MODELLING THE TOTAL ELECTRON CONTENT OVER MALAYSIA USING MODIFIED SPHERICAL CAP HARMONIC ANALYSIS

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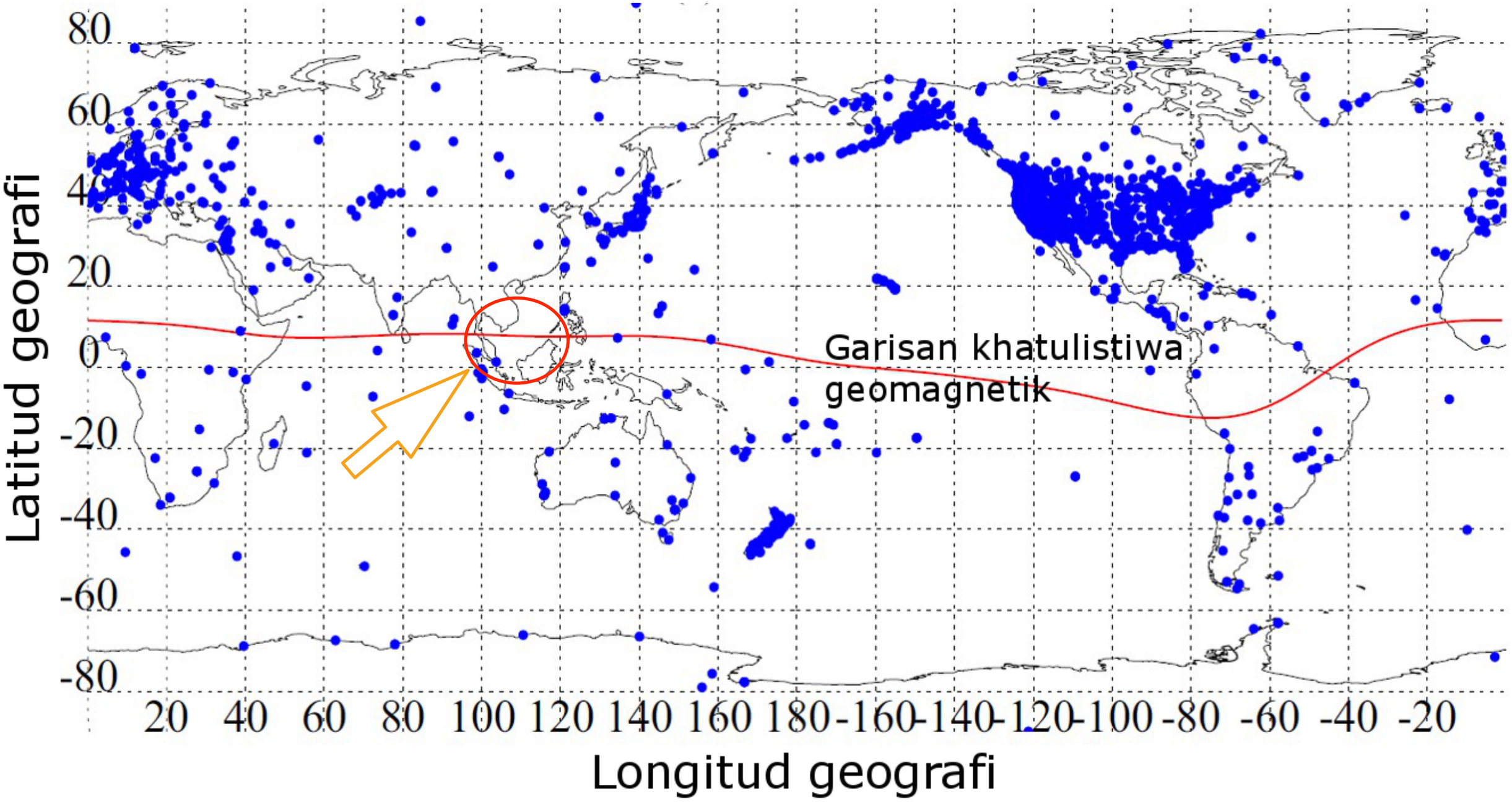
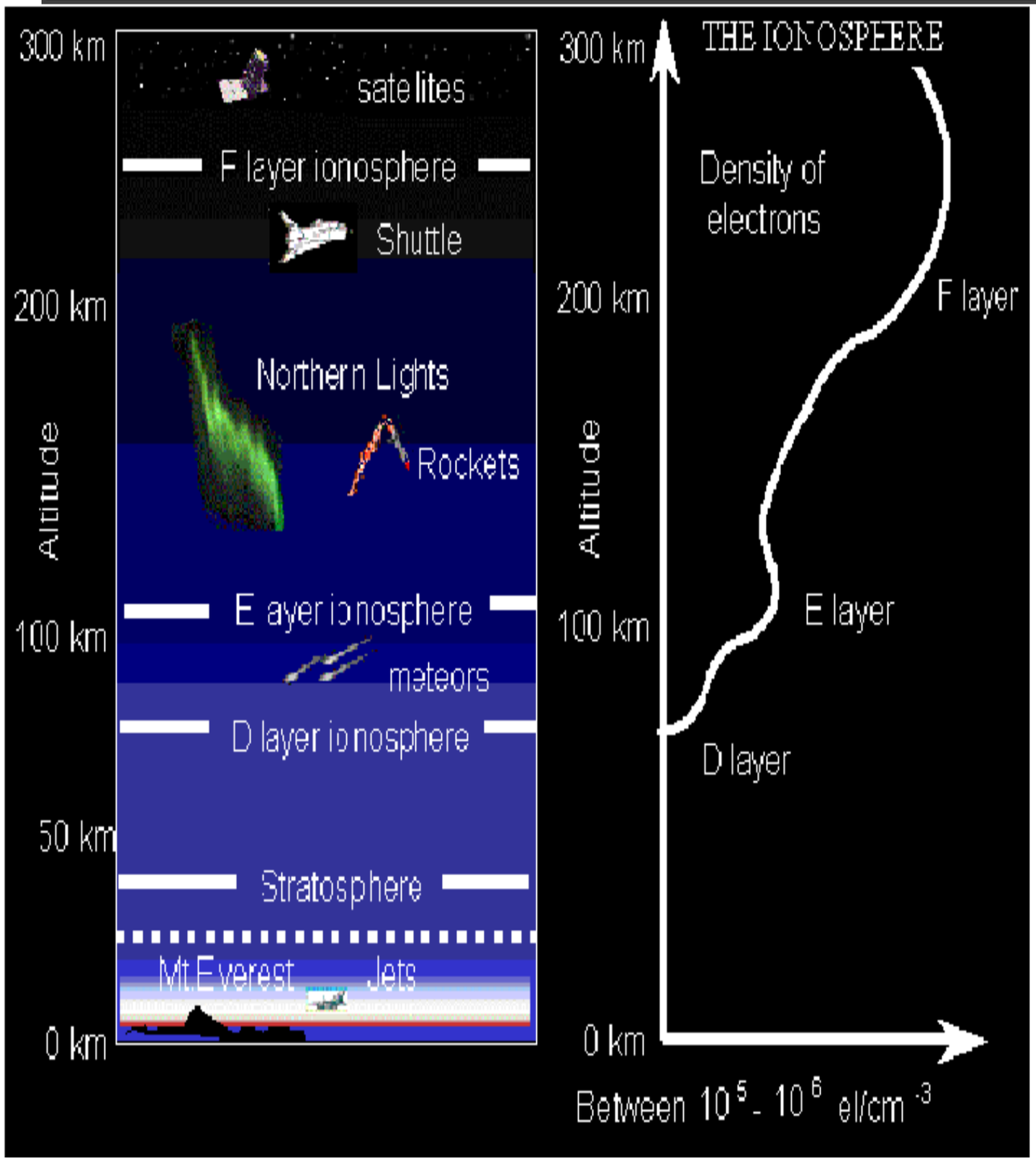
OUTLINE

