P3.8

INTEGRATING A DOPPLER SODAR WITH NUCLEAR POWER PLANT METEOROLOGICAL DATA

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1. INTRODUCTION

A Doppler sodar owned by the Illinois Emergency Management Agency (IEMA) has been operating since December 1998 near the Dresden, LaSalle, and Braidwood nuclear power stations in northern Illinois (see Figure 1). The sodar provides mixing height data for dose assessment models as well as horizontal and vertical winds with height. Integrating the IEMA Doppler sodar with the meteorological data from Braidwood, Dresden, and LaSalle nuclear power stations ultimately can provide emergency responders with a valuable three-dimensional picture of how and where accidental releases may be transported from these sites as well as providing a better understanding of the overall regional transport of effluents.

On November 13, 2002 a large grass fire near the Dresden nuclear power plant created a large plume of smoke that had an interesting vertical structure that could only be explained with the IEMA sodar data. With pictures of the grass fire as a backdrop, this paper describes the various meteorological data displays available at IEMA that can be used to assist in plume transport and dose assessment activities and documents the value of employing a sodar for emergency response.

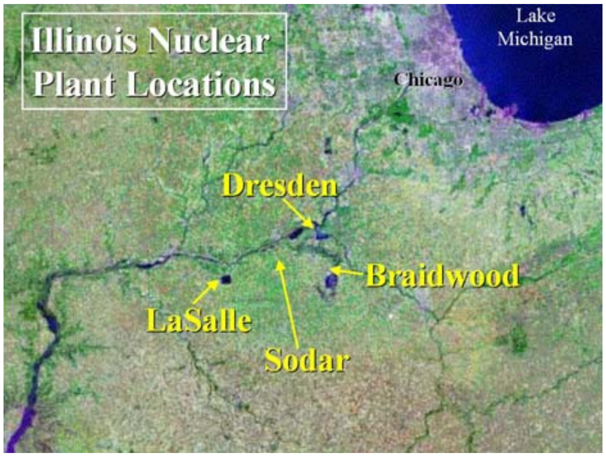

Figure 1. IEMA sodar and Illinois nuclear power plant locations.

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2. AVAILABLE METEOROLOGICAL DATA

Meteorological data at IEMA is currently available from three sources: the sodar, the nuclear power stations, and the Internet.

The IEMA sodar, shown in Figure 2, is an Aerovironment Model 2000 Doppler Acoustic Sounder. On the quarter hour, the sodar system processes data and automatically sends this data via radio-modem to Springfield where it is processed into 630 distinct point identifications and validated by an in-house algorithm. The mixing height is also derived for each 15-minute average. Wind direction, wind speed, vertical velocity, and other parameters are available in 30-meter increments up to 600 meters above ground level.

Figure 2. The IEMA sodar at 14:12 local time on 11/13/2002 with the ongoing grass fire in the background.

Each nuclear power station has meteorological instrumentation at various levels above the ground that are routinely polled by the nuclear plant's main computer. Figure 3 shows a 3-level meteorological tower similar to towers at LaSalle and Dresden. Braidwood has a 2-level meteorological tower. IEMA computers located at each nuclear power station receive meteorological data, as well as pertinent reactor parameters, and send this data to Springfield every minute. Raw data, one-minute averages, and 15-minute averages are available for wind speed, wind direction, sigma theta, delta temperature, temperature, dew point and precipitation.

Figure 3. A three level meteorological tower similar to one at Dresden and LaSalle Nuclear power station.

Since the fall of 2004, METAR data (i.e. airport surface observations) from Illinois and surrounding areas are downloaded from the Internet by FTP every 20 minutes from the National Weather Service. The METAR data are processed into distinct point identifications that can be used easily by IEMA in dose assessment activities.

3. METEOROLOGICAL DATA DISPLAYS

To provide inputs for dose assessment and to help understand potential effluent transport from any nuclear power station, meteorological data at IEMA can be displayed in three general forms: text displays, graphical displays, and plume transport displays.

3.1 *Text displays*

Text displays, usually from a single nuclear power plant site, generally are the best source for obtaining meteorological data for inputs to dose assessment codes. Figure 4 shows all the meteorological data for the Dresden nuclear power station. Figure 5 shows all available sodar data. Invalid or suspect sodar data is noted in bold and with an abnormal status.

3.2 *Graphical displays*

Graphical displays, usually from multiple sites, can show meteorological trends with graphs, with wind vectors, or both. These displays can provide: trends of vertical stability (Figure 6), surface wind vectors for the sodar and nearby nuclear power stations (Figure 7), all surface wind vectors with temperature and wind speed graphs for the sodar and nearby nuclear power stations (Figure 8), a 24–hour time versus height display for horizontal sodar wind vectors (Figure 9) and vertical sodar wind vectors (Figure 10), an hourly time versus height display for the horizontal sodar wind vectors (Figure 11), a snapshot of all nuclear power station surface conditions and sodar wind vectors (Figure 12), a 24-hour mixing height graph with sodar vertical echo intensities (Figure 13), and an hourly vertical velocity display from the sodar combined with stability class data from the nearby nuclear stations (Figure 14). Figures 9 through 14 each have information from the sodar that have been useful for determining conditions aloft especially during nighttime boundary layer decoupling and low level jet formation, during frontal passages including the Lake Michigan lake breeze, during transition periods, and during near calm events. Dose assessors can easily input the mixing height into dose assessment codes from Figure 13 or text displays (not shown). Figure 14 uses the sodar data to provide a side view profile to show how effluents released by the nearby nuclear power stations can be affected by vertical motion. Since vertical motions are not accurately accounted for in most Gaussian dose assessment codes, this display can help dose assessors determine if vertical motion will increase or decrease doses at ground level.

3.3 *Plume transport displays*

Plume transport displays show a plan view from above where potential effluents may have traveled from any nuclear power station using the most recent meteorological data. Figure 15 provides a picture of where potential effluents may have traveled over the past 2 hours from the Dresden nuclear power station. The magenta plume is derived from the recent upper level meteorological data (wind direction, wind speed, and stability class) and represents an elevated release. The white plume is derived from the lower level meteorological data and represents a ground level release. Plume travel distances, numbered evacuation zones, and offsite gamma radiation monitor locations are provided to assist overall emergency response efforts.

