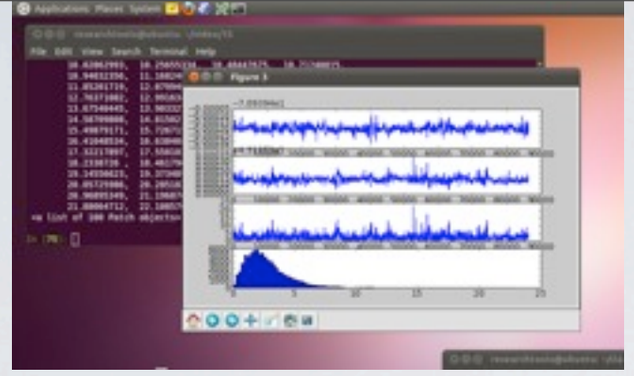
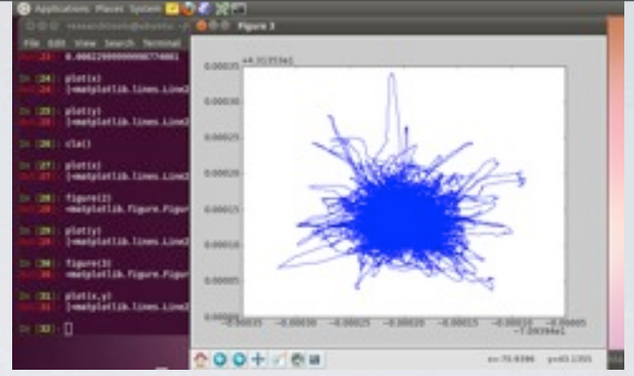
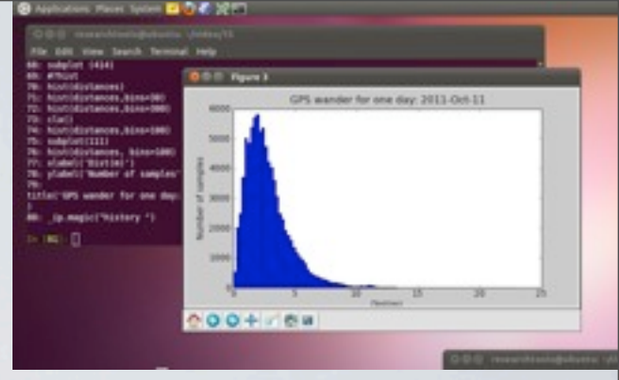





RESEARCH TOOLS 2011
VIDEO 15

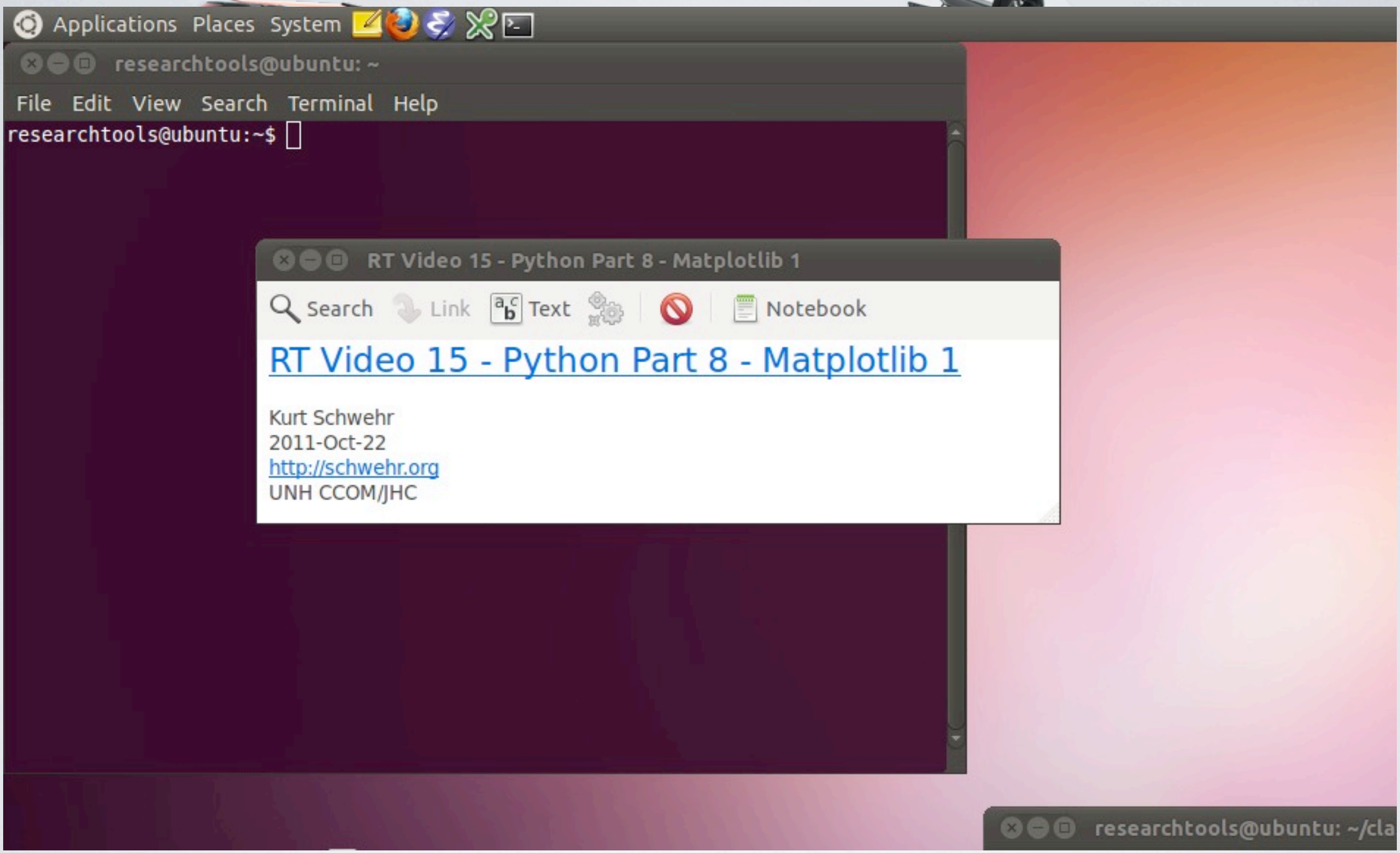
2011-Oct-23

Kurt Schwehr
http://schwehr.org

UNH CCOM/JHC

Python Part 8: Python 8 - Matplotlib part 1

http://vislab-ccom.unh.edu/~schwehr/Classes/2011/esci895-researchtools/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researchtools@ubuntu:~$
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Link
Text
Notebook
RT Video 15 - Python Part 8 - Matplotlib 1
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2011-Oct-22
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vislab-ccom.unh.edu/~schwehr/rt/examples/

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2011-10-11.gga.dat.bz2	20-Oct-2011 08:21	221K
ccom-airmar-2011-08-28.bz2	06-Sep-2011 06:05	5.1M
ccom-airmar-2011-08-29.bz2	06-Sep-2011 06:05	4.9M
ccom-airmar-2011-08-30.bz2	06-Sep-2011 06:05	4.7M
ccom-airmar-2011-10-11.bz2	14-Oct-2011 14:30	4.8M
examples-20110913.tar.bz2	13-Sep-2011 10:46	80M
examples-20110913/	13-Sep-2011 09:43	-
google-earth-line-end.kml	16-Oct-2010 14:30	109
google-earth-line-start.kml	16-Oct-2010 14:30	311

http://vislab-ccom.unh.edu/~...ples/2011-10-11.gga.dat.bz2

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```
researchtools@ubuntu:~$ mkdir -p video/15
researchtools@ubuntu:~$ cd video/15
researchtools@ubuntu:~/video/15$ wget http://vislab-ccom.unh.edu/~schwehr/rt/exa
mples/2011-10-11.gga.dat.bz2
--2011-10-20 14:36:55--  http://vislab-ccom.unh.edu/~schwehr/rt/examples/2011-10
-11.gga.dat.bz2
Resolving vislab-ccom.unh.edu... 132.177.103.235
Connecting to vislab-ccom.unh.edu|132.177.103.235|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 226512 (221K) [application/x-bzip2]
Saving to: `2011-10-11.gga.dat.bz2'

100%[======================================>] 226,512     1.22M/s   in 0.2s

2011-10-20 14:36:55 (1.22 MB/s) - `2011-10-11.gga.dat.bz2' saved [226512/226512]

researchtools@ubuntu:~/video/15$ file 2011-10-11.gga.dat.bz2
2011-10-11.gga.dat.bz2: bzip2 compressed data, block size = 900k
researchtools@ubuntu:~/video/15$ bzcat 2011-10-11.gga.dat.bz2 | less
```

researchtools@ubuntu: ~/cla

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researchtools@ubuntu: ~/video/15

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```
# x y z quality satellites hdop
-70.9395833333 43.1354166667 35.7 2 9 1.1
-70.9395766667 43.135415 36.1 2 9 1.1
-70.93957 43.1354133333 36.5 2 9 1.1
-70.9395666667 43.1354133333 37.0 2 9 1.1
-70.9395633333 43.1354133333 37.4 2 9 1.1
-70.9395633333 43.1354133333 37.8 2 9 1.1
-70.9395616667 43.1354133333 38.3 2 9 1.1
-70.9395616667 43.135415 38.7 2 9 1.1
-70.93956 43.1354133333 39.1 2 9 1.1
-70.93956 43.1354133333 39.5 2 9 1.1
-70.93956 43.1354133333 39.8 2 9 1.1
-70.93956 43.1354133333 40.2 2 9 1.1
-70.93956 43.1354133333 40.5 2 9 1.1
-70.9395583333 43.1354116667 40.8 2 9 1.1
-70.9395566667 43.1354116667 41.1 2 9 1.1
-70.9395566667 43.1354116667 41.4 2 9 1.1
-70.9395566667 43.1354116667 41.7 2 9 1.1
-70.9395566667 43.13541 42.0 2 9 1.1
-70.9395566667 43.13541 42.3 2 9 1.1
-70.9395566667 43.1354116667 42.5 2 9 1.1
-70.9395566667 43.13541 42.7 2 9 1.1
-70.9395583333 43.13541 42.8 2 9 1.1
-70.9395583333 43.13541 43.0 2 9 1.1
-70.9395583333 43.13541 43.2 2 9 1.1
:
```

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```
-11.gga.dat.bz2
Resolving vislab-ccom.unh.edu... 132.177.103.235
Connecting to vislab-ccom.unh.edu|132.177.103.235|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 226512 (221K) [application/x-bzip2]
Saving to: `2011-10-11.gga.dat.bz2'

