Processing Ionospheric Data Using MATLAB

Daniel Okoh

NASRDA Center for Atmospheric Research

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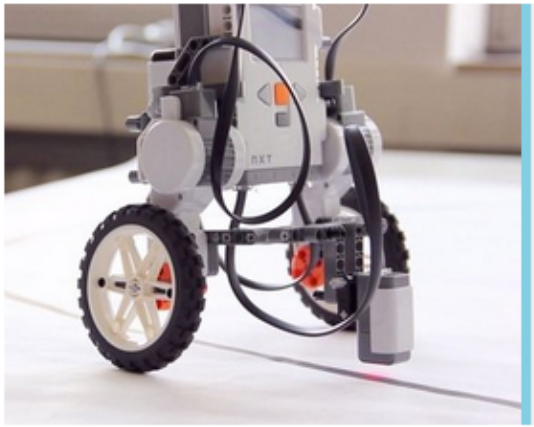
Licensing

Recently, various legal free copies of the software from Mathworks

Modeling and Simulation using MATLAB on iversity (https://iversity.org)



INTERDISCIPLINARY

Modelling and Simulation using MATLAB®

Prof. Dr.-Ing. Georg Fries, Prof. Dr. Peter Dannenmann, Prof. Dr. Karin Graeslun...

How can I simulate a water treatment plant or realize a new business venture? This MOOC explains how to model and simulate innovative ideas using MATLAB/Simulink.

22 APR. 2014 ENGLISH

GO TO COURSE

Outline

Calling the IRI Model from MATLAB
(An offline MATLAB version of the IRI Model)

Reducing GPS Data on MATLAB

Data Visualization on MATLAB
(Spatial & Temporal)

A bit of IRI Intro

The IRI is acronym for International Reference Ionosphere;

- **International Standard for Specifying Ionospheric Parameters (Bilitza, 2001)**

Model is developed empirically

Parameters include electron densities, plasma frequencies, peak heights and densities, TEC, etc.

IRI Availability through IRI Homepage (http://irimodel.org/)

Online Computation

Fortran source code

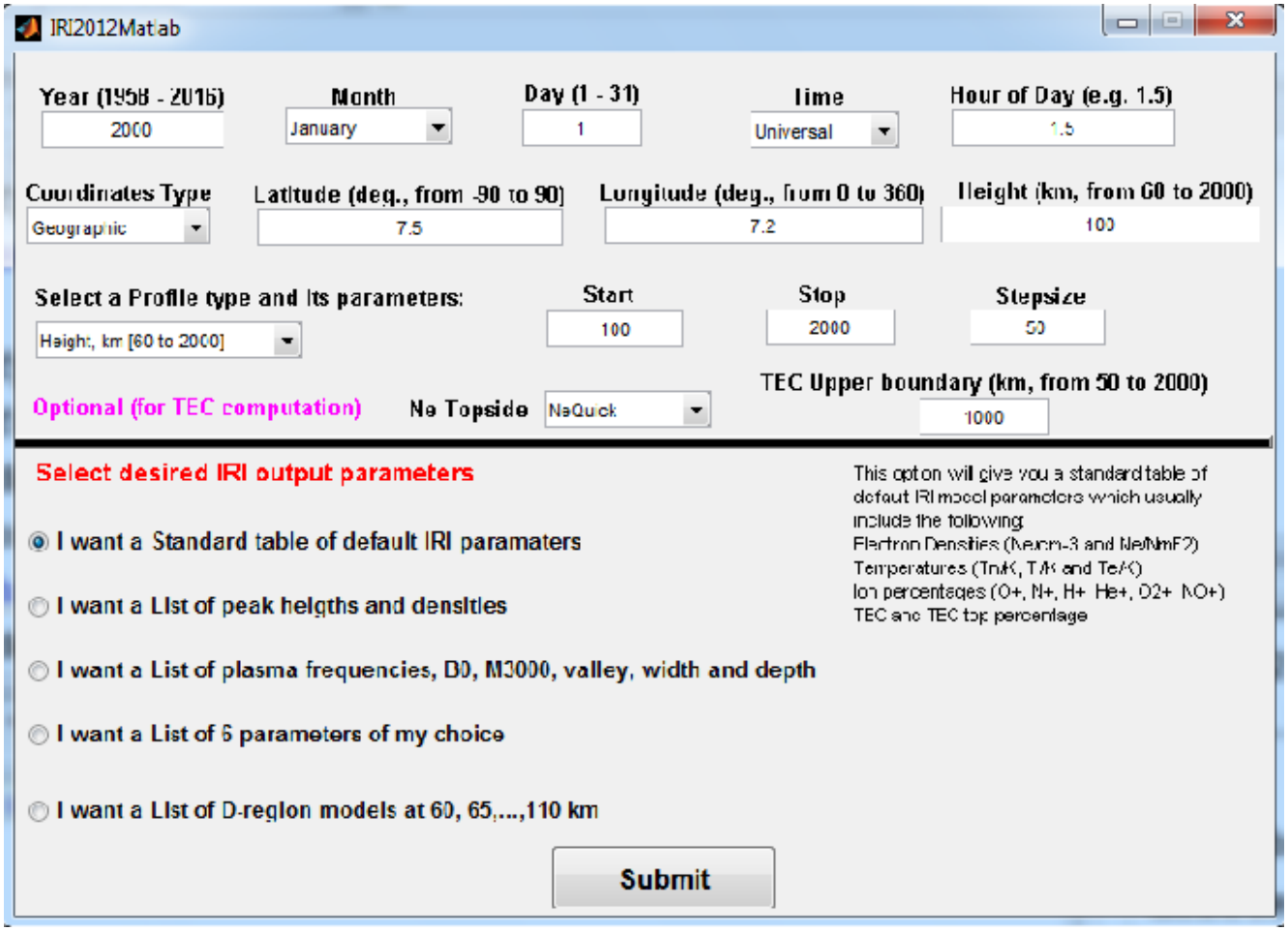
MATLAB Version (By Drew Compston); Requires internet; as it works with the online interface

