Compare time series growth rates

MANIPULATING TIME SERIES DATA IN PYTHON

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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)

```
google = pd.read_csv('google.csv', parse_dates=['date'], index_col='date')
google.head(3)
```

```
             price
date
2010-01-04  313.06
2010-01-05  311.68
2010-01-06  303.83
```

```
first_price = google.price.iloc[0]  # int-based selection
first_price
```

iloc is easier because you don’t have to know the first available date.

```
313.06
```

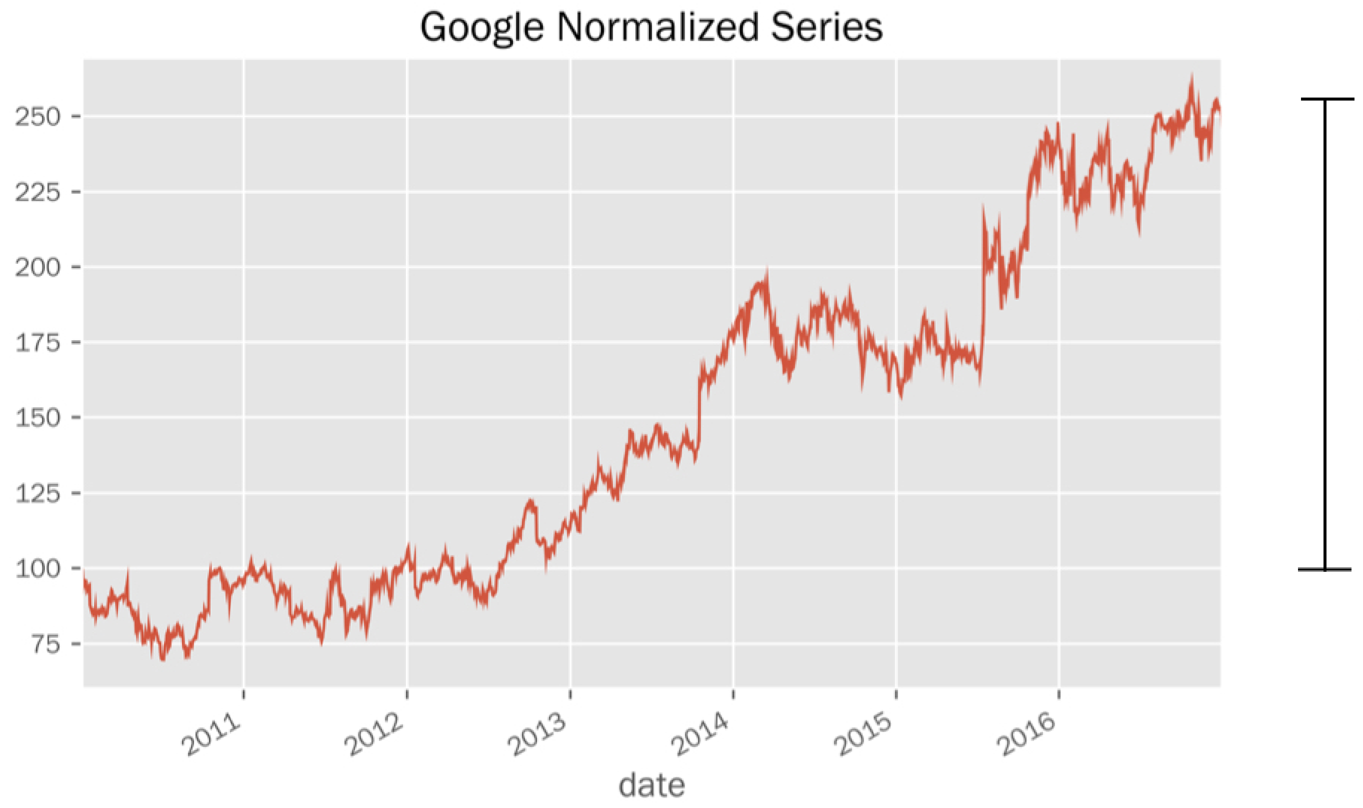
```
first_price == google.loc['2010-01-04', 'price']
```

```
True
```

Normalizing a single series (2)

```
normalized = google.price.div(first_price).mul(100)

normalized.plot(title='Google Normalized Series')
```



150 Percentage Points

Normalizing multiple series (1)

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

```
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)

```
prices.iloc[0]
```

You obtain a Series that represents the first row of the DataFrame.

