pandas

Working with CSV data files

ESS 116 | Fall 2024

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

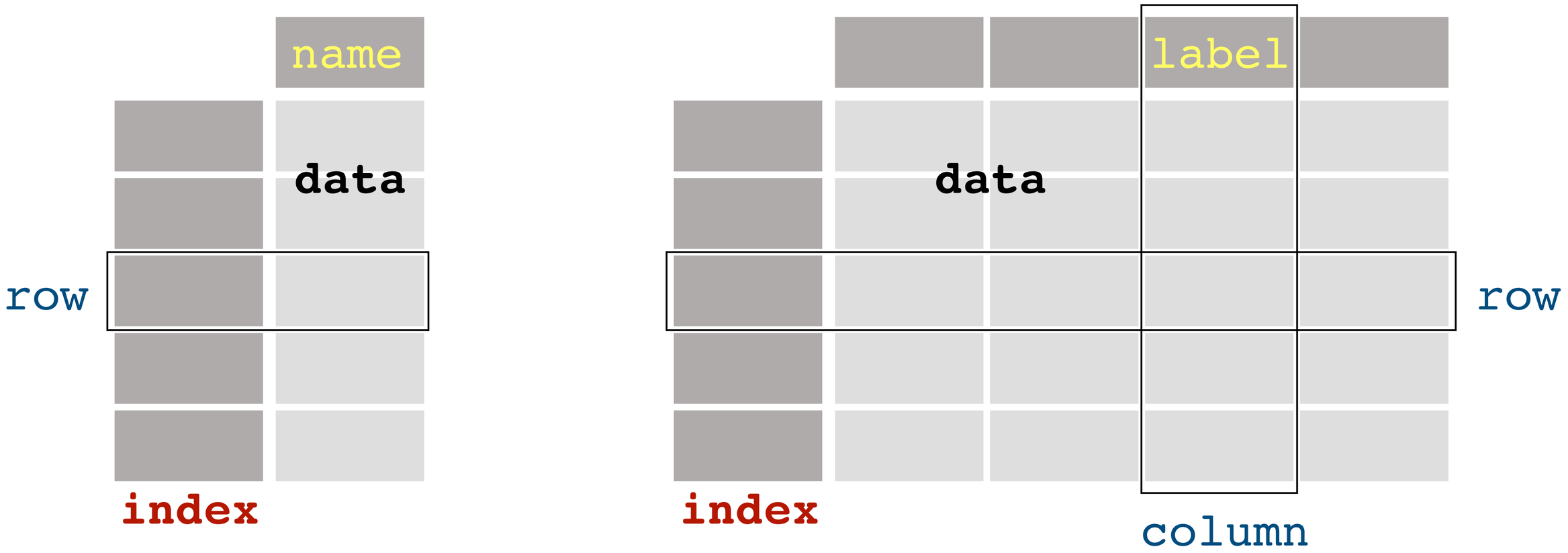
What we'll cover in this lesson

1. **`pandas`: `Series` objects**
2. `pandas`: `DataFrame` objects; CSV files

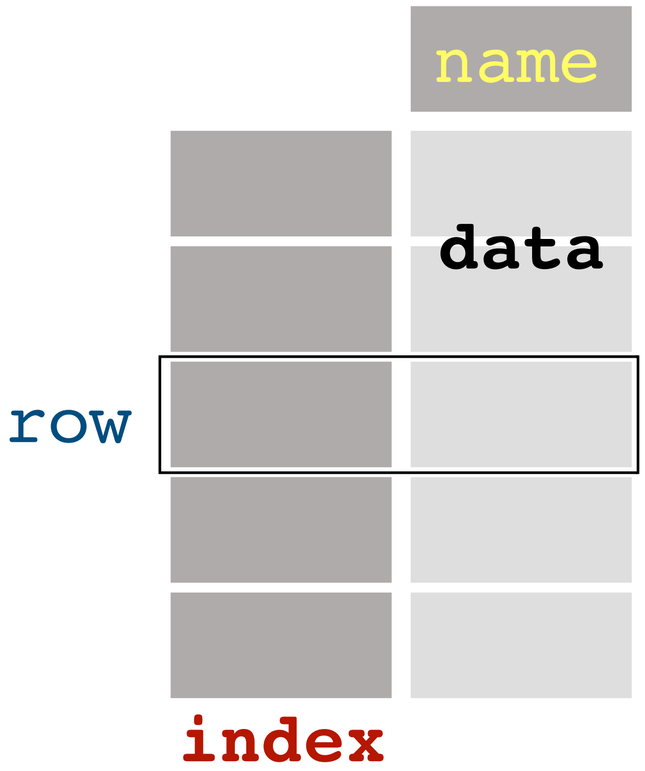
Loading `pandas`

```
import pandas as pd
```

