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THE PRODUCTION AND USE OF QUANTITATIVE PRECIPITATION FORECASTS IN THE MODERNIZED NWS AND TDL'S ROLE IN THEIR PRODUCTION

Harry R. Glahn, Jerome P. Charba, J. Paul Dallavalle, and Robert E. Saffle

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1. INTRODUCTION

An important aspect of the National Weather Service's (NWS's) modernization and restructuring program is to provide an environment wherein greatly improved cooperation and coordination is achieved between the hydrology and meteorology components of the NWS. The implementation of advanced technologies such as the Next Generation Weather Radar (NEXRAD), the Automated Surface Observing System (ASOS), the Advanced Weather Interactive Processing System for the 1990's (AWIPS-90), the Next Generation Geostationary Operational Environmental Satellite (GOES-NEXT), profiler, and lightning location networks will provide the detailed observations and forecast information necessary to produce more accurate, site specific, and timely meteorological and hydrologic forecast products. Hydrometeorological services to the public will be significantly improved with the establishment of a Hydrometeorological Analysis and Support (HAS) function in each River Forecast Center (RFC). The HAS personnel, functioning as part of the RFC staff, will be responsible for facilitating support and cooperation between the staffs at collocated RFCs and Weather Forecast Offices (WFOs), and between each RFC and all WFOs within its area of responsibility [Office of Hydrology (OH), 1991a].

Although the variety of products produced by WFOs and RFCs that lie, at least in part, within the ill-defined zone between meteorology and hydrology is considerable, the most important products include flash flood warnings and watches and main-stem river stage forecasts (OH, 1991b). Undoubtedly, the most important observed and/or forecast "weather" element for producing these products is quantitative precipitation, although other observed or forecast elements--such as temperature and soil moisture--can certainly play an important role. Additionally, soil moisture is not only physically dependent on precipitation, but is estimated in real time by the RFCs largely from past precipitation. The sources of quantitative precipitation observations will be considerably expanded within the next few years; a summary of such observations is given in the Appendix.

The users' needs for quantitative precipitation forecasts (QPFs), as well as the techniques available and the input data necessary to produce them, vary by forecast projection. In this paper, this issue is discussed, along with the Techniques Development Laboratory's (TDL's) activities and plans for producing QPF guidance forecasts.

2. USER REQUIREMENTS, AND TECHNIQUES AND DATA FOR PRODUCING QPF GUIDANCE

Figure 1 shows three time (forecast projection) ranges for which most parameters related to the automated production and use of guidance QPFs (and, for that matter, other forecasts) vary. The end points are, of course, not absolute, but only roughly delineate the ranges. Table 1 indicates, for each of the ranges, characteristics of the production of the forecasts and their uses.

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+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+----+----+----+----+
  1 2 3     6          12          18          24    2    3    4    5
  (Hours)           Forecast Projection            (Days)

              +-------------------------------------------------------
                          6 hours - 10 days

  +--------------------------------------+
      1 - 20 hours

+-----+
0 - 3 hours
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Figure 1. Time ranges for producing objective forecast guidance.

A. Range: 6 Hours - 10 Days

The models to use are almost exclusively sophisticated, dynamic models of the atmosphere, together with statistical interpretation of them in terms of QPF. Input to these models, models which might have a resolution on the order of 80 km, would be from a variety of sources, including wind, temperature, and moisture from radiosondes; profilers; Doppler radar winds; aircraft; surface observations; and satellites. Today's models produce QPFs, generally accumulated over some period of time such as 6 hours. QPFs directly from dynamic models are not always well calibrated, and changes to the models may change the characteristics of the QPFs.

The Regional Analysis and Forecast System (RAFS), with its imbedded Nested Grid Model (NGM) (Hoke et al., 1989), was built at the National Meteorological Center (NMC) "...with a fundamental goal of improving the operational forecasts of heavy precipitation out to 48 hours" (NWS, 1985), although the grid spacing (about 80 km at 40° N) and twice-per-day cycle cannot meet all AWIPS-era WFO and RFC short-range forecast needs. The RAFS data available to the WFO in gridpoint form will be for 2-h increments out to 24 hours and at 6-h increments from 24 hours to 48 hours, and will have a resolution of 40 km[1] at 35° N (NWS, 1990, AWIPS-90 SRS, current version Appendix K, p. SRSI-K-41). Gridpoint data from the aviation/global model will also be available on a 40-km grid and will be produced four times per day (Ibid., p. SRSI-K-45).

