OBSERVED AND SIMULATED TRENDS OF DAILY PEAK WIND GUSTS ACROSS NORTHERN EUROPE

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Abstract

Extreme wind hazards have a substantial societal and environmental impact. Due to their complex origins, there are great knowledge gaps about their variations and the associated mechanisms, which makes the prediction challenging. Specifically there is a urgent need to evaluate numerical models' capability in simulate extreme wind conditions. This study focuses on assessing variabilities and trends of Daily Peak Wind Gust (DPWG) and its extreme (defined as 90th percentile) cross Northern Europe, based on observation during 1996-2016 and Regional Climate Model (RCM) simulations for 1970-2016. The aim is to evaluate RCMs' ability in simulating past changes of the DPWG and its extreme as reflected in the observations. RCMs are the key tools available for the prediction of wind conditions. An improved understanding about how these models perform can help identify eventual deficiencies in the models, which may enhance our prediction ability.

Data

Observed DPWG

Observed DPWG series from available anemometer measurements (Table 1).

# of series	Country	Time period covered
46	Denmark	2004-2016
17	Finland	1996-2016
20	Norway	1996-2016
90	Sweden	1996-2016

Table 1. List and info of DPWG measuring stations adopted for this study.

HOMOGENIZATION with CLIMATOL to correct inhomogeneities *(anemometer height changes, station relocation, …)*

Reference series for homogenization: daily maximum geostrophic wind, i.e. the highest geostrophic wind speed value calculated in 24 hours

Simulated DPWG

Simulated DPWG series from 4 RCMs in the Coordinated Regional Climate Downscaling Experiment (CORDEX). Comparison between RCMs with different wind gust parametrizations but same driving model and ensemble (Table 2).

#	RCM	Project	Domain	Driving model	Ensemble	RCP	Calendar
1	RCA4	CORDEX	EUR-11	MPI-M-MPI-ESM-LR	r1i1p1	historical, rcp45, rcp85	standard
2	REMO2009	CORDEX	EUR-11	MPI-M-MPI-ESM-LR	r1i1p1	historical, rcp45, rcp85	standard
3	CCLM4-8-17	CORDEX	EUR-11	MPI-M-MPI-ESM-LR	r1i1p1	historical, rcp45, rcp85	standard
4	RCA4	CORDEX	EUR-11	MOHC-HadGEM2-ES	r1i1p1	historical, rcp45, rcp85	360 days
5	RACMO22E	CORDEX	EUR-11	MOHC-HadGEM2-ES	r1i1p1	historical, rcp45, rcp85	360 days
6	CCLM4-8-17	CORDEX	EUR-11	MOHC-HadGEM2-ES	r1i1p1	historical, rcp45, rcp85	360 days

Table 2. List and info of RCMs adopted for this study.

Spatial scale

To which RCM grid point should a given measuring station be compared with?

Comparisons were only made between observed DPWG at a given measuring station and simulated DPWG of the closest "representative" grid point. A grid point is classified as "Representative" if:

i. It is located over land in the model sea-land mask;
ii. Its distance to the station is less than the *representative spatial scale* for that country (Table 3).

	Representative spatial scale
Denmark 2004-2016	137 km
Finland 1996-2016	150 km
Norway 1996-2016	93 km
Sweden 1996-2016	113 km

Table 3. Representative spatial scale of observed DPWG.

- **Spatial scale:** e-folding distance of the correlation decay
- **Representative spatial scale:** distance that corresponds to the Pearson's correlation coefficient equal to 0.8 in the spatial scale fit.

