INFLUENCES OF INTERPLANETARY MAGNETIC FIELD ON THE VARIABILITY OF THE AEROSPACE MEDIA

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

TOLGA YAPICI

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
AEROSPACE ENGINEERING

SEPTEMBER 2007

Approval of the thesis

INFLUENCES OF INTERPLANETARY MAGNETIC FIELD ON THE VARIABILITY OF THE AEROSPACE MEDIA

submitted by **TOLGA YAPICI** in partial fulfillment of the requirements for the degree of **Master of Science in Aerospace Engineering Department, Middle East Technical University** by,

Prof. Dr. Canan Özgen
Dean, Gradute School of **Natural and Applied Sciences** _____

Prof. Dr. İsmail Hakkı Tuncer
Head of Department, **Aerospace Engineering** _____

Prof. Dr. Yurdanur Tulunay
Supervisor, **Aerospace Engineering Dept., METU** _____

Examining Committee Members:

Assoc. Prof. Dr. Serkan Özgen
Aerospace Engineering Dept., METU _____

Prof. Dr. Yurdanur Tulunay
Aerospace Engineering Dept., METU _____

Assoc. Prof. Dr. Altan Kayran
Aerospace Engineering Dept., METU _____

Assoc. Prof. Dr. Tolga Çiloğlu
Electrical and Electronical Engineering Dept., METU _____

Dr. Sartuk Karasoy
ROKETSAN _____

Date: _____

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: TOLGA YAPICI

Signature :

ABSTRACT

INFLUENCES OF INTERPLANETARY MAGNETIC FIELD ON THE VARIABILITY OF THE AEROSPACE MEDIA

Yapıcı, Tolga

M.S., Department of Aerospace Engineering

Supervisor : Prof. Dr. Yurdanur Tulunay

September 2007, 50 pages

The Interplanetary Magnetic Field (IMF) has a controlling effect on the Magnetosphere and Ionosphere. The objective in this work is to investigate the probable effects of IMF on Ionospheric and Geomagnetic response. To fulfill the objective the concept of an event has been created based on the polarity reversals and rate of change of the interplanetary magnetic field components, B_z and B_y. Superposed Epoch Method (SPE) was employed with the three event definitions, which are based on IMF B_z southward turnings ranging from 6 to 11 nT in order to quantify the effects of IMF B_y and B_z. For the first event only IMF B_z turnings were taken into account while for the remaining, positive and negative polarity for IMF B_y were added. Results showed that the increase in the magnitude of IMF B_z turnings increased the drop of F layer critical frequency, f_0F2. The drop was almost linear with the increase in magnitude of polarity reversals. Reversals with a positive IMF B_y has resulted in the continuation of geomagnetic activity more than 4 days, that is to say, the energy, that has penetrated as a consequence of reversal with a positive B_y polarity, was stored in outer Magnetosphere,whereas, with a negative IMF B_y the energy was consumed in a small time scale.

At the second step of the work, although conclusions about geomagnetic activity could be done, as a consequence of data gaps for f_0F2 in addition to having low numbers of events,

characterization of f_0F2 due to constant IMF B_y polarity could not be accomplished. Thus, a modeling attempt for the characterization of the response due to polarity reversals of IMF components with the Genetic Programming was carried out. Four models were constructed for different polarity reversal cases and they were used as the components of one general unique model. The model is designed in such a way that given 3 consecutive value of f_0F2, IMF B_y and IMF B_z, the model can forecast one hour ahead value of f_0F2. The overall model, GETY-IYON was successful at a normalized error of 7.3%.

Keywords: Magnetosphere, Ionosphere, Interplanetary Magnetic Field, Modeling, Genetic Programming

ÖZ

GEZEGENLERARASI MANYETIK ALANININ HAVACILIK VE UZAY ORTAMINDAKI OLASI ETKILERI

Yapıcı, Tolga
Yüksek Lisans, Havacılık ve Uzay Mühendisligi Bölümü
Tez Yöneticisi : Prof. Dr. Yurdanur Tulunay

Eylül 2007, 50 sayfa

Gezegenlerarası Manyetik Alanın (IMF), Manyetosfer ve İyonküre üzerinde kontrol edici etkisi vardır. Bu çalışmada amaç Gezegenlerarası Manyetik Alanın İyon küresel ve Jeomanyetik olası tepkileri incelenmektedir. IMF'nin z yönündeki bileşeni, IMF B_z'nin 6 nT ile 11 nT arasında değişen büyüklüklerinde, 3 adet "olay" tanımına dayalı "Superposed Epoch" yöntemi uygulanmıştır. Birinci "olay" tanımı için sadece IMF B_z kutuplaşma dönüşleri değerlendirilirken, diğerleri için positif ve negatif IMF B_y kutuplaşması eklenmiştir. Sonuçlar, IMF B_z kutuplaşma dönüşlerindeki büyüklüğün artışının, F katmanı kritik frekansı, f_0F2'daki düşüşü artırdığı göstermiştir. Düşüş, neredeyse, kutuplaşma dönüşünün büyüklüğü ile doğrusal olarak değişmektedir. Positif IMF B_y ve IMF B_z kutuplaşma dönüşleri sırasında, Jeomanyetik aktivitenin 4 günden fazla devam ettiği sonucuna varılmıştır.

Çalışmanın ikinci basamağında, Jeomanyetik aktivite hakkında bazı sonuçlara varılabilmişse de, düşük sayıdaki olaylara ek olarak f_0F2 verilerindeki boşluklardan ötürü, f_0F2'ye sabit IMF B_y kutuplaşmasının etkisinin tanımlanması yapılamamıştır. Bu yüzden, IMF kutuplaşma dönüşlerinin etkilerinin tanımlanmasıiçin "Genetik Programlama"yla modelleme denemesi yapılmıştır. Değişik kutuplaşma dönüşleri için dört model oluşturulmuş ve bu modeller tek genel ve eşsiz bir modelin bileşenleri olarak kullanılmıştır. Model verilen ardışık 3 saat-

lik f_0F2, IMF B_y ve IMF B_z verileriyle bir saat sonraki f_0F2 değerini kestirmek için dizayn edilmiştir.

Anahtar Kelimeler: Manyetik Küre, İyonküre, Gezegenler Arası Manyetik Alan, Modelleme, Genetik Programlama

To my family and my lovely girl friend

ACKNOWLEDGMENTS

I would like to express my gratitude to my advisor Prof. Dr. Yurdanur Tulunay and Prof. Dr. Ersin Tulunay for her help, advice and guidance during my thesis.

There are no words to describe the appreciation and gratitude I feel for my family. I am proud to have such a family which gave me valuable advice and support when I needed it most. And special thanks to my lovely girlfriend for her endless love, faith in me, understanding and continued patience. Also, I would like to thank my colleagues and my friends, Emre Altuntaş and Zeynep Kocabaş for their help during the whole study.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES