10.7 Operational Polar Satellite Validation and Evaluation Systems

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1. INTRODUCTION

During the past 25 years of NOAA operational polar satellites, the problem of providing reliable and timely monitoring and scientific validation of operational measurements and derived meteorological products has been an ongoing issue. The systems to provide this function have significantly evolved from hardcopy printouts of software system diagnostics and statistical summaries to elaborate in-house and web based protocols allowing NESDIS scientists and national and international users alike to analyze operational data using enhanced graphical illustrations of real-time data using a variety of geographical orientations and display options.

The following report provides a system summary of the current Environmental Data Graphics and Evaluation (EDGE) (Brown *et al*., 1992) system which provides the bulk of operational monitoring at NESDIS for polar orbiting satellites. The EDGE system is comprised of three basic functions:

1) EDGEIS, the horizontal field display system,
2) PDISP, the vertical profile display system, and
3) VSTATS, the vertical statistics compilation and display system.

Another important component of the NESDIS operational monitoring protocol is the Polar Orbiting Satellite Sounding Evaluation (POSSE) system, which is web based and available to national and international users for real-time evaluation of NESDIS data and products. POSSE allows remote users to access and analyze operational sounder data and associated products in a horizontal graphical display scenario similar to EDGE. NESDIS also provides a more basic validation function through its official web site "poes.nesdis.noaa.gov" but without the numerous options provided by POSSE. However, the "poes" site does include current and past statistical analysis (similar to VSTAT) capability and up to date system and scientific documentation concerning operational products and plans.

The EDGE system was recently delivered to EUMETSAT to assist that agency in the development and deployment of METOP scheduled in 2006, and will provide the benchmark capability for in support of next generation NPP and NPOES systems planned by NOAA (Aumann *et al*., 2003).

2. SYSTEM ARCHITECTURE

The data used by the EDGE graphical programs are generated on the same computer that the NOAA operational ATOVS sounding processing system (Reale *et al*., 2002) resides on, currently and IBM SP. Selected data are extracted and sent to either a file server or a local computer. That data is then read by one of the graphical programs. All graphical programs are written in platform-independent Java, making them available on most major operating systems.

As mentioned, the three main system components of EDGE are:
EDGEIS, providing horizontal field, vertical cross-section and limited vertical profile analysis,
PDISP, providing detailed vertical display of collocated satellite, radiosonde and nwp profiles, and
VSTATS, providing vertical statistics of collocated satellite and radiosonde observations and archive.

The primary function of EDGEIS is to provide a user interface for horizontal field analysis of satellite measurements and products and comparable data platforms, for example, NOAA operational numerical weather prediction (NWP) (Kalnay *et al*. 1990). The layout of the programs and most program functions

were designed using these horizontal images as the starting point for providing a variety of user functions to manage and manipulate the extensive volumes of data available in a given session. EDGEIS also provides several additional meteorological analytical tools such as

- vertical cross-sections of the atmosphere,
- individual vertical profiling
- the scanning of the complete observational data files
- differencing of selected images and/or data parameters on selected files
- blinking function that highlight data within a specified range of values, and
- image manipulation functions to display multiple images at a time .

The EDGEIS vertical cross section function allows meteorological analysis through active features such as weather fronts. These cross-sections can cut though the atmosphere between any two points on the Earth. When this is done, the vertical cross-sections will show all available profile data (i.e., satellite, NWP, etc).

EDGEIS provides the ability to display any parameter stored on an operational data file, including the vertical profiling of sounding and available ancillary profile data, for example, first guess and NWP profiles.

The Profile Display (PDISP) system allows for the display of individual profiles of collocated satellite and other conventional observations most notably the radiosondes and NWP data These collocations are accessed from datasets that are routinely compiled during the processing of operational satellite sounding products (Tilley *et.al*. 2000). Plotted data include annotation on the radiosonde and satellite observation times, location, distance and geographic location.

PDISP has many individual functions which allow user to specify the satellite and collocation data sets to be plotted, the plot type (i.e. skew-T, log-linear, etc),.view the global distribution of collocation available, and sub-sample the collocations to plot, for example, based on location, time-window, radiosonde type, radiosonde site, satellite, sounding type.

Similar to EDGEIS, users can interrogate the complete data record associated with the collocation(s) being viewed. An important feature of PDISP is the concept of creating internal file structures capable of storing the multiple collocations of satellite (and NWP) observations typically available for a given radiosonde observation, and the available options to view any combination of the multiple profiles typically available for each collocation.

