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JP1.30 HOMOGENEOUS BLENDED WIND DATA OVER THE CONTIGUOUS UNITED STATES

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1. INTRODUCTION

Hourly wind data from 1655 stations over the lower 48 states for the period of record (through 2000) have been quality controlled, the station history of the anemometer elevation digitized for most of these stations, and the station records merged with historical snow on the ground information. With this, homogeneous time series of wind speed at the10-meter height above the ground/surface for the entire period of digital record were generated. For the First Order Stations this is usually, since 1948 and for other

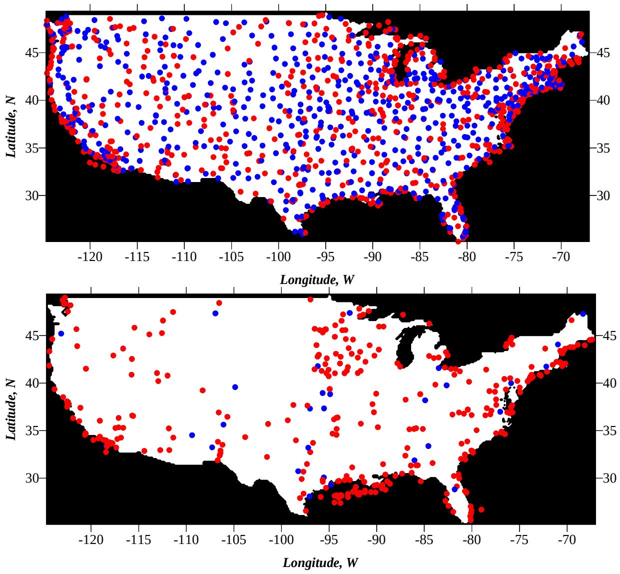

Figure 1. ***Top***. **Stations with digitized record of anemometer elevation. *Bottom*. Stations with wind information available in the NCDC data archives in digital form but station history is absent. Blue dots indicate the ASOS stations on both maps.**

sites with digitized record of anemometer elevation since early 1970s. Since the Automated Surface Observation System (ASOS) implementation at the site, its elevation is known. Archive TD-6421 (NCDC 2001) is now available. Figure 1 shows spatial distribution of the stations and Figure 2 the data availability within this archive. A station was considered present in a given year when it has at least 300 valid hourly wind speed values. Stations (90 of them) that do not have at least 1000 valid hourly records during the entire 1931-2000 period were skipped in Figure 2.

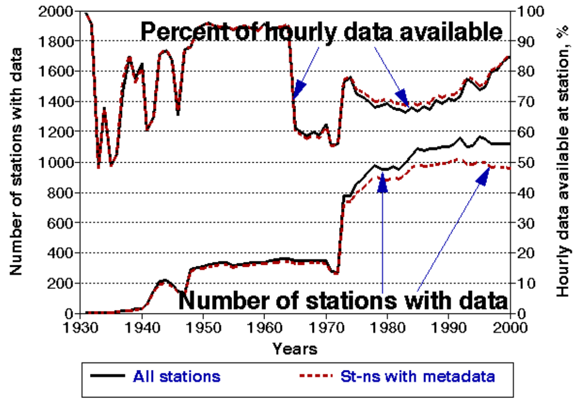

Figure 2. Annual variations of the number of stations with valid data in the archive and the mean percent of valid hourly data available at these stations.

2. METHODOLOGY

Anemometer elevations throughout the U.S. stations varied widely with time (on average there was one change per decade at any station with more than 10 years of record). Therefore, the elevation homogenization of the near-surface wind time series is a necessary pre-requisite for any climatological assessments. In this process we assume standard logarithmic near-surface profile for unobstructed wind movement because most of the sites are in the airport or coastal locations. Specifically, the formulae were used:

$$U_{10g} = U_a \log[(10-H_{snod})/z_0]/\log[(H_a - H_{snod})/z_0],$$

and

$$U_{10s} = U_a \log[10/z_0]/\log[(H_a - H_{snod})/z_0],$$

where z_0 is the surface roughness (a function of the presence of snow cover at the site); H_{snod} is the snow depth; H_a is the anemometer height above the ground; U_a is the wind speed at the anemometer height, U_{10g} is the speed at 10 meters above the ground, and U_{10s} is the speed at 10 meters above the surface; units are in SI.

