Consiglio Nazionale delle Ricerche
National Research Council of Italy
Istituto di Geoscienze e Georisorse
Institute of Geosciences and Earth Resources

EVOLVE: a virtual museum for a new perspective on the changing Earth System

Mariasilvia Giamberini, Antonello Provenzale
Institute of Geoscience and Earth Resources
National Research Council of Italy

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Cover: William Anders, The Earthrise, 1968, credits: NASA

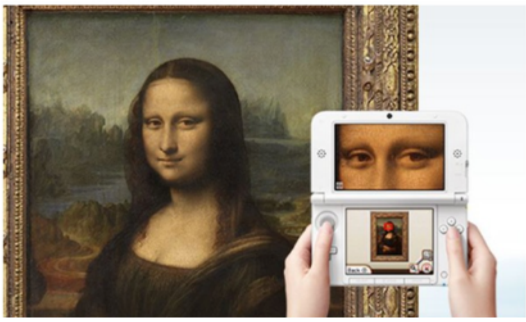
Executive Summary

We propose the design and realisation of a prototype of a scientific virtual museum, aimed to describe a new approach in the study of terrestrial ecosystems, both in the means of monitoring and investigation and in the scientific framework. Also, the novelty is represented in the use of the technologies of the virtual museum themselves, making use of portable devices and augmented reality applications.

In particular, the innovations brought in this proposal are:

- The virtual museum: the use of portable devices, internet technologies, 3D visualisation technologies and augmented reality applications make possible to extend the access to the “museum” outside its physical location, and the “object” of the museum, also rendering the visit personalised on the profile of the user;
- The creation of an open laboratory of innovation on scientific dissemination, focussed on this project and aiming also to guarantee the sustainability of the project: the virtual museum can serve as a laboratory for experimenting new technologies and new dissemination and teaching approaches, also in collaboration with schools; at the same time, the scientific content will be maintained at “state of the art” level.
- The scientific content: focussing on a new multidisciplinary approach to the study of ecosystems, under the framework of the “Earth Critical Zone”, that is the layer going from the bedrock to the canopy of trees where all the ecosystem processes happen, and that has been subject to enormous changes in the Anthropocene.
- The observation tools: from In-situ to the newest satellite missions, we are aiming to let the general public know about how processes and changes in the ecosystems are monitored and how data are acquired. The virtual museum will make it possible to make the visit to the “museum rooms” like a journey from the grater scale of visualisation to the smaller scale.

Why a virtual museum?



Digital technologies allow a great variety of means for accessing information, including texts, images, and videos, and for building new learning experiences that can enhance our perception of reality.
Some museums have made the most of these opportunities, expanding the possibility for visitors to access documents and to learn more about the collections through virtual environments.

More recently, virtual museums have attracted the interest of the research community in many disciplines such as archaeology, history, cultural heritage and, of course, information technology and natural sciences. It is easy to explore what is the wide offer from the several types of virtual museum experiences available nowadays, just browsing the web.
The *Encyclopaedia Britannica* defines a virtual museum as “a collection of digitally recorded images, sound files, text documents, and other data of historical, scientific, or cultural interest that are accessed through electronic media” (https://www.britannica.com/topic/virtual-museum).

Although formally correct, this definition is limited to the mere increase of information provided through electronic documents and images (hyper-documents), accompanying the traditional collections with some additions such as the possibility to create “virtual collections” of specimen located in different museums, and/or adding videos or pictures of natural and archaeological sites, giving broad access to archives of ancient and precious documents, as well as making virtual 3D reconstructions (e.g. of a monument or an archaeological finding or site or a fossil).

Such tools, although very useful in enhancing the learning experience, usually respond to the needs of a physical museum to enlarge their offer and accessibility to documents and collections, but still do not make the most of the technological possibilities that are available today.