100%[======================================>] 226,512     1.22M/s   in 0.2s

2011-10-20 14:36:55 (1.22 MB/s) - `2011-10-11.gga.dat.bz2' saved [226512/226512

researchtools@ubuntu:~/video/15$ file 2011-10-11.gga.dat.bz2
2011-10-11.gga.dat.bz2: bzip2 compressed data, block size = 900k
researchtools@ubuntu:~/video/15$ bzcat 2011-10-11.gga.dat.bz2 | less
researchtools@ubuntu:~/video/15$ bzcat 2011-10-11.gga.dat.bz2 | head
#  x y z quality satellites hdop
-70.9395833333 43.1354166667 35.7 2 9 1.1
-70.9395766667 43.135415 36.1 2 9 1.1
-70.93957 43.1354133333 36.5 2 9 1.1
-70.9395666667 43.1354133333 37.0 2 9 1.1
-70.9395633333 43.1354133333 37.4 2 9 1.1
-70.9395633333 43.1354133333 37.8 2 9 1.1
-70.9395616667 43.1354133333 38.3 2 9 1.1
-70.9395616667 43.135415 38.7 2 9 1.1
-70.93956 43.1354133333 39.1 2 9 1.1
researchtools@ubuntu:~/video/15$
```

researchtools@ubuntu: ~/cla

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researchtools@ubuntu: ~/video/15

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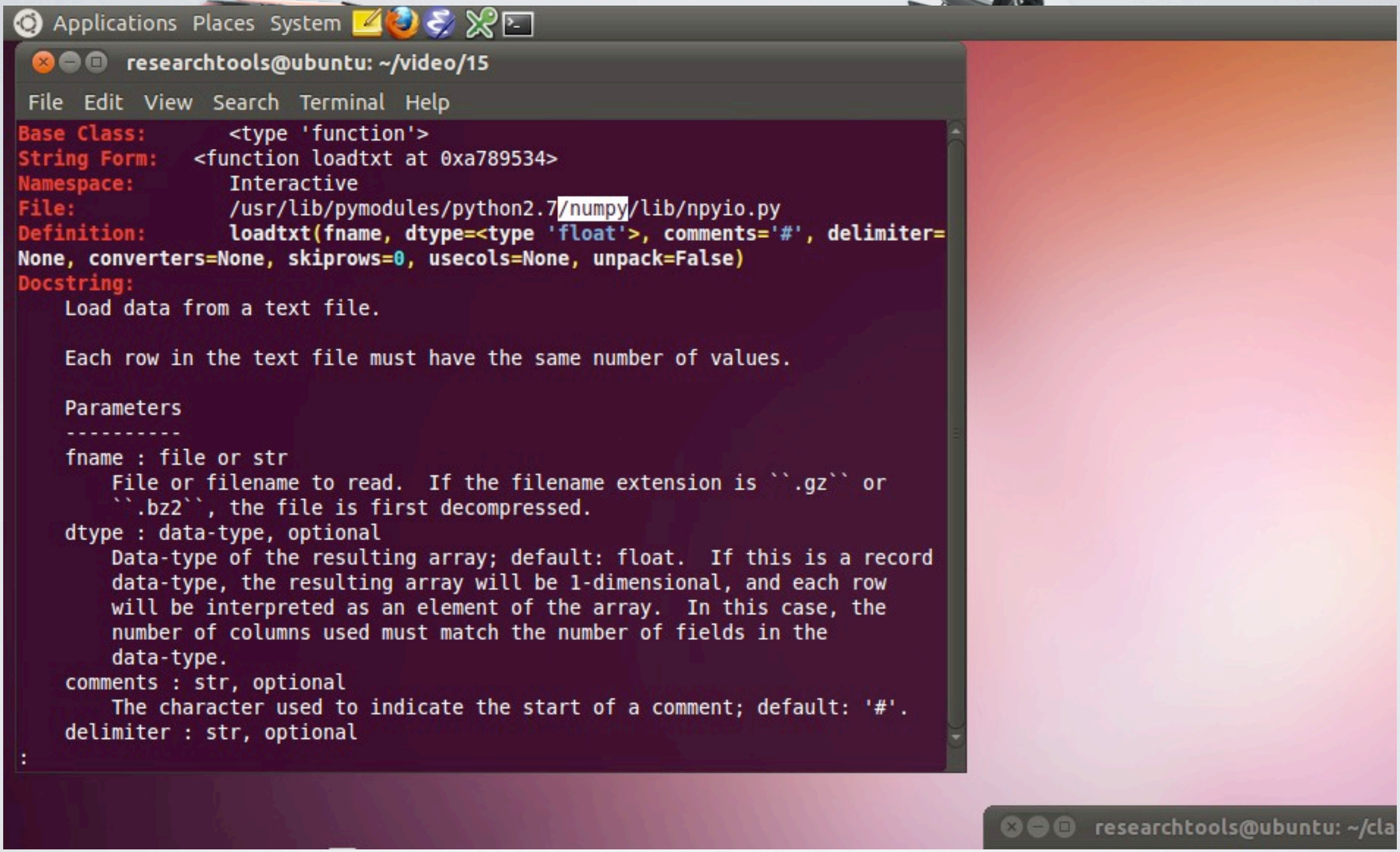
```
-70.9395666667 43.1354133333 37.0 2 9 1.1
-70.9395633333 43.1354133333 37.4 2 9 1.1
-70.9395633333 43.1354133333 37.8 2 9 1.1
-70.9395616667 43.1354133333 38.3 2 9 1.1
-70.9395616667 43.135415 38.7 2 9 1.1
-70.93956 43.1354133333 39.1 2 9 1.1
researchtools@ubuntu:~/video/15$ ipython --pylab
Python 2.7.1+ (r271:86832, Apr 11 2011, 18:05:24)
Type "copyright", "credits" or "license" for more information.

IPython 0.10.1 -- An enhanced Interactive Python.
?         -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object'. ?object also works, ?? prints more.

  Welcome to pylab, a matplotlib-based Python environment.
  For more information, type 'help(pylab)'.

In [1]: pwd
Out[1]: '/home/researchtools/video/15'

In [2]: ls
2011-10-11.gga.dat.bz2

In [3]: loadtxt?
```

researchtools@ubuntu: ~/cla


Applications Places System
researchtools@ubuntu: ~/video/15
File Edit View Search Terminal Help
Base Class: <type 'function'>
String Form: <function loadtxt at 0xa789534>
Namespace: Interactive
File: /usr/lib/pymodules/python2.7/numpy/lib/npyio.py
Definition: loadtxt(fname, dtype=<type 'float'>, comments='#', delimiter=
None, converters=None, skiprows=0, usecols=None, unpack=False)
Docstring:
Load data from a text file.
Each row in the text file must have the same number of values.
Parameters
fname : file or str
File or filename to read. If the filename extension is ``.gz`` or
``.bz2``, the file is first decompressed.
dtype : data-type, optional
Data-type of the resulting array; default: float. If this is a record
data-type, the resulting array will be 1-dimensional, and each row
will be interpreted as an element of the array. In this case, the
number of columns used must match the number of fields in the
data-type.
comments : str, optional
The character used to indicate the start of a comment; default: '#'.
delimiter : str, optional
:
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```
In [3]: loadtxt?

In [4]: data = loadtxt('2011-10-11.gga.dat.bz2')

In [5]: type (data)
Out[5]: <type 'numpy.ndarray'>

In [6]: len(data)
Out[6]: 86330

In [7]: !bzcat 2011-10-11.gga.dat.bz2 | wc -l
86331

In [8]: data[0]
Out[8]:
array([-70.93958333,  43.13541667,  35.7       ,   2.        ,
         9.        ,   1.1       ])

In [9]: whos
Variable   Type       Data/Info
------------------------------
data       ndarray    86330x6: 517980 elems, type `float64`, 4143840 bytes (3 M
b)

In [10]: del(data
```

researchtools@ubuntu: ~/cla

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```
        The string used to separate values.  By default, this is any
        whitespace.
    converters : dict, optional
        A dictionary mapping column number to a function that will convert
        that column to a float.  E.g., if column 0 is a date string:
        ``converters = {0: datestr2num}``.  Converters can also be used to
        provide a default value for missing data:
        ``converters = {3: lambda s: float(s or 0)}``.  Default: None.
    skiprows : int, optional
        Skip the first `skiprows` lines; default: 0.
    usecols : sequence, optional
        Which columns to read, with 0 being the first.  For example,
        ``usecols = (1,4,5)`` will extract the 2nd, 5th and 6th columns.
        The default, None, results in all columns being read.
    unpack : bool, optional
        If True, the returned array is transposed, so that arguments may be
        unpacked using ``x, y, z = loadtxt(...)``.  The default is False.

    Returns
    -------
    out : ndarray
        Data read from the text file.

    See Also
    --------
:
```

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```
Interactive namespace is empty.

In [12]: loadtxt?

In [13]: x,y,z,quality,satellite,hdop = loadtxt('2011-10-11.gga.dat.bz2',unpack=True)

In [14]: type(x)
Out[14]: <type 'numpy.ndarray'>

In [15]: len(x)
Out[15]: 86330

In [16]: x[0]
Out[16]: -70.939583333300007

In [17]: x
Out[17]:
array([-70.93958333, -70.93957667, -70.93957   , ..., -70.93955167,
       -70.93955167, -70.93955167])

In [18]: y
Out[18]:
array([ 43.13541667,  43.135415  ,  43.13541333, ...,  43.13545667,
        43.13545667,  43.13545833])

In [19]:
```

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```
In [17]: x
Out[17]:
array([-70.93958333, -70.93957667, -70.93957   , ..., -70.93955167,
       -70.93955167, -70.93955167])

In [18]: y
Out[18]:
array([ 43.13541667,  43.135415  ,  43.13541333, ...,  43.13545667,
        43.13545667,  43.13545833])

In [19]: average(x)
Out[19]: -70.939601490675187

In [20]: average(y)
Out[20]: 43.135434976022353

In [21]: min(x)
Out[21]: -70.939716666699994

In [22]: max(x)
Out[22]: -70.939486666700006

In [23]: max(x)-min(x)
Out[23]: 0.00022999999998774001

In [24]: plot(x)
```

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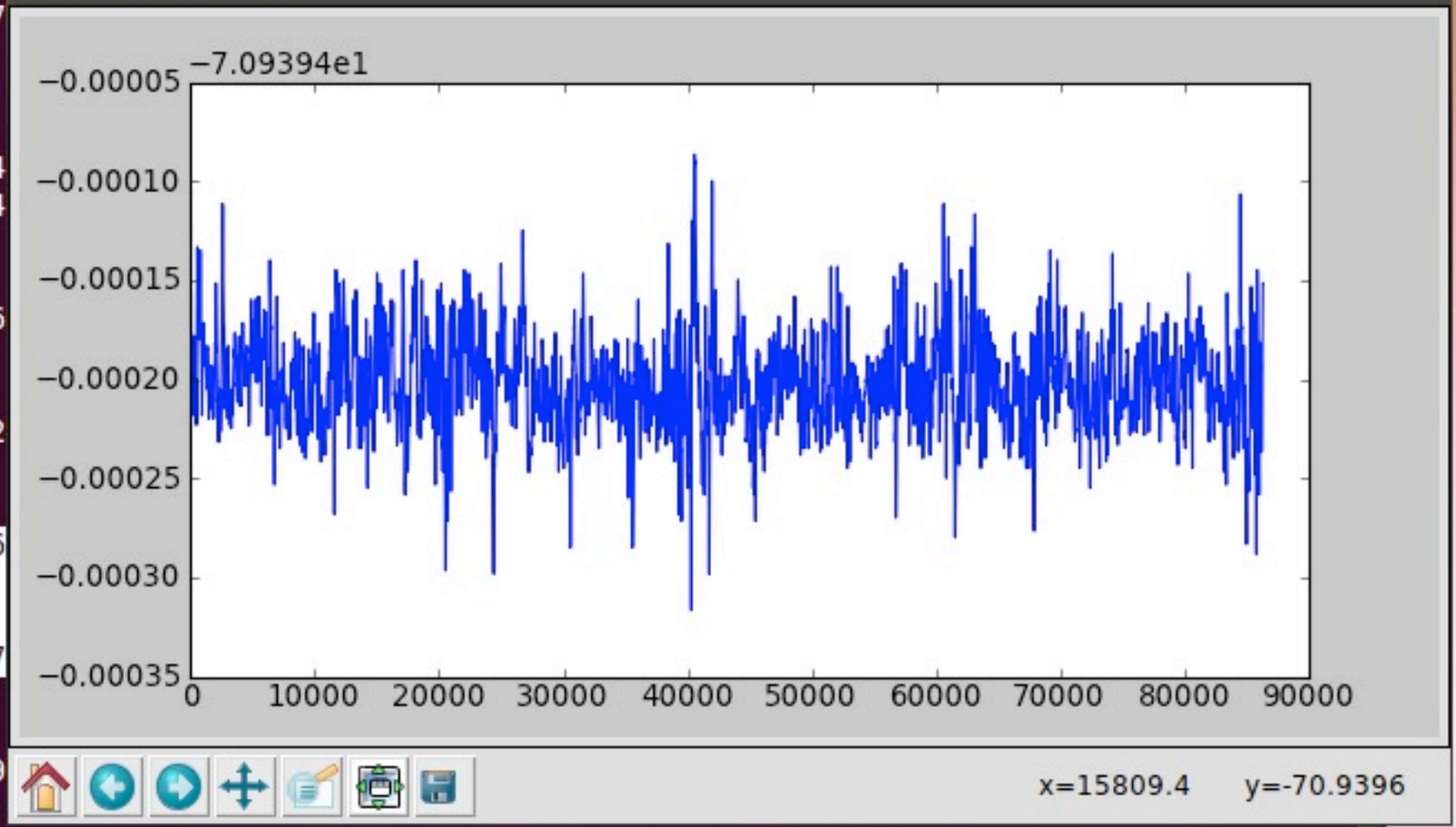
File Edit View Search

```
       -70.93955167, -7

In [18]: y
Out[18]:
array([ 43.13541667,  4
        43.13545667,  4

In [19]: average(x)
Out[19]: -70.9396014906

In [20]: average(y)
Out[20]: 43.13543497602

In [21]: min(x)
Out[21]: -70.9397166666

In [22]: max(x)
Out[22]: -70.9394866667

In [23]: max(x)-min(x)
Out[23]: 0.000229999999

In [24]: plot(x)
Out[24]: [<matplotlib.lines.Line2D object at 0xaefa3ac>]

