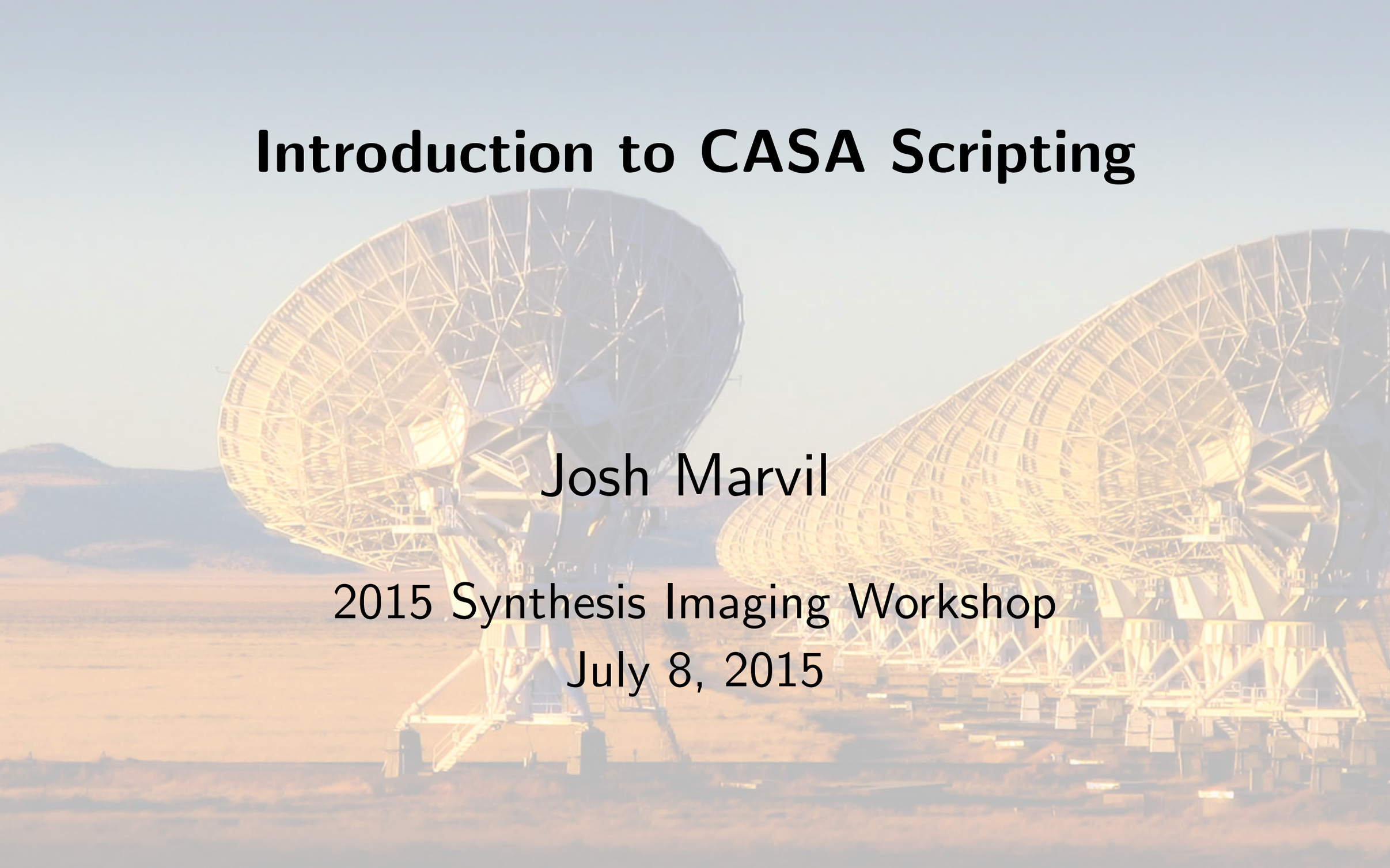


Introduction to CASA Scripting

Josh Marvil

2015 Synthesis Imaging Workshop

July 8, 2015

Outline of this Talk

The CASA Environment
Writing and Running Scripts
Basic Python in Scripts
Writing CASA Tasks
Examples

The CASA Environment

Python 2.7.9 - Standard Library

iPython - Interactive Shell

Additional Python Modules

CASA Tasks

CASA Toolkit

CASA GUI Applications

— plotms, viewer, browser, logger —

The CASA Environment

- Additional Python Modules
  - Numpy
  - Scipy
  - Matplotlib
  - etc...

