# E layer critical frequency over an equatorial location in Thailand

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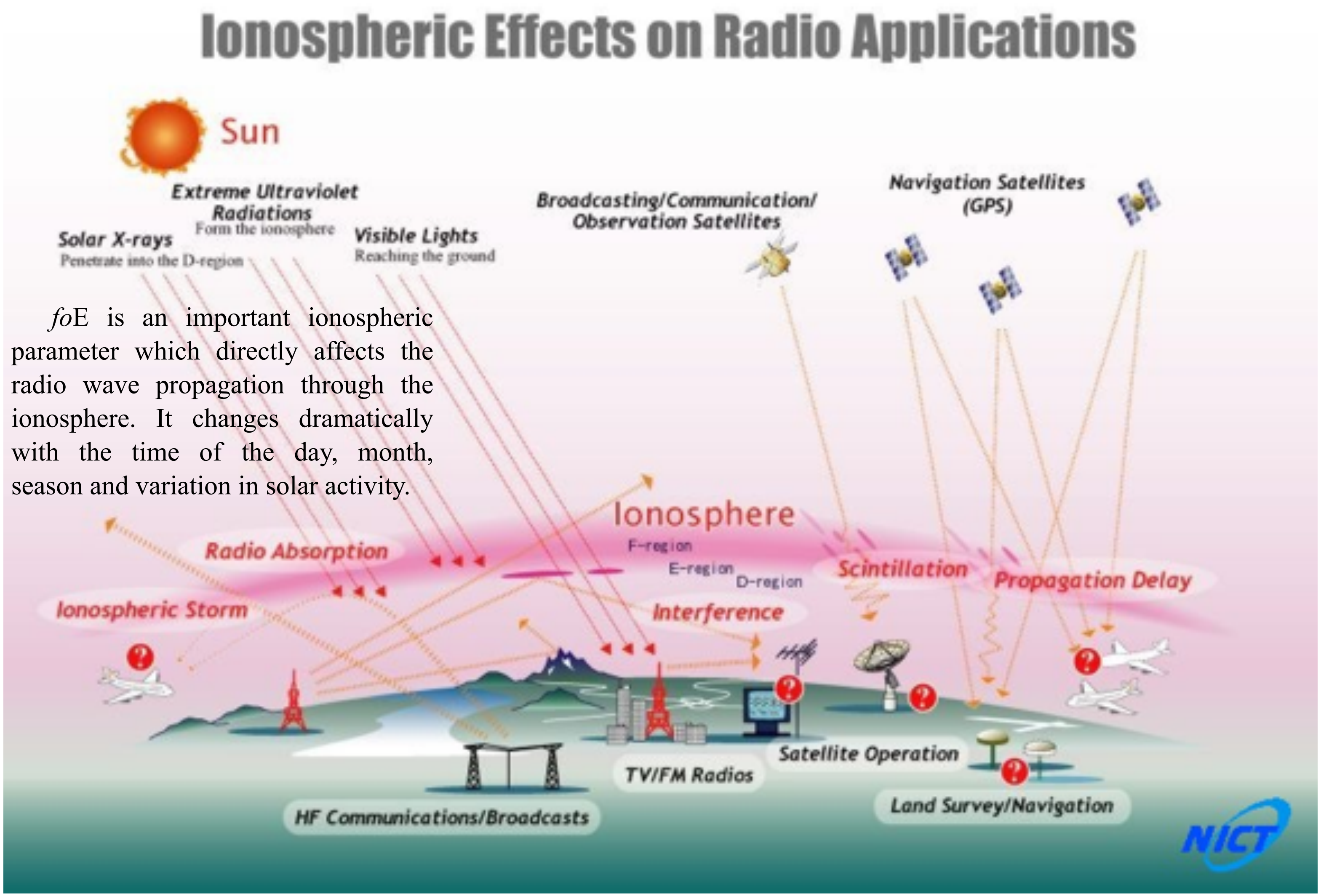
- Introduction
- Methodology
- Results
- Summary

