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Data Exchange Server (DES) application: data handling from acquisition to sensor observation services

Costa Armin, Frisinghelli Daniel, Marsh-Hunn Daniel,
Monsorno Roberto, Rossi Mattia, Ventura Bartolomeo, Vianello Andrea

Institute for Earth Observation – eurac research

Geospatial Sensor Webs - from data to information in the Sensor Web
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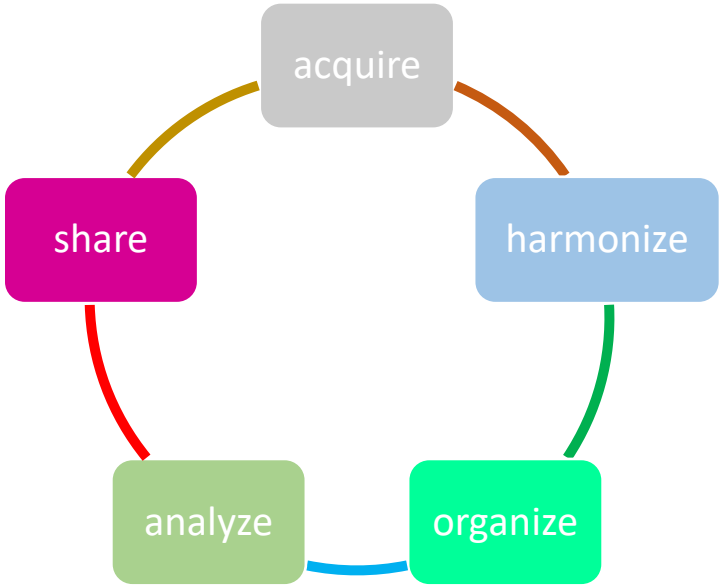
Researcher's question

how to handle multiple data?

Especially if they belong
to different sensors at different
scale
with different characteristics

Common Technology Platform

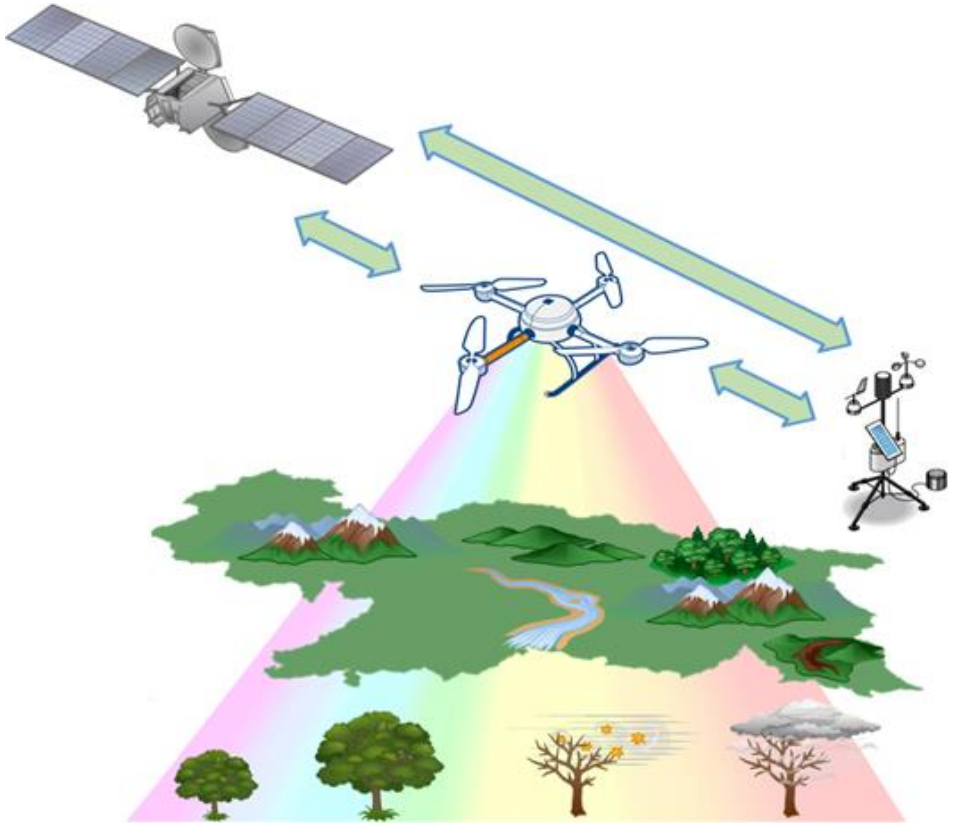
Automation of the Data Life Cycle



Test case: MONALISA project

The MONALISA (*MON*itoring key environmental parameters in the *AL*pine environment *I*nvolving *S*cience, technology and *A*pplication) project's main goal is the ***development of multi-scale monitoring approaches for key environmental parameters*** and production processes using innovative monitoring technologies and non-destructive methods in the ***application field of agriculture***.

biophysical parameters and all information coming from different sources:
Remote Sensing, UAV, ground stations, laboratory

