

Economic impacts of atmospheric radiation storm on aircraft operations and potential use of space weather information

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Secondary particles generated by a solar energetic particle (SEP) event cause an atmospheric radiation storm (ARS) at aircraft cruising altitudes. Radiation storm is one of the advisories in the space weather information service for aircraft operations provided by the International Civil Aviation Organization (ICAO). However, it has not been defined well how aircraft operators should react when such advisories are issued.

In order to contribute to establishing effective reactions to space weather information, we estimate the economic impact which would be induced when certain means are taken to mitigate the radiation hazard. This would be an important information to establish effective reactions to space weather radiation advisories.

We used the Warning System for Aviation Exposure to Solar energetic particle (WASAVIES) to estimate the effective dose rate (EDR) along the aircraft trajectory. Flight path length, flight time, and fuel consumption for realistic flight routes are calculated by using a flight trajectory generation algorithm and the aircraft performance parameters from the Base of Aircraft Data (BADA) model developed by EUROCONTROL.

We used the conditions of the GLE-69 event as a reference. Two routes from Japan which go through high latitude regions, from New York JFK airport (JFK) to Tokyo Narita airport (NRT) and from NRT to London Heathrow airport (LHR), are chosen as examples. We set up flight scenarios based on several strategies of mitigation where constraints on the flight altitude and the latitude are imposed. For each scenario, flight path length, flight time, and fuel consumption were estimated.

Our results show that the fuel consumption could be increased by 33-58% for JFK-NRT, if very conservative mitigation strategies are taken. Similar analysis has been performed for NRT-LHR.

This economic impact may be reduced, if the space weather nowcast for the ARS associated with the SEP and an optimal flight trajectory generation algorithm are used together. Setting more flexible constraints in the flight route and generating optimal flight trajectories with minimal economic impacts by fully utilizing the global EDR distribution would be effective, which is our next step. Furthermore, prediction of the progress of ARS associated with SEP events would be effective in reducing the economic impacts by adaptively modifying the flight path during the flight.

Keywords: Solar energetic particle event, Economic impact in aircraft operation, Radiation