Python Satellite Data Analysis Toolkit

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Angeline Burrell
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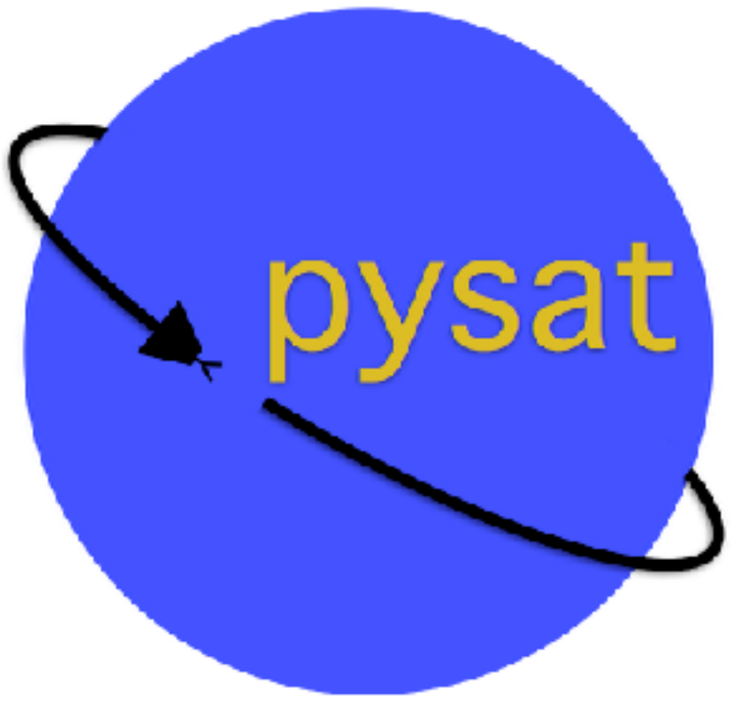


Tool for System Science

- If we are going to integrate the full array of space science measurements then we need a common ground for all instruments and an implementation of the process of space science analysis

- Package with support for common problems
  - Downloading
  - Organizing Files
  - Loading
  - Cleaning
  - Modifying/Processing
  - Exploit routines from other packages
  - Instrument specific analysis
  - Instrument independent analysis

- Support for a variety of unique datasets and processing chains

- Web Tour - **Python 2/3 Compatible!!**

Short History

- pysat was forged in the fires of the C/NOFS mission
- Began life in IDL as a GUI
    - Lack of behind the scenes capabilities prompted a refactor of the back end
        - Attended scipy 2012 in Austin, TX - Refactored into Python immediately after
- Goals expanded with capabilities
- Feature set and structure reflects my scientific requirements for space science

Since Last Update

- IVM processing for the upcoming ICON and COSMIC-2 Missions runs on top of pysat
    - pysat runs at UC Berkeley, UCAR, UTD, and …
        - Officially speaking lots of money depends upon pysat
- Added significant unit testing coverage: 80%
- Added additional instruments

Installation

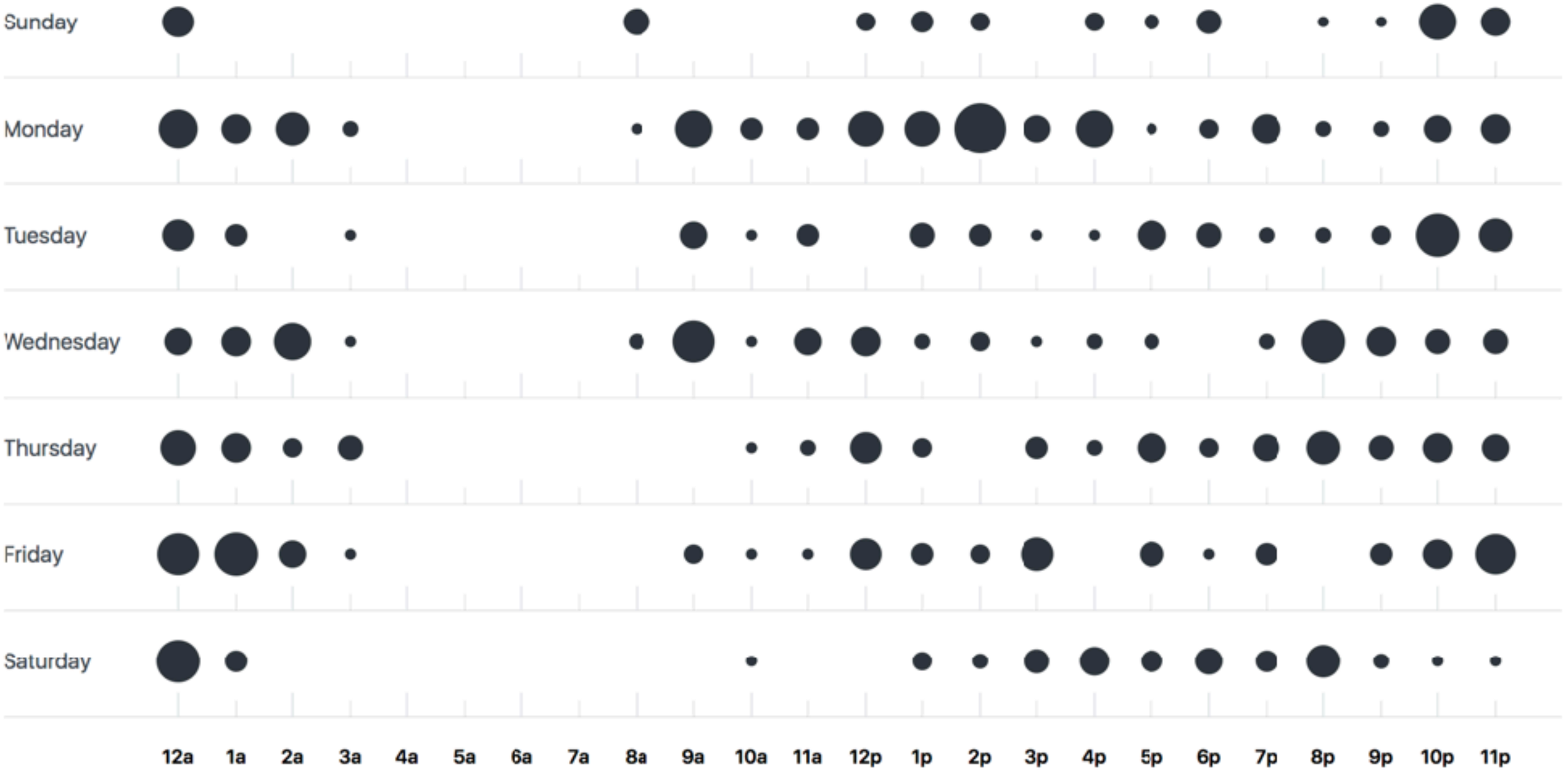
- pip install pysat
  - Support for system science
  - or, python setup.py install
- pip install pysatCDF
  - Support for NASA's CDF library, includes everything you need including NASA's CDF library
- Going to pursue inclusion into Enthought Repository

rstoneback / pysat

Unwatch 4 | Unstar 3 | Fork 3

Code | Issues 0 | Pull requests 0 | Projects 0 | Wiki | Settings | Insights

Contributors | Traffic | Commits | Code frequency | **Punch card** | Network | Members | Dependents



What is pysat again?

