CGMS-34, NOAA-WP-13
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2005 / 2006 Report on NOAA / NESDIS GOES Soundings

NOAA-WP-13 summarizes the current NOAA/NESDIS operational sounding product suite derived from the GOES. The status of other products is also summarized.

2005 / 2006 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-11 at 135 W) soundings (retrievals) are produced hourly at approximately 10 km nominal resolution (1x1 Field of View (FOV)) in clear skies over North America and adjacent oceans. On 3 November 2005, NOAA/NESDIS began generating operational retrievals at the new Single FOV (SFOV) resolution. Previously, the NOAA/NESDIS operational retrievals had been 5x5 FOVs in size. SFOV retrievals show details not seen in coarser resolution retrievals. On another note, GOES-11 replaced GOES-10 as the operational GOES West satellite on 21 June 2006.

Derived Product Images (DPI) of Total column Precipitable Water vapor (TPW) and atmospheric stability (Lifted Index (LI)) continue to be used by National Weather Service forecast offices. The 1x1 FOV derived products are also available on the Advanced Weather Interactive Processing System (AWIPS). This information is used by the National Weather Service (NWS) for a number of applications. For example, the GOES Sounder is used for monitoring atmospheric instability and heavy precipitation potential. Furthermore, selected GOES Sounder bands are available via AWIPS. Regional forecast models have used three layers of moisture derived from the GOES soundings over land. GOES Sounder Cloud-top Pressure and Effective Cloud Amount at SFOV resolution are being generated and used in several numerical weather prediction models. In addition, quantitative products from the GOES Imager are also being generated. These include the clear-sky radiance and GOES-12 Imager cloud-top information.

2. Performance of GOES Soundings

Operational production of GOES-East and -West soundings continues on an hourly basis over North America and adjacent oceans. For the last several years, GOES retrievals at NOAA/NESDIS operations (designated as OPS), CIMSS (Cooperative Institute for Meteorological Satellite Studies), and OPDB (NOAA/NESDIS/STAR/SMCD Operational Products Development Branch) have been produced using a nonlinear physical retrieval algorithm. This algorithm uses GOES Sounder cloud-free radiances that have been averaged over NxN FOVs to adjust first guess vertical profiles of temperature and moisture. The operational retrievals at NOAA/NESDIS are now produced using a 1x1 FOV matrix of radiances, using a new “merged” retrieval software system from OPDB that produces not only SFOV retrievals, but also the SFOV cloud product. This new software was

implemented on 03 November 2005. In addition, legacy 3x3 FOV retrievals are still generated at CIMSS, and legacy 5x5 FOV retrievals continue to be produced at NESDIS. Experimental work involving SFOV retrievals is ongoing both at CIMSS and OPDB.

Statistics from the operational NOAA/NESDIS 1x1 FOV retrievals, the legacy CIMSS 3x3 FOV retrievals, and the legacy NOAA/NESDIS 5x5 FOV retrievals, with collocated radiosondes, are shown in Table 1. For GOES-12, the statistics are valid for the period 01 September 2005 through 31 August 2006. For GOES-11, the statistics are valid for the period 22 June 2006 through 31 August 2006. Finally, the statistics for GOES-10 are valid for the period 01 September 2005 through 21 June 2006.

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 01 September 2005 (2005244) through 31 August 2006 (2006243) between the GFS model first guess, various GOES Sounder retrievals, and 00 and 12 UTC radiosonde observations, all collocated within 11.1 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 10 (out of 25 possible) for each 5x5 FOV match. GS = retrieval guess, RT = retrieval, RB = radiosonde, SB2S2 = SQRT($BIAS^2$ + SD^2), AVGX is the average retrieval value, AVGY is the average radiosonde value, N is the total sample size, TPW = Total Precipitable Water vapor, WV1 = precipitable water from 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, -11 and –10 NOAA/NESDIS operational 1x1 FOV retrievals. Blue numbers denote GOES-12, -11 and -10 legacy CIMSS 3x3 FOV retrievals. Black numbers denote GOES-12, -11 and -10 legacy NOAA/NESDIS 5x5 FOV retrievals.

