Multi-dimensional NumPy arrays

ESS 116 | Fall 2024

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(Modified from Ethan Campbell and Katy Christensen's materials for UW's Ocean 215)

What we'll cover in this lesson

1. NumPy arrays – arithmetic, logical operations, indexing
2. NumPy functions and constants
3. Multi-dimensional NumPy arrays
4. More array functions

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Loading NumPy ("Numeric Python")

Makes this package available to Python

This is a shortcut; you can choose any name but `np` is most common

```
import numpy as np
```

This part is technically optional

Package names are usually all lowercase

Checking a package's version

```python
import numpy as np

print(np.__version__)
```

```
1.18.5
```

That's a double underscore: __

The NumPy array (`ndarray`)

"N-dimensional array" (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
np.array([5,6,7,8])
```

Similarities between lists and NumPy 1-D arrays

Both are **mutable** (they can be changed)

```
numbers = np.array([5,6,7,8])
numbers[1] = 13
print(numbers)
```

```
[ 5 13  7  8]
```

Both are **iterable**

```
for num in numbers:
  print(num)
```

```
5
13
7
8
```

Both are compatible with **indexing** and **slicing**

```
print(numbers[-3:])
```

```
[13  7  8]
```

Find length using `len()`

```
print(len(numbers))
```

```
4
```

Check membership using `in` and `not in`

```
print(13 in numbers)
print(14 in numbers)
```

```
True
False
```

Differences between lists and NumPy 1-D arrays

Lists	**NumPy 1-D arrays**
• Lists can contain a mix of object types (integers, strings, sub-lists, etc.)	• Arrays can contain only a single object type (check using `.dtype`, change using `.astype()`)
• Lists are computationally inefficient (avoid using to store large data sets)	• Arrays are fast for computation and small in memory (great for big data)

```python
numbers = np.array([5,6,7,8])
print(numbers.dtype)
print(numbers.astype(str))
```

```
int64
['5' '6' '7' '8']
```

Differences between lists and NumPy 1-D arrays

Lists

- Lists don't preserve scientific notation in floating-point numbers

```
print([3.5e9,1.4e-3])
```

```
[3500000000.0, 0.0014]
```

- Use Python's **in-place** `append()` or `extend()`, `insert()`, `del`, `reverse()`, `remove()`, `pop()`

```
numbers = [5,6,7,8]
numbers.append([9,10])
print(numbers)
```

```
[5, 6, 7, 8, [9, 10]]
```

NumPy 1-D arrays

- Arrays preserve scientific notation

```
print(np.array([3.5e9,1.4e-3]))
```

```
[3.5e+09 1.4e-03]
```

- NumPy's `append()`, `insert()`, `delete()`, `flip()` functions are **not in-place**; note the different syntax; no functions to remove, pop

```
numbers = np.array([5,6,7,8])
numbers = np.append(numbers,[9,10])
print(numbers)
```

```
[ 5  6  7  8  9 10]
```

Differences between lists and NumPy 1-D arrays

Lists

- Convert from list → array using:

```
my_list = [5,6,7,8]
my_array = np.array(my_list)
```

- Adding lists **concatenates** (joins) **them**:

```
a = [1,2,3,4]
b = [5,6,7,8]
print(a + b)
```

```
[1, 2, 3, 4, 5, 6, 7, 8]
```

NumPy 1-D arrays

- Convert from array → list using:

```
my_list1 = my_array.tolist()
my_list2 = list(my_array)
```

- Adding arrays actually **adds them**!*

```
a = np.array([1,2,3,4])
b = np.array([5,6,7,8])
print(a + b)
```

```
[ 6  8 10 12]
```

* Note that NumPy also has a `concatenate()` function.

Arithmetic operations with arrays

Arithmetic operators

+	Addition
-	Subtraction
*	Multiplication
/	Division
**	Exponential
%	Remainder
//	Floor

Element-wise arithmetic between two or more arrays

```
a = np.array([1,2,3,4])
b = np.array([5,6,7,8])

print('a + b =',a + b)
print('a - b =',a - b)
print('a * b =',a * b)
```

```
a + b = [ 6  8 10 12]
a - b = [-4 -4 -4 -4]
a * b = [ 5 12 21 32]
```

Element-wise arithmetic with an array and a number

