9A.2 The NOAA PROducts (integrated) Validation System (NPROVS) and Environmental Data Graphical Evaluation (EDGE) Interface; Part-1: System

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1. INTRODUCTION

During the past 30 years of NOAA operational polar satellites, the problem of providing reliable and consistent monitoring and scientific validation of operational measurements and derived satellite soundings has been addressed through the compilation and analysis of collocated satellite and radiosonde observation datasets. The NOAA Products Validation System (NPROVS) (Reale *et al.* 2009), recently deployed at the Center for Satellite Applications and Research (STAR), centralized the routine compilation of satellite and radiosonde collocation datasets among the multiple satellite derived sounding product systems operated by NOAA, including respective observation screening. These datasets have also proven to be useful for characterizing the performance of respective platforms and for computing coefficients in support of derived satellite sounding algorithms (Reale and Tilley 2009)

The following report presents an overview of three graphical tools that have been developed in support of NPROVS. These tools provide STAR scientists with the ability to:

- Monitor the NPROVS system.
- Compare the quality of data produced by multiple satellite systems.
- Identify problems that might exist.
- Test the impact of algorithm and quality control changes.

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2. NPROVS

Satellite derived sounding products are routinely produced by NOAA for a number satellite platforms including GOES, NOAA-18, MetOp, NASA–EOS-AIRS and DMSP and a number of processing approaches including operational Advanced TIROS Operational Vertical Sounder (ATOVS) (Reale et al. 2008), Microwave Integrated Retrieval System (MIRS) (Boukabara et al. 2007) and hyper-spectral sounder approaches for AIRS and MetOp-IASI (Barnet). Although not currently used at most of the NWP centers, derived soundings remain a mainstay of NOAA ground processing systems and may yet play a key role as an efficient data compression mechanism for assimilating hyper-spectral observations and in climate.

Figure 1 shows a schematic diagram of NPROVS and multiple satellite platforms and processing suites, including NWP, that are routinely collocated with the ground-truth (mainly radiosondes) observations.

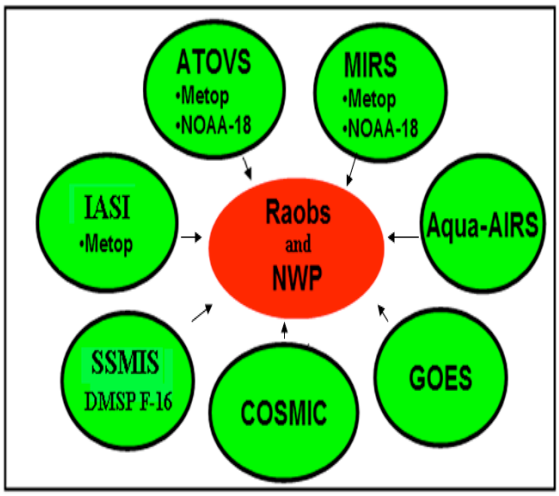

Figure 1: Diagram of NPROVS satellite data (green) access and collocation with ground truth (red).

The NPROVS system produces a daily file containing the collocated data. Each record in the file represents a single collocation with data from one or more satellites matched to a single source of ground truth (radiosondes).

The daily NPROVS file is made available for STAR scientists for evaluation. To aid in the visualization of the data, the graphical programs described here were created.

3. PROFILE DISPLAY

The primary function of the first graphical program, ProfileDisplay (PDISP), is to display the data that are contained within the NPROVS collocation file. The program can display individual sounding profiles, a geographic distribution of collocations, vertical accuracy statistics, and scatter plots. This provides users with the ability to view the data with both a broad and a narrow focus.

3.1 Display Of Individual Sounding Profiles

The main window (figure 2) in PDISP displays all available sounding profiles for a single collocation. Controls are provided to switch between each collocation in the file.

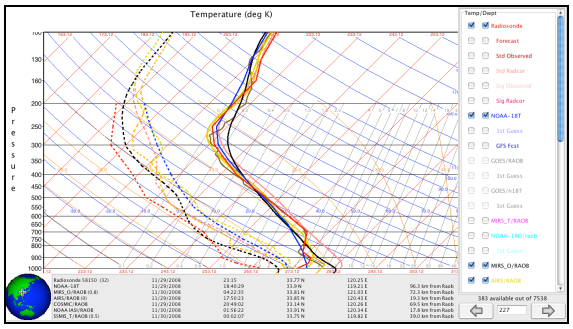

Figure 2: The main graph window in PDISP showing temperature (solid lines) and moisture (dashed lines) profiles from several satellite systems.

