P5.12 SOME RESULTS FROM THE NOAA-17 ON-ORBIT VERIFICATION

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1. INTRODUCTION

The National Environmental Satellite, Data and Information Service (NESDIS), which is part of the National Oceanographic and Atmospheric Administration (NOAA), operates the United States' fleet of polar and geosynchronous orbiting weather satellites. NOAA/NESDIS has a long history of cooperation with the National Aeronautics and Space Administration (NASA). NASA procures the instruments and spacecraft, supervises the integration of the system, and provides launch facilities for the NOAA Polar Orbiting Environmental Satellite Program (POES). NASA also performs an on-orbit verification (OV) test to assure that the spacecraft and instruments are healthy and performing to specification. In the past, NOAA has taken a passive role in the OV test. However, with the launch of NOAA-17 on 24 June 2002, NOAA has taken a more active role in the OV. It is not the intent of NOAA scientists to replicate any NASA tests, but rather to supplement the NASA OV with tests analyzing the more subtle scientific characteristics of the instruments. This paper provides a sample of the results from the NOAA OV. No attempt will be made in this limited venue to give a comprehensive accounting of the NOAA OV.

2. NOAA POES INSTRUMENTATION

The instruments that will be discussed here are those that comprise the Advanced TIROS Operational Vertical Sounder system (ATOVS). This consists of 1) the High Resolution InfraRed Sounder (HIRS-3), the Advanced Microwave Sounding Unit – A (AMSU-A), and the Advanced Microwave Sounding Unit – B (AMSU-B). The HIRS senses infrared radiation in 19 channels from 3.7 to 14.9 μm, and one channel in the visible. The AMSU-A is in itself composed of two instruments, the A1 and the A2. The AMSU-A1 senses radiation from the surface and atmosphere in 13 channels from 50 to 89 GHz. The AMSU-A2 has two channels that sense radiation primarily from the surface at 23.8 and 31.4 GHz. The AMSU-B is provided to NOAA by the MetOffice in the United Kingdom. It has five channels which sense radiation emitted by the surface and atmospheric water vapor at frequencies from 89 to 190 GHz. Details of these instruments can be found in Kidwell (2002).

3. NOAA OV TESTS

The NOAA OV tests are too numerous to list in this paper. Only those tests performed or controlled by the author will be described here. Other participants in the NOAA OV are named in the acknowledgements.

The tests fall into three general categories: 1) instrument geolocation, 2) instrument pointing, and 3) scan bias assessment. A grant was issued to Ralf Bennarz of the University of Wisconsin, Madison to perform 3 studies relating to geolocation and instrument pointing

3.1 *Geolocation tests*

Bennartz (2000) described a method for absolute geo-referencing of AMSU window channel data. He used a high resolution land-sea mask convoluted with an idealized antenna pattern. The navigation provided with the level 1B data (Kidwell, 2000) was varied about its initial state and the correlation function was computed between the observed brightness temperatures and the land/sea mask. The maximum correlation indicates the navigation/pointing error that best fits the observed scene. Tables 1 and 2 give the along-track and cross–track geo-reference accuracy for AMSU-A1, AMSU-A2 and AMSU-B. The net result is that the AMSU-A errors are quite small compared to the footprint size (48 km at nadir), while the AMSU-B errors are relatively large compared to the footprint (16 km). This will be discussed further in the next section.

3.2 *Instrument Pointing*

Bennartz (2000) also studied the relative geolocation of the AMSU-B to AMSU-A. He

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used the Backus-Gilbert (1968) method to interpolate the AMSU-B 89GHz channel to the AMSU-A 89 GHz channel location. By varying the interpolation coefficients he determined the along track and cross track offset that minimized the RMS difference between the two channels. Figure 1 shows that the RMS difference is minimized at about +0.3 FOV cross track, and about +0.4 scans along track. These numbers are in rough agreement with those presented in Table 1.

Another method for assessing instrument pointing/ geolocation errors was suggested by R. Spencer (personal communication). AMSU brightness temperatures for 45 days were binned in 0.5 x 0.5 degree latitude-longitude bins separately for ascending and descending portions of the orbit. The ascending and descending data were then differenced and imaged. If there is a cross track displacement of the data, red outlines appear near the coastlines on one side of the continents, and blue outlines appear on the other. Along track displacements exhibit these outlines on the north and south coasts. The AMSU-A1 and A2 on NOAA-17 do not exhibit noticeable outlines, but the AMSU-B does, as seen in Figure 2. This figure does not, however, distinguish between errors associated with geolocation and pointing errors.

3.3 *Scan Bias*

AMSU brightness temperatures for ten consecutive days were averaged as a function of scan position. Since the AMSU instruments scan symmetrically about nadir, a simple method for determining scan bias is to subtract the corresponding FOVs, in this case right of nadir minus left of nadir. Figure 3 gives the results of this for the 15 AMSU-A channels. The data in this and Figure 4 are ocean only, 40N to 40S, with precipitation screening provided by Grody (personal communication). With the exception of channel 2, most channels appear to be systematically warmer on the left side of scan by about 0.5 to 1.0 K.

The AMSU-B average brightness temperature as a function of scan position is given in Figure 4. This figure presents data from two-10 day periods. Channels 1-3 appear to be fairly symmetric without large biases. However, channel 4 exhibits a rather unusual pattern with some noticeable biases. Channel 5 has almost a saw-toothed pattern, with variations of average brightness temperature from one FOV to the next of up to 0.5K . N. Atkinson (personal communication) of the Metoffice attributes this to interference from the local oscillator on channel 1.

4. SUMMARY

A series of tests have been performed on selected NOAA 17 instruments to ascertain geolocation errors and scan biases. The AMSU-A appears to have reasonable geolocation, but also has a small warm bias on the left side of the scan. The AMSU-B appears to have a small geolocation error, as well as significant scan biases in channels 4 and 5.

5. ACKNOWLEGEMENTS

Other NOAA scientists who participated in the OV include C. Cao, T. Mo, J. Sullivan, M. Weinreb and F. Wu. The Bennartz work was supported by a grant from the NOAA/NESDIS Office of Systems Development.

6. REFERENCES

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			Cross-Track		**Along-Track**	
Instrument	**Orbit**	**Des/Asc**	[AMSU-A FOVS]		[Scan lines]	
AMSU-A2 23GHz	D02251 S0939	D	+0.03	+0.03	-0.01	-0.01
	D02251 S1835	A	0.00	0.00	+0.09	+0.09
	D02252 S0910	D	-0.02	+0.03	0.00	0.00
	D02252 S1812	A	-0.02	-0.03	+0.06	+0.06
A2-Average			**+0.02 (=+1.0km@nadir)**		**+0.04 (=+2.0km@nadir)**	
AMSU-A1 50GHz	D02251 S0939	D	+0.03	+0.03	0.00	0.00
	D02251 S1835	A	0.00	0.00	+0.11	+0.11
	D02252 S0910	D	0.06	0.00	0.00	00.0
	D02252 S1812	A	-0.04	-0.04	+0.06	+0.03
A1-Average			**+0.01 (=+0.5km@nadir)**		**+0.04 (=+2.0km@nadir)**	
AMSU-B 89GHz	D02251 S0939	D	+0.30	+0.40	+0.20	+0.30
	D02251 S1835	A	+0.20	+0.20	+0.40	+0.40
	D02252 S0910	D	+0.30	+0.30	+0.20	+0.30
	D02252 S1812	A	+0.10	+0.10	+0.30	+0.40
B-Average			**+0.24 (=+4.2km@nadir)**		**+0.31 (=+5.5 km@nadir)**	

Table 1: From Bennartz (2002), Appendix A. Accuracy of AMSU-A1, AMSU-A2, and AMSU-B geo-referencing for four overpasses over northern Europe for days 251/02 and 252/02. The values are given in units of instrument FOVS for the cross-track direction (i. e. a value of +1 means that the navigation has to be shifted by one FOV in positive scan direction) and in scan lines for the along track direction (i. e. a number of +1 means that the navigation has to be shifted by one scan line in positive flight direction). Note that these scales are different for AMSU-A and AMSU-B. Calculations have been done with two different methods: (1) for each entire overpass over the region and (2) only for those data which are within one FOV from a coastline. The resulting average geo-referencing errors are also given in km for nadir observations.

			Cross-Track		**Along-Track**	
Instrument	**Orbit**	**Des/Asc**	[Instrument FOVS]		[Scan lines]	
AMSU-A2 23 GHz	D02251 S0102	D	+0.03	+0.08	-0.05	-0.05
	D02251 S1317	A	-0.01	-0.02	+0.15	+0.20
	D02252 S0051	D	+0.03	+0.04	-0.15	-0.10
	D02252 S0248	A	+0.05	+0.20	+0.10	+0.10
A2-Average			**+0.05 (=+2.5 km@nadir)**		**+0.03 (=-1.5 km@nadir)**	
AMSU-A1 50 GHz	D02251 S0102	D	+0.02	+0.08	-0.04	0.00
	D02251 S1317	A	-0.03	-0.03	+0.20	+0.20
	D02252 S0051	D	0.00	+0.06	-010	-0.15
	D02252 S0248	A	+0.06	-0.20	+0.15	+0.15
A1-Average			**+0.02 (=+1.0 km@nadir)**		**+0.06 (=+3.0 km@nadir)**	
AMSU-B 89 GHz	D02251 S0102	D	+0.30	+0.30	-0.10	-0.10
	D02251 S1317	A	+0.05	+0.20	+0.80	+0.50
	D02252 S0051	D	+0.30	+0.40	-0.10	-0.10
	D02252 S0248	A	+0.20	+0.30	+0.40	+0.40
B-Average			**+0.25 (=4.4+km@nadir)**		**+0.20 (=+3.5 km@nadir)**	

Table 2: Same as Table 1 but for four overpasses over Indonesia on days 251/02 and 252/02. Orbits and instruments with navigation deviations higher than 0.15 AMSU-A scan lines or FOVS are highlighted in red (0.5 scan-lines or FOVS for AMSU-B).

