LIGHTNING DETECTION

LIGHTNING DETECTION SYSTEMS: A STATUS REPORT

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ABSTRACT

The proliferation of lightning detection systems (LDSs) in recent years has led to their growing application in meteorological operations. Primary use has developed in observations and analysis as input to short-term forecasting. The emerging techniques and technology for ground-based LDSs have offered the opportunity for the first time to obtain a comprehensive picture of lightning activity over large areas of the United States.

A great deal still remains to be learned about the relationship of lightning to other weather phenomena. No doubt much will be learned as LDSs come into greater use, and research and applications are expanded—similarly to the evolutionary use of radar and satellite data. The National Weather Service and other federal agencies have gradually expanded their use of lightning data in recent years. This paper focuses on how lightning data is used today, particularly among government agencies, and the plans agencies have for future applications.

1. INTRODUCTION

Various Federal agencies during the past decade have begun to take advantage of lightning detection systems (LDSs) to meet their operational requirements. Much of this has taken place independently of meteorology, and primarily in response to unique agency needs. The early development of LDSs was mainly in response to the protection of sensitive operations such as those at airports, rocket launching sites, and nuclear power plants. With time, LDS data began to be applied to gaining a better understanding of mesoscale meteorological processes—particularly as related to severe storms. The LDS data are also finding growing application by physicists concerned with the earth's electrical budget (global circuit), and observations of lightning from space (Orville and Henderson, 2).

2. WHY LIGHTNING DATA

Apart from manual observations by weather observers, pilots, mariners, and others, there is no completely effective way to obtain lightning data. Lightning can be inferred from radar and satellite information, but not in terms of type (cloud-ground, cloud-cloud, and in-cloud), charge (positive or negative), and intensity (amount of current, frequency of strokes, extent of coverage).

The emerging techniques and technology for ground-based LDSs have offered the opportunity for the first time, to obtain a comprehensive picture of lightning activity over large areas of the United States. This in turn has led to growing applications for, and uses of, the data derived from LDSs.

Some of the advantages of LDS data include:

1. Pinpointing convective activity and supporting mesoscale analysis.
2. Discriminating between showers and thundershowers.
3. Increasing lead time for spotting thunderstorms, and
4. Filling data gaps of other observing systems.

In addition, compared to most other observing systems, LDSs are relatively inexpensive, and the use of lightning data requires comparatively little training.

3. LIGHTNING HAZARDS

Although lightning presents a hazard to people in most of the United States, certain areas are much more prone to receive lightning strikes than others due to climatological and topographical factors. The primary area for lightning activity in the United States is contained in a belt along the Gulf Coast extending from Florida to Louisiana (Baldwin, 3). Another major area for lightning includes the Rocky Mountain States—particularly New Mexico and Colorado.

Certain activities and operations are particularly sensitive to lightning hazards. These include many forms of recreation such as boating and golfing, as well as activities carried on by industry including aviation operations, power generation and transmission by utility companies, computer operations, construction, and communications.

4. USES OF LIGHTNING DATA

The major uses of lightning data which have emerged during the past decade are:

1. Protection of federal lands including national parks and forests.
2. Protection of power generating plants and transmission networks (Shepard, 4), and more recently.
3. Meteorological applications.

The first two uses of lightning data are predicated on the idea of early notification of lightning strikes, followed by the rapid deployment of resources to protect property, fight fires, and restore service.

A major cost of maintaining federal lands is connected with fighting forest fires. Studies have shown that getting to the scene of a fire in its early stages will often result in early containment and substantial savings. For this reason, the U.S. Department of Interior's Bureau of Land Management (BLM) has invested in a lightning detection network covering much of the western U.S., where most federal land is located. The BLM had devised its Initial Attack Management System (IAMS), which is designed to rapidly deploy resources to fight forest fires, based on a network of spotters and lightning detectors (OFCM, 5).

Various utility companies have banded together through the Electric Power Research Institute (EPRI) to avail themselves of lightning data—particularly in the eastern U.S. The data is used to monitor field operations, and to assist in the planning of transmission networks.