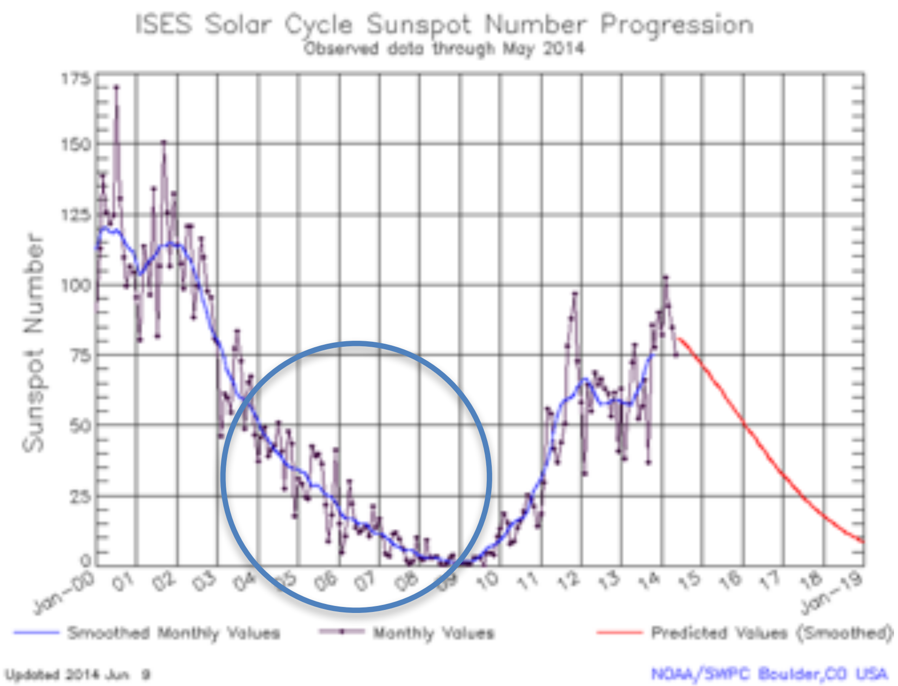
# Introduction



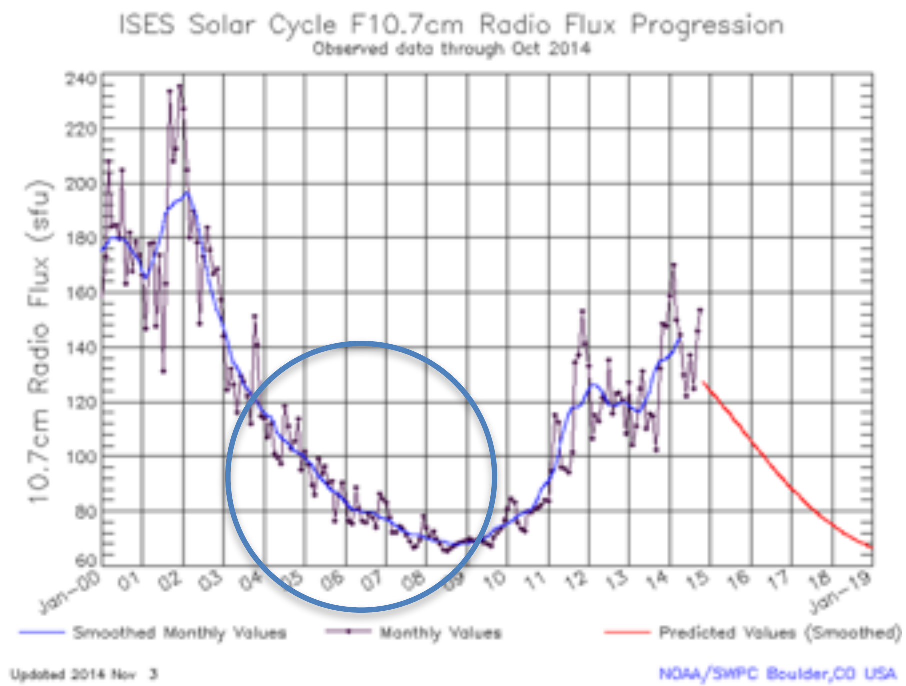

*fo*E is an important ionospheric parameter which directly affects the radio wave propagation through the ionosphere. It changes dramatically with the time of the day, month, season and variation in solar activity.

