everest

D3.6

Supersite Use Case Demonstration Report

Workpackage	**WP 3**	**VRE User Cases**	
Task	3.6	Supersite Use Case Demonstration Report	
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Definitions and Acronyms

Acronym	Description
CEOS	Committee for Earth Observation Satellites
COTS	Components Off-the-Shelf
DOI	Digital Object Identifier
EU	European Union
FAIR	Findable, Accessible, Interoperable, Usable Data
GEP	Geohazard Exploitation Platform
GSNL	Geoharzard Supersites and Natural Laboratories Initiative
PID	Persistent Identifier
SAR	Synthetic Aperture Radar
SLC	Single Look Complex
VM	Virtual Machine
VRC	Virtual Research Community
VRE	Virtual Research Environment
WP	Work Package

Applicable and Reference Documents

Document ID	Document Title
[1]	European Virtual Environment for Research - Earth Science Themes, Grant Agreement N° 674906 – Available on the EVER-EST Alfresco Platform under WP1 Management Folder
[2]	EVER-EST Description Of Work – Available on the EVER-EST Alfresco Platform under WP1 Management Folder
[3]	EVER-EST Consortium Agreement – Available on EVER-EST Alfresco platform under WP1 Management Folder
[4]	European Commission Research and Innovation Participant Portal, http://ec.europa.eu/research/participants/portal/desktop/en/home.html
[5]	EVER-EST Project Web Site, www.ever-est.eu
[6]	EVER-EST VRE Portal, https://vre.ever-est.eu/
[7]	D. 3.1.1 Deliverable: EVER-EST VRE Use Case Description and User Needs
[8]	D. 3.2 Deliverable: EVER-EST VRE Validation Plan
[9]	D. 3.7 Deliverable: EVER-EST Overall Assessment Report
[10]	D. 2.5 Deliverable: Report on training activities
[11]	D. 6.2 Deliverable: Report on VRE population and testing

Abstract
This report describes the validation of the VRE infrastructure, with reference to the functionalities and requirements of the Geohazard Supersites VRC, and the demonstration of the use of the VRE by several users from the Supersites community.
The community created several Research Objects to exchange bibliographic information, scientific workflows, datasets and scientific results.

1 Introduction

1.1 Document scope

This document describes in detail the validation of the EVER-EST VRE functionalities, tested against the 4 Geohazard Supersites VRC Use cases defined in [7], and the results of the general demonstration activities which were carried out by the larger community since October 2017. The VRE use has been demonstrated through:

a) the development and re-use of Workflow ROs for the generation of geohazard science products from satellite and in situ data (for monitoring and modelling/ analysis);
b) the generation of Bibliographic ROs, some of which were archived with DOI;
c) the generation of ROs containing data or scientific results.

The document also describes the fulfilment of the User requirements, Smart Objectives ad KPIs.

1.2 Relations with other EVER-EST work packages

The WP3 activities have been closely coordinated with those carried out in WP2, WP4 and WP6. Given such close links, some of the information reported here is shared (in different format and level of detail) with other reports from these WPs. For example the Use case tests are also reported in [11] (requirement testing is reported); the training activities are partially reported in [10].

2 The Geohazard Supersites VRC

The scope, organization, and functional aspects of the Geohazard Supersite initiative are described below.

The Geohazard Supersites and Natural Laboratory initiative (GSNL) is a voluntary international partnership formalised under GEO - Group on Earth Observations, aiming to improve, through an Open Science approach, geophysical scientific research and geohazard assessment, promoting rapid and effective uptake of the new scientific results for enhanced societal benefits in Disaster Risk Reduction (DRR).

The GSNL goal is pursued promoting broad international scientific collaboration and open access to a variety of space- and ground-based data, focusing on areas with important scientific problems and high risk levels: The Supersites and the Natural Laboratories. For these areas a joint effort is carried out: the CEOS space agencies provide satellite imagery at no cost for scientific use, the monitoring agencies provide access to ground-based data, the global scientific community exploits these data to generate state of the art scientific results.

The coordination of each Supersite is normally assumed by one or more local geohazard scientific institutions which are part of a national, authoritative framework able to provide information for science-based decision making in DRR (either for Prevention or Emergency response). GSNL supports a leading role by the local scientific community, to stimulate a coordinated international collaboration, focusing on the aspects which have the highest potential to benefit Risk Reduction actions.

GSNL is a network, and as such aims to connect the various nodes (the Supersites and Natural Laboratories) promoting transfer of knowledge, data, personnel, tools, as well as best practice for optimal uptake of scientific results.

The main objectives of the GSNL initiative are:

1. to provide the global scientific community with open, full and easy access to a variety of space- and ground-based data over the Supersites and the Natural Laboratories;
2. to promote advancements in geohazard science over the selected sites;
3. to promote rapid uptake of scientific results by DRR stakeholders and decision makers;
4. to innovate technologies, processes, and communication models, enhancing data sharing, global scientific collaboration, and capacity building in geohazard science.

There are three main types of stakeholders involved in each Supersite or Natural Laboratory:

- The data providers: geophysical monitoring agencies and space agencies. They support the initiative to demonstrate the societal benefits of the data they produce.
- The global geohazard scientific community. Within a Supersite community, scientists can access thousands of satellite images and important in situ datasets (seismic, geodetic, geologic, geochemical, etc.), which they can exploit in the collaborative framework to improve their knowledge and contribute results of direct societal benefit in DRR. Furthermore, thanks to the increased visibility and DRR focus, Supersite scientific research may benefit from specific funding lines at national or international level. *The EVER-EST VRE has been designed to support the needs of this category of GSNL stakeholders.*
- The final users of the geohazard scientific information. This category includes public risk reduction agencies, policy makers at various scales, and in general all subjects who can benefit from science-based decision making in DRR.

Since the start of the EVER-EST project, the GSNL network has grown to include 10 Permanent Supersites and 1 Natural Laboratory:

Permanent Supersite	Coordinator	Coordinator institution	Date established	End-user
Hawaiian volcanoes	M. Poland	USGS, USA	October 2012	Hawai'I County Civil Defense, Hawai'I Volcanoes National Park
Icelandic volcanoes	F. Sigmundsson, K. Vogfjord	University of Iceland and IMO, Iceland	November 2013	Icelandic Police - Dep.t of Civil Protection and Emergency Management, Environmental Agency of Iceland, Directorate of Health
Mt.Etna volcano	G. Puglisi	INGV, Italy	April 2014	National Department of Civil Protection, Regional Civil Defense
Campi Flegrei & Vesuvius volcano	S. Borgstrom	INGV, Italy	April 2014	National Department of Civil Protection, Regional Civil Defense
Marmara Fault	S. Ergintav	KOERI, Turkey	April 2014	Istanbul municipality
Ecuadorian volcanoes	P. Mothes	IGEPN, Ecuador	October 2014	Secretariat for Risk Management, Regional governments, Municipalities
Taupo volcanic zone, NZ	N. Fournier, I. Hamling	GNS Science, New Zealand	October 2014	Ministry of Civil Defence and Emergency Management, Department of Conservation, Regional councils, MetService
Gulf of Corinth-Ionian Islands	A. Savvaidis	ITSAK , Greece	November 2016	EPPO, Greek Civil Defense
San Andreas Fault Natural Laboratory	C. Wicks	USGS, USA	April 2017	California Office of Emergency Services, Federal Emergency Management Agency, plus many other local stakeholders
Southern Andes Volcanoes	L. Lara	SERNAGEOMIN, Chile	October 2017	ONEMI (Oficina Nacional de Emergencias), under the Ministry of Interior and Public Safety
Virunga volcanoes	C. Balagizi	Goma Volcano Observatory, D.R. of Congo	October 2017	DRC Civil Protection, NGOs for Emergency and Disaster Management, also in Rwanda, Virunga National Park offices

In the same period (2016-2018), two Event Supersites were established:

1. the unrest event at Sinabung volcano, Indonesia, in 2017, which later subsided without an eruption;
2. the 7.3 magnitude earthquake occurred at the Iran-Iraq border near the town of Azgeleh, Iran, in 2017.

As explained in [7], the scientific community interested in conducting research on seismic and volcanic phenomena occurring at the Supersites, is granted open access to in situ and satellite data, according to site-specific conditions set by Supersite data policies.

While the GSNL initiative was started essentially to promote Open Data sharing (which was the focus of GEO in its first Work Program), in the last few years it has evolved towards a more comprehensive Open Science approach. In essence, Open Science is a set of practices which aim at making Scientific Knowledge openly shared and reusable for maximum societal benefit. There may be legal barriers to do this with privately funded research, thus the OS approach is mainly concerning publicly funded science.

Open Data is certainly a fundamental component of OS, however it is not sufficient to attain a full sharing of scientific information. Open Access to scientific literature is also one of the practices now promoted to disseminate knowledge in a more open way, but it is acknowledged that while publications are still the most common method to disseminate scientific knowledge, they do not optimise timeliness, completeness, reusability and reproducibility of scientific research.

In addition to a worldwide change in the metrics of science, and actions in the social and cultural domains, the full adoption of Open Science requires the implementation of specific technical solutions to support the optimal sharing and re-use of knowledge. The EVER-EST platform, in the version tailored to the Geohazard Supersite initiative, is a true Open Science environment built on the requirements of the volcanological and seismological communities.

3 Demonstration activities

The VRE demonstration activities started formally on June 20, 2017, when the first release of the platform was made available to the Research Communities. However, this initial release was not stable enough to be distributed to the community and it was tested and debugged only by the INGV users involved in the project.

A more stable version was released on October 1st, 2017. The platform was considered ready for use by the community and the involvement of other researchers. Other minor changes to the platform were implemented during the demonstration phase to suit further needs from users, mostly concerning the VRE interface.

As described below, in-depth training was considered fundamental and was carried out during specific international scientific events. In addition, a detailed user's manual was generated to support the scientists who could not be trained.

3.1 Validation of user requirements

In this section the details of the validation of the VRE user requirements provided by the Supersite community and described in D3.1. are reported. The requirements were validated for all releases, starting from the first VRE release at Month 18; such progressive assessment was instrumental in providing information for the constant improvement of the platform. The final validation with respect to the last, stable release of the VRE platform is provided.

General usability requirements of the VRE

As mentioned in [7], the overall mandatory requirement for the VRE was a high level of usability of the platform, meaning high efficiency of services, friendliness of interfaces, high flexibility and good computing power, without which the researchers, even if potentially interested in the VRE services, would not have invested in changing their working procedures and habits.

A brief discussion on how the general VRE requirements defined in [7] have been implemented is given below.

1. **Efficiency** - the advantages obtained by a researcher from the use of the VRE are strongly correlated with the use of Research Objects in his/her work. In fact, among the various services provided, those exploiting the RO concept and its capacity to provide documentation, sharing, re-use, preservation and attribution of intellectual work, are the most innovative and potentially useful. ROs are considered very effective tools to support a researcher's work, and the VRE is providing a friendly interface which allows not only the creation and management of ROs (as the ROHUB portal does), but integration of them seamlessly in the research work by allowing full re-use capabilities. However, the effectiveness of the VRE in RO management and re-use, and thus in supporting Open Science, can only be fully exploited if the RO concept is adopted by the community as a professional tool. Clearly this process requires a critical mass of adopters which could not be reached during the 1-year demonstration phase of the project.
2. **User friendliness** - It was not straightforward for the technical partners to develop a friendly VRE GUI, since the VRE users did not have experience in managing and using ROs. Due also to the simultaneous new developments occurring in ROHUB, it took a long time, and many interactions between users and technical partners, to develop a satisfactory VRE GUI. While the final version of the interface was considered easy to use by most users, additional improvements could further facilitate community involvement.
3. **Flexibility** - The flexibility of the platform is measured in terms of how many limitations it can pose to carrying out everyday research work. The provision of Linux and Windows Virtual Machines (VMs),

with full user control and high-end computing power, implies a high flexibility: researchers can develop, upload, run their codes and data analysis procedures in computing environments which are the same, and often more powerful than those available on their desks. The creation and re-use of workflow ROs is also made flexible by the provision of EO data search and access tools, and by two processing options: download and run them in the VMs or run them directly in the VRE using the Workflow Runner tool.

4. **Authorization and IPR protection -** the Single Sign On accounting system, allowing the same user credentials for accessing the VRE, ROHUB, and Seafile, is considered very positive. The management of confidentiality of scientific results is possible through RO settings, as well as the attribution of a Persistent Identifier (DOI) to an Archived RO which the author wants to disseminate. This option in particular is considered very useful in the framework of Open Science implementation, promoting the sharing of data, results and software within the community even before publication. It is also considered very useful for the sharing of grey literature as fully attributed ROs.
5. **Processing tools** - as mentioned above, the user is given the flexibility to process his/her data on powerful Linux or Windows VM systems. After an initial survey of user needs, the main commercial software products needed by our community were selected and installed on all the EVER-EST VMs. They are: Matlab, ENVI/IDL, SarScape, ArcGIS, plus a suite of open products, GMT and Taverna. All this software can be complemented by those personally installed by the different users. For the sharing of scientific codes developed directly by the scientists, the Taverna workflow management environment was provided. In the later stages of the VRE development, the Jupyter Notebook application was tested, providing a friendly and flexible processing environment.
6. **Data access** - this was one important requirement from our community, since at each Supersite a variety of EO data must be open access to all but there is no unique access interface. The data infrastructures of space agencies are all different and require different credentials and data download procedures. The use of a single data access interface as that provided by EVER-EST, for nearly all satellite data types of interest for the Supersites is considered a great improvement which can save much time to scientists. In addition, the integration of data access in the VRE allows documentation of data use for scientific investigations in ROs.

User requirement testing

As soon as the first VRE version was released, INGV started to verify compliance with the user requirements implementing testing procedures based on the four use cases (and their variations) defined in D3.1 (there called User scenarios). The four use cases were chosen among other possible scenarios of use because they represented research/monitoring activities most typically carried out at the Supersites, but also because during their execution the majority of user requirements could be validated.

Since all use cases involve the multiple and dynamic use of various functions and tools of the VRE, in agreement with [8] (section 2), they were validated using testing.

The tables below detail the test results of the four Supersite use cases. Note that the following tables only report the latest verification runs, executed on the more stable version. The tables also report the single user requirements which could be validated during each Test Case. A summary table is also reported with the test results for each user requirement.

Test Case ID	**1**
Test Case Title	**Ground deformation investigation using the SarScape COTS**

Reference to D3.1	Appendix B - Supersites VRC Use Case Scenario
Verification method	Test
Test scope	Test VRE Data access procedure, Seafile storage use and SAR data processing in the VM
Preconditions	SarScape should be installed in the VM
User Role	Operator
Expected Results	Ground deformation maps in ENVI format
Pass /Fail Criteria	Ground displacement maps are successfully generated
Inclusion/Exclusion Points	
Verification steps	1. User logins in the VRE - Supersite portal, and selects the Hawaii Supersite as his area of interest. 2. User opens discovers all the S1 images over Mauna Loa volcano, ascending and descending orbits, using the discovery service in the VRE portal. 3. User selects the data of interest through spatial and temporal queries. 4. User selects the Seafile directory where the datasets will be downloaded and runs the download process. 5. User opens a Windows Virtual Machine using a RDP application. 6. He launches the ENVI COTS in which the SAR processing software SarScape is embedded. 7. User starts by providing in the various interfaces input data files and processing parameter. 8. User discovers and downloads the DEM of Mauna Loa volcano from a web catalogue. 9. User completes the parameter definition and starts the InSAR processing. 10. User opens an ENVI window to check the interferograms created by SarScape, then proceeds with unwrapping and geocoding of final results. 11. User stores the final results in the same area as the input data. 12. From the VRE interface, the user creates a RO with the final results of the processing.
Test Report	
Execution date	11/04/2018
Results	RO URL: http://sandbox.rohub.org/rodl/ROs/mauna_loa_displacement-release/
Pass/Fail	Pass
Remarks	None
User requirements validated during the Test Case	
PASSED: EVER-COM-010, EVER-COM-030, EVER-COL-010, EVER-RE-010, EVER-RE-020, EVER-RE-050, EVER-RE-060, EVER-RE-080, EVER-RE-090, R-RE-150, EVER-RE-160 **FAILED:** EVER-COL-020, EVER-COL-030, EVER-COL-040, EVER-RE-030, EVER-RE-040, EVER-RE-100, EVER-RE-	

140

Test Case ID	**2**
Test Case Title	Ash cloud investigation
Reference to D3.1	Appendix B - Supersites VRC Use Case Scenario
Verification method	Demonstration
Test scope	Test VRE Data access procedure, Seafile storage use and MODIS data processing in the VM
Preconditions	A workflow RO for the Volcanic Plume Retrieval method should exist
User Role	Test
Expected Results	The output parameters of the VPR processing, i.e. the aerosol optical depth, the effective radius, and the columnar abundance of the ash cloud.
Pass /Fail Criteria	The above output parameters are successfully generated
Inclusion/Exclusion Points	
Verification steps	1. User logins in the VRE - Supersite portal, and selects the Iceland Supersite as his area of interest (Eyjafjallajökull volcano). 2. User discovers the input MODIS data using the Data access tool in the VRE portal. 3. User selects the data of interest through spatial and temporal queries. 4. User selects the Seafile directory where the datasets will be downloaded and runs the download process 5. User searches for the VPR procedure workflow RO using the VRE RO Search tool. 6. User finds the VPR workflow RO and uploads the Taverna executable to Seafile. 7. User reads the VPR RO Readme file and prepares the input data (including MODIS and ancillary data) in a compressed archive. 8. User opens a Linux VM and runs the Taverna workflow. 9. When the run ends, the outputs (ash mass, effective radius, SO2 columnar content and aerosol optical depth) are stored in the same VRE storage area where the input data are located. 10. From the VRE interface, the user creates a RO with the final results of the processing, adding documentation.
Test Report	
Execution date	06/10/2017
Results	RO URL: http://sandbox.rohub.org/rodl/ROs/output_20100511_14.05.bundle/
Pass/Fail	Pass
Remarks	None

User requirements validated during the Test Case
PASSED: EVER-COM-010, EVER-COM-030, EVER-COL-010, EVER-RE-010, EVER-RE-020, EVER-RE-050, EVER-RE-060, EVER-RE-070, EVER-RE-080, EVER-RE-090, EVER-RE-110, EVER-RE-120, EVER-RE-150, EVER-RE-160 **FAILED:** EVER-COL-020, EVER-COL-030, EVER-COL-040, EVER-RE-030, EVER-RE-040, EVER-RE-100, EVER-RE-140

Test Case ID	**3**
Test Case Title	Volcano Source Modelling
Reference to D3.1	Appendix B - Supersites VRC Use Case Scenario
Verification method	Test
Test scope	Test re-use of a RO, VSM modelling procedure and Seafile storage use in the VM
Preconditions	A workflow RO for the Volcano Source Modelling (VSM) method must exist.
User Role	Operator
Expected Results	The frequency histograms of the searched models, inversion performances and best-fit model for the volcanic source.
Pass /Fail Criteria	The above output are successfully generated
Inclusion/Exclusion Points	
Verification steps	1. User logins in the VRE - Supersite portal, and selects the Campi Flegrei Supersite as his area of interest. 2. Using the Seafile Uploader the User uploads the deformation data files from his/her desktop PC to Seafile. 3. User searches for "VSM" RO in the VRE. 4. User finds a RO with a study of the volcanic source at Campi Flegrei 5. User downloads the RO workflow 6. User opens a Linux VM to perform volcano source modelling. 7. User opens Taverna and open the VSM workflow. 8. User runs the Volcano Source Modelling SW in the VM. 9. User provides input data and parameters to the VSM interface into Taverna. 10. User selects the spherical source, and the range of the parameter values. 11. User starts the inversion process. 12. User verifies that output results have been generated and placed in Seafile. 13. User creates a new RO including reference to all the input and output files. The VSM executable file is embedded in the RO.
Test Report	
Execution date	18/06/2018
Results	RO URL: http://www.rohub.org/rodetails/vsm_campi_flegrei_20112013-

	release/overview
Pass/Fail	Pass
Remarks	None
User requirements validated during the Test Case	
PASSED: EVER-COM-010, EVER-COM-030, EVER-COL-010, EVER-RE-020, EVER-RE-050, EVER-RE-060, EVER-RE-070, EVER-RE-080, EVER-RE-090, EVER-RE-110, EVER-RE-120, EVER-RE-150, EVER-RE-160 **FAILED:** EVER-COL-020, EVER-COL-030, EVER-COL-040, EVER-RE-030, EVER-RE-040, EVER-RE-100, EVER-RE-140	

Test Case ID	**4**
Test Case Title	The water vapour content investigation
Reference to D3.1	Appendix B - Supersites VRC Use Case Scenario
Verification method	Test
Test scope	Test the algorithm in the WF runner
Preconditions	None
User Role	Operator
Expected Results	ASCII files of water vapour content
Pass /Fail Criteria	ASCII files of water vapour content are successfully generated
Inclusion/Exclusion Points	
Verification steps	1. User signs in the VRE - Supersite portal, and selects the Iceland Supersite as his area of interest (Eyjafjallajökull volcano). 2. User discovers the input MODIS data using the Data access tool in the VRE portal. 3. User uploads them on Seafile 4. Login in the VRE 5. Open map browser and select the area of the Iceland Supersite 6. Open the Data access tool 7. Search MODIS data and upload them on Seafile 8. Search the IPWV algorithm RO and open it in the VRE using the Workflow Runner tool 9. In the WF Runner interface dialog, provide the Seafile URL of the MODIS data as input and run the WF contained in the RO 10. Add the obtained results to a new RO and complete the RO with documentation
Test Report	

Execution date	20/07/2018
Results	http://sandbox.rohub.org/rodl/ROs/IPWV_Iceland_runner-IPWV-on-Iceland-test-results/
Pass/Fail	Pass
Remarks	None
User requirements validated during the Test Case	
PASSED: EVER-COM-010, EVER-COM-030, EVER-COL-010, EVER-RE-020, EVER-RE-050, EVER-RE-060, EVER-RE-070, EVER-RE-080, EVER-RE-090, EVER-RE-110, EVER-RE-120, EVER-RE-150, EVER-RE-160 **FAILED:** EVER-COL-020, EVER-COL-030, EVER-COL-040, EVER-RE-030, EVER-RE-040, EVER-RE-100, EVER-RE-140	

Table summarizing the validation of the User requirements for the Geohazard Supersites VRC

Requirement	Type	Validation method	Result
EVER-COM-010	Mandatory	Test Case 1,2,3,4	Pass
EVER-COM-020	Mandatory	Demonstration through RO: EVER-EST4GSNL@EGU2018, and many other Biblio ROs	Pass
EVER-COM-030	Mandatory	Test Case 1,2,3,4	Pass
EVER-COL-010	Mandatory	Test Case 1,2,3,4	Pass
EVER-COL-020	Mandatory	Test Case 1,2,3,4	Fail
EVER-COL-030	Mandatory	Test Case 1,2,3,4	Fail
EVER-COL-040	Optional	Test Case 1,2,3,4	Fail
EVER-RE-010	Mandatory	Test Case 1,2,4	Pass
EVER-RE-020	Mandatory	Test Case 1,2,4	Pass
EVER-RE-030	Optional	Test Case 1,2,3,4	Fail
EVER-RE-040	Optional	Test Case 1,2,3,4	Fail
EVER-RE-050	Mandatory	Test Case 1,2,4	Pass
EVER-RE-060	Mandatory	Test Case 1,2,4	Pass
EVER-RE-070	Mandatory	Test Case 2,3,4	Pass
EVER-RE-080	Mandatory	Test Case 1,2,3,4	Pass
EVER-RE-090	Mandatory	Test Case 1,2,3,4	Pass
EVER-RE-100	Mandatory	Test Case 1,2,3,4	Fail
EVER-RE-110	Mandatory	Test Case 2,3,4	Pass
EVER-RE-120	Mandatory	Test Case 2,3,4	Pass
EVER-RE-130	Mandatory	Demonstration through RO: InSAR and GPS data of the 2011-2013 unrest at Campi Flegrei (Italy)	Pass
EVER-RE-140	Optional	Test Case 1,2,3,4	Fail
EVER-RE-150	Mandatory	Test Case 1,2,3,4	Pass
EVER-RE-160	Mandatory	Test Case 1,2,3,4	Pass

3.2 Training of the Supersite community

The Research Object concept is potentially able to strongly support Open Science and improve research sharing and re-use. This potential is easily understood in general terms; however, as the EVER-EST scientific partners have learnt during the project, the full adoption of ROs by researchers is not straightforward, due to technological and cultural barriers.

The VRE platform was developed to address the technological issues preventing full RO re-use, and it was designed to require as little training as possible, with a friendly GUI and straightforward logical procedures.

The cultural barrier is exemplified by questions as "why should I use ROs? how could they benefit my work?". These questions can only be convincingly addressed through face to face discussions of use cases of interest to the community, and through dedicated training.

Since project inception, it was predicted that the cultural barriers were going to be the most difficult to overcome and since the early phases of the project, even before the first platform release, the RO concept was gradually being introduced to the community. Until the publication of the stable release of the VRE in October 2017, the training consisted of presentation and dissemination of the VRE and RO concepts, explaining how they could boost Open Science implementation for the GSNL community. From October 2017 onwards, the utilisation of the VRE on real use cases began, complementing the presentations with actual hands-on training courses.

Main scientific presentations and dissemination events

Conference, workshop, event	Session, ad hoc meeting	Title, subject
European Geosciences Union annual conference 2016	Session NH2.3/GMPV7.4/SM7.7 The European contribution to the GEO Supersite initiative, April 18, 2016	Improving the scientific research for the Geohazard Supersites through a Virtual Research Environment: the H2020 EVER-EST Project.
European Geosciences Union annual conference 2016	Session NH2.3/GMPV7.4/SM7.7 The European contribution to the GEO Supersite initiative, April 18, 2016	The GEO Geohazard **Supersites** and Natural Laboratories - GSNL 2.0: improving societal benefits of Geohazard science.
American Geophysical Union Fall Meeting, 2016	Crossing the Globe with Virtual Research Environments, Science Gateways, and Virtual Laboratories Posters, December 14, 2016	Improving Scientific Research for the GEO Geohazard Supersites through a Virtual Research Environment.
American Geophysical Union Fall Meeting, 2016	Splinter meeting of the Geohazard Supersite research community, December 15, 2016	Presentation of the EVER-EST platform and how it will be able to support the GSNL community
European Geosciences Union annual conference 2017	The GEO Geohazards Supersite initiative: improving science uptake in Disaster Risk Reduction, April 27, 2017	Contribution of the EVER-EST project to the community of the Geohazard Supersites initiative
European Geosciences Union	The GEO Geohazards Supersite initiative: improving science uptake	GSNL 2.0: leveraging on Open Science to promote science-based

annual conference 2017	in Disaster Risk Reduction, April 27, 2017	decision making in Disaster Risk Reduction
European Geosciences Union annual conference 2017	EVER-EST Supersite community meeting, April 26, 2017	Technical meeting of the Supersite community members involved in the EVER-EST project. Update on VRE development and RO use.
American Geophysical Union Fall Meeting, 2017	International Collaboration on Environmental Data and Service Infrastructures, Practices, Access, and Technologies, December 15, 2017	The EVER-EST Virtual Research Environment for the European Volcano Supersites
American Geophysical Union Fall Meeting, 2017	Earth Observations in Support of the Sustainable Development Goals (SDGs), the Paris Agreement, and the Sendai Framework for Disaster Risk Reduction, December 12, 2017	From Open Data to Science-Based Services for Disaster Risk Management: the Experience of the GEO Geohazards Supersite Network
New Dimensions for Natural Hazards in Asia: An AOGS-EGU Joint Conference	Natural hazard communications, warning systems and monitoring programmes, February 6, 2018	The GEO Geohazard Supersites Initiative: An Opportunity for Scientific Communities. Mentions the use of ROHUB for data and information sharing.
Meeting at the Instituto Geofisico Escuela Politecnica Nacional de Ecuador, Quito	Ad hoc meeting for the presentation of the EVER-EST platform, March 5, 2018	Presentation of the VRE and description of use cases and potential advantages of EVER-EST
Primera Reunión Operativa Asociación Latinoamericana de Geodesia Volcánica, workshop organized by USGS and SGC in Pasto, Colombia	Presentation of the GSNL initiative and the EVER-EST platform, March 7, 2018	Operational demonstration of use cases and potential advantages of EVER-EST. Detailed training on InSAR processing with EVER-EST. Solicitation to subscribe.
Workshop in Lima with top managers of the Instituto Geológico Minero y Metalúrgico (INGEMMET), Instituto Nacional de Investigación en Glaciares y Ecosistemas de Montaña (INAIGEM), and the Instituto Geofísico del Perú (IGP)	Presentation of the GSNL initiative and its advantages for the geohazard community of Peru, including the EVER-EST platform, March 9, 2018	Description of the potential advantages of EVER-EST for the Supersite community.
European Geosciences Union annual conference 2018	Satellite-based quantification and modelling of volcanic gas, aerosol and ash emission: dispersal and chemical evolution, April 13, 2018	The 03-09 December 2015 Etna eruption volcanic parameters retrieved using Volcanic Plume Removal procedure on EVER-EST project platform

3rd GEO Data Providers Workshop, 2018	Lightning talk on Disasters, May 2, 2018	The GSNL way to Open Science
11th Meeting of the Community of Users on Secure, Safe and Resilient Societies	Theme10: Geological Disasters, June 6, 2018	Presentation of the new Open Science implementation steps for GSNL, including EVER-EST
NextGEOSS Summit, Geneve	Lightning talks from stakeholders on current challenges/ community priorities, June 14, 2018	Open Science implementation for the Geohazard Supersite and Natural Laboratories initiative using the Research Objects concept and EVER-EST.

Hands-on training courses carried out since the VRE stable version was released:

Location	Session	Subject
EVER-EST Plenary meeting in Reykjavik	Training course for Iceland Supersite researchers at the Iceland Meteorological Office, October 12, 2017.	Description of the Research Object and VRE concepts and interfaces. Practical demonstration of two use cases: 1) Retrieval of volcanic plume parameters for the Eyjafjallajökull eruption in Iceland (RO available at: http://www.rohub.org/rodetails/output_20100507_12.35.bundle/overview), and 2) Geodetic data inversion to model a magmatic source at Campi Flegrei (Italy) caldera (RO available at: http://www.rohub.org/rodetails/VSM_CampiFlegrei.bundle-release/overview).
American Geophysical Union Fall Meeting, 2017	Splinter meeting of the Geohazard Supersite research community, December 14, 2017.	Training on the VRE stable release. Creation of workflow RO, re-use within the VRE and in the VM, InSAR data processing in a Windows VM and final creation of a result RO. Practical demonstration of two use cases: 1) Geodetic data inversion to model a magmatic source at Campi Flegrei (Italy) caldera (RO available at: http://www.rohub.org/rodetails/VSM_CampiFlegrei.bundle-release/overview), and 2) InSAR processing of Sentinel-1 data for Mauna Loa (Hawaii, USA) volcano.
Reunión de la Asociación Latinoamericana de Geodesia Volcánica (GEOVOL)	EVER-EST training course, 4 hours, March 7, 2018.	Description of the Research Object and VRE concepts and interfaces. Creation of workflow RO, re-use within the VRE and in the VM, InSAR data processing in a Windows VM and final creation of a result RO.

