SCIKIT- data access
DATA INTERFACES FOR PYTHON

Skdaccess: The **Scikit Data Access** Python Package Quick Start Guide

v1.9.15 for Python 3.6
https://pypi.python.org/pypi/scikit-dataaccess

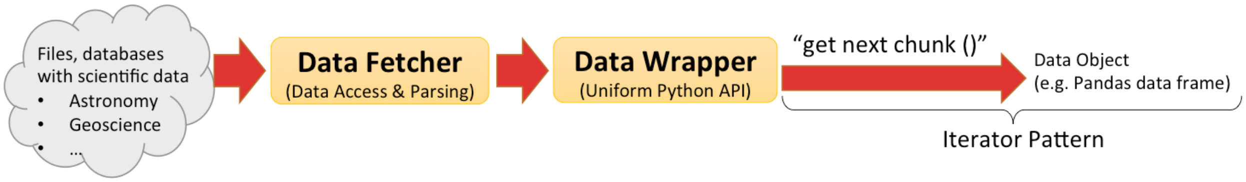
Created and maintained by
Massachusetts Institute of Technology
Haystack Observatory, Astro-&Geo-Informatics Group

Project lead: Victor Pankratius
Contact email: skdaccess@mit.edu

Code Contributors: Cody M. Rude, Justin D. Li, Guillaume Rongier, David M. Blair, Michael G. Gowanlock, Victor Pankratius

1 Overview

The Scikit Data Access package simplifies the handling of scientific data sets in Python. It provides a common interface across all data sets, based on a data fetcher and iterator pattern, as illustrated in the Figure below.



This paradigm places the requirements for parsing and interpreting the data inside of the data fetcher, which returns a data wrapper that provides a uniform method for accessing the data. In particular, the data wrapper implements an iterator which returns the next segment of data when requested by another function or by the user.

Advantages of Scikit Data Access

- Import scientific data from various sources through one easy Python API.
- Use iterator patterns for each data source (configurable data generators + functions to get next data chunk).
- Skip parser programming and file format handling.
- Enjoy a common namespace for all data and unleash the power of data fusion.
- Handle data distribution in different modes: (1) local download, (2) caching of accessed data, or (3) online stream access.
- Easily pull data on cloud servers through Python scripts and facilitate large-scale parallel processing.

- Build on an extensible plattform: Adding access to a new data source only requires addition of its "DataFetcher.py".
- Open source (MIT License).

2 Supported Data Sets

The package introduces a common namespace and currently supports the following data sets:

Namespace	Data structure	Original Source	Data Size	Description
skdaccess.astro.kepler	Dictionary of Data Frames	Mikulski Archive for Space Telescopes (ftp://archive.stsci.edu/pub/kepler/lightcurves/)	≈ 1TB	Light curves for stars imaged by the *Kepler* Space Telescope (https://keplerscience.arc.nasa.gov/). This data set uses a cache data fetcher.
skdaccess.astro.spectra	Dictionary of Data Frames	Sloan Digital Sky Survey Science Archive Server (https://data.sdss.org/sas/)	100KB / image	Spectra from the Sloan Digital Sky Server (https://www.sdss.org/dr14/spectro/). This data set uses a stream data fetcher.
skdaccess.astro.voyager	Dictionary of Data Frames	Space Physics Data Facility (https://spdf.gsfc.nasa.gov/pub/data/voyager/)	≈ 0.1GB	Data from the Voyager mission (https://voyager.jpl.nasa.gov/mission/). This data set uses a cache data fetcher.
skdaccess.engineering.la.traffic_counts	Dictionary of Data Frames	Los Angeles Open Data (https://data.lacity.org)	≈ 0.1MB	Traffic count data in Los Angeles (https://data.lacity.org/A-Livable-and-Sustainable-City/LADOT-Traffic-Counts-Summary/94wu-3ps3). This data set uses a stream data fetcher.
skdaccess.finance.timeseries	Dictionary of Data Frames	Alpha Vantage (https://www.alphavantage.co/)	Data product dependent	Stock data obtained from Alpha Vantage (https://www.alphavantage.co/). This data set uses a stream data fetcher.
skdaccess.geo.era_interim	XArray Dataset	The University Corporation for Atmospheric Research (https://rda.ucar.edu/datasets/ds627.0/)	≈ 0.1GB / day	Atmospheric weather information from the ERA-Interim project at various pressure levels (https://www.ecmwf.int/en/forecasts/datasets/archive-datasets/reanalysis-datasets/era-interim). This data set uses a cache data fetcher.
skdaccess.geo.gldas	Dictionary of Data Frames	NASA Jet Propulsion Laboratory (ftp://podaac-ftp.jpl.nasa.gov/allData/tellus/L3/gldas_monthly/netcdf)	≈ 0.1GB	Land hydrology model produced by NASA. This version of the data is generated to match the GRACE temporal and spatial characteristics and is available as a complementary data product (https://grace.jpl.nasa.gov/data/get-data/land-water-content/). This data set uses a download data fetcher.

skdaccess.geo.grace	Dictionary of Data Frames	NASA Jet Propulsion Laboratory (ftp://podaac-ftp.jpl.nasa.gov/allData/tellus/L3/land_mass/RL05/netcdf)	≈ 0.1GB	GRACE Tellus Monthly Mass Grids. 30-day measurements of changes in Earth's gravity field to quantify equivalent water thickness (https://grace.jpl.nasa.gov/data/get-data/monthly-mass-grids-land/). This data set uses a download data fetcher.
skdaccess.geo.grace.mascon	Dictionary of Data Frames	NASA Jet Propulsion Laboratory (ftp://podaac.jpl.nasa.gov/allData/tellus/L3/mascon/RL05/JPL/CRI/netcdf)	≈ 1GB	GRACE Tellus Monthly Mass Grids - Global Mascons. 30-day measurements of changes in Earth's gravity field to quantify equivalent water thickness (https://grace.jpl.nasa.gov/data/get-data/jpl_global_mascons). This data set uses a download data fetcher.
skdaccess.geo.groundwater	Dictionary of Data Frames	USGS National Water Information System (https://waterservices.usgs.gov/rest/DV-Service.html)	≈ 1GB	United States groundwater monitoring wells measuring the depth to water level (https://waterservices.usgs.gov/). This data set uses a download data fetcher.
skdaccess.geo.magnetometer	Dictionary of Data Frames	USGS National Geomagnetism Program (https://geomag.usgs.gov/products/downloads.php)	≈ 1GB	Measurement of Earth's magnetic field from the USGS geomagnetism program (https://geomag.usgs.gov/). This data set uses a stream data fetcher.
skdaccess.geo.mahali.rinex	List of rinex file paths	MIT-Haystack Observatory (http://apollo.haystack.mit.edu/mahali-data/)	≈ 10GB	Rinex files from the MIT led NSF project studying the Earth's ionosphere with GPS (http://mahali.mit.edu). This data set uses a cache data fetcher.
skdaccess.geo.mahali.tec	Dictionary of Data Frames	MIT-Haystack Observatory (http://apollo.haystack.mit.edu/mahali-data/)	≈ 1GB	TEC measurements from the MIT led NSF project studying the Earth's ionosphere with GPS (http://mahali.mit.edu). This data set uses a cache data fetcher.
skdaccess.geo.mahali.temperature	Dictionary of Data Frames	MIT-Haystack Observatory (http://apollo.haystack.mit.edu/mahali-data/)	≈ 0.1GB	Temperature measurements from the MIT led NSF project studying the Earth's ionosphere with GPS (http://mahali.mit.edu). This data set uses a stream data fetcher.
skdaccess.geo.modis	Dictionary of Numpy arrays	NASA MODIS (https://ladsweb.modaps.eosdis.nasa.gov/tools-and-services/)	≈ 100MB /image	Spectroradiometer aboard the NASA Terra and Aqua satellites that generates approximately daily images of the Earth's surface (https://modis.gsfc.nasa.gov/). This data set uses a cache and stream data fetcher.

skdaccess.geo.pbo	Dictionary of Data Frames	UNAVCO Plate Boundary Observatory (ftp://data-out.unavco.org/pub/products/position/pbo.nam08.pos.tar.gz and https://www.unavco.org/data/gps-gnss/derived-products/derived-products.html)	≈ 1GB	Daily GPS displacement time series measurements throughout the United States (http://www.unavco.org/projects/major-projects/pbo/pbo.html). This data set uses a download data fetcher.
skdaccess.geo.sentinel_1	Dictionary of Numpy arrays	Alaska Satellite Facility (https://www.asf.alaska.edu/sentinel/)	≈ 1 – 10GB / image	Synthetic Aperture Radar data from the Sentinel 1 satellites operated by the European Space Agency (https://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-1). This data set uses a cache data fetcher.
skdaccess.geo.srtm	Dictionary of Numpy arrays	United States Geological Survey (https://e4ftl01.cr.usgs.gov/MEASURES/)	≈ 100GB	Digital elevation data from the Shuttle Radar Topography Mission (https://www2.jpl.nasa.gov/srtm/). This data set uses a cache data fetcher.
skdaccess.geo.uavsar	Dictionary of Numpy arrays	NASA Jet Propulsion Laboratory (https://uavsar.jpl.nasa.gov/cgi-bin/data.pl)	Data product dependent	Synthetic Aperture Radar Single Look Complex data from the Uninhabited Aerial Vehicle Synthetic Aperture Radar (https://uavsar.jpl.nasa.gov/). This data set uses a cache data fetcher.
skdaccess.geo.wyoming_sounding	Dictionary of Data Frames	University of Wyoming (http://weather.uwyo.edu/upperair/sounding.html)	≈ 10GB	Sounding data from The University of Wyoming (http://weather.uwyo.edu/upperair/sounding.html). This data set has a cache and stream data fetcher.
skdaccess.planetary.ode	Dictionary of Numpy arrays	Orbital Data Explorer at the University of Washington in St. Louis (http://oderest.rsl.wustl.edu)	Data product dependent	Planetary data from PDS Geosciences Node's Orbital Data Explorer (http://pds-geosciences.wustl.edu/default.htm). This data set uses a cache data fetcher
skdaccess.solar.sdo	Dictionary of Numpy arrays	Solar Dynamics Observatory (https://sdo.gsfc.nasa.gov/assets/img/browse/) and the Joint Science Operations Center (http://jsoc2.stanford.edu/data/aia/synoptic/	Data product dependent	Images from the Solar Dynamics Observatory (https://sdo.gsfc.nasa.gov). This data set uses a stream data fetcher.

3 Installation and Modes of Operation

The package can easily installed by using the standard Python “pip install” command:

```
> pip install scikit-dataaccess
```

After successful installation, a script called “skdaccess” allows users to specify the data sets that should be downloaded from their original sources to the local machine. The PBO, GRACE and groundwater data sets must be downloaded using this script before they can be used. For example, to download the PBO data use:

```
> skdaccess pbo
```

The script also completes all necessary configurations to make the data access seamlessly available in the Python environment.

3.1 Modes of Operation

There are three modes of operation available for accessing the data through the skdaccess package. The two local options are ”Download” and ”Cache”. Using the ”Download” option, the dataset is downloaded to local disk before use. The ”Cache” option allows for data of interest to be downloaded during use and stored in case of future use. The online option is ”Stream”, which accesses the data without storing a local copy.

3.2 The Skdaccess Script

This script downloads scientific data sets from preconfigured Web sources, makes them available offline on the user's machine, and configures the Python environment for data access.

For the following data sets, the skdaccess script must be used to download and prepare the data.

- GPS data from the Plate Boundary Observatory
- Depth to groundwater for wells in California
- Equivalent water thickness from GRACE Tellus Monthly Land Grids
- Equivalent water thickness from GLDAS

The skdaccess script does not download Kepler data, as the data is downloaded for each star individually the first time the star is accessed by the data fetcher.

To download a dataset, use the command with the dataset name as the argument. For example, to download groundwater data available from California type

```
> skdaccess groundwater
```

The data will be downloaded into the current directory, and the .skdaccess config file located in the user's home directory will be updated. Each data set can be downloaded into different directories depending on the user preferences.

To list all supported data sets, call

```
> skdaccess -l
This utility can install one of the following data sets:

        PBO - Plate Boundary Observatory GPS Time Series
        GRACE - Monthly Mass Grids
        GLDAS - Monthly estimates from GDLAS model in same resolution as GRACE
        Groundwater - Ground water daily values from across the US
```

Calling the script without any arguments provides a list of available commands as shown below.

```
> skdaccess
usage: skdaccess [-h] [-l] [-i LOCAL_DATA] [-c] [data_set]

The Sci-kit Data Access (skdaccess) package is a tool for integrating various
scientific data sets into the Python environment using a common interface.
This script can download different scientific data sets for offline analysis.

positional arguments:
  data_set              Name of data set

optional arguments:
  -h, --help            show this help message and exit
  -l, --list            List data sets
  -i LOCAL_DATA, --input LOCAL_DATA
                        Use LOCAL_DATA that has already been downloaded
  -c, --check           Print data location for data set
```

4 Scientific Data Access in Python

Data is retrieved in a Python program via a DataFetcher object. Each data set has its own data fetcher. There are two ways of handling the data: (1) directly accessing the data structure created by the DataFetcher, or (2) through an iterator interface provided by a data wrapper.

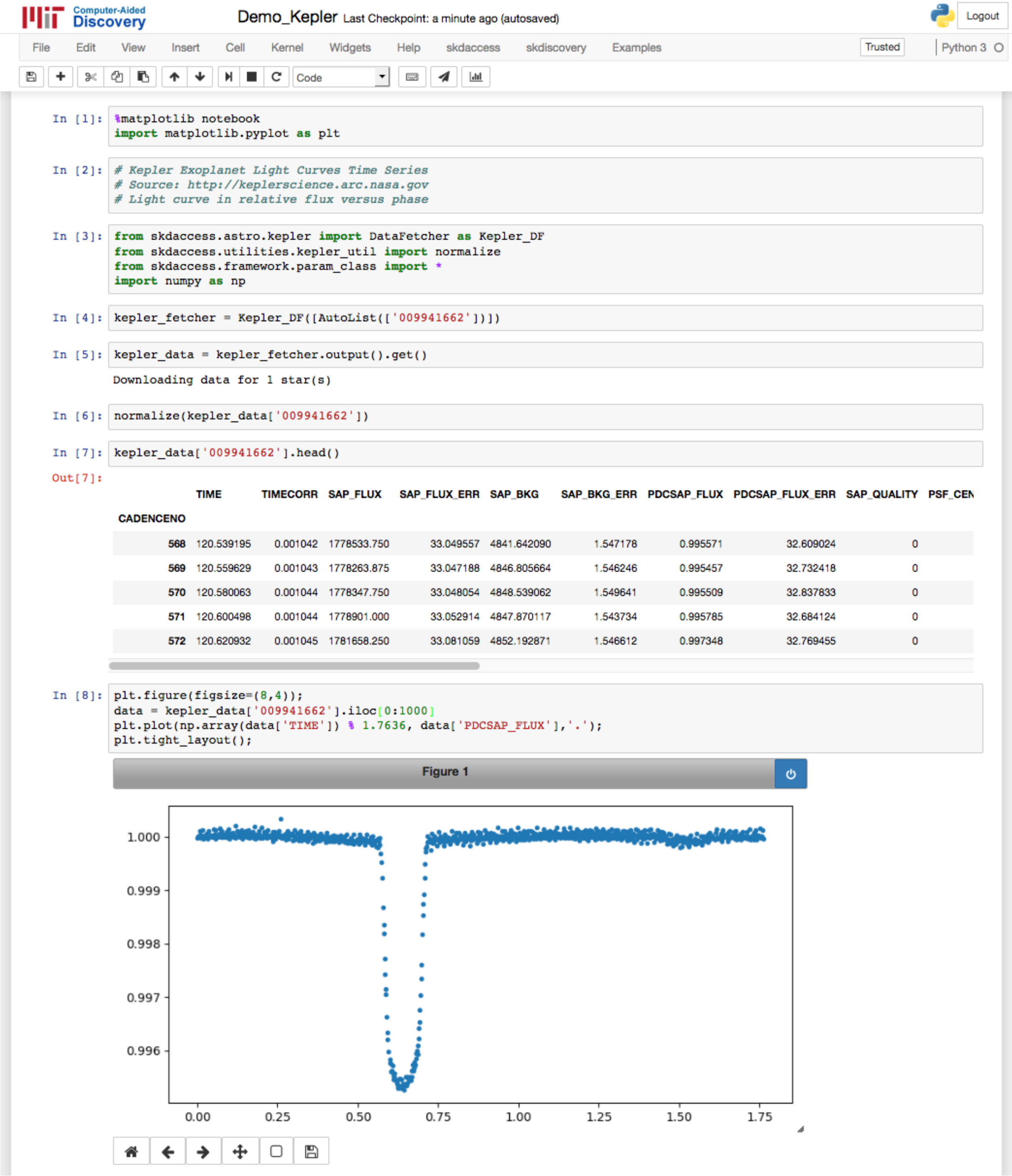
Data Access Example:

```
# First import the data generator for water
# Note: This assumes the groundwater data has been downloaded
from skdaccess.geo.groundwater import DataFetcher as waterDF

# Create a data fetcher and get the data wrapper:
fullDF = waterDF(start_date=’2007-01-01’, end_date=’2011-01-01’)
wdata = fullDF.output().get()
```

5 Usage Examples

The following examples show how to use the data fetcher for the data sets described earlier and displaying / plotting the data. These notebooks can be accessed at https://github.com/MITHaystack/scikit-dataaccess/tree/master/skdaccess/examples.