In [25]:
```

Figure 1



x=15809.4 y=-70.9396

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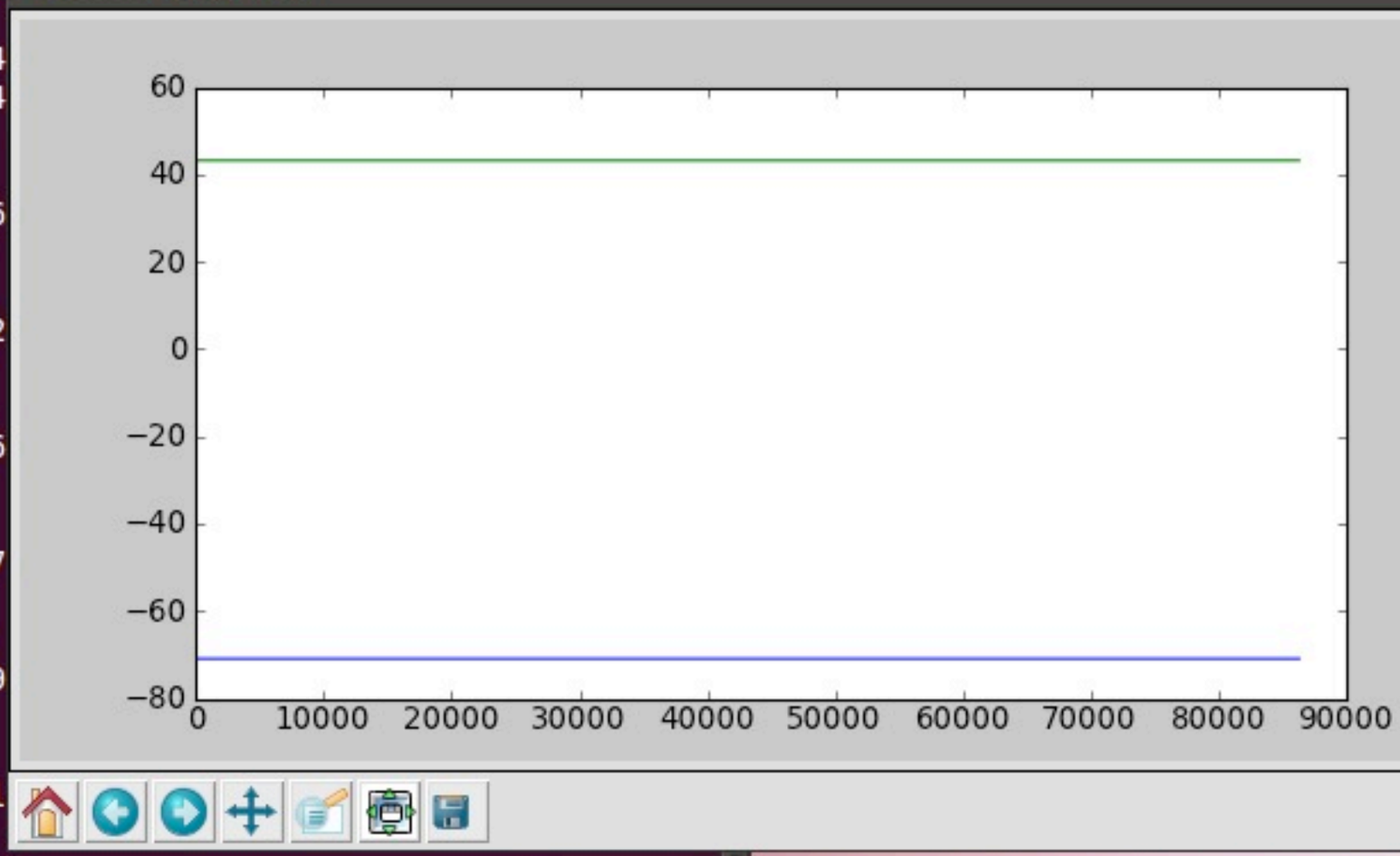
```
Out[18]:
array([ 43.13541667,  4
        43.13545667,  4

In [19]: average(x)
Out[19]: -70.9396014906

In [20]: average(y)
Out[20]: 43.13543497602

In [21]: min(x)
Out[21]: -70.9397166666

In [22]: max(x)
Out[22]: -70.9394866667

In [23]: max(x)-min(x)
Out[23]: 0.000229999999

In [24]: plot(x)
Out[24]: [<matplotlib.l

In [25]: plot(y)
Out[25]: [<matplotlib.lines.Line2D object at 0xae8e8ec>]

In [26]:
```

Figure 1



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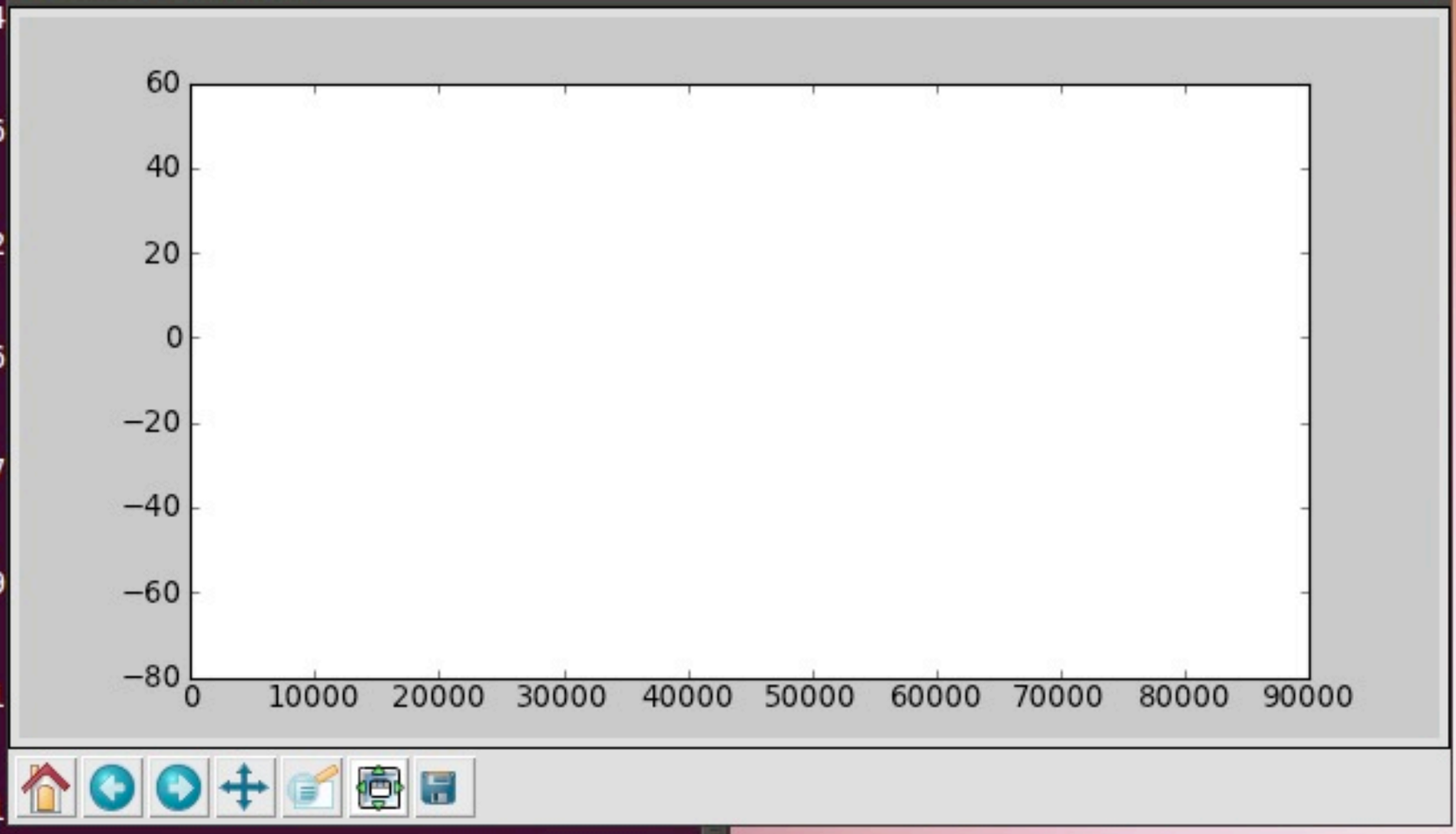
```
        43.13545667,  4

In [19]: average(x)
Out[19]: -70.9396014906

In [20]: average(y)
Out[20]: 43.13543497602

In [21]: min(x)
Out[21]: -70.9397166666

In [22]: max(x)
Out[22]: -70.9394866667

In [23]: max(x)-min(x)
Out[23]: 0.000229999999

In [24]: plot(x)
Out[24]: [<matplotlib.l

In [25]: plot(y)
Out[25]: [<matplotlib.l

In [26]: cla()

In [27]:
```

Figure 1



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```
Out[21]: -70.939

In [22]: max(x)
Out[22]: -70.939

In [23]: max(x)-
Out[23]: 0.00022

In [24]: plot(x)
Out[24]: [<matpl

In [25]: plot(y)
Out[25]: [<matpl

In [26]: cla()

In [27]: plot(x)
Out[27]: [<matpl

In [28]: figure(
Out[28]: <matplotlib.figure

In [29]: plot(y)
Out[29]: [<matplotlib.lines

In [30]:
```

Figure 1

−7.09394e1

−0.00005
−0.00010
−0.00015
−0.00020
−0.00025
−0.00030
−0.00035

Figure 2

+4.31353e1

0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000

0 10000 20000 30000 40000 50000 60000 70000 80000 90000

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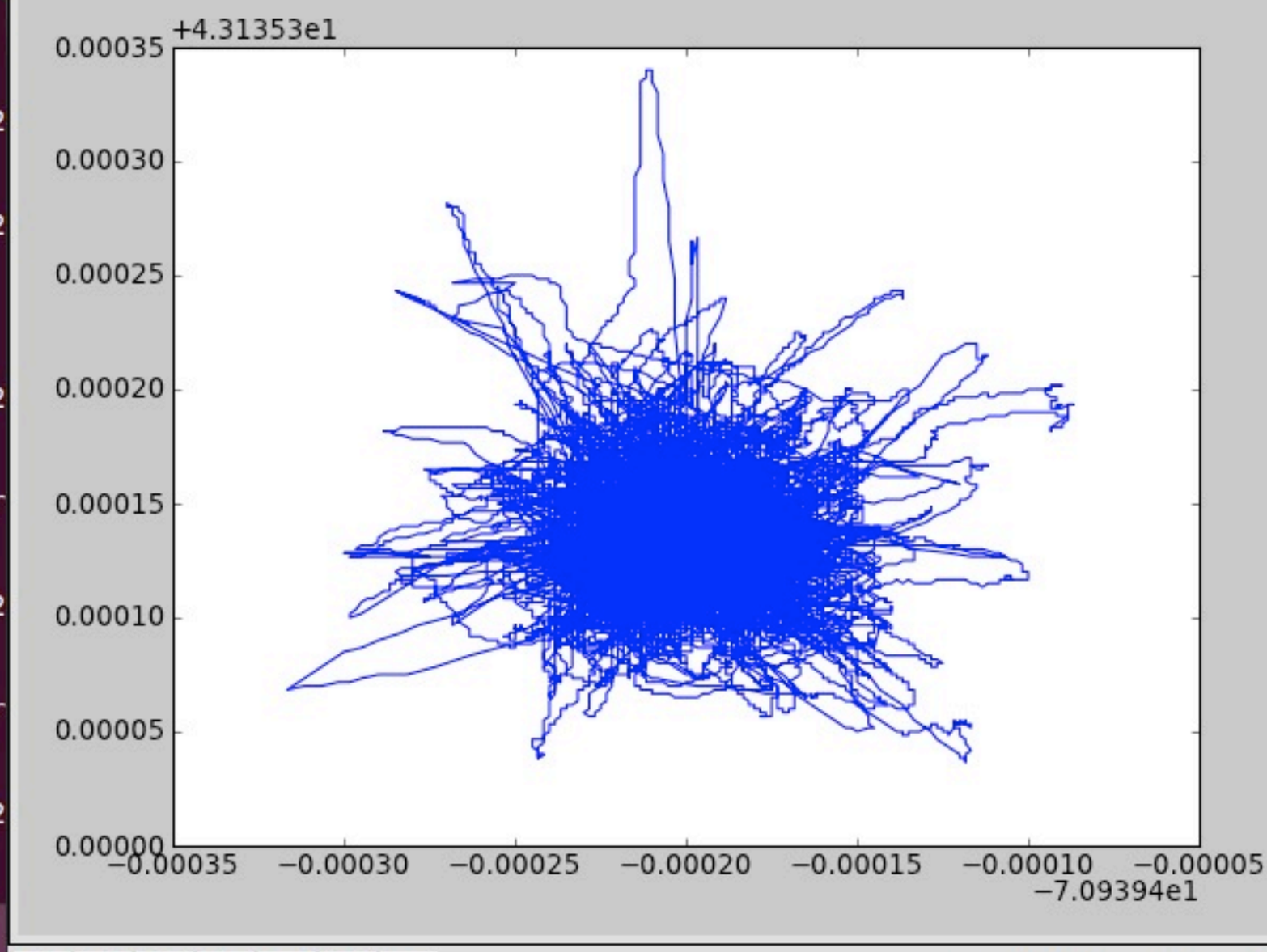
```
Out[23]: 0.00022999999998774001

In [24]: plot(x)
Out[24]: [<matplotlib.lines.Line2

In [25]: plot(y)
Out[25]: [<matplotlib.lines.Line2

In [26]: cla()

In [27]: plot(x)
Out[27]: [<matplotlib.lines.Line2

In [28]: figure(2)
Out[28]: <matplotlib.figure.Figur

In [29]: plot(y)
Out[29]: [<matplotlib.lines.Line2

In [30]: figure(3)
Out[30]: <matplotlib.figure.Figur

In [31]: plot(x,y)
Out[31]: [<matplotlib.lines.Line2

In [32]:
```

