Audrey Marescaux's PhD Defense

Audrey Marescaux

Carbon cycling across the human-impacted Seine River basin: from the modeling of carbon dioxide outgassing to the assessment of greenhouse gas emissions
The 11-12-2018at14h00

Members of the jury:

Steven Bouillon Pr., Katholieke Universiteit Leuven, Rapporteur

Damien Cardinal, Pr. Sorbonne Université (Paris), Examinateur

Alexandra Coynel, MC Université de Bordeaux, Examinatrice

Josette Garnier, DR CNRS (Paris), Directrice de thèse

Emmanuel Soyeux, Expert Véolia VERI (Maisons-Laffitte), Invité

Vincent Thieu, MC Sorbonne Université (Paris), Encadrant de thèse

Julien Tournebize, MC Irstea (Anthony), Rapporteur

Lauriane Vilmin, Dr Utrecht University, Examinatrice

Summary :

Several recent studies have highlighted significant fluxes of carbon dioxide (CO_2) from inland waters in the global carbon cycling. The first main objective of this thesis was to quantify and understand carbon dynamics in the Seine River basin, which is deeply impacted by human activities. For this purpose a new inorganic carbon (IC) module was implemented in the biogeochemical Riverstrahler model, to simulate spatial and temporal variations in carbon forms in the drainage work. A second major objective was to size both aquatic and terrestrial emissions as a part of a joint assessment of three main GHGs (CO_2, methane ?CH_4, and nitrous oxide ?N_2O) .

Field campaigns in rivers draining various land uses in different hydrological seasons, showed a supersaturation in CO_2 of the Seine hydrosystem leading to CO_2 emissions to the atmosphere. The main factor controlling the CO_2 partial pressure (pCO_2) was the concentration of dissolved organic carbon (DOC) (R^2 =0.56, n=119, $p<0.05$), modulated by hydro-climatic conditions and groundwater contribution. In small streams, DOC concentrations were dependent on the soil organic carbon stock. For the main stem, a long-term analysis (1970-2015) showed that pCO_2 tracked urban pollution, decreasing from the 2000s after improvement of wastewater treatment.

The validation of the IC module newly implemented in Riverstrahler showed that IC inputs to the Seine River dominated the overall carbon budget (1134 ktC yr-1 on average for the period 2010-2013) of which less than 2% was produced from biogeochemical processes (27 ktC yr-1). In addition, CO_2 outgassing represented 37% of IC outputs while exports to the estuary

represented 62% of IC outputs. OC inputs were comparatively lower, accounting for only 104 ktC yr-1
. Analysis of the biogeochemical processes of the Seine River showed a negative net ecosystem production (NEP), the river being mostly heterotrophic.

In order to complete the modeling of the fate of carbon in the Seine River, the Riverstrahler model was combined with the estuarine C-GEM model, towards an integrated approach to the Land-to-Ocean Aquatic continuum. Representing less than 1% of cumulated length of the river, the estuary thus contributes ~16% of the CO_2 emitted from the whole estuary-river aquatic continuum (estimated at 540 kt C for the year 2010).

In addition, analyses of available institutional databases and measurements of other GHGs (CH_4 a nd N_2O) enabled estimation of aquatic emissions at 3.7% of the Seine basin total emissions (2,276 ktCO_2 equivalent yr-1
), dominated by CO_2 (95.3%), while agricultural (14,295 ktCO_2 equivalent yr-1
) and urban emissions (44,713 ktCO_2 equivalent yr-1
) accounted for 23.3% and 73.0%, respectively. A historical reconstruction of agricultural emissions for the whole of France (1850-2014) estimated that, among the 114,000 ktCO_2 equivale nt yr-1
 emitted by the agricultural sector, 22% were represented by CO_2, 49% by CH_4 and 29% by N_2O. Finally, two contrasting scenarios were explored (horizon 2040). The first, characterized by the current trend towards specialization and intensification, predicted an almost 1.5-fold increase in agricultural emissions. While the second, characterized by a transition to organic agriculture and dietary change, would reduce current emissions by about 50%.

Contact : audrey.marescaux@upmc.fr