A MATLAB version that does not require internet

Utilizes the Fortran source code, and so does not require internet

Any suitable Fortran compiler can be used to compile the IRI source code; I use simplyFortran (http://simplyfortran.com/)

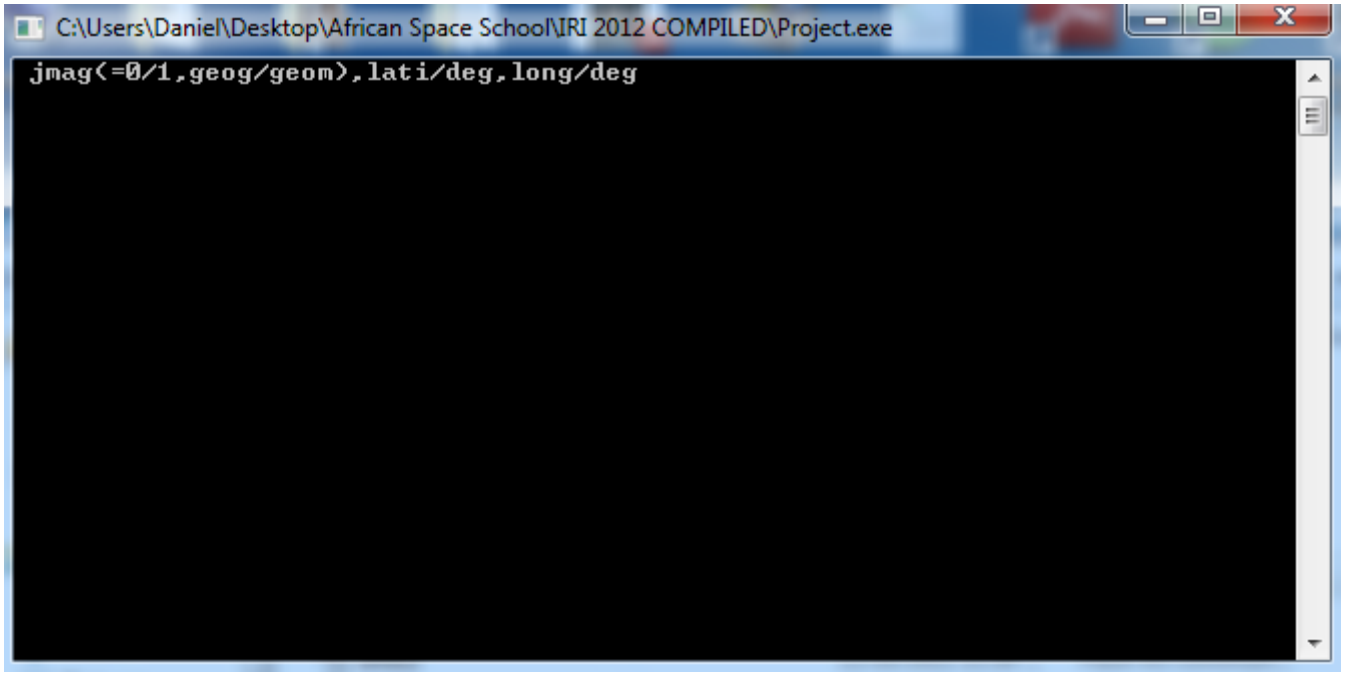
A MATLAB version that does not require internet



