P3.38 IS THE RESOLUTION OF GOES SOUNDER DATA SUFFICIENT TO SUPPORT SINGLE FIELD OF VIEW RETRIEVALS AND DERIVED PRODUCTS?

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1. INTRODUCTION

Atmospheric profiles of temperature and moisture, and subsequent derived product imagery of precipitable water, lifted index and skin temperature, are calculated from Geostationary Operational Environmental Satellite (GOES) sounder radiances (Ma et al., 1999) in clear-sky Fields of View (FOV). In cloudy areas, cloud-top parameters are generated from sounder radiances. The sounder instrument FOV varies from approximately a 10 km by 10 km square at nadir to about a 11 km (east-west) by 16 km (north-south) rectangle in the mid-latitudes. Operationally, the data are spatially averaged over a field of regard (FOR) of 5x5 pixels. Hence temperature and moisture retrievals (at 40 pressure levels) have a spatial resolution of, at best, about 50 km. The signal-to-noise ratio of the GOES-9 sounder (launched in May 1995) improved from that of GOES-8 (launched in April 1993) (Menzel et al., 1998) and the trend has continued through GOES-11 (launched in May 2000), Daniels and Schmit, 2001.

At the Cooperative Institute for Meteorological Satellite Studies (CIMSS), retrievals and derived product images (DPI) are produced routinely with a 3x3 FOR. Sounder DPI consist of 3-layer precipitable water (PW1, PW2, PW3), total precipitable water (TPW), lifted index (LI), and skin temperature (SKN T). TPW (surface to 300 hPa) is the product considered in this paper since it is an integrated value.

The improved spatial resolution of approximately 30 km from 50 km allows more precise depiction of cloudy/clear regions, profiles of temperature and dew point temperature, and DPI. Since FOV averaging is done to reduce instrument noise and the signal-to-noise ratios have improved, the question then arises whether single FOV (SFOV), i.e. each individual pixel (1x1) retrievals and DPI depict true meteorological signal or whether the instrument noise remains too large. Ferraro and Daniels, 2001, found the similarity between GOES-8 and –10 and AMSU TPW retrievals to decrease for SFOV. Comparisons of 5x5, 3x3 and 1x1 TPW are presented. MODIS (MODerate resolution Imaging Spectroradiometer) data (Ackerman et al. 1998) are used as a source of validation.

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2. GOES SOUNDER RETRIEVAL AND DERIVED PRODUCT IMAGERY ALGORITHM

Retrievals and DPI may be produced only in clear skies; therefore, the first step in the retrieval process determines the location of cloud (Schreiner et al. 2001), sometimes referred to as the cloud mask. For each FOV, a flag is set that indicates clear, cloudy, or unknown conditions.

To produce 5x5 or 3x3 FOR retrievals and DPI, there must be a minimum number of clear FOVs. For example, a 3x3 FOR is flagged cloudy if 5 or more FOV are cloudy and a 5x5 FOR is flagged cloudy for 9 or more cloudy FOV. Retrievals that otherwise might have been made in the clear SFOV are not made (a drawback of spatial averaging). Next, the algorithm attempts to achieve convergence for the retrieval within three iterations. If convergence is not reached, the retrieval is abandoned and the next 3x3 FOR is

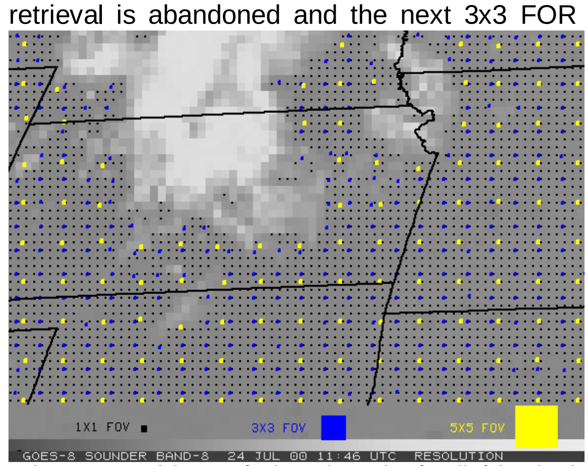

Fig. 1. Grid resolution for single field of view (SFOV), 3x3 field of regard (FOR) and 5x5 FOR. Image shown is 12:00 UTC on 24 Jul 2000 centered on Kansas. The three boxes at the bottom show spatial coverage for 1x1, 3x3 and 5x5 FOR, respectively.

examined. DPI are calculated from the temperature/moisture retrievals. Everywhere that 3x3 FOR retrievals are made, DPI are calculated for the clear-flagged SFOV within the 3x3 FOR. If a 3x3 retrieval is not made, SFOV DPI are not attempted since it was not possible to update the model guess.