```
AAPL      30.57
GOOG     313.06
YHOO      17.10
Name: 2010-01-04 00:00:00, dtype: float64
```

```
normalized = prices.div(prices.iloc[0])
normalized.head(3)
```

```
                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)

```
index = pd.read_csv('benchmark.csv', parse_dates=['date'], index_col='date')
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)
```

```
prices = pd.concat([prices, index], axis=1).dropna()
prices.info()
```

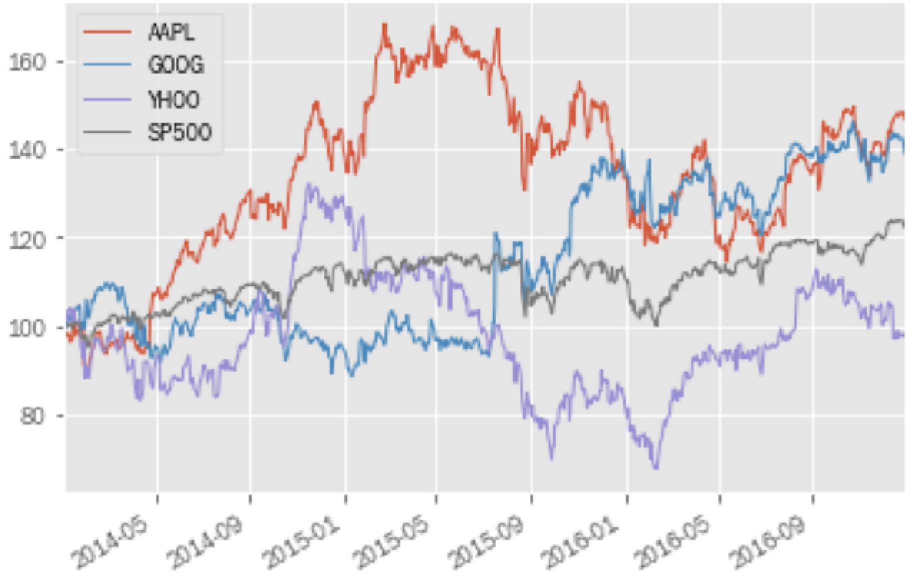
```
DatetimeIndex: 1761 entries, 2010-01-04 to 2016-12-30
Data columns (total 4 columns):
AAPL     1761 non-null float64
GOOG     1761 non-null float64
YHOO     1761 non-null float64
SP500    1761 non-null float64
dtypes: float64(4)
```

Comparing with a benchmark (2)

```
prices.head(1)
```

```
                AAPL    GOOG   YHOO    SP500
2010-01-04  30.57  313.06  17.10  1132.99
```

```
normalized = prices.div(prices.iloc[0]).mul(100)
normalized.plot()
```



