MANIPULATING TIME SERIES DATA IN PYTHON

Compare Time Series Growth Rates

Comparing Stock Performance

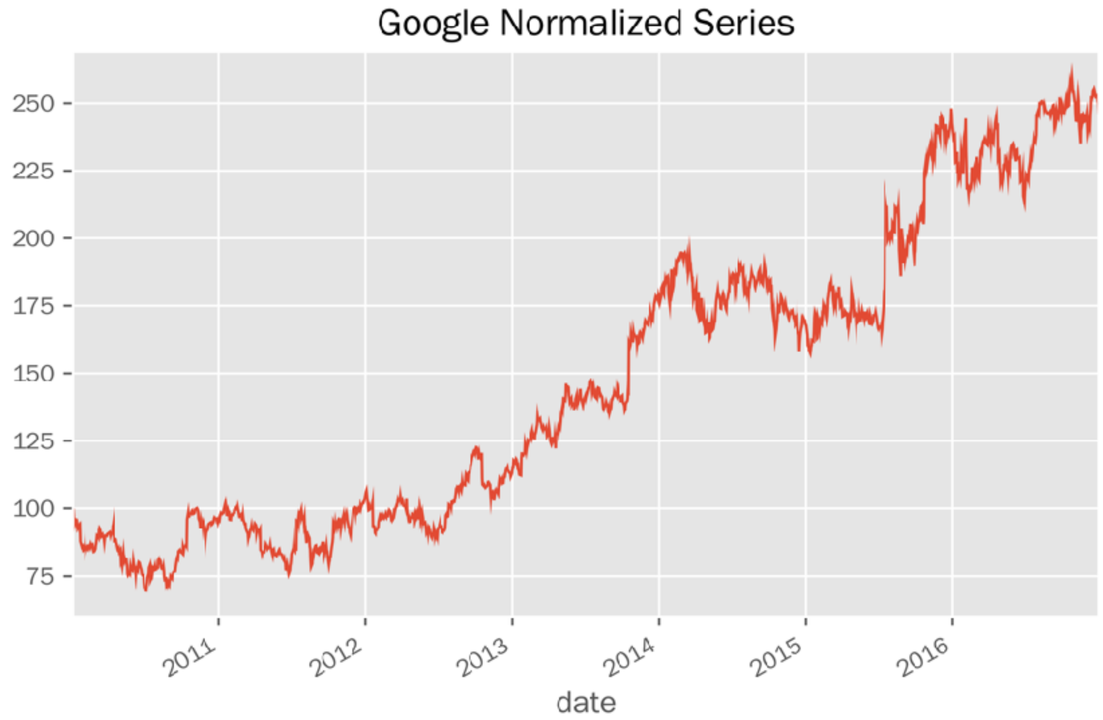
- Stock price series: hard to compare at different levels
- Simple solution: normalize price series to start at 100
- Divide all prices by first in series, multiply by 100
  - Same starting point
  - All prices relative to starting point
  - Difference to starting point in percentage points

Normalizing a Single Series (1)

```
In [1]: google = pd.read_csv('google.csv', parse_dates=['date'],
                             index_col='date')

In [2]: google.head(3)
Out[2]:
              price
date
2010-01-04  313.06
2010-01-05  311.68
2010-01-06  303.83

In [3]: first_price = google.price.iloc[0]  # int-based selection

In [5]: first_price
313.06

In [6]: first_price == google.loc['2010-01-04', 'price']
Out[6]: True
```

Normalizing a Single Series (2)

```
In [6]: normalized = google.price.div(first_price).mul(100)

In [7]: normalized.plot(title='Google Normalized Series')
```



150 Percentage Points

Normalizing Multiple Series (1)

```
In [10]: prices = pd.read_csv('stock_prices.csv',
                              parse_dates=['date'],
                              index_col='date')

In [11]: prices.info()
DatetimeIndex: 1761 entries, 2010-01-04 to 2016-12-30
Data columns (total 3 columns):
AAPL    1761 non-null float64
GOOG    1761 non-null float64
YHOO    1761 non-null float64
dtypes: float64(3)

In [12]: prices.head(2)
              AAPL    GOOG   YHOO
Date
2010-01-04  30.57  313.06  17.10
2010-01-05  30.63  311.68  17.23
```