Temperature (solid) and moisture (dashed) profiles are plotted on the graph with the color of each line matched to a satellite or radiosonde. Each radiosonde and satellite may contain one or more profiles. Checkboxes for each profile allow the user to turn selected profiles on or off.

By default, the profiles are plotted on a skew-temperature log-pressure graph. The type of plot can be changed to one of several pre-defined plot types including three skew-t log-p variations and five XY plots which use different methods for plotting pressure

3.2 Raw Data

Although the individual sounding profile graph provides a good view of the collocated data, it is sometimes advantageous to be able to look at the data more closely. PDISP does this by displaying all available raw data.

The display of the raw data is broken into sections. One section contains a table of temperature and moisture data at every pressure level for every satellite and radiosonde. This table shows the exact data values and allows for quick comparisons between satellites.

Other sections of raw data exist for each satellite. When the NPROVS Collocation File is created, all available data for each satellite are stored in the file. PDISP reads all of the data and formats the data for raw data display.

3.3 Geographic Distribution

The geographic distribution feature of PDISP displays the location of every collocation in the file (figure 3). Each dot in the image shows the location of the ground truth to which each satellite was collocated. The color of the dot represents the terrain type of the ground truth.

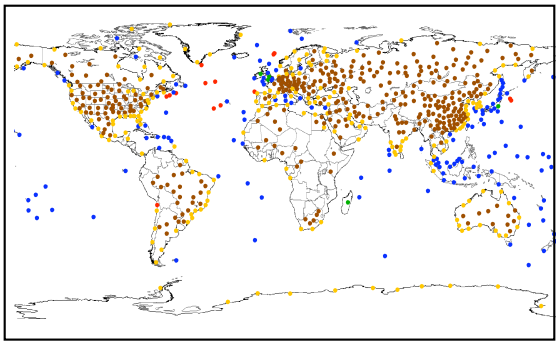

Figure 3: Global location of radiosondes collocated with at least one satellite observation platform for a 2-day period during January 2009; colors indicate the terrain flag of the radiosonde (red, ship; brown, land; yellow, coast; blue, island and green, inland island).

In addition to the location of each collocation, the geographic distribution map can be altered to display addition information including radiosonde station ID and radiosonde instrument type.

The location of each satellite in relation to

the ground truth can be plotted on the map. Additionally, the radiosonde balloon drift can be plotted. Figure 4 shows a single collocation where the ground truth is a radiosonde (red) launched near Ocean City, Maryland. The locations of the satellite soundings are also plotted. The red line extended eastward from the radiosonde shows the location of the balloon as it ascended.

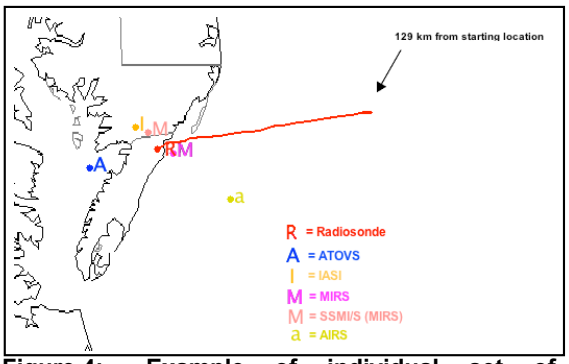

Figure 4: Example of individual set of collocated radiosonde (red) and respective satellite observations (other colors) and the associated drift (red line) of the radiosonde during flight in vicinity of Ocean City, Maryland on January 2, 2009.

3.4 Sub-selection

An important function provided by ProfileDisplay is the ability to sub-select collocations. When an NPROVS Collocation File is initially opened, by default every collocation in the file is available for viewing. PDISP provides a set of controls that can be used to select a specific subset of collocations. When viewing each collocation, only those that match the sub-selection controls will be available.

Sub-selection is performed by setting various controls that key on certain collocation parameters. Some of the sub-selection options include:

- Collocation day and time.
- Ground truth terrain type.
- Radiosonde quality control flags.
- Satellite availability.
- Satellite quality control flags.
- Time difference between each satellite and the ground truth.
- Distance between each satellite and the ground truth.
- Radiosonde station ID.
- Radiosonde instrument type.

The geographic distribution map is also used for sub-selection. One or more boxes can be drawn around collocations on the map. Those collocations that are not within the boxes will be unavailable.

3.5 Vertical Accuracy Statistics

In order to provide a view of the overall quality of data in an NPROVS Collocation File, ProfileDisplay generates vertical accuracy statistics which creates a summary of satellite minus ground truth at every pressure level.

