Heavy Snow Cloud Detection in Satellite Images Based on Semi-Supervised Image Segmentation

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Long-term analysis of snowfall in Antarctica is important to figure out the surface mass balance of Antarctica. However, it is difficult to measure snowfall intensity over Antarctica for various reasons. Although, the polar orbiting satellites, such as NOAA, continuously image the clouds over Antarctica. Hence, it is crucial to estimate snowfall from satellite cloud images.

In this work, we introduce a novel deep learning method called CoSPA (Cost-effective Segmentation framework with Partial Annotations) [1] to detect heavy snow clouds from satellite images automatically. CoSPA relies on a semi-supervised binary classification of partial patch annotations, which significantly reduces annotation costs compared to supervised deep learning methods.

We performed snow cloud segmentation tests using satellite images from AVHRR (The Advanced Very High-Resolution Radiometer) on the NOAA-18, 19 satellites [3] observed in 2008 and 2010. The classifier of CoSPA was trained by 1,000 positive (could regions) and negative (others) patch annotations with 2,000 randomly generated unlabeled patch annotations. We compared the cloud segmentation performances of CoSPA with a well-known Encoder-Decoder Network called U-Net [2] trained in a supervised manner. The segmentation performances were evaluated based on two indices, IoU (Intersection over Unions) and the Dice Coefficient.

Comparing CoSPA and U-Net segmentation results, CoSPA has lower average values of IoU and Dice coefficients, but the segmentation results are closer to the shape of actual cloud regions. The lower average IoU and Dice coefficients for CoSPA may be because CoSPA detects regions other than the desired cloud regions, such as the thin clouds around the annotated cloud, on the test data. Possible solutions to these problems include narrowing the range of hyperparameter values used and applying image processing, such as contrast processing, to the cloud images so that differences appear between detected cloud regions and other regions. It is possible to narrow the range of hyperparameters that adjust the ratio of Positive-Unlabeled learning and the value that points to the ratio of positive data in unlabeled data in the training datasets of CoSPA. Also, we can improve the models' performance by using a different loss function during training. As prospects for this research, we plan to optimize the hyperparameters of CoSPA and compare it with other segmentation methods using semi-supervised learning to verify the effectiveness and generalization performance of CoSPA.

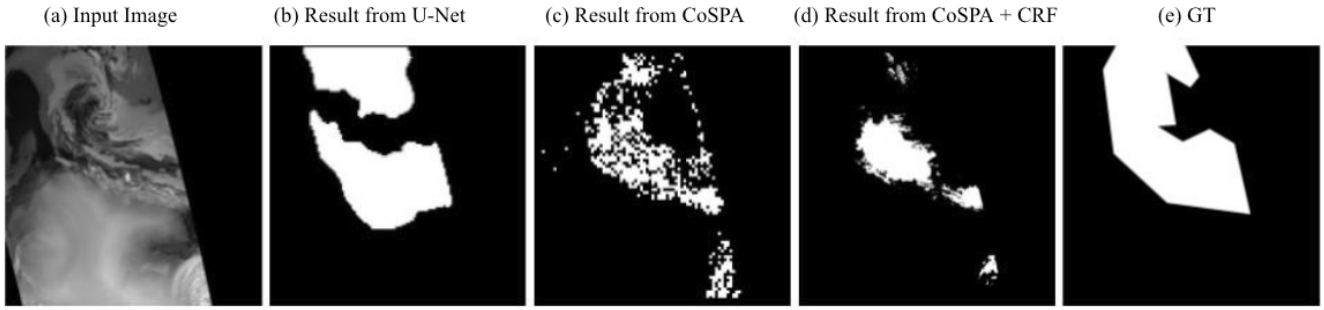

Figure 1. Summary of Results

References

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