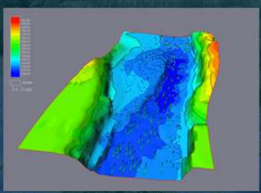
Říční systémy - současné směry výzkumu a vybrané případové studie

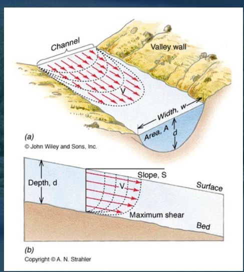
Monika Šulc

MUNI

Rivers in context of actual problems

Rivers – dynamics natural sytems





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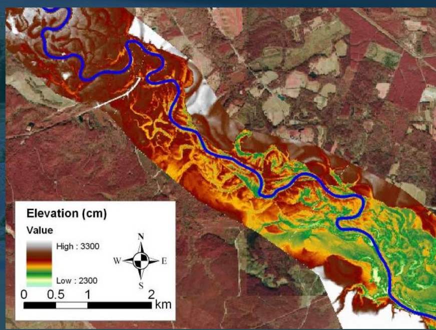
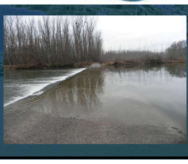
TYPICAL FLOODPLAIN TOPOGRAPHY FROM LiDAR, BOGUE CHITTO RIVER, LOUISIANA

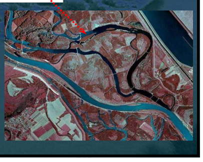


PRESENT STATE OF THE FORMER CHANNELS´ SYSTEM

AFTER DANUBE DAMMING THE FORMER CHANNEL SYSTEM HAS BEEN ALMOST FULLY SEPARATED:

- WATER SUPPLY: THROUGH THE BARRAGE- SEASONAL FLOW VARIATION ($43<Q<200\ m^3/s$)
- WEIRS INSIDE THE FORMER CHANNEL SYSTEM CREATE A CASCADE OF SLOWLY FLOWING WATER BODIES





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Introduction
Overview of research topics

1. MEANDERING RIVER SYSTEMS
   - Spatiotemporal evolution of a unique meandering systems - SACRAMENTO, SAJO, MORAVA RIVER
2. RIVER RESTAURATION – RHONE RIVER
3. UAV MAPPING (in collaboration with Palacký university)
4. DELINEATION OF FLOOD EXTENDS BY GIS-TOOL
5. EROSION-SEDIMENTATION MODELLING IN SMALL CATCHMENTS

CHALLENGES: MOUNTAIN STREAMS AND FLUXES OF COARSE SEDIMENTS (in collaboration with Ostrava University)

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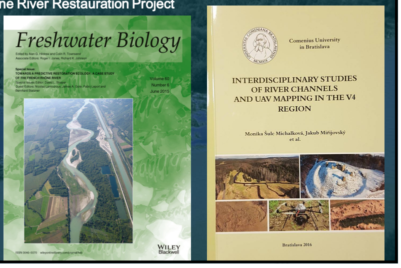
Projects

- 2013 – 2015: IVF Strategic Grant – Detailed aerial mapping and flood impact monitoring in the V4 region, Head of the Project
- 2012: IVF Small Grant – Evaluation of a new remote sensing methodology for detailed international mapping in the V4 region, Head of the Project
- 2003 - 2015 – Rhone River Restauration Project



Case studies

Earth Surface Processes and Landforms

Research Article

Lateral erosion of the Sacramento River, California (1942–1999), and responses of channel and floodplain lake to human influences

M. Michalková, H. Piégay, G.M. Kondolf, S.E. Greco

Earth Surface Processes and Landforms

Research Article

Morphodynamics of the exit of a cutoff meander: experimental findings from field and laboratory studies†

