Lab Center – Hands-On Lab – Part TWO

Session 1239 - IBM Think2020 IoT Lab

Hyper-Local Weather and Crop prediction using Watson: Analysing Weather Data using Jupyter Notebook

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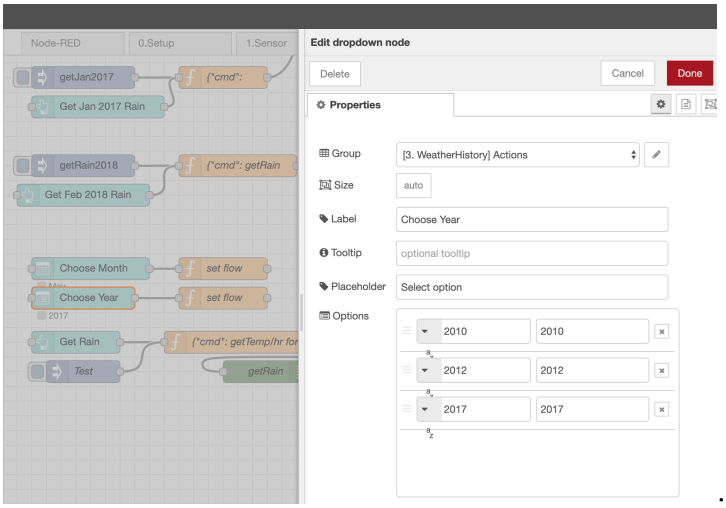
Table of Contents



1 Objective

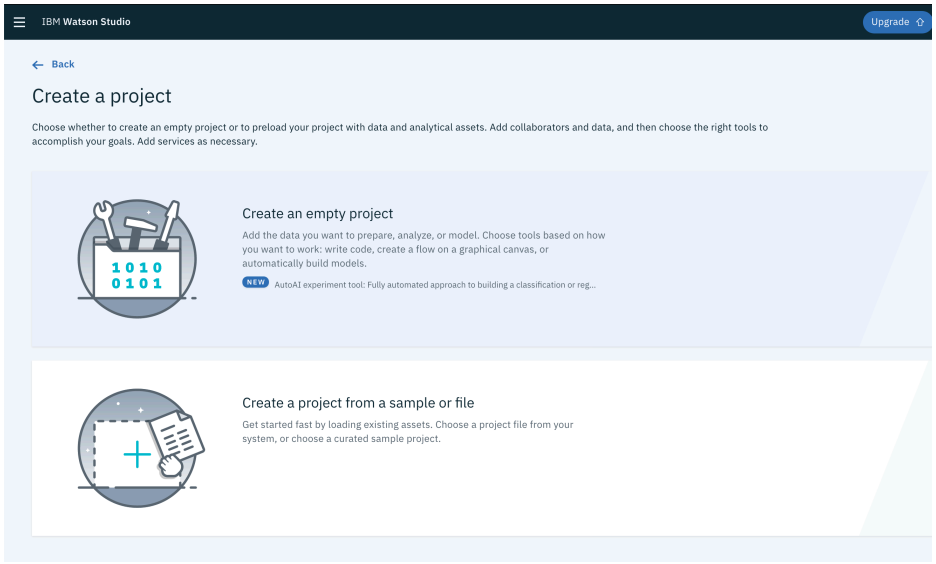
In this part of the LAB we will setup a WatsonStudio Instance with a Jupyter Notebook to analyse some weather data (ideally our own weather data we collected in previous years). Once we analyse the data we will setup a connection to our Node-RED instance and query the data and display it in Node-RED.

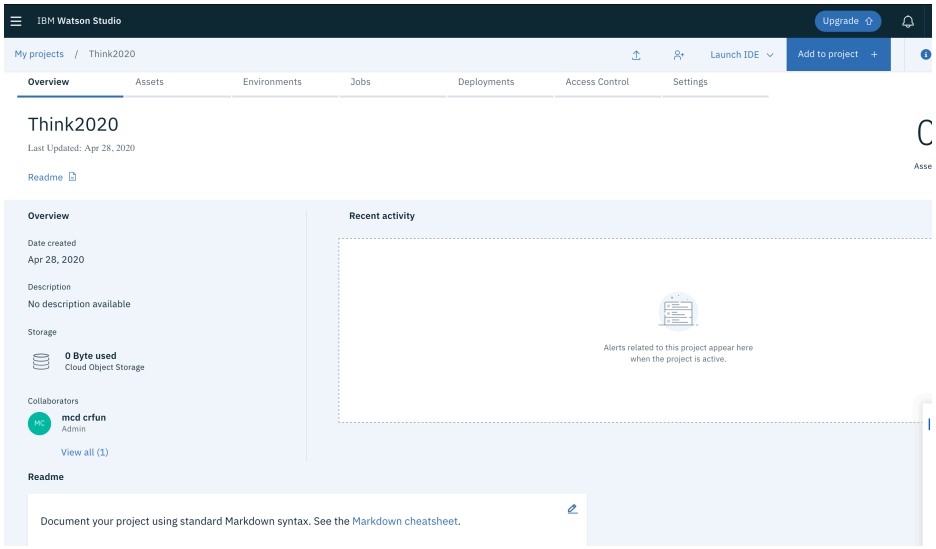
Note: We will walkthrough Part two together 1s.t

1.1 Pre-Requisite

Please sign up for a free WatsonStudio/IBM Cloud account [Register for WatsonStudio](https://dataplatform.cloud.ibm.com/registration/stepone)
https://dataplatform.cloud.ibm.com/registration/stepone

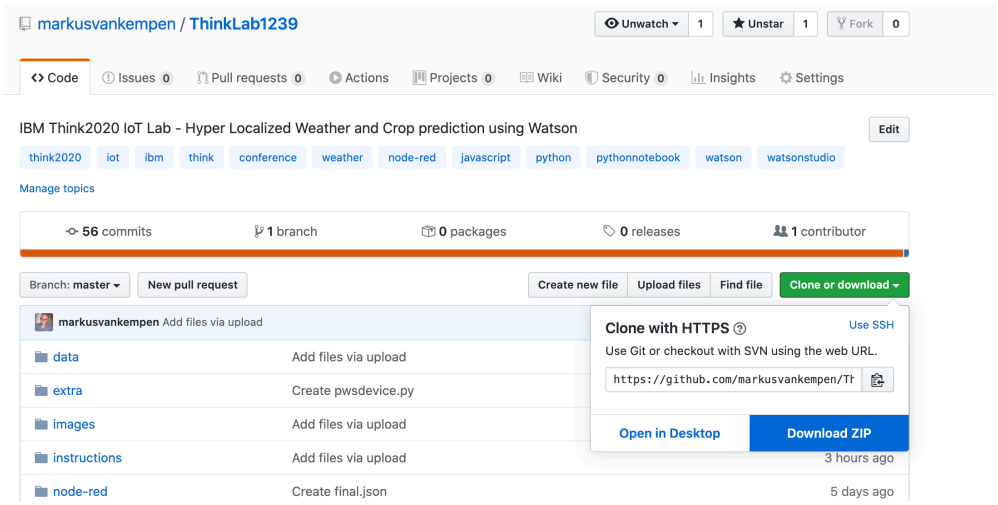
Create an empty project with the name Think2020. You will be ask to add an object store just follow the steps.