Data	BIAS(mm)	SD(mm)	SB2S2	AVGX(mm)	AVGY(mm)	CC	N	Collocation
TPW								
G12,N1x1	0.66	3.62	3.68	21.85	21.19	0.970	33027	GSvsRB
	0.61	3.37	3.43	21.79	21.19	0.970	33027	RTvsRB
C3x3	-0.07	3.02	3.02	19.91	19.98	0.973	1832	GSvsRB
	-0.74	2.75	2.84	19.24	19.98	0.978	1832	RTvsRB
N5x5	0.19	3.45	3.45	21.22	21.03	0.965	255	GSvsRB
	-0.67	2.95	3.03	20.36	21.03	0.973	255	RTvsRB
G11,N1x1	0.00	4.13	4.13	17.77	17.78	0.850	1614	GSvsRB
	0.47	3.88	3.91	18.24	17.78	0.870	1614	RTvsRB

C3x3	-0.59	3.39	3.44	17.93	18.51	0.912	102	GSvsRB
	0.66	3.42	3.48	19.17	18.51	0.913	102	RTvsRB
N5x5	-1.71	3.53	3.93	19.89	21.60	0.968	10	GSvsRB
	-1.72	3.60	3.99	19.88	21.60	0.968	10	RTvsRB
G10,N1x1	0.22	2.83	2.84	11.08	10.85	0.900	6412	GSvsRB
	0.16	2.68	2.69	11.01	10.85	0.920	6412	RTvsRB
C3x3	-0.11	2.38	2.38	10.53	10.64	0.941	553	GSvsRB
	0.69	2.34	2.44	11.33	10.64	0.952	553	RTvsRB
N5x5	-1.33	3.08	3.35	9.13	10.46	0.803	36	GSvsRB
	-1.31	2.29	2.64	9.15	10.46	0.896	36	RTvsRB
WV1								
G12,N1x1	-0.59	1.42	1.53	7.49	8.08	0.960	33027	GSvsRB
	-0.59	1.44	1.55	7.49	8.08	0.960	33027	RTvsRB
C3x3	-0.62	1.34	1.47	7.20	7.81	0.961	1832	GSvsRB
	-0.61	1.30	1.44	7.21	7.81	0.964	1832	RTvsRB
N5x5	-0.83	1.54	1.75	7.42	8.25	0.945	255	GSvsRB
	-0.67	1.50	1.64	7.58	8.25	0.948	255	RTvsRB
G11,N1x1	-1.06	1.75	2.05	4.94	6.00	0.720	1614	GSvsRB
	-0.91	1.80	2.02	5.09	6.00	0.710	1614	RTvsRB
C3x3	-1.61	1.59	2.26	4.69	6.29	0.763	102	GSvsRB
	-0.94	1.75	1.99	5.35	6.29	0.725	102	RTvsRB
N5x5	-1.74	1.25	2.15	5.34	7.08	0.953	10	GSvsRB
	-0.91	1.08	1.41	6.18	7.08	0.957	10	RTvsRB
G10,N1x1	-0.55	1.19	1.31	3.34	3.89	0.860	6412	GSvsRB
	-0.59	1.13	1.27	3.30	3.89	0.870	6412	RTvsRB
C3x3	-0.81	1.02	1.30	3.16	3.97	0.907	553	GSvsRB
	-0.30	1.00	1.05	3.68	3.97	0.915	553	RTvsRB
N5x5	-1.14	0.83	1.41	2.84	3.98	0.875	36	GSvsRB
	-0.52	0.87	1.01	3.46	3.98	0.878	36	RTvsRB
WV2								
G12,N1x1	0.63	2.10	2.20	9.92	9.30	0.950	33027	GSvsRB
	0.55	2.06	2.13	9.84	9.30	0.950	33027	RTvsRB
C3x3	0.28	1.68	1.71	9.07	8.79	0.962	1832	GSvsRB
	0.13	1.65	1.66	8.92	8.79	0.962	1832	RTvsRB
N5x5	0.37	1.89	1.92	9.89	9.53	0.954	255	GSvsRB
	0.14	1.79	1.80	9.66	9.53	0.960	255	RTvsRB
G11,N1x1	0.42	2.32	2.35	8.41	7.99	0.800	1614	GSvsRB
	0.72	2.28	2.39	8.71	7.99	0.820	1614	RTvsRB
C3x3	0.57	1.78	1.87	8.91	8.34	0.883	102	GSvsRB
	1.10	1.95	2.24	9.44	8.34	0.872	102	RTvsRB
N5x5	-0.07	2.05	2.05	9.57	9.65	0.935	10	GSvsRB
	0.41	2.72	2.75	10.07	9.65	0.908	10	RTvsRB
G10,N1x1	0.39	1.56	1.60	5.15	4.76	0.870	6412	GSvsRB
	0.34	1.56	1.60	5.10	4.76	0.870	6412	RTvsRB
C3x3	0.41	1.32	1.39	5.00	4.58	0.920	553	GSvsRB
	0.67	1.40	1.55	5.25	4.58	0.926	553	RTvsRB
N5x5	-0.30	1.81	1.84	4.22	4.52	0.681	36	GSvsRB
	-0.42	1.39	1.45	4.11	4.52	0.811	36	RTvsRB
WV3								
G12,N1x1	0.61	1.55	1.67	4.35	3.74	0.890	33027	GSvsRB
	0.63	1.40	1.53	4.37	3.74	0.920	33027	RTvsRB
C3x3	0.26	1.30	1.33	3.58	3.32	0.911	1832	GSvsRB
	-0.25	1.06	1.09	3.07	3.32	0.934	1832	RTvsRB
N5x5	0.62	1.32	1.46	3.83	3.21	0.919	255	GSvsRB
	-0.16	0.91	0.93	3.05	3.21	0.945	255	RTvsRB
G11,N1x1	0.63	1.56	1.68	4.36	3.73	0.820	1614	GSvsRB
	0.65	1.27	1.42	4.38	3.73	0.880	1614	RTvsRB
C3x3	0.44	1.27	1.34	4.28	3.84	0.902	102	GSvsRB

