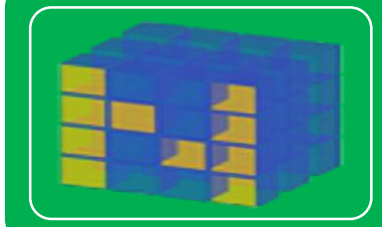
Lectures 3

Python Basics

- Background
- Installation & setup
- Python Language

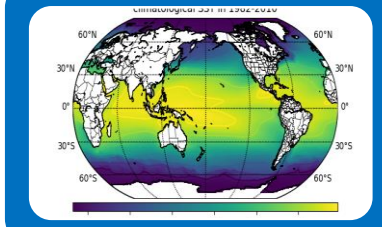
Python Advanced

- I/O & Exceptions Handling
- Modules & Packages
- Object-Oriented Programming in Python



Python for Scientific Computation

- Array computation with Numpy
- Common scientific computation with Scipy
- Draw common 2D figures with Matplotlib

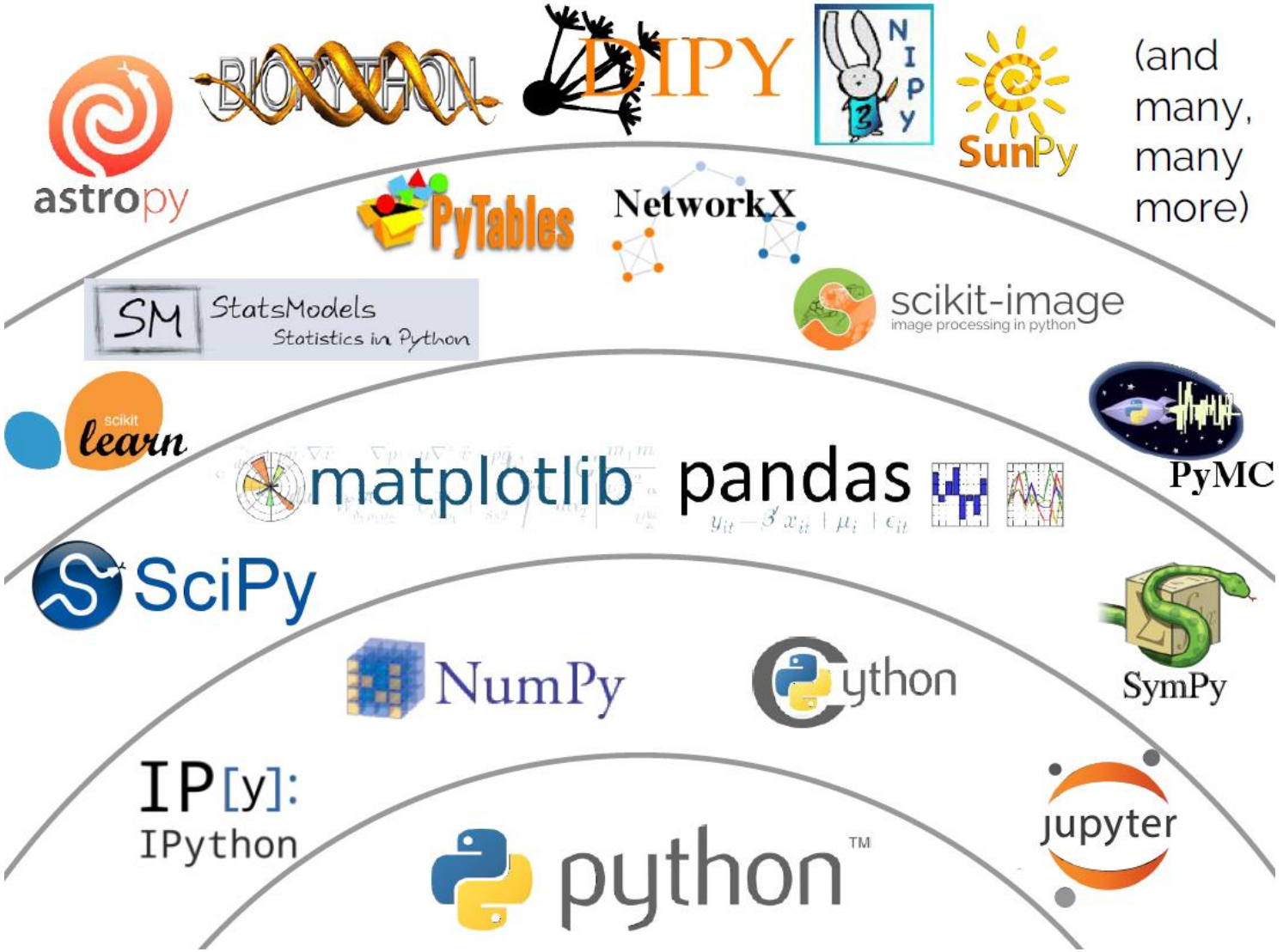


Python for Oceanography

- Read/Write netCDF files
- Draw data on maps with basemap

Python for Scientific Computation

Python Scientific Computation Stack

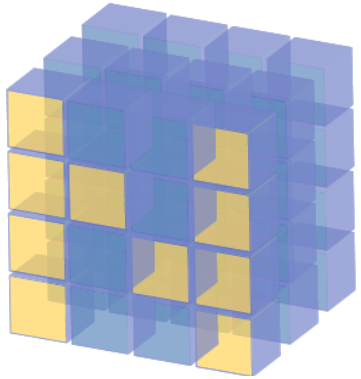


source: [Jake VandPlas 2015 SciPy Talk]

Common packages for scientific computation

- Numpy
- Scipy
- Matplotlib
  - Line, scatter, vector, contour

Numpy



NumPy

- Fundamental package for scientific computing in Python
- N-dimensional array object
- Linear algebra, Fourier transform, and random number capabilities
- Matlab-like interface
- Open source

Numpy for MATLAB users

- Some key differences

MATLAB	NumPy
1 based indexing. a(1) for the first element in a sequence	0 based indexing. a[0] for the first element in a sequence
N-dimensional array (of double precision floating point numbers) based matrix operations in linear algebra	N-dimensional array based element-wise operations. Special matrix type for linear algebra
arrays have pass-by-value semantics. Slice operations copy parts of the array	arrays have pass-by-reference semantics. Slice operations are views into an array

1/3/2018 NumPy for MATLAB users – Mathesaurus

NumPy for MATLAB users

Help

MATLAB/Octave	Python	Description
doc	help()	Browse help interactively
help -i % browse with Info		
help help *OR* doc doc	help	Help on using help
