Ionospheric Models: IRI, NeQuick, Ionolab, IRI-Plas and Neural Network

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INTERNATIONAL COLLOQUIUM ON EQUATORIAL & LOW-LATITUDE IONOSPHERE; 15 - 17 September 2020

Introduction

- **Total Electron Content as an important descriptive parameter of the ionosphere.**
- **TEC is very important for ionospheric studies.**
- **A key parameter in propagation**
- **TEC is the major observable parameter in Space Weather, TEC Mapping (Spatial Interpolation), Ionospheric Characterization and Computerized Ionospheric Tomography (CIT).**

Introduction

- **TEC from different sources:**
  - **GPS-TEC (Gopi and Ionolab Techniques)**
  - **IRI-TEC**
  - **NeQuick-TEC**
  - **IRI-Plas-TEC**
  - **CAR NN Ionospheric model (Dr D.I. Okoh will help us on this)**

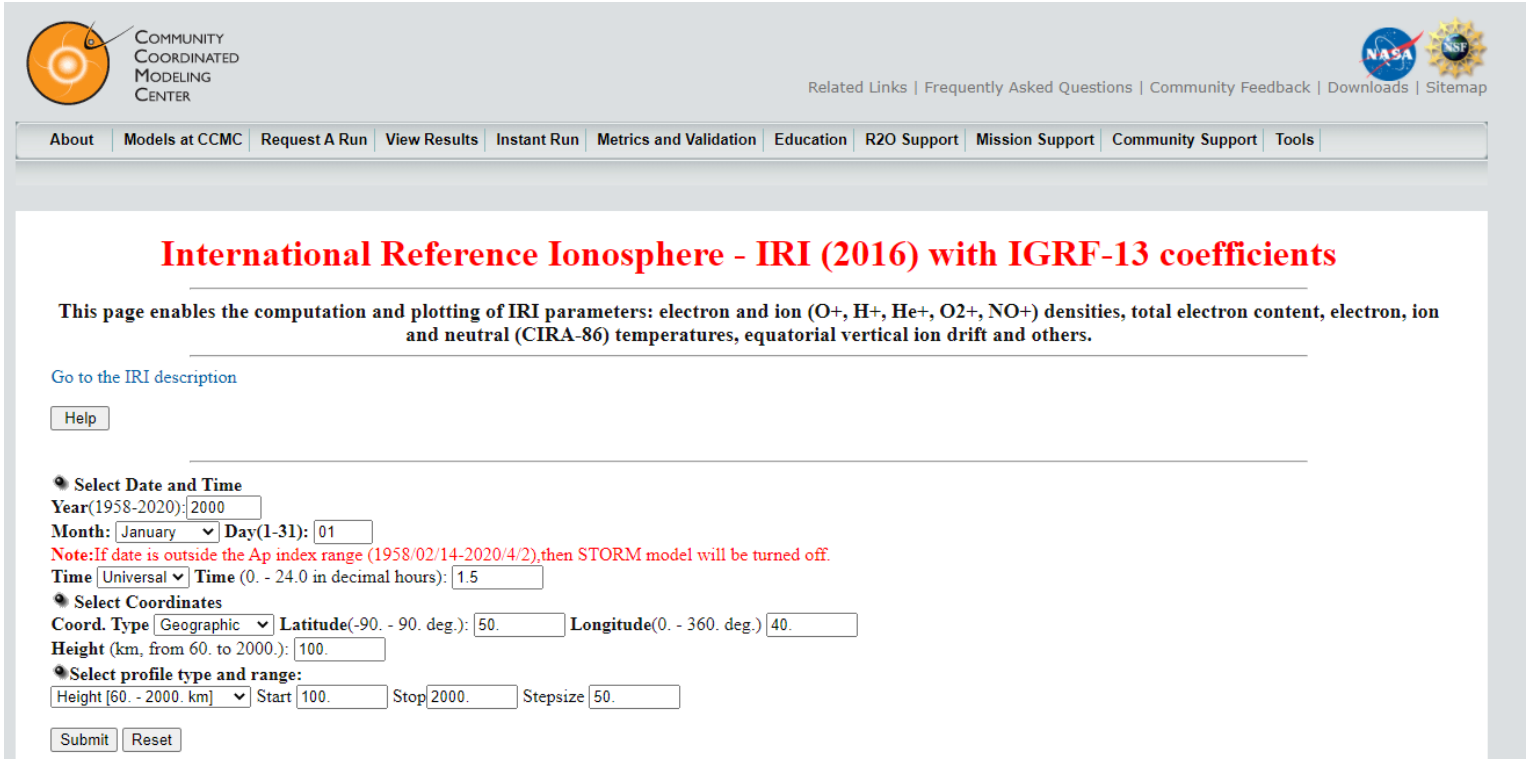
IRI Model

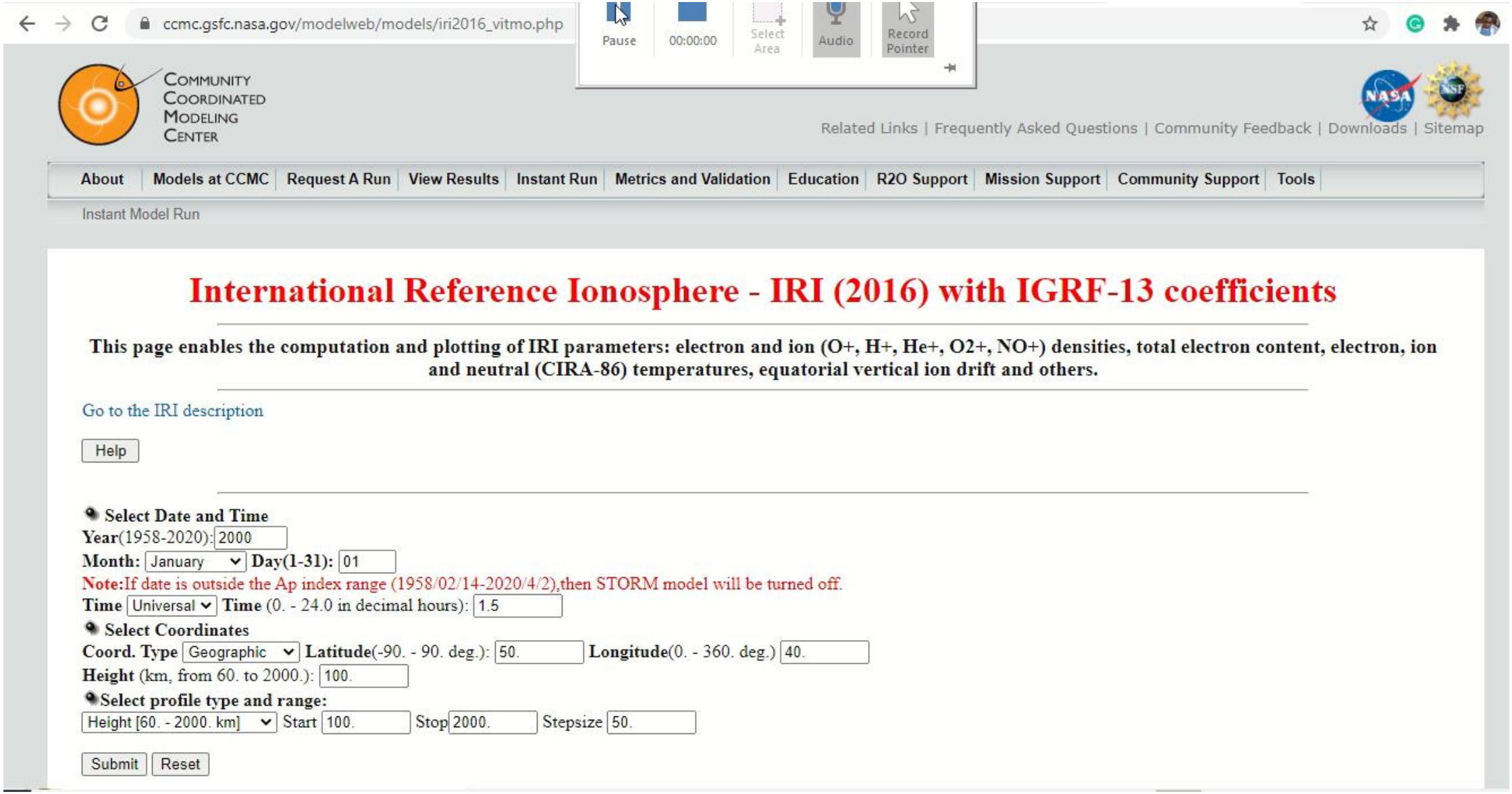
- The International Reference Ionosphere (IRI) is the most commonly used model.
- The IRI project is a joint programme of COSPAR and URSI
- Initiated in the late sixties with the aim of launching an international standard for the specification of ionospheric parameters.
- IRI is an empirical ionospheric model based on experimental observations of the ionospheric plasma.
- altitude range of 50 – 2000 km.
- The IRI model provides three options for the prediction of TEC, namely: IRI-2001, IRI01-Corr and NeQuick.