Moreover, in the current landscape of the existing real and virtual museums, novel branches of natural science are scarcely explored, if not explored at all: as an example, we think of the novel concept of the “Earth Critical Zone” (ECZ, the thin layer of our planet between the bedrock and the tree canopy, where all the biological and geo-biochemical processes sustaining life occur), that can be studied and explored both at the smallest and at the largest scales through innovative means of Earth Observation and visual representations of the Earth surface.

The vision

1. Biosphere-geosphere interactions across scales and new perspectives on our planet.

It is now a century since mankind took a first look over Earth from an airplane, and started its exploration from above that lead to the iconic "Earthrise" image of Apollo 8 in 1968, and then to new generations of Earth Observation missions such as the ESA Sentinels and new consciousness of the planet, finally fully perceived as "One Grand Organic Whole" (in the words of A.R. Wallace). At the beginning of last century, scientists like Vladimir Vernadskij and Arthur Tansley gave birth to ecology and biogeosciences as a scientific discipline. At present, the most advanced branches of natural science consider all the processes in the biosphere interconnected through complex interactions with multiple feedbacks across spatial and temporal scales, that include also geological and climate processes.

Since ever, the development of novel conceptual frameworks in natural science is possible only when new observing tools are made available. This is particularly evident when visiting the Museum of the History of Science "Galileo" in Florence, where the first telescopes and other instruments for accurate astronomic measures are displayed, explaining that only a fertile environment where extremely able craftsmen could build precision instruments made it possible the birth of modern astronomy. It is not a coincidence that the Galileo Museum has been the first science museum to allow a complete virtual visit to its collection (https://catalogue.museogalileo.it/).

Today, the exploration of Planet Earth from space, and in particular the last generation of missions that allow to obtain very high-resolution images, together with the enhanced investigation and calculation tools available, made a new perspective on our planet possible, as well as the birth of multidisciplinary approaches in interpreting and modelling the processes within and between the ecosystems.

These approaches have now lead to abating the boundaries of the so called "spheres" into which the Earth surface has been artificially divided (geosphere, biosphere, atmosphere, hydrosphere, …), instead starting to develop an integrated view where the interconnections of the many processes at work cannot be described within single components.

In particular, the interactions between "living" and "non-living" components is now central to the understanding of the Earth System, together with the need of properly considering the continuum of spatial and temporal scales across which interactions take place.

An especially intriguing concept is now the "Earth Critical Zone" (ECZ), that is, the layer extending from the un-weathered rock to the top of the vegetation canopy. In the ECZ, physical, biological, geological and hydrological processes interact at multiple temporal and spatial scales, creating complex ecosystem dynamics and providing essential services such as soil water retention, weathering and erosion control, carbon sequestration, and regulation of water and energy fluxes, to name a few. The ECZ is the support system for all terrestrial life, and it is that "one physical system with its environment" as Tansley indicated when using for the first time the term "ecosystem". It is now time to let also the non-specialist public to experience this new wonderful way to explore our planet from a different perspective and enter a novel exciting journey, using the Earth Critical Zone as a guide into the complexities of how the Earth System works.

2. The changing Earth System

In the last decades, the human influence on the Earth System has been growing unbounded, leading to a geological period that Paul Crutzen has named the "Anthropocene". Such changes had positive effects (larger amounts of food, and improved health conditions in several parts of the world, for example) but are also threatening some of the main environmental processes supporting our societies, with negative outcomes such as rapid climate change and its consequences, intense air and soil pollution, water and environment, biodiversity loss, reduction of ecosystem services, uncontrolled changes in biogeochemical cycles (nitrogen), soil loss and erosion, to name but a few.
Far from considering human activities as "external" to the Earth System (as we evolved in it and from it), it is important to realize that humanity has become a powerful motor of change and has all the potentials to both damage the environment and repair the damage.
The Earth System has been constantly changing through its geological and biological history, and this fact has to be properly addressed. On top of this changing world, our own species has imposed new, rapid modifications that must also be witnessed and reported by the Virtual Museum, focusing on our current ability to observe, monitor and understand the ongoing changes through Earth Observations from remote devices and field measurements.

