ENVRI^{plus} DELIVERABLE

D11.4

Report on interdisciplinary integration capacity, end user needs, TNA implementation requirement and added value for the scientific community.

WORK PACKAGE 11 – New concepts and tools for physical access

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ABSTRACT

This deliverable document aims at describing the potential of ENVRIplus for bringing together different environmental research infrastructures (RI) communities for investigating the interdisciplinary integration capacity of Environmental RIs by exploring synergies and use of joint observation sites. Within ENVRIplus, a pilot programme for transnational, interdisciplinary access has been implemented involving multidisciplinary observational facilities. This document describes this new concept of physical access, presents its implementation and results, the required tools, methods and access procedures, explores the needs of users for interdisciplinary research opportunities, and demonstrates the benefits and its relevance for the scientific community via an integrated approach on a European scale.

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PROJECT SUMMARY

ENVRIplus is a Horizon 2020 project bringing together Environmental and Earth System Research Infrastructures, projects and networks together with technical specialist partners to create a more coherent, interdisciplinary and interoperable cluster of Environmental Research Infrastructures across Europe. It is driven by three overarching goals: 1) promoting cross-fertilization between infrastructures, 2) implementing innovative concepts and devices across RIs, and 3) facilitating research and innovation in the field of environment for an increasing number of users outside the RIs.

ENVRIplus aligns its activities to a core strategic plan where sharing multidisciplinary expertise will be most effective. The project aims to improve Earth observation monitoring systems and strategies, including actions to improve harmonization and innovation, and generate common solutions to many shared information technology and data related challenges. It also seeks to harmonize policies for access and provide strategies for knowledge transfer amongst RIs. ENVRIplus develops guidelines to enhance transdisciplinary use of data and data-products supported by applied use-cases involving RIs from different domains. The project coordinates actions to improve communication and cooperation, addressing Environmental RIs at all levels, from management to end-users, implementing RI-staff exchange programs, generating material for RI personnel, and proposing common strategic developments and actions for enhancing services to users and evaluating the socio-economic impacts.

ENVRIplus is expected to facilitate structuration and improve quality of services offered both within single RIs and at the pan-RI level. It promotes efficient and multidisciplinary research offering new opportunities to users, new tools to RI managers and new communication strategies for environmental RI communities. The resulting solutions, services and other project outcomes are made available to all environmental RI initiatives, thus contributing to the development of a coherent European RI ecosystem.

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1. INTRODUCTION

The understanding of environmental phenomena is beyond the knowledge of any single environmental science discipline. The grand challenges our society faces – energy, water, climate, food, and health – can only be solved by crossing the boundaries of environmental domains through an interdisciplinary approach, by using and integrating knowledge from different areas of expertise. Knowledge about the scientific processes, environmental changes, and mitigation of natural crises rely on efficient and effective communication and interaction of key scientific actors in different domains. Within ENVRIplus, a transnational pilot access programme has been implemented to explore the opportunities for physical access among the participating RIs to enable research at the interface of different environmental domains.

This deliverable reports on the integration capacity of the multidisciplinary observations sites to which physical access has been provided. Although interdisciplinary research has been the overall aim of this new type of physical access, the task is complex and remains a challenging goal. Therefore, our approach is mainly building on promoting multidisciplinarity as a first step. **Multidisciplinary research** brings people from different disciplines together, whereby each group draws on their disciplinary knowledge. **Crossdisciplinary research** tries to explain the aspects of one discipline from the perspective of another. **Interdisciplinarity research**, however, integrates the knowledge and methods from different disciplines, using a real synthesis of approaches. The various types of terminology used are not interchangeable and should be correctly applied, as also illustrated below in Figure 1.

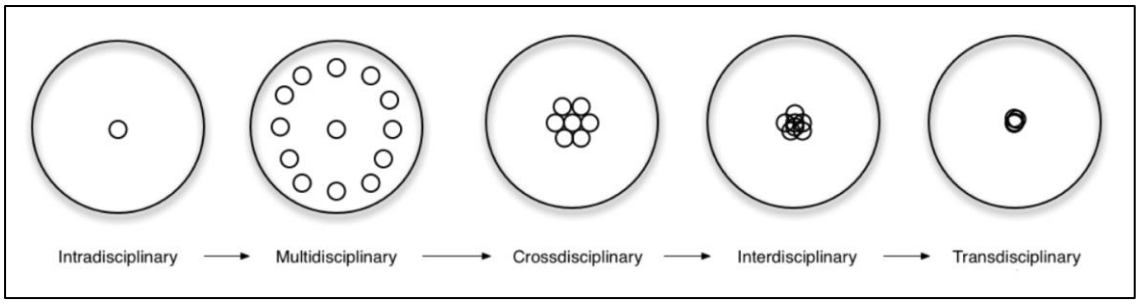

Figure 1: Illustration of types of disciplinarity (according to Jensenius, 2012[1])

The document intends to provide a report on the concept and tools of the physical access provision to multidisciplinary observation platforms within the ENVRIplus project, and to recommend best practices on the methods and procedures.

The first section focuses on describing the pilot access programme, the selected multidisciplinary platforms, the successful implementation of the access process and

[1] Jensenius, A. R. (2012, March Monday). Disciplinarities. From ARJ: http://www.arj.no/2012/03/12/disciplinarities-2/

interaction with its key actors, and results. The second section describes the end user needs based on the ENVRIplus experience, including an analysis of the feedback collected from the users based on the post access questionnaire. The third section describes the added value of the pilot access programme for promoting research at the interface of different disciplines and its relevance for the scientific RI communities, and gives recommendations for future interdisciplinary access provision.

2. ENVRIPLUS MULTIDISCIPLINARY PILOT ACCESS PROGRAMME

The access pilot programme aimed at promoting physical access and use of multi-instrumented observation platforms for multidisciplinary research. This involved a selection of dedicated multidisciplinary observation sites and the definition of a coordinated access process among the different actors concerned, including central management, users, access providers, as well as a review panel representing various environmental domains for evaluating the requests for multidisciplinary access. The different aspects are addressed in the following sub sections.

2.1: Choice of multidisciplinary sites

ENVRIplus tested physical access at different multidisciplinary platforms. Each platform required to cover at least two or more environmental domains (atmosphere, bio-ecosphere, marine, and solid earth domain), and involve at least one or several RI in order to enable multidisciplinary research through access to state-of-the-art instrumentation and expertise. The location of the selected multidisciplinary observation platforms is indicated in Figure 2, comprising:

- The HYYTIÄLÄ boreal forest site SMEAR II in Finland, involved in the RIs ICOS, ACTRIS, and ANAEE (bio-ecosphere, atmosphere);
- The multidisciplinary platform OSUR -R located in La Réunion, the southwestern Indian Ocean, France, comprises 5 geophysical stations: i) the Maïdo atmospheric observatory (involved in ACTRIS), a volcanic observatory, a marine station for observations of the reef zone, the coast line, and coastal aquifers, a forest station, and a hydrological station (atmosphere, solid earth, bio-ecosphere, marine);
- The Mt. ETNA INGV observatory in Italy, involved in EPOS (atmosphere, solid earth);
- The SOERE-ACBB platform in Lusignan, France, for combined bio-ecological and atmospheric field research, involved in ANAEE (bio-ecosphere, atmosphere);
- The Unmanned System Research Laboratory (USRL) in Cyprus, with a large fleet of research unmanned aerial vehicle, coupling atmospheric, marine, and bio-ecosphere domain (and involved in ACTRIS) (atmosphere, bio-ecosphere, marine);
- The drone-based research platform P2OA in Lannemezan, French Pyrenees, involved in ACTRIS and ICOS (atmosphere, bio-ecosphere, marine).

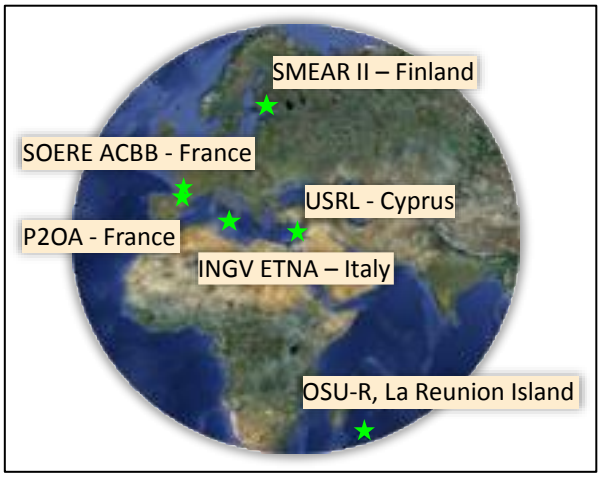

Figure 2: Geographical location of the ENVRIPLUS multidisciplinary platforms providing physical access.

The two airborne platforms (USRL in Cyprus and P2OA-Drones in France) were added during the course of the project based on user demand and corresponding research needs. The test cases were either singled sited, offering multidisciplinary collaboration in a single location (SMEAR II, SOERE-ACBB, USRL, P2OA), or multi-sited with several facilities located within a confined area (ETNA INGV, OSUR). All facilities offer access to the state-of-the-art on-site instrumentation, space for additional equipment, and in particular the expertise of the scientific and technical staff to support the access, as required. The six facilities are illustrated in Figure 3.

Figure 3: Overview of multidisciplinary sites within ENVRIplus providing physical access.

2.2: Implementation of a coordinated process

The development of a coordinated process for ENVRIplus is a prerequisite for efficient and effective access. This is due to the fact that different RIs have adopted different access modalities and that facilities are distributed, and it help for steer the access process given the multidisciplinary nature. Key to the coordinated process is a centralized access management with single point of entry, based on the EU transnational access (TNA) scheme, and involving various essential steps. The steps include:

i) the appointment of access providers for each of the selected observations sites, able to coordinate the on-site activities and support to respond to the need of the multidisciplinary demands involving various facilities and teams of staff;
ii) the designing and preparation of the call for access and schedule, access advertisement, required documentation, conditions and criteria for physical access;
iii) the overall access procedure and modalities (application, selection and evaluation);
iv) the establishment of an evaluation panel;
v) the interaction with the access providers and the access provision and support and; and
vi) the post access process.

