# SmallSat Images Need “Closed-form Method for Atmospheric Correction” (CMAC)

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## Correct Images = Better Utility

### SmallSats, Big Problem

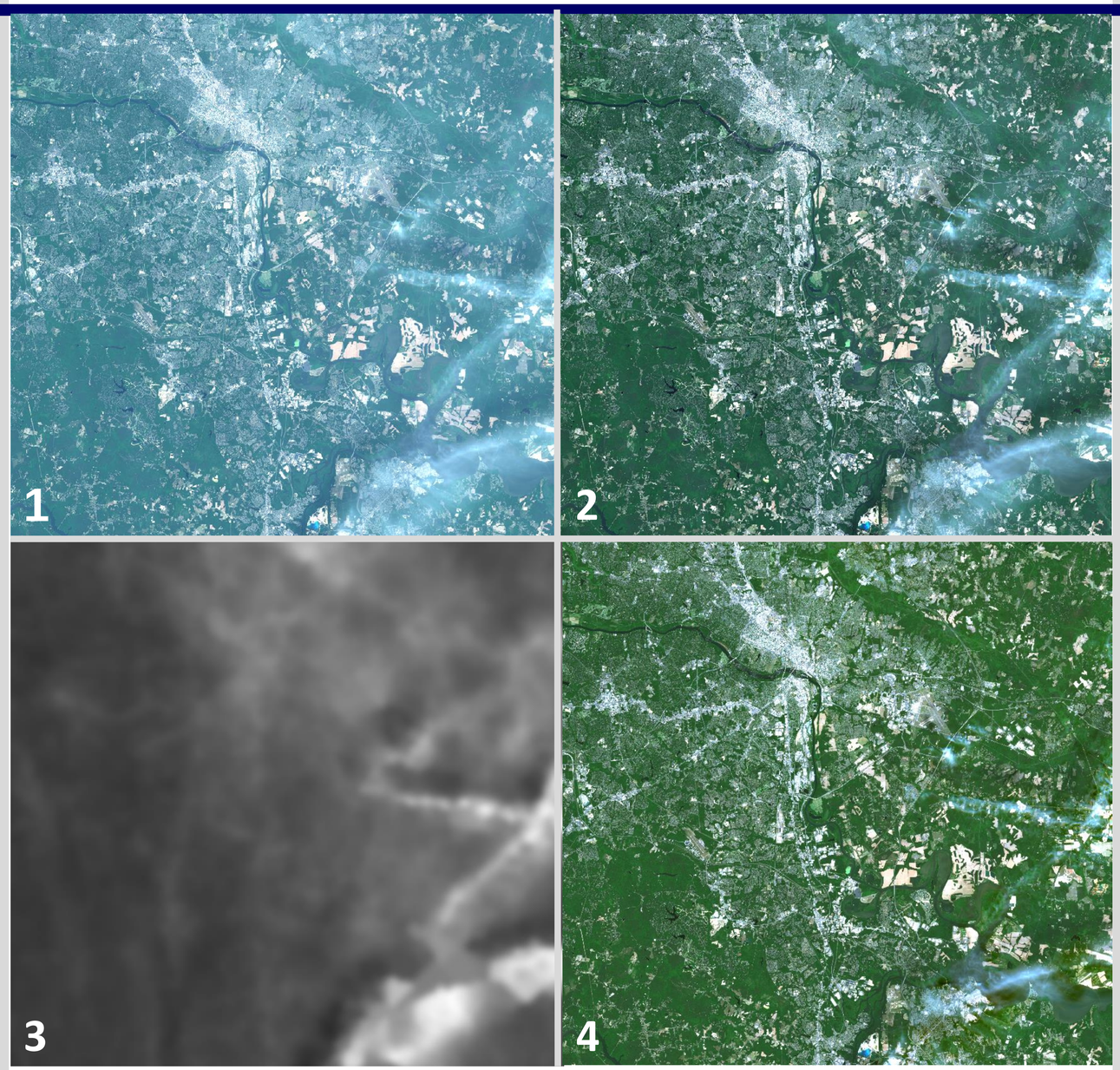
Flocks of smallsats are the only practical solution for daily overpasses that achieve at least weekly cloud-free viewing. Periodic views are especially important for defense recon and agriculture. An impediment is the need to correct the data to surface reflectance, as if measured on the ground to remove effects from dust, smoke, thin clouds, and water vapor. Precision agriculture is a good example: uncorrected images are unreliable because crop analysis uses indices, thresholds, and ratiometry in various band combinations but each band is affected differently by atmospheric conditions.

Correction to surface reflectance is critical for defense recon and will soon become so for the emerging carbon market that will affect decisions of widespread economic consequence. Accurate corrected data are necessary to get it right!

Existing atmospheric correction methods fall short for correcting smallsats – delaying the products, requiring extra calculations, and doing so with less accuracy (compare Figs 2 and 4).

### ARSI’s CMAC, the Solution

Two-step CMAC first maps an atmospheric effects index (Fig 3) and then reverses it to deliver surface reflectance, doing so in near real-time using only the data from each image. Compared to existing methods, CMAC is more accurate and can correct two to three times the level of atmospheric effect (Fig 4). For companies that fly imaging smallsats, CMAC can simplify the workload by replacing radiance harmonization and especially cross calibration with data not corrected as well as CMAC (Fig 2). To be commercialized in two years, next-gen CMAC, will simplify and improve your image data stream. Accuracy matters!




**May 20, 2021 Sentinel 2 image of Richmond, Virginia**

**1.** uncorrected; **2.** Sen2Cor (European Space Agency software); **3.** CMAC atmospheric index grayscale (brighter means more correction); and **4.** CMAC correction: remaining cloud artifacts lacked sufficient ground signal for correction.

## Next-gen Solutions

Additional R&D is underway to replace complex decision trees with neural network (NN) analyses that are expected to decrease the processing time and make CMAC highly accurate in all global environments. Closed form solutions in CMAC enable selection of the fewest, most influential variables to train NN.

## Collaborate with ARSI –

ARSI welcomes opportunities to work with the smallsat industry Here are two examples:

### Defense

ARSI seeks collaboration with a smallsat company for an ARSI project to R&D a system to calibrate new smallsats for CMAC application using only several calibration target overpasses. CMAC software can convert top-of-atmosphere data to surface reflectance from then on. Additional overpasses can QA/QC calibration, adjust for sensor drift, and potentially predict sensor failure. We would purchase and use large volumes of your smallsat data for R&D and develop calibration for your smallsats to use CMAC while developing software to run hundreds of on-the-fly smallsats. We would jointly seek funding for this program through the Department of Defense. You would keep us informed about your data processing to ensure CMAC reliability and accuracy.

### Agriculture

ARSI is finalizing a turn-key system for agriculture applications. We have experience building software for satellite-based precision agriculture – e.g., IP in HydroBio, Inc. bought by Climate Corp (2017), now irrigating globally.

**ARSI thanks NSF SBIR and USDA for support to R&D and apply CMAC, and South Dakota for proof-of-concept seed funds to start the R&D process.**

ARSI is also hosting a side meeting – please attend!

small SATELLITE Virtual Conference, August 7-12, 2021