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Operational Applications of Real-time Lightning Data

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***Abstract*—Schneider Electric, the nation's leading business weather organization, has a long-standing partnership with Vaisala, utilizing their real-time lightning information to provide improved severe weather services to its clients. Beyond monitoring and alerting of lightning, Schneider Electric has merged the data from Vaisala's various lightning networks with other appropriate real-time meteorological datasets to provide enhanced operational functionality for use either by its team of meteorologists or for a value-add into its forecast generation process. This paper will detail the integration of the advanced datasets, specific customer requirements, and the output of results.**

Keywords—weather; forecasting; lightning; meteorology

I. INTRODUCTION

Schneider Electric has been a long-time business partner with Vaisala, integrating real-time, global lightning data into its proprietary suite of MxVision WeatherSentry™ products. The product suite provides location specific weather forecast information along with advanced decision support tooling, including patented alerting capabilities.[1] The combination of state-of-the-art lightning datasets along with custom alerting capabilities allows business professionals to monitor developing weather conditions, assisting with critical decisions for planning, preparing, and mitigation of severe weather to their operations.

Beyond providing enhanced severe weather management tools to thousands of organizations, Schneider Electric employs a team of fifty degreed Meteorologists who provide custom weather content and consultation to its client base. Through various Meteorologist tooling applications and dataset integration, the Schneider Electric Meteorology Operations (MetOps) team utilizes real-time lightning datasets for cutting-edge operational functionality. Each forthcoming section will highlight how Schneider Electric applies real-time lightning datasets for specific customer or forecast application usage beyond its standard product offerings.

[1] Products mentioned may be covered by one or more of the following patents: U.S. Patent No. 6,753,784, or 7,602,285.

II. CUSTOM LIGHTNING DENSITY APPLICATION

Schneider Electric's MetOps team works closely with managers at a Florida-based power utility who are responsible for the transmission and distribution of power, including restoration when lightning impacts their service territory. Like many utilities, the customer requires an understanding of real-time lightning information to allow for appropriate staffing resources during critical restoration efforts.

Florida has long been known as having one of the highest flash densities (fl/sq km/yr) throughout the United States,[2] thus being able to quantify the amount of cloud-to-ground lightning impacting a given section of the customer's service territory is more valuable than just displaying raw lightning information.

Working in conjunction with the customer's in-house Meteorologist, a scale was devised that highlights the density of lightning across the customer's service territory. The 'Storm-Scale' is a rolling one-hour depiction of cloud-to-ground lightning over a 5km by 5km grid across the state of Florida. The depiction recalculates the rolling storm scale every 5 minutes and is based on a one through six scale as illustrated in Table 1. Each level, one through six, relates to a specific restoration action for the customer when lightning impacts a given area.

To visually represent this information, Schneider Electric created a web-based product that utilizes Vaisala's National Lightning Detection Network (NLDN) feed coupled with the 5km by 5km grid over the state of Florida applied to an open-source mapping technology. Every 5 minutes, the page refreshes with the latest information, calculating total cloud-to-ground lightning in the previous 60 minutes across each grid of the approximately 3 square miles of operating area. Schneider Electric's team of Utility Meteorologists view this information with a standard color coding as depicted in Fig. 1 and have specific alerting procedures for customer delivery notification.

[2] http://goo.gl/MAB8sL

TABLE I. STORM SCALE LEVEL DEFINITION FOR FLORIDA UTILITY COMPANY

Storm Scale Level	Cloud to Ground Lightning per rolling 60 minutes (5km x 5km grid area)
1	None
2	1-75
3	76-150
4	151-300
5	301-450
6	451+

In summary, through building a custom client-specific lightning density scale, Schneider Electric is able to communicate to the customer potential impacts from lightning on terms that are immediately actionable to their operations.

III. ENHANCED AVIATION FORECAST GENERATION AND TOOLING

The Schneider Electric MetOps team was built upon Aviation weather services and has been providing Terminal Aerodrome Forecasts (TAF) to a wide variety of clients since 1981. A TAF is a concise statement for reporting weather forecast information, particularly as it relates to Aviation. TAFs generally apply to a 24 or 30 hour period and an area within approximately five statute miles from the center of an airport runway complex.

