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KONYA - 1975

Determination of Regional TEC Values by GNSS Measurements, A Case Study: Central Anatolia Sample, Turkey

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PLAN OF PRESENTATION

- INTRODUCTION
- GLOBAL IONOSPHERE MAPS (GIMS)
- INTERNATIONAL REFERENCE IONOSPHERE MODEL (IRI)
- APPLICATION
- CONCLUSION

1. INTRODUCTION

The atmosphere surrounding the earth as a cover is divided into different layers depending on its characteristics such as density, heat and height. A part of the atmosphere containing free electrons and ions is called the ionosphere. The ionosphere is a natural plasma environment located at an altitude of 60 km to 1000 km of the atmosphere and shaped by radiation from the Sun.

Monitoring the ionosphere is important for mainly GNSS (Global Navigation Satellite System) and for study areas like communication, security, navigation as well. Changes in ionosphere effect satellite based studies directly. GNSS receivers are widely used in studies related ionosphere, because they spread most of the world and the information (Total Electron Content, TEC) about ionosphere can be obtained from satellites monitored by these receivers.

Total Electron Content (TEC) is one of the important parameters expressed to characterize of the ionosphere which has great importance for satellite based positioning, shortwave and satellite communication systems. Determination of the TEC change is important for modeling the ionosphere.

TEC (Total Electron Content) is the total number of electrons integrated between satellite and its receiver, along a cylinder of one meter squared cross section and is usually expressed in TECU (Total Electron Content Unit).

2- Global Ionosphere Maps (GIMs)

GNSS measurements and TEC values can be obtained both from directly data belongs to the station and from generated GNSS based models. International Reference Ionosphere (IRI) which can be calculated online and Global Ionosphere Maps (GIM) can be an example for this.

There are a lot of institutions in the world that produce global ionospheric TEC map (GIM). CODE (European Orbit Determination Center, Switzerland), ESA / ESOC (European Space Operations Center, Germany), JPL (Jet Propulsion Laboratory, California) are some of these institutions.

Global ionosphere map (GIM) is issued in the format of IONEX (IONosphere map EXchange). IONEX formatted TEC values are lined up as involving all over the world. IONEX formatted global ionosphere maps are produced at intervals of 2 hours. For TEC values, the increase in the longitude is 5^{o} and the increase in the latitude is 2.5^{o}. The accuracy of TEC values published in IONEX format varies between 2-8 TECU.

3- International Reference Ionosphere Model (IRI)

International reference ionosphere (IRI) can present a number of parameters related to the ionosphere, including the TEC value for ionospheric heights between 60 km and 2000 km, as to required location, date and time. TEC values can be calculated via internet as being online with international reference ionosphere model (IRI-2012). The last version of the model that you may get the data via online is IRI-2012.

Virtual Ionosphere, Thermosphere, Mesosphere Observatory (VITMO)

International Reference Ionosphere - IRI-2012

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 (NRL-MSIS-2002) temperatures, equatorial vertical ion drift and others.

Go to the IRI description

Help

Select Date and Time

Year(1958-2019): 2000

Note:If date is outside the Ap index range (1958-2016/02/15), then STORM model will be turned off.

Month: January Day(1-31): 01

Time Universal Hour of day (e.g. 1.5): 1.5

Select Coordinates

Coordinates Type Geographic

Latitude(deg., from -90. to 90.): 50. Longitude(deg., from 0. to 360.) 40.

Height (km, from 60. to 2000.): 100.

Select a Profile type and its parameters:

Height,km [60. - 2000.] Start 100. Stop 2000. Stepsize 50.

Submit Reset

Optional Input:

Sunspot number, Rz12 (0. - 400.) Ionospheric index, IG12 (-50. - 400.)

F10.7 radio flux, daily (0. - 400.) F10.7 radio flux, 81-day (0. - 400.)

Electron content: Upper boundary (km., from 50. - 2000.)

Ne Topside NeQuick F peak model URSI foF2 Storm model on

Bottomside Thickness ABT-2009 F1 occurrence probability: Scotto-1997 no L

Auroral boundary off foE auroral storm model off Ne D-Region IRI-95

Te Topside TBT-2012 Ion Composition RBV10/TTS03

4. APPLICATION

In this study, to generate a regional ionosphere model, data obtained from 12 IGS stations and 8 CORS-TR stations, which are located in Turkey between 37º -41º latitudes and 31º - 37º longitudes were evaluated (Fig.1). Regional TEC values for 2015 for the selected area was obtained via evaluation done with the help of Bernese v5.2 GNSS software. For comparison of generated TEC values, IRI-2012 model (International Reference Ionosphere) and GIM values generated by CODE, ESA, JPL were used.

