

Forest Ecosystem Services and Climate Change: the role of Digitalization

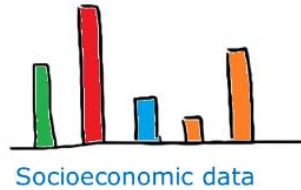
Monia Santini,
Foundation CMCC

DESIRA project 2nd webinar
«Boosting sustainable digitalization
in agriculture, forestry and rural areas by 2040»
June 30th 2021

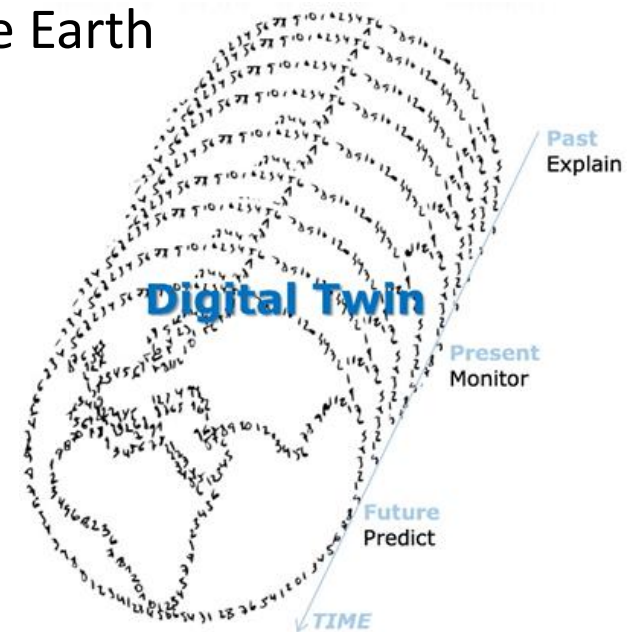
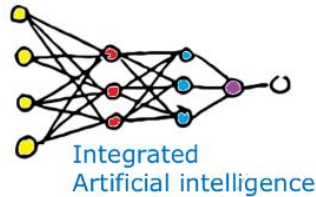


Programme Destination Earth (DestinE; 2021-2030)

Towards a Digital Twin of the Earth



Impact Sector science and
simulations



Modified from
http://www.classic.grss-ieee.org/earthvision2020/july_stuff/webpage/keynotes/Loekken.pdf



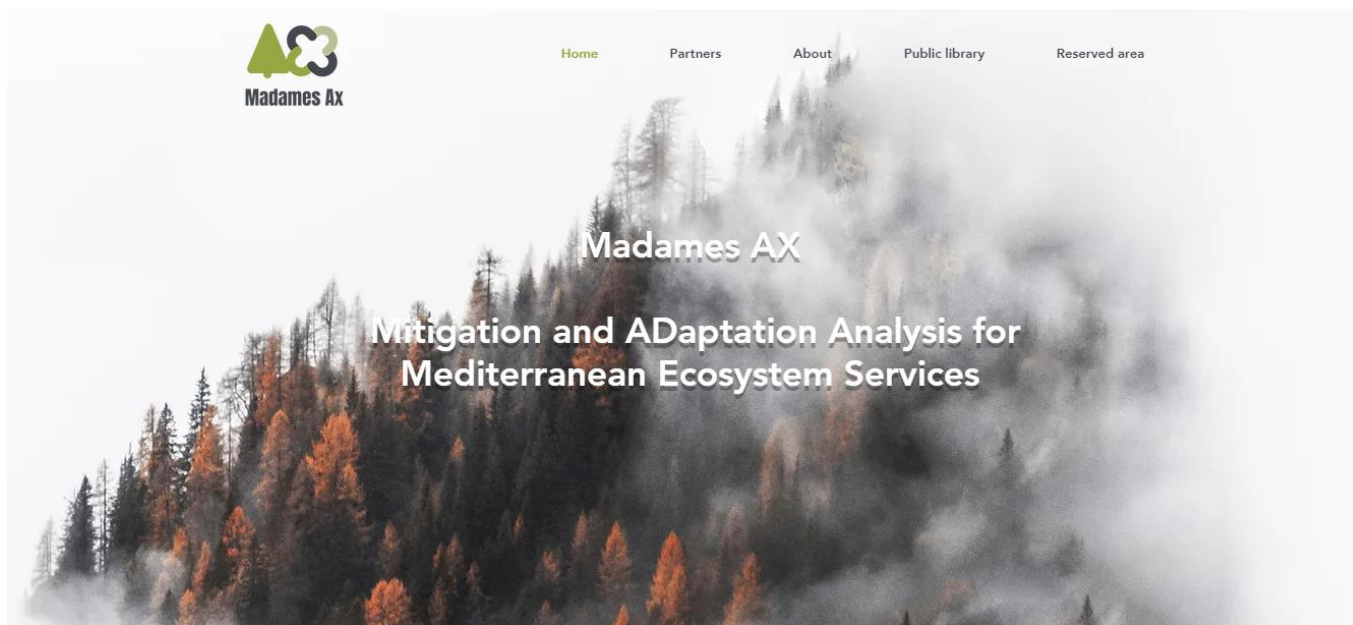
“Here, the challenge will be to design a digital twin that allows users to intervene, extract information and influence the system trajectory across time and space, as done — albeit often unwittingly — in the real world.”

