Deliverable D5.3: Online ACTRIS MOOC on observing technologies

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Contents

Sustainability of ACTRIS beyond the term of the project requires actions towards both end-users and stakeholders that will address education, training, and dissemination of ACTRIS results to the community and the public. Training is key to this end. Ensuring proper training of scientists/engineer/students across the ACTRIS components and beyond is essential in the long-run to make sure of efficient use of ACTRIS Research Infrastructure platforms.

Developing a widespread knowledge of Earth Observation relevance and challenges also from the technical viewpoint will require to address the different strategies to transfer the technical information on the use of instruments and data sources within the experimental framework. The use of forefront methods and their fast evolvements imply the challenge to maintain a very high level of qualification of all the data producers. While ACTRIS-2 maintains its unique cross-border training courses that have made the reputation of the RI, it also needs to differentiate its training offers and open to new users by offering additional opportunities within and outside the ACTRIS consortium to train new users on the ACTRIS products and tools. A proposal was made to develop an online MOOC (Massive Open Online Course) -type ACTRIS course directed towards new operators of observing facilities (to be accessed through the ACTRIS data centre).

Among the main objectives of the MOOC was to develop a platform where harmonized practices for the best atmospheric composition observations could be found, and seen as a place for sharing scientific and technical experiences as well as training new operators. The potential services provided have to be explained and the whole data provision chain well described.

Definition and interest of online resources

An online open course is a sequence with a pedagogical objective, containing training sessions and skill evaluation tests. The sequence can have different formats such as video, quiz, serious games. Online courses are exclusively broadcasted on the web from a dedicated platform. The course is easily accessible and designed for a well-defined profile of attendees. An online course is not just a passive activity. Attendees are asked to evaluate their skills along the course. A certificate of qualification can be obtained at the end.
Depending on the objectives we can distinguish:

- MOOC (Massive Online Open courses) designed to have the larger number of participants. They are well adapted to present general topics like “Air quality issues”.
- Small Online Open Courses (SOOC) dealing with more focused subjects and consequently expecting less participants. Example is an online training course presenting technical procedures on how to operate instruments or analyze data
- Corporate Open Online Courses (COOC) on topics specific to a defined community. An example can be the description of an infrastructure organization or of internal processes

Online courses can be structured and combined as a set to explain/present from the general framework to very technical procedures. In addition to online courses, other online resources are useful to both promote and present different types of platforms.

The interests of online courses are multiple:

- The rise in competence is very flexible. Participants can learn at different speeds depending on their a-priori level and their availability
- It is a very powerful tool when potential learners are spread geographically since it can be accessible from anywhere, providing Internet access is available. Resources can also be made

available as transcripts (for videos) or PDF files in case of low-speed connections, videos can be subtitled in different languages.

- An online course is most of the time very innovative and playful, using serious game, tutorials, auto-evaluation tests. It aims at favouring an active learning behaviour. Besides by monitoring/encouraging the involvement of participants, the courses can be adapted and optimized.
- Beyond the training session, the online course will largely promote it producers and their framework.

Depending on the subject, although very efficient for theoretical aspects, the online courses may have to be completed by additional practical sessions in classroom or in situ.

How to create a MOOC

The time and the difficulty to create a MOOC is very often underestimated. The creation of MOOC has to be led as a large project involving a team combining several skills. A general schematic of the structuration of the different tasks and timeline are presented in Figure 1. The team should include experts in the concerned topics, experts in training engineering and communication specialists. A project leader has to be appointed in order to manage the entire process from designing to operation.

