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on behalf of the Forest Modelling Lab., CNR-ISAFO

A Vegetation Simulation Platform in a Global Change Context



What is the “Three Dimensional – Coupled Model Carbon Cycle”?



- A framework which different components and modules can be incorporated into
- Lead, developed and hosted by the Forest Modelling Lab @ CNR-ISAFOM
- Written in C-language (pointers and dynamic arrays and structures)
e.g. `cells[cell].heights[height].dbhs[dbh].ages[age].species[species]`
- Several R-wrappers for pre- and post processing (and an R-package coming...)

The conceptual scheme

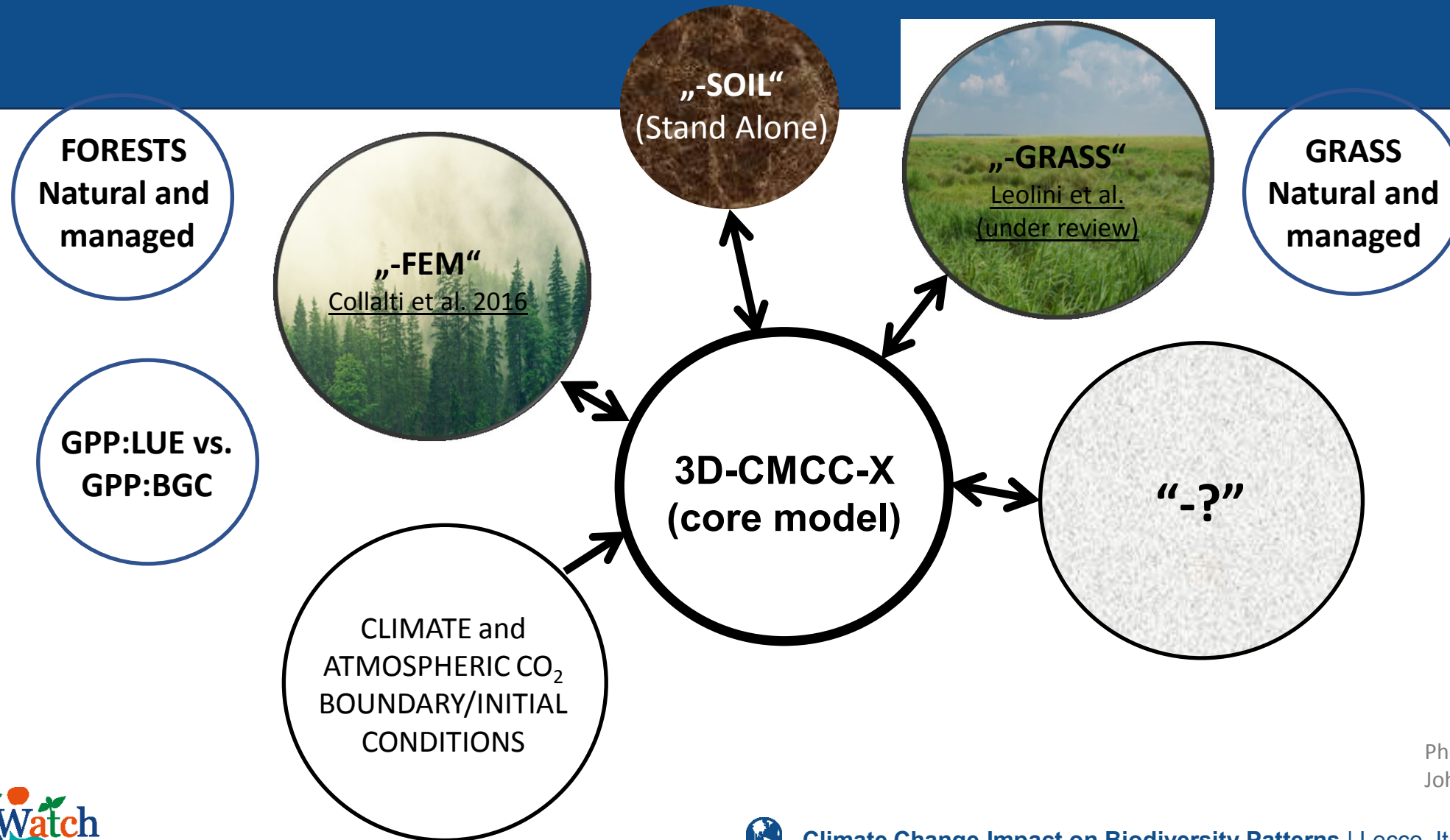
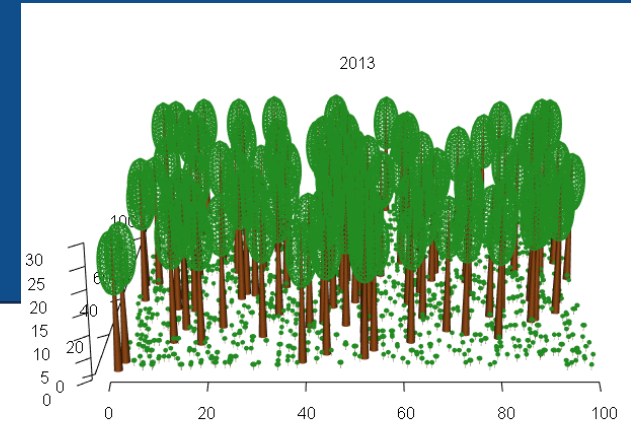


Photo by [Stanislav Klimanskii](#)
Johannes Plenio

The “*Forest Ecosystem Module*” (FEM)



