reflectance

October 8, 2023

0.1 Reflectance

[1]:
```
import os
```

[2]:
```
granule_asset_id = 'EMIT_L2A_RFL_001_20231005T044255_2327803_027.nc'
fp = f'./{granule_asset_id}'
```

[3]:
```
import netCDF4 as nc
```

[4]:
```
ds_nc = nc.Dataset(fp)
ds_nc
```

[4]:
```
<class 'netCDF4._netCDF4.Dataset'>
root group (NETCDF4 data model, file format HDF5):
    ncei_template_version: NCEI_NetCDF_Swath_Template_v2.0
    summary: The Earth Surface Mineral Dust Source Investigation (EMIT) is an
Earth Ventures-Instrument (EVI-4) Mission that maps the surface mineralogy of
arid dust source regions via imaging spectroscopy in the visible and short-wave
infrared (VSWIR). Installed on the International Space Station (ISS), the EMIT
instrument is a Dyson imaging spectrometer that uses contiguous spectroscopic
measurements from 410 to 2450 nm to resolve absoprtion features of iron oxides,
clays, sulfates, carbonates, and other dust-forming minerals. During its one-
year mission, EMIT will observe the sunlit Earth's dust source regions that
occur within +/-52° latitude and produce maps of the source regions that can be
used to improve forecasts of the role of mineral dust in the radiative forcing
(warming or cooling) of the atmosphere.\n\nThis file contains L2A estimated
surface reflectances and geolocation data. Reflectance estimates are created
using an Optimal Estimation technique - see ATBD for details. Reflectance values
are reported as fractions (relative to 1). Geolocation data (latitude,
longitude, height) and a lookup table to project the data are also included.
    keywords: Imaging Spectroscopy, minerals, EMIT, dust, radiative forcing
    Conventions: CF-1.63
    sensor: EMIT (Earth Surface Mineral Dust Source Investigation)
    instrument: EMIT
    platform: ISS
    institution: NASA Jet Propulsion Laboratory/California Institute of
Technology
    license: https://science.nasa.gov/earth-science/earth-science-data/data-
```

information-policy/
    naming_authority: LPDAAC
    date_created: 2023-10-06T01:49:51Z
    keywords_vocabulary: NASA Global Change Master Directory (GCMD) Science
Keywords
    stdname_vocabulary: NetCDF Climate and Forecast (CF) Metadata Convention
    creator_name: Jet Propulsion Laboratory/California Institute of Technology
    creator_url: https://earth.jpl.nasa.gov/emit/
    project: Earth Surface Mineral Dust Source Investigation
    project_url: https://earth.jpl.nasa.gov/emit/
    publisher_name: NASA LPDAAC
    publisher_url: https://lpdaac.usgs.gov
    publisher_email: lpdaac@usgs.gov
    identifier_product_doi_authority: https://doi.org
    flight_line: emit20231005t044255_o27803_s002
    time_coverage_start: 2023-10-05T04:42:55+0000
    time_coverage_end: 2023-10-05T04:43:16+0000
    software_build_version: 010618
    software_delivery_version: 010618
    product_version: V001
    history: PGE Run Command: {python /beegfs/store/emit/ops/repos/emit-
sds-l2a/spectrum_quality.py /tmp/emit/ops/emit20231005t044255_emit.L2AReflectanc
e_20231005t183016/output/emit20231005t044255_rfl /tmp/emit/ops/emit20231005t0442
55_emit.L2AReflectance_20231005t183016/output/emit20231005t044255_rfl_quality.tx
t}, PGE Input Files: {radiance_file=/beegfs/store/emit/ops/data/acquisitions/202
31005/emit20231005t044255/l1b/emit20231005t044255_o27803_s002_l1b_rdn_b0106_v01.
img, pixel_locations_file=/beegfs/store/emit/ops/data/acquisitions/20231005/emit
20231005t044255/l1b/emit20231005t044255_o27803_s002_l1b_loc_b0106_v01.img, obser
vation_parameters_file=/beegfs/store/emit/ops/data/acquisitions/20231005/emit202
31005t044255/l1b/emit20231005t044255_o27803_s002_l1b_obs_b0106_v01.img,
surface_model_config=/beegfs/store/emit/ops/repos/emit-
sds-l2a/surface/surface_20221020.json}
    crosstrack_orientation: as seen on ground
    easternmost_longitude: 111.88940435238018
    northernmost_latitude: 45.5444967848159
    westernmost_longitude: 109.744332502246
    southernmost_latitude: 44.265370269531125
    spatialResolution: 0.000542232520256367
    spatial_ref: GEOGCS["WGS 84",DATUM["WGS_1984",SPHEROID["WGS 84",6378137,298.
257223563,AUTHORITY["EPSG","7030"]],AUTHORITY["EPSG","6326"]],PRIMEM["Greenwich"
,0,AUTHORITY["EPSG","8901"]],UNIT["degree",0.0174532925199433,AUTHORITY["EPSG","
9122"]],AXIS["Latitude",NORTH],AXIS["Longitude",EAST],AUTHORITY["EPSG","4326"]]
    geotransform: [1.09744333e+02 5.42232520e-04 -0.00000000e+00
4.55444968e+01
 -0.00000000e+00 -5.42232520e-04]
    day_night_flag: Day
    title: EMIT L2A Estimated Surface Reflectance 60 m V001

```
    dimensions(sizes): downtrack(2272), crosstrack(1242), bands(285),
ortho_y(2359), ortho_x(3956)
    variables(dimensions): float32 reflectance(downtrack, crosstrack, bands)
    groups: sensor_band_parameters, location
```

[5]:
```
import xarray as xr
```

[6]:
```
ds = xr.open_dataset(fp)
ds
```

```
C:\Users\59175\anaconda3\lib\site-packages\scipy\__init__.py:146: UserWarning: A
NumPy version >=1.16.5 and <1.23.0 is required for this version of SciPy
(detected version 1.26.0
  warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversion}"
```

[6]:
```
<xarray.Dataset>
Dimensions:      (downtrack: 2272, crosstrack: 1242, bands: 285)
Dimensions without coordinates: downtrack, crosstrack, bands
Data variables:
    reflectance  (downtrack, crosstrack, bands) float32 …
Attributes: (12/38)
    ncei_template_version:             NCEI_NetCDF_Swath_Template_v2.0
    summary:                           The Earth Surface Mineral Dust Source …
    keywords:                          Imaging Spectroscopy, minerals, EMIT, …
    Conventions:                       CF-1.63
    sensor:                            EMIT (Earth Surface Mineral Dust Sourc…
    instrument:                        EMIT
    …                                  …
    southernmost_latitude:             44.265370269531125
    spatialResolution:                 0.000542232520256367
    spatial_ref:                       GEOGCS["WGS 84",DATUM["WGS_1984",SPHER…
    geotransform:                      [ 1.09744333e+02  5.42232520e-04 -0.00…
    day_night_flag:                    Day
    title:                             EMIT L2A Estimated Surface Reflectance…
```