3. The Virtual Museum: abating the walls

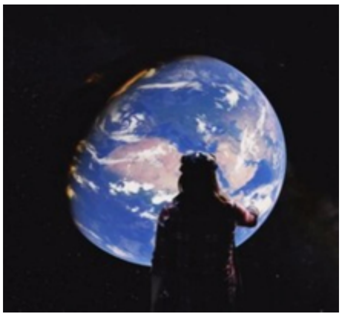
When museums were born, the locations resembled the houses and castles of the rich families who started the first collections. The architecture of museums changed over the last decades, becoming open spaces where visitors are free to move and adapting the room size to new needs to display big paintings or to let the museum display interactive games as well as videos and movies or reproducing the outer environment, but virtual museums suddenly changed the perspective, allowing a complete new concept of museum location, abating the traditional museum walls and letting the museum experience to be widened in time and space.
Museums can now be visited and explored before, during and after the visit, at home, at school, while travelling, included airports and also in open spaces.
Portable devices can be used to enhance the accessibility of the museum and to enhance the museum experience within and outside the museum walls. New technologies that allow three-dimensional visualization can let people experience a completely new world. The exhibit themselves may become something different from the "real" objects that once were preserved and displayed in the museums. Together with the aim of conservation, education has become a more and more important mission, sometimes separating the object of conservation from what is offered to the public. In addition, open spaces can be perceived as open-air museums, with the possibility to explore and access a wide range of information by means of augmented reality.

"World Skin, A Photo Safari in the Land of War" – *Maurice Benayoun, Jean-Baptiste Barrière, Virtual Reality Installation - 1997*

Several research projects are now exploring the use of new virtual reality technologies for enhancing the experience of a visit to a museum in different ways: the more common one is to introduce visual technologies in the museums themselves, offering new perspectives in observing the

exhibits and visiting the museum through multimedia and interactive devices. See for example the FP7 project "Chess" (http://www.chessexperience.eu/); the project is mainly aimed to the introduction of virtual reality tools in cultural heritage museums, but also the "Citè de l'Espace" in Toulouse is one of the partners. We think instead of **using web supported visual technologies for expanding the "museum experience" outside the museum wall themselves** (e.g. at school and at home) and using also open space places as exhibits in connection with the museum rooms (e.g. in Protected Areas). Making the museum accessible outside the building itself enlarges the accessibility to knowledge while making a bond with the museum institution itself.
A possibility to be analysed could be to let the "museum" be visited in a completely different environment, as for example in a street, or in a shop, outside of a museum context. The visitor will experiment then a completely different experience, very immersive also because it will highlight the importance of natural processes in a completely non-natural environment, making the visit experience emotionally strong.

4. The learning experience: abating the classroom



A virtual museum can be used as a learning tool in schools and universities, extending the visit experience before and after the visit to the physical museum and breaking the spatial limits of the physical museum location.

Schools at all levels and in every location in the world can enter the museum even without travelling, and let pupils virtually explore and "touch" objects. Schools can be one of the main targets for a virtual museum because they can make the most of the availability of information "outside" the museum walls, and let the learning experience being really interactive. Especially in rural locations far from the main museums and cities, or in less developed regions, the possibility of accessing a virtual museum can open new perspectives. Schools can also be actors of the virtual museum design, and using it as a long-term living laboratory for experimenting novel teaching methods. Education experts state that schools may have a great opportunity of improving the teaching effectiveness by using tools as augmented reality, in particular in the field of natural science where students can easily explore an object from a 3D perspective, being it a cell of a plant or a planet.
The plot of the museum will be designed together with experts in scientific dissemination aimed to schools from MUSE and from Centroscienza.

5. A multidisciplinary vision: abating disciplines' taxonomy

As shown by the iconic "Blue Marble" image of Apollo 17 in 1972, the Earth is a complex, highly connected systems where interactions take place across all time and space scales and among all its components. In this sense, separating atmospheric from ocean dynamics, vegetation from hydrology, and aerosols from the cryosphere is an artificial construct necessary to reduce and treat the overwhelming complexity of the system, but potentially hiding the fully interlinked nature of the Earth System.

