pySPEDAS: Space Physics Environment Data Analysis Software in Python

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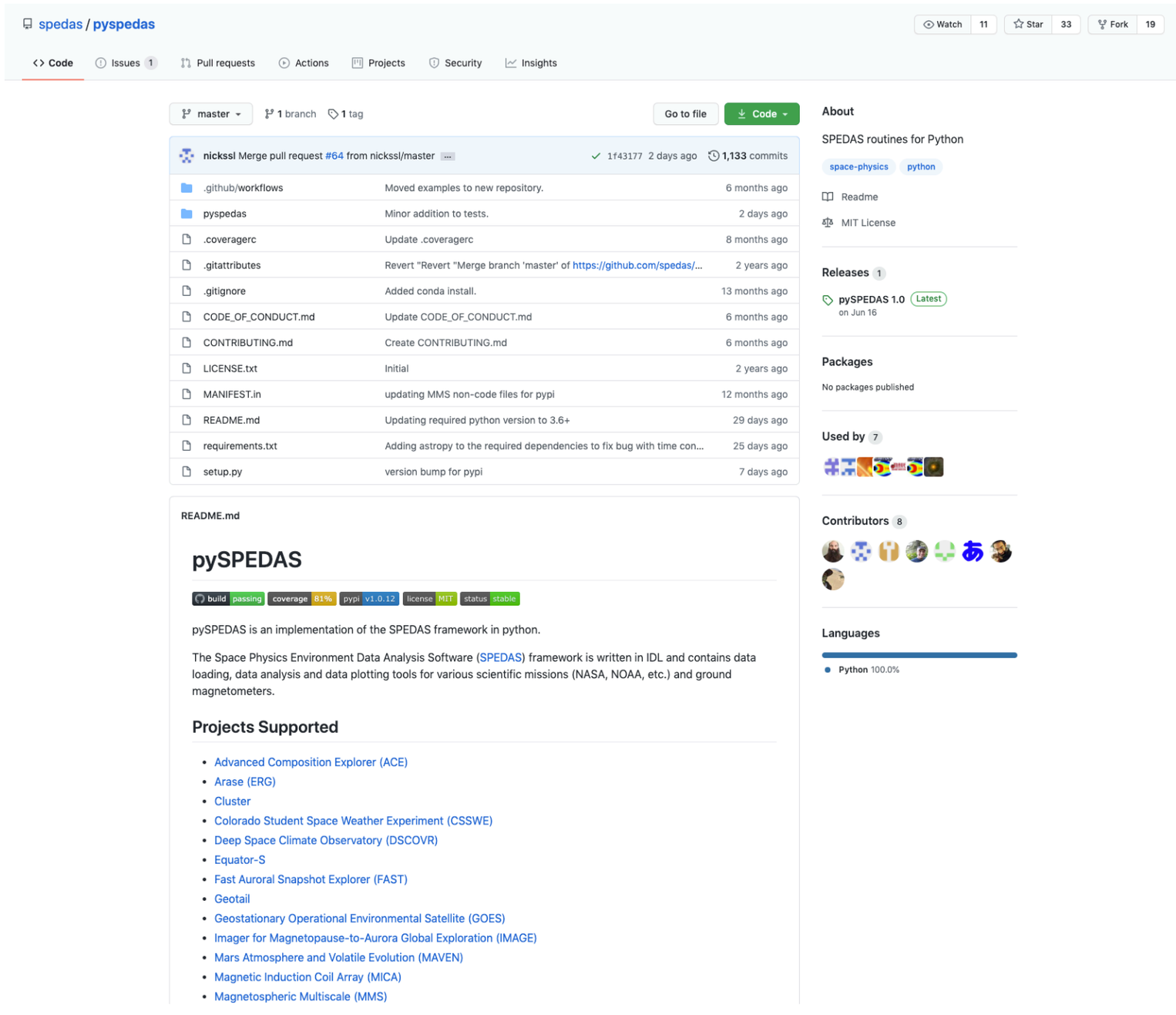
pySPEDAS: Getting Started