```
print('a + 10 =',a + 10)
print('10 * a =',10 * a)
print('a / 10 =',a / 10)
print('a**2 =',a**2)
```

```
a + 10 = [11 12 13 14]
10 * a = [10 20 30 40]
a / 10 = [0.1 0.2 0.3 0.4]
a**2 = [ 1  4  9 16]
```

Element-wise operations require arrays to be the same dimensions

```python
x = np.array([1,2,3])
y = np.array([11,12,13,14,15])

print(x + y)
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-97-d5d99ad6233b> in <module>()
      2 y = np.array([11,12,13,14,15])
      3
----> 4 print(x + y)

ValueError: operands could not be broadcast together with shapes (3,) (5,)
```

Logical operations with arrays

Comparison operators

==	Equal
!=	Not equal
>	Greater than
>=	Greater than or equal to
<	Less than
<=	Less than or equal to

Element-wise comparisons between two arrays or an array and a number

```python
u = np.array([1,2,3,4])
v = np.array([0,2,4,6])

print(u == v)
print(u < v)
print(v != 0)
print(v <= 4)
```

```
[False  True False False]
[False False  True  True]
[False  True  True  True]
[ True  True  True False]
```

Instead of comparing Boolean arrays with `and`/`or`, use `np.logical_and()` and `np.logical_or()`

```python
bool1 = np.array([True,False,True])
bool2 = np.array([True,False,False])

print(np.logical_and(bool1,bool2))
print(np.logical_or(bool1,bool2))
```

```
[ True False False]
[ True False  True]
```

New indexing options with arrays

When you want to access certain value(s) in an array:

```
v = np.array([10,11,12,13])

print(v[3])

print(v[[2,3]])

print(v[v >= 12])

print(v[[False,False,True,True]])
```

Python prints:	
`13`	Traditional list-style **single index**
`[12 13]`	**Multiple indices** retrieves multiple elements
`[12 13]`	**Logical conditions** also work…
`[12 13]`	… because they evaluate to **Boolean arrays**

When you want the indices of certain values in an array:

```
print(np.where(v >= 12))

print(np.where(v >= 12)[0])
```

`(array([2, 3]),)`	`np.where()` gives the indices at which a Boolean condition is satisfied…
`[2 3]`	… but you have to index into the result using `[0]`

What we'll cover in this lesson

1. NumPy arrays – arithmetic, logical operations, indexing
2. **NumPy functions and constants**
3. Multi-dimensional NumPy arrays
4. More array functions

Most functions acting on NumPy arrays can be called two ways

```
x = np.array([10,11,12,13])
```

```
np.sum(x)
```

Evaluates to: 46

```
x.sum()
```

Evaluates to: 46

NumPy functions can also be applied to lists

```
x = [10,11,12,13]
```

```
np.sum(x)
```

Evaluates to: 46

```
x.sum()
```

Evaluates to: 46

Mathematical reductions (array → number)

```
x = np.array([10,11,12,13])
```

Function:	Purpose:	Evaluates to:
`np.sum(x)`	Sum	46
`np.mean(x)`	Mean (average)	11.5
`np.median(x)`	Median	11.5
`np.max(x)`	Maximum value	13
`np.min(x)`	Minimum value	10
`np.std(x)`	Standard deviation	1.11803...

Mathematical constants (each return a `float`)

Constant value:	Purpose:	Evaluates to:
`np.pi`	π (pi)	3.14159...
`np.e`	*e* (Euler's number)	2.71828...
`np.inf`	Positive infinity	inf
`np.nan`	"Not a Number" (used as a placeholder for missing data)	nan

Note:

