HUB-Workflow Documentation

Release 0.19.0

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General

This documentation is structured as follows:

CHAPTER 1

About

The HUB-Workflow package offers a high level interface for implementing image processing workflows.

CHAPTER 2

Contact

Please provide feedback to Andreas Rabe (andreas.rabe@geo.hu-berlin.de) or create an issue on Bitbucket.

CHAPTER 3

Installation

Install the latest release with pip:

```
python -m pip install https://bitbucket.org/hu-geomatics/hub-workflow/get/master.tar.
↪gz
```

Or manually download a release from Bitbucket.

CHAPTER 4

HUB Workflow Cookbook

4.1 General

4.1.1 Is HUB Workflow installed

Imports HUB Workflow and exits the program if the modules are not found.

```
import sys
try:
    import hubflow.core
except:
    sys.exit('ERROR: cannot find HUB Workflow modules')
```

4.1.2 Is the testdata installed

In this guide we use the EnMAP-Box testdata (https://bitbucket.org/hu-geomatics/enmap-box-testdata).

```
import sys
try:
    import enmapboxtestdata
except:
    sys.exit('ERROR: cannot find EnMAP-Box Testdata modules')
```

4.1.3 Check versions installed

```
import hubdc
import enmapboxtestdata
```

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```
print(hubdc.__version__)
print(enmapboxtestdata.__version__)
```

4.2 Raster

4.2.1 Save raster to new location and specific format

```
import enmapboxtestdata
from hubflow.core import *

raster = Raster(filename=enmapboxtestdata.enmap)

# save raster with ENVI driver
copy = raster.saveAs(filename='raster.dat', driver=RasterDriver(name='ENVI'))
print(copy.dataset().driver())

# save raster with driver derived from file extension
copy2 = raster.saveAs(filename='raster.tif')
print(copy2.dataset().driver())
```

Prints:

```
RasterDriver(name='ENVI')
RasterDriver(name='GTiff')
```

4.2.2 Apply a spatial convolution filter

```
from astropy.convolution import Gaussian2DKernel, Kernel2D
import enmapboxtestdata
from hubflow.core import *

raster = Raster(filename=enmapboxtestdata.enmap)

# apply a Gaussian filter
kernel = Gaussian2DKernel(x_stddev=1, y_stddev=1, x_size=7, y_size=7)
print(np.round(kernel.array, 3))
filteredGaussian = raster.convolve(filename='filteredGaussian.bsq', kernel=kernel)

# apply a Highpass filter
kernel = Kernel2D(array=[[-1, -1, -1],
                         [-1,  8, -1],
                         [-1, -1, -1]])
print(kernel.array)
filteredHighpass = raster.convolve(filename='filteredHighpass.bsq', kernel=kernel)
```

Prints:

```
[[0.    0.    0.001 0.002 0.001 0.    0.   ]
 [0.    0.003 0.013 0.022 0.013 0.003 0.   ]
 [0.001 0.013 0.059 0.097 0.059 0.013 0.001]
```

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```
 [0.002 0.022 0.097 0.159 0.097 0.022 0.002]
 [0.001 0.013 0.059 0.097 0.059 0.013 0.001]
 [0.    0.003 0.013 0.022 0.013 0.003 0.   ]
 [0.    0.    0.001 0.002 0.001 0.    0.   ]]
[[-1 -1 -1]
 [-1  8 -1]
 [-1 -1 -1]]
```

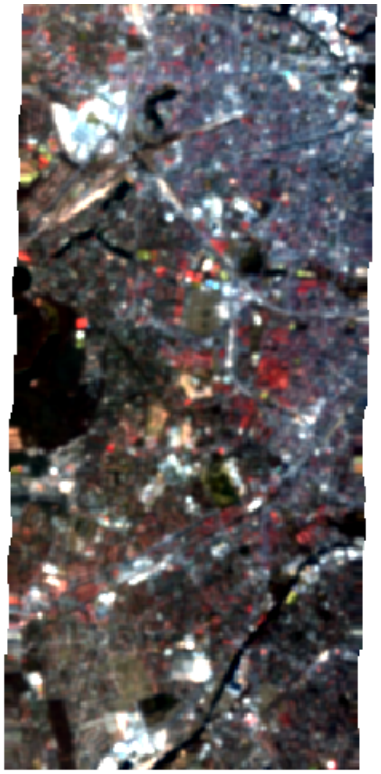

Fig. 1: Result of Gaussian filter

4.3 Classification

4.3.1 Reclassify a classification

Merge 6 detailed landcover classes into a binary *urban* vs *non-urban* classification.

```
import enmapboxtestdata
from hubflow.core import *

# create test classification
classification = Classification(filename=enmapboxtestdata.
↪createClassification(gridOrResolution=5, level='level_3_id', oversampling=1))

# reclassify
reclassified = classification.reclassify(filename='classification.bsq',
                                         classDefinition=ClassDefinition(names=['urban
↪', 'non-urban'], colors=['red', 'green']),
```

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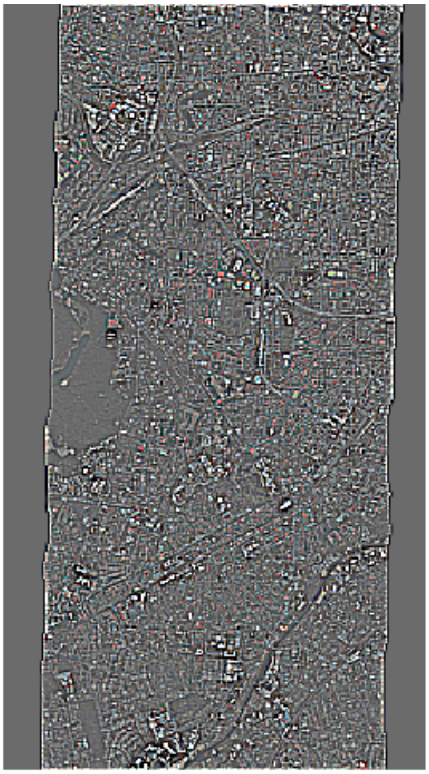

Fig. 2: Result of High-Pass filter

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```
                                        mapping={1: 1, 2: 1, 3: 2, 4: 2, 5: 2, 6: 2})

print(classification.classDefinition())
print(reclassified.classDefinition())
```

Prints:

```
ClassDefinition(classes=6, names=['roof', 'pavement', 'low vegetation', 'tree', 'soil
↪', 'water'], colors=[Color(([230, 0, 0],)), Color(([156, 156, 156],)), Color(([152,␣
↪230, 0],)), Color(([38, 115, 0],)), Color(([168, 112, 0],)), Color(([0, 100, 255],
↪))])
ClassDefinition(classes=2, names=['urban', 'non-urban'], colors=[Color(([255, 0, 0],
↪)), Color(([0, 128, 0],))])
```

4.3.2 Fit Random Forest classifier, apply to a raster and assess the performance

```
import enmapboxtestdata
from hubflow.core import *

# create classification sample
raster = Raster(filename=enmapboxtestdata.enmap)
classification = Classification(filename=enmapboxtestdata.
↪createClassification(gridOrResolution=raster.grid(), level='level_2_id',␣
↪oversampling=5))
```

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Fig. 3: Original

Fig. 4: Reclassified

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```
sample = ClassificationSample(raster=raster, classification=classification)

# fit classifier
from sklearn.ensemble import RandomForestClassifier
classifier = Classifier(sklEstimator=RandomForestClassifier(n_estimators=10))
classifier.fit(sample=sample)

# classify a raster
prediction = classifier.predict(filename='randonForestClassification.bsq',␣
↪raster=raster)

# asses accuracy
performance = ClassificationPerformance.fromRaster(prediction=prediction,␣
↪reference=classification)
performance.report().saveHTML(filename='ClassificationPerformance.html')
```

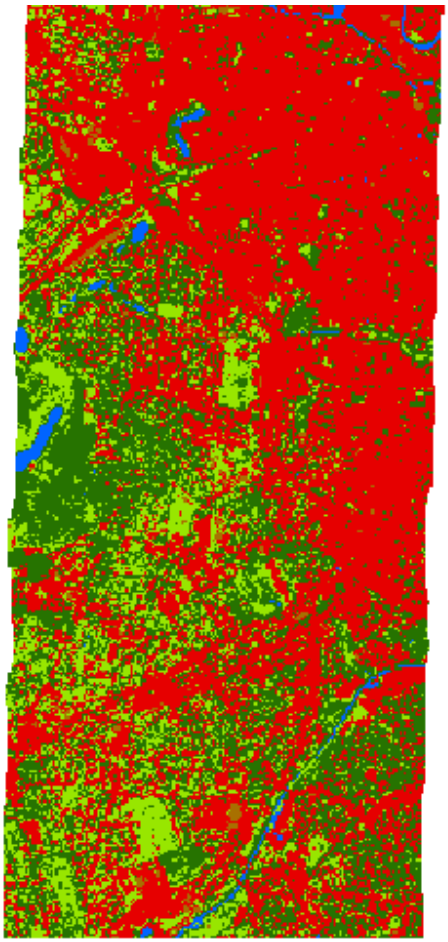


Fig. 5: Random Forest Classification

HTML report:

4.3.3 Set class definition

```
from hubflow.core import *

# create a raster
Raster.fromArray(array=[[[0, 1, 2, 3]]], filename='classification.bsq')

# open the raster as classification in Update mode
classification = Classification(filename='classification.bsq', eAccess=gdal.GA_Update)

# set the class definition
classDefinition = ClassDefinition(classes=3, names=['c1', 'c2', 'c3'], colors=['red',
↪'green', 'blue'])
classification.setClassDefinition(classDefinition)

# re-open the classification (required!)
classification.close()
classification = Classification(filename='classification.bsq')

print(classification)
```

Prints:

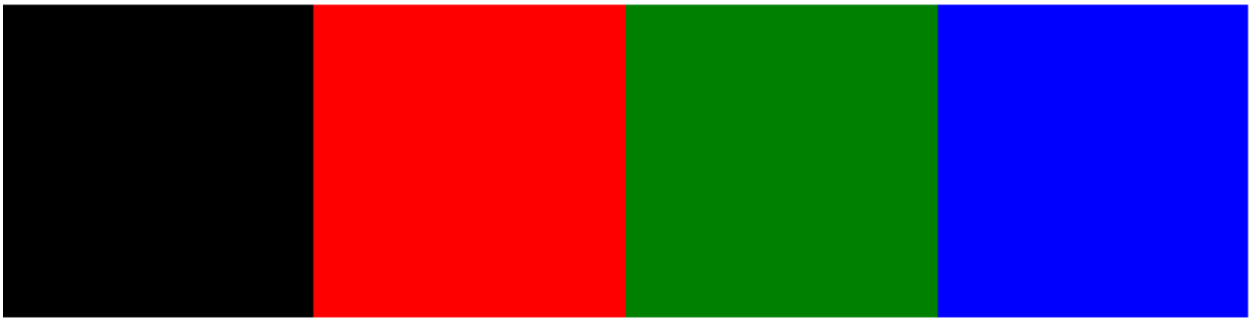
```
Classification(filename=classification.bsq, classDefinition=ClassDefinition(classes=3,
↪ names=['c1', 'c2', 'c3'], colors=[Color(([255, 0, 0],)), Color(([0, 128, 0],)),␣
↪Color(([0, 0, 255],))]), minOverallCoverage=0.5, minDominantCoverage=0.5)
```

4.4 Regression

4.4.1 Fit Random Forest regressor, apply to a raster and assess the performance

```
import enmapboxtestdata
from hubflow.core import *

# create (multi tagret) regression sample (labels are landcover class fractions)
raster = Raster(filename=enmapboxtestdata.enmap)
regression = Regression(filename=enmapboxtestdata.
↪createFraction(gridOrResolution=raster.grid(), level='level_1_id', oversampling=5))
sample = RegressionSample(raster=raster, regression=regression)

# fit regressor
from sklearn.ensemble import RandomForestRegressor
regressor = Regressor(sklEstimator=RandomForestRegressor(n_estimators=10))
regressor.fit(sample=sample)

# regress a raster
prediction = regressor.predict(filename='randonForestRegression.bsq', raster=raster)

# asses accuracy
performance = RegressionPerformance.fromRaster(prediction=prediction,␣
↪reference=regression)
performance.report().saveHTML(filename='RegressionPerformance.html')
```

HTML report:



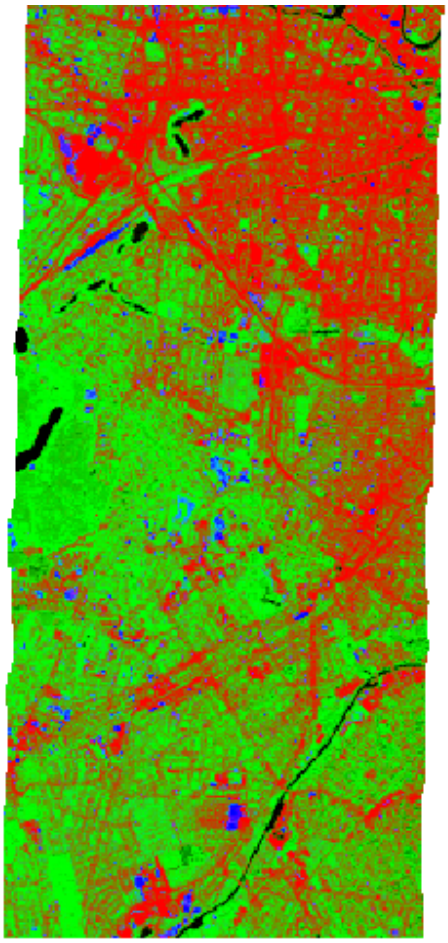


Fig. 6: Random Forest (multi target) regression as false-color-composition (Red='impervious', Green='vegetation' and Blue='soil' pixel fractions)

4.5 Clustering

4.5.1 Fit K-Means clusterer, apply to a raster and assess the performance

```
import enmapboxtestdata
from hubflow.core import *

# create (unsupervised) sample
raster = Raster(filename=enmapboxtestdata.enmap)
sample = Sample(raster=raster)

# fit clusterer
from sklearn.cluster import KMeans
clusterer = Clusterer(sklEstimator=KMeans(n_clusters=5))
clusterer.fit(sample=sample)

# cluster a raster
prediction = clusterer.predict(filename='kmeanClustering.bsq', raster=raster)

# asses accuracy
reference = Classification(filename=enmapboxtestdata.
↪createClassification(gridOrResolution=raster.grid(), level='level_2_id',␣
↪oversampling=5))
performance = ClusteringPerformance.fromRaster(prediction=prediction,␣
↪reference=reference)
performance.report().saveHTML(filename='ClusteringPerformance.html')
```

HTML report:

4.6 Transformer

4.6.1 Fit PCA transformer and apply to a raster

```
import enmapboxtestdata
from hubflow.core import *

# create (unsupervised) sample
raster = Raster(filename=enmapboxtestdata.enmap)
sample = Sample(raster=raster)

# fit transformer
from sklearn.decomposition import PCA
transformer = Transformer(sklEstimator=PCA(n_components=3))
transformer.fit(sample=sample)

# transform a raster
transformation = transformer.transform(filename='transformation.bsq', raster=raster)

# inverse transform
inverseTransformation = transformer.inverseTransform(filename='inverseTransformation.
↪bsq', raster=transformation)
```

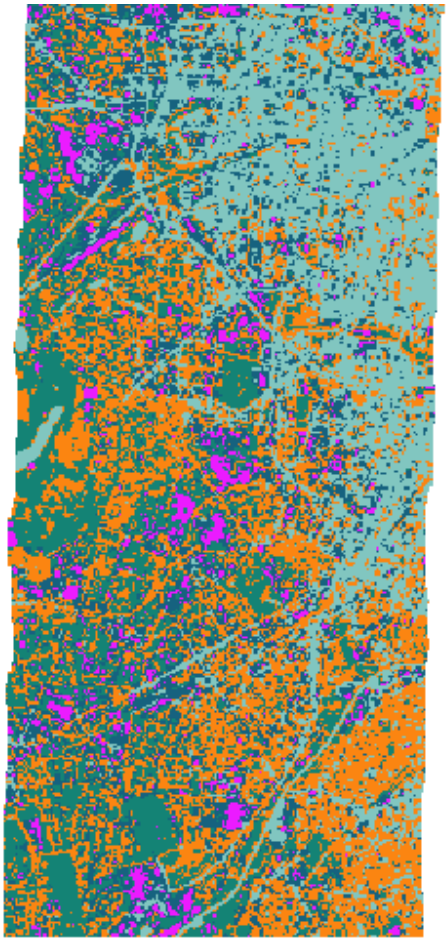


Fig. 7: K-Means clustering.

