Accuracy Assessment of Atmospheric Sounding Data from Terra/MODIS

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Abstract: Two MODIS instruments on board the Terra and Aqua Satellites are operational for global remote sensing of the land, ocean and atmosphere. Atmospheric sounding data with a high spatial resolution from MODIS will provide a wealth of useful information. The vertical air temperature and moisture data were retrieved using the MODIS data, and compared with the radiosonde data obtained in the Korean Peninsula. The correlation coefficient are 0.99 and 0.89 for air temperature and moisture cases, respectively. Air temperature data were relatively good agreement, but the moisture data from MODIS were underestimated.
Keywords: MODIS, radiosonde

1. Introduction

The development of global climate and weather models requires accurate monitoring of atmospheric temperature and moisture, as well as trace gases and aerosols. Until recently, continuous monitoring of changes in there parameters on a global scale has been difficult. The Moderate Resolution Imaging Spectroradiometer (MODIS) offers a new opportunity to improve global monitoring of temperature, moisture and ozone distributions and changes therein. MODIS was launched on board the National Aeronautics and Space Administration (NASA) Earth Observing System (EOS) Terra and Aqua platforms on 18 December 1999 and 4 May 2002, respectively and are operational for global remote sensing of the land, ocean and atmosphere.
The instrument is a scanning spectrodiometer with 36 visible (VIS), near-infrared (NIR), and infrared (IR) spectral bands between 0.645 and 14.235 μm (King et al., 1992).

The wide spectral range, high spatial resolution, and near-daily global coverage of MODIS enable it to observe the earth's atmosphere and continuously monitor changes. MODIS retrievals of atmospheric water vapor and temperature distributions are intended to advance understanding of the role played by energy and water cycle processes in determining the global weather and climate. MODIS temperature and moisture products can be used together with other satellite measurements in numerical weather prediction models in the regions where conventional meteorological observations are sparse (strabala et al., 2002). The advantage of MODIS for retrieving the distribution of atmospheric temperature and moisture is its combination of short wave and long wave infrared spectral bands (3~14.5μm) that are useful for sounding and its high spatial resolution that is suitable for imaging (1 km at nadir). The increased spatial resolution of MODIS measurements delineates horizontal gradients of moisture, temperature better than companion instruments. However the MODIS broadband spectral resolution provides only modest information content regarding vertical profiles. True sounder radiances with higher spectral resolution contain more information about the atmospheric vertical distribution of temperature and moisture. Because of the limited spectral resolution of MODIS, the strength of its retrieved products lies in the resolution of horizontal gradients and the distribution of retrieved quantities in integrated vertical layers (Seemann et al., 2003).

This study describes retrieval of the atmospheric temperature profile, moisture profile from Terra-MODIS through the atmospheric profile (MOD07) algorithm. Retrieved temperature and moisture compared with radiosonde observations and determined the retrieval accuracy.

2. Data and Methodology

The atmospheric profile (MOD07) algorithm which is developed at the Space Science and Engineering Center (SSEC) at the University of Wisconsin-Madison performs statistical retrievals of atmospheric temperature, moisture, total column ozone burden, integrated total column precipitable water vapor and several atmospheric stability indices using 12 infrared spectral channels with wavelengths between 4.465 and 14.235 μm.

Table 1. MODIS spectral band specifications used in profile products.

Band (μm)	Band width (μm)	Primary atmospheric Application
24	4.433~4.498	Temperature Profile
25	4.482~4.549	
27	6.535~6.895	Moisture Profile
28	7.175~7.475	
29	8.400~8.700	
30	9.580~9.880	Ozone
31	10.780~11.280	Surface Tempeature
32	11.770~12.270	
33	13.185~13.485	Temperature Profile
34	13.485~13.785	
35	13.785~14.085	
36	14.085~14.385	

Table 1 shows the MODIS spectral bands that are used in the profile products. The MODIS clear-sky retrievals are performed over land and ocean for both day and night when at least 20% of the radiances measured within a 5 × 5 field-of-view area (approximately 5km resolution) are cloud-free. Retrieval profile atmospheric levels are 20 which are 1000, 950, 920, 850, 780, 700, 620, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10 hPa (Menzel et al., 2002).

