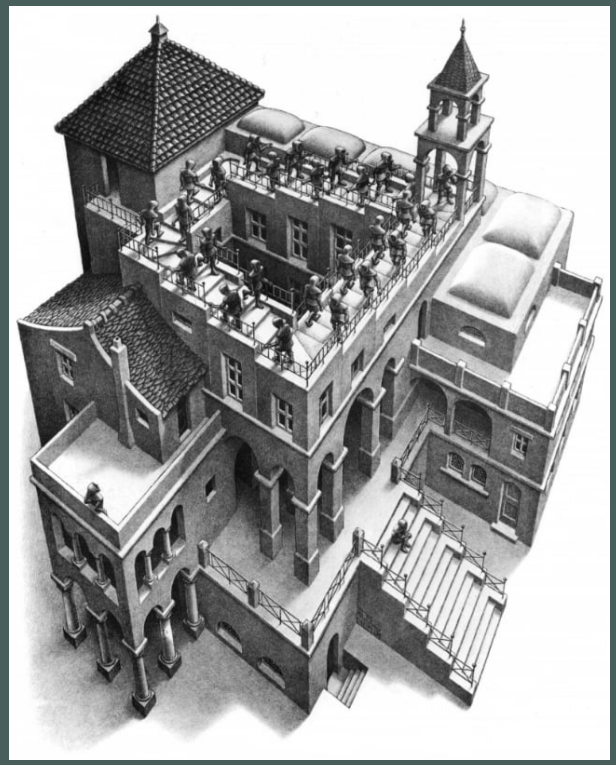
1.1 - Introduction to process-based forest modelling

Miquel De Cáceres, Victor Granda, Aitor Ameztegui

Ecosystem Modelling Facility

2022-06-13



Outline

1. Fundamental concepts

2. Modelling cycle

3. Overview of process-based forest models

1. Fundamental concepts

Models

- *Model* - A simplification of reality constructed to gain insights into a set of attributes of a physical, biological, economic, or social system.
- *Conceptual model* - A hypothesis regarding the important factors that govern the behavior of an object or a process of interest.
- *Statistical model* - A model built using observations within a probabilistic framework.
- *Mechanistic (or process-based) model* - A model that explicitly represents the understanding of physical, chemical or biological processes.
- *Simulation model* - A model that represents the development of a solution by incremental steps through the model domain.

Model components

- *Modules* - An independent or self-contained component of a model.
- *State variables* - The dependent variables calculated within a model, which often change over the simulation.

1. Fundamental concepts

Models

- *Model* - A simplification of reality constructed to gain insights into a set of attributes of a physical, biological, economic, or social system.
- *Conceptual model* - A hypothesis regarding the important factors that govern the behavior of an object or a process of interest.
- *Statistical model* - A model built using observations within a probabilistic framework.
- *Mechanistic (or process-based) model* - A model that explicitly represents the understanding of physical, chemical or biological processes.
- *Simulation model* - A model that represents the development of a solution by incremental steps through the model domain.

Model components

- *Modules* - An independent or self-contained component of a model.
- *State variables* - The dependent variables calculated within a model, which often change over the simulation.
- *Parameters* - Terms in the model that are fixed during a model run or simulation but can be changed in different runs.
- *Constants* - Fixed values (e.g. the speed of light) representing known physical, biological or ecological activities.