`pandas` handles tabular data (tables or spreadsheets)



`pandas` handles tabular data (tables or spreadsheets)

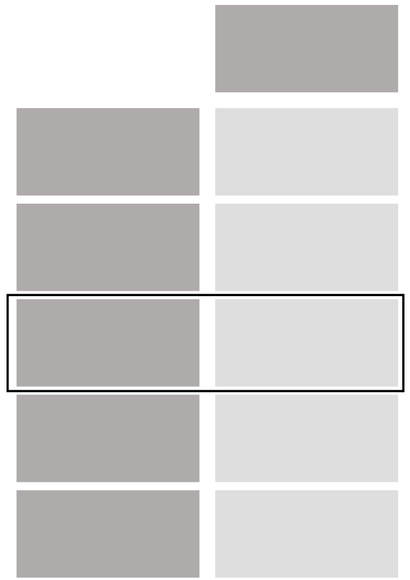


The `index` of a `Series` or `DataFrame` doesn't need to contain integers starting at 0.

An `index` can consist of values of any type (e.g. `float`, strings, `datetime` objects).

Creating a `Series` object

`pd.Series(``index=`<list or 1-D NumPy array>`,`
`data=`<list or 1-D NumPy array>`,name=`<string>**`)`**



```
# Create two new Pandas Series objects
s1 = pd.Series(index=[2016,2017,2018,2019,2020],
               data=[4.1,5.2,6.3,7.4,8.5],
               name='Temperature')
s2 = pd.Series(index=[2016,2017,2018,2019,2020],
               data=[35.5,35.0,34.5,34.0,33.5],
               name='Salinity')

# Series still have a length, as with lists and NumPy arrays
print(len(s1))
```

```
5
```

Getting the index and data from a `Series`

```
1 # Extract parts of the Series object
2 print(s1.index)          # get index as Index object (not very useful)
```

```
Int64Index([2016, 2017, 2018, 2019, 2020], dtype='int64')
```

```
1 print(s1.index.values)  # get index converted into NumPy array
```

```
[2016 2017 2018 2019 2020]
```

```
1 print(s1.values)        # get data converted into NumPy array
```

```
[4.1 5.2 6.3 7.4 8.5]
```

Selecting data from a `Series` using `.iloc[ ]` (selection by integer index)

Returns a single value

<Series>`.iloc[`<single integer index>

Example:

```
s1.iloc[3]
```

Returns part of the original Series

OR <list or array of indices>

```
s1.iloc[[2,3,4]]
```

OR <slice of integer indices>

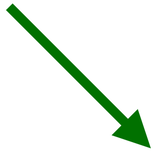
```
s1.iloc[2:5]
```

OR <Boolean array>`]`

```
s1.iloc[[False,False,
         True,True,False]]
```

Selecting data from a `Series` using `.loc[ ]` (selection by label)

Returns a single value



<Series>**`.loc[`** <single index label>

OR <list or array of labels>

Returns part of the original Series

OR <slice of index labels>**`]`**

Example:

```
s1.loc[2019]
```

```
s1.loc[[2018,2019,2020]]
```

```
s1.loc[2018:2020]
```

Unlike Python/NumPy slicing, the end value is inclusive!

