WP10 JRA3
Facilitating the re-use and exchange of experimental data

Task 10.6 Knowledge transfer

D10.5 Tools for hydraulic data interrogation and experimental expertise knowledge transfer (Demonstrator for Data Flux)

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EXECUTIVE SUMMARY

The HYDRALAB+ project is aimed at strengthening the coherence of experimental hydraulic and hydrodynamic research undertaken across its partner organisations. Work package 10 is tasked with Facilitating the Re-use and Exchange of Experimental Data (FREE Data). As part of this work package, HYDRALAB+ deliverable D10.5 is a portfolio of tools for hydraulic data interrogation and experimental expertise knowledge transfer: HydraDAC, visualization tools and the HYDRALAB Wiki.

The HydraDAC tool allows a hierarchical folder to be zipped quickly and efficiently into numerous sub folders. The development of this tool is based on making it easier for end users to access content from a dataset. If a single zip folder is uploaded to a repository, such as Zenodo, the end user only has the option to download a single and sometimes large zip file. In some cases an end user may only wish to access a subset of data such as that for a single day's experiments or a single experiment's dataset. The HydraDAC tool allows us to offer such arrangements of data to end users.

The online visualization tools offer the capability to interactively visualize data that are stored online. Such online visualization tools cannot be used with Zenodo and requires another storage technology: the OpenDAP server. The packaging of the data is performed using a tool specifically developed at LEGI called project-meta. This tool also embeds the capability to prepare an archive for publication on Zenodo. Once the data are publically available online on the OpenDAP server, Jupyter Notebooks are used to read the data and do some interactive plots such as profiles, colour plots or vector plots depending on the nature of the data to be visualized.

In order to facilitate the transfer of knowledge and expertise on subjects related to hydraulic laboratory practice HydralabWiki (http://wiki.hydralab.eu) was initialized from the partners of HYDRALAB+ and has been online since July 2018. HydralabWiki is built on MediaWiki platform, being the most advanced and popular open source wiki platform in the wiki space to date. Its purpose is:

- to share in-depth knowledge and expertise which may not be found in conventional literature;
- to provide introductory information about the concepts and procedures in hydraulic laboratories in order to connect the non-professional user with the professional literature; and
- to be an interactive tool in the teaching/learning process. The active collaboration of learners in developing the dynamic contents of the wiki will benefit both the learners and the wiki.

CONTENTS

1 Tools

The HYDRALAB+ project is aimed at strengthening the coherence of experimental hydraulic and hydrodynamic research undertaken across its partner organisations. Work package 10 is tasked with Facilitating the Re-use and Exchange of Experimental Data (FREE Data). As part of this work package, HYDRALAB+ deliverable D10.5 is a portfolio of tools for hydraulic data interrogation and experimental expertise knowledge transfer. This brief report serves as an inventory for this portfolio and provides a brief description of each tool.

Each tool in the portfolio has been developed in response to a direct need identified during the activities undertaken by work package 10. These are introduced in sections 1.1, 1.2 and 1.3 and are described in more detail in sections 2, 3 and 4 respectively.

1.1 HydraDAC

The HydraDAC tool allows a hierarchical folder to be zipped quickly and efficiently into numerous sub folders. The development of this tool is based on making it easier for end users to access content from a dataset. If a single zip folder is uploaded to a repository, such as Zenodo, the end user only has the option to download a single and sometimes large zip file. In some cases an end user may only wish to access a subset of data such as that for a single day's experiments or a single experiment's dataset. The HydraDAC tool allows us to offer such arrangements of data to end users.

1.2 Online Visualization Tools

The online visualization tools offer the capability to interactively visualize data that are stored online. Such online visualization tools cannot be used with Zenodo and requires another storage technology: the OpenDAP server.

The protocol OPeNDAP (Open-source Project for a Network DataAccess Protocol) includes standards for encapsulating structured data, annotating the data with attributes and adding semantics that describe the data. The protocol is based on http, so that data can be scanned with an ordinary web browser, but added functionality of data visualization is provided by graphics programs (like Matlab, GrADS, Ferret or ncBrowse). Compared to ordinary file transfer protocols (e.g. FTP) a major advantage using OPeNDAP is the ability to retrieve subsets of files, so it is possible to work remotely without downloading whole data files.

OPeNDAP is widely used by governmental agencies such as NASA and NOAA to serve satellite, weather and other observed earth science data. However, no standard server is currently available for hydraulic research. Therefore a DAP server has been implemented at LEGI http://servdap.legi.grenoble-inp.fr/opendap/ with a few prototype examples of data sets.

The packaging of the data is performed using a tool specifically developed at LEGI called project-meta (http://servforge.legi.grenoble-inp.fr/projects/soft-trokata/wiki/SoftWare/ProjectMeta). This tool also embeds the capability to prepare an archive for publication on Zenodo. Once the data are publically available online on the DAP server, data can be directly scanned and visualized by Matlab

functions provided in a package uvmat (http://servforge.legi.grenoble-inp.fr/projects/soft-uvmat).
An alternative possibility, which does not require any software installation for the user, is to use
Jupyter Notebooks to read the data and do some interactive plots such as profiles, colour maps or
vector plots depending on the nature of the data to be visualized.

1.3   HYDRALABWIKI

In order to facilitate the transfer of knowledge and expertise on subjects related to hydraulic
laboratory practice HydralabWiki (http://wiki.hydralab.eu) was initialized from the partners of
HYDRALAB+ and has been online since July 2018. HydralabWiki is built on MediaWiki platform,
being the most advanced and popular open source wiki platform in the wiki space to date, and it
shall be employed on three levels:

1. In-depth knowledge and expertise which may not be found in conventional literature,
   particularly the knowledge generated within the current and the previous HYDRALAB
   projects could be integrated in HydralabWiki using its capability to handle rich contents.
2. Introductory information about the concepts and procedures in hydraulic laboratories may
   be used to connect the non-professional user with the professional literature.
3. Interactive tool in teaching/learning process. Active collaboration of learners in
   development of the dynamic contents of the wiki will benefit both the learners and the wiki,
   as well as the video tutorial which explain the use of innovative instruments in experimental
   hydraulics.

