

2004 / 2005 Report on NOAA / NESDIS GOES Soundings

Summary and Purpose of Document

This paper summarizes the current NOAA/NESDIS operational sounding product suite derived from the GOES. Improvements under study are also summarized.

Action Requested: None

2004 / 2005 REPORT ON NOAA/NESDIS GOES SOUNDINGS

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1. Introduction

The NOAA/NESDIS operational Geostationary Operational Environmental Satellite (GOES) East (GOES-12 at 75 W) and West (GOES-10 and 135 W) soundings (retrievals) continue to be produced nearly every hour at approximately 50 km resolution (5X5 Fields of View (FOV)) in clear skies over North America and adjoining oceans. Additionally, GOES-9 (at 155 E) products are being generated in an experimental mode and will continue to be generated until the end of the GOES-9 Sounder data availability. Research retrievals are routinely generated at single FOV (SFOV) resolution (approximately 10 km). The NESDIS operational retrievals are evolving to single FOV, beginning in October 2005. Derived Product Images (DPI) of Total column Precipitable Water vapor (TPW) and atmospheric stability (Lifted Index, LI) are being used by National Weather Service forecast offices. The 5x5 FOV derived products are also available on the Advanced Weather Interactive Processing System (AWIPS). Furthermore, some of the GOES sounder bands are now also available in the AWIPS. Three layers of moisture derived from the GOES soundings have been used operationally by regional forecast models over land. Cloud-top Pressure and Effective Cloud Amount at SFOV resolution are being generated and used in several numerical weather prediction models.

2. Performance of GOES Soundings

Operational production of GOES-East and -West soundings continues nearly every hour over North America and adjacent oceans. For the last several years, GOES retrievals at NESDIS operations (designated as OPS), CIMSS (Cooperative Institute for Meteorological Satellite Studies), and FPDT (NOAA/NESDIS Forecast Products Development Team) have been produced using a nonlinear physical retrieval algorithm. This algorithm uses GOES Sounder cloud-free radiances that have been averaged over N x N FOVs to adjust first guess vertical profiles of temperature and moisture. The operational retrievals are produced using a 5 X 5 FOV matrix at NESDIS, 3x3 FOV at CIMSS, and single FOV at FPDT.

Statistics from operational NOAA/NESDIS 5x5 FOV retrievals and collocated radiosondes are shown in Table 1. For reference, statistics from legacy 3 x 3 FOV CIMSS retrievals and a version of the SFOV retrievals produced at CIMSS are also shown. The statistics are valid for the period 1 September 2004 through 31 July 2005. In general, the standard deviation (SD) was reduced when comparing retrievals and radiosondes versus retrieval guesses and radiosondes. Furthermore, the correlation coefficient (CC) usually increased from the guess/radiosonde to the retrieval/radiosonde comparisons. This means the retrieved moisture information tended to more closely mimic the radiosonde data than did the guess as one compared successive retrieval/radiosonde pairs.

Table 1. Moisture (mm) retrieval differences from 1 September 2004 (2004245) through 31 July 2005 (2005212) between the GFS model first guess, various GOES Sounder retrievals, and radiosondes observations all collocated within 25 kilometers. Bias and standard deviation (SD) are indicated. Sigma levels are defined as the pressure divided by surface pressure. Minimum clear retrieval Fields of View (FOV) required are 4 (out of 9 possible) for each 3x3 FOV match, and 4 (out of 25 possible) for each 5x5 FOV match. GS = retrieval guess, RT = retrieval, RB = radiosonde, SB2S2 = $\text{SQRT}(\text{BIAS}^2 + \text{SD}^2)$, WV = Total Precipitable Water vapor, WV1 = 1.0 sigma -> 0.9 sigma (approximately 1000hPa -> 900hPa), WV2 = 0.9 sigma -> 0.7 sigma (900 -> 700), and WV3 = 0.7 sigma -> 0.3 sigma (700 -> 300). Red numbers denote GOES-12 and -10 NESDIS operational 5x5 FOV retrievals. Blue numbers denote GOES-12 and -10 CIMSS 3x3 FOV retrievals. Green numbers denote GOES-12 and -10 CIMSS/FPDT experimental SFOV retrievals.