Process of Space Science Data Analysis
Implemented like a music recording signal chain
Currently 1 channel - no automatic mixing

C/NOFS IVM

```
In [31]: import pysat
    ...: pysat.utils.set_data_dir('/Users/rstoneba/demo')
    ...: ivm = pysat.Instrument('cnofs', 'ivm', clean_level='clean')
    ...: ivm.download(pysat.datetime(2010,1,1), pysat.datetime(2010, 1, 2))
    ...: ivm.load(2010,1)
    ...: np.log10(ivm[0:1000,'ionDensity']).plot(title='IVM Ion Density')
    ...: plt.ylabel('Log Density (N/cc)')
Downloading data to:  /Users/rstoneba/demo/cnofs/ivm/
Downloading file for 01/01/10
Downloading file for 01/02/10
Updating pysat file list
pysat is searching for cnofs ivm files.
Found 2 of them.
Updating instrument object bounds.
Returning cnofs ivm data for 01/01/10
Out[31]: <matplotlib.text.Text at 0x123eb2790>
```

Data is preliminary

C/NOFS IVM

```
In [31]: import pysat
    ...: pysat.utils.set_data_dir('/Users/rstoneba/demo')
    ...: ivm = pysat.Instrument('cnofs', 'ivm', clean_level='clean')
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    ...: np.log10(ivm[0:1000,'ionDensity']).plot(title='IVM Ion Density')
    ...: plt.ylabel('Log Density
Downloading data to:  /Users/rsto
Downloading file for 01/01/10
Downloading file for 01/02/10
Updating pysat file list
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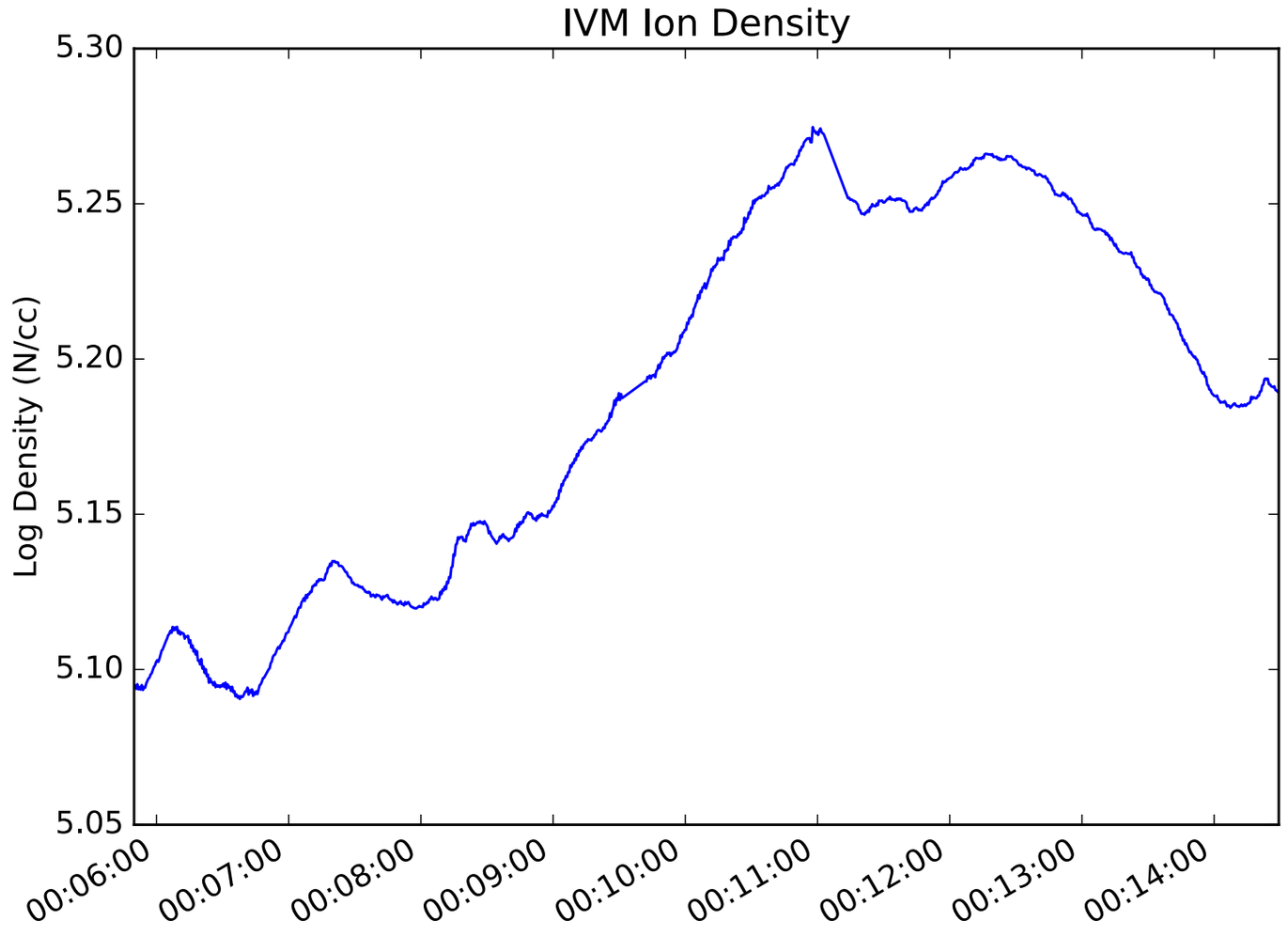
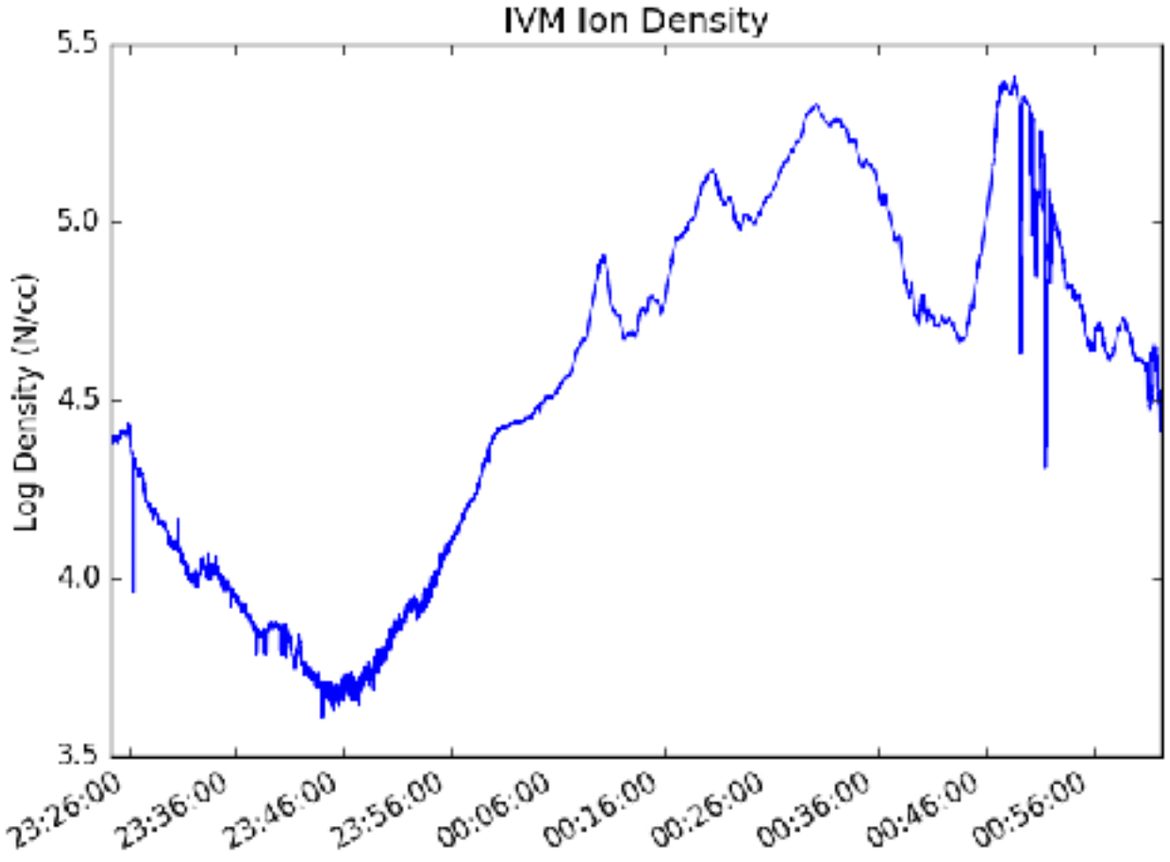
Found 2 of them.
Updating instrument object bounds
Returning cnofs ivm data for 01/0
Out[31]: <matplotlib.text.Text at
```