		Practical demonstration of two use cases: 1) Geodetic data inversion to model a magmatic source at Campi Flegrei (Italy) caldera (RO available at: http://www.rohub.org/rodetails/VSM_CampiFlegrei.bundle-release/overview), and 2) InSAR processing of Sentinel-1 data for Mauna Loa (Hawaii, USA) volcano. The training material is available at: http://www.rohub.org/rodetails/everest_vre_demonstration_at_the_geovol_2018_pasto/overview
European Geosciences Union conference 2018	Annual EGU splinter meeting of the Geohazard Supersites community, April 11, 2018.	Description of the Research Object and VRE concepts and interfaces. Creation of workflow RO, re-use within the VRE and in the VM, InSAR data processing in a Windows VM and final creation of a result RO. Practical demonstration of two use cases: 1) Retrieval of volcanic plume parameters for the Eyjafjallajökull eruption in Iceland (RO available at: http://www.rohub.org/rodetails/output_20100507_12.35.bundle/overview), and 2) InSAR processing of Sentinel-1 data for Mauna Loa (Hawaii, USA) volcano.
INGV headquarters, Rome	Ad hoc training course for the Etna and Campi Flegrei-Vesuvius Supersites community, May 8, 2018.	Description of the Research Object and VRE concepts and interfaces. Creation of workflow RO, re-use within the VRE and in the VM, InSAR data processing in a Windows VM and final creation of a result RO. Practical demonstration of three use cases: 1) Retrieval of volcanic plume parameters for the Etna eruption (RO available at: http://www.rohub.org/rodetails/VPR_results_Etna_20151204_09_45/overview), 2) InSAR processing of Sentinel-1 data for Mauna Loa (Hawaii, USA) volcano, 3) re-use of the VSM workflow RO for geodetic modeling (RO available at: http://www.rohub.org/rodetails/VSM_CampiFlegrei.bundle-release/overview).

At each training event the users showed much interest in the RO concept and in the VRE.

The best appreciated tools in the VRE were different depending on the community. Researchers in countries with limited access to computing resources and commercial software appreciated the possibility of using powerful Virtual Machines to analyse the EO data and model the results. Researchers from more developed countries appreciated the possibility of easy re-use of workflows published in a RO and the option of assigning a DOI to an archived RO. All appreciated the EO data access interface, allowing a single point of access to a variety of SAR and optical data.

3.3 Community usage of the VRE

The dissemination and training events raised the interest in the VRE capabilities and, starting from December 2017, several researchers registered to the VRE. In March 2018 a change was requested in the registration page, since new users for our community could not indicate their work organization (the only option was INGV). The page was modified for new registrants, while old users were automatically requested to provide their work organization separately.

This is the list of active users of the upersites VRC as of August 2018:

No.	Username	Organization	Category
1	User 1	INGV	Scientist
2	User 2	INGV	Scientist
3	User 3	INGV	Scientist
4	User 4	INGV	Scientist
5	User 5	INGV	Scientist
6	User 6	ESI	Scientist
7	User 7	INGV	Scientist
8	User 8	INGV	Scientist
9	User 9	INGV	Scientist
10	User 10	IES	Scientist
11	User 11	INGV	Scientist
12	User 12	IES	Scientist
13	User 13	INGV	Scientist
14	User 14	INGV	Scientist
15	User 15	INGV	Scientist
16	User 16	INGV	Scientist
17	User 17	SERNAGEOMIN	Scientist
18	User 18	IGEPN	Scientist
19	User 19	IGEPN	Scientist
20	User 20	IGEPN	Scientist
21	User 21	INGV	Scientist
22	User 22	SGC	Scientist
23	User 23		Other
24	User 24		Other
25	User 25	IGEPN	Scientist
26	User 26	INGV	Scientist
27	User 27	Goma Volcano Observatory	Scientist
28	User 28	University of Iceland	Scientist
29	User 29	SERNAGEOMIN	Scientist

30	User 30	INGEMMET	Scientist

Most users generated at least one Research Object. The list of ROs generated by the Supersite scientific community is reported in Appendix B.

The community generated ROs belonging to the following four types:

- Bibliographic Research Objects
- Workflow Research Objects
- Data Research Objects
- Result Research Objects

The use of these ROs for different tasks and activities is described below.

3.3.1 Bibliographic Research Objects

One of the basic features of a Geohazard Supersite is the possibility for the scientific community, to access past, present and future scientific information enabling effective re-use of this information. For each Supersite a virtual scientific library must therefore be built and maintained for future reference. The Supersite library should contain all scientific publications (by reference), information on the volcano activity and the monitoring of the various parameters, other relevant information concerning, for instance, past projects which were focused on the volcano, technical reports on the implementation/upgrade of monitoring networks, photo and video material on the volcano, etc.

The community discussed the possibility of generating a RO for scientific publications and decided that such a RO would simply be a duplication of the journal article and it would not be widely used. The only exception could be for historical material, as for instance articles or reports only available as scanned copies, for which the RO provides a good way to facilitate discovery and access.

A RO aggregating all articles ever published for a specific area, theme or event (e.g. an eruption) could be useful to easily access scientific work, however the utility of such a RO would be limited if it were not constantly kept updated with the most recent publications. This can only be effectively done through an automatic procedure and, since this was not implemented in EVER-EST, a decision was taken to avoid generating such ROs.

Grey literature is a good candidate for a bibliographic RO, since it is not normally easily findable and accessible, and also not well documented by metadata. Moreover, these kinds of documents do not normally have public identifiers. By using ROs, this shortcoming can be solved by assigning a DOI when the RO is archived therefore protecting ownership and promoting open access. In this category, organizational documents, reports, project documents, conference presentations, etc. might be included.

To test this concept, several ROs were generated and published, see Appendix B. The usage of such ROs were promoted to disseminate grey literature among the various Supersites and it is expected that in the next few years the number of bibliographic ROs will steadily increase.

An important piece of information for a volcanic area is the periodic monitoring bulletin which most volcano observatories publish when a volcano enters an unrest phase (Figure 1). Some volcano observatories also routinely publish a bulletin on a weekly or monthly basis reporting on the status of the volcano and the value of the monitored geophysical parameters (Figure 2).

During a volcanic eruption, the bulletins are published more frequently and contain more detailed information, directed also to public administrators and the general population.

While these bulletins only contain high level summaries of data analyses and plots of geophysical parameters, and do not list actual measurement values, they are widely used by scientists to follow the temporal evolution of the eruption and the changes in activity.

The Supersite library should provide accessibility to the public bulletins and maintain them in the long-term. To facilitate their re-use, they should be grouped in subsets associated with specific eruption periods.

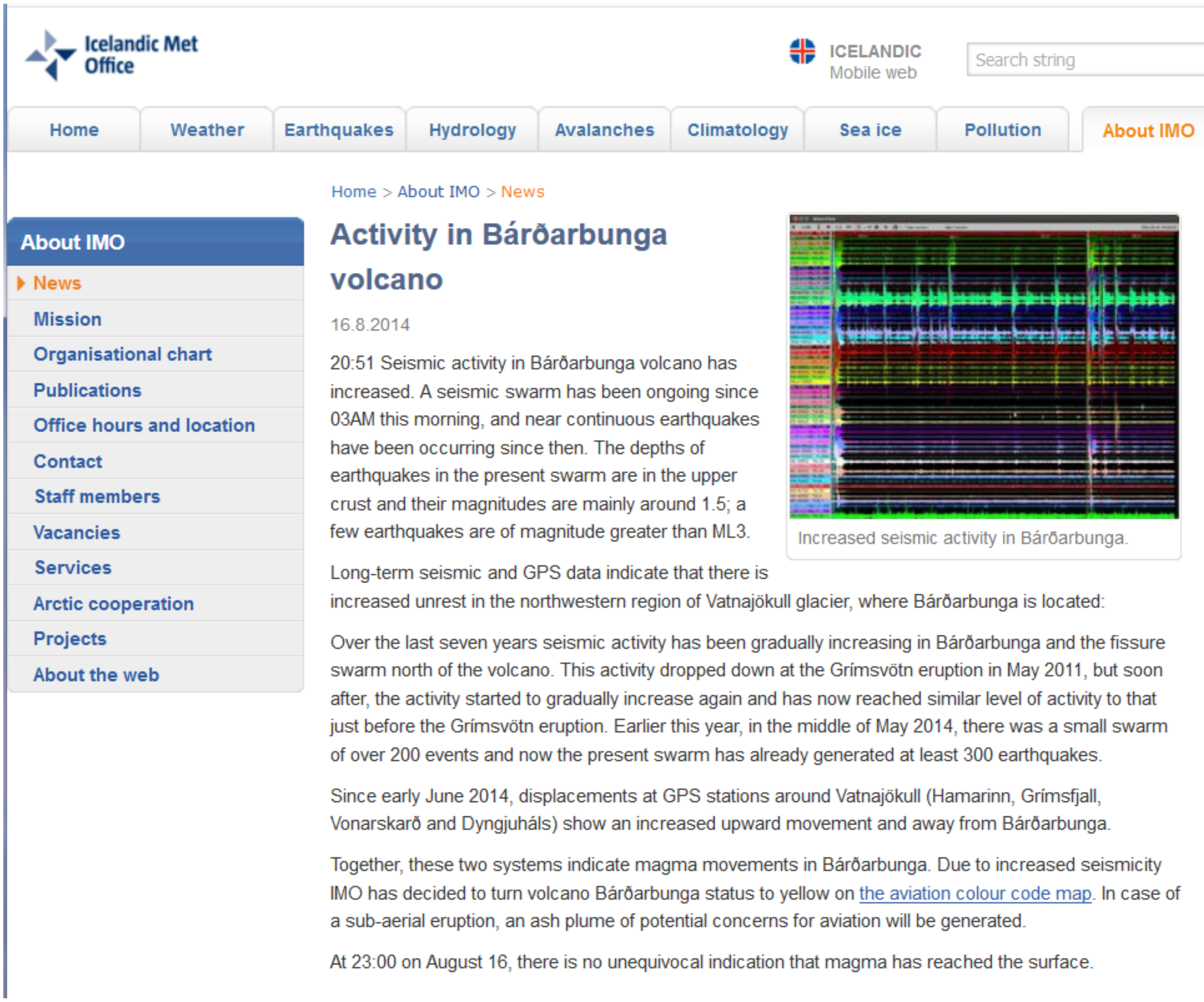


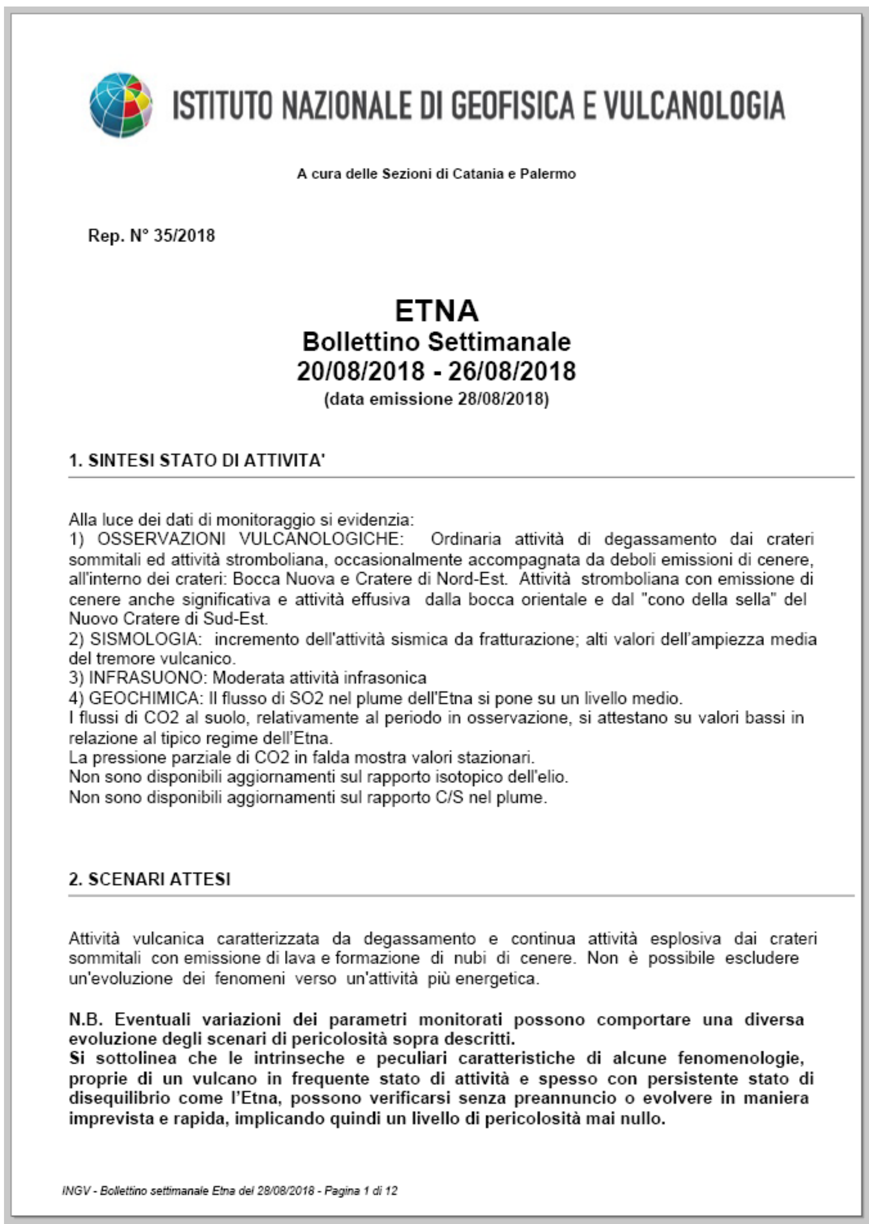
Figure 1 - The information published by the Iceland Meteorological Office when there is unrest at a volcano.

In EVER-EST the RO concept was explored as an option for creating such a library, and tested the generation of a number of bulletin Research Objects (Appendix B) for the Campi Flegrei - Vesuvius

Supersite, for which the information has a good level of detail and is collected in a single PDF document.

Given the scope of the project, it was decided to generate ROs only for volcano information with a level of detail useful for scientific use. The test was thus not applied to the Iceland Supersite since this volcano information is at present only published as a news webpage mostly targeted at the population (Figure 1).

Unfortunately, at present the Campi Flegrei - Vesuvius volcano periodic bulletins are only published in Italian, and this diminishes their usefulness for the international scientific community. This issue, and their publication through web services (which would allow an automatic RO generation), is presently being addressed by the Supersite Coordinator in the framework of the EPOS project and, once this shortcoming is solved, it is planned to create ROs to disseminate the periodic bulletins, enriching them with further metadata.



ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

A cura delle Sezioni di Catania e Palermo

Rep. N° 35/2018

ETNA
Bollettino Settimanale
20/08/2018 - 26/08/2018
(data emissione 28/08/2018)

1. SINTESI STATO DI ATTIVITA'

Alla luce dei dati di monitoraggio si evidenzia:
1) OSSERVAZIONI VULCANOLOGICHE: Ordinaria attività di degassamento dai crateri sommitali ed attività stromboliana, occasionalmente accompagnata da deboli emissioni di cenere, all'interno dei crateri: Bocca Nuova e Cratere di Nord-Est. Attività stromboliana con emissione di cenere anche significativa e attività effusiva dalla bocca orientale e dal "cono della sella" del Nuovo Cratere di Sud-Est.
2) SISMOLOGIA: incremento dell'attività sismica da fratturazione; alti valori dell'ampiezza media del tremore vulcanico.
3) INFRASUONO: Moderata attività infrasonica
4) GEOCHIMICA: Il flusso di SO2 nel plume dell'Etna si pone su un livello medio.
I flussi di CO2 al suolo, relativamente al periodo in osservazione, si attestano su valori bassi in relazione al tipico regime dell'Etna.
La pressione parziale di CO2 in falda mostra valori stazionari.
Non sono disponibili aggiornamenti sul rapporto isotopico dell'elio.
Non sono disponibili aggiornamenti sul rapporto C/S nel plume.

2. SCENARI ATTESI

Attività vulcanica caratterizzata da degassamento e continua attività esplosiva dai crateri sommitali con emissione di lava e formazione di nubi di cenere. Non è possibile escludere un'evoluzione dei fenomeni verso un'attività più energetica.

N.B. Eventuali variazioni dei parametri monitorati possono comportare una diversa evoluzione degli scenari di pericolosità sopra descritti.
Si sottolinea che le intrinseche e peculiari caratteristiche di alcune fenomenologie, proprie di un vulcano in frequente stato di attività e spesso con persistente stato di disequilibrio come l'Etna, possono verificarsi senza preannuncio o evolvere in maniera imprevista e rapida, implicando quindi un livello di pericolosità mai nullo.

INGV - Bollettino settimanale Etna del 28/08/2018 - Pagina 1 di 12

Figure 2 - The first page of the bulletin published weekly by INGV for the Etna Volcano Supersite. View complete bulletin HERE. The bulletin is only published in Italian. INGV plans to generate a Research Object to disseminate the volcano bulletins.

3.3.2 Workflow Research Objects

Since the Geohazard Supersite initiative promotes an Open Science approach to research, the demonstration of the use of ROs for sharing geophysical algorithms and models was considered very important. While the mere sharing of written code through ROs was considered of minor importance, since there are well established alternatives (e.g.; GitHub), the use of workflow ROs to share readily executable software was favoured. There are various possible re-use cases for a RO containing an executable code: a researcher may want to apply an existing algorithm to different data over the same volcano, or he/she may want to study a different area or phenomena, or even modify or integrate the code itself and test its new capacities with the example data included in the original RO. etc.

The platform constraint for implementing an executable workflow was that it had to be run through a Workflow Management System (WMS). During the development of the EVER-EST platform the WMS Taverna Workbench was chosen. Taverna is employed to easily and rationally organize the input/output of personal workflows, to make them reusable and executable with minimum effort, and to facilitate the creation of Research Objects within a clear and straightforward procedure.

Since in the geophysical science domain the use of Taverna (but in general of any WMS) is not very common, this created an initial difficulty for the scientists involved in the project. Once this issue was overcome by self-training and "internal" workflow ROs were created for the use cases defined in [7], difficulties were still encountered in convincing our community to embed codes in Taverna to make them executable as workflow ROs within EVER-EST. The main problem was the investment in terms of human resources (to learn Taverna) which they could not afford.

Thus, only the workflow ROs relevant to the use cases described in [7], plus an additional one describing the dModels inversion code, have been implemented through Taverna. They can be re-used through a direct execution using the Workflow Runner tool in the VRE, or running Taverna in a Virtual Machine.

Three other workflows have been created which do not use Taverna, but can be executed in the EVER-EST Virtual Machines, where the necessary software is available.

The table below shows the main Workflow ROs of the Supersite VRC. Several others have been created based on re-using these ROs with different data or on different locations (see Appendix B).

Title	Description	URL	Taverna (Y/N)	Re-used by RO:
VSM from Taverna - Campi Flegrei 2004-2006	The VSM (Volcano Source Modeling) workflow models ground deformation detected by the most common geodetic techniques (interferometric SAR, GPS, and leveling).	http://www.rohub.org/rodetails/vsm_tav_cf_2004_06_basic-1-release/overview	Y	http://www.rohub.org/rodetails/vsm_campi_flegrei_20112013-release/overview
Volcanic Plume	VPR is a procedure developed to retrieve the ash optical	http://www.rohub.org/rodetails/volcanic_plume_procedure	Y	http://www.rohub.org/rodetails/VPR_results_Etna_201

Retrievals Procedure (VPR) (v.01032018)	depth, effective radius and mass, and sulfur dioxide mass contained in a volcanic cloud from the thermal radiance at 8.7, 11, and 12 µm	_vpr/overview		51204_09_45/overview
IPWV on Iceland	This RO contains a workflow to evaluate the precipitable water content on Iceland using MOD/MYD05 level 2 data satellite data. The RO includes the Taverna workflow.	http://www.rohub.org/rodetails/IPWV_Iceland_new/overview	N	http://www.rohub.org/rodetails/ipwv_on_iceland_31_january_2015/overview
VEM_code_Santorini	This RO contains an application of the VEM code to the 2011-2012 unrest at Santorini volcano. VEM is a code to model the temporal variation in the volume change of a magmatic source surrounded by a viscoelastic shell.	http://www.rohub.org/rodetails/vem_code_santorini/overview	N	
dMODELS for GPS inversion	This RO contains an implementation of the dMODELS inversion code by Maurizio Battaglia. This version allows to model geophysical sources (for earthquakes or volcanoes) by inverting GPS data only.	http://www.rohub.org/rodetails/dMODELS_GPS/overview	N	http://www.rohub.org/rodetails/campi_flegrei_20112012_dmodels/overview
REFIR_code_Eyjafjallajokull	REFIR (Real-time Eruption source parameters FutureVolc Information and Reconnaissance system) is a quasi-autonomous real-time multi-parameter system, that integrates a wide-ranging set of sensors capable of providing information on the eruption source. In this RO it is applied to the eruption of 2010 of Eyjafjallajökull volcano (Iceland).	http://www.rohub.org/rodetails/refir_code_eyjafjallajokull/overview	N	

Three examples of reuse of workflow ROs for different applications are described below.

Reuse of the Volcano Source Modelling Workflow RO

The Volcano Source Modelling (VSM) tool is a FORTRAN software tool developed by INGV, which can be used to model geodetic data from volcanic areas, considering the deformation due to magma input at depth. VSM performs a data inversion to estimate position, depth, shape and volume variation of the magma chamber. All these parameters are of primary importance in order to understand the state of activity of the volcano itself.

The workflow RO containing the VSM tool has been archived and given a DOI to allow citation and attribution of IPRs during reuse. The Archive RO is available at: http://www.rohub.org/rodetails/vsm_tav_cf_2004_06_basic-1/overview, and it has the following DOI: 10.5072/ro-id.JJH3OHNHFG

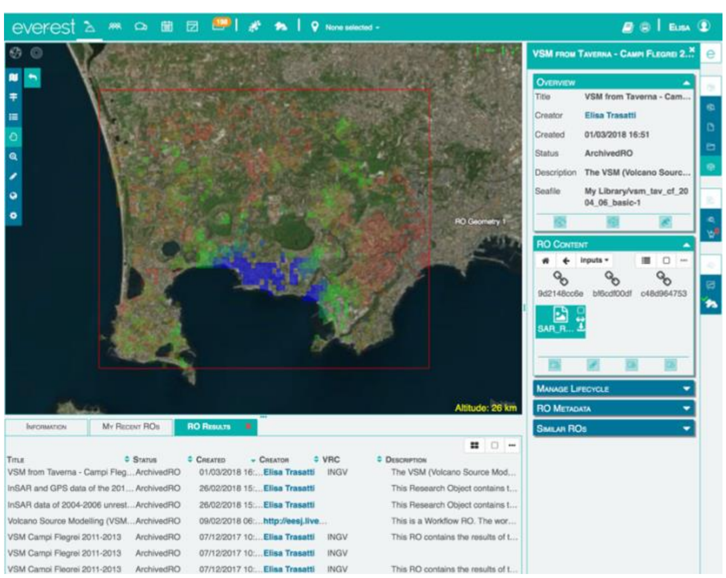
The original RO contains an example of inversion for ground deformation data relevant to the period 2004-2006 for the Campi Flegrei volcano. The inverted datasets were ascending and descending Line of Sight ground displacements from COSMO-SkyMed InSAR time series (source IREA-CNR). The data were modelled with a spherical magma chamber.

The resulting parameters of the modeled source were:

Longitude of center, m UTM	**Latitude of center, m UTM**	**Depth, m**	**Volume, m^3**
425717	4518784	-2923	663259

The source (magma chamber) is located under the town of Pozzuoli, where the maximum uplift was registered during 2004-2006.

The RO contains, in the various folders, all the information needed to reuse the procedure: a file with instructions (HOW_TO_USE_VSM_TAVERNA.pdf, in the documents folder), the Taverna Workflow (workflows folder), example datasets (datasets/inputs folder) and the bibliography (biblio folder).



The VSM RO content opened in the VRE. The map shows the 2004-2006 InSAR ground deformation used by the RO.

During the demonstration, the VSM RO was reused to model more recent (2011-2013) InSAR ground displacements from the same volcano, and also GPS site displacements.

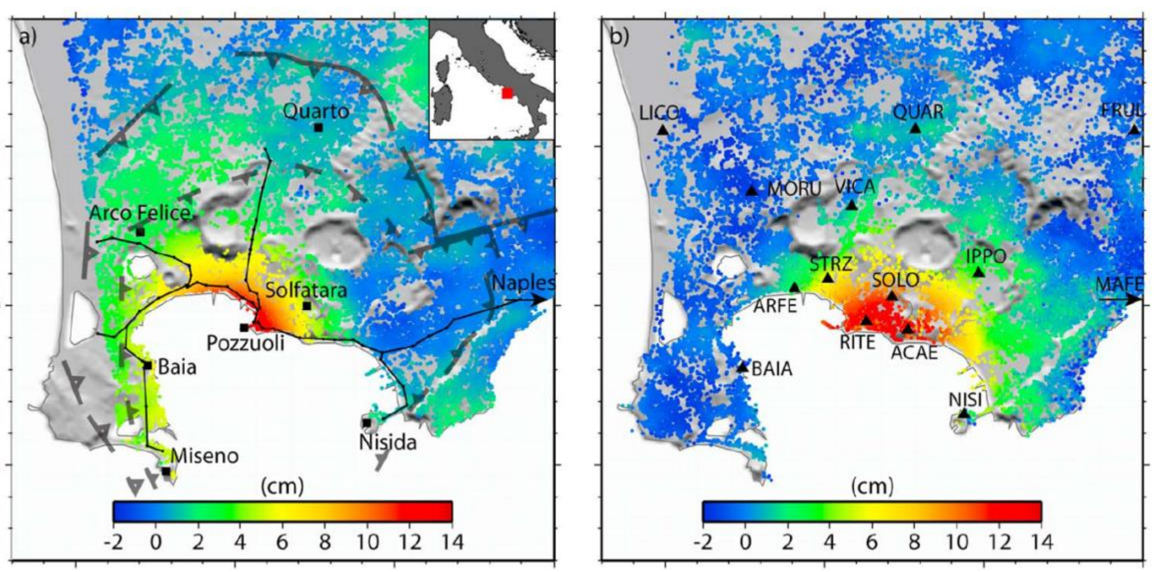
Reuse procedure:

The user discovers the VSM RO for the 2004-2006 source model in the VRE, and decides to invert new data using the same procedure in order to investigate the evolution of the magma chamber and monitor the volcanic activity. The user then accesses the documentation in the RO (HOW_TO_USE_VSM_TAVERNA.pdf file), in order to learn how to execute the VSM procedure.

Since the VSM RO contains a Taverna file (t2flow), the workflow can be run in the Workflow Runner Tool of the VRE. Running a RO in the WF Runner implies that the input and output data can be easily mapped through a global URI, and the creation of the Result RO is straightforward at the end of the execution.

Outside of the VRE, the user prepares the input files for the modeling, formatting the Campi Flegrei GPS and InSAR 2011-2013 data and inversion parameters. The user then uploads these files in his/her Seafile personal area as a single .zip file, and obtains the following Direct Download global URL: http://box.everest.psnc.pl/f/1abec2be38/?raw=1.

For reference, the input data (but not the parameters) are also collected in a RO: http://www.rohub.org/rodetails/InSAR_GPS_Campi_Fregrei_2011_2013-release/overview (DOI: https://doi.org/10.5072/ro-id.LZ743KUH7Q). The data RO also contains visual maps of the data, shown below.



InSAR ground displacements in 2011-2013 at Campi Flegrei volcano. Left - ascending orbit, right - descending orbit datasets. The triangles on the right show the GPS stations.

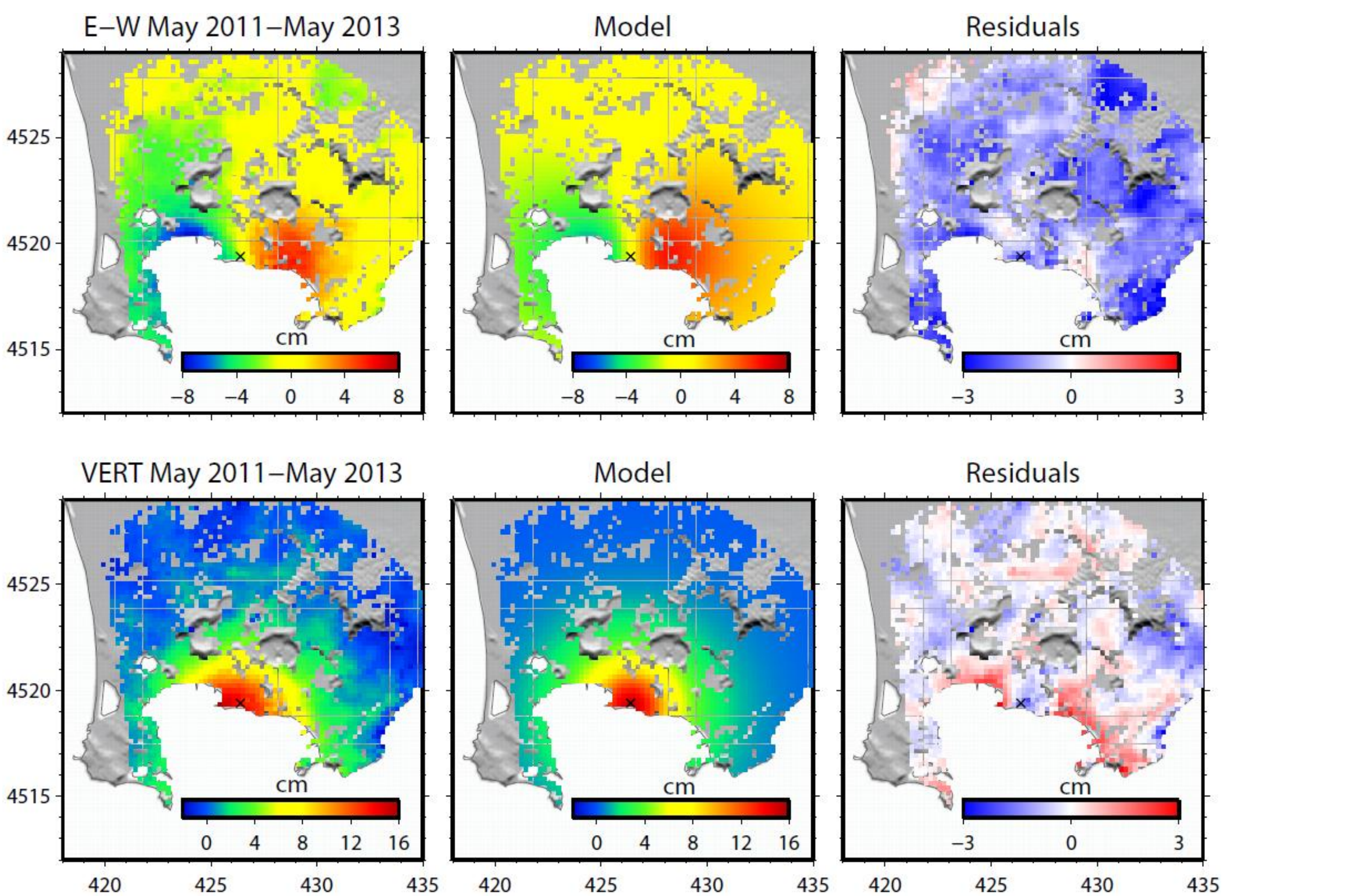
With the VSM 2004-2006 RO opened in the VRE, the user selects the WF Runner button; the application recognizes the presence of one or more executable Taverna files (extension: .t2flow), and opens some dialog boxes where the user first selects the t2flow executable of the VSM RO, and then the FORTRAN executable (https://box.everest.psnc.pl/f/357cf0b776/?dl=1) and the input .zip file (https://box.everest.psnc.pl/f/0ae03201cfab4ff0be8b/?dl=1). The user then executes the WF Runner service.