[Bauer et al., 2021](#) Nature Climate Change



Merging data and models to predict FES

Application scenario of key digital technologies ([DESIRA Paper](#)):
forest management, monitoring and decision making



What does "Ecosystem service" means?



How to measure ecosystem services?



How to exchange ecosystem services?

<https://www.madames-ax.info/>

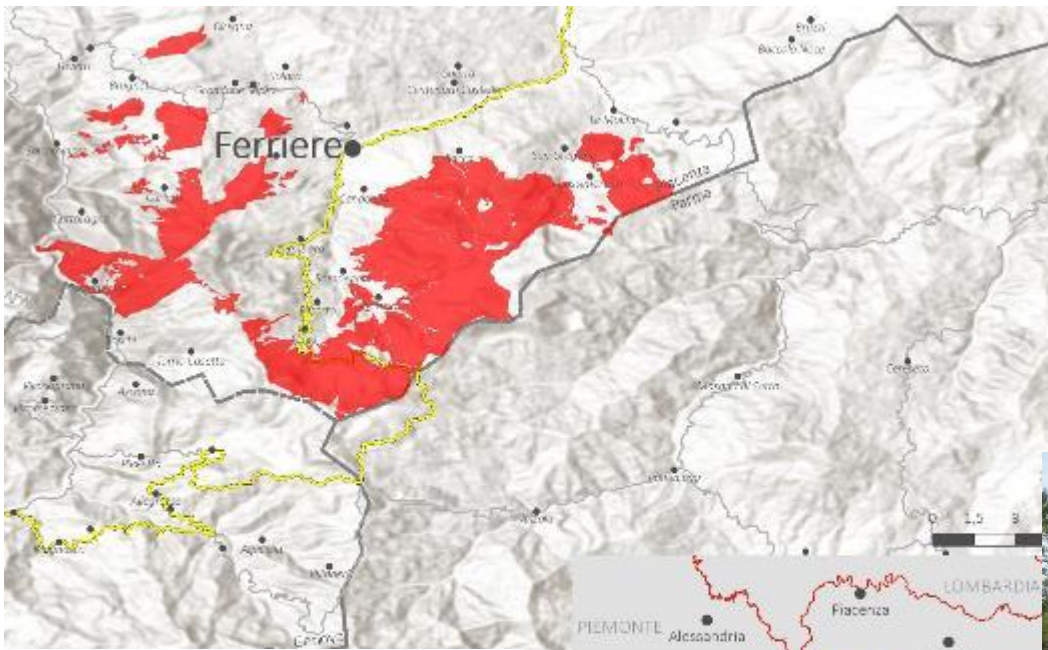
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The study site: Comunelli di Ferriere (Italy)



