Wind Speeds in ASCE 7 Standard Peak-Gust Map: Assessment

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Abstract: The ASCE 7 peak-gust map divides the United States into two main adjacent wind speed zones that do not reflect correctly the country's differentiated extreme wind climate. Following a request by the National Institute of Standards and Technology (NIST), CPP Inc. through Texas Tech Univ. provided information used for the development of the map and for its a posteriori justification. Using this information we show that the methodology used in the map's development averages out real climatological differences and causes severe bias errors for the following reasons: (1) the estimation of the speeds was based on superstations, of which 80% included stations that were also contained in one or more other superstations; (2) stations with significantly different physical geography and meteorology were in many cases included in the same superstation; (3) legitimate wind speed data were omitted from data records in cases in which analyses resulted in speeds different from those postulated in the map; (4) and off-the-shelf smoothing software was used that does not account for physical geography and meteorological differences. Case studies show that the map entails severe bias errors, causing unnecessary waste due to overestimated wind loads or potential losses due to underestimated wind loads.

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Introduction

One of the major products of the National Science Foundation sponsored cooperative program in wind engineering between Colorado State Univ. (CSU) and Texas Tech Univ. (TTU) was the generation by CSU of a peak-gust wind speed map for the continental United States and Alaska (Cooperative Program in Wind Engineering) (CPWE, 1994). This map was adopted for use in the 1995 and subsequent versions of the American Society for Civil Engineers (ASCE 7) Standard Minimum Design Loads for Buildings and Other Structures (ASCE 1995), and is referred to in this report as the ASCE 7 peak-gust map.

The ASCE 7 peak-gust map differs from the ASCE 7-93 wind map (ASCE 1993) in three major ways: First, it provides values of 50 year peak 3 s gust speeds, instead of 50 year fastest-mile wind speeds, as was the case for the ASCE 7-93 wind map. Based on research conducted at Texas Tech Univ. for five National Weather Service stations (Lubbock, Tex.; Amarillo, Tex.; Kansas City, Mo.; Minneapolis; and Syracuse, N.Y.), a ratio between 3 s peak-gust speeds and the corresponding fastest-mile wind speed of about 1.2 was judged to be reasonable (CPWE, 1994, p. 7). If this ratio is used, 3 s speeds of 38 m/s (85 mph) and 40 m/s (90 mph) correspond approximately to 31 m/s (70 mph) and 33 m/s (75 mph) fastest-mile speeds, respectively.

Second, it is based on analyses of data for sets of stations ("superstations"), rather than on analyses of data for individual stations. In principle, the aggregation of individual stations into superstations has the advantage of yielding estimates based on larger data sets and therefore having smaller sampling errors. This advantage is real, however, only if the aggregation is sound from a statistical and meteorological viewpoint.

Third, with the exception of hurricane-prone areas and areas of special winds, the ASCE peak-gust map is divided into two adjacent wind speed zones. In the first zone, comprising the entire conterminous United States except for California, Oregon, and Washington, the specified 50 year 3 s peak gust speed is 40 m/s (90 mph). The second zone comprises these three states, for which the specified speed is 38 m/s (85 mph). The changes in design wind speeds entailed by the use of the ASCE 7 peak-gust map instead of the ASCE 7-93 map have the following consequences.

For areas for which (1) the ASCE 7-93 standard specified a 31 m/s (70 mph) 50 year fastest-mile speed (corresponding in accordance with the proposed CPWE (1994) ratio to an approximately 37 m/s (84 mph) 3 s peak-gust speed); and (2) the ASCE 7 peak-gust map specifies a 40 m/s (90 mph) 50 year 3 s peak gust, the ASCE 7 peak- gust map entails an increase in wind loads by a factor of about $(90/84)^2 = 1.15$. In structural engineering terms this is significant, and would be equivalent to increasing the wind load factor from 1.6 to 1.84, or from 1.5 to 1.72. For areas for which (1) the ASCE 7-93 standard specified a 36 m/s (80 mph) 50 year fastest-mile speed; and (2) the ASCE 7 peak-gust map specifies a 38 m/s (85 mph) 3 s peak gust, the ASCE 7 peak-gust map entails a decrease of the wind loads by a factor of $(85/96)^2 = 0.78$. This factor is even smaller for the considerable areas where the actual peak-gust wind speed is larger than $36 \times 1.2 = 43$ m/s (96 mph).

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Is the ASCE 7 peak-gust map warranted from a climatological point of view or is it the result of an inadequate meteorological and statistical approach to its development? This question was raised in a discussion by Simiu and Filliben (1999) of the Peterka and Shahid (1998) paper in which—3 years after its adoption in the ASCE 7-95 standard—the ASCE 7 peak-gust map was for the first time presented in a refereed journal. It was noted in that discussion that neither the data nor the superstation definitions used for the development of the ASCE 7 peak-gust map were available to the engineering community, and that this rendered impossible an independent, objective, and reliable scrutiny of the basis for the map.

For this reason the National Institute of Standards and Technology (NIST)/TTU Cooperative Agreement/Windstorm Mitigation Initiative, with Dr. Peterka's helpful cooperation, undertook the task of making public the information needed to verify the adequacy of the map. A report by CPP Inc. (CPP 2001), which includes a document by Peterka and Esterday (2001) and a compact disk (CD), is available from the Wind Engineering Research Center at Texas Tech Univ. (TTU). The CD includes the description of the superstations used for the original estimates (i.e., the names of the individual stations of which the superstations are composed), the recorded largest annual peak gusts at each station, the station anemometer height histories, the largest annual speeds at 10 m above ground at each station, and the description of two additional sets of alternative superstation definitions (see also files accessible as indicated in Appendix II.

In the next section we list and discuss the composition of the superstations used for the original estimates, and note that 80% of the superstations include stations appearing in two or more superstations. In the following section we consider typical case studies from the alternative superstations of CPP (2001). The paper ends with a set of conclusions.

Superstations Used for Development of ASCE 7 Peak-Gust Map

One feature of the superstations used for the development of the ASCE 7 peak-gust map is that the overwhelming majority contain stations included in at least two superstations. The inclusion of the same stations in more than one superstation weakens differences between superstations and is therefore inappropriate for statistical analysis purposes. A critique of this feature was therefore produced by NIST within the framework of the NIST/TTU Cooperative Agreement/Windstorm Mitigation Initiative. Following this critique CPP (2001) performed analyses of alternatively aggregated superstations, in which no station appears in more than one superstation. We comment on the composition of and statistical analyses for the alternative superstations in the next section.

Table 1 of Appendix I lists the superstations used to develop the ASCE peak-gust wind map. Their identifying numbers are taken from the CPP (2001) CD. Two or more stations with the same name listed in one superstation represent nearby but distinct stations (with one station run, e.g., by the National Weather Service, and the other by, e.g., the Air Force). Station longitudes/latitudes are available in the CPP (2001) CD.

As noted earlier, about 80% of the total number of superstations contain stations included in at least two superstations. Of the remaining 20%, more than half consist of at most three stations. Given the composition of the superstations it is not surprising that the estimates reflected in the maps tend to consist of the same wind speeds over areas in which the extreme wind climates are in fact nonuniform.

Alternative Superstations (CPP 2001)

Following questions raised by NIST on the composition of the superstations listed in the preceding section, two sets of alternative superstations with no common stations were developed by CPP (2001) to justify the validity of the wind speeds used in the ASCE 7 map. The sets are listed as Sets 1 and 2 (see files accessible as indicated in Appendix II). We now comment on the composition of typical alternative superstations and on the results obtained from the analysis of the respective data.

For consistency with the estimates by Peterka and Shahid (1998) and CPP (2001), our own estimates were obtained by the method of moments applied to the Extreme Value Type I distribution (see Simiu and Scanlan 1996, Chap. 3)

$$V_{50}=\overline{X}+2.6s$$

$$\mathrm{SD}(V_{50})=3.376\frac{s}{\sqrt{n}}$$

where V_{50}=estimated 50 year speed; SD(V_{50})=estimated standard deviation of the sampling error in the estimation of the 50 year speed; $\overline{X}$ and s=sample mean and standard deviation of the largest yearly speeds, respectively; and n=sample size. The data used for the estimates were the peak-gust speeds at 10 m elevation contained in the CPP (2001) CD and in the files accessible as indicated in Appendix II.