[7]:
```
ds_nc.groups.keys()
```

[7]:
```
dict_keys(['sensor_band_parameters', 'location'])
```

[8]:
```
wvl = xr.open_dataset(fp,group='sensor_band_parameters')
wvl
```

[8]:
```
<xarray.Dataset>
Dimensions:           (bands: 285)
Dimensions without coordinates: bands
Data variables:
    wavelengths       (bands) float32 …
```

```
    fwhm              (bands) float32 …
    good_wavelengths  (bands) float32 …
```

[9]:
```
loc = xr.open_dataset(fp,group='location')
loc
```

[9]:
```
<xarray.Dataset>
Dimensions:  (downtrack: 2272, crosstrack: 1242, ortho_y: 2359, ortho_x: 3956)
Dimensions without coordinates: downtrack, crosstrack, ortho_y, ortho_x
Data variables:
    lon      (downtrack, crosstrack) float64 …
    lat      (downtrack, crosstrack) float64 …
    elev     (downtrack, crosstrack) float64 …
    glt_x    (ortho_y, ortho_x) float64 …
    glt_y    (ortho_y, ortho_x) float64 …
```

[10]:
```
# Create coordinates and an index for the downtrack and crosstrack dimensions,␣
 ↪then unpack the variables from the wvl and loc datasets and set them as␣
 ↪coordinates for ds
ds = ds.assign_coords({'downtrack':(['downtrack'], ds.downtrack.
 ↪data),'crosstrack':(['crosstrack'],ds.crosstrack.data), **wvl.variables,␣
 ↪**loc.variables})
ds
```

[10]:
```
<xarray.Dataset>
Dimensions:            (downtrack: 2272, crosstrack: 1242, bands: 285,
                        ortho_y: 2359, ortho_x: 3956)
Coordinates:
  * downtrack          (downtrack) int64 0 1 2 3 4 5 … 2267 2268 2269 2270 2271
  * crosstrack         (crosstrack) int64 0 1 2 3 4 … 1237 1238 1239 1240 1241
    wavelengths        (bands) float32 …
    fwhm               (bands) float32 …
    good_wavelengths   (bands) float32 …
    lon                (downtrack, crosstrack) float64 …
    lat                (downtrack, crosstrack) float64 …
    elev               (downtrack, crosstrack) float64 …
    glt_x              (ortho_y, ortho_x) float64 …
    glt_y              (ortho_y, ortho_x) float64 …
Dimensions without coordinates: bands, ortho_y, ortho_x
Data variables:
    reflectance        (downtrack, crosstrack, bands) float32 …
Attributes: (12/38)
    ncei_template_version:             NCEI_NetCDF_Swath_Template_v2.0
    summary:                           The Earth Surface Mineral Dust Source …
    keywords:                          Imaging Spectroscopy, minerals, EMIT, …
    Conventions:                       CF-1.63
    sensor:                            EMIT (Earth Surface Mineral Dust Sourc…
```

```
    instrument:                         EMIT
    …                                   …
    southernmost_latitude:              44.265370269531125
    spatialResolution:                  0.000542232520256367
    spatial_ref:                        GEOGCS["WGS 84",DATUM["WGS_1984",SPHER…
    geotransform:                       [ 1.09744333e+02  5.42232520e-04 -0.00…
    day_night_flag:                     Day
    title:                              EMIT L2A Estimated Surface Reflectance…
```

[11]:
```
ds = ds.swap_dims({'bands':'wavelengths'})
ds
```

[11]:
```
<xarray.Dataset>
Dimensions:           (downtrack: 2272, crosstrack: 1242, wavelengths: 285,
                       ortho_y: 2359, ortho_x: 3956)
Coordinates:
  * downtrack         (downtrack) int64 0 1 2 3 4 5 … 2267 2268 2269 2270 2271
  * crosstrack        (crosstrack) int64 0 1 2 3 4 … 1237 1238 1239 1240 1241
  * wavelengths       (wavelengths) float32 381.0 388.4 … 2.486e+03 2.493e+03
    fwhm              (wavelengths) float32 …
    good_wavelengths  (wavelengths) float32 …
    lon               (downtrack, crosstrack) float64 …
    lat               (downtrack, crosstrack) float64 …
    elev              (downtrack, crosstrack) float64 …
    glt_x             (ortho_y, ortho_x) float64 …
    glt_y             (ortho_y, ortho_x) float64 …
Dimensions without coordinates: ortho_y, ortho_x
Data variables:
    reflectance       (downtrack, crosstrack, wavelengths) float32 …
Attributes: (12/38)
    ncei_template_version:              NCEI_NetCDF_Swath_Template_v2.0
    summary:                            The Earth Surface Mineral Dust Source …
    keywords:                           Imaging Spectroscopy, minerals, EMIT, …
    Conventions:                        CF-1.63
    sensor:                             EMIT (Earth Surface Mineral Dust Sourc…
    instrument:                         EMIT
    …                                   …
    southernmost_latitude:              44.265370269531125
    spatialResolution:                  0.000542232520256367
    spatial_ref:                        GEOGCS["WGS 84",DATUM["WGS_1984",SPHER…
    geotransform:                       [ 1.09744333e+02  5.42232520e-04 -0.00…
    day_night_flag:                     Day
    title:                              EMIT L2A Estimated Surface Reflectance…
```

[12]:
```
del wvl
del loc
```

[13]:
```
import hvplot.xarray
```

[14]:
```
example = ds['reflectance'].sel(downtrack=660,crosstrack=370)
example.hvplot.line(y='reflectance',x='wavelengths', color='black')
```

```
C:\Users\59175\anaconda3\lib\site-packages\holoviews\core\data\pandas.py:39:
FutureWarning: Series.__getitem__ treating keys as positions is deprecated. In a
future version, integer keys will always be treated as labels (consistent with
DataFrame behavior). To access a value by position, use `ser.iloc[pos]`
  return dataset.data.dtypes[idx].type
C:\Users\59175\anaconda3\lib\site-packages\holoviews\core\data\pandas.py:39:
FutureWarning: Series.__getitem__ treating keys as positions is deprecated. In a
future version, integer keys will always be treated as labels (consistent with
DataFrame behavior). To access a value by position, use `ser.iloc[pos]`
  return dataset.data.dtypes[idx].type
```

[14]:
```
:Curve   [wavelengths]   (reflectance)
```

[15]:
```
import numpy as np
```

[17]:
```
ds['reflectance'].data[:,:,ds['good_wavelengths'].data==0] = np.nan
```

[18]:
```
ds['reflectance'].sel(downtrack=660,crosstrack=370).hvplot.
↪line(y='reflectance',x='wavelengths', color='black')
```

```
C:\Users\59175\anaconda3\lib\site-packages\holoviews\core\data\pandas.py:39:
FutureWarning: Series.__getitem__ treating keys as positions is deprecated. In a
future version, integer keys will always be treated as labels (consistent with
DataFrame behavior). To access a value by position, use `ser.iloc[pos]`
  return dataset.data.dtypes[idx].type
C:\Users\59175\anaconda3\lib\site-packages\holoviews\core\data\pandas.py:39:
FutureWarning: Series.__getitem__ treating keys as positions is deprecated. In a
future version, integer keys will always be treated as labels (consistent with
DataFrame behavior). To access a value by position, use `ser.iloc[pos]`
  return dataset.data.dtypes[idx].type
```

