# Artificial Neural Network Applied in AIP Data

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## Abstract

Equatorial plasma bubbles are elongated depletions of ionospheric plasma density that occur during the local nighttime in the low latitudes, and can cause significant scintillation in trans-ionospheric satellite navigation and communications signals. One of the ionospheric plasma bubbles formation mechanisms is known to be large positive vertical plasma number density gradients and large vertical plasma drift during the night time. The Advanced Ionospheric Probe (AIP), a piggyback science payload developed by National Central University for FORMOSAT-5 satellite to explore space weather and seismic precursors associated with strong earthquakes, is an all-in-one plasma sensor that measures ionospheric plasma concentrations, velocities, and temperatures in a time-sharing way and is capable of measuring ionospheric plasma irregularities. In this study, the AIP data could be used for examine the relation between plasma bubbles, vertical plasma drift, and other geophysical indices by artificial neural network, creating a model that can compute the plasma number density standard deviation expected for a corresponding season, longitude, latitude, solar activity index and vertical plasma drift velocity.

Key word: plasma bubble, AIP, artificial neural network, vertical plasma drift

## 1.Introduction

Plasma bubbles are a species of ionospheric irregularity, forming in the low latitudes during the local nighttime. After the F region loses dissociation of sunlight, plasma in the lower level starts to revert to neutral because of β-type loss, while upper level not existing enough neutral particles, remain fairly more charged particles. In this case, the upper F region has greater plasma number density than lower, forming the Rayleigh–Taylor instability. Once the gravity waves that spread from the lower atmosphere had reached the unstable area, it may bring about a severe disturbance, becoming plasma bubbles, causing a great error ranging from GNSS position and interfering the communication between satellites and ground stations.

Advanced Ionospheric Probe (AIP), installed on FORMOSAT-5, was designed to measure the properties of plasma bubbles, it can provide the science data in 720 km height, F region. These data cover up all longitude for middle and low latitude in the same local time, combining with the F10.7 index (2800 MHz), we could create a preliminary model via Artificial Neural Network (ANN). ANN can examine the relationship between plasma bubbles, vertical plasma drift, and other geophysical indices, also, giving a reference value of grid standard deviation expected for a corresponding season, longitude, latitude, solar activity index and vertical plasma drift velocity.

## 2.Data Processing

Adopted data period is from 307 (day of year), 2017 to 181, 2019, including 1111 files , each file has data from a few orbit periods, and ion number density from each orbit period will be detrended by reference smooth function. After ion number density has been detrended, calculate the standard deviation of each grid divided by longitude and latitude, and it will become a training importation of ANN.

In order to improve the quality of ANN training results, filtering out defective data points would be necessary. The outliers and constant value may lead to a divergent result, besides, FORMOSAT-5 comply attitude transform while entering a high latitude area which is not the investigation target in this plan, in this case, any data latitude bigger than 45 degree will be deleted. Another problem is the outliers (Fig.1 to Fig.4), those cannot filter out easily, over filters might delete the data in the plasma bubbles structure. Evaluating the Weighting of standard deviation can be a way to filter out part of outliers, makes high standard deviation value more conform to the plasma bubbles. Fig.5 to Fig.7 shows the result after preliminary filter out by 0.00001 of standard deviation for threshold.

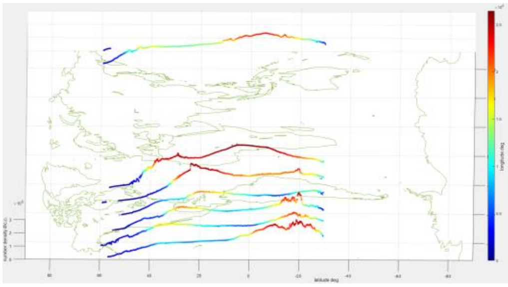


Fig.1
The original number density top view in No.100 file

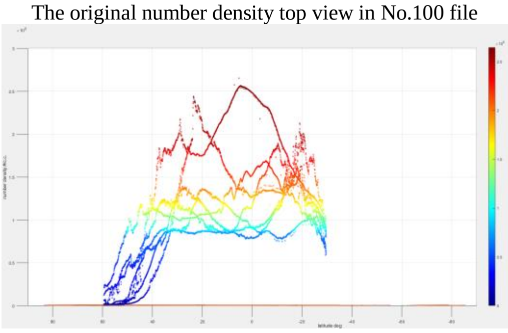
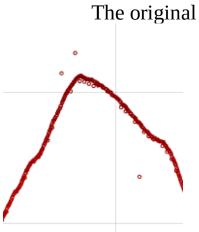


Fig.2
The original number density side view



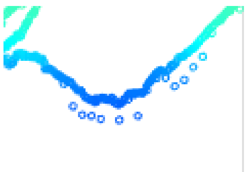


Fig.3 Fig.4
Zoomed-in view to the original number density

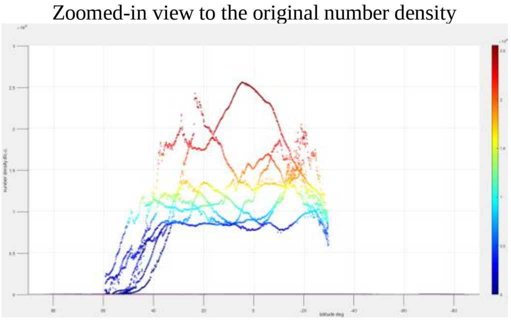
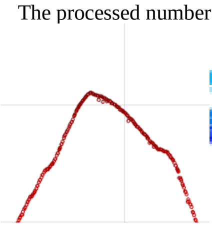


Fig.5
The processed number density side view in No.100 file



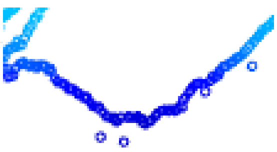


Fig.6 Fig.7
Zoomed-in view to the processed number density

After deleting outliers, detrending, these data could be divided into different latitude and longitude grids, calculating the standard deviation of each grid (Fig.8), the region in plasma bubbles will respond to a higher standard deviation. The final step is ANN training and I'm still working on loading the F10.7 index and time parameters, those also will be used as training importation of ANN.

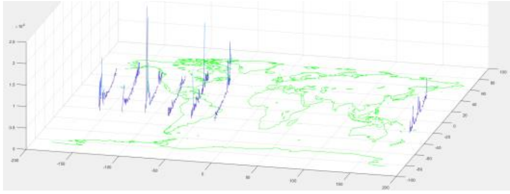


Fig.8
The top view of processed, detrended number density standard deviation in grid

# 3.Future Work

ANN training results don't have a 100% chance to converge successfully, it depends on the qually of the importation, even some factors beyond our cognition. Although deleting all the outliers is a way to increase the success rate, I still can't make progress in this part, it needs time to examine the weighting.

Once the training result has been done, it could be used for calculating a reference value of ion number density standard deviation expected for a corresponding season, longitude, latitude, F10.7 index and vertical plasma drift velocity. The value can be considered as a plasma bubbles emerge possibility, also can be used to compare with the follow up data from AIP, verify the credibility of this training result.

# 4.Reference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