



**Report on the operational
implementation of the carbon
monitor infrastructure: existing
stations upgrade and expansion of
the terrestrial ecosystem
measurement site network**



Deliverable number:	D8.7
Work package:	WP8 - Virtual Research Environments and Cross-disciplinary Activities
Intermediate Objective:	IO6
Deliverable type:	<input checked="" type="checkbox"/> Document, report
	<input type="checkbox"/> Websites, patent filings, videos, etc.
	<input type="checkbox"/> Other: please specify
Dissemination level:	<input checked="" type="checkbox"/> Public
	<input type="checkbox"/> Restricted
Estimated delivery (bimester):	B9
Actual delivery date:	23/05/2024
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Reviewed by:	ITINERIS Executive Board
Note:	

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System - CUP B53C22002150006 (D.D. n. 130/2022)
 Funded by EU - Next Generation EU
 Mission 4 “Education and Research” - Component 2: “From research to business” -
 Investment 3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”

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1. INTRODUCTION

Activity 8.6 was created with the general aim to provide a Virtual Research Environment (VRE) dedicated to the carbon budget (Carbon VRE), which aspires to be the reference platform for carbon at national level. This VRE will account for the main carbon reservoirs (atmosphere, biosphere, ocean, geosphere) producing spatially explicit data to characterize different compartments of carbon budget that will be useful for a wide spectrum of stakeholders including researchers, institutions, local administrators, agencies. The outputs will be based on the interconnection of different methodological approaches ranging from in situ measurement infrastructures to modelling and remote sensing. Indeed, the combination of eddy covariance ecosystem station flux data network with remote sensing and/or land surface model is a typical productive method to scale up data measured in a single site point to a regional level. Nevertheless, the heterogeneity of land surface can lead to bias in the spatial representativeness. Among the carbon site monitoring network, the main role is played by ICOS ERIC that since 2008 provides accessible high-quality data related to carbon emission and removal. The ICOS Italy network consists of 25 stations, of which 15 are Ecosystem, 5 Ocean and 5 Atmosphere stations. Although ICOS Italy Ecosystem stations are numerous and attempt to cover several land types, the landscape's biodiversity presents in Italy is wide and it is fundamental to understand how the different ecosystems respond to abiotic and biotic stressors imposed by changing climate, especially if they will become carbon sinks (removing carbon dioxide from atmosphere) or source (release carbon dioxide to atmosphere) with negative or positive feedback to the rate of global warming.

2. NETWORK EXPANSION

For this purpose, within Activity 8.6 was expanded the measurement site network. The site selection was accurately done and was based on:

- i) Cover as much as possible the heterogeneity of ecosystem typology and plant functional type also accounting for the relative national land cover (larger the cover - larger the impact)
- ii) Account for ecosystem dynamics. Typically, “stable” systems are the preferred location for field measurements. However, disturbances are a recurring event in Italian ecosystems, such as renewing a forest stands after wild fire events, pest attacks or forest regeneration in abandoned pasture, just to cite a few.
- iii) Sites cluster approach. The generation of small observatories where scientist can collect dataset of carbon fluxes together with others biophysical processes. Within each cluster

are present more than one eddy tower measuring different ecosystem types or different regeneration approaches. The major goal of this cluster approach is to understand if there are general trends in carbon stock and fluxes in response to climate, disturbances and/or regenerative technique used.

- iv) Sites robustness and long-term perspective. The sites were selected also considering the possibility to remain after the project and for a period of at least 5 years in order to collect enough data to characterize the interannual variability.

Based on the above criteria, the following 7 sites were selected, as reported in Table 1. In respect to the initial proposal, the number of the sites that will enter in the network and will provide data for the Carbon VRE has been increased by one unit. In all the sites the activities are ongoing and the construction under finalization in order to cover the 2024 summer in most of them. The operational date is slightly postponed compared to the timing foreseen by the ITINERIS project in its drafting phase, but this doesn't impact the project aims, due to the long term perspective of the measurements. The main delay was due to the time needed for the equipment suppliers (in many cases extra-EU) and their administrations to understand and handle the EU Regulation 241/2021 related to the DNSH ('Do No Significant Harm' protocol) e.g. the chemical composition of measuring instruments and the presence and percentage of heavy metals. In the case of the Castelporziano cluster some administrative work to get all the permissions to install the towers in a protected area, not publicly accessible, was also needed.