Figure 3



x=-70.9396 y=43.1355

/cla

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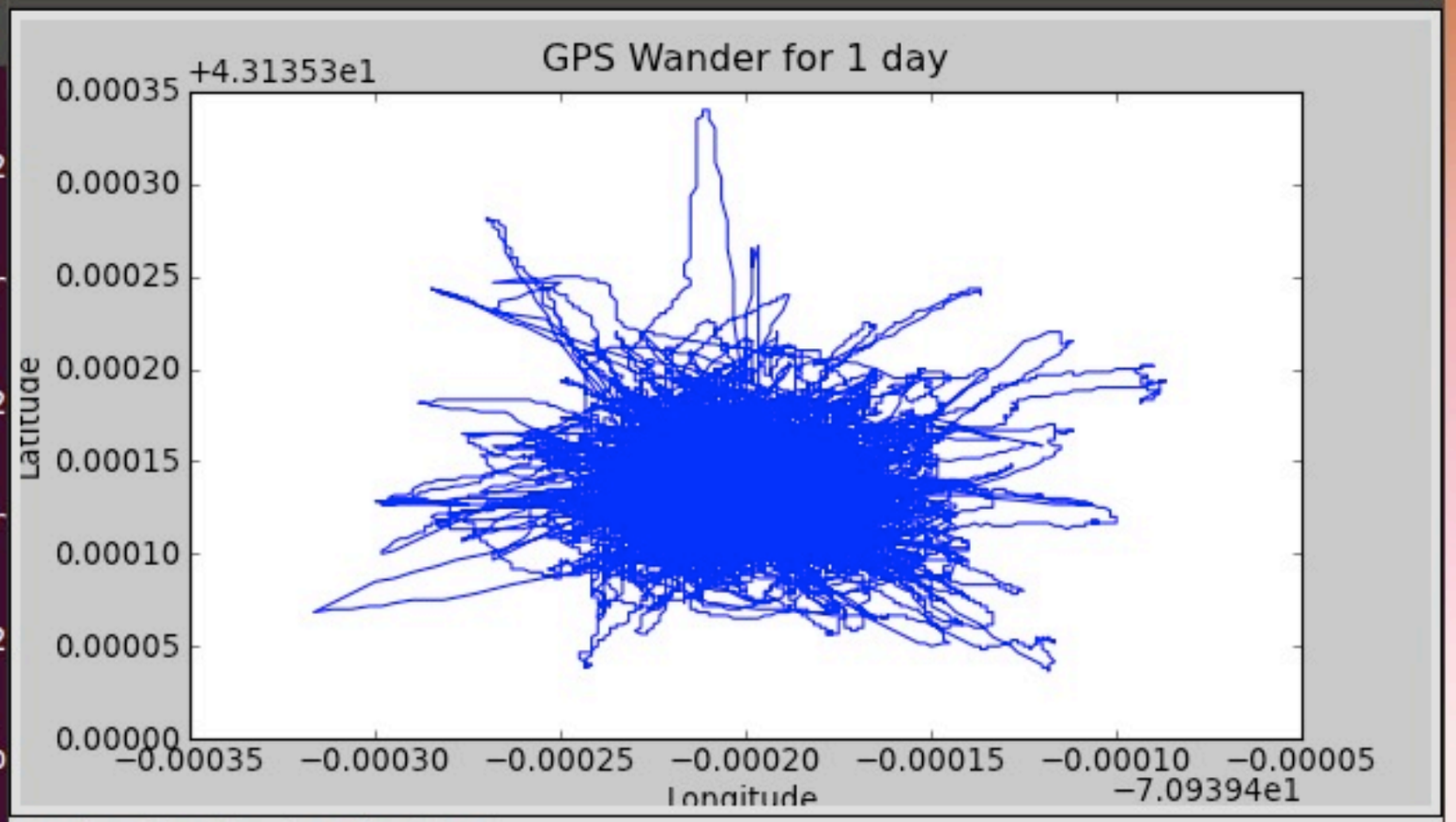
File Edit View Search Terminal

```
In [27]: plot(x)
Out[27]: [<matplotlib.lines.Line2

In [28]: figure(2)
Out[28]: <matplotlib.figure.Figur

In [29]: plot(y)
Out[29]: [<matplotlib.lines.Line2

In [30]: figure(3)
Out[30]: <matplotlib.figure.Figur

In [31]: plot(x,y)
Out[31]: [<matplotlib.lines.Line2

In [32]: title('GPS Wander for 1
Out[32]: <matplotlib.text.Text ob

In [33]: xlabel('Longitude')
Out[33]: <matplotlib.text.Text ob

In [34]: ylabel('Latitude')
Out[34]: <matplotlib.text.Text object at 0xbf2e42c>

In [35]:
```

Figure 3



40000 50000 60000 70000 80000 90000

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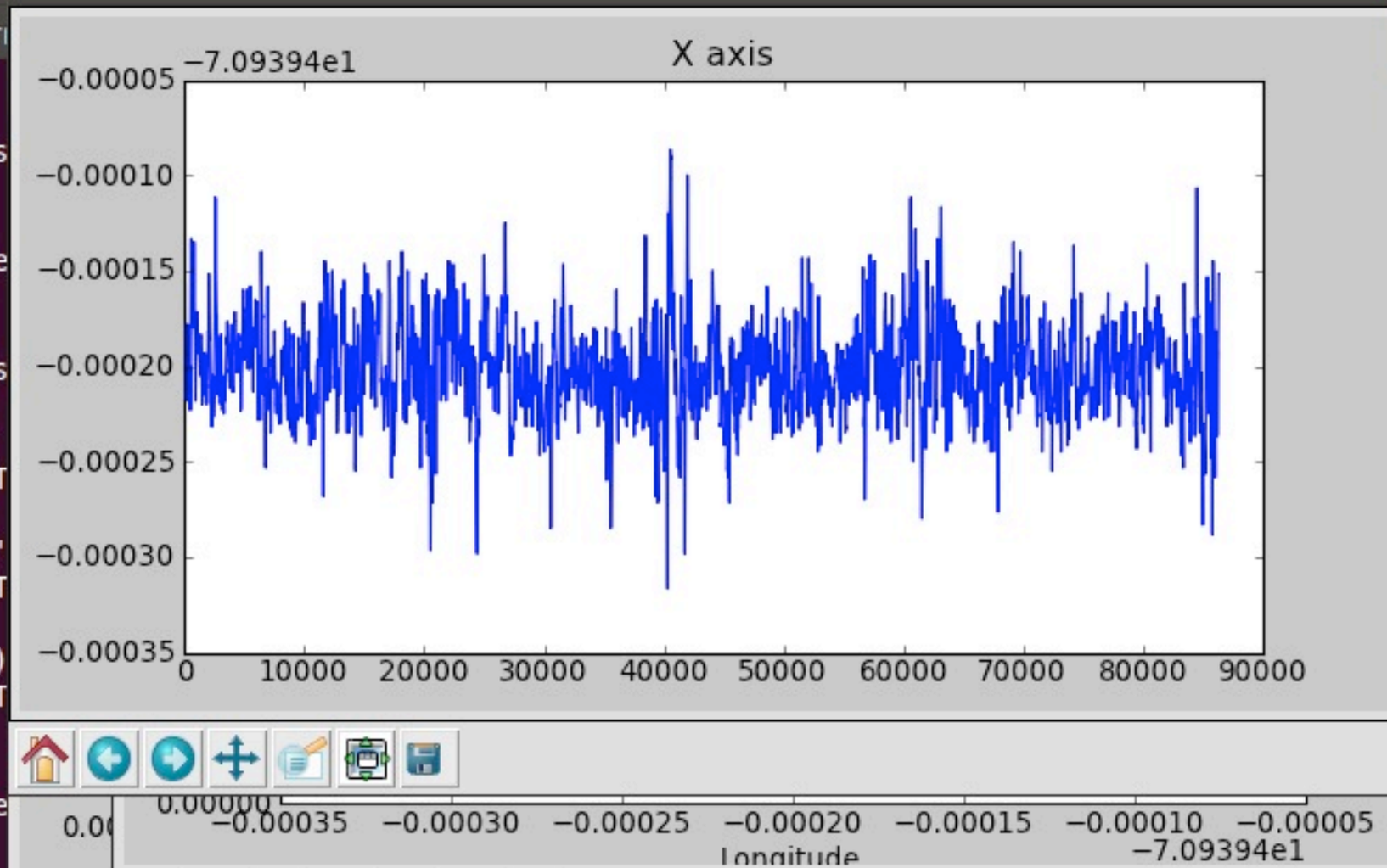
```
In [29]: plot(y)
Out[29]: [<matplotlib.lines

In [30]: figure(3)
Out[30]: <matplotlib.figure

In [31]: plot(x,y)
Out[31]: [<matplotlib.lines

In [32]: title('GPS Wander
Out[32]: <matplotlib.text.T

In [33]: xlabel('Longitude'
Out[33]: <matplotlib.text.T

In [34]: ylabel('Latitude')
Out[34]: <matplotlib.text.T

In [35]: figure(1)
Out[35]: <matplotlib.figure

In [36]: title('X axis')
Out[36]: <matplotlib.text.T

In [37]:
```

