CLOUD-BASED WEB SERVICE FOR OUTLIER ANALYSIS IN ENVIRONMENTAL TIME SERIES SERVED VIA SOS

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EOSC-hub

eLTER

ENVIRONMENT AGENCY AUSTRIA umweltbundesamt

BACKGROUND

- Research Infrastructures (RI) seek to provide standardised facilities, resources, processes and services for specific research domains, such as Long Term Ecological Research (LTER)
- Ongoing digitalisation puts focus on data aspects across the whole data life cycle
- RI increasingly use cloud data repositories for sharing and publishing data
  SOS is a natural choice for provision of geo-referenced time-series
- Data quality assessment is an important aspect of high relevance across and beyond RI

ELTER RI

- European Long-Term Ecosystem, critical zone and socio-ecological systems ESFRI-RI
- Mission: Research into ecosystem structures and functions
  site-based, multi-scale and cross-disciplinary
- Systematic coverage of major European terrestrial, freshwater and transitional water environments
  ~250 selected research sites
- eLTER Service Portal – access to data and sites

DEIMS-SDR	(Site and dataset registry)
DIP	(Data Integration Portal)
CDN	(Central Data Node – SOS based)

Current development: Virtual Data Labs

OUTLIER DETECTION IN TIME SERIES

- Data quality assessment is prerequisite for aggregation/re-use of data from different sources
  Outlier detection is one important aspect

- Separate technical reasons (Resulting in missing or incorrect measurement data)
  - Covered sensor, Overflowing container, Bad calibration, Flawed sensor, Data corruption during transmission

  from „unusual“ observations (Correct measurements with values outside the norm)
  - Wind speed during storm, High temperature during heatwave, Water level during heavy rain

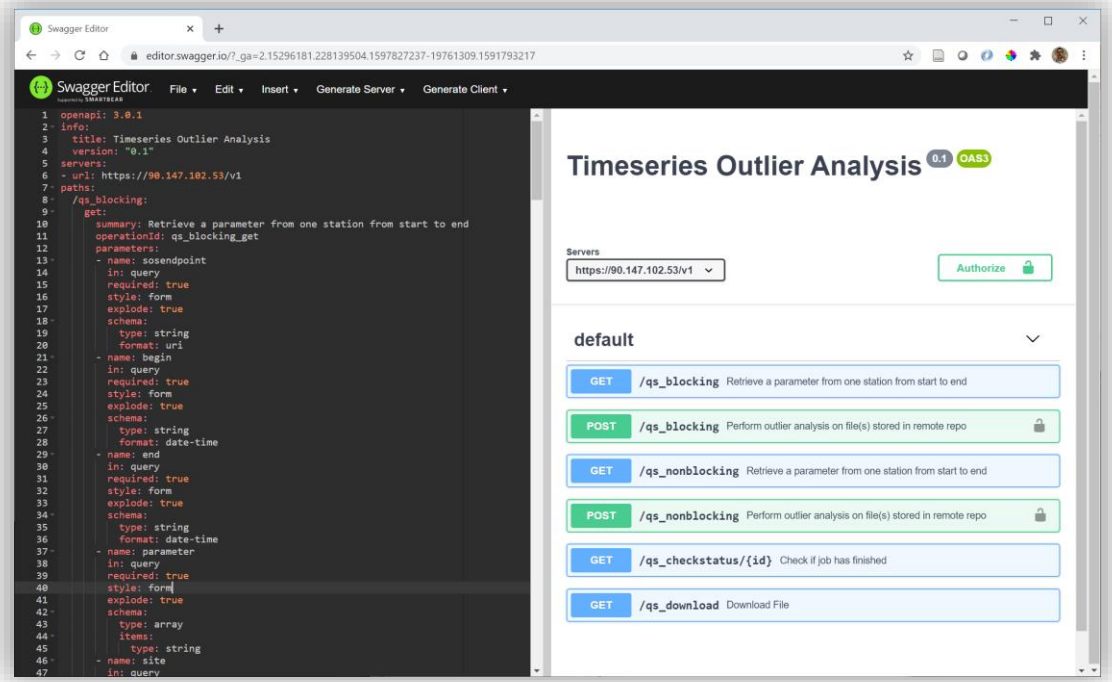
- Many different methods to detect outliers, desire to standardise approaches within the same RI