1.2 Download the github repository

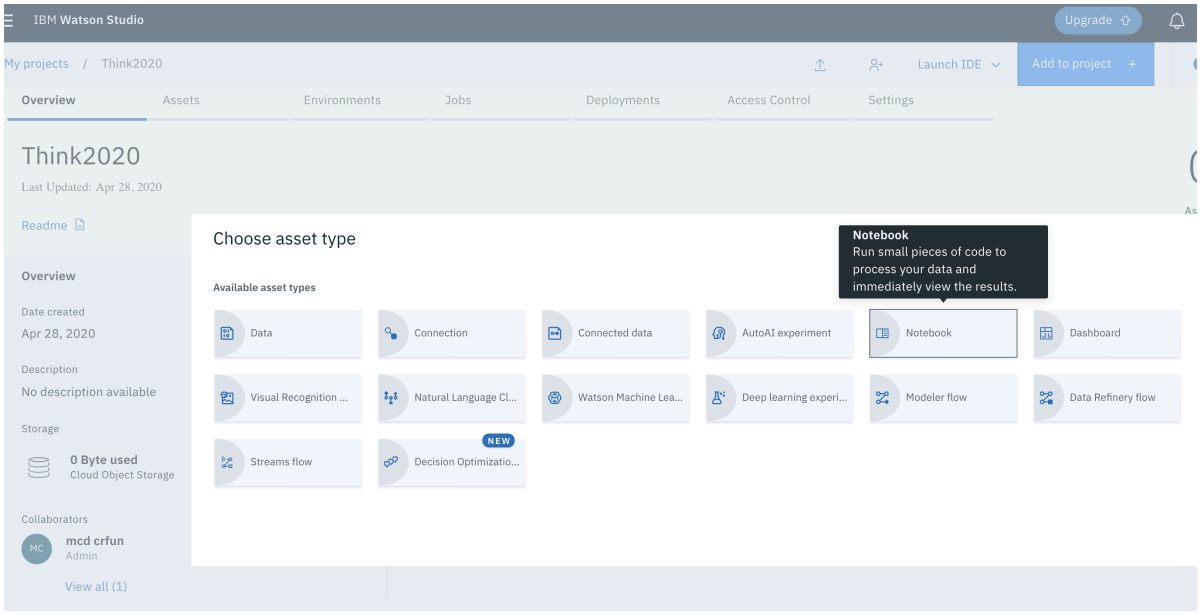
Downloading the github repository



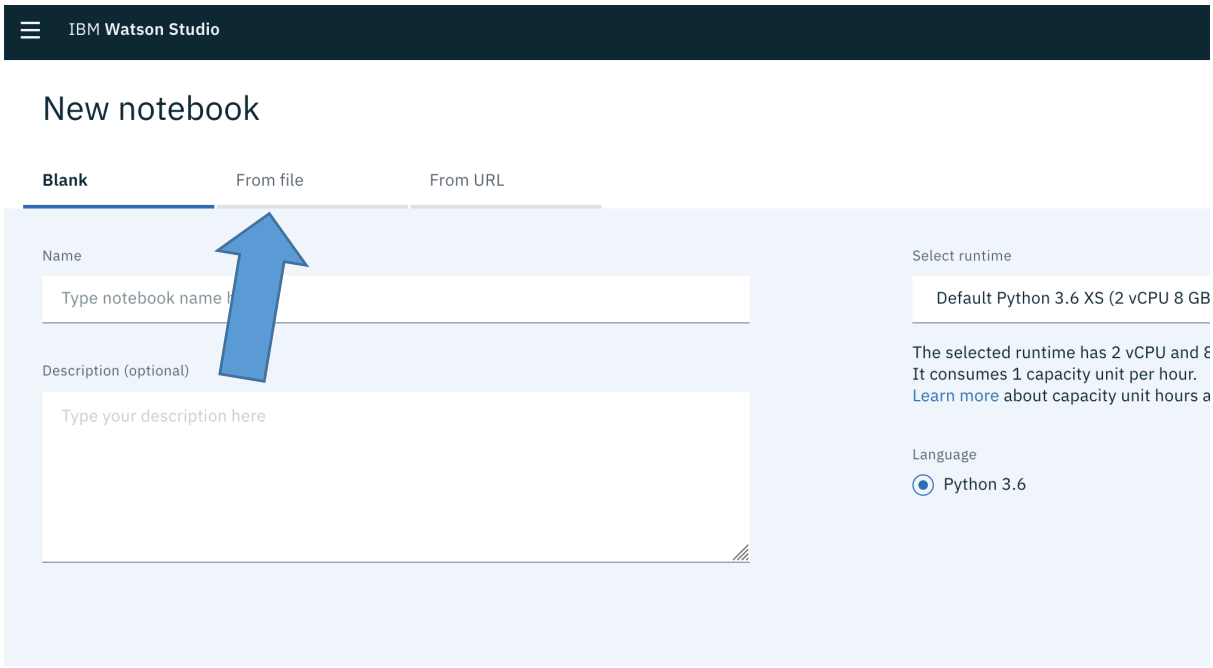
Download the github repository form here
https://github.com/markusvankempen/ThinkLab1239
and unzip the file onto your VM / Desktop.