```
print(5 * np.inf)
print(5 * np.nan)
```

```
inf
nan
```

Element-wise functions (number → number, or array → array)

Function:	Purpose:	Evaluates to arrays:
`np.absolute([-2,-1])`	Absolute value	`[2,1]`
`np.round([5.23,5.29],1)`	Round to a certain decimal place	`[5.2,5.3]`
`np.sqrt([4,9,16])`	Square root (same as `**0.5`)	`[2.,3.,4.]`
`np.exp([0,1,2])`	Exponential (same as `np.e**`)	`[1.,2.718…,7.389…]`
`np.sin([0,np.pi/2])`	Sine (from radians)	`[0.,1.]`
`np.cos([np.pi,2*np.pi])`	Cosine	`[-1.,1.]`

Functions to create new arrays

Function:	Purpose:	Evaluates to arrays:
`np.zeros(4)`	Array of given length filled with zeros	`[0.,0.,0.,0.]`
`np.ones(4)`	Array of given length filled with ones	`[1.,1.,1.,1.]`
`np.full(4,2)`	Array of given length filled with given value	`[2,2,2,2]`
`np.arange(4)`	Same as `range()`…	`[0,1,2,3]`
`np.arange(0,1,0.25)`	…except floats and fractional increments are allowed	`[0.,0.25,0.5,0.75]`
`np.linspace(0,1,5)`	Returns the given number of evenly spaced values from start to end (both are inclusive)	`[0.,0.25,0.5,0.75,1.]`

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The NumPy array (`ndarray`)

“N-dimensional array” (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
np.array([5,6,7,8])
```

A one-dimensional (1-D) numpy array

The NumPy array (`ndarray`)

"N-dimensional array" (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
np.array([[1,2,3,4],[5,6,7,8]])
```

A two-dimensional (2-D) numpy array

The NumPy array (`ndarray`)

“N-dimensional array” (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

Inner list brackets

```
np.array([[1,2,3,4],[5,6,7,8]])
```

Outer list brackets

Slicing and indexing N-dimensional arrays

```python
a = np.array([[1,2,3,4],[5,6,7,8]])
print(a)
```

```
[[1 2 3 4]
 [5 6 7 8]]
```

Slicing and indexing N-dimensional arrays

```
1 a = np.array([[1,2,3,4],[5,6,7,8]])
2 print(a)
```

[[1 2 3 4]	0
[5 6 7 8]]	1

First dimension (rows)

Slicing and indexing N-dimensional arrays

```python
a = np.array([[1,2,3,4],[5,6,7,8]])
print(a)
```

```
[[1 2 3 4]
 [5 6 7 8]]
```

0	1	2	3

Second dimension (columns)

Slicing and indexing N-dimensional arrays

```
a = np.array([[1,2,3,4],[5,6,7,8]])
print(a)
```

[[1	2	3	4]	0
[5	6	7	8]]	1
0	1	2	3	

First dimension (rows)

Second dimension (columns)

Slicing and indexing N-dimensional arrays

```python
a = np.array([[1,2,3,4],[5,6,7,8]])
print(a)
```

[[1	2	3	4]	0
[5	6	7	8]]	1
0	1	2	3	

A single number index gives the **items** of the outer list.

```python
print(a[0])
```

```
[1 2 3 4]
```

Slicing and indexing N-dimensional arrays

```
a = np.array([[1,2,3,4],[5,6,7,8]])
print(a)
```

[[1	2	3	4]	0
[5	6	7	8]]	1
0	1	2	3	

A single number index gives the **items** of the outer list.

```
print(a[0])

```

```
[1 2 3 4]
```

Select specific items using the row and column index values

```
print(a[0,0])
print(a[1,0])
print(a[0,1])
print(a[0,3])
```

```
1
5
2
4
```

[row, column]

Slicing and indexing N-dimensional arrays

```
a = np.array([[1,2,3,4],[5,6,7,8]])
print(a)
```

[[1	2	3	4]	0
[5	6	7	8]]	1
0	1	2	3	

A single number index gives the **items** of the outer list.

```
print(a[0])
```

```
[1 2 3 4]
```

Select specific items using the row and column index values

```
print(a[0,0])
print(a[1,0])
print(a[0,1])
print(a[0,3])
```

[row, column]

```
1
5
2
4
```

Arrays can also be sliced with rows and columns

```
print(a[0,:2])
print(a[:,1])
```

```
[1 2]
[2 6]
```

The NumPy array (`ndarray`)

"N-dimensional array" (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
np.array([[1,2,3,4],[5,6,7,8]])
```

The NumPy array (`ndarray`)

“N-dimensional array” (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
np.array([[[1,2,3,4],[5,6,7,8]],
 [[9,10,11,12],[13,14,15,16]]])
```

A three-dimensional (3-D) numpy array

The NumPy array (`ndarray`)

"N-dimensional array" (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
np.array([[[1,2,3,4],[5,6,7,8]],
 [[9,10,11,12],[13,14,15,16]]])
```

Outer brackets

Middle brackets

Inner brackets

The NumPy array (`ndarray`)