IRI-TEC

Visit
https://ccmc.gsfc.nasa.gov/modelweb/models/iri2016_vitmo.php

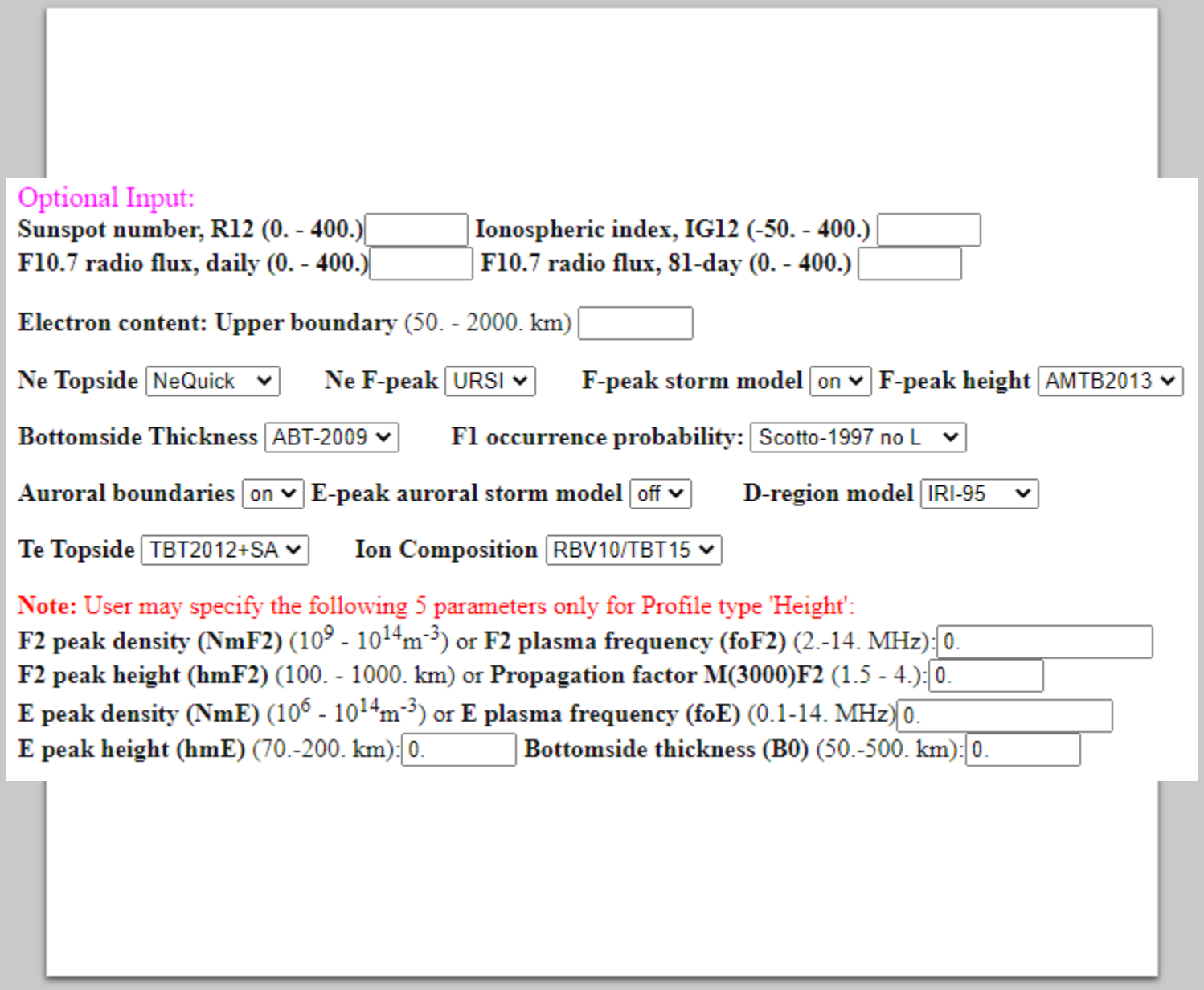
Play the video




ccmc.gsfc.nasa.gov/modelweb/models/iri2016_vitmo.php
Pause
00:00:00
Select Area
Audio
Record Pointer
COMMUNITY COORDINATED MODELING CENTER
Related Links | Frequently Asked Questions | Community Feedback | Downloads | Sitemap
About | Models at CCMC | Request A Run | View Results | Instant Run | Metrics and Validation | Education | R2O Support | Mission Support | Community Support | Tools
Instant Model Run
International Reference Ionosphere - IRI (2016) with IGRF-13 coefficients
This page enables the computation and plotting of IRI parameters: electron and ion (O+, H+, He+, O2+, NO+) densities, total electron content, electron, ion and neutral (CIRA-86) temperatures, equatorial vertical ion drift and others.
Go to the IRI description
Help
Select Date and Time
Year(1958-2020): 2000
Month: January Day(1-31): 01
Note:If date is outside the Ap index range (1958/02/14-2020/4/2),then STORM model will be turned off.
Time Universal Time (0. - 24.0 in decimal hours): 1.5
Select Coordinates
Coord. Type Geographic Latitude(-90. - 90. deg.): 50. Longitude(0. - 360. deg.) 40.
Height (km, from 60. to 2000.): 100.
Select profile type and range:
Height [60. - 2000. km] Start 100. Stop 2000. Stepsize 50.
Submit Reset

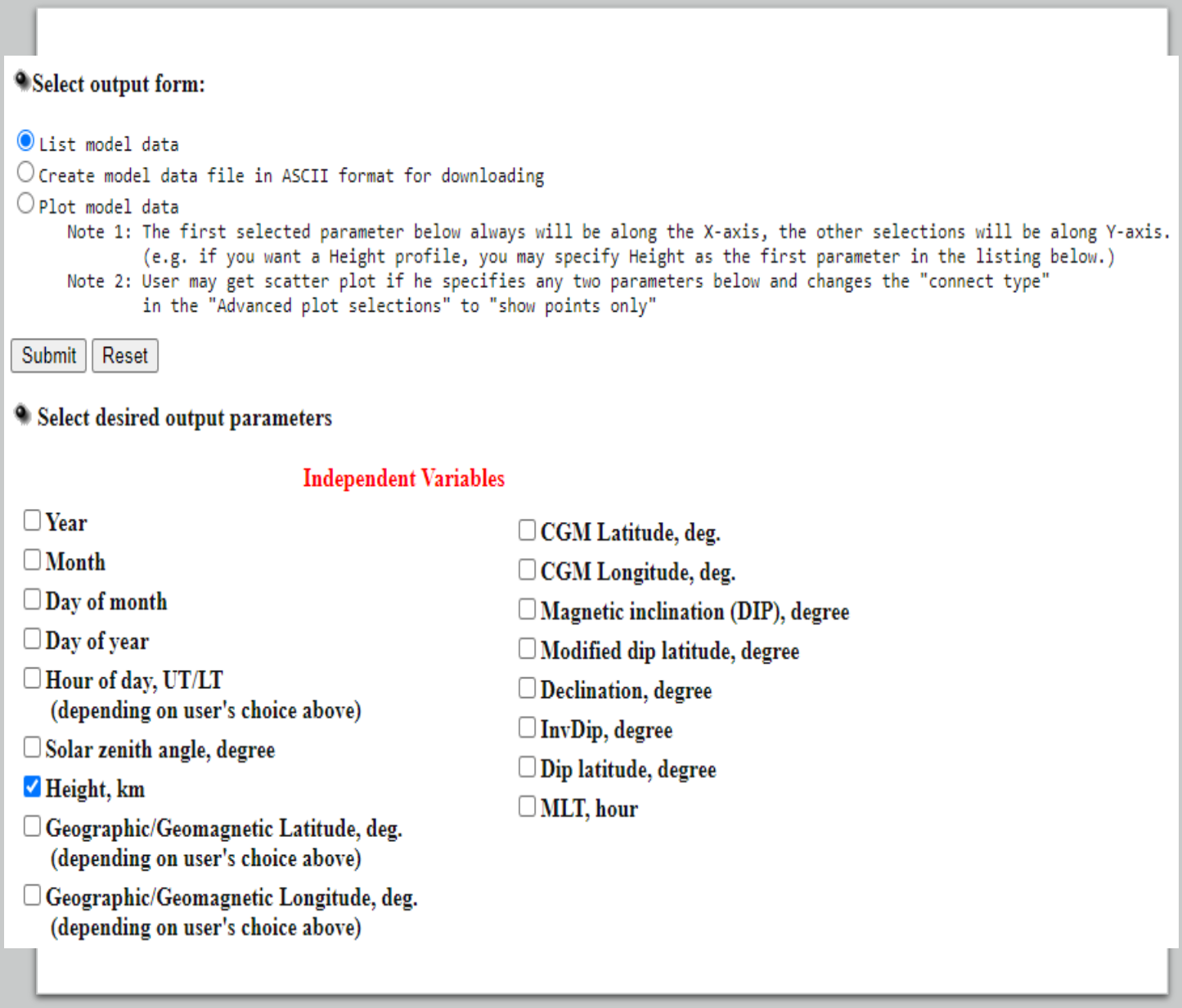
IRI-TEC

- **Visit** https://ccmc.gsfc.nasa.gov/modelweb/models/iri2016_vitmo.php
- **Play the video**



