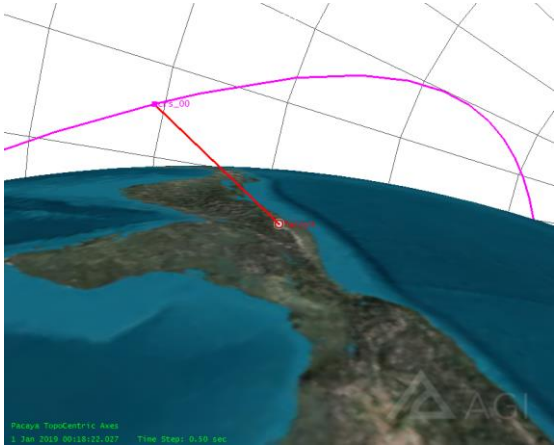

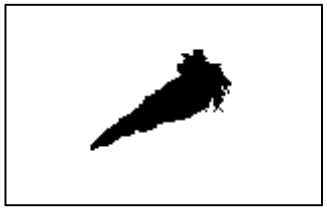

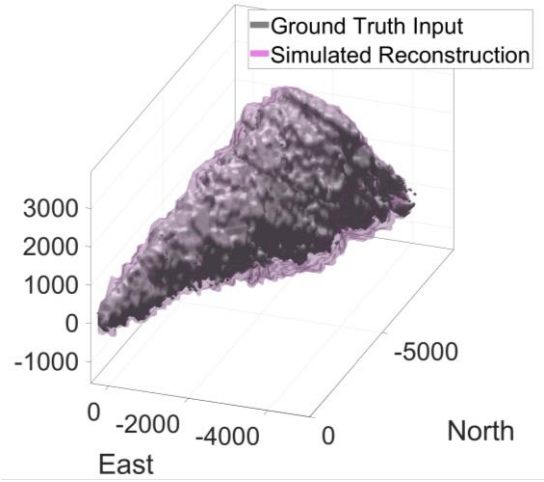

3D Reconstruction of Volcanic Ash Clouds Using Simulated Satellite Imagery

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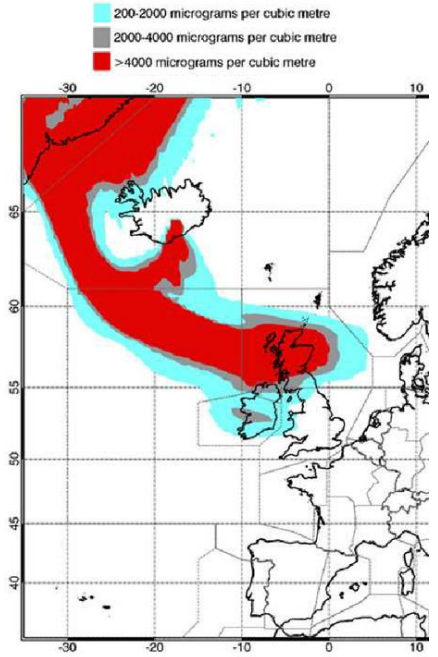
Motivation

- Volcanic ash suspended in the atmosphere poses a significant hazard to aviation.
- Knowledge of 3D plume shapes and volumes can aid in constraining ATDM models for forecasting.
- 3D reconstruction has been demonstrated with ground-based and UAS-based platforms.
- Satellite-based platforms would provide a unique perspective, although few current satellites can provide the required multi-angle imagery.
- Recent advances in small satellite technology, formation flying, and constellations could change this in the coming years.



Ash advisory published following the 2011 Grímsvötn eruption.
Credit: London VAAC, 24 May 2011

