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Mesoscale Atmosphere Icing Event, March 1991

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ABSTRACT

During a field experiment designed to characterize winter atmospheric meteorological conditions and the physical properties of the snow cover backgrounds at Ft. Drum, New York, a severe atmospheric icing/glaze event occurred. This icing event was documented with an automatic meteorological recording station located near the center of the storm track. The measurement recording interval was set at a frequency of 10 minutes, and three days of icing precipitation and glaze formation data were measured. Over the three days, varying intensities and/or combinations of freezing rain and drizzle, rain, snow, ice pellets and fog occurred at the measurement site. The severity of this event was described by newspaper headlines such as "Ice Storm Closes Jefferson County," "Ice Creates Emergency" and "Seven Counties in Western and Northern New York State Paralyzed by Ice Storm." The synoptic situation during this event included a low pressure center, with supporting cold and warm fronts that combined as an occluded front over central New York state. This front stalled and the resulting mixture of cold and warm air masses included nearly all types of high intensity frozen precipitation. This moisture (when precipitating out of the cloud formation) resulted in up to 1 in. (2.5 cm) of ice accretion and glaze formation on all exposed objects over a large geographical area.

INTRODUCTION

From 22 February through 16 March 1991 (Bates et al. 1992), winter field experiments designed to measure the effect of the background on airborne millimeter wave radar systems were conducted at Ft. Drum, New York (Fig. 1). During this multi-lab field experiment, personnel from the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) were responsible for measurement of site meteorology, soil temperature, and snow property characterization and temperatures of other elements in the background scene.

This test, intended to take place with snow on the ground, sometimes had the area almost devoid of snow during the field experiment. The highlight of the experiment included in this paper was an extreme atmospheric icing event that occurred from 3 to 5 March 1991. This icing event paralyzed seven counties of western and northern New York State (*Daily Times* 1991, *Post Standard* 1991) (Fig. 1). A quarter of a million people were out of electricity because of this event. The documentation of this icing event at our test facility and photos of this destructive event are the subject of this poster presentation/report.

METEOROLOGICAL MEASUREMENTS

CRREL measured meteorological data continuously at Ft. Drum, New York, from 24 February to 16 March 1991. A 6-m meteorological tower was located adjacent to the study area (Fig. 1) with sensors at three levels (0.5, 2, and 6 m). Meteorological elements measured during the test were air temperature, relative humidity, wind speed and direction, solar radiation, atmospheric pressure and soil temperature. The 2-m tower level measured wind, air temperature, relative humidity and atmospheric pressure during the icing event, and these data are included in Table 1 of this report. At 1 m above the surface both incoming and reflected solar ra-

