Plotting the Grow Dataset

Task

You are provided with:

- The Grow dataset Growlocations.csv. This file contains the locations of all the GROWsensors as Latitude and Longitude
- A map of the UK from Openstreet map.

You should create a Python program that can read the dataset into a dataframe and plot the locations of the sensors on the map provided. You can use online tutorials to do this (but mention them in comments section of your code). However there are a number of errors with the dataset that you will need to fix in order to get the correct plot.

These include:

- Some location values are way outside the allowed values for latitude and Longitude.
- Some locations are not on the map provided.
- The labels of the columns have not be verified so may be incorrect.

The bounding box for the map is as follows:

- Longitude Min -10.592
- Longitude Max 1.6848
- Latitude Min 50.681
- Latitude Max 57.985

Marks will be allocated as follows:

- Reading the data into a data frame. 25%
- Removing bad values. . 25%
- Fixing other problems. . 25%
- Plotting the data correctly. . 25%

An example map is on the next page. Note, I do not expect you to get the sensors in the absolute correct locations, but the locations should match approximately the ones on the map below.

Imports

```
import pandas as pd
import matplotlib.pyplot as plt
```

Reading the data into a data frame

```
grow_locations_df = pd.read_csv("GrowLocations.csv")
grow_locations_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 39294 entries, 0 to 39293
Data columns (total 8 columns):
 #   Column      Non-Null Count  Dtype  
---  ------      --------------  -----  
 0   Serial      39252 non-null  object 
 1   Latitude    39294 non-null  float64
 2   Longitude   39294 non-null  float64
 3   Type        39294 non-null  object 
 4   SensorType  39294 non-null  object 
 5   Code        39294 non-null  object 
 6   BeginTime   39294 non-null  object 
 7   EndTime     39294 non-null  object 
dtypes: float64(2), object(6)
memory usage: 2.4+ MB
```

```
grow_locations_df.head()
```

```
               Serial  Latitude  Longitude  \
0  PI040298AD5J215142    -7.923      54.98   
1  PI040298AD5J215142    -7.923      54.98   
2  PI040298AD5J215142    -7.923      54.98   
3  PI040298AD5J215142    -7.923      54.98   
4  PI040298AD5J215142    -7.923      54.98   

                                           Type    SensorType  \
0   Thingful.Connectors.GROWSensors.AirTemperature  Flower Power   
1     Thingful.Connectors.GROWSensors.BatteryLevel  Flower Power   
2  Thingful.Connectors.GROWSensors.FertilizerLevel  Flower Power   
3            Thingful.Connectors.GROWSensors.Light  Flower Power   
4     Thingful.Connectors.GROWSensors.SoilMoisture  Flower Power   

                             Code                 BeginTime  \
0  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   
1  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   
2  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   
3  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   
4  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   

                    EndTime  
0  2018-10-17T13:59:07.000Z  
1  2018-10-17T13:59:07.000Z  
2  2018-10-17T13:59:07.000Z  
3  2018-10-17T13:59:07.000Z  
4  2018-10-17T13:59:07.000Z  
```

```
# Number of serial numbers
grow_locations_df['Serial'].nunique()
```

```
6310
```

Identifying potential issues

From the assignment we know the geographical location that we are looking at.

The bounding box for the map is as follows:

- Longitude Min -10.592
- Longitude Max 1.6848
- Latitude Min 50.681
- Latitude Max 57.98

