

# Climate change and large-scale winds in the North Sea region: The KNMI'14 scenarios

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The wind climate and its possible change in a warming world are important topics for many applications, among which marine and coastal safety and wind energy generation. Therefore, wind is an important variable for climate change scenarios to consider. For the wind assessment of the KNMI'14 climate change scenarios output from several model categories have been analyzed, ranging from global GCMs via RCMs to suitably resampled RCM output. The main conclusion is that global warming will not change the wind climate over the Netherlands and the North Sea beyond the large range of natural climate variability that has been experienced in the past.

## 1. Method

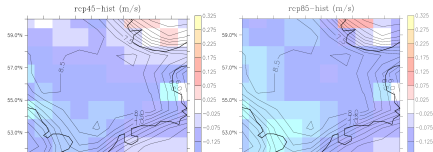
Will the wind and storm climate in the North Sea area change due to the increasing greenhouse effect? To answer this question we examined output from a variety of climate models

- CMIP5 model output
- EC-Earth simulations
- EC-Earth, downscaled with RACMO

We investigated maximum (extreme) wind speeds, mean winds, calm conditions, and wind directions.

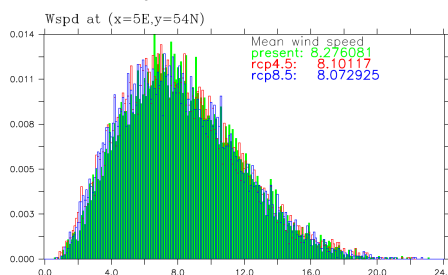
## 2. Mean wind conditions

Figure 1 shows future-present differences in annual-mean wind speeds over the North Sea region from EC-Earth runs for two climate change scenarios. In both cases a statistically non-significant decrease is found.



**Figure 1:** Differences (in m/s) of annual-mean 10m wind speed between 2071-2100 and 1976-2005 from EC-Earth for (left) rcp4.5 and (right) rcp8.5 in the North Sea region (color shading). Superimposed as contours is the climatology 1976-2005. All differences are statistically non-significant (95%).

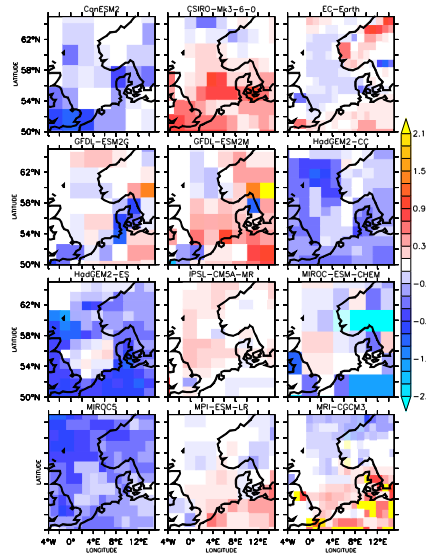
This point is further illustrated with histograms of daily-mean winds speeds for a grid point in the southern North Sea (Figure 2). The histograms for all three cases are virtually identical.



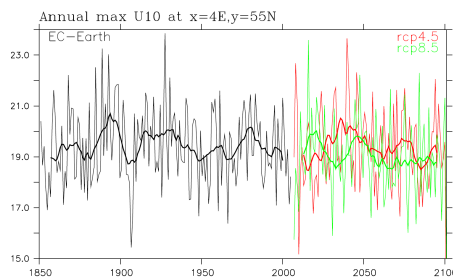
**Figure 2:** Histograms of daily-mean 10m wind speeds from EC-Earth for a point in the southern North Sea for the historical period and for two climate-change scenarios (30 years, bin size 0.1 m/s).

## 3. Extreme winds

From a safety perspective, extreme winds are much more important than mean winds. Figure 3 shows changes in the annual-maximum daily-mean winds from 12 CMIP5 models. There is no sign of a consistent climate change signal. Some models show an increase, others a decrease, and hardly any of the changes is statistically significant.