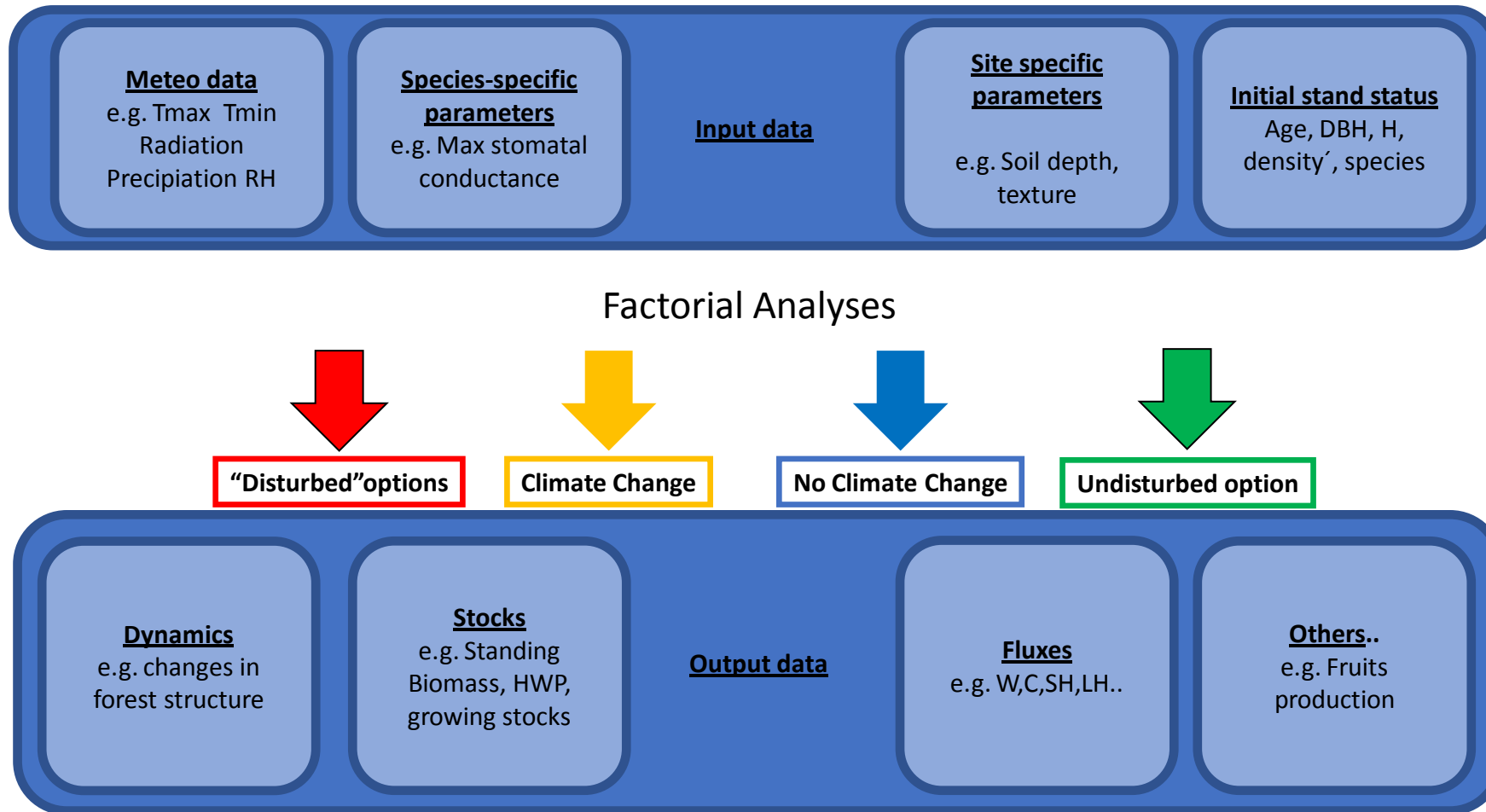
Graphic animation of 3D-CMCC-FEM output data at the Cansiglio site

- Simulate **stand growth** and **development** under current and future conditions (grassland modeling under construction)
- Simulate **C, N, H₂O** and **Energy -fluxes** (and **-stocks**)
- **Bio-geochemical, Bio-physical, Process-Based Model**
- Variable **temporal** scale (daily to annual) and variable **spatial** scale (1ha to xKm²)
- **Forest Management** (thinning, harvest, replanting) and other “**disturbances**”
- **C-language** (>30.000 lines of code) but with lots of **R-wrappers!**
- **14** peer-reviewed articles (+2 under review), **4** MsC and PhD thesis, **2** theoretical e technical guides
- First “**Core Model!**” Platform 4 BES-NBFC + **ISIMIP** member



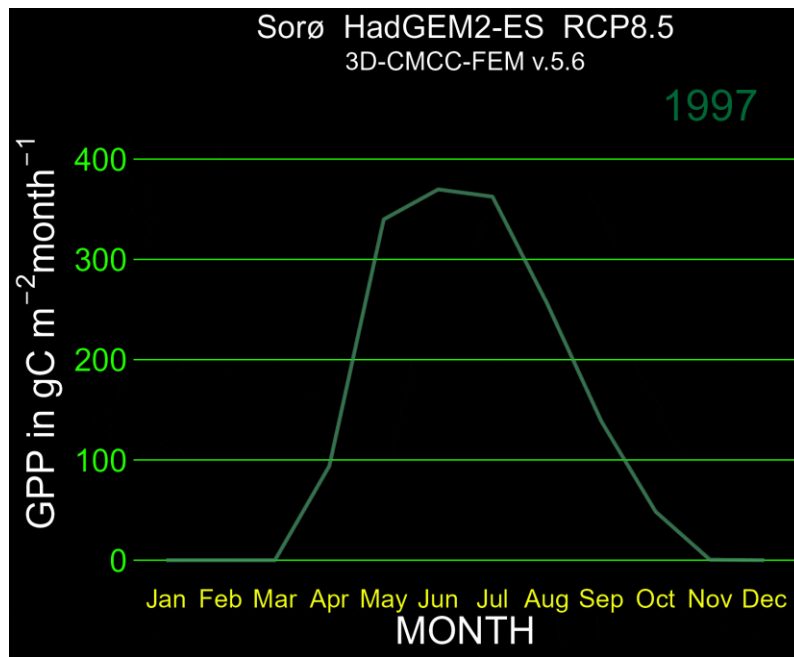
15 years of 3D-CMCC-FEM applications and validations across Europe

Input and output data

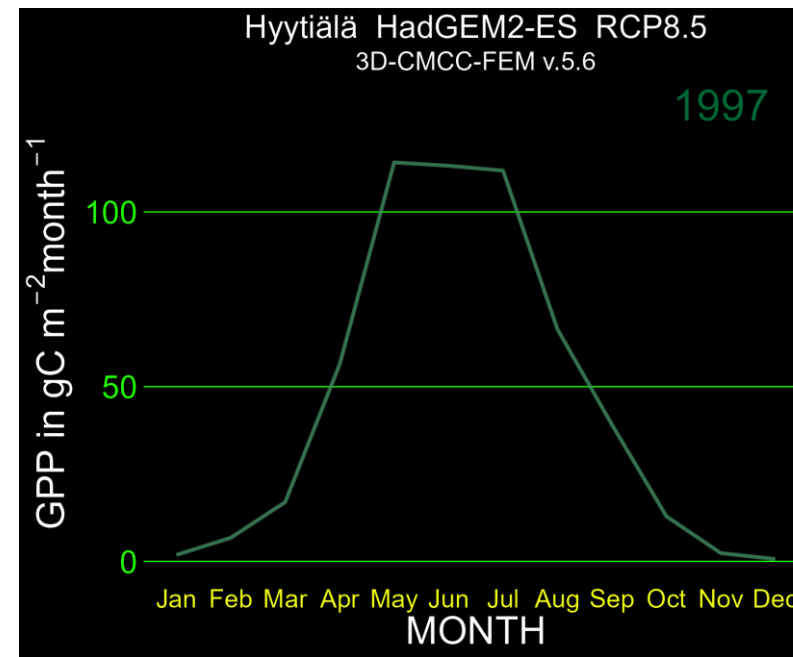


Applications: make predictions on impact of Climate Change

GENERAL AIM: to quantify the potential changes in **phenology** and **GPP** under different **climate forcing scenarios** from 1995 to 2100



Sorø site (Denmark)
Fagus sylvatica L.