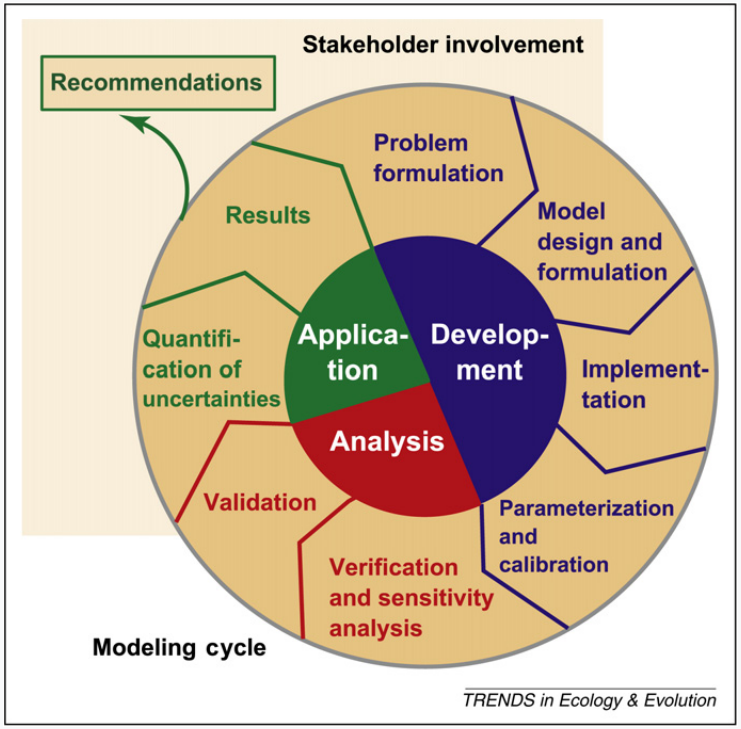
Model assessment

- *Verification* - Examination of the implementation to ascertain that they truly represents the conceptual model and there are no inherent numerical problems.
- *Qualitative assessment* - Uncertainty in model predictions that cannot be quantified (i.e. about the theory underlying the model or the model design).
- *Uncertainty analysis* - Investigation of the effects of lack of knowledge or potential errors on the model output.
- *Robustness* - The capacity of a model to perform well across the full range of environmental conditions for which it was designed.
- *Sensitivity* - The degree to which the model outputs are affected by changes in selected input parameters.
- *Transparency* - The clarity and completeness with which data, assumptions, and methods of analysis are documented.

