# AIADS Algorithms

Version 5.0.8

Overview

AIADS has 3 types of configurable algorithms which are used to create an anomaly image for a tile:

- **indices** which transform the bands of the image into some quantity which is used by the method and metric.
- **methods** which measure the difference between 2 pixels
- **metrics** which evaluate the difference between the candidate pixel and a list of historical pixels in order to generate an anomaly score

AIADS's plugin system allows users to create custom versions of each of these types of algorithms.
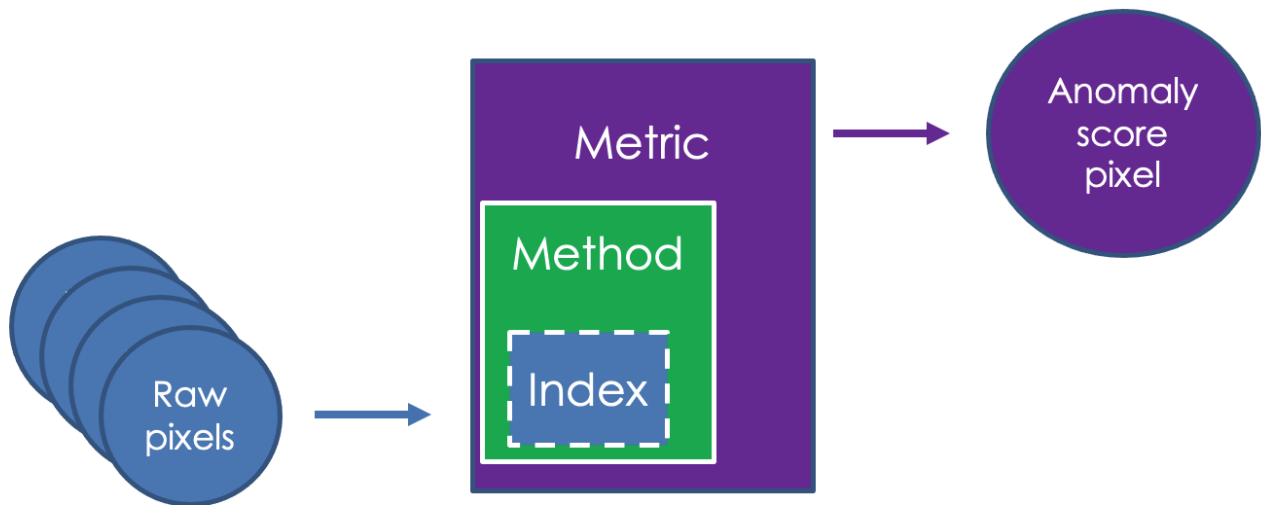
Indices

Indices are spectral bands themselves, or manipulations of spectral bands. When creating an index, the required bands to calculate that index must be labeled in the configuration file. AIADS uses the names of the bands in the configuration file to instantiate the index.

There are 2 basic types of indices: **transfer indices**, which simply reify the band's values to the rest of the system, and **computed indices**, which apply a computation to named bands.

The transfer index takes the same name as the band. Thus, the configuration may call out bands ["red", "green", "blue", "alpha"], and the indices may call out ["red", "green", "blue"].

A computed index has a special name, which specifies the computation as well as the bands it uses for the computation. An example is "intensity", which computes the gray scale intensity of a RGB image. It uses red, green, and blue bands. The bands for the index, ["red", "green", "blue", "alpha"], must be specified in the configuration file, and the entry in the indices section of the configuration file would be ["intensity"]. Then, an index plugin uses the bands to compute the index value.

Transfer Indices and Band Names

These are all the recognized transfer index names for bands.

"red"

"green"

"blue"

"panchromatic"

"band1"

"band2"

"band3"

"band4"

"band5"

"band6"

"band7"

"band8"

"band8a"

"band9"

"band10"

"band11"

"band12"

"band13"

"band14"

"band15"

"band16"

"band17"

"band18"

"band19"

"band20"

"vv"

"vh"

"hh"

"hv"

If any of these names are used in the "bands" parameter of the config file, then that same name will call the transfer index when used in the "indices" parameter.

Computed Indices

Computed indices provide information that is not directly encoded in one band, but is the result of combining bands or otherwise processing them so that the computed index value, rather than the band value is used for computation. An example of a computed index is NDVI, the Normalized Difference Vegetation Index, which is used to indicate the presence of live green vegetation.

A computed index will call out the bands it needs and connect to them in its initialization. Failure to connect is typically because a required band of the index does not appear in the "bands" parameter.