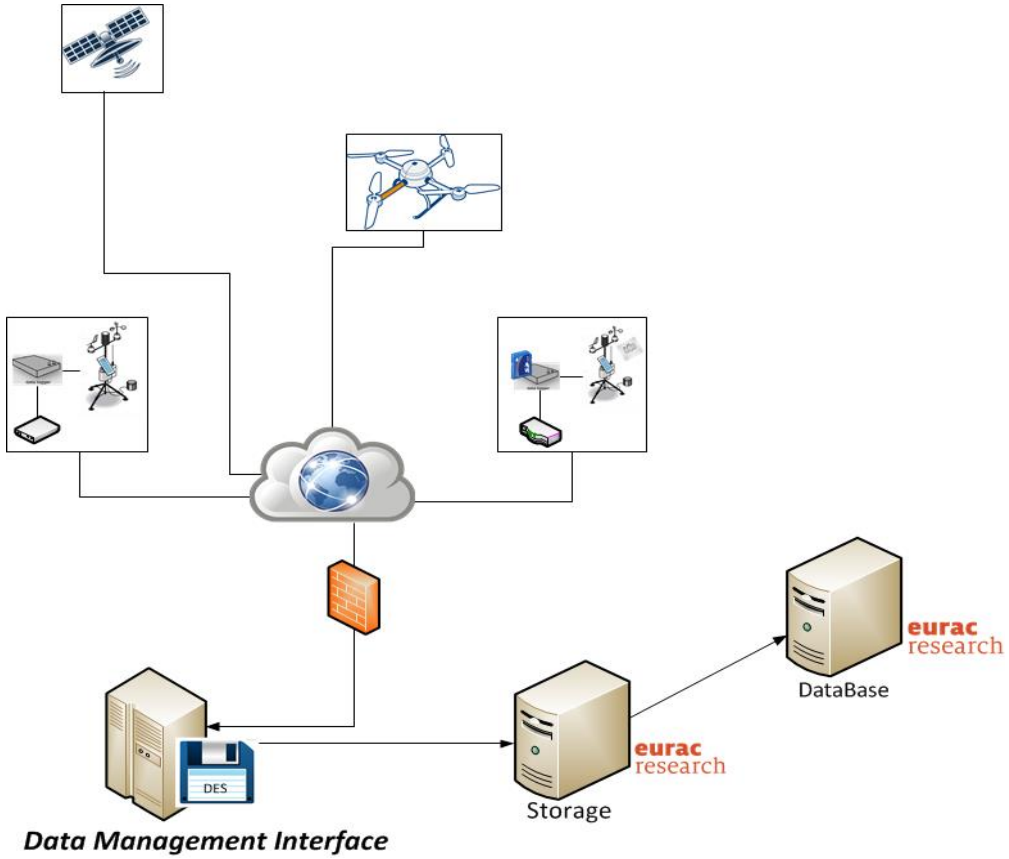


For further information please visit: http://monalisasos.eurac.edu/sos/

Data Acquistion: DES (Data Exchange Server)

DES (**Data Exchange Server**) is a standalone application, developed in-house, to enable the execution of tasks and data transfers from and to different systems by means of a set of XML processor configuration files.

It implements a concurrent, multi-threaded mechanism to transfer different kinds of data in PUSH and GET mode by using standard protocols like SFTP, FTP, SSH.



DMI (**Data Management Interface**):
data are collected and distributed on an online server available to the public at eomountdata.eurac.edu via HTTP and FTP protocols.

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DES and data life cycle

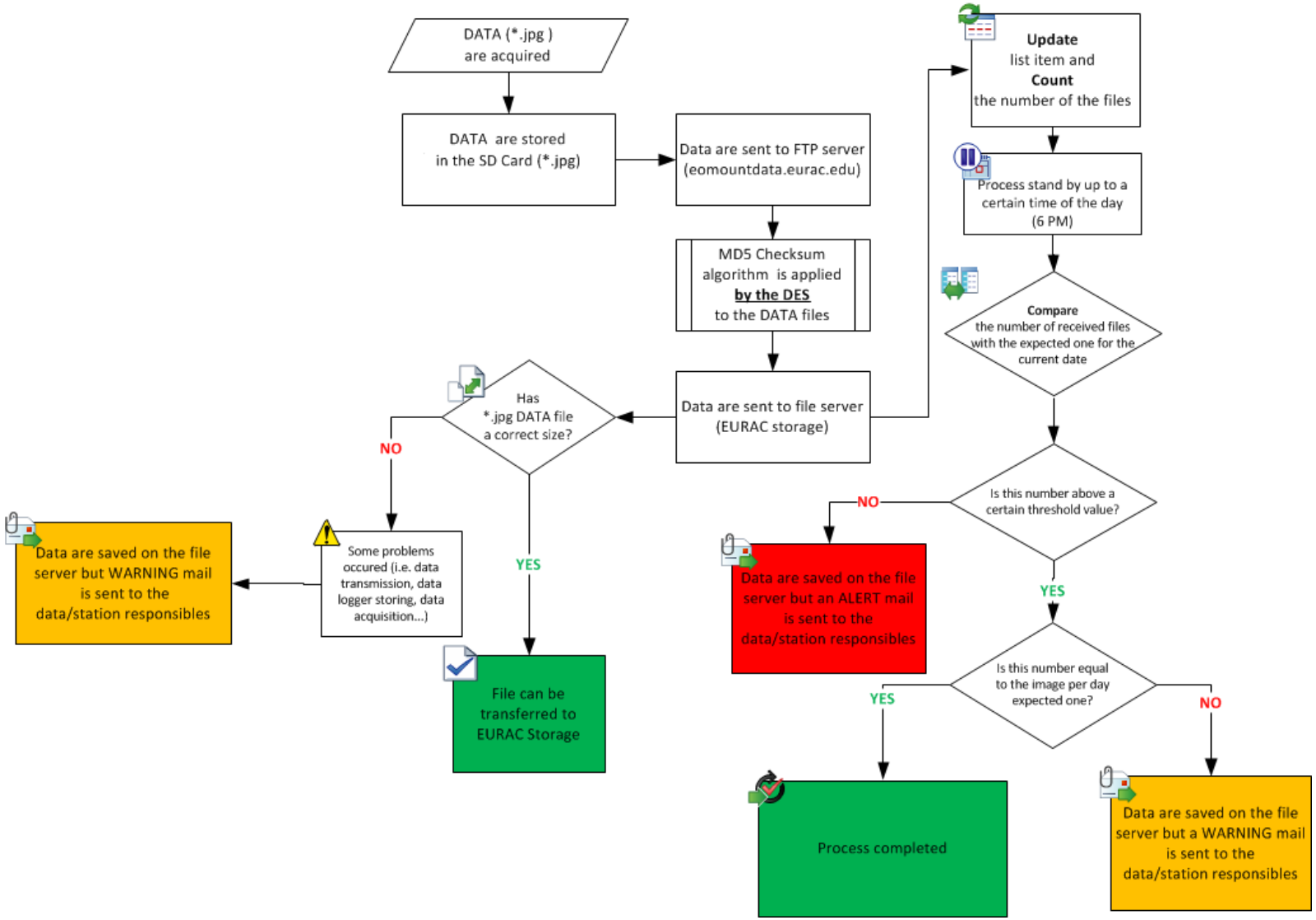
(example 1)

To summarize

DES is a multi-tasking application that can execute any kind of configurable tasks or jobs implemented as dedicated plug-ins.

In this particular scenario dedicated plug-ins, for example, implement:

- ✓ data collection,
- ✓ data validation,
- ✓ data check,
- ✓ data warning,
- ✓ data move to final location.

