- **Problem Statement**

  To analyse the data and draw inferences. Major focus of the analysis is
    - Filling the missing values
    - Finding the operational temperature range of each freezer
    - Finding the daily average of door open duration per freezer
    - Classification of freezers based on their operational health

- **Dataset**

  Dataset contains temperature data for 45 freezers spread across 4 sites for 16 days from 7th May to 22nd May 2019, sampled at 1 minute.
  Dataset contains floating feature variables and one date-time variable with shape (23040, 46).

- **Approach**
    - **Filling Missing values**

      There are various ways to fill the missing values. Some of the ways are:

      1. Replace the missing value with the next (or previous) value in the data frame
      2. Fill the missing values with the mean of the data
      3. Fill the missing values with the mode of the data

      Since this is a time series data and the temperature largely depend upon freezer operational time, So I decided to fill the missing value with the average temperature of that particular hour.

    - **Finding operational temperature range**

      To find the operational temperature range of each freezer, minimum and maximum temperature of each freezer is calculated.

```
In [7]:   # Printing minimum and maximum value for each freezer
          for i in cols:
              range_=min_max(df[i])
              print("For ",i," Minimum Temperature : ",range_[0], ", Maximum Temperature : ",range_[1])

          For  Site-1 > Freezer-1  Minimum Temperature :   2.87 , Maximum Temperature :   18.62
          For  Site-1 > Freezer-2  Minimum Temperature :  -25.56 , Maximum Temperature :   3.93
          For  Site-1 > Freezer-3  Minimum Temperature :   1.62 , Maximum Temperature :   26.56
          For  Site-1 > Freezer-4  Minimum Temperature :  19.93 , Maximum Temperature :   27.06
          For  Site-1 > Freezer-5  Minimum Temperature :   2.43 , Maximum Temperature :   19.75
          For  Site-1 > Freezer-6  Minimum Temperature :  -26.12 , Maximum Temperature :   13.68
          For  Site-1 > Freezer-7  Minimum Temperature :   8.31 , Maximum Temperature :   23.93
          For  Site-1 > Freezer-8  Minimum Temperature :   8.93 , Maximum Temperature :   26.06
          For  Site-1 > Freezer-9  Minimum Temperature :   5.18 , Maximum Temperature :   22.93
          For  Site-2 > Freezer-1  Minimum Temperature :   6.68 , Maximum Temperature :   19.81
          For  Site-2 > Freezer-2  Minimum Temperature :   6.31 , Maximum Temperature :   25.06
          For  Site-2 > Freezer-3  Minimum Temperature :   7.62 , Maximum Temperature :   25.25
          For  Site-2 > Freezer-4  Minimum Temperature :   6.0 , Maximum Temperature :   17.56
          For  Site-2 > Freezer-5  Minimum Temperature :   3.18 , Maximum Temperature :   29.87
          For  Site-2 > Freezer-6  Minimum Temperature :   8.06 , Maximum Temperature :   25.25
          For  Site-2 > Freezer-7  Minimum Temperature :   5.62 , Maximum Temperature :   20.81
          For  Site-2 > Freezer-8  Minimum Temperature :   2.56 , Maximum Temperature :   23.81
          For  Site-2 > Freezer-9  Minimum Temperature :   5.93 , Maximum Temperature :   14.75
          For  Site-2 > Freezer-10  Minimum Temperature :   10.25 , Maximum Temperature :   23.06
          For  Site-2 > Freezer-11  Minimum Temperature :   8.43 , Maximum Temperature :   24.75
          For  Site-3 > Freezer-1  Minimum Temperature :   1.37 , Maximum Temperature :   28.0
          For  Site-3 > Freezer-2  Minimum Temperature :  13.31 , Maximum Temperature :   21.75
          For  Site-3 > Freezer-3  Minimum Temperature :  24.37 , Maximum Temperature :   29.12
          For  Site-3 > Freezer-4  Minimum Temperature :   0.37 , Maximum Temperature :   26.25
          For  Site-3 > Freezer-5  Minimum Temperature :   1.37 , Maximum Temperature :   13.62
          For  Site-3 > Freezer-6  Minimum Temperature :  -15.31 , Maximum Temperature :   19.75
```

