European biogenic VOC Emissions: A Model Comparison, and Future Emission Trends from European Forests.

Trevor Keenan[1], Ulo Niinemets[3], Stephan Noe[3], Josep Penuelas[1], Shelley Pressley[4], Santi Sabaté[1,2] , Dominique Serca[5] & Carlos Gracia[1,2]

[1] Centre for Ecological Research and Forestry Applications (CREAF). Barcelona, Spain. t.keenan@creaf.uab.es.
[2] Department of Ecology. Faculty of Biology. Barcelona University. Spain.
[3] Department of Plant Physiology, University of Tartu, Estonia .
[4] Department of Civil & Environmental Engineering, Washington State University. USA.
[5] Laboratoire d'Aerologie, Toulouse. France.

INTRODUCTION

The study of terrestrial ecosystems requires the use of predictive tools such as functional simulation models. This is of particular importance in quantifying fluxes of carbon, water, nutrients and volatile organic compounds. This work focuses on the capacity, both present and future, of European forests to generate biogenic Volatile Organic Compounds. BVOCs are of particular importance due to their role in atmospheric chemistry, and their capacity to generate a feedback under climate change scenarios. Three emission models of varying approaches and complexity were compared, both under current and future climatic conditions, on a Europe-wide scale.

AIMS

The main aims of this work (within the GREENCYCLES project) are:

- Modelling BVOC emissions with GOTILWA+ to explore the effects of climate change, land use change and management scenarios on European forest emissions.
- Compare the predictions of three distinct emission models, under current and expected future climatic conditions.

THE GOTILWA+ ECO-PHYSIOLOGICAL MODEL

GOTILWA+, *Growth Of Trees Is Limited by WAter,* (Gracia *et al.* 1999) is a mechanistic model that simulates forest growth from water and carbon fluxes and balances in the system. The model can to be applied to different types of forest ecosystems (from boreal to Mediterranean regions) and to different species types (evergreen or deciduous, broad-leaded or needle-leaved).

THE EMISSION MODELS COMPARED:

GUENTHER EMISSION MODEL:

- Simple empirical model based on leaf temperature and light intensity.
- Simple, yet efficient.
- Empirical - May not be applicable under climate change conditions.

MODIFIED MARTIN EMISSION MODEL:

- Highly mechanistic model describing emission through the interaction of three limiting factors.
  - The supply of carbon from Pyruvate
  - The supply of ATP from phosphorylation
  - The temperature dependency of the isoprene synthase reaction rate

NIINEMETS EMISSION MODEL:

- Highly mechanistic model, linking emission rates to the electron transport rate.
- Accounts for enzyme activity and leaf internal carbon concentration
- Suitable for applications in drought conditions and climate change scenarios.

Applying GOTILWA+ in Europe

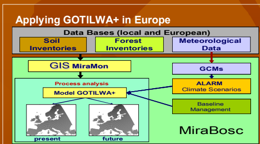


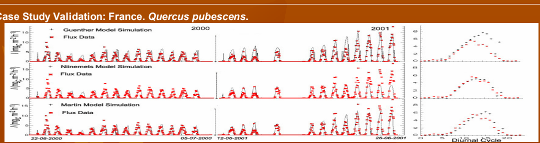
Diagram of the CREAF approach and procedure in ALARM project.

ALARM scenarios

A2 (BAMBU): Intermediate scenario of climate change

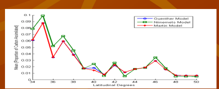
RESULTS:

A Case Study Validation: France. *Quercus pubescens*.



Each model compared well against the data. The Guenther model effectively captured inter daily variation, but tended to overestimate afternoon emissions considerably. The Niinemets model accurately simulated the afternoon drop in emissions, but was not accurate in predicting emissions at high temperatures. The Martin model was the most effective, capturing both the diurnal cycle and the inter daily variation.

Europe-Wide Simulations: Broadleaf Evergreen, Coniferous and Deciduous Functional Types.



The proportion of assimilated carbon lost through emissions for Broadleaf Evergreen across a latitudinal gradient.

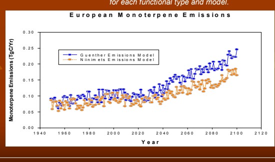
The proportion of carbon assimilated depends on the plant functional type, with each one with an individual basal emissions factor. Here it can be seen that Broadleaf Evergreen trees use a substantially higher proportion of assimilated carbon to emit Isoprene and Monoterpene, followed by Coniferous and then Deciduous. The three model approaches were in close agreement as to the extent of these emissions. Small differences, however, lead to bigger ones when considering emissions on a European Scale.

	Guenther	Niinemets	Martin Hybrid
Evergreen:			
Mean	2.98%	3.00%	2.96%
Standard Deviation	10.90%	12.42%	10.82%
Deciduous:			
Mean	0.0083%	0.009%	0.0081%
Standard Deviation	0.68%	0.76%	0.0059%
Coniferous:			
Mean	0.43%	0.41%	n.a.
Standard Deviation	2.56%	2.97%	n.a.

Mean and Standard Deviation of proportions of assimilated carbon lost through emissions for each functional type and model.

Preliminary Future European Emissions Results:

Results simulations with the A2 scenario under HadCM3. Mean Monoterpene emission rates increased dramatically, whilst Isoprene emissions are predicted to remain relatively stable.



The Guenther Monoterpene model shows a higher sensitivity to climatic variability, and predicts considerably higher emissions than those of the Niinemets model.

CONCLUSIONS

- **The Guenther model overestimated emissions slightly, but captured the daily variation. The Niinemets models conferred on the magnitude of emissions, but was undersensitive to daily variation. The Martin model proved most effective, capturing both the daily variation and the magnitude of emissions.**
- **Higher proportions of assimilated carbon were lost through emissions in the Broadleaf Evergreen class, followed by Coniferous and then Deciduous plant functional types.**
- **The effect of the continuous loss of assimilated carbon on modelled state variables (GPP, LAI etc.) was not noticeable until after 60 years of simulation.**
- **Predictions of future emissions of Monoterpene show a positive response to climate change, representing a possible feedback mechanism.**
- **Future emissions of Isoprene from European forests are predicted to remain stable.**

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www.greencycles.org/Greencycles_Personal_Page_Trevor.html

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