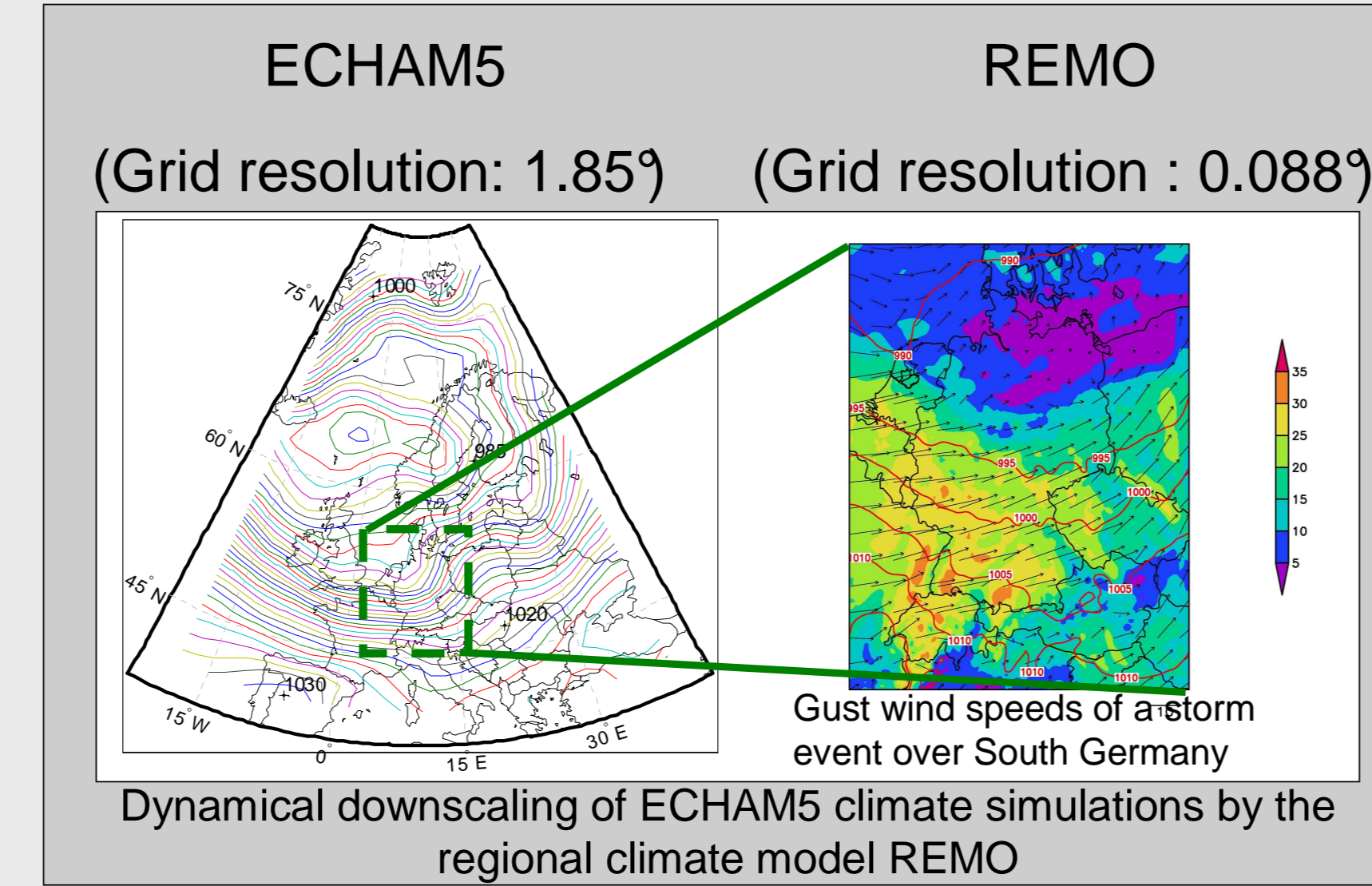


## Introduction

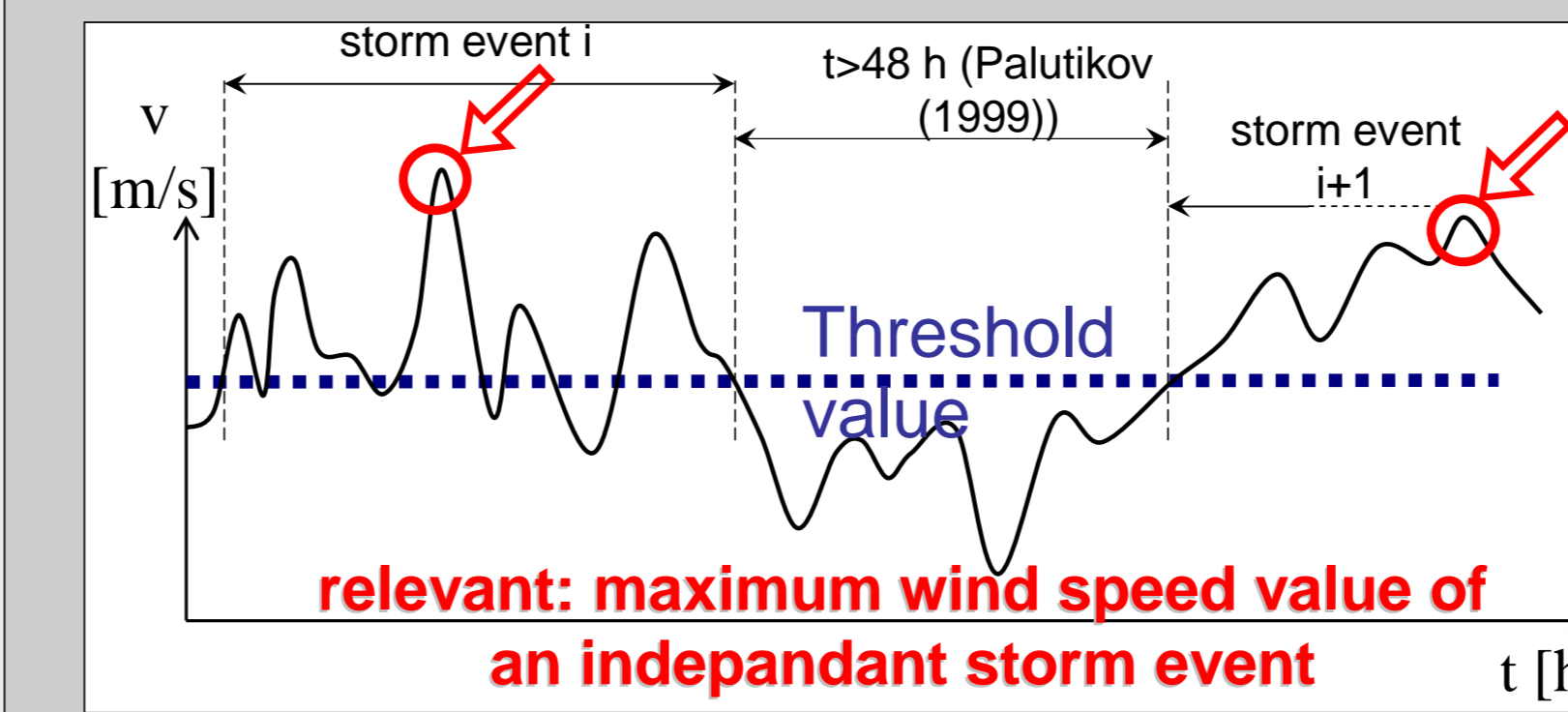
In this contribution, the changes in winter storm activity will be estimated for Germany. This estimation is done by using the output of the regional high resolution climate Model REMO, which is driven by the GCM ECHAM5. To get an estimation of the reliability of the REMO data, model results for the control period 1971- 2000 are evaluated against point measurements and results from a different approach. The data from the control period are compared against that of the projection period 2021-2050. By applying extreme value statistics, expected changes for the future are quantified. The analysis is focussing on the changes in the probability of occurrence for extreme wind speeds.