Bleeding edge: https://github.com/spedas/pyspedas



pySPEDAS: Getting Started

- Internally, pySPEDAS uses pyTplot to load the data into variables and create plots:

https://github.com/MAVENSDC/PyTplot

https://pytplot.readthedocs.io

Getting Started: Installing

pip install pyspedas

or

pip install pyspedas --upgrade

Getting Started: Data Directories

- By default, the data are placed in the directory where pySPEDAS is installed; you can configure this with the **SPEDAS_DATA_DIR** environment variable
- Most missions also have their own environment variable, which overrides **SPEDAS_DATA_DIR**, e.g., **MMS_DATA_DIR**
- These environment variables also work with our latest IDL versions; so if you load data in IDL, pySPEDAS should automatically find the data files locally

Getting Started: Data Sources

- These depend on the mission; e.g., for MMS, the default data source is the official Science Data Center at LASP, and data can be loaded from NASA SPDF using the **spdf** keyword to the load routine
- Most other missions (but not all) load data from NASA SPDF by default

Missions Supported

Advanced Composition Explorer (ACE)
Arase (ERG) - still experimental
Cluster - currently loads data from SPDF
Colorado Student Space Weather Experiment (CSSWE)
Deep Space Climate Observatory (DSCOVR)
Equator-S
Fast Auroral Snapshot Explorer (FAST)
Geotail
Geostationary Operational Environmental Satellite (GOES)
Imager for Magnetopause-to-Aurora Global Exploration (IMAGE)
Mars Atmosphere and Volatile Evolution (MAVEN)
Magnetic Induction Coil Array (MICA)
Magnetospheric Multiscale (MMS)
OMNI
Polar Orbiting Environmental Satellites (POES)
Polar
Parker Solar Probe (PSP)
Van Allen Probes (RBSP)
Solar Terrestrial Relations Observatory (STEREO)
Time History of Events and Macroscale Interactions during Substorms (THEMIS)
Two Wide-Angle Imaging Neutral-Atom Spectrometers (TWINS)
Ulysses
Wind

Note: while we can load CDFs from most instruments on each of these missions, post-processing of the data products for most missions are not at the same fidelity as our IDL tools

Load Routines

- Data are loaded by functions that follow the general form:

pyspedas.mission.instrument()

e.g., for MMS FPI data:

pyspedas.mms.fpi()

or RBSP EMFISIS data:

pyspedas.rbsp.emfisis()

Keywords

- Just as with our IDL load routines, the options are set with some standard keywords, e.g.,
  - trange - time range; e.g, [‘2015-12-15’, ‘2015-12-16’]
  - level - level of the data; e.g., ‘l2’, ‘l3’, etc
  - + many more
- To see all of the keywords supported by a load routine, use the Python help function, e.g.,

help(pyspedas.mms.fpi)