	BIAS(mm)	SD(mm)	SB2S2	AVGX(mm)	AVGY(mm)	CC	N			
TPW,G12	0.49	3.43	3.46	21.73	21.24	.964	1301	GS wrt RB	OPS	5x5
	-0.57	2.92	2.97	20.67	21.24	.973	1301	RT wrt RB	OPS	5x5
G12	0.31	3.00	3.01	21.55	21.24	.971	1301	GS wrt RB	CMS	3x3
	-0.33	2.75	2.77	20.91	21.24	.975	1301	RT wrt RB	CMS	3x3
TPW,G10	-0.79	2.77	2.88	13.55	14.34	.948	252	GS wrt RB	OPS	5x5
	-1.19	3.00	3.23	13.15	14.34	.941	252	RT wrt RB	OPS	5x5
G10	-0.37	3.04	3.07	14.16	14.53	.942	252	GS wrt RB	CMS	3x3
	0.74	3.05	3.13	15.27	14.53	.951	252	RT wrt RB	CMS	3x3
WV1,G12	-0.75	1.65	1.81	7.75	8.50	.941	1301	GS wrt RB	OPS	5x5
	-0.65	1.54	1.67	7.85	8.50	.949	1301	RT wrt RB	OPS	5x5
G12	-0.67	1.54	1.68	7.82	8.49	.948	1301	GS wrt RB	CMS	3x3
	-0.69	1.53	1.68	7.80	8.49	.949	1301	RT wrt RB	CMS	3x3
WV1,G10	-1.39	1.51	2.05	4.06	5.45	.841	252	GS wrt RB	OPS	5x5
	-0.68	1.30	1.47	4.76	5.45	.885	252	RT wrt RB	OPS	5x5
G10	-1.18	1.41	1.84	4.31	5.49	.868	252	GS wrt RB	CMS	3x3
	-0.50	1.33	1.42	4.99	5.49	.888	252	RT wrt RB	CMS	3x3
WV2,G12	0.59	2.06	2.15	10.13	9.54	.943	1301	GS wrt RB	OPS	5x5
	0.28	1.91	1.93	9.82	9.54	.953	1301	RT wrt RB	OPS	5x5
G12	0.48	1.81	1.88	10.02	9.55	.954	1301	GS wrt RB	CMS	3x3
	0.40	1.70	1.75	9.95	9.55	.959	1301	RT wrt RB	CMS	3x3
WV2,G10	0.17	1.66	1.67	6.28	6.11	.916	252	GS wrt RB	OPS	5x5
	-0.08	1.96	1.96	6.03	6.11	.902	252	RT wrt RB	OPS	5x5
G10	0.28	1.85	1.87	6.49	6.21	.905	252	GS wrt RB	CMS	3x3
	0.69	1.97	2.08	6.90	6.21	.908	252	RT wrt RB	CMS	3x3
WV3,G12	0.63	1.37	1.51	3.78	3.15	.885	1301	GS wrt RB	OPS	5x5
	-0.20	1.01	1.03	2.95	3.15	.923	1301	RT wrt RB	OPS	5x5
G12	0.49	1.23	1.32	3.64	3.15	.902	1301	GS wrt RB	CMS	3x3
	-0.04	0.92	0.92	3.12	3.15	.933	1301	RT wrt RB	CMS	3x3
WV3,G10	0.41	1.07	1.14	3.16	2.75	.923	252	GS wrt RB	OPS	5x5
	-0.43	0.93	1.03	2.32	2.75	.937	252	RT wrt RB	OPS	5x5
G10	0.51	1.21	1.31	3.31	2.80	.918	252	GS wrt RB	CMS	3x3
	0.54	1.15	1.27	3.34	2.80	0.929	252	RT wrt RB	CMS	3x3

GOES-12 total column water vapor is also being validated at the DOE ARM CART site near Lamont, Oklahoma, USA. Comparisons between the GOES-12 Sounder SFOV moisture retrievals produced and a Microwave Radiometer (MWR) show good agreement (Fig. 1).