# Solar activities

## Sunspot number




## F10.7 centimeter



# International Reference Ionosphere

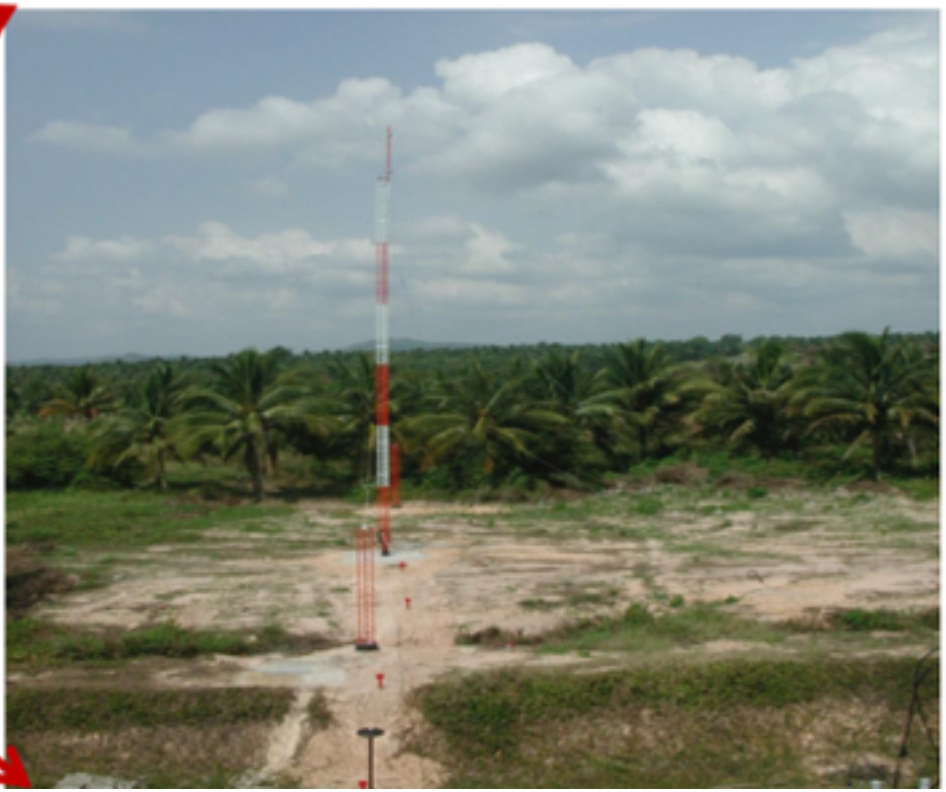

**The objective of this research is as a part of working towards improving the IRI over magnetic equatorial region**

# Methodology

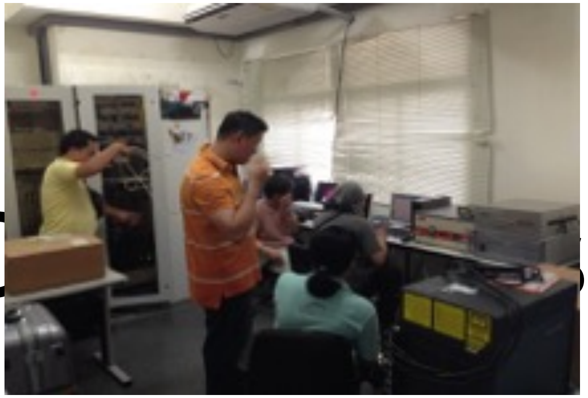
- Observation
- IRI Model

# Ionospheric Chumphon station

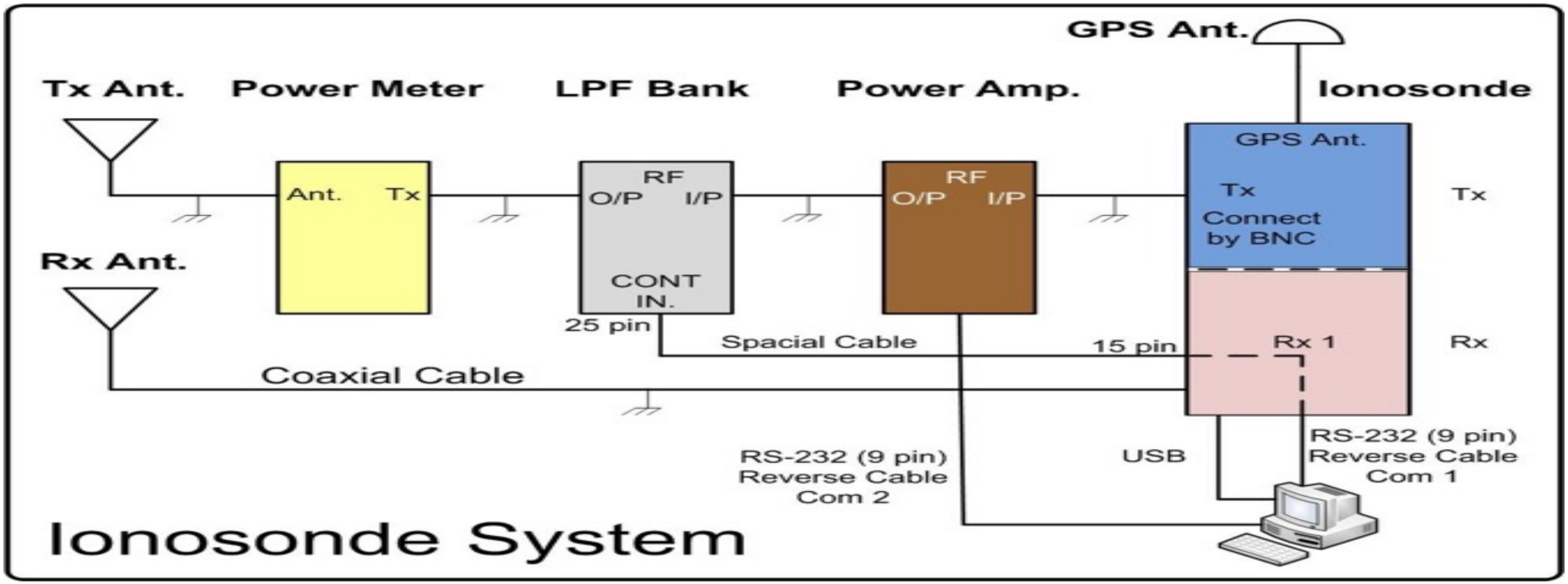

| Location | Latitude | Longitude | Geomagnetic Latitude |
|---|---|---|---|
| Chumphon | 10.72 °N | 99.37 °E | 3.00 ° |