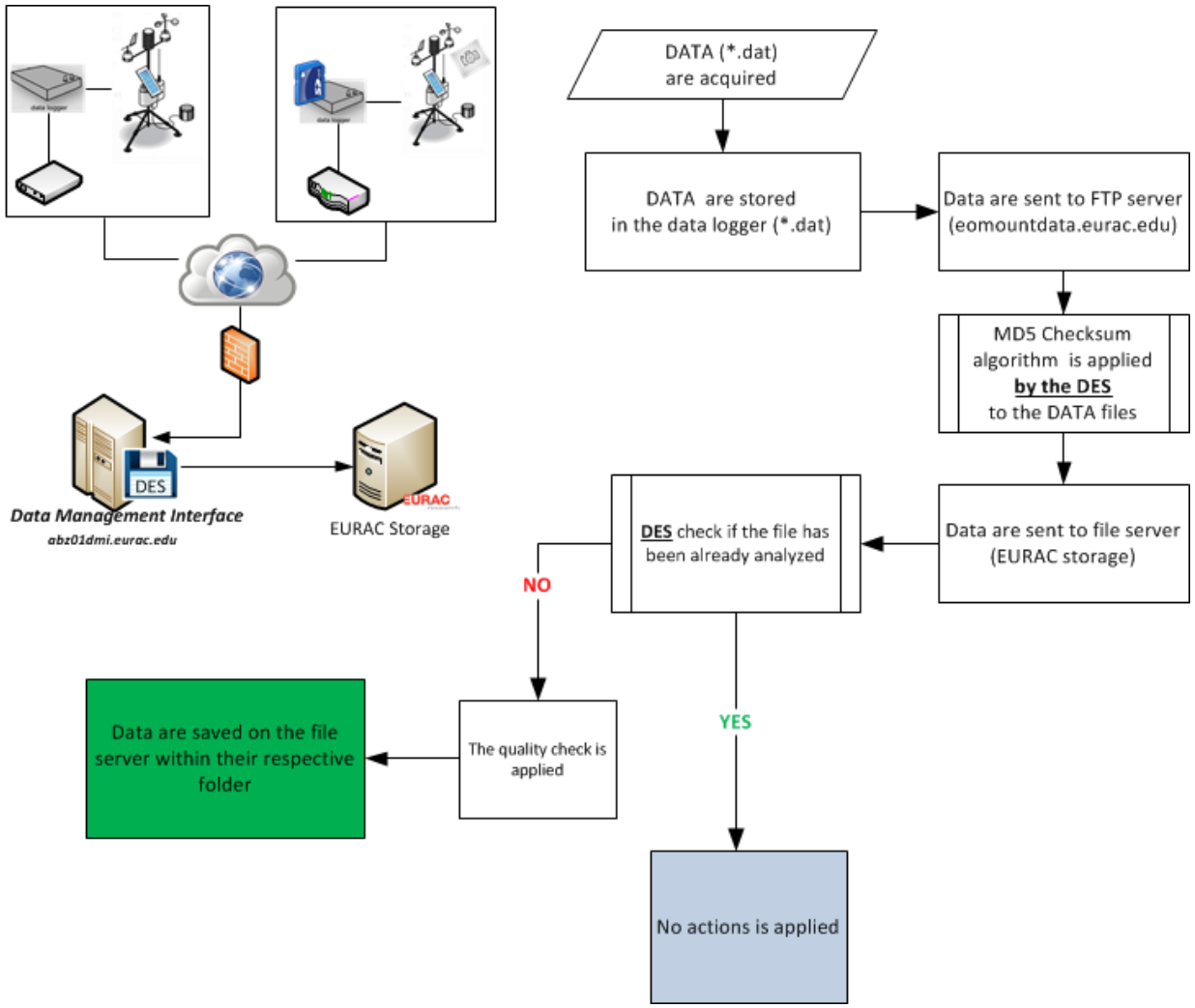


DES and data life cycle

(example 2)

In this particular scenario dedicated plug-ins, for example, implement:

- ✓ data collection,
- ✓ data check,
- ✓ data quality check,
- ✓ data move to final location.



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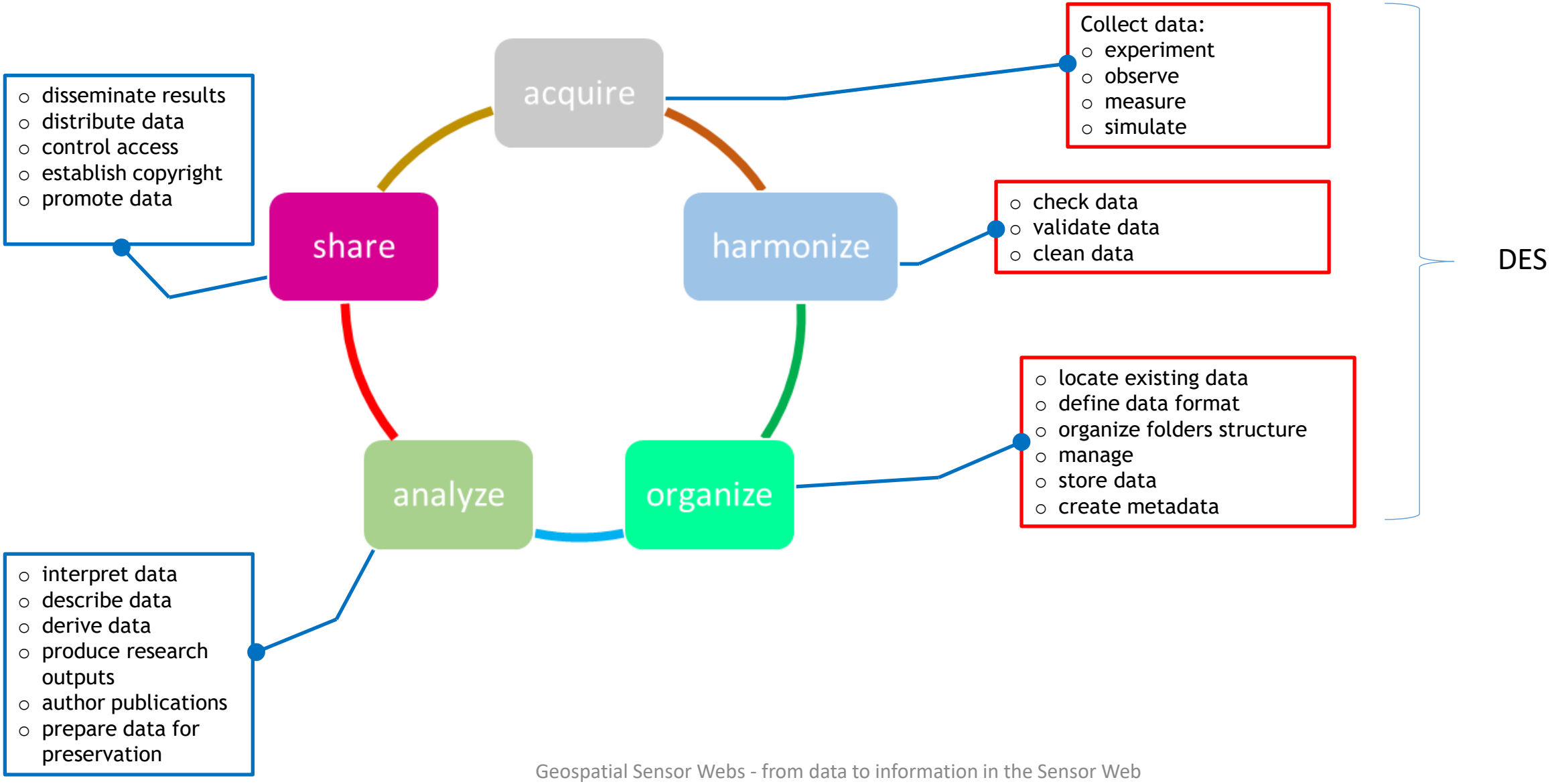
data lifecycle



