NORTH EASTERN SPACE APPLICATIONS CENTRE

Government of India, Department of Space
Umiam-793103, Meghalaya

Project Report
On
“Ka-Band Propagation Experiment over Umiam region”

Submitted in requirement for the award of the degree of
BACHELOR OF TECHNOLOGY
IN
ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

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<u>ACKNOWLEDGEMENT</u>

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I perceive as this opportunity as a big milestone in my career development. I will strive to use gained skills and knowledge in the best possible way and will try to nurture in the future also.

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ABSTRACT

The tremendous worldwide growth in the use of Internet and multimedia services prompted the ambitious planning for evolution of commercial and broadband satellite communication systems. The traditional C and Ku bands in satellite communications are getting crowded, So the systems are moving towards higher frequency ranges above 20 GHz. The Ka-band (18-40 GHz) frequency spectrum has gained attention for satellite communication. The inherent drawback of Ka-band satellite system is that increase in signal distortion resulting from propagation effects. Atmospheric attenuation in Ka-band is always severe, especially in the presence of rain. Thus, New technologies are required for Ka-band systems, such as multiple hopping antenna beams and regenerative transponders to support aggregate data rates in the range of 1 - 20 Gbps per satellite, which can provide DTH, HDTV, mobile and fixed Internet users with broadband connection. Currently in India C and Ku-band frequencies are being used for commercial satellite communications. In future Ka-band will be used for wideband applications. Keeping in view of the socio-economic and geographical diversities of India. Propagation studies are essential for estimation of attenuation, so that Ka-band satellite links operating in different parts of Indian region can be registered appropriately. Ka-band system is recognized as a new generation in communication satellites that encompasses a number of innovative technologies such as on board processing (OBP) for multimedia applications and switching to provide two way services to and from small ground terminals. To do this efficiently multiple pencil like spot beams are used. One distinct feature of this propagation being used to address this problem is Satellite Spot-Beam. To design effective satellite communication system, the arrangement of spot beam locations in Indian subcontinent, the study and analysis of link availability for Ka-band satellite communication in various geographically separated spot beams in India using statistical data is necessary. Based on global rain models integrated with the link budget, the study allows us to examine major system design issues encountered in Ka-band satellite communication that are susceptible to propagation impairments. This system can be flexible enough to increase power on specific transmissions to compensate for local weather conditions. This can make better use of the available bandwidth than C or Ku-band satellite, and more users can get higher level of services.

CONTENTS

Attenuation due to Rain-A Mini-Review

Rain-caused attenuation affects radar and communication systems operating at centimeter or millimeter wavelengths. The nature of rain-caused effects have been known since before World War II. Early work on rain effects centered on theoretical estimation of specific attenuation and scattering cross section and experimental verification of the theoretical estimates. It is noted that the experimental observations did not agree with the theoretical estimates and concluded that the theory was wrong. Later it was found that the problem was not in the theoretical analysis but was in the rainfall measurements. At the present time most workers agree that
good agreement can be obtained between theoretical estimates and carefully obtained experimental observations. Current work is directed towards the construction of statistical models for the occurrence of rain-caused attenuation and toward an understanding of second-order effects such as depolarization and bandwidth limitation. The area requiring the most work is model building for the prediction of attenuation statistics.

ITU-R Rain Attenuation Model

There are many rain attenuation models for calculating attenuation in signals due to rain. But the ITU-R rain attenuation model is the most widely accepted international method and benchmark for comparative studies.This model is semi-empirical and often employs the local climatic parameters at a desired probability of exceedance.

The ITU-R 618-10 gives summarized procedures for the computation of a satellite path rain attenuation. In order to compute the slant-path rain attenuation using point rainfall rate, the following parameters are required:

f: the frequency of operation in GHz,
µ: the elevation angle to the satellite, in degrees,
Á: the latitude of the ground station, in degrees N and S,
hs: the height of the ground station above sea level, in km,
Re: effective radius of the Earth (8 500 km),
R0.01: point rainfall rate for the location of interest for 0.01% of an average year (mm/hr).

Estimation of rain attenuation along the slant-path of a satellite link requires an understanding of rain height. The method, adopted by ITU-R, assumes the rain structure to be uniform from the ground level to the 0±C isotherm height, hR, simply termed the effective rain height. Often the empirical formula is used to estimate the value of hR due to a scarcity of measured data.Though the model is less accurate, it is widely employed to calculate the average rain height. The mean rain height above mean sea level is expressed as:

$$h_R = h_0 + 0{:}36 km \quad (1)$$

where h0 is the average annual 0 degree C isotherm height.

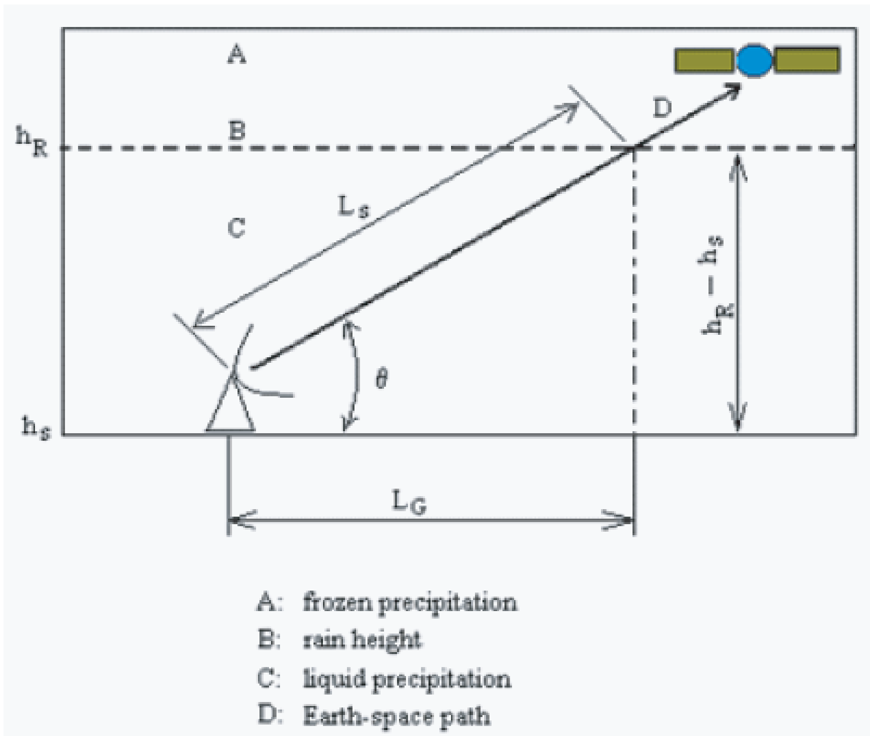


Figure 1: Slant path through rain.

Step-by-step procedures for the computation of the rain attenuation along the slant-path of a satellite system are summarized as follows:

Step 1: Determine the rain height, hR, as given in (1) and contour map in Recommendation ITU-R P.839.

Step 2: Determine the slant-path length and the horizontal projection.The slant-path length Ls, expressed in km, is calculated from:

$$L_s = \left\{ \begin{array}{ll} \frac{(h_r - h_s)}{\sin\theta} & \text{for } \theta \geq 5^\circ \\ \frac{2(h_r - h_s)}{\left(\sin^2\theta + \frac{2(h_r - h_s)}{R_e}\right)^{1/2} + \sin\theta} & \text{for } \theta < 5^\circ \end{array} \right\} \text{(km)} \quad (2)$$

The horizontal projection is then expressed as:

LG = Ls cos(□) (3)

where LG and Ls are in km.

Step 3: Determine the rain rate at 0.01% for the location of interest over an average year. In this work, Table 1 is used, which is a derived rain rate at one-minute integration time at 0.01% of exceedance from long-term local data.

Step 4: Calculate the specific attenuation, a function of desired frequency, polarization and rain rate. The relationship between rain rate, R(mm/h), and specific attenuation, □ (dB/km), is given as:

□ = aRb (dB/km) (4)

a and b are regression coefficients which depend on the drop shape of the falling rain, raindrop density, polarization and frequency. The regression coefficients in Equation (1) are computed by using ITU-R P.838-3 [4]:

$$a = \left[a_H + a_V + (a_H - a_V)\cos^2\theta\cos 2\tau\right]/2 \quad (5)$$

$$b = \left[a_H b_H + a_V b_V + (a_H b_H - a_V b_V)\cos^2\theta\cos 2\tau\right]/2a \quad (6)$$

where τ is the polarization tilt angle relative to the horizontal and □ is the path elevation angle. The polarization tilt angle τ = 90 degree for vertical polarization and τ= 0 degree for horizontal polarization while circular polarization is given as τ = 45 degree. The frequency dependent coefficients aH, aV , bH and bV are presented in Table 2 for both horizontal and vertical polarization over frequencies of 1-400 GHz.

***Step 5*:** Calculate the horizontal reduction factor, $r_{0.01}$ at 0.01% probability and expressed as:

$$r_{0.01} = \frac{1}{1 + 0.78\sqrt{\frac{L_G \gamma_R}{f}} - 0.38(1 - e^{-2L_G})} \tag{7}$$

Note: L_G is the horizontal projection as determined in Step 2 and f is the operating frequency measured in GHz.

***Step 6*:** Calculate the vertical adjustment factor, $v_{0.01}$, for 0.01% of the time.

$$v_{0.01} = \frac{1}{1 + \sqrt{\sin(\theta)}\left[31\left(1 - e^{-(\theta/1+x)}\right)\frac{\sqrt{L_R \gamma_R}}{f^2} - 0.45\right]} \tag{8}$$

$$L_R = \left\{ \begin{array}{ll} \frac{L_G r_{0.01}}{\cos\theta}\ \text{km} & \text{for } \xi > \theta \\ \frac{(h_R - h_s)}{\sin\theta}\ \text{km} & \text{for } \xi \leq \theta \end{array} \right\} \tag{9}$$

and

$$\xi = \tan^{-1}\left(\frac{h_R - h_s}{L_G r_{0.01}}\right) \text{ degrees} \tag{10}$$

$$x = \left\{ \begin{array}{ll} 36 - |\phi| \text{ degrees} & \text{for } |\phi| < 36 \\ 0 & \text{for } |\phi| \geq 36 \end{array} \right\} \tag{11}$$

Table 2: The specific attenuation parameters.

Frequency GHz	a_H	a_V	b_H	b_V
1	0.000387	0.00000352	0.912	0.880
2	0.00154	0.000138	0.963	0.923
4	0.000650	0.000591	1.121	1.075
6	0.00175	0.0155	1.308	1.265
7	0.00301	0.00265	1.332	1.312
8	0.00454	0.00395	1.327	1.310
10	0.0101	0.00887	1.276	1.264
12	0.0188	0.0168	1.217	1.200
15	0.0367	0.0335	1.154	1.128
20	0.0751	0.0691	1.099	1.065
25	0.124	0.113	1.061	1.030
30	0.187	0.167	1.021	1.000
35	0.263	0.233	0.979	0.963
40	0.350	0.310	0.939	0.929
45	0.442	0.393	0.903	0.897
50	0.536	0.479	0.873	0.868
60	0.707	0.642	0.826	0.824
70	0.851	0.784	0.793	0.793
80	0.975	0.906	0.769	0.769
90	1.06	0.999	0.753	0.754
100	1.12	1.06	0.743	0.744
120	1.18	1.13	0.731	0.732
150	1.31	1.27	0.710	0.711
200	1.45	1.42	0.689	0.690
300	1.36	1.35	0.688	0.689
400	1.32	1.31	0.683	0.684

Step 7: The effective path length is then computed from:

LE = LRv0.01 km (12)

Step 8: Calculate the attenuation exceeded for 0.01% of an average year.

$$A_{0.01} = \gamma_R L_E \, \mathrm{dB} \tag{13}$$

The attenuation value for other percentages of exceedance is determined by using the expression below:

$$A_p = A_{0.01} \left(\frac{p}{0.01} \right)^{-[0.655 + 0.033 \ln(p) - 0.045 \ln(A_{0.01}) - \beta(1-p) \sin(\theta)]} \mathrm{dB} \tag{14}$$

where

$$\beta = \left\{ \begin{array}{ll} 0 & \text{if } p \geq 1\% \text{ or } |\phi| \geq 36^\circ \\ -0.005(|\phi| - 36) & \text{if } p < 1\% \text{ and } |\phi| < 36^\circ \text{ and } \theta \geq 25^\circ \\ -0.005(|\phi| - 36) + 1.8 - 4.25 \sin\theta & \text{otherwise} \end{array} \right\} \tag{15}$$

SATELLITE SERVICES

There is a vast variety of satellites orbiting the earth and offering different services to different parts of the world. Most satellite services are offered at C and Ku-band frequencies, with a lot of interest emerging in deploying Ka-band based satellites as well. The advantages offered by satellite-based services include terrain independence and large coverage area. The congestion at lower bands due to increased demand for diverse services and increased bandwidth demand calls for exploration of the advantages offered by higher frequency bands. The major drawback to operating at such frequencies (Ka-band and above) is signal distortion due to factors such as free space and rainfall.The most prominent, however, is the presence of rainfall along the signal path. This paper thus focuses on the signal fading due to rainfall at frequencies up to V-band.

Geostationary Satellites

Satellites whose orbit appears to be stationary relative to the earth exhibit circular orbits. These satellites are thus referred to as having a geostationary earth orbit (GEO) and hence the term geostationary satellite. Geostationary satellites rotate at a constant speed equal to that of the earth with an inclination of zero, i.e., the satellite's orbit lies in the equatorial plane of the Earth.Their large distance from the earth gives them a large coverage area as opposed to low earth orbit (LEO) satellites. A GEO satellite offers a 24 hour view of a particular area, which leads to its wide use as a provider for broadcast satellite services (BSS) and multipoint applications. However, the GEO's distance from the earth leads to a comparatively weak signal strength and a time delay in the received signal. This is a challenge that system designers are faced with and hence compensation techniques are employed to curb this situation.

GSAT-14, a step towards Indian Advance Communications Satellite

GSAT-14 is an Indian Geostationary satellite launched for enhancement in the field of Communication.GSAT-14 satellite is planned for technology development and testing of Ka band payload.

GSAT-14 Ka band payloads:

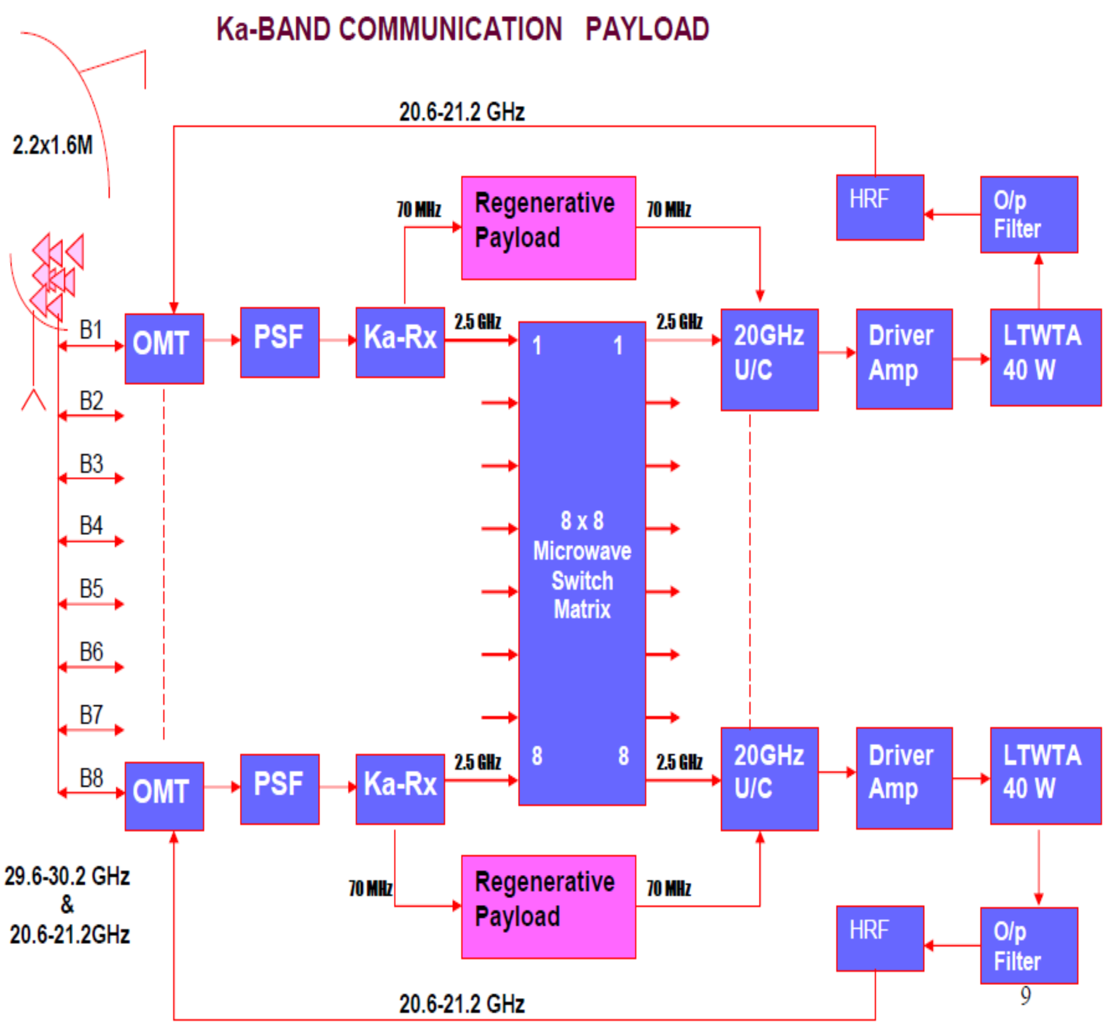
• Primary objectives
– to test new technologies in Ka band
• on board antenna with high gain and shaped
spot beams
• onboard processing and switching
• compact Ground terminals
– to learn the signal propagation behaviour
at 20/30 GHz band over India
that has a tropical climate

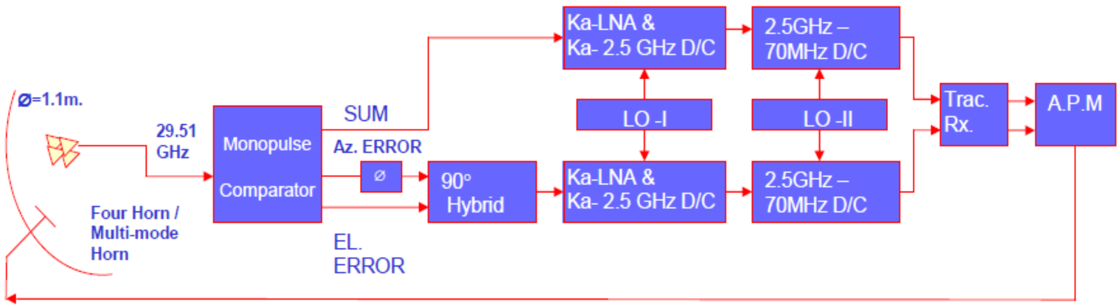
GSAT-14 Salient Features:

- I. 8 spot beams for India coverage
- Each spot beam contains
  a.Bent pipe transponder
  b.Regenerative transponder
- Beam inter connectivity

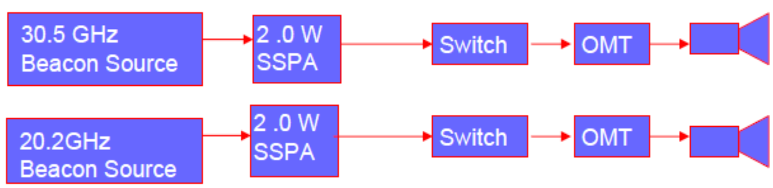
a.Microwave Switch Matrix
b.2 Mbps and 64 Kbps regenerative channels

- 29.510 GHz RF tracking system for APM
- Beacon Transmitters for propagation experiments:
  20.2 GHz & 30.5 GHz with polarization change switch