	0.50	1.01	1.12	4.34	3.84	0.930	102	RTvsRB
N5x5	0.11	1.19	1.20	4.92	4.81	0.970	10	GSvsRB
	-1.24	1.80	2.18	3.57	4.81	0.990	10	RTvsRB
G10,N1x1	0.38	1.03	1.10	2.54	2.16	0.860	6412	GSvsRB
	0.40	0.97	1.05	2.56	2.16	0.880	6412	RTvsRB
C3x3	0.29	0.96	1.00	2.34	2.05	0.888	553	GSvsRB
	0.31	0.85	0.91	2.37	2.05	0.909	553	RTvsRB
N5x5	0.10	0.94	0.94	2.03	1.93	0.801	36	GSvsRB
	-0.38	0.72	0.81	1.55	1.93	0.884	36	RTvsRB

To expound further on Table 1, Figure 1 shows a more detailed daily plot of retrieval-radiosonde TPW bias from just before and just after the switch was made from GOES-10 to GOES-11 on 21 June 2006. Note that in general similar bias values are observed before and after the switchover.

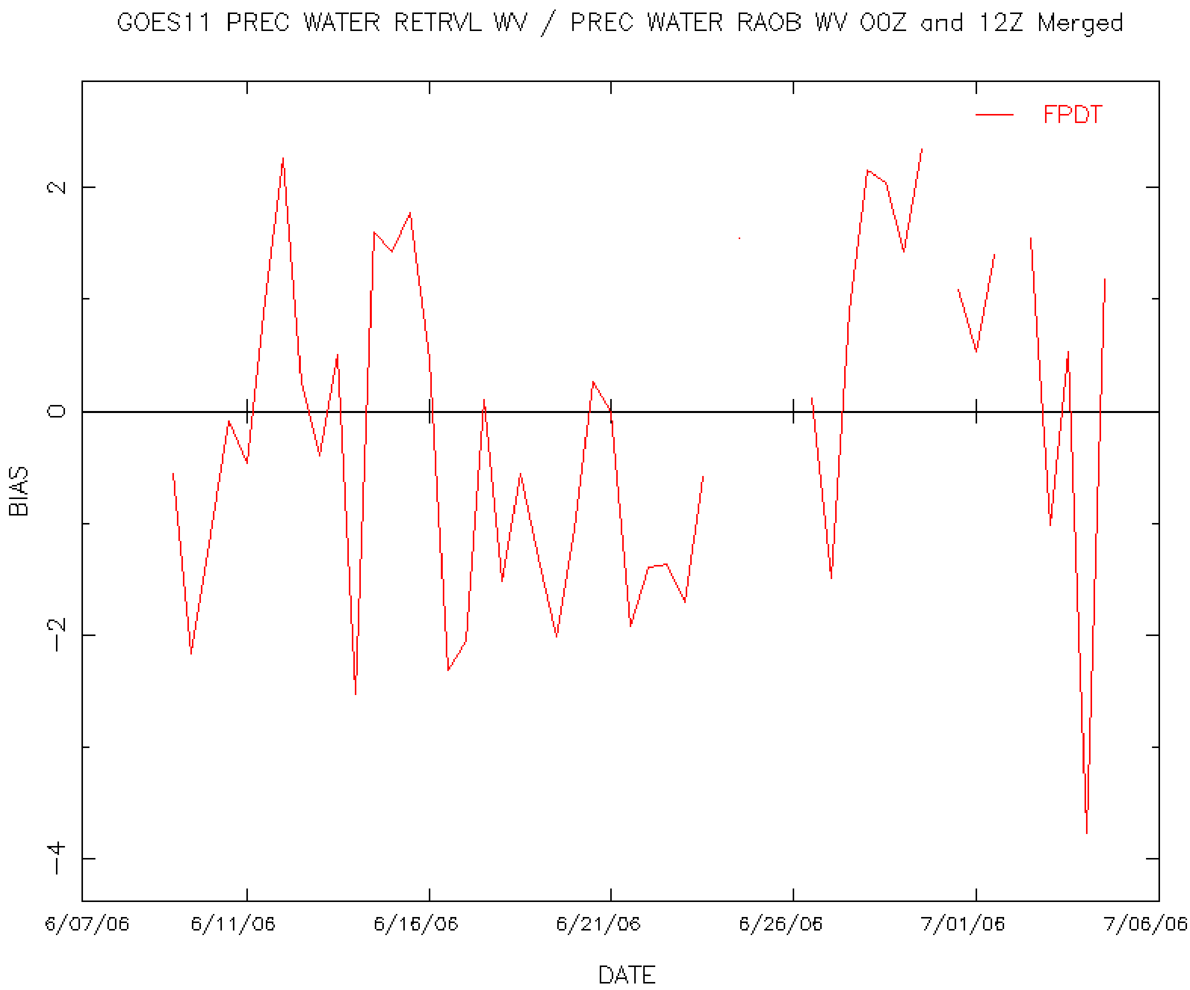

Figure 1: GOES-West retrieval comparison to radiosondes for TPW measurements for the two weeks before (GOES-10) and after the switchover (to GOES-11) on 21 June 2006.

3. GOES-11 Radiances

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 both offer sounders that can realistically achieve single FOV (SFOV) retrievals. The reduced noise of GOES-11 compared with GOES-10 can be seen in Figs. 2 and 3, both image sets have been remapped to a common projection. For example, note the improved image quality in Sounder band 15 (4.5 um) between GOES-11 and GOES-10. The switch to GOES-11 has not been entirely fruitful, however. GOES-11 has exhibited more diurnally changing striping of several of the window bands (not shown).

