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THE NEW OPERATIONAL GOES MERGED SOUNDER PRODUCT SYSTEM (MSPS) at NOAA/NESDIS

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1. INTRODUCTION

Since 1995, the National Environmental Satellite, Data, and Information Service (NESDIS) has produced, on an operational basis every hour, a variety of retrieved atmospheric and surface quantities from GOES sounder measurements taken from the GOES-East and GOES-West satellites. Specifically, the sounder products generated from sounder radiances (Ma et al., 1999) include : clear-sky radiances, precipitable water (PW), vertical temperature and moisture profiles, surface skin temperatures, cloud top information, and atmospheric stability indices, including Lifted Index (LI) and Convective Available Potential Energy (CAPE). The resolution of the operational GOES sounder products is approximately 50km by 50km, with the exception of the cloud products, which are generated at full resolution (10km by 10km). The products are provided in a variety of formats, including ASCII (text), BUFR and Derived Product Imagery (DPI). The GOES sounder clear-sky radiance , PW, and cloud products are assimilated into the operational numerical weather prediction (NWP) models run by the National Center for Environmental Prediction (NCEP)/Environmental Modeling Center (EMC). In October 2002, the GOES sounder retrieved products were added to the National Weather Service (NWS) Advanced Weather Interactive Processing System (AWIPS).

Figures 1 and 2 show examples of the GOES lifted index derived from the current operational GOES product system and the new merged Sounder Product System (MSPS). The differences will be discussed in further detail, but this image comparison is provided as an illustration of the large differences in product density and coverage between the two product systems.

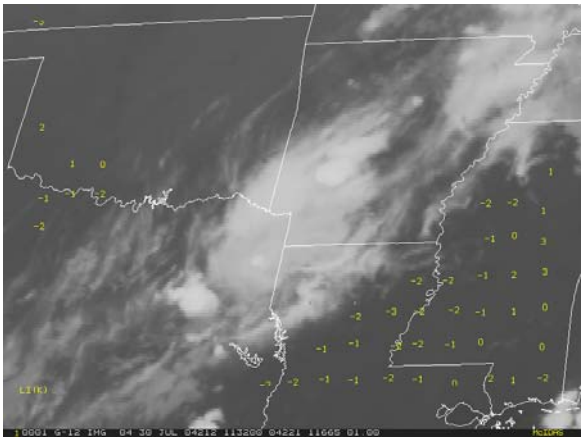

Figure 1: Operational GOES soundings Lifted Index at 50km resolution

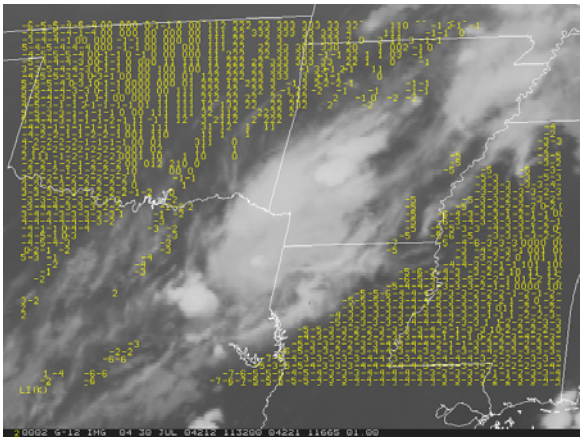

Figure 2: MSPS GOES soundings Lifted Index at 10km resolution.

2. NEW PRODUCT SYSTEM DEMANDS

The 50km x 50km resolution GOES sounder products continue to serve the needs of the user community. However, the advent of higher resolution NWP models and the need for higher resolution satellite products on AWIPS have led to new requirements for higher resolution GOES sounder products. Meeting these new requirements was a challenge. More attention had to be given to the cloud clearing process which identifies each pixel as clear or cloudy. Timely production of a full suite of sounder products at full resolution was also a challenge. For most product systems, a 10km product system equates to 25 times as much data processing as compared to the baseline 50km product. Simply relying on advances in computer processor speed advances could not be done. A significant amount of system redesign and development had to be done.

3. MERGED SOUNDER PRODUCT SYSTEM

With the aforementioned requirements, the Office of Research and Applications (ORA) and the Cooperative Institute for Meteorological Satellite Studies (CIMSS) have worked to provide GOES sounder retrieved products at 10km resolution. This has led to the new GOES Merged Sounder Product System (MSPS). The MSPS has been designed and developed in ORA to generate the entire suite of full resolution GOES sounder products in a consolidated and scientifically consistent way.