- INTRODUCTION
- OBJECTIVE
- METHODOLOGY
- RESULTS AND DISCUSSION :
- CONCLUSION
- ACKNOWLEDGEMENT

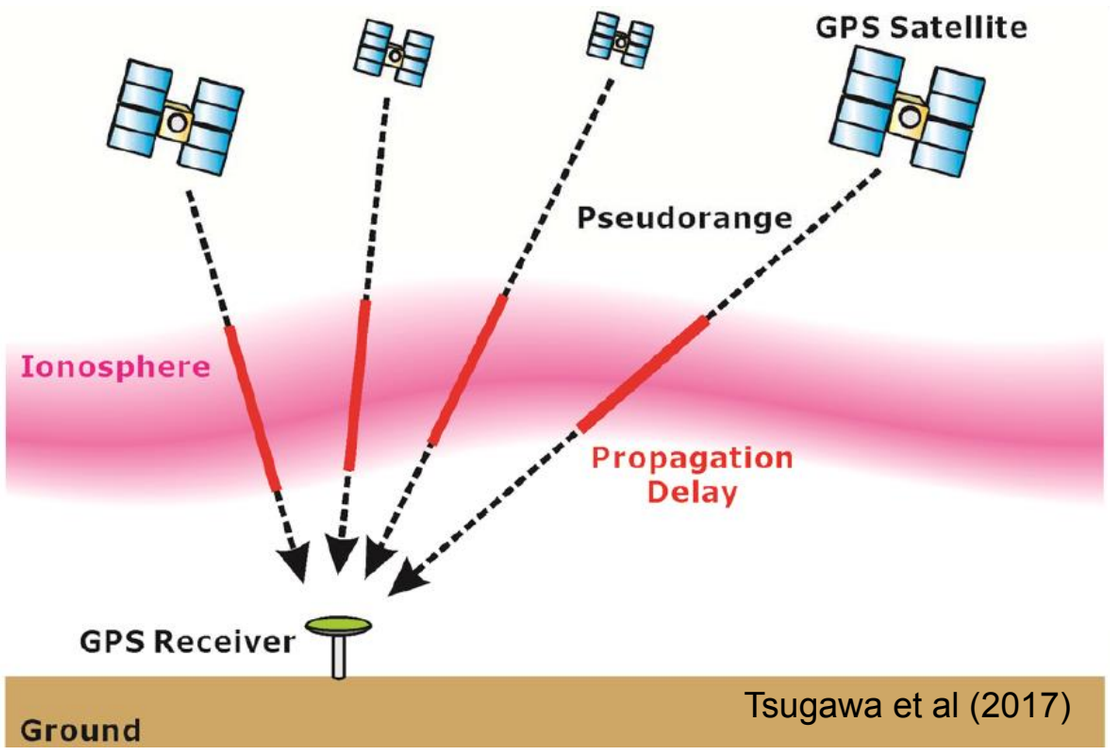
Where is Malaysia?



