Climatic impacts on managed forests: projecting the future from the past

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Climatic impacts on managed forests: projecting the future from the past

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The process based model GO+ is used for projecting the future of managed forests. Past observations from different networks are used to calibrate the model with Bayesian methods through a hierarchical approach.

Introduction

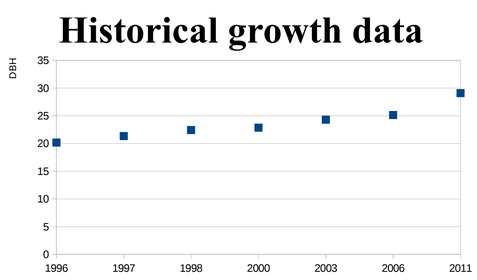
Understanding the response of forest ecosystems to a changing environment forms the basis of climate scenario projections, a critical issue for forest stakeholders and forest policy makers. Process based models are now commonly used to look back to the past to understand interactions between forest ecosystem and the environment and then to make projections in the future (Loustau et al., 2005). It is assumed that the robustness of projections relies upon the physical and biological basis pertaining to such models. Process models include a large number of physical or biological parameters, most of them being insufficiently determined and therefore needing appropriate calibration.

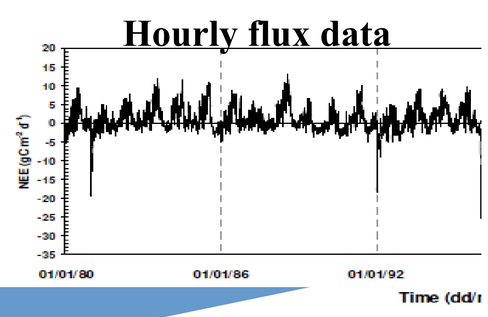
The GO+ forest growth model developed in INRA Bordeaux is composed of different processes which are organized logically according to the system physics: phenology, radiative balance, energy balance and convective fluxes, water balance, carbon balance, growth and carbon allocation. Hence, for instance, the radiative balance (i.e. the energy entering the ecosystem) is handled before the photosynthetic carbon fluxes or growth are calculated. Accounting for this process hierarchy, we propose to adopt a hierarchical, step-by-step, approach to calibrate each of the main processes of the model with Bayesian methods (Van Oijen et al. 2005). This poster illustrates this approach and shows the prediction capacity of our model compared to observed data. An example of scenario projection of the Gross Primary Projection of Pine forests is also shown.

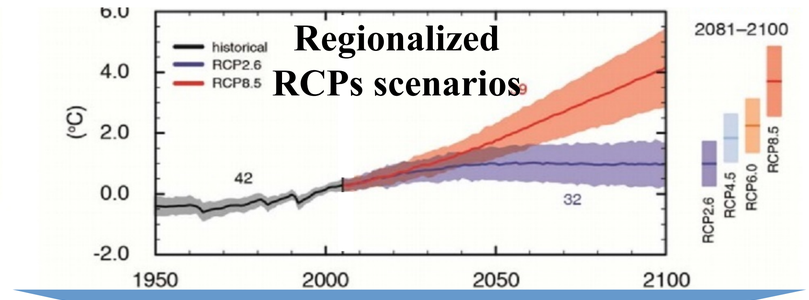
Materials and methods

1980 — 2000 — 2015 — 2100

From the Past to the Future







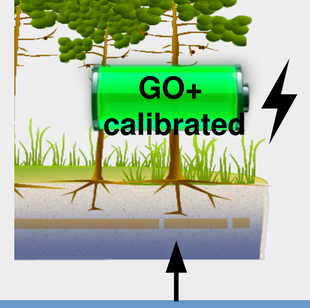
1. Model calibration : a hierarchical approach

Step	Used data-set	Processes	Calibrated parameters
0.	IGN Presence absence	Tree distribution	Probability of presence
1.	Budburst senescence — ICP Forests	Phenology	Phenology model parameters
2.	Rn	Radiative balance	Spectral properties (albedo...)
3.	ICOS, FLUXNET — LE, H	Convective heat flux	Diffusive parameters (Stomatal conductance...)
4.	NEE	Carbon balance	Photosynthesis parameters (Vcmax, Jmax...)
5.	Office National des Forêts, CNPF, GIS Coop — DBH	Growth	Allocation

+ Climate (T°, Prec, R, wind, P) and management forcings (ploughing, thinning...)

