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REPORT ON THE ACQUIRED INSTRUMENTATION TO FILL THE KNOWLEDGE GAPS IN THE CONSTRUCTION OF THE CZ VRE SERVICES

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Author(s) (Partner-OU):	SIMONA GENNARO, PASQUALE BOVE, MATIA MENICHINI, MARCO DOVERI, BRUNELLA RACO, MARCO CHIMENTI, ANDREA DINI, GIANNA VIVALDO, ILARIA BANESCHI, SILVIO MARTA, FRANCESCA CAPARRINI, PASQUALE PAGANO, ANTONELLO PROVENZALE
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1. PROGRESSES OF THE ITINERIS PROJECT – WP 8, TASK 8.1

Task 8.1 activities – progresses

The main goal of the ITINERIS WP8 Task 8.1 is the development of a framework for the analysis and modelling of CZ processes and their response to environmental changes, including the dynamics of groundwater in both the saturated and unsaturated zones. Such framework will be made available in the form of a Virtual Research Environment to both researchers and more general stakeholders, with particular attention to environmental managers and technical personnel of protected areas.

The design and development of the Critical Zone Virtual Research Environment (CZ VRE) thus represents an important part of the ITINERIS WP8 Task 8.1 PNRR Project.

The VRE implementation was carried out using the D4science e-Infrastructure provided by ISTI-CNR, and the primary services offered are a workspace with a shareable folder system, a social network board and a system of integrated analytical methods.

The VRE has an exceptionally reliable, distributed, online file system that allows one to upload files, create private folders, share folders with specific colleagues, publish folders, share data in a VRE, and publish data in a catalogue. The CZ VRE was designed with a connection to a GeoNetwork Catalogue. The social networking board system integrated into the VRE allows the exchange of messages between users; there is a board for open discussions where it is possible to attach links and files from the VRE folders. The VRE offers the possibility of implementing integrated analytical methods using integrated importer software or RStudio on a virtual machine connected to the workspace folder system.

The CZ VRE will integrate data, tools for data visualization and analysis and modelling services in a web-based (e-Science) platform that will allow researchers to access and analyze data from different observation sites in Italy and Europe, and to share data and models with other researchers and stakeholders.

To be fully functional, the CZ VRE must include data and information coming from field measurements and analytical laboratories, allowing for the complete characterization of Critical Zone processes. Along such lines, the activities of Task 8.1 thus aim also to increase the capabilities of the existing facilities and the creation of new laboratories and the inclusion of field measurements. To fill the existing knowledge gaps and respond to the need of creating an integrated and innovative Research Infrastructure.

In order to reach all the objectives of Task 8.1 and fill the knowledge gaps currently existing in CZ research in Italy, the acquisition of a selected set of new instruments (both for field measurements and for the laboratories in IGG Pisa) was considered a necessary step.

In particular, a set of instruments (Eddy-Covariance Tower, Cosmic Ray Neutron Sensing, and high-precision lysimeters, multi-parameter probes and instrument for flow-rate measurements) were deemed necessary to support Critical Zone field measurements in the high-altitude grasslands and nival valleys of Cimalegna, Monte Rosa (at about 2500 m amsl), to complete the currently performed measurements devoted to soil and snow measurements and to vegetation surveys. Some of the instruments will be transported in this area for on-site measurements during each field campaign, while others (Eddy Covariance, lysimeter) will be temporarily installed at Cimalegna for a period of continuous measurements, to be then returned to CNR IGG Pisa at the end of the campaign. In this way, ITINERIS will support a new CZ observatory to be subsequently proposed in the framework of eLTER RI, ICOS ERIC and as a source of data, analysis and modelling approaches and information for LifeWatch ERIC. The data and information provided by the field measurement campaigns at Cimalegna will provide a companion field information, at comparable altitude, to the already existing CZ observatory at the Nivolet Plain in the Gran Paradiso National Park (2600 m amsl) managed by CNR IGG and to the instrumented site of Torgnon (about 2000 m amsl) managed by ARPA VdA, thus providing a relevant and broad coverage of the CZ dynamics in the north-western Italian Alps. After completing the measurements at Cimalegna, these instruments will be used for further field measurements in other mountain sites.

