Using MTSAT-2 Visible Images to Retrieve Aerosol Optical Depth (AOD)

Chien-Ben Chou
Central Weather Bureau Taipei , 10048, Taiwan (joujb@cwb.gov.tw)
Huei-Ping Huang
School for Engineering of Matter, Transport, and Energy, Arizona State University, Tempe, AZ 85281, USA

Abstract

A geostationary satellite can provide observations at a higher frequency and with greater area coverage than an orbital satellite. This study uses data from geostationary satellite MTSAT-2 to retrieve the aerosol optical depth over eastern Asia. The 6S radiative-transfer model is used to generate a look-up table to facilitate the estimate of surface reflectance and retrieval of the optical depth of aerosols. A comparison of the optical depth retrieved from MTSAT-2 observations with the visibility measured at ground stations reveals a good match in their spatial patterns. The aerosol optical depth from MTSAT-2 is hence useful for monitoring the daily evolution and distribution of aerosols.

method and formula

$$R_{sat}(\mu,\phi,\mu_0,\phi_0) = R_{atm}(\mu,\phi,\mu_0,\phi_0) + T_{atm}(\mu_0)T_{atm}(\mu)R_{suf}/(1-R_{suf}S_\lambda) \quad (1)$$

R_{sat} : reflectance received by satellite ; μ : cos(satellite view zenith angle) ; μ_0 : cos(solar zenith angle) ; ϕ :azimuth angle of satellite ; ϕ_0 : azimuth angle of solar ; R_{atm} : reflectance from atmosphere ; $T_{atm}(\mu_0)$: downward transmission from solar direction ; $T_{atm}(\mu)$: upward transmission in direction of satellite ; R_{suf}: surface reflectance ; S_λ : atmospheric back-scattering ratio

$$R_{atm}(\mu,\phi,\mu_0,\phi_0) = R_{aerosol}(\mu,\phi,\mu_0,\phi_0) + R_{Ray}(\mu,\phi,\mu_0,\phi_0) \quad (2)$$

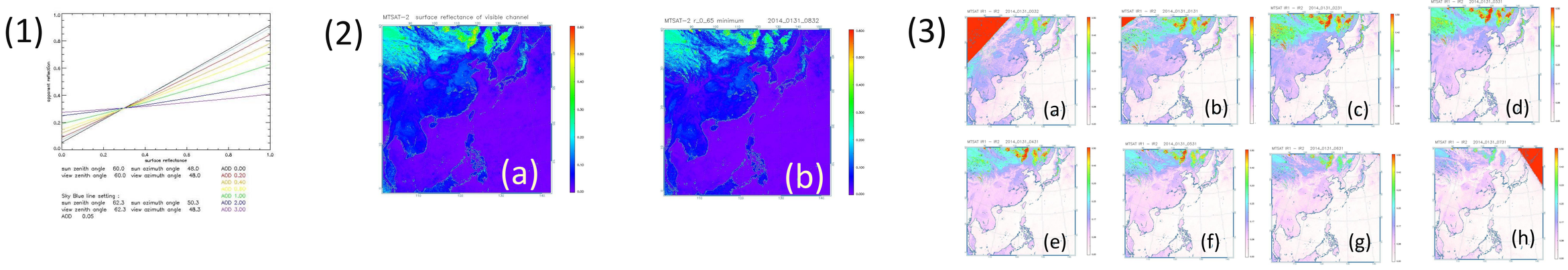
$R_{aerosol}(\mu,\phi,\mu_0,\phi_0)$: reflectance of aerosol ; $R_{ay}(\mu\ \phi\ \mu_0\phi_0)$: reflectance of molecules. Replacing the R_{atm} in (1) with (2) get (3).

$$R_{aerosol}(\mu,\phi,\mu_0,\phi_0) = R_{sat}(\mu,\phi,\mu_0,\phi_0) - R_{Ray}(\mu,\phi,\mu_0,\phi_0) - T_{atm}(\mu_0)T_{atm}(\mu)R_{suf}/(1-R_{suf}S_\lambda) \quad (3)$$

Look up table: Using 6S package with suitable aerosol model and (3), one can obtain the dependence of $R_{aerosol}$ (aerosol optical depth) on reflectance received by satellite (R_{sat}) and surface reflectance (R_{suf}) for each given set of angular (μ, ϕ, μ_0, ϕ_0). Using look-up table create pre-determined surface reflectance first, then the aerosol optical depth can be obtained with pre-determined surface reflectance for every apparent reflectance form satellite observation.