While disciplinary views remain essential to develop the analysis tools and specific expertise in the individual processes, it is urgent to identify aspects of the Earth System that can be explored as an organic and integrated complex of processes. Examples include the coastal zone, the dynamics of boreal and tropical forests, the Arctic regions, and, of interest here, the Earth Critical Zone (ECZ), that is, the layer between the "undisturbed" rock below and the top of the vegetation canopy. Here, physical, chemical, geological, biogeochemical, hydrological and biological processes interact on spatial scales from microns to the whole landscape, and on time scales from a few minutes to the Millennia and longer. Soil is a central object of this layer, with all the biotic processes associated with it (plant photosynthesis and respiration, soil respiration, carbon cycling), the dynamics of underground water and the processes of chemical and biological rock weathering. The ECZ is the support system of terrestrial ecosystems and it has been identified as an integrated research theme in the early years of this century, leading the US National Science Foundation to support the establishment of a network of Critical Zone Observatories. In Europe, Critical Zone Observatories are now being organized in the framework of the European Long-Term Ecosystem Research Network, with projects such as eLTER and ECOPOTENTIAL including an ECZ part, and hopefully the inclusion in a new European Research Infrastructure devoted to long-term ecosystem research.


Smoke and ash drifts toward the African coast from Mount Etna in a ESA MERIS image of 28 October, 2002. ©ESA

Central to ECZ studies, but still in its infancy, is the use of Remote Sensing information to complete and fill the gaps of the data provided by field research and in-situ measurements and provide a large-scale perspective of in-situ data, such as the role of Saharan dust or of the smoke and ash from Mt. Etna in enriching and affecting soil dynamics. Along these lines, Europe can play a pivotal role in linking field measurements and satellite observations, bringing ECZ studies to a new and deeper level.

Parallel to the research activities, ECZ is a wonderful topic to be used as a pilot case for a Virtual Museum, because no physical museums can display the range of spatial and temporal scales and the fundamental interconnectedness of this integrated system.

In practice, the narrative for a "ECZ room" in the Virtual Museum should accompany the visitor, allowing for choosing different pathways, in a journey from the landscape scale (as seen by satellites, for example) to the soil pore scale, going through vegetation, soil invertebrates, and element cycling. Among the possible pathways, one could follow a molecule of water, or an atom of carbon, to see how it is exchanged and used by the ecosystem and introducing the basic concepts of isotope fractionation and geochemistry. Another option is to use different organisms such as ants or bacteria as "testimonials" that could provide both a "guiding spirit" into the complexity of the Critical Zone, as well as underline the fact that the ecosystem is composed of many tiny organisms that are, after all, more important than the most visible and charismatic ones.

Clearly, such approach will be discussed and established with the professional figures dealing with science dissemination and museum design, such as the MUSE and Centroscienza staff.

6. The technologies: new tools for a new perception

Since the invention of print, photography and cinema, the perception of reality has continuously evolved. In the last decades, the video and computer-era, including the birth of videogames, changed the way natural science museums display their collections and entertain visitors, especially the youngest ones. The exhibits have become more and more interactive using simple computers that give access to videos and games, also sometimes personalising the access to the information accompanying the museum collection and permitting a sort of dialogue. Today, the availability of portable devices embedding a camera and connected to the internet, as well as the possibility of rendering synthetic images of virtual 3D objects and environments, opens a wide range of possibilities for enhancing vision and perception of objects. Sociologists, cognitive scientists, psychologists, education scientists are discussing on the advantages of the use of such tools.
What we foresee is the possibility of making the most of such technologies for letting the visitors of the virtual museum enter in a “room” where exploration can go from the greater scale of Earth observation from satellites to the smaller scale of the analysis of processes at local and ground scale or even at molecular scale, choosing the preferred path and personalising the journey interactively.
The improving possibilities of human-computer interaction make the visit to the museum