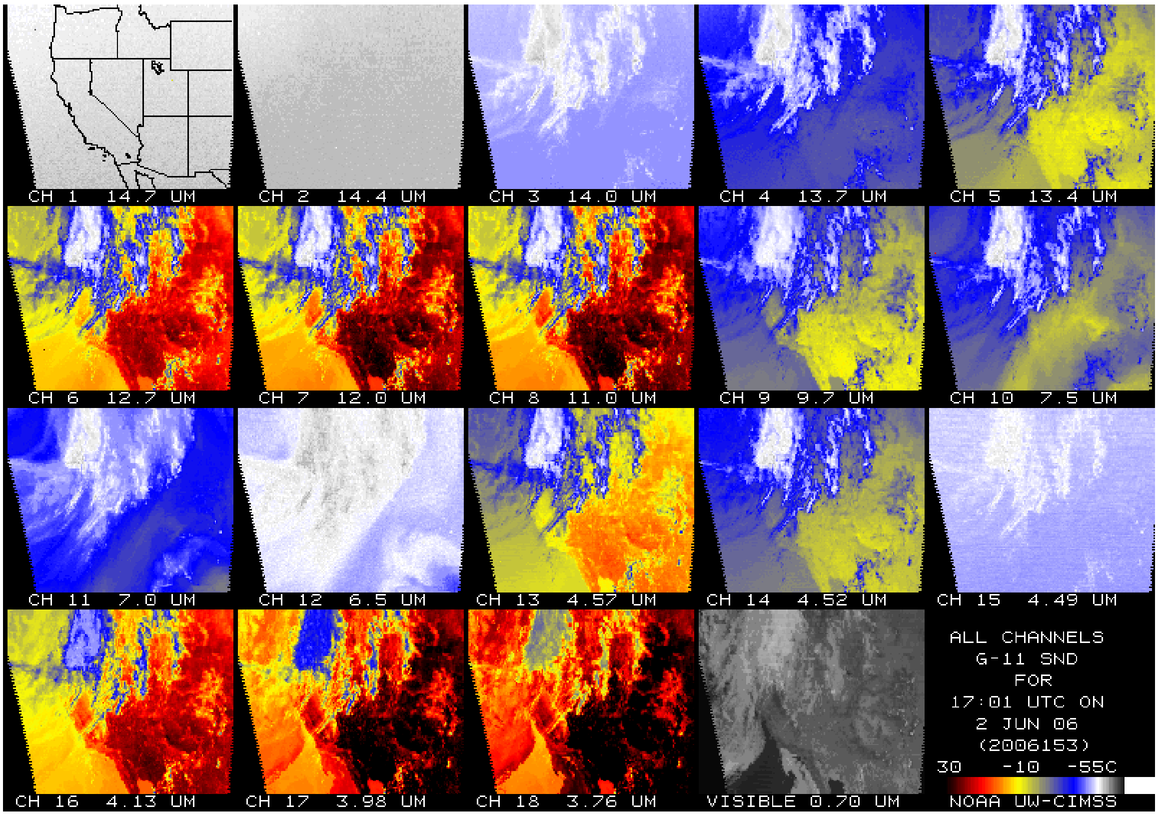

Figure 2. The 19 bands of the GOES-11 Sounder at 17UTC 02 June 2006.