help plot	help(plot) *OR* ?plot	Help for a function
help splines *OR* doc splines	help(pylab)	Help for a toolbox/library package
demo		Demonstration examples

Searching available documentation

MATLAB/Octave	Python	Description
lookfor plot		Search help files
help	help(); modules [Numeric]	List available packages
which plot	help(plot)	Locate functions

Using interactively

MATLAB/Octave	Python	Description
octave -q	ipython -pylab	Start session
TAB *OR* M-?	TAB	Auto completion
foo(.m)	execfile('foo.py') *OR* run foo.py	Run code from file
history	hist -n	Command history
diary on [..] diary off		Save command history

exit *OR* quit	CTRL-D
	CTRL-Z # windows
	sys.exit()
		End session

Operators

MATLAB/Octave	Python	Description
help -		Help on operator syntax

Arithmetic operators

MATLAB/Octave	Python	Description
a=1; b=2;	a=1; b=1	Assignment; defining a number
a + b	a + b *OR* add(a,b)	Addition
a - b	a - b *OR* subtract(a,b)	Subtraction
a * b	a * b *OR* multiply(a,b)	Multiplication

http://mathesaurus.sourceforge.net/matlab-numpy.html 1/14

source: MATLAB/NumPy cross-reference

Numpy: useful sub-modules

- Mathematical functions
  - Trigonometric functions, rounding, sums, products, etc.
- Discrete Fourier Transform: numpy.fft

```
In [6]: np.fft.
np.fft.absolute_import  np.fft.fft2     np.fft.fftpack_lite  np.fft.ifft       np.fft.ihfft   np.fft.irfftn          np.fft.rfftfreq
np.fft.bench            np.fft.fftfreq  np.fft.fftshift      np.fft.ifft2      np.fft.info    np.fft.print_function  np.fft.rfftn
np.fft.division         np.fft.fftn     np.fft.helper        np.fft.ifftn      np.fft.irfft   np.fft.rfft            np.fft.test
np.fft.fft              np.fft.fftpack  np.fft.hfft          np.fft.ifftshift  np.fft.irfft2  np.fft.rfft2
```

