KŌNIGSWEG

Introduction to Pandas and Time Series Analysis

60 minutes director's cut incl. deleted scenes

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KŌNIGSWEG

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Origin und Goals

- Open Source Python Library
- practical real-world data analysis - fast, efficient & easy
- gapless workflow (no switching to e.g. *R* language)
- 2008 started by Wes McKinney,

  now PyData stack at Continuum Analytics ("Anaconda")
- very stable project with regular updates
- https://github.com/pydata/pandas

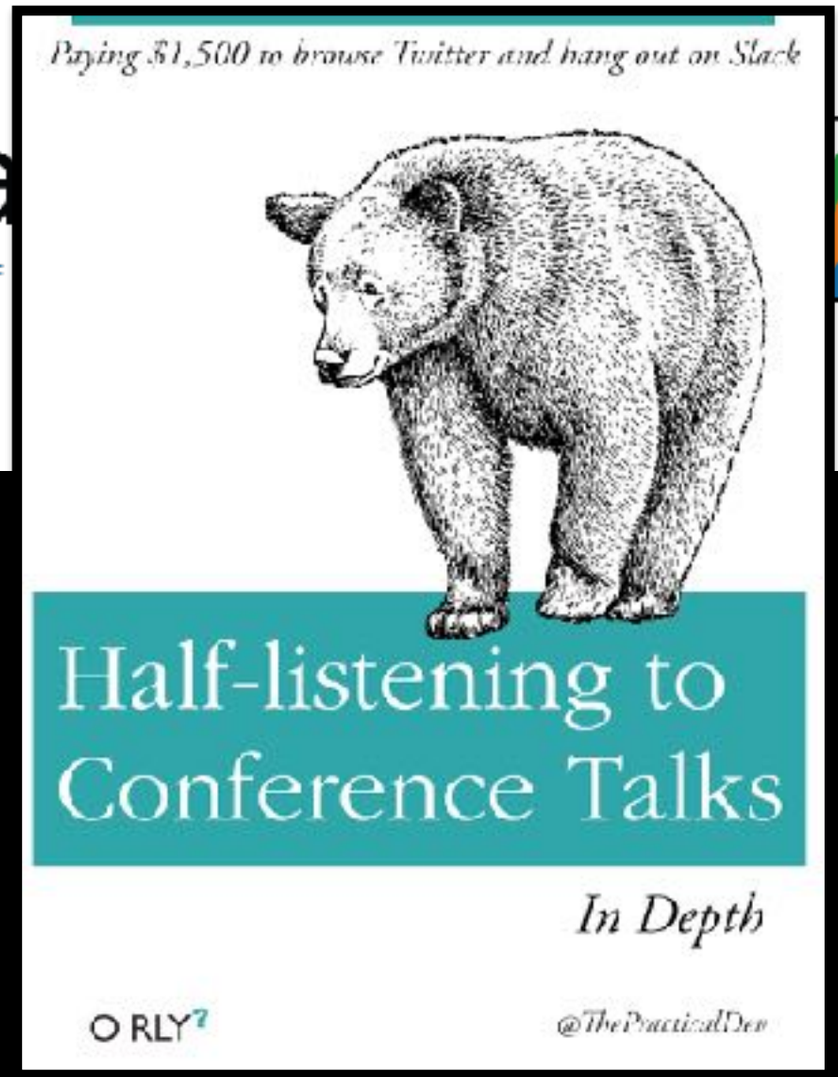
Main Features

- Support for CSV, Excel, JSON, SQL, SAS, clipboard, HDF5,...
- Data cleansing
- Re-shape & merge data (joins & merge) & pivoting
- Data Visualisation
- Well integrated in Jupyter (iPython) notebooks
- Database-like operations
- Performant

Today

Part 1:

Basic functionality of Pandas



Part 2:

A deeper look at the index with the TimeSeries Index

Git featuring this presentation's code examples:
https://github.com/Koenigsweg/data-timeseries-analysis-with-pandas

2014-08-10T05:00:00,14
2014-08-21T22:50:00,12.0
2014-08-17T13:20:00,16.0
2014-08-06T01:20:00,14.0
2014-09-27T06:50:00,11.0
2014-08-25T21:50:00,13.0
2014-08-14T05:20:00,13.0
2014-09-14T05:20:00,16.0
2014-08-03T02:50:00,21.0
2014-09-29T03:00:00,13
2014-09-06T08:20:00,16.0
2014-08-19T07:20:00,13.0
2014-09-27T22:50:00,10.0
2014-08-28T08:20:00,12.0
2014-08-17T01:00:00,14
2014-09-27T14:00:00,17
2014-09-10T18:00:00,18
2014-09-22T23:00:00,8
2014-09-20T03:00:00,9
2014-08-29T09:50:00,16.0
2014-08-16T01:50:00,13.0
2014-08-28T22:00:00,14
2014-08-03T08:50:00,23.0

In [1]:
```
import pandas as pd
```

In [4]:
```
# read data from file
# Aarhus, Denmark (Open Data Aarhus)

df = pd.read_csv('raw_weather_data_aug_sep_2014/tempm.csv', header=None)
df.head(5)
```

Out[4]:

	0	1
0	2014-09-26T03:50:00	14.0
1	2014-08-10T05:00:00	14.0
2	2014-08-21T22:50:00	12.0
3	2014-08-17T13:20:00	16.0
4	2014-08-06T01:20:00	14.0

In [ ]:

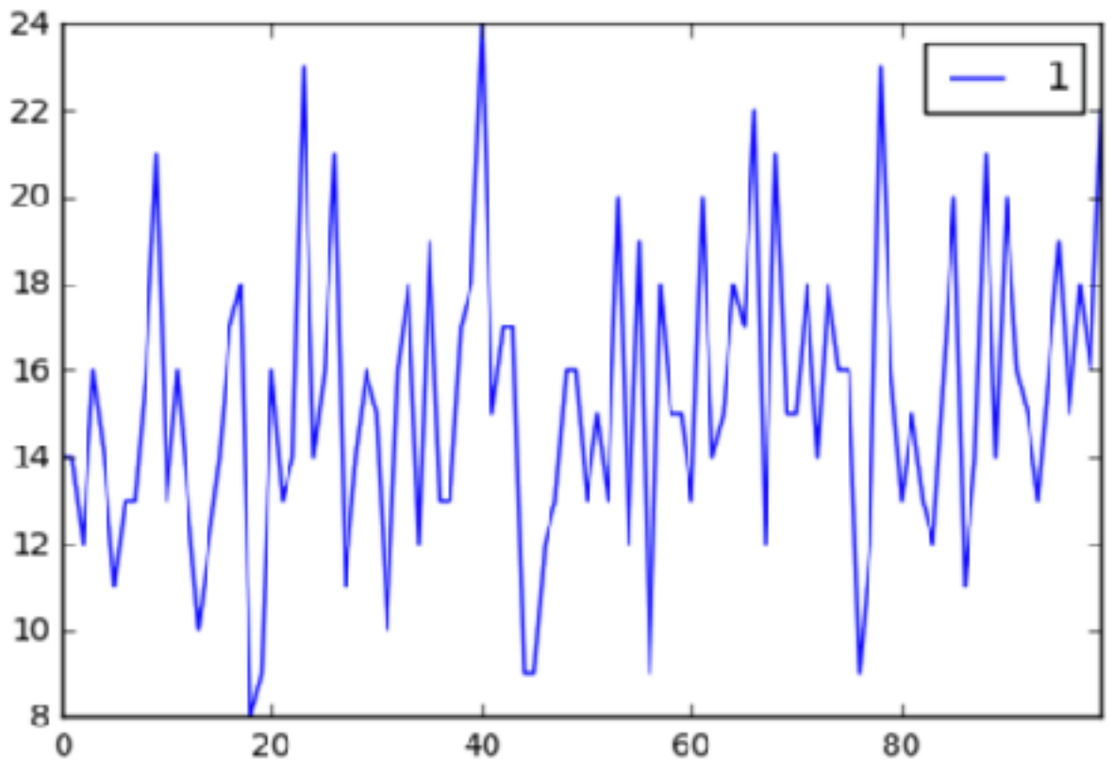
I/O and viewing data

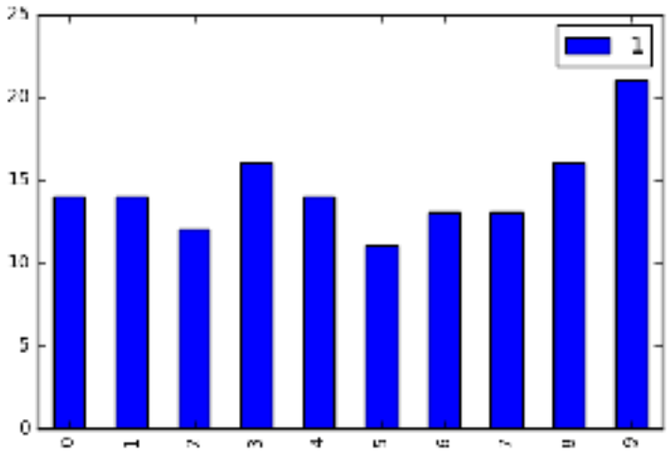
- convention `import pandas as pd`
- *example:* `pd.read_csv()`
  - very flexible, ~40 *optional* parameters included
    (*delimiter, header, dtype, parse_dates,...*)
- preview data with
  `.head(#number of lines)` and
  `.tail(#number of lines)`

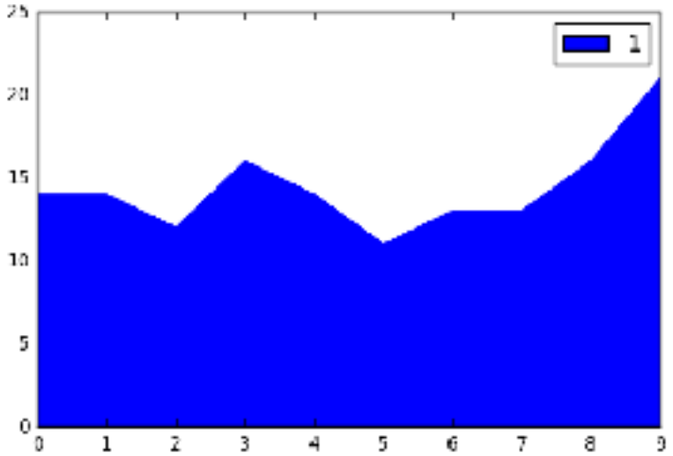
In [4]:
```
import matplotlib
%matplotlib inline
```