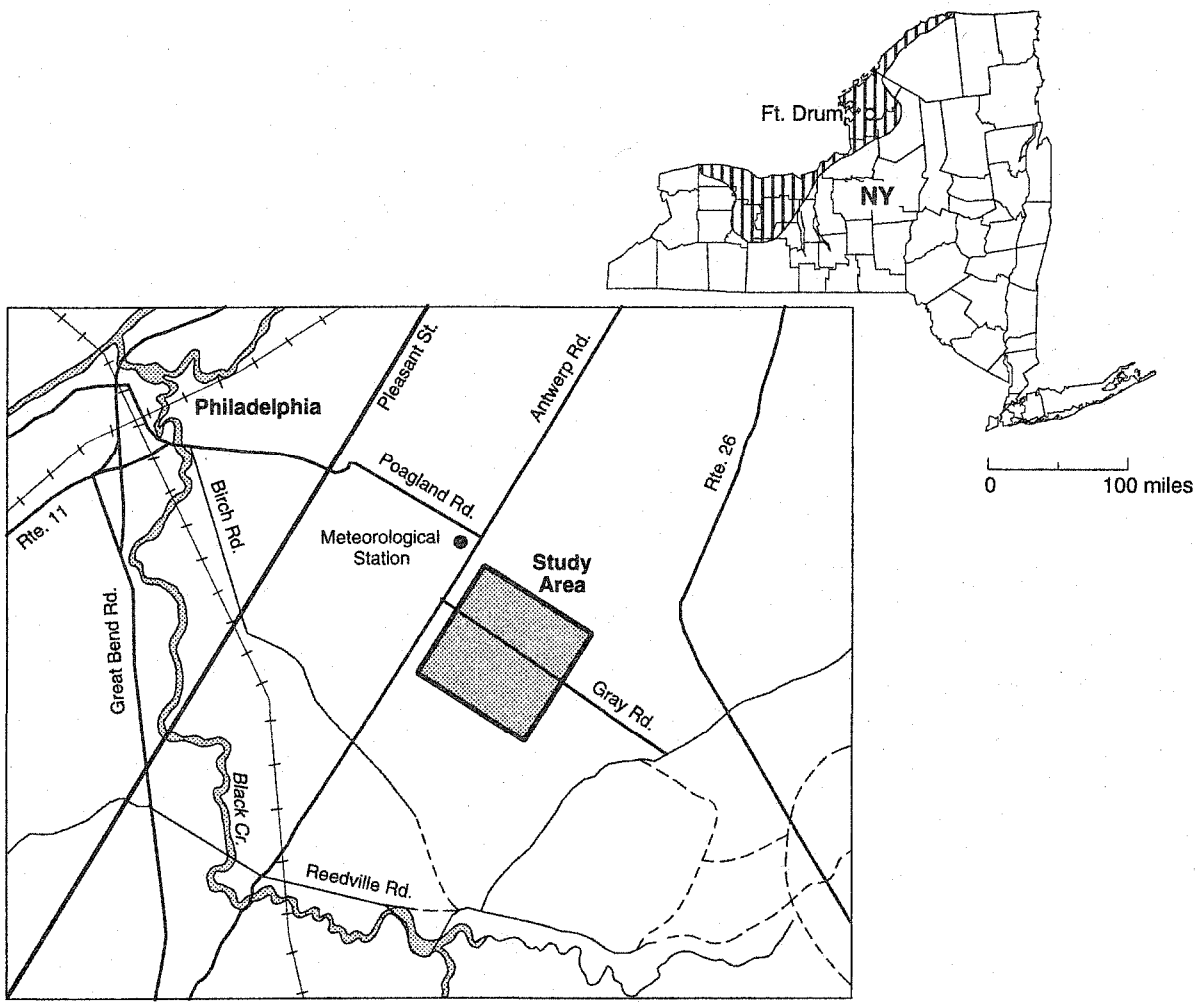

Figure 1. Study area and ice storm location (shaded area on upper map).

diation at two wavelength bands (0.3–3.0 and 3.0–50.0 μm) and precipitation were measured and are also included in Table 1. Temperatures were measured at 14 points from the ground surface to a height of 0.5 m. The data logger was normally programmed to record data at 1-minute intervals for all sensors (and to average every 30 min), 24 hours a day. As a rain event was occurring on 2 March, we programmed the data logger to average at a 10-min rate, and consequently we recorded data at this rate for the entire icing period. These data, averaged every 30 min, are presented in Table 1 for the three days of the severe icing storm.

SYNOPTIC METEOROLOGY

This section of the report gives the synoptic conditions for the five days before and the three days during the severe icing event. Table 2 gives a summary of the hourly surface observations measured during the icing event at Wheeler-Sack Army Airfield at Ft. Drum.

25–28 February, 1–2 March

In general the synoptic meteorology for this February period was dominated by a weak high pressure system. This included light snow showers daily from lake effect instability with little if any snow accumulation. Snow depth on the ground varied between 0 and 8 cm, and air temperatures generally ranged from –10°C overnight to near or above freezing during midday, with a maximum of 1°C observed at midnight on 28 February. Sky cover for this period was mostly scattered to broken with ceilings around 1000 m. The 1st and 2nd of March period were dominated by warm southerly winds as the high pressure moved eastward. Air temperatures ranged between 1 and 15°C. Rain, fog, and thundershowers were experienced and nearly all snow and ice cover melted except in protected, wooded and snowdrift areas

Table 1. Meteorological data, Fort Drum, New York, 3–5 March 1991.

