Cross-sectoral OptimESM and ISIMIP workshop 2025

ISIMIP regional forest sector:

Country-scale modelling of climate impacts on EU forests

Climate Impacts on Italian Forests

Information compiled by:

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CNR - ISAFOM

Forest Modelling Lab.

3D CMCC FEM

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

05-08 May 2025 - PIK Potsdam, Germany

ISIMIP regional forest sector: Country-scale modelling of climate impacts on EU forests - Objectives

Objectives:

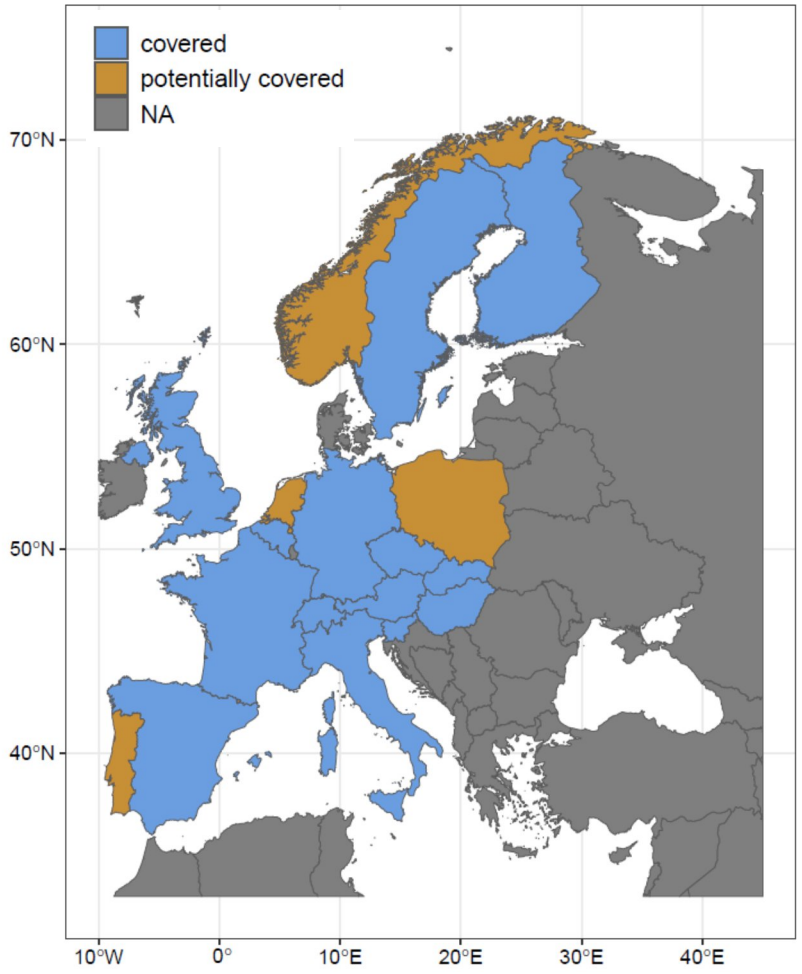
- **compile and exchange data** for country-scale forest modeling
- **coordinate and conduct country-level model simulations** in European forest within ISIMIP3a/b for impact attribution and future scenario analysis

Coordination: Thirza van Laar, Mats Nieberg, Christopher Reyer

Contributors: Alessio Collalti, Andreas Huth, Andy Krause, Andrey Lessa Derci Augustynczik, Anja Rammig, Annikki Mäkelä, Christian Hochauer, Christophe Francois, Daniela Dalmonech, Denis Loustau, Doroteja Bitunjac, Elia Vangi, Francesco Minunno, Hannes Böttcher, Harald Bugmann, Jean-Christophe Domec, Jonas Kerber, Katarina Merganicova, Klaus Hennenberg, Konstantin Gregor, Laura Dobor, Louis Francois, Manfred J. Lexer, Marc Djahangard, Marc Grünig, Marion Jourdan, Mart-Jan Schelhaas, Masa Ostrogovic, Mauro Morichetti, Mathieu Jonard, Mikko Peltoniemi, Miquel De Cáceres, Mirjam Pfeiffer, Mykola Gusti, Rasoul Yousefpour, Ritika Srinet, Rupert Seidl, Rüdiger Grote, Sina Heubel, Tarunsinh Chaudhari, Tim Anders, Tomás Hlásny, Werner Rammer

ISIMIP regional forest sector: Country-scale modelling of climate impacts on EU forests - European forest models

Best case coverage by regional forest models



Model	Country
3D-CMCC-FEM	**Italy**
3PG-Hydro	**Germany (subset)**
4C	**Germany,** (Poland, France, Slovenia)
Biome-BGC-MuSo	**Czech Republic, Slovakia**
BiomeBGC-MuSo	**Croatia**
CARAIB	Belgium, Netherlands, Spain, Europe
CASTANEA	France, Europe
EFISCEN-Space	**Europe (15 countries), few scenarios**
Fabio	Germany
ForClim / LandClim	Switzerland, central Europe planned
FORMIND	Germany
G4M	**Europe, countries, global**
GO+	France
HETEROFOR 1.0	**Belgium (Wallonie, selected stands)**
iLand	Germany (subset)
Landscape-DNDC	**Germany**
LPJ-GUESS (Frankfurt/TUM)	**Europe**
MedFate	Catalonia
PICUS	Austria, Czech Republic, Slovakia, Slovenia, Germany
PREBAS	**Finland**
SIBYLA	Czech Republic, Slovakia
SVD	Europe