"N-dimensional array" (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
np.array([[[1,2,3,4],[5,6,7,8]],
 [[9,10,11,12],[13,14,15,16]]])
```

Outer brackets
Middle brackets
Inner brackets

The NumPy array (`ndarray`)

"N-dimensional array" (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
np.array([[[1,2,3,4],[5,6,7,8]],
 [[9,10,11,12],[13,14,15,16]]])
```

Outer brackets
Middle brackets
Inner brackets

The NumPy array (`ndarray`)

"N-dimensional array" (e.g. 1-D, 2-D, 3-D, 4-D, etc.)

```
b = np.array([[[1,2,3,4],[5,6,7,8]],
              [[9,10,11,12],[13,14,15,16]]])
print(b)
```

```
[[[ 1  2  3  4]
  [ 5  6  7  8]]

 [[ 9 10 11 12]
  [13 14 15 16]]]
```

2 layers with 2 rows and 4 columns each

[layer, row, column]

```
print(b[0,1,3])
```

```
8
```

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1. NumPy arrays – arithmetic, logical operations, indexing
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4. **More array functions**

Multi-dimensional NumPy arrays have more than just a length

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

Multi-dimensional NumPy arrays have more than just a length

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

len( )

Gives the number of items in the outer list dimension

Example

```
print(len(d1))
print(len(d2))
print(len(d3))
```

```
4
2
3
```

Multi-dimensional NumPy arrays have more than just a length

```python
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

len( )
Gives the number of items in the outer list dimension

size
Gives the total number of items in the array

Example

```python
print(d1.size)
print(d2.size)
print(d3.size)
```

```
4
8
24
```

Notice there are no parentheses at the end of this. This is because size is not a function, but an attribute of the array.

Multi-dimensional NumPy arrays have more than just a length

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

len( )

Gives the number of items in the outer list dimension

size

Gives the total number of items in the array

ndim

Gives the number of dimensions in an array

Example

```
print(d1.ndim)
print(d2.ndim)
print(d3.ndim)
```

```
1
2
3
```

Multi-dimensional NumPy arrays have more than just a length

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

len( )
Gives the number of items in the outer list dimension

size
Gives the total number of items in the array

ndim
Gives the number of dimensions in an array

shape
Gives the number of items in each dimension of an array

Example

```
print(d1.shape)
print(d2.shape)
print(d3.shape)
```

```
(4,)
(2, 4)
(3, 2, 4)
```

Notice these are given as tuples

You can change the shape of a NumPy array

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

You can change the shape of a NumPy array

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

reshape( )

Changes the shape of the array into a given shape

Example

```
d1_to_d2 = d1.reshape((2,2))
print(d1_to_d2)
print()

d3_to_d2 = d3.reshape((2,12))
print(d3_to_d2)
```

```
[[1 2]
 [3 4]]

[[ 1  2  3  4  5  6  7  8  9 10 11 12]
 [13 14 15 16 17 18 19 20 21 22 23 24]]
```

You can change the shape of a NumPy array

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

reshape( )

Changes the shape of the array into a given shape

flatten( )

Creates a copy of an array as a 1-D array

Example

```
print(d3)
print()
print(d3.flatten())
```

```
[[[ 1  2  3  4]
  [ 5  6  7  8]]

 [[ 9 10 11 12]
  [13 14 15 16]]

 [[17 18 19 20]
  [21 22 23 24]]]

[ 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24]
```

You can change the shape of a NumPy array

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

reshape( )

Changes the shape of the array into a given shape

flatten( )

Creates a copy of an array as a 1-D array

transpose( )

Permutes (e.g. rotates) the axes of an array

Example

```
print(d2)
print()
print(d2.transpose())
```

```
[[1 2 3 4]
 [5 6 7 8]]

[[1 5]
 [2 6]
 [3 7]
 [4 8]]
```

Arithmetic operations with arrays

Arithmetic operators

+	Addition
-	Subtraction
*	Multiplication
/	Division
**	Exponential
%	Remainder
//	Floor

Element-wise arithmetic between two or more arrays

```python
a = np.array([1,2,3,4])
b = np.array([5,6,7,8])

print('a + b =',a + b)
print('a - b =',a - b)
print('a * b =',a * b)
```

```
a + b = [ 6  8 10 12]
a - b = [-4 -4 -4 -4]
a * b = [ 5 12 21 32]
```

Element-wise arithmetic with an array and a number

