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DERIVED CLOUD PRODUCTS FROM THE GOES-M IMAGER

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1. INTRODUCTION

With the launch of the next in the series of geostationary platforms, Geostationary Operational Environmental Satellite (GOES) – M Imager, a modification in the suite of bands has been introduced. The current Imager obtains information from four infrared bands and one visible band (Menzel and Purdom, 1994). GOES-M continues the same number of bands, but initiates several changes. Table 1 summarizes those spectral changes.

Table 1. GOES Imager spectral widths for GOES-8 (similar for GOES-9 through GOES-11) and GOES-M. The units of wavelength are µm; the units for wavenumber are cm^{-1}.

GOES-8 Imager Bandwidths

Ch. No.	Wavelength Range	Central Wave-length	Wavenumber Range
1	0.53-0.72	0.64	13812-19048
2	3.78-4.03	3.91	2482.2-2647.7
3	6.47-7.03	6.75	1421.8-1544.5
4	10.21-11.20	10.69	892.5-979.1
5	11.54-12.47	11.97	802.1-866.2
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GOES-M Imager Bandwidths

Ch. No.	Wavelength Range	Central Wave-length	Wavenumber Range
1	0.53-0.77	0.65	12970-18939
2	3.76-4.03	3.90	2481.9-2656.4
3	5.77-7.33	6.48	1363.3-1733.4
4	10.23-11.24	10.71	889.7-977.1
5	---	---	---
6	12.96-13.72	13.31	729.0-771.6

The GOES-M Imager includes a band centered at 13.3 µm and improves north-south spatial resolution of a spectrally modified 6.5 µm band. The addition of the 13.3 µm band comes at the expense of eliminating the 12 µm band on the Imagers. GOES-8 and GOES-M Imager spectral response functions are shown in Fig. 1. Note the elimination of the 12 µm band and the addition of the 13.3 µm band, in addition to the modified "water vapor" band.

With the current series of GOES Imagers cloud height or cloud top pressures from the GOES Imager are available using either the IR Window Technique (Schreiner, et al; 1993) or the IR Window-Water Vapor Intercept Technique (Nieman, et al; 1993). By including a "CO_2" band (13.3 µm) among the suite of Imager channels the opportunity for more frequent (than the GOES Sounder) and accurate cloud products (than the GOES Imager) is now possible using the CO_2 Absorption Technique (CAT) (Wylie and Menzel, 1999). The CAT will provide more accurate calculations of Effective Cloud Amount (ECA) than currently available from the GOES Imager, more frequent and timely Satellite Cloud Products (SCP) in support of the Automated Surface Observing System (ASOS), and hemispheric coverage of the CAT for input into numerical prediction models.

The objective of this paper is twofold. First, to briefly describe the changes on the GOES-M Imager. Second, to introduce the cloud product based on the Imager data.

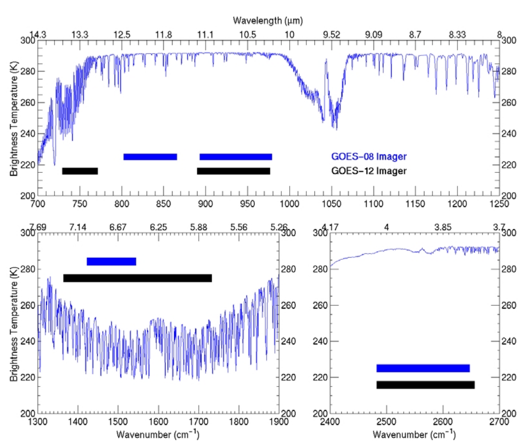

Fig. 1. Spectral ranges for the GOES-8 (top bars) and GOES-M (bottom bars) Imagers. A sample high spectral-resolution earth emitted spectra is also plotted.