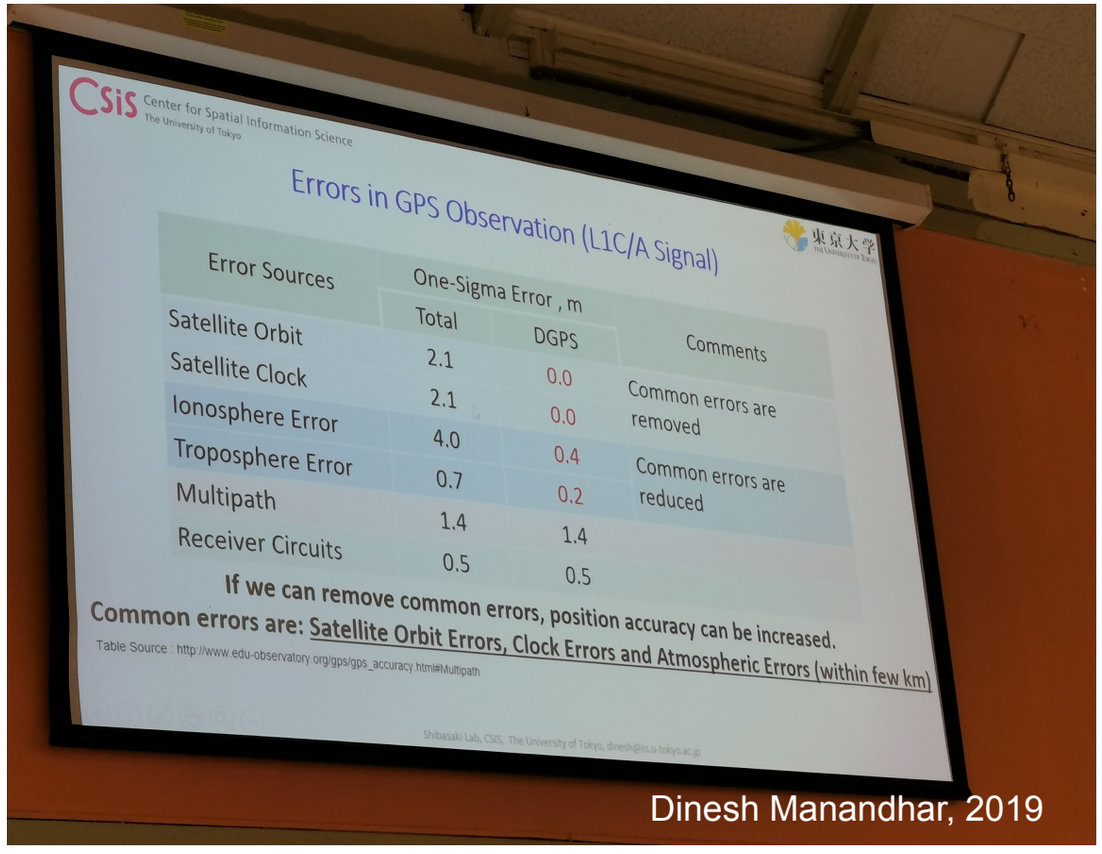
INTRODUCTION



- Ruth A. Bamford

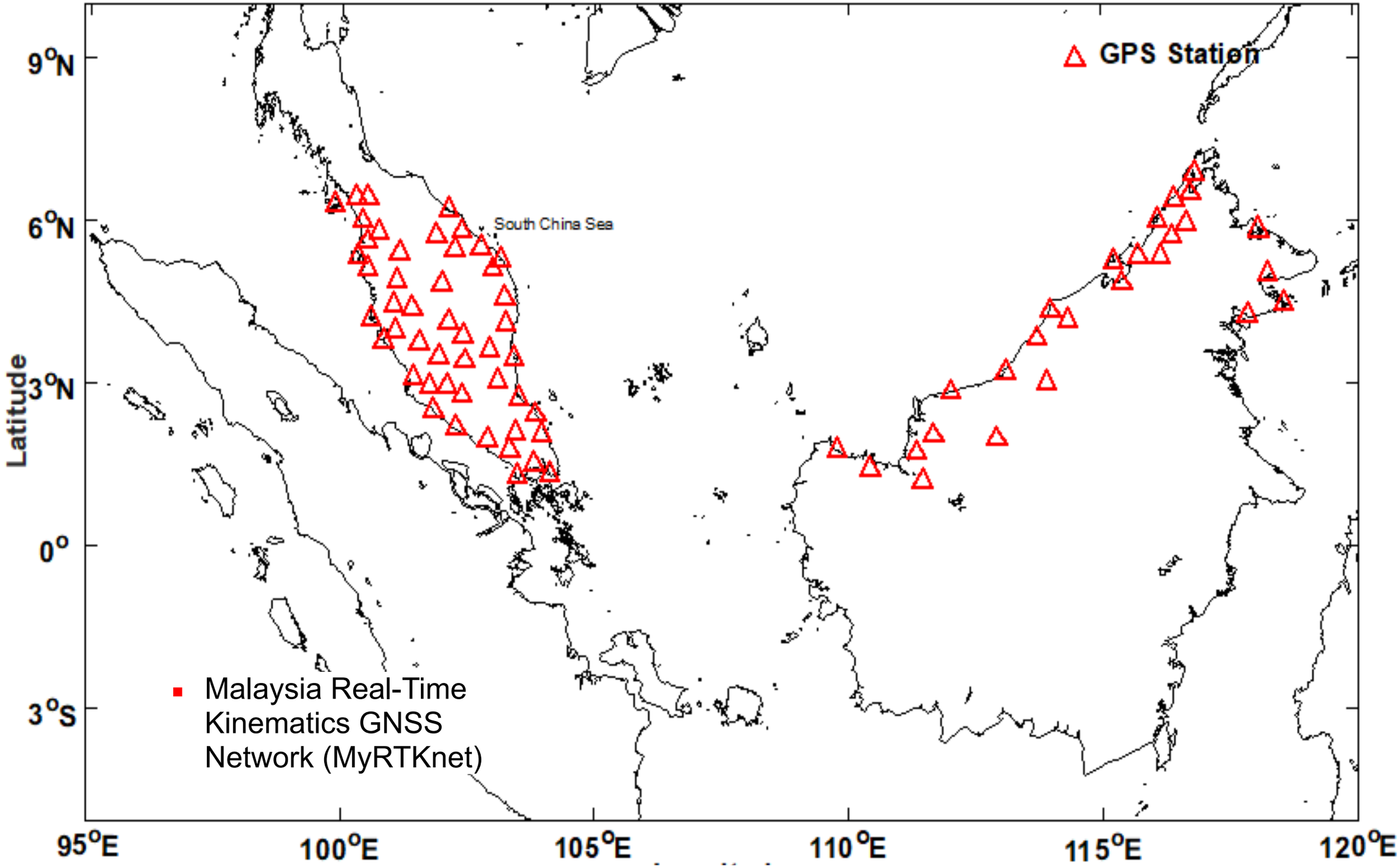


Tsugawa et al (2017)



Dinesh Manandhar, 2019

MOTIVATION



GNSS network owned by JUPEM (78 GNSS Stations in 2014, currently have 96)

http://www.data.gov.my/data/en_US/dataset/senarai-lokasi-stesen-rangkaian-myrtknet-di-malaysia/resource/098acba8-e803-47c1-bfda-9128ab9e3068

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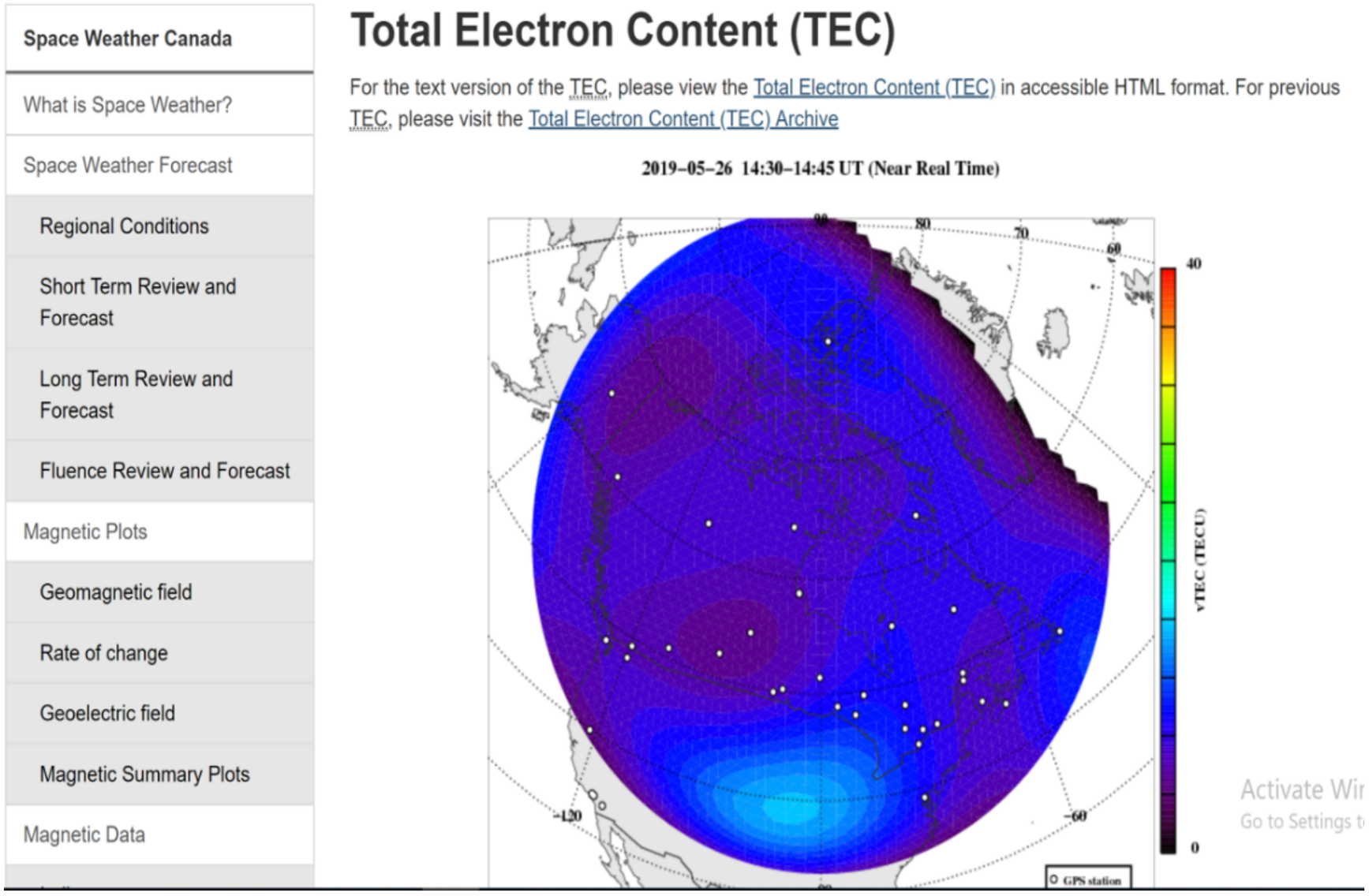