Normalizing Multiple Series (2)

```
In [13]: prices.iloc[0]
Out[13]:
AAPL     30.57
GOOG    313.06
YHOO     17.10
Name: 2010-01-04 00:00:00, dtype: float64

In [14]: normalized = prices.div(prices.iloc[0])

In [15]: normalized.head(3)
Out[15]:
                AAPL      GOOG      YHOO
Date
2010-01-04  1.000000  1.000000  1.000000
2010-01-05  1.001963  0.995592  1.007602
2010-01-06  0.985934  0.970517  1.004094
```

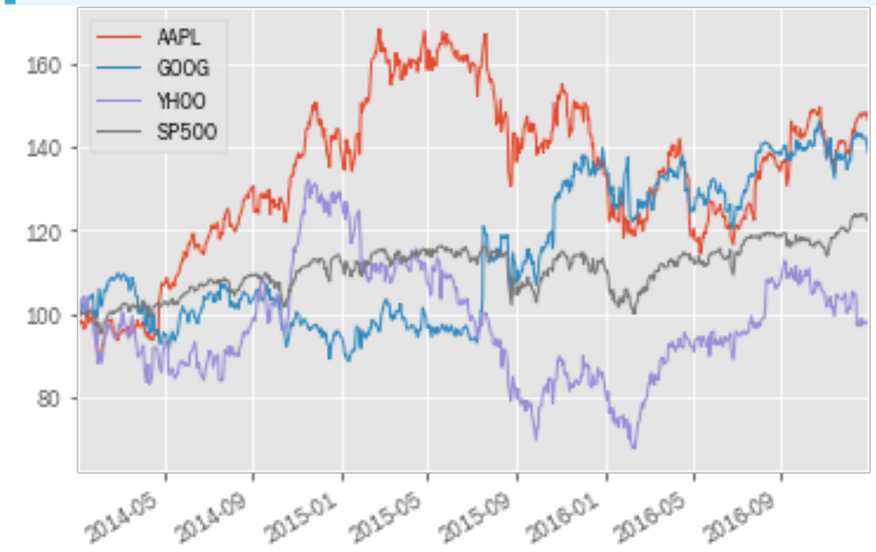
`.div()`:
automatic alignment of Series index & DataFrame columns

Comparing with a Benchmark (1)

```
In [16]: index = pd.read_csv('benchmark.csv',
                             parse_dates=['date'],
                             index_col='date')
In [17]: index.info()
DatetimeIndex: 1826 entries, 2010-01-01 to 2016-12-30
Data columns (total 1 columns):
SP500    1762 non-null float64
dtypes: float64(1)

In [18]: prices = pd.concat([prices, index], axis=1).dropna()

In [19]: prices.info()
DatetimeIndex: 1761 entries, 2010-01-04 to 2016-12-30
Data columns (total 4 columns):
AAPL     1761 non-null float64
GOOG     1761 non-null float64
YHOO     1761 non-null float64
SP500    1761 non-null float64
dtypes: float64(4)
```

Comparing with a Benchmark (2)

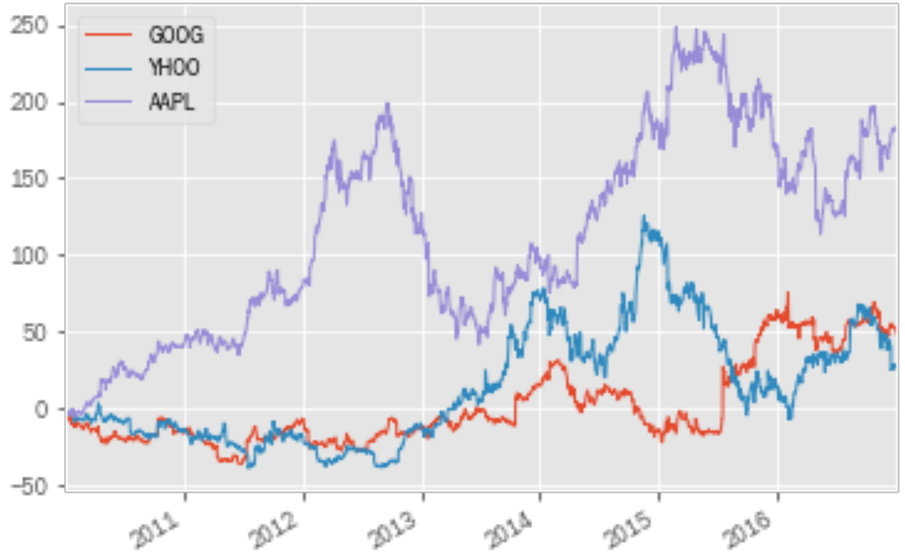
```
In [20]: prices.head(1)
Out[20]:
                AAPL    GOOG   YHOO     SP500
2010-01-04   30.57   313.06   17.10   1132.99

In [21]: normalized = prices.div(prices.iloc[0]).mul(100)

In [22]: normalized.plot()
```