Figure 16 displays a regional assessment where potential effluents may have traveled over the past 2 hours from each Illinois nuclear power station and the Zion spent nuclear fuel island. Plumes are drawn as in Figure 15 and are overlaid with the most recent METAR data from around northern Illinois. This display provides dose assessors with confidence in regional transport away from each nuclear power station, some forecast capability, as well as identifying areas where gaussian plume model assumptions are violated that may lead to invalid dose assessments

DRESDEN METEOROLOGICAL DISPLAY 22-OCT-04 12:01:46

PRESS X TO EXIT PRESS H FOR HELP	WIND DIRECTION 300' 150' 35'	WIND SPEED 300' 150' 35'	SIGMA THETA 300' 150' 35'	HORZ STAB CLASS 300' 150' 35'	DELTA T'S UPPER LOWER	VERT STAB CLASS UPPER LOWER	TEMPS AMB DEW	RAIN SNOW
ENV POINTS 15 MIN AVERAGES OF RAW RDL DATA	QRA QRA QRA 155.6 156.0 156.4 sect / degrees	15.9 14.6 12.8 MPH M/S 7.1 6.5 5.7	8.2 9.9 10.2 degree	D D D (3)	-1.80 -0.79 deg f	D D (1)	59.8 ----- deg f deg f	0.00 inches
15 MIN AVERAGES DRESDEN 2 DRESDEN 3 FROM RDL	155.7 156.1 156.5 155.4 155.5 155.9 dgrees	7.1 6.6 5.7 7.1 6.5 5.7 m/sec	9.9 11.8 12.2 10.0 12.4 12.9 dgree (3)		(2) -1.24 -1.26 -1.24 -1.25 c/100 m	SITE GRAPHICS (5)		
1 MIN AVERAGES DRESDEN 2 DRESDEN 3 FROM RDL	143.3 138.9 136.7 148.0 135.8 135.8 dgrees	14.2 14.3 14.3 14.2 15.1 12.8 m.p.h	2.3 5.8 5.1 10.4 8.2 5.1 dgree			ILLINOIS WINDFIELD (4)		
RAW RDL FOR DN2 RAW RDL FOR DN3 RAW RDL FOR DN3	139.5 135.0 133.1 171.3 160.7 136.4 171.3 160.7 136.4 dgrees	15.7 14.4 13.4 14.2 16.0 10.4 14.0 16.0 10.4 m.p.h.			(1) -1.77 -0.80 -1.76 -0.79 -1.70 -0.79 deg. f		60.1 deg. f	0.991 inches

Figure 4. An IEMA text display showing meteorological data from the Dresden nuclear power station.

SITE 2 BLOCK21944 SAMPLE INTERVAL 10/26 15:00 TO 10/26 15:15 CST (3)750 METER DISPLAY 26-OCT-04 16:28:23
3 COMPONENT N+00E+00 FIXD AGC:28N34E33V HTS=20 TEST=3 ZENITH=30° ROTATION= 0° BOLD DATA FAILS VALIDATION TEST

HT *	NS	R	N *	EW	R	N *	W	SD	R	N *	MAG	DIR	SDD	R	N	HT *	IN	IE	IV*	DELM	DELD*	SDV	SDU	SDN	SDE
600	-8.2	9	3	-4.1	5	7					9.2	207		9	3	600	10	8				99.9	1.1	0.5	3.8
570	-8.9	9	3	-7.5	9	3					11.6	220		9	3	570	10	6		3.5	79	1.7	1.7	0.3	1.3
540	-7.7	9	2	-7.1	4	5					10.4	223		9	2	540	10	6		1.3	201	3.2	3.2	0.6	2.5
510	-8.3	9	1	0.7	9	3					8.4	175		9	1	510	12	8		7.8	275	0.9	0.0	0.0	0.5
480	-8.9	9	2	-5.9	4	7					10.7	214		9	2	480	12	8		6.6	85	2.8	2.8	0.6	2.2
450	-8.7	9	2	-4.2	4	8	-0.4	0.0	9	1	9.6	206		9	2	450	11	8	11	1.7	263	4.7	0.0	0.8	2.1
420	-8.4	9	3	-7.3	4	7	-0.4	0.0	9	1	11.2	221		9	3	420	13	6	10	3.2	94	2.2	2.2	0.5	1.7
390	-8.6	9	4	-7.6	4	5	-0.3	0.0	9	1	11.5	222		9	4	390	10	6	13	0.3	61	2.1	2.1	0.3	1.6
360	-9.2	9	3	-5.7	5	5	0.1	0.3	9	3	10.8	212		9	3	360	12	8	15	2.1	288	2.9	2.9	0.4	2.3
330	-9.7	9	3	-6.5	4	13	-0.1	0.4	9	4	11.6	214		9	3	330	11	6	14	1.0	61	2.7	2.7	0.5	2.1
300	-9.5	9	4	-3.7	4	7	-0.1	0.2	9	3	10.2	201		9	4	300	10	6	13	2.8	266	5.0	0.0	0.4	2.3
270	-9.2	9	4	-4.3	4	8	0.0	0.1	9	3	10.1	205		9	4	270	12	7	18	0.7	117	5.0	0.0	0.5	2.2
240	-8.6	5	7	-2.7	0	18	0.0	0.4	5	13	9.0	197		5	7	240	13	7	19	1.7	250	4.7	0.0	0.6	2.2
210	-8.1	4	15	-0.7	0	36	0.0	0.4	1	18	8.1	185	17	4	15	210	15	9	24	2.1	257	2.4	1.1	0.6	1.2
180	-7.5	0	27	-0.3	0	46	0.0	0.5	1	38	7.5	182	14	0	27	180	17	10	30	0.8	215	1.8	1.1	0.5	0.9
150	-6.8	0	50	0.3	0	61	0.0	0.4	1	47	6.8	177	6	0	50	150	23	15	38	0.9	221	0.7	1.2	0.6	0.3
120	-5.7	0	60	0.3	0	68	0.0	0.3	1	60	5.7	177	7	0	60	120	31	28	49	1.1	180	0.7	1.3	0.7	0.3
90	-4.8	0	63	0.5	0	69	0.0	0.3	1	63	4.9	174	10	0	63	90	39	40	58	0.9	195	0.8	1.4	0.7	0.4
60	-3.6	0	62	0.6	0	69	0.0	0.3	1	62	3.7	171	14	0	62	60	35	36	41	1.3	183	0.9	1.5	0.8	0.5
10	-1.8	0	69	0.3	0	69	0.0	0.1	0	69	1.8	170	6	0	69	10			0			0.2	0.8		

CHANNEL: 04= 0 05= 0 06= 0 07= 0 08= 29 09= 0 10= 0 11= 0 12= 0 13= 0 14= 0 15= 0 SHELTER TEMP= 67.2

Figure 5. An IEMA text display showing all available sodar data. Invalid or suspect data is highlighted.