Plotting performance difference

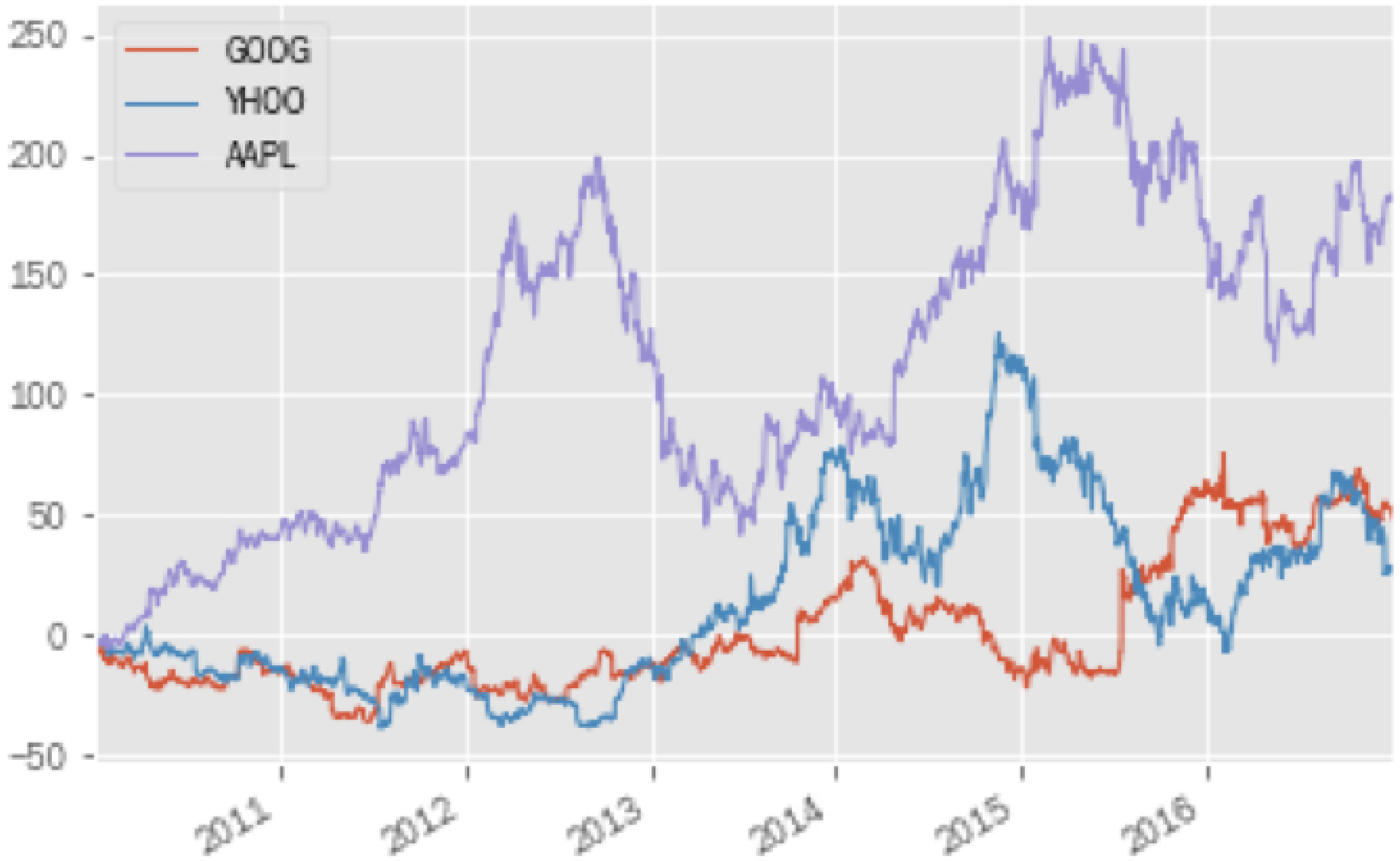
```
diff = normalized[tickers].sub(normalized['SP500'], axis=0)
```

```
                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
```

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

Plotting performance difference

```
diff.plot()
```



Let's practice!

MANIPULATING TIME SERIES DATA IN PYTHON

Changing the time series frequency: resampling

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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

```
dates = pd.date_range(start='2016', periods=4, freq='Q')
data = range(1, 5)
quarterly = pd.Series(data=data, index=dates)
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

```
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
```

- Upsampling creates missing values

```
monthly = monthly.to_frame('baseline') # to DataFrame
```

You can convert a Series to a DataFrame by applying the to_frame() method, passing a column name as parameter.

Upsampling: fill methods

```
monthly['ffill'] = quarterly.asfreq('M', method='ffill')
monthly['bfill'] = quarterly.asfreq('M', method='bfill')
monthly['value'] = quarterly.asfreq('M', fill_value=0)
```

Upsampling: fill methods

- `bfill` : backfill
- `ffill` : forward fill propagate any value into the future if the future contains missing values

```
            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
```

Add missing months: .reindex()

```
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')
```

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

```
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
```

Let's practice!

Upsampling & interpolation with .resample()

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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

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