Plotting Performance Difference

```
In [23]: diff = normalized[tickers].sub(normalized['SP500'], axis=0)

                 GOOG      YHOO      AAPL
2010-01-04   0.000000  0.000000  0.000000
2010-01-05  -0.752375  0.448669 -0.115294
2010-01-06  -3.314604  0.043069 -1.772895

In [24]: diff.plot()
```

`.sub(…, axis=0)`: Subtract a `Series` from each `DataFrame` column by aligning indexes



MANIPULATING TIME SERIES DATA IN PYTHON

Let’s practice!

MANIPULATING TIME SERIES DATA IN PYTHON

Changing the Time Series Frequency: Resampling

Changing the Frequency: Resampling

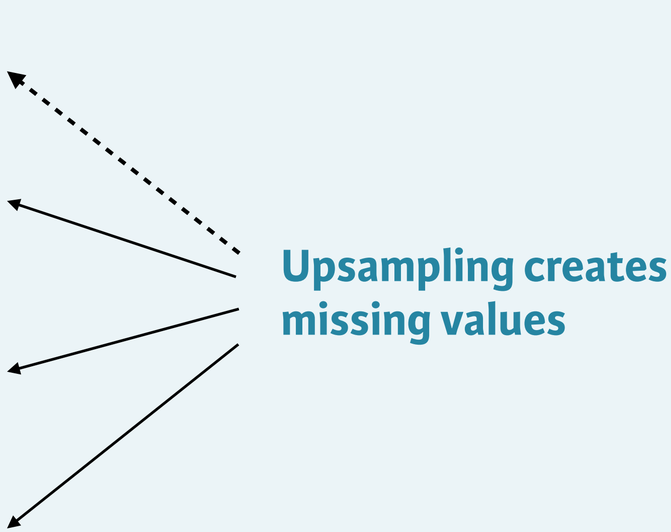
- `DateTimeIndex`: set & change `freq` using `.asfreq()`
- But frequency conversion affects the data
  - Upsampling: fill or interpolate missing data
  - Downsampling: aggregate existing data
- `pandas` API:
  - `.asfreq()`, `.reindex()`
  - `.resample()` + transformation method

Getting started: Quarterly Data

```
In [1]: dates = pd.date_range(start='2016', periods=4, freq='Q')

In [2]: data = range(1, 5)

In [3]: quarterly = pd.Series(data=data, index=dates)

In [4]: quarterly

2016-03-31    1
2016-06-30    2
2016-09-30    3
2016-12-31    4
Freq: Q-DEC, dtype: int64 # Default: year-end quarters
```

Upsampling: Quarter => Month

```
In [5]: monthly = quarterly.asfreq('M') # to month-end frequency

                 
2016-03-31    1.0
2016-04-30    NaN
2016-05-31    NaN
2016-06-30    2.0
2016-07-31    NaN
2016-08-31    NaN
2016-09-30    3.0
2016-10-31    NaN
2016-11-30    NaN
2016-12-31    4.0
Freq: M, dtype: float64

In [6]: monthly = monthly.to_frame('baseline') # to DataFrame
```



Upsampling creates missing values

Upsampling: Fill Methods

```
In [7]: monthly['ffill'] = quarterly.asfreq('M', method='ffill')

In [8]: monthly['bfill'] = quarterly.asfreq('M', method='bfill')

In [9]: monthly['value'] = quarterly.asfreq('M', fill_value=0)
```

	baseline	ffill	bfill	value
2016-03-31	1.0	1	1	1
2016-04-30	NaN	1	2	0
2016-05-31	NaN	1	2	0
2016-06-30	2.0	2	2	2
2016-07-31	NaN	2	3	0
2016-08-31	NaN	2	3	0
2016-09-30	3.0	3	3	3
2016-10-31	NaN	3	4	0
2016-11-30	NaN	3	4	0
2016-12-31	4.0	4	4	4

