wis2box

Release 0.2.0

World Meteorological Organization (WMO)

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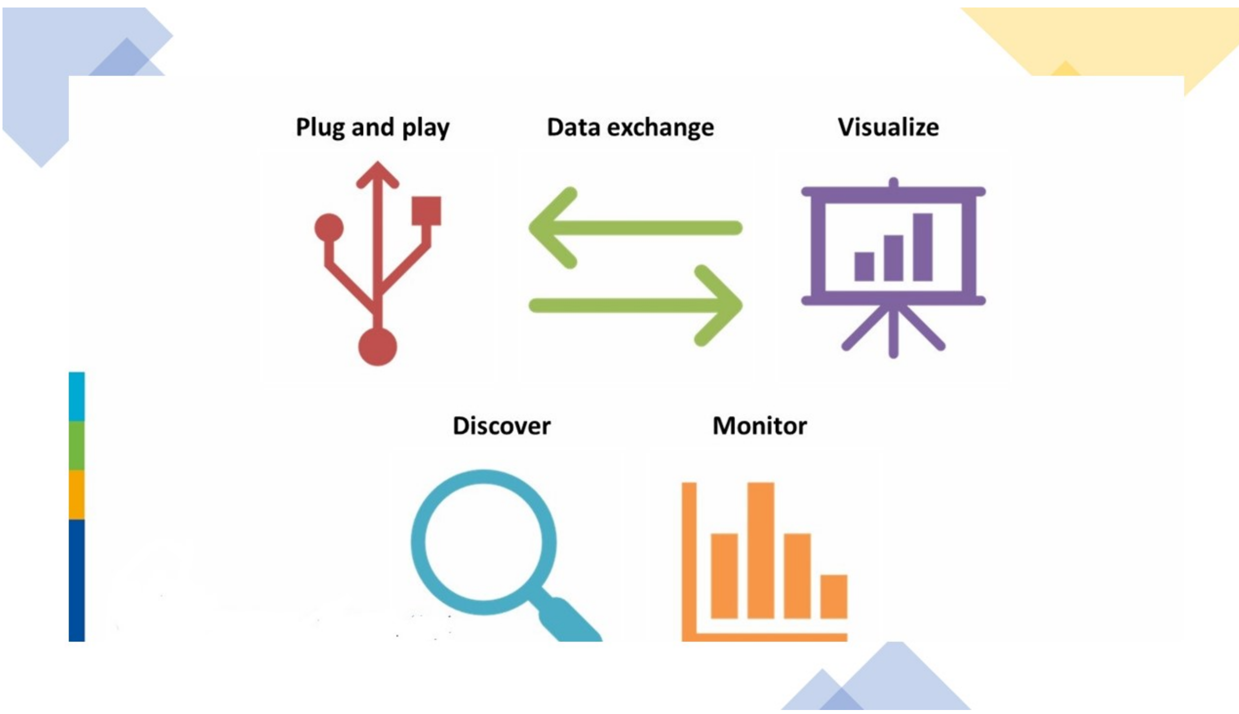
CHAPTER

ONE

OVERVIEW

wis2box is a Python reference implementation of a WMO WIS 2.0 node. The project provides a plug and play toolset to ingest, process, and publish weather/climate/water data using standards-based approaches in alignment with the WIS 2.0 principles. In addition, wis2box also provides access to all data in the WIS 2.0 network, from other wis2box instances and global centres.

wis2box is designed to have a low barrier to entry for data providers, providing enabling infrastructure and services for data discovery, access, and visualization.



1.1 Features

- WIS 2.0 compliant: easily register your wis2box to WIS 2.0 infrastructure, conformant to WMO data and metadata standards
- event driven or interactive data ingest/process/publishing pipeline
- visualization of stations/data on interactive maps
- discovery metadata management and publishing

- download/access of data from WIS 2.0 network to your local environment
- standards-based data services and access mechanisms:
  - Data formats
    - BUFR
    - GeoJSON
  - Message formats
    - GeoJSON
  - Access and notification protocols
    - HTTP
    - MQTT
  - APIs
    - OGC API
- robust and extensible plugin framework. Write your own data processing engines and integrate seamlessly into wis2box!
- free and open source (FOSS)
- containerized: use of Docker, enabling easy deployment

CHAPTER

TWO

QUICKSTART

Download wis2box and start using Malawi test data:

```
git clone https://github.com/wmo-im/wis2box.git
cd wis2box
```

For the purposes of a quickstart, this deployment expects the test environment, which includes data and metadata, and runs on localhost. This is done by using the test environment file:

```
cp tests/test.env dev.env
vi dev.env
```

Note: For more information on deployment, see *Administration* and *Configuration*

Start wis2box with Docker Compose and login to the wis2box container:

```
python3 wis2box-ctl.py start
python3 wis2box-ctl.py status --all # The --all flag shows all containers, even ones
↪that are down.
python3 wis2box-ctl.py login
```

Once logged in, create the enviroment and verify it is correct:

```
wis2box environment create
wis2box environment show
```

Setup observation data processing and API publication:

```
wis2box data setup --topic-hierarchy data.core.observations-surface-land.mw.FWCL.
↪landFixed
wis2box api add-collection --topic-hierarchy data.core.observations-surface-land.mw.FWCL.
↪landFixed $WIS2BOX_DATADIR/metadata/discovery/surface-weather-observations.yml
```

Publish station collection and discovery metadata to the API:

```
wis2box metadata discovery publish $WIS2BOX_DATADIR/metadata/discovery/surface-weather-
↪observations.yml
wis2box metadata station cache $WIS2BOX_DATADIR/metadata/station/station_list.csv
wis2box metadata station publish-collection
```

Ingest and publish data via command-line interface (CLI) or an MQTT event driven workflow:

```
# CLI
wis2box data ingest --topic-hierarchy data.core.observations-surface-land.mw.FWCL.
↪landFixed --path $WIS2BOX_DATADIR/observations
# OR
# Event driven
cp $WIS2BOX_DATADIR/observations/* $WIS2BOX_DATADIR/data/incoming/data/core/observations-
↪surface-land/mw/FWCL/landFixed
```

Re-publish the stations collection to additionally include link relations to collections with observations published from that station:

```
wis2box metadata station publish-collection
```

Logout of wis2box container:

```
exit
```

From here, you can run `python3 wis2box-ctl.py status` to confirm that containers are running.

To explore your wis2box installation and services, visit http://localhost:8999 in your web browser.

CHAPTER

THREE

WIS 2.0

The WMO Information System is a coordinated global infrastructure responsible for telecommunications and data management functions and is owned and operated by WMO Members.

WIS provides an integrated approach suitable for all WMO Programmes to meet the requirements for routine collection and automated dissemination of observed data and products, as well as data discovery, access, and retrieval services for weather, climate, water, and related data produced by centres and Member countries in the framework of any WMO Programme. It is capable of exchanging large data volumes, such as new ground and satellite-based systems, finer resolutions in numerical weather prediction, and hydrological models and their applications. These data and products must be available to National Hydrological and Meteorological Services (NHMS), but also national disaster authorities for more timely alerts where and when needed.

WIS is a vital data communications backbone for integrating the diverse real-time and non-real-time high priority data sets, regardless of location.

Further documentation on WIS 2.0 can be found at the following links:

- WIS Overview

CHAPTER

FOUR

HOW WIS2BOX WORKS

wis2box is implemented in the spirit of the Twelve-Factor App methodology.

wis2box is a Docker and Python-based platform with the capabilities for centres to integrate their data holdings and publish them to the WMO Information System with a plug and play capability supporting data publishing, discovery and access.

4.1 High level system context

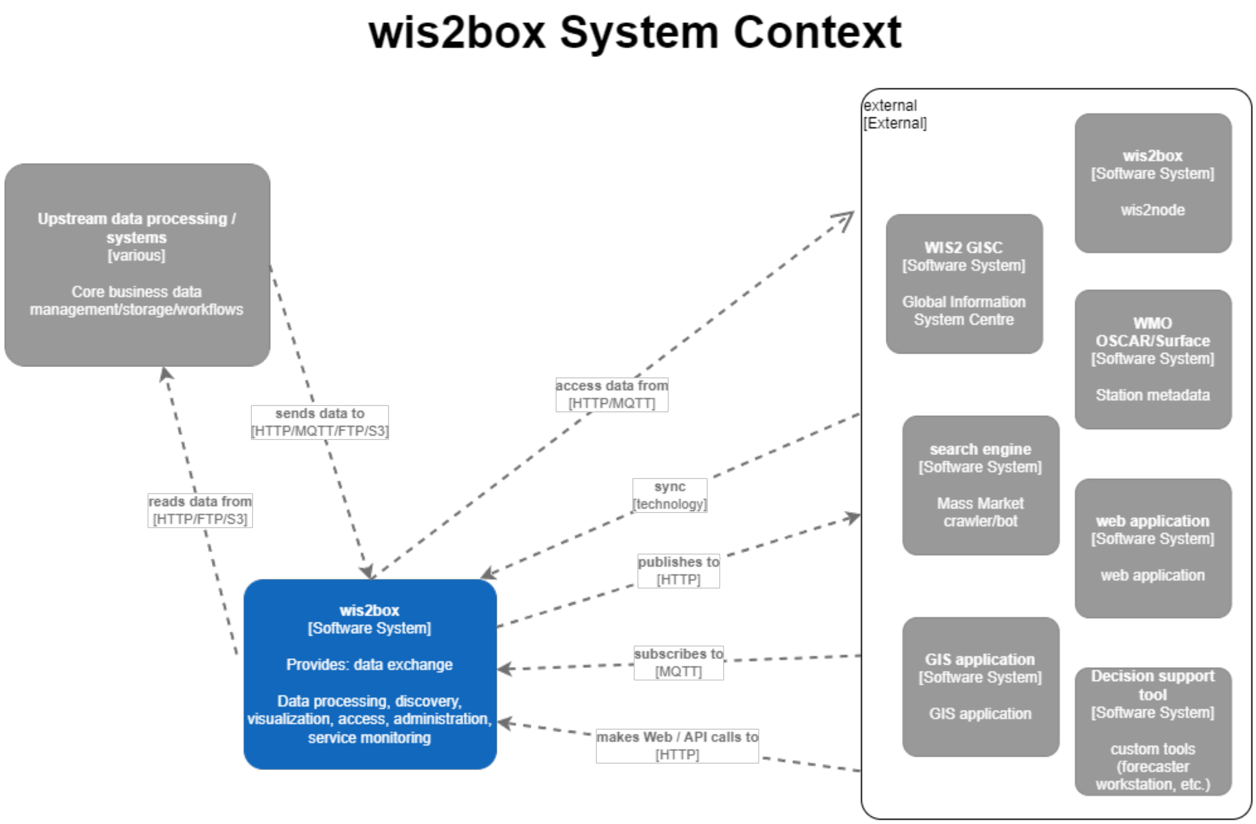
The following diagram provides a high level overview of the main functions of wis2box:

Core wis2box functionality includes the ability to:

- integrate your existing data processing pipeline
- cache station metadata from the OSCAR/Surface station metadata management tool
- process and transform your weather/climate/water data into official WMO data formats
- create and publish discovery metadata of your datasets
- provide your data via OGC and PubSub standards mechanisms to your data, enabling easy access for web applications, desktop GIS tools, mobile applications
- connect your wis2box to the WIS 2.0 network
- make your data and services available to market search engines
- subscribe to and download weather/climate/water data from the WIS 2.0 network