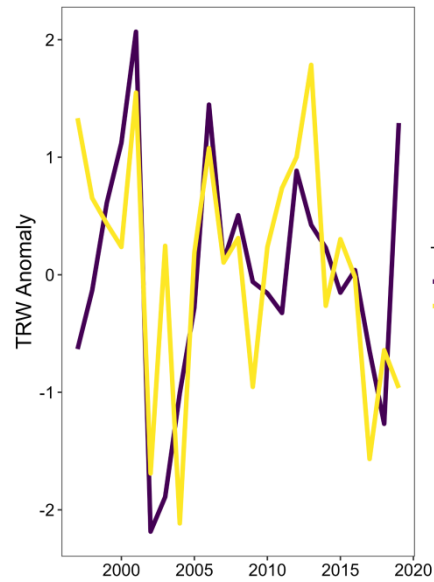


Hyytiälä site (Finland)
Pinus sylvestris L.

(Collalti et al. 2018, JAMES; Dalmonch et al. 2022, AFM)

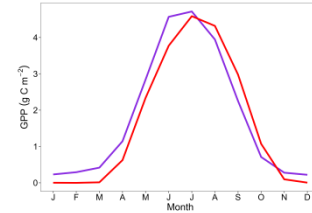
Applications: tree ring width, WUE and Modelling

GENERAL AIM: to evaluate the link between **wood growth** and **climate** and some **water use strategies** in forests along a latitudinal gradient finding out reasons where sites will be more **vulnerable** to decline and if they are losing capability to fix carbon (source or sink) under long-term climate variability



