Met Office Atmospheric Radiation: Pathway to Operations

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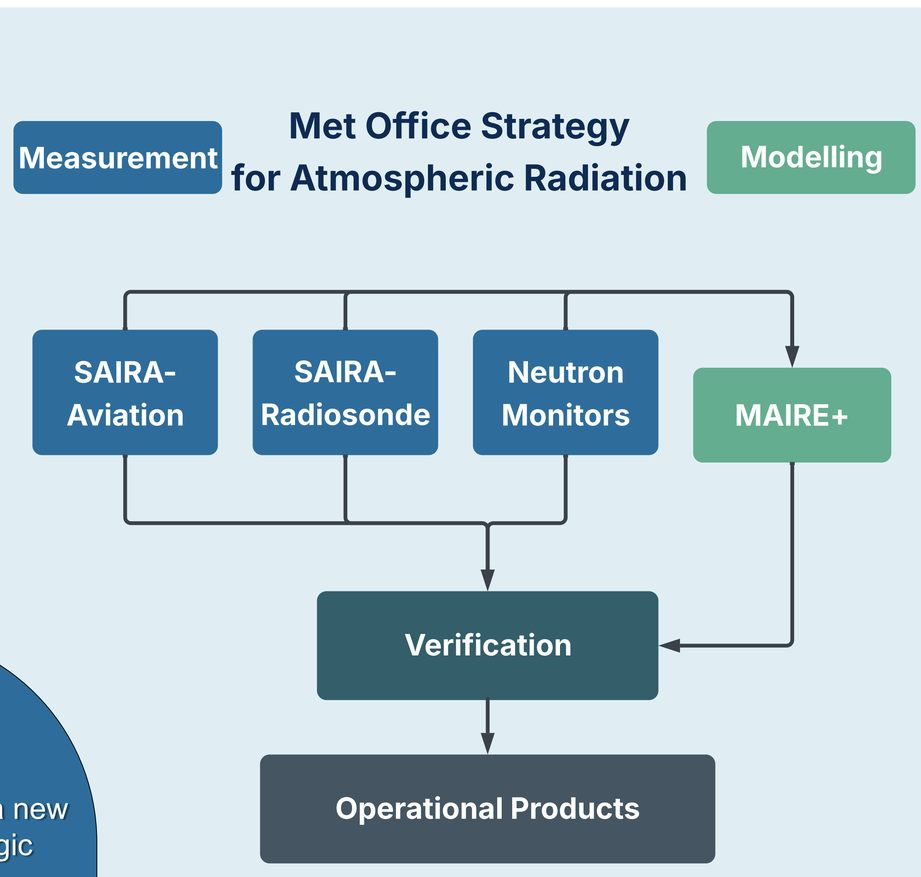
Atmospheric radiation originating from solar and galactic particles significantly influences space weather, with potential impacts on technology and the safety of aviation personnel and passengers. Despite its importance, the ability to accurately model and assess radiation dose levels remains limited globally, and particularly within the UK. To address this, the Met Office is advancing efforts to integrate atmospheric radiation dose monitoring into space weather operations by deploying new modelling and measurement capabilities in partnership with the University of Surrey and University of Lancaster. This initiative includes the deployment of the MAIRE+ atmospheric radiation model, incorporation of new neutron monitor data from the UK, and a program of direct radiation dose measurements utilising the SAIRA instrument on aircraft and radiosonde launches from Met Office locations. Here, we present the main elements of the strategy designed to deliver operational assessment of atmospheric radiation.



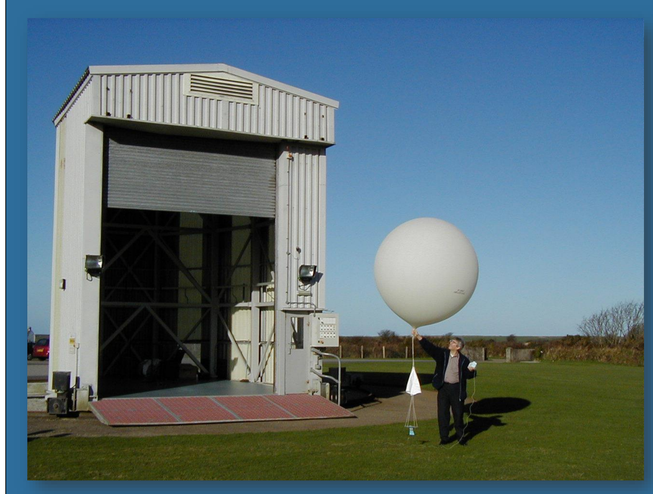
The Met Office strategy for assessing and monitoring atmospheric radiation applies a dual approach combining modelling with measurements supported by the organisation's 24/7 operational capacity.
A key element of this approach involves leveraging data from new instruments to verify and validate the MAIRE+ model. Looking ahead, collaborative, user-focused research with partner industries and agencies will be harnessed to create new operational products and guidance based on these enhanced measurement and modelling capabilities. This strategy aims to translate scientific advancements into practical services, establishing a distinctive national capability supporting essential national infrastructure.