○ **Finding daily average of door open duration**

To find the daily average of door open duration, assumption is taken that the temperature of the freezer will increase only when the door of freezer will be opened and the temperature will decrease only when the door of freezer will be closed.

```
In [10]:   duration_dic={}   # This will contain the total open duration for each freezer
           for i in cols:
               count=avg_opening(df[i])   # Calculating open duration for each freezer
               # Since the data is for 16 days, so to find average duration i am dividing the data by 16
               print("Daily average of door open duration is :", count/16, "minutes for ", i)
               duration_dic[i]=count/16

           Daily average of door open duration is : 251.5 minutes for  Site-1 > Freezer-1
           Daily average of door open duration is : 346.875 minutes for  Site-1 > Freezer-2
           Daily average of door open duration is : 526.6875 minutes for  Site-1 > Freezer-3
           Daily average of door open duration is : 600.625 minutes for  Site-1 > Freezer-4
           Daily average of door open duration is : 696.125 minutes for  Site-1 > Freezer-5
           Daily average of door open duration is : 357.375 minutes for  Site-1 > Freezer-6
           Daily average of door open duration is : 542.0625 minutes for  Site-1 > Freezer-7
           Daily average of door open duration is : 545.875 minutes for  Site-1 > Freezer-8
           Daily average of door open duration is : 369.0625 minutes for  Site-1 > Freezer-9
           Daily average of door open duration is : 231.6875 minutes for  Site-2 > Freezer-1
           Daily average of door open duration is : 336.0625 minutes for  Site-2 > Freezer-2
           Daily average of door open duration is : 895.25 minutes for  Site-2 > Freezer-3
           Daily average of door open duration is : 1016.6875 minutes for  Site-2 > Freezer-4
           Daily average of door open duration is : 258.125 minutes for  Site-2 > Freezer-5
           Daily average of door open duration is : 727.875 minutes for  Site-2 > Freezer-6
           Daily average of door open duration is : 855.125 minutes for  Site-2 > Freezer-7
           Daily average of door open duration is : 311.1875 minutes for  Site-2 > Freezer-8
           Daily average of door open duration is : 192.75 minutes for  Site-2 > Freezer-9
           Daily average of door open duration is : 284.25 minutes for  Site-2 > Freezer-10
           Daily average of door open duration is : 753.5 minutes for  Site-2 > Freezer-11
           Daily average of door open duration is : 405.875 minutes for  Site-3 > Freezer-1
           Daily average of door open duration is : 231.625 minutes for  Site-3 > Freezer-2
           Daily average of door open duration is : 297.25 minutes for  Site-3 > Freezer-3
           Daily average of door open duration is : 304.6875 minutes for  Site-3 > Freezer-4
```