[18]:
```
:Curve   [wavelengths]   (reflectance)
```

[19]:
```
refl850 = ds.sel(wavelengths=850, method='nearest')
```

[20]:
```
pip install --upgrade pandas dask[complete]
```

```
Requirement already satisfied: pandas in c:\users\59175\anaconda3\lib\site-
packages (2.1.1)Note: you may need to restart the kernel to use updated
packages.
Requirement already satisfied: dask[complete] in
c:\users\59175\anaconda3\lib\site-packages (2023.9.3)
Requirement already satisfied: python-dateutil>=2.8.2 in
```

```
c:\users\59175\anaconda3\lib\site-packages (from pandas) (2.8.2)
Requirement already satisfied: tzdata>=2022.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas) (2023.3)
Requirement already satisfied: numpy>=1.22.4 in
c:\users\59175\anaconda3\lib\site-packages (from pandas) (1.26.0)
Requirement already satisfied: pytz>=2020.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas) (2023.3.post1)
Requirement already satisfied: fsspec>=2021.09.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (2023.9.2)
Requirement already satisfied: packaging>=20.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (23.2)
Requirement already satisfied: importlib-metadata>=4.13.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (6.8.0)
Requirement already satisfied: pyyaml>=5.3.1 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (6.0.1)
Requirement already satisfied: toolz>=0.10.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (0.11.2)
Requirement already satisfied: cloudpickle>=1.5.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (2.0.0)
Requirement already satisfied: partd>=1.2.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (1.2.0)
Requirement already satisfied: click>=8.0 in c:\users\59175\anaconda3\lib\site-
packages (from dask[complete]) (8.0.4)
Requirement already satisfied: lz4>=4.3.2 in c:\users\59175\anaconda3\lib\site-
packages (from dask[complete]) (4.3.2)
Requirement already satisfied: pyarrow>=7.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (13.0.0)
Requirement already satisfied: colorama in c:\users\59175\anaconda3\lib\site-
packages (from click>=8.0->dask[complete]) (0.4.6)
Requirement already satisfied: zipp>=0.5 in c:\users\59175\anaconda3\lib\site-
packages (from importlib-metadata>=4.13.0->dask[complete]) (3.17.0)
Requirement already satisfied: locket in c:\users\59175\anaconda3\lib\site-
packages (from partd>=1.2.0->dask[complete]) (1.0.0)
Requirement already satisfied: six>=1.5 in c:\users\59175\anaconda3\lib\site-
packages (from python-dateutil>=2.8.2->pandas) (1.16.0)
Requirement already satisfied: bokeh>=2.4.2 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (3.2.2)
Requirement already satisfied: jinja2>=2.10.3 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (3.1.2)

Requirement already satisfied: distributed==2023.9.3 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (2023.9.3)
Requirement already satisfied: psutil>=5.7.2 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (5.8.0)
Requirement already satisfied: tblib>=1.6.0 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (1.7.0)
```

```
Requirement already satisfied: urllib3>=1.24.3 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (1.26.17)
Requirement already satisfied: zict>=3.0.0 in c:\users\59175\anaconda3\lib\site-
packages (from distributed==2023.9.3->dask[complete]) (3.0.0)
Requirement already satisfied: sortedcontainers>=2.0.5 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (2.4.0)
Requirement already satisfied: msgpack>=1.0.0 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (1.0.2)
Requirement already satisfied: tornado>=6.0.4 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (6.3.3)
Requirement already satisfied: xyzservices>=2021.09.1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=2.4.2->dask[complete])
(2023.10.0)
Requirement already satisfied: pillow>=7.1.0 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=2.4.2->dask[complete])
(10.0.1)
Requirement already satisfied: contourpy>=1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=2.4.2->dask[complete])
(1.1.1)
Requirement already satisfied: MarkupSafe>=2.0 in
c:\users\59175\anaconda3\lib\site-packages (from jinja2>=2.10.3->dask[complete])
(2.1.3)
```