Keywords

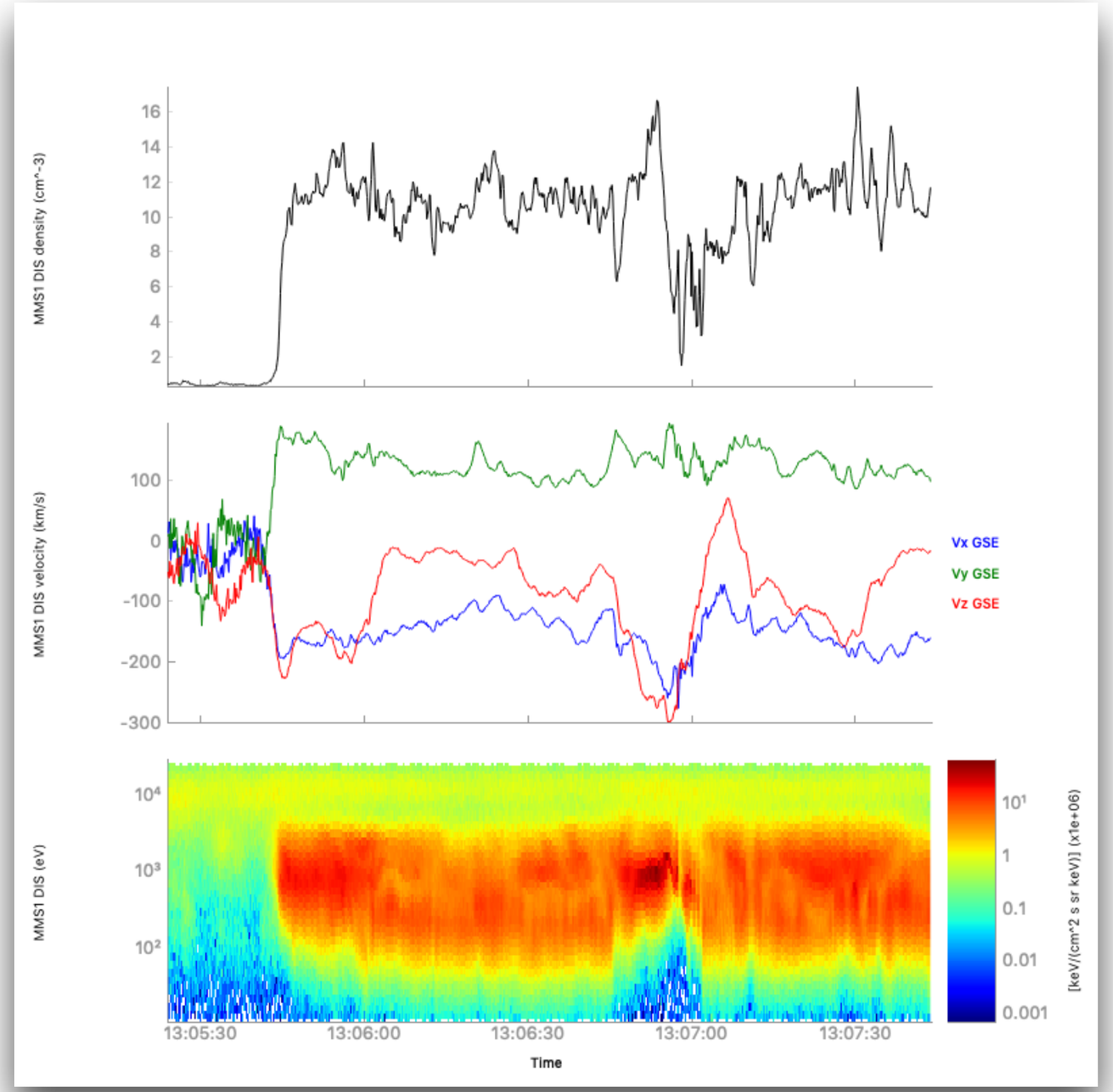
```
Help on function mms_load_fpi in module pyspedas.mms:

mms_load_fpi(*args, **kwargs)
    This function loads FPI data into tplot variables

    Parameters:
        trange : list of str
            time range of interest [starttime, endtime] with the format
            'YYYY-MM-DD','YYYY-MM-DD'] or to specify more or less than a day
            ['YYYY-MM-DD/hh:mm:ss','YYYY-MM-DD/hh:mm:ss']

        probe : str or list of str
            list of probes, valid values for MMS probes are ['1','2','3','4'].

        data_rate : str or list of str
            instrument data rates for FPI include 'brst', 'fast'. The
            default is 'srvy'.

        level : str
            indicates level of data processing. the default if no level is specified is 'l2'

        datatype : str or list of str
            Valid datatypes for FPI are:
             'des-moms', 'dis-moms' (default)
             'des-dist', 'dis-dist'

        get_support_data: bool
            Data with an attribute "VAR_TYPE" with a value of "support_data"
            will be loaded into tplot.  By default, only loads in data with a
            "VAR_TYPE" attribute of "data".

        time_clip: bool
            Data will be clipped to the exact trange specified by the trange keyword.

        varformat: str
            The file variable formats to load into tplot.  Wildcard character
            "*" is accepted.  By default, all variables are loaded in.

        suffix: str
            The tplot variable names will be given this suffix.  By default,
            no suffix is added.

        center_measurement: bool
            If True, the CDF epoch variables are time-shifted to the middle
            of the accumulation interval by their DELTA_PLUS_VAR and
            DELTA_MINUS_VAR variable attributes

        notplot: bool
            If True, then data are returned in a hash table instead of
            being stored in tplot variables (useful for debugging, and
            access to multi-dimensional data products)

        available: bool
            If True, simply return the available data files (without downloading)
:
```