```python
print('a + 10 =',a + 10)
print('10 * a =',10 * a)
print('a / 10 =',a / 10)
print('a**2 =',a**2)
```

```
a + 10 = [11 12 13 14]
10 * a = [10 20 30 40]
a / 10 = [0.1 0.2 0.3 0.4]
a**2 = [ 1  4  9 16]
```

Element-wise operations require arrays to be the same dimensions

```python
x = np.array([1,2,3])
y = np.array([11,12,13,14,15])

print(x + y)
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-97-d5d99ad6233b> in <module>()
      2 y = np.array([11,12,13,14,15])
      3
----> 4 print(x + y)

ValueError: operands could not be broadcast together with shapes (3,) (5,)
```

Element-wise operations require arrays to broadcast to the same dimensions

```python
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

Example

```python
print(d2)
print()
print(d1)
print()

print(d2+d1)
```

```
[[1 2 3 4]
 [5 6 7 8]]

[1 2 3 4]

[[ 2  4  6  8]
 [ 6  8 10 12]]
```

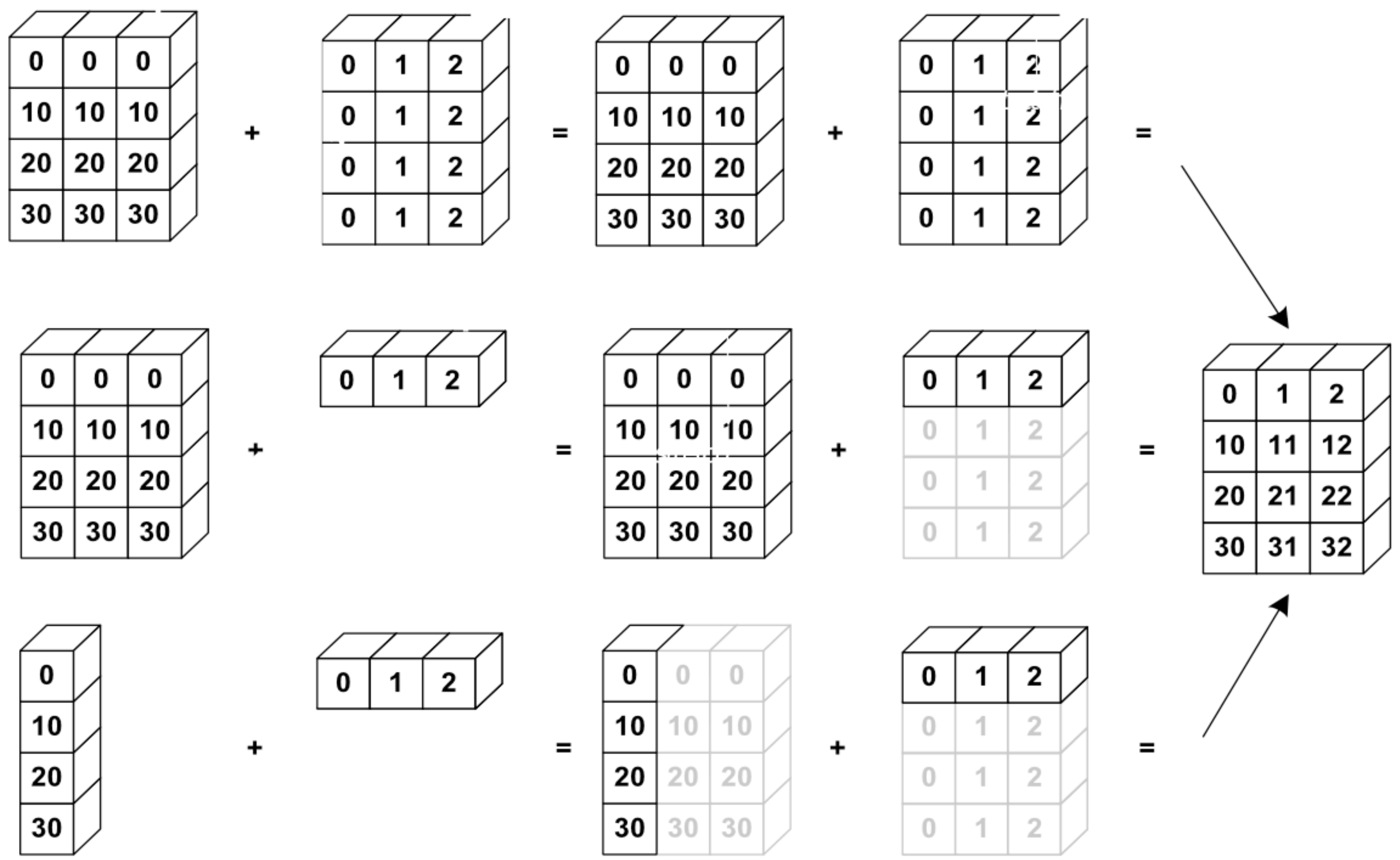

Image: http://scipy-lectures.org/_images/numpy_broadcasting.png

You can combine NumPy arrays

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

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```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

