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Relative linkages of peatland methane and carbon dioxide fluxes with climatic, environmental and ecological parameters and their inter-comparison

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Although methane (CH4) is the second most important greenhouse gas (GHG) after CO_2, about 80% of its global production is biogenic (wetlands, enteric fermentation and water disposal from animals) contrary to major anthropogenic sources of most other GHGs. Although on a shorter time scale, global emissions of methane are greater (10 year time frame) or about 80% (20 year time frame) of those of carbon dioxide in terms of their influence on global warming, methane emissions have been studied much less than CO_2 emissions. Lakes, reservoirs and wetlands are estimated to contribute about 15-40% to the global methane source budget, which is higher than total oceanic CH4 emission. Half of the world's wetlands are represented by peatlands which cover 3% of the global total land area. Peatlands have a thick water-logged organic soil layer (peat) made up of dead and decaying plant material. Moreover, they are carbon rich, containing twice as much stock as the entire forest biomass of the world (550 Gt carbon). When disturbed, they can become significant sources of greenhouse gas emissions. The organic carbon exposed to air due to various mechanisms can release CH4 or CO_2 in the atmosphere. Thus the nature of vegetation cover, radiation environment, wind turbulence, soil characteristics, water table depth etc. are expected to be important forcings that influence the emission of CH4 or CO_2 in the shorter time scale. However, long term climate change can also influence these governing factors themselves over a larger time scale, which in turn can influence the wetland GHG emissions. Thus developing a predictive framework and long term source appropriation for wetland CH4 or CO_2 warrants an identification of the major environmental forcings on the CH4 or CO_2 flux. In the present work, we use a simple and systematic data-analytics approach to determine the relative linkages of different climate and environmental variables with the canopy level half-hourly CH4 or CO_2 fluxes over a peatland in Germany. We utilize multivariate pattern recognition techniques of principle component and factor analysis to group and classify climatic, environmental and ecological variables based on their similarity as drivers. Three biophysical process components emerge from the clustering analysis which describe the system-data variances. We find that soil conditions (soil temperature and soil heat flux) are most important in explaining the CH4 flux. The radiation and energy components (sensible heat flux, photosynthetically active radiation (PAR), latent heat flux, net radiation) and turbulence components (wind speed, friction velocity) are moderately linked with the CH4 flux. On the other hand, the CO_2 flux has poor linkage with the soil environment variables, while it is strongly linked with the radiation environment components and the turbulence parameters. Quantifying these linkages using factor analysis can be up-scaled to include decadal scale variability to study the effect of climate change on wetland GHG emissions as well.