Identifying priority areas of paleolimnological research

Authors: J-P. Jenny\textsuperscript{1,2}, Z.E. Taranu\textsuperscript{3}, P. Francus\textsuperscript{1,2}, I. Gregory-Eaves\textsuperscript{3,4}, P. A. Normandeau\textsuperscript{5}, F. Lapointe\textsuperscript{1,2}, O.P. Nzekwe\textsuperscript{1}, J. Jautzy\textsuperscript{6}

1 Centre - Eau Terre Environnement, INRS, Québec (Qc), Canada; 2 GEOTOP Research Center, Montréal (Qc), Canada; 3 Department of Biology, McGill University, Montréal (Qc); 4 Interuniversity Research Group in Limnology, McGill University, Montréal (Qc), Canada; 5 Department of Geography and Planning, Queen’s University, Kingston, Canada; 6Department of Earth Sciences, University of Ottawa, ON, Ottawa

Lake sediment records are well known to provide response histories to environmental forcings, but how many cores are necessary to accurately depict how lakes from a region respond to these forcings?

**Abstract** Globally, we conducted an exhaustive analysis to map where sediment cores have been collected and noted a strong bias towards the temperate-subarctic zones of North America and Europe. We are now quantifying global heterogeneity in environmental, climatic and human dynamics (e.g. land use, temperature and human population) and historical perturbations to identify hotspots of global change and pin-point regions where high resolution analyses of well dated cores are needed to properly characterize historical trajectories. These results will inform a regional study of soil erosion dynamics.

**Method** To calculate spatial heterogeneity and temporal dynamics, we extracted modern and past data from 550,000 watersheds. Our study relies on four global databases: 1) Sediment core data set at global scale (Jenny et al. 2016, and this study); 2) HydroBASIN watershed boundaries at a global scale (Lehner et al. 2013); 3) HYDE historical land-use change data set (Goldewijk et al. 2011); 4) UDEL historical climate data set at global scale (Willmott et al. 1995). Coefficients of variance (CV) were used to identify regions in the worlds of high local heterogeneities. Additive mixed-effect model (AMM) were used to calculate regional trends of land cover/uses during the Anthropocene and to delineate regional boundaries. New time series data are under collection - collaboration with National Lacustrine Core Facility (LacCore, US) and INRS (Qc).

**Figure 1** Summary of our approach. Green colour highlights the part of the study we have conducted so far (on landscape and climate). Lake dynamics will be reconstructed via high-resolution XRF, CT-scan, and TOC, C, N, O\textsuperscript{18}, O\textsuperscript{13}C data acquisition on sediment cores from 300 lakes worldwide, as well as using data from literature.

**Figure 2** Watersheds are our spatial units. Distribution of lakes and lake sediment cores

**Figure 3** Distribution of lakes (WWF) and of almost 6,000 lake sediment cores (from bibliographic search in 2016).

**Figure 4** Distribution of historical maximum in extension of cropland areas (over the last 300 years). Variability is high among and within regions. Europe presents a latitudinal gradient in the % of cropland areas, whereas China and the US presents longitudinal gradients. Interaction between climate and land uses gradients are expected to to result in pronounced differences lake responses. Directions (and patterns) of climatic and human-mediated landscape gradients need to be considered for thorough description of the pressure gradients.

**Figure 5** Regions of the world with high (red) and low (green) heterogeneity among watersheds. In regions of high land cover heterogeneity, more cores are needed to adequately capture regional dynamics. We calculated coefficients of variance (CV) using two size resolutions of basin to estimate the spatial heterogeneity.

**Figure 6** Moment of the maximum perturbation over the last 300 years. Percentage of cropland area were the highest in the 1940-60s in Europe and the United States, whereas the perturbation is the highest today in China. This means that China is experiencing both accelerated climate change and landscape perturbations.

**Figure 7** Regional changes in percentage of cropland area in Europe, United States and China. The dynamics over the last 50 years (i.e. with instrumental data) are small compared to the much larger changes evident over the past 300 years. To evaluate how well land use dynamics are characterized by the number of watershed represented, we have randomly sampled a varying number of watersheds in three different areas. Qualitatively, one can see that with reducing the % of all available watersheds to 5%, trends are similar to those shown with 80% of the watersheds.

**References**

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**Identifying:**

- 1) hotspots of rapid changes
- 2) zones of heterogeneties
- 3) coherent regional units

**Priority areas of paleolimnological research**

**Climate dynamics**

- Model reconstructions of precipitations/ temperatures (UDEL)

**Landscape dynamic**

- Model reconstructions of the landscape (HYDE)

**Lake dynamic**

- Paleolimnological time series/ interval (e.g. CT-scan) and organic geochemistry

**Figure 8** Distribution of historical maximum perturbation/ last 300 yrs

**Heterogeneity in land cover distribution**

**Hotspots of change in land cover/ 300 yrs**

**Maximum of perturbation/ last 300 yrs**