The Vertical Statistics (VSTAT) system accesses input files that are similar to PDISP, and provides a thorough capability to view pre-computed sets of ensemble statistics comparing collocated radiosonde and satellite derived products data. An important feature of the VSTAT system is that it allows users to compare statistics from multiple satellite product systems, including statistics generated from a common data base of radiosondes. The statistics computed are the mean, standard deviation and root-mean square of the satellite minus radiosonde differences for temperature and water vapor mixing ratio, with user options to also view layer mean temperature and geopotential height differences.

The VSTATS system provides multiple options of viewing statistics for selected satellite systems, geographic regions, and satellite sounding types, and time periods. Selected statistics for a year or more are stored on a weekly basis and are available for viewing by users.

The Polar Orbiting Satellite Sounding Evaluator is basically a web-based version of EDGEIS. It was originally designed to allow users outside of NOAA/NESDIS to access most of the data that is available in EDGEIS. However, recent security issues have mitigated this capability restricting in to more of an in house capability for NOAA/NESDIS scientists to access the latest ATOVS orbital data in real-time.

3. SCIENTIFIC ANALYSIS

The use of EDGE graphical capabilities to routinely monitor and evaluate the NESDIS operational sounding products is pivotal for maintaining and improving scientific product integrity. Examples of using each of the EDGE subsystems in this respect are illustrated in Figures 1 through 4.