3. Projections forced by climate and management scenarios

Climate scenarios from regionalized RCPs



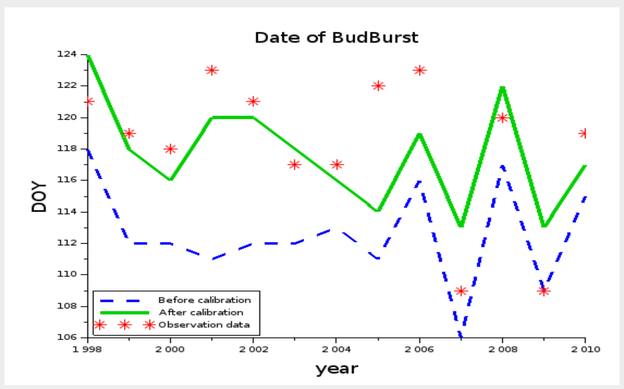
Management scenarios

Standard — Intensive — Very Intensive

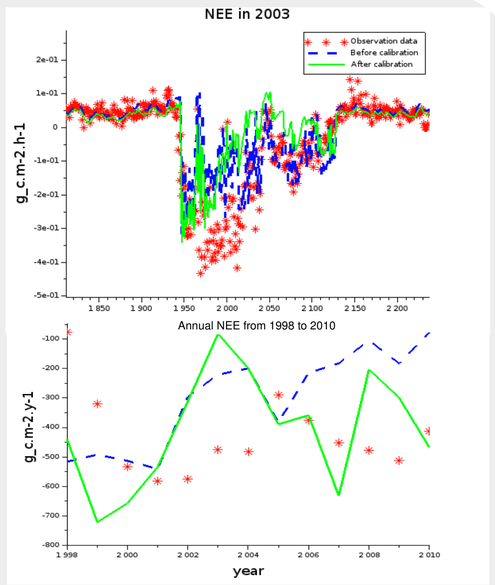
Forest stakeholders are involved to describe management scenarios. The scenarios include a potential soil preparation, rotation length, fertilization, thinning...

2. Calibration results

In this example, the Bayesian algorithm is applied to the *Fagus sylvatica* model version. Modeled results are compared to observation data for 3 successive years of measurements chosen to include extreme conditions.



Results of the Bayesian calibration on the day of budburst occurrence prediction.



Results of the Bayesian calibration on daily and annual NEE

4. Simulations /projections

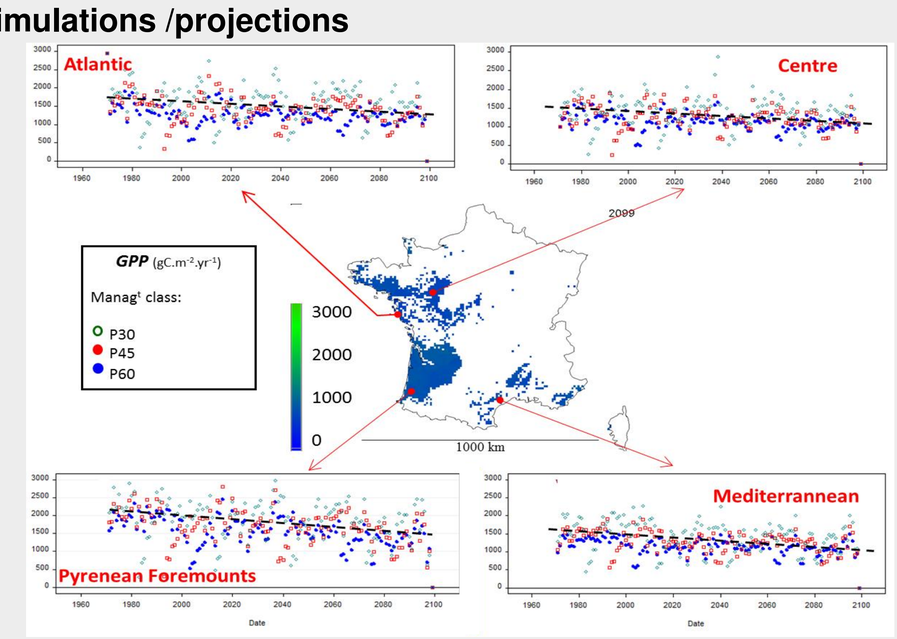


Figure above illustrates a projection of the Gross Primary Production of *Pinus pinaster* forest stands as projected by the calibrated model forced by climate scenario (A2) at four grid points of the maritime Pine area. A2 scenario downscaled by the ARPEGE model (Météo-France) includes a decrease in Spring and Summer precipitation together with an enhancement of air water vapour saturation deficit. This growing aridity explains the decreasing trend of GPP along the 21st century.

Results

Conclusion

The richness of data available regarding *e.g.* phenology, ecosystem energy and mass fluxes, long term growth etc. allows to calibrate process models process by process following a logical hierarchical approach. This approach has been applied to the cases of *Pinus* sp., *Fagus sylvatica* and *Pseudotsuga menziesii* in France using the INRA GO+ model and provide parameters values with meaningful distribution. In addition, making benefit from the wide range of geographical climate and soil conditions covered by observations, calibration of each process can be operated using data covering the range of values projected by climate scenarios to some extent. Availability of data renders still this approach tedious and lengthy and it is hoped that future infrastructures dedicated to environmental observations such as ICOS and Copernicus observation programs will make it much easier and quicker.

Once calibrated with appropriate data, process based models can assess the impact of climate and management scenarios in terms of ecosystem services (carbon sequestration, wood supply, water regulation). We show in particular that the important mitigation role played by the forests could be reduced in certain southern European regions if no adaptive strategy is undertaken. Further work will begin to improve the representation of nutrients cycle and for example help to better understand the effects of atmospheric nitrogen deposition and the interaction with other environmental changes.

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