Table 1 - Sites for network expansion and timing of the implementation

<i>Site Name</i>	<i>Timing of implementation</i>	<i>Cluster site (y/n)</i>
Malga Arpaco	Operational- Measuring	n
Collelongo	Start measurements End 2024	n
Torgnon Forest	Operational- Measuring	y
Torgnon reforestation	Start measurements July 2024	y
Castelporziano Farnete	Start measurements June 2024	y
Castelporzioano Pine_1	Start measurements June 2024	y
Castelporziano Pine_2	Start measurements June 2024	y

Here below are listed the characteristics of the selected sites and what was supplied by ITINERIS project.

Malga Arpaco

Tesino Upland is located in the Alps, in the southern part of external Dolomites; its Northern border is marked by the Lagorai mountains (2,700 m). The site is located next to a farm (Malga Arpaco) at

1,663 m. a.s.l. (46.11402° N; 11.70334° E), and it is a seasonality pasture (alpeggio) with pasture times from the beginnings of June to the end of August (around 100 days). The climate in the southern part of Dolomites is influenced by the Adriatic Sea, with an annual rainfall is between 1100–1500 mm with a bimodal distribution (max in spring and autumn). The average temperature is lower than 0 °C from December to March. The soil is an alfisol, sandy-loam and a Typic Hapludalfs (FAO 2008). Activity 8.6 provided to this site a CH₄ open path analyzer, Sonic Anemometer, CO₂ analyzer, data management and data processing.

Collelongo

The experimental site is located in Central Italy, Abruzzo region near the village of Collelongo. The Selva Piana forest stand (41.84936° N; 13.58814° E, 1,560 m.a.s.l.) belongs to a 3,000 ha forest community which is part of a wider forest area. The environmental and structural conditions of the stand are representative of central Apennines beech forests, thus for this it was fundamental to have inside the network. Since 2006, the site has become one of the main stations of the Long-Term Ecological Research site “Forests of the Apennine”. Over the years, the site was included in several EU and national research, monitoring and environmental projects. It is a pure beech forest The climate at the site is Mountain-Mediterranean with an average annual temperature of 6.9 °C and an average annual precipitation of 1,230 mm. Snow cover can last from mid-December to mid-March–early April. Activity 8.6 provides to this site data management and data processing, while sensors and other goods are provided by ITINERIS project via CNR IBE.

Torgnon Cluster

Torgnon Forest. The site is located at an altitude of 2050 m a.s.l., Aosta Valley, Torgnon municipality. It is a cluster site, indeed is few km away from the Torgnon pasture site (IT-Tor). The forest is mainly composed of European larch (*Larix decidua* Mill.), which represents approximately 90% of tree cover, while the spruce is the remaining species. The climate is characterized by cold winters, with an average air temperature of around 2 °C, and mild summers, with an average air temperature of around 12°C. The annual precipitation is around 880 mm, while the average duration of snow cover ranges from November to May, with an average height of the snow cover between 50 and 120 cm. Activity 8.6 provided to this site the logging system, the power supply and the data connection together with data management and data processing.

Torgnon reforestation. The station is located close to the Torgnon grassland site (45.84444°N, 7.578055°E, 2180 m a.s.l.), already labelled in ICOS as Associated station. It is the same type of grassland but in this case the area has been abandoned and it is under a natural recolonization process by the forest. The station is maintained through the collaboration with ARPA Valle d'Aosta that is managing all the three stations in the cluster. This site is also used for the PhD thesis of one of the ITINERIS PhD students recruited in the WP3 training activities. Activity 8.6 provided to the site the logging system and sensors, in addition to site data management and data processing.