5.1 skdaccess.astro.kepler



```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt
```

```
In [2]: # Kepler Exoplanet Light Curves Time Series
        # Source: http://keplerscience.arc.nasa.gov
        # Light curve in relative flux versus phase
```

```
In [3]: from skdaccess.astro.kepler import DataFetcher as Kepler_DF
        from skdaccess.utilities.kepler_util import normalize
        from skdaccess.framework.param_class import *
        import numpy as np
```

```
In [4]: kepler_fetcher = Kepler_DF([AutoList(['009941662'])])
```

```
In [5]: kepler_data = kepler_fetcher.output().get()

        Downloading data for 1 star(s)
```

```
In [6]: normalize(kepler_data['009941662'])
```

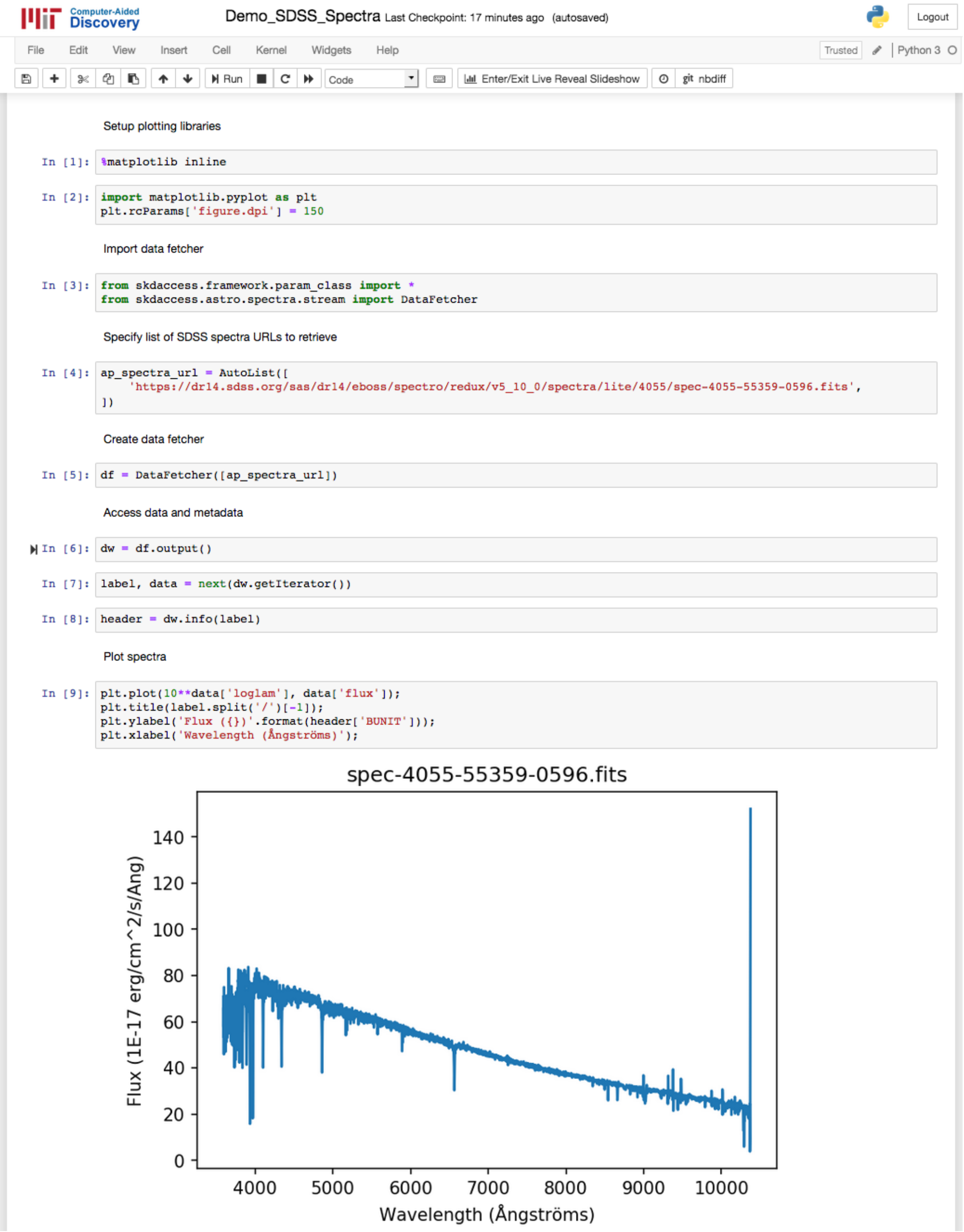
```
In [7]: kepler_data['009941662'].head()
```

Out[7]:

	TIME	TIMECORR	SAP_FLUX	SAP_FLUX_ERR	SAP_BKG	SAP_BKG_ERR	PDCSAP_FLUX	PDCSAP_FLUX_ERR	SAP_QUALITY	PSF_CEN
CADENCENO										
568	120.539195	0.001042	1778533.750	33.049557	4841.642090	1.547178	0.995571	32.609024	0	
569	120.559629	0.001043	1778263.875	33.047188	4846.805664	1.546246	0.995457	32.732418	0	
570	120.580063	0.001044	1778347.750	33.048054	4848.539062	1.549641	0.995509	32.837833	0	
571	120.600498	0.001044	1778901.000	33.052914	4847.870117	1.543734	0.995785	32.684124	0	
572	120.620932	0.001045	1781658.250	33.081059	4852.192871	1.546612	0.997348	32.769455	0	

```
In [8]: plt.figure(figsize=(8,4));
        data = kepler_data['009941662'].iloc[0:1000]
        plt.plot(np.array(data['TIME']) % 1.7636, data['PDCSAP_FLUX'],'.');
        plt.tight_layout();
```

5.2 skdaccess.astro.spectra



Setup plotting libraries

```
In [1]: %matplotlib inline
```

```
In [2]: import matplotlib.pyplot as plt
        plt.rcParams['figure.dpi'] = 150
```

Import data fetcher

```
In [3]: from skdaccess.framework.param_class import *
        from skdaccess.astro.spectra.stream import DataFetcher
```

Specify list of SDSS spectra URLs to retrieve

```
In [4]: ap_spectra_url = AutoList([
            'https://dr14.sdss.org/sas/dr14/eboss/spectro/redux/v5_10_0/spectra/lite/4055/spec-4055-55359-0596.fits',
        ])
```

Create data fetcher

```
In [5]: df = DataFetcher([ap_spectra_url])
```

Access data and metadata

```
In [6]: dw = df.output()
```

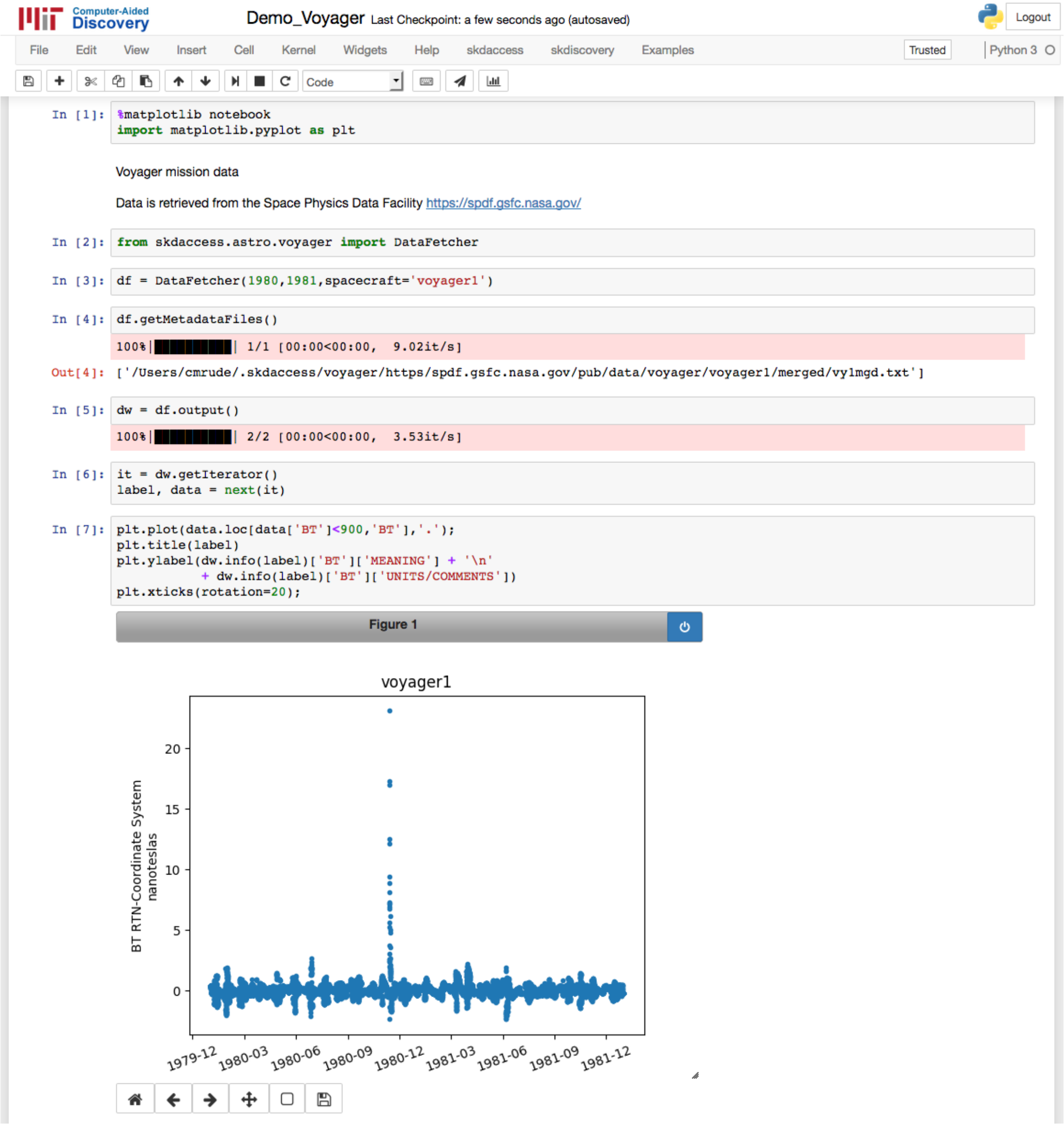
```
In [7]: label, data = next(dw.getIterator())
```

```
In [8]: header = dw.info(label)
```

Plot spectra

```
In [9]: plt.plot(10**data['loglam'], data['flux']);
        plt.title(label.split('/')[-1]);
        plt.ylabel('Flux ({})'.format(header['BUNIT']));
        plt.xlabel('Wavelength (Ångströms)');
```

5.3 skdaccess.astro.voyager



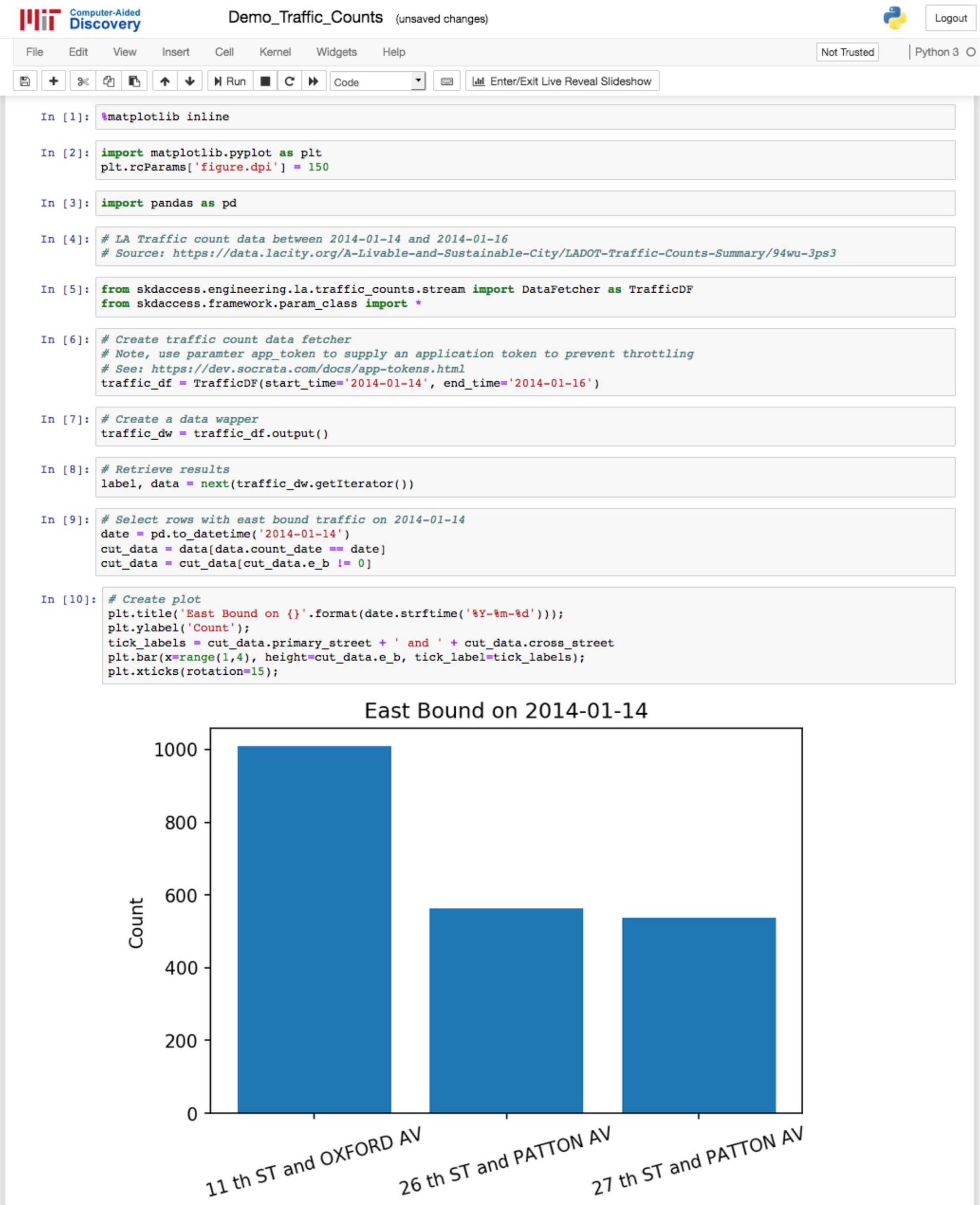
```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt
```