The mesoscale model being developed at NMC will likely have a grid spacing of 35 to 50 km and will be run four times per day (BAMS, 1990). Data will be available at 2-h intervals out to 18 hours, then at 3- or 4-h intervals to 36 hours, all on a 20-km grid (NWS, 1990, AWIPS-90 SRS, current version

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[1] Note that even though the data are planned to be made available and stored at a resolution of 40 km, the basic data are produced by the model at only 80-km resolution. This allows a better rendition of the forecasts when they are transformed from the polar stereographic map projection on which they are produced to the Lambert map projection for use at WFOs.

Table 1. Characteristics of products, data, and techniques for time ranges of forecasts shown in Fig. 1.

Characteristic	Range 0-3 Hours	 1-20 Hours	 6 Hours-10 Days
Products Supported	Flash Flood Warnings	Flash Flood Warnings/ Watches Main Stem River Forecasts	Main Stem River Forecasts Flash Flood Watches
Spatial Resolution Needed	2-20 km	10-40 km	40-80 km
Projection Resolution Needed	10 minutes - 1 hour	1 hour - 6 hours	6 hours - 24 hours
Production Frequency Needed	Each 5 to 10 minutes	hourly	2 to 4 per day
Predominant Input Data Type	Radar Reflectivity Lightning Strike Surface Obs Profiler Radar Winds	Numerical Model Output Radar Reflectivity Surface Obs Radar Winds Radiosonde Profiler Satellite	Radiosonde Radar Winds Aircraft Profiler Satellite Surface Obs
Models/ Techniques	Extrapolative Statistical Advective Statistical Interpretive	Mesoscale Dynamic Advective Statistical Interpretive	Primitive Equation Dynamic Statistical Interpretive

Appendix K, p. SRSI-K-39). Eventually, of course, even finer resolution models will be implemented, especially as upper air observations become more frequent in space and time.

Partly because most uses of QPFs require the forecasts to be unbiased,[2] statistical interpretation of the numerical model output is desirable. TDL has been providing QPF forecasts to NMC and field forecasters based on the

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[2] "Unbiased" means that no matter what area the precipitation forecast applies to, it is the expected amount averaged over that defined area. As an illustration, if 1 inch of precipitation were forecast at a point or over some particular area on many occasions, the observed amounts, averaged over the area and over those occasions, should be approximately 1 inch.

Model Output Statistics (MOS) concept since 1977 (Carter, et al., 1989). Current plans are to provide twice daily the probability of liquid equivalent precipitation for the amounts and periods shown in Table 2 for about 600 locations in the continental U.S.

Table 2. Characteristics of statistical QPF guidance to be produced centrally for 6- to 60-h projections. In addition to probabilities, an expected amount will be furnished for each projection.

Element/Projection	Definition
6-h PoP	Probability of 0.01 inches or more of liquid equivalent precipitation in a 6-h period.
12-h PoP	Same as 6-h PoP, except over a 12-h period.
24-h PoP	Same as 6-h PoP, except over a 24-h period.
6-h QPF	Probabilities of categories ≥ 0.10, ≥ 0.25, ≥ 0.50, and ≥ 1.00 inches of liquid equivalent precipitation in a 6-h period. 6-h PoP and 6-h QPF are combined to produce categorical forecasts of ≤ 0.01 inches, 0.01-0.09, 0.10-0.24, 0.25-0.49, 0.50-0.99, and ≥ 1.00 inches of precipitation. Also, an unbiased estimate of precipitation amount will be made.
12-h QPF	Same as 6-h QPF, except ≥ 2.00 inches of precipitation is also forecast. Categorical amounts include 1.00-1.99 and ≥ 2.00 inches.
24-h QPF	Same as 12-h QPF.

