Reshaping Data for Analysis

In this notebook, we will using daily temperature data from the National Centers for Environmental Information (NCEI) API. We will use the Global Historical Climatology Network - Daily (GHCND) data set; see the documentation here.

This data was collected for New York City for October 2018, using the Boonton 1 station (GHCNDUSC00280907). It contains:

- the daily minimum temperature (TMIN)
- the daily maximum temperature (TMAX)
- the daily temperature at time of observation (TOBS)

Note: The NCEI is part of the National Oceanic and Atmospheric Administration (NOAA) and, as you can see from the URL for the API, this resource was created when the NCEI was called the NCDC. Should the URL for this resource change in the future, you can search for the NCEI weather API to find the updated one.

Setup

We need to import `pandas` and read in the long-format data to get started

```
import pandas as p

long_df = p.read_csv(
    '/content/long_data.csv',
    usecols=['date', 'datatype', 'value']
).rename(
    columns={
        'value' : 'temp_C'
}
).assign(
    date=lambda x: p.to_datetime(x.date),
    temp_F=lambda x: (x.temp_C * 9/5) + 32
)

long_df.head()
```

	datatype	date	temp_C	temp_F
0	TMAX	2018-10-01	21.1	69.98
1	TMIN	2018-10-01	8.9	48.02
2	TOBS	2018-10-01	13.9	57.02
3	TMAX	2018-10-02	23.9	75.02
4	TMIN	2018-10-02	13.9	57.02

Transposing

Transposing swaps the rows and the columns. We use `T` attribute to do so:

```
1 long_df.head().T
```

	0	1	2	3	4
datatype	TMAX	TMIN	TOBS	TMAX	TMIN
date	2018-10-01 00:00:00	2018-10-01 00:00:00	2018-10-01 00:00:00	2018-10-02 00:00:00	2018-10-02 00:00:00
temp_C	21.1	8.9	13.9	23.9	13.9
temp_F	69.98	48.02	57.02	75.02	57.02

Pivoting

Going from long to wide format.

`pivot()`

We can restruct our data by picking a column to go in the index (`index`), a column whose unique values will become column names (`columns`), and the values to place in those columns (`values`). The `pivot()` method can be used when we don't need to perform any aggregation in addition to our restructuring [when our index is unique]; if this is not the case, we need the `pivot_table` method which we will cover in future modules.

```
1 pivoted_df = long_df.pivot(
2     index='date', columns='datatype', values='temp_C'
3 )
4 pivoted_df.head()
```

datatype	TMAX	TMIN	TOBS
date			
2018-10-01	21.1	8.9	13.9
2018-10-02	23.9	13.9	17.2
2018-10-03	25.0	15.6	16.1
2018-10-04	22.8	11.7	11.7
2018-10-05	23.3	11.7	18.9

Note there is also the `pd.pivot()` funciton that yields equivalent results:

```
p.pivot( long_df,
    index='date', columns='datatype', values='temp_C'
).head()
```

datatype	TMAX	TMIN	TOBS
date			
2018-10-01	21.1	8.9	13.9
2018-10-02	23.9	13.9	17.2
2018-10-03	25.0	15.6	16.1
2018-10-04	22.8	11.7	11.7
2018-10-05	23.3	11.7	18.9

Now that the data is pivoted, we have wide-format data that we can grab summary statistics with:

```
pivoted_df.describe()
```

datatype	TMAX	TMIN	TOBS
count	31.000000	31.000000	31.000000
mean	16.829032	7.561290	10.022581
std	5.714962	6.513252	6.596550
min	7.800000	-1.100000	-1.100000
25%	12.750000	2.500000	5.550000
50%	16.100000	6.700000	8.300000
75%	21.950000	13.600000	16.100000
max	26.700000	17.800000	21.700000