Other instruments were acquired for the newly developing coastal wetland CZ observatory at Bosco Mesola, in the Po Delta. Here, piezometers and the floating carbon flux chambers coupled to IRGA spectrophotometers will provide a first set of instrumental tools to be used on-site during the measurement campaign, to characterize one of the most iconic Italian wetlands, studying in particular the effects of aquifer salinization and of different levels of water oxygen content. This area will be the first wetland CZ observatory in Italy and the data measured in this observatory will be complemented by data analysis methods and wetland ecosystem modelling suites, to be included in the CZ VRE and in LifeWatch ERIC platforms.

At laboratory level, a new high-performance Field Emission Scanning Electron Microscope (FESEM), currently non-existent in Italy, has been acquired and it is being installed at CNR IGG Pisa. This instrument, together with the instruments for determining total carbon in water and sediments, provides a highly-competitive facility to foster Italian research and its contribution to European research infrastructures. The system will be complemented by a high-performance lysimeter to be first used at CNR IGG to test various methods to estimate soil water dynamics and evapotranspiration (and the associated uncertainties) and subsequently installed in a field site such as the Po Delta CZ observatory.

Finally, a system of servers to store and statistically analyze the data and to support the functioning of the CZ VRE had been acquired. Part of the server system will be installed in the framework of the cloud computing system that sustains the use of D4SCIENCE in the CZ VRE, while some of the storage will be kept in-house for the first collection and quality control of the data coming from the various field and laboratory facilities.

In the following, we provide the details of each type of instrumentation.

2. ACQUIRED INSTRUMENTATION IN THE FRAMEWORK OF THE ITINERIS PROJECT – WP 8 AND TASK 8.1

Instrument for determining total C in water and solid matrices

On 28/12/2023 an exploratory market investigation, for an instrument dedicated to the determination of the total Carbon in water and solid matrices, was started (Prot. n. 418197). The instrument for determining total C in water and solid matrices system was awarded following an evaluation of the offers received during the market investigation phase aimed at collecting informal quotations. The direct purchase (TD) was signed on 19/02/2024 (Prot. n. 54913).

Soils comprise the largest terrestrial carbon (C) pool (Schlesinger, 2000) and it has a vital role as a global C sink. Soil carbon occurs in two forms: (i) soil organic carbon (SOC) and (ii) soil inorganic carbon (SIC) (Eswaran et al. 2000, Zhang et al., 2015, Gao et al., 2017). Understanding the distribution of both SOC and SIC carbon storage in soil profiles is crucial for assessing regional, continental and global soil C stores and predicting the consequences of global and environmental changes. Much work has been performed regarding SOC related to its accumulation and storage in soil, but inorganic carbon is often ignored, resulting in the sparse availability of data (Ferdush and Paul, 2021; Batool et al. 2024). Additionally, SOC and SIC are present in soils as dissolved organic/inorganic carbon in water and their export fluxes could vary in space and time both in their respective magnitudes and in relation to each other, and these variations are driven by hydrologic dynamics and ecosystems.

For these reasons, conducting comprehensive research focused on the different C pools and discriminating the different C in soil under different hydrological conditions, climates, and human activities is crucial in the framework of the study of the critical zone. At this moment, the lack of an instrument able to perform this analysis represents the reason for an important knowledge gap.

In order to address this knowledge gap, an instrument able to analyze carbon content in solid and liquid matrixes was acquired by the CNR-IGG. This instrument will be used to quantify organic and inorganic carbon in soils and water samples collected in the IGG critical zone observatories (CZOs).

The preparation system was awarded following an evaluation of the offers received during the market investigation phase aimed at collecting informal quotations. The supply was awarded to Verder Scientific S.r.l..

The integrated system for the preparation of solid organic-inorganic materials is composed by:

1) a QPOL VIBRO vibrating polishing machine, for the final polishing of thin sections and mounts used for imaging and geochemical maps in FE-SEM laboratory.
2) A Retsch PM300 planetary ball mill complete with 2 EasyFit 250ml agate grinding jars and 80 15mm diameter agate grinding balls allowing pulverization at nm scale.
3) A Carbolite PF120 convection stove equipped with a PID-R38 controller for the drying of powders and solid samples.