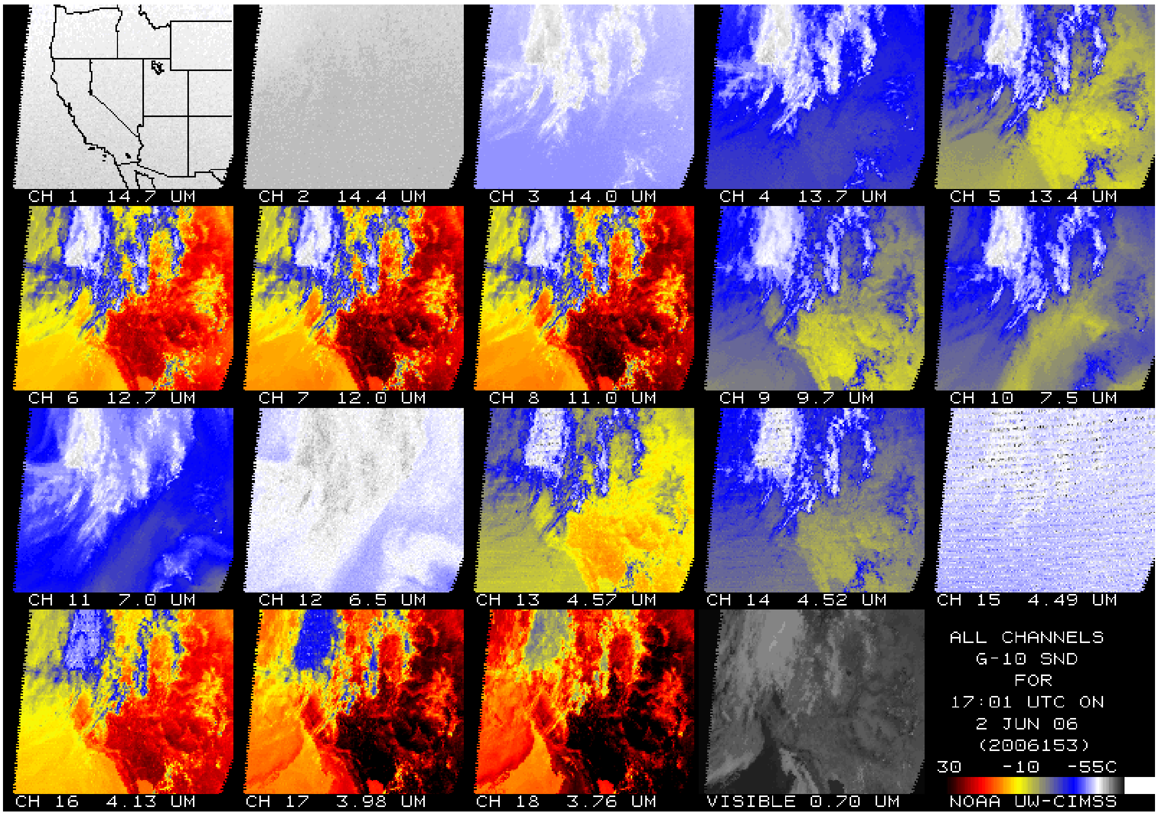

Figure 3. The 19 bands of the GOES-10 Sounder at 17UTC 02 June 2006.