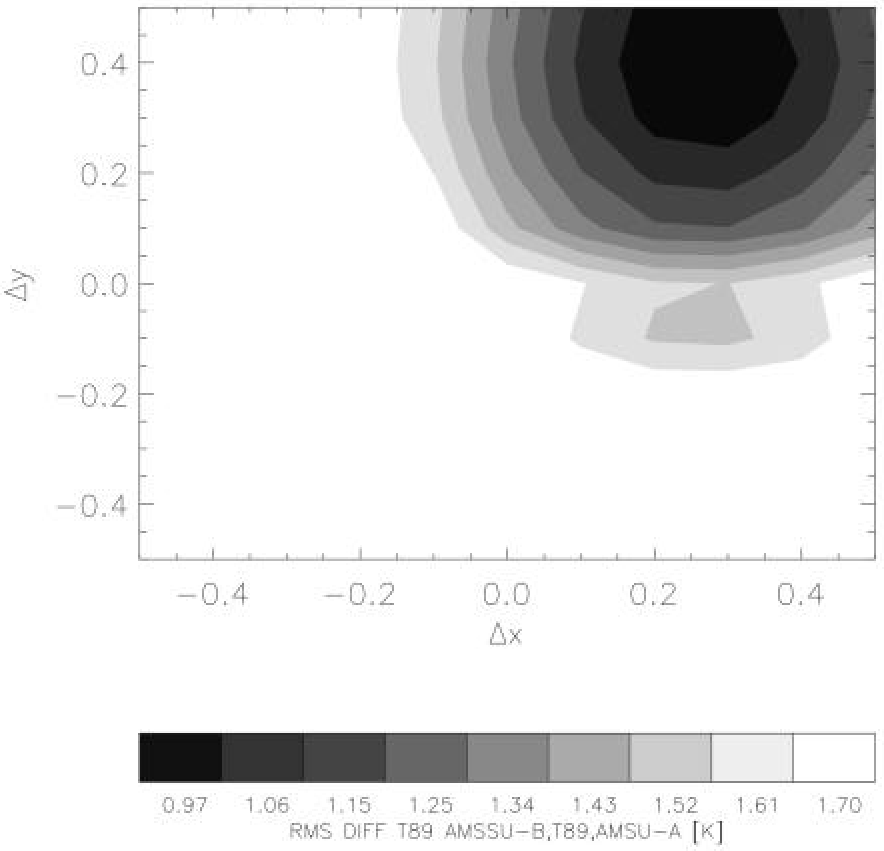

Figure 1. From Bennartz (2000). RMS-deviation (bias-corrected) between AMSU-A 89 GHz and Backus-Gilbert convolved AMSU-B 89 GHz brightness temperatures. The x-axis gives the cross-track shift in units of instrument AMSU-B FOVS for the cross-track direction (i. e. a value of +1 means that the relative navigation of AMSU-B to AMSU-A has to be shifted by one FOV in positive scan direction). The y-axis gives the along-track shift values of scan (i. e. a number of +1 means that the navigation has to be shifted by one scan line in positive flight direction).