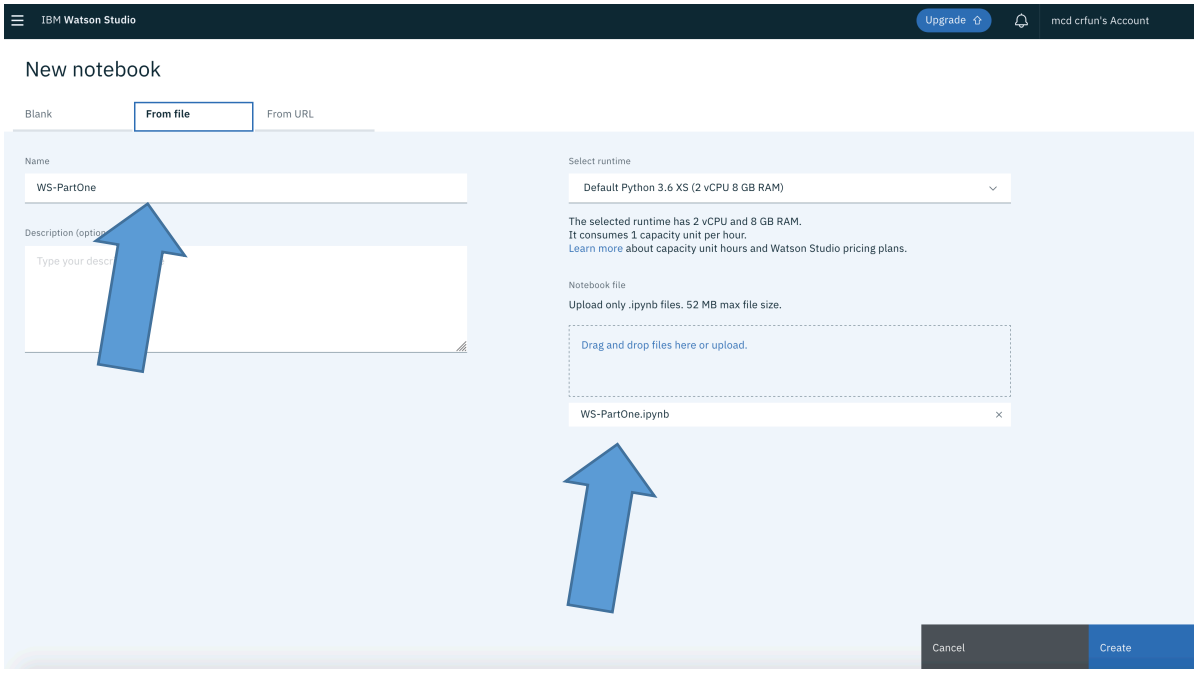
1.3 Import the Jupyter Notebook

Go back to the WatsonStudio browser window and import the notebook

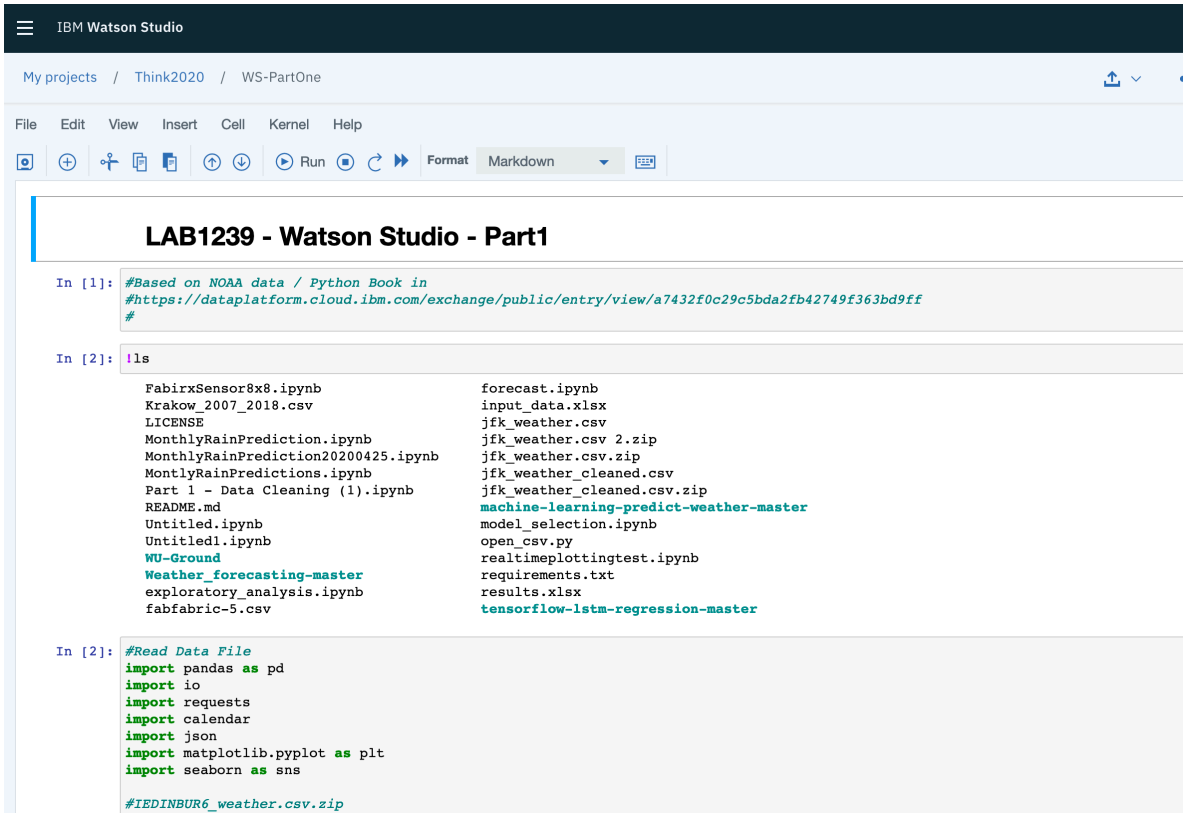


Find then notebook WS-PartOne.ipynb in your downloaded/zip file on you VM/Desktop. It should be in a directory that looks something like : … /thinklab1239/note-books/



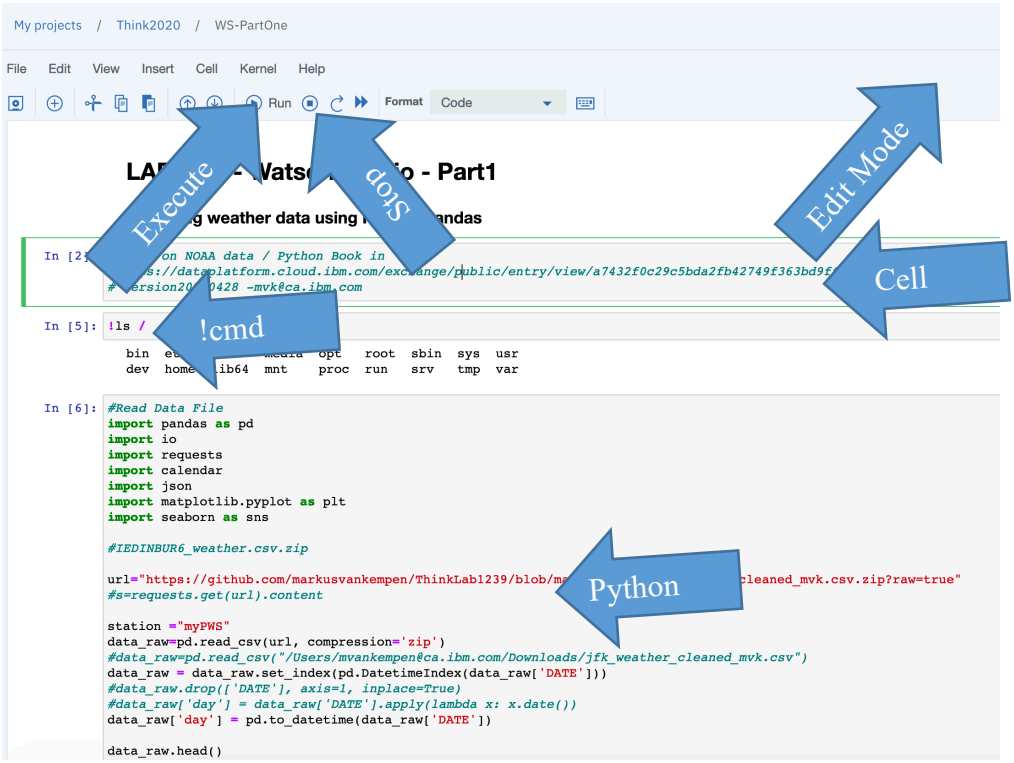


Click create. You should see the following screen.

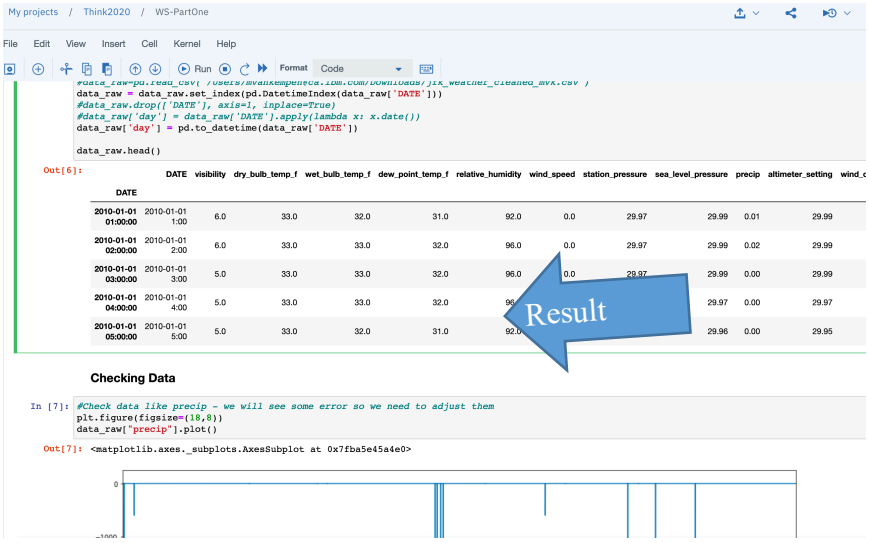


1.4 How to navigate Jupyter Notebook

Just a quick couple of pointers to how to execute a Notebook. The Notebook has documentation and code cell both can be “execute” with the arrow button on the top. After execution of a cell, you may see result at the bottom on the cell. The cursors will be automatically move to the next cell.



Note: Will see execution result once the Notebook is imported but these are just from save from an old session you always need to start from the top to execute the cell once you opened a Notebook /Put in Edit Mode



TIP: Use the Save Button regularly

1.5 Fixing Outliers in our Weather data

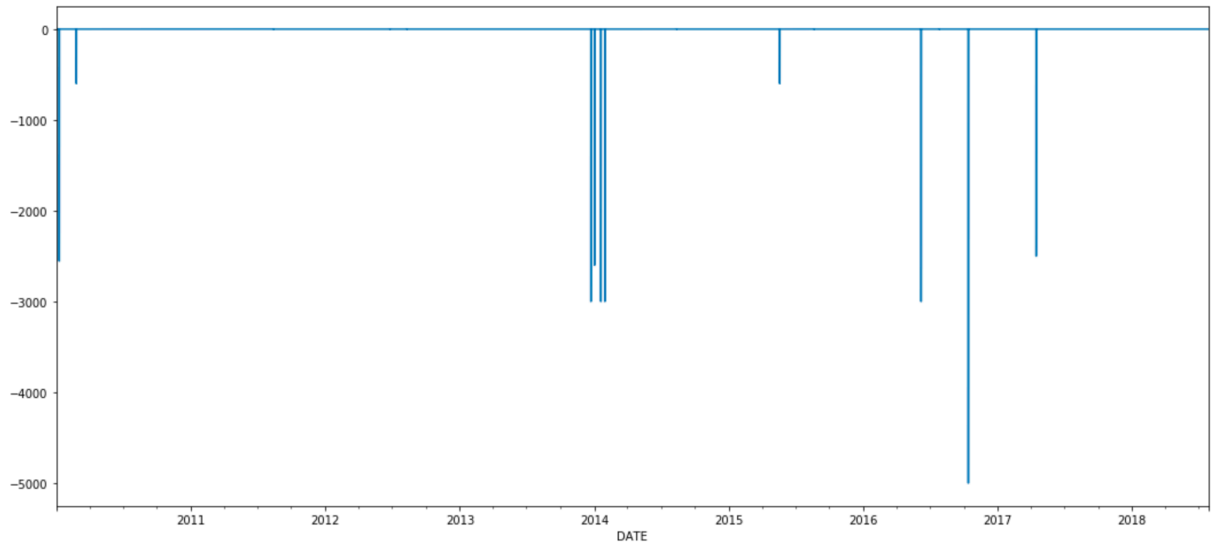
We will read a csv file with weather data in the Notebook/Python and display the columns and rows of data. Data is taken by the hour from 2010 -2018. When you have executed the first code cell you will see the data/structure of the file *(See above picture).* Our first task is to get a picture of the data to check consistency etc.

