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Implementation of Image Restoration Technique for Aqua Moderate Resolution Imaging Spectroradometer (Aqua Modis) Satellite Image

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***Abstract* - Satellite image as a type of data obtained from sensory and stored in certain format should be displayed on the screen for an analysis where quality of the image can be seen clearly. Quality of satellite image is determined based on quantitative and qualitative point of view. Image restoration is needed when quality of particular image cannot meet the requirement of particular application. Basically, all images captured using sensor recording devices have certain errors due to device mechanism, geometrical form, configuration of the earth surface and atmosphere condition when the images are captured. These flaws should be corrected so that geometrical and radio metrical aspects of an image can meet requirements of various types of related application. The purpose of the study is conducting atmospheric restoration technigue for the AQUA MODIS satellite image. The findings show that the restored images have better sharpness level and are clearer. In addition, the AQUA MODIS images that have been through geometrical restoration have been mapped correctly.**

Keywords- Restoration ,Remote Sensing, Image Processing

I. INTRODUCTION

Remote sensing refers to a branch of knowledge and arts that provides information about an object, an area or a phenomenon by analyzing data obtained using certain devices without making direct contact to the object, area or phenomenon being observed (Lillesand dan Kiefer, 1990). Pivotal component in satellite remote sensing is electromagnetic power source, atnosphere, interaction between the power source and object and sensory (Sutanto, 1998. Remote sensing sytem scheme can be seen in figure 1.

Remote sensing technology, more particularly one using satellite, has been applied extensively to gain information about oceanography and fisheries. Satellite remote sensing is able to provide global information regularly related to condition of certain area of water which refers to (a) ability of satelilite remote sensing to cover large area, (b) satellite remote sensing is homogenous that refers to its ability to cover similar area with the same spatial, scale and geometrical angle (spatial resolution), and (c) record the same earth surface regularly (temporal resolution) (Jansen, 2000 as cited in Purwandaru, 2007).

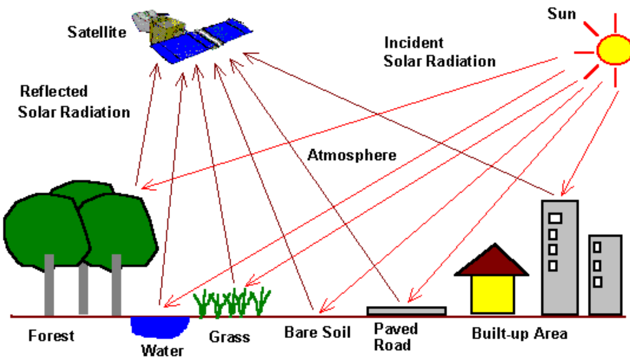

Fig. 1. Remote Sensing System

The main power source used in remote sensing is electromagnetic. Electromagnetic power house is combination of electricity and magnetism that moves with lighting speed in certain frequency and wavelength as well as particular amount of power (Chanlett, 1979 as cited in Sutanto, 1998). Electromagnetic transfer is carried out in three methods namely conduction, convection and radiation.

For remote sensing of the earth, the most important source of electromagnetic radiation is the sun. The temperature of the sun surface is 6,000 K and it reflects energy that involves wavelength of ultraviolet area, clear and infrared. The dominant wavelength occurs in 0.5 µm (green light) that can be seen with naked eyes. It is the result of the sun reflection. Besides that, temperature of the Earth surface is lower, 300 K and based on Wien's displacement law, dominant wavelength changes during longer wavelength that is 9,7 µm, placed in thermal infrared area and electromagnetic spectrum.

II. AQUA MODIS SATELLITE

The MODIS instrument provides high radiometric sensitivity (12 bit) in 36 spectral bands ranging in wavelength from 0.4 µm to 14.4 µm. The responses are custom tailored to the individual needs of the user community and provide exceptionally low out-of-band response. Two bands are imaged at a nominal resolution of 250 m at nadir, with five bands at 500 m, and the remaining 29 bands at 1 km. A ±55-degree scanning pattern at the EOS orbit of 705 km achieves a 2,330-km swath and provides global coverage every one to two days.

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The Scan Mirror Assembly uses a continuously rotating double-sided scan mirror to scan ±55-degrees and is driven by a motor encoder built to operate at 100 percent duty cycle throughout the 6-year instrument design life. The optical system consists of a two-mirror off-axis afocal telescope, which directs energy to four refractive objective assemblies; one for each of the VIS, NIR, SWIR/MWIR and LWIR spectral regions to cover a total spectral range of 0.4 to 14.4 µm.