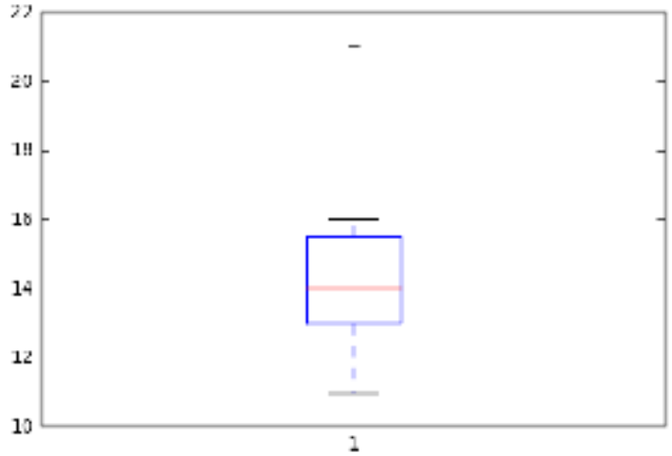
In [11]:
```
df[:100].plot()
```

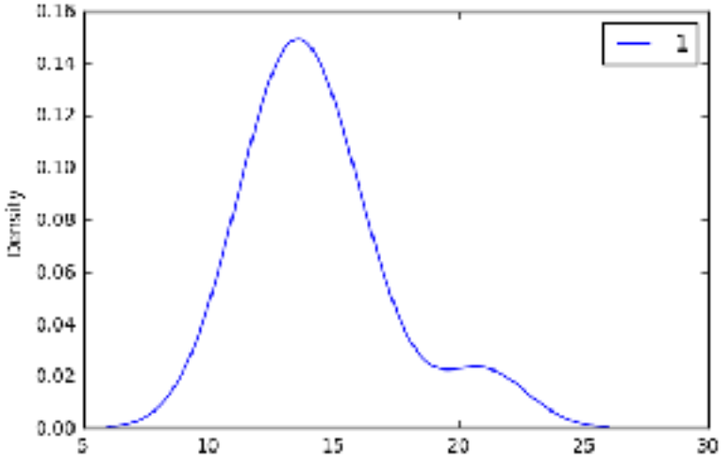
Out[11]: <matplotlib.axes._subplots.AxesSubplot at 0x10bb13f98>



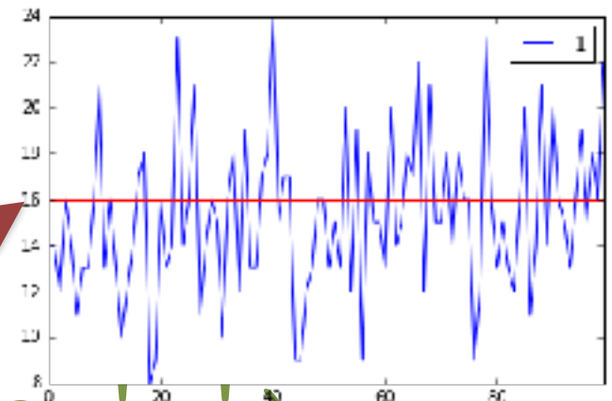









```
df.plot(kind='bar')
```

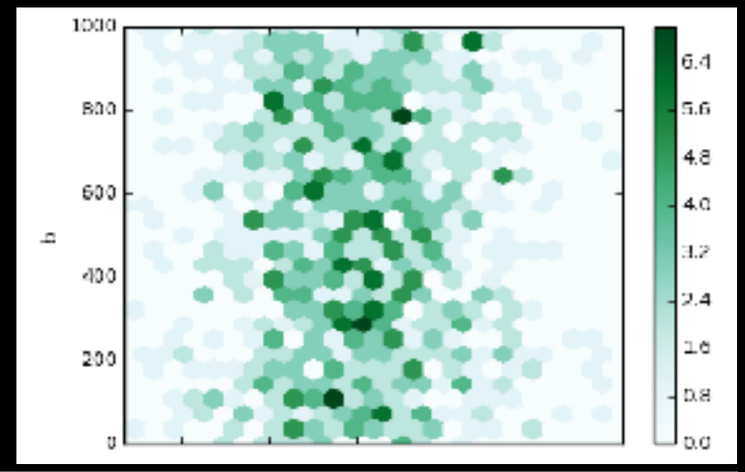


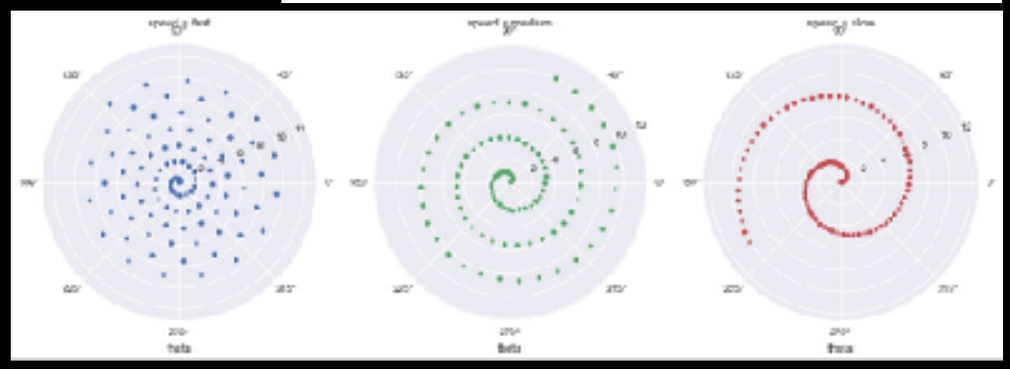

```
ax = df[:100].plot()

ax.axhline(16, color='r', linestyle='-')
```

Visualisation

- matplotlib (http://matplotlib.org) integrated, `.plot()`
- custom- and extendable, `plot()` returns `ax`
- Bar-, Area-, Scatter-, Boxplots u.a.





- *Alternatives*:

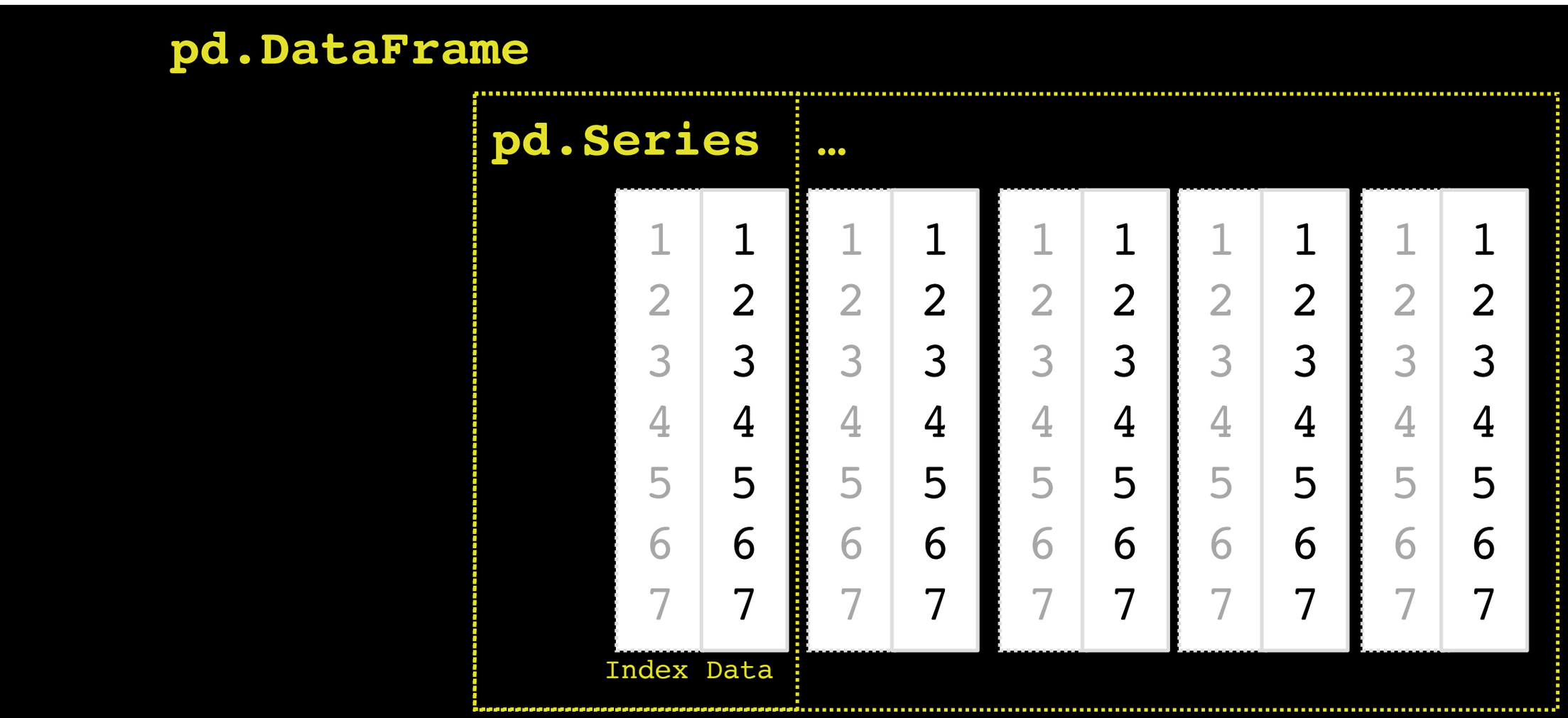
  Bokeh (http://bokeh.pydata.org/en/latest/)

  Seaborn (https://stanford.edu/~mwaskom/software/seaborn/index.html)

pandas

$$y_i t = \beta' x_{it} + \mu_i + \epsilon_{it}$$

Structure



Structure: DataSeries

- one dimensional, labeled series, may contain any data type
- the label of the series is usually called **`index`**
- **`index`** automatically created if not given
- **One** data type,

  datatype can be set or transformed dynamically in a

  pythonic fashion

  also be explicitly set

```
In [41]: series = pd.Series(np.random.rand(n))
         series
```

```
Out[41]: 0    0.183418
         1    0.836998
         2    0.045299
         3    0.894486
         4    0.433939
         dtype: float64
```

simple series, auto data type auto, index auto

```
In [42]: series = pd.Series(np.random.randint(1, 5, n))
         series
```

```
Out[42]: 0    4
         1    3
         2    3
         3    3
         4    4
         dtype: int64
```

simple series, auto data type, index auto

```
In [43]: series = pd.Series(np.random.randint(1, 5, n), dtype=np.float64)
         series
```

```
Out[43]: 0    2.0
         1    3.0
         2    4.0
         3    1.0
         4    4.0
         dtype: float64
```

simple series, auto **data type set**, index auto

```
In [48]: series = pd.Series(np.random.randint(1, 5, n), dtype=np.float64, index=[n*x for x in range(n)])
         series
```

```
Out[48]: 0     3.0
         5     3.0
         10    1.0
         15    2.0
         20    4.0
         dtype: float64
```

simple series, auto **data type set**, ***numerical*** **index given**

```
In [79]: series = pd.Series(np.random.randint(1, 100, n), dtype=np.float64, index=list('ABCDEFGHIJKLMNOPQRSTUVWXYZ')[:n])
         series
```

```
Out[79]: A    71.0
         B    60.0
         C    75.0
         D    18.0
         E    77.0
         dtype: float64
```

simple series, auto **data type set**, ***text-label*** **index given**

```
In [80]: series['A']
Out[80]: 71.0
```

access via index / **label**

```
In [81]: series[0]
Out[81]: 71.0
```

access via index / **position**

```
In [82]: series[['A', 'D']]
Out[82]: A    71.0
         D    18.0
         dtype: float64
```

access **multiple** via index / **label**

```
In [83]: series[1:3]
Out[83]: B    60.0
         C    75.0
         dtype: float64
```

access **multiple** via index / **position range**

```
In [84]: series[[1, 3]]
Out[84]: B    60.0
         D    18.0
         dtype: float64
```