The foregoing uses of lightning data have helped pave the way for meteorological applications. Of particular significance in the National Weather Service (NWS) has been the application of lightning data by the NWS Western Region. Weather forecasting in the western United States is hampered by a lack of surface and radar observations. The BLM lightning detection network helps to fill the gap, and has proved to be a valuable tool in the detection of thunderstorms. A variety of lightning products are routinely available to forecasters in the western U.S. Sufficient lightning data has now been collected from some networks so as to provide a basis for developing lightning climatologies and refining thunderstorm probability forecasts, particularly in the West.

Other federal agencies have established their own LDSs to meet their unique requirements. These systems are often for local use as opposed to network configurations. Examples include the USAF/NASA local network at the Kennedy Space Center (KSC) in Florida, and the U.S. Department of Energy local network in Texas associated with a munitions plant.

Many federal agencies have research and development programs underway to delve into further applications of lightning data, as well as to establish a more fundamental understanding of how lightning correlates with other weather phenomena. In some respects, research has lagged behind operational use of the data. The National Severe Storms Laboratory (NSSL) is the leading research agency in the United States with respect to research in storm electricity and mesocale convective systems.

An effort is also underway at NSSL to objectively determine how effectively LDSs actually perform. This is being done in central and eastern Oklahoma where lightning detection systems overlap (as shown in Fig. 1). One system is manufactured by Lightning Location and Protection, Inc., while the other system, referred to as LPATS, is manufactured by Atlantic Scientific Corporation. The area of overlap encompasses NSSL facilities

