Velocity determination of plasma depletion with all-sky airglow 630nm images using Horizontal Pixel Mean method over Gadanki

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***Abstract*—**We analyzed all-sky imager airglow 630nm emission data during the month of January 2016from Gadanki (13.5^0N, 72.9^0E), Indian low latitude region. The Horizontal Pixel Mean method is used to determine velocity. In this method the horizontal pixels of each row are divided into some groups as five pixels per group and average value of each group is considered as single pixel. We also observed movements and their directions of plasma bubbles. Experimental values of seven days data when the sky is clear and compared with previous method usd for calculating various plasma depletions. Plasma patterns are very clear and correct movement of plain plasma bubbles are observed. We also prominent that the variations between measurements of our method and previous cross correlation and Keogram models.

Keywords*—Airglow, Enhancement, Morphological opening, Horizontal Pixel Mean, Plasma depletion*

I. INTRODUCTION

Irregularities of the equatorial spread F (ESF) occurring on low latitude ionosphere and night side of the equatorial has been learned for number of decades using different variety of instruments [1]. The optical patterns of equatorial plasma bubbles (EPBs) depletion were initially discovered by measurements of in-situ satellite [2], [3]. Based on many studies using data from ground based techniques, it is accepted that the 630nm(OI) emissions are generated at F-region heights (250Km to 300Km). The emission of OI 630nm is closely belongs to electron density of the F-region [4-]-[6]. During the plasma depletion expansion the velocity of plasma with in a bubble is dissimilar from ambient plasma velocity. Earlier analysis of Sharma et al.[7] presented seasonal verity and characteristics of EPBs. The aim of present study is to measure plasma characteristics in easy way using HPM method to get correct plasma patterns and exact values of drift velocities of plasma depletion. However, there are additionally as many reports indicate that midnight drift velocities have some positive correlation along with solar activities [8]. We studied the possibilities of such causes small duration data of velocities of EPBs drift and monitored time stretches of EPBs. Then the studied zonal drift velocities of plasma bubbles are compared with velocities obtained with various earlier methods..

II. INSTRUMENTATION

The instrument exploited in present investigation is an airglow night all-sky imager placed at National Atmospheric Research Laboratory, Gadanki called as NAI (NARL All-Sky Imager) The NAI accumulate the radiation through a fisheye lens and a set of Plano-convex lenses and supervises OH, OI557.7nm, and OI630nm night airglow emissions with interference filters placed in a wheel of temperature controlled filter. The filter wheel movement is synchronized with the detector operation of charge coupled devise (CCD).These functions are computerized with the software called menu driven software. The CCD camera employs an illuminated 1K×1K pixel CCD (i.e. Action Pixis 1024B) of size 13.3 µm, full fill factor, and the depth of 16 bit. To increase the signal to noise ratio, all the images are binned for 2×2 pixels on the chip building an effective 512×512 super pixel image. Depending on the background luminosity, transmission of interference filter and actual brightness of airglow, at present we depict the OH filter for 16 seconds, The OI 557.7nm and OI630nm filters are descript for 95 second each. We limit the image field of view to 117^0 to pass up nonlinearity. All details about NAI, analysis system is explained by Taori et. al.[9]. In this paper we only presented new HPM method for calculating the exact drift velocities of IO630nm plasma bubbles/depletion of ionosphere emissions.

III. PROPOSED METHOD

In this proposed method we explained all imaging steps of 630nm (OI) airglow images to manipulate characteristics and behavior of plasma depletion which contains direction of movements of radiation patterns of plasma and their drift velocity measurements. First of all the OI (630nm) of size 512×512 images are collected from NARL which are already captured by NAI instrument. The raw image which is as shown in figure1 is a dark image and cannot be able to identify any features. To observe plasma features/patterns on the image we enhanced the image using concept of contrast adjustment. The algorithm for proposed method is neatly offered in table1.

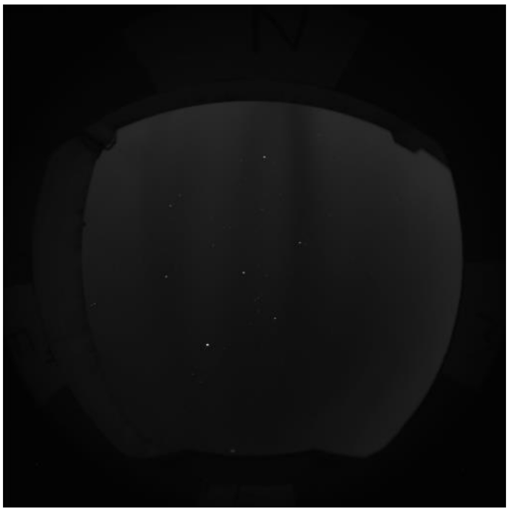


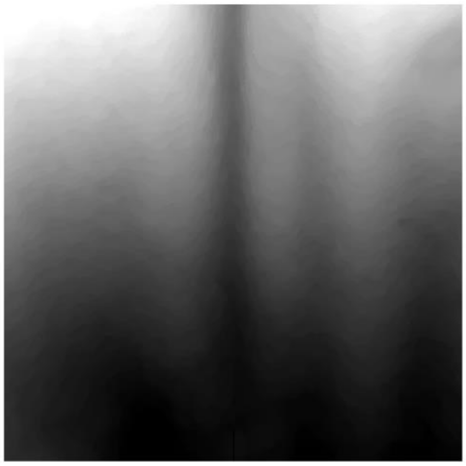
Figure1: The raw image of OI(630nm) of the size 512×512 captured on 4th January 2016 at the Universal Time (UT) of 171924 hours.