Voyager mission data

Data is retrieved from the Space Physics Data Facility https://spdf.gsfc.nasa.gov/

```
In [2]: from skdaccess.astro.voyager import DataFetcher

In [3]: df = DataFetcher(1980,1981,spacecraft='voyager1')

In [4]: df.getMetadataFiles()

        100%|██████████| 1/1 [00:00<00:00,  9.02it/s]

Out[4]: ['/Users/cmrude/.skdaccess/voyager/https/spdf.gsfc.nasa.gov/pub/data/voyager/voyager1/merged/vy1mgd.txt']

In [5]: dw = df.output()

        100%|██████████| 2/2 [00:00<00:00,  3.53it/s]

In [6]: it = dw.getIterator()
        label, data = next(it)

In [7]: plt.plot(data.loc[data['BT']<900,'BT'],'.');
        plt.title(label)
        plt.ylabel(dw.info(label)['BT']['MEANING'] + '\n'
                   + dw.info(label)['BT']['UNITS/COMMENTS'])
        plt.xticks(rotation=20);
```

5.4 skdaccess.engineering.la.traffic_counts



```
In [1]: %matplotlib inline
```

```
In [2]: import matplotlib.pyplot as plt
        plt.rcParams['figure.dpi'] = 150
```

```
In [3]: import pandas as pd
```

```
In [4]: # LA Traffic count data between 2014-01-14 and 2014-01-16
        # Source: https://data.lacity.org/A-Livable-and-Sustainable-City/LADOT-Traffic-Counts-Summary/94wu-3ps3
```

```
In [5]: from skdaccess.engineering.la.traffic_counts.stream import DataFetcher as TrafficDF
        from skdaccess.framework.param_class import *
```

```
In [6]: # Create traffic count data fetcher
        # Note, use paramter app_token to supply an application token to prevent throttling
        # See: https://dev.socrata.com/docs/app-tokens.html
        traffic_df = TrafficDF(start_time='2014-01-14', end_time='2014-01-16')
```

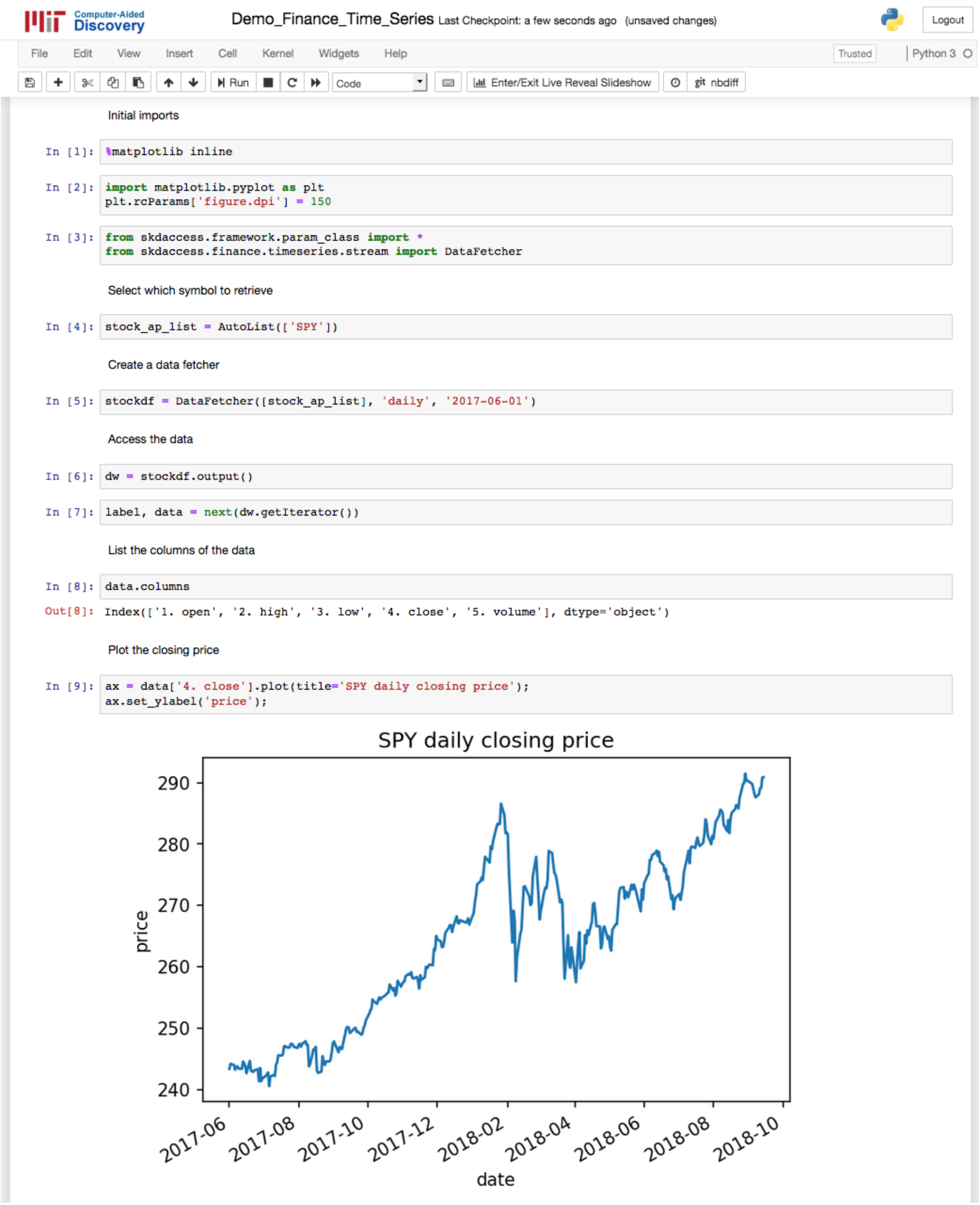
```
In [7]: # Create a data wapper
        traffic_dw = traffic_df.output()
```

```
In [8]: # Retrieve results
        label, data = next(traffic_dw.getIterator())
```

```
In [9]: # Select rows with east bound traffic on 2014-01-14
        date = pd.to_datetime('2014-01-14')
        cut_data = data[data.count_date == date]
        cut_data = cut_data[cut_data.e_b != 0]
```

```
In [10]: # Create plot
         plt.title('East Bound on {}'.format(date.strftime('%Y-%m-%d')));
         plt.ylabel('Count');
         tick_labels = cut_data.primary_street + ' and ' + cut_data.cross_street
         plt.bar(x=range(1,4), height=cut_data.e_b, tick_label=tick_labels);
         plt.xticks(rotation=15);
```

5.5 skdaccess.finance.timeseries



Initial imports

```
In [1]: %matplotlib inline
```

```
In [2]: import matplotlib.pyplot as plt
        plt.rcParams['figure.dpi'] = 150
```

```
In [3]: from skdaccess.framework.param_class import *
        from skdaccess.finance.timeseries.stream import DataFetcher
```

Select which symbol to retrieve

```
In [4]: stock_ap_list = AutoList(['SPY'])
```

Create a data fetcher

```
In [5]: stockdf = DataFetcher([stock_ap_list], 'daily', '2017-06-01')
```

Access the data

```
In [6]: dw = stockdf.output()
```

```
In [7]: label, data = next(dw.getIterator())
```

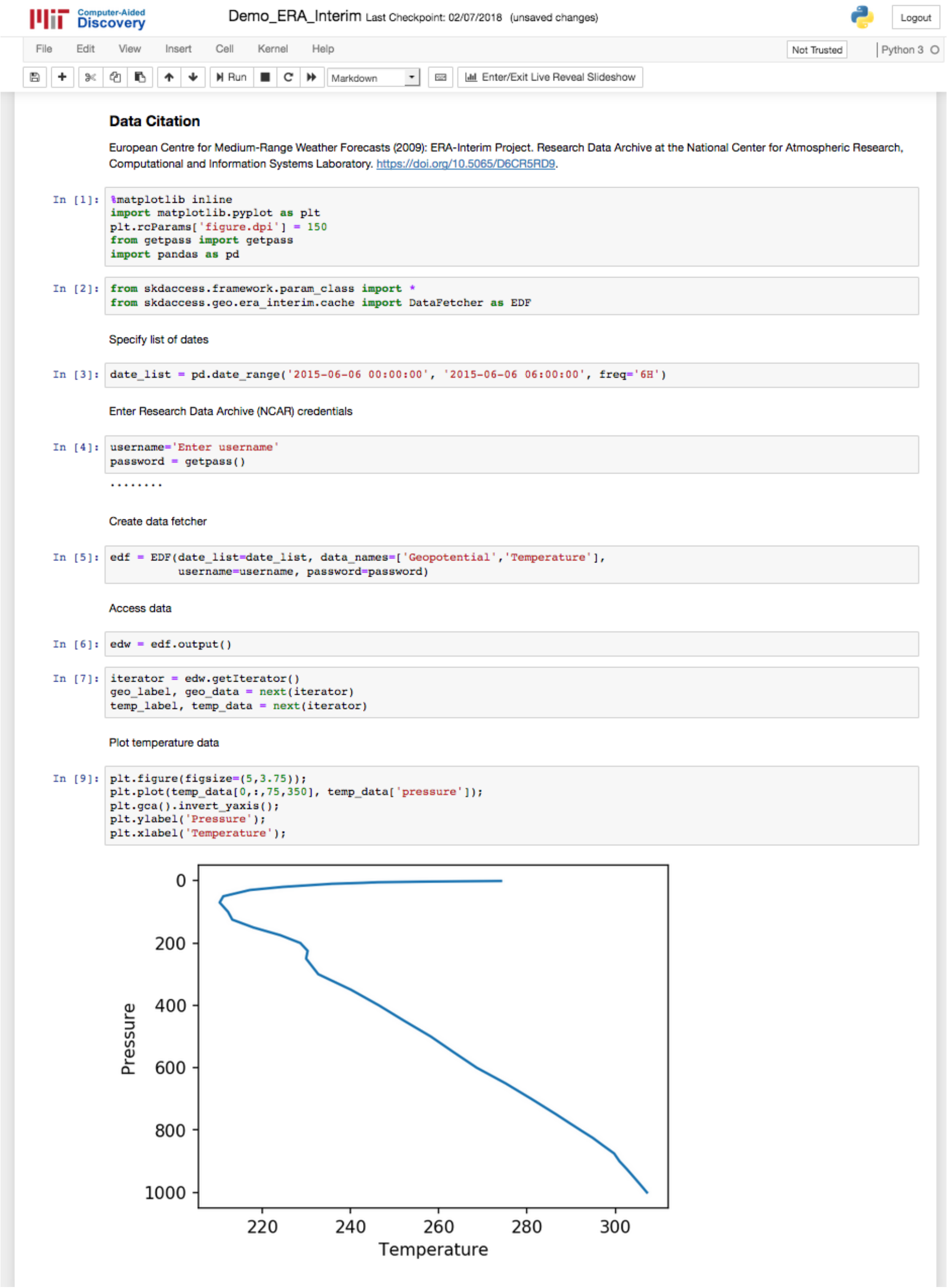
List the columns of the data

```
In [8]: data.columns
Out[8]: Index(['1. open', '2. high', '3. low', '4. close', '5. volume'], dtype='object')
```

Plot the closing price

```
In [9]: ax = data['4. close'].plot(title='SPY daily closing price');
        ax.set_ylabel('price');
```

5.6 skdaccess.geo.era_interim



Computer-Aided Discovery
Demo_ERA_Interim Last Checkpoint: 02/07/2018 (unsaved changes)
Logout
File Edit View Insert Cell Kernel Help
Not Trusted
Python 3 ○
Run
Markdown
Enter/Exit Live Reveal Slideshow

Data Citation

European Centre for Medium-Range Weather Forecasts (2009): ERA-Interim Project. Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory. https://doi.org/10.5065/D6CR5RD9.

```
In [1]: %matplotlib inline
        import matplotlib.pyplot as plt
        plt.rcParams['figure.dpi'] = 150
        from getpass import getpass
        import pandas as pd
```

```
In [2]: from skdaccess.framework.param_class import *
        from skdaccess.geo.era_interim.cache import DataFetcher as EDF
```

Specify list of dates

```
In [3]: date_list = pd.date_range('2015-06-06 00:00:00', '2015-06-06 06:00:00', freq='6H')
```

Enter Research Data Archive (NCAR) credentials

```
In [4]: username='Enter username'
        password = getpass()

        ········
```

Create data fetcher

```
In [5]: edf = EDF(date_list=date_list, data_names=['Geopotential','Temperature'],
                  username=username, password=password)
```

Access data

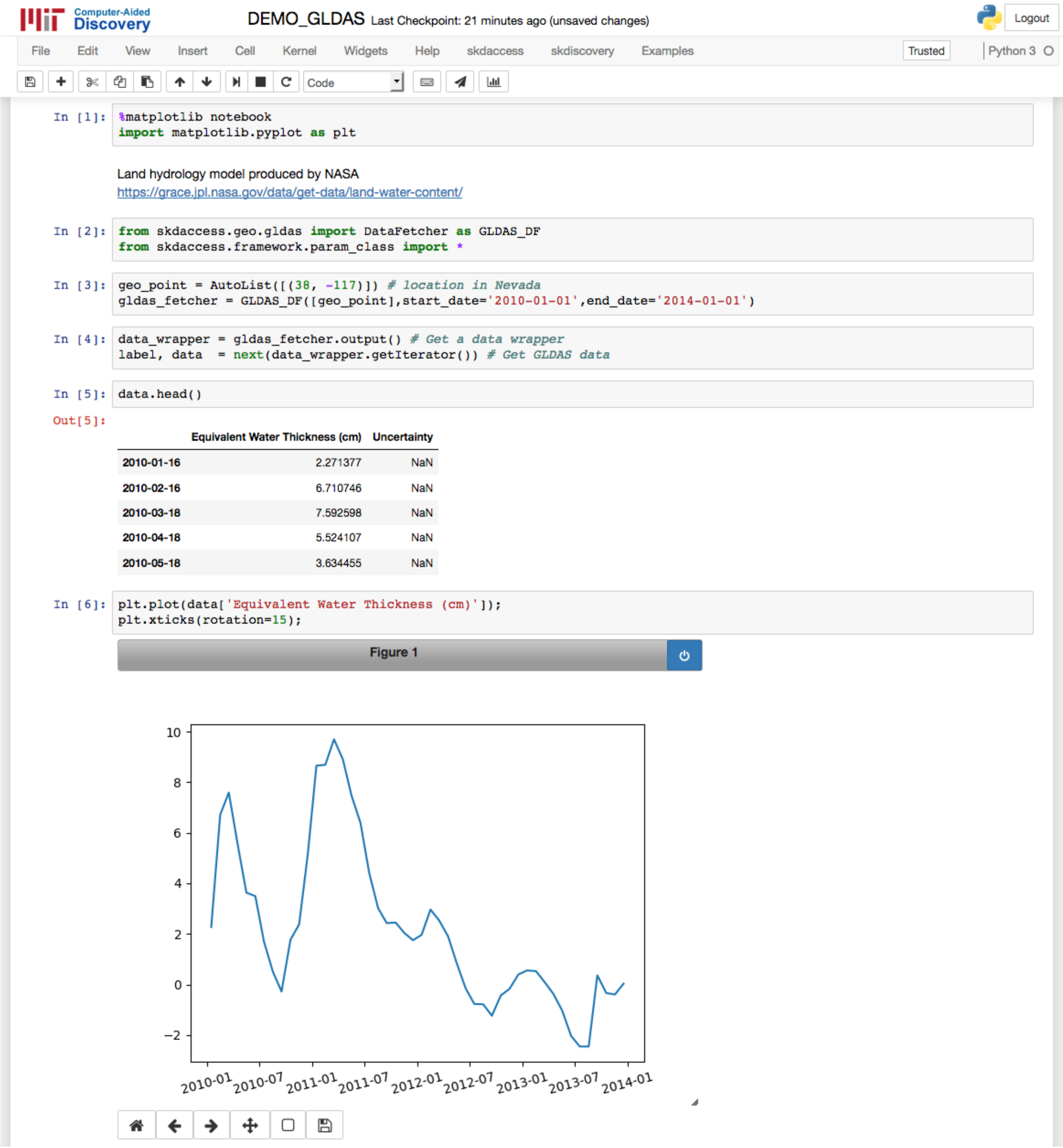
```
In [6]: edw = edf.output()
```

```
In [7]: iterator = edw.getIterator()
        geo_label, geo_data = next(iterator)
        temp_label, temp_data = next(iterator)
```