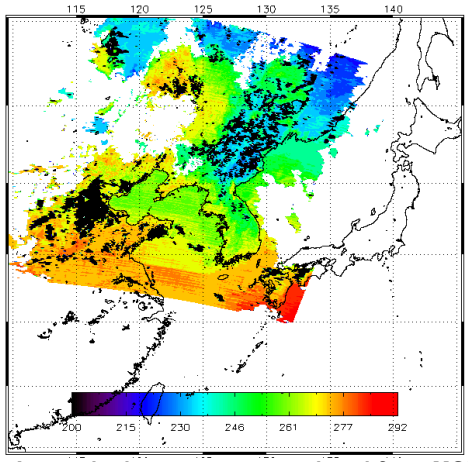


Fig. 1. Atmospheric temperature retrieved from MODIS coverage on March 1, 2002 at UTC 0245.

Fig. 1.shows the average temperatures retrieved from Terra-MODIS radiances on March 1 , 2002 at 0245 UTC at only 20 levels.

Radiosondes are routinely launched only two times each day at 0000 UTC and 1200 UTC simultaneously 6 sites around Korea. Data from radiosonde have the information of pressure, height, temperature, dew point temperature, relative humidity, mixing ratio, direction of wind, potential temperature, station information and sounding indices. It is therefore not possible to obtain many time and space collocated MODIS radiances. A total of 8789 MODIS retrievals and collocated radiosonde observations were compared twice a day 0000 UTC and 1200 UTC in 2002.

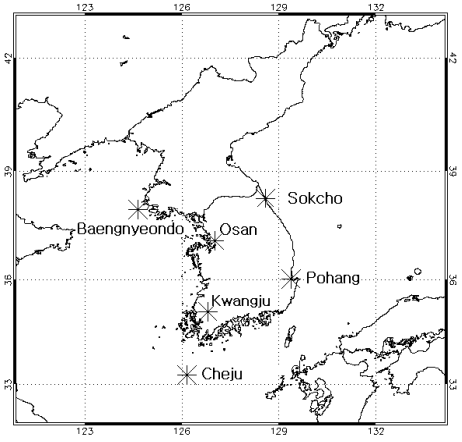


Fig. 2. 6 Radiosonde Sites used in comparison of MODIS.

3. Results

MODIS atmospheric profile (MOD07) algorithm has been used for operational retrievals of temperature and moisture from MODIS. The accuracy of retrieved temperature and moisture from MODIS is verified in comparison with radiosonde observations. Below we show a few results of the comparison of MODIS retrievals and radiosonde sounding data obtained 6 locations.

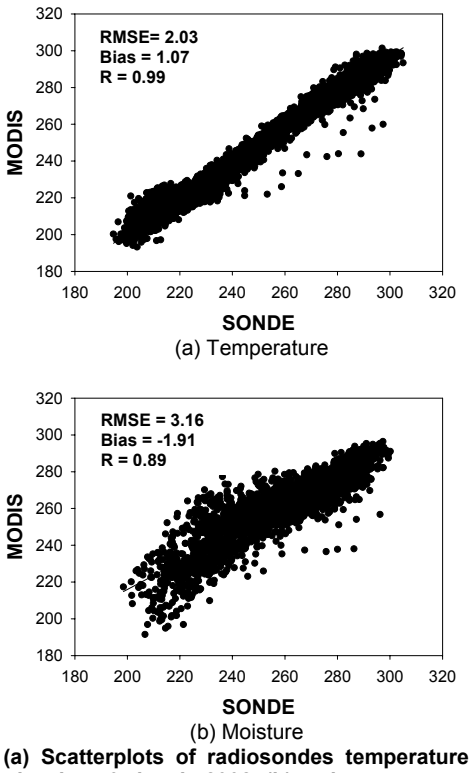
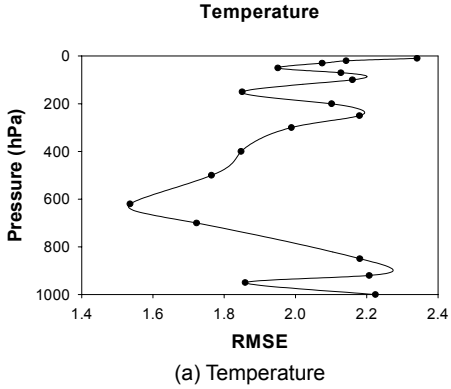


