CERES TRMM-PFM-VIRS Edition1 SSF Aerosol Properties - Accuracy and Validation

Aerosol optical depth (AOD) is being retrieved from calibrated reflectances from the Visible Infrared Scanner (VIRS) onboard the Tropical Rainfall Measuring Mission (TRMM) satellite, launched in 1997. The retrieval algorithm is the one used with Advanced Very High Resolution Radiometer (AVHRR) data in NOAA/NESDIS operations, referred to as the 2nd generation algorithm. It is discussed in detail in papers listed in the reference section. The algorithm uses pre-computed look-up tables from the Dave radiative transfer code to relate cloud-free reflectances in the VIRS channels 1 (0.63 µm) and 2 (1.61 µm) to AOD and illumination/viewing geometry for a plane parallel atmosphere, bounded by a Lambertian lower reflecting ocean surface. The calibration and cloud masking algorithms are described in detail in other sections of this quality summary. The parts of these algorithms unique to the AOD retrieval are:

- The need to correct the channel 2 reflectance for a leak of thermal radiation at 5.2 µm, referred to as the dark albedo correction.
- Only certain cloud mask conditions are acceptable for aerosol retrieval: cloudy (with 3.7 µm albedo less than 3%), strong-clear, weak-clear, aerosol-clear, glint-clear, and smoke-clear.
- All aerosol cases have to pass a 2x2 adjacent pixel uniformity test with VIRS channel 1 reflectance (R1max - R1min less than 0.3%).

To avoid problems with the spherical atmosphere and specular reflection from the ocean surface, the retrievals are restricted to the following geometrical limits: solar zenith angles less than 70°, satellite viewing zenith angles less than 60°, relative azimuth angle between 90 and 180 degrees, and glint angle (angle between reflected ray and specular ray for a flat ocean) greater than 40°. The VIRS visible AOD and near IR AOD pixel level retrievals are mapped into the CERES Single Scanner Footprint (SSF) and their mean value is computed. In addition to many other VIRS and CERES parameters on the SSF (see SSF Collection Guide), the mean of the VIRS pixel level radiances used to compute the AOD value is also saved. This value can be used, with the associated geometrical parameters stored on the SSF, to test improvements to AOD using other retrieval algorithms.

Data Accuracy

Until the SSF Edition1 data set is completed, ValidationR4 is the most current and complete SSF data set available for analysis. The table below shows the systematic errors (differences) predicted for the ValidationR4 SSF parameters "Total aerosol A optical depth - visible" (AOD1) and "Total aerosol A optical depth - near IR" (AOD2) values at extreme and mean values of optical depth, as derived from linear regression relationships, using AOD1 and AOD2 estimates from Aerosol Robotic Network (AERONET) data as ground truth. The standard error of regression is also interpreted to represent the random error of the VIRS retrievals. However, one must note that these error predictions are essentially worst case, as they do not account for any error coming from the AERONET observations themselves, or for the departure of the ocean/atmosphere system at these island locations from that of the deep ocean, as assumed in the retrieval model. Also, the regression coefficients are derived from only 25 comparison points, which also increases their uncertainty. None-the-less, we offer this table as a VERY PRELIMINARY assessment of the performance of the Edition1 SSF aerosol optical depth parameters. It will be finalized once the eight months of Edition1 SSF data are received (see the Validation Results sub-section below for further discussion). The table shows that on average, the AOD1 values are biased high by about 0.06 relative to AERONET, with random error of about 0.06. For AOD2, using the calibration of VIRS for the SSF data set version ValidationR4, it is only biased high by 0.02, with random error of 0.04. However, for Edition1 SSF the radiances for channel 2 VIRS were elevated by 17%. The effect of this is shown in the table, bringing the systematic bias up to about 0.04, more consistent with the AOD1 bias.

