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Discussed in WG-2

2000/2001 Report on NOAA/NESDIS GOES Soundings

Summary and Purpose of Document

An overview of the performance of the NOAA/NESDIS operational GOES soundings and ongoing research developments.

Action Requested: None

2000/2001 REPORT ON NOAA/NESDIS GOES SOUNDINGS

W. Paul Menzel [1], Timothy J. Schmit [1], Jaime Daniels [1],
Youri Plokhenko [2], James P. Nelson III [2], and Gail Bayler [2]

[1] - NOAA/NESDIS/ORA
[2] - Cooperative Institute for Meteorological Satellite Studies
Madison, Wisconsin

I. Introduction

The NOAA/NESDIS operational GOES-8/10 soundings continue to be produced every hour at 50 km resolution in clear skies (research retrievals are being run at 30 km resolution). Derived Product Images (DPI) of Total column Precipitable Water vapor (TPW) and atmospheric stability are being used by the National Weather Service forecast offices. GOES definition of three layers of moisture is used operationally by regional forecast; impact of cloud properties at single field of view (FOV) resolution (approximately 10 km) is being investigated. The effects of surface emissivity in profile retrievals from infrared multispectral radiances are being studied. GOES-11 performance has been checked out; GOES-12 check out is proceeding late summer/fall 2001.

II. Performance of Operational GOES Soundings

Operational production of GOES-8/10 soundings continues every hour over North America and the nearby oceans. For the last several years, GOES retrievals at both CIMSS and NESDIS (also designated as OPS) have been produced using a nonlinear physical retrieval algorithm (Ma et al. 1999). This algorithm uses GOES Sounder cloud-free radiances that have been averaged N x N Fields of View (FOV) to adjust first guess vertical profiles of temperature and moisture. At CIMSS, the averaging is done within a 3 X 3 matrix of FOVs, while the NESDIS operational retrievals are produced using a 5 X 5 FOV matrix. Since the nominal horizontal resolution of a GOES Sounder FOV is 10km, the nominal dimensions of the CIMSS and NESDIS retrievals are approximately 30 X 30 and 50 X 50 km, respectively.

Table 1 shows retrieval versus radiosonde statistics for both the CIMSS and OPS retrievals. Each GOES retrieval is collocated within approximately 0.1 degrees latitude/longitude with a radiosonde. The GOES-8 TPW tends to be drier than the collocated RAOB TPW. The standard deviation (SD) is reduced for all retrievals compared to the first guess. The 12Z retrieval SD values tend to be larger than their 00Z counterparts. GOES-10 TPW bias and SD values are reduced compared to GOES-8 data; also average GOES-10 TPW are significantly smaller than for GOES-8. However, the retrieved GOES-10 TPW is closer to the collocated radiosonde TPW than the guess when compared to GOES-8. Finally, the correlation coefficients (CC) are also smaller for GOES-10 than for GOES-8.

Figure 1 shows a time series of GOES-8 00UTC and 12UTC combined TPW retrieval versus radiosonde bias for the CIMSS and OPS retrievals. Note the overwhelming tendency for negative biases, in agreement with Table 1. Also, the biases for both the CIMSS and OPS retrievals are maximized, in terms of largest dry bias versus the radiosondes, during the warmest and most moist summer months, and minimized during the cooler/dryer months. The same warm/moist and cool/dry seasonal tendencies also exist for GOES-10 (not shown). Furthermore, comparing the CIMSS and OPS biases to each other, one can see an interesting shift that occurred about July 2000. Prior to that time, the CIMSS biases tended to be closer to zero than the OPS retrievals, while after that point the OPS retrieval biases were closer to 0.

GOES-11 soundings were established during a checkout period in August 2000. The GOES-11 signal to noise performance of the sounding channels was improved over previous sounders and GOES-11 moisture retrievals improved over those from GOES-8. For 50 radiosonde/retrieval

comparisons, the rms TPW was 5.3 mm for GOES-11, 6.1 mm for GOES-8, and 6.7 mm for the model first guess. See http://cimss.ssec.wisc.edu/goes/g11_report/index.html for more information.