Spruce



Beech



Oak

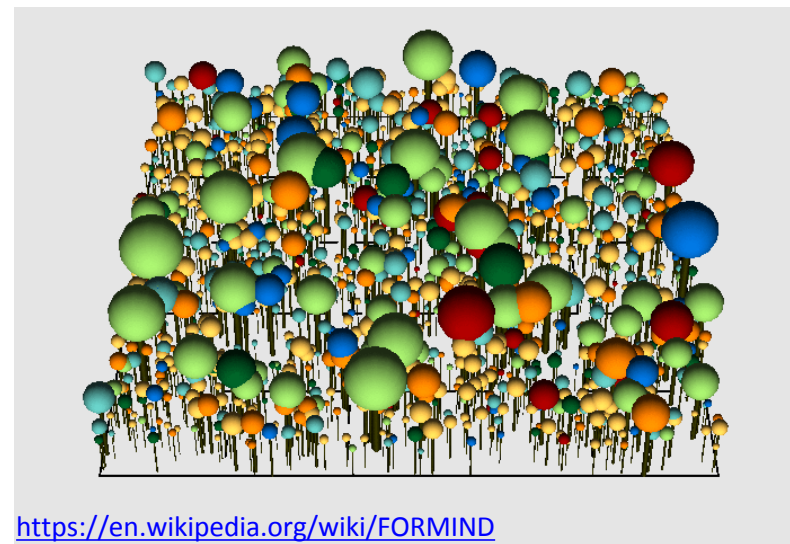
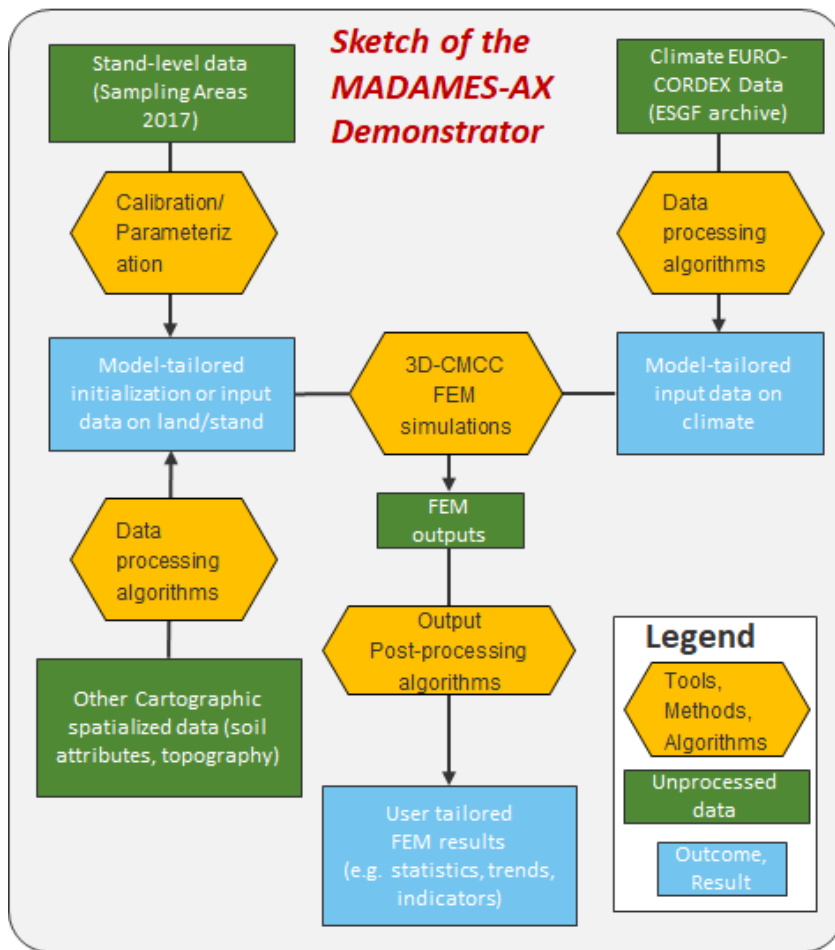