The management from a centralized point is essential, allowing for efficient contact between users, the access providers at the supporting facilities before and during their access to the sites, and the panel members. Figure 4 below shows the overall process as agreed, from proposal submission, selection, acceptance, and finally to the end of the process with results dissemination. The details are described in the following sections.

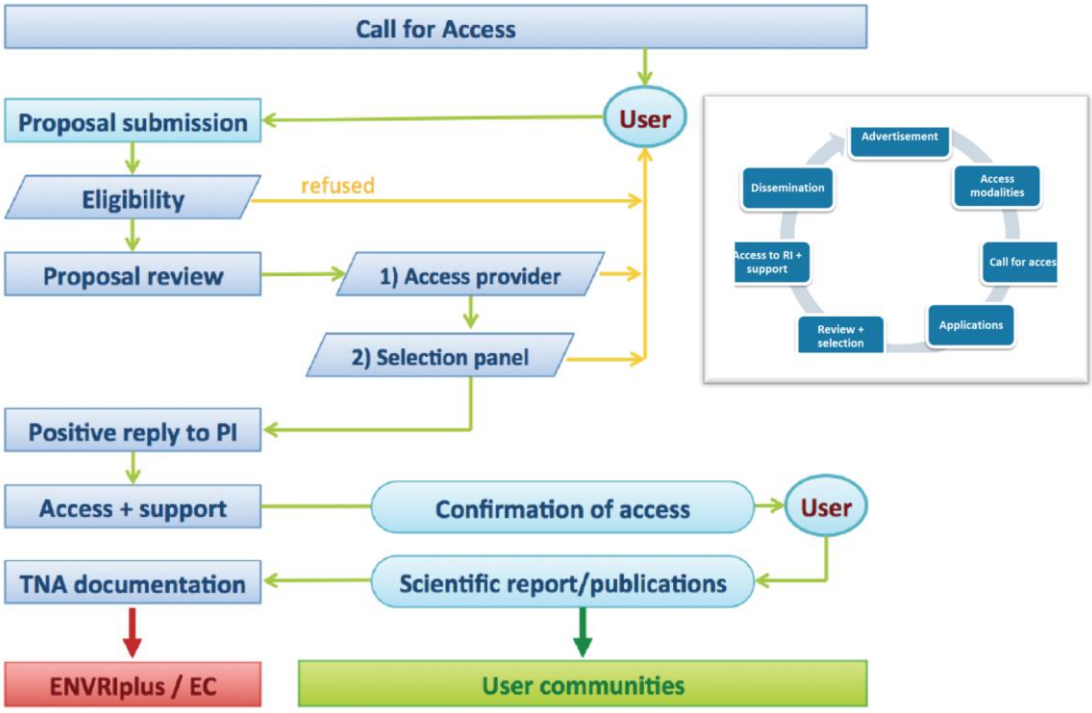

Figure 4: Access process

2.2.1. Central access management

A central access management allows for overall coordination and monitoring of the access process, adequate promotion of the multidisciplinary opportunities for access, single calls to be made, informational support to the users, communication with all key actors involved in the process, reception of the proposals, coordinating the evaluation process, communication of the selection results to the users, collection of the reporting documentation and user feedback, and dissemination of the results. The access management office provided administrative as well as financial support to facilitate the access of the users and their reimbursement of travel and subsistence expenses.

2.2.2. Call publicity

During the course of the ENVRIplus project, three calls for multidisciplinary access were made. As multidisciplinary research opportunities are novel, relevant advertisement has been crucial. The three calls for access were generally open for two months and were widely advertised via multiple channels: ENVRIplus website, social media and mailing lists, platform websites and communication, mailing lists of other RIs, networks, and projects. The calls for access also included a detailed presentation of the multidisciplinary platforms as well as details of the access opportunities and modalities. Funding for supporting the access of the user groups has been offered with up 5'000 EUR per project. This amount has been increased after the first call to 10'000 EUR in order to foster multidisciplinary and high-quality projects. Table 1 below summarizes the timeline of the calls with amount of travel and subsistence offered.

Table 1: Timing and support for travel and subsistence (T&S) of ENVRIplus calls for access

Calls[2]	Launch date	End date	Access period	Total T&S offered
Call 1	18 January 2016	18 March 2016	June 1, 2016 – August, 31 2017	up to 5000 EUR per user group
Call 2	22 December 2016	February 24 2017	May 1, 2017 – July 31, 2018	up to 10000 EUR per user group
Call 3	15 January 2018	9 March 2018	1 May – 31 December 2018	up to 10000 EUR per user group

2.2.3. Application procedure

A succinct application form was developed together with the access providers to allow evaluating the project excellence, infrastructure needs, estimated costs, and project results. Particular emphasis was given to the multidisciplinary aspects that were required to be met in the project planning, its methodology and work plan, choice of participants, and overall objectives. Applicants were also required to agree on making available the results from the access (including data and publications).

2.2.4. Review and selection process

A two-stage evaluation procedure was agreed upon in order to select the projects to be supported, and guarantee efficient use and outcome of the access. The first stage involved a first review by the access provider with potential interactions with the users, to confirm technical feasibility, on-site capacity and requirements, logistics and timing. The second stage was an independent, peer-review evaluation of the proposals by a multi-domain review panel based on defined selection criteria, and final selection of the proposals.

The set-up of the review panel was made in the beginning of ENVRIplus, and consisted of 12 international scientists from within and outside the project with strong expertise in either atmospheric, marine, bio-ecological or geological fields. The panel members are listed in table 2. The evaluation was made following assignment of primary and secondary reviewers, and face-to-face review meeting for discussion and selection of the proposal to be supported.

[2] Call information: Call 1 (http://www.envriplus.eu/1st-envriplus-call-for-transnational-access-is-closed/), Call 2 (http://www.envriplus.eu/calls/2nd-envriplus-call-for-transnational-access-is-open/), Call 3 (http://envri.eu/2018/03/04/3rdenvriplustnacallopen/ and also widely advertised via)

Table 2: Review panel

Review panel member	ENV domain	Affiliation
Karine Sellegri	ATMO	CNRS, France
Kostas Tsigaridis	ATMO/ MULTI-DOM	Columbia University, USA
Ulrich Bundke	ATMO	FJZ / IAGOS, Germany
Abad Chabbi	ECO-BIO	INRA, France
Markus Steffens	ECO-BIO	TU Munich, Germany
Michaela Dippold	ECO-BIO	University of Göttingen, Germany
Sylvie Pichereau	MARINE	IFREMER, France
Stefania Sparnocchia	MARINE	CNR-ISMAR, Italy
Jean-Pierre Vilotte	SOLID EARTH	IPGP Paris, Seismology, Italy
Antonello Provenzale	SOLID EARTH	CNR Geoscience + Georesources, Italy
Jon Borre Orbaek	MULTI-DOM	Research Council of Norway
Sabine Philippin	(access coordinator)	CNRS, France

In the first stage evaluation, the access providers were asked to consider the following aspects for each of the projects:

- Scientific motivation, relevance & impact of the proposal.
- Multidisciplinarity, considering the choice of participants, instrumentation, objectives and intended results of the proposal.
- Method & experimental setup, the choice of infrastructure, the efficient use of the facilities, feasibility of the projects, accommodation of the site and on-site support possible in the form of instrumentation and staff.
- Project timeline and capacity at platform, number of participants, role and need of participants to achieve objectives.
- Budget: reasonable planning of costs,
- Strong points and weak points of the proposals.
- General comments and their approval or refusal of the project.

Only projects that passed the first stage were accepted for the 2nd stage of the evaluation. The review panel was requested to evaluate the proposal on the following criteria:

- Multi- /inter-disciplinarity with respect to objectives, methodology, participating groups and role of participants, use of infrastructure as well as impact with a weight score of 5/30.
- The scientific objectives which measured originality, scientific quality, quality of the methodology, interest to scientific community and impact, availability and use of results with a weight score of 15/30.
- Innovation which required collaboration with private sector (approach, potential). This was weighed at a possible maximum score of 3/30.
- The user profile which looked at scientific excellence of the research team, training benefit privileging young researchers or cross-domain training. New users of the

platform as well as female participation was considered and weighed at a maximum possible score of 6/30.

- A bonus point of 1/30.

The initial ranking was based on the following scoring grid: A - excellent (26- 30), B - good (20- 25), C - average (15- 19), D - poor (0- 14), E - rejected or not eligible. All proposals were read, evaluated, and discussed by all panel members. The scoring focused primarily on the assessment of the primary or secondary reviewers, but was made by agreement among all panel members.

The evaluation process has been the results of continuous discussions and improvement with the access providers and particularly with the panel members. This was done at review meetings and ENVRIweek meetings in order to optimize the process and reinforce and help trigger the notion of multidisciplinarity in the very diverse ENVRI community. The central management office communicates the results of the proposal selection to the users, along with any pertinent reviewer's comments to be addressed by the accepted users groups and taken into account for planning and execution of the project.

2.2.5. Support of user access

The access of users to the multidisciplinary platforms is free-of-charge and was supported throughout the process by the central management office. On-site support comprised administrative and logistic support including customs, shipping and transport of instrumentation, specific permissions, instrument and/or storage space, arrangements of travel and accommodation, scientific and technical support for project planning, preparation, set-up and disassembly, instrument handling and operation, training on the use of the facility, scientific expertise, and other necessary information related to on-site needs, data handling and archiving. The facilities available for access were communicated during the call and the needs of the users were indicated in the application form and clarified, if needed, in direct exchange with the access provider. Multidisciplinary projects, often involving large user groups and the availability of diverse instrumentation and staff expertise, need good planning and interactions with the access providers is essential.

2.2.6. Post access

After completion of the user access, the central management office collects the report documents (confirmation of access dates and quantity of access provided, scientific activity report, travel document), as well as the user feedback via a post-access questionnaire. The scientific activity reports address aspects such as scientific objectives, motivation and reasons for choosing the platform, methodology and experimental set-up, and preliminary results (focusing on the multidisciplinary and

added value to ENVRIplus), and are published on the ENVRIplus public wiki[3]. They outline the multidisciplinary aspect and finally what the outcomes of the project were. Furthermore, it was a pre-requisite that users that received support for access provided access to data resulting from the access and published the results. Users are encouraged to acknowledge the support of the facility and staff, as well as ENVRIplus.