2   HYDRADAC USER GUIDE

The HydraDAC tool allows a hierarchical folder to quickly and efficiently be zipped into numerous
sub folders. The development of this tool is based on making it easier for end users to access content
from a dataset. If a single zip folder is uploaded to a repository, such as Zenodo, the end user only
has the option to download a single and sometimes large zip file. In some cases an end user may
only wish to access a single day's experiment data or a single experiments dataset which is what the
HydraDAC tool allows us to offer. If the dataset owner was tasked with zipping a large number of
folders it would be quite time consuming but HydraDAC takes a fraction of the time by selecting the
folder to compress, the sub level at which to create the zips and providing an output folder to save
the zip files to.

A HydraDAC User Guide is provided below.

2.1   DOWNLOAD APPLICATION

The HydraDAC application is available on Mac, Windows and Linux and may be downloaded from the
following URLs:

Mac Installer -
Windows Installer -
Linux Installer -

You will then need to run the installer and follow any necessary steps requested.

2.2   LOAD AND RUN THE APPLICATION

HydraDAC can be run in three easy steps, as shown below.

2.2.1   Step 1: Load Application and select folders

Open the application in your chosen platform, which will present the opening screen shown in Figure 1.

Select Dataset and Output folders. The dataset folder is the root folder of your dataset. The output folder should be an empty folder that will be used to place all zipped content in the final step. The selection of a dataset folder is shown in Figure 2.

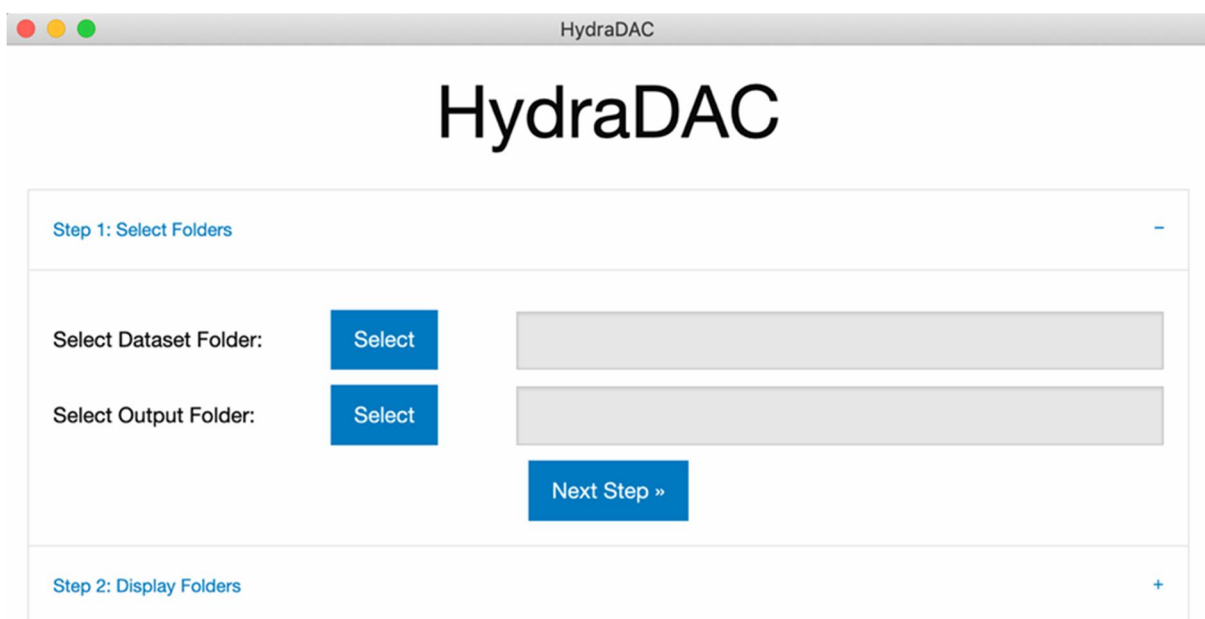Once you have selected both folders press Next Step to advance.
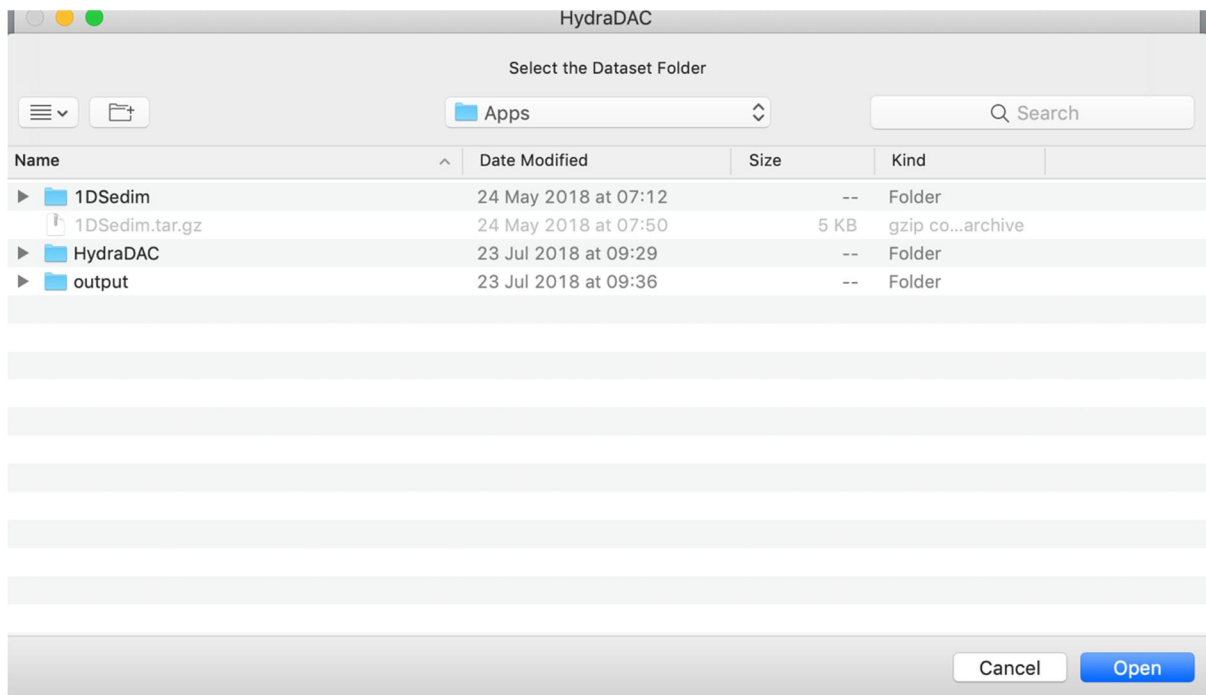