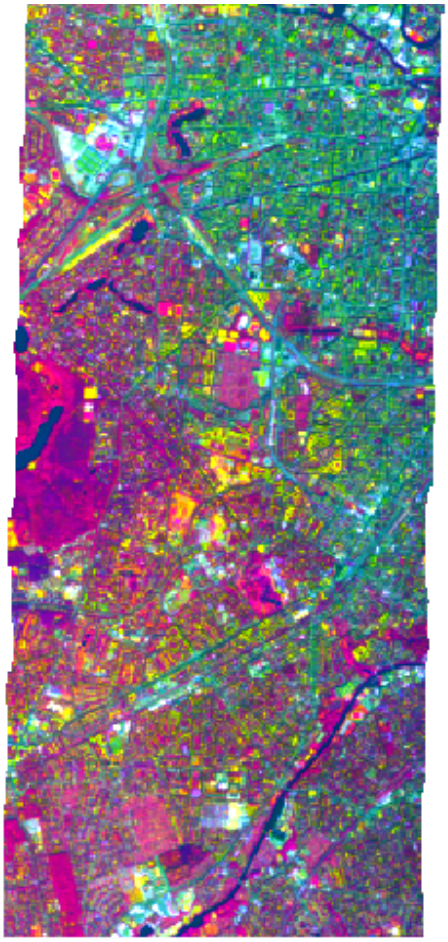


Fig. 8: PCA transformation as false-color-composition (Red='pc 1', Green='pc 2' and Blue='pc 3')

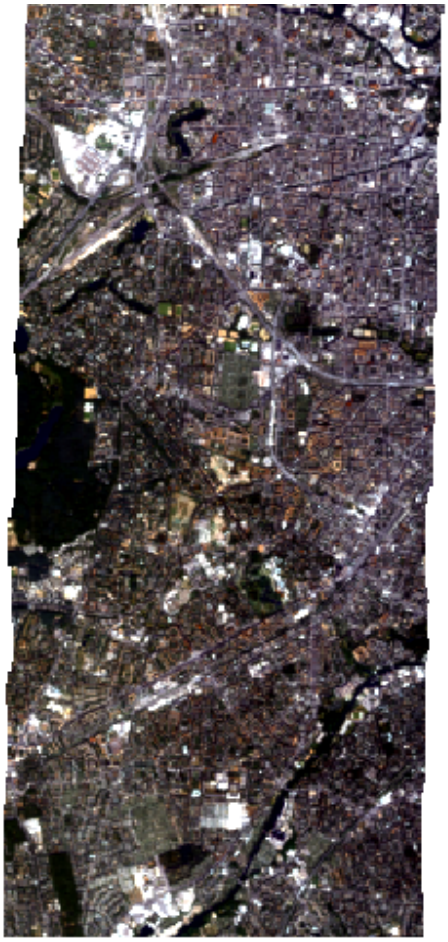


Fig. 9: Reconstructed raster (inverse transformation of PCA transformation) as true-color-composition

4.7 Mask

4.7.1 Mask values inside valid range

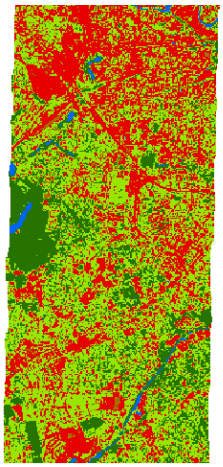
```
import enmapboxtestdata
from hubflow.core import *

raster = Raster(filename=enmapboxtestdata.enmap)
mask = Mask.fromRaster(filename='mask.bsq', raster=raster, true=[range(0, 100)],
                       aggregateFunction=lambda a: np.any(a, axis=0))
```

4.7.2 Mask values outside valid range

```
import enmapboxtestdata
from hubflow.core import *

raster = Raster(filename=enmapboxtestdata.enmap)

mask = Mask.fromRaster(filename='mask.bsq', raster=raster, false=[range(0, 100)],␣
↪initValue=True,
                       aggregateFunction=lambda a: np.all(a, axis=0))
```

4.7.3 Mask water bodies from classification

```
import enmapboxtestdata
from hubflow.core import *

# create classification
classification = Classification(filename=enmapboxtestdata.
↪createRandomForestClassification())
print(classification)

# create mask for water bodies (id=5)
mask = Mask.fromRaster(filename='mask.bsq', raster=classification, true=[5])
```



4.7.4 Apply mask to raster

```
import enmapboxtestdata
from hubflow.core import *

# mask out all pixel that are covered by the vector
raster = Raster(filename=enmapboxtestdata.enmap)
mask = VectorMask(filename=enmapboxtestdata.landcover_polygons)
maskedRaster = raster.applyMask(filename='maskedRaster.bsq', mask=mask)

# mask out all pixel that are NOT covered by the vector
mask2 = VectorMask(filename=enmapboxtestdata.landcover_polygons, invert=True)
maskedRaster2 = raster.applyMask(filename='maskedRaster2.bsq', mask=mask2)
```

4.8 ClassificationSample

4.8.1 Create classification sample

Warning: todo

4.9 EnviSpectralLibrary

4.9.1 Read profiles and metadata from library

```
import enmapboxtestdata
from hubflow.core import *

# open library
speclib = EnviSpectralLibrary(filename=enmapboxtestdata.library)

# treat library as raster with shape (wavelength, profiles, 1)
```

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Fig. 10: Raster masked by vector.

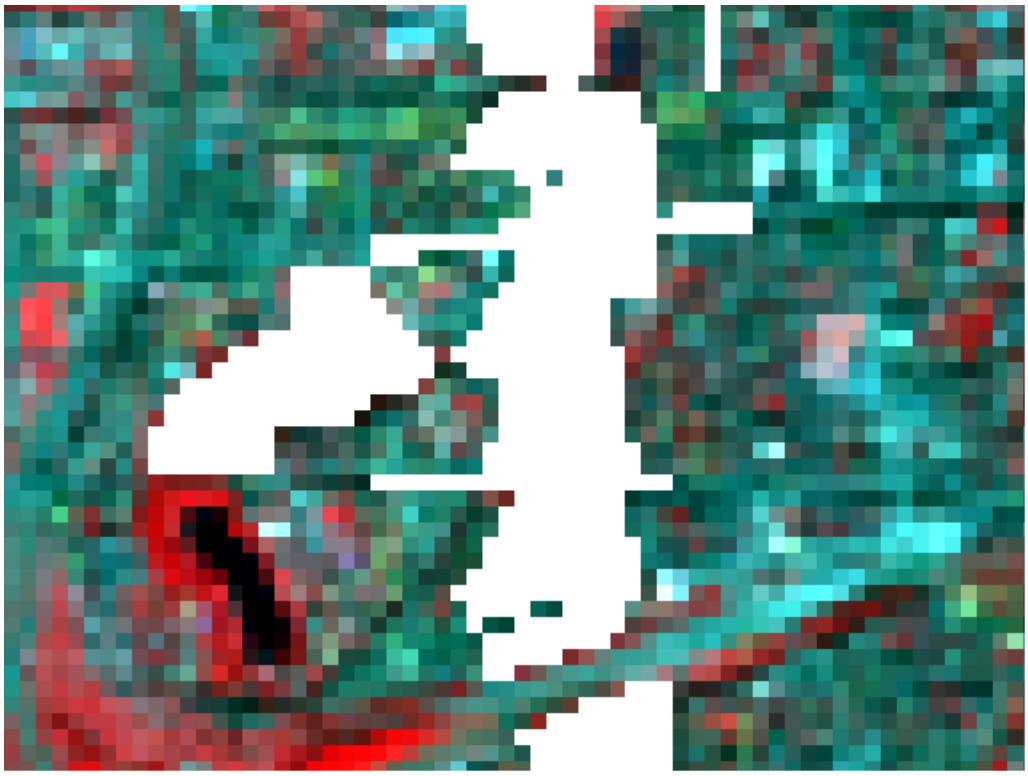

Fig. 11: Raster masked by inverted vector.

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```
raster = speclib.raster()

# read profiles
print(raster.dataset().array().shape)

# read metadata
print(raster.dataset().metadataItem(key='wavelength', domain='ENVI', dtype=float))
```

Prints:

```
(177, 75, 1)
[0.46, 0.465, 0.47, 0.475, 0.479, 0.484, 0.489, 0.494, 0.499, 0.503, 0.508, 0.513, 0.
↪518, 0.523, 0.528, 0.533, 0.538, 0.543, 0.549, 0.554, 0.559, 0.565, 0.57, 0.575, 0.
↪581, 0.587, 0.592, 0.598, 0.604, 0.61, 0.616, 0.622, 0.628, 0.634, 0.64, 0.646, 0.
↪653, 0.659, 0.665, 0.672, 0.679, 0.685, 0.692, 0.699, 0.706, 0.713, 0.72, 0.727, 0.
↪734, 0.741, 0.749, 0.756, 0.763, 0.771, 0.778, 0.786, 0.793, 0.801, 0.809, 0.817, 0.
↪824, 0.832, 0.84, 0.848, 0.856, 0.864, 0.872, 0.88, 0.888, 0.896, 0.915, 0.924, 0.
↪934, 0.944, 0.955, 0.965, 0.975, 0.986, 0.997, 1.007, 1.018, 1.029, 1.04, 1.051, 1.
↪063, 1.074, 1.086, 1.097, 1.109, 1.12, 1.132, 1.144, 1.155, 1.167, 1.179, 1.191, 1.
↪203, 1.215, 1.227, 1.239, 1.251, 1.263, 1.275, 1.287, 1.299, 1.311, 1.323, 1.522, 1.
↪534, 1.545, 1.557, 1.568, 1.579, 1.59, 1.601, 1.612, 1.624, 1.634, 1.645, 1.656, 1.
↪667, 1.678, 1.689, 1.699, 1.71, 1.721, 1.731, 1.742, 1.752, 1.763, 1.773, 1.783, 2.
↪044, 2.053, 2.062, 2.071, 2.08, 2.089, 2.098, 2.107, 2.115, 2.124, 2.133, 2.141, 2.
↪15, 2.159, 2.167, 2.176, 2.184, 2.193, 2.201, 2.21, 2.218, 2.226, 2.234, 2.243, 2.
↪251, 2.259, 2.267, 2.275, 2.283, 2.292, 2.3, 2.308, 2.315, 2.323, 2.331, 2.339, 2.
↪347, 2.355, 2.363, 2.37, 2.378, 2.386, 2.393, 2.401, 2.409]
```

4.9.2 Create labeled library from raster and vector points

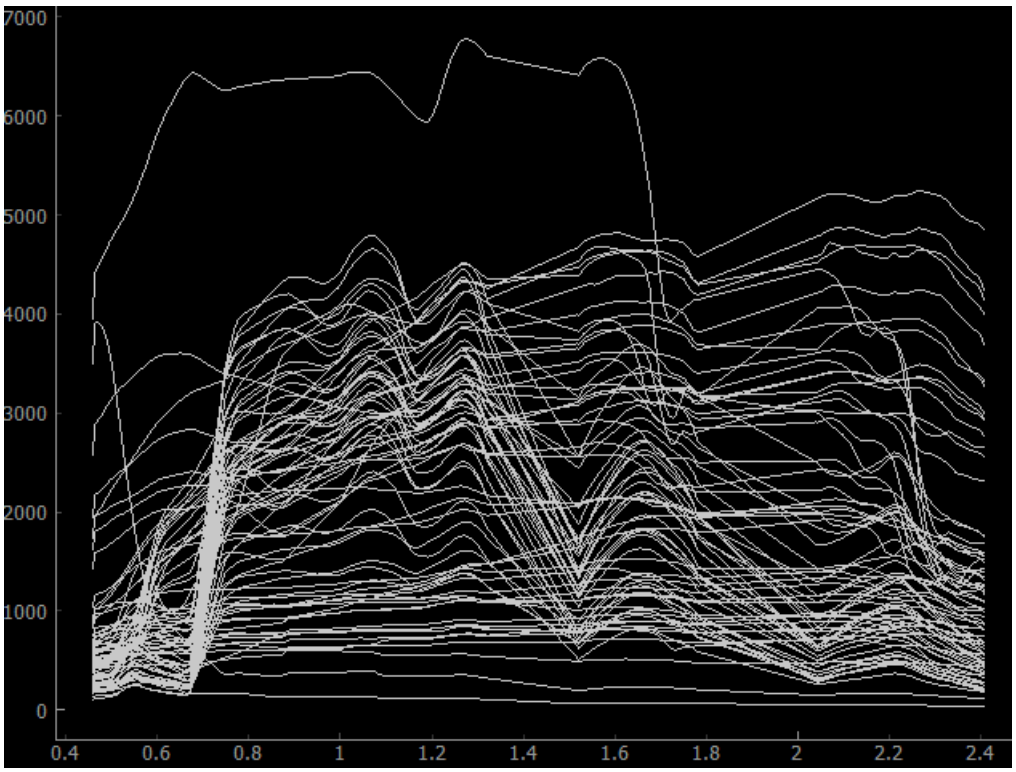
```
import enmapboxtestdata
from hubflow.core import *

# open raster and vector points
enmap = Raster(filename=enmapboxtestdata.enmap)
points = VectorClassification(filename=enmapboxtestdata.landcover_points,␣
↪classAttribute='level_2_id')

# rasterize points onto raster grid
classification = Classification.fromClassification(classification=points, grid=enmap.
↪grid(), filename='/vsimem/classification.bsq')

# create classification sample
sample = ClassificationSample(raster=enmap, classification=classification)

# create ENVI spectral library from sample
speclib = EnviSpectralLibrary.fromSample(sample=sample, filename='speclib.sli')
```


7000
6000
5000
4000
3000
2000
1000
0
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4

CHAPTER 5

Classes

5.1 Raster Maps

5.1.1 Raster

- ***hubflow.core.Raster*:**
  - *applyMask() applySpatial() array() asMask() convolve() dataset() dtype() filename() fromArray() fromRasterDataset() fromVector() grid() metadataFWHM() metadataWavelength() noDataValue() noDataValues() resample() scatterMatrix() sensorDefinition() statistics() subsetBands() uniqueValues()*

class hubflow.core.**Raster**(*filename*, *eAccess=<sphinx.ext.autodoc.importer._MockObject object>*)

Bases: hubflow.core.Map

Class for managing raster maps like *Mask*, *Classification*, *Regression* and *Fraction*.

applyMask(*filename*, *mask*, *noDataValue=None*, ***kwargs*)

Applies a mask to itself and returns the result. All pixels where the mask evaluates to False, are set to the no data value. If the no data value is nut defined, 0 is used.

Parameters

- **filename** (*str*) – output path
- **mask** (*Map*) – a map that is evaluated as a mask
- **noDataValue** (*float*) – set no data value if undefined (default is to use 0)
- **kwargs** – passed to *hubflow.core.Applier*

Return type *Raster*

Example

```
>>> raster = Raster.fromArray(array=[[[1, 2, 3]]], filename='/vsimem/raster.
↪bsq', noDataValues=[-1])
>>> mask = Mask.fromArray(array=[[[0, 0, 1]]], filename='/vsimem/mask.bsq')
>>> result = raster.applyMask(filename='/vsimem/result.bsq', mask=mask)
>>> result.array()
array([[[-1, -1,  3]]])
```

applySpatial (*filename*, *function*, ***kwargs*)
Apply given `function` to each band of itself and return the result raster.

Parameters

- **filename** (*str*) –
- **function** (*function*) – user defined function that takes one argument `array`
- **kwargs** – passed to *hubflow.core.Applier*

Return type *Raster*

Example

```
>>> raster = Raster.fromArray(array=[[[1, 2, 3]]], filename='/vsimem/raster.
↪bsq')
>>> raster.array()
array([[[1, 2, 3]]])
>>> def square(array): return array**2
>>> result = raster.applySpatial(filename='/vsimem/result.bsq',␣
↪function=square)
>>> result.array()
array([[[1, 4, 9]]])
```

array (***kwargs*)
Return raster data as 3d array of shape = (zsize, ysize, xsize). Additional `kwargs` are passed to Raster.dataset().array.

asMask (*noDataValues=None*, *minOverallCoverage=0.5*, *indices=None*, *invert=False*)
Return itself as a *Mask*.

Parameters

- **noDataValues** (*List[Union[None, float]]*) – list of band-wise no data values
- **minOverallCoverage** (*float*) – threshold that defines, in case of on-the-fly average-resampling, which pixel will be evaluated as True
- **indices** (*int*) – if set, a band subset mask for the given `indices` is created
- **invert** (*int*) – whether to invert the mask

Return type *Mask*

Example

