SOUTHERN THUNDER (ST09) LIGHTNING WORKSHOP

MEETING SUMMARY

Cocoa Beach, FL, July 28-30, 2009

The Third Southern Thunder (ST09) total lightning workshop was held July 28-30, 2009 at Cocoa Beach, FL. The workshop was organized by NOAA, NASA, and Vaisala, and hosted locally by the NASA Kennedy Space Center, the 45th Weather Squadron at Cape Canaveral, ENSCO Inc., and Lockheed-Martin. This workshop was a follow-on from the inaugural workshop held in April 2004 in Huntsville, AL and subsequent workshop held in Fort Worth, TX in July 2005. These workshops were driven by new and expanding opportunities in the U.S. and elsewhere to observe total lightning activity by regional ground-based systems, and by the planned launch in 2015 of the Geostationary Lightning Mapper (GLM) on the next generation Geostationary Operational Environmental Satellite series (GOES-R). Additionally, these workshops aim to deliver real-time data products to National Weather Service (NWS) forecaster workstations within the areas covered by present ground-based total lightning mapping systems. This workshop continued addressing the goals of the earlier workshops to

- Bring the system and product developers together with the product and decision-making end users,
- Form collaborations to advance the scientific understanding of thunderstorm processes, and
- Develop and evaluate nowcasting and warning decision-making applications that use total lightning in an operational environment.

Scientific advancement, advanced concept and product refinement, algorithm validation, and product evaluation and feedback from forecasters using the Advanced Weather Information Processing System (AWIPS/AWIPS II) and Weather Event Simulator (WES) now and in the coming years will help accelerate the transition to operations for ground-based and satellite total lightning observations over the western hemisphere.

The workshop format consisted of a combination of presentations and break-out discussions. At ST09 there were 48 presentations in five sessions addressing present and future systems, science, and operational demonstrations/applications including the GOES-R Proving Ground, and three break-out sessions focused on validation, product development, and strategy/coordination for incorporating total lightning products into the AWIPS-II. Of the 66 attendees, approximately half represented the NWS headquarters, regions, national centers, and forecast offices. As with previous workshops, the presentations and meeting summary are posted at the Short-term Prediction Research and Transition (SPoRT) Center web site: http://weather.msfc.nasa.gov/sport/southernthunder/southern_thunder.html.

Time was purposely scheduled after each session to facilitate in-depth discussion of the topics presented. Participants were then able to engage in a more lengthy dialogue about issues than is typically afforded by a 2-3 minute question and answer period after each presentation, as given in a standard conference presentation. These discussions also helped the group develop the topics for the break-out sessions.

BREAK-OUT SESSIONS: DISCUSSIONS AND ACTIONS

A. Validation Breakout Session Summary:

The validation group began with a review of planned field programs in the next few years that will provide opportunities to collect data that may be used for validation of lightning mapping systems. Known near-term field programs are presented in Table 1.

Table 1. Near-term Planned Field Experiments

Experiment	Dates
NSF Vortex II (Great Plains) Experiment	May-Jun 2010
NSSL central Oklahoma Hydrology experiment	2011
NASA Genesis and Rapid Intensification Processes (GRIP, tropical cyclones and hurricanes)	2011
GOES-R Proving Ground at NOAA Hazardous Weather Testbed and others	2010-onward
NSF DC3-Deep Convective Clouds and Chemistry (CO, OK, AL)	2012

Existing lightning mapping systems that might provide useful data in support of these campaigns include various regional total lightning mapping systems, including

- New Mexico Tech's portable VHF Lightning Mapping Array (LMA),
- Vaisala's VHF Lightning Detection and Ranging (LDAR II) time-of-arrival system, Surveillance et Alerte Foudre par Interférometrie (SAFIR) interferometer, and LS8000 integrated VHF/LF system,
- The Weatherbug Total Lightning Network, and
- NASA's Lightning Imaging Sensor (LIS) on the Tropical Rainfall Measuring Mission (TRMM) satellite.