J. Le Coz, M. Michalková, A. Hauet, M. Čomaj, G. Dramais, K. Holubová, H. Piégay, A. Paquier

Catena 127 (2015) 300–311

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Spatiotemporal evolution of a unique preserved meandering system in Central Europe — The Morava River near Litovel

Jakub Miřijovský [a,1], Monika Šulc Michalková [b,c], Otmar Petyniak [a], Zdeněk Máčka [b], Milan Trizna [c]

Journal of Environmental Management

Volume 248, 15 October 2019, 109277

Research article

Detailed assessment of spatial and temporal variations in river channel changes and meander evolution as a preliminary work for effective floodplain management. The example of Sajó River, Hungary

László Bertalan [a], Jesús Rodrigo-Comino [b], Nicola Surian [c], Monika Šulc Michalková [d], Zoltán Kovács [a], Szilárd Szabó [a], Gergely Szabó [a], Janet Hooke [e]

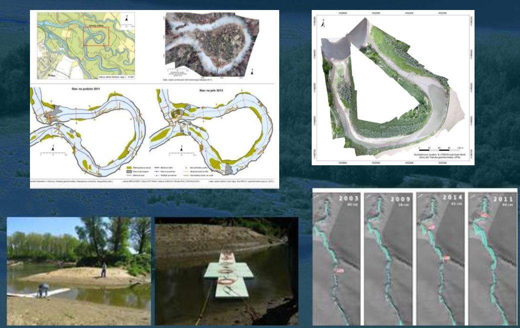
Freshwater Biology

Original Article

Hydromorphological conditions in eighteen restored floodplain channels of a large river: linking patterns to processes

Jérémie Riquier, Hervé Piégay, Monika Šulc Michalková

1. Meandering Rivers - Morava case studies
2. UAV mapping

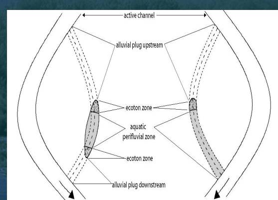


Research on meanders

- Empirical approach includes essentially 3 research directions including
- (1) reconstructions of planimetric development of meandering rivers from archival documents such as maps and aerial images,
- (2) repeated field surveys of meandering reaches illustrating rates of lateral channel migration, changes in channel geometry, and formation of oxbow lakes, and
- (3) physical modelling of cutoff process in laboratory experiments (flume studies).

Floodplain lake

- **a floodplain lake** is an area of fluvial hydrosystem spatial delimited by an axis of ancient active channel.
- It is composed from two parts: humid perifluvial (aquatic perifluvial zone with ecoton zone) and terestric zone presented by an alluvial plug (Rollet, Citterio, Piégay, 2004).



Aim of study

- to bring a new knowledges about selected characteristics of floodplain lakes as a part of a fluvial system.
- It responds to this issue with three specific tasks and work on different rivers and scales.
- Three main axes:

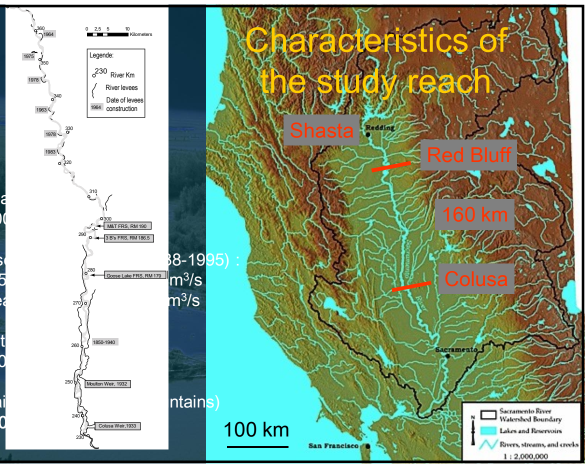
1. the first one presents a historical spatio-temporal analysis of the Sacramento River,
2. the second part includes a post-restoration analysis of the Rhone River
3. the third one brings the results from numerical and physical modeling of flow dynamics and sediment transport applied on the Morava River.