Table 1

Step1:	512×512 pixel size image is cropped as 330×330 pixel size to delete extra portion other than airglow region.
Step2	330×330 pixel size image is enhanced by adjusting contrast.
Step3	Enhanced image is converted from geometrical coordinating system to actual rectilinear coordinating system.
Step4	Whole enhanced image is converted as 330×32 pixel size image using HPM method
Step5	Observe consecutive plasma pattern positions in consecutive images
Step6	Finding the drift velocity and direction of movement of plasma bubbles.

Useless portion around airglow image on four sides belongs to walls where imager is installed, street lights near the imager location is deleted using Matlab2013a commands. The cropped/image with airglow region is of the size 330×330 after removing unwanted potion. Then that cropped portion of the image is enhanced by adjusting as low intensity gray values into very low or zero levels and high intensity gray values into very high levels to make the image visible to human eyes.. The enhanced image is captured by fisheye lens. So, all the pixels of this image are in spherical coordinating system. The spherical coordinating image is converted in to rectilinear and pixel resolution is calculated using Kubota et al/ [10] as shown in figure2(a-b) for deferent timings.

(a)



(b)

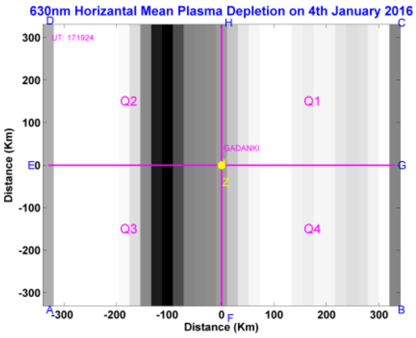
Figur2. Enhanced version of rectilinear 630nm plasma depletion images (a) 630nm image captured at 171924 UT (b) 630nm image captured at 172704 UT

To get correct patterns of plasma, we divide every row of rectilinear image into 32 groups of 10 pixels each. We also find mean values of all groups and which are arranged in same row which is known as horizontal pixel mean (HPM) image. Spatial calibration is done for all the images to get pixel resolution. Full details of spatial calibration for the image are explained by Lakhsminarayana et al. [11]. The spatial calibrated HPM image of size330×32 is shown in figure4. The black vertical patterns in figure 3(a) and 3(b) represents movement of plasma bubbles in different timings. The drift velocity of plasma depletions can be calculated as the ratio of difference of pixel positions of plasma patterns in any two images to their difference of corresponding capture timings. If the position of plasma pattern of first image is (x1, y1) with captured time t1 and the position of same pattern in the second image is (x2, y2) with captured time t2 then travelling distance 'd', time difference 'td' and drift speed 'vd' of the plasma depletion are defines as

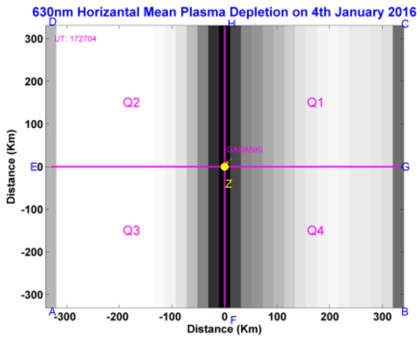
$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (1)$$

$$t_d = (t_2 - t_1) \quad (2)$$

$$v_d = \frac{d}{t_d} \quad (3)$$



(a)



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(b)

Figure 3. HPM plasma depletion patterns offigure3 at (a) 171924 UT and (b) 172704 UT

We divide whole HPM image into four equal parts as four equal quadrants to identify plasma movements and to indicate imager location. Yellow circle indicates location of imager(i.e. Gadanki).We observed positions of plasma patterns (i.e. black vertical bars) on the horizontal line and calculated travelling distance of plasma bubbles. The direction of the movement of the plasma bubbles/depletion is clearly observed as West to East direction. The pixel resolution for actual enhanced image (figure2) is 2.0 Km and for the horizontal distance of each pixel in HPM image is 20.0 Km. The drift velocity is obtained approximately as as 168.06 m/s.