Figure 1



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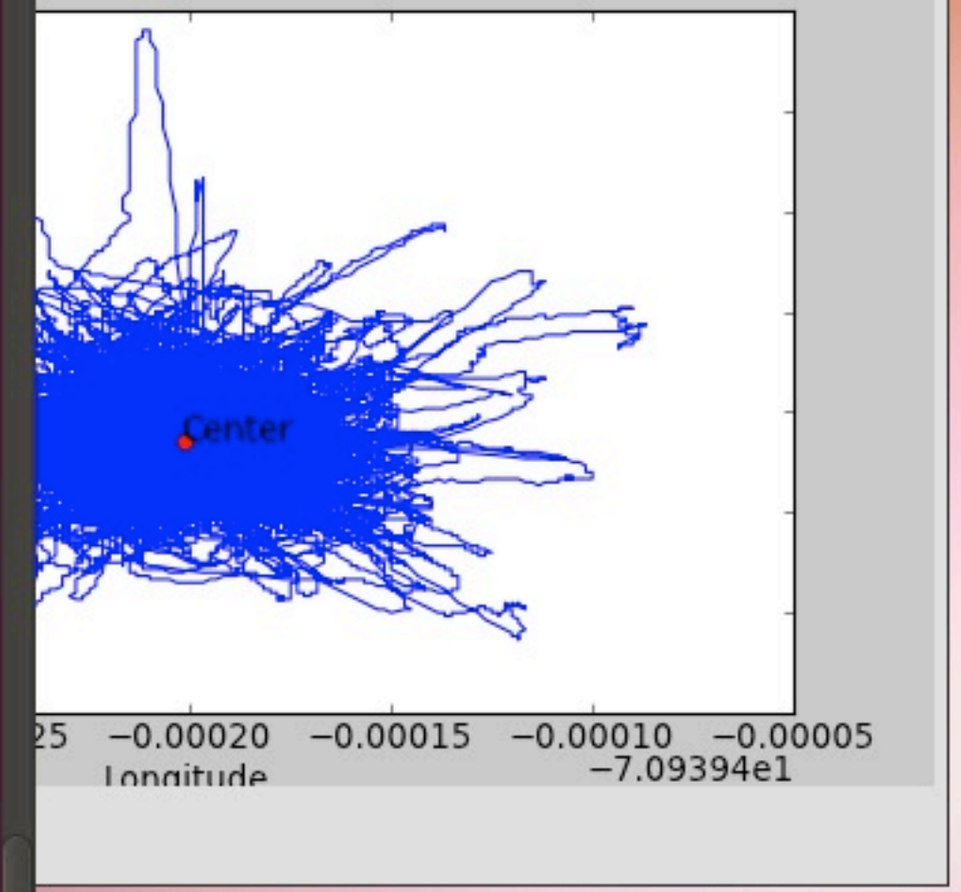
```
In [31]: plot(x,y)
Out[31]: [<matplotlib.lines.Line2D object at 0xc247d0c>]

In [32]: title('GPS Wander for 1 day')
Out[32]: <matplotlib.text.Text object at 0xbf3b60c>

In [33]: xlabel('Longitude')
Out[33]: <matplotlib.text.Text object at 0xbf296cc>

In [34]: ylabel('Latitude')
Out[34]: <matplotlib.text.Text object at 0xbf2e42c>

In [35]: figure(1)
Out[35]: <matplotlib.figure.Figure object at 0xae8e86c>

In [36]: title('X axis')
Out[36]: <matplotlib.text.Text object at 0xaefac0c>

In [37]: annotate('Center', xy = (average(x), average(y)))
Out[37]: <matplotlib.text.Annotation object at 0xbba906c>

In [38]: plot(average(x),average(y), 'ro')
Out[38]: [<matplotlib.lines.Line2D object at 0xae8f72c>]

In [39]:
```



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```
In [37]: annotate('Center', xy = (average(x), average(y)))
Out[37]: <matplotlib.text.Annotation object at 0xbba906c>

In [38]: plot(average(x),average(y), 'ro')
Out[38]: [<matplotlib.lines.Line2D object at 0xae8f72c>]

In [39]: import pyproj

In [40]: pyproj.Geod?
Type:           type
Base Class:     <type 'type'>
String Form:    <class 'pyproj.Geod'>
Namespace:      Interactive
File:           /usr/lib/pymodules/python2.7/pyproj/__init__.py
Docstring:
    performs forward and inverse geodetic, or Great Circle,
    computations.  The forward computation (using the 'fwd' method)
    involves determining latitude, longitude and back azimuth of a
    terminus point given the latitude and longitude of an initial
    point, plus azimuth and distance. The inverse computation (using
    the 'inv' method) involves determining the forward and back
    azimuths and distance given the latitudes and longitudes of an
    initial and terminus point.


In [41]: geod = pyproj.Geod(ellps='WGS84'
```

00005

3.1354

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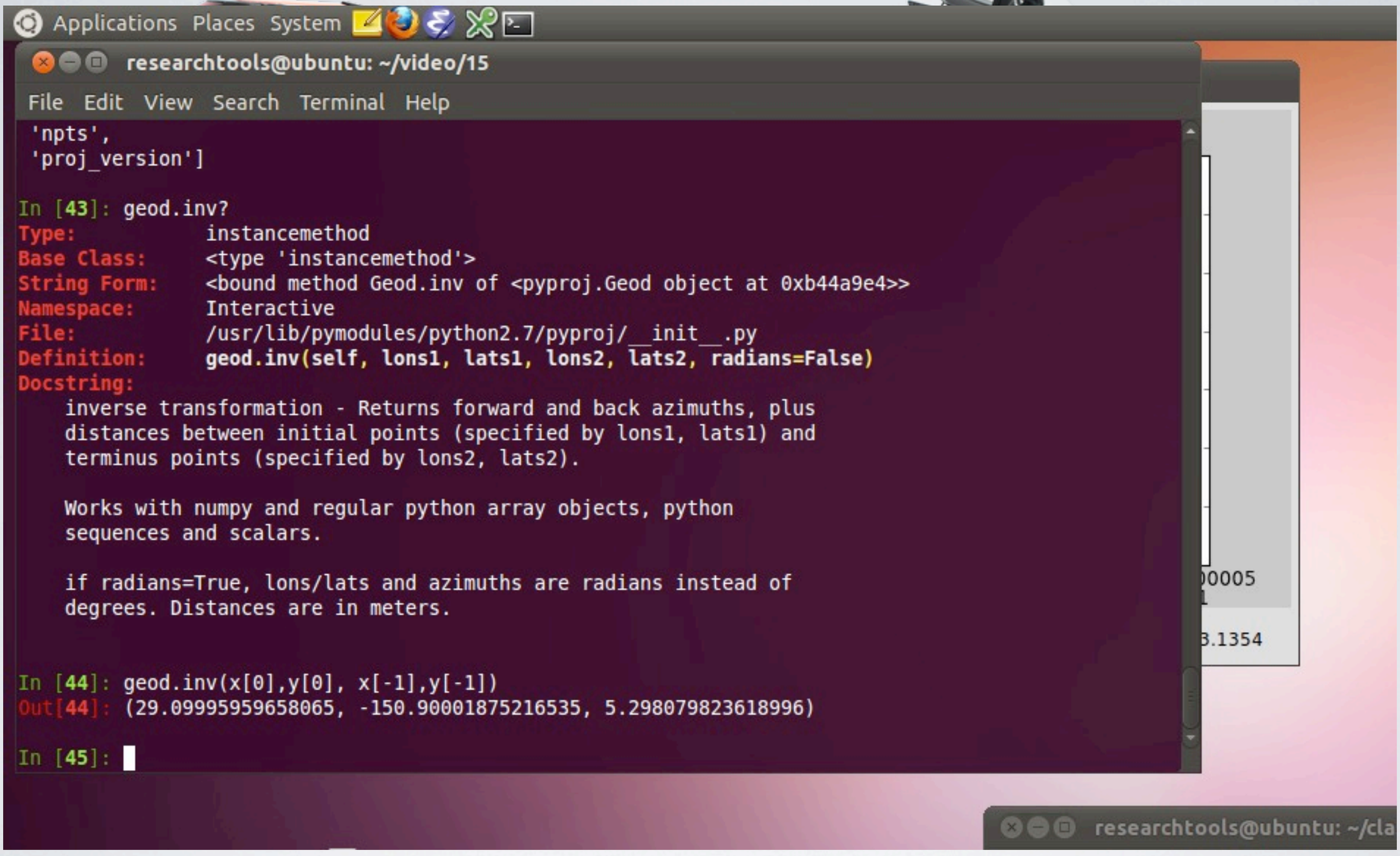
Applications Places System
researchtools@ubuntu: ~/video/15
File Edit View Search Terminal Help
'npts',
'proj_version']
In [43]: geod.inv?
Type: instancemethod
Base Class: <type 'instancemethod'>
String Form: <bound method Geod.inv of <pyproj.Geod object at 0xb44a9e4>>
Namespace: Interactive
File: /usr/lib/pymodules/python2.7/pyproj/__init__.py
Definition: geod.inv(self, lons1, lats1, lons2, lats2, radians=False)
Docstring:
inverse transformation - Returns forward and back azimuths, plus
distances between initial points (specified by lons1, lats1) and
terminus points (specified by lons2, lats2).
Works with numpy and regular python array objects, python
sequences and scalars.
if radians=True, lons/lats and azimuths are radians instead of
degrees. Distances are in meters.
In [44]: geod.inv(x[0],y[0], x[-1],y[-1])
Out[44]: (29.09995959658065, -150.90001875216535, 5.298079823618996)
In [45]:
researchtools@ubuntu: ~/cla

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```
22: max(x)
23: max(x)-min(x)
24: plot(x)
25: plot(y)
26: cla()
27: plot(x)
28: figure(2)
29: plot(y)
30: figure(3)
31: plot(x,y)
32: title('GPS Wander for 1
33: xlabel('Longitude')
34: ylabel('Latitude')
35: figure(1)
36: title('X axis')
37: annotate('Center', xy =
38: plot(average(x),average(
39: import pyproj
40: #?pyproj.Geod
41: geod = pyproj.Geod(ellps
42: dir(geod)
43: #?geod.inv
44: geod.inv(x[0],y[0], x[-1
45: _ip.magic("history ")

In [46]:
```

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File Edit Options Buffers Tools IM-Python Python YASnippet Help

```
import pyproj
import numpy as np

def wander_list(filename):
    geod = pyproj.Geod(ellps='WGS84')
```

-U:**- wander.py All L7 (Python yas)----------

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```
7 : _ip.system("bzcat 2011-1
8 : data[0]
9 : _ip.magic("whos ")
10: del(data)
11: _ip.magic("whos ")
12: #?loadtxt
13: x,y,z,quality,satellite,
14: type(x)
15: len(x)
16: x[0]
17: x
18: y
19: average(x)
20: average(y)
21: min(x)
22: max(x)
23: max(x)-min(x)
24: plot(x)
25: plot(y)
26: cla()
27: plot(x)
28: figure(2)
29: plot(y)
30: figure(3)
31: plot(x,y)
32: title('GPS Wander for 1
```

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File Edit Options Buffers Tools IM-Python Python YASnippet Help

```
import pyproj
import numpy as np

def wander_list(filename):
    geod = pyproj.Geod(ellps='WGS84')
    x,y,z,quality,satellite,hdop = loadtxt('2011-10-11.gga.dat.bz2',unpack=True)
```

-U:**- **wander.py** All L9 (Python yas)----------

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Applications Places System

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```
25: plot(y)
26: cla()
27: plot(x)
28: figure(2)
29: plot(y)
30: figure(3)
31: plot(x,y)
32: title('GPS Wander for 1
33: xlabel('Longitude')
34: ylabel('Latitude')
35: figure(1)
36: title('X axis')
37: annotate('Center', xy =
38: plot(average(x),average(
39: import pyproj
40: #?pyproj.Geod
41: geod = pyproj.Geod(ellps
42: dir(geod)
43: #?geod.inv
44: geod.inv(x[0],y[0], x[-1
45: _ip.magic("history ")

In [46]: geod.inv(x[0],y[0],
Out[46]: (29.09995959658065,

In [47]:
```

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File Edit Options Buffers Tools IM-Python Python YASnippet Help

```
import pyproj
import numpy as np

def wander_list(filename):
    geod = pyproj.Geod(ellps='WGS84')
    x,y,z,quality,satellite,hdop = loadtxt('2011-10-11.gga.dat.bz2',unpack=True)

    x_ave = average(x)
    y_ave = average(y)

    m = [ ]
    for i in range(len(x)):
        results = geod.inv(x_ave,y_ave, x[i], y[i])
        m.append(results[2])
```

-U:**- wander.py All L16 (Python yas)----------

Closes block: ...for i in range(len(x)):

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Applications Places System

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```
 'np',
 'pyproj',
 'wander_list']

In [49]: #wander.wander_list

In [50]: reload wander
-------> reload(wander)
Out[50]: <module 'wander' fr

In [51]: distances = wander.
---------------------------
NameError

/home/researchtools/video/15

/home/researchtools/video/15
      5 def wander_list(file
      6     geod = pyproj.Ge
----> 7     x,y,z,quality,sa
      8
      9     x_ave = average(

NameError: global name 'load

In [52]:
```

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File Edit Options Buffers Tools IM-Python Python YASnippet Help