# Ionospheric Chumphon station

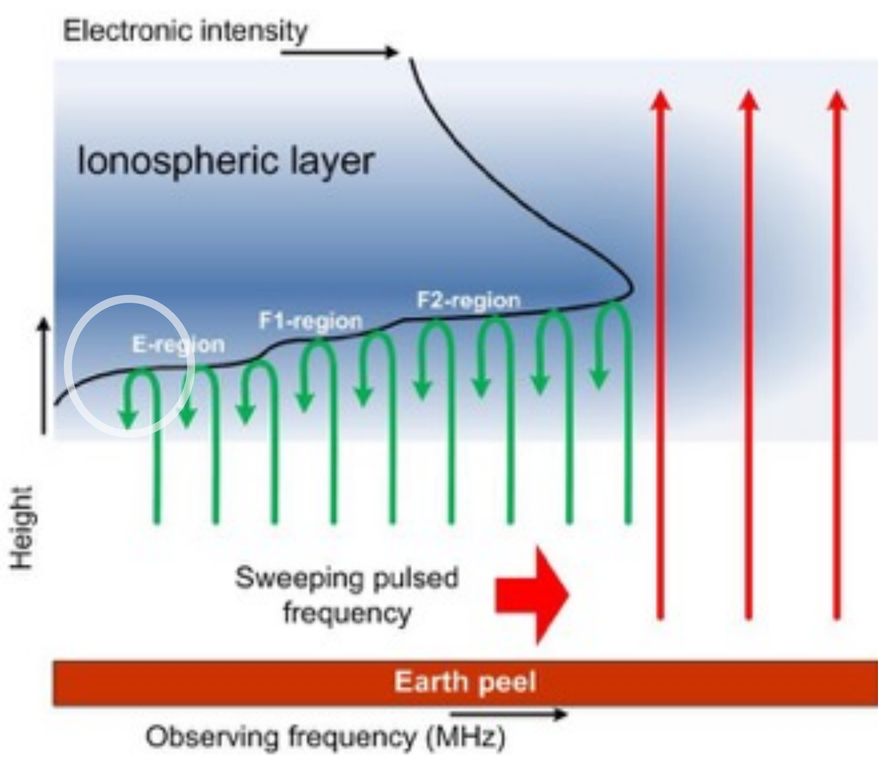



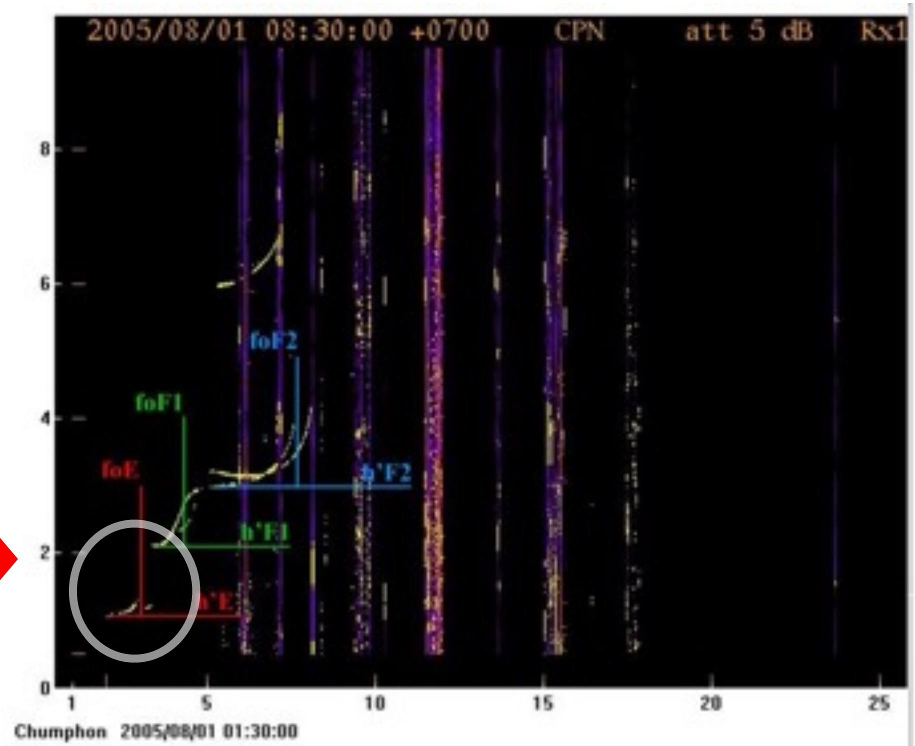
# Ionosonde




Source: "The variation of critical frequency of E layer over the magnetic equatorial region, Chumphon, Thailand." by Wongcharoen et al., 2013, *IRI2013 Workshop,* Poland.

# Parameters on ionogram



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# IRI 2012 MODEL

## 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**(1958-2017): 2000
Note:If date is outside the Ap index range (1958-2014/06/30), 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** on **Ne D-Region** IRI-95

**Te Topside** TBT-2012 **Ion Composition** RBV10/TTS03
Note: User may specify the following four parameters only for Profile type 'Height':
**F2 peak density (NmF2), cm$^{-3}$** ($10.^{3}$ - $10.^{8}$) or **F2 plasma frequency (foF2), MHz** (2.-14.): 0.
**F2 peak height (hmF2), km** (100. - 1000.) or **Propagation factor M(3000)F2** (1.5 - 4.): 0.
**E peak density (NmE), cm^-3** (20. - $10.^{5}$) or **E plasma frequency (foE), MHz** (0.1-14.): 0.
**E peak height (hmE), km** (70.-200.): 0.

**Independent Variables**

- Year
- Month
- Day of month
- Day of year
- Hour of day, UT/LT (depending on user's choice above)
- Solar zenith angle, degree
- Height, km
- Geographic/Geomagnetic Latitude, deg. (depending on user's choice above)
- Geographic/Geomagnetic Longitude, deg. (depending on user's choice above)
- CGM Latitude, deg.
- CGM Longitude, deg.
- Magnetic inclination (DIP), degree
- Modified dip latitude, degree
- Declination, degree
- InvDip, degree
- Dip latitude, degree
- MLT, hour

**IRI Model Parameters**

- Electron_density (Ne), m$^{-3}$
- Ratio of Ne and F2 peak density(Ne/NmF2)
- Neutral Temperature Tn, K
- Ion Temperature Ti, K
- Electron Temperature, Te, K
- Atomic Oxygen ions ($O^+$), percentage
- Atomic Hydrogen ($H^+$) ions, percentage
- Height of F2 peak (hmF2), km
- Height of F1 peak (hmF1), km
- Height of E peak (hmE), km
- Height of D peak (hmD), km
- Density of F2 peak (NmF2), m$^{-3}$
- Density of F1 peak (NmF1), m$^{-3}$
- Density of E peak (NmE), m$^{-3}$
- Density of D peak (NmD), m$^{-3}$
- Equatorial vertical ion drift, m/s
- Ratio of foF2 storm to foF2 quiet
- F1 probability
- Atomic Helium ($He^+$), ions, percentage
- Molecular Oxigen ($O_2^+$) ions, percentage
- Nitric Oxide ions ($NO^+$), percentage
- Cluster ions, percentage
- Atomic Nitrogen ($N^+$) ions, percentage
- Total Electron Content (TEC), $10^{16}$ m$^{-2}$
- TEC top, percentage
- Propagation factor M(3000)F2
- Bottomside thickness (B0), km
- Bottomside shape (B1)
- E-valley width, km
- E-valley depth (Nmin/NmE)
- F2 plasma frequency (foF2), MHz
- F1 plasma frequency (foF1), MHz
- E plasma frequency (foE), MHz
- D plasma frequency (foD), MHz
- CGM lat of auroral oval boundary
- Ratio foE storm to foE quiet
- Spread-F probability