vstack( )

Stacks arrays on top of each other vertically

Example

```
print(d1)
print()
print(d2)
print()

print(np.vstack((d1,d2)))
```

```
[1 2 3 4]

[[1 2 3 4]
 [5 6 7 8]]

[[1 2 3 4]
 [1 2 3 4]
 [5 6 7 8]]
```

You can combine NumPy arrays

```
d1 = np.array([1,2,3,4])

d2 = np.array([[1,2,3,4],[5,6,7,8]])

d3 = np.array([[[1,2,3,4],[5,6,7,8]],
               [[9,10,11,12],[13,14,15,16]],
               [[17,18,19,20],[21,22,23,24]]])
```

vstack( )

Stacks arrays on top of each other vertically

hstack( )

Stacks arrays horizontally

Example

```
d1_vert = np.array([[1],[2],[3],[4]])
print(d1_vert)
print()
print(d2.transpose())
print()

print(np.hstack((d1_vert,d2.transpose())))
```

```
[[1]
 [2]
 [3]
 [4]]

[[1 5]
 [2 6]
 [3 7]
 [4 8]]

[[1 1 5]
 [2 2 6]
 [3 3 7]
 [4 4 8]]
```

Mathematical reductions (array → number)

```
x = np.array([10,11,12,13])
```

Function:	Purpose:	Evaluates to:
`np.sum(x)`	Sum	46
`np.mean(x)`	Mean (average)	11.5
`np.median(x)`	Median	11.5
`np.max(x)`	Maximum value	13
`np.min(x)`	Minimum value	10
`np.std(x)`	Standard deviation	1.11803...

Mathematical reductions (array → number)

