A study on the behavior of Ionosphere with 205 MHz ST Wind Profiler Radar at Cochin coastal region

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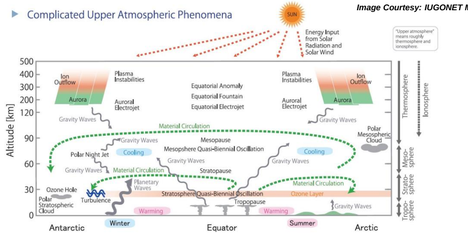
Introduction

Electromagnetic waves have been used for over 4 decades to study ionospheric density irregularities. Ionosphere is a region of atmosphere where the ions exists, in combined state, electrically neutral in most of the areas. Although ions give their name to the region, free electrons actually affect radio waves. The number of electrons start to increase at an altitude of about 30 km, but the electron density isn't sufficient to affect radio waves until about 60 km. For the convenience for many explanations, the ionosphere is splited into number of distinct layers, but they are not entirely accurate as the entire ionosphere contains ionized molecules (and free electrons).

Image Courtesy: IUGONET Magazine



Overview and Background

Preliminary observation on the layers of ionosphere, their behavior during different seasons (present study was conducted during Northern Hemisphere summer and the equinox period) was carried out during day and night, using the newly established World's first Stratosphere Troposphere Wind Profiler Radar operating at 205 MHz located at Cochin (10.04°N, 76.33°E) India, which is configured in Doppler Beam Steering (DBS) mode. The Radar beam is tilted 8° towards North (Geomagnetic latitude 1.72°N, 149.66°E) so that it is perpendicular to magnetic field at the Radar location.

The radar has the beam steering capability to scan up to ±30° in any direction. The radar system employs an Active Phased Antenna Array with 0.3 MW peak power consisting of 619 Transmit Receive modules. 0.73 m irregularities was observed with ST Radar. Power spectra were obtained in every 5 second with a range resolution of 45 m.

Experimental Setup:

Radar was operated continuously in a particular configuration covering the height from 90 to 350 km with a height resolution of 45 m in which the ionospheric disturbances were observed. The radar was operated during the period April to August 2017.

Calculation of Inclination Angle (*Ref: WMM2015 & IGRF12*)

Magnetic Field

Model Used:	WMM2015
Latitude:	10.04° N
Longitude:	76.33° E
Elevation:	143.0 m GPS

Date	Declination (+ E | - W)	Inclination (+ D | - U)	Horizontal Intensity	North Comp (+ N | - S)	East Comp (+ E | - W)	Vertical Comp (+ D | - U)	Total Field
2017-08-08	-1.6981°	7.0622°	40,235.0 nT	40,217.4 nT	-1,192.3 nT	4,984.6 nT	40,542.6 nT
Change/year	0.0712°/yr	0.1233°/yr	22.7 nT/yr	24.1 nT/yr	49.3 nT/yr	90.7 nT/yr	33.6 nT/yr
Uncertainty	0.28°	0.22°	133 nT	138 nT	89 nT	165 nT	152 nT

Observations

Parameters set for the observation of Ionosphere Echoes between altitude range 90 to 110 km are given below.

Table:1. Experiment Configuration (90 to 110 km)

S. No:	Parameter	Value
1	Operating Frequency	205MHz
2	No. of Antenna Elements	619
3	Radiated Peak Power (approx.)	327kW
4	PRF	1300Hz
5	Baud	0.3µs
6	Code Length	64 bit
7	Pulse Width	19.2 µs
8	Duty Ratio	2.50%
9	No. of Coherent Integration (NCI)	2
10	No. of FFT (NFFT)	1024
11	No. of Spectral Averages (NSA)	1
12	Start Height	90km
13	Stop Height	110km
14	Beam Directions	0° Azimuth 8° Off-Zenith
15	MGC Gain	30
16	Doppler Span	±325Hz
17	Mode of Operation	Coded – Complementary
18	Beam Dwell Time	2 s

The 3D Power spectra, 2D Spectra and its corresponding SNR during the observation period are shown below.

