P7.4 PROCESSING AND DISPLAY OF ATMOSPHERIC ELECTRICITY DATA TO SUPPORT LAUNCH OPERATIONS AT THE EASTERN RANGE

Joseph S. Wakefield[*,1], Philip A. McDonald[2], MarySue Schultz[1,3], Xiangbao Jing[1,4], and James E. Ramer[1,3]

[1]NOAA Research - Forecast Systems Laboratory, Boulder, Colorado

[2]Digital Glyphix, Inc., Nederland, Colorado

[3]in collaboration with Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Ft. Collins, Colorado

[4]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, Colorado

1. INTRODUCTION

Since 2001, the Forecast Systems Laboratory (FSL) has been supporting the Air Force Range Standardization and Automation (RSA) program. Based on the National Weather Service's Advanced Weather Interactive Processing System (AWIPS), a system has been tailored by FSL to support space launch operations at the Western (Vandenberg) and Eastern (Cape Canaveral) Ranges. A major goal of this work is to replace legacy systems with an integrated weather display, thus improving the Launch Weather Officers' effectiveness and efficiency.

The space launch community requires access to standard weather datasets, which are supplied to the Ranges by the National Oceanic and Atmospheric Administration's NOAAPORT (NWS 2004) data service. A connection to the local WSR-88D radar provides local radar data, with products from nearby radars also available via NOAAPORT. Launch and recovery operations, however, are subject to stringent weather-related constraints such as wind shear, temperature, and atmospheric electrical activity. A significant part of FSL's RSA development work (Davis et al. 2002) has involved the collection, processing, and display of these local datasets, including instrumented towers, profilers, SODARs (sonic detection and ranging systems), and atmospheric electricity sensors.

2. DATA INGEST AND PROCESSING

The two Ranges are in markedly different climate regimes. At Vandenberg, lightning is infrequent, whereas Cape Canaveral is one of the most electrically active places in the world. Accordingly, different sets of sensors are installed at the Ranges. At the Western Range, cloud-to-ground strikes are monitored by a Lightning Location and Protection System (LLPS) network. At the Eastern Range, a similar Cloud-to-Ground Lightning Surveillance System (CGLSS) network is operated. In addition, a network of field mills to detect the electrostatic field strength above the instrument is deployed around the Cape Canaveral area, and a Lightning Detection and Ranging (LDAR) system monitors electrical activity in the atmosphere above the launch complexes.

At both Ranges, however, the locally-collected data are preprocessed external to FSL's weather subsystem.

2.1 *Ingest of two-dimensional data*

The two-dimensional data (LLPS/CGLSS and field mills, in particular) are ingested as illustrated in Figure 1. Data in comma-separated-variable (CSV) form are sent into the weather subsystem using the Unidata Local Data Manager (LDM; Unidata 2002), processed by an appropriate decoder, and stored in netCDF files. The display system reads these data and renders them in various forms and on appropriate map backgrounds to the user display. The local data can be combined with local or national model data, satellite, radar, and/or other observations such as METARs and ship or buoy reports.

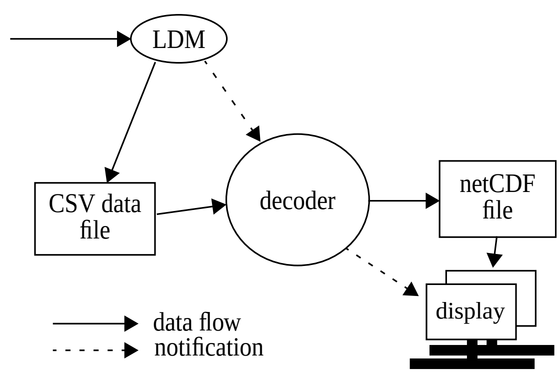


Figure 1. Generic flow for RSA local data ingest and display.

2.2 *Ingest of three-dimensional data*

The high frequency of LDAR reports and the display requirements imposed by flight safety rules demand a different type of data ingest for the 3-D lightning data. Three methods of getting data to the user's display were considered and designed into the software. In all cases, the storage of data is similar to the method shown in Figure 1. A RAM file system was tested

* *Corresponding author address:* Joseph S. Wakefield, NOAA/FSL R/FS4, 325 Broadway, Boulder, CO 80303-3328; e-mail joseph.s.wakefield@noaa.gov.

for the intermediate data storage. While it worked well, a standard disk file also performed well, and is easier to manage.