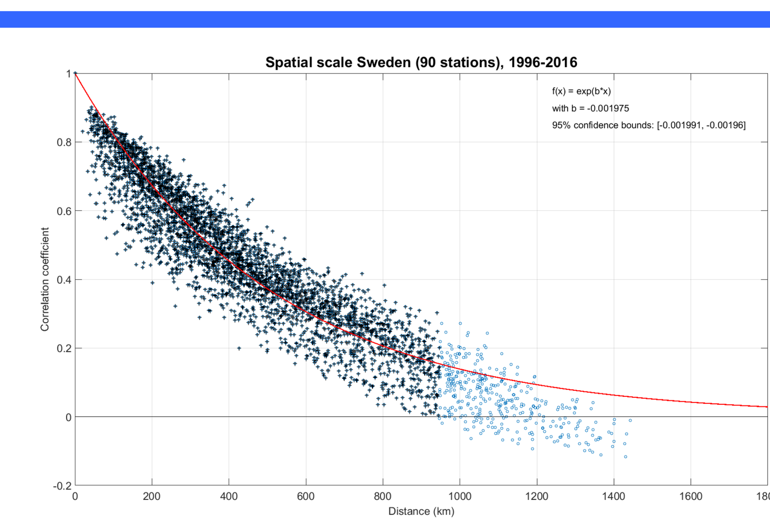

Figure 1. Example of the definition of spatial scale for observed DPWG across Sweden. Crosses indicate the points that were used in fitting to the exponential function.

Results

Comparison observed - simulated DPWG

Climatology (mean, maximum, and standard deviation) differences: RCMs - observations