Figure 1 HydraDAC start screen

Figure 2 Selection of HydraDac dataset folder

2.2.2   Step2: Select folder levels

Step 2 allows you to choose which level you would like to create the zip folders from, as shown in Figure 3. HydraDAC will default to the level that it believes is most suitable, however you can change to suit your requirements.
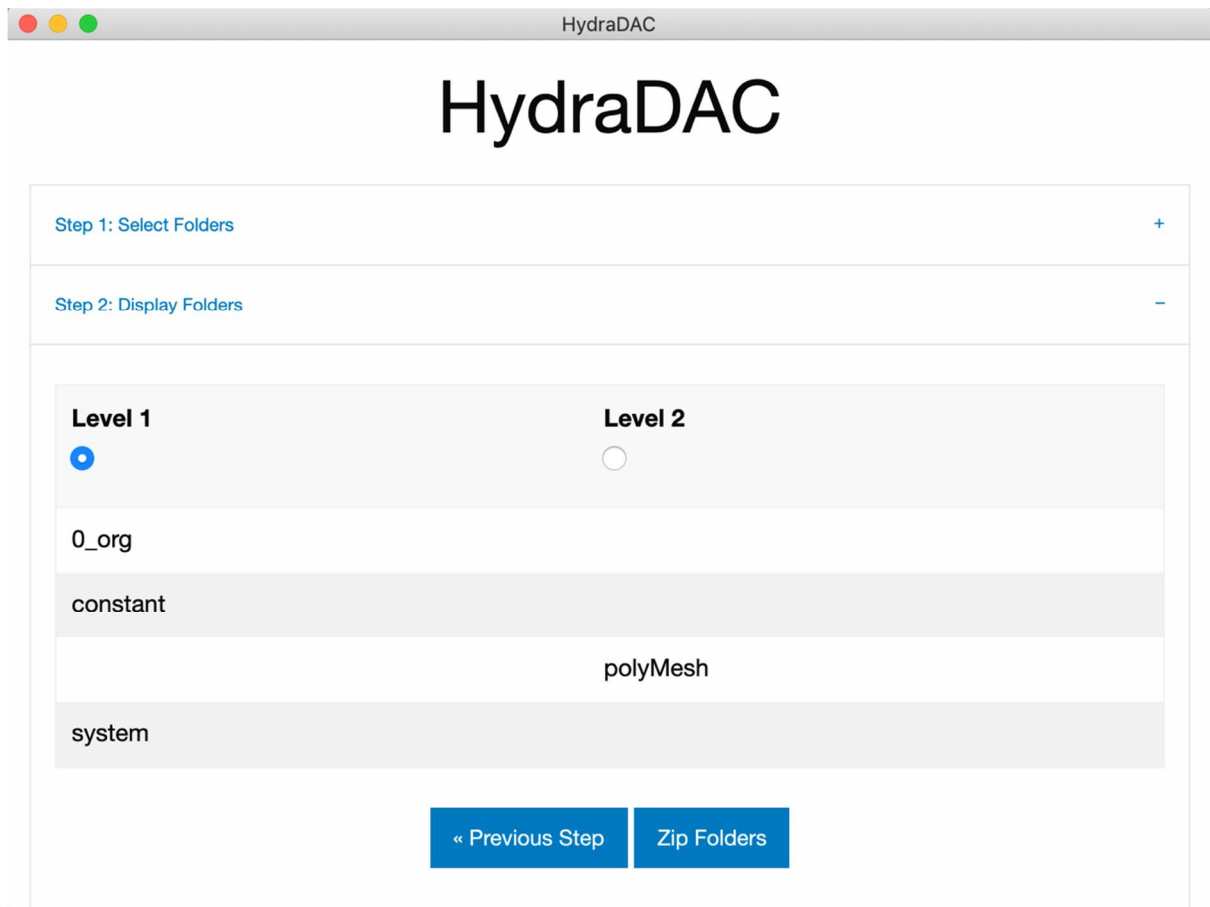
Figure 3 Selection of file structure level for creating of zip folders

2.2.3   Step 3: Zip Folders

When you have selected the level you wish to zip folders at, you can press the Zip Folders button which will start the process. For large amounts of data you will see a progress update with a success message upon completion, as shown in Figure 4.

If you return to the folder you selected as the output folder, you will see that it now includes a number of zip files named according to the folder hierarchy, as shown in Figure 5. Each underscore represents a folder the contents originally sat within.

