Multiscale UAS Radiation Mapping Within the Chernobyl Exclusion Zone (CEZ).

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The accident occurring at the Chernobyl Nuclear Power Plant (ChNPP) in 1986 remains the most prolific in the history of civil nuclear power generation. In the decades since the incident, remote characterisation technologies have advanced significantly in their capabilities. Current knowledge of $^{137}$Cs distribution within the CEZ is provided by extensive ground sampling investigations conducted at the turn of the millennium. Whilst this method has a high degree of accuracy, it does not allow for local-scale variation to be resolved. Furthermore, the physical collection of samples is labour intensive and suffers from inconsistent sampling densities throughout the extent of the surveyed area. Inconsistent data spacing occurs due to time and resource constraints, terrain difficulties and exposure risk from the physical radiation hazard, which all relate to using humans to collect the samples. Airborne monitoring using UASs is a solution to overcoming the drawbacks experienced from ground-based sampling, albeit coming at a loss of absolute measurement accuracy. This method allows for the creation of a consistent network of sampling points at a high resolution, independent from terrain conditions and without exposing the operators to potentially harmful doses of radiation.

This work presents a comprehensive UAS radiation mapping investigation aiming to evaluate the $^{137}$Cs distribution within the CEZ using two distinct radiation mapping UASs to conduct surveys at different spatial resolutions. The first comprises of a lightweight (8 kg) fixed-wing UAS equipped with a dual detector payload (2 x 32.8 cm$^2$ CsI[Tl] detectors) to map over large areas at a relatively high forward velocity (14 – 18 m s$^{-1}$) and a medium-low spatial resolution (20 – 60 m pixel$^{-1}$). A multi-rotor aerial vehicle is preferred for the second system, which was used to monitor smaller areas of interest (highlighted by the fixed-wing survey), at a higher spatial resolution (3 – 10 m pixel$^{-1}$) and a much lower forward velocity of approximately 3 m s$^{-1}$. This system was heavier than...
the fixed-wing variant, weighing approximately 11 kg.

In the seven days of active fieldwork in the CEZ, more than 650 km of combined flight distance was covered by the two systems, characterising a total area of approximately 15 km$^2$. Through a series of carefully calibrated processing algorithms, both the $^{137}$Cs activity (in kBq m$^{-2}$) and the dose-rate ($\mu$Sv hr$^{-1}$) resulting from $^{137}$Cs deposition at one metre above ground level are evaluated. Error propagation through this procedure indicates a base-rate error of 11.5-13.9% in the estimation of $^{137}$Cs activity from the air, while the basal error for the dose-rate estimation is lower at approximately 5.5 – 6.2%. Minimum detectable activity (MDA) was calculated as 98.1 ± 0.4 kBq m$^{-2}$ for the fixed-wing system operating at 40 - 60 m altitude and 33.5 ± 0.9 kBq m$^{-2}$ for the multi-rotor at 8 - 20 m altitude.