Outside ILLUSTRATION

Stages/Considerations

Ordinarily, a compiled IRI Fortran code will require user inputs on the command prompt; could be strenuous to generate a single profile



Outside ILLUSTRATION

Stages/Considerations

Modification of the fortran code before compilation:

- **the program should read inputs from a specified file rather than wait for the user inputs on the command prompt**

MATLAB file processing used to write user inputs from the GUI to the specified file

The compiled IRI program is called using the MATLAB 'dos' command

MATLAB file processing used to read IRI data from the IRI output file

Reading and Writing to Files on MATLAB

Writing:

```
fid=fopen('filename.txt', 'wt');
a=magic(7)
fprintf(fid, '%f\t %f\t %f\t %f\t %f\t %f\t %f\n', a');
```

Reading:

```
fid=fopen('filename.txt');
b=textscan(fid, '%f\t %f\t %f\t %f\t %f\t %f\t %f\n')
```

Multiple Profiles

Example; Daily profiles for a whole year

GPS TEC from GPS Observations & RINEX Files

A MATLAB RINEX2TEC converter

Elaborate treatment by John Raquet & Luigi Ciraolo next week

The ionosphere delays GPS signals by amounts that depend on the signal frequencies.
By receiving at 2 different frequencies, we can estimate these delays, which in turn correspond to some value of TEC

Reducing GPS TEC Data (A Case of SCINDA GPS)

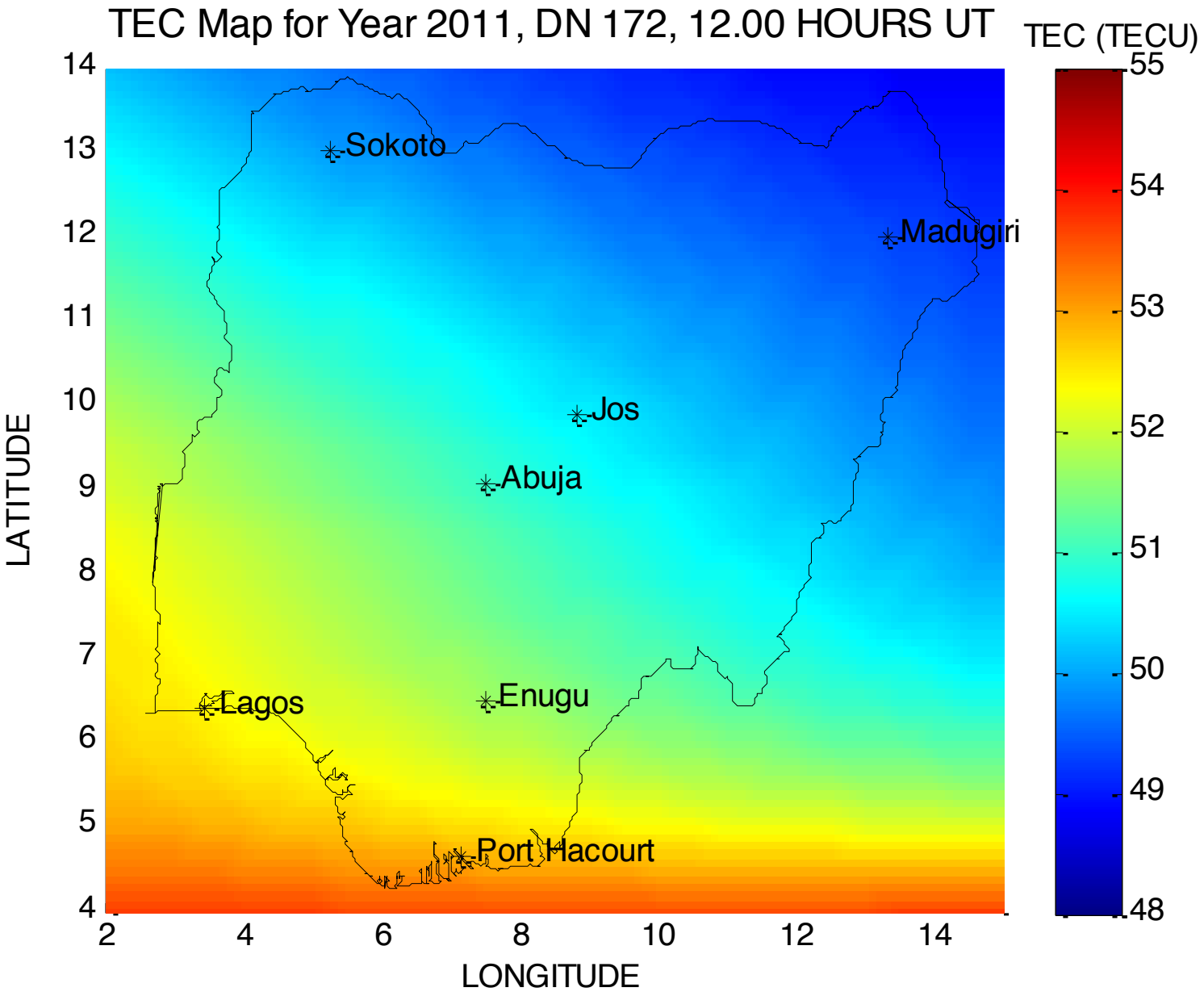
WinTEC-P computes TEC from RINEX files; produces compressed (.gz) files