```
>>> raster = Raster.fromArray(array=[[[-1, 0, 5, 3, 0]]], filename='/vsimem/
↪raster.bsq',
...                            noDataValues=[-1])
>>> raster.array()
array([[[-1,  0,  5,  3,  0]]])
>>> raster.asMask().array()
array([[[0, 1, 1, 1, 1]]], dtype=uint8)
```

close()
See RasterDataset.show.

convolve(*filename*, *kernel*, ***kwargs*)
Perform convolution of itself with the given `kernel` and return the result raster, where an 1D kernel is applied along the z dimension, an 2D kernel is applied spatially (i.e. y/x dimensions), and an 3D kernel is applied directly to the 3D z-y-x data cube.

Parameters

- **filename** (*str*) – output path
- **kernel** (*astropy.convolution.kernels.Kernel*) –
- **kwargs** – passed to *hubflow.core.Applier*

Return type *Raster*

Example

```
>>> array = np.zeros(shape=[1, 5, 5])
>>> array[0, 2, 2] = 1
>>> raster = Raster.fromArray(array=array, filename='/vsimem/raster.bsq')
>>> raster.array()
array([[[ 0.,  0.,  0.,  0.,  0.],
        [ 0.,  0.,  0.,  0.,  0.],
        [ 0.,  0.,  1.,  0.,  0.],
        [ 0.,  0.,  0.,  0.,  0.],
        [ 0.,  0.,  0.,  0.,  0.]]])
```

```
>>> from astropy.convolution.kernels import Kernel2D
>>> kernel = Kernel2D(array=np.ones(shape=[3, 3]))
>>> kernel.array
array([[ 1.,  1.,  1.],
       [ 1.,  1.,  1.],
       [ 1.,  1.,  1.]])
>>> result = raster.convolve(filename='/vsimem/result.bsq', kernel=kernel)
>>> result.array()
array([[[ 0.,  0.,  0.,  0.,  0.],
        [ 0.,  1.,  1.,  1.,  0.],
        [ 0.,  1.,  1.,  1.,  0.],
        [ 0.,  1.,  1.,  1.,  0.],
        [ 0.,  0.,  0.,  0.,  0.]]], dtype=float32)
```

dataset()
Return the `hubdc.core.RasterDataset` object.

dtype()
Return numpy data type

filename()
Return the filename.

classmethod fromArray(*array*, *filename*, *grid=None*, *noDataValues=None*, *descriptions=None*, ***kwargs*)
Create instance from given `array`.

Parameters

- **array** (*Union[numpy.ndarray, list]*) –
- **filename** (*str*) – output path

- **grid** (*hubdc.core.Grid*) – output grid
- **noDataValues** (*List[float]*) – list of band no data values
- **descriptions** (*List[str]*) – list of band descriptions (i.e. band names)
- **kwargs** – passed to constructor (e.g. Raster, Classification, Regression, . . .)

Return type *Raster*

Example

```
>>> raster = Raster.fromArray(array=np.zeros(shape=[177, 100, 100]), filename=
↪'/vsimem/raster.bsq')
>>> raster.shape()
(177, 100, 100)
>>> raster.grid() # default grid uses WGS84 projection and millisecond (1/
↪3600 degree) resolution
Grid(extent=Extent(xmin=0.0, xmax=0.02777777777777776, ymin=0.0, ymax=0.
↪02777777777777776), resolution=Resolution(x=0.0002777777777777778, y=0.
↪0002777777777777778), projection=Projection(wkt=GEOGCS["WGS84", DATUM["WGS_
↪1984", SPHEROID["WGS84",6378137,298.257223563, AUTHORITY["EPSG","7030"]],␣
↪AUTHORITY["EPSG","6326"]], PRIMEM["Greenwich",0, AUTHORITY["EPSG","8901"]],␣
↪UNIT["degree",0.0174532925199433, AUTHORITY["EPSG","9122"]], AUTHORITY["EPSG
↪","4326"]])
```

static fromEnviSpectralLibrary(*filename*, *library*)

Create instance from given `library`.

Parameters

- **filename** (*str*) – output path
- **library** (*EnviSpectralLibrary`*) –

Return type *Raster*

Example

```
>>> import enmapboxtestdata
>>> speclib = EnviSpectralLibrary(filename=enmapboxtestdata.speclib)
>>> raster = Raster.fromEnviSpectralLibrary(filename='/vsimem/raster.bsq',␣
↪library=speclib)
>>> raster.shape()
(177, 75, 1)
```

classmethod fromRasterDataset(*rasterDataset*, ***kwargs*)

Create instance from given `rasterDataset`.

Parameters

- **rasterDataset** (*hubdc.core.RasterDataset*) – existing hubdc.core.RasterDataset
- **kwargs** – passed to class constructor

Return type *Raster*

Example

```
>>> rasterDataset = RasterDataset.fromArray(array=[[[1,2,3]]], filename='/
↪vsimem/raster.bsq', driver=EnviBsqDriver())
>>> rasterDataset # doctest: +ELLIPSIS
```

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```
RasterDataset(gdalDataset=<osgeo.gdal.Dataset; proxy of <Swig Object of type
↪'GDALDatasetShadow *' at 0x...> >)
>>> Raster.fromRasterDataset(rasterDataset=rasterDataset)
Raster(filename=/vsimem/raster.bsq)
```

classmethod fromVector(*filename*, *vector*, *grid*, *noDataValue=None*, ***kwargs*)

Create instance from given `vector` by rasterizing it into the given `grid`.

Parameters

- **filename** (*str*) – output path
- **vector** (Vector) – input vector
- **grid** (*hubdc.core.Grid*) – output pixel grid
- **noDataValue** (*float*) – output no data value
- **kwargs** – passed to *hubflow.core.Applier*

Return type *hubflow.core.Raster*

Example

```
>>> import tempfile
>>> vector = Vector.fromPoints(points=[(-1, -1), (1, 1)],␣
↪filename=join(tempfile.gettempdir(), 'vector.shp'), projection=Projection.
↪wgs84())
>>> grid = Grid(extent=Extent(xmin=-1.5, xmax=1.5, ymin=-1.5, ymax=1.5),␣
↪resolution=1, projection=Projection.wgs84())
>>> raster = Raster.fromVector(filename='/vsimem/raster.bsq', vector=vector,␣
↪grid=grid)
>>> print(raster.array())
[[[ 0.  0.  1.]
  [ 0.  0.  0.]
  [ 1.  0.  0.]]]
```

grid()

Return grid.

metadataFWHM(*required=False*)

Return list of band full width at half maximums in nanometers. If not defined, list entries are `None`.

Example

```
>>> import enmapboxtestdata
>>> Raster(filename=enmapboxtestdata.enmap).metadataFWHM() # doctest:␣
↪+ELLIPSIS
[5.8, 5.8, 5.8, ..., 9.1, 9.1, 9.1]
```

metadataWavelength()

Return list of band center wavelengths in nanometers.

Example

```
>>> import enmapboxtestdata
>>> Raster(filename=enmapboxtestdata.enmap).metadataWavelength() # doctest:␣
↪+ELLIPSIS
[460.0, 465.0, 470.0, ..., 2393.0, 2401.0, 2409.0]
```

noDataValue (*default=None*, *required=False*)
Return no value value.

noDataValues (*default=None*)
Return bands no value values.

resample (*filename*, *grid*, *resampleAlg=<sphinx.ext.autodoc.importer._MockObject object>*, ***kwargs*)
Return itself resampled into the given `grid`.

Parameters

- **filename** (*str*) – output path
- **grid** (*hubdc.core.Grid*) –
- **resampleAlg** (*int*) – GDAL resampling algorithm
- **kwargs** – passed to *hubflow.core.Applier*

Return type *Raster*

Example

```
>>> raster = Raster.fromArray(array=[[[1, 2, 3]]], filename='/vsimem/raster.
↪bsq')
>>> raster.array()
array([[[1, 2, 3]]])
>>> grid = Grid(extent=raster.grid().extent(),
...             resolution=raster.grid().resolution() / (2, 1))
>>> result = raster.resample(filename='/vsimem/result.bsq', grid=grid)
>>> result.array()
array([[[1, 1, 2, 2, 3, 3]]])
```

saveAs (*filename*, *driver=None*, *copyMetadata=True*, *copyCategories=True*)
Save copy of self at given `filename`. Format will be derived from filename extension if not explicitely specified by `driver` keyword.

scatterMatrix (*raster2*, *bandIndex1*, *bandIndex2*, *range1*, *range2*, *bins=256*, *mask=None*, *stratification=None*, ***kwargs*)
Return scatter matrix between itself's band given by `bandIndex1` and `raster2`'s band given by `bandIndex2` stored as a named tuple `ScatterMatrix(H, xedges, yedges)`. Where `H` is the 2d count matrix for the binning given by `xedges` and `yedges` lists. If a `stratication` is defined, `H` will be a list of 2d count matrices, one for each strata.

Parameters

- **raster2** (`Raster`) –
- **bandIndex1** (*int*) – first band index
- **bandIndex2** (*int*) – second band index
- **range1** (*Tuple[float, float]*) – first band range as (min, max) tuple
- **range2** (*Tuple[float, float]*) – second band range as (min, max) tuple
- **bins** – passed to `np.histogram2d`
- **mask** (*Map*) – map that is evaluated as a mask
- **stratification** (`Classification`) – classification that stratifies the calculation into different classes
- **kwargs** – passed to *hubflow.core.Applier*

Return type ScatterMatrix(H, xedges, yedges)

Example

```
>>> # create two single band raster
>>> raster1 = Raster.fromArray(array=[[[1, 2, 3]]], filename='/vsimem/raster1.
↪bsq')
>>> raster2 = Raster.fromArray(array=[[[10, 20, 30]]], filename='/vsimem/
↪raster2.bsq')
>>> # calculate scatter matrix between both raster bands
>>> scatterMatrix = raster1.scatterMatrix(raster2=raster2, bandIndex1=0,␣
↪bandIndex2=0, range1=[1, 4], range2=[10, 40], bins=3)
>>> scatterMatrix.H
array([[1, 0, 0],
       [0, 1, 0],
       [0, 0, 1]], dtype=uint64)
>>> scatterMatrix.xedges
array([ 1.,  2.,  3.,  4.])
>>> scatterMatrix.yedges
array([ 10.,  20.,  30.,  40.])
```

sensorDefinition()

Return `SenserDefinition` created from center wavelength and FWHM.

Example

```
>>> SensorDefinition.predefinedSensorNames()
['modis', 'moms', 'mss', 'npp_viirs', 'pleiades1a', 'pleiades1b', 'quickbird',
↪ 'rapideye', 'rasat', 'seawifs', 'sentinel2', 'spot', 'spot6', 'tm',
↪'worldview1', 'worldview2', 'worldview3']
>>> SensorDefinition.fromPredefined('sentinel2') # doctest: +ELLIPSIS,␣
↪+NORMALIZE_WHITESPACE
SensorDefinition(wavebandDefinitions=[WavebandDefinition(center=443.0,␣
↪fwhm=None, responses=[...], name=Sentinel-2 - Band B1), ...,
                                      WavebandDefinition(center=2196.5,␣
↪fwhm=None, responses=[...], name=Sentinel-2 - Band B12)])
```

show()

See RasterDataset.show.

statistics(*bandIndices=None*, *mask=None*, *calcPercentiles=False*, *calcHistogram=False*, *calcMean=False*, *calcStd=False*, *percentiles=[]*, *histogramRanges=None*, *histogramBins=None*, ***kwargs*)

Return a list of BandStatistic named tuples:

key	value/description
index	band index
nvalid	number of valid pixel (not equal to noDataValue and not masked)
ninvalid	number of invalid pixel (equal to noDataValue or masked)
min	smallest value
max	largest value
percentiles+	list of (rank, value) tuples for given percentiles
std+	standard deviation
mean+	mean
histo+	Histogram(hist, bin_edges) tuple with histogram counts and bin edges

+set corresponding calcPercentiles/Histogram/Mean/Std keyword to True

Parameters

- **bandIndices** (*Union[None, None, None]*) – calculate statistics only for given bandIndices
- **mask** (*Union[None, None, None]*) –
- **calcPercentiles** (*bool*) – if set True, band percentiles are calculated; see percentiles keyword
- **calcHistogram** (*bool*) – if set True, band histograms are calculated; see histogramRanges and histogramBins keywords
- **calcMean** (*bool*) – if set True, band mean values are calculated
- **calcStd** (*bool*) – if set True, band standard deviations are calculated
- **percentiles** (*List[float]*) – values between 0 (i.e. min value) and 100 (i.e. max value), 50 is the median
- **histogramRanges** (*List[numpy.histogram ranges]*) – list of ranges, one for each band; ranges are passed to numpy.histogram; None ranges are set to (min, max)
- **histogramBins** (*List[numpy.histogram bins]*) – list of bins, one for each band; bins are passed to numpy.histogram; None bins are set to 256
- **kwargs** – passed to *hubflow.core.Applier*

Return type List[BandStatistics(index, nvalid, ninvalid, min, max, percentiles, std, mean, histo)]

Example

```
>>> # create raster with no data values
>>> raster = Raster.fromArray(array=[[[1, np.nan, 3], [0, 2, np.inf], [1, 0,␣
↪3]]], filename='/vsimem/raster.bsq', noDataValues=[0])
>>> # calculate basic statistics
>>> statistics = raster.statistics()
>>> print(statistics[0])
BandStatistics(index=0, nvalid=5, ninvalid=4, min=1.0, max=3.0,␣
↪percentiles=None, std=None, mean=None, histo=None)
>>> # calculate histograms
>>> statistics = raster.statistics(calcHistogram=True, histogramRanges=[(1,␣
↪4)], histogramBins=[3])
>>> print(statistics[0].histo)
Histogram(hist=array([2, 1, 2], dtype=int64), bin_edges=array([ 1.,  2.,  3.,␣
↪ 4.]))
>>> # calculate percentiles (min, median, max)
>>> statistics = raster.statistics(calcPercentiles=True, percentiles=[0, 50,␣
↪100])
>>> print(statistics[0].percentiles)
[Percentile(rank=0, value=1.0), Percentile(rank=50, value=2.0),␣
↪Percentile(rank=100, value=3.0)]
```

subsetBands (*filename*, *indices*, *invert=False*, ***kwargs*)

Return the band subset given by indices.

Parameters

- **filename** (*str*) – output path
- **indices** (*list*) –

- **invert** (*bool*) – wether to invert the indices list (i.e. dropping bands instead of selecting)
- **kwargs** (*dict*) – passed to gdal.Translate

Return type *Raster*

Example

TODO

```
>>> raster = Raster.fromArray(array=[[[1]], [[2]], [[3]]], filename='/vsimem/
↪raster.bsq')
>>> raster.array()
array([[[1, 2, 3]]])
```

uniqueValues(*index*)

Return unique values for band at given `index`.

Example

```
>>> raster = Raster.fromArray(array=[[[1, 1, 1, 5, 2]]], filename='/vsimem/
↪raster.bsq')
>>> raster.uniqueValues(index=0)
array([1, 2, 5])
```

5.1.2 Mask

- ***hubflow.core.Mask*:**
  - *indices() invert() minOverallCoverage() noDataValues() resample()*

class hubflow.core.**Mask**(*filename*, *noDataValues=None*, *minOverallCoverage=0.5*, *indices=None*, *invert=False*)

Bases: *hubflow.core.Raster*

static fromRaster(*filename*, *raster*, *initValue=False*, *true=()*, *false=()*, *invert=False*, *aggregateFunction=None*, ***kwargs*)

Returns a mask created from a raster map, where given lists of `true` and `false` values and value ranges are used to define True and False regions.