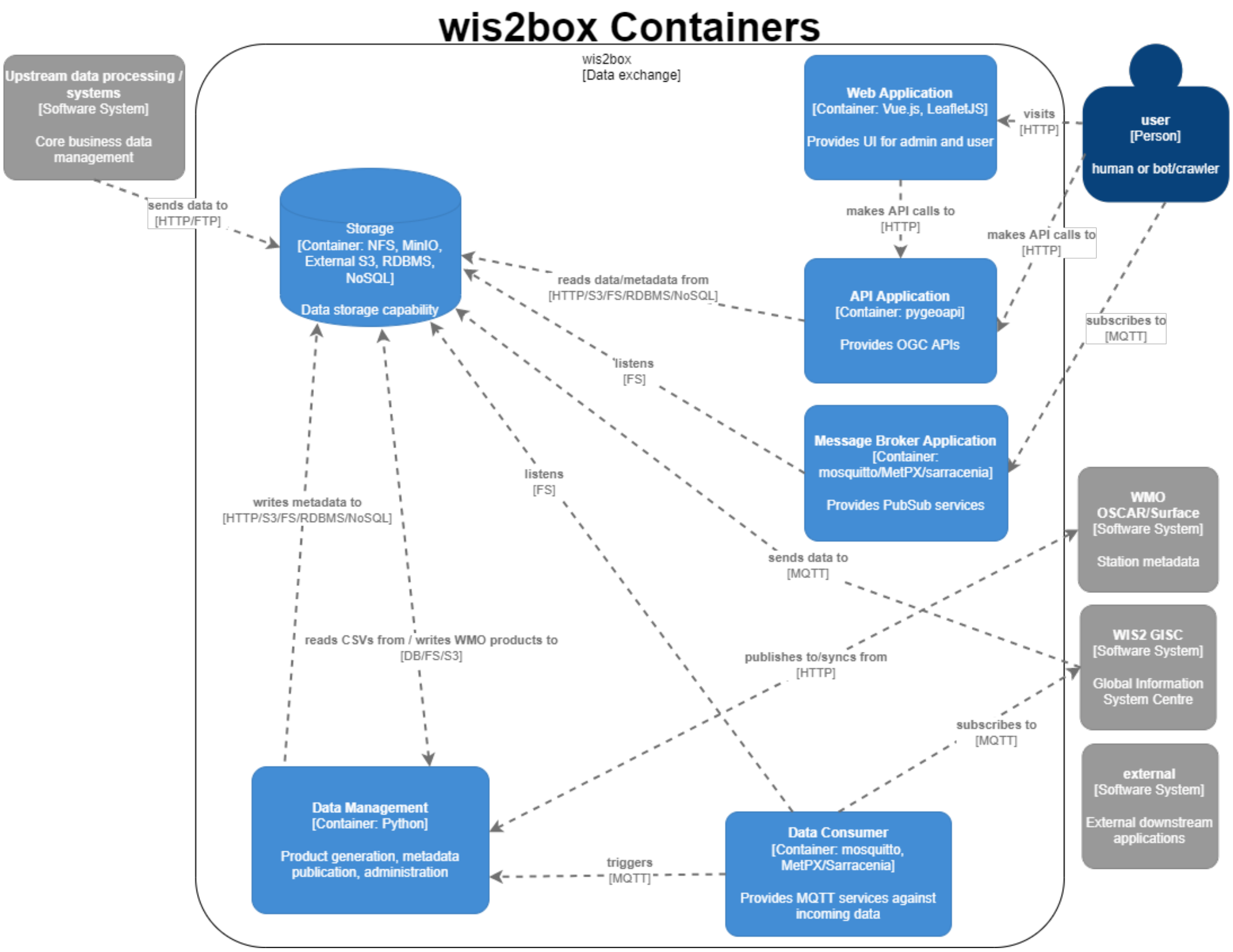
4.2 Docker Compose

wis2box is built as Docker Compose application, allowing for easy install and container management.


wis2box System Context
external
[External]
Upstream data processing / systems
[various]
Core business data management/storage/workflows
sends data to
[HTTP/MQTT/FTP/S3]
reads data from
[HTTP/FTP/S3]
access data from
[HTTP/MQTT]
sync
[technology]
publishes to
[HTTP]
subscribes to
[MQTT]
makes Web / API calls to
[HTTP]
wis2box
[Software System]
Provides: data exchange
Data processing, discovery, visualization, access, administration, service monitoring
wis2box
[Software System]
wis2node
WIS2 GISC
[Software System]
Global Information System Centre
WMO OSCAR/Surface
[Software System]
Station metadata
search engine
[Software System]
Mass Market crawler/bot
web application
[Software System]
web application
GIS application
[Software System]
GIS application
Decision support tool
[Software System]
custom tools (forecaster workstation, etc.)

4.3 Container workflow

Let's dive a little deeper. The following diagram provides a view of all wis2box containers:



Container functionality can be described as follows:

- **Data Consumer**: the data entry point of wis2box. Data pipelines and workflow begins here
- **Data Management**: the epicentre of wis2box. Provides core wis2box administration and data/workflow/publishing utilities
- **Storage**: core data persistence
- **API Application**: OGC APIs providing geospatial web services
- **Web Application**: user interface

4.4 Technology

wis2box is built on free and open source (FOSS) technology.

Container	Function	Technology	Standards
Data Consumer	PubSub	mosquitto MetPX-Sarracenia	MQTT
Data Management	data processing and publishing	ecCodes csv2bufr bufr2geojson pygeometa pyoscar	WCMP (WMO Core Metadata Profile) WMDR (WIGOS Metadata Record)
API Application	data discovery and access	pygeoapi Elasticsearch	OGC API
Web Application	data discovery and visualization	Vue.js Leaflet	OGC API

CHAPTER

FIVE

INSTALLATION

wis2box leverages Docker for easy installation across operating systems and environments.

5.1 Requirements and dependencies

Dependencies are installed as containers in the deployment of wis2box. This is true for the wis2box software itself, which runs as a container orchestrating the necessary data management workflows of a node in the WIS 2.0 network.

wis2box requires the following prior to installation:

Requirement	Version
Python	3.8
Docker Engine	20.10.14
Docker Compose	2.4.1

If these are already installed, you can skip to installing wis2box.

- To install Python, follow Python installation.
- To install Docker, follow Docker Engine installation.
- To install Docker Compose, follow Compose installation.

Successful installation can be confirmed by inspecting the versions on your system.

```
docker version
docker compose version
python3 -V
```

Note: Docker may require post-install configuration. Linux users may need to follow post install steps to grant docker privileges. Users in corporate settings my need to configure Docker's HTTP/HTTPS proxy.

5.2 Installing wis2box

Once Python and Docker are installed, the wis2box software needs to be installed.

5.2.1 ZIP Archive

wis2box can be installed from a ZIP archive of a the latest branch or a wis2box release.

```
# curl, wget or download from your web browser
curl https://github.com/wmo-im/wis2box/archive/refs/heads/main.zip
cd wis2box-main
```

5.2.2 GitHub

wis2box can also be installed using the git CLI.

```
# clone wis2box GitHub repository
git clone https://github.com/wmo-im/wis2box.git
cd wis2box
```

5.3 Summary

Congratulations! Whichever of the abovementioned methods you chose, you have successfully installed wis2box onto your system. From here, you can get started with test data by following the *Quickstart*, or continue on to *Configuration*.

CHAPTER

SIX

CONFIGURATION

Once you have installed wis2box, it is time to setup the configuration. wis2box setup is based on a simple configuration that can be adjusted depending the user's needs and deployment environment.

6.1 Environment variables

wis2box configuration is driven primarily by a small set of environment variables. The runtime configuration is defined in the Env format in a plain text file named `dev.env` and `docker/default.env`.

Any values set in `dev.env` override the default environment variables in `docker/default.env`. For further / specialized configuration, see the sections below.

6.1.1 `WIS2BOX_HOST_DATADIR`

The minimum required setting in `dev.env` is the `WIS2BOX_HOST_DATADIR` environment variable. Setting this value is **required** to map the wis2box data directory from the host system to the containers.

It is recommended to set this value to an absolute path on your system.

6.2 Sections

Note: A reference configuration can always be found in the wis2box GitHub repository. The *Quickstart* uses a variant of `wis2box.env` with mappings to the test data, as an example. For complex installations, it is recommended to start configuring wis2box by copying the example `wis2box.env` file and modifying accordingly.

wis2box environment variables can be categorized via the following core sections:

- **Data**: locations of where data is stored as well as retention specifications
- **API**: API configuration for provisioning the OGC API capabilities
- **Logging**: logging configuaration for wis2box
- **PubSub**: PubSub options
- **Other**: other miscellaneous options

Note: Configuration directives and reference are described below via annotated examples. Changes in configuration require a restart of wis2box to take effect. See the *Administration* section for information on managing wis2box.

6.2.1 Data

The data configurations provide control of directories on the host machine bound into the Docker volume and wis2box. The default relationship below resembles the directory structure within the wis2box volume.

Note: Make sure to use **absolute paths** instead of relative paths.

```
WIS2BOX_HOST_DATADIR=${PWD}/wis2box-data  # wis2box host data directory
WIS2BOX_DATADIR=/data/wis2box  # wis2box data directory
WIS2BOX_DATA_RETENTION_DAYS=7  # wis2box data retention time, in days. Data older than␣
↪this value is
                               # is deleted on a daily basis
```

6.2.2 API

API configurations drive control of the OGC API setup.

```
WIS2BOX_API_TYPE=pygeoapi  # server tpye
WIS2BOX_API_URL=http://localhost:8999/pygeoapi  # public landing page endpoint
WIS2BOX_API_CONFIG=${PWD}/docker/pygoeoapi/pygeoapi-config.yml  # configuration file
WIS2BOX_API_BACKEND_TYPE=Elasticsearch  # backend provider type
WIS2BOX_API_BACKEND_URL=http://elasticsearch:9200  # internal backend connection URL
```

6.2.3 Logging

The logging directives control logging level/severity and output.

```
WIS2BOX_LOGGING_LOGLEVEL=ERROR  # the logging level (see https://docs.python.org/3/
↪library/logging.html#logging-levels)
WIS2BOX_LOGGING_LOGFILE=stdout  # the full file path to the logfile or ``stdout`` to␣
↪display on console
```

6.2.4 PubSub

PubSub configuration provides connectivity information for the PubSub broker.

```
WIS2BOX_BROKER=mqtt://wis2box:wis2box@mosquitto/  # RFC 1738 syntax of internal broker␣
↪endpoint
WIS2BOX_MQTT_URL=mqtt://localhost:1883  # public MQTT url
```

6.2.5 Other

Additional directives provide various configurationscontrol of configuration options for the deployment of wis2box.

```
WIS2BOX_OSCAR_API_TOKEN=some_token  # OSCAR/Surface API token for OSCAR API interaction
WIS2BOX_URL=http://localhost:8999/  # public wis2box url
WIS2BOX_AUTH_STORE=/data/wis2box/auth.db # wis2box auth location
```

Note: To access internal containers, URL configurations should point to the named containers as specified in `docker-compose.yml`.

A full configuration example can be found below:

```
# Required
# Host machine data directory path
WIS2BOX_HOST_DATADIR=/path/to/local/data/directory

# Optional
# Environment variable overrides
```

```
# data paths and retention
WIS2BOX_DATADIR=/data/wis2box
WIS2BOX_DATA_RETENTION_DAYS=7

# API
WIS2BOX_API_TYPE=pygeoapi
WIS2BOX_API_URL=http://localhost:8999/oapi
WIS2BOX_API_CONFIG=/data/wis2box/wis2box-api-config.yml
WIS2BOX_API_BACKEND_TYPE=Elasticsearch
WIS2BOX_API_BACKEND_URL=http://elasticsearch:9200
WIS2BOX_DOCKER_API_URL=http://wis2box-api:80/oapi

# logging
WIS2BOX_LOGGING_LOGLEVEL=ERROR
WIS2BOX_LOGGING_LOGFILE=stdout

# PubSub
WIS2BOX_BROKER=mqtt://wis2box:wis2box@mosquitto
WIS2BOX_MQTT_URL=mqtt://localhost:1883

# other
WIS2BOX_OSCAR_API_TOKEN=some_token
WIS2BOX_URL=http://localhost:8999

# mappings of topic hierarchy to wis2box data plugins
# optionally override default mappings from wis2box data plugins
# WIS2BOX_DATADIR_DATA_MAPPINGS=${PWD}/wis2box-data-mappings.yml

# access control
WIS2BOX_AUTH_STORE=/data/wis2box/auth.db
```

6.3 Docker Compose

The Docker Compose setup is driven from the resulting `dev.env` file created. For advanced cases and/or power users, updates can also be made to `docker-compose.yml` or `docker-compose.override.yml` (for changes to ports).