`bfill`: backfill

`ffill`: forward fill

Add missing months: `.reindex()`

```
In [10]: dates = pd.date_range(start='2016', periods=12, freq='M')

DatetimeIndex(['2016-01-31', '2016-02-29',…, '2016-11-30', '2016-12-31'],
              dtype='datetime64[ns]', freq='M')

In [11]: quarterly.reindex(dates)

2016-01-31    NaN
2016-02-29    NaN
2016-03-31    1.0
2016-04-30    NaN
2016-05-31    NaN
2016-06-30    2.0
2016-07-31    NaN
2016-08-31    NaN
2016-09-30    3.0
2016-10-31    NaN
2016-11-30    NaN
2016-12-31    4.0
```

`.reindex()`:

- **conform `DataFrame` to new index**
- **same filling logic as `.asfreq()`**

MANIPULATING TIME SERIES DATA IN PYTHON

Let’s practice!

MANIPULATING TIME SERIES DATA IN PYTHON

Upsampling & Interpolation with `.resample()`

Frequency Conversion & Transformation Methods

- `.resample()`: similar to `.groupby()`
- Groups data within resampling period and applies one or several methods to each group
- New date determined by `offset` - start, end, etc
- Upsampling: fill from existing or interpolate values
- Downsampling: apply aggregation to existing data

Getting started: Monthly Unemployment Rate

```
In [1]: unrate = pd.read_csv('unrate.csv', parse_dates['Date'],
                             index_col='Date')

In [2]: unrate.info()

DatetimeIndex: 208 entries, 2000-01-01 to 2017-04-01
Data columns (total 1 columns):
UNRATE    208 non-null float64 # no frequency information
dtypes: float64(1)

In [3]: unrate.head()
Out[3]:
            UNRATE
DATE
2000-01-01     4.0
2000-02-01     4.1
2000-03-01     4.0
2000-04-01     3.8
2000-05-01     4.0
```

Reporting date:
1st day of month

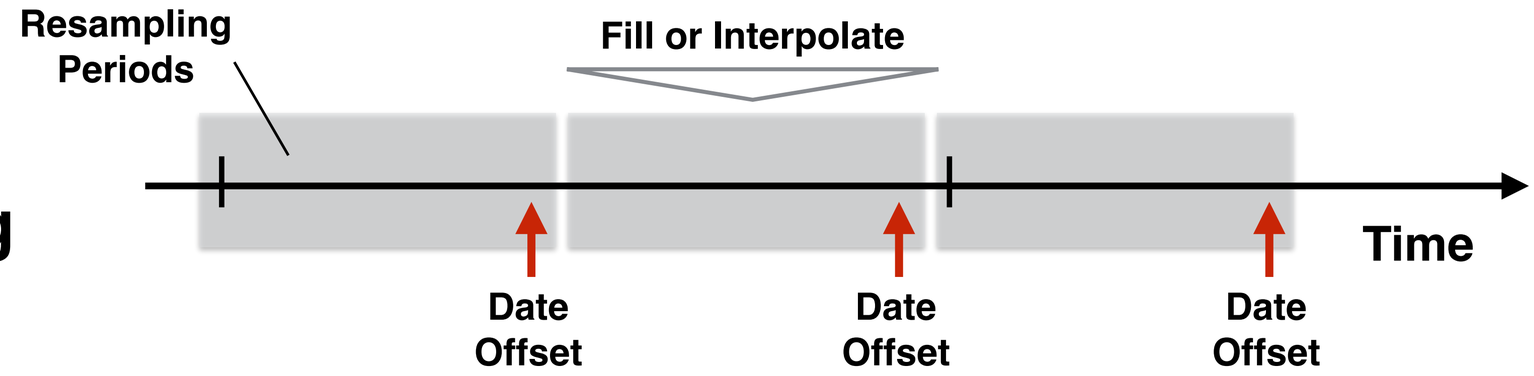
Resampling Period & Frequency Offsets

- Resample creates new date for frequency offset
- Several alternatives to calendar month end