These 600 locations are essentially all those for which surface observations have been taken over a substantial period of time and are currently being reported in a timely manner. The guidance forecasts based on the NGM will cover 6-, 12-, and 24-h intervals. The 6-h (12-h) interval forecasts will be for every 6 (12) hours, the first interval being 6-12 (12-24) hours after model cycle times (0000 and 1200 UTC). The 24-h interval forecasts will be every 24 hours, the first interval being 12-36 (24-48) hours after cycle time of 0000 (1200) UTC. Forecasts will be of the probability of each of the amount categories shown in Table 2, and there will also be an expected amount provided.[3] Although these guidance forecasts are for specific locations, they can be mapped to a grid. Such grids, as well as the point values, can be used by the Meteorological Operations Division (MOD) of NMC and at WFOs.

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[3] Currently, the algorithm for producing a categorical forecast from the probabilities gives a biased forecast--one that, to some extent, maximizes the threat score [or, equivalently, the critical success index (NWS, 1982)]. If the unbiased estimates needed for hydrologic models do not meet other users' needs, the current algorithm (or another suitable one) can also be used to provide another categorical forecast.

There are no firm plans to develop statistical guidance specifically tailored to the new mesoscale model, although that will be considered after the model has been operational for a while and in light of available resources.

MOD uses all the information available to it, including direct model output and statistical interpretation of it, to arrive at QPF products. Now graphical in form, products will also be available in the AWIPS-era in digital, gridded form. It is planned that these will be produced regularly four times per day and be updated as often as every 3 hours when requested by the field or deemed necessary by NMC. Products will include 6-hourly forecasts valid from 6 hours to 36 hours, 12- and 24-hourly forecasts for longer projections, and an excessive rainfall outlook (NMC, 1990, pp. 16-21). The gridpoint products will have a grid length of 40 km at 35° N (NWS, 1990, AWIPS-90 SRS, current version Appendix K, p. SRSI-K-47). Although these products will undoubtedly evolve over time, it is likely the time and space scales will continue to be commensurate with NMC's highest resolution model being run at the time. The 6-hourly forecasts can be produced about 2 hours after the model data that the forecasts are to be based on are available (NMC, 1990, p. 20).

B. Range: 1 - 20 Hours

Experimental, limited-area, dynamic mesoscale models have been in existence for over a decade. Success, however, has been considerably more limited than with the hemispheric and global models which concentrate on synoptic scale features. Because of this and other factors, including the computer time that would be involved in both development and operations, TDL plans to implement a system which will make use of advective models rather than sophisticated, primitive equation models. Although rather simple, the sea level pressure model and the moisture model being used are actually the so-called Reed and SLYH models, respectively, which were run at NMC in the early days of numerical weather prediction.[4]

This system will cover the gap that exists between the very fine resolution Weather Surveillance Radar-1988, Doppler (WSR-88D) related products--products that can be produced every few minutes and could be valid for projections up to 2 or 3 hours after the radar volumetric scan--and the considerably coarser resolution, centrally produced products that will be available on the order of every 6 or 12 (and on an ad hoc basis, every 3) hours. Basically, it is an update system--one that will be exercised each hour, as needed, and will update the centrally produced MOS QPF forecasts in the 1- to 20-h time period. The QPF forecasts will be made on a 20-km grid, and will be available about 15 minutes after the most recent observations input to the system. This is the same resolution as most gridpoint data that will be stored on the AWIPS Local Area (NWS, 1990, AWIPS-90 SRS, p. SRSI-A-10). The characteristics of this QPF guidance to be produced locally are shown in Table 3.

Some adjustments may need to be made based on observed relative frequencies of rainfall in specific amount and range bands. Also, further coordination with the Offices of Meteorology and Hydrology may necessitate modifications as planning for the production and use of QPFs progresses.

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[4] The Reed and SLYH models have been tailored somewhat for the specific use being made of them (see Glahn and Unger, 1986).

Table 3. Characteristics of statistical QPF guidance to be produced locally for 1- to 20-h projections. In addition to probabilities, an expected amount will be furnished for each projection.

