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Vulnerability of grassland systems to climate change and extreme events: a case study from the Central Massif of France

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The project VALIDATE (French National Research Agency, 2008-2011)
- VALIDATE: Vulnerability of grasslands and livestock to climatic changes and extreme events in France and Europe (http://www1.clermont.inra.fr/validate)
- Objectives:
  - To represent the variability in temperature and precipitation via regionalized climate scenarios
  - To determine experimentally the impacts of extreme events (soil drought, heat waves) in interaction with an average climate change
  - To model impacts, adaptations and vulnerability at plot, farm and regional scales

The same objectives are shared by the EU project CARBO-Extreme (http://www.carbo-extreme.eu)

Experimental setup
- An experiment was set up with a permanent grassland in the upland central France (Massif Central, Theix, 45° 43’ North, 07° 06’ East, 890 m a.s.l.), conducted under actual and altered climatic conditions (warmer and drier), and managed intensively (6 cuts per year) or extensively (i, three cuts per year) without fertilisers addition

- For 2009, the Pasture Simulation Model (PASIM) was calibrated against vegetation (dry matter yield) and soil (temperature, moisture, organic matter) variables and employed to generate a variety of outputs related to carbon and nitrogen fluxes (CO2 and N2O emissions, gross and net productivity) and global warming potential under four climatic conditions:
  - Actual climate (C-): 240.5 mm (summer rain), 768.8 mm (annual rain)
  - Actual climate with summer extreme event (C+): heat wave (active warming system) and precipitation reduction (162 mm, 693.8 mm)
  - Future climate (F+) corresponding to a projection of SRES A2 scenario for 2020-2049: night temperature increase (passive warming system) and precipitation reduction (146.0 mm, 564.8 mm)
  - Future climate with summer extreme event (F+): active warming system to mimic extreme event under projected scenario (71 mm, 491.3 mm)

General conclusions
- Grassland practices may determine the incidence of the impacts associated with extreme events and/or warming:
  - Climate extremes tend to have major impacts (C losses, positive GWP) on extensively-managed systems (-), which may be mitigated by a warming climate (+)
  - On intensively-managed grasslands, some adverse impacts are likely from extreme events (- / +) occurring in a changing climate (-)

The following annual outputs are shown:
- Ecosystem respiration (Reco, kg C m^-2)
- Net biome productivity (NBP, kg C m^-2)
- Nitrous oxide (N2O) emissions (kg N ha^-1)

For 2009
- The simulated yield compared well to the observations, reflecting the within-year dynamic of grassland production under different managements and treatments
- Extreme events tend to reduce the potential for grassland productivity
- Extreme events tend to increase the potential for grassland CO2-N2O emissions
- Extreme events tend to decrease the potential for grassland CH4 emissions

For the NBP, simulations show increased carbon (C) losses with extreme events occurring under today’s conditions, while under future climate C losses are reduced; intensively-managed grasslands appear more adapted to current conditions but may lose more C in the future

All treatments and managements contribute to the warming effect, with GWP largely reflecting the NBP and yield dynamics

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