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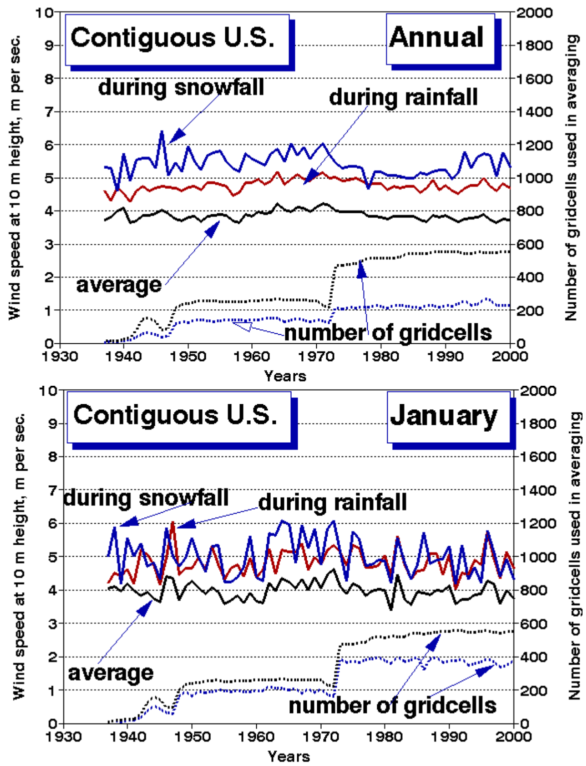

Figure 3. Annual and January wind speed at 10 meters above the ground averaged for all hours and (separately) only for hours with rainfall and with snowfall. Number of 1º x 1º grid cells with valid wind data (used in the averaging routine for mean wind and for winds during snowfall events) are also shown.

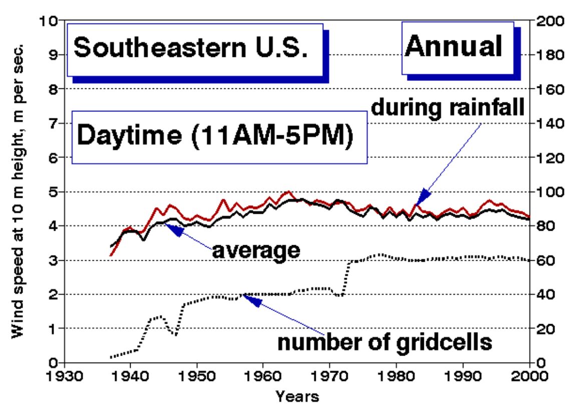

Figure 4. Same as Figure 3 but daytime wind over the Southeastern United States.

3. CLIMATOLOGIES

After homogenization, a group of climatologies and time series were derived Including area-averages. Averaging has been performed for anomalies from the reference period 1973-1992 within 1º x 1º grid cells with valid data. This was followed with an averaging of the mean grid cell anomalies and restoration of actual wind values as the last step. Among these climatologies are:

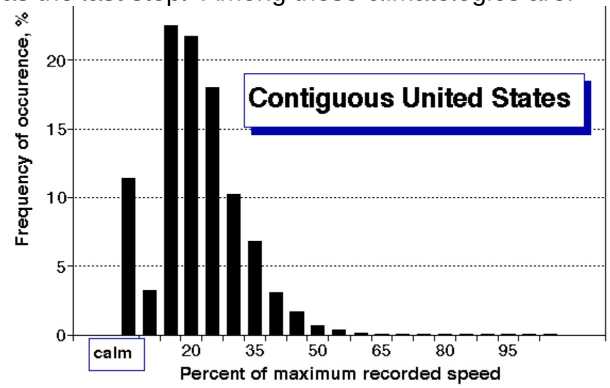

Figure 5. Typical shape of the wind speed distribution over the contiguous United States in the 1980s. Composite nationwide average.

- mean daily and daytime wind speed time series (e.g., Figures 3 and 4);
- climatology and time series of wind speed during various precipitation events (e.g., Figures 3 and 4);
- normalized wind speed distribution for each station for the assessment of their changes after the ASOS introduction (e.g., Figures 5 through 7);
- wind roses; monthly/seasonal wind climatology for major wind directions with preserved diurnal cycle (e.g., Figure 8); frequency of calm winds; frequency of strong winds above several thresholds;
- climatology and time series of "wilting" winds frequency (i.e., the frequency of those winds that occur with surface air temperature above 10°C and relative humidity below 30%), of wind chill and of the apparent temperature (Quayle and Steadman 1998; Steadman 1984; Figure 9).

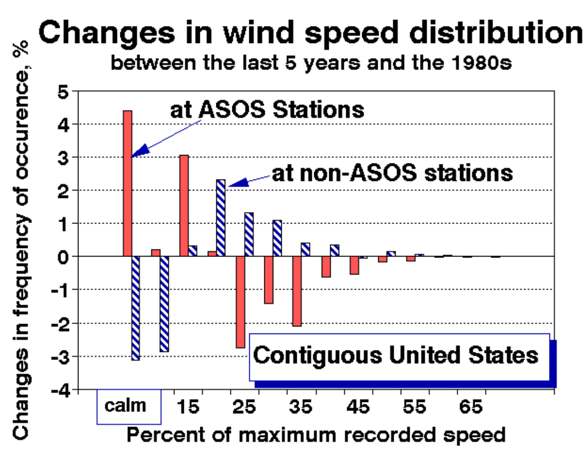

Figure 6. Evidence of the homogeneity problem in the U.S. wind speed data due to the ASOS implementation.