Utilizing hourly updating meteorological model guidance, Schneider Electric recently created an automated TAF engine, completely reinventing the manner in which TAFs are prepared and managed on a daily basis. The end result is the new Synchronized Model and Real-Time Terminal Area Forecast (SMaRT-TAF) allowing for increased scalability of a once laborious product.

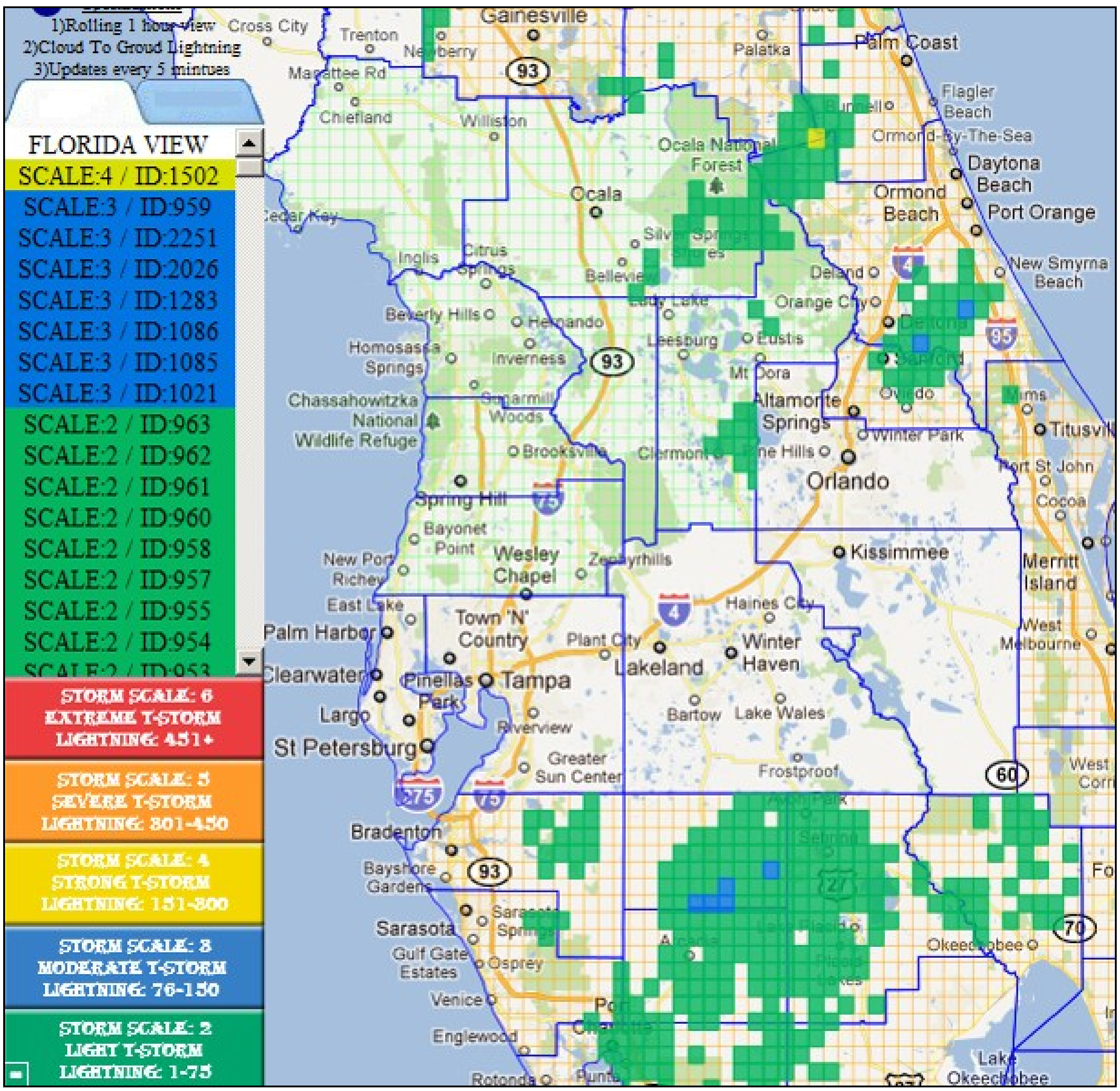

Fig. 1. View of Custom Storm Scale Lightning Density Display for Florida Utility

Schneider Electric has integrated real-time lightning information into the initial creation of the SMaRT-TAF, but equally as important, into a monitoring tool, alerting the meteorologist that an amendment may be required as the forecast period progresses.