Lateral Erosion of the Sacramento River, California: Human influences and consequences for floodplain lake habitats

Objectives

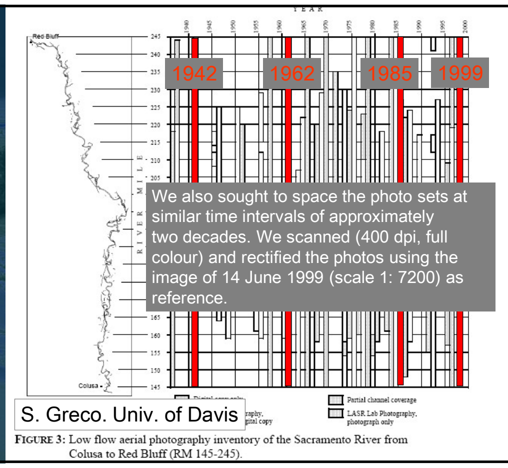
- Problem statement : on a local scale, causes of fluvial changes are difficult to determine because the location and time of causal factors not always the same as the associated changes
- our objective is :
  - to work on a reach scale
  - to relate the spatial and temporal patterns to causal factors using a comparative approach and multifactorial analysis
- Why this case-study?
  - Long alluvial reach with potential structural and spatial variability (160 km)
  - Numerous works have been carried out on local scales and a general background is needed
  - Continuing scientific debate on the factors of change and meandering process
  - A lot of data available of good quality

Characteristics of the study reach



Material & methods

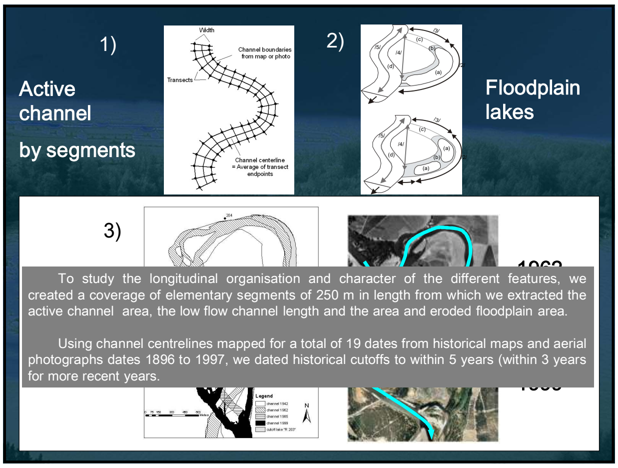
- Select and rectify aerial photos
- Describe relevant geomorphological units (GIS mapping and measurements)
  - Main channel (low flow + unvegetated bars)
  - Floodplain lakes
- Compare multiple components over space and time to identify differences among them and to order them on longitudinal and temporal gradients (creation of GIS attribute tables, statistical analysis)
- Literature review and analysis of existing data to identify the potential causal factors (hydrological signal, geological settings, history of infrastructures…)