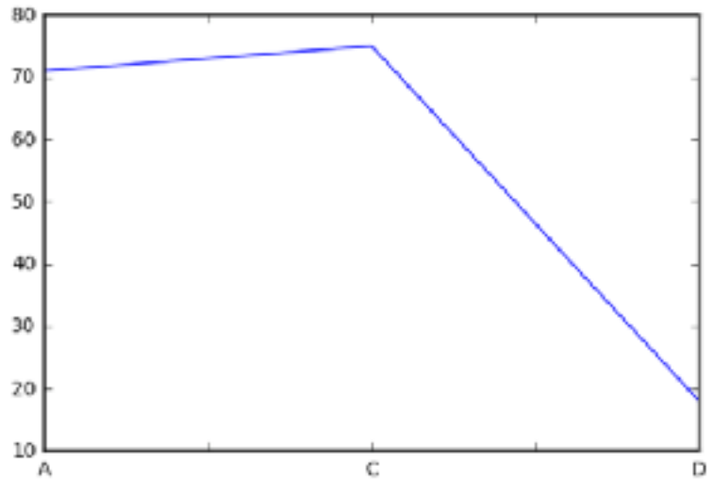
access **multiple** via index / **multiple positions**

```
In [85]: series[lambda x: x%2 == 0]
Out[85]: B    60.0
         D    18.0
         dtype: float64
```

access via **boolean index / lambda function**

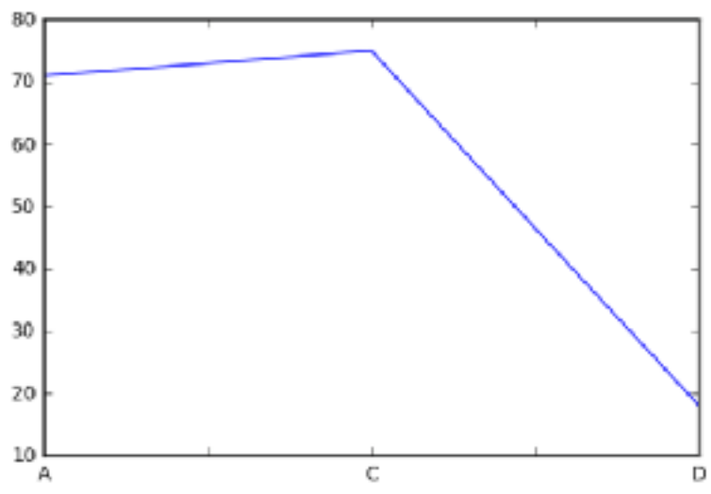
```
A    71.0
B    60.0
C    75.0
D    18.0
E    77.0
dtype: float64
```

```
In [90]: ax = series.loc[['A', 'C', 'D']].plot()
```



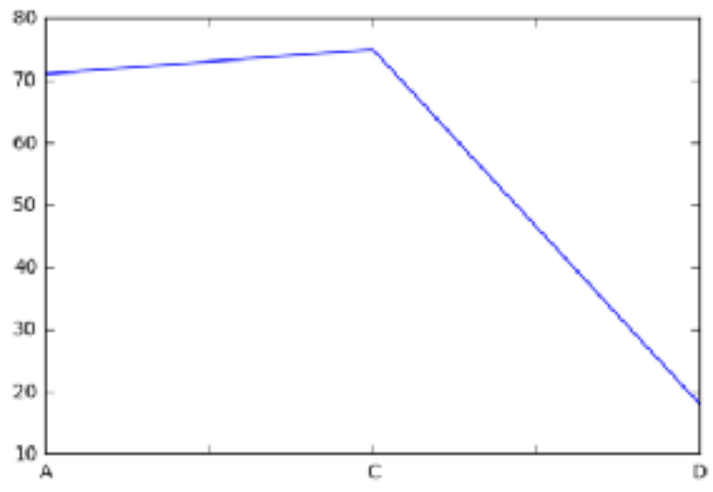
`.loc()`
index label

```
In [91]: ax = series.iloc[[0, 2, 3]].plot()
```



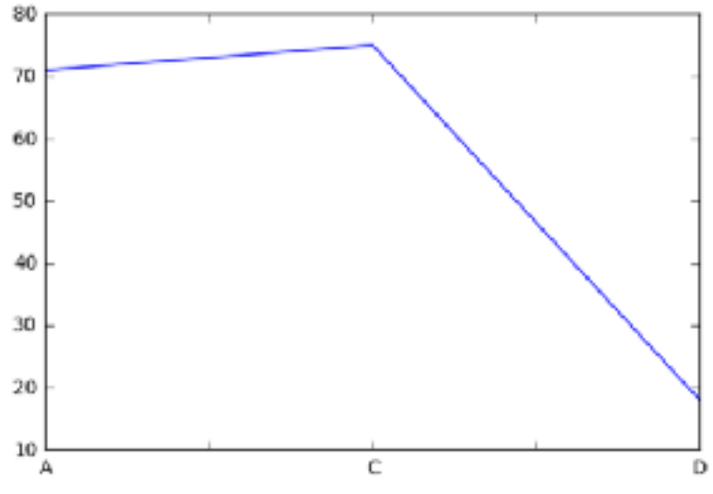
`.iloc()`
index position

```
In [94]: ax = series.ix[['A', 'C', 'D']].plot()
```



`.ix()`
index *guessing*
label/position
fallback

```
In [95]: ax = series.ix[[0, 2, 3]].plot()
```



```
In [100]: series.sample(2)

Out[100]: B    60.0
          A    71.0
          Name: some data, dtype: float64
```

`.sample()`
sampling data set

```
In [97]: series.name = "some data"
         series

Out[97]: A    71.0
         B    60.0
         C    75.0
         D    18.0
         E    77.0
         Name: some data, dtype: float64
```

`.name`
(column) names

Selecting Data

- Slicing
- Boolean indexing

series[x], series[[x, y]]

series[2], series[[2, 3]], series[2:3]

series.ix() / .iloc() / .loc()

series.sample()

Structure: DataFrame

- **Two**dimensional, labeled data structure of e. g.
  - DataSeries
  - 2-D numpy.ndarray
  - other DataFrames
- **`index`** automatically created if not given

Structure: Index

- Index
  - automatically created if not given
  - can be reset or replaced
  - types: position, timestamp, time range, labels,...
  - one or more dimensions
  - may contain a value more than once (NOT UNIQUE!)

Examples

- work with series / calculation
- create and add a new series
- how to deal with null (NaN) values
- method calls directly from Series/ DataFrames

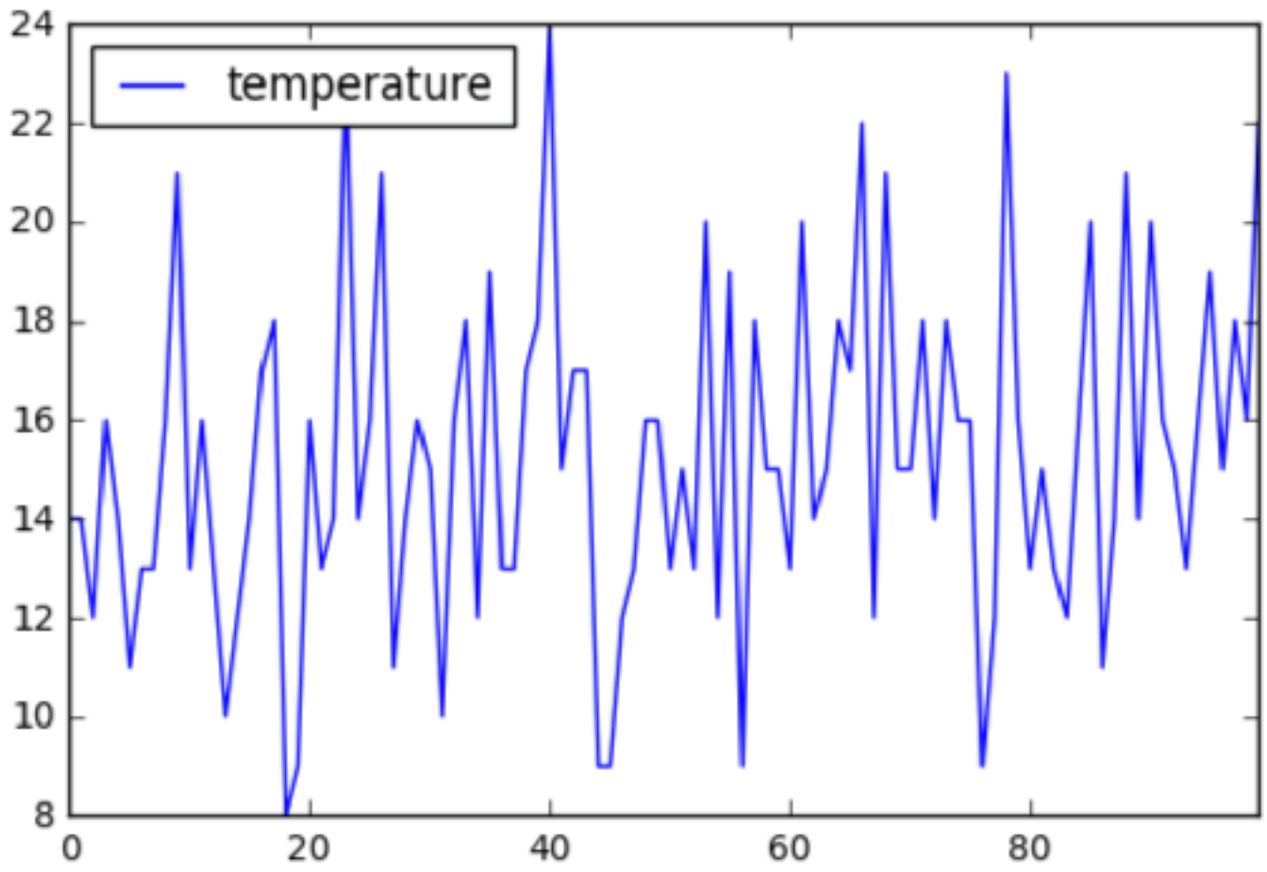
In [16]:
```
df.columns = ['timestamp', 'temperature']
df.head(3)
```

Out[16]:

	timestamp	temperature
0	2014-09-26T03:50:00	14.0
1	2014-08-10T05:00:00	14.0
2	2014-08-21T22:50:00	12.0