Creation—The first essential component required for the creation of a SMaRT-TAF is a clean METAR observation. METAR is the name of the international meteorological code for an aviation routine weather report. METAR observations are normally taken and disseminated on the hour. This presents a challenge as weather conditions can rapidly change between METAR observations. Since METAR information is typically available once every hour, real-time lightning data is used to make thunderstorm forecasting within the SMaRT-TAF as proactive as possible. Thunderstorms are inserted into the first hour of the SMaRT-TAF if lightning from Vaisala's Global Lightning Dataset (GLD360) is detected within 20km of the aerodrome.

Monitoring—SMaRT-TAFs, while meteorologically sound, are forecasts and must be monitored for any required amendments based on evolving weather conditions. Schneider Electric created a web-based interface to perform this task (Figure 2).

The SMaRT-TAF Monitor tool was designed to organize the SMaRT-TAF so that it clearly depicts the SMaRT-TAF that is in the most need of attention by the Meteorologist. SMaRT-TAFs are continuously compared with METAR observations evaluating the overall forecast compliance. Examples for potential amendments to the forecast include ceiling height, visibility, wind speed, and direction. As mentioned above, the use of real-time lightning information from the GLD360 has also been built into the SMaRT-TAF Monitoring tool to alert the meteorologist that lightning is within 20km of the aerodrome and not currently being advertised in that period of the SMaRT-TAF. After the monitoring tool identifies lightning within a certain radius of the airport, a new SMaRT-TAF is automatically created and the Meteorologist can choose to immediately issue to the client or reevaluate.

All sites checked at 2014-01-29 21:31:24Z Refresh

	AMD	Site	RAMTAF	METAR	SMaRT-TAF	Causes	Age
		OEGN	1/29/2014 13:30	1/29/2014 21:00	1/29/2014 21:31	Cat,V	08:07
		TXKF	1/29/2014 20:58	1/29/2014 20:55	1/29/2014 21:31	C	00:39
		EPKT	1/29/2014 20:40	1/29/2014 21:00	1/29/2014 21:31	V, C	00:57
		KHDN	1/29/2014 19:10	1/29/2014 21:15	1/29/2014 21:31	V, C	02:27
		OERK	1/29/2014 13:00	1/29/2014 21:00	1/29/2014 21:31	D, V	08:37
		TDPD	1/29/2014 20:15	1/29/2014 21:00	1/29/2014 21:31	C	01:22
		UCFM	1/29/2014 18:56	1/29/2014 21:00	1/29/2014 21:31	Time	02:41
		KESC	1/29/2014 14:14	1/29/2014 21:15	1/29/2014 21:31	S	07:23
		KTEX	1/29/2014 18:08	1/29/2014 21:15	1/29/2014 21:31	D, S	03:29
		MKJS	1/29/2014 13:27	1/29/2014 21:00	1/29/2014 21:31	D, S	08:10
		KMVY	1/29/2014 21:14	1/29/2014 20:53	1/29/2014 21:31		00:23
		KDRO	1/29/2014 14:08	1/29/2014 20:53	1/29/2014 21:31		07:29
		UATE	1/29/2014 20:55	1/29/2014 21:00	1/29/2014 21:31		00:42
		2AL4	1/29/2014 13:30	1/29/2014 20:53	1/29/2014 21:31		08:07
		KOAJ	1/29/2014 21:20	1/29/2014 21:15	1/29/2014 21:31		00:17
		KDTW	1/29/2014 21:14	1/29/2014 20:53	1/29/2014 21:31		00:23
		UHHH	1/29/2014 20:34	1/29/2014 21:00	1/29/2014 21:31		01:03
		KELM	1/29/2014 21:14	1/29/2014 20:53	1/29/2014 21:31		00:23
		UHWW	1/29/2014 20:37	1/29/2014 21:00	1/29/2014 21:31		01:00
		7LA5	1/29/2014 20:08	1/29/2014 20:53	1/29/2014 21:31		01:29
		KOSC	1/29/2014 21:20	1/29/2014 21:14	1/29/2014 21:31		00:17
		OEGS	1/29/2014 19:01	1/29/2014 21:00	1/29/2014 21:31		02:36
		UKFF	1/29/2014 20:45	1/29/2014 21:00	1/29/2014 21:31		00:52
		7LS3	1/29/2014 13:30	1/29/2014 21:15	1/29/2014 21:31		08:07