Also, to be valid, latitudes should be between + and - 90, and longditudes +- 180.

```
# Look at the most extreme values for latitude for potential problems

grow_locations_df.sort_values('Latitude')
```

```
                                                        Serial 
Latitude  \
38880                                       PI040298AD5I209078     -18.144

38708                                       PI040298AD5G203374     -18.144

38709                                       PI040298AD5G203374     -18.144

38710                                       PI040298AD5G203374     -18.144

38885                                       PI040298AD5I209078     -18.144

...                                                        ...         ...

37761  PI040307AA4A016608. FuturePractice:,Id:1192,La...  465958.000

37762  PI040307AA4A016608. FuturePractice:,Id:1192,La...  465958.000

37758  PI040307AA4A016608. FuturePractice:,Id:1192,La...  465958.000

37759  PI040307AA4A016608. FuturePractice:,Id:1192,La...  465958.000

37763  PI040307AA4A016608. FuturePractice:,Id:1192,La...  465958.000


        Longitude                                         Type  \
38880      27.754   Thingful.Connectors.GROWSensors.AirTemperature
38708      27.754  Thingful.Connectors.GROWSensors.FertilizerLevel
38709      27.754            Thingful.Connectors.GROWSensors.Light
38710      27.754     Thingful.Connectors.GROWSensors.SoilMoisture
38885      27.754   Thingful.Connectors.GROWSensors.WaterTankLevel
...           ...                                              ...
37761  360431.000            Thingful.Connectors.GROWSensors.Light
37762  360431.000     Thingful.Connectors.GROWSensors.SoilMoisture
```

```
37758  360431.000   Thingful.Connectors.GROWSensors.AirTemperature
37759  360431.000     Thingful.Connectors.GROWSensors.BatteryLevel
37763  360431.000   Thingful.Connectors.GROWSensors.WaterTankLevel

         SensorType                            Code
BeginTime  \
38880  Flower Power  Grow.Thingful.Sensors_j3wnhkx4  2019-09-
11T07:55:27.000Z
38708  Flower Power  Grow.Thingful.Sensors_9h1fyfnq  2019-09-
11T06:47:05.000Z
38709  Flower Power  Grow.Thingful.Sensors_9h1fyfnq  2019-09-
11T06:47:05.000Z
38710  Flower Power  Grow.Thingful.Sensors_9h1fyfnq  2019-09-
11T06:47:05.000Z
38885  Flower Power  Grow.Thingful.Sensors_j3wnhkx4  2019-09-
11T07:55:27.000Z
...             ...                             ...
...
37761  Flower Power  Grow.Thingful.Sensors_fbrmxjh3  2019-10-
10T12:05:26.000Z
37762  Flower Power  Grow.Thingful.Sensors_fbrmxjh3  2019-10-
10T12:05:26.000Z
37758  Flower Power  Grow.Thingful.Sensors_fbrmxjh3  2019-10-
10T12:05:26.000Z
37759  Flower Power  Grow.Thingful.Sensors_fbrmxjh3  2019-10-
10T12:05:26.000Z
37763  Flower Power  Grow.Thingful.Sensors_fbrmxjh3  2019-10-
10T12:05:26.000Z

                        EndTime
38880  2019-09-20T09:10:27.000Z
38708  2019-09-20T09:17:05.000Z
38709  2019-09-20T09:17:05.000Z
38710  2019-09-20T09:17:05.000Z
38885  2019-09-20T09:10:27.000Z
...                         ...
37761  2019-10-28T14:35:48.000Z
37762  2019-10-28T14:35:48.000Z
37758  2019-10-28T14:35:48.000Z
37759  2019-10-28T14:35:48.000Z
37763  2019-10-28T14:35:48.000Z

[39294 rows x 8 columns]
```

The low values for latitude here are valid, but far away from the region to be plotted, and can be filtered out, as they are probably just from a different place.