Plot temperature data

```
In [9]: plt.figure(figsize=(5,3.75));
        plt.plot(temp_data[0,:,75,350], temp_data['pressure']);
        plt.gca().invert_yaxis();
        plt.ylabel('Pressure');
        plt.xlabel('Temperature');
```

5.7 skdaccess.geo.gldas



```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt
```

Land hydrology model produced by NASA
https://grace.jpl.nasa.gov/data/get-data/land-water-content/

```
In [2]: from skdaccess.geo.gldas import DataFetcher as GLDAS_DF
        from skdaccess.framework.param_class import *
```

```
In [3]: geo_point = AutoList([(38, -117)]) # location in Nevada
        gldas_fetcher = GLDAS_DF([geo_point],start_date='2010-01-01',end_date='2014-01-01')
```

```
In [4]: data_wrapper = gldas_fetcher.output() # Get a data wrapper
        label, data  = next(data_wrapper.getIterator()) # Get GLDAS data
```

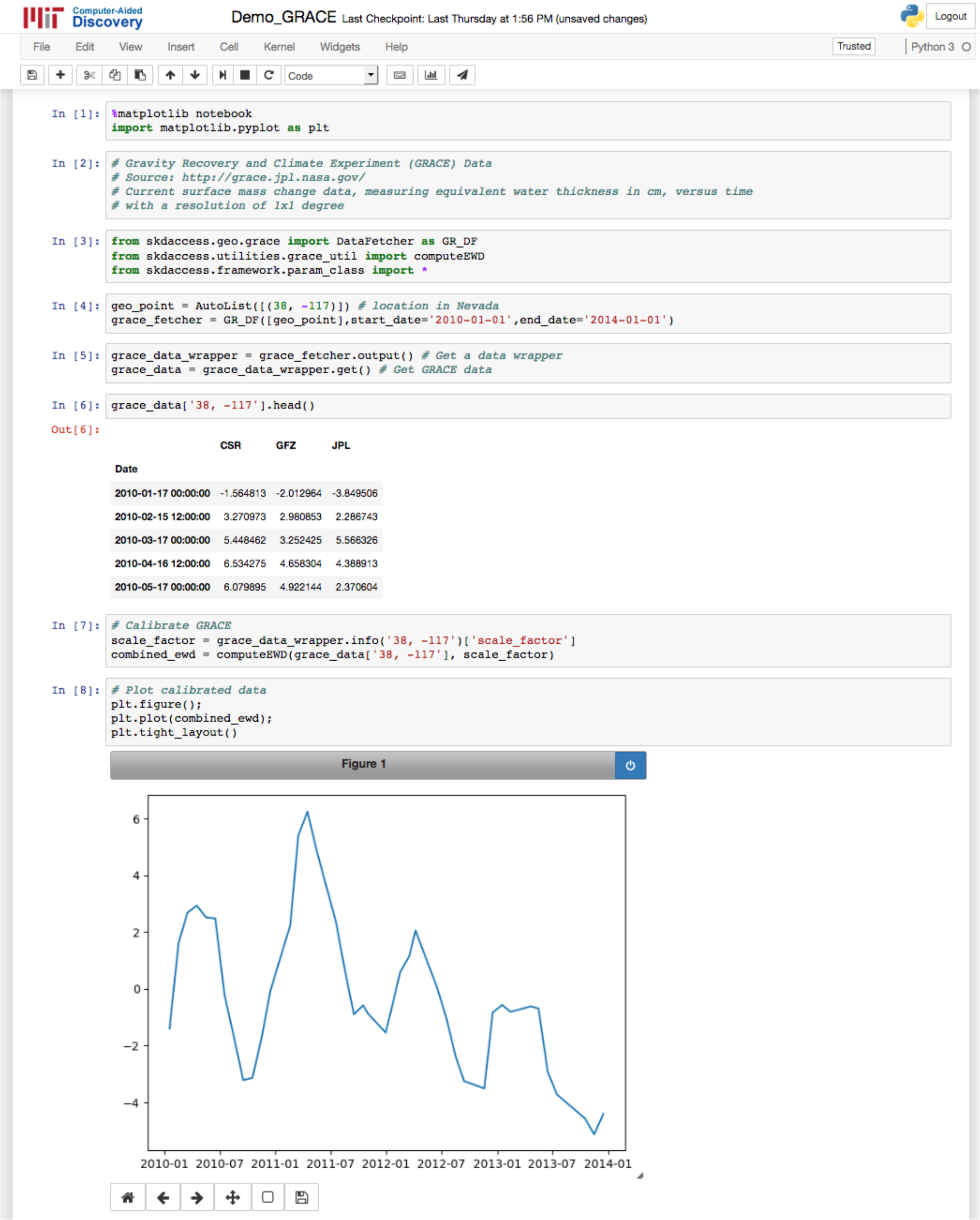
```
In [5]: data.head()
```

Out[5]:

	Equivalent Water Thickness (cm)	Uncertainty
2010-01-16	2.271377	NaN
2010-02-16	6.710746	NaN
2010-03-18	7.592598	NaN
2010-04-18	5.524107	NaN
2010-05-18	3.634455	NaN

```
In [6]: plt.plot(data['Equivalent Water Thickness (cm)']);
        plt.xticks(rotation=15);
```

5.8 skdaccess.geo.grace

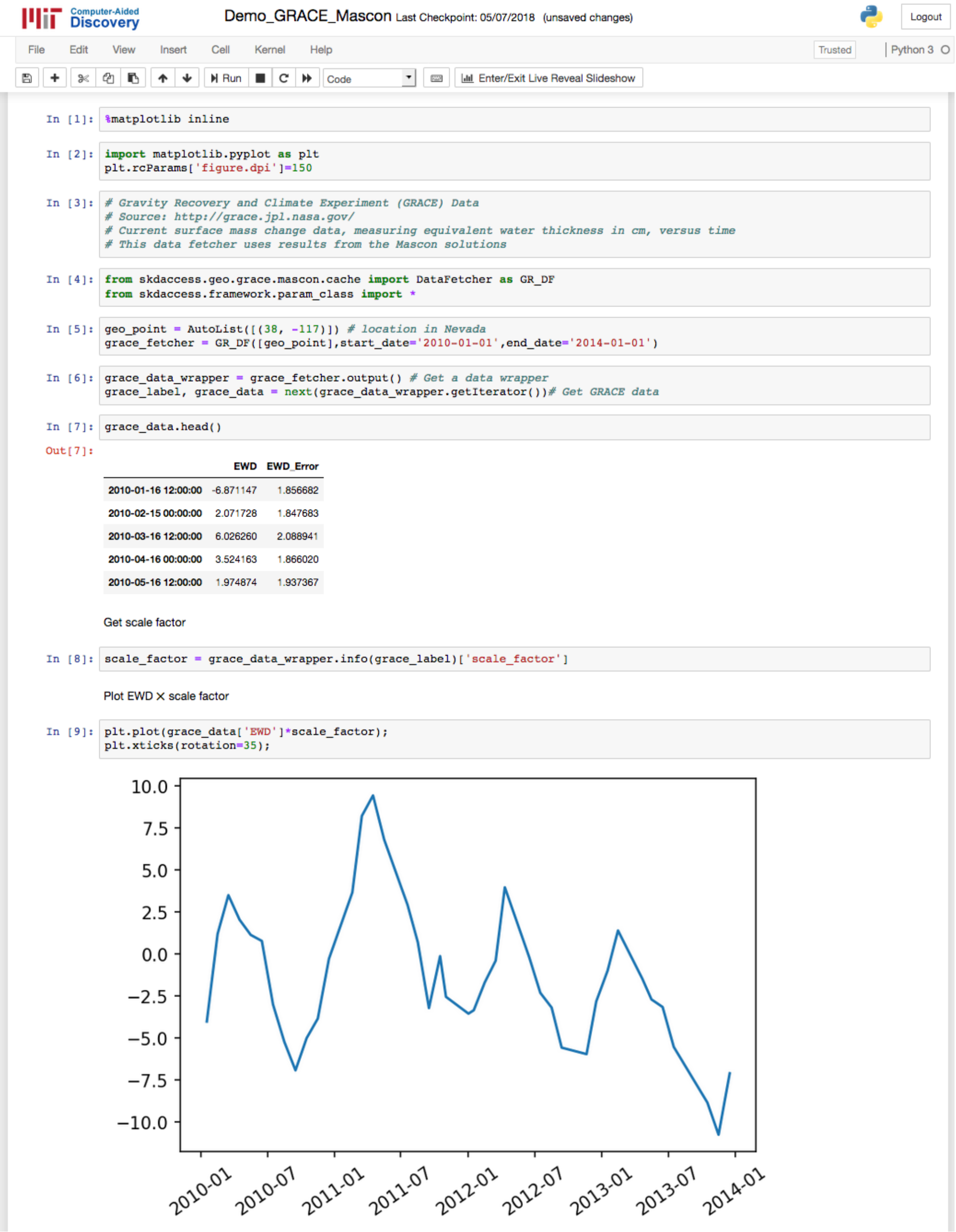


```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt

In [2]: # Gravity Recovery and Climate Experiment (GRACE) Data
        # Source: http://grace.jpl.nasa.gov/
        # Current surface mass change data, measuring equivalent water thickness in cm, versus time
        # with a resolution of 1x1 degree

In [3]: from skdaccess.geo.grace import DataFetcher as GR_DF
        from skdaccess.utilities.grace_util import computeEWD
        from skdaccess.framework.param_class import *

In [4]: geo_point = AutoList([(38, -117)]) # location in Nevada
        grace_fetcher = GR_DF([geo_point],start_date='2010-01-01',end_date='2014-01-01')

In [5]: grace_data_wrapper = grace_fetcher.output() # Get a data wrapper
        grace_data = grace_data_wrapper.get() # Get GRACE data

In [6]: grace_data['38, -117'].head()

Out[6]:
```

	CSR	GFZ	JPL
Date			
2010-01-17 00:00:00	-1.564813	-2.012964	-3.849506
2010-02-15 12:00:00	3.270973	2.980853	2.286743
2010-03-17 00:00:00	5.448462	3.252425	5.566326
2010-04-16 12:00:00	6.534275	4.658304	4.388913
2010-05-17 00:00:00	6.079895	4.922144	2.370604

```
In [7]: # Calibrate GRACE
        scale_factor = grace_data_wrapper.info('38, -117')['scale_factor']
        combined_ewd = computeEWD(grace_data['38, -117'], scale_factor)

In [8]: # Plot calibrated data
        plt.figure();
        plt.plot(combined_ewd);
        plt.tight_layout()
```

5.9 skdaccess.geo.grace.mascon


Computer-Aided
Discovery
Demo_GRACE_Mascon Last Checkpoint: 05/07/2018 (unsaved changes)
Logout
File
Edit
View
Insert
Cell
Kernel
Help
Trusted
Python 3
Run
Code
Enter/Exit Live Reveal Slideshow

```
In [1]: %matplotlib inline
```

```
In [2]: import matplotlib.pyplot as plt
        plt.rcParams['figure.dpi']=150
```

```
In [3]: # Gravity Recovery and Climate Experiment (GRACE) Data
        # Source: http://grace.jpl.nasa.gov/
        # Current surface mass change data, measuring equivalent water thickness in cm, versus time
        # This data fetcher uses results from the Mascon solutions
```

```
In [4]: from skdaccess.geo.grace.mascon.cache import DataFetcher as GR_DF
        from skdaccess.framework.param_class import *
```

```
In [5]: geo_point = AutoList([(38, -117)]) # location in Nevada
        grace_fetcher = GR_DF([geo_point],start_date='2010-01-01',end_date='2014-01-01')
```

```
In [6]: grace_data_wrapper = grace_fetcher.output() # Get a data wrapper
        grace_label, grace_data = next(grace_data_wrapper.getIterator())# Get GRACE data
```

```
In [7]: grace_data.head()
```

Out[7]:

	EWD	EWD_Error
2010-01-16 12:00:00	-6.871147	1.856682
2010-02-15 00:00:00	2.071728	1.847683
2010-03-16 12:00:00	6.026260	2.088941
2010-04-16 00:00:00	3.524163	1.866020
2010-05-16 12:00:00	1.974874	1.937367

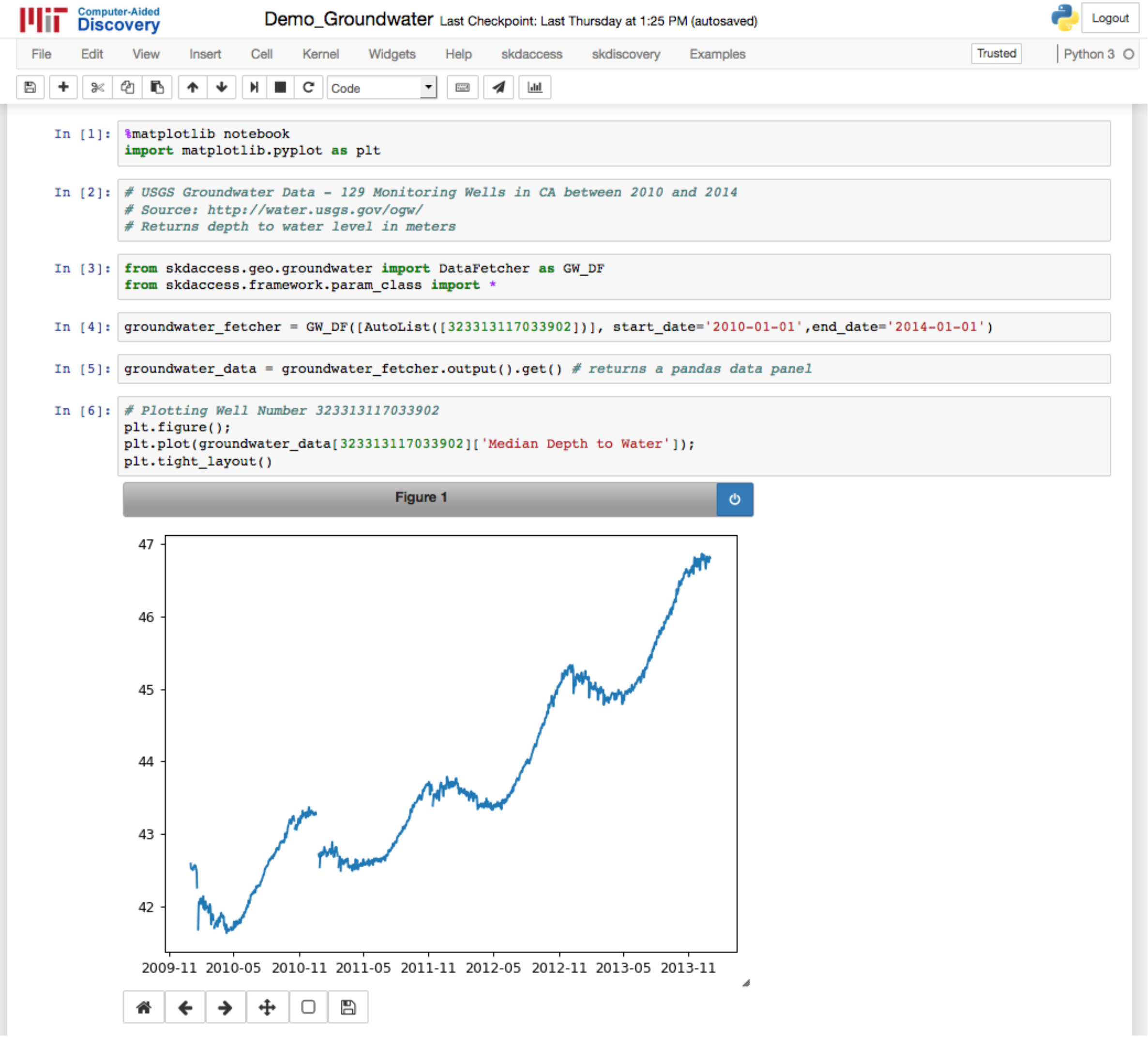
Get scale factor

```
In [8]: scale_factor = grace_data_wrapper.info(grace_label)['scale_factor']
```