rooms completely tailored for an array of different users according to their profiles, being young students, adults, scholars, laypersons.
Especially important is to decide from the beginning the level of technology and the related issue of the targeted audience: Complex and expensive technologies such as those using the *Oculus rift* are appropriate for installation in specialized centres (physical museums, large schools, universities), while, on the other hand of the technology spectrum, personalized and simplified approaches to virtual reality can be devoted to portable devices (cell phones) with minimal additions such as special glasses (cardboard visor devices).

7. The sustainability: a permanent laboratory of innovation

“As an institution, the digital and "wired" virtual museum is still in the earliest stages of its development. As a consequence, the key questions to ask will certainly change, and new ones will be added to the list. Much will depend on the development rate and the spreading of higher speed Internet connectivity to everyday consumers. However, solving problems of routing and data-transfer is not everything. Our modes and routines of communicating and interfacing with multimedia databases are cultural, historical and ideological issues as well. Considering precedents from the non-digital eras - covering most of the history of mankind so far - should not be neglected.”

From: “On the Origins of the Virtual Museum”
Prof. Erkki Huhtamo - University of California, Los Angeles
Nobel Symposium Lectures on “Virtual Museums and Public Understanding of Science and Culture” - May 26-29, 2002, Stockholm, Sweden

Such far-sighted words will surely remain valid for a long time because they look forward to the future as well as they look behind to the past. The whole lecture of Prof. Huktamo on virtual museums takes inspiration on how the perception of art (but the same applies to science) has changed through centuries and how museums were able to foster this change. The perception of reality, as well as the perception of the representation of reality that is given in a museum, both in art and science, have deep cultural roots that need to be taken into account. As knowledge and technologies evolve, we feel at the same time the need to stay updated and to enforce the cultural instruments that let us understand and interpret the categories of a changing world.
In this framework, and considering the rapid technological development of virtual reality tools, we want to put the basis for building a Virtual Museum that is long-lived and "sustainable", preserving it from obsolescence. The Virtual Museum, thus, needs to be constantly updated. This is possible only if it is conceived and designed to be an open and permanent laboratory for experimenting and developing concepts as well as technologies. In our vision, the Virtual Museum is an open "agora" where researchers in natural science, space technologies, IT technologies meet together with museum experts and teachers, as well as also experts in communication, social science, cognitive science and philosophers, forming a multidisciplinary team able to interpret and let us see the world with new eyes.

8. Outreach and dissemination: schools and general public

The technological developments and the potentialities of the Virtual Museum should be communicated to the potential users, in schools and at the general public level, to foster its widespread use and innovation nature, and to support the development of the permanent knowledge laboratory mentioned above.
Such goal can be best achieved through collaboration with a physical natural history museum (in this case the MUSE in Trento) and science dissemination associations with long-standing expertise in organising science outreach events in schools and for the general public (in our case, the Centroscienza Association of Torino).
Specific training meetings will be organised in selected schools and at the museum, and an explanatory video/webinar will be produced.

The proposal

EVOLVE: Experimenting new perspectives of a changing planet

1. The museum object(s)

We think of a virtual place where visitors can interactively explore several different virtual 3D rooms in which the main concepts of the complex workings of the Earth System can be experienced. This virtual place is “the museum”, and the “rooms” are not (or not only) a place where the exhibits are displayed, but they are more like windows, or doors, used for starting an exploration of the outer world.
In the virtual museum, visitors can thus explore the frontiers of Earth Observation on small and large scales, and learn more about the new findings and theories, as well as how research is performed, in the several marine and terrestrial ecosystem types, through the branches of natural and physical sciences, and about how Earth is observed today. The museum exhibits are not only images reproducing real museum exhibits, but they become virtual reproduction of real plants, animals, landscapes as well as scientific instruments, and Earth Observation maps.