In [17]:
```
df[:100].plot()
```

Out[17]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x10c39a0b8>
```



In [13]:
```
def to_fahrenheit(celsius):
    return (celsius * 9./5.) + 32.
```

In [14]:
```
df['temperature'].map(to_fahrenheit)[:5]
```

Out[14]:
```
0    57.2
1    57.2
2    53.6
3    60.8
4    57.2
Name: temperature, dtype: float64
```

In [15]:
```
df['temperature F'] = df['temperature'].map(to_fahrenheit)
df.head(5)
```

Out[15]:

	timestamp	temperature	temperature F
0	2014-09-26T03:50:00	14.0	57.2
1	2014-08-10T05:00:00	14.0	57.2
2	2014-08-21T22:50:00	12.0	53.6
3	2014-08-17T13:20:00	16.0	60.8
4	2014-08-06T01:20:00	14.0	57.2

In [16]:
```
df['temperature F'] = df['temperature'].apply(lambda x: (x * 9./5.) + 32.)
df.head()
```

Out[16]:

	timestamp	temperature	temperature F
0	2014-09-26T03:50:00	14.0	57.2
1	2014-08-10T05:00:00	14.0	57.2
2	2014-08-21T22:50:00	12.0	53.6
3	2014-08-17T13:20:00	16.0	60.8
4	2014-08-06T01:20:00	14.0	57.2

In [17]:
```
df['ruleoftumb'] = df['temperature F'] / df['temperature']
df.head()
```

Out[17]:

	timestamp	temperature	temperature F	ruleoftumb
0	2014-09-26T03:50:00	14.0	57.2	4.085714
1	2014-08-10T05:00:00	14.0	57.2	4.085714
2	2014-08-21T22:50:00	12.0	53.6	4.466667
3	2014-08-17T13:20:00	16.0	60.8	3.800000
4	2014-08-06T01:20:00	14.0	57.2	4.085714

In [18]:
```
df['ruleoftumb'].describe()
```

Out[18]:
```
count    4356.000000
mean        3.988146
std         0.709771
min         2.985185
25%         3.577778
50%         3.933333
75%         4.261538
max        17.800000
Name: ruleoftumb, dtype: float64
```

In [19]:
```
df.rename(columns={'ruleoftumb': 'bad_rule'}, inplace=True)
df.head()
```

Out[19]:

	timestamp	temperature	temperature F	bad_rule
0	2014-09-26T03:50:00	14.0	57.2	4.085714
1	2014-08-10T05:00:00	14.0	57.2	4.085714
2	2014-08-21T22:50:00	12.0	53.6	4.466667
3	2014-08-17T13:20:00	16.0	60.8	3.800000
4	2014-08-06T01:20:00	14.0	57.2	4.085714

In [20]:
```
df.drop('bad_rule', axis=1, inplace=True)
df.head()
```

Out[20]:

	timestamp	temperature	temperature F
0	2014-09-26T03:50:00	14.0	57.2
1	2014-08-10T05:00:00	14.0	57.2
2	2014-08-21T22:50:00	12.0	53.6
3	2014-08-17T13:20:00	16.0	60.8
4	2014-08-06T01:20:00	14.0	57.2

Modifying Series/DataFrames

- Methods applied to Series or DataFrames **do not change** them, but **return** the result as Series or DataFrames
- With parameter `inplace` the result can be deployed directly into Series / DataFrames
- Series can be removed from DF with `drop()`

In [21]:
```
df.groupby('temperature').count()
```

Out[21]:

	timestamp	temperature F
temperature		
2.0	1	1
3.0	8	8
4.0	1	1
5.0	6	6
6.0	7	7
7.0	25	25
8.0	29	29
9.0	69	69
10.0	143	143
11.0	233	233
12.0	242	242
13.0	455	455
14.0	552	552
15.0	464	464
16.0	504	504
17.0	368	368
18.0	371	371

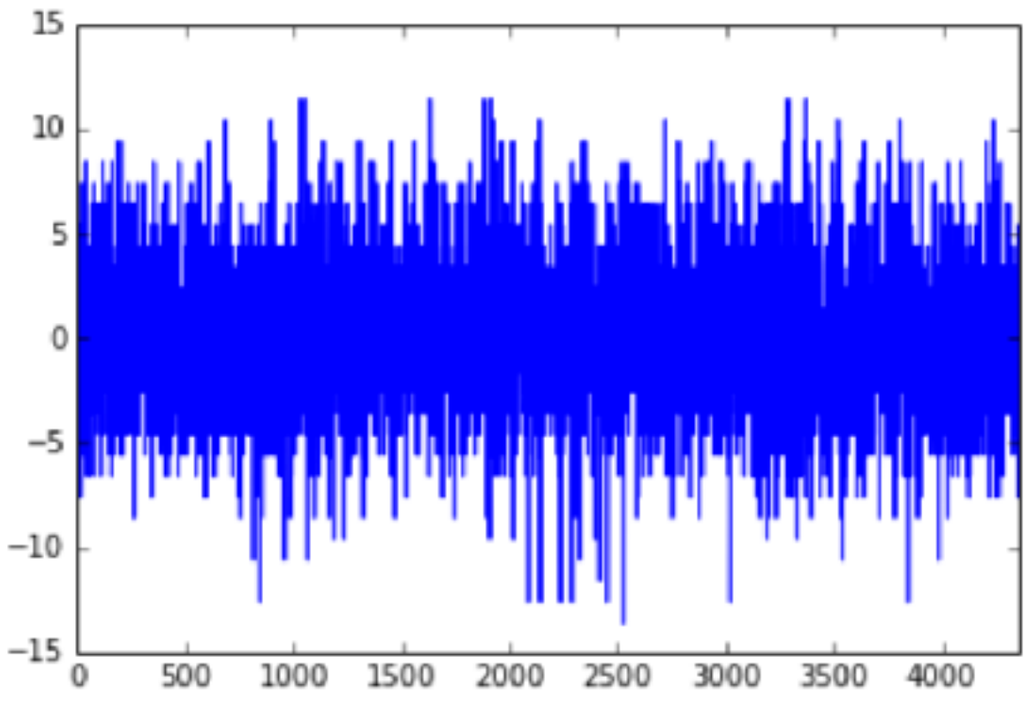
In [22]:
```
df['deviation'] = df['temperature'] - df['temperature'].mean()
df.head()
```

Out[22]:

	timestamp	temperature	temperature F	deviation
0	2014-09-26T03:50:00	14.0	57.2	-1.59045
1	2014-08-10T05:00:00	14.0	57.2	-1.59045
2	2014-08-21T22:50:00	12.0	53.6	-3.59045
3	2014-08-17T13:20:00	16.0	60.8	0.40955
4	2014-08-06T01:20:00	14.0	57.2	-1.59045

In [23]:
```
df['deviation'].plot()
```

Out[23]: <matplotlib.axes._subplots.AxesSubplot at 0x114a07c88>



In [31]:
```
df['timestamp'].describe()
# get info, text = object
```

Out[31]:
```
count                    4357
unique                   4357
top       2014-08-04T21:50:00
freq                        1
Name: timestamp, dtype: object
```

In [32]:
```
df['temperature'].describe()
# get basic stats
```

Out[32]:
```
count    4354.000000
mean       15.590951
std         3.596220
min         2.000000
25%        13.000000
50%        15.000000
75%        18.000000
max        27.000000
Name: temperature, dtype: float64
```

In [93]:
```
df.describe(percentiles=[.1, .5, .6, .7])
# get basic stats
```

Out[93]:

	temperature	temperature F	deviation	weekday
count	4354.000000	4354.000000	4.354000e+03	4354.000000
mean	15.590951	60.063712	5.548565e-16	3.024575
std	3.596220	6.473197	3.596220e+00	2.029326
min	2.000000	35.600000	-1.359095e+01	0.000000
10%	11.000000	51.800000	-4.590951e+00	0.000000
50%	15.000000	59.000000	-5.909508e-01	3.000000
60%	16.000000	60.800000	4.090492e-01	4.000000
70%	17.000000	62.600000	1.409049e+00	4.000000
max	27.000000	80.600000	1.140905e+01	6.000000

In [92]:
```
df.describe(percentiles=[.1, .5, .6, .7], include=[np.float64])
# get basic stats
```

Out[92]:

	temperature	temperature F	deviation
count	4354.000000	4354.000000	4.354000e+03
mean	15.590951	60.063712	5.548565e-16
std	3.596220	6.473197	3.596220e+00
min	2.000000	35.600000	-1.359095e+01
10%	11.000000	51.800000	-4.590951e+00
50%	15.000000	59.000000	-5.909508e-01
60%	16.000000	60.800000	4.090492e-01
70%	17.000000	62.600000	1.409049e+00
max	27.000000	80.600000	1.140905e+01

Data Aggregation

- describe()
- groupby()
- groupby([]) & unstack()
- mean(), sum(), median(),...

In [35]:
```
df[df['temperature'].isnull()]
```

Out[35]:

	timestamp	temperature	temperature F	deviation
timestamp				
2014-09-09 03:50:00	2014-09-09T03:50:00	NaN	NaN	NaN
2014-09-15 10:00:00	2014-09-15T10:00:00	NaN	NaN	NaN
2014-08-27 05:00:00	2014-08-27T05:00:00	NaN	NaN	NaN

In [37]:
```
df['temperature'].isnull()[2350:2357]
```

Out[37]:
```
timestamp
2014-08-24 10:20:00    False
2014-09-14 02:20:00    False
2014-09-29 05:00:00    False
2014-08-10 12:00:00    False
2014-08-27 05:00:00     True
2014-09-28 12:50:00    False
2014-08-05 01:00:00    False
Name: temperature, dtype: bool
```

In [38]:
```
df['temperature'].isnull().any()
```

Out[38]:
```
True
```

In [38]:
```
df.dropna()
df['temperature'].isnull().any()
```

Out[38]: True

In [39]:
```
df.dropna(inplace=True)
df['temperature'].isnull().any()
```

Out[39]: False

NaN Values & Replacing

- NaN is representation of `null` values
- series`.describe()` ignore NaN
- NaNs:
  - remove `drop()`
  - replace with default
  - forward- or backwards-fill, interpolate

End Part 1

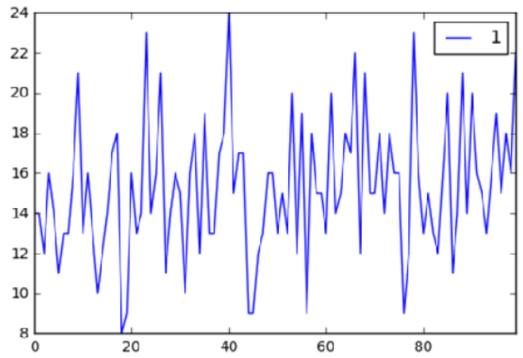
- DataSeries & DataFrame
- I/O
- Data analysis & aggregation
- Indexes
- Visualisation
- Interacting with the data

Part 2

A deeper look at the index with the TimeSeries Index

- TimeSeriesIndex
- `pd.to_datetime()` ! US date friendly
- Data Aggregation examples

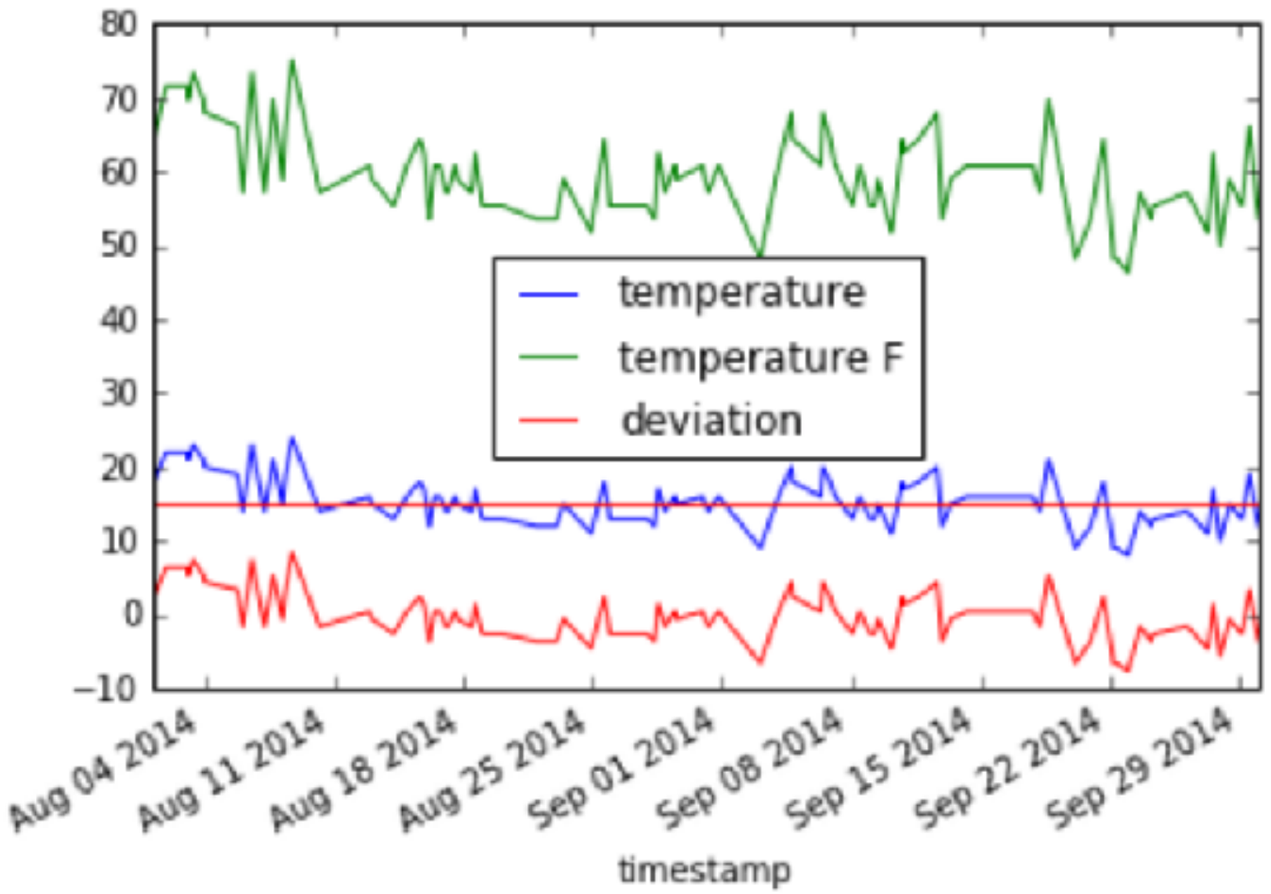
In [24]:
```
# create TimeSeries Index
df.index = pd.to_datetime(df['timestamp'])
```



before TimeSeries Index: unordered