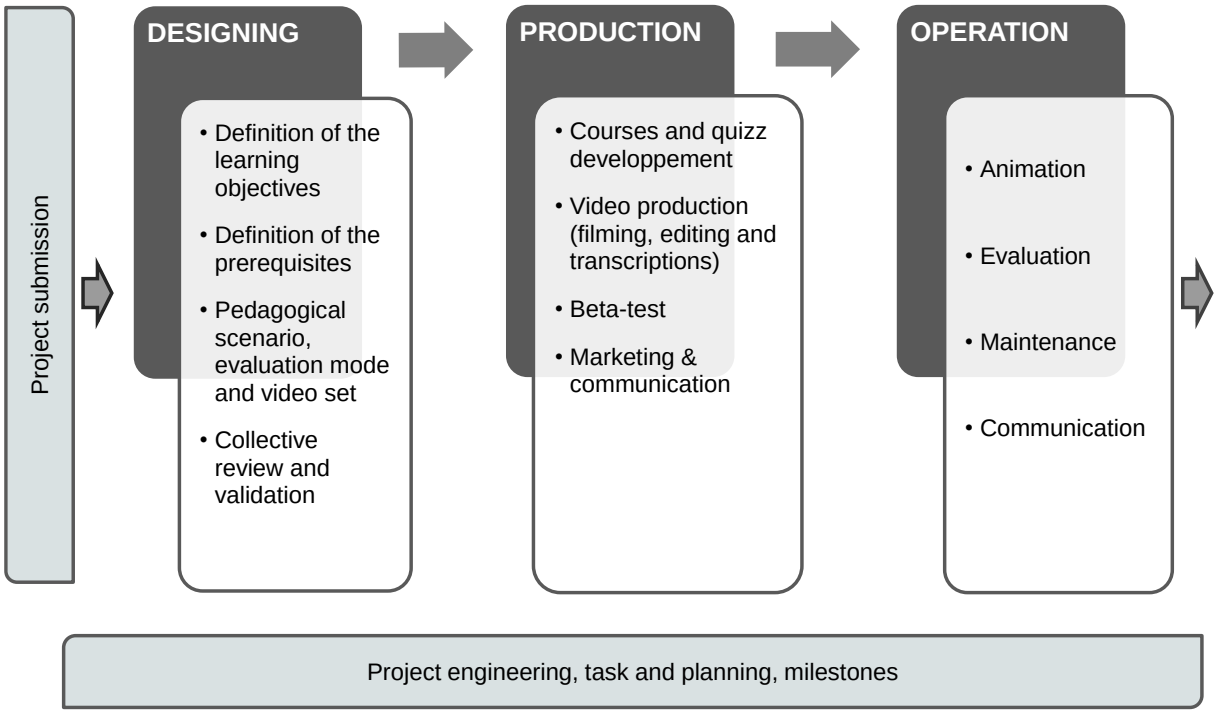

Fig. 1: Production steps of an online course

Regarding the production process and the corresponding needs, the production cost can be evaluated. By considering a MOOC (in mother language) of 4 to 5 weeks with a volume of 2 to 5 hours per week for the learners, the Institute-Mines-Telecom (IMT) has estimated the cost at 18 Pers.Months including half for the teaching team and half for the support (IMT Report *"4 years of MOOC from 2013 to 2018")*. The support mainly stands for the video production (3 PM), the management (2 PM), communication (2 PM), learning engineering (1 PM) and the broadcast platform (1 PM).

Existing online resources (not exhaustive)

Table 1 lists a few resources (in English[1]) which have been (in grey) or are still available online at no cost for the users.

[1] Some potentially interesting resources exist already in French, for instance:

- e-learning modules from the Airducation project (https://www.airducation.eu/parcours-environnement);
- training schools for Bachelor students using integrated numerical tools (digital notebooks) and observation databases at SIRTA,
- e-learning modules developed in the framework of Labex-IPSL (https://claroline.locean-ipsl.upmc.fr/) and at LACY (https://lacy.univ-reunion.fr/production/films-multimedia/mooc/)
- videos presenting observatories (SIRTA: https://www.youtube.com/watch?v=4-fmTc2JYUc; Puy-de-Dôme: https://videotheque.cnrs.fr/index.php?urlaction=doc&id_doc=4056; MAIDO: https://lacy.univ-reunion.fr/production/films-multimedia/visite-virtuelle-maido)