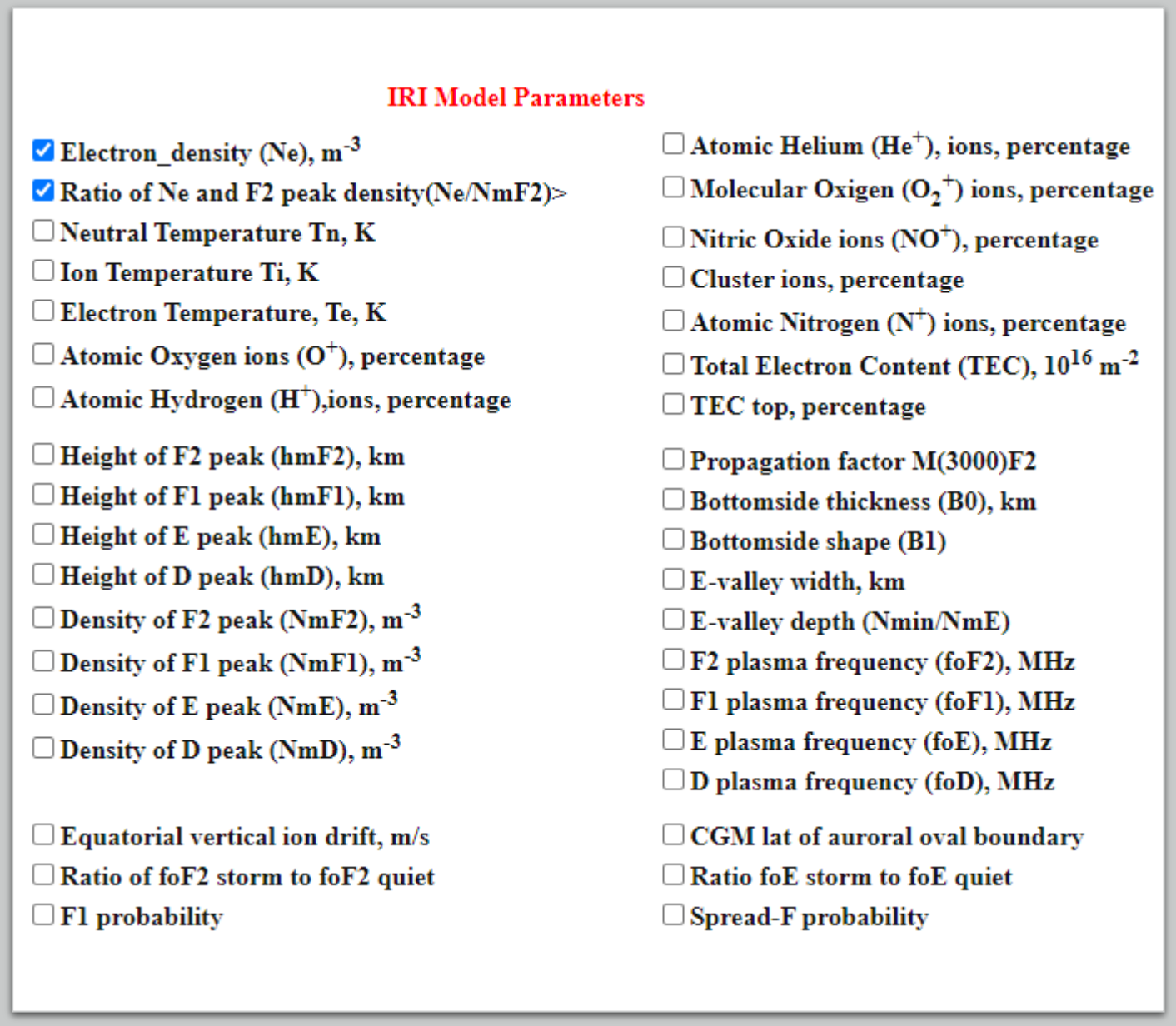
IRI-TEC

- **Visit** https://ccmc.gsfc.nasa.gov/modelweb/models/iri2016_vitmo.php
- **Play the video**



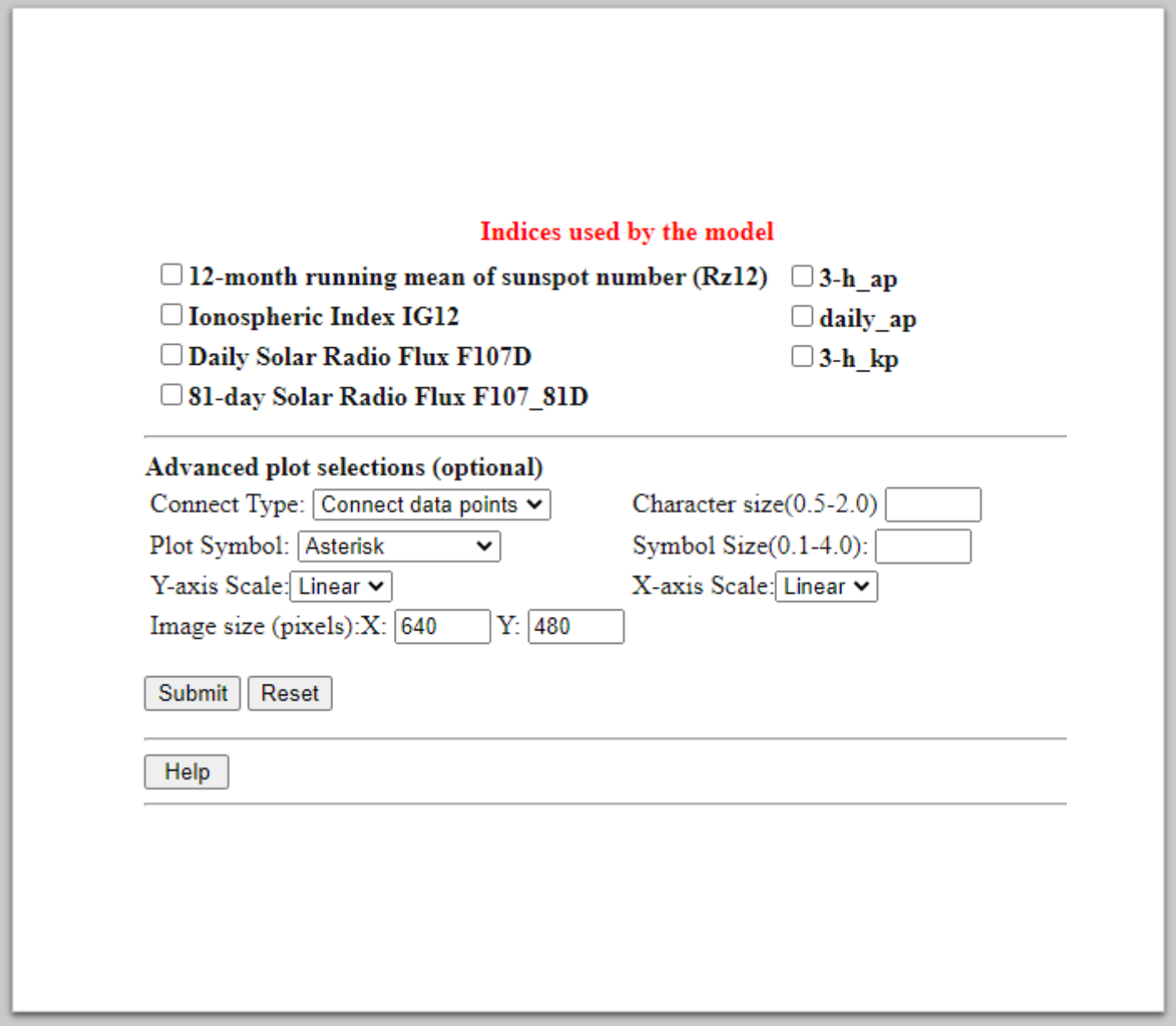
IRI-TEC

- **Visit** https://ccmc.gsfc.nasa.gov/modelweb/models/iri2016_vitmo.php
- **Play the video**



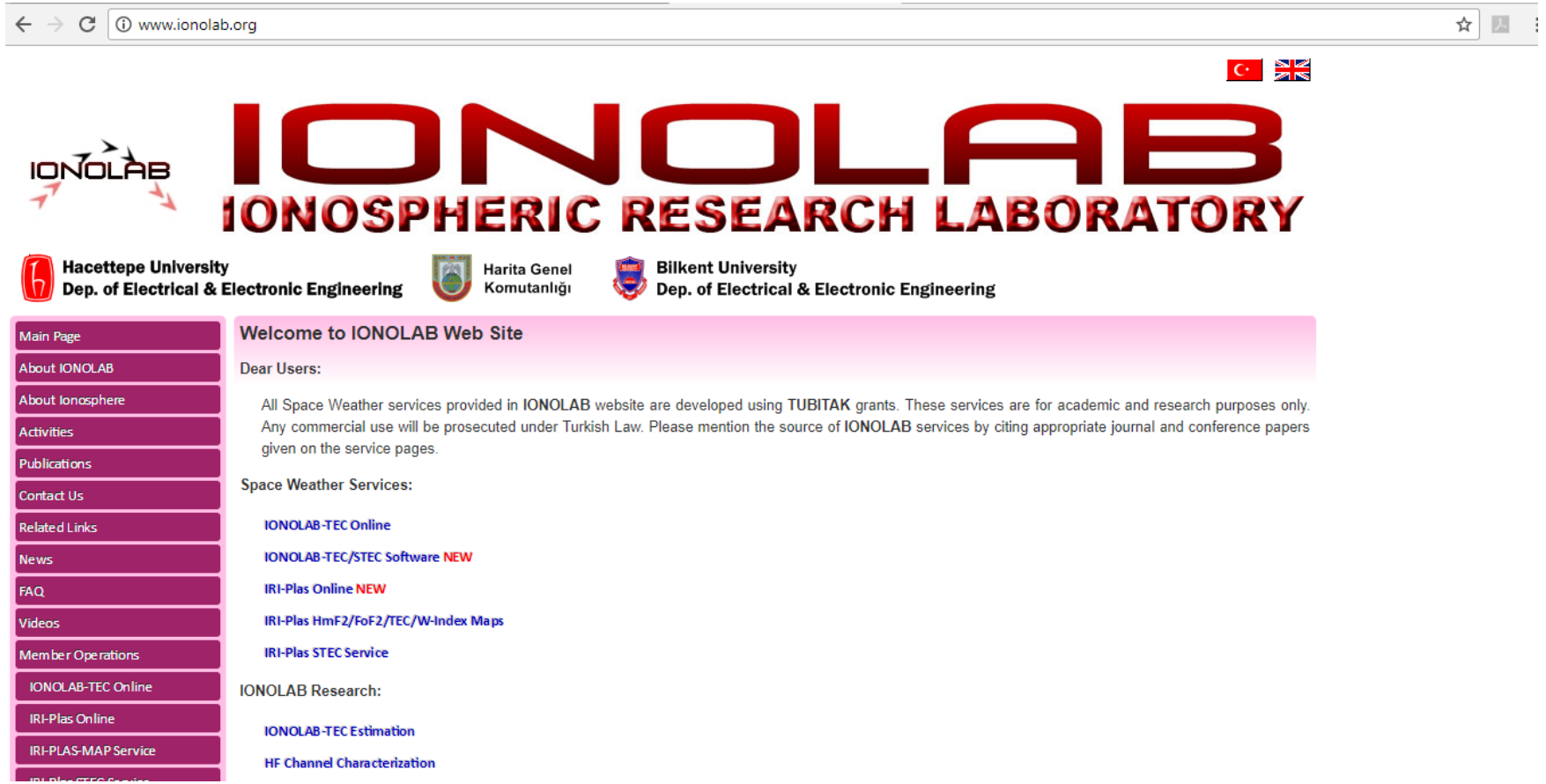
IRI-TEC

- **Visit** https://ccmc.gsfc.nasa.gov/modelweb/models/iri2016_vitmo.php
- **Play the video**