Figure 4 Success message

Figure 5 Contents of HydraDAC output directory

3   ONLINE VISUALISATION TOOLS USER GUIDE

3.1   INTRODUCTION

The online visualization tools offer the capability to interactively visualize data that are stored online. Such online visualization tools cannot be used with Zenodo and requires another sto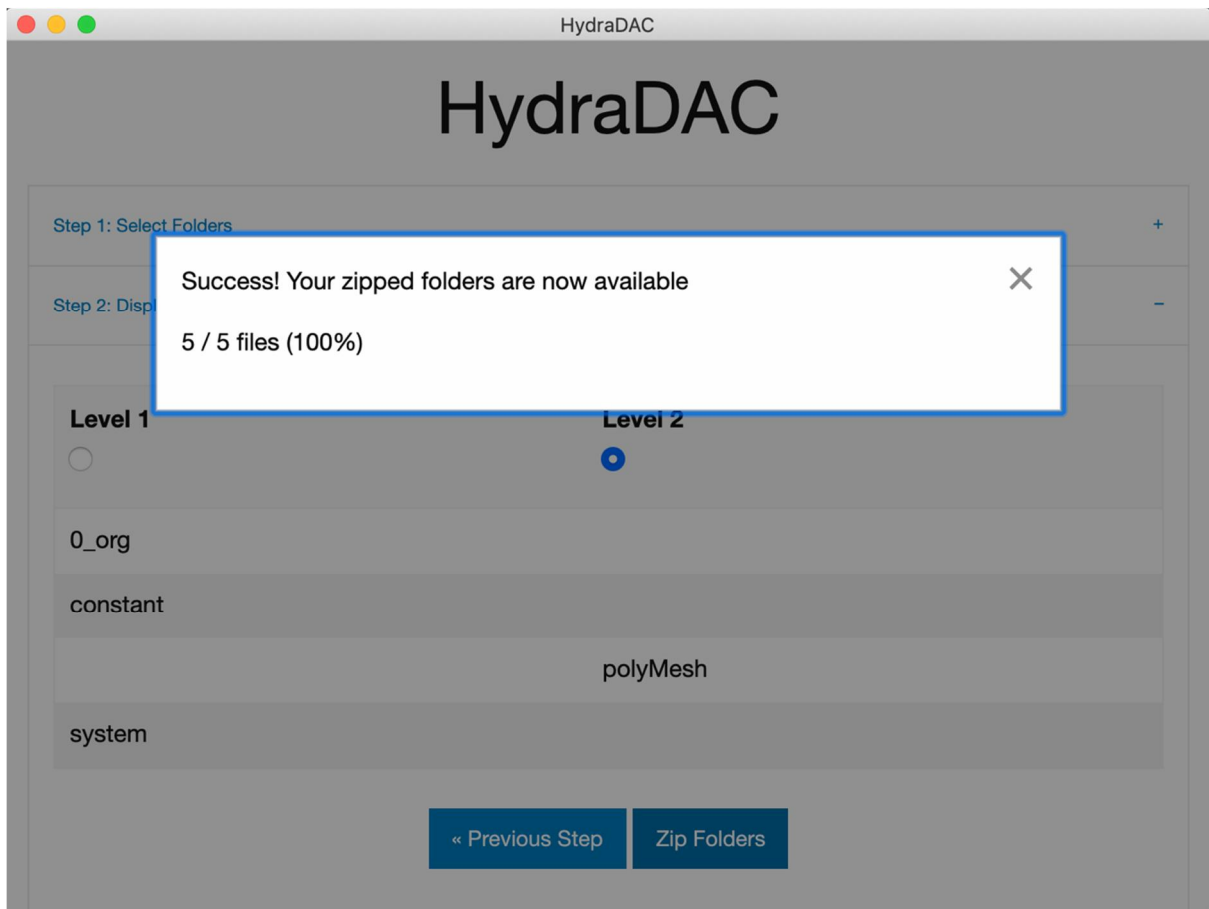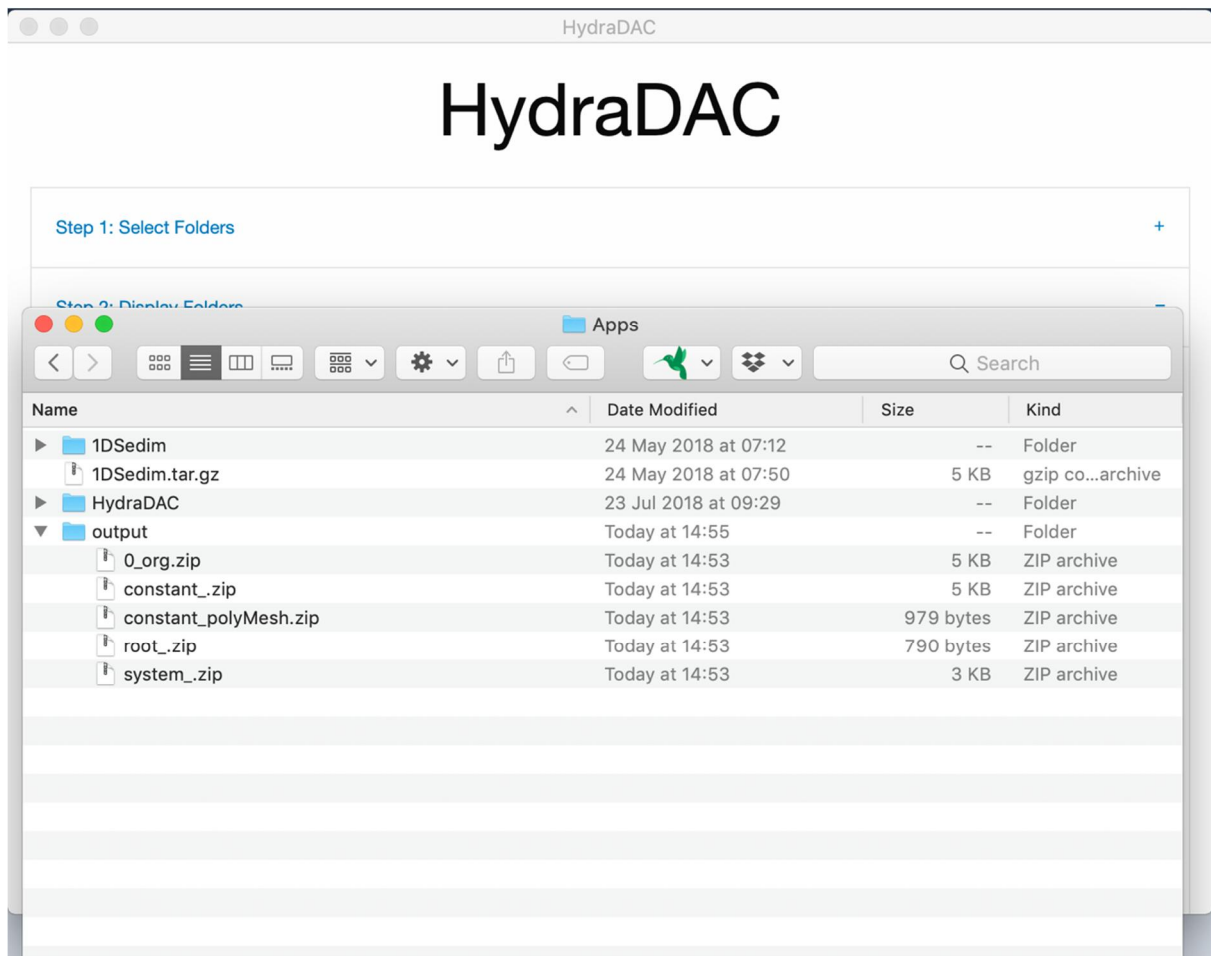rage technology: the OpenDAP server. The packaging of the data is performed using a tool specifically developed at LEGI called project-meta. This tool also embeds the capability to prepare an archive for publication on Zenodo. Once the data are publically available online on the OpenDAP server, Jupyter Notebooks are used to read the data and do some interactive plots such as profiles, colorplots or vectorplots depending on the nature of the data to be visualized. The user does not need to install anything on his computer, the notebook is simply accessible through a web link. Jupyter Notebooks offers an IPython interface through a web browser and the user can run and modify the scripts to adapt it for his or her specific application.