This project is part of the programme "challenge of climate change", which is funded by the state of Baden-Württemberg.

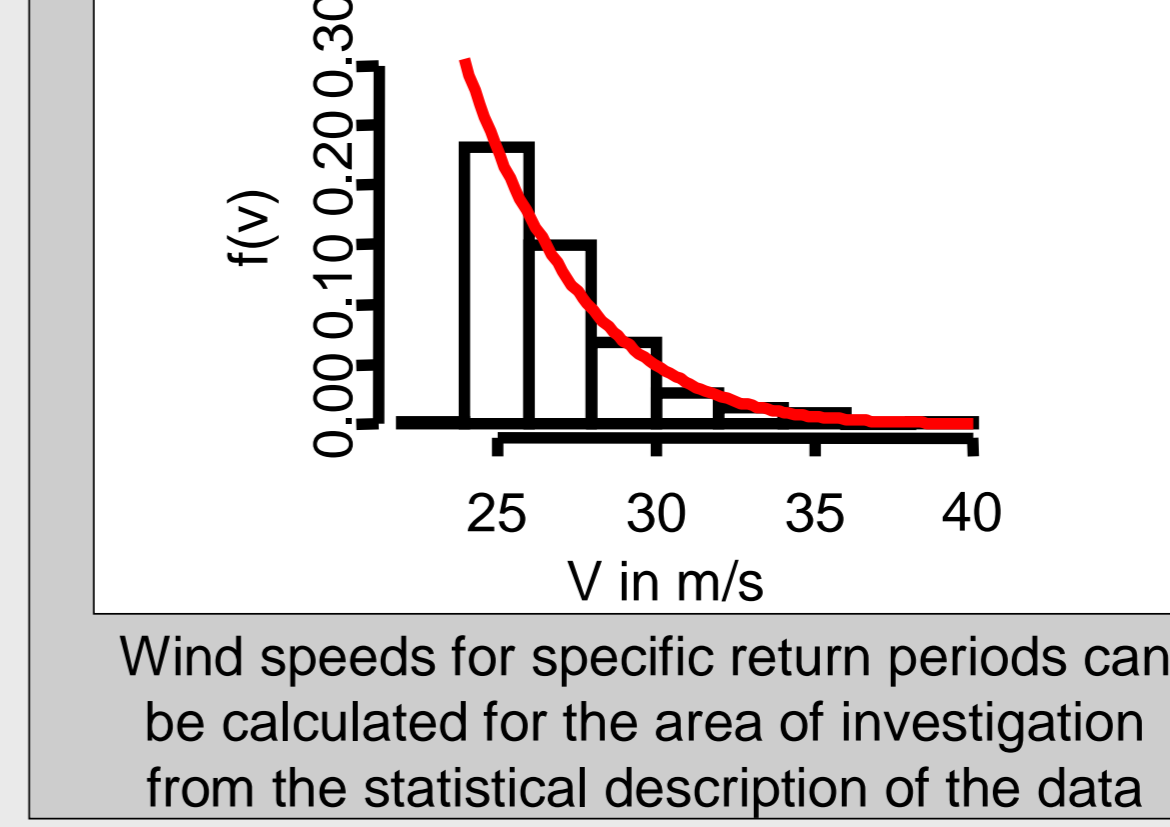
## Data and Methods



Identification of independent storm events in wind time series using the 'Peaks over Threshold'-Method