2. Modelling cycle

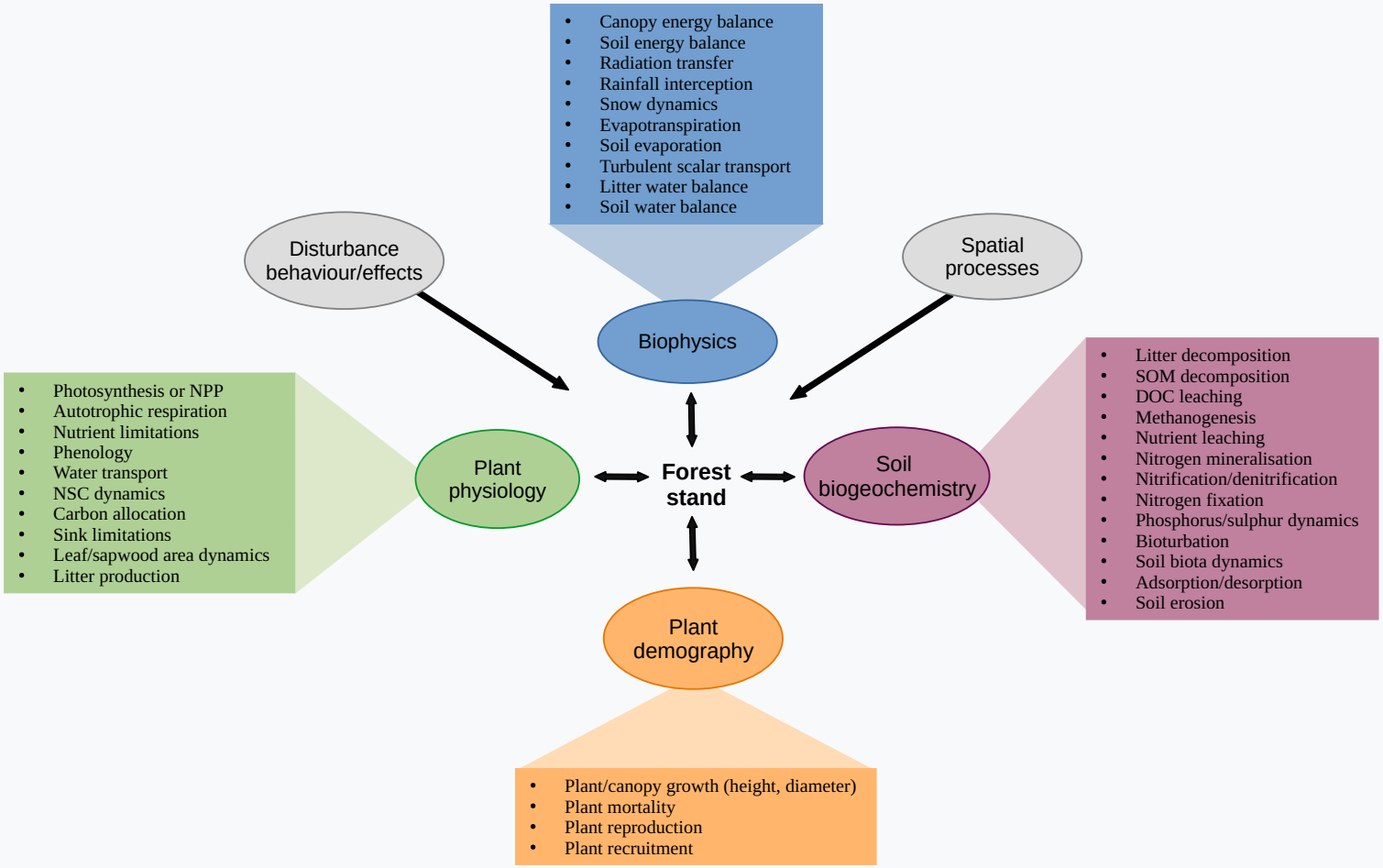
Modelling tasks

1. *Problem formulation*
    - Definition of objectives
    - Definition of the spatio-temporal physical domain
2. *Model design and formulation*
    - Data availability
    - Use of existing vs. new model
    - Conceptual model
    - Use of existing modules
3. *Implementation*
    - Algorithmic design
    - Model coding (e.g. C++)
4. *Parameterization and calibration*
    - Sources for direct parameter estimation
    - Sources for parameter calibration
5. *Model assessment*
    - Verification and qualitative assessment
    - Sensitivity/uncertainty analysis
    - Formal evaluation (validation)
6. *Model application*
    - Simulation and documentation
    - Quantifying uncertainty
    - Evidence for decision



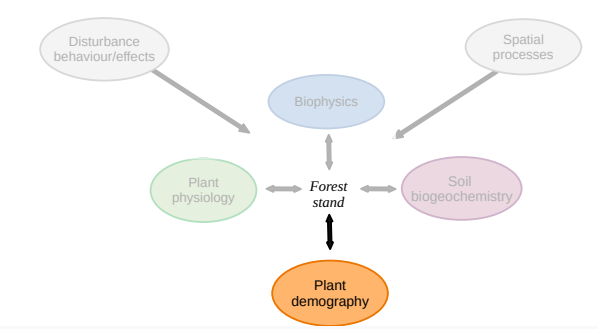
3. Overview of process-based forest models

A typology of forest processes



3. Overview of process-based forest models

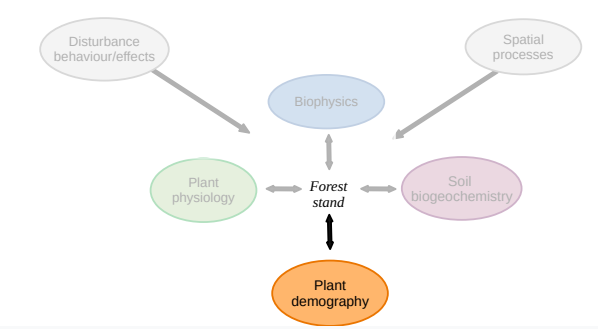
Forest gap models



e.g., FORCLIM, FORCEEPS, GREFOS

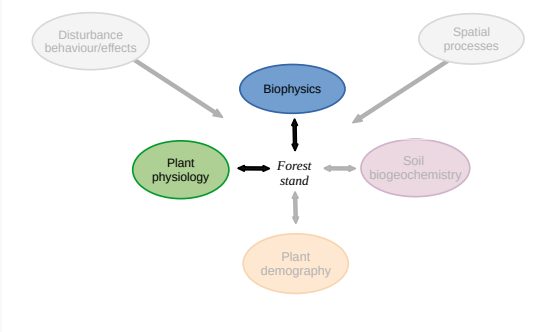
3. Overview of process-based forest models

Forest gap models



e.g., FORCLIM, FORCEEPS, GREFOS

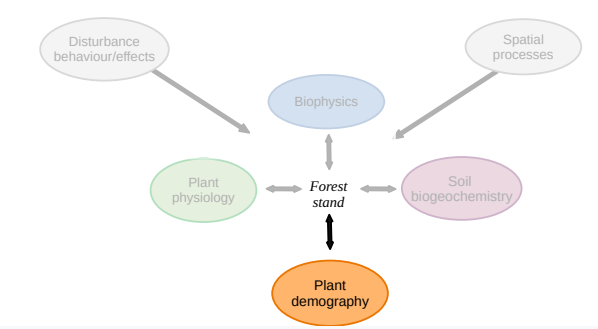
Soil-vegetation-atmosphere transfer model



e.g., BILJOU, MuSICA, CANVEG

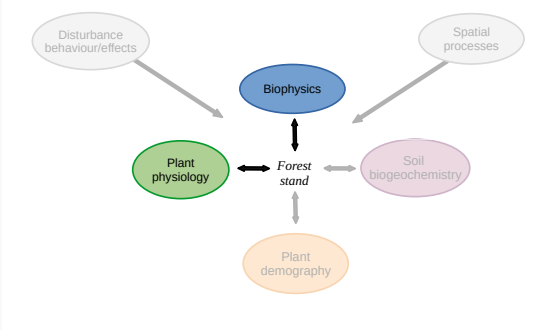
3. Overview of process-based forest models