Ka- BAND MONOPULSE TRACKING SYSTEM



BEACON SOURCES

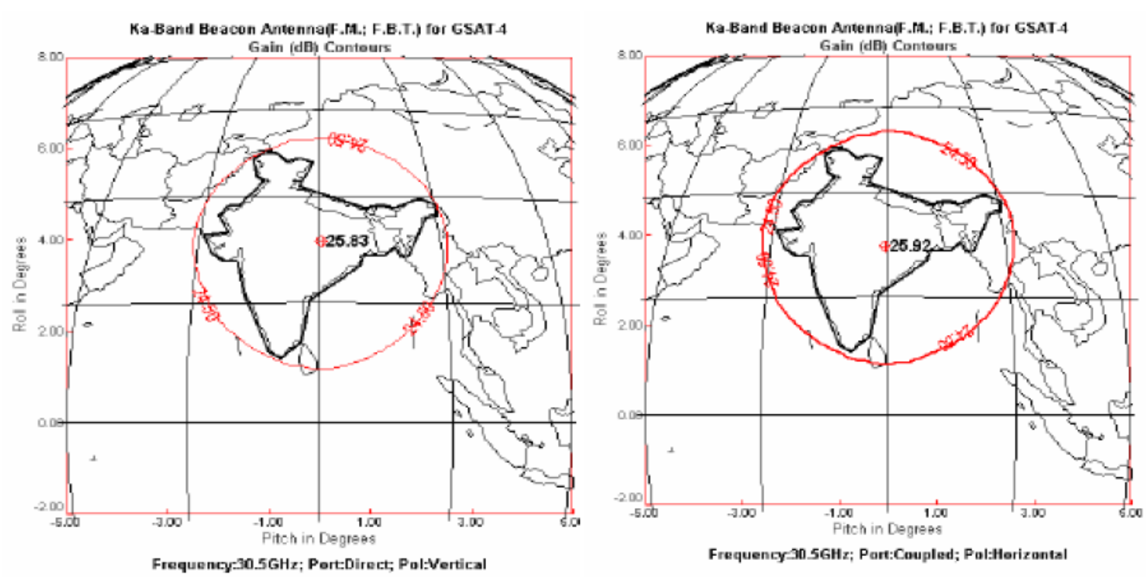
Brief Specifications (communications payload)

Sr. No.	Parameter	Unit	Specification
1	Receive band Transmit band	GHz	29.6-30.2 20.6-21.2
2	Saturation flux density	dBW/m^2	-87.0
3	EIRP	dBW	50.5@ saturation
4	G/T	dB/K	6.0
5	Inter beam isolation	dB	25
6	Rx/Tx polarization	-	Linear V/H
7	Rx/Tx beam width	Deg.	1.3
8	Antenna pointing accuracy	Deg.	± 0.08
9	Tracking range	Deg.	± 0.4
10	No. of beams	-	8

Beacon Transmitters

Sr No	Parameter	Unit	Specification	
			30 GHz	20 GHz
1	Transmit Frequency	GHz	30.5	20.2
2	Transmit Polarization (Change polarization on command)	-	Linear H & V	Linear H & V
3	Transmit EIRP	dBW	24.0	24.0
4	Frequency Stability -over operating temperature -over Design Life	ppm	 ±1.0 ±7.0	 ±1.0 ±7.0
5	Spurious Output At Tx. Antenna -in any 4 KHz band -in any 1 MHz band	dBW	 -60 -55	 -60 -55

Contour Plots of 30.5 GHz Beacon



GSAT-4 MASS & POWER

	Weight (Kg)	Power (W)
Ka-BAND REG. PAYLOAD WITH TRACKING Rx & BEACON SOURCE	151.46	1406.60
SATNAV (GAGAN) PAYLOAD	52.38	234.50
TOTAL	203.84	1641.10

GSAT-4 Ground Terminals

Terminal NB for regenerative payload

Antenna size	0.28 m
EIRP	42 dBW
G/T	8.7 dB/K
Packaging	Compact Light Weight Suitcase

Terminal WB for regenerative payload

Antenna size	0.75 m
EIRP	54 dBW
G/T	17 dB/K
Packaging	Portable

Terminal for bent-pipe payload

Antenna size	2.4 m
EIRP	67 dBW
G/T	27.5 dB/K
Packaging	Transportable

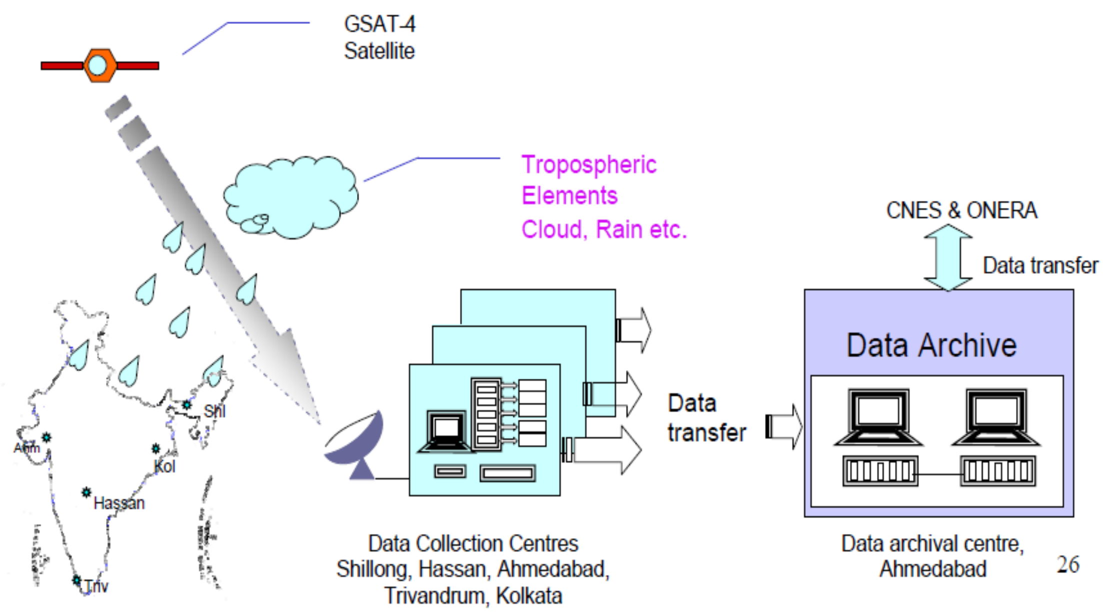
Terminal for SatGrid Application

Antenna size	2.4 m
EIRP	67 dBW
G/T	27.5 dB/K
IDU	combined NB, WB and Bent-pipe

GSAT-14 Ka band Propagation experiment

- Joint activity between ISRO, CNES and ONERA
- Activities

– Met and satellite data collection from different locations in India
– Duration of data collection : at least five years
– Preprocessing and archival of data
– Exchange data among participating agencies for analysis



Location features

Site Name	Annual Total Rain (mm)	No of Rainy days	Elevation angle for GSAT-4	Data Collection supprt agency	Remark
Shillong	2415.3	128.1	58.53°	NE-SAC	Hilly, SW & NE monsoon
Kolkata	1641.4	82.2	62.95°	RRSSC	Near Coastal, Plane SW & NE monsoon
Hassan	912.8	65.0	72.65°	MCF	Plane, SW monsoon
Trivandrum	1827.7	99.7	77.76°	SPL	Coastal, Plane, SW monsoon
Ahmedabad	803.4	35.8	60.59°	SAC	Plane, SW monsoon
Port Blair	3168.8	135.8	72.23°	ISTRAC	Island, Plane, SW & NE monsoon

Equipment at each station

- **Beacon Receiver :** Received beacon power level
- **Radiometer :** Set reference level, Calibration of receiver
- **Disdrometer :** Surface Rainfall drop-size distribution, rain rate and cumulative rain and statistics
- **Micro Rain Radar**: Vertical Profile of Rainfall and drop distribution
- **Automatic Weather Station :** Ground values of meteorological data
- **Tipping Bucket :** Ground Truth of Rain Rate
- **Data logger :** Continuous PC based acquisition of data from all instruments and storage

Met equipment deployed at Shillong

Analysis

Using the data received by Beacon receivers, we plot the Signal Magnitude and Noise Floor w.r.t. Time to observe the attenuation in MATLAB.

Data file format :

```
//--------------------------20.20000GHz Station Measurements--------------------//

  Station Name: Shillong
  Station Code: SHL
      Latitude: 25.675
     Longitude: 91.910
 Channel Polarization: Horizontal
 Sampling Rate: 10 Hz
 Configuration File: DefaultConfiguration_#_2016_02_26_08h_26min.cfg

//---------------------------------------------------------------------------//

DateTime       FreqMax     AmpMax         NoiseFloor  SignalStatus    AntennaTemp OnBoardTemp
04h07m41s      4992183     -45.702     -83.858     3       +0.148      +38.005
04h07m41s      4993117     -44.079     -82.465     3       +0.770      +38.010
04h07m41s      4993117     -44.033     -81.844     2       +1.310      +38.007
04h07m41s      4993116     -44.045     -81.379     1       +1.923      +38.007
04h07m41s      4993115     -46.191     -76.864     1       +2.469      +38.008
04h07m41s      4993116     -45.849     -77.859     1       +2.954      +38.008
04h07m42s      4993116     -45.814     -78.548     1       +3.528      +38.010
04h07m42s      4993116     -45.712     -78.797     1       +4.035      +38.010
04h07m42s      4993116     -45.814     -79.158     1       +4.536      +38.010
04h07m42s      4993116     -45.845     -79.431     1       +5.073      +38.010
04h07m42s      4993112     -45.289     -79.040     1       +5.528      +38.011
04h07m42s      4993115     -45.598     -79.189     1       +5.994      +38.011
04h07m42s      4993115     -45.701     -79.290     1       +6.509      +38.008
04h07m42s      4993116     -45.766     -79.517     1       +6.931      +38.011
04h07m42s      4993116     -45.809     -79.558     1       +7.386      +38.008
04h07m42s      4993117     -45.540     -79.563     1       +7.857      +38.006
04h07m43s      4993116     -45.754     -79.712     1       +8.225      +38.008
04h07m43s      4993113     -45.244     -79.222     1       +8.681      +38.008
04h07m43s      4993112     -45.216     -78.808     1       +9.133      +38.011
04h07m43s      4993116     -45.722     -79.176     1       +9.474      +38.006
04h07m43s      4993116     -45.560     -79.337     1       +9.906      +38.011
04h07m43s      4993116     -45.652     -79.429     1       +10.287     +38.011
04h07m43s      4993116     -45.726     -79.593     1       +10.628     +38.009
04h07m43s      4993116     -45.642     -79.738     1       +11.063     +38.009
04h07m43s      4993116     -45.738     -79.837     1       +11.421     +38.006
04h07m43s      4993116     -45.681     -79.863     1       +11.731     +38.011
04h07m44s      4993116     -45.733     -79.845     1       +12.128     +38.011
04h07m44s      4993116     -45.575     -79.871     1       +12.454     +38.012
04h07m44s      4993116     -45.736     -79.811     1       +12.758     +38.012
04h07m44s      4993116     -45.681     -79.787     1       +13.152     +38.012
04h07m44s      4993116     -45.654     -79.915     1       +13.412     +38.012
04h07m44s      4993116     -45.624     -79.765     1       +13.743     +38.009
04h07m44s      4993116     -45.647     -79.685     1       +14.101     +38.009
```

Code for plotting one specified day data:

```
monthFolder= 'H:\Ka-Band Raw Data\Raw Data\Y2018\BR\20\M03\';
cd(monthFolder);
dayFolders=dir ('*D*') ;
sortedDayFolders=natsort({dayFolders.name});
noDayFolders = length(dayFolders);
for j=1%:noDayFolders
    disp(sortedDayFolders{1,j});
    cd(monthFolder);
    dayFolder= sortedDayFolders{1,j};
    cd(dayFolder);
    MyFolderInfo = dir(fullfile('*.dat'));
    MyFolderInfoSortedNames=natsortfiles({MyFolderInfo.name});
    data =zeros(10000000,6);
    time=zeros(10000000,1);
    ampmax = zeros(10000000,1);
    noisefloor=zeros(10000000,1);
    lngth = length(MyFolderInfo);
    disp(lngth);
    for i=1:lngth
        disp(MyFolderInfoSortedNames{1,i});
        fileID = fopen(MyFolderInfoSortedNames{1,i});
        C_data0 = textscan(fileID,'%q %*d %f %f %*d %f %f', 'HeaderLines',13);
        dt = datetime(C_data0{1},'InputFormat','HH''h''mm''m''ss''s','Format','HH:mm:ss');
        C_data0{6}=dt;
        if i==1
            data = C_data0;
        else
            data = vertcat(data,C_data0);
        end
    end

    for i=1:lngth
        if i==1
            time=data{i,6};
            ampmax=data{i,2};
            noisefloor = data{i,3};
        else
            time = vertcat(time,data{i,6});
            ampmax = vertcat(ampmax,data{i,2});
            noisefloor=vertcat(noisefloor,data{i,3});
        end
    end
    figure();
    plot(time,ampmax,time,noisefloor);
    xlabel('Time');
    legend('AmpMax','Noisefloor');
```

Code for plotting each day data in a month:

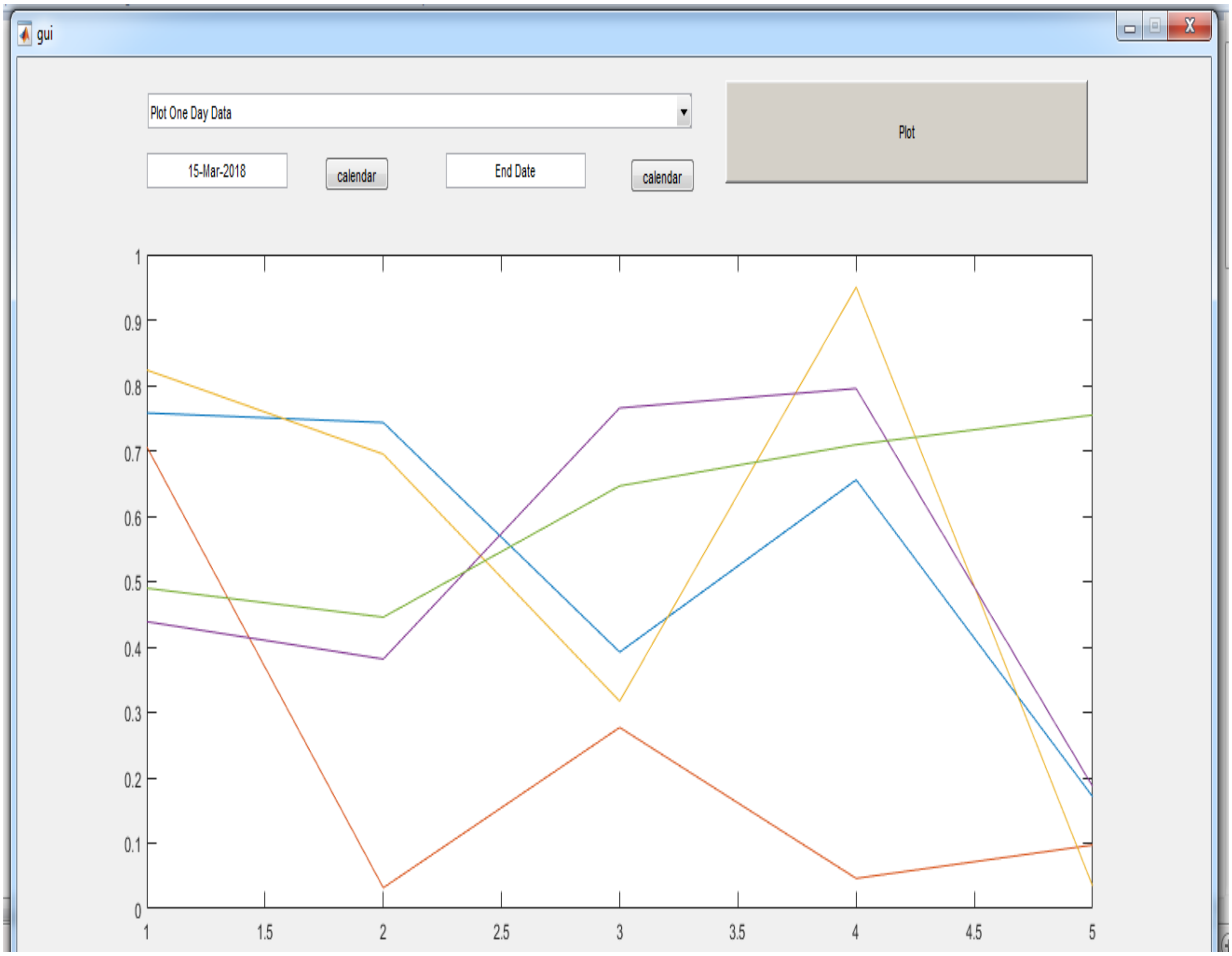
```
monthFolder= 'H:\Ka-Band Raw Data\Raw Data\Y2018\BR\20\M03\';
cd(monthFolder);
dayFolders=dir ('*D*') ;
sortedDayFolders=natsort({dayFolders.name});
noDayFolders = length(dayFolders);
for j=1:noDayFolders
    disp(sortedDayFolders{1,j});
    cd(monthFolder);
    dayFolder= sortedDayFolders{1,j};
    cd(dayFolder);
    MyFolderInfo = dir(fullfile('*.dat'));
    MyFolderInfoSortedNames=natsortfiles({MyFolderInfo.name});
    data =zeros(10000000,6);
    time=zeros(10000000,1);
    ampmax = zeros(10000000,1);
    noisefloor=zeros(10000000,1);
    lngth = length(MyFolderInfo);
    disp(lngth);
    for i=1:lngth
        disp(MyFolderInfoSortedNames{1,i});
        fileID = fopen(MyFolderInfoSortedNames{1,i});
        C_data0 = textscan(fileID,'%q %*d %f %f %*d %f %f', 'HeaderLines',13);
        dt = datetime(C_data0{1},'InputFormat','HH''h''mm''m''ss''s','Format','HH:mm:ss');
        C_data0{6}=dt;
        if i==1
            data = C_data0;
        else
            data = vertcat(data,C_data0);
        end
    end
    for i=1:lngth
        if i==1
            time=data{i,6};
            ampmax=data{i,2};
            noisefloor = data{i,3};
        else
            time = vertcat(time,data{i,6});
            ampmax = vertcat(ampmax,data{i,2});
            noisefloor=vertcat(noisefloor,data{i,3});
        end
    end
    figure();
    plot(time,ampmax,time,noisefloor);
    xlabel('Time');
    legend('AmpMax','Noisefloor');
end
```

Using these basic codes we implemented a GUI program in MATLAB where we can do:

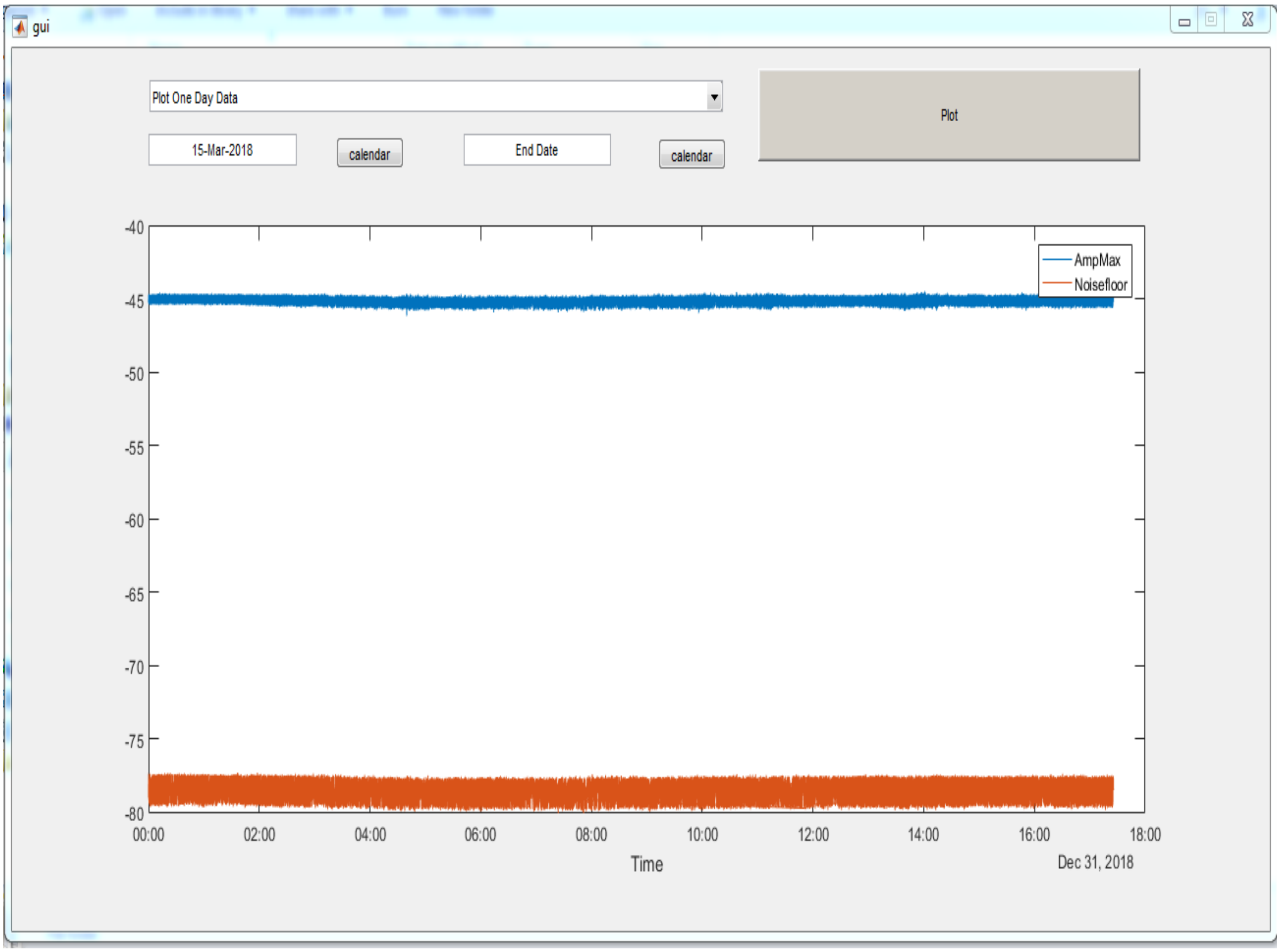
1. **Plot the data of a particular day:**