OUTLIER DETECTION SERVICE FOR ELTER RI

- Support data aggregation for standardised eLTER RI Data Products
  - Offer general quality assessment service for data providers
- Standardised „non blackbox“ array of outlier detection methods
  - Centralised maintenance and lower usage threshold
- Offer R-Script based workflow encapsulated behind REST-API
  - Operates on data offered via SOS or file based cloud repositories
  - R-script environment can also be provided for local or offline use
- Support data provenance, traceability and trust for eLTER RI workflows (and those of others)

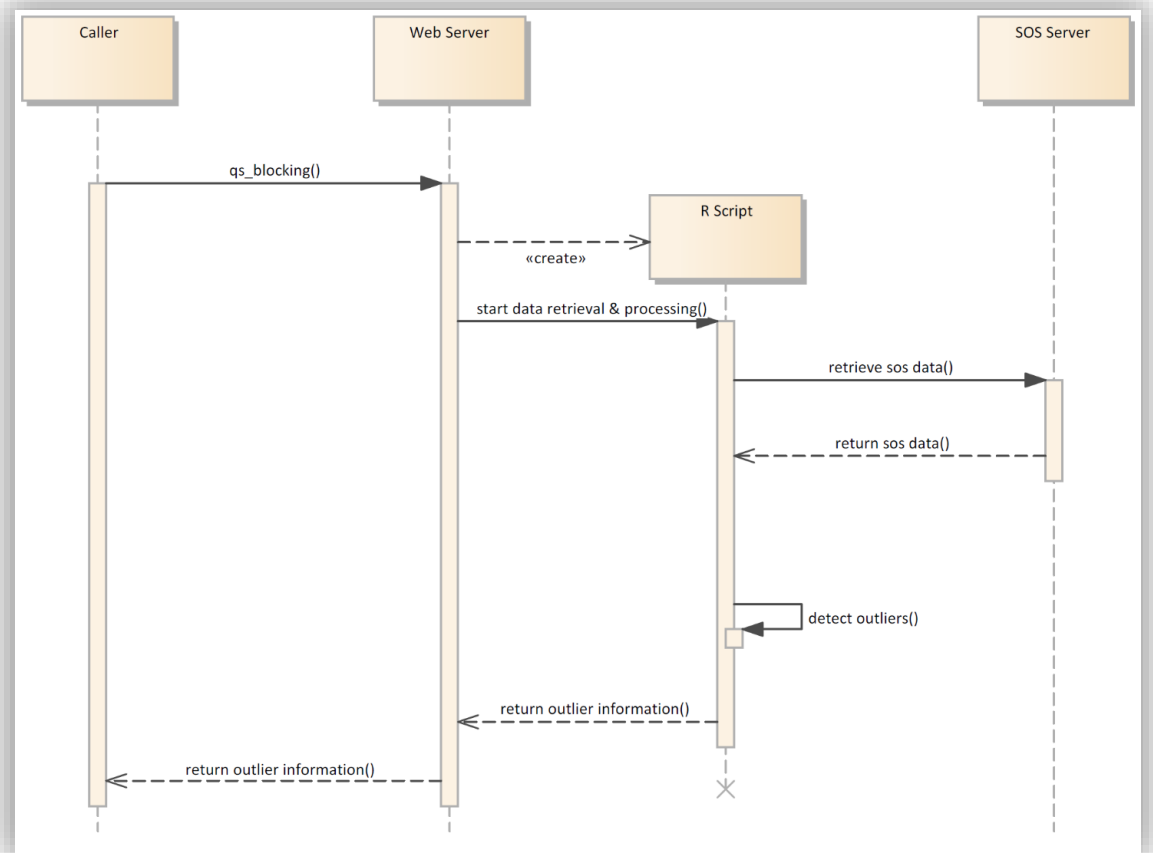
REST-API BASED ON OPENAPI SPECIFICATION

- Standardised description of REST API functions and parameters
- Automatic generation of server stubs from specification
- Connexion framework for Python/Flask based Web Servers



