roocs-utils Documentation

Release 0.1.3

Eleanor Smith

Oct 21, 2020

CONTENTS:

CHAPTER

ONE

QUICK GUIDE

1.1 roocs-utils

A package containing common components for the roocs project

- Free software: BSD - see LICENSE file in top-level package directory
- Documentation: https://roocs-utils.readthedocs.io.

1.1.1 Features

- 1. Data Inventories

1. Data Inventories

The module `roocs_utils.inventory` provides tools for writing inventories of the known data holdings in a YAML format, e.g.:

```
$ python roocs_utils/inventory/inventory.py -pr c3s-cmip5
[INFO] Reading /group_workspaces/jasmin2/cp4cds1/vol1/data/c3s-cmip5/output1/MOHC/
↪HadGEM2-ES/rcp45/mon/atmos/Amon/r1i1p1/tas/v20111
↪                              128/tas_Amon_HadGEM2-ES_rcp45_r1i1p1_212412-214911.nc
[INFO] Reading /group_workspaces/jasmin2/cp4cds1/vol1/data/c3s-cmip5/output1/MOHC/
↪HadGEM2-ES/rcp45/mon/atmos/Amon/r1i1p1/ts/v201111
↪                              28/ts_Amon_HadGEM2-ES_rcp45_r1i1p1_209912-212411.nc
[INFO] Wrote: c3s-cmip5_MOHC_HadGEM2-ES.yml
```

One file is created for each model/institute pairing. These can be merged to one file using `roocs_utils/inventory/merge_yaml.py`

Writes:

```
- base_dir: /group_workspaces/jasmin2/cp4cds1/vol1/data/
  project: c3s-cmip5

- path: c3s-cmip5/output1/MOHC/HadGEM2-ES/rcp45/mon/atmos/Amon/r1i1p1/tas/v20111128
  dsid: c3s-cmip5.output1.MOHC.HadGEM2-ES.rcp45.mon.atmos.Amon.r1i1p1.tas.v20111128
```

(continues on next page)

(continued from previous page)

```
  var_id: tas
  array_dims: time lat lon
  array_shape: 3529 145 192
  time: 2005-12-16T00:00:00 2299-12-16T00:00:00
  facets:
    activity: c3s-cmip5
    ensemble_member: r1i1p1
    experiment: rcp45
    frequency: mon
    institute: MOHC
    mip_table: Amon
    model: HadGEM2-ES
    product: output1
    realm: atmos
    variable: tas
    version: v20111128
```

1.2 Credits

This package was created with `Cookiecutter` and the `audreyr/cookiecutter-pypackage` project template.

- Cookiecutter: https://github.com/audreyr/cookiecutter
- cookiecutter-pypackage: https://github.com/audreyr/cookiecutter-pypackage

CHAPTER

TWO

INSTALLATION

2.1 Stable release

To install roocs-utils, run this command in your terminal:

```
$ pip install roocs-utils
```

This is the preferred method to install roocs-utils, as it will always install the most recent stable release.

If you don't have pip installed, this Python installation guide can guide you through the process.

2.2 Install from GitHub

roocs-utils can be downloaded from the Github repo.

```
$ git clone git://github.com/roocs/roocs-utils
$ cd roocs-utils
```

Get the submodules with ESGF test data:

```
$ git submodule update --init --recursive
```

Create Conda environment named *roocs_utils*:

```
$ conda env create -f environment.yml
$ source activate roocs_utils
```

Install roocs-utils in development mode:

```
$ pip install -r requirements.txt
$ pip install -r requirements_dev.txt
$ pip install -e .
```

Run tests:

```
$ python -m pytest tests/
```

CHAPTER

THREE

USAGE

To use roocs-utils in a project:

```
import roocs_utils
```

CHAPTER

FOUR

API

4.1 Parameters

class roocs_utils.parameter.area_parameter.**AreaParameter**(*input*)

Bases: roocs_utils.parameter.base_parameter._BaseParameter

Class for area parameter used in subsetting operation.

Area can be input as:
A string of comma separated values: "0.,49.,10.,65"
A sequence of strings: ("0", "-10", "120", "40")
A sequence of numbers: [0, 49.5, 10, 65]

An area must have 4 values.