Data resulting from the access will eventually be sent to data processing facilities, although the accessibility of the access data depends on the user policy and is not fully clarified. A point was made at the final ENVRIweek to consider archiving of the resulting trans-RI data in the framework of the recently started ENVRIFAIR project.

2.3: Results of multidisciplinary user access

The ENVRIplus pilot programme was very successful in implementing three calls for multidisciplinary access and support to high-quality projects. The selected projects present a clear added value to ENVRIplus, beyond the limits that a single environmental RI could achieve and are a first step towards cutting-edge research at the interface of different environmental domains. The three calls for multidisciplinary access resulted in 25 high quality projects being selected out of a total of 39 proposals received from both multi-domain and multi-national research teams. 23 of the projects were carried out. More than 80 researchers (including senior and early career scientists), engineers and technicians from 19 different countries inside and outside the European Union accessed the platforms. An overview of the projects carried out is given in table 3, and the details of the research projects are summarized in annex 1.

[3] https://wiki.envri.eu/display/EC/Multidisciplinary+Access

Table 3: Overview of 1st, 2nd 3rd call of access

	Proposal acronym	Proposal title	Platform involved	ENV Domain	Access dates
CALL 1					
1	IBAIRN (J. Crowley)	Influence of Biosphere-Atmosphere Interactions on the Reactive Nitrogen Budget	SMEAR II	ATMO, BIO	Sep 2016
2	COSMOS (H. Chen)	Constraining gross carbon fluxes using ecosystem flux and atmospheric concentration measurements of carbonyl sulfide (COS) and CO2	SMEAR II	ATMO, BIO	Sep 2016
3	SIMCIO (J. Andrianaivoarisoa)	Seismic and Infrasound Monitoring of Cyclones in the Indian Ocean	OSU-R	ATMO, SOLID EARTH	Jun-Jul 2016
4	VAMOS (M. Ripepe)	Volcano Acoustic Monitoring from near and far-field Observations	OSU-R	ATMO, SOLID EARTH	Aug-Oct 2017
5	EtnaPlumeLab-RADIO (P. Sellito)	Radioactive Aerosols and other source parameters for better atmospheric Dispersion and Impact estimatiOns	ETNA INGV	ATMO, SOLID EARTH	Jul 2016 (+2017)
6	ETNASH (M. Polacci)	Ash fragmentation at Mount Etna and implications of different particle shape on ash dispersal in the atmosphere	ETNA INGV	ATMO, SOLID EARTH	May 2017
7	MeRnETNA (J. Kotnik)	Mercury emissions, its influence and correlation to Rn in Mt. Etna area	ETNA INGV	ATMO, SOLID EARTH	(Cancelled)
8	ETNA-Nuc (B. Foucart)	Aerosol nucleation in the ETNA passive plume	ETNA INGV	ATMO, SOLID EARTH	Jun 2017
9	VolcaDronEtna (P. Labazuy)	In situ observations and sampling of volcanic emissions at Etna with an unmanned aerial vehicles, UAVs	ETNA INGV	ATMO, SOLID EARTH	(Cancelled)
10	ILUC-SH-GHGE (Taken over by N. Bilyera)	Impact of land-use changes on soil health and greenhouse gases emissions	SOERE-ACBB	ATMO, BIO, SOLID EARTH	Jun – Dec 2018
CALL 2					
1	METHANE-FLUX (L. Siebicke)	Ecosystem level methane fluxes: disentangling sources and sinks from transport using true eddy accumulation, eddy covariance, gradient and chamber flux methods	SMEAR II	ATMO, BIO	Jul 2017
2	RELECT (S. Barbosa)	Radioactivity and electric field monitoring campaign at Hyytiälä	SMEAR II	ATMO, SOLID EARTH	Jun-Jul 2017

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3	UP-DASH (M. Burton)	Ultraviolet Polarised light for Detection of volcanic ASH	ETNA-INGV	ATMO, SOLID EARTH	Sep 2017, Jul-Sept 2018
4	EPICC (E. Dekemper)	Etna Plume Imaging and Chemical Composition	ETNA-INGV	ATMO, SOLID EARTH	July 2018
5	MACRORE (I. Samarra)	Productivity, Blue carbon, and nutrient cycling of marine macrophytes in Reunion Island	OSUR	BIO, MARINE	Jun 2018
6	NICO (M. Liuzzo)	Natural Impact of passive and active volcanic CO2 degassing activity on the atmosphere	OSUR	ATMO, SOLID EARTH	Sep 2017
7	TMCFcz-pbl (T. Giambelluca)	Critical Zone in Tropical Montane Cloud Forest of a Volcanic Island: Specific constraints and forcings	OSUR	ATMO, BIO, SOLID EARTH	Jun-Dec 2017
8	IsoTrans (G. Moinet)	Carbon stable isotopes measurement of the transitory carbon pool as an early indicator of land use induced soil carbon sequestration	ACBB	ATMO, BIO	Jun-Jul 2017
		CALL 3			
1	NOME-TROPITREES (K. Machacova)	Nitrous oxide (N2O) and methane (CH4) fluxes from stems of different tropical tree species in Mare Longue Nature Reserve	OSUR	ATMO, BIO	Oct-Nov 2018
2	ENTER (A.L. Rizzo)	Emission in atmosphere of Natural gases and TEmporal variations Related to volcanic activity	OSUR	ATMO, SOLID EARTH	Oct 2018
3	RAVE@Etna (P.J. Gauthier)	Radon Analyses in Volcanic Emissions from Etna volcano: a tool to shed light on magmatic processes and environmental issues	ETNA-INGV	ATMO,BIO SOLID EARTH	May/ Jul/ Oct 2018
4	GEOCUBE+@Etna (P. Briole)	Design of a light multi-parameters station based of the GEOCUBE+ architecture	ETNA-INGV	ATMO, SOLID EARTH	July/ Oct 2018
5	VAMOS-MS (J. Diaz)	Volcanic Airborne Gas Monitoring using the miniGas and miniature Mass Spectrometer UAV based Systems	ETNA-INGV	ATMO, SOLID EARTH	Sep 2018
6	FOXYY (I. Van Der Laan-Luijkx)	Measuring Forest Carbon and Oxygen Exchange in Hyytiälä	SMEAR II	ATMO, BIO	May/ Jul 2018
7	InLandOnABL&RCC (L. Pysarenko)	The Influence of Land cover changes On Atmospheric Boundary Layer and Regional Climate Characteristics	SMEAR II	ATMO, BIO	Aug 2018

2.3.1. Limitations of the pilot access programme

The individual calls for access triggered between 10-15 submitted projects. All calls were very well planned and were accompanied by efficient advertisement through multiple channels, and significant financial support was provided to each user groups. The specific nature of the call, with focus on multidisciplinarity, might have limited responses of the user communities, and was possibly the reason why almost half of the proposals were considered insufficient either for their scientific quality or the missing multidisciplinary nature of the project. A further step towards interdisciplinarity, requiring users from different domains to plan and develop cross-domain challenges to be tackled through physical access, might require a long(er) time period and maturation among and across the research communities. In a number of proposals received, the implication of the resources from multiple domains, including personnel, expertise, and instrumentation, has still been limited. The results, nevertheless, have proven that the access opportunities with some additional financial support have allowed to advance the knowledge, stimulate world-class research, and leverage the realization of novel projects and new collaboration at the interface of environmental domains.

3. USER NEEDS FOR CROSS-CUTTING RESEARCH AND APPROACHES

Interdisciplinary research is considered as essential approach to tackle the environmental problems that our society is facing, as the processes between the biosphere, geosphere, hydrosphere, and atmosphere are closely interlinked. Experience from the pilot programme for multidisciplinary access shows, however, that interdisciplinary research requires more time and effort than single discipline research. In order to encourage interdisciplinary research, dedicated and coordinated research programmes are needed to encourage and support a user-driven approach to bring together several disciplines to study specific scientific research topics. Specific effort is needed to promote the formation of a collaborating user team involving researchers and combining expertise from different domains, and to overcome in principle simple but blocking issues such as communication among the different RIs and scientific communities. Combining different disciplinary methods also requires flexibility in adapting to other methods and having the willingness to accept and learn from other methodologies and approaches.

In collaboration with ENVRIplus WP4, a Science-Across-Observatory-Networks-Workshop was organized to assess the synergies across the environmental RIs and how emerging environmental research questions stand to benefit from such interactions. The ENVRIplus community members have identified scientific themes in the form of four case studies: 1.Nitrogen from the field to the coastal ocean; 2.Phytoplankton blooms from costal to open ocean; 3. Arctic observation, with special focus on CH4; 4. Simulating and monitoring O3 and CO2

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deposition/coupling/interaction. The presented case studies triggered discussions regarding the need for further cross-disciplinary collaboration, interoperability and infrastructure improvements and existing gaps for integrated approach to be successful and confirmed that interdisciplinary collaboration is still not well developed and does not yet easily occur.

3.1. ENVRIplus post-access questionnaire

As part of the pilot access programme, a post-access questionnaire was used to investigate and analyse the user needs for interdisciplinary research and tailor the opportunities, fostering a bottom up instead of a top down approach. It furthermore aimed at improving the future implementation of access to world-class facilities among collaborating environmental research platforms based on the collected feedback.