6.4 Summary

At this point, you have defined the runtime configuration required to administer your wis2box installation.

CHAPTER SEVEN

ADMINISTRATION

wis2box is designed to be built as a network of virtual machines within a virtual network. Once this is built, users login into the main wis2box machine to setup their workflow and configurations for data processing and publishing.

The `wis2box-ctl.py` utility provides a number of tools for managing the wis2box containers.

The following steps provide an example of container management workflow.

```
# build all images
python3 wis2box-ctl.py build

# start system
python3 wis2box-ctl.py start

# stop system
python3 wis2box-ctl.py stop

# view status of all deployed containers
python3 wis2box-ctl.py status
```

Note: Run `python3 wis2box-ctl.py --help` for all usage options.

With wis2box now installed and started, it's time to start up the box and login to the wis2box container:

```
python3 wis2box-ctl.py start
python3 wis2box-ctl.py login
```

Now that you are logged into the wis2box container, it's now time to manage station metadata, discovery metadata and data processing pipelines.

CHAPTER

EIGHT

RUNNING

wis2box workflows can be categorized as design time (interactive) or runtime (automated).

8.1 Design time

- environment creation
- topic hierarchy registration
- station metadata caching
- station metadata API publishing
- discovery metadata API publishing

8.2 Runtime

- automated data processing and API/PubSub publishing

8.3 Running topics

8.3.1 Environment

wis2box requires the environment to be initialized before data processing or publishing.

```
wis2box environment create
```

This command will create all the directories required. You can check the environment at any time with:

```
wis2box environment show
```

For the purposes of documentation, the value `WIS2BOX_DATADIR` represents the base directory for all data managed in wis2box.

8.3.2 Concepts

Let's clarify a few concepts as part working with wis2box:

- **topic hierarchy**: thesaurus defined by WMO to categorize and classify data, allowing for easy and efficient search
- **discovery metadata**: description of a dataset to be included in the WIS 2.0 global catalogue
- **catalogue**: a collection of discovery metadata records
- **station metadata**: description of the properties of an observing station, which provides observations and measurements
- **data mappings**: the wis2box mechanism to define and associate a topic hierarchy to a processing pipeline

8.3.3 Topic hierarchy

Note: The WIS 2.0 topic hierarchies are currently in development. wis2box implementation of the topic hierarchies will change, based on ratifications/updates of the topic hierarchies in WMO technical regulations and publications.

wis2box implements the WIS 2.0 topic hierarchies, which are designed to efficiently categorize and classify data, by implementing directory hierarchies. For example, the below exemplifies a WIS 2.0 topic hierarchy as implemented in wis2box:

WIS 2.0 topic hierarchy	wis2box directory
`foo.bar.baz`	`foo/bar/baz`

wis2box topic hierarchies are managed **under** the various wis2box directories, and are used as part of both design time and runtime workflow.

To create a wis2box topic hierarchy:

```
wis2box data setup --topic-hierarchy foo.bar.baz
```

This will create the topic hierarchy under the required wis2box directories in support of automated processing and publishing.

To view a given topic hierarchy setup:

```
wis2box data info --topic-hierarchy foo.bar.baz
```

8.3.4 Data mappings

Once a topic hierarchy is defined, it needs to be included in the wis2box data mappings configuration. wis2box provides a default data mapping (in YAML format):

```
data:
    data.core.observations-surface-land.mw.FWCL.landFixed:
        plugins:
            csv:
                plugin: wis2box.data.observations.ObservationDataCSV
                template: synop-bufr.json
```

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```
                file-pattern: '^WIGOS_(\d-\d+-\d+-\w+)_.*\.csv$'
            bufr4:
                plugin: wis2box.data.bufr4.ObservationDataBUFR
                template:
                file-pattern: '^WIGOS_(\d-\d+-\d+-\w+)_.*\.bufr4$'
            geojson:
                plugin: wis2box.data.base.BaseAbstractData
                template:
                file-pattern: '^WIGOS_(\d-\d+-\d+-\w+)_.*\.geojson$'
```

The data mappings are indicated by the `data` keyword, with each topic having a separate entry specifying:

- `plugin`: the codepath of the plugin.
- `template`: additional argument allowing a mapping template name to be passed to the plugin.
- `file-pattern`: additional argument allowing a file pattern to be passed to the plugin.

The default data mapping can be overriden by user-defined data mappings with the following steps:

- create a YAML file similar to the above to include your topic hierarchy
- set the `WIS2BOX_DATADIR_DATA_MAPPINGS` environment variable to point to the new file of definitions
- restart wis2box

See *Extending wis2box* for more information on adding your own data processing pipeline.

8.3.5 Station metadata

wis2box is designed to support data ingest and processing of any kind. For observations, processing workflow typically requires station metadata to be present at runtime.

wis2box provides the ability to cache station metadata from the WMO OSCAR/Surface system.

To cache your stations of interest, create a CSV file formatting per below, specifying one line (with station name and WIGOS station identifier [WSI]) per station:

```
station_name,wigos_station_identifier
Balaka,0-454-2-AWSBALAKA
Kayerekera,0-454-2-AWSKAYEREKERA
Lobi_EPA,0-454-2-AWSLOBI
Malomo_EPA,0-454-2-AWSMALOMO
Namitambo,0-454-2-AWSNAMITAMBO
Nkhoma_University,0-454-2-AWSNKHOMA
Toleza,0-454-2-AWSTOLEZA
```

Use this CSV to cache station metadata:

```
wis2box metadata station cache /path/to/station_list.csv
```

Resulting station metadata files (JSON) are stored in `WIS2BOX_DATADIR/data/metadata/station` and can be used by wis2box data processing pipelines. These data are required before starting automated processing.

8.3.5.1 Summary

At this point, you have cached the required station metadata for your given dataset(s).

8.3.6 Discovery metadata

Discovery metadata describes a given dataset or collection. Data being published through a wis2box requires discovery metadata (describing it) to be created, maintained and published to the wis2box catalogue API.

wis2box supports managing discovery metadata using the WMO Core Metadata Profile (WCMP) 2.0 standard.

Note: WCMP 2.0 is currently in development as part of WMO activities.

Creating a discovery metadata record in wis2box is as easy as completing a YAML configuration file. wis2box leverages the pygeometa project's metadata control file (MCF) format. Below is an example MCF file.

```yaml
wis2box:
    retention: P30D
    topic_hierarchy: data.core.observations-surface-land.mw.FWCL.landFixed
    data_category: observationsSurfaceLand
    country_code: mw
    originator: FWCL
    station_type: landFixed

mcf:
    version: 1.0

metadata:
    identifier: data.core.observations-surface-land.mw.FWCL.landFixed
    language: en
    language_alternate: fr
    charset: utf8
    hierarchylevel: dataset
    datestamp: 2021-11-29

spatial:
    datatype: vector
    geomtype: point

identification:
    language: en
    charset: utf8
    title:
        en: Surface weather observations (hourly)
    abstract:
        en: Surface weather observations (hourly)
    dates:
        creation: 2021-11-29
        publication: 2021-11-29
    keywords:
        default:
            keywords:
```

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```
                en:
                    - surface weather
                    - temperature
                    - observations
        wmo:
            keywords:
                en:
                    - weatherObservations
            keywords_type: theme
            vocabulary:
                name:
                    en: WMO Category Code
                url: https://github.com/wmo-im/wcmp-codelists/blob/main/codelists/WMO_
↪CategoryCode.csv
        wis2:
            keywords:
                en:
                    - mw.malawi.weatherObservations.dataset_name
            keywords_type: theme
            vocabulary:
                name:
                    en: WMO Core Metadata profile topic hierarchy
                url: https://github.com/wmo-im/wcmp2-codelists/blob/main/codelists/topic_
↪hierarchy.csv

    topiccategory:
        - climatologyMeteorologyAtmosphere
    extents:
        spatial:
            - bbox: [32.6881653175,-16.8012997372,35.7719047381,-9.23059905359]
              crs: 4326
        temporal:
            - begin: 2021-11-29
              end: null
              resolution: P1H
    fees: None
    accessconstraints: otherRestrictions
    rights:
        en: WMO Unified Policy for the International Exchange of Earth System Data
    url: https://example.org/malawi-surface-weather-observations
    status: onGoing
    maintenancefrequency: continual

contact:
    pointOfContact: &contact_poc
        organization: Department of Climate Change and Meteorologial Services (DCCMS)
        url: https://www.metmalawi.gov.mw
        individualname: Firstname Lastname
        positionname: Position Name
        phone: +265-1-822-014
        fax: +265-1-822-215
        address: P.O. Box 1808
```

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```yaml
        city: Blantyre
        administrativearea: Blantyre District
        postalcode: M3H 5T4
        country: Malawi
        email: you@example.org
        hoursofservice: 0700h - 1500h UTC
        contactinstructions: email

    distributor: *contact_poc

dataquality:
    scope:
        level: dataset
    lineage:
        statement: this data was generated by the csv2bufr tool
```

Note: There are no conventions to the MCF filename. The filename does not get used/exposed or published. It is up to the user to determine the best filename, keeping in mind your wis2box system may manage and publish numerous datasets (and MCF files) over time.

8.3.6.1 Summary

At this point, you have created discovery metadata for your given dataset(s).

8.3.7 Data ingest, processing and publishing

At this point, the system is ready for ingest/processing and publishing.

Data ingest, processing and publishing can be run in automated fashion or via the wis2box CLI. Data is ingested, processed, and published as WMO BUFR data, as well as GeoJSON features.

Warning: GeoJSON **data** representations provided in wis2box are in development and are subject to change based on evolving requirements for observation data representations in WIS 2.0 technical regulations.

8.3.7.1 Interactive ingest, processing and publishing

The *wis2box* CLI provides a data subsystem to process data interactively. CLI data ingest/processing/publishing can be run with explicit or implicit topic hierarchy routing (which needs to be tied to the pipeline via the *Data mappings*).

Explicit topic hierarchy workflow

```
# process a single CSV file
wis2box data ingest --topic-hierarchy foo.bar.baz -p /path/to/file.csv

# process a directory of CSV files
wis2box data ingest --topic-hierarchy foo.bar.baz -p /path/to/dir

# process a directory of CSV files recursively
wis2box data ingest --topic-hierarchy foo.bar.baz -p /path/to/dir -r
```

Implicit topic hierarchy workflow

```
# process incoming data; topic hierarchy is inferred from fuzzy filepath equivalent
# wis2box will detect 'foo/bar/baz' as topic hierarchy 'foo.bar.baz'
wis2box data ingest -p /path/to/foo/bar/baz/data/file.csv
```

8.3.7.2 Event driven ingest, processing and publishing

One all metadata, topic hierarchies, and data configurations are setup, event driven workflow will immediately start to listen on files in `WIS2BOX_DATADIR/data/incoming` as they are placed in the appropriate topic hierarchy directory.

Note: wis2box can make `WIS2BOX/data/incoming` accessible via WebDAV by enabling `docker/extras/docker-compose.webdav.yml`.

8.3.7.3 Summary

Congratulations! At this point, you have successfully setup a wis2box data pipeline. Data should be flowing through the system.

8.3.8 API publishing

At this stage:

- station metadata has been configured
- discovery metadata has been created
- data pipelines are configured and running

Let's dive into publishing the data and metadata:

wis2box provides an API supporting the OGC API standards using pygeoapi.

8.3.8.1 Station metadata API publishing

The first step is to publish our station metadata to the API. The command below will generate local station collection GeoJSON for pygeoapi publication.