Table1: Non-exhaustive list of resources in English

Type	Title	Content / Objective	Duration (hours/wk)	Provider (platform) / link
MOOC [a]	Echoes in space / Introduction to radar remote sensing	Basics that will help to understand where this technology is coming from, how the images are acquired and which manifold applications already use Radar Remote Sensing to help protect our planet • History of Radar technology and the discovery of electromagnetic waves • Image acquisition Geometry of airborne and space borne Radar systems • Land applications of Radar remote sensing • Applications of radar remote sensing over Water • Application of Radar remote sensing for Hazard management	5 weeks (3)	ESA (EO College) / https://eo-college.org/courses/echoes-in-space/
MOOC [b]	Monitoring Climate from Space	What is Earth observation? How do we observe the Earth with satellites? And what role does Earth observation play in climate policy and planning? How do we use different types of mission, instrumentation and data to study changes to our atmosphere, land, oceans and ice? How does Earth observation help us set policy; plan for climate risk, resilience and adaptation; and manage resources and biodiversity? How do we make sense of the large amount of data produced by Earth observation? Can crowdsourcing and citizen science play a role in developing climate change models?	5 weeks (3)	ESA (FutureLearn) / https://www.futurelearn.com/courses/climate-from-space

MOOC [b]	Earth Observation from Space: the Optical View	Introduction to optical Earth observation - monitoring our planet from satellites, using photography, imaging in various wavelengths, lidar and other optical sensing technologies. How satellite data is acquired and used, the range of data types available, and the terminology and techniques involved. Detailed case studies of how this data is used in diverse fields, from climate science to humanitarian relief, monitoring of urban change to agriculture, and many other areas.	5 weeks (4)	ESA (FutureLearn) / https://www.futurelearn.com/courses/optical-earth-observation
MOOC [c]	Air Quality / Air pollution causes and impacts	Focus on issues related to air quality. Basics of air pollution and its environmental, health, social and economic effects	3 weeks (2-3)	IMT Lille Douai (EdX) / https://www.edx.org/course/air-pollution-causes-and-impacts
MOOC [a]	Monitoring Atmospheric Composition	• Explore how we observe and measure the atmosphere with satellites, ground-based and other forms of in-situ measurements • Understand the importance of satellite observations and other forms of measurements for atmospheric monitoring • Investigate how atmospheric data is used in policy and decision-making, in a range of arenas, in conjunction with models • Recognise the importance of the data for monitoring long-range transportation of pollutants in the atmosphere	5 weeks (3)	EUMETSAT, CAMS, ECMWF (FutureLearn) / https://www.futurelearn.com/courses/atmospheric-composition

MOOC[d]	Introduction to Geographical Information Systems (GIS)	Introduction to GIS and the principles of spatial data in personal life as well as applications of GIS across various industries. Major components of the course include computer representation of geographic information, the basics of GIS databases, spatial analysis with GIS, and application areas of GIS. At the end of the course, students will have an understanding of elementary GIS theory and examples of GIS-based solutions in the world around them.	6 weeks (2-3)	University of West Florida (Canvas network) / https://www.canvas.net/browse/uwf-geodata-center/courses/geographical-information-systems-gis-0
MOOC[e]	Discovering Science: Atmospheric Chemistry	Learn about the role that radiation and greenhouse gases play in our understanding of atmospheric chemistry. As levels of CO2 in the atmosphere increase, you will discover the solutions scientists are exploring to reduce levels. And, discover how missions to other planets and moons in our solar system are revealing extraordinarily diverse atmospheres. Explore how an exponential increase in the discovery of new exoplanets is helping us learn about the evolution of our own atmosphere.	2 weeks (5)	University of Leeds (FutureLearn) / https://www.futurelearn.com/courses/discovering-science-atmospheric-chemistry
Open course	Atmosphere, Ocean and Environmental Change	Explores the physical processes that control Earth's atmosphere, ocean, and climate. Quantitative methods for constructing mass and energy budgets. Topics include clouds, rain, severe storms, regional climate, the ozone layer, air pollution, ocean currents and productivity, the seasons, El Niño, the history of Earth's climate, global warming, energy, and water resources.	35 lectures, videos of 45 min each (self-paced)	Yale University (Open Yale courses) / https://oyc.yale.edu/geology-and-geophysics/gg-140?qt-course=2#qt-course