Validates the area input and parses the values into numbers.

asdict()

Returns a dictionary of the area values

parse_method = '_parse_sequence'

property tuple

Returns a tuple of the area values

class roocs_utils.parameter.collection_parameter.**CollectionParameter**(*input*)

Bases: roocs_utils.parameter.base_parameter._BaseParameter

Class for collection parameter used in operations.

A collection can be input as:
A string of comma separated values:
"cmip5.output1.INM.inmcm4.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga,cmip5.output1.MPI-M.MPI-ESM-LR.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga"
A sequence of strings: e.g. ("cmip5.output1.INM.inmcm4.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga", "cmip5.output1.MPI-M.MPI-ESM-LR.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga")

Validates the input and parses the ids.

parse_method = '_parse_sequence'

property tuple
Returns a tuple of the collection ids

class roocs_utils.parameter.level_parameter.**LevelParameter**(*input*)
Bases: roocs_utils.parameter.base_parameter._BaseParameter

Class for level parameter used in subsetting operation.

Level can be input as:
A string of slash separated values: "1000/2000"
A sequence of strings: e.g. ("1000.50", "2000.60")
A sequence of numbers: e.g. (1000.50, 2000.60)

A level input must be 2 values.

If using a string input a trailing slash indicates you want to use the lowest/highest level of the dataset. e.g. "/2000" will subset from the lowest level in the dataset to 2000.

Validates the level input and parses the values into numbers.

asdict()
Returns a dictionary of the level values

parse_method = '_parse_range'

property tuple
Returns a tuple of the level values

class roocs_utils.parameter.time_parameter.**TimeParameter**(*input*)
Bases: roocs_utils.parameter.base_parameter._BaseParameter

Class for time parameter used in subsetting operation.

Time can be input as:
A string of slash separated values: "2085-01-01T12:00:00Z/2120-12-30T12:00:00Z"
A sequence of strings: e.g. ("2085-01-01T12:00:00Z", "2120-12-30T12:00:00Z")

A time input must be 2 values.

If using a string input a trailing slash indicates you want to use the earliest/ latest time of the dataset. e.g. "2085-01-01T12:00:00Z/" will subset from 01/01/2085 to the final time in the dataset.

Validates the times input and parses the values into isoformat.

asdict()
Returns a dictionary of the time values

parse_method = '_parse_range'

property tuple
Returns a tuple of the time values

roocs_utils.parameter.parameterise.**parameterise**(*collection=None*, *area=None*, *level=None*, *time=None*)
Parameterises inputs to instances of parameter classes which allows them to be used throughout roocs. For supported formats for each input please see their individual classes.

Parameters

- **collection** – Collection input in any supported format.
- **area** – Area input in any supported format.
- **level** – Level input in any supported format.
- **time** – Time input in any supported format.

Returns Parameters as instances of their respective classes.

4.2 Xarray Utils

`roocs_utils.xarray_utils.xarray_utils.get_coord_by_attr(ds, attr, value)`

Returns a coordinate based on a known attribute of a coordinate.

Parameters

- **ds** – Xarray Dataset or DataArray
- **attr** – (str) Name of attribute to look for.
- **value** – Expected value of attribute you are looking for.

Returns Coordinate of xarray dataset if found.

`roocs_utils.xarray_utils.xarray_utils.get_coord_by_type(ds, coord_type, ignore_aux_coords=True)`

Returns the xarray Dataset or DataArray coordinate of the specified type.

Parameters

- **ds** – Xarray Dataset or DataArray
- **coord_type** – (str) Coordinate type to find.
- **ignore_aux_coords** – (bool) If True then coordinates that are not dimensions are ignored. Default is True.

Returns Xarray Dataset coordinate (ds.coords[coord_id])

`roocs_utils.xarray_utils.xarray_utils.get_coord_type(coord)`

Gets the coordinate type.

Parameters **coord** – coordinate of xarray dataset e.g. coord = ds.coords[coord_id]

Returns The type of coordinate as a string. Either longitude, latitude, time, level or None

`roocs_utils.xarray_utils.xarray_utils.get_main_variable(ds, exclude_common_coords=True)`

Finds the main variable of an xarray Dataset

Parameters

- **ds** – xarray Dataset
- **exclude_common_coords** – (bool) If True then common coordinates are excluded from the search for the main variable. common coordinates are time, level, latitude, longitude and bounds. Default is True.