Overcoming the scientific challenge of the cloud contamination was less problematic than expected. Older versions of the GOES soundings production would allow for the inclusion of potentially cloud-contaminated pixels within a 50km (5-pixel by 5-pixel) area where a mix of clear and cloudy pixels occurred. Since pixel averaging was done, a small amount of cloud contamination could be tolerated. However, for the GOES MSPS system, cloudy pixels needed to be clearly identified. An analysis was conducted on the various cloud screening tests currently in use in the operational GOES soundings system. It was found that two cloud screening tests alone were largely responsible for the cloudy/clear determinations, and the limits used in these screening tests were derived largely empirically. As such, they could be easily tuned to perform exceptionally well for SFOV production. This is clearly evident in Figures 1 and 2. Note that the coverage in the MSPS production is far more complete, yet it successfully avoids retrieving products in cloudy regions.

Dealing with the mere functionality of a system attempting to produce 25 times as much data was a far more daunting task. The GOES MSPS will replace three independent operational GOES sounder product systems. Presently, the DPI production operates completely autonomously from the Soundings production, while the ASOS product system is semi-autonomous from the Soundings production. The MSPS production removes tremendous redundancy by combining these three product systems into one. Furthermore, more than just “redundant” code is removed. All code intended to process “boxes” (5-pixel by 5-pixel) of data and handle pixel averages could be removed. Also eliminated is code to extract cloud data from soundings to generate ASOS products. This is no longer required as cloud algorithms extracted from the DPI production system can feed cloud data directly into the ASOS system. To put this into hard numbers, the operational Soundings, ASOS and DPI systems total, roughly, 300,000 lines of code. The new MSPS system is only approximately

75,000 lines of code, one fourth the size of the original systems.

In another effort to overcome the overwhelming processing barriers, DPI production has been made more versatile. Entire product arrays are passed into a product-independent routine to generate the various DPI image products. This makes DPI production, and the introduction of new DPI parameters a trivial matter. To further improve the timeliness of the GOES SFOV products, the preprocessing of ancillary data that includes NCEP model data and NWS hourly surface observations, is now done independently of and before the product processing step. These steps, together with the redesign and streamlining of the product software, means the MSPS system completes product production sooner than the current operational, low resolution, soundings-only production. This translates to more timely products to the user community.

4. VALIDATION AND RESULTS

GOES PW retrievals from the GOES MSPS have been validated against ground-based radiosonde observations over the past two years. Recent comparison statistics are shown in Table 1. Previous validation results (Gray et al., 2001) demonstrated that the GOES SFOV PW products compare as well or better to collocated ground-based measurements of PW from the operational 50km resolution GOES soundings. The more recent statistics shown in Table 1 do not show the MSPS quality to be superior, but it is equitable with the operational 50km resolution product.

	%MAE	%RMSE	%Bias
50km TPW	9.2%	11.8%	-1.0%
10km TPW	10.2%	13.1%	+0.2%
50km PW1	12.4%	15.2%	-7.3%
10km PW1	16.1%	19.2%	-13.2%
50km PW2	14.8%	18.6%	+8.8%
10km PW2	14.3%	18.3%	+6.2%

Table 1: Comparison statistics between GOES PW and radiosonde PW .

This is indicative of the success of the aforementioned cloud screening upgrades, as cloud contamination is not degrading the MSPS SFOV quality. PW1 is the low level (Surface – 900mb) precipitable water and PW2 is the mid-level (700-900mb) precipitable water. The mean absolute error (MAE) statistics show both products to be fairly equitable throughout. The RMSE does favor the 50km product in the lowest levels, but this is a very modest difference and conflicts with previous findings. Also, the 10km results are marginally superior in the PW2 layer. Therefore, it is reasonable to assess the two products as being of equal quality.

The SFOV products offer better coverage and improved depiction of gradient information than the current, lower resolution operational products. Because the 50km resolution product requires that a certain number of 25 pixels be clear before outputting a sounding, the MSPS/SFOV coverage is not enhanced only by the resolution increase. The MSPS/SFOV production is also able to successfully generate products where few, small breaks in the clouds occur. In areas such as these, which are so important meteorologically, the 50km products will consistently fail to be generated. Again, this can be plainly seen in Figures 1 and 2. Besides the vast area of Oklahoma not observed by the operational production, note the small cloud-free swath over eastern Texas. This is embedded within a “region of interest”. The operation production again failed to generate soundings, while the MSPS successfully produced quality results.

