Evaluation of atmospheric correction models and Landsat surface reflectance product in Daerah Istimewa Yogyakarta, Indonesia

Febrina Ramadhani Yusuf, Kurniawan Budi Santoso, Muhammad Ulul Lizamun Ningam, Muhammad Kamal, Pramaditya Wicaksono

Department of Geographic Information Science
Faculty of Geography
Universitas Gadjah Mada

febrina.ramadhani.y@mail.ugm.ac.id

Abstract. The atmospheric disturbance in remote sensing imagery greatly influences the object's spectral response in the imagery. This, in turn, will impact the object characterization. The atmospheric effects on remote sensing imagery can be reduced through atmospheric correction. There are various types of atmospheric correction methods and each of them has its own working principles. Daerah Istimewa Yogyakarta (DIY) Province, Indonesia, was chosen to be study area for this research. The research objectives are to evaluate the atmospheric correction method, which consist of Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH), Quick Atmospheric Correction (QUAC), Dark Object Subtraction (DOS), Second Simulation of the Satellite Signal in the Solar Spectrum (6S), Atmospheric Correction (ATCOR2), and Landsat 8 Surface Reflectance Code (LaSRC) by NASA. The compared objects consist of water, vegetation, and soil objects. The evaluation was based on Standard Error of Estimate (SEE), accuracy, and curve pattern. The result shows that the best atmospheric correction varies on each object. The spectral response curve pattern shows similarity but each object has its own accurate atmospheric method based on SEE result. The FLAASH, 6s, and ATCOR2 method show the lowest SEE result for mature vegetation leaves, beach sand, sand suns, and, lagoon, while QUAC method shows the lowest SEE result for young vegetation leaves, paddy plants, grass, and reservoir.

Keyword: Atmospheric Correction, Remote Sensing, Spectral Response Curve, Standard Error of Estimate

1. Introduction
Remote sensing is regarded as the acquisition of information about an object without physical contact with it [1]. The collection of information as well as various phenomena on the Earth's surface is called earth observation. Observation of the earth's surface and phenomena above it involves a wide variety of instruments and platforms for the detection of radiation at different wavelengths. The radiation itself can be either radiation originating from the sun, radiation emitted at the surface of the earth, or the radiation generated by the remote sensing instruments themselves and reflected back from the earth's surface [1]. Objects or phenomena recorded by satellite sensors produce output in the form of remote
sensing imagery. The image can be used as a source of data to identify and analyze various phenomena on the earth’s surface. Analysis of the earth’s surface objects using remote sensing data is considered highly efficient, especially when the area of study is very broad. The extent of territorial coverage is inseparable from any influence or disturbance whether caused by aerosols, clouds, or shadow of objects [2]. The existence of those disturbances will bring impact on the capability of object characterization on the surface of the earth, especially in the reflectance value of the object. Therefore, it is necessary to eliminate the influence of atmospheric disturbance so that the objects in the imagery could fully represent the ground situation. The spectral radiance measured by satellite sensors is affected by absorption and scattering by atmospheric particles. Therefore, to obtain constant and accurate ground signatures, it is necessary to remove atmospheric artefacts using an efficient and reliable atmospheric correction methods [3]. Atmospheric correction phase aims to retrieve, from at sensor radiance, the reflectance as associated to the targeted surface, which is by nature independent of the radiance conditions on the one hand and of the environment topography on the other hand [4].

There are different types of atmospheric correction methods and each of them has its own characteristics and assumptions. In this study, we used the Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH), Quick Atmospheric Correction (QUAC), Dark Object Subtraction (DOS), Second Simulation of the Satellite Signal in the Solar Spectrum (6S), Atmospheric Correction (ATCOR2) and Landsat 8 Surface Reflectance Code (LaSRC) by NASA. This comparison of atmospheric correction was conducted with the area of study located in the Special Region of Yogyakarta. DIY itself is one of the provinces in Indonesia which has tropical climate, with periods of wet months and dry months. The dynamics of atmospheric conditions in the DIY region will surely affect the appearance of objects in remote sensing imagery. This study aims to evaluate and determine which atmospheric correction method is appropriate to be applied in DIY region. In order to know that, a test of atmospheric correction types was conducted using the reflectance value of the homogeneous object in the field, which was obtained by the measurement of the spectrometer. The atmospheric correction with the pixel value approaching the reflectance value of the object in the field with the smallest error of estimate and indicates the consistent curve reflectance pattern is considered to be the most appropriate to be applied in the study area.