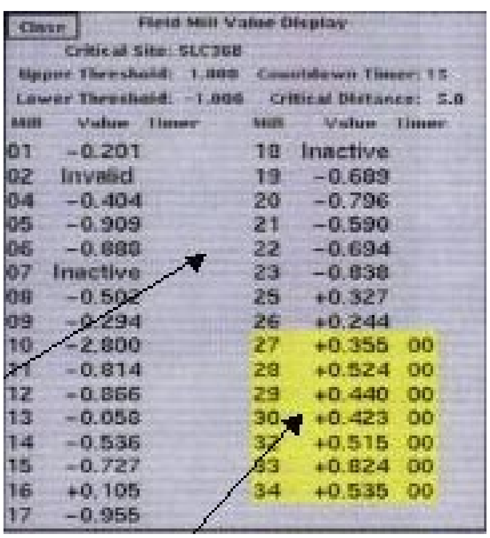
The first data delivery method considered uses a NFS (Network File System) mount point to pick up the data on the workstation via the network (as is standard for all other datasets). An LDAR Inventory process runs on each workstation to maintain a rolling inventory of available data slices. The LDM distribution method uses LDM to pass the raw data to each workstation, where the storage method is replicated for local access. The third data distribution method uses a multicast model to pass the data to the workstations for local storage and retrieval. Since the NFS method matches what is used elsewhere in the system, and testing showed it to meet the requirement of no more than five-second latency, the LDM and multicast methods were never developed.

3. DISPLAY

The Eastern Range atmospheric electricity data are displayed in three basic ways: as text, in a tabular format; in two dimensions, as plan views of strike locations or electric field intensity, as well as contour or image renderings of the latter; and in three dimensions for the volumetric LDAR data.

3.1 *Tabular text*

Of the electricity data, only the field mill electric field measurements are displayed in text form on the RSA weather system. Range safety rules require monitoring of the electric field strength within a mission-specific range of the launch pad. A snapshot of the legacy display of field mills is shown in Figure 2, with the critical field mills highlighted in yellow. If a measurement exceeding the safety threshold is observed, the station is highlighted in red, and a 15-minute timer is initiated. The RSA weather version is still under development; a completed display will be shown at the conference.



Close | Field Mill Value Display

Critical Site: SLC36B

Upper Threshold: 1.000 Countdown Timer: 15

Lower Threshold: -1.000 Critical Distance: 5.0

Mill	Value	Timer	Mill	Value	Timer
01	-0.201		18	Inactive	
02	Invalid		19	-0.689	
04	-0.404		20	-0.796	
05	-0.909		21	-0.590	
06	-0.880		22	-0.694	
07	Inactive		23	-0.838	
08	-0.502		25	+0.327	
09	-0.294		26	+0.244	
10	-2.800		27	+0.355	00
11	-0.814		28	+0.524	00
12	-0.866		29	+0.440	00
13	-0.058		30	+0.423	00
14	-0.536		32	+0.515	00
15	-0.727		33	+0.824	00
16	+0.105		34	+0.535	00
17	-0.955				

Figure 2. Legacy field mill tabular display. Stations within 5 nautical miles of the launch pad are highlighted in yellow.

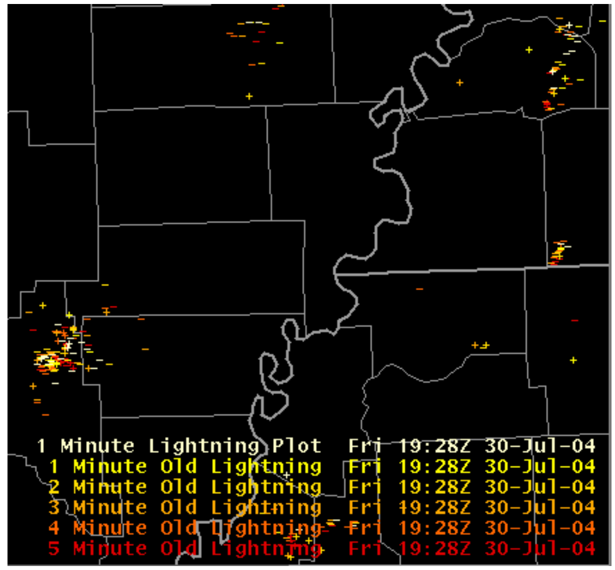


Figure 3. Five-minute lightning sequence. Each minute's strikes are plotted in a different color

3.2 *2-d display*

Two-dimensional (plan-view) displays of the atmospheric electricity datasets include one- and five-minute summaries of both CGLSS and field mill-detected strikes; five-minute sequences from each of these systems, color coded by age (see Figure 3); and plots of the field mill charge values, along with contour and image depictions of an on-the-fly analysis of these data (Figure 4).