```
wis2box metadata station publish-collection
```

8.3.8.2 Discovery metadata API publishing

This step will publish dataset discovery metadata to the API.

```
wis2box metadata discovery publish /path/to/discovery-metadata.yml
```

8.3.8.3 Dataset collection API publishing

The below command will add the dataset collection to pygeoapi from the discovery metadata MCF created as described in the *Discovery metadata* section.

```
wis2box api add-collection $WIS2BOX_DATADIR/data/config/foo/bar/baz/discovery-metadata.
↪yml --topic-hierarchy foo.bar.baz
```

To delete the colection from the API backend and configuration:

```
wis2box api delete-collection --topic-hierarchy foo.bar.baz
```

Note that the data itself is being published to the API backend automatically given the event driven workflow. If manual ingest is needed, the following command can be run in interactive mode:

```
wis2box api add-collection-items --topic-hierarchy foo.bar.baz
```

Note: Changes to the API configuration are reflected and updated automatically.

8.3.8.4 Summary

At this point, you have successfully published the required data and metadata collections to the API.

8.3.9 Data retention

wis2box is configured to set data retention according to your requirements. Data retention is managed via the `WIS2BOX_DATA_RETENTION_DAYS` environment variable as part of configuring wis2box. Data retention includes cleaning of published data and archiving of incoming/raw data.

8.3.9.1 Cleaning

Cleaning is performed by default daily at 0Z by the system, and can also be run interactively with:

```
# delete data older than WIS2BOX_DATA_RETENTION_DAYS by default
wis2box data clean


# delete data older than --days (force override)
wis2box data clean --days=30
```

8.3.9.2 Archiving

Cleaning is performed on incoming data by default daily at 1Z by the system, and can also be run interactively with:

```
wis2box data archive
```

Data is archived to `WIS2BOX_DATADIR/data/archive`.

CHAPTER

NINE

MONITORING

wis2box has built-in monitoring functions based on Prometheus, Loki and Grafana.

The Grafana endpoint can be visualized at http://localhost/monitoring.

Grafana uses two data sources to display monitoring data:

- Prometheus: actively 'scrapes' data from the configured prometheus-client exporters every X seconds
- Loki: logging endpoint for the Docker containers that compose the wis2box

9.1 Prometheus exporters for wis2box

The exporters for wis2box are based on the Prometheus Python Client

- metrics_collector: collects data on filesystem
- mqtt_metric_collector: collects data on messages published, using an mqtt-session subscribed to the wis2box-broker

9.2 Loki logging

The logs of the following Docker containers are sent to Loki:

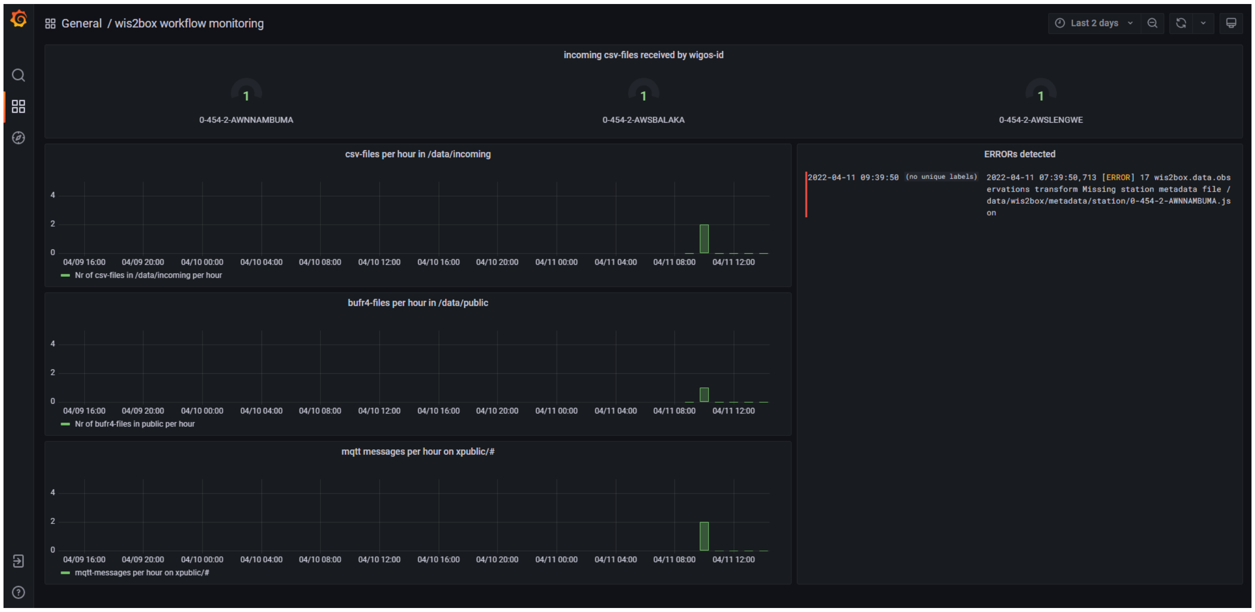
- data-consumer
- mqp-publisher
- wis2box
- wis2box-ui
- mosquitto
- wis2box-api
- wis2box-auth

9.3 Monitoring topics

9.3.1 Grafana dashboards

Grafana is exposed via */monitoring* on the localhost running wis2box. The home dashbaord can be visuais made available

Go to http://localhost/monitoring to see the home dashboard of wis2box once the stack is running.

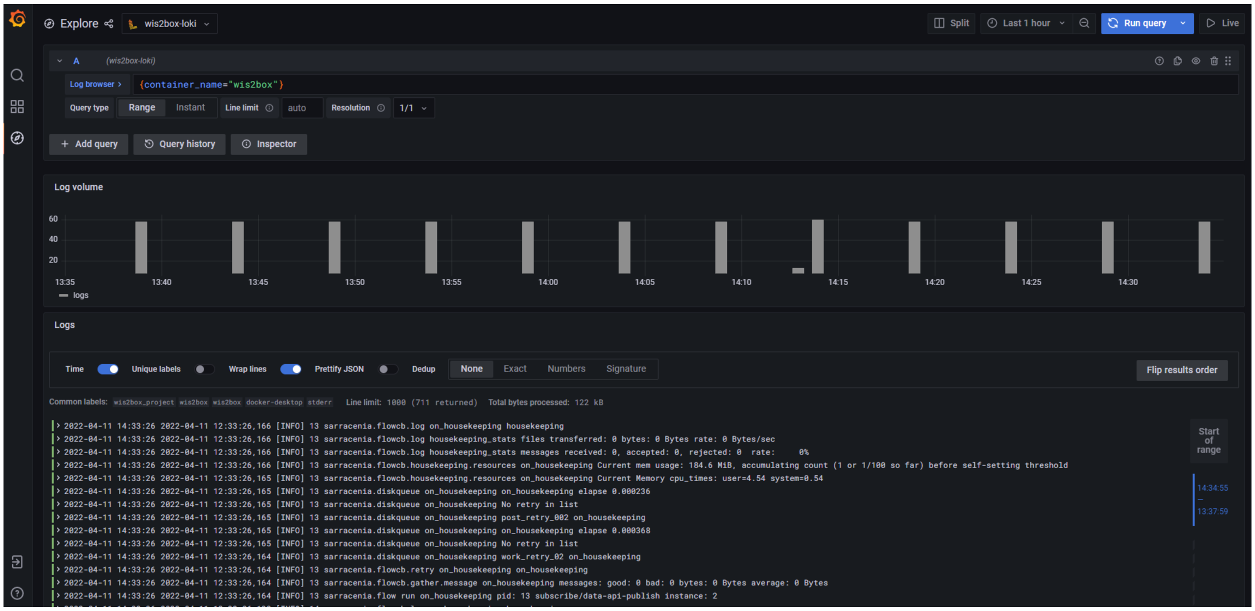


The home dashboard is defined in the source code in *docker/grafana/dashboards/home.json*

9.3.2 Exploring logs

You can explore logs by selecting explore from the side-bar in Grafana.

Select *wis2box-loki* as a data source to browse the logs produced by the Docker containers that compose wis2box:


Explore
wis2box-loki
Split
Last 1 hour
Run query
Live
A
(wis2box-loki)
Log browser
{container_name="wis2box"}
Query type
Range
Instant
Line limit
auto
Resolution
1/1
Add query
Query history
Inspector
Log volume
60
40
20
13:35
13:40
13:45
13:50
13:55
14:00
14:05
14:10
14:15
14:20
14:25
14:30
logs
Logs
Time
Unique labels
Wrap lines
Prettify JSON
Dedup
None
Exact
Numbers
Signature
Flip results order
Common labels: wis2box_project wis2box wis2box docker-desktop stderr
Line limit: 1000 (711 returned)
Total bytes processed: 122 kB
2022-04-11 14:33:26 2022-04-11 12:33:26,166 [INFO] 13 sarracenia.flowcb.log on_housekeeping housekeeping
2022-04-11 14:33:26 2022-04-11 12:33:26,166 [INFO] 13 sarracenia.flowcb.log housekeeping_stats files transferred: 0 bytes: 0 Bytes rate: 0 Bytes/sec
2022-04-11 14:33:26 2022-04-11 12:33:26,166 [INFO] 13 sarracenia.flowcb.log housekeeping_stats messages received: 0, accepted: 0, rejected: 0 rate: 0%
2022-04-11 14:33:26 2022-04-11 12:33:26,166 [INFO] 13 sarracenia.flowcb.housekeeping.resources on_housekeeping Current mem usage: 184.6 MiB, accumulating count (1 or 1/100 so far) before self-setting threshold
2022-04-11 14:33:26 2022-04-11 12:33:26,165 [INFO] 13 sarracenia.flowcb.housekeeping.resources on_housekeeping Current Memory cpu_times: user=4.54 system=0.54
2022-04-11 14:33:26 2022-04-11 12:33:26,165 [INFO] 13 sarracenia.diskqueue on_housekeeping on_housekeeping elapse 0.000236
2022-04-11 14:33:26 2022-04-11 12:33:26,165 [INFO] 13 sarracenia.diskqueue on_housekeeping No retry in list
2022-04-11 14:33:26 2022-04-11 12:33:26,165 [INFO] 13 sarracenia.diskqueue on_housekeeping post_retry_002 on_housekeeping
2022-04-11 14:33:26 2022-04-11 12:33:26,165 [INFO] 13 sarracenia.diskqueue on_housekeeping on_housekeeping elapse 0.000368
2022-04-11 14:33:26 2022-04-11 12:33:26,165 [INFO] 13 sarracenia.diskqueue on_housekeeping No retry in list
2022-04-11 14:33:26 2022-04-11 12:33:26,164 [INFO] 13 sarracenia.diskqueue on_housekeeping work_retry_02 on_housekeeping
2022-04-11 14:33:26 2022-04-11 12:33:26,164 [INFO] 13 sarracenia.flowcb.retry on_housekeeping on_housekeeping
2022-04-11 14:33:26 2022-04-11 12:33:26,164 [INFO] 13 sarracenia.flowcb.gather.message on_housekeeping messages: good: 0 bad: 0 bytes: 0 Bytes average: 0 Bytes
2022-04-11 14:33:26 2022-04-11 12:33:26,164 [INFO] 13 sarracenia.flow run on_housekeeping pid: 13 subscribe/data-api-publish instance: 2
Start of range
14:34:55
13:37:59

CHAPTER

TEN

SERVICES

wis2box provides a number of data access services and mechanisms in providing data to users, applications and beyond.

10.1 Discovery Catalogue

The discovery catalogue is powered by OGC API - Records and is located at http://localhost:8999/oapi/collections/discovery-metadata

The OGC API endpoint is located by default at http://localhost:8999/oapi. The discovery catalogue endpoint is located at http://localhost:8999/oapi/collections/discovery-metadata

Below are some examples of working with the discovery catalogue.

- description of catalogue: http://localhost:8999/oapi/collections/discovery-metadata
- catalogue queryables: http://localhost:8999/oapi/collections/discovery-metadata/queryables
- catalogue queries
  - records (browse): http://localhost:8999/oapi/collections/discovery-metadata/items
  - query by spatial (bounding box): http://localhost:8999/oapi/collections/discovery-metadata/items?bbox=32,-17,36,-8
  - query by temporal extent (since): http://localhost:8999/oapi/collections/discovery-metadata/items?datetime=2021/..
  - query by temporal extent (before): http://localhost:8999/oapi/collections/discovery-metadata/items?datetime=../2022
  - query by freetext: http://localhost:8999/oapi/collections/discovery-metadata/items?q=observations

Note:

- adding `f=json` to URLs will provide the equivalent JSON/GeoJSON representations
- query predicates (`datetime`, `bbox`, `q`, etc.) can be combined

See also:

Data access

10.2 Data API

wis2box data is made available via OGC API - Features and is located at http://localhost:8999/oapi standards.

The OGC API endpoint is located by default at http://localhost:8999/oapi

Below are some examples of working with the discovery catalogue.

Note:

- the examples below use the `data.core.observations-surface-land.mw.FWCL.landFixed` collection as described in the *Quickstart*. For other dataset collections, use the same query patterns below, substituting the collection id accordingly

- list of dataset collections: http://localhost:8999/oapi/collections
- collection description: http://localhost:8999/oapi/collections/data.core.observations-surface-land.mw.FWCL.landFixed
- collection queryables: http://localhost:8999/oapi/collections/data.core.observations-surface-land.mw.FWCL.landFixed/queryables
- collection items (browse): http://localhost:8999/oapi/collections/data.core.observations-surface-land.mw.FWCL.landFixed/items
- collection queries
  - set limit/offset (paging): http://localhost:8999/oapi/collections/data.core.observations-surface-land.mw.FWCL.landFixed/items?limit=1&startindex=2
  - query by spatial (bounding box): http://localhost:8999/oapi/collections/data.core.observations-surface-land.mw.FWCL.landFixed/items?bbox=32,-17,36,-8
  - query by temporal extent (since): http://localhost:8999/oapi/collections/data.core.observations-surface-land.mw.FWCL.landFixed/items?datetime=2021/..
  - query by temporal extent (before): http://localhost:8999/oapi/collections/data.core.observations-surface-land.mw.FWCL.landFixed/items?datetime=../2022

Note:

- adding `f=json` to URLs will provide the equivalent JSON/GeoJSON representations
- query predicates (`datetime`, `bbox`, `q`, etc.) can be combined

See also:

Data access

10.3 SpatioTemporal Asset Catalog (STAC)

The wis2box SpatioTemporal Asset Catalog (STAC) endpoint can be found at:

http://localhost:8999/stac

. . . providing the user with a crawlable catalogue of all data on a wis2box.

10.4 Web Accessible Folder (WAF)

The wis2box SpatioTemporal Asset Catalog (STAC) endpoint can be found at:

http://localhost:8999/data/

. . . providing the user with a crawlable online folder of all data on a wis2box.

10.5 Broker

The wis2box broker is powered by MQTT and can be found at:

mqtt://localhost:1883

. . . providing a PubSub capability for event driven subscription and access.

10.6 Adding services

wis2box's architecture allows for additional services as required by adding Docker containers. Examples of additional services include adding a container for a samba share or FTP server. Key considerations for adding services:

- volume mapping data directories: all wis2box data can be found at `${WIS2BOX_DATADIR}` - incoming: `${WIS2BOX_DATADIR}/data/incoming` - public: `${WIS2BOX_DATADIR}/data/public`
- Elasticsearch indexes can be found at the container/URL `http://elasticsearch:9200`

Examples of additional services can be found in `docker/extras`.

CHAPTER

ELEVEN

DATA ACCESS

11.1 Overview

This section provides examples of interacting with wis2box data services as described in *Services* using a number of common tools and software packages.

11.2 API

11.2.1 Using Python, requests and Pandas

Python is a popular programming language which is heavily used in the data science domains. Python provides high level functionality supporting rapid application development with a large ecosystem of packages to work with weather/climate/water data.

Let's use the Python requests package to further interact with the wis2box API, and Pandas to run some simple summary statistics.

[1]:
```python
import json

