Forecasting the Earth's Trapped Particle Distribution Using Hierarchical Bayesian Spatio Temporal Model

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Forecasting the Earth's Trapped Particle Distribution Using Hierarchical Bayesian Spatio Temporal Model

Wayan Suparta[1,*], **Gusrizal**[1]

[1]Institute of Space Sciences (ANGKASA), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Darul Ehsan, Malaysia

E-mail: wayan@ukm.my

Abstract. We employed the Hierarchical Bayesian spatio temporal (HBST) Gaussian Process (GP) model for forecasting the distribution of the Earth's trapped particle. The model was applied in the South Atlantic Anomaly (SAA) region. Data from 1-30 January 2000 of >30 keV electron flux acquired by National Oceanic and Atmospheric (NOAA) 15 satellite was carried to model. The purpose was to forecast the flux value on 31 January 2000. Gridding process of 10x10 lot-lan was performed after cleaning and log transforming data. The HBST GP model was undertaken by implementing the Monte Carlo Markov Chain (MCMC) method. The forecasting result was interpolated by using Kriging technique to draw the distribution map of particle flux. Statistical validation represented by mean square error, root mean square error, mean absolute error, mean absolute percentage error, bias, relative bias, and mean relative separation shows good indicators. The visual validation also figured a quite similarity with NOAA's map that the model capable to forecast the particle flux.

1. Introduction

Trapped particle is one of major radiation in the space environment. It is produced by solar flares and CMEs and flows out to the Earth's atmosphere by the solar wind [1]. Due to geomagnetic field line the charged particle is trapped into two areas of Van Allen radiation belt: the inner radiation belt and the outer radiation belt. Trapped particle could cause harmful effects to the spacecraft that pass through their region especially for low earth orbit (LEO) satellite [2]. Therefore, it is important to model the distribution of Earth's trapped particle. There are several trapped particle models that have been developed, mostly are based on physics - magneto hydro dynamics (MHD) frame, such as SWMF/BATS-R-US with RCM [3], Fok Ring Current [4], Plasma sphere [5], CIMI [6]. The most used and the stable one, the AE-9/AP-9 [7] is run in a statistical modeling framework.

In this work, we choose to employ a statistical model, named hierarchical Bayesian spatio temporal model (HBST). The unique of this model because it works on a geographical coordinate rather than the (L, B) coordinate like the others. Although the approach of representing the trapped particle in magnetic coordinate is preferred in scientific application, the necessity of simple displayed model for the end user like satellite operator and designer is taking into account [8]. In addition, the model can be employed for both proton and electron in every condition of solar activity. The model can also perform a long time forecast like daily or weekly of solar trapped particle flux value. Our objective of this work is attempted to build the trapped particle distribution forecasting system for satellite operator and designer.