Steps:

A. Select “Plot on day data” and enter the input date:



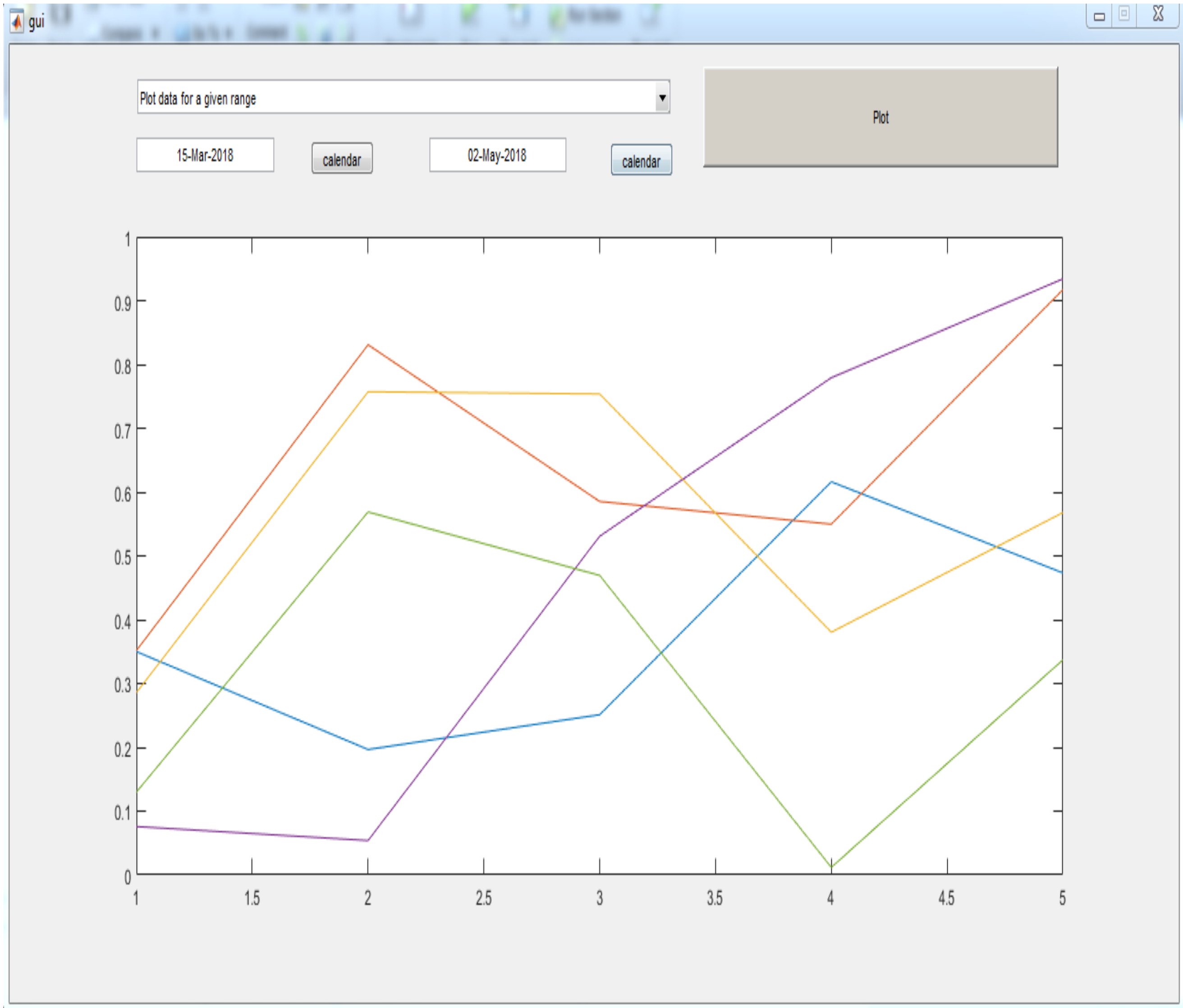
B. Tap the button “Plot”:



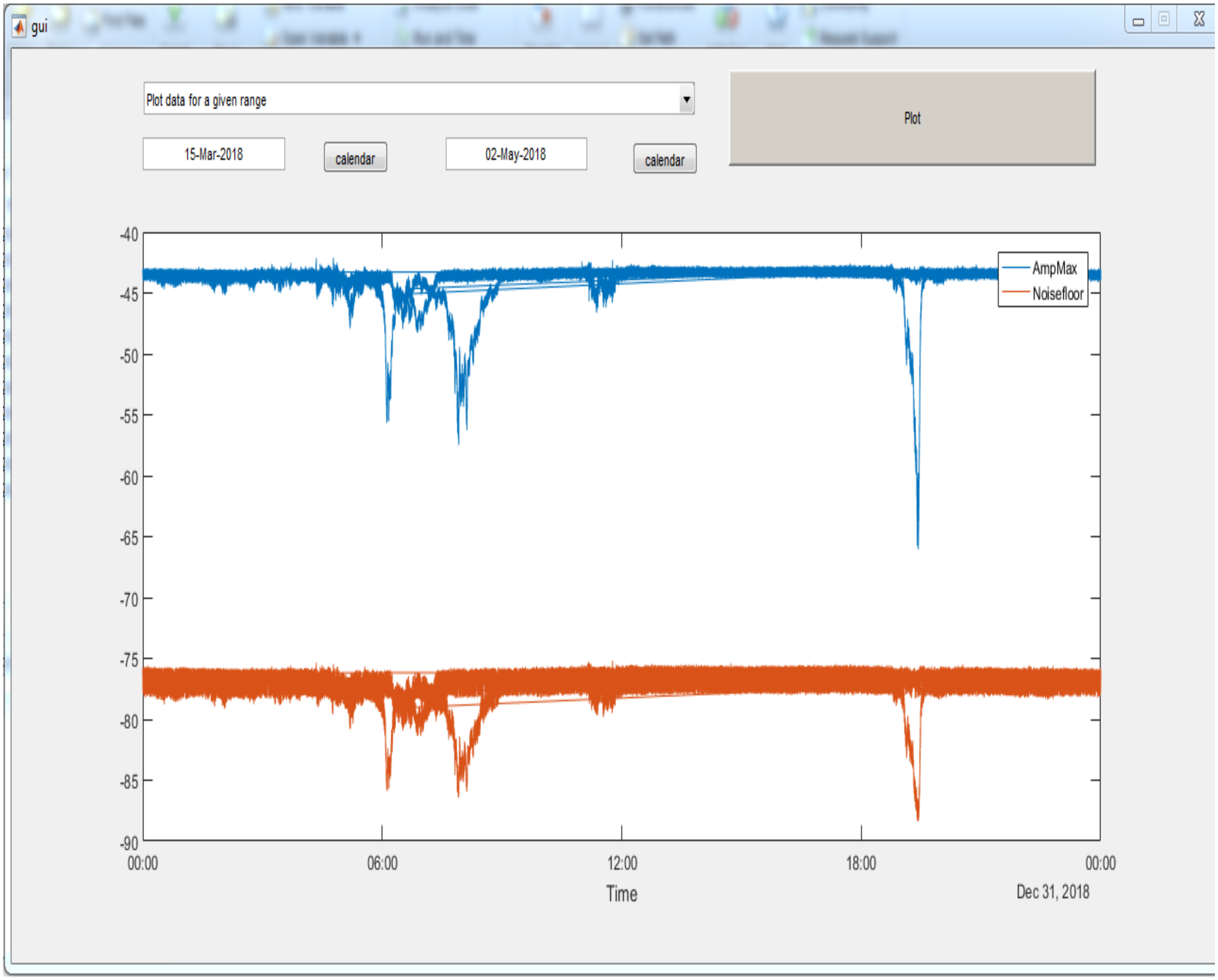
2. Plot the data for a given range:

Steps:

A. Select “Plot data for a range” and enter the starting date and ending date:



B. Tap the button “Plot”:

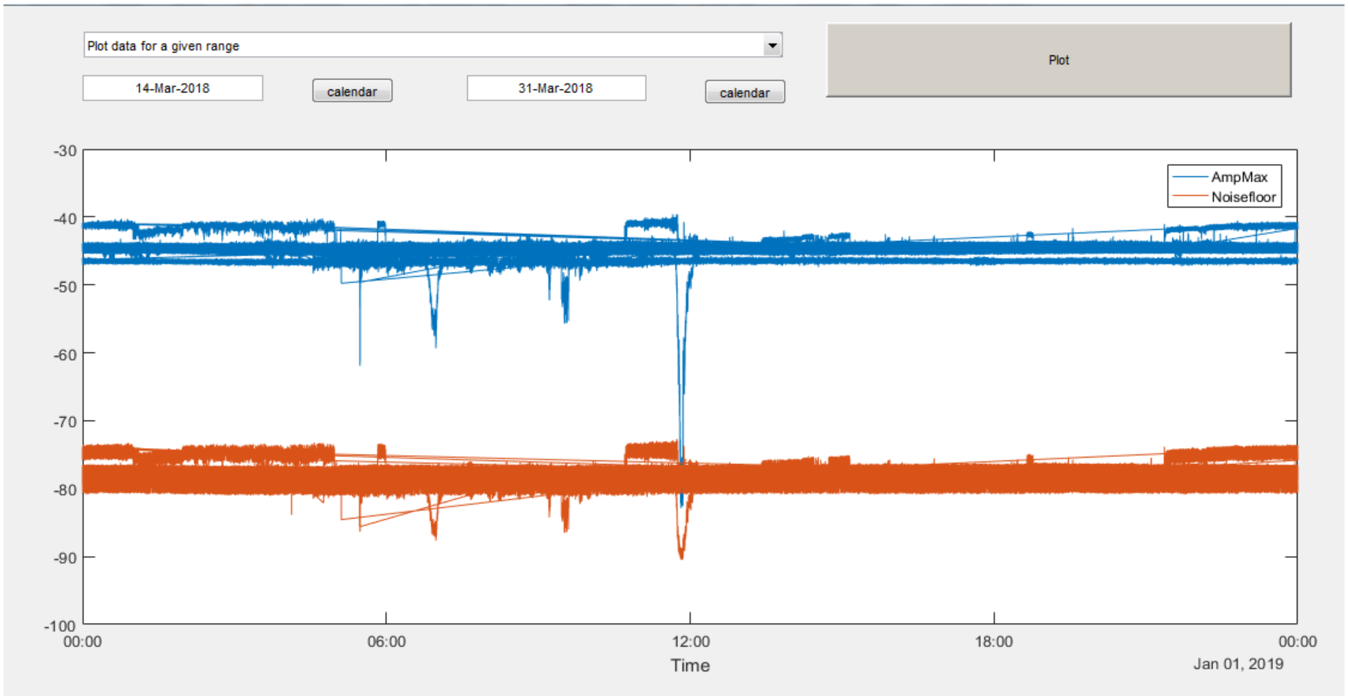


RESULT :