Problem Definition

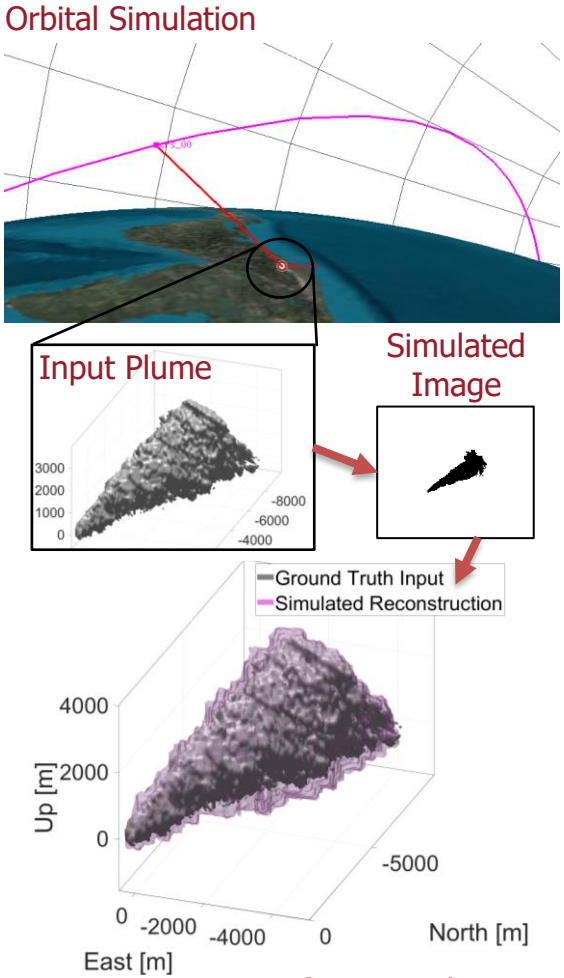
- To assess the feasibility of 3D reconstruction from space, a simulation framework was developed.
- This framework was then used to investigate the reconstruction performance for several imaging scenarios based off a theoretical University of Bristol CubeSat (UoBSat).

Methodology

- The simulated reconstruction can be split into four stages:
  1. Orbital simulation.
  2. 'Ground truth' plume input generation.
  3. Simulated image generation.
  4. 3D reconstruction with simulated images.

Methodology

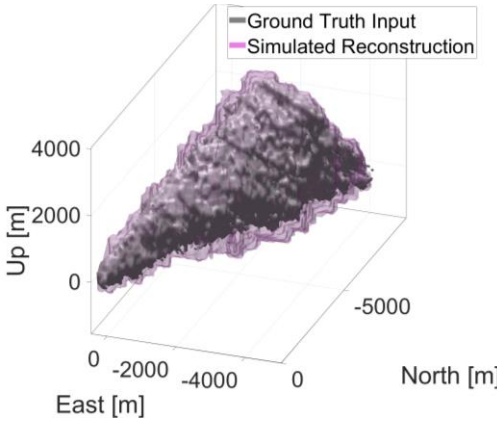
1. A simple orbital simulation is used to obtain satellite, and thus image, locations.
2. A pre-generated input plume model is used as a 'ground truth', this could be a primitive shape, a rough plume model, or an accurate simulated plume.
3. A set of simulated images of the input plume model are generated at the provided image locations, emulating satellite imaging.
4. A 3D reconstruction scheme is then applied to the simulated images as if they were real data. This generates a reconstructed plume model to compare with the 'ground truth'.

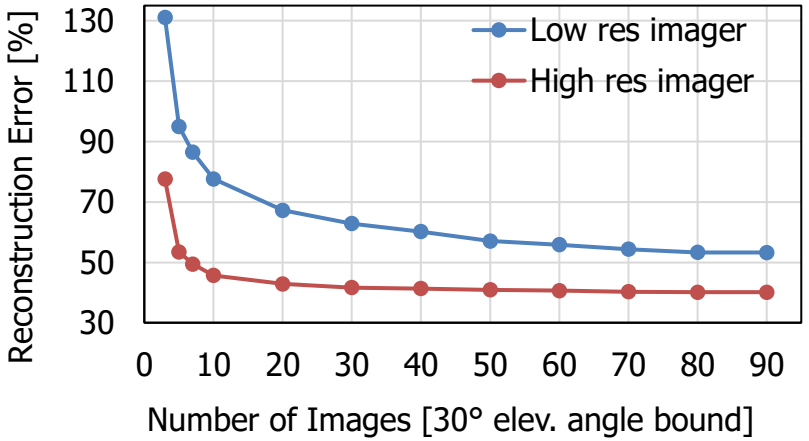


Comparison of input and reconstructed plume

Results

- The simulation framework demonstrated accurate 3D reconstruction of volcanic ash clouds from a space-based platform.
- Reconstruction performance was investigated for various imaging scenarios of a theoretical UoBSat.
- E.g. the number of images required to reach 'diminishing returns' for different resolution imagers (see right).
- Other scenarios could include image frequency, elevation angle bounds, or 'off-track' imaging.





Future Work

- Future work focuses on improving the simulation framework. This consists of validation of the reconstruction scheme and reducing any limiting simulation assumptions, some examples are given below.

Validation

- Performance is based on the final reconstruction; this scheme would ideally be validated against real-world satellite data (potentially from MISR, ASTER, or Planet Labs imagery).

Assumptions

- Current simulated images perfectly identify the plume, real images will include artifacts / meteorological clouds which will obscure the plume.
- The input 'ground truth' plume used so far is not particularly realistic. Additional plumes/orientations will make resulting trends more reliable.