In the superstations listed in this section the first, second, and third number within parentheses and separated by commas indicates, for each station, the estimated 50 year 3 s peak gust speed, the sample size, and the corresponding estimated standard deviation of the sampling error in the estimation of that speed. The numbers in bold type following the semicolon indicate the estimated speed for the superstation based on the consolidated set of superstation data. All speeds and their standard deviations are listed in m/s and (mph). In some cases these estimated speeds differ by small amounts [e.g., 0.5 m/s (1 mph)] from their counterparts as estimated in CPP (2001). Physical station descriptions contained in this section are based on National Climatic Center/Local Climatological Data Narrative Summaries. The locations of the stations are shown in the maps of Simiu et al. (2001), seven of which are reproduced in this paper. Owing to space limitations, and because they are typical of the approach used in CPP (2001), 14 typical superstations from Set 1 are commented upon. For maps of states containing other superstations, see Simiu et al. (2001). For data and complete Sets 1 and 2 superstation listings, see files accessible as indicated in Appendix II.

Set 1, Superstation 99100 (Ore.): Burns [36(81),5,6(14)], Eugene [32(71),19,3(6)], Medford [31(69),21,2(5)], Salem [33(75),19,3(6)], Klamath Falls [33(75),20,2(5)]; **33(74)**. *Comment*: For this superstation, the consolidation of the individual station data into a larger data set does not appear to add any useful information as far as most individual stations are concerned. The exception is Burns, for which the sample size is too small, however, for the statistical analysis to yield reliable results.

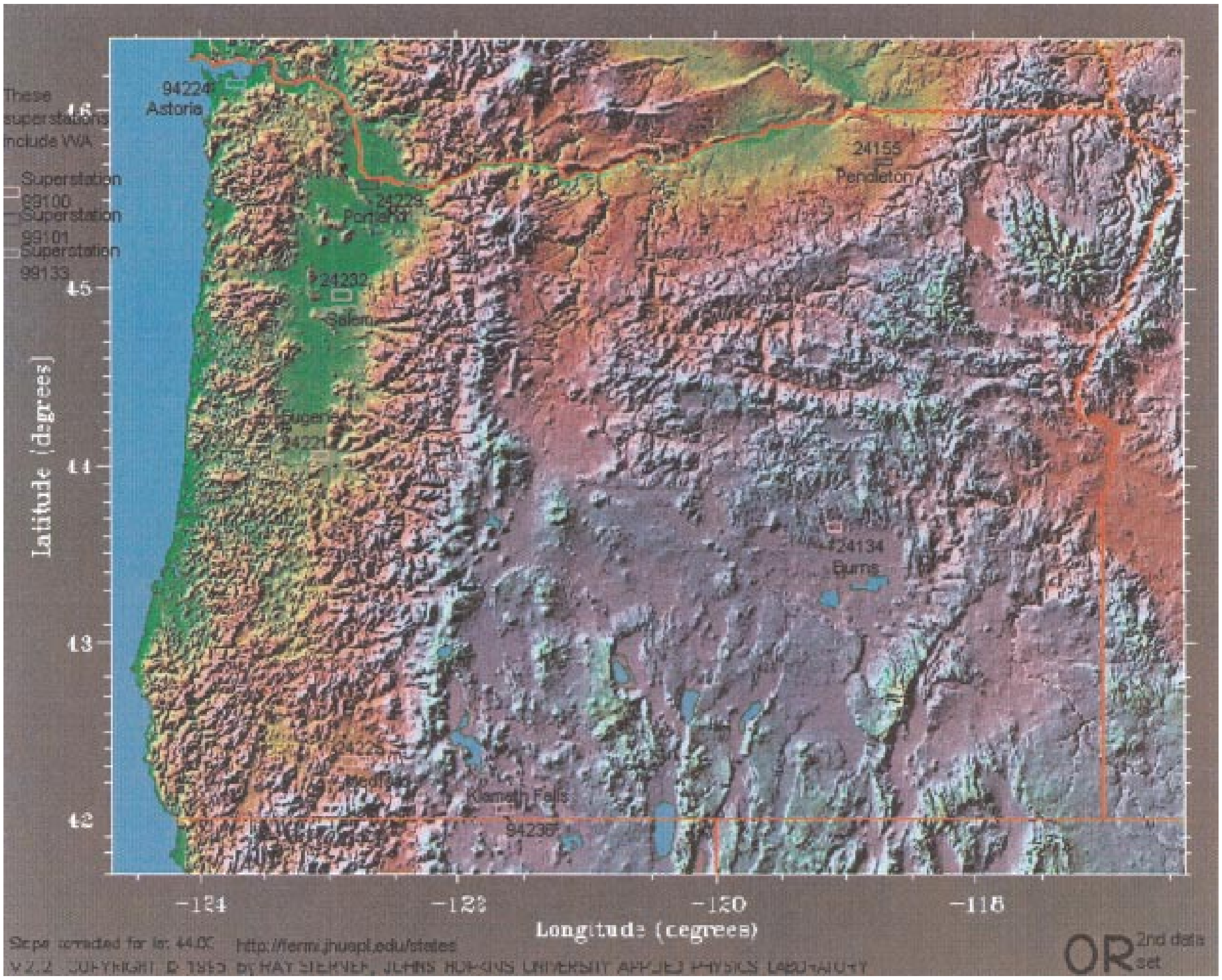

Fig. 1. (Color) Map of Oregon with stations and set 1 (CPP 2001) superstations

As can be seen from the map of Oregon (Fig. 1), the wind climates of Eugene or Salem on the one hand and Burns, Medford, or Klamath Falls on the other are determined by different meteorological conditions. Eugene is located at the southern end of Willamette Valley between the Coast Range and the Cascade Mountains, and experiences relatively strong winds mostly from the southwest. Burns is located near the center of a high plateau area. Before reaching Burns, maritime air moving in from the Pacific Ocean is modified not only by the Coast Range but by the Cascade Mountains as well. Highest wind velocities in Medford are reached when a well-developed storm off the coast of California causes a chinook wind off the Siskiyou Mountains in the south. There is little commonality between Medford's wind meteorology and, say, Eugene's. Even though in the particular case of these two stations the respective estimated 50 year speeds are almost the same, it is generally not the case that superstations can be composed without regard for their specific meteorological and physical geography features. This is clearly demonstrated by other examples given in this section.

Set 1, Superstation 99101 (Ore., Wash.): Pendleton [37(83),19,3(6)], Olympia [31(70),16,3(6)], Portland [40(90),32,3(7)], Yakima [34(76),20,2(5)]; **37(84)**. *Comment*: Pendleton is located in the southeastern part of the Columbia basin, which is almost entirely surrounded by mountains, the most important break in the barriers surrounding the basin being the gorge in the Cascade Range on the west (Fig. 1). Olympia is well protected by the Coast Range from the strong south and southwest winds accompanying many of the Pacific storms during the fall and winter (Fig. 2). In contrast, the protection offered by the Coast Range to Portland is described by the National Climatic Center as limited. This may explain Portland's stronger extreme wind climate relative to Olympia's. Yakima is located in a small East–West valley in the northwestern part of Yakima Valley. Local topography is complex, resulting in marked variations in winds within short distances. Note, for example, that the inclusion of Portland in a superstation with stations having different physical geography results in a significant reduction of its estimated extreme speeds. Such a reduction is in our opinion unwarranted.

Set 1, Superstation 99961 (Me.): Loring [32(71),35,1(3)]; **32(71)**. *Comment*: This "superstation" consists of only one station. In this case this is, in our opinion, judicious. This station's conditions are different from those of other stations in Me. owing both to its physical geography and its distance from the coast. However, given that the estimated peak-gust speed is 32 m/s (71 mph), there is no reason arbitrarily to assign to this superstation a 40 m/s (90 mph) 50 year peak-gust speed, as is done in the ASCE 7 peak-gust map.