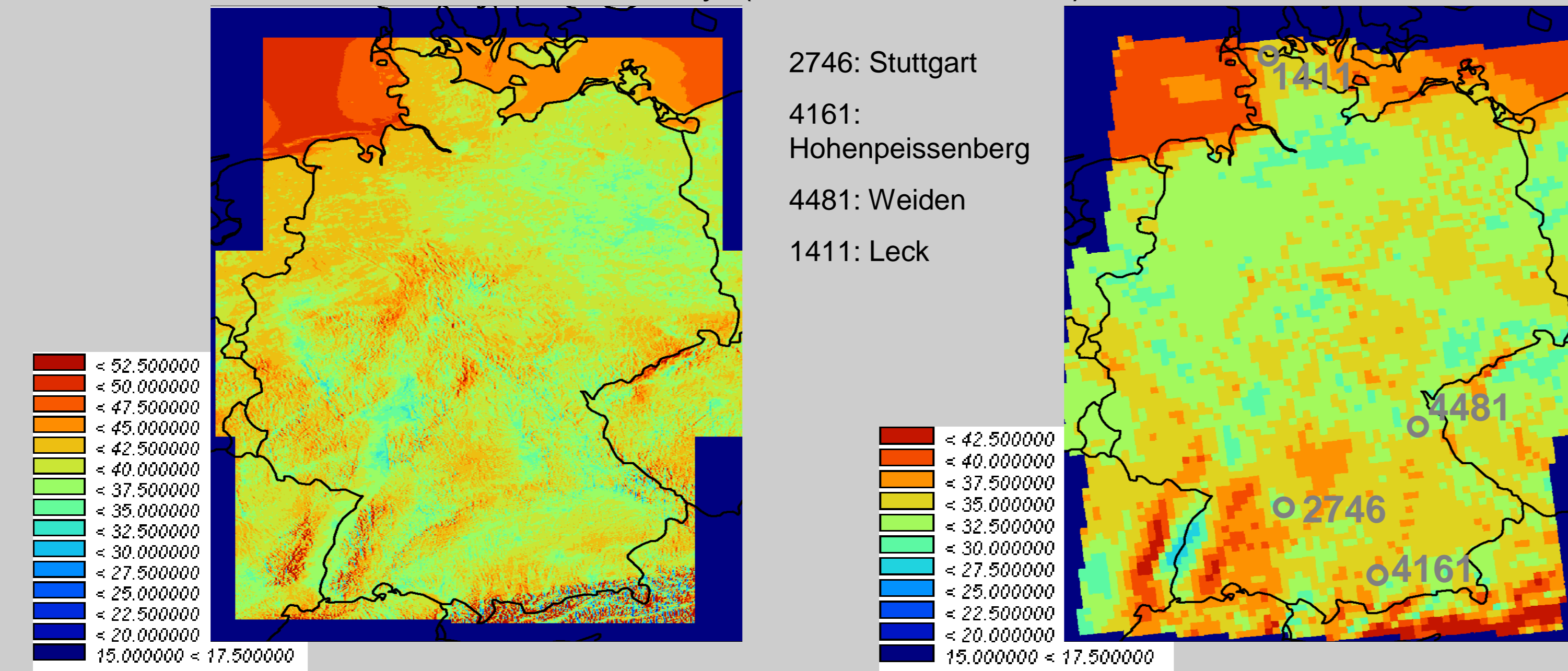


Fitting the resulting wind speed distribution with the 'Generalized Pareto Distribution' (GPD)



