Understanding the Systematic Errors of CHAMP Accelerometer-Derived Neutral Mass Density Data Using Data Assimilation

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Keywords *CHAMP*

Abstract

Accelerometer-derived neutral mass density (NMD) is an important measurement of the variability in upper atmosphere and one of the widely used sources to calibrate and validate models associated with satellite orbit determination and prediction. It is a significant challenge to provide precise information about the true uncertainty of these NMD products. Using multiple data assimilation (DA) experiments and robust statistical techniques, we investigate the uncertainty distribution of three different accelerometer-derived NMD products from the CHAMP satellite mission. Here, in three different DA experiments, we use an ensemble Kalman filter to drive a physics-based model with CHAMP in-situ electron density and temperature data as well as neutral wind estimates from an empirical model. Using a multi-model ensemble comprised of both physical and empirical models, we characterize the error variances among the different NMD products. Our results indicate considerable differences among the CHAMP data sets and also show a pronounced latitudinal dependency for the estimated error distributions. On average, the error estimates for NMD vary in the range 6.5–15.6%. Our experiments demonstrate that DA significantly enhances the capability of the physical model. We note that the generic strategies applied here may be useful and applicable to other space missions spanning over longer time periods.