This integrated system will allow the preparation of complex solid matrices (inorganic-organic) to study the processes that occur in the Critical Zone, in support of the ITINERIS WP8 - Activity 8.1 - VRE Critical Zone Services project. It will make possible the state-of-the-art preparation of solid samples with a complex matrix (embedded as they are and pulverized) for electron microscopy imaging and for textural, mineralogical and geochemical mapping, filling knowledge gaps on organic matter/organic matter interaction processes and contributing to the scientific network for the sharing and development of services for the study of the Critical Zone (CZ). This integrated system is fundamental for acquiring the best results using the new FESEM Sigma 360 and other analytical facilities hosted by IGG-CNR.

Cosmic ray neutron sensing (CRNS) detector system

As part of the National Recovery and Resilience Plan (PNRR) (mission 4 component 2 - investment 3.1 - ITINERIS project), the Institute of Geosciences and Georesources – CNR (Pisa) decided to carry out a procedure to acquire a Cosmic ray neutron sensing (CRNS) detector system.

The furniture of the Cosmic ray neutron sensing (CRNS) detector system includes the following elements:

- n. 2 Cosmic Neutron Detector (model: S2+);
- n. 2 Data logger;
- n. 1 Casing, PV Panel, Battery (battery 26 Ah), Charger, Pole;
- n. 1 Casing, PV Panel, Battery (battery 60 Ah), Charger, Pole;
- n. 2 GSM modem for telemetry;
- n. 2 Thermal neutron shield based on Gadolinium;
- n. 2 TPRh Sensors;
- n. 2 Technical support for installation on-site (Italian Alps) and training (1 day);
- n. 2 Software and firmware upgrades.

In particular, the cost of the furniture comprises shipping, remote assistance and the installation of the instruments in the alpine sites selected.

The Cosmic Ray Neutron Sensing (CRNS) detector system will be installed in remote alpine sites monitored by the IGG (CZOs) covering an area of about 200 m². The instruments will allow the daily monitoring of the water content in the first 30 cm of the soil.

By monitoring the variations in water content daily, the system will help fill knowledge gaps on the processes linked to the critical zone. It will also allow researchers to study the impact of environmental parameters such as temperature, humidity, and air pressure on the water content in the soil. The data collected by the CRNS detector will contribute to the development of a network for sharing and developing services for the study of the critical zone. This will provide valuable insights into the hydrological cycle in the Critical Zone – in support of the ITINERIS WP8 project - Activity 8.1 - VRE Critical Zone Services – and help advance our understanding of this important field of research.

Field Emission Scanning Electron Microscope (FE-SEM)

As part of the National Recovery and Resilience Plan (PNRR) (mission 4 component 2 - investment 3.1 - ITINERIS project - B53C22002150006 - CIG 97695442C0), the Institute of Geosciences and Georesources – CNR (Pisa) carried out an open tender procedure above the threshold. With provision 0257512 of 05/09/2023, the CNR ordered the award of the supply of a FESEM Zeiss Sigma 360 equipped with EDS-WDS-microXRF.

The new FE-SEM, which will be installed and tested by the end of May 2024, has a configuration strongly aimed at the chemical characterization of materials, from inorganic to organic, as well as being a good/excellent system for imaging. It will be equipped with three detectors/sources for micro analysis: 1) new generation EDS (SDD) of 100 mm2; 2) WDS parallel beam with 5 crystals covering from Be to U; Micro-XRF source for light to heavy elements up to concentrations of a few tens of µg/g.

The large surface of the EDS detector (100 mm^2) will allow to work well at low voltage and low vacuum, therefore also investigating materials sensitive to high currents (organic s.l.; sulphates, clays, etc.) providing geochemical mapping of any type of previously prepared and C-coated material. The raw data for each acquisition will contain the spectrum for each analysis point of the map which, depending on the sampling step chosen, can reach several million analyses/samples. This data lends itself to the application of innovative machine-learning methods in the field of critical zone and petrology.

The WDS detector will allow the quantitative study of materials that contain elements of interest that are difficult to resolve in energy dispersion, measuring contents up to hundreds of µg/g. WDS is also excellent for those relatively light elements (e.g., F, Cl, N, C) that are not quantifiable with EDS.

