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A statistical model to compute global wetland CH4 emissions from an ensemble of predictors

Spyridon Paparrizos (1), Philippe Ciais (1), Philippe Peylin (1), Vladislav Bastrikov (1), Shushi Peng (2), and Fréderic Chevallier (1)

(1) Laboratoire des Sciences du Climat et l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, FR-91191 Gif-sur-Yvette, France, (2) Sino-French Institute for Earth System Science, College of Urban Environmental Sciences, Peking University, Beijing 100871, China

The growth rate of methane (CH4) concentrations in the atmosphere is responsible for approximately 20% of contemporary climate change. While the anthropogenic emissions represent 2/3 of the global methane emissions, the rest 1/3 constitute natural emissions, are dominated by natural wetlands and significantly vary from year to year depending on various climatological parameters.

Currently, process-based models are used to compute wetland extent and CH4 fluxes for these wetland areas based on the soil carbon content, soil temperature, humidity, etc. but they can be time-consuming and may require significant calibration effort. The objective is to substitute these models by a statistical model that operates very efficiently and can be easily implemented.

We develop an algorithm that constitutes a fast-forward stepwise regression to compute wetland CH4 emissions based on an ensemble of predictors. The algorithm is trained using as dependant variable wetland CH4 fluxes produced by ORCHIDEE-WET as pseudo-data with a 12-month climatology of wetland area, while the explanatory variables that are included in the analysis are obtained from the CRU-NCEP climate reanalysis set.

The regression analyses are performed globally using monthly time series and per pixel with a resolution of 0.5^{o}x 0.5^{o}for the period 2000-2011. R^2 was implemented to build the fitted model, while Akaike Information Criterion (AIC), or Bayesian Information Criterion (BIC) are included in order to validate the credibility of the selected 'best' model.

The final output corresponds to a fitted model for each month (12 monthly models) with the same explanatory variables than those selected during the analysis, but with various regression coefficients for each variable and month. The model output equations can be further supplied with climatological data of any desired resolution and period and simulate the CH4 wetland fluxes.

The results of the analysis using the CRU-NEP dataset showed a global correlation of 0.61, while the fitted models were built based on surface air temperature, wind, incoming longwave radiation and air specific humidity. The global mean difference between the "pseudo-data" and the simulated fluxes was 15.6%.

Overall, the CH4 wetland fluxes were simulated with very good accuracy, while adding/dropping co-variants (explanatory variables) gives the ability to produce a set of 12 models that can be finally fitted either globally or for a specific region. Additionally, it requires significantly less amount of time compared with process-based models. Robustness and the relatively good model performances of the global approach suggested the adoption of a unique model structure that can be applied globally.