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Historical trends in wind speeds from observational data, reanalysis output and Regional Climate Model simulations over the continental USA

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The USA is investing in renewable energy resources to meet national and international goals related to reducing greenhouse gas/pollutant emissions and to improve the diversity of energy portfolios and security of supply. During 2005 and 2006 over 5000 MW of wind energy developments came online, increasing installed capacity by approximately one-third. Identification of optimal sites for development of wind farms relies on detailed knowledge regarding the local wind climates and hence likely power production. In the context of wind energy applications, it is necessary to estimate the power output over the 20-30 lifetime of the wind farm for economic feasibility. Thus in the context of wind energy developments the questions that arise are; 'what is the current inter-annual variability in likely power production and will non-stationarities in the global climate system cause that variability or magnitude of a *normal wind year* to evolve on timescales of relevance to wind energy developments?'. Herein we focus on quantifying historical variability and trends using in situ observations, reanalysis products and output from a Regional Climate Model, and specifically address four objectives:

1. To quantify historical (1973-2005) trends in near-surface wind speeds across

the contiguous US based on in situ observations and to assess their statistical significance.

2. To compare trends in time-series of near-surface wind speeds from individual stations with those derived from gridded reanalysis data.

3. To evaluate whether the temporal trends exhibit substantial bias with hour of observation.

4. To assess the impact of any temporal trends on the magnitude of the wind energy resources and the feasibility of wind energy developments.

Initial results based on analysis of in situ data and reanalysis products from the NCEP/NCAR and ERA-40 data sets indicate:

Objective (1) and (2): As in our prior research across the European continent there are quantitative differences in mean wind speeds and trends in wind speed percentiles between reanalysis data sets. Based on the analysis presented herein we would further note there are substantial differences between trends derived from carefully quality controlled observational data and the reanalysis products. While these differences can not be fully explained they must be acknowledged and their presence strongly advocates for use of multiple data sets in analyses of wind speed climates.

Objective (3): There is no strong evidence of substantial bias in temporal trends with hour of the day.

Objective (4): It is difficult to quantify possible changes in the wind energy climate of the contiguous US given the large discrepancies in trend analyses conducted using three independent data sets.

Temporal trends in wind speeds and/or energy density need not be linear with time. While in our initial research we have focused on linear trends due to the inter-annual variability inherent in wind speeds and energy density (note the inter-annual variability in wind indices across the Midwest implies the energy density in individual years varies by over $\pm$20% from the 1992-2001 mean) and because we are seeking to identify a possible long-term trend associated with global climate change, future work will also incorporate analyses of periodic variations.

Given the importance of the wind energy industry to meeting Federal and State mandates for increased use of renewable energy supplies, further research on wind climate variability and evolution is required, as is a detailed analysis focused on reconciling the discrepancies illuminated herein.