The impact of anthropogenic global warming on the United States wind resource: studies using the NARCCAP dataset

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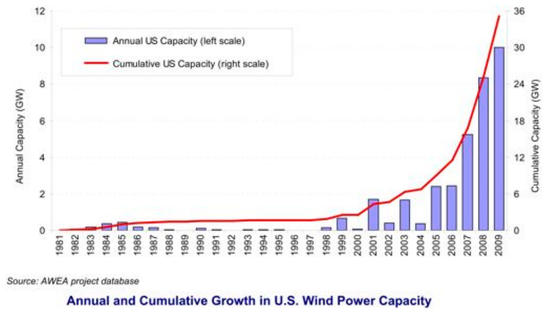
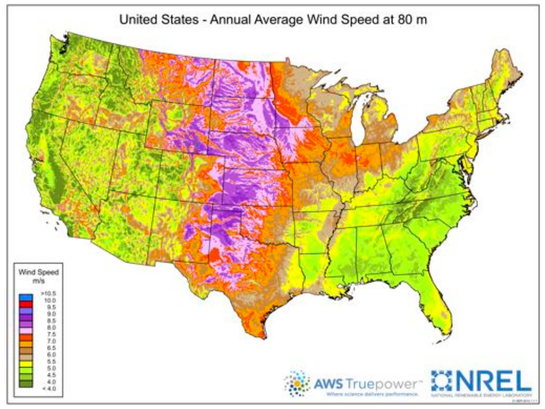
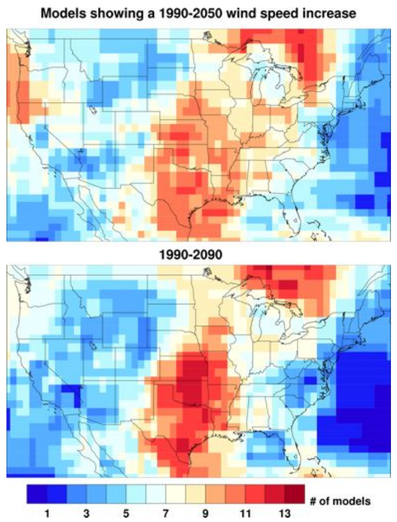


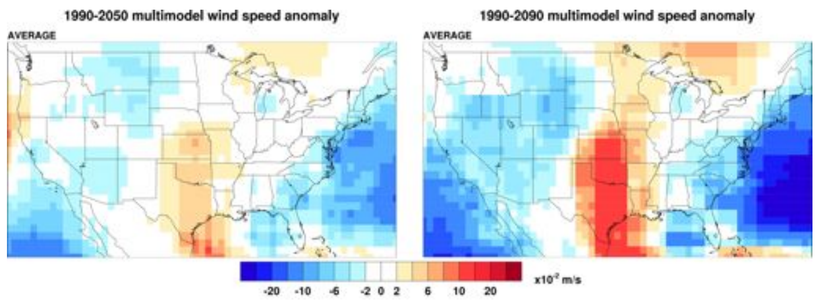
Annual and Cumulative Growth in U.S. Wind Power Capacity