Additionally, cloud-to-ground (CG) lightning networks that could provide a sub-set of useful and ancillary information (e.g., strike location and polarity) include the

- Vaisala National Lightning Detection Network (NLDN) and Global Lightning Detection Network (GLD360),
- WSI U. S. Precision Lightning Detection Network (USPLN),
- World Wide Lightning Location Network (WWLLN), and
- Los Alamos Sferics Array (LASA).

1. Validation of Ground-Based Lightning Mapping Systems:

There exists a great need to monitor and estimate the impact of the loss or degradation of any sensor in a mapping system, and a need to validate these estimates. For each system, it is important to determine the location accuracy, detection efficiency, and accuracy of lightning parameters (flash type, number of return strokes, signal amplitude, peak current, return stroke polarity, radiated power, etc., as appropriate for a given system) for in-cloud flashes (IC), CG flashes, and undetermined flashes. These should to be determined as a function of range from each system, and possibly time of day. The primary ground truth facilities currently available for validating system performance are

- VHF mapping systems,
- Field mill or slow antenna networks, and
- ELF systems.

Other facilities that may be available for validation on occasion in some locations include:

- Triggered lightning facilities in FL and NM or possibly a mobile triggered lightning facility,
- Instrumented towers and lightning rods,
- Video cameras, and
- An airborne sparker, preferably with signal amplitude control (this was considered a good means for validating VHF systems)

Another point of discussion was that inter-comparisons among the ground-based systems are valuable in showing differences and similarities in what is detected.

- For commercial networks, ground truth data can be provided by the various research VHF mapper installations and by ELF and/or slow antenna networks to provide reliable identification of flash type.
- For VHF mapping systems, ground truth data can be provided by an airborne variable amplitude VHF sparker with GPS tracking to verify location accuracy and sensitivity.

2. Validation of the GOES-R GLM:

Primary sources of validation data for GOES-R GLM will be reliable ground-based systems and aircraft over-flights of downward looking optical arrays. Another excellent method for validation will be inter-comparisons with other satellite lightning mappers that may be operational at GLM launch (e.g., TRMM LIS). Additional opportunities will exist for inter-comparisons between the GOES-R and GOES-S (i.e., GOES-E and GOES-W) GLM instruments where the fields of view overlap, and with the planned Meteosat Third Generation (MTG) Lightning Imager mission planned for launch in 2015. Airborne, space-based, and to a lesser extent long range lightning networks will be the only source of validation data for GLM performance assessment over remote open oceans.

The recommended independent validation systems include:

- VHF mapping systems, particularly the acquisition of a government-owned deployable VHF mapping system that can be deployed in various locations, including maritime islands;
- Aircraft over-flights of storms to include downward looking optical arrays among sensors being flown in a coordinated field program to validate various GOES-R instruments; and
- Inter-comparisons with low earth orbiting lightning mappers (LIS and VHF).

Other possibilities for validation data sources include

- Developing motes, which are conceived as very small packages carrying one or more sensors to be released into storms and carried by the wind, and
- Developing an airborne VHF mapping system.

3. **Validation of Potential Products/Forecasts for Operational Use:**

   Examples of products, forecasts, and algorithms needing verification include

   - Lightning flash definition and flash type identification,
   - Lightning forecast techniques and products, and
   - Forecasts that use lightning data, such as lightning data assimilation schemes for forecast models and algorithms for estimating the probability of other severe weather hazards.

   For both ground-based systems and the GLM, the following types of algorithms or products require validation:

   - Lightning jump algorithms,
   - Lightning clustering algorithms,
   - Cell identification and tracking products using lightning data,
   - Flash definition,
   - Severe weather flags, and
   - Prediction of lightning
     - Initiation,
     - Flash rate change (intensification and decay),
     - Cessation, and
     - Warning products (including fire weather).

4. **Evaluation of Potential Products for Operational Use:**

   Evaluation naturally falls under the mission of the GOES-R Proving Ground (http://cimss.ssec.wisc.edu/goes_r/proving-ground.html) and the various test-beds. Evaluations should incorporate the following elements:

   - How well do the products or forecasts do what they claim?
   - How useful are the products or forecasts under realistic operational conditions?
   - What impacts are caused by differences in what various mapping systems detect (for products or forecasts capable of using data from more than one type of mapping system)?
   - What impacts are caused by degradations in mapping system performance, either because of sensor degradation or decreasing performance with range or as a function of time of day?