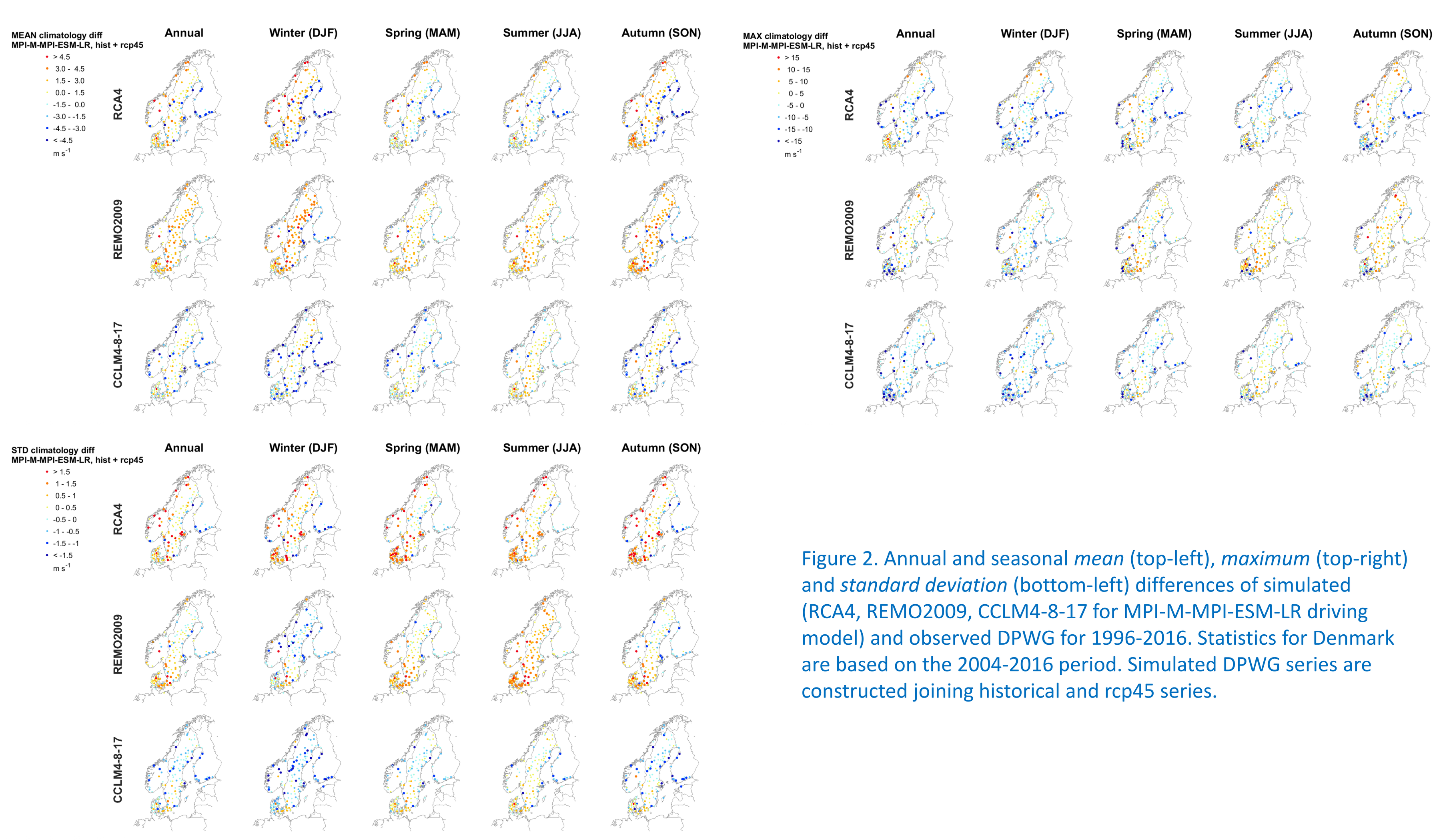

Figure 2. Annual and seasonal *mean* (top-left), *maximum* (top-right) and *standard deviation* (bottom-left) differences of simulated (RCA4, REMO2009, CCLM4-8-17 for MPI-M-MPI-ESM-LR driving model) and observed DPWG for 1996-2016. Statistics for Denmark are based on the 2004-2016 period. Simulated DPWG series are constructed joining historical and rcp45 series.

Box-plot comparison: observations vs RCMs

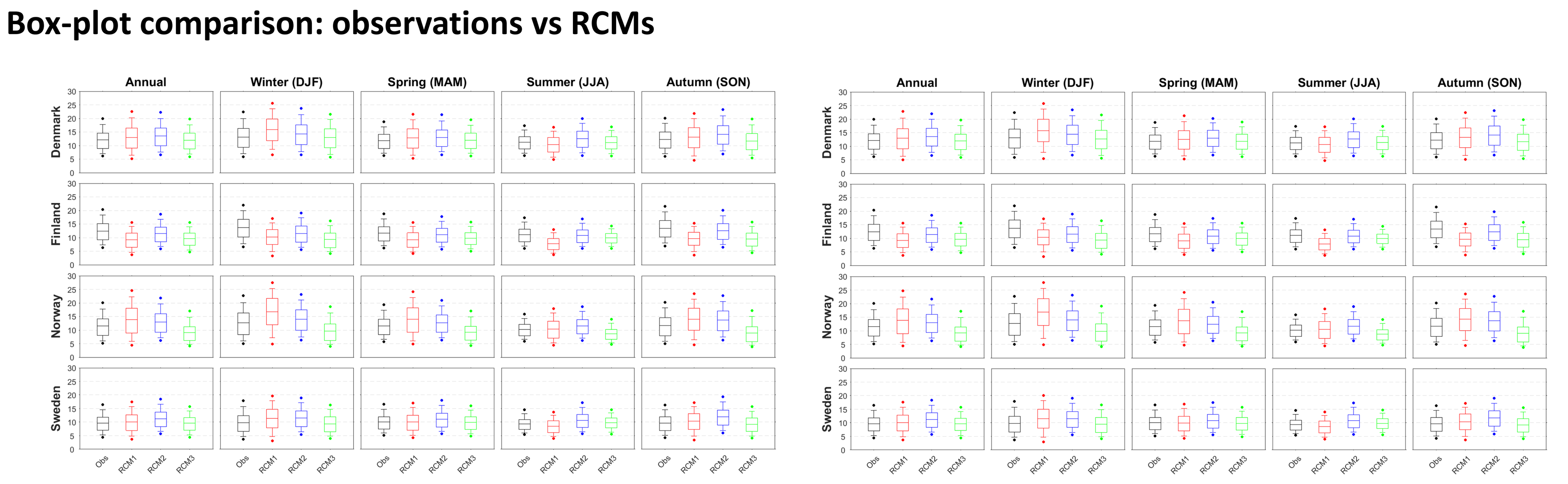

Figure 3. Annual and seasonal box-and-whisker plots of observed and simulated (RCA4 [red], RACMO22E [blue], CCLM4-8-17 [green] for MOHC-HadGEM2-ES driving model) DPWG for Denmark, Finland, Norway and Sweden during 1996–2016. Statistics for Denmark are based on the 2004-2016 period. The mean (middle line), the 25th and 75th percentile range (boxes), the10th and 90th percentiles (whiskers), and the 5th and 95th percentiles (blue dots) are represented. Simulated DPWG series are constructed joining historical to rcp45 series (left) and historical to rcp85 series (right) .