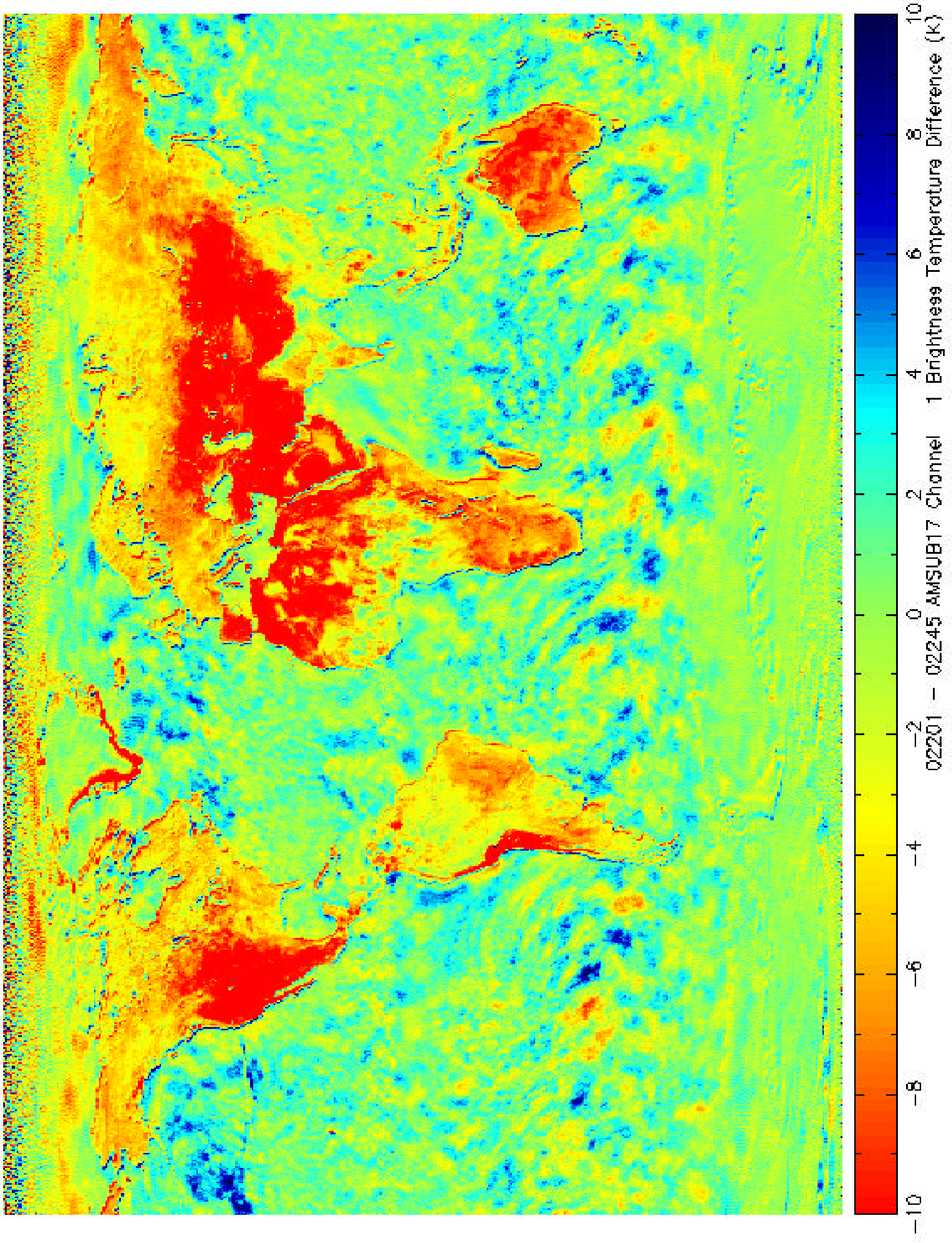

Figure 2. AMSU-B average brightness temperature, ascending node minus descending node. Note the blue outlines in the Gulf of Mexico and along the Peruvian coast, and the red outline along the coast of Brazil.

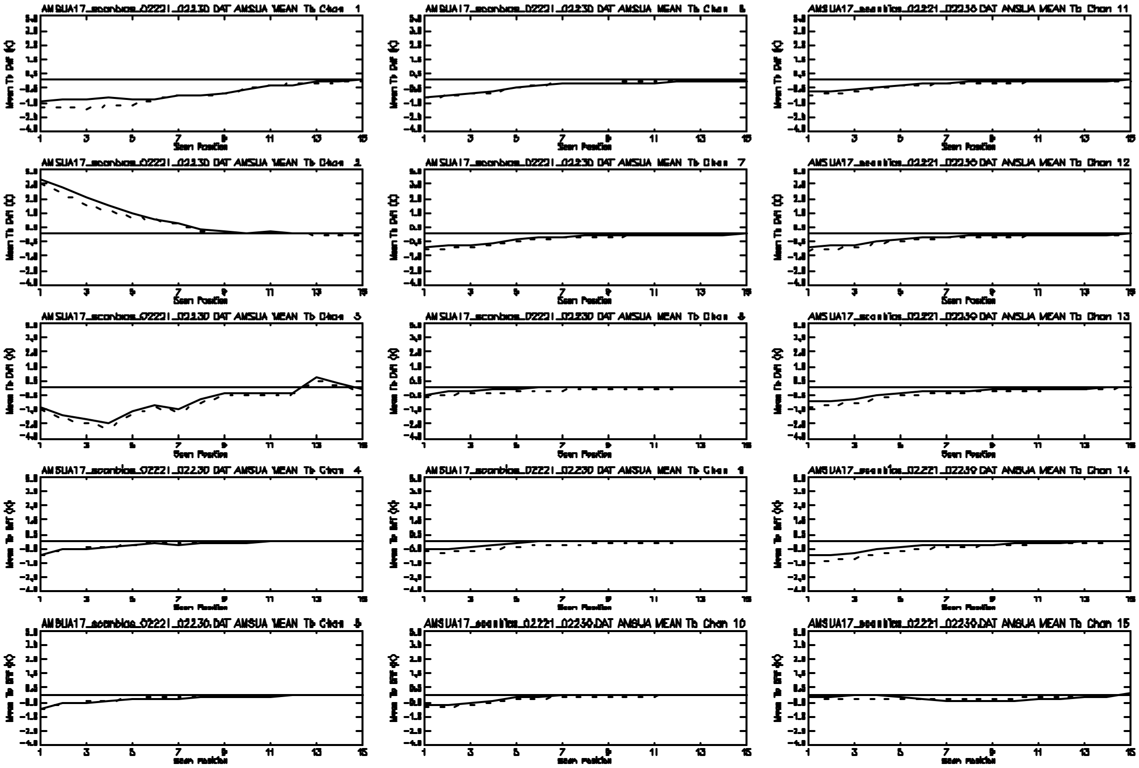

Figure 3. AMSU-A scan biases. Solid line is computed from ascending nodes, dotted line is computed from descending nodes. All data are ocean only, 40N-40S, using Grody cloud liquid water algorithm (personal communication) to screen precipitation.