The micro-XRF poly-capillary source will allow the production of chemical maps of major and trace elements of any type of material, even on large surfaces, and without any specific preparation (e.g. no coating, no polishing). The acquisition times, thanks to a piezoelectric "rapid stage", will be extremely fast (about 20 min for an area of 15-30 cm^2; much faster than EDS maps), with a spatial resolution of 35 µm. These maps are semi-quantitative but can be "calibrated" by running quantitative profiles in EDS/WDS.

The instrument will also be equipped with software dedicated to "Automated Mineralogical Quantification" (with EDS or micro-XRF) which will allow obtaining the mineralogical maps of the sample which, together with the co-generated chemical maps, will be part of an automatic report which will contain also the dimensional, morphological and chemical characterization of each individual material grain as well as the modal analysis and the

average chemical composition of the material. The raw data will be used to identify the mineral granules most suitable for the application of other analytical methodologies (e.g., geochronology, isotopes), to define the size classes (e.g., CSD analysis), the chemical composition of the rock, correlative analysis of the chemical zoning of the crystals of different minerals, etc.

This FE-SEM will be able to contribute to research in many fields of Earth System Sciences and, in particular, to characterize complex inorganic/organic matrices such as those characterizing the Critical Zone field. It will allow us to fill a truly relevant gap in the characterization of Critical Zone materials by providing robust background information for the interpretation of geochemical and isotopic data acquired on air and water samples, as well as for the integration with flux data and multiparametric monitoring data.

Eddy-Covariance Tower

An integrated monitoring station was acquired in the framework of the PNRR project. In particular, carried out an open tender procedure under the threshold for the supply of an Eddy Covariance.

The integrated monitoring station will perform the long-term and high-resolution (sub-daily scale) automatic measurements of meteorological and environmental variables, as well as of the turbulent fluxes of carbon dioxide, water and energy using the Eddy Covariance (EC) method.
In particular, the instrumentation acquired recently will be installed close to the Scientific Institute “Angelo Mosso” (also known only as “Mosso”). This site is located close to the border between the Piedmont and Valle d'Aosta regions in the Alagna Valsesia, in the Monte Rosa chain and will be dedicated to the study of an alpine ecosystem (North-Western Italian Alps).

In particular, the furniture will include the following sensors:

EC sensors:

- Enclosed CO_2/H_2O analyzer with heated intake tubes, inlet caps and particle filters,
- Analyzer Interface Unit (AIU), housing the gas analyzer electronics,
- Flow module to control the airflow rate,
- Three-dimensional ultrasonic anemometer to perform wind and turbulence parameters measurements.

Meteorological sensors:

- Temperature and atmospheric humidity sensor with radiation shield,
- barometric sensor,
- radiometric sensors: 1 net radiometer, and 2 photosynthetically active radiation sensors,
- soil sensors of moisture, temperature and heat flow,
- pluviometer and nivometer.

Other equipment:

- modem and datalogger for the acquisition and transmission of data,
- tripod adjustable from 2 to 4 meters.

The supply will also include shipping and installation of equipment, as well as station executive design documents.

All instrumentation will comply with ICOS (Integrated Carbon Observatory System) standards, since the ultimate goal will be to make the Monte Rosa site a CZO, part of the ICOS network as an "ecosystem station".

Mountain ecosystems are known to be particularly sensitive to the effects of climate change, especially in the Mediterranean area which is known to be a "hotspot" of climate change. Nevertheless, the understanding of crucial biogeochemical variables, essential to understand how these ecosystems respond to varying environmental conditions – such as carbon dioxide fluxes in the Critical Zone of high-altitude grassland and Alpine tundra – remains incomplete.

Concerning the European ICOS network, the stations dedicated to the study of high mountain ecosystems are few, mainly located in the Alps (https://www.icos-cp.eu/observations/ecosystem/stations). In Italy only four mountain ecosystem sites are present: Nivolet and Torgnon in the Western Alps, Renon and Monte Bodone in the Eastern Alps. The main drawbacks characterizing the long-term trend monitoring of mountain sites is related to the harsh and remote environments in which they are located. Moreover, some of them are part of "National Parks", which are protected areas characterized by strong restrictions. All this results in huge drawbacks affecting measurements, such as the lack of appropriate power supply and the inability to install high-impact instruments. Moreover, data are affected by several gaps produced by exogenous causes (e.g., extreme weather), not always easy to fill by standard statistical techniques.