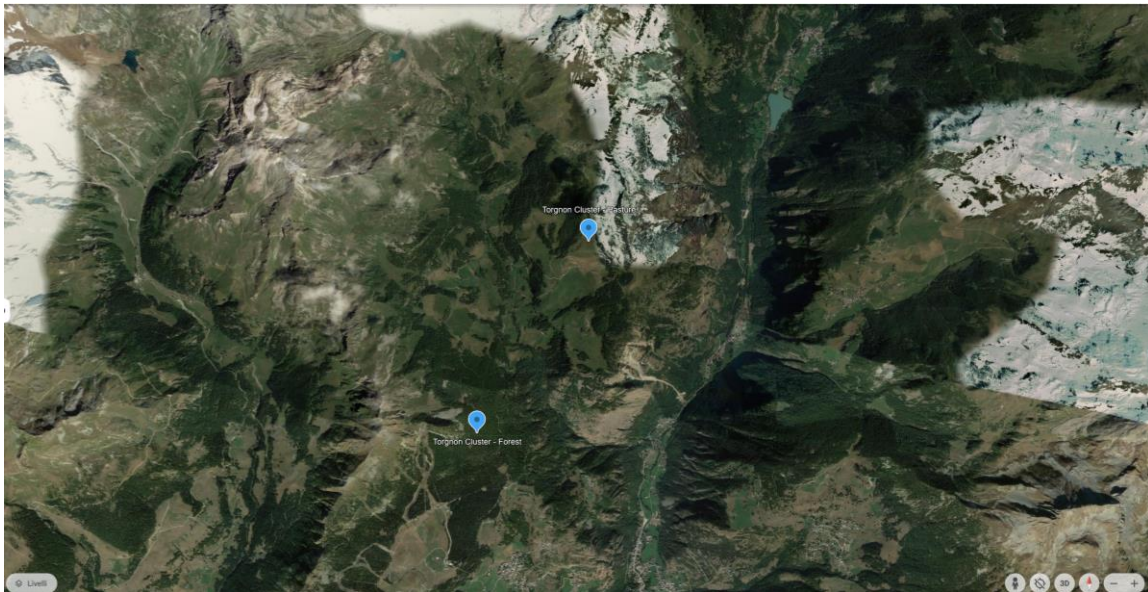


Fig. 1. Location of the Sites of Torgnon Cluster

Castelporziano Cluster

The Castelporziano Presidential Estate is a natural reserve with an extension of about 6000 ha, in large part covered by forest that hosts one ICOS Class 1 station (IT-Cp2). Here, thanks to the synergic activity of ITINERIS and NBFC national projects, three additional sites will be operational for the end of June 2024.

One site will be the Farnete Castelporziano, located at an altitude of 10 m a.s.l.. It is a mixed deciduous oak forest dominated by *Quercus cerris* and *Quercus pubescens*. For this site, Activity 8.6 will provide the power supply system, the data transfer, meteorological sensors, data management and data processing.

Pine_1 and Pine_2 sites are the result of an expected large land use change caused by the attack of *Toumeyella parvicornis*, the insect that since 2017 killed more than 200 ha of pine forest. Now the dead trees have been almost completely removed and there are different strategies for the ecosystem

restoration: reforestation with a mix of autochthonous deciduous species and some area left to the natural evolution but in different conditions (grazing protection or unprotection). This gives the possibility to create together with the ICOS tower a new unique long-term observatory. For this sites Activity 8.6 will provide the all the sensors, the power supply system, the data transfer, data management and data processing.



Figure 2. Location of the Sites of Castelporziano Cluster

3. NETWORK UPGRADE

In order to upgrade all the ecosystem network and to give the possibility to gather some important information within the Carbon VRE, Activity 8.6 has provided a complete kit for measuring gas exchange in different ecosystem compartments and chlorophyll fluorescence at leaf level. The kit allows to perform in-depth photosynthesis and fluorescence measurements, including traditional and rapid response curves, on higher plants, bryophytes, both in the field and in the laboratory. The kit also allows to perform rapid prospecting measurements on broad-leaved trees with stomatal conductance recording, fluorescence, PAR, position and orientation of leaves. It allows also to carry out respiration and net photosynthesis measurements on soil. There are specific chambers for the measurement of bryophyte, large leaves, needles, insect respiration, soil respiration. Finally, there is also a trace gas sub sampling kit that will give the possibility to sample important products of secondary metabolism of plant such as BVOC.