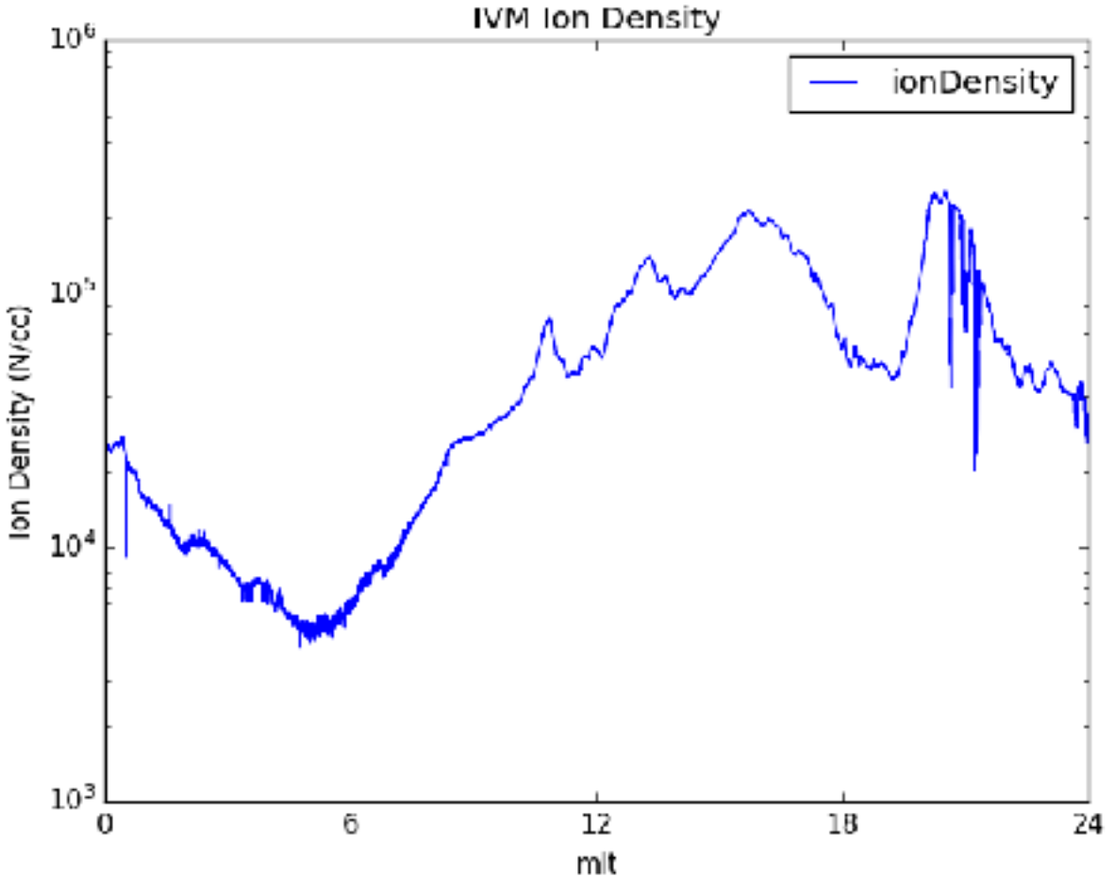
Data is preliminary

C/NOFS IVM by Orbit

```
In [40]: ivm = pysat.Instrument('cnofs', 'ivm',
    ...:                         clean_level='dirty',
    ...:                         orbit_info={'index':'mlt'})
    ...: ivm.load(2010,2)
    ...: ivm.orbits.next()
    ...: np.log10(ivm['ionDensity']).plot(title='IVM Ion Density')
    ...: plt.ylabel('Log Density (N/cc)')
Returning cnofs ivm data for 01/02/10
Returning cnofs ivm data for 01/01/10
Returning cnofs ivm data for 01/02/10
Loaded Orbit:0
Out[40]: <matplotlib.text.Text at 0x1250fab90>
```




```
In [48]: ivm = pysat.Instrument('cnofs', 'ivm',
    ...:                         clean_level='dirty',
    ...:                         orbit_info={'index':'mlt'})
    ...: ivm.load(2010,2)
    ...: ivm.orbits.next()
    ...: ivm.data.plot(x='mlt', y='ionDensity',
    ...:               title='IVM Ion Density',
    ...:               logy=True,
    ...:               xticks=[0,6,12,18,24])
    ...: plt.ylabel('Ion Density (N/cc)')
Returning cnofs ivm data for 01/02/10
Returning cnofs ivm data for 01/01/10
Returning cnofs ivm data for 01/02/10
Loaded Orbit:0
Out[48]: <matplotlib.text.Text at 0x1284af410>
```



ROCSAT

```
In [17]: ivm = pysat.Instrument('rocsat', 'ivm',
    ...:                         clean_level='none',
    ...:                         orbit_info={'index':'lhr'})
    ...: ivm.download(pysat.datetime(2002,1,1), pysat.datetime(2002,1,2))
    ...: ivm.load(2002,2)
    ...: ivm.orbits.next()
    ...: ivm.data.plot(x='lhr', y='logN',
    ...:               title='IVM Ion Density',
    ...:               xticks=[0,6,12,18,24])
    ...: plt.ylabel('Ion Density (N/cc)')
pysat is searching for rocsat ivm files.
Unable to find any files. If you have the necessary files please check pysat settings and file locations.
Downloading data to:  /Users/rstoneba/demo/rocsat/ivm/
Downloading file for 01/01/02
Downloading file for 01/02/02
Updating pysat file list
pysat is searching for rocsat ivm files.
Found 2 of them.
Updating instrument object bounds.
Returning rocsat ivm data for 01/02/02
Returning rocsat ivm data for 01/01/02
Returning rocsat ivm data for 01/02/02
Loaded Orbit:0
Out[17]: <matplotlib.text.Text at 0x124132e50>
```