[22]:
```
!pip install hvplot datashader numba --upgrade
```

```
Requirement already satisfied: hvplot in c:\users\59175\anaconda3\lib\site-
packages (0.8.4)
Requirement already satisfied: datashader in c:\users\59175\anaconda3\lib\site-
packages (0.13.0)
Collecting datashader
  Using cached datashader-0.15.2-py2.py3-none-any.whl (18.3 MB)
Requirement already satisfied: numba in c:\users\59175\anaconda3\lib\site-
packages (0.55.1)
Collecting numba
  Using cached numba-0.58.0-cp39-cp39-win_amd64.whl (2.6 MB)
Requirement already satisfied: bokeh>=1.0.0 in
c:\users\59175\anaconda3\lib\site-packages (from hvplot) (3.2.2)
Requirement already satisfied: colorcet>=2 in c:\users\59175\anaconda3\lib\site-
packages (from hvplot) (3.0.1)
Requirement already satisfied: numpy>=1.15 in c:\users\59175\anaconda3\lib\site-
packages (from hvplot) (1.22.4)
Requirement already satisfied: packaging in c:\users\59175\anaconda3\lib\site-
packages (from hvplot) (23.2)
Requirement already satisfied: panel>=0.11.0 in
```

```
c:\users\59175\anaconda3\lib\site-packages (from hvplot) (1.2.3)
Requirement already satisfied: param>=1.9.0 in
c:\users\59175\anaconda3\lib\site-packages (from hvplot) (1.13.0)
Requirement already satisfied: pandas in c:\users\59175\anaconda3\lib\site-
packages (from hvplot) (2.1.1)
Requirement already satisfied: holoviews>=1.11.0 in
c:\users\59175\anaconda3\lib\site-packages (from hvplot) (1.17.1)
Requirement already satisfied: pyct in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (0.5.0)
Requirement already satisfied: xarray in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (2023.9.0)
Requirement already satisfied: requests in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (2.31.0)
Requirement already satisfied: scipy in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (1.7.3)
Requirement already satisfied: datashape in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (0.5.4)
Requirement already satisfied: dask in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (2023.9.3)
Requirement already satisfied: pillow in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (10.0.1)
Requirement already satisfied: toolz in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (0.11.2)
Collecting llvmlite<0.42,>=0.41.0dev0
  Using cached llvmlite-0.41.0-cp39-cp39-win_amd64.whl (28.1 MB)
Requirement already satisfied: tornado>=5.1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=1.0.0->hvplot) (6.3.3)
Requirement already satisfied: contourpy>=1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=1.0.0->hvplot) (1.1.1)
Requirement already satisfied: Jinja2>=2.9 in c:\users\59175\anaconda3\lib\site-
packages (from bokeh>=1.0.0->hvplot) (3.1.2)
Requirement already satisfied: PyYAML>=3.10 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=1.0.0->hvplot) (6.0.1)
Requirement already satisfied: xyzservices>=2021.09.1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=1.0.0->hvplot)
(2023.10.0)
Requirement already satisfied: pyviz-comms>=0.7.4 in
c:\users\59175\anaconda3\lib\site-packages (from holoviews>=1.11.0->hvplot)
(3.0.0)

ERROR: Cannot uninstall 'llvmlite'. It is a distutils installed project and thus
we cannot accurately determine which files belong to it which would lead to only
a partial uninstall.

Requirement already satisfied: MarkupSafe>=2.0 in
c:\users\59175\anaconda3\lib\site-packages (from
Jinja2>=2.9->bokeh>=1.0.0->hvplot) (2.1.3)
Requirement already satisfied: pytz>=2020.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas->hvplot) (2023.3.post1)
```

```
Requirement already satisfied: python-dateutil>=2.8.2 in
c:\users\59175\anaconda3\lib\site-packages (from pandas->hvplot) (2.8.2)
Requirement already satisfied: tzdata>=2022.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas->hvplot) (2023.3)
Requirement already satisfied: mdit-py-plugins in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (0.4.0)
Requirement already satisfied: tqdm>=4.48.0 in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (4.66.1)
Requirement already satisfied: typing-extensions in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (4.8.0)
Requirement already satisfied: markdown-it-py in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (3.0.0)
Requirement already satisfied: linkify-it-py in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (2.0.2)
Requirement already satisfied: bleach in c:\users\59175\anaconda3\lib\site-
packages (from panel>=0.11.0->hvplot) (6.1.0)
Requirement already satisfied: markdown in c:\users\59175\anaconda3\lib\site-
packages (from panel>=0.11.0->hvplot) (3.5)
Requirement already satisfied: six>=1.5 in c:\users\59175\anaconda3\lib\site-
packages (from python-dateutil>=2.8.2->pandas->hvplot) (1.16.0)
Requirement already satisfied: colorama in c:\users\59175\anaconda3\lib\site-
packages (from tqdm>=4.48.0->panel>=0.11.0->hvplot) (0.4.6)
Requirement already satisfied: webencodings in
c:\users\59175\anaconda3\lib\site-packages (from bleach->panel>=0.11.0->hvplot)
(0.5.1)
Requirement already satisfied: importlib-metadata>=4.13.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask->datashader) (6.8.0)
Requirement already satisfied: fsspec>=2021.09.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask->datashader) (2023.9.2)
Requirement already satisfied: partd>=1.2.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask->datashader) (1.2.0)
Requirement already satisfied: click>=8.0 in c:\users\59175\anaconda3\lib\site-
packages (from dask->datashader) (8.0.4)
Requirement already satisfied: cloudpickle>=1.5.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask->datashader) (2.0.0)
Requirement already satisfied: zipp>=0.5 in c:\users\59175\anaconda3\lib\site-
packages (from importlib-metadata>=4.13.0->dask->datashader) (3.17.0)
Requirement already satisfied: locket in c:\users\59175\anaconda3\lib\site-
packages (from partd>=1.2.0->dask->datashader) (1.0.0)
Requirement already satisfied: multipledispatch>=0.4.7 in
c:\users\59175\anaconda3\lib\site-packages (from datashape->datashader) (0.6.0)
Requirement already satisfied: uc-micro-py in c:\users\59175\anaconda3\lib\site-
packages (from linkify-it-py->panel>=0.11.0->hvplot) (1.0.2)
Requirement already satisfied: mdurl~=0.1 in c:\users\59175\anaconda3\lib\site-
packages (from markdown-it-py->panel>=0.11.0->hvplot) (0.1.2)
Requirement already satisfied: urllib3<3,>=1.21.1 in
c:\users\59175\anaconda3\lib\site-packages (from requests->datashader) (1.26.17)
Requirement already satisfied: idna<4,>=2.5 in
```

```
c:\users\59175\anaconda3\lib\site-packages (from requests->datashader) (3.4)
Requirement already satisfied: charset-normalizer<4,>=2 in
c:\users\59175\anaconda3\lib\site-packages (from requests->datashader) (2.1.1)
Requirement already satisfied: certifi>=2017.4.17 in
c:\users\59175\anaconda3\lib\site-packages (from requests->datashader)
(2023.7.22)
Installing collected packages: llvmlite, numba, datashader
  Attempting uninstall: llvmlite
    Found existing installation: llvmlite 0.38.0
```

[23]:
```
!pip show hvplot datashader numba
```

```
Name: hvplot
Version: 0.8.4
Summary: A high-level plotting API for the PyData ecosystem built on HoloViews.
Home-page: https://hvplot.pyviz.org
Author: Philipp Rudiger
Author-email: developers@pyviz.org
License: BSD
Location: c:\users\59175\anaconda3\lib\site-packages
Requires: panel, pandas, colorcet, holoviews, param, packaging, numpy, bokeh
Required-by:
---
Name: datashader
Version: 0.13.0
Summary: Data visualization toolchain based on aggregating into a grid
Home-page: https://datashader.org
Author:
Author-email:
License: New BSD
Location: c:\users\59175\anaconda3\lib\site-packages
Requires: pillow, xarray, scipy, datashape, param, colorcet, dask, pyct, numpy,
numba, pandas
Required-by:
---
Name: numba
Version: 0.55.1
Summary: compiling Python code using LLVM
Home-page: https://numba.pydata.org
Author:
Author-email:
License: BSD
Location: c:\users\59175\anaconda3\lib\site-packages
Requires: numpy, llvmlite, setuptools
Required-by: datashader
```

[24]:
```
refl850.hvplot.image(cmap='viridis', aspect='equal')
```

[24]: :Image [crosstrack,downtrack] (reflectance)

0.2 1.4 Orthorectification

[25]:
```
loc = xr.open_dataset(fp,group='location')
loc
```

[25]:
```
<xarray.Dataset>
Dimensions:  (downtrack: 2272, crosstrack: 1242, ortho_y: 2359, ortho_x: 3956)
Dimensions without coordinates: downtrack, crosstrack, ortho_y, ortho_x
Data variables:
    lon      (downtrack, crosstrack) float64 …
    lat      (downtrack, crosstrack) float64 …
    elev     (downtrack, crosstrack) float64 …
    glt_x    (ortho_y, ortho_x) float64 …
    glt_y    (ortho_y, ortho_x) float64 …
```

[26]:
```
del loc
del example
```

[27]:
```
import sys
sys.path.append('../modules/')
from emit_tools import emit_xarray
help(emit_xarray)
```

```
Help on function emit_xarray in module emit_tools:

emit_xarray(filepath, ortho=False, qmask=None, unpacked_bmask=None)
    This function utilizes other functions in this module to streamline opening
an EMIT dataset as an xarray.Dataset.

    Parameters:
    filepath: a filepath to an EMIT netCDF file
    ortho: True or False, whether to orthorectify the dataset or leave in
crosstrack/downtrack coordinates.
    qmask: a numpy array output from the quality_mask function used to mask
pixels based on quality flags selected in that function. Any non-orthorectified
array with the proper crosstrack and downtrack dimensions can also be used.
    unpacked_bmask: a numpy array from  the band_mask function that can be used
to mask band-specific pixels that have been interpolated.

    Returns:
    out_xr: an xarray.Dataset constructed based on the parameters provided.
```