We can also provide multiple values to pivot on, which will result in a hierarchical index:

```
pivoted_df = long_df.pivot(
    index='date', columns='datatype', values=['temp_C', 'temp_F']
)
pivoted_df.head()
```

	temp_C			temp_F		
datatype	TMAX	TMIN	TOBS	TMAX	TMIN	TOBS
date						
2018-10-01	21.1	8.9	13.9	69.98	48.02	57.02
2018-10-02	23.9	13.9	17.2	75.02	57.02	62.96
2018-10-03	25.0	15.6	16.1	77.00	60.08	60.98
2018-10-04	22.8	11.7	11.7	73.04	53.06	53.06
2018-10-05	23.3	11.7	18.9	73.94	53.06	66.02

With the hierarchical index, if we want to select `TMIN` in Fahrenheit, we will first need to select `'temp_F'` and then `'TMIN'`:

```
pivoted_df['temp_F']['TMIN'].head()
```

```
---------------------------------------------------------------------------
KeyError                                  Traceback (most recent call last)
/usr/local/lib/python3.10/dist-packages/pandas/core/indexes/base.py in get_loc(self,
key, method, tolerance)
   3801             try:
-> 3802                 return self._engine.get_loc(casted_key)
   3803             except KeyError as err:

                                4 frames
pandas/_libs/hashtable_class_helper.pxi in
pandas._libs.hashtable.PyObjectHashTable.get_item()

pandas/_libs/hashtable_class_helper.pxi in
pandas._libs.hashtable.PyObjectHashTable.get_item()

KeyError: 'temp_F'

The above exception was the direct cause of the following exception:

KeyError                                  Traceback (most recent call last)
/usr/local/lib/python3.10/dist-packages/pandas/core/indexes/base.py in get_loc(self,
key, method, tolerance)
   3802                 return self._engine.get_loc(casted_key)
   3803             except KeyError as err:
-> 3804                 raise KeyError(key) from err
   3805             except TypeError:
   3806                 # If we have a listlike key,  check indexing error will
```

`unstack()`

We have been working with a single index throughout this chapter; however, we can create an index from any number of columns with `set_index()`. This gives us a `MultiIndex` where the outermost level corresponds to the first element in the list provided to `set_index()`:

```
1 multi_index_df = long_df.set_index(['date', 'datatype'])
2 multi_index_df
```

		temp_C	temp_F
date	datatype		
2018-10-01	TMAX	21.1	69.98
	TMIN	8.9	48.02
	TOBS	13.9	57.02
2018-10-02	TMAX	23.9	75.02
	TMIN	13.9	57.02
...	...	...	...
2018-10-30	TMIN	2.2	35.96
	TOBS	5.0	41.00
2018-10-31	TMAX	12.2	53.96
	TMIN	0.0	32.00
	TOBS	0.0	32.00

93 rows × 2 columns

With the `MultiIndex`, we can no longer use `pivot()`. We must use `unstack()`, which by default moves the innermost index onto the columns:

```
1 unstacked_df = multi_index_df.unstack()
2 unstacked_df.head()
```

	temp_C			temp_F		
datatype	TMAX	TMIN	TOBS	TMAX	TMIN	TOBS
date						
2018-10-01	21.1	8.9	13.9	69.98	48.02	57.02
2018-10-02	23.9	13.9	17.2	75.02	57.02	62.96
2018-10-03	25.0	15.6	16.1	77.00	60.08	60.98
2018-10-04	22.8	11.7	11.7	73.04	53.06	53.06
2018-10-05	23.3	11.7	18.9	73.94	53.06	66.02

The `unstack()` method also provides the `fill_value` parameter, which let's us fill-in any `NaN` values that might arise from this restructuring of the data. Consider the case that we have data for the average temperature on October 1, 2018, but no other date:

```
extra_data = long_df.append(
    [{'datatype' : 'TAVG', 'date' : '2018-10-01', 'temp_C' : 10, 'temp_F' : 50}]
).set_index(['date', 'datatype']).sort_index()

extra_data.head(8)
```

```
<ipython-input-43-8640eea126a6>:1: FutureWarning: The frame.append method is deprecat
  extra_data = long_df.append(
<ipython-input-43-8640eea126a6>:3: FutureWarning: Inferring datetime64[ns] from data
  ).set_index(['date', 'datatype']).sort_index()
```

		temp_C	temp_F
date	datatype		
2018-10-01	TAVG	10.0	50.00
	TMAX	21.1	69.98
	TMIN	8.9	48.02
	TOBS	13.9	57.02
2018-10-02	TMAX	23.9	75.02
	TMIN	13.9	57.02
	TOBS	17.2	62.96
2018-10-03	TMAX	25.0	77.00