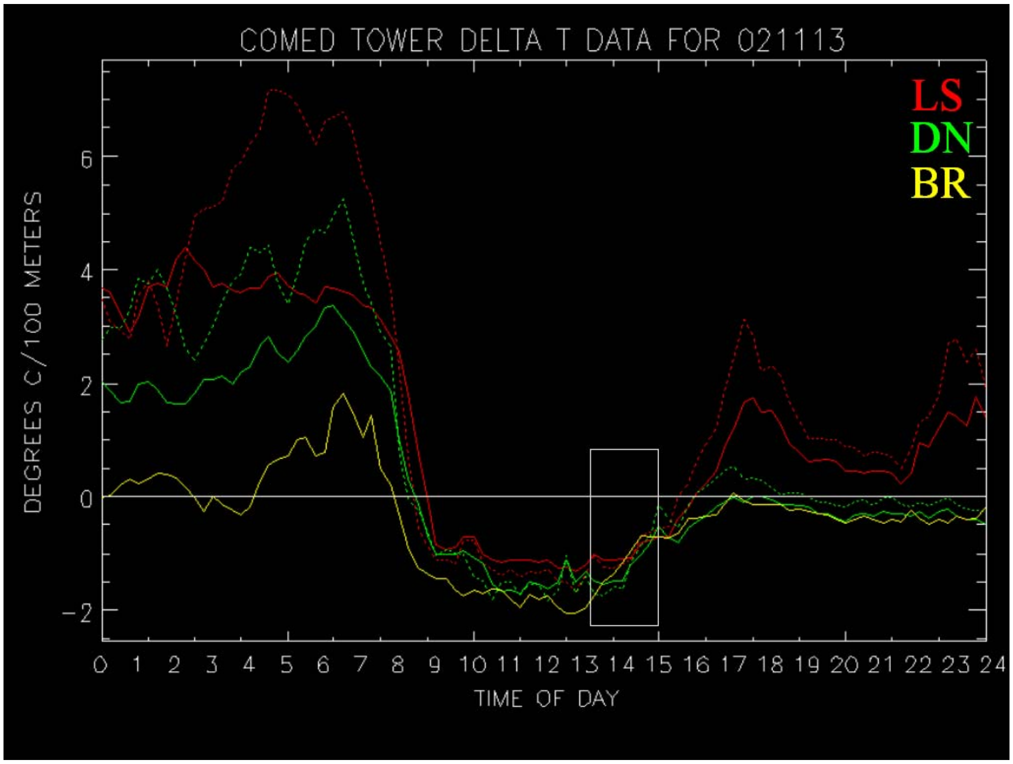

Figure 6. An IEMA graphical display showing the vertical stability values (delta T) from the LaSalle (red), Dresden (green), and Braidwood (yellow) nuclear power stations for 11/13/2002. Solid lines are the upper minus lower level delta T and dotted lines are middle minus lower level delta T.

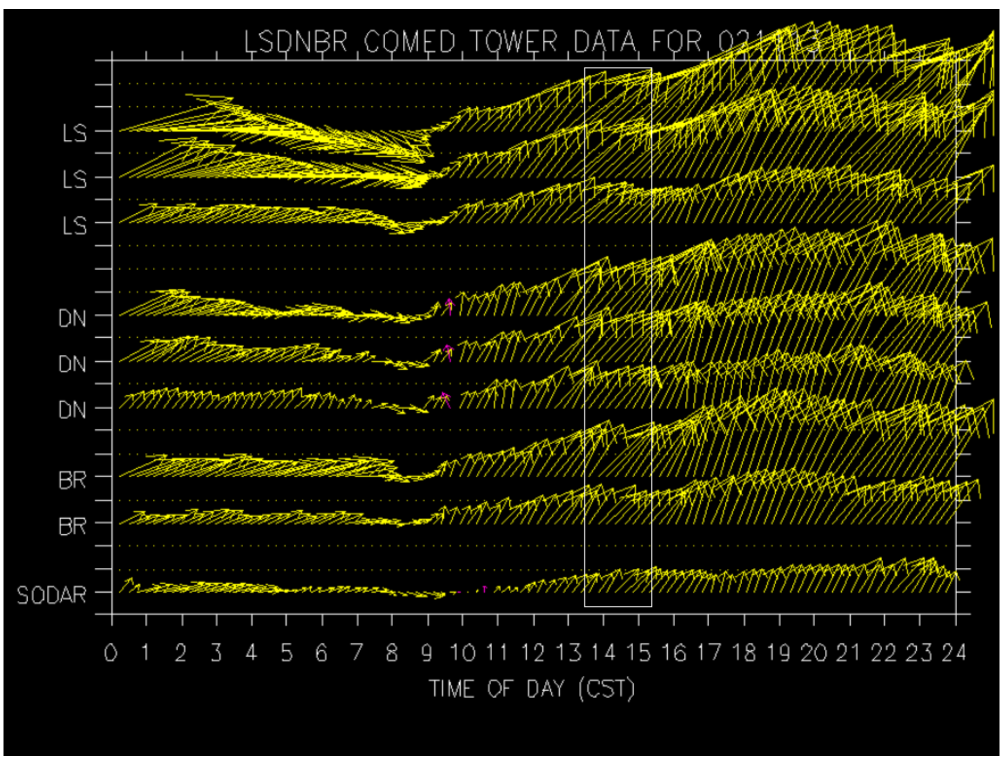

Figure 7. An IEMA graphical display for 11/13/2002 showing the surface wind vectors for the sodar and all levels from the LaSalle (LS), Dresden (DN), and Braidwood (BR) nuclear power stations. Westerly component winds are colored yellow and easterly component winds are colored purple

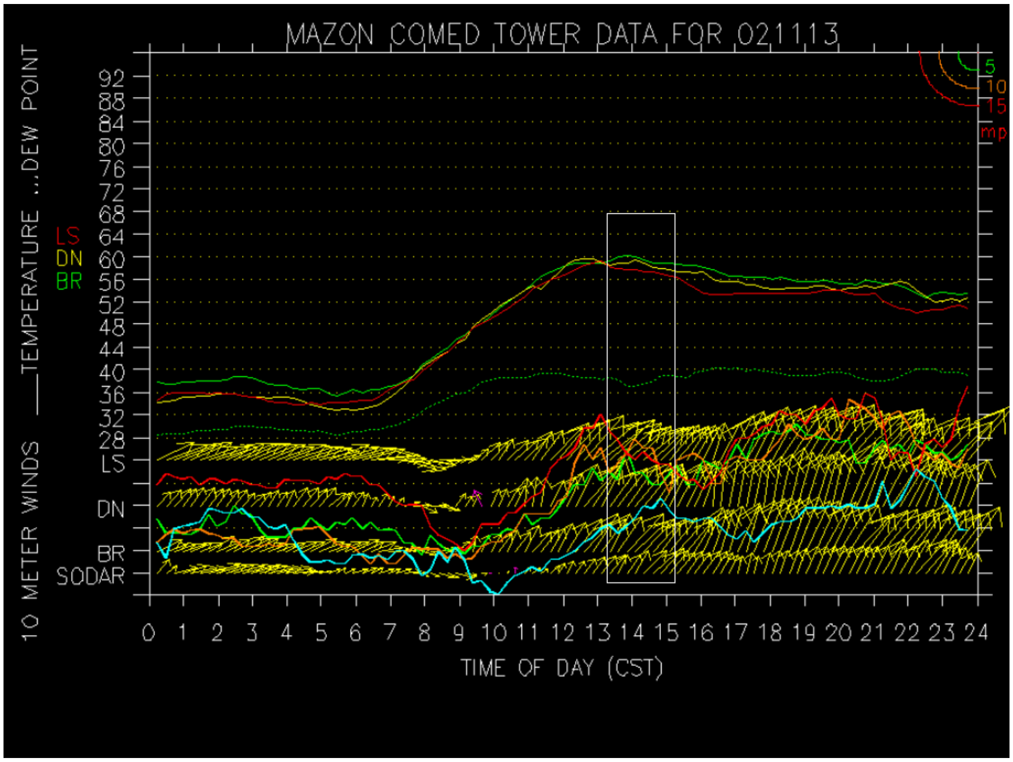

Figure 8. An IEMA graphical display for 11/13/2002 showing all surface wind vectors for the sodar and nearby nuclear power stations. Graphs of temperature, dew point and wind speed are also shown. The color cyan is used for the sodar wind speed.