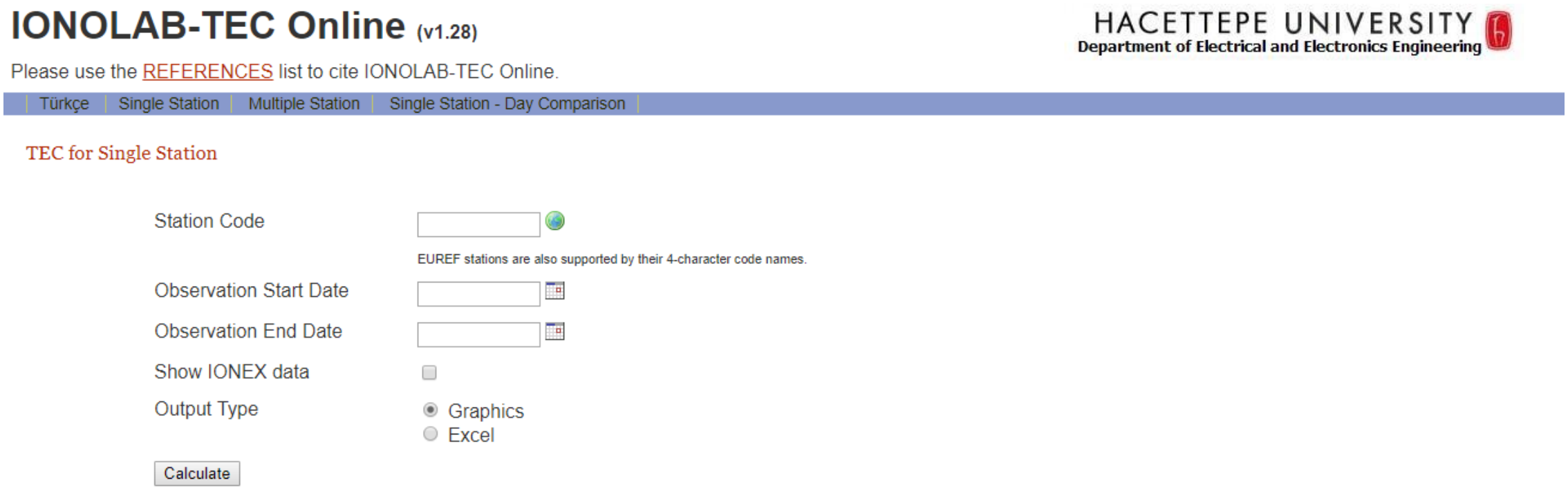


Ionolab-TEC

- Visit ionolab.org
- Register
- Services include
  - IONOLAB-TEC online
  - IRI-Plas Online
  - IRI-PLAS-MAP Service
  - IRI-Plas STEC
  - IONOLAB-TEC Software