ROCSAT

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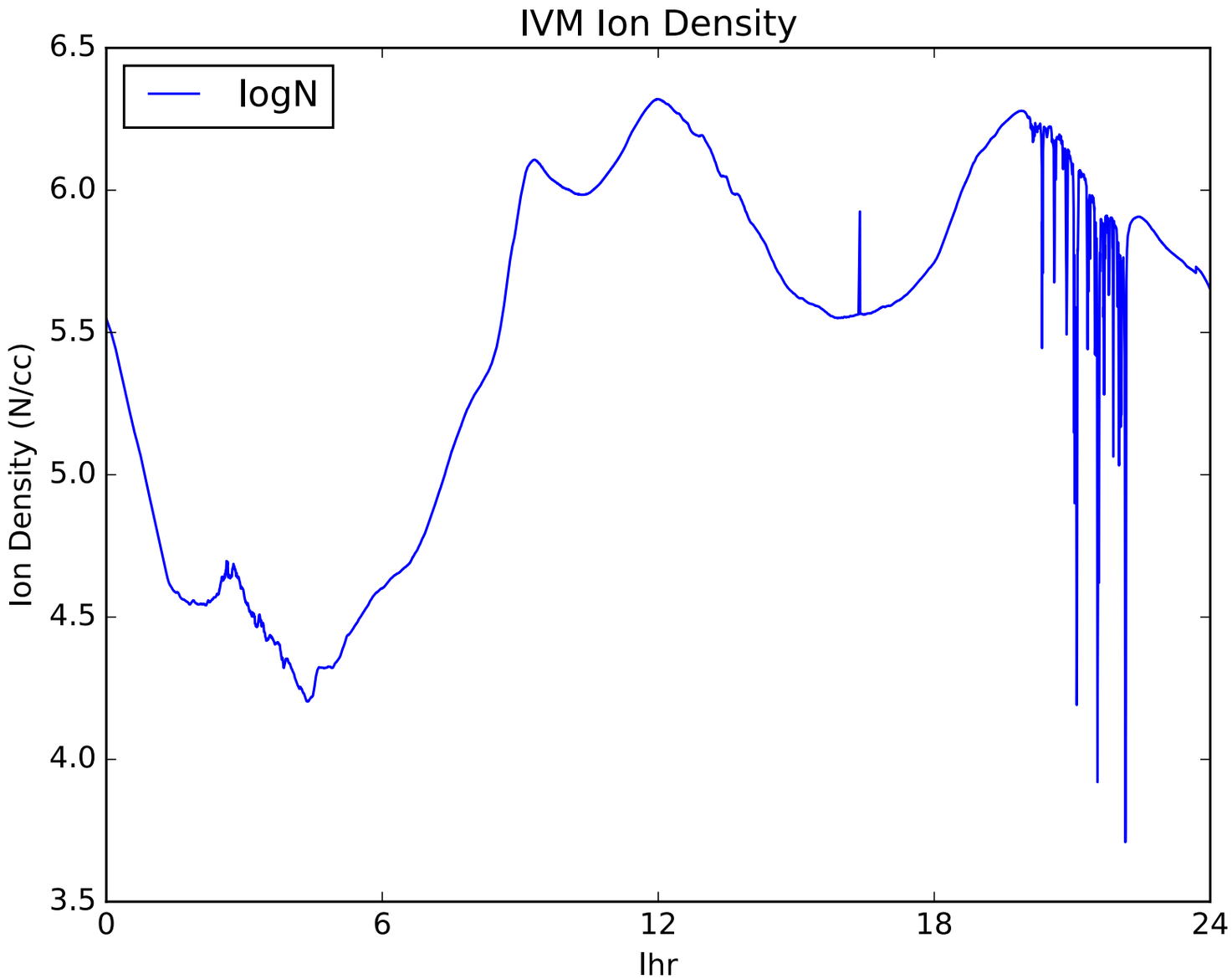
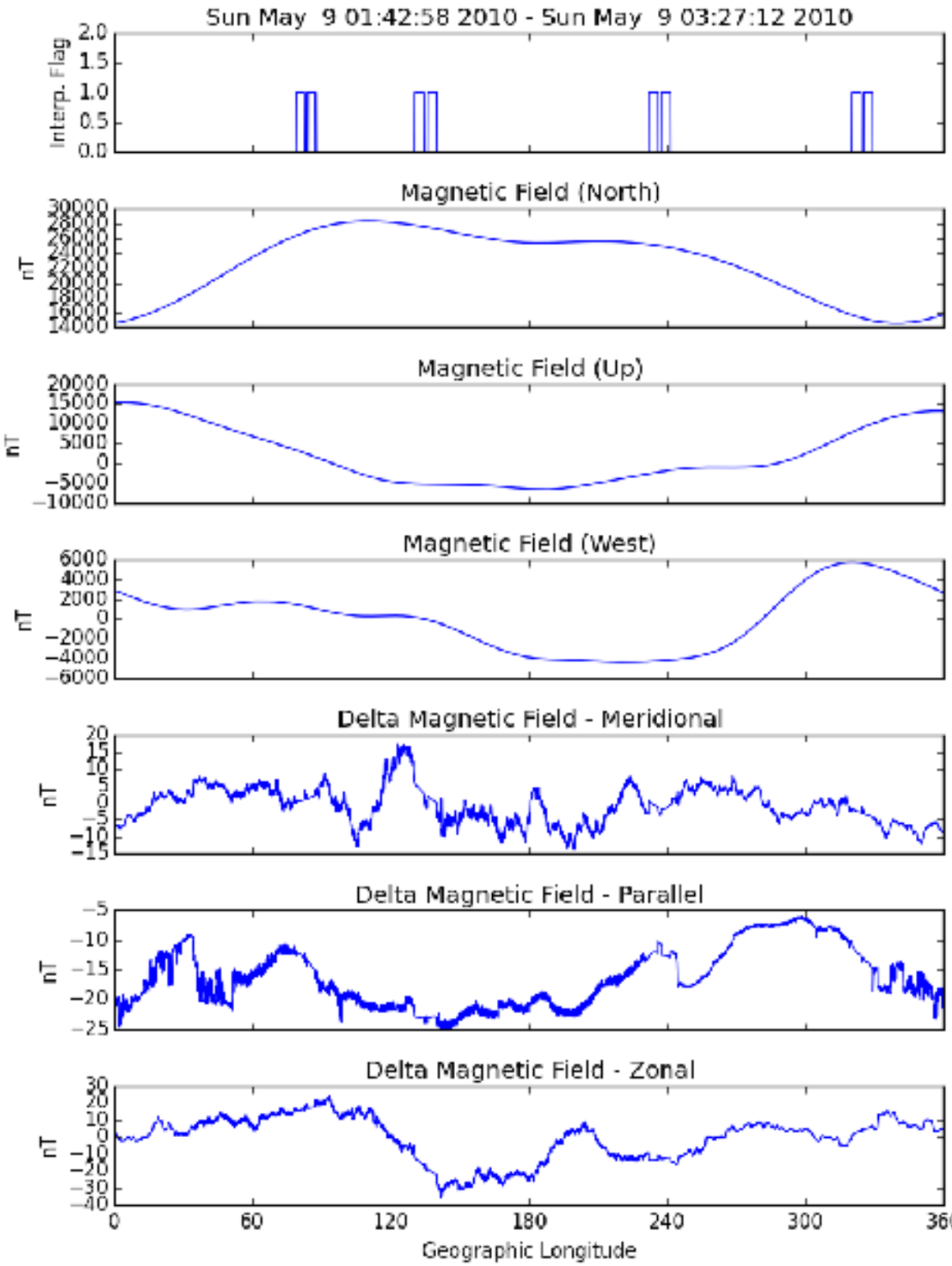
In [17]: ivm = pysat.Instrument('rocsat', 'ivm',
    ...:                         clean_level='none',
    ...:                         orbit_info={'index':'lhr'})
    ...: ivm.download(pysat.datetime(2002,1,1), pysat.datetime(2002,1,2))
    ...: ivm.load(2002,2)
    ...: ivm.orbits.next()
    ...: ivm.data.plot(x='lhr', y='log
    ...:               title='IVM Ion
    ...:               xticks=[0,6,12,
    ...: plt.ylabel('Ion Density (N/cc
