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Chapter 2

Cloud-Top Radiance Analysis for SeaWiFS Bilinear Gain Knee Calibration

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Abstract

The CVT of the SeaWiFS Project has used the distribution of cloud-top radiances, as observed by SeaWiFS, to determine the saturation counts for the ocean detectors more precisely than is possible based on prelaunch calibration data alone.

2.1 INTRODUCTION

An examination of histograms of cloud-top radiances observed by SeaWiFS shows anomalous distributions of radiances in the vicinity of the knee of the bilinear response for each SeaWiFS band. These anomalous distributions are observed in high resolution picture transmission (HRPT), local area coverage (LAC), and global area coverage (GAC) images. Typical histograms for HRPT images, which are plotted for each band in Fig. 1, show unexpected discontinuities in the distribution of radiances in the vicinity of the knees: there are fewer pixels at the knee radiances than expected from the number of points with radiances below and above the knees. These discontinuities in the radiance distribution would give rise to errors in the retrieved radiances of thin dust and thin clouds, as measured by SeaWiFS.

Each SeaWiFS band has three ocean detectors, with high radiometric sensitivity and low saturation radiances, and one cloud detector, with low radiometric sensitivity and high saturation radiances. During the collection of ocean data, SeaWiFS averages the output from the four detectors within each band. The knees in the response occur where the ocean detectors saturate. Figure 2 shows bilinear response for bands 1–8 in the vicinity of the knees. A plot of the biliner response of band 1 over the full dynamic range of the instrument is shown in Fig. 8 of Johnson et al. (1999).

The discontinuities in radiance in the vicinity of the knees of the bilinear response are due to uncertainties in determining the output counts at which saturation occurs for the ocean detectors. The prelaunch radiometric calibration of SeaWiFS was performed in the laboratory at four radiance levels, which were either below or above the knee radiances (Johnson et al. 1999). Sunlight reflected from cloud tops provides a continuum of radiances in the vicinity of the knees. The CVT has undertaken an analysis of the distribution of cloud-top radiances measured by SeaWiFS to make a more precise determination of the saturation counts for the ocean detectors than is possible based on the prelaunch calibration data alone.

2.2 DETERMINING KNEE COUNTS

The CVT can adjust the counts at which saturation occurs for each detector in the SeaWiFS calibration model by changing the offsets used in computing the counts-to-radiance conversion factors from the detector gains (Darzi et al. 1995). The CVT performed the adjustment for a given band with a trial-by-error approach, where the offsets for each detector were changed individually and the resulting radiance distribution was examined. The goal of these adjustments was to improve the distribution of radiances in the vicinity of the knees for each band. The final offsets were those which yielded the smoothest radiance distrubutions at the knees. Because SeaWiFS only collects ocean data for gain 1, this knee calibration can only be performed at this gain.

Figure 1 also shows the radiance distributions resulting from the modified knees for bands 2–8. For each of these bands, the distribution for the modified knees is an improvement over the original distribution. A correction could not be determined for band 1 because a one count adjustment of the saturated counts for this band resulted in a worse radiance distribution. Figure 2 shows the locations of the modified knees for each band.

The change in location of the knee radiances and counts for each band is shown also by comparing Tables 1 and 2, which list the radiance and counts at the three knees before and after the adjustments of the offsets. The changes in