Ionolab-TEC Online - 1



Ionolab-TEC Online - 2

TEC for Single Station

Station Code: zeck

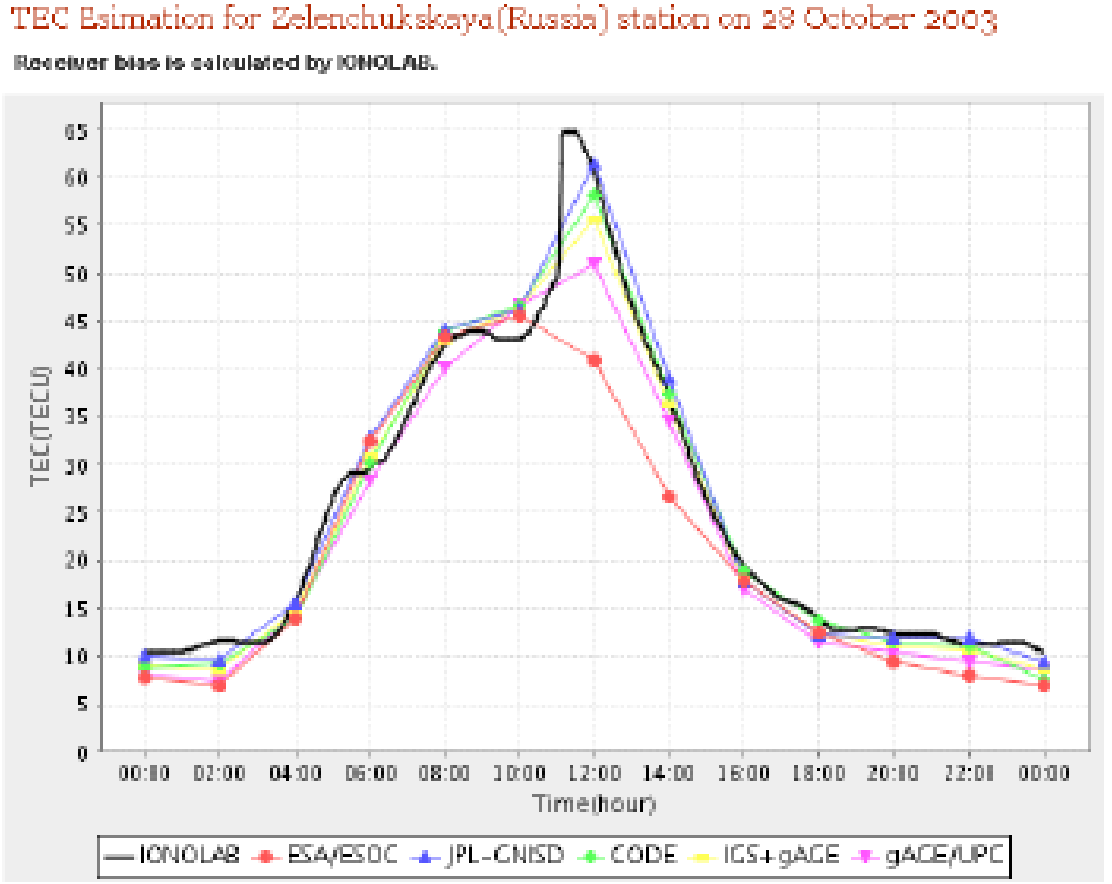
Observation Start Date: 28-10-2003

Observation End Date: 28-10-2003

Show IONEX data

Output Type: Graphics / Excel

Calculate



Ionolab-TEC Online - 3

TEC Comparion for Different Stations

Station Codes

ankr
dgar

Observation Start Date 10-10-2003

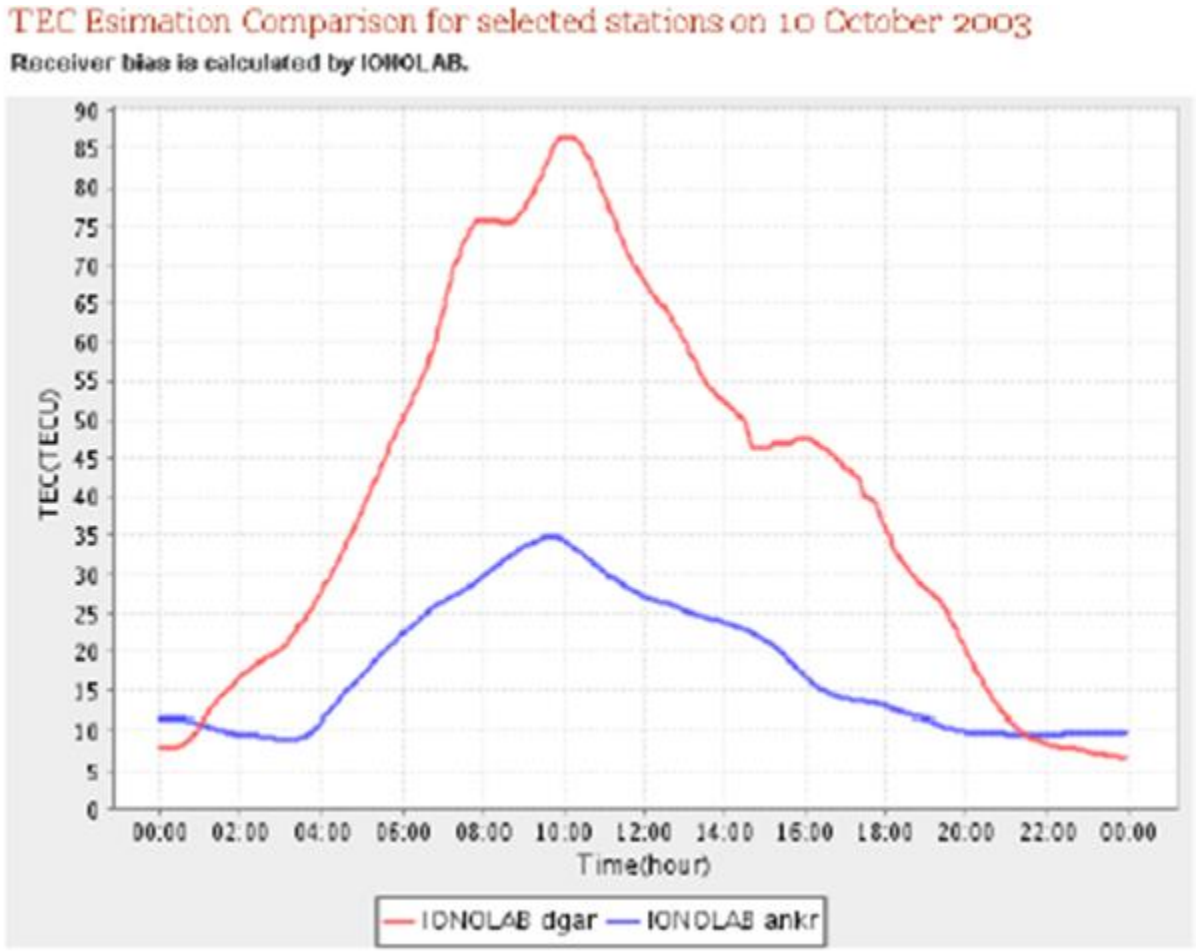
Observation End Date 10-10-2003

Show IONEX data

Output Type

Graphics
Excel

Calculate



Ionolab-TEC Online - 4

The output can be given in the form of an Excel file into a user defined directory with 2.5 min time resolution

	A	B	C	D	E	F	G
1	TEC Esimation for Zelenchukskaya(Russia) station on 10/28/03 12:00 AM						
2	Date	Time	TEC(TECU)				
3	28.10.2003	00:00:00	10,54843281				
4	28.10.2003	00:02:30	10,54843281				
5	28.10.2003	00:05:00	10,54843281				
6	28.10.2003	00:07:30	10,54843281				
7	28.10.2003	00:10:00	10,54843281				
8	28.10.2003	00:12:30	10,54843281				
9	28.10.2003	00:15:00	10,54843281				
10	28.10.2003	00:17:30	10,54843281				
11	28.10.2003	00:20:00	10,54843281				
12	28.10.2003	00:22:30	10,51602579				
13	28.10.2003	00:25:00	10,46986127				
14	28.10.2003	00:27:30	10,43218492				
15	28.10.2003	00:30:00	10,40602088				

Reference
U. Sezen, F. Arikan, O. Arikan, O. Ugurlu, and A. Sadeghimorad, Online, automatic, near-real time estimation of GPS-TEC: IONOLAB-TEC, *Space Weather*, (11),1–9, doi:10.1002/swe.20054, 2013.

Practical Session (If time permits)

- **Visit www.ionolab.org**

Ionolab-TEC Software - 1

- **Copyright (c) 2016 IONOLAB Group, Hacettepe University, Ankara.**
- **IONOLABTEC executable is provided for non-commercial purposes only.**
- **ionolabtec.exe is a command line tool to calculate GPS TEC for a given GPS receiver and date**
- **by downloading and processing the necessary RINEX, SP3, DCB and IONEX files.**
- **IONOLABTEC executable uses the wget executable located in the apps folder to perform the necessary downloads.**

Ionolab-TEC Software - 2

- **Follow the steps below.**

- **1. Verify the MATLAB Compiler Runtime (MCR) is installed and ensure you have installed version 8.1 (R2013a).**
- **You can download the necessary 'MCRInstaller.exe' from the IONOLAB-TEC Executable page on the IONOLAB website (www.ionolab.org).**
- **You can also download the Windows 32-bit version of the MCR for R2013a from the MathWorks Web site by navigating to http://www.mathworks.com/products/compiler/mcr/index.html**
- **NOTE: You will need administrator rights to run MCRInstaller.**
- **You need to do this step only once.**

Ionolab-TEC Software - 3

- **2. Extract the ZIP file "ionolabtecv1.25.zip" to an appropriate place**
- **3. In Windows Explorer select the folder which holds extracted contents**
- **4. Press the Shift key on the keyboard and right-click on the folder while pressing the Shift key**
- **5. Then select "Open command window here" option from the right-click menu.**

Ionolab-TEC Software - 4

- 6. Once the Command Window is open now you can run the ionolabtec executable
- a. Type "ionolabtec ankr 2015-05-19" in the command window
- b. The program will start downloading the necessary RINEX, SP3, DCB and IONEX files from the HTTP/FTP sites specified in the config file "ionolabtec.cfg" to the local folders specified in the config file "ionolabtec.cfg"
- and calculate GPS TEC value from the RINEX file downloaded.

Ionolab-TEC Software - 5

- **GPS TEC results will be saved to a text file named with the receiver name and the date given**
- **(e.g., ankr_20150519.txt).**
- **c. If files already present in the local directories, then those files are not downloaded again.**
- **Try running the same command (ionolabtec ankr 2015-05-19) again, you will notice that program will not download the downloaded files again.**

Practical Session (If time permits)

- **Press the Shift key on the keyboard and right-click on the folder while pressing the Shift key**
- **Then select "Open command window here" option from the right-click menu.**

IRI-Plas 2017 (Online) - 1

IRI-Plas 2017 Online

T. Gulyaeva, F. Arikan, L. Poustovalova and U. Sezen, "TEC proxy index of solar activity for the International Reference Ionosphere IRI and its extension to plasmasphere IRI-PLAS model," Int. J. Sci. Eng. Applied Sci., 3(5), pp. 144-150, May. 2017.
Available at http://ijseas.com/volume3/v3i5/ijseas20170519.pdf

IRI-Plas (by T.L. Gulyaeva) source and executables are available at ftp://ftp.izmiran.ru/pub/izmiran/SPIM/. This website uses the 2017-05-27 release.

Please use the REFERENCES list to cite IRI-Plas Online.

Hacettepe University
Dep. of Electrical & Electronic Engineering

IONOLAB

IZMIRAN
Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of the Russian Academy of Sciences

Türkçe | Multiple Input

Required Inputs

- Date (YYYY-MM-DD) [ ] Kp
- Hour (HH:MM) [ ] (•) UTC ( ) Local Time
- Coordinate (Lat, Lon) [ ] °N [ ] °E (•) Geocentric ( ) Geomagnetic

Optional Inputs

- F2-peak Plasma Frequency (foF2) [ ] MHz [2 MHz - 15 MHz]
- Propagation Information (•) F2-peak Height (hmF2) [ ] km [100 km - 999 km]
  ( ) Propagation Factor (M3000F2) [ ] [1.5 - 4.0]
- Total Electron Content (TEC) [ ] TECU [0 - 300 TECU] GIM TEC (since 1998-06-01)
- Solar Activity (•) Sunspot Number (Rz12) [ ] [0 - 400]
  ( ) F10.7 Radio Flux (F10.7D) [ ] sfu [0 - 400 sfu]
- F-peak Model (•) CCIR ( ) URSI
- foF2 Storm Model (•) On ( ) Off
- Solar Proxy Index (•) SSN1 ( ) SSN2 ( ) F107 ( ) GEC ( ) TEC ( ) IG ( ) MGII ( ) Lyman-α ( ) GEC_RZ

IRI-Plas 2017 (Online)– 2

Optional Outputs

Generate Ne(h) & fN(h) profiles On Off

Currently, list is empty.

Description of Outputs Add Clear Run

```
IRI-PLAS 2017 (27 May 2017)
PC Date: Year,Month,Day = 20170911   Time = 1548
*** ISO_IRI parameters are being calculated ***
Ne, B0: Bottomside thickness is obtained with Gulyaeva-1987 model.
    hmF2: CCIR model is used.
Ne, foF2: CCIR model is used.
Ne, foF2:  STORM  model included.
hmF2(foF2) STORM2 model included.
YEAR MMDD UThr LThr XHI  SSN  COV  Kpm    L  Glati Glong Mlati Mlong MoDip  hmF2  foF2
2017  901  1.0  1.2 157.  22.  79. 3.3  1.02   6.5   3.4   8.7  77.3 -12.1 277.3  5.61
   NmF2   Nes       QF     MLT   ECbot  ECtop   ECpl   TEC    TAU  h05b  h05t   Hsc   SP
 390471.  16717.  1.180   1.400   1.80  10.76   1.62  14.17  363.0 233.1 432.0  245.0 ssn1+f107
   H         NE         FN      Te       Ti       Tn
20200.   1.1511E+08    0.096  3744.89  3738.80   784.32
20000.   1.1800E+08    0.098  3744.23  3738.09   783.98
18000.   1.5116E+08    0.110  3720.74  3714.01   780.37
16000.   1.9354E+08    0.125  3659.62  3652.26   776.30
14000.   2.4711E+08    0.141  3551.03  3542.99   771.70
12000.   3.1232E+08    0.159  3386.37  3377.62   766.43
10000.   3.8625E+08    0.176  3160.26  3150.76   760.33
 9000.   4.2500E+08    0.185  3023.80  3013.89   756.91
 8000.   4.6448E+08    0.194  2872.30  2861.94   753.21
 7000.   5.0499E+08    0.202  2706.68  2695.83   749.19
 6000.   5.4858E+08    0.210  2528.27  2516.82   744.83
 5000.   6.5024E+08    0.229  2338.55  2326.35   740.12
 4000.   9.2091E+08    0.273  2138.32  2125.04   735.07
 3000.   1.7368E+09    0.374  1924.10  1909.13   729.81
 2500.   2.8030E+09    0.475  1806.58  1790.32   727.21
 2000.   5.2633E+09    0.651  1673.66  1655.56   724.78
 1800.   7.1379E+09    0.759  1612.97  1593.85   723.90
```