Below we simply plot the precipitation (rain) data into a chart. We can see there is something wrong with some of the data. This kind of data glitch can happen when your PWS gets cleaned or if there is an power outage/surge. It's always good practice to analyze the consistency to the data/columns and remove the outliers.

Checking Data

```
#Check data like precip - we will see some error so we need to adjust them
plt.figure(figsize=(18,8))
data_raw["precip"].plot()
```

```
: <matplotlib.axes._subplots.AxesSubplot at 0x7fba5e45a4e0>
```



Exercise:

We see in image above that there is negative rain on some days hours of the year. I order to get consistency we need to add some code in the Code Cell bellow … Something which simply zeros the entries like:

```
data_raw = data_raw[data_raw['precip'] > -500] #Fixing
```

Feel free to experiment with the code!

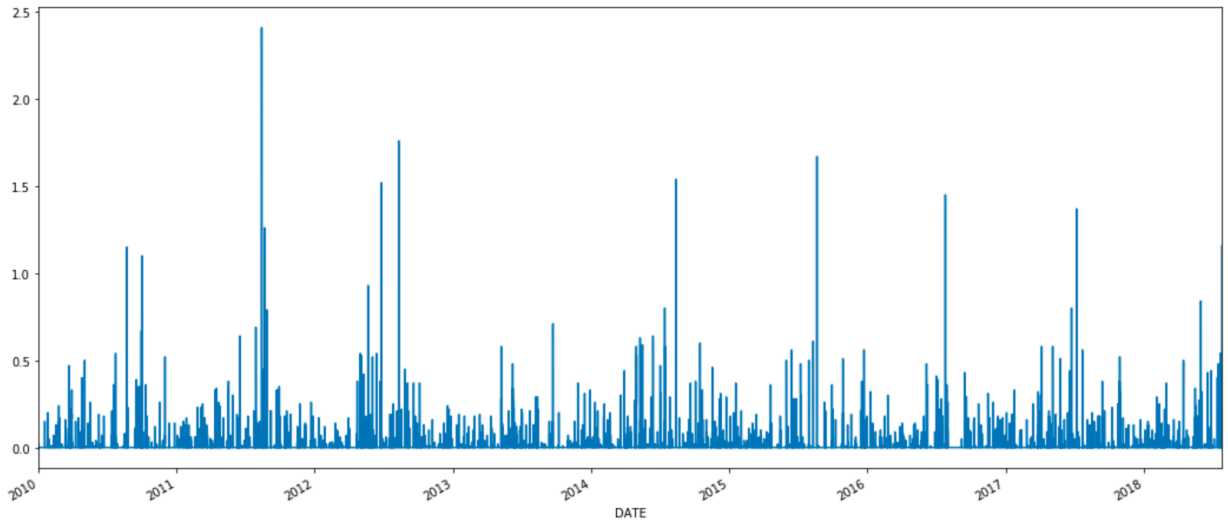
https://stackoverflow.com/questions/23199796/detect-and-exclude-outliers-in-pandas-data-frame

Once the code is executed with the fix we should see all rain data being positive in the chart.

Fixing Data

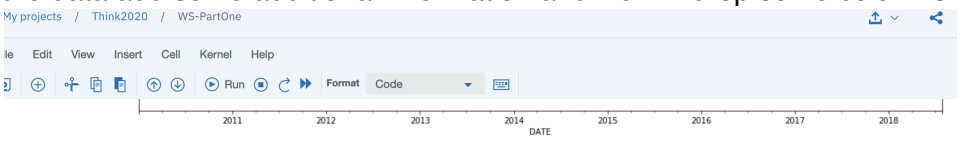
```
[8]: #  Can we fix the outliers ????
     data_raw = data_raw[data_raw['precip'] > -500] #Fixing
     plt.figure(figsize=(18,8))
     data_raw["precip"].plot()
```

```
Out[8]: <matplotlib.axes._subplots.AxesSubplot at 0x7fba5d2a7be0>
```



1.6 Preprocessing Weather data

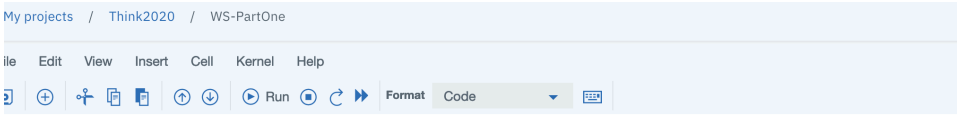
At the end we want to the data by month with Dry and Rainy days. In the next code sections, we group the data add some additional information and we will drop some columns form out data set.




```
In [5]: import calendar
#hourly_data_renamed['precip'].sum()
# Assign the "day" to every date entry
#hourly_data_renamed['day'] = hourly_data_renamed.apply(lambda x: x.date())
#len(hourly_data_renamed['relative_humidity'] > 96)
#hourly_data_renamed[hourly_data_renamed['raining'] == True].groupby('day').any()
mydata=data_raw
mydata['day'] = mydata.index
mydata['rain'] = data_raw['relative_humidity'] > 96
mydata['day'] = mydata['day'].apply(lambda x: x.date())
mydata['raintotal'] =mydata.groupby('day')['precip'].sum()
mydata['month'] = mydata['day'].apply(lambda x: x.month)
mydata["month_name"] = mydata['month'].apply(lambda x: calendar.month_abbr[x])
mydata.head()
```

Out[5]:

f	relative_humidity	wind_speed	station_pressure	sea_level_pressure	precip	...	wind_direction_sin	wind_direction_cos	pressure_tendency_incr	pressure_tendency_decr	press
0	92.0	0.0	29.97	29.99	0.01	...	0.0	1.0	0	1	
0	96.0	0.0	29.97	29.99	0.02	...	0.0	1.0	0	1	
0	96.0	0.0	29.97	29.99	0.00	...	0.0	1.0	0	1	
0	96.0	0.0	29.95	29.97	0.00	...	0.0	1.0	0	1	
0	92.0	0.0	29.93	29.96	0.00	...	0.0	1.0	0	1	




```
In [12]: columns_drop = [

    'dew_point_temp_f',

    'sea_level_pressure',
    'altimeter_setting',
    'wind_direction_sin',
    'wind_direction_cos',
    'pressure_tendency_incr',
    'pressure_tendency_decr',
    'pressure_tendency_const'
]
mydata=mydata.drop(columns=columns_drop)
print(len(mydata[mydata.precip >= 0.06]))
#print(len(mydata[mydata.relative_humidity >= 99]))
#mydata['rainh']= if(mydata.relative_humidity > 0.1
#mydata.replace({"rainh": {True: 1, False:0}}, inplace=True)
mydata['rainh']=mydata.precip.apply(lambda x: (x>=0.06),1,0)

mydata["2010-01-17":].head()
```

```
1786
```

Out[12]:

	DATE	visibility	dry_bulb_temp_f	wet_bulb_temp_f	relative_humidity	wind_speed	station_pressure	precip	
DATE									
2010-01-17 00:00:00	2010-01-17 0:00	10.0	33.0	31.0	82.0	7.0	30.12	0.0	2010-0
2010-01-17 01:00:00	2010-01-17 1:00	9.0	34.0	32.0	85.0	7.0	30.11	0.0	2010-0
2010-01-17 02:00:00	2010-01-17 2:00	9.0	31.0	30.0	89.0	0.0	30.09	0.0	2010-0
2010-01-17 03:00:00	2010-01-17 3:00	9.0	32.0	31.0	88.0	0.0	30.10	0.0	2010-0
2010-01-17 04:00:00	2010-01-17 4:00	9.0	33.0	32.0	89.0	0.0	30.11	0.0	2010-0

Exercise: Drop the **web_bulb_temp_f** and the **station pressure** columns as well .

1.6.1 Group the data by DAY

Here is the data group from hours to days and calculating hours of rain during the day and rain in mm/in.