2. Data and Methods

2.1. Area of study
DIY province is located between 7°33’-8°12’ South Latitude – 110°00’-110°50’ East Longitude, administratively consist of Kulonprogo regency Bantul regency Gunungkidul regency, Sleman regency and Yogyakarta city. DIY is an area with a high variation of land cover and height, that ranging from 0 msl to 1356 msl at the peak of Mount Merapi. This location is hilly area with high intensity of rainfall and cloud cover.

2.2. Data and field measurement
Remote sensing data that was used in this study is Landsat 8 OLI imagery with recording date on September 7, 2017. The recording time of the imagery used was adjusted to the cloud cover conditions in the study area and was assumed to have relatively equal atmospheric conditions when fieldwork was performed (in the same season). The information of solar zenith angle (θd), the zenith angle sensor (θs), and the solar azimuth angle (φs) were obtained from metadata of the imagery, while the water vapor and aerosol optical depth information obtained from MODIS Terra Daily Level-3 (1° x 1°) global atmospheric product (MOD08_D3) with recording time at 02:15 GMT. Information of columnar ozone (O3) was obtained from OMI Daily Level-3 (0.25° x 0.25°) and global gridded product recorded at 03:07:57 GMT.
Table 1. Inputted Parameters for 6S, ATCOR2, and FLAASH

| Parameters                      | Information                                      |
|--------------------------------|--------------------------------------------------|
| Sensor                         | OLI                                             |
| Sensor altitude (km)            | 705                                             |
| Pixel size (m)                  | 30                                              |
| Image time (GMT hd)             | 02:48:14.2612860                                 |
| Scene centre longitude (dd)     | 110.02672                                       |
| Scene centre latitude (dd)      | -7.2320675                                      |
| Solar zenith angle ($\theta_z$) | 30.41138361                                     |
| Sensor zenith angle ($\theta_o$)| -                                               |
| Solar azimuth angle ($\phi_o$)  | -                                               |
| Atmospheric model               | Tropical                                        |
| Water vapour (g cm\(^{-2}\))   | 3.269                                           |
| Ozone (cm-atm)                  | 0.2567                                          |
| Aerosol model                  | Urban, Maritime, Continental                     |
| Visibility (km)                 | 29                                              |
| Aerosol optical depth at 550 nm | 0.283                                           |

Fieldwork was conducted on December 12-13, 2017 by using spectrometer to obtain the reflectance values of each object under actual ground conditions (Table 1). Field measurements were performed on several locations with different types of objects, which consist of water, vegetation, and soil.

2.3. Atmospheric correction types

2.3.1. Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH). FLAASH is an atmospheric correction based on MODTRAN4 code. FLAASH is used to eliminate the influence of air and light, by removing disturbances to the parameters of reflection, emissivity, surface temperature, and physical surface reflections. The equations used are:

\[
L = \left(\frac{A \rho}{1 - \rho S}\right) + \left(\frac{B \rho e}{1 - \rho e S}\right) + L_a
\]

(1)

where $\rho$ is the surface reflectance, $\rho_e$ is the reflection of the mean surfaces for the pixels and the surrounding region, $S$ is the spherical albedo from the atmosphere, $L_a$ is a dispersed re-emission in the atmosphere, $A$ and $B$ are coefficients that depend on atmospheric and geometric conditions but not on the surface. The values of $A$, $B$, $S$ and $L_a$ were derived from the MODTRAN4 calculation based on the sun angle at recording and the mean of surface elevation of the recording location by using the assumption of atmospheric model, aerosol type, and certain visibility level.

2.3.2. Quick Atmospheric Correction (QUAC). QUAC is performed by statistical methods, directly considering the reflectance value of objects on each bands, without any addition or subtraction of information such as atmospheric correction in general, so that this correction is performed more quickly. The equations used are:

\[
\rho' = \frac{\rho_1 + \rho_2 + \ldots + \rho_n}{n}
\]

(2)

Based on the equation above, the QUAC correction depends on the segmentation of each section because it corresponds to the average value of each section used in the calculation of the surface reflection. The working steps of the QUAC correction are illustrated in the Figure 1.
2.3.3. **Dark Object Subtraction (DOS).** DOS is an atmospheric correction that based on the assumption that there are several radian pixels in a cloud-enclosed location that acceptable for the sensor as the result from atmospheric scattering (path radiance). Based on these assumptions, it uses a simple technique by drawing the minimum value of each image band to zero to obtain the actual reflected value.

\[ \rho = \frac{[\pi \cdot (L_{\text{sat}} - L_{\text{haze}})] \cdot d^2}{(E_{\text{SUN}} \cdot \cos \theta)} \]  

(2.3)

Where \( L_{\text{haze}} \) is the path of radiance at band \( \lambda \), \( E_{\text{SUN}} \) is Exo-atmospheric solar irradiance at band \( \lambda \), and \( d \) is the distance of earth-sun (in astronomical unit).