Figure 6 shows the composite nationwide differences in wind distribution between the last five years compared to the 1980s reported by the stations that were operational during the past 20 years and where ASOS was not yet implemented. These differences are opposite to those reported by the long-term stations where ASOS was installed in the 1990s and are consistent from region to region.

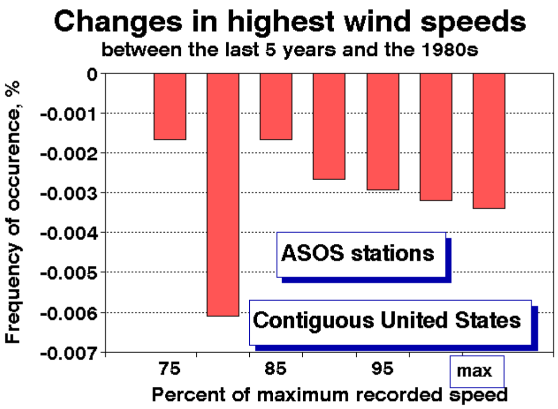

Figure 7. Same as Figure 6 but only ASOS stations are shown for an upper fraction of wind speed distribution (above the 75% of the maximum recorded speed at each station).

There was a statistically significant nationwide decrease (~5% in the past 50 years) in mean annual wind speed that cannot be attributed only to the ASOS implementation in the 1990s. ASOS switched to a 2-minute averaging routine instead of previously used 1-minute averages which resulted in increased reporting of calm conditions and less frequent reports of extreme wind speeds (Figures 6 & 7).

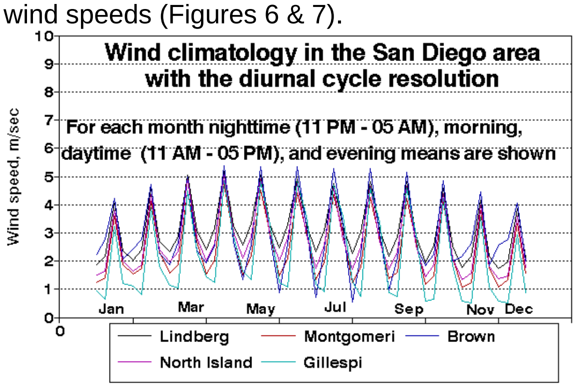

Figure 8. Example of products generated from TD-6421: diurnal cycle of wind speed at several locations around San Diego, California.

4. COMPARISON WITH THE ETA MODEL

Since April 1995, the near-surface winds are included in the standardized 40 km x 40 km grid cell output of the mesoscale ETA model for the contiguous U.S. (Black 1994). Intercomparison of this output with observations from TD-6421 has shown significant seasonal and diurnal variations in quality and scale of reproduction of the in-situ winds by the model (Figure 10). Some of these variations have occurred due to a gradual improvement of the model physics and spatial resolution (Rogers et al. 1997, 2000, 2001) that resulted in a very good correlation between observations and the model output since the 1998 for the eastern two-thirds of the contiguous U.S. However, scale differences between the model output and observations remain significant and distinctively different within the diurnal cycle. Therefore, in order to blend the model output with in-situ observations, we selected 13 periods of constant model output, separating warm and cold seasons and treating morning, daytime, evenings, and nighttime separately. Scale adjustments were developed for each "core" 40 km x 40 km grid cell where at least one TD-6421 station was operational during the period (and time of the day) in question. These adjustments were expanded to a 1º x 1º neighborhood of the "core" grid and finally readjusted model output of gridded near-surface winds was generated for most of the contiguous U.S. for the period from April 30, 1995 to Dec. 31, 2000 with a 3-hourly time resolution. Hours when there was no model output including the entire period Sept. 27 to Dec. 31, 1999 (computer crash and recovery period at NCEP) were skipped. The adjustment routine does not use sites where observed and model winds do not correlate well ($R < 0.5$ for a given period and time of the day), or neighbor grid cells where wind speeds do not correlate well with winds in core grid cells (a few mountain grid cells in the West). Therefore, some grid cells over the contiguous U.S. are not covered, especially in the pre-1998 period.