However, the highest values here are clearly a mistake, and there is some nested data in the serial column that might give a clue.

```
# Unfortunately the data is not in here
print(grow_locations_df.loc[37763, 'Serial'])
print(grow_locations_df.loc[37759, 'Serial'])
```

```
PI040307AA4A016608.
FuturePractice:,Id:1192,LandCoverOverlay:,LandCoverTypes:,LandManageme
nt:,LandUseArea:,LandUseSpot:,Latitude:,Longitude:,ParcelSize:,Photos:
,SensorId:Stc,_rde_field opp
house,SensorMissionManagement:,SensorOnMulchedGround:,SensorOvergrown:
,SensorShadedByTrees:,SlopeAspect:,SlopePosition:,SoilTextureClay:,Soi
lTextureSand:,SoilTextureSilt:,StoneContent:,SubmissionTimestamp:2019-
10-20T12:52:43.906027+00:
PI040307AA4A016608.
FuturePractice:,Id:1192,LandCoverOverlay:,LandCoverTypes:,LandManageme
nt:,LandUseArea:,LandUseSpot:,Latitude:,Longitude:,ParcelSize:,Photos:
,SensorId:Stc,_rde_field opp
house,SensorMissionManagement:,SensorOnMulchedGround:,SensorOvergrown:
,SensorShadedByTrees:,SlopeAspect:,SlopePosition:,SoilTextureClay:,Soi
lTextureSand:,SoilTextureSilt:,StoneContent:,SubmissionTimestamp:2019-
10-20T12:52:43.906027+00:
```

```
# I want to how many of the sensors have invalid latitude and/or
longitude
valid_lat = grow_locations_df['Latitude'].between(-90, 90,
inclusive='both')
valid_long = grow_locations_df['Longitude'].between(-180, 180,
inclusive='both')
grow_locations_df[~(valid_lat & valid_long)]['Serial'].nunique()
```

```
9
```

```
# It's not so many, so I can take a look at them all at once
grow_locations_df[~(valid_lat & valid_long)][['Serial', 'Latitude',
'Longitude']].drop_duplicates()
```

```
                                                  Serial  Latitude
Longitude
23652                                 PI040298AA4C055243       2.0
4903185.0
37746  PI040307AA4C019989. FuturePractice:,Id:1196,La...  465652.0
360502.0
37752                                 PI040307AA4A016667  465652.0
360472.0
37758  PI040307AA4A016608. FuturePractice:,Id:1192,La...  465958.0
360431.0
37950                                 PI040307AA4C020377  465943.0
360373.0
37956                                 PI040307AA4A016727  465883.0
360323.0
37962  PI040307AA4A016520. FuturePractice:,Id:1194,La...  465662.0
```

```
360213.0
37968  PI040307AA4C019855. FuturePractice:,Id:432,Lan...  465643.0
360206.0
37974  PI040307AA4C020026. FuturePractice:,Id:431,Lan...  465632.0
360196.0
```

```
print(grow_locations_df[~(valid_lat & valid_long)][['Serial',
'Latitude', 'Longitude']].drop_duplicates()['Serial'].values)
```

```
['PI040298AA4C055243'
 'PI040307AA4C019989.
FuturePractice:,Id:1196,LandCoverOverlay:,LandCoverTypes:,LandManageme
nt:,LandUseArea:,LandUseSpot:,Latitude:,Longitude:,ParcelSize:,Photos:
,SensorId:Stc_rde_oak Below Anthony
MWoo,SensorMissionManagement:,SensorOnMulchedGround:,SensorOvergrown:,
SensorShadedByTrees:,SlopeAspect:,SlopePosition:,SoilTextureClay:,Soil
TextureSand:,SoilTextureSilt:,StoneContent:,SubmissionTimestamp:2019-
10-20T13:08:15.052917+00:'
 'PI040307AA4A016667'
 'PI040307AA4A016608.
FuturePractice:,Id:1192,LandCoverOverlay:,LandCoverTypes:,LandManageme
nt:,LandUseArea:,LandUseSpot:,Latitude:,Longitude:,ParcelSize:,Photos:
,SensorId:Stc,_rde_field opp
house,SensorMissionManagement:,SensorOnMulchedGround:,SensorOvergrown:
,SensorShadedByTrees:,SlopeAspect:,SlopePosition:,SoilTextureClay:,Soi
lTextureSand:,SoilTextureSilt:,StoneContent:,SubmissionTimestamp:2019-
10-20T12:52:43.906027+00:'
 'PI040307AA4C020377' 'PI040307AA4A016727'
 'PI040307AA4A016520.
FuturePractice:,Id:1194,LandCoverOverlay:,LandCoverTypes:,LandManageme
nt:,LandUseArea:,LandUseSpot:,Latitude:,Longitude:,ParcelSize:,Photos:
,SensorId:Stc_.rde_low Whitmoor
3,SensorMissionManagement:,SensorOnMulchedGround:,SensorOvergrown:,Sen
sorShadedByTrees:,SlopeAspect:,SlopePosition:,SoilTextureClay:,SoilTex
tureSand:,SoilTextureSilt:,StoneContent:,SubmissionTimestamp:2019-10-
20T13:01:51.93976+00:'
 'PI040307AA4C019855.
FuturePractice:,Id:432,LandCoverOverlay:,LandCoverTypes:[Additional:
[],Cover:> 91%,Id:4057,Name:Other ground covering plants (weeds,
grasses)],LandManagement:,LandUseArea:Cultivated, agricultural
land,LandUseSpot:Field or grazing
pasture,Latitude:52.2899971,Longitude:-6.799615,ParcelSize:1  5
ha,Photos:,SensorId:Moor
2,SensorMissionManagement:true,SensorOnMulchedGround:false,SensorOverg
rown:true,SensorShadedByTrees:false,SlopeAspect:,SlopePosition:Flat,So
ilTextureClay:,SoilTextureSand:,SoilTextureSilt:,StoneContent:,Submiss
ionTimestamp:2018-12-01T13:35:15.484092+00:'
 'PI040307AA4C020026.
FuturePractice:,Id:431,LandCoverOverlay:,LandCoverTypes:[Additional:
[],Cover:> 91%,Id:4057,Name:Other ground covering plants (weeds,
grasses)],LandManagement:,LandUseArea:Cultivated, agricultural
land,LandUseSpot:Field or grazing
pasture,Latitude:52.2898827,Longitude:-6.79935455,ParcelSize:1  5
ha,Photos:,SensorId:Moor
1,SensorMissionManagement:true,SensorOnMulchedGround:false,SensorOverg
rown:true,SensorShadedByTrees:false,SlopeAspect:,SlopePosition:Flat,So
ilTextureClay:,SoilTextureSand:,SoilTextureSilt:,StoneContent:,Submiss
ionTimestamp:2018-12-01T13:35:08.160331+00:']

# Some of these do have valid lat and long values buried in their
serial columns that could be extracted

grow_locations_df['Serial'].str.extract(pat='Latitude:(.*?),Longitude:
(.*?),').dropna()

                0          1
54     47.309803  18.4156017
55     47.309803  18.4156017
56     47.309803  18.4156017
57     47.309803  18.4156017
58     47.309803  18.4156017
...          ...         ...
39181   50.88384  15.5616245
39182   50.88384  15.5616245
39183   50.88384  15.5616245
39184   50.88384  15.5616245
39185   50.88384  15.5616245

[2658 rows x 2 columns]

# I also want to check if all lines that have the same serial number
have the same lat and long