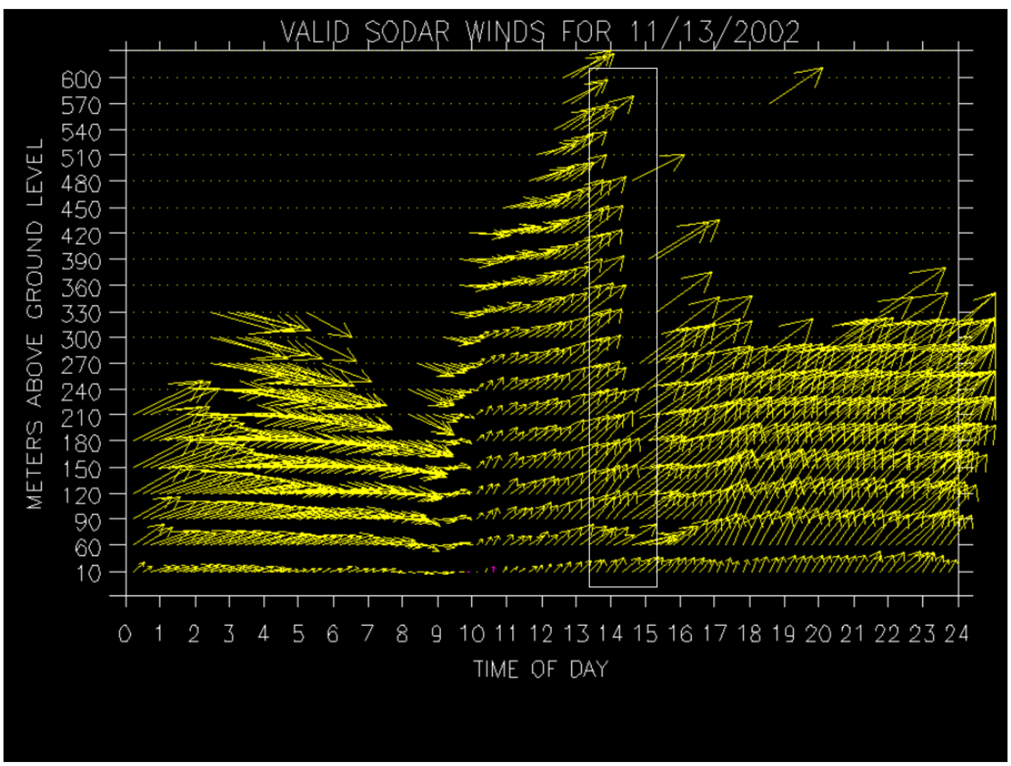

Figure 9. An IEMA graphical display for 11/13/2002 showing a 24-hour time versus height display for the sodar horizontal wind vectors. Westerly component winds are colored yellow and easterly component winds are colored purple.

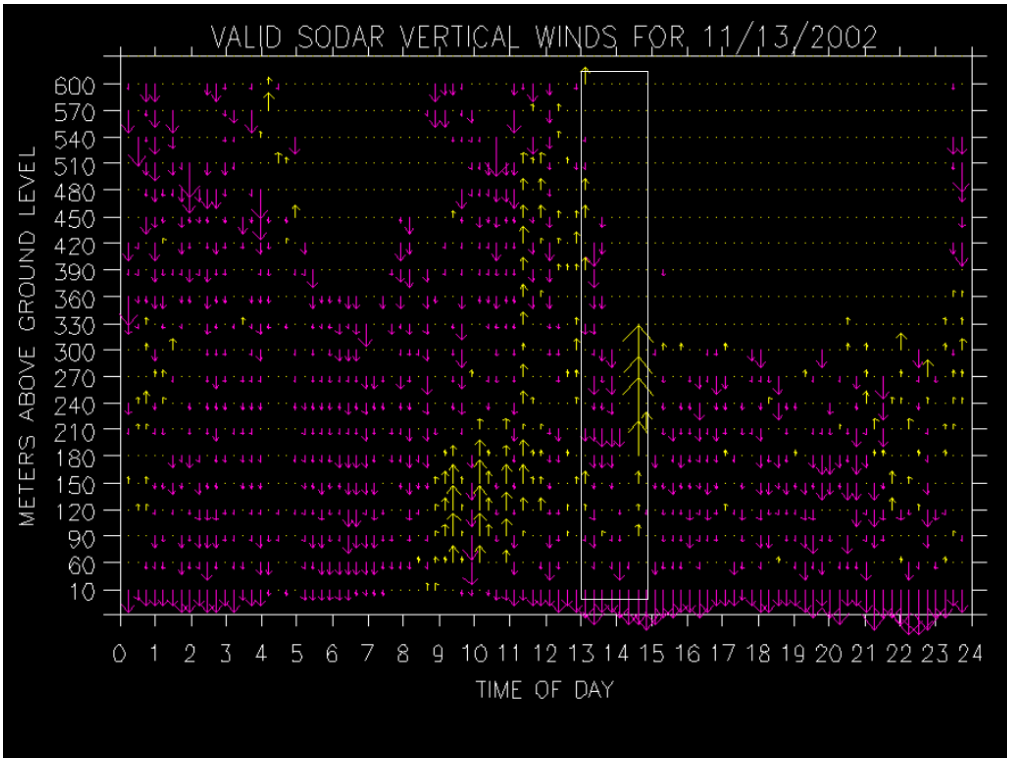

Figure 10. An IEMA graphical display for 11/13/2002 showing a 24-hour time versus height display for the sodar vertical wind vectors. Descending component winds are colored purple and ascending component winds are colored yellow.