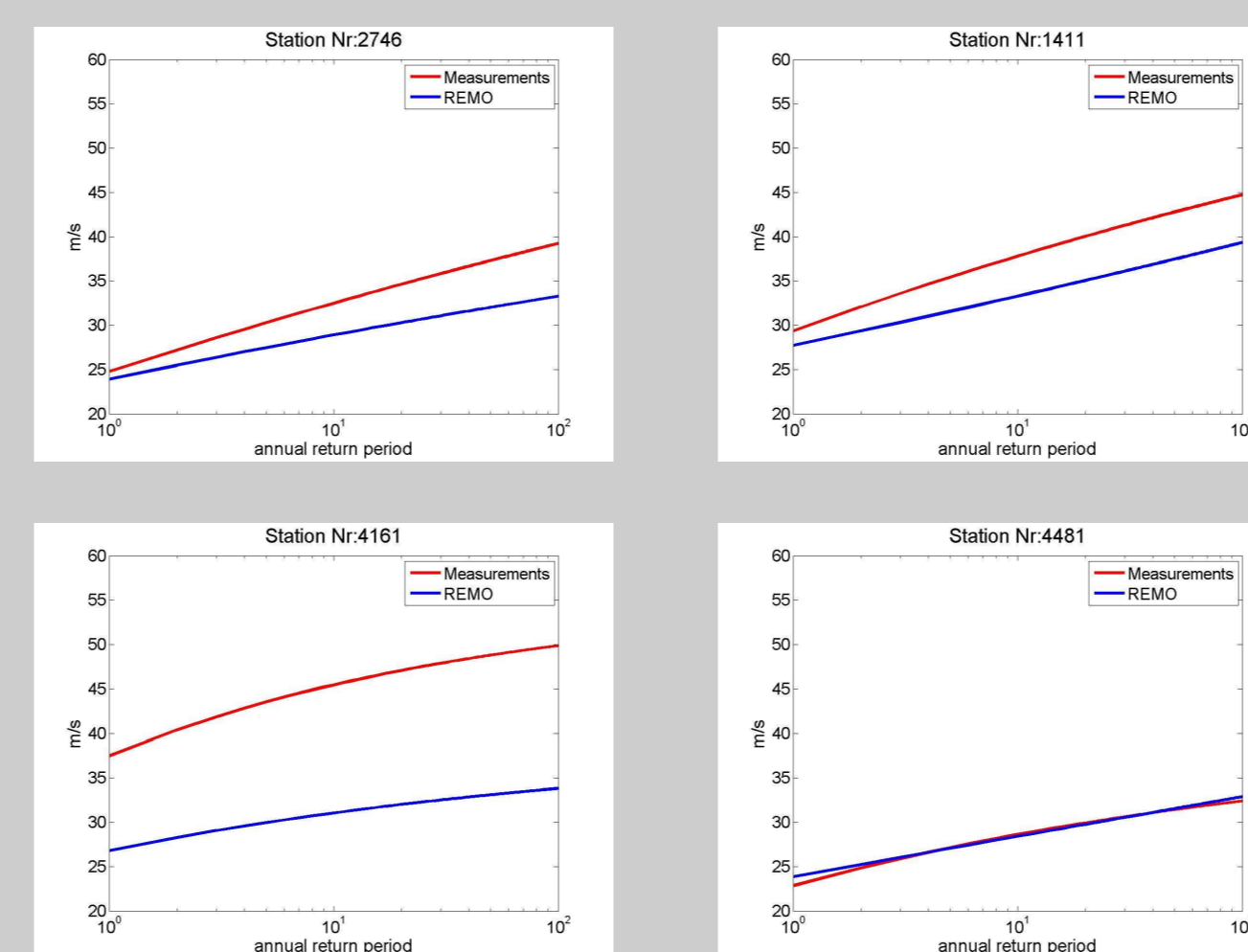
## Evaluation of the data

Areal comparison of wind speeds for a 50 yr return period: REMO data vs. 'Storm Hazard Map Germany' (Heneka et al., 2006)