duplicated = grow_locations_df[['Serial', 'Latitude',
'Longitude']].drop_duplicates().groupby('Serial').nunique()
duplicated[(duplicated['Latitude'] > 1) | (duplicated['Longitude'] >
1)]

                                                    Latitude
Longitude
Serial

PI040297AA3I001108                                         2
2
PI040297AA3I001108. FuturePractice:,Id:399,Land...         2
2
PI040297AA3J003673                                         2
1
PI040297AA3L024781                                         2
2
PI040297AD5I205735                                         2
2
```

```
...                                                      ...        ..
.
PI040307AD5I203792                                         2
2
PI040307AD5I203906                                         2
2
PI040307AD5I204104                                         2
2
PI040307AD5I204402                                         2
2
PI040307AD5I204477                                         2
2

[180 rows x 2 columns]

# This example looks like the sensor has either moved slightly or has
been entered slightly differently
grow_locations_df[grow_locations_df['Serial']=='PI040297AA3I001108']

                  Serial  Latitude  Longitude  \
564   PI040297AA3I001108    19.813     48.004
565   PI040297AA3I001108    19.813     48.004
566   PI040297AA3I001108    19.813     48.004
567   PI040297AA3I001108    19.813     48.004
568   PI040297AA3I001108    19.813     48.004
569   PI040297AA3I001108    19.813     48.004
1026  PI040297AA3I001108    19.817     48.015
1027  PI040297AA3I001108    19.817     48.015
1028  PI040297AA3I001108    19.817     48.015
1029  PI040297AA3I001108    19.817     48.015
1030  PI040297AA3I001108    19.817     48.015
1031  PI040297AA3I001108    19.817     48.015

                                                 Type    SensorType  \
564    Thingful.Connectors.GROWSensors.AirTemperature  Flower Power
565      Thingful.Connectors.GROWSensors.BatteryLevel  Flower Power
566   Thingful.Connectors.GROWSensors.FertilizerLevel  Flower Power
567              Thingful.Connectors.GROWSensors.Light  Flower Power
568      Thingful.Connectors.GROWSensors.SoilMoisture  Flower Power
569    Thingful.Connectors.GROWSensors.WaterTankLevel  Flower Power
1026   Thingful.Connectors.GROWSensors.AirTemperature  Flower Power
1027     Thingful.Connectors.GROWSensors.BatteryLevel  Flower Power
1028  Thingful.Connectors.GROWSensors.FertilizerLevel  Flower Power
1029             Thingful.Connectors.GROWSensors.Light  Flower Power
1030     Thingful.Connectors.GROWSensors.SoilMoisture  Flower Power
1031   Thingful.Connectors.GROWSensors.WaterTankLevel  Flower Power

                                Code                 BeginTime  \
564   Grow.Thingful.Sensors_mnz0tndr  2018-10-31T14:38:01.000Z
565   Grow.Thingful.Sensors_mnz0tndr  2018-10-31T14:38:01.000Z
```

```
566   Grow.Thingful.Sensors_mnz0tndr  2018-10-31T14:38:01.000Z
567   Grow.Thingful.Sensors_mnz0tndr  2018-10-31T14:38:01.000Z
568   Grow.Thingful.Sensors_mnz0tndr  2018-10-31T14:38:01.000Z
569   Grow.Thingful.Sensors_mnz0tndr  2018-10-31T14:38:01.000Z
1026  Grow.Thingful.Sensors_vscm8nca  2018-11-02T12:37:13.000Z
1027  Grow.Thingful.Sensors_vscm8nca  2018-11-02T12:37:13.000Z
1028  Grow.Thingful.Sensors_vscm8nca  2018-11-02T12:37:13.000Z
1029  Grow.Thingful.Sensors_vscm8nca  2018-11-02T12:37:13.000Z
1030  Grow.Thingful.Sensors_vscm8nca  2018-11-02T12:37:13.000Z
1031  Grow.Thingful.Sensors_vscm8nca  2018-11-02T12:37:13.000Z

                       EndTime
564   2018-10-31T15:23:01.000Z
565   2018-10-31T15:23:01.000Z
566   2018-10-31T15:23:01.000Z
567   2018-10-31T15:23:01.000Z
568   2018-10-31T15:23:01.000Z
569   2018-10-31T15:23:01.000Z
1026  2018-11-12T12:22:13.000Z
1027  2018-11-12T12:22:13.000Z
1028  2018-11-12T12:22:13.000Z
1029  2018-11-12T12:22:13.000Z
1030  2018-11-12T12:22:13.000Z
1031  2018-11-12T12:22:13.000Z
```

```
# Some rows are 0,0 lat,long
min_max = grow_locations_df.groupby('Serial').agg({'Latitude': ['min',
'max'], 'Longitude': ['min', 'max']})
min_max['lat_diff'] = min_max['Latitude', 'max'] - min_max['Latitude',
'min']
min_max['long_diff'] = min_max['Longitude', 'max'] -
min_max['Longitude', 'min']
min_max.sort_values('lat_diff', ascending=False).head(20)
```

```
                   Latitude         Longitude         lat_diff
long_diff
                        min     max       min     max

Serial

PI040307AD5G202249      0.0  21.316       0.0  48.165   21.316
48.165
PI040307AD5G200425      0.0  21.315       0.0  48.168   21.315
48.168
PI040307AD5G200335      0.0  21.302       0.0  48.169   21.302
48.169
PI040298AD5G204879      0.0  21.301       0.0  48.166   21.301
48.166
PI040298AD5I208522      0.0  21.299       0.0  48.168   21.299
48.168
```

```
PI040307AD5I203792      0.0  21.298       0.0  48.169   21.298
48.169
PI040298AA3J019994      0.0  21.039       0.0  48.364   21.039
48.364
PI040297AD5J210378      0.0  20.768       0.0  48.104   20.768
48.104
PI040297AD5I209992      0.0  20.768       0.0  48.104   20.768
48.104
PI040298AA3I004792      0.0  20.765       0.0  48.082   20.765
48.082
PI040298AA3I003514      0.0  20.765       0.0  48.082   20.765
48.082
PI040298AA4A043084      0.0  20.765       0.0  48.082   20.765
48.082
PI040298AA3J012441      0.0  20.765       0.0  48.082   20.765
48.082
PI040298AA3J020848      0.0  20.765       0.0  48.082   20.765
48.082
PI040298AA3I001081      0.0  20.765       0.0  48.082   20.765
48.082
PI040298AA3J009751      0.0  20.765       0.0  48.082   20.765
48.082
PI040298AA3L037484      0.0  20.765       0.0  48.082   20.765
48.082
PI040298AA3I000856      0.0  20.764       0.0  48.082   20.764
48.082
PI040298AA3I001504      0.0  20.764       0.0  48.082   20.764
48.082
PI040298AA3I001582      0.0  20.764       0.0  48.082   20.764
48.082
```