It was clear that the scientific community is greatly favourable to the interdisciplinary access programme and to the provision of a framework and research capacity for multidisciplinary approaches on a user-oriented basis. Specific user feedback from the questionnaire is highlighted below:

- The research goals would not have been achievable without close collaboration with the colleagues at the Hyytiälä site. We intend to maintain this collaboration with future field intensives at SMEAR II (TNA project "IBAIRN").
- The ENVRIplus TNA provided a unique opportunity for collaborative and multidisciplinary research, particularly for young researchers. It was a great opportunity to lead, for the first time, an interdisciplinary project. TNA is also a great platform for interaction among researchers. During our stay in Reunion Island and work at University of Reunion and OSUR we had an overview on the research carried out at the (different) research facilities. We also had the opportunity to interact with several researchers and had fruitful scientific discussions ("MACRORE").
- The TNA project has been an excellent opportunity to gather a research team that has never worked together before and start an interdisciplinary collaboration ("MACRORE").
- The participation to a TNA project confirmed the impression that interdisciplinary approach is today fundamental for making science in a successful way. In addition, it gives the opportunity to start transnational collaborations that improved the user and other team colleague's expertise ("ENTER").
- The TNA project offered participant researchers a rare opportunity to work collaboratively with other team members from different scientific environments. Moreover, it stimulated those involved to think and organize the research using multidisciplinary approaches and in so doing broaden, the impact and findings of the project ("NICO").

- "The TNA and the ensuing scientific interaction with the Ions group at Helsinki University allowed to broaden the interdisciplinary nature of my research activity ("RELECT").
- The benefits of the TNA for the team extended their international scientific cooperation and opportunity to work on the interdisciplinary project ("ILUC-SH-GHGE").

4. ADDED VALUE OF ENVRIPLUS ACCESS, RELEVANCE TO THE SCIENTIFIC COMMUNITY AND RECOMMENDATIONS FOR IMPLEMENTATION

4.1. Benefits of interdisciplinary research opportunities through physical access

4.1.1 Added value for the scientific community

The ENVRIplus multidisciplinary pilot access programme has been very successful, demonstrating that some of multidisciplinary research projects would have never been carried out without the support of a coordinated framework. The requirements and multidisciplinary criteria have achieved a synergistic approach on two levels for both advancing the integration of research activities across environmental domains at the RI and facilities and for pushing multidisciplinary collaboration among the scientific user communities world-wide. It is obvious that a purely user-driven approach by itself is not sufficient to promote interdisciplinarity, and particularly not within a single research infrastructure. Coordinated programmes, access procedures and funding are required to promote and tackle scientific challenges across RIs and domains.

ENVRIplus TNA has enabled the formation of multi-national research teams to work together. Multidisciplinary research is challenging, as it requires combining diverse expertise and well-chosen skills that are required to for the type of research question. A strategy is required to provide for integration among the scientific communities around a multi- or interdisciplinary research project. Experience from ENVRIplus has shown that initial collaborations have triggered further research.

Similar to conventional integrating activities for access within a single discipline, some financial support, even small, is key to trigger high-quality research and outcomes. In this sense, ENVRIplus has been efficient in promoting the mobility of environmental researchers and staff. Initial communication and interaction between different research communities is important to be supported towards multidisciplinary research goals, and which does not occur easily and for which extra effort is needed.

Additionally to communication issues, multidisciplinary research benefits from coordinated programmes in order to overcome different procedures and methodologies, understanding and respect for other disciplines and approaches. Multi- and interdisciplinarity requires appropriate ways of thinking, coherent

methodologies, and common objectives. Innovation is part of the integration process but requires incentives. Multidisciplinarity and collaboration across RIs is a major first step for heading towards interdisciplinary research.

4.1.2. Added value for the RI and for the society

The processes of our Earth's system are complex, driven by multiple feedback mechanisms and interlinks between its different components such as the atmosphere, the biosphere, the geosphere, and the hydrosphere. Interdisciplinary research is an approach to address the environmental problems we are facing today. Changes in the environment cannot be decoupled form our economic, societal, and political structures. Advances in science, integrating the knowledge and expertise of different RIs, allows for optimized use of the available RIs and facilities in a most efficient and innovative way. This in turn can help to address environmental issues and bring important benefits for the society. New insights from multidisciplinary science are for the benefit of the society as a whole. Optimizing the use and access to RIs for multidisciplinary research by scientists and stimulating innovation will promote competitiveness and set the ground for addressing societal challenges.

4.2. Recommendations for promoting interdisciplinary research through physical access

Based on lessons learnt from the pilot access programme, ENVRIplus recommends best methods for implementing physical access to interdisciplinary research capabilities, towards an integrated interdisciplinary approach which should be clearly encouraged and supported by the RIs's strategy.

4.2.1. Enhancing multidisciplinary RIs for physical access provision

A first step towards multidisciplinarity builds on the existing RIs and benefits from synergies of such joint observation sites. ENVRIplus experience has shown that the pilot access programme was of high benefit for the RIs, in terms of visibility and impact, but also for more efficient use and international collaborations. Physical, multidisciplinary access requires, however, efforts on the level of the observation platforms and RI facilities. Bringing together the research teams from multiple disciplines at locations where several RIs are present as well as encouraging and optimizing multiple platform use is key to integration. Although a culture for interdisciplinary collaboration across RIs must develop over time, the role of the access providers is key for coordinating the local research activities in a multidisciplinary context and to connect and combine the expertise and state-of-the-art in each of the disciplines involved. The readiness may diverge depending on the type of RI site. RI managers within multi-sited platforms covering different disciplines within a confined geographical area may more easily implement multidisciplinary approaches, compared to single discipline sites that are not easily ready to integrate research teams, instrumentation and work methods from other disciplines and require specific efforts and flexibility. Physical access provision requires additional

human and technical resources that must be made available in order to plan, prepare, set-up and carry out multidisciplinary projects, and suitable facility and working space to accommodate large multidisciplinary research teams. Further efforts are needed to favour the exchange of multidisciplinary expertise by different RI staff, to make available the different knowhow and instrumentation, to develop multi-domain on-site support and flexibility towards common initiatives. A corresponding strategy and dialogue are required within and at all RI levels, to enhance synergies across the disciplinary boundaries.

4.2.2. Governance tools, centralized management and access process

Central access management and a coordinated access process based on adequate governance tools are essential to the implementation of physical access to any single RI, and the same principles apply in case of access programmes involving multiple RIs and for multidisciplinary purposes. This requires also consideration and of the different RIs' policy and management plans regarding their compatibility: i) the access policy to govern the principles for access of users to RI services and resources and access management plan to describe the modalities and procedures for the management of the access and its process, and ii) the data policy that sets the principles for the use, sharing, and exploitation of the access to data and products and data management plan to describe the methods and procedures for the management of data and description of the data lifecycle. Access to data and management of data is important as data are one the main outcomes resulting from physical access to the observation platforms.

Central access management will ensure that the strategy of access within a given context (such as multidisciplinary conditions) is adequately implemented. It steers the entire access process from the planning of the access and documentation, to the application procedure, the evaluation and selection process, the support of users for access, to the management of results, dissemination, and monitoring. Centralized management ensures that the required communication and access procedure between the key actors in the process are efficient and effective: for the users to have a unique contact and entry point of information and guidance; for the access providers to exchange on available services and capacity, involvement in the review process, the access provision and on-site support; and for the reviewers participating in the evaluation process. It ensures that the access provision responds to all relevant criteria including ethical issues, handling of sensitive data, intellectual property rights, or any other local or national laws, permissions, or regulations, including health and safety aspects during the user access. Central access management and a coordinated access process are the mandatory ingredient for successful implementation.

4.2.3. Use and availability of results from access

Physical access to RI facilities will produce results in form of data and publication (or other forms of dissemination). The multidisciplinary data resulting from access is a

most valuable resource and may be the basis for the creation of new discoveries and knowledge. Therefore, the RIs should encourage the users to provide their data from physical access and make them available to for further use and exploitation (in accordance with the RIs' data policies, management plans and FAIR principles). The archiving and management of such multidisciplinary data may be still challenging, as it requires some degree of interoperability between RIs and handling of often heterogeneous use data, potentially or partially collected by non-standardized methodologies.

The existing environmental RIs and their scientific excellence are the fundamental conditions for advancing our knowledge. Research findings and highlights from multidisciplinary research collaborations and synergistic approaches should be made available to the scientific communities. The RIs should strongly encourage the users to publish the results from their multidisciplinary research in peer-reviewed publications while ensuring proper citation and acknowledgement of the RIs, facilities, and contributing staff involved in the access process. Multidisciplinary research may produce new breakthroughs and be essential for advancing our knowledge and understanding of the environmental processes and interactions, and be of great benefit for scientists, modellers, regional and national authorities, and the society.

4.2.4. Funding of access to multidisciplinary research

Physical access requires additional resources both at RI level to provide the required capacity (in terms of personnel and technical resources) but also at user level to facilitate their mobility. Although the RI access funding model can only be tackled at RI level or with additional funding through different sources (national, EU funding), the funding and financial support to users is not necessarily very significant but is, however, crucial. Experience from ENVRIplus has shown that some limited funding has been the key for initiating new collaborations and to develop multidisciplinary research projects, and to allow composition of multi-national research teams with expertise across domains. Specific and dedicated funding is a big and necessary incentive for promoting multidisciplinary research.

4.2.5. Communication and outreach

Communication and outreach are crucial in advertising any access opportunities, even more so within a multidisciplinary framework. Communication is a key and strategic tool to promote the available multidisciplinary capabilities to wide user communities and beyond the RI boundaries, and should make use of various communication measures in order to reach out widely (websites, social media, conferences, newsletters, brochures, etc.). In a multidisciplinary framework, communicating before issuing the call to attract potential users and explaining the benefits of participating through a webinar for instance could be of interest. Communication is, furthermore, fundamental for building the bridges between the RIs and their scientific communities in order to bring them closer towards common multi-/interdisciplinary research goals.

4.2.5. Enhancing attractiveness for users

Multi-/interdisciplinary research is still developing and is often hindered by a lack of communication between the RIs and research communities, and an intradisciplinary (and limited) vision for addressing scientific questions. Coordinated access programmes and appropriate funding based on a coherent approach where different stakeholders (funders, research organisations, RIs, scientists, users) contribute at a fair level, are essential to enhance the attractiveness of multidisciplinary research opportunities. The challenges of multidisciplinary research let alone interdisciplinary research from the perspective of an RI arise from the fact that the scope of research remains user-driven. As a strategy, future coordinated programmes could have access providers initiate a series of multidisciplinary calls to users while considering possible research gaps. The challenge for users can also be that of finding common ground for research. Some major issues pertaining to multidisciplinary access were outlined from this ENVRIplus experience by both users and access providers. The need for scientific contacts with experts among the environmental domains in order to fully exploit cross-cutting scientific topics is evident. Therefore networking efforts will be essential in future to stimulate the research across domains towards interdisciplinarity.