2.3.4. **Second Simulation of the Satellite Signal in the Solar Spectrum (6S).** 6S is an advanced radiative transfer code designed to simulate the reflectance value of solar radiation with some atmospheric surface systems for various atmospheric, spectral, and geometric conditions. 6S calculates the atmospheric correction coefficient \( x_a \), \( x_b \) and \( x_c \) separately for each band based on the input data used in accordance with atmospheric conditions during recording. The equations used are as follows:

\[ y = x_a \cdot (L_{\text{rad}}) - x_b \]  

(2.4)

\[ \rho = y / (1 + x_c \cdot y) \]  

(2.5)

Where \( x_a \) is the inverse of atmospheric transmission, \( x_b \) is atmospheric scattering, \( x_c \) is the atmospheric reflectance of isotropic light.

2.3.5. **Atmospheric Correction (ATCOR2).** ATCOR2 is an atmospheric correction module available in ERDAS Imagine software. This atmospheric correction is based on MODTRAN4 code as well as the FLAASH correction. ATCOR2 is basically divided into two types, the first involves atmospheric effects with the assumption of isotropic or Lambertian reflection law, regardless of the adjacency effect, and the second reflects the reflected radiation of the surrounding environment by considering the adjacency effect. Surface reflectance that ignore adjacency effect are obtained by the equation below:

\[ \rho_{SUP} = \frac{1}{a_1} \left( \frac{\pi \cdot L_{\text{TDA}} \cdot d^2}{E_{\text{TDA}} \cdot \cos \theta_1} - a_0 \right) \]  

(2.6)

To obtain the coefficients \( a_0 \) and \( a_1 \), it takes the estimate of atmospheric parameters (aerosol type, optical visibility or thickness and vapor column). In contrast, the surface reflectance that considers the adjacency effect obtained by the following equation:

\[ \rho'_{SUP} = \rho_{SUP} + \left( \frac{1}{\lambda_1} \int_{\lambda_1}^{\lambda_2} \frac{T_{\text{diff}}}{Rd\lambda} \right) \left( \rho_{SUP} - \sum_{i=1}^{n_R} \vec{p}_{SUP} \cdot \omega_i \right) \]  

(2.7)
where \( \text{dif} \) and \( \text{dir} \) are transmission diffusion, \( R \) is the spectral response curve of each sensor and \( \omega_i \) is the weighted coefficient as a distance-dependent function.

### 2.3.6. Landsat 8 Surface Reflectance Code (LaSRC)

LaSRC is an automated satellite image processing system developed by NASA for Landsat-8 image atmospheric correction and also the development of Landsat Ecosystem Disturbance Adaptive Processing Systems (LEDAPS). LaSRC system is different from LEDAPS because it uses internal radiative transfer code algorithm, with calculation of atmospheric pressure from elevation, moisture from MODIS CMA, air temperature from MODIS CMA, ozone from MODIS CMG, and AOT from MODIS CMA.

### 2.4. Comparison of Atmospheric Correction Results

Comparison is done by using spectral curve and Standard Error of Estimate (SEE) as the representing value of the accuracy level of each surface reflectance value of atmospheric correction on imagery and surface reflectance value of field measurement. The equations used to determine the values of SEE:

\[
\text{SEE} = \sqrt{\frac{\sum_{i=1}^{n} (y_i - y'_i)^2}{n-p}} \quad (2.8)
\]

Where \( y_i \) is measurement value, \( y'_i \) is surface reflectance value which conducted from atmospheric correction, \( n \) is the number of samples, and \( p \) is the number of parameter.

### 3. Results and Discussion

#### 3.1. Imagery used and sample description

Comparison of atmospheric correction types was performed by using Landsat 8 OLI imagery (Figure 2.). We can see that part of study area was covered by clouds and quite hazy. Based on MODIS and OMI imageries, the obtained AOT value of 0.283, vapor value of 3.269 g/cm\(^2\), and ozone value of 0.2567 cm-atm, which means that the study area were hazy (AOT>0.1) with a highly vapor concentration.