Analyze: Automatic data insertion

Different data organization with respect to the same sensor

Different sensors and stations

Different name of input files

Different data organization

Absence of a unique structure of the input data

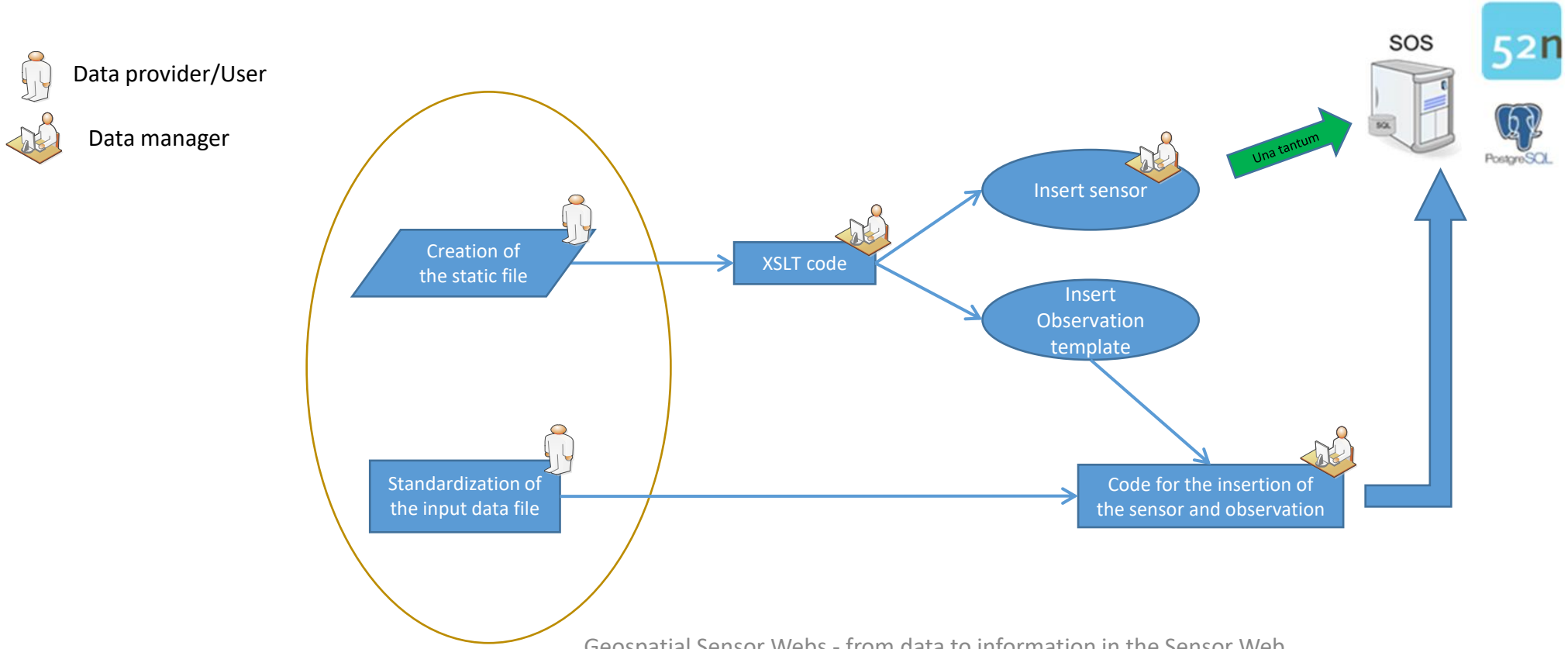
Define rules for the input data format

1. *Input data naming convention*
2. *Date and time format of the measurement*
3. *Structure of the input file*
4. *Presence of the header in each input file*

Automatic data insertion

From the data provider/user point of view only two actions are requested:

1. *Creation of the static file*
2. *Standardization of the input data file following the previous 4 rules*



Automatic data insertion

- **Definition of a static file (XML format)**

The idea of creating a static file is essentially twofold:

- *it will contain all the information useful to create those information for filling the database (Insert Sensor and Insert Observation XML file)*;
- *it can be seen as a raw version of the **metadata** for the considered monitoring station (Feature Of Interest)*.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<static>
   <FOI_list></FOI_list>
   <FOI_coordinates_list></FOI_coordinates_list>
```

```xml
<?xml version="1.0" encoding="UTF-8"?>
<static>
   <FOI_list>Tramin13er,Unterrain2FuchsangerEppan,
      Gries2NeufeldGreifensteinerweg,Girlan1Lamm,Lana6</FOI_list>
   <FOI_coordinates_list>46.3291770 11.2445070,46.5016200
      11.2504780,46.5017570 11.2802830,46.4558950 11.2795330,46.6165530
       11.1517880</FOI_coordinates_list>
```

```xml
<observedProperty>
   <short_name></short_name>
   <long_name></long_name>
   <long_name_def></long_name_def>
   <uom></uom>
   <id_sensor_num>1</id_sensor_num>
</observedProperty>
```

```xml
<observedProperty>
   <short_name>NDVI_UpRed_Avg</short_name>
   <long_name>Normalized Differenced Vegetation Index Up Red</long name>
   <long_name_def>
      Normalized_Differenced_Vegetation_Index_UpRed_Avg</long_name_def>
   <uom>None</uom>
   <id_sensor_num>1</id_sensor_num>
</observedProperty>
```

```xml
<coordinate>
   <easting></easting>
   <northing></northing>
   <altitude></altitude>
</coordinate>
```