Element/Projection	Definition
1-h QPF	Probabilities of amounts in categories ≤ 0.09, 0.10-0.24, 0.25-0.49, 0.50-0.99, 1.00-1.99, and ≥ 2.00 inches. Valid for the 0-1 and 1-2 h periods after nominal run time.
2-h QPF	Same as 1-h QPF, except over a 2-h period. Valid for the 1-3 h period after nominal run time.
3-h QPF	Same as 1-h QPF, except over a 3-h period. Valid for the 1-4 h period after nominal run time. Also, 3-h QPFs are provided for two time periods fixed to UTC, e.g., 0900-1200 UTC and 1200-1500 UTC, etc. for a nominal run time of 0500 UTC.
6-h QPF	Same as 1-h QPF, except over a 6-h period. In addition, the upper category will be split into 2.00-2.99 and ≥ 3.00 inches. Valid for two time periods fixed to UTC, e.g., 1200-1800 UTC and 1800-0000 UTC for a nominal run time near 0500 UTC.

In order to accomplish the objective of providing the guidance defined in Table 3 in time for an AWIPS Initial Operating Capability (IOC), it is necessary to use the LAMP (Local AWIPS MOS Program) framework which has been under development for a number of years (see Glahn and Unger, 1986, and Unger et al., 1989). However, in most respects, the QPF work is a new developmental effort, started only a year or so ago. Multiple linear regression, with all of the variations that TDL has used in the past, such as appropriate stratification of data samples in time and space, use of binary and interactive predictors, etc., will be used to obtain the relationships between the predictands and predictors.

A similar QPF product has been developed previously by Charba (NWS, 1987); this product has been produced at NMC and has been available on the Automation of Forecast Operations and Services (AFOS) System for some start times and seasons since May 1987. Therefore, much of what was learned in that work can be applied to the new development. Objective analyses of surface observations and computations made from them, such as moisture divergence, are extremely important for the first few hours after observation time. The development of displaced, interactive, and linearized predictors to insert into the linear regression equations is quite important. Basically, these "derived" predictors allow highly nonlinear relationships between predictands and "raw" predictors to be accounted for.

Forecasts for projections beyond a few hours must rely heavily on the output of complex numerical models. In LAMP, the intelligence of such models run at NMC is carried to the local system through MOS. ("MOS" is used here in a rather generic sense, meaning "statistical guidance." The exact procedures used today need not be used in the future.) This allows LAMP to be an "update" system and not "cut loose" from the centralized MOS. This procedure also has the advantage of greatly reducing the development and implementation effort by decreasing the number of predictor variables involved. Furthermore, the LAMP relationships must be developed in such a way that they will be highly stable over time; the biases of MOS will likely be much more controlled than the biases of individual variables provided by a variety of NMC models. MOS is very important beyond a few hours, and in general, LAMP forecasts become very close to MOS forecasts by about 18 or 20 hours.

Detailed climatic variables--specifically, relative frequencies of rainfall amounts stratified by time of day and of year--are quite important. Although the data currently available are barely adequate, TDL will establish such climatic "maps" on a 20-km grid. It is expected that these will be important predictors in "sharpening" the probabilities that would be obtained without such climatic frequencies. The detailed climatic variables, together with topography on that same scale, will interact with synoptic and sub-synoptic variables to simulate orographic controls on the distribution of heavy rainfall.

Radar data will play an important role, although developmental data are currently available only at 40-km resolution. It is expected that such data will enter directly into the equations, and radar data also provide an important element of the objective analysis of atmospheric moisture used as input to the moisture advection model of LAMP. As WSR-88D data become available, they will be used at a 20-km resolution, commensurate with the scales of the topographic and climatic data. Precipitation estimates from satellites can also contribute to the initial analysis, especially where radar coverage is less complete, such as in the western mountains.

Some enhancements will be necessary to existing software to accommodate QPF development on a grid. Also, LAMP at present uses an 80-km grid (having been developed and tested on AFOS), and some accommodation must be made for more resolution, although a 20-km QPF grid does not necessitate that all of LAMP be run on a 20-km grid. Eventually, especially as finer-scale data become available, more of LAMP will be run on a finer-scale grid.

