

Space Weather and its Effects on Satellites

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Abstract

Over the last 10 years the number of operational satellites in orbit has grown from 450 to more than 1400. We rely on these satellites more than ever before for a wide range of applications such as mobile phones, TV signals, internet, navigation and financial services. During geomagnetic storms the electron flux inside the van Allen radiation belts can increase by four orders of magnitude on a timescale of a few days, but the timescale can be as fast as 2 minutes. The increase in flux causes an increased risk of damage to satellites and in some cases has resulted in total satellite loss. The number of spacecraft that could be damaged in an extreme space weather event remains very uncertain and the impact needs to be assessed so that we can mitigate the risk through better design and operational procedures.

In this general lecture, we discuss some of the impacts of space weather in general and then focus on the effects on satellites. We discuss the Earth's radiation belts, present some of the latest research on wave-particle interactions including those from the new Rad-Sat project, and show how wave-particle interactions dominate the transport, acceleration and loss of high-energy relativistic electrons that damage satellites. We show how global models can be used to reconstruct radiation belt variations and be used to test our understanding of different physical processes. We discuss extreme space weather events and show how models can be used to assess the orbits most at risk and complement statistical analyses to determine the electron flux for a 1 in 150 year event. We discuss the implications of these results in terms of the shielding required to protect new spacecraft. Finally, we show how one global model has been integrated with radiation effects models to provide 4 different risk indicators, and developed into a prototype operational forecasting system in collaboration with the UK Met Office and European Space Agency to forecast the risk of damage to satellites in different orbits.

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