1. **CODE**

**A.1.1 ROTI Code**

clc;

clear all;

close all;

file1=xlsread('1-10.xlsx');

time1=file1(:,2);

PRN1=file1(:,3);

el1=file1(:,5);

STEC1=file1(:,8);

sTEC=[];

STEC=[];

tIME=[];

TIME=[];

time\_roti=[];

len\_stec=[];

len\_time=[];

m=1;

num=0;

den=0;

rot=[];

ROTI=[];

len\_roti=0;

for k=1:32

 m=1;

 for i=1:length(STEC1)

 if PRN1(i)==k &&time1(i)>0%&& el1(i)>=30

 new\_STEC(m)=STEC1(i);

 new\_time(m)=time1(i);

 m=m+1;

 end

 end

 sTEC=[sTEC;{new\_STEC}];

 tIME=[tIME;{new\_time}];

end

allLengths\_stec = cellfun(@length, sTEC);

maxLength\_stec = max(allLengths\_stec);

allLengths\_time = cellfun(@length, tIME);

maxLength\_time = max(allLengths\_time);

for i=1:32

 numericVector\_stec = cell2mat(sTEC(i));

 l=length(numericVector\_stec);

 len\_stec=[len\_stec,l];

 l=maxLength\_stec - l;

 numericVector\_stec=[numericVector\_stec zeros(1,l)];

 STEC = [STEC; numericVector\_stec];

end

STEC=STEC.';

for i=1:32

 numericVector\_time = cell2mat(tIME(i));

 l=length(numericVector\_time);

 len\_time=[len\_time,l];

 l=maxLength\_time - l;

 numericVector\_time=[numericVector\_time zeros(1,l)];

 TIME = [TIME; numericVector\_time];

end

TIME=TIME.';

%ROT

for i=1:32

 for j=1:len\_stec(i)-1

 num=STEC(j+1,i)-STEC(j,i);

 den=TIME(j+1,i)-TIME(j,i);

 rot(j,i)=num/den;

 end

end

len\_rot=length(rot);

len\_roti=fix(len\_rot/10);

%ROTI -avg\_rot

s=0;

avg\_rot=[];

avg=0;

for i=1:32

 t=0;

 m=1;

 for k=1:len\_rot

 s=s+rot(k,i);

 t=t+1;

 if t==10

 avg=s/10;

 avg\_rot(m,i)=avg;

 time\_roti(m,i)=TIME(k-9);

 m=m+1;

 t=0;

 s=0;

 end

 end

end

s=0;

t=0;

r=mod(len\_rot,10);

l=len\_rot-r;

%ROTI

for i=1:32

 m=1;

 for k=1:l

 s=s+(rot(k,i)-avg\_rot(m,i))^2;

 t=t+1;

 if t==10

 t=0;

 s=s/10;

 ROTI(m,i)=sqrt(s);

 m=m+1;

 s=0;

 end

 end

end

TIME(end,:) = [];

figure(1)

title('ROT (October 1st 2020 - IISC Station)');

hold on

for i=1:32

 plot(TIME(:,i),rot(:,i));

end

xlabel('Time(hours)');

ylabel('ROT (TECU/sec)');

figure(2)

title('ROTI (October 1st 2020 - IISC Station)');

hold on

p=length(time\_roti);

for i=1:32

 plot(time\_roti(1:p-10,i),ROTI(1:p-10,i));

end

xlabel('Time(hours)');

ylabel('ROTI (TECU/sec)');

**A.1.2 DROT Code**

clc;

clear all;

close all;

file1=xlsread('13-02-2015 tubi.xlsx'); % Reading file from the system

time1=file1(:,2);

PRN1=file1(:,3);

el1=file1(:,5);

STEC1=file1(:,8);

sTEC=[];

STEC=[];

tIME=[];

TIME=[];

time\_roti=[];

len\_stec=[];

len\_time=[];

m=1;

num=0;

den=0;

rot=[];