Fig:1. 24 May 2017 17:30:00 to 19:30:00 Hrs.

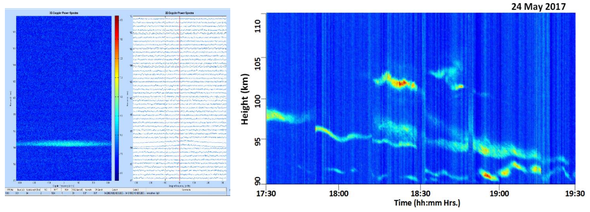


Fig:2. 29 June 2017 9:30:00 to 11:30:00 Hrs.

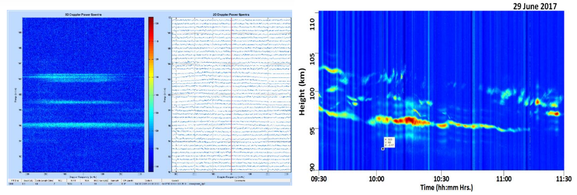


Fig:3. 07 July 2017 15:00:00 to 17:00:00 Hrs.

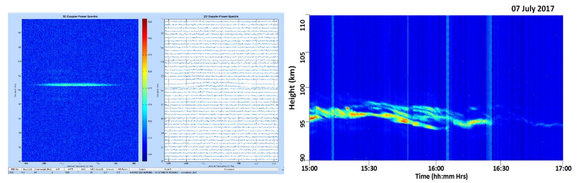
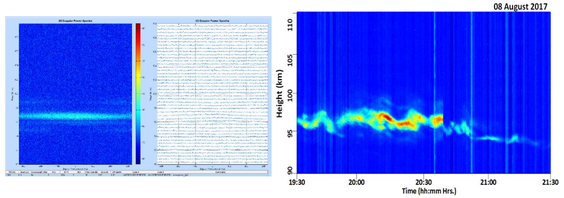


Fig:4 08 August 2017 19:30:00 to 21:30:00 Hrs.

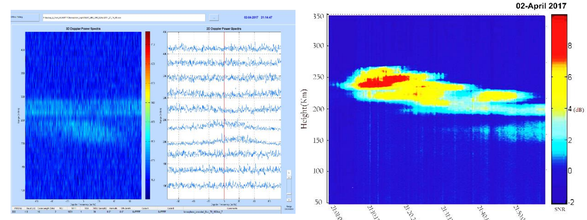


Radar operated on 2nd April 2017 covering the height from 50 to 350 km with an un-coded mode of operation. Parameters set for the observation are given below.

Table: 2. Experiment Configuration (50 to 350 km)

S. No:	Parameter	Value
1	Operating Frequency	205MHz
2	No. of Antenna Elements	619
3	Radiated Peak Power (approx.)	327kW
4	PRF	300Hz
5	Baud	4.8µs
6	Code Length	16 bit
7	Pulse Width	76.8 µs
8	Duty Ratio	2.30%
9	No. of Coherent Integration (NCI)	2
10	No. of FFT (NFFT)	1024
11	No. of Spectral Averages (NSA)	1
12	Start Height	50km
13	Stop Height	350km
14	Beam Directions	0° Azimuth 8° Off-Zenith
15	MGC Gain	30
16	Doppler Span	±75Hz
17	Mode of Operation	Uncoded
18	Beam Dwell Time	7 s

Fig:5. 2-April-2017:21:00:00 to 21:30:00 Hrs



Conclusions

Ionosphere experiments with a newly developed wind profiler Radar at 205 MHz was conducted for different altitudes within the Ionosphere. These are the first observations of the ionospheric disturbances from 205 MHz frequency. More experiments on the same for different seasons are required to explain the mechanism behind ionospheric irregularities.

References

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