Parameters

- **filename** – output path
- **raster** (hubflow.core.Raster) – input raster
- **initValue** (*bool*) – initial fill value, default is False
- **true** (*List[number or range]*) – list of forground numbers and ranges
- **false** (*List[number or range]*) – list of forground numbers and ranges
- **invert** (*bool*) – whether to invert the mask
- **aggregateFunction** (*func*) – aggregation function (e.g. numpy.all or numpy.any) to reduce multiband rasters to a single band mask; the default is to not reduce and returning a multiband mask
- **kwargs** – passed to hubflow.core.Applier

Returns hubflow.core.Mask

Return type

Example

```
>>> raster = Raster.fromArray(array=[[[-99, 1, 2, 3, 4, 5]]], filename='/
↪vsimem/raster.bsq')
>>> raster.array()
array([[[-99,   1,   2,   3,   4,   5]]])
>>> # values 1, 2, 3 are True
>>> Mask.fromRaster(raster=raster, true=[1, 2, 3], filename='/vsimem/mask.bsq
↪').array()
array([[[0, 1, 1, 1, 0, 0]]], dtype=uint8)
>>> # value range 1 to 4 is True
>>> Mask.fromRaster(raster=raster, true=[range(1, 4)], filename='/vsimem/mask.
↪bsq').array()
array([[[0, 1, 1, 1, 1, 0]]], dtype=uint8)
>>> # all values are True, but -99
>>> Mask.fromRaster(raster=raster, initValue=True, false=[-99], filename='/
↪vsimem/mask.bsq').array()
array([[[0, 1, 1, 1, 1, 1]]], dtype=uint8)
```

Different aggregations over multiple bands

```
>>> raster = Raster.fromArray(array=[[[0, 0, 1, 1]], [[0, 1, 0, 1]]],␣
↪filename='/vsimem/raster.bsq')
>>> raster.array()
array([[[0, 0, 1, 1]],
<BLANKLINE>
       [[0, 1, 0, 1]]])
>>> # no aggregation
>>> Mask.fromRaster(raster=raster, true=[1], filename='/vsimem/mask.bsq').
↪readAsArray()
array([[[0, 0, 1, 1]],
<BLANKLINE>
       [[0, 1, 0, 1]]], dtype=uint8)
>>> # True if all pixel profile values are True
>>> def aggregate(array): return np.all(array, axis=0)
>>> Mask.fromRaster(raster=raster, true=[1], aggregateFunction=aggregate,␣
↪filename='/vsimem/mask.bsq').readAsArray()
array([[[0, 0, 0, 1]]], dtype=uint8)
```

```
>>> # True if any pixel profile values are True
>>> def aggregate(array): return np.any(array, axis=0)
>>> Mask.fromRaster(raster=raster, true=[1], aggregateFunction=aggregate,␣
↪filename='/vsimem/mask.bsq').readAsArray()
array([[[0, 1, 1, 1]]], dtype=uint8)
```

static fromVector(*filename*, *vector*, *grid*, ***kwargs*)

Create a mask from a vector.

Parameters

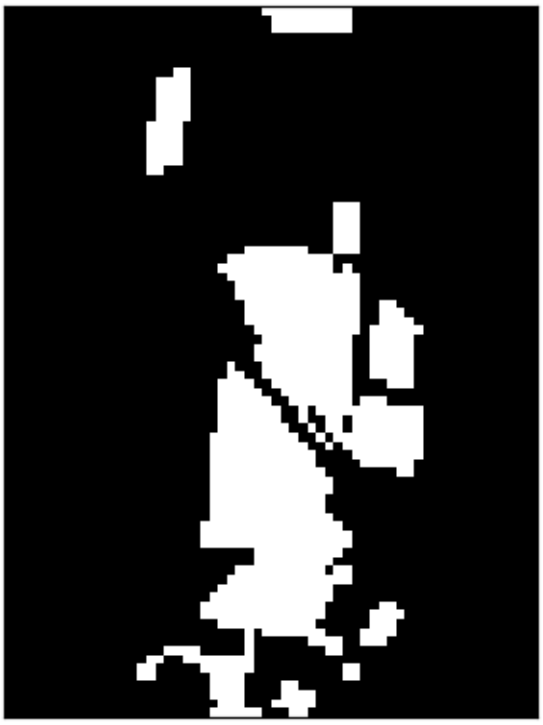
- **filename** – output path
- **vector** (hubflow.core.Vector) – input vector
- **grid** (*hubdc.core.Grid*) –
- **kwargs** –

Returns

Return type *hubflow.core.Mask*

Example

```
>>> import enmapboxtestdata
>>> vector = Vector(filename=enmapboxtestdata.landcover, initValue=0)
>>> grid = Raster(filename=enmapboxtestdata.enmap).grid()
>>> mask = Mask.fromVector(filename='/vsimem/mask.bsq', vector=vector,␣
↪grid=grid)
>>> plotWidget = mask.plotSinglebandGrey()
```



indices()
Return band subset indices.

invert()
Whether to invert the mask.

minOverallCoverage()
Return minimal overall coverage threshold.

noDataValues()
Return band no data values.

resample(*filename*, *grid*, ***kwargs*)
Returns a resampled mask of itself into the given `grid`.

Parameters

- **filename** (*str*) – output path
- **grid** (*hubdc.core.Grid*) – output grid
- **kwargs** – passed to hubflow.core.Applier

Returns

Return type *hubflow.core.Mask*

Example

```
>>> mask = Mask.fromArray(array=[[[0, 1]]], filename='/vsimem/mask.bsq')
>>> grid = Grid(extent=mask.grid().extent(), resolution=mask.grid().
↪resolution().zoom(factor=(2, 1)))
>>> mask.resample(grid=grid, filename='/vsimem/resampled.bsq').array()
array([[[0, 0, 1, 1]]], dtype=uint8)
```

5.1.3 Classification

- ***hubflow.core.Classification*:**
  - *asMask() classDefinition() dtype() fromArray() fromClassification() fromFraction() fromRasterAndFunction() minDominantCoverage() minOverallCoverage() noDataValues() reclassify() resample() statistics()*

class hubflow.core.**Classification**(*filename*, *classDefinition=None*, *minOverallCoverage=0.5*, *minDominantCoverage=0.5*, *eAccess=<sphinx.ext.autodoc.importer._MockObject object>*)

Bases: *hubflow.core.Raster*

Class for managing classifications.

asMask(*minOverallCoverage=0.5*, *invert=False*)
Return itself as a mask.

classDefinition()
Return class definition.

dtype()
Return the smalles data type that is suitable for the number of classes.

classmethod fromArray(*array*, *filename*, *classDefinition=None*, *grid=None*, ***kwargs*)
Create instance from given `array`.

Parameters

- **array** (*numpy.ndarray*) – input array of shape (1, lines, sample)
- **filename** (*str*) – output path
- **classDefinition** (hubflow.core.ClassDefinition) –
- **grid** (*hubdc.core.Grid*) –
- **kwargs** – additional kwargs are passed to Classification contructor

Returns

Return type *hubflow.core.Classification*

Exemple

```
>>> Classification.fromArray(array=[[[0, 1],[1,2]]],
...                          filename='/vsimem/classification.bsq',
...                          classDefinition=ClassDefinition(colors=['red',
↪'blue']))
Classification(filename=/vsimem/classification.bsq,␣
↪classDefinition=ClassDefinition(classes=2, names=['class 1', 'class 2'],␣
↪colors=[Color(255, 0, 0), Color(0, 0, 255)]), minOverallCoverage=0.5,␣
↪minDominantCoverage=0.5)
```

classmethod fromClassification(*filename*, *classification*, *grid=None*, *masks=None*, ***kwargs*)

Create instance from classification-like raster.

Parameters

- **filename** (*str*) – output path
- **classification** (*Union[Classification, VectorClassification, Fraction]*) – classification-like raster
- **grid** (*hubdc.core.Grid*) –
- **masks** (Mask) –
- **kwargs** – passed to Applier

Returns

Return type *hubflow.core.Classification*

static fromEnviSpectralLibrary(*filename*, *library*, *attribute*, *classDefinition=None*)

Create instance from library attribute. If the ClassDefinition is not defined, it is taken from an accompanied JSON file.

Parameters

- **filename** – output path
- **library** (*EnviSpectralLibrary*) –
- **attribute** (*str*) – attribute defined in the corresponding csv file
- **classDefinition** (ClassDefinition) –

Returns

Return type *Classification*

Example

```
>>> import enmapboxtestdata
>>> library = EnviSpectralLibrary(filename=enmapboxtestdata.library)
>>> Classification.fromEnviSpectralLibrary(filename='/vsimem/classification.
↪bsq', library=library, attribute='level_1')
```

classmethod fromFraction(*filename*, *fraction*, *grid=None*, *masks=None*, ***kwargs*)

Forwarded to *fromClassification()*.

classmethod fromRasterAndFunction(*filename*, *raster*, *ufunc*, *classDefinition=None*, ***kwargs*)

Create instance from raster by applying a user-function to it.

Parameters

- **filename** (*str*) – output path
- **raster** (Raster) – input raster
- **ufunc** (*function*) – user-function (taking two arguments: array, metadataDict) to be applied to the raster data (see example below)
- **classDefinition** (ClassDefinition) –
- **kwargs** – passed to Applier

Returns

Return type *Classification*

Example

```
>>> raster = Raster.fromArray(array=[[[1,2,3,4,5]]], filename='/vsimem/raster.
↪bsq')
>>> def ufunc(array, metadataDict):
...     result = np.zeros_like(array) # init result with zeros
...     result[array < 3] = 1 # map all values < 3 to class 1
...     result[array > 3] = 2 # map all values > 3 to class 2
...     return result
>>> classification = Classification.fromRasterAndFunction(raster=raster,␣
↪ufunc=ufunc, filename='/vsimem/classification.bsq')
>>> classification.array()
array([[[1, 1, 0, 2, 2]]], dtype=uint8)
```

minDominantCoverage()
Return minimal dominant class coverage threshold.

minOverallCoverage()
Return minimal overall coverage threshold.

noDataValues()
Returns always [0].

reclassify(*filename*, *classDefinition*, *mapping*, ***kwargs*)
Reclassify classes by given `mapping` new `classDefinition`.

Parameters

- **filename** (*str*) – output path
- **classDefinition** (ClassDefinition) –
- **mapping** (*dict*) –
- **kwargs** – passed to Applier

Returns

Return type *Classification*

Example

```
>>> classification = Classification.fromArray(array=[[[1,2,3,4]]], filename='/
↪vsimem/classification.bsq')
>>> reclassified = classification.reclassify(filename='/vsimem/reclassified.
↪bsq',
...                                          ␣
↪classDefinition=ClassDefinition(classes=2),
...                                           mapping={1: 0, 2: 1, 3: 1, 4: 2})
>>> reclassified.array()
array([[[0, 1, 1, 2]]], dtype=uint8)
```

resample(*filename*, *grid*, ***kwargs*)
Resample itself into the gives `grid`.

Parameters

- **filename** (*str*) – output path
- **grid** (*hubdc.core.Grid*) –
- **kwargs** – passed to Applier

Returns

Return type *Classification*

Example

Resample into a grid with 2x finer resolution

```
>>> classification = Classification.fromArray(array=[[[1,2,3,4]]], filename='/
↪vsimem/classification.bsq')
>>> classification.array()
array([[[1, 2, 3, 4]]], dtype=uint8)
>>> grid = classification.grid()
>>> grid2 = grid.atResolution(resolution=grid.resolution()/2)
>>> resampled = classification.resample(filename='/vsimem/resampled.bsq',␣
↪grid=grid2)
>>> resampled.array()
array([[[1, 1, 2, 2, 3, 3, 4, 4],
        [1, 1, 2, 2, 3, 3, 4, 4]]], dtype=uint8)
```

setClassDefinition(*classDefinition*)

statistics(*mask=None*, ***kwargs*)

Returns list of class counts.

Parameters

- **mask** (Mask) –
- **kwargs** – passed to Applier

Returns

Return type list

Example

```
>>> Classification.fromArray(array=[[[1, 1, 2, 3, 3, 3]]], filename='/vsimem/
↪classification.bsq').statistics()
[2, 1, 3]
```

5.1.4 Fraction

- ***hubflow.core.Fraction*:**
  - *asClassColorRGBRaster()* *classDefinition()* *fromClassification()* *minDominantCoverage()* *minOverallCoverage()* *noDataValues()* *resample()* *subsetClasses()* *subsetClassesByName()*

class hubflow.core.**Fraction**(*filename*, *classDefinition=None*, *minOverallCoverage=0.0*, *minDominantCoverage=0.0*)

Bases: *hubflow.core.Regression*

Class for managing fraction maps.

asClassColorRGBRaster(*filename*, ***kwargs*)

Create RGB image, where the pixel color is the average of the original class colors, weighted by the pixel fractions. Regions with purer pixels (i.e. fraction of a specific class is near 1), appear in the original class colors, and regions with mixed pixels appear in mixed class colors.

Parameters

- **filename** – input path
- **kwargs** – passed to Applier

Returns

Return type

```
>>> import enmapboxtestdata
>>> fraction = Fraction(filename=enmapboxtestdata.landcoverfractions)
>>> rgb = fraction.asClassColorRGBRaster(filename='/vsimem/rgb.bsq')
>>> rgb.plotMultibandColor()
```

classDefinition()
Return the class definition.

classmethod fromClassification(*filename*, *classification*, ***kwargs*)
Create instance from given classification. A simple binarization in fractions of 0 and 1 is performed.

Parameters

- **filename** – output path
- **classification** (Classification) – input classification
- **kwargs** – passed to Applier

Returns Fraction

Return type

Example

```
>>> classification = Classification.fromArray(array=[[[1, 2, 3]]], filename='/
↪vsimem/classification.bsq')
>>> classification.array()
array([[[1, 2, 3]]], dtype=uint8)
>>> fraction = Fraction.fromClassification(classification=classification,␣
↪filename='/vsimem/fraction.bsq')
>>> fraction.array()
array([[[ 1.,  0.,  0.]],
<BLANKLINE>
       [[ 0.,  1.,  0.]],
<BLANKLINE>
       [[ 0.,  0.,  1.]]], dtype=float32)
```

minDominantCoverage()
Return the minimal dominant class coverage threshold.

minOverallCoverage()
Return the minimal overall coverage threshold.

noDataValues()
Returns no data values.

resample(*filename*, *grid*, ***kwargs*)
Resample itself into the given grid using gdal.GRA_Average resampling.

Parameters

- **filename** – output path
- **grid** (*hubdc.core.Grid*) –
- **kwargs** – passed to Applier

Returns

Return type *Fraction*

Example

Resample into grid that is 2x as fine.

```
>>> fraction = Fraction.fromArray(array=[[[0., 0.5, 1.]],
...                                      [[1., 0.5, 1.]]],
...                                filename='/vsimem/fraction.bsq')
>>> fraction.array()
array([[[ 0. ,  0.5,  1. ]],
<BLANKLINE>
       [[ 1. ,  0.5,  1. ]]])
>>> grid = fraction.grid()
>>> grid2 = grid.atResolution(grid.resolution()/(2, 1)) # change only␣
↪resolution in x dimension
>>> resampled = fraction.resample(grid=grid2, filename='/vsimem/resampled.bsq
↪')
>>> resampled.array()
array([[[ 0. ,  0. ,  0.5,  0.5,  1. ,  1. ]],
<BLANKLINE>
       [[ 1. ,  1. ,  0.5,  0.5,  1. ,  1. ]]])
```

subsetClasses(*filename*, *labels*, ***kwargs*)
Subset itself by given class labels.

Parameters

- **filename** – input path
- **labels** – list of labels to be subsetted
- **kwargs** – passed to Applier

Returns

Return type *Fraction*

Example

Subset 2 classes fom a fraction map with 3 classes.

```
>>> fraction = Fraction.fromArray(array=[[[0.0, 0.3]],
...                                      [[0.2, 0.5]],
...                                      [[0.8, 0.2]]],
...                                filename='/vsimem/fraction.bsq')
>>> fraction.array()
array([[[0. , 0.3]],
<BLANKLINE>
       [[0.2, 0.5]],
<BLANKLINE>
       [[0.8, 0.2]]])
>>> subsetted = fraction.subsetClasses(labels=[1, 3], filename='/vsimem/
↪subsetted.bsq')
>>> subsetted.array()
array([[[0. , 0.3]],
<BLANKLINE>
       [[0.8, 0.2]]])
```

subsetClassesByName (*filename*, *names*, ***kwargs*)

Subset itself by given class names.