C. Range: 0 - 3 Hours

The production of quantitative precipitation analyses and QPFs for the 0- to 3-h time period will involve a combination of objective techniques and forecaster interactions and procedures. The final products will support routine forecasts and flash flood watches and warnings at WFOs, as well as main stem river flow forecasting and flash flood guidance (FFG) generation at RFCs.

A basic input to many of the procedures for this time period will be the 1-h Digital Precipitation Analysis (DPA) produced by the WSR-88D as part of Stage I processing. This product [on the 4-km, Hydrologic Rainfall Analysis Project (HRAP) grid, a grid which is a superset of the NMC Limited-area Fine Mesh (LFM) grid related to the polar stereographic map projection] will be objectively quality controlled (QCed) through WFO Stage II processing (planned for AWIPS IOC), which will make use of GOES infrared data, rain gauge data, and eventually other hydrological information (OH, 1991a, p. 3-31; Requirement 6.1.5, AWIPS-90 SRS, Vol. 1, p. 2J-22, and p. SRSI-G-1.74). The QCed product will be available for further WFO use and will also be transmitted to those RFCs having a need for it. At RFCs, it will be used in Stage III mosaicing which will start in the Modernization and Associated Restructuring (MAR) Initial Stage 2 (OH, 1991a, pp. 2-42, 2-46). The mosaic product will, along with rain gauge data, be used to generate FFG values "at least four (times) per day" (OH, 1991a, p. 2-59).

A very short range (0- to 3-h), high areal resolution (4- to 20-km) QPF product is being developed by TDL. This product will be generated for time periods of 0 to 30 min; 0 to 1 hour; and, if shown to improve upon the 1-20 hour techniques, 1 to 3 hours. The product is intended primarily to support the flash flood warning mission at the WFO and will be a candidate for incorporation into the WFO Flash Flood Potential (FFP) technique. The FFP technique will use Qced DPAs, QPF values, and FFG values to calculate flash flood potentials for specific periods such as 1 hour and 3 hours.

The key features of the TDL QPF algorithm are its grounding in statistical relationships between observed rainfall and a variety of radar-derived predictors, and its use of extrapolated patterns of the precipitation field. The combination of these features should lead to forecasting skill beyond that available from other currently-available techniques.

The TDL 0-3 h QPF algorithm will utilize predictors such as low-level reflectivity, vertically integrated liquid water (VIL), echo top heights, and the Qced DPA. The final rainfall forecast will be a function of these fields, both at the latest radar scan time and as extrapolated forward during the forecast period. Statistical regression on a sample of historical cases will be used to determine the optimum combination of predictors. Most other techniques (Austin and Bellon, 1974; Walton and Johnson, 1986; Andersson and Ivarsson, 1991) have treated rain rate strictly as a function of low-level reflectivity through the Marshall-Palmer relationship. However, earlier research (Saffle and Elvander, 1981) suggests that extrapolative forecasts of the precipitation field can be improved by incorporating volumetric reflectivity observations.

In this context, an effort is underway to assess the relative merits of different methods of estimating a storm motion vector. The methods being tested include pattern matching of current and previous base elevation reflectivity fields, similar pattern matching for VIL fields, analysis of the movement of heavy precipitation "cores" during the previous hour, and inference from environmental "steering" winds. Experiments will also be carried out with an adaptive approach that utilizes either pattern matching or environmental winds, depending upon which has best tracked the radar field over the previous 30 minutes. The main criterion for deciding upon a "best" method will be skill in extrapolating the stronger features of the predictor fields. [See Elvander (1976) and Saffle and Elvander (1981) for further discussions of this topic.]

The developmental data for the 0-3 h QPF algorithm will be Radar Data Processor, Version II (RADAP II) archives of Weather Surveillance Radar, Model 57 (WSR-57) reflectivity data and hourly climatic rain gauge data. Since the rain gauge network is very sparse compared to the resolution of radar products, radar-based estimates will be used for observed precipitation amounts in the relationship development procedure. The rain gauge values will be used as independent data for verifying the relationships.