Fieldwork was conducted at several locations (Figure 2) with vegetation, water and soil samples. Vegetation objects were indicated by the locations of number 1, 2, and 3. Location 1 has an object of Salak vegetation, where the dominant surface reflectance is affected by the internal structure of the vegetation itself. At this location there are two tested samples, which are young Salak Pondoh leaf and mature Salak Pondoh leaf to compare the spectral response of vegetation with different ages. Location 2 is located in the Kridosono Stadium with the object tested in the form was grass, and the third location lies in paddy fields in Bantul regency. Objects tested on the location 3 is irrigated paddy field with land cover object of paddy plants. When the field measurement was performed, the paddy plants...
condition was almost mature, ready to be harvested and is assumed to have the same condition with the recorded imagery of three months and 6 days earlier.

The fourth and fifth locations are soil objects. In the study area it is very difficult to find sufficiently large samples with homogeneous soil objects, so the selected samples are samples on beach sand and sand dunes. Location 4 is located on the sand dune with the dominant object of deposited sand that was carried by the wind from the sea. Location 5 is Parangtritis beach with the object of sample is beach sand. At this location, the tested sand is moist sand and frequently being hit by the ocean currents. Measurements at this location were done at 14.34 p.m which is not at peak time of tide or low tide so it is assumed to have the same condition at the time of image recording at 09.48 a.m.

Location 6, 7, and 8 were water. The sixth location is located on the Opak River with the object of study of flowing turbid water that contains suspended materials. The seventh location lies in the Sermo Reservoir with the object of calm turbid water with suspended materials that resulted from sedimentation of the surrounding area. The eighth location is a lagoon of Glagah Beach that has shallow turbid water that was suspended by mosses. Field measurements were made at some of these sites because it was assumed that each location had a homogeneous reflective value on one Landsat 8 OLI image pixel (spatial resolution of 30 meters). The image used was recorded on September 7, 2017 while field measurements were conducted on December 12 and 13, 2017. This is because the imagery has relatively atmospheric conditions that can be used to measure surface reflectance values and is close to the time when fieldwork was performed.

3.2. Evaluation of atmospheric correction models
The ability of each atmospheric correction was evaluated by comparing each atmospheric correction on imagery results with spectrometer reflectance data from field measurements, both statistically based on SEE and visually based on spectral reflectance curves of each object (Table 2).

| Object Samples          | Atmospheric Correction Types |
|-------------------------|------------------------------|
|                         | LaSRC | DOSh | QUAC | FLASH| Urban | FLASH | Rural | FLASH | Maritime | ATCOR2 | Urban | ATCOR2 | Maritime | 6S | Urban | 6S | Rural | 6S | Maritime |
| Young leaf of Salak Pondoh | 0.257 | 0.269 | 0.217 | 0.223 | 0.244 | 0.246 | 0.226 | 0.248 | 0.249 | 0.225 | 0.248 | 0.265 |
| Mature leaf of Salak Pondoh | 0.108 | 0.124 | 0.083 | 0.078 | 0.097 | 0.100 | 0.079 | 0.090 | 0.100 | 0.080 | 0.100 | 0.117 |
| Grass | 0.149 | 0.173 | 0.097 | 0.139 | 0.144 | 0.144 | 0.138 | 0.138 | 0.137 | 0.148 | 0.147 | 0.154 |
| Paddy plants | 0.090 | 0.107 | 0.025 | 0.063 | 0.080 | 0.081 | 0.063 | 0.071 | 0.070 | 0.075 | 0.085 | 0.090 |
| Sand dunes | 0.081 | 0.094 | 0.136 | 0.065 | 0.069 | 0.068 | 0.067 | 0.077 | 0.076 | 0.063 | 0.073 | 0.079 |
| Beach sand | 0.011 | 0.044 | 0.049 | 0.033 | 0.029 | 0.020 | 0.031 | 0.013 | 0.013 | 0.045 | 0.020 | 0.015 |
| River | 0.122 | 0.117 | 0.144 | 0.094 | 0.104 | 0.105 | 0.096 | 0.112 | 0.113 | 0.092 | 0.107 | 0.117 |
| Reservoir | 0.059 | 0.050 | 0.042 | 0.008 | 0.059 | 0.037 | 0.063 | 0.046 | 0.042 | 0.075 | 0.057 | 0.046 |
| Lagoon | 0.032 | 0.039 | 0.041 | 0.048 | 0.037 | 0.034 | 0.046 | 0.031 | 0.026 | 0.060 | 0.040 | 0.027 |