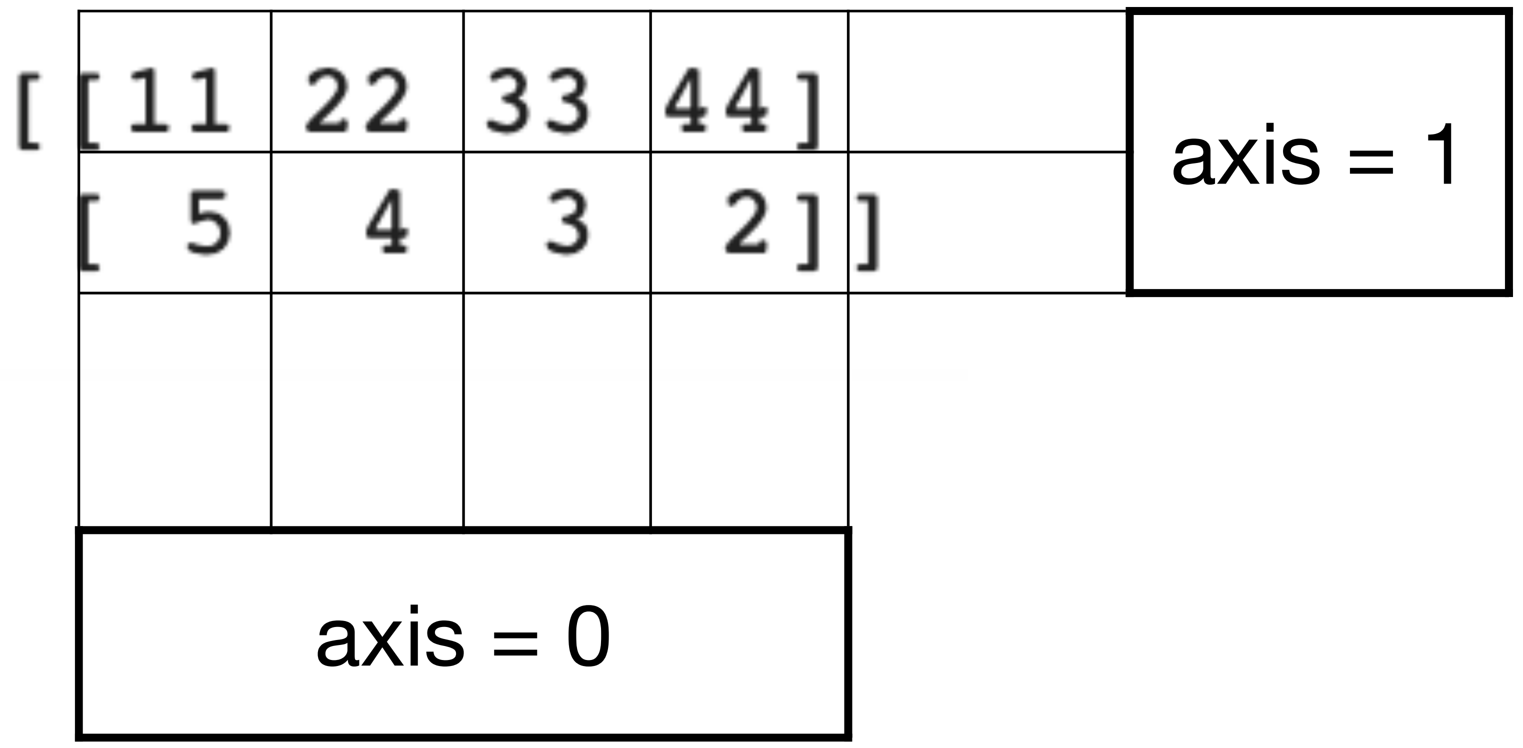
```
x = np.array([[11,22,33,44],[5,4,3,2]])
```

```
[[11 22 33 44]
 [ 5  4  3  2]]
```

Function:	Evaluates to:
`np.sum(x,axis=0)`	`[16 26 36 46]`
`np.mean(x,axis=1)`	`[27.5  3.5]`
`np.median(x,axis=0)`	`[ 8. 13. 18. 23.]`
`np.max(x)`	`44`
`np.min(x,axis=1)`	`[11  2]`
`np.std(x)`	`14.84082…`

Mathematical reductions (array → number)

`x = np.array([[11,22,33,44],[5,4,3,2]])`



Function:	**Evaluates to:**
`np.sum(x,axis=0)`	`[16 26 36 46]`
`np.mean(x,axis=1)`	`[27.5  3.5]`
`np.median(x,axis=0)`	`[ 8. 13. 18. 23.]`
`np.max(x)`	`44`
`np.min(x,axis=1)`	`[11  2]`
`np.std(x)`	`14.84082…`

Functions to create new arrays

Function:	Purpose:	Evaluates to arrays:
`np.zeros(4)`	Array of given length filled with zeros	`[0.,0.,0.,0.]`
`np.ones(4)`	Array of given length filled with ones	`[1.,1.,1.,1.]`
`np.full(4,2)`	Array of given length filled with given value	`[2,2,2,2]`
`np.arange(4)`	Same as `range()`…	`[0,1,2,3]`
`np.arange(0,1,0.25)`	…except floats and fractional increments are allowed	`[0.,0.25,0.5,0.75]`
`np.linspace(0,1,5)`	Returns the given number of evenly spaced values from start to end (both are inclusive)	`[0.,0.25,0.5,0.75,1.]`

Functions to create new arrays

Function:	Purpose:	Evaluates to arrays:

`np.zeros((4,3))`	Array of given length filled with zeros	`[[0. 0. 0.]`
		` [0. 0. 0.]`
		` [0. 0. 0.]`
		` [0. 0. 0.]]`

`np.ones((4,))`	Array of given length filled with ones	`[1. 1. 1. 1.]`

`np.full((2,3,4),2)`	Array of given length filled with given value	`[[[2 2 2 2]`
		`  [2 2 2 2]`
		`  [2 2 2 2]]`
		
		` [[2 2 2 2]`
		`  [2 2 2 2]`
		`  [2 2 2 2]]]`