Horizontal resolution is not the only improvement in the product quality in the MSPS system. The GOES MSPS uses NWP model data as its first guess in the retrieval algorithm. The use of this NWP data was upgraded to use all available vertical levels of NWP data. Presently, the MSPS uses the GFS as its first guess. The GFS vertical levels are at a relatively coarse resolution compared to the ETA model. As such, this upgrade has had only a very limited positive impact on product quality. However, the ETA had been previously used as the first guess and was only abandoned after low level temperature issues were detected. These may well have been resolved, and the

ETA will be revisited as the first guess source of choice. This is notable because its available vertical resolution exceeds that of the GFS. As a result, this vertical resolution upgrade in the MSPS may yield significant benefits in an ETA first guess environment. Future testing will answer this. In terms of specific levels, operational production contains 24 temperature levels and 19 moisture levels in the first guess. The MSPS can utilize up to 42 temperature levels and 21 moisture levels in the first guess.

Attention has been given not only to the quality of the products, but also to their timeliness. Users deem this to be a critically important requirement for these products. As previously discussed, the GOES MSPS is far more streamlined, leading to more timely products. The BUFR encoding processing step has also been streamlined. This has resulted in the production of more timely BUFR product files. This improved timeliness allows for the opportunity to add on additional product generation, such as new DPI parameters. For example, Figures 3 and 4 show GOES DPI of 700mb relative humidity and the Showalter Stability Index, respectively. The MSPS is more flexible in that these new DPI parameters can easily be added and distributed to the user community. In the experimental processing system run within NESDIS/ORA, over *sixty* additional DPI parameters are being generated with virtually no impact whatsoever on processing time.

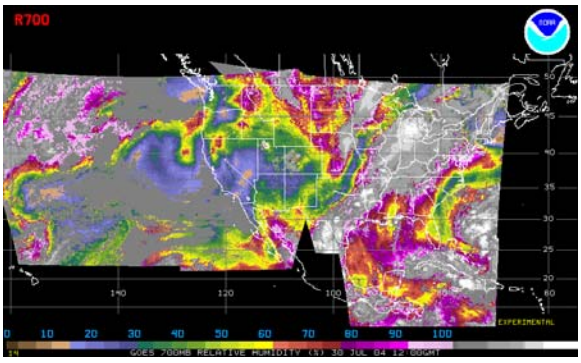

Figure 3: Additional DPI imagery example. This image shows the 700mb relative humidity.

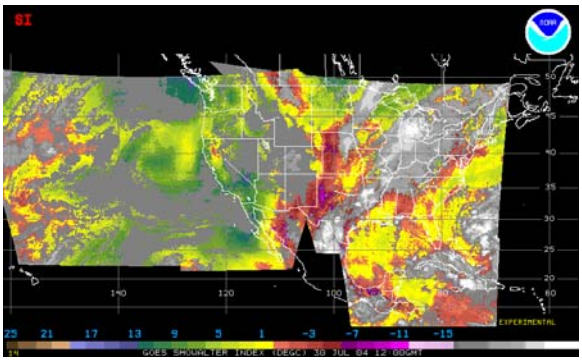

Figure 4: Another additional DPI example showing the Showalter Index.

5. SUMMARY

The new GOES MSPS is a revolutionary advancement in the GOES sounder product processing system. It does away with the old, terribly inefficient paradigm of independent product processing systems. Rather, it merges together the products by instrument, the GOES sounder, thereby eliminating the duplication of instrument-level processing. This, and other major streamlining, has allowed for significant product expansion, including single field of view soundings and a host of new DPI parameters. This is all done in such a timely manner that product availability is considerably sooner than in the present operational system.

The end goal in all of this is to meet the demands of the user community. Users from all communities have sought the higher resolution of the SFOV soundings. Many of these same users have also requested that this higher resolution data not only be available on the same time schedule as the low resolution data, but sooner. Meanwhile, these requests must be satisfied without sacrificing product quality. Finally, many in the forecasting community have requested new Derived Product Imagery parameters, such as Convective Inhibition, Equilibrium Level, Equilibrium Level Temperature, and many others. The GOES MSPS meets all of these user demands. Present plans call for the GOES MSPS to replace the existing operational GOES sounder product systems in late 2004.

6. ACKNOWLEGDEMENTS

The views, opinions, and findings contained in this report are those of the authors and should not be construed as an official National Oceanic and Atmospheric Administration or U.S. Government position, policy, or decision.

7. REFERENCES

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