Legend:

Bold: plan for contribution is mostly clear

Red: very active but unclear if planned analysis fit into "cross-country framework"

Normal: contribution currently not clear/dormant

21 models, 14 countries/regions + several European models

Many European forest models can cover one or more countries but none can cover them all

ISIMIP regional forest sector: Country-scale modelling of climate impacts on EU forests - Topical Collection

Home > Collection

Climate impacts on European forests and their mitigation potentials and ecosystem service provisioning (by invitation only)

Participating journal: Regional Environmental Change

Open for submissions

Submission deadline
30 September 2025

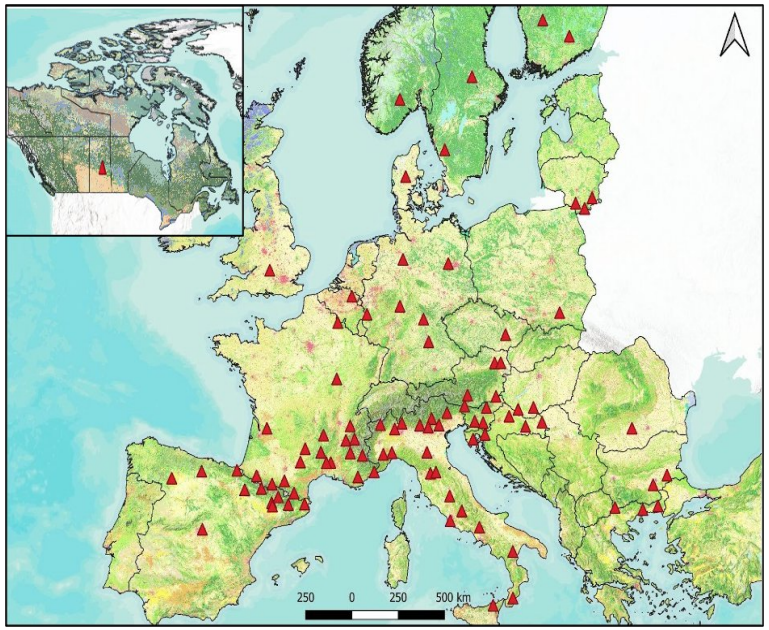
Forest modeling to quantify forest ecosystem services such as timber harvests, climate mitigation potentials and habitat for biodiversity and to assess climate impacts on forests has a long tradition in Europe. Over the past 20–30 years, many process–based models of forest growth and dynamics have developed from mostly stand–based applications to applications for entire regions and countries using newly available National Forest Inventory (NFI) and remote sensing data. Many models are specialized for a specific country/region making best use of the available data and the knowledge about management rules and specific ecosystem services that are relevant in the region. This has led to a situation where several models that simulate forest ecosystem services under climate change are available that each simulate individual countries in Europe. If those country–level…

Show more

3D-CMCC-FEM

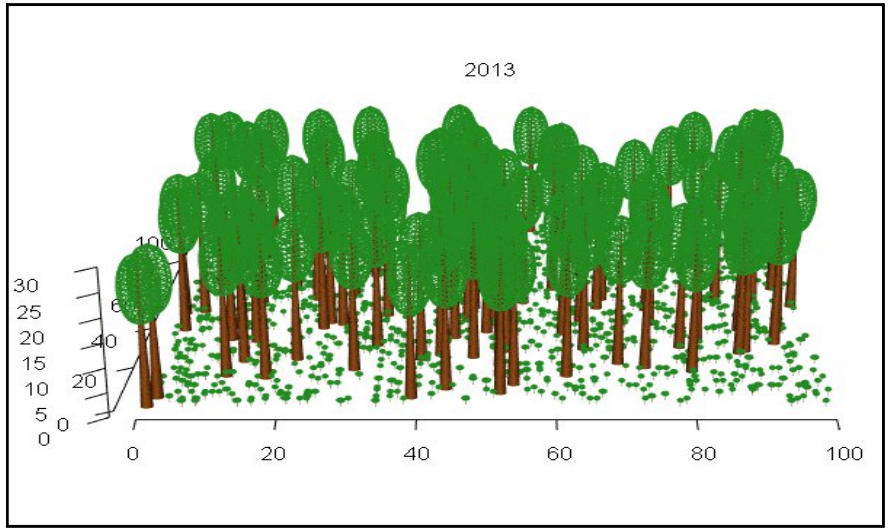
3-Dimensional-Coupled Model Carbon Cycle-Forest Ecosystem Module