The output of the algorithm will consist of the probability of rainfall accumulation above certain threshold amounts (see Table 4) for 0-30 minute and 0-60 minute periods, and the expected accumulation for each period. A 1-3 hour product will also be developed, but it is anticipated that additional predictors involving mesoscale moisture divergence, humidity, and static stability will be required in addition to the radar data. The skill of the 1-3 hour forecasts will be compared to the same period forecasts from the 1-20 hour QPF techniques discussed earlier. If sufficient skill is demonstrated, the algorithm will combine outputs to produce a 0-3 hour QPF. The spatial resolution of the forecasts will be chosen based on verifications of skill, but the goal is to have a resolution of 4 to 10 km for the 0-30 minute period and 10 to 20 km for longer periods. Regardless of the forecast spatial resolution, the algorithm will interpolate the forecast values to grid resolutions required (e.g., the 4-km HRAP grid).

Table 4. Characteristics of statistical QPF guidance to be produced locally for 0- to 3-h projections. In addition to probabilities, an expected amount will be furnished for each projection.

Element/Projection	Definition
0-30 minute QPF	Probabilities of amounts greater than or equal to 0.1, 0.5, 1.0, and 2.0 inches.
0-60 minute QPF	Same as 0-30 minute QPF, except for 60-minute period.
1-3 h QPF	Same as 0-30 minute QPF, except for 1-3 h period.

Each WFO will produce subjective, 0-6 hour QPFs on a fine time and space scale for its forecast area. These QPFs will be used in the routine forecasting and flash flood watch areas; they will also be transmitted to necessary RFCs for mosaicing and use within the river flow forecast models. HAS personnel at the RFCs will ensure consistency among the QPFs received from the set of WFOs within the RFC area of responsibility. The WFO forecaster will use QCed DPAs; short range, objective QPFs (from both the 1-20 h and the 0-3 h techniques); and other hydrometeorological products within the AWIPS database as input for the QPF preparation. Although this task could be time consuming for the forecaster, "the entire QPF preparation procedure will be highly automated to ensure that a minimal amount of WFO staff time is required" (OH, 1991a, p. 2-47). In order to reduce the staff time needed, it is imperative that good guidance be provided for this critical product and that efficient interactive procedures be available in AWIPS. The interactive capability will be provided by AWIPS at IOC (Requirement 9.1.1, AWIPS-90 SRS, Vol. 1, p. 2J-22, p. 3J-11, and p. SRSI-G-1.93). We believe that the short range QPF product being developed in TDL will contribute substantially to the quality QPF guidance needed.

D. SUMMARY AND CONCLUSIONS

As was indicated earlier, the spatial and temporal resolution of guidance needed by WFOs and RFCs, as well as the data and techniques for producing that guidance, varies with projection. The "need" for guidance is largely the result of technological capabilities. That is, we would like to be able to make an accurate flash flood forecast for a small stream a day or more in advance. However, our data and techniques/models only allow for a much smaller lead time.

It is TDL's intent to develop and implement QPF guidance covering the range from a few minutes and a few square kilometers to about 2 1/2 days. The longer projections, even though the forecasts may be for points, will not have fine spatial detail. Every effort will be made to provide unbiased (expected) amounts, usually from a probability base, which will also be available to the forecasters.

The 1-20 hour forecasts produced locally will be true updates of the longer range, centrally produced guidance. Although the details are not as clear yet, the 0-3 hour techniques and the 1-20 hour techniques must be merged in some way so that a 2-h forecast from the former will be substantially an update of the latter.