```
unrate.head()
```

```
            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
```

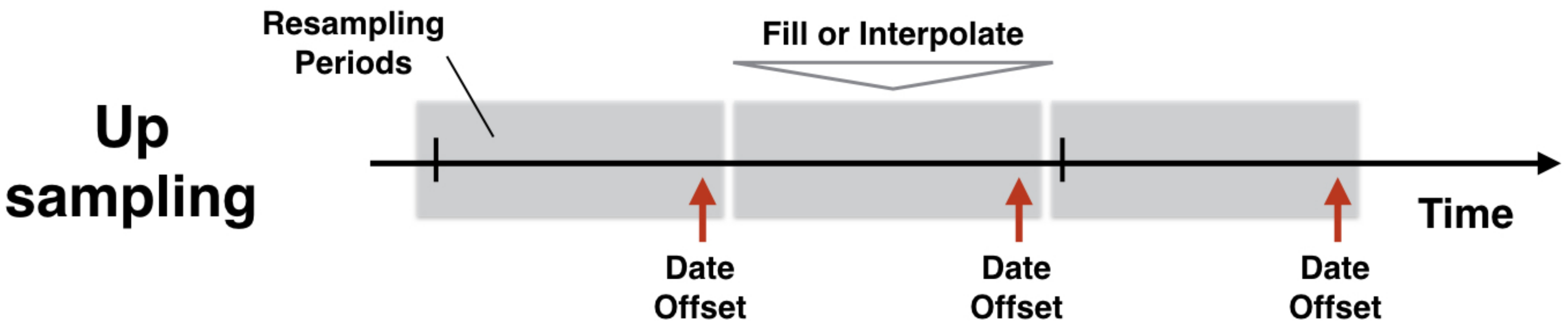
- Reporting date: 1st day of month

Resampling Period & Frequency Offsets

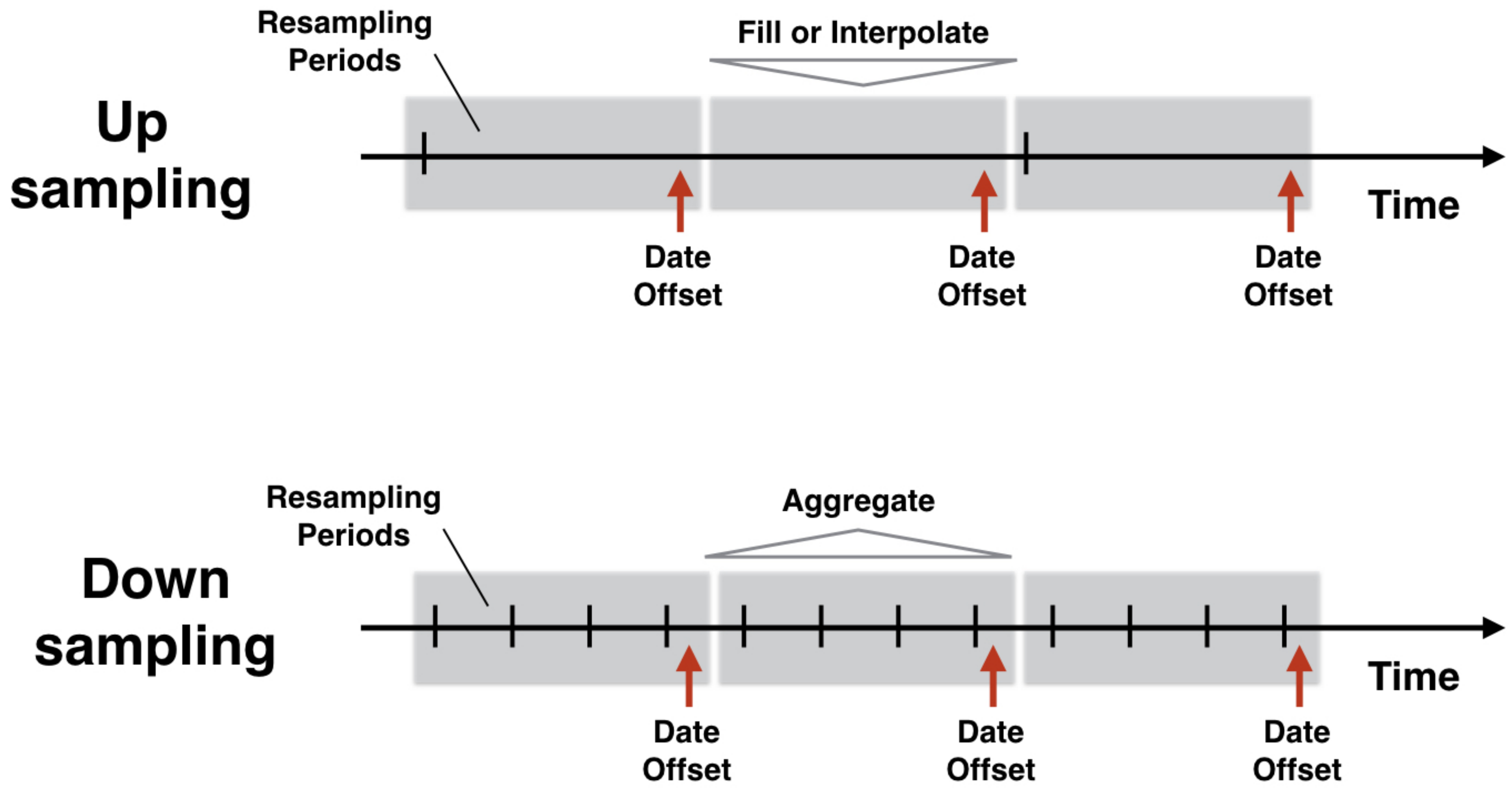
- Resample creates new date for frequency offset
- Several alternatives to calendar month end

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



Resampling logic



Assign frequency with .resample()