If we use `unstack()` in this case, we will have `NaN` for the `TAVG` columns every day but October 1, 2018

```
extra_data.unstack().head()
```

	temp_C				temp_F			
datatype	TAVG	TMAX	TMIN	TOBS	TAVG	TMAX	TMIN	TOBS
date								
2018-10-01	10.0	21.1	8.9	13.9	50.0	69.98	48.02	57.02
2018-10-02	NaN	23.9	13.9	17.2	NaN	75.02	57.02	62.96
2018-10-03	NaN	25.0	15.6	16.1	NaN	77.00	60.08	60.98
2018-10-04	NaN	22.8	11.7	11.7	NaN	73.04	53.06	53.06
2018-10-05	NaN	23.3	11.7	18.9	NaN	73.94	53.06	66.02

To address this, we can pass in an appropriate `fill_value` . However, we are restricted to passing in a value for this, not a strategy (like we saw with `fillna()`), so while `-40` is definitely

not be the best value, we can use it to illustrate how this works, since this is the temperature at which Fahrenheit and Celsius are equal:

```
1 extra_data.unstack(fill_value=-40).head()
```

	temp_C				temp_F			
datatype	TAVG	TMAX	TMIN	TOBS	TAVG	TMAX	TMIN	TOBS
date								
2018-10-01	10.0	21.1	8.9	13.9	50.0	69.98	48.02	57.02
2018-10-02	-40.0	23.9	13.9	17.2	-40.0	75.02	57.02	62.96
2018-10-03	-40.0	25.0	15.6	16.1	-40.0	77.00	60.08	60.98
2018-10-04	-40.0	22.8	11.7	11.7	-40.0	73.04	53.06	53.06
2018-10-05	-40.0	23.3	11.7	18.9	-40.0	73.94	53.06	66.02

Melting

Going from wide to long format.

Setup

```
1 wide_df = p.read_csv('/content/wide_data.csv')
2 wide_df.head()
```

	date	TMAX	TMIN	TOBS
0	2018-10-01	21.1	8.9	13.9
1	2018-10-02	23.9	13.9	17.2
2	2018-10-03	25.0	15.6	16.1
3	2018-10-04	22.8	11.7	11.7
4	2018-10-05	23.3	11.7	18.9

`melt()`

In order to go from wide format to long format, we use the `melt()` method. We have to specify:

- which column contains the unique identifier for each row (`date` , here) to `id_vars`
- the column(s) that contain the values (`TMAX` , `TMIN` , and `TOBS` , here) to `value_vars`

Optionally, we can also provide:

- `value_name` : what to call the column that will contain all the values once melted
- `var_name` : what to call the column that will contain the names of the variables being measured

```
melted_df = wide_df.melt(
    id_vars='date',
    value_vars=['TMAX', 'TMIN', 'TOBS'],
    value_name='temp_C',
    var_name='measurement'
)
melted_df.head()
```

	date	measurement	temp_C
0	2018-10-01	TMAX	21.1
1	2018-10-02	TMAX	23.9
2	2018-10-03	TMAX	25.0
3	2018-10-04	TMAX	22.8
4	2018-10-05	TMAX	23.3

Just as we also had `pd.pivot()` there is a `pd.melt()` :

```
p.melt(
    wide_df,
    id_vars='date',
    value_vars=['TMAX', 'TMIN', 'TOBS'],
    value_name='temp_C',
    var_name='measurement'
).head()

```

	date	measurement	temp_C
0	2018-10-01	TMAX	21.1
1	2018-10-02	TMAX	23.9
2	2018-10-03	TMAX	25.0
3	2018-10-04	TMAX	22.8
4	2018-10-05	TMAX	23.3