Simple Example

```
>>> import pyspedas
>>>
>>> pyspedas.mms.fpi(trange=['2015-10-16/13:06', '2015-10-16/13:07'], center_measurement=True, data_rate='brst', datatype='dis-moms')
13-Oct-20 13:59:50: Loading /Volumes/data/data/mms/mms1/fpi/brst/l2/dis-moms/2015/10/16/mms1_fpi_brst_l2_dis-moms_20151016130524_v3.3.0.cdf
Loaded variables:
mms1_dis_errorflags_brst
mms1_dis_compressionloss_brst
mms1_dis_startdelphi_count_brst
mms1_dis_startdelphi_angle_brst
mms1_dis_sector_despinp_brst
mms1_dis_energyspectr_px_brst
mms1_dis_energyspectr_mx_brst
mms1_dis_energyspectr_py_brst
mms1_dis_energyspectr_my_brst
mms1_dis_energyspectr_pz_brst
mms1_dis_energyspectr_mz_brst
mms1_dis_energyspectr_omni_brst
mms1_dis_spectr_bg_brst
mms1_dis_numberdensity_bg_brst
mms1_dis_numberdensity_brst
mms1_dis_densityextrapolation_low_brst
mms1_dis_densityextrapolation_high_brst
mms1_dis_bulkv_dbcs_brst
mms1_dis_bulkv_spintone_dbcs_brst
mms1_dis_bulkv_gse_brst
mms1_dis_bulkv_spintone_gse_brst
mms1_dis_prestensor_dbcs_brst
mms1_dis_prestensor_gse_brst
mms1_dis_pres_bg_brst
mms1_dis_temptensor_dbcs_brst
mms1_dis_temptensor_gse_brst
mms1_dis_heatq_dbcs_brst
mms1_dis_heatq_gse_brst
mms1_dis_temppara_brst
mms1_dis_tempperp_brst
['mms1_dis_errorflags_brst', 'mms1_dis_compressionloss_brst', 'mms1_dis_startdelphi_count_brst', 'mms1_dis_startdelphi_angle_brst', 'mms1_dis_sector_despinp_brst', 'mms1_dis_energyspectr_px_brst', 'mms1_dis_energyspectr_mx_brst', 'mms1_dis_energyspectr_py_brst', 'mms1_dis_energyspectr_my_brst', 'mms1_dis_energyspectr_pz_brst', 'mms1_dis_energyspectr_mz_brst', 'mms1_dis_energyspectr_omni_brst', 'mms1_dis_spectr_bg_brst', 'mms1_dis_numberdensity_bg_brst', 'mms1_dis_numberdensity_brst', 'mms1_dis_densityextrapolation_low_brst', 'mms1_dis_densityextrapolation_high_brst', 'mms1_dis_bulkv_dbcs_brst', 'mms1_dis_bulkv_spintone_dbcs_brst', 'mms1_dis_bulkv_gse_brst', 'mms1_dis_bulkv_spintone_gse_brst', 'mms1_dis_prestensor_dbcs_brst', 'mms1_dis_prestensor_gse_brst', 'mms1_dis_pres_bg_brst', 'mms1_dis_temptensor_dbcs_brst', 'mms1_dis_temptensor_gse_brst', 'mms1_dis_heatq_dbcs_brst', 'mms1_dis_heatq_gse_brst', 'mms1_dis_temppara_brst', 'mms1_dis_tempperp_brst']
>>>
```