[28]:
```
pip install dask[complete]
```

```
Requirement already satisfied: dask[complete] in
c:\users\59175\anaconda3\lib\site-packages (2023.9.3)
Requirement already satisfied: importlib-metadata>=4.13.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (6.8.0)
Requirement already satisfied: cloudpickle>=1.5.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (2.0.0)
Requirement already satisfied: toolz>=0.10.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (0.11.2)
Requirement already satisfied: pyyaml>=5.3.1 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (6.0.1)
Requirement already satisfied: partd>=1.2.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (1.2.0)
Requirement already satisfied: packaging>=20.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (23.2)
Requirement already satisfied: fsspec>=2021.09.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (2023.9.2)
Requirement already satisfied: click>=8.0 in c:\users\59175\anaconda3\lib\site-
packages (from dask[complete]) (8.0.4)
Requirement already satisfied: lz4>=4.3.2 in c:\users\59175\anaconda3\lib\site-
packages (from dask[complete]) (4.3.2)
Requirement already satisfied: pyarrow>=7.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (13.0.0)
Requirement already satisfied: colorama in c:\users\59175\anaconda3\lib\site-
packages (from click>=8.0->dask[complete]) (0.4.6)
Requirement already satisfied: zipp>=0.5 in c:\users\59175\anaconda3\lib\site-
packages (from importlib-metadata>=4.13.0->dask[complete]) (3.17.0)
Requirement already satisfied: locket in c:\users\59175\anaconda3\lib\site-
packages (from partd>=1.2.0->dask[complete]) (1.0.0)
Requirement already satisfied: numpy>=1.16.6 in
c:\users\59175\anaconda3\lib\site-packages (from pyarrow>=7.0->dask[complete])
(1.22.4)
Requirement already satisfied: distributed==2023.9.3 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (2023.9.3)
Requirement already satisfied: bokeh>=2.4.2 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (3.2.2)
Requirement already satisfied: jinja2>=2.10.3 in
c:\users\59175\anaconda3\lib\site-packages (from dask[complete]) (3.1.2)
Requirement already satisfied: pandas>=1.3 in c:\users\59175\anaconda3\lib\site-
packages (from dask[complete]) (2.1.1)
Requirement already satisfied: tornado>=6.0.4 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (6.3.3)
Requirement already satisfied: urllib3>=1.24.3 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (1.26.17)
Requirement already satisfied: msgpack>=1.0.0 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (1.0.2)
```

```
Requirement already satisfied: psutil>=5.7.2 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (5.8.0)
Requirement already satisfied: sortedcontainers>=2.0.5 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (2.4.0)
Requirement already satisfied: zict>=3.0.0 in c:\users\59175\anaconda3\lib\site-
packages (from distributed==2023.9.3->dask[complete]) (3.0.0)
Requirement already satisfied: tblib>=1.6.0 in
c:\users\59175\anaconda3\lib\site-packages (from
distributed==2023.9.3->dask[complete]) (1.7.0)
Requirement already satisfied: pillow>=7.1.0 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=2.4.2->dask[complete])
(10.0.1)
Requirement already satisfied: contourpy>=1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=2.4.2->dask[complete])
(1.1.1)
Requirement already satisfied: xyzservices>=2021.09.1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=2.4.2->dask[complete])
(2023.10.0)
Requirement already satisfied: MarkupSafe>=2.0 in
c:\users\59175\anaconda3\lib\site-packages (from jinja2>=2.10.3->dask[complete])
(2.1.3)
Requirement already satisfied: tzdata>=2022.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.3->dask[complete])
(2023.3)
Requirement already satisfied: pytz>=2020.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.3->dask[complete])
(2023.3.post1)
Requirement already satisfied: python-dateutil>=2.8.2 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.3->dask[complete])
(2.8.2)
Requirement already satisfied: six>=1.5 in c:\users\59175\anaconda3\lib\site-
packages (from python-dateutil>=2.8.2->pandas>=1.3->dask[complete]) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

[29]:
```
import xarray as xr
ds_geo = xr.open_dataset(fp, chunks={'time': 10}) # example chunking by 'time'
ds_geo
```

[29]:
```
<xarray.Dataset>
Dimensions:      (downtrack: 2272, crosstrack: 1242, bands: 285)
Dimensions without coordinates: downtrack, crosstrack, bands
Data variables:
    reflectance  (downtrack, crosstrack, bands) float32
dask.array<chunksize=(2272, 1242, 285), meta=np.ndarray>
Attributes: (12/38)
```

```
    ncei_template_version:             NCEI_NetCDF_Swath_Template_v2.0
    summary:                           The Earth Surface Mineral Dust Source …
    keywords:                          Imaging Spectroscopy, minerals, EMIT, …
    Conventions:                       CF-1.63
    sensor:                            EMIT (Earth Surface Mineral Dust Sourc…
    instrument:                        EMIT
    …                                  …
    southernmost_latitude:             44.265370269531125
    spatialResolution:                 0.000542232520256367
    spatial_ref:                       GEOGCS["WGS 84",DATUM["WGS_1984",SPHER…
    geotransform:                      [ 1.09744333e+02  5.42232520e-04 -0.00…
    day_night_flag:                    Day
    title:                             EMIT L2A Estimated Surface Reflectance…
```

[30]:
```
print(ds_geo)
print(ds)
```

```
<xarray.Dataset>
Dimensions:      (downtrack: 2272, crosstrack: 1242, bands: 285)
Dimensions without coordinates: downtrack, crosstrack, bands
Data variables:
    reflectance  (downtrack, crosstrack, bands) float32
dask.array<chunksize=(2272, 1242, 285), meta=np.ndarray>
Attributes: (12/38)
    ncei_template_version:             NCEI_NetCDF_Swath_Template_v2.0
    summary:                           The Earth Surface Mineral Dust Source …
    keywords:                          Imaging Spectroscopy, minerals, EMIT, …
    Conventions:                       CF-1.63
    sensor:                            EMIT (Earth Surface Mineral Dust Sourc…
    instrument:                        EMIT
    …                                  …
    southernmost_latitude:             44.265370269531125
    spatialResolution:                 0.000542232520256367
    spatial_ref:                       GEOGCS["WGS 84",DATUM["WGS_1984",SPHER…
    geotransform:                      [ 1.09744333e+02  5.42232520e-04 -0.00…
    day_night_flag:                    Day
    title:                             EMIT L2A Estimated Surface Reflectance…
<xarray.Dataset>
Dimensions:           (downtrack: 2272, crosstrack: 1242, wavelengths: 285,
                       ortho_y: 2359, ortho_x: 3956)
Coordinates:
  * downtrack         (downtrack) int64 0 1 2 3 4 5 … 2267 2268 2269 2270 2271
  * crosstrack        (crosstrack) int64 0 1 2 3 4 … 1237 1238 1239 1240 1241
  * wavelengths       (wavelengths) float32 381.0 388.4 … 2.486e+03 2.493e+03
    fwhm              (wavelengths) float32 …
    good_wavelengths  (wavelengths) float32 1.0 1.0 1.0 1.0 … 1.0 1.0 1.0 1.0
    lon               (downtrack, crosstrack) float64 …
```