Fig. 2. Schneider Electric SMaRT-TAF Monitor Tool

In summary, Schneider Electric is leveraging real-time lightning information for both the generation and monitoring of its SMaRT-TAF technology to ensure that its Aviation customers have the most up-to-date forecast to mitigate the risk of lightning on operations.

IV. Near Term Convective Precipitation Forecasting Using Real-Time Lightning Data

Schneider Electric staffs meteorologists on a 24x7 basis to continuously produce short-term (0-84 hour) precipitation forecasts for our suite of MxVision WeatherSentry™ products. The meteorologist utilizes a blend of high resolution weather model data as the baseline for the forecast and then tweaks accordingly given their experience towards a given meteorological situation. This combination of human interaction with a blend of superior forecast models has proven successful as Schneider Electric has been awarded for the sixth consecutive year, the most accurate weather vendor of Short Term Probability of Precipitation Accuracy among a group of top commercial weather companies.[3]

With that said, often times, numerical models have a common shortfall when it comes to convective forecasting, such as under forecasting amounts, miscalculating the speed of convective lines, and misplacing the general areas of convective precipitation. These shortfalls can be attributed to a lack of resolution and/or limited initial conditions. Forecasters can catch some of deficiencies, however, the task can be difficult and time consuming, not to mention that there is always risk that an event will be missed or not corrected until after the event has already made a significant impact.

The other effect is over-forecasting to ensure that missed events are avoided, however, over-forecasting can also be detrimental to customers with false alerts to events that sometimes clearly will not happen.

To offset, Schneider Electric has implemented a scalable technique which enhances near term precipitation forecasts using real-time lightning data, surface observations, and radar data, ultimately assisting in timeliness and coverage of convective events. The result is a far superior baseline forecast that provides more reasonable quantitative precipitation forecasts, employing a relationship between remote sensing data with the numerical model forecast parameters.

Schneider Electric leverages the Graphical Forecast Editor (GFE) as the primary tool for precipitation forecast preparation. One of the primary functions of the GFE is to allow users to ingest grids of digital model data and other sensible weather information. Using the NLDN, Schneider Electric creates a 1/10 degree flash density grid of lightning every 10 minutes and populates it into the GFE. Equally as important are the created grids of surface observations and current radar imagery. From there, the observations and remote sensing data is integrated into Schneider Electric's model blend used in the creation of the baseline precipitation forecast. Algorithms are used to approximate the additional precipitation necessary to represent the worst case of all observational inputs, but individually, the minimum threshold acceptable given the value of the observation or remote sensing data.

Fig. 3 shows the result of this operational forecast technology for a standard cold frontal passage in the Southeastern United States. On the left is a 3 hour forecasted blend of raw model input, displayed in the GFE. Note the relatively light precipitation forecast amounts over southeastern Alabama, southwestern Georgia, and the panhandle of Florida. The middle image represents the revised first forecast, utilizing surface observations, radar, and Vaisala's real-time lightning data. One should note the increased precipitation forecast in the above mentioned locations. On the right is a capture of 3 hour precipitation observations throughout the region highlighting amounts that are depicted with much more accuracy by the algorithm applied to the raw model data rather than the input itself.