```
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)
```

```
unrate.resample('MS') # creates Resampler object
```

```
DatetimeIndexResampler [freq=<MonthBegin>, axis=0, closed=left,
                        label=left, convention=start, base=0]
```

Assign frequency with .resample()

```
unrate.asfreq('MS').equals(unrate.resample('MS').asfreq())
```

You can apply the asfreq method to just assign the data to their offset without modification.

```
True
```

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

Quarterly real GDP growth

```python
gdp = pd.read_csv('gdp.csv')
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)
```

```python
gdp.head(2)
```

```
            gpd
DATE
2000-01-01  1.2
2000-04-01  7.8
```

Interpolate monthly real GDP growth

```
gdp_1 = gdp.resample('MS').ffill().add_suffix('_ffill')
```

```
       gpd_ffill
DATE
2000-01-01   1.2
2000-02-01   1.2
2000-03-01   1.2
2000-04-01   7.8
```

Interpolate monthly real GDP growth

```
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

```
df1 = pd.DataFrame([1, 2, 3], columns=['df1'])
df2 = pd.DataFrame([4, 5, 6], columns=['df2'])
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
```

Concatenating two DataFrames

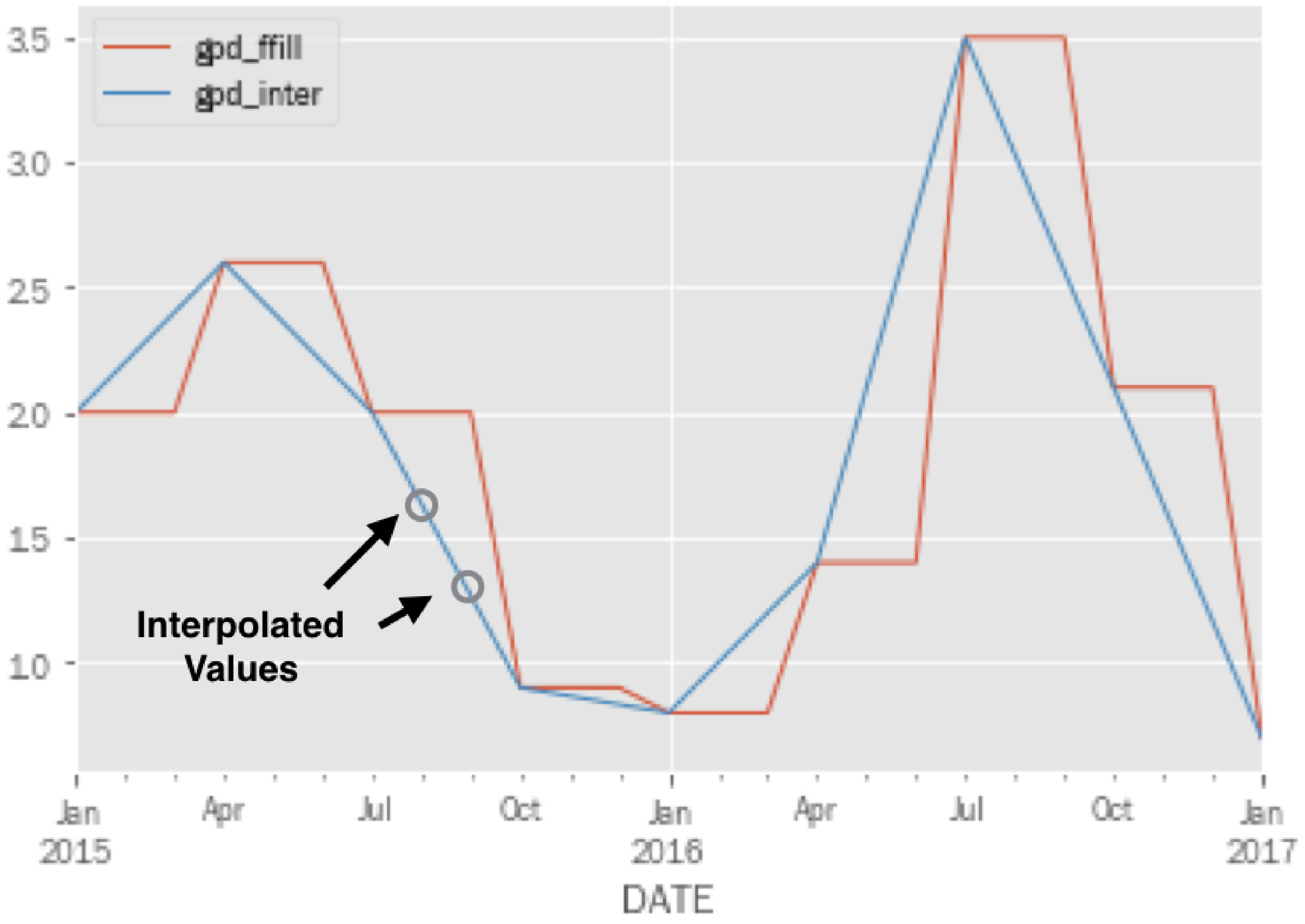
```
pd.concat([df1, df2], axis=1)
```

```
   df1  df2
0    1    4
1    2    5
2    3    6
```