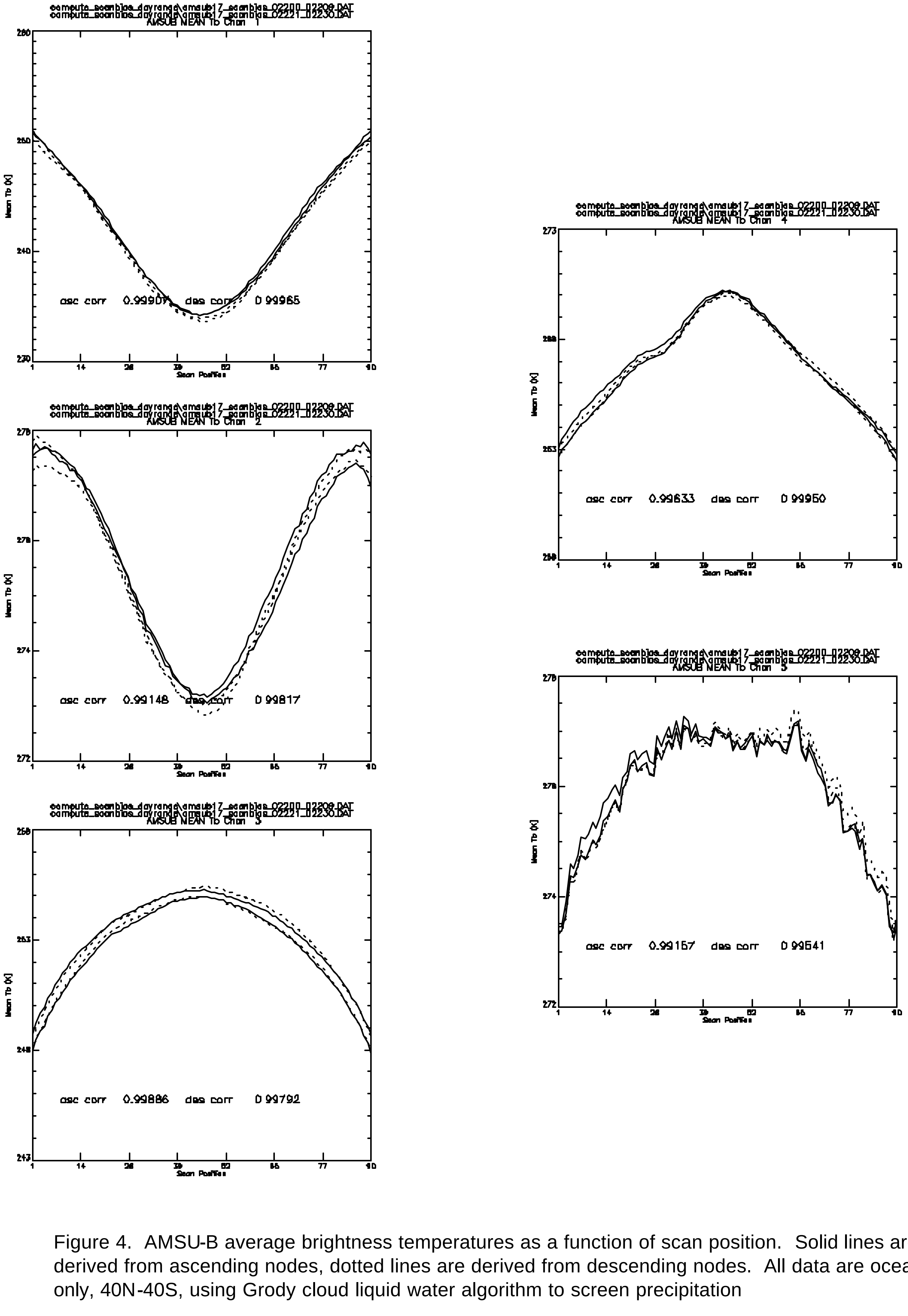

Figure 4. AMSU-B average brightness temperatures as a function of scan position. Solid lines are derived from ascending nodes, dotted lines are derived from descending nodes. All data are ocean only, 40N-40S, using Grody cloud liquid water algorithm to screen precipitation