3.2   WORKFLOW

The process for using the developed online visualization tools relies on a good organization of the raw data. Three steps can be distinguished in the data flow from the experiments, as sketched in Figure 6. The data from instruments are first stored on a local disk, often in proprietary format imposed by the policy of instrument providers and by the constraints of real time data transfer. It then leads to processed data after calibration, Particle Image Velocimetry or other processing which are directly linked to the instrumental techniques. In a second stage, various scientific analysis can be performed, leading to the final published data that can be stored on Zenodo and on an OpenDAP server. Those can and should be stored in standard formats, preferably NetCDF. The main advantages of Zenodo are to provide a Digital Object Identifier together with a long-term storage of the data. The main drawback is that the stored data cannot be retrieved interactively. This can be problematic when large datasets need to be analyzed and it does not allow for direct online visualization.
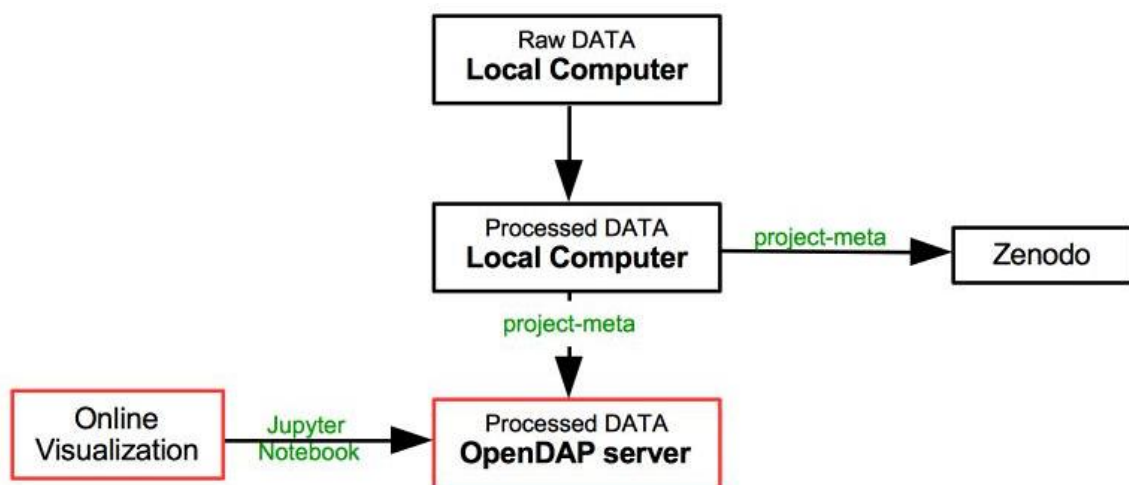

Figure 6 Workflow for the online visualisation tools

Here we propose an alternative or a complementary online storage option using an openDAP server that will be presented in more details in section 3.3. As illustrated in Figure 6, the data stored on this server can be directly accessed by the web to perform online visualization without installing any software on the user computer. This visualization tools are developed using Jupyter Notebooks written using the Python language. An alternative option for visualizing the data is to use matlab or python directly from a local computer. For example, a DAP browser has been developed in UV-MAT (matlab GUI for PIV/PTV analysis: http://servforge.legi.grenoble-inp.fr/projects/soft-uvmat/) that allows the user to directly access the data stored on the DAP server.

3.3 OPENDAP SERVER

The data are stored online using the protocol OPeNDAP (Open-source Project for a Network Data Access Protocol). This includes standards for encapsulating structured data, annotating the data with attributes and adding semantics that describe the data. OPeNDAP is widely used by governmental agencies such as NASA and NOAA to serve satellite, weather and other observed earth science data.

The protocol is based on http, so that data can be scanned with an ordinary web browser. However added functionality of data visualization is provided by graphics programs (like Matlab, Python, GrADS, Ferret or ncBrowse). Compared to ordinary file transfer protocols (e.g. FTP) a major advantage using OPeNDAP is the ability to retrieve subsets of files, so it is possible to work remotely without downloading whole data files.

Although any file format can be used, data are often in HDF or NetCDF formats. The older NetCDF format is limited to arrays of numbers, while HDF provides wider possibilities of data structures (and it contains NetCDF as a particular case). The NetCDF format is preferred as it is sufficient for hydralab applications and can be more easily read with various software.

A DAP server has been implemented at LEGI http://servdap.legi.grenoble-inp.fr/. It has been used for a few years to publish data from ocean dynamic modelling. Extension to laboratory data, with an improved organization, has been undergone in the frame of JRA FREE-Data of HYDRALAB+.

3.4 PROJECT-META

As illustrated above one of the key feature of the Online Visualization Tools is the publication of the data on a DAP server. This step requires a dedicated tool for the packaging and publication of the data. This is performed using the software project-meta specifically developed during JRA FREE-Data. This software aims at allowing the end-user to scan and visualize the data without downloading and integrate the publication of open data in the data analysis procedure, with minimal additional work. Beyond these two key features the software also aims at allowing the user to distribute, search, link, crawl and mine the data. The software is accessible at the following link: http://servforge.legi.grenoble-inp.fr/projects/soft-trokata/wiki/SoftWare/ProjectMeta

A video tutorial about how to use the software is available online at: http://servdap.legi.grenoble-inp.fr/opendap/meige/18PROJECT-META-TEST/ProjectMetaWorkflow.m4v

3.4.1 Description

The creation of the OpenDAP repository is done by the software project-meta using UNIX commands, scripts in Perl and C++.