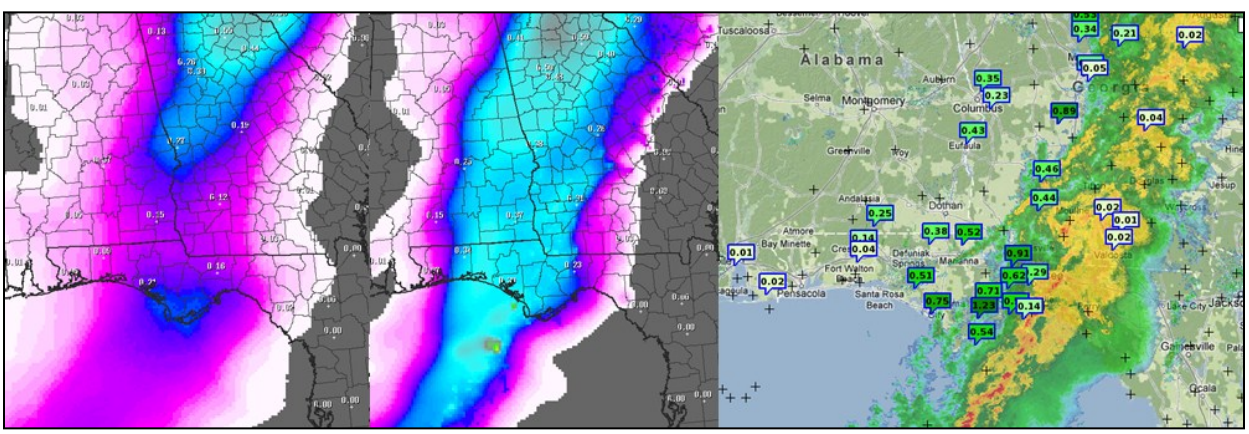

Fig. 3. **Left:** Baseline 3 hour forecast of a raw model blend. **Middle**: Revised baseline forecast utilizing blend of real-time lightning, observations, and radar. **Right**: 3 hour observed rainfall highlighting improved forecast.

[3] http://goo.gl/GmDwAh

In summary, Schneider Electric has successfully deployed a precipitation forecast enhancement scheme that utilizes real-time lightning information coupled with observations and radar data to improve the quantitative accuracy of near-term events.

V. HIGH VISIBILITY EVENT ON-SITE METEOROLOGICAL SUPPORT

Lightning is the single most significant and dangerous weather phenomenon impacting operations at high-profile outdoor events. Given the considerable safety risk as well as the time and complexity associated with evacuations, an advanced system of instrumentation components that provides a very clear and accurate assessment of a localized lightning threat is required.

Schneider Electric has a team of six meteorologists that provides unique meteorological support at large outdoor events. Since 2005, these on-site meteorologists have traveled around the western hemisphere supporting the PGA Tour, Champions Tour, Web.com Tour, LPGA, PGA of America, State Fairs, and other high-profile events.

Schneider Electric's on-site team utilizes Vaisala's NLDN and GLD360 datasets to ascertain the movement of clusters of existing lightning producing storms. The team views the real-time lightning information within Schneider Electric's MxVision WeatherSentry™ Online platform. Coupled with an electric field meter at each event, these state-of-the-art lightning datasets allow the meteorologist to provide advance warning of the development and movement of lightning activity that may threaten tournament operations.

In Fig. 4 below, Schneider Electric's MxVision WeatherSentry™ Online platform is displayed with an intense amount of lightning approaching a PGA Tour event.

In summary, the presence of experienced on-site meteorologists having access to a state-of-the-art global lightning network along with a high precision electric field meter combines to provide the most comprehensive state-of-the-art approach to lightning protection for high profile events.

VI. INTEGRATED TURBULENCE FORECASTS

Turbulence injures more passengers and flight personnel and inflicts more damage to aircraft than any other aviation mishap, outside of crashes. Estimates have suggested that annual costs from turbulence due to injury lawsuits or repairing damaged aircraft run on the order of the hundreds of millions of dollars.[4]

Schneider Electric provides global turbulence forecasts, based on the standard International Civil Aviation Organization unit of Eddy Dissipation Rate (EDR) where the EDR value