Returns (str) The main variable of the dataset e.g. 'tas'

`roocs_utils.xarray_utils.xarray_utils.is_latitude(coord)`

Determines if a coordinate is latitude.

Parameters **coord** – coordinate of xarray dataset e.g. coord = ds.coords[coord_id]

Returns (bool) True if the coordinate is latitude.

`roocs_utils.xarray_utils.xarray_utils.`**`is_level`**(*coord*)

Determines if a coordinate is level.

Parameters **coord** – coordinate of xarray dataset e.g. coord = ds.coords[coord_id]

Returns (bool) True if the coordinate is level.

`roocs_utils.xarray_utils.xarray_utils.`**`is_longitude`**(*coord*)

Determines if a coordinate is longitude.

Parameters **coord** – coordinate of xarray dataset e.g. coord = ds.coords[coord_id]

Returns (bool) True if the coordinate is longitude.

`roocs_utils.xarray_utils.xarray_utils.`**`is_time`**(*coord*)

Determines if a coordinate is time.

Parameters **coord** – coordinate of xarray dataset e.g. coord = ds.coords[coord_id]

Returns (bool) True if the coordinate is time.

4.3 Other utilities

`roocs_utils.utils.common.`**`parse_size`**(*size*)

Parse size string into number of bytes.

Parameters **size** – (str) size to parse in any unit

Returns (int) number of bytes

`roocs_utils.utils.time_utils.`**`to_isoformat`**(*tm*)

Returns an ISO 8601 string from a time object (of different types).

Parameters **tm** – Time object

Returns (str) ISO 8601 time string

CHAPTER

FIVE

EXAMPLES

[27]:
```
import roocs_utils
```

[28]:
```
dir(roocs_utils)
```

[28]:
```
['AreaParameter',
 'CONFIG',
 'CollectionParameter',
 'LevelParameter',
 'TimeParameter',
 '__author__',
 '__builtins__',
 '__cached__',
 '__contact__',
 '__copyright__',
 '__doc__',
 '__file__',
 '__license__',
 '__loader__',
 '__name__',
 '__package__',
 '__path__',
 '__spec__',
 '__version__',
 'area_parameter',
 'base_parameter',
 'collection_parameter',
 'config',
 'exceptions',
 'get_config',
 'level_parameter',
 'parameter',
 'parameterise',
 'roocs_utils',
 'time_parameter',
 'utils',
 'xarray_utils']
```

5.1 Parameters

Parameters classes are used to parse inputs of collection, area, time and level used as arguments in the subsetting operation

The area values can be input as: * A string of comma separated values: "0.,49.,10.,65" * A sequence of strings: ("0", "-10", "120", "40") * A sequence of numbers: [0, 49.5, 10, 65]

[29]:
```
area = roocs_utils.AreaParameter("0.,49.,10.,65")

# the lat/lon bounds can be returned in a dictionary
print(area.asdict())

# the values can be returned as a tuple
print(area.tuple)
```

```
{'lon_bnds': (0.0, 10.0), 'lat_bnds': (49.0, 65.0)}
(0.0, 49.0, 10.0, 65.0)
```

A collection can be input as * A string of comma separated values: "cmip5.output1.INM.inmcm4.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga,cmip5.output1.MPI-M.MPI-ESM-LR.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga" * A sequence of strings: e.g. ("cmip5.output1.INM.inmcm4.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga","cmip5.output1.MPI-M.MPI-ESM-LR.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga")

[30]:
```
collection = roocs_utils.CollectionParameter("cmip5.output1.INM.inmcm4.rcp45.mon.
↪ocean.Omon.r1i1p1.latest.zostoga,cmip5.output1.MPI-M.MPI-ESM-LR.rcp45.mon.ocean.
↪Omon.r1i1p1.latest.zostoga")

# the collection ids can be returned as a tuple
print(collection.tuple)
```

```
('cmip5.output1.INM.inmcm4.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga', 'cmip5.
↪output1.MPI-M.MPI-ESM-LR.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga')
```

Level can be input as: * A string of slash separated values: "1000/2000" * A sequence of strings: e.g. ("1000.50", "2000.60") A sequence of numbers: e.g. (1000.50, 2000.60)

