

Continuing Project

Monroe Community College Geospatial research experience with University of Maine – CAFS

Funding provided by *Skills Training in Advanced Research & Technology (START) Supplemental Funding Request for ATE at Monroe Community College (Award #1955256) with IUCRC Phase 3 at University of Maine - Center for Advanced Forestry Systems (CAFS).*

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- MCC has a NSF Advanced Technological Education grant: (Award #1955256) *Meeting Workforce Needs for Skilled Geospatial Technicians through Virtual Geospatial Information Science Technology (GIST) Education*
- Program consists of an online stackable A.A.S. in GIST, 24 credit GIST Certificate, and a 9 credit GIST micro-credential for professionals (Python, web mapping, data)
- Program offers alumni and peer support, virtual desktop, virtual internships (for credit and paid), and more.
- Up until the START grant, the program was lacking research opportunities.



Objectives

- 1) Partner with the University of Maine's CAFS faculty/staff
- 2) Provide two 2-year Community College students with a paid 8-week summer internship
 - Collect and process field data for remote sensing applications, particularly tree species composition
 - Present work
- 3) Provide 2 students with a credit-based virtual internship
- 4) Present work



(LEFT): Casmir & Rissa recording data. (CENTER): Wayne calculating azimuth with a compass. (RIGHT): Casmir using a BAF prism to identify variable point samples.



Methods

- MCC faculty provide guidance/support
- Students work with CAFS partners in Maine.
 - Barbara Wheatland
Geospatial Lab (Tony Guay,
Dr. Kasey Legaard,
Dave Sandilands, &
Dr. Dan Hayes)
 - Penobscot Experimental Forest (Graduate students, Stephanie Wilsey and Rissa)
 - Town of Orono (student Dave Ludwig)
 - University of Maine at Fort Kent (Dr. Ned Rubert-Nason)
 - Dr. Pari Rahimzadeh
 - Schoodic Institute (Dr. Peter Nelson)

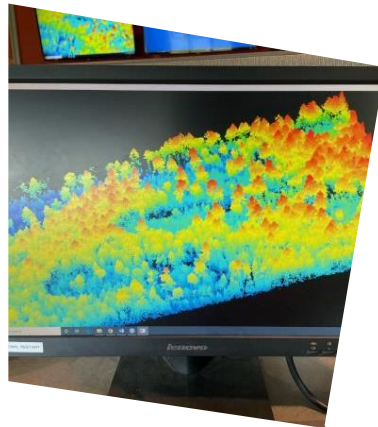


Kasey, Casmir, and Bryon working on Round 2 of training samples for cloud masking.



Major Findings

- Successful experience thanks to Dr. Aaron Wiskettiel and CAFS partners!




Tony giving a presentation on remote sensing and data collection/processing.




- Student Story Map (Week 1-4, 5-8)
- Student Presentations and Poster

Evaluation of Sentinel-2 imagery cloud & shadow masking by a machine-learning algorithm and Fmask post-processing

Casmir Brown
August 4, 2022





Background

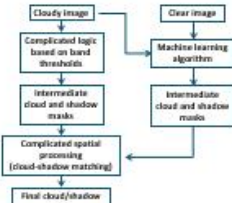
The ability to remove clouds from satellite imagery that will be analyzed/processed is crucial in the reduction of inaccuracies and systematic errors when producing maps. Current standard of Fmask developed in 2012 has high accuracy, but not enough for the detailed work done in forests of Maine.

Methodology


Goal is to train the XGBoost ML algorithm to detect cloud and shadow pixels. Two images are needed: one cloud-free (control) and one heavily clouded (variable). Satellite imagery was acquired from Sentinel-2, processed in QGIS.

Round 1 training points on variable images are selected via a principal components analysis to define 300 clusters of similar pixels, from which samples are drawn at random. Points are user-classified in attribute table as clear, cloud, shadow, or uncertain; points are digitally organized and aided by implementation of Python code for QGIS toolbar.