**Indices used by the model**

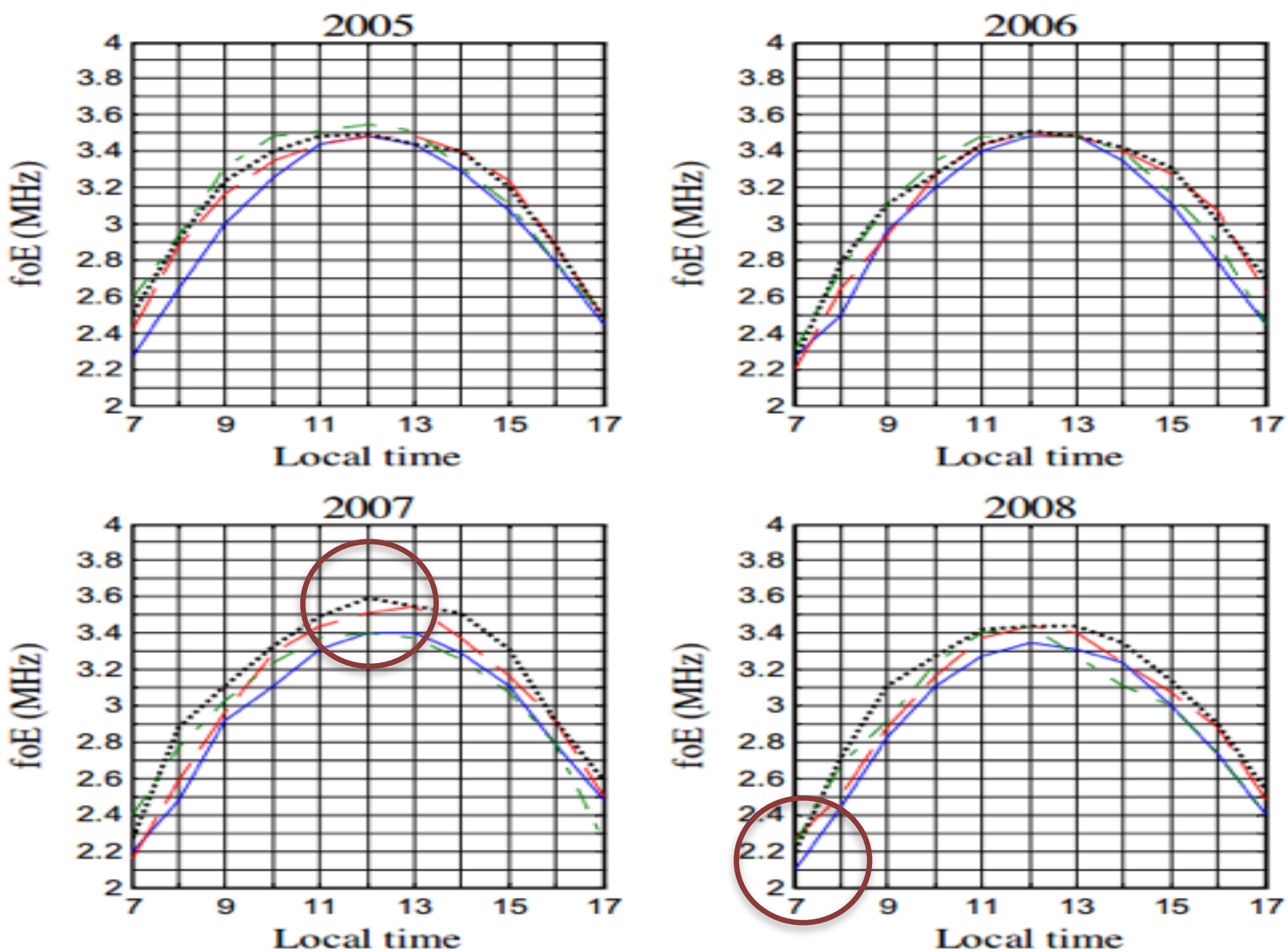
- 12-month running mean of sunspot number (Rz12)
- Ionospheric Index IG12
- Daily Solar Radio Flux F107D
- 81-day Solar Radio Flux F107_81D
- 3-h_ap
- daily_ap
- 3-h_kp