Reminder: convert the resulting `Series` to a NumPy array

```
s1.loc[2018:2020]
```

gives a `Series` object

```
s1.loc[2018:2020].values
```

gives a NumPy array

Changing data in a `Series` using `.iloc[ ]` and `.loc[ ]`

```
1 s1.loc[2018] = 5.3
2 print(s1)
```

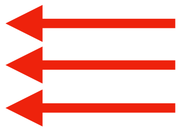
```
2016    4.1
2017    5.2
2018    5.3
2019    7.4
2020    8.5
Name: Temperature, dtype: float64
```

```
1 s1.iloc[3:5] = [6.4,7.5]
2 print(s1)
```

```
2016    4.1
2017    5.2
2018    5.3
2019    6.4
2020    7.5
Name: Temperature, dtype: float64
```

```
1 s1.loc[2018:2020] += 1
2 print(s1)
```

```
2016    4.1
2017    5.2
2018    6.3
2019    7.4
2020    8.5
Name: Temperature, dtype: float64
```



Adding new data to a `Series` using `.loc[ ]` with a new label

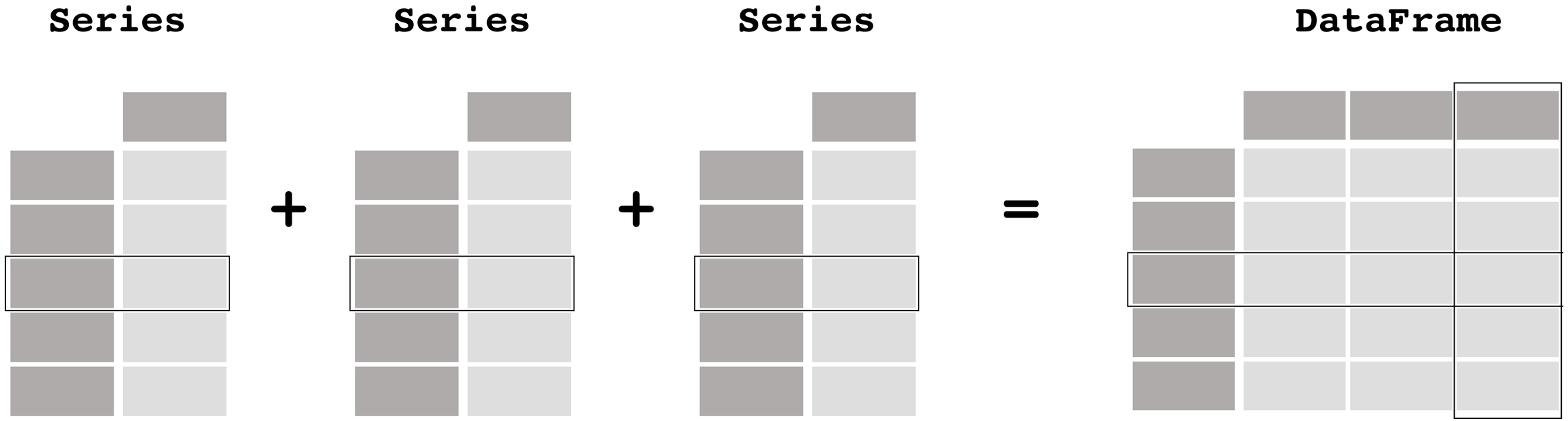
```
1 s1.loc[2021] = 9.6
2
3 print(s1)
```

```
2016    4.1
2017    5.2
2018    6.3
2019    7.4
2020    8.5
2021    9.6
Name: Temperature, dtype: float64
```