SFOV retrievals and DPI do not use a 3x3 FOR guess and so both are made at each clear-flagged FOV.

3. COMPARISON OF SPATIAL AVERAGING

A case study is presented for 24 July 2000 with data from both GOES-8 and GOES-11. Figure 1 illustrates the retrieval locations of the three spatial resolutions considered. GOES-8 TPW calculated as SFOVs exhibit some striping compared to 3x3 FOR and 5x5 FOR. In Fig. 2a, this striping, variation in TPW values in rows of pixels, is exhibited in central Oklahoma parallel to the axis of instability in the 20-30 mm range. Most likely, this is an artifact of the instrument since atmospheric TPW variations are typically more continuous and because averaging into 3x3 or 5x5 FOR generally removes striping, Fig. 2b. Detail is lost with 3x3 processing, however, as Fig. 2b depicts a less continuous axis of instability.

a)

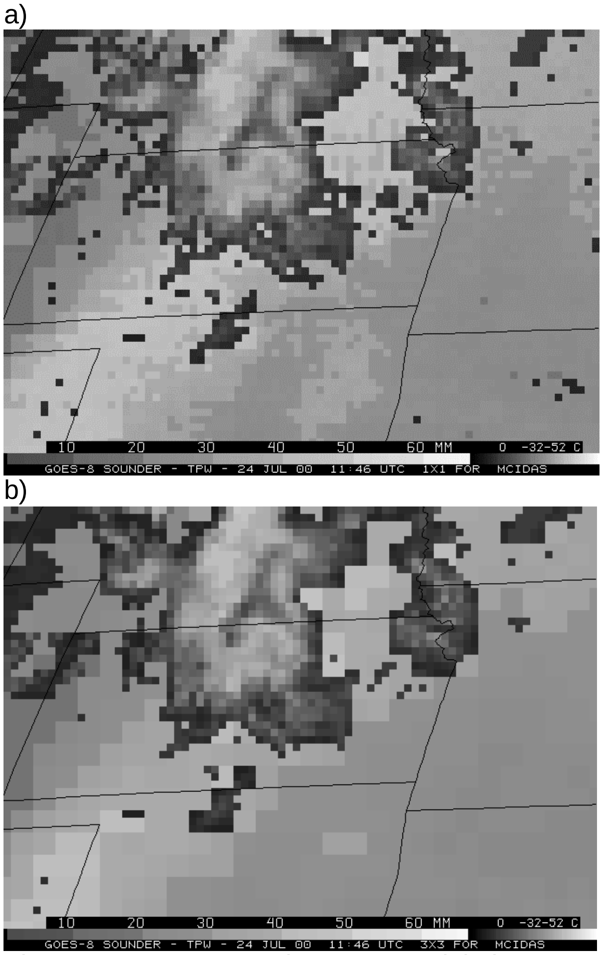

Fig. 2. GOES-8 sounder total precipitable water (mm) at 11:46 UTC on 24 Jul 2000. Cloud edges are black. a) single field of view (1x1) with evidence of striping over central Oklahoma. b) 3x3 field of regard. where spatial averaging minimizes striping.

a)