`stack()`

Another option is `stack()` which will pivot the columns of the dataframe into the innermost level of a `MultiIndex` . To illustrate this, let's set our index to be the `date` column:

```
wide_df.set_index('date', inplace=True)
wide_df.head()
```

date	TMAX	TMIN	TOBS
2018-10-01	21.1	8.9	13.9
2018-10-02	23.9	13.9	17.2
2018-10-03	25.0	15.6	16.1
2018-10-04	22.8	11.7	11.7
2018-10-05	23.3	11.7	18.9

By running `stack()` now, we will create a second level in our index which will contain the column names of our dataframe (`TMAX` , `TMIN` , `TOBS`). This will leave us with a `Series` containing the values:

```
stacked_series = wide_df.stack()
stacked_series.head()
```

```
date
2018-10-01  TMAX    21.1
            TMIN     8.9
            TOBS    13.9
2018-10-02  TMAX    23.9
            TMIN    13.9
dtype: float64
```

We can use the `to_frame()` method on our `Series` object to turn it into a `DataFrame` . Since the series doesn't have a name at the moment, we will pass in the name as an argument:

```
stacked_df = stacked_series.to_frame('values')
stacked_df.head()
```

date		values
2018-10-01	**TMAX**	21.1
	TMIN	8.9
	TOBS	13.9
2018-10-02	**TMAX**	23.9
	TMIN	13.9

Once again, we have a `MultiIndex`:

```
1 stacked_df.index
```

```
                ('2018-10-04', 'TOBS'),
                ('2018-10-05', 'TMAX'),
                ('2018-10-05', 'TMIN'),
                ('2018-10-05', 'TOBS'),
                ('2018-10-06', 'TMAX'),
                ('2018-10-06', 'TMIN'),
                ('2018-10-06', 'TOBS'),
                ('2018-10-07', 'TMAX'),
                ('2018-10-07', 'TMIN'),
                ('2018-10-07', 'TOBS'),
                ('2018-10-08', 'TMAX'),
                ('2018-10-08', 'TMIN'),
                ('2018-10-08', 'TOBS'),
                ('2018-10-09', 'TMAX'),
                ('2018-10-09', 'TMIN'),
                ('2018-10-09', 'TOBS'),
                ('2018-10-10', 'TMAX'),
                ('2018-10-10', 'TMIN'),
                ('2018-10-10', 'TOBS'),
                ('2018-10-11', 'TMAX'),
                ('2018-10-11', 'TMIN'),
                ('2018-10-11', 'TOBS'),
                ('2018-10-12', 'TMAX'),
                ('2018-10-12', 'TMIN'),
                ('2018-10-12', 'TOBS'),
                ('2018-10-13', 'TMAX'),
                ('2018-10-13', 'TMIN'),
                ('2018-10-13', 'TOBS'),
                ('2018-10-14', 'TMAX'),
                ('2018-10-14', 'TMIN'),
                ('2018-10-14', 'TOBS'),
                ('2018-10-15', 'TMAX'),
                ('2018-10-15', 'TMIN'),
                ('2018-10-15', 'TOBS'),
                ('2018-10-16', 'TMAX'),
                ('2018-10-16', 'TMIN'),
                ('2018-10-16', 'TOBS'),
                ('2018-10-17', 'TMAX'),
                ('2018-10-17', 'TMIN'),
                ('2018-10-17', 'TOBS'),
                ('2018-10-18', 'TMAX'),
                ('2018-10-18', 'TMIN'),
                ('2018-10-18', 'TOBS'),
```

```
('2018-10-22', 'TOBS'),
('2018-10-23', 'TMAX'),
('2018-10-23', 'TMIN'),
('2018-10-23', 'TOBS'),
```

Unfortunately, we don't have a name for the `datatype` level:

```
stacked_df.index.names
```

```
FrozenList(['date', None])
```

We can use `rename()` to address this though:

```
stacked_df.index.rename(['date', 'datatype'], inplace=True)
stacked_df.index.names
```

```
FrozenList(['date', 'datatype'])
```