5. CONCLUSIONS

ENVRIplus has successfully implemented a new and unique access programme to multidisciplinary observation platforms. Three calls for access have resulted in supporting more than twenty high-quality, multidisciplinary projects with participants worldwide that have accessed the sites, demonstrating the potential for testing the integrating capacity of the environmental RIs. The pilot programme has triggered cross-disciplinary, cutting-edge research projects and new scientific insights at the interface of different environmental domains. It has encouraged and promoted mobility of multi-national and multidisciplinary research teams from within and outside EU and has been a unique opportunity for new collaborations to gather research teams that have never worked together before and set ground for potential collaborations in the future. The financial support, although limited, has been essential to leverage world-class projects and the benefits for the RI and facilities are high in terms of visibility, cooperation, use, and impact. However, multidisciplinary research is not possible without the driving force of the user communities, appropriate framework programmes and tools for implementation of access and corresponding funding mechanisms. The promising results from the experience demonstrate that future cross-disciplinary access programmes are greatly needed.

6. IMPACT ON PROJECT

ENVRIplus was conceived with a vision to bring together environmental RIs to promote RI cross-fertilization, innovative concepts and common solutions, and facilitate the research and innovation for the users. The theme on multidisciplinary access provision has largely embarked on the ENVRIplus goals to make this possible through a

successful physical access programme, based on selection of joint observation platforms and implementation of a coordinated access concept for promoting the synergy use of the resources and services at the joint observation sites for the users. The process has engaged the communication between and feedback of the essential actors in the process (RIs, access providers, scientific community, users) and clearly showed the benefits of the new concepts of sharing RI resources and providing access. Experiences and results of the multidisciplinary access provision have furthermore provided valuable input to the work for developing governance tools for sustainable and adjustable access to RIs (WP10). Impact on the project objectives is, therefore, considered significant.

7. IMPACT ON STAKEHOLDERS

The novel concept of access provision by environmental RIs for multidisciplinary research has demonstrated the need of a new approach for addressing scientific questions and challenges that are difficult to be tackled in an intradisciplinary way. Coordinated research and funding programmes and RI-overarching government tools are essential to stimulate interdisciplinarity and align the strategies of the environmental infrastructures. This deliverable is an important contribution to the needs and benefits of implementing initiatives that drive and advance interdisciplinary research.

8. REFERENCES

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9. APPENDICES

Appendix 1: Summary of projects

1st Call Summaries

Influence of Biosphere-Atmosphere Interactions on the Reactive Nitrogen Budget (IBAIRN): The project had a few strengths, it proposed a comprehensive suite of observations with an unprecedented capacity to provide novel insights into nitrogen budget in the boreal environment. The chosen site was noted to be extensively characterized by biogenic VOC emissions but to date of the proposal request there were no concerted measurements of organic nitrates at the site. The TNA group was strong and highly experienced.

Outcome and future studies stemming from the project were a comprehensive dataset covering many aspects of the interaction between the biogenic emissions of the boreal forest and pollutant emissions in this low-NOx environment. Although the detailed analysis of the data is in its infancy, the group have identified several interesting topics to pursue as joint publications. Potential future studies are intended with a sub-set of the instruments deployed in IBAIRN. The plan will be to investigate the seasonality of some of the observations made and to further investigate open questions that arise from further analysis.

Constraining gross carbon fluxes using ecosystem flux and atmospheric concentration measurements of carbonyl sulfide (COS) and CO2, (COSMOS). The objective of the project to improve knowledge about the fluxes of COS and CO2 on ecosystem scales, and to derive a better GPP estimate of northern high latitude boreal forests than was achieved so far with the current knowledge. Specifically, we will: 1) observe the leaf-scale uptake of COS and CO2, and make accurate in situ atmospheric concentration measurements of COS for a whole growing season at a boreal forest site; 2) Verify the use of COS as a tracer for GPP on the ecosystem scale 3) improve the parameterization of a biosphere model (SiB4) COS simulations; 4) derive an improved GPP estimate of northern high latitude boreal forest. The results learned from the TNA campaign are very useful to the understanding of GPP estimates, and will be used to improve the model simulations, e.g. MuSICA (Ogée et al., 2016) and SiB (Berry et al., 2013). The study was performed at a boreal forest, however, the findings shed lights on other ecosystems.

***Seismic and Infrasound Monitoring of Cyclones in the Indian Ocean, (SIMCIO)*.** The team proposed to use two independent observables for tracking cyclones in the SW Indian Ocean, by analysing data from an infrasound array located at the OPAR / Maido observatory, and from seismic stations from the OVPF volcano observatory. The objective was to make well-known the relationship between sources and oceanic swell during a passage of the storm by using two different techniques (seismic and infrasound). The major impact of this collaboration was that it made advances in combining infrasound and seismic data to locate and to track tropical cyclones. The results will be part of the thesis of project leader and should be published in an international journal.

Volcano Acoustic Monitoring from near and far-field ObServations (VAMOS). The team had a project with the aim to evaluate the possibility and the limitations of the use of the infrasound technology for volcano monitoring in La Réunion. Aim of the project was to show that infrasound can be successfully used to locate the source, detect the onset, and track the evolution of the effusive phases as well as to investigate the source dynamics.

Through the synergy between the two OSU-R infrastructures (OVPF and OPAR) and the Laboratory of Experimental Geophysics of the University of Firenze, the future of the project is expected to lead to a full analysis of acoustic wave-field produced by this style of volcanic activity and to improve our knowledge on the use of infrasound as monitoring tool at the mid-range distance. Besides, the results are intended to be presented in conferences also as a part of the HORIZON 2020 - ARISE2 design study project and published in international journals.

Etna Plume Lab - Radioactive Aerosols and other source parameters for better atmospheric Dispersion and Impact estimatiOns, (EPL-RADIO). The team had a project to bring together a variety of innovative information, exploiting expertise from both atmospheric sciences and volcanology specialists. This information was derived from the observation of: a) coupled direct/remote size- resolved aerosols distribution and composition, b) primary/secondary near-source sulfate aerosols partitioning and c) radioactive disequilibria of radon daughters. These observations have systematically been coupled with the detailed characterisation of the environmental conditions, in terms of the plume's gasses composition and its thermodynamics. The results relative to points a) and b) allow a detailed size-resolved physico-chemical characterisation of the emitted aerosols to constrain the regional climatic impacts of Mt. Etna in the Mediterranean area (from local to regional scale). With regards to the latter, it should be mentioned that it has been recently demonstrated that Mt. Etna's emissions have the potential to significantly modulate the atmospheric composition, the optical properties of the distal aerosol layer [2] and the radiative balance in the Mediterranean area [3], thus producing regional climate forcing, which depends on the chemical and micro-physical characterisation of the emitted and produced (in- plume) aerosols [4]. The results of point c) provide new information on inner degassing dynamics.

Ash fragmentation at Mount Etna and implications of different particle shape on ash dispersal in the atmosphere, (ETNASH). The team had the scientific objectives to review the characteristics of ash and ash- dominated eruptions at Mount Etna, ii) investigate different episodes of ash emissions with ash samples coming either from the past, each associated with a different eruptive style and marked by a different duration, intensity and sedimentation rate of the ash fallout, or on-going Etna activity, iii) link such ash emissions to a different mechanism of ash fragmentation, and iv) investigate ash dispersal in the atmosphere via numerical modelling. The results of this study were expected to produce a paradigm shift on knowledge of mechanisms through which ash fragments are dispersed in the atmosphere not only at Mount ETNA but also at other basaltic volcanoes. The project led to discussions in a 3 day meeting in Catania between 18-21 June 2017 where they addressed points i), ii) and iii) described under Scientific objectives, this meeting leading to a publication. A potential PhD project involving the School of Earth and Environmental Sciences in

Manchester, Osservatorio Etneo (ETNA-INGV) in Catania, and the INGV office in Pisa was discussed as a an outcome too.

Aerosols in the Etna passive plume (Etna-Nuc). The main objective of this campaign was to obtain innovative measures on full size range of particles (from nano to micron particles) in the passive plume in order to improve the nucleation and magnification schemas on the basis of gaseous compounds in meteorological models. To capture the particles of the plume, they planned to send five instruments at Osservatorio Astrofisico di Serra La Nave which is situated at 1500 m above sea level, 7 km away South-East of the Etna vent. Respecting the budget, they sent only 3 of them, the SMPS, the OPC (GRIMM) and SO2 analyser. Unfortunately, the OPC did not work correctly during the implementation of the operation. However, SO2 and SMPS data was obtained. Both operated simultaneously and continuously since the beginning of June. As first results, the nucleation phenomenon has been observed several times since this period and the nucleation event frequency is estimated to be 79% for July. Compared to other altitude sites they noticed that it was a very high value.

Impact of land-use changes on soil health and greenhouse gas emissions [ILUC-SH-GHGE] to the SOERE ACBB facility in France had the scientific objectives of finding the impact of land use changes on soil, health and GHG emissions by studying elements in regard to the biosphere, earth solids and atmosphere disciplines. The below were the intended objectives: The dynamics of quantitative and qualitative evolution of soil organic matter under land-use changes, the microbial dynamics and functioning in relation to the land use changes, microbial enzyme activities related to carbon, nitrogen and phosphorous cycles and their indirect impact on GHG emission. The project aimed at combining data from several domains as well as their interactions in order to generate knowledge on both the agricultural and environmental effect of grassland introduction into cropping cycle as an example of land use changes. Preliminary results were obtained. And they will be valuable for the experts in land management and this should help them better understand land use changes that will permit adaptation. There was at the end of the project a definite future need foreseen for future studies to conduct similar experiments at contrast climatic zones to take into account temperature and precipitation effects.