Type
 — TRW_ANOMALY
 — TRW_anomaly_model_man_var_2017_EC_SR 2002-2011

GPP - MEAN SEASONAL CYCLE



all_5_6_GJP_GJP_meteo.txt_(1999-2019)_CO2_CN_GJP_co2.txt_Min_VAR_d

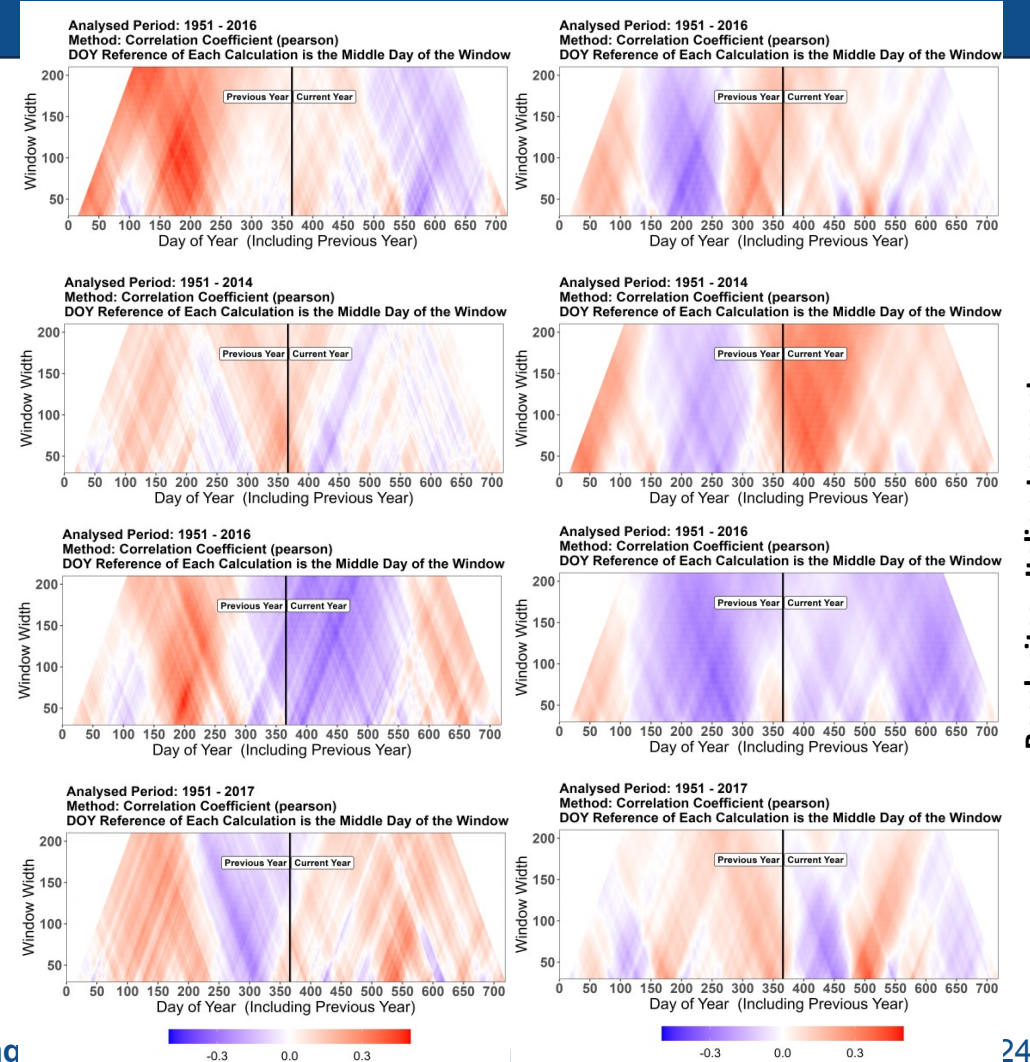


Type
 — CWA
 — RWA
 — STEM_C_acumulated
 — TRW_ANOMALY

CWA = cell wall area
 RWA = ring wall area
 TRW = tree ring width

GPP *Pinus banksiana* - Old Black Spruce (OBS), Canada

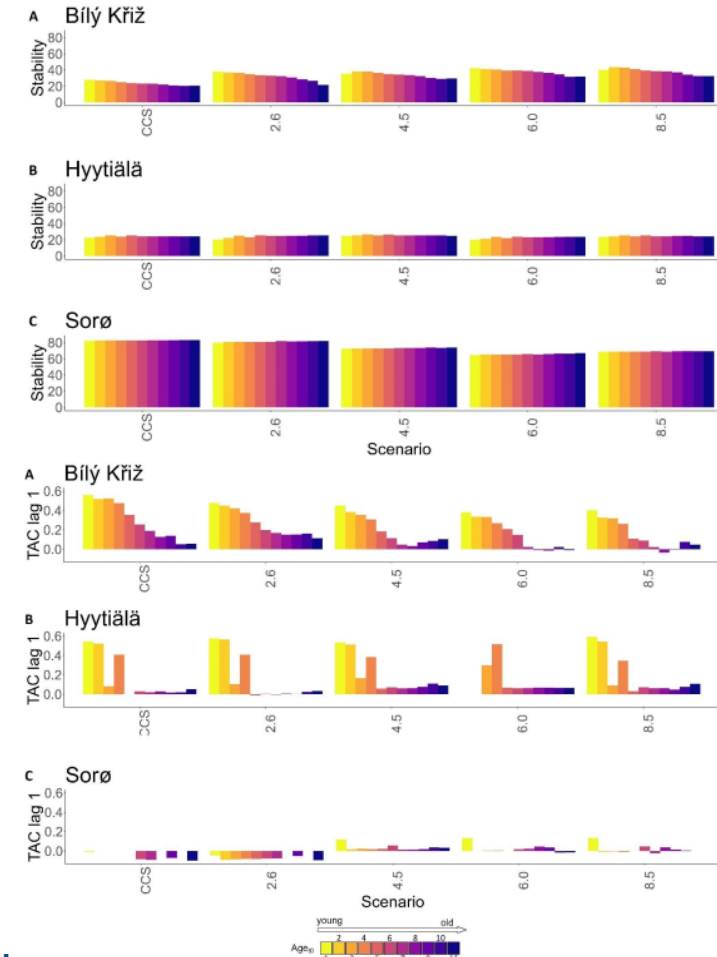
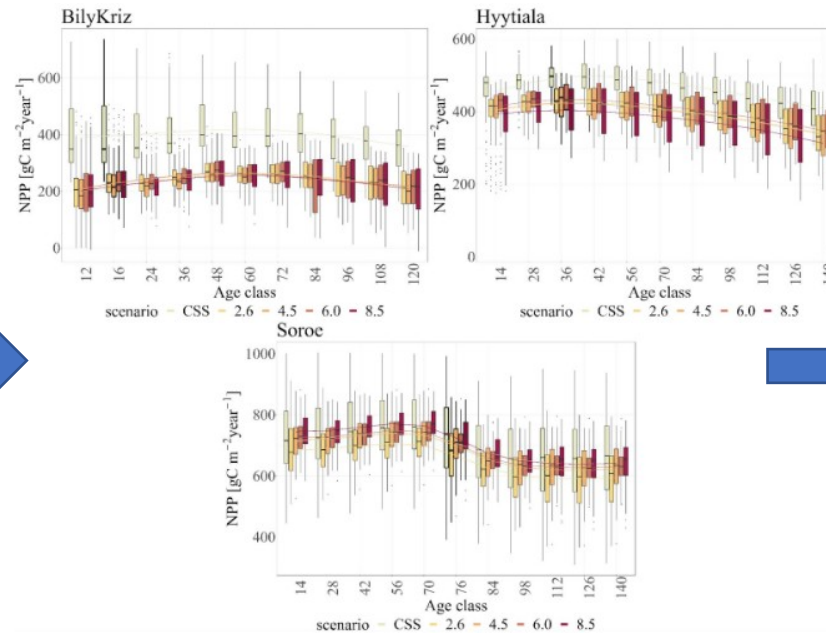
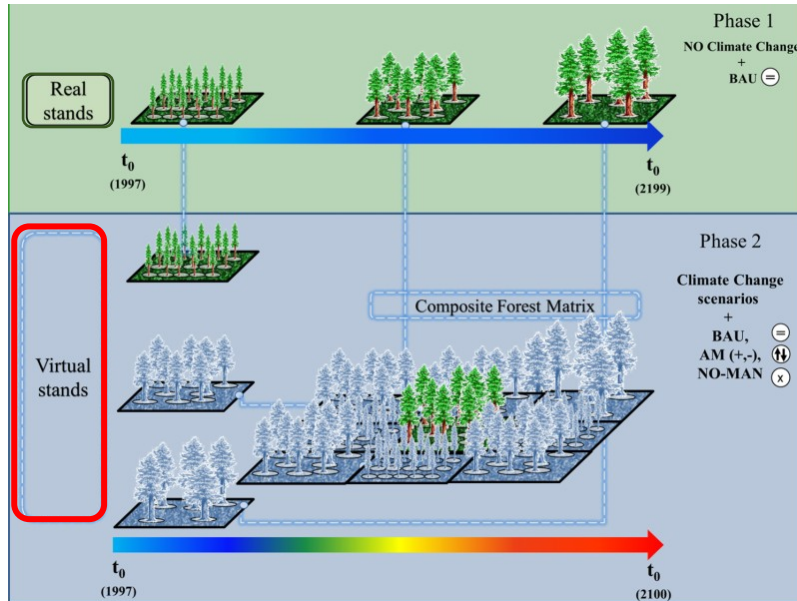
(Puchi et al., in prep.)