The first pilot realization, which is proposed here, will focus on Earth Critical Zone processes in several different ecosystems, **continuously moving between small and large scales, as well as between In-Situ (field) observations and Remote Sensing**. ECZ is especially appropriate for this endeavour, owing both to its crucial relevance in the Earth System and for the huge modifications taking place in it as a result of environmental pressures and in particular of climate and land-use change. In the ECZ, the interplay of extremely small-scale components (bacteria, earthworms, other small invertebrates) and landscape-scale dynamical processes makes it difficult to confine the description in a “physical room” and calls for a virtual reality approach.

Two versions of the virtual museum are possible (and a choice has to be made in order to start with a feasible plan):

- Rooms are accessible inside a physical museums (e.g., MUSE), at school, at home as well as in open spaces (such as in protected areas, providing the public with information on the ecosystems and bio-geochemical processes that happens in the ECZ and where Earth Observation data are available). The rooms are accessible via a website and also make use of an “augmented reality” application on portable devices such as tablets and smartphones, as explained below.
- A complete virtual environment where the visitor is fully immersed using a device like the *Oculus rift* (https://www.oculus.com/). This device is located in a dedicated museum space or in an exhibition space. It complements and recalls the web-based virtual museum and allows to enhance the 3D exploring experience.

In practice, and as an example for the “portable version” (first option above), the visitor can choose one among several terrestrial ecosystems (the rooms) and enter the visit. The visit can start from ground level and explain the several components of the ecosystem, biotic and abiotic, and then let the visitor choose if to visit from space or from ground level or at a microscopic scale. All the elements that it is possible to investigate will be presented and a special emphasis will be given to the biotic-abiotic interconnections, the positive or negative feedbacks, the cycling of the elements, the anthropic pressures (both environmental and climate) and the detection of changes.

A design will be made for using the augmented reality technology on an open environment, e.g. in a protected area or in an open laboratory (an Earth Critical Zone observatory or an LTER site) where scientists run their monitoring activities, for letting both ecosystem and the scientific activities in field being visited.

2. The tools

A woman wearing a head-mounted display incorporating Pop Optics goggles developed by NASA's Ames Research Centre, and wired gloves. The goggles are now displayed in the Dulles Annex of the National Air and Space Museum of the Smithsonian Institution, US.

The virtual visit can be made available on different devices that make use of 3D visualization tools: a "low virtual reality level" portable version, hosted on a web site and made available also for portable devices as tablets and smartphones, and a "high virtual reality version" made available on virtual reality tools as the *Oculus rift*, to be made available in museum institutions, schools, educational centres.

Both versions can make use of the technologies available for 3D virtual exploration, taken from the world of computer games, where the visitor is the actor of the exploration and, similar to Alice in Wonderland, can virtually "travel" through several virtual rooms and environments, including open spaces at smaller scales (as waterbodies, soil, vegetation) and larger scales (as forests, seas, deserts, mountains…). The "portable version" can make use of "augmented reality" technologies, for making available information and visual experiences through personal devices pointing their camera at an object that is recognised by an augmented reality application.

At this stage, it will be possible to build a prototype version of the virtual room for the portable version of the museum, and to present a feasibility study of a full virtual reality room to be implemented via *Oculus rift* or similar technologies that may become available.

3. The workflow

We propose a small-scale pilot project where one "virtual room" of the museum can be designed, implemented and tested for the two technological approaches cited above.

The total duration of this pilot project is expected to be 12 months.

A. design: review of advances in the available technologies - selection and design of the prototype virtual room
B. co-design/writing of the storyline and of the visualisation of the plot with the team of experts and stakeholders (natural science researchers, remote sensing researchers, museum, school, IT experts)
C. final choice of the technology (Milestone)
D. implementation
E. testing
F. delivery

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A												
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4. The team

<u>National Research Council of Italy (CNR)</u>

Antonello Provenzale, PhD in Physics, Director of the Institute of Geoscience and Earth Resources of the National Research Council (CNR), Italy, since 2015, formerly Research Director at the at the Institute of Atmospheric Sciences and Climate (ISAC), coordinator of the H2020 project ECOPOTENTIAL. His most recent research interests focus on the biosphere-geosphere interactions and the Earth Critical Zone. In the framework of the H2020 project ECOPOTENTIAL, he is coordinating the activities for the new ECZ observatory in Gran Paradiso National Park, Italy.