pysat is searching for rocsat ivm file
Unable to find any files. If you have
Downloading data to:  /Users/rstoneba/
Downloading file for 01/01/02
Downloading file for 01/02/02
Updating pysat file list
pysat is searching for rocsat ivm file
Found 2 of them.
Updating instrument object bounds.
Returning rocsat ivm data for 01/02/02
Returning rocsat ivm data for 01/01/02
Returning rocsat ivm data for 01/02/02
Loaded Orbit:0
Out[17]: <matplotlib.text.Text at 0x1
```

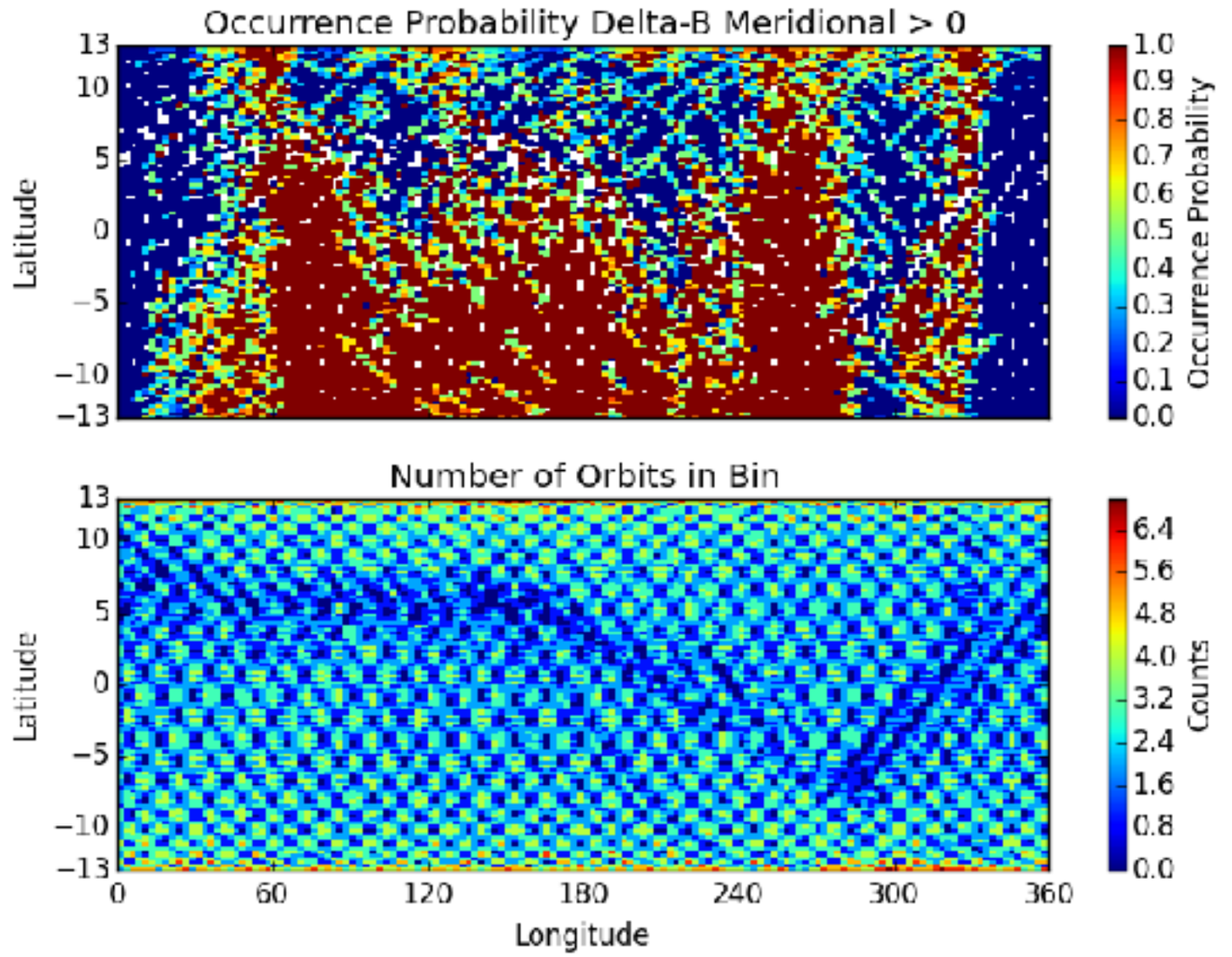


C/NOFS VEFI



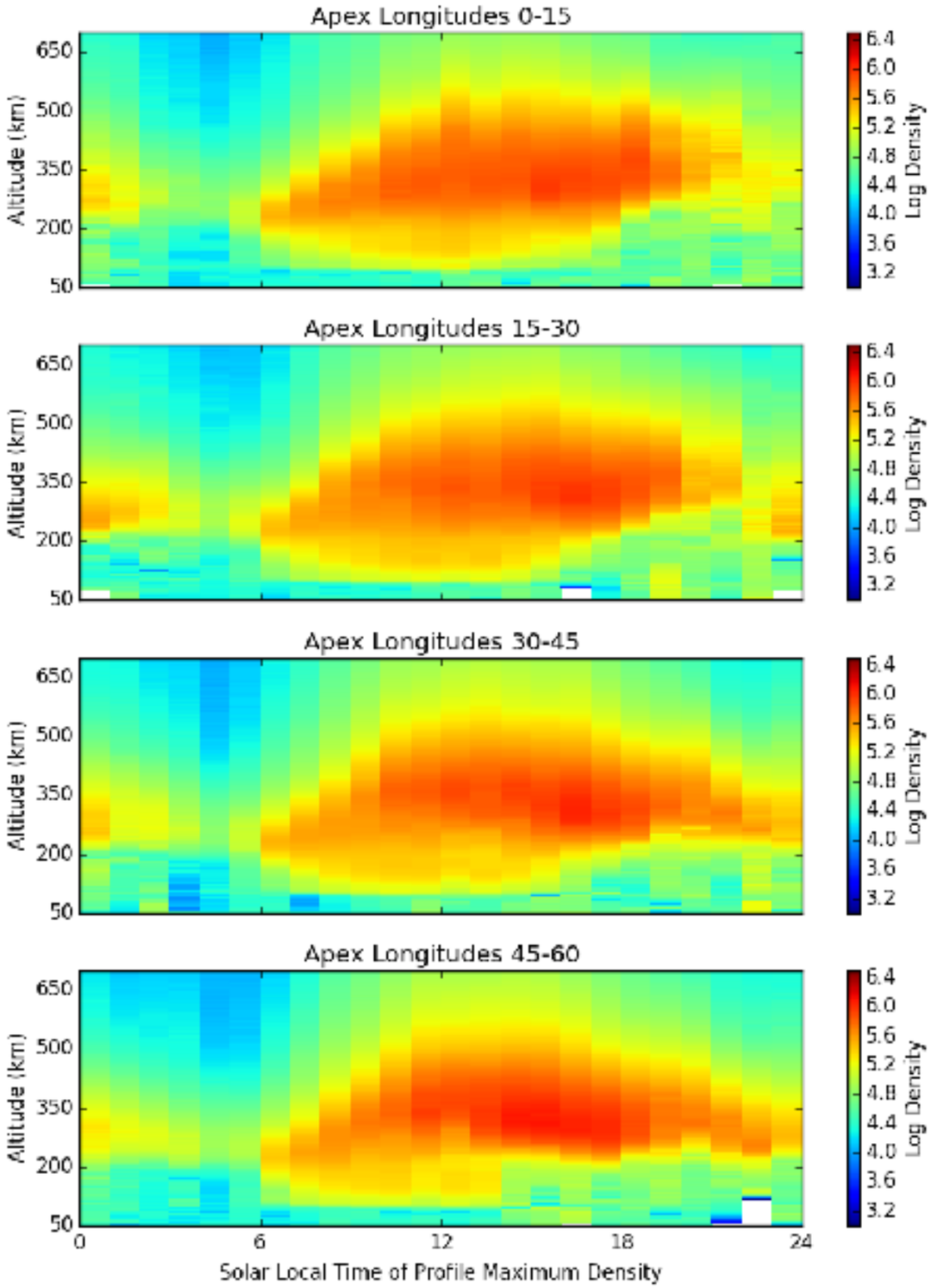