   These issues need to be considered and evaluated early in the product design and development stage. Validation should not wait to begin until a product or forecast technique has been developed. These can be evaluated in various test-beds and by sensitivity studies or simulations. In addition, it would be useful to conduct a collaborative Flash Inter-comparison Project (FIP) among interested research groups. The FIP would compare the various algorithms used to identify flashes from VHF mapping systems. A similar comparison for other types of mapping systems (including the GLM) is highly recommended, because flash identification algorithms are tuned to the property (optical signal, VHF radiation, VLF radiation, etc.) used to detect lightning.

B. National Strategy Breakout Session Summary

The national strategy breakout group was formed to address the perception that there is a gap between the valuable and successful regional demonstrations of total lightning data and products and the goal of achieving a national forecast and warning capability employing total lightning data. Forecaster training will be critical and should build on current training that is more narrowly focused on CG lightning (http://rammb.cira.colostate.edu/visit/ltgmet1.html). A comprehensive strategy is needed to address how the total lightning data products would become part of the next generation AWIPS-II baseline. The main themes that emerged from the breakout group were:

- Continued support for the ongoing regional studies (e.g., LMA/LDAR/ LS8000),
- Coordination and cooperation between proving grounds and test-beds,
- Development of a group to determine baseline products and how to move forward, and
- Determination of longer term user needs and requirements.

The following actions and issues were identified.

1. **Creation of a Lightning Research and Operations Working Group**
    - Must have a small team to further develop the national strategy, and more importantly to ensure the process is seen through;
    - Draw members from various groups that represent different needs and requirements;
    - Help determine test-bed products in addition to national baseline products (i.e., definition of products, matching with users);
    - Develop a path forward (i.e., concepts → products → implementation);
    - Determine, evaluate, and prepare products for the OSIP process (i.e., mission of needs, concept of operations, etc.) now, during the next 4 to 5 years, and beyond;
    - Consider the NEXRAD model as an example;
    - Develop plans but also ensure their flexibility;
    - Establish operational requirements;
    - Evaluate and determine priorities; and
    - Ensure the NWS is not using experimental products for its chartered or established responsibilities.
2. **Other Significant Questions and Considerations**
    - How do we gather support?
    - How do we communicate feedback?
    - How do we expand engagement with end users and build capacity and advocacy for total lightning?
    - How do we determine the balance between national, regional, and local products?
    - Is there a common set of products to be expanded nationwide?
    - A GLM-centric paradigm vs. viewing the GLM as more of a complimentary dataset?

C. Products Breakout Session Summary

The products breakout group examined forecaster needs and how lightning data products be used in the best manner.

1. Forecaster Needs

Automated decision aids are needed to assist the forecasters, not more data. The total lightning information must be naturally integrated into the forecast environment and warning decision-making process. At times, forecasters are overwhelmed with information. This situation will be exacerbated in the future when new observing systems become operational. Forecasters will be inundated by more information and rapid updates from systems such as the NWS polarimetric weather radar network and the GOES-R 16-channel imager and GLM. New systems, including total lightning, need to provide complementary information not available from other sources. The FAA uses automated products to make many high impact weather-related decisions, but most NWS forecast applications are a blend of objective guidance and human interpretation. For most NWS forecast decisions, the automated tools would be used to aid in making the forecast, not as the final forecast provided to the public.

2. Total Lightning Products

When total lightning information is introduced into a forecast office, the following issues should be considered:

- Forecasters are not interested in using a new data type, including total lighting data, until they see it and understand its usefulness.
- Forecasters need to understand how instruments work, including their inherent limitations, in order to properly interpret the data.
- Training on the physical basis and application of total lightning data in the forecast and warning process needs to accompany the introduction of this new type of data.
- A consistent suite of data sets is needed, as are basic products that are tunable to remove any bias inherited from the region in which the products were developed.
- Raw data should be available in real time, as well as automated products that incorporate the raw data.
- Lightning data are perishable, so distribution must be efficient. To make sure the total lightning distribution is efficient, test it in AWIPS II using several temporal refresh intervals (1s, 10s, etc.).
- Retain the base data native resolution in space and time for the greatest number of end-users possible.
- Provide forecasters with software tools that track storm objects with time, displaying feature-based trends. Examples include the System for Convection Analysis and Nowcasting *(*SCAN), and Vertically Integrated Lightning (composite VHF sources from the Lightning Mapping Array) or VILMA.
- Lightning climatologies, simple to complex conditional, would be very helpful in creating daily forecasts.