import requests

def pretty_print(input):
    print(json.dumps(input, indent=2))


# define the endpoint of the OGC API
api = 'http://localhost:8999/oapi'
```

11.2.1.1 Stations

Let's find all the stations in our wis2box:

[2]:
```python
url = f'{api}/collections/stations/items?limit=50'

response = requests.get(url).json()

print(f"Number of stations: {response['numberMatched']}")

```

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```
print('Stations:\n')
for station in response['features']:
    print(station['properties']['name'])
```

```
Number of stations: 26
Stations:

NAMBUMA
BALAKA
BILIRA
CHIDOOLE
CHIKANGAWA
CHIKWEO
CHINGALE
KALAMBO
KASIYA AWS
KASUNGU NATIONAL PARK AWS
KAWALAZI
KAYEREKERA
LENGWE NATIONAL PARK
LOBI AWS
MAKANJIRA
MALOMO
MISUKU
MLARE
MLOMBA
MTOSA BENGA
NAMITAMBO
NANKUMBA
NKHOMA UNIVERSITY
NKHULAMBE
NYACHILENDA
TOLEZA
```

11.2.1.2 Discovery Metadata

Now, let's find all the dataset that are provided by the above stations. Each dataset is identified by a WIS 2.0 discovery metadata record.

[3]:
```
url = f'{api}/collections/discovery-metadata/items'

response = requests.get(url).json()

print('Datasets:\n')
for dataset in response['features']:
    print(f"id: {dataset['properties']['id']}, title: {dataset['properties']['title']}")
```

```
Datasets:

id: data.core.test-passthrough, title: Surface weather observations (passthrough)
id: data.core.observations-surface-land.mw.FWCL.landFixed, title: Surface weather␣
↪observations (hourly)
```

Let's find all the data access links associated with the Surface weather observations (hourly) dataset:

```
[4]: dataset_id = 'data.core.observations-surface-land.mw.FWCL.landFixed'

url = f"{api}/collections/discovery-metadata/items/{dataset_id}"

response = requests.get(url).json()

print('Data access links:\n')
for link in response['links']:
    print(f"{link} {link['href']} ({link['type']}) {link['rel']}")
    link['rel']

[link['href'] for link in response['links']]
```

```
Data access links:

{'rel': 'self', 'type': 'application/geo+json', 'title': 'This document as GeoJSON',
↪'href': 'http://localhost:8999/oapi/collections/discovery-metadata/items/data.core.
↪observations-surface-land.mw.FWCL.landFixed?f=json'} http://localhost:8999/oapi/
↪collections/discovery-metadata/items/data.core.observations-surface-land.mw.FWCL.
↪landFixed?f=json (application/geo+json) self
{'rel': 'alternate', 'type': 'application/ld+json', 'title': 'This document as RDF (JSON-
↪LD)', 'href': 'http://localhost:8999/oapi/collections/discovery-metadata/items/data.
↪core.observations-surface-land.mw.FWCL.landFixed?f=jsonld'} http://localhost:8999/oapi/
↪collections/discovery-metadata/items/data.core.observations-surface-land.mw.FWCL.
↪landFixed?f=jsonld (application/ld+json) alternate
{'rel': 'alternate', 'type': 'text/html', 'title': 'This document as HTML', 'href':
↪'http://localhost:8999/oapi/collections/discovery-metadata/items/data.core.
↪observations-surface-land.mw.FWCL.landFixed?f=html'} http://localhost:8999/oapi/
↪collections/discovery-metadata/items/data.core.observations-surface-land.mw.FWCL.
↪landFixed?f=html (text/html) alternate
{'rel': 'collection', 'type': 'application/json', 'title': 'Discovery metadata', 'href':
↪'http://localhost:8999/oapi/collections/discovery-metadata'} http://localhost:8999/
↪oapi/collections/discovery-metadata (application/json) collection
```

```
[4]: ['http://localhost:8999/oapi/collections/discovery-metadata/items/data.core.observations-
↪surface-land.mw.FWCL.landFixed?f=json',
 'http://localhost:8999/oapi/collections/discovery-metadata/items/data.core.observations-
↪surface-land.mw.FWCL.landFixed?f=jsonld',
 'http://localhost:8999/oapi/collections/discovery-metadata/items/data.core.observations-
↪surface-land.mw.FWCL.landFixed?f=html',
 'http://localhost:8999/oapi/collections/discovery-metadata']
```

Let's use the OGC API - Features (OAFeat) link to drill into the observations for Chidoole station

```
[5]: dataset_api_link = 'http://localhost:8999/oapi/collections/data.core.observations-
↪surface-land.mw.FWCL.landFixed'

dataset_api_link
```

```
[5]: 'http://localhost:8999/oapi/collections/data.core.observations-surface-land.mw.FWCL.
↪landFixed'
```

11.2.1.3 Observations

Let's inspect some of the data in the API's raw GeoJSON format:

[6]:
```python
url = f'{dataset_api_link}/items'

query_parameters = {
    'wigos_station_identifier': '0-454-2-AWSCHIDOOLE',
    'limit': 10000,
    'name': 'air_temperature'
}

response = requests.get(url, params=query_parameters).json()

pretty_print(response['features'][0])
```


```
{
  "id": "WIGOS_0-454-2-AWSCHINGALE_20220112T135500-25",
  "reportId": "WIGOS_0-454-2-AWSCHINGALE_20220112T135500",
  "type": "Feature",
  "geometry": {
    "type": "Point",
    "coordinates": [
      35.11,
      -15.24,
      623.0
    ]
  },
  "properties": {
    "wigos_station_identifier": "0-454-2-AWSCHINGALE",
    "phenomenonTime": "2022-01-12T13:55:00Z",
    "resultTime": "2022-01-12T13:55:00Z",
    "name": "air_temperature",
    "value": 24.85,
    "units": "Celsius",
    "description": null,
    "metadata": [
      {
        "name": "station_or_site_name",
        "value": null,
        "units": "CCITT IA5",
        "description": "Chingale"
      },
      {
        "name": "station_type",
        "value": 0,
        "units": "CODE TABLE",
        "description": "Automatic"
      },
      {
        "name": "height_of_barometer_above_mean_sea_level",
        "value": 624.0,
        "units": "m",
        "description": null
```


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```
      },
      {
        "name": "height_of_sensor_above_local_ground_or_deck_of_marine_platform",
        "value": 1.5,
        "units": "m",
        "description": null
      }
    ],
    "index": 25,
    "fxxyyy": "012101",
    "id": "WIGOS_0-454-2-AWSCHINGALE_20220112T135500-25"
  }
}
```

Let's inspect what's measured at Chidoole:

[7]:
```
print('Observed property:\n')
feature = response['features'][9]
print(f"{feature['properties']['name']} ({feature['properties']['units']})")
```

```
Observed property:

air_temperature (Celsius)
```

11.2.1.4 Pandas

Let's use the GeoJSON to build a more user-friendly table

[8]:
```
import pandas as pd

datestamp = [obs['properties']['resultTime'] for obs in response['features']]
air_temperature = [obs['properties']['value'] for obs in response['features']]

d = {
    'Date/Time': datestamp,
    'Air temperature (°C)': air_temperature
}

df = pd.DataFrame(data=d)
```

[9]:
```
df
```

[9]:
```
                 Date/Time  Air temperature (°C)
0     2022-01-12T13:55:00Z                 24.85
1     2022-01-12T14:55:00Z                 27.25
2     2022-01-12T15:55:00Z                 26.65
3     2022-01-12T16:55:00Z                 25.95
4     2022-01-12T17:55:00Z                 25.45
...                    ...                   ...
5101  2022-06-09T12:55:00Z                 21.35
5102  2022-06-09T13:55:00Z                 22.25
5103  2022-06-09T14:55:00Z                 20.25
```

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```
5104  2022-06-10T12:55:00Z                 23.75
5105  2022-06-10T14:55:00Z                 21.15

[5106 rows x 2 columns]
```