The final goal of ICOS – and most in general of all the worldwide monitoring networks dedicated to the study of greenhouse gases (e.g., FLUXNET, refer to https://fluxnet.org/about/regional-networks/) – is to produce standardized, high-precision and long-term observations. In this context, a new mountain Italian ecosystem site, featuring distinct abundances and environmental conditions, will be extremely useful to fill the knowledge gap which still affects the Mediterranean area mountains, especially in terms of long-term measurements with high-resolution sampling.

Floating chamber and flux-meter

As part of the National Recovery and Resilience Plan (PNRR) (mission 4 component 2 - investment 3.1 - ITINERIS project), the Institute of Geosciences and Georesources – CNR (Pisa) decided to open an exploratory market investigation to acquire a floating accumulation chamber and a flux-meter.

The furniture object of this order comprises a portable accumulation chamber assembled for measuring CO_2, H_2O and CH_4 fluxes simultaneously at the air-water interface in lakes, lagoons, marshes, and humid peat bogs. The supply includes an assembled portable flux meter (with the carrier frame system and a case) that can simultaneously detect CO_2, H_2O and CH_4 fluxes. The fluxes measurements will be performed punctually and based on the stationary static accumulation chamber technique. The system, compounded by the sensors, a pump, a battery, a housing for a removable mass flow controller and the electronic interface, is contained in a case. In particular, the portable fluxmeter includes:

- One non-dispersive infrared (NDIR) gas analyzer for CO_2 and H_2O with:

a. CO_2 measurement range: 0 ÷ 20000 ppm,
b. CO_2 flux measurement range: 2 ÷ 150000 mmol/(m^2 * day),
c. CO_2 precision: < 1.5%,
d. RMS Noise CO_2 @ 370 ppm (with 1s signal filter): <1 ppm,
e. CO_2 measurement range: 0 ÷ 20000 ppm,
f. H_2O measurement range: 0 ÷ 60 mmol/mol,
g. RMS Noise H_2O @ 10 mmol/mol (with 1s signal filter): <0.01 mmol/mol,
h. operating temperatures: from -20°C to +45°C.

- Modular diode laser analyzer coupled with a multi-pass cell for the CH_4 with the following technical details:

a. concentration measurement range: 0 ÷ 40000 ppm,
b. flow measurement range: 0.5 ÷ 100000 mmol/(m^2 * day),
c. a resolution of 0.01 ppm and precision <0.8 ppm;
d. operating temperatures: from -10 to +50 °C.

- One Accumulation Chamber (AC) made of polymethyl methacrylate (PMMA) with an internal diameter of 290 mm and height of 100 mm and where the mixing inside is ensured without any part mechanics. The AC is equipped with a pressure sensor and is supplied with a floating ring. The floating ring is mandatory to perform flux measurements in these contexts and it allows the chamber to be placed on the water at least 1 cm below this surface and with a steel collar equipped with a gasket that ensures that the system remains closed.

- Dedicated inputs for temperature probe also suitable for soil (PT100) and a probe for volumetric soil water content. The data recorded by such probes must be managed and integrated together with data on fluxes.
- Handheld configured to manage the fluxmeter via the specific app and Bluetooth connection in order to view and record the concentration curves of the target gases and, so, calculate the fluxes. The handheld device is also configured to manage the parameters of the environmental sensors via the same app and to record the latitude and longitude coordinates (CRS: WGS84) via the integrated GPS receiver. The device can also record the altitude of each measurement point.

The supply also included the shipping costs and the delivery, as well as the free remote assistance.

Air-water interfaces have a predominant role in GHG emissions into the atmosphere, playing a notable contribution to the global carbon budget (Erkkilä et al., 2018; Huang et al., 2022). The understanding of the fluxes dynamics in these areas and the quantification of the fluxes represents a key point in the study of global and environmental changes.
The instrumentation will allow the determination of carbon fluxes from important study areas like lakes and wetlands located in key sites to study the carbon cycle in the Critical Zone. For this reason, this represents a crucial tool to support the ITINERIS WP8 project - Activity 8.1 - VRE Critical Zone Services and this purchase will help to deepen knowledge on carbon emissions from aqueous systems and thus fill knowledge gaps on carbon budgets.