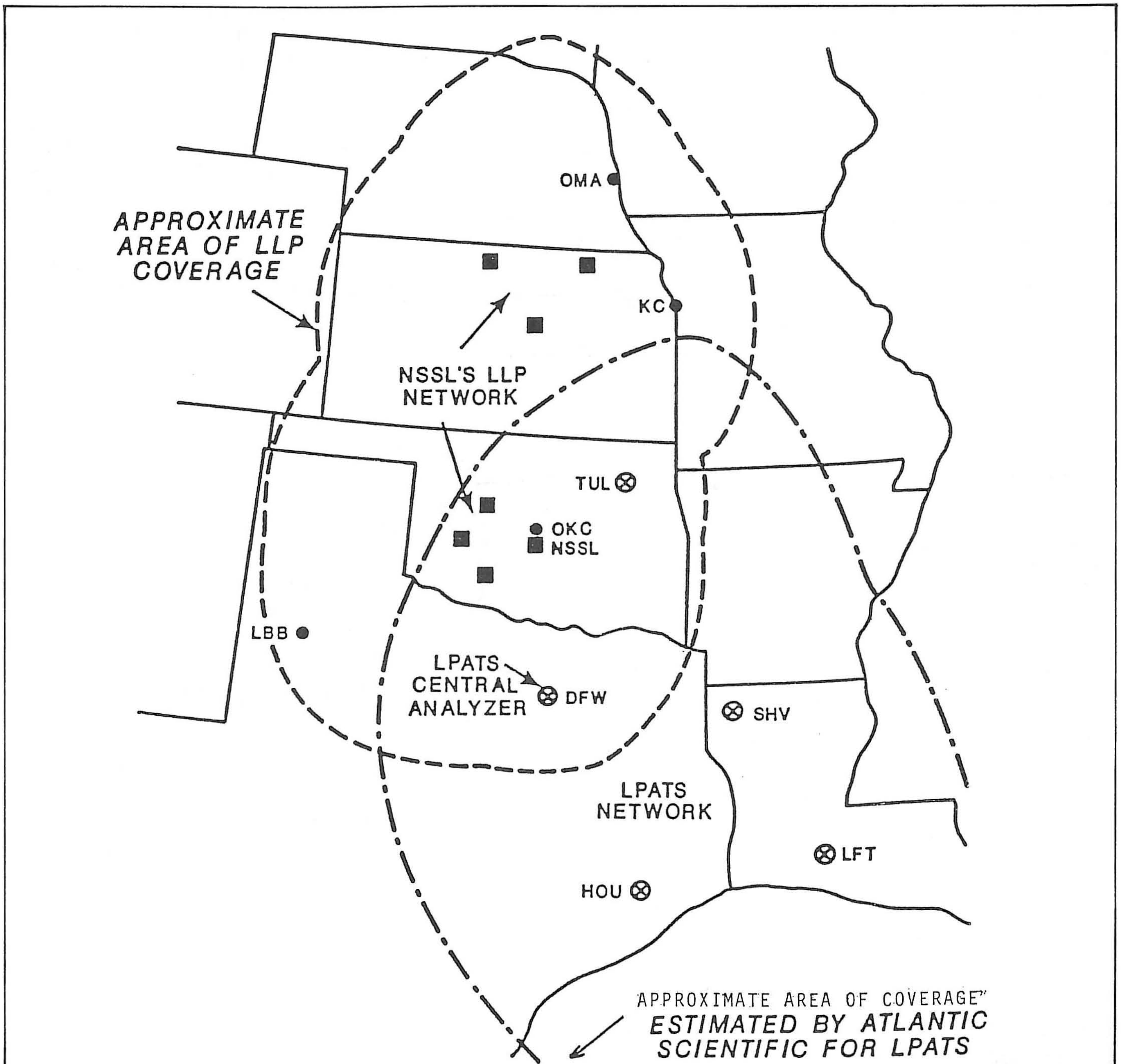

Fig. 1. Coverage of direction-finder (squares) and time-of-arrival (circles) networks. NSSL test being conducted in Oklahoma where the networks overlap.

including mobile storm-chasing vans equipped with video cameras which are used to obtain ground-truth data on lightning strikes. The laboratory also uses two all-azimuth cameras and an extremely low-frequency radio system to provide reliable identification of ground strikes. This is a two-year effort covering 1986 and 1987 with a final report expected in 1988.

5. FUTURE PLANS AND PROGRAMS

Federal agencies, in addition to pursuing a variety of operational and research interests with respect to lightning data, have banded together to share information and coordinate their activities. This is being done through a newly-formed group under the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM). The group has documented the activities of the respective agencies in the lightning field. The group is working toward a national plan for lightning detection systems (OFCM, 6).

Various federal agencies are engaged in operational and resarch activities with lightning data. Some of these have been noted earlier. Others, such as the National Weather Service, are engaged in a variety of field evaluation programs in order to ascertain how lightning data best fits into forecasting operations. Still others, such as the FAA and AWS are beginning to examine possibilities for applying lightning data to operational and development activities.

While ground-based LDSs have continued to proliferate during the 1980's, another device has emerged as a possibility for the 1990's. This is the lightning mapper (LM), which is under development by NASA. The LM is a sensor dsigned to detect lightning activity from space. The LM is being considered as a sensor to be flown on a future geostationary satellite (Christian et al., 7). If the LM is implemented, it is expected to complement ground-based systems by providing coverage of all types of lightning activity over large areas.

5.1 Recent Developments

Interest in lightning detection continues to grow. With LDS coverage now available over most of the U.S., a proposal was presented to federal agencies by the State University of New York (SUNY) at Albany to integrate data from regional networks into a national data base (Orville, 8). The proposal for this experimental effort was accepted, and the effort is expected to last 3 years. Agencies will be able to access the data, at their own cost, for evaluation purposes. As in other areas of data exchange, the use of satellite communications is expected to lower costs for individual users. The "building blocks" for the national data base are shown in Fig. 2.

NOTES AND REFERENCES

1. Mr. Newhouse received the B.S. in Meteorology from the City College of New York, and the M.P.A. from the American University, Washington, DC. He is a former field forecaster and presently a meteorologist at National Weather Service Headquarters, Office of Meteorology, Systems Requirements Branch.