Beech sites - Italian transect

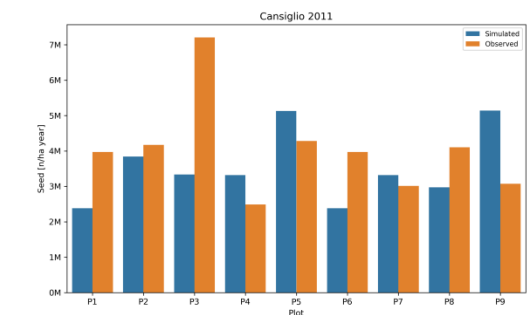
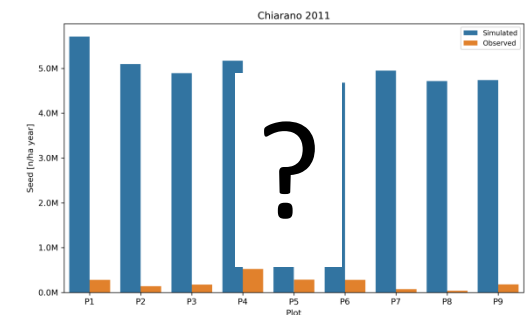
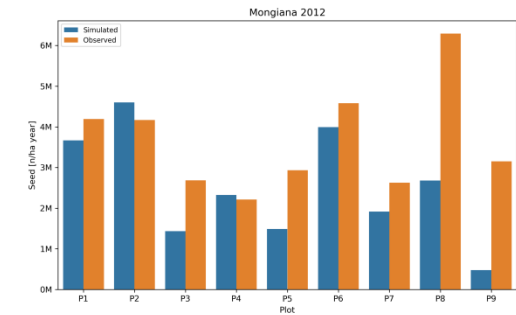
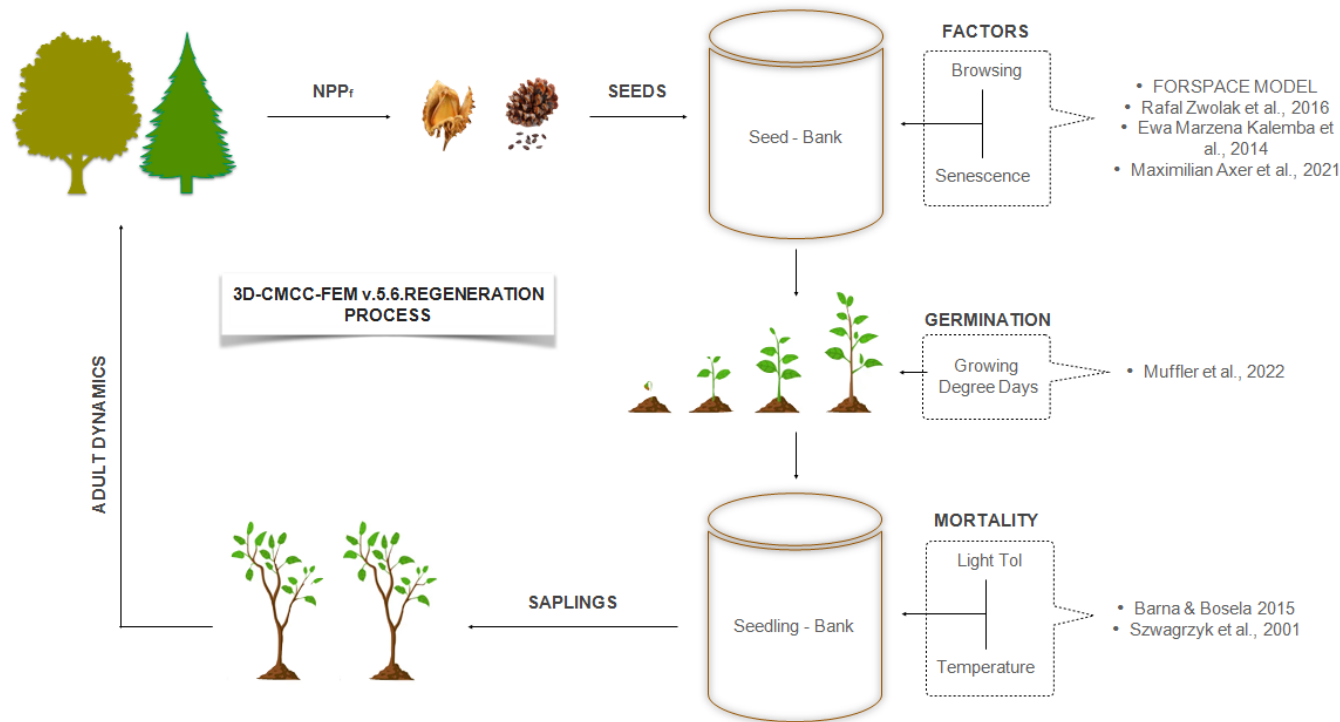
Applications: effects of Stand Age and CC on Resilience and Stability

GENERAL AIM: to analyze effects of **stand age diversity** in terms of **sensitivity, stability and resilience** on NPP under future climate change scenarios in European forests



Applications: studies on forest renovation and Climate Change

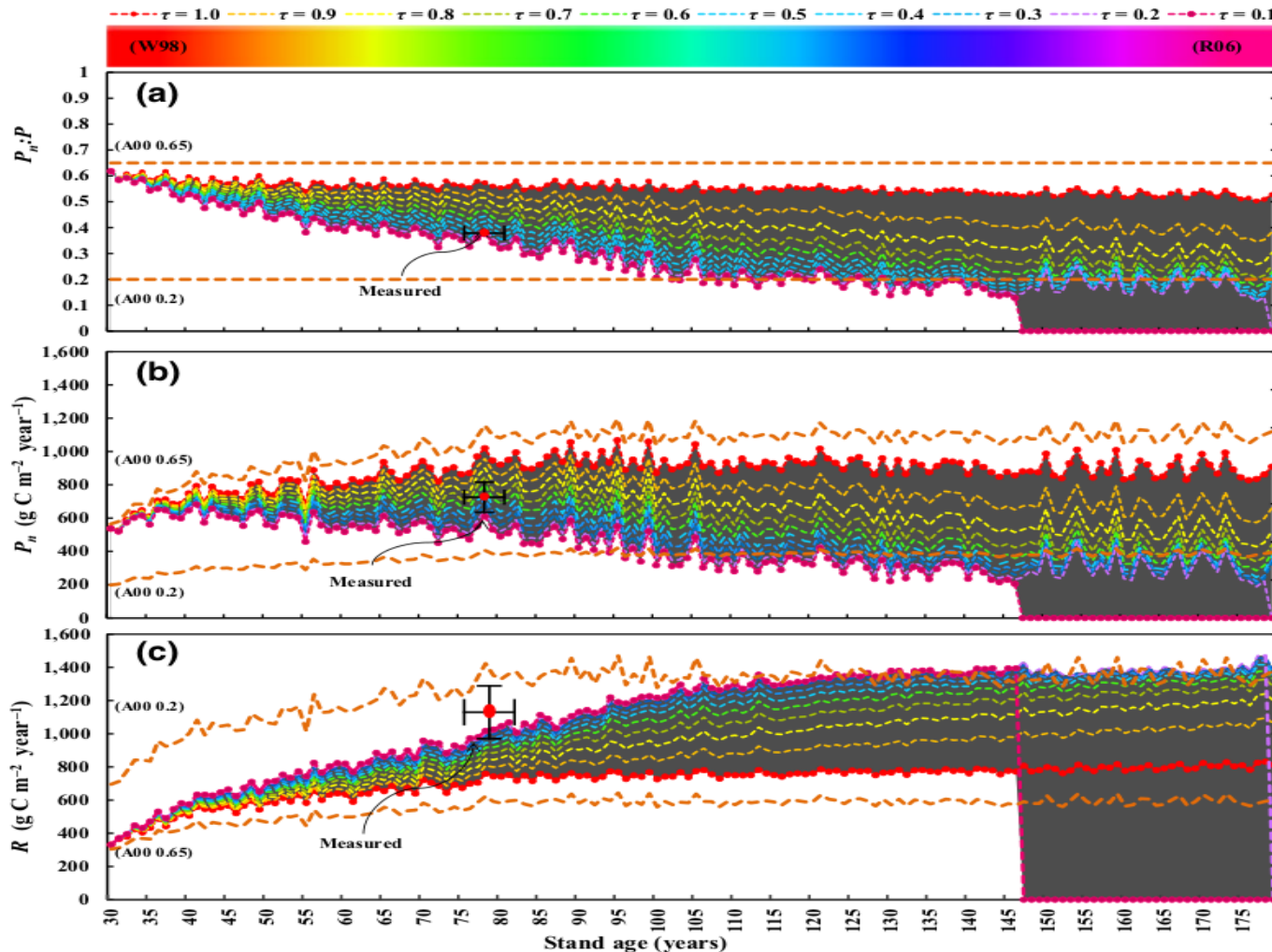
GENERAL AIM: to simulate **seed production** as part of the C-cycle and C-budget allowing the 3D-CMCC-FEM to simulate renovation processes in forest dynamic as similarly as in the DVMs (Dynamic Vegetation Models)



