Variation of $N_{m}F_{2}$ and $h_{m}F_{2}$ deduced from DPS-4 over Multan (Pakistan) and their comparisons with IRI-2007 & IRI-2012 during the deep solar minimum between 23rd and 24th solar cycles

Muhammad Ayyaz Ameen, Kazim Raza & Muhammad Ayub

Pakistan Space & Upper Atmosphere Research Commission (SUPARCO)
Space Weather Monitoring in Pakistan

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Total</td>
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<td>Water (%)</td>
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<table>
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<th>Population</th>
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<td>2014 estimate</td>
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<td>2013 estimate</td>
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Wikipedia

17 October 2014
COSPAR 2014 Moscow, Russia
Pakistan - at GIRO
History of Multan Station

• An ionospheric station was established at Multan in the vicinity of Bahauddin Zakaria University in 1987 to cover the east-central part of the country. An old PIR-9 was shifted to Multan

• DPS-4 was installed at Multan in April 2008
From analogue to digital
Some initial ionograms
Foreword

Digisonde DPS-4 data of Multan (geog coord. 30.18°N, 71.48°E) is being reported for the first time. The variations in F$_2$-layer peak electron density $N_mF_2$ and its height $h_mF_2$ have been studied during the deep solar minimum between 23rd and 24th solar cycles along their comparisons with IRI-2007 & IRI-2012 predications.
Introduction

• The recent solar minimum was different
  – as it lasted for longer than the usual and
  – it was a deep solar minimum

• Period of study May 2008 – Apr 2009 (SSN<4)

• The two objectives of present study are
  – reporting the Multan DPS-4 data and
  – their comparison with two versions of IRI
Methodology

• $N_m F_2$ is calculated from the critical plasma frequency, $f_o F_2$, of the $F_2$-layer by

$$N_m F_2 \text{ (el-m}^{-3}) = 1.24 \times 10^{10} \times (f_o F_2/\text{MHz})^2$$

• $h_m F_2$ values are obtained from SAO-X which are based upon true height profile inversion algorithm.

• For the investigation of $F_2$-layer behaviours under deep solar minimum, the data under geomagnetic quiet-conditions from May 2008 to April 2009 are selected
# IQD & IDD

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</table>
Methodology

• The modelled values $h_m F_2$ and $N_m F_2$ are predicted by the IRI-2007 and IRI-2012.

• $h_m F_2$ is modelled through its close correlation with the propagation factor $M(3000)F_2$.

• Mapping options

<table>
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<tr>
<th>Parameters</th>
<th>IRI-2007</th>
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<tr>
<td>$N_m F_2$</td>
<td>CCIR, URSI</td>
<td>CCIR, URSI</td>
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<tr>
<td>$h_m F_2$</td>
<td>CCIR</td>
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</table>
Methodology

• It is noted that the IRI uses ionosphere-effective IG_{12} to predict N_{m}F_{2} (f_{o}F_{2}) and the sunspot number, R_{z12} for h_{m}F_{2}.

• Moreover, the observed A_{p} and F_{10.7} indices are used in the IRI modelling for month-to-month variability.

• Since the ionosphere can be disturbed even under quiet magnetic conditions, therefore monthly hourly observed and modelled data under geomagnetic quiet-conditions are applied in this study.
$N_m F_2$ over Multan for Equinox
\( N_m F_2 \) over Multan for Winter

![Graph of \( N_m F_2 \) over Multan for Winter with LT on the x-axis and \( N_m F_2 (m^{-3}) \times 10^{10} \) on the y-axis, showing data points for Nov.08, Dec.08, Jan.09, Feb.09, and the median.]

**Source:** SUPARCO
$N_{m}F_2$ over Multan for Summer
$h_m F_2$ over Multan for Equinox

Mar.09  Apr.09  Sept.08  Oct.08  Median

$h_m F_2$ (km)

LT

10 October 2014
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$h_m F_2$ over Multan for Winter

May.08  Jun.08  Jul.08  Aug.08  Median

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$h_mF_2$ over Multan for Summer

**Graph:**
- Nov.08
- Dec.08
- Jan.09
- Feb.09
- Median

**Axes:**
- $h_mF_2$ (km) on the y-axis.
- LT (local time) on the x-axis.

**Key Points:**
- The graph shows the variation of $h_mF_2$ over Multan from November 2008 to February 2009.
- The median values are indicated by a blue line.

**Context:**
- Image from the COSPAR 2014 conference.
- Reconstruction from the extracted text.
$N_mF_2$ comparison with IRI-2007
$N_m F_2$ comparison with IRI-2012

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$h_m F_2$ comparison with IRI-2007
$h_m F_2$ comparison with IRI-2012
Results & Conclusion

• The observation results show that the $N_{m}F_2$ values are greater and smaller during daytime and nighttime, respectively.

• The $h_{m}F_2$ observations show sunrise peaks along with some prominent pre-sunrise peaks in some months.

• Seasonal variations show that the daytime $N_{m}F_2$ are greater in the equinox and summer months, while the daytime $h_{m}F_2$ are slightly greater in the equinox and winter months.

• Comparison of observations with IRI (next slide)
Results & Conclusion

– The observed $h_m F_2$ values are closer to IRI-2007 than to IRI-2012.
– The $N_m F_2$ of URSI map of IRI-2012 agrees well with the observations in equinox.
– The IRI-2007 agrees better with the $N_m F_2$ observations for winter and summer than IRI-2012, whereas IRI-2012 is closer to the observations for equinox months.

• Since Multan lies at the verge of low and mid-latitude and hence both $E\times B$ drifts and thermospheric winds are affecting the location
спасибо

17 October 2014
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