Plot EWD × scale factor

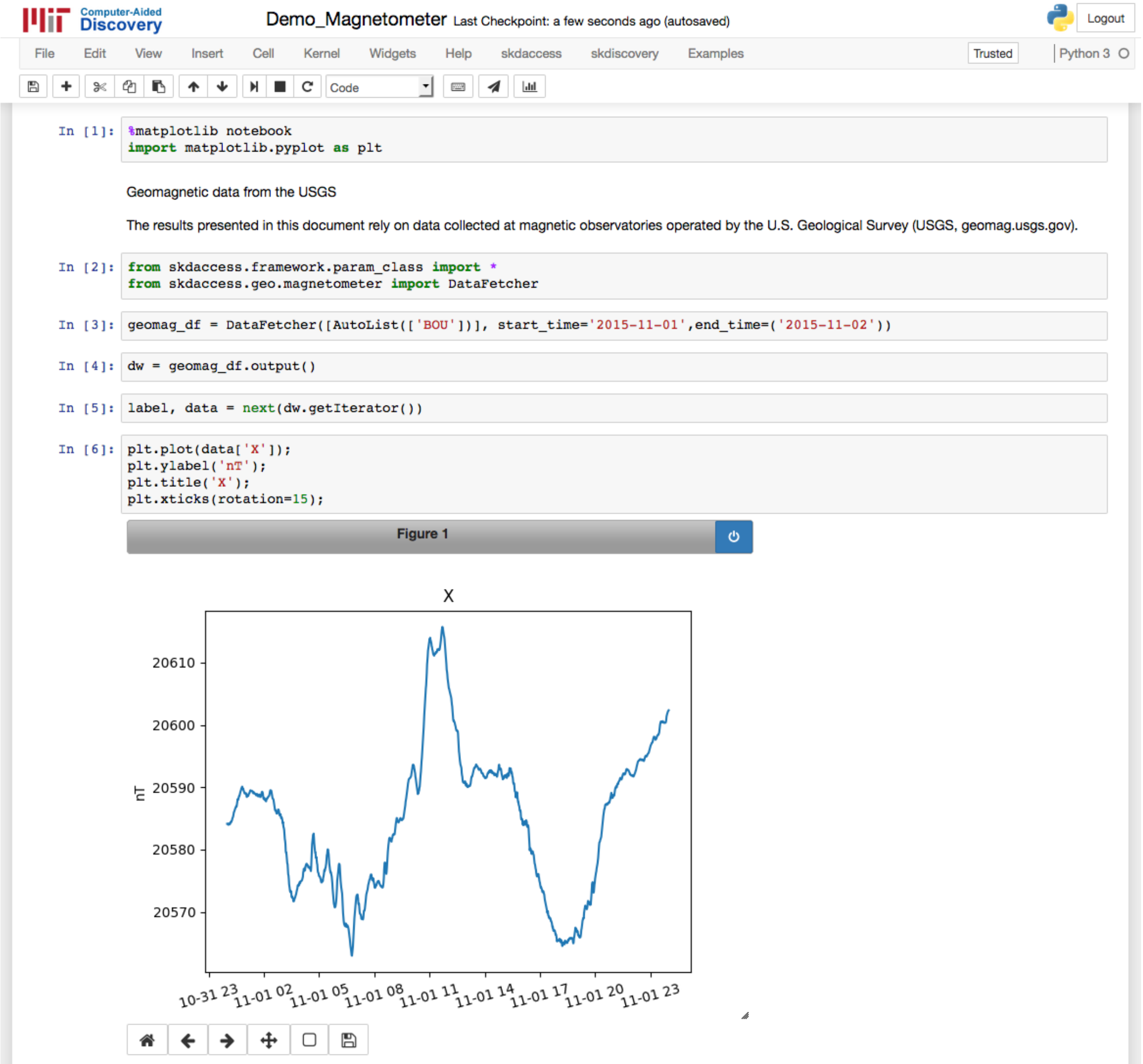
```
In [9]: plt.plot(grace_data['EWD']*scale_factor);
        plt.xticks(rotation=35);
```

5.10 skdaccess.geo.groundwater



```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt

In [2]: # USGS Groundwater Data - 129 Monitoring Wells in CA between 2010 and 2014
        # Source: http://water.usgs.gov/ogw/
        # Returns depth to water level in meters

In [3]: from skdaccess.geo.groundwater import DataFetcher as GW_DF
        from skdaccess.framework.param_class import *

In [4]: groundwater_fetcher = GW_DF([AutoList([323313117033902])], start_date='2010-01-01',end_date='2014-01-01')

In [5]: groundwater_data = groundwater_fetcher.output().get() # returns a pandas data panel

In [6]: # Plotting Well Number 323313117033902
        plt.figure();
        plt.plot(groundwater_data[323313117033902]['Median Depth to Water']);
        plt.tight_layout()
```

5.11 skdaccess.geo.magnetometer



```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt
```

Geomagnetic data from the USGS

The results presented in this document rely on data collected at magnetic observatories operated by the U.S. Geological Survey (USGS, geomag.usgs.gov).

```
In [2]: from skdaccess.framework.param_class import *
        from skdaccess.geo.magnetometer import DataFetcher
```

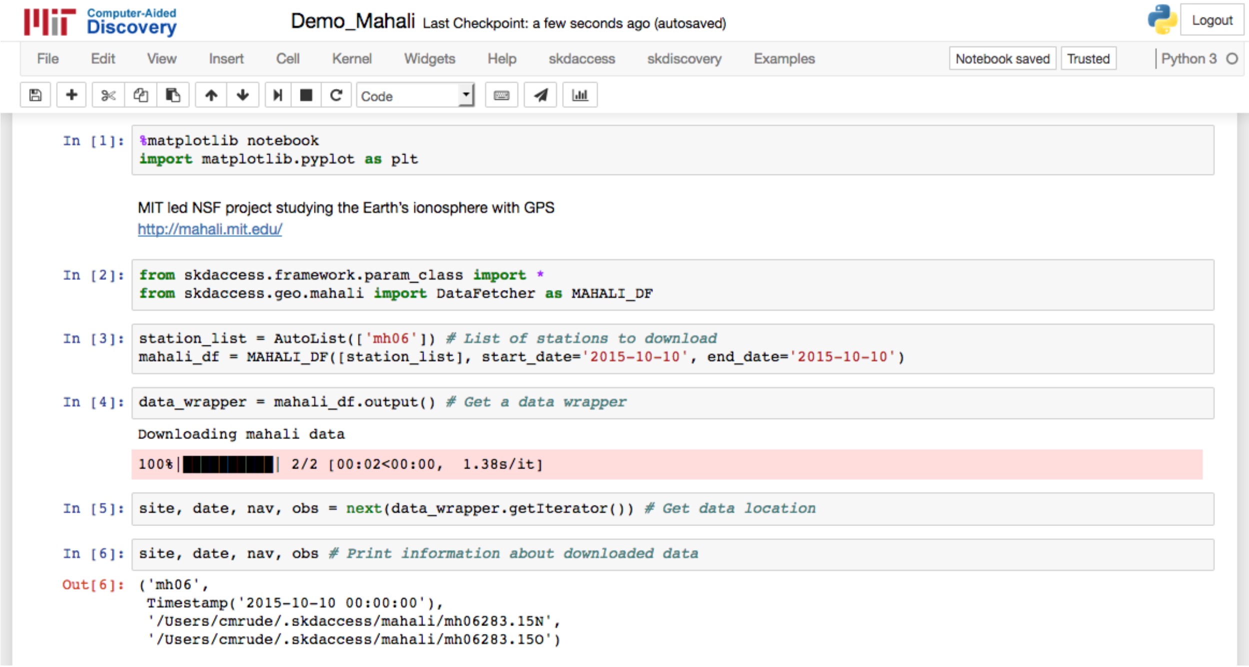
```
In [3]: geomag_df = DataFetcher([AutoList(['BOU'])], start_time='2015-11-01',end_time=('2015-11-02'))
```

```
In [4]: dw = geomag_df.output()
```

```
In [5]: label, data = next(dw.getIterator())
```

```
In [6]: plt.plot(data['X']);
        plt.ylabel('nT');
        plt.title('X');
        plt.xticks(rotation=15);
```

5.12 skdaccess.geo.mahali.rinex

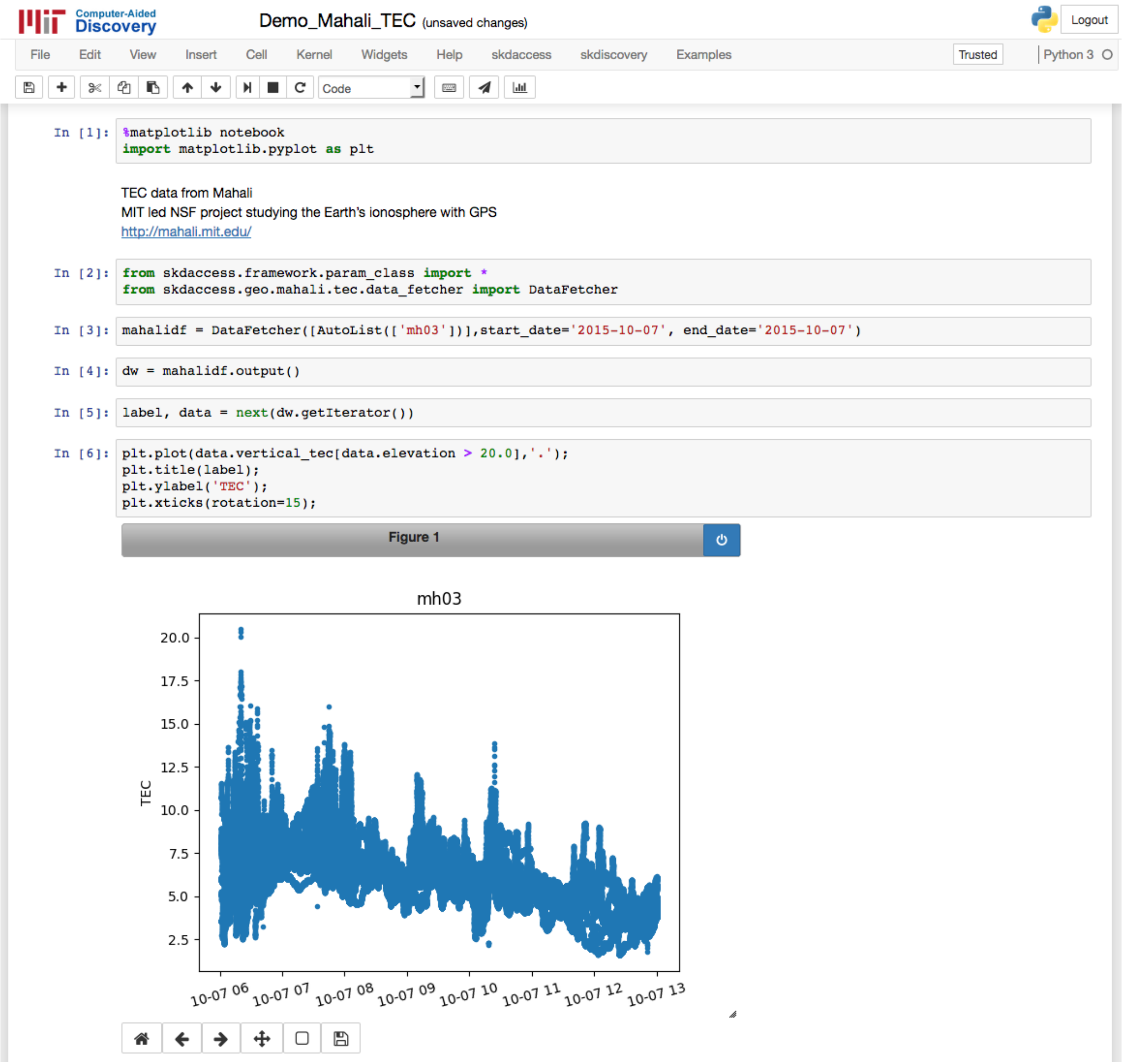


```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt
```

MIT led NSF project studying the Earth's ionosphere with GPS
http://mahali.mit.edu/

```
In [2]: from skdaccess.framework.param_class import *
        from skdaccess.geo.mahali import DataFetcher as MAHALI_DF

In [3]: station_list = AutoList(['mh06']) # List of stations to download
        mahali_df = MAHALI_DF([station_list], start_date='2015-10-10', end_date='2015-10-10')

In [4]: data_wrapper = mahali_df.output() # Get a data wrapper

        Downloading mahali data
        100%|██████████| 2/2 [00:02<00:00,  1.38s/it]

In [5]: site, date, nav, obs = next(data_wrapper.getIterator()) # Get data location

In [6]: site, date, nav, obs # Print information about downloaded data

Out[6]: ('mh06',
         Timestamp('2015-10-10 00:00:00'),
         '/Users/cmrude/.skdaccess/mahali/mh06283.15N',
         '/Users/cmrude/.skdaccess/mahali/mh06283.15O')
```

5.13 skdaccess.geo.mahali.tec

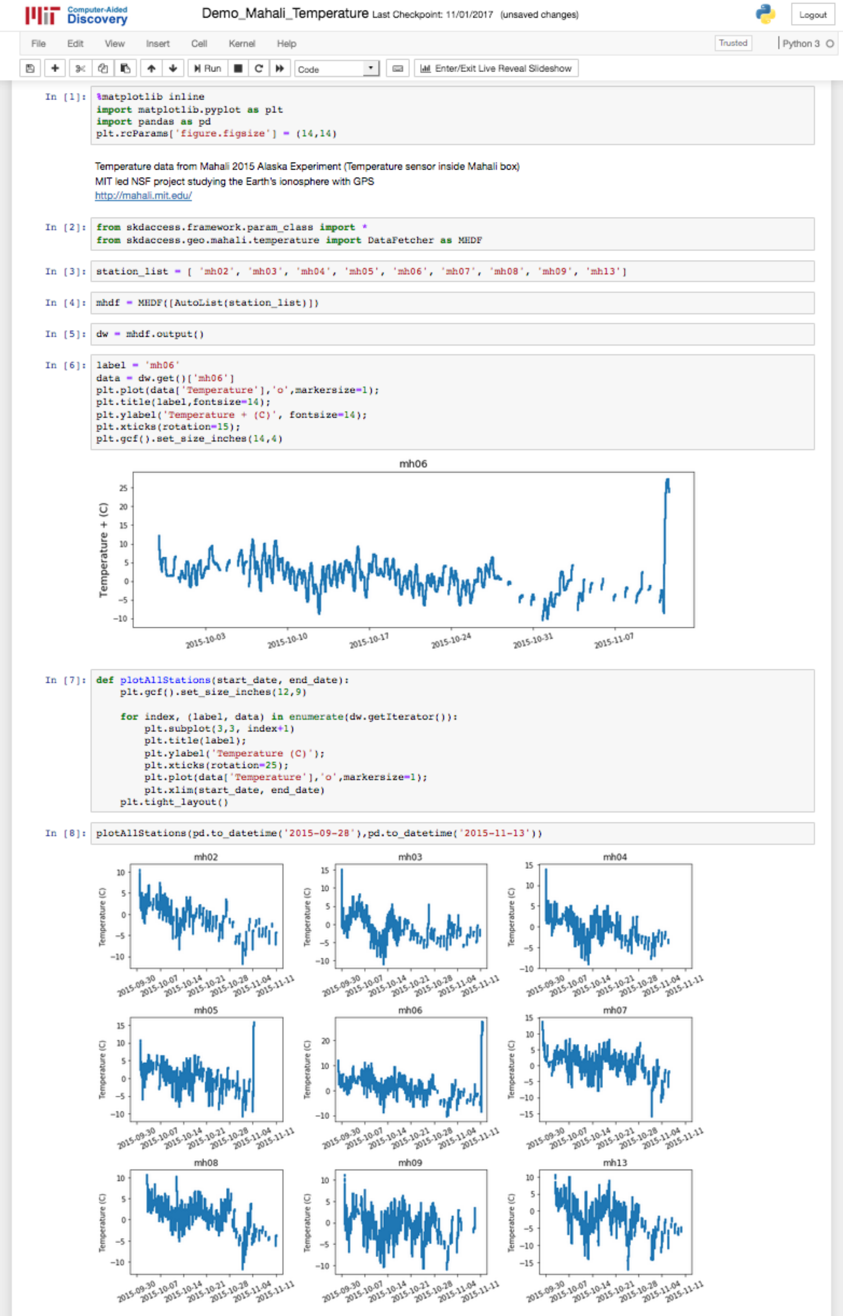


```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt
```