Set 1, Superstation 99132 (Vt., N.Y.): Burlington [33(75),16,3(6)], Plattsburgh [32(72),33,1(3)]; **32(73)**. *Comment*: Judging from the New York and Vermont maps in Figs. 3 and 4, the consolidation of these stations into one superstation is in our opinion warranted. If the 50 year 3 s gust for Burlington is esti-

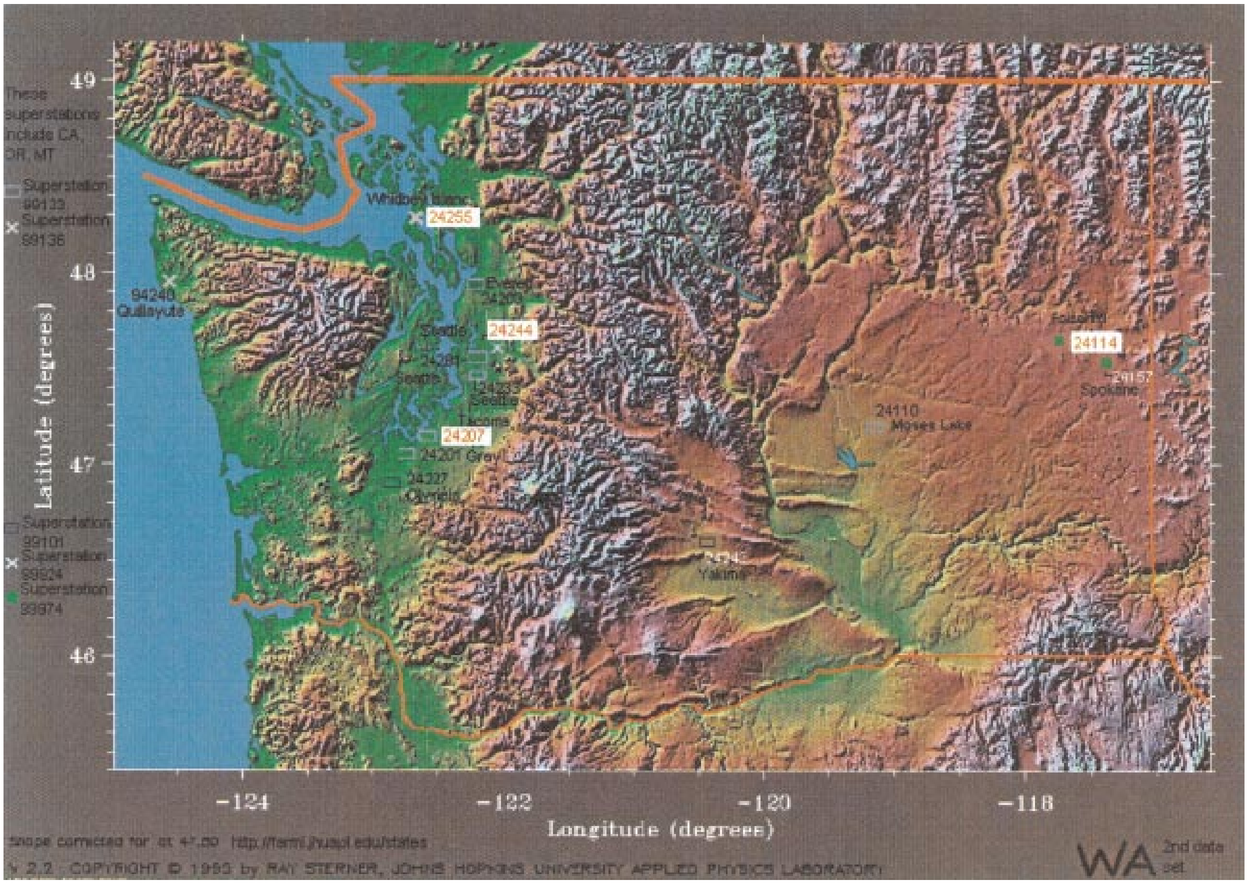

Fig. 2. (Color) Map of Washington with stations and set 1 (CPP 2001) superstations

mated from the 33 year fastest-mile speeds record (see Simiu et al. 1979, p. 280) by using a 1.2 ratio between fastest mile and 3 s peak gusts speeds, the result obtained is 35 m/s (79 mph). There is in our opinion no reason to believe that the 32 m/s (73 mph) estimate obtained by consolidating the two stations is more realistic than the 35 m/s (79 mph) estimate. However, this is a moot point. What is definitely the case is that the 50 year 3 s peak gust speed for Burlington and Plattsburgh should be less than 40 m/s (90 mph). In fact the value corresponding to the fastest-mile speed specified in the ASCE 7-93 map is about 37 m/s (84 mph). In contrast, ASCE 7 peak-gust map specifies a 40 m/s (90 mph) speed. It was seen earlier that the assignment of a blanket 38 m/s (85 mph) value for the whole state of Oregon is not appropriate for the Portland, Ore. area. The assignment of a 40 m/s (90 mph) for the Burlington and Plattsburgh areas is similarly inappropriate.

Set 1, Superstation 99927 (N.J.; Mass.; N.Y.; Ct.; R.I.): Belmar [30(67),7,3(7)], Newark [38(85),17,3(6)], McGuire [36(81),42,3(6)], Lakehurst [39(87),41,3(6)]; Maynard [30(67),13,4(9)], Fort Devens [28(63),18,2(4)], Chicopee Falls [42(95),21,4(9)], Falmouth [41(93),22,3(6)], Boston [40(89),42,2(4)], Milton [55(123),8,8(18)], South Weymouth [35(78),33,2(5)], Worcester [36(80),29,2(4)]; Hampstead [38(86),13,4(9)], Stewart [36(81),21,3(6)], Suffolk County [37(84),12,4(8)], New York [46(104),18,4(9)], Albany [34(76),19,2(5)], New York/Central Park [28(64),7,4(9)], New York [35(79),9,4(8)]; Bridgeport [33(75),16,3(6)], Hartford [41(93),10,7(16)], Providence [40(91),38,3(6)], Quonset Point [43(96),26,3(7)]; **40(90)**. *Comment*: In contrast to the Loring, Me. ‘‘superstation’’ which, with due consideration of specific geographical features, consisted of only one station, this superstation consists of a large number of stations consolidated, in our opinion, in an indiscriminate fashion. For example, it may be expected that New York/Central Park, being in the center of a large city, has a local wind climate different from that of a typical airport. In view of the ASCE assumption that wind maps represent wind speeds in open terrain, the inclusion of this station in the superstation is, in our opinion, inappropriate. Albany is located some 240 km (150 miles) north of New York City and the Atlantic Ocean. Its wind conditions bear no resemblance to those of, say, Belmar, N.J., and its inclusion in the same superstation as the latter and other Atlantic Coast locations is questionable (see Fig. 5). For Milton, Mass. it is indicated in the National Climatic Center Local Climatological Data Summaries that hills increase the wind speed (Fig. 6). This is confirmed by its relatively high average wind speed [as indicated in the Summaries, more than 7 m/s (15 mph), versus a less than 4 m/s (9 mph) average for Albany]. CPP (2001) also implies that the extreme wind climate in Central Mass. (Fig. 6) is similar to the wind climates in Central N.J. (Fig. 5) and on the Atlantic Coast from Belmar to Boston. In our opinion this is unconvincing. As the results of the analyses show, for numerous areas included in this superstation the 50 year 3 s peak gust speed at 10 m in open terrain is considerably less than the 40 m/s (90 mph) value estimated, in our opinion, incorrectly, by consolidating those areas into one superstation.