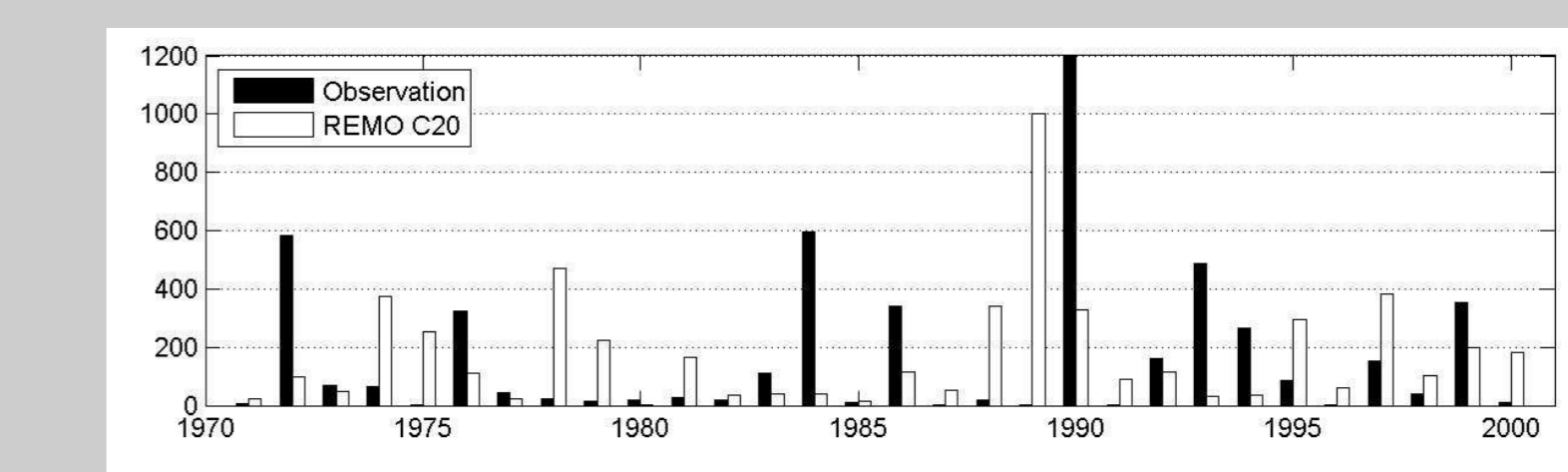
To allow for this kind of comparison, the statistical method of the REMO data processing was adapted to the method of the 'Storm Hazard Map Germany' (Gumbel distribution; Heneka et al., 2006). It can be seen, that the REMO calculated wind speeds are generally too low. From a qualitative point of view, there are some discrepancies but also several correspondences, which is remarkable because of the completely different approaches of the two methods.

Comparison between REMO data and observations at selected SYNOP-stations



As already seen in the spatial distribution, this evaluation further confirms the general underestimation in wind speed by REMO. While some stations in the northern as well as in the southern part (1411, 2746 in the left map) are showing a good agreement, mountainous stations seems to be more sensitive (4161: Hohenpeissenberg). But also, for some stations, a very good agreement can be seen (4481).