Mariasilvia Giamberini, Master degree in Chemistry and in Environmental management, geochemists and environmental chemist, currently technician at Institute of Geoscience and Earth Resources of the National Research Council (CNR); she is communication officer of the H2020 project ECOPOTENTIAL, where she is also taking part to the research activities for the new ECZ observatory in Gran Paradiso National Park, Italy, and she is member of the science dissemination committee of the CNR Research Area of Pisa.

Elisa Palazzi, Researcher at the Institute of Atmospheric Sciences and Climate (ISAC) of the National Research Council (CNR), Italy, since 2011, PhD in Physical Modelling for the Environmental Protection. She works on the climate system and its processes with a focus on the past and future changes in the hydrological cycle in high-elevation areas and in elevation-dependent warming. She is taking part to the research activities of the H2020 project ECOPOTENTIAL.

Roberto Scopigno, Research Director at the Institute for the Science and Technologies of Information of the National Research Council of Italy (ISTI-CNR), coordinator of the Visual Computing Lab (https://scholar.google.it/citations?user=QrDzBjUAAAAJ&hl=it)Vast experience in 3D Computer Graphics and visual technologies. Partner of various EC projects focused on 3D Graphics and its application on Cultural Heritage (ViHAP3D, 3DCOFORM, V-MUST, ARIADNE, PARTHENOS, ArchAIDE, EMOTIVE).

Marco Callieri, researcher at the Visual Computing Lab of the Institute for the Science and Technologies of Information (ISTI) of the National Research Council of Italy (https://scholar.google.it/citations?user=Vshulj0AAAAJ&hl=it)
His work is mostly focused towards 3D Graphics applied to Cultural Heritage. He works on the topics regarding the digitization, processing and visualization of large 3D datasets.

Science Museum of Trento, Italy (MUSE)
Michele Lanzinger, director of the Science Museum of Trento, Italy, since 1992. (MUSE, http://www.muse.it/), holds a degree Geology and a PhD in Anthropological Sciences. Since then dr. Lanzinger has developed an intensive program of temporary exhibitions which led to a significant increase in the number of visitors to the Museum. He promoted the Museum's teaching program, which is now used by 70% of Trentino's school population (figure from 2010). From 1997 to 2004 he was president of the National Association of Science Museums (ANMS). Since 2011, he is the only Italian representative on the Board of ECSITE, the European network of science centres and museums.

Associazione CentroScienza, Turin (Italy):
Laura Celeghin, founder of Associazione CentroScienza Onlus of Turin together with Piero Angela, Tullio Regge and Piero Bianucci. One of the main targets of CentroScienza Onlus is the dissemination of the scientific culture, with a particular focus on schools of all grades. Since 1985 she collaborates with the organization Experimenta's, the first exhibition with interactive tools and since 1987, in collaboration with the Scientific Committee, organizes the scientific conferences GiovedìScienza (more than 450 appointments). In 2010, a year before becoming Director of the Association, was in the Directive Committee of ESOF 2010 (Euroscience Open Forum). Since 2005, in collaboration with the four Universities of Piedmont, organizes the European Researchers' Night in Piedmont.

In addition, one or more IT companies specialised in virtual reality technologies (to be identified)

5. Output

A working prototype of the Earth Critical Zone room for the Virtual Museum on the web (made available also for tablet and smartphone devices) and installed in one physical museum, in one school and in an open laboratory.

A work-plan and web tutorial for guiding a complete visit to the virtual museum.

A feasibility study for implementing a virtual visit using *Oculus Rift* (or similar) technologies.