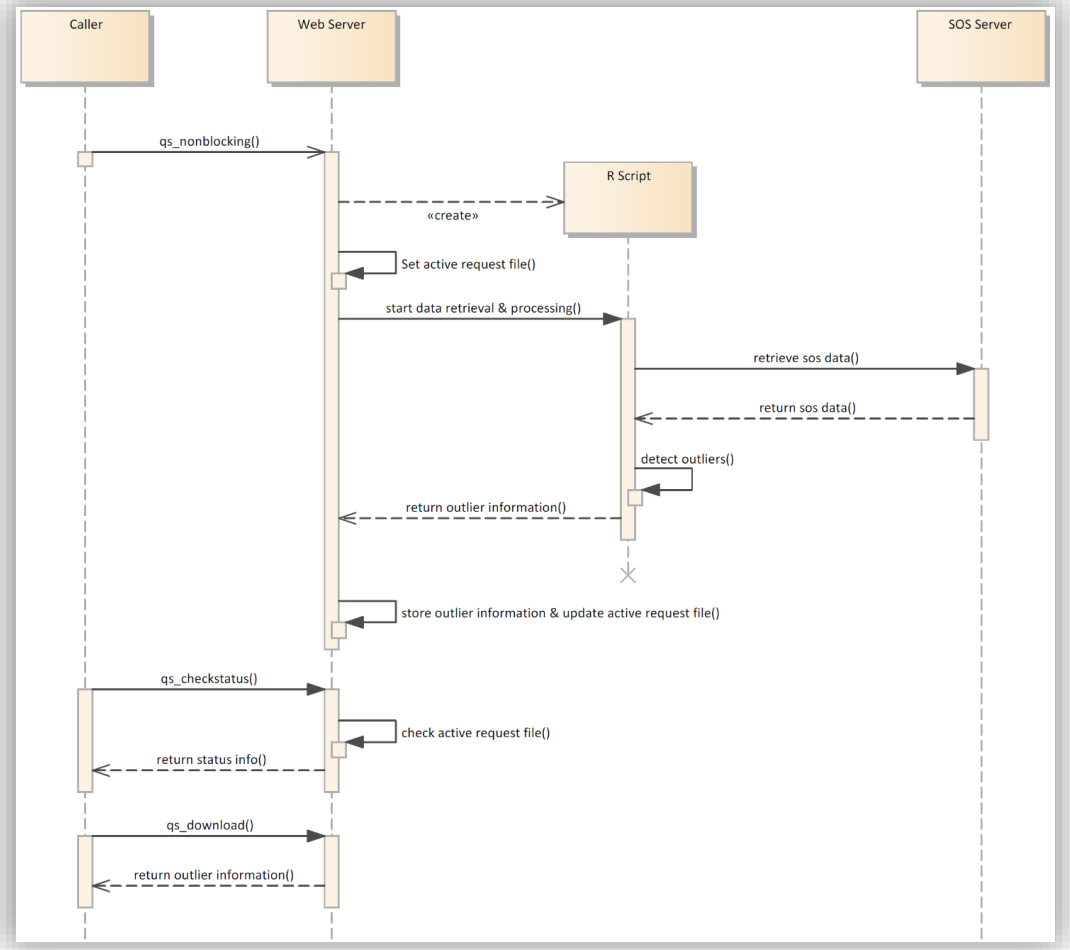
SYNCHRONOUS (BLOCKING) REQUESTS

- Processing of time-series with many values can take a long time



ASYNCHRONOUS (NONBLOCKING) REQUESTS

- Initiate processing, do not wait but occasionally poll status and pick up results once available