Pine



>5'000 ha (>90% wood)

The model framework



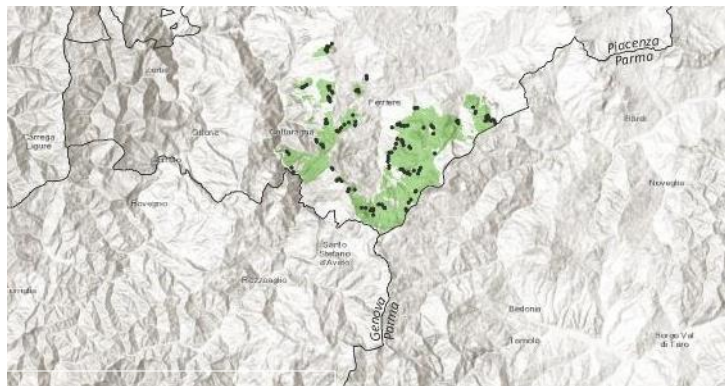
<https://www.cmcc.it/it/models/3d-cmcc-fem-three-dimension-forest-ecosystem-model>

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The input databases



Regione Emilia-Romagna

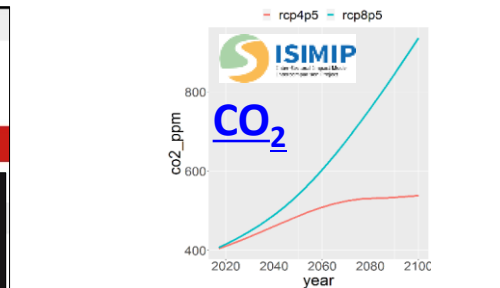
Geoportale Topography

Cerca i dati | Ottieni i dati | Approfondisci

Catalogo / Dati

DTM 5x5

Modelli digitali del Terreno a celle di 5 m x 5 m a cui è associata l'altimetria ricavata dalla DTM aggiornata sul rilievo Lidar



Stand data



Studio Associato di Maggari G. e Simonelli R.

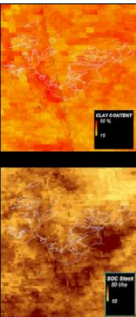


ISRIC World Soil Information

SoilGrids — global gridded soil information

A system for digital soil mapping based on global compilation of soil profile data and environmental layers

SoilGrids™ (hereafter SoilGrids) is a system for global digital soil mapping that uses state-of-the-art machine learning methods to map the spatial distribution of soil properties across the globe. SoilGrids prediction models are fitted using over 230 000 soil profile observations from the [WOCAS database](#) and a series of environmental covariates. Covariates were selected from a pool of over 400 environmental layers from Earth observation derived products and other environmental information including climate, land cover and terrain morphology. The outputs of SoilGrids are global soil property maps at six standard depth intervals (according to the GlobalSoilMap IUS working group and its specifications) at a spatial resolution of 250 meters. Prediction uncertainty is quantified by the lower and upper limits of a 90% prediction interval. The additional uncertainty layer displayed at [soilgrids.org](#) is the ratio between the inter-quantile range and the median. The SoilGrids maps are publicly available under the [CC-BY 4.0 License](#).

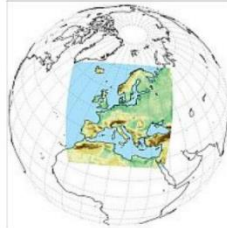


Coordinated Downscaling Experiment - European Domain

EURO-CORDEX

Climate

EURO-CORDEX - Coordinated Downscaling Experiment - European Domain



EURO-CORDEX is the European branch of the International CORDEX Initiative, which is a program sponsored by the World Climate Research Program (WRC) to organize an internationally coordinated framework to produce improved regional climate change projections for all land regions world-wide. The CORDEX-results will serve as input for climate change impact and adaptation studies within the timeline of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) and beyond.