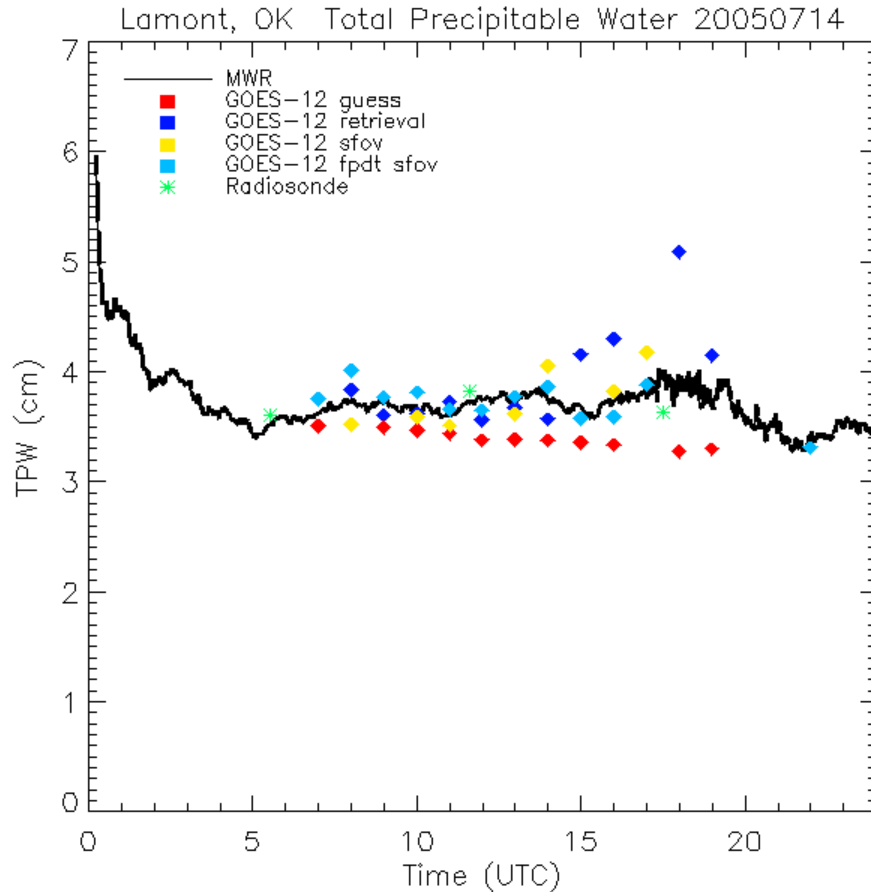


Figure 1: GOES-12 sounder TPW validations with a Microwave Radiometer (MWR) at the Department of Energy – Atmospheric Radiation Program (DOE ARM) Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site. Microwave radiometer (solid line), numerical model forecast (red diamonds), radiosonde (green asterisks) and GOES-12 physical retrieval of total precipitable water vapor values are compared near Lamont, Oklahoma on 14 July 2005. The 3x3 FOV (dark blue diamonds) show possible evidence of contamination due to afternoon clouds, while the SFOV (yellow and light blue diamonds) match the MWR data more closely.

3. Single FOV Soundings

The GOES sounder signal-to-noise ratio has improved steadily with each successive sounder launched into orbit – the May 2000 launch of GOES-11 and the July 2001 launch of GOES-12 offer sounders that can achieve single FOV (SFOV) retrievals. SFOV retrievals are being generated and studied by both FPDT and CIMSS. SFOV retrievals show details not seen in coarser resolution retrievals. A new “merged” retrieval system from FPDT produces not only SFOV retrievals, but also the SFOV cloud product; these will be implemented operationally in October of 2005. Sample 5x5 FOV (the currently-operational NESDIS product) and SFOV Derived Product Imagery (DPI) of atmospheric instability are shown in Figures 2 and 3, respectively, for the afternoon and early evening of 18 Aug 2005 (day 230)..