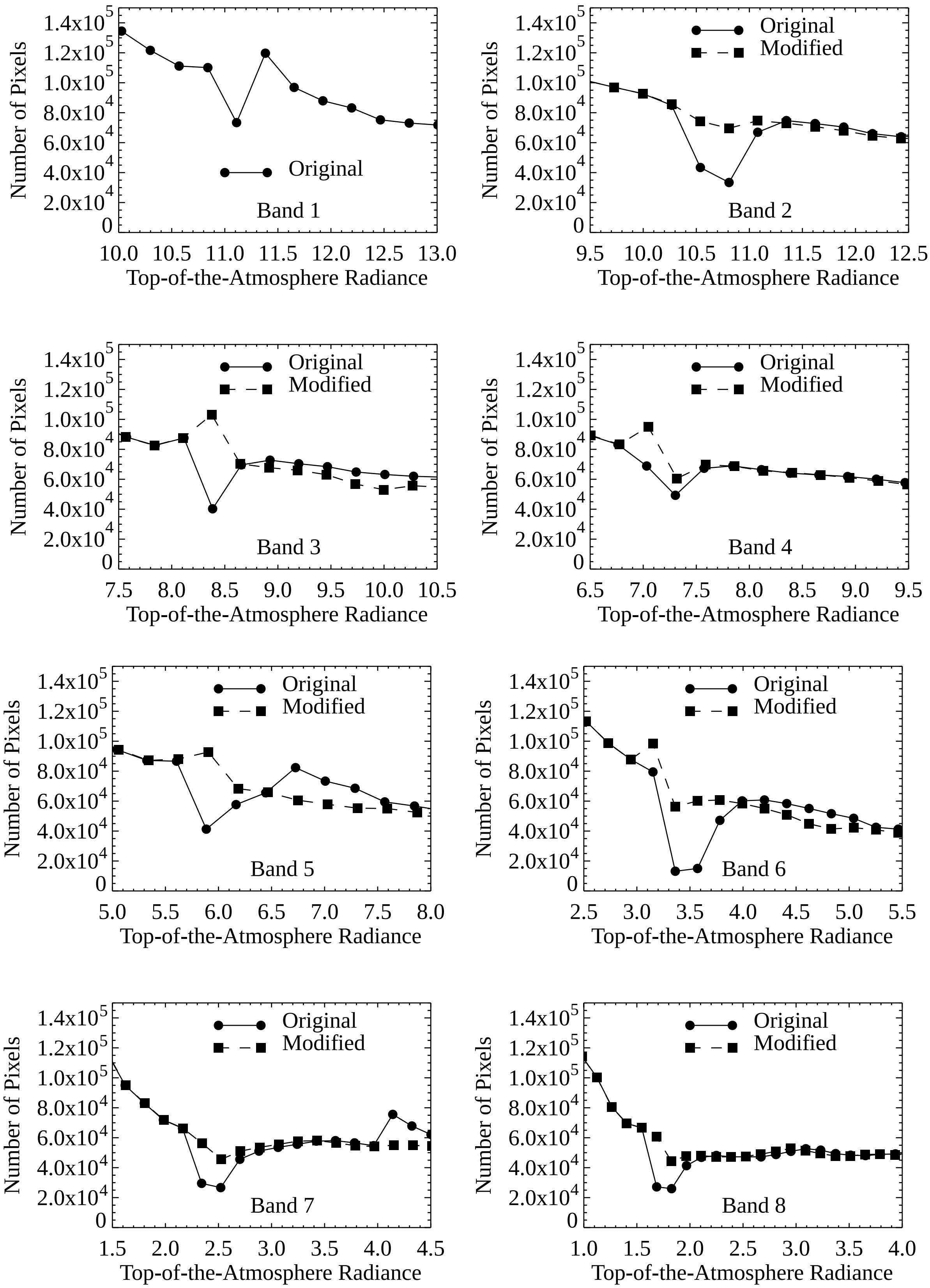

Fig. 1. Histograms of radiance distributions in the vicinity of the knees in the bilinear radiometric response.