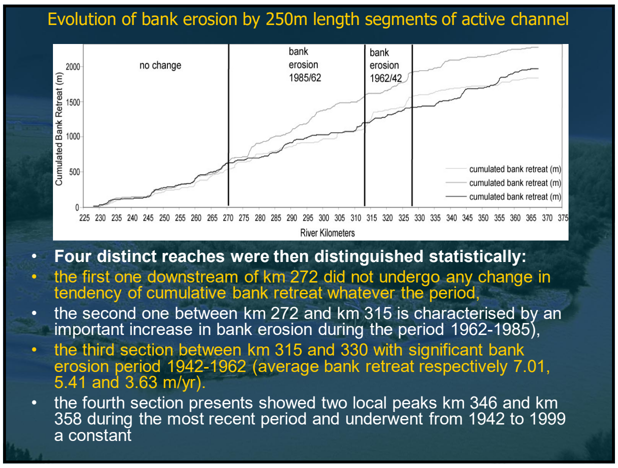


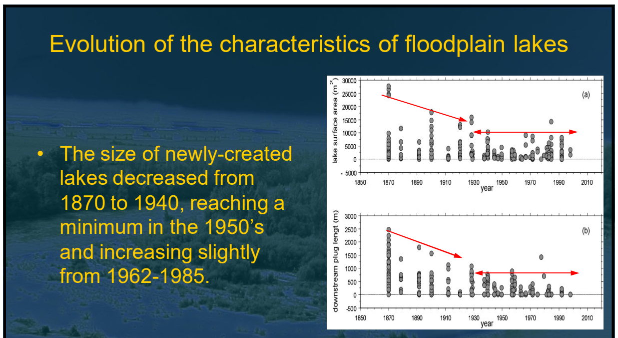
We also sought to space the photo sets at similar time intervals of approximately two decades. We scanned (400 dpi, full colour) and rectified the photos using the image of 14 June 1999 (scale 1: 7200) as reference.

S. Greco. Univ. of Davis

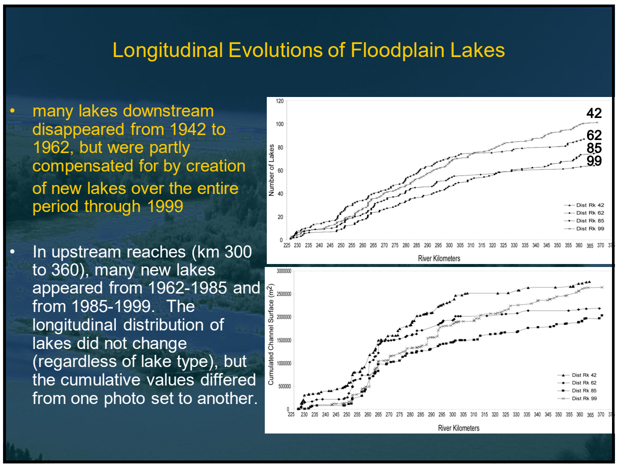
FIGURE 3: Low flow aerial photography inventory of the Sacramento River from Colusa to Red Bluff (RM 145-245).

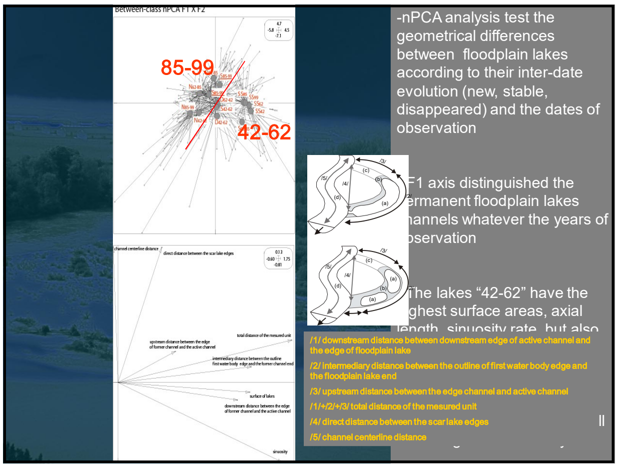




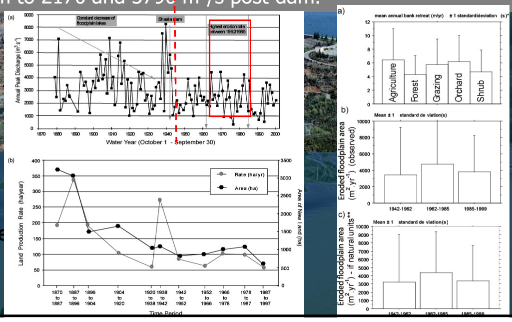


	1999	1985	1962	1942
Appeared since 1985	37			
Observed in 1985	31	39		
Observed in 1962	10	13	33	
Observed in 1942	20	24	35	96
Total	98	76	68	96





River regulation has reduced the magnitude and frequency of high-flow events and has increased low-flow discharges during the summer and autumn irrigation seasons. At Red Bluff, records from the longest-running streamflow gauge show 2 and 10-year flood peaks reduced from 3310 and 5840 m^3/s respectively pre-dam to 2170 and 3790 m^3/s post-dam.