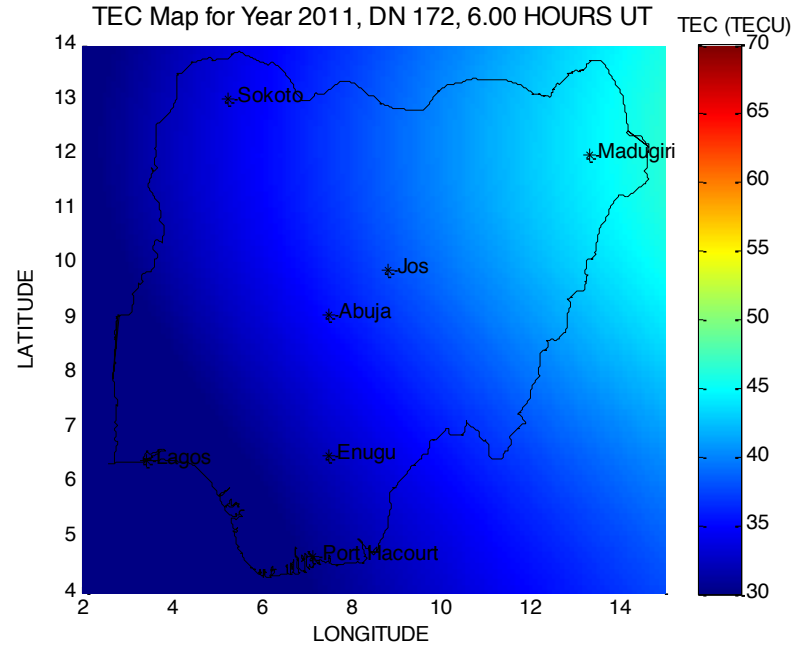
```
gunzip('*.gz'); %to uncompress all GNU zip files to a new folder named 'output' in the current folder

find(vtec~=-1 & elev>=20); % to exclude vtec data = -1.00 and satellite elevations less than 20 degrees

find(yy==y & mm==m & dd==d & hfrac==round(h)); % y is year, m is month, dd is day of month, hfrac is hour fraction
```

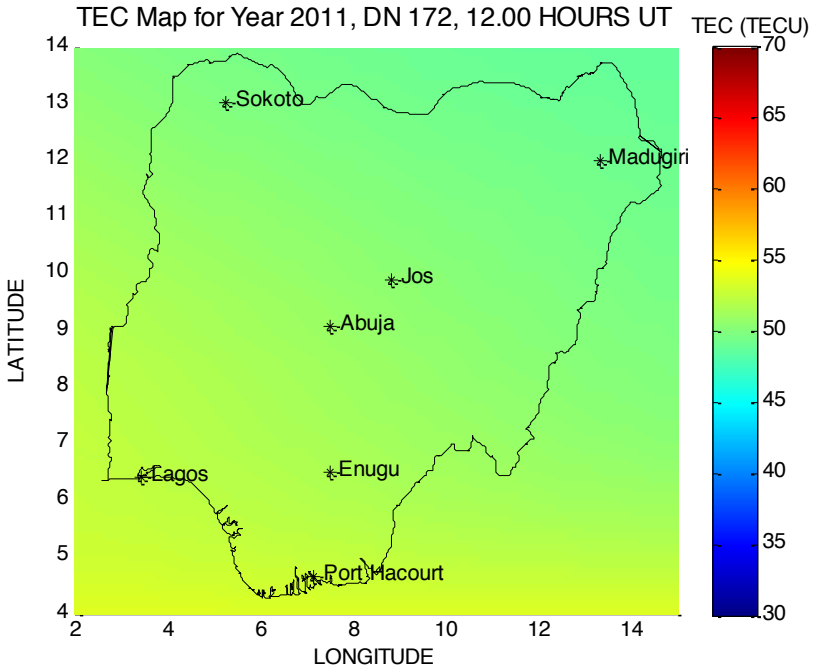
Data Visualization

Spatial Variations and Temporal Variations

Spatial Variations




TEC Map for Year 2011, DN 172, 6.00 HOURS UT
TEC (TECU)
LATITUDE
LONGITUDE
Sokoto
Madugiri
Jos
Abuja
Lagos
Enugu
Port Hacourt


