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Reconstruction of Dynamically Evolving Volcanic Ash Clouds from Simulated Satellite Imagery

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Large volcanic eruptions can pose significant hazards over a range of domains. One such hazard is volcanic ash becoming suspended in the atmosphere. This can lead to significant risks to aviation, with the potential to cause severe or critical damage to jet engines. As such, the effective measurement and forecasting of ash contaminated airspace is of vital importance. Forecasts are generally produced using volcanic ash atmospheric transportation and dispersion models (ATDMs). Among the inputs to these models are eruption source parameters such as cloud-top height and cloud volume. One method of providing estimates of these source parameters, and to aid in characterising the size, shape, and distribution of a volcanic plume, is the reconstruction of the outer hull of the plume using multi-angle imagery.

When considering platforms for generating this imagery, satellites provide a range of advantages. These include the potential for global coverage, the wide range of viewing angles during an orbital pass, and being safely removed from any potential volcanic hazards. This method of plume reconstruction has been previously demonstrated by the authors using simulated satellite imagery of a model volcanic plume. However, the simple model plume used during this previous work was static and did not evolve with time, an assumption that is not realistic.

This presentation builds on the previous work and assess the efficacy of satellite imagery-based plume reconstruction under conditions closer to real-world, namely with a plume that is evolving with time. The time evolving plume model is produced via a Blender particle simulation. The images required for reconstruction are then generated at multiple user-determined time intervals and locations. A Space Carving reconstruction method is then applied to the imagery to generate the reconstructed plume. Performance and reconstruction accuracies are investigated by comparison of the reconstructed plume with the 'ground-truth' simulation model. The impacts of a range of variables on the reconstruction performance are investigated, including plume size, imager properties, satellite orbit, and the use of additional satellites. The accuracy of the Blender plume simulation is compared with more mature plume simulations such as the University of Bristol PlumeRise model. These comparison models were not themselves used for the

reconstruction process due to issues with the generation of accurate imagery.

The improved simulation environment presented in this work further demonstrates the efficacy of a satellite-based reconstruction process for the measurement and forecasting of volcanic ash, potentially leading to improvements in hazard monitoring and aviation safety.