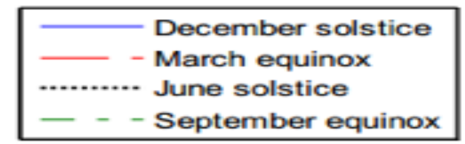
www.irimodel.org

# Results

- *fo*E variation
- *fo*E comparison
- Percentage of errors

# *fo*E variation

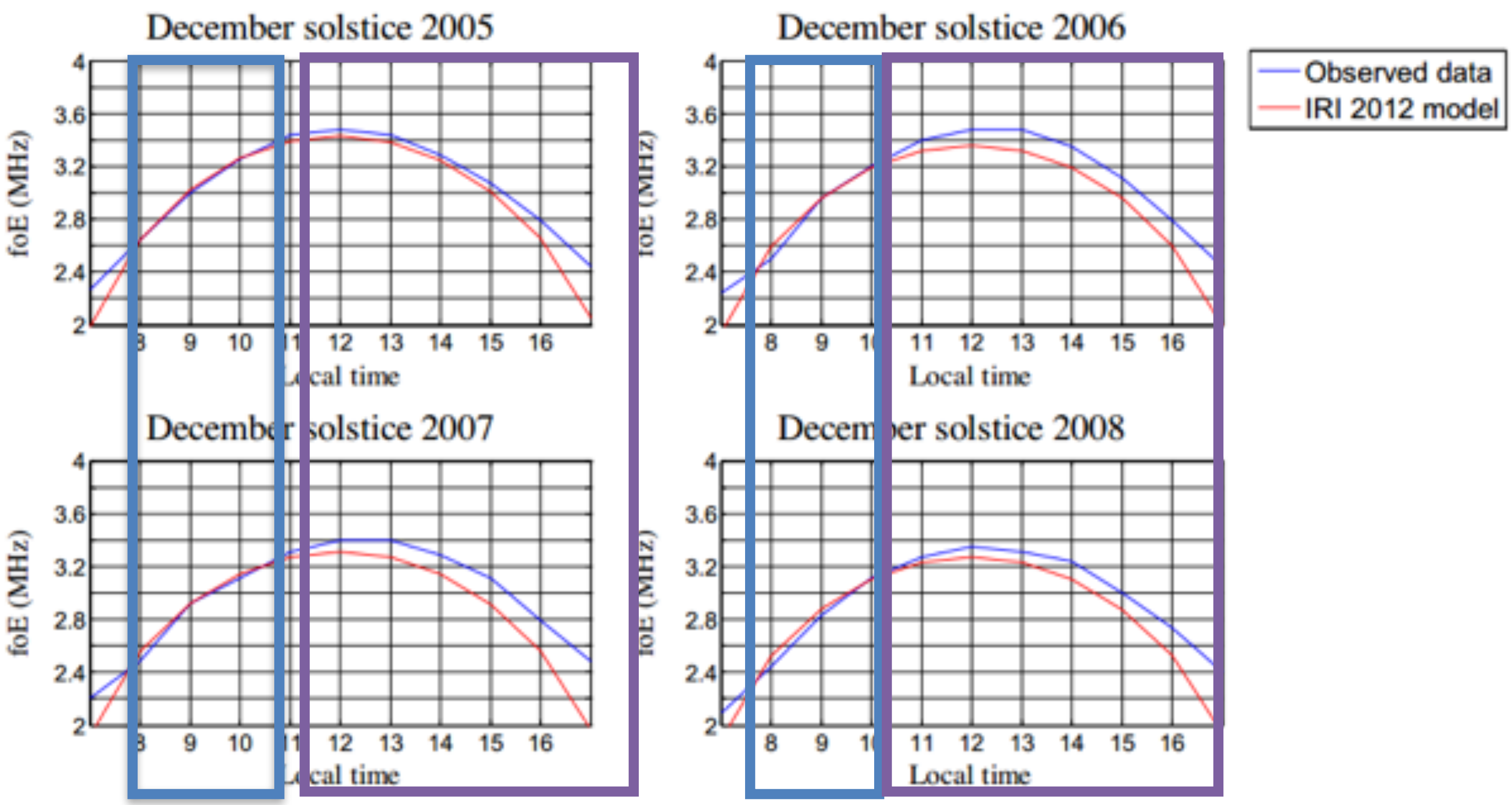




Wongcharoen, P., Kenpankho, P., Supnithi, P., Ishii, M., and Tsugawa, T., Comparison of E layer critical frequency over the Thai station Chumphon with IRI, *Advances in Space Research* xxx (2015) xxx–xxx.

# *fo*E comparison

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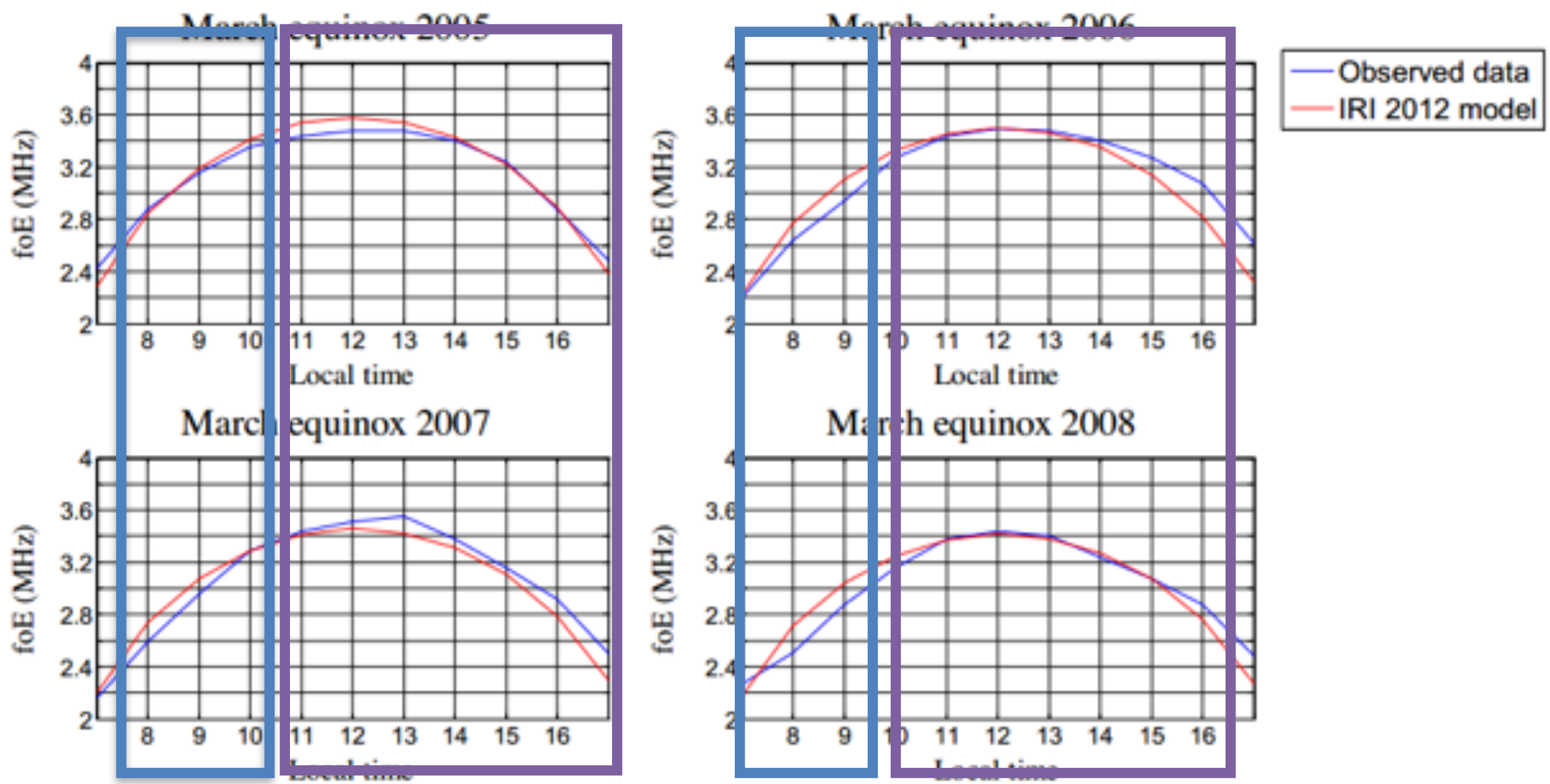