3 March 1991

							RADIATION		WATTS/M^2	
TIME	WD/SP	WD/DIR	TEMP	RH	STEMP	PRCP	PSP	PSP	PIR	PIR
hhmm	mps	deg	c	%	c	mm	vert	invert	vert	invert
0030	4.8	25	4.5	98	3.9	0.00	0	0	314	348
0100	4.1	22	3.8	98	3.3	0.25	0	0	314	345
0130	3.4	25	3.3	98	2.6	0.00	0	0	313	342
0200	5.1	19	2.4	98	2.1	0.25	0	0	314	338
0230	4.7	21	1.8	98	1.4	0.00	0	0	314	335
0300	4.5	22	1.4	98	1.0	0.00	0	0	313	334
0330	4.8	30	0.9	98	0.5	0.00	0	0	314	331
0400	5.9	31	0.6	98	0.2	0.25	0	0	314	330
0430	5.4	24	0.3	98	-0.2	0.25	0	0	314	330
0500	6.1	27	0.2	98	-0.5	0.00	0	0	314	330
0530	4.4	28	-0.1	98	-0.5	0.00	0	0	315	329
0600	4.6	29	-0.2	98	-0.6	0.00	0	0	310	329
0630	3.1	29	-0.2	97	-0.6	0.00	0	0	311	329
0700	3.6	33	-0.3	97	-0.6	0.00	0	0	313	328
0730	4.4	28	-0.5	98	-0.6	0.00	3	0	311	328
0800	5.1	26	-0.7	97	-0.6	0.00	17	2	312	328
0830	4.3	27	-0.8	97	-0.6	0.00	26	3	313	328
0900	2.9	30	-1.0	97	-0.6	0.00	17	2	312	327
0930	3.2	29	-0.8	97	-0.7	0.00	25	3	319	330
0930	3.2	33	-0.8	97	-0.5	0.00	25	3	319	330
1000	3.4	34	-0.7	97	-0.7	0.00	22	3	313	328
1030	2.9	26	-0.4	97	-0.7	0.00	37	4	311	329
1100	1.9	27	-0.2	97	-0.6	0.25	74	9	310	329
1130	1.8	30	-0.2	96	-0.6	0.00	74	10	310	330
1200	1.9	27	-0.2	96	-0.5	0.00	95	13	310	330
1230	2.4	32	-0.3	96	-0.5	0.00	81	11	311	329
1300	2.2	41	-0.6	95	-0.5	0.00	55	8	312	329
1330	2.0	36	-0.7	96	-0.5	0.00	99	14	312	330
1400	2.0	31	-0.8	96	-0.5	0.00	59	8	311	328
1430	1.9	32	-1.0	96	-0.5	0.00	41	6	312	328
1500	1.9	37	-1.3	96	-0.6	0.00	41	6	312	326
1530	2.0	35	-1.6	96	-0.6	0.00	34	5	312	326
1600	1.6	32	-1.7	96	-0.6	0.00	25	4	311	325
1630	1.6	31	-1.9	96	-0.7	0.00	13	2	312	325
1700	1.9	32	-2.3	96	-0.6	0.00	11	2	312	323
1730	2.1	36	-2.4	96	-0.7	0.00	4	0	312	321
1800	1.4	34	-2.5	96	-0.6	0.00	0	0	312	322
1830	1.9	39	-2.7	96	-0.7	0.00	0	0	312	321
1900	2.0	40	-2.8	96	-0.7	0.00	0	0	312	321
1930	1.6	41	-2.7	96	-0.7	0.00	0	0	311	321
2000	1.5	41	-2.2	96	-0.7	0.00	0	0	312	325
2030	1.3	41	-1.9	96	-0.7	0.00	0	0	311	325
2100	1.1	41	-1.6	96	-0.7	0.00	0	0	318	328
2130	0.9	41	-1.3	97	-0.6	0.00	0	0	314	328
2200	0.8	38	-1.2	97	-0.7	0.00	0	0	314	328
2230	0.8	37	-0.8	97	-0.6	0.25	0	0	315	328
2300	0.5	36	-0.7	97	-0.6	1.02	0	0	309	328
2330	0.4	36	-0.8	97	-0.6	0.25	0	0	318	329
2400	0.0	66	-0.3	97	-0.6	0.76	0	0	310	329
AVG	2.8		+0.1	97	-0.6					
MAX	6.5		+1.4	98	-0.5					
MIN			-1.7	96	-0.7					
TOT						3.53	281			

Table 1 (cont'd). Meteorological data, Fort Drum, New York, 3–5 March 1991.