TEC Map for Year 2011, DN 172, 12.00 HOURS UT
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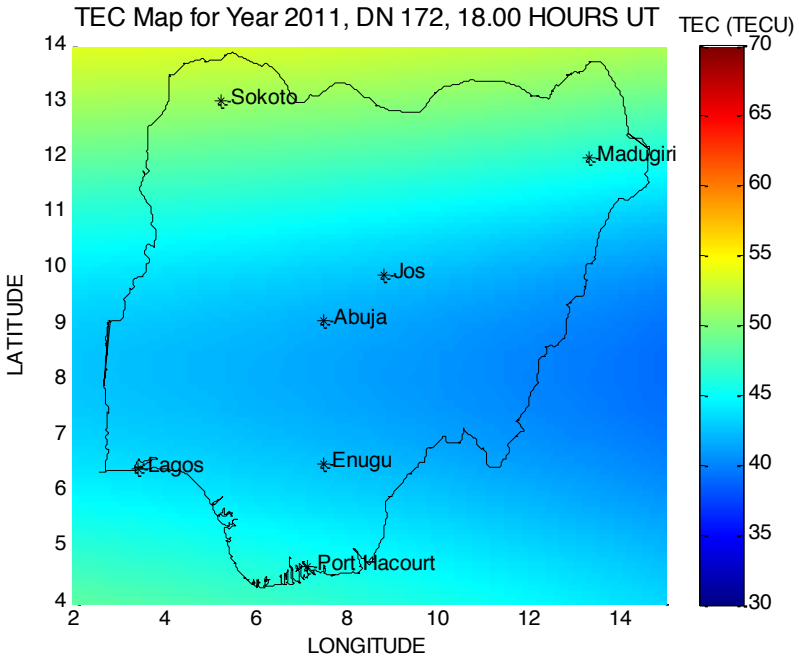
