

Possible enhancement to specifications of several Moderate Resolution Imaging Spectroradiometer visible and near-IR channels

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Abstract. The Moderate Resolution Imaging Spectroradiometer (MODIS) instruments onboard the NASA Terra and Aqua Spacecrafts have provided unprecedented capabilities in global observations of land, ocean, and atmosphere. In this paper, we report that, under certain atmospheric and surface conditions, several MODIS channels in the visible and near-IR spectral regions can saturate. The radiance dynamic ranges of similar channels for future satellite earth observing instruments should be increased. Instrument designers and MODIS data users should be aware of the saturation problems associated with these MODIS channels.

Keywords: remote sensing, MODIS, imaging, clouds, land, ocean color.

1 INTRODUCTION

Two Moderate Resolution Imaging Spectrometer (MODIS) instruments [1], [2], [3], one on board the NASA Terra spacecraft launched in December of 1999 and the other on board the Aqua spacecraft launched in May of 2002, are designed with a wide spectral coverage between 0.4 and 14.3 μm for remote sensing of land, ocean, and atmosphere. Together they have collected more than 10 years of global earth observing data sets. Operational land, ocean, and atmospheric data products are routinely produced and distributed [4]. At present, over 1300 scientific papers involving the MODIS instruments and data products have been published in refereed journals. In spite of MODIS' great successes in earth observations, minor problems with the MODIS instruments do exist. We report in this paper the saturation problems associated with several MODIS channels in the visible and near-IR spectral regions. Scientists and instrument designers should be aware of the problems identified from MODIS design and on-orbit observations so that improved instrument specifications can be made for future earth observing satellite instruments.

2 BACKGROUND

MODIS has a total of 36 channels located within a wide spectral range from 0.4 to 14.3 μm . Among these channels, there are two sub-sets of channels located in the visible and near-IR spectral region between 0.4 and 2.5 μm [5]. One set of channels, Channels 1 – 7, is mainly designed for remote sensing of land and clouds with spatial resolutions (nadir) of 250 m and 500 m. The other set of channels, Channel 8 – 16, with spatial resolution at 1 km, is specifically designed for remote sensing of the darker ocean surfaces. Table 1 summarizes the main characteristics of these two sets of channels. From this table, it is seen that the signal to noise ratios (SNRs) specified for ocean color channels are significantly higher than the corresponding land channels. In addition, the spectral bandwidths for the ocean color channels are narrower than the land channels. Because land is generally brighter than ocean, the

spectral radiances and the maximum reflectances specified for land channels are generally larger than those for the corresponding ocean color channels. It should be pointed out that the specified spectral radiances in this table are the radiances expected for typical scenes (L_{typ}). When defining SNRs, the reference signals (or radiances) are the typical scene radiances, not the maximum radiances (L_{max}) above which the channels would saturate.

Table 1. Specifications of two sets of MODIS land and ocean channels in the visible and near-IR spectral regions. Here R_{max} is the maximum equivalent Lambertian reflectance.

Primary use	Channel	Bandwidth (nm)	Spectral radiance ($W/m^2-\mu m-sr$)	Signal to noise ratio	R_{max}
Land/Cloud	1	620 – 670	21.8	128	1.49
	2	841 – 876	24.7	201	1.00
	3	459 – 479	35.3	243	1.04
	4	545 – 565	29.0	228	0.93
	5	1230 – 1250	5.4	74	0.51*
	6	1628 – 1652	7.3	275	1.02
	7	2105 – 2155	1.0	110	0.81
Ocean Color	8	405 – 420	44.9	880	0.33
	9	438 – 448	41.9	838	0.23
	10	83 – 493	32.1	802	0.17
	11	526 – 536	27.9	754	0.15
	12	546 – 556	21.0	750	0.12
	13	662 – 672	9.5	910	0.08
	14	673 – 683	8.7	1087	0.07
	15	743 – 753	10.2	586	0.07
	16	862 – 877	6.2	516	0.06

* R_{max} for Channel 5 was changed to 0.80 by the MODIS Project Office in December 1992.

3 SATURATION OF MODIS VISIBLE AND NEAR-IR CHANNELS

Soon after the Terra MODIS data became available for analyses in the spring of 2000, we realized that a number of MODIS channels in the 0.4 to 2.5 μm spectral region could saturate under certain atmospheric and surface conditions. We first reported the saturation problems during the June 2000 MODIS Science Team Meeting. However the saturation problems with MODIS channels have not been generally recognized in the scientific community. Therefore, there is a great need to alert the scientific community and, especially, general users about the saturation problems and to help improve their understanding of existing MODIS data products.

5 SUMMARY

The MODIS ocean color channels were originally designed for remote sensing of the “case 1” waters. We have reported in this paper that these channels can saturate over the brighter coastal waters, shallow waters with bottom reflections, and open waters when phytoplankton blooming occurs. We have also reported that some MODIS land channels in the visible and near-IR spectral region can saturate over bright clouds in the tropical region. Scientists and instrument designers should be aware of the MODIS saturation problems so that improved instrument specifications can be made for future earth observing satellite instruments.