Level inputs should be a range of the levels you want to subset over

[31]:
```
level = roocs_utils.LevelParameter((1000.50, 2000.60))

# the first and last level in the range provided can be returned in a dictionary
print(level.asdict())

# the values can be returned as a tuple
print(level.tuple)
```

```
{'first_level': 1000.5, 'last_level': 2000.6}
(1000.5, 2000.6)
```

Time can be input as: * A string of slash separated values: "2085-01-01T12:00:00Z/2120-12-30T12:00:00Z" * A sequence of strings: e.g. ("2085-01-01T12:00:00Z", "2120-12-30T12:00:00Z")

Time inputs should be the start and end of the time range you want to subset over

[32]:
```
time = roocs_utils.TimeParameter("2085-01-01T12:00:00Z/2120-12-30T12:00:00Z")

# the first and last time in the range provided can be returned in a dictionary
```

(continues on next page)

(continued from previous page)

```
print(time.asdict())

# the values can be returned as a tuple
print(time.tuple)
```

```
{'start_time': '2085-01-01T12:00:00+00:00', 'end_time': '2120-12-30T12:00:00+00:00'}
('2085-01-01T12:00:00+00:00', '2120-12-30T12:00:00+00:00')
```

Parameterise parameterises inputs to instances of parameter classes which allows them to be used throughout roocs.

[33]:
```
roocs_utils.parameter.parameterise("cmip5.output1.INM.inmcm4.rcp45.mon.ocean.Omon.
↪r1i1p1.latest.zostoga", "0.,49.,10.,65", (1000.50, 2000.60), "2085-01-01T12:00:00Z/
↪2120-12-30T12:00:00Z")
```

[33]:
```
{'collection': Datasets to analyse:
 cmip5.output1.INM.inmcm4.rcp45.mon.ocean.Omon.r1i1p1.latest.zostoga,
 'area': Area to subset over:
  (0.0, 49.0, 10.0, 65.0),
 'level': Level range to subset over
  first_level: 1000.5
  last_level: 2000.6,
 'time': Time period to subset over
  start time: 2085-01-01T12:00:00+00:00
  end time: 2120-12-30T12:00:00+00:00}
```

5.2 Xarray utils

Xarray utils can bu used to identify the main variable in a dataset as well as idnetifying the type of a coordinate or returning a coordinate based on an attribute or a type

[34]:
```
from roocs_utils.xarray_utils import xarray_utils as xu
import xarray as xr
```

[35]:
```
ds = xr.open_mfdataset("../tests/mini-esgf-data/test_data/badc/cmip5/data/cmip5/
↪output1/MOHC/HadGEM2-ES/rcp85/mon/atmos/Amon/r1i1p1/latest/tas/*.nc", use_
↪cftime=True, combine="by_coords")
```

[36]:
```
# find the main variable of the dataset
main_var = xu.get_main_variable(ds)

print("main var =", main_var)

ds[main_var]
```

```
main var = tas
```

[36]:
```
<xarray.DataArray 'tas' (time: 3530, lat: 2, lon: 2)>
dask.array<concatenate, shape=(3530, 2, 2), dtype=float32, chunksize=(300, 2, 2),␣
↪chunktype=numpy.ndarray>
Coordinates:
    height   float64 1.5
  * lat      (lat) float64 -90.0 35.0
  * lon      (lon) float64 0.0 187.5
  * time     (time) object 2005-12-16 00:00:00 ... 2299-12-16 00:00:00
Attributes:
```

(continues on next page)

(continued from previous page)

```
    standard_name:     air_temperature
    long_name:         Near-Surface Air Temperature
    comment:           near-surface (usually, 2 meter) air temperature.
    units:             K
    original_name:     mo: m01s03i236
    cell_methods:      time: mean
    cell_measures:     area: areacella
    history:           2010-12-04T13:50:30Z altered by CMOR: Treated scalar d...
    associated_files:  baseURL: http://cmip-pcmdi.llnl.gov/CMIP5/dataLocation...
```