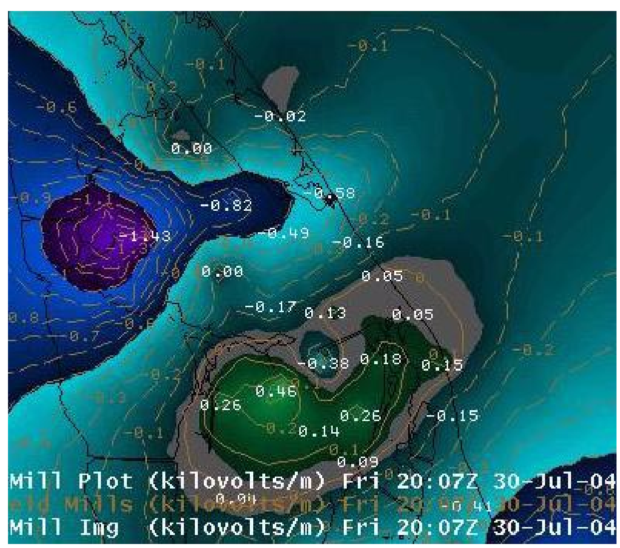


Figure 4. Plot, contour, and image depiction of simulated field mill data. Character size, contour interval, and color settings can be adjusted by the user.

3.3 *3-D display*

As noted, the LDAR system monitors electrical activity in the space above the launch facilities, reporting three-dimensional locations of in-cloud and cloud-to-ground discharges using seven antennae. The legacy display shows south, west, and top views of the volume, and a histogram of the number of strikes by minute. The new display replicates these items, and adds an interactive 3-D window to examine the volume. Figure 5 is a snapshot of the data part of this display. The user can zoom in on the *Top* and *3D* panels using the mouse or the controls shown in Figure 6. The *West* and *South* views are ganged to the *Top* view, so they respond to its magnification. The *3D* view can also be rotated to any perspective using the mouse.