```xml
<coordinate>
   <easting>11.2445070</easting>
   <northing>46.3291770</northing>
   <altitude>239</altitude>
</coordinate>
```

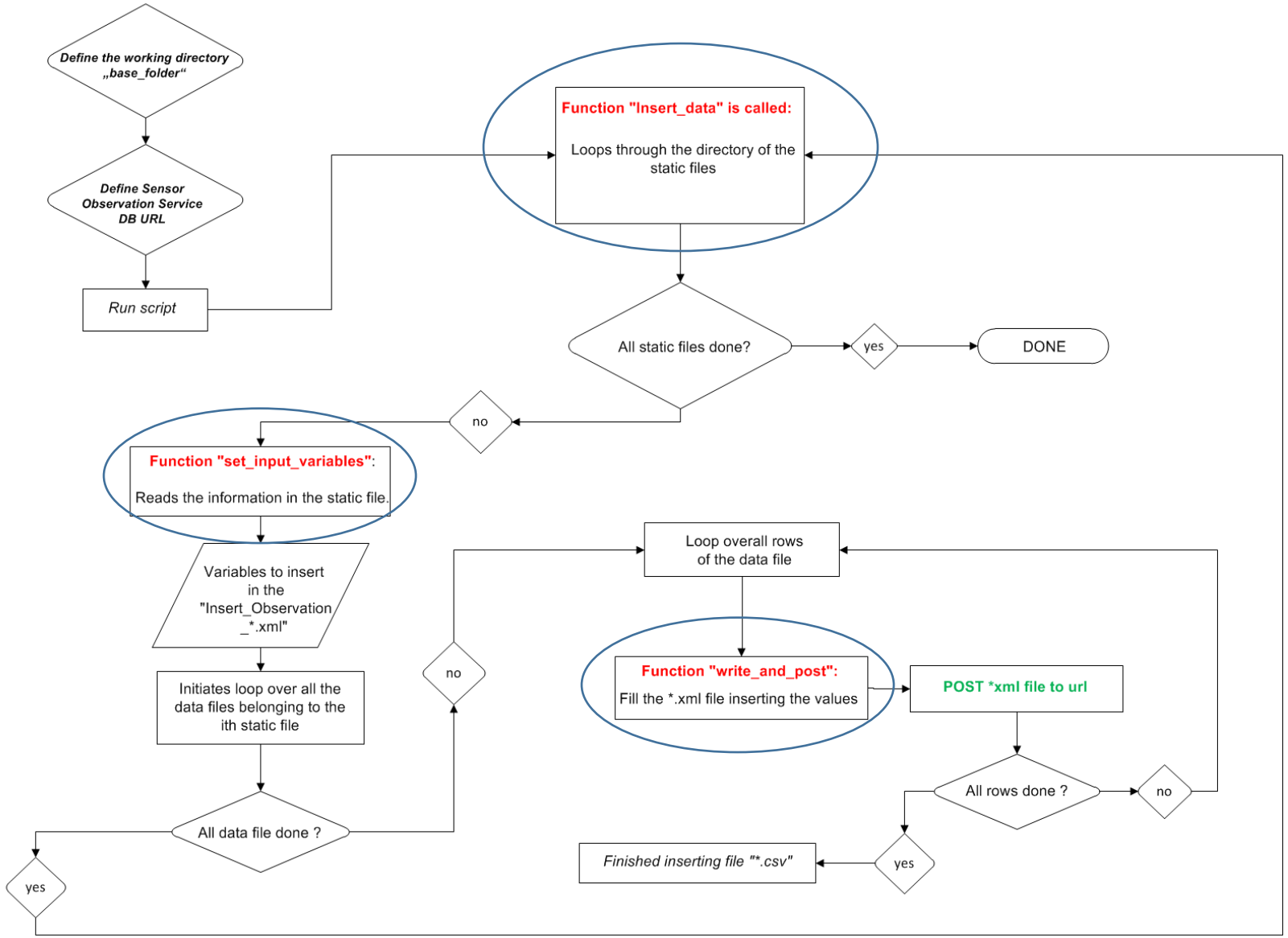
Insert of the observations

A python script has been developed.
The necessary information for this script are:

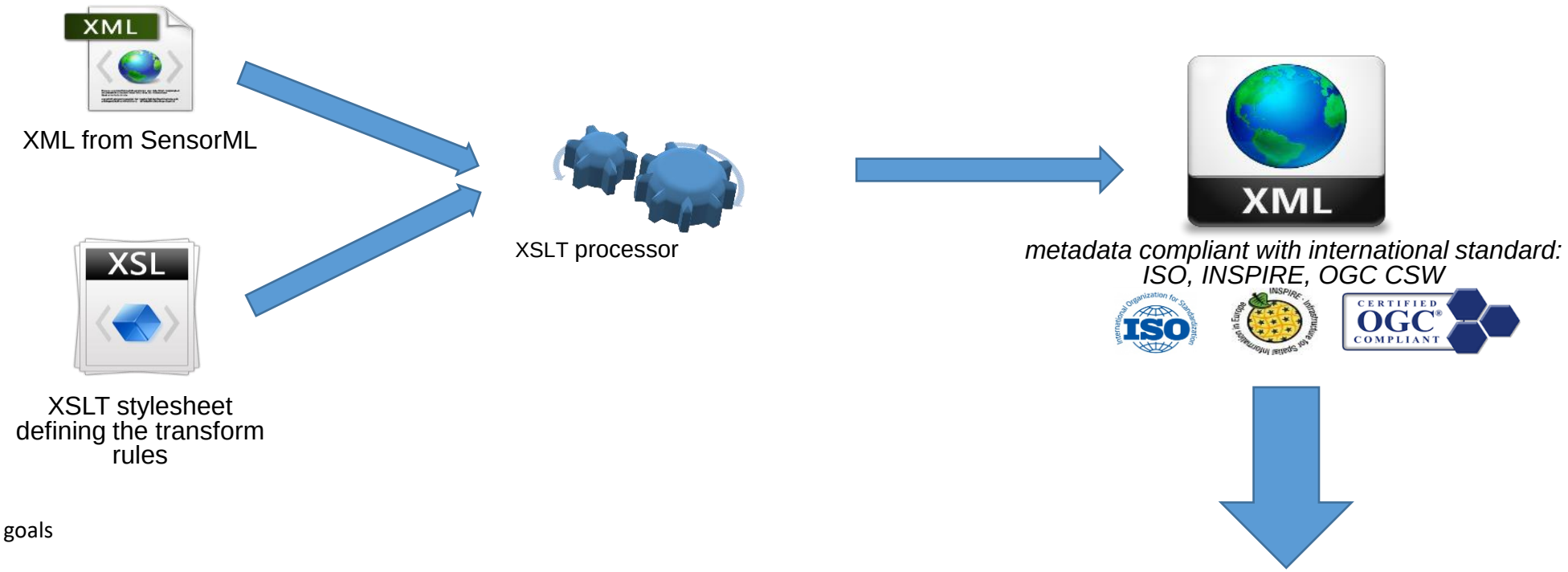
1. Working directory base folder
2. SOS Database URL

The main phases of the script are:

- ✓ The insertion of the data which loops through the directory of the static files
- ✓ Set the input variables extracted from the ith static file
- ✓ Fill the *.xml of the insert observation file inserting the values and post it to the SOS Database



Metadata: data about the data



Search and Discover sensors and their data information

XSLT definition and goals

Definition:

- XSL stands for: ***Ex**tensible **S**tylesheet **L**anguage*, and it is a style sheet language for XML documents.
- XSLT stands for: ***XSL T**ransformations*

Goals:

- XSLT is a transformation language for XML.
- XSLT is a W3C XML language (the usual XML well-formedness criteria apply)
- XSLT can translate XML into almost anything, e.g.
  - ✓ Well-formed HTML (closed tags)
  - ✓ Any XML, e.g. yours or other XML languages like SVG, X3D
  - ✓ Non XML, e.g. PDF, ZIP, … etc

Environmental Database

The MONALISA Database has been implemented using 52North SOS project following the OGC Sensor Web Enablement standards

- 1 unique database
- + 30.000.000 record collected for scientific analysis
- 75 environmental parameters + 10 laboratory measurements
- + 80 installed sensors
- 31 stations of measurements dislocated in the province of Bolzano

- 2 different but complementary ways to access to the Database:
  - Web Application (Helgoland)
  - Plugin SOS_R-Access

Helgoland Web Application

http://monalisasos.eurac.edu/sos/