[37]:
```
# to get the coord types

for coord in ds.coords:
    print("\ncoord name =", coord, "\ncoord type =", xu.get_coord_type(ds[coord]))

print("\n There is a level, time, latitude and longitude coordinate in this dataset")
```

```
coord name = height
coord type = level

coord name = lat
coord type = latitude

coord name = lon
coord type = longitude

coord name = time
coord type = time

 There is a level, time, latitude and longitude coordinate in this dataset
```

[38]:
```
# to check the type of a coord

print(xu.is_level(ds["height"]))
print(xu.is_latitude(ds["lon"]))
```

```
True
None
```

[39]:
```
# to find a coordinate of a specific type

print("time =", xu.get_coord_by_type(ds, "time"))

# to find the level coordinate,set ignore_aux_coords to False

print("\nlevel =", xu.get_coord_by_type(ds, "level", ignore_aux_coords=False))
```

```
time = <xarray.DataArray 'time' (time: 3530)>
array([cftime.Datetime360Day(2005, 12, 16, 0, 0, 0, 0),
       cftime.Datetime360Day(2006, 1, 16, 0, 0, 0, 0),
       cftime.Datetime360Day(2006, 2, 16, 0, 0, 0, 0), ...,
       cftime.Datetime360Day(2299, 10, 16, 0, 0, 0, 0),
       cftime.Datetime360Day(2299, 11, 16, 0, 0, 0, 0),
       cftime.Datetime360Day(2299, 12, 16, 0, 0, 0, 0)], dtype=object)
Coordinates:
    height   float64 1.5
```

(continues on next page)

(continued from previous page)

```
  * time     (time) object 2005-12-16 00:00:00 ... 2299-12-16 00:00:00
Attributes:
    bounds:         time_bnds
    axis:           T
    long_name:      time
    standard_name:  time

level = <xarray.DataArray 'height' ()>
array(1.5)
Coordinates:
    height   float64 1.5
Attributes:
    units:          m
    axis:           Z
    positive:       up
    long_name:      height
    standard_name:  height
```

[40]:
```
# to find a coordinate based on an attribute you expect it to have

xu.get_coord_by_attr(ds, "standard_name", "latitude")
```

[40]:
```
<xarray.DataArray 'lat' (lat: 2)>
array([-90.,  35.])
Coordinates:
    height   float64 1.5
  * lat      (lat) float64 -90.0 35.0
Attributes:
    bounds:         lat_bnds
    units:          degrees_north
    axis:           Y
    long_name:      latitude
    standard_name:  latitude
```

5.3 Other utilities

Other utilities allow parsing a memory size of any unit into bytes and converting a time object into an ISO 8601 string

[41]:
```
from roocs_utils.utils.common import parse_size
from roocs_utils.utils.time_utils import to_isoformat
from datetime import datetime
```

[42]:
```
# to parse a size into bytes
size = '50MiB'
size_in_b = parse_size(size)
size_in_b
```

[42]:
```
52428800.0
```

[43]:
```
# to convert a time object into a time string
time = datetime(2005, 7, 14, 12, 30)
time_str = to_isoformat(time)
time_str
```

[43]:
```
'2005-07-14T12:30:00'
```

CHAPTER

SIX

CONTRIBUTING

Contributions are welcome, and they are greatly appreciated! Every little bit helps, and credit will always be given.

You can contribute in many ways:

6.1 Types of Contributions

6.1.1 Report Bugs

Report bugs at https://github.com/roocs/roocs-utils/issues.

If you are reporting a bug, please include:

- Your operating system name and version.
- Any details about your local setup that might be helpful in troubleshooting.
- Detailed steps to reproduce the bug.

6.1.2 Fix Bugs

Look through the GitHub issues for bugs. Anything tagged with "bug" and "help wanted" is open to whoever wants to implement it.

6.1.3 Implement Features

Look through the GitHub issues for features. Anything tagged with "enhancement" and "help wanted" is open to whoever wants to implement it.

6.1.4 Write Documentation

roocs-utils could always use more documentation, whether as part of the official roocs-utils docs, in docstrings, or even on the web in blog posts, articles, and such.

6.1.5 Submit Feedback

The best way to send feedback is to file an issue at https://github.com/roocs/roocs-utils/issues.

If you are proposing a feature:

- Explain in detail how it would work.
- Keep the scope as narrow as possible, to make it easier to implement.
- Remember that this is a volunteer-driven project, and that contributions are welcome :)

6.1.6 Get Started!

Ready to contribute? Here's how to set up `roocs-utils` for local development.

