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Modelling interannual variability of methane emissions from a temperate degraded peatland

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La Guette peatland is a temperate ombrotrophic fen located in the Sologne region (France), dominated by Sphagnum. The site is instrumented for long term monitoring of hydrological variables, GHG emissions and biodiversity. An analysis of La Guette peatland methane emissions is presented where CH₄ fluxes measured by the dynamic close chamber method in the field are compared with CH₄ fluxes simulated by the ORCHIDEE model. Our study focuses on the 2014-2019 period after an hydrological restoration was undertaken to raise the water table level and promote the rewetting of the peat.

Site Description

- La Guette peatland : temperate ombrotrophic fen peat dominated by *Sphagnum*, located in Sologne region
- Perturbation of the peat due to urbanisation :
 - Water table level decrease
 - Vascular plants (*Molinia caerulea*, *Erica Tetralix*) invasion
- Hydrological restoration and vegetation experiments :
 - Dam built at the outlet of the downstream sub-watershed in 2014
 - Control (C) plots with intact vegetation
 - Bare (B) plots = bare peat
 - Sphagnum (S) plot = bare peat seeded with Sphagnum

Dam built in feb. 2014

Model Description and Set-up

- ORCHIDEE land surface model adapted for peatland (Largeron et al., 2018; Qiu et al., 2018)
- Set-up from Qiu et al. (2018) :
 - Spin-up to accumulate soil carbon (with preindustrial CO₂ concentrations)
 - Transient simulations from 1860 to now driven by meteorological data from La Guette and CRUNCEP data as well as CO₂ time series concentrations.
 - Photosynthetic parameter (Vcmax) tuned to match GPP derived from La Guette (D'Angelo et al., 2016) .
- Implementation of a methane module (Salmon et al., 2021)

The diagram shows the ORCHIDEE model (Terrestrial Biosphere) receiving inputs like temperature, winds, precipitation, and radiation. It outputs CO₂ emissions and CH₄ emissions. The Methane module includes processes like Methanogenesis, Methanotrophy, and Plant transport, which interact with soil carbon and root oxidation.

RESULTS

A) Comparison between observations and simulations

- Higher water table level for downstream station than upstream station and magnitude of water table fluctuations smaller for downstream than for upstream station
 - Hydrological restoration has worked
- Decreasing trend of water table position between 2014 and 2019
- Water table variations correctly captured by the model.
- Seasonal variation correctly reproduced
- Variation with depth indicates an overestimation of thermal conductivity

Methane Flux: CH₄ flux (gCH₄m⁻²day)

- Higher emission for downstream station than upstream station
- Decreasing trend of CH₄ flux with time between 2014 and 2019
- Modelled flux :
 - Seasonality well reproduced,
 - Decreasing trend of CH₄ flux not reproduced, peat too dry in summer
 - overestimation of methane diffusion

Consistent with WTD

RESULTS

B) Simulations Analysis

Modelled methane production, oxygen and carbon soil profiles :

- CH₄ production and O₂ profile concentrations compare well with previous work

Relative contribution of different processes :

- Contribution to the total methane Flux :
 - Plant-mediated transport 70%
 - Ebullition flux 14%
 - Diffusion flux 16%
- Factors controlling Methanogenesis (MG) and methanotrophy (MT):
 - MG (blue) correlates with ground temp. (red)
 - Decrease of water table level too small to affect methanogenesis
 - MT (blue) correlates with plant biomass (via root oxidation) and not water table level (red) variation that is too weak.

Further work

- Better representation of peat humidity.
- Investigate the decrease of methane flux between 2014-2019