What we'll cover in this lesson

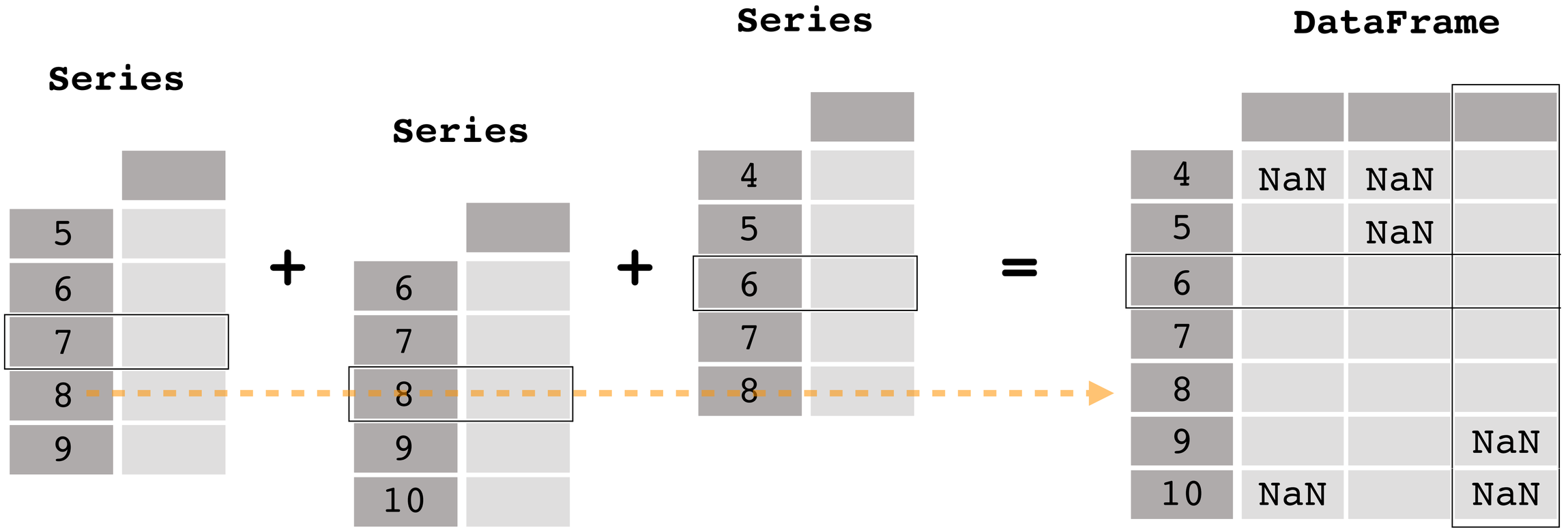
1. pandas: `Series` objects
2. **pandas: `DataFrame` objects; CSV files**
3. `xarray`: `DataArray` and `Dataset` objects; netCDF files
4. `xarray`: working with higher-dimensional data

Two or more `Series` can be concatenated to become a `DataFrame`




```
pd.concat([s1,s2,s3,…],axis=1)
```

Concatenation along columns respects the index values




```
pd.concat([s1,s2,s3,…],axis=1,join='outer')
```

You can also create a new `DataFrame` object directly

`pd.DataFrame(``index=`<list or 1-D NumPy array>`,`
`data=`<dictionary of string:list/array pairs>**`)`**


```
1 df = pd.DataFrame(index=[2016,2017,2018,2019,2020],
2                   data={'Temperature':[4.1,5.2,6.3,7.4,8.5],
3                         'Salinity':[35.5,35.0,34.5,34.0,33.5]})
```

Getting information about a `DataFrame`

`.shape`

```
1 df.shape
```

```
(5, 2)
```

`.size`

```
1 df.size
```

```
10
```

`print()`

```
1 print(df)
```

```
      Temperature  Salinity
2016          4.1      35.5
2017          5.2      35.0
2018          6.3      34.5
2019          7.4      34.0
2020          8.5      33.5
```

`display()`

```
1 display(df)
```

	Temperature	Salinity
2016	4.1	35.5
2017	5.2	35.0
2018	6.3	34.5
2019	7.4	34.0
2020	8.5	33.5

`.describe()`

```
1 df.describe()
```

	Temperature	Salinity
count	5.000000	5.000000
mean	6.300000	34.500000
std	1.739253	0.790569
min	4.100000	33.500000
25%	5.200000	34.000000
50%	6.300000	34.500000
75%	7.400000	35.000000
max	8.500000	35.500000