Parameters

- **filename** – input path
- **names** – list of class names to be subsetted
- **kwargs** – passed to Applier

Returns

Return type *Fraction*

Example

Subset 2 classes fom a fraction map with 3 classes.

```
>>> fraction = Fraction.fromArray(array=[[[0.0, 0.3]],
...                                      [[0.2, 0.5]],
...                                      [[0.8, 0.2]]],
...                                classDefinition=ClassDefinition(names=['a',
↪'b', 'c']),
...                                filename='/vsimem/fraction.bsq')
>>> fraction.classDefinition().names()
['a', 'b', 'c']
>>> fraction.array()
array([[[0. , 0.3]],
<BLANKLINE>
       [[0.2, 0.5]],
<BLANKLINE>
```

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```
       [[0.8, 0.2]]])
>>> subsetted = fraction.subsetClassesByName(names=['a', 'c'], filename='/
↪vsimem/subsetted.bsq')
>>> subsetted.classDefinition().names()
['a', 'c']
>>> subsetted.array()
array([[[0. , 0.3]],
<BLANKLINE>
       [[0.8, 0.2]]])
```

5.1.5 Regression

- ***hubflow.core.Regression*:**
  - *asMask() minOverallCoverage() noDataValues() outputNames() outputs() resample()*

class hubflow.core.**Regression**(*filename*, *noDataValues=None*, *outputNames=None*, *minOverallCoverage=0.5*)

Bases: *hubflow.core.Raster*

Class for managing regression maps.

asMask(*minOverallCoverage=None*, *noDataValues=None*)
Creates a mask instance from itself. Optionally, the minimal overall coverage can be changed.

minOverallCoverage()
Return minimal overall coverage threshold.

noDataValues(*default=None*, *required=True*)
Return no data values.

Example

```
>>> import enmapboxtestdata
>>> Regression(filename=enmapboxtestdata.landcoverfractions).noDataValues()
[-1.0, -1.0, -1.0, -1.0, -1.0, -1.0]
```

outputNames()
Return output names.

Example

```
>>> import enmapboxtestdata
>>> Regression(filename=enmapboxtestdata.landcoverfractions).outputNames()
['Roof', 'Pavement', 'Low vegetation', 'Tree', 'Soil', 'Other']
```

outputs()
Return number of outputs (i.e. number of bands).

Example

```
>>> import enmapboxtestdata
>>> Regression(filename=enmapboxtestdata.landcoverfractions).outputs()
6
```

resample(*filename*, *grid*, ***kwargs*)
Resample itself into the given grid using gdal.GRA_Average resampling.

Parameters

- **filename** – output filename
- **grid** – hubdc.core.Grid
- **kwargs** – passed to Applier

Returns Regression

Return type

Example

Resample into a grid that is 1.5x as fine.

```
>>> regression = Regression.fromArray([[[0., 0.5, 1.]]], noDataValues=[-1],␣
↪filename='/vsimem/regression.bsq')
>>> regression.array()
array([[[ 0. ,  0.5,  1. ]]])
>>> grid = regression.grid()
>>> grid2 = grid.atResolution(resolution=grid.resolution() / 2)
>>> resampled = regression.resample(grid=grid2, filename='/vsimem/resampled.
↪bsq')
>>> resampled.array()
array([[[ 0. ,  0. ,  0.5,  0.5,  1. ,  1. ],
        [ 0. ,  0. ,  0.5,  0.5,  1. ,  1. ]]])
```

5.2 Vector Maps

5.2.1 Vector

- ***hubflow.core.Vector*:**
  - *allTouched()* *burnAttribute()* *burnValue()* *dataset()* *dtype()* *extent()* *filename()* *filterSQL()* *fromPoints()* *fromRandomPointsFromClassification()* *fromRandomPointsFromMask()* *fromVectorDataset()* *grid()* *initValue()* *layer()* *metadataDict()* *metadataItem()* *noDataValue()* *projection()* *uniqueValues()*

class hubflow.core.**Vector**(*filename*, *layer=0*, *initValue=0*, *burnValue=1*, *burnAttribute=None*, *allTouched=False*, *filterSQL=None*, *dtype=<sphinx.ext.autodoc.importer._MockObject object>*, *noDataValue=None*)

Bases: hubflow.core.Map

Class for managing vector maps. See also *VectorMask*, *VectorClassification*

allTouched()
Return rasterization all touched option.

burnAttribute()
Return rasterization burn attribute.

burnValue()
Return rasterization burn value.

dataset()
Return hubdc.core.VectorDataset object.

dtype()
Return rasterization data type.

extent()
Returns the spatial extent.

Example

```
>>> import enmapboxtestdata
>>> Vector(filename=enmapboxtestdata.landcover).extent() # doctest: +ELLIPSIS
SpatialExtent(xmin=383918.24389999924, xmax=384883.2196000004, ymin=5815685.
↪854300001, ymax=5818407.0616999995, projection=Projection(wkt=PROJCS["WGS_
↪1984_UTM_Zone_33N", GEOGCS["GCS_WGS_1984", DATUM["WGS_1984", SPHEROID["WGS_
↪84",6378137,298.257223563]], PRIMEM["Greenwich",0], UNIT["Degree",0.
↪0174532925199433295], AUTHORITY["EPSG","4326"]], ..., AUTHORITY["EPSG","32633
↪"]]))
```

filename()
Return filename.

filterSQL()
Return rasterization SQL filter statement.

classmethod fromPoints(*filename*, *points*)
Create instance from given points. Projection of first point is used.

Example

```
>>> vector = Vector.fromPoints(points=[(-1, -1), (1, 1)],␣
↪filename=join(tempfile.gettempdir(), 'vector.shp'))
>>> grid = Grid(extent=Extent(xmin=-1.5, xmax=1.5, ymin=-1.5, ymax=1.5),␣
↪resolution=1, projection=Projection.wgs84())
>>> raster = Raster.fromVector(filename='/vsimem/raster.bsq', vector=vector,␣
↪grid=grid)
>>> raster.array()
array([[[ 0.,  0.,  1.],
        [ 0.,  0.,  0.],
        [ 1.,  0.,  0.]]], dtype=float32)
```

classmethod fromRandomPointsFromClassification(*filename*, *classification*, *n*, ***kwargs*)
Draw stratified random locations from raster classification and return as point vector.

Parameters

- **filename** (*str*) – output path
- **classification** – input classification used as stratification
- **n** (*List[int]*) – list of number of points, one for each class
- **kwargs** – passed to hubflow.core.Applier

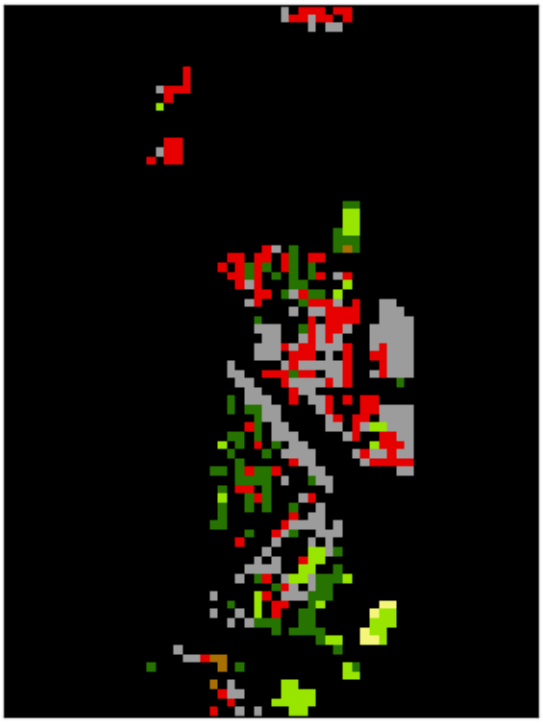
Returns

Return type *hubflow.core.Vector*

Example

Create classification from landcover polygons, ...

```
>>> import enmapboxtestdata
>>> grid = Raster(filename=enmapboxtestdata.enmap).grid()
>>> vectorClassification = VectorClassification(filename=enmapboxtestdata.
↪landcover,
...                                                    ␣
↪classAttribute=enmapboxtestdata.landcoverAttributes.Level_2_ID,
...                                                    ␣
↪classDefinition=ClassDefinition(colors=enmapboxtestdata.
↪landcoverClassDefinition.level2.lookup),
...                                                     oversampling=5)
>>> classification = Classification.fromClassification(filename='/vsimem/
↪classification.bsq', classification=vectorClassification, grid=grid)
>>> classification.plotCategoryBand()
```

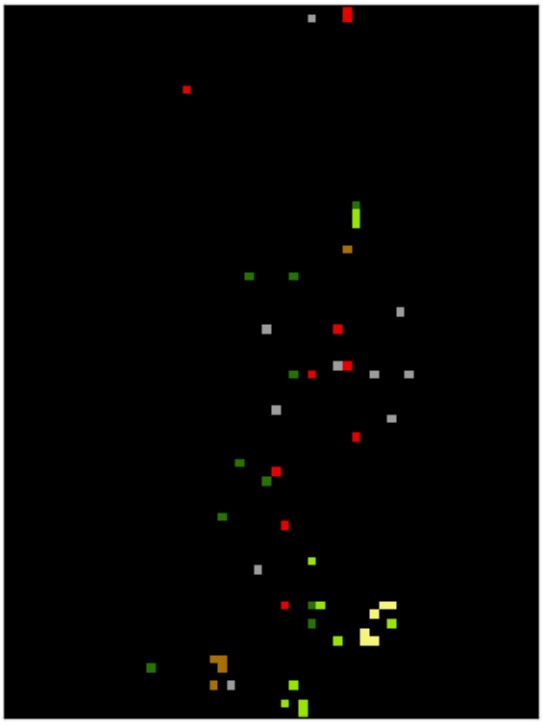


... draw 10 random locations from each class, ...

```
>>> points = Vector.
↪fromRandomPointsFromClassification(classification=classification, n=[10]*6,␣
↪filename=join(tempfile.gettempdir(), 'vector.shp'))
```

... apply those points as mask to the original classification

```
>>> labels = classification.applyMask(filename='/vsimem/labels.bsq',␣
↪mask=points)
>>> labels.plotCategoryBand()
```



classmethod fromRandomPointsFromMask (*filename*, *mask*, *n*, ***kwargs*)

Draw random locations from raster mask and return as point vector.

Parameters

- **filename** (*str*) – output path
- **mask** (hubflow.core.Mask) – input mask
- **n** (*int*) – number of points
- **kwargs** – passed to hubflow.core.Applier

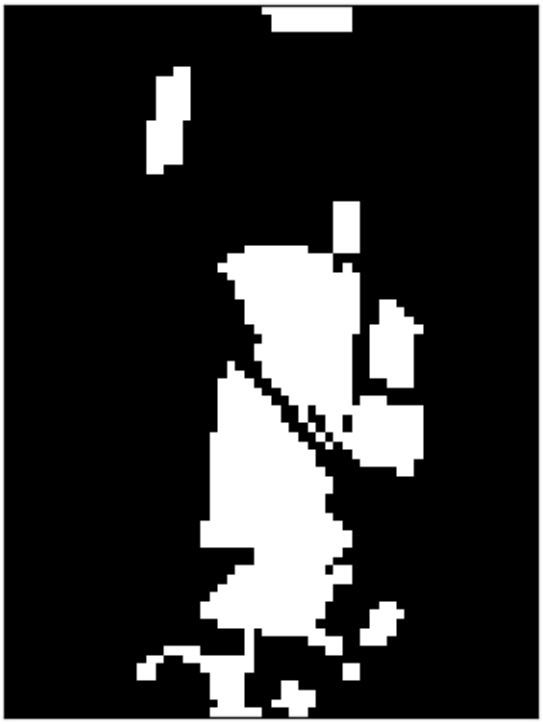
Returns

Return type *hubflow.core.Vector*

Example

Create a mask, . . .

```
>>> import enmapboxtestdata
>>> grid = Raster(filename=enmapboxtestdata.enmap).grid()
>>> mask = Mask.fromVector(filename='/vsimem/mask.bsq',
...                        vector=Vector(filename=enmapboxtestdata.landcover),
↪ grid=grid)
>>> mask.plotSinglebandGrey()
```

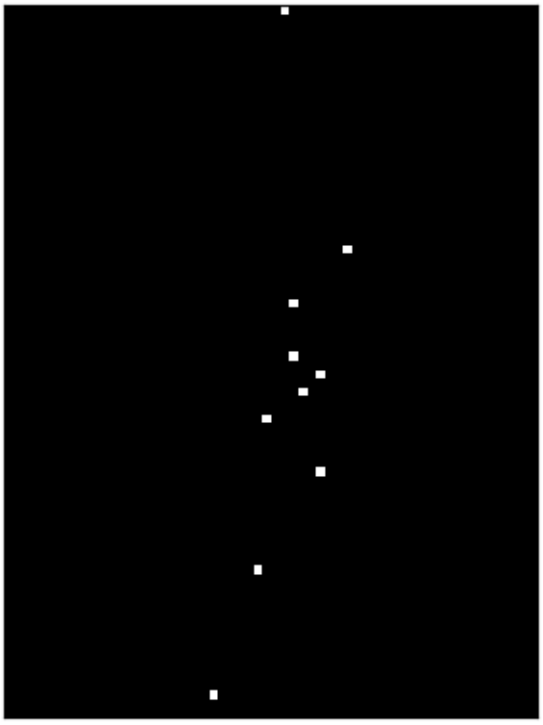


... draw 10 random locations, ...

```
>>> points = Vector.fromRandomPointsFromMask(mask=mask, n=10,␣
↪filename=join(tempfile.gettempdir(), 'vector.shp'))
```

... and rasterize the result into the grid of the mask.

```
>>> Mask.fromVector(filename='/vsimem/mask.bsq', vector=points, grid=grid).
↪plotSinglebandGrey()
```



classmethod fromVectorDataset(*vectorDataset*, ***kwargs*)

Create instance from `vectorDataset`. Additional `kwargs` are passed to the contructor.

Example

```
>>> import enmapboxtestdata
>>> vectorDataset = Vector(filename=enmapboxtestdata.landcover).dataset()
>>> Vector.fromVectorDataset(vectorDataset=vectorDataset) # doctest:␣
↪+ELLIPSIS, +NORMALIZE_WHITESPACE
Vector(filename=...LandCov_BerlinUrbanGradient.shp, layer=0, initValue=0,␣
↪burnValue=1, burnAttribute=None, allTouched=False, filterSQL=None, dtype=
↪<class 'numpy.float32'>, noDataValue=None)
```

grid(*resolution*)

Returns the grid for the given `resolution`.

Example

```
>>> import enmapboxtestdata
>>> Vector(filename=enmapboxtestdata.landcover).grid(resolution=30) #␣
↪doctest: +ELLIPSIS, +NORMALIZE_WHITESPACE
Grid(extent=Extent(xmin=383918.24389999924, xmax=384878.24389999924,
                   ymin=5815685.854300001, ymax=5818415.854300001),
     resolution=Resolution(x=30.0, y=30.0),
     projection=Projection(wkt=PROJCS["WGS_1984_UTM_Zone_33N", GEOGCS["GCS_
↪WGS_1984", DATUM["WGS_1984", SPHEROID["WGS_84",6378137,298.257223563]],␣
↪PRIMEM["Greenwich",0], UNIT["Degree",0.017453292519943295], AUTHORITY["EPSG
↪","4326"]], ..., AUTHORITY["EPSG","32633"]])
```

initValue()

Return rasterization initialization value.

layer()

Return layer name or index

metadataDict()
Return the metadata dictionary for all domains.

metadataItem(*key*, *domain=''*, *dtype=<class 'str'>*, *required=False*, *default=None*)
Returns the value (casted to a specific `dtype`) of a metadata item.

noDataValue(*default=None*)
Return rasterization no data value.

projection()
Returns the projection.

Example

```
>>> import enmapboxtestdata
>>> Vector(filename=enmapboxtestdata.landcover).projection() # doctest:␣
↪+ELLIPSIS
Projection(wkt=PROJCS["WGS_1984_UTM_Zone_33N", GEOGCS["GCS_WGS_1984", DATUM[
↪"WGS_1984", SPHEROID["WGS_84",6378137,298.257223563]], PRIMEM["Greenwich",
↪0], UNIT["Degree",0.0174532925199433295], AUTHORITY["EPSG","4326"]],␣
↪PROJECTION["Transverse_Mercator"], PARAMETER["latitude_of_origin",0],␣
↪PARAMETER["central_meridian",15], PARAMETER["scale_factor",0.9996],␣
↪PARAMETER["false_easting",500000], PARAMETER["false_northing",0], UNIT[
↪"Meter",1], AUTHORITY["EPSG","32633"]])
```

uniqueValues(*attribute*, *spatialFilter=None*)
Return unique values for given attribute.

Parameters

- **attribute** (*str*) –
- **spatialFilter** (*hubdc.core.Geometry*) – optional spatial filter

Returns

Return type List

Example