4. GOES-13 Radiances

GOES-13, launched on 24 May 2006, is currently undergoing post-launch engineering testing. Preliminary estimates show that the GOES-13 signal-to-noise ratio is the best of any of the GOES Sounders to date. This is due to the new spacecraft bus that allows the detectors to function at much colder temperatures. More analysis of GOES-13 data will be done during the science post-launch test slated for December 2006. Figures 4 and 5 show remapped images of the GOES-13 and GOES-11 Sounders. Note that the satellite view angles are different for each satellite.

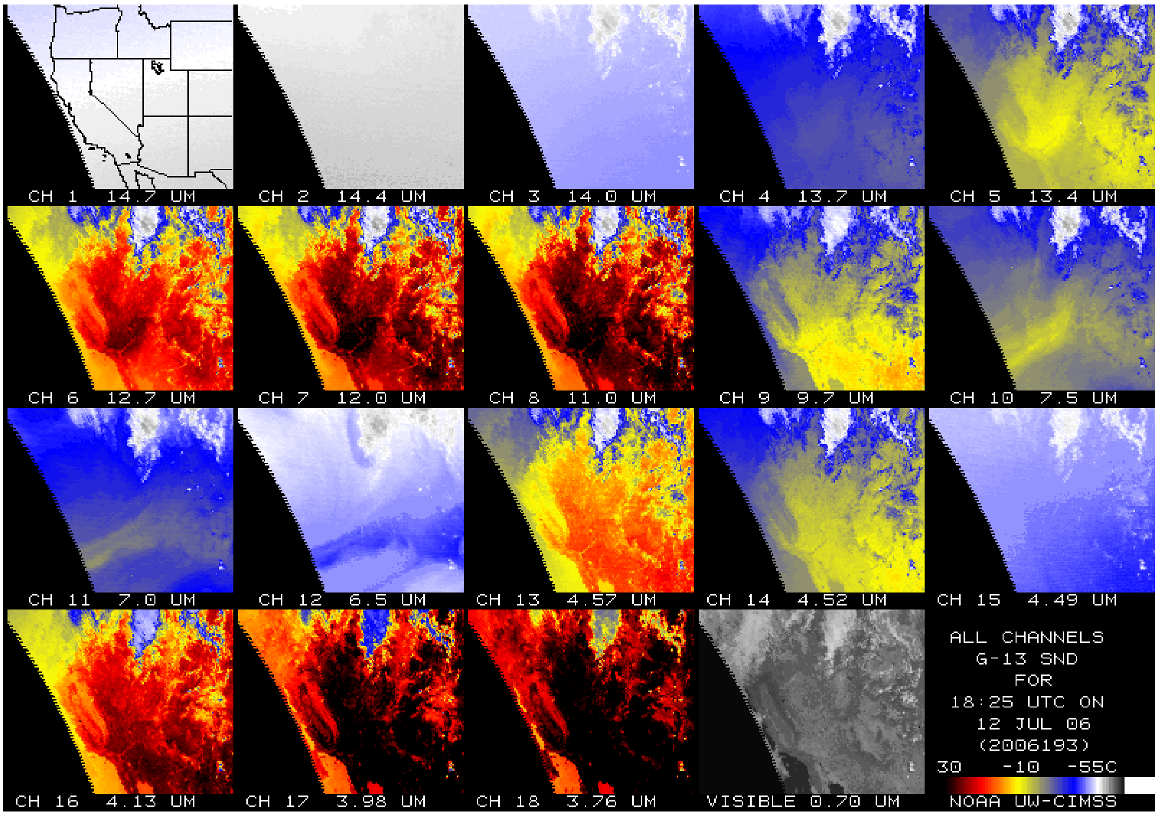

Figure 4. The 19 bands of the GOES-13 Sounder at 18:25UTC 12 July 2006.