```
import pyproj
import numpy as np

def wander_list(filename):
    geod = pyproj.Geod(ellps='WGS84')
    x,y,z,quality,satellite,hdop = loadtxt(filename,unpack=True)

    x_ave = average(x)
    y_ave = average(y)

    m = [ ]
    for i in range(len(x)):
        results = geod.inv(x_ave,y_ave, x[i], y[i])
        m.append(results[2])

    return m
```

-U:--- wander.py All L7 (Python yas)----------

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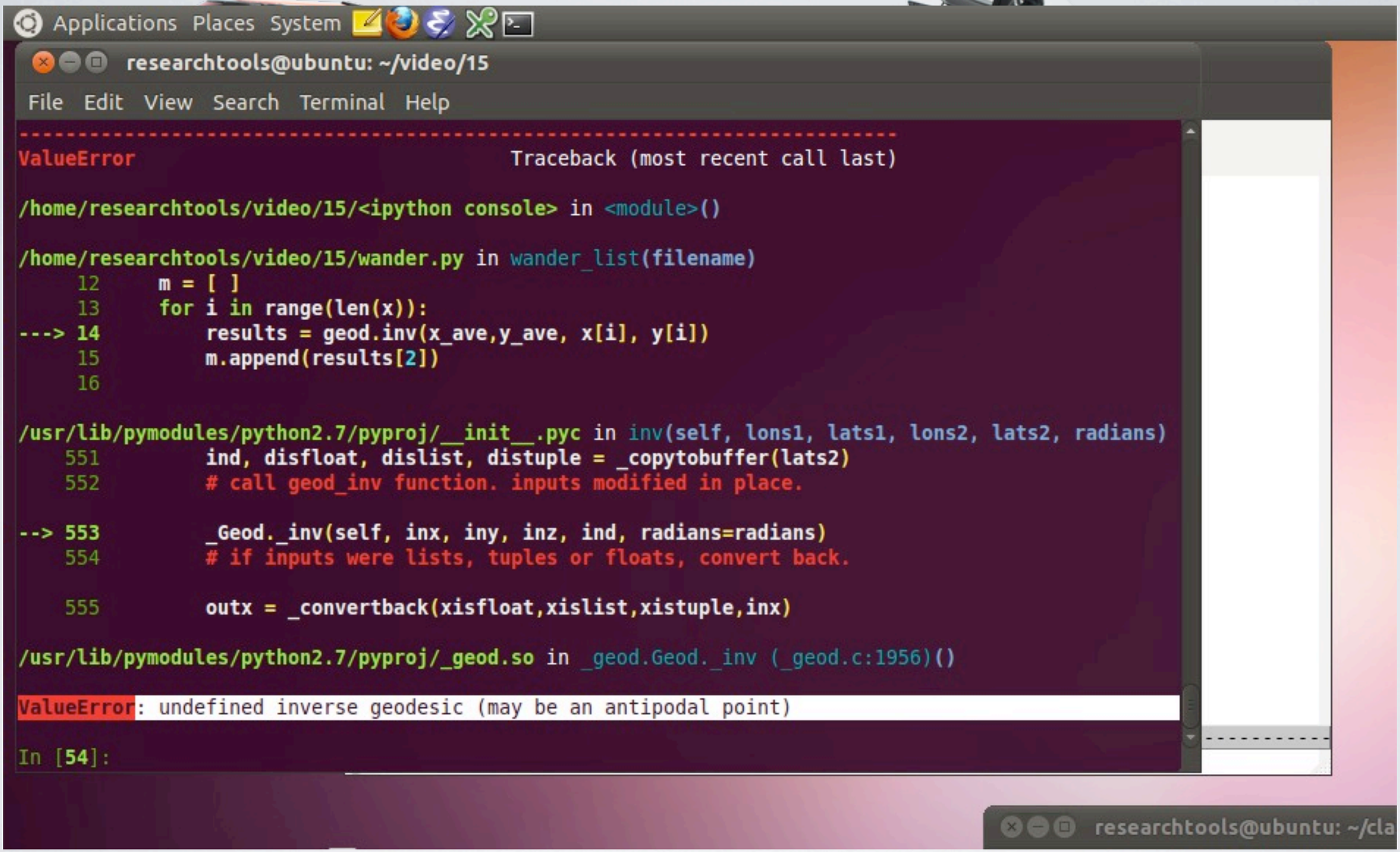
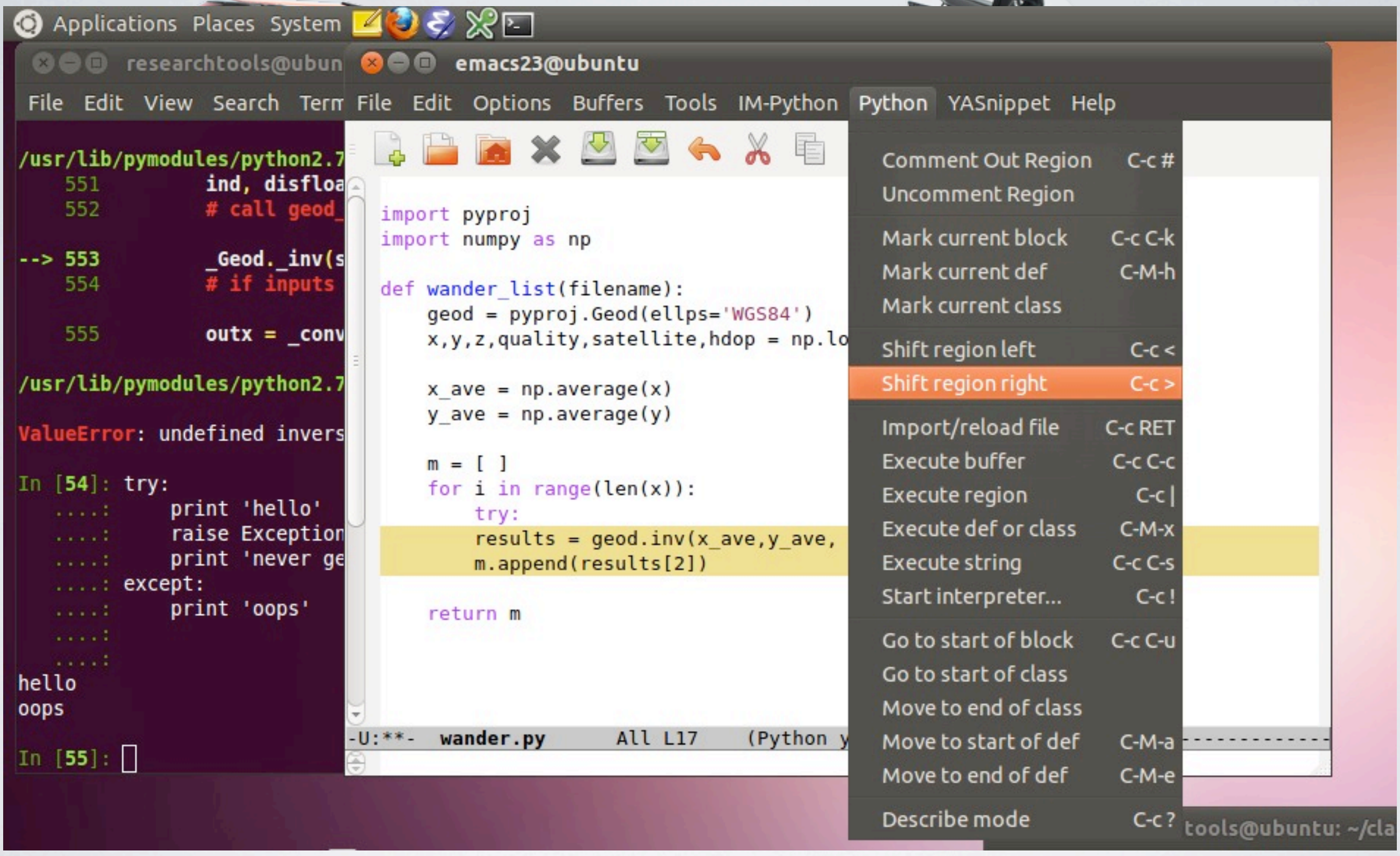

Applications Places System
researchtools@ubuntu: ~/video/15
File Edit View Search Terminal Help
ValueError Traceback (most recent call last)
/home/researchtools/video/15/<ipython console> in <module>()
/home/researchtools/video/15/wander.py in wander_list(filename)
12 m = [ ]
13 for i in range(len(x)):
---> 14 results = geod.inv(x_ave,y_ave, x[i], y[i])
15 m.append(results[2])
16
/usr/lib/pymodules/python2.7/pyproj/__init__.pyc in inv(self, lons1, lats1, lons2, lats2, radians)
551 ind, disfloat, dislist, distuple = _copytobuffer(lats2)
552 # call geod_inv function. inputs modified in place.
--> 553 _Geod._inv(self, inx, iny, inz, ind, radians=radians)
554 # if inputs were lists, tuples or floats, convert back.
555 outx = _convertback(xisfloat,xislist,xistuple,inx)
/usr/lib/pymodules/python2.7/pyproj/_geod.so in _geod.Geod._inv (_geod.c:1956)()
ValueError: undefined inverse geodesic (may be an antipodal point)
In [54]:
researchtools@ubuntu: ~/cla


Applications Places System
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File Edit View Search Term
/usr/lib/pymodules/python2.7
551 ind, disfloa
552 # call geod_
--> 553 _Geod._inv(s
554 # if inputs
555 outx = _conv
/usr/lib/pymodules/python2.7
ValueError: undefined invers
In [54]: try:
....: print 'hello'
....: raise Exception
....: print 'never ge
....: except:
....: print 'oops'
....:
....:
hello
oops
In [55]:
emacs23@ubuntu
File Edit Options Buffers Tools IM-Python Python YASnippet Help
import pyproj
import numpy as np
def wander_list(filename):
geod = pyproj.Geod(ellps='WGS84')
x,y,z,quality,satellite,hdop = np.lo
x_ave = np.average(x)
y_ave = np.average(y)
m = [ ]
for i in range(len(x)):
try:
results = geod.inv(x_ave,y_ave,
m.append(results[2])
return m
-U:**- wander.py All L17 (Python y
Comment Out Region C-c #
Uncomment Region
Mark current block C-c C-k
Mark current def C-M-h
Mark current class
Shift region left C-c <
Shift region right C-c >
Import/reload file C-c RET
Execute buffer C-c C-c
Execute region C-c |
Execute def or class C-M-x
Execute string C-c C-s
Start interpreter... C-c !
Go to start of block C-c C-u
Go to start of class
Move to end of class
Move to start of def C-M-a
Move to end of def C-M-e
Describe mode C-c ?
tools@ubuntu: ~/cla

Applications Places System

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```
/usr/lib/pymodules/python2.7
    551          ind, disfloa
    552          # call geod_

--> 553          _Geod._inv(s
    554          # if inputs

    555          outx = _conv

/usr/lib/pymodules/python2.7

ValueError: undefined invers

In [54]: try:
   ....:     print 'hello'
   ....:     raise Exception
   ....:     print 'never ge
   ....: except:
   ....:     print 'oops'
   ....:
   ....:
hello
oops

In [55]:
```

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File Edit Options Buffers Tools IM-Python Python YASnippet Help

```
import pyproj
import numpy as np

def wander_list(filename):
    geod = pyproj.Geod(ellps='WGS84')
    x,y,z,quality,satellite,hdop = np.loadtxt(filename,unpack=True)

    x_ave = np.average(x)
    y_ave = np.average(y)

    m = [ ]
    for i in range(len(x)):
        try:
            results = geod.inv(x_ave,y_ave, x[i], y[i])
            m.append(results[2])
        except:
            m.append(0)

    return m
```