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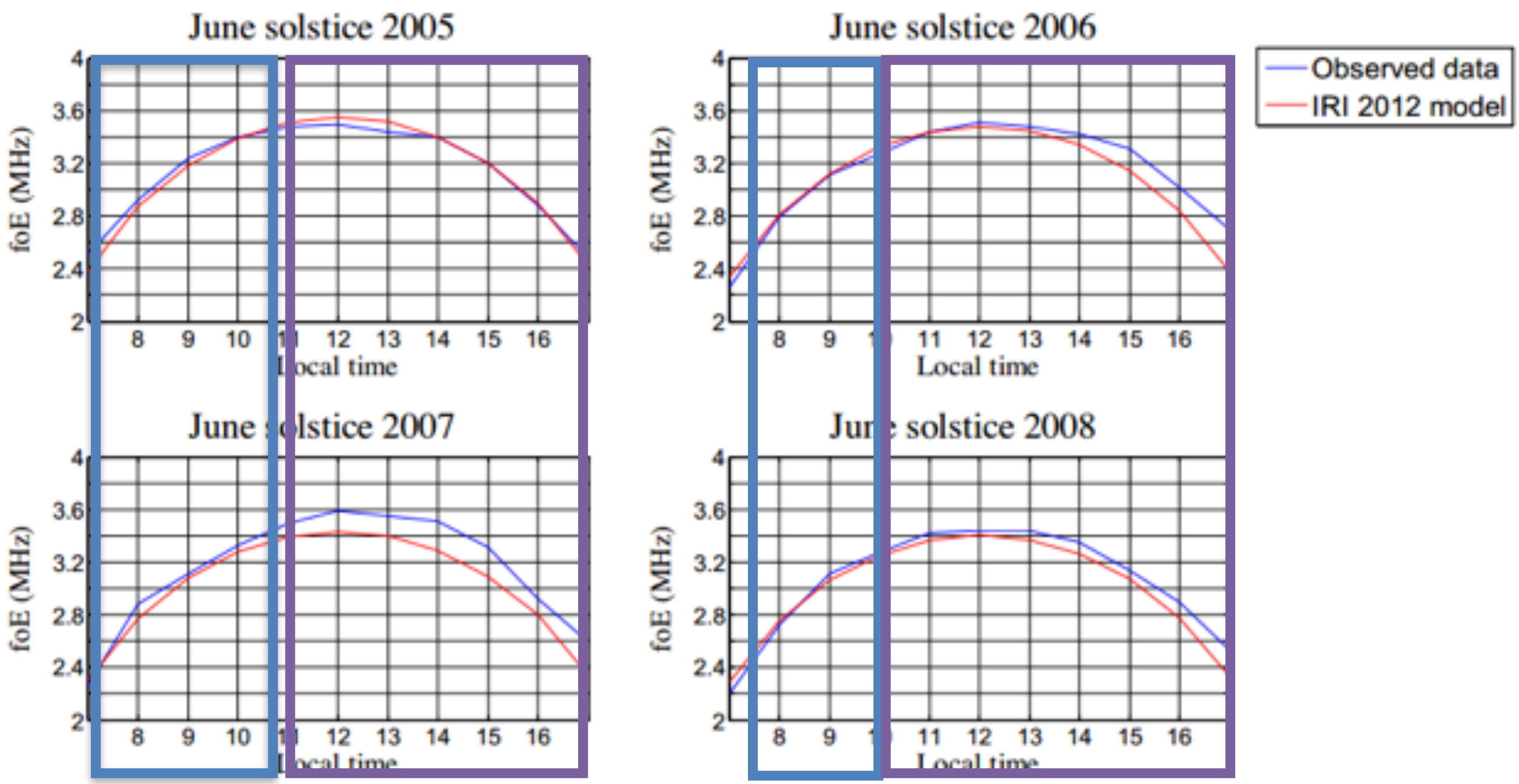


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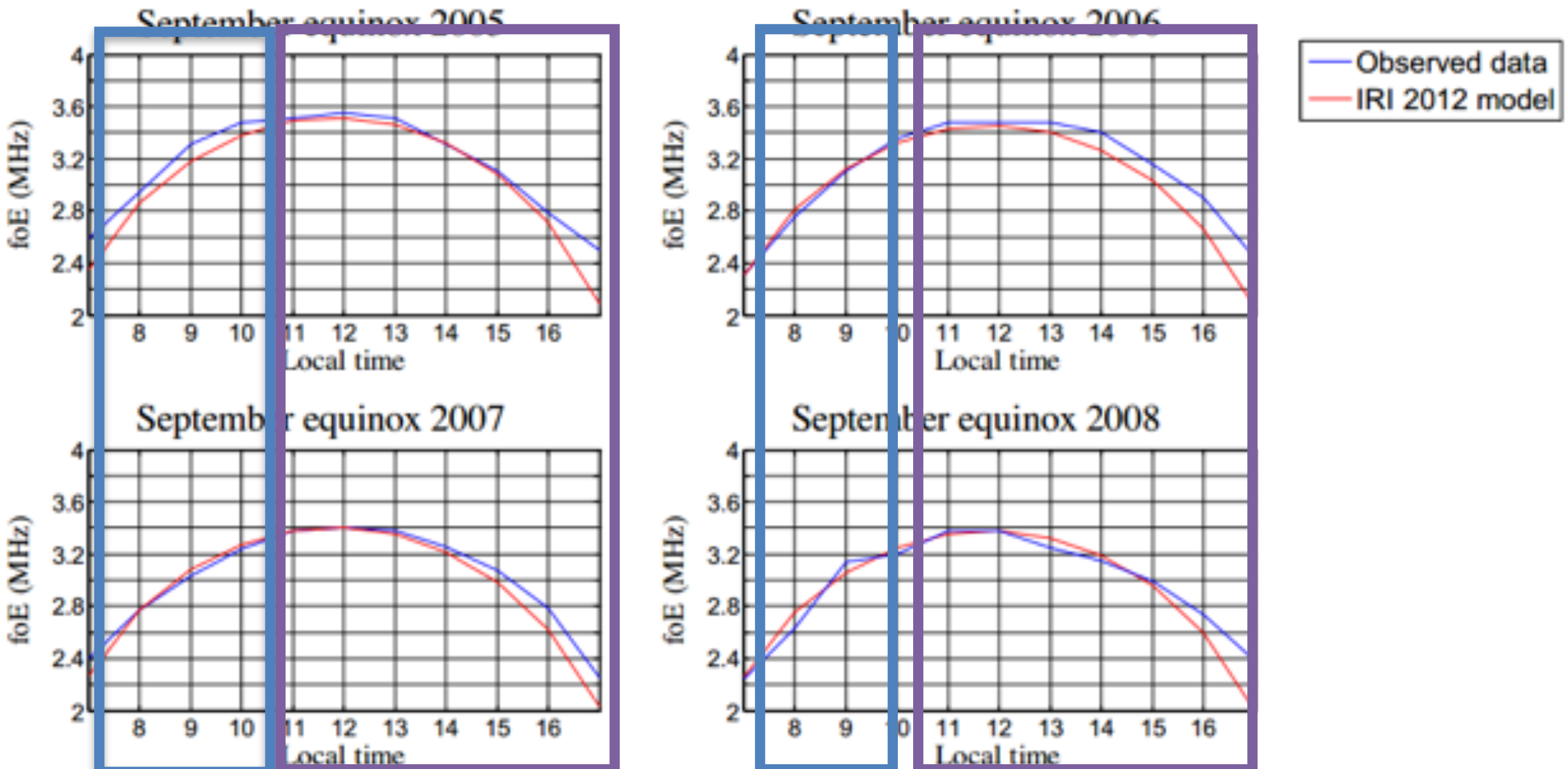