Summary and interpretation

The history showed that the floodplain habitats of the Sacramento underwent significant changes during the 20th century:

i) channel narrowing induced a longitudinal simplification of the aquatic channel and gravel bar habitats, providing new riparian pioneer habitats upstream

ii) large oxbow lakes have not been created since the late 20th century.

More active bank erosion upstream of km 260 from 1962-1985, increased the rate of new lake creation, but these new lakes were smaller and less sinuous and straighter, reflecting their creation by chute cutoff rather than by neck cutoff.

Conclusions

- Major impacts of bank protection on channel erosion and floodplain lake formation and geometry
- Change in peak flow as a result of the construction of Shasta Dam would have induced greater changes in bank erosion and lake formation if the bank protection measures have not been in place.
- Artificial bank protection has affected the distribution and character of floodplain lakes and the floodplain ecosystem.
- Shasta Dam and other influences have served to homogenise the channel geometry along the entire 140-km reach, reducing the active channel width.

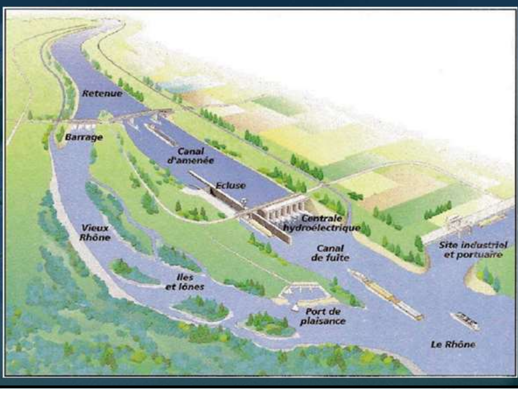
II

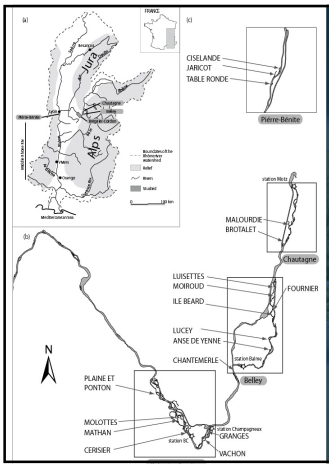
EVS ZABR

Feedbacks on Restored Floodplain Lakes Sedimentation of Upper Rhône River

UNIVERSITÉ DE LYON · STU · CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

Rhone River





- The floodplain lakes are located along the River Rhône, France.
- The French Rhône drains the south-eastern part of France from Lac of Geneva to the Mediterranean Sea.
- The river crosses different climatic zones (continental, oceanic, mountain and Mediterranean climates) and is linked by the Rhodanian alluvial corridor.
- The Rhône is one of the largest European rivers (812 km, watershed area = 95 500 km^2, mean annual discharge at the mouth = 1710 m^3/s).
- The hydrologic regime is characterised by high discharges in spring and summer.

Objectives

The objectives of study is to:

i) to evaluate the variability in habitat conditions inside of floodplain lakes from inter-lake comparison,

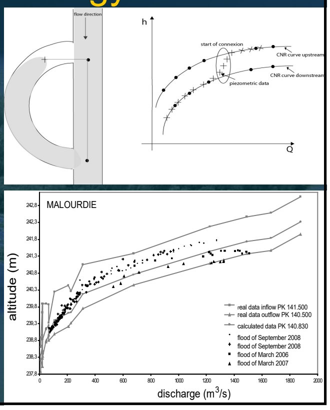
ii) to advise the time evolution of habitat conditions.