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2. INSTRUMENT CHANGES

The GOES-M "water vapor" band is spectrally wider than the current 6.7 µm band. The spectral width covers the region from 5.77 to 7.33 µm with a center wavelength of 6.5 µm (Table 1). The water vapor spectral response function was made spectrally wider to improve the signal-to-noise ratio, and thus compensate for the smaller Field Of View (FOV) on GOES-M than previous Imagers. The spectral shift will make it similar to the current European METEOSAT (METEOrological SATellite) "water vapor" band. The current Meteosat bandwidth for the "water vapor" band is 5.7 to 7.1 µm Schmetz et al., 1998). Radiative transfer calculations for a standard atmosphere show that the GOES-M band 3 will be approximately 2 K warmer than the current Imager band 3 onboard GOES-8. This difference is consistent for a variety of atmospheres (not shown) (Schmit et al., 2001).

The GOES-M 6.5 µm band will also have a higher north-south spatial resolution. It will change from approximately 8 km to 4 km at the sub-satellite point. On the GOES Imagers, the IGFOVs are over-sampled in the east/west direction by a factor of 1.75 providing an effective resolution in the east-west direction of 2.3 km (Menzel and Purdom, 1994).

Table 2. GOES-8 (top) and GOES-M (bottom) Imager spatial characteristics. Detector Instantaneous Geometric Field Of View (IGFOV) or footprint is in km at the sub-satellite point. The Sampled Subpoint Resolution (SSR) is also in km and is a finer resolution due to over sampling in the east-west direction. The spatial characteristics are listed as the east-west by north-south dimensions, respectively.

	GOES-8		
Ch.	Descr.	IGFOV	SSR
1	Visible	1.0 x 1.0	0.57 x 1.0
2	SW window	4.0 x 4.0	2.3 x 4.0
3	Water Vapor	8.0 x 8.0	2.3 x 8.0
4	LW window	4.0 x 4.0	2.3 x 4.0
5	Split window	4.0 x 4.0	2.3 x 4.0
6	CO_2	---	---

	GOES-M		
Ch.	Descr.	IGFOV	SSR
1	Visible	1.0 x 1.0	0.57 x 1.0
2	SW window	4.0 x 4.0	2.3 x 4.0
3	Water Vapor	4.0 x 4.0	2.3 x 4.0
4	LW window	4.0 x 4.0	2.3 x 4.0
5	Split window	---	---
6	CO_2	8.0 x 8.0	2.3 x 8.0

The 13.3 µm band, referred to as the GOES Imager band 6, will allow for cloud height determinations. This band is similar, although with a broader spectral response function, to band 5 on the current GOES Sounder (Menzel et al., 1998) (Fig. 2). Forward radiative transfer calculations for a standard atmosphere show the GOES-M Imager 13.3 µm band will have a slightly higher mean brightness temperature than the Sounder band 5 (Fig. 3). This difference of approximately 1.5 K exists for other atmospheres as well (not shown). The GOES-M 13.3 µm spatial resolution will be approximately 8 km in the north-south direction (Table 2).

The addition of the 13.3 µm band results in the elimination of the 12 µm band on the GOES-M/N/O/P Imager. For the GOES cloud product the 12 µm band is used for detecting the presence, or lack of clouds prior to determining the height and amount of cloud (Hayden, et al; 1996 and Schreiner et al; 2001).

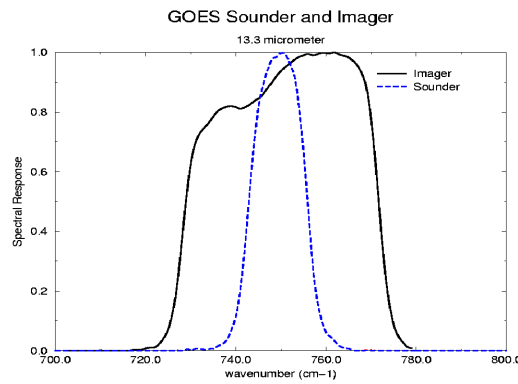

Fig.2. Normalized spectral response function for the GOES-M Imager 13.3 µm band and the corresponding Sounder band.

3. CLOUD PRODUCTS

Cloud products generated via the CO_2 absorption technique have been demonstrated from instruments on both geostationary and polar-orbiting platforms (Wylie and Wang, 1997; Wylie and Menzel, 1999; Schreiner et al., 2001). Cloud products derived from the GOES Sounder have been used to initialize numerical models (Bayler et al., 2001 and Kim et al., 2000). Improved products from the GOES-M Imager will include cloud top pressure, effective cloud amount and cloud top temperature. Fig. 4 shows the Cloud Top Pressure (CTP) derived image using only spectral bands from the GOES Sounder that will be available on the GOES-M Imager. This image has been compared to one derived from the full set of Sounder bands used for deriving CTP. With a sample size of 3533, the bias (Sounder minus Imager derived CTP) was 20 hPa and the root mean square (rms) was 112 hPa.