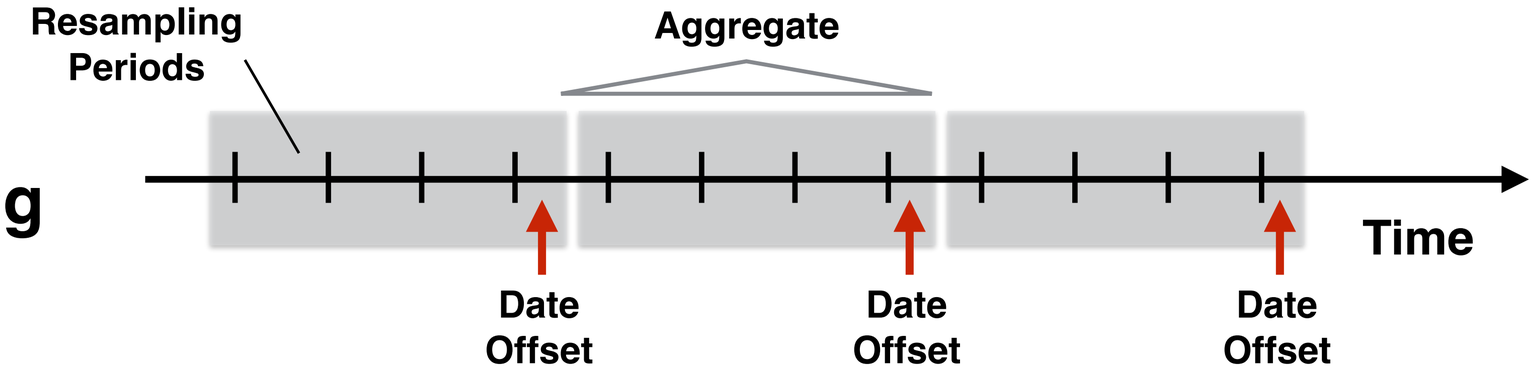
Frequency	Alias	Sample Date
Calendar Month End	M	2017-04-30
Calendar Month Start	MS	2017-04-01
Business Month End	BM	2017-04-28
Business Month Start	BMS	2017-04-03

Resampling Logic

Up sampling



Down sampling



Assign frequency with `.resample()`

```
In [4]: unrate.asfreq('MS').info()

DatetimeIndex: 208 entries, 2000-01-01 to 2017-04-01
Freq: MS
Data columns (total 1 columns):
UNRATE    208 non-null float64
dtypes: float64(1)

In [5]: unrate.resample('MS') # creates Resampler object
DatetimeIndexResampler [freq=<MonthBegin>, axis=0, closed=left,
label=left, convention=start, base=0]

In [6]: unrate.asfreq('MS').equals(unrate.resample('MS').asfreq())
True
```

`.resample()`:
returns data only when calling another method

Quarterly Real GDP Growth

```
In [7]: gdp = pd.read_csv('gdp.csv')

In [8]: gdp.info()

DatetimeIndex: 69 entries, 2000-01-01 to 2017-01-01
Data columns (total 1 columns):
gpd    69 non-null float64 # no frequency info
dtypes: float64(1)

In [9]: gdp.head(2):
             gpd
DATE
2000-01-01   1.2
2000-04-01   7.8
```

Interpolate Monthly Real GDP Growth

```
In [10]: gdp_1 = gdp.resample('MS').ffill().add_suffix('_ffill')
Out[10]:
            gpd_ffill
DATE
2000-01-01         1.2
2000-02-01         1.2
2000-03-01         1.2
2000-04-01         7.8

In [11]: gdp_2 = gdp.resample('MS').interpolate().add_suffix('_inter')

                gpd_inter
DATE
2000-01-01      1.200000
2000-02-01      3.400000
2000-03-01      5.600000
2000-04-01      7.800000
```