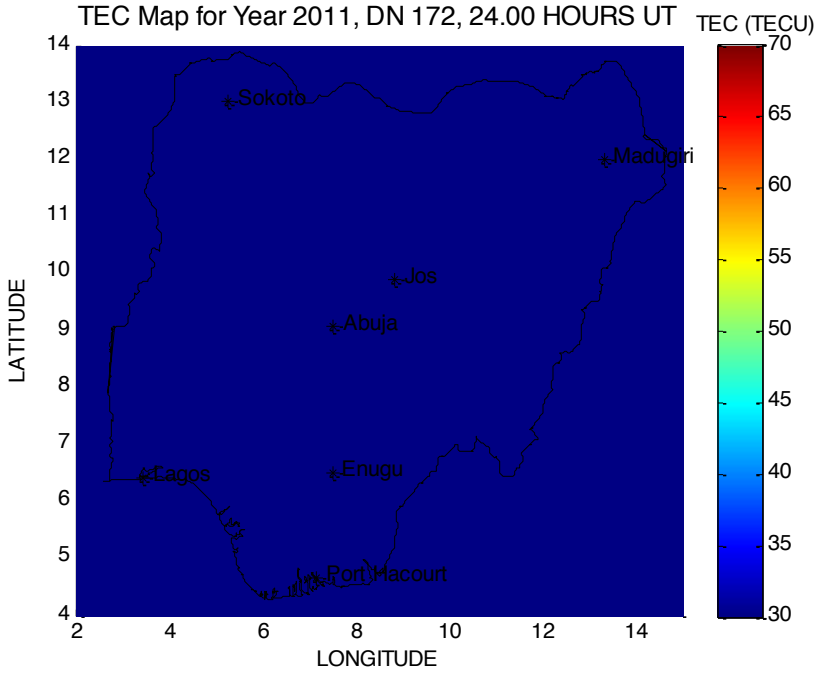
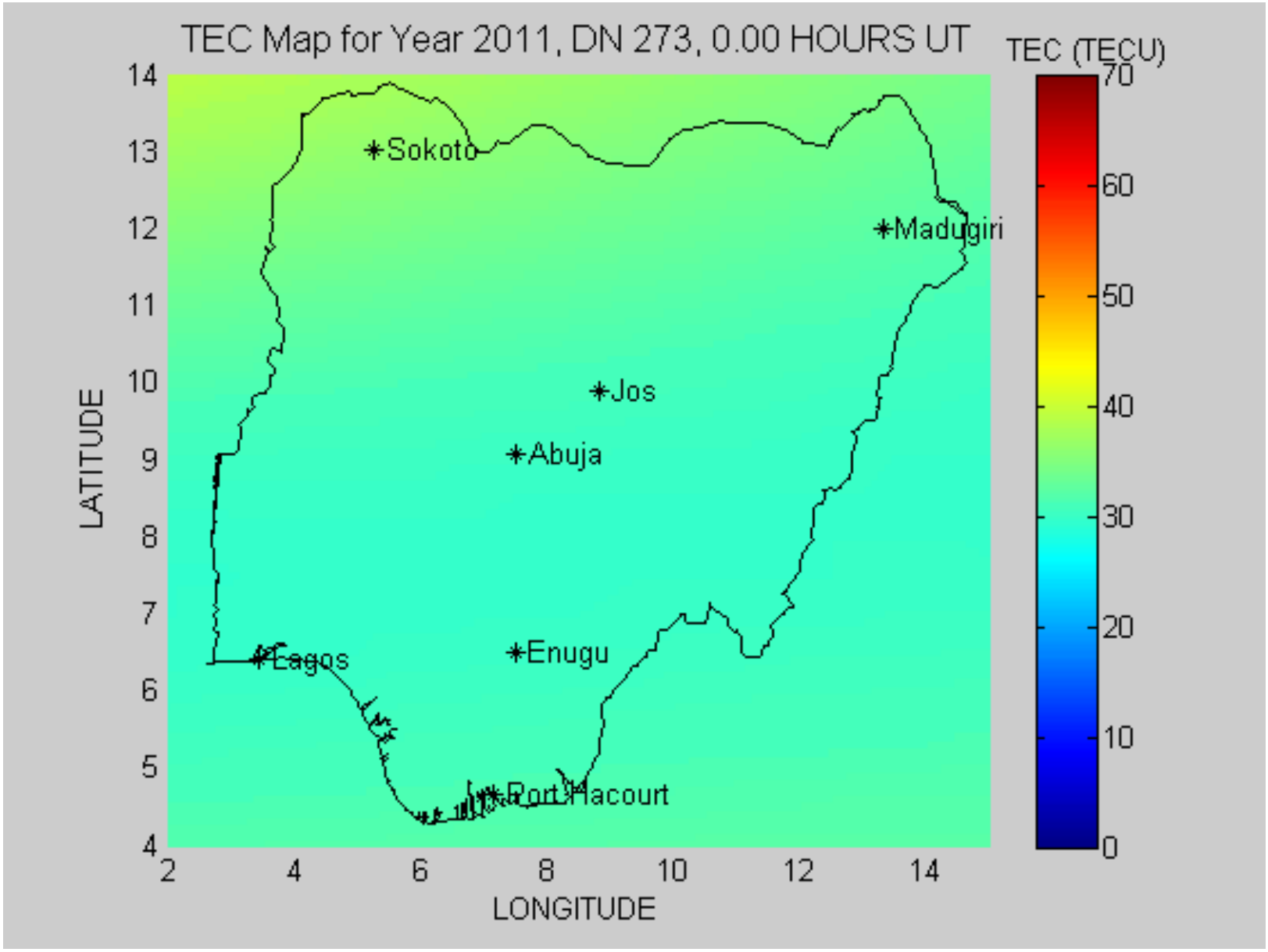
LONGITUDE
Sokoto
Madugiri
Jos
Abuja
Lagos
Enugu
Port Hacourt

