THREAT AGENT DEFEAT MODELING AND TESTING

Measurements Of Three-dimensional Flow And Contaminant Dispersion Within And Around A Stadium Using Magnetic Resonance Imaging

Andrew Banko United States Military Academy **Michael Benson** United States Military Academy **Ty Homan** United States Military Academy **Megan Colpo** United States Military Academy **Zachary Zalar** United States Military Academy **Christopher Elkins** Stanford University

Developing mitigation and emergency response strategies for airborne chem-bio threats in urban areas is complicated by the fact that contaminants can infiltrate and exfiltrate ventilated structures, such as open-air buildings, garages, and stadiums. This can increase the hazard for building occupants in the event of an external release, or for the surrounding area if an internal plume escapes the structure. Therefore, models must be able to predict the effect of interacting internal and external flow fields on contaminant concentrations. Unfortunately, field and laboratory scale data of such interacting systems are typically composed of a limited set of point measurements for inherently three-dimensional flow fields, making it difficult to explain and improve model discrepancies. In this work, we describe a novel application of magnetic resonance imaging (MRI) techniques to obtain three-dimensional velocity and concentration data within ventilated structures. The technique is applied to the flow through a stadium geometry with an internal contaminant release. Since MRI does not require optical access, the internal and external flow fields are measured simultaneously on a volumetric cartesian grid composed of several million data points. The internal and external flow fields interact via several realistic features, including an asymmetric roof opening, ventilation slits, and entrance tunnels. Sensitivity to wind direction is assessed by designing the stadium on a rotatable platform, and measurements are performed at wind angles of 45 degrees and 90 degrees relative to the major axis of the roof opening. Results show that flow entering the tunnels and slits generates internal recirculation patterns that produce a non-uniform concentration distribution within the stadium. This suggests that models using a well-mixed assumption for the internal concentration field may not be accurate. Varying the wind direction causes the flow within several tunnels to reverse direction, switching from infiltrating flow to exfiltrating flow. In all cases, the majority of the contaminant exits through the roof opening, producing an elevated plume that would interact with downstream buildings. Overall, the three-dimensional data obtained under well-controlled laboratory conditions are expected to provide rigorous validation benchmarks for flow and dispersion models.

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