```
In [25]: ax = df[:100].plot()
         ax.axhline(df[:100]['temperature'].median(), color='r', linestyle='-')
```

```
Out[25]: <matplotlib.lines.Line2D at 0x114dd6978>
```



In [26]:
```
df.head()
```

Out[26]:

	timestamp	temperature	temperature F	deviation
timestamp				
2014-09-26 03:50:00	2014-09-26T03:50:00	14.0	57.2	-1.59045
2014-08-10 05:00:00	2014-08-10T05:00:00	14.0	57.2	-1.59045
2014-08-21 22:50:00	2014-08-21T22:50:00	12.0	53.6	-3.59045
2014-08-17 13:20:00	2014-08-17T13:20:00	16.0	60.8	0.40955
2014-08-06 01:20:00	2014-08-06T01:20:00	14.0	57.2	-1.59045

In [27]:
```
df.index.view
```

Out[27]:
```
<bound method Index.view of DatetimeIndex(['2014-09-26 03:50:00', '2014-08-10 05:00:00',
               '2014-08-21 22:50:00', '2014-08-17 13:20:00',
               '2014-08-06 01:20:00', '2014-09-27 06:50:00',
               '2014-08-25 21:50:00', '2014-08-14 05:20:00',
               '2014-09-14 05:20:00', '2014-08-03 02:50:00',
               ...
               '2014-08-22 10:00:00', '2014-09-10 16:20:00',
               '2014-08-14 15:50:00', '2014-09-05 04:00:00',
               '2014-09-29 02:50:00', '2014-08-21 01:50:00',
               '2014-09-13 10:00:00', '2014-08-16 23:20:00',
               '2014-09-28 10:20:00', '2014-09-25 18:20:00'],
              dtype='datetime64[ns]', name='timestamp', length=4357, freq=None)>
```

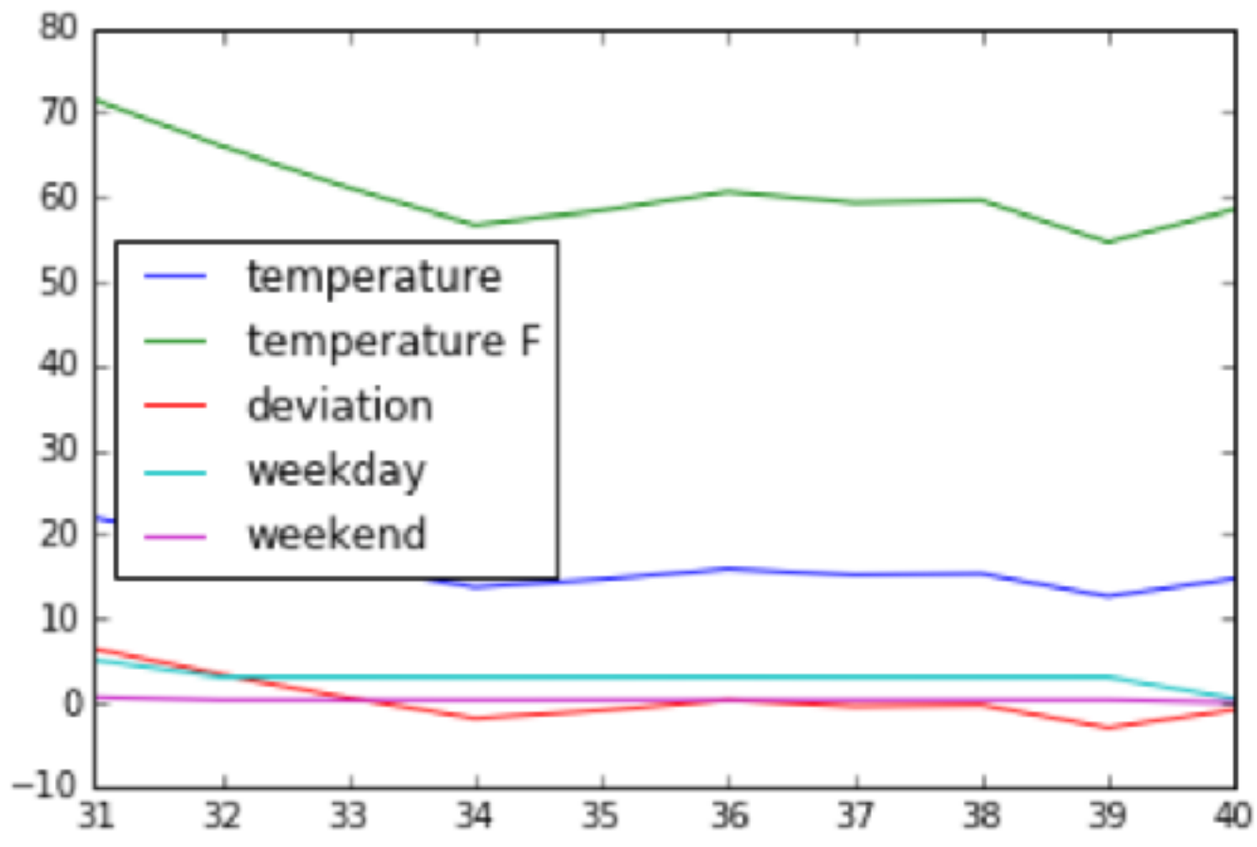
In [61]:
```
df.groupby(df.index.date).count()
```

Out[61]:

	timestamp	temperature	temperature F	deviation	weekday	weekend
2014-08-01	66	66	66	66	66	66
2014-08-02	72	72	72	72	72	72
2014-08-03	70	70	70	70	70	70
2014-08-04	72	72	72	72	72	72
2014-08-05	68	68	68	68	68	68
2014-08-06	72	72	72	72	72	72
2014-08-07	72	72	72	72	72	72
2014-08-08	72	72	72	72	72	72
2014-08-09	72	72	72	72	72	72
2014-08-10	72	72	72	72	72	72
2014-08-11	72	72	72	72	72	72
2014-08-12	68	68	68	68	68	68
2014-08-13	71	71	71	71	71	71
2014-08-14	71	71	71	71	71	71
2014-08-15	71	71	71	71	71	71
2014-08-16	72	72	72	72	72	72
2014-08-17	72	72	72	72	72	72
2014-08-18	72	72	72	72	72	72
2014-08-19	72	72	72	72	72	72

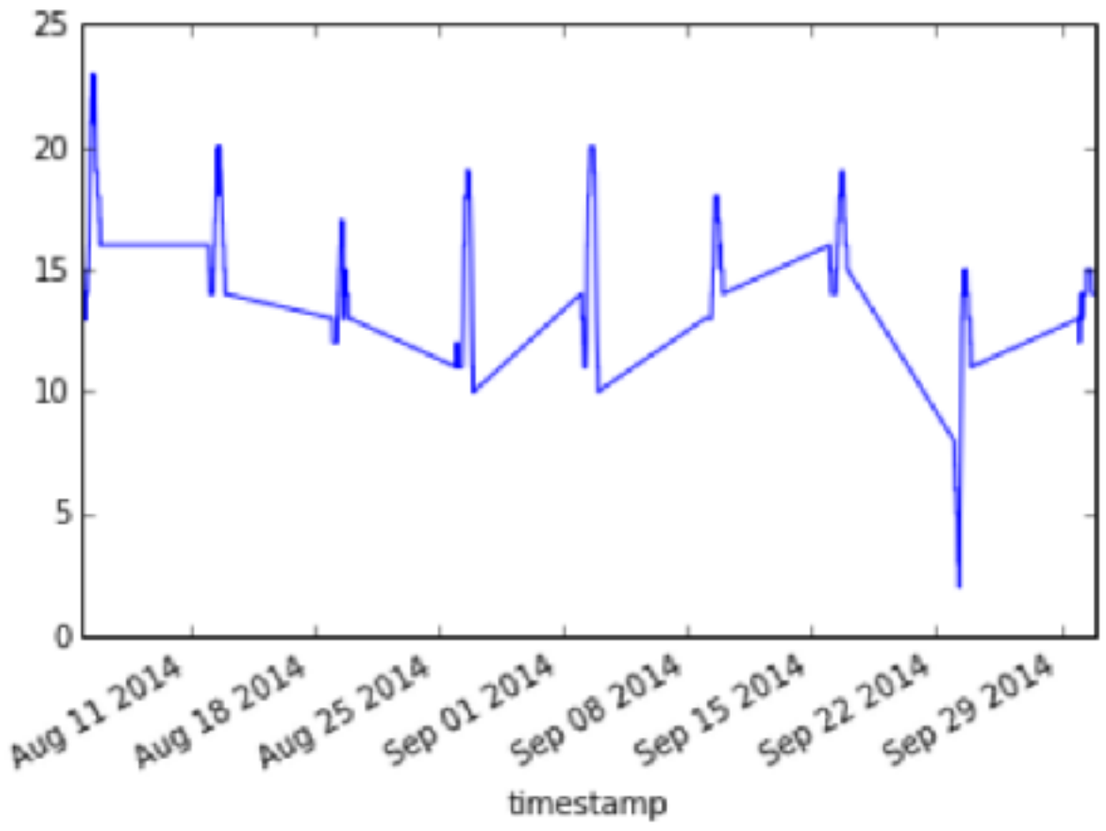
In [47]:
```
df.groupby(df.index.week).mean().plot()
```

Out[47]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x11481e7b8>
```