TEC data from Mahali
MIT led NSF project studying the Earth's ionosphere with GPS
http://mahali.mit.edu/

```
In [2]: from skdaccess.framework.param_class import *
        from skdaccess.geo.mahali.tec.data_fetcher import DataFetcher

In [3]: mahalidf = DataFetcher([AutoList(['mh03'])],start_date='2015-10-07', end_date='2015-10-07')

In [4]: dw = mahalidf.output()

In [5]: label, data = next(dw.getIterator())

In [6]: plt.plot(data.vertical_tec[data.elevation > 20.0],'.');
        plt.title(label);
        plt.ylabel('TEC');
        plt.xticks(rotation=15);
```

5.14 skdaccess.geo.mahali.temperature



Demo_Mahali_Temperature Last Checkpoint: 11/01/2017 (unsaved changes)

```
In [1]: %matplotlib inline
        import matplotlib.pyplot as plt
        import pandas as pd
        plt.rcParams['figure.figsize'] = (14,14)
```

Temperature data from Mahali 2015 Alaska Experiment (Temperature sensor inside Mahali box)

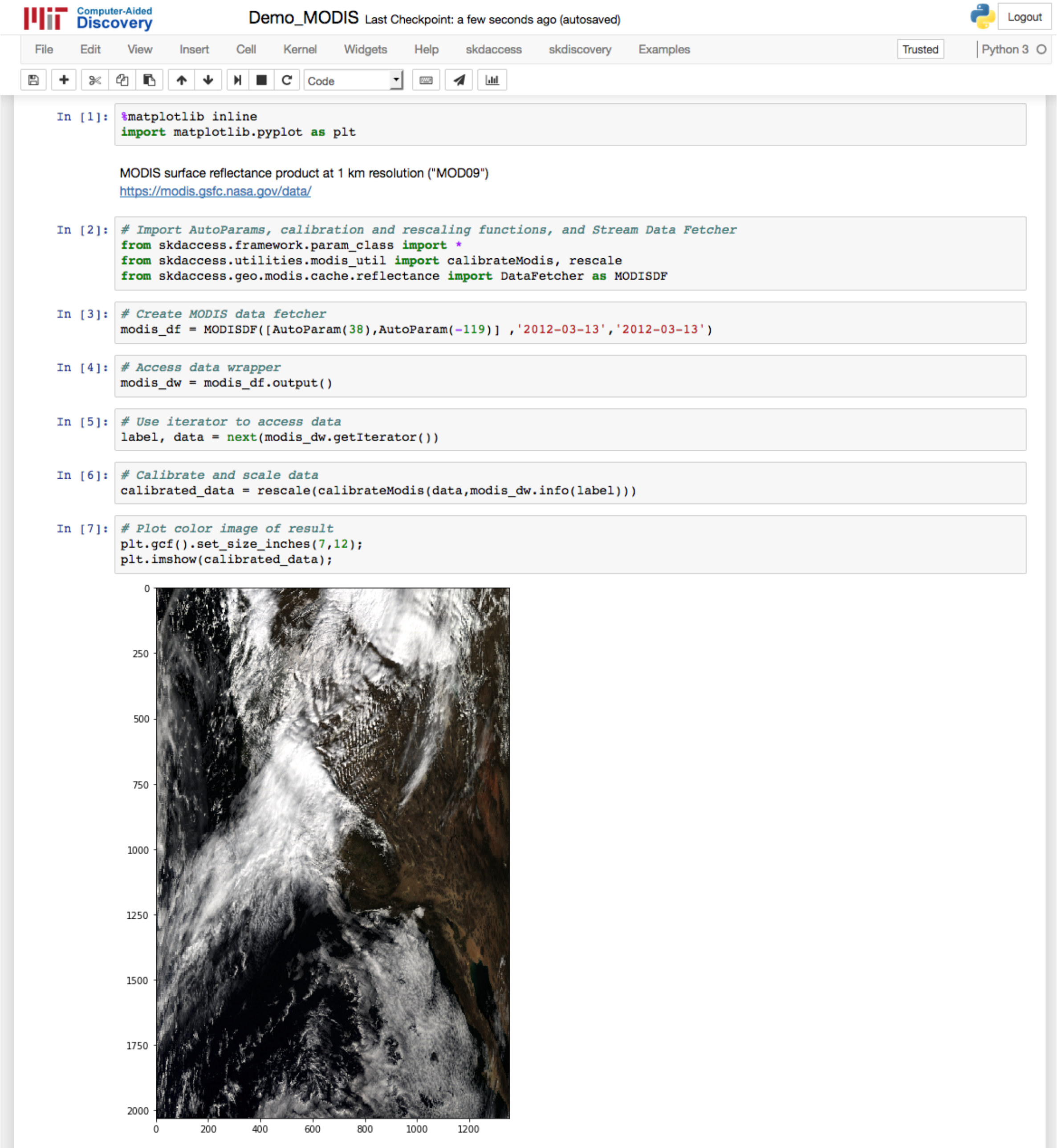
MIT led NSF project studying the Earth's ionosphere with GPS

http://mahali.mit.edu/

```
In [2]: from skdaccess.framework.param_class import *
        from skdaccess.geo.mahali.temperature import DataFetcher as MHDF

In [3]: station_list = [ 'mh02', 'mh03', 'mh04', 'mh05', 'mh06', 'mh07', 'mh08', 'mh09', 'mh13']

In [4]: mhdf = MHDF([AutoList(station_list)])

In [5]: dw = mhdf.output()

In [6]: label = 'mh06'
        data = dw.get()['mh06']
        plt.plot(data['Temperature'],'o',markersize=1);
        plt.title(label,fontsize=14);
        plt.ylabel('Temperature + (C)', fontsize=14);
        plt.xticks(rotation=15);
        plt.gcf().set_size_inches(14,4)
```

```
In [7]: def plotAllStations(start_date, end_date):
            plt.gcf().set_size_inches(12,9)

            for index, (label, data) in enumerate(dw.getIterator()):
                plt.subplot(3,3, index+1)
                plt.title(label);
                plt.ylabel('Temperature (C)');
                plt.xticks(rotation=25);
                plt.plot(data['Temperature'],'o',markersize=1);
                plt.xlim(start_date, end_date)
            plt.tight_layout()

In [8]: plotAllStations(pd.to_datetime('2015-09-28'),pd.to_datetime('2015-11-13'))
```

5.15 skdaccess.geo.modis.cache.reflectance

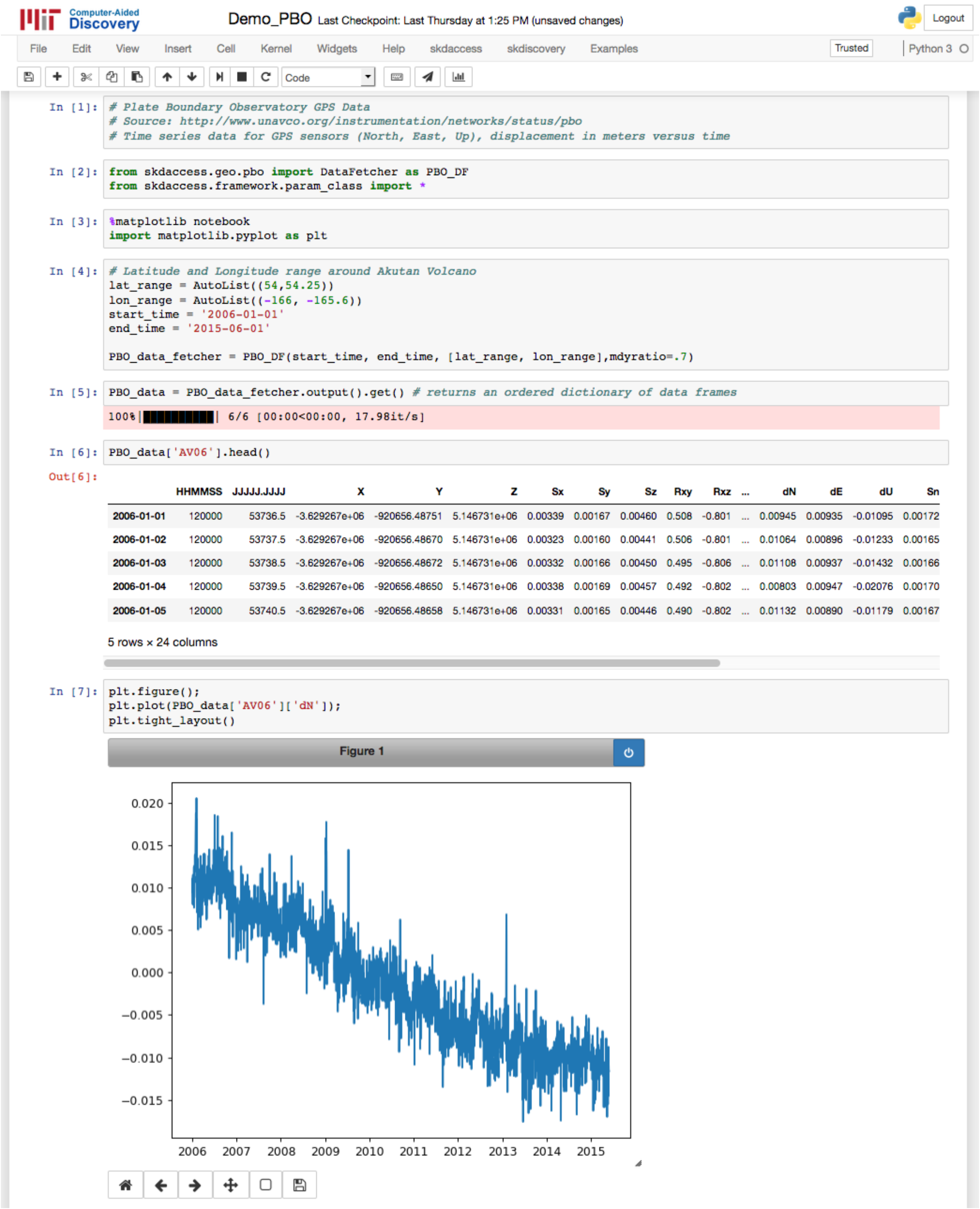


```
In [1]: %matplotlib inline
        import matplotlib.pyplot as plt
```

MODIS surface reflectance product at 1 km resolution ("MOD09")
https://modis.gsfc.nasa.gov/data/

```
In [2]: # Import AutoParams, calibration and rescaling functions, and Stream Data Fetcher
        from skdaccess.framework.param_class import *
        from skdaccess.utilities.modis_util import calibrateModis, rescale
        from skdaccess.geo.modis.cache.reflectance import DataFetcher as MODISDF

In [3]: # Create MODIS data fetcher
        modis_df = MODISDF([AutoParam(38),AutoParam(-119)] ,'2012-03-13','2012-03-13')

In [4]: # Access data wrapper
        modis_dw = modis_df.output()

In [5]: # Use iterator to access data
        label, data = next(modis_dw.getIterator())

In [6]: # Calibrate and scale data
        calibrated_data = rescale(calibrateModis(data,modis_dw.info(label)))

In [7]: # Plot color image of result
        plt.gcf().set_size_inches(7,12);
        plt.imshow(calibrated_data);
```

5.16 skdaccess.geo.pbo



```
In [1]: # Plate Boundary Observatory GPS Data
        # Source: http://www.unavco.org/instrumentation/networks/status/pbo
        # Time series data for GPS sensors (North, East, Up), displacement in meters versus time
```

```
In [2]: from skdaccess.geo.pbo import DataFetcher as PBO_DF
        from skdaccess.framework.param_class import *
```

```
In [3]: %matplotlib notebook
        import matplotlib.pyplot as plt
```

```
In [4]: # Latitude and Longitude range around Akutan Volcano
        lat_range = AutoList((54,54.25))
        lon_range = AutoList((-166, -165.6))
        start_time = '2006-01-01'
        end_time = '2015-06-01'

        PBO_data_fetcher = PBO_DF(start_time, end_time, [lat_range, lon_range],mdyratio=.7)
```

```
In [5]: PBO_data = PBO_data_fetcher.output().get() # returns an ordered dictionary of data frames
        100%|██████████| 6/6 [00:00<00:00, 17.98it/s]
```

```
In [6]: PBO_data['AV06'].head()
```

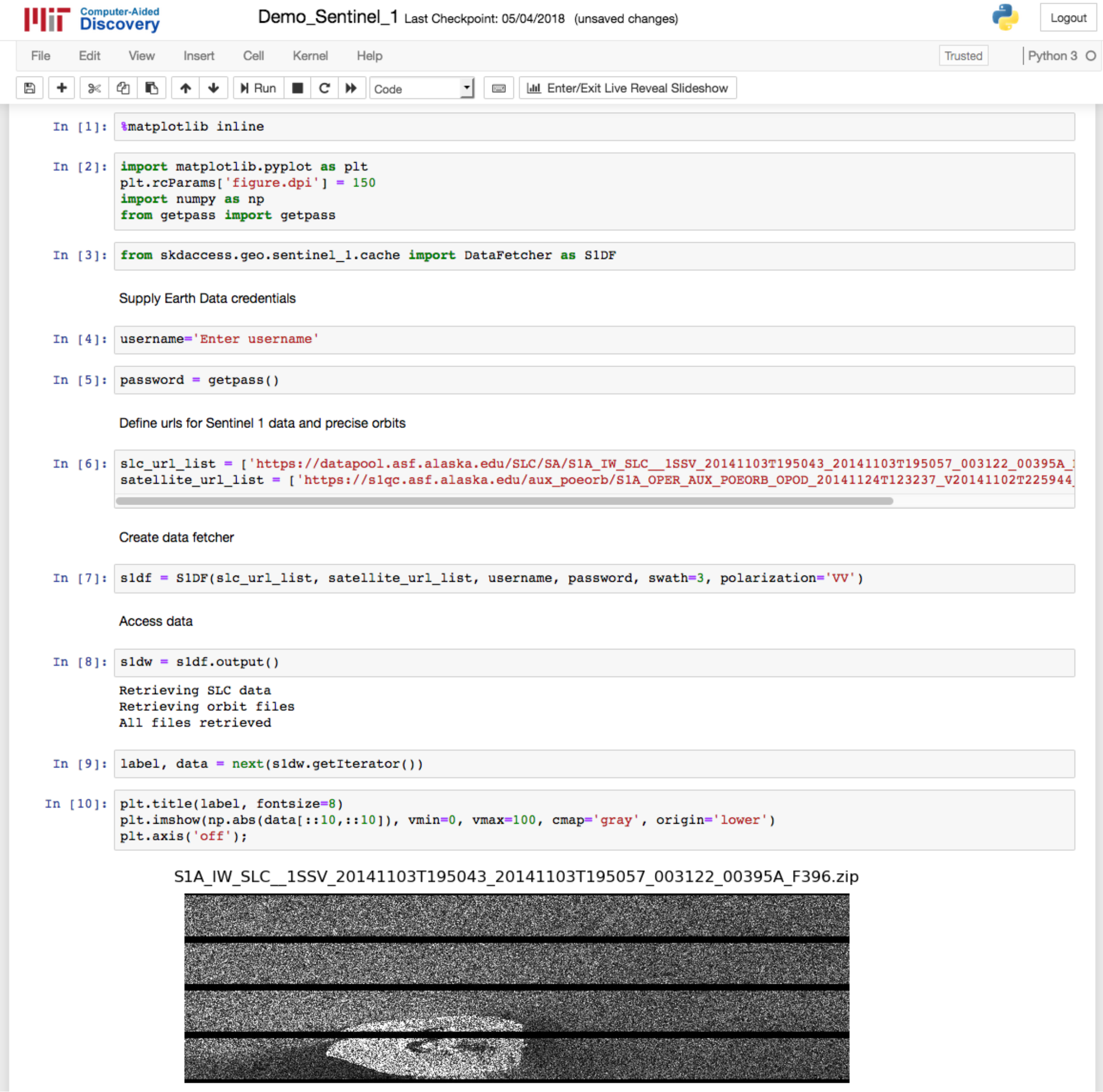
Out[6]:

	HHMMSS	JJJJJ.JJJJ	X	Y	Z	Sx	Sy	Sz	Rxy	Rxz	...	dN	dE	dU	Sn
2006-01-01	120000	53736.5	-3.629267e+06	-920656.48751	5.146731e+06	0.00339	0.00167	0.00460	0.508	-0.801	...	0.00945	0.00935	-0.01095	0.00172
2006-01-02	120000	53737.5	-3.629267e+06	-920656.48670	5.146731e+06	0.00323	0.00160	0.00441	0.506	-0.801	...	0.01064	0.00896	-0.01233	0.00165
2006-01-03	120000	53738.5	-3.629267e+06	-920656.48672	5.146731e+06	0.00332	0.00166	0.00450	0.495	-0.806	...	0.01108	0.00937	-0.01432	0.00166
2006-01-04	120000	53739.5	-3.629267e+06	-920656.48650	5.146731e+06	0.00338	0.00169	0.00457	0.492	-0.802	...	0.00803	0.00947	-0.02076	0.00170
2006-01-05	120000	53740.5	-3.629267e+06	-920656.48658	5.146731e+06	0.00331	0.00165	0.00446	0.490	-0.802	...	0.01132	0.00890	-0.01179	0.00167

5 rows × 24 columns

```
In [7]: plt.figure();
        plt.plot(PBO_data['AV06']['dN']);
        plt.tight_layout()
```

5.17 skdaccess.geo.sentinel_1


Computer-Aided
Discovery
Demo_Sentinel_1 Last Checkpoint: 05/04/2018 (unsaved changes)
Logout
File
Edit
View
Insert
Cell
Kernel
Help
Trusted
Python 3 ○
Run
Code
Enter/Exit Live Reveal Slideshow

```
In [1]: %matplotlib inline
```

```
In [2]: import matplotlib.pyplot as plt
        plt.rcParams['figure.dpi'] = 150
        import numpy as np
        from getpass import getpass
```

```
In [3]: from skdaccess.geo.sentinel_1.cache import DataFetcher as S1DF
```

Supply Earth Data credentials

```
In [4]: username='Enter username'
```

```
In [5]: password = getpass()
```

Define urls for Sentinel 1 data and precise orbits

```
In [6]: slc_url_list = ['https://datapool.asf.alaska.edu/SLC/SA/S1A_IW_SLC__1SSV_20141103T195043_20141103T195057_003122_00395A_
        satellite_url_list = ['https://s1qc.asf.alaska.edu/aux_poeorb/S1A_OPER_AUX_POEORB_OPOD_20141124T123237_V20141102T225944_
```

Create data fetcher

```
In [7]: s1df = S1DF(slc_url_list, satellite_url_list, username, password, swath=3, polarization='VV')
```

Access data

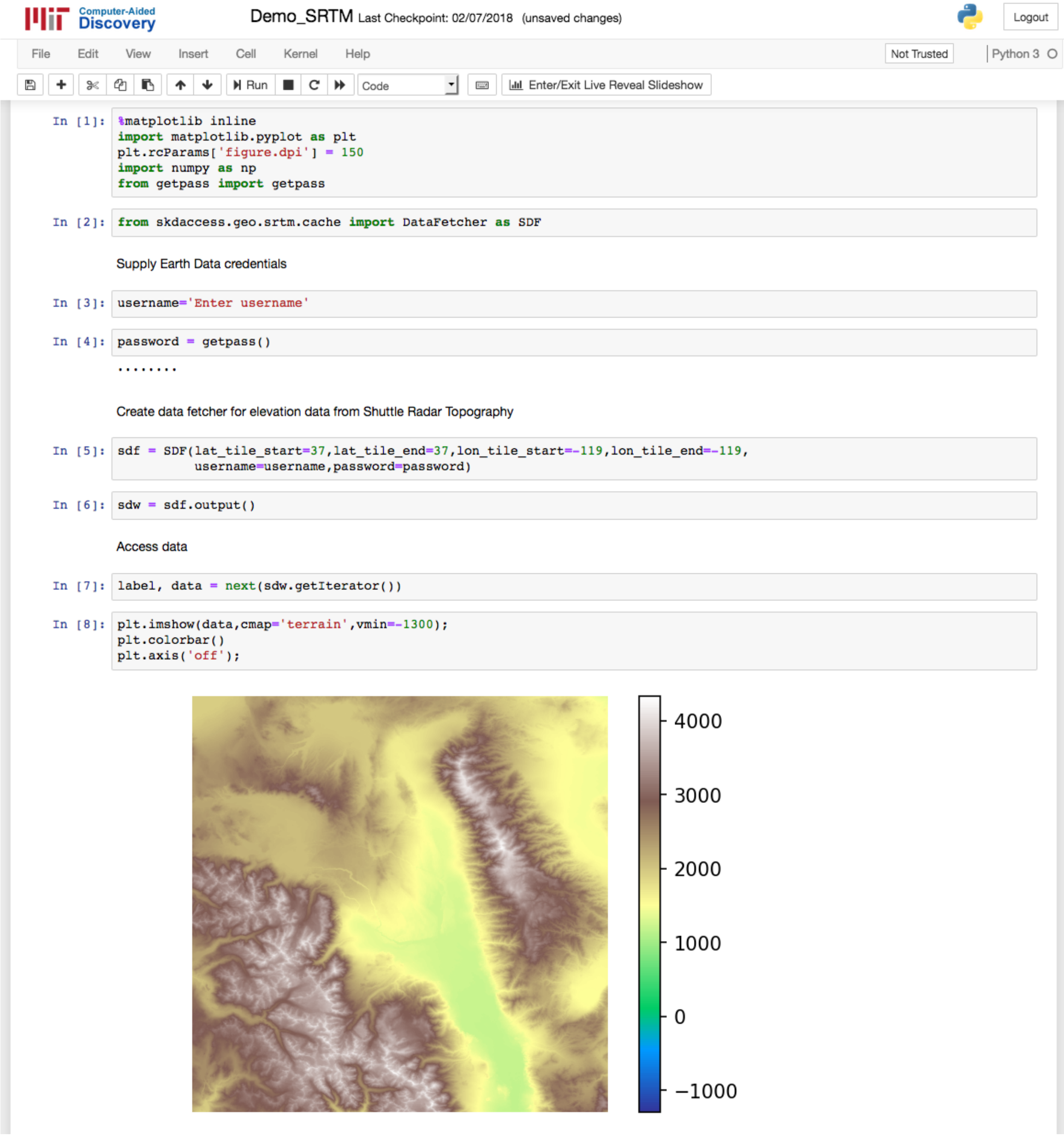
```
In [8]: s1dw = s1df.output()

Retrieving SLC data
Retrieving orbit files
All files retrieved
```

```
In [9]: label, data = next(s1dw.getIterator())
```

```
In [10]: plt.title(label, fontsize=8)
         plt.imshow(np.abs(data[::10,::10]), vmin=0, vmax=100, cmap='gray', origin='lower')
         plt.axis('off');
```

S1A_IW_SLC__1SSV_20141103T195043_20141103T195057_003122_00395A_F396.zip

5.18 skdaccess.geo.srtm



```
In [1]: %matplotlib inline
        import matplotlib.pyplot as plt
        plt.rcParams['figure.dpi'] = 150
        import numpy as np
        from getpass import getpass
```

```
In [2]: from skdaccess.geo.srtm.cache import DataFetcher as SDF
```

Supply Earth Data credentials

```
In [3]: username='Enter username'
```

```
In [4]: password = getpass()

        ........
```

Create data fetcher for elevation data from Shuttle Radar Topography

```
In [5]: sdf = SDF(lat_tile_start=37,lat_tile_end=37,lon_tile_start=-119,lon_tile_end=-119,
                    username=username,password=password)
```

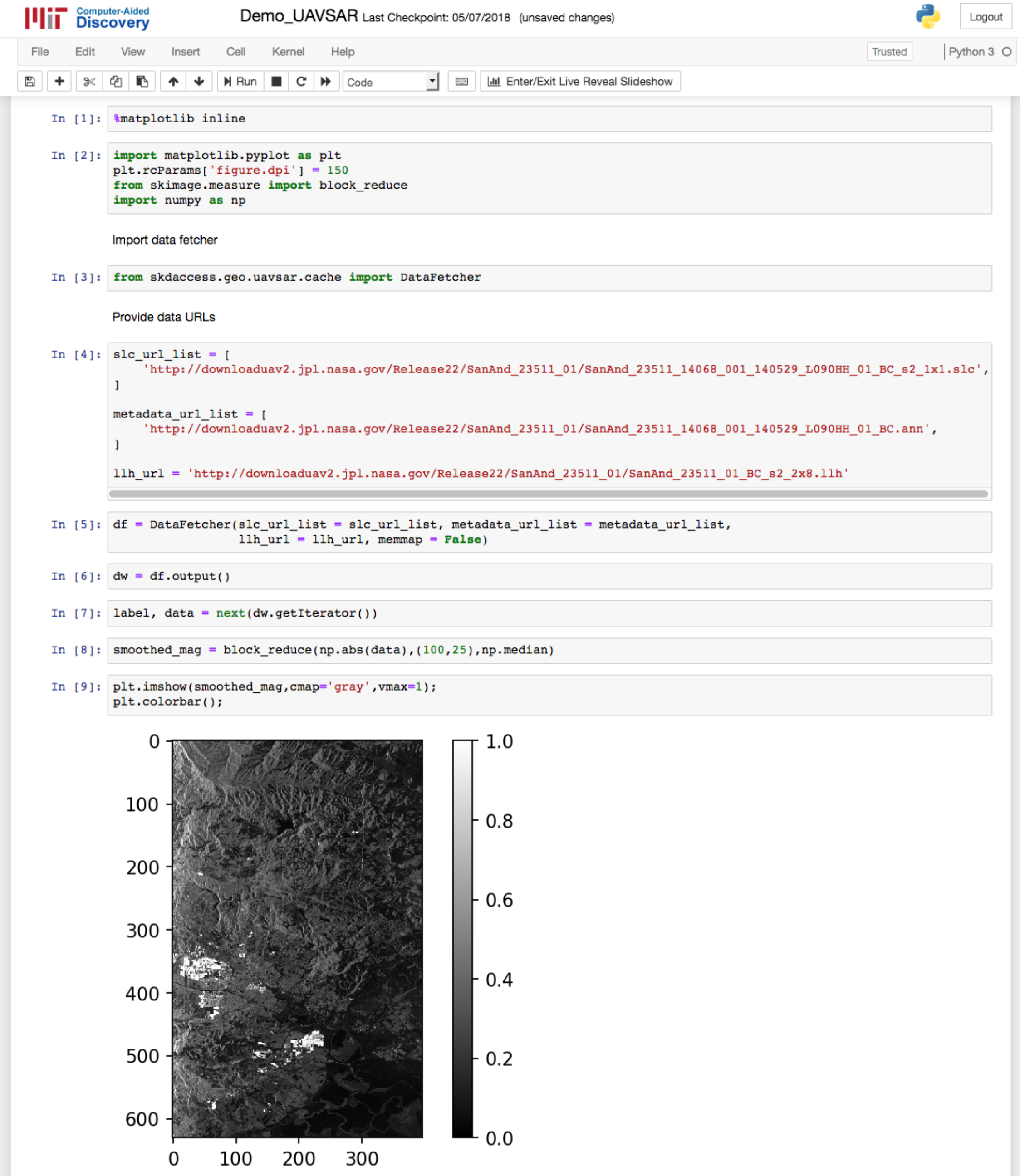
```
In [6]: sdw = sdf.output()
```

Access data

```
In [7]: label, data = next(sdw.getIterator())
```

```
In [8]: plt.imshow(data,cmap='terrain',vmin=-1300);
        plt.colorbar()
        plt.axis('off');
```

5.19 skdaccess.geo.uavsar


Computer-Aided Discovery
Demo_UAVSAR Last Checkpoint: 05/07/2018 (unsaved changes)
Logout
File
Edit
View
Insert
Cell
Kernel
Help
Trusted
Python 3
Run
Code
Enter/Exit Live Reveal Slideshow

In [1]:
```
%matplotlib inline
```

In [2]:
```
import matplotlib.pyplot as plt
plt.rcParams['figure.dpi'] = 150
from skimage.measure import block_reduce
import numpy as np
```

Import data fetcher

In [3]:
```
from skdaccess.geo.uavsar.cache import DataFetcher
```

Provide data URLs

In [4]:
```
slc_url_list = [
    'http://downloaduav2.jpl.nasa.gov/Release22/SanAnd_23511_01/SanAnd_23511_14068_001_140529_L090HH_01_BC_s2_1x1.slc',
]

metadata_url_list = [
    'http://downloaduav2.jpl.nasa.gov/Release22/SanAnd_23511_01/SanAnd_23511_14068_001_140529_L090HH_01_BC.ann',
]

llh_url = 'http://downloaduav2.jpl.nasa.gov/Release22/SanAnd_23511_01/SanAnd_23511_01_BC_s2_2x8.llh'
```

In [5]:
```
df = DataFetcher(slc_url_list = slc_url_list, metadata_url_list = metadata_url_list,
                 llh_url = llh_url, memmap = False)
```

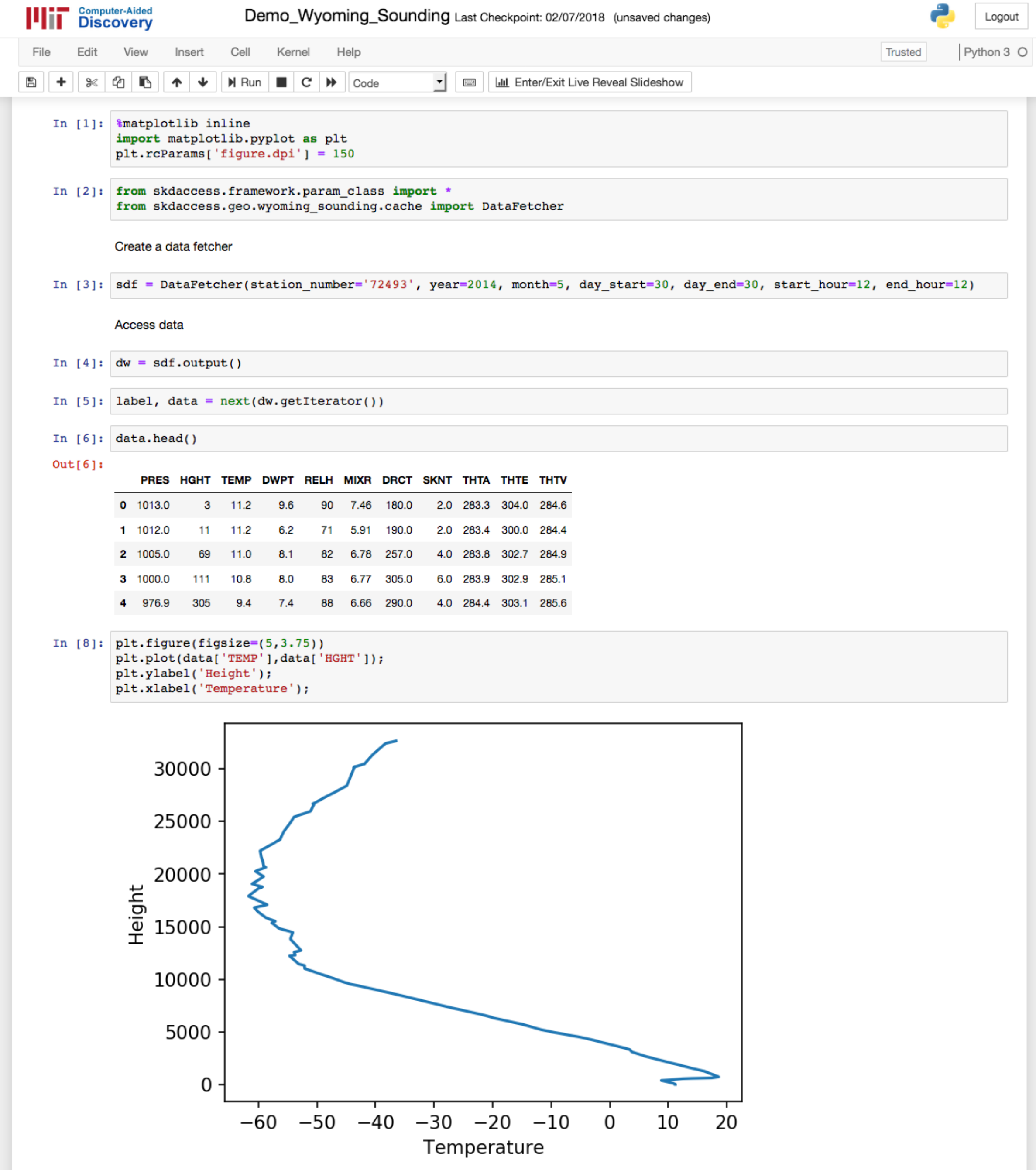
In [6]:
```
dw = df.output()
```

In [7]:
```
label, data = next(dw.getIterator())
```

In [8]:
```
smoothed_mag = block_reduce(np.abs(data),(100,25),np.median)
```

In [9]:
```
plt.imshow(smoothed_mag,cmap='gray',vmax=1);
plt.colorbar();
```

5.20 skdaccess.geo.wyoming_sounding


Computer-Aided Discovery
Demo_Wyoming_Sounding Last Checkpoint: 02/07/2018 (unsaved changes)
Logout
File
Edit
View
Insert
Cell
Kernel
Help
Trusted
Python 3
Run
Code
Enter/Exit Live Reveal Slideshow