- Develop methods to assimilate total lightning data into regional (e.g., Weather Research and Forecasting (WRF) and High Resolution Rapid Refresh (HRRR)) as well as global operational models. Total lightning has been shown to be a valuable tool as an advanced indication of initial CG strikes. Studies could be conducted on how to use other data, such as from radar, to forecast the first flash, either IC or CG, and the threat area around it.
- A helpful product would be to combine total lightning with satellite data without losing satellite detail, such as is done now in AWIPS with radar and satellite data.
- A three-dimensional display of total lightning is currently in WDSSII, and needs to be added to AWIPS.

3. Programs

To know what products are needed and how to evaluate them, we need to define the term "user". Is it the forecasters or the users of the forecasts? Public safety should be the goal for product development and use. Predicting the first flash and threat area around it, whether IC or CG, as previously mentioned is an example of a tool that could be used for public safety. A Services Group is needed to define the requirements for similar products. This group would help determine what products are most useful to create the best forecasts for the forecast end-users. Conducting programs to test watches and warnings as was done at NWS MLB for local airports should be replicated at other offices. This could be extended to FEMA and other agencies.

D. Summary of Action Items from the Three Breakout Sessions

1. Validation (Rich Blakeslee, Don MacGorman)

- Ground-based total lightning networks
  - Ground truth and analysis: verify using aircraft sparker with GPS
    - VHF systems
    - ELF systems
  - Plan for GLM
    - Need for a portable VHF system to move to various locations
    - Over-flights coordinated with field programs
    - Inter-compare with aircraft and LEO observations
- Products and Forecasts
  - Inter-compare flash creation algorithms, will likely need different algorithms for different networks
  - Need group to guide evaluations
  - Evaluation needs to be added to the Proving Ground and test-beds missions

2. National Strategy (Steve Goodman)

- Develop training (Geoffrey Stano and Mark DeMaria)
  - Update VisitView and other media training modules
  - Update Chris Darden's original work
  - Incorporate SPoRT total lightning web module
  - Package with GLM information
  - Include conceptual models / events

  - Request Africa work from Steve Goodman
  - Need a 10 question quiz
  - Add GLM to Shymet (Bernie Connel and Mark DeMaria)
- Form the Lightning Research to Operations Working Group (L-R2OWG, Dave Sharp, Steve Zubrick, Chris Darden)
  - Different name for group?
- Define the L-R2OWG members representing multiple backgrounds
  - National Weather Service
  - Universities
  - GOES-R
  - Storm Prediction Center
  - Private industry
  - National Weather Service Regions
- Define the L-R2OWG tasks
  - Help organize the Spring Experiment and other test-bed activities (short-term)
  - Help define lightning products for baseline AWIPS II use
  - Produce input of future requirements (long-term)

3. **Products (Dave Andra)**
   - Create a services group
     - Science: Observations and model development
     - Services: Public and private interests in GLM data
   - Early training for forecasters (Dave Andra and Jim Gurka)
     - Leverage from existing training
     - GOES-R may sponsor training
   - List of potential products and services (Rusty Billingsley)
     - Potential end users:
       - Emergency managers
       - Pilots
       - Forecasters
       - Modelers
       - Public safety
       - Etc.

ST09 WORKSHOP SUMMARY

The ST09 workshop was successful at bringing the research and operational total lightning user community together. The jointly developed list of actions resulting from the workshop will be addressed during the next two years. It is expected that these actions will be completed in time for the Fourth Southern Thunder Workshop, currently planned to be held at the National Weather Center in Norman, OK in April 2011.