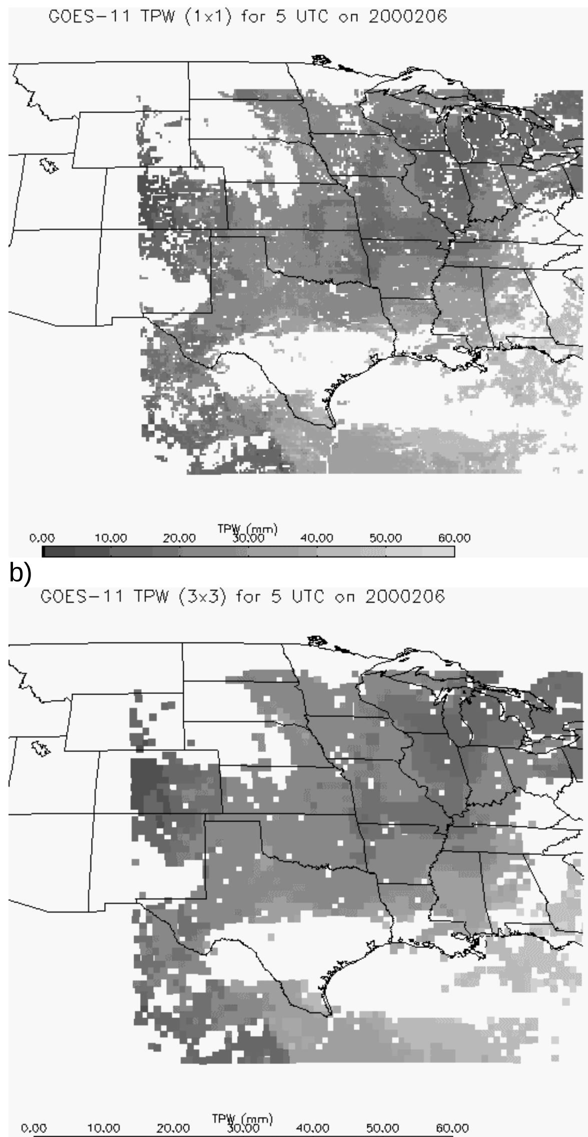

Fig. 3. GOES-11 sounder total precipitable water (mm) at 05:00 UTC on 24 Jul 2000 for a) single field of view (1x1) and b) 3x3 field of regard.

Figures 3a and 3b depict GOES-11 1x1 and 3x3 FOR respectively, at 05:00 UTC for the same day. The GOES-11 data came from the 6-week NOAA science test during the satellite check-out phase. Striping is not manifested in Fig. 3a. Thus instrument improvements may mean SFOV DPI are feasible.

GOES-8 TPW is verified against radiosonde data at 12:00 UTC for 24 Jul 2000 (Table 1). For each spatial resolution, retrievals within 55 km (half a degree) of the radiosonde were verified. Differing resolution retrievals within 5 km of each other were then extracted for final statistics. This colocation was done so comparisons were between spatially close retrievals and the compared retrievals were verified with the same radiosonde data. Although the sample size is small, the statistics indicate that both 3x3 and 5x5 spatial averaging for GOES-8 produce retrievals that more closely agree with radiosonde TPW.

Table 1. Radiosonde verification of GOES-8 sounder total precipitable water at 12:00 UTC on 24 Jul 2000.

RAOB vs. Retrieval	1x1 vs. 3x3	1x1 vs. 5x5
Bias*	2.75/2.04	2.92/2.30
standard deviation	3.22/2.26	2.60/2.27
RMSE**	4.24/3.04	3.91/3.23
Number of matches	23	13
Max. match distance between retrievals	5 km	5 km
Avg. match distance between RAOB and retrievals	34/34 km	39/38 km

*Bias=RAOB-retrieval
**RMSE=SQRT((bias)^2+(standard deviation)^2)

High spatial resolution MODIS TPW data, an independent source of verification, is shown in Fig. 4. MODIS data are collected in 5 minute granules; therefore, this is a two granule image, from 04:50 and 04:55 UTC. The southern Gulf States exhibit TPW values (mm) in the high 20s, with the tip of Texas and southward in the 30s. The large, dark area in the northwest corner represents TPW values of 15 mm. The MODIS and GOES-11 TPW data qualitatively agree.

4. SUMMARY

Improvements in sounder technology over the succession of the GOES-8-11 have yielded improved signal-to-noise ratios. To minimize striping, spatial averaging (3x3 or 5x5 FOR) was a necessity for GOES-8. The striping is not seen with a case comparing GOES-11 sounder total precipitable water data. Additionally, values compare well with higher resolution MODIS data. Thus for this case, single field of view TPW DPI are feasible with GOES-11 sounder data. New case studies will be examined and further radiosonde comparisons will be made.

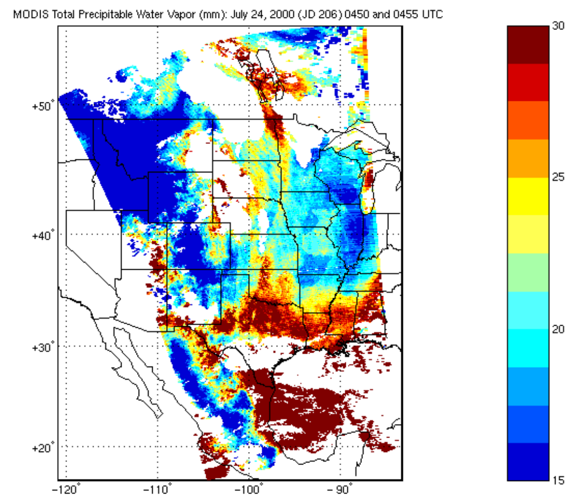

Fig. 4. MODIS total precipitable water (mm) at 4:50 and 4:55 UTC on 24 Jul 2000.

5. REFERENCES

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