- ❑ **Ten years of model application**

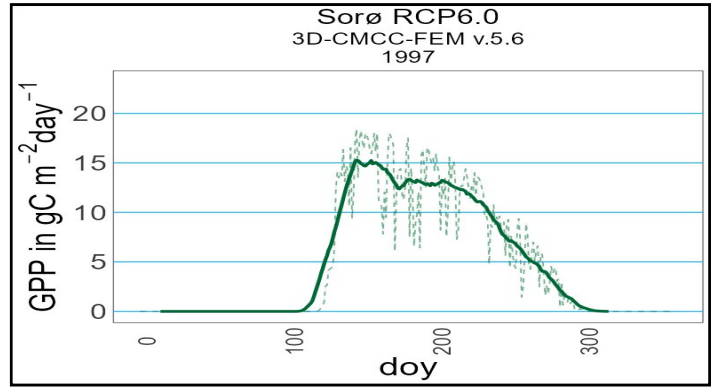


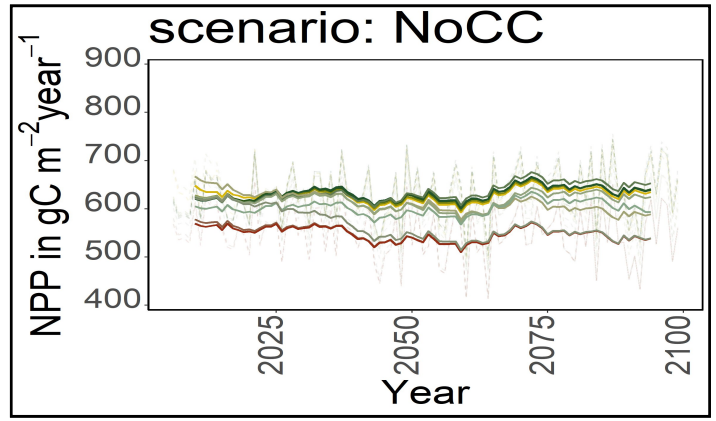
3D CMCC FEM

- ❑ **Bio-chemical, Bio-physical, Process-Based Forest Model**
- ❑ **Couple the Process-Based models' robustness of the layer and cohort models**
- ❑ **Variable temporal scale** (daily to annual)
- ❑ **Variable spatial scale** (1ha to x Km^2)
- ❑ **Management** (thinning, harvest, replanting, change of species)



- ❑ Simulate **stand growth and development, Carbon and Water fluxes** under current and future climate conditions

