Cloud-Top Height Field Estimation from Aerial Imagery

RAFT Optical Flow Method

Ian Kelk, Yash Nahar, Chandrakant Shendarkar, Christina Wang, Guilherme Zuanazzi
Harvard University in collaboration with NASA

Problems

- Cloud-top heights are vital for predicting weather, radiation, and climate.
- LiDAR gives precise but sparse data (one point per frame).
- RAFT provides dense motion fields from image sequences that can be used to generate cloud height fields.

Approach

Extracted sequences of 2–5 consecutive frames paired with aircraft metadata and LiDAR height. Applied fisheye lens correction, histogram equalization, and random cropping.

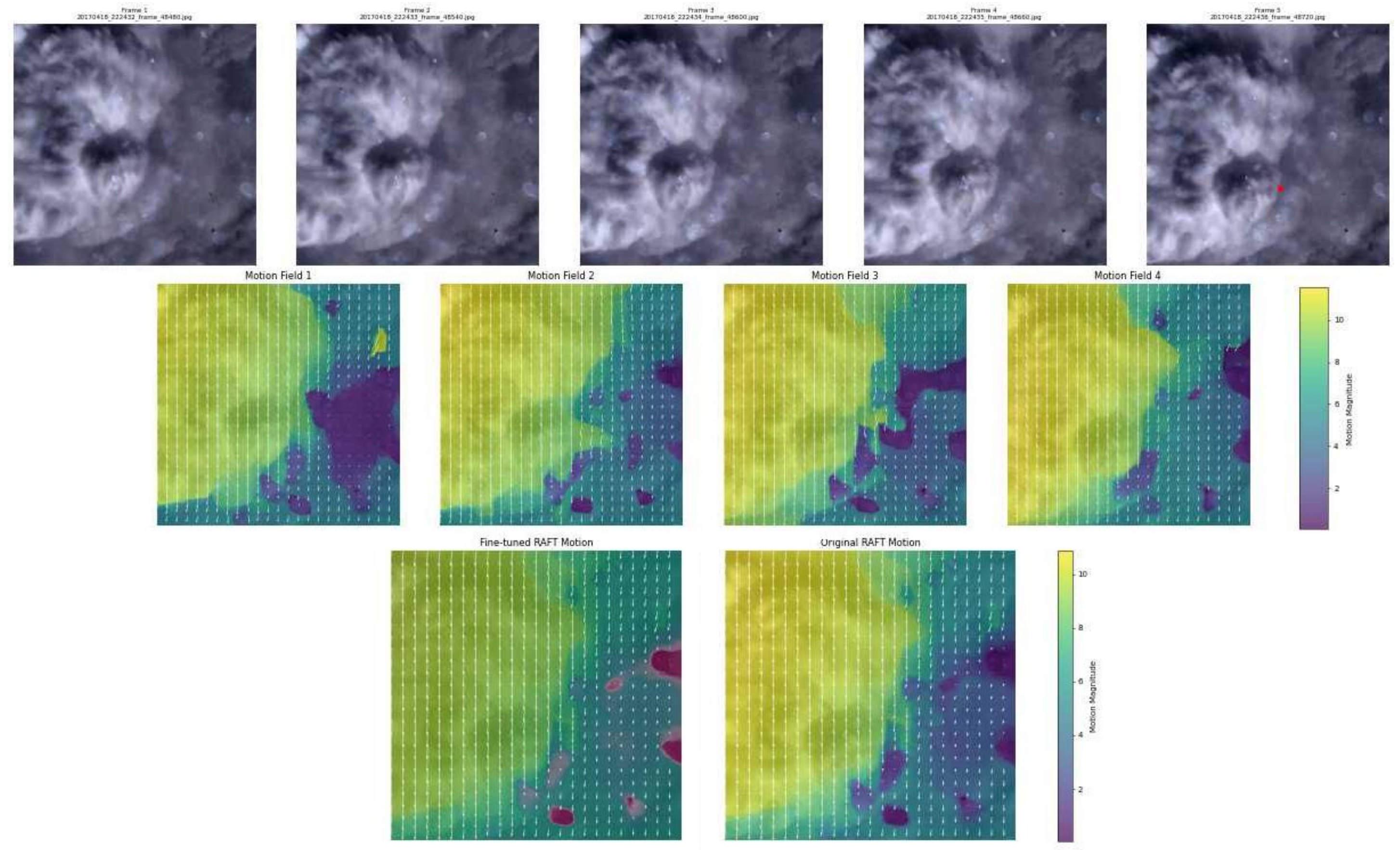
The RAFT model was fine-tuned using photometric, smoothness, and flow consistency losses, with weak LiDAR supervision to guide motion-to-height calibration.

Calculate cloud height fields using pixel motion, aircraft speed, and aircraft height.