DPWG trends, 1970-2016

Trends in DPWG

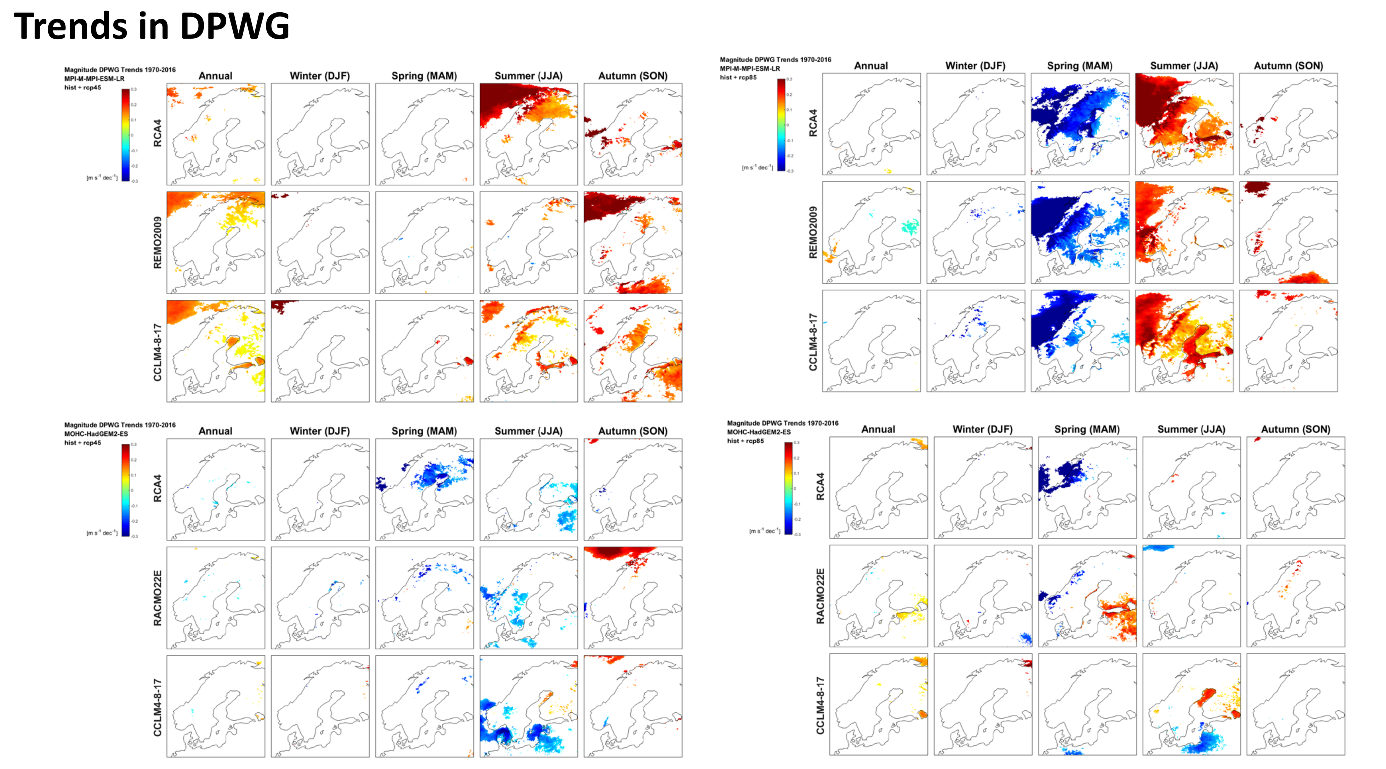

Figure 4. Spatial distribution of the sign and magnitude of trends in annual and seasonal mean DWPG during 1970-2016 for different RCMs (top: RCA4, REMO2009, CCLM4-8-17 for MPI-M-MPI-ESM-LR driving model; bottom: RCA4, RACMO22E, CCLM4-8-17 for MOHC-HadGEM2-ES driving model). The simulated DPWG series are constructed joining historical to rcp45 series (left) and historical to rcp85 series (right) . Only trends significant at the 5% significance level are shown.

