Evaluation of Geomagnetic Field Models using Magnetometer Measurements for Satellite Attitude Determination System at Low Earth Orbits: Case Studies

Demet Cilden-Guler, Zerefsan Kaymaz, Chingiz Hajiyev

PII: S0273-1177(17)30779-2
DOI: https://doi.org/10.1016/j.asr.2017.10.041
Reference: JASR 13473

To appear in: *Advances in Space Research*

Received Date: 31 July 2017
Revised Date: 29 September 2017
Accepted Date: 25 October 2017

Evaluation of Geomagnetic Field Models using Magnetometer Measurements for Satellite Attitude Determination System at Low Earth Orbits: Case Studies

Demet Cilden-Guler[1], Zerefsan Kaymaz, and Chingiz Hajiyev

Istanbul Technical University, Faculty of Aeronautics and Astronautics, Maslak, Istanbul, Turkey

Abstract

In this study, different geomagnetic field models are compared in order to study the errors resulting from the representation of magnetic fields that affect the satellite attitude system. For this purpose, we used magnetometer data from two Low Earth Orbit (LEO) spacecraft and the geomagnetic models IGRF-12 (Thébault et al., 2015) and T89 (Tsyganenko, 1989) models to study the differences between the magnetic field components, strength and the angle between the predicted and observed vector magnetic fields. The comparisons were made during geomagnetically active and quiet days to see the effects of the geomagnetic storms and sub-storms on the predicted and observed magnetic fields and angles. The angles, in turn, are used to estimate the spacecraft attitude and hence, the differences between model and observations as well as between two models become important to determine and reduce the errors associated with the models under different space environment conditions. We show that the models differ from the observations even during the geomagnetically quiet times but the associated errors during the geomagnetically active times increase. We find that the T89 model gives closer predictions to the observations, especially during active times and the errors are smaller compared to the IGRF-12 model. The magnitude of the error in the angle under both environmental conditions was found to be less than 1^{o}. For the first time, the geomagnetic models were used to address the effects of the near Earth space environment on the satellite attitude.

Key Words: Spacecraft attitude, IGRF-12, T89 model, geomagnetic storms

1. Introduction

Magnetometers are one of the attitude determination sensors for small satellites at Low Earth Orbit (LEO). In the absence of the actual and reliable magnetic field measurements, on-board model magnetometers and a model of the Earth's magnetic field are needed for the prediction of the geomagnetic field at the satellite's altitude. The conventional methodology while estimating the satellite's attitude involves the angle between the magnetic field vectors from the simulated magnetometer and the model of the Earth's geomagnetic field. Therefore, the accuracy of the geomagnetic fields from the model is critical for a precise attitude determination. As scientific payloads, the magnetometers on-board the satellites return data in space within their built-in

[1] Corresponding Author, cilden@itu.edu.tr