At the end of the program execution the user clicks on the Outputs tab to check all the resulting files. The inversion produced a best fitting source which has a slightly different location than the one modeled in the original RO, but a large volume difference:

Temporal span of inverted data	Center longitude, m UTM	Center latitude, m UTM	Depth, m	Volume, m^3
2004-2006	425717	4518784	-2923	663259
2011-2013	426310	4518794	-2657	1738375

The result shows that the location of the magmatic sources is very similar, having only about 600 m difference along the East. The depth is also very close and within the model uncertainties. The source volume associated with the two periods is different, due to the different amount of deformation observed. Thus the main result of the research is that there is an increase in magma accumulation in the same magma chamber.

The output files of the modeling can be inspected on the VRE using the embedded file viewer (pdf, png, jpeg, txt, csv files), downloaded, or visualized offline, as shown below.



Observed (left column), modeled (central column) and un-modeled residual (right column) of the surface deformations observed at Campi Flegrei during 2011-2013. Top row refers to the E-W horizontal ground displacements, bottom row to the vertical displacements.
The cross shows the location of the volcanic source modeled by the VSM inversion at a depth of 2600 m below the town of Pozzuoli.

Finally, the user saves the output .zip file in Seafile and creates a new RO to document this research, listing his/her data and results.
This RO is available at:
http://www.rohub.org/rodetails/vsm_taverna_campiflegrei_2011_2013/overview.

Reuse of the Volcano Plume Retrieval Workflow RO

The workflow RO containing the Volcanic Plume Retrieval Procedure (VPR) (v.01032018) (http://www.rohub.org/rodetails/volcanic_plume_procedure_vpr/overview) contains customized parameters for MODIS data analysis over the Etna (Italy) and Eyjafjallajökull (Iceland) volcano Supersites.

The VPR is used to calculate the optical depth, effective radius and mass of volcanic ash in a volcanic cloud (plume), and the sulfur dioxide mass. These observables are estimated through the thermal radiance at 8.7, 11, and 12µm bands measured by sensors on board satellites.

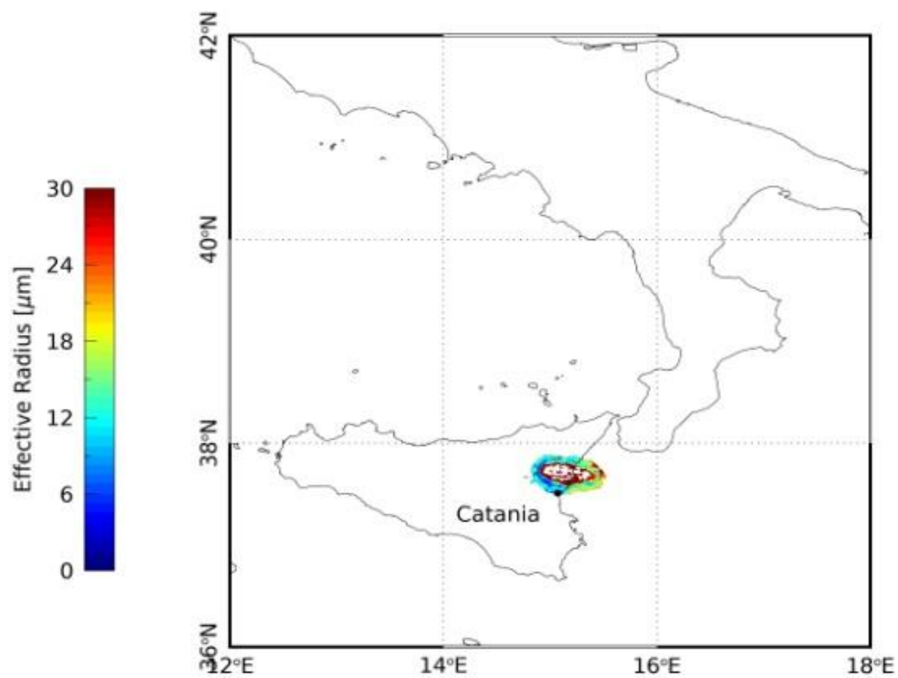
The plume altitude is the only input parameter required to run the procedure, while surface emissivity, temperature, atmospheric profiles, ash optical properties, and radiative transfer models are not necessary to perform the atmospheric corrections. The best results are obtained when the surface under the plume has a uniform radiance.

The user can find all the information needed to reuse the procedure in the different RO folders: a readme file with instructions (documents folder), the Taverna Workflow (workflow folder), example datasets (dataset/input folder) and the bibliography (biblio folder).

This RO was reused to analyze MODIS data to investigate the Etna volcano plume emitted on December 4, 2015 associated with one of the biggest lava fountains which occurred at the Etna volcano after 2011, during the 3 - 9 December 2015 eruption. The RO was accessed using the VRE and the workflow was re-run in an EVER-EST Linux VM, accepting as input the MODIS granule of 2015_12_04_09.45.

To reuse the RO and run the VPR using different satellite data the user followed the steps described in the readme file (http://box.everest.psnc.pl/f/e48f264537/).

The result of the run was stored in another RO named VPR_results_Etna_20151204_0945 (http://www.rohub.org/rodetails/vpr_result_etna_20151204_09_45/overview). Here the Outputs folder contains a link to a compressed file containing all the resulting maps of the ash and SO2 estimated by the procedure. As an example, the figure below reports the Effective Radius of the ice particles estimated from the MODIS image of December 4, 2015 at 09.45.



Effective Radius of the ice particles estimated by the VPR procedure from the MODIS image of December 4, 2015 at 09.45.

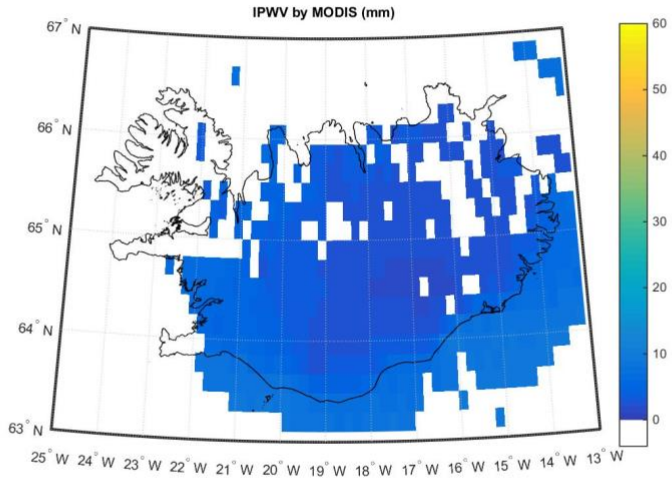
Reuse of the IPWV Workflow RO

The workflow RO containing the Integrated Precipitable Water Vapor Procedure (IPWV) (http://www.rohub.org/rodetails/IPWV_Iceland_new/) performs a MODIS data analysis to estimate the columnar IPWV in mm for each image pixel.

The user can find all the information needed to reuse the procedure in the different RO folders: a readme document with instructions, the Taverna Workflow (workflows folder), example datasets (dataset/input folder) and other information (hypothesis and conclusions).

The RO includes the Taverna workflow (with extension .t2flow) to process MODIS MOD/MYD05 level 2 data. The workflow can run on a Linux OS; it requires as input a link to a MOD/MYD05 file; the code produces ascii files containing IPWV values in mm at the resolution of 0.2 degrees and quick look maps of precipitable water.

This RO was reused to calculate the water vapor concentration over Iceland on 31 January 2015 (http://www.rohub.org/rodetails/ipwv_on_iceland_31_january_2015/overview/). The data were derived from the MODIS acquisition at 12:25 UTC. The compressed file output20150131_1225.zip in the *results* folder contains three ascii files and one quick look image. The ascii files report latitude, longitude and water content at the spatial resolution of 0.2 deg, plotted in the figure below.



Columnar water content over Iceland on January 31, 2015, calculated by the IPWV procedure using MODIS data.

3.3.3 Results and Data Research Objects

Typical uses for a RO are the dissemination of research results (Research Product RO) or data (Data centric RO). These two RO types, however, must not be used to duplicate the information which is already effectively distributed through well-established methods, as peer-reviewed scientific publication and digital data portals. They should be used instead to complement them, providing a more effective dissemination of information associated with both datasets or scientific papers. Within our community these RO types were used to document research results belonging to one of the following three cases:

A. dissemination of data or research results prior to publication. For instance, when there is a volcanic crisis and the researchers collaborate to provide scientific products to support the Crisis response. In this case, the GSNL initiative encourages the scientists to share their data and results with the community even before they are published. The possibility of ensuring a traceability of the authorship using an Archive RO with a DOI can support this process. An example of this use is provided by this RO:

   http://www.rohub.org/rodetails/coseismic_displacement_leyte_philippine_eq_6_july_2017-release/overview

B. dissemination of data or digital material which is not distributed in other ways (through journals or data portals). Even if most scientific journals provide a way to associate additional material with an article, such material is normally only an additional document listing some data or providing additional figures. It does not contain digital material in a structured, searchable and re-usable way, as a RO can do. In the case of data, it is sometimes important to provide reference to a complex, multidisciplinary dataset used during an experiment or investigation, so that other scientists could easily access the same data to reproduce the same results. An example of this use is provided by the following RO:
   http://www.rohub.org/rodetails/Colli_Albani_InSAR_1992_2010-release/overview.

The RO above contains digital material (InSAR displacement data) used in a published scientific paper on volcano source modelling, and it is cited within the journal article so that the readers can collect the data through the RO: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2017GC007303

C. dissemination of data or results which for any reason have not (or cannot) be published. Sometimes when a scientific investigation or experiment produces negative (or null) results, scientists or journals may not consider them worthy of publication. Still, negative results can be of interest to many, for instance to prevent other scientists repeating the same experiment or investigation. The same can happen with very local or small datasets. A RO could be an effective way to publish these results attributing authorship and allowing citation through a DOI. An example of this use is provided by these ROs: http://www.rohub.org/rodetails/vpr_eyja_20100509_1415/overview, http://www.rohub.org/rodetails/campi_flegrei_20112012_dmodels/overview

4 Compliance to Smart Objectives and Key Performance Indicators

4.1 Smart Objectives

The Smart Objective #2.4 is relevant to the GEO Supersite community (Table 7).

SM_OB#2.4	Validate and demonstrate the VRE functionalities within the GEO Supersites VRC
Measured by	Number of users reached (around 100 researchers) and positive feedback received; increased use of EO/in situ data and science products by users; assessment of VRE usability performances through ad hoc metrics.
Achievable	VRE validation using two INGV Supersites. VRE demonstration by entire GEO Supersite community.
Relevant	Globally distributed community and local Disaster Risk Reduction users will ensure a comprehensive test of research product generation and uptake by users.
Timely	Each VRC will receive proper training on the VRE functionalities during the first phase of the project. The VRC will be able to use the VRE services starting from M18 and eventually request changes and adaptation.

Table 1 GeoHazard Supersites VRC Smart Objective

The compliance to the Smart Objective is measured against: number of users for the VRC, feedbacks received, increased use of data and products, assessment of VRE performances.

Number of Users

As described in section 3, during the validation and demonstration phases, 29 researchers were involved in the use of the VRE and in the generation and re-use of ROs. A few more did not register on the VRE but have become users of the VM processing services by sharing the access to the VM with a registered colleague in their institute (e.g. the users from the Colombian Geological Service, see feedback table below). We were not able to reach the number of 100 users for the reasons explained below.

A first issue was due to the novelty of the Research Object approach and the difficulties faced by researchers in appreciating the possible innovative use of ROs in their work routine. Even if the general RO concept was seen as potentially very effective to promote information exchange and Open Science, the advantages with respect to what is already available to the community (as scientific publications, data infrastructures, academic social networks, etc.) was not immediately clear. The learning curve to achieve full knowledge of the possible RO uses is still considered steep by a normal Earth scientist. In addition, the willingness of a researcher to start using ROs on a routine basis is strongly dependent on how popular their use is by the entire community, as was shown by previous projects.

Finally, the mere fact of promoting the use of ROs through a VRE developed within a project was a difficulty. During the training and dissemination events, most scientists asked what was the prospective sustainability of the VRE platform at the end of the project, and the lack of a long-term support discouraged many from investing their time in learning, not only how to operate the VRE, but also how the ROs could support their activities.

Feedback from the users

Feedback was requested to all users; the replies are shown below.

User name	Role	Main activities carried out in the VRE and in the VM	Evaluation of the services used (VRE and VMs)
Jorge Alpala	Researcher at Colombian Geological Service - Volcanological and Seismological Observatory of Popayán	SAR data processing for monitoring of volcano deformation in Puracé, Sotará and Nevado del Huila volcanoes.	The VM is a very useful service that has allowed me to start making interferograms of the volcanoes that we monitor in our area of influence and has a very user-friendly interface
Rosa Alpala	Researcher at Colombian Geological Service - Volcanological and Seismological Observatory of Popayán	SAR data processing for monitoring of volcano deformation in Puracé, Sotará and Nevado del Huila volcanoes.	The VM is a very useful service that has allowed me to start making interferograms of the volcanoes that we monitor in our area of influence and has a very user-friendly interface
Milton Ordoñez	Researcher at Colombian Geological Service - Volcanological and Seismological Observatory of Manizales	SAR data processing for monitoring of volcano deformation in Nevado del Ruiz, Cerro Machin, Santa Isabel, Tolima, Cerro Bravo, Santa Rosa, Quindio and El Esondido volcanoes.	The VM is a very useful service that has allowed me to start making interferograms of the volcanoes that we monitor in our area of influence and has a very user-friendly interface
Alejandra Tapasco	Researcher at Colombian Geological Service - Volcanological and Seismological Observatory of Manizales	SAR data processing for monitoring of volcano deformation in Nevado del Ruiz, Cerro Machin, Santa Isabel, Tolima, Cerro Bravo, Santa Rosa, Quindio and El Esondido volcanoes.	The VM is a very useful service that has allowed me to start making interferograms of the volcanoes that we monitor in our area of influence and has a very user-friendly interface
Cristian Lopez	Researcher at Colombian Geological Service - Volcanological and Seismological Observatory of Manizales	SAR data processing for monitoring of volcano deformation in Nevado del Ruiz, Cerro Machin, Santa Isabel, Tolima, Cerro Bravo, Santa Rosa, Quindio and El Esondido volcanoes.	The VM is a very useful service that has allowed me to start making interferograms of the volcanoes that we monitor in our area of influence and has a very user-friendly interface
Lourdes Narváez	Researcher at Colombian Geological Service - Volcanological and Seismological Observatory of Pasto	SAR data processing for monitoring of volcano deformation in Galeras, Azufral, Cumbal, Doña Juana, Animas, Chiles and Cerro Negro volcanoes.	The VM is a very useful service that has allowed me to start making interferograms of the volcanoes that we monitor in our area of influence and has a very user-friendly interface
Dario Arcos	Researcher at Colombian Geological Service - Volcanological and Seismological Observatory of Pasto	SAR data processing for monitoring of volcano deformation in Galeras, Azufral, Cumbal, Doña Juana, Animas, Chiles and Cerro Negro volcanoes.	The VM is a very useful service that has allowed me to start making interferograms of the volcanoes that we monitor in our area of influence and has a very user-friendly interface
Nikos Svigkas	Post doc at INGV-ONT, Roma, Italy	Use of the EVER-EST VRE for sharing research results.	The creation of a Research Object is straightforward, quick and intuitive. It is easy

		InSAR data processing in the VM.	to locate a Research Object and understand what it is about through the description shown at the search results. The platform can be used as an on-line archive of my research, which can be very easily accessible also from other colleagues within the community. The ability to attribute a DOI to a Research Object helps protecting my work and can be used for any further reference. I used the Windows VM to process InSAR data (Sentinel-1, ALOS-2) over Iran, the Philippines, Turkey, Greece.
Santiago Aguaiza	Researcher at the Instituto Geofisico Escuela Politecnica Nacional, Quito, Ecuador	Access to InSAR images for the Ecuadorian volcanoes from the VRE. SAR data processing using SarScape in the VM.	I found the processing service with the VM and the software provided very fast and powerful. I saved time because with my normal PC could take days for processing. Email service is also good to be informed about downloading process (success or failure). I suggest to improve the downloading service. We had problems because there were many incomplete or failed images downloads.
Aram Fathian	Researcher at RWTH Aachen University, Germany	SAR data processing for the Azgeleh earthquake of 12 Nov 2017 (Iran-Iraq border), and the Shonbeh earthquake of 9 Apr 2013 (southwestern Iran) using SarScape in the Windows VM.	I had the opportunity of getting access to the license of SarScape, an efficient commercial software for SAR data processing, I managed to process huge amounts of data in a way much faster than before. This is very crucial for me as I am processing time-series SAR data demanding high performance computation and large capacity of storage. The storage limit remained an issue and I have problems to set data stacking to a large amount. Also, transferring the data and results–with a size of around 2TB– to the Seafile cloud is another issue. This process is quite time-consuming. Apart from the storage issue I would evaluate the entire platform and VM as an outstanding experience for me, it has been of high contribution to my research so far and I appreciate it very much.
Cristiano Tolomei	Researcher at INGV-ONT, Italy	SAR data processing for volcano source modeling in Mexico and Central Italy, using the SBAS and PS approaches.	I find the processing service provided with the VM very useful for my work. The possibility to have high computational capabilities and work via remote connection is very useful. I find the possibility to create a Research Object describing my research very important because it is possible to share results with other colleagues and to distribute the obtained processing outputs even if not yet published, by associating to them a DOI. For improvement, I suggest to increase the storage capacity so as to allow multi-temporal InSAR processing in a faster and easier way.
Marco	Researcher at the Instituto Geofisico Escuela Politecnica	InSAR processing for crustal deformation analysis in the andean volcanoes within the	In the last decade, Ecuador has experienced an increase in the activity of several volcanoes, which represents a threat for towns and cities

Yepez	Nacional, Quito, Ecuador	Ecuadorian territory. SAR data searching and downloading through the Ever-Est portal. Data processing, interferogram generation and modeling using SarScape in the virtual machine.	around them. The use of the InSAR technique for volcano monitoring and analysis in Latin America is very limited due to technological and educational issues. The use of the virtual machines and the support of Ever-Est staff, make it possible the knowledge broadcast about the InSAR technique. The software available in the VM, is very useful and is a powerful tool for data processing, analysis and modelling. The creation of Research Objects allows to quickly find the data as well as to organize the results obtained at the end of the processing.

Increased use of data and products

While it was impossible to quantitatively verify this parameter for all users, for those in Ecuador and Colombia, the VMs processing services provided through the EVER-EST platform were the first possibility to start processing satellite InSAR data by themselves (i.e. no data were processed beforehand). Now they process on a routine basis tens of Sentinel 1 SAR images per month over several active volcanoes.

Moreover, based on the feedback received, and our own experience, users do appreciate the possibility of accessing a variety of satellite data from a unique interface (Data access tool) and the integration of the simple data access GUI with the RO and processing services, providing a unique and effective working environment which is extremely well appreciated.

Assessment of VRE performances

The performance of the VRE for the needs of the Supersite VRC was validated by the Etna and Iceland Supersite scientists using the four Use cases (section 3.1) and then during the demonstration phase the users generated several ROs and research products using the VRE and VM services. During this period we identified some issues with the performance of the Windows VMs, and requested the provision of VMs with better computing capacities. After this improvement, the users were very satisfied.

4.2 Compliance to Key Performance Indicators

The table below shows the values of the KPIs for the Supersite VRC at the date of this report.

ID	Key Performance Indicators	Target	Value
1	Number of user requirements successfully addressed	Mandatory Requirements : 95%	16/19 → 94%
		Optional Requirements: 85%	0/4 → 0%
2	Percentage of VRC requested Earth Science data collections discoverable through the VRE (e.g. data collections from: Sentinel-1, Sentinel-2, Sentinel-3, Landsat-8, MODIS, data from marine campaigns, in-situ data collections, etc.)	90%	11/11 → 100%

3	Number of the Earth Science data products used by the VRCs within the VRE	More than 10000	
4	VRE versatility - Percentage of implemented types of executable resources (R, Matlab, Maxent, ArcGIS, Fortran, IDL, Python, C/C++, Java, etc.)	90 %	5/5 → 100%
5	Number of ROs implemented in Earth Science (Golden Exemplar, VRC ROs)	GE: 8	GE:8
		VRC ROs: 500	VRC ROs: 259
6	Average of Golden Exemplar and VRC ROs	GE: 90% - Automaticallty Generated RO: 90%	GE: 100% - VRC: 60%
		Automaticallty Generated RO: 90%	
7	Number of ROs viewed/downloaded/re-used	Viewed: 100% GEs, 40% AROs (automatically generated)	N/A
		Downloaded: 80% GEs, 25% AROs	N/A
		Forked via Rohub: 25% ROs Re-executed via VRE portal:50%	N/A
8	Number of registered/active VRC - VRE users	Registered: 100	30
		Active: 30 (10 EU + 20 extra-EU)	10

Table 2 Assessment of KPIs for the Supersite VRC

5 Appendix A – Supersites VRC User's manual

everest

VRE user's manual for the

Geohazard Supersites Research Community

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Table of Contents

Introduction to the use of the VRE and the Research Objects

Virtual Research Environments (VRE) - also called Virtual Laboratories or Science Gateways - are community-oriented digital systems designed to help scientists collaborate and pursue common scientific goals. As such, they are one of the enabling pillars of the Open Science paradigm.

The EVER-EST VRE has been developed to support (among others) the scientific community gathered around the GEO Geohazard Supersites and Natural Laboratories (GSNL) initiative (www.geo-gsnl.org). It provides a set of digital services which allow scientists to share data, results, knowledge and workflows, to use high performance processing capacities, to document all the components of their research in a structured way exploiting the Research Object (RO) concept. It also allows to assign Digital Object Identifiers (DOI) to proprietary research work, providing one of the preconditions needed to establish a trustworthy collaboration within a globally dispersed scientific community.

The main functions of the VRE are explained below.

5.1 Data discovery

EVER-EST provides an interface to access satellite Earth Observation (EO) data from a variety of sources (at present Sentinel-1 and MODIS, for our community), and store them in a personal area in the cloud (managed by the *Seafile* file-hosting application) for subsequent processing.

5.2 Data analysis

EVER-EST grants the authorised user access to a Linux or Windows Virtual Machine (VM) already configured with commercial software packages and compilers needed to perform the most common EO data analyses used by the GSNL community[1]. The user can install and run his/her own codes in the VM, taking also advantage of the Taverna workflow management system to make the code easily reusable by others. The user can also upload, modify and execute existing workflows which have been saved as Research Objects (ROs).

[1] As of April 2018, Matlab, Fortran, Taverna, ENVI/IDL are installed on the LINUX VM. On the WINDOWS VM, ENVI/IDL and SARscape are installed.

5.3 Documentation for knowledge sharing and attribution

The EVER-EST VRE provides interfaces to access and create Research Objects as a way to facilitate knowledge sharing and proper attribution. The concept of Research Object was developed by Bechhofer et al. (2010), and successively expanded through demonstration and practical use in various scientific disciplines (see www.researchobject.org).

ROs are aggregations of resources that bring together data, methods, results and people to document scientific investigations. They are used to encapsulate knowledge and provide a structured mechanism for sharing and reusing it. The content of a RO could be for instance:

- a set of scientific articles and/or grey literature reports/bulletins concerning a specific subject, event and/or area (e.g. all material describing a specific eruption in one of the volcano Supersites);
- an aggregation of different datasets used for a specific experiment (to facilitate data sharing and reuse);
- a complete representation of a processing workflow, including the input data, the executable code, the output results, information on the workflow procedure, information on attribution and provenance of the research (using e.g. a DOI and the researcher's ORCID ID).

In EVER-EST, users have an interface to create a RO, to reuse an existing workflow-centric RO, and in general to search and display the content of any RO. To fully manage the RO metadata and all its properties, the user needs to use an external resource: the ROHUB portal (www.rohub.org), which provides access to the RO database and to the complete set of RO management functions.

The full exploitation of the RO potential by the Earth Science scientific community is one major goal of the EVER-EST project, and is an important step towards the implementation of the Open Science paradigm in the GEO-GSNL initiative and elsewhere.

5.4 Manual structure

This manual is organized as follows: Section 2 provides a description of the main components of the VRE, Sections 3, 4, and 5 provide three different examples of use of the VRE during a scientific investigation, Section 6 is common to all use cases and provides guidance to RO creation and management.

To a new user it is suggested to start from the description of the use cases, and to use Section 2 as a reference to the different components.

Please provide your feedback and suggestions for improvement to the contacts listed at the end of this manual.

6 High level description of the VRE components

6.1 The Graphical User Interface (GUI)

At the address https://vre.ever-est.eu/supersites/ you can access the EVER-EST GUI customized for the Supersite community. The use of the Chrome browser is strongly suggested to avoid malfunctions and it is advisable to set a small character size in your browser.

The GUI has three main panels: the 'Virtual Globe Panel' in the center, the 'Information Panel' right below it, and the 'Command Panel' on the right, see the Figure below.

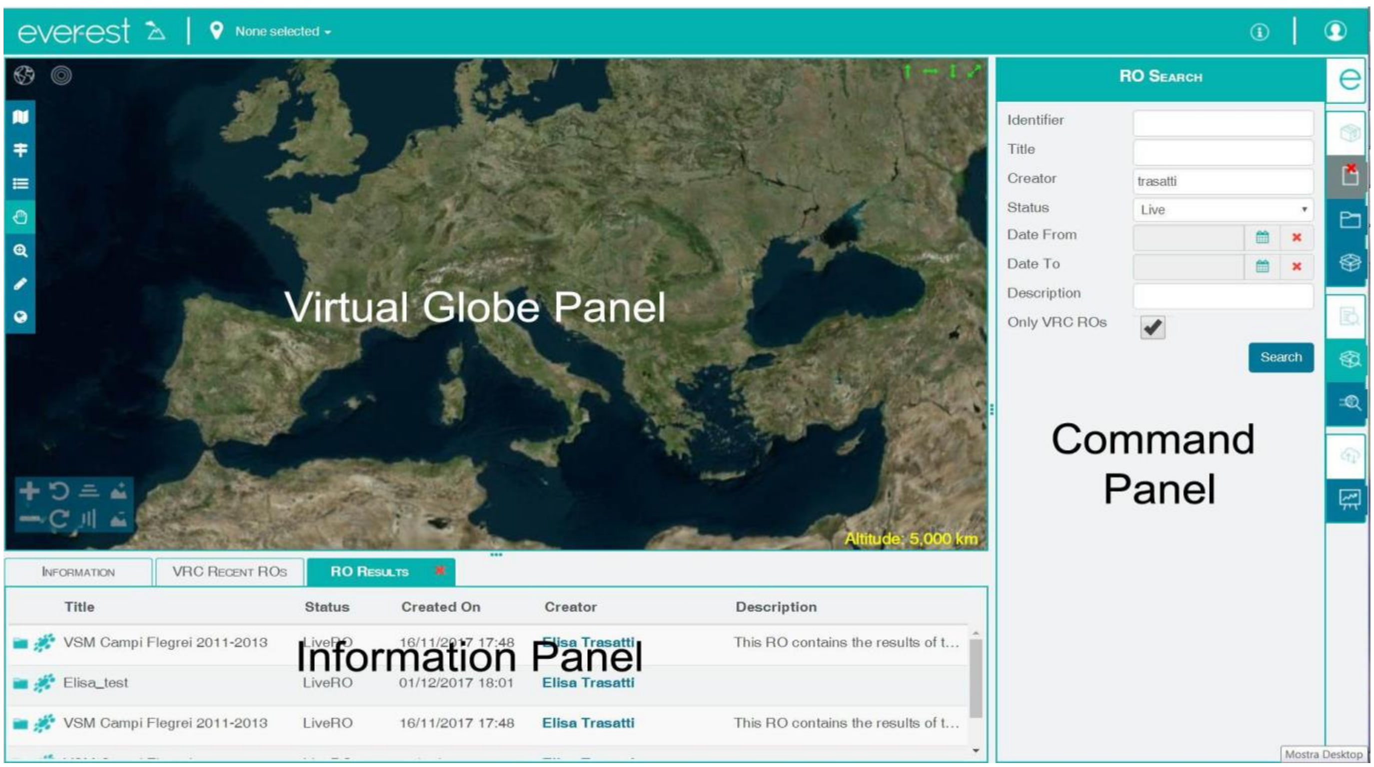


Figure 1- EVER-EST GUI

If the user is not logged in, he can only search ROs, visualize their content, and perform search and discovery of satellite imagery[2].

[2] As of April 2018, only Sentinel-1 and MODIS are supported.

After logging in the VRE, the 'Top menu' appears and more services become available to the user in the 'Command menu', see all the menus in the figure below.

