GÖTEBORGS UNIVERSITET

Changes in near-surface winds across Sweden over the past decades

Observations and simulations

Lorenzo Minola
Institutionen för geovetenskaper
Naturvetenskapliga fakulteten

Akademisk avhandling för filosofie doktorsexamen i Naturgeografi,
som med tillstånd från Naturvetenskapliga fakulteten kommer att offentligt försvaras
fredagen den 11 december 2020, kl. 15:00 i Hörsalen, Institutionen för
geovetenskaper, Guldhedsgatan 5A, Göteborg.

ISBN: 978-91-8009-122-0 (PRINT)
ISBN: 978-91-8009-122-7 (PDF)
Available at: http://hdl.handle.net/2077/66844

SUMMARY

Driven by a combination of anthropogenic activities and climate changes, near-surface terrestrial winds displayed a large decrease in their magnitude in the past decades, named “stilling”, and a recent recovery in their slowdown. Understanding how wind has changed and identifying the factors behind the observed variabilities is crucial so that reasonable future wind scenarios can be constructed. In this way, adaptation strategies can be developed to increase society’s resilience to the plausible future wind climate. This is particularly important for Sweden, which is largely vulnerable to changes in mean wind speed conditions and to the occurrence of extreme winds. Therefore, this thesis investigates past variations in near-surface winds across Sweden and explores the mechanisms behind their variabilities and changes. This is done by using the first homogenized dataset of in-situ observations and by analyzing current simulations of wind gusts.

Results show that, during the past decades, both observed mean and gust wind speed underwent nonlinear changes, driven by the dominant winter variability. In particular, consistent with the stilling-reversal phenomena, the significant stilling ceased in 2003, followed by no clear trend afterwards. The detected stilling-reversal is linked to large-scale atmospheric circulation changes, in particular to the North Atlantic Oscillation, and the intensity changes of extratropical cyclones passing across Sweden. The comparison with reanalysis outputs reveals that, in addition to the large-scale interannual variability, changes in surface roughness (e.g. changes in forest cover) have most likely contributed to the observed wind change across Sweden. Moreover, this thesis finds that current regional climate models and reanalyses do not have adequate skills in simulating past wind gusts across inland and mountain regions. Major improvements are achieved when the elevation differences are considered in the formulation of the gust parametrization and the convective gust contribution is adjusted according to the observed climatology.

The presented work advances the understanding of how surface winds change in a warmer climate at high midlatitudes and improves the model forecasting of wind gustiness over Sweden.

Keywords: mean and gust wind speed; stilling-reversal phenomena; regional climate models; climate reanalyses; ERA5; parametrization; NAO; extratropical cyclones; surface roughness; Sweden.