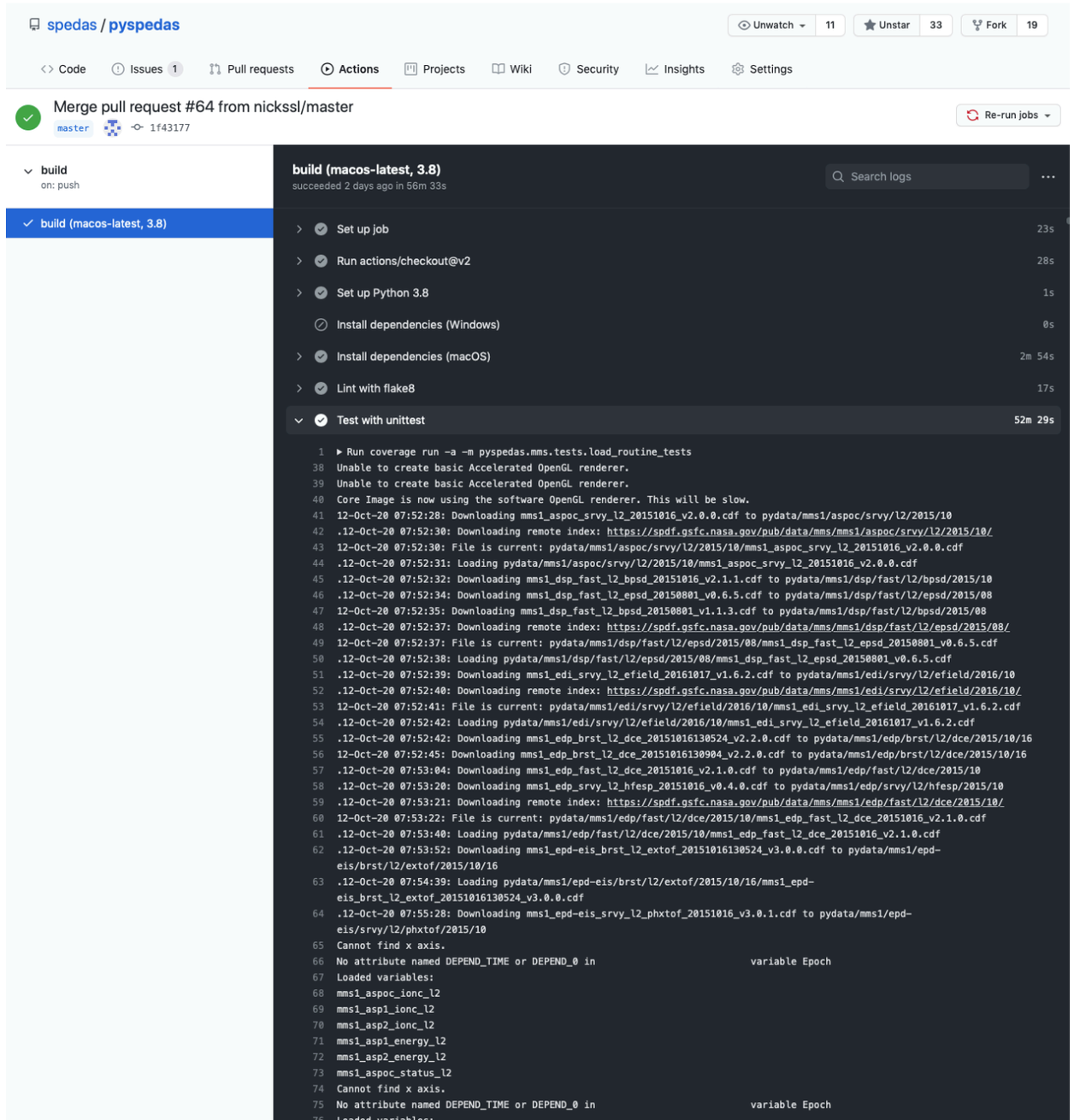
Simple Example

```
>>> from pytplot import tplot
>>>
>>> tplot(['mms1_dis_numberdensity_brst', 'mms1_dis_bulkv_gse_brst', 'mms1_dis_energyspectr_omni_brst'])
```