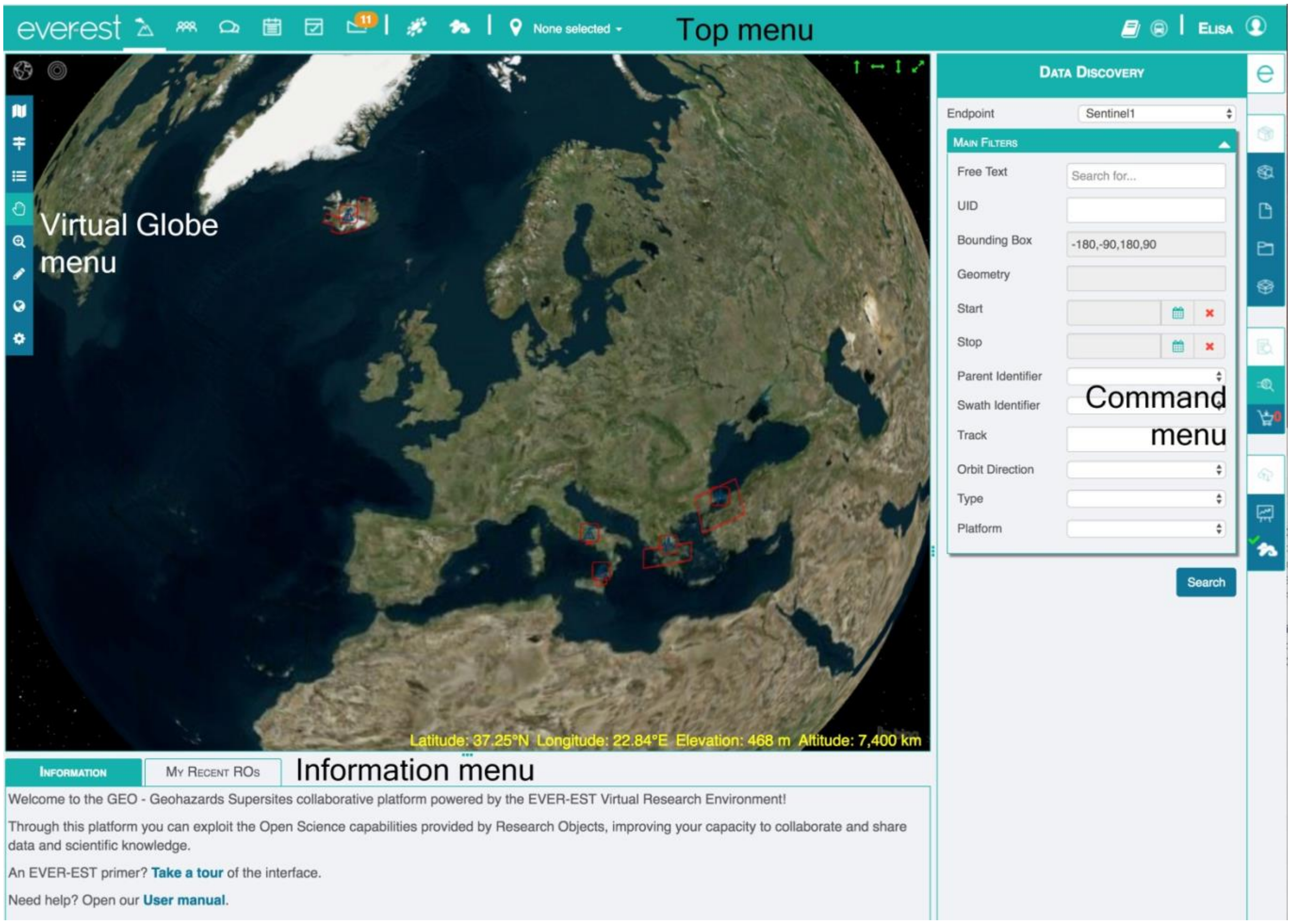


Figure 2- EVER-EST GUI with full menus

6.2 Registration and authentication

When connected to the **Supersite VRE** site at https://vre.ever-est.eu/supersites/, the user can access the authentication page by clicking on the icon at the top right corner (see the Figure below, left panel).

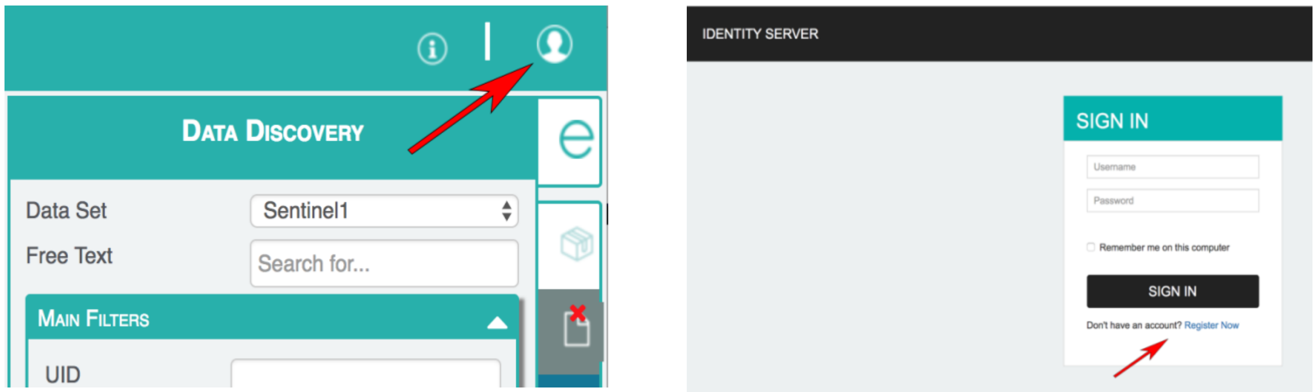


Figure 3- Authentication and registration to the VRE - Left figure: access to login page. Right figure: sign in page.

On the authentication page an existing user can sign in with his credentials, while a new user needs to register by clicking the appropriate link. In the latter case a registration page opens, requesting the information needed to set up the new account. NOTE: we will need to keep the number of accounts compatible with an effective use of the cloud resources, and delays can occur.

Once authorized, the user holds an **EVER-EST id** and can login into the VRE.

The VRE uses the *Single Sign On* technology, i.e. the registered EVER-EST credentials can be used to access the other VRE components: *Seafile*, Rohub and the Collaboration Sphere. They cannot be used to access the Virtual Machines, for which the credentials will be provided on request by the GSNL Chair (see later).

Figure 4- The EVER-EST components requiring authentication for which the Single Sign On is valid.

6.3 The Seafile storage area

The VRE provides a storage area to the users, based on the *Seafile* file-hosting platform (an application similar to DropBox or Google Drive). Personal files can be put in a specific server, can be synchronised and shared across different devices and may be accessed as a virtual disk on the user's PC. The user can access the *Seafile* app at the https://box.everest.psnc.pl/ server using the "Shibboleth" login option, which will prompt for the EVER-EST credentials.

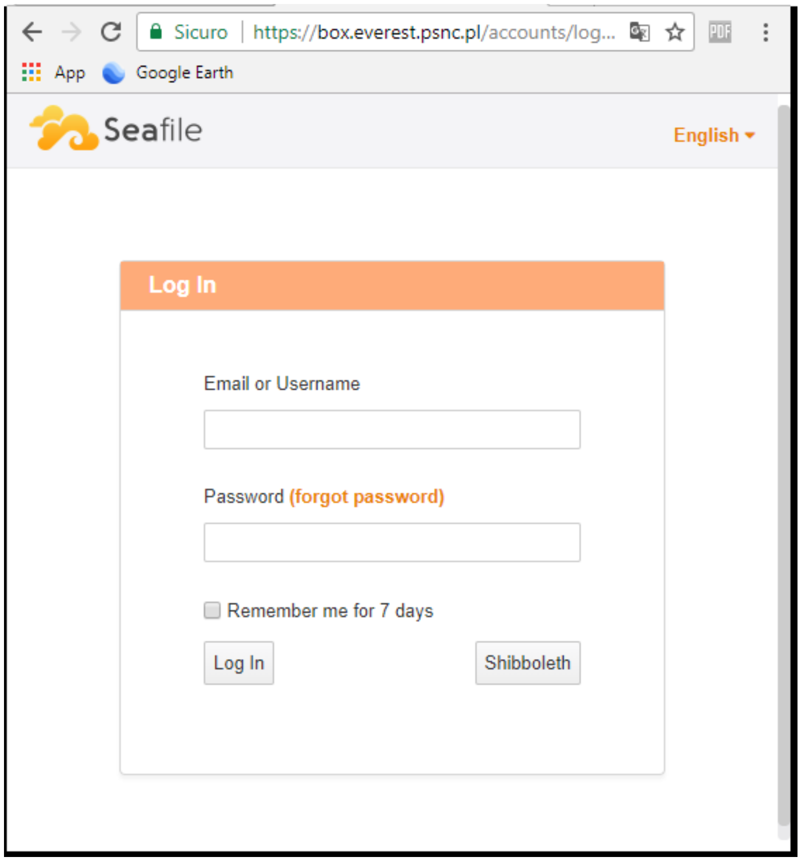


Figure 5- Login window of the Seafile server at https://box.everest.psnc.pl/.

Upon login, the *Seafile* folder structure is visible in the web browser.

The *Seafile* storage area can also be accessed through a client in a Virtual Machine (VM) or in your local device; for this the user needs to download and install the client from [https://www.*Seafile*.com/en/download/](https://www.Seafile.com/en/download/). Configure the client to use the https://box.everest.psnc.pl/ server, then select the Single Sign On option to use the EVER-EST credentials for login. From the client app, the local folders can be synchronised with those on *Seafile*, and vice versa. The owner can choose which folders to synchronise.

The *Seafile* storage area is also accessible from the EVER-EST GUI. An icon in the *Command menu* allows to upload files to *Seafile* (Figure 6): click on the icon to open the uploader GUI and then upload files by drag and drop. The green check mark indicates that connection with *Seafile* is up.

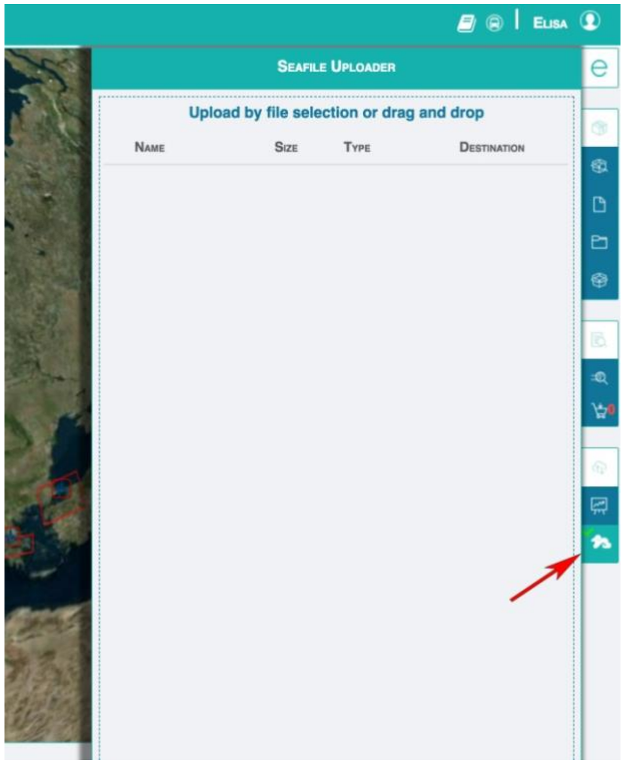


Figure 6- The Seafile storage area is accessible from the VRE Command menu. If connected, the icon has a green check mark.

6.4 ROHUB

ROHUB (http://www.rohub.org) is the Research Object repository and management platform. It makes available and discoverable new knowledge through the Research Object paradigm, supporting the preservation and lifecycle management of scientific data, workflows, investigations, etc. ROHUB natively implements the full Research Object model, it hosts the RO resources (or links them by reference), and the RO metadata in a user and machine readable form.

Before the implementation of the EVER-EST VRE, ROs could only be accessed through ROHUB. Now a user of the EVER-EST VRE can create, open and carry out the most common RO operations within the VRE without having to access ROHUB, although not all RO editing options are provided in the VRE.

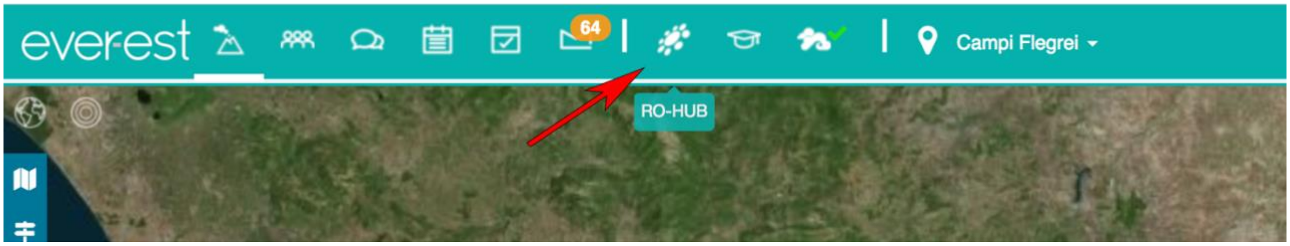


Figure 7- Rohub is accessible from the GUI.

6.5 Collaboration Sphere

The **Collaboration Sphere** is a tool, which searches more relevant ROs and structures them through semantic intelligence. If a user feels overwhelmed by a large collection of ROs and finds it difficult to define the right query for the sought information, the Collaboration Sphere can help, implementing a search by example, providing recommendations based on a selection of ROs or researchers from the user's community. A user simply drags and drops a RO in the sphere to see related ROs obtained through the automatic analysis of the content. The site for the semantic search is http://everest.expertsystemlab.com/spheres/index.html, and the user can login from the top right corner.

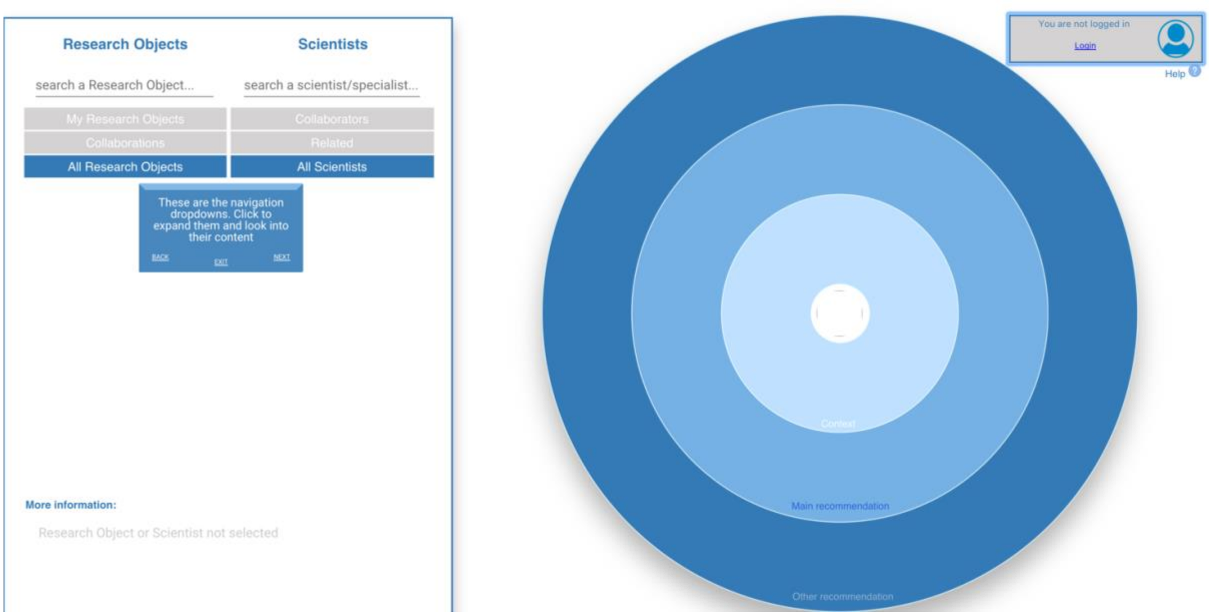


Figure 8- The collaboration sphere creates a structured collection of resources (RO and scientists) related with each other with different degrees of affinity.

Once logged in, the user is in the center of the sphere, and can drag & drop a research object, a scientist and other resources in order to find resources related. In the following, a research object is chosen and dropped in the center, so that further research objects related to the topic appear. More information here http://everest.expertsystemlab.com/home/.

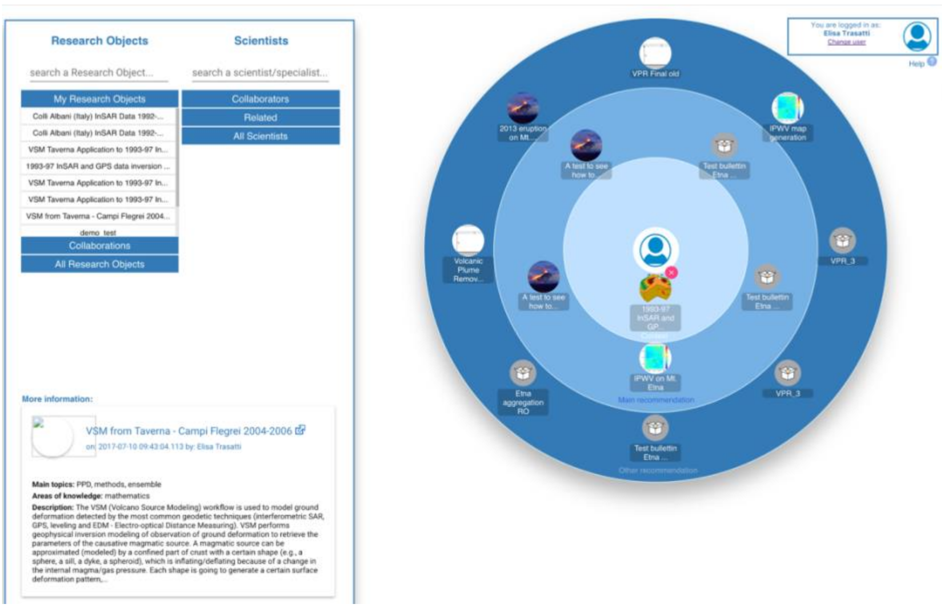


Figure 9- Example of the use of the collaboration sphere.

The Collaboration Spheres are integrated with the EVER-EST VRE through a single sign on mechanism, and are accessible in the GUI at the top left corner of the virtual globe.

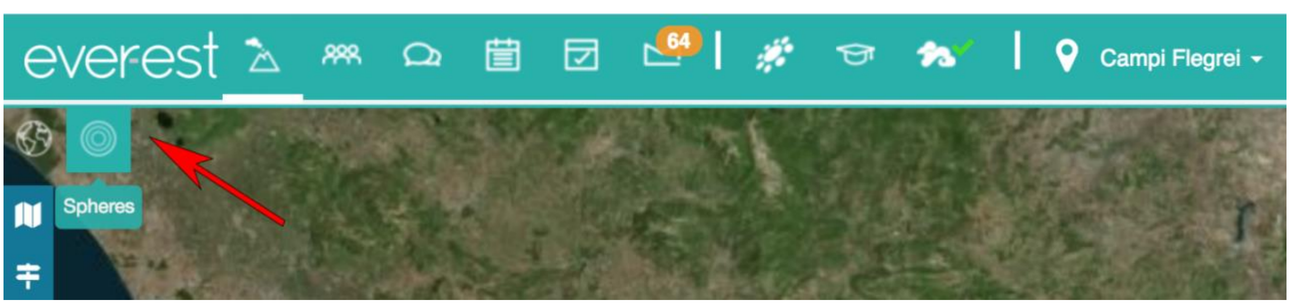


Figure 10- The collaboration sphere is accessible from the GUI.

6.6 Workflow Management System

To facilitate the sharing and execution of scientific workflows, EVER-EST supports the **Taverna** open source Workflow Management System. The Taverna suite (Fig. 11) is written in Java and includes the **Taverna Engine** (used for enacting workflows) that powers both the **Taverna Workbench** (the desktop client application) and the **Taverna Server** (which executes remote workflows). Taverna is also available as a Command-line Tool for faster execution of workflows from a terminal without the overhead of a GUI.

Taverna automates experimental methods through the use of a number of different (local or remote) services from a diverse set of scientific domains. Taverna enables a scientist with a limited computing skills, technical resources or support, to construct complex analyses using data and computational resources that may be public or private, from any platform.

Taverna can be downloaded from https://taverna.incubator.apache.org/.

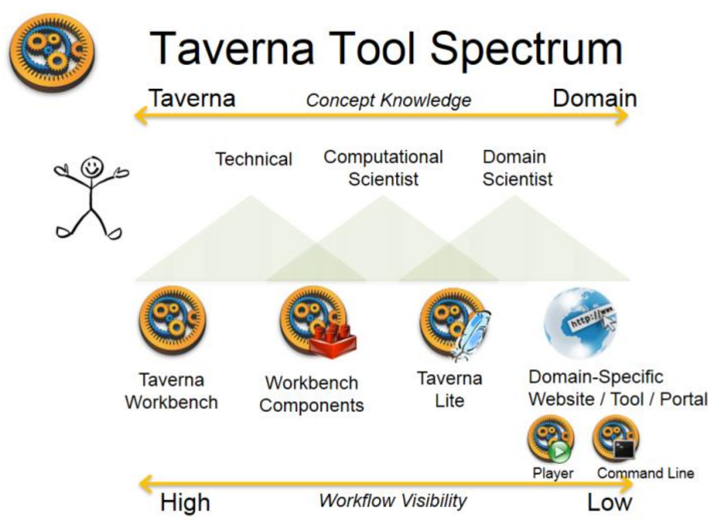


Figure 11- Scheme of the Taverna Tools.

In EVER-EST the use of Taverna is suggested to easily and rationally organize the input/output of personal workflows, to make them reusable, and to easily create Research Objects from a workflow execution.

6.7 Processing environments

The EVER-EST VRE offers two types of processing environments. It offers Virtual Machine resources (VM), for either Linux or Windows operative systems, and the Taverna server application directly embedded in the VRE.

When using the EVER-EST VM environment, the user is given access to a Virtual Machine with a set of pre-installed software packages. The Linux VMs are equipped with *Seafile*, Taverna workbench, Fortran (gfortran 90), Matlab and GMT. The Windows VMs are equipped with *Seafile*, Taverna workbench, ENVI/IDL/SARscape, ESRI ArcMap, and GMT.

To request access to a pre-defined VM, the user needs to contact the GEO-GSNL initiative management at *info@geo-gsnl.org.*

The second processing environment (Taverna server) allows the execution of a workflow from the EVER-EST GUI without the need to access a virtual machine. The Taverna server, available in the Command menu (see below), can be used to run workflows previously created in Taverna (files with a .t2flow extension), stored in a Research Object (see the example in section 4). The execution requires that input files or folders can be accessed using global URLs, as those obtainable from the Seafile storage area.

6.8 EVER-EST VRE GUI description

The Graphical User Interface of the EVER-EST platform customised for the Supersite community, contains four main menus:

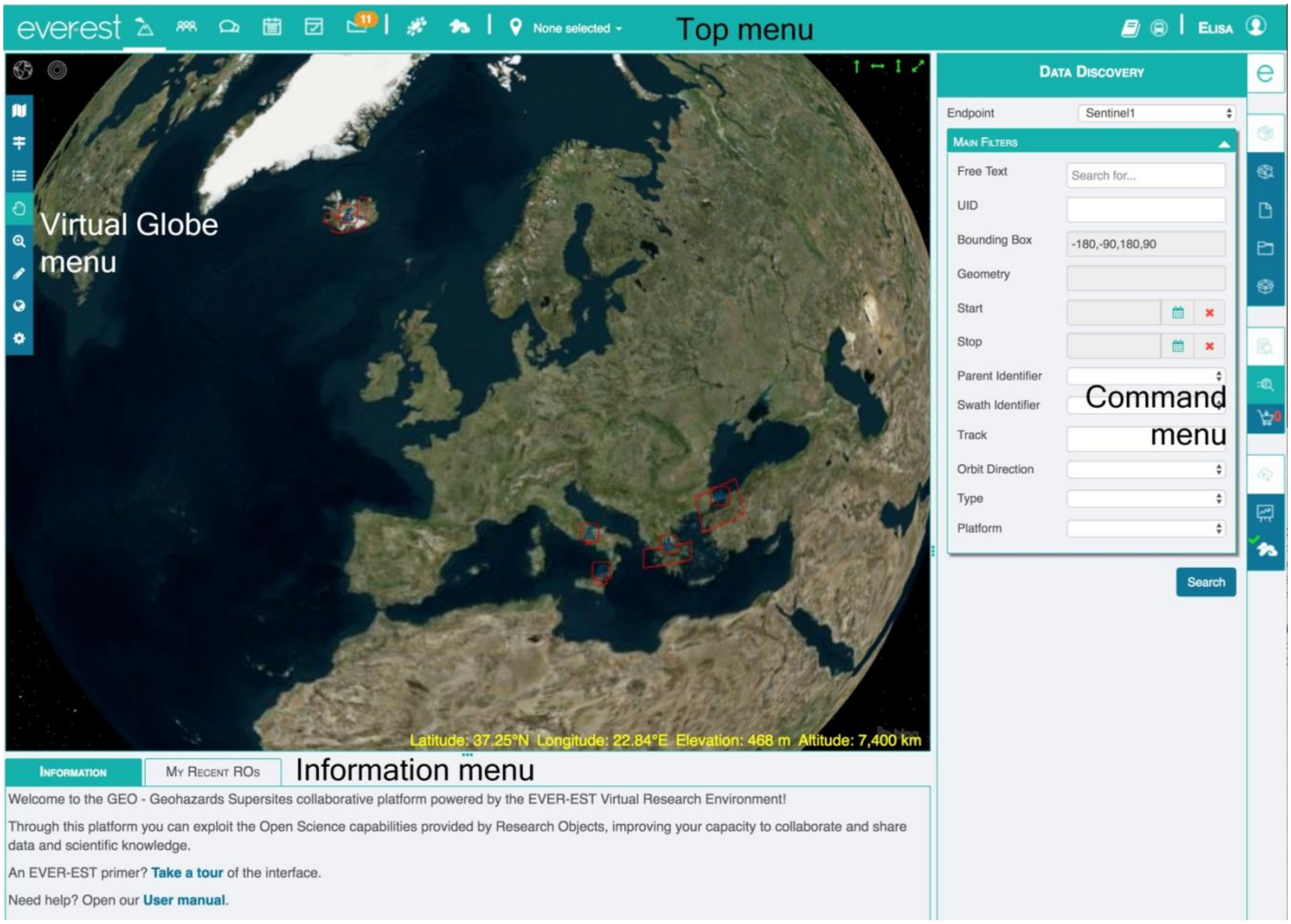


Figure 12- The different menus in the EVER-EST VRE GUI for the Supersite community.

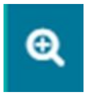
The 'Virtual Globe' menu collects a set of functionalities to operate within the virtual globe. Press a button to activate the option, press again to hide the option parameter window. From top to bottom:

 Map Projection. Allows to project the virtual globe in 5 different projections.

 Search Location. You can search the globe by name or Latitude and Longitude (in this order).

 Manage Layers. Allows to display different user layers on the globe (formats such as kml/kmz, tif, shp, png can be used)

 Pan

 Zoom by box. Allows to drag a zoom window on the globe. Use the “go back” sign to return to the previous zoom level.

 Draw options. Allows to draw points, areas and polygons on the map.

 Switch from satellite to street maps

The ‘Top’ menu (Figure 12) contains a set of buttons, most of which are used to activate general services. From left to right: a button to show the VRE to which the user is registered, instant messaging (chat), forum, task management, user validation requests, mailing (a new message is sent to the user when a RO is created or updated by a colleague in the same user group). The first button after the vertical bar provides access to the ROHUB website (see section 2.3), while the second allows to access the personal area in the *Seafile* cloud. After the second vertical bar, there is a drop-down menu allowing to select one of the active global Supersites, upon selection the virtual globe will zoom to the selected Supersite.

The ‘Command’ menu (Figure 12) is the operational menu with the main VRE functionalities. It has three main vertical sub-menus, each one starting with a white icon. From the top: the Research Object, Data Discovery and Services menus.

From the RO menu, it can be created a new RO or opened a recent one. From the data discovery, the user can search ROs or satellite data (Sentinel-1 and MODIS). The last icon of this submenu is the basket, used when discovering data. The chosen imaged, indeed, are stored in the basket until check out, when they are downloaded to the personal *Seafile* storage area. The last submenu lists the available services. The first choice is the workflow server, where .t2flow files (native Taverna files) can be run within the GUI. See related use cases below. The second last icon allows to upload resources (files and links) in *Seafile*. The green check of the icon indicate the user is properly connected to the personal area on *Seafile.*

The ‘Information’ menu is the info area. It contains information regarding the selected Supersite, and in additional tabs it may contain the results of data query, or research object query, or the list of recent research object created, etc.

7 Use case 1: execution of a Matlab code as a Taverna Workflow

7.1 Description

This example shows how to access a RO containing a Taverna workflow embedding a Matlab code, how to upload the workflow file and the input data to the *Seafile* storage area, and how to execute the code in a Linux VM within the Taverna environment. The example show the execution of the Volcanic Plume Retrieval procedure.

During eruptions, volcanoes emit large quantities of particles (ash, water vapour, ice) and gases into the atmosphere. The Volcanic Plume Retrieval procedure (VPR - Pugnaghi et al., 2013; Guerrieri et al., 2015; Pugnaghi et al., 2016) has the capability, simultaneously and in real time, to estimate physical parameters of volcanic ash and SO2 clouds from multispectral MODIS data in the Thermal InfraRed (TIR) spectral range. Plume altitude and temperature are the only two input parameters required to run the procedure. By linearly interpolating the radiances surrounding a detected volcanic plume, the VPR procedure computes the radiances that would have been measured by the sensor in the absence of a plume, and reconstructs a new image without plume. The new image and the original one allow computation of plume transmittance in the TIR-MODIS bands 29, 31, and 32 (8.6, 11.0 and 12.0 µm) by applying a simplified model consisting of a uniform plume at a fixed altitude and temperature. The transmittances are then refined using a polynomial relationship obtained by means of MODTRAN simulations adapted for the geographical region, ash type, and atmospheric profiles.

Once polynomial coefficients have been computed for a specific area and volcano, the procedure can be executed again for different MODIS data and periods.

In the RO reused in this example we report coefficients computed for the Etna (Italy) and Eyjafjallajokull (Iceland) volcanoes. If the reader is interested in using the VPR on other volcanoes, please contact stefano.corradini@ingv.it

The example shows how the user can find the RO to run the VPR procedure (actually the RO contains a Taverna Workflow which is used to execute the actual VPR Matlab code), how new MODIS input data can be downloaded using the VRE interface, how the Taverna .t2flow file can be run to estimate plume parameters from the new MODIS data over the Etna volcano.

The user must already be logged in the VRE for the Supersites community (https://vre.ever-est.eu/supersites/, see Section 2.2), then he will go through the following steps:

1- Select the VPR RO and download the Taverna workflow to his Seafile personal area
2- Discovery and download MODIS images to his Seafile personal area
3- Open a Linux Virtual Machine and launch the VPR workflow from the Taverna *.t2flow* file
4- Create a compressed file (zip format) containing all required input files in the appropriate folder in his Seafile personal area
5- Execute the workflow to compute the volcanic cloud ash Mass, Effective radius and Aerosol Optical Depth, and the SO_2 columnar content
6- Create a new Research Object to document the research

7.2 Selection of VPR workflow Research Object and MODIS input data

7.2.1 Selection of the VPR RO

In order to run the VPR code, the user must first find the Research Object containing the appropriate Taverna workflow, using the *RO search* panel opened by clicking the corresponding button in the *Command menu* (Figure 13).

If the user wants to limit the search to ROs created by users registered under the Supersite Community, he can select the option *Only VRC*[3] *ROs*.