Set 1, Superstation 99112 (Tex.): Victoria [35(79),32,2(4)],

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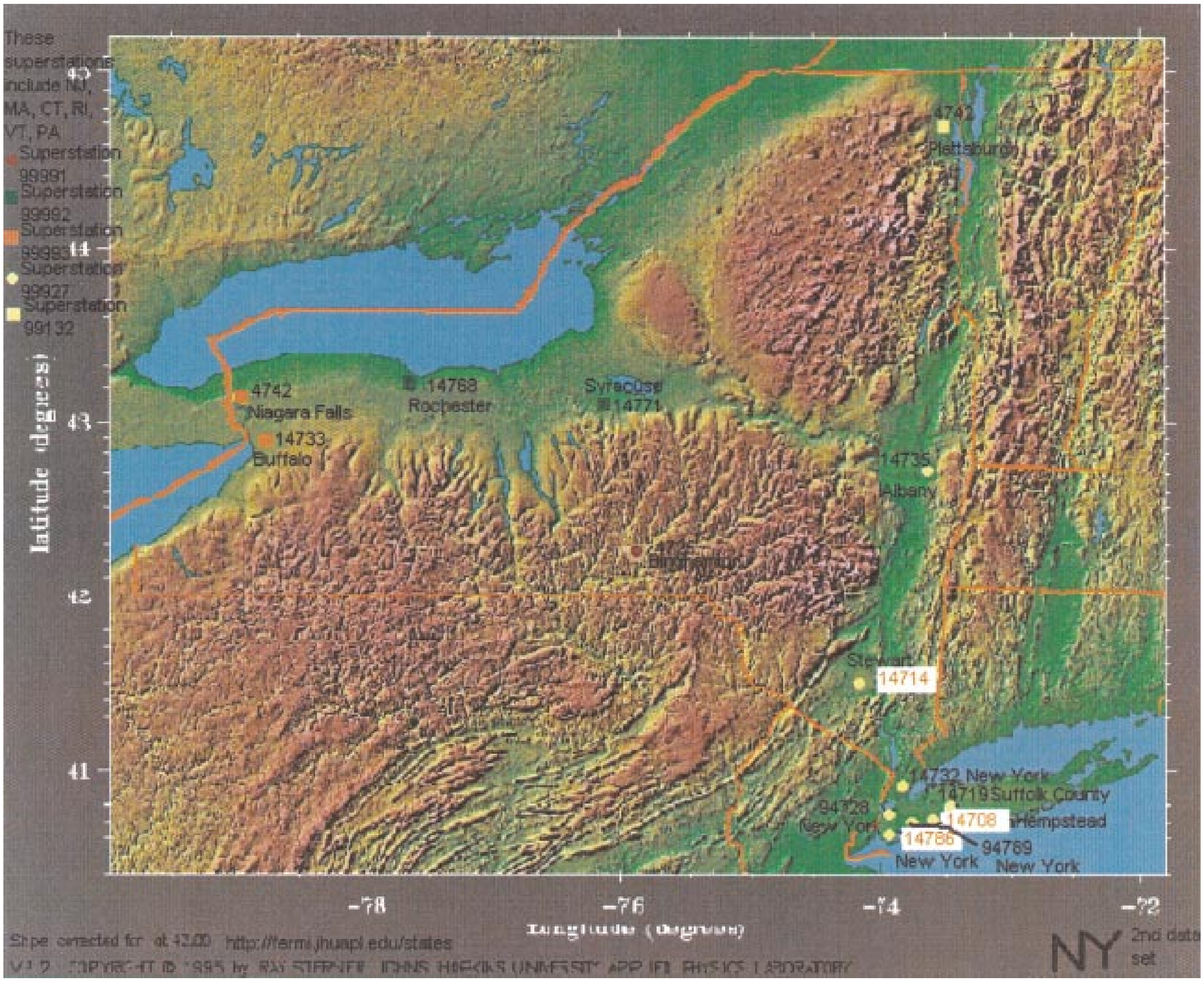

Fig. 3. (Color) Map of New York with stations and set 1 (CPP 2001) superstations

Victoria [32(72),10,2(5)], Corpus Christi [38(86),20,3(7)], Beeville [37(84),33,3(6)], Corpus Christi [45(100),43,3(7)], Kingville [41(91),38,3(7)]; **39(88)**. *Comment*: All the stations included in this superstation are on the Gulf coast (see Fig. 7). Some of the wind speeds listed for these stations were induced by hurricanes (e.g., Corpus Christi, 08/10/1980; 09/11/1961; 09/20/1967; 08/03/1970). The estimation of wind speeds by fitting the superstation data to an Extreme Value Type I distribution is therefore of dubious validity (see, e.g., Simiu and Scanlan 1996, Chap. 3).

Set 1, Superstation 99113 (Tex.): Houston [38(86),38,2(5)], San Antonio [36(82),44,2(5)], San Marcos [28(63),5,3(6)], Randolf [35(79),43,2(4)], Port Arthur [34(76),19,3(6)], San Antonio [36(81),21,3(7)], San Antonio [36(80),11,4(9)], Houston [42(95),22,5(10)]; **37(83)**. *Comment*: The ASCE 7-93 map specifies for San Antonio a 50 year fastest-mile wind speed of about 31 m/s (70 mph), equivalent to a 50 year 3 s peak gust speed of about 37 m/s (84 mph). In contrast, the ASCE 7 peak-gust wind map specifies a speed of 40 m/s (90 mph). The analyses for the individual San Antonio records in this superstation do not warrant the specification of a 50 year 3 s peak gust in excess of 38 m/s (85 mph). This superstation includes Gulf coast stations (Fig. 7), which should not be consolidated with inland stations for extreme wind speed estimation purposes. Even this consolidation, effected for the superstation by CPP (2001), does not result in speeds higher than 37 m/s (83 mph). These comments again support our view that there is no justification to assigning a blanket 38 m/s (85 mph) speed to the states of California, Oregon, and Washington, and a blanket 40 m/s (90 mph) speed to the rest of the conterminous United States except for special wind and hurricane-prone regions.

Set 1, Superstation 99114 (Tex.): Austin [36(81),43,2(5)], Austin [35(78),20,3(6)]; **36(80)**. *Comment*: For Austin the ASCE 7 standard peak-gust map specifies a peak gust speed of 40 m/s (90 mph), in spite of the lower estimated wind speeds shown above. Again, there is in our opinion no justification for doing so.

Set 1, Superstation 99115 (Tex.): Robert Gray [37(83),26,3(6)], Fort Hood [31(69),10,2(5)], Waco [33(75),17,3(6)], Waco [38(85),19,4(8)]; **36(80)**. *Comment*: same as for Superstation 99114.

Set 1, Superstation 99117 (Tex.): Webb [48(107),23,5(10)], San Angelo [28(64),11,2(5)], Midland [43(96),19,3(7)], San Angelo [44(98),19,4(8)]; **45(101)**. *Comment*: For this superstation the ASCE 7 peak-gust map specifies a speed of 40 m/s (90 mph). For the San Angelo station containing 11 yearly wind speed data, the anemometer elevation is: (1) unknown for the first 5 years (1948–1952); (2) 43 m (140 ft) for the years 1953, 1955, and 1956, (3) 31 m (101 ft) for 1954; and (4) 20 m (66 ft) for 1957–1958. Since the data are relatively old, were recorded at anemometer elevations that are unknown for almost half of the data and