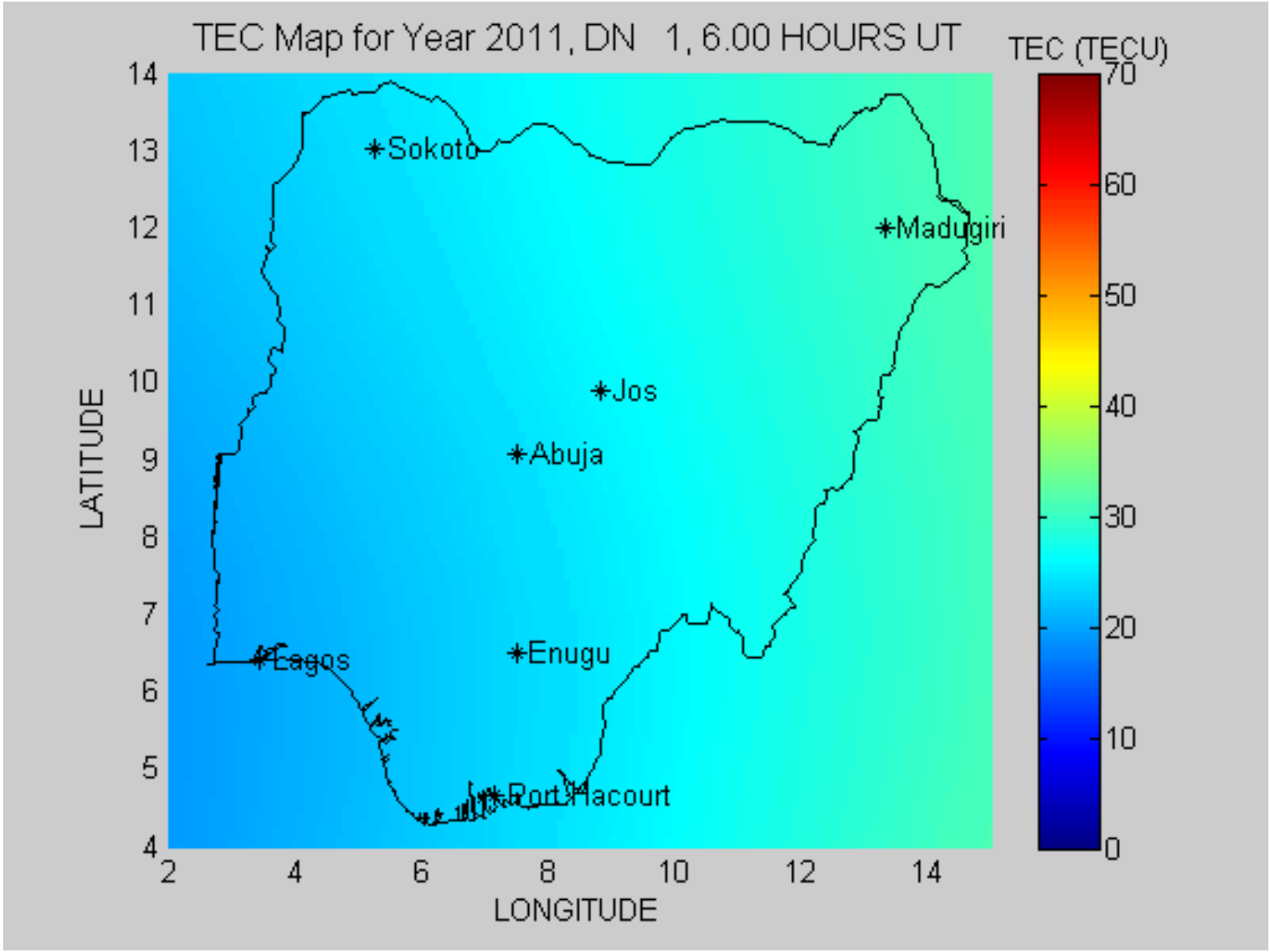

TEC Map for Year 2011, DN 172, 18.00 HOURS UT
TEC (TECU)
LATITUDE
LONGITUDE
Sokoto
Madugiri
Jos
Abuja
Lagos
Enugu
Port Hacourt


TEC Map for Year 2011, DN 172, 24.00 HOURS UT
TEC (TECU)
LATITUDE
LONGITUDE
Sokoto
Madugiri
Jos
Abuja
Lagos
Enugu
Port Hacourt

Spatial and Temporal



Spatial and Temporal 2



MATLAB Script; Spatial

imagesc

imagesc(tec)

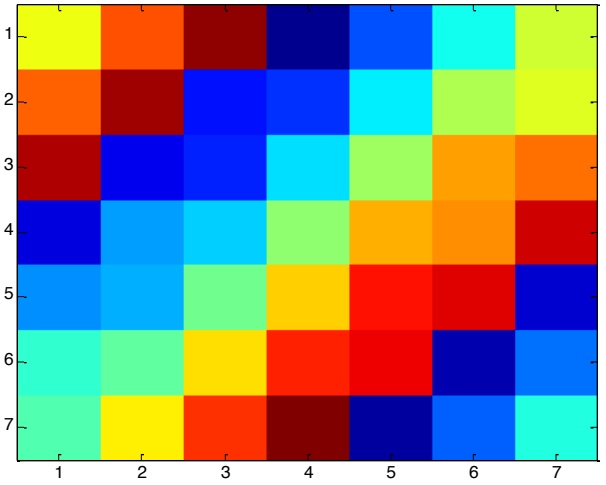
Example tec=

```
[30   39   48    1   10   19   28
 38   47    7    9   18   27   29
 46    6    8   17   26   35   37
  5   14   16   25   34   36   45
 13   15   24   33   42   44    4
 21   23   32   41   43    3   12
 22   31   40   49    2   11   20];
```