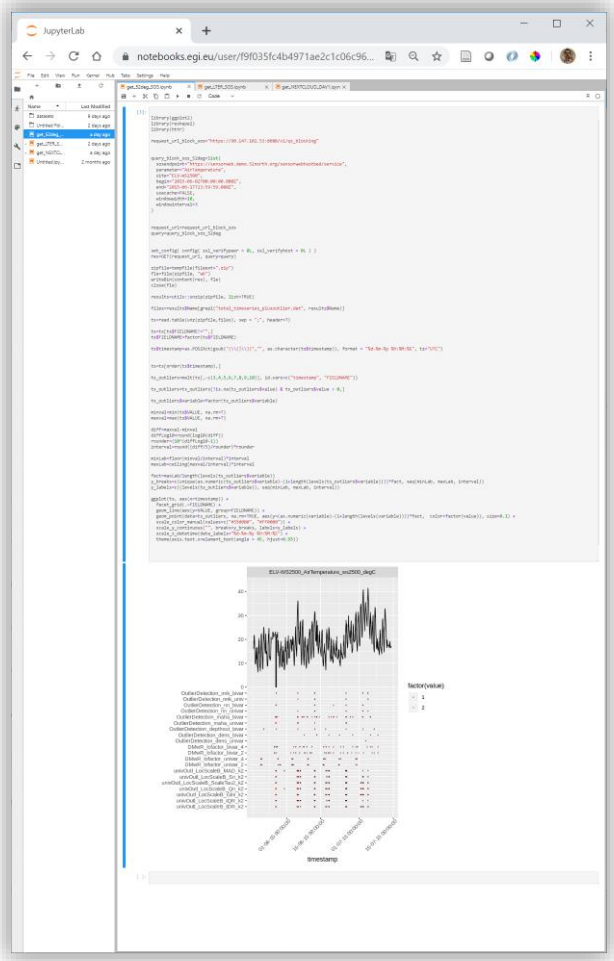


OUTLIER DETECTION

- Selection of methods made available via existing R-packages
- Detection usually based on moving window with caller-specified width and interval
- Currently 9 different methods
  - **Outlier identification by classifying the forward and backward absolute change**
  - **Rosner's Test for Outliers (R-package::function = EnvStats::rosnerTest)**
  - **Univariate outlier detection with bounds based on robust location and scale estimates (R-package::function = univOutl::LocScaleB)**
  - **An implementation of the LOF algorithm (R-Package::function = DMwR::lofactor)**
  - **Outlier detection using Robust Kernel-based Outlier Factor (RKOF) algorithm (R-Package::function = OutlierDetection::dens)**
  - **Outlier detection using Mahalanobis Distance (R-Package::function = OutlierDetection::maha)**
  - **Outlier detection using k Nearest Neighbours Distance method (R-Package::function = OutlierDetection::nn)**
  - **Outlier detection using kth Nearest Neighbour Distance method (R-Package::function = OutlierDetection::nnk)**

OUTLIER DETECTION

- Results made available in different files, packaged in a ZIP file
  - Annotated original time series (Each value has flags set if determined as outlier by a specific detection method)
  - More detailed analysis of outliers wrt moving window etc in separate files



LESSONS LEARNED SO FAR

- Identify individual time series in SOS?

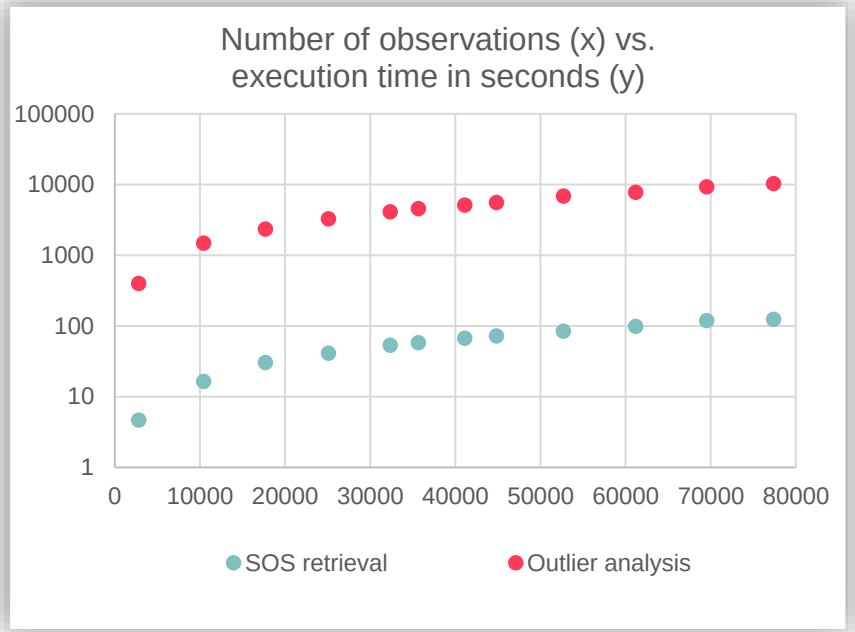
  Parameter + FoI + Begin + End ?

  Parameter + Procedure + FoI + Begin + End ?

  Offering + Begin + End ?

  - Configuration dependent, no universally valid approach
    → Potentially problematic for generic application
  - Consider specification or reuse of dedicated profile
    → within RI, or even beyond

- Performance
  - Linear increase in retrieval/processing time
  - Outlier analysis consumes most of the time
  - Improve code efficiency, parallel execution
  - Consider caching of results



OUTLOOK

- Service will play important role in eLTER RI
- Implement provenance trace
- Evaluate additional, especially multivariate, outlier detection methods
- Data caching strategies, Performance improvements

THANK YOU

- Contact: doron.goldfarb@umweltbundesamt.at
- Source Code: https://github.com/d0rg0ld/OutlierDetection4EOSC