The CASA Environment

- CASA Tasks: `tasklist()`, `taskhelp()`
  - Import/Export
  - Information
  - Editing
  - Manipulation
  - Calibration
  - Modeling
  - Imaging
  - Analysis
  - Visualization
  - Simulation
  - Single Dish
  - Utility

The CASA Environment

- CASA Tools: `toolhelp()`
  - `at:` Atmosphere
  - `cl:` Components
  - `ia:` Image Analysis
  - `im:` Imaging
  - `lm:` Linear Mosaic
  - `me:` Measures
  - `ms:` Measurement Set
  - `qa:` Quantities
  - `rg:` Regions
  - `tb:` Tables
  - `vp:` Voltage Pattern
  - `pl:` Pylab

A CASA Script

- Example script: G55.7 tutorial [casaguides.nrao.edu]

```
setjy(vis='G55.7+3.4_10s.ms', field='0542*',
          spw='2~3,5~6', modimage='3C147_L.im')

gaincal(vis='G55.6+3.4_10s.ms', caltable='G55.6+3.4_10s.G0',
     spw='2~3,5~6',  solint='int', calmode='p', field='0542*')
```

- Write your script with a text editor
- Name your script almost anything you want, *e.g.*, myScript.py

A CASA Script

- Run your script in CASA:

```
CASA>> execfile('myScript.py')
```

- Run your script from the terminal:

```
bash$ casapy -c myScript.py
```

A CASA Script

- Run your script remotely:

```
bash$ nohup casapy -c myScript.py &
```

- Or using Screen

```
bash$ screen
bash$ casapy -c myScript.py    < CTRL-A D >
```

- Or using a VNC server

A CASA Script

- Another example: listobs.last

```
taskname              = "listobs"
vis                   =  "G55_split1.ms"
verbose               =  True
listfile              =  "G55_split1.ms.listobs.txt"

#listobs(vis="G55_split1.ms",verbose=True,
        listfile="G55_split1.ms.listobs.txt")
```

A CASA Script

- Function call vs. command line style:

```
setjy(vis='G55.7+3.4_10s.ms', field='0542*',
          spw='2~3,5~6', modimage='3C147_L.im')
```

```
default( 'setjy' )
vis= 'G55.7+3.4_10s.ms'
field = '0542*'
spw = '2~3,5~6'
modimage = '3C147_L.im'
setjy()
```

Basic Python in Scripts

- Common numerical types

```
x=1          x=1L          x=1.0          x=1e0          x = 1 + 0j
```

- Example strings

```
x=''          x='1'          x='one'
```

- Example lists

```
x=[]          x=[1]          x=[ 1.0, 2, '3' ]
```

Basic Python in Scripts

- Index selection

```
x = 'abc'                    x = [ 'a', 'b', 'c' ]

a = x[ 0 ]          b = x[ 1:2 ]          c = x[ -1 ]
ab = x[ :2 ]        bc = [ 1: ]           cba = [ ::-1 ]
```

Basic Python in Scripts

- Adding strings and lists → concatenation

```
ab = 'a' + 'b'                    x = [ 1, 2 ] + [ 3, 4 ]
ab = 'ab'                         x = [ 1, 2, 3, 4 ]
```

- Multiplying strings and lists → replication

```
ab2 = 2 * 'ab'                    x2 = 2 * [ 1, 2 ]
ab2 = 'abab'                      x2 = [ 1, 2, 1, 2 ]
```