Methodology

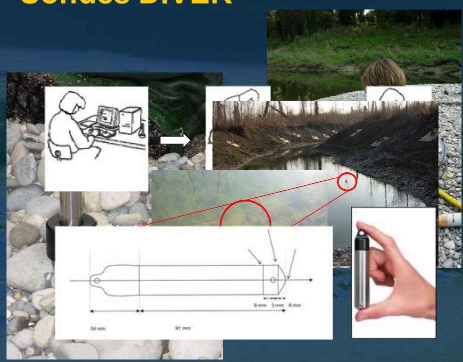
- From methodological point of view, we used the methodology of sediment survey established recently by Citterio & Piégay, 2008.
- Two steps were considered:

i) the measurement of the sedimentation rates based on the ratio between the mean sediment thickness and the date of the revitalisation;

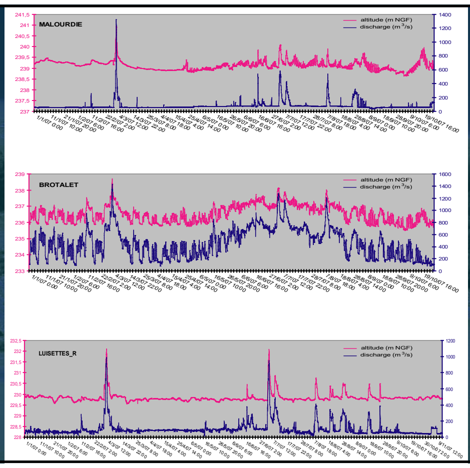
ii) the statistical analysis of the relationships and inter-lake analysis (the characterisation of connexion frequency and to define the life expectancy of former channels).



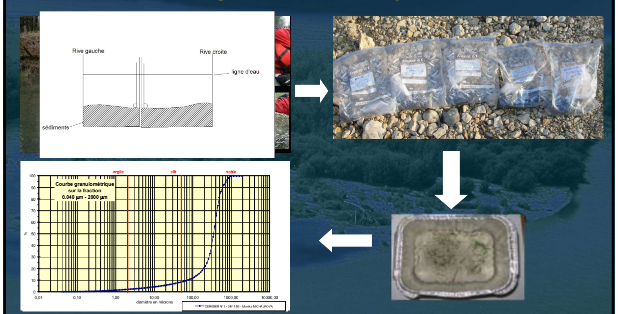
Sondes DIVER



and hydrologic data of discharge (source: CNR)