3.2.1. Mature leaf of Salak Pondoh
The spectral reflectance curves (Figure 3) of mature Salak Pondoh vegetation show that the spectral response of vegetation in general gives high reflection in green band and very high in near infrared band. This might be caused by the leaf pigment or the internal structure of the leaf. On this object, the absorption from red band is quite weak, which was depicted by the lack of contrast between difference of reflection value from green band to red band. According to the spectral reflection curve comparison on mature leaves, it can be deduced that the measurement result of reflection value from spectrometer is higher than the used atmospheric correction result. It can be the case that during the field measurement, the leaves sample were single sample, and on the object imagery, it was the canopy of
the vegetation that was shown. Even so, the reflection curve for the correction result and the field measurement demonstrate a similarity in pattern.

3.2.2. Young leaf of Salak Pondoh
The spectral reflectance curves of the Salak Pondoh vegetation with young leaves is shown in Figure 4. There is similarity on reflective pattern with the mature leaves, yet they still have distinct reflective value. On the vegetation with young leaves the electromagnetic wave is highly absorbed in red band, which was illustrated by the difference between the reflection on green band and red band. This young-leafed vegetation have lower reflection value because of unripen pigment. The lowest SEE value that was shown by the QUAC atmospheric correction was 0.21662. In contrast, the mature vegetation has best correction on FLAASH urban. The SEE value resulted from the young vegetation has higher SEE value. The sample location that was dominated by mature-leafed vegetation causing the impurity in imagery pixels might be the reason for this difference.

3.2.3. Grass
The spectral reflectance curves of grass object (Figure 5) demonstrate the difference in spectral response pattern between spectrometer measurement and atmospheric correction in imagery. The reason for this discrepancy might come from the fact that the sample object measurement on the field used pure or single grass while the imagery contain mixed pixel that might come from other object like dirt. The lowest SEE value was from QUAC, which was 0.09654.
3.2.4. Paddy plants

Based on the spectral reflectance curves in Figure 6, the pattern of paddy object though smaller, is considerably similar with the young salak pondoh object. The low reflection of this plant can be from the impact of water content or the mature age of the rice. In addition, the lowest SEE value of 0.02512 was from QUAC. In general, for the vegetation objects, QUAC atmospheric correction demonstrates the lowest SEE value. Thus it is also concluded that this atmospheric correction type is the most suitable for vegetation objects.

3.2.5. Sand dunes

The curves of the spectral reflectance value of the object (Figure 7) generally show a linear increase in field measurement whereas the reflectance value of the imagery occurred a significant increase in band 5. This was occurred because the field measurement was performed on a single object, while the pixels in imagery are a mixed pixel, which means there are more than one object in one pixel, so that the reflectance value was an accumulative value of each object in one pixel. Generally seen, the overall result of atmospheric correction yields the same pattern and the QUAC method produces a curve that has the furthest distance from the curve of the field measurement compared to other correction methods. Of the various methods of atmospheric correction, the urban model 6S method yields the lowest standard error value of 0.06302 compared to other methods, especially FLAASH, ATCOR2, and LaSRC, which is a physical based correction atmospheric based method. These results are similar to previous studies which suggested that the results of the 6S method are generally better than FLAASH and ATCOR2 on sand objects especially in bands 1-4 [3]. The lowest SEE value of the 6S, FLAASH, and ATCOR2 methods are in the urban aerosol model. This is because the pixels at the observation site are mixed pixels that were impacted by the spectral reflectance value of vegetation, as evidenced by the high reflectance value of the imagery on all the correction methods at band 5.

3.2.6. Beach Sand

The spectral reflectance curves in Figure 8. show a different pattern of reflectance curves on atmospheric correction results and field measurements. All of the correction methods, except LaSRC, did not have the same pattern with the result of the curve from the field measurement. The spectral pattern of field measurement results is seem to be increased linearly with
a significant increase at band 3. The DOS1 method has a pattern that resembles the fieldwork result, but at band 3, the reflectance value was decreased. LaSRC method shows the smallest standard error value of 0.01063 and followed by ATCOR2 Rural of 0.01304, ATCOR2 Marine of 0.01324, and 6S Marine of 0.01474. The LaSRC method used MODIS CMA and CMG images to obtain the parameters required for the calculations. At the location of the object, the parameters used were close to the ground situation so that the results of reflectance values on this method close to the reflectance value of the field measurement results. The ATCOR2 method with rural model aerosols is better than ATCOR2 with maritime model. However, the correction model of 6S and FLAASH which has the smallest SEE value is the method with maritime aerosol model which means that at this location is dominantly influenced by aerosols from the sea.

