

Policy brief

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The SWITCH-ON Virtual Water Science Laboratory: Facilitating collaborative and reproducible Open Science

SWITCH-ON explores and exploits the substantial and untapped potential of open data to improve water management. One of the project's premises is that new water-related information and knowledge can lead to more efficient use of natural resources and facilitate environmental protection. This policy brief introduces the **SWITCH-ON Virtual Water Science Laboratory**, a digital platform for scientific research and collaboration built upon the principles of transparency, community and open access. The lab implements Open Science by encouraging collaborative experiment definition and by facilitating the search and upload of open datasets.

The promise of collaborative Open Science

Scientific research is swiftly shifting towards an open, collaborative, and global approach – Open Science. The trend is clear: the science of the future is distributed, international, collaborative, and aims to communicate knowledge as quickly and as widely as possible. The theoretical benefits of Open Science are clear: increased transparency, speed, reliability, and wider engagement. However, making the approach a reality implies overcoming problems associated with accessing open data, sharing information with others and generating reproducible science.

SWITCH-ON's contribution: The Virtual Water Science Laboratory

The SWITCH-ON **Virtual Water Science Laboratory** is a working example of Open Science in action and illustrates many of the benefits promised by this transformation. Research already completed on the platform is characterised by international cooperation and applications, transparency, reproducibility, and a commitment to openness.

The Virtual Lab features two key components: a collaborative experiment platform and a data catalogue. The Virtual Lab hosts detailed experiment protocols that ensure replicable research with greater reach. Its extensive open data catalogue, featuring more than 800 spatially-located and keyword-searchable metadata and links to water-relevant open datasets, allows users to easily inspect and download data from various data providers.

The Virtual Lab was developed, tested, and demonstrated within the SWITCH-ON project, and it is now open to any scientist for launching new ideas, posing scientific questions, sharing data, proposing experiments, and discussing and replicating results. Eight completed and three ongoing experiments, including three by groups external to the SWITCH-ON project, have proven that SWITCH-ON's Virtual Water Science Laboratory can facilitate the EU's vision of a shift to robust, reproducible, and globally collaborative research. The ultimate result: more reliable, efficient and responsive science, better suited to meeting the needs of an interconnected and interdependent Europe and world in the 21st Century.



The collaborative experiment platform

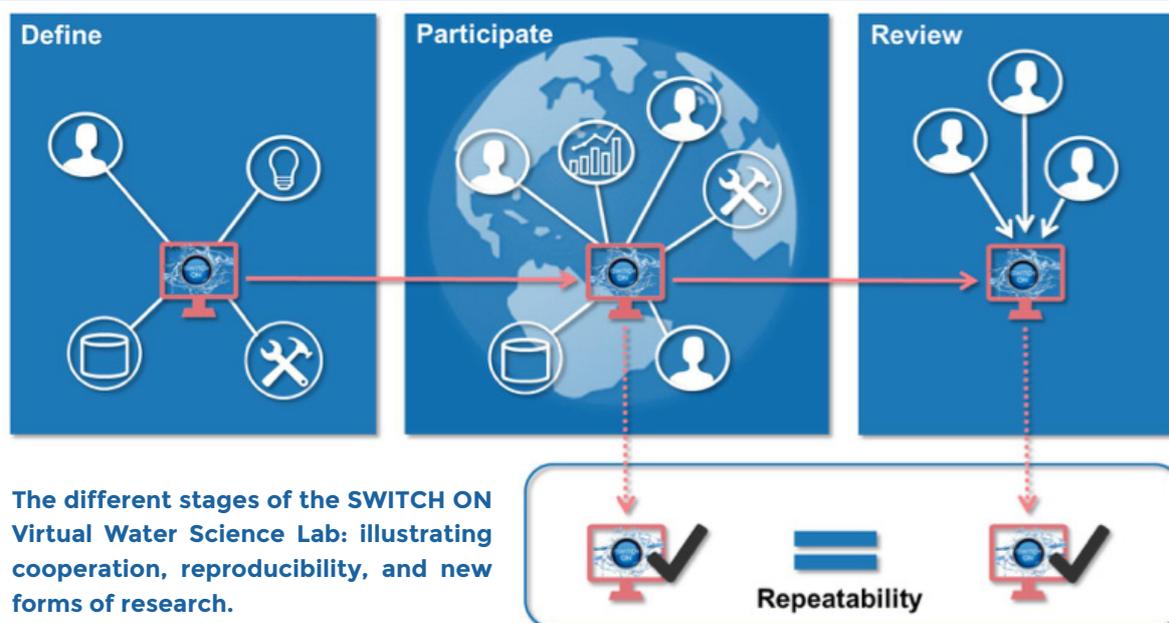
Motivated by a desire to overcome the traditional isolation of water scientists by means of a virtual and efficient meeting and working place, the SWITCH-ON Virtual Water Science Laboratory is an online platform that streamlines international and online collaboration. Through the development of agreed protocols (a carefully detailed plan for a scientific experiment), the Virtual Lab facilitates the sharing of ideas, procedures, data, models and any other relevant supporting information, thus allowing experiments on a common basis of open data and well-defined procedures.