Visual Exploration and Analysis of Sensor Web Data

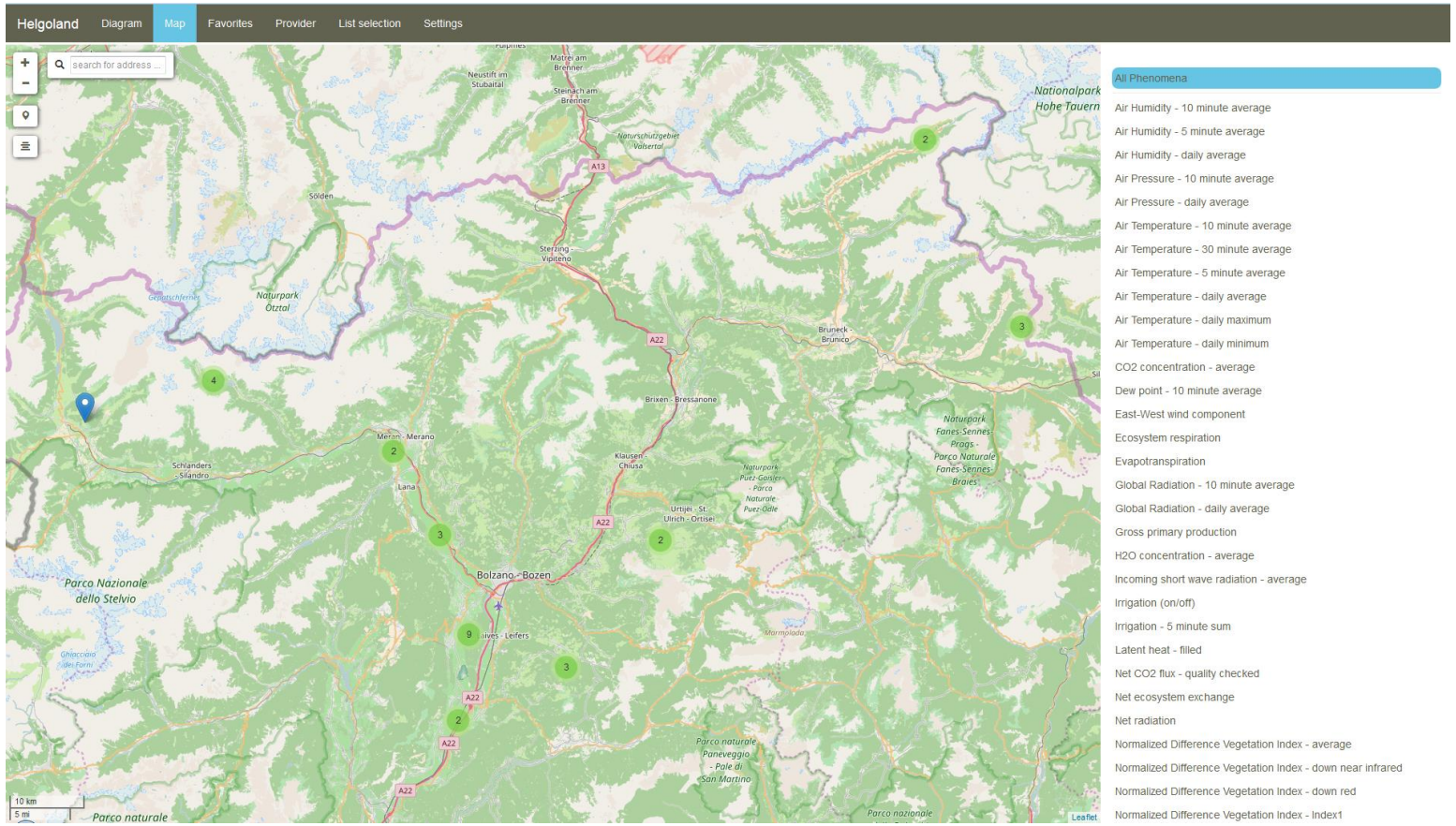
Helgoland is a lightweight web application to explore, analyze and visualize a broad range of sensor data. You can:

- ✓ explore stations or mobile sensor platforms in a map,
- ✓ select time series by a list selection,
- ✓ visualize time series data,
- ✓ or create favorites of selected time series.

The application is based on HTML, JavaScript and CSS and can connect to different Sensor Web endpoints (REST-APIs). These Sensor Web REST-APIs provide a thin access layer to sensor data via RESTful Web binding with different output formats.

Features:

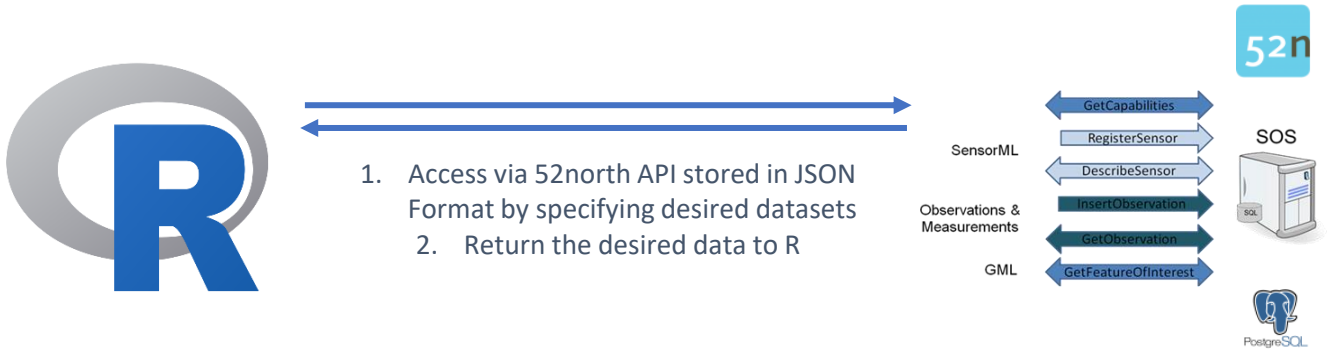
- ❑ access to SOS instances (supports OGC SOS spec...)
- ❑ diagram view of multiple time series, temporal zooming & panning...
- ❑ data export (pdf, Excel, CSV)
- ❑ Combination w/ R...
- ❑ Architectural basis: HTML, JavaScript, CSS



For more information, please visit https://github.com/52North/helgoland

MONALISA SOS_R-Access

- **Provides automated access to the MONALISA SOS Database via R**
  - *Accessing and exploring the structure of the whole SOS Database via .JSON featuring API*
  - *(Bulk) Download and storage of the data as '.csv' tables and/or '.RData' listed files*
  - *Create different plots of months and/or years selected (Work in progress)*
  - *Reproducible for other APIs featuring the JSON Format*
  - *Multiple R-Scripts stored and documented in a Git repository*
    - *Soon a central MONALISA repository will be set up*



SOS Database

Generated with the General Functions and Download Scripts

MONALISA SOS_R-Access

Access and Download MONALISA API via R

Script based:

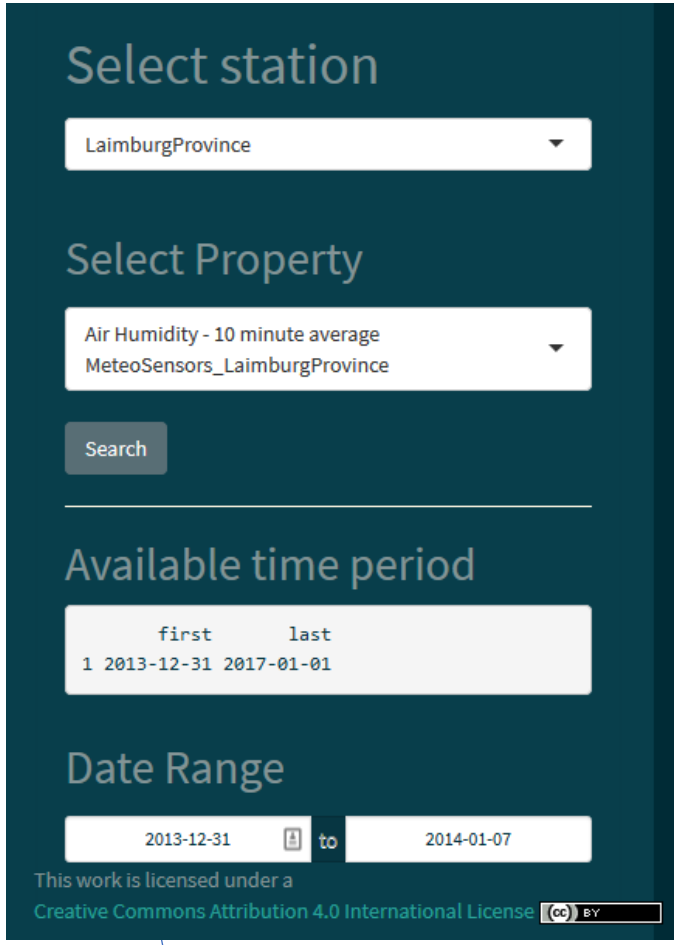
sos4Monalisa_Executable.R* | app.R | sos4Monalisa_jsonDownload.R | Old_Functions.R

Source on Save