3.2.7. River
Based on the spectral reflectance curve in Figure 9, generally, there is no atmospheric correction method which has the same spectral response pattern with field measurement results. This occurs because field measurements were conducted after flood so that sediment concentration contained in water is higher than its normal condition that was recorded by the imagery and causing the reflectance value to increase from band 2 to band 4. The method which has the lowest SEE value was 6s method with urban-type aerosol of 0.09247 and followed by FLAASH Urban of 0.09446.

3.2.8. Reservoir
Based on previous research, it is known that in turbid water objects there are three conditions that occur at visible wavelength to near infrared. At wavelengths between 400 and 580 nm, there is a linear increase due to optical conditions of mixed waters dominated by phytoplankton, CDOM, and unidentifiable sedimentation [5]. At wavelengths between 580 and 700 nm is influenced by water characteristics with high sediment concentrations [6], and at wavelengths between 740 to 900 nm is predominantly affected by water absorption and back scattering of sediments. Based on Figure 10, the field measurement result was lower than the result of the atmospheric correction method. This can be assumed as the concentration of sediment when the image was recorded is higher than during field measurement. Based on the reflectance curve, in general physical-based atmospheric correction method produces a relatively similar spectral pattern that decreases reflected values at bands 2 and 4. On the other hand, image based atmospheric correction produces a much different pattern. The method that has the lowest SEE value on this object is ATCOR2 Maritime of 0.04202 and QUAC of 0.04206. QUAC has a fairly low SEE value due to the smaller reflected value, compared to other methods, although it can be seen from the reflectance curve that this method does not have an appropriate pattern like the other method. It is different with the ATCOR2 Marine that has a low error standard and a relatively appropriate pattern.
3.2.9. Lagoon

The object at this location is turbid water with high concentration of phytoplankton. Based on the spectral reflectance curve in Figure 11, it can be seen that there are no significant changes that occurred at 3-month interval. The reflectance curve indicates that the LARSC correction method depicts similar result with the field measurement. In contrast, other atmospheric correction methods are observed to have high reflectance value at band 1, thus it is considered less appropriate with the spectral pattern of the field. The method of atmospheric correction with the lowest standard error is ATCOR2 Maritime with 0.02570. The methods of ATCOR2, 6S, and FLAASH aerosol models that have the lowest standard error are maritime aerosols which means that at this location is dominantly influenced by aerosols from the sea.

4. Conclusions

The result shows that, generally, the object spectral pattern that obtained from the atmospheric correction of the imagery has the same spectral pattern with the field measurement results. Physical based methods have the lowest standard error values for all objects compared to the image based method, except on the vegetation object in which the QUAC method is the method with the lowest SEE. This is because the reference value used in this study comes from direct measurement of the field at the pixel location taken from the imagery. The SEE value does not indicate the actual accuracy of the compared atmospheric correction method, but shows the magnitude of the difference in the absolute value of each method of correction on each object as a mere comparison. In general there is no best atmospheric correction method in all conditions and universally applicable, each object has its own accurate atmospheric method, depends on the location and condition of the object in an image pixel.

References

[1] Cracknell, P. A., & Hayes, L. (2007). Introduction to Remote Sensing: Second Edition. USA: CRC Press.
[2] Liang, S. (2004). Quantitative Remote Sensing of Land Surfaces. Canada: John Wiley & Sons.
[3] Nazeer, M., Nichol, J. E., & Yung, Y.-K. (2014). Evaluation of Atmospheric Correction Models and Landsat Surface Reflectance Product in An Urban Coastal Environment. International Journal of Remote Sensing.
[4] Roussel, G., Weber, C., Xavier, B., & Xavier, C. (2017). Comparison of Two Atmospheric Correction Methods for the Classification of Spaceborne Urban Hyperspectral Data Depending on the Spatial Resolution. International Journal of Remote Sensing, vol. 39, pp. 1593-1614.
[5] Siswanto, E., Ishizaka, J., Tripathy, S., & Miyamura, K. (2013). Detection of Harmful Algal Blooms of Karenia Mikimotoi Using MODIS Measurements: A Case Study of Seto-Inland Sea, Japan. Remote Sensing of Environment, 185-196.
[6] Kutser, T., Metsamaa, L., Strömbeck, N., & Vahtmäe, E. (2006). Monitoring Cyanobacterial Blooms by Satellite Remote Sensing. Estuarine Coastal Shelf Science, 303-312.