[3] VRC stands for Virtual Research Community

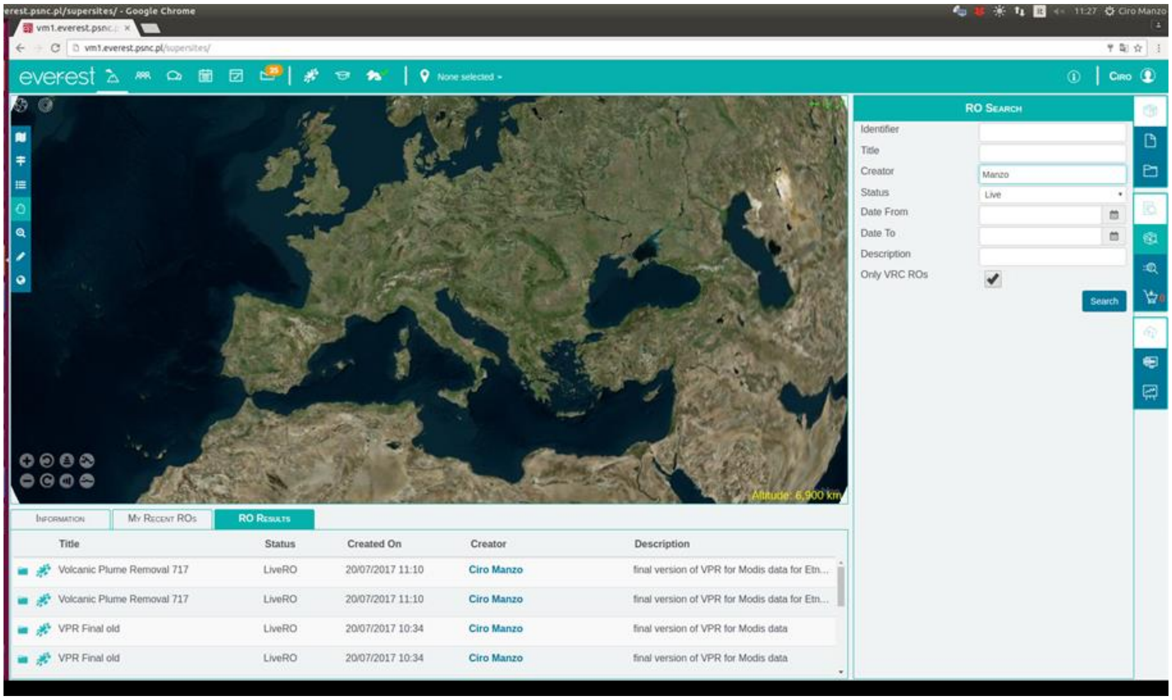


Figure 13-. The RO Search panel.

In this use case, the term 'VPR' is typed in the Title field within the search command panel (Figure 14). A list of ROs having the term *VPR* in the title is then displayed in the *Information Panel* (Figure 14).

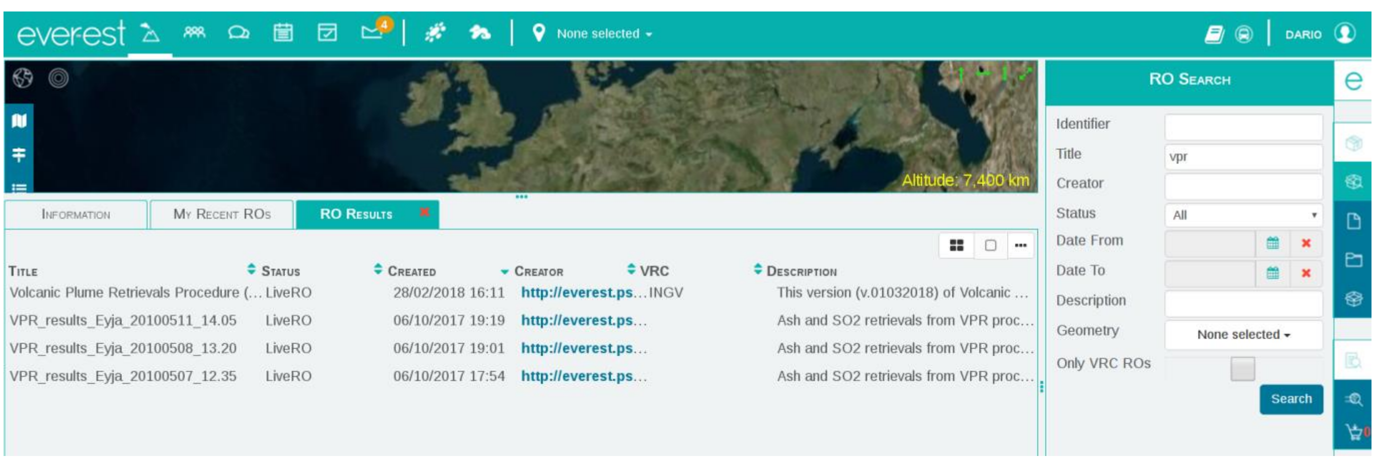


Figure 14- The search for VPR has returned a number of ROs. The user can display them in the Command panel by clicking on the folder icon at the end of the line. The icon only appears when the RO is selected.

The user can select the RO which contains the VPR procedure workflow. To better identify a specific RO the user can display its full content in the VRE by selecting the RO and clicking on the folder icon at the right end of the line (*Open on EVER-EST*). The RO content is displayed in the *Command Panel* on the right.

When the RO is displayed in the *Command panel,* the user can check its Description field (and the other fields and annotations) to verify if that is the desired RO, as shown on Figure 15.

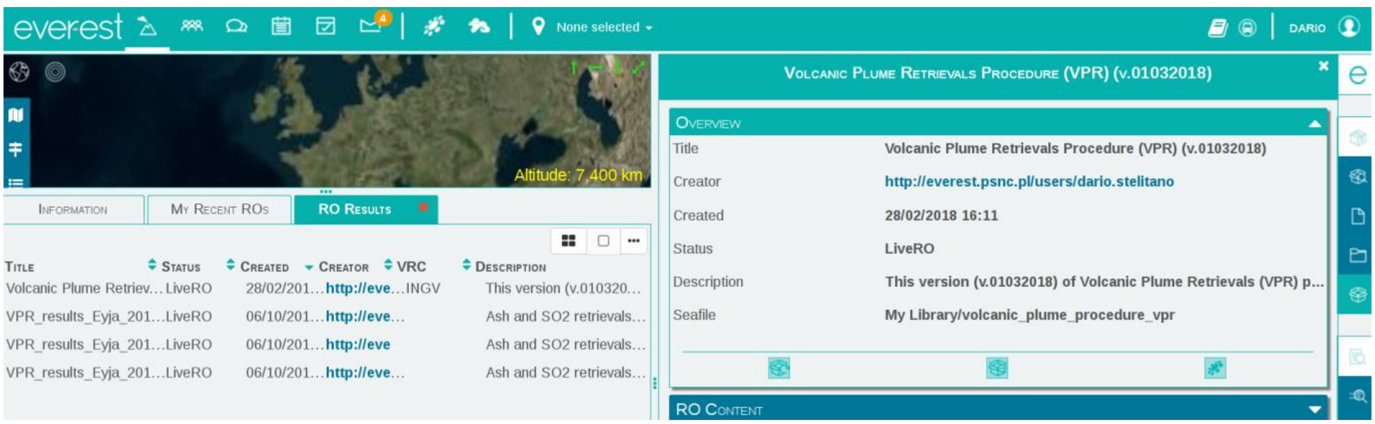


Figure 15- The overview of the selected RO in the Command panel. The version of the VPR code used in the Taverna workflow inside this RO is visible in both the Title and the Description fields.

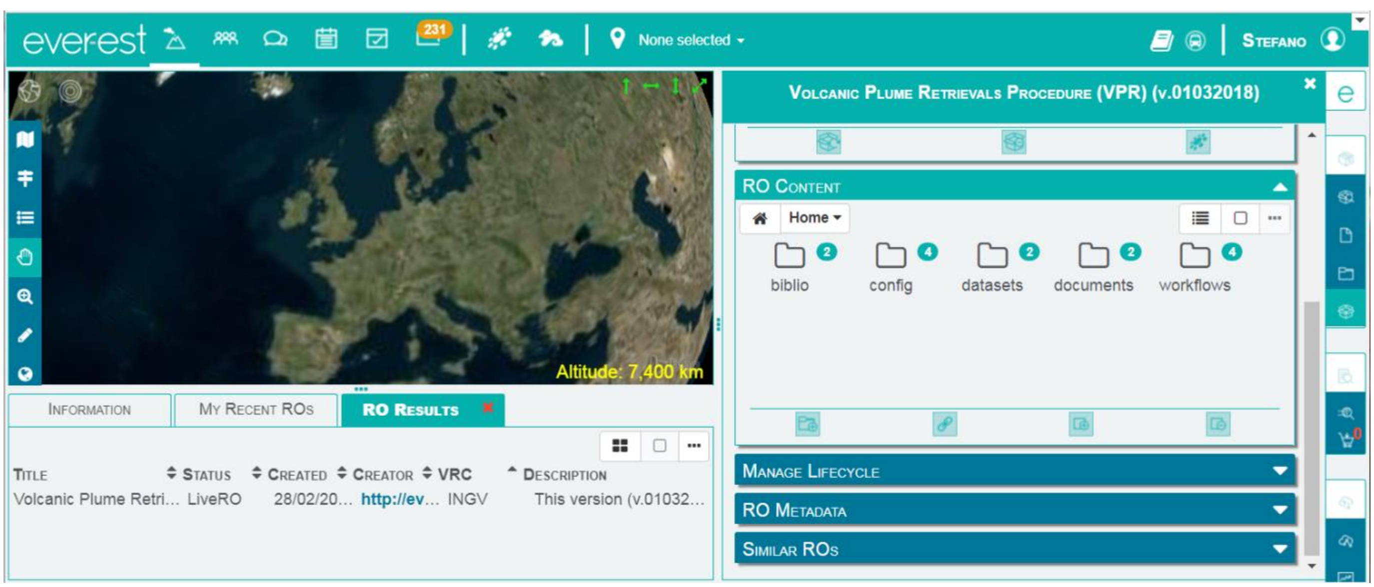


Figure 16- The content of the selected Research Object is examined in the VRE.

In the *RO Content* tab, the user can find the Taverna Workflow file under the "workflows" folder (Figure 16), and can download it by right-clicking on the file icon. Furthermore, the user can inspect the content (Figure 17).

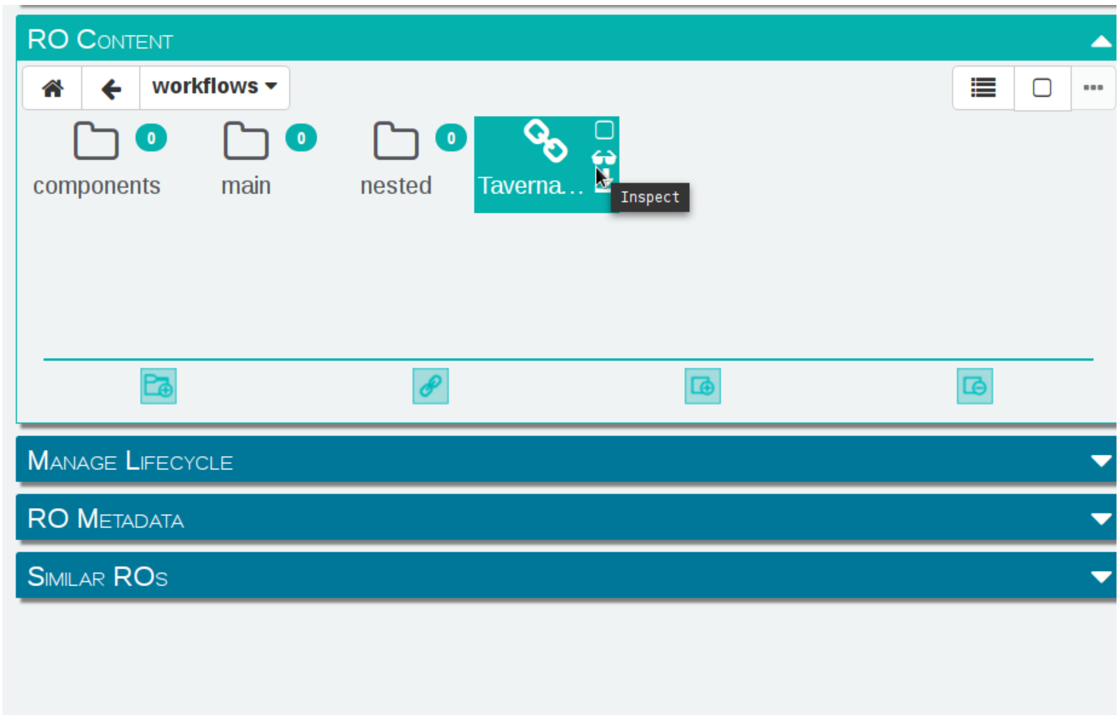


Figure 17- Download and inspect of the workflow from the RO.

To be executed from the EVER-EST VM, the Taverna workflow (*.t2flow file*) embedding the VPR procedure should be saved on the user's Seafile personal area. To do this the user can save the file either in the Seafile synchronised folder in the VM, or first save it locally and then upload it to Seafile.

Note that, as documented in the Readme file in the VPR RO *Documents* folder, the *.t2flow* file from this specific RO works only on a Linux VM and with Matlab 2014 or newer, Python 2.7 or newer (import *requests* module if 2.7 version) and Taverna 2.5 installed.

7.2.2 Discovery and download of MODIS data

To find and discover MODIS data the user selects the Supersite (Mt. Etna Volcano in the present example) in the *Top Menu* of the EVER-EST platform (see Figure 18). While the menu provides a shortcut to the active Supersites areas, the following procedure applies to any other area.

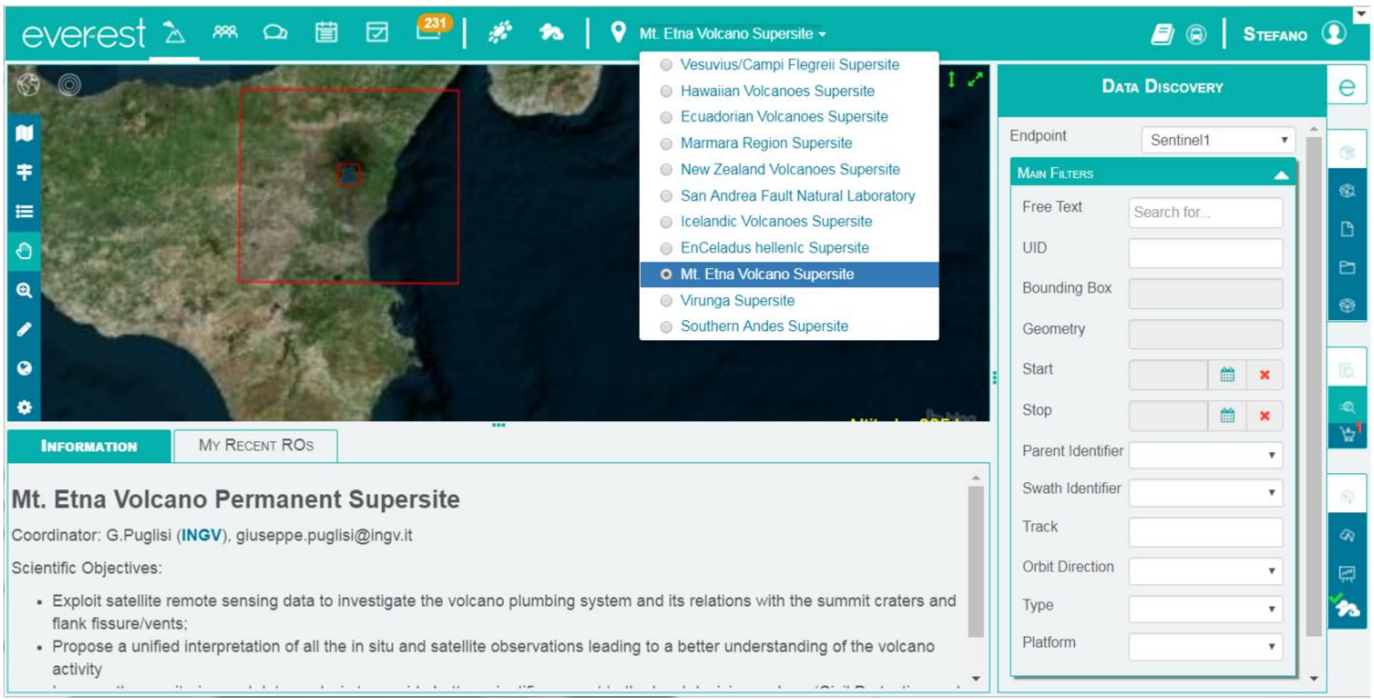


Figure 18- The Mt Etna volcano Supersite selected from Top Menu.

The user opens the *Data discovery* tab from the *Command menu* and can select the area of interest by means of the drawing tools in the *Virtual Globe Panel* (see section 2.8). The user selects *draw polygon* in the *Virtual Globe menu*, draws the area of interest, and the coordinates of the AOI are automatically added to the *Bounding box* field of the *Data discovery* tab.

The user then selects MxD03 (MOD03 or MYD03 depending on the satellite) from the *Endpoint* drop down menu and defines the preferred temporal slot using the *Start, Stop* fields (Figure 19).

As a result, a list of MODIS images is shown in the *Data Discovery Results* tab in the *Information panel* (Figure 19).

The user can inspect the image metadata and add the images of interest to the basket using the cart button which appears when hovering on the image line. When the basket is complete, the user can click the Checkout button to upload the images on his *Seafile* personal area (Figure 20). The *Configuration* tab provides options for defining a Seafile destination folder, for automatically adding the links to the images to the RO presently opened in EVER-EST, or to add the image links to a new RO.

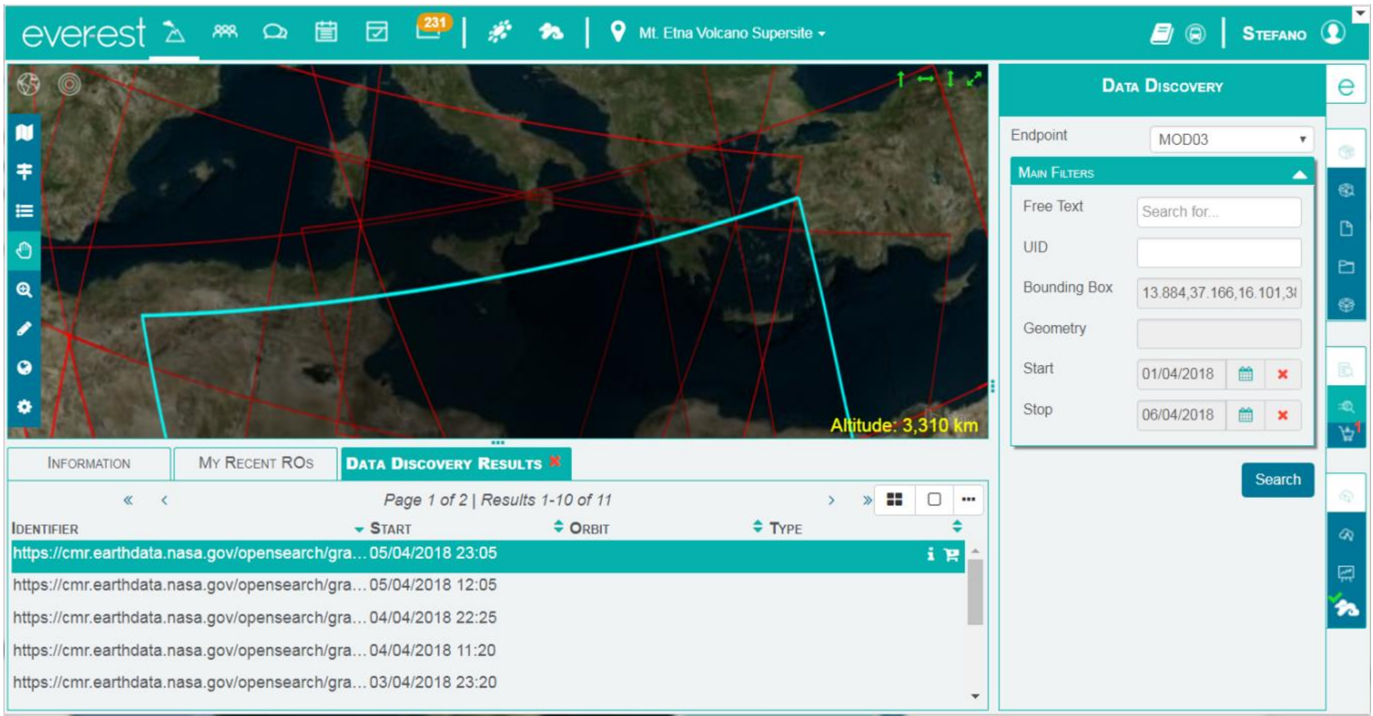


Figure 19- Data discovery and selection.

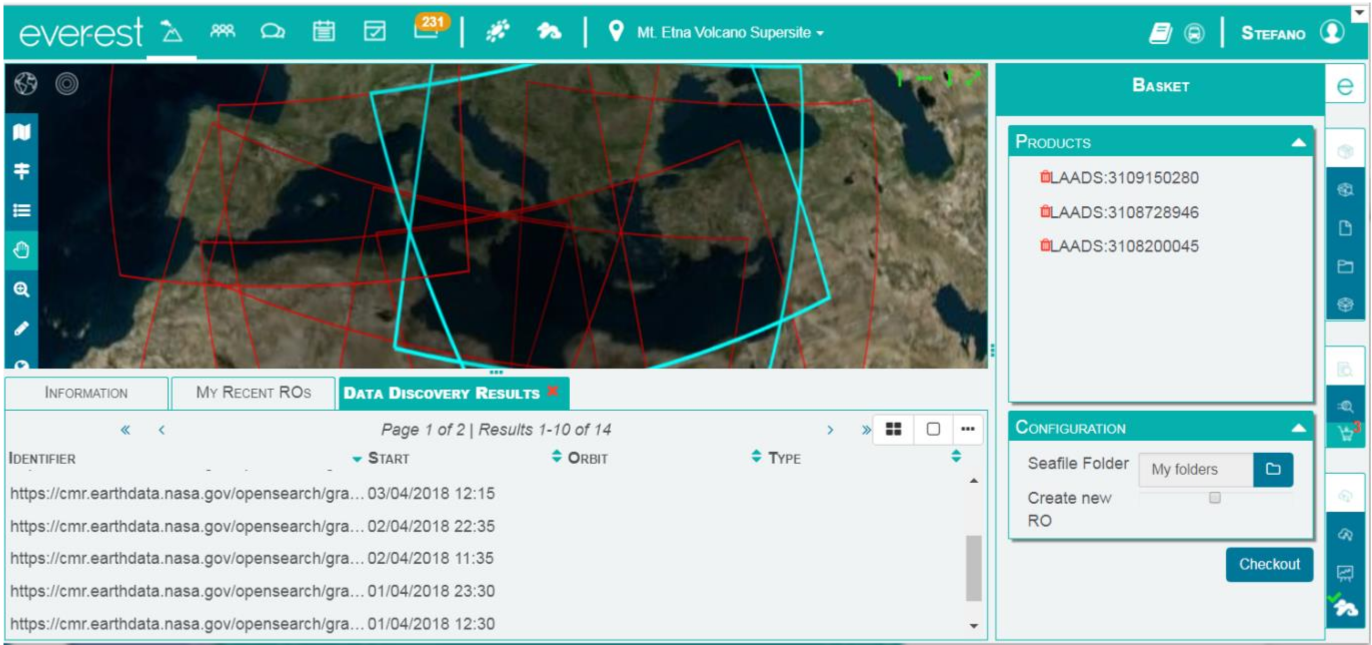


Figure 20- The selected image data are added to the basket and downloaded to the chosen Seafile folder.

The user then repeats the procedure for the MxD21 MODIS data (MOD21 or MYD21 depending on the satellite).

7.3 Access to the Linux Virtual Machine

The user must have obtained from the Supersite Coordinator the IP address and the credentials necessary to login into a Linux VM (see section 2.7). Then the user connects to the Linux VM (e.g., by using the Windows "Remote Desktop" or a similar application).

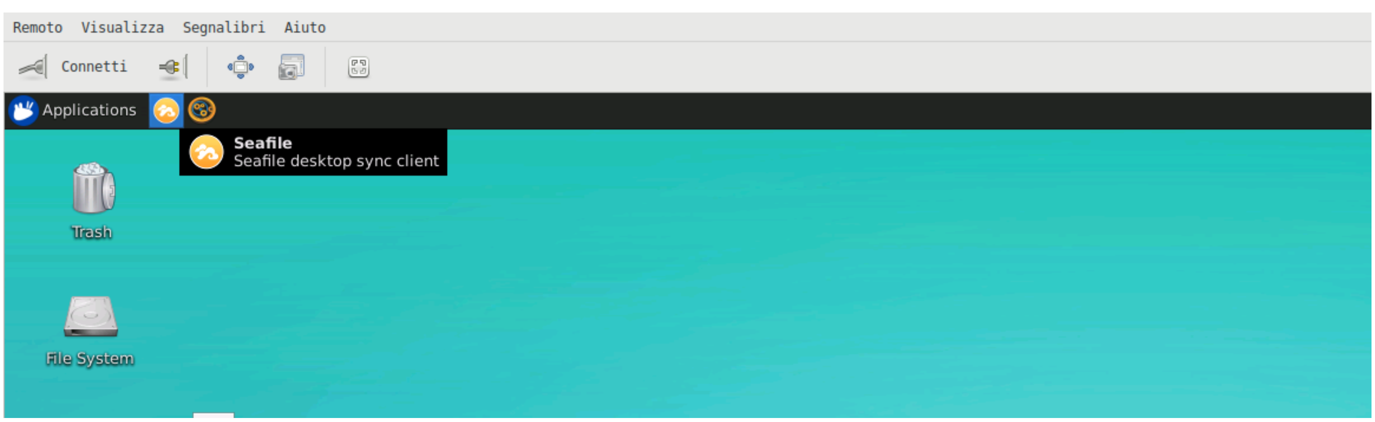
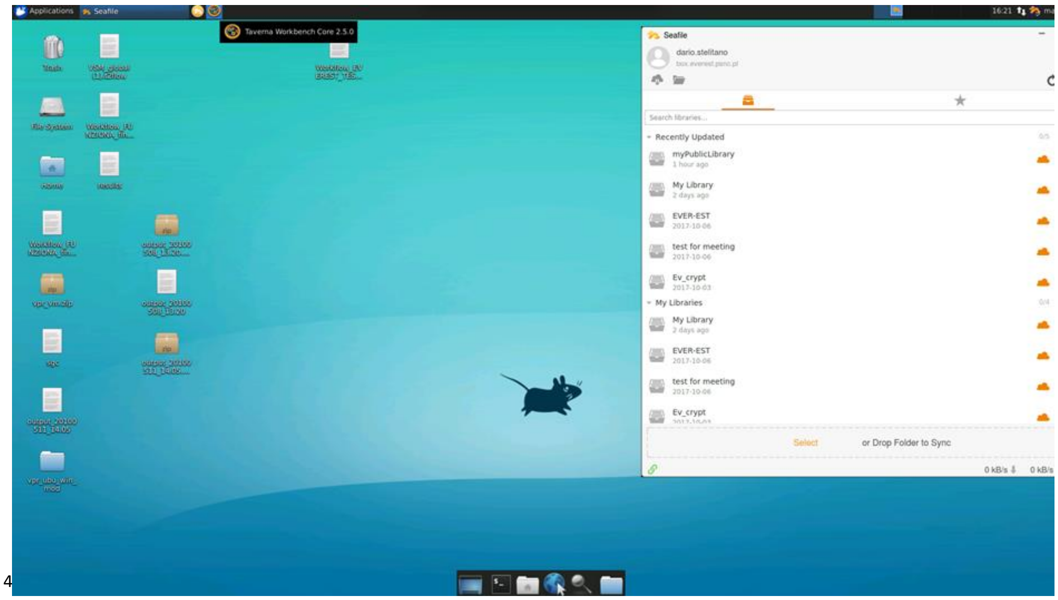


Figure 21- The Seafile and Taverna icons on the Virtual Machine top bar.

In the *Application* menu of the Linux VM the user will find the *Seafile* and *Taverna* icons (Figure 21). The user can access the personal *Seafile* storage area from the *Client* as described above (Section 2.3).



[4]

Figure 22- The Linux Virtual Machine desktop. The Seafile client is running.

7.4 Workflow execution

Once into the VM, the user can launch the Taverna software from the *Application Menu*. Using *File -> Open Workflow* the user opens the *.t2flow* file which was saved in the Seafile folder from the VRE (see Section 3.2.1); the main panel shows the flow diagram of the workflow (Figure 23), in the bottom left panel the input and output ports of flow elements are present. It is possible to modify the flow elements using the right mouse button.

[4] Warning: Connection to the VM could be impossible using WiFi connections in highly secure private networks

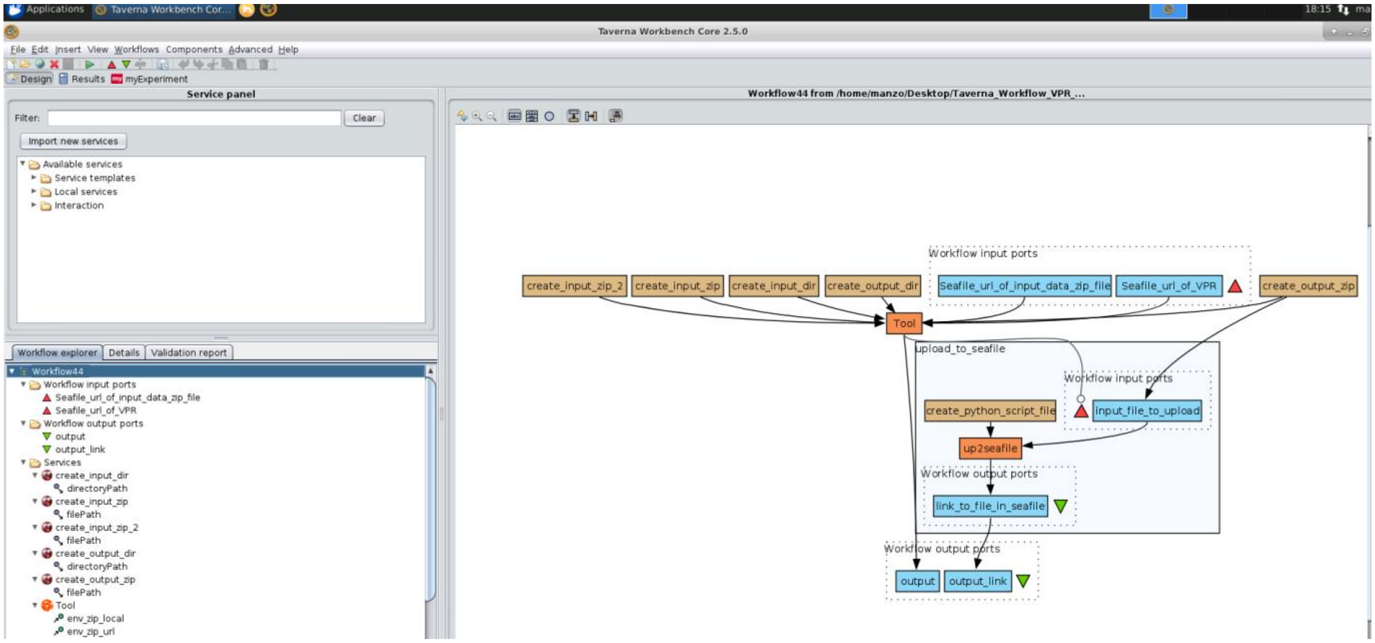


Figure 23 - The VPR workflow in the Taverna environment.