In [1]:
```
%matplotlib inline
import matplotlib.pyplot as plt
plt.rcParams['figure.dpi'] = 150
```

In [2]:
```
from skdaccess.framework.param_class import *
from skdaccess.geo.wyoming_sounding.cache import DataFetcher
```

Create a data fetcher

In [3]:
```
sdf = DataFetcher(station_number='72493', year=2014, month=5, day_start=30, day_end=30, start_hour=12, end_hour=12)
```

Access data

In [4]:
```
dw = sdf.output()
```

In [5]:
```
label, data = next(dw.getIterator())
```

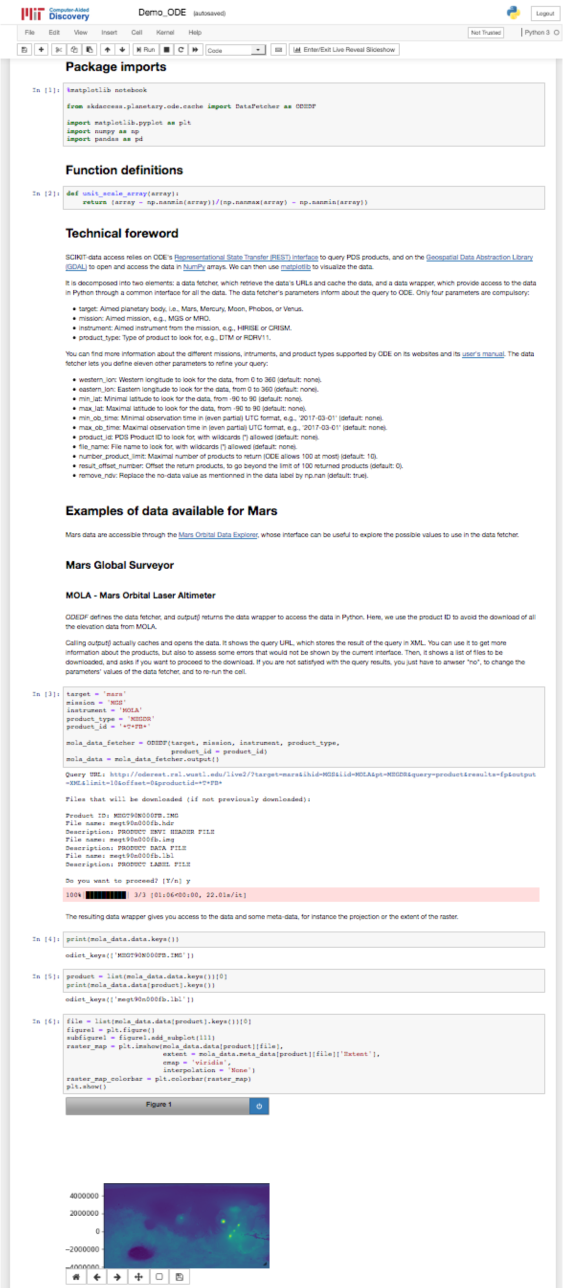
In [6]:
```
data.head()
```

Out[6]:

	PRES	HGHT	TEMP	DWPT	RELH	MIXR	DRCT	SKNT	THTA	THTE	THTV
0	1013.0	3	11.2	9.6	90	7.46	180.0	2.0	283.3	304.0	284.6
1	1012.0	11	11.2	6.2	71	5.91	190.0	2.0	283.4	300.0	284.4
2	1005.0	69	11.0	8.1	82	6.78	257.0	4.0	283.8	302.7	284.9
3	1000.0	111	10.8	8.0	83	6.77	305.0	6.0	283.9	302.9	285.1
4	976.9	305	9.4	7.4	88	6.66	290.0	4.0	284.4	303.1	285.6

In [8]:
```
plt.figure(figsize=(5,3.75))
plt.plot(data['TEMP'],data['HGHT']);
plt.ylabel('Height');
plt.xlabel('Temperature');
```

5.21 skdaccess.planetary.ode



Package imports

```
In [1]: %matplotlib notebook

        from skdaccess.planetary.ode.cache import DataFetcher as ODEDF

        import matplotlib.pyplot as plt
        import numpy as np
        import pandas as pd
```

Function definitions

```
In [2]: def unit_scale_array(array):
            return (array - np.nanmin(array))/(np.nanmax(array) - np.nanmin(array))
```

Technical foreword

SCIKIT-data access relies on ODE's Representational State Transfer (REST) interface to query PDS products, and on the Geospatial Data Abstraction Library (GDAL) to open and access the data in NumPy arrays. We can then use matplotlib to visualize the data.

It is decomposed into two elements: a data fetcher, which retrieve the data's URLs and cache the data, and a data wrapper, which provide access to the data in Python through a common interface for all the data. The data fetcher's parameters inform about the query to ODE. Only four parameters are compulsory:

- target: Aimed planetary body, i.e., Mars, Mercury, Moon, Phobos, or Venus.
- mission: Aimed mission, e.g., MGS or MRO.
- instrument: Aimed instrument from the mission, e.g., HIRISE or CRISM.
- product_type: Type of product to look for, e.g., DTM or RDRV11.

You can find more information about the different missions, intruments, and product types supported by ODE on its websites and its user's manual. The data fetcher lets you define eleven other parameters to refine your query:

- western_lon: Western longitude to look for the data, from 0 to 360 (default: none).
- eastern_lon: Eastern longitude to look for the data, from 0 to 360 (default: none).
- min_lat: Minimal latitude to look for the data, from -90 to 90 (default: none).
- max_lat: Maximal latitude to look for the data, from -90 to 90 (default: none).
- min_ob_time: Minimal observation time in (even partial) UTC format, e.g., '2017-03-01' (default: none).
- max_ob_time: Maximal observation time in (even partial) UTC format, e.g., '2017-03-01' (default: none).
- product_id: PDS Product ID to look for, with wildcards (*) allowed (default: none).
- file_name: File name to look for, with wildcards (*) allowed (default: none).
- number_product_limit: Maximal number of products to return (ODE allows 100 at most) (default: 10).
- result_offset_number: Offset the return products, to go beyond the limit of 100 returned products (default: 0).
- remove_ndv: Replace the no-data value as mentionned in the data label by np.nan (default: true).

Examples of data available for Mars

Mars data are accessible through the Mars Orbital Data Explorer, whose interface can be useful to explore the possible values to use in the data fetcher.

Mars Global Surveyor

MOLA - Mars Orbital Laser Altimeter

ODEDF defines the data fetcher, and *output()* returns the data wrapper to access the data in Python. Here, we use the product ID to avoid the download of all the elevation data from MOLA.

Calling output() actually caches and opens the data. It shows the query URL, which stores the result of the query in XML. You can use it to get more information about the products, but also to assess some errors that would not be shown by the current interface. Then, it shows a list of files to be downloaded, and asks if you want to proceed to the download. If you are not satisfyed with the query results, you just have to anwser "no", to change the parameters' values of the data fetcher, and to re-run the cell.

```
In [3]: target = 'mars'
        mission = 'MGS'
        instrument = 'MOLA'
        product_type = 'MEGDR'
        product_id = '*T*FB*'

        mola_data_fetcher = ODEDF(target, mission, instrument, product_type,
                                  product_id = product_id)
        mola_data = mola_data_fetcher.output()
```

```
Query URL: http://oderest.rsl.wustl.edu/live2/?target=mars&ihid=MGS&iid=MOLA&pt=MEGDR&query=product&results=fp&output
=XML&limit=10&offset=0&productid=*T*FB*

Files that will be downloaded (if not previously downloaded):

Product ID: MEGT90N000FB.IMG
File name: megt90n000fb.hdr
Description: PRODUCT ENVI HEADER FILE
File name: megt90n000fb.img
Description: PRODUCT DATA FILE
File name: megt90n000fb.lbl
Description: PRODUCT LABEL FILE

Do you want to proceed? [Y/n] y

100%|██████████| 3/3 [01:06<00:00, 22.01s/it]
```

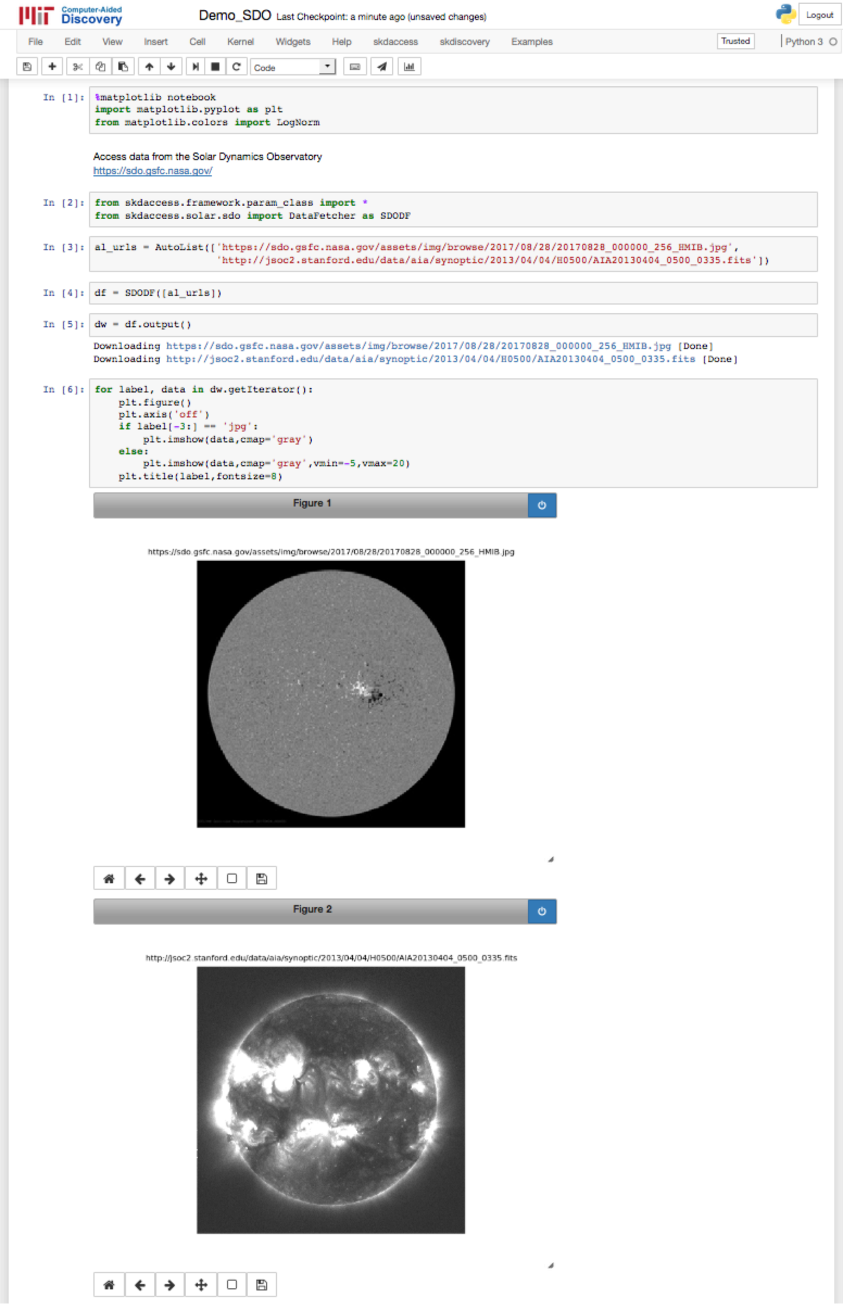
The resulting data wrapper gives you access to the data and some meta-data, for instance the projection or the extent of the raster.

```
In [4]: print(mola_data.data.keys())

odict_keys(['MEGT90N000FB.IMG'])
```

```
In [5]: product = list(mola_data.data.keys())[0]
        print(mola_data.data[product].keys())

odict_keys(['megt90n000fb.lbl'])
```

```
In [6]: file = list(mola_data.data[product].keys())[0]
        figure1 = plt.figure()
        subfigure1 = figure1.add_subplot(111)
        raster_map = plt.imshow(mola_data.data[product][file],
                                extent = mola_data.meta_data[product][file]['Extent'],
                                cmap = 'viridis',
                                interpolation = 'None')
        raster_map_colorbar = plt.colorbar(raster_map)
        plt.show()
```

5.22 skdaccess.solar.sdo


Computer-Aided Discovery
Demo_SDO Last Checkpoint: a minute ago (unsaved changes)
Logout
File
Edit
View
Insert
Cell
Kernel
Widgets
Help
skdaccess
skdiscovery
Examples
Trusted
Python 3
Code
Figure 1
https://sdo.gsfc.nasa.gov/assets/img/browse/2017/08/28/20170828_000000_256_HMIB.jpg
Figure 2
http://jsoc2.stanford.edu/data/aia/synoptic/2013/04/04/H0500/AIA20130404_0500_0335.fits

```
In [1]: %matplotlib notebook
        import matplotlib.pyplot as plt
        from matplotlib.colors import LogNorm
```

Access data from the Solar Dynamics Observatory
https://sdo.gsfc.nasa.gov/

```
In [2]: from skdaccess.framework.param_class import *
        from skdaccess.solar.sdo import DataFetcher as SDODF

In [3]: al_urls = AutoList(['https://sdo.gsfc.nasa.gov/assets/img/browse/2017/08/28/20170828_000000_256_HMIB.jpg',
                            'http://jsoc2.stanford.edu/data/aia/synoptic/2013/04/04/H0500/AIA20130404_0500_0335.fits'])

In [4]: df = SDODF([al_urls])

In [5]: dw = df.output()

        Downloading https://sdo.gsfc.nasa.gov/assets/img/browse/2017/08/28/20170828_000000_256_HMIB.jpg [Done]
        Downloading http://jsoc2.stanford.edu/data/aia/synoptic/2013/04/04/H0500/AIA20130404_0500_0335.fits [Done]

In [6]: for label, data in dw.getIterator():
            plt.figure()
            plt.axis('off')
            if label[-3:] == 'jpg':
                plt.imshow(data,cmap='gray')
            else:
                plt.imshow(data,cmap='gray',vmin=-5,vmax=20)
            plt.title(label,fontsize=8)
```

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