-U:**- wander.py   All L18   (Python yas)----------

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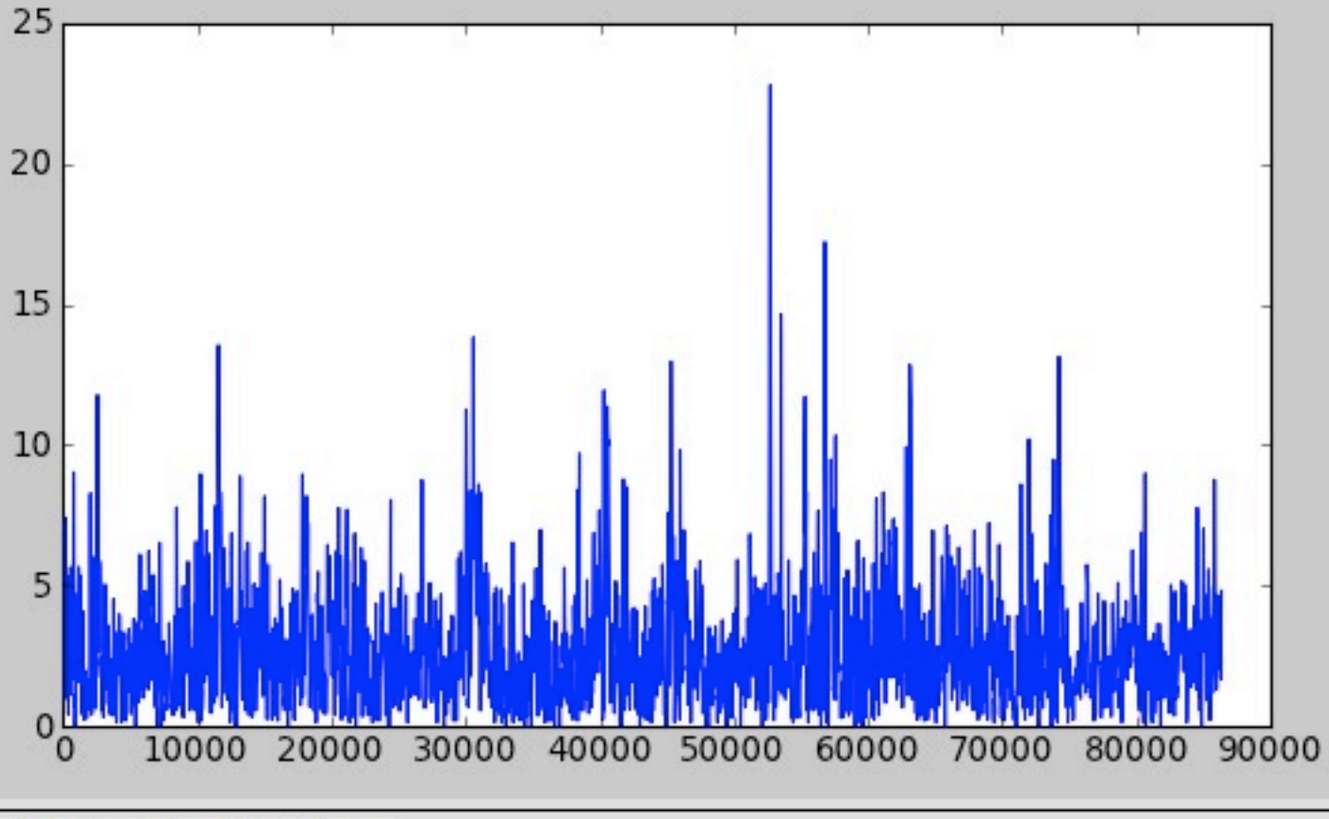
```
   ....:
   ....:
hello
oops

In [55]: reload wander
-------> reload(wander)
Out[55]: <module 'wander' from '

In [56]: distances = wander.wanc

In [57]: cla()

In [58]: plot(dist
dist                    dist_poir

In [58]: plot(distan
distances               distances

In [58]: plot(distances)
Out[58]: [<matplotlib.lines.Line2D object at 0xbb524ac>]

In [59]:
```

Figure 3



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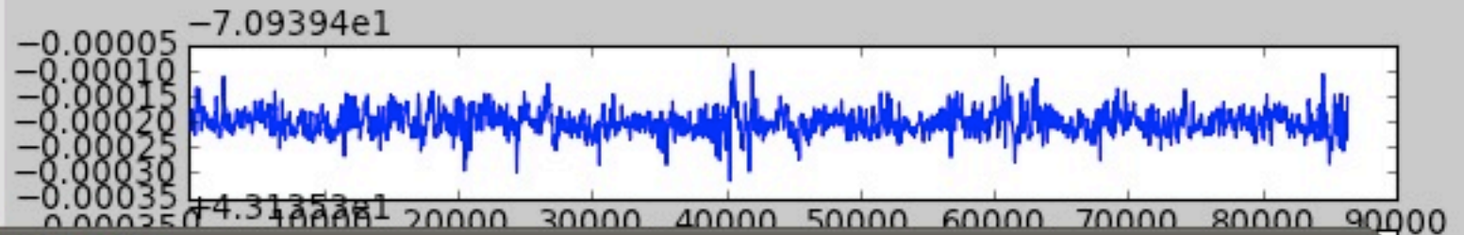
Applications Places System

Figure 3



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File Edit View Search Terminal Help

```
Out[59]: 2.7593596863410674

In [60]: cla()

In [61]: subplot (411)
Out[61]: <matplotlib.axes.AxesSubplot object at 0xbb4eeec>

In [62]: plot(x)
Out[62]: [<matplotlib.lines.Line2D object at 0xc26358c>]

In [63]: subplot (412)
Out[63]: <matplotlib.axes.AxesSubplot object at 0xcf5fd0c>

In [64]: plot(y)
Out[64]: [<matplotlib.lines.Line2D object at 0xc41e1cc>]

In [65]: plo
```

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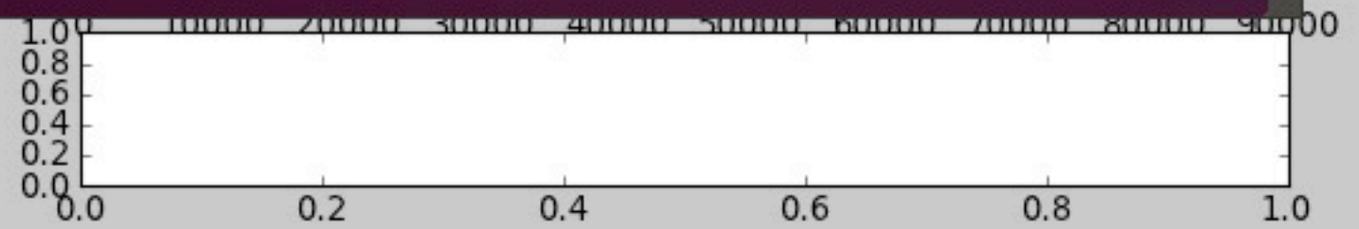
researchtools@ubuntu: ~/video/15

File Edit View Search Terminal Help

```
String Form:   <function hist at 0xae6f6f4>
Namespace:        Interactive
File:             /usr/lib/pymodules/python2.7/matplotlib/pyplot.py
Definition:       hist(x, bins=10, range=None, normed=False, weights=None, cumulative=False, bottom
=None, histtype='bar', align='mid', orientation='vertical', rwidth=None, log=False, hold=None, **kw
args)
Docstring:
    call signature::

      hist(x, bins=10, range=None, normed=False, cumulative=False,
           bottom=None, histtype='bar', align='mid',
           orientation='vertical', rwidth=None, log=False, **kwargs)

    Compute and draw the histogram of *x*. The return value is a
    tuple (*n*, *bins*, *patches*) or ([*n0*, *n1*, ...], *bins*,
    [*patches0*, *patches1*,...]) if the input contains multiple
:
```



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researchtools@ubuntu: ~/video/15

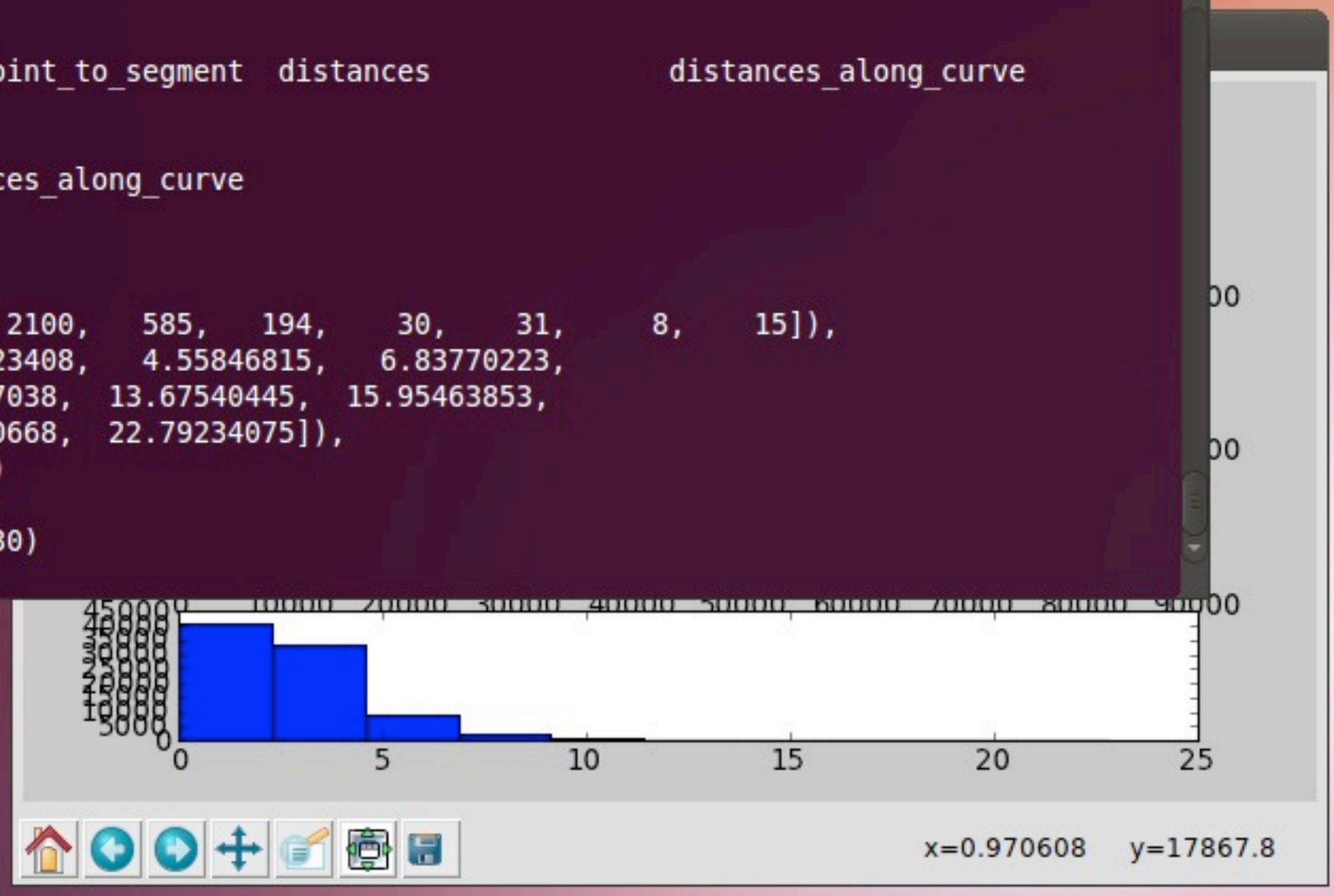
File Edit View Search Terminal Help

```
In [70]: hist(dist
dist                    dist_point_to_segment  distances             distances_along_curve

In [70]: hist(distan
distances               distances_along_curve

In [70]: hist(distances)
Out[70]:
(array([40897, 33576,  8894,  2100,   585,   194,    30,    31,     8,    15]),
 array([  0.        ,   2.27923408,   4.55846815,   6.83770223,
         9.1169363 ,  11.39617038,  13.67540445,  15.95463853,
        18.2338726 ,  20.51310668,  22.79234075]),
 <a list of 10 Patch objects>)

In [71]: hist(distances,bins=30)
```



x=0.970608 y=17867.8

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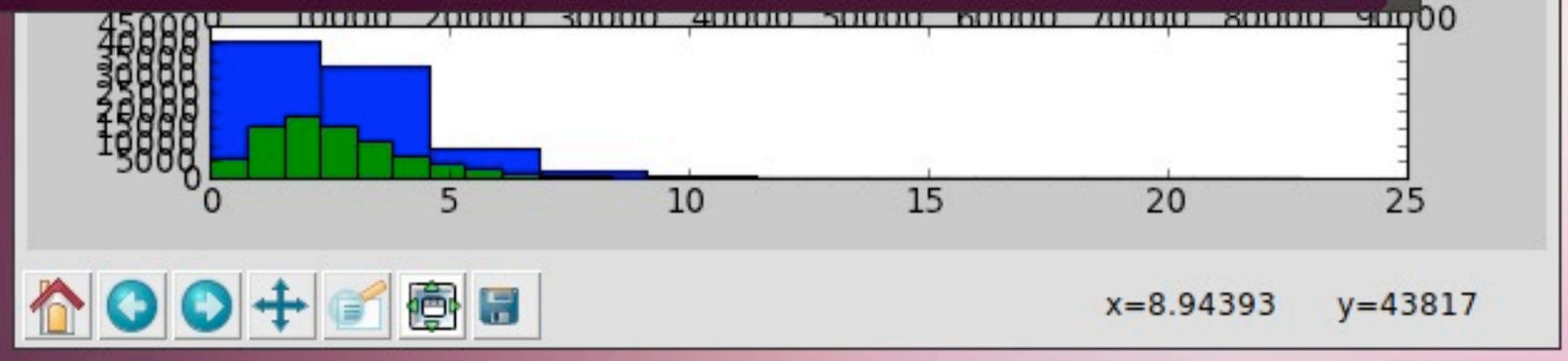
File Edit View Search Terminal Help

```
In [71]: hist(distances,bins=30)
Out[71]:
(array([ 6241, 15809, 18847, 15954, 10921,  6701,  4469,  2907,  1518,
         1013,   649,   438,   187,   175,   223,    92,    60,    42,
           10,    12,     8,    13,    16,     2,     2,     2,     4,
            3,     4,     8]),
 array([  0.        ,   0.75974469,   1.51948938,   2.27923408,
          3.03897877,   3.79872346,   4.55846815,   5.31821284,
          6.07795753,   6.83770223,   7.59744692,   8.35719161,
          9.1169363 ,   9.87668099,  10.63642568,  11.39617038,
         12.15591507,  12.91565976,  13.67540445,  14.43514914,
         15.19489383,  15.95463853,  16.71438322,  17.47412791,
         18.2338726 ,  18.99361729,  19.75336198,  20.51310668,
         21.27285137,  22.03259606,  22.79234075]),
 <a list of 30 Patch objects>)

In [72]:
```