Open course	Atmospheric chemistry	Detailed overview of the chemical transformations that control the abundances of key trace species in the Earth's atmosphere. Emphasizes the effects of human activity on air quality and climate. Topics include photochemistry, kinetics, and thermodynamics important to the chemistry of the atmosphere; stratospheric ozone depletion; oxidation chemistry of the troposphere; photochemical smog; aerosol chemistry; and sources and sinks of greenhouse gases and other climate forcers.	13 lectures, PDF files with simplified content	MIT (MITOpenCourseWare) / https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-84j-atmospheric-chemistry-fall-2013/lecture-notes/
Open course	Atmospheric physics and chemistry	This course provides an introduction to the physics and chemistry of the atmosphere including experience with computer codes, aerosols and theories of their formation, evolution, and removal. Topics covered include, gas and aerosol transport from urban to continental scales, coupled models of radiation, transport, and chemistry, solution of inverse problems to deduce emissions and removal rates, emissions control technology and costs, and applications to air pollution and climate. It is intended for undergraduates and first year graduate students.	27 lectures, PDF files for 13 of them	MIT (MITOpenCourseWare) / https://ocw.mit.edu/courses/chemical-engineering/10-571j-atmospheric-physics-and-chemistry-spring-2006/lecture-notes/
Open course	Dynamics of the atmosphere	This course begins with a study of the role of dynamics in the general physics of the atmosphere, the consideration of the differences between	13 chapters, complete PDF files	MIT (MITOpenCourseWare) / https://ocw.mit.edu/courses/earth-atmospheric-and-

		modeling and approximation, and the observed large-scale phenomenology of the atmosphere. Only then are the basic equations derived in rigorous manner. The equations are then applied to important problems and methodologies in meteorology and climate, with discussions of the history of the topics where appropriate. Problems include the Hadley circulation and its role in the general circulation, atmospheric waves including gravity and Rossby waves and their interaction with the mean flow, with specific applications to the stratospheric quasi-biennial oscillation, tides, the super-rotation of Venus' atmosphere, the generation of atmospheric turbulence, and stationary waves among other problems. The quasi-geostrophic approximation is derived, and the resulting equations are used to examine the hydrodynamic stability of the circulation with applications ranging from convective adjustment to climate.		planetary-sciences/12-810-dynamics-of-the-atmosphere-spring-2008/lecture-notes/
Open course	The Atmosphere	The composition and circulation of the atmosphere with a focus on explaining the fundamentals of weather and climate. Topics include solar and terrestrial radiation, clouds, and weather patterns.	19 lectures, videos of ~1 hour each	UC Irvine (UCI Open) / http://ocw.uci.edu/courses/ess_5_the_atmosphere.html

[a] Closed for now; [b] Not available anymore; [c] Archived (still open for registration but support is not guaranteed between sessions; first session in Oct. 2018 was followed by ~870 learners from 71 countries); [d] Closed for now, last session in 2015; [e] Running at the time of the report (started on Mar. 25, 2019)

Typical cost for the implementation of a MOOC and implications of an ACTRIS-MOOC

Implementing a MOOC within ACTRIS cannot be proposed without a careful cost-benefits analysis that should not only include cost of developing the course but also its maintenance in the short-to-medium terms. There is little publicly available information on MOOC costs and the original dedicated budget in ACTRIS-2 was close to 4 k€. Discussion with different parties (administrators, faculty members, researchers, and other actors in the MOOC space) clearly showed that institutional resources required for the development and delivery of MOOCs, is much higher, ranging from several Tens of K€ to several thousands of k€. The original budget planed was therefore clearly underestimated. Clearly, MOOCs are a one-time investment profitable to many users and should still be considered as a cost-effective way to transfer knowledge. In the case of ACTRIS however, to expected number of potential users following a MOOC on the technical implementation of ACTRIS techniques will remain limited to mostly self-motivated learners. As an indication, the whole series of ACTRIS courses offered with WP2 and WP3 in ACTRIS-2 are currently gathering less than 100 participants / year which could be a higher estimate of followers of an ACTRIS MOOC. Estimates of typical cost/students of current online courses is ranging anywhere from 50€ to 500€/course. Considering a 5-year MOOC lifetime, an initial investment of 25k€ and 5 k€/year maintenance, and 50 followers/session, cost/student will be on an acceptable range of 100€/course.