A high-performance passive radiative cooler provides cooling to 83K for the 20 infrared spectral bands on two HgCdTe Focal Plane Assemblies (FPAs). Novel photodiode-silicon readout technology for the visible and near infrared provide unsurpassed quantum efficiency and low-noise readout with exceptional dynamic range. Analog programmable gain and offset and FPA clock and bias electronics are located near the FPAs in two dedicated electronics modules, the Space-viewing Analog Module (SAM) and the Forward-viewing Analog Module (FAM) . A third module, the Main Electronics Module (MEM) provides power, control systems, command and telemetry, and calibration electronics.

The system also includes four on-board calibrators as well as a view to space: a Solar Diffuser (SD), a v-groove Blackbody (BB), a Spectroradiometric calibration assembly (SRCA), and a Solar Diffuser Stability Monitor (SDSM).

The first MODIS Flight Instrument, ProtoFlight Model or PFM, is integrated on the Terra (EOS AM-1) spacecraft. Terra successfully launched on December 18, 1999. The second MODIS flight instrument, Flight Model 1 or FM1, is integrated on the Aqua (EOS PM-1) spacecraft; it was successfully launched on May 4, 2002. These MODIS instruments offer an unprecedented look at terrestrial, atmospheric, and ocean phenomenology for a wide and diverse community of users throughout the world.

Table 1. Technical Specification of Aqua MODIS

Orbit Type	1:30 *pm.ascending node, sun-snchronous, near-polar*
Height	705 km
Wide View	2,330 km
Temporal Resolution	1 time/day
Spatial Resolution	250 m (bands 1-2) 500 m (bands 3-7) 1000 m (bands 8-36)
Life Span	6 years

(Source: http:// modis.gsfc.nasa.gov/about/specifications.html)

Table 2 Spectral information of Aqua MODIS

Primary Use	Band	wavelength
Land/Cloud/Aerosol Boundaries	1	620 – 670 nm
	2	841 – 876 nm
Land/Cloud/AerosolsProperties	3	459 – 479 nm
	4	545 – 565 nm
	5	1230 – 1250 nm
	6	1628 – 1652 nm
	7	2105 – 2155 nm
Oceancolor/Phytoplankton/Biogeochemistry	8	405 – 420 nm
	9	438 – 448 nm
	10	483 – 493 nm
	11	526 – 536 nm
	12	546 – 556 nm
	13	662 – 672 nm
	14	673 – 683 nm
	15	743 – 753 nm
	16	862 – 877 nm
AtmosphericWater Vapor	17	890 – 920 nm
	18	931 – 941 nm
	19	915 – 965 nm
Surface/CloudTemperature	20	3.660 - 3.840 µm
	21	3.929 - 3.989 µm
	22	3.929 - 3.989 µm
	23	4.020 - 4.080 µm
AtmosphericTemperature	24	4.433 - 4.498 µm
	25	4.482 - 4.549 µm
Cirrus CloudsWater Vapor	26	1.360 - 1.390 µm
	27	6.535 - 6.895 µm
	28	7.175 - 7.475 µm
Cloud Properties	29	8.400 - 8.700 µm
Ozone	30	9.580 - 9.880 µm
Surface/Cloud Temperature	31	10.780 - 11.280 µm
	32	11.770 - 12.270 µm
Cloud Top Altitude	33	13.185 - 13.485 µm
	34	13.785 - 14.085 µm
	35	13.785 - 14.085 µm
	36	14.085 - 14.385 µm

(Source : *http:// modis.gsfc.nasa.gov/about/specifications.html*)

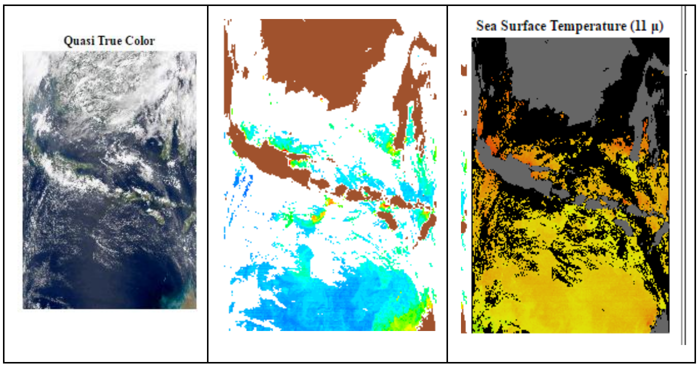

Fig 2. Sample data from Aqua Modis taken on 26 July 2016

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2.1 Pre-Image Processing

Image captured using remote sensing method experiences various distortion due to sensory movement, media and the object itself. As the effect, the images require restoration. The procedure is frequently called preliminary data processing or *pre*-image processing that involves various corrections.