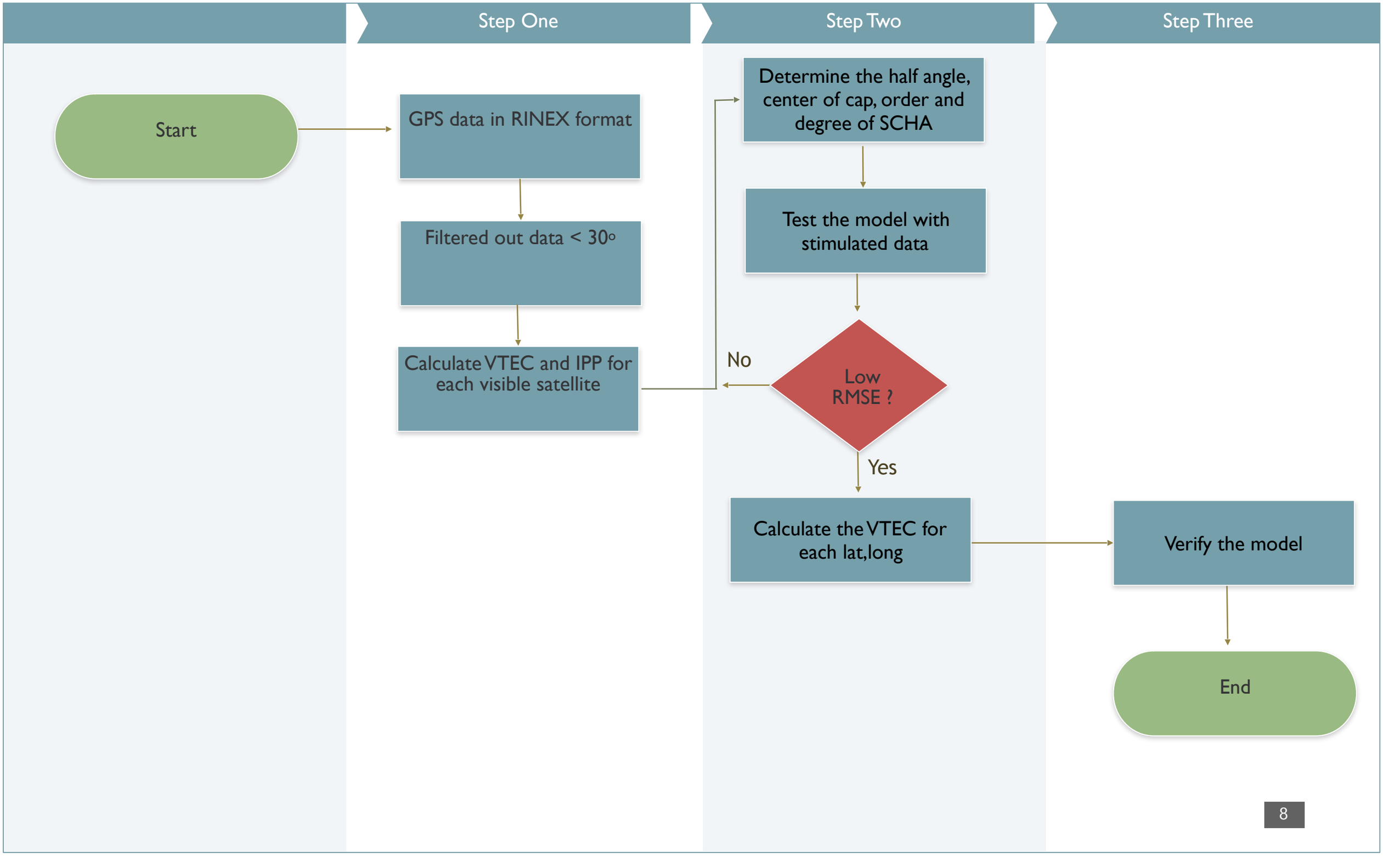
- Spherical Cap Harmonic Analysis (SCHA) has been used by Canada Space Weather Centre to model the ionosphere over their own region.
- Previous studies showed that SCHA is capable of modelling and mapping the ionospheric parameters over small region with accuracy of 2 TECU (Liu et al 2010,2014)

OBJECTIVES

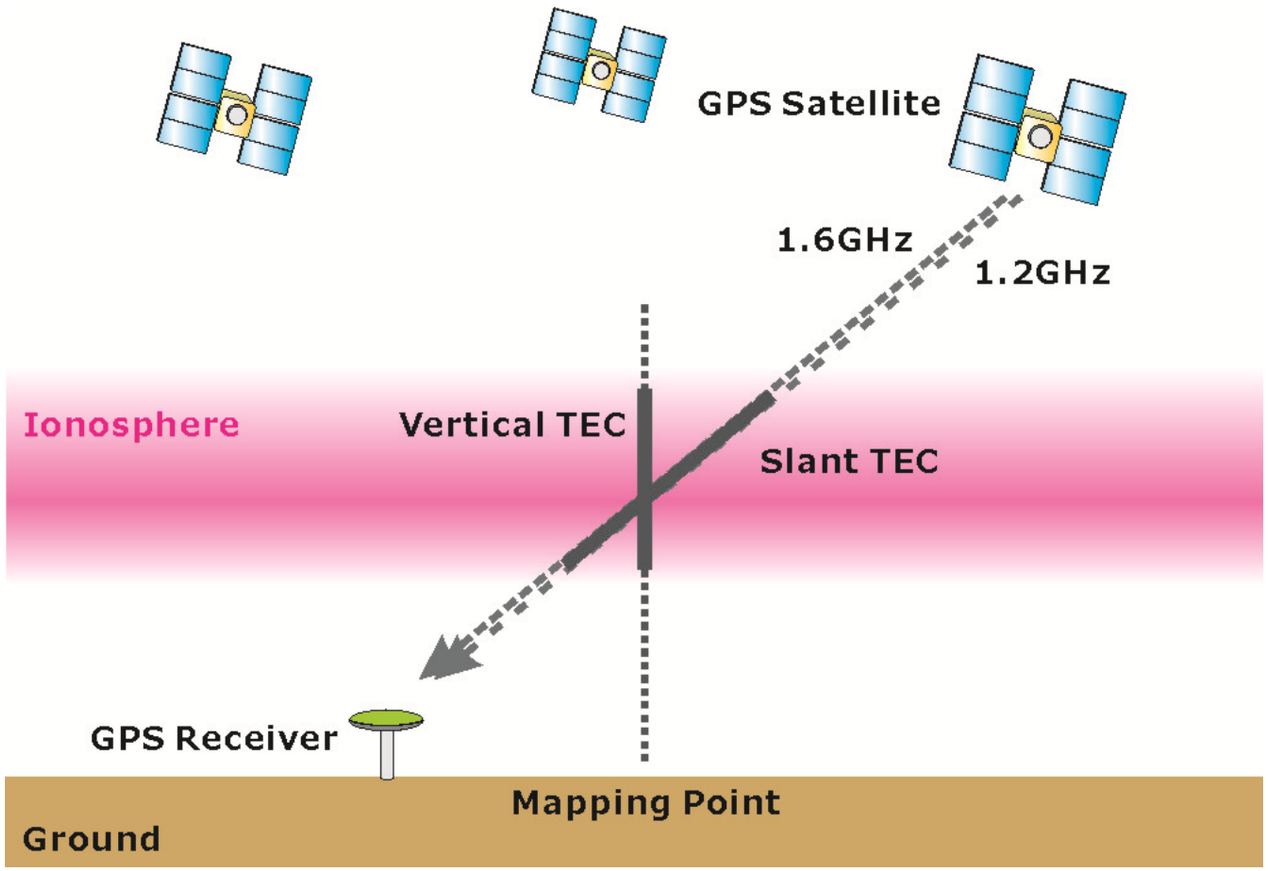
1) to develop a regional ionospheric model using modified SCHA through the utilisation of the GPS network over Malaysia.

2) to verify the model using actual measurements and established models.

FLOWCHART OF METHODOLOGY



STEP 1 :VTEC AND IPP CALCULATION FROM GPS DATA OVER MALAYSIA



- TEC is the number of electrons in a vertical column that extends from the satellite to the receiver on the Earth.

$$TEC = \frac{(f_1 \cdot f_2)^2}{k\left(f_1^2 - f_2^2\right)} \times (L_1 \cdot \lambda_1 - L_2 \cdot \lambda_2)$$