While the original VPR RO contains some example data which could be reused to test the procedure, in this example we explain how the user can provide his input data to the VPR workflow.

The input files must be organized and compressed in a .zip archive located in Seafile. They are:

- the MODIS images MxD03 and MxD21;

- the SO_2 and ash and ice plume masks;

- a local Radiosounding profile.

Detail on the naming conventions and formats are given in the Readme file stored in the VPR RO (*/documents* folder).

Once the zip file is in Seafile the user can right-click it and obtain the Direct Download Link (Figure 24), which must be provided as input to the Taverna workflow.

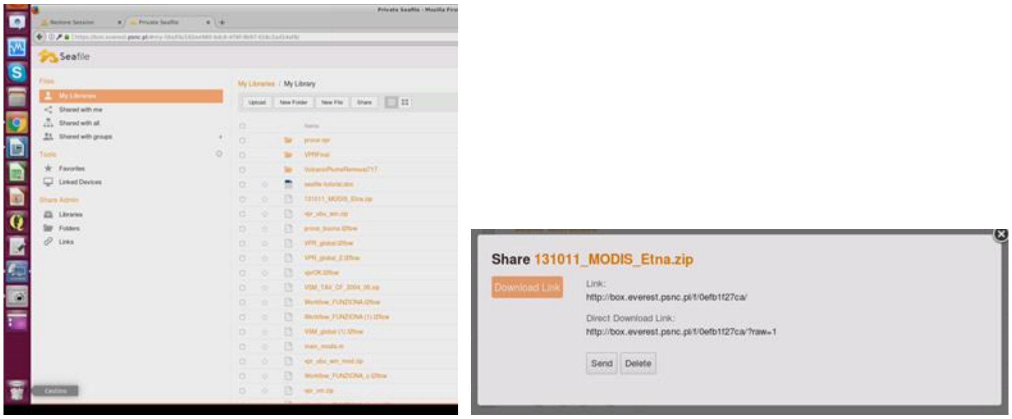


Figure 24- A download link is obtained for the .zip file containing the input data on Seafile.

In the Taverna interface (Figure 23), the user clicks the green triangular button on the top icon bar (*Run the Workflow*). In the new window (Figure 25) the user selects *use examples* in the bottom bar, then in the form opened by the *Seafile_url_of_input_data_zip_file* tab he places the Seafile link in the white box.

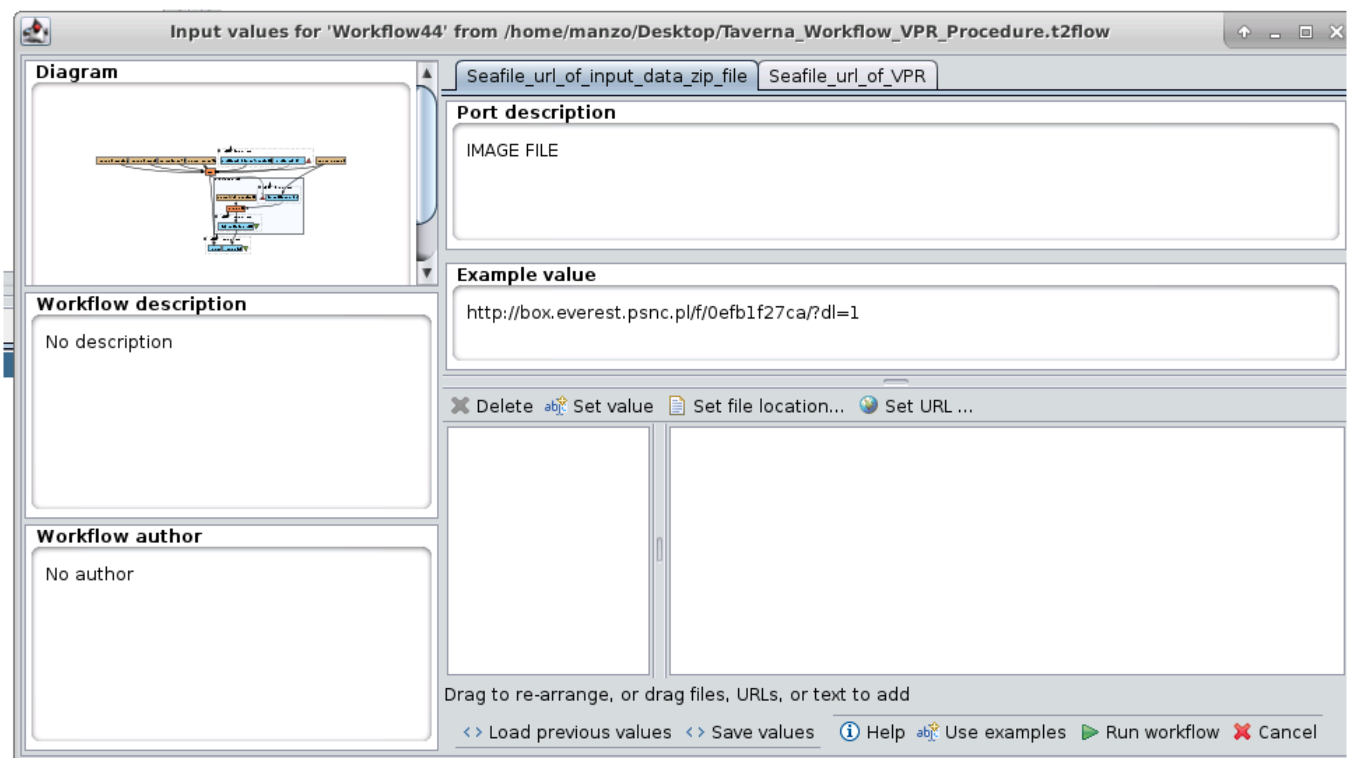


Figure 25- The input is the url of the image file. The url is the link previously generated.

At this point the user can start the workflow execution by clicking the green triangular button (*Run workflow)* at the bottom of the page (Figure 25). During the VPR execution, the procedure uncompresses the .zip file in a local temporary folder and asks the user to select:

- The image file contained in the folder (Figure 26)
- The choice of volcano test case (Etna or Eyjafyallajokull) and the plume height, the only parameter the VPR needs, both for the SO_2 and the Ash and Ice plumes (Figure 27)

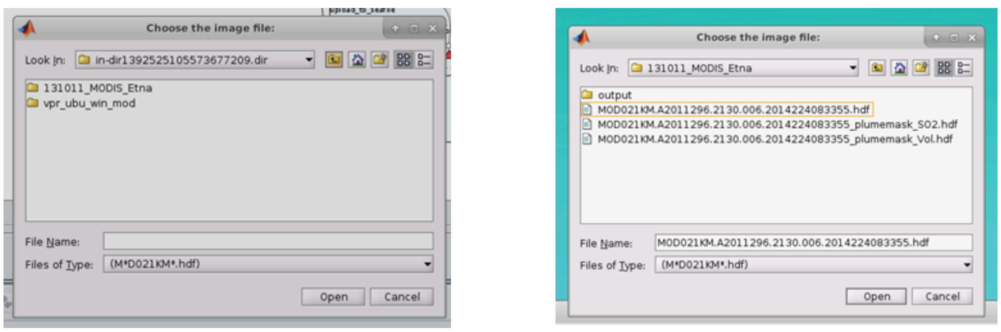


Figure 26 – 1st input during the VPR run.

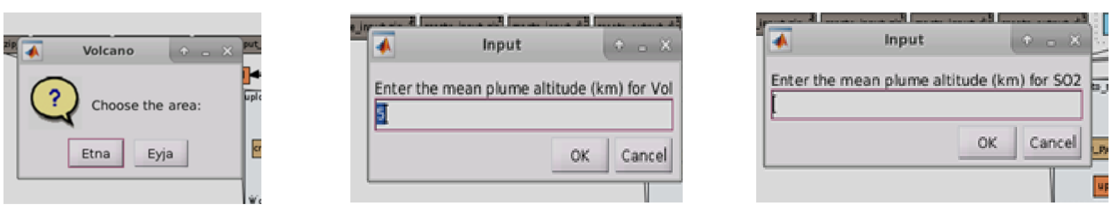


Figure 27 - 2nd input (left) and 3rd input (center and left) during the VPR run.

7.5 Management of output results

At the end of the VPR execution the workflow creates a compressed .zip archive containing the results and uploads it on a *Seafile* folder[5]. By clicking the *Output_link* tab and then "*Value 1*", the user obtains the link to the .zip archive on Seafile (Figure 28).

[5] Note that this folder is NOT on the accessible user's personal area but on a hidden area for common use.

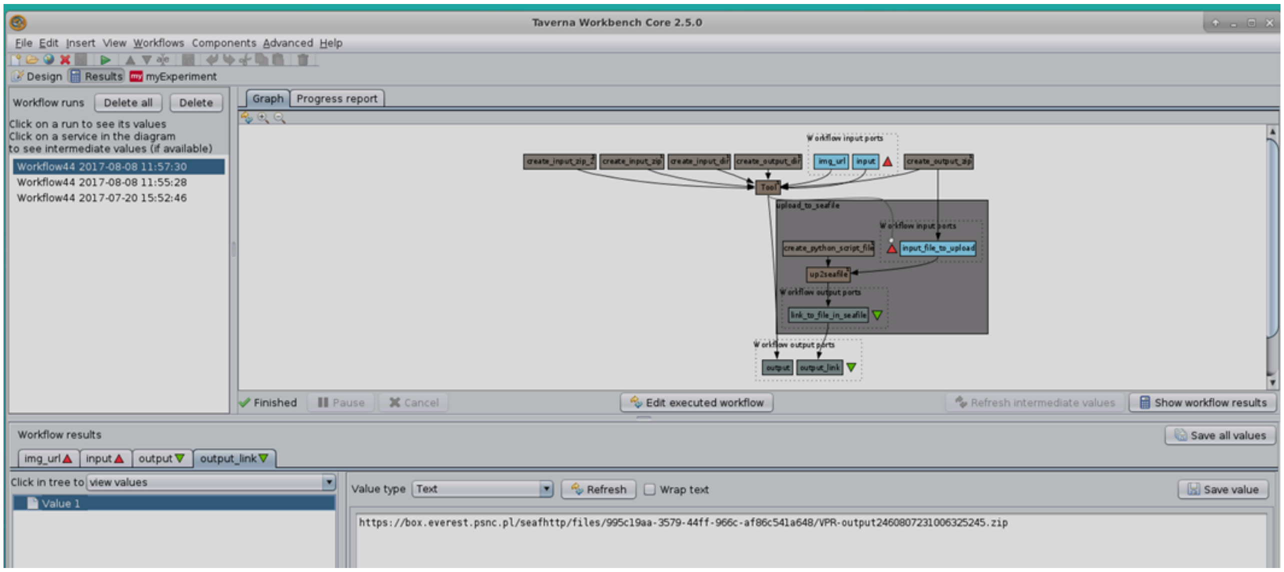


Figure 28- After the VPR execution, Taverna stores all the results in a zip archive and uploads it to Seafile. The link to such archive is can be obtained from the output_link tab.

Taverna can also save all the input/output files and the workflow in a single organized zip archive. This archive is called a Taverna Bundle and when unzipped it will automatically create a folder structure (including the */input*, */output*, */workflow* folders) and place the relative files in the appropriate folders. To create the bundle file, the user clicks on the *Save all values* button (Figure 28) and then, in the new pop up window, on the *save provenance bundle* button (Figure 29). The bundle file can be used to create the RO folder structure with the relative content. On Figures 30, two of VPR outputs are shown. The maps of Ice Mass (Figure 30, left) and Ice Effective radius (Figure 30, right) are created using an own software outside the EVER-EST platform. Finally, if the user wants to document his research with a RO, he can use the procedure explained in Section 6 to create a new RO, and then uncompress the bundle file in the new RO to upload the input/output files and the workflow. The user will then have to refine the RO by adding documentation, bibliography, etc., using the procedure explained in Section 6.

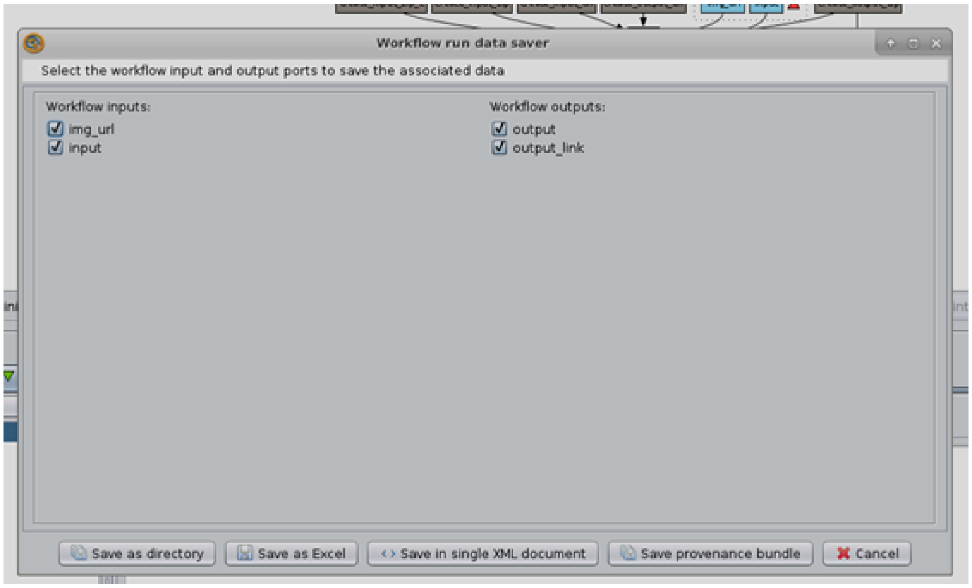


Figure 29- All the resources used and created during the run in Taverna can be stored in a zip file to be saved and exported in a RO.

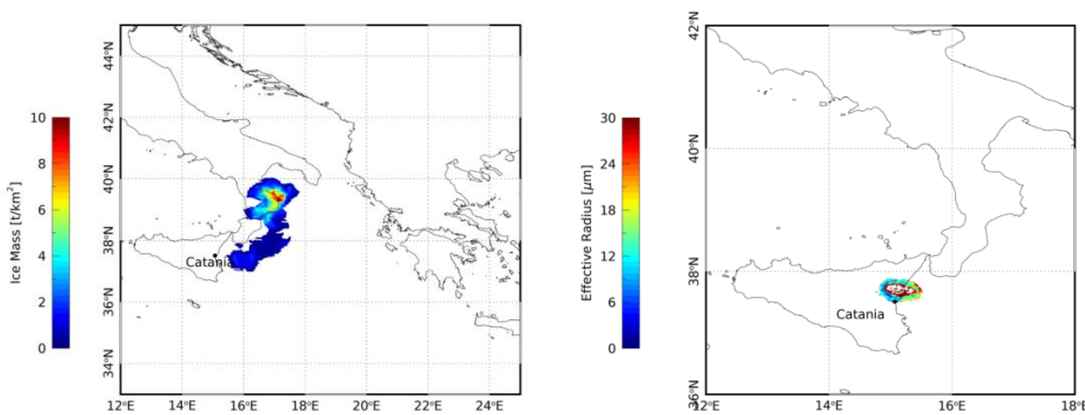


Figure 30: the maps of two VPR outputs obtained running the procedure in the EVER-EST platform. The left panel shows the Ice Particles Mass retrieved using MODIS image of 3 December 2015. The right panel reports the Effective Radius for same particles type using MODIS image of 4 December 2015.

8 Use case 2: geodetic data inversion as a Taverna Workflow run in the VRE

8.1 Description

This use case shows how an existing RO which contains a Taverna workflow can be accessed and executed directly in the VRE, without the need to access a Virtual Machine. This option is useful when the user needs to carry out a repetitive task.

The Taverna workflow contained in the existing RO was generated to run the Volcanic Source Modelling (VSM) tool over data from the Campi Flegrei volcano Supersite (Italy). The VSM is a FORTRAN software developed by INGV, which can be used to model geodetic data from volcanic areas, considering the deformation due to magma input at depth. VSM performs a data inversion to estimate position, depth and shape of the magma chamber.

The RO was created by E. Trasatti, who used the VSM code to invert 2004-2006 ground deformation data for the Campi Flegrei volcano. The inverted datasets were ascending and descending Line of Sight ground displacements from COSMO-SkyMed InSAR time series (source IREA-CNR). The data were modelled with a spherical magma chamber. At the end of his inversion procedure, Elisa created a RO containing the input data, the inversion workflow, and the output results (the source parameters), then added some descriptive information and finally archived the RO with a DOI to ensure authorship of the research.

In this use case, another researcher (the user) has obtained more recent GPS and InSAR displacements data from the same volcano (for 2011-2013), and wants to invert these data to model the magma chamber. The user searches the RO archive to see if there is some pre-existing RO containing inversion result for the Campi Flegrei volcano. When the user discovers that there is a workflow RO for the 2004-2006 InSAR data inversion decides to invert his data using the same workflow.

As explained later, using the *Taverna Workflow Runner* (available from the *Command Menu*), the user can simply re-execute the existing VSM workflow RO in the VRE to invert the new deformation data, and he does not need to access a Virtual Machine as in the previous use case.

8.2 Discovery and access of the existing VSM RO

The user is logged in the VRE (see Section 2.2). The user opens the *RO search* from the *Command panel,* then types "Campi Flegrei" in the *Title* field. He also selects Status: *Archived*, since these are ROs whose content is final and publicly available (normally Archived ROs have also a DOI for citation). Alternatively, the user could have searched using the *Geometry* option and choosing *Vesuvius/Campi Flegrei Supersite* (Area of Interest-AOI), to list all ROs related to that Supersite.

The option *Only VRC ROs* is used to search only ROs which have been created by members of the Supersite Virtual Research Community (VRC). He leaves this option unchecked and clicks Search (Figure 31).

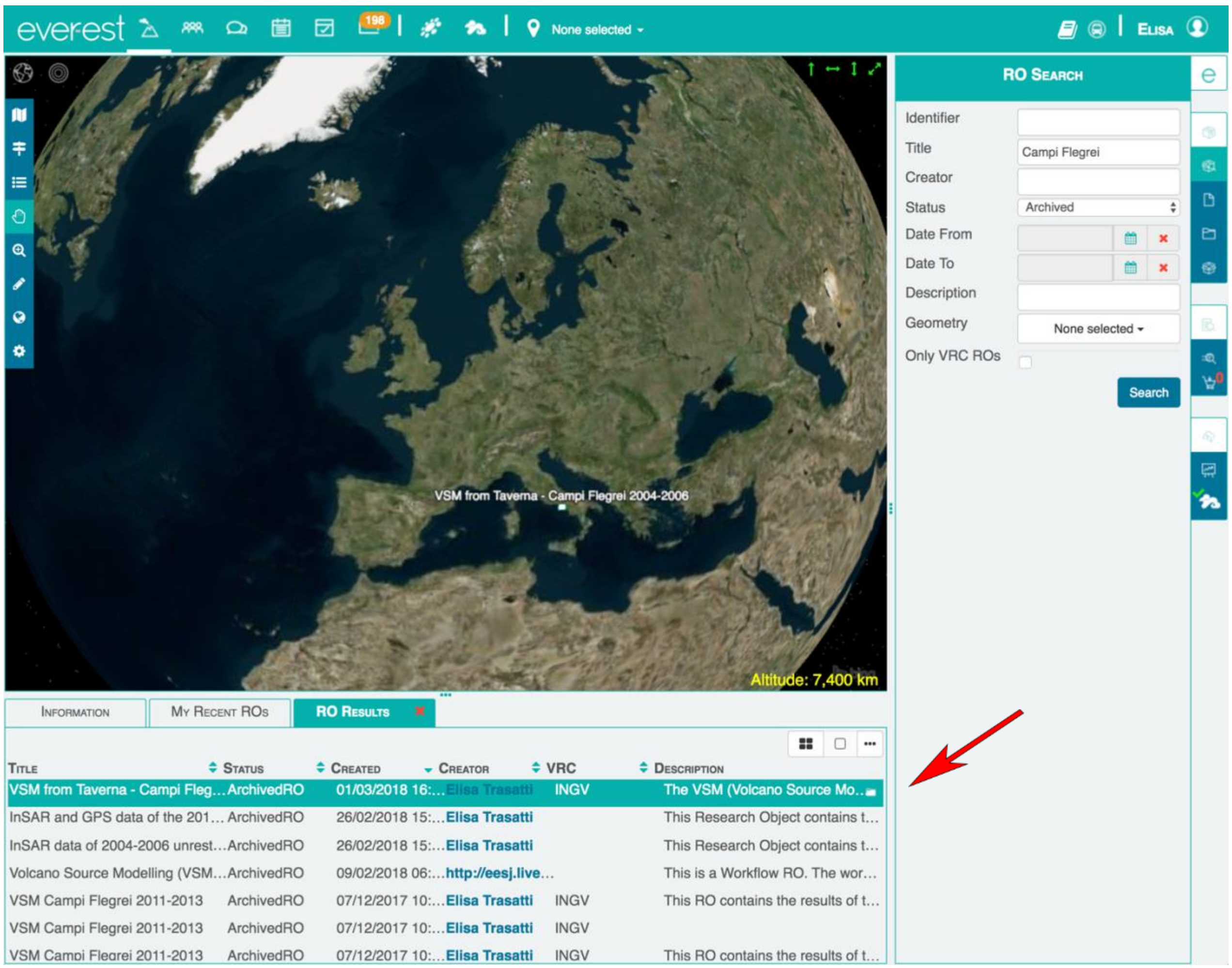


Figure 31- The user has searched for ROs containing the term 'Campi Flegrei' in the Description field, with status "Archived". From the RO Results tab, the user can further browse the RO of interest.

The search results are displayed in the *Information panel* as a list of ROs[6].

[6] The RO visualization in the *Information panel* can be improved reducing the number of columns to show and enlarging upward the *Information panel* using the appropriate handle.

In this example, after exploring the different ROs, the user chooses the one called "**VSM from Taverna - Campi Flegrei 2004-2006**", created by E. Trasatti, because as specified in the documentation it contains a Taverna workflow which can be executed directly in the VRE. See the file HOW_TO_RUN_VSM_TAVERNA in the RO *documents* folder.

8.2.1 Exploring the RO content

To better identify a specific RO the user can examine its full content by hovering the cursor on the RO and clicking on the icon at the right end of the line (*Open on EVER-EST*, Figure 31). The RO content is then displayed in the *Command panel* to the right (Figure 32), and can be inspected as explained below.

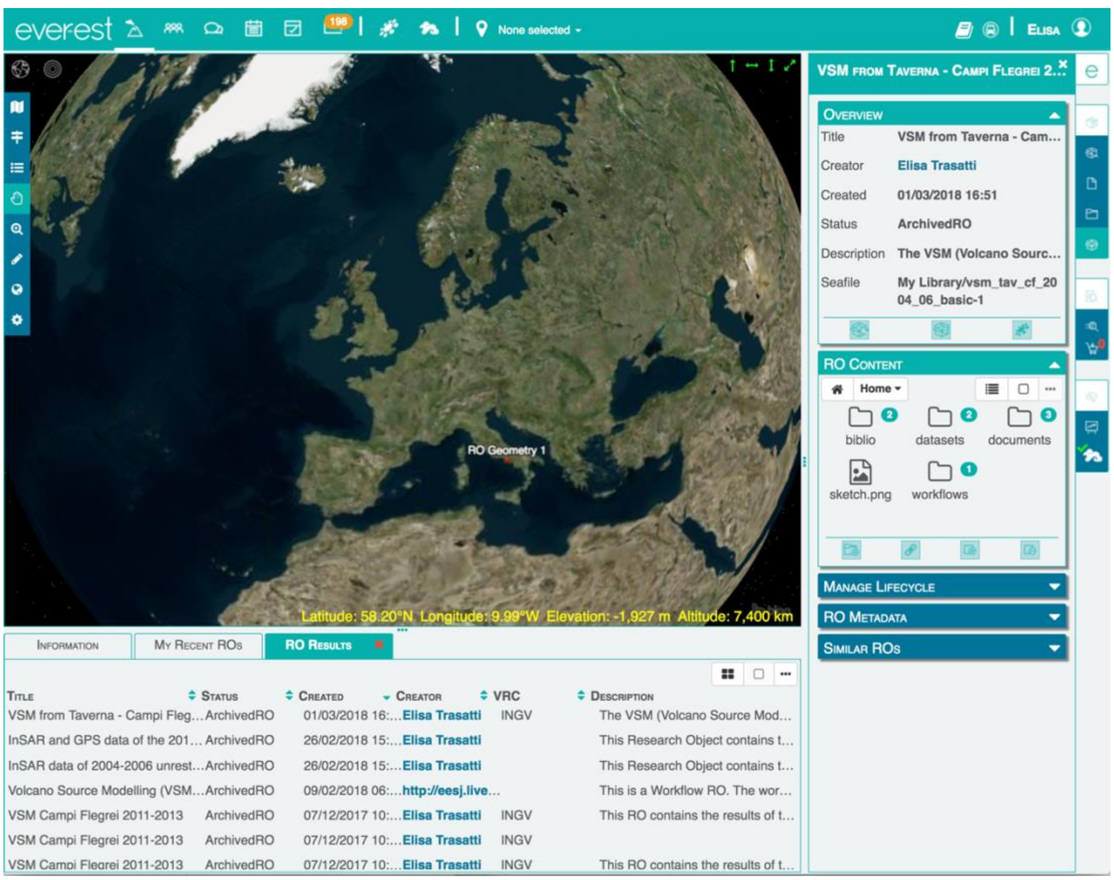


Figure 32. The VSM from Taverna - Campi Flegrei 2004-2006 RO is inspected in the command panel.

Under the *Overview* tab the user can click on the *Description* line and read a synthetic explanation of the RO content/significance.

In the *RO Content* tab a series of folders with specific information on the RO content, is shown. For this VSM RO the *biblio* folder contains web links to published papers presenting or applying the inversion method. The *documents* folder contains a text file explaining how the VSM tool works, and how to run the code in Taverna. The *datasets* folder contains the input files for the inversion (2004-2006 data and parameters) and the output results, in this case the data to invert are bundled in a zip file (for execution in Taverna). The folder contains also .png images of the 2004-2006 deformation field which can be displayed in the Virtual globe (Figure 33). The *workflows* folder contains the Taverna executable (with extension *.t2flow*) used to run the Fortran code.

The *RO Metadata* tab lists a number of different metadata items, which may not be of interest to the normal user.

All the resources (files, URLs) in the RO can be inspected or/and downloaded using the options which appear when hovering the cursor on each resource icon.

⚠ **Warning**: depending on the type of resource, the Inspect function may substitute the Download function.

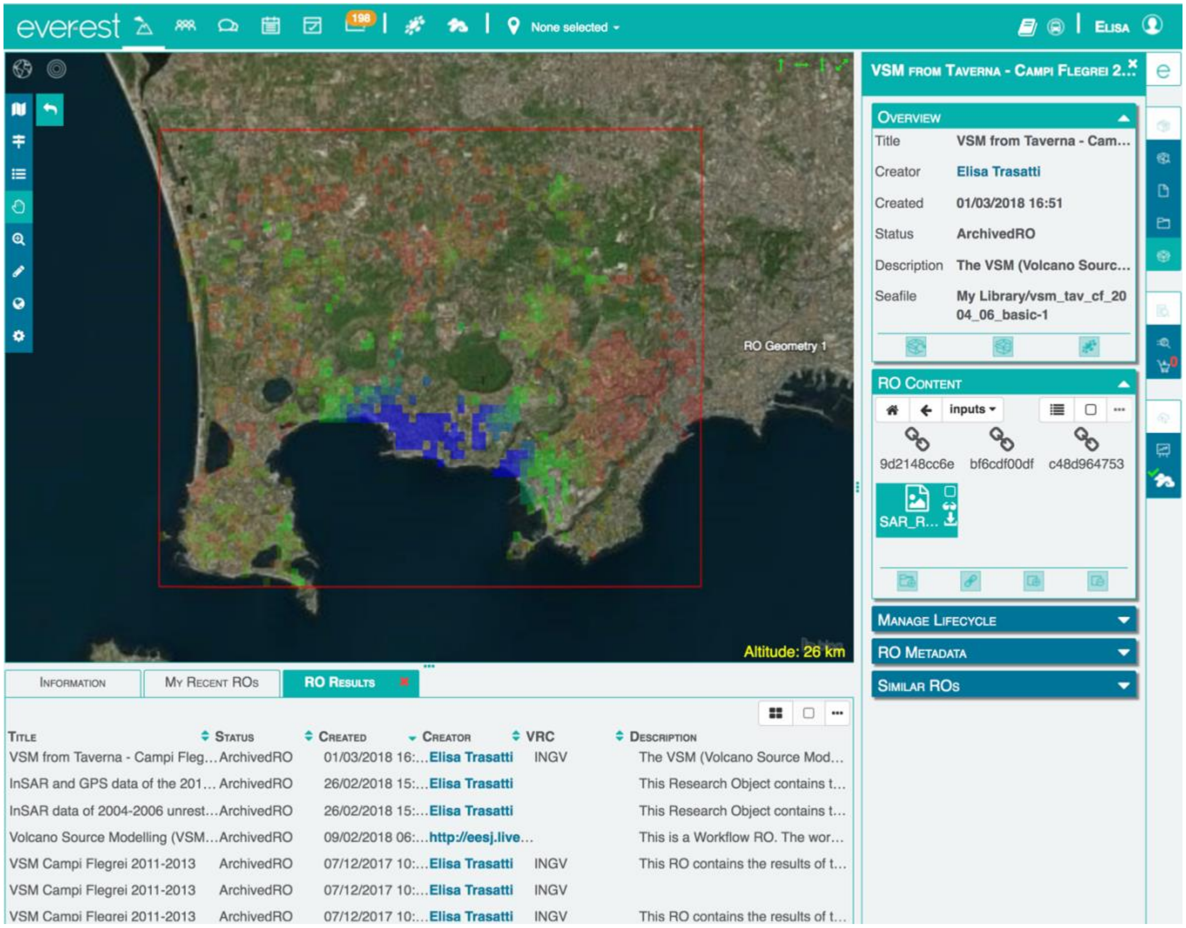


Figure 33- Data visualization within the 'Virtual Globe'. Blue colours evidence uplift in the Campi Flegrei Caldera.

8.3 Preparing for workflow execution

Before running the existing VSM RO to invert the 2011-2013 ground deformation for the Campi Flegrei volcanic area, the user needs to set the right format of the input data and define the inversion parameters.