- Linear algebra: numpy.linalg

```
In [6]: np.linalg.
np.linalg.LinAlgError       np.linalg.det       np.linalg.eigvalsh     np.linalg.lstsq         np.linalg.pinv           np.linalg.svd
np.linalg.absolute_import   np.linalg.division  np.linalg.info         np.linalg.matrix_power  np.linalg.print_function  np.linalg.tensorinv
np.linalg.bench             np.linalg.eig       np.linalg.inv          np.linalg.matrix_rank   np.linalg.qr             np.linalg.tensorsolve
np.linalg.cholesky          np.linalg.eigh      np.linalg.lapack_lite  np.linalg.multi_dot     np.linalg.slogdet        np.linalg.test
np.linalg.cond              np.linalg.eigvals   np.linalg.linalg       np.linalg.norm          np.linalg.solve
```

- Random sampling: numpy.random
- Matrix library: numpy.matlib

```
In [6]: np.matrix.
np.matrix.A           np.matrix.base       np.matrix.diagonal  np.matrix.getI       np.matrix.ndim          np.matrix.round          np.matrix.take
np.matrix.A1          np.matrix.byteswap   np.matrix.dot       np.matrix.getT       np.matrix.newbyteorder  np.matrix.searchsorted   np.matrix.tobytes
np.matrix.H           np.matrix.choose     np.matrix.dtype     np.matrix.getfield   np.matrix.nonzero       np.matrix.setfield       np.matrix.tofile
np.matrix.I           np.matrix.clip       np.matrix.dump      np.matrix.imag       np.matrix.partition     np.matrix.setflags       np.matrix.tolist
np.matrix.T           np.matrix.compress   np.matrix.dumps     np.matrix.item       np.matrix.prod          np.matrix.shape          np.matrix.tostring
np.matrix.all         np.matrix.conj       np.matrix.fill      np.matrix.itemset    np.matrix.ptp           np.matrix.size           np.matrix.trace
np.matrix.any         np.matrix.conjugate  np.matrix.flags     np.matrix.itemsize   np.matrix.put           np.matrix.sort           np.matrix.transpose
np.matrix.argmax      np.matrix.copy       np.matrix.flat      np.matrix.max        np.matrix.ravel         np.matrix.squeeze        np.matrix.var
...                   ...                  ...                 ...                  ...                     ...                      ...
```

Numpy references

- http://numpy.scipy.org/
- https://docs.scipy.org/doc/numpy-1.14.0/reference/index.html
- https://docs.scipy.org/doc/numpy/user/numpy-for-matlab-users.html

SciPy

- A collection of mathematical algorithm and functions
- Built on the Numpy extension of Python
- Make IPython comparable with MATLAB, IDL, Octave, and SciLab

