



D6.1 - Coordination center fully operative and HPC dedicated to data processing and demonstration tower operational at the ICOS ETC



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1. STATUS AND NEEDS

The ITINERIS project offers the possibility to increase the robustness level of the ICOS centralized services to the Italian ICOS network and to extend the services (mainly data processing but also training, protocols definition and improvement and data FAIRness and availability) to other Research Infrastructures using the same ICOS core methodologies (eddy covariance and meteorology), in particular ELTER, ANAEE and DANUBIUS. In addition, the same services can be extended to other individual sites in Italy, that would enhance the Italian data availability on carbon and other GHGs fluxes and exchanges between ecosystems and atmosphere.

1.1 The ICOS ETC

The ICOS Ecosystem Thematic Centre (ICOS ETC) is one of the four Thematic Centres of the Integrated Carbon Observation System European Research Infrastructure, together with the Atmospheric Thematic Centre (ICOS ATC, hosted in France and Finland), the Ocean Thematic Centre (ICOS OTC, hosted in Norway and United Kingdom) and the Central Analytical Laboratory (ICOS CAL, hosted in Germany). The ICOS ETC is hosted in Italy, Belgium and France. It is coordinated and operated by the Euro-Mediterranean Centre on Climate Change (CMCC) in collaboration with the University of Tuscia (UNITUS) in Viterbo, Italy, the University of Antwerp (Research Centre of Excellence on Plant and Ecosystems: PLECO) in Belgium and the French National Research Institute for Agriculture, Food and Environment (INRAE) in France.

The Italian participation to ICOS, defined, coordinated and regulated by the ICOS Italy Joint Research Unit (JRU), includes also the contribution and participation to the ICOS ETC. The ITINERIS Operative Unit CNR IRET is the coordinator of the ICOS Italy JRU and for this reason also participating indirectly to the ICOS ETC.

The ICOS ETC coordinates the ICOS Ecosystem network by continuous support for the station teams and training activities. It performs the centralized data processing and quality control, and it provides technical assistance to the stations. The ICOS ETC develops and tests new measurement data processing methods, measurement techniques and instruments with the aim to evaluate their use in the ICOS network in collaboration with the assembly of the monitoring stations (MSA) and the scientific community. The ICOS ETC is responsible for the processing of data on net ecosystem fluxes and their components, carbon pools and other auxiliary data as well as for instrument development in cooperation with the wider community. Diverse processing hierarchies are used for the production of the various datasets, resulting in various data levels, some of them released in Near Real Time and used also for a continuous control of the data quality. Ancillary information about the sites (for example vegetation and soil characteristics; disturbances; management) are processed, often starting from raw measurements, to ensure a high standardization across the network. All the data and metadata are delivered to the ICOS Carbon Portal (hosted in Sweden) for further distribution to the data users.

All the ICOS ETC services are dedicated to the Class1 and Class2 ICOS stations. However the competences of the ICOS ETC on the data processing and quality check of GHGs fluxes measured with the eddy covariance technique and meteorological data, the capacity for training and support in the site setup and maintenance and the possibilities in the data sharing and visibility would be particularly important also for the ICOS Associated stations (stations affiliated to ICOS but not following all the protocols required in the RI), the sites part of other RIs and more in general the Italian scientific communities operating similar measurement stations.

1.2 Coordination center.

There is a clear need to coordinate the ICOS extended activities foreseen in ITINERIS, with services offered to other RIs and to the national communities, and the final aim to propose the Italian scheme

of coordination also at European level. The coordination center should be constructed and designed to be a reference point for all the information and guidelines for the participation in ICOS Italy and the use of the ICOS data processing facilities, the ICOS sensors (also through the organization of a specific hub), the definition of procedures, formats and data submission system and the coordination and organization of specific training events based on the ICOS and other RIs needs.

1.3 High Performance Computing needs.

The extension of the ICOS services to the Associated ICOS stations, to other RIs and to additional eddy covariance stations in Italy, requires an enlargement of the processing capacities. This will be needed to implement the full fluxes' calculation pipeline, starting from the raw data and metadata and producing ICOS compliant and FAIR products. This will ensure the needed robustness and capabilities needed to reach the expected goals without risks to affect the commitments already agreed toward the ICOS Research Infrastructure where the ICOS ETC is responsible for the processing of all the European ICOS stations. The investment in the High Performance Computing (HPC) capacities must be done in coordination with the ICOS ETC in order to ensure the possibility to use, without large investments, the processing pipelines already developed and running in ICOS.

1.4 Demonstration tower.

A demonstration tower, where multiple sensors can be installed in parallel and managed in an easy and financially sustainable way, is foreseen in the ITINERIS project, with the aim to cover a number of services and activities: (i) ensure the correct application and implementation of the ICOS protocols, in the ICOS stations but also in other sites interested to follow the ICOS standards, (ii) organize training events also in collaboration with the WP3, dedicated to PhD students and to RIs participants and focused on the installation of eddy covariance and micrometeorological systems and sensors, (iii) perform long term comparison of sensors used in ICOS in order to evaluate their performances and differences under different meteorological conditions and at the same time increase the level of knowledge of ICOS sensors by the personnel dedicated to support the network, (iv) to test new sensors or methodologies proposed and compare them with the current standards used in ICOS and (v) to offer a possibility to the companies and SME producing new sensors to test their prototypes in parallel with established sensors/methodologies. The tower should ensure enough capacity to install sensors, easy reachability for the training and the needed power and data connection. A direct link to the ICOS ETC is also needed in order to support the service offered at European level.