4 March 1991

							RADIATION		WATTS/M^2	
TIME	WD/SP	WD/DIR	TEMP	RH	STEMP	PRCP	PSP	PSP	PIR	PIR
hhmm	mps	deg	c	%	c	mm	vert	invert	vert	invert
0030	0.0	38	-0.5	97	-0.6	0.00	0	0	311	330
0100	0.0	42	-0.4	97	-0.6	0.25	0	0	199	329
0130	0.0	90	-0.2	97	-0.6	0.25	0	0	183	329
0200	0.0	90	-0.1	97	-0.6	0.51	0	0	309	330
0230	0.0	90	0.2	97	-0.6	0.00	0	0	308	331
0300	0.0	90	0.3	98	-0.6	0.25	0	0	298	331
0330	0.0	90	0.3	98	-0.6	0.76	0	0	231	331
0400	0.0	90	0.6	98	-0.6	2.03	0	0	234	332
0430	0.0	90	0.5	98	-0.5	0.76	0	0	226	332
0500	0.0	90	0.5	98	-0.6	0.25	0	0	209	332
0530	0.0	90	0.5	98	-0.5	1.02	0	0	241	332
0600	0.0	90	0.7	98	-0.6	0.25	0	0	300	332
0630	0.0	90	0.6	98	-0.6	0.00	0	0	202	332
0700	0.0	90	0.7	98	-0.6	0.00	2	0	195	332
0730	0.0	90	0.7	97	-0.6	0.25	5	0	193	331
0800	0.0	90	0.5	97	-0.5	0.51	14	2	176	331
0830	0.0	90	0.6	97	-0.5	0.51	23	3	158	331
0900	0.0	90	0.5	97	-0.5	0.76	22	3	173	331
0930	0.0	90	0.6	97	-0.5	0.51	40	6	178	332
1000	0.0	90	0.8	97	-0.5	0.76	54	8	182	332
1030	0.0	90	0.9	97	-0.5	0.76	65	10	187	332
1100	0.0	90	0.9	97	-0.5	0.25	70	12	190	332
1130	0.0	90	1.0	97	-0.5	0.76	49	8	193	332
1200	0.0	90	1.3	97	-0.6	1.52	130	23	199	333
1230	0.0	90	1.4	96	-0.5	1.27	94	17	195	332
1300	0.0	90	1.3	96	-0.6	0.51	123	24	197	332
1330	0.0	90	1.3	96	-0.5	0.51	97	20	193	332
1400	0.0	90	1.1	96	-0.5	0.51	94	20	189	332
1430	0.0	90	1.1	97	-0.5	0.51	81	17	187	332
1500	0.0	90	1.1	97	-0.5	0.00	99	22	195	332
1530	0.0	90	1.0	96	-0.5	0.51	50	11	192	331
1600	0.0	90	0.7	97	-0.5	0.00	25	5	191	331
1630	0.0	90	0.3	97	-0.5	0.00	17	4	301	330
1700	0.0	90	0.1	97	-0.5	0.00	8	2	308	329
1730	0.0	90	-0.3	97	-0.5	0.00	5	1	293	327
1800	0.0	90	-0.7	97	-0.5	0.00	0	0	291	327
1830	0.0	90	-0.9	97	-0.6	0.00	0	0	291	326
1900	0.0	90	-1.0	97	-0.6	0.00	0	0	291	325
1930	0.0	90	-1.0	97	-0.6	0.00	0	0	291	325
2000	0.0	90	-1.3	96	-0.6	0.00	0	0	291	325
2030	0.0	90	-1.3	96	-0.6	0.00	0	0	290	325
2100	0.0	90	-1.3	96	-0.7	0.00	0	0	290	324
2130	0.0	90	-1.5	96	-0.6	0.00	0	0	288	323
2200	0.0	90	-1.5	96	-0.6	0.00	0	0	288	323
2230	0.0	90	-1.7	96	-0.7	0.00	0	0	288	322
2300	0.0	90	-1.7	96	-0.7	0.00	0	0	288	323
2330	0.0	90	-1.6	96	-0.6	0.00	0	0	288	323
2400	0.0	90	-1.7	96	-0.6	0.00	0	0	287	322
AVG	0.0		+0.1	97	-0.6					
MAX	0.1		+1.4	98	-0.5					
MIN			-1.7	96	-0.7					
TOT						16.74	281			

All equipment covered with ice

Table 1 (cont'd).