x=8.94393 y=43817

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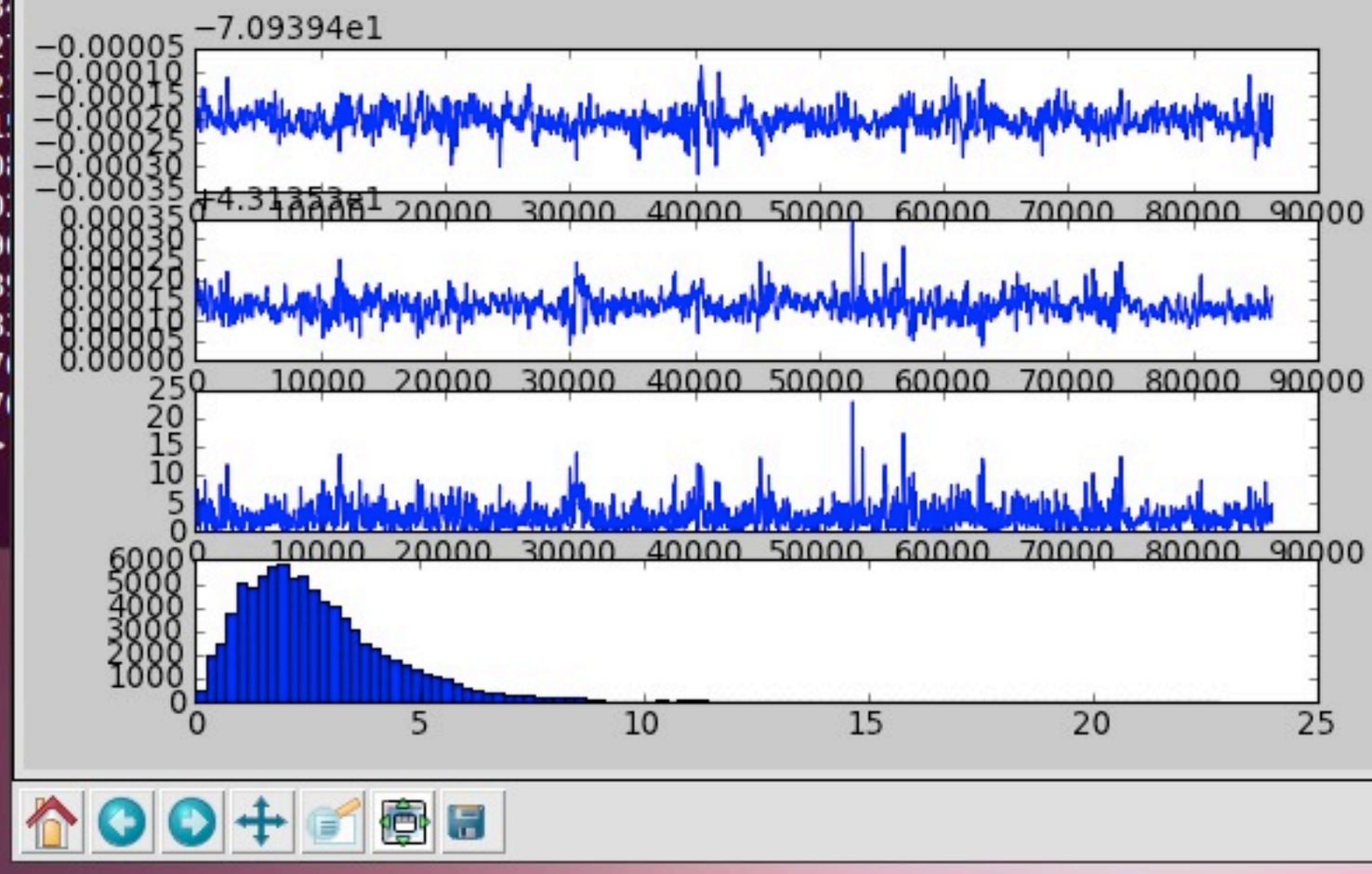
```
        10.02862993,  10.25655334,  10.48447675,  10.71240015,
        10.94032356,  11.16824
        11.85201719,  12.07994
        12.76371082,  12.99163
        13.67540445,  13.90332
        14.58709808,  14.81502
        15.49879171,  15.72671
        16.41048534,  16.63840
        17.32217897,  17.55010
        18.2338726 ,  18.46179
        19.14556623,  19.37348
        20.05725986,  20.28518
        20.96895349,  21.19687
        21.88064712,  22.10857
<a list of 100 Patch objects>

In [75]:
```

Figure 3



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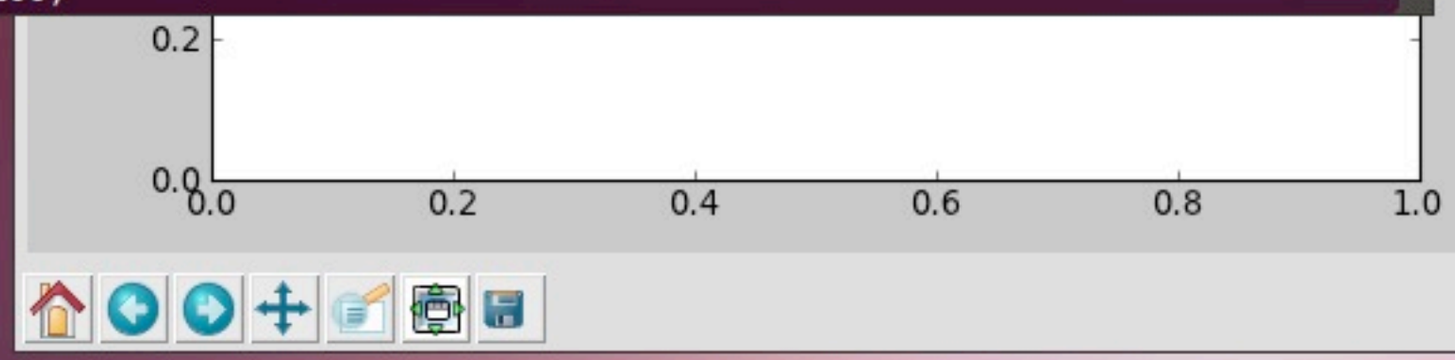
File Edit View Search Terminal Help

```
        12.76371082,  12.99163423,  13.21955764,  13.44748104,
        13.67540445,  13.90332786,  14.13125127,  14.35917467,
        14.58709808,  14.81502149,  15.0429449 ,  15.2708683 ,
        15.49879171,  15.72671512,  15.95463853,  16.18256193,
        16.41048534,  16.63840875,  16.86633216,  17.09425556,
        17.32217897,  17.55010238,  17.77802579,  18.00594919,
        18.2338726 ,  18.46179601,  18.68971942,  18.91764282,
        19.14556623,  19.37348964,  19.60141305,  19.82933645,
        20.05725986,  20.28518327,  20.51310668,  20.74103008,
        20.96895349,  21.1968769 ,  21.42480031,  21.65272371,
        21.88064712,  22.10857053,  22.33649394,  22.56441734,  22.79234075]),
 <a list of 100 Patch objects>)

In [75]: subplot(111)
Out[75]: <matplotlib.axes.AxesSubplot object at 0xc4ea7ac>

In [76]: hist(distances,bins=100)
```



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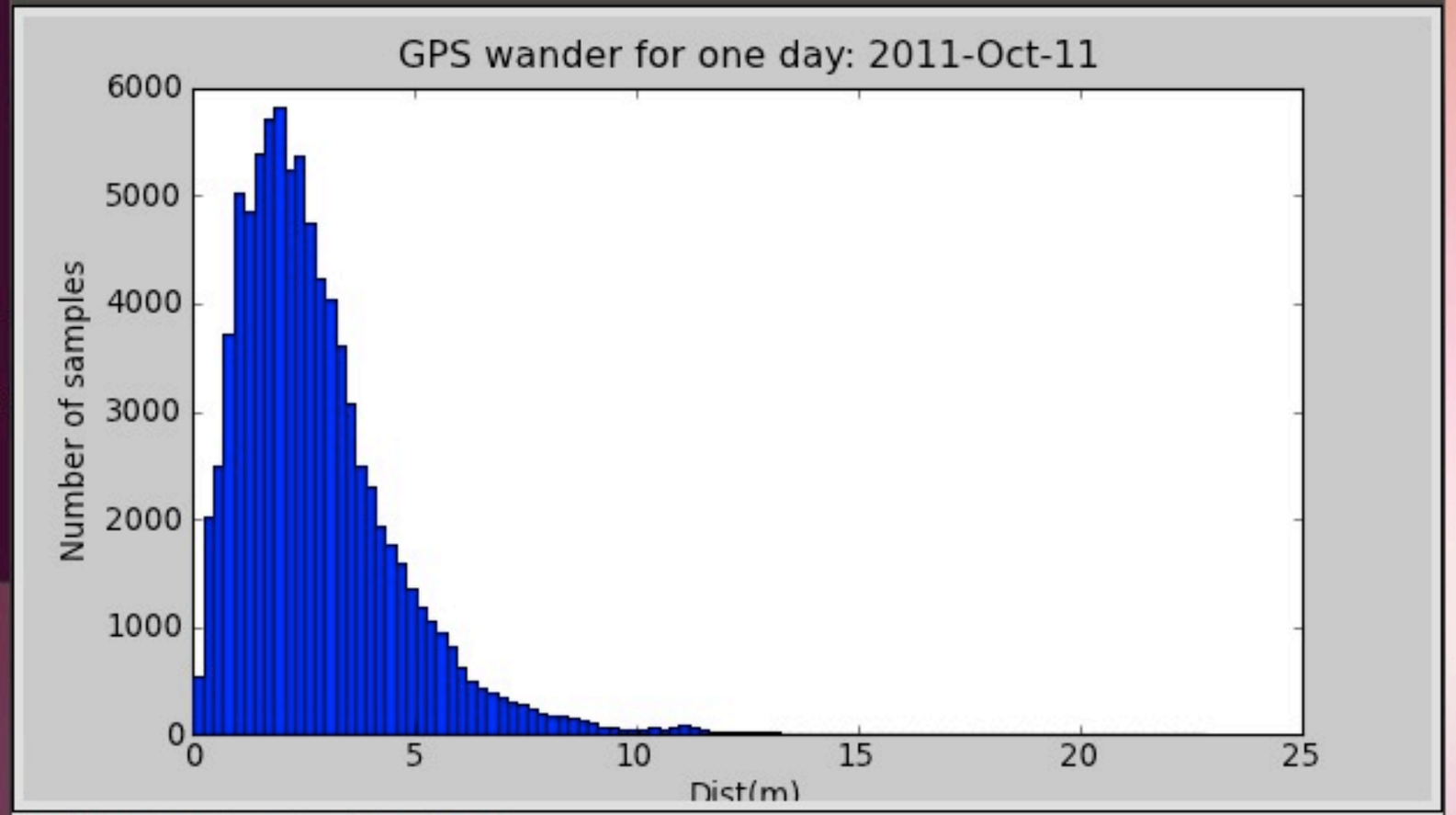
File Edit View Search Terminal Help

```
68: subplot (414)
69: #?hist
70: hist(distances)
71: hist(distances,bins=30)
72: hist(distances,bins=300)
73: cla()
74: hist(distances,bins=100)
75: subplot(111)
76: hist(distances, bins=100)
77: xlabel('Dist(m)')
78: ylabel('Number of samples'
79:
title('GPS wander for one day:
)
80: _ip.magic("history ")

In [81]:
```

Figure 3



researchtools@ubuntu: ~/cla