- `axis=1` : concatenate horizontally

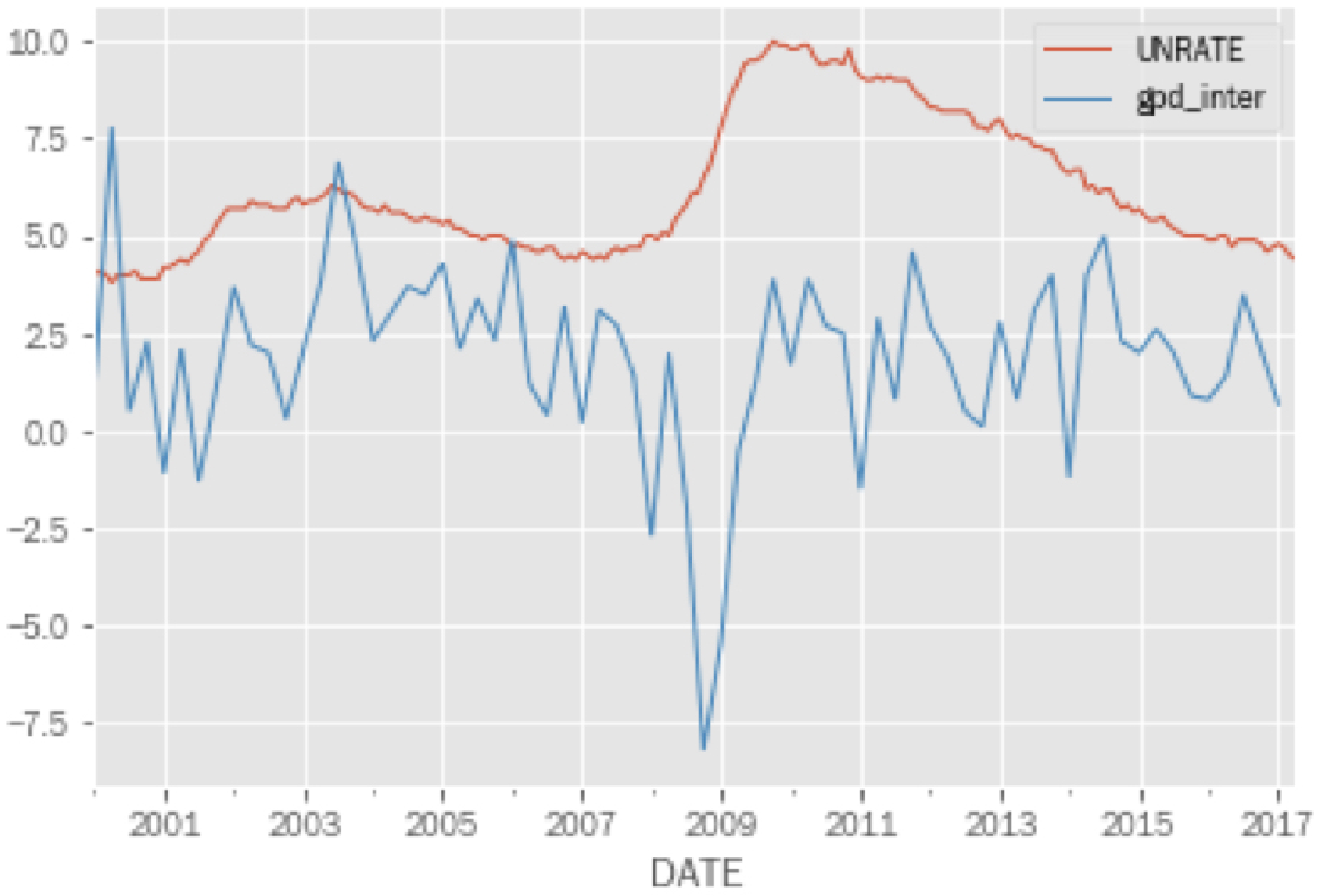
Plot interpolated real GDP growth

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



Combine GDP growth & unemployment

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



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Downsampling & aggregation

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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

```
ozone = pd.read_csv('ozone.csv',
                     parse_dates=['date'],
                     index_col='date')
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)
```

```
ozone = ozone.resample('D').asfreq()
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

```
ozone.resample('M').mean().head()
```

```
             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
```

```
ozone.resample('M').median().head()
```

```
             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

```
ozone.resample('M').agg(['mean', 'std']).head()
```

```
               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

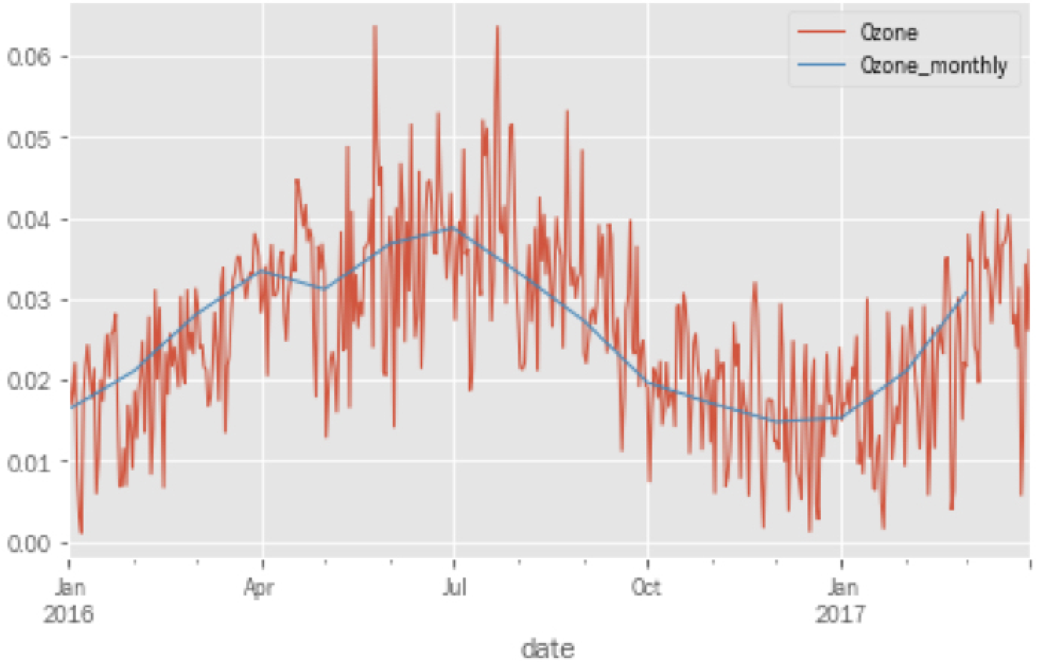
Plotting resampled ozone data

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

ax = ozone.plot()

monthly = ozone.resample('M').mean()

monthly.add_suffix('_monthly').plot(ax=ax)
```



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

The resampled data are much smoother since the monthly volatility has been averaged out.

Resampling multiple time series

```
data = pd.read_csv('ozone_pm25.csv',
                   parse_dates=['date'],
                   index_col='date')
data = data.resample('D').asfreq()
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

```
data = data.resample('BM').mean()

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

```
df.resample('M').first().head(4)
```

Pandas provides first and last methods that allow you to select the first or last value from the resampling period to represent the group.

```
               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
```

```
df.resample('MS').first().head()
```

```
               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
```

Let's practice!

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