Cleanup

```
# Get the more accurate latitude and longitudes
grow_locations_with_extra_latlong = pd.concat([grow_locations_df,
grow_locations_df['Serial'].str.extract(pat='Latitude:(.*?),Longitude:
(.*?),')], axis=1)
grow_locations_with_extra_latlong['Latitude'] =
pd.to_numeric(grow_locations_with_extra_latlong[0]).fillna(grow_locati
ons_with_extra_latlong['Latitude'])
grow_locations_with_extra_latlong['Longitude'] =
pd.to_numeric(grow_locations_with_extra_latlong[1]).fillna(grow_locati
ons_with_extra_latlong['Longitude'])
grow_locations_with_extra_latlong
```

```
                   Serial  Latitude  Longitude  \
0      PI040298AD5J215142    -7.923     54.980
1      PI040298AD5J215142    -7.923     54.980
2      PI040298AD5J215142    -7.923     54.980
```

```
3      PI040298AD5J215142    -7.923     54.980
4      PI040298AD5J215142    -7.923     54.980
...                   ...       ...        ...
39289  PI040298AA4E057627   -17.895     27.825
39290  PI040298AA4E057627   -17.895     27.825
39291  PI040298AA4E057627   -17.895     27.825
39292  PI040298AA4E057627   -17.895     27.825
39293  PI040298AA4E057627   -17.895     27.825

                                                  Type
SensorType  \
0       Thingful.Connectors.GROWSensors.AirTemperature  Flower Power

1         Thingful.Connectors.GROWSensors.BatteryLevel  Flower Power

2      Thingful.Connectors.GROWSensors.FertilizerLevel  Flower Power

3                Thingful.Connectors.GROWSensors.Light  Flower Power

4         Thingful.Connectors.GROWSensors.SoilMoisture  Flower Power

...                                                ...           ...

39289     Thingful.Connectors.GROWSensors.BatteryLevel  Flower Power

39290  Thingful.Connectors.GROWSensors.FertilizerLevel  Flower Power

39291            Thingful.Connectors.GROWSensors.Light  Flower Power

39292     Thingful.Connectors.GROWSensors.SoilMoisture  Flower Power

39293   Thingful.Connectors.GROWSensors.WaterTankLevel  Flower Power


                                 Code                 BeginTime  \
0      Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z
1      Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z
2      Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z
3      Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z
4      Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z
...                               ...                       ...
39289  Grow.Thingful.Sensors_v5g5zde1  2019-10-19T14:48:29.000Z
39290  Grow.Thingful.Sensors_v5g5zde1  2019-10-19T14:48:29.000Z
39291  Grow.Thingful.Sensors_v5g5zde1  2019-10-19T14:48:29.000Z
39292  Grow.Thingful.Sensors_v5g5zde1  2019-10-19T14:48:29.000Z
39293  Grow.Thingful.Sensors_v5g5zde1  2019-10-19T14:48:29.000Z

                        EndTime    0    1
0      2018-10-17T13:59:07.000Z  NaN  NaN
1      2018-10-17T13:59:07.000Z  NaN  NaN
2      2018-10-17T13:59:07.000Z  NaN  NaN
```

```
3      2018-10-17T13:59:07.000Z  NaN  NaN
4      2018-10-17T13:59:07.000Z  NaN  NaN
...                         ...  ...  ...
39289  2019-10-30T15:33:29.000Z  NaN  NaN
39290  2019-10-30T15:33:29.000Z  NaN  NaN
39291  2019-10-30T15:33:29.000Z  NaN  NaN
39292  2019-10-30T15:33:29.000Z  NaN  NaN
39293  2019-10-30T15:33:29.000Z  NaN  NaN

[39294 rows x 10 columns]
```

```
grow_locations_with_extra_latlong['Serial'].nunique()
```

```
6310
```

```
# Remove the locations outside the uk map bounding box
uk_lat = grow_locations_with_extra_latlong['Latitude'].between(50.681,
57.985, inclusive='both')
uk_long = grow_locations_with_extra_latlong['Longitude'].between(-
10.592, 1.6848, inclusive='both')
grow_locations_uk = grow_locations_with_extra_latlong[uk_lat &
uk_long]
grow_locations_uk.shape
```

```
(660, 10)
```

```
# Deuduplicate the serial numbers taking the most recent
most_recent = grow_locations_uk.groupby('Serial')
['EndTime'].transform('rank', method='first', ascending=False)
grow_locations_to_plot = grow_locations_uk[most_recent== 1]
print(grow_locations_to_plot.shape)
grow_locations_to_plot
```