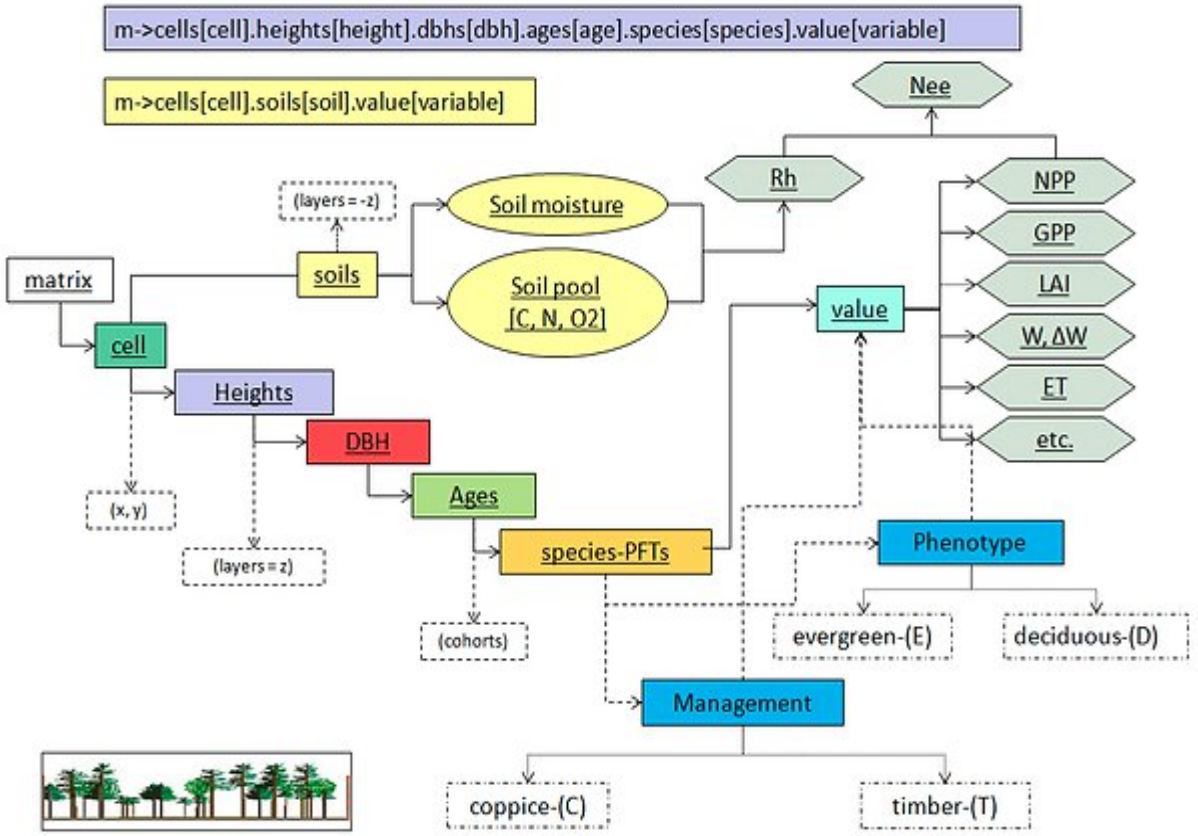




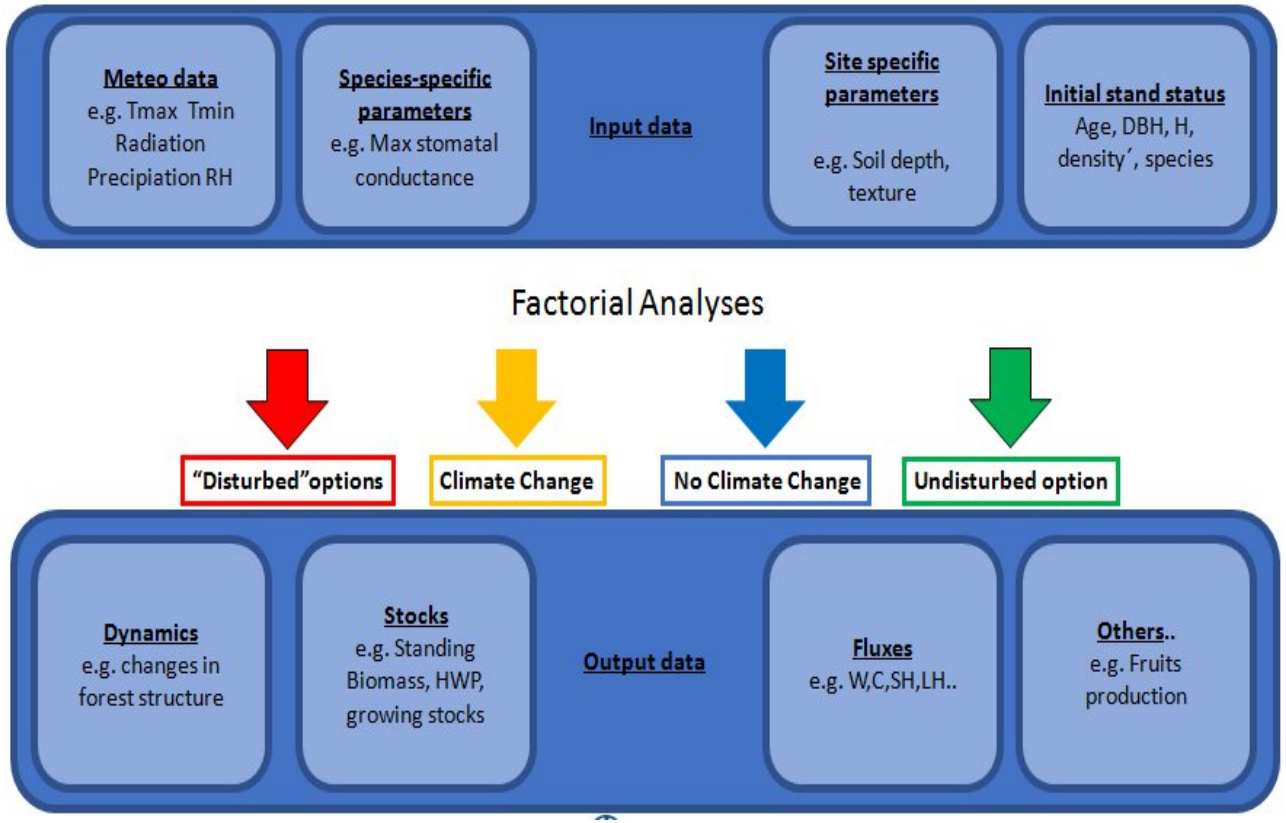
3D-CMCC-FEM

3-Dimensional-Coupled Model Carbon Cycle-Forest Ecosystem Module

Flowchart of the C-programming logical structure

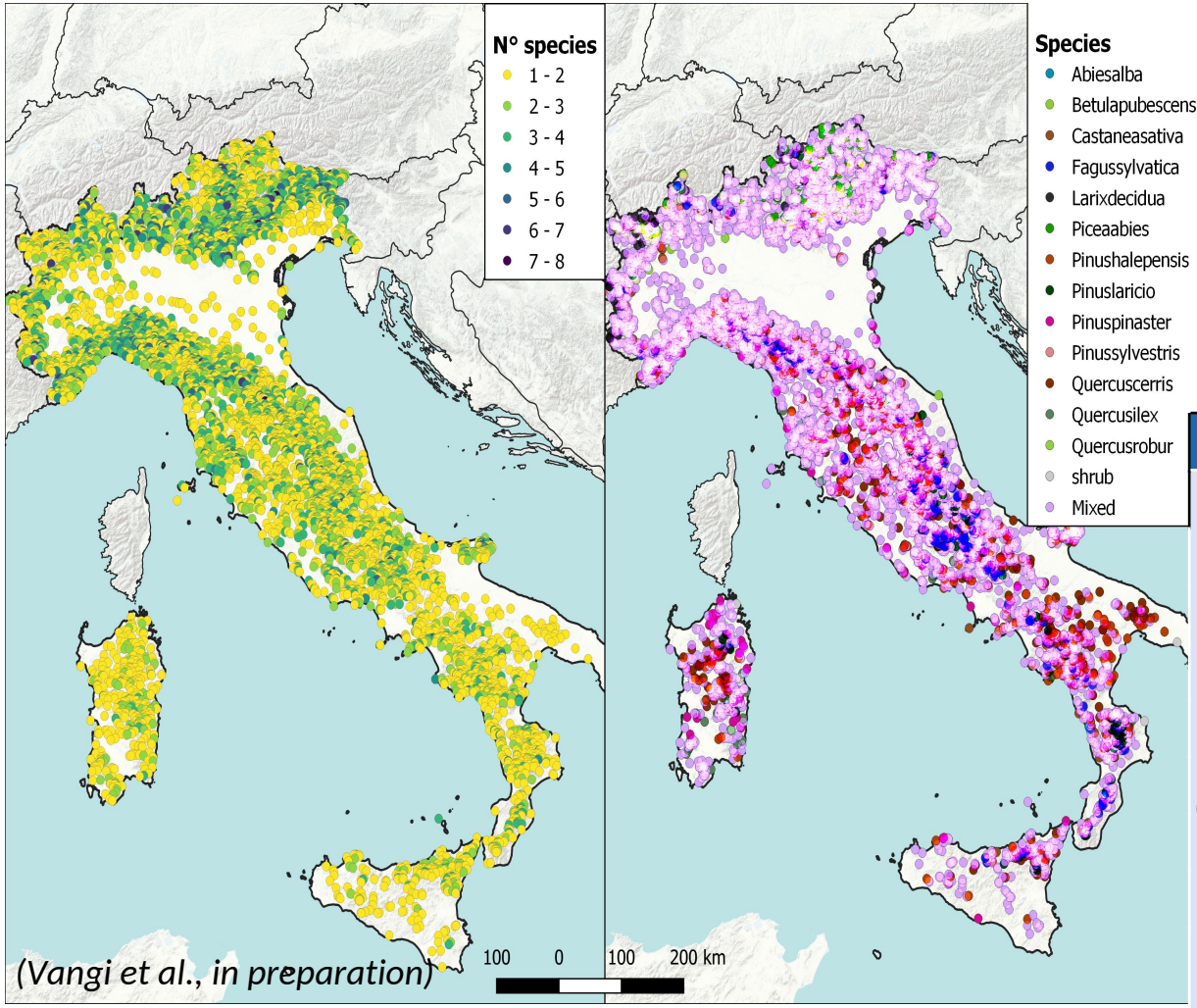