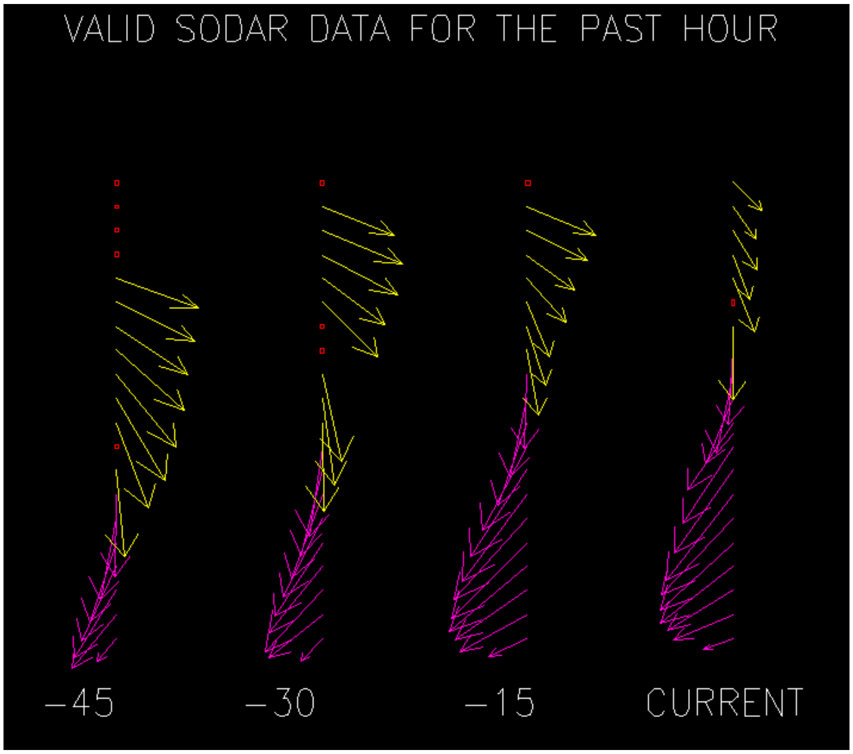

Figure 11. An IEMA graphical display showing a one-hour versus height display for the sodar horizontal wind vectors. Westerly component winds are colored yellow and easterly component winds are colored purple. This display shows strong vertical wind direction changes with height important for understanding plume transport.

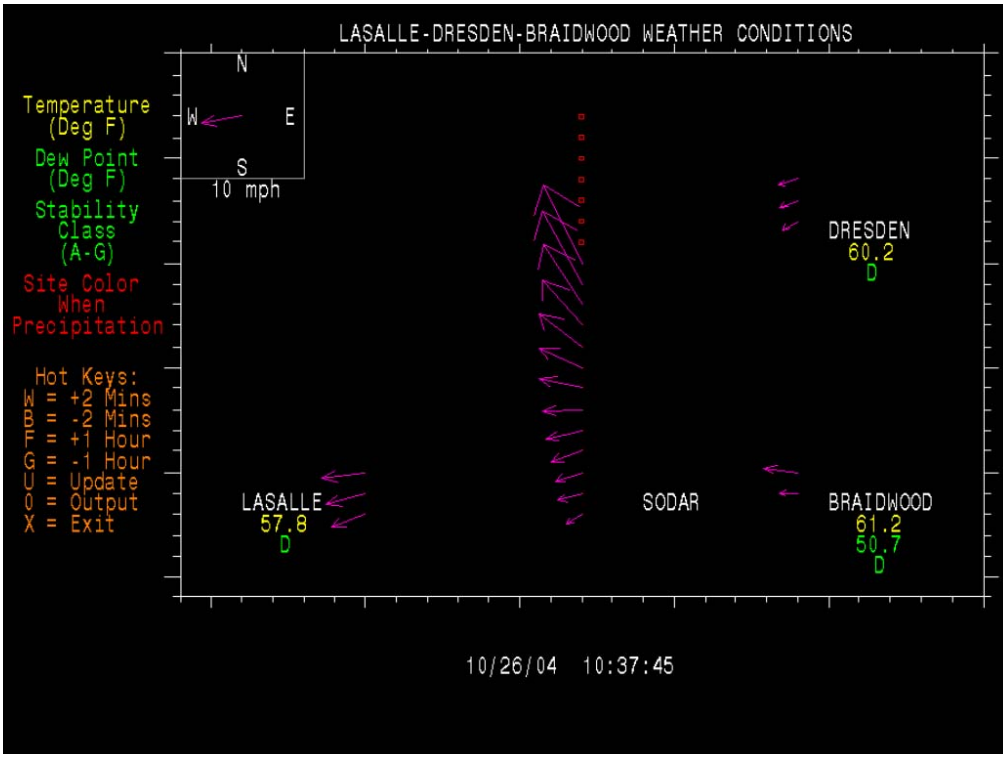

Figure 12. An IEMA graphical display showing a snapshot of all nuclear power station meteorological data and the sodar wind vectors.

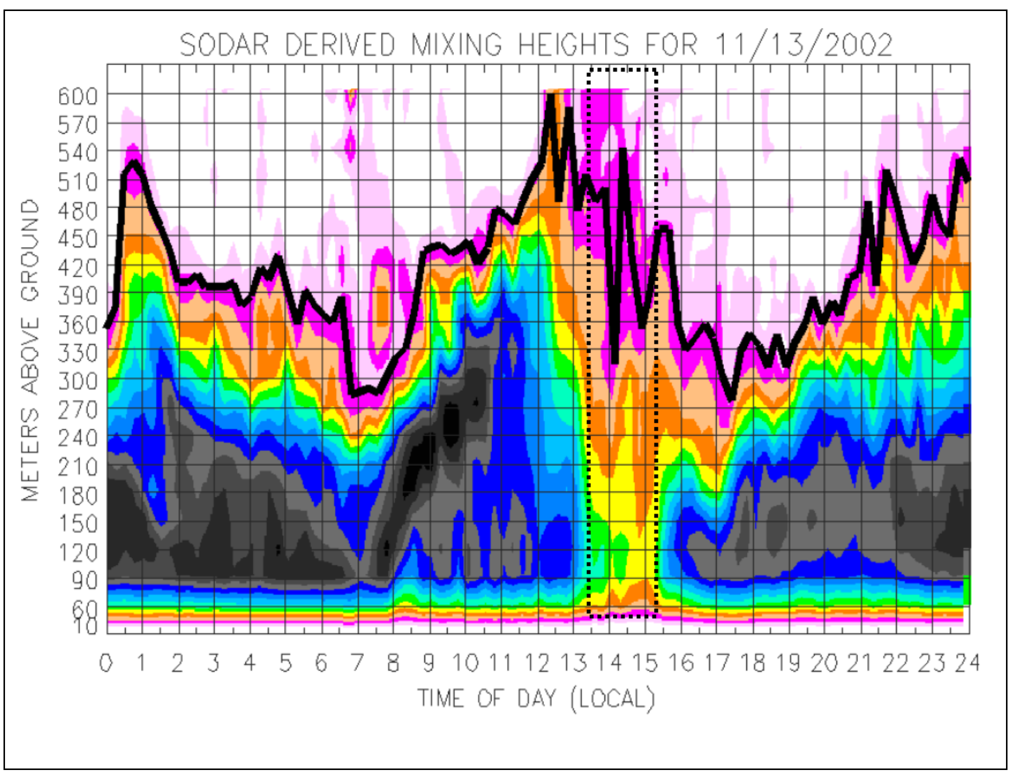

Figure 13. An IEMA graphical display for 11/13/2002 showing a 24-hour plot of mixing height (solid black line) and sodar vertical antenna echo intensity. Reference 1 discusses calculating mixing height with sodar.