```
    lat               (downtrack, crosstrack) float64 …
    elev              (downtrack, crosstrack) float64 …
    glt_x             (ortho_y, ortho_x) float64 …
    glt_y             (ortho_y, ortho_x) float64 …
Dimensions without coordinates: ortho_y, ortho_x
Data variables:
    reflectance       (downtrack, crosstrack, wavelengths) float32 0.0006587 …
Attributes: (12/38)
    ncei_template_version:             NCEI_NetCDF_Swath_Template_v2.0
    summary:                           The Earth Surface Mineral Dust Source …
    keywords:                          Imaging Spectroscopy, minerals, EMIT, …
    Conventions:                       CF-1.63
    sensor:                            EMIT (Earth Surface Mineral Dust Sourc…
    instrument:                        EMIT
    …                                  …
    southernmost_latitude:             44.265370269531125
    spatialResolution:                 0.000542232520256367
    spatial_ref:                       GEOGCS["WGS 84",DATUM["WGS_1984",SPHER…
    geotransform:                      [ 1.09744333e+02  5.42232520e-04 -0.00…
    day_night_flag:                    Day
    title:                             EMIT L2A Estimated Surface Reflectance…
```

[31]:
```
pip install "dask[dataframe]" --upgrade
```

```
Requirement already satisfied: dask[dataframe] in
c:\users\59175\anaconda3\lib\site-packages (2023.9.3)
Requirement already satisfied: fsspec>=2021.09.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[dataframe]) (2023.9.2)
Requirement already satisfied: importlib-metadata>=4.13.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[dataframe]) (6.8.0)
Requirement already satisfied: packaging>=20.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[dataframe]) (23.2)
Requirement already satisfied: cloudpickle>=1.5.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[dataframe]) (2.0.0)
Requirement already satisfied: pyyaml>=5.3.1 in
c:\users\59175\anaconda3\lib\site-packages (from dask[dataframe]) (6.0.1)
Requirement already satisfied: click>=8.0 in c:\users\59175\anaconda3\lib\site-
packages (from dask[dataframe]) (8.0.4)
Requirement already satisfied: partd>=1.2.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[dataframe]) (1.2.0)
Requirement already satisfied: toolz>=0.10.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask[dataframe]) (0.11.2)
Requirement already satisfied: pandas>=1.3 in c:\users\59175\anaconda3\lib\site-
packages (from dask[dataframe]) (2.1.1)
Requirement already satisfied: colorama in c:\users\59175\anaconda3\lib\site-
packages (from click>=8.0->dask[dataframe]) (0.4.6)
Requirement already satisfied: zipp>=0.5 in c:\users\59175\anaconda3\lib\site-
packages (from importlib-metadata>=4.13.0->dask[dataframe]) (3.17.0)
```

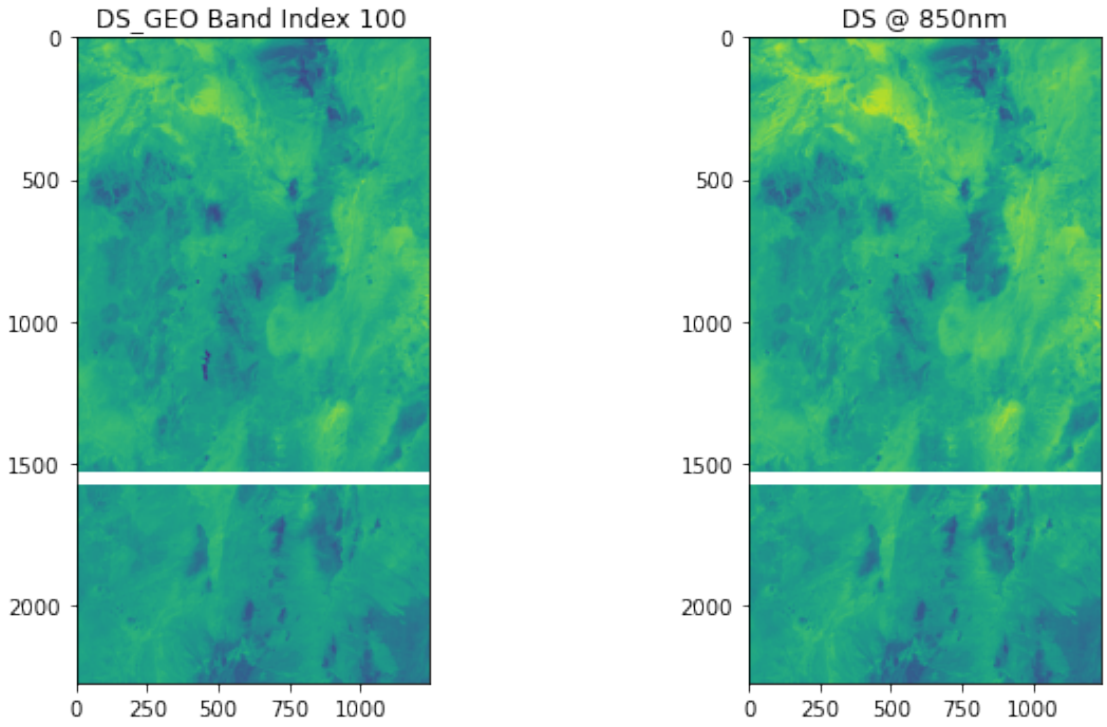
```
Requirement already satisfied: numpy>=1.22.4 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.3->dask[dataframe])
(1.22.4)
Requirement already satisfied: tzdata>=2022.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.3->dask[dataframe])
(2023.3)
Requirement already satisfied: python-dateutil>=2.8.2 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.3->dask[dataframe])
(2.8.2)
Requirement already satisfied: pytz>=2020.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.3->dask[dataframe])
(2023.3.post1)
Requirement already satisfied: locket in c:\users\59175\anaconda3\lib\site-
packages (from partd>=1.2.0->dask[dataframe]) (1.0.0)
Requirement already satisfied: six>=1.5 in c:\users\59175\anaconda3\lib\site-
packages (from python-dateutil>=2.8.2->pandas>=1.3->dask[dataframe]) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

[32]:
```
!pip install matplotlib xarray
```

```
Requirement already satisfied: matplotlib in c:\users\59175\anaconda3\lib\site-
packages (3.5.1)
Requirement already satisfied: xarray in c:\users\59175\anaconda3\lib\site-
packages (2023.9.0)
Requirement already satisfied: pillow>=6.2.0 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib) (10.0.1)
Requirement already satisfied: numpy>=1.17 in c:\users\59175\anaconda3\lib\site-
packages (from matplotlib) (1.22.4)
Requirement already satisfied: kiwisolver>=1.0.1 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib) (1.4.5)
Requirement already satisfied: fonttools>=4.22.0 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib) (4.43.1)
Requirement already satisfied: packaging>=20.0 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib) (23.2)
Requirement already satisfied: cycler>=0.10 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib) (0.12.1)
Requirement already satisfied: pyparsing>=2.2.1 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib) (3.1.1)
Requirement already satisfied: python-dateutil>=2.7 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib) (2.8.2)
Requirement already satisfied: pandas>=1.4 in c:\users\59175\anaconda3\lib\site-
packages (from xarray) (2.1.1)
Requirement already satisfied: pytz>=2020.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.4->xarray)
(2023.3.post1)
Requirement already satisfied: tzdata>=2022.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas>=1.4->xarray) (2023.3)
Requirement already satisfied: six>=1.5 in c:\users\59175\anaconda3\lib\site-
```

```
packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
```