Getting the columns, index, and data from a `DataFrame`

```
1 # Get index as a NumPy array
2 print(df.index.values)
```

```
[2016 2017 2018 2019 2020]
```

```
1 # Get column names as a NumPy array
2 print(df.columns.values)
```

```
['Temperature' 'Salinity']
```

```
1 # Get data as a NumPy array
2 print(df.values)
```

```
[[ 4.1 35.5]
 [ 5.2 35. ]
 [ 6.3 34.5]
 [ 7.4 34. ]
 [ 8.5 33.5]]
```

```
1 # Get one column as a NumPy array
2 # (think of this like dictionary indexing)
3 print(df['Salinity'].values)
```

```
[35.5 35.  34.5 34.  33.5]
```

Selecting data from a `DataFrame` using `.iloc[ ]` and `.loc[ ]`

Selection by index: <DataFrame>`.iloc[` <single integer index>
OR <list or array of indices>
OR <slice of integer indices>
OR <Boolean array>`]`

Selection by label: <DataFrame>`.loc[` <single index label>
OR <list or array of labels>
OR <slice of index labels>`]`

Selecting data from a `DataFrame` using `.iloc[ ]` and `.loc[ ]`

Selection by index:

<DataFrame>`[`<column label(s)>`].iloc[`<index or indices>`]`

Selection by label:

<DataFrame>`[`<column label(s)>`].loc[`<label or labels>`]`

Example: `df['Salinity'].loc[2019]`

Applying NumPy functions to a `Series` or `DataFrame`

```
df.mean()
df.mean(axis=0)
```

both take the average along the index (axis 0)

Example:

```
Temperature     6.3
Salinity       34.5
dtype: float64
```

```
df.mean(axis=1)
```

takes the average along the columns (axis 1)

Example:

```
2016    19.8
2017    20.1
2018    20.4
2019    20.7
2020    21.0
dtype: float64
```

```
df.mean(skipna=True)
```

ignores NaN values (if present) when calculating the average

Putting it all together

Combine column extraction, selection by label, and applying a NumPy function

Start with a `DataFrame`

```
df['Salinity'].loc[2017:].mean()
```

This gives a `Series`

This gives a slice from that `Series`

This gives a single value: the average salinity from 2017 onwards

Philosophy of `pandas` and `xarray`

Do more with less code.

Benefit: You'll spend more time "doing science" and less time writing code.

Make your code more readable.

Benefit: You'll make fewer errors, and it will be easier to understand what you were thinking when you revisit your code a few weeks or months later.

Philosophy of `pandas` and `xarray`

Which code is easiest to understand?

`for` loop:

```
1 sum = 0.0
2 for index in range(len(data)):
3   if times[index].year == 2019:
4     sum += data[index]
5 average = sum / len(data)
```

NumPy:

```
1 data[np.logical_and(times > datetime(2019,1,1),
2                     times < datetime(2019,12,31))].mean()
```

`pandas`:

```
1 data.loc['2019'].mean()
```

Shortcut for indexing into a `datetime` index

Loading/saving CSV and Excel files using `pandas`

Save a `DataFrame` as a CSV file:

```
df.to_csv('filepath/including/filename.csv')
```

Read a CSV file as a `DataFrame`:

```
df = pd.read_csv('filepath/including/filename.csv',
                 delimiter=',',delim_whitespace=False,
                 header=0, …)
```

→ Documentation (API): https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.read_csv.html

Read an Excel spreadsheet as a `DataFrame`:

```
df = pd.read_excel('filepath/including/filename.xlsx',
                   sheet_name='Sheet 1', …)
```

→ Documentation (API): https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.read_excel.html

Resources: `pandas` documentation

“Getting started” tutorials:

https://pandas.pydata.org/docs/getting_started/intro_tutorials/

Full user guide:

https://pandas.pydata.org/docs/user_guide/index.html