



Deliverable D8.18 – CPP VRE

REPORT ON THE COMPLETE VERSION OF THE AGRO-ECOLOGICAL MODELLING PLATFORM API SOLUTION OF THE CCP VRE, AND THE ASSOCIATED USER GUIDE





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Author(s) (Partner-OU):	Alessandro Montaghi (IBE) (IRET-FI)
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1. EXECUTIVE SUMMARY – WP 8, TASK 8.3

Task 8.3 Overview of the work package

The present document provides a condensed summary of Deliverable CPP 8.3 developed within the ITINERIS project, specifically within Work Package 8 dedicated to the development of Virtual Research Environments (VREs). The ITINERIS initiative aims to integrate and strengthen Italian environmental research infrastructures through advanced digital services, interoperable data systems, and cloud-based scientific platforms. Within this context, Task 8.3 focuses on the development of the Crop, Plants and Pests Virtual Research Environment (CPP-VRE), a digital infrastructure designed to support agro-ecological modelling and environmental data analysis.

The objective of the CPP-VRE is to provide researchers with access to modelling tools, datasets, and computational services through a unified and interoperable digital platform. By exposing modelling capabilities through web-based interfaces, the platform allows scientists to run simulations, analyse environmental data, and integrate modelling results into external analytical workflows. The platform represents an important step toward the creation of integrated digital infrastructures capable of supporting interdisciplinary research in agriculture, ecology, and environmental sciences.

The development of the Agro-Ecological Modelling Platform builds upon previous experience gained within European research infrastructures, particularly the AnaEE (Analysis and Experimentation on Ecosystems) infrastructure. AnaEE is a distributed research infrastructure that integrates experimental facilities, modelling platforms, and analytical laboratories across Europe to support ecosystem research. The experience gained within AnaEE provided both the conceptual and technological foundations for the development of interoperable modelling services and digital infrastructures within ITINERIS.

Within the AnaEE ecosystem, several supranational centres coordinate research infrastructure activities. The Technology Centre is responsible for monitoring technological innovation and coordinating experimental protocols. The Data and Modelling Centre supports data management, modelling services, and interoperability between infrastructures. The Interface and Synthesis Centre promotes the integration of scientific results and facilitates knowledge transfer between research communities and policy makers. These structures provide the broader scientific and organizational framework within which the modelling services described in this deliverable have been developed.



<i>Name</i>	<i>Short description</i>	<i>Type</i>
Infections Models	set of infection models	REST
Advanced Infection Models	new set of infection models with crop phenology	REST
Vine varieties classifier	grapevine varieties identification from leaf	REST
Weather Anomalies Checks and Corrections	check and correct data weather anomalies	REST
Cloud Service Optimizer	model optimizer	REST
Model APIs - v1		REST

Task 8.3 BioMA (Biophysical Model Applications) Model

A key technological component underlying the Agro-Ecological Modelling Platform is the BioMA (Biophysical Model Applications) modelling framework. BioMA is an open-source framework specifically designed to support the development and execution of biophysical models in agriculture and environmental sciences. The framework follows a modular architecture in which modelling components represent distinct conceptual or computational processes, such as plant growth, pathogen development, soil dynamics, or environmental interactions. By combining these components, researchers can construct complex simulation models while maintaining transparency and flexibility in the modelling workflow.

The modular architecture of BioMA offers several advantages. First, it promotes the reuse of modelling components across different research projects. Second, it facilitates model maintenance and extension because individual components can be updated independently. Third, it improves transparency and reproducibility by making the internal structure of models explicit. These characteristics are particularly important in scientific contexts where modelling results must be verifiable and reproducible by other researchers.

From a technological perspective, the BioMA framework is implemented using the C# programming language within the Microsoft .NET ecosystem. This environment provides a robust and scalable infrastructure capable of supporting computationally intensive simulations and complex modelling workflows. The separation between modelling components and user interfaces also allows the framework to be integrated into different technological environments, including cloud-based services and web applications.



Task 8.3 CPP APIs (Application Programming Interfaces)

In order to make modelling capabilities accessible to a wider community of users, the Agro-Ecological Modelling Platform exposes its services through Application Programming Interfaces (APIs). APIs provide standardized interfaces that allow independent software systems to communicate with each other and exchange data. Through these interfaces, users can submit modelling requests, execute simulations, retrieve results, and integrate modelling outputs into their own analytical workflows.

The platform follows a client–server architecture in which modelling services are executed on remote servers while users interact with the system through client applications. Communication between clients and servers occurs through the HTTP protocol using a request–response interaction model. This approach enables flexible integration with a wide range of programming environments and analytical tools, including Python, R, and web-based applications.

The API architecture of the platform follows the REST (Representational State Transfer) design paradigm, which has become the dominant architectural style for modern web services. In REST-based systems, services are organized around resources that can be accessed using standard HTTP methods such as GET, POST, PUT, and DELETE. Each resource is identified by a unique URI and can represent entities such as datasets, model runs, simulation results, or configuration parameters.