```
# select vefi dc magnetometer data, use longitude to determine where
# there are changes in the orbit (local time info not in file)
orbit_info = {'index':'longitude', 'kind':'longitude'}
vefi = pysat.Instrument(platform='cnofs', name='vefi', tag='dc_b',
                        clean_level=None, orbit_info=orbit_info)
```

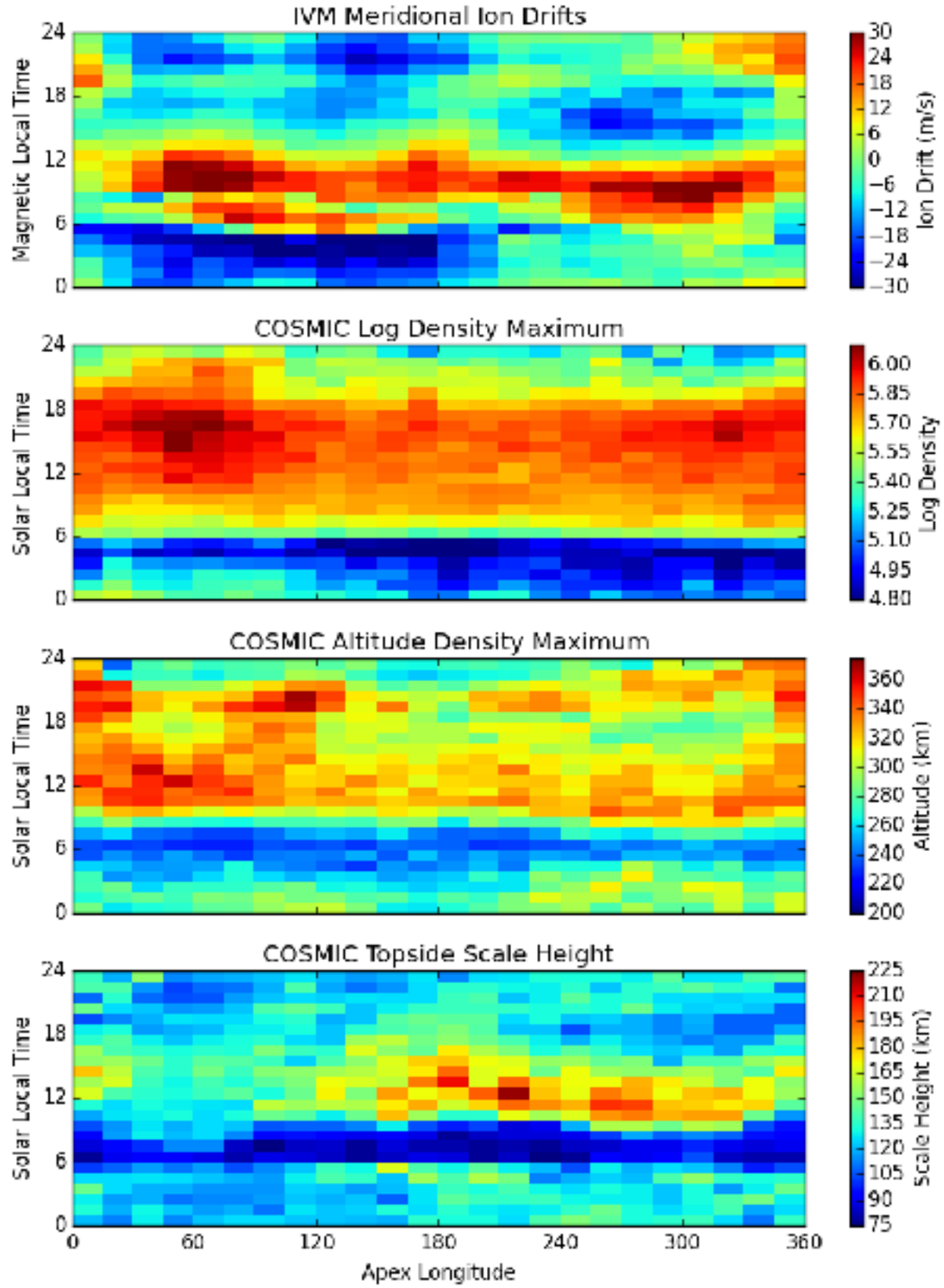
```
# perform occurrence probability calculation
# any data added by custom functions is available within routine below
ans = pysat.ssnl.occur_prob.by_orbit2D(vefi, [0,360,144], 'longitude',
                [-13,13,104], 'latitude', ['dB_mer'], [0.], returnBins=True)
```



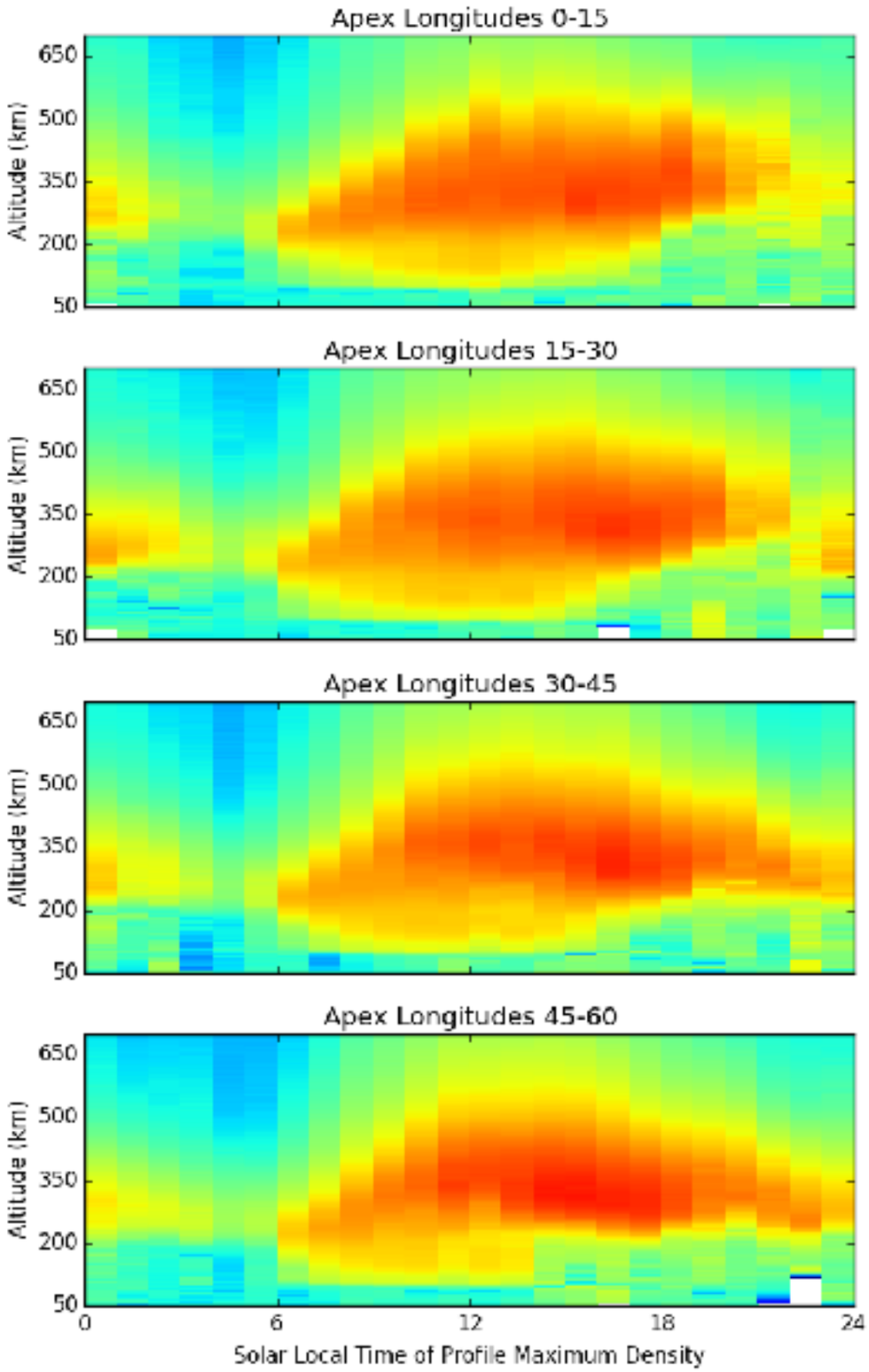
Full Code in Demo Area of Repo

COSMIC and IVM Demo

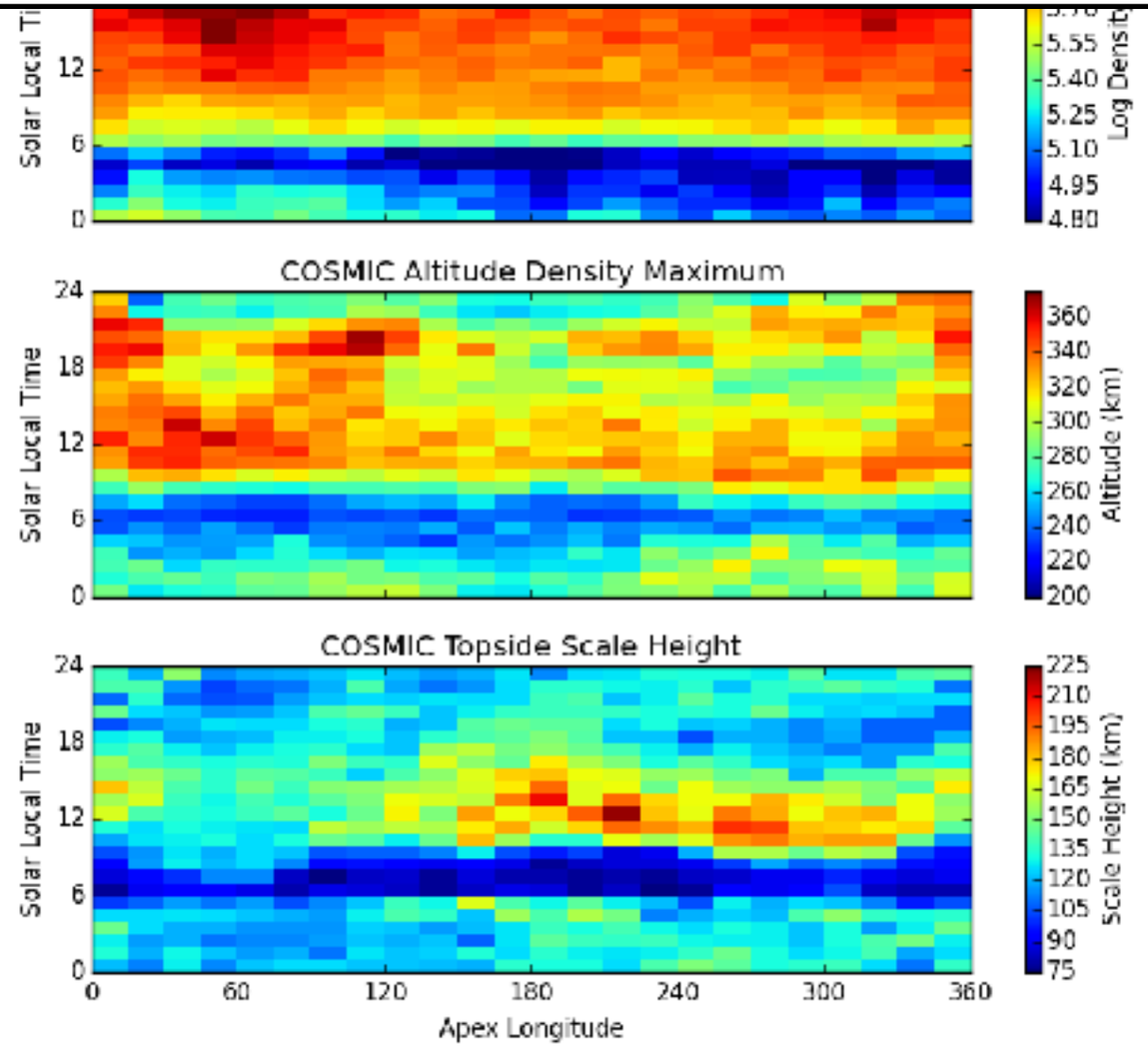




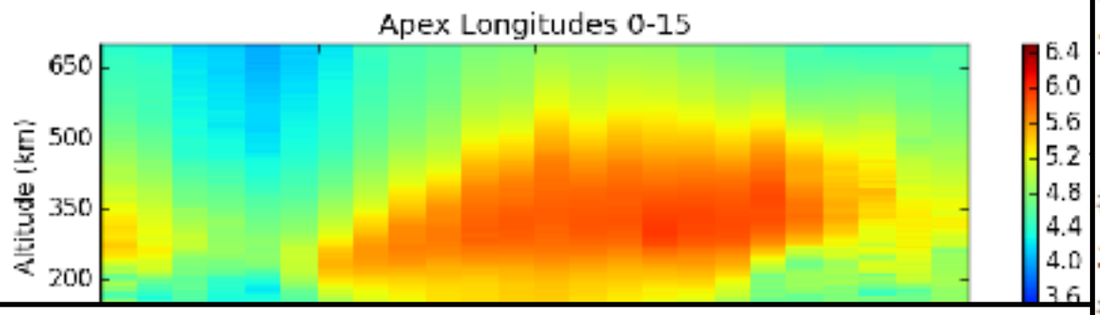
COSMIC and IVM Demo