Basic Python in Scripts

- Example script: G55.7 tutorial

```
setjy(vis='G55.7+3.4_10s.ms', field='0542*',
          spw='2~3,5~6', modimage='3C147_L.im')

gaincal(vis='G55.6+3.4_10s.ms', caltable='G55.6+3.4_10s.G0',
     spw='2~3,5~6',  solint='int', calmode='p', field='0542*')
```

Basic Python in Scripts

- Generalizing the script with Python strings:

```
vis = 'G55.7+3.4_10s.ms'
field = '0542*'
spw = '2~3,5~6'

setjy(vis=vis, field=field, spw=spw,  modimage='3C147_L.im')

gaincal(vis=vis, caltable=vis[ :-2 ]+'gain', field=field,
        spw=spw,  solint='int', calmode='p')
```

Basic Python in Scripts

- Conditional statements and logical operators

```
doThis = True
if doThis:
    print 'this will happen'
```

```
x = 3.0

if (x == '3'): print 'this will not happen'
elif (x > 5.0): print 'this will not happen either'
else: print 'this will happen'
```

Basic Python in Scripts

- Objects with length can be iterated

```
x = 'abc'

for item in x:  print item
```

- *E.g.*, clean multiple fields

```
allFields = [ '0', '3', '7' ]

for field in allFields:
    clean( field = field ...
```

Basic Python in Scripts

- The Python dictionary

```
x = { 'firstKey' : 3.0, 'secondKey' : 'a' }
x[ 'thirdKey' ] = [ 1, 2 ]

a = x[ 'secondKey' ]
x_keys = x.keys()
```

Basic Python in Scripts

- Using dictionaries in CASA

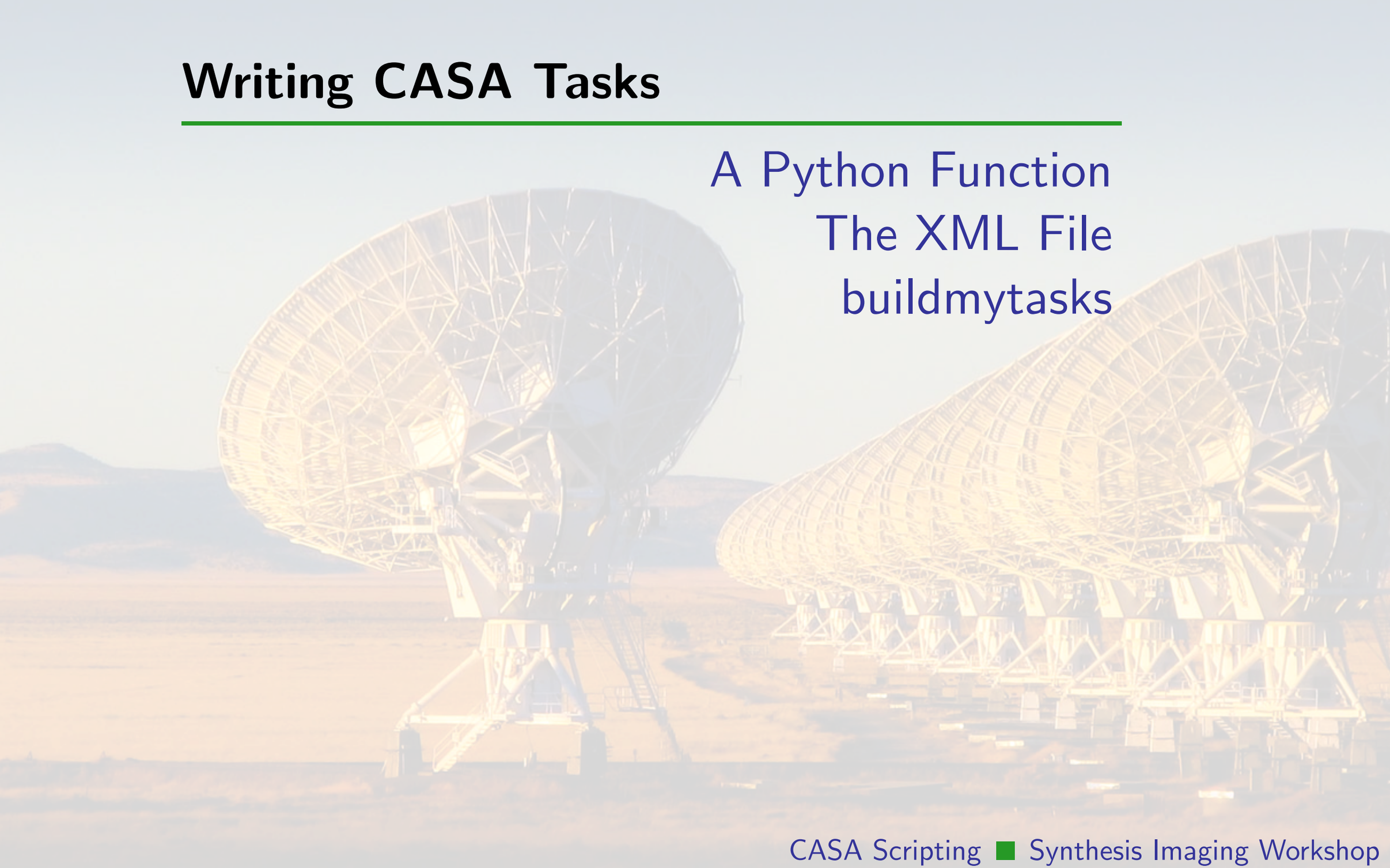
```
raster = { 'file' : 'DSS_poss1_red.image',
           'colormap' : 'Greyscale 1'  }

contour = { 'file' : 'EVLA_Cband.image',
            'levels' : [ 1, 2, 3, 5 ],
            'unit' : 0.45,
            'base' : 0 }

imview(raster=raster, contour=contour, out='filename.ps')
```