The REST approach provides several advantages for scientific platforms. It simplifies the interaction between clients and servers, improves scalability, and ensures technological independence. Because RESTful services are stateless, each request contains all the information necessary for processing, allowing the system to scale efficiently across distributed computational infrastructures.

The platform primarily exchanges data using the JSON (JavaScript Object Notation) format. JSON has become the standard data representation format for modern web APIs because it is lightweight, human-readable, and compatible with most programming languages. The use of standardized data formats ensures that modelling outputs can be easily processed by external analytical tools and integrated into reproducible research workflows.

Another key design principle guiding the development of the platform is the adoption of FAIR data principles. FAIR stands for Findable, Accessible, Interoperable, and Reusable. These principles provide guidelines for designing research data infrastructures that facilitate data discovery, sharing, and long-term reuse. Within the Agro-Ecological Modelling Platform, FAIR principles are

implemented through the use of standardized metadata, persistent identifiers, open communication protocols, and interoperable data formats.

The Findability principle ensures that datasets and modelling outputs can be easily discovered through searchable metadata and unique identifiers. Accessibility ensures that data can be retrieved through standardized protocols while respecting authentication and authorization policies. Interoperability allows datasets and models to be integrated with other scientific systems using shared standards. Reusability ensures that data are accompanied by sufficient documentation and provenance information to allow their reuse in future studies.

The platform currently provides several specialized modelling and analytical services through dedicated API endpoints. These services demonstrate how agro-ecological models, environmental data processing tools, and machine learning algorithms can be integrated within a unified computational environment. Among the available services are plant disease infection models that simulate pathogen development under specific environmental conditions.

These infection models allow researchers to analyse the relationship between climatic variables, crop phenology, and pathogen dynamics. Such simulations can support the development of decision support systems for crop protection and integrated pest management strategies. By running these models through cloud-based services, researchers can easily perform scenario analysis and evaluate the potential impacts of different environmental conditions on crop health.

In addition to infection models, the platform includes advanced services for meteorological data quality control. Environmental datasets often contain missing values, measurement errors, or anomalous observations. The weather data quality services implemented within the platform allow users to detect such anomalies and apply correction algorithms to improve the reliability of meteorological time series. High-quality environmental data are essential for reliable agro-ecological modelling and simulation.

Another service integrated within the platform supports model calibration and parameter optimization. Calibration is a crucial step in modelling workflows because it allows researchers to adjust model parameters so that simulations reproduce observed data. The platform provides cloud-based optimization services that allow researchers to perform calibration experiments using distributed computational resources.

The integration of machine learning techniques within the platform is demonstrated by computer-vision models designed for grapevine variety identification. These models analyse images of grapevine leaves and classify them



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according to their botanical variety. Such tools illustrate how traditional agro-ecological modelling approaches can be complemented by modern artificial intelligence techniques to support agricultural research and monitoring.

To facilitate the use of the platform, a comprehensive user guide has been developed using Jupyter Notebooks. Jupyter provides an interactive computational environment in which executable code, explanatory text, and visual outputs can be combined within a single document. This approach allows users to follow step-by-step tutorials demonstrating how to interact with the platform's APIs.

Within notebooks, users can learn how to authenticate with the platform, submit modelling requests, retrieve simulation results, and visualize outputs. Because the notebooks contain executable code, users can reproduce the examples directly and adapt them to their own research workflows. This approach promotes transparency, reproducibility, and knowledge transfer across the research community.

In conclusion, the Agro-Ecological Modelling Platform developed within the ITINERIS project represents an important step toward the creation of integrated digital infrastructures for environmental and agricultural research. By combining modular modelling frameworks, cloud-based services, standardized APIs, and FAIR data principles, the platform provides a flexible and interoperable environment for scientific experimentation.

The platform enables researchers to access modelling tools and environmental datasets through simple web interfaces while maintaining transparency and reproducibility. In the long term, the integration of such services within national and European research infrastructures will strengthen collaboration between research communities and support data-driven decision making in agriculture, ecosystem management, and environmental policy.



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Task 8.3 Interoperability and Integration of ITINERIS with ANAEE-BIOMA

Once access to the ITINERIS platform has been granted, users are able to directly access the ANAEE APIs, enabling seamless interaction with the services and resources provided by the ANAEE infrastructure.

Name	Description	Type
BioMa cloud	The BioMa framework complete suite	REST
BioMA crop infection models	A collection of models for some common crop diseases such as Powdery Mildew and Downy Mildew.	REST
CREA AA Italian historical weather series	A large collection of historical weather data curated by CREA-AA.	REST
CREA ERAS mirror	An API to access CREA's mirror of the Copernicus ERAS dataset	REST
Vine varieties classifier	A Computer vision model to identify grapevine variety from leaf images. Leaf images must be full frontal and in good light conditions. It identifies 27 distinct varieties from the CREA collection.	REST
Weather Anomalies Checks and Corrections	API to check anomalies in a weather data series and correct them according to a set of rules	REST