Output Sample

IRI-Plas 2017 (MATLAB) – 1

- **Be sure you have MATLAB installed**
- **Open the folder – IRI Plas**
- **Open the MATLAB file – inputCreator.m (to generate the input data set**
- **Input the name of the stations, Year, Lat and long of the station (in 1dp).**
- **Run**
- **This will generate input file saved as note pad - Input.FILE.**

```
fid=fopen('Input.inp', 'wt');
%statns={'ILOR', 'TETN', 'RABT', 'SHEB', 'DASM', 'DAMY', 'ROBE', 'YKRO', 'EBBE', '
%lats=[8.5 35.6 34.0 15.9 11.8 9.6 7.8 6.9 0.1 0.4 -8.6 -9.3 -20.9 -28.8 -32.4];
%longs=[4.5 5.4 6.9 39.1 41.0 41.9 40.0 5.2 32.5 34.0 39.3 33.7 57.5 32.1 20.7];
statns={'AZU1', 'BAY3'};
lats=[34.13 55.2];
longs=[242.1 197.3];
year=2000;
```

IRI-Plas 2017 (MATLAB) – 1

- Open the isomain (It is an Application).
- Type Input.inp
- This produces the output which contains TEC data as Input.out in note pad

```
PC Date: Year,Month,Day = 20170911  Time = 1529
 ENTER THE PATH & NAME OF INPUT FILE=
Input.inp
```

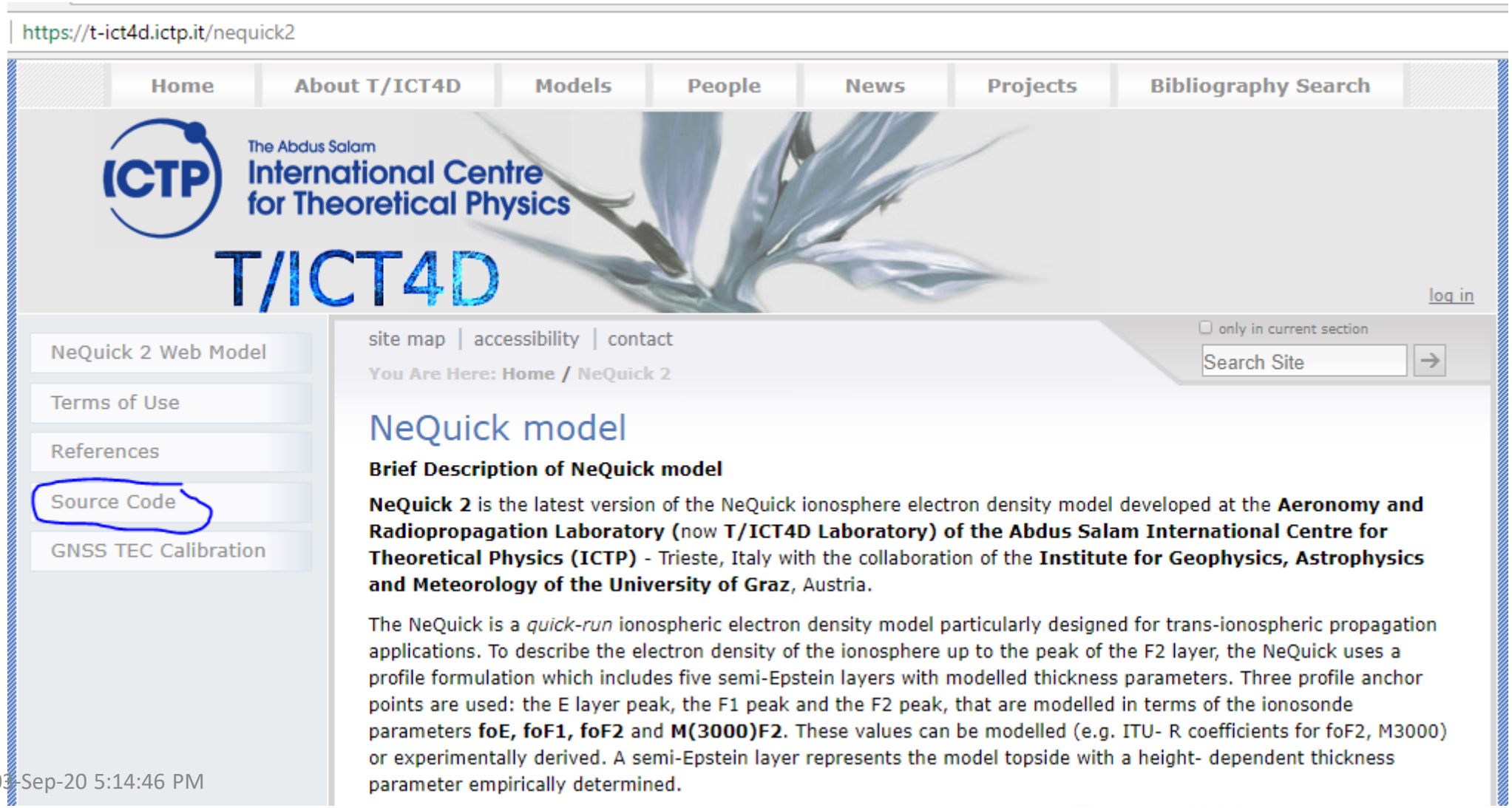
IRI-Plas 2017 (MATLAB) – 1

- Next, Open the MATLAB file – separator
- Input the name of the stations, Year, Lat and long of the station (in 1dp). (Just as you have it in inputCreator.m)
- Run.
- The final data is stored in the folder - Output

header_line_remove_iono.m | inputCreator.m | separator.m | IRI2001.m | IRI01cor.m | IRInequick.m | TEC

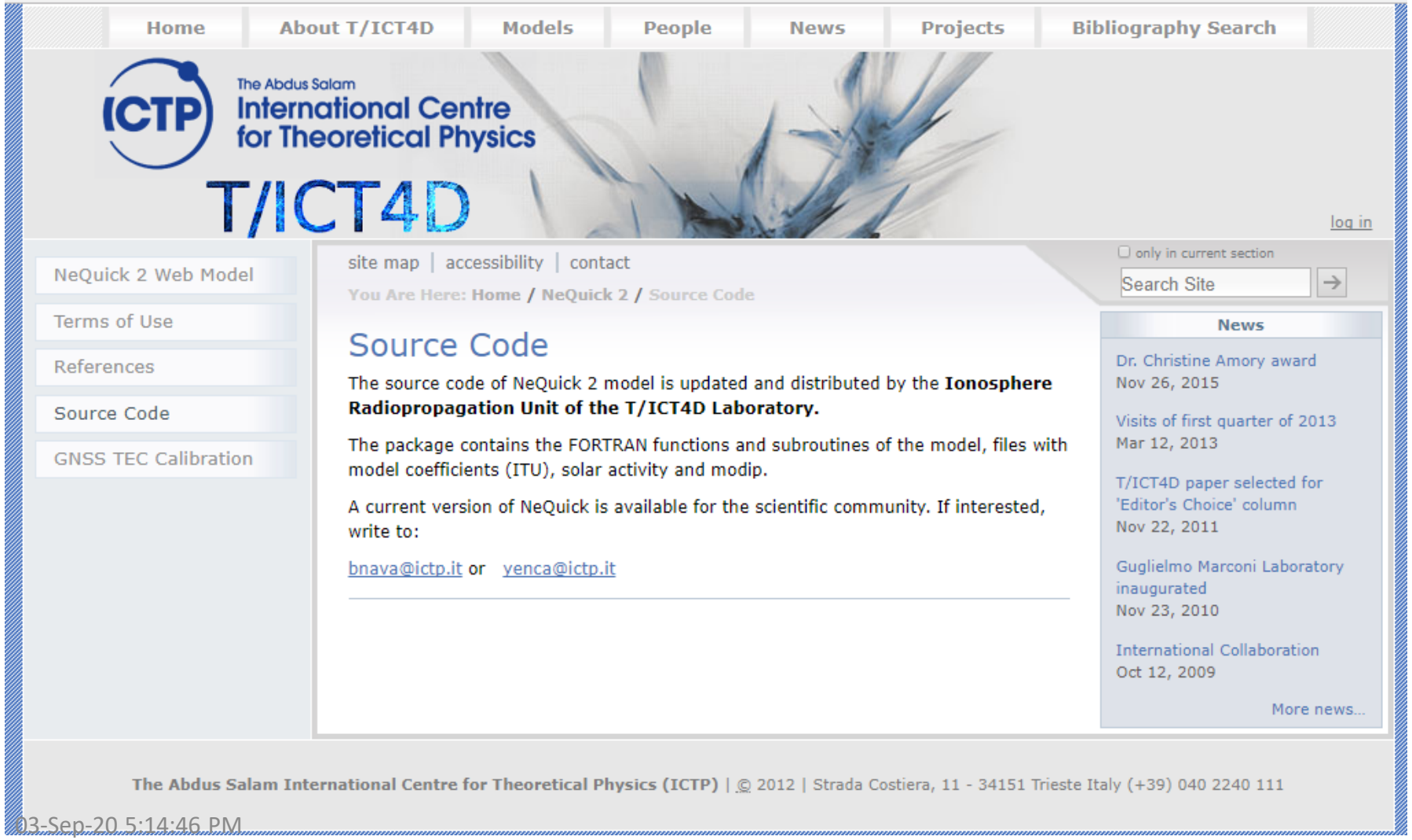
```
1 -     fid=fopen('Input.out');
2       %statns={'ILOR', 'TETN', 'RABT', 'SHEB', 'DASM', 'DAMY', 'ROBE', 'YKRO', 'EBBE', 'I
3 -     statns={'AZU1', 'BAY3'};
4       %lats=[8.5 35.6 34.0 15.9 11.8 9.6 7.8 6.9 0.1 0.4 -8.6 -9.3 -20.9 -28.8 -32.4];
5       %longs=[4.5 5.4 6.9 39.1 41.0 41.9 40.0 5.2 32.5 34.0 39.3 33.7 57.5 32.1 20.7];
6 -     lats=[34.13 55.2];
7 -     longs=[242.1 197.3];
```