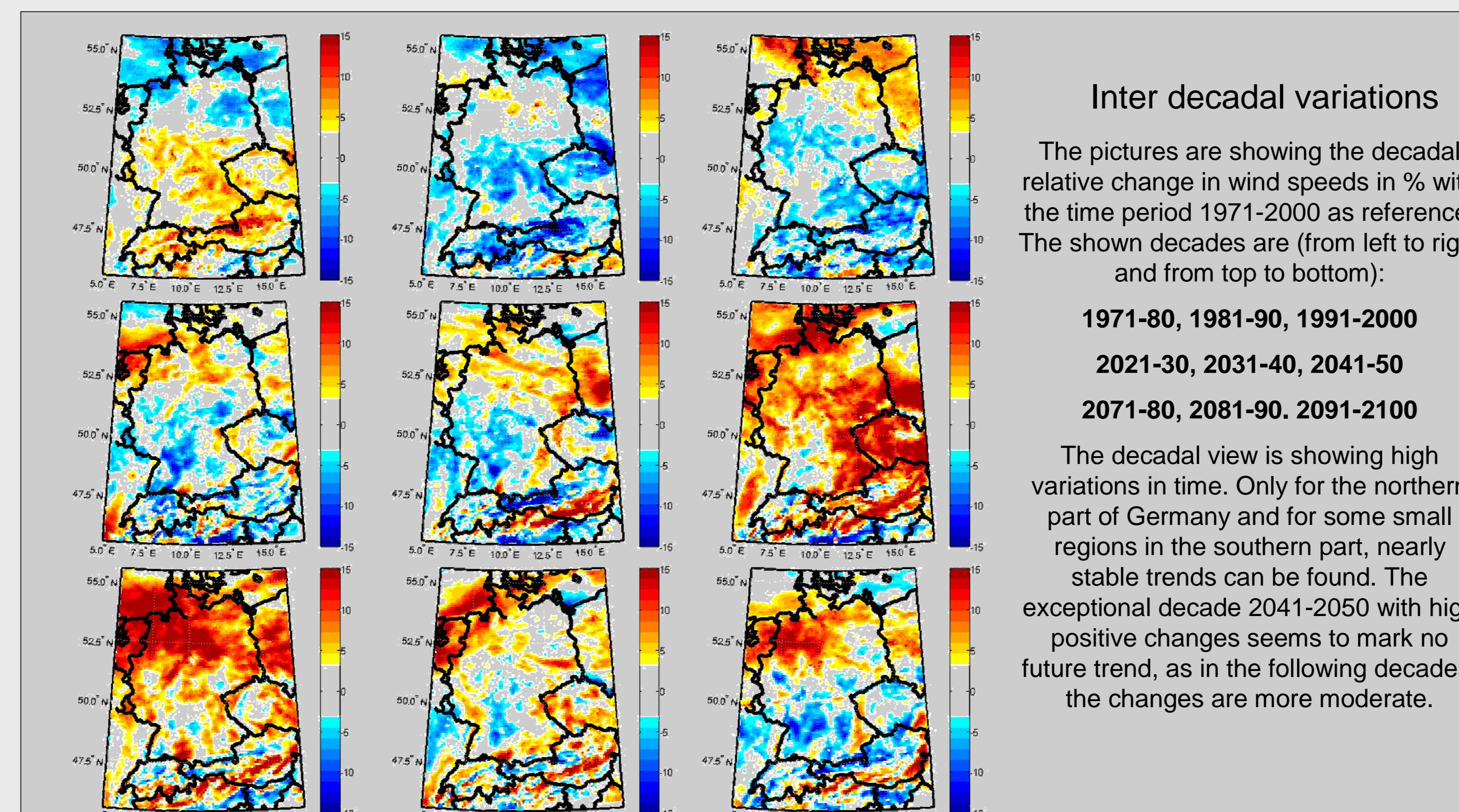
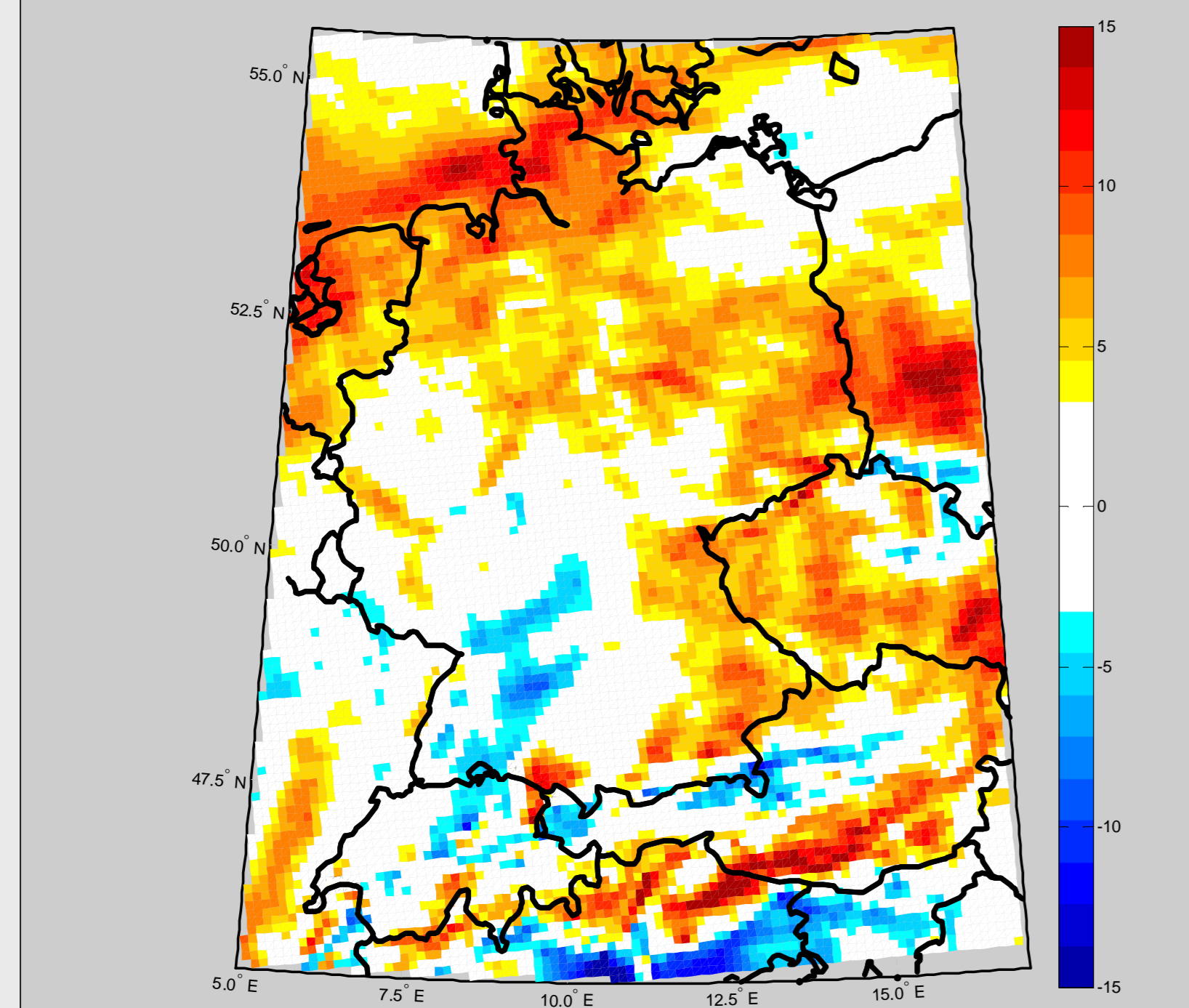
Annual loss by storm damage on residential buildings: comparison real vs. REMO storms for Germany