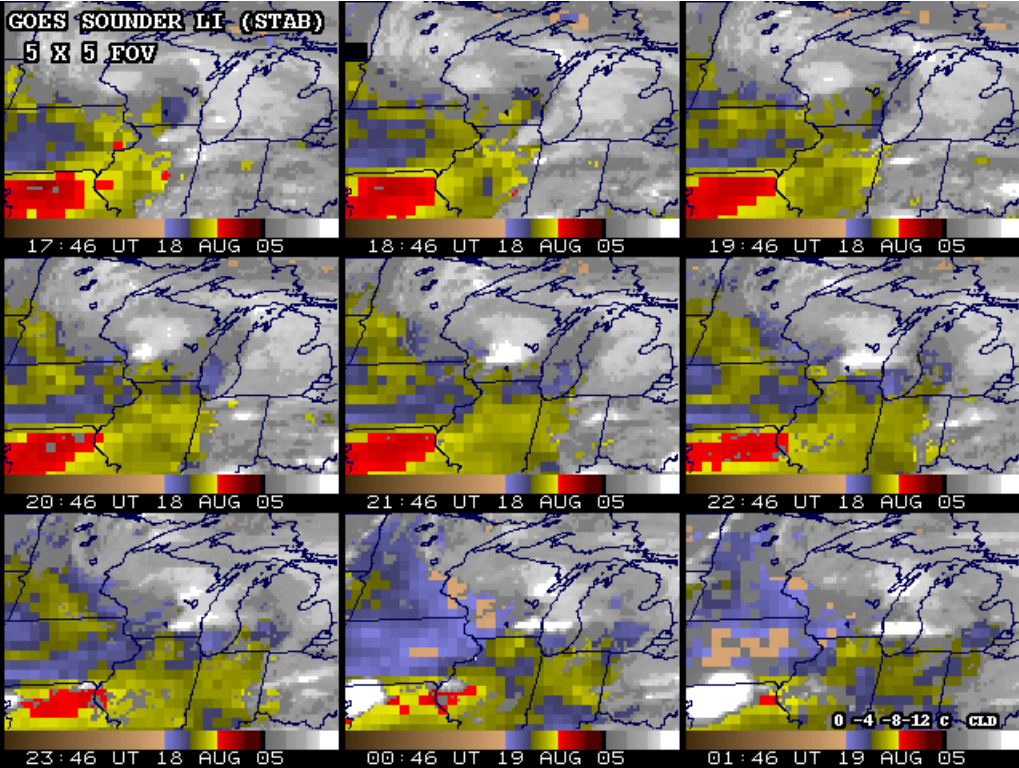


Figure 2. 5x5 FOV GOES Sounder LI DPI produced by NOAA/NESDIS operations from approximately 18UTC 18 Aug 2005 through approximately 0200UTC 19 Aug 2005.

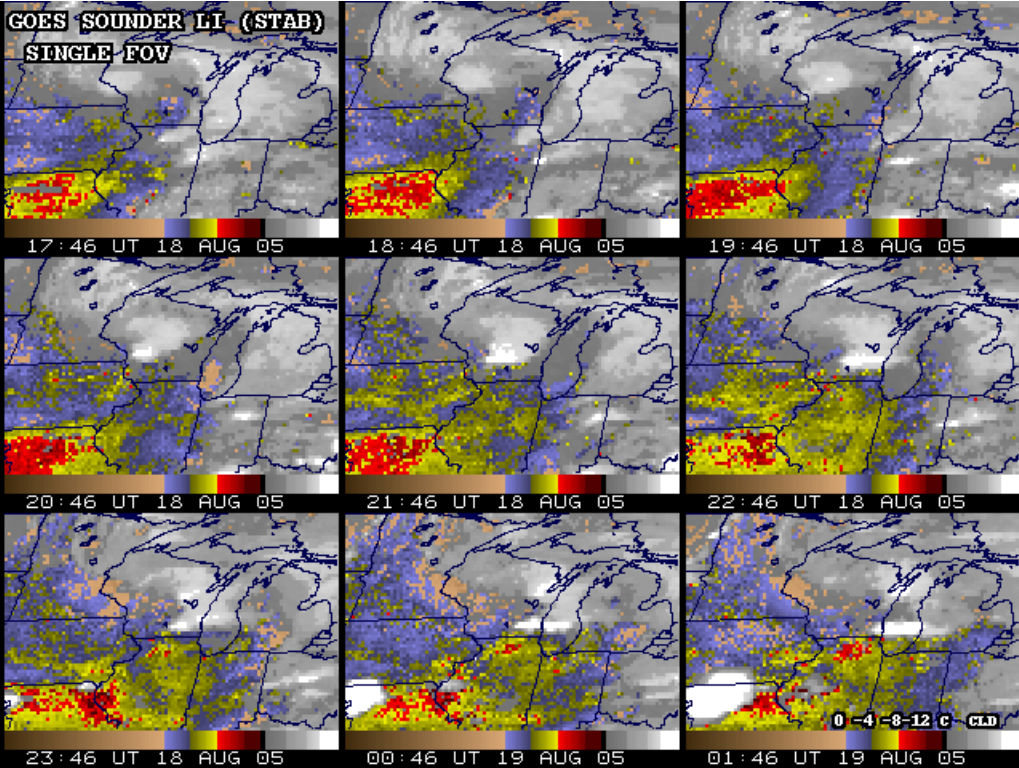


Figure 3. SFOV GOES Sounder LI DPI produced by ORA from approximately 18UTC 18 Aug 2005 through approximately 0200UTC 19 Aug 2005.