[38]:
```python
import matplotlib.pyplot as plt

# Suponiendo que ds_geo y ds son xarray Datasets ya cargados
band_index_for_ds_geo = 100  # Esto es solo un ejemplo, reemplaza con el índice correcto
wavelength_selected = 850

# Seleccionamos la banda correspondiente para ds_geo y la longitud de onda más cercana a 850 para ds
image1 = ds_geo.reflectance.isel(bands=band_index_for_ds_geo)
image2 = ds.reflectance.sel(wavelengths=wavelength_selected, method='nearest')

fig, ax = plt.subplots(1, 2, figsize=(10, 5))

# Primera imagen
ax[0].imshow(image1, cmap='viridis', aspect='equal')
ax[0].set_title('DS_GEO Band Index ' + str(band_index_for_ds_geo))

# Segunda imagen
ax[1].imshow(image2, cmap='viridis', aspect='equal')
ax[1].set_title('DS @ 850nm')

plt.tight_layout()
plt.show()
```



[39]:
```
selected_data = ds.sel(wavelengths=850, method='nearest')
simple_plot = selected_data.hvplot.image(cmap='viridis', frame_width=500)
simple_plot
```

[39]: :Image [crosstrack,downtrack] (reflectance)

[42]:
```
import holoviews as hv
```

[44]:
```
pip install --upgrade numba datashader llvmlite xarray hvplot geoviews
```

```
Requirement already satisfied: numba in c:\users\59175\anaconda3\lib\site-
packages (0.55.1)
Collecting numba
Note: you may need to restart the kernel to use updated packages.

ERROR: Cannot uninstall 'llvmlite'. It is a distutils installed project and thus
we cannot accurately determine which files belong to it which would lead to only
a partial uninstall.

  Using cached numba-0.58.0-cp39-cp39-win_amd64.whl (2.6 MB)
Requirement already satisfied: datashader in c:\users\59175\anaconda3\lib\site-
packages (0.13.0)
Collecting datashader
  Using cached datashader-0.15.2-py2.py3-none-any.whl (18.3 MB)
Requirement already satisfied: llvmlite in c:\users\59175\anaconda3\lib\site-
packages (0.38.0)
Collecting llvmlite
  Using cached llvmlite-0.41.0-cp39-cp39-win_amd64.whl (28.1 MB)
Requirement already satisfied: xarray in c:\users\59175\anaconda3\lib\site-
packages (2023.9.0)
Requirement already satisfied: hvplot in c:\users\59175\anaconda3\lib\site-
packages (0.8.4)
Requirement already satisfied: geoviews in c:\users\59175\anaconda3\lib\site-
packages (1.10.1)
Requirement already satisfied: numpy<1.26,>=1.21 in
c:\users\59175\anaconda3\lib\site-packages (from numba) (1.22.4)
Requirement already satisfied: datashape in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (0.5.4)
Requirement already satisfied: pillow in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (10.0.1)
Requirement already satisfied: colorcet in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (3.0.1)
Requirement already satisfied: scipy in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (1.7.3)
Requirement already satisfied: requests in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (2.31.0)
```

```
Requirement already satisfied: dask in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (2023.9.3)
Requirement already satisfied: pandas in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (2.1.1)
Requirement already satisfied: toolz in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (0.11.2)
Requirement already satisfied: pyct in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (0.5.0)
Requirement already satisfied: param in c:\users\59175\anaconda3\lib\site-
packages (from datashader) (1.13.0)
Requirement already satisfied: packaging>=21.3 in
c:\users\59175\anaconda3\lib\site-packages (from xarray) (23.2)
Requirement already satisfied: bokeh>=1.0.0 in
c:\users\59175\anaconda3\lib\site-packages (from hvplot) (3.2.2)
Requirement already satisfied: holoviews>=1.11.0 in
c:\users\59175\anaconda3\lib\site-packages (from hvplot) (1.17.1)
Requirement already satisfied: panel>=0.11.0 in
c:\users\59175\anaconda3\lib\site-packages (from hvplot) (1.2.3)
Requirement already satisfied: pyproj in c:\users\59175\anaconda3\lib\site-
packages (from geoviews) (3.5.0)
Requirement already satisfied: shapely in c:\users\59175\anaconda3\lib\site-
packages (from geoviews) (2.0.1)
Requirement already satisfied: cartopy>=0.18.0 in
c:\users\59175\anaconda3\lib\site-packages (from geoviews) (0.22.0)
Requirement already satisfied: xyzservices in c:\users\59175\anaconda3\lib\site-
packages (from geoviews) (2023.10.0)
Requirement already satisfied: Jinja2>=2.9 in c:\users\59175\anaconda3\lib\site-
packages (from bokeh>=1.0.0->hvplot) (3.1.2)
Requirement already satisfied: PyYAML>=3.10 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=1.0.0->hvplot) (6.0.1)
Requirement already satisfied: tornado>=5.1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=1.0.0->hvplot) (6.3.3)
Requirement already satisfied: contourpy>=1 in
c:\users\59175\anaconda3\lib\site-packages (from bokeh>=1.0.0->hvplot) (1.1.1)
Requirement already satisfied: matplotlib>=3.4 in
c:\users\59175\anaconda3\lib\site-packages (from cartopy>=0.18.0->geoviews)
(3.5.1)
Requirement already satisfied: pyshp>=2.1 in c:\users\59175\anaconda3\lib\site-
packages (from cartopy>=0.18.0->geoviews) (2.3.1)
Requirement already satisfied: pyviz-comms>=0.7.4 in
c:\users\59175\anaconda3\lib\site-packages (from holoviews>=1.11.0->hvplot)
(3.0.0)
Requirement already satisfied: MarkupSafe>=2.0 in
c:\users\59175\anaconda3\lib\site-packages (from
Jinja2>=2.9->bokeh>=1.0.0->hvplot) (2.1.3)
Requirement already satisfied: fonttools>=4.22.0 in
c:\users\59175\anaconda3\lib\site-packages (from
matplotlib>=3.4->cartopy>=0.18.0->geoviews) (4.43.1)
```

```
Requirement already satisfied: kiwisolver>=1.0.1 in
c:\users\59175\anaconda3\lib\site-packages (from
matplotlib>=3.4->cartopy>=0.18.0->geoviews) (1.4.5)
Requirement already satisfied: pyparsing>=2.2.1 in
c:\users\59175\anaconda3\lib\site-packages (from
matplotlib>=3.4->cartopy>=0.18.0->geoviews) (3.1.1)
Requirement already satisfied: cycler>=0.10 in
c:\users\59175\anaconda3\lib\site-packages (from
matplotlib>=3.4->cartopy>=0.18.0->geoviews) (0.12.1)
Requirement already satisfied: python-dateutil>=2.7 in
c:\users\59175\anaconda3\lib\site-packages (from
matplotlib>=3.4->cartopy>=0.18.0->geoviews) (2.8.2)
Requirement already satisfied: tzdata>=2022.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas->datashader) (2023.3)
Requirement already satisfied: pytz>=2020.1 in
c:\users\59175\anaconda3\lib\site-packages (from pandas->datashader)
(2023.3.post1)
Requirement already satisfied: linkify-it-py in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (2.0.2)
Requirement already satisfied: typing-extensions in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (4.8.0)
Requirement already satisfied: bleach in c:\users\59175\anaconda3\lib\site-
packages (from panel>=0.11.0->hvplot) (6.1.0)
Requirement already satisfied: markdown in c:\users\59175\anaconda3\lib\site-
packages (from panel>=0.11.0->hvplot) (3.5)
Requirement already satisfied: markdown-it-py in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (3.0.0)
Requirement already satisfied: mdit-py-plugins in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (0.4.0)
Requirement already satisfied: tqdm>=4.48.0 in
c:\users\59175\anaconda3\lib\site-packages (from panel>=0.11.0->hvplot) (4.66.1)
Requirement already satisfied: certifi in c:\users\59175\anaconda3\lib\site-
packages (from pyproj->geoviews) (2023.7.22)
Requirement already satisfied: six>=1.5 in c:\users\59175\anaconda3\lib\site-
packages (from python-dateutil>=2.7->matplotlib>=3.4->cartopy>=0.18.0->geoviews)
(1.16.0)
Requirement already satisfied: colorama in c:\users\59175\anaconda3\lib\site-
packages (from tqdm>=4.48.0->panel>=0.11.0->hvplot) (0.4.6)
Requirement already satisfied: webencodings in
c:\users\59175\anaconda3\lib\site-packages (from bleach->panel>=0.11.0->hvplot)
(0.5.1)
Requirement already satisfied: cloudpickle>=1.5.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask->datashader) (2.0.0)
Requirement already satisfied: partd>=1.2.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask->datashader) (1.2.0)
Requirement already satisfied: click>=8.0 in c:\users\59175\anaconda3\lib\site-
packages (from dask->datashader) (8.0.4)
Requirement already satisfied: importlib-metadata>=4.13.0 in
```

```
c:\users\59175\anaconda3\lib\site-packages (from dask->datashader) (6.8.0)
Requirement already satisfied: fsspec>=2021.09.0 in
c:\users\59175\anaconda3\lib\site-packages (from dask->datashader) (2023.9.2)
Requirement already satisfied: zipp>=0.5 in c:\users\59175\anaconda3\lib\site-
packages (from importlib-metadata>=4.13.0->dask->datashader) (3.17.0)
Requirement already satisfied: locket in c:\users\59175\anaconda3\lib\site-
packages (from partd>=1.2.0->dask->datashader) (1.0.0)
Requirement already satisfied: multipledispatch>=0.4.7 in
c:\users\59175\anaconda3\lib\site-packages (from datashape->datashader) (0.6.0)
Requirement already satisfied: uc-micro-py in c:\users\59175\anaconda3\lib\site-
packages (from linkify-it-py->panel>=0.11.0->hvplot) (1.0.2)
Requirement already satisfied: mdurl~=0.1 in c:\users\59175\anaconda3\lib\site-
packages (from markdown-it-py->panel>=0.11.0->hvplot) (0.1.2)
Requirement already satisfied: idna<4,>=2.5 in
c:\users\59175\anaconda3\lib\site-packages (from requests->datashader) (3.4)
Requirement already satisfied: urllib3<3,>=1.21.1 in
c:\users\59175\anaconda3\lib\site-packages (from requests->datashader) (1.26.17)
Requirement already satisfied: charset-normalizer<4,>=2 in
c:\users\59175\anaconda3\lib\site-packages (from requests->datashader) (2.1.1)
Installing collected packages: llvmlite, numba, datashader
  Attempting uninstall: llvmlite
    Found existing installation: llvmlite 0.38.0
```