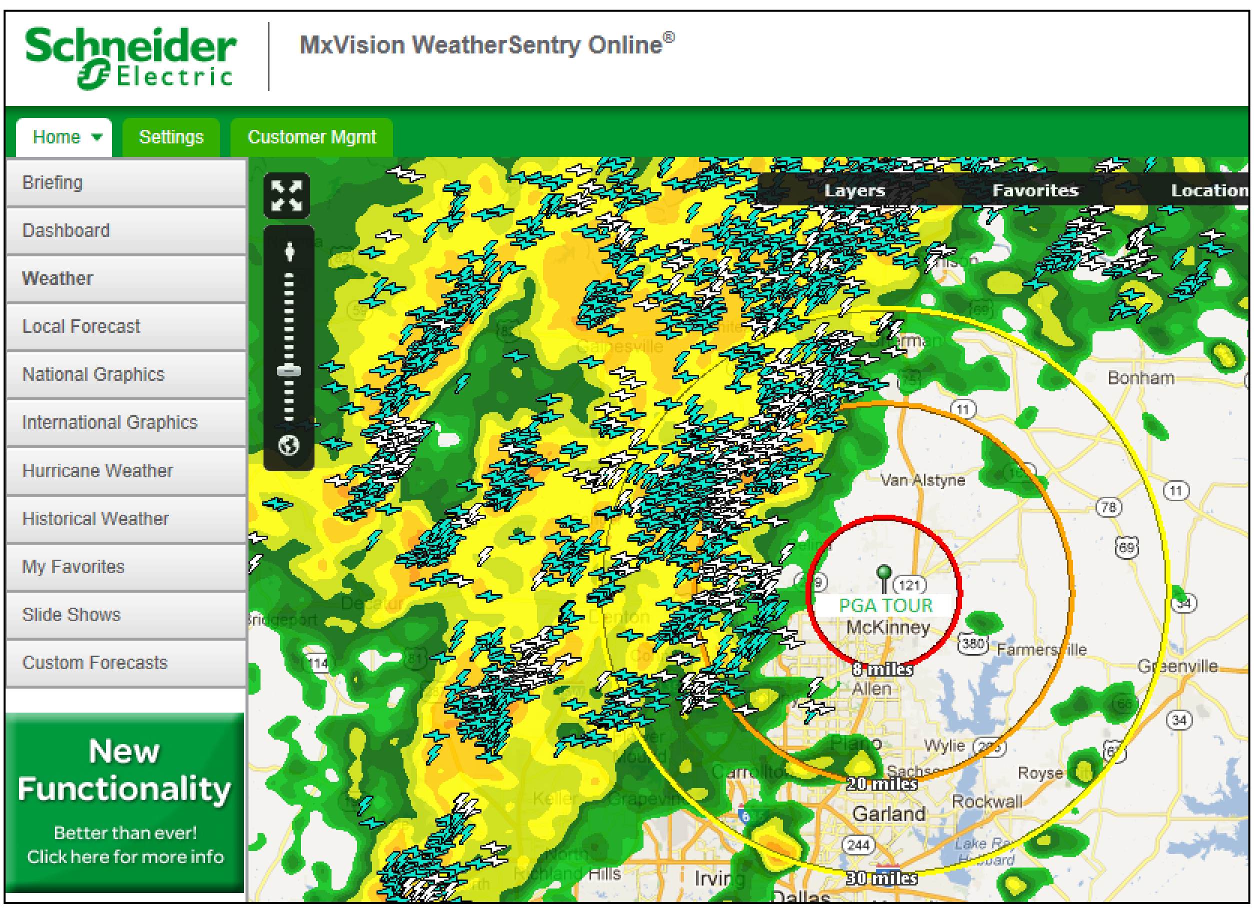

Fig. 4. Clusters of lightning approaching a PGA Tour event in Texas

[4] http://goo.gl/hlDNjL

represents a aircraft-specific turbulence intensity. The global forecasts can be utilized from the surface to the highest cruising altitudes and have the output flexibility to be used in preflight planning as well as inflight tactical use.

Schneider Electric computes a single EDR forecast from the four primary sources of turbulence; Clear-Air, Mountain Wave, Boundary Layer, and Convective. The focus of this section will be surrounding Convective turbulence and how real-time lightning information plays a key role in the forecast preparation.

The Convective Turbulence algorithm that Schneider Electric employs outputs grids of convective vertical velocities at all model levels.[5] In addition, the algorithm outputs grids of the maximum updraft, updraft tops, and updraft triggers, all key pieces of information when forecasting the location and intensity of potential convection.