#. Fork the `roocs-utils` repo on GitHub. #.

Clone your fork locally:

$ git clone git@github.com:your_name_here/roocs-utils.git

1. Install your local copy into a virtualenv. Assuming you have virtualenvwrapper installed, this is how you set up your fork for local development:

   $ mkvirtualenv roocs-utils $ cd roocs-utils/ $ python setup.py develop

2. Create a branch for local development:

   $ git checkout -b name-of-your-bugfix-or-feature

   Now you can make your changes locally.

3. When you are done making changes, check that your changes pass flake8 and the tests, including testing other Python versions with tox:

   $ flake8 roocs-utils tests $ python setup.py test or py.test $ tox

   To get flake8 and tox, just pip install them into your virtualenv.

4. Commit your changes and push your branch to GitHub:

   $ git add . $ git commit -m "Your detailed description of your changes." $ git push origin name-of-your-bugfix-or-feature

5. Submit a pull request through the GitHub website.

6.2 Pull Request Guidelines

Before you submit a pull request, check that it meets these guidelines:

1. The pull request should include tests.
2. If the pull request adds functionality, the docs should be updated. Put your new functionality into a function with a docstring, and add the feature to the list in README.md.
3. The pull request should work for Python 2.7, 3.4, 3.5 and 3.6, and for PyPy. Check https://travis-ci.com/github/roocs/roocs-utils/pull_requests and make sure that the tests pass for all supported Python versions.

6.3 Tips

To run a subset of tests:

$ py.test tests.test_roocs_utils

6.4 Deploying

A reminder for the maintainers on how to deploy. Make sure all your changes are committed (including an entry in HISTORY.md). Then run:

```
$ bumpversion patch # possible: major / minor / patch
$ git push
$ git push --tags
```

Travis will then deploy to PyPI if tests pass.

CHAPTER

SEVEN

CREDITS

7.1 Lead

- Ag Stephens ag.stephens@stfc.ac.uk

7.2 Contributors

- Eleanor Smith eleanor.smith@stfc.ac.uk
- Carsten Ehbrecht ehbrecht@dkrz.de

CHAPTER

EIGHT

VERSION HISTORY

8.1 v0.1.3 (2020-10-15)

Fixing formatting of doc strings and pip install

8.1.1 New Features

- Added a notebook to show examples

8.1.2 Bug Fixes

- Importing and using roocs-utils when pip installing now works

8.1.3 Other Changes

- Updated formatting of doc strings

8.2 v0.1.2 (2020-10-15)

Updating the documentation and improving the changelog.

8.2.1 Other Changes

- Updated doc strings to improve documentation.
- Updated documentation.

8.3 v0.1.1 (2020-10-12)

Fixing mostly existing functionality to work more efficiently with the other packages in roocs.

8.3.1 Breaking Changes

- `environment.yml` has been updated to bring it in line with requirements.txt.
- `level` coordinates would previously have been identified as `None`. They are now identified as `level`.

8.3.2 New Features

- `parameterise` function added in `roocs_utils.parameter` to use in all roocs packages.
- `ROOCS_CONFIG` environment variable can be used to override default config in `etc/roocs.ini`. To use a local config file set `ROOCS_CONFIG` as the file path to this file. Several file paths can be provided separated by a `:`
- Inventory functionality added - this can be used to create an inventory of datasets. See `README` for more info.
- `project_utils` added with the following functions to get the project name of a dataset and the base directory for that project.
- `utils.common` and `utils.time_utils` added.
- `is_level` implemented in `xarray_utils` to identify whether a coordinate is a level or not.

8.3.3 Bug Fixes

- `xarray_utils.xarray_utils.get_main_variable` updated to exclude common coordinates from the search for the main variable. This fixes a bug where coordinates such as `lon_bounds` would be returned as the main variable.

8.3.4 Other Changes

- `README` update to explain inventory functionality.
- `Black` and `flake8` formatting applied.
- Fixed import warning with `collections.abc`.

8.4 v0.1.0 (2020-07-30)

- First release.

CHAPTER

NINE

INDICES AND TABLES

- genindex
- modindex
- search