Enhancement of GOES Satellite Imagery: Phase II

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1. INTRODUCTION

One of the primary responsibilities of the National Oceanic and Atmospheric Administration (NOAA) is to provide significantly improved short-term warning and forecast products and services that enhance public safety and the economic productivity of the Nation. The Geostationary Operational Environmental Satellite (GOES) is one of the main instruments that support this activity. The current generation GOES imagery is limited to 1 km in the visible and 4 km spatial resolution for the 10.7 micron band (Band 4). Our Phase I Study demonstrated that the resolution of the GOES imagery could be enhanced by the Maximum Entropy Method (MEM), potentially resulting in improved meteorological products. The purpose of this study was to further verify and quantify the resolution enhancement, radiometric accuracy and precision provided by the MEM.

In a previous reporting of our effort to enhance satellite imagery from GOES at the 17th IIP AMS meeting, we reported on spatial resolution improvement of 15 - 30 % from our base of 1 Km in the visible and 4 Km in the IR (Band 4 - 10.7 um). In Phase II we have further demonstrated enhancement of the temperature accuracy, precision and resolution. We validated these enhancement both with Monte-Carlo simulations utilizing MODIS airborne simulator data and against AVHRR data from the same time and location.

2.0 DISCUSSION AND RESULTS

Figure 1 shows a GOES Band 4 (10.7 micron) cloud scene with varying temperatures that we explored by comparing our maximum entropy (MEM) algorithm against AVHRR. In Figure 2 we took the small cloud in the center and zoomed in to show more detail. The top left of Figure 2 shows the unenhanced GOES image (center of Figure 1), the top center of Figure 2 shows the computer enhanced MEM GOES image and the top right shows the AVHRR of the same region at the same time. The bottom of Figure 2 shows temperature traces through each of the above images. Note that in the AVHRR the temperature ranges are larger than the unenhanced GOES, i.e, the software pulls up the peak temperatures and lowers the minimal temperatures giving a more accurate rendition of temperature when compared against AVHRR. The unenhanced GOES has 4 km detector size when projected on the ground; after enhancement the ground sampling is 2 km and AVHRR is 1 km. The enhancement in temperature accuracy is because the resolution is enhanced allowing discernment of finer features, thus removing the averaging of temperature over the 4km detector area.

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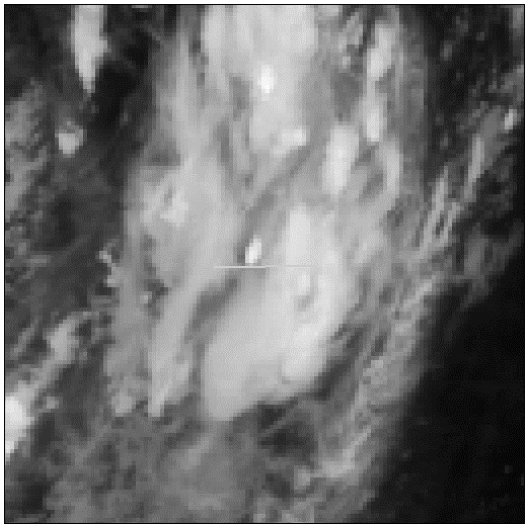