5 March 1991

							RADIATION		WATTS/M^2	
TIME	WD/SP	WD/DIR	TEMP	RH	STEMP	PRCP	PSP	PSP	PIR	PIR
hhmm	mps	deg	c	%	c	mm	vert	invert	vert	invert
0030	0.0	90	-1.7	96	-0.6	0.00	0	0	281	322
0100	0.0	90	-1.7	96	-0.7	0.00	0	0	281	321
0130	0.0	90	-1.8	95	-0.6	0.00	0	0	281	321
0200	0.0	90	-1.8	95	-0.7	0.00	0	0	281	321
0230	0.0	90	-2.3	94	-0.7	0.00	0	0	282	318
0300	0.0	90	-2.7	93	-0.7	0.00	0	0	282	317
0330	0.0	90	-2.8	92	-0.7	0.00	0	0	282	316
0400	0.0	90	-3.3	92	-0.8	0.00	0	0	282	314
0430	0.0	90	-3.5	91	-0.8	0.00	0	0	285	310
0500	0.0	90	-4.2	91	-0.8	0.00	0	0	286	307
0530	0.0	90	-4.6	91	-0.9	0.00	0	0	287	305
0600	0.0	90	-5.0	91	-0.9	0.00	0	0	288	307
0630	0.0	90	-5.1	91	-1.0	0.00	0	0	283	314
0700	0.0	90	-4.7	92	-0.9	0.00	10	7	281	316
0730	0.0	90	-4.1	92	-0.9	0.00	34	18	281	318
0800	0.0	90	-3.5	92	-0.8	0.00	42	21	288	319
0830	0.0	90	-3.1	90	-0.8	0.00	59	29	281	321
0900	0.0	90	-2.6	90	-0.7	0.00	89	43	259	323
0930	0.0	90	-2.3	89	-0.6	0.00	112	53	297	325
1000	0.0	83	-2.3	89	-0.7	0.00	99	46	296	322
1030	2.4	328	-2.3	89	-0.8	2.54*	146	58	285	323
1100	1.6	289	-2.2	90	-0.8	0.00	125	51	286	325
1130	1.9	282	-1.9	92	-0.7	0.00	139	56	288	325
1200	2.6	267	-1.5	91	-0.7	0.00	197	77	289	327
1230	2.3	271	-1.4	91	-0.6	0.00	166	65	289	326
1300	2.3	275	-1.3	91	-0.6	0.00	162	63	291	327
1330	2.3	273	-1.1	91	-0.6	0.00	195	73	292	328
1400	2.4	273	-0.8	90	-0.6	0.00	220	80	292	329
1430	1.3	269	-0.7	91	-0.6	0.00	191	69	293	329
1500	1.2	262	-0.6	91	-0.5	0.00	145	51	293	329
1530	1.6	255	-0.3	91	-0.5	0.00	156	54	292	330
1600	1.2	253	-0.3	90	-0.5	0.00	112	39	292	329
1630	1.7	258	-0.1	89	-0.5	0.00	163	53	263	328
1700	1.5	252	0.5	88	-0.6	0.00	82	26	219	322
1730	0.7	254	0.5	88	-0.7	0.00	52	12	224	319
1800	1.0	234	-0.6	91	-0.7	0.00	0	0	267	321
1830	2.0	234	-0.3	92	-0.7	0.00	0	0	281	324
1900	1.5	225	-0.3	92	-0.7	0.00	0	0	219	319
1930	1.9	184	-1.4	93	-0.8	0.00	0	0	214	312
2000	2.0	161	-2.3	93	-0.8	0.00	0	0	213	310
2030	2.3	158	-2.3	93	-0.9	0.00	0	0	215	310
2100	2.0	162	-2.5	93	-0.9	0.00	0	0	215	309
2130	3.0	158	-2.4	93	-0.9	0.00	0	0	216	310
2200	2.2	158	-2.8	92	-1.0	0.00	0	0	216	308
2230	3.0	155	-2.5	92	-1.0	0.00	0	0	216	309
2300	3.4	154	-2.5	91	-1.1	0.00	0	0	216	310
2330	3.5	158	-2.8	91	-1.1	0.00	0	0	215	308
2400	3.6	157	-2.7	91	-1.2	0.00	0	0	216	309
AVG	1.1		-2.1	92	-0.8					
MAX	3.7		+0.6	96	-0.5					
MIN			-5.2	88	-1.2					
TOT						2.54	1677			

*Precipitation is from ice deposited on bucket walls.

Table 2. Fort Drum, New York, icing event WX summary, 3–5 March 1991. Data from Wheeler-Sack Army Airfield, Ft. Drum.

Time (LST)	*Wx and obs to vision*	*VSBY (km)*	*Temp (°C)*	*D.P. (°C)*	*Wind direction (degrees)*	*Windspeed (m/s)*	*Remarks*
3 Mar							
0000–0400	R-, F	6	4 to 0	3 to –1	030	3–6	Sky condition
0500–0900	R, ZR, L-F	6 to 10	0 to –1	–1 to –3	030	3–4	100- to 300-m ceiling all day
1000–1500	ZR, F	8 to 11	–0.5 to –1	–2 to –3	030	4	
1600–1800	ZL, F	6	–1 to –3	–3 to –4	030	3–5	
1900–2200	ZR, F	5 to 6	–3 to –1.5	–4 to 3.5	000	0	Anemometer frozen
2300–2400	R, AR, IP	6 to 10	–1.5 to –1	–1.5 to –3	000	0	
4 Mar							
0000–0500	R, ZR-, IP-	10	–0.5 to 0	2 to –1	000	0	Anemometer frozen all day
0600–0800	ZR-	6 to 11	0	–1	000	0	
0900–1100	ZR-	11 to 6	–0.5 to 0	–2 to –1.5	000	0	Sky condition
1200–1400	R-	8 to 11	0 to 0.5	–1.5 to –1	000	0	partially obscured to overcast
1500–1600	L-F	5 to 1.5	0.5	–1	000	0	100- to 300-m ceiling all day
1600–1700	L-S-IP-F	1.5	0	–1	000	0	
1800–1900	S-F	1.2	–1	–2	000	0	
1900–000	S-F	6	–1 to –3	–3 to –5.5	000	0	
5 Mar							
0000–0200	ZL-F	6	–3	–6.5	000	0	Anemometer frozen until
0200–0300	ZL-F	11	–3 to –3.5	–6.5 to –7	000	0	0800 LST
0400–0500	None	11	–4 to –5	–7 to –11.5	000	0	
0600–0800	None	11 to 18	–5 to –4	–11.5 to –9	000	0	Ice storm over
1030	None	16	–2	–9	NW	2–4	Wind sensor back on line fixed manually

where the snow cover was deeper. Total water equivalent precipitation for this period was approximately 20 mm, mostly rain. The period had mostly overcast sky conditions with ceilings generally less than 1000 m, occasionally to 200 m.