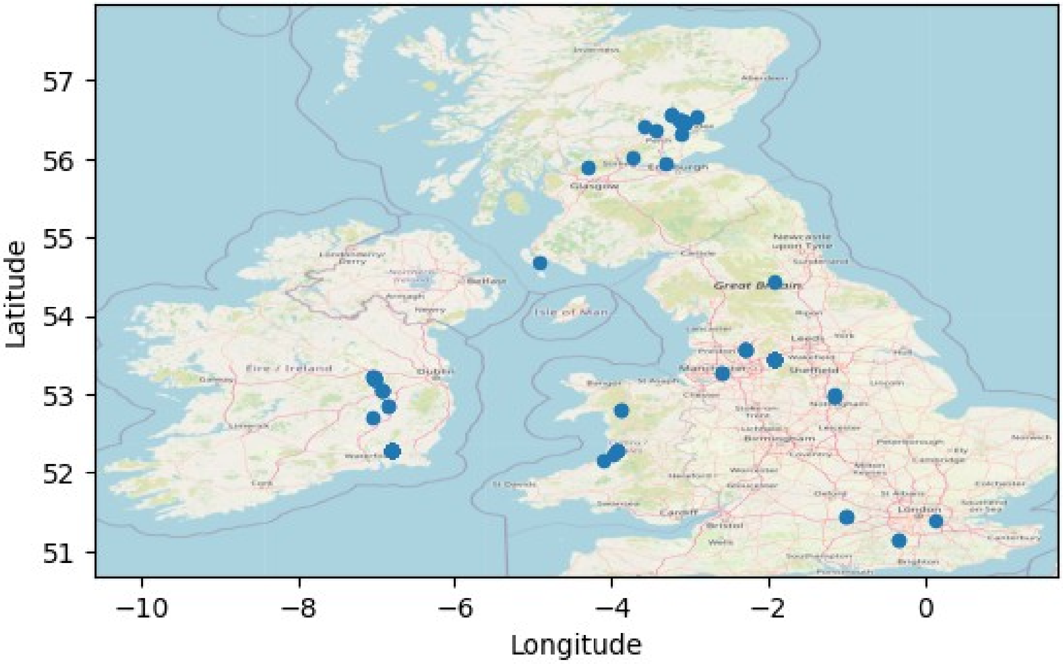
```
(110, 10)

                                                  Serial   Latitude  \
132    PI040297AD5I210109. FuturePractice:,Id:461,Lan...  56.572296   
180    PI040297AD5I206301. FuturePractice:,Id:721,Lan...  52.798020   
3960   PI040297AD5I209213. FuturePractice:,Id:336,Lan...  51.395985   
4086   PI040297AD5I207697. FuturePractice:,Id:630,Lan...  55.902340   
5400   PI040297AD5I206478. FuturePractice:,Id:406,Lan...  55.955933   
...                                                  ...        ...   
34584  PI040298AA3J007511. FuturePractice:,Id:1186,La...  52.222220   
34638  PI040298AA3I006517. FuturePractice:,Id:1187,La...  52.150745   
36546  PI040307AA4C021673. FuturePractice:,Id:721,Lan...  52.798020   
37968  PI040307AA4C019855. FuturePractice:,Id:432,Lan...  52.289997   
37974  PI040307AA4C020026. FuturePractice:,Id:431,Lan...  52.289883   

       Longitude                                          Type  \
132    -3.233928  Thingful.Connectors.GROWSensors.AirTemperature   
180    -3.871406  Thingful.Connectors.GROWSensors.AirTemperature   
```

```
3960    0.122108  Thingful.Connectors.GROWSensors.AirTemperature
4086   -4.305260  Thingful.Connectors.GROWSensors.AirTemperature
5400   -3.301378  Thingful.Connectors.GROWSensors.AirTemperature
...          ...                                             ...
34584  -3.981412  Thingful.Connectors.GROWSensors.AirTemperature
34638  -4.092808  Thingful.Connectors.GROWSensors.AirTemperature
36546  -3.871406  Thingful.Connectors.GROWSensors.AirTemperature
37968  -6.799615  Thingful.Connectors.GROWSensors.AirTemperature
37974  -6.799355  Thingful.Connectors.GROWSensors.AirTemperature

         SensorType                             Code
BeginTime  \
132    Flower Power  Grow.Thingful.Sensors_pgr59nte  2018-10-
20T16:11:44.000Z
180    Flower Power  Grow.Thingful.Sensors_0gzbnyhs  2018-10-
27T12:11:54.000Z
3960   Flower Power  Grow.Thingful.Sensors_dedfkptc  2018-08-
14T15:05:10.000Z
4086   Flower Power  Grow.Thingful.Sensors_116wcr07  2018-08-
21T08:56:31.000Z
5400   Flower Power  Grow.Thingful.Sensors_mxfd4554  2018-09-
07T13:43:16.000Z
...             ...                             ...
...
34584  Flower Power  Grow.Thingful.Sensors_g7a079p9  2019-09-
21T16:07:50.000Z
34638  Flower Power  Grow.Thingful.Sensors_fn5n4tfd  2019-09-
23T16:54:58.000Z
36546  Flower Power  Grow.Thingful.Sensors_03ajjw5b  2019-10-
09T17:54:27.000Z
37968  Flower Power  Grow.Thingful.Sensors_ergwswmt  2019-10-
10T11:09:33.000Z
37974  Flower Power  Grow.Thingful.Sensors_hxpc7x6d  2019-10-
10T10:58:59.000Z

                        EndTime           0            1
132    2019-05-12T19:00:16.000Z  56.5722961  -3.23392773
180    2019-01-19T14:24:56.000Z    52.79802   -3.8714056
3960   2019-10-30T15:52:13.000Z  51.3959846    0.1221083
4086   2019-08-12T08:26:11.000Z    55.90234     -4.30526
5400   2019-10-28T15:17:24.000Z  55.9559326  -3.30137753
...                         ...         ...          ...
34584  2019-10-23T15:06:17.000Z    52.22222  -3.98141217
34638  2019-10-07T17:54:23.000Z  52.1507454    -4.092808
36546  2019-10-29T18:08:52.000Z    52.79802   -3.8714056
37968  2019-10-28T14:24:58.000Z  52.2899971    -6.799615
37974  2019-10-28T14:29:12.000Z  52.2898827  -6.79935455

[110 rows x 10 columns]
```