Figure 1 - *GOES Band Image, Band 4 at 10.7 microns*

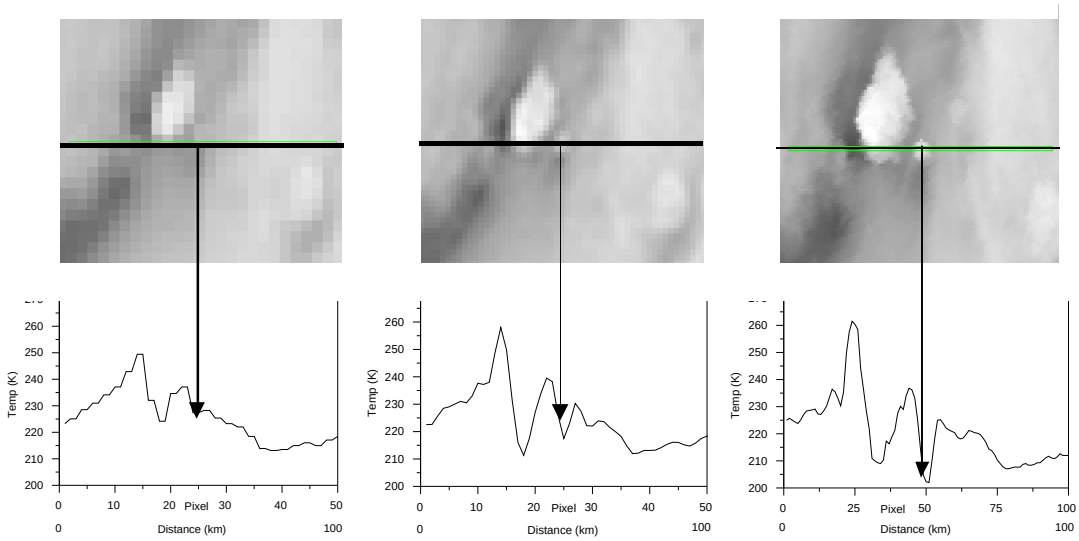

Figure 2 - *Unenhanced GOES, Enhanced GOES and AVHRR*

The next activity included in this study was the use of MODIS airborne simulator (MAS) in nearly the same wavelength band to construct a simulation. We used MAS channel 44 data, convolved it with the GOES point spread function and degraded the sampling to match GOES. We then enhanced this simulated data as a function of overlap and signal-to-noise (SNR) and compared the results against *truth*, i.e. the initial MAS data. With a 50% overlap east to west, i.e. the GOES case, we find a 17% net gain in resolution, at 75% overlap we find a 23% net gain in resolution. While GOES overlaps in the east to west, it would be possible to step the scan line in the north - south for overlap there also. In the case of 75% overlap in east-west and 75% overlap in the north-south we get gains approaching 30% in resolution. Figure 3 shows the net gain in resolution for the various

combinations of overlap simulated. The abscissa shows the overlaps in the notation, e.g. OOEW-OONS implies no overlap in either direction. The family of curves are for different signal-to-noise ratios. There were not significant differences in the resolution gain until the SNR drops lower than 100.

In general the resolution gain should not be used as a stand alone metric for measuring the improvement in image quality. We used other metrics such as SNR, root mean square error etc.

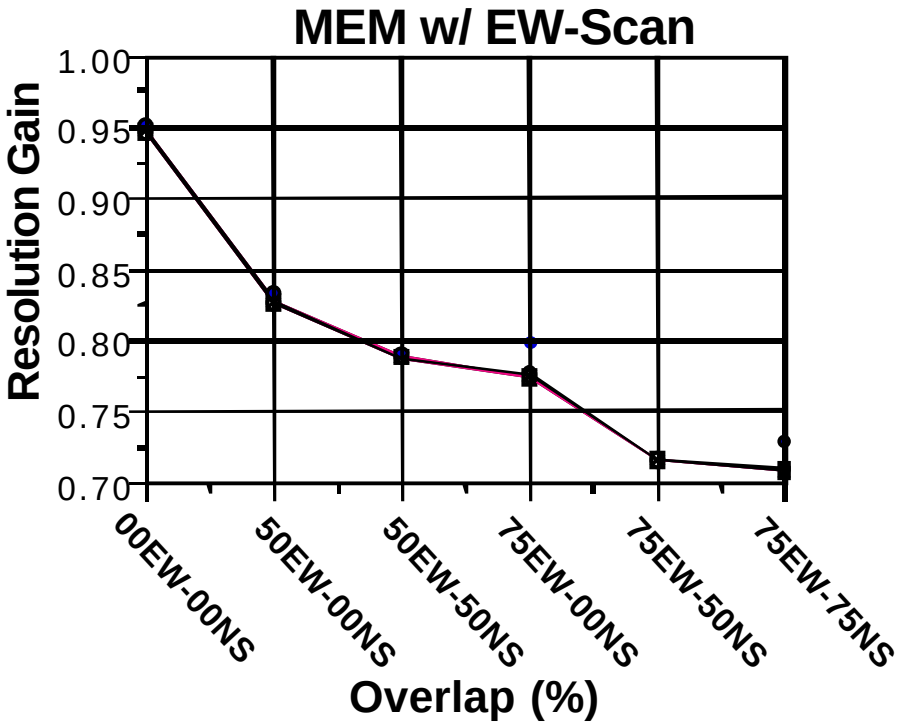

Figure 3 - *Resolution Gain vs. Overlap vs. Signal-to-Noise*

3. RECOMMENDATION

As a result of these GOES image enhancement studies, Phase I and Phase II, it is recommended that a limited operational, trial site be established where a meteorologist can utilize the MEM algorithm on a daily basis for selected images. With this testing, feedback could be provided on the usefulness of the enhancements for future products.