3–5 March

By 0700 EST on 3 March an intense low pressure center developed in the southeastern U.S. and atmospheric pressure fell rapidly as the system moved north. This low was centered over central Pennsylvania by 0700 on 4 March. Figure 2 shows this situation and locates the center of the low pressure with its associated fronts. As the low stalled, warm moist air was advected into the low pressure system from the Gulf of Maine. The low intensified and an upper level trough formed (dashed line through center of low) from Syracuse, New York, over Watertown, New York, and along eastern Lake Ontario west of Burlington, Vermont, and then into Canada (Fig. 2). The large moisture band associated with this system flowed counterclockwise around the low and combined with colder air from Canada. This storm brought varying intensities and mixtures of rain, ice pellets and snowfall, causing one of the most severe icing/glaze events in central northwestern New York State in many years. The major ice load event destroyed power lines, trees and closed the city of Watertown/Fort Drum, New York, and surrounding areas for nearly three days. The region was declared a disaster area. The total accumulated water equivalent for the icing event was 23 mm (0.9 in.). Nearly all exposed surfaces such as tree branches and powerlines, our meteorology tower and other surfaces colder than 0°C accreted ice to a thickness of 12 to 20 mm, or nearly 0.80 in. (Fig. 3). Some areas on the ground had ice deposits, which fell from trees and suspended objects, up to approximately 50 mm (2 in.) in thickness (Fig. 4).

6 March

As the intense low moved off to the northeast, warm weather prevailed with temperatures ranging between 12° and –1°C.

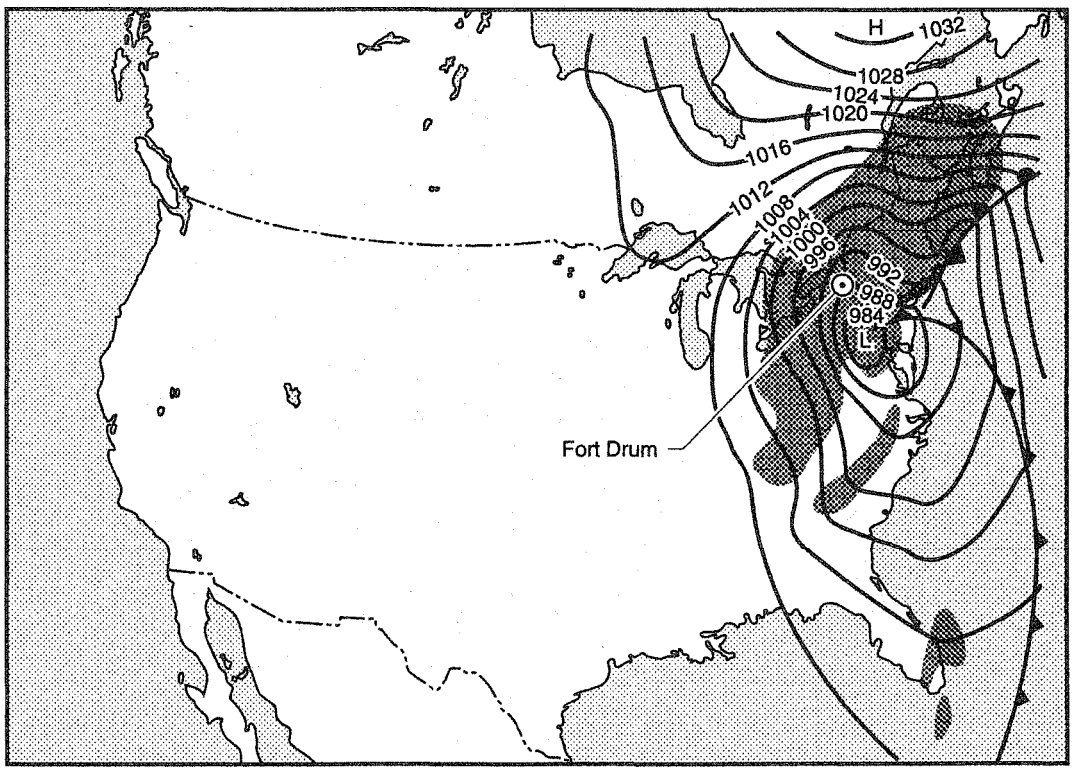

Figure 2. Meteorological conditions for 4 March 1991, 0700 hours (shading indicates precipitation; pressures are in millibars).