4. GOES-9 Retrievals

GOES-9, positioned over the western Pacific (155 E) since May 2003, has been providing additional sounder data and products. These experimental products include TPW and cloud-product information. As long as the satellite remains operational, displays of GOES-9 real time radiance data (Fig. 4) and associated products will be available at <http://cimss.ssec.wisc.edu/goes/realtime/grtmain.html#gsall>.

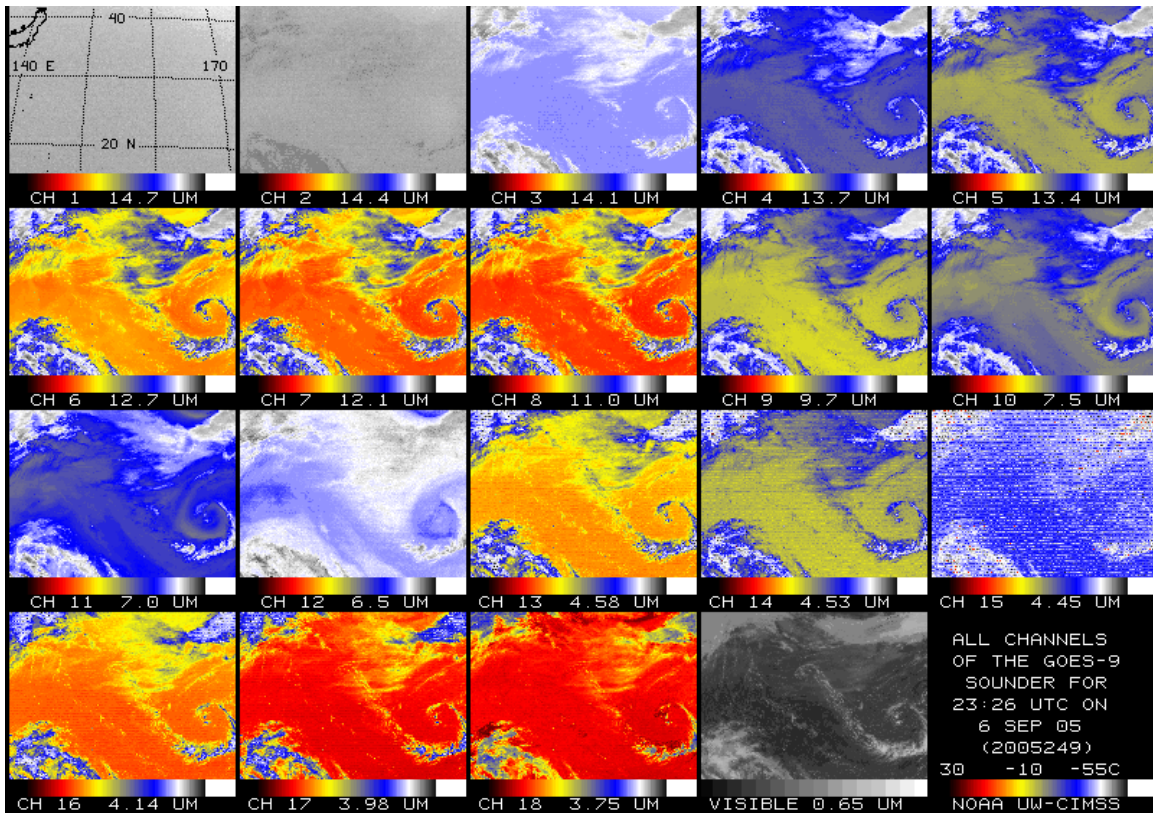


Figure 4. GOES-9 Sounder 18-band radiance data for approximately 00UTC 7 Sept 2005.