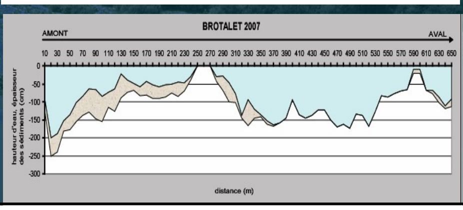


Measurements « HE+ES » and granulometry

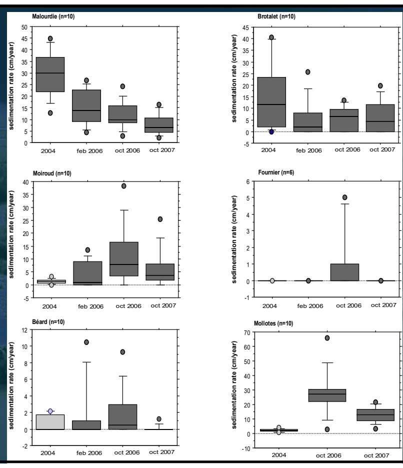


Water depth and sedimentation

	Annual mean sedimentation rate(cm/year)				Mean water level (cm)			
Chautagne	T	T+1	T+2	T+3	T	T+1	T+2	T+3
MAL	29,93	14,62	11,47	7,7	74,4	106,02	96,42	121,6
BRO	15,47	5,57	6,06	6,56	104,6	161,28	93,34	104,6
Belley	T-1	T	T+1	T+2	T-1	T	T+1	T+2
LUI	0	0	0	0	110	102,5	98	113
MOI	1,22	11	11,12	6,27	67,2	115,46	110,59	108,67
FOU	0	0	0,83	0	61,67	125,2	96	89,83
BEA	0,7	1,75	1,87	0,12	7,3	76,02	56,1	48,8
LUC	0	0	0,95	0,42	98,8	112,4	92,3	89,7
YEN	0	0	0	0	3,75	119,25	101,88	97,75
CHA	ND	2	ND	ND	ND	151,6	ND	ND
Bregnier-Cordon	T-1	T	T+1	T+2	T-1	T	T+1	T+2
GRA	0	2,32	0	in 2008	0	129,2	136,5	in 2008
VAC	0	0	0	in 2008	96,7	96,4	97,7	in 2008
CER	0,27	9,16	7,08	in 2008	65,4	76,48	68,48	in 2008
MAT	0,76	6,4	en 2007	in 2008	22,4	85,8	en 2007	in 2008
MOL	2,26	27,7	17,34	in 2008	54,8	145,2	148,54	in 2008
PLA	5,05	33,9	18,77	in 2008	55,1	165,2	182,75	in 2008

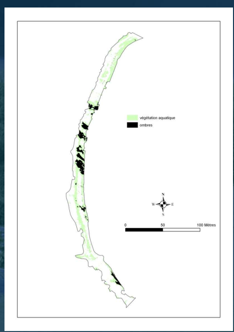


Sedimentation rates in floodplain lakes T-1 (before), T (rest.year), T+1 (after)



➢Monitoring « lône de la Malourdie » - Vegetalizácia koryta

Iniciálny stav (20/04/2006)



Mapa akvatickej vegetácie (traitements d'images)

✓ Kolonizovaná rozloha : 29%

➢Monitoring « lône de Brotalet »

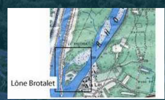
Počiatočný stav (20/04/2006)

✓ Nemožná rekonštrucia batymetrie

✓ Nemožné rekonštrukcia korytových fácií

↳ príliš veľa plavenín. Prečo ?

- Otázka lokality



- Absencia freatického prísunu

• 2ᵉ état des lieux réalisé fin 2006

Conclusions

- The unique methodology of floodplain lake monitoring has been presented. The annual measurements have been done.
- The first feedbacks permit to visualise the lake types. Also the connecting discharges and the shear stress have been calculated.
- The duration of the post-restoration period concerning the floodplain lakes of Brégnier-Cordon and Belley is relatively short and so the comparison between pre- and post-restoration state is only just possible.

III

Výskumný ústav vodného hospodárstva

EVS

Morphodynamics of the Exit of a Cut-off Meander: Experimental Findings from Field and Laboratory Studies

UNIVERSITÉ DE LYON

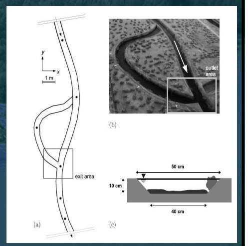
STU

CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

Objective

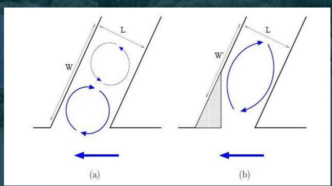
- The main goal of this study is to investigate the flow and erosion/deposition processes taking place in the exit of an floodplain lake.
- Such a situation is common during ordinary floods, as the inundation frequency is usually much higher at the exit than at the entrance.
- This kind of 'backflow' into the downstream part of the abandoned channel is a key-process for the infilling of oxbow-lakes (Shields and Abt, 1989).