`.interpolate()`

- finds points on straight line between existing data

Concatenating two DataFrames

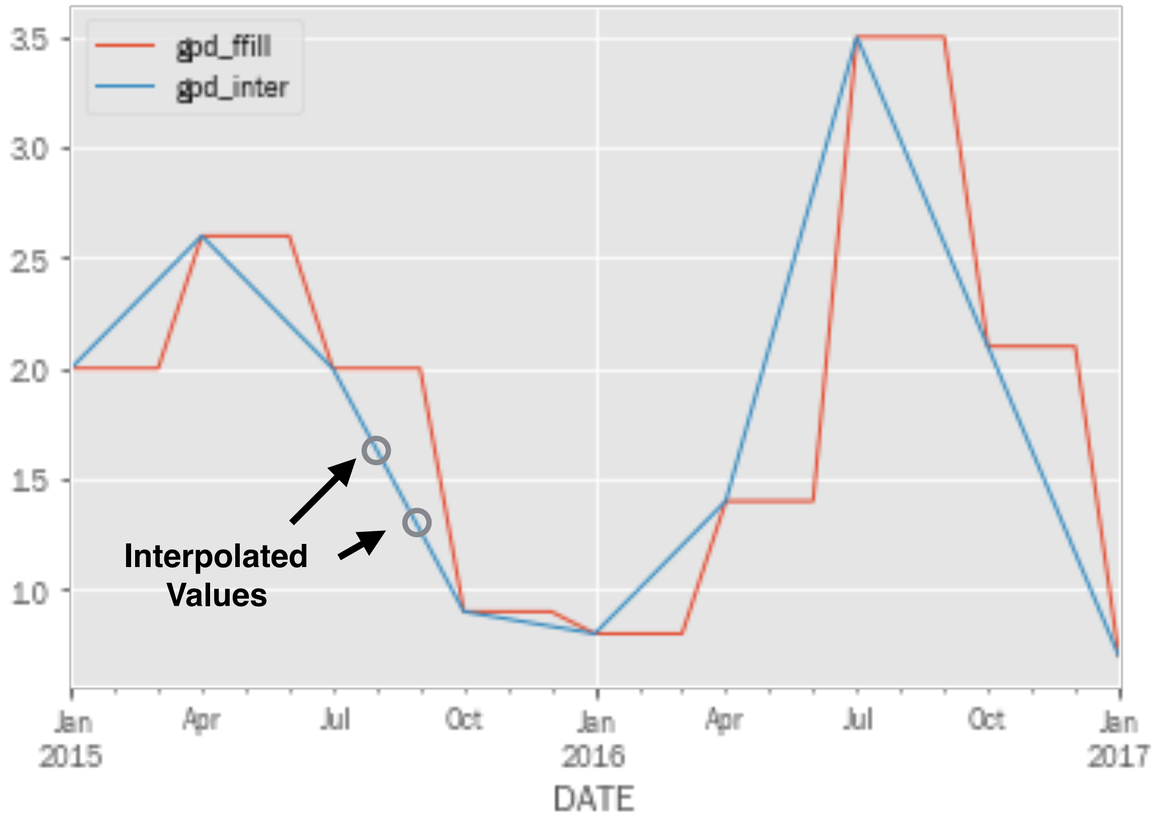
```
In [12]: df1 = pd.DataFrame([1, 2, 3], columns=['df1'])

In [13]: df2 = pd.DataFrame([4, 5, 6], columns=['df2'])

In [14]: pd.concat([df1, df2])
   df1  df2
0  1.0  NaN
1  2.0  NaN
2  3.0  NaN
0  NaN  4.0
1  NaN  5.0
2  NaN  6.0

In [15]: pd.concat([df1, df2], axis=1)
   df1  df2
0    1    4
1    2    5
2    3    6
```

axis=1:

- **concatenate horizontally**

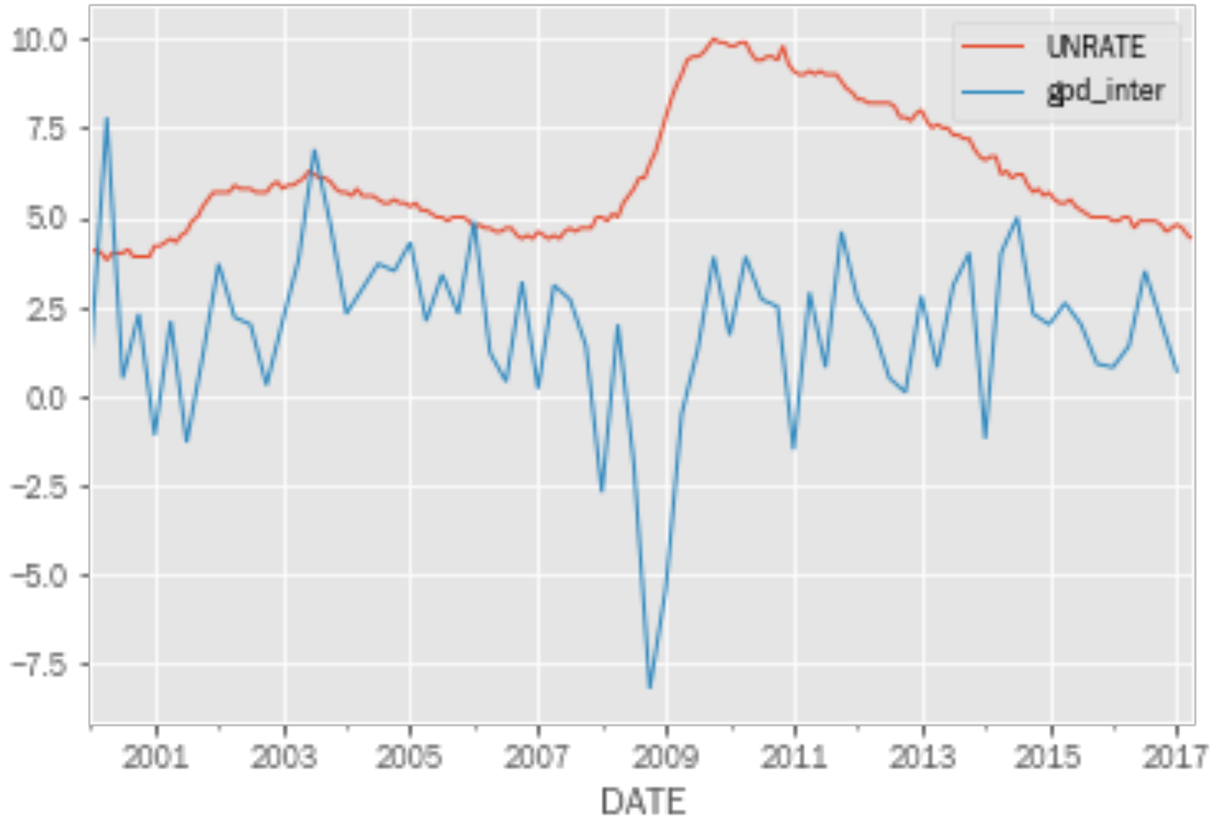
Plot Interpolated Real GDP Growth

```
In [16]: pd.concat([gdp_1, gdp_2], axis=1).loc['2015':].plot()
```



Combine GDP Growth & Unemployment

```
In [17]: pd.concat([unrate, gdp_inter], axis=1).plot();
```



MANIPULATING TIME SERIES DATA IN PYTHON

Let’s practice!

MANIPULATING TIME SERIES DATA IN PYTHON

Downsampling & Aggregation

Downsampling & Aggregation Methods

- So far: upsampling, fill logic & interpolation
- Now: downsampling
  - hour to day
  - day to month, etc
- How to represent the existing values at the new date?
- Mean, median, last value?

Air Quality: Daily Ozone Levels

```
In [1]: ozone = pd.read_csv('ozone.csv',
                            parse_dates=['date'],
                            index_col='date')
In [2]: ozone.info()

DatetimeIndex: 6291 entries, 2000-01-01 to 2017-03-31
Data columns (total 1 columns):
Ozone    6167 non-null float64
dtypes: float64(1)

In [3]: ozone = ozone.resample('D').asfreq()

In [4]: ozone.info()

DatetimeIndex: 6300 entries, 1998-01-05 to 2017-03-31
Freq: D
Data columns (total 1 columns):
Ozone    6167 non-null float64
dtypes: float64(1)
```

Creating Monthly Ozone Data

```
In [5]: ozone.resample('M').mean().head()
Out[5]:
                Ozone
date
2000-01-31  0.010443
2000-02-29  0.011817
2000-03-31  0.016810
2000-04-30  0.019413
2000-05-31  0.026535

In [6]: ozone.resample('M').median().head()
Out[6]:
                Ozone
date
2000-01-31  0.009486
2000-02-29  0.010726
2000-03-31  0.017004
2000-04-30  0.019866
2000-05-31  0.026018
```