○ **Classification of freezers based on operational health**

For this purpose, freezers are categorised on the basis of their door open duration. The assumption taken here is that if the door is open it's mean it is operational in that period.

```python
if (0 < duration_dic[w] < 120):   # This class will contains freezers which operational
    print (w,": Class 1")
elif (120 < duration_dic[w] < 240): # This class will contains freezers which operatio
    print(w,": Class 2")
elif (240 < duration_dic[w] < 360): # This class will contains freezers which operatio
    print(w,": Class 3")
elif (360 < duration_dic[w] < 480): # This class will contains freezers which operatio
    print(w,": Class 4")
elif (480 < duration_dic[w] < 600): # This class will contains freezers which operatio
    print(w,": Class 5")
elif (600 < duration_dic[w] < 720): # This class will contains freezers which operatio
    print(w,": Class 6")
elif (720 < duration_dic[w] < 840): # This class will contains freezers which operatio
    print(w,": Class 7")
elif (840 < duration_dic[w] < 1080): # This class will contains freezers which operati
    print(w,": Class 8")
```

```
Site-1 > Freezer-1 : Class 3
Site-1 > Freezer-2 : Class 3
Site-1 > Freezer-3 : Class 5
Site-1 > Freezer-4 : Class 6
Site-1 > Freezer-5 : Class 6
Site-1 > Freezer-6 : Class 3
Site-1 > Freezer-7 : Class 5
Site-1 > Freezer-8 : Class 5
Site-1 > Freezer-9 : Class 4
Site-2 > Freezer-1 : Class 2
Site-2 > Freezer-2 : Class 3
Site-2 > Freezer-3 : Class 8
Site-2 > Freezer-4 : Class 8
Site-2 > Freezer-5 : Class 3
Site-2 > Freezer-6 : Class 7
```
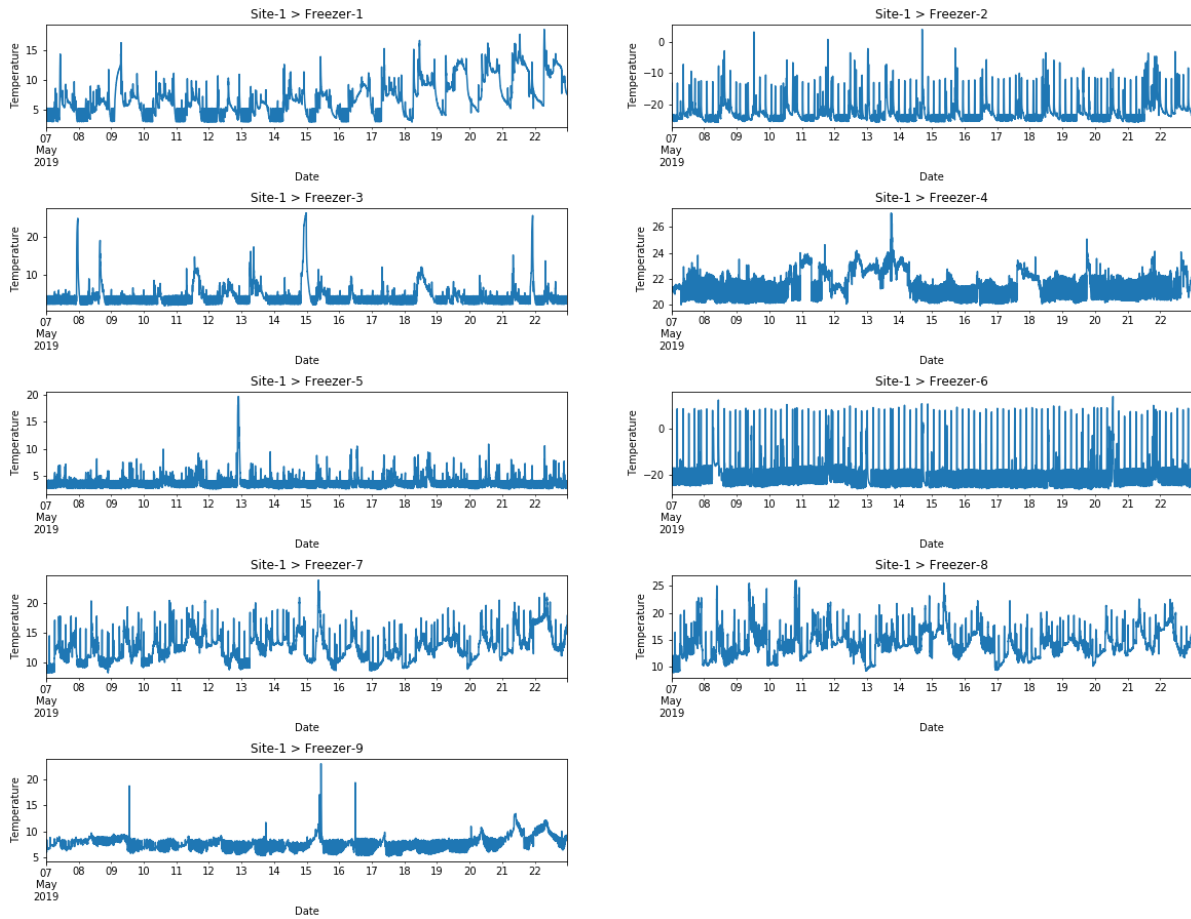
● **Other Inferences**