Calculating Rain per Day

In [26]:
```
#
data=mydata.groupby('day')['relative_humidity'].max().reset_index()
data=data.set_index(data['day'])
data.index.name="index"
data['rain_mm']   = pd.Series(mydata.groupby('day')['precip'].sum(), index=data.index)
data['rain_daily_hours']   = pd.Series(mydata.groupby('day')['rainh'].sum(), index=data.index)
data['temp_f_max']= pd.Series(mydata.groupby('day')['dry_bulb_temp_f'].mean(), index=data.index)
#
#
#
print("Records by day since 2010 - 2018-07 ="+str(len(data)))
print("Total Days with data.relative_humidity >= 96  = "+ str(len(data[data.relative_humidity > 95]))) ## use prec/rain
print("Total Days with data.rain_mm > 0.15           = "+ str(len(data[data.rain_mm >= 0.17])))
#
#
data=data.set_index(data['day'])
data.index = pd.to_datetime(data.index)
data.index.name="index"
data['date'] = pd.to_datetime(data['day'])
data['ym'] = data.date.apply(lambda x: x.strftime('%Y%m'))
#
#
#
data['rainy']= data.rain_mm >= 0.15
data['rainday'] = data.rainy.apply(lambda x: (x>=0.15),1,0)
#
#
#
print("Rainy days in 2017 with  data.rain_mm >= 0.15  = "+str(len(data["2017":"2017"][data.rain_mm >= 0.17])))
print("Rainy days in 2016 with  data.rain_mm >= 0.15 = "+str(len(data["2016":"2016"][data.rain_mm >= 0.17])))
data["2010-01-17":"2012"].head(10)
```

```
Records by day since 2010 - 2018-07 =3130
Total Days with data.relative_humidity >= 96  = 488
Total Days with data.rain_mm > 0.15           = 488
Rainy days in 2017 with  data.rain_mm >= 0.15  = 58
Rainy days in 2016 with  data.rain_mm >= 0.15 = 51
```

Exercise:
There are some discrepancies between **rain_mm** and **relative_humidity**. Try to get the days of **rain_mm** and **relative_humidity** to match up. See above; 488 days in 8 years see to be a good number.

1.6.2 Group the data and calculating Dry and Wet days

Creating a couple of dataframes and merging back together to get Wet/Dry days per month:

Grouping and Calculating Dry and Wet days.

```
?7]: #Calucate Wet and Dry days
monthly = pd.DataFrame(data.groupby('ym')['rainy'].value_counts())
monthly.columns = ['Days']
monthly.reset_index(inplace = True)
monthly.columns = ['month', 'Rainy', 'Days']
monthly.replace({"Rainy": {True: "Wet", False:"Dry"}}, inplace=True)
monthly.head()
#
#
ndata=monthly.pivot(index ='month', columns ='Rainy')
#
#
ndata=ndata.droplevel(0, axis=1)
ndata.reset_index(inplace = True)
ndata=ndata.fillna(0)
dataX=data.merge(ndata, left_on='ym', right_on='month')
dataX.reset_index(inplace = True)

dataX=dataX.set_index(dataX['date'])

dataX.drop(columns='index')
dataX["2010-01-17":"2012"].head(10)
```

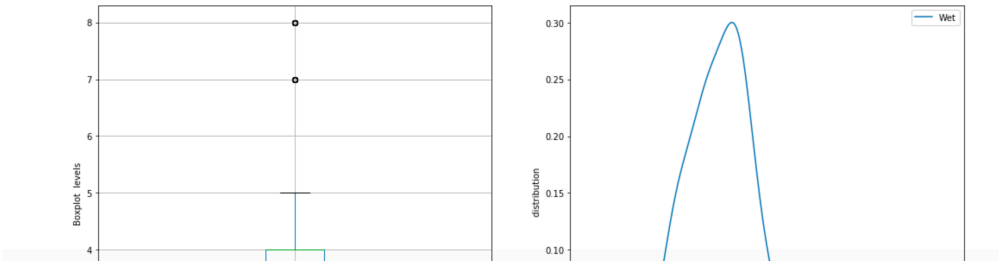
t[27]:

date	index	day	relative_humidity	rain_mm	rain_daily_hours	temp_f_max	date	ym	rainy	rainday	month	Dry	Wet
2010-01-17	16	2010-01-17	96.0	0.64	5.0	37.250000	2010-01-17	201001	True	True	201001	29.0	2.0
2010-01-18	17	2010-01-18	89.0	0.02	0.0	42.416667	2010-01-18	201001	False	False	201001	29.0	2.0
2010-01-19	18	2010-01-19	96.0	0.00	0.0	40.416667	2010-01-19	201001	False	False	201001	29.0	2.0
2010-01-20	19	2010-01-20	79.0	0.00	0.0	37.791667	2010-01-20	201001	False	False	201001	29.0	2.0

Next we check the distribution of Dry /Wet days.

Check Distribution

```
[30]: import numpy as np
import matplotlib.pyplot as plt
def plotBoxNdendity(data,col=None):
  if col in data.columns:
    plt.figure(figsize=(18,8))

    ax1 = plt.subplot(121)
    data.boxplot(col,ax=ax1)
    ax1.set_ylabel('Boxplot  levels', fontsize=10)

    ax2 = plt.subplot(122)
    data[col].plot(ax=ax2,legend=True,kind='density')
    ax2.set_ylabel(' distribution', fontsize=10)

  else:
    print("Column not in the data")
plotBoxNdendity(dataX[:'2010'],'Wet')
#plotBoxNdendity(dataWeekly,'rainday')
```



Exercise: Try multiple plots with different years.

Like

```
plotBoxNdendity(dataX[:'2012'],'Wet')
plotBoxNdendity(dataX[:'2014'],'Wet')
```

1.6.3 Sampling Monthly data

Here we resample the daily / hourly data to a month, so we get a nice small dataset.

Creating Monthly Data

23]:
```
#data.index = pd.to_datetime(data.index, unit='s')
#data['date']=pd.to_datetime(data['date'], infer_datetime_format=True)
#data.index = pd.to_datetime(data.index)
dataM=dataX.resample('M').max(); # monthly
dataM['year'] = dataM['day'].apply(lambda x: x.year)
dataM['month'] = dataM['day'].apply(lambda x: x.month)
dataM["month_name"] = dataM['month'].apply(lambda x: calendar.month_abbr[x])
dataM["temp_c_max"] = round((dataM["temp_f_max"] - 32) * 5/9,2)
dataM=dataM.drop(columns = "relative_humidity")
dataM=dataM.drop(columns = "index")
dataM=dataM.drop(columns = "day")
dataM=dataM.drop(columns = "rain_mm")
dataM=dataM.drop(columns = "rain_daily_hours")
dataM=dataM.drop(columns = "rainday")
dataM=dataM.drop(columns = "ym")
dataM=dataM.drop(columns = "temp_f_max")
dataM=dataM.drop(columns = "rainy")
dataM=dataM.drop(columns = "month")
#dataM=dataM.drop(columns = "temp_c_max")
dataM=dataM.drop(columns = "date")

#dataM[dataM.relative_humidity >= 98].head()
dataM['2017-01':].head()
```

t[23]:

date	Dry	Wet	year	month_name	temp_c_max
2017-01-31	22.0	9.0	2017	Jan	10.51
2017-02-28	25.0	3.0	2017	Feb	14.05

#Exercise:

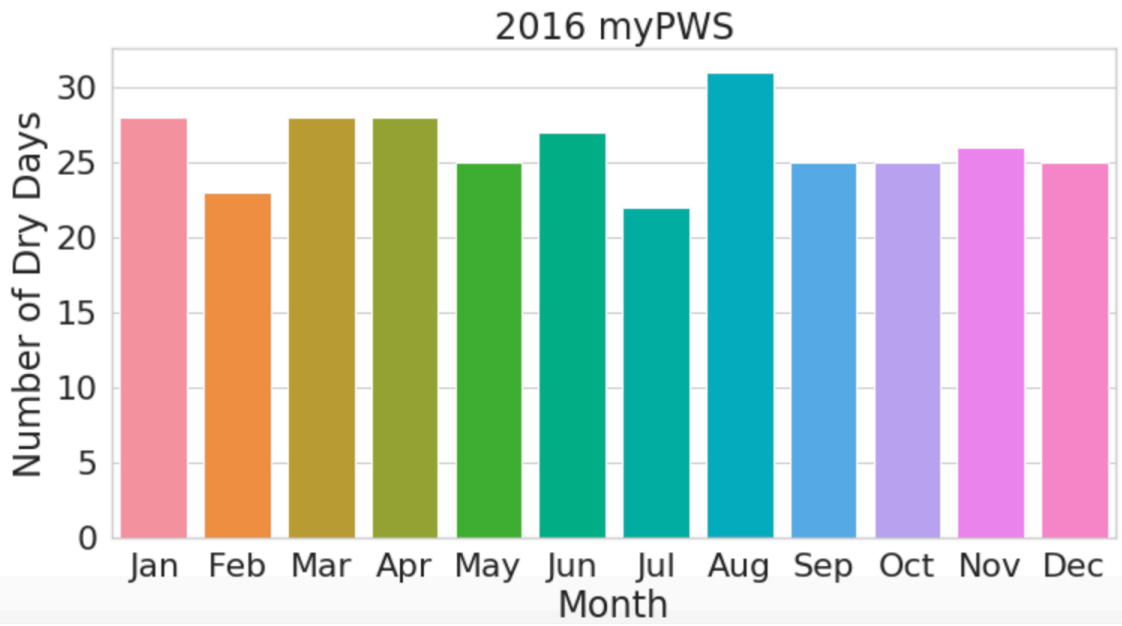
Try adding or leaving out some columns, like average temperature `(mean())` or temperature in Fahrenheit

1.6.4 Plot the Monthly data.

Plot the Monthly sample data

```
37]: import matplotlib.pyplot as plt
     import seaborn as sns
     # Monthly plot of rainy days
     plt.figure(figsize=(12,6))
     sns.set_style("whitegrid")
     sns.set_context("notebook", font_scale=2)
     sns.barplot(x="month_name", y="Dry",  data=dataM["2016-01":"2016-12"])

     plt.xlabel("Month")
     plt.ylabel("Number of Dry Days")
     plt.title("2016 {}".format(station))
     #Exerise display different years / data Elements
```

```
ıt[37]: Text(0.5, 1.0, '2016 myPWS')
```



Exercise
Display different years / data Elements like temperature

1.7 Playground for Query testing

Here we will work on the data queries, which we will send via commands from Node-RED, to get back the data. From Node-RED we will send a command call getInfo which should give us information about the data size — maybe the amount of years we have in the dataset. Take a look at the different function examples and execute them.

In [49]:
```
# GetInfo
dataY = dataM.resample('Y').mean(); # yearly averages
dataY.year.count()
getInfo = '{"cmd":"getInfo","tablesize":'+str(len(dataM))+',"years":'+str(dataY.year.count())+'}'; # yearly av

print(getInfo)
```

```
{"cmd":"getInfo","tablesize":103,"years":9}
```

In [48]:
```
#getJan2017
datain = {'cmd' : 'getInfo'}
dry=dataM["2017":"2017"].loc[dataM['month_name'] == 'Apr'].values[0][0]
wet=dataM["2017":"2017"].loc[dataM['month_name'] == 'Apr'].values[0][1]
yy=dataM["2017":"2017"].loc[dataM['month_name'] == 'Apr'].values[0][2]
mm=dataM["2017":"2017"].loc[dataM['month_name'] == 'Apr'].values[0][3]
temp=dataM["2017":"2017"].loc[dataM['month_name'] == 'Apr'].values[0][4]
mvk = {'Wet': wet,'Dry' : dry,"Month" : mm ,"Year":yy}
mvk["cmd"]=datain['cmd']
mvk
```

Out[48]:
```
{'Wet': 6.0, 'Dry': 24.0, 'Month': 'Apr', 'Year': 2017, 'cmd': 'getInfo'}
```

In [50]:
```
#Get A range
sel= dataM["2017-01":"2017-03"]
mvk=sel.reset_index().to_json(orient='records')
getInfo={"cmd":"cmd","info":[]}
info=json.loads(mvk)
getInfo['info']=info
getInfo["cmd"]=datain['cmd']
print(getInfo)
```

```
{'cmd': 'getInfo', 'info': [{'date': 1485820800000, 'Dry': 22.0, 'Wet': 9.0, 'year': 2017, 'month_name': 'Ja
3.0, 'year': 2017, 'month_name': 'Feb', 'temp_c_max': 14.05}, {'date': 1490918400000, 'Dry': 26.0, 'Wet': 5.
```

In [54]:
```
#GetRain
```

Above data example are the dataset/json we will send back to Node-RED based on the query/command. We will need to implement these functions in the next sections.

2 Connecting to Node-RED

In the next section we will install some websocket packages and adjust the URL to our Node-RED instance.

We need to install the websocket-client client via a unix command like:
`!pip install websocket-client`

Just uncomment the command and execute it.

Connecting to Node-RED

In [26]:
```
#Create commincaton with Node-RED instance
#You need to instal the client 1st
!pip install websocket-client
import websocket
import _thread
import time
import json

def on_open(ws):
    print("on open")
    ws.send(mysdata.loc[mysdata['month_name'] == 'Jan'])
    def run(*args):
        for i in range(10000):
            hbeat = '{"cmd":"Python NB HeartBeat"}'
            print("send cmd")
            ws.send(hbeat)
            time.sleep(1000)

    _thread.start_new_thread(run, ())
```

Once executed you will see some output at the bottom to of the cell —see below

```
    # ws.send("Watson Studio Listen open")
    ws.on_open = on_open
    ws.run_forever()

start_websocket_listener()
```

```
Collecting websocket-client
  Downloading https://files.pythonhosted.org/packages/4c/5f/f61b420143ed1c8dc69f9eaec5ff1ac361
     |████████████████████████████████| 204kB 9.3MB/s eta 0:00:01
Requirement already satisfied: six in /opt/conda/envs/Python36/lib/python3.6/site-packages (fr
Installing collected packages: websocket-client
Successfully installed websocket-client-0.57.0
connecting
on open
```

Once you executed the code - comment the line again . Like #!pip install websocket-client

Adjust the line below with your Node-RED instance, such as: thinklab??.mybluemix.net/ws/myweather/

```
            getInfo={"cmd":"cmd","info":[]}
            info=json.loads(mvk)
            getInfo['info']=info
            getInfo["cmd"]=datain['cmd']
            print(getInfo)
            ws.send(json.dumps(getInfo))

        if (datain['cmd'] == 'getTemp'):
            yy=datain['year']
            mm=datain['month']
            temp=dataM[yy:yy].loc[dataM['month_name'] == mm].values[0][4]
            getInfo = {'Temp' :temp,"Month" : mm ,"Year":yy}
            getInfo["cmd"]=datain['cmd']
            print(getInfo)
            ws.send(json.dumps(getInfo))
        if (datain['cmd'] == 'getAll'):
            mysdata.to_json()


    except:
        print("Error no json  / no  valid command")
####   ws://thinklab2020nr.mybluemix.net/ws/myweather/"
#### use your own isntance
def start_websocket_listener():
    #websocket.enableTrace(True)
    ws = websocket.WebSocketApp("ws://thinklab1239.mybluemix.net/ws/myweather/", #<<<<<<< ADJUST
                                on_message = on_message,
                                on_error = on_error,
                                on_close = on_close)
    print("connecting")
   # ws.send("Watson Studio Listen open")
    ws.on_open = on_open
    ws.run_forever()
```

When you have adjusted the cell with your instance name, execute the cell again
You should see at the bottom of the cell some text like:

```
   # ws.send("Watson Studio Listen open")
    ws.on_open = on_open
    ws.run_forever()

start_websocket_listener()
```