2nd Call Summaries

Ecosystem level methane fluxes: disentangling sources and sinks from transport using true eddy accumulation, eddy covariance, gradient and chamber flux methods (METHANE-FLUX). The team had the scientific objectives to assess drivers and quantify magnitudes of ecosystem-scale methane fluxes by micrometeorological methods (true eddy accumulation, eddy covariance), 2) partition methane fluxes into components from soil, stems and shoots using enclosure methods, 3) operate for the

first time a novel true eddy accumulation system side-by-side to both conventional eddy covariance and gradient techniques for CH4, CO2 and H2O fluxes and assess method specific differences, 4)develop and promote high performance true eddy accumulation. This project successfully performed proposed flux measurements using both eddy covariance and eddy accumulation approaches. The project outcome comprises a data set of measurements of methane and CO2 fluxes from above specified methods and instruments. Following the project, further studies are required to analyse this data set with regards to comparing the performance of the different methods, investigating drivers of methane fluxes and to relate micrometeorological observations of net ecosystem exchange of methane with local chamber based methane flux estimates of soil and vegetation components and methane flux models upscaling the local chamber measurements.

Radioactivity and ELECTric field monitoring campaign at Hyytiälä, (RELECT). The team had the main objective to perform simultaneous measurements of radon gas concentration, gamma radiation and local electric field at the Hyytiälä research infrastructure. Hyytiälä is a particularly appealing location given its geographical location at high latitude, making it very suitable for addressing the influence of cosmic rays and solar energetic particles on the local electric field. Another objective was the simultaneous monitoring of the local electric field and of environmental radioactivity. The project enabled the collection at the research infrastructure of time series of radon concentration (Fig. 5), gamma radiation (Fig. 6) and atmospheric electric field (Fig. 7). All the collected data are publicly available: https://rdm.inesctec.pt/dataset/cs-2017-011 (radon concentration every 2-hours in Bq.m-3), https://rdm.inesctec.pt/dataset/cs-2017-010 (gamma radiation in counts.minute-1 every 5-minutes), https://rdm.inesctec.pt/dataset/cs-2017-009 (electric field in V.m-1 every 1-minute).

***Ultraviolet Polarised light for Detection of volcanic ASH*, (UP-DASH)**. The team had two main aims of their visit i) to discuss in depth plans and aims for the project with the project members at INGV, and to perform preliminary fieldwork to assess the use of depolarisation of scattered sunlight from ash as a detection method. The first part of the trip consisted of a two day stay in Catania working at INGV. During this time meetings were held. One primary point of discussion was the use of the LiDAR at INGV Catania as a method of validation of the ground based UV measurements, and it was discussed as to how we would achieve this. The second part of the visit was spent on Stromboli, where observations of explosions from the volcano were made from a position called “Punta Labronzo”, which offers good views of the activity from the volcano. Here the spectrometers were deployed again, and measurements of the depolarisation, denoted here, from the ash produced in explosions were made.

Etna Plume Imaging and Chemical Composition (EPICC). The scientific objectives of the EPICC campaign were to operate for the first time a NO2 camera

pointing at a volcanic plume in order to detect potential traces of NO2, transient or not. Such a detection would contribute to solving some pending questions in the volcanic plume chemistry. ii) Perform simultaneous acquisitions by SO2 cameras and the NO2 camera from two or more locations in order to obtain a dataset enabling progresses in the field of 3-D modelization of plumes. The simultaneous observation of the SO2 contained in volcanic plumes from different points of view was the key to a better estimation of the SO2 emission fluxes. Campaigns allowing to set up SO2 cameras in at least three sites for a longer time (weeks) have the best chance to succeed. For EPICC, an air quality instrument (the NO2 camera) was operated on a volcanic site with SO2 cameras. Maybe in a future campaign, one should consider to proceed the other way around: bringing the SO2 cameras to an industrial site such as a coal-firing power plant in order to take advantage of the strong SO2 and NO2 plumes.

Productivity, Blue Carbon and nutrient cycling of marine macrophytes in Reunion Island (MACRORE). The team accessed the OSUR (LA REUNION ISLAND) site, with a project with scientific questioning to respond to rapid urbanization of coastal areas in La Réunion and the global climate change. This made the project relevant with potential strong local effect.

The project was conceived and designed as a multidisciplinary project. It combined different research areas related to marine ecology and ecosystem functioning with a diverse research team including chemists, biologist and marine scientists. They had even more diverse expertise in marine ecology, oceanography, chemistry, biogeochemistry, eco-physiology and seagrass biology. The team was from various origins hence enabling multinational cooperation. A scaling-up approach from individual organism, through the associated community up to ecosystem was applied. To reach this objective, a combination of instrumentation and methodologies from different disciplines was implemented including autonomous physico-chemical probes, oceanographic chemical analysis, high precision microelectrodes and optodes. The use of all the data obtained from different domains was planned and implemented to understand the role that seagrasses play in the Reunion lagoon and the implications for the ecosystem functioning. This was intended to also provide valuable insights on the bottom-up and top -down mechanisms taking place in the lagoon pointing to future lines of interdisciplinary research.

The scientific results have been presented at international conferences (7th ENVRI week, Riga) and are envisaged to be presented in further conferences and published in international high-impact peer-reviewed open-access journals. ENVRIplus support is acknowledged in all dissemination actions. Continuity of the research collaboration is foreseen via TNA Access calls associated to next ENVRI project as well as other national and international funding agencies.

Natural Impact of passive and active volcanic CO2 degassing activity on the atmosphere, (NICO). The team intended to address the existing gap in knowledge by 1) defining the chemical and isotopic characteristics of magmatic fluids (CO2, SO2 and noble gases) either at source or in distal areas; 2) quantifying the amount of volatiles emitted from the volcano and their evolution in the atmosphere; 3) evaluating the impact of volcanic emissions in the local atmosphere. Outcomes from the campaign of study were: Soil CO2 flux measurements, SO2 flux time series during the eruption period (14 July – 28 August 2017), time series of SO2 molar concentration in plume from proximal to distal area from the eruptive vent, isotopic signature of free gases from hydrothermal spring waters, and helium isotopic ratio and concentration from free gases of hydrothermal spring waters. Future studies will focus on the integration of the data collected and in the definition of an interpretative model for the volcanic gas emitted in the atmosphere during the last eruption of the Piton de la Fournaise volcano.

Critical Zone in Tropical Montane Cloud Forest of a Volcanic Island: Specific Constraints and Forcings (TMCFcz-pbl). The team had a purpose to develop a research protocol to investigate the upstream region of the Erorun watershed, in the heart of a preserved tropical forest, including in a National Park, using the field-instrumented site of OSUR/FOREST at "Plaine des Fougères" (1350 m) dedicated to the water balance monitoring. This site is already equipped with a weather station, soil water tension gauges and hydrometric station for runoff flows, the implementation of new sensors will lead to measure TF, and SF directly at the study site. CWI, Ei and ΔS will be calculated using the method of Takahashi et al. (2011). Following the project new collaborative multidisciplinary research efforts are expected among scientists within OSUR/Erorun and in Hawai'i. These future collaborations will take the form of integrated studies of the ecology, climate, hydrology, and biogeochemical processes occurring in TMCFs in Reunion, Hawai'i and other tropical islands.

Carbon stable isotopes measurement of the transitory carbon pool as an early indicator of land use Impact on soil carbon sequestration, (IsoTrans). The team with this project aimed at verifying if measurements of p_t can provide reliable assessment of the impact of different management practices on future changes in soil organic carbon stocks. Exceptionally dry conditions at the time of the experiment prevented the direct validation of pt as an indicator of future changes in carbon stocks and this should be the subject of future research. Results indicated that in well-watered conditions, the indicator pt should be measured for a range of agricultural management practices known to be resulting in contrasting directions and rates of SOC stock changes. The SOERE platform of INRA in Lusignan presents a large range of practices including croplands, most of them resulting in continued SOC losses, and grasslands mostly resulting in SOC stock increases. Therefore, the site was suitable for validating the indicator pt, but this required including croplands as well as grasslands

amongst the experimental treatments. As shown in the present experiment, the dynamics of CO2 respired from different components of the soil are affected by soil water content. It is likely that other environmental variables may affect these dynamics and although it was not the case for soil water content, it is not known whether other variables may result in changes in the indicator pt. Particularly, under an experimental set up including croplands, the effect of soil disturbance through ploughing should also be assessed in future.

3rd Call Summaries

Nitrous oxide (N20) and methane (CH4) fluxes from stems of different tropical tree species in Mare Longue Nature Reserve (NOME-TROPITREES). The project's objective was to quantify N20 , CH 4 and additionally carbon dioxide (C02, indicator of physiological activity) exchange of common tree species in Mare Longue Nature Reserve at Reunion Island (Syzygium borbonicwn, Doratoxylon apetalwn, Antirhea borbonica , Ho111aliw11 paniculatum , Mi 111.usops halata and Labourdonnaisia calophylloides), and of adjacent soil. The aim was to determine whether and to which extent these trees , growing on lava flow covered with thin and irregular organic soil layer, exchange N20 and CH4 with the atmosphere. Moreover, the gas exchange capacity of common cryptogamic stem covers (Pyrrhobryum spiniforme, Leucoloma sp., Leucophanes sp.) was studied. The overall aim of the project was to clarify the role of the studied forest components in N20 and CH4 exchange of the tropical lowland rain forest. The project was a first case study of its kind at the island. It was found that the tropical lowland rain forest grown on a lava flow seems to be a significant sink for CH4 and plays only a minor role in the global N20 exchange. After extensive data processing, the obtained results will be presented at an international conference (EGU 2019, Vienna, Austria) and published in an impact journal. The project has established new cooperation with the researchers from the University of Reunion Island, which will be a basis for future common experiments. The results of this case study need to be verified by a larger future project directed to studying spatial and seasonal variability in CH4 and N20 exchange of soil and trees, as well as to understanding the role of cryptogams in the GHGs exchange under different climatic conditions. The future studies should involve measurements of CH4 and N20 exchange of soil and trees, if present, in different natural ecosystems in the whole altitudinal profile at the island including high elevated mountain ecosystems. Such measurements are crucial for the future estimation of CH4 and N20 budget of the volcanic Reunion Island, and therefore of global GHGs flux inventories.

