located approximately 1 km upstream of the confluence, constitutes a massive gravel pit, trapping the Buech sediments and preventing them from reaching the Durance. The exact volume of sediment accumulated in the pit is evaluated biannually from topo-bathymetric surveys. While this operation constitutes a potentially environmentally sustainable and viable long-term solution for decreasing the risk of flooding associated with both the Saint-Lazare dam and the confluence, it is not without risks. Annual dredging of the riverbed in this downstream zone has the potential of destabilising the Buech riverbed. Indeed, a common process that could generate a signal of relative base-level fall (and as a result and upstream migrating knickpoint) would be oversteepening of the riverbed due to sediment mining. On the other hand, a decision to not dredge the pit during summer low flows in a given year (due to low sediment accumulation volumes when the environmental oversight committee meets in the spring) carries the risk that a subsequent series of large floods will fill the pit beyond its capacity leading to bed aggradation and flooding.

Bedload transport, particularly in gravel-bed rivers, is inherently stochastic and therefore notoriously difficult to predict accurately. Its nonlinear dependency on flow discharge is even more complicated in braided rivers where flow is non-uniformly distributed and highly variable in time and space, and where antecedent flow conditions play an important role in how mobile the bed is (by promoting the development of armouring for example). Direct measurements of bedload transport are particularly difficult in gravel-bed rivers influenced by mediterranean climates because of the danger and logistical challenges associated with using classical measurement techniques (e.g. Helley-Smith sampling) during morphogenic flows. But these types of rivers are precisely the ones that need to be better managed due to their often significant sediment loads and locations within

densely populated regions. The Buech sediment control zone provides an unprecedented opportunity for scientists to study the morphodynamics of an active alpine braided gravel-bed river and improve our understanding of the relationship between hydrology, sediment transport, and channel morphology, and thus our capacity to predict sediment flux and channel dynamics. With a capacity of approximately 180 000 m3, the pit is orders of magnitude larger than any other sediment trap installation available for research, providing a unique constraint on the sediment flux. In addition to accumulated sediment volumes in the pit, continuous hourly flow discharge is available (since 1990) via a gauging station maintained by EDF.

Over the past 3 years the CEREGE group has been developing and installing a monitoring program along the lowermost 10 km of the Buech. The work has focused on quantifying the morphological evolution of the braidplain using repeat high-resolution photogrammetry (SfM) aquired by drone and ultralight aircraft and using this data to improve our understanding of the relationship between morphological change and sediment flux and ability to estimate the latter. The group is also working on understanding the relationship between sediment transport on the scale of individual grains up to the bar scale and total sediment flux (measured both in the gravel pit and from morphological evolution). Sediment transport is being estimated at a detailed study site located 1.2 km upstream of the gravel pit using indirect measurement techniques that include scour chains, (passive) RFID tags, and painted plots. This past spring a hydrophone was installed in order to estimate the critical discharge for sediment transport as well as a pressure guage and a time-lapse camera in order to estimate flow depths and active widths, and monitor channel migration. Finally, we are testing the use of an aquatic drone to conduct repeat bathymetry in the gravel pit at high frequency.

A the end of what will be 3 years of developing monitoring techniques and testing hypotheses based on preliminary data analysis, the timing is perfect for a PhD student to consolidate the monitoring and data analysis. The outcomes of the proposed thesis are two-fold. The study will provide a quantitative physically-based assessment of the sustainability of dredging to control water levels and reduce the risk of flooding at the confluence of the Buech and the Durance. It will also provide novel and fundamental insights on the mechanics of sediment transport in gravel bed rivers that will improve river management on a local and regional scale.

The specific questions that will be addressed as part of the PhD include:

- What are the characteristic spatial and temporal timescales of sediment storage and release in the braidplain and how are these related to channel morphology?
- What are the dominant sources of sediment input into the channel? i.e., what are the relative contributions of sediment from the bed, the banks, and the upstream catchment?
- What characteristics of the flood hydrograph (e.g., flow duration, Q_max, total runoff volume, antecedent conditions…etc) are the most deterministic in terms of the volumes of sediment transported in a given event?
- What impact does a modification on an annual time scale of channel base level have on channel long-profile? What is the timescale, magnitude, and spatial extent over which this perturbation affects the system?
- Which governing variables in empirical equations of sediment transport best predict transport volumes?
- Which measurement techniques are best suited for estimating transport volumes in rivers of this type?