```
>>> import enmapboxtestdata
>>> vector = Vector(filename=enmapboxtestdata.landcover)
>>> vector.uniqueValues(attribute=enmapboxtestdata.landcoverAttributes.Level_
↪2)
['Low vegetation', 'Other', 'Pavement', 'Roof', 'Soil', 'Tree']
```

```
>>> spatialFilter = SpatialExtent(xmin=384000, xmax=384800,
...                               ymin=5818000, ymax=5819000,
...                               projection=vector.projection()).geometry()
>>> spatialFilter # doctest: +ELLIPSIS
SpatialGeometry(wkt='POLYGON ((384000 5819000 0,384800 5819000 0,384800␣
↪5818000 0,384000 5818000 0,384000 5819000 0))',␣
↪projection=Projection(wkt=PROJCS["WGS_1984_UTM_Zone_33N", ..., AUTHORITY[
↪"EPSG","32633"]]))
>>> vector.uniqueValues(attribute=enmapboxtestdata.landcoverAttributes.Level_
↪2,
...                     spatialFilter=spatialFilter)
['Low vegetation', 'Pavement', 'Roof', 'Tree']
```

5.2.2 VectorMask

- ***hubflow.core.VectorMask*:**
  - *invert() kwargs()*

class hubflow.core.**VectorMask**(*filename*, *invert=False*, ***kwargs*)
Bases: *hubflow.core.Vector*

Class for managing vector masks.

invert()
Returns whether to invert the mask.

kwargs()
Returns additional keyword arguments.

5.2.3 VectorClassification

- ***hubflow.core.VectorClassification*:**
  - *classAttribute() classDefinition() minDominantCoverage() minOverallCoverage() oversampling()*

class hubflow.core.**VectorClassification**(*filename*, *classAttribute*, *classDefinition=None*, *layer=0*, *minOverallCoverage=0.5*, *minDominantCoverage=0.5*, *dtype=<sphinx.ext.autodoc.importer._MockObject object>*, *oversampling=1*)
Bases: *hubflow.core.Vector*

Class for manaing vector classifications.

classAttribute()
Returns the class attribute.

classDefinition()
Returns the class definition.

minDominantCoverage()
Returns the minimal dominant class coverage threshold.

minOverallCoverage()
Returns the minimal overall coverage threshold.

oversampling()
Returns the oversampling factor.

5.3 Samples

5.3.1 Sample

- ***hubflow.core.Sample*:**
  - *extractAsArray() extractAsRaster() grid() mask() masks() raster()*

class hubflow.core.**Sample**(*raster*, *mask=None*, *grid=None*)
Bases: *hubflow.core.MapCollection*

Class for managing unsupervised samples.

extractAsArray(*grid=None*, *masks=None*, *onTheFlyResampling=False*, ***kwargs*)
Extract profiles from raster as array

Parameters

- **grid** (*Grid*) – optional grid for on-the-fly resampling
- **masks** (*List[Map]*) – list of masks instead of self.masks()
- **onTheFlyResampling** (*bool*) – whether to allow on-the-fly resampling
- **kwargs** – passed to Applier

Returns

Return type *Sample*

Example

```
>>> sample = Sample(raster=Raster.fromArray(array=[[[1, 2, 3]],
...                                                [[1, 2, 3]]],
...                                         filename='/vsimem/fraction.bsq'),
...                 mask=Mask.fromArray(array=[[[1, 0, 1]]],
...                                     filename='/vsimem/mask.bsq'))
>>> sample.extractAsArray()[0]
array([[1, 3],
       [1, 3]])
```

extractAsRaster(*filenames*, *grid=None*, *masks=None*, *onTheFlyResampling=False*, ***kwargs*)
Performes *extractAsArray()* and stores the result as raster.

grid()
Return grid.

mask()
Return mask.

masks()
Return maps concidered as masks during sampling (i.e. both raster and mask)

raster()
Return raster.

5.3.2 ClassificationSample

- ***hubflow.core.ClassificationSample*:**
  - *classification() masks() synthMix()*

class hubflow.core.**ClassificationSample**(*raster*, *classification*, *mask=None*, *grid=None*)
Bases: *hubflow.core.Sample*

Class for managing classification samples.

classification()

masks()
Return maps concidered as masks during sampling (i.e. both raster and mask)

synthMix(*filenameFeatures*, *filenameFractions*, *target*, *mixingComplexities*, *classLikelihoods=None*, *n=10*, *includeEndmember=False*, *includeWithinclassMixtures=False*, *targetRange=(0, 1)*, ***kwargs*)

5.3.3 FractionSample

- ***hubflow.core.FractionSample*:**
  - *fraction()*

class hubflow.core.**FractionSample**(*raster*, *fraction*, *mask=None*, *grid=None*)
Bases: *hubflow.core.RegressionSample*

fraction()

5.3.4 RegressionSample

- ***hubflow.core.RegressionSample*:**
  - *masks() regression()*

class hubflow.core.**RegressionSample**(*raster*, *regression*, *mask=None*, *grid=None*)
Bases: *hubflow.core.Sample*

masks()
Return maps concidered as masks during sampling (i.e. both raster and mask)

regression()

5.3.5 MapCollection

- ***hubflow.core.MapCollection*:**
  - *extractAsArray() extractAsRaster() maps()*

class hubflow.core.**MapCollection**(*maps*)
Bases: hubflow.core.FlowObject

Class for managing a collection of Map 's.

extractAsArray(*masks*, *grid=None*, *onTheFlyResampling=False*, ***kwargs*)
Returns a list of arrays, one for each map in the collection. Each array holds the extracted profiles for all pixels, where all maps inside masks evaluate to True.

Parameters

- **masks** (*List[Map]*) – List of maps that are evaluated as masks.
- **grid** (*hubdc.core.Grid*) – If set to None, all pixel grids in the collection and in masks must match. If set to a valid Grid and onTheFlyResampling=True, all maps and masks are resampled.
- **onTheFlyResampling** (*bool*) – If set to True, all maps and masks are resampled into the given grid.
- **kwargs** – passed to *hubflow.core.Applier*

Returns list of 2d arrays of size (bands, profiles)

Return type List[numpy.ndarray]

Example

```
>>> raster = Raster.fromArray(array=[[[1, 2], [3, 4]],[[1, 2], [3, 4]]],␣
↪filename='/vsimem/raster.bsq')
>>> raster.array()
array([[[1, 2],
        [3, 4]],
<BLANKLINE>
       [[1, 2],
        [3, 4]]])
>>> mask = Mask.fromArray(array=[[[1, 0], [0, 1]]], filename='/vsimem/mask.bsq
↪')
>>> mask.array()
array([[[1, 0],
        [0, 1]]], dtype=uint8)
>>> mapCollection = MapCollection(maps=[raster])
>>> mapCollection.extractAsArray(masks=[mask])
[array([[1, 4],
       [1, 4]])]
```

extractAsRaster (*filenames*, *masks*, *grid=None*, *onTheFlyResampling=False*, ***kwargs*)

Returns the result of *extractAsArray()* as a list of Map objects.

Parameters **filenames** (*List[str]*) – list of output paths, one for each map inside the collection

Return type List[Map]

All other parameters are passed to *extractAsArray()*.

Example

Same example as in *extractAsArray()*.

```
>>> raster = Raster.fromArray(array=[[[1, 2], [3, 4]],[[1, 2], [3, 4]]],␣
↪filename='/vsimem/raster.bsq')
>>> raster.array()
array([[[1, 2],
        [3, 4]],
<BLANKLINE>
       [[1, 2],
        [3, 4]]])
>>> mask = Mask.fromArray(array=[[[1, 0], [0, 1]]], filename='/vsimem/mask.bsq
↪')
>>> mask.array()
array([[[1, 0],
        [0, 1]]], dtype=uint8)
>>> mapCollection = MapCollection(maps=[raster])
>>> extractedRaster = mapCollection.extractAsRaster(filenames=['/vsimem/
↪rasterExtracted.bsq'], masks=[mask])
>>> extractedRaster[0].array()
array([[[1],
        [4]],
<BLANKLINE>
       [[1],
        [4]]])
```

maps()

Return the list of maps

5.4 Estimators

5.4.1 Classifier

- ***hubflow.core.Classifier*:**
  - *PREDICT_TYPE()* *SAMPLE_TYPE()* *crossValidation()* *fit()* *predict()* *predictProbability()*

class hubflow.core.**Classifier**(*sklEstimator*, *sample=None*)
Bases: hubflow.core.Estimator

PREDICT_TYPE
alias of *Classification*

SAMPLE_TYPE
alias of *ClassificationSample*

crossValidation(*sample=None*, *cv=3*, *n_jobs=None*)

fit(*sample*)

predict(*filename*, *raster*, *mask=None*, ***kwargs*)

predictProbability(*filename*, *raster*, *mask=None*, *mask2=None*, ***kwargs*)

5.4.2 Regressor

- ***hubflow.core.Regressor*:**
  - *PREDICT_TYPE() SAMPLE_TYPE() fit() predict()*

class hubflow.core.**Regressor**(*sklEstimator*, *sample=None*)
Bases: hubflow.core.Estimator

PREDICT_TYPE
alias of *Regression*

SAMPLE_TYPE
alias of *RegressionSample*

fit(*sample*)

predict(*filename*, *raster*, *mask=None*, ***kwargs*)

5.4.3 Clusterer

- ***hubflow.core.Clusterer*:**
  - *PREDICT_TYPE()* *SAMPLE_TYPE()* *classDefinition()* *fit()* *predict()* *transform()*

class hubflow.core.**Clusterer**(*sklEstimator*, *sample=None*, *classDefinition=None*)
Bases: hubflow.core.Estimator

PREDICT_TYPE
alias of *Classification*

SAMPLE_TYPE
alias of *Sample*

classDefinition()

fit(*sample*)

predict(*filename*, *raster*, *mask=None*, ***kwargs*)

transform(*filename*, *raster*, *inverse=False*, *mask=None*, *mask2=None*, ***kwargs*)

5.4.4 Transformer

- ***hubflow.core.Transformer*:**
  - *PREDICT_TYPE() SAMPLE_TYPE() fit() inverseTransform() transform()*

class hubflow.core.**Transformer**(*sklEstimator*, *sample=None*)
Bases: hubflow.core.Estimator

PREDICT_TYPE
alias of *Raster*

SAMPLE_TYPE
alias of *Sample*

fit(*sample*)

inverseTransform(*filename*, *raster*, *mask=None*, *mask2=None*, ***kwargs*)

transform(*filename*, *raster*, *inverse=False*, *mask=None*, *mask2=None*, ***kwargs*)

5.5 Accuracy Assessment

5.5.1 ClassificationPerformance

- ***hubflow.core.ClassificationPerformance*:**
  - *report()*

class hubflow.core.**ClassificationPerformance**(*yP*, *yT*, *classDefinitionP*, *classDefinitionT*, *classProportions=None*, *N=0*)
Bases: hubflow.core.FlowObject

static fromRaster(*prediction*, *reference*, *mask=None*, ***kwargs*)

report()

5.5.2 RegressionPerformance

- ***hubflow.core.RegressionPerformance*:**
  - *fromRaster() report()*

class hubflow.core.**RegressionPerformance**(*yT*, *yP*, *outputNamesT*, *outputNamesP*)
Bases: hubflow.core.FlowObject

classmethod fromRaster(*prediction*, *reference*, *mask=None*, ***kwargs*)

report()

5.5.3 FractionPerformance

- ***hubflow.core.FractionPerformance*:**
  - *fromRaster() report()*

class hubflow.core.**FractionPerformance**(*yP*, *yT*, *classDefinitionP*, *classDefinitionT*)

Bases: hubflow.core.FlowObject

Class for performing ROC curve analysis.

classmethod fromRaster(*prediction*, *reference*, *mask=None*, ***kwargs*)

Parameters

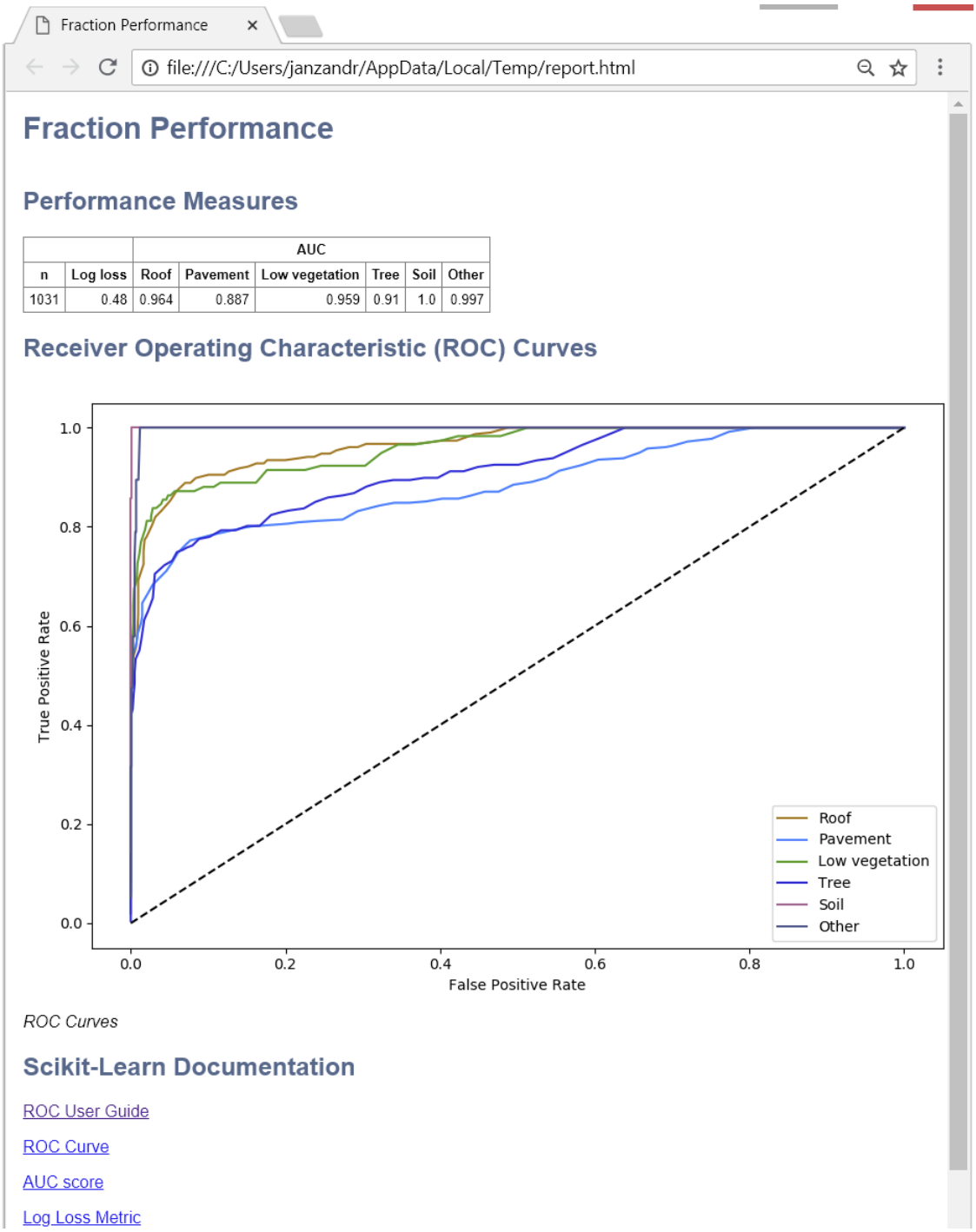
- **prediction** (Fraction) –
- **reference** (Classification) –
- **mask** (Mask) –
- **kwargs** – passed to Applier

Returns

Return type *FractionPerformance*

Example