```r
##############################################
### Program for the automatic SOS Download ####
### By Daniel Frisinghelli & Mattia Rossi  ####
### EURAC Research                         ####
##############################################
# 1 ####################################
######## INITIALIZATION ################
########################################

source("R/DependingFunctions.R")
source("R/sos4Monalisa_jsonDownload.R")

# 2 ####################################
###### MANDATORY INPUT #################
########################################

starturl = "http://monalisasos.eurac.edu/sos/api/v1/timeseries/"
datestart = "2015-12-31 00:00"
dateend = "2016-02-28 00:00"
# csv = TRUE
path = "Y:/Workspaces/FrD/2017/SOS/SOS4R"

# 3 ####################################
####### PERFORM THE DOWNLOAD ###########
########################################

SOS = SOS_download_data_json(starturl, datestart, dateend, path)
```

„sos4MONALISA_Executable.R“ Script

Web Interface based (Shiny):



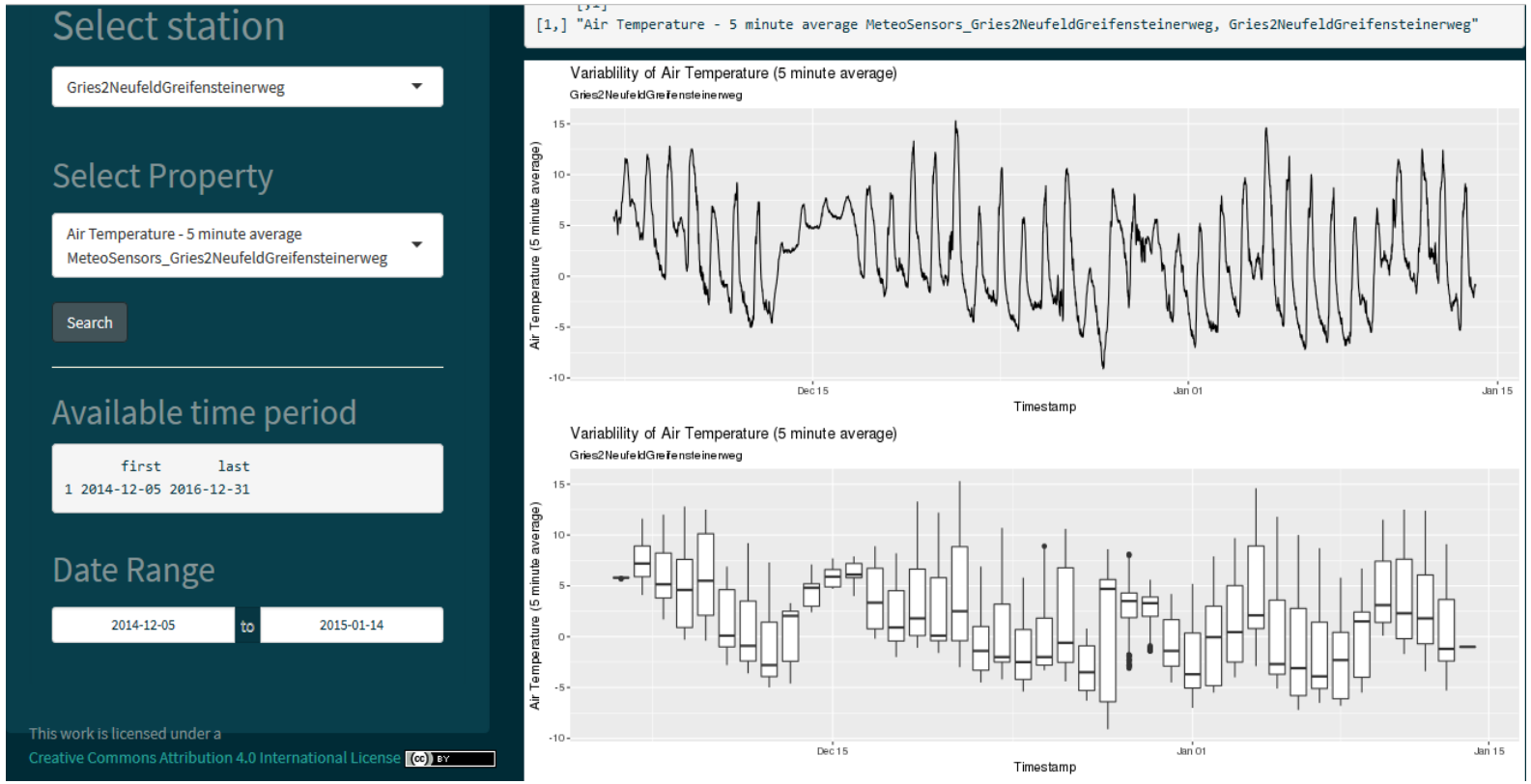
„sos4MONALISA_ShinyApp.R“ Script

MONALISA SOS_R-Access

Script based visualization:

```
# 3 ##################################
####### PERFORM THE DOWNLOAD ###########
########################################

SOS = SOS_download_data_json(starturl= starturl,
                             datestart=datestart,
                             dateend=dateend,
                             path=path,csv=F)

# 3 ##########################################
####### Iterative Plotting of the Download ###
##############################################

outdir<-"Y:/Workspaces/RosM/MONALISA/Images/"
dircheckup(outdir)

for(i in 1:length(SOS)){

  x<-SOS[[i]]
  gout<-arrange_SOS_plots(SOS_get_lineplot(DAT[[1]]),SOS_get_boxplot(DAT[[1]]))

  props<-names(x)[2] %>% str_split(.," \\(") %>% .[[1]] %>% .[1]
  fois <-x$FOI %>% unique
  ggsave(gout,filename = paste0(outdir,"ArrangePlot_",fois,"_",props,".png"), width = 10, height = 7 )
}
```

„sos4MONALISA_Executable.R“ Script



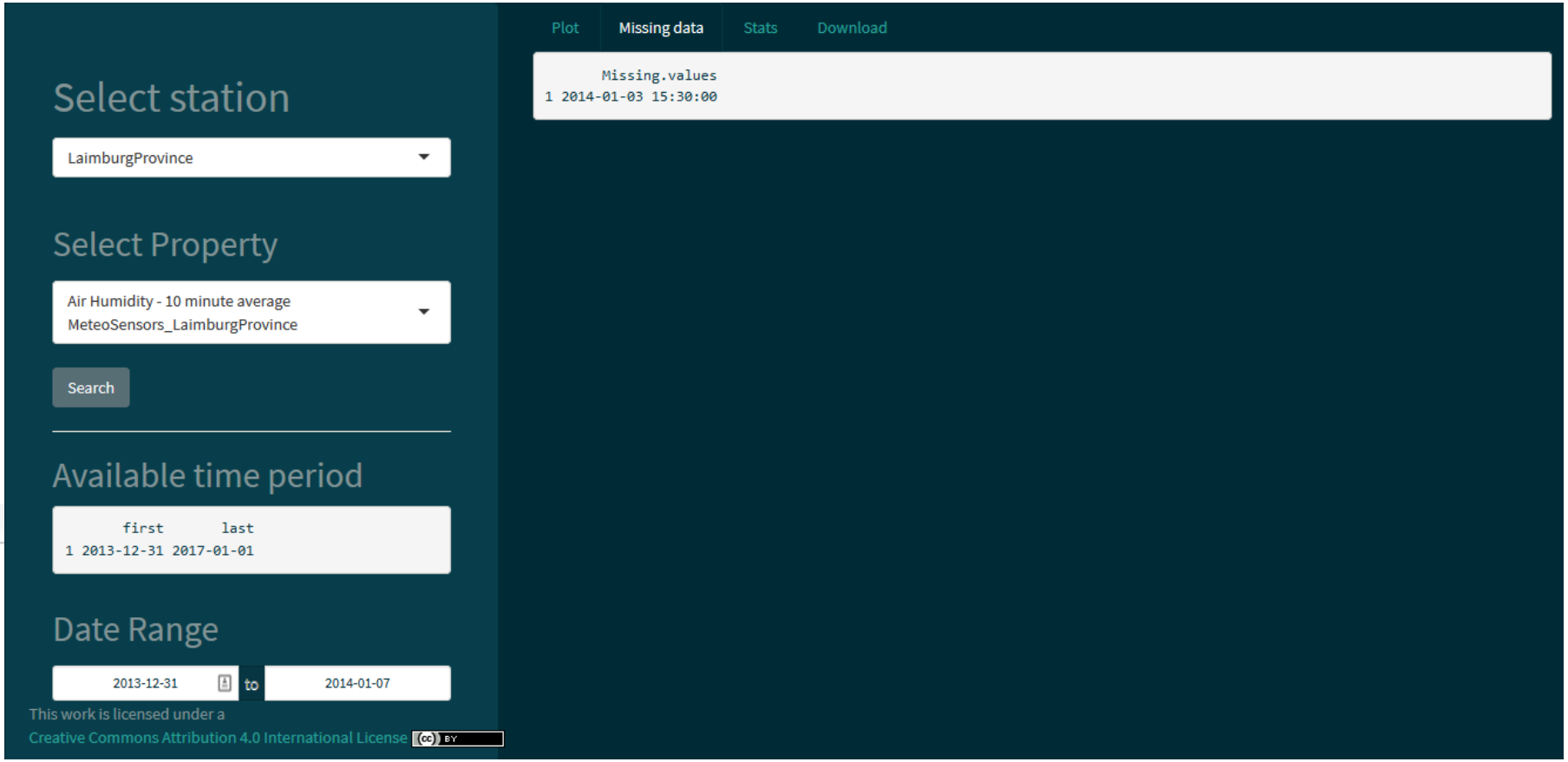
MONALISA SOS_R-Access

Shiny visualization:

- *Basically a web interface*
- *Still in initial phase but already working*
- *Will be published online once 100% stable and tested*

```r
source("R/DependingFunctions.R")
source("R/Shiny/global.R")
source("R/Shiny/ui.R")
source("R/Shiny/server.R")

shinyApp(ui = ui, server = server)
```

„sos4MONALISA_ShinyApp.R“ Script



Conclusions

An automatic system to handle the entire lifecycle of heterogeneous data has been developed combining

Data Exchange Server *52°North SOS* web-service

Considering the generic approach of this system, it can be used for any other kinds of data:

Environmental, Farming activities, renewable energy, wireless sensor network, …

Two different ways to query, use and analyze the data stored in the database have been introduced:

MONALISA SOS_R-Access *Helgoland*

Work in progress

- A GIT Repository will be soon available where the python script and the SOS_R-Access plugin will be available together with a user manual and data to be used for testing the system
- A user-friendly web interface will be developed to help the data provider/user to create the static file
- The exploitation about how to combine Shiny with the entire system will be further implemented and investigated

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Thank you for your attention

http://monalisasos.eurac.edu/sos/

bartolomeo.ventura@eurac.edu
support.rs@eurac.edu