NeQuick - 2

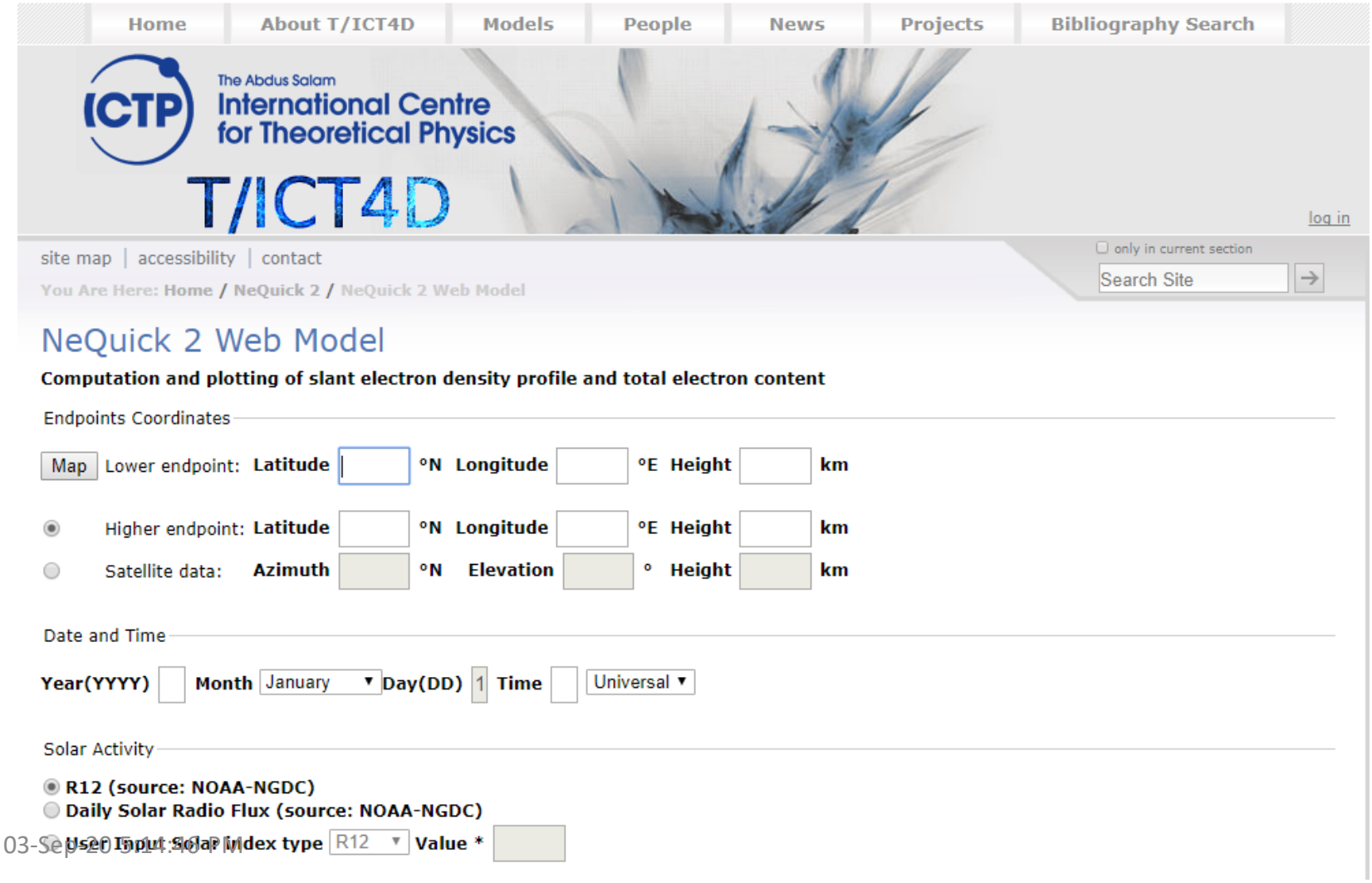

https://t-ict4d.ictp.it/nequick2
Home
About T/ICT4D
Models
People
News
Projects
Bibliography Search
The Abdus Salam
International Centre
for Theoretical Physics
T/ICT4D
log in
NeQuick 2 Web Model
Terms of Use
References
Source Code
GNSS TEC Calibration
site map | accessibility | contact
You Are Here: Home / NeQuick 2
only in current section
Search Site
NeQuick model
Brief Description of NeQuick model
NeQuick 2 is the latest version of the NeQuick ionosphere electron density model developed at the Aeronomy and Radiopropagation Laboratory (now T/ICT4D Laboratory) of the Abdus Salam International Centre for Theoretical Physics (ICTP) - Trieste, Italy with the collaboration of the Institute for Geophysics, Astrophysics and Meteorology of the University of Graz, Austria.
The NeQuick is a quick-run ionospheric electron density model particularly designed for trans-ionospheric propagation applications. To describe the electron density of the ionosphere up to the peak of the F2 layer, the NeQuick uses a profile formulation which includes five semi-Epstein layers with modelled thickness parameters. Three profile anchor points are used: the E layer peak, the F1 peak and the F2 peak, that are modelled in terms of the ionosonde parameters foE, foF1, foF2 and M(3000)F2. These values can be modelled (e.g. ITU- R coefficients for foF2, M3000) or experimentally derived. A semi-Epstein layer represents the model topside with a height- dependent thickness parameter empirically determined.

NeQuick – 2 (Source Code)

https://t-ict4d.ictp.it/nequick2/source-code



NeQuick – 2 (Online Model)



NeQuick – 2 (Online Model)

Some Research Works - 1

TEC derived from some GPS stations in Nigeria and comparison with the IRI and NeQuick models

ADVANCES IN SPACE RESEARCH
(a COSPAR publication)
www.elsevier.com/locate/asr

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Received 31 October 2013; received in revised form 1 February 2014; accepted 6 February 2014
Available online 15 February 2014

Abstract

Total electron content (TEC) measured simultaneously using Global Positioning System (GPS) ionospheric monitors installed at some locations in Nigeria during the year 2011 ($Rz = 55.7$) was used to study the diurnal, seasonal, and annual TEC variations. The TEC exhibits daytime maximum, seasonal variation and semiannual variations. Measured TEC were compared with those predicted by the improved versions of the International Reference Ionosphere (IRI) and NeQuick models. The models followed the diurnal and seasonal variation patterns of the observed values of TEC. However, IRI model produced better estimates of TEC than NeQuick at all locations.