The first step is to make a list of the data folders to display. This list needs to be introduced in a text file, complemented by some information about the authors of the work and about related publications. This text file (Box 1) must be put in your current folder with the name `PROJECT-META.yml`. The text structure must follow some simple rules consisting in the YAML format. An example can be found in the Project-Meta repository or online PROJECT-META.sample.yml.

```
project-meta help
man project-meta
```
Box 1 Project-META.yml meta file

This file is at the core of the procedure. The first task consists in listing the data files and folders to be published. For that purpose, a good practice is to organise the data such that the final data to be published are contained in folders named with specific extensions. A search tool can then be used to list all the selected folders. For instance the unix command in Box 2 allows to list all the folders with extension `*.mproj*` and append it to the file `PROJECT-META.yml`:

```
find . -name '*.mproj*' -a -type d | sed 's/^/    - /;' >>PROJECT-META.yml
```
Box 2 Unix command to list and append folders

The `find` command only searches the folders with the right extension (recursively) under the current one (.) and the `sed` command adds 4 spaces and the dash at the beginning of each line in order to respect the YAML format. This procedure has been specifically developed for UVMAT users and CORIOLIS platform Transnational Access program.

The YAML file has to be complemented by general information about the authors and the related publications, following the template PROJECT-META.sample.yml.

3.4.2   Debian package
Debian is a GNU/Linux distribution. Debian (and certainly Ubuntu) package for amd64 arch that can be downloaded at: http://servforge.legi.grenoble-inp.fr/pub/soft-trokata/project-meta/download.

You can then install it with the command shown in Box 3, just replacing * with the version you want to download.

```
sudo dpkg -i project-meta_*_amd64.deb
```
Box 3 Command for installing Debian

3.5   JUPYTER NOTEBOOKS
This document presents the online visualization tools using Jupyter Notebooks and data stored on the DAP server. Jupyter Notebooks provide an IPython development interface through a web browser. The user can run and modify python commands/scripts on a remote server. It means that the user does not need to have a full python environment installed on his machine. The notebook is simply accessible by copying a link.

Two examples are used to illustrate the approach developed for the Online Visualization Tools: sheet-flow and Coriolis data.

3.5.1   Sheet-flow data

The sheet flow sediment transport regime has been investigated at the LEGI laboratory. NetCDF files containing concentration, velocity, stress or turbulence characteristics profiles are available on Zenodo (https://doi.org/10.5281/zenodo.1156633) and on the LEGI DAP server (http://servdap.legi.grenoble-inp.fr/opendap/).

A Jupyter Notebook (Figure 7) is created to interactively visualize the data. The notebook is stored on a GitHub repository and is accessible via the Jupyter Notebooks hosting tool Binder from the link: https://mybinder.org/v2/gh/CyrilleBonamy/notebook_opendata/master?filepath=plot_sheetflow.ipynb
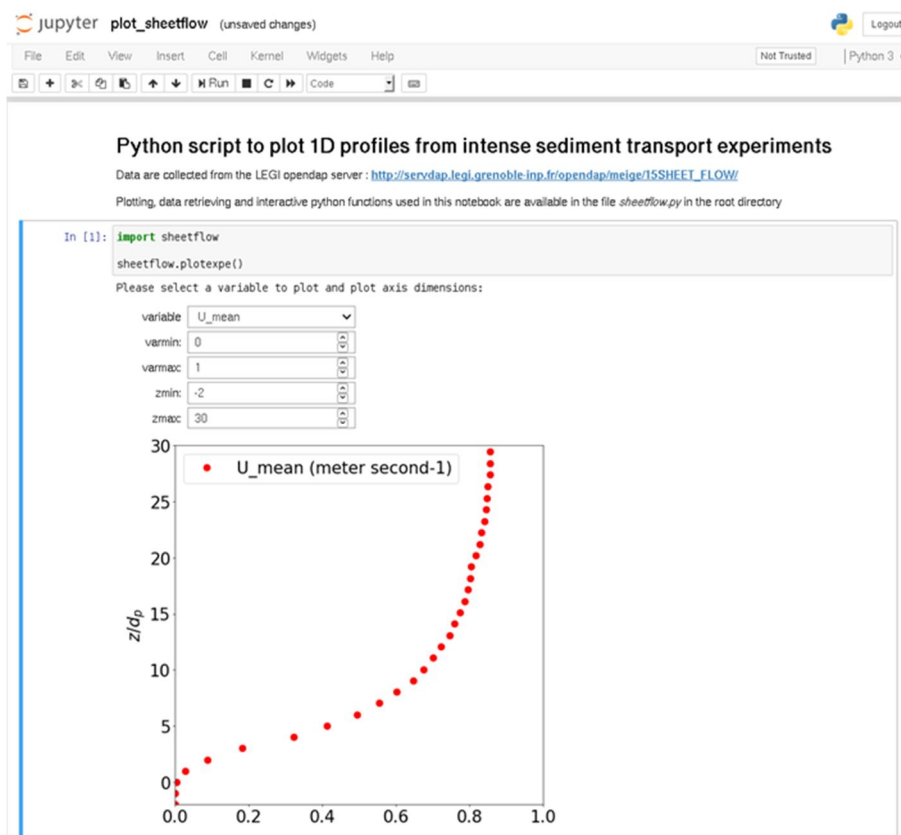
Figure 7 Juypiter notebook for sheet flow data

In the first cell, the function plotexpe() is called. This function creates a plotting window using IPython widgets to interact with the user. The netCDF files are retrieved from the OpenDAP server using the python package netCDF4. The file is imported simply by reading the URL address of the file on the OpenDAP server. The profiles are plotted using the python package matplotlib. The user can directly choose the different profiles to be plotted through the list "variable" in fig. 1. The other lists allows the user to set the axis dimensions. To interactively plot the figure, the user does not require any programming skill. However, if the user needs it, he can access and modify the python code from the sheetflow.py file provided with the notebook.

This jupyter notebook is a proof of concept but more complex datasets can also be displayed. In the next section, a more complete notebook is introduced to plot velocity fields from different

experiments performed in the Coriolis platform in the framework of HYDRALB Transnational Access projects.