[10]:
```
print("Time extent\n")
print(f'Begin: {df["Date/Time"].min()}')
print(f'End: {df["Date/Time"].max()}')

print("Summary statistics:\n")
df[['Air temperature (°C)']].describe()
```

```
Time extent

Begin: 2022-01-12T13:55:00Z
End: 2022-06-10T14:55:00Z
Summary statistics:
```

[10]:

	Air temperature (°C)
count	5106.000000
mean	23.541559
std	4.053172
min	13.550000
25%	20.950000
50%	23.350000
75%	26.350000
max	37.850000

[ ]:

11.2.2 Using Python and OWSLib

OWSLib is a Python package which provides Pythonic access to OGC APIs and web services. Let's see how easy it is to work with wis2box with standards-based tooling:

[1]:
```
from owslib.ogcapi.features import Features

import pandas as pd

def pretty_print(input):
    print(json.dumps(input, indent=2))


api = 'http://localhost:8999/oapi'
```

Let's load the wis2box API into OWSLib and inspect some data

[2]:
```
oafeat = Features(api)

collections = oafeat.collections()
```

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```
print(f'This OGC API Features endpoint has {len(collections["collections"])} datasets')

for dataset in collections['collections']:
    print(dataset['title'])

malawi_obs = oafeat.collection_items('data.core.observations-surface-land.mw.FWCL.
↪landFixed')
malawi_obs_df = pd.DataFrame(malawi_obs['features'])

# then filter by station
obs = oafeat.collection_items('data.core.observations-surface-land.mw.FWCL.landFixed',␣
↪wigos_station_identifier='0-454-2-AWSCHIDOOLE', name='air_temperature', limit=10000)

datestamp = [obs['properties']['resultTime'] for obs in obs['features']]
air_temperature = [obs['properties']['value'] for obs in obs['features']]

d = {
    'Date/Time': datestamp,
    'Air temperature (°C)': air_temperature
}

df = pd.DataFrame(data=d)
```

```
This OGC API Features endpoint has 4 datasets
Surface weather observations (passthrough)
Discovery metadata
Stations
Surface weather observations (hourly)
```

[3]:
```
df.dtypes
```

[3]:
```
Date/Time                 object
Air temperature (°C)     float64
dtype: object
```

[4]:
```
df.head(3)
```

[4]:

	Date/Time	Air temperature (°C)
0	2022-01-12T13:55:00Z	24.85
1	2022-01-12T14:55:00Z	27.25
2	2022-01-12T15:55:00Z	26.65

[5]:
```
print("Time extent\n")
print(f'Begin: {df["Date/Time"].min()}')
print(f'End: {df["Date/Time"].max()}')

print("Summary statistics:\n")
df[['Air temperature (°C)']].describe()
```

```
Time extent

Begin: 2022-01-12T13:55:00Z
End: 2022-06-10T14:55:00Z
```

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```
Summary statistics:
```

[5]:

```
       Air temperature (°C)
count           5106.000000
mean              23.541559
std                4.053172
min               13.550000
25%               20.950000
50%               23.350000
75%               26.350000
max               37.850000
```

[ ]:

```

```

11.2.3 R

R is a common programming language for data analysis and visualization. R provides easy access to various statiscal analysis libraries. We are going to use the R libraries: sf to load features, dplyr for data manipulation, and

Install Requirements

[ ]:

```
install.packages("sf")
install.packages("dplyr")
```

Import Requirements

[1]:

```
library(sf)
library(dplyr)

oapi <- "http://oapi/oapi" # jupyter is run through docker
#oapi = http://localhost:8999/oapi # jupyter is run on host machine
```

```
Linking to GEOS 3.10.2, GDAL 3.4.1, PROJ 8.2.1; sf_use_s2() is TRUE


Attaching package: ‘dplyr’


The following objects are masked from ‘package:stats’:

    filter, lag


The following objects are masked from ‘package:base’:

    intersect, setdiff, setequal, union
```

11.2.3.1 Stations

[2]:
```
stations <- read_sf(paste0(oapi,"/collections/stations/items?f=json"))
print(stations)
```

```
Simple feature collection with 7 features and 5 fields
Geometry type: POINT
Dimension:     XYZ
Bounding box:  xmin: 33.67305 ymin: -15.84052 xmax: 35.27428 ymax: -9.92951
z_range:       zmin: 618 zmax: 1288
Geodetic CRS:  WGS 84
# A tibble: 7 × 6
  wigos_id              name        url   status    id                  geometry
  <chr>                 <chr>       <chr> <chr>   <int>              <POINT [°]>
1 0-454-2-AWSLOBI       LOBI AWS    http... opera... 65618 Z (34.07244 -14.39528 12...
2 0-454-2-AWSKAYEREKERA KAYEREKERA  http... opera... 91840 Z (33.67305 -9.92951 848)
3 0-454-2-AWSMALOMO     MALOMO      http... opera... 91873 Z (33.83727 -13.14202 10...
4 0-454-2-AWSNKHOMA     NKHOMA UNI... http... opera... 91875 Z (34.10468 -14.04422 12...
5 0-454-2-AWSTOLEZA     TOLEZA      http... opera... 91880    Z (34.955 -14.948 764)
6 0-454-2-AWSNAMITAMBO  NAMITAMBO   http... opera... 91885 Z (35.27428 -15.84052 80...
7 0-454-2-AWSBALAKA     BALAKA      http... opera... 91893 Z (34.96667 -14.98333 61...
```

11.2.3.2 Discovery Metadata

[3]:
```
discovery_metadata <- read_sf(paste0(oapi,"/collections/discovery-metadata/items"))
print(discovery_metadata)
```

```
Simple feature collection with 1 feature and 13 fields
Geometry type: POLYGON
Dimension:     XY
Bounding box:  xmin: 32.68817 ymin: -16.8013 xmax: 35.7719 ymax: -9.230599
Geodetic CRS:  WGS 84
# A tibble: 1 × 14
  identifier externalId title description themes providers language type  extent
  <chr>      <chr>      <chr> <chr>       <chr>  <chr>     <chr>    <chr> <chr>
1 data.core... "[ { \"sc... Surf... Surface we... "[ { ... "[ { \"n... en       data... "
↪{ \"...
# ... with 5 more variables: created <date>, rights <chr>,
#   X_metadata.anytext <chr>, id <chr>, geometry <POLYGON [°]>
```

11.2.3.3 Observations

[4]:
```
malawi_obs <- read_sf(paste0(oapi,"/collections/data.core.observations-surface-land.mw.
↪FWCL.landFixed/items"))
print(malawi_obs)
```

```
Simple feature collection with 10 features and 7 fields
Geometry type: POINT
Dimension:     XYZ
Bounding box:  xmin: 35.27 ymin: -15.84 xmax: 35.27 ymax: -15.84
z_range:       zmin: 806 zmax: 806
```