Input and output data



"***Monitoring and Predicting Forest Growth and Dynamics***", CNR Edizioni, Roma, ISBN: 978-88-8080-655-4

Italian National Forest Inventory – Study Area and Climate

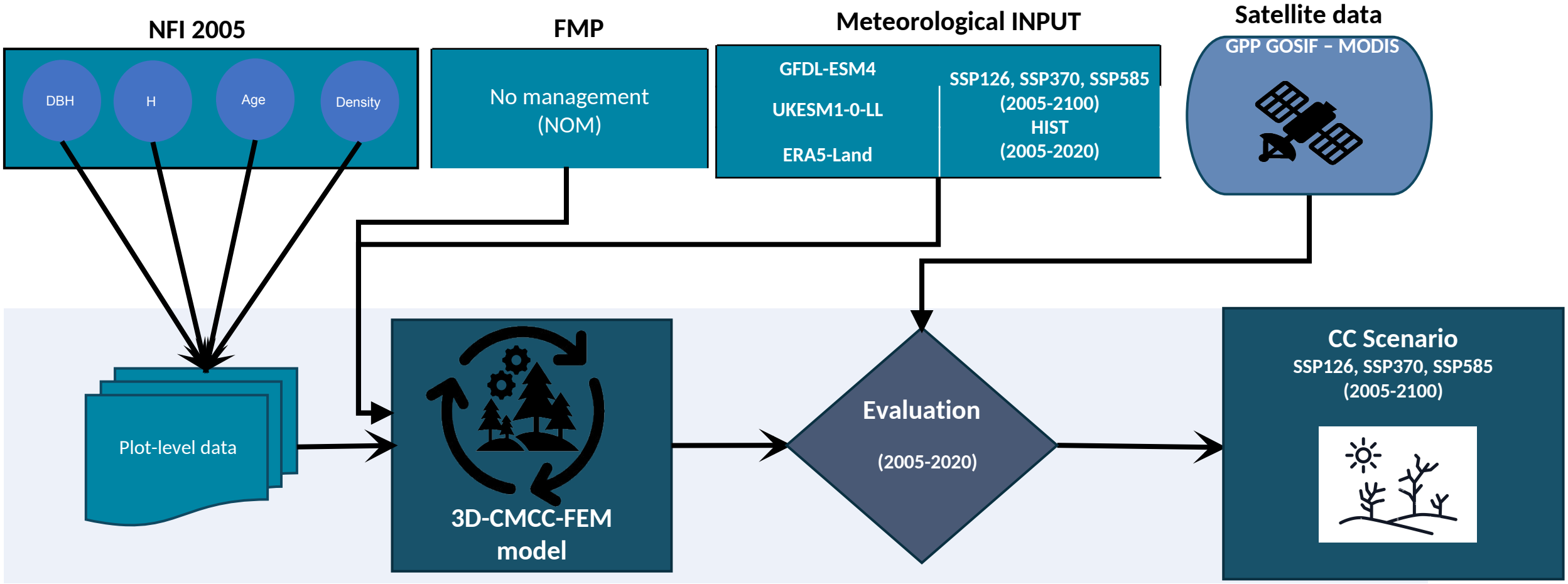


(Vangi et al., in preparation)