High-precision lysimeters, multi-parameter probes and instrument for flow-rate measurements

As part of the National Recovery and Resilience Plan (PNRR) (mission 4 component 2 - investment 3.1 - ITINERIS project), the Institute of Geosciences and Georesources – CNR (Pisa), on 20/10/2023 (Prot. n. 0312787) the decision to stipulate a contract (DAC) was signed. Different providers were selected to acquire the following instrumentations:

- meteorological instrument (Lotto 1 A01D903845): n. 2 high-precision lysimeters with associated n. 2 weather stations,
- n. 4 multi-parameter probes (CTD) for hydro-physical-chemical parameters (Lotto 2 A01D9F71A2).
- instrument for flow-rate measurement (Lotto 3 A01DA9218B).

The high-precision lysimeter is an instrument that allows the quantification of water that return to the atmosphere through evapotranspiration at the air-soil interface experimentally and with extreme accuracy, as well as the water that percolates underground. Specifically, being equipped at different depths (30, 50 and 80 cm) with sensors for measuring temperature, tensiometers and water content probes, it allows the humid front to be followed in terms of physical characteristics and timing up to the terminal part of the monolith, as well as allowing the quantification of infiltration water and its sampling using a tilting system. The two lysimetric stations purchased are composed of a soil monolith of 50 cm in diameter and heights of 60 and 90 cm, respectively, associated with a stainless steel control station where in addition to the remote control and data transmission system there is a container for the storage of infiltration water and the weather station for measuring weather and climate parameters. Two piezometers are moreover set near each lysimeters for monitoring the water level in the saturated zone of the shallow and unconfined aquifer, thus verifying the timing of groundwater response to effective infiltration evolution.

Server system (hardware) for the CZ VRE

As part of the National Recovery and Resilience Plan (PNRR) (mission 4 component 2 - investment 3.1 - ITINERIS project - IR0000032 - CUP B53C22002150006 – CIG A02A124F12 – CUI F80054330586202300336), the Institute of Geosciences and Georesources – CNR (Pisa) carried out procedure to acquire a 4GPU server from R1 S.p.A. (contract signed on 29/12/2023, Prot. n. 0419800). In particular, the direct purchase (TD) was signed on 17/11/2023 (Prot. n. 353600).

A server DELL Poweredge XE8545 was acquired. The DELL Poweredge XE8545 is a server which supercharges computation performance thanks to a 2-socket, 4U system designed to optimize the latest industry technologies.
The server (4GPU), its components and the configuration specifications were selected in order to meet the specific needs of the infrastructure used to create the Virtual Research Environment (CZ VRE).

In particular, the server was acquired by the CNR-IGG to create an extension of the current D4Science computational infrastructure and, therefore it was selected considering that strict technological compatibility was required. The supply also included shipping and installation of the equipment, as well as free remote assistance.

Considering the needs and requirements of the CZ VRE implementation, the acquisition of additional servers was considered necessary.

Technical data regarding the configuration system of the DELL Poweredge XE8545 server are provided in Fig. 1.

Modulo	Descrizione	SKU	Tipo di imposta	Q.tà
Componenti				
PowerEdge XE8545	PowerEdge XE8545	210-AXZM	SR	1
FRONT STORAGE	2.5 Chassis	379-BDTF		1
Trusted Platform Module	Trusted Platform Module 2.0 V3	461-AAIG		1
Chassis Configuration	XE8545 4U Chassis with 4 GPU 10 x 2.5 SAS/SATA	321-BGDL	SR	1
Processor	AMD EPYC 7513 2.6GHz, 32C/64T, 128M Cache (200W) DDR4-3200	338-BZYW	SR	1
Additional Processor	AMD EPYC 7513 2.6GHz, 32C/64T, 128M Cache (200W) DDR4-3200	338-BZYS	SR	1
PCIe Riser	Assembly BOSS Blank	329-BERC		1
PCIe Riser	Riser Config 1, 2 x16 + 2 x8 (with BOSS)	330-BBSH	SR	1
Processor Thermal Configuration	High Performance Heatsink	412-AAUU	SR	1
Memory Configuration Type	Performance Optimized	370-AAIP		1
Memory DIMM Type and Speed	3200MT/s RDIMMs	370-AEVR		1
Memory Capacity	64GB RDIMM, 3200MT/s, Dual Rank, 16Gb	370-AEVP	SR	16
RAID Configuration	Unconfigured RAID	780-BCDS		1
RAID/Internal Storage Controllers	PERC H755 Adapter Full Height	405-AAZD	SR	1
RAID/Internal Storage Controllers	Adapter Cable, PERC, XE8545	470-AFFT	SR	1
Hard Drives	1.92TB SSD vSAS Mixed Use 12Gb ps 512e 2.5in Hot-Plug ,AG Drive SED, 3DWPD	345-BCSK	SR	8
BIOS and Advanced System Configuration Settings	Power Saving BIOS Settings	384-BBBH		1
Fans	Very High Performance Fan x6	750-ADGJ	SR	1
Power Supply	Quad, Hot-Plug Power Supply, Redundant (2+2), 2800W D Titanium	450-AMLS	SR	1