k = 40.3 $m^3 s^{-2}$

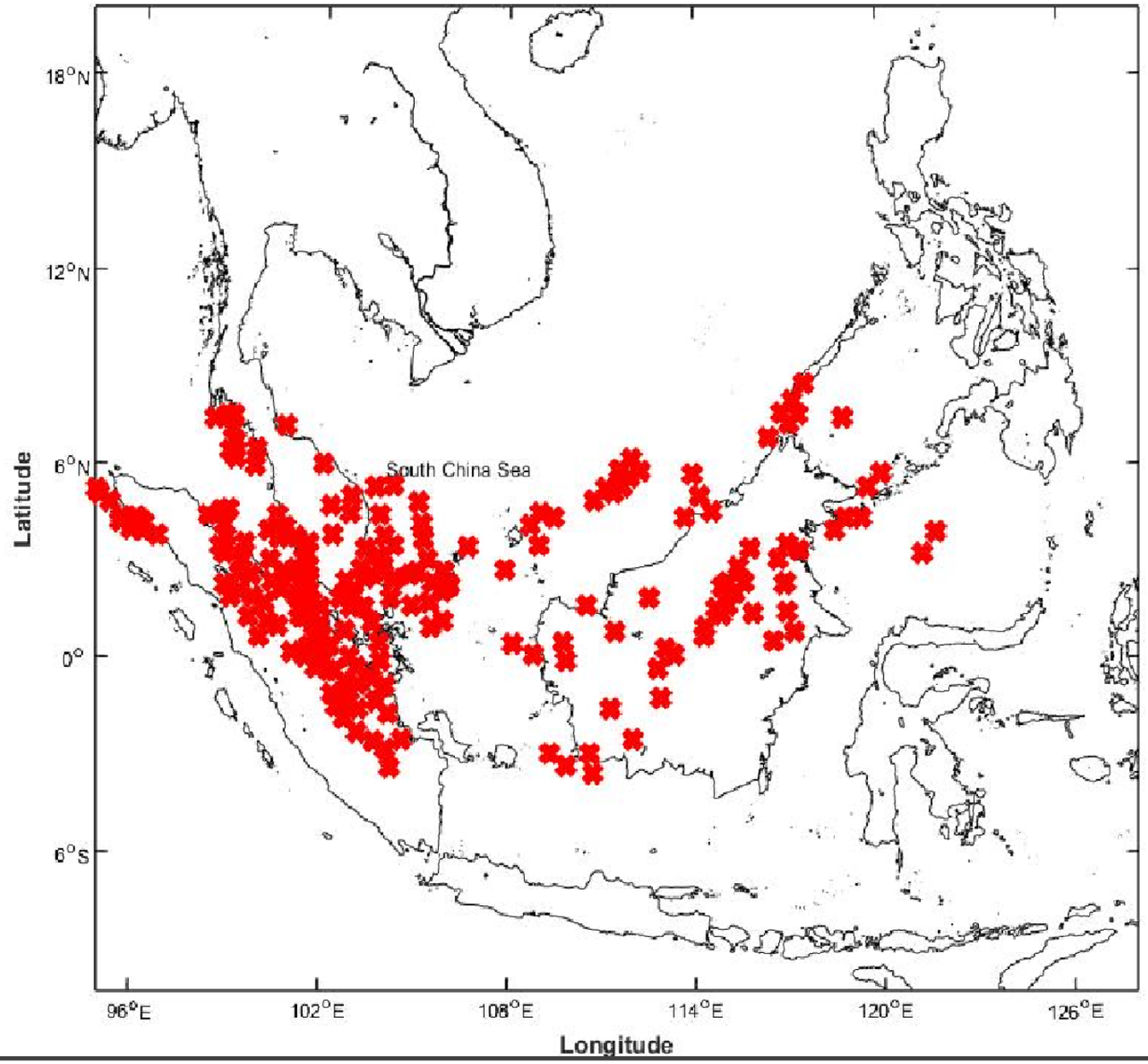
f_1 = 1575.42 MHz. f_2 = *1227.60 MHz*

L1 , *L2* – Carrier phase

- To remove the dependency from the elevation angle μ of the ray path, slant TEC is converted to the vertical TEC by applying a mapping function M(μ)
- Assumed that ionosphere is a thin shell. The thin-shell model assumption is used to convert the slant TEC into vertical TEC.

METHODOLOGY

- STEP 1 :VTEC AND IPP CALCULATION FROM GPS DATA OVER MALAYSIA



IPP POINTS OVER MALAYSIA (19 JAN 2010, 0800 LT)

- STEP 2 : SPHERICAL CAP HARMONIC ANALYSIS

• Determine the half angle and pole of spherical cap based on the IPP

$$TEC(\theta,\lambda) = \sum_{n=0}^{K_{max}} \sum_{m=0}^{n} [a_n^m \cos(m\lambda) + b_n^m \sin(m\lambda)] \,.\, P_{n_k(m)}^m(cos\theta)$$

θ, λ : latitude, longitude

$P_{n_k(m)}^m(cos\theta)$: is the associated Legendre Functions of non-integer degree n_k and integer order m

k : is the integer degree-index

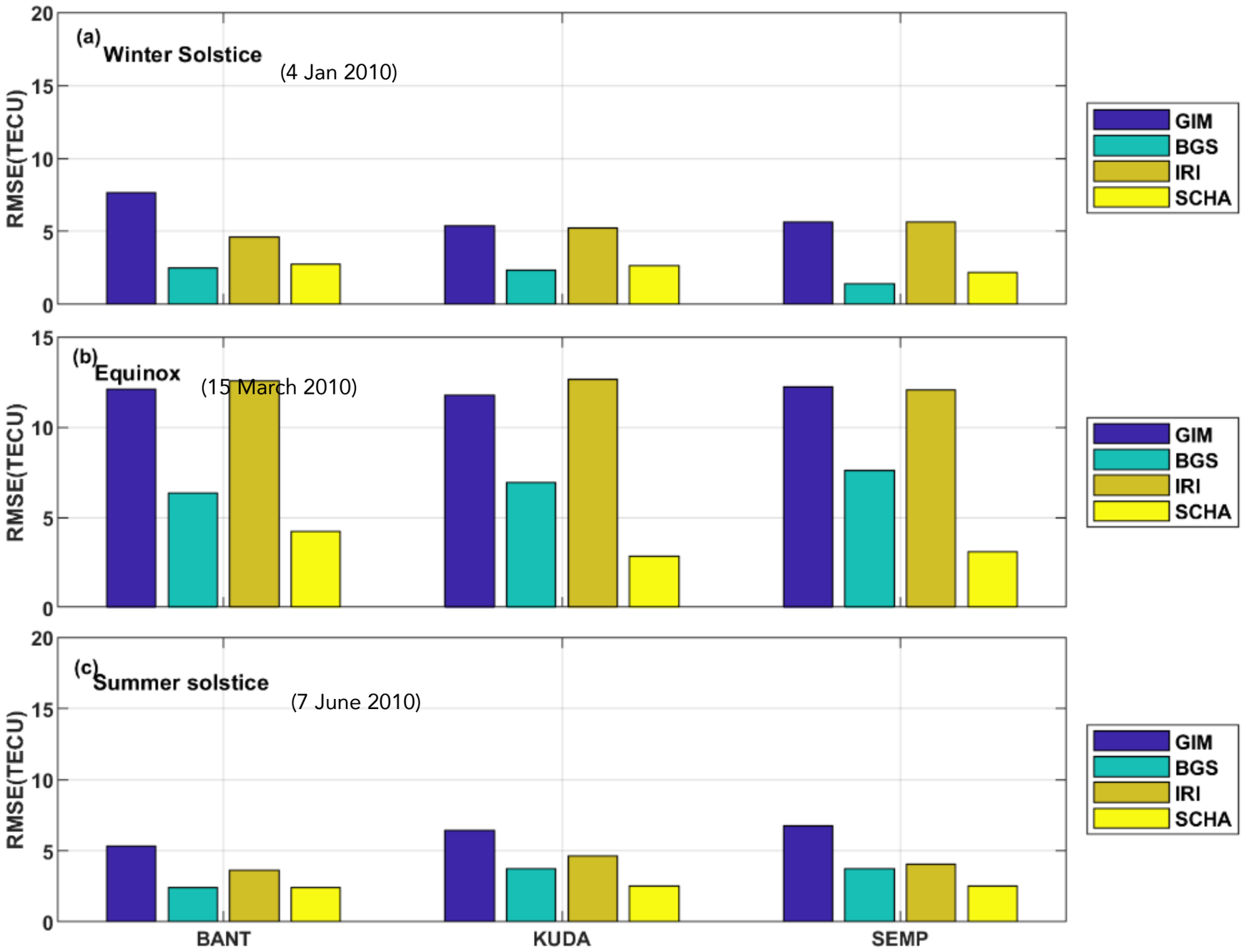
K_{max} : is the maximum degree-index

a_n^m, b_n^m : are the unknown coefficients that characterize the expansion

$P_{n_k(m)}^m(cos\theta)sin(m\lambda), P_{n_k(m)}^m(cos\theta)cos(m\lambda)$: is the ordinary surface spherical harmonics.