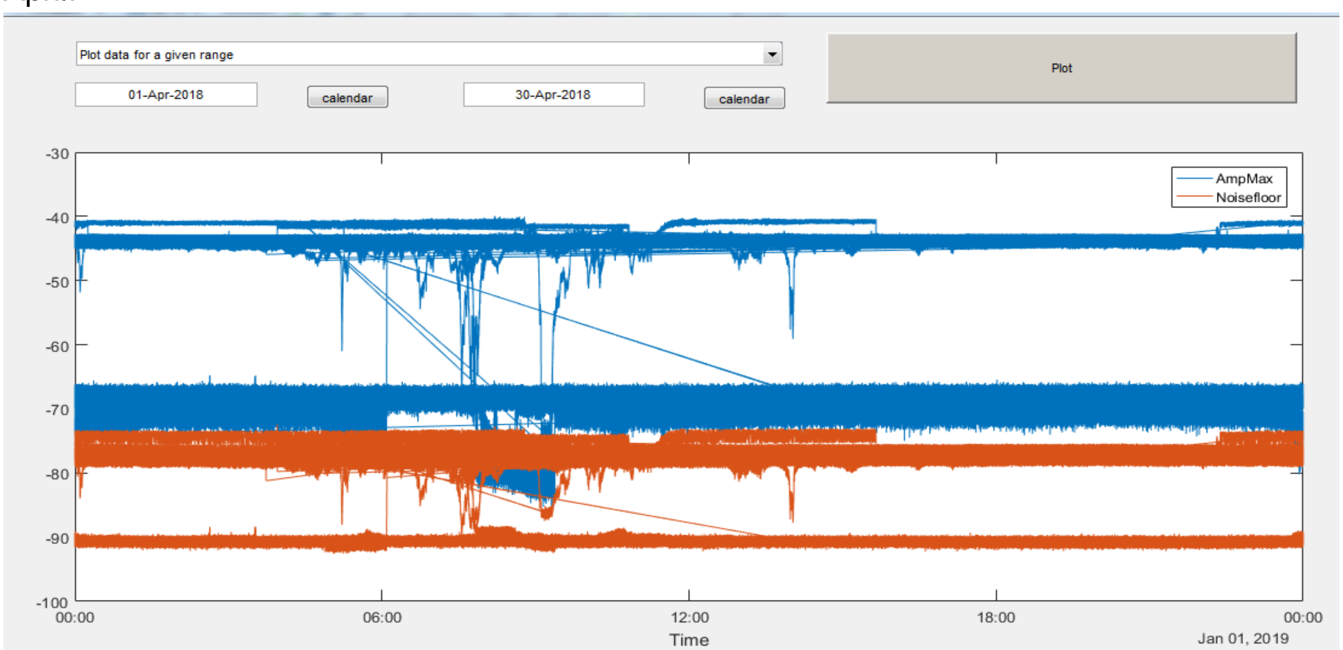
As at the time of our experiment we did not have the data for 2019, so we performed the analysis on the previous year's data(2018). The plots for all the seasons are as follows :

1. **Spring Season:**

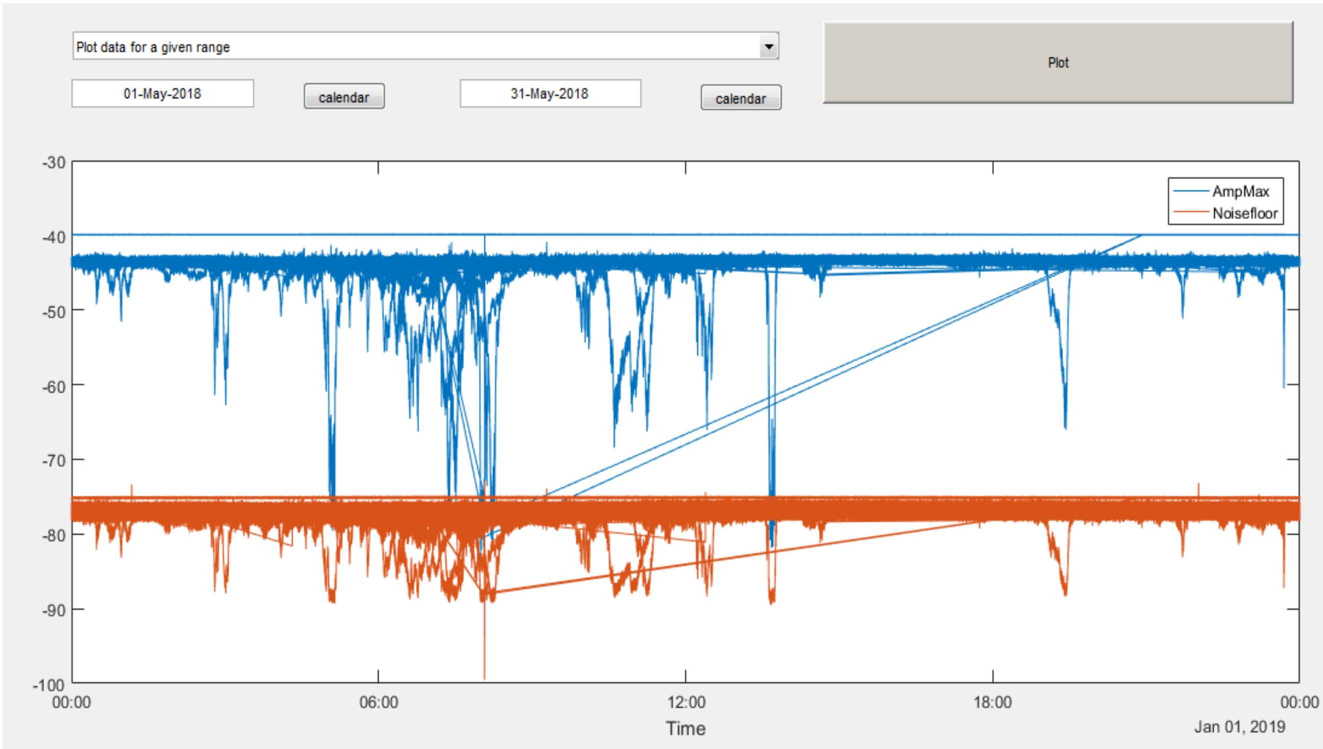
March:



April:

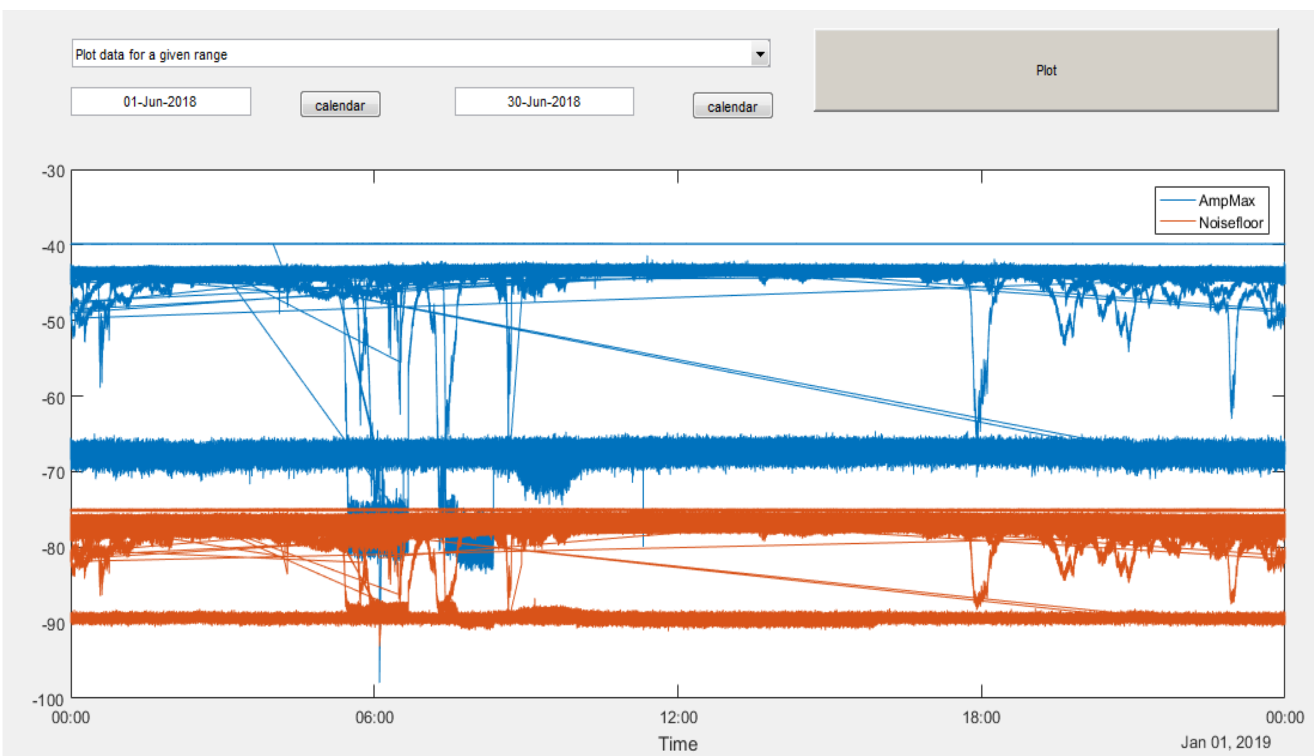


May:

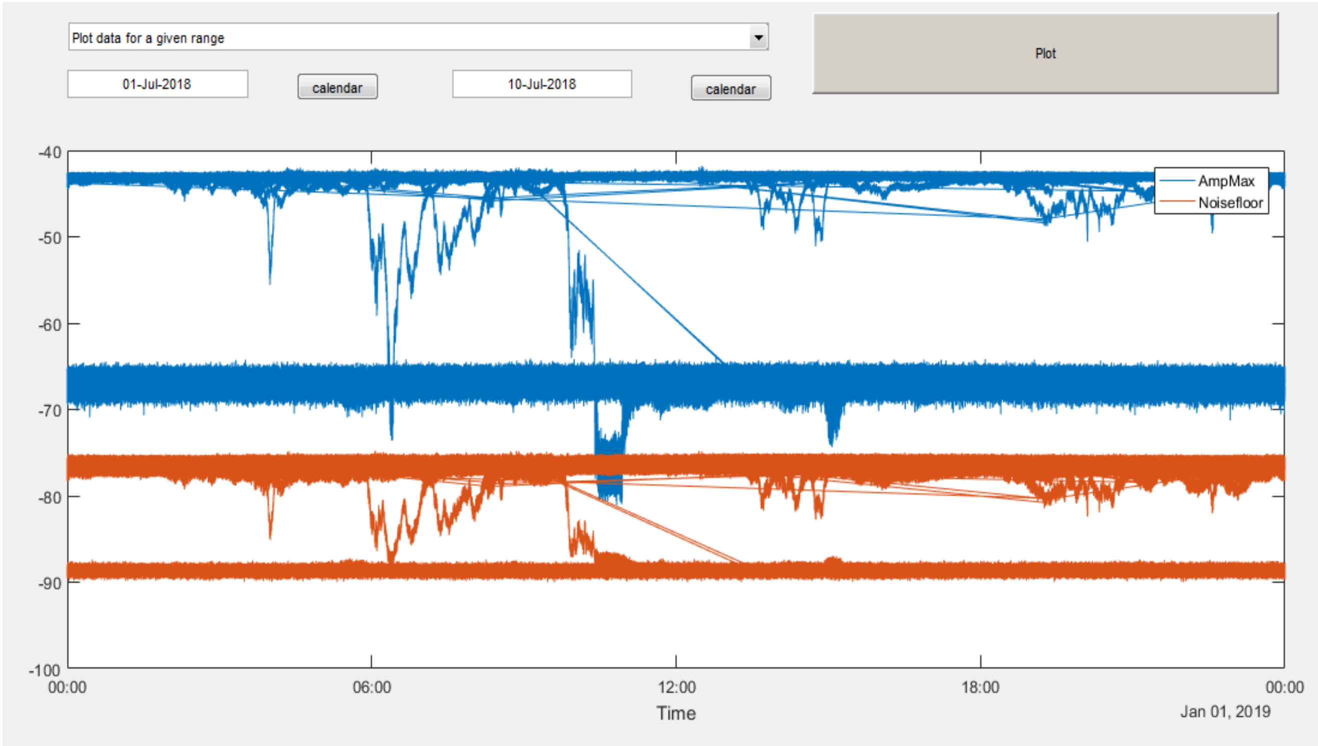


2. Summer Season:

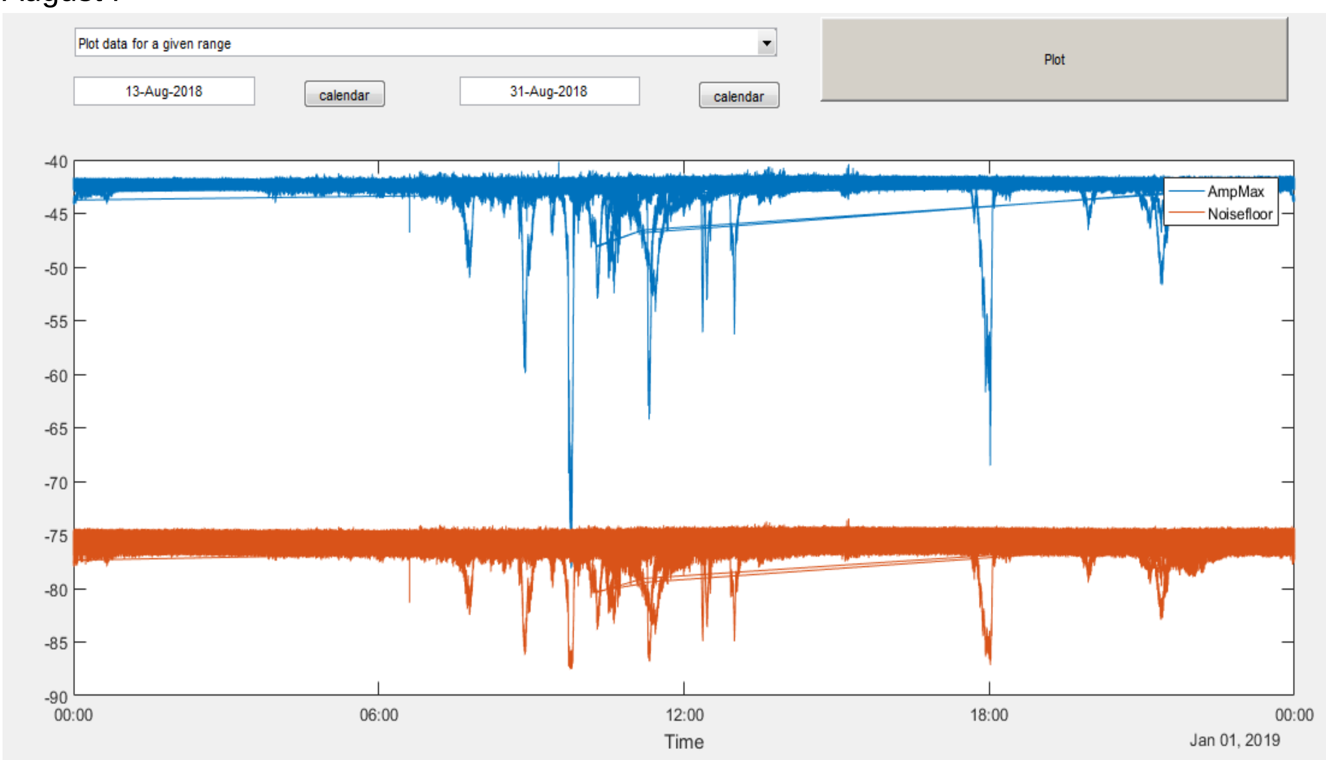
June:



July:

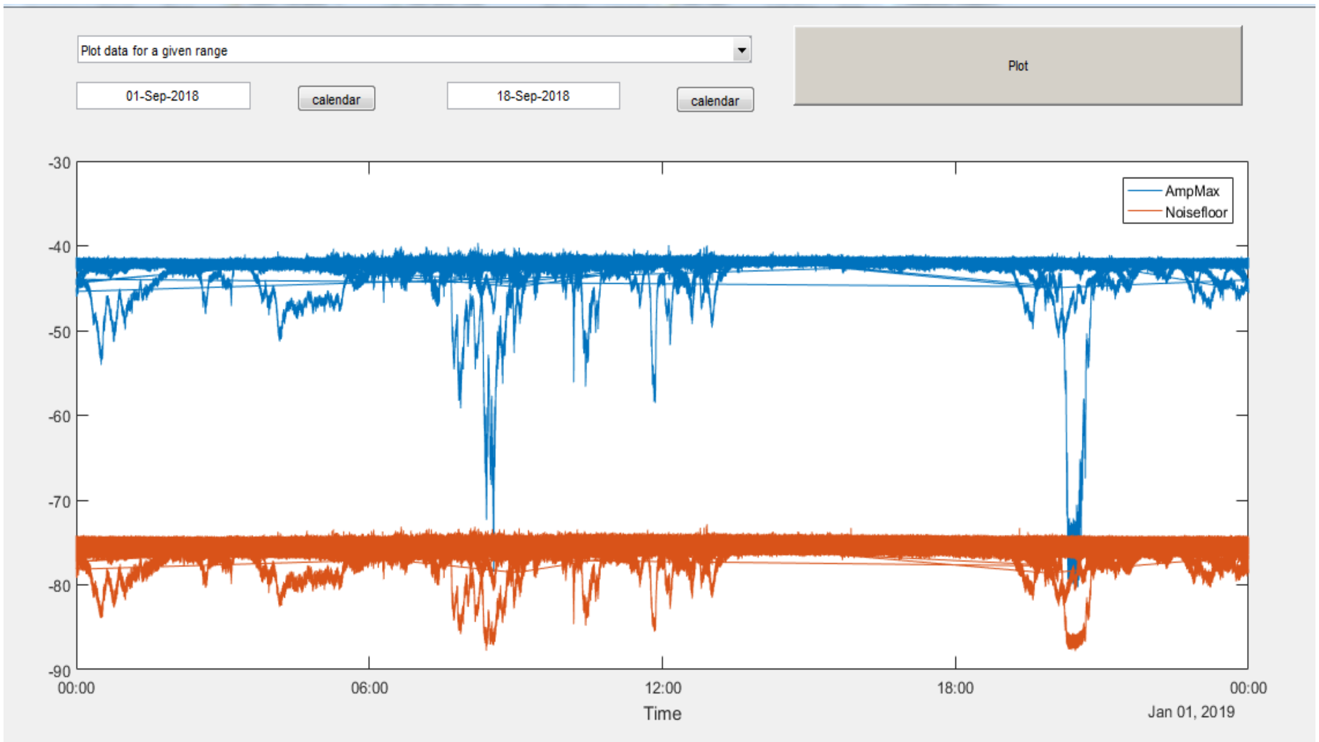

Plot data for a given range
01-Jul-2018
calendar
10-Jul-2018
calendar
Plot
AmpMax
Noisefloor
-40
-50
-60
-70
-80
-90
-100
00:00
06:00
12:00
18:00
00:00
Time
Jan 01, 2019

August :