Table 1: Systematic and Random Errors for VIRS ValidationR4 SSF

		Systematic Error				
VIRS Channel	**µm**	**Minimum**	**Mean**	**Maximum**	**Random Error**	**Samples**
#1	0.63	+0.09 at 0.0	+0.06 at 0.17	-0.07 at 1.00	+/- 0.06	25
#2	1.61	+0.03 at 0.0	+0.02 at 0.09	-0.07 at 1.00	+/- 0.04	25
#1 + 17% (Edition1)	1.61	+0.03 at 0.0	+0.04 at 0.09	+0.11 at 1.00	+/- 0.04	25

Validation Study Results

The only quantitative evaluation done with CERES SSF values of aerosol optical depth (AOD) has been with the ValidationR4 SSF version of the data, as reported at the 21st CERES science team meeting. This was done for all ValidationR4 SSF data from 1998 using the NASA

Aerosol Robotic Network (AERONET) system of scanning sky radiometer/sun-photometer instruments and their estimates of AOD as ground truth. Unfortunately, only 25 daily matchups were found, so these are very preliminary estimates. With such a small sample it is only possible to assess the performance on a global basis (ensemble of all AERONET sites) of the algorithm, rather than a regional one (at each AERONET location). The results are shown in table format (see Accuracy Table above).

Other changes expected with Edition1 SSF which will make this AERONET validation more statistically representative, as well as possibly improve the quality (lower biases and random errors) of the AOD retrievals are: a much higher resolution land mask (18km vs 270km), which should greatly increase the numbers of matchups when Edition1 SSF data become available for 1998; an improved cloud mask, which uses reflectance uniformity as a criteria for VIRS pixels to be cloud free. As an example, the 8 day sample of Edition1 SSF data for February, 1998, increased the number of matchups relative to ValidationR4 SSF by about 30%.

As mentioned earlier, the channel 2 albedo requires a correction for thermal emission at 5.2 µm. It is termed the "dark albedo" correction because it is quantified as a reflectance equivalent to the thermal radiance observed at night, but applied in the daytime. It was developed from one orbit of VIRS pixel level data on May 1, 1998 using regression analysis relating this dark albedo to the thermal radiances in channels 4 (10.8 µm) and 5 (11.9 µm), and view zenith angle (see Cloud Properties - Accuracy and Validation). To determine the stability of this correction over the entire eight month record of TRMM/CERES SSF, hour = 2 nighttime ValidationR4 SSF data from the first day of each month were processed. The dark albedo is computed from the channel 2 radiance and subtracted from the dark albedo estimated by the regression formula. If the correction is working as expected from the May 1st analysis (see Ignatov and Stowe, 2000), a histogram of these differences should be centered about 0.0% with extremes less than 0.2% (albedo units; this is equivalent to an AOD2 ~ 0.04). It was found that for May - August, this was indeed the observed behavior of the dark albedo correction. However, from January - April, the distribution was centered about -0.2% with extremes from -0.4% to 0.0%. This is consistent with the considerable number of negative AOD2 retrievals observed from consistency analyses (see Cautions and Helpful Hints). There are at least two possible reasons for this discrepancy between the two four month periods; VIRS calibration changes and nighttime data availability. Since the calibration of VIRS has been extensively studied by others on the CERES team (see Cloud Properties - Accuracy and Validation), it is probably not the cause. Rather, this discrepancy is probably due to latitudinal differences in the nighttime data sample of the first four months of 1998 from that of the one day used in developing the regression relationship, and from the last four months of 1998. The dark albedo regression formula has terms in it that are latitudinally dependent (infrared radiances and their differences [related to water vapor]), so differences in latitudinal sampling may cause differences in the regression equation's performance. In fact, the nighttime sampling of reflectance channels changed dramatically after April 8, 1998, when the VIRS procedure to restrict nighttime data transmissions to only infrared channels terminated (at our request), and they began to transmit reflectance data both day and night. Thus, the first four months of our dark albedo study used nighttime channel 2 data which was poorly sampled in latitude, compared with the regression development day and the last four months of the study. Therefore, it can be concluded that the dark albedo correction works well, provided it is applied over the same latitude range for which it was derived. Since there is no restriction in the latitudinal range of VIRS data during daytime that would restrict the performance of the channel 2 dark albedo correction, it is probably working as expected over the entire record of Edition1 SSF data for 1998.

Return to Quality Summary for: SSF TRMM Edition1 | SSF TRMM Beta2