RESULTS AND DISCUSSIONS

MODEL VERIFICATION :SINGLE RECEIVER COMPARISON WITH FOUR MODELS IN TEMPORAL AND SPATIAL SCALES



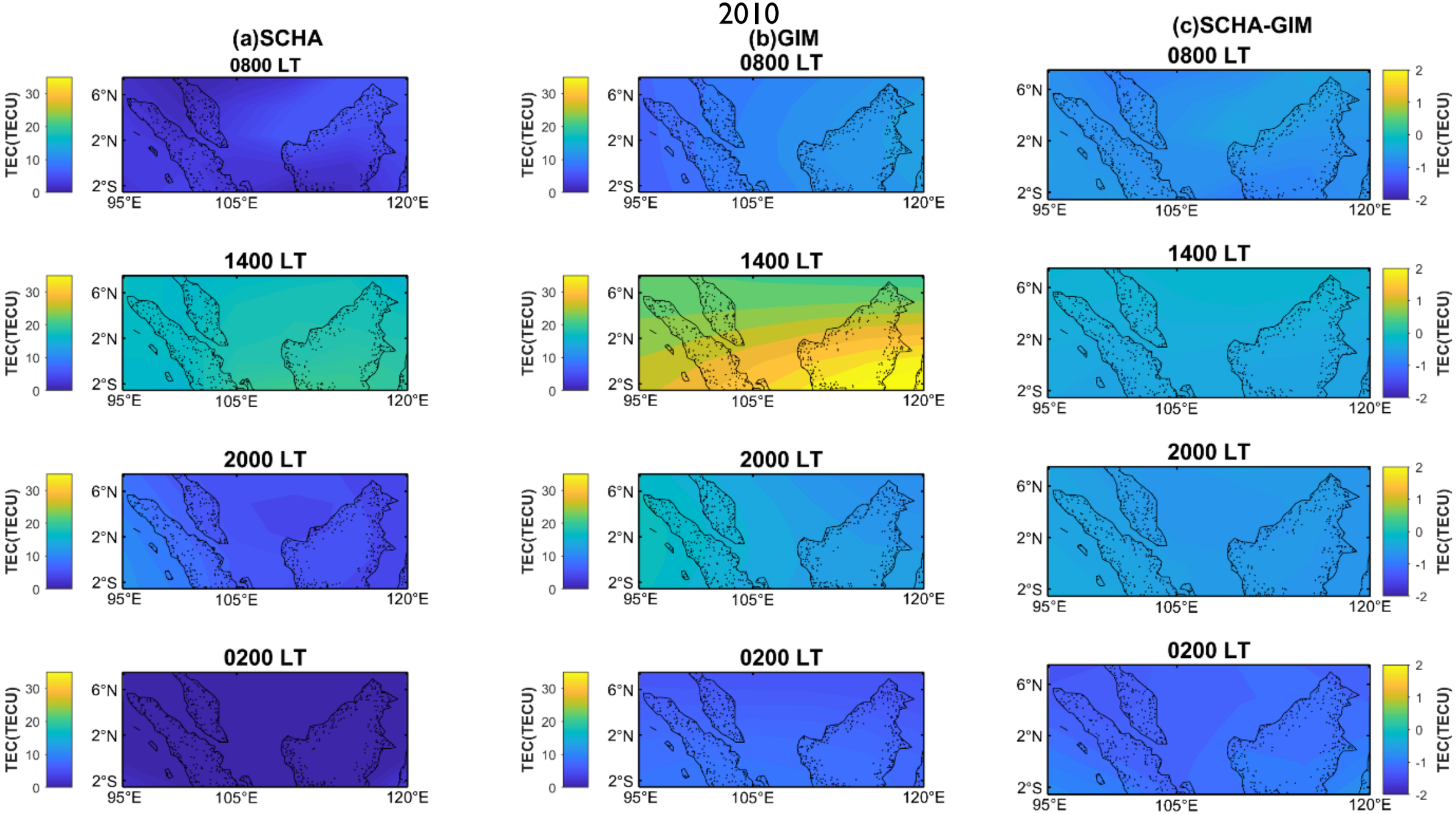
RMSE for 2010 for three stations (BANT, KUDA and SEMP) in which actual observations are compared to 4 types of model for different seasons. Blue = GIM, Cyan = BGS, Olive = IRI and Yellow = SCHA

MODEL VERIFICATION :SINGLE RECEIVER COMPARISON WITH FOUR MODELS IN TEMPORAL AND SPATIAL SCALES

RMSE for 2014 for three stations (BANT, KUDA and SEMP) in which actual observations are compared to 4 types of model for different seasons. Blue = GIM, Red = BGS, Orange = IRI and Purple = SCHA

MODEL VERIFICATION :SINGLE RECEIVER COMPARISON WITH FOUR MODELS IN TEMPORAL AND SPATIAL SCALES

- Comparison of VTEC map from (a)SCHA, (b) GIM and (c) difference between TEC from SCHA and GIM for 4 January 2010