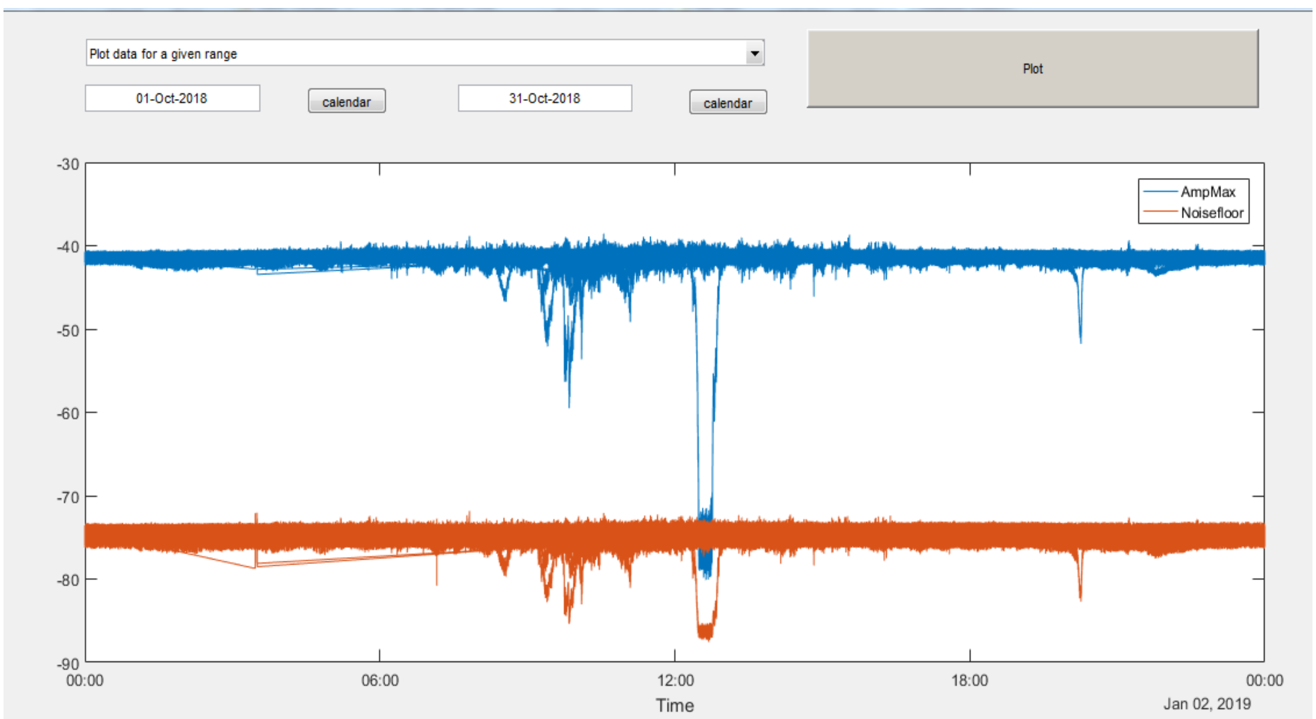

Plot data for a given range
13-Aug-2018
calendar
31-Aug-2018
calendar
Plot
AmpMax
Noisefloor
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
00:00
06:00
12:00
18:00
00:00
Time
Jan 01, 2019

3. Autumn Season:

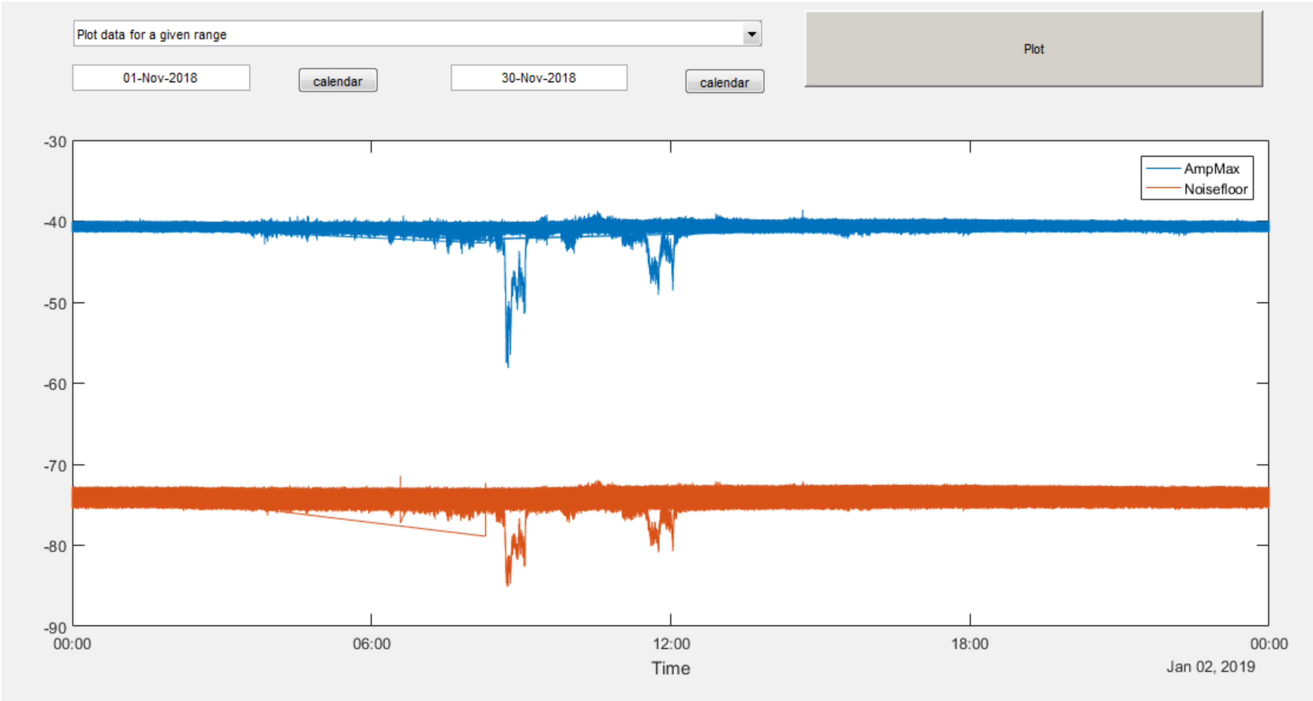
September:



October:

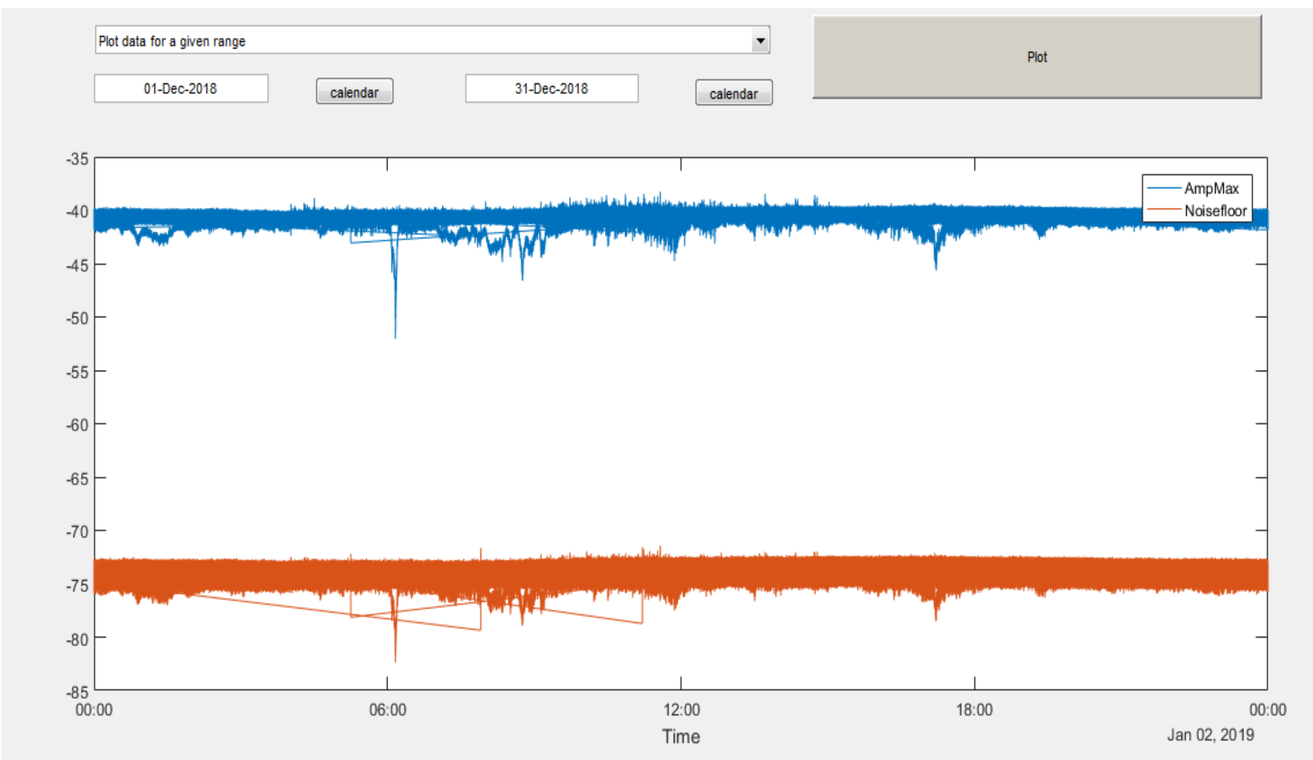


November:



4.Winter season:

December:



**The data for months January and February are yet to be collected .

CONCLUSION

From the above plots of signal amplitude and noise floor vs. time for all the months, we can observe that for the season **Spring** : in March, the signal amplitude and noise floor were pretty constant all around the month. But in April we can see that the signal amplitude and noise floor distorts from its constant values during many of the days in that month. In May we can observe that the distortion pronounced more. We can conclude that in season Spring as we move from March to May the noise floor starts to rise and the signal amplitude decreases.

For the season **Summer** : As we can see in Summer season for all the months June, July and August the signal amplitude and noise floor always kept varying.

For the season **Autumn** : In Autumn season as we move from September to November, we can see that the variations tend to decrease in both signal amplitude and noise floor.

For the season **Winter** : We can see in December that the variations in values of signal amplitude and noise floor tend to decrease a lot in comparison to other seasons i.e. the values almost remain constant.

From the above observations we can see that **Rain** is performing a crucial part in the signal amplitudes which we receive on earth from the satellites. As rain is maximum in Summer season the signal amplitudes tend to more variations than the other seasons.

FUTURE WORK:

We will study how the rain affects the signal on its way from satellite to earth and will find different parameters associated with this.