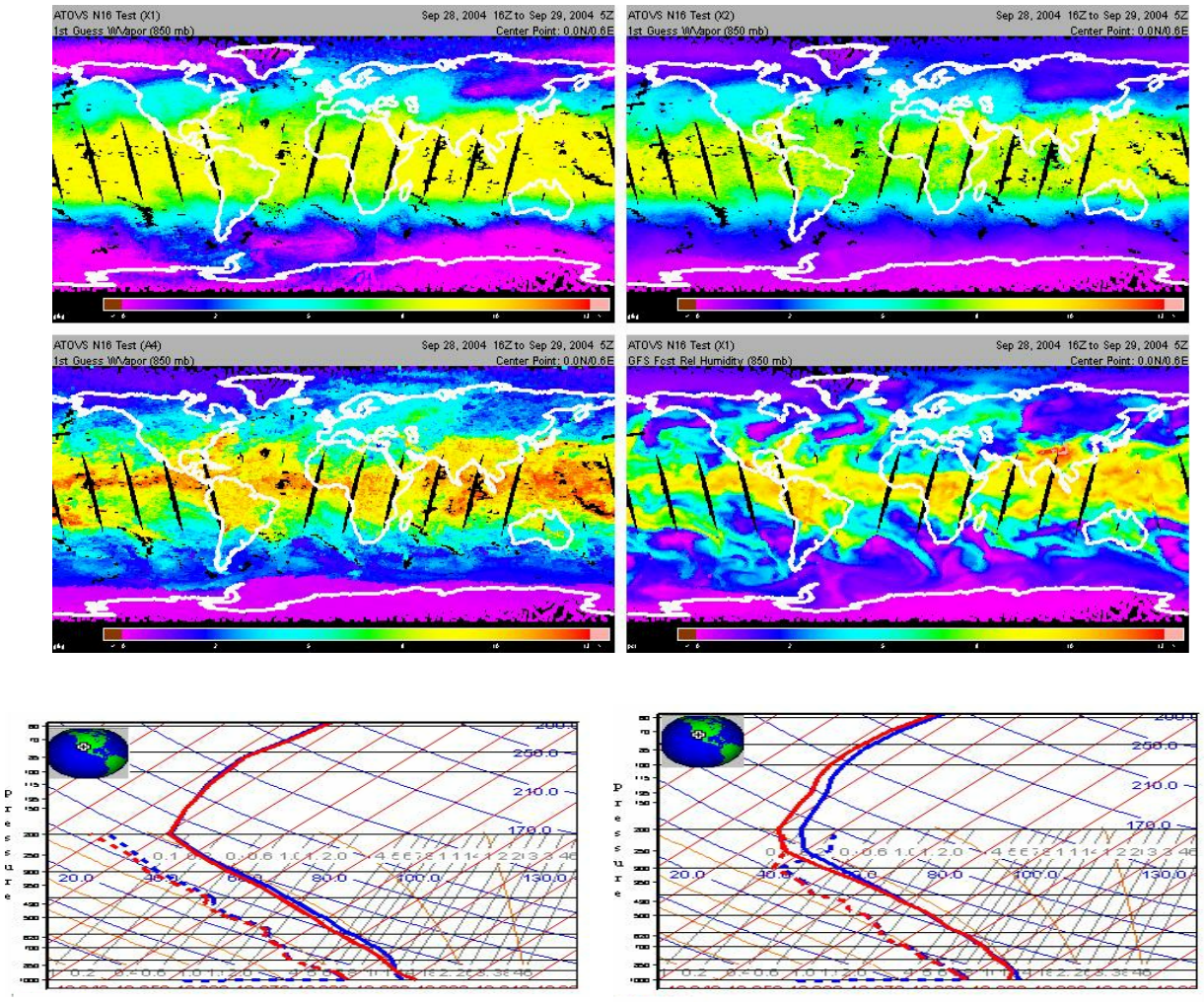

Figure 1: Examples of EDGEIS capability illustrating horizontal fields of 850mb water vapor mixing ration from individual satellite test processing systems (upper two panels), current operation (lower left panel) and NWP (lower right panel, and corresponding vertical profiles of temperature and moisture over the southwest US coast from the lower left and upper right fields.

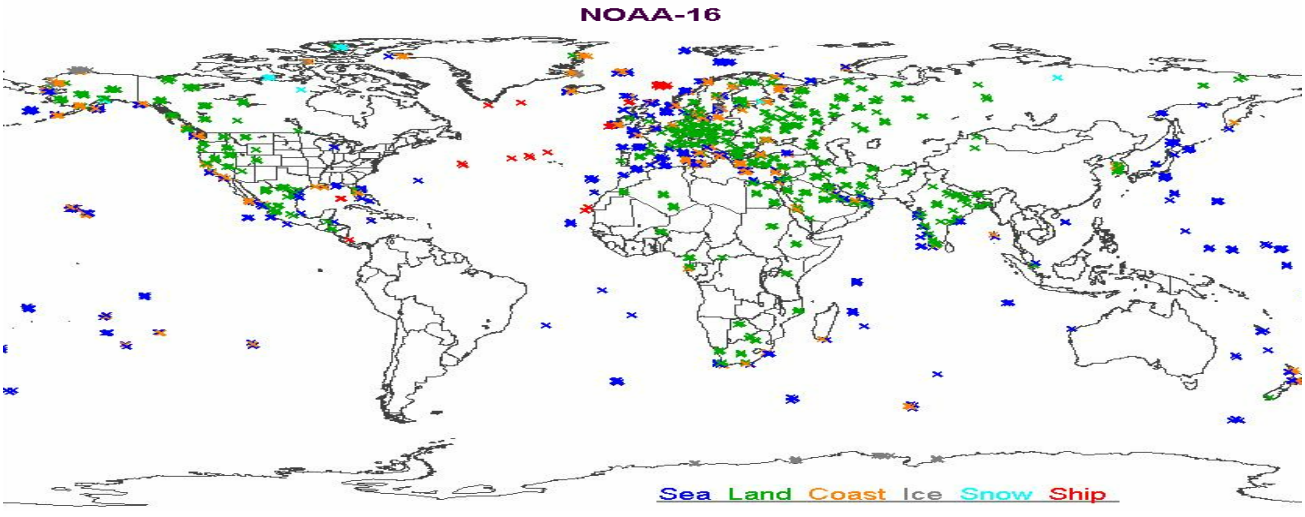

Figure 2: Example of global distribution of collocated radiosonde and satellite observations from PDISP