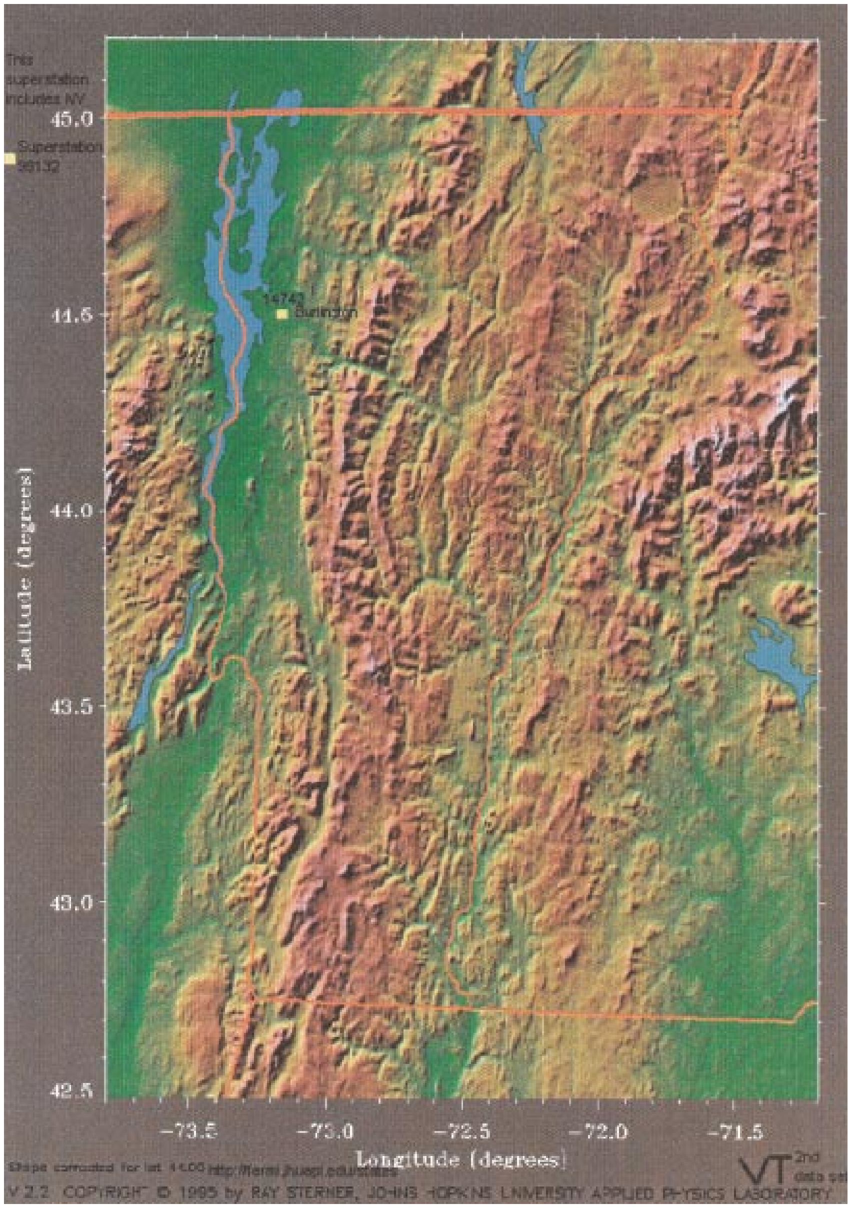

Fig. 4. (Color) Map of Vermont with stations and set 1 (CPP 2001) superstations

varied somewhat erratically for the other half; and constitute a relatively small sample, their use might weaken the overall quality of the estimates. The area covered by this superstation should be assigned a peak gust speed of about 45 m/s (100 mph) or more. The 40 m/s (90 mph) specified in the ASCE 7 peak-gust map leads in this case to an underestimation of wind loads for this region by a factor of about 0.81 or less.

Set 1, Superstation 99128 (Utah): Ogden [45(100),44,3(6)]; **45(100)**. The results of the statistical analysis of the data at this ''superstation'' again show that the 40 m/s (90 mph) specified for Ogden in the ASCE 7 peak-gust map is too low.

Set 1, Superstation 99138 (Wis.): Green Bay [39(88), 16, 4(9)]**; 39(88)**. *Comment*: On the basis of the analysis of the Green Bay data from CPP (2001), it would appear that the 40 m/s (90 mph) speed specified in the ASCE 7 peak-gust speed map is appropriate. However, the sample size for this ''superstation'' is relatively small, and the corresponding standard deviation of the sampling errors is relatively large. The sample size for the fastest-mile wind speed record at Green Bay is larger (29 years, rather than 16 years), and the estimated 50 year fastest-mile wind speed is 39 m/s (88 mph) (Simiu et al. 1979). If the 1.2 ratio between the peak-gust and the fastest-mile speed is assumed (CPWE 1994), this fastest-mile speed corresponds approximately to a 106 mph (47 m/s) peak-gust speed. Note that, during the 29 year period 1949–1977, the highest recorded fastest-mile wind speed reduced to 10 m above ground elevation at Green Bay was 46 m/s (103 mph). In our opinion, the fact that CPP (2001) did not take into account the extreme wind climatological information listed by Simiu et al. (1979) weakens the quality of the estimates, as is shown clearly by this example. For the particular case of this ''superstation'' the available data suggest that the peak-gust speed specified for Green Bay should exceed 40 m/s (90 mph).

Set 1, Superstation 99139 (Wis.): Madison [44(98),19,5(10)]; **44(98)**. *Comment*: The analysis of the CPP (2001) data shows that the 40 m/s (90 mph) speed specified in the ASCE 7 peak-gust map for the Madison ''superstation'' is too low. This is confirmed by statistical analysis of the 31 year fastest-mile wind speed data set listed in Simiu et al. (1979), according to which the estimated

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Fig. 5. (Color) Map of New Jersey with stations and set 1 (CPP 2001) superstations

50 year fastest-mile wind speed in Madison is 38 m/s (85 mph). This corresponds to a 50 year 3 s peak gust of about $1.2\times 38 = 45$ m/s (102 mph).

Set 1, Superstation 99140 (W.V.): Beckley [32(71),15,2(5)]; **32(71)**. *Comment*: The analysis of the CPP (2001) data shows that the 40 m/s (90 mph) speed specified in the ASCE 7 peak-gust map for Beckley is too high.

In our opinion, the typical examples shown in this section show that the blanket 38 m/s (85 mph) and 40 m/s (90 mph) 50 year 3 s peak gust speeds specified in the ASCE 7 wind map do not reflect the reality of the extreme wind climate in the United States. This conclusion is valid regardless of whether Sets 1 or 2 is considered.

CPP (2001) state that "the overall pattern of contours remains very similar" if superstation definition is changed. They conclude on this basis that "the speeds obtained from the superstation analysis are sufficiently close to and centered about 40 m/s (90 mph) for states east of Calif., Ore., and Wash. that closer specification by a contour map for design wind speeds does not appear to be necessary or desirable." Our results show that this is not the case unless:

1. Relatively large wind speeds are arbitrarily eliminated from data sets. For example, Peterka and Esterday (2001) state: "by removing one data point from station 23034 (93 mph, 41 m/s) .... the 95 mph (42 m/s) region disappears." Thus, CPP (2001) eliminated from their analyses the largest speed from the 19-year record at San Angelo, Tex. [i.e., the 44 m/s (98 mph) speed at 10 m elevation or 41 m/s (93 mph) at 6 m elevation recorded in 1974]. By means of this elimination

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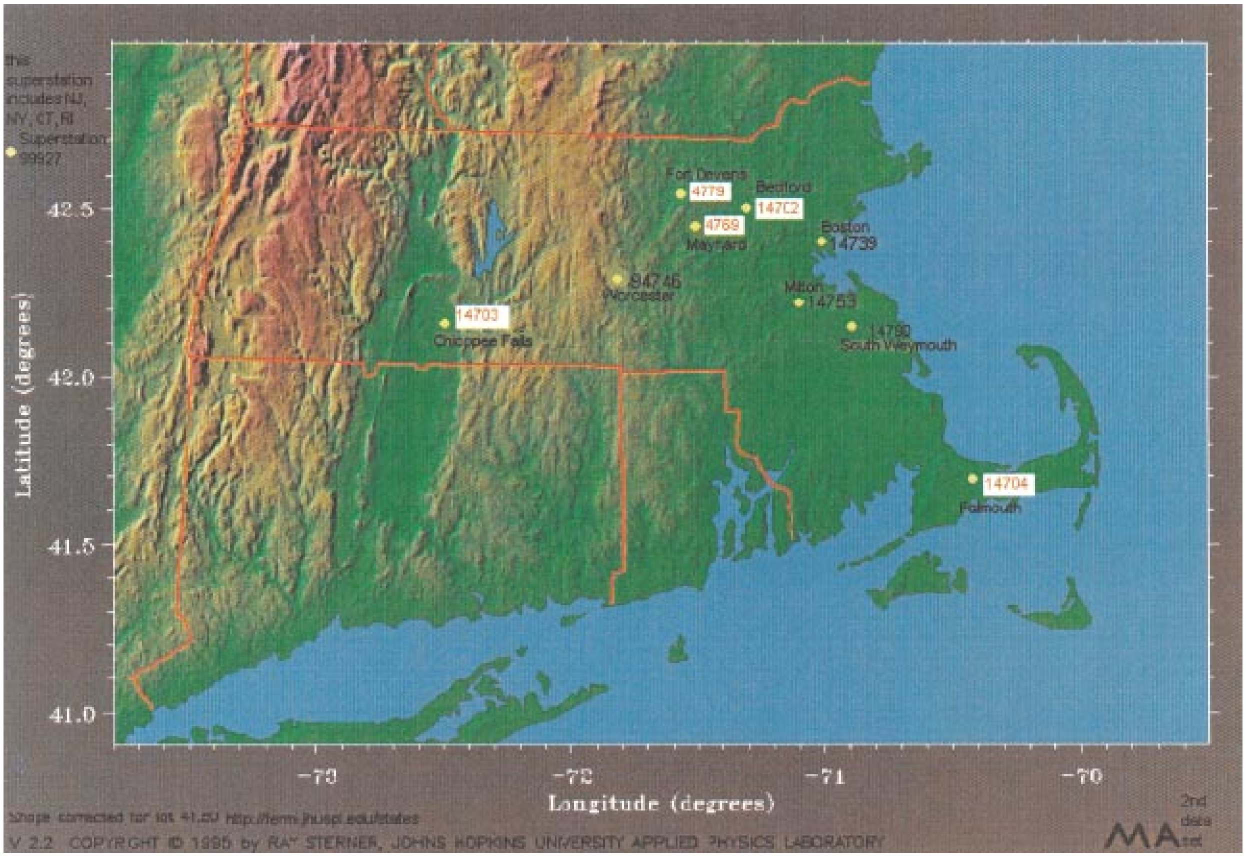