2. ACTIVITIES AND RESULTS

In the months between the preparation of the project proposal and the implementation of the activities a number of new developments and clarifications occurred that led to the definition of a new and optimized strategy, based on the best possible use of the resources. The objectives of the Deliverable and activities remained unchanged like also the primary goal of the actions, however they have been reached following a different strategy that allowed also to cover new, unexpected needs.

2.1 Establishment and organization of the Coordination center

A coordination center has been established at the Operative Unit CNR IRET in Montelibretti (Roma). The coordination center, led by a personnel unit hired specifically in the project, focused the activities of the first year on a set of specific tasks that have been considered of higher priority.

- Instruments hub organization. The ITINERIS project has, for the ecosystem component of ICOS, the primary goal of making the network more robust and performing, through the

provision of backup sensors and integration of new instruments and products in the measurement collections as site level. To reach this goal, a large number of sensors, instruments and loggers have been bought or ordered. For the best possible management of these sensors, a deposit and centralized hub has been organized in two dedicated rooms available of the OU. All the sensors are recorded in a digital inventory, with a unique permanent identifier assigned to each sensor that will be used for the sensor tracking of use and maintenance/calibration/repairment operations. The digital inventory will become open to all the ICOS members as soon as the correct legal framework for the instruments loan will be defined.

Update of activities: the number of sensors purchased and made available to the network increased and are now also installed in field at different stations, mainly in Castelporziano where a special activity has been initiated but also in three ICOS stations that required a temporary replacement (radiometer at the IT-Ren ICOS station) and a collaboration in the measurements of high interest for the project (a SmartFlux logger at the IT-Tor needed to ensure correct data acquisition and a sonic anemometer and a gas analyser for the IT-OXm site to ensure compatibility with the ICOS standards). The OU started the procedure to improve the level of organization, service and quality of the storage and management of the hub sensors, selecting another location in the property and starting the process for its reorganization and preparation to host the new hub.

- Instruments loan legal framework preparation. Loan of instruments to ICOS stations requires the definition of a legal agreement that regulates the procedure, timing, responsibilities and financial implications. At the same time, the need of reducing as much as possible gaps in the data due to sensors malfunctioning requires an agreement agile enough to be prepared and signed rapidly. The scheme of the agreement, developed during the project, is under final evaluation and will be proposed to the ICOS network for the final approval.

Update of activities: the formal documentation for instrument loan in case of short term replacement needed to ensure data continuity and minimum gaps length has been finalized and already used. A similar but specific formal agreement has been also prepared and already used in the case of collaborations where the OU is interested to collect data in a specific ecosystem for the ITINERIS aims and the infrastructure is managed by a different group. Both documents have been validated by the administrative and legal point of view.

- Definition of inter-RIs relations. One of the major improvements expected thanks to the ITINERIS activities linked to ICOS, is the organization of the data handling (from storage to FAIRness, processing and distribution) of similar measurements performed by other RIs. The Coordination center developed a first scheme of the processing agreement, where the basis is the acceptance of a common open data sharing policy (CC-BY), already implemented in ICOS. The discussion with the other RIs will need a number of iteration but the agreement will be finalized before the end of the project and the first data processed to test the feasibility and estimate the resources needed.

Update of activities: the inter-RI relations have been developed for the measurements point of view in this phase, with the expert teams from ICOS supporting other RIs in the installation of eddy covariance stations. In addition a specific activity has been organized in Castelporziano where ICOS and eLTER are both involved.

- Coordination with ICOS ETC. The data processing for Associated ICOS stations and other RIs, the training on the ICOS protocols and the test of new sensors and methodologies, can not be done without a coordination with the ICOS ETC. An alignment on the general strategy for collaboration and options for the resources needed has been drafted and will be finalized after a more precise evaluation of the workload, possible only when the new datasets will be processed. The general strategy has been defined and there is perfect alignment between the ICOS Coordination center developed in ITINERIS and the ICOS ETC, as demonstrated also in the activities reported below.

2.2 Alternative solution for the HPC needs

In the original text of the project proposal it was foreseen to invest in data storage and computing power in the existing HPC hub connected to the ICOS ETC at the University of Tuscia, without creating a new center that would in any case require a large investment in terms of structure and personnel.

In the last year however the ICOS ETC invested in the HPC system currently used, both in terms of data storage and processing capacities (CPUs). In addition, an ICOS processing and storage facility has been completed in Naples by the local unit of CNR IRET. These two new resources are sufficient for the needs of the ICOS activities in the context of ITINERIS, also considering that the processing pipelines and tools will be organized and programmed in a way that will allow their deployment also in other computing environments if needed, e.g. connected to EOSC or to the National Supercomputing Center (ICSC).