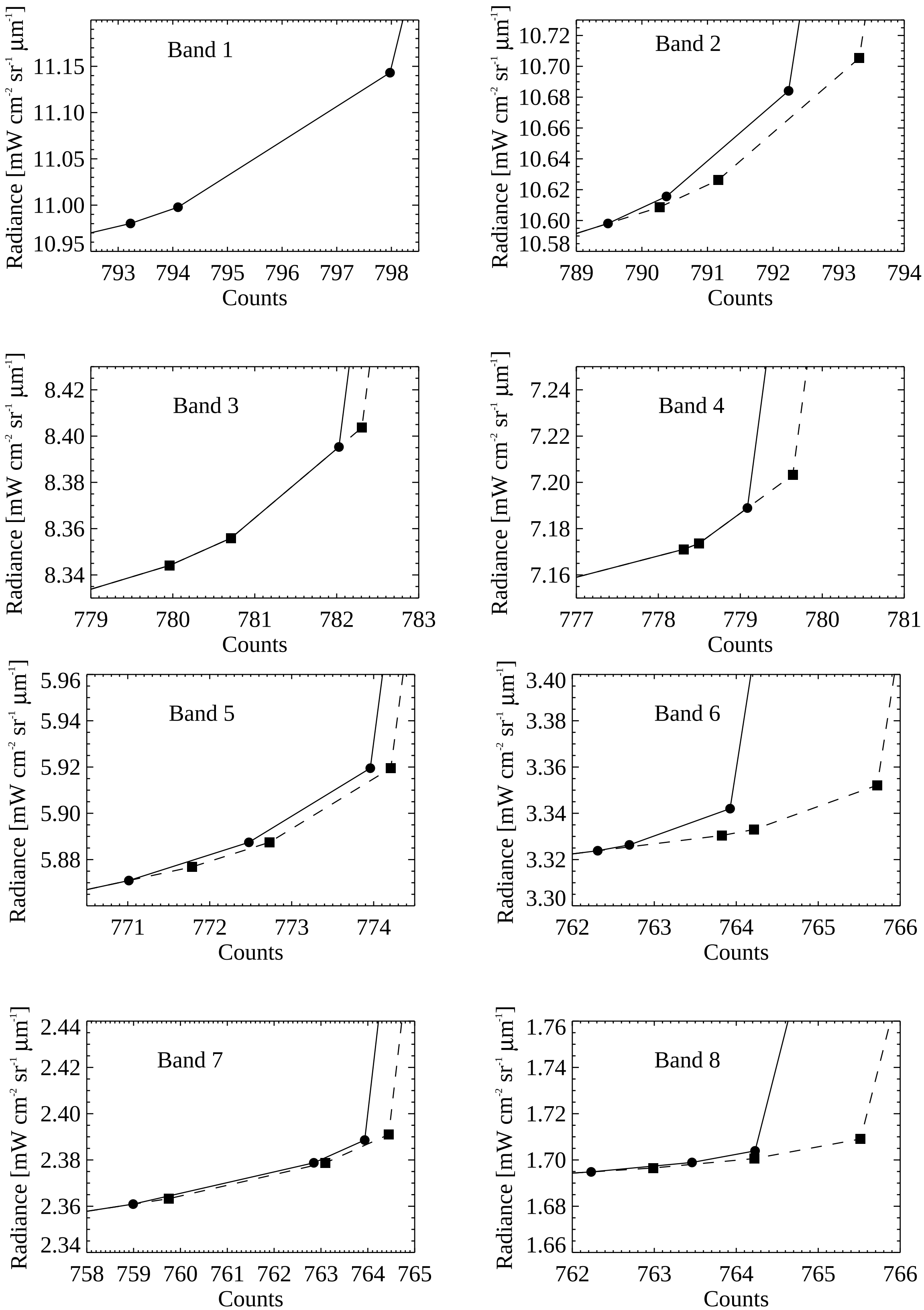

Fig. 2. SeaWiFS bilinear radiometric response in the vicinity of the knees.

Table 1. Knees of the original SeaWiFS bilinear gains for gain 1.

Band	*Knee 1*		*Knee 2*		*Knee 3*		*Saturation*	
	Radiance	*Counts*	*Radiance*	*Counts*	*Radiance*	*Counts*	*Radiance*	*Counts*
1	10.98	793.23	11.00	794.10	11.14	797.98	60.69	1002.25
2	10.60	789.48	10.62	790.37	10.68	792.24	68.85	1004.50
3	8.344	799.96	8.356	780.71	8.395	782.03	69.46	1002.25
4	7.171	778.31	7.174	778.50	7.189	779.09	67.10	1002.75
5	5.871	771.01	5.887	772.48	5.920	773.96	67.19	1001.25
6	3.324	762.31	3.326	762.70	3.342	763.93	57.05	999.75
7	2.361	758.99	2.379	762.85	2.389	763.93	43.64	1000.25
8	1.695	762.23	1.699	763.46	1.704	764.23	34.94	1002.75

Table 2. Knees of the modified SeaWiFS bilinear gains for gain 1.

Band	*Knee 1*		*Knee 2*		*Knee 3*		*Saturation*	
	Radiance	*Counts*	*Radiance*	*Counts*	*Radiance*	*Counts*	*Radiance*	*Counts*
1	10.98	793.23	11.00	794.10	11.14	797.98	60.69	1002.25
2	10.61	790.27	10.63	791.16	10.71	793.31	68.85	1005.50
3	8.344	799.96	8.356	780.71	8.404	782.31	69.46	1002.50
4	7.171	778.31	7.174	778.50	7.203	779.64	67.10	1003.25
5	5.877	771.78	5.887	772.73	5.920	774.21	67.19	1001.50
6	3.330	763.83	3.333	764.22	3.352	765.72	57.05	1001.50
7	2.363	759.75	2.379	763.10	2.391	764.45	43.64	1000.75
8	1.697	762.99	1.701	764.22	1.709	765.52	34.94	1004.00

the saturated counts at the knees are from 0.0–1.8 counts, with a mean of 0.6 counts. The typical change in the radiance for a given instrument output below the knee is 0.1%, which is within the uncertainty of the instrument calibration (Johnson et al. 1999). The typical change in the radiance above the knee is 0.8%, which again is within the uncertainty of the instrument calibration (Johnson et al. 1999). The changes in the above-the-knee radiances should improve the determination of dust and absorbing aerosol masks for SeaWiFS (Hsu 2000). The offsets for the modified knee locations have been incorporated into the SeaWiFS calibration table that will be used for the third reprocessing of SeaWiFS data.

2.3 DISCUSSION

By using the distribution of cloud-top radiances in the vicinity of the knees of the SeaWiFS bilinear gains, the CVT made more precise determinations of the knee counts than were possible from the prelaunch calibration data. While the adjusted knee counts have little effect on the ocean data, they should significantly improve the determination of the radiances of thin dust and clouds in the vicinity of, and above, the knees.

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