Global model	Radiative forcing	Regional model	n. of bias correction methods
CNRM-CM5	rcp4.5 rcp8.5	CCLM4-8-17	1
	rcp4.5 rcp8.5	RCA4	1
EC-EARTH	rcp4.5 rcp8.5	RACMO22E	2
	rcp4.5 rcp8.5	CCLM4-8-17	2
MPI-ESM-LR	rcp4.5 rcp8.5	REMO2009	1
	rcp4.5 rcp8.5	RCA4	1

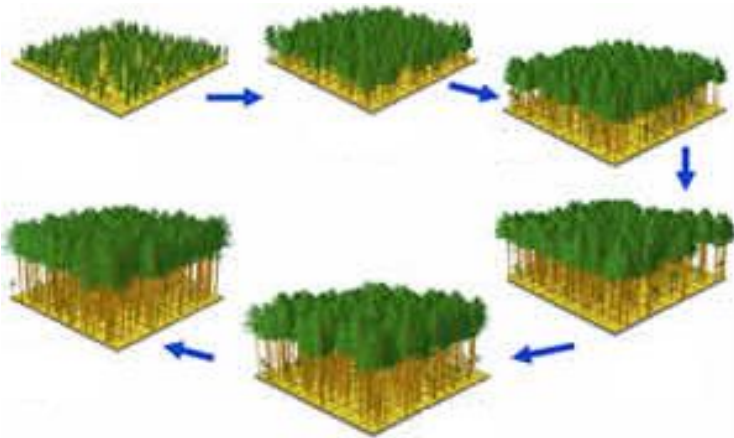
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Simulations and FES indicators



Total 1600 simulations from 2017 to 2100:

50 sampling areas*

8 model chains

2 GHG concentration scenarios (RCPs)

2 management (on/off: frequency & intensity of cuts)

*Spruce (1), Beech (41), Pine (7), Oak (1)

Modified from <http://www.ruraltech.org/tools/>

Results aggregated into 3 periods:

Present Time (PT): from 2017 to 2037 (2027)

Near Future (NF): from 2040 to 2060 (2050)

Far Future (FF): from 2080 to 2100 (2090)

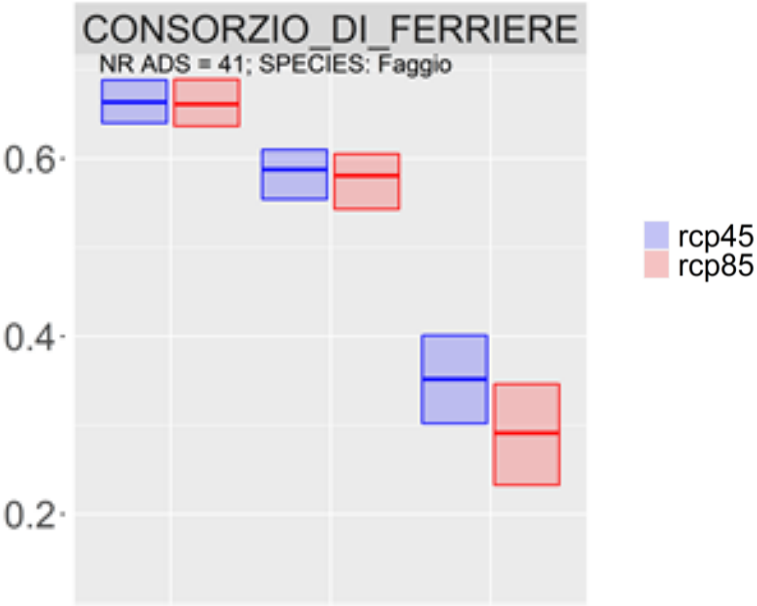
$$\text{Carbon Use Efficiency} = \frac{NPP}{GPP}$$