When vertical statistics are generated, all collocations that match the current sub-selection are used. Temperature and moisture statistics are generated for each pressure level.

The vertical statistics graph (figure 5) displays multiple statistics including:

- Bias.
- Standard deviation.
- Root mean square.
- Minimum difference.
- Maximum difference.

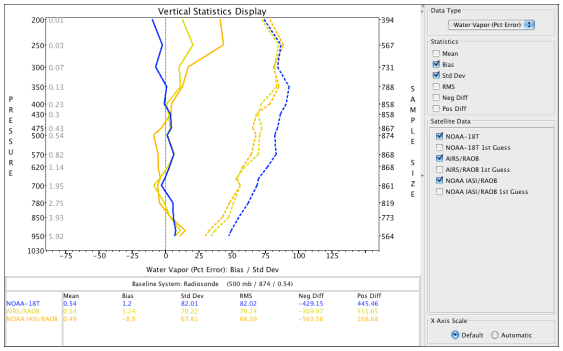

Figure 5: Vertical accuracy graph showing bias (solid line) and standard deviation (dashed line) for NOAA-18, AIRS and NOAA IASI.

3.6 Scatter Plots

Scatter plots in PDISP are generated in a manner that is similar to vertical accuracy statistics. Sub-selected collocations are processed and a graph is displayed which shows the scatter plot (figure 6).

The ground truth system is displayed along the X-axis while the data for each selected satellite are displayed along the Y-axis. Scatter plots are generated for each pressure level. A slider is provided along the right-hand side of the window to switch between pressure levels.

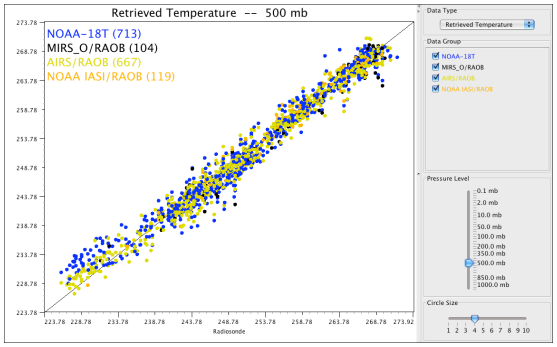

Figure 6: Scatter plot with ground truth (radiosonde) plotted along X-axis and satellite temperature values plotted along Y-axis.

4. ENVIRONMENTAL DATA GRAPHICAL EVALUATION IMAGING SYSTEM

While ProfileDisplay provides STAR scientists with the ability to view satellite data that have been collocated by NPROVS with a radiosonde, it is often useful to view all of the data from a satellite prior to the collocation process. The Environment Data Graphical Evaluation Imaging System (EDGEIS) provides this capability by reading satellite sounding data and creating an image of a chosen parameter (figure 7).

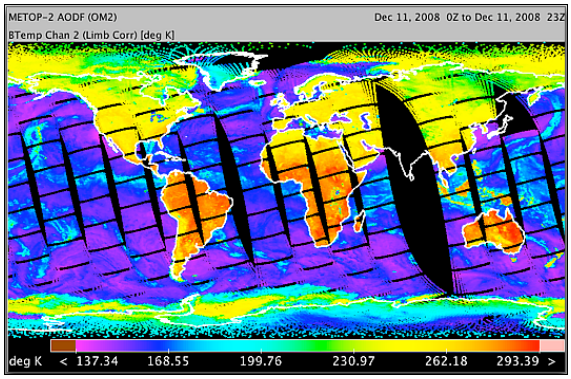

Figure 7: EDGEIS image of AMSU-A brightness temperature data from the NOAA MetOp-2 satellite system.

4.1 Horizontal Atmospheric Cross-sections

EDGEIS is currently able to read and display data from every satellite system used by NPROVS. Any parameter produced by a given satellite, including temperature and moisture level data, can be displayed.

A variety of options are available that allow the user to select the data being displayed and to adjust the manner in which the data are displayed. Some of these options include:

- Zooming.
- Projection (Cartesian, Orthographic, Polar-Sterographic, Mollweide).
- Map overlay (continental, country/state borders).
- Value masking.
- Smoothing and contouring.
- Color scale (pre-defined or custom).

4.2 Comparison Using Differencing

With EDGEIS, users are able to perform a pixel-level comparison of any two images. This allows for a quick view of the difference between two parameters from the same satellite or from different satellites.