IV. RESULTS AND DISCUSSION

Plasma drift velocities for seven days in January 2016 when sky is cleared are measured and sample HPM plasma depletion images are shown in figure3. A plasma pattern (i.e. vertical black bar) is located at -110Km in horizontal line at the UT 171924 for the first image [figure3 (a)]. The same pattern is located in the next image at -30Km in the same horizontal line at UT 172404 [figure3 (b)]. The distance between these two patterns is 80Km and time difference is 278 seconds. Then the drift velocity of plasma is 287.7 m/s. The drift velocity values in 4th January at different timings are tabulated in table2. These values are compared with the existing values obtained by cross correlation method [9] and Keogram method [12].The drift/ speed of the plasma bubbles at 141054 UT is 210m/s in proposed method, 215.5m/s in cross correlation (CC) method and 220m/s for Keogram (KG) method. The same drift speeds at 161950 UT are 167.71m/s, 171.5m/s and 173m/s in proposed, CC and KG methods respectively. At 171924 UT these values are increased and obtained as 362m/, 363.5m/s and 278.7m/s for CC, KG and proposed method. Moreover, the movements of plasma bubbles are again decreased with drift speed 146.5m/s, 137m/s and 125.78m/s for CC, KG and proposed methods respectively. We get approximately same results for all the methods.

Table 2

Drift velocities of plasma bubbles on 4th January 2016

Universal time in (hh-mm-ss)	Cross correlation method (m/s)	Keogram method (m/s)	Proposed method (m/s)
141054	215.5	220	210.08
150821	180.5	175	195.05
161950	171.5	173	167.71
171924	362	345.5	278.7
180821	110.5	115	125.78

After comparison of drift velocities in the above three methods the proposed method values are almost less and approximately same as previous method values. The graphical analysis of plasma behavior at different instant of times using CC, KG and HPM (proposed) method is shown in figure4.

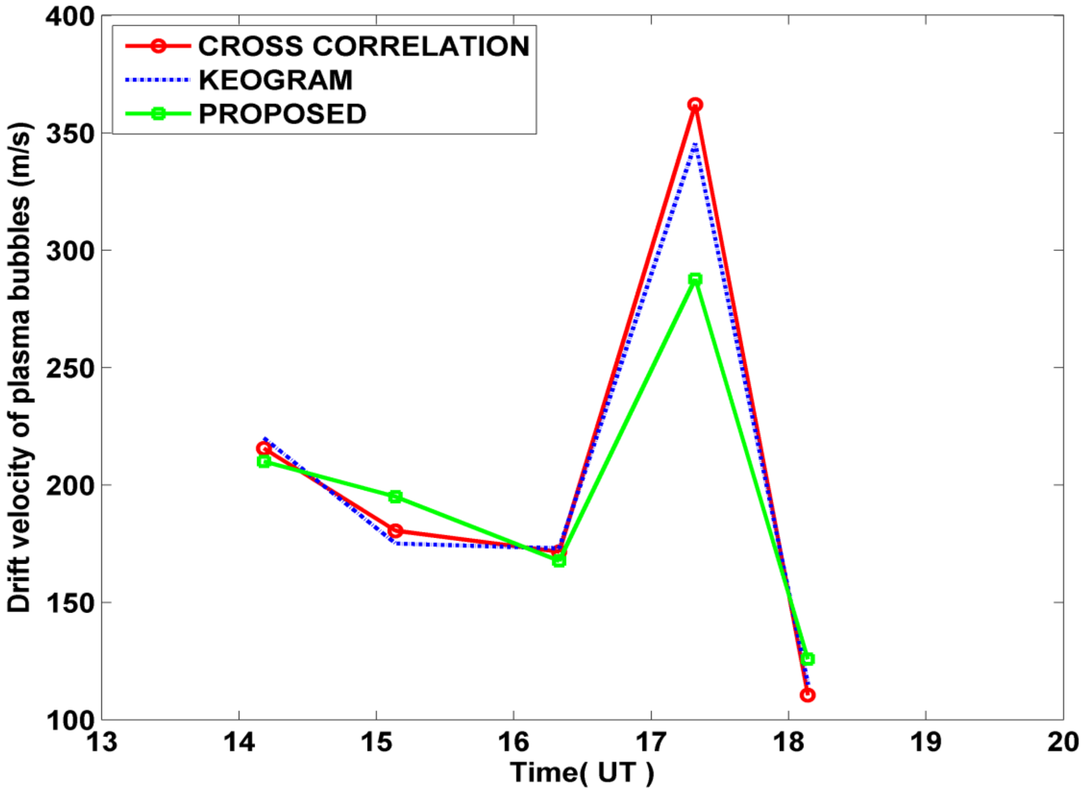

Figure4. Comparison of plasma drift velocity estimates using cross correlation method , Keogram method and horizontal .pixel mean method

It is prominent that there is good conformity in drift velocity estimates attained by horizontal pixel mean method. It is also noted that the HPM method has less variability than other methods.

V. RESULTS AND DISCUSSION

We have revealed that the data of an airglow image of one night in the given day is not less than 125 images can be represented in simple horizontal pixel mean maps. The obtainable values with image-by-image analysis and keogram analysis and also determined with the help of horizontal pixel mean method. This type of analysis of airglow atmospheric data is most important for recognizing the existing variations in long database. We understand that this method is a best and imperative for the community.

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