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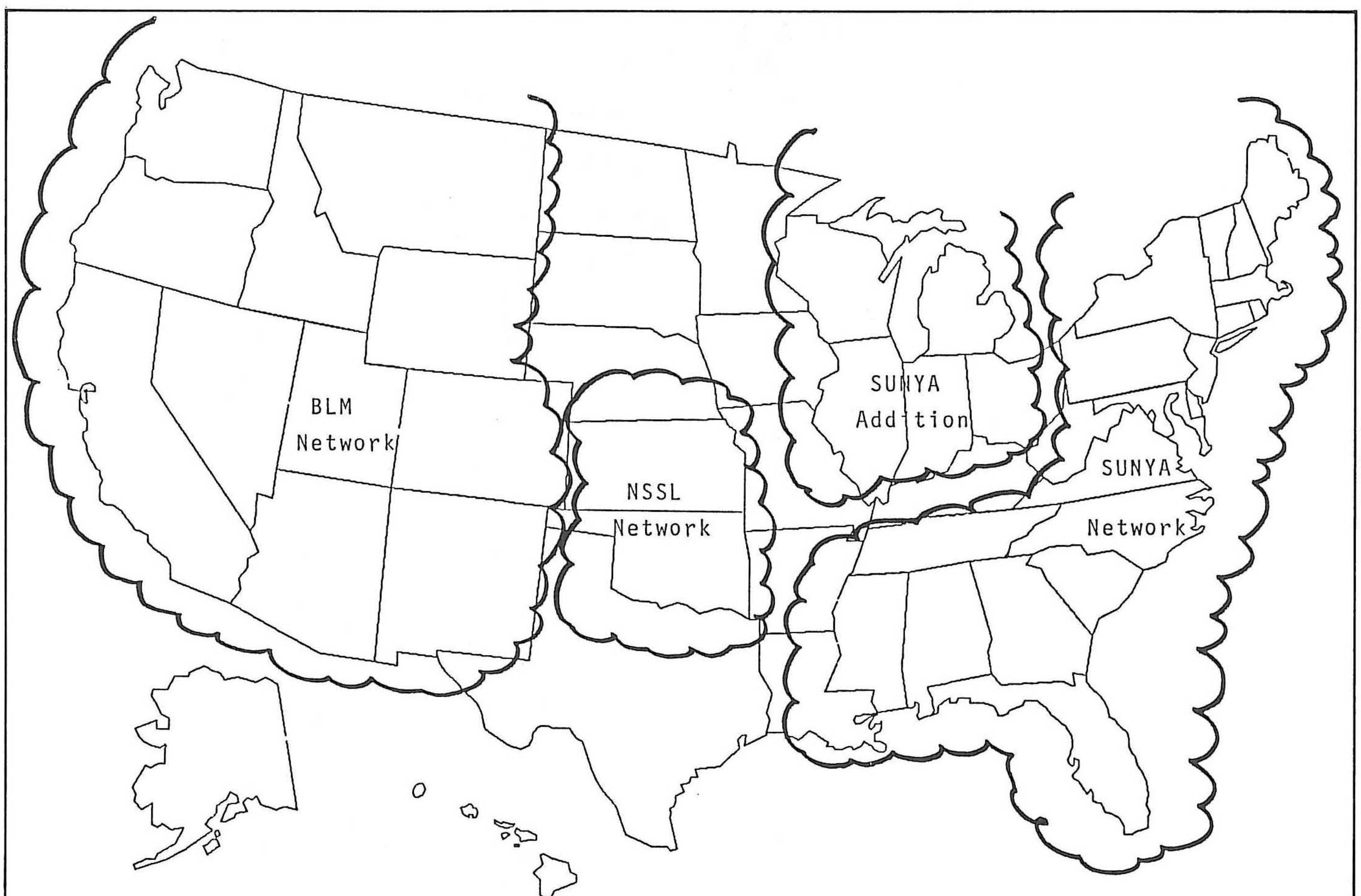

Fig. 2. A National Lightning Detection Network

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