Fig. 6. (Color) Map of Massachusetts with stations and set 1 (CPP 2001) superstations

procedure, estimated wind speeds were changed to conform to the postulated wind speed pattern of the ASCE 7 peak-gust map.

2. The estimated speeds, already smoothed out among various stations by virtue of the arbitrary aggregation of stations into superstations and the selective elimination of data, are again smoothed out by computer smoothing routines which are not designed to take physical geography or meteorological features into account.

Conclusions

Our conclusions are as follows:

1. The ASCE 7 peak-gust map division of the conterminous United States into two main adjacent wind speed zones—with the exception of hurricane-prone areas and zones of special winds—does not reflect correctly the differentiated extreme wind climate of the United States. The methodology used to develop the map tends to average out real wind climatological differences among stations, for the following reasons: (1) The estimation of the speeds specified in the ASCE 7 peak-gust map was originally based on the use of superstations so composed that, in 80% of the cases, component stations belong to more than one superstation. (2) Superstations were in many instances composed of stations with different physical geography and meteorological features. (3) For a number of stations, legitimate wind speed data (i.e., data of which there is no reason to believe that they entailed recording or measurement errors) were omitted from the record. The omission of such data biased extreme speed estimates and eliminated correct estimates that did not conform to the speeds arbitrarily assigned to those stations in the ASCE peak-gust map. (4) In the development of the map its authors used off-the-shelf smoothing software that lacks the capability to account for physical geography and meteorological differences. Such differences are readily apparent to human operators and played a significant role in the development of the ASCE 7-93 wind map. Therefore, the approach used to develop the ASCE 7 peak-gust map creates multiple biases in the estimated speeds for large numbers of stations. The biases by far outweigh any advantages that might be obtained from a reduction of the sampling errors.
2. In our opinion, failure to make use of publicly accessible sets of National Climatic Data Center fastest-mile wind speed data lowers the quality of extreme wind speed estimates. Such data should therefore be included in future extreme speed estimation efforts. It should be recalled in this connection that fastest-mile wind speed data are more stable (i.e., they have smaller inherent variability) than peak gust data. They cover in many instances periods not covered by peak gust data. Finally, the possibility may exist of combining historic fastest-mile data sets not only with peak gust data, but also with adjusted largest 2 min data currently being recorded at Automated Surface Observation System (ASOS) stations (ASOS 2001, p. 14).
3. The ASCE 7 peak-gust map entails, on a national scale, significant waste of material due to overestimated wind loads and losses due to underestimated wind loads. Therefore, the wind map to be included in future versions of the ASCE 7 Standard needs to be improved substantially with respect to

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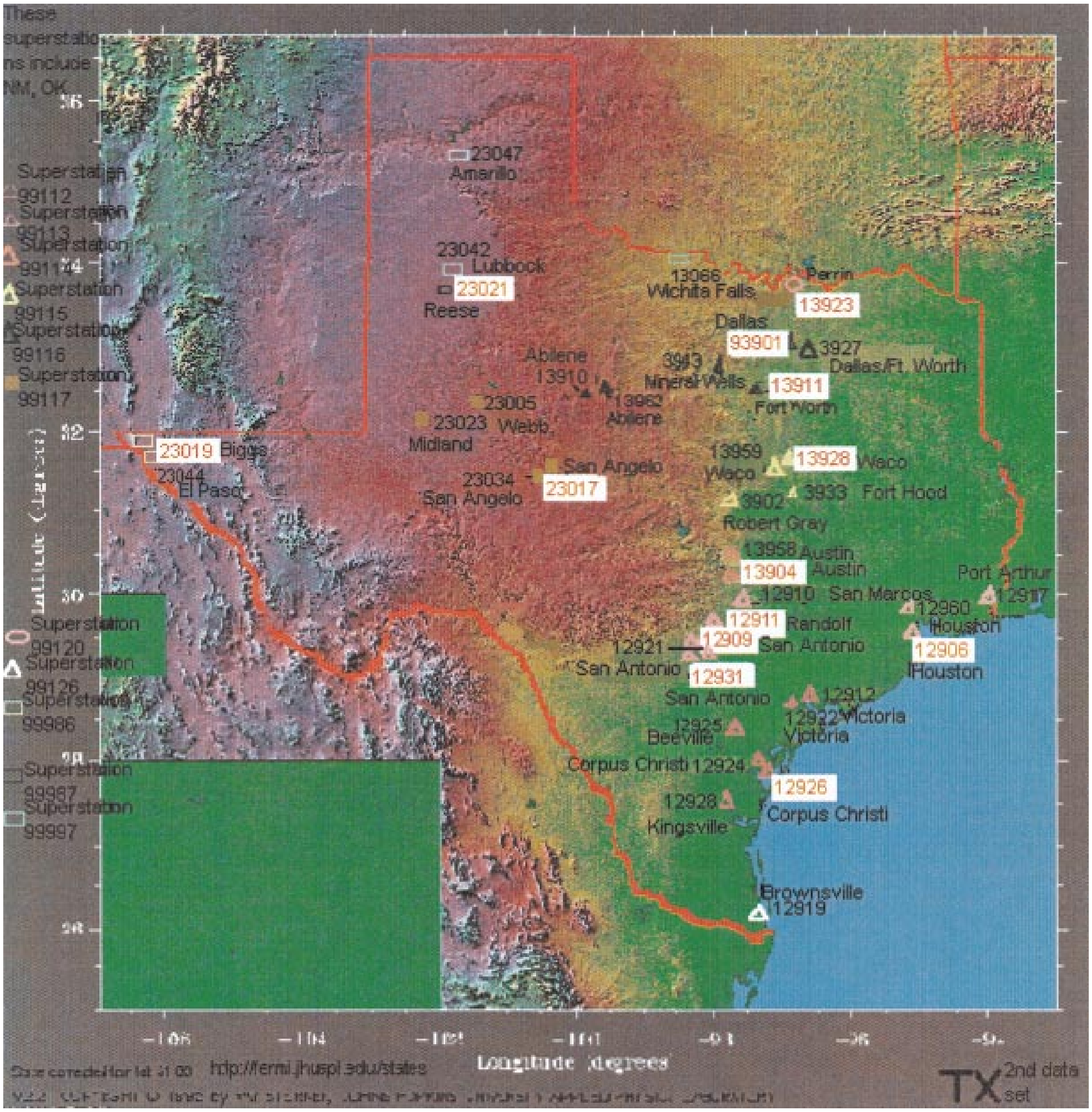

Fig. 7. (Color) Map of Texas with stations and set 1 (CPP 2001) superstations

the current map. The improved map should be based on estimates that benefit from the experience accumulated in the development of the current and earlier wind maps. Its developers should utilize and make public the requisite data and other relevant information, and promote the early public scrutiny of the data and methodologies proposed for the development of the map.