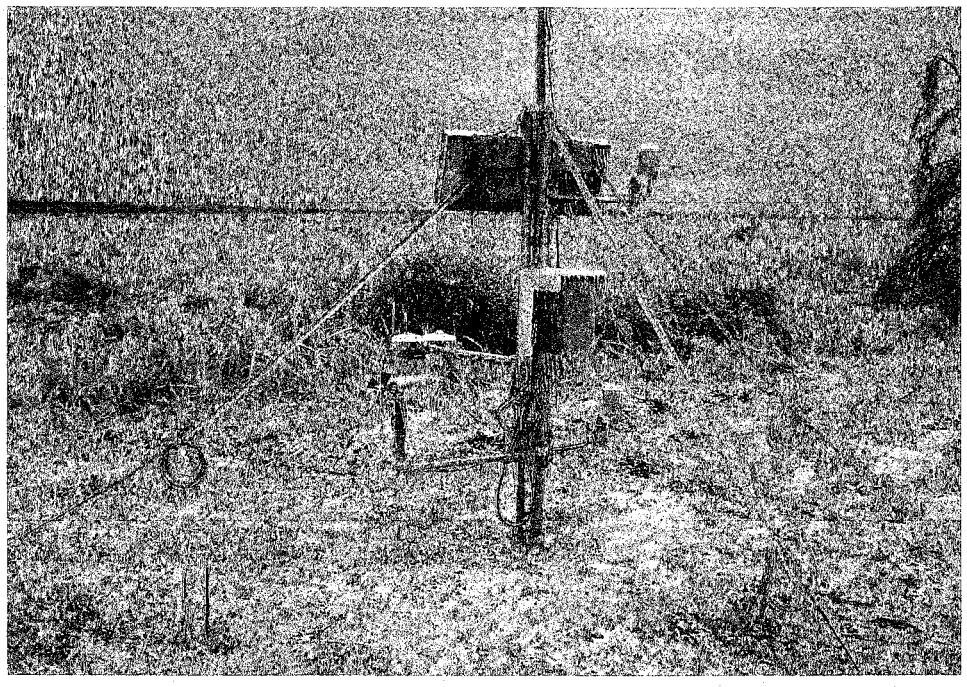

Figure 3. Icing on meteoorological site equipment.

Figure 4. Icing on tree limbs.

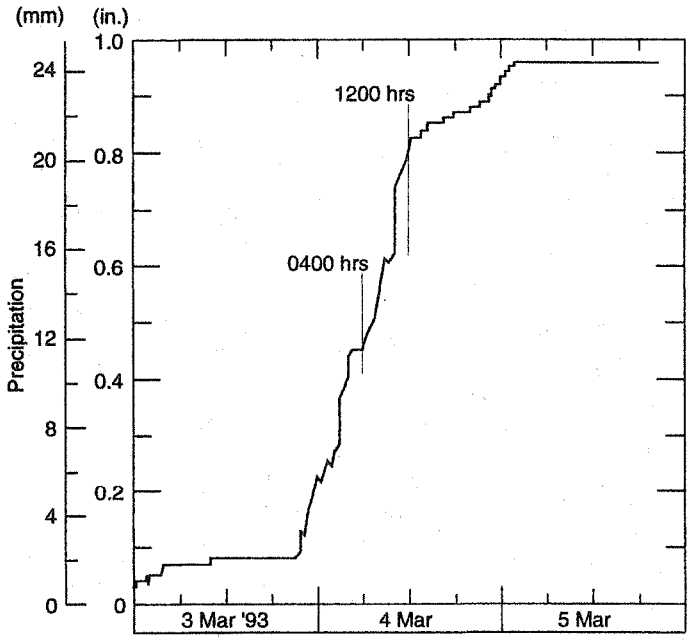

Figure 5. Water equivalent precipitation during 3-day icing event.

ICING/GLAZE/ICE ACCRETION

The ice storm closed down the Ft. Drum base and its airfield and, consequently, the field experiment site from 3–5 March. Although electrical power was out of service, data collection platforms and sensors remained on line with solar-charged batteries. Personnel from CRREL traveled to the field experiment site on 5 March and collected the meteorological data from the data logger storage modules, obtained icing information, cleared rime/glaze ice accumulation from the meteorological sensors and restarted the measurement program.

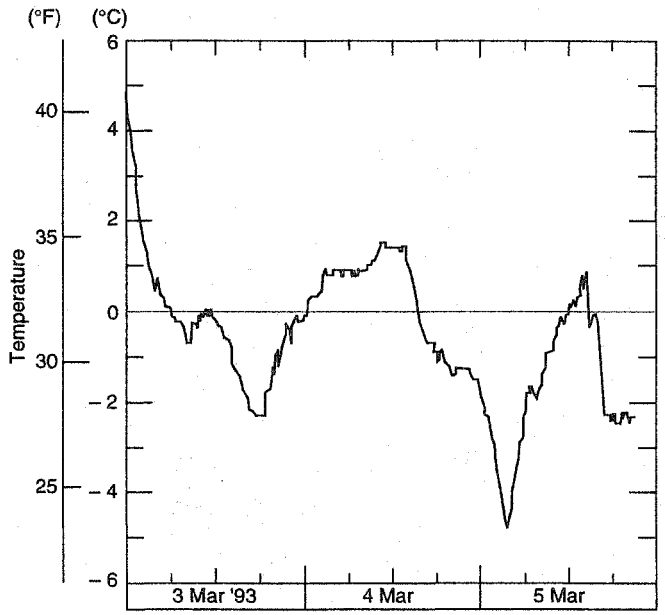

Figure 6. Air temperature data, 3-day icing event.

