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GOES-11 AND GOES-8 SOUNDERS DURING THE INTERNATIONAL H2O PROJECT (IHOP)-2002 FIELD EXPERIMENT

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1. INTRODUCTION

The International H2O Project (IHOP) was a field experiment conducted over the Southern Great Plains of the United States (US) from 13 May to 25 June 2002. [http://www.atd.ucar.edu/dir_off/projects/2002/IHOP.html] The main purpose of the IHOP was to improve the characterization of the atmospheric water vapor distribution and its application to prediction of convection. The Geostationary Operational Environmental Satellites (GOES), operated by the National Environmental Satellite, Data, and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration (NOAA), provided an essential component of the observation capabilities used for the IHOP. The Imager instrument on GOES provides imagery over the US in five spectral bands (including visible and infrared (IR) window and water vapor channels) at intervals of 15 minutes or less with nominal horizontal resolutions of 1 km (visible) or 4 km (IR).

However, the focus of this paper is to describe the display and use, during IHOP, of data from the Sounder instrument on GOES. The Sounder provides radiance measurements in 19 spectral bands (with temperature and moisture sounding channels) at hourly intervals or better with sub-satellite horizontal resolution of 10 km (Menzel and Purdom, 1994).

GOES-8 (launched in 1994 and stationed over the equator at longitude 75 West) was the primary geostationary satellite available to support IHOP and it provided data throughout the field campaign. In addition, NESDIS took GOES-11 (launched in 2000 and stationed over the equator at longitude 100 West) out of on-orbit storage on 29 May 2002 and returned it to storage mode on 21 June 2002. The advantages of GOES-11 data over that from GOES-8 during IHOP included improved viewing geometry, better signal-to-noise ratio, and higher temporal resolution. During the GOES-11 post-launch test in the summer of 2000, it was shown that the GOES-11 Sounder was superior in terms of radiances observed, compared with those from GOES-8 (less noise and less striping) (Daniels and Schmit, 2001).

2. THE REAL-TIME SUITE DURING IHOP

At the Cooperative Institute for Meteorological Satellite Studies (CIMSS), a number of products were routinely generated and made available every hour during the IHOP period, from both the GOES-8 and (when available) –11 Sounders. The retrieved atmospheric profiles (or "retrievals") from the GOES Sounders were produced with a physical retrieval algorithm that uses the observed radiances as well as an ancillary first-guess field generated from the latest surface observations and a numerical model forecast (Hayden, 1988; Ma et al., 1999). In addition, retrieval information is also presented in an image format, known as Derived Product Images (DPI). These images are made as spatial composites; in clear regions, values of a retrieval parameter (such as total column moisture) are color enhanced, while in cloudy regions, cloud tops are shown in shades of gray, depending upon their window channel brightness temperature (Hayden et al., 1996). (See Fig. 1) Retrieval

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DPI include: total precipitable water (TPW), Lifted Index (LI) stability, Convective Available Potential Energy (CAPE), Convective Inhibition (CIN), and surface skin temperature. Besides products in clear air, cloud top information is also derived from GOES Sounder data (Schreiner et al., 2001). For cloud DPI, the cloudy regions are color enhanced (as for their pressure heights), while the clear regions indicate surface temperatures and are shown in shades of gray, depending upon their window channel brightness temperatures. (See Fig. 2)

2.1 Single Field of View Processing

Traditionally, GOES Sounder retrievals at CIMSS have been generated with a 3x3 field-of-view (FOV) spatial resolution; historically, this was done to take advantage of spatial averaging (to reduce noise) and to process in a timely fashion. However, faster computers, better radiometric signal (with the newer GOES satellites), and a desire to take advantage of the best resolution available (especially for an experiment like IHOP that focuses on mesoscale events) all contributed to achieving implementation, at CIMSS, of GOES Sounder retrieval processing at single FOV (SFOV) resolution before IHOP (Bayler et al., 2001). The much finer resolution realized with GOES SFOV products is approximately 12 km east-west by 15 km north-south within the IHOP domain (southern Kansas, Oklahoma, and the Texas Panhandle).

At SFOV retrieval resolution, the processing of any parameter from the retrieval file into a DPI (for example, 850 hPa dewpoint temperature, first-guess 500 hPa temperature,.

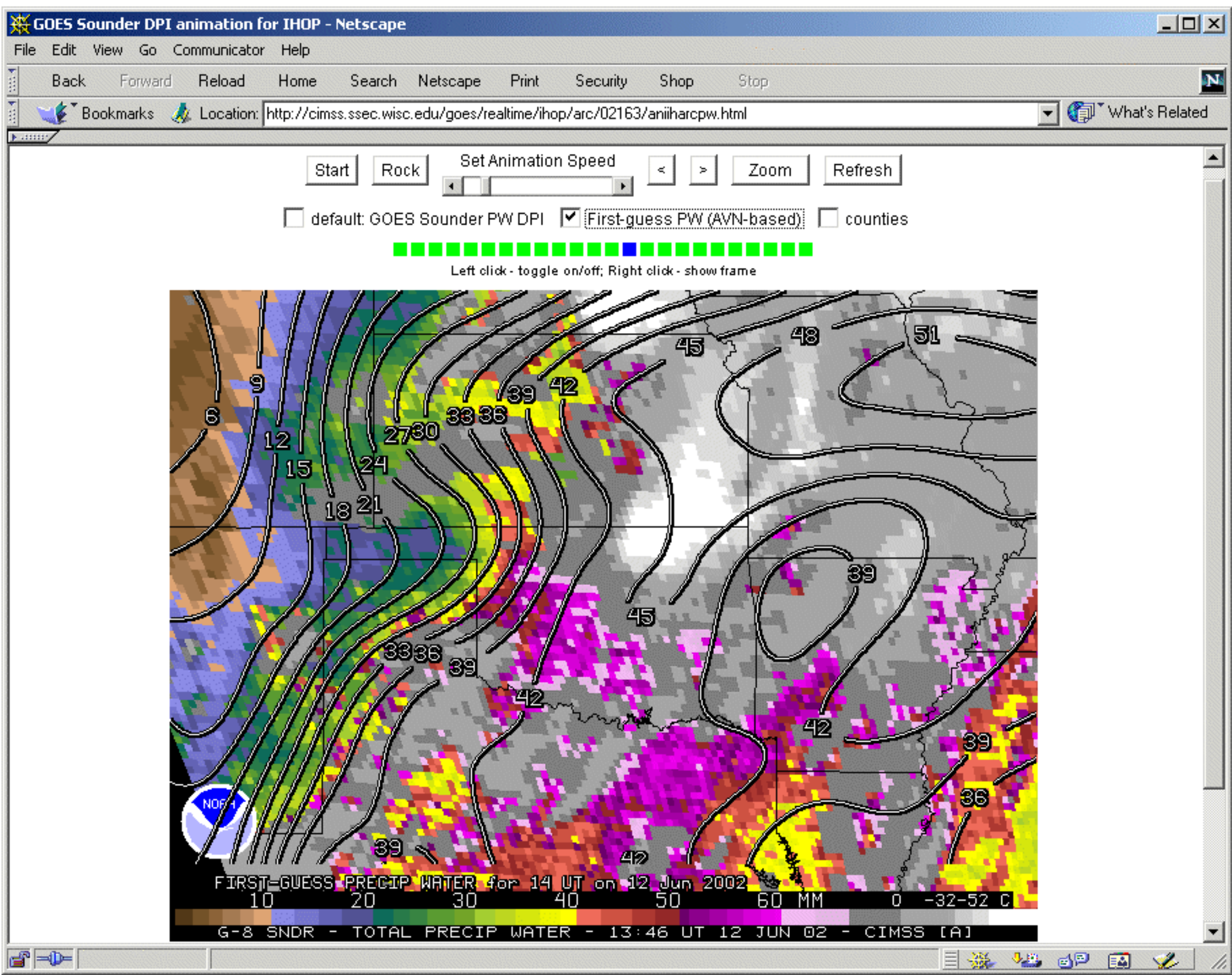

Fig. 1 Web capture of display of total precipitable water vapor (mm) SFOV DPI from GOES-8 Sounder at 1346 UTC on 12 June 2002 with first-guess overlay.

middle layer precipitable water, etc.) is straightforward, given the one-to-one correspondence between a retrieval profile and a FOV. Previously, with the older 3x3 FOV products, only three "true" SFOV DPI were possible with the software, generally being the TPW, LI, and surface skin temperature. As only the final 3x3 FOV (average) retrievals were saved, access to the SFOV information was only available while the program was running, and thus, only the three chosen "true" SFOV DPI were possible. DPI of other parameters were then created only as "pseudo" 3x3 FOV DPI. For IHOP, the SFOV retrieval processing allowed for "true" SFOV DPI of parameters such as CAPE and CIN.

2.2 DPI Display on the Web

GOES retrieval profiles were accessible to IHOP scientists and forecasters as text files (ascii) from the web. However, in real-time, the emphasis was to showcase the SFOV DPI over the IHOP domain. Various image displays, animations, and overlays were provided on the CIMSS GOES IHOP web page. The Java "AnimationS" applets, developed by T. M. Whittaker (http://www.ssec.wisc.edu/visit/AniS/), were utilized to provide an easy means to observe temporal trends as well as to allow interactive comparisons of the GOES DPI in a variety of ways. These included toggling on/off first-guess fields, radiosonde values, visible imagery, and different satellites (GOES-11 versus GOES-8) (Fig. 1). County map overlays were added, as this relatively high resolution display of the GOES DPI made such maps

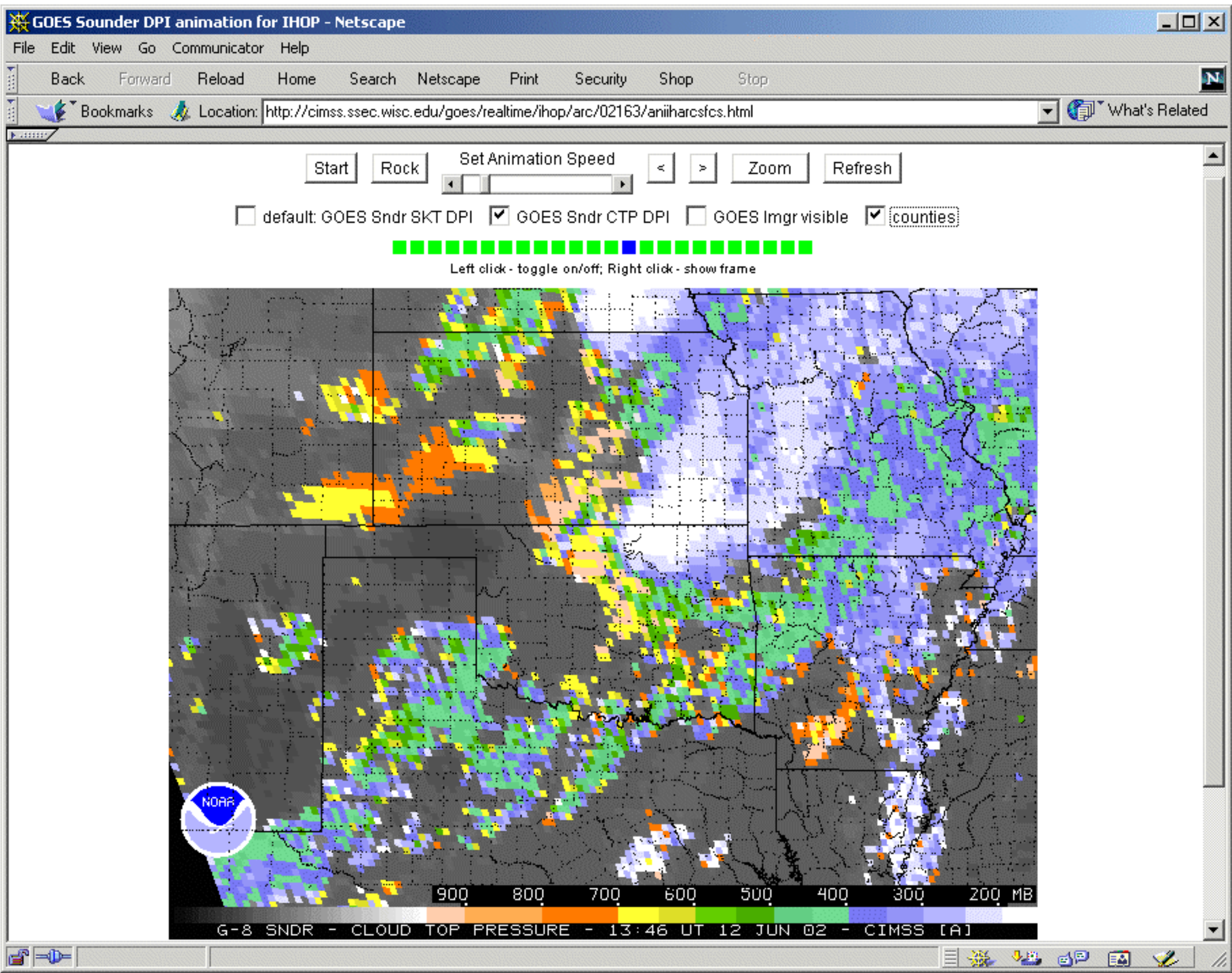

Fig. 2 Web capture of display of cloud top pressure (hPa) from GOES-8 Sounder at 1346 UTC on 12 June 2002 with county overlay.

legitimate. (Fig 2)

3. THE CASE OF 12 JUNE 2002

3.1 Meteorological Background

On 12 June 2002, the IHOP operations plan was set for a “Convective Initiation” mission (study) in the eastern Oklahoma Panhandle. [http://www.joss.ucar.edu/cgi-bin/catalog/ihop/htmlwrap?/ihop/catalog/report/ops/20020612/report.ops.200206122004.plan_of_the_day.html] The focus was on the evolution of a surface “triple point” at the extreme northeastern edge of the Oklahoma Panhandle. The point of interest was at the intersection of a larger scale outflow boundary (that resulted from a mesoscale convective system (MCS) that had moved across Kansas overnight), oriented east-west across northwest Oklahoma, and a cold front/surface trough, oriented southwest-northeast, from the central Texas Panhandle into the northeast corner of the Texas Panhandle. Southerly winds ahead of the cold front brought very warm, very moist (dewpoints of 70+ F) air into the southeastern Texas Panhandle and into central and western Oklahoma (Fig. 3). GOES-11 Imager data (1 km visible) were extremely useful to forecasters in identifying and following the boundaries by being able to observe their small scale cloud signatures. [http://www.joss.ucar.edu/cgi-bin/catalog/ihop/htmlwrap?/ihop/catalog/report/weather/20020612/report.weather.200206122035.NOWCAST.html] By 2100 UTC, strong convection had started in far northern northwest Oklahoma; the storms continued to develop

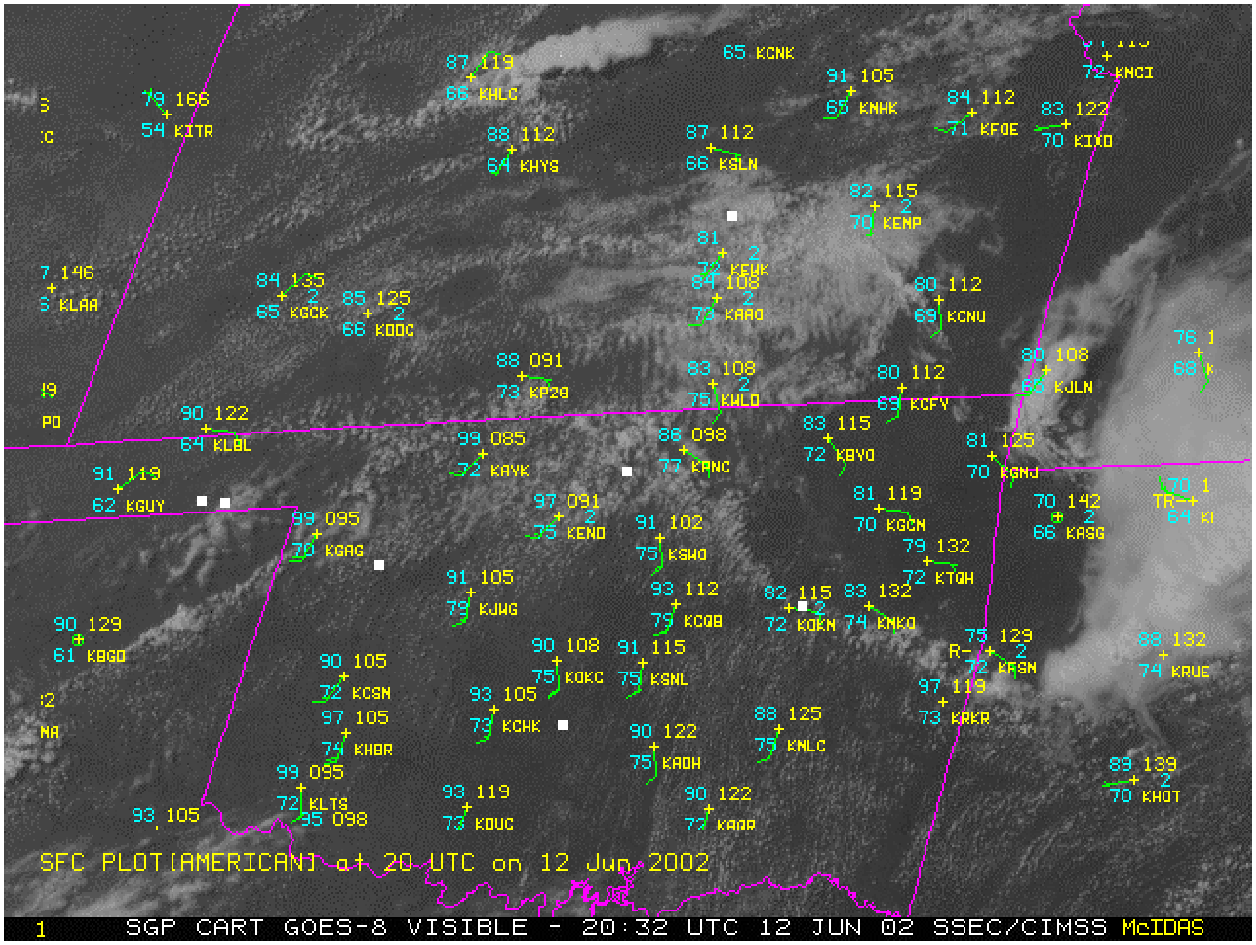

Fig. 3 Web capture of display of visible image from GOES-8 Imager at 2032 UTC on 12 June 2002 with traditional plot of surface reports at 2000 UTC (temperature (F), dewpoint (F), pressure ([10] hPa*10), and wind (flag)).

across the area just south of the central Oklahoma/Kansas border and later became severe (with numerous hail and wind reports into the evening). Some convection did also develop in the Texas Panhandle but the Oklahoma activity was stronger and longer lived.

3.2 Atmospheric Moisture (GOES Sounder)

GOES Sounder moisture and stability DPI showed similarly very favorable patterns for strong convection across the IHOP domain on 12 June 2002. GOES TPW values over southern Oklahoma and eastern Texas already were in the 40-50+ mm range overnight, with values to 60 mm across much of southern Oklahoma and north central Texas by mid-morning (Fig. 1). Figure 4 shows the SFOV TPW DPI from both GOES-8 and –11 at nominally 0600, 1400, and 0000 UTC, with both sequences showing generally similar patterns. However, striping, evident in the GOES-8 data, particularly overnight, is not present with GOES-11. Some calibration difficulties extant for GOES-8, from extraneous intrusion of sunlight from near the earth's limb around local midnight, were mitigated substantially for later GOES spacecraft (including GOES–11) by mechanical instrument modifications before launch.

3.3 Atmospheric Stability (GOES Sounder)

GOES LI DPI showed an instability pattern by mid-morning that also focused attention towards the "warm sector" delineated by the Texas Panhandle cold front and the old outflow boundary across northern Oklahoma (Fig 5). Comparison of the GOES LI image, with the National Centers for Environmental

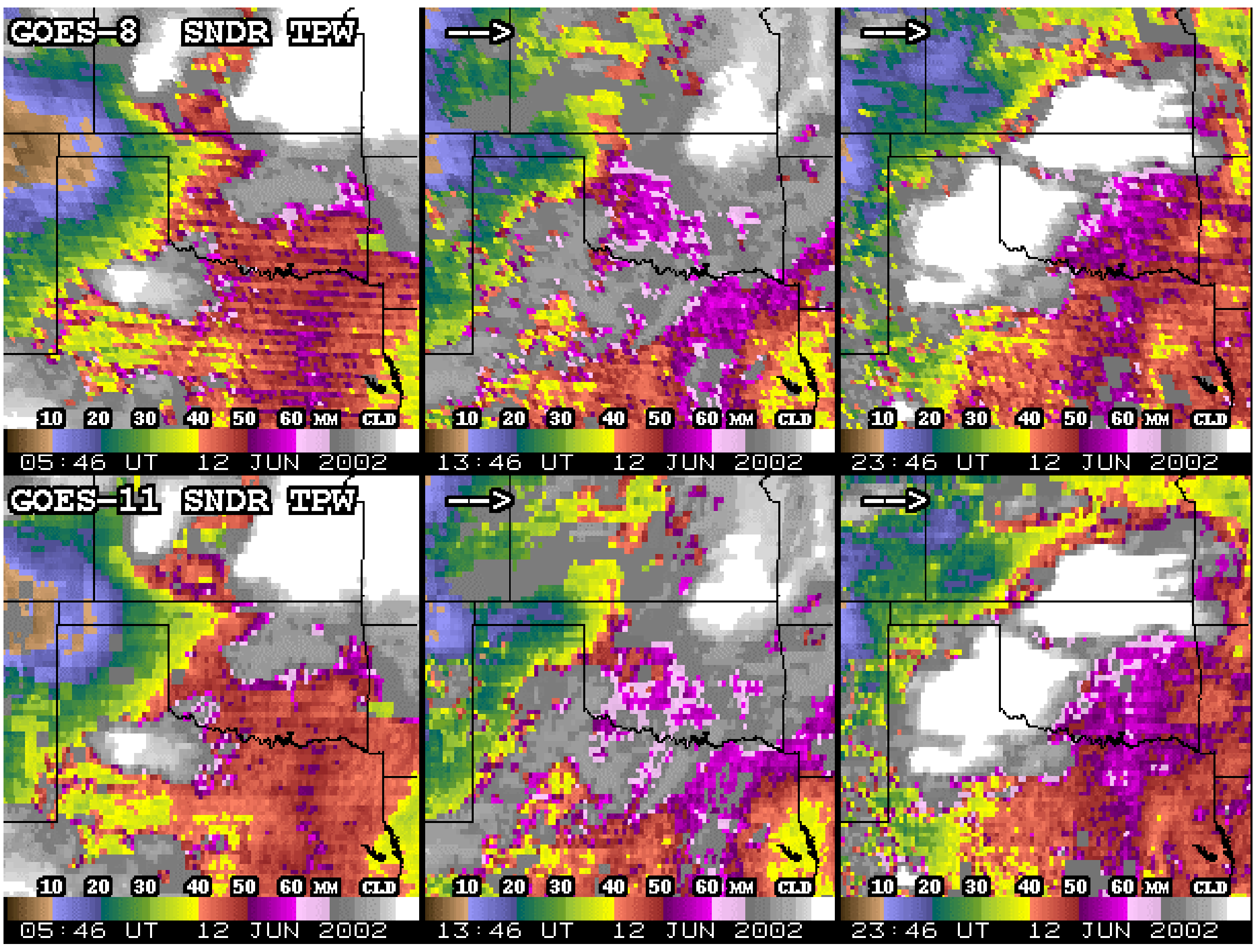

Fig. 4 Time sequence of total precipitable water SFOV DPI at 0546 (left), 1346 (center) and 2346 (right) UTC on 12 June 2002 for GOES-8 (top) and GOES-11 (bottom).

Prediction (NCEP) Eta numerical weather prediction model forecast valid at the same time, showed very unstable conditions for both data sources (Eta to –8; GOES to –12 (deg-C)). The strength of the GOES data lies not in its absolute magnitude, but rather in its spatial patterns and temporal trends (Menzel et al., 1998; Dostalek and Schmit, 2001; Schrab, 2001; Schmit et al., 2002; Weaver et al., 2002). In this case, GOES emphasized the northwest Oklahoma region, while the Eta maximum was more oriented back across the eastern Texas Panhandle. Note that the GOES first-guess for SFOV processing was made from the NCEP AVN model; regardless, the Eta forecasts are quite familiar to and commonly used by forecasters, and thus, that comparison was considered.

In real-time during IHOP, the GOES SFOV retrieval processing was not optimal, specifically with respect to cloud determination during mid-day. [Surprisingly, GOES Sounder retrieval and cloud DPI are not generated simultaneously, but rather in separate programs. Ideally, one cloud "mask" would be beneficial, but issues remain, especially for treating very low clouds for both retrievals and cloud products.] Thus, unfortunately, some clear areas in the retrieval DPI (including high interest portions over IHOP) were often incorrectly set to being cloudy during the field experiment. This deficiency is being investigated (assumed primarily to be with updating of needed empirical surface modeling coefficients) and re-processing has begun. Nonetheless, some currently available DPI examples suffer substantially from this problem.

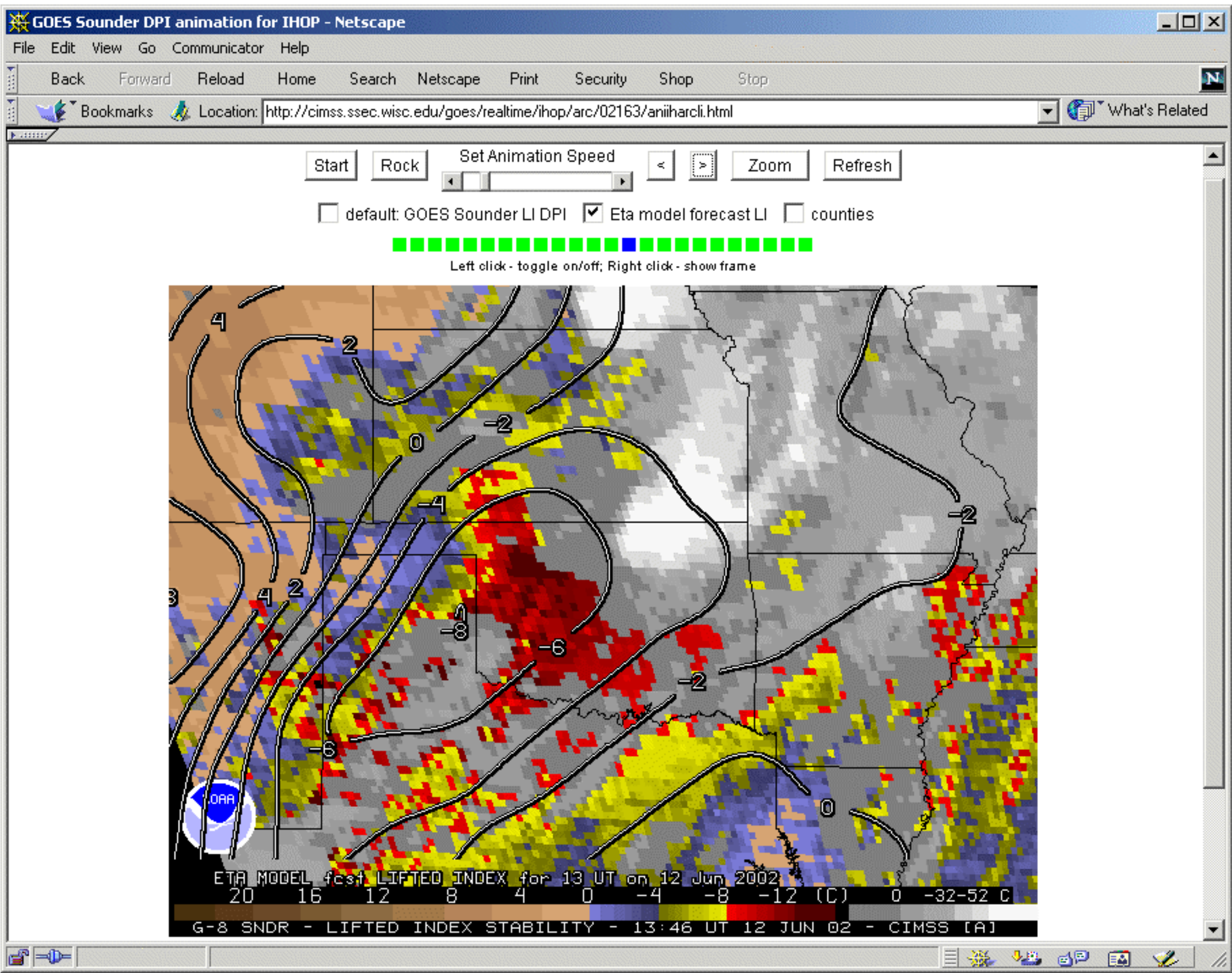

Fig. 5 Web capture of display of lifted index stability (deg-C) SFOV DPI from GOES-8 Sounder at 1346 UTC on 12 June 2002 with overlay of Eta model forecast.

At mid-day, despite being "too cloudy" Fig. 6), the GOES derived CAPE values also showed a favorable air mass over the middle portions of the IHOP domain, with very unstable values (isolated values to 3000+ J/kg surrounded by 2000+ J/kg data). In conjunction with the available potential for convection (as shown by CAPE – the "positive area" on a thermodynamic diagram), the convective inhibition (CIN – the "negative area") is considered to help indicate when that potential could be realized (as the thermodynamic impediment to convection decreases). Traditionally in severe weather forecasting, radiosonde profiles, with relatively high vertical resolution, would be assessed for the presence of convection-prohibiting "caps" (or temperature inversions aloft). Such detailed features are difficult to observe with the GOES Sounder, especially if the caps are weaker. Nonetheless, CIN values can be computed from the GOES retrieval profiles and be displayed as DPI, yielding reasonable outputs (Weaver et al., 2001). The CIN DPI on 12 June 2002 (although also plagued with excess cloud) did show decreases from inhibiting values earlier in the morning over the Oklahoma Panhandle and far northwest corner of Oklahoma (more than (-) 300-400 J/kg) to minimal levels (much less than (-) 50 J/kg) by mid-afternoon.

5. CONCLUSION AND FUTURE WORK

In summary, atmospheric parameters, in image format, derived from both the GOES-8 and GOES-11 Sounders, were provided in real-time and posted to the web for use during the IHOP 2002 field campaign. A sample snapshot at experiment's end as well as an archive of all

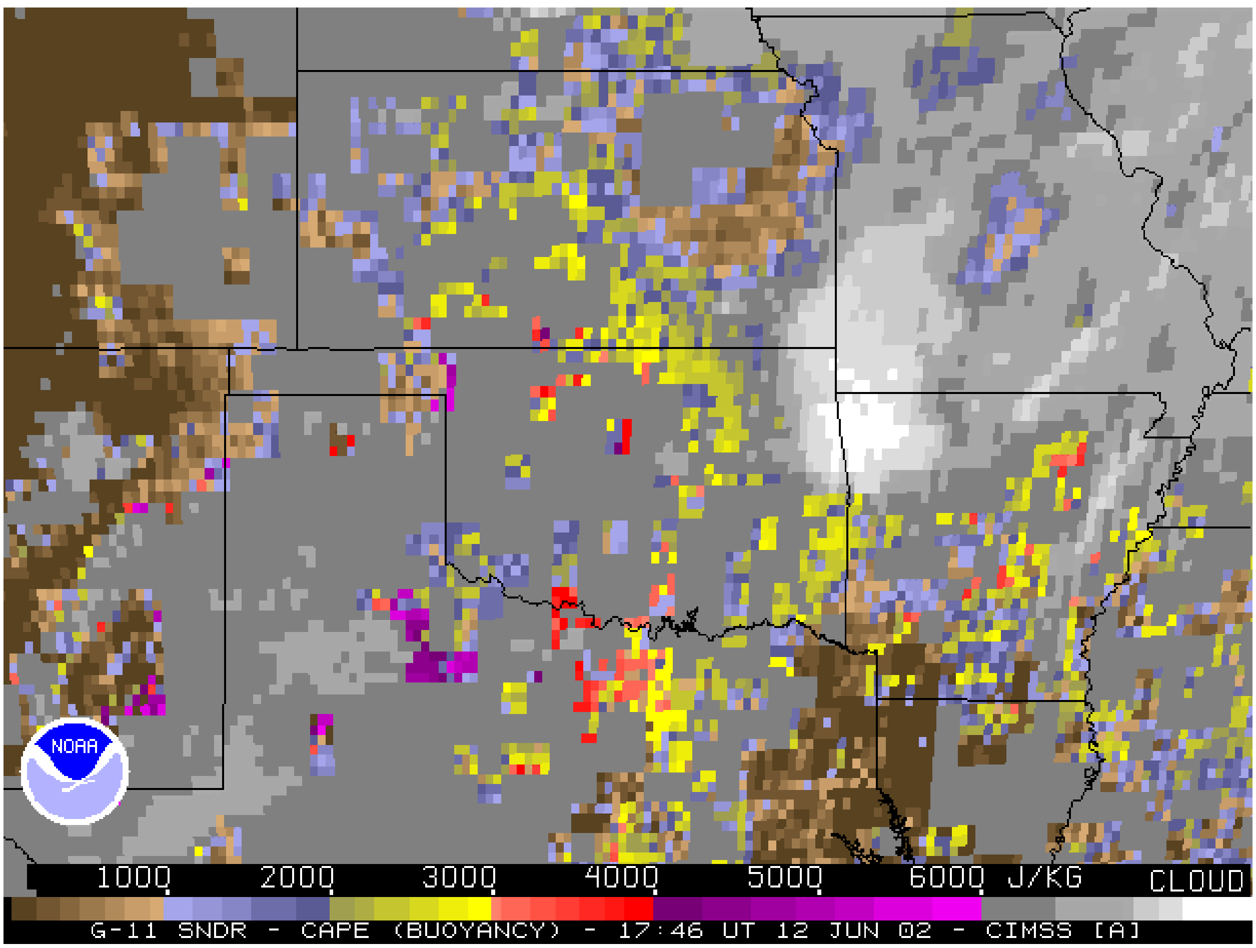

Fig. 6 Display of convective available potential energy (CAPE) (J/kg) SFOV DPI from GOES-11 Sounder at 1746 UTC on 12 June 2002.

animations and displays from each day of the experiment remain accessible on the web at - http://cimss.ssec.wisc.edu/goes/realtime/ihop/. Moisture and stability patterns appeared reasonable, but further comparison with the re-processed DPI is needed to show significant impact or improvement to first-guess fields. [Results of such work will be added for the poster at the conference.] GOES- 11 data did appear cleaner, and less striped, than that from GOES-8, but any numerical advantage for retrieval parameters was not readily evident by significant, applicable differences in the DPI patterns between the satellites. Other more detailed comparisons of GOES Sounder data with the wide variety of special and unique co-located measurements (remote and in-situ) during IHOP will also continue (Feltz et al., 2003).

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