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```
Geodetic CRS:  WGS 84
# A tibble: 10 × 8
   identifier  phenomenonTime      resultTime          wigos_station_i... metadata
   <chr>       <dttm>              <dttm>              <chr>              <chr>
 1 WIGOS_0-45... 2021-07-07 14:55:00 2022-02-21 14:15:14 0-454-2-AWSNAMI... "[ { \"...
 2 WIGOS_0-45... 2021-07-07 15:55:00 2022-02-21 14:15:14 0-454-2-AWSNAMI... "[ { \"...
 3 WIGOS_0-45... 2021-07-07 16:55:00 2022-02-21 14:15:14 0-454-2-AWSNAMI... "[ { \"...
 4 WIGOS_0-45... 2021-07-07 17:55:00 2022-02-21 14:15:14 0-454-2-AWSNAMI... "[ { \"...
 5 WIGOS_0-45... 2021-07-07 18:55:00 2022-02-21 14:15:14 0-454-2-AWSNAMI... "[ { \"...
 6 WIGOS_0-45... 2021-07-07 19:55:00 2022-02-21 14:15:15 0-454-2-AWSNAMI... "[ { \"...
 7 WIGOS_0-45... 2021-07-07 20:55:00 2022-02-21 14:15:15 0-454-2-AWSNAMI... "[ { \"...
 8 WIGOS_0-45... 2021-07-07 21:55:00 2022-02-21 14:15:15 0-454-2-AWSNAMI... "[ { \"...
 9 WIGOS_0-45... 2021-07-07 22:55:00 2022-02-21 14:15:15 0-454-2-AWSNAMI... "[ { \"...
10 WIGOS_0-45... 2021-07-07 23:55:00 2022-02-21 14:15:15 0-454-2-AWSNAMI... "[ { \"...
# ... with 3 more variables: observations <chr>, id <chr>, geometry <POINT [°]>
```

[ ]:

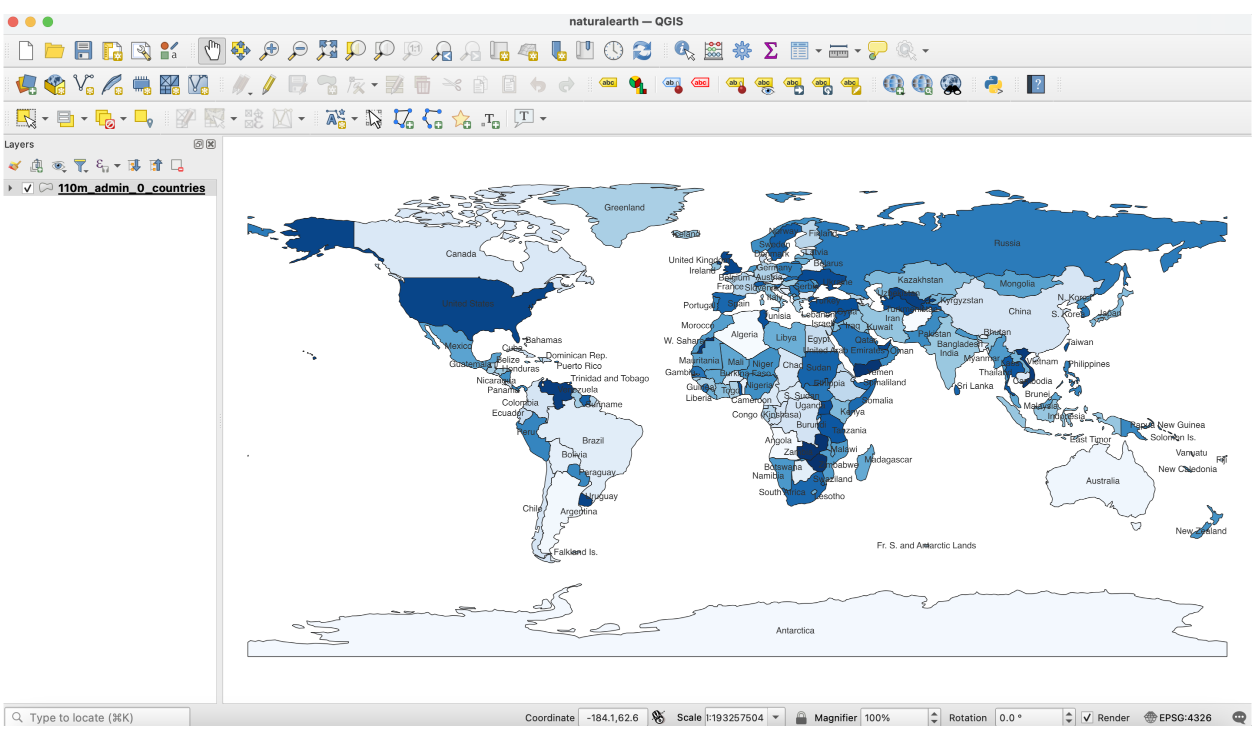
```
```

11.2.4 Using QGIS

11.2.4.1 Overview

This section provides examples of interacting with wis2box API using QGIS.

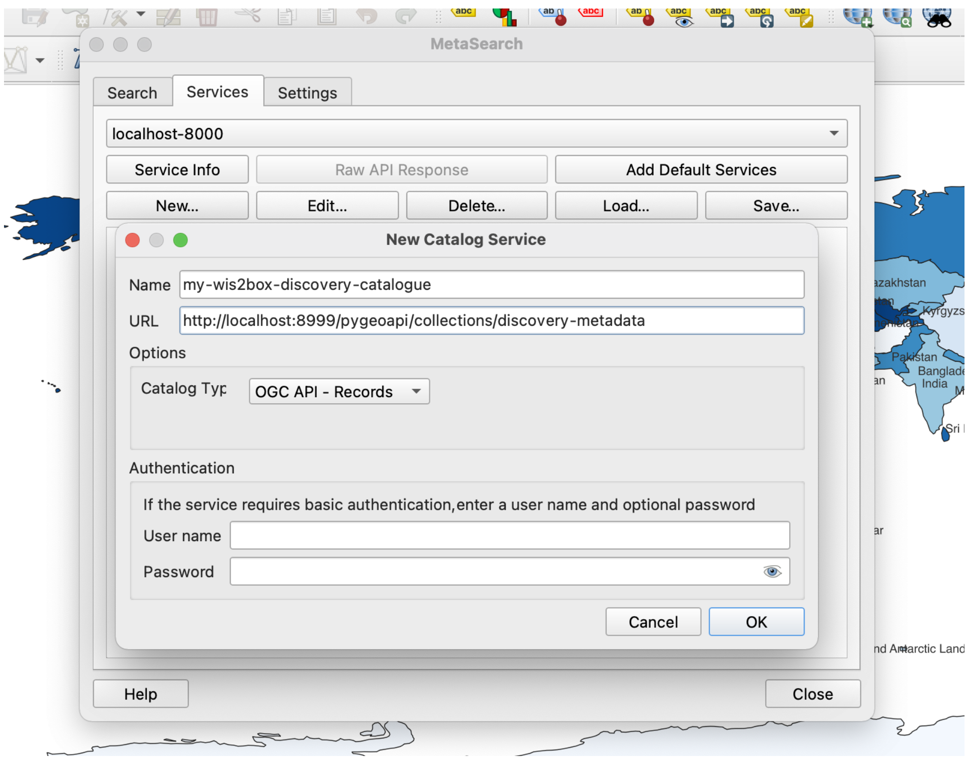
QGIS is a free and open-source cross-platform desktop GIS application that supports viewing, editing, and analysis of geospatial data. QGIS supports numerous format and encoding standards, which enables plug-and-play interoperability with wis2box data and discovery metadata.



11.2.4.2 Accessing the discovery catalogue

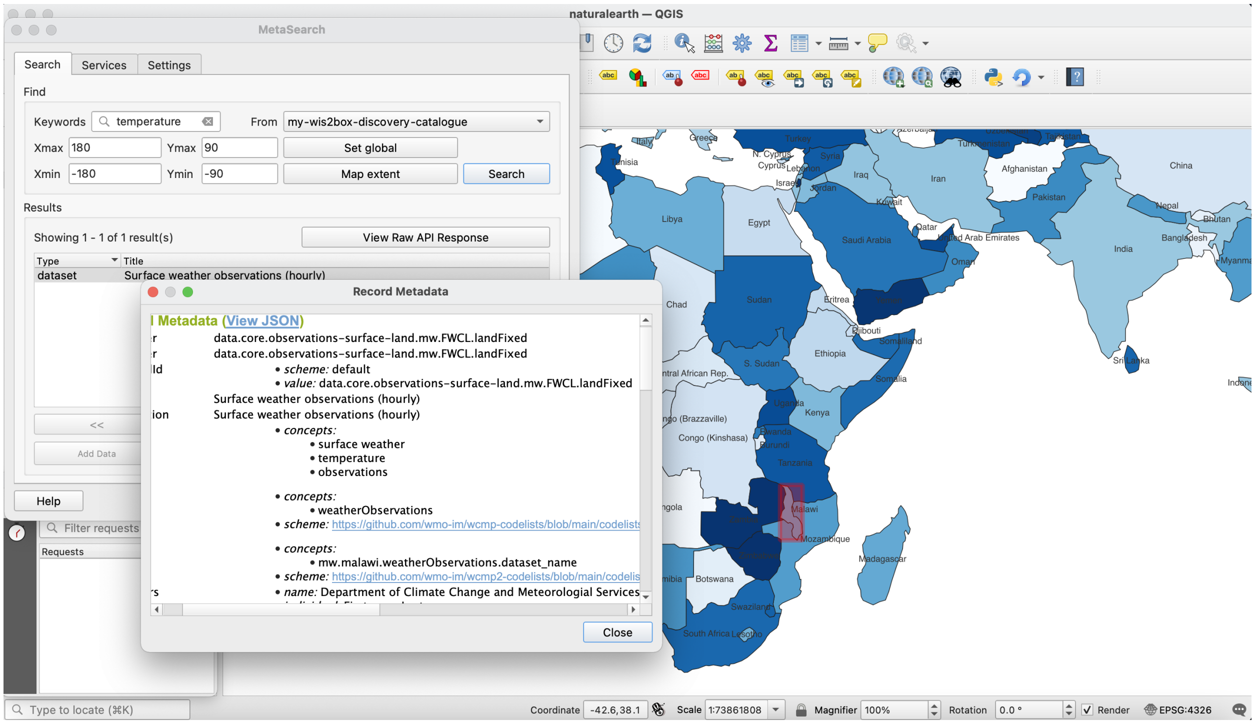
QGIS provides support for the OGC API - Records standard (discovery). To interact with the wis2box discovery catalogue:

- from the QGIS menu, select *Web -> MetaSearch -> MetaSearch*
- click the "Services" tab
- click "New"
- enter a name for the discovery catalogue endpoint
- enter the URL to the discovery catalogue endpoint (i.e. `http://localhost:8999/oapi/collections/discovery-metadata`)
- ensure "Catalogue Type" is set to "OGC API - Records"
- click "OK"



This adds the discovery catalogue to the MetaSearch catalogue registry. Click "Service Info" to display the properties of the discovery catalogue service metadata.

To search the discovery catalogue, click the "Search" tab, which will provide the ability to search for metadata records by bounding box and/or full text search. Click the "Search" button to search the discovery catalogue and visualize search results. Clicking on metadata records in the search result table will show footprints on the map to help provide the location of the search result. Double-clicking a search result will show the entire metadata record.

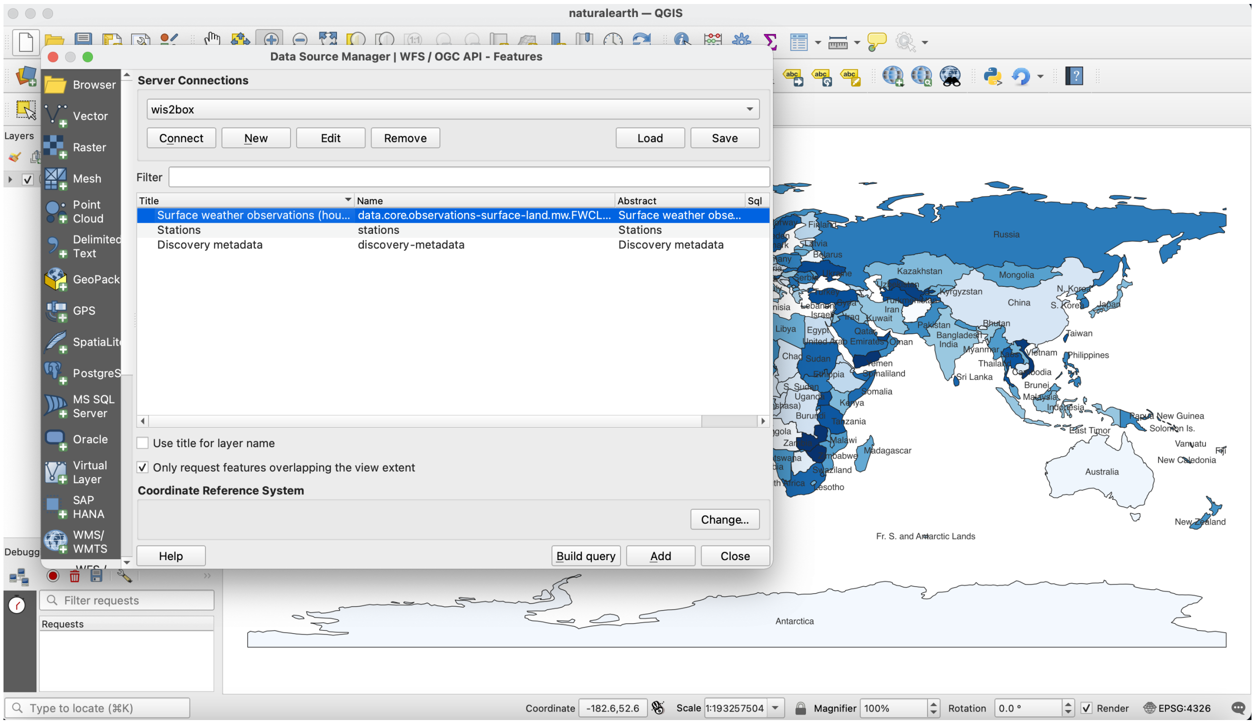


Note: For more information on working with catalogues, consult the official QGIS MetaSearch documentation.

11.2.4.3 Visualizing stations

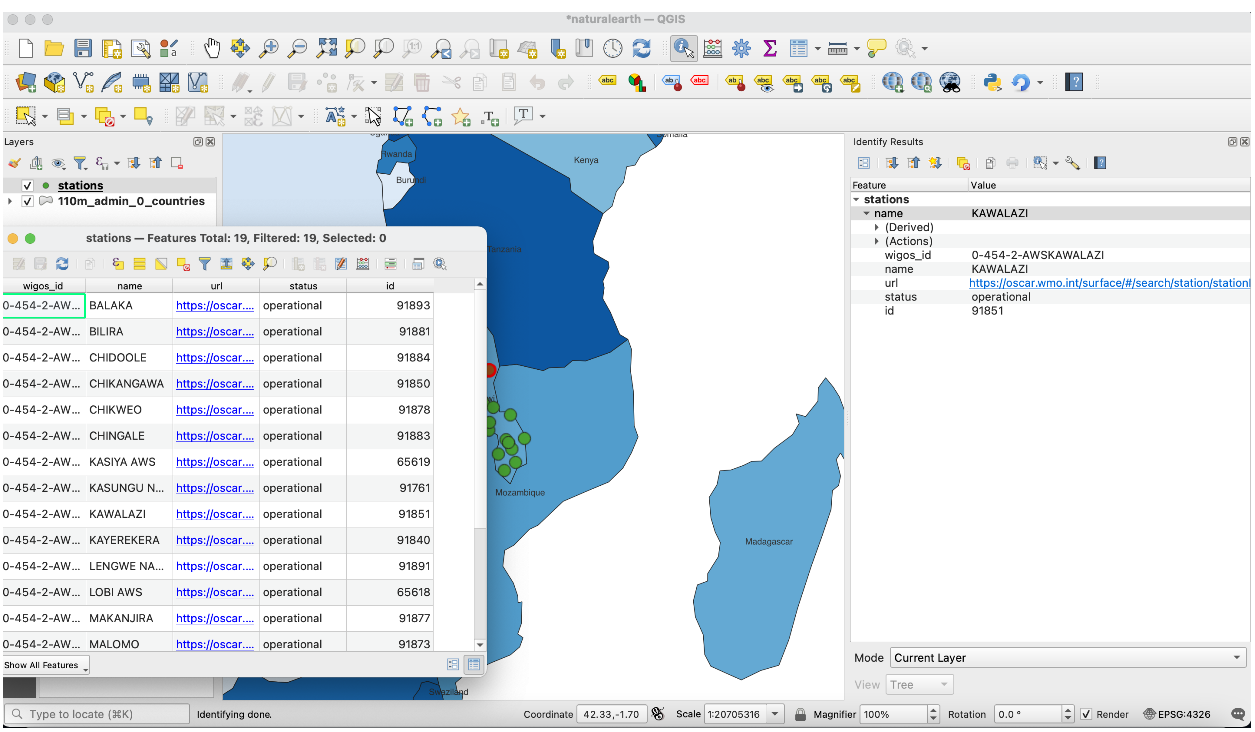
QGIS provides support for the OGC API - Features standard (access). To interact with the wis2box API:

- from the QGIS menu, select *Layer -> Add Layer -> Add WFS Layer…*
- click "New"
- enter a name for the API endpoint
- enter the URL to the API endpoint (i.e. `http://localhost:8999/oapi`)
- under "WFS Options", set "Version" to "OGC API - Features"
- click "OK"
- click "Connect"



A list of collections is displayed. Select the "Stations" collection and click "Add". The Stations collection is now added to the map. To further explore:

- click on the "Identify" (i) and click on a station to display station properties
- select *Layer -> Open Attribute Table* to open all stations in a tabular view



Note that the same QGIS workflow can be executed for any other collection listed from wis2box API.

Note: For more information on working with OGC API - Features, consult the official QGIS WFS documentation.

11.2.4.4 Summary

The above examples provide a number of ways to utilize the wis2box API from the QGIS desktop GIS application.

11.3 PubSub

11.3.1 Using Python and paho-mqtt

This example will use widely available and used python language and libraries to download some announcements, and then retrieve the corresponding data, using only the paho-mqtt client library, in addition to Python standard libraries.

[1]:
```
import json
import paho.mqtt.client as mqtt
import random
import urllib
import urllib.request