Fig. 3. (a) Scatterplots of radiosondes temperature and MODIS retrievals at 6 sites in 2002; (b) moisture comparison

Fig. 3(a) shows the scattering plots of radiosondes temperature and MODIS retrievals in 2002 and (b) points the distribution of radiosondes moisture and MODIS retrievals in 2002. Fig. 3(a) indicates that there is good agreement between MODIS and radiosondes temperature measurements with an root-mean-square-error (RMSE) of 2.03K and a correlation coefficient of 0.99. Fig. 3(b) means moisture retrievals have an rmse of 3.16K and a correlation coefficient of 0.89 that inaccurate than temperature relatively.



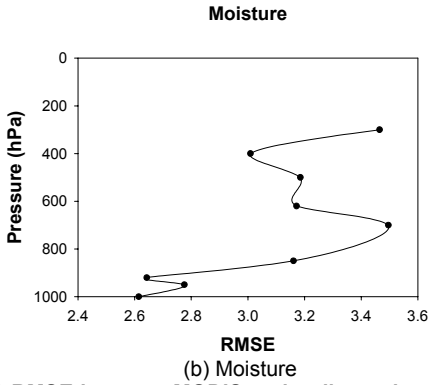


Fig. 4. (a) RMSE between MODIS and radiosondes observations temperature in 2002; (b) RMSE between MODIS and radiosondes measurements moisture in 2002.

Fig. 4(a) and (b) show the rmse of the retrieved vertical profiles of temperature and moisture compared with radiosonde observations profiles according to levels respectively. Results show the most accurate MODIS temperature retrievals are between 800-400hPa, where the rmse is approximately 1.6 K. Near the surface, rmse increased to 2.2 K. Moisture retrieval accuracy decreases with height from an rmse maximum of 3.5 K at the lowest levels.

Table 2. Comparison temperature and moisture between MODIS and Radiosonde with correlation coefficient, bias, rmse.

	Tempeature			Moisture		
Mon.	R	bias	rmse	R	bias	rmse
1	0.978	0.70	2.09	0.901	-3.49	2.99
2	0.981	-0.07	2.12	0.864	-5.40	3.19
3	0.986	0.12	2.02	0.901	-4.17	3.14
4	0.987	-0.76	2.19	0.854	-4.24	3.40
5	0.990	1.02	2.05	0.832	-0.72	3.24
6	0.989	1.71	2.18	0.835	0.29	3.35
7	0.992	2.74	2.18	0.879	2.62	2.99
8	0.996	2.15	1.89	0.892	1.22	3.00
9	0.995	1.73	1.86	0.831	-1.54	3.36
10	0.992	1.24	1.93	0.906	-0.62	2.93
11	0.988	0.97	1.90	0.898	-3.75	2.95
12	0.991	1.04	1.78	0.856	-3.58	3.12
ave	0.9891	1.049	2.016	0.871	-1.95	3.32

Table 2 indicates correlation coefficient, bias and rmse between radiosonde observations and retrieved temperature and moisture from MODIS separated into monthly time intervals. The average correlation coefficient is 0.989 at temperature. However the mean moisture correlation coefficient is 0.871 relatively lower than temperature. The high variability in the temperature bias is shown during summer (from May to October) relatively. Some of the variability in this table is related to moisture bias. The average temperature bias 1.049 K agrees fairly well with temperature bias. Rmse of temperature from summer to winter is below 2 K. The average rmse of moisture is reached 3.32 K. Table 2 shows most of moisture bias values are below zero.

3. Conclusions

To determine the retrieval accuracy of MODIS, 6 sites of radiosonde data and MODIS retrievals are compared.

The retrieval validation shows that the MODIS measurements have the accuracy of 2.02 K for atmospheric temperature profiles and 2.9-3.4 K for moisture profiles. The correlation coefficient between MODIS and radiosonde temperature and moisture are 0.99 and 0.89 respectively.

Terra–MODIS algorithms have been adapted to the second MODIS instrument on board the Aqua platform. Aqua-MODIS provides better depiction of gradients and allows full use of high spatial resolution measurements. Future work will focus on validation and application of Aqua-MODIS atmospheric retrievals.

Acknowledgement

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