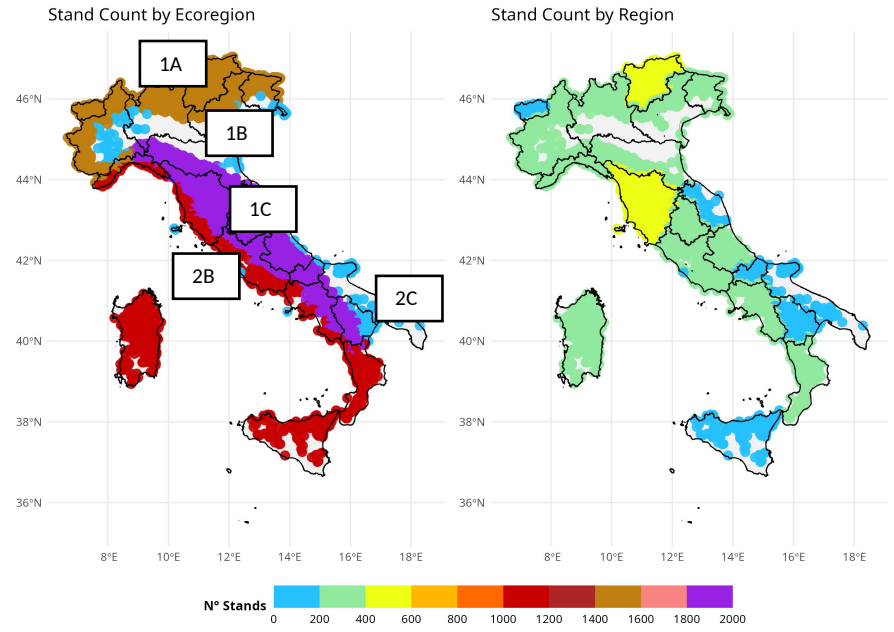
- Pure and mixed plots undisturbed initialized in 2005, for a total of 5135 NFI plots and 14 species (including the "mixed" category).
- The Italian peninsula has a wide environmental and climate gradient, from the seaside to high mountain ranges. Thanks to its complexity, Italy has the highest level of biodiversity in Europe

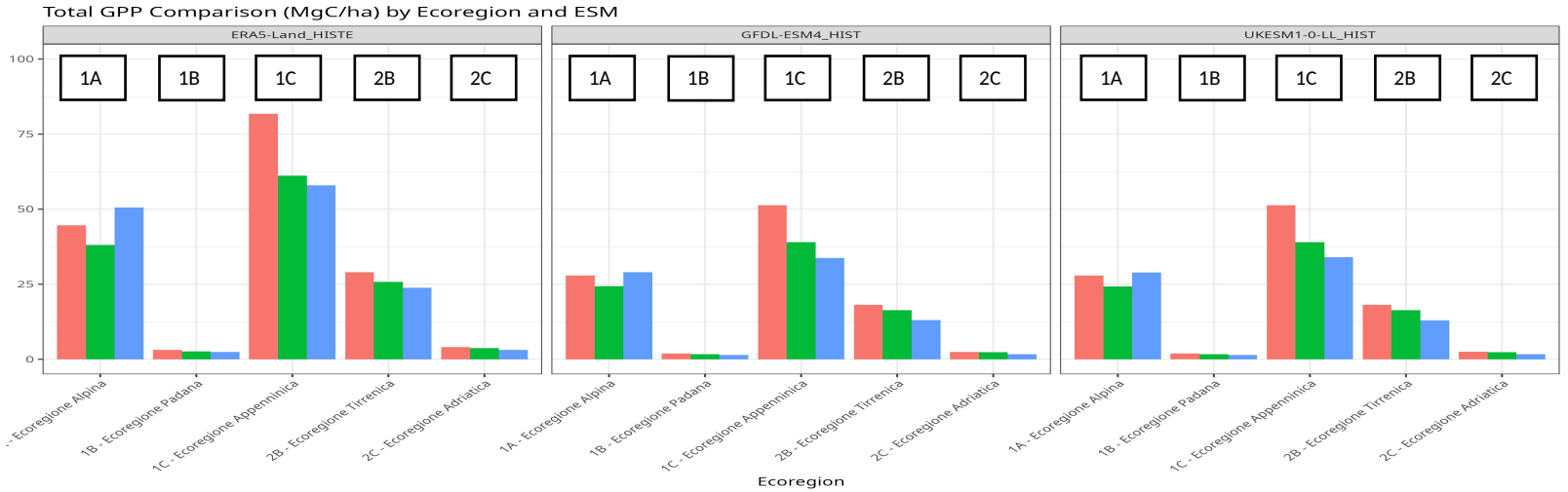
Plots	ESM	SCENARIO	Time resolution
5135 NFI + Collelongo + Castelporziano (FLUXNET sites)	GFDL-ESM4	HIST+SSP126	2005-2100
		HIST+SSP370	2005-2100
		HIST+SSP585	2005-2100
		HIST	2005-2014
	UKESM1-0-LL	HIST+SSP126	2005-2100
		HIST+SSP370	2005-2100
		HIST+SSP585	2005-2100
		HIST	2005-2014
	ERA5-Land	HIST	2005-2021