3.5.2   Coriolis data

Velocity fields from experiments performed in the Coriolis platform are also available on the OpenDAP server. Another Jupyter Notebook is created, as shown in Figure 8, to navigate between the projects and interactively plot the velocity fields. The notebook is available following the link: https://mybinder.org/v2/gh/CyrilleBonamy/notebook_opendata/master?filepath=plot_fields.ipynb.
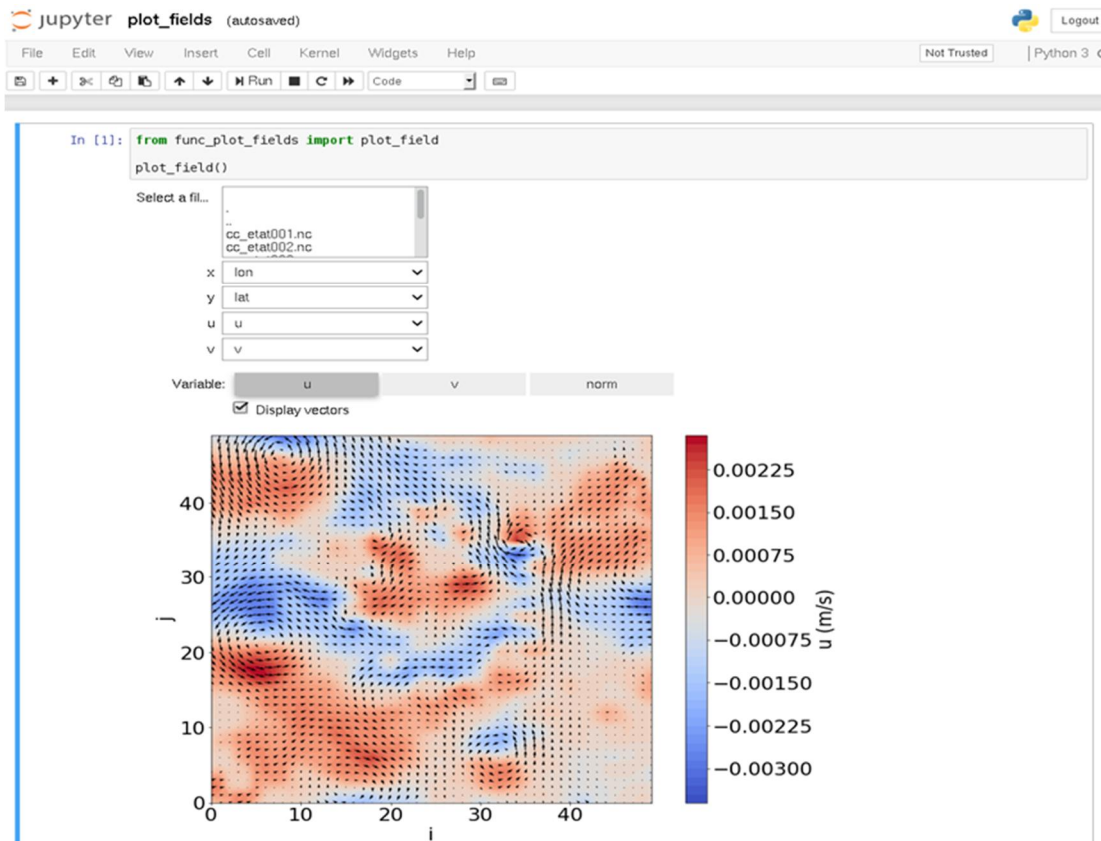

Figure 8 Coriolis data Juypiter notebook

Similarly to the function plotexpe() in the notebook presented in section 1, the function plot_field() creates an interactive plotting window. There is a navigator that allows the user to explore the OpenDAP server and choose the file to be plotted. The user selects the datasets for x, y, horizontal and vertical velocities (u and v respectively) and the variable to be displayed (u, v or the velocity norm). Furthermore, the velocity vectors can be computed and displayed. All the interactive and plotting functions are also available in the file func_plot_fields.py provided with the notebook.

Jupyter Notebooks coupled with a DAP server constitute the Online Visualization Tools to retrieve, post-process and display the data through a simple web browser. Jupyter Notebooks can be easily modified and adapted to any kind of data to be visualized. The two notebooks presented above should be considered as tutorials for the development of a wider variety of notebooks in the future.

4 HYDRALABWIKI

4.1.1 Introduction

One explicit task of FREEData is the development of modular interactive tools, which go beyond classical knowledge resources like books or scripts, in order to provide easier and more effective transfer of knowledge and expertise on subjects related to hydraulic laboratory practice, such as setting up an experiment or understanding and communicating data. This is in line with the recent trend in learning research community recommending thoroughly application of Web 2.0 technologies in different aspects of knowledge management. Web 2.0, a term now widely used in the information and learning research community, refers to community-driven interactive web applications and technologies which facilitate the collaborative creation and publication of digital content in a way that any user without having expertise in web technologies like HTML, JavaScript, etc., will be able to participate in the digital content development process (Conole and Alevizou, 2010; Greenhow et al., 2009; Murphy and Salomone, 2013; O'Reilly, 2005).

4.1.2 Wiki technology

Among Web 2.0 concepts, the wiki technology is one of the most popular and advantageous mediums (Kennedy and Kai-Wai Chu, 2011; Rollett et al., 2007). The name wiki is coined for a concept first developed by Ward Cunningham in 1995 (Pei Lyn Grace, 2009) and is defined as fully open to edit interlinked web-pages utilizing a hypertext system to modify and store content of any type of knowledge (Leuf and Cunningham, 2001). The major characteristics of wikis are as follows (Dave and Koskela, 2009; Dengler et al., 2009; Engstrom and Jewett, 2005; Pei Lyn Grace, 2009):

- Enabling collaborative development of pages.
- Easy to learn and use marked up language with the capability to embed rich content (i.e. image, multimedia).
- Saving the edit trail enabling version control.
- Built-in search engine.
- Enabling social interaction using conversation spaces built for every page.

Table 1 shows that among different web 2.0 technologies, wiki has the most capabilities needed to achieve the objectives of FREE-Data task 10.6.2.