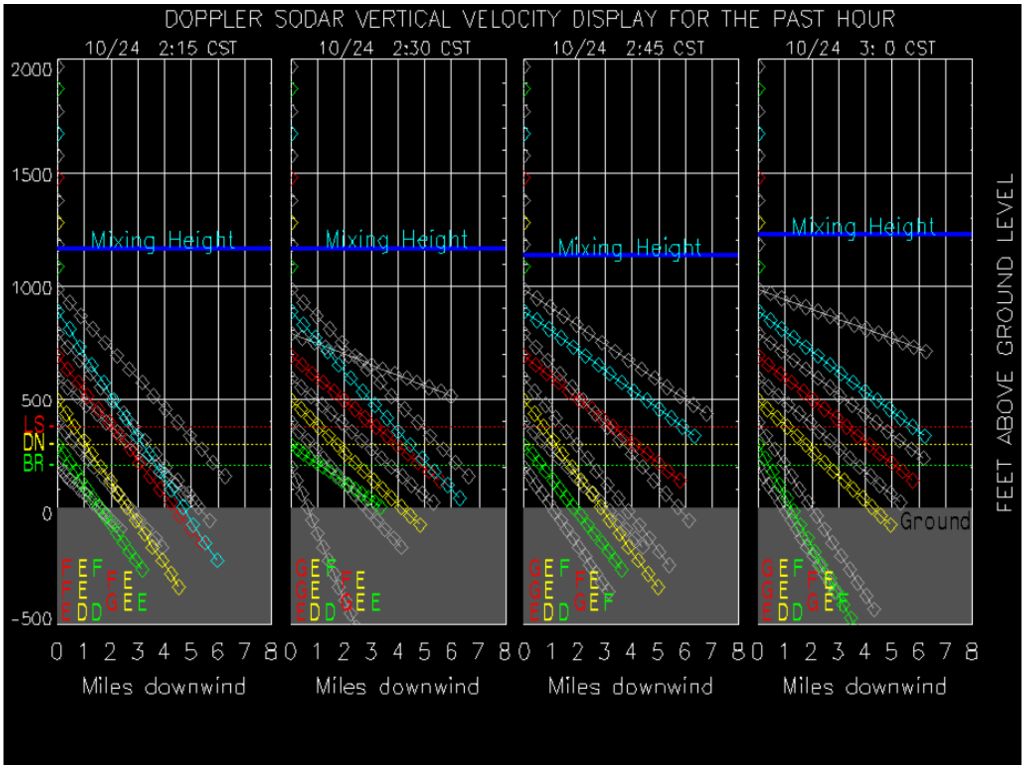

Figure 14. An IEMA graphical display showing four separate 15-minute periods of the sodar vertical velocity data, combined with mixing height level and stability class data for each nearby nuclear power plant. LS, DN, and BR note the highest release point at each nuclear power station. Pasquill stability classes are colored by nuclear power station. The stability classes grouped to the left are horizontal stabilities from the upper, middle and lower sensor levels. The stability classes grouped to the right are vertical stabilities calculated by upper minus lower delta T (top) and middle minus lower delta T (bottom). This display provides a side view profile to show how effluents released by the nearby nuclear power stations can be affected by vertical motion.

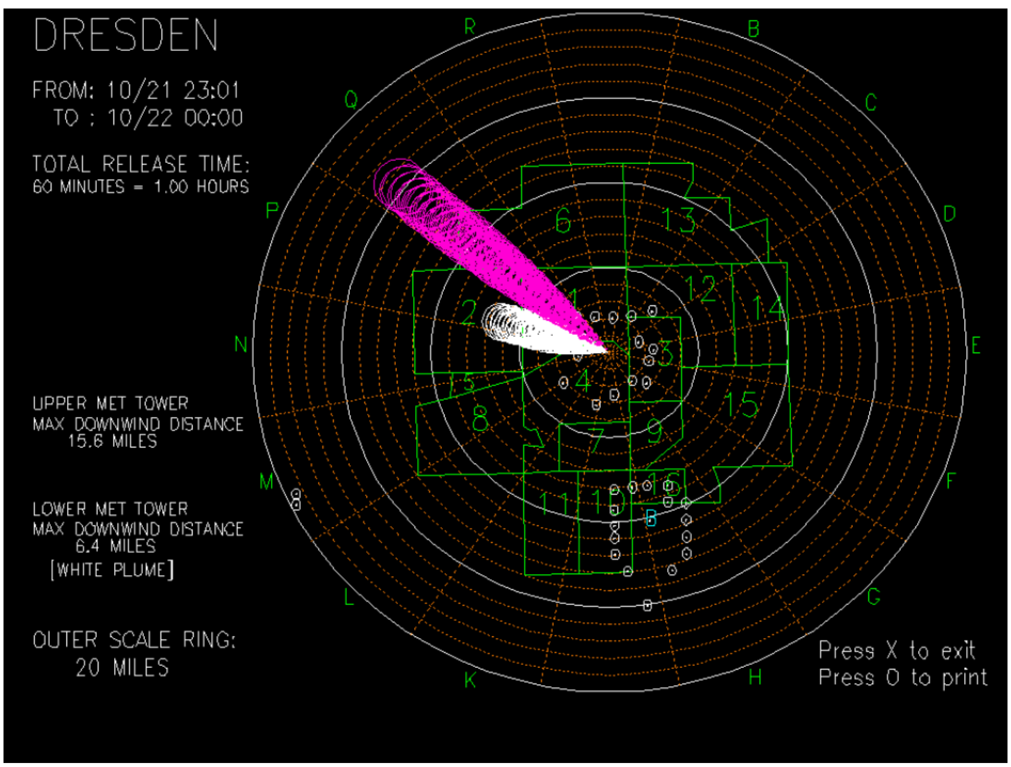

Figure 15. An IEMA plume transport display for the Dresden nuclear power station. See Section 3.3 for discussion.