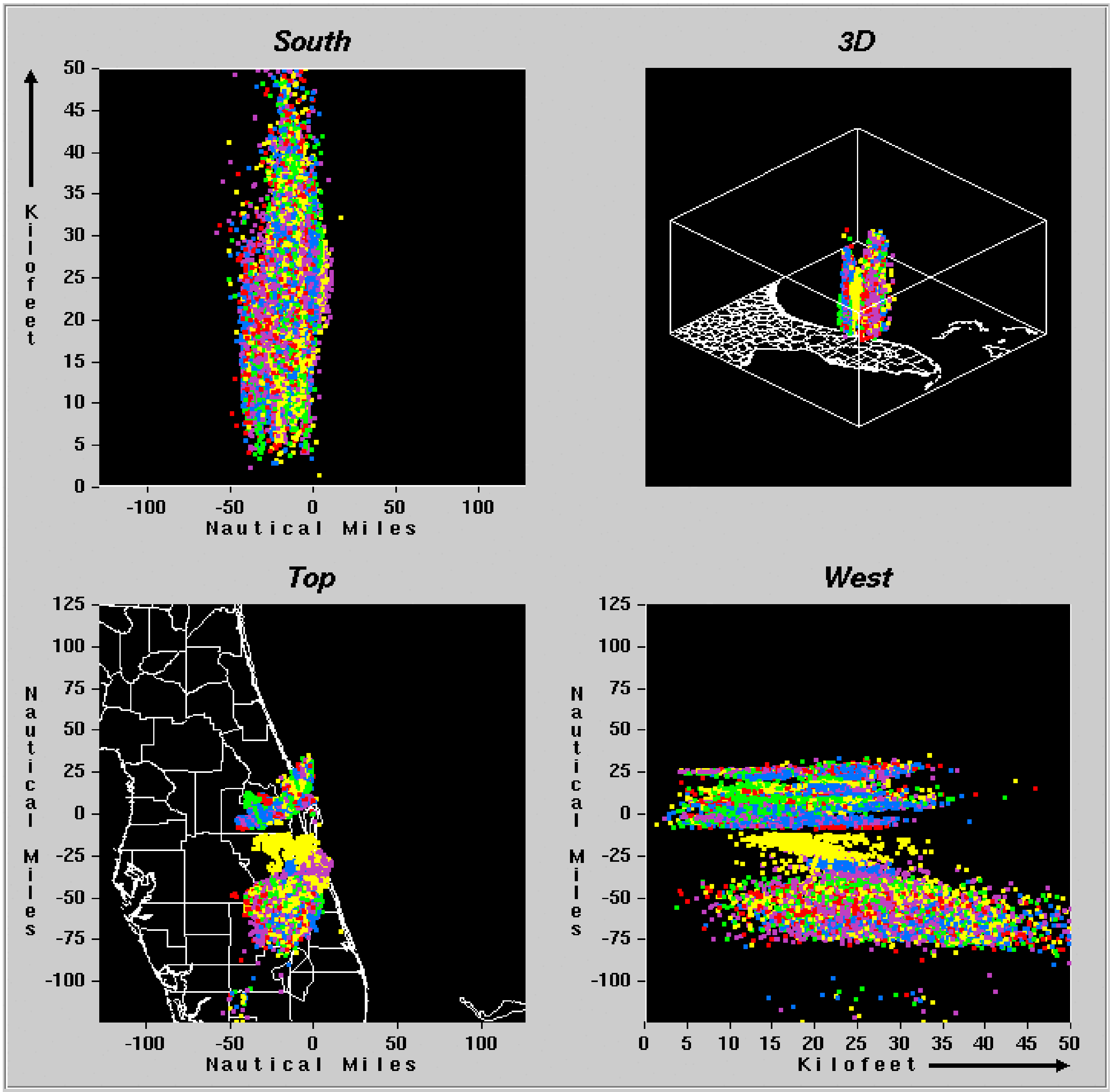


Figure 5. Data section of 3-D LDAR display. Events are color coded by age, as indicated in the data histogram in Figure 6.

(On the display, the controls shown in Figure 6 and the panels in Figure 5 are parts of the same window; they are separated here for publication purposes.)

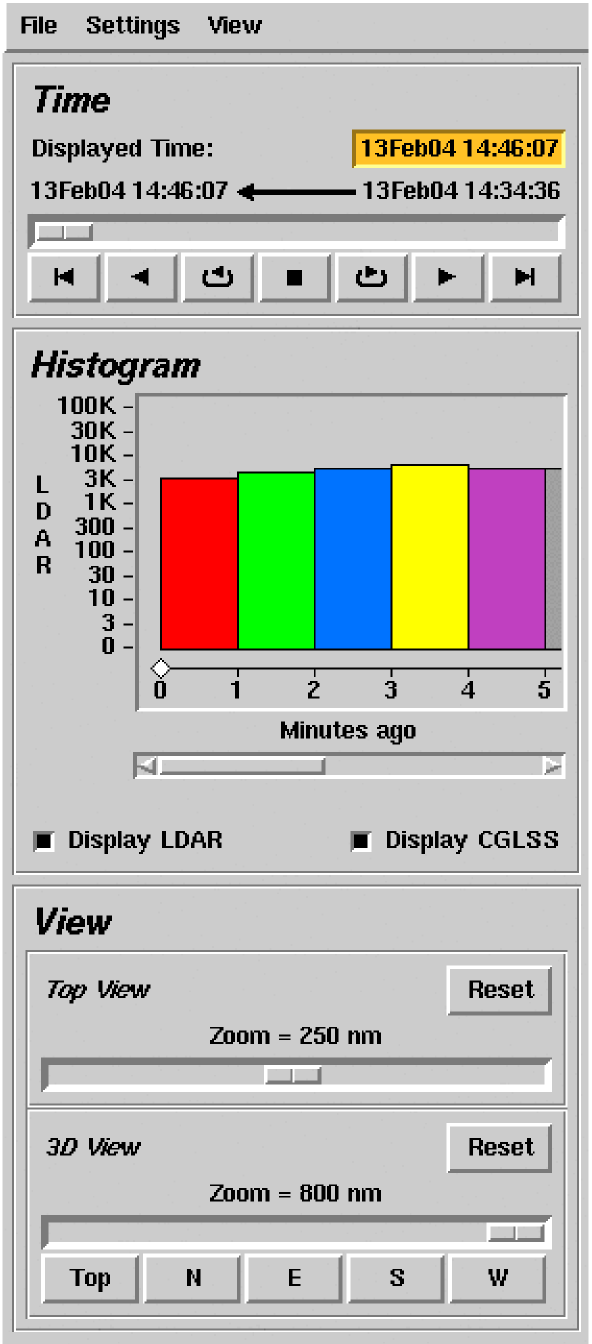


Figure 6. 3-D lightning display controls. The *Time* section contains information about the time and status of the LDAR data, and animation controls; the *Histogram* section shows a color-coded temporal histogram of LDAR events and toggles for the data displays; and the *View* section has controls for modifying the display panels.

4. CONCLUDING REMARKS

As the legacy systems at the two space launch weather centers are replaced, we do not expect that the Launch Weather Officers' jobs will get any easier, but believe that the new tools should help them do their job more effectively and efficiently. The atmospheric electricity displays outlined in this paper are more integrated with other datasets than the subsystems they replace, and such integration leads to better and quicker comprehension of the weather situation by the user.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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