DATASET	PERIOD	BIAS	SD	AVG GUESS / RET TPW	AVG RAOB TPW	CC	N
00Z CIMSS G-8 TPW guess	1/98-6/01	-0.62	3.15	16.25	16.88	0.959	2260
00Z CIMSS G-8 TPW retrieval	1/98-6/01	-0.64	3.04	16.23	16.88	0.961	2260
12Z CIMSS G-8 TPW guess	1/98-6/01	-1.10	3.39	16.51	17.61	0.957	1870
12Z CIMSS G-8 TPW retrieval	1/98-6/01	-0.89	3.22	16.72	17.61	0.961	1870
00Z OPS G-8 TPW guess	1/98-6/01	-0.23	3.33	17.68	17.91	0.956	750
00Z OPS G-8 TPW retrieval	1/98-6/01	-0.62	3.05	17.29	17.91	0.963	750
12Z OPS G-8 TPW guess	1/98-6/01	-0.61	3.38	17.65	18.26	0.963	679
12Z OPS G-8 TPW retrieval	1/98-6/01	-1.11	3.29	17.15	18.26	0.965	679
00Z CIMSS G-10 TPW guess	1/99-6/01	-0.40	2.62	10.00	10.40	0.906	630
00Z CIMSS G-10 TPW retrieval	1/99-6/01	-0.35	2.05	10.05	10.40	0.944	630
12Z CIMSS G-10 TPW guess	1/99-6/01	-0.86	2.73	11.06	11.92	0.925	442
12Z CIMSS G-10 TPW retrieval	1/99-6/01	-0.41	2.56	11.51	11.92	0.936	442
00Z OPS G-10 TPW guess	1/99-6/01	-0.11	2.59	12.17	12.29	0.928	143
00Z OPS G-10 TPW retrieval	1/99-6/01	0.12	2.46	12.41	12.29	0.935	143
12Z OPS G-10 TPW guess	1/99-6/01	-0.76	2.66	10.72	11.48	0.900	170
12Z OPS G-10 TPW retrieval	1/99-6/01	-0.49	2.46	10.99	11.48	0.914	170

Table 1. Retrieval versus radiosonde statistics. Collocation distance is approximately 0.1 degrees latitude/longitude. BIAS, SD and AVG values are in mm.

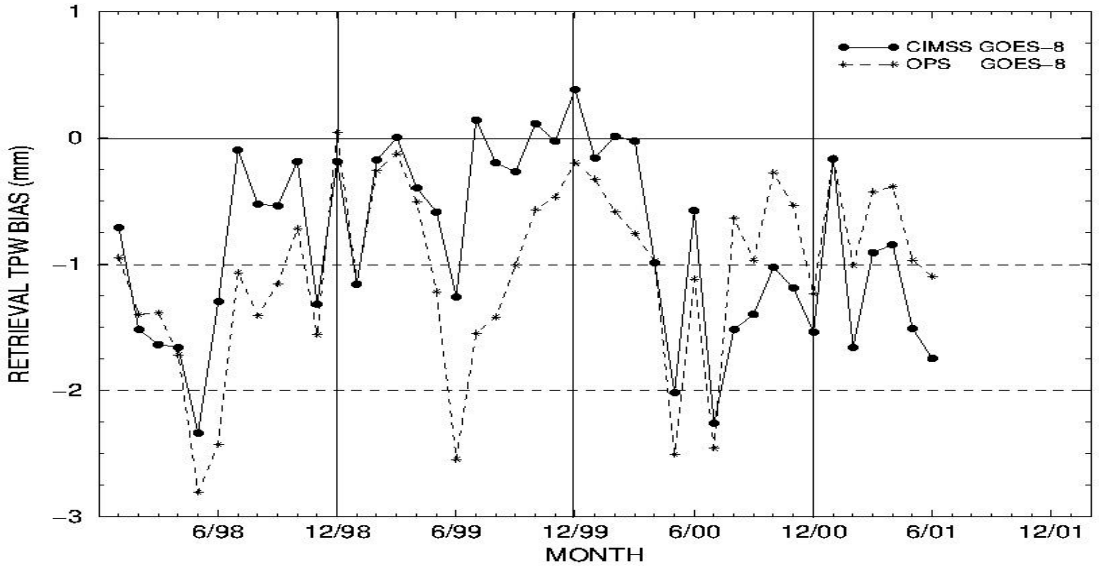

Figure 1. GOES-8 CIMSS and OPS monthly TPW bias for Jan 1998 through Jun 2001.

III. Use of the Soundings at Weather Forecast Offices

Soundings and Derived Product Images (DPI) continue to be used at NWS Forecast Offices in realtime, assisting the forecasters with their short-term forecast responsibilities. New displays have been developed to assist the forecaster in diagnosing atmospheric trends; these include plotting GOES minus first-guess values over the matching DPI (to highlight impact areas), including primary representative parameters and levels with respect to stability (850mb T, Td;

500mb T), and adding three layers of moisture DPI (compared to only total values previously). Figure 2 shows an example from 8 Aug 2000.

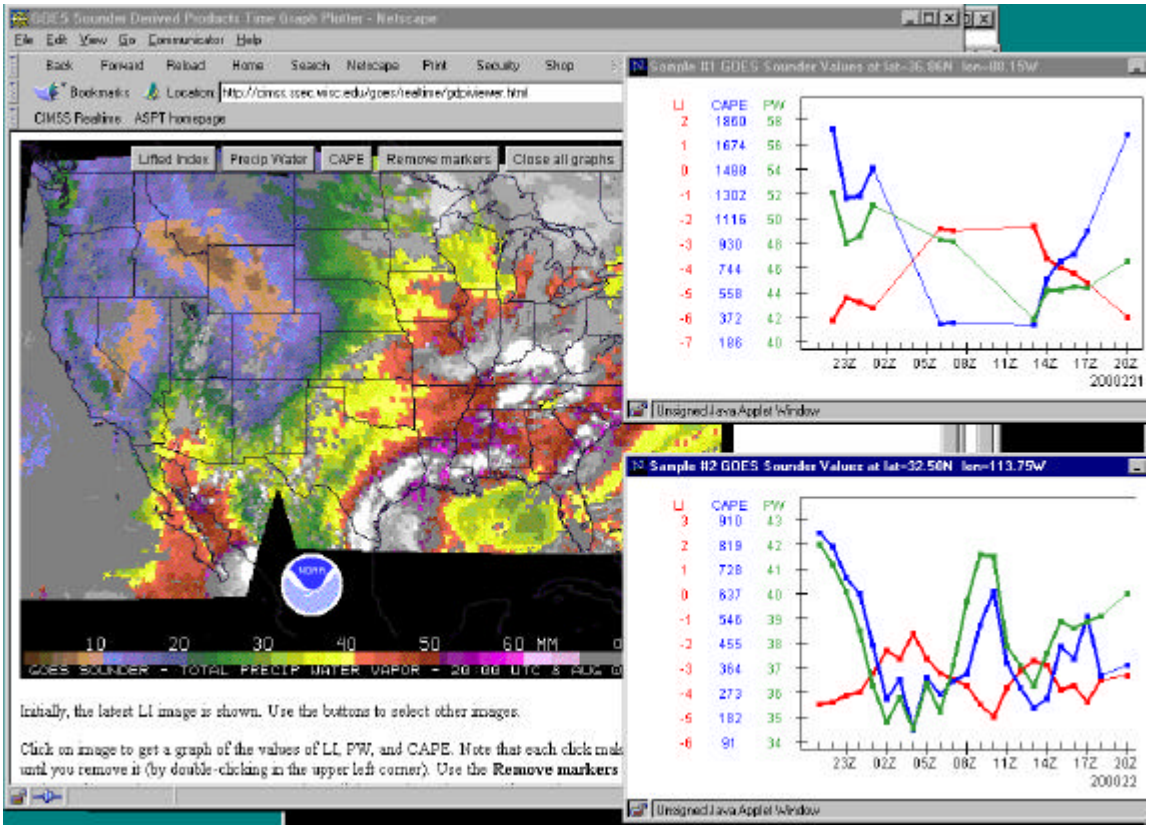

Figure 2. GOES Sounder determinations of atmospheric trends inferred from hourly Convective Available Potential Energy (CAPE), Lifted Index (LI) and Total Precipitable Water Vapor (TPW) on 8 Aug 2000. The top trend shows afternoon destabilization in far western Kentucky and the bottom trend shows monsoon moisture re-surging in southwestern Arizona. The Derived Product Image of TPW is for 2000 UTC.

Real-time examples of both retrieved moisture and stability information as well as cloud top pressures continue to be displayed on the CIMSS web site at http://cimss.ssec.wisc.edu. Another site with real-time GOES sounder products supported by the NOAA/NESDIS Forecast Products Development Team is http://orbit-net.nesdis.noaa.gov/goes/.

III. CART-site Validation of Moisture Soundings

Validation with respect to measurements from the Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site continues. GOES retrievals are compared with Microwave Radiometer (MWR) moisture determinations. Figure 3 shows a one-day comparison of TPW on 6 Aug 2000 from the GOES-11 checkout. While the first guess from time-interpolated Eta forecasts is relatively flat throughout the period, the GOES retrieval algorithm produces nearly the same water vapor tendency patterns as measured by the MWR. GOES follows the water vapor fluctuations between a local maximum at approximately 900 UTC to a local minimum at 1700 UTC; the temporally and spatially coarse radiosonde network does not capture those changes. Overall, GOES demonstrates skill in resolving the mesoscale water vapor fluctuations on this day.

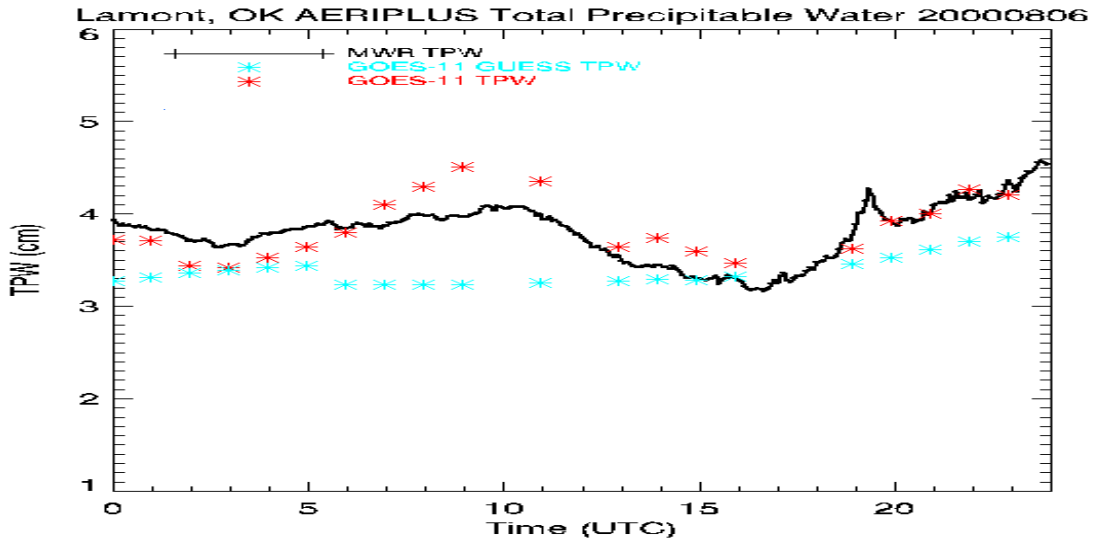

Figure 3. Microwave radiometer (solid line), model first guess (blue stars), and GOES-11 physical retrieval (red stars) TPW comparisons near Lamont, OK on 6 Aug 2000. First-guess trace is flat but GOES-11 retrievals show ability to capture the diurnal trend and range of moisture variation.

IV. Single FOV Soundings

Single FOV (SFOV) retrievals are being investigated as the signal-to-noise ratio of the GOES sounders continues to improve with the May 2000 launch of GOES-11and the July 2001 launch of GOES-12. To minimize striping, spatial averaging (3x3 or 5x5 FOV) was a necessity for GOES-8. Striping is not seen in GOES-11 sounder SFOV total precipitable water retrievals. SFOV retrievals can achieve coverage not possible with coarser resolution retrievals. Additionally, values compare well with higher resolution MODIS (MODerate resolution Imaging Spectro-radiometer) data. Figure 4 presents an example comparison of GOES-11 and MODIS TPW from 24 Jul 2000.

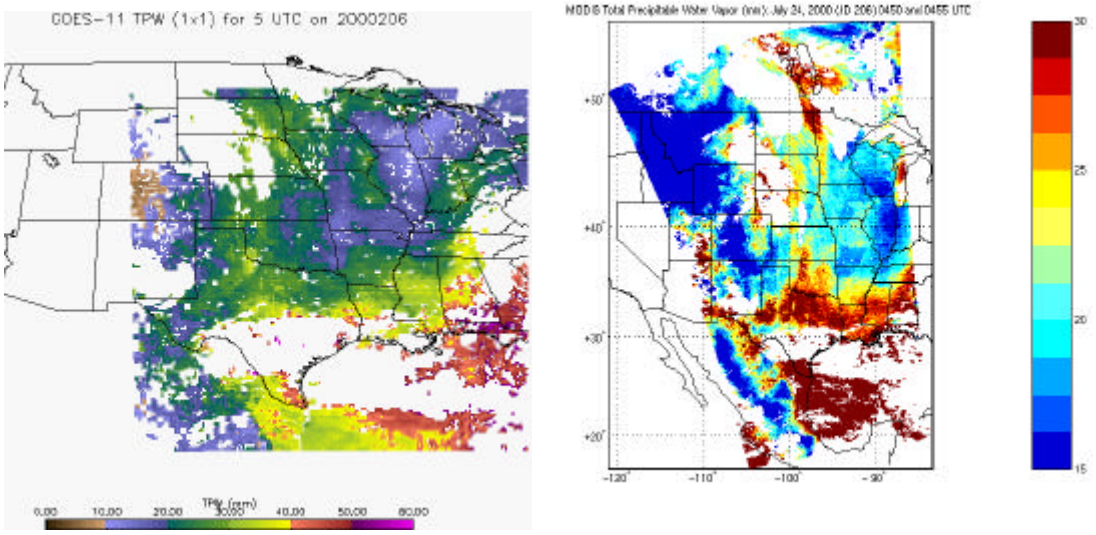

Figure 4. (left) GOES-11 Sounder SFOV 10 km retrievals of TPW (mm) at 0500 UTC on 24 Jul 2000 and (right) MODIS 5 km retrievals of TPW (mm) at 455 UTC on 24 Jul 2000.

V. Model Independent Soundings

In an attempt to reduce the dependence of the GOES soundings on a model first guess, a regression relationship between the Sounder radiances and colocated radiosonde determinations of atmospheric temperature and moisture has been established for use as an alternate first guess. Figure 5 shows a preliminary comparison of GOES-11 retrievals using a model versus regression first guess. Overall agreement is good, but differences (especially in the pan-handle of Texas) are apparent. Work continues in this area.

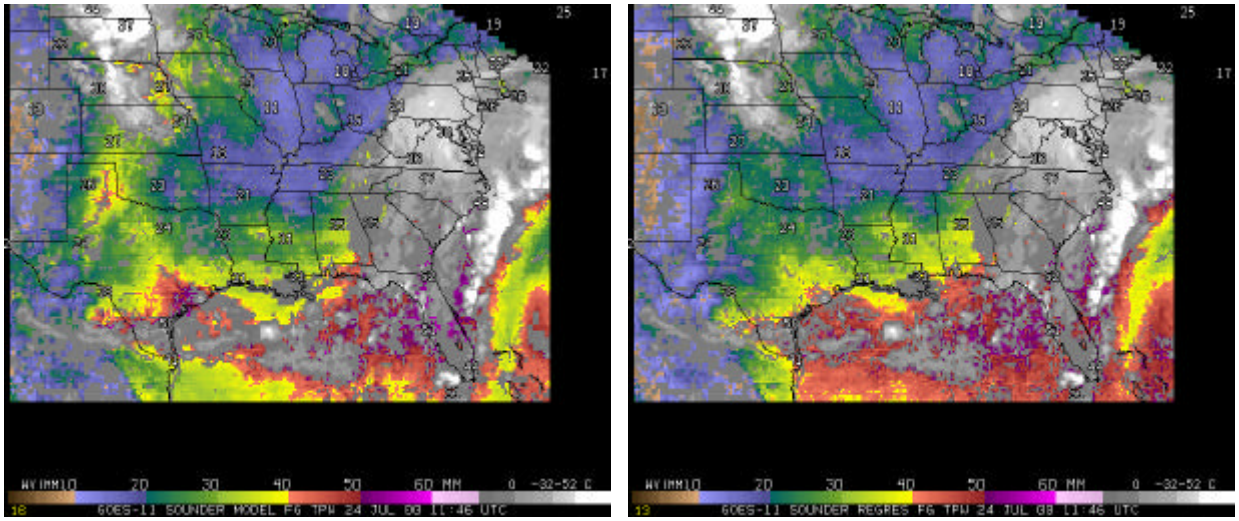

Figure 5. GOES-11 Sounder TPW with model (left) and regression (right) first guess at 1200 UTC on 24 July 2000.

VI. Accounting for Land Emissivity

To improve the accuracy of vertical temperature-moisture profiles retrieved from GOES sounder IR measurements, the surface emissivity (SE) must be accounted for in the solution of the inverse problem. A model accounting for SE and an algorithm of solution have been developed. The solution includes SE, the surface temperature, and the temperature-moisture profile. Results over land have shown that accounting for SE positively effects the solution.

It is found that over land the SW band is noticeably cooler (~2 [K]) than in LW band; over water the reverse is true. On average land SE in the SW are noticeably less than in the LW. Water SE variations within the spectrum are small. SE reduction decreases the contribution of the warm surface into the outgoing radiance and increases the contribution of the cooler atmosphere.

Figure 6 shows the SW SE retrieved from GOES Sounder radiance measurements at 10 UTC for May through June 2000. The SW SE ranges from 0.86 to 0.96 and exhibits strong spatial variability. The associated atmospheric temperature and moisture retrievals (not shown) exhibit more spatial continuity (and hence more thermo-dynamical consistency) than retrievals that do not account for non-blackbody surface emissivity variations.

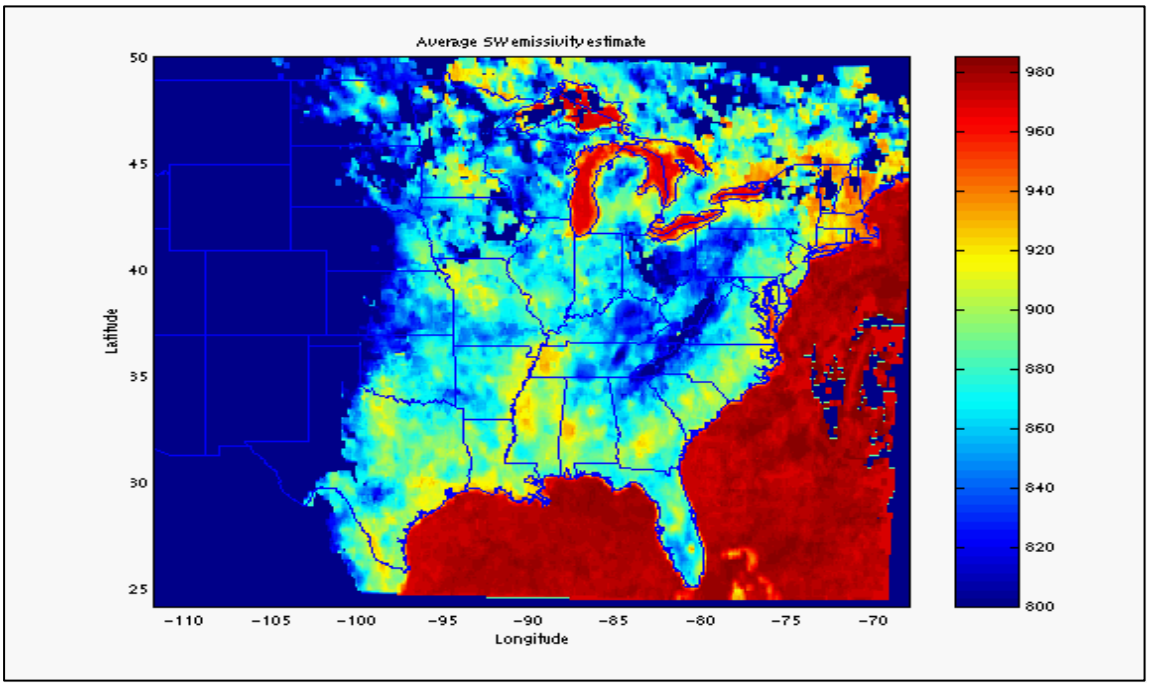

Figure 6: Average of GOES-8 estimates of 3.8-4.2 micron (SW) surface emissivity (SE) for 10 UTC in May through June 2000. Dark blue areas indicate missing estimates due to persistent cloud cover.

Recent References

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