14.3 POTENTIAL IMPACT OF PROPOSED ADVANCED BASELINE IMAGER (ABI) CHANNELS ON SATELLITE PRECIPITATION ESTIMATION

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1. BACKGROUND

Algorithms for estimating precipitation from satellite brightness temperatures typically use only the 10.7-μm infrared window channel to discriminate raining from non-raining clouds and to estimate rainfall rates. This approach is predicated on the assumption that the rainfall rate is related to the cloud depth, and that the cloud height (which is indicated in a relative sense by the 10.7-μm temperature) is an appropriate proxy for cloud depth. However, there are limitations to this approach. Such algorithms frequently mistake cold (but nonraining) cirrus anvils for raining clouds and incorrectly assign high rates to the cold cirrus, or fail to detect precipitation from relatively warm clouds.

The use of information from other channels in combination with 10.7-μm data in order to improve discrimination of raining and non-raining clouds has been pursued since the 1970's. Most of these efforts have focused on combining visible with IR data, but the Geostationary Operational Environmental Satellite (GOES) Mult-Spectral Rainfall Algorithm (GMSRA), which was developed by Ba and Gruber (2001), uses data from four of the five GOES channels:

- visible (0.69-μm) data to discriminate thin (nonraining) clouds from thicker precipitating clouds
- 3.9-μm data to estimate cloud particle size from reflectance values during the daytime, which is used to identify clouds with large particles that are producing precipitation despite warm tops;
- 6.7-μm data to identify overshooting cumulus tops and distinguish them from cirrus anvils;
- 10.7-μm data to determine probability of precipitation and rainfall rate.

However, the current generation of GOES Imagers have only 5 spectral bands, which leaves significant untapped potential in using satellite data from multiple channels to retrieve cloud characteristics and thus to improve satellite-based precipitation estimates. For instance, Ackerman et al. (1990) demonstrated the usefulness of brightness temperature differences between 8, 11, and 12 μm for distinguishing ice clouds from water clouds, while Baum et al. (2000) showed the sensitivity of near-IR reflectances to cloud particle size and phase.

Consequently, the availability of 16 channels on the Advanced Baseline Imager (ABI) on the GOES-R series of satellites will significantly enhance the ability to estimate precipitation using satellite data, particularly in the area of discriminating raining from nonraining clouds.

2. METHODOLOGY

In terms of both spatial and spectral resolution, data from the MODerate-resolution Imaging Spectroradiometer (MODIS) provides a reasonably close match to a number of the planned ABI channels (Fig. 1). Consequently, MODIS data were considered to be suitable proxies for the ABI channels shown in Table 1.

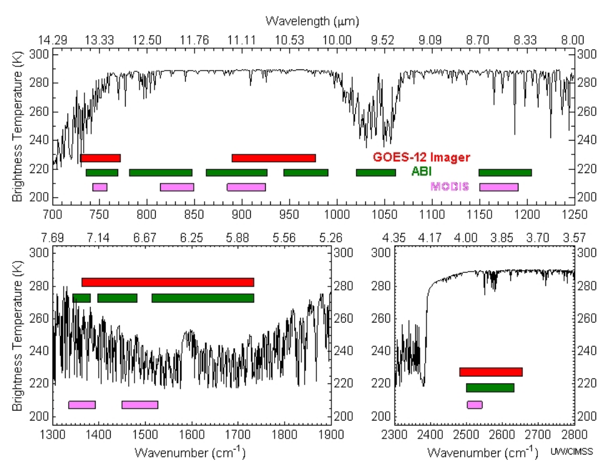

Figure 1. Depiction of current GOES Imager (red), ABI (green), and selected MODIS (magenta) bands superimposed over the spectral response for a standard atmosphere with no clouds. (Figure courtesy Mat Gunshor, CIMSS).

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ABI band	MODIS band	ΔT_b (K)
3.9 µm	4.0 µm	+0.10
6.1 µm	6.8 µm	+2.06
7.0 µm	7.3 µm	+9.13
8.5 µm	8.5 µm	+0.01
11.2 µm	11.0 µm	+0.10
12.3 µm	12.0 µm	+1.38
13.3 µm	13.4 µm	-4.08

Table 1. Comparison of ABI and MODIS spectral bands. Brightness temperature (T_b) differences (ΔT_b=ABI-MODIS) are computed from a forward radiative transfer model for a standard atmosphere (courtesy Mat Gunshor of CIMSS).

The precipitation data against which the MODIS data were matched consisted of 15-minute radar reflectivities that were converted to rainfall rates and then bias-corrected using the Stage IV hourly radar/raingauge totals. This was done by computing hourly rainfall totals from the reflectivity data (using the standard Z-R relationship), computing a ratio to the corresponding Stage IV estimates, and then applying the resulting ratio fields to the individual 15-minute rainfall fields. This resulted in a product that had a time resolution that was closer to the instantaneous nature of the MODIS data but yet had some bias correction as well.

The work was performed using matched data from MODIS and the bias-corrected radar data from 4 to 31 July 2001 for all scans in which MODIS data were available over the CONUS. This resulted in a relatively limited data set since MODIS data are only available twice per day at a given location.

3. RESULTS AND FUTURE WORK

Although some positive impact was achieved when using the additional information at 8.5 µm, the improvement in skill was generally on the order of only one to two percent. A significant difficulty in using infrared information for estimating precipitation is that the cloud thickness will be far beyond the threshold value for opacity (grey cloud) before precipitation begins to fall from the cloud. Consequently, differences in the absorption of terrestrial radiation by cloud water and ice as a function of wavelength are fairly minimal for clouds that are opaque but still too thin to produce precipitation. This suggests that a more fruitful direction of research may be to pursue the differences in reflected solar radiation at the lower IR frequencies, which have been exploited by others such as Lensky and Rosenfeld (1997).

Consequently, the next step will be to explore the analogous MODIS and ABI channels in the visible and near-IR region of the spectrum, though this analysis is more complex since an analysis of reflectance of solar radiation at these frequencies requires an accounting for the rapid changes in the sun-satellite angle with time when determining the reflectivity values.

4. REFERENCES

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