Summer extreme climatic event in the future: impact on net CO2 and water fluxes of an upland grassland and buffering impact of elevated atmospheric CO2.

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Summer extreme climatic event in the future: impact on net CO$_2$ and water fluxes of an upland grassland and buffering impact of elevated atmospheric CO$_2$

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3 platforms:

12 macrocosms
12 (300) microcosms
24 mesocosms

THE EUROPEAN MONTPELLIER ECOTRON
A research platform to analyse the responses of ecosystems, organisms and biodiversity to environmental changes

Open to international consortia
Call in summer 2013
Intact soil monoliths
From a mid-altitude grassland

Inserted in the macrocosms
of the Ecotron
Air diffusing ring

Tefzel sheet

Intact ecosystem sample

Internal mixing flux (2 vol / mn)

75 m³ / mn

Air outlet

Air inlet

Air conditioning unit

2,5 m³ / mn
On line measurements

Net CO$_2$ Exchange: every 12 mn

$$\text{NEE} = \frac{[F \times (C_{\text{out}} - C_{\text{in}})]}{S}$$

Whole system calibration every night in one macocosm by simulating known additional respiration

Evapotranspiration: continuous measured by weight loss (straingauges)
2010: preconditioning warmer and dryer scenario reproducing the 2050 forecasted climate for the sampled site

<table>
<thead>
<tr>
<th></th>
<th>Annual Precipitation</th>
<th>Annual Mean Air Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>856 mm</td>
<td>8,6 °C</td>
</tr>
<tr>
<td>2050</td>
<td>770 mm</td>
<td>10,9 °C</td>
</tr>
<tr>
<td>Difference 2050/1999</td>
<td>- 10%</td>
<td>+ 2,3 °C</td>
</tr>
</tbody>
</table>

2011: full experiment
T°C and rainfall = 2050
6 macrocosms ambiant CO₂: 390 ppm
6 macrocosms 2050 CO₂: 520 ppm

Summer drought : - 50% rainfall
Drought (0 %) + heat wave + 3,5 °C
Gradual rewatering
Averaged environmental conditions achieved in the 4 treatments

<table>
<thead>
<tr>
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<th>Ctrl 390</th>
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<th>Extr 390</th>
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<th>Ctrl 520</th>
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<tr>
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<td>mean</td>
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<tr>
<td>CO2</td>
<td>391,0</td>
<td>1,6</td>
<td>392,3</td>
<td>1,1</td>
<td>520,9</td>
<td>1,6</td>
<td>518,9</td>
<td>2,5</td>
</tr>
<tr>
<td>T °C</td>
<td>15,46</td>
<td>0,03</td>
<td>16,03</td>
<td>0,09</td>
<td>15,48</td>
<td>0,05</td>
<td>16,09</td>
<td>0,04</td>
</tr>
<tr>
<td>VPD</td>
<td>0,71</td>
<td>0,03</td>
<td>0,91</td>
<td>0,02</td>
<td>0,76</td>
<td>0,03</td>
<td>0,90</td>
<td>0,01</td>
</tr>
</tbody>
</table>
Soil moisture at 7cm depth

Control 2050: cold colors
Extreme 2050: warm colors
Elevated CO2: lighter colors
Net Ecosystem Exchange (24h)

- Climate: -181% $p=0.000$
  - CO$_2$: +29% $p=0.020$

Time (Year/month)

- Control $T^\circ C$: 2050, Rain: 2050
- T$^\circ C$: 2050, Rain: 2050
- T$^\circ C$: 2050, Rain: 50%
- T$^\circ C$: 2050, Rain: 0%
- T$^\circ C$: 2050, Rain: Gradual
**Net Ecosystem Exchange (24h)**

- **CO₂**: +29% \( p=0.020 \)
- **Climate**: -181% \( p=0.000 \)
- **Climate**: +152% \( p=0.005 \)
- **CO₂**: +143% \( p=0.006 \)

**Analysis:**
- **Effect CO₂**: \( F(1, 8)=14.00 \quad p=0.006 \) \( \text{Vertical Bars IC} = 0.95 \)
- **Effect Climate**: \( F(1, 8)=14.89 \quad p=0.005 \) \( \text{Vertical Bars IC à} 0.95 \)

**Graph:**
- Time (Year/month)
- NEE (g CO₂.m⁻².day⁻¹)
- C-380
- E-380
- C-520
- E-520

**Legend:**
- **T°C: 2050 Rain: 2050**
- **Cut 1**
- **Cut 2**
- **Cut 3**
- **Cut 4**
- **Climate:**
  - **Control T°C: 2050 Rain: 2050**
  - **TC-2050 Rain: -50%**
  - **TC-25°C Rain: 10%**
  - **TC-2050 Rain Gradient**
  - **T°C: 2050 Rain: 2050**
Evapotranspiration (24h)

- **Temperature (°C):** 2050
- **Rain:** 2050

**Climate:** - 49%  p=0.000

**CO₂:** - 3%  p=0.021

Graph showing evapotranspiration over time with different scenarios.

- **ETR (kg·day⁻¹/4m²):**
- **Time (Year/month):** 2010 to 2011

Legend:
- C-380
- E-380
- C-520
- E-520

Graph highlights different conditions and their impact on evapotranspiration.
Ecosystem Water Use Efficiency (diurnal)

Climate: - 150 % \( p=0.000 \)

\( \text{CO}_2: + 31 \% \quad p=0.007 \)
Ecosystem Water Use Efficiency (diurnal)

CO₂: + 31 %  p=0.007
Climate: - 150 %  p=0.000

CO₂: + 44 %  p=0.011
Climate: + 51 %  p=0.012

Period Post Stress
Effect CO₂ : F(1, 8)=10.87  p=0.011
Effect Climate: F(1,8)=10.51  p=0.012
ETR 11 months

NEE 11 months

Root Growth Rate

Extr 520

Above ground biomass

Sum all cuts

Root growth at different periods
Conclusions:

Significant impact of extreme drought-Temperature on NEE

Significant positive impact of CO2, overcompensate the negative effect of extremes

More impact on roots and soil than on above ground biomass

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