Simulation of nitrous oxide emission from maritime pine forest

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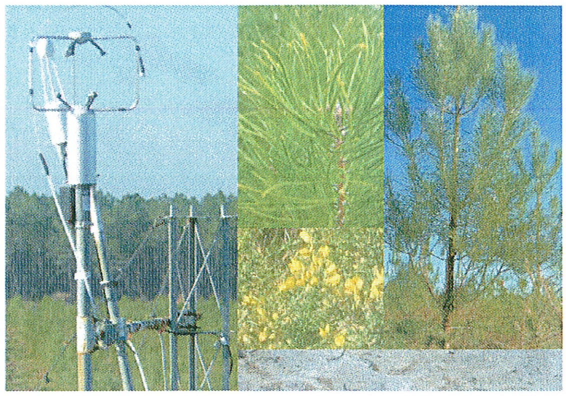
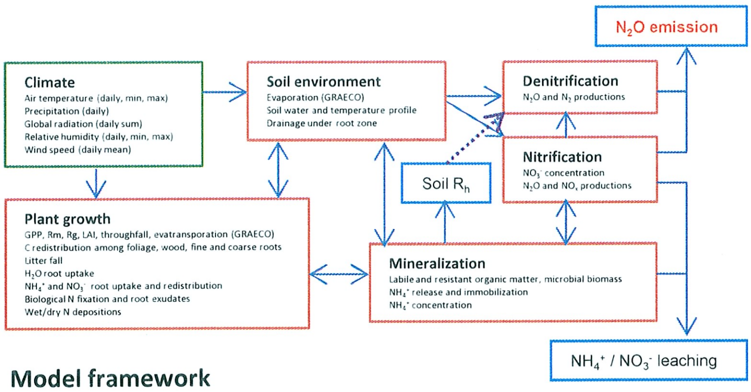
Introduction

Atmospheric nitrous oxide (N_2O) contributes to the global warming and stratospheric ozone depletion. Temperate forest is a significant source of N_2O, mostly due to enhanced nitrogen (N) deposition (Papen and Butterbach-Bahl, 1999). Biological N fixation can be an extra N input to the ecosystem. Since legumes and N mineral fertilisers could be widely used in intensive forest management alternatives, a better knowledge of the greenhouse gases balances of these intensive forests is requested, as well as its environmental and silvicultural drivers. To this end, both observed data and modelling tools are required.

GRAECO is a process-oriented model that simulates the energy, carbon (C) and water (H_2O) balances between forest and atmosphere (Loustau et al., 2005; Moreaux, 2012). Within the WP3 of the GHG-Europe project our specific objective is to develop a N dynamic submodel to assess N_2O emission and run the integrated model over the Leyre river forest catchment in South-western France from 1990 to 2010.

Meanwhile, we are starting N_2O flux measurement using the eddy covariance technique over a maritime pine forest at the Bilos site, 50 km south-west of Bordeaux, France.





Model framework

- Biological N fixation depends on soil temperature, the fraction of nodulated root and the root mass (Houlton et al., 2008).
- Organic matter is divided into several C pools, each representing a specific decomposition rate and C:N ratio.
- NH_4^+ is released and/or immobilized following the C flow between different pools.
- N_2O is produced through nitrification and denitrification which are controled by soil NH_4^+ and NO_3^- concentrations, soil water content and temperature.
- Soil water content and pH control the N_2O fraction in the gas productions of nitrification and denitrification.

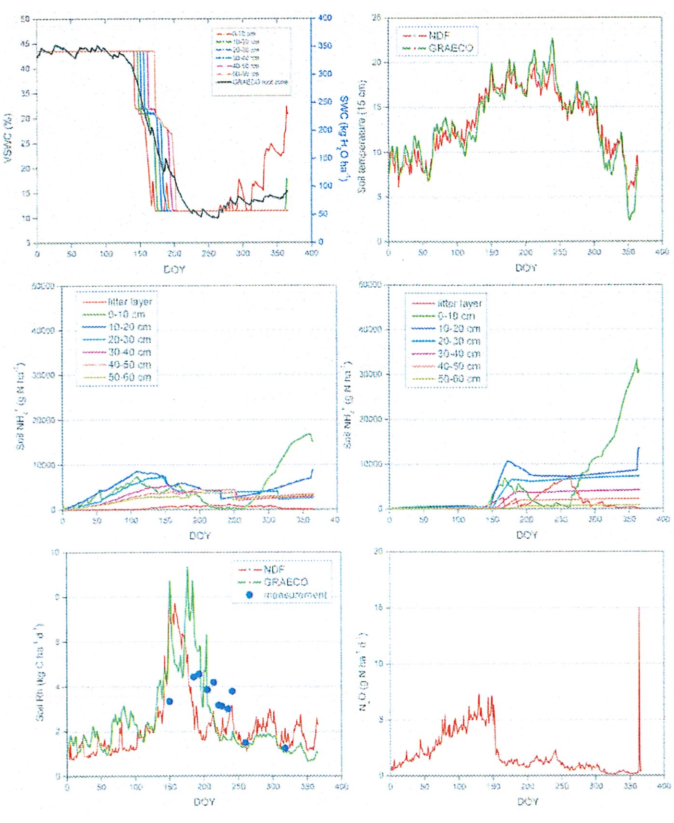
Site description and N_2O flux measurement

- Maritime pine (*Pinus pinaster* Ait.), seeded in 2004, covers a 1.0×0.6 km² area (Moreaux et al., 2011).
- 70% of the well-developed understory (biomass) are *Ulex minor*, a kind of gorse with nodulated roots.
- Topsoil has a sand content over 90% and a pH 4.5.
- Land is mostly flooded during winter and spring.
- Fast response N_2O analyzer (LGR CO/N_2O analyzer) will be run at 10 Hz frequency with gas sampling tube installed at z=9.6 m on a tower with sonic anemometer Gill R3. Half hourly values of energy, CO_2, and H_2O fluxes are monitored at the same level.
- Soil temperature and water content in 5 soil layers (5-45 cm) are measured across four vertical soil profiles located around the tower.
- Soil NH_4^+ and NO_3^- concentrations are analyzed twice a month.

Simulation

- Simulations of topsoil temperature and water content agree well between the two models and with data collected at the C-Europe Bray site (Berbigier et al., 2001)
- The submodel can catch the seasonal pattern of soil heterotrophic respiration, as compared with chamber measurements; however, the simulations of GRAECO show two peaks in spring.
- As expected, soil NH_4^+ and NO_3^- accumulated during the summer and autumn, due to little rainfall that limited the plant growth and denitrifier activity. *
- Annual N_2O loss predicted is 0.7 kg N ha^{-1}, in which denitrification contributes 70%. *

* The simulation needs to be validated with the ongoing measurement.



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