Plot the locations

```
# reference: https://stackoverflow.com/questions/34458251/plot-over-an-image-background-in-python

%matplotlib inline
im = plt.imread("map7.png")
ax = grow_locations_to_plot.plot('Longitude', 'Latitude', xlim = (-10.592, 1.6848), ylim = (50.681, 57.985), kind='scatter')
ax.imshow(im, extent=[-10.592, 1.6848, 50.681, 57.985])
```

```
<matplotlib.image.AxesImage at 0x1d28fe7eb90>
```



Assessing the result

When comparing my plot to the one given in the assignment, mine looks a lot more sparse, and there were whole areas that have many sensors, such as Northern Ireland, in the example given that are not in my plot. Looking at the assignment, there's a hint that the columns might not be named correctly. That gives me the idea to see if the lattitude and longitude are swapped.

Swapping lat and long

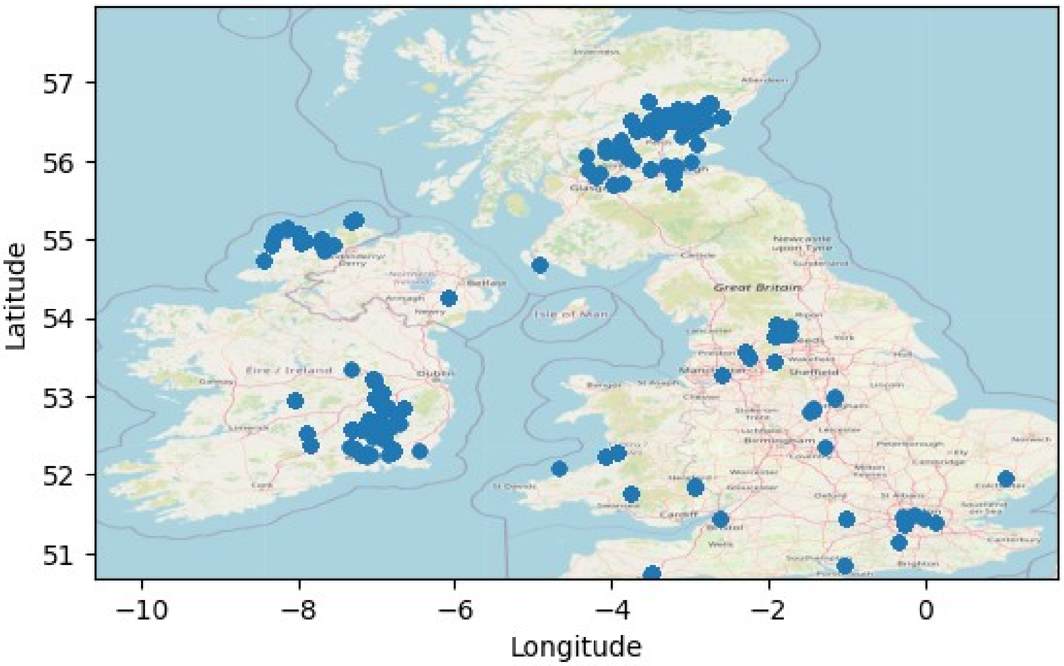
```
grow_locations_swapped = grow_locations_df.rename({'Longitude': 'Latitude', 'Latitude': 'Longitude'}, axis=1)
grow_locations_swapped.head()
```

```
               Serial  Longitude  Latitude  \
0  PI040298AD5J215142     -7.923     54.98
```

```
1  PI040298AD5J215142     -7.923     54.98
2  PI040298AD5J215142     -7.923     54.98
3  PI040298AD5J215142     -7.923     54.98
4  PI040298AD5J215142     -7.923     54.98

                                              Type    SensorType  \
0   Thingful.Connectors.GROWSensors.AirTemperature  Flower Power   
1     Thingful.Connectors.GROWSensors.BatteryLevel  Flower Power   
2  Thingful.Connectors.GROWSensors.FertilizerLevel  Flower Power   
3            Thingful.Connectors.GROWSensors.Light  Flower Power   
4     Thingful.Connectors.GROWSensors.SoilMoisture  Flower Power   

                             Code                 BeginTime  \
0  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   
1  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   
2  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   
3  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   
4  Grow.Thingful.Sensors_5tjrqt1c  2018-10-17T13:14:07.000Z   

                    EndTime
0  2018-10-17T13:59:07.000Z
1  2018-10-17T13:59:07.000Z
2  2018-10-17T13:59:07.000Z
3  2018-10-17T13:59:07.000Z
4  2018-10-17T13:59:07.000Z
```

```
%matplotlib inline
im = plt.imread("map7.png")
ax = grow_locations_swapped.plot('Longitude', 'Latitude', xlim = (-
10.592, 1.6848), ylim = (50.681, 57.985), kind='scatter')
ax.imshow(im, extent=[-10.592, 1.6848, 50.681, 57.985])
```

```
<matplotlib.image.AxesImage at 0x1d2901ad050>
```