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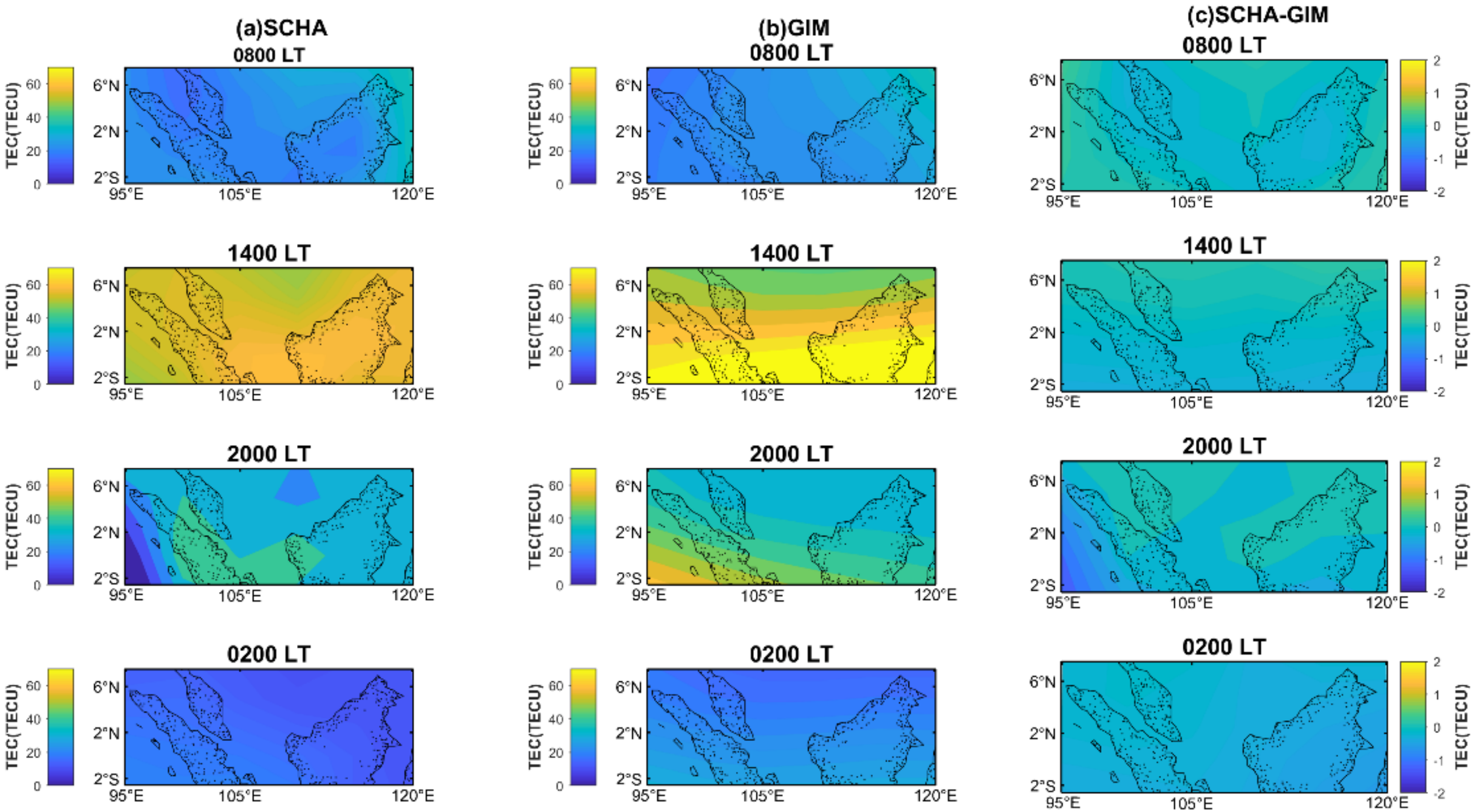
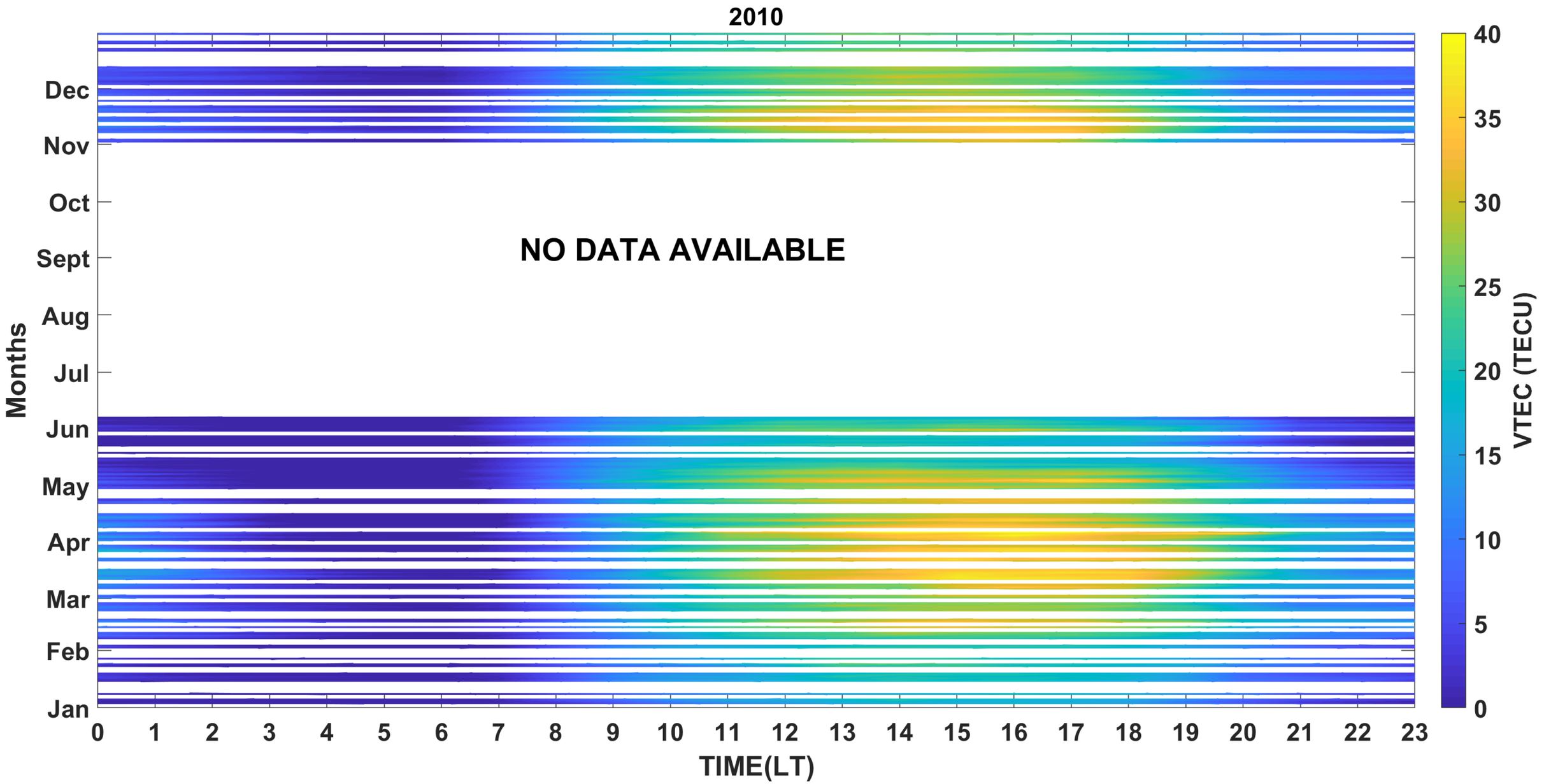
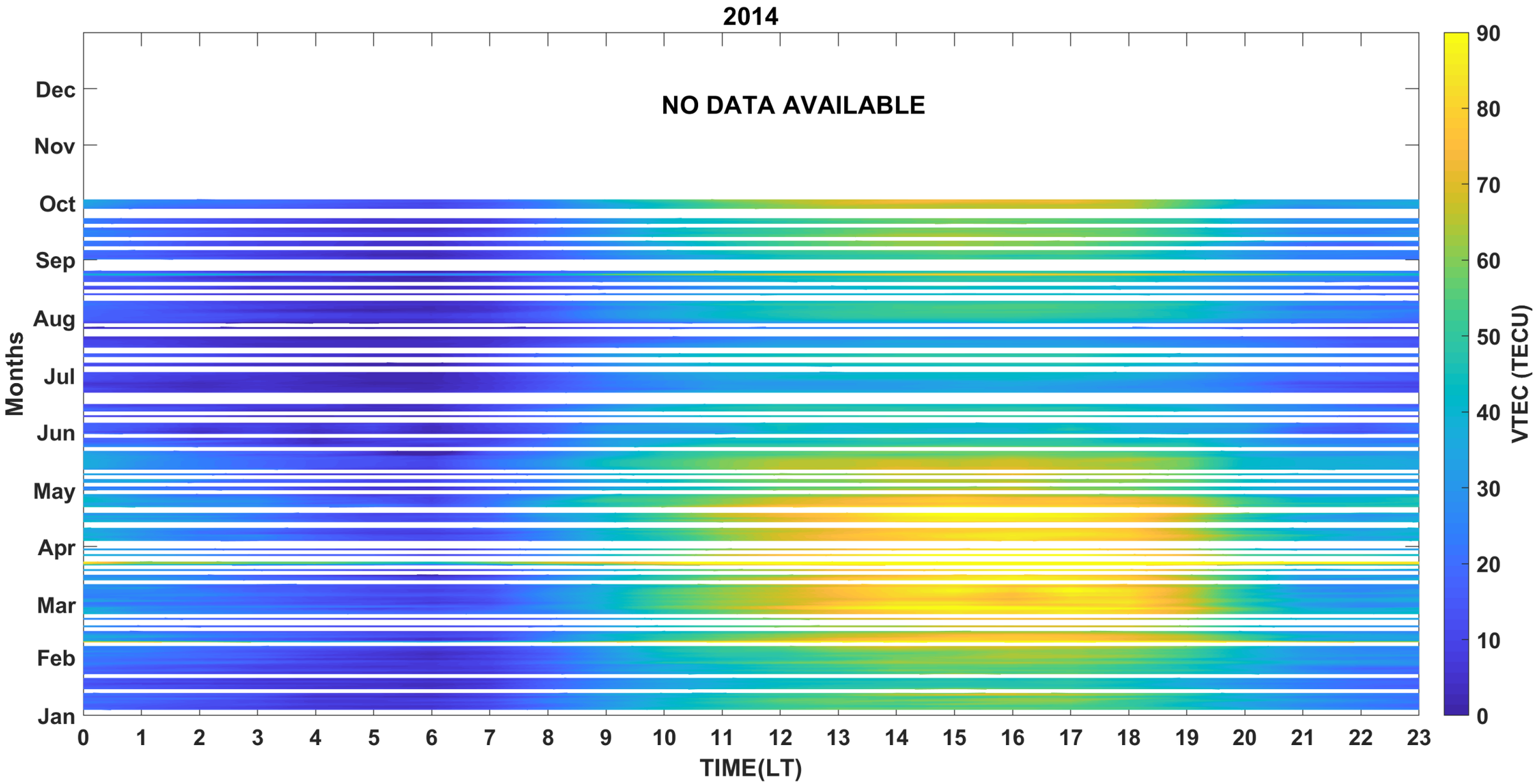