To draw more inferences some graphs are drawn

○ **Date-Time graph**

Variation of temperature over the entire day from 7th May to 22th May are plotted to understand the temperature distribution of each freezer.
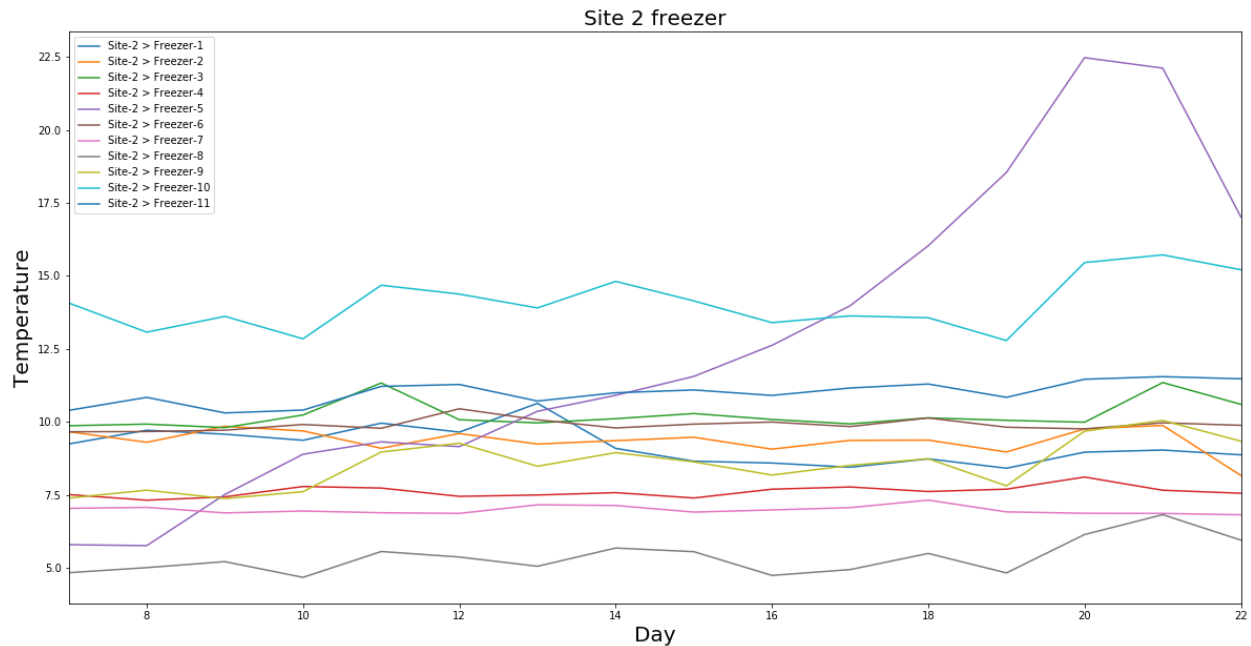
- ○ **Hourly average temperature graph**

  Graph of hourly average temperature of freezer per day are plotted to understand the pattern of temperature per hour on a day.
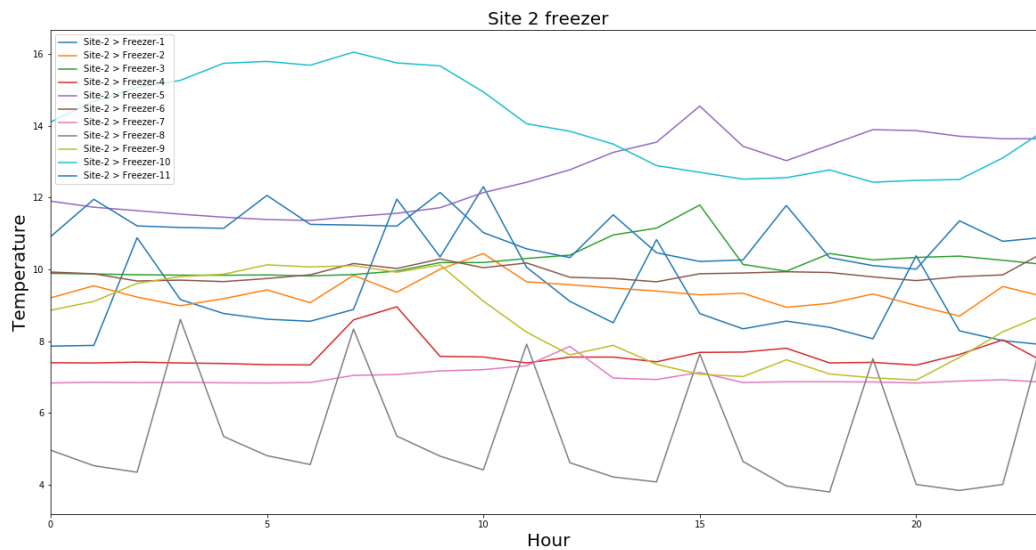
○ **Daily average temperature of freezer graph**

