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Accounting for Uncertainties in MSIS 2.0

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Modeling of the upper atmosphere, specifically the thermosphere mass density, remains the primary source of uncertainty in satellite drag and orbital operations in low Earth orbit (LEO). The variations in mass density are dominated by changes in solar irradiance on the timescales of the solar cycle, however, short-term space weather changes can significantly impact the state of the thermosphere, especially during geomagnetic storms. Because of our limited understanding of such variations and the resulting inaccurate modeling, quantifying the uncertainty in density specification and forecasting becomes critical for space operations including decision making for collision avoidance and safeguarding of our space assets.

The Naval Research Laboratory's MSIS model is one of the most widely used models in operations, especially in the commercial industry. Several different versions of the models have been developed, the most recent being MSIS 2.0. A new methodology for calibration of the MSIS model with exospheric temperatures inverted using accelerometer-derived density estimates has recently been developed. In this work, we apply a similar but updated methodology to the MSIS 2.0 model and use machine learning, specifically a neural network, to develop a version of the MSIS 2.0 model calibrated to the accelerometer-derived density estimates that also provides reliable uncertainty estimates.