Control, variable images, and classified training points are fed into XGBoost algorithm, which produces intermediate cloud/shadow masks and calculates areas of low confidence from which Round 2 training points on variable images are manually selected. Round 2 points are fed into ML algorithm again in a repeating cycle to fine-tune ML output of cloud/shadow mask.



ML cloud/shadow mask is then post-processed with Fmask's spatial processing to match shadows to a cloud based off the SQA7 benefit and azimuth angles, and the geometric relationship between a cloud and its shadow.



Research Question

If a ML algorithm can be trained to detect and mask cloud/shadow from Sentinel-2 imagery, how will the trained ML algorithm's ability to detect and mask cloud/shadow pixels compare to current standard, Fmask? Is it possible to create a better tool? be available to the public?




Figure 1. Training points for cloud detection. The variable cloud image and control clear image are used to train the ML algorithm.




Figure 2. Training points for shadow detection. The variable shadow image and control clear image are used to train the ML algorithm.




Figure 3. Round 1 ML output for cloud detection. The ML algorithm has identified cloud pixels in the variable image.

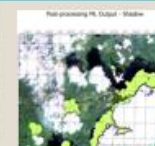


Figure 4. Round 1 ML output for shadow detection. The ML algorithm has identified shadow pixels in the variable image.

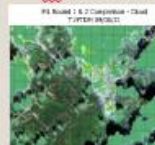


Figure 5. Round 2 ML output for cloud detection. The ML algorithm has refined cloud pixel detection.

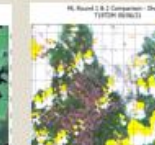


Figure 6. Round 2 ML output for shadow detection. The ML algorithm has refined shadow pixel detection.

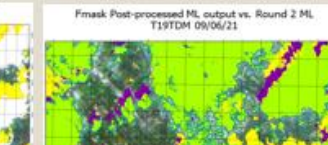


Figure 7. Fmask post-processed ML output vs Round 2 ML. The Fmask algorithm has refined the ML output.

Future Work

The form accuracy assessment & quantitative comparison on ML output

- Compare to Fmask accuracy (between 94 and 96.4% dependent on definition and source of imagery)
- Evaluation of additional band-on imagery
- Further refinement of ML
- More training points for shadow
- Tests for cloud/shadow detection on full-striping imagery
- Software development
 - Expand service to predict all clouds on imagery within Maine
 - QGIS Plugin
- Continued work with an MCC student intern for a GISQGIS Student Capstone Project, Spring 2023

Results

Fmask VS. Round 2 ML Output – Clouds (Figure 2)

- Fmask cloud coverage is greater, but less detailed (due to buffering of mask)
- XGBoost 2 ML output underestimates cloud coverage

Shadow Output (Figures 3 to 5)

- Fmask overestimates areas of shadow in areas of visible clear pixels
- Underestimation of shadow in areas of visible shadow pixels
- Round 2 ML output refines shadow coverage, reduces overestimation from Round 1
- Post-processing ML Fmask output is less accurate than the Round 2 ML output

ML Round Comparison (Figures 6 & 7)

- Cloud matching nearly identical, increased this cloud detection with Round 2
- Shadow refinement reduces errors, fewer clear pixels labeled as shadow

Post-processing ML Fmask output VS. Round 2 ML Output (Figure 8)

- Shadow refinement reduces errors, fewer clear pixels labeled as shadow
- PP ML predicts a 50% with same high accuracy as Round 2 ML output, but adds a buffer
 - Beneficial in areas of slope, thin clouds
- Round 2 predicts shadow much more accurately than PP ML output.
 - PP ML still relies on cloud-shadow matching. Highly selective algorithm needs to be fine-tuned to allow for more variation in potential best-match imagery.

References & Data Sources

Images acquired from Sentinel-2. All maps are projected in WGS 1984 UTM Zone 18N.