Writing CASA Tasks

A Python Function
The XML File
buildmytasks



Writing CASA Tasks

- Start with a CASA script

```
## script plotweather.py

vis = 'msName.ms'
seasonal_model = 0.5
doPlot = True

tb.open( vis + '/WEATHER' )
myTimes = tb.getcol( 'TIME' )
if doPlot:
    pl.plot( myTimes, ...
```

Writing CASA Tasks

- Turn your script into a Python function

```
from casa import table as tb
import pylab as pl
...

def plotweather(vis='', seasonal_weight=0.5, doPlot=True):

    tb.open( vis + '/WEATHER' )
    myTimes = tb.getcol( 'TIME' )
    if doPlot:
        pl.plot( myTimes, ...
```

Writing CASA Tasks

- Write the xml file (task interface)

```
[XML header -- copy from cookbook]

<task type="function" name="plotweather">
<shortdescription> short description </shortdescription>

<input>  [details of each input parameter]  </input>

<example>example text</example>
</task>
</casaxml>
```

Writing CASA Tasks

- Inside the input tag

```
<param type="string" name="vis" kind="ms" mustexist="true">
<description>MS name</description>
<value></value>
</param>
...
[second input parameter]
...
[third input parameter]
```

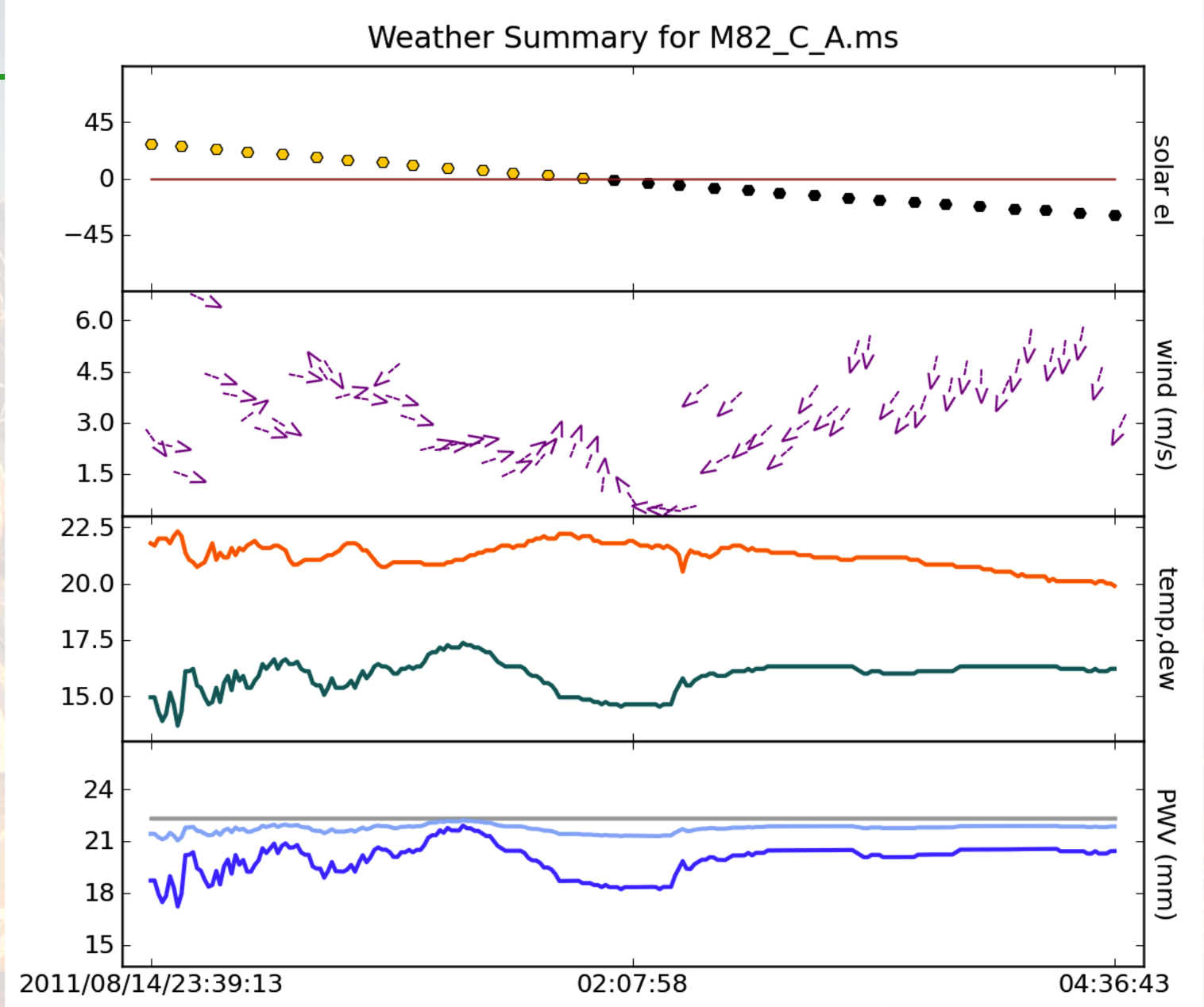
Writing CASA Tasks

- Name your function file task_taskname.py
- Name your xml file taskname.xml
- Building and importing your task

```
CASA>> !buildmytasks taskname
CASA>> execfile( 'mytasks.py' )
CASA>> inp taskname
```

plotweather

- the tb tool
- the qa tool
- the me tool
- the pl tool
- the at tool



Examples

- The quanta tool (qa)

```
x = qa.quantity( 12.4, 'deg' )
x_rad = qa.convert( x, 'rad' )
x_dms = qa.angle( x )
x_hms = qa.time( x )
```

```
mp = qa.constants( 'mp' )
c2 = qa.pow( qa.constants('c'), 2 )
E = qa.mul( mp, c2 )
qa.convert( E, 'MeV' )
```

Examples

- The measures tool (me)

```
me.doframe( me.observatory( 'VLA' ) )
me.doframe( me.epoch( 'utc', 'today' ) )
me.measure( me.direction( 'SUN' ), 'AZELGEO' )
```

```
M81 = me.direction( 'B1950', '9:51:27', '69.18.08'  )
M82 = me.direction( 'J2000', '9:55:53', '69.40.46'  )
me.separation( M81, M82 )
```

