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**Extreme snow events along the coast of the northeast United States:
Potential changes due to global warming**

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This supporting information provides details on the 110 observed extreme snowstorms affecting the northeast United States in 1980–2015 (Table S1), how events were selected for WRF simulations, and how cyclone centers were diagnosed in this study.

Event selection

In the early stage of this study, we noticed that the snowfall of some events was significantly underestimated in WRF simulations as well as in the ERA-Interim 12-hour forecast, implying that the ERA data may have large biases in large-scale meteorological conditions of these events. This makes these events no longer representative of extreme snowstorms. To alleviate their effects on the result statistics, we excluded the events in which the regional-mean ERA forecast SWE (snow water equivalent) depth over the core region containing all four cities (37°N–44°N, 79°W–70°W; red rectangle in Fig. 3a) was less than 0.025 of the GHCN snowfall depth (i.e. the forecast snowfall was less or around ¼ of the observed assuming a simple 10:1 snow-to-liquid ratio). There were 17 such events identified (highlighted in bold in Table S1) for investigation. These events also had underestimated total precipitation in the ERA forecast (less than or around 0.5 of the GHCN observation). Meanwhile, it was noticed that all these events followed another extreme-snow day (e.g. 1988-01-09 followed 1988-01-08), indicating that they were at the closing stage of synoptic systems.

Cyclone center diagnosis

The cyclone centers were diagnosed with the simulated sea-level surface pressure (PSL) in D1 using an algorithm based on Bauer and Del Genio (2006) and Lin (2015). For each event, the cyclone center was first diagnosed using the daily-mean field of sea-level surface pressure (P_{SL}) with the following procedure: 1) P_{SL} contours were plotted in every 1 hPa; 2) all local minimums in the domain that had at least one closed contour that covered more than 25 grids were located; 3) the cyclone center responsible for the snowstorm was manually identified from

the minimums; and 4) the cyclone-center position was calculated by averaging longitudes and latitudes of all grids at the innermost contour. If no cyclone center could be clearly found in either the historical or future case, the same procedure was then applied in P_{SL} fields at 06, 12, 18 and 24 UTC of the day. It was ensured that cyclone centers in two cases of a given event must be both diagnosed using either the daily-mean P_{SL} field or the P_{SL} field at the identical moment of the day. Cyclone centers were successfully diagnosed in 87 events using the daily-mean P_{SL} and in 6 events using one of the 6-hourly P_{SL} .

TABLES

Table S1. The dates of extreme-snow events and the corresponding daily snowfall (mm) at Boston, New York City (NYC), Philadelphia (Philly) and Washington D.C. (D.C.) identified from GHCN station observation during November–March in 1980–2015. The extreme-snow day was defined when the four cities either individually or collectively experienced daily snowfall exceeding the local 95th percentile thresholds i.e. 137, 118, 105 and 111 mm respectively from north to south. There were 110 events in total, and 17 events (highlighted with bold font) were discarded in this study because of large biases in the reanalysis data. All the 17 events followed another extreme snowstorm (e.g., 1988-01-09 followed 1988-01-08). The events leading events on 1984-03-30, 2001-02-06, 2002-12-26, 2008-12-20 and 2015-03-06, not shown in the list, produced heavy snowfall over the inland area rather than the coastal region.

date	Boston	NYC	Philly	D.C.	date	Boston	NYC	Philly	D.C.
1980-11-18	137	19	1	0	2003-02-07	114	112	123	127
1981-03-05	0	126	129	3	2003-02-08	156	16	5	0
1981-12-06	285	0	0	0	2003-02-16	0	35	129	288
1982-01-14	172	94	72	62	2003-02-17	139	304	252	182
1982-12-12	33	53	105	140	2003-02-18	285	73	42	20
1983-01-16	183	68	13	1	2003-12-06	205	136	79	48
1983-02-07	171	68	58	37	2003-12-07	301	57	16	2
1983-02-11	29	192	192	356	2004-01-28	32	146	65	8
1983-02-12	320	238	145	79	2004-12-27	192	34	15	0
1984-01-11	172	88	71	26	2005-01-22	138	134	141	45
1984-03-09	75	133	155	35	2005-01-23	385	137	128	28
1984-03-30	155	7	2	0	2005-02-21	81	118	49	0
1985-02-06	140	62	52	0	2005-03-01	190	77	97	36
1986-11-19	152	5	0	0	2005-12-09	139	119	79	53
1987-01-22	84	164	180	217	2005-12-10	159	0	2	0
1987-01-26	64	61	109	205	2006-02-12	232	400	221	257
1987-02-23	16	100	297	272	2006-02-13	139	21	13	5
1987-11-11	60	21	15	152	2007-12-16	147	19	0	0
1987-11-12	150	15	4	54	2008-02-22	74	140	58	2
1988-01-08	99	113	124	130	2008-12-20	180	35	0	0
1988-01-09	145	29	15	0	2009-01-19	190	37	9	0

1988-02-12	137	98	16	2	2009-03-02	181	130	113	123
1990-12-28	79	161	104	31	2009-12-19	0	101	125	225
1991-01-12	155	42	3	0	2009-12-20	194	154	139	230
1992-03-19	61	143	14	0	2010-02-06	0	7	270	488
1992-12-12	213	27	0	0	2010-02-07	0	0	53	130
1992-12-13	147	24	0	0	2010-02-10	15	195	182	147
1993-02-22	137	34	18	14	2010-02-11	25	116	105	117
1993-03-05	145	10	0	0	2010-02-26	2	227	96	1
1993-03-13	155	221	240	227	2010-12-26	75	180	61	1
1993-03-14	154	114	96	39	2010-12-27	225	228	123	6
1993-03-24	180	0	0	0	2011-01-12	305	170	111	31
1993-12-30	194	45	13	0	2011-01-26	23	127	147	58
1994-01-04	160	48	8	15	2011-01-27	268	230	210	133
1994-01-08	163	28	5	2	2011-02-02	180	13	0	0
1994-02-09	198	110	45	5	2013-02-09	441	140	44	0
1994-02-11	88	178	135	59	2013-03-08	269	99	18	0
1995-02-04	132	208	237	139	2013-03-19	167	19	1	0
1995-12-20	182	147	86	7	2013-12-15	137	31	33	2
1996-01-03	191	57	0	0	2014-01-03	224	136	143	76
1996-01-07	38	129	263	319	2014-01-21	35	152	113	43
1996-01-08	297	372	334	198	2014-01-22	99	108	148	109
1996-02-03	122	136	132	110	2014-02-03	16	139	72	0
1996-02-16	54	68	99	122	2014-02-13	44	183	204	284
1996-03-08	152	103	84	60	2014-02-14	105	152	95	58
1997-12-23	137	0	0	0	2014-03-17	0	0	54	190
1999-03-15	151	90	31	23	2015-01-27	424	116	42	34
2000-01-25	72	80	149	208	2015-01-28	258	2	0	0
2000-12-30	24	176	119	0	2015-02-02	212	117	12	4
2001-01-21	102	121	68	46	2015-02-03	187	20	0	0
2001-02-06	152	92	59	1	2015-02-09	227	2	0	0
2001-03-06	276	58	9	2	2015-02-10	155	1	0	0
2001-12-09	139	0	0	0	2015-02-15	300	8	28	26
2002-12-05	21	87	101	128	2015-02-22	42	24	45	113
2002-12-26	159	82	13	10	2015-03-06	1	34	93	123

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