- Zhu, Z., & Woodcock, C. E. (2012). Object-based cloud and cloud shadow detection in Landsat imagery. *Remote Sensing of Environment*, 118, 83–94. <https://doi.org/10.1016/j.rse.2011.11.014>
- Zhu, Z., Wang, S., & Woodcock, C. E. (2015). Improvement and expansion of the Fmask algorithm: cloud shadow, and snow detection for Landsat 8–7, 8, and Sentinel 2 images. *Remote Sensing of Environment*, 150, 268–277. <https://doi.org/10.1016/j.rse.2014.12.014>

Acknowledgements

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Company Benefits

- Expand institutional knowledge re: student summer research experiences
- Share geospatial educational opportunities at MCC

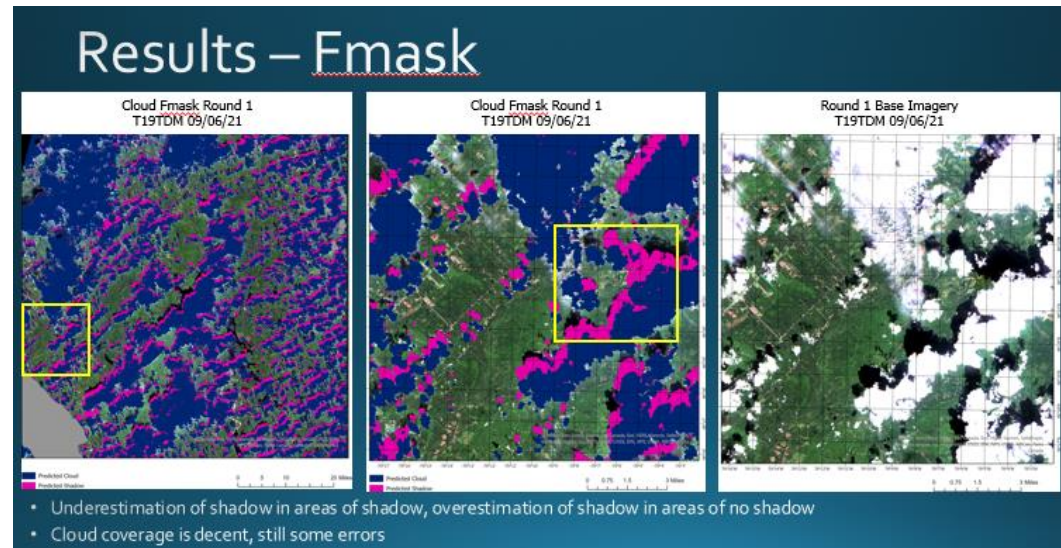


The screenshot shows the Esri website header with navigation links: Products, Industries, Support & Services, Stories, and About. A search icon and a user profile icon are visible on the right. The main content area features a blurred background image of a classroom. Overlaid on this is a white box with the text 'USER STORY' and the title 'How to Modernize GIS Education with a Microcredential to Ensure Workplace Success'. Below the title is a blue horizontal line, followed by a short paragraph: 'Monroe Community College (MCC) in Rochester, New York, has shaped its coursework with labor market intelligence to ensure that its campus of more than 12,000 students is meeting emerging workforce needs.' To the right of this paragraph is a grey rectangular placeholder.



Recommendations

- We are always looking for internship hosts for our Geospatial Capstone course offered Feb-May each spring. This is the last course in our 5 course GIS Certificate program and in our 8 GIS AAS. If interested, let me know.
- Consider partnering with CAFS on a NSF REU (Research Experience for Undergraduates)



Summary

- 1) Partnered with the University of Maine's CAFS faculty/staff and provided two 2-year Community College students with a paid 8-week summer internship
- 2) Thank you Dr. Aaron Weiskittel and everyone we worked with this summer with CAFS!
- 3) Looking ahead
 - Two virtual internships planned with Dr. Kasey Legaard and Barbara Wheatland Geospatial Lab spring of 2023.
 - Present at CAFS IAB meeting spring of 2023
 - Consider partnering with CAFS on NSF REU

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