CLIMATOLOGY OF TEC OVER MALAYSIA FOR 2010 AND 2014



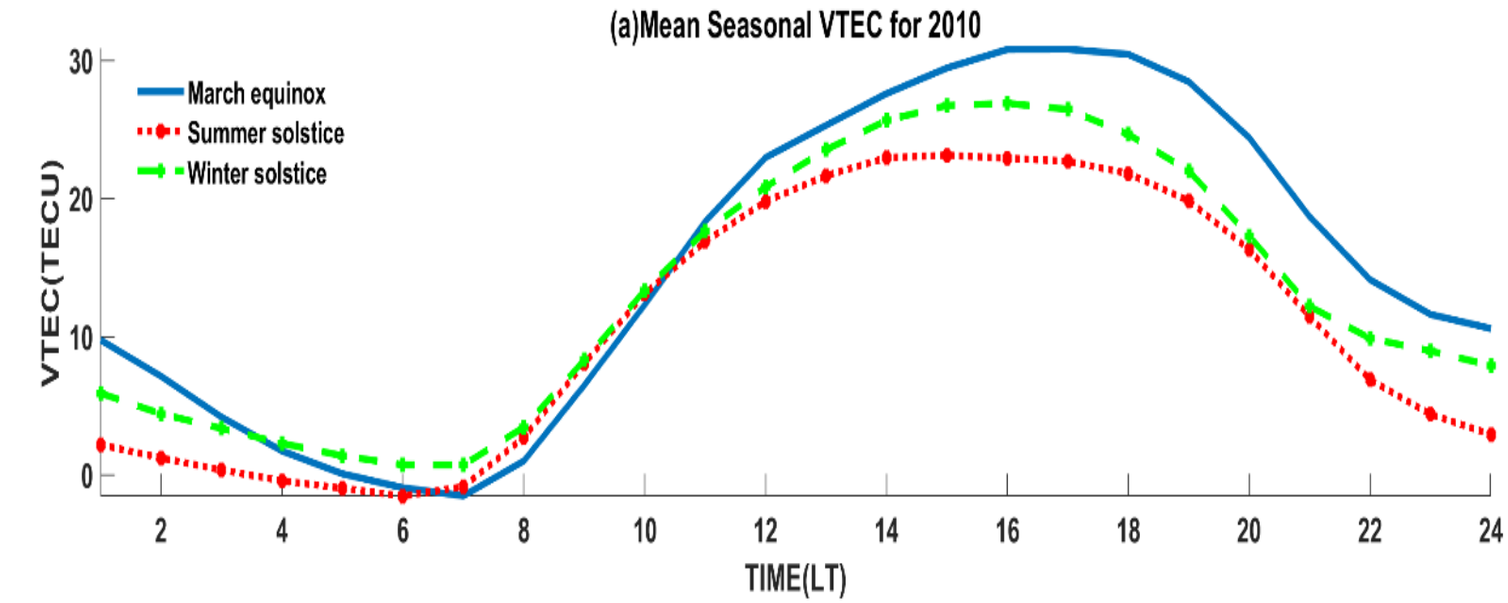
- Diurnal variations of mean TEC over equatorial for year of 2010

CLIMATOLOGY OF TEC OVER MALAYSIA FOR 2010 AND 2014

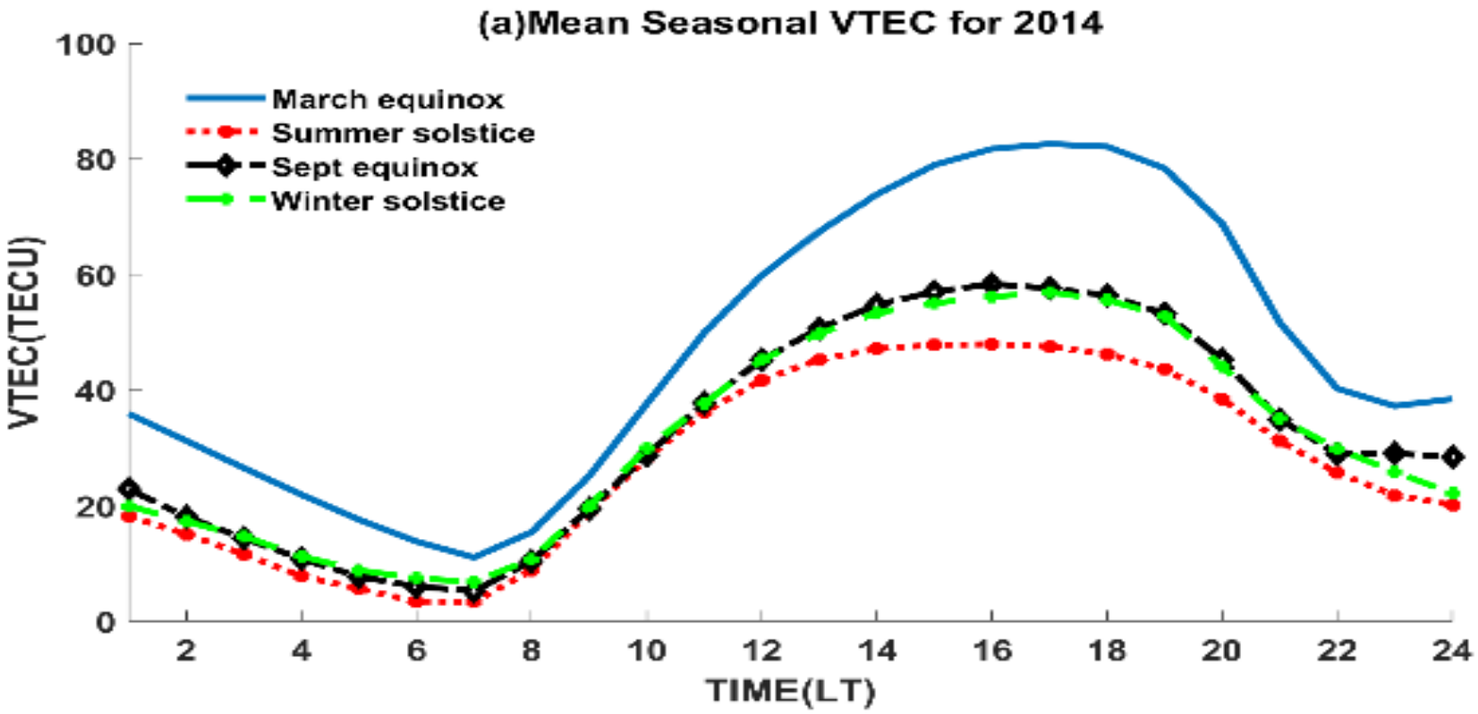


- Diurnal variations of mean TEC over equatorial for year of 2014

CLIMATOLOGY OF TEC OVER MALAYSIA FOR 2010 AND 2014 (SEASONAL VARIATIONS)



- March equinox (February, March and April)
- September equinox (August, September and October.)
- Winter Solstices (January, November and December)
- Summer Solstices(May, June and July)



- Max TEC - March equinox
- Min TEC - summer

CONCLUSION

- The regional ionospheric model based on SCHA using GPS over Malaysia was developed and verified.
- The degree for this model is 4 with half angle 10, and pole of spherical cap is 4.01 N, 108.8 E.
- In general, the diurnal pattern of mean TEC showed a steady increase from about sunrise to post noon and then gradually decreased after sunset to attain minimum just before sunrise throughout the years of analysis.

ACKNOWLEDGEMENT

- United Nations Office for Outer Space Affairs (UNOOSA)
- The International Committee on Global Navigation Satellite Systems (ICG)
- The University of the South Pacific (USP)
- Universiti Kebangsaan Malaysia
- Department of Mapping and Surveying Malaysia

THANK YOU FOR YOUR TIME AND ATTENTION