4. The potential for the development of a significantly improved, more realistic wind map exists and should be utilized. Where appropriate, such development may include the use of the superstation concept, provided that careful consideration is given to relevant meteorological and physical geography factors and that good statistical practices are used. Current NIST research addresses the issues of observation errors, errors in the estimation of the ratio between peak gust and sustained wind speeds, errors in the estimation of terrain roughness and the corresponding wind profile, and sampling errors in the estimation of extreme wind speeds. It is expected that this effort will yield results to be used in the development of an improved wind map and improved wind load factors.

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Appendix I

Table 1. Original Superstations Used in Development of ASCE7 Peak-Gust Map

Superstation	Stations that appear in more than one superstation	Other stations
99100 (Ore.)	Eugene, Salem	Burns, Medford, Klamath Falls
99101 (Ore.,Wash.)	Eugene, Olympia, Salem, Yakima, Astoria	Pendleton, Portland
99102 (Del., Pa.)	Dover, Philadelphia, Philadelphia, Wilmington	
99103 (N.J., Pa.)	Belmar, McGuire, Middletown, Allentown, Lakehurst, Willow Grove, Pittsburgh	
99104 (N.Y., N.J., Mass., Pa., Ct., Ohio)	Binghamton, Belmar, Chicopee Falls, McGuire, Hempstead, Middletown, Suffolk County, Stewart, New York, Buffalo, Newark, Albany, Allentown, Hartford, Wilkes-Barre, Lakehurst, New York, Willow Grove, Youngstown, Bridgeport, New York, New York, Pittsburgh	Williamsport, Erie
99105 (R.I.)	Providence, Quonset Point	
99106 (Ga., S.C.)	Augusta, Myrtle Beach, Sumter, Columbia	
99107 (Ga., S.C.)	Augusta, Savannah, Myrtle Beach, Savannah, Sumter, Columbia	Greer, Charleston, Beaufort
99108 (S.D.)	Huron, Rapid City, Rapid City	
99109 (S.D.)	Huron, Sioux Falls, Rapid City, Rapid City	Aberdeen
99110 (Ark., Tenn.)	Blytheville, Memphis, Memphis	Chattanooga, Knoxville
99111 (Tenn., Ohio)	Sewart, Nashville, Cincinnati	Bristol
99112 (Tex.)	Corpus Christi, Corpus Christi, Kingsville	
99113 (Tex.)		Victoria, Victoria, Beeville
99114 (Tex.)		Houston, San Antonio, San Marcos, Randolf, Port Arthur, San Antonio, San Antonio, Houston, Del Rio, Del Rio
99115 (Tex.)		Austin, Austin
99116 (Tex.)		Robert Gray, Fort Hood, Waco, Waco
99117 (Tex.)	San Angelo, San Angelo	
99118 (Tex.)	San Angelo, San Angelo	Midland
99119 (Tex.)		Biggs, El Paso
99120 (Tex.)	Dallas/Ft Worth, Fort Worth	
99121 (Tex.)	Dallas/Ft Worth, Abilene, Fort Worth, Abilene	Mineral Wells
99122 (Tex.)	Abilene, Abilene	
99123 (Tex.)	Abilene, Abilene	Webb
99124 (Tex.)	Perrin, Wichita Falls, Reese, Lubbock	
99125 (Okla., Tex.)	Clinton, Altus, Oklahoma City, Perrin, Wichita Falls, Oklahoma City, Reese, Lubbock	Amarillo
99126 (Tex.)	Corpus Christi, Corpus Christi, Kingsville	Brownsville
99127 (Utah)	Dugway, Salt Lake City	Milford, Ogden
99128 (Utah)	Dugway, Salt Lake City	
99129 (Va., N.C.)	Norfolk, Norfolk, Oceana, Weeksville	
99130 (Va.)	Lynchburg, Richmond, Roanoke, Chincoteague	Langley, Fort Eustis
99131 (Md., Va.)	Washington DC, Washington DC, Anacostia, Dahlgren, Quantico, Davison, Washington DC	
99132 (N.Y., Mass., Vt., N.H.)	Plattsburgh, Maynard, Fort Devens, Bedford, Chicopee Falls, Albany, Boston, Concord, Milton, Worcester	Burlington
99133 (Wash.)	Olympia, Yakima	
99134 (Wash.)	Fairchild, Spokane	
99135 (Wash.)	Moses Lake, Fairchild, Spokane	
99136 (Wash.)	Gray, Everett, Tacoma, Seattle, Seattle, Seattle	
99137 (Wash., Ore.)	Moses Lake, Fairchild, Spokane, Gray, Everett, Tacoma, Olympia, Seattle, Yakima, Seattle, Seattle, Astoria	Whidbey Island, Quillayute
99138 (Wis., Mich.)	Green Bay, Houghton Lake	
99139 (Wis., Mich., Ill.)	Milwaukee, Muskegon, Glenview, Green Bay, Grand Rapids	Madison
99140 (W.V., Va., Ohio)	Beckley, Lynchburg, Roanoke, Columbus	Huntington, Elkins, Charleston
99141 (W.V., Va.)	Beckley, Lynchburg, Richmond, Roanoke	
99142 (Wyo.)	Lander, Casper	Cheyenne
99143 (Wyo.)	Lander Casper	Sheridan

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Table 1. (*Continued*)

Superstation	Stations that appear in more than one superstation	Other stations
99144 (N.Y., Mass.)	Binghamton, Plattsburgh, Maynard, Fort Devens, Bedford, Chicopee Falls, Boston, Milton, Worcester	
99910 (Fla., Miss., Ala.)	Pensacola, Pensacola, Keesler, Mobile, Mobile, Barin, Pensacola, Pensacola, Whiting	
99911 (Ala.)	Maxwell, Craig, Montgomery	
99912 (Ala., Ga.)	Cairns Field, Albany, Maxwell, Fort Benning, Craig, Marietta, Atlanta, Birmingham, Montgomery, Atlanta, Columbus	
99913 (Ala.)	Huntsville, Maxwell, Craig, Birmingham, Montgomery	
99914 (Ark., Tenn.)	Blytheville, Memphis, Memphis	Little Rock, Little Rock
99915 (Ariz.)	Yuma, Yuma, Davis, Monthan, Tucson, Yuma	Fort Huachuca
99916 (Ariz.)	Yuma, Yuma, Davis, Monthan, Tucson, Yuma	Flagstaff, Williams, Luke, Pheonix, Winslow, Litchfield Park
99917 (Calif.)		San Diego, Chula, Vista, El Centro, Miramar, San Diego, Imperial Beach
99918 (Calif.)		Camp Pendleton, March, Long Beach, Los Angeles, El Toro, Los Alamitos, Tustin, San Nicholas, San Clemente
99919 (Calif.)	Edwards, Norton, George	Oxnard, Sandberg Point, Mugu, Vandenberg
99920 (Calif.)	China Lake	Bakersfield
99921 (Calif.)		Lemoore, Monterey, Fresno, Fritzsche, Jolon
99922 (Calif.)		Castle, Oakland, San Francisco, Stockton, Alameda, Moffet Field
99923 (Calif.)		Travis, Mather, McClellan, Hamilton
99924 (Calif.)		Blue Canyon, Eureka, Red Bluff, Beale
99925 (Colo.)	Alamosa, Colorado Springs, Pueblo, USAF Academy	
99926 (Colo.)	Alamosa, Colorado Springs, Pueblo, USAF Academy	Denver, Denver, Grand Junction
99927 (Conn., R.I.)	Hartford, Providence, Quonset Point, Bridgeport	
99928 (Del., Pa.)	Dover, Philadelphia, Philadelphia, Wilmington	
99929 (Del., N.J., Pa., Va.)	Dover, Atlantic City, Philadelphia, Atlantic City, Chincoteague, Philadelphia, Wilmington, Atlantic City	
99930 (Fla.)	Key West, Key West	
99931 (Fla.)	Homestead, Miami, Miami	
99932 (Fla.)	Homestead, Key West, Miami, Key West, Miami	West Palm Beach
99933 (Fla.)		Avon Park, Macdill, Tampa
99934 (Fla.)		Orlando, Sanford, Cocoa Beach, Cape Canaveral
99935 (Fla.)		Apalachicola, Daytona Beach
99936 (Fla.)	Mayport, Jacksonville, Jacksonville, Jacksonville	
99937 (Fla., Ala.)	Pensacola, Pensacola, Tyndall, Tallahassee, Barin, Pensacola, Pensacola, Whiting	Duke, Valparaiso, Valparaiso
99938 (Ga., Ala., Fla.)	Savannah, Cairns Field, Mayport, Albany, Savannah, Fort Benning, Tyndall, Jacksonville, Tallahassee, Jacksonville, Columbus	Macon, Valdosta, Warner Robins, Brunswick
99939 (Ga., S.C.)	Augusta, Sumter, Marietta, Atlanta, Columbia, Atlanta	Athens
99942 (Minn., Iowa, Neb., S.D.)	Rochester, Des Moines, Omaha, Sioux Falls, Omaha, Waterloo, North Omaha	Sioux City
99943 (Id.)		Mountain Home, Boise, Pocatello
99944 (Ill., Miss.)	St Louis, Rantoul, Peoria	Belleville, Springfield
99945 (Ill., Wis., Ind.)	Rantoul, Milwaukee, Peoria, South Bend, Glenview, Peru	Chicago, Moline, Chicago O'Hare
99946 (Ind.)	South Bend	Fort Wayne
99947 (Ill., Ind.)	Rantoul, Peru	Evansville, Indianapolis
99948 (Kan.)		McConnel, Wichita, Dodge City, Hutchinson
99949 (Miss., Kan.)	Richards Gebaur, Whiteman, Olathe	Forbes, Salina
99950 (Kan.)	Concordia	Fort Riley, Topeka
99951 (Kan.)	Concordia	Goodland