`.resample().mean()`:
Monthly average, assigned to end of calendar month

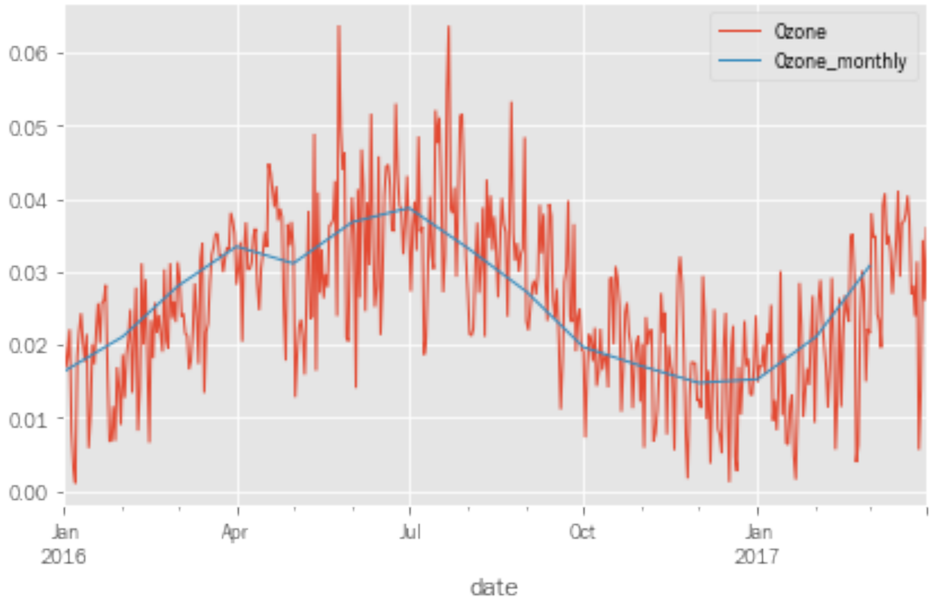
Creating Monthly Ozone Data

```
In [7]: ozone.resample('M').agg(['mean', 'std']).head()
Out[7]:
                Ozone
                 mean       std
date
2000-01-31  0.010443  0.004755
2000-02-29  0.011817  0.004072
2000-03-31  0.016810  0.004977
2000-04-30  0.019413  0.006574
2000-05-31  0.026535  0.008409
```

`.resample().agg()`:
List of aggregation functions like `groupby`

Plotting Resampled Ozone Data

```
In [8]: ozone = ozone.loc['2016':]

In [9]: ax = ozone.plot()

In [10]: monthly = ozone.resample('M').mean()

In [11]: monthly.add_suffix('_monthly').plot(ax=ax)
```



ax=ax:
Matplotlib let's you plot again on the axes object returned by the first plot

Resampling Multiple Time Series

```
In [12]: data = pd.read_csv('ozone_pm25.csv',
                            parse_dates=['date'],
                            index_col='date')

In [13]: data = data.resample('D').asfreq()

In [14]: data.info()

DatetimeIndex: 6300 entries, 2000-01-01 to 2017-03-31
Freq: D
Data columns (total 2 columns):
Ozone    6167 non-null float64
PM25     6167 non-null float64
dtypes: float64(2)
```

Resampling Multiple Time Series

```
In [16]: data = data.resample('BM').mean()

In [17]: data.info()
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 207 entries, 2000-01-31 to 2017-03-31
Freq: BM
Data columns (total 2 columns):
ozone    207 non-null float64
pm25     207 non-null float64
dtypes: float64(2)
```

Resampling Multiple Time Series

```
In [18]: df.resample('M').first().head(4)
Out[18]:
                Ozone        PM25
date
2000-01-31   0.005545   20.800000
2000-02-29   0.016139    6.500000
2000-03-31   0.017004    8.493333
2000-04-30   0.031354    6.889474

In [19]: df.resample('MS').first().head()
Out[19]:
                Ozone        PM25
date
2000-01-01   0.004032   37.320000
2000-02-01   0.010583   24.800000
2000-03-01   0.007418   11.106667
2000-04-01   0.017631   11.700000
2000-05-01   0.022628    9.700000
```

MANIPULATING TIME SERIES DATA IN PYTHON

Let’s practice!