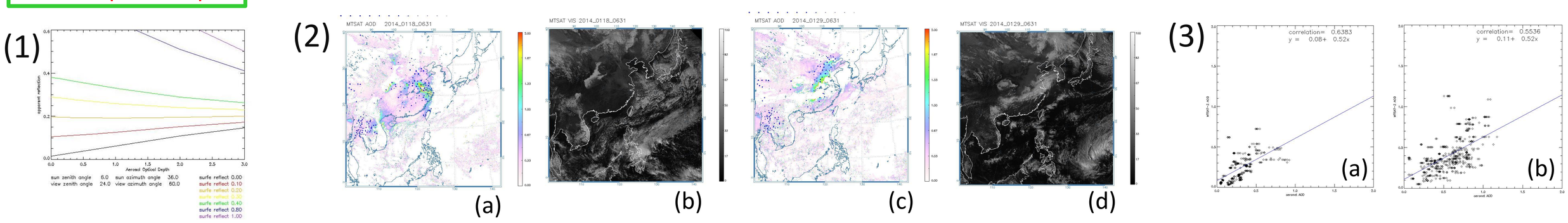
experiment results

pre-determined surface reflectance



(1) A example of look-up table, relation between surface reflectance and apparent reflectance at specific angles with varied AOD, steel blue line AOD=0.05. (2) surface reflectance for January 2014 as estimated from (a) second minimum value (avoid shade) and from (b) minimum surface reflectance. Both use a look-up table to correct atmospheric effect with aerosol optical depth set to 0.05. (3) estimated surface reflectance for January 2014. From (a) to (h) at particular time of the day, from 0000 too 007 TUC step 1 hour.

aerosol optical depth



(1) An example of a look-up table that show the relation between aerosol optical depth and apparent reflectance. The lines of different colors correspond to different values of surface reflectance. This example is for a particular set of solar and satellite-view zenith and azimuth angles, as indicated in the bottom of the plot. If the surface reflectance has been evaluated as above (pre-determinded reflucatnce) one can use look-up table to estimate aerosol optical depth for every apparent reflectance received by satellite. (2) (a) Retrieved aerosol optical depth for January 18, 2014, at 0631 UTC. Blue dots represent the observations of visibility from ground stations. The largest dot indicates visibility less than 1 km, second largest indicates visibility less than 2 km, and so on. (b) Visible channel imagery. Figures (c) and (d) are same as (a) and (b) but for January 29, 2014, at 0631 UTC. (3) (a) Comparison of the aerosol optical depth retrieved from MTSAT-2 data and its counterpart from AERONET (0.55vm) observation at Chiayi City in Taiwan. (b) Same as (b) but for Taipei City.

remark

Aerosol optical depth over a large area is retrieved from geostationary satellite observations using a look-up table generated by running a radiative transfer code. The results indicate the potential of this approach for monitoring aerosol concentration over regions with relatively low surface reflectance. This work uses the data from MTSAT-2. The approach developed here could be applied to newer instruments such as Advanced Himawari Imager (AHI) on board Himawari-8.

reference

Kaufman, Y. J., Tanre, D., Remer, L. A., Vermote, E. F., Chu, A., and Holben, B. N.: Operational remote sensing of tropospheric aerosol over land from EOS moderate resolution imaging spectroradiometer, *J. Geophys. Res.*, **102**, 1751-17067, doi:10.1029/96JD03988, 1997.