```
# instantiate IVM Object
ivm = pysat.Instrument(platform='cnofs',
                       name='ivm', tag='',
                       clean_level='clean')
# restrict meausurements to those near geomagnetic equator
ivm.custom.add(restrictMLAT, 'modify', maxMLAT=25.)
# perform seasonal average
ivm.bounds = (startDate, stopDate)
ivmResults = pysat.ssnl.avg.median2D(ivm, [0,360,24], 'alon',
                       [0,24,24], 'mlt', ['ionVelmeridional'])
```



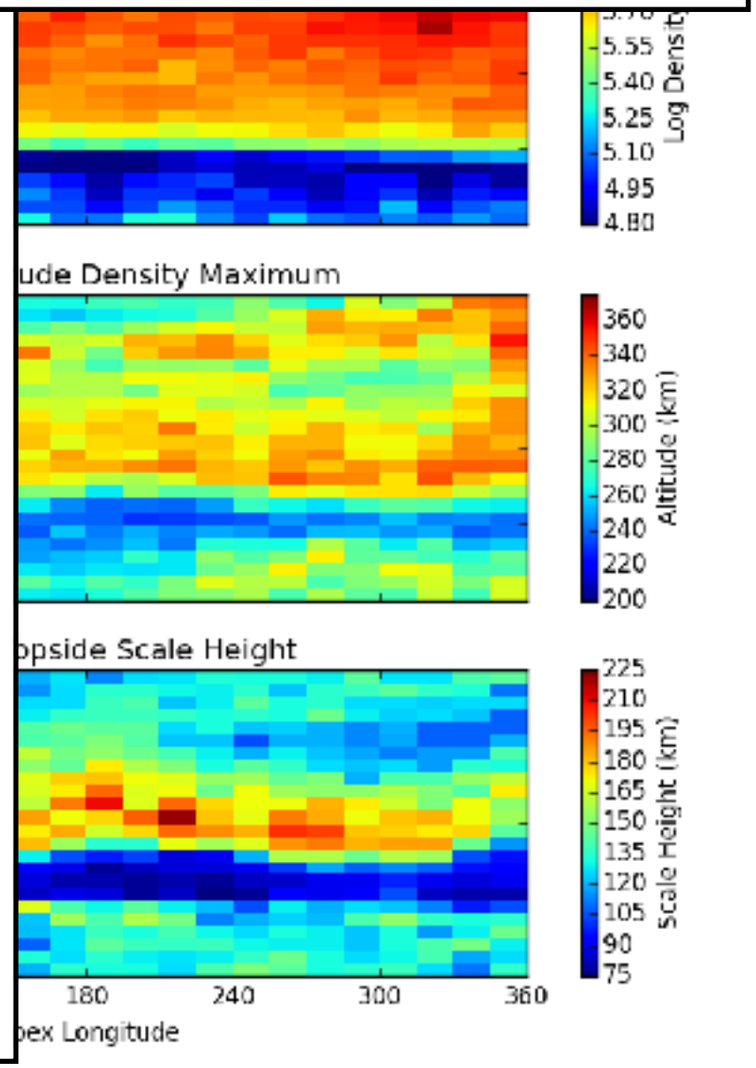
COSMIC and IVM Demo



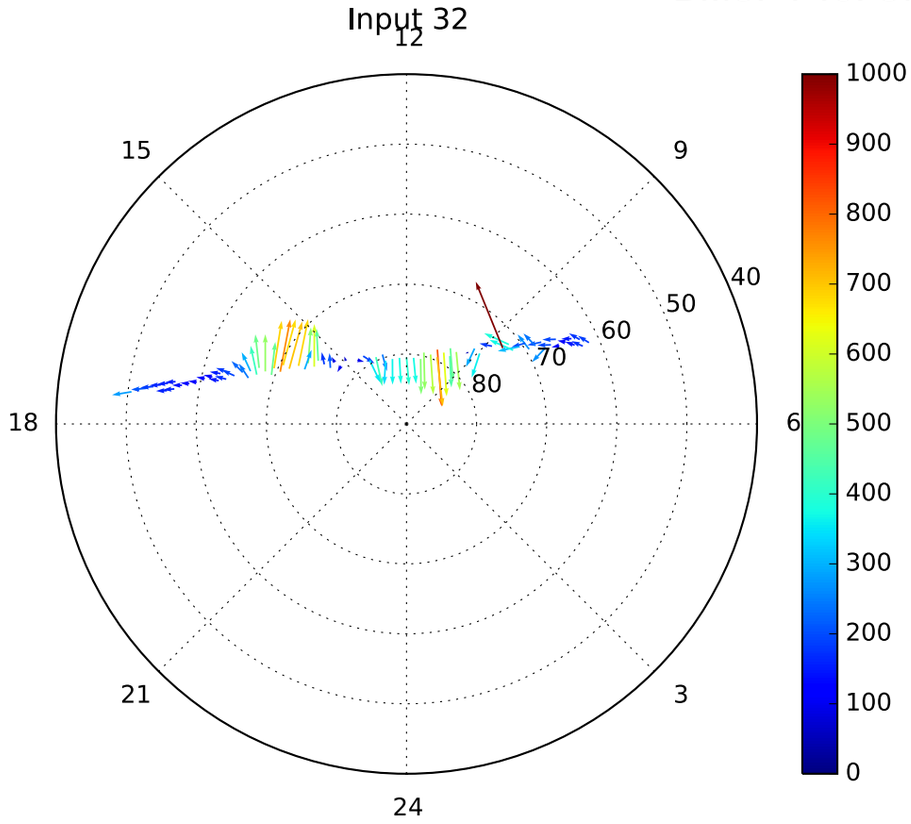