Graph of average temperature of freezer in a whole day from 7th May to 22th May are plotted to understand the operational duration of freezer per day.


● **Anomaly detection**

Anomalies are the unexpected behaviour in the observed world.
There are various methods for finding anomaly. In this problem we are going to find anomaly in temperature with the help of Moving Average Method.

For window size 60, we will calculate the mean and standard deviation of the data.If the next entry in the dataframe lies between mean(+-)sd, it is considered normal else it is considered an anomaly.
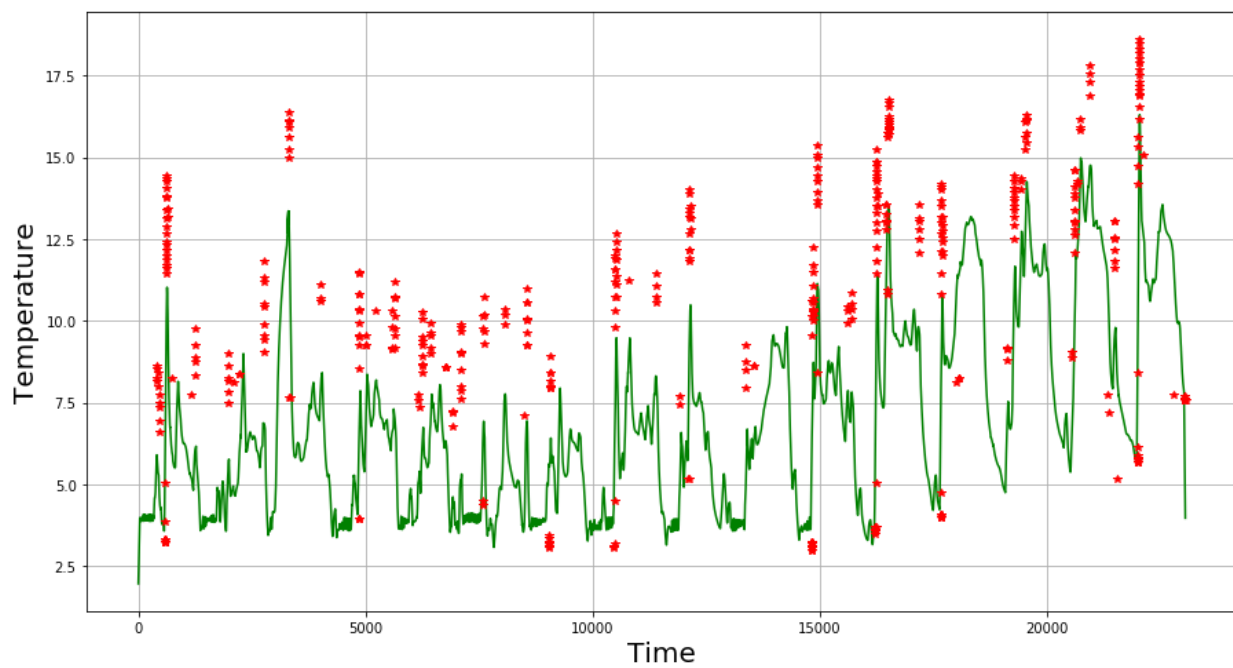
Note: Red points represent anomalies in temperature