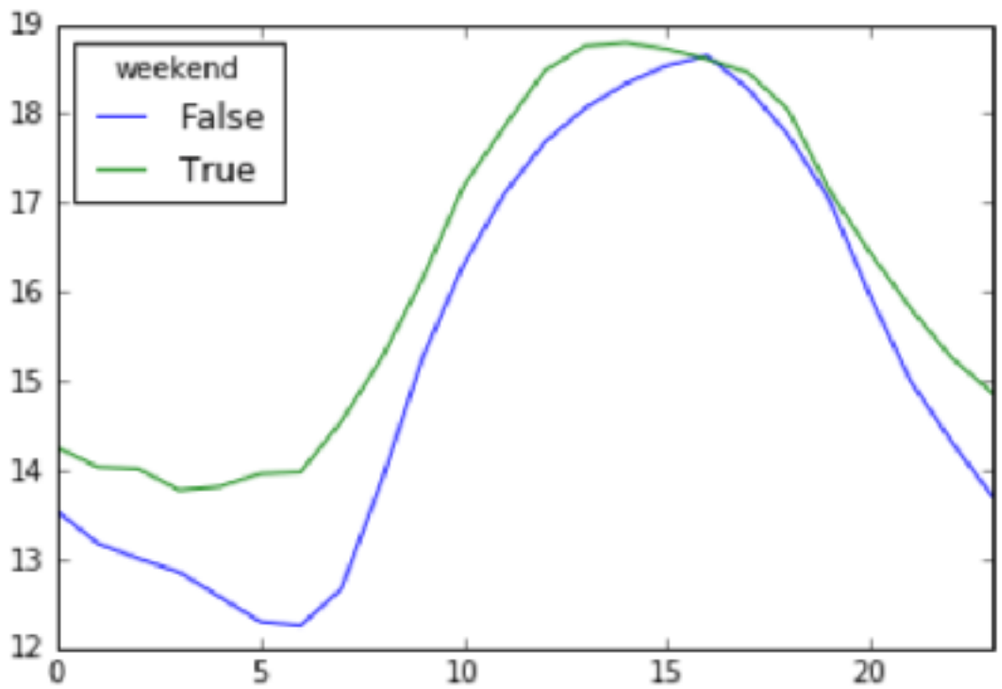
```
In [42]: df[df.index.weekday == True]['temperature'].plot()
```

```
Out[42]: <matplotlib.axes._subplots.AxesSubplot at 0x115e01828>
```



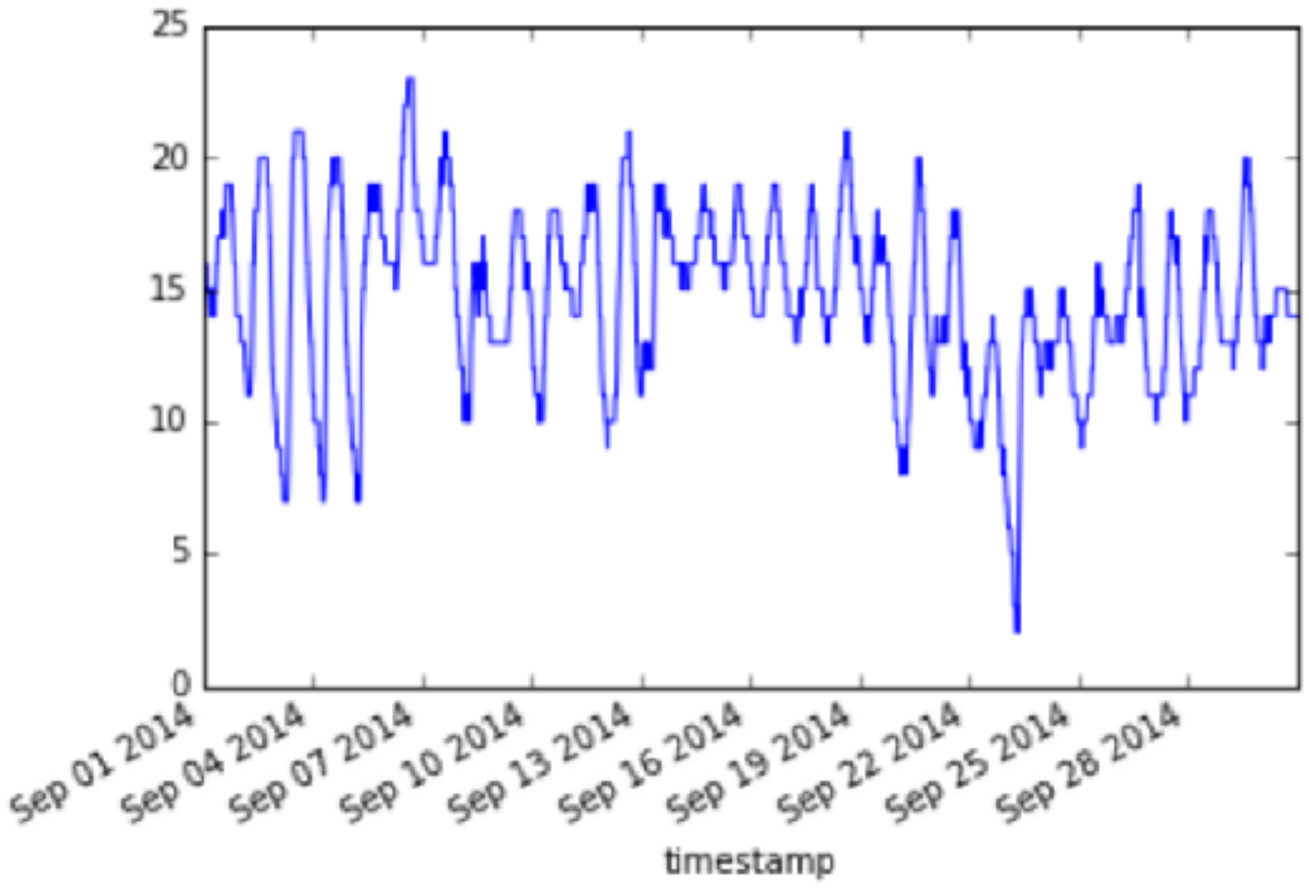
In [40]:
```
df['weekday'] = df.index.weekday
df['weekend'] = df['weekday'].isin({5, 6})
df.groupby(['weekend', df.index.hour])['temperature'].mean().unstack(level=0).plot()
```

Out[40]: <matplotlib.axes._subplots.AxesSubplot at 0x114b72fd0>



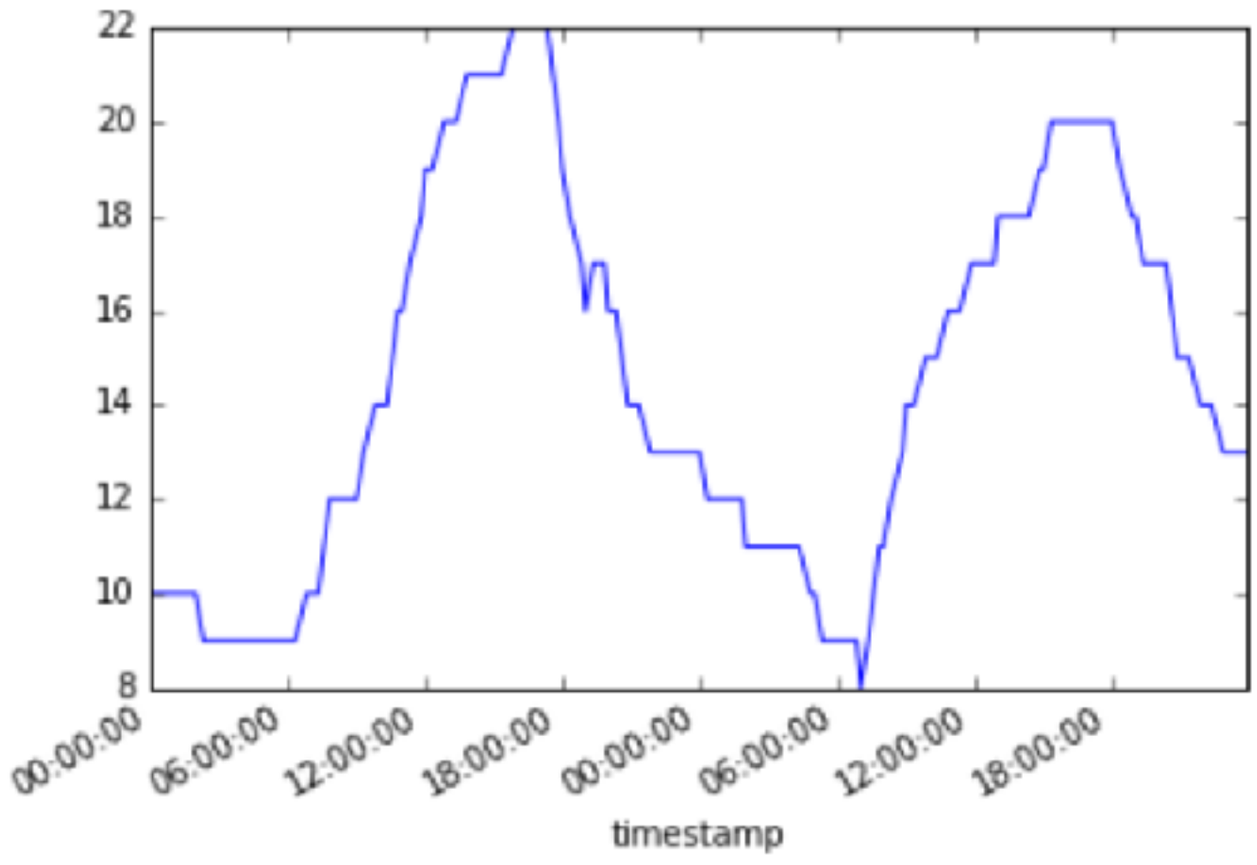
```
In [43]: df['2014-09']['temperature'].plot()
```

```
Out[43]: <matplotlib.axes._subplots.AxesSubplot at 0x1148d8eb8>
```