Trends in extreme (90th percentile) of DPWG

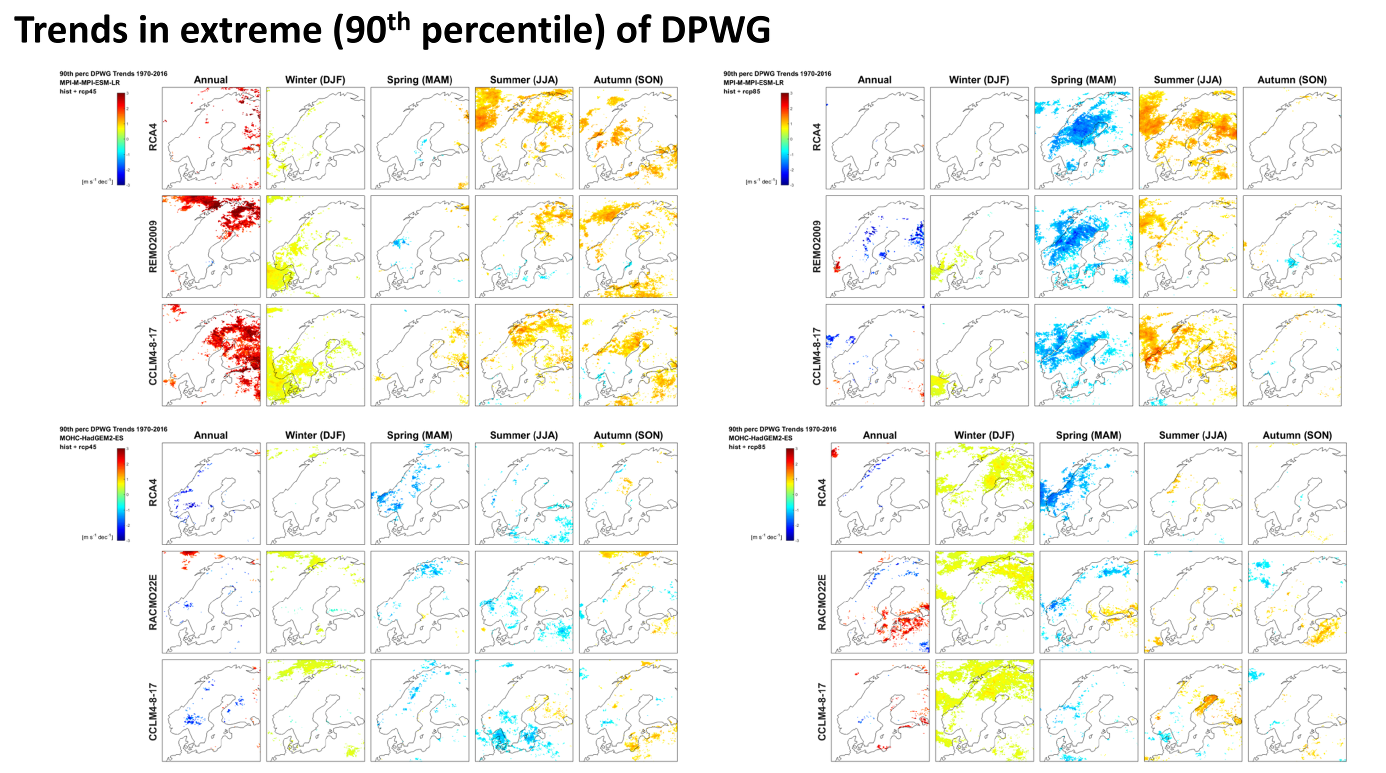

Figure 5. Spatial distribution of the sign and magnitude of trends in annual and seasonal number of days exceeding the 47 year 90th DWPG percentile during 1970-2016 for different RCMs (top: RCA4, REMO2009, CCLM4-8-17 for MPI-M-MPI-ESM-LR driving model; bottom: RCA4, RACMO22E, CCLM4-8-17 for MOHC-HadGEM2-ES driving model). The simulated DPWG series are constructed joining historical to rcp45 series (left) and historical to rcp85 series (right) . Only trends significant at the 5% significance level are shown.

Conclusions

Do the RCMs examined have proper skills in simulating DPWG?
Observed and simulated DPWG are statistically different for most of the time series analysed: the RCMs are not able to properly simulate wind gust observations. The poor performance of the RCMs in reproducing DPWG is also shown by the differences in calculated trends.

Implications for RCM development and studies of extreme wind conditions
RCMs need to be further developed with regard to t wind gust parametrization, before they can be used to study the past changes and to project future changes across Northern Europe. Meanwhile, observations remain the main source of information for the past changes.

Further research: To attribute the causes behind the differences between observed and simulated DPWG series by identifying the conditions when simulated wind gusts fit best with measurements.

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