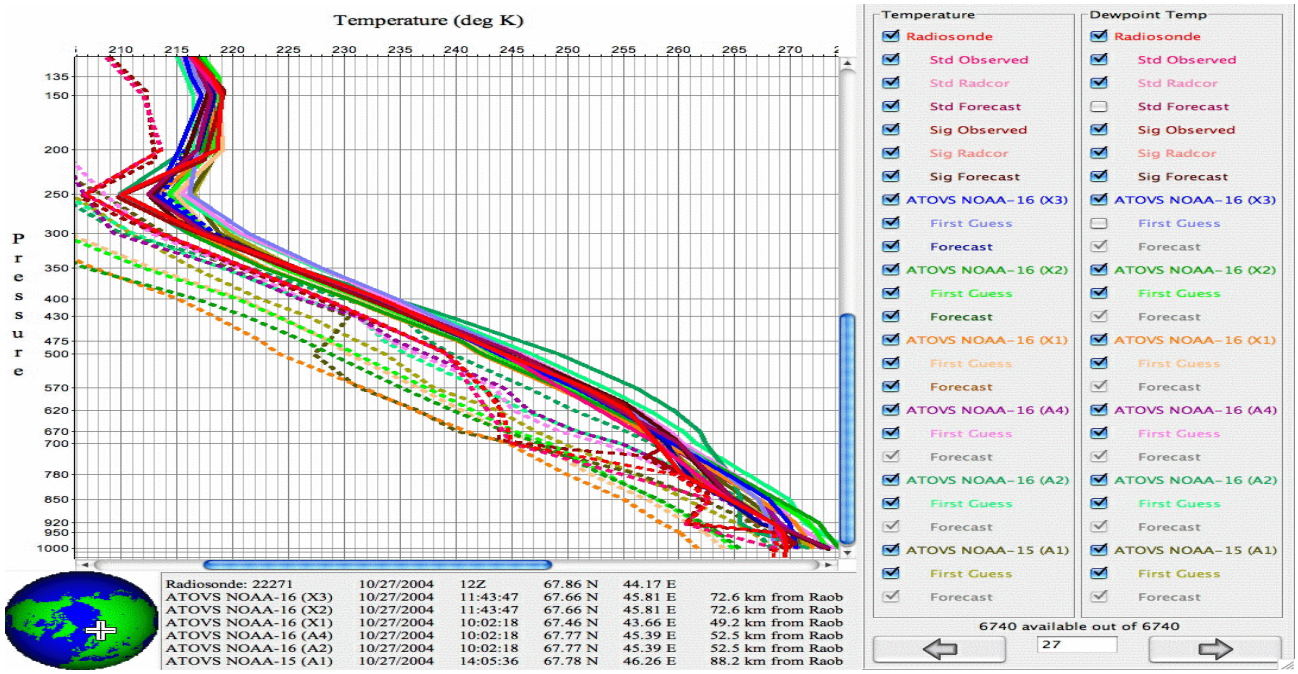

Figure 3: Examples of vertical temperature (solid) and moisture (dashed) profiles available from a single collocation of satellite and radiosonde observations available using PDISP.