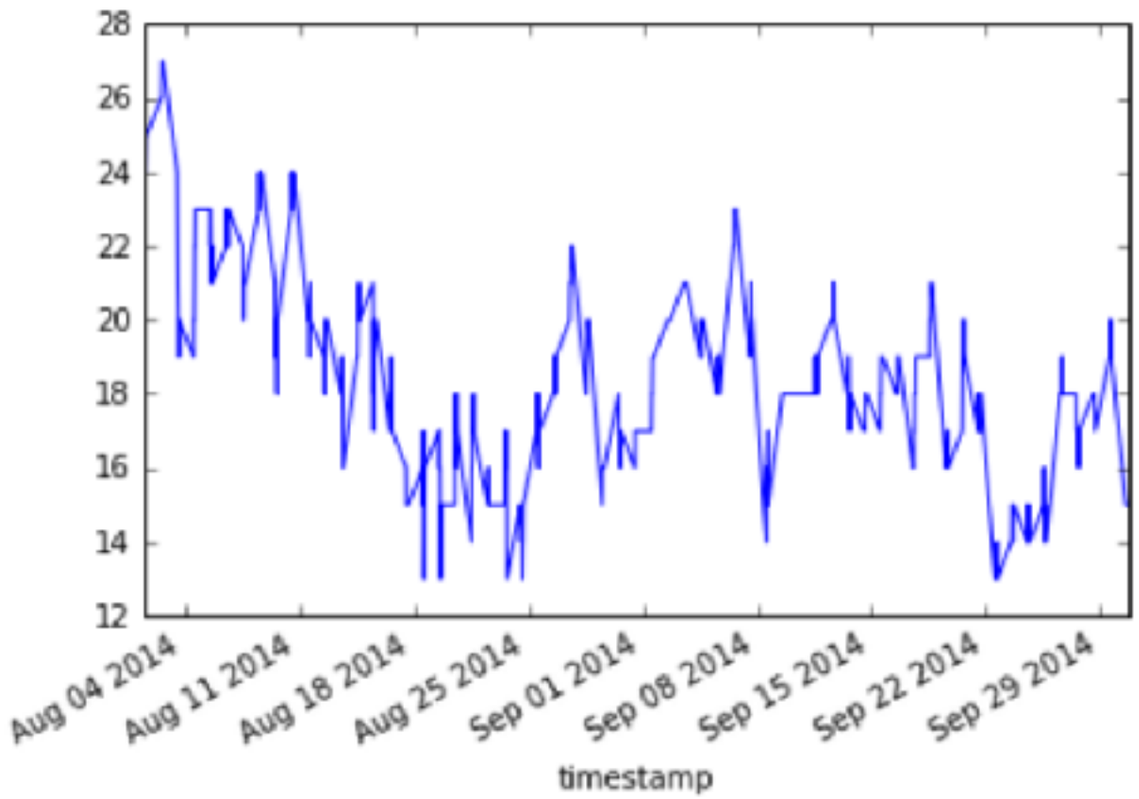
In [41]:
```
# selecting ranges
df["2014-08-27":"2014-08-28"]['temperature'].plot()
```

Out[41]: <matplotlib.axes._subplots.AxesSubplot at 0x114a55780>



```
In [44]: df[(df.index.hour > 12) & (df.index.hour <=16)]['temperature'].plot()
```

```
Out[44]: <matplotlib.axes._subplots.AxesSubplot at 0x1148a3e10>
```



In [45]:
```
df.resample('D').max().head()
```

Out[45]:

	timestamp	temperature	temperature F	deviation	weekday	weekend
timestamp						
2014-08-01	2014-08-01T23:50:00	25.0	77.0	9.409049	4	False
2014-08-02	2014-08-02T23:50:00	27.0	80.6	11.409049	5	True
2014-08-03	2014-08-03T23:50:00	25.0	77.0	9.409049	6	True
2014-08-04	2014-08-04T23:50:00	24.0	75.2	8.409049	0	False
2014-08-05	2014-08-05T23:50:00	23.0	73.4	7.409049	1	False

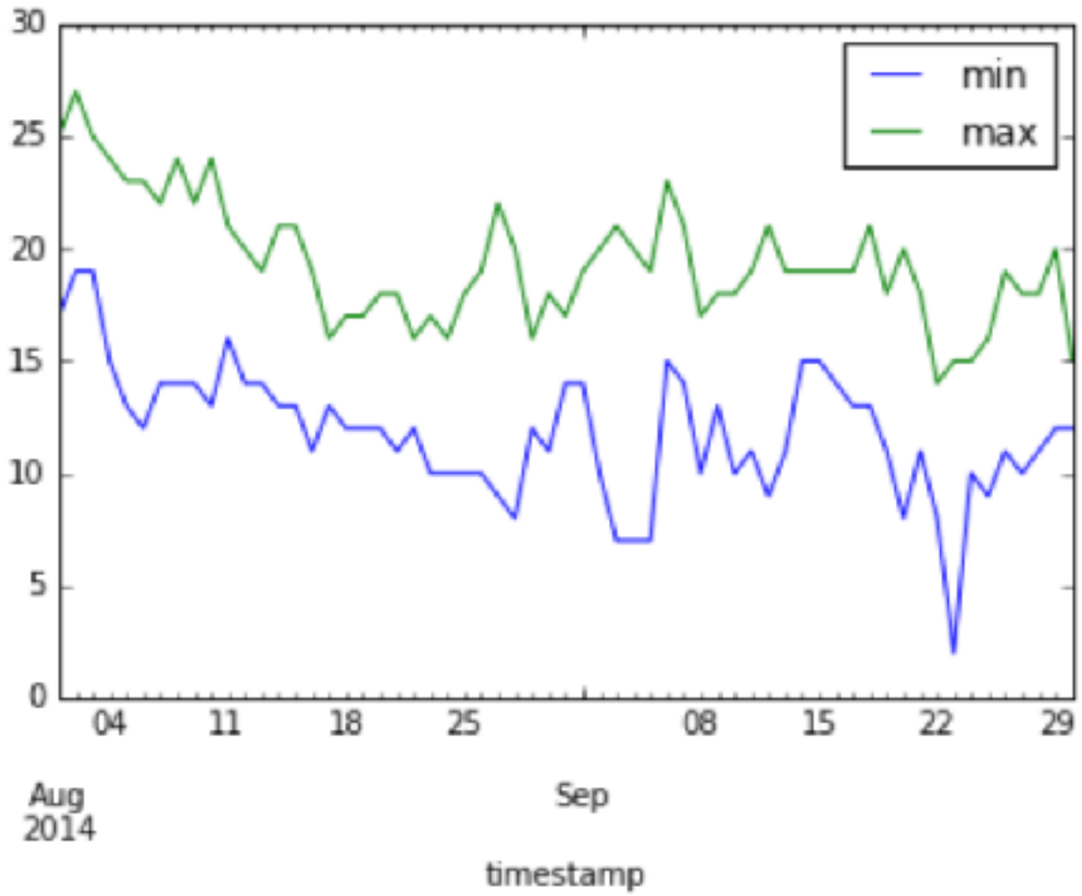
In [46]:
```
df.resample('M').mean().head()
```

Out[46]:

	temperature	temperature F	deviation	weekday	weekend
timestamp					
2014-08-31	16.436652	61.585973	0.845701	3.201810	0.324434
2014-09-30	14.719216	58.494590	-0.871734	2.841884	0.267724

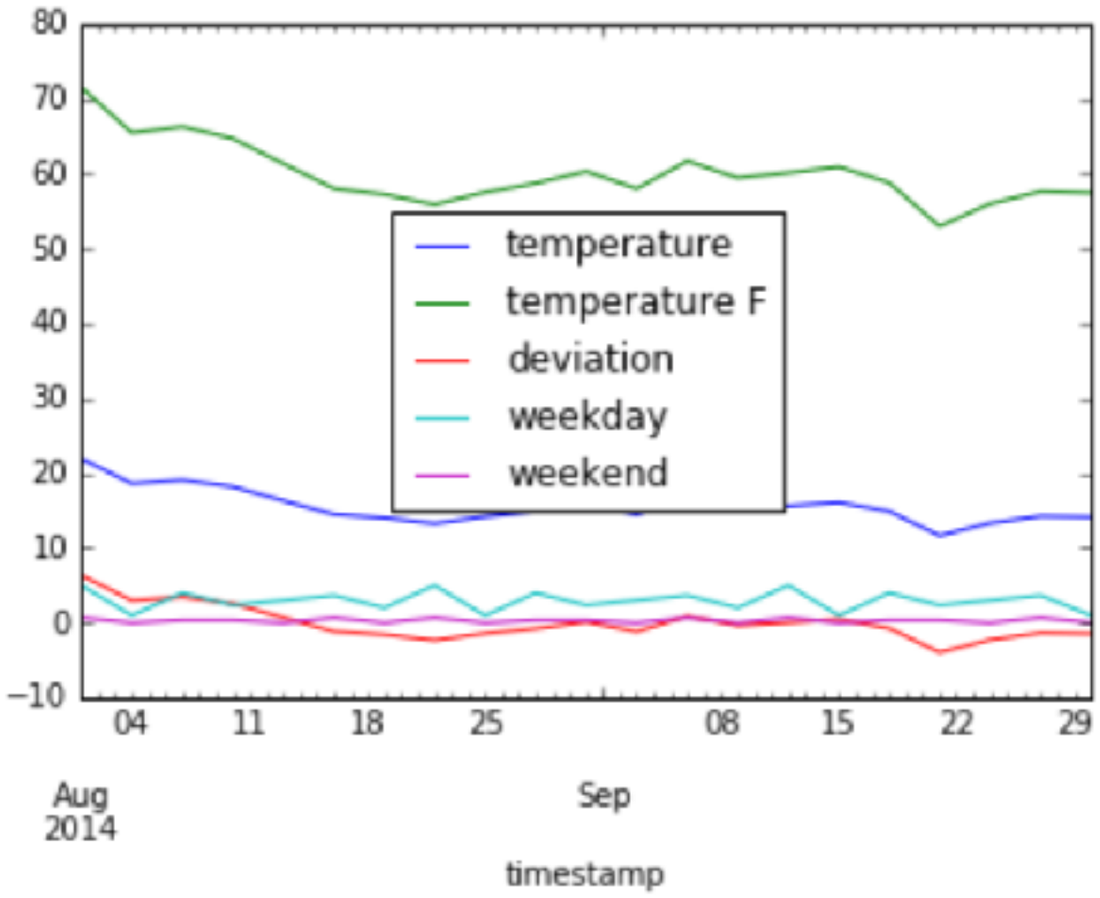
In [53]:
```
df['temperature'].resample('D').agg(['min', 'max']).plot()
```