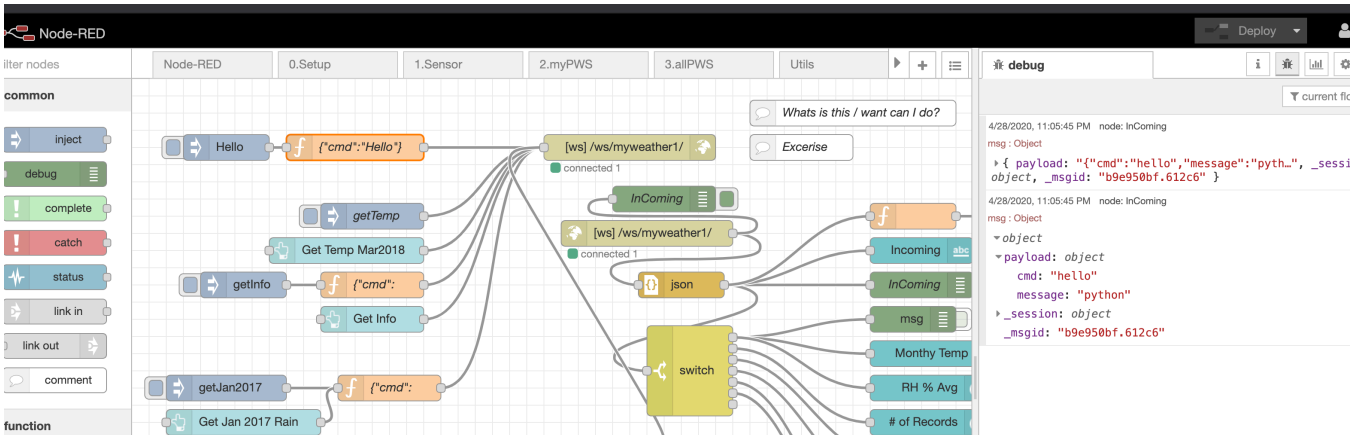
```
connecting
on open
```

```
In [ ]:  1  ### Start with  Part Two
```

Once you see this, let's switch back to Node-RED and the Weather History Tab
Note: Keep WatsonStudio open. We will switch between Node-RED our Dashboard and the Watson studio.

3 Sending a command to Python

Back in Node-RED, click on the Weather history tab. You should see a green info message on the websocket connection with a message like "connected 1". If this is the case, send a hello message and see if you receive a hello back, and check the message in Node-RED

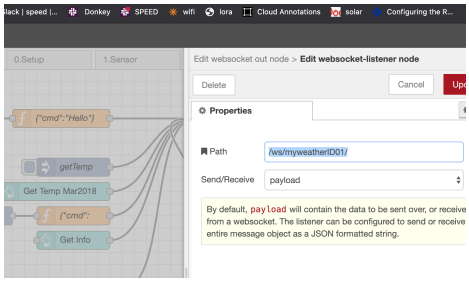


Note: If everything is working you should see as above in the debug console.

Troubleshooting:

1. Check the hostname in the Python Notebook should be ws://thinklab**??**.mybluemix.net/ws/myweather/ With your lab ID instead of ??

2. If you cannot get a connection change the websocket endpoint in the Notebook and Node-RED



Make sure it's the same on both sides. You will need to stop and restart the cell in the Notebook

3. The Notebook websocket might be closed, in which case you must restart the cell.

```
hello
{"cmd":"hello","message":"python"}

closed
```

```
[27]: ### Start with  Part Two
```

In the Notebook cell you should see message at the bottom like.

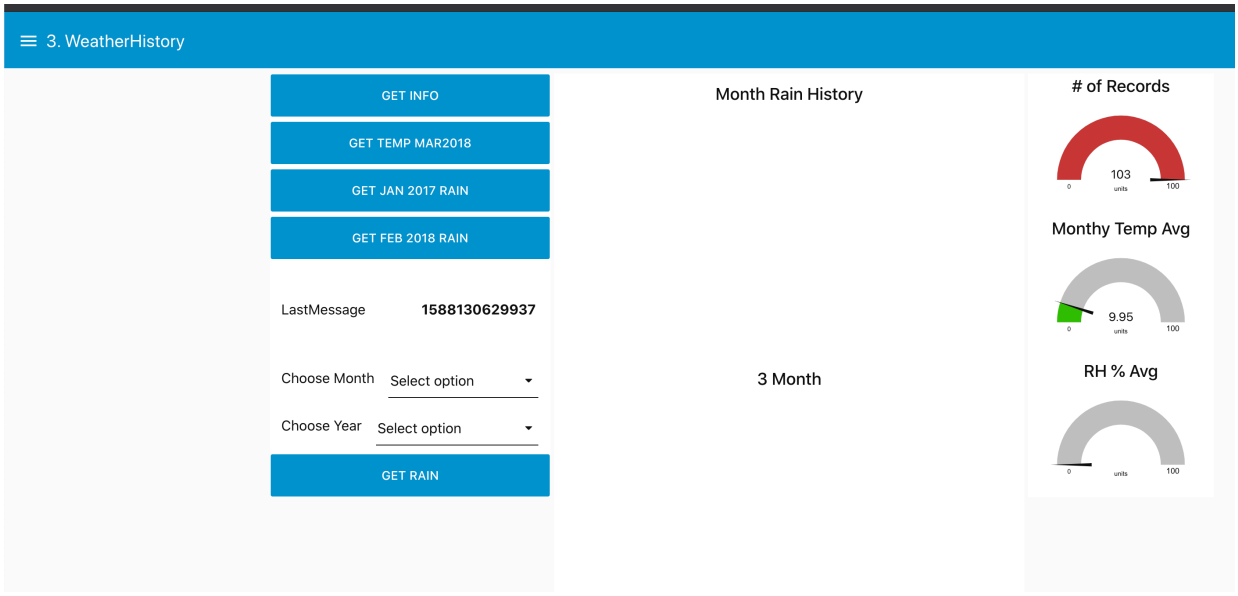
```
    ws.on_open = on_open
    ws.run_forever()

start_websocket_listener()
```

```
connecting
on open
{"cmd":"hello"}
hello
{"cmd":"hello","message":"python"}
{"cmd":"hello"}
hello
{"cmd":"hello","message":"python"}
{"cmd":"hello"}
hello
{"cmd":"hello","message":"python"}
{"cmd":"hello"}
hello
{"cmd":"hello","message":"python"}
```

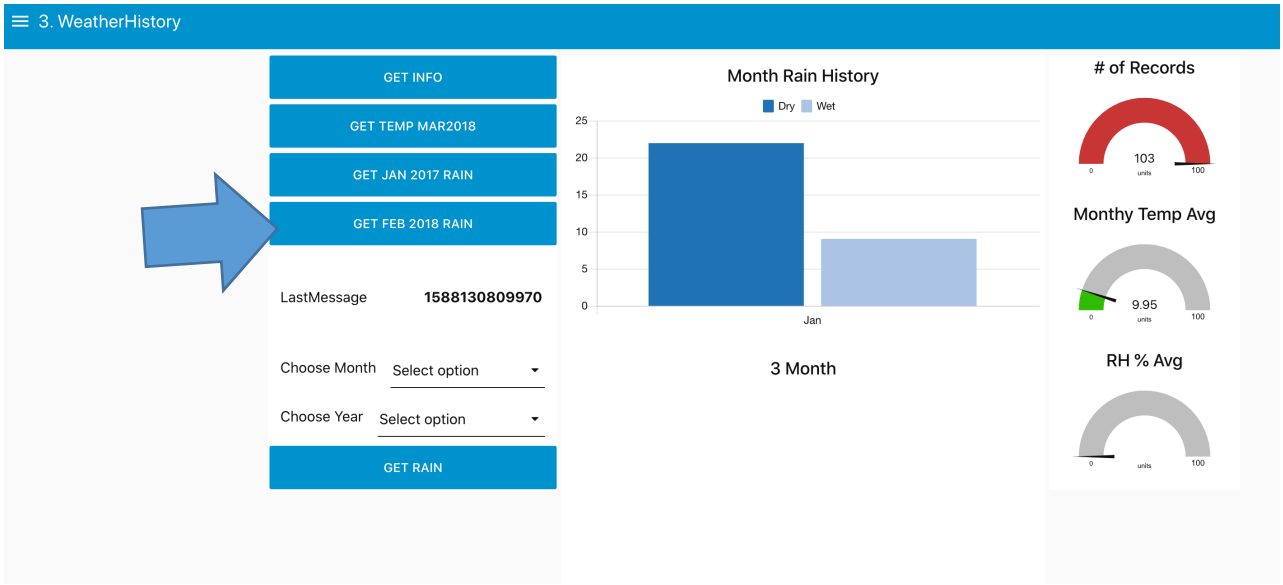
[27]:
```
### Start with  Part Two
```

4 Using the Dashboard and data Queries

Once we got all the connections working let's look at our Dashboard.
Select the 3. WeatherHistory Menu



Click on the Jan and Feb **Rain** buttons to retrieve the data form your Notebook. You should get some data back which is displayed.