$$\text{Water Use Efficiency} = \frac{NPP}{\text{Canopy Transp.}}$$

Loss in Carbon Use Efficiency due to CC

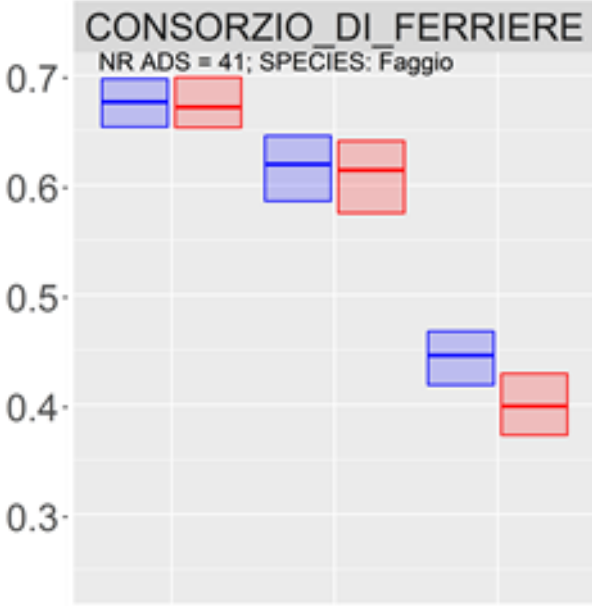


Without management



FF vs. PT -52% (-47%; -56%)

With management



FF vs. PT -37% (-34%; -40%)

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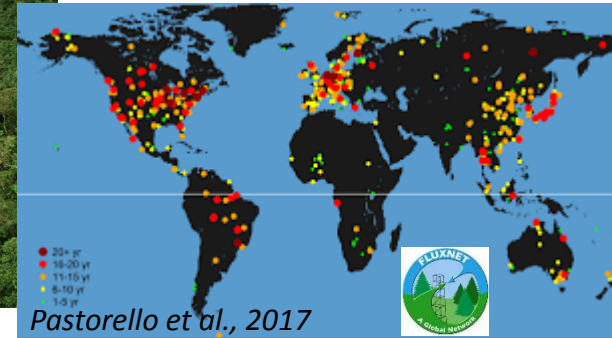


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The key role of monitoring

Measurements are crucial for initialization, parameters' calibration and evaluation of models

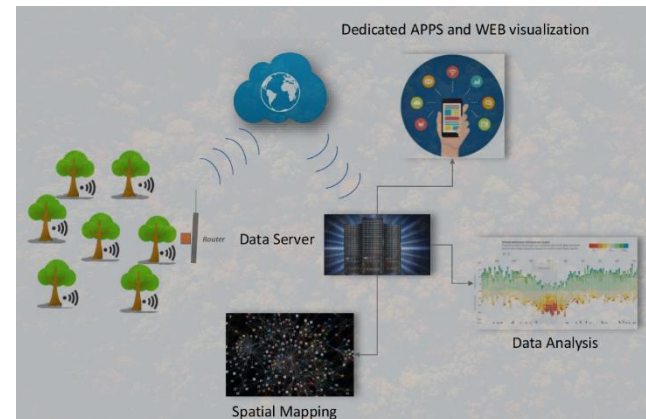
- Carbon/water/energy fluxes (e.g. [ICOS](#), [FLUXNET](#))



- Ecophysiological monitoring (e.g. TreeTalker network)



Piegaro (Umbria, Italy) – [TRACE](#) project



Key elements supporting Digitalization

Synergistic use of multi-source monitoring data and modelling approaches

Investments in HPC/data infrastructure

Use of indicators to generate user-tailored information



**Thank you for your attention
and
thanks to the MADAMES-AX team**

<https://www.madames-ax.info/>