[46]:
```
pip install cartopy
```

```
Requirement already satisfied: cartopy in c:\users\59175\anaconda3\lib\site-
packages (0.22.0)
Requirement already satisfied: numpy>=1.21 in c:\users\59175\anaconda3\lib\site-
packages (from cartopy) (1.22.4)
Requirement already satisfied: packaging>=20 in
c:\users\59175\anaconda3\lib\site-packages (from cartopy) (23.2)
Requirement already satisfied: pyproj>=3.1.0 in
c:\users\59175\anaconda3\lib\site-packages (from cartopy) (3.5.0)
Requirement already satisfied: pyshp>=2.1 in c:\users\59175\anaconda3\lib\site-
packages (from cartopy) (2.3.1)
Requirement already satisfied: matplotlib>=3.4 in
c:\users\59175\anaconda3\lib\site-packages (from cartopy) (3.5.1)
Requirement already satisfied: shapely>=1.7 in
c:\users\59175\anaconda3\lib\site-packages (from cartopy) (2.0.1)
Requirement already satisfied: cycler>=0.10 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib>=3.4->cartopy)
(0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib>=3.4->cartopy)
(4.43.1)
Requirement already satisfied: pyparsing>=2.2.1 in
```

```
c:\users\59175\anaconda3\lib\site-packages (from matplotlib>=3.4->cartopy)
(3.1.1)
Requirement already satisfied: pillow>=6.2.0 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib>=3.4->cartopy)
(10.0.1)
Requirement already satisfied: python-dateutil>=2.7 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib>=3.4->cartopy)
(2.8.2)
Requirement already satisfied: kiwisolver>=1.0.1 in
c:\users\59175\anaconda3\lib\site-packages (from matplotlib>=3.4->cartopy)
(1.4.5)
Requirement already satisfied: certifi in c:\users\59175\anaconda3\lib\site-
packages (from pyproj>=3.1.0->cartopy) (2023.7.22)
Requirement already satisfied: six>=1.5 in c:\users\59175\anaconda3\lib\site-
packages (from python-dateutil>=2.7->matplotlib>=3.4->cartopy) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

[54]:
```
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
import cartopy.feature as cfeature

# Selecciona la banda específica en el segundo dataset
image = ds.reflectance.isel(wavelengths=100)

# Extraer las matrices de longitud y latitud
lon_matrix = ds['lon'].values
lat_matrix = ds['lat'].values

# Determine the extent using the lon and lat matrices
extent = [lon_matrix.min(), lon_matrix.max(), lat_matrix.min(), lat_matrix.
 ↪max()]

# Crea el gráfico geográfico
fig, ax = plt.subplots(figsize=(10, 6), subplot_kw={'projection': ccrs.
 ↪PlateCarree()})
img = ax.imshow(image, origin='upper', transform=ccrs.PlateCarree(),␣
 ↪extent=extent, cmap='viridis')

# Agregar características geográficas y la cuadrícula
ax.add_feature(cfeature.COASTLINE)
ax.add_feature(cfeature.BORDERS, linestyle=':')
ax.gridlines(draw_labels=True)

# Configura los títulos de los ejes
ax.set_xlabel('Longitude')
ax.set_ylabel('Latitude')
```

```
# Muestra la barra de colores
plt.colorbar(img, ax=ax, orientation='vertical', label='Reflectance')

plt.show()
```

```
C:\Users\59175\anaconda3\lib\site-packages\cartopy\io\__init__.py:241:
DownloadWarning: Downloading:
https://naturalearth.s3.amazonaws.com/10m_physical/ne_10m_coastline.zip
  warnings.warn(f'Downloading: {url}', DownloadWarning)
C:\Users\59175\anaconda3\lib\site-packages\cartopy\io\__init__.py:241:
DownloadWarning: Downloading: https://naturalearth.s3.amazonaws.com/10m_cultural
/ne_10m_admin_0_boundary_lines_land.zip
  warnings.warn(f'Downloading: {url}', DownloadWarning)
```