Advances in Space Research 53 (2014) 1290–1303

Some Research Works - 1

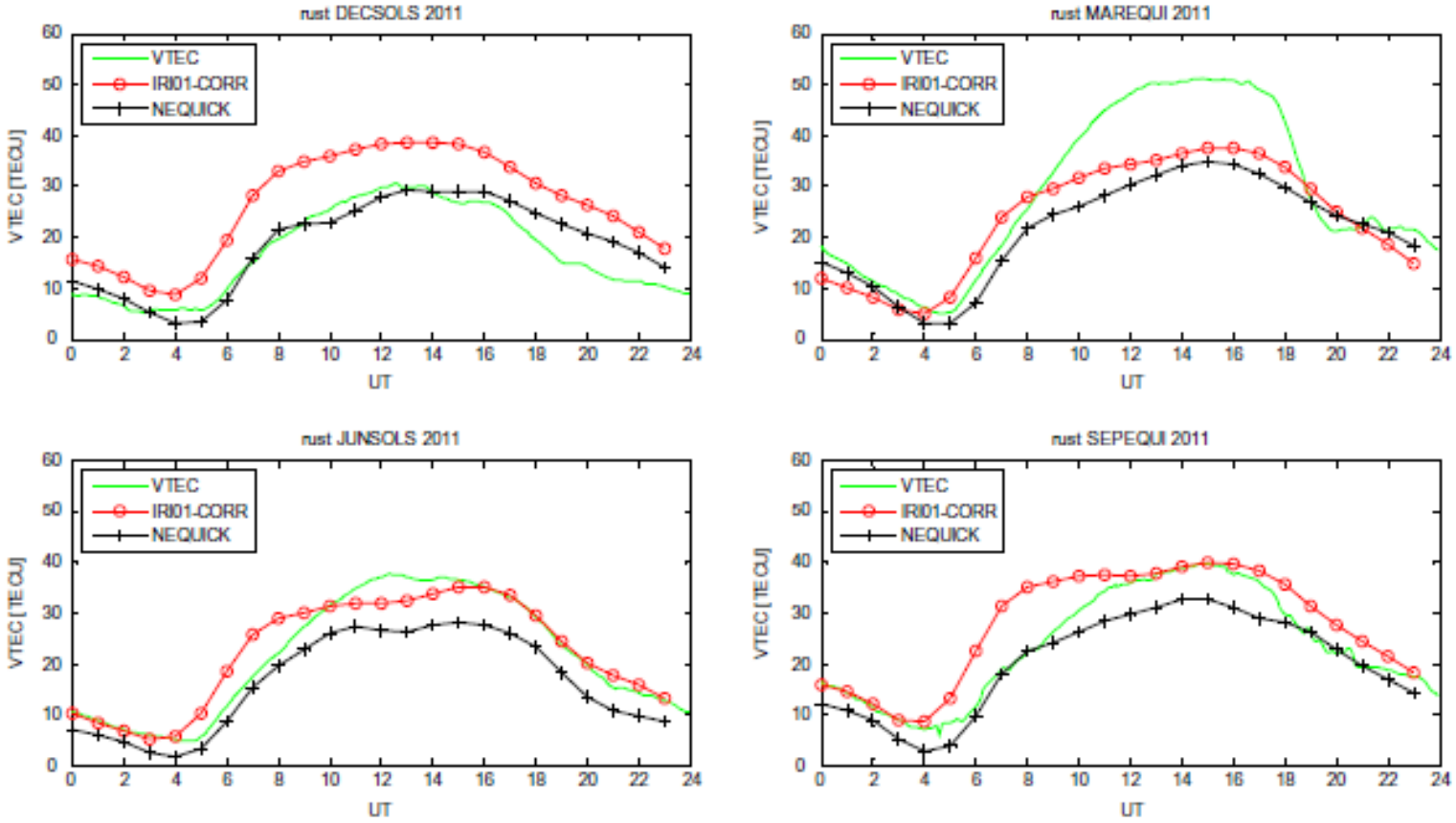


Fig. 8. Diurnal variations of observed mean values of TEC at RUST along with the IRI and NeQuick predicted values.

ADVANCES IN SPACE RESEARCH
(a COSPAR publication)
www.elsevier.com/locate/asr

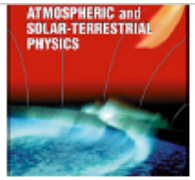
Advances in Space Research 53 (2014) 1290–1303

Some Research Works - 2

ELSEVIER

Journal of Atmospheric and Solar-Terrestrial Physics

journal homepage: www.elsevier.com/locate/jastp



Assessment of IRI-2012, NeQuick-2 and IRI-Plas 2015 models with observed equatorial ionization anomaly in Africa during 2009 sudden stratospheric warming event

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Journal of Atmospheric and Solar-Terrestrial Physics 164 (2017) 203–214

ARTICLE INFO

Keywords:
Sudden stratospheric warming
Equatorial ionization anomaly
Plasma transportation
Ionospheric empirical models

ABSTRACT

In Africa, we assessed the performance of all the three options of International Reference Ionosphere 2012, IRI-2012 (i.e. IRI-2001, IRI-2001COR and IRI-NeQuick), NeQuick-2 and IRI-Plas 2015 models prior to and during 2009 sudden stratospheric warming (SSW) event to predict equatorial ionization anomaly (EIA) crest locations and their magnitudes using total electron content (TEC) from experimental records of Global Positioning System (GPS). We confirmed that the IRI-Plas 2015 that appeared as the best compared to all of the models as regard

Some Research Works - 3

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Advances in Space Research 49 (2012) 316–326

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Low solar activity variability and IRI 2007 predictability of equatorial Africa GPS TEC

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Received 11 July 2011; received in revised form 28 September 2011; accepted 29 September 2011
Available online 7 October 2011

Abstract

Diurnal, seasonal and latitudinal variations of Vertical Total Electron Content (VTEC) over the equatorial region of the African continent and a comparison with IRI-2007 derived TEC (IRI-TEC), using all three options (namely; NeQuick, IRI01-corr and IRI-2001), are presented in this paper. The variability and comparison are presented for 2009, a year of low solar activity, using data from thirteen Global Positioning System (GPS) receivers. VTEC values were grouped into four seasons namely March Equinox (February, March,

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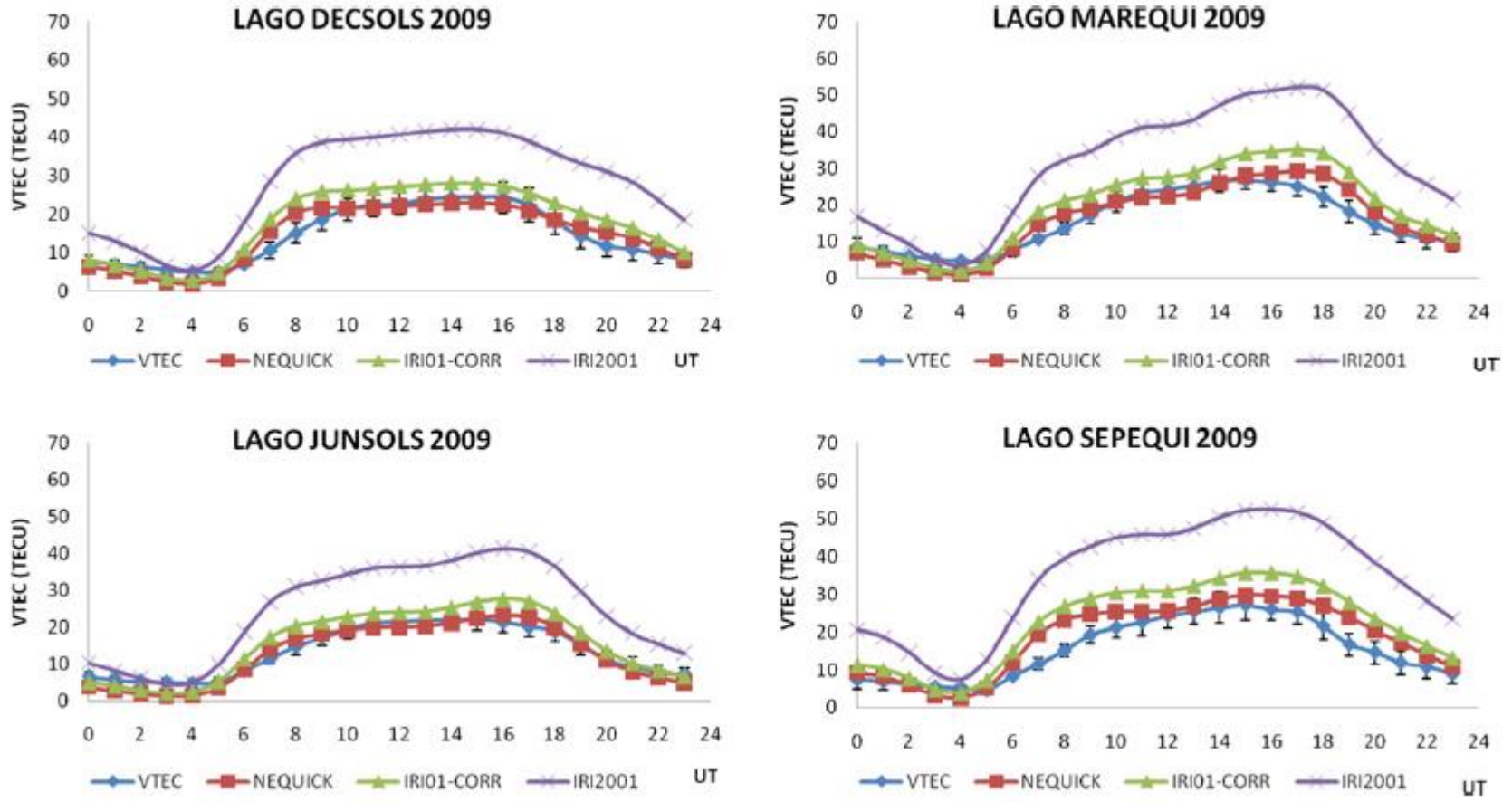

Fig. 5. Diurnal variations of observed mean values of TEC at Lagos along with the IRI-2007 modeled values using the three options.

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Advances in Space Research 56 (2015) 1686–1698

ADVANCES IN SPACE RESEARCH (a COSPAR publication)

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Comparison of GPS-TEC observations over Addis Ababa with IRI-2012 model predictions during 2010–2013

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Received 3 January 2015; received in revised form 15 July 2015; accepted 16 July 2015
Available online 1 August 2015

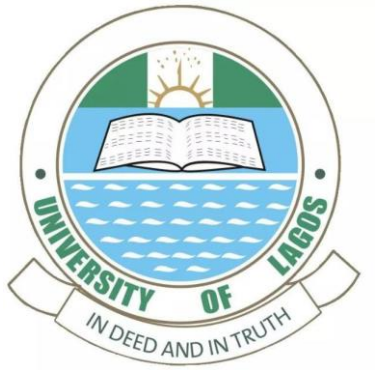
Abstract

This study presents Global Positioning System-Total Electron Content (GPS-TEC) observations over Addis Ababa (Lat: 9.03°N Lon: 38.77°E Mag. lat: 0.18°N) and an evaluation of the accuracy of International Reference Ionosphere-2012 (IRI-2012) model predictions during 2010–2013. Generally, on a diurnal scale, TEC recorded minimum values at 0400–0600 LT and maximum at 1400–1600 LT. Seasonally, TEC recorded maximum values during December solstice and September equinox, and minimum during June solstice. On a year-by-year basis, 2013 recorded the highest values of TEC for both the observed and the model measurements, while 2010 recorded the lowest, implying the solar activity dependence of TEC. Furthermore, we observed discrepancies in the comparison of

More Research Works

- **Comparing CAR NN Ionospheric TEC model with IRI-Plas, NeQuick etc**
- **Comparing experimental values of TEC from different techniques.**
- **Others…**

Acknowledgment



Thank you for listening

ありがとうございました