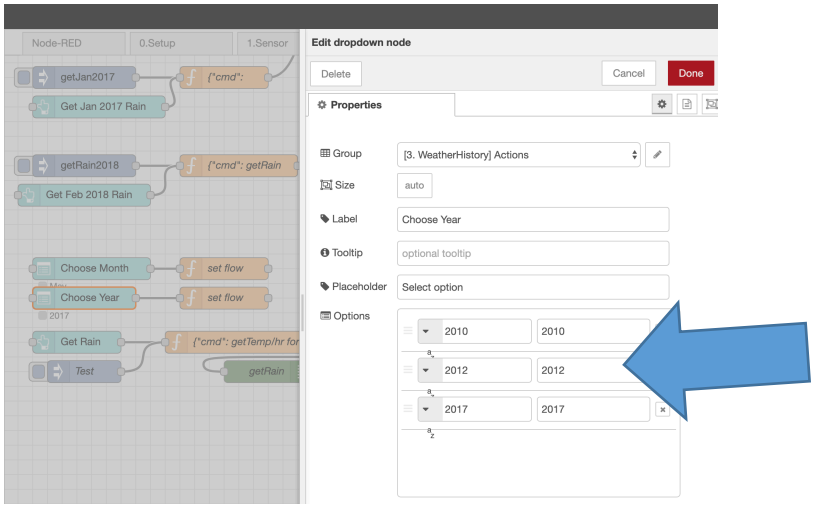
Flip back and check the message on Node-RED and NoteBook.

4.1 Adding more functionally

We now have functionality to get Temperature in some Months with Dry and Wet Days. We need to add more flexible function to get Rain Data from Notebook. We also need to add some more data such as years and months to the dashboard drop-downs.

Exercise

1. Add more Month and Years to the Drop down on the Dashboard.



2. Fix the code in the Notebook to return the data base on the drop down selection ... see getRain command.

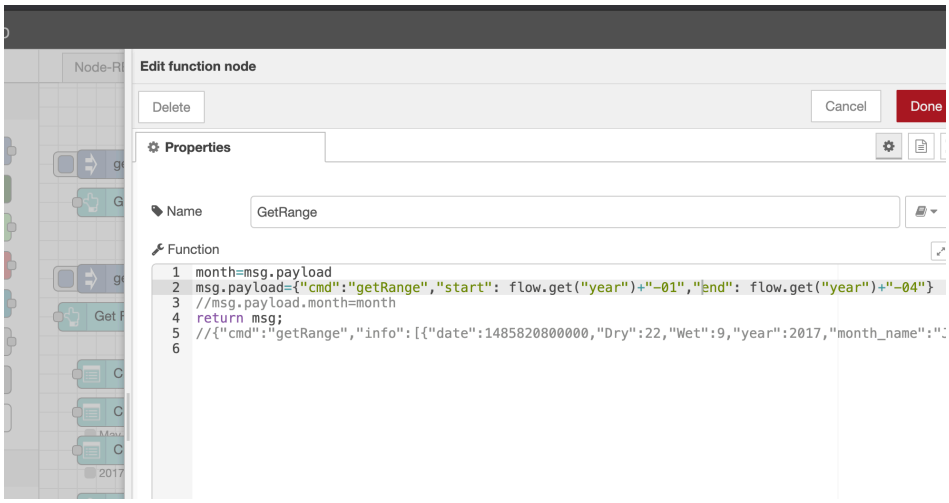
```
            ws.send(getInfo)

        if (datain['cmd'] == 'getJan2017'):
            dry=dataM["2017":"2017"].loc[dataM['month_name'] == 'Jan'].values[0][0]
            wet=dataM["2017":"2017"].loc[dataM['month_name'] == 'Jan'].values[0][1]
            yy=dataM["2017":"2017"].loc[dataM['month_name'] == 'Jan'].values[0][2]
            mm=dataM["2017":"2017"].loc[dataM['month_name'] == 'Jan'].values[0][3]
            getInfo = {'Wet': wet,'Dry' : dry,"Month" : mm ,"Year":yy}
            getInfo["cmd"]=datain['cmd']
            print(getInfo)
            ws.send(json.dumps(getInfo))
        #Get Rain for a month Month  in coming {"cmd":"getRain","month":"Feb","year":"2018"}
        if (datain['cmd'] == 'getRain'):
#
# Excerise Change here see above function
#
            getInfo = {'Wet': wet,'Dry' : dry,"Month" : "FixCode" ,"Year":"FixCode"}
            getInfo["cmd"]=datain['cmd']
            print(getInfo)
            ws.send(json.dumps(getInfo))
```

(see next page)

#Get Rain for a Month in coming

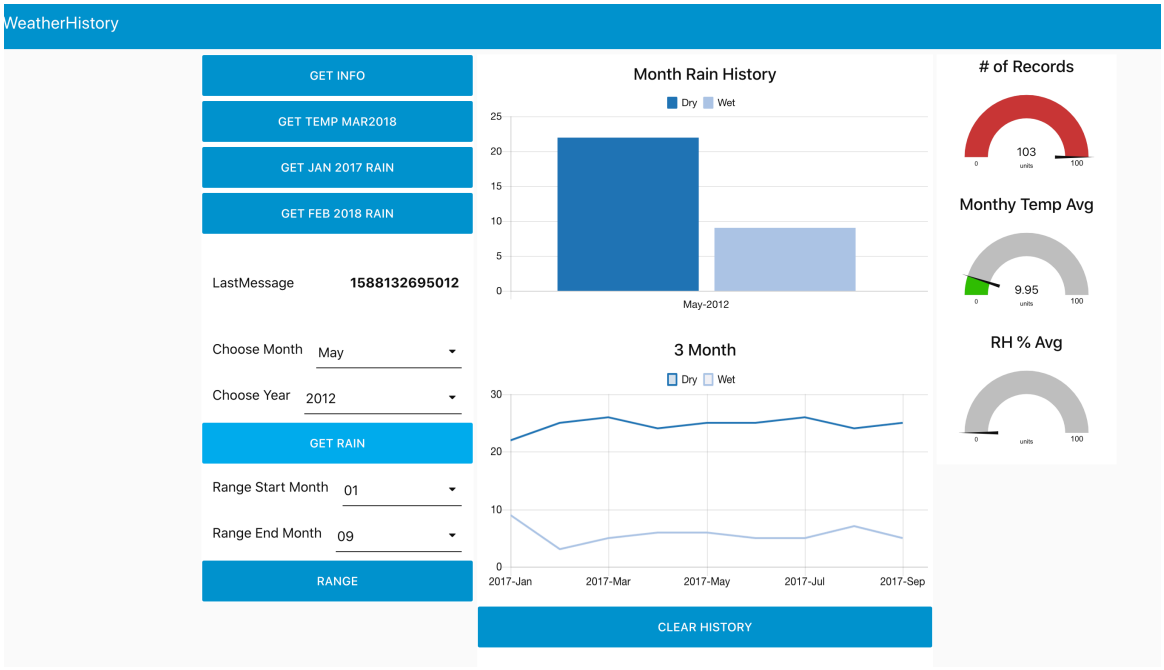
```
{"cmd":"getRain","month":"Feb","year":"2018"}
        if (datain['cmd'] == 'getRain'):
            yy=datain['year']
            mm=datain['month']
            dry=dataM[yy:yy].loc[dataM['month_name'] ==
mm].values[0][0]
            wet=dataM[yy:yy].loc[dataM['month_name'] ==
mm].values[0][1]
            getInfo = {'Wet': wet,'Dry' : dry,"Month" : mm ,"Year":yy}
            getInfo["cmd"]=datain['cmd']
            print(getInfo)
            ws.send(json.dumps(getInfo))
```

3. The getRrange command is hard coded in Node-RED . I always retrieve Jan to March. Add a other dropdown and add the range flow var to the code in Node-RED




```
msg.payload={"cmd":"getRange","start": flow.get("year")+"-
"+flow.get("startrange"),"end": flow.get("year")+"-
"+flow.get("endrange")}
```

You should see something like this if everything is working



Please note: the above exercises are not required for the next part of the lab.
Feel free to move on without coding.

In Part Three of the LAB we will work with Watson Studio so please make sure to sign up for an free account. [Register for WatsonStudio](https://dataplatform.cloud.ibm.com/registration/stepone)
https://dataplatform.cloud.ibm.com/registration/stepone

Get the instructions for LAB Part Three here
https://github.com/markusvankempen/ThinkLab1239/tree/master/instructions

For more details got to the github

https://github.com/markusvankempen/ThinkLab1239

Cheers
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