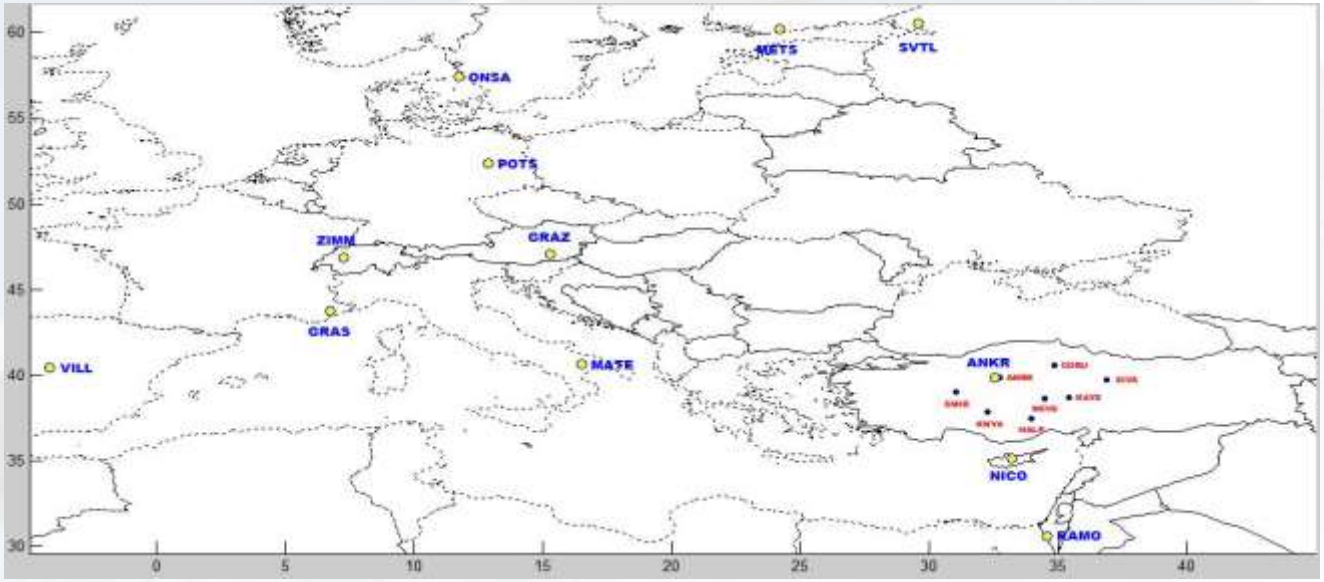

Figure 1. General Structure of Network

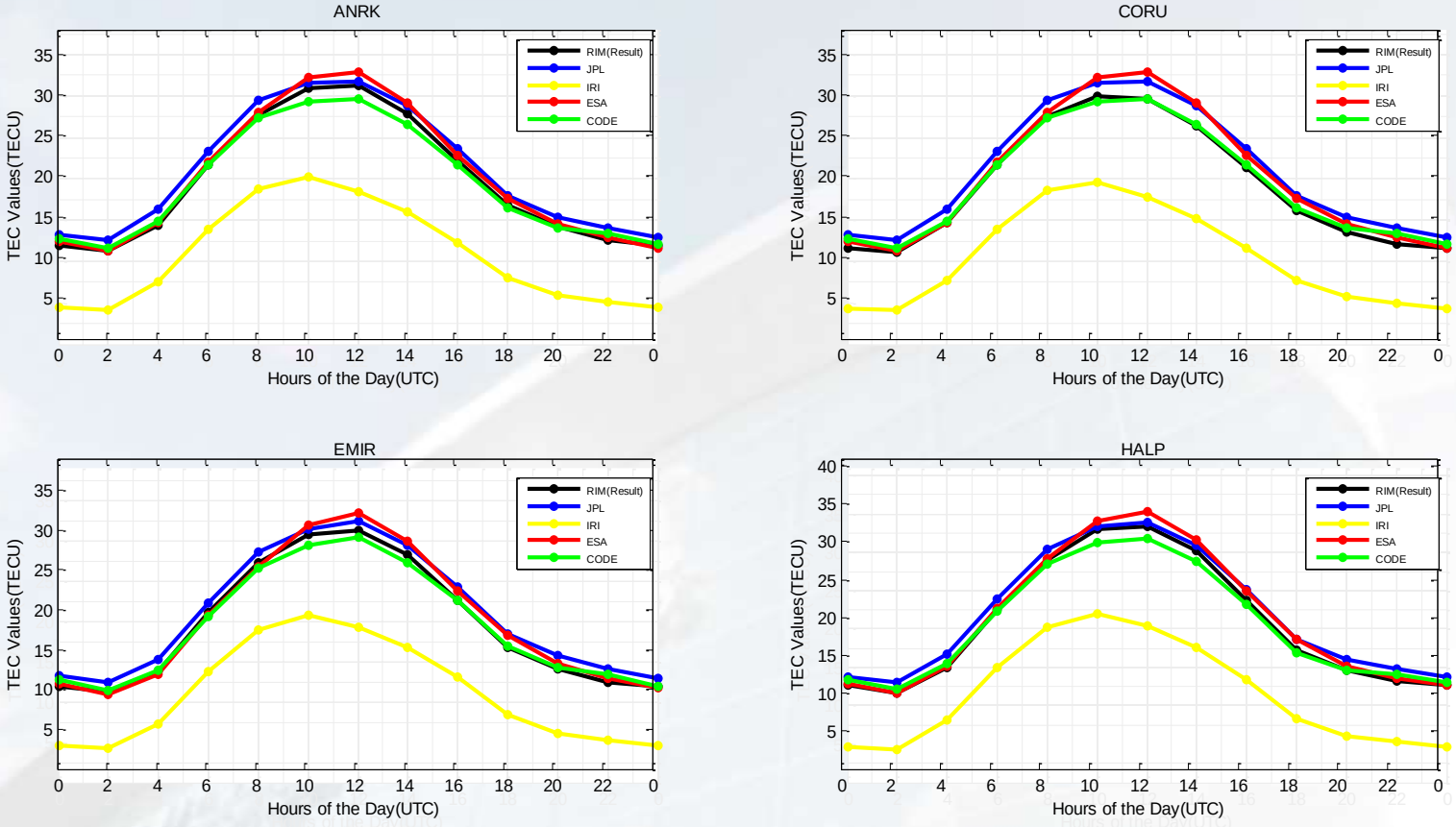

Figure 2. Comparison of the average TEC (RIM-Result) values obtained from the analysis of the stations used for the year 2015 with global TEC values.