Measurement

The Met Office is in the process of deploying the capability for operational measurements of radiation within the atmosphere down to ground level. This is achieved by radiation sensors flown on aircraft and launched via radiosonde, and a new UK neutron monitor capability; these instruments were developed under the Strategic Priority Fund SWIMMR programme.

Smart Atmospheric Ionising RAdiation (SAIRA)
SAIRA is a radiation monitor developed by the University of Surrey, based on a solid state silicon detector, with the ability to detect ionising particle radiation in 16 energy channels from **80 keV to > 50 MeV.** These measurements are processed to derive radiation dose rates and SEE rates. Two variants of SAIRA are used to deploy the instrument 1) onboard aircraft and 2) launch via radiosonde.

SAIRA-Aviation
Is portable and installed in an aircraft on a semi-permanent basis. Currently there are SAIRA units being flown by British Airways and Virgin Atlantic aircraft. Additional units are planned to be flown by RAF A400 flights and in future intended to be integrated directly into airframes.



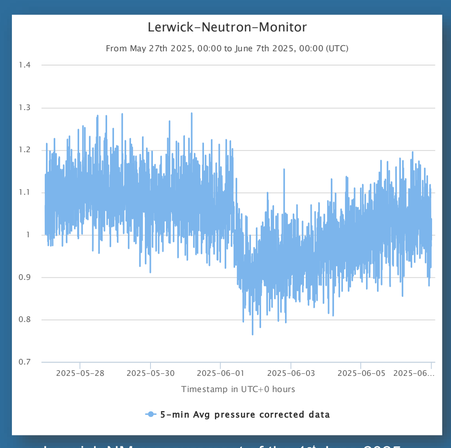
SAIRA-Radiosonde
The SAIRA instrument, adapted for connection to a radiosonde and launched via weather balloon, is based at the Met Office Camborne and Lerwick sites. These units are launched during significant GLE events as notified by the Met Office Space Weather Operations Centre and data received in real time via the Met Office radiosonde observing system.

Neutron Monitors

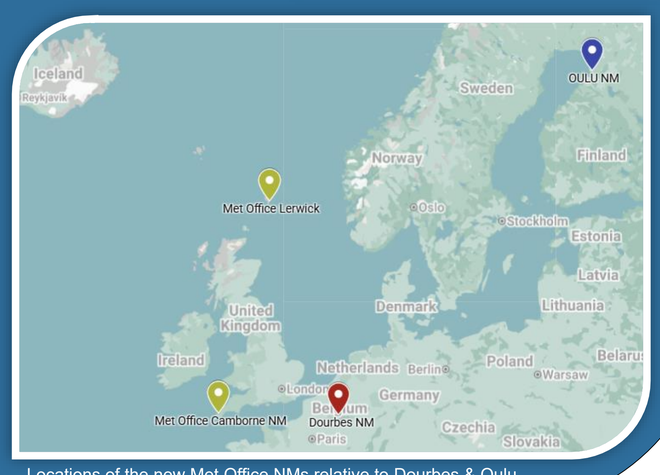
The Camborne NM-2023 neutron monitor, developed by the University of Lancaster and commissioned at the Met Office Camborne site in December 2024, is a smaller and lighter ^{3}He-based instrument compared to the traditional NM-64 design. This restores the UK's capability to monitor ground-level neutrons, which has been lacking since the 1980s, and the data will be available to the NMDB network.

Lerwick Compact Neutron Monitor is an additional conceptual NM developed by the University of Surrey (Baird, 2025) based on the instrument used within the UK-COSMOS soil moisture network.

The Camborne NM-2023 enclosure.



Lerwick NM measurement of the 1st June 2025 Forbush decrease.



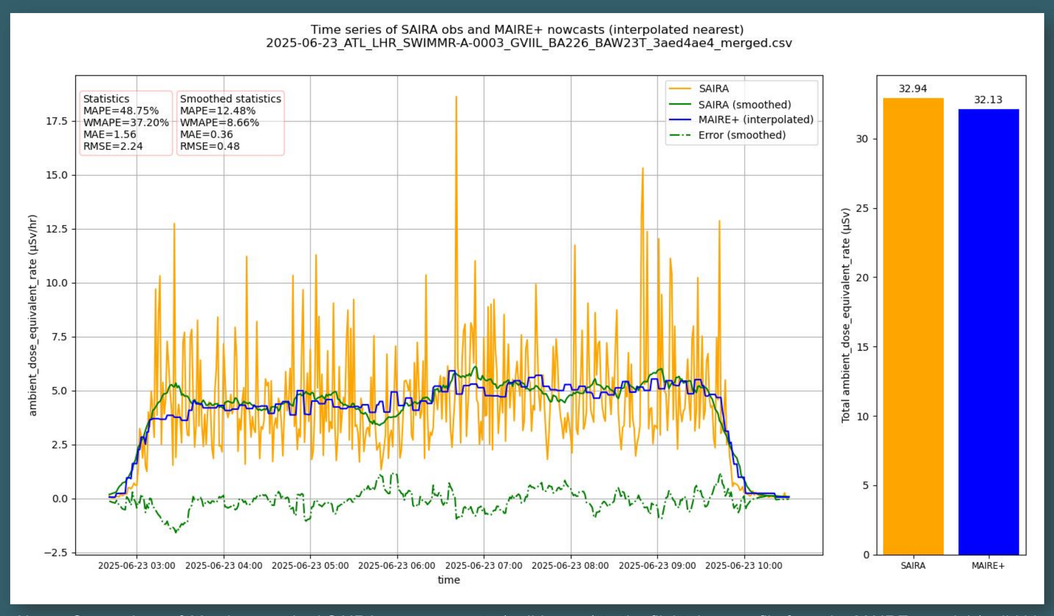
Locations of the new Met Office NMs relative to Dourbes & Oulu.