Emission in atmosphere of Natural gases and TEmporal variations Related to volcanic activity (ENTER) to OSUR La Reunion had the strength of being multidisciplinary nature and was compliant to an open science question. The project was carried out successfully with an intention of studying volcanic emissions with a

focus on isotope measures and on a multidisciplinary approach. The attempt of making in the field real-time measurements of the isotope composition of CO2 represented novelty for the scientific community and a promising way to better evaluate the degassing of the volcano and its impact into the atmosphere. The primary aim of ENTER project was the improvement of knowledge on the origin of volcanic gases (mainly CO2) emitted from the Piton de la Fournaise and their incidence in the local atmosphere. The ENTER project aimed at improving the knowledge on the isotope composition of CO2 emitted on La Réunion island, focusing in two key degassing areas: the first is in Gite, which is proximal to the volcano, Piton de la Fournaise where most of the present eruptions occur; the second is in Cilaos, and represents an important source of CO2 degassing where clues on the probable connection of Cilaos degassing regime and the deeper magmatic activity at Piton de Fournaise were arising. We plan to better define the origin of CO2 and evaluate possible short-term variations due to volcano-tectonic activity and environmental conditions.

Radon Analyses in Volcanic Emissions from Etna volcano: a tool to shed light on magmatic processes and environmental issues (RAVE@Etna). The main objectives of this project are thus threefold: i) Benefit from innovative 222Rn measurements in the diluted plume of Etna to implement existing degassing models (Terray et al., 2018) and derive sharper constraints on shallow magma dynamics and degassing processes. A long-term time-series of these parameters related to the style and intensity of degassing/eruptive activity will contribute to better volcanic hazard assessment. ii) Use unprecedented 222Rn measurements to quantify for the first time Etna's degassing budgets in terms of radionuclides injected into the atmosphere, and estimate radiation levels at the summit craters and at distances from the active vents, with implications for radiation safety and related health issues. iii) Collect and analyze biological samples to study a) whether microbial (and other micro- organisms) life may exist under extreme conditions in a volcanic and radioactive environment and how it evolves to get adapted to it; b) how more evolved species (honeybees) react to this specific stress and may act as a dissemination factor of radioactivity through beehive products, with implications for life origin and evolution. Results are yet to be presented in a final report to be submitted.

Design of a light multi-parameters station based of the GEOCUBE+ architecture (GEOCUBE+@Etna) had an objective to consolidate the results acquired during the previous year as well as the GNSS aspects of the Géocube. It coupled experiments with aerosols sensors in order to assess in the field, the issues to be solved to implement in the future Géocube+. To assess the capability of recording information on gas and aerosols with appropriate add-on sensors. The projected outcome is to develop an array of light and rugged multi-parameter stations organized around the original concept of Géocube.

Volcanic Airborne Gas Monitoring using the miniGAS and miniature Mass Spectrometer UAV based Systems (VAMOS-UAV). The projects objectives were to characterize the gas emission of Mt. Etna Volcano using the recently developed UAV ready miniature multiple Gas System (miniGAS) and miniature Mass Spectrometer System (mMS) targeted for in-situ volcanic gas emission analysis during ground and airborne campaigns. The mMS have been used to support earth science missions for both atmospheric and volcanic studies providing a robust and broad spectrum of in situ gas sampling with trace gas analysis capability (1 to 150 amu), combined with temperature, humidity, pressure, position, and particle characterization data for ash-driven volcanic plumes. The system has been tested in Costa Rica and Italy but Mt Etna represent a new and challenging target to characterize the gas emissions with in situ mass spectrometry, measure the different gas ratios among the different gases detected to assess the condition of the volcano and compare to other techniques used by the INGV, to better understand the geochemistry of the volcano. The deployment of the miniGAS and mMS systems at Mt. Etna will serve as a demonstration of the capabilities of the instrument under normal operating condition of a volcanic research center for solid earth and atmospheric studies. The deployment was a success and demonstrated the capabilities of the miniGAS instruments (PRO, NTX, Lite versions) for airborne in situ gas measurements using UAVs in complement with other techniques such as the thermal and optical cameras deployed by ONGV Rome and Napoli. The deployment provided a unique collection of Mt Etna's degassing concentrations to compare with both ground measurements stations and remote sensing instruments. It also provided a list of lessons learned to develop better and more robust systems for permanent monitoring of volcanic activity using drones and portable instruments. As an important note, this was the first time a miniature mass spectrometer to be flown in a small UAV at a volcano with the elevation of Mt Etna, which constitute a milestone in the Chemistry, Physics, Engineering and Volcanology fields but the instrument still requires more development in both the UAV platform and instrument fronts. The team will produce at least 2 scientific papers form this deployment and several conference presentations and they hope to continue this area of work at Mt Etna in 2019 and other locations.

Measuring Forest Carbon and Oxygen Exchange in Hyytiälä (FOXYY). This project aimed to provide new insights in the forest carbon balance by separately quantifying photosynthesis and respiration through innovative and challenging atmospheric measurements. Objectives of the study were to measure highly precise atmospheric CO2 and O2 mole fractions in different forests. ii) Develop a novel modelling framework to interpret CO2 and O2 exchange in forests. iii) Interpret existing and new observations to separately estimate and understand the two major terms in the forest carbon balance: photosynthesis and respiration. This project intended to provide new constraints on the biospheric CO2 exchange processes based on combined atmospheric O2 and CO2 signals. The results could eventually allow

climate models to better constrain the impact of rising CO2 concentrations on our future climate by quantifying the largest fluxes in the carbon cycle and allow to better estimate how much of the CO2 emitted by fossil fuel combustion will remain in our atmosphere. The next steps include processing all data and finalizing the calibrations. Furthermore, they intended to develop a modelling framework which combines a biosphere and atmospheric component. This will allow further the interpretation of the measurements. Following the project, a second campaign in Hyytiälä, for spring/summer 2019. These new measurements will allow comparison from year to year.

The Influence of Land cover changes On Atmospheric Boundary Layer and Regional Climate Characteristics, (InLandOnABL&RCC). The project's objective was to obtain valuable skills for young researchers under a guidance of experienced trainers in both aerosol measurements on modern equipment and their further application as initial data for modelling of biosphere-atmosphere interaction. A second objective was to process observational data from SMEAR II archive to estimate ecosystem components' and ABL sustainability by annual cycle of climatic indicators in Boreal forest. And finally to study and to adapt online coupled integrated meteorology-chemistry-aerosol Enviro- HIRLAM model developed in UHel for Ukraine as a part of the Enviro-PEEX on ECMWF HPC project. The project sought to answer some questions about atmosphere-biosphere interactions, namely finding correlations between meteorological parameters and plant's development. In this report air temperature transitions through 0, 5, 10°C and their seasons' lengths: warm season, growing season and season of active vegetation for 1996-2017, were calculated. In overall, extensions of all studied seasons have been revealed. The most significant changes are found towards the later ending of warm season of almost 9 days per decade and for earlier start of active vegetation season (T>10°C) of 7-8 days per decade. On the contrary, start of vegetation season (T>5°C) shifted to later dates about 3 days per decade and as a result, period between 5°C and 10°C has shrunk notably. Hydrothermal Vorobiov's and Selianinov's indices were calculated for estimating heat and moisture availability for vegetation. The most intensive absorption of PAR was after T>0°C and before T<10°C which is connected with long sunshine duration and as a consequence, increase of leaf area index and more intensive process of photosynthesis. Absorbed PAR variated within 70-90% and had less variability in warm season in compare to cold one. Also, a slight increase in PAR absorbing was within season T >10°C. It can be connected with leaf area increase. Some essential decreases in absorbed PAR were associated with intensive precipitation obviously connected with dense multilayer clouds. It was realized that obtained results need discussions with experts in forestry for further application and have to be supplemented with phenological data and possibly atmosphere-chemistry data from Finnish models, such as Enviro-HIRLAM. A plan was therefore made to

extend the conducted project towards further investigation on interconnections between PAR, CO2 and monoterpene fluxes with meteorological characteristics.

Appendix 2: Post Access questionnaire

ENVRIplus Post Access Questionnaire[4]

1. Name and last Name

2. Title and acronym of the project

3. Name of the chosen platform

4. How did you come to know about the ENVRIplus Transnational Access funding?

- ✓ ENVRIplus official website Information received by colleagues
- ✓ Through a mailing list I am subscribed to
- ✓ Other

5. Without the support of the ENVRIplus funding, would you still have been able to access the research platform?

- ✓ Yes
- ✓ No

If your answer was no, briefly specify why (financial and/or interdisciplinary opportunity, knowledge about the platforms, etc.)

6. Please assess the service provided by the ENVRIplus access team (0= not evaluable, 1= very poor, 2=sufficient, 3=good, 4=excellent):

- ✓ Publicity and practical information on how to apply
- ✓ Easiness of the procedure to apply
- ✓ Quantity of documentation required
- ✓ Scientific and technical support at the facility
- ✓ Other?

7. The focus of the ENVRIplus Transnational Access is that of promoting inter-disciplinary research activities and it is also a fundamental criteria on which applications are evaluated. Do you believe that this point was sufficiently underlined in the information about the call for proposal and in the application procedure?

- ✓ Yes
- ✓ No

8. Has the TNA project triggered/pushed the interdisciplinary nature of the research activity you are focusing on? If so, please briefly describe how:

[4] http://www.envriplus.eu/envriplus-post-access-questionnaire/

9. Please evaluate the overall service provided by the ENVRIplus Transnational Access (0= not evaluable, 1= very poor, 2=sufficient, 3=good, 4=excellent):

10. If your evaluation is below the score of 3, please briefly explain why:

11. Shortly comment the benefits of the TNA and/or lessons learnt:

12. Do you have any suggestion for improvement?

Appendix 3: List of Publications

Below is a list of the latest publications resulting from the ENVRIplus PILOT TNA programme. This list is not exhaustive as more publications are expected given that some projects were carried out later, during the final reporting period of the project.

1st call

Chen H., Kooijmans, L.M.J., Sun, W., Aalto, J., Erkkilä, K.-M., Maseyk, K., Seibt, U., Vesala, T., Mammarella, I: "Observations of carbonyl sulfide in a boreal forest", Keck Institute for Space Studies workshop, Caltech, Pasadena, CA, USA, Sep 18 – 22, 2017.