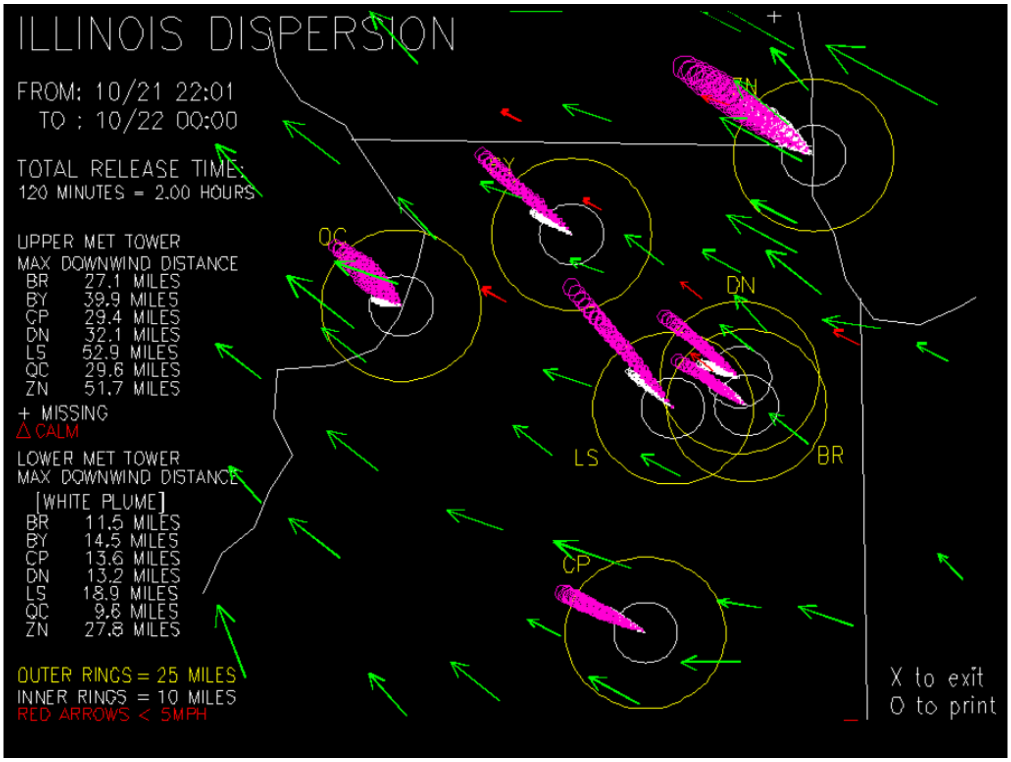

Figure 16. An IEMA regional plume transport display for northern Illinois. See Section 3.3 for discussion. Wind data colored in red note areas where gaussian model assumptions may be invalid.

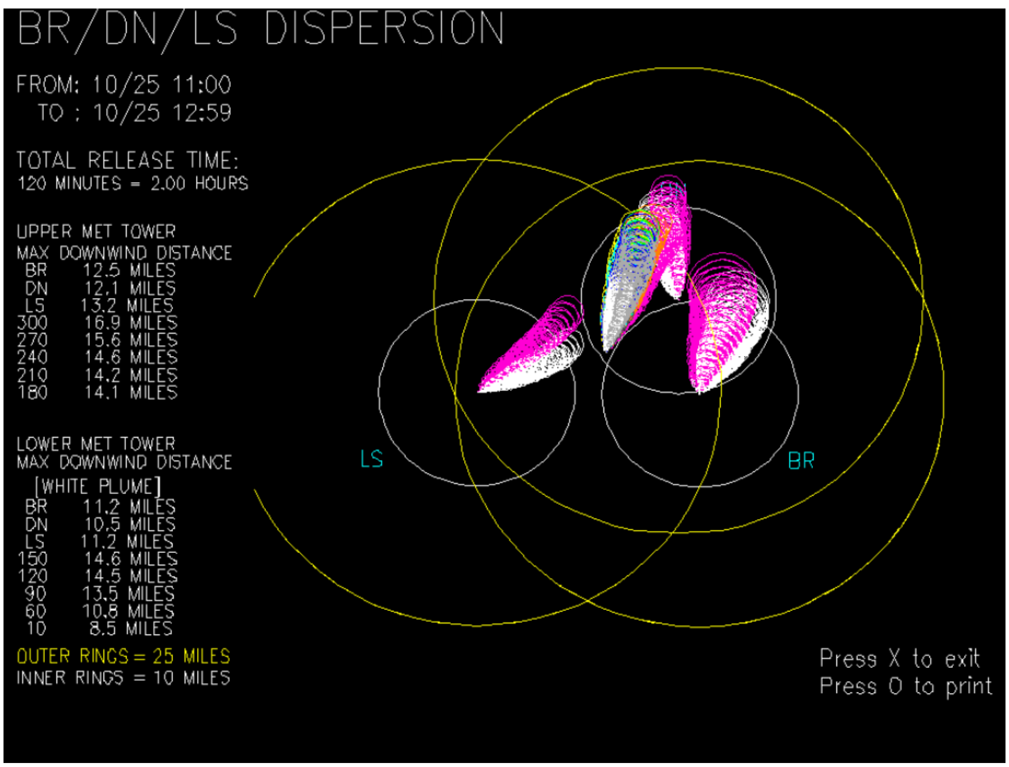

Figure 17. An IEMA plume transport display for the LaSalle, Dresden, and Braidwood nuclear power stations and the first 10 levels of the sodar data. See Section 3.3 for discussion.

Figure 17 shows where potential effluents may have traveled over the past 2 hours from the lowest 10 levels of the sodar as well as from each of nuclear power stations near the sodar. This display, which can become very busy looking depending on meteorological conditions, can be used in the same manner describe above.

4. THE LARGE GRASS FIRE

On November 13, 2002, a large grass fire about 2km (~1 mile) southwest of the Dresden nuclear power station in Goose Lake Prairie State Park was documented with several photographs. The fire created a large plume of smoke that was detected by the National Weather Service Doppler radar located about 16km (21 miles) to northeast in Lockport, Illinois. The fire provided good visual evidence of horizontal and vertical plume behavior that may occur with an effluent release from a nuclear power station. The fire was first noticed at 14:12 local time from the sodar located about 15km (~9.5 miles) to the west-southwest (See Figure 2) of the fire.

The meteorological conditions at the Dresden nuclear power station during the time of the grass fire (14:00-15:00 local time) indicated nothing overly concerning from a dose assessment perspective. A box on Figures 6-10, and 13 highlights the conditions at Dresden during the time of the grass fire. These figures show that Dresden had southwest and south-southwest winds at 5-7m/s (11-15 mph) at the lower level and 7-9m/s (15-20 mph) at the upper level, surface temperatures of 15°C (59°F), a dew point temperature of ~4°C (38°F), horizontal stability classes of D and E, and vertical stability classes of C and D. Basically, this was a nice sunny November day in Illinois.

Figures 18 and 19 are photographs taken at 1456 and 1500 local time, respectively, about 3km (2miles) west-southwest of the fire. These figures, including Figure 2, provide some interesting evidence about the vertical structure above the fire that is revealed in the sodar data.

5. RESULTS FROM THE SODAR

Figure 2 shows a nice buoyant plume created by the heat of the grass fire that rises upward, descends slightly, then levels off. This could be explained with a mixing height located approximately where the plume appears to level off. The initial heated plume punches upward but cannot penetrate greatly above the mixing height. As the plume cools and moves downwind, it descends and begins to mix below the mixing height. The mixing height in Figure 2 is calculated to be about 500 meters high, which is in good agreement with the sodar derived mixing height on Figure 13 at 1400 local time.

Looking at Figures 18 and 19 taken 45 minutes after Figure 2, it is obvious that the plume is undergoing some new vertical processes. The mixing height appears to be lower and the plume appears to be pushed towards the ground as it travels downwind. If this plume was really radioactive material released from a nuclear power station, this is a case where dose assessment models could greatly under predict doses at ground level. For this time period, the sodar provides three important parameters that help determine the vertical structure of the boundary layer: the mixing layer height and the horizontal and vertical wind speeds aloft.

Figure 13 does show that the mixing height derived by the sodar is decreasing about 50 meters per hour throughout the afternoon.

Figure 18. The grass fire in Goose Lake Prairie State Park at 1456 local time from 3km south-southwest of the fire.

Figure 19. The grass fire in Goose Lake Prairie State Park at 1500 local time from 3km south-southwest of the fire.