This plot looks very similar to the one given in the assignment. Aside from switching latitude and longitude, this data did not have any of the cleaning steps done in the "Cleanup" section. If the plot did not already look so much like the example output, I would repeat those cleaning steps with the renamed lat and long.

Any points outside of the bounding box or are unallowed values are not a problem for producing the plot, because the plot has the limits set already.

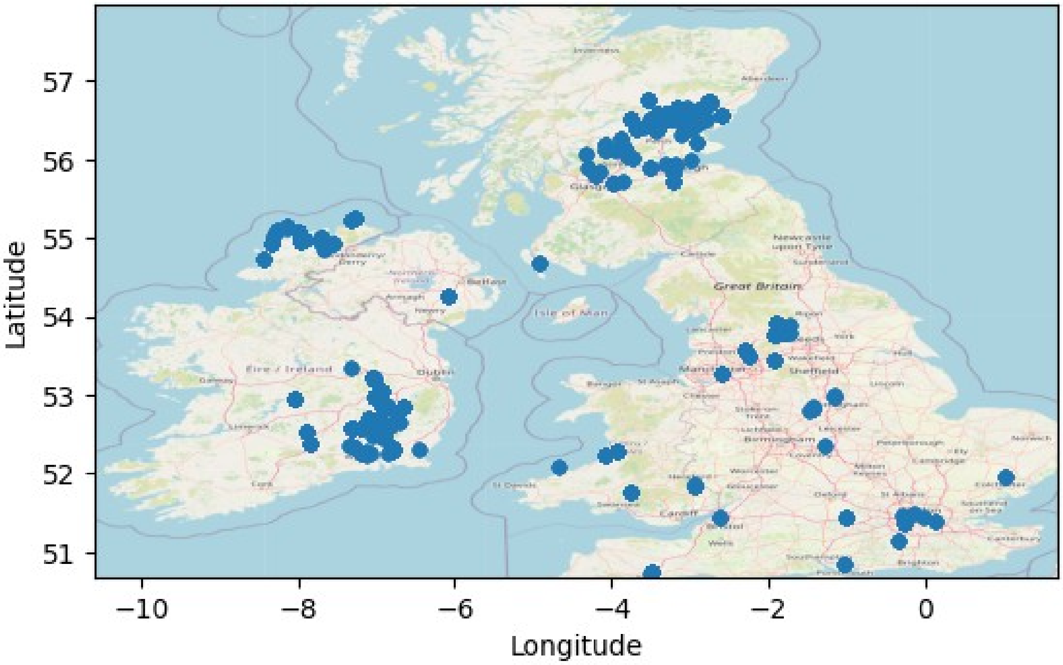
If I were to work on this problem in another context, I would ask some questions about how the data was produced to get some answers to these questions:

- Were the readings gathered as seperate files and then put into one? If so, it may be that some of the datapoints were not swapped between lat and long, so they might need to be selectively swapped.
- When the same Serial has different lat and long values, either slightly or a lot, what does that mean? Should all values be included? In this image, they are all included because it looks similar to the example output given.

Solution Code

```
# Here's a recap of the end to end process

# Do imports
import pandas as pd
import matplotlib.pyplot as plt

# Load data
grow_locations_df = pd.read_csv("GrowLocations.csv")
```

```
# Swap lat and long
grow_locations_swapped = grow_locations_df.rename({'Longitude':
'Latitude', 'Latitude': 'Longitude'}, axis=1)

# Make plot
im = plt.imread("map7.png")
ax = grow_locations_swapped.plot('Longitude', 'Latitude', xlim = (-
10.592, 1.6848), ylim = (50.681, 57.985), kind='scatter')
ax.imshow(im, extent=[-10.592, 1.6848, 50.681, 57.985])
plt.savefig('output.png')
```


57
56
55
54
53
52
51
Latitude
−10
−8
−6
−4
−2
0
Longitude
Great Britain
Isle of Man
Éire / Ireland