For this reason, it has been decided to not invest any more in the implementation of new HPC capacities but rather work to find the best possible synergies with the existing computing facilities that have been improved and increased in the storage and processing capacities in the last 12 months. Agreements have been already found for the ICOS ETC HPC system while for the Naples system a discussion is ongoing to evaluate a specific setup that would facilitate the use of the ICOS ETC processing pipeline.

Update of activities: the cluster at University of Tuscia is currently covering all the calculation needs of the OU for the activities related to WP6. The implementation of the storage hub at the Naples facility under the same OU responsibility is ongoing.

2.3 Optimization of test and demonstration facilities

The original plan of building a demonstration tower and new sensors and methods test facility at the ICOS ETC (University of Tuscia) encountered practical and formal limitations and for this reason alternatives able to achieve all the expected project results have been evaluated. The selected option has been to differentiate the locations of the test and demonstration facilities, based on criteria such the availability of existing structures and competences and the specific correspondence to the needs. Respect to the original idea of using the same location for training/demonstration and test/comparison, it has been decided to separate the two aspects.

The hub for the instruments and sensors used in ICOS is established at the OU of CNR IRET in Montelibretti and this would facilitate the training activities organized directly there. At the OU it is available a tower for micrometeorological sensors but it is not ideal for the training activities (too high and able to host maximum two people on top). However, the training can be done also using short portable and temporary towers (3 meters height). This will give the opportunity to work in parallel in small groups and to optimize the logistic, function of the specific training needs (type of sensors and setup). At the CNR IRET in Montelibretti there is a conference room for classes and seminars on the theory of eddy covariance and meteorological sensors while it is not available a classroom equipped with computers for the training on data processing. The solution identified for this part of the training is a collaboration with the ICOS ETC that have all the capacities and competences to organize the part of the course on data handling. In addition the ICOS ETC has access to the classrooms equipped with computers available at the University of Tuscia that are suitable for the training on data processing.

Long term test and comparison of the sensors used in ICOS and test of new sensors and methods require a specific installation structure and environment. Although the possibility to use the same infrastructure for all the measurements and sensors (as suggested in the original proposal) would help to simplify organization and management of the activities and increase the visibility of the facility, the selected location could be not optimal for all the quantities monitored. For this reasons it has been

decided to install the sensors for long term comparison in the best specific location, trying to find the optimal compromise between quality of the measurements (linked to the environmental conditions), possibility and capacity to perform the needed management and calibration procedures and accessibility to add new sensors.

For example, the rain gauges equipped with the wind deflectors (three different models, used in the ICOS network) will be installed in a unique facility available at the didactic farm of the University of Tuscia, where a 100 m² pluviometer has been realized and is maintained by the personnel of the University. The rain gauges, owned by the CNR IRET RM, will be installed by the ITINERIS personnel that will be also responsible for the sensors management and data processing, in collaboration with the ICOS ETC personnel. The comparison of the precipitation measurements with a reference value coming from the large pluviometer will give important information about data quality and their uncertainty under different wind conditions.

The specific solution for all the sensors will be defined during the project, when all the sensors will become available. Starting from the optimal conditions for the type of measurement to perform, the sensors will be grouped whenever possible to facilitate the management and continuous data submission.

Update of activities: a potential area for the large scale validation and comparison of eddy covariance and meteorological sensors has been identified in the Castelporziano area. The option is under evaluation because there are positive aspects like the stability of the area from a land use perspective, the support and safety due to the position in the Presidential reserve, but also potentially limiting factors like, for example, a complex procedure to get the authorization to enter the facility that could be particularly problematic from some companies or nationalities.

2.4 New needs and strategy

During the first year of the project new needs have been identified that require additional resources. Among them, the definition and publication of protocols for new variables by the ICOS Ecosystem community and ICOS ETC in 2023 requires the acquisition of new sensors. In particular eddy covariance of CH₄ and N₂O and automatic dendrometers are now a standard measurement in ICOS and they were not directly considered in the original version of the project. In addition, there are activities ongoing in the community to evaluate the addition of new measurements in the ICOS network, where the setup of sensors in the Italian ICOS sites could be an example also at European level. Among them there are the Soil Water Potential and the Cosmic ray for the soil water content. Finally, the new training strategy, with a set of single and short poles and arms for the installation of the sensors, that can be used also in specific measurements campaigns, requires a change in the budget allocation to buy all the needed structures for the training setups.

The new strategy for the data processing HUB led to a saving of budget that for this reason will be used to cover the costs of these new needs, increasing both the robustness and the visibility of the ICOS Ecosystem network.

Update of activities: the opportunity to monitor a large scale landuse change in Castelporziano as inter-RI collaboration (ICOS, eLTER, LifeWatch and the NBFC) led to a number of needs in terms of sensors and mobile structures that are under acquisition thanks to the saving in part of the budget.