```
# create COSMIC instrument object
cosmic = pysat.Instrument(platform='cosmic2013',
                          name='gps',tag='ionprf'
                          clean_level='clean',
                          altitude_bin=3)
# apply custom functions to all data that is loaded through cosmic
cosmic.custom.add(addApexLong, 'add')
# select locations near the magnetic equator
cosmic.custom.add(filterMLAT, 'modify', mlatRange=(0.,10.) )
# take the log of NmF2 and add to the dataframe
cosmic.custom.add(addlogNm, 'add')
# calculates the height above hmF2 to reach Ne < NmF2/e
cosmic.custom.add(addTopsideScaleHeight, 'add')

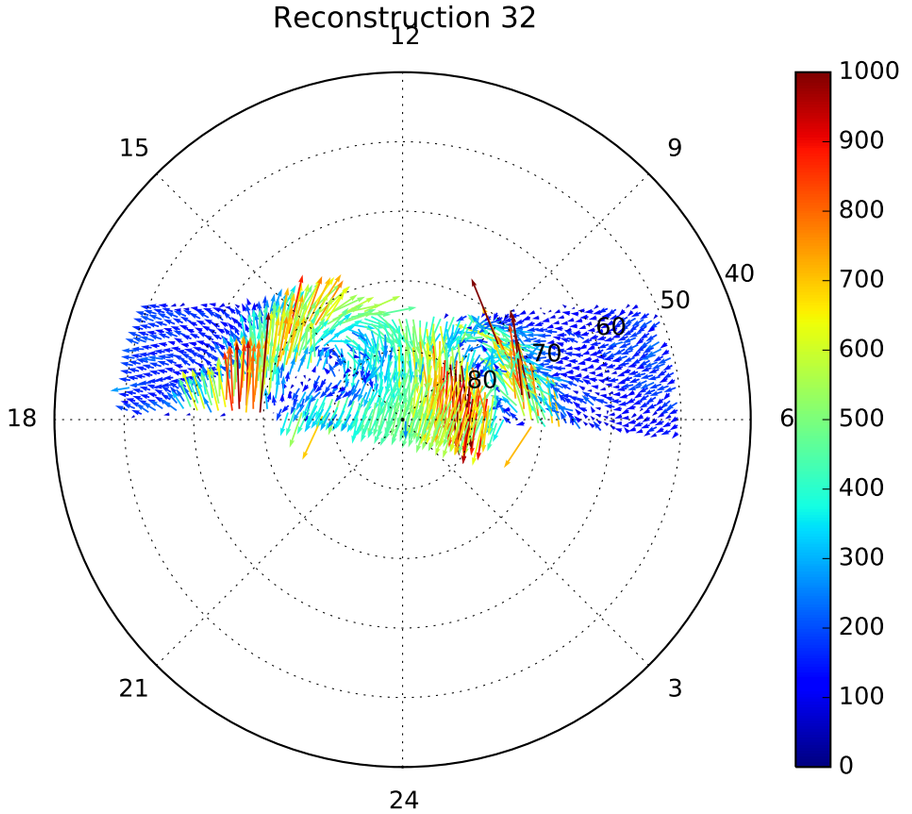
# do an average of multiple COSMIC data products
# from startDate through stopDate
# a mixture of 1D and 2D data is averaged
cosmic.bounds = (startDate, stopDate)
cosmicResults = pysat.ssnl.avg.median2D(cosmic, [0,360,24], 'apex_long',
       [0,24,24],'edmaxlct', ['profiles', 'edmaxalt', 'lognm', 'thf2'])
```

```
# instantiate IVM Object
ivm = pysat.Instrument(platform='cnofs',
                       name='ivm', tag='',
                       clean_level='clean')
# restrict meausurements to those near geomagnetic equator
ivm.custom.add(restrictMLAT, 'modify', maxMLAT=25.)
# perform seasonal average
ivm.bounds = (startDate, stopDate)
ivmResults = pysat.ssnl.avg.median2D(ivm, [0,360,24], 'alon',
                     [0,24,24], 'mlt', ['ionVelmeridional'])
```

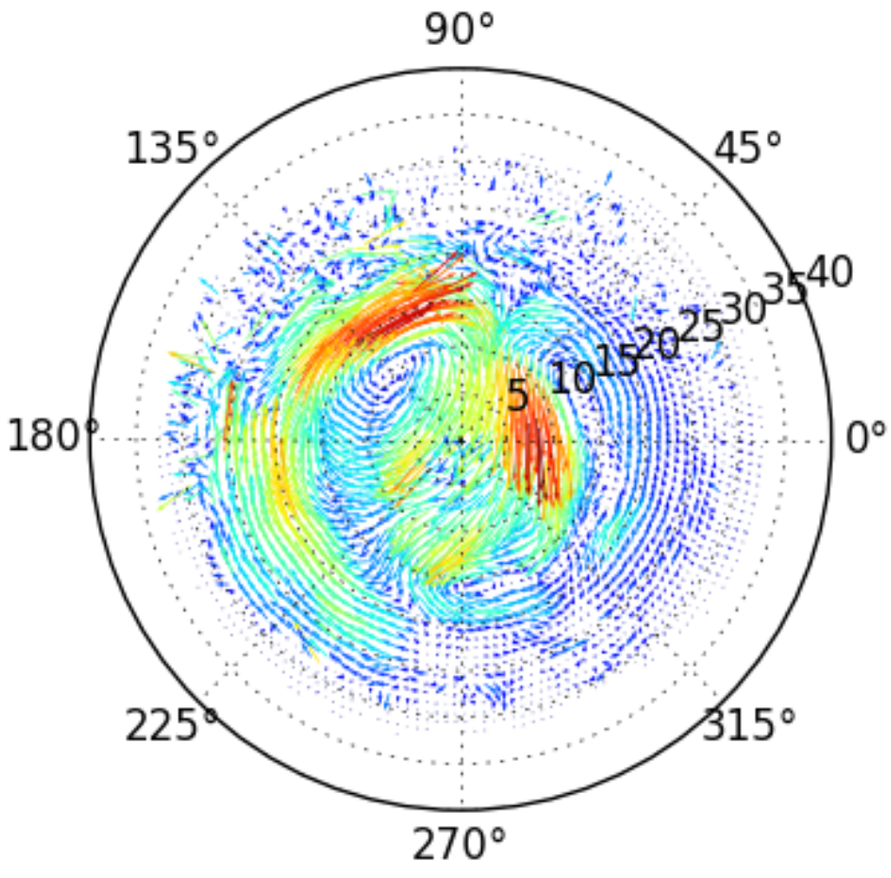


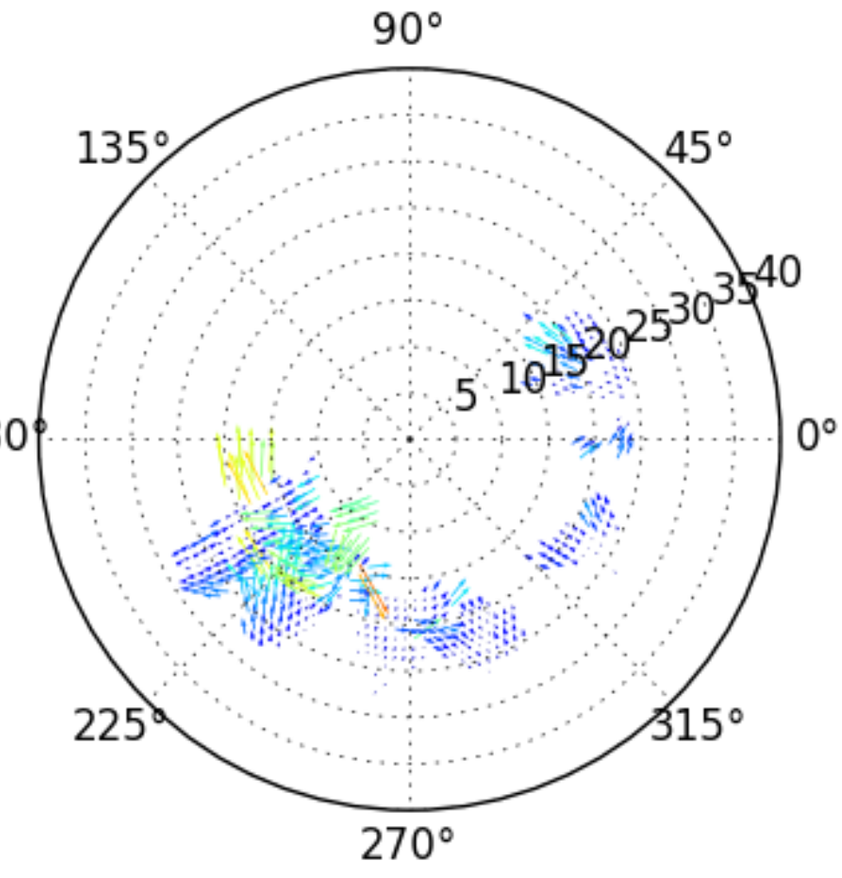
Northern Polar Hemisphere Convection
DMSP F13: Orbit - by - Orbit





Reconstruction and Input 2001-01-03 06:47:28





Future

- Transition to a hybrid Pandas/Xarray data model
    - Expected to be backwards compatible
    - Update metadata to be practical but careful about handling case
    - Polish
    - Submitted proposal about extending this type of functionality to constellations - collections of instruments that can acted upon as one - multichannel audio mixer