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APPENDIX

SOURCES OF QUANTITATIVE PRECIPITATION OBSERVATIONS

A. NEXRAD Quantitative Precipitation Estimates

Probably the most useful "observation" of quantitative precipitation, especially for flash flood warnings, will be produced by NEXRAD, although it is, of course, actually an estimate based on remotely sensed precipitation particles, calibrated by rain gauge observations when feasible. The space and time scales will be much better (on the order of a few kilometers and 5 or 6 minutes) than any other source. Stage I Precipitation processing (see OH, 1991a, p. 2-28, for a description of the stages of precipitation processing), of these data will occur within the WFO's WSR-88D computer. Stage I products will include temporal resolutions of 1 hour [One Hour Precipitation (OHP), Digital Precipitation Array (DPA)], 3 hours [Three-Hour Precipitation (THP)], and storm duration [Storm Total Precipitation (STP)]. The OHP, DPA, and STP products will be updated at the frequency of the radar volume sampling interval; the THP will be updated hourly. The OHP, THP, and STP products will be generated on a 2-km grid and the DPA on a 4-km grid. These products are discussed in the Federal Meteorological Handbook No. 11, Part C (Office of the Federal Coordinator, 1991, pp. 2-45, 2-46, 2-47, 2-77, 2-78, 2-85, 2-86). Finer temporal resolution can be obtained by subtracting two successive storm total products.

B. Conventional Surface Observations

Not only will present-day airways reports and synoptic observations and the replacement ASOS observations be available on a scheduled basis, but the ASOS sites will be able to furnish information much more frequently to AWIPS. ASOS will generate record and special Surface Airways Observations (SAOs) in approximately the same format as today's SAOs, but specials may be generated more frequently than under present-day manual procedures. Messages containing measured quantitative precipitation information encoded in Standard Hydrometeorological Exchange Format (SHEF) will also be sent automatically as often as every 15 minutes when either the 15-minute or 1-h alert criterion is met. When the 15-minute (1-h) criterion is met, the last four 15-min (1-h) incremental amounts will be sent (NWS, 1988, ASOS RFP, Appendix A to Section C, dated October 18, 1988, pp. C-A-232-237, Solicitation pages 455-460; NWS, 1990, AWIPS-90 SRS, p. SRSI-E-2). In addition, a forecaster can request of ASOS, via AWIPS, the latest fixed field weather message; such messages are generated by ASOS, for release when polled, once each minute. These messages contain essentially the same weather variables as the SAOs, including precipitation occurrence and intensity (NWS, 1988, ASOS RFP, Appendix I, dated May 1989, Solicitation pages 669-704). Such messages will be requested by AWIPS every 15 minutes (5 minutes) when in the Alert (Warning) mode (NWS, 1990, AWIPS-90 SRS, p. SRSI-4-8 and p. SRSI-E-3).

C. Local Area Networks, Data Collection Platforms, and Cooperative Observations

In certain localities, there are local observing sites (or networks), that report precipitation in real time (e.g., IFLOWS, ALERT, ROSA). These will undoubtedly expand, at least to some extent, in the future. These reports will be accepted (collected) by AWIPS[5] at WFOs or, for many of the Data Collection Platforms (DCPs), the data will come to WFOs and RFCs via satellite, the NWS Telecommunications Gateway (NWSTG), and the AWIPS Communications Network (ACN). Reports from various automated observing systems, such as the Automatic Hydrologic Observing System (AHOS), and cooperative observations will be collected by AWIPS as available (NWS, 1990, AWIPS-90 SRS, pp. SRSI-E-1-9).

D. Satellite Precipitation Estimates

Each WFO will receive precipitation estimates obtained via AWIPS from the National Environmental Satellite and Data Service (NESDIS). Although the AWIPS SRS indicates this will be an alphanumeric product that will be produced by NESDIS twice per day but as often as 48 times per day "depending on weather situation" (NWS, 1990, AWIPS-90 SRS, p. SRSI-K-49) and that there could be as many as 12 per day pertaining to a particular WFO (Ibid., p. SRSI-F-40), NESDIS indicates this will be a gridpoint product (NESDIS, 1990, p. 2). Agreement needs to be reached as to whether automated estimates will be sent, whether both automated estimates and those produced interactively will be sent, and what grid the data will be in reference to, if indeed a gridpoint product is produced. The NESDIS document implies a Lambert projection for the conterminous states, but other rainfall data used at WFOs and RFCs are on the polar stereographic projection.

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[5] Plans are being formulated for a separate device to actually collect such data and to provide them to AWIPS.