5. REFERENCES

Black, T.L., 1994: The new NMC mesoscale Eta Model: Description and forecast examples. *Wea. Forecasting*, **9**, 265-278 (see also http://meted.comet.ucar.edu/nwp/pcu2/etintro.htm)

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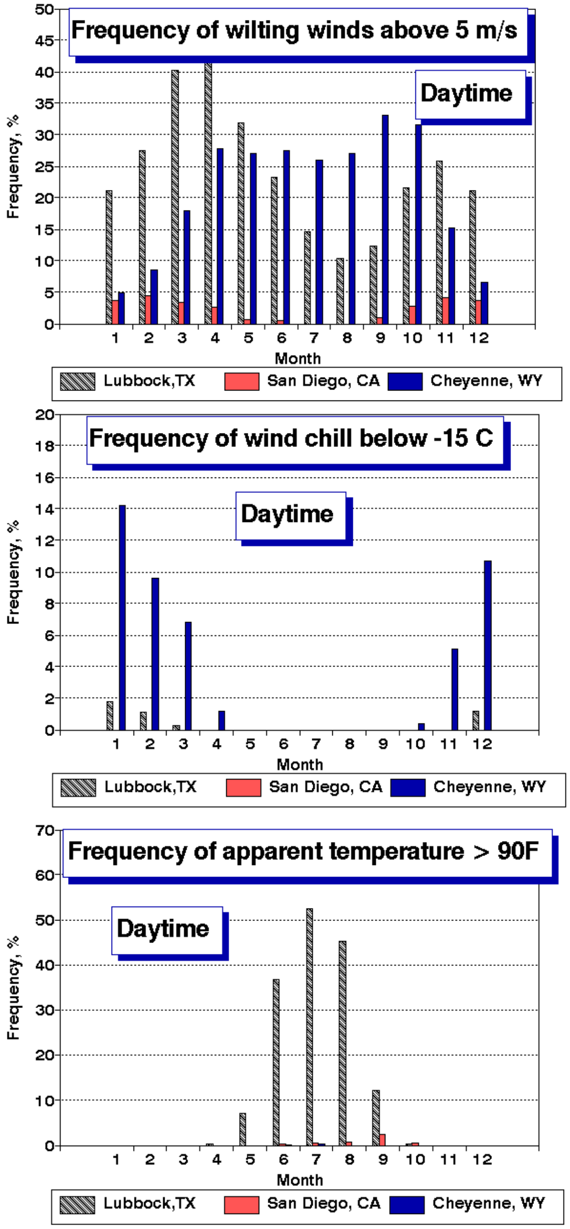

Figure 9. Examples of products generated from TD-6421 and its predecessor data at three stations of the western United States.

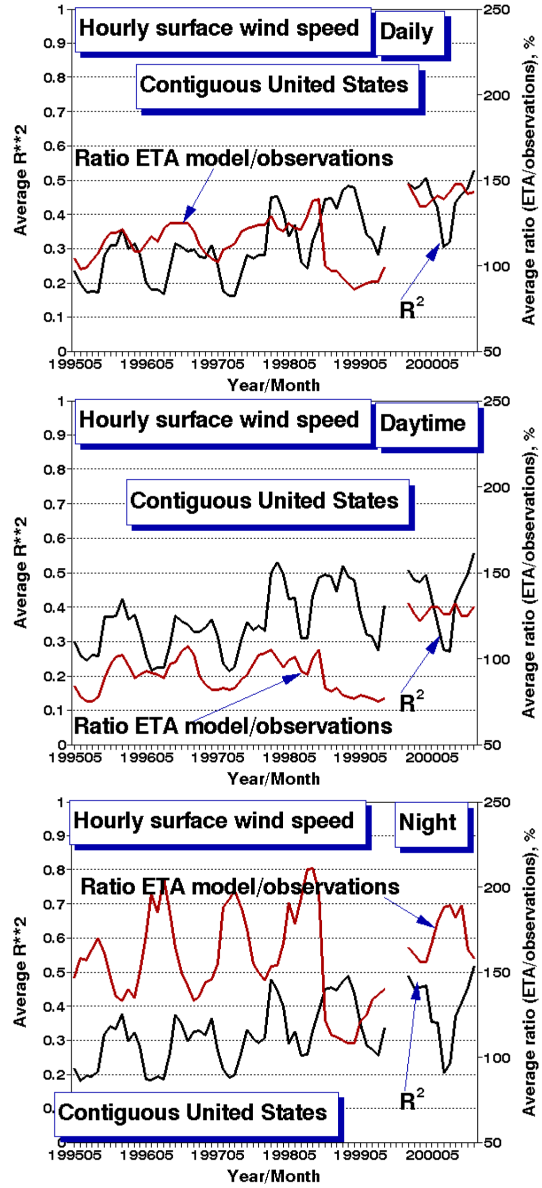

Figure 10. Month by month field comparison of hourly wind speed at 10 meters above the ground from observations and derived by the ETA model diagnostic algorithm. Average square of correlation coefficients between individual locations (R^2) and average ratio of monthly mean values of wind speed (in percent of observed wind speed) are shown.