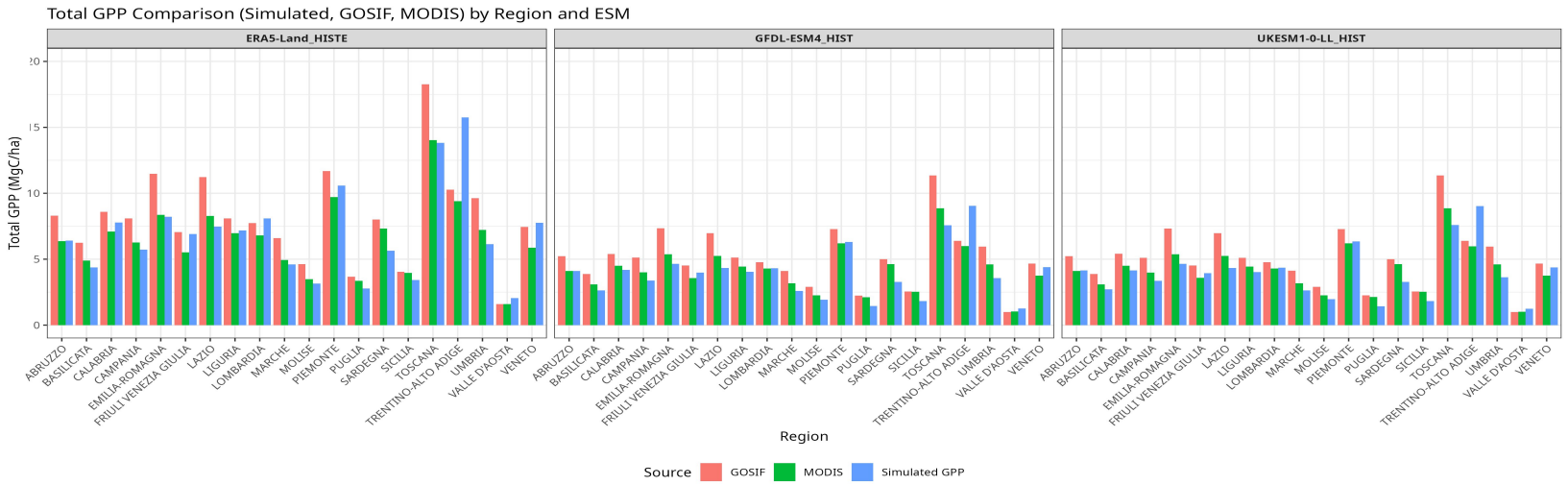
Flowchart INFC Simulations



Total GPP - Modis Vs Gosif

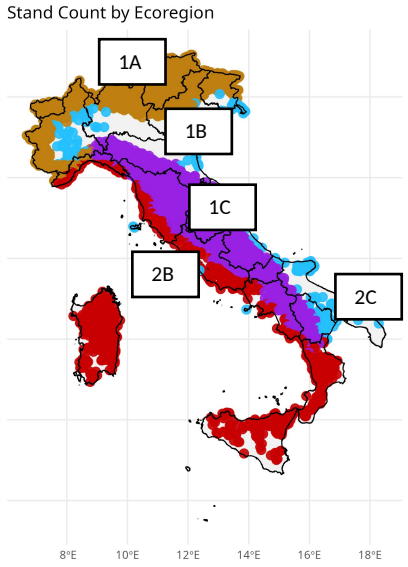


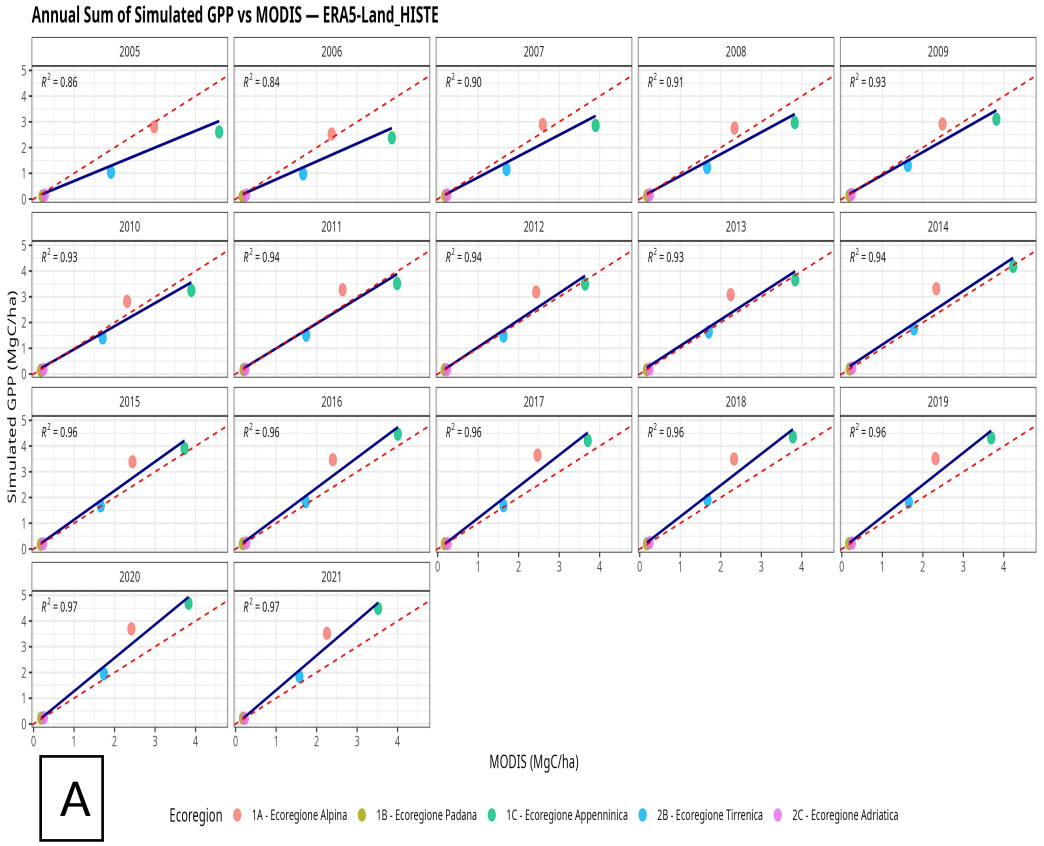


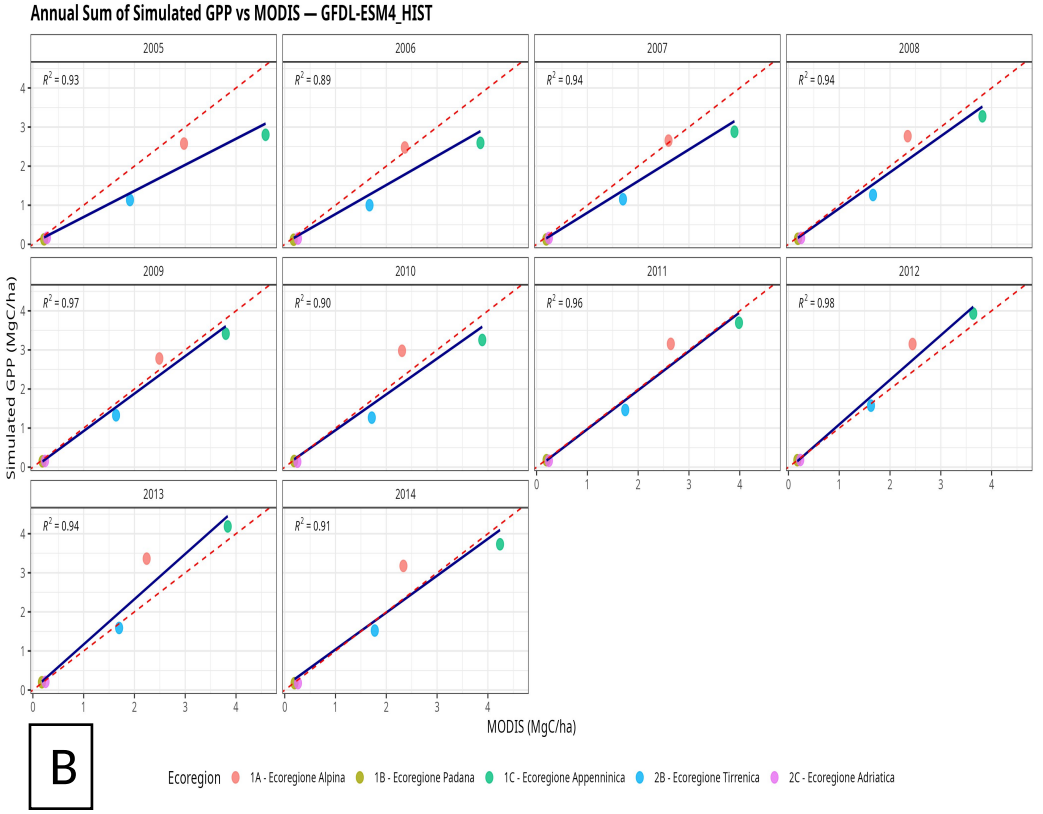


- **The ecoregions with the highest number of plots**—and consequently the highest Gross Primary Production (GPP)—**are the Apennine and Alpine ecosystems.**
- **The simulated GPP is more consistent with MODIS** observations than with GOSIF data.
- Overall, **the model tends to underestimate GPP.**

Validation – HIST Vs CC scenario







- Two climate inputs were used: A) ERA5-Land, with a 9×9 km grid, and B) GFDL-ESM4, with a 50×50 km grid. Despite the substantial difference in spatial resolution, **the outputs from both models show only minor differences.**
- The model tends to underestimate measured GPP during the first three years—likely due to spin-up effects. Beyond that period, **there is a very high agreement between simulated and observed GPP.**

CC Scenario – CAI

- **Current Annual Increment (CAI) under two future climate scenarios:** sustainable mitigation (SSP1-2.6) and fossil expansion (SSP5-8.5).
- Projection of climate pathways influence forest **productivity across latitudes and species.**

Conclusions

- Italy complex topography, ranging from coastal zones to alpine areas, supports exceptional biodiversity. **Among the various ecoregions, the Apennine and Alpine ecosystems dominate in terms of both plot representation and Gross Primary Production (GPP).**

- **Model outputs show a high degree of consistency with MODIS-derived GPP, though they are less aligned with GOSIF observations**. A slight underestimation of GPP is observed overall, particularly during the initial three-year spin-up phase. After this period, **the agreement between simulated and observed GPP improves significantly.**

- The model was tested under two climate forcing datasets—ERA5-Land (high-resolution) and GFDL-ESM4 (coarser resolution). **Despite the large difference in spatial scale, simulation results were largely consistent across both inputs**, suggesting robustness of the model to climate data resolution.

- **The 3D-CMCC-FEM model effectively simulates stand dynamics and ecosystem fluxes across Italy's diverse environmental and climatic conditions.**

- Climate pathways can influence forest **productivity across latitudes and species.**

Thank you

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