```
>>> import enmapboxtestdata
>>> performance = FractionPerformance.
↪fromRaster(prediction=Fraction(filename=enmapboxtestdata.
↪landcoverfractions),
...
↪reference=Classification(filename=enmapboxtestdata.landcoverclassification))
>>> performance.log_loss
0.4840965149878993
>>> performance.roc_auc_scores
{1: 0.9640992638757171, 2: 0.8868830628381189, 3: 0.9586349099478203, 4: 0.
↪9102916036557301, 5: 0.9998604910714286, 6: 0.9966195132099022}
>>> performance.report().saveHTML(filename=join(tempfile.gettempdir(),
↪'report.html'), open=True)
```



report()
Returns report. :return: :rtype: hubflow.report.Report

5.5.4 ClusteringPerformance

- ***hubflow.core.ClusteringPerformance***:
  - *report()*

class hubflow.core.**ClusteringPerformance**(*yT*, *yP*)
Bases: hubflow.core.FlowObject

static fromRaster(*prediction*, *reference*, *mask=None*, ***kwargs*)

report()

5.6 Miscellaneous

5.6.1 ClassDefinition

- ***hubflow.core.ClassDefinition*:**
  - *classes() color() colorByName() colors() colorsFlatRGB() dtype() equal() labelByName() labels() name() names() noDataColor() noDataName() setNoDataNameAndColor()*

class hubflow.core.**ClassDefinition**(*classes=None*, *names=None*, *colors=None*)
Bases: hubflow.core.FlowObject

Class for managing class definitions.

classes()
Return number of classes.

color(*label*)
Return color for given label.

colorByName(*name*)
Return color for given name.

colors()
Return class colors.

colorsFlatRGB()
Return colors as flat list of r, g, b values.

Example

```
>>> ClassDefinition(colors=['red', 'blue']).colorsFlatRGB()
[255, 0, 0, 0, 0, 255]
```

dtype()
Return the smalles unsigned integer data type suitable for the number of classes.

Example

```
>>> ClassDefinition(classes=10).dtype()
<class 'numpy.uint8'>
>>> ClassDefinition(classes=1000).dtype()
<class 'numpy.uint16'>
```

equal(*other*, *compareColors=True*)
Return whether self is equal to another instance.

static fromArray(*array*)
Create instance by deriving the number of classes from the maximum value of the array.

Example

```
>>> ClassDefinition.fromArray(array=[[[1, 2, 3]]]) # doctest: +ELLIPSIS
ClassDefinition(classes=3, names=['class 1', 'class 2', 'class 3'], colors=[..
↪.])
```

static fromENVIClassification(*raster*)
Create instance by deriving metadata information for *classes*, *class names* and *class lookup* from the ENVI domain.

static fromENVIFraction(*raster*)
Create instance by deriving metadata information for *band names* and *band lookup* from the ENVI domain.

static fromGDALMeta(*raster*, *index=0*, *skipZeroClass=True*)
Create instance by deriving category names and color table from GDAL raster dataset.

static fromQml(*filename*, *delimiter=';'*)
Create instance from QGIS QML file.

static fromRaster(*raster*)
Create instance by trying to 1) use *fromENVIClassification()*, 2) use *fromGDALMeta()* and finally 3) derive number of classes from raster band maximum value.

labelByName(*name*)
Return label for given name.

labels()
Return class labels.

name(*label*)
Return name for giben label.

names()
Return class names.

noDataColor()
Return no data color.

noDataName()
Return no data name.

setNoDataNameAndColor(*name='Unclassified'*, *color='black'*)
Set no data name and color.

5.6.2 SensorDefinition

- ***hubflow.core.SensorDefinition*:**
  - fromENVISpectralLibrary() *plot()* *resampleProfiles()* *resampleRaster()* *wavebandCount()* *wavebandDefinition()* *wavebandDefinitions()*

class hubflow.core.**SensorDefinition**(*wavebandDefinitions*)
Bases: hubflow.core.FlowObject

Class for managing sensor definitions.

classmethod fromEnviSpectralLibrary(*library*, *isResponseFunction*)
Create instance from EnviSpectralLibrary.

Parameters

- **library** (*EnviSpectralLibrary*) –

- **isResponseFunction** (*bool*) – If True, `library` is interpreted as sensor response function. If False, center wavelength and FWHM information is used.

Return type *SensorDefinition*

Example

Case 1 - Library contains spectra with wavelength and FWHM information (i.e. set `isResponseFunction=False`)

```
>>> import enmapboxtestdata
>>> library = EnviSpectralLibrary(filename=enmapboxtestdata.speclib)
>>> SensorDefinition.fromEnviSpectralLibrary(library=library,␣
↪isResponseFunction=False) # doctest: +ELLIPSIS, +NORMALIZE_WHITESPACE
SensorDefinition(wavebandDefinitions=[WavebandDefinition(center=460.0, fwhm=5.
↪8, responses=[...], name=None),
                                      ...,
                                      WavebandDefinition(center=2409.0,␣
↪fwhm=9.1, responses=[...], name=None)])
```

Case 2 - Library contains response function (i.e. set `isResponseFunction=True`)

```
>>> import hubflow.sensors, os.path
>>> library = EnviSpectralLibrary(filename = os.path.join(hubflow.sensors.__
↪path__[0], 'sentinel2.sli'))
>>> SensorDefinition.fromEnviSpectralLibrary(library=library,␣
↪isResponseFunction=True) # doctest: +ELLIPSIS, +NORMALIZE_WHITESPACE
SensorDefinition(wavebandDefinitions=[WavebandDefinition(center=443.0,␣
↪fwhm=None, responses=[...], name=Sentinel-2 - Band B1),
                                      ...,
                                      WavebandDefinition(center=2196.5,␣
↪fwhm=None, responses=[...], name=Sentinel-2 - Band B12)])
```

static fromPredefined(*name*)

Create an instance for a predefined sensor (e.g. `name='sentinel2'`). See *predefinedSensorNames()* for a full list of predifined sensors. Sensor response filter functions (.sli files) are stored here *hubflow/sensors*.

Example

```
>>> SensorDefinition.fromPredefined(name='sentinel2') # doctest: +ELLIPSIS,␣
↪+NORMALIZE_WHITESPACE
SensorDefinition(wavebandDefinitions=[WavebandDefinition(center=443.0,␣
↪fwhm=None, responses=[...], name=Sentinel-2 - Band B1),
                                      ...,
                                      WavebandDefinition(center=2196.5,␣
↪fwhm=None, responses=[...], name=Sentinel-2 - Band B12)])
```

static fromRaster(*raster*)

Forwards *Raster.sensorDefinition()*.

plot(*plotWidget=None*, *yscale=1.0*, ***kwargs*)

Return sensor definition plot.

Parameters

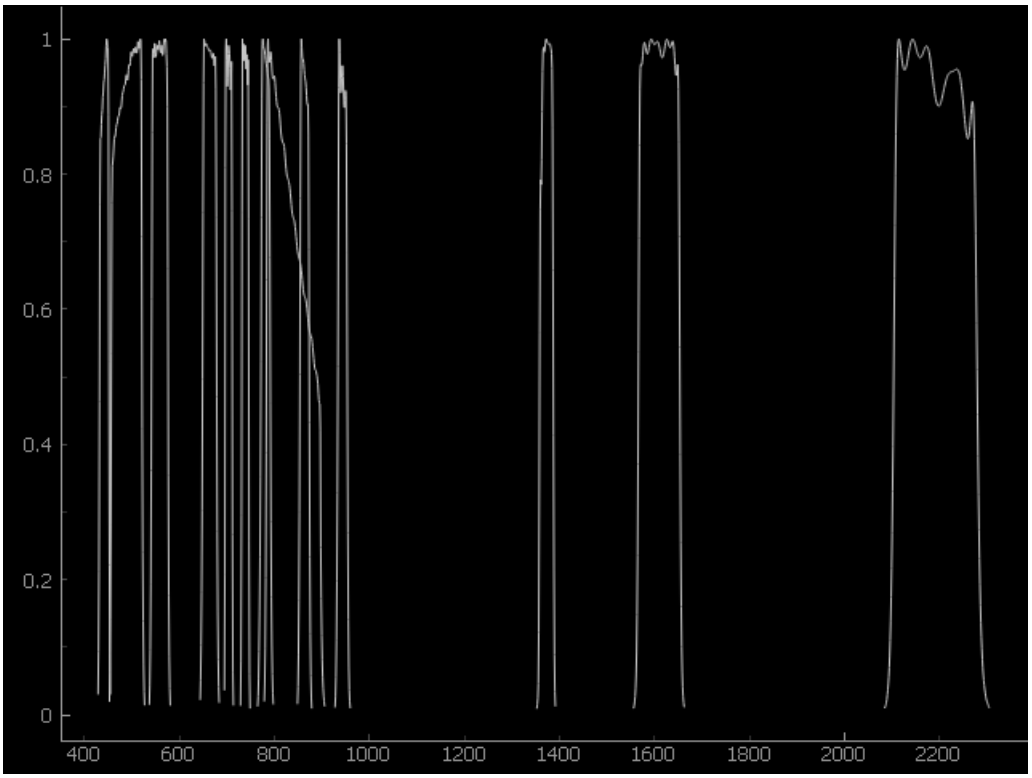
- **plotWidget** (*pyqtgraph.graphicsWindows.PlotWindow*) – if None, a new plot widget is created, otherwise, the given `plotWidget` is used
- **yscale** (*float*) – scale factor for y values

- **kwargs** – passed to `pyqtgraph.graphicsWindows.PlotWindow.plot`

Return type pyqtgraph.graphicsWindows.PlotWindow

Example

```
>>> plotWidget = SensorDefinition.fromPredefined(name='sentinel2').plot()
```



static predefinedSensorNames()

Return list of predefined sensor names.

Example

```
>>> SensorDefinition.predefinedSensorNames()
['modis', 'moms', 'mss', 'npp_viirs', 'pleiades1a', 'pleiades1b', 'quickbird',
↪ 'rapideye', 'rasat', 'seawifs', 'sentinel2', 'spot', 'spot6', 'tm',
↪'worldview1', 'worldview2', 'worldview3']
```

resampleProfiles(*array*, *wavelength*, *wavelengthUnits*, *minResponse=None*, *resampleAlg=None*, ***kwargs*)

Resample a list of profiles given as a 2d `array` of size (profiles, bands).

Implementation: the `array`, together with the `wavelength` and `wavelengthUnits` metadata, is turned into a spectral raster, which is resampled using :class:~hubflow.core.SensorDefinition.resampleRaster‘‘.

Parameters

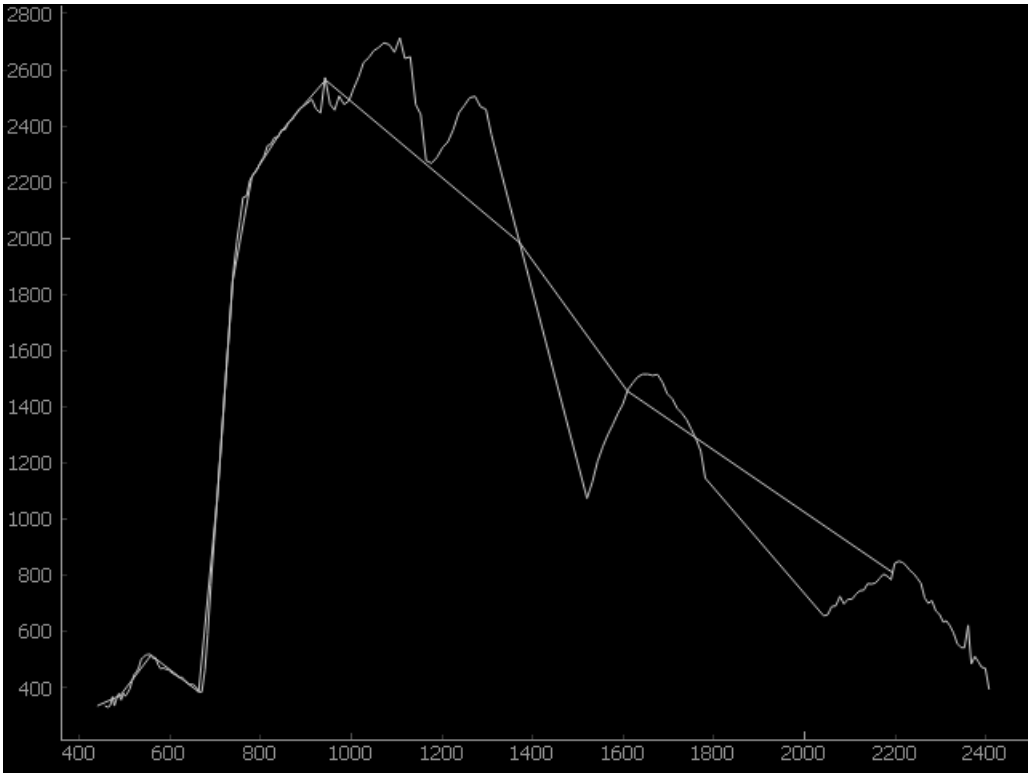
- **array** (*Union[list, numpy.ndarray]*) – list of profiles or 2d array of size (profiles, bands)
- **wavelength** (*List[float]*) – list of center wavelength of size (bands,)
- **wavelengthUnits** (*str*) – wavelength unit ‘nanometers’ | ‘micrometers’

- **minResponse** – passed to *resampleRaster()*
- **resampleAlg** – passed to *resampleRaster()*
- **kwargs** – passed to *resampleRaster*

Return type numpy.ndarray

Example

```
>>> import pyqtgraph as pg
>>> import enmapboxtestdata
>>> sentinel2Sensor = SensorDefinition.fromPredefined(name='sentinel2')
>>> enmapRaster = Raster(filename=enmapboxtestdata.enmap)
>>> enmapArray = enmapRaster.array().reshape((enmapRaster.shape()[0], -1)).T
>>> resampled = sentinel2Sensor.resampleProfiles(array=enmapArray,␣
↪wavelength=enmapRaster.metadataWavelength(), wavelengthUnits='nanometers')
>>> index = 0 # select single profile
>>> plotWidget = pg.plot(x=enmapRaster.metadataWavelength(),␣
↪y=enmapArray[index]) # draw original enmap profile
>>> plotWidget = plotWidget.plot(x=[wd.center() for wd in sentinel2Sensor.
↪wavebandDefinitions()], y=resampled[index]) # draw resampled profile on top
```



resampleRaster (*filename*, *raster*, *minResponse=None*, *resampleAlg='linear'*, ***kwargs*)

Resample the given spectral `raster`.

Parameters

- **filename** (*str*) – output path
- **raster** (hubflow.core.Raster) – spectral raster
- **minResponse** (*float*) – limits the wavelength region of the response filter function to wavelength with responses higher than `minResponse`; higher values speed up compu-

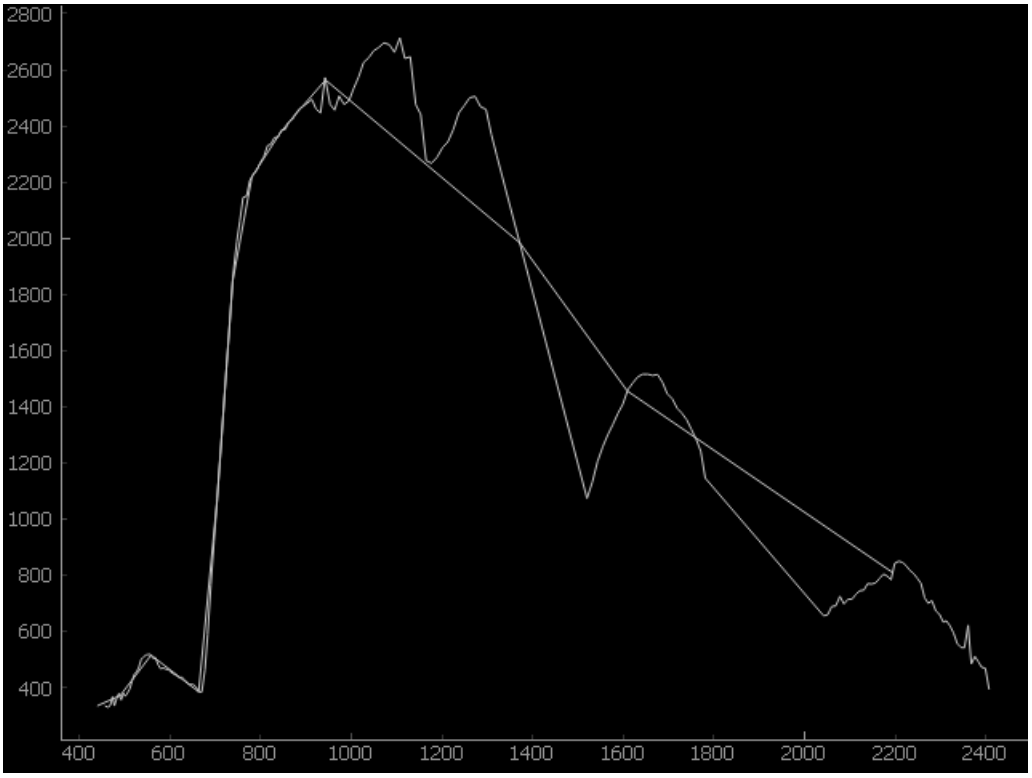
tation; 0.5 corresponds to the full width at half maximum region; values greater 0.5 may lead to very inaccurate results

- **resampleAlg** (*enum(SensorDefinition.RESAMPLE_LINEAR, SensorDefinition.RESAMPLE_RESPONSE)*) – available resampling algorithms are linear interpolation between neighbouring wavelength and response function filtering
- **kwargs** – passed to hubflow.core.Applier

Return type Union[*hubflow.core.Raster*, None]

Example

```
>>> import enmapboxtestdata
>>> sentinel2Sensor = SensorDefinition.fromPredefined(name='sentinel2')
>>> enmapRaster = Raster(filename=enmapboxtestdata.enmap)
>>> resampled = sentinel2Sensor.resampleRaster(filename='/vsimem/
↪resampledLinear.bsq', raster=enmapRaster)
>>> pixel = Pixel(x=0, y=0)
>>> plotWidget = enmapRaster.plotZProfile(pixel=pixel, spectral=True,␣
↪xscale=1000) # draw original enmap profile
>>> plotWidget = resampled.plotZProfile(pixel=pixel, spectral=True,␣
↪plotWidget=plotWidget) # draw resampled profile on top
```



wavebandCount()
Return number of wavebands.

wavebandDefinition(*index*)
Return *WavebandDefinition* for band given by index.

wavebandDefinitions()
Return iterator over all *WavebandDefinition*'s.