Schneider Electric leverages real-time lightning information as one of the observational inputs masking off convectively induced turbulence. The intersection of the lightning and the model generated vertical velocities results in a 'nowcast' turbulence forecast for the next several hours after proprietary algorithms convert the turbulence kinetic energy to a specific EDR value.

Shown below in Fig. 5 is an example of the hourly EDR forecast available within Schneider Electric's MxVision AviationSentry Online product suite.

In summary, Schneider Electric is utilizing real-time lightning information as an input into its turbulence forecasting algorithms to have an enhanced baseline of vertical updraft strength.

VII. CONCLUSION

Schneider Electric has merged the data from Vaisala's various lightning networks with other appropriate real-time meteorological datasets to provide enhanced operational functionality for use either by its team of meteorologists or for a value-add into its forecast generation process.

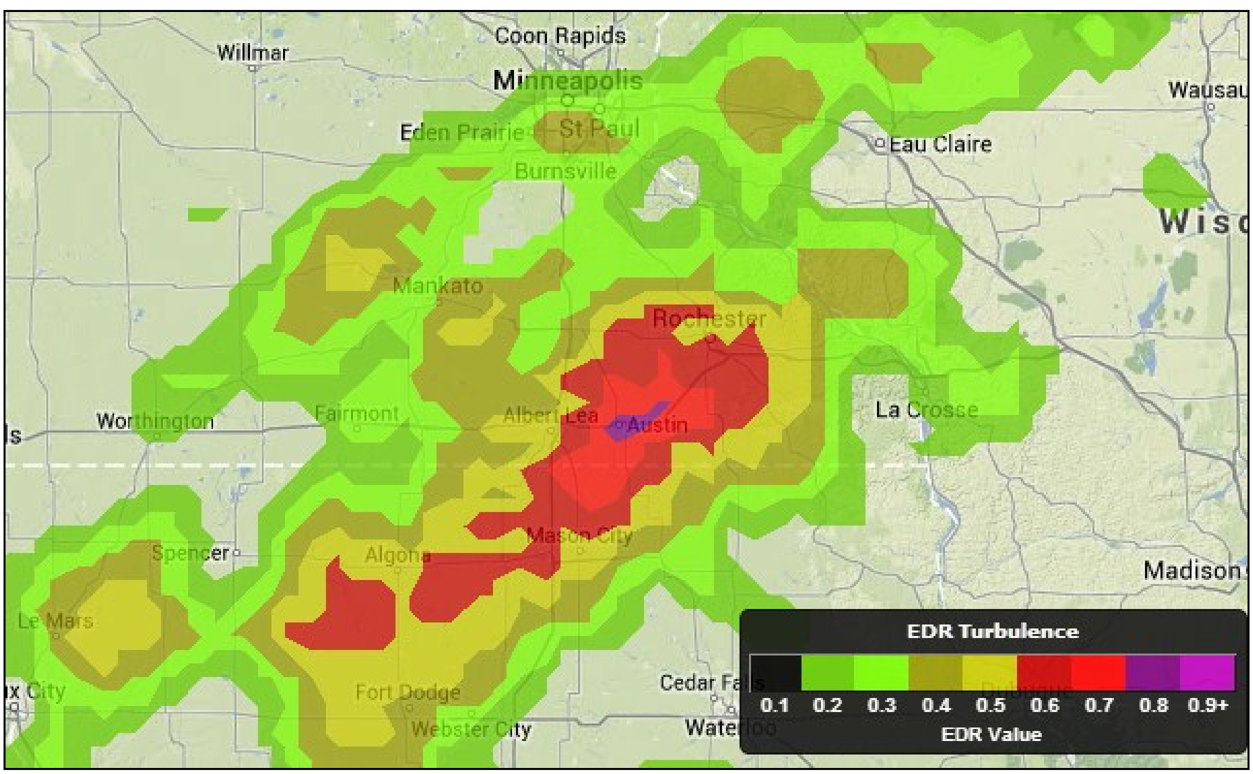

Fig. 5. Moderate to Severe EDR Forecast over Southeastern Minnesota

[5] http://goo.gl/zOcOu1