- Experiments were conducted on a 8.60m × 19m physical model built within the VUVH hydraulic facility (Bratislava, Slovakia).
- The model simulates a 2400m-long reach of the lower Morava river, which forms the boundary between Slovakia and Austria. This originally free-meandering tributary of the Danube was heavily regulated and channelized in the mid XXth century.
- The physical model was used to study several reopening scenarios for two disconnected meanders, as part of a European Phare project (Holubova *et al.*, 1999).
- The main channel and the floodplain, including disconnected meanders, were reproduced from bathymetry surveys and aerial photographs. The floodplain (coarse sand) and the channel banks and substratum (concrete) were inerodible.
- In this study, the entrance of the main meander was closed. Observations were focused on the downstream exit, which was directly open to the main channel.



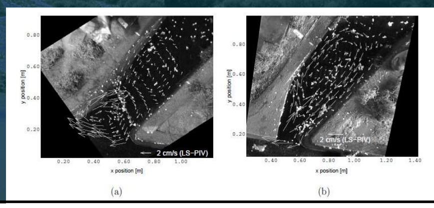
Measurements

- For two different simulation runs, contrasting shapes were given to the downstream corner of the exit. Run 1 was conducted with a smooth corner (flow incidence angle roughly 60◦), whereas run 2 was conducted with a sharp corner and a reduced mouth (flow incidence angle roughly 90◦).



(a) (b)

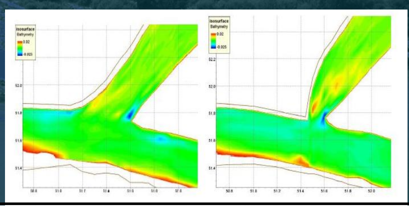
- During run 1 (smooth corner, a), a 2-gyre system developed, as observed in spanwise elongated open-channel side cavities.
- The gyre at the mouth of the channel had a mean surface velocity magnitude that was roughly 3 cm/s in the inflow and less than 2 cm/s in the outflow.
- The velocities measured near the downstream corner suggested a highly 3D flow structure, confirmed by visual observation of liquid particles traced by dye injection.



(a) (b)

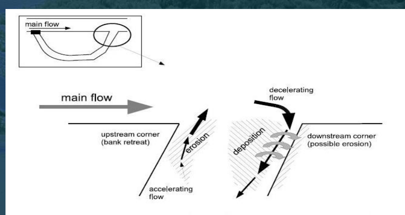
Results

- Topography surveys for both experimental runs yielded similar erosion/deposition spatial patterns in the meander exit and in the main channel.
- Some elongated deposits developed in the vicinity of the downstream side of the exit.
- In run 1, this effect was less visible because 3D currents were not as strong because of the smoother shape of the downstream corner. Visual observation indicated an movement of particles inward.



Consistency of Local Morphodynamical Processes

- Erosion and deposition areas appear to be associated with acceleration (outflow) and deceleration (inflow) trends, and also with 3D currents induced by the solid boundaries.
- In contrast, sand and silt are deposited in the cavity wherever the velocity magnitude.



Conclusion

- In agreement with previous studies on open-channel side-cavity flows, a main recirculating flow always develops in the entrance.
- In the laboratory case, a change in the shape of the downstream corner of the cavity induced a two-gyre system instead.
- In the field case, three regimes of complex flow patterns were distinguished according to the discharge in the main channel.
- In both cases, a simple analogy - in rectangular cavities was used to explain the observations.

General Conclusion

- Floodplain lakes have mostly been studied by ecologists, because their evaluation of river habitats. But the essential element to know is the structure and functioning of this part of a fluvial hydrosystem.
- The factor of anthropic pressure cannot be excluded from analyses of the functioning of floodplain lakes.
- The examples studied in our work join the hydrological processes and morphological consequences on a fluvial system.
- The scientific monitoring was the response to different projects developed by river managers. This can help with the construction of the coordinated management of a fluvial system, where the evolution of different parts (such as floodplain lakes) is included.