During ACTRIS-2, several institutions were contacted to evaluate their interest for funding (or contributing to funding) a MOOC on Earth Observation techniques from the ground. We received positive answers from:

- The World Meteorological Organisation that was seeing the MOOC as a additional resource to GAWTEC (https://www.gawtec.de/)
- The IMT-Douai, which is a higher education institution already experienced in on-line courses
- The space agencies (ESA, EUMETSAT) although it was only seen as a potential addition to already existing on-line resources. Recently (EGU2019) ACTRIS-2 attended a meeting with key stakeholders and science representatives to propose and identify the priorities for training and applications to be promoted in the next years in the field of atmospheric composition. Specific needs of ACTRIS for training dedicated to in-situ component of Earth Observation was mentioned by ACTRIS to the Space agencies organizing the session, which have in their agenda an obvious priority on satellite observations from past, current and planned missions.

Conclusion and suggestions for implementation

Training is a focal point of ACTRIS activities that will need to be further developed in the future. For this purpose, online resources constitute high potential tools in addition to face-to-face training sessions such as summer and winter schools.
Several online resources related to ACTRIS scope already exist within the atmospheric science community and could be promoted through a dedicated platform. For instance, the ACTRIS website may include a section related to available “online resources” structured depending on the needs: general knowledge on atmospheric science, observing systems, up to technical procedures. That will simply be an inventory of existing resources in the laboratories involved within ACTRIS, and beyond, at the European level.
Developing specific targeted MOOC-type on-line resources for ACTRIS operations is a more complex issue that will require a substantial amount of additional resources. At minima, the simplest approach could be to use current resources as as they are, simply providing subtitled/translated or easily modified version with the authorization of owners to meet the needs of the infrastructure at a reasonable cost. Ideally, the approach should be more ambitious.
Here are the following recommendations:

- Focus of a Corporate Open Online Courses (COOC) rather than a MOOC. COOCs are more appropriate in terms of product to meet the internal needs of ACTRIS, i.e. training resources to

develop technical skills. A MOOC will ideally have larger scope that ACTRIS and it is clear that an offer already exist on the market. Developing a MOOC, with specific ACTRIS sessions, is an option that could be under the responsibility of one or more higher education partner(s) in ACTRIS, already proposing online resources related to atmospheric sciences.

- In that respect, a suggestion at this stage would be to identify ACTRIS partners willing to design and produce a core MOOC covering ACTRIS topics, which could be interlinked with existing online resources. The objectives of this ACTRIS MOOC would be for the followers: 1) to understand and be aware of the main scientific issues ACTRIS deals with, 2) to be convinced of the usefulness of atmospheric observations, 3) to know how these observation data are produced and 4) to have a presentation of the services ACTRIS can provide.
- A wider ENVRI (Environmental Research Infrastructures) approach can be suggested, perhaps at this stage limited to the atmospheric domain, with other RIs such as ICOS, IAGOS participating.
- A more targeted COOC focusing on the technical aspects of Earth Observation from the ground is clearly a better choice than a MOOC in the context of ACTRIS. In the organizational framework of the RI, it would clearly be under the responsibility of ACTRIS Topical centres that have the expertise to evaluate the need for such resources. It is a possibility in the future to include among their activities the development of operating procedures which will be made online accessible.
- A 5-year workplan is needed to both design a dedicated COOC that would be accessible through the ACTRIS website. It is recommended that the COOC would address the full data chain, from provision to data transmission, and possibly including specific sessions dedicated to data usage. AT this stage, it is more reasonable to address the internal needs of ACTRIS community (also including the international community involved in Earth Observations from the ground) rather than focussing on a wider audience, without a clear concept for an added-value product.
- It remains that online resources COOC/MOOC remain tools that could be more efficiently use in the future, for many applications in particular related to QA/QC in the RIs, that will prove to be a cost-efficient solution for the operational phase of the RI.