How we're testing

- We're using Github Actions to run unit tests that load the data; we currently have > 80% test coverage



Validating the data products from IDL

- We also have IDL unit tests that load the data in IDL and Python and check that the data products match

```
function mms_python_validation_ut::test_aspoc_default
  mms_load_aspoc, probe=1, trange=['2015-10-16','2015-10-17']
  py_script = ["from pyspedas import mms_load_aspoc", "mms_load_aspoc(probe=1, trange=['2015-10-16','2015-10-17'])"]
  vars = ['mms1_aspoc_ionc_l2']
  return, spd_run_py_validation(py_script, vars)
end
```

```
function mms_python_validation_ut::test_fgm_default
  mms_load_fgm, probe=1, trange=['2015-10-16','2015-10-17']
  py_script = ["from pyspedas import mms_load_fgm", "mms_load_fgm(probe=1, trange=['2015-10-16','2015-10-17'])"]
  vars = ['mms1_fgm_b_gse_srvy_l2', 'mms1_fgm_b_gsm_srvy_l2']
  return, spd_run_py_validation(py_script, vars)
end

function mms_python_validation_ut::test_fgm_brst
  mms_load_fgm, data_rate='brst', probe=4, trange=['2015-10-16/13:06', '2015-10-16/13:07']
  py_script = ["from pyspedas import mms_load_fgm", "mms_load_fgm(data_rate='brst', probe=4, trange=['2015-10-16/13:06', '2015-10-16/13:07'])"]
  vars = ['mms4_fgm_b_gse_brst_l2', 'mms4_fgm_b_gsm_brst_l2']
  return, spd_run_py_validation(py_script, vars)
end

function mms_python_validation_ut::test_fgm_curlometer
  mms_load_fgm, data_rate='brst', probe=[1, 2, 3, 4], trange=['2015-10-30/05:15:45', '2015-10-30/05:15:48'], /get_fgm_ephem, /time_clip
  fields = 'mms'+['1', '2', '3', '4']+'_fgm_b_gse_brst_l2'
  positions = 'mms'+['1', '2', '3', '4']+'_fgm_r_gse_brst_l2'

  mms_curl, trange=['2015-10-30/05:15:45', '2015-10-30/05:15:48'], fields=fields, positions=positions
  py_script = ["from pyspedas import mms_load_fgm", $
               "from pyspedas.mms import curlometer", $
               "mms_load_fgm(time_clip=True, data_rate='brst', probe=[1, 2, 3, 4], trange=['2015-10-30/05:15:45', '2015-10-30/05:15:48'])", $
               "positions = ['mms1_fgm_r_gse_brst_l2', 'mms2_fgm_r_gse_brst_l2', 'mms3_fgm_r_gse_brst_l2', 'mms4_fgm_r_gse_brst_l2']", $
               "fields = ['mms1_fgm_b_gse_brst_l2', 'mms2_fgm_b_gse_brst_l2', 'mms3_fgm_b_gse_brst_l2', 'mms4_fgm_b_gse_brst_l2']", $
               "curlometer(fields=fields, positions=positions)"]
  vars = ['baryb', 'curlB', 'divB', 'jtotal', 'jpar', 'jperp', 'alpha', 'alphaparallel']
  return, spd_run_py_validation(py_script, vars, tol=1e-4)
end
```

Finding More Examples

- We're using Jupyter notebooks to create examples; to find these, visit: https://github.com/spedas