Examples

- Opening tables with browsetable

```
CASA>> browsetable( 'myTable' )

bash$ casabrowser myTable
```

- Opening tables with the tb tool:

```
tb.open( 'myTable' )
myData = tb.getcol( 'DATA' )
tb.close()
```

Examples

- Using the table query language (TaQL)

```
tb.open( 'myTable'  )
stb = tb.query( 'ANTENNA1 == 3 && FIELD_ID == 1' )
myGains, myTimes = stb.getcol( 'GAIN' ), stb.getcol( 'TIME' )
tb.close()
```

Examples

- Iterate over large data columns

```
ms.open( 'MSname' )
ms.iterinit( interval=1000 )
ms.iterorigin()

moretodo = True
while moretodo:
    myData = ms.getdata( items=['data'] )
    ...
    moretodo = ms.iternext()

ms.close()
```

Examples

- Opening images with the ia tool:

```
ia.open( 'myImage' )
mySummary = ia.summary()
myData = ia.getregion( region = 'myRegion' )
myStats = ia.statistics( region = 'myRegion' )
myCsys = ia.coordsys()
ia.regrid( outfile = 'newImage.image', csys = 'newCsys' )
ia.close()
```

Examples

- The pl tool (numpy)

```
x = pl.array( [1,2,3,4] )
y = 2*x**3 - 4

y2 = y[ y > 2 ]
x2 = x[ y > 2 ]

x = pl.linspace( 1, 10, 100 )
x_log = pl.logspace( 0, 1, 100 )
noise = pl.randn( 100 )
```

Examples

- The pl tool (matplotlib)

```
pl.plot( x )
pl.plot( x, y, 'k--' )
pl.errorbar( x, y, xerr=xerr, yerr=yerr )

pl.semilogy( x, y, 'bo', ms=4 )
pl.hist( x, bins=pl.linspace(0,20,21) )
pl.imshow( X, cmap = 'gray')
```

Examples

- More with matplotlib

```
pl.plot( x1, y1, 'bo', label= 'firstLabel' )
pl.plot( x2, y2, 'gd', label= 'secondLabel' )
pl.legend()

pl.title( 'Sample Title' )
pl.xlabel( 'Sample Label' )
pl.text( 3, 4.5, 'Sample Text' )
```

Examples

- There is also scipy

```
from scipy.optimize import curve_fit
from scipy.integrate import odeint
from scipy.special import gamma
from scipy.interpolate import interp1d
from scipy.stats import ks_2samp
```

Examples

- Searching strings

```
x = 'abc'
myIndex = x.find( 'b' )
```

- Searching lists

```
x = [ 'a', 'b', 'c' ]
myIndex = x.index( 'b' )
```

Examples

- Handling errors in your script:

```
x = [ 2, 3 ]
searchThis = 1
stopOnError = True

try:
    myIndex = x.index( searchThis )

except:
    print 'index not found: ', searchThis
    if stopOnError: raise
```

Examples

- Open and parse a text file:

```
for line in open('myText.txt', 'r'):
  line1 = line.split(' ')
```

- Append a value to a text file:

```
x = 3.0
out1 = open('myText.txt', 'a')
out1.write( str(x) + '\n' )
out1.close()
```

Examples

- Running commands from the system shell

```
os.system( 'xv myPlotFile.png &' )

os.system( 'pdflatex myTexFile.tex' )

os.system( 'mutt -s '+thisSubject+' -a '+thisAttachment+ \
           '  '+thisAddress+' < '+thisBody )
```

References

- Python Documentation
  - `http://docs.python.org/release/2.6/`
  - `http://docs.scipy.org`
  - `http://matplotlib.org`
- CASA Documentation
  - `http://casa.nrao.edu/casa_cookbook.pdf`
  - `http://casa.nrao.edu/docs/casaref/CasaRef.html`
  - `http://casaguides.nrao.edu`
  - `https://science.nrao.edu/forums/`
  - `http://casa.nrao.edu/help_desk_all.shtml`