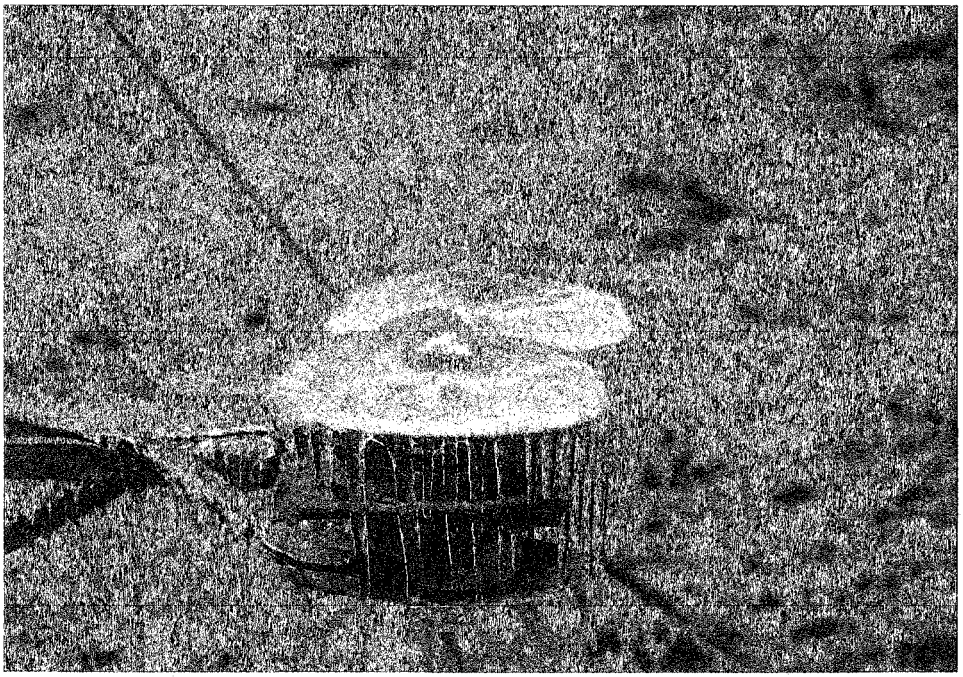

Figure 7. Ice accumulation on radiometers.

DATA ANALYSIS FOR THE ICING EVENT

This icing event reached maximum intensity of 2.03 mm/hr water equivalent at approximately 0400 EST on 4 March. The storm continued at an average accumulation rate of 1.3 mm/hr between 0400 and 1200 EST (see both Table 2 and Fig. 5 for data). This is a considerable accumulation for a freezing rain and drizzle event over an 8-hour period. Air temperature at this time was 0.3 to 0.6°C, and relative humidity was 98% (Fig. 6). Wind speed averaged 3 m/s gusting to 10 m/s from the northeast, on 3 March prior to the icing event. However, wind data are not available for most of this icing event as the anemometer froze during calm icing conditions at 0030 EST on 4 March and data are shown as 000 00 during this

Figure 8. Icing accumulation on trees, along route to field experiment site.

period in Table 1. Also, the incoming visible and infrared radiometer data shown in Table 1 are incomplete as glaze ice covered the upward looking sensors from 1900 EST on 3 March until they cleared at 0830 LST on 5 March. For any additional meteorological data refer to Table 1. Refer to Figures 7–8 for photos of the icing/glaze effects and surface ice accretion conditions.

SUMMARY

As stated earlier, these tests were designed for characterization of winter conditions; however, the weather for most of the test period was quite mild and more characteristic of the transition period between winter and spring. Background conditions in general prior to the icing event consisted of areas of spotty snow cover, frozen or partially frozen ground, and some ice on standing ponded water areas that had surface melt during warmer daytime periods. The area mostly consisted of open fields overgrown with scrub brush that also collected considerable ice. The significant weather event during the test period was the ice storm described in the text. This severe icing/rime formation/glaze icing event (that we were fortunate to document) resulted in 12 to 25 mm of accretion on all exposed objects, and was supported by high frequency meteorological data (10-min. average) throughout. Incoming solar radiation and wind data were lost during the heavier part of the event due to icing.

REFERENCES

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