5. Imager Clear-Sky Brightness Temperature

Clear sky radiances from the GOES imagers were requested by the National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC) and the European Centre for Medium-range Weather Forecasts (ECMWF) for assimilation into global weather prediction models (Fig. 5). As a result, NESDIS/ORA and CIMSS developed software that selects cloud-free fields-of-view (FOVs), averages these data to 50 km areas, and stages the information to BUFR-format files. These hourly Clear Sky Brightness Temperature (CSBT) fields for the water vapor spectral band from the GOES-9 (western Pacific), GOES-12 (East), and GOES-10 (West) Imagers are being used operationally by ECMWF. NCEP/EMC is looking at the GOES-10/12 data. The CSBT product will be produced operationally by NOAA/NESDIS beginning in October 2005.

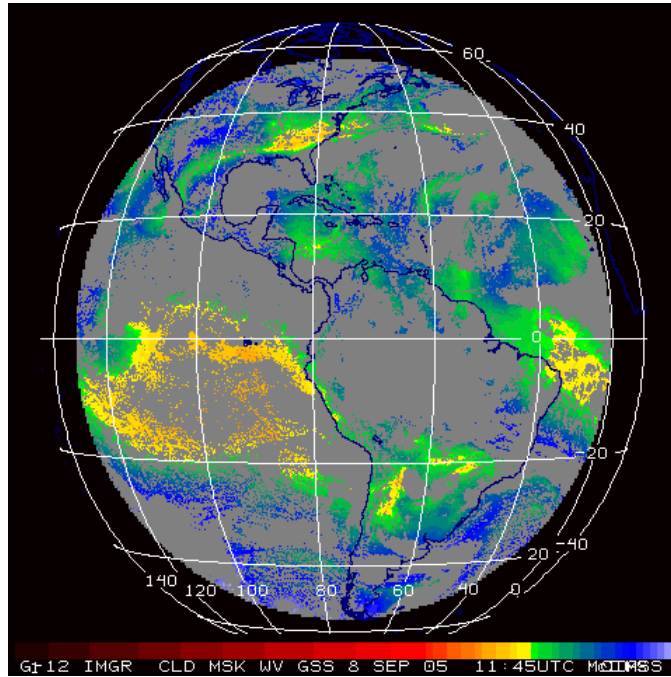


Figure 5: GOES--12 Imager "water vapor" band CSBT image from 12 UTC 8 Sept 2005.

6. GOES Imager Cloud-top information

When GOES-12 replaced GOES-8, cloud top products became possible from measurements at 13.3 and 11 microns (Fig. 6). The cloud top pressure product is running in experimental mode each hour at CIMSS. There are plans to make this product operational at NOAA/NESDIS in 2006.

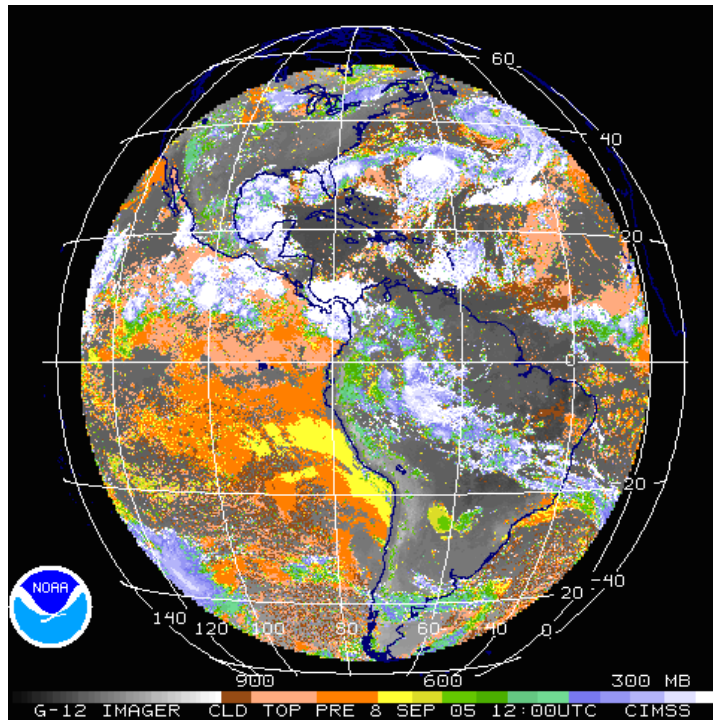


Figure 6: GOES-12 Imager Cloud-top Pressure from approximately 12 UTC 8 Sept 2005.

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