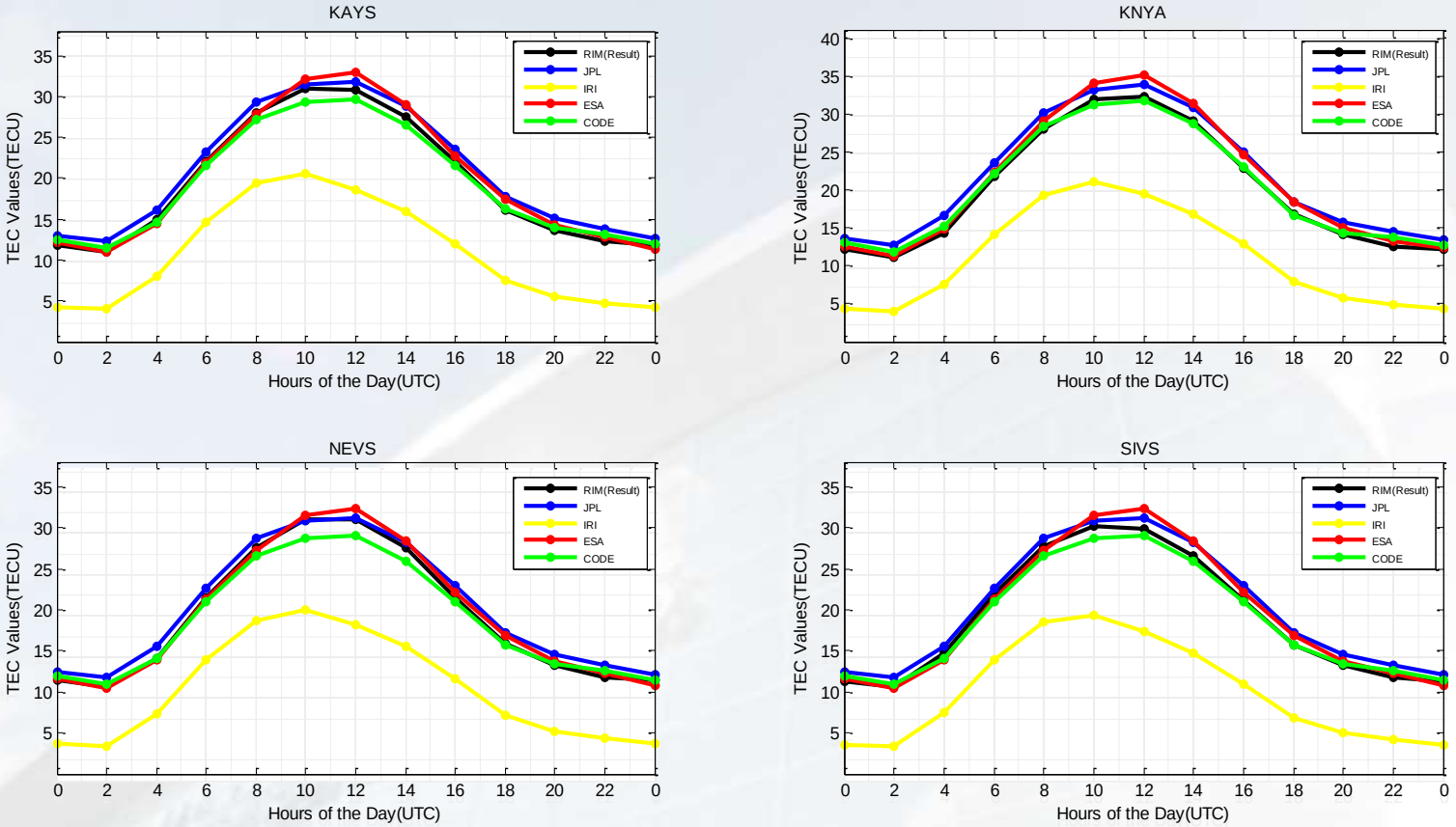

Figure 2. Comparison of the average TEC (RIM-Result) values obtained from the analysis of the stations used for the year 2015 with global TEC values (Continued).

Table 1. Statistical values of TEC values obtained from stations used in evaluation (TECU)

Station Name	Difference Statistics	RIM-CODE	RIM-ESA	RIM-JPL	RIM-IRI
ANRK	Maximum	1.5	0.4	-0.6	12.7
	Minimum	-0.9	-1.8	-2.0	6.8
	Average	0.2	-0.6	-1.3	8.9
	Std. Deviation	0.85	0.50	0.42	1.93
	Correlation	0.998584	0.999210	0.998770	0.986824
CORU	Maximum	0.6	0.1	-1.2	11.9
	Minimum	-1.3	-3.3	-2.5	7.0
	Average	-0.3	-1.1	-1.8	8.7
	Std. Deviation	0.52	1.03	0.31	1.69
	Correlation	0.998917	0.995621	0.999357	0.989486
EMIR	Maximum	1.4	0.5	-0.6	12.1
	Minimum	-0.9	-2.0	-1.7	6.5
	Average	0.2	-0.6	-1.3	8.5
	Std. Deviation	0.71	0.88	0.33	1.83
	Correlation	0.999205	0.995634	0.999371	0.988279
HALP	Maximum	1.7	0.1	-0.3	13.1
	Minimum	-0.9	-1.9	-1.9	6.7
	Average	0.3	-0.6	-1.2	9.1