```
RESAMPLE_LINEAR = 'linear'

RESAMPLE_OPTIONS = ['linear', 'response']

RESAMPLE_RESPONSE = 'response'
```

5.6.3 WavebandDefinition

- ***hubflow.core.WavebandDefinition*:**
  - *center() fwhm() name() plot() resamplingWeights() responses()*

class hubflow.core.**WavebandDefinition**(*center*, *fwhm=None*, *responses=None*, *name=None*)
Bases: hubflow.core.FlowObject

Class for managing waveband definitions.

center()
Return center wavelength location.

```
>>> WavebandDefinition(center=560).center()
560.0
```

static fromFWHM(*center*, *fwhm*, *sigmaLimits=3*)
Create an instance from given center and fwhm. The waveband response function is modeled inside the range: center +/- sigma * sigmaLimits, where sigma is given by fwhm / 2.3548.

Example

```
>>> WavebandDefinition.fromFWHM(center=500, fwhm=10) # doctest: +ELLIPSIS,␣
↪+NORMALIZE_WHITESPACE
WavebandDefinition(center=500.0, fwhm=10.0, responses=[(487.0, 0.
↪009227241211564235), (488.0, 0.01845426465118729), (489.0, 0.
↪03491721729455092), (490.0, 0.06250295020961404), (491.0, 0.
↪10584721091054979), (492.0, 0.1695806637893581), (493.0, 0.
↪2570344015689991), (494.0, 0.3685735673688072), (495.0, 0.5000059003147861),
↪ (496.0, 0.6417177952459099), (497.0, 0.7791678897157294), (498.0, 0.
↪8950267608170881), (499.0, 0.9726554065273144), (500.0, 1.0), (501.0, 0.
↪9726554065273144), (502.0, 0.8950267608170881), (503.0, 0.7791678897157294),
↪ (504.0, 0.6417177952459099), (505.0, 0.5000059003147861), (506.0, 0.
↪3685735673688072), (507.0, 0.2570344015689991), (508.0, 0.1695806637893581),
↪ (509.0, 0.10584721091054979), (510.0, 0.06250295020961404), (511.0, 0.
↪03491721729455092)], name=None)
```

fwhm()
Return full width at half maximum.

```
>>> WavebandDefinition(center=560, fwhm=10).fwhm()
10.0
```

name()
Return waveband name.

Example

```
>>> for wavebandDefinition in SensorDefinition.fromPredefined(name='sentinel2
↪').wavebandDefinitions():
...     print(wavebandDefinition.name())
Sentinel-2 - Band B1
```

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```
Sentinel-2 - Band B2
Sentinel-2 - Band B3
Sentinel-2 - Band B4
Sentinel-2 - Band B5
Sentinel-2 - Band B6
Sentinel-2 - Band B7
Sentinel-2 - Band B8
Sentinel-2 - Band B8A
Sentinel-2 - Band B9
Sentinel-2 - Band B10
Sentinel-2 - Band B11
Sentinel-2 - Band B12
```

plot (*plotWidget=None*, *yscale=1.0*, ***kwargs*)

Return response function plot.

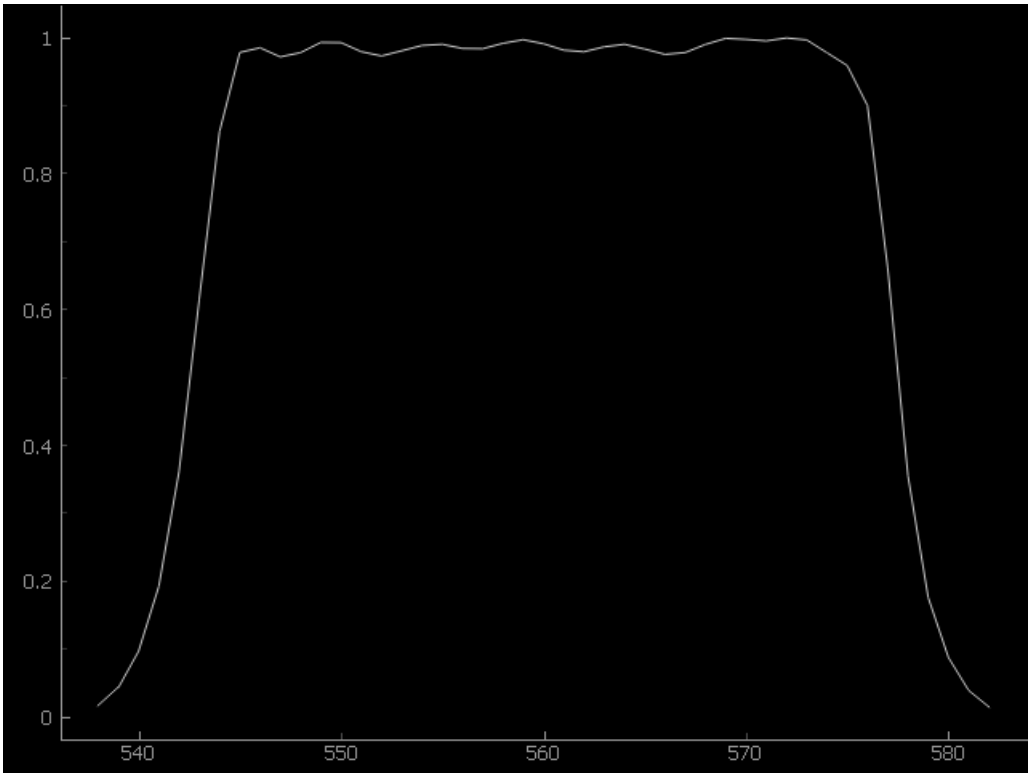
Parameters

- **plotWidget** (*pyqtgraph.graphicsWindows.PlotWindow*) – if None, a new plot widget is created, otherwise, the given `plotWidget` is used
- **yscale** (*float*) – scale factor for y values
- **kwargs** – passed to `pyqtgraph.graphicsWindows.PlotWindow.plot`

Return type pyqtgraph.graphicsWindows.PlotWindow

Example

```
>>> plotWidget = SensorDefinition.fromPredefined(name='sentinel2').
↪wavebandDefinition(index=2).plot()
```



resamplingWeights(*sensor*)

Return resampling weights for the center wavelength of the given *SensorDefinition*.

Example

Calculate weights for resampling EnMAP sensor into Sentinel-2 band 3.

```
>>> import enmapboxtestdata
>>> enmapSensor = Raster(filename=enmapboxtestdata.enmap).sensorDefinition()
>>> enmapSensor # doctest: +ELLIPSIS, +NORMALIZE_WHITESPACE
SensorDefinition(wavebandDefinitions=[WavebandDefinition(center=460.0, fwhm=5.
↪8, responses=[(452.0, 0.0051192261189367235), ..., (466.0, 0.
↪051454981460462346)], name=None),
                                      ...,
                                      WavebandDefinition(center=2409.0,␣
↪fwhm=9.1, responses=[(2397.0, 0.008056878623001433), ..., (2419.0, 0.
↪035151930528992195)], name=None)])
>>> sentinel2Band4 = SensorDefinition.fromPredefined(name='sentinel2').
↪wavebandDefinition(index=2)
>>> sentinel2Band4 # doctest: +ELLIPSIS, +NORMALIZE_WHITESPACE
WavebandDefinition(center=560.0, fwhm=None, responses=[(538.0, 0.01591234), ..
↪., (582.0, 0.01477064)], name=Sentinel-2 - Band B3)
>>> weights = sentinel2Band4.resamplingWeights(sensor=enmapSensor)
>>> centers = [wd.center() for wd in enmapSensor.wavebandDefinitions()]
>>> list(zip(centers, weights)) # doctest: +ELLIPSIS, +NORMALIZE_WHITESPACE
[(460.0, 0.0), ..., (533.0, 0.0), (538.0, 0.01591234), (543.0, 0.6156192),␣
↪(549.0, 0.99344666), (554.0, 0.98899243), (559.0, 0.99746124), (565.0, 0.
↪98366361), (570.0, 0.99787368), (575.0, 0.95940618), (581.0, 0.03900649),␣
↪(587.0, 0.0), ..., (2409.0, 0.0)]
```

responses()

Return response function as list of (wavelength, response) tuples.

Example

```
>>> sentinelBlue = SensorDefinition.fromPredefined(name='sentinel2').
↪wavebandDefinition(index=1)
>>> sentinelBlue.responses()
[(454.0, 0.02028969), (455.0, 0.06381729), (456.0, 0.14181057), (457.0, 0.
↪27989078), (458.0, 0.53566604), (459.0, 0.75764752), (460.0, 0.81162521),␣
↪(461.0, 0.81796823), (462.0, 0.82713398), (463.0, 0.8391982), (464.0, 0.
↪85271397), (465.0, 0.85564352), (466.0, 0.85505457), (467.0, 0.86079216),␣
↪(468.0, 0.86901422), (469.0, 0.8732093), (470.0, 0.8746579), (471.0, 0.
↪87890232), (472.0, 0.88401742), (473.0, 0.88568426), (474.0, 0.8864462),␣
↪(475.0, 0.89132953), (476.0, 0.89810187), (477.0, 0.89921862), (478.0, 0.
↪89728783), (479.0, 0.899455), (480.0, 0.90808729), (481.0, 0.91663575),␣
↪(482.0, 0.92044598), (483.0, 0.92225061), (484.0, 0.9262647), (485.0, 0.
↪93060572), (486.0, 0.93187505), (487.0, 0.93234856), (488.0, 0.93660786),␣
↪(489.0, 0.94359652), (490.0, 0.94689153), (491.0, 0.94277939), (492.0, 0.
↪93912406), (493.0, 0.9435992), (494.0, 0.95384075), (495.0, 0.96115588),␣
↪(496.0, 0.96098811), (497.0, 0.96023166), (498.0, 0.96653039), (499.0, 0.
↪97646982), (500.0, 0.98081022), (501.0, 0.97624561), (502.0, 0.97399225),␣
↪(503.0, 0.97796507), (504.0, 0.98398942), (505.0, 0.98579982), (506.0, 0.
↪98173313), (507.0, 0.97932703), (508.0, 0.98329935), (509.0, 0.98777523),␣
↪(510.0, 0.98546073), (511.0, 0.97952735), (512.0, 0.97936162), (513.0, 0.
↪98807291), (514.0, 0.99619133), (515.0, 0.99330779), (516.0, 0.98572054),␣
↪(517.0, 0.9860457), (518.0, 0.99517659), (519.0, 1.0), (520.0, 0.99782113),␣
↪(521.0, 0.93955431), (522.0, 0.70830999), (523.0, 0.42396802), (524.0, 0.
↪24124566), (525.0, 0.13881543), (526.0, 0.07368388), (527.0, 0.03404689),␣
↪(528.0, 0.01505348)]
```

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5.6.4 MetadataEditor

- ***hubflow.core.MetadataEditor*:**
  - *bandCharacteristics()* *bandNames()* *setBandCharacteristics()* *setBandNames()* *setFractionDefinition()* *setRegressionDefinition()*

class hubflow.core.**MetadataEditor**

Bases: object

classmethod bandCharacteristics(*rasterDataset*)

classmethod bandNames(*rasterDataset*)

classmethod setBandCharacteristics(*rasterDataset*, *bandNames=None*, *wavelength=None*, *fwhm=None*, *wavelengthUnits=None*)

classmethod setBandNames(*rasterDataset*, *bandNames*)

static setClassDefinition(*rasterDataset*, *classDefinition*)

classmethod setFractionDefinition(*rasterDataset*, *classDefinition*)

classmethod setRegressionDefinition(*rasterDataset*, *noDataValues*, *outputNames*)

5.7 Applier

5.7.1 Applier

- ***hubflow.core.Applier*:**
  - *apply()* *setFlowClassification()* *setFlowFraction()* *setFlowInput()* *setFlowMask()* *setFlowMasks()* *setFlowRaster()* *setFlowRegression()* *setFlowVector()* *setOutputRaster()*

class hubflow.core.**Applier**(*defaultGrid=None*, ***kwargs*)

Bases: sphinx.ext.autodoc.importer._MockObject

apply(*operatorType=None*, *description=None*, **ufuncArgs*, ***ufuncKwargs*)

setFlowClassification(*name*, *classification*)

setFlowFraction(*name*, *fraction*)

setFlowInput(*name*, *input*)

setFlowMask(*name*, *mask*)

setFlowMasks(*masks*)

setFlowRaster(*name*, *raster*)

setFlowRegression(*name*, *regression*)

setFlowVector(*name*, *vector*)

setOutputRaster(*name*, *filename*)

5.7.2 ApplierOperator

- ***hubflow.core.ApplierOperator*:**
  - *flowClassificationArray()* *flowFractionArray()* *flowInputArray()* *flowInputDType()* *flowInputZSize()* *flowMaskArray()* *flowMasksArray()* *flowRasterArray()* *flowRegressionArray()* *flowVectorArray()* *maskFromArray()* *maskFromBandArray()* *maskFromFractionArray()* *setFlowMetadataBandNames()* *setFlowMetadataClassDefinition()* *setFlowMetadataFractionDefinition()* *setFlowMetadataNoDataValues()* *setFlowMetadataRegressionDefinition()* *setFlowMetadataSensorDefinition()*

class hubflow.core.**ApplierOperator**(**args*, ***kwargs*)

Bases: sphinx.ext.autodoc.importer._MockObject

flowClassificationArray(*name*, *classification*, *overlap=0*)

flowFractionArray(*name*, *fraction*, *overlap=0*)

flowInputArray(*name*, *input*, *overlap=0*)

flowInputDType(*name*, *input*)

flowInputZSize(*name*, *input*)

flowMaskArray(*name*, *mask*, *aggregateFunction=None*, *overlap=0*)

flowMasksArray(*masks*, *aggregateFunction=None*, *overlap=0*)

flowRasterArray(*name*, *raster*, *indices=None*, *overlap=0*)

flowRegressionArray(*name*, *regression*, *overlap=0*)

flowVectorArray(*name*, *vector*, *overlap=0*)

maskFromArray(*array*, *noDataValues=None*, *defaultNoDataValue=None*, *noDataValueSource=None*, *aggregateFunction=None*)

maskFromBandArray(*array*, *noDataValue=None*, *noDataValueSource=None*, *index=None*)

maskFromFractionArray(*fractionArray*, *minOverallCoverage*, *minDominantCoverage*, *invert=False*)

setFlowMetadataBandNames(*name*, *bandNames*)

setFlowMetadataClassDefinition(*name*, *classDefinition*)

setFlowMetadataFractionDefinition(*name*, *classDefinition*)

setFlowMetadataNoDataValues(*name*, *noDataValues*)

setFlowMetadataRegressionDefinition(*name*, *noDataValues*, *outputNames*)

setFlowMetadataSensorDefinition(*name*, *sensor*)

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