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For example, the S2SAVI index calls out the "band4" and "band8" bands of a Sentinel-2 image. To use the S2SAVI index with Sentinel-2, for instance, the bands should be specified as:

["band1", "band2", "band3", "band4", "band5", "band6", "band7", "band8", "band8a", "band9", "band10", "band11", "band12"]

The indices should be specified as ["s2savi"]

An entry must exist for every band occuring in the input images, and at least 1 index must occur that can be computed or transferred from the bands. Any string may be used in the bands parameter, only band names which are called out by indices (transfer or computed) are ever accessed.

Index Name	Bands used by Index	Description
*band*_db	*band,* where band is vv, vh, hh, vv	rescale the band from power to Decibels (impose a logarithmic scale).
*band*_power	*band*, where band is vv, vh, hh, vv	rescale the band from Decibels to power (impose a linear scale)
intensity	red, green, blue	Produce a Grayscale value, accounting for the human eyes absorption of RGB
mbsi	red, green	Modified Bare Soil Index
osavi	red, nir	Optimized Soil Adjusted Vegetation Index
s2arvi	band2, band4, band8	Atmospherically Resilient Vegetation Index; Sentinel 2
s2blfei	band3, band4, band11, band12	Builtup Land Feautres Extraction Index; Sentinel 2
s2bsi	band2, band4, band8, band11	Bare Soil Index; Sentinel-2
s2mndwi	band4, band11	Modified Normalized Difference Water Index; Sentinel-2
s2ndbi	band8, band11	Normalized Difference Builtup Index; Sentinel-2

s2ndvi	band4, band8	Normalized Difference Vegetation Index (Red) ; Sentinel-2
s2ndwi	band3, band8	Normalized Difference Water Index; Sentinel-2
s2savi	band4, band8	Soil-Adjusted Vegetation Index; Sentinel-2

Note that Sentinel 2 Indices can be applied to other sensing platforms by substituting the appropriate band names for the actual bands of the sensor. Bands can typically be substituted for bands of similar wavelengths.

Methods

Methods measure the distance between two pixels. *Indices* create the pixel values that a method uses. Methods can compare pixels generated by different indices.

AIADS come with two built-in methods, "**euclidean**" and "**center**".

The first, "**euclidean**", takes a Euclidean distance between the pixels, by measuring the square root of the sum of squares of the differences of each pixel value. To use the euclidean method, the pixels generated by the index or indices should be in the same scale, i.e. range from 0 to 1, range from -1 to 1, or be normalized.

The "**center**" method normalizes the Euclidean distance by finding the center (mean) of each index in the tile. The center method uses the mean (average, or center) of each band in the tile to generate a value. For example, if we're comparing the blue band, the center would first determine the average value of all the blue band values in the tile. Then, the distance between the actual band value (in this example the blue value for a pixel) and the mean for all the pixels in the tile for that band, is derived. This results in a signed distance from the mean of the band to the band value. The center method then uses this signed distance from the mean to determine the distance between the pixels, rather than using the raw pixel value.

Note that because the tile averages are used, this method can create tiling effects in the output anomaly image, where the edges of the tiles may have spurious anomaly values.

Metrics

Metrics evaluate the candidate and historical pixels to generate an anomaly score for the candidate pixel. Some metrics use a method to distinguish between pixels, others do not. Four metrics are built-in to AIAFDS: **min_dist**, **variation_dist**, **change**, and **volume**.

<u>Method-based metrics</u>

"**min_dist**" finds the minimum distance *d* from the candidate pixel to a historical pixel (basically the distance to the closest historical pixel value), and renders the anomaly score as *d* * scale (scale is a parameter specified in the configuration file). Note that *d* is in the units of the indices.

"**variation_dist**" first finds the distances between each pair of temporally ordered historical pixels. Then it determines the mean and standard deviation of those distances, and then Z-normalizes the distance from the candidate to the most recent historical pixel. This Z score is divided by 9 and multiplied by the scale. Thus at the recommended scale of 3.0, the maximum anomaly score represents 3 sigma. If the scale was instead specified as 4.5 in the configuration file, then the maximum anomaly score would be 2 sigma.

"**change**" is basically change detection, where only one historical image is used. It finds the distance between the candidate pixel and the most recent historical pixel as *d*. The anomaly score is *d* * scale. This metric generates the most anomalies, showing every difference, no matter how small, in the two images.

<u>Non-method based metrics</u>

"**volume**" finds the degree to which the candidate is not in the convex hull of the historical images by an efficient estimation.