Modelling

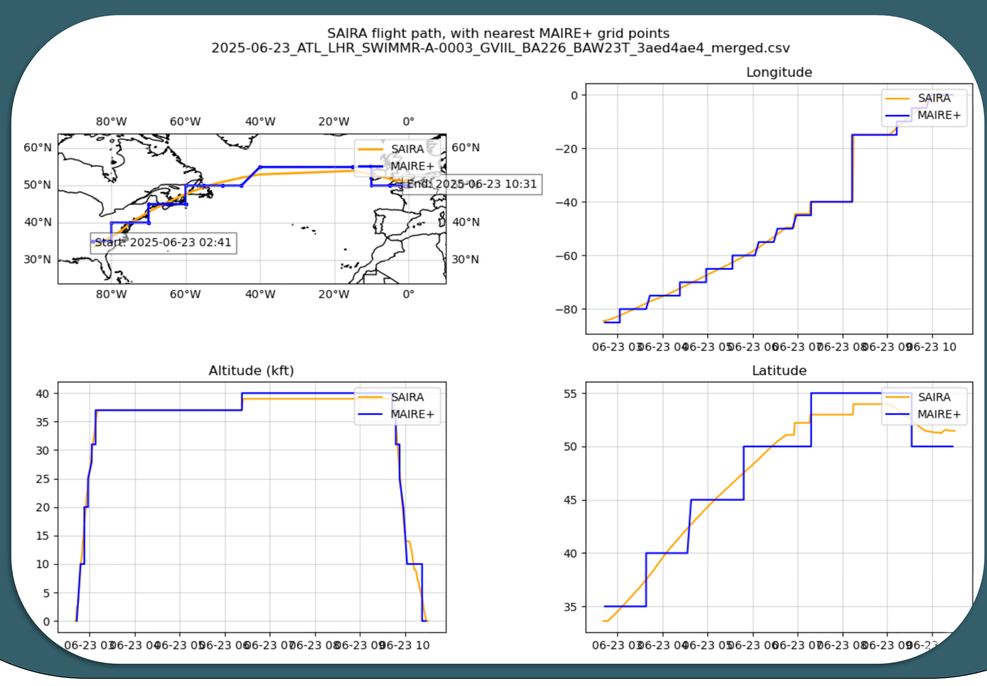
Model for Atmospheric Ionising Radiation Effects (MAIRE+)
MAIRE+ is a semi-empirical model (Hands,2022) developed by the University of Surrey that produces a nowcast of global radiation at 3kft intervals in altitude, with a resolution of 5x5 degrees in latitude and longitude. As input, MAIRE+ uses Oulu & Dourbes NM data, GOES protons and Kp-index. MAIRE+ is now running every 5-mins within the Met Office Space Weather Research-to-Operations environment and is targeted to be fully operational and available to MOSWOC during 2026. The MAIRE+ output allows assessment of radiation dose experienced throughout any aircraft flightpath up to 60kft.

Verification

A critical part of using a model to provide operational guidance is that it's characteristics and uncertainties are understood by undertaking model verification. Airborne measurements fill critical data gaps left by ground and space instruments for accurate radiation model validation. This synergy between modelling and measurement is being carried out via the Met Office strategy. Initial verification comparison results are shown below for a SAIRA-Aviation British Airways flight from Atlanta to London Heathrow and compare the measured dose to the modelled flight dose profile derived from the MAIRE+ model.



Above: Comparison of 30-min smoothed SAIRA measurements (*solid green*) to the flight dose profile from the MAIRE+ model (*solid blue*)



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Baird, F., Ryden, K. A., Lei, F., & Dyer, C. S. (2025). A Compact solution for improving the spatial density of observations of large Ground Level Enhancements. *Space Weather*, *23*, e2024SW004230. https://doi.org/10.1029/2024SW004230

Hands, A. D. P., Lei, F., Davis, C. S., Clewer, B. J., Dyer, C. S., & Ryden, K. A. (2022). A new model for nowcasting the aviation radiation environment with comparisons to in situ measurements during GLEs. Space Weather, 20, e2022SW003155. https://doi.org/10.1029/2022SW003155

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