An example of the differencing feature is shown in Figure 8. In this example, individual pixel values from the upper right image (first guess temperature) were subtracted from the corresponding pixel values in the upper left image (retrieved temperature). The result of the subtraction is shown in the lower right image. The white areas show where the two upper images contain the same values. The blue areas show where the temperature values in the upper left image were colder than in the upper right image.

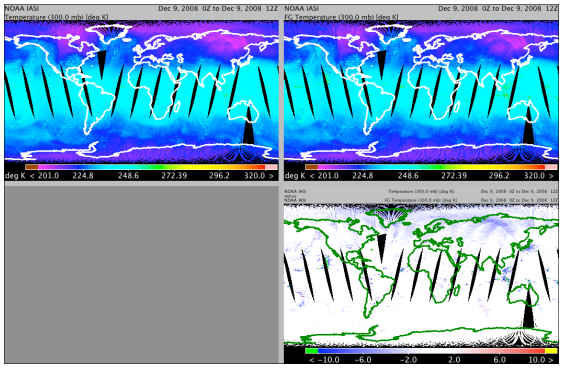

Figure 8: Image differencing within EDGEIS. In the lower right image, white areas show where the two upper images agree. Blue areas show a cold bias in the upper left image.

4.3 Sounding Profiles and Vertical Atmospheric Cross-sections

When a horizontal image is displayed in EDGEIS, the user can click on any location in the image. A window will pop up (figure 9) that displays all temperature and moisture profiles associated with the selected sounding. Any additional data are also displayed alongside the graph.

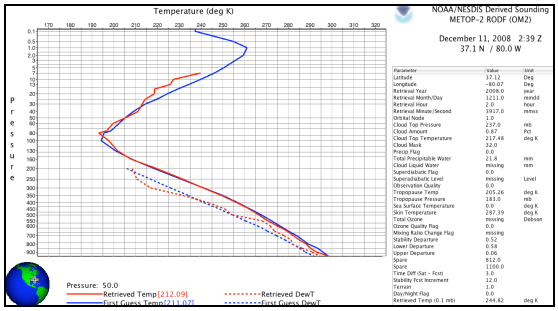

Figure 9: Temperature (solid) and moisture (dashed) profiles from an individual sounding that was selected from within EDGEIS.

In addition to individual sounding profiles, EDGEIS can display vertical atmospheric cross-sections of temperature and moisture data. This is done by drawing a line across any horizontal image. The resulting window will display either the temperature or moisture cross-section (figure 10).

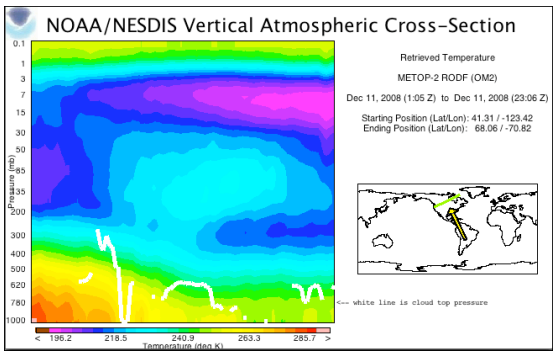

Figure 10: Vertical atmospheric cross-section of retrieved temperature from Vancouver, Canada (left) to Baffin Bay (right). Cloud top pressure (white line) is also shown.

5. NPROVS Collocation Summary System

The NPROVS Collocation Summary System provides long term trending statistics of collocated data. The number of available radiosondes per day is stored along with the number of collocations for each satellite. Also stored is a running average of satellite minus radiosonde bias and standard deviation.

The statistics are displayed for the radiosonde and satellite data (figure 11). Daily statistics can be displayed for each day within the time period. The statistics can also be grouped into weekly or monthly statistics.

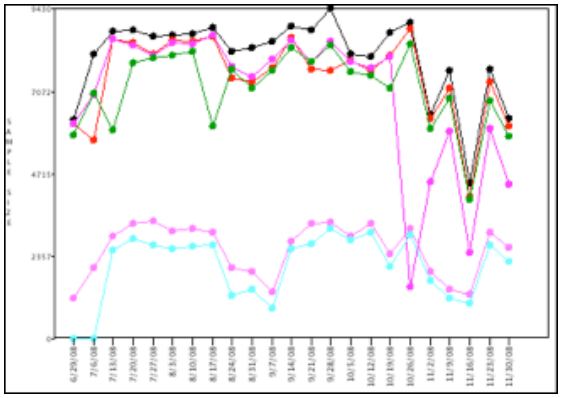

Figure 11: Weekly collocation sample size from NPROVS including radiosonde counts (black) and counts from several collocated satellites.

6. REFERENCES

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