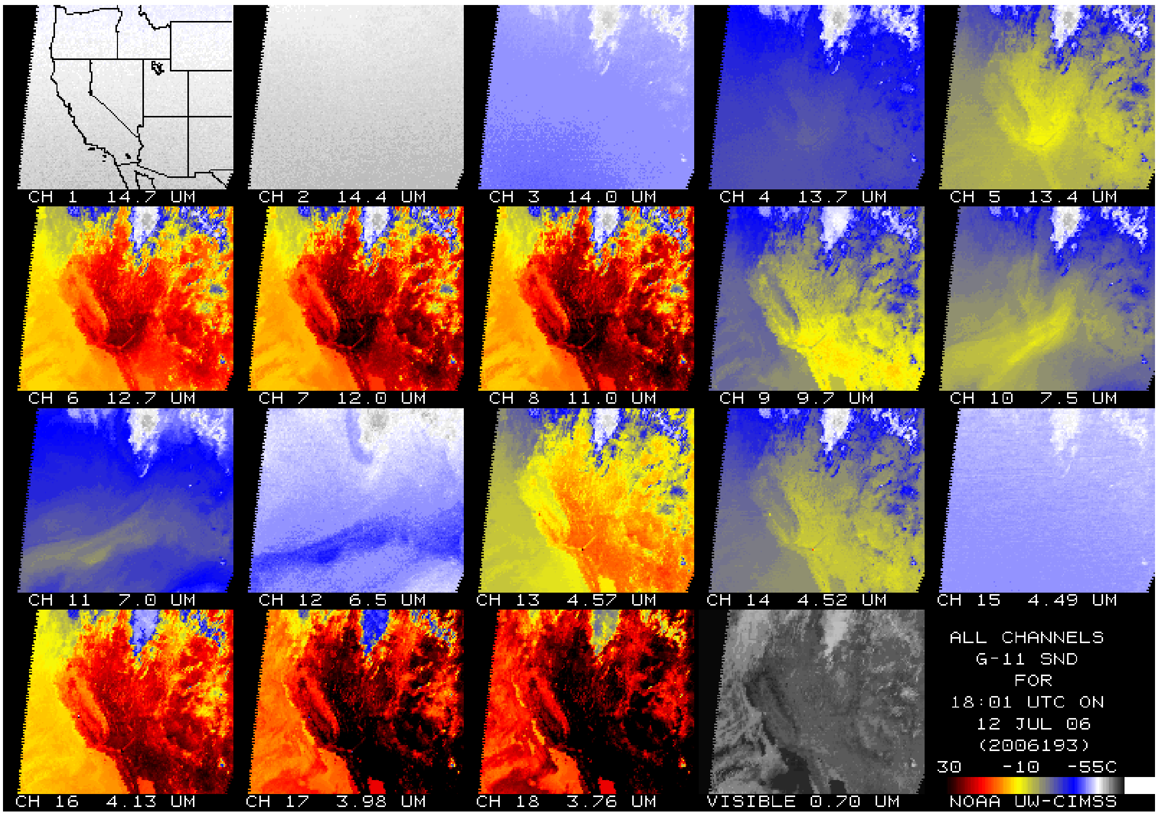

Figure 5. The 19 bands of the GOES-11 Sounder at 19:01UTC 12 July 2006.

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. 6). As a result, NESDIS/ORA and CIMSS developed software that selects cloud-free fields-of-view (FOVs), averages these data to approximate 50 x 50 km boxes, and stages the information to BUFR-format files. These hourly Clear Sky Brightness Temperature (CSBT) fields for the water vapor spectral band are generated from both GOES-12 and GOES–11 . GOES-12 water vapor data are being used operationally by ECMWF, and GOES-11 data are currently being tested in parallel. NCEP/EMC is studying the GOES-11/12 data. The CSBT product has been produced operationally by NOAA/NESDIS since October 2005.