SciPy Organization

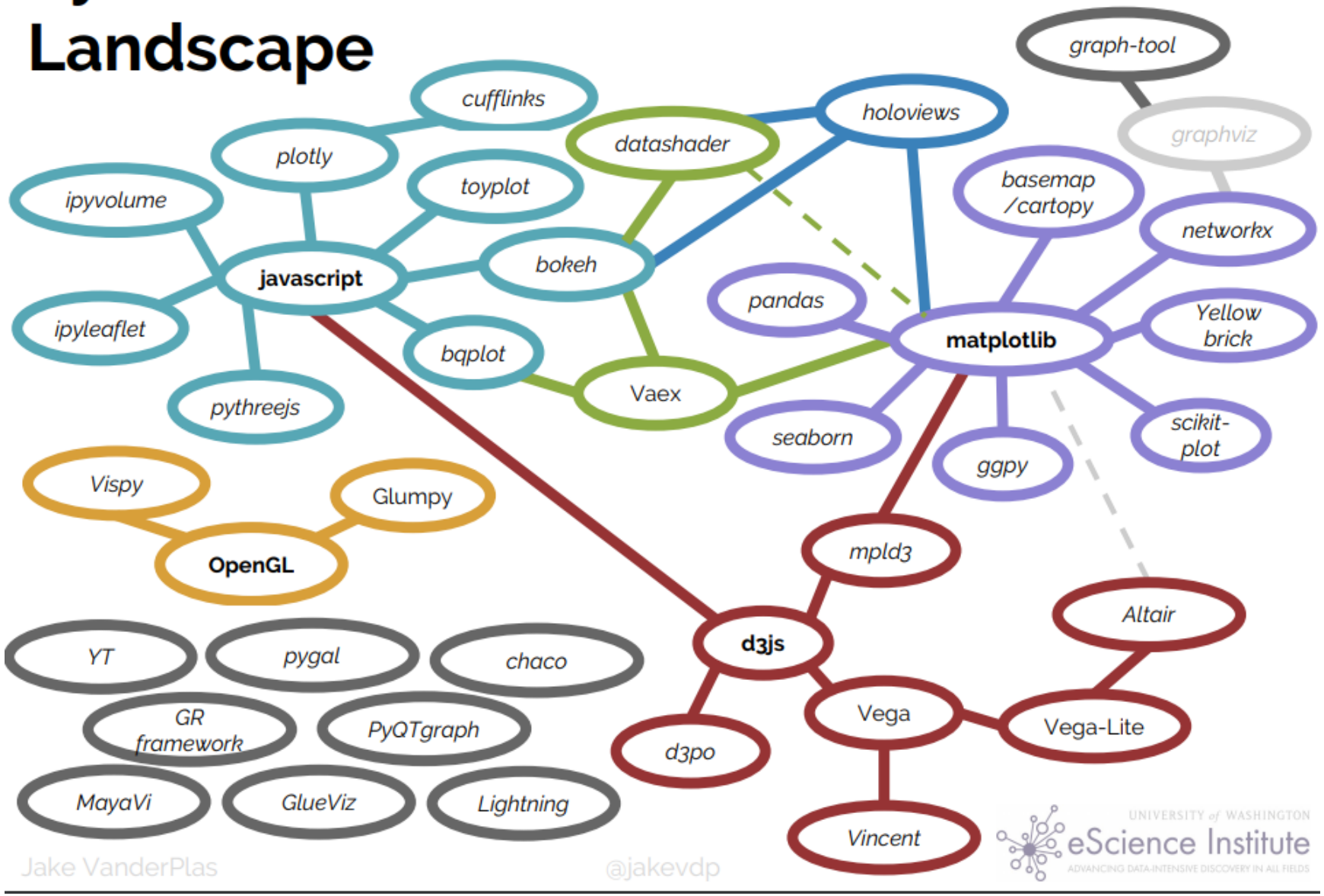
- SciPy is organized into subpackages covering different scientific computing domains:

Subpackage	Description
cluster	Clustering alrogithms
constants	Physical and mathematical constant
fftpack	Fast Fourer Transform routines
integrate	Integrate and ordinary differential equation solvers
interpolate	Interpolation and smoothing splines
io	Input and Output
linalg	Linear algebra
ndimage	N-dimensional image processing
odr	Orthogonal distance regression
optimize	Optimization and root-finding routines
signal	Signal processing
sparse	Sparse matrices and associated routines
stats	Statistical distributions and runctions
spatial	Spatial data structure and algorithms
special	Special functions

SciPy references

- https://docs.scipy.org/doc/

Python's Visualization Landscape



source: [Jake VandPlas 2017 PyCon Talk]

SciPy

- 2D plotting library to produce publication quality figures
- across platforms
- MATLAB-like API and Object-Oriented API

matplotlib references

- https://matplotlib.org/
- https://matplotlib.org/gallery/index.html
- http://www.labri.fr/perso/nrougier/teaching/matplotlib/
- https://matplotlib.org/thirdpartypackages/index.html#mapping-toolkits
- https://speakerd.s3.amazonaws.com/presentations/a2d86983ff634ac3871ad4e5a308a67b/Python-Vis-Landscape__2_.pdf
- https://github.com/matplotlib/cmocean