(Saponaro et al., in prep.)

Applications: analysing long-lasting ecological theories

GENERAL AIM: to tackle the long lasting theory in (I) forest ecology that plants' respiration is only controlled by photosynthesis, and (II) in quantitative ecology that plants' respiration increases ~isometrically (or under any of the proposed scalars)(the “Metabolism Scaling Theory”) with biomass



If respiration would be controlled only by photosynthesis in winter, when photosynthesis is stopped, all live cells would die. However, there have been found r

REJECTED

H₁: Respiration controlled by **photosynthesis**

If respiration would be controlled only by biomass at increasing forest age respiration would become too high, consuming too much carbon, and trees would completely die

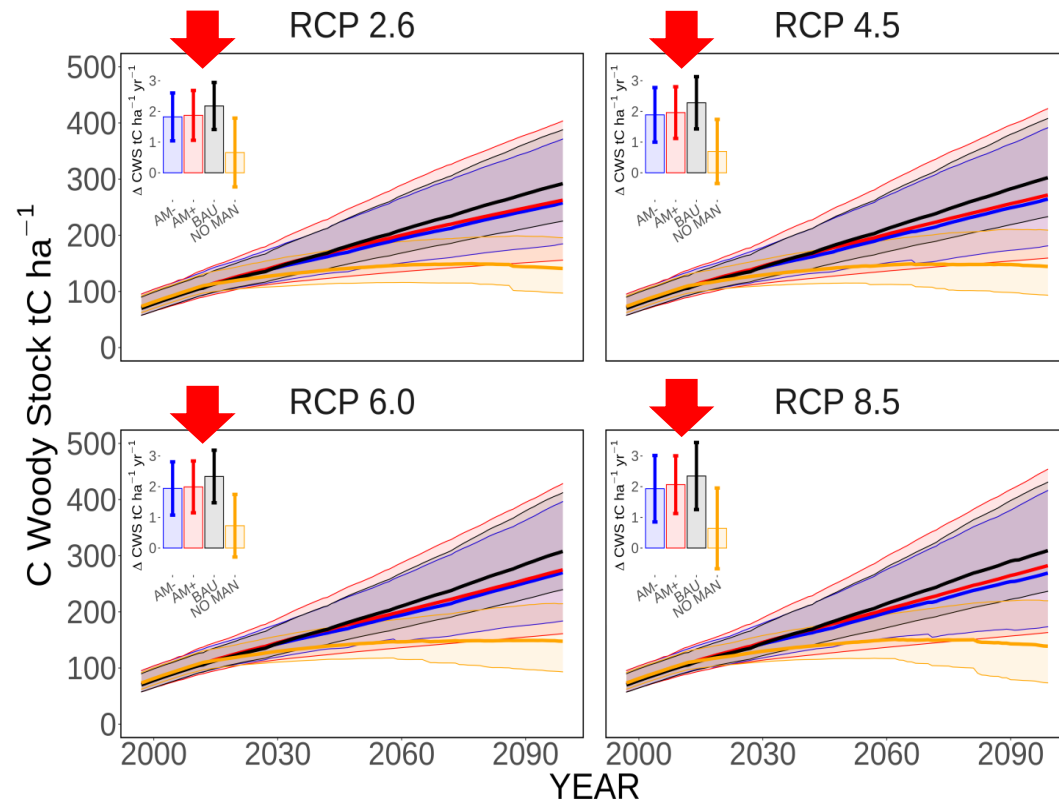
REJECTED

H₂: Respiration controlled by (total) **biomass**

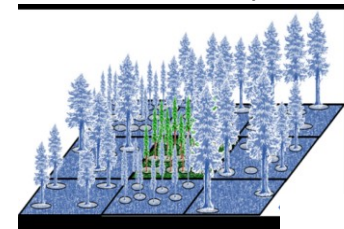
(Collalti et al. 2020, GCB)

Applications: effects of forest management under climate change

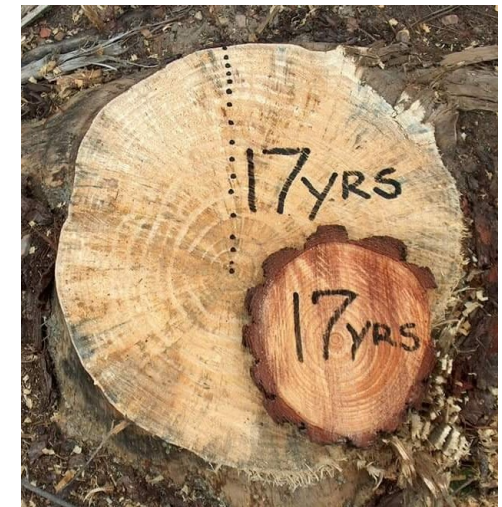
GENERAL AIM: to analyze the effects of **different management schemes** (both in terms of management types and intensity and including a “no management one”) on the carbon fluxes and stocks in Europe under different climate scenarios)