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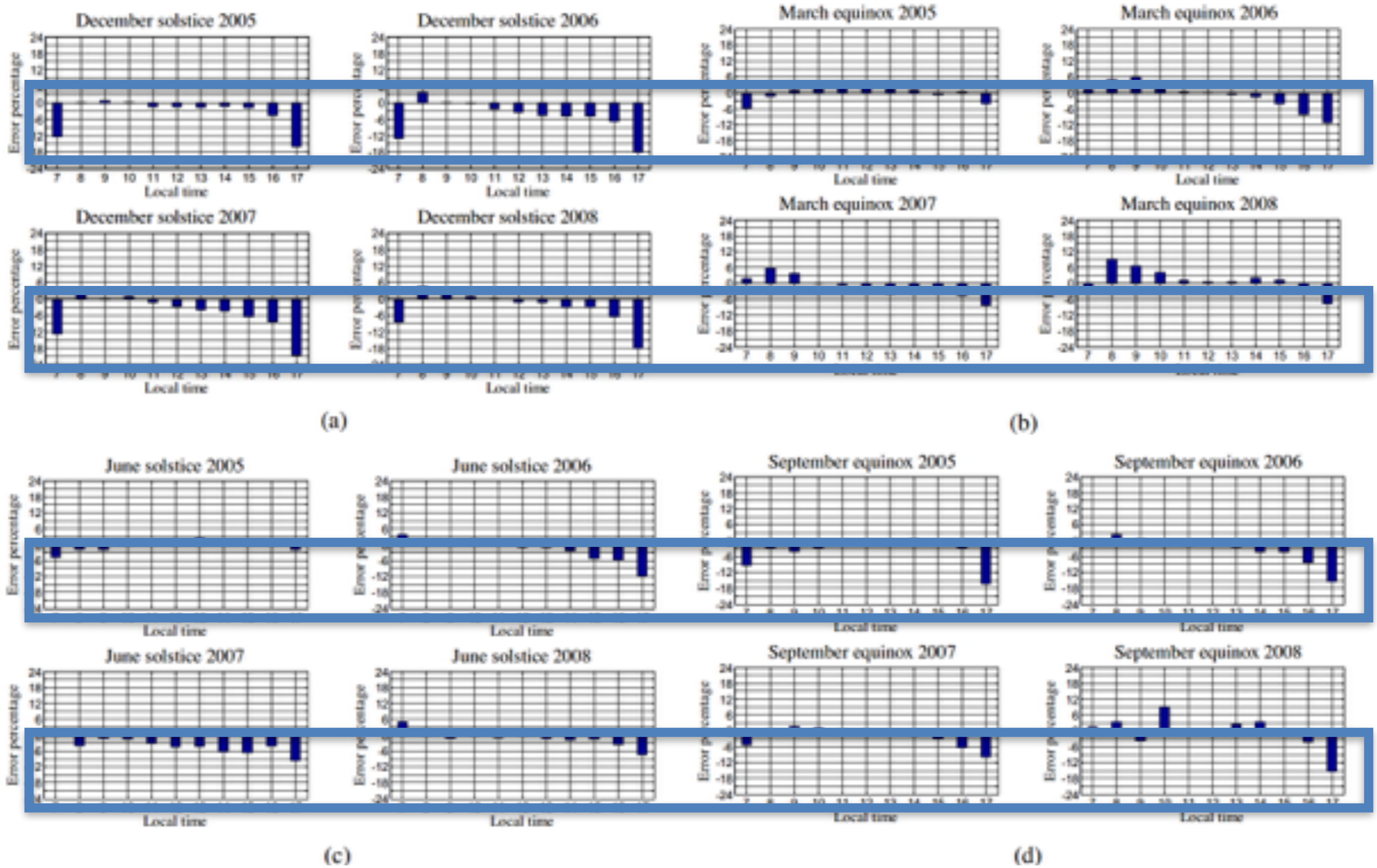
$$\%E = \left[ \frac{(foE_{IRI} - foE_{obs})}{foE_{obs}} \right] \times 100 \qquad (\%)$$

# Percentage of errors

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# Root mean square error (RMSE)

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(foE_{obs,i} - foE_{model,i})^2}{n}}$$

| Seasons | RMSE (MHz) | | | |
|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 |
| December solstice | 0.007 | 0.006 | 0.006 | 0.006 |
| March equinox | 0.008 | 0.008 | 0.011 | 0.007 |
| June solstice | 0.007 | 0.002 | 0.003 | 0.002 |
| September equinox | 0.030 | 0.008 | 0.003 | 0.003 |

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# Summary

- The *f*oE at equatorial ionosphere over Chumphon region increases with the increase in solar activity and declines as sun begins to moves towards dusk.
- The *f*oE reaches its maximum during local noon and decreases towards sunrise and sunset for all the seasons.
- For a declining phase of the solar cycle (2005-2008), IRI predicts the Chumphon *f*oE measurements quite well, closely following the diurnal variation of the data.
- The largest *f*oE differences are found during sunrise and sunset indicating that IRI may not accurately represent the actual sunrise and sunset times. Since IRI is an average model, the sunrise and sunset times are also averages over the season and altitude range.

Wongcharoen, P., Kenpankho, P., Supnithi, P., Ishii, M., and Tsugawa, T., Comparison of E layer critical frequency over the Thai station Chumphon with IRI, *Advances in Space Research* xxx (2015) xxx–xxx.

We look forward to working with all of you!

# THANK YOU VERY MUCH FOR YOUR ATTENTION.