Dataset & Code: https://github.com/cloud-2-cloud/c2c

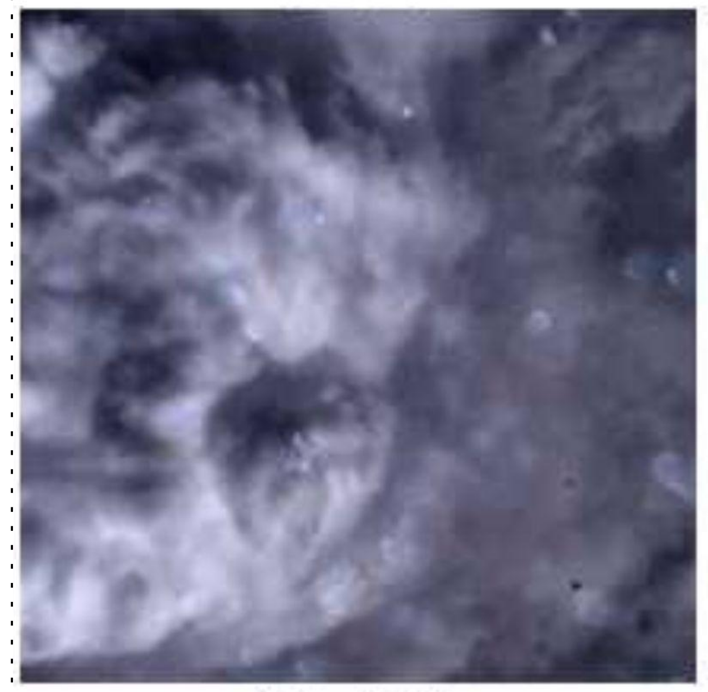
Motion Sequences

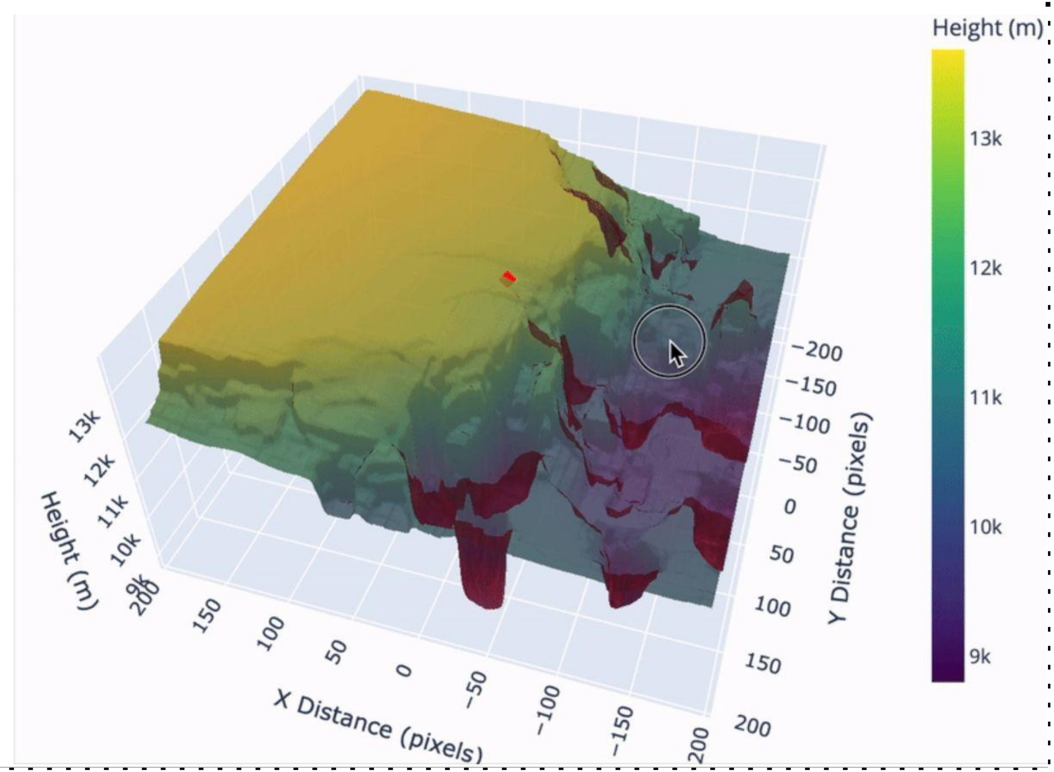
Consecutive cloud images from the FEGS camera, followed by the estimated motion fields between each pair of frames. The bottom row compares the final aggregated motion fields.



Predicted Height Field

A cloud formation as captured from an ER-2 aircraft and a 3D cloud-top height field predicted from motion using RAFT. This demonstrates that the model captures the visible structure and infers realistic depth variation, enabling dense height estimation.





Stitching

- This composite height field and confidence map stitches together 10 consecutive predictions, covering approximately 10 km of cloud tops as the aircraft traveled at 200 m/s for 50 seconds.