Annual total loss (residential buildings; in Mio €) time series for the control period 1971-2000. The model to calculate the amount of loss was developed by Heneka et al. (2006). Any temporal correlation in damage is coincidental because the climate model is independent from real weather conditions. But in the sum of losses, the climate model matches quite well with real conditions.

## Results

Relative change in wind speeds for a 10 yr return period between control period (1971-2000) and projection period (2021-2050) in %.



### Inter decadal variations

The pictures are showing the decadal relative change in wind speeds in % with the time period 1971-2000 as reference. The shown decades are (from left to right and from top to bottom):

1971-80, 1981-90, 1991-2000

2021-30, 2031-40, 2041-50

2071-80, 2081-90, 2091-2100

The decadal view is showing high variations in time. Only for the northern part of Germany and for some small regions in the southern part, nearly stable trends can be found. The exceptional decade 2041-2050 with high positive changes seems to mark no future trend, as in the following decades, the changes are more moderate.

## Summary

An estimation for return periods of wind speeds can be obtained by the applying extreme value statistics on the REMO data set. The high resolution of the climate data allows to compare between various other data sets. This comparison shows a qualitative agreement with major quantitative differences, which are not surprising considering that fundamental different methods are used.

As a result of the analysis, the data shows an increase of winter storms in the northern and partially the south-eastern part of Germany for the projection period 2021-2050. The high variance in time suggests that long time periods are required to get robust results.

A calculation of future damage in combination with a loss model could show which changes can be expected in storm hazard.

## Bibliography

- Heneka, P., T. Hofherr, B. Ruck, und Ch. Kottmeier, 2006: Winter storm risk of residential structures – model development and application to the German state of Baden-Württemberg. Nat. Hazards Earth Syst. Sci., 6, 721-733. doi:
- Palutikof, J.P., Brabson, B.B., Lister, D.H. and Adcock, S.T., 1999: A review of methods to calculate extreme wind speeds. Meteorological Applications, 6, 119-132.