In the *documents* folder of the VSM RO the user can find instructions on how to format the input files and set up the modelling parameters (file HOW_TO_RUN_VSM_TAVERNA). The user can also open the input files in the *datasets* folder to check their format and/or re-use them for the new run.

The input required by the VSM is a set of separate files containing data and inversion settings. In particular, as shown in the *dataset* folder, the code needs:

- an ascii file for each data-type to invert (InSAR, GPS, levelling, etc.), named *obs_sar.dat, obs_gps.dat*, etc.
- an ascii file containing the inversion settings, named *na.in*.
- an ascii file containing the model set up, named *param_setting_multi*.

Since the VSM tool is embedded in a Taverna workflow (this is needed to run the code in the VRE *Workflow runner*), all these files must be referenced by an URL. In VSM the workflow expects to receive a single URL referring to a .zip archive containing all the input files. The input .zip file could be stored anywhere provided it can be accessed through a URL (Seafile, Google Drive, etc.).

For the present use case, the user has formatted his GPS and COSMO-SkyMed 2011-2013 displacements as required; the *obs_sar.dat* file contains Line of Sight displacements for the ascending and descending orbit (the two datasets are separated by a header line). Since GPS data were not used in the VSM 2004-2006 inversion, the user must be careful to include this new dataset in the model set up file.

We assume that the user has created and stored the input .zip file for the 2011-2013 inversion, in his *Seafile* personal area (Figure 34). In Seafile, he generates a *Direct Download Link* to obtain a unique URL for direct download of the zip file. This is the URL: http://box.everest.psnc.pl/f/1abec2be38/?raw=1.

The user is then ready for the workflow execution.

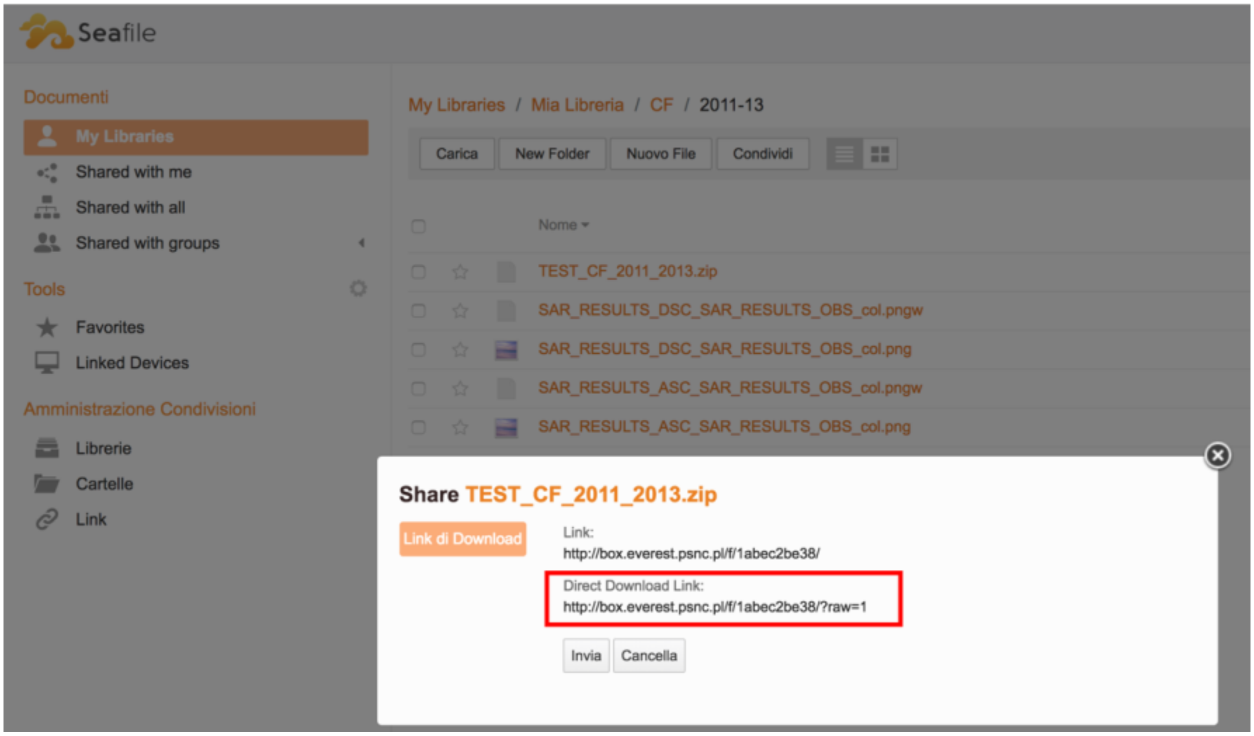


Figure 34- The input data for the 2011-2013 inversion are stored in Seafile as a .zip file, and the user can obtain a unique Direct Download URL.

8.4 Running VSM using the Taverna workflow runner

With the VSM 2004-2006 RO opened in the VRE, the user clicks on the *Workflow runner* button (next to last bottom icon of the *Command menu*). The application recognizes the presence of a Taverna workflow file (.t2flow) in the opened RO and the user can select it from the drop-down menu (an RO may contain more than one .t2flow file).

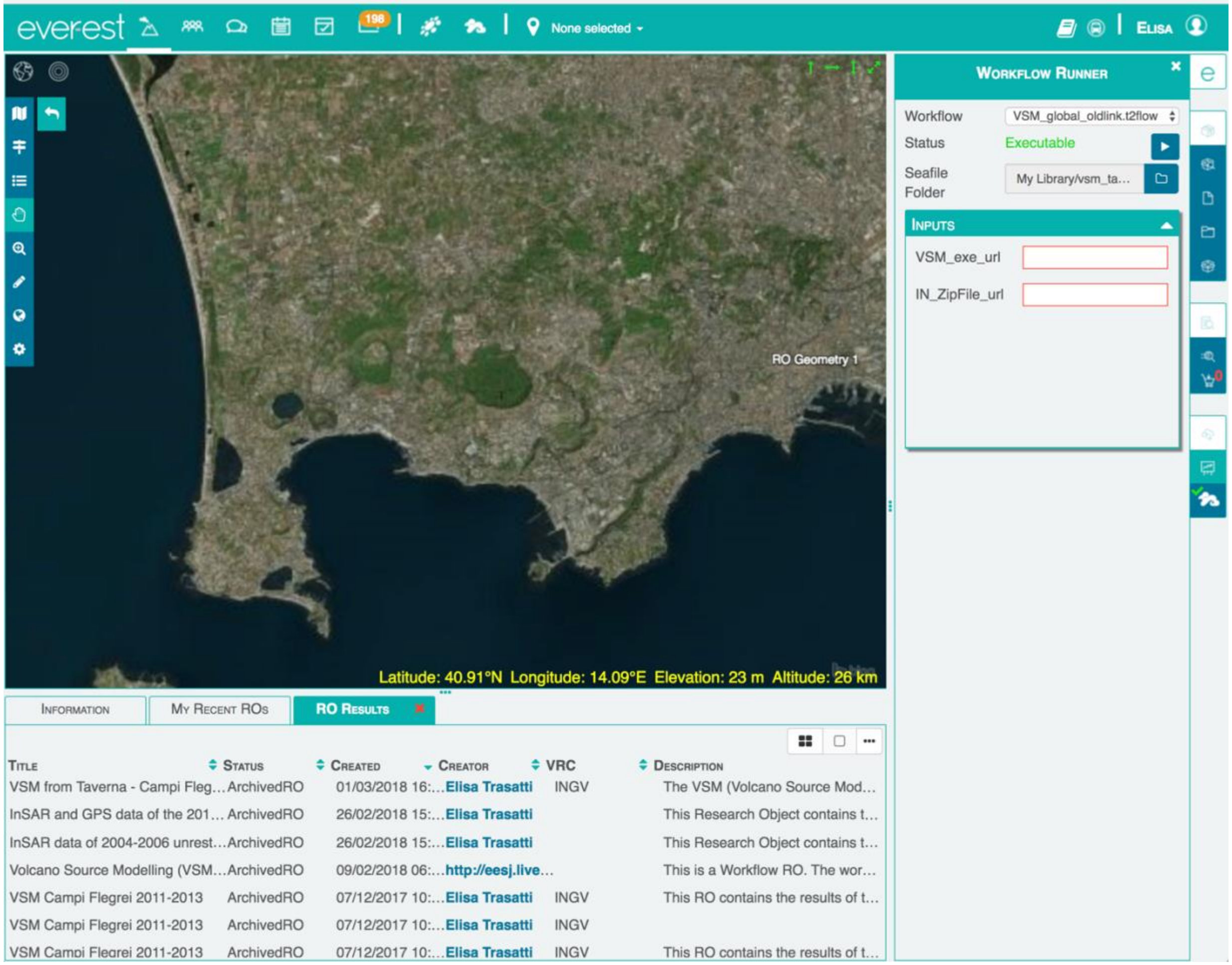


Figure 35- The Workflow runner interface in the VRE. The workflow is selected from the active RO. The user must provide the URLs to the executable code and input files.

Before executing the workflow, the user must specify the Seafile folder where the results will be stored. To run the workflow the user should enter the following two items (Figure 35):

1. the URL referring to the Fortran executable.
2. the URL of the .zip file containing the input datasets and the inversion settings.

Item 1: since the *Workflow runner* uses Linux, the user must enter the URL referring to the Linux Fortran executable of the VSM code, which can be found in the *documentation* folder of the RO (in the file HOW_TO_USE_VSM_TAVERNA).

This URL is http://box.everest.psnc.pl/f/11ef876776/?raw=1.

Item 2: the .zip input file was created by the user in the previous step and stored in Seafile. Its URL is: http://box.everest.psnc.pl/f/1abec2be38/?raw=1 .

After launching the execution, a message alerts that the process is running, placing an orange working icon on the *Workflow runner* button. If the process ends successfully, a green check mark appears on the button (Figure 36).

Figure 36- The running state of the workflow: running (left) and successful execution (right).

8.5 Management of output results

The result of the VSM workflow is a set of files bundled in a .zip archive stored in the *Workflow runner* system. At the end of the run the user click on the *Workflow runner* button and opens the interface with two new tabs (see Figure 37).

In the *Outputs* tab all the resulting files are shown and the user can inspect/download them individually, as explained before. Alternatively, the user can use one of the two buttons in the tab to save the entire .zip archive to the specified Seafile folder. The other button is used to save the .zip file in the results folder of the original RO (the VSM 2004-2006). This is not needed in this use case but may be useful when the user wants to run several instances of the same workflow and compare the results afterwards.

The *RO* tab instead provides an option to automatically create a new descendant RO including only the results, but linked to the original one containing the workflow. This option is not used in this case.

If the user is satisfied with his results, he can then create a new RO to document his research, including reference to the VSM 2004-2006 workflow, but listing his data and results. Section 6 explains how to create and populate a new RO.

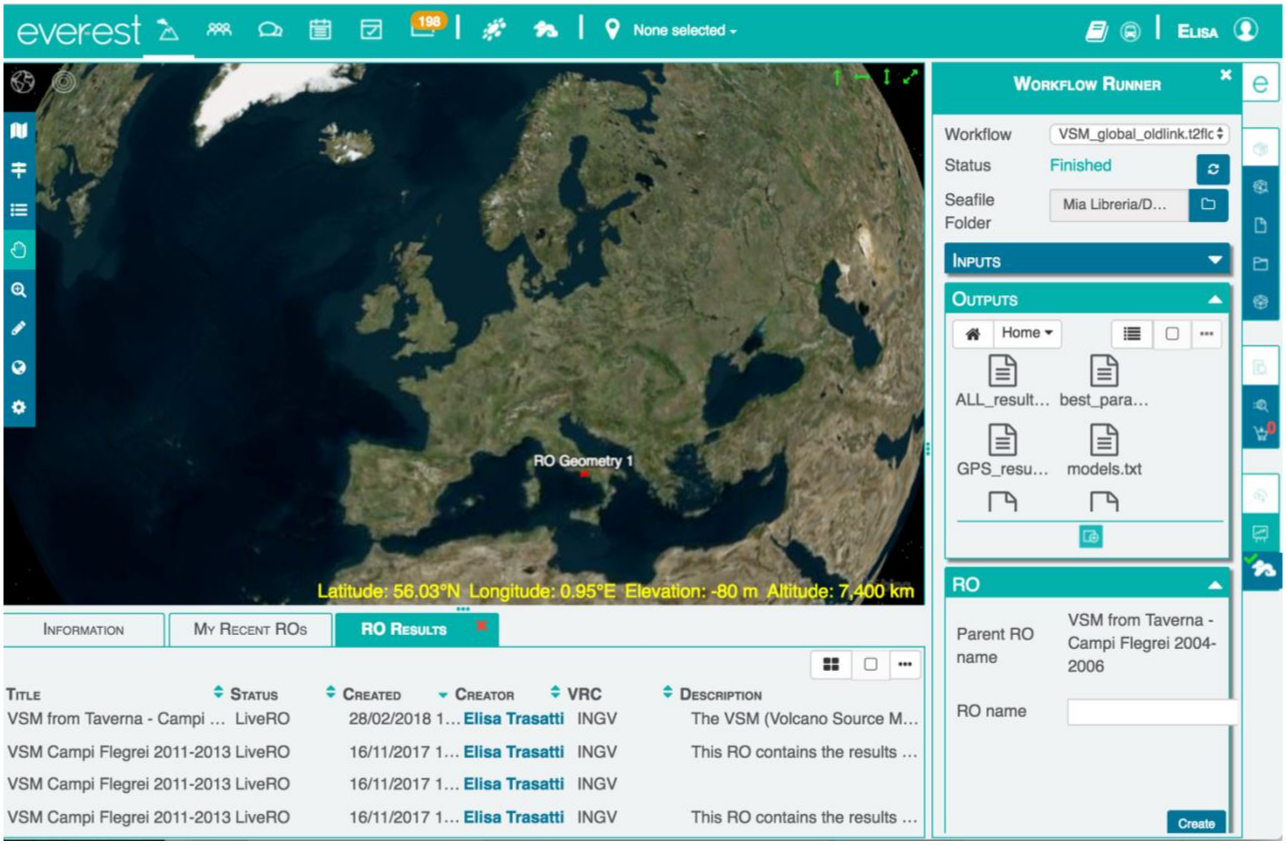


Figure 37- Results of the WF runner listed in the VRE to be inspected, visualized or downloaded.

9 Use case 3: InSAR processing with SARscape™ on a Windows Virtual Machine

9.1 Description of the use case

This use case shows how to download Sentinel 1 SAR image data from the EVER-EST VRE interface, and launch the SARscape SAR processing software in a Windows Virtual Machine to carry out Interferometric SAR processing.

SARscape is a commercial software embedded in the ENVI/IDL image processing suite, which allows to process SAR imagery with a variety of methods and for a number of applications (http://www.sarmap.ch/page.php?page=sarscape). It is provided in EVER-EST for use by the Geohazard Supersites community[7].

Interferometric Synthetic Aperture Radar (InSAR) methods are used to estimate ground motion (displacement or velocity) from radar satellite (or airborne) images. If needed, a detailed explanation of the InSAR theory and methods with reference to the SARscape tools is available at link http://www.sarmap.ch/page.php?page=sarscape .

The classic InSAR technique combines two complex radar images of the same ground area obtained before and after a ground deformation event (e.g. an earthquake), to form an *interferogram* which permits the estimation of the differences in the radar range (antenna-to-ground distance) for each image pixel.

This use case does not explain how to carry out InSAR data processing with SARscape. If the user is not familiar with the software, he can refer to the documentation available in the software web link and some steps are described here http://box.everest.psnc.pl/f/3f5178d010/?raw=1.

9.2 Sentinel 1 data discovery and access

The user is logged in the VRE for the Supersites community (see Section 2.2).

In this use case, user wants to study the ground displacement field generated by a small shallow earthquake in the Ischia island, Southern Italy. As a first step, the user selects two Sentinel 1 SAR images acquired before and after the earthquake.

The user opens the *Data discovery* tab from the *Command menu*. The user defines the Area Of Interest by means of the drawing tools in the *Virtual Globe Panel*, the coordinates of the AOI are added to the *Bounding*

[7] Please note that at present this is a limited resource which is shared by the entire community of users. Please use the software only for the time necessary to process your Supersite data, to allow use by other colleagues.

box field (Figure 38). The user then defines the other search fields (e.g. start and stop date, orbit direction, image type, etc.) and runs the query through the *Search* Button.

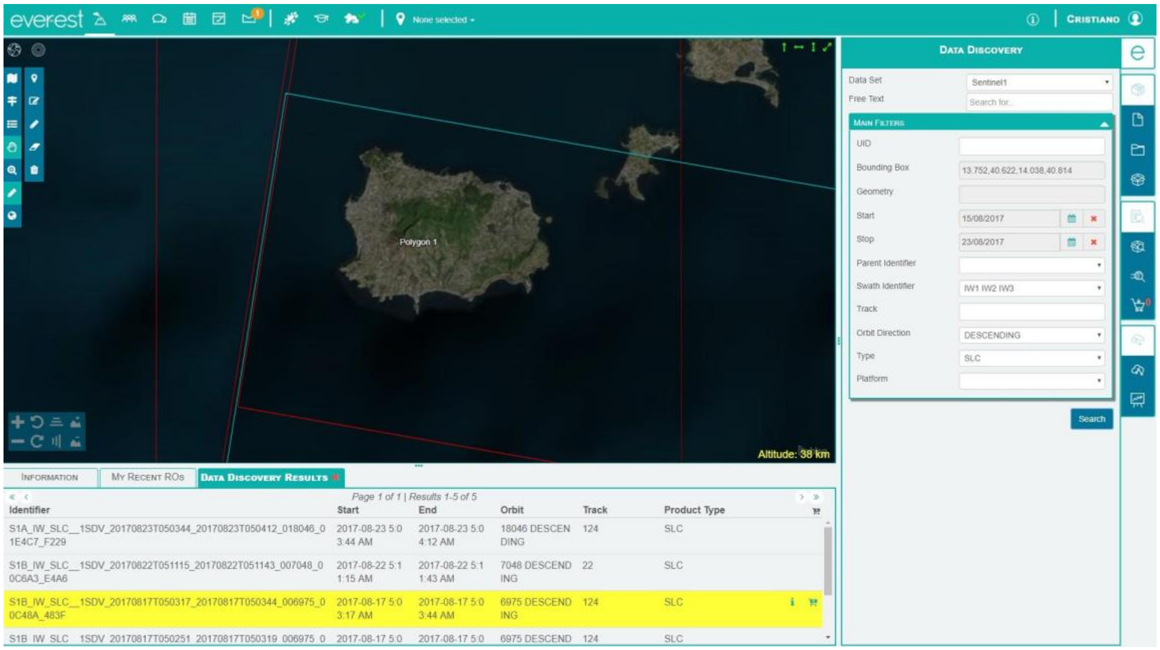


Figure 38- Data discovery in the GUI.

A list of Sentinel 1 images will be displayed under the *Data discovery results* tab in the *Information panel* (Figure 38). The image footprints are also shown in the *Virtual* globe. The user can select the images (from the list or the map) and add them to the basket for download (Figure 39).

The basket tab is opened in the *Command panel* and shows the selected products. The user must also define the *Seafile* folder in his *Personal area* where the images will be downloaded[8].

Finally, the user has also the option to create a data-centric RO containing the URLs of the downloaded images. A data-centric RO contains (or reference) a dataset used for a scientific investigation, and is useful for documentation purposes and long term preservation of scientific research.

[8] At present, there is no option for downloading to a local folder on the user's computer.

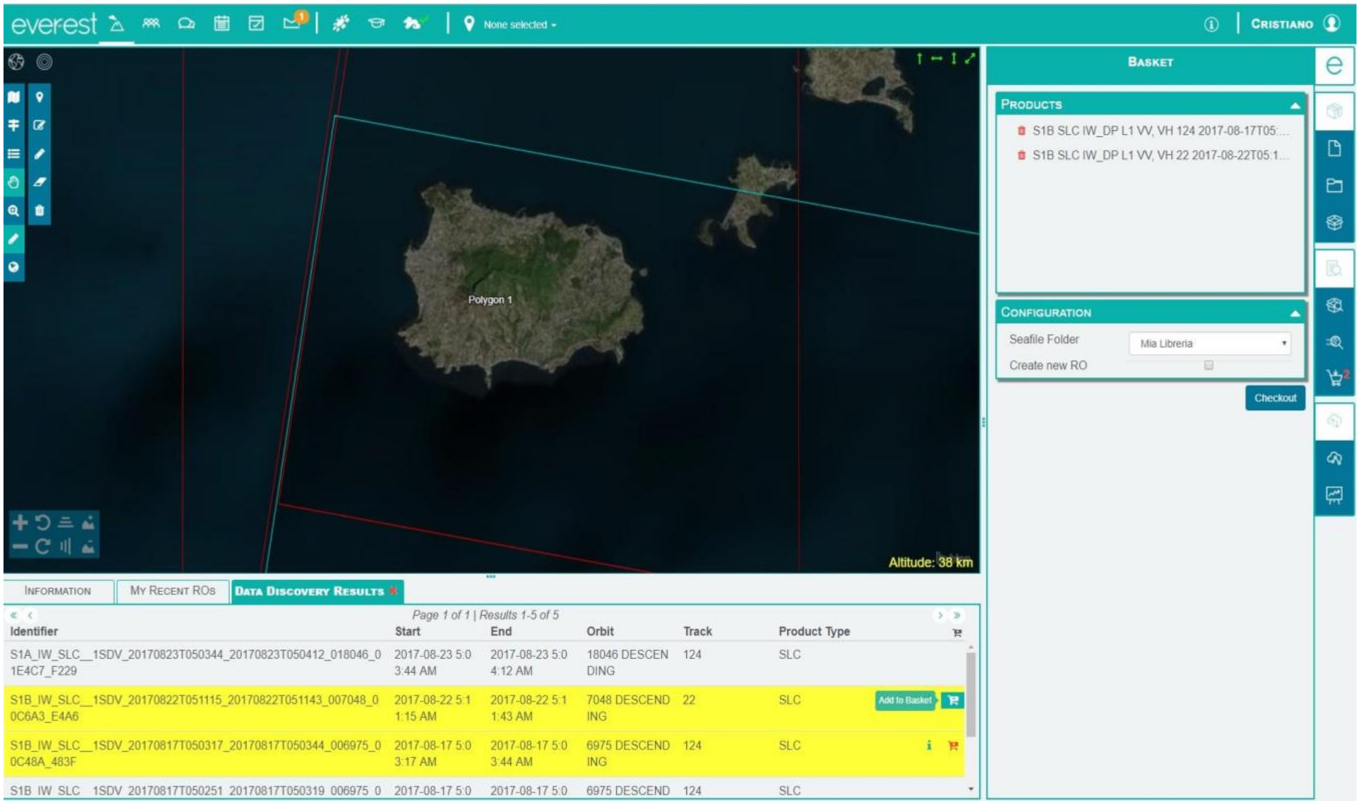


Figure 39- Images are selected and added to the cart for download.

By clicking the *checkout* button, a pop-up window appears informing the user that the download has started. At the end of the download the user will receive a confirmation email.

9.3 Access to the ENVI and SARscape environments

In EVER-EST, the ENVI/IDL/SARscape environments are only available in Windows Virtual Machines, so the user should have obtained from the Supersite administrator, the IP of a Windows VM and login credentials (see Section 2.8 or write to INGV – emails below - for updated credentials policy).

Warning: Connection to a VM could be impossible in highly secure private networks, due to limitations on usable ports. Consult your network administrator.

The user then accesses the VM using the Windows Remote Desktop Connection or a similar application.

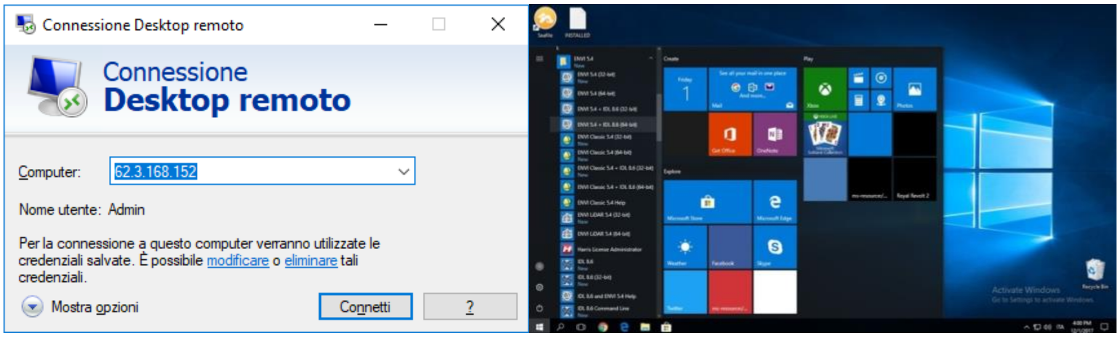


Figure 40- Access to the Windows Virtual Machine

Once in the Windows environment, the user runs the ENVI program. The SARscape software modules are available in the ENVI toolbox window to the right (Figure 40).

Before starting the processing, the user should also open the *Seafile* client application to verify that the Sentinel 1 images have been downloaded to the Seafile cloud area and synchronised to the VM local storage.

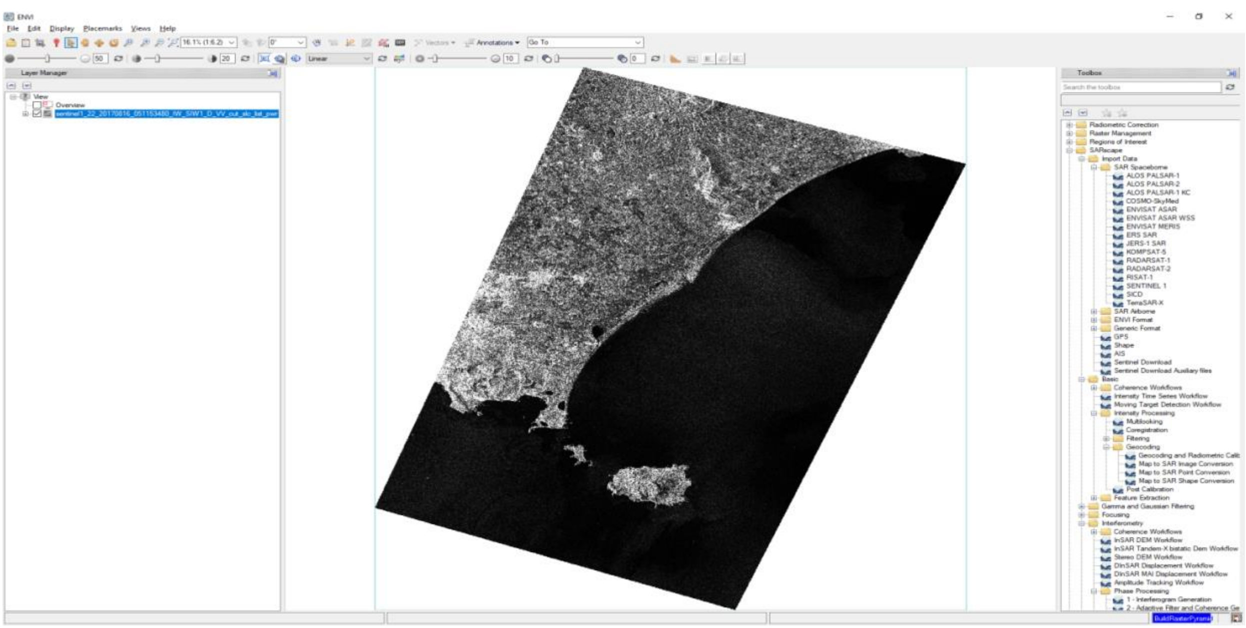


Figure 41- The ENVI software interface. SARscape modules are available in Toolbox window.

9.4 Data processing

As mentioned before, this manual does not cover InSAR data processing with SARscape. However, the Supersite network promotes capacity building through collaborative work and there might be opportunities for SARscape training within the community. Please contact your Supersite Coordinator or the GSNL Chair for information (http://www.geo-gsnl.org).

9.5 Management of output results

Figure 42 shows the SAR interferogram obtained for the Ischia earthquake co-seismic ground displacement.

Once the user is satisfied with the result he can create a RO to document his entire research and assign a DOI to it. This is explained in the next section.

It is however important to note that all the contents of the RO must be located in the cloud (to be referenced by a URL), so it necessary that the user stores all the processing results in the local Seafile folder, which is automatically synchronised to the Seafile cloud personal area.

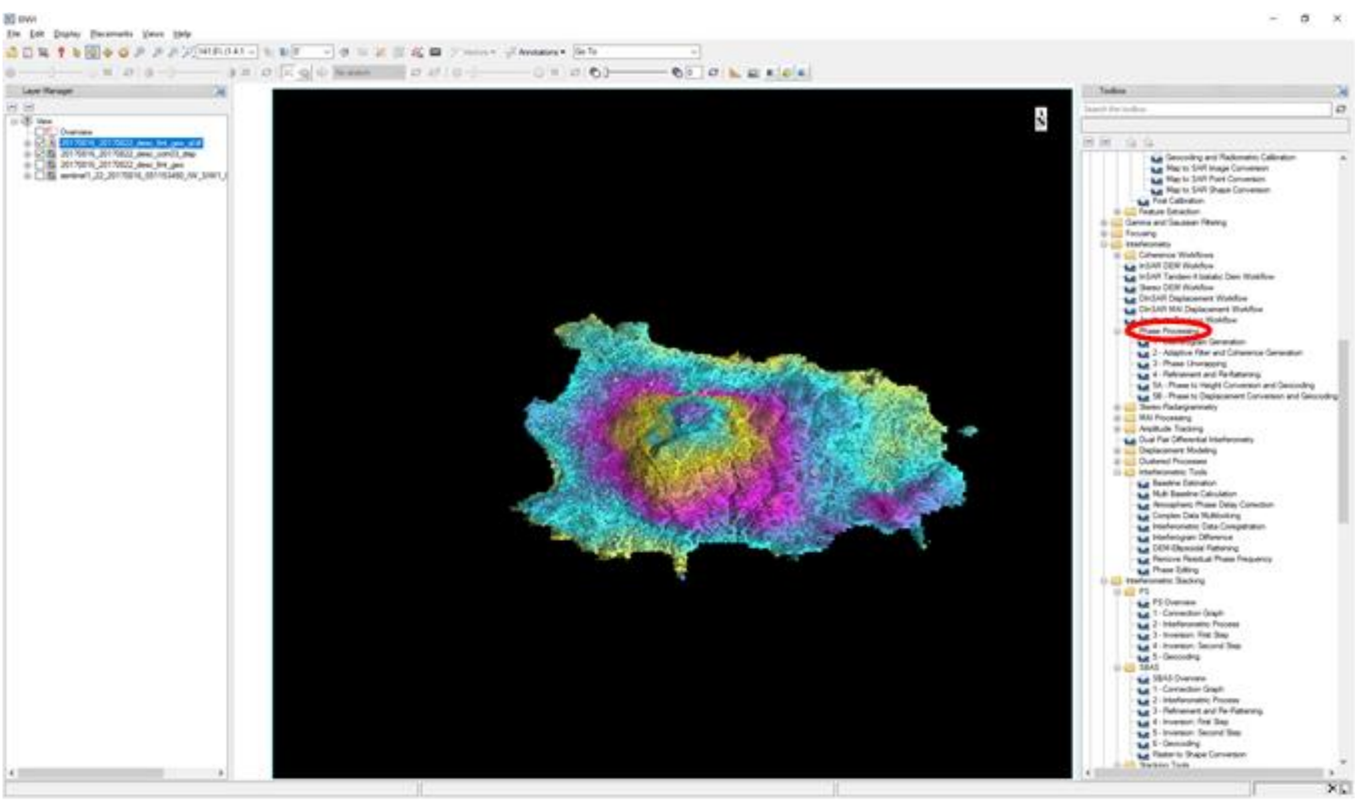


Figure 42- The final Ischia earthquake interferogram.