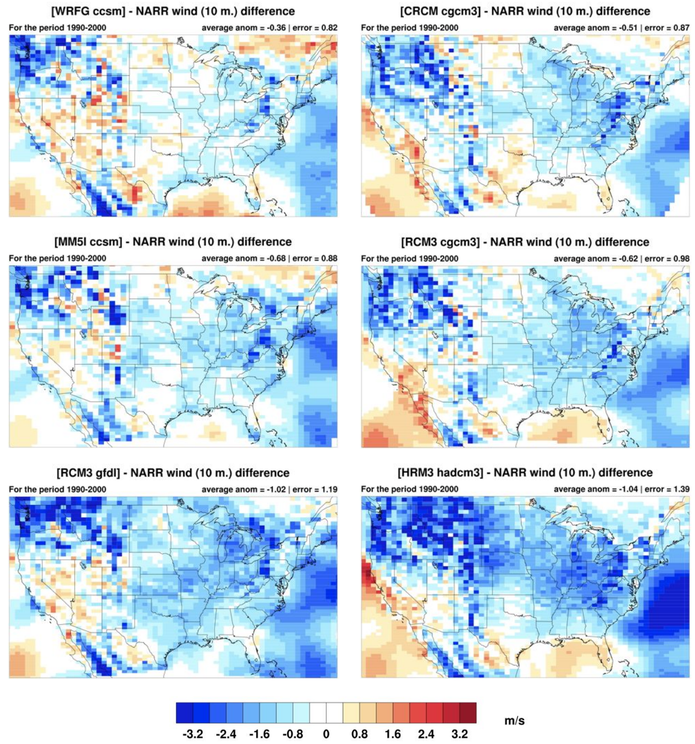


Wind energy has grown rapidly in the United States (above, left), especially over the past few years when it has accounted for the greatest share of newly installed electrical generation capacity. Due to low installation costs, high project performance, and land availability, many modern wind farms are being constructed in the central United States where there is a strong wind resource (above, right). Climate change may impact the wind resource over broad regions, which would alter the output of wind farms. The effects could be pronounced in regions where wind generation is clustered over small distances as the large-scale climate change forcing could be nearly homogenous over such an area; 14% of total domestic capacity is installed in the extreme south of Minnesota and northwestern half of Iowa; 21% is installed in West Central Texas and the northeastern part of the Permian basin in Texas.



Results from thirteen third Coupled Model Intercomparison Project (CMIP3) models data sets were evaluated to explore wind speed trends in the mid to late 21st century from a baseline in the 1990's. Most of the models agree on an increase in wind speed in the Central United States by the 2050's with a strengthening of the trend over the rest of the century along with a decrease in winds over the North Atlantic (left). However, the average magnitude of the projected change is small (below), on the order of 0.1 to 0.3 m/s. Although the models agree on the sign of the change, they don't tend to agree on the magnitude of the change.

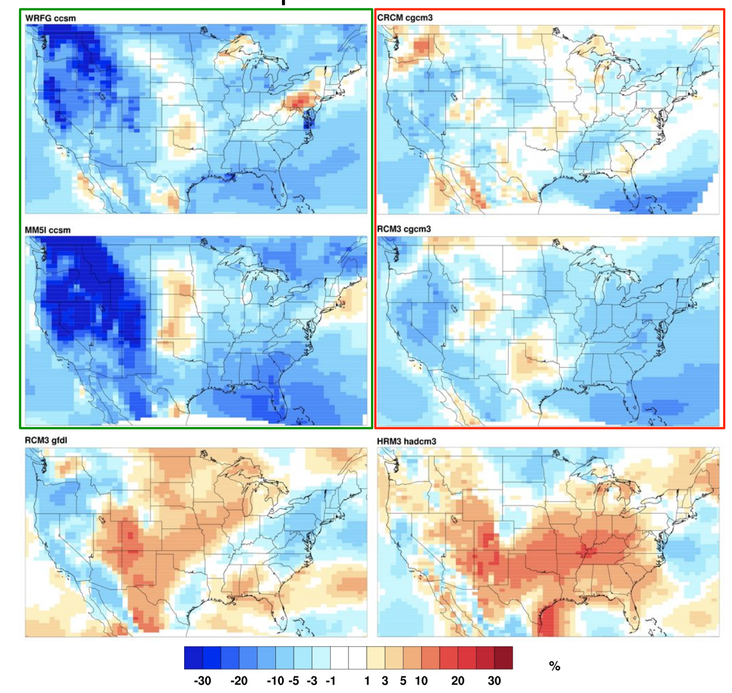




Six NARCCAP GCM-RCM model combinations were compared with data from the North American Regional Reanalysis, a 32-km resolution reanalysis product that covers the North American domain. The models are ordered from left to right and then top to bottom according to their average absolute error over the displayed domain in the figure to the left. In general, the NARCCAP models have a negative bias in areas of high topography such as the Rocky, Appalachian, and Sierra Madre Mountains. This is possibly due to the finer resolution of the NARR model, which would enable it to simulate topographically-forced winds with greater fidelity. The models are in good agreement with the reanalysis over the Central United States.

2040-1990 wind power anomalies

The mid-century anomalies in wind power (power is proportional to the cube of speed) are shown in the figures to the right. The figures are ordered in the same manner as the NARR comparisons shown above. The anomaly patterns and magnitudes are well correlated when the regional model is forced by the same GCM boundary condition as shown for the model results highlighted in the green box (CCSM forcing) and the red box (CGCM3 forcing). In general, as the 21st century progresses, the patterns shown in the figures to the right strengthen. However, the late century results produced by the two regional models (CRCM and RCM3) forced by the CGCM3 GCM divorce as the century progresses (below), which indicates that the observed patterns are strongly influenced by the particularities of the regional model's physics and parameterizations.



2090-1990 wind power anomalies