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.


To cite this version:

Jacques Roy, Damien Landais, Clément Piel, Marc Defossez, Christophe Escape, et al.. 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.. , OpenScienceConference on Climate Extremes and Biogeochemical Cycles in the Terrestrial Biosphere: Impacts and Feedbacks Across Scales, Max-Planck-Institut. Jena, DEU., 2013, Seefeld, Austria. hal-02806538
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$_2$

Jacques Roy and col. : European Ecotron of Montpellier CNRS France

Michael Bahn : Institute of Ecology University of Innsbruck Austria

Florence Volaire : CEFE CNRS, INRA Montpellier France

Angela Augusti, J-F Soussana, C. Picon-Cochard : UREP INRA Clermont-Ferrand France
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
Air outlet
Internal mixing flux (2 vol / mn)
75 m³ / mn
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

T°C: 2050 Rain: 2050

July - August
Averaged environmental conditions achieved in the 4 treatments

<table>
<thead>
<tr>
<th></th>
<th>Ctrl 390</th>
<th></th>
<th>Extr 390</th>
<th></th>
<th>Ctrl 520</th>
<th></th>
<th>Extr 520</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>stan error</td>
<td>mean</td>
<td>stan error</td>
<td>mean</td>
<td>stan error</td>
<td>mean</td>
<td>stan error</td>
</tr>
<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>
Net Ecosystem Exchange (24h)

Climate: -181 % p=0.000

CO₂: +29% p=0.020

Control T°C: 2050 Rain: 2050

2010 1 2 3 4 5 6 7 8 9 10 11
Time (Year/month)
Net Ecosystem Exchange (24h)

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

**Effect of Climate:**
- F(1, 8)=14.89 \( p=0.005 \)
- Vertical Bars IC à 0.95

**Effect of CO₂:**
- F(1, 8)=14.00 \( p=0.006 \)
- Vertical Bars IC = 0.95

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

**Time (Year/month)**
- 2010
- 2011
Evapotranspiration (24h)

- **T°: 2050  Rain: 2050**
- **Climate: - 49 %  p=0,000**
- **CO₂: - 3 %  p=0,021**

<table>
<thead>
<tr>
<th>Cut 1</th>
<th>Cut 2</th>
<th>Cut 3</th>
<th>Cut 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>T°: 2050 Rain: 2050</td>
<td>T°: 2050 Rain: 50%</td>
<td>T°: 35°C Rain: 0%</td>
<td>T°: 2050 Rain: Gradual</td>
</tr>
</tbody>
</table>

ETR (kg·day⁻¹/4m²)

Time (Year/month) from 2010 to 2011
Evapotranspiration (24h)

<table>
<thead>
<tr>
<th>Time (Year/month)</th>
<th>Evapotranspiration (24h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control T°C: 2050 Rain: 2050</td>
<td>CO2: -3% p=0.021</td>
</tr>
<tr>
<td>Control T°C: 2050 Rain: 2050</td>
<td>Climate: -49% p=0.000</td>
</tr>
<tr>
<td>T°C: 2050 Rain: 2050</td>
<td>CO2 * Climate: p=0.006</td>
</tr>
</tbody>
</table>

- CO2: -3% p=0.021
- Climate: -49% p=0.000
- CO2 * Climate: p=0.006
Ecosystem Water Use Efficiency (diurnal)

Climate: - 150 % p=0.000

CO₂: + 31 % p=0.007

Time (Year/month)

2010

2011
Ecosystem Water Use Efficiency (diurnal)

**Temperature:** 2050
**Rain:** 2050

- **Climate:** -150% p=0.000
- **CO₂:** +31% p=0.007
- Climate: +51% p=0.012

**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

Above ground biomass

Root growth at different periods

Ctrl 390
Extr 390
Ctrl 520
Extr 520

Sum all cuts

Ctrl 390
Extr 390
Ctrl 520
Extr 520
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

Hope to welcome you in the Ecotron
ExpeER funds Transnational Access to more than 30 European experimental sites

www.expeeronline.eu