Probabilistic Decadal Forecast for Central and Western Europe (MiKlip-PRODEF)

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Summary MiKlip-PRODEF

PRODEF is part of the MiKlip-Module C ("Regionalisation"), and aims at the development of a combined statistical-dynamical downscaling (*SDD*) and probabilistic forecast tool for high-resolution decadal predictions over Central and Western Europe. Focus is given on three different climate-related and impact-relevant topics: Windstorms, wind potential for energy supply, and severe convective rainfall events leading to floods. *SDD* consists of three steps (cf. Fig. 3): (i) Identification and subdivision into large-scale weather types (*WTs*) using reanalysis data or global climate models (GCM / MPI-ESM), (ii) dynamical downscaling of representative episodes for each *WT* using COSMO-CLM, and (iii) construction of local climate parameter distributions (*PDFs*) for different periods (e.g. single decades) by recombining dynamical downscaled episodes weighted with the respective *WT* frequencies.

Analysis of large-scale synoptic variability in the MPI-ESM-LR

First, it is analysed in how far the MPI-ESM is able to reproduce and forecast the synoptic variability on the large scale. **i)** The general frequencies of circulation weather types (*CWTs*) over Europe are matched well by the historical and decadal simulations of the MPI-ESM-LR, despite a systematic bias for westerly and anti-cyclonic *CWTs* (Fig. 1).

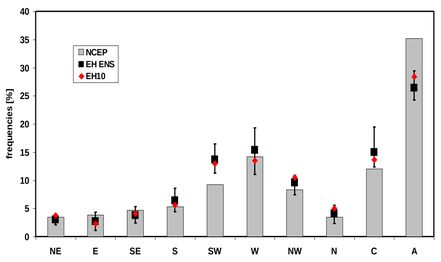

Fig. 1: CWT frequencies exemplary shown for the 10th realisation (EH10) and for the ensemble mean of decadal2000 (EH ENS) compared to NCEP.

ii) The MPI-ESM shows a more zonal orientation of the North-Atlantic (*NA*) stormtrack compared to the reanalysis (Fig. 2a,b). For 1yr lead times of yearly initialised decadal hindcasts a slight positive correlation with NCEP stormtracks is observed for the central *NA* and Europe (Fig. 2c). For 2-5yr lead times a negative skill for most of the central *NA* and the stormtrack centre is detected when using ensemble means of historical runs as reference (Fig. 2d). The skill for 1yr lead times looks similar, with a slightly enhanced skill near Newfoundland, while for 6-9yr a positive skill is found for most of Europe (not shown).

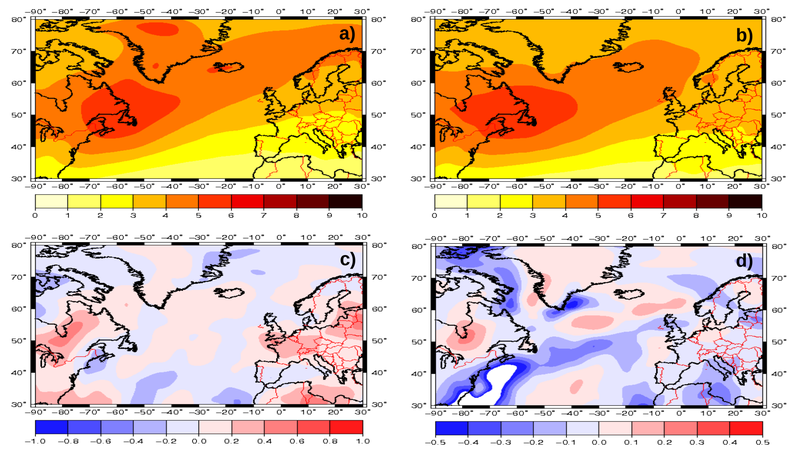

Fig. 2: a) Climatology of winter stormtrack (Oct-March) for NCEP reanalysis (1960-2005). b) As a) but for the 1st realisation of the MPI-ESM-LR historical run. c) Correlation coefficient between NCEP and 1yr lead times of the 3-member ensemble mean of the decadal runs. d) RMSE skillscore of the stormtracks for 2-5yr lead times of the decadal runs.

Application of the SDD to the MPI-ESM-LR

The main target of DS1 was the establishment of *SDD* methods (*Pinto et al.,* 2010) for the three focal points of PRODEF. The *SDD* has successfully been applied to reanalysis data and the full ensemble of baseline 0 of the MPI-ESM-LR (3 historical and 286 decadal runs) with respect to windstorms and wind energy. Here, preliminary results are exemplary presented for windstorms and gusts to illustrate the crucial steps of the *SDD* (Fig. 3).

A classification of temporal evolving SLP-fields (Fig. 4a) to 55 *WT* clusters (Fig. 4b) has been performed. Simulated representative episodes of all 55 clusters are taken from a COSMO-CLM control run forced with ERA-Interim (Fig. 5). By using the cluster frequencies, the downscaled episodes are recombined to obtain wind gust *PDFs* for each CLM grid point, separately (Fig. 6). By applying the *SDD* to the full ensemble of the decadal runs, skills of the downscaled MPI-ESM-LR for different lead times and wind gust percentiles can be determined. Fig. 7 exemplary shows the RMSE skillscore of the 98th wind gust percentile for 2-5yr lead time. According to the *SDD* approach, a positive skill is found for most of the North Sea and the *NA*, while the skill is negative over major parts of Europe.

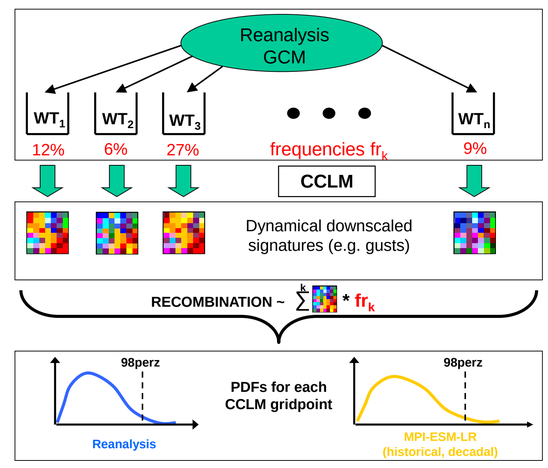

Fig. 3: Simplified illustration of the probabilistic SDD approach.

WT classification

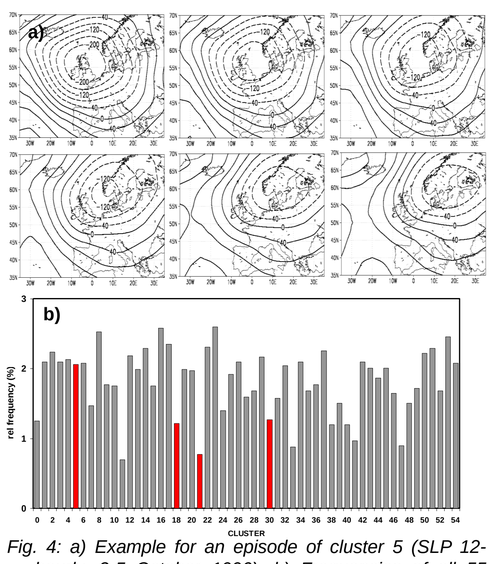

Fig. 4: a) Example for an episode of cluster 5 (SLP 12-hourly, 3-5 October 1990). b) Frequencies of all 55 clusters for the NCEP reanalysis. Storm clusters are marked in red.

dynamical downscaling