Forest gap models



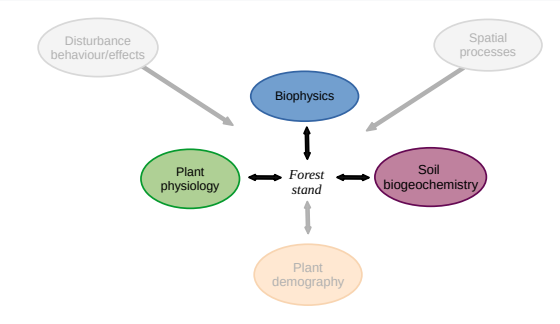
e.g., FORCLIM, FORCEEPS, GREFOS

Soil-vegetation-atmosphere transfer model



e.g., BILJOU, MuSICA, CANVEG

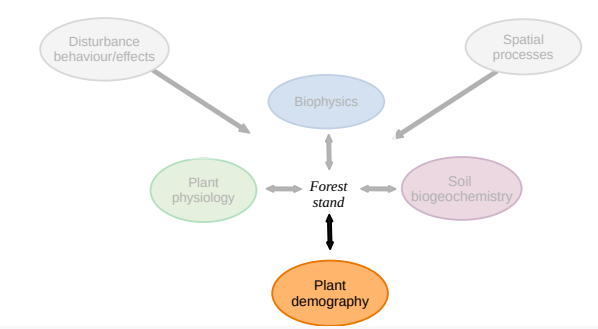
Forest biochemical model



e.g., CASTANEA, GOTILWA+, FOREST-BGC

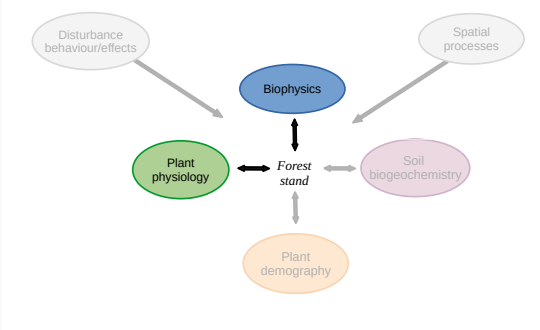
3. Overview of process-based forest models

Forest gap models



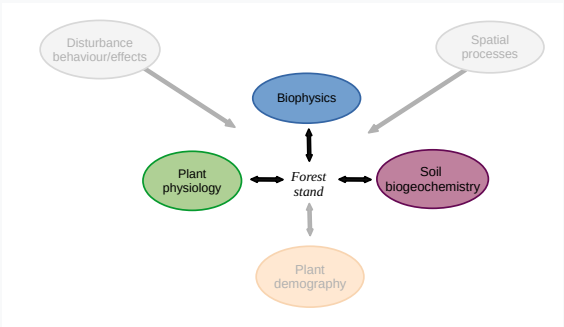
e.g., FORCLIM, FORCEEPS, GREFOS

Soil-vegetation-atmosphere transfer model



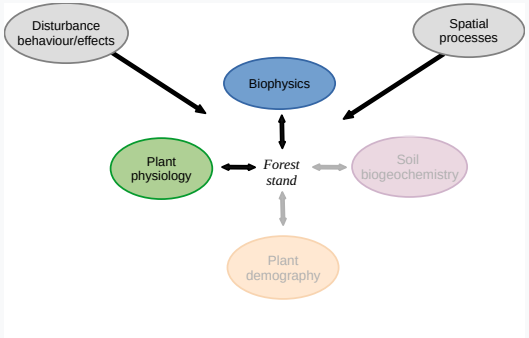
e.g., BILJOU, MuSICA, CANVEG

Forest biochemical model



e.g., CASTANEA, GOTILWA+, FOREST-BGC

Watershed ecohydrological model



e.g., RHESYS, ECH2O, Tethys-Chloris

M.C. Escher - Ascending and Descending, 1960