Out[53]: <matplotlib.axes._subplots.AxesSubplot at 0x1167c0f60>



In [51]:
```
df.resample('3D').mean().plot()
```

Out[51]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x11480b128>
```



Resampling

- H hourly frequency
- T minutely frequency
- S secondly frequency
- L milliseonds
- U microseconds
- N nanoseconds

- D calendar day frequency
- W weekly frequency
- M month end frequency
- Q quarter end frequency
- A year end frequency

- B business day frequency
- C custom business day frequency (experimenta
- BM business month end frequency
- CBM custom business month end frequency
- MS month start frequency
- BMS business month start frequency
- CBMS custom business month start frequency
- BQ business quarter endfrequency
- QS quarter start frequency
- BQS business quarter start frequency
- BA business year end frequency
- AS year start frequency
- BAS business year start frequency
- BH business hour frequency

In [72]:
```
import random
index = pd.date_range('1/1/2016', periods=1200, freq='S')
series = pd.Series([random.randint(0,100) for p in range(1200)], index=index)
series
```

Out[72]:
```
2016-01-01 00:00:00     85
2016-01-01 00:00:01     54
2016-01-01 00:00:02     81
2016-01-01 00:00:03      1
2016-01-01 00:00:04     83
2016-01-01 00:00:05     80
2016-01-01 00:00:06     69
2016-01-01 00:00:07     86
2016-01-01 00:00:08      1
2016-01-01 00:00:09     83
2016-01-01 00:00:10     95
2016-01-01 00:00:11     51
2016-01-01 00:00:12     80
2016-01-01 00:00:13      7
2016-01-01 00:00:14     27
2016-01-01 00:00:15      6
2016-01-01 00:00:16     33
2016-01-01 00:00:17     32
2016-01-01 00:00:18      4
2016-01-01 00:00:19     82
2016-01-01 00:00:20     39
2016-01-01 00:00:21     12
2016-01-01 00:00:22     11
2016-01-01 00:00:23     92
```

In [90]:
```
resampled = series.resample('5T', label='right', closed='right').mean()
resampled
```

Out[90]:
```
2016-01-01 00:00:00    85.000000
2016-01-01 00:05:00    48.530000
2016-01-01 00:10:00    48.290000
2016-01-01 00:15:00    53.116667
2016-01-01 00:20:00    47.953177
Freq: 5T, dtype: float64
```

In [84]:
```
upsampled = resampled.resample('90S').mean()[:6]
upsampled
```

Out[84]:
```
2016-01-01 00:00:00       85.0
2016-01-01 00:01:30        NaN
2016-01-01 00:03:00        NaN
2016-01-01 00:04:30    14559.0
2016-01-01 00:06:00        NaN
2016-01-01 00:07:30        NaN
Freq: 90S, dtype: float64
```

In [85]:
```
upsampled = resampled.resample('90S').pad()[:6]
upsampled
```

Out[85]:
```
2016-01-01 00:00:00       85
2016-01-01 00:01:30       85
2016-01-01 00:03:00       85
2016-01-01 00:04:30       85
2016-01-01 00:06:00    14559
2016-01-01 00:07:30    14559
Freq: 90S, dtype: int64
```

In [86]:
```
upsampled = resampled.resample('90S').bfill()[:6]
upsampled
```

Out[86]:
```
2016-01-01 00:00:00       85
2016-01-01 00:01:30    14559
2016-01-01 00:03:00    14559
2016-01-01 00:04:30    14559
2016-01-01 00:06:00    14487
2016-01-01 00:07:30    14487
Freq: 90S, dtype: int64
```

In [89]:
```
def myresmapler(*args, **kwargs):
    return random.randint(1, 100)

upsampled = resampled.resample('90S').apply(myresmapler)
upsampled
```

Out[89]:
```
2016-01-01 00:00:00    35
2016-01-01 00:01:30    94
2016-01-01 00:03:00    46
2016-01-01 00:04:30    55
2016-01-01 00:06:00    63
2016-01-01 00:07:30    99
2016-01-01 00:09:00    73
2016-01-01 00:10:30    54
2016-01-01 00:12:00    17
2016-01-01 00:13:30    10
2016-01-01 00:15:00    27
2016-01-01 00:16:30    13
2016-01-01 00:18:00    76
2016-01-01 00:19:30    67
Freq: 90S, dtype: int64
```

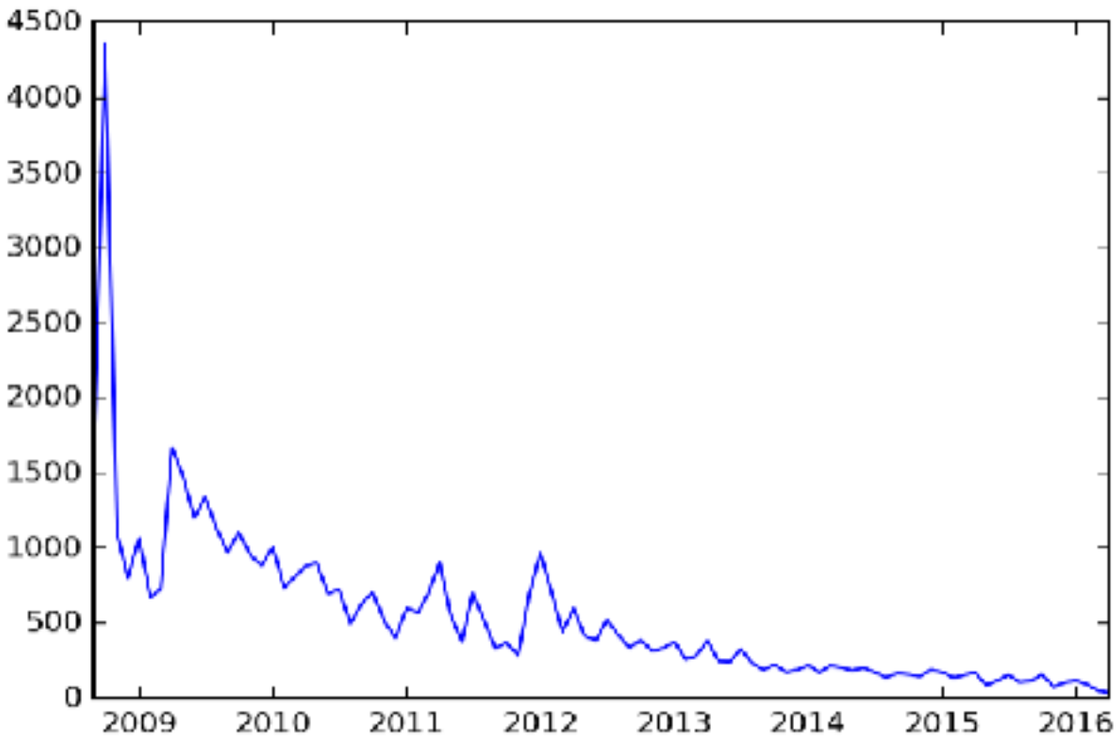
pandas

$$y_i t = \beta' x_{it} + \mu_i + \epsilon_{it}$$

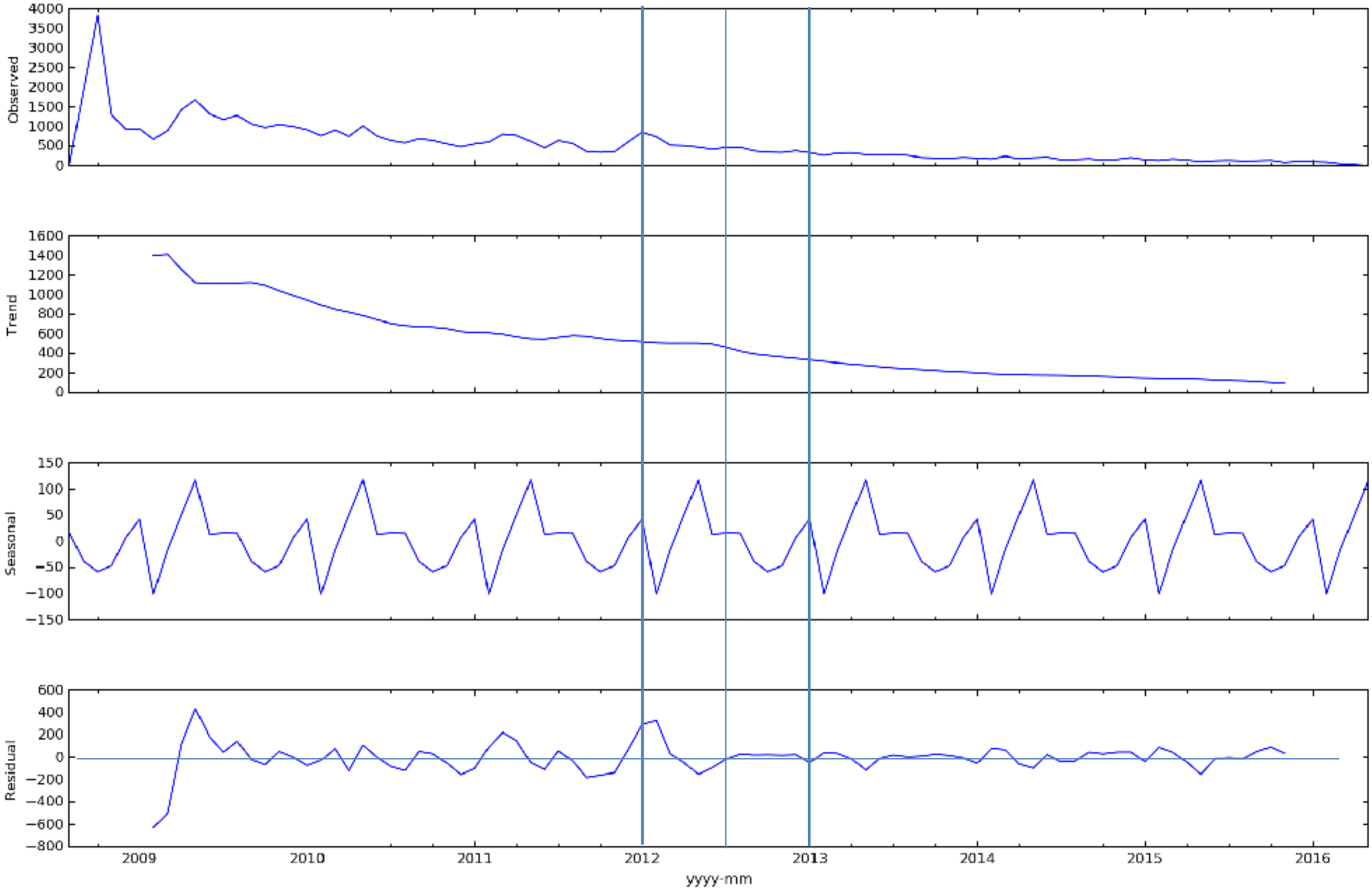
Bonus: statsmodels

is a Python module that allows users to explore data, estimate statistical models,
and perform statistical tests

Some sales data of a single product



n [44]:
```
dtap = pd.DataFrame(mdf.groupby(mdf.index)['activity'].sum())
# deal with missing values. see issue
dtap.activity.interpolate(inplace=True)
res = sm.tsa.seasonal_decompose(dtap.activity)
resplot = res.plot()
resplot.set_size_inches(15,15)
```


Observed
4000
3500
3000
2500
2000
1500
1000
500
0
Trend
1600
1400
1200
1000
800
600
400
200
0
Seasonal
150
100
50
0
−50
−100
−150
Residual
600
400
200
0
−200
−400
−600
−800
2009
2010
2011
2012
2013
2014
2015
2016
yyyy-mm

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PyData

EuroPython 2017

KŌNIGSWEG

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Code-Examples
https://github.com/Koenigsweg/data-timeseries-analysis-with-pandas

bonus: I/O large datasets

"...pandas works well on 1GB of data, but less well on 10GB. This has to change ... in the future"

(Wes McKinley blog, http://wesmckinney.com/blog/outlook-for-2017/)

- read data in chunks:
  - read chunk, group chunk, just keep result, read next chunk...
  - concatenate pre-aggregated result