Along with the convenience of the platform, the transparency, consistency, and open access ensured by the Virtual Lab engender three key benefits:

- ✓ **Cooperation around the world** – helps connect scientists around the world to collaborate and perform comparative analyses, accelerating scientific advances.
- ✓ **Repeatability of experiments** – enables thorough review of a large variety of numerical experiments, a foundational principle in scientific research.
- ✓ **New forms of scientific research** – new ideas are elaborated using ‘living’ online protocols, allowing large teams of colleagues to share data, tools, models, etc.

The collaborative experiment platform has three stages:

- 1 **Define a new experiment** – After registering, any scientist can launch a fully documented computational experiment and invite others to participate.
- 2 **Participate in an ongoing experiment** – Anyone can view ongoing experiments. The protocols for the experiments are ‘living’ and are where participants can ensure that all tasks are described clearly and comprehensively (including links to data and relevant scripts).
- 3 **Review or repeat completed experiments** – All important experimental information is recorded, enabling anyone to view the protocol and understand how experiments were run, and/or to set up the experiment themselves, a key aspect of reproducibility and transparency in science.



The Data Catalogue

Whether or not you are using the collaborative research platform element of the Virtual Lab, you can download, as well as upload your own datasets to the SWITCH-ON data catalogue:

Data search: The database currently hosts more than 800 searchable and mapped metadata entries that link to open data relevant to hydrological studies and applications. 87% of the data is open access for non-commercial or with acknowledgment use. This includes, for example, remote sensing land cover and meteorological data and in situ hydrological time-series measurements. The data catalogue features predominantly European data (with some global data), due to contributors/sources being majority European (including the European Environmental Agency, Member State governmental agencies, and SWITCH-ON experiments and products).

Data upload: A step-by-step approach simplifies the creation of descriptive metadata for uploading your own datasets. This ensures that your data is fully documented and can be used with confidence by subsequent researchers, and is searchable in the data catalogue.

Featured research: Virtual Laboratories

Collaborators: Eighteen researchers from Italy, Sweden, Austria, UK, and the Netherlands, researching 12 catchments.

Findings: Sharing comprehensive and precise protocols and running the experiments within a controlled environment (e.g. virtual laboratory) is as fundamental as sharing data and tools for ensuring experiment repeatability and reproducibility; doing so could advance hydrology in a coherent way.

[doi:10.5194/hess-19-2101-2015](https://doi.org/10.5194/hess-19-2101-2015)

Using the Virtual Laboratory: Recommendations for success

To ensure that the virtual laboratory is a success, users must:

- 1 Ensure code is readable and reusable by the community;
- 2 Create workflows that tie together data and reusable code to unambiguously document the provenance of published scientific results;
- 3 Make reusable code and workflows available and easy to find through consistent use of repositories and creation of code metadata;
- 4 Cite reusable and reproducible code in publications using unique persistent identifiers (e.g., DOIs) to clearly show the provenance of published scientific findings;
- 5 Develop new procedures that ensure scientific rigor in circumstances where reproducing large-scale studies is computationally expensive and time consuming (Hutton et al., 2016).

Open Science Transformation - what else is needed?

Along with new technologies such as the Virtual Lab, transformational changes are required to realise open and collaborative science. We must:

- Train young scientists to adopt reproducible practices - which increase the citation and reuse of an individual's work.
- Initiate a new collective commitment to openness across the science community, including real buy-in from journals and funding bodies.
- Utilise the new transparency in science communication to increase policymakers' trust in scientific results.
- Ensure incentives for Open Science are in place through adequate funding and evaluation of scientific research.



Further information

SWITCH-ON Virtual Water Science Laboratory | www.switch-on-vwsl.eu

SWITCH-ON Website | www.water-switch-on.eu

This policy brief also draws on the following reports:

Ceola, S. et al. (2015) Virtual laboratories: new opportunities for collaborative water science. *Hydrol. Earth Syst. Sci.*, 19, 2101–2117. Available: www.hydrol-earth-syst-sci.net/19/2101/2015/hess-19-2101-2015.pdf

European Commission (2016) Open innovation, open science, open to the world. Available: <https://ec.europa.eu/research/openvision/index.cfm>

Hutton, C. et al. (2016) Most computational hydrology is not reproducible, so is it really science? *Water Resour. Res.*, 52, 7548–7555. Available: onlinelibrary.wiley.com/doi/10.1002/2016WR019285/full

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