Geometrical correction refers to process of revising geometrical errors and transforming remote sensing images in order that the images meet certain mapping projection. Geometrical error may occur because of deflecting direction of light, sub-optical system abrasion, non-linear scanning system, change of height and speed of the satellite, change in satellite position, the earth rotation and curve.

Radiometric error refers to image pixel. It happens due to errors in optical system, disruption of radiation energy in the atmosphere and sun elevation angle. Once radiometric error is not restored, the method used to analyze an image (for example algorithm being developed) cannot be applied to other images taken on different date or place.

Radiometric correction is needed to standardized angle of sun elevation and the sun-earth distance in different time and place. Radiometric correction for Aqua MODIS image is carried out by counting reflectance value of vivid imaging and that of thermal imaging using the following formula:

$$R_i = Rscale_i\left(B_i - Roffset_i\right)$$

where:

R_i = image reflectance/ radiance
R_i scale = image scale reflectance/ radiance
B_i = data band
R_i offset = offset imaging reflectance/ radiance

Geometric correction is carried out by analyzing Ground Control Point/ GCP. The process begins with exporting GCP from Aqua MODIS data level 1A to Aqua MODIS data level 1B. Projecting system used is geographic Lat/Lon. The geometric correction process is facilitated using Modis toolbox that can be downloaded freely in www.ittvis.com

III. RESEARCH METHOD

3.1. Image Delimitation

In order to limit the area of the imaging study, image delimitation is carried out. Latitude and longitude are used as the bases. Thus, the scope of the study is images located within the following latitude and longitude, 127º30'EL – 130º EL and 2º30'SL – 4º SL.

3.2. Radiometric Correction

Radiometric correction for Aqua MODIS images is carried out by counting radiance and reflectance value of the images with the following equations:

- Radiance Value: R_b = R scale$_b$ (B_b – R offset$_b$)
  with:
  R_b = radiance value of b
  R scaleb = radiance scale of b
  B_b = b channel
  R offsetb = Radiance offsets of b

- Zenith censory radiance value:
  R_z = R scale$_z$ * i_z * pi/180
  with:
  R_z = zenith sensory radiance value
  R scale$_b$ = radiance scale in zenith sensory
  i_z = zenith sensory

- Reflectance value: Ref$_b$ = R scale$_b$ (B_b – R offset$_b$)
  with :
  R_b = reflectance value of b
  R scale$_b$ = radiance scale of b
  B_b = b channel
  R offset$_b$ = Radiance offsets of b

Radiance scale and radiance offsets value of the data band used can be seen in Table 3.

Table 3. Radiance offsets and scale of Aqua MODIS data

Band	Radiance scale	Radiance offsets
3	0.00003397	0.00000000
10	0.00000603	316.97219849
12	0.00000382	316.97219849
20	0.00006931	2467.26440430
31	0.00065081	2035.93322754
32	0.00057100	2119.08447266
Zenith Sensory	0.01000000	-

Source: Aqua MODIS data attribute (Watts/m^2/µm/sr)

IV. RESULTS AND DISCUSSION

The findings describe comparison between Aqua MODIS images captured on May 16, 2016 and the result of image restoration process on the same date from 2015 to 2016 and selected images captured every month in 2016.