Kooijmans, L.M.J., Maseyk, K., Vesala, T., Mammarella, I., Baker, I.T., Seibt, U., Sun, W., Aalto, J., Franchin, A., Erkkilä, K.-M., Kolari, P., Keskinen, H., Levula, J., and H. Chen: "From Carbonyl Sulfide (COS) ecosystem fluxes to GPP: integrating soil, branch and ecosystem fluxes", AGU Fall meeting, 12-16 December, San Francisco, California, 2016.

Kooijmans, L.M.J., Sun, W., Aalto, J., Erkkilä, K.-M., Maseyk, K., Seibt, U., Vesala, T., Mammarella, I., and H. Chen: "From Carbonyl Sulfide (COS) ecosystem fluxes to GPP: integrating soil, branch and ecosystem fluxes", International Carbon Dioxide conference, 21-25 August, Interlaken, Switserland, 2017.

Kooijmans, L.M.J. "Carbonyl Sulfide as a tracer for gross primary production (GPP): from instrumentation to application", BBOS autumn meeting, 25-27 October, Nijmegen, The Netherlands.

Linda M. J. Kooijmans, Wu Sun, Juho Aalto, Kukka-Maaria Erkkilä, Kadmiel Maseyk, Ulrike Seibt, Timo Vesala, Ivan Mammarella, and Huilin Chen: "Influences of light and humidity on carbonyl sulfide-based estimates of photosynthesis", PNAS February 12,2019 https://doi.org/10.1073/pnas.1807600116

Liebmann, J., Karu, E., Sobanski, N., Schuladen, J., Ehn, M., Schallhart, S., Quéléver, L., Hellen, H., Hakola, H., Hoffmann, T., Williams, J., Fischer, H., Lelieveld, J., and Crowley, J. N.: Direct measurement of NO3 reactivity in a boreal forest, Atmos. Chem. Phys. Discuss., 2017, 1-34, doi:10.5194/acp-2017-975, 2017.

Liebmann J., Sobanski N., Schuladen J., Karu1 E., Hellen H., Hakola H., Ehn M., Riva M., Williams J., Fischer H., Lelieveld J. and Crowley J.N.: Alkylnitrates in the boreal forest: Formation via the NO3 and OH induced oxidation of BVOCs and atmospheric lifetimes, Atmos. Chem. Phys., 18, 3799-3815, https://doi.org/10.5194/acp-18-3799-2018, 2018.

M. Polacci, D. Andronico, J. Taddeucci, A. Cristaldi, M. de' Michieli Vitturi, Mechanisms of ash generation at Mount Etna, manuscript in preparation.

P. Sellitto, G. Salerno, P. Briole, The EtnaPlumeLab (EPL) research cluster: advance the understanding of Mt. Etna plume, from source characterisation to downwind impact, Annals of Geophysics, 60, ISSN 2037-416X, 2017

P. Sellitto, G. Salerno, A. La Spina, T. Caltabiano, L. Terray, P.-J. Gauthier, P. Briole, A novel methodology to determine volcanic aerosols optical properties in the UV and NIR and Ångström parameters using sun-photometry. Journal of Geophysical Research: Atmospheres, Accepted for publication. Doi: 10.1002/2017JD026723, 2017.

P. Sellitto, G. Salerno, A. La Spina, T. Caltabiano, S. Scollo, A. Boselli, G. Leto, R. Zanmar Sanchez, S. Crumeyrolle, and P. Briole "Small-scale volcanic aerosols variability, processes and direct radiative impact observed at Mount Etna during the EPL-RADIO campaigns", in Preparation

P. Sellitto, S. Scollo, A. Boselli, G. Leto, R. Zanmar Sanchez, G. Salerno, A. La Spina, T. Caltabiano "LiDAR observation of co-located volcanic, dust and biomass-burning aerosol and their radiative impact", in Preparation

Terray L., Gauthier P.-J., Salerno G., Caltabiano T., La Spina A., Sellitto P., Briole P., A New Degassing Model to Infer Magma Dynamics from Radioactive Disequilibria in Volcanic Plumes, MDPI Geosciences, 8(1), 27; Doi:10.3390/geosciences8010027, 2018.

Zha, Q., Yan, C., Junninen, H., Riva, M., Aalto, J., Quéléver, L., Schallhart, S., Dada, L., Heikkinen, L., Peräkylä, O., Zou, J., Rose, C., Wang, Y., Mammarella, I., Katul, G., Vesala, T., Worsnop, D. R., Kulmala, M., Petäjä, T., Bianchi, F., and Ehn, M.: Vertical characterization of Highly Oxygenated Molecules (HOMs) below and above a boreal forest canopy, Atmos. Chem. Phys. Discuss., 2017, 1-32, doi:10.5194/acp-2017-1098, 2017.

P. Sellitto, G. Salerno, A. La Spina, S. Scollo, A. Boselli, G. Leto, R. Z. Sanchez, T. Caltabiano, S. Crumeyrolle, and P. Briole. Small-scale volcanic aerosols variability and processes observed at Mount Etna during the EPL-RADIO measurement campaigns, EGU General Assembly 2019 (Wien, Austria), 2019

P. Sellitto, G. Salerno, A. La Spina, S. Scollo, A. Boselli, G. Leto, R. Z. Sanchez, T. Caltabiano, P.-J. Gauthier, L. Terray, S. Crumeyrolle, and P. Briole. Caracterisation of volcanic aerosols emissions, small-scale variability and processes at Mount Etna during the EPL-RADIO measurement campaigns. IAVCEI Cities on Volcanoes 2018 (Naples, Italie), 2018.

P. Sellitto, G. Salerno, A. La Spina, S. Scollo, A. Boselli, G. Leto, R. Z. Sanchez, T. Caltabiano, P.-J. Gauthier, L. Terray, and P. Briole. Small-scale volcanic aerosols

variability and processes observed at Mount Etna during the EPL-RADIO measurement campaigns. Journée thématique LiDAR 2017 (Palaiseau, France), 2018.

P. Sellitto, G. Salerno, and P. Briole. The Etna Plume Lab research cluster. 2eme Colloque ENS/SGF (Ecole Normale Supérieure/Société Géologique de France) Panaches Volcaniques (Paris, France), 2017.P. Sellitto and A. Miconi. Expédition au sommet de l'Etna. GEO France (online), https://photo.geo.fr/expedition-au-sommet-de-l-etna-19882, 2017

S. Barbosa, 2018, Space-atmosphere-surface interactions from ambient radioactivity measurements at Hyytiälä RI – 7Th ENVRI week 5-9 November 2018 Tallink Hotel Riga - Latvia

N. Bilyera, 2019 Grassland introduction into cropping cycles increases natural soil fertility and soil microbial activity. - Lunch-Time Talks At Envri Community Booth - ENVRI Community Booth @EGU19 Stands 02-03, Exhibition Entrance Hall

2nd Call

Moinet, G. Y., Midwood, A. J., Hunt, J. E., Rumpel, C., Millard, P., & Chabbi, A. (2019). Grassland Management Influences the Response of Soil Respiration to Drought. Agronomy, 9(3), 124. https://doi.org/10.3390/agronomy9030124

Marco Liuzzo; Andrea Luca Rizzo; Andrea Di Muro; Patrice Boissier; Philippe Kowalski; Guillaume Boudoire; Pierre Tulet; Jean-Marc Metzger Natural Impact of passive and active volcanic CO2 degassing activity on the atmosphere. ENVRI week 14-18 May 2018 NH Hotel Zandvoort - Netherlands

Irene Olive Samarra, 2018 MACRORE project - A multidisciplinary approach for tropical seagrass – 7Th ENVRI week 5-9 November 2018 Tallink Hotel Riga - Latvia

3rd Call

Lasri, Mohamed-Amjad, Briole, P, Thom, Christian, Martin, Olivier, Verluise, F, Bonforte, Alessandro, VOLCANOES MONITORING USING THE GEOCUBE SENSORS NETWORK. Feed-back from a deployment on Mount Etna, DOI 10.13140/RG.2.2.35180.05761, Doctoral Congres ED560, 2018 March 2018

Lasri, Mohamed-Amjad, Utilisation de réseaux de capteurs pour la mesure conjointe des déformations du sol par GPS de précision et de paramètres physico-chimiques dans un contexte volcanique, Thèse de l'Ecole Normale Supérieure, 2018 December 18.

Machacova K, Borak L, Agyei T (2019) Trees as net sinks for nitrous oxide (N2O) and methane (CH4) in tropical rain forest on La Reunion island. EGU General

Assembly 2019, Vienna, Austria, 7–12 April 2019. (Geophysical Research Abstracts Vol. 21, EGU2019-7045, 2019).

Boudoire, G., Rizzo, A.L., Arienzo, I., Di Muro, A., 2019. Helium isotopes decipher paroxysmal eruptions inducing caldera collapse. EGU General Assembly 2019.

Boudoire, G., Rizzo, A.L., Di Muro, A., Grassa, F., Liuzzo, M., 2018. Extensive CO2 degassing in the upper mantle beneath oceanic basaltic volcanoes: first insights from Piton de la Fournaise volcano (La Réunion Island). Cities on Volcanoes 10 Conference.

Andrea L. Rizzo, Marco Liuzzo, Guillaume Boudoire, Fausto Grassa(, Andrea Di Muro, Patrice Boissier, Philippe Kowalski, Pierre Tulet, Guillaume Guimbretiere, Jean-Marc Metzger 2019. Emission in atmosphere of natural gases and temporal variations related to volcanic activity – 7Th ENVRI week 5-9 November 2018 Tallink Hotel Riga - Latvia

Marco Liuzzo, A.L. Rizzo, G. Boudoire, F. Grassa, A. Di Muro, P. Boissier, P. Kowalski, P. Tulet, G. Guimbretiere, J-M. Metzger 2019. Volcanic gas emissions in the atmosphere at la Reunion Island: results from NICO and ENTER projects supported in the framework of the ENVRIplus (TNA) - Lunch-Time Talks At Envri Community Booth - Life Below Water & Multi-topic - ENVRI Community Booth @EGU19 Stands 02-03, Exhibition Entrance Hall