ROTI=[];

len\_roti=0;

for k=1:32

 m=1;

 for i=1:length(STEC1)

 if PRN1(i)==k &&time1(i)>0% && el1(i)>=40

 new\_STEC(m)=STEC1(i);

 new\_time(m)=time1(i);

 m=m+1;

 end

 end

 sTEC=[sTEC;{new\_STEC}];

 tIME=[tIME;{new\_time}];

end

allLengths\_stec = cellfun(@length, sTEC);

maxLength\_stec = max(allLengths\_stec);

allLengths\_time = cellfun(@length, tIME);

maxLength\_time = max(allLengths\_time);

for i=1:32

 numericVector\_stec = cell2mat(sTEC(i));

 l=length(numericVector\_stec);%

 len\_stec=[len\_stec,l];

 l=maxLength\_stec - l;

 numericVector\_stec=[numericVector\_stec zeros(1,l)];

 STEC = [STEC; numericVector\_stec];

end

STEC=STEC.';

for i=1:32

 numericVector\_time = cell2mat(tIME(i));

 l=length(numericVector\_time);

 len\_time=[len\_time,l];

 l=maxLength\_time - l;

 numericVector\_time=[numericVector\_time zeros(1,l)];

 TIME = [TIME; numericVector\_time];

end

TIME=TIME.';

%ROT

for i=1:32

 for j=1:len\_stec(i)-1

 num=STEC(j+1,i)-STEC(j,i);

 den=TIME(j+1,i)-TIME(j,i);

 rot(j,i)=num/den;

 end

end

len\_rot=length(rot);

FM=[]; %first median values

fm=[];

for i=1:32

 for j=1:len\_stec(i)-1

 M(j)=rot(j,i);

 H=movmedian(M,60);

 %H=H.';

 end

 fm=[fm;{H}];

 %FM(:,i)=H;

end

allLengths\_fm = cellfun(@length, fm);

maxLength\_fm = max(allLengths\_fm);

len\_fm=[];

for i=1:32

 numericVector\_fm = cell2mat(fm(i));

 l=length(numericVector\_fm);

 len\_fm=[len\_fm,l];

 l=maxLength\_fm - l;

 numericVector\_fm=[numericVector\_fm zeros(1,l)];

 FM = [FM; numericVector\_fm];

end

FM=FM.';

SM=[]; %second median values

sm=[];

M2=[];

H2=[];

for i=1:32

 for j=1:len\_fm(i)-1

 M2(j)=FM(j,i);

 H2=movmedian(M2,360);

 %H=H.';

 end

 sm=[sm;{H2}];

 %FM(:,i)=H;

end

allLengths\_sm = cellfun(@length, sm);

maxLength\_sm = max(allLengths\_sm);

len\_sm=[];

for i=1:32

 numericVector\_sm = cell2mat(sm(i));

 l=length(numericVector\_sm);

 len\_sm=[len\_sm,l];

 l=maxLength\_sm - l;

 numericVector\_sm=[numericVector\_sm zeros(1,l)];

 SM = [SM; numericVector\_sm];

end

SM=SM.';

SM=[SM;zeros(1,32)];

D=FM - SM;

%DROT

sn=0;

sd=0;

DROT=[];

num=[];

den=[];

for i=1:32

 sn=0;

 sd=0;

 for j=1:length(D)

 sn=sn+(D(j,i))^2;

 sd=sd+ (FM(j,i))^2;

 end

 sn=sqrt(sn);

 sd=sqrt(sd);

 num=[num,sn];

 den=[den,sd];

end

for i=1:32

 DROT(i)=(num(i) ./ den(i)) \* 100;

end

DROT

%PLOTS

TIME(end,:) = [];

figure(1)

title('ROT for October 1st 2020 - IISC Station');

hold on

for i=1:32

 plot(TIME(1:len\_time(i)-1,i),rot(1:len\_stec(i)-1,i));

end

figure(2)

title('1st MEDIAN');