**Figure 3:** Change (in m/s) in the annual-maximum daily-mean 10m wind speed over the North Sea in 12 CMIP5 models under global warming (rcp8.5). Full colours denote areas where the change is statistically significant (95%).

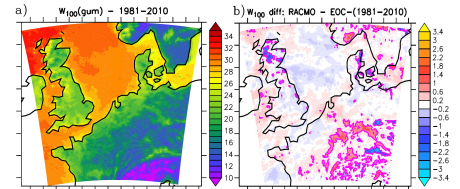


**Figure 4:** Annual-maximum daily-mean 10m wind speeds (m/s) from EC-Earth for a point in the southern North Sea for the historical period and for two climate-change scenarios.

Figure 4 shows a time series of annual maximum wind speeds for a point in the southern North Sea from EC-Earth. Clearly, there are no differences between the historical and the future periods or between the two emission scenarios.

This is not an artifact of the coarse GCM resolution.

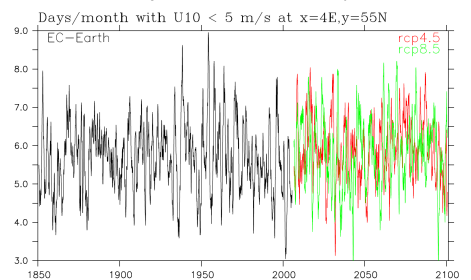
Figure 5 shows 100-year return wind speeds and their projected changes as obtained from output of the RACMO2 RCM. The lateral forcing is obtained from EC-Earth. Again, no changes are found.



**Figure 5:** 100-year return values (in m/s) of daily-maximum 10m wind speed as obtained from a Gumbel fit to the RACMO2 output. (a) Values for the historical period (1981-2010), and (b) difference between the last 30 years of the 21st century (2071-2100) and the historical period. Differences that are (not) significant at the 95% level are in full (pale) colours and surrounded by a pink line.

## 5. Low winds

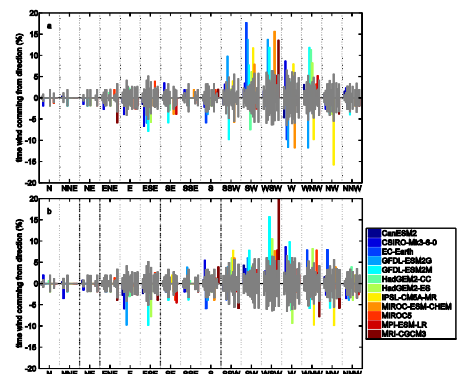
For wind energy production instances of low wind (= no production!) are very important. Figure 6 shows that the number of days with low wind speeds does not behave differently for current and future periods.



**Figure 6:** Number of days/month (12mm smoothed) on which the daily-mean 10m wind speed is lower than 5 m/s for a point in the southern North Sea for the historical period and for two climate-change scenarios as simulated by EC-Earth.

## 6. Wind directions

Finally, Figure 7 shows changes in the direction of the annual-maximum daily-mean wind speeds from 12 CMIP5 models. There is a small tendency for future maximum winds to come more often from (south-) westerly directions, and less often from (south-) easterly ones.



**Figure 7:** Changes in the percentage of time that the annual-maximum daily-mean 10m wind is projected to come from a certain direction (a) rcp4.5 - historical, (b) rcp8.5 - historical. In gray, the standard deviation of the historical run is depicted as an indication of the statistical uncertainty. Values are for the box 53°N-57°N, 1°E-7°E in the southern North Sea.

## Conclusion

None of the investigated aspects of the North Sea wind climate shows a significant change in future climate simulations. The wind climate of the North Sea is very variable and will remain so in the future, without an extra anthropogenic effect.

## References

- [1] R.C. de Winter, A. Sterl, B.G. Ruessink (2013): Wind extremes in the North Sea basin under climate change: an ensemble study of 12 CMIP5 GCMs. *J. Geophys. Res.*, 118, 1601-1612, doi: 10.1002/jgrd.50147
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