IEMA Doppler sodar vertical velocities in meter/second for November 13, 2002

Height in meters	12:00 to 12:15	12:15 to 12:30	12:30 to 12:45	12:45 to 13:00	13:00 to 13:15	13:15 to 13:30	13:30 to 13:45	13:45 to 14:00	14:00 to 14:15	14:15 to 14:30	14:30 to 14:45	14:45 to 15:00	15:00 to 15:15	15:15 to 15:30	15:30 to 15:45	16:45 to 16:00	16:00 to 16:15	Height in meters
600	-0.2		0.0	-0.1	0.3													600
570	-0.2	0.1	0.0	0.0														570
540	-0.2	0.1	0.0	0.0	-0.1													540
510	-0.1	0.0	0.1	-0.1	-0.1													510
480	-0.1	0.0	0.0	0.0	0.2													480
450	-0.2	0.1	0.0	0.1	0.2		-0.2											450
420	-0.3	0.1	0.0	0.2	0.0	-0.4	-0.2											420
390	-0.2	0.1	0.1	0.1	0.2	-0.3								-0.1				390
360	-0.2	0.0	0.0	0.0	0.0	-0.2	-0.2								0.0			360
330	-0.1	-0.1	0.0	0.1	-0.2	-0.2								0.0	0.0			330
300	-0.1	-0.1	0.0	0.2	0.0	-0.1	-0.2	-0.3					-0.1	0.1	0.0	0.1	0.0	300
270	0.0	-0.1	0.1	0.1	0.0	-0.3	-0.1	-0.3			0.9		0.0	-0.1	0.0	0.0	-0.1	270
240	0.0	0.0	0.0	0.1	0.0	-0.1	-0.1	-0.2			0.8		0.0	-0.1	0.0	-0.1	-0.1	240
210	-0.1	-0.2	0.0	0.0	-0.2	-0.2	-0.3	-0.3	-0.3		0.9	0.3	0.0	-0.1	-0.2	-0.1	-0.1	210
180	-0.1	-0.1	0.1	0.0	0.0	-0.2	-0.2	-0.2	0.0		0.6	0.0	-0.2	0.0	-0.1	-0.2	-0.1	180
150	-0.1	0.0	0.0	0.1	0.2	-0.1	0.0	-0.1	0.0	0.0	0.2	0.0	-0.1	-0.1	-0.2	-0.1	-0.1	150
120	-0.1	-0.1	0.1	0.0	0.1	-0.2	0.0	0.0	-0.1	0.0	0.1	-0.1	0.0	-0.1	-0.1	-0.1	-0.2	120
90	-0.2	-0.1	0.1	0.0	-0.1	-0.2	0.1	-0.1	-0.1	0.0	0.2	0.0	0.0	-0.1	-0.1	-0.1	-0.2	90
60	-0.3	-0.1	0.0	0.0	0.0	-0.1	0.0	-0.1	-0.3	-0.1	0.0	0.0	-0.2	-0.1	-0.1	-0.1	0.0	60
10	-0.3	-0.4	-0.3	-0.4	-0.5	-0.6	-0.4	-0.4	-0.5	-0.6	-0.6	-0.7	-0.6	-0.5	-0.5	-0.4	-0.4	10

IEMA Doppler sodar horizontal wind speeds in meter/second for November 13, 2002

Height in meters	12:00 to 12:15	12:15 to 12:30	12:30 to 12:45	12:45 to 13:00	13:00 to 13:15	13:15 to 13:30	13:30 to 13:45	13:45 to 14:00	14:00 to 14:15	14:15 to 14:30	14:30 to 14:45	14:45 to 15:00	15:00 to 15:15	15:15 to 15:30	15:30 to 15:45	16:45 to 16:00	16:00 to 16:15	Height in meters
600			7.8	8.2	7.2													600
570			7.4	7.3														570
540		6.4	6.7	7.6	7.3	9.7												540
510	5.9	6.5	6.3	7.4														510
480	5.3	6.3	6.2	7.8							9.8							480
450	4.8	5.8	6.1	7.6	7.4	8.6												450
420	4.7	5.3	5.8	7.2	7.4	7.9												420
390	4.3	4.9	5.8	7.3	7.4	8.3							12.1	12.7				390
360	4.3	4.8	5.5	7.3		8.3												360
330	4.2	4.6	5.4	7.2	7.9	7.9								11.7				330
300	4.2	4.5	5.6	7.0	7.7	7.8									11.9			300
270	4.1	4.4	5.5	7.0	7.4	7.8						10.4	11.0	11.0	11.4		12.8	270
240	4.0	4.1	5.8	6.9	7.3	7.6	6.4					10.5	10.7		11.0		12.6	240
210	3.9	4.1	5.6	6.8	7.0	7.3	6.7	7.7			10.2	10.2		10.0	10.3	11.1	11.9	210
180	3.8	4.2	5.5	6.7	7.0	7.3	7.0	7.5		8.2		9.8	9.4	9.2	9.7	10.2	11.0	180
150	3.8	4.2	5.5	6.7	7.0	7.0	6.9	7.4	7.4		9.5	9.5	8.8	8.4	8.8	9.3	10.1	150
120	3.7	4.1	5.2	6.4	6.8	6.6	6.8	7.0	7.2	8.3	9.0	8.9	8.1	7.9	8.1	8.5	8.7	120
90	3.5	4.2	5.2	6.0	6.5	6.3	6.9	6.7	6.9	8.1	8.5	8.4	7.4	7.2	7.3	7.3	7.6	90
60	2.9	3.8	4.8	5.6	5.6	5.3	4.8	5.0	3.8	6.7	6.2	5.8	4.4	5.0	5.7	5.4	6.7	60
10	1.7	1.9	2.3	2.5	2.9	3.1	2.7	3.0	3.3	3.9	3.8	4.2	3.7	3.3	3.3	3.2	3.3	10

Figure 20. IEMA Doppler sodar wind speeds during the time of the fire on November 13, 2002.

Associated with this decrease in the mixing height, the sodar horizontal winds aloft begin to increase and the sodar vertical winds begin descending motion. Figure 20 shows the actual values of the sodar vertical and horizontal wind speeds aloft. Descending winds up to -0.3 m/s (or 18m/min) from the sodar, shaded in gray on the top portion of Figure 20, explain why the plume appears to be pushed towards the ground. The increasing horizontal sodar winds, shaded in gray on the bottom portion of Figure 20, also provide a mechanism that stretches the plume downwind. These three parameters from the sodar provide good information about the vertical structure of this plume, for a nice November day, which seemingly had no dose assessment concerns.

6. CONCLUSIONS

IEMA dose assessment personnel, to determine if vertical motion will increase or decrease doses at ground level during a nuclear power station incident, use numerous sodar data displays. The IEMA sodar currently provides dose assessment support for the LaSalle, Dresden, and Braidwood nuclear power stations located 16km (10miles), 18km (~11miles), and 22km (14miles) away from the sodar, respectively. When properly integrated, a sodar can greatly augment nearby nuclear power station meteorological data, and provide a three-dimensional picture how and where accidental releases may be transported from these nuclear power stations.

7. REFERENCES

Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005, February 2000.