host='localhost'
user='wis2box'
password='wis2box'

r = random.Random()
clientId='MyQueueName'+ f"{r.randint(1,1000):04d}"
# number of messages to subscribe to.
messageCount = 0
messageCountMaximum = 5

# maximum size of data download to print.
sizeMaximumThreshold = 1023
```

The above imports the required modules. It is also assumed that `localhost` is set up and is publishing messages. Message queueing protocols provide real-time notification about availability of products.

The standard Python package used to subscribe to messages is `paho-mqtt` (`paho.mqtt.client`). The package uses callbacks.

Note that `messageCount` is used to limit the length of the demonstration (otherwise infinite, as it is a continuous flow).

Let's investigate our callbacks.

[2]:
```
def sub_connect(client, userdata, flags, rc, properties=None):
    print("on connection to subscribe: ", mqtt.connack_string(rc))
    for s in ["xpublic/#"]:
        client.subscribe(s, qos=1)
```

The `sub_connect` callback needed is called when the connection is established, which required to subscribe to topics we are interested in (topics are: `xpublic/#`, where `/` is a topic separator and `#` is a wildcard for any tree of topics.

The `qos=1` refers to Quality of Service, where 1 establishes reception of messages at least once. `qos=1` is recommended.

The next callback is called every time a message is received, and decodes and prints the message.

To keep the output short for the demonstration, we limit the subscriber to a few messages.

[3]:
```
def sub_message(client, userdata, msg):
    """
    print messages received.  Exit on count received.
    """

    global messageCount,messageCountMaximum

    m = json.loads(msg.payload.decode('utf-8'))

    print(f"message {messageCount} topic: {msg.topic} received: {m}")
    print(f"message {messageCount} data: {getData(m)}")

    messageCount += 1

    if messageCount > messageCountMaximum:
        client.disconnect()
        client.loop_stop()
```

The message handler above calls the `getData()` (below). The messages themselves are usually announcements of data availability, but when data is small, they can include the data itself (inline) in the `content` field. Usually the message refers to the data using a link. Here is a routine to obtain the data given an announcement message:

[4]:
```
def getData(m, sizeMaximum=1000):
    """
    given a message, return the data it refers to
    """

    if 'size' in m and m['size'] > sizeMaximum:
        return f" data too large {m['size']} bytes"
    elif 'content' in m:
        if m['content']['encoding'] == 'base64':
            return b64decode(m['content']['value'])
        else:
            return m['content']['value'].encode('utf-8')
    else:
        url = m['baseUrl'] + '/' + m['relPath']
        with urllib.request.urlopen(url) as response:
            return response.read()
```

The calling code then registers the callbacks, connects to the broker, and starts the event loop:

[ ]:
```
client = mqtt.Client(client_id=clientId, protocol=mqtt.MQTTv5)
client.on_connect = sub_connect
client.on_message = sub_message
client.username_pw_set(user, password)
client.connect(host)

client.loop_forever()
```

```
on connection to subscribe:  Connection Accepted.
on connection to subscribe:  Connection Accepted.
```

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```
on connection to subscribe:  Connection Accepted.
on connection to subscribe:  Connection Accepted.
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```

```
[ ]:
```

11.4 Running the examples

To be able to run these examples, one needs to start up a Jupyter Notebook environment. Below is an example of starting a Jupyter session:

```
git clone https://github.com/wmo-im/wis2box.git
cd docs/source/data-access
jupyter notebook --ip=0.0.0.0 --port=8888
```

When Jupyter starts up it may open a browser window for you. If not you would need to to point a browser at http://localhost:8888 to see the menu of notebooks available in this directory.

11.5 Summary

The above examples provide a number of ways to utilize the wis2box suite of services.

CHAPTER

TWELVE

AUTHENTICATION AND ACCESS CONTROL

wis2box provides built in access control for the WAF and API on a topic hierarchy basis. Configuration is done using the wis2box command line utility. Authentication tokens are only required for topics that have access control configured.

12.1 Adding Access Control

All topic hierarchies in wis2box are open by default. A topic becomes closed, with access control applied, the first time a token is generated for a topic hierarchy.

Note: Make sure you are logged into the wis2box container when using the wis2box CLI

```
wis2box auth add-token --topic-hierarchy data.core.observations-surface-land.mw.FWCL.
↪landFixed mytoken
```

If no token is provided, a random string will be generated. Be sure to the record token now, there is no way to retrieve it once it is lost.

12.2 Authenticating

Token credentials can be validated using the wis2box command line utility.

```
wis2box auth show
wis2box auth has-access --topic-hierarchy data.core.observations-surface-land.mw.FWCL.
↪landFixed mytoken
wis2box auth has-access --topic-hierarchy data.core.observations-surface-land.mw.FWCL.
↪landFixed notmytoken
```

Once a token has been generated, access to any data of that topic in the WAF or API requires token authentication. Tokens are passed as a bearer token in the Authentication header or as an argument appended to the URI. Headers can be easily added to requests using cURL.

```
curl -H "Authorization: Bearer mytoken" "http://localhost:8999/oapi/collections/data.
↪core.observations-surface-land.mw.FWCL.landFixed"
curl -H "Authorization: Bearer notmytoken" "http://localhost:8999/oapi/collections/data.
↪core.observations-surface-land.mw.FWCL.landFixed"
```

12.3 Removing Access Control

A topic becomes open and no longer requires authentication when all tokens have been deleted. This can be done by deleting individual tokens, or all tokens for a given topic hierarchy.

```
wis2box auth remove-tokens --topic-hierarchy data.core.observations-surface-land.mw.FWCL.
↪landFixed
wis2box auth show
```

12.4 Extending Access Control

wis2box provides access control out of the box with subrequests to wis2box-auth. wis2box-auth could be replaced in nginx for another auth server like Gluu or a Web SSO like LemonLDAP or Keycloak. These services are not yet configurable via the wis2box command line utility.

wis2box is intentionally plug and playable. Beyond custom authentication servers, extending wis2box provides an overview of more modifications that can be made to wis2box.

CHAPTER

THIRTEEN

EXTENDING WIS2BOX

At its core, wis2box is a plugin architecture orchestrating all the required components of a node in the WIS 2.0 network. Driven by topic hierarchies, wis2box can be used to process and publish any type of geospatial data beyond the requirements of the WIS 2.0 itself.

In this section we will to explore how wis2box can be extended. wis2box plugin development requires knowledge of how to program in Python as well as Python's packaging and module system.

13.1 Building your own data plugin

The heart of a wis2box data plugin is driven from the `wis2box.data.base` abstract base class (ABC) located in `wis2box/data/base.py`. Any wis2box plugin needs to inherit from `wis2box.data.base.BaseAbstractData`. A minimal example can be found below:

```
from datetime import datetime
from wis2box.data.base import BaseAbstractData

class MyCoolData(BaseAbstractData):
    """Observation data"""
    def __init__(self, topic_hierarchy: str) -> None:
        super().__init__(topic_hierarchy)

    def transform(self, input_data: Path) -> bool:
        # transform data
        # populate self.output_data with a dict as per:
        self.output_data {
            'c123': {
                '_meta': {
                    'identifier': 'c123'
                    'data_date': datetime_object
                },
                'bufr4': bytes(12356),
                'geojson': geojson_string
            }
        }
        return True
```

The key function that plugin needs to implement is the `transform` function. This function should return a `True` or `False` of the result of the processing, as well as populate the `output_data` property.

The `output_data` property should provide a `dict` of keys/values. Each key should be the identifier of the item, with the following values `dict`:

- `_meta`: object with `identifier` and `data_date` (as Python datetime objects) based on the observed datetime of the data
- `<format-extension>`: 1..n properties for each format representation, with the key being the filename extension. The value of this property can be a string or bytes, depending on whether the underlying data is ASCII or binary, for example

13.2 Packaging

The next step is assembling your plugin using standard Python packaging. All plugin code and configuration files should be made part of the package so that it can operate independently when running in wis2box. For distribution and installation, you have the following options:

- publish to the Python Package Index (PyPI) and install in the wis2node container with `pip3 install wis2box-mypackage`
- `git clone` or download your package, and install via `python3 setup.py install`

See the Python packaging tutorial or Cookiecutter PyPackage for guidance and templates/examples.

Note: It is recommended to name your wis2box packages with the convention `wis2box-MYPLUGIN-NAME`, as well as adding the keywords/topics `wis2box` and `plugin` to help discovery on platforms such as GitHub.

13.3 Integration

Once your package is installed on the wis2box container, the data mappings need to be updated to connect your plugin to a topic hierarchy. See *Data mappings* for more information.

An example plugin for proof of concept can be found in https://github.com/wmo-cop/wis2box-csv-observations

13.4 Example plugins

The following plugins provide useful examples of wis2box plugins implemented by downstream applications.

Plugin(s)	Organization/Project	Description
wis2box-csv-observations	WMO	plugin for CSV surface observation data
wis2box-pyopencdms-plugin	OpenCDMS	plugin for connecting the Open Climate Data Management System to wis2box

CHAPTER

FOURTEEN

DEVELOPMENT

wis2box is developed as a free and open source project on GitHub. The wis2box codebase can be found at https://github.com/wmo-im/wis2box.

14.1 Testing

14.1.1 Unit testing

TODO

14.1.2 Integration testing

TODO

14.1.3 Functional testing

All commits and pull requests to wis2box trigger continuous integration (CI) testing on GitHub Actions.

14.2 Versioning

wis2box follows the Semantic Versioning Specification (SemVer).

14.3 Code Conventions

Python code follows PEP8 coding conventions.

CHAPTER

FIFTEEN

CONTRIBUTING

wis2box is developed as a free and open source project on GitHub. Contributing to (documentation, bug fixes, enhancements, tests, etc.) is welcome and encouraged. Please consult the wis2box Contribution guidelines for more information.

CHAPTER

SIXTEEN

SUPPORT

Please consult the wis2box Discussions for support with the project.

CHAPTER SEVENTEEN

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CHAPTER

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INDICES AND TABLES

- genindex
- modindex
- search