10 Creation of a new Research Object

This section describes how to create a new RO to document a scientific investigation and encapsulate the output results.

The user must be logged in the VRE. The user opens the *New RO* tab using the button in the *Command menu* (Figure 43).

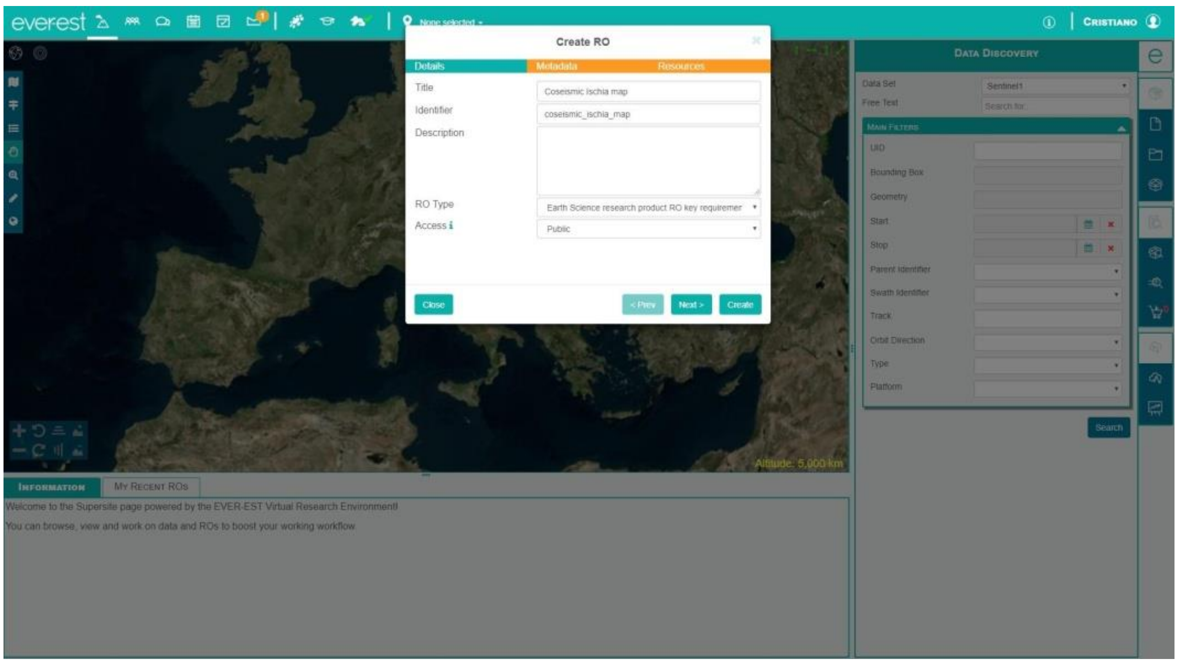
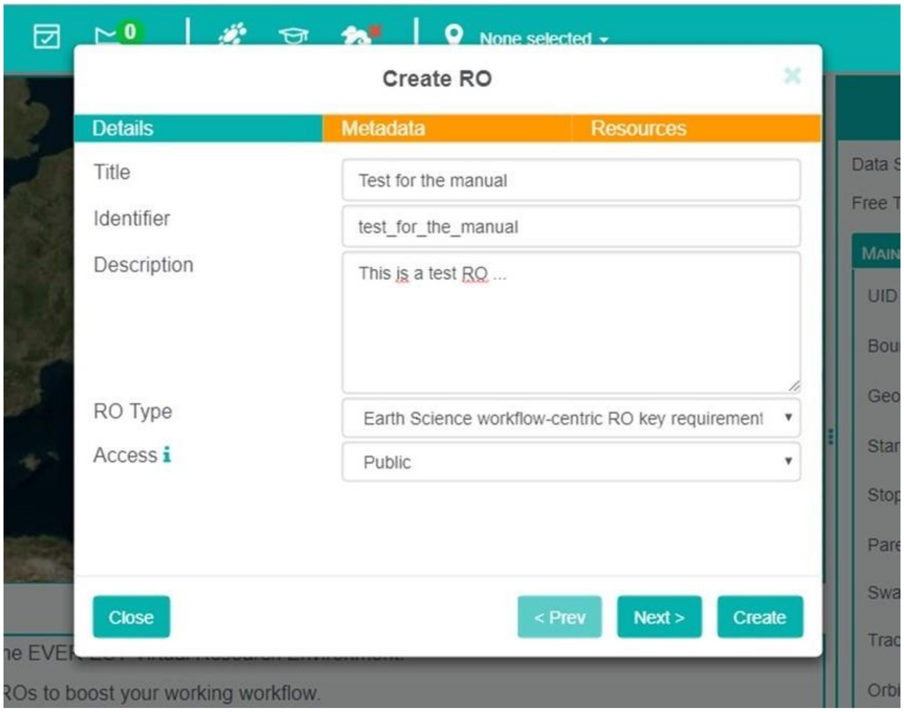
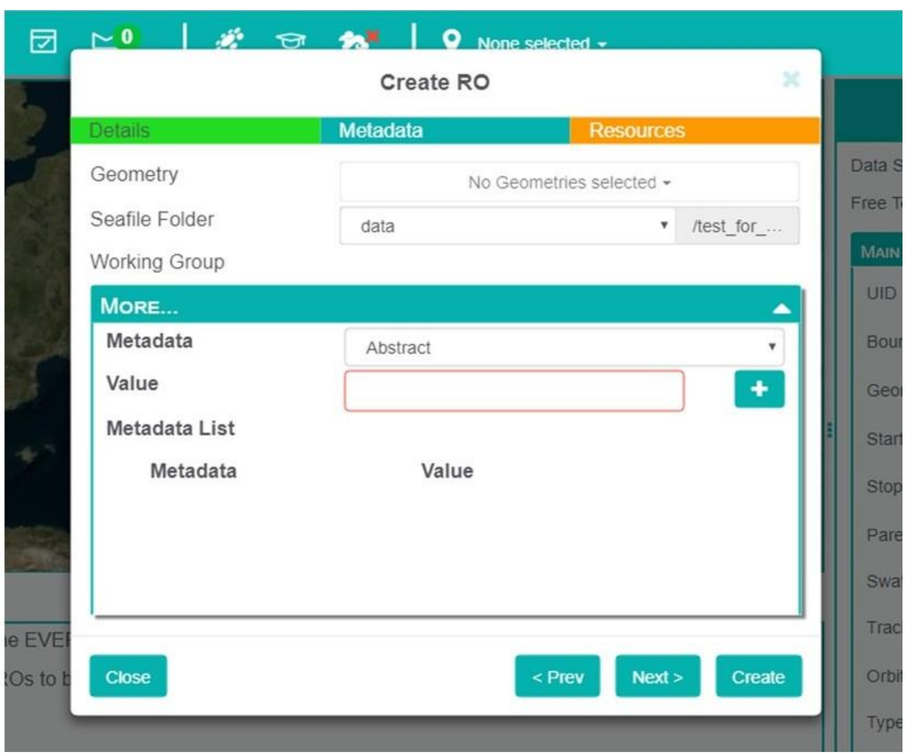


Figure 43- Creation of the RO.

The window for the RO creation consists of three different tabs: *'Details'*, *'Metadata'* and *'Resources'* (see Figure 44, top, medium and bottom, respectively).


None selected
Create RO
Details
Metadata
Resources
Title
Test for the manual
Identifier
test_for_the_manual
Description
This is a test RO ...
RO Type
Earth Science workflow-centric RO key requirement
Access
Public
Close
< Prev
Next >
Create
ROs to boost your working workflow.


None selected
Create RO
Details
Metadata
Resources
Geometry
No Geometries selected
Seafile Folder
data
/test_for_...
Working Group
MORE...
Metadata
Abstract
Value
Metadata List
Metadata
Value
Close
< Prev
Next >
Create

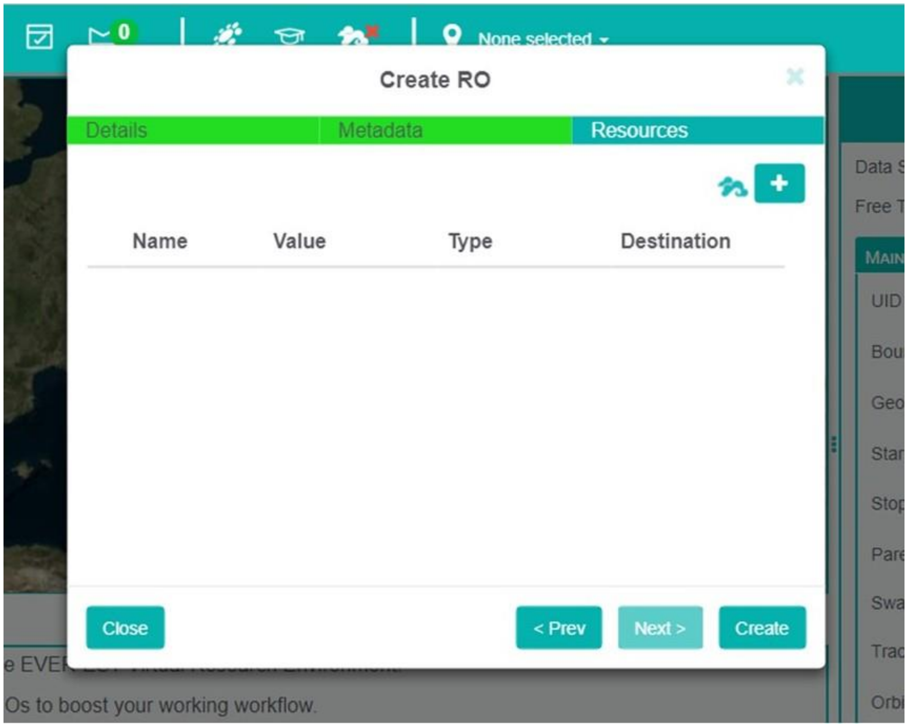


Figure 44- 'Details', 'Metadata' and 'Resources' tabs (top, medium and bottom, respectively) for creating a new Research Object.

You can use the *'Next'* and *'Back'* buttons to move among these three tabs.

In the *Details* tab the user must provide the following inputs:

- Title. The title should convey the main content at first sight, but very long titles are not needed since the RO content can be searched through its Description
- Type. Available RO types are:
    - Basic RO: a general, non-type specific research object (default value).
    - Data RO: a research object encapsulating primarily dataset resources.
    - Workflow RO: a research object encapsulating primarily scientific workflows and related resources.
    - Research Product RO: a research object representing a research product.
    - Bibliographic RO: a research object encapsulating primarily bibliographic resources.
- Description. May contain several lines of text describing the RO content. This field is optional but is highly recommended and should contain the keywords by which the RO should be found.

The user should also define the access level:

- Private (only users with permissions can read/write).
- Public (any authenticated user can read, only users with permissions can write).

Once set fields in the *'Details'* tab (as described above), you can go on the *'Metadata'* tab to add several types of metadata associated to the RO (i.e. date, format, source etc.). In the *'Resources'* tab (see Figure 44, bottom) it is possible to add resources from local files and/or from an External URL (i.e. dataset, documents, files etc.). Now, you can create the new RO by pressing the *'Create'* button.

11 References

Bechhofer, Sean & De Roure, David & Gamble, Matthew & Goble, Carole & Buchan, Iain. (2010). *Research Objects: Towards Exchange and Reuse of Digital Knowledge.* Nature Precedings. doi: 10.1038/npre.2010.4626.1.

Bechhofer S, Buchan I, De Roure D, Missier P, Ainsworth J, Bhagat J, Couch P, Cruickshank D, Delderfield M, Dunlop I, Gamble M, Michaelides D, Owen S, Newman D, Sufi S, Goble C. (2013). *Why linked data is not enough for scientists.* Futur. Gener. Comput. Syst. 29:599–611. doi: 10.1016/j.future.2011.08.004.

Guerrieri, L., Merucci, L., Corradini, S., and Pugnaghi, S., (2015). *Evolution of the 2011 Mt. Etna ash and SO2 lava fountain episodes using SEVIRI data and VPR retrieval approach*. JVGR, 291, 63-71.

Pugnaghi, S., Guerrieri, L., Corradini, S., Merucci, L., Arvani, B.. (2013) *A new simplified approach for simultaneous retrieval of SO2 and ash content of tropospheric volcanic clouds: an application to the Mt Etna volcano.* Atmos. Meas. Tech. 6 (5), 1315–1327.

Pugnaghi S., Guerrieri L., Corradini S., Merucci L. (2016). *Real time retrieval of volcanic cloud particles and SO2 by satellite using an improved simplified approach*. Atmos. Meas. Tech., 9. doi:10.5194/amt-9-1-2016.

6 Appendix B – Research Objects for the Supersite Community

We list below all the ROs created by the Supersite VRC during the validation and demonstration of the VRE. We indicate the number of ROs generated at the date of this report.

They are divided in the following tables (click on the link to access the RO):

- Workflow ROs (12)
- Data ROs (7)
- Research product ROs (18)
- General Bibliographic ROs (20)
- Bibliographic ROs for the Campi Flegrei-Vesuvius Supersite periodic bulletins (202)

Workflow ROs

Title	Content
IPWV on Mt. Etna	This RO contains the workflow which allows to obtain an integrated map of the precipitable water content over the Mt. Etna supersite, by using satellite and GPS data. The RO includes the Taverna workflow (with extension .t2flow) allowing to process MOD/MYD05 level 2 and GPS data. The workflow can run on a Linux OS (please read the "README.docx" document in the 'Content' Section). The required inputs are links to a MOD/MYD05 file and GPS text files; the RO produces ascii files containing IPWV values and quick look maps at the resolution of 0.2 deg. More informations are available on the manual at the following link: http://www.rohub.org/rodetails/everest_users_manual_for_gsnl_v27/content
REFIR_code_Eyjafjallajokull	REFIR (Real-time Eruption source parameters FutureVolc Information and Reconnaissance system) is a quasi-autonomous real-time multi-parameter system, that integrates a wide-ranging set of sensors capable of providing information on the eruption source. The system has been developed to process streaming data from a suite of sensors, including C- and X-band radars, web-cam based plume height tracking systems, imaging ultra-violet and infrared cameras and electric field sensors. In this RO it is applied to the eruption of 2010 of Eyjafjallajokull volcano (Iceland).
dMODELS for GPS inversion	This RO contains an implementation of the dMODELS inversion code by Maurizio Battaglia. This version allows to model geophysical sources (for earthquakes or volcanoes) by inverting GPS data only. More details are available in the 'config' folder within the 'Content' section (see 'Description dModels.docx').
IPWV on Iceland (wf runner)	This RO contains the workflow which allows to evaluate the precipitable water content on Iceland by using MODIS satellite data. The RO includes the Taverna workflow (with extension .t2flow) allowing to process MOD/MYD05 level 2 data. The required input is a link to a MOD/MYD05 file acquired on Iceland; the RO produces ascii files containing IPWV values at the resolution of 0.2 deg. The workflow can run on a Linux OS or on the Workflow Runner tool (please read the "README.docx" document in the 'Content' Section) implemented in the software platform of the EVER-EST project. More informations are available on the manual at the following link: http://www.rohub.org/rodetails/everest_users_manual_for_gsnl_v27/content

Volcano Source Modelling VSM	The VSM (Volcano Source Modeling) tool is a fortran code used to model ground deformation detected by the most common geodetic techniques (interferometric SAR, GPS, leveling and EDM - Electro-optical Distance Measuring). VSM performs geophysical inversion modeling of observation of ground deformation to retrieve the parameters of the causative magmatic source. A magmatic source can be approximated (modeled) by a confined part of crust with a certain shape (e.g., a sphere, a sill, a dyke, a spheroid), which is inflating/deflating because of a change in the internal magma/gas pressure. Each shape is going to generate a certain surface deformation pattern, and comparing the modeled deformation with that actually observed at the surface, it is possible to estimate the best-fit source parameters. The VSM tool carries out this task by minimizing the difference between the observed and the computed displacement field, through a process called data inversion.The VSM tool allows the user to choose among several geometrical shapes: sphere, spheroid, ellipsoid, fault, sill and retrieves the best-fit source parameters. More sources can be combined. The VSM software tool is developed by INGV, in Fortran 90. The non-linear inversion core is by M. Sambridge. This Research Object contains the OSX and Linux executables, documentation and input/output if a real example. Please refer to documentation for further information.
IPWV on Iceland	This RO contains the workflow which allows to evaluate the precipitable water content on Iceland by using MODIS satellite data. The RO includes the Taverna workflow (with extension .t2flow) allowing to process MOD/MYD05 level 2 data. The workflow can run on a Linux OS (please read the "README.docx" document in the 'Content' Section). The required input is a link to a MOD/MYD05 file acquired on Iceland; the RO produces ascii files containing IPWV values at the resolution of 0.2 deg and quick look maps of precipitable water on Iceland. More informations are available on the manual at the following link: http://www.rohub.org/rodetails/everest_users_manual_for_gsnl_v27/content
VSM Campi Flegrei 2011-2013	This RO contains the results of the geodetic inversion of the 2011-2013 InSAR data at Campi Flegrei (Italy) due to the action of a deep magmatic source. VSM performs geophysical inversion modeling of observation of ground deformation to retrieve the parameters of the causative magmatic source. The VSM tool carries out this task by minimizing the difference between the observed and the computed displacement field, through a process called data inversion.The VSM software tool is developed by INGV, in Fortran 90. The non-linear inversion core is by M. Sambridge. Please refer to documentation for further information.
Volcanic Plume Retrievals Procedure (VPR) (v.01032018)	This version (v.01032018) of Volcanic Plume Retrievals (VPR) procedure works only using MODIS data for Etna (Italy) and Eyjafjallajokull (Iceland) volcanoes. Others versions of procedure could use differents satellites platforms to retrieve differents volcanoes particles. VPR is a procedure developed to retrieve the ash optical depth, effective radius and mass, and sulfur dioxide mass contained in a volcanic cloud from the thermal radiance at 8.7, 11, and 12Ã‚Âµm. ** RO contains: the abstract (documents folder), the Taverna Workflow (workflow folder), the example of data (dataset/input folder) and the bibliography (biblio folder)

VEM_code_Santorini	This RO contains the VEM code, and the application to the 2011-2012 unrest at Santorini volcanic complex. VEM is a code to model the temporal variation in the volume change of a magmatic source surrounded by a viscoelastic shell. The code computes the ductile deformation of a concentric viscoelastic shell surrounding a shallow magma chamber, driven by separate increases in pressure. The viscoelastic model consists of a magma chamber located at a depth, d, beneath the surface, with a radius R1. The magma chamber is surrounded by a viscoelastic shell of radius of R2-R1 and rigidity mu, embedded in an elastic half-space. The code is written in Mathematica. For further documentation refer to Parks et al., Journal of Geophysical Research, doi: 10.1002/2014JB011540, 2014.
VPR_result_Etna_20151204_09_45	Ash and SO2 retrievals from VPR procedure (v.01032018) applied on Etna MODIS data of 2015_12_04_09.45 granule.
VSM Campi Flegrei 2011-2013	This RO contains the results of the geodetic inversion of the 2011-2013 InSAR data at Campi Flegrei (Italy) due to the action of a deep magmatic source. The VSM (Volcano Source Modeling) workflow models ground deformation detected by the most common geodetic techniques (interferometric SAR, GPS, and leveling). VSM performs geophysical inversion modeling of observation of ground deformation to retrieve the parameters of the causative magmatic source. The VSM software tool is developed by INGV, in Fortran 90. The non-linear inversion core is by M. Sambridge. Please refer to documentation for further information.
VSM_TAVERNA_CAMPIFLEGREI_2011_2013	This RO contains the run of the VSM code to model the InSAR and GPS data of 2011-2013 at Campi Flegrei. Results were generated by the re-use of the following RO containing the workflow VSM http://www.rohub.org/rodetails/vsm_tav_cf_2004_06_basic-1/overview in the EVER-EST VRE https://vre.ever-est.eu/supersites/. The input InSAR and GPS data are also available in the data RO http://www.rohub.org/rodetails/InSAR_Campi_Flegrei_2004_2006-release/overview .

Data ROs

Title	Content
Sentinel-1 data 2014-2017 Mauna Loa (Hawaii)	This Research Object contains the link to Sentinel-1 data of 22 December 2014 and 25 October 2017.
Colli Albani (Italy) InSAR Data 1992-2010	This dataset contains cumulate displacements in Ascending and Descending Line of Sights from ERS/Envisat satellites during 1992-2010 at Colli Albani (Italy), a volcanic area close to Rome.
InSAR data of 2004-2006 unrest at Campi Flegrei (Italy)	This Research Object contains the InSAR data (ENVISAT ascending and descending orbits) at Campi Flegrei during 2004-2006. The dataset was processed with SBAS and is subsampled with step 100m-150m. Ascii file and png images are stored.
InSAR and GPS data of the 2011-2013 unrest at Campi Flegrei (Italy)	This Research Object contains the InSAR data (COSMO-Skymed ascending and descending orbits) and GPS data from INGV related to the Campi Flegrei caldera during 2011-2013. The dataset was processed with GAMMA software and was subsampled with step 100m-150m. Ascii file and png images are stored.

Research product ROs

Title	Content
Mauna Loa displacement	Descending S1 data
Mauna Loa S1 displacement investigation	Descending data march-April 2018
Mauna Loa displacement	Mauna Loa sin_eruptive displacement field retrieved by InSAR technique (S1 descending SAR data).
Coseismic Displacement Leyte (Philippine) Eq 6 July 2017	Coseismic displacement retrieved from InSAR data (Sentinel-1) of the 6 July 2017 Mw 6.5 earthquake in Leyte (Philippine). https://en.wikipedia.org/wiki/2017_Leyte_earthquake
Mauna Loa displacement	Mauna Loa sin_eruptive displacement field retrieved by InSAR technique (S1 descending SAR data).
Mauna Loa displacement	Descending s1 data
VPR_Eyja_20100509_14.15	Ash and SO2 retrievals from VPR procedure (v.01032018) applied on Eyja MODIS data of 2010_05_09_14.15 granule. Information of VPR Procedure on http://www.rohub.org/rodetails/volcanic_plume_procedure_vpr/overview
Campi Flegrei 2011-2012 dMODELS	The analytical model of deformation dMODELS was applied to the Campi Flegrei case study for the period 2011-2012. This RO contains the source parameters and the estimated errors committed in modeling the geophysical source by inverting GPS data; the shape of the source is considered as a sphere. More details are available in the 'documents' folder within the 'Content' section (see 'Description dModels_Campi_Flegrei.docx').
Surface displacement caused from the Philippines 6 July 2017 earthquake	Unwrapped interferogram of the co-seismic event
Co-seismic surface displacement of the Bodrum-Kos earthquake (20 July 2017)	In 20 July 2017 an earthquake (Mw 6.6) struck the area of southeastern Aegean. The research object contains the measured surface deformation as derived from SAR interferometry.
VPR_Eyja_20100509_14.15	Ash and SO2 retrievals from VPR procedure (v.01032018) applied on Eyja MODIS data of 2010_05_09_14.15 granule. Information of VPR Procedure on http://www.rohub.org/rodetails/volcanic_plume_procedure_vpr/overview
Waveform Inversion results of the Kefalonia 2014 seismic sequence	Table with the moment tensor inversion results of the sequence.

Coseismic Displacement Leyte (Philippine) Eq 6 July 2017	Coseismic displacement retrieved from InSAR data (Sentinel-1) of the 6 July 2017 Mw 6.5 earthquake in Leyte (Philippine). https://en.wikipedia.org/wiki/2017_Leyte_earthquake
Waveform Inversion results of the Kefalonia 2014 seismic sequence	Table with the moment tensor inversion results of the sequence.
VPR_Eyja_20100509_14.15	Ash and SO2 retrievals from VPR procedure (v.01032018) applied on Eyja MODIS data of 2010_05_09_14.15 granule. Information of VPR Procedure on http://www.rohub.org/rodetails/volcanic_plume_procedure_vpr/overview
IPWV on Iceland 31 January 2015	This RO contains data relating to the water vapor concentration over Iceland for the day 31 January 2015. The data were derived from MODIS sensor acquisition. More details are available in the 'documents' folder within the 'Content' section. The present RO was obtained by running the following workflow RO: http://www.rohub.org/rodetails/IPWV_Iceland_new/.

General Bibliographic ROs

Title	Content
BigaSwarm2017@ESC2018	Poster presented at ESC conference "A source study of the February 2017 Biga Peninsula (Aegean Sea) earthquake swarm inferred from InSAR and seismic waveform measurements" by Svigkas N., Atzori A., Kiratzi A., Tolomei C., and Salvi S.
IranQuakeNov2017@IGARSS	Poster presented at IGARSS 2018 conference, "Surface Deformation and Source Modeling for the Mw 7.3 Iran Earthquake (November 12, 2017) Exploiting Sentinel-1 and Alos-2 Insar Data" by Tolomei C.,Svigkas, N., Fathian, A., Atzori, S., Pezzo G.
Colli_Albani@COV2018	Poster Presented at Cities on Volcanoes (COV) 2018, entitled: Deformation time-series integrated with multidisciplinary data to constrain source processes: Evidence of magma recharge at Colli Albani, the volcanic district at the gates of Rome (Italy), by Elisa Trasatti, Fabrizio Marra, Marco Polcari, Giuseppe Etiope, Giancarlo Ciotoli, Thomas H. Darrah, Dario Tedesco, Salvatore Stramondo, Fabio Florindo, Guido Ventura
GSNL@AGU2017	GSNL presentation at AGU 2017, entitled: From Open Data to Science-Based Services for Disaster Risk Management: the Experience of the GEO Geohazard Supersites Network, by S. Salvi, G. Puglisi, S. Borgstrom, M. Poland, C. Wicks, F. Sigmundsson, K. Vogfjord, S. Ergintav, N. Fournier, I. Hamling, P. Mothes, A. Savvaidis
GSNL@AOGS-EGU_2018	Presentation of the GEO-GSNL initiative at the AOGS-EGU Joint Conference in Tagaytay, Philippines

EVER-EST4GSNL@EGU2018	Poster presented at EGU 2018, entitled: The 03-09 December 2015 Etna eruption volcanic parameters retrieved using Volcanic Plume Removal procedure on EVER-EST project platform, by Dario Stelitano, Ciro Manzo, Lorenzo Guerrieri, Stefano Corradini, Luca Merucci, Vito Romaniello, Elisa Trasatti, Stefano Salvi, and Giuliana Rubbia
EVER-EST4GSNL@EGU2016	Poster presented at EGU 2016, entitled: Improving the scientific research for the Geohazard Supersites through a Virtual Research Environment: the H2020 EVER-EST Project, by E. Trasatti and S. Salvi
EVER-EST User's manual for GSNL v.2.7	User's manual of the EVER-EST Virtual Research Environment for the GEO-GSNL Geohazard Supersites Research Community
Campi_Flegrei_GSNL@EGU2016	Poster presented at EGU 2016, entitled: Geodetic constraints to the source mechanism of the 2011–2013 unrest at Campi Flegrei (Italy) caldera, by E. Trasatti; M. Polcari; M. Bonafede; S. Stramondo
Krafla_Magma_Testbed@EGU2018	Oral presentation entitled "Krafla MagmaTestbed: an International In-situ Magma Laboratory for the Future" at the European Geosciences Union General Assembly in Vienna, Austria, 8–13 April 2018. Authors: Freysteinn Sigmundsson, John Eichelberger, Hjalti Páll Ingólfsson, Paolo Papale, John N. Ludden, Yan Lavallee, Donald Bruce Dingwell, Sigurður Markússon, Gunnar Skúlason Kaldal, and the KMT-1 team.
REYKJANES4GSNL@EGU2018	Poster presented at EGU 2018, entitled: Deformation due to geothermal exploitation at Reykjanes, Iceland, by Michelle Parks, Freysteinn Sigmundsson, Omar Sigurdsson, Andrew Hooper, Sigrun HreinsdÃ³ttir, Benedikt Ã"feigsson, Karolina Michalczewska
EVER-EST4GSNL@EGU2017	Poster presented at EGU 2017, entitled: Contribution of the EVER-EST project to the community of the Geohazard Supersites initiative, by Elisa Trasatti, Giuliana Rubbia, Vito Romaniello, Luca Merucci, Stefano Corradini, Claudia Spinetti, Giuseppe Puglisi, Sven Borgstrom, Stefano Salvi, Michelle Parks, Tobias Dürig, and Freysteinn Sigmundsson
EVER-EST VRE demonstration at the GEOVOL_2018_Pasto	A presentation to introduce the EVER-EST platform during the demonstration of the VRE at the GEOVOL in Pasto (Colombia), 7th March 2018. Authors E. Trasatti and S. Salvi.
EVER-EST4GSNL@AGU2017	Poster presented at AGU 2017, entitled: The EVER-EST Virtual Research Environment for the European Volcano Supersite, by S. Salvi; E. Trasatti; G. Rubbia; V. Romaniello; F. Marelli
EVER-EST4GSNL@AGU2016	EVER-EST presentation at AGU 2016, entitled: Improving Scientific Research for the GEO Geohazard Supersites through a Virtual Research Environment, by S. Salvi, E. Trasatti, G. Rubbia, V. Romaniello, C. Spinetti, S. Corradini, L. Merucci
Azgeleh_eq@IGARSS2018	This RO contains the poster presented at IGARSS 2018 and entitled: "SURFACE DEFORMATION AND SOURCE MODELING FOR THE MW 7.3 IRAN EARTHQUAKE (NOVEMBER 12, 2017) EXPLOITING SENTINEL-1 AND ALOS-2 INSAR DATA" by C. Tolomei, N. Svigkas, A. Fathian, S. Atzori, G. Pezzo
GSNL@EGU2016	Presentation of the GSNL initiative at the EGU 2016, entitled: The GEO Geohazard Supersites and Natural Laboratories - GSNL 2.0: improving societal benefits of Geohazard science, by S. Salvi

Bibliographic ROs for the Campi Flegrei-Vesuvius Supersite periodic bulletins

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report Flegrei (2014-01-07)	Official periodic report: Bollettino_Flegrei_2014_01_07.pdf
report Campani Month (2014-01-01)	Official periodic report: Bollettino_Vulcani_Campani_ 2014_01.pdf