	Std. Deviation	0.88	0.63	0.45	2.08
	Correlation	0.999160	0.998478	0.999292	0.984730
KAYS	Maximum	1.7	0.5	-0.6	12.0
	Minimum	-1.0	-2.1	-1.6	6.8
	Average	0.3	-0.5	-1.2	8.7
	Std. Deviation	0.79	0.76	0.28	1.78
	Correlation	0.999347	0.996673	0.999566	0.986339
KNYA	Maximum	0.7	-0.1	-1.3	12.7
	Minimum	-1.2	-2.9	-2.3	6.7
	Average	-0.3	-1.2	-1.7	8.9
	Std. Deviation	0.61	0.86	0.30	1.96
	Correlation	0.999032	0.998485	0.999282	0.986150
NEVS	Maximum	2.3	0.6	0.1	12.9
	Minimum	-0.9	-1.2	-1.6	6.7
	Average	0.5	-0.3	-1.0	8.9
	Std. Deviation	1.03	0.47	0.54	2.01
	Correlation	0.999068	0.998462	0.998933	0.984971
SIVS	Maximum	1.6	0.8	-0.6	12.4
	Minimum	-0.8	-2.4	-1.7	7.2
	Average	0.3	-0.5	-1.2	9.0
	Std. Deviation	0.73	0.98	0.35	1.79
	Correlation	0.998634	0.994339	0.998960	0.986824

TEC maps were generated in MATLAB via help of Global TEC values and TEC values obtained via result of analysis for selected region for 2015. Obtained TEC maps covers 24 hours starting from 00:00 with two hours intervals.