With the addition of the 13.3 µm band on the GOES-M Imager, the Satellite Cloud Product (SCP) that complements the ground-based ASOS (Automated Surface Observing System) could be generated from the Imager rather than the Sounder (Schreiner et al., 1993). The SCP, based on GOES-M Imager data, could be available in a more timely fashion since the Imager coverage rate is much faster than the Sounder.

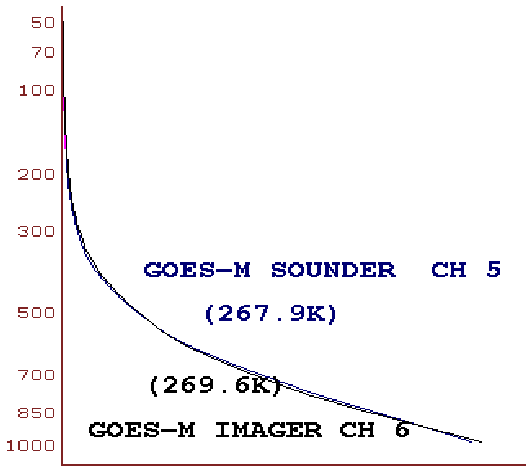

Fig. 3. Weighting function for both the 13.3 µm GOES-M Sounder and Imager bands for a standard atmosphere. The units of the ordinate are pressure (hPa).

An additional product available to the modeling community will be near-hemispheric cloud top information. Assuming the GOES-M schedule is similar to the current GOES-8 a hemispheric view of the earth will occur every three hours. Output from these processed data will provide cloud information in addition to clear, cloudy, and averaged brightness temperatures from 65N to 65S. An example of what such a cloud image may look like will be shown.

The loss of the 12 µm band will negatively impact the detection of low cloud. Currently, 11 minus 12 µm differences are used extensively to flag the presence of clouds at night. Without the 12 µm data, there will be more reliance on visible data during the day and 3.9 µm data during the night for cloud detection. The 13.3 µm data may also help to mitigate the loss of the 12 µm band for cloud detection. Experience with actual GOES-M data during the post-launch checkout will answer this question.

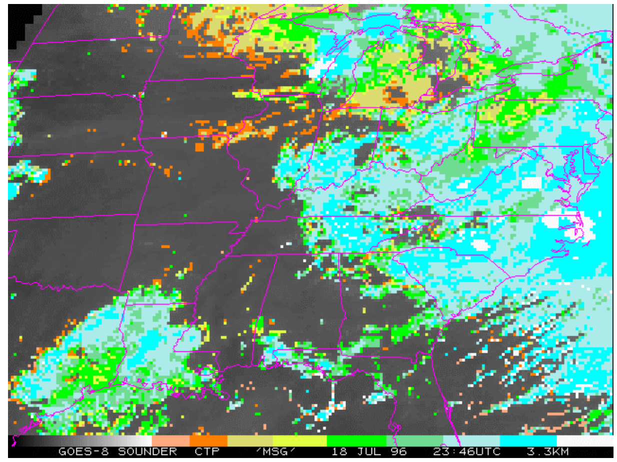

Fig. 4. Derived cloud top pressure image using the GOES Sounder 13.3 µm data and LW infrared window.

4. SUMMARY

Cloud products from the GOES-M Imager will benefit from the inclusion of a band centered at 13.3 µm. Among them are cloud height and effective cloud amount via the CO2 Absorption Technique. Quantitative coverage, both spatially and temporally, will increase. This will benefit the SCP for ASOS and the numerical modeling community.

In order to accommodate the 13.3 µm band, the 12 µm band was eliminated on the GOES-M Imager. This change may affect the ability to detect some clouds, especially low clouds at night. The 12 µm band, along with a host of other bands, will be included on the next generation series of GOES Imagers, beginning with GOES-R in the 2010 era.

5. REFERENCES

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