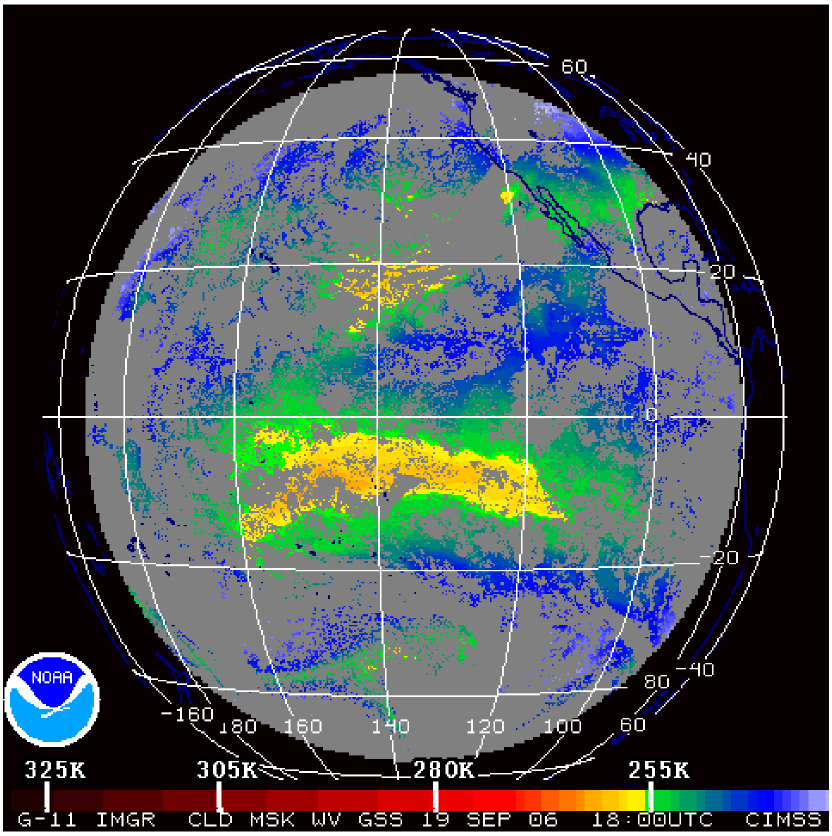

Figure 6: GOES--11 Imager "water vapor" band CSBT image from 18UTC 19 Sept 2006.

6. GOES Imager Cloud-top information

When GOES-12 replaced GOES-8, cloud top products became possible from measurements at 13.3 um and 11 um (Fig. 7). The cloud top pressure product is running in experimental mode each hour at CIMSS. This product was made operational at NOAA/NESDIS on 31 July 2006.

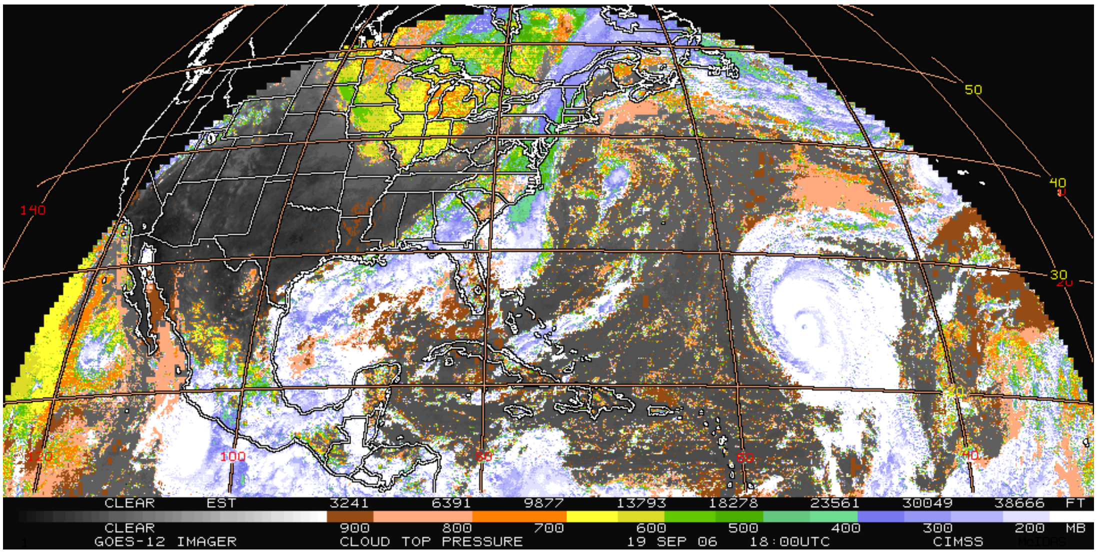

Figure 7: GOES-12 Imager Cloud-top Pressure from approximately 18UTC 19 Sept 2006.

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