Figure 1. Technical details of the 4GPU Server acquired.

The administrative details of the new purchases listed above are summarized in Table 1. All the new facilities will help to reach the objectives of the ITINERIS Project – WP8 Task 8.1, producing quality data and the VRE capable of containing, cataloguing and processing it.

Par.	Description	CIG	E.O.
2.1	Instrument for determining total C in water and solid matrices	B06879F8C6	M3 S.r.l.
2.2	Integrated system for the preparation of solid organic-inorganic materials	B069FC6726	Verder Scientific S.r.l.
2.3	Cosmic ray neutron sensing (CRNS) detector system	9884548B0B	
2.3	Cosmic ray neutron sensing (CRNS) detector system	A0259A70A0	
2.4	Field Emission Scanning Electron Microscope (FE-SEM)	97695442C0	CARL ZEISS S.P.A
2.5	Eddy-Covariance Tower	A00F303AF4	
2.5	Eddy-Covariance Tower	A03BFE8495	West Systems S.r.l.
2.6	Floating chamber and flux-meter		
Par.	Description	**CIG**	**E.O.**
2.7	High-precision lysimeters, multi-parameter probes and instrument for flow-rate measurements	Lotto 1 A01D903845	
		Lotto 2 A01D9F71A2	
		Lotto 3 A01DA9218B	Codevinte c italiana s.r.l.
	Server system (hardware) for the CZ VRE	92241812F7	Italware S.r.l.
2.8	Server system (hardware) for the CZ VRE	9884461342	
2.8	Server system (hardware) for the CZ VRE	A02A124F12	Ditta R1 S.p.A.

Table 1. Details of the facilities acquired in the framework of the National Recovery and Resilience Plan (PNRR) (mission 4 component 2 - investment 3.1 - ITINERIS project, WP8 Activity 8.1).

3. FILLING THE KNOWLEDGE GAPS

The development of an integrated system of laboratory facilities connected to a Virtual Research Environment is one of the main goals of the CZ VRE. This integrated system is composed of existing instrumentation and the newly acquired instruments listed above and devoted to geochemistry and isotope geochemistry, the measurement of soil, water and rock samples and properties, water and carbon dynamics, and mineralogy.

In particular, here we summarize the connection between the new facilities acquired and the main information gaps that were recognized and reported in D8.1.

The link between water dynamics and biotic/weathering/chemical processes in the CZ is crucial, but these dynamics are still not fully understood. The new instruments will be used to acquire new field data that can help researchers understand these important elements of the CZ.

The acquired facilities and the new knowledge they will generate, will be used to study the CZ in an integrated way, considering also other land surface and geomorphological processes which play fundamental roles, in particular, in high-latitude and mountain areas, e.g., in the Alpine areas which represent key sites for the analysis of climate and environmental changes, and in wetland environments. The integrated study of the various aspects cannot preclude the analysis of standard parameters and descriptors (e.g., temperature, precipitation, carbon fluxes), as well as more ecosystem-specific parameters (e.g., snow cover, meltwater, or salinity of transitional waters). The new instrument will also help to perform standardized and easy-to-perform measurements that will be used to populate and implement the CZ Virtual Research Environment. These facilities will produce data and knowledge that could also become part of other VREs (e.g., the ISOTOPE VRE and the CARBON VRE) under development in the framework of the ITINERIS Project.