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Table 1. (*Continued*)

Superstation	Stations that appear in more than one superstation	Other stations
99144 (N.Y., Mass.)	Binghamton, Plattsburgh, Maynard, Fort Devens, Bedford, Chicopee Falls, Boston, Milton, Worcester	
99952 (Ky., Tenn.)	Sewart, Nashville, Cincinnati	Fort Campbell
99953 (Ky.)		Paducah, Jackson, Fort Knox
99954 (Ky.)		Lexington, Louisville
99955 (La.)	Fort Polk, Lake Charles	Barksdale, Shreveport
99956 (La.)	Fort Polk, Lake Charles	Boothville, New Orleans, New Orleans, England, Baton Rouge, New Orleans
99957 (Mass., N.Y., Conn.)	Maynard, Fort Devens, Bedford, Chicopee Falls, Suffolk County, Boston, Hartford, Milton, Worcester	Falmouth, South Weymouth
99958 (Md., Va.)	Washington DC, Washington DC, Anacostia, Dahlgren, Quantico, Davison, Washington DC	Andrews, Patuxent, Annapolis
99959 (Md.)		Aberdeen, Baltimore, Fort Meade
99960 (N.H., Me.)	Portsmouth, Brunswick, Portland	
99961 (Me.)		Dow Loring
99962 (Mich.)	Mount Clemens, Detroit, Flint, Lansing, Grosse Ile, Detroit, Grand Rapids	
99963 (Mich.)	Mount Clemens, Oscoda, Detroit, Flint, Lansing, Muskegon, Grosse Ile, Houghton Lake, Detroit, Grand Rapids	
99964 (Mich.)	Oscoda, Houghton Lake	Sault, Ste. Marie, Kincheloe, Gwinn, Alpena
99965 (Minn., Iowa)	Minneapolis, Rochester, Minneapolis, Waterloo	
99966 (Minn.)	Minneapolis, Minneapolis	Duluth International Falls
99967 (Miss.)	Fort Leonard, Wood, Columbia	
99968 (Miss.)	Whiteman, Springfield	
99969 (Miss., Kan.)	Richards Gebaur, Fort Leonard, Wood, Columbia, Whiteman, St. Louis, Springfield, Olathe	Kansas City, Fort Leavenworth
99970 (Miss.)	Meridian, Meridian	
99971 (Miss.)	Columbus	
99972 (Ala., Miss.)	Huntsville, Meridian, Keesler, Maxwell, Columbus, Mobile, Craig, Meridian, Birmingham, Mobile, Montgomery, Barin	Tupelo
99973 (Mont.)	Malmstrom, Great Falls, Helena, Missoula	Billings
99974 (Wash., Mont.)	Moses Lake, Malmstrom, Fairchild, Great Falls, Helena, Missoula, Spokane	Kalispell
99975 (N.C.)	Wilmington, Cherry Point, New River	
99976 (N.C.)	Goldsboro, Raleigh, Cape Hatteras, Fort Bragg	
99977 (N.C.)	Charlotte	Asheville
99978 (N.C., Va.)	Goldsboro, Raleigh, Norfolk, Wilmington, Norfolk, Cherry Point, Oceana, Weeksville, Charlotte, New River, Cape Hatteras, Fort Bragg	Fayetteville, Greensboro
99979 (N.D.)		Fargo, Grand Forks
99980 (N.D.)		Bismarck, Minot, Williston
99981 (Neb.)		Lincoln, Grand Island, Lincoln
99982 (Iowa, Neb.)	Des Moines, Omaha, Omaha, North Omaha	Norfolk, North Platte
99983 (N.H., Me.)	Portsmouth, Brunswick, Concord, Portland	
99984 (N.J.)	Atlantic City, Atlantic City, Atlantic City	
99985 (N.J., N.Y.)	Belmar, McGuire, Hempstead, Suffolk County, New York, Newark, Lakehurst, New York, New York, New York	
99986 (N.M.)		Holloman, Las Cruces
99987 (N.M., Tex.)	Reese	Clovis, Albuquerque
99988 (Nev., Calif.)	Edwards, Norton, George, China Lake	Desert Rock, Las Vegas, Las Vegas
99989 (Nev.)		Stead, Ely, Reno, Winnemucca, Fallon
99990 (N.Y., N.J.)	Hempstead, Suffolk County, New York, Newark, New York, New York, New York	
99991 (N.Y., Pa., Conn.)	Stewart, Wilkes-Barre, Bridgeport	
99992 (N.Y., Mass.)	Binghamton, Chicopee Falls, Buffalo, Albany	
99993 (N.Y.)		Niagara Falls, Rochester, Syracuse

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Table 1. (*Continued*)

Superstation	Stations that appear in more than one superstation	Other stations
99144 (N.Y., Mass.)	Binghamton, Plattsburgh, Maynard, Fort Devens, Bedford, Chicopee Falls, Boston, Milton, Worcester	
99994 (Ohio)	Columbus	Springfield, Wright Patterson, Wright Patterson, Wilmington, Dayton
99995 (Ohio, Pa.)	Pittsburgh	Columbus, Columbus, Mansfield, Akron
99996 (Ohio)	Youngstown	Cleveland, Toledo
99997 (Okla.)	Altus	Fort Sill
99998 (Okla.)	Clinton, Oklahoma City, Oklahoma City	
99999 (Okla.)		Enid, Tulsa

Appendix II: Instructions for Accessing Files Excerpted from CCP (2001)

The files can be downloaded from the following FTP site: ''ftp-.nist.gov'' using the username *anonymous* and, as a password, the user's e-mail address. The files are located in the subdirectory: ''pub/bfrl/emil/NISTTTU''. In this subdirectory, five files can be downloaded. They include the following:

- *ReadMeCPP.txt*;
- *Original Superstation List.txt*: contains the list of original superstations used in the development of the ASCE 7-95 peak-gust map;
- *Set1 Superstation List.txt* and *Set2 Superstation List.txt*: contain lists of alternative superstations in CCP (2001);
- *wind speed data.txt*: contains wind speed data for the stations included in the superstations.

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