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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 CH<sub>4</sub> fluxes measured by the dynamic close chamber method in the field are compared with CH<sub>4</sub> 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 CO<sub>2</sub> concentrations)
  - Transient simulations from 1860 to now driven by meteorological data from La Guette and CRUNCEP data as well as CO<sub>2</sub> 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 CO<sub>2</sub> emissions and CH<sub>4</sub> 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

- Water table depth:** Comparison of observed (aval, amont) and modeled water table levels from 2014 to 2020. The model captures the seasonal fluctuations and the overall decreasing trend.
- Humidity content:** Heatmap showing soil humidity content (water vol./soil vol.) over time and depth. The model (moudel) closely follows observed (mesure) data.
- Ground temperature:** Time series of ground temperature at different depths (20 cm, 40 cm, 60 cm, 80 cm). The model (moudel) matches observed (mesure) data well.
- Methane Flux:** Methane emissions from La Guette peatland. The model (Model) captures the seasonal peaks and the decreasing trend over time, consistent with observations (Obs aval, Obs amont).

- 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

**Consistent with WTD**

- Higher emission for downstream station than upstream station
- Decreasing trend of CH<sub>4</sub> flux with time between 2014 and 2019
- Modelled flux :
  - Seasonality well reproduced,
  - Decreasing trend of CH<sub>4</sub> flux not reproduced, peat too dry in summer
  - overestimation of methane diffusion

## RESULTS

### B) Simulations Analysis

#### Modelled methane production, oxygen and carbon soil profiles :

- Methanogenesis (gCH<sub>4</sub>/day/m<sup>3</sup>soil):** Heatmap showing methane production rates over time and depth. The model (moudel) compares well with measured data (mesure 1, 2).
- O<sub>2</sub> (gO<sub>2</sub>/day/m<sup>3</sup>soil):** Heatmap showing oxygen concentrations over time and depth. The model (moudel) compares well with measured data (mesure 1, 2).
- Soil carbone (kg/m<sup>3</sup>):** Time series of soil carbon content at different depths. The model (moudel) matches measured data (mesure 1, 2).

- CH<sub>4</sub> production and O<sub>2</sub> profile concentrations compare well with previous work

#### Relative contribution of different processes :

- CH<sub>4</sub> emission (gCH<sub>4</sub>/m<sup>2</sup>/day):** Breakdown of total flux into Plant-mediated transport (70%), Ebullition flux (14%), and 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