COMPOSITE FOREST MATRIX (18480 model runs)



- AM+** = Increased management intensity
- AM-** = Decreased management intensity
- BAU** = Business as Usual
- NO MAN** = No management



Business as Usual is the best choice for **NPP** and **C-Stocks**
(and no apparent differences across RCPs)

(Dalmonech et al. 2022, AFM; Testolin et al. 2023, STOTEN)

Applications: effects of forest management under climate change (part 2)

GENERAL AIM: Model Intercomparison Project between different European Forest Models (n>5) stand-level simulations under future climate scenarios **Man vs. No Man 2B** experiments (preliminary results)

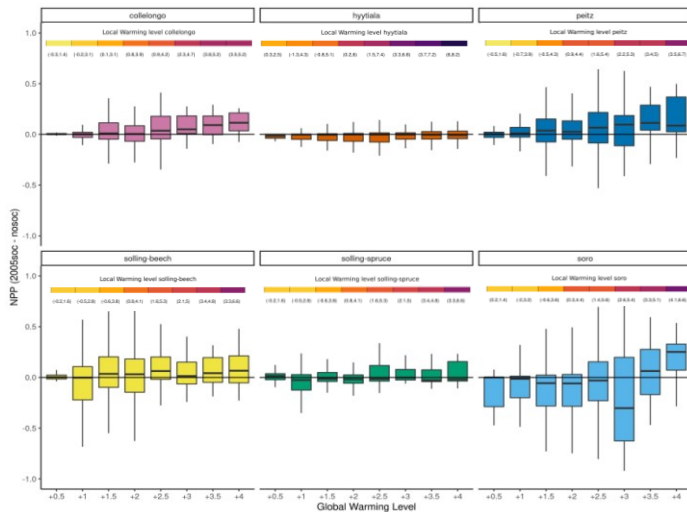


Basic info: 4-7 forest models, 3 ESMs climate data under 4RCPs, 6 sites, a COMMON protocol

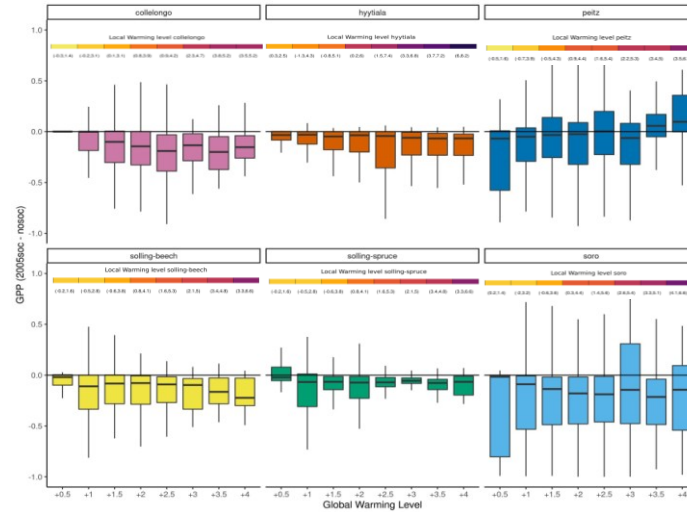


Management vs. No management

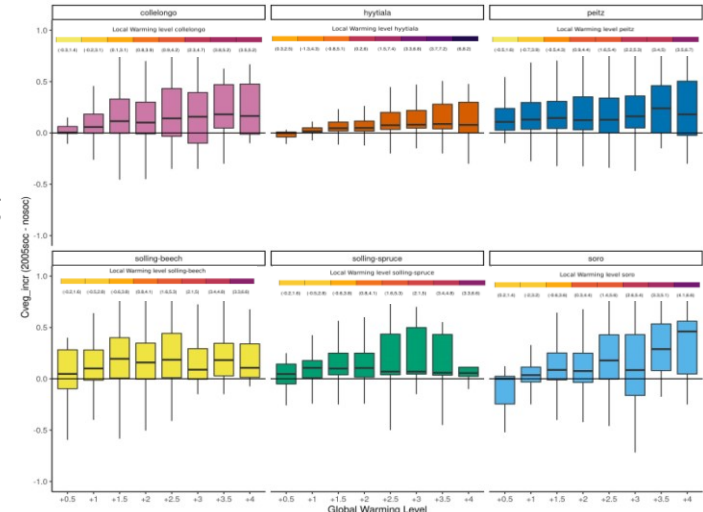
NPP ↑



GPP ↓



C-Veg ↑

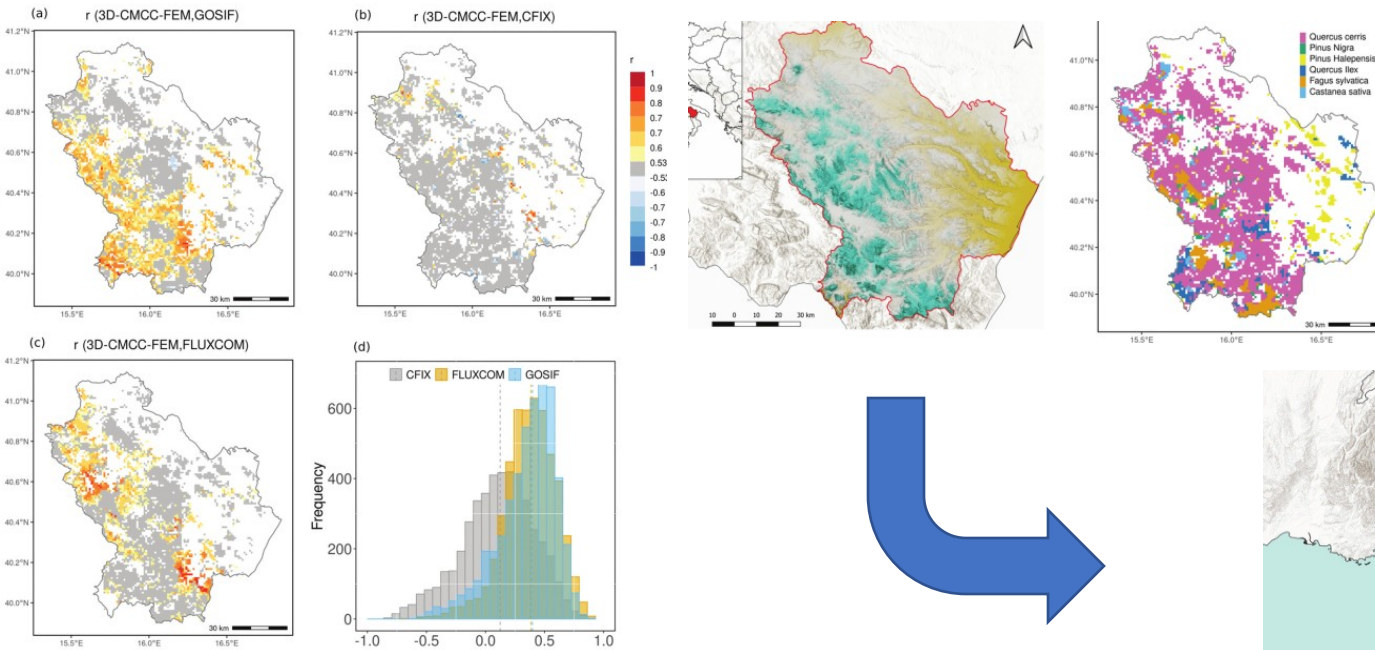


(Mahnken et al. 2022, GCB; Dalmonech et al., in prep.)