Relevant technology features	Blog	Forum	Instant messaging	Email	Social media (e.g. Twitter)	Wiki
Exchange of ideas and solutions		x	x	x	x	x
Searching capability		x				x
Publishing rich content	x					x
Knowledge documentation	x					x
Developing professional networks		x	x	x	x	x

Table 1 Comparison of Web 2.0 technologies; idea from Dave and Koskela (2009)

4.1.3 HydralabWiki

In order to facilitate the transfer of knowledge and expertise on subjects related to hydraulic laboratory practice *HydralabWiki* (http://wiki.hydralab.eu) was initialized from the partners of HYDRALAB+ and has been online since July 2018 (Figure 9). *HydralabWiki* is built on *MediaWiki* platform, being the most advanced and popular open source wiki platform in the wiki space to date, and it shall be employed on three levels:

1. In-depth knowledge and expertise which may not be found in conventional literature, particularly the knowledge generated within the current and the previous HYDRALAB projects could be integrated in HydralabWiki using its capability to handle rich contents.
2. Introductory information about the concepts and procedures in hydraulic laboratories may be used to connect the non-professional user with the professional literature.
3. Interactive tool in teaching/learning process. Active collaboration of learners in development of the dynamic contents of the wiki will benefit both the learners and the wiki, as well as the possibility to post and use video tutorial for teaching how to use new instruments in experimental hydraulics.

Management and structuring the articles in *Mediawiki* is implemented by the concept of categorization, in order to group together pages on similar subjects. Categories allow articles to be placed in one or more groups and allow groups of categories to be further categorized. Therefore, there could be sub-categories and parent categories in a tree-like structure.
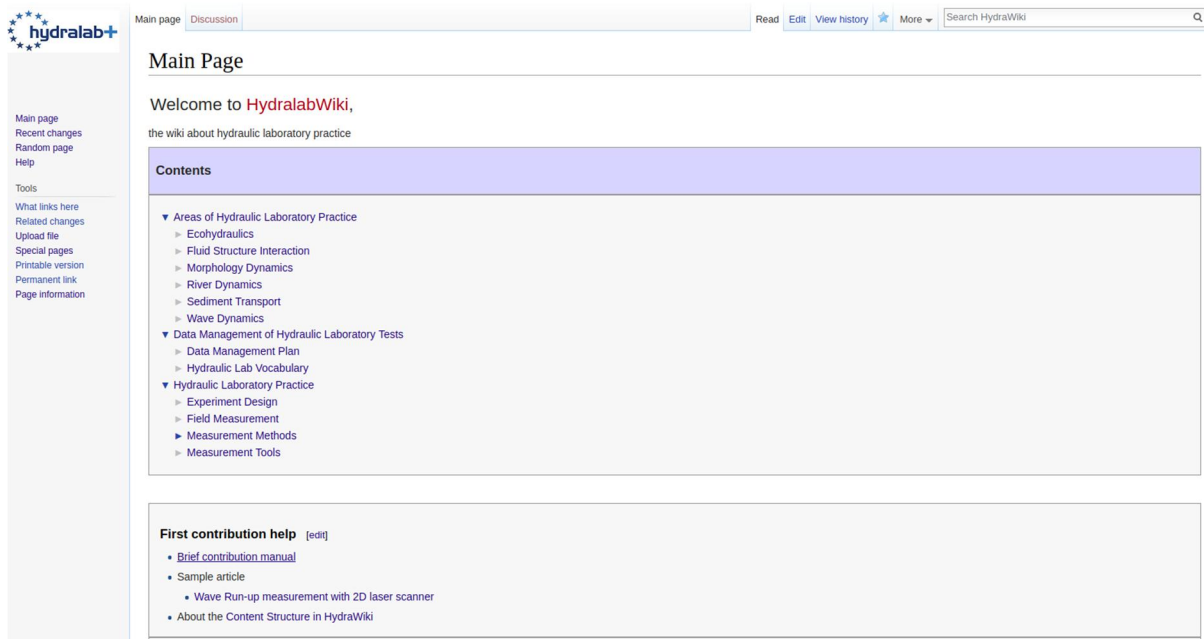
Figure 9 : HydralabWiki screenshot (Aug 6th 2018)

An important additional feature of *MediaWiki* is its capability to upgrade *HydralabWiki* into a semantic annotated wiki. Semantic annotation is a process in which additional information is attached to the various types of concepts inside a text (e.g. places, facilities, physical variables etc.). As an example, let's assume one is looking for a particular experiment in which PIV technique is applied in studying bed profile evolution. This query seems easy to answer but in fact it is not as simple as it seems. One needs to read through all the pages a keyword search would retrieve from the document database. In a semantic annotated document, one may see mark-up syntax which is not seen in the document view mode and adds metadata to the text, such as:

```
[[is experiment :: projectName]]

[[has measurement technique :: PIV]]
```

The above lines tag some properties to the text. The first annotation line tags the document with a category (experiment), which means that the article is about an experiment. The second line add a property tag (has measurement technique) with the value: PIV. In a semantic query, one employs not only the keywords but the meaning of them and the connection between them, which are defined with the semantic annotation. Therefore, a semantic query of the mentioned example search would look like the following:

```
{{ #ask:

    [[category :: experiment]]

    [[has measurement technique :: PIV]]

}}
```

The concepts and the attached information should be standardized with a given ontology in order to be interoperable and processable by software programs. Further information about semantic annotation can be found for instance in Popov et al. (2003), Oren et al. (2006) and Uren et al. (2006).

However, the semantic annotation is an add-on, which still needs to be worked out. Now, as *HydralabWiki* had been set-up and recently went online it needs to be filled with content first. Some sample articles are already available and the HYDRALAB+ community will increase the knowledge base continuously. It is expected that by that also the wider community is attracted to use and to contribute to *HydralabWiki*. The first page of *HydralabWiki* (Figure 9) is therefore dedicated to help the users to understand the idea and structure of the wiki and to learn how to contribute by presenting the whole content structure and providing sample articles as well as a short manual how to contribute (http://wiki.hydralab.eu/index.php?title=HydraWiki_contribution_manual).

4.1.4   References

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