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CRITICAL PEAT project : The importance of hydrology for Carbon Reactivity along with atmosphere - peatland interactions. Preliminary results from the Frasne peatland monitoring (Jura Mountains, France).

Alexandre Lhosmot, G. Bertrand, M. Steinmann, M.L. Toussaint, C. Bertrand, L. Collin, A. Ponçot, G. Magnon, H. Jeanton, A.V. Walter, et al.

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I Peatlands: a threatened 3 pillar equilibrium

~3% of emerged surfaces (Joosten and Clarke, 2002)
 ~30% of soil carbon (Parish et al, 2008), an underestimated stock? (Nichols et al., 2019)
 ~10% of global freshwater resources (Joosten and Clarke, 2002)

Global threats
 Global air temperature increase (IPCC, 2014), rainfall regime changes (Trenberth, 2011)

Local threats
 Peat extraction and drainage (XVIIIth to XXth century)
 Restoration (2015/2016)

Peatland observatory in Frasne (Jura mountains, NE France) since 2008

Monitoring of possible hydro-ecological changes.

Retroaction ?

The Frasne peatland is representative of a sensitive compartment of the Critical Zone combining water, carbon and biodiversity stakes.

II Context: a pedo-geological mosaic?

Geological framework
 A large Jurassic syncline of the Jura arc: karstified limestones overlain by moraines. Mountainous area at 800 to 1100 m asl. Frasne peatland at 834 m asl.

Pedological framework

A diversified peatland patchwork: ecological mosaic (vegetation, peat fiber rate) (Briot, 2004; Grosvernier, 2005), variable peat thickness (Collin, 2016).

These heterogeneities could favor a patchwork-like hydro-ecological functioning.

III Materials and methods

Peatland observatory since 2008

- Meteorology (e.g. P, T)
- Hydrology (Water Table Depth, WTD)

Eddy Covariance Tower since 2018

- Gross primary prod.
- Ecosystem respiration
- Net ecosystem exchanges
- Evapotranspiration
- Methane fluxes

Water Sampling throughout the peatland

- Geochemical characterization
- Outlet monitoring

Vanessa Outlet Eddy Tower

IV A Hydro-geochemical mosaic?

Electrical Conductivity (EC; Nov. 2018): A vertical mosaic?

Water isotopic signature (Aug. 2016): A mosaic of water origins and fates?

Local precipitation? Regional GW? Evaporation

• Heterogeneous vertical EC gradient throughout the peatland.
 → Irregular peat/moraine contact? Small-scaled permeability and pressure changes as suggested by Hare et al. (2017)?

• Deepest water (< -50 cm) close to the LMWL (1200 m).
 • Enriched superficial water (> -50 cm) suggesting evaporation.

→ 2 hypotheses : (1) Water/moraine interaction may vary laterally due to variable residence times, leading to contrasted EC. (2) Alternatively, punctual injection of karstic water at the bottom of the peatland.

V 10 years of hydro-meteorological monitoring, decomposition, and relationships

Air T (°C)
 Temperature increases significantly: +1 °C in 10 years.

Precipitation (mm/day)
 Precipitation (P) pattern: interannual variability and slight increase since 2008.

WTD (m)
 Similar patterns for WTD and precipitation: the multi-year WTD follows precipitation. Buffered impact of the restoration at the center of the peat.

Seasonal and multi-year trend correlations

- Seasonal T variability explains 67% of the WTD variability, highlighting the importance of evapotranspiration for seasonal WTD changes.
- In contrast, P seasonality is not relevant for seasonal WTD changes, but P multi-year trend may explain 44% of the WTD multi-year trend.

→ Ongoing climate evolution implies contrasted effects with variable temporal scales over the peatland WTD.

VI Preliminary results from 1,5 year of Eddy Covariance monitoring

Potential links with hydrology

$NEE = R_{ECO} + GPP$

Net Ecosystem Exchange [NEE] ($\mu\text{molCO}_2\cdot\text{m}^{-2}\cdot\text{s}^{-1}$)
Ecosystem respiration [R_{ECO}] ($\mu\text{molCO}_2\cdot\text{m}^{-2}\cdot\text{s}^{-1}$)
Gross Primary Production [GPP] ($\mu\text{molCO}_2\cdot\text{m}^{-2}\cdot\text{s}^{-1}$)
Evapotranspiration ($\text{mm H}_2\text{O}\cdot\text{h}^{-1}$)
Outlet water level (cm)
Piezometer WTD (m)
Air temperature (°C)
Electrical Conductivity (EC) ($\mu\text{S}\cdot\text{cm}^{-1}$)
Precipitation ($\text{mm}\cdot\text{day}^{-1}$)

Atmospheric CO₂ fluxes

- The peatland was a CO₂ sink in summer 2019, but a source of CO₂ during the rest of the time.
- C balance of the peatland since July 2008: +167,8 gC/m².

Outlet flow monitoring

- Low EC during high flow (winter), high EC in summer.
- Mobilization of strongly mineralized deep peat water or input of GW (moraines, karst) during dry periods.

→ C sink function ($NEE < 0$) partially dependent on the hydrological conditions. In particular, during the maximum metabolism period ($ET > 0$), great WTD (below -0,20 m) seems to be associated with a source function ($R_{ECO} > |GPP|$). In contrast, when WTD is closer to the surface, $|GPP| > R_{ECO}$.

VII Take Home Messages: Synthesis → Perspective

- Water supply from local P + regional GW? → To be evaluated through to LMWL under construction.

- WTD evolution strongly controlled by long-term P trend and seasonal T trend: multiscale temporal sensitivity → Hydro-climatic modelling for IPCC's scenarios (RCP's 4.5 and 8.5) until 2100 in progress.

- Atmosphere-peatland C exchange potentially changing when WTD = -0,20 m during active metabolism period. Lack of hindsight of restoration impact. → Need to integrate the interaction between the C, water, biodiversity pillars: CH₄ and CO₂ flux measurements combined with hydro-ecological conditions across the mosaic (WTD, peat T°, water quality, snow cover, vegetation type) starting in 2020 (See you next year? ;-)).

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