One full scene of Aqua MODIS image record that involves the setting of the study can be seen in figure 3. In order to give clear difference between the land and the ocean, band 721 false color composite is used

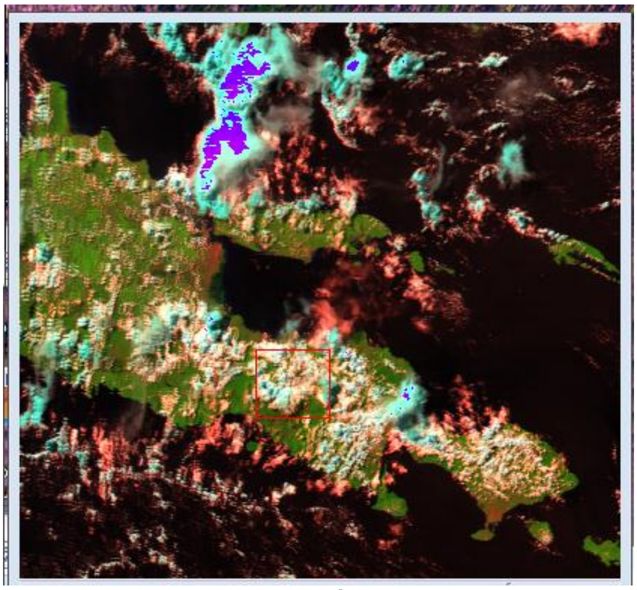
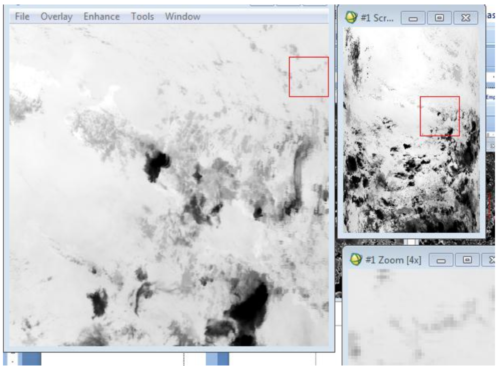


Fig. 3. Aqua MODIS image captured on May 16, 2016 at 05.15 a.m.

4.1. Pre-Image Processing (Geometric Correction)

The result of pre-image processing being presented is band 10 image that represents spread of chlorophyll and band 31 image for analyzing temperature of sea surface. Both images can be seen in figure 4 and figure 5.

.Fig.4. Radiometric Correction in Band 10



.Fig.5. Radiometric Correction in Band 10

4.2. Pre-Image Processing (Radiometric Correction)

Dark substraction method is used in the process and the results are as follow:

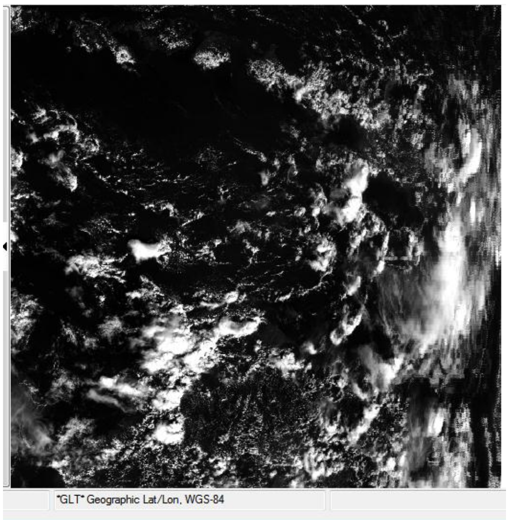


Fig.6. Radiometric Correction in Band 10

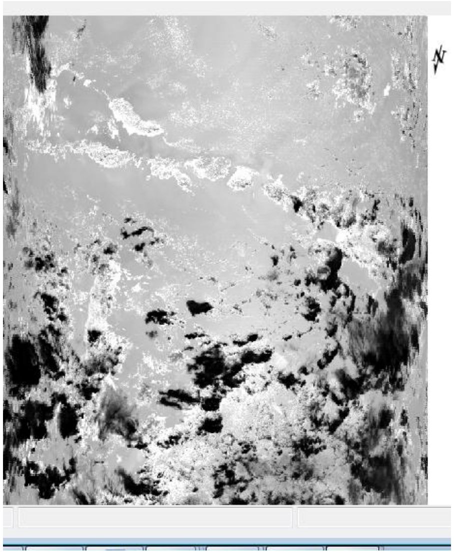


Fig.7. Radiometric Correction in Band 31

CONCLUSION

Prior to analysis, the satellite images are restored using both radio metric and geometric corrections. The purpose of radio metric correction is to get clear detail information to avoid errors in interpretation, identification and classification of the satellite image. On the other hand, the purpose of geometric correction is to position satellite image against the world map in order to get an image of which latitude and longitude match the topography and the scale of the map is accurate.

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