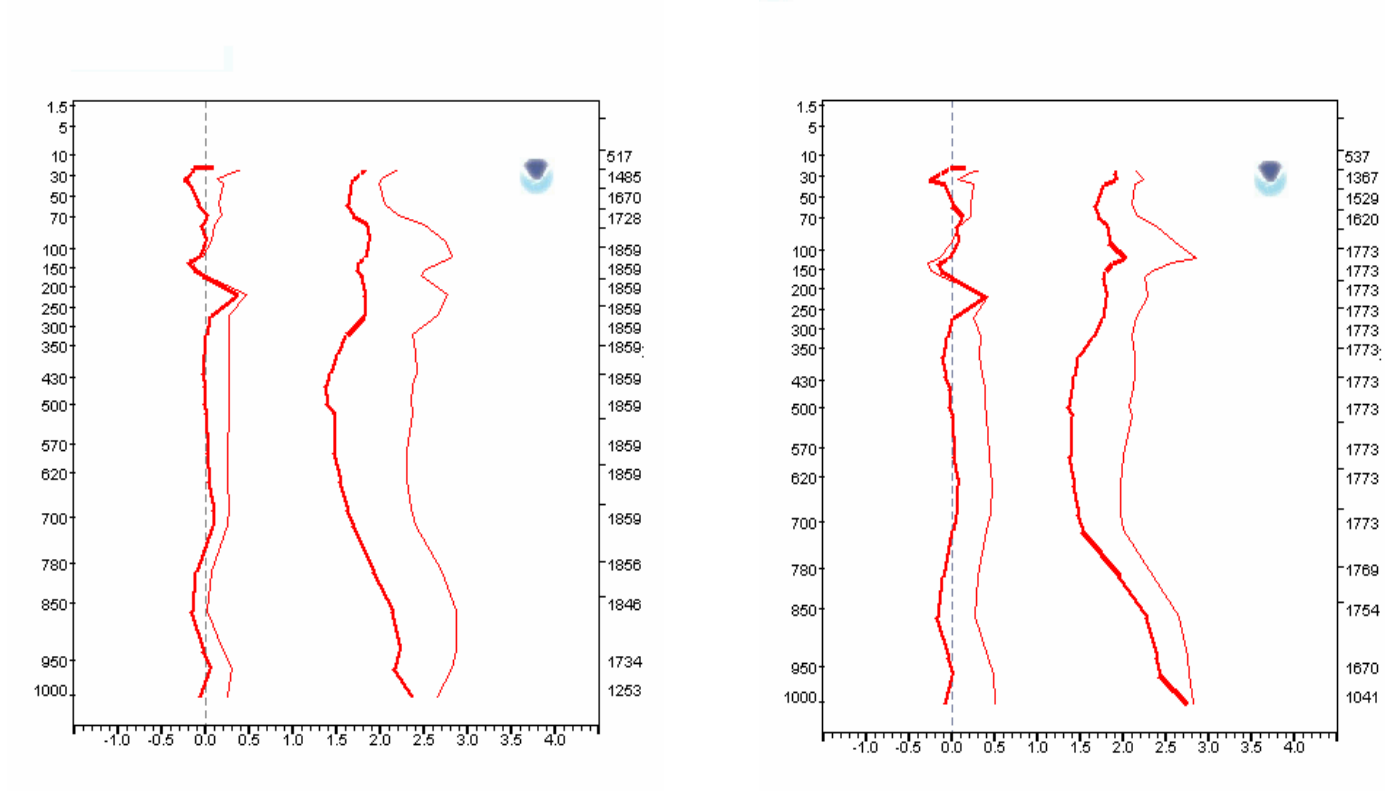

Figure 4: Examples of vertical statistics of radiosonde minus satellite temperature differences for NOAA-16 Clear (left) and Cloudy (right) derived soundings from the 60N to 60S global region; the dark curves are for the final soundings and the lighter curves for the first guess profiles.

The six panels of Figure 1 illustrate graphical capabilities from EDGEIS. The top four panels show global fields of water vapor mixing ratio at 850mb. The two upper panels are for two different parallel processing systems being used to test a new retrieval approach, the lower left panel the current operational approach with all three showing first guess values. The lower right panel is the concurrent NWP analysis for 850mb moisture. A quick glance identifies differences and possible deficiencies in the performance of the two test systems. The bottom two panels illustrate vertical profiles of temperature and moisture at the same location from the operational (left) and one of the test systems (right), respectively, with the blue curves indicating the first guess profiles and the red curves the final sounding. As can be seen, the test system moisture is different than the operation particularly in the upper atmosphere (above 300mb) where it is supersaturated, an obvious problem needing correction.

Figures 2 and 3 illustrate graphical capabilities from PDISP. Figure 2 shows a typical plot of the global distribution of collocated radiosonde and satellite observations as routinely compiled in support of NESDIS operational product systems (Tilley *et al.* 2000 and Reale *et al.* 2002), in this case for NOAA-16. As shown, the global distributions are not uniform with more collocations clustered in the western parts of Europe and N. America. This is a by-product of the 3-hour time windows used when collocating satellite observations with predominantly synoptic radiosonde observations (at 00Z and/or 12Z) over land.

Figure 3 shows the multiple profile data sets of temperature (solid) and moisture (dashed) available from a single collocation data record, with over 6000 records available on a given file. The radiosonde location (northern Europe) and respective data systems are annotated and color coded (i.e., the radiosonde is in red) as indicated on the right. The plots include satellite derived and NWP profiles collocated to the radiosonde report. Although seemingly tedious, a scanning of all (6000) profiles can be very enlightening of difference ranges and problems inherent in the respective data.

Figure 4 illustrates graphical capabilities from VSTAT. The left panel shows vertical statistics of the mean (left curves) and standard deviation (right curves) of first guess (light curves) and final sounding (heavy curves) differences from the radiosondes, respectively. The left panel shows these statistics for clear soundings and the right panel for cloudy soundings from ATOVS for NOAA-16, for the region 60N to 60S. The sample sizes at each pressure level are shown along the right vertical axis. The convergent nature of NESDIS operational soundings is revealed by the smaller differences for the final soundings versus the guess. However the regional skewing of the samples used to compute these statistics (Figure 2) limits there reliability as an indicator of global performance (Reale and Thorne 2004).

4. FUTURE PLANS

All graphical systems are being expanded to include research satellites, additional stages of satellite radiometric processing, and calculations of radiometric data from radiosondes, nwp, and derived satellite products. A broadening of all systems to routinely report differences among the various data sources is planned. This would include for example, gridded horizontal datasets of satellite derived minus NWP product differences, and vertical statistics of calculated versus observed satellite radiances. Plans include making these systems and data accessible to users.

5. ACKNOWLEDGEMENTS

The contents are the opinions of the authors and do not necessarily constitute a statement of policy, decision, or position on behalf of the U.S. Government.

6. REFERENCES

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