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Semidiurnal and seasonal variations in methane (CH_4) emissions from a subtropical hydroelectric reservoir (Nam Theun 2 Reservoir) measured by eddy covariance technique

Chandrashekhar Deshmukh (1,2), Dominique Serça (1), Raphael Tardif (3), Maud Demarty (4), Stéphane Descloux (5), Vincent Chanudet (5), Pierre Guédant (3), Frédéric Guérin (6,7,8)

(1) Laboratoire d'Aérologie - Université de Toulouse - CNRS UMR 5560; 14 Av. Edouard Belin, F-31400, Toulouse, France, (2) TERI University, New Delhi, India, (3) Nam Theun 2 Power Company Ltd., Aquatic Environment Laboratory (AE Lab), Gnommalath, LAO PDR, (4) Environnement Illimite, 1453 rue Saint Timothee, Montreal QC, Canada, (5) Electricité de France, Hydro Engineering Centre, Risk and Sustainable Development Dpt, Savoie Technolac, F-73373 Le Bourget du Lac, France, (6) IRD ; UR 234, GET ; 14 avenue E. Belin, F-31400, Toulouse, France, (7) Departamento de Geoquimica, Universidade Federal Fluminense, Niteroi-RJ, Brasil, (8) Université de Toulouse ; UPS GET, 14 avenue E. Belin, F-31400 Toulouse, France

Hydroelectric reservoirs have globally been identified as a significant source of methane (CH_4) to the atmosphere, especially in the tropics. Assessing these emissions and their variations at small and large time scale represent important scientific challenges. In this context, the objectives of this work are (i) to compare different methodologies used to assess CH_4 emissions. (ii) to determine the temporal variations in these emissions at different scales i.e. from daily to seasonal, and link these variations to environmental controlling factors.

Measurements of CH_4 emissions were made in a recently impounded (May 2008) subtropical hydroelectric reservoir, Nam Theun 2 (NT2), in Lao PDR, Asia. The sampling strategy included three different types of flux measurement techniques: floating chambers (FC), submerged funnels (SF), and the eddy covariance technique (EC). Flux measurements were carried out during four field campaigns conducted between May 2009 and June 2011. Eddy covariance system, composed by a 3D sonic anemometer coupled with a DLT-100 fast methane analyzer (Los Gatos Inc®), was deployed on a mast erected in a large surface of open water. Diffusive and bubbling fluxes were measured using respectively the FC and the SF techniques within the footprint of the EC station.

Results from the four field campaigns show individual EC fluxes (30min) varying over 4 orders of magnitude (from 0.01 to 102 mmol.m^{-2}.day^{-1}). Individual diffusive fluxes measured by floating chambers ranged between 0.2 and 3.2 mmol.m^{-2}.day^{-1}. Bubbling fluxes were found to be highly sporadic, with individual daily flux values varying from 0 to 102 mmol.m^{-2}.day^{-1}. For all field campaigns, EC fluxes were very consistent with the sum of the two terms measured independently (diffusive fluxes + bubbling fluxes = EC fluxes), indicating that the eddy covariance system picked-up both diffusive and bubbling emissions from the reservoir, which is a very new and encouraging result for further studies. To our knowledge, this is the first example of an inter-comparison for CH_4 flux measurement where EC flux data were used to compare/validate the fluxes measured with traditional methodologies (i.e. floating chamber and funnel measurements).

Semidiurnal variations of EC fluxes were observed with two peaks per day - one in early morning and one in the afternoon, linked to the semi-diurnal variation of the atmospheric pressure. Due to the larger drop in atmospheric pressure in the late morning than in the night, the noon flux peak is higher than the night flux peak. Both funnel and EC techniques show that ebullition of CH_4 increased from 5 ± 3.5 to 28 ± 16 mmol.m^{-2}.day^{-1} with the depth of the water column increasing from 10.5 to 2 m. This result suggests that the significant seasonal variation in CH_4 emissions by ebullition was essentially driven by the water level variations.

Keywords: Methane emissions, eddy covariance, floating chambers, submerged funnels, methods intercomparison, semidiurnal variation, seasonal variation, subtropical hydroelectric reservoir, Nam Theun 2 reservoir