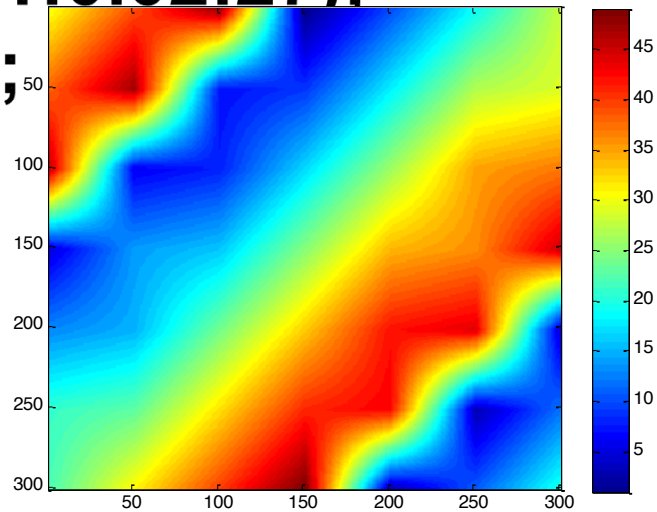
MATLAB Script; Spatial

```
a=magic(7);
imagesc(a);
```

```
29
   46    6    8   17   26   35
37
    5   14   16   25   34   36
45
   13   15   24   33   42   44
 4
   21   23   32   41   43    3
12
   22   31   40   49    2   11
20
```

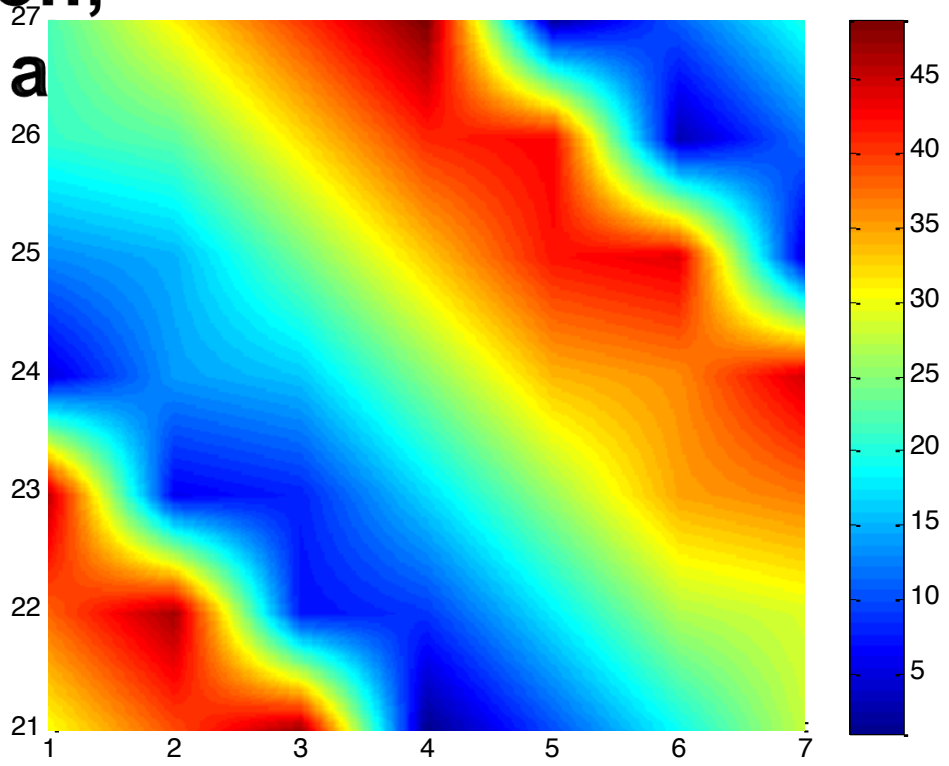



```
a=magic(7);
[long lat]=meshgrid(1:7, 21:27);
[long2 lat2]=meshgrid(1:0.02:7, 21:0.02:27);
a2 = interp2(long,lat,a,long2,lat2);
imagesc(a2);
colorbar;
```



MATLAB Script; Spatial

```
a=magic(7);
[long lat]=meshgrid(1:7, 21:27);
[long2 lat2]=meshgrid(1:0.02:7, 21:0.02:27);
a2 = interp2(long,lat,a,long2,lat2);
axis([1 7 21 27]); hold on;
imagesc([1 7], [21 27], a
colorbar;
```



MATLAB Script; Spatial & Temporal

```
aviobj = avifile('filename.avi');

for t=1:n
    Program to make each figure here
    F = getframe(gcf);
    aviobj = addframe(aviobj,F);
end

aviobj = close(aviobj);
```

```
for t=1:50
    a=magic(7)-t;
    [long lat]=meshgrid(1:7, 21:27);
    [long2 lat2]=meshgrid(1:0.02:7,
21:0.02:27);
    a2 = interp2(long,lat,a,long2,lat2);
    axis([1 7 21 27]); hold on;
    imagesc([1 7], [21 27], a2);
    caxis([-10 60]); colorbar;
    title(['t=' num2str(t)]); hold off;
    F = getframe(gcf);
    aviobj = addframe(aviobj,F);
end
aviobj = close(aviobj);
```

Thank you