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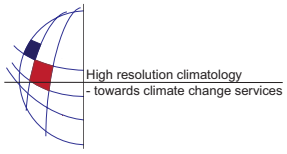

Widespread land surface wind decline in the Northern Hemisphere

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The decline of surface wind observed in many regions of the world is a potential source of concern for wind power electricity generation. It is also suggested as the main cause of decreasing pan evaporation. In China, a persistent and significant decrease of monsoon winds was observed in all seasons. Surface wind declines were also evidenced in several regions of the world (U.S., Australia, several European countries). Except over China, no clear explanation was given for the wind decrease in the regions studied. Whether surface winds decrease is due to changes in the global atmospheric circulation or its variability, in surface processes or to observational trends has therefore not been elucidated. The identification of the drivers of such a decline requires a global investigation of available surface and upper-air wind data, which has not been conducted so far. Here we use global datasets of in-situ wind measurements that contain surface weather stations wind data (hourly or three-hourly data acquisition time step) and rawinsonde vertical wind data profiles (monthly time step) prepared by the NCAR. A set of 822 worldwide surface stations with continuous wind records was selected after a careful elimination of stations with obvious breaks and large gaps. This dataset mostly covers the Northern mid latitudes over the period 1979-2008.

Using this data set, we found that annual mean wind speeds have declined at 73% of the surface stations over the past 30 years. In the Northern Hemisphere, positive wind trends are found only in a few places. In Europe, Central Asia, Eastern Asia and in North America the annual mean surface wind speed has decreased on average at a rate of -2.9, -5.9, -4.2, and -1.8 %/decade respectively, i.e. a decrease of about 10% in 30 years and up to about 20% in Central Asia. These results are robust to changes in the station selection method and parameters. By contrast, upper-air winds observed from rawinsondes, geostrophic winds deduced from pressure gradients, and modeled winds from weather re-analyses do not exhibit any comparable stilling trends than at surface stations. For instance, large-scale circulation changes captured in the most recent European Centre for Medium Range Weather Forecast re-analysis (ERA-interim) can only explain only up to 30% of the Eurasian wind stilling. In addition, a significant amount of the slow-down could originate from a generalized increase in surface roughness, due for instance to forest growth and expansion, and urbanization. This hypothesis is supported by theoretical calculations combined with meso-scale model simulations. For future wind power energy resource, the part of wind decline due to land cover changes is easier to cope with than that due to global atmospheric circulation slow down.