hold on

for i=1:32

 plot(TIME(1:len\_time(i)-1,i),FM(1:len\_fm(i),i));

end

figure(3)

title('2nd MEDIAN');

hold on

for i=1:32

 plot(TIME(1:len\_time(i)-2,i),SM(1:len\_sm(i),i));

end

figure(4)

title('DIFFERENCE VECTOR for October 1st 2020 - IISC Station');

hold on

for i=1:32

 plot(TIME(1:len\_time(i)-1,i),D(1:len\_fm(i),i));

end

figure(5)

title('STEC vs Time for October 1st 2020 - IISC Station');

for i=1:32

 plot(TIME(1:len\_time(i),i),STEC(1:len\_stec(i),i));

end

**A.1.3 Ionospheric Disturbances for month wise Code**

clc

clear all

% reading file

file=xlsread('may 2020.xlsx');

% x-days

x=file(:,1);

% y - DROT values

y=file(:,2);

% plotting the graph

plot(x,y)

% threshold of < 50% - SSTID

yline(50,'-','thershold (<50-SSTID)');

% threshold of > 50% < 70% - MSTID

% threshold >70% - LSTID

yline(70,'-','thershold (>50&<70-MSTID)');

title('Ionospheric distubances from DROT for May 2020-IISC Station');

xlabel('Date');

ylabel('DROT value');

ax=gca;

ax.FontSize=15;

**A.1.4 Number of Large Scale Ionospheric Disturbances Code**

clear all;

close all;

c=0;

file1=xlsread('2020.xlsx');

jan=file1(:,1);

feb=file1(:,2);

mar=file1(:,3);

apr=file1(:,4);

may=file1(:,5);

jun=file1(:,6);

july=file1(:,7);

aug=file1(:,8);

sep=file1(:,9);

oct=file1(:,10);

nov=file1(:,11);

dec=file1(:,12);

errors=[0,0,0,0,0,0,0,0,0,0,0,0];

for i=2:31

 if jan(i)>70.0

 c=c+1;

 end

end

errors(1)=c;

c=0;

for i=2:31

 if feb(i)>70.0

 c=c+1;

 end

end

errors(2)=c;

c=0;

for i=2:31

 if mar(i)>70.0

 c=c+1;

 end

end

errors(3)=c;

c=0;

for i=2:31

 if apr(i)>70.0

 c=c+1;

 end

end

errors(4)=c;

c=0;

for i=2:31

 if may(i)>70.0

 c=c+1;

 end

end

errors(5)=c;

c=0;

for i=2:31

 if jun(i)>70.0

 c=c+1;

 end

end

errors(6)=c;

c=0;

for i=2:31

 if july(i)>70.0

 c=c+1;

 end

end

errors(7)=c;

c=0;

for i=2:31

 if aug(i)>70.0

 c=c+1;

 end

end

errors(8)=c;

c=0;

for i=2:31

 if sep(i)>70.0

 c=c+1;

 end

end

errors(9)=c;

c=0;

for i=2:31

 if oct(i)>70.0

 c=c+1;

 end

end

errors(10)=c;

c=0;

for i=2:31

 if nov(i)>70.0

 c=c+1;

 end

end

errors(11)=c;

c=0;

for i=2:31

 if dec(i)>70.0

 c=c+1;

 end

end

errors(12)=c;

c=0;

sum(errors)

% month=('Jan','Feb','March','Apr','May','Jun','July','Aug','Sep','Oct','Nov','Dec');

month = categorical({'Jan','Feb','March','Apr','May','Jun','July','Aug','Sep','Oct','Nov','Dec'});

month = reordercats(month,{'Jan','Feb','March','Apr','May','Jun','July','Aug','Sep','Oct','Nov','Dec'});

bar(month,errors);

xlabel('Months of the year ');

ylabel('Number of Ionospheric disturbances');

title('Ionospheric disturbances from DROT for the year 2020-IISC Station');

ax=gca;

ax.FontSize=15;