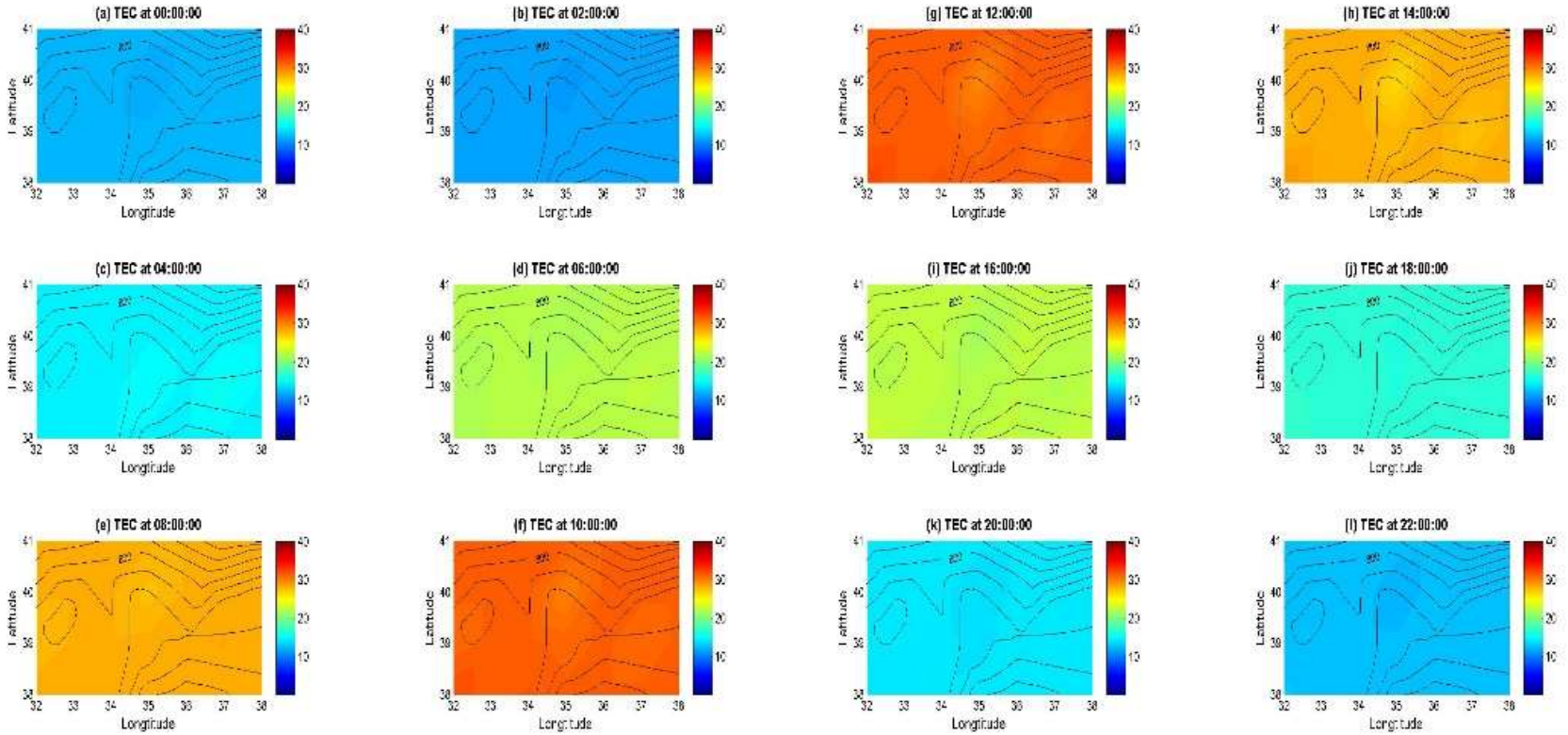

Figure 3. Regional RIM TEC maps generated in two hours intervals for 2015

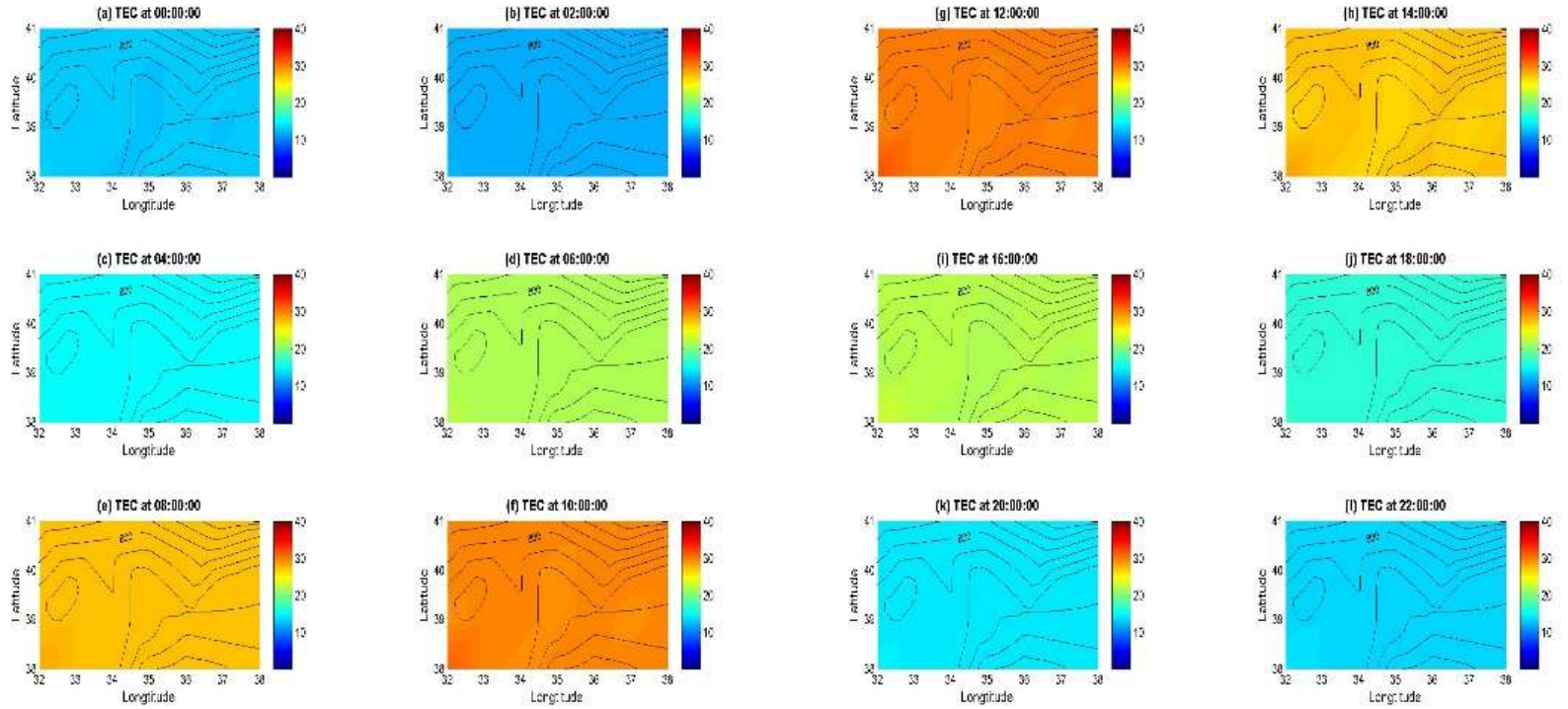

Figure 4. CODE TEC maps generated in two hours intervals for 2015

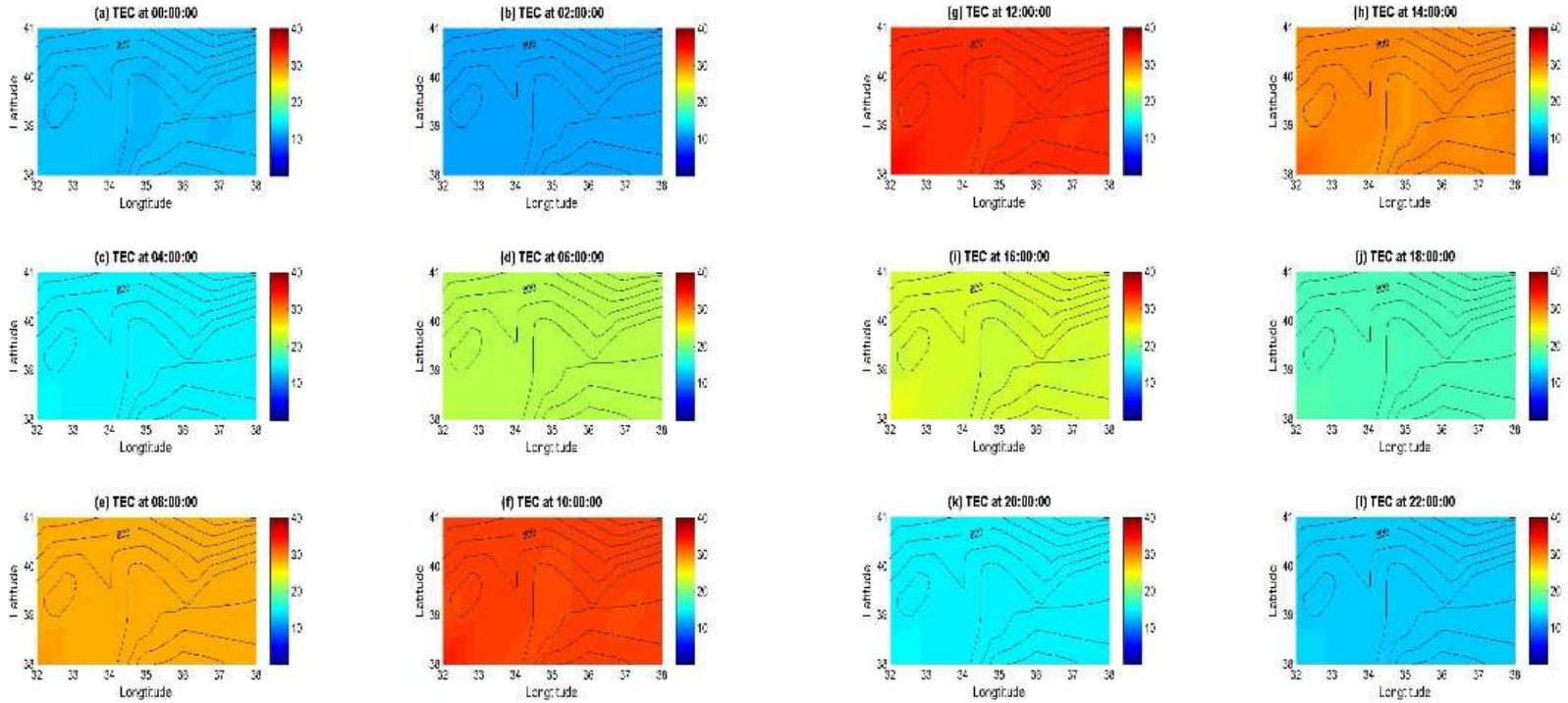

Figure 5. ESA-TEC maps generated in two hours intervals for 2015

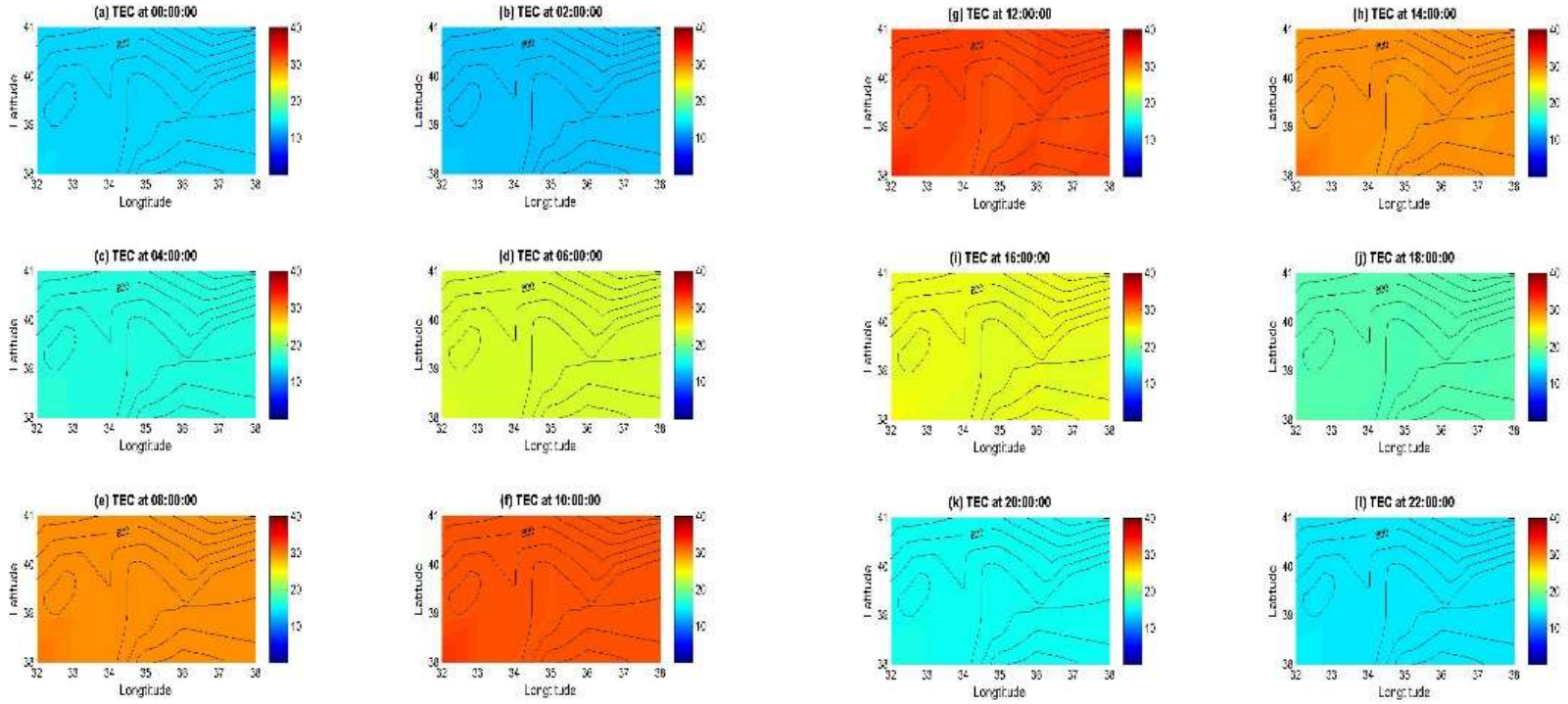

Figure 6. JPL-TEC maps generated in two hours intervals for 2015

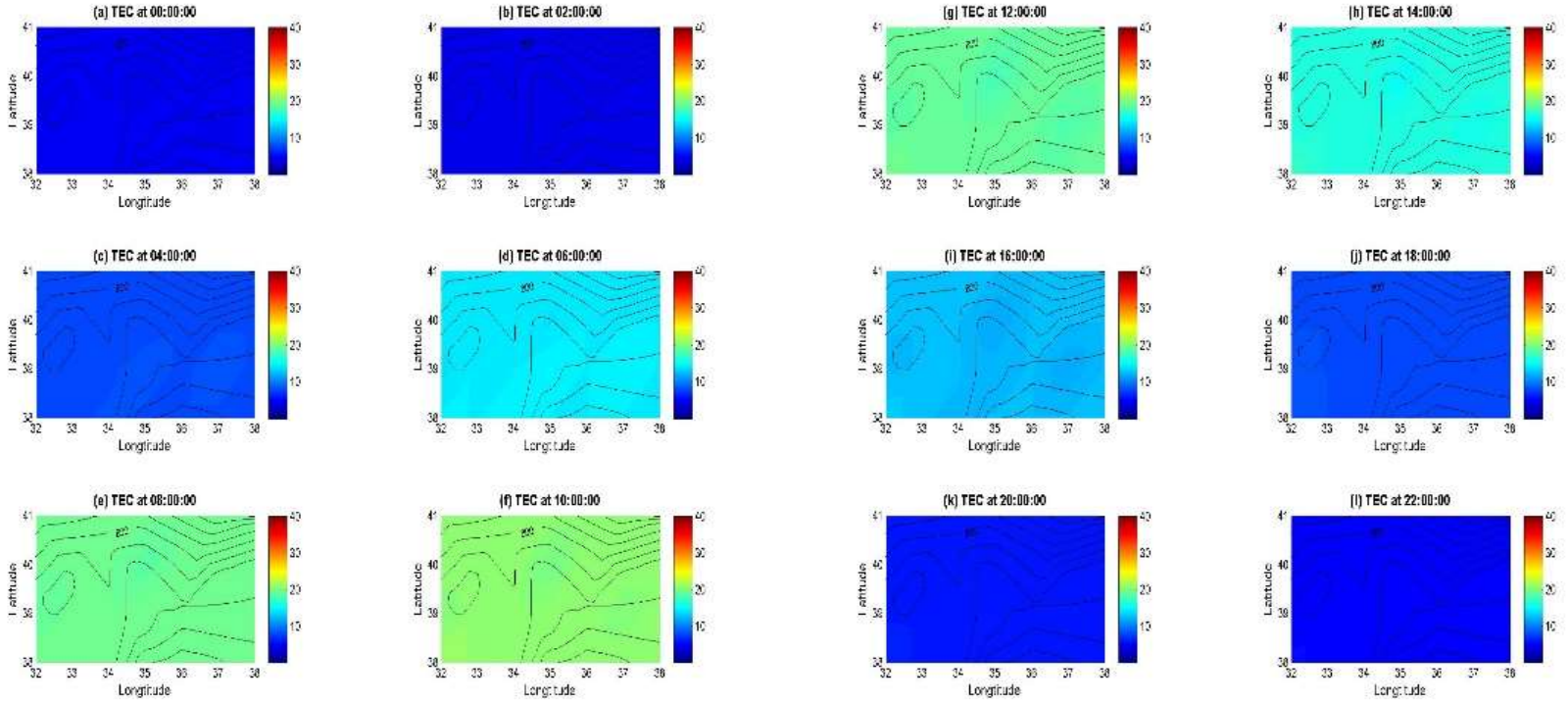

Figure 7. IRI-TEC maps generated in two hours intervals for 2015

5- CONCLUSION

Regional (RIM) TEC values were generated for the year of 2015. Obtained results were compared with average values of GIM values published by CODE, ESA, JPL and TEC values obtained by IRI-2012 (Figure 2). When results are evaluated, it is seen that regional (RIM) TEC values obtained via analysis are in harmony with global (CODE, ESA, JPL) TEC values, however, TEC values obtained from IRI is lower than these four values. These obtained five different TEC values are observed to behave similarly in a day. It is seen that each of the five values are increased till noon than, the TEC values are decreased because of regrouping of free ions.

TEC values, obtained from regional ionosphere model (RIM), from global ionosphere models (CODE, ESA, JPL) and from IRI model, in general, started to increase at 02:00 am and reached maximum at 12:00 pm. It was seen that the values reached minimum at 02:00 am and the density was seen at maximum between 10:00 am – 14:00 pm.

Via CORS-TR with instant data obtained from 142 stationary GNSS station, near real time model of ionosphere will be done more precisely. Since there are not enough old data about ionosphere which has an important role in shortwave communications and navigation, GNSS measurements done before will be crucial for new models.

THANK YOU VERY MUCH FOR YOUR ATTENTİON.