data integration is needed. Observations of corotating interaction regions, which are shock regions that corotate with the Sun, were suggested as a way of increasing the predictability of recurring solar activity. An operational space weather surveillance system is in a testing phase.

A discussion of the polar cap high-latitude regions poleward of auroral regions and the recent extended solar minimum highlighted the important role that CGSM plays in monitoring high latitudes. CGSM observations can provide invaluable data in looking at the polar cap during quiet solar conditions. It was suggested that time should be spent examining the impact of the recent solar minimum.

Another effort that stimulated discussion was that of the detection and modeling of ultralow-frequency (ULF) waves. It was noted that ULF observations have been detected by many CGSM instruments. Several models were discussed that may cause ULF waves to develop. Some difficulties highlighted with the models include the lack of feedback and the uncontrolled growth of the waves. Discussion of how to integrate the models and observations for ULF waves is ongoing.

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Advancing Research and Applications With Lightning Detection and Mapping Systems

Southern Thunder 2011 Workshop; Norman, Oklahoma, 11–14 July 2011

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The Southern Thunder 2011 (ST11) Workshop was the fourth in a series intended to accelerate research and operational applications made possible by the expanding availability of ground-based and satellite systems that detect and map all types of lightning (in-cloud and cloud-to-ground). This community workshop, first held in 2004, brings together lightning data providers, algorithm developers, and operational users in government, academia, and industry.

ST11 presentations described the ongoing expansion of regional ground-based networks that map the location of all types of lightning and updated plans for the Geostationary Lightning Mapper (GLM) planned for launch on the next-generation Geostationary Operational Environmental Satellite-R series (GOES-R) in late 2015 (http://www.goes-r.gov). Presentations also described new techniques for tracking trends in lightning flash rates, displaying and using those trends in National Weather Service (NWS) forecast offices, and improving lightning safety.

During ST11, two breakout groups, each composed of NOAA, NASA, and university participants, addressed four issues:

1. More extensive testing is needed of a technique for using sudden jumps in total lightning flash rates as indicators of intensifying storm updrafts and increasing severe weather potential to help improve severe weather warnings. A recent test involving more than 700 storms found that the technique improved severe weather warnings (hail, wind, tornado) by reducing false alarms to 36% (currently as high as 80% nationwide) with a probability of detection of 79% and increased lead time of 21 minutes (currently 13 minutes averaged nationally). However, this technique needs more comprehensive testing and validation in a broader range of environments and seasons before being accepted for implementation in routine NWS operations with current and planned lightning mapping systems. One breakout group is continuing work after ST11 to develop an experimental design for extensive testing, independent verification, and operational implementation of the technique.

2. To enable forecasters to use total lightning data in NWS operations, visualization tools are necessary. Forecasters will need to integrate an increasing flood of data from new forecast model capabilities and new observational systems to extract the information required to improve warnings of weather hazards. ST11 delineated issues concerning lightning data that need to be addressed by integration development and discussed concepts for blending and fusing lightning, radar, satellite, and model data to use the value added by total lightning data in applications for high-impact weather, aviation, and fire management.

3. To use total lightning data effectively during severe weather episodes, forecasters must be trained to thoroughly understand the data. Thus, ST11 provided guidance for developing training modules and gathering comprehensive data sets for use in a variety of storm situations.

4. Assimilating GLM and other total lightning data into numerical forecast models will improve forecasts in downstream regions. The GLM will detect thunderstorms over mountains and oceans throughout most of the Western Hemisphere more reliably and rapidly than possible by the observational systems available now. One breakout group examined recently developed lightning data assimilation techniques and discussed the challenges and advancements needed to make lightning data assimilation feasible for operational use.

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