Applications: Simulations over large/national scale

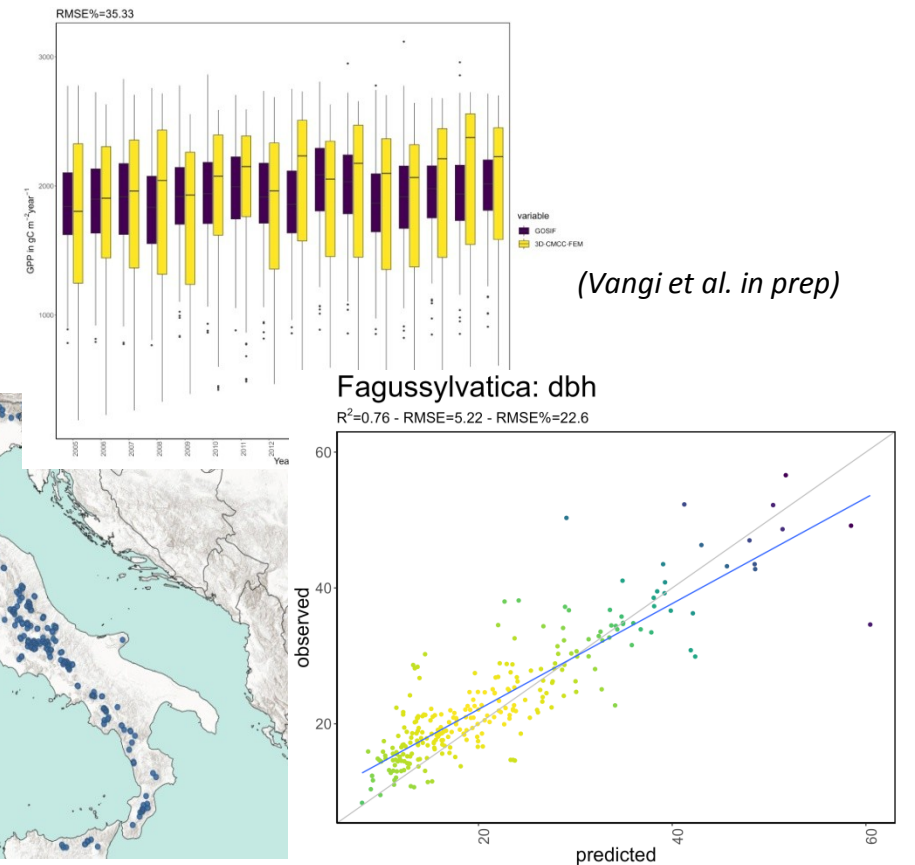
GENERAL AIM: to apply the previous analyses to large/national scale using NFI (INFC) data

BASILICATA REGION



(Dalmonech et al. 2024, EJRS)

NATIONAL LEVEL



(Vangi et al. in prep)

General info:

User's Guide 2023

Novità editoriali



Novità editoriali 2024



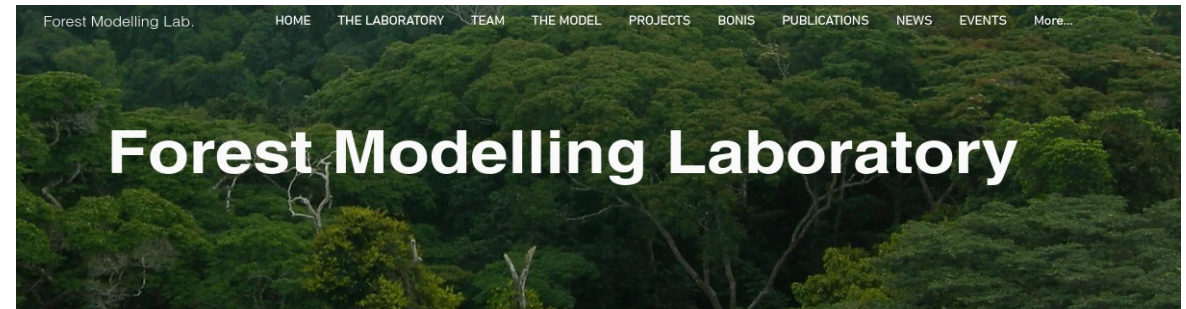
Theoretical bases



General info and conclusions:



- The **3D-CMCC-"X"** is basically a research tool which is freely available **only** for non-commercial use but OPEN to collaborations and developments.
- The **3D-CMCC-"X"** code is released under the GNU General Public Licence v3.0 (GPL) and some "constraints".
- To avoid multiple model versions (code and version fragmentation) we ask users to use our **GitHub** versioning at: <https://github.com/Forest-Modelling-Lab/3D-CMCC-FEM>
- C-language but with lots of R-wrappers for run and pre- post-processing!
- R-Package for CRAN is coming!

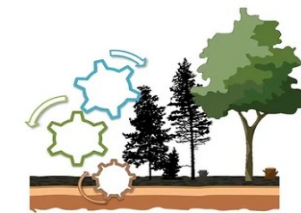


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Forest Modelling Lab.



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2024

LifeWatch ERIC 2024 Thematic Service Workshop Series

Thank you for your attention!
Any questions?



Taxonomy | Brussels, Belgium, 30 January 2024



Climate Change Impact on Biodiversity Patterns | Lecce, Italy, 21-22 February 2024



Animal Movement and Biologging | Ostend, Belgium, 22 March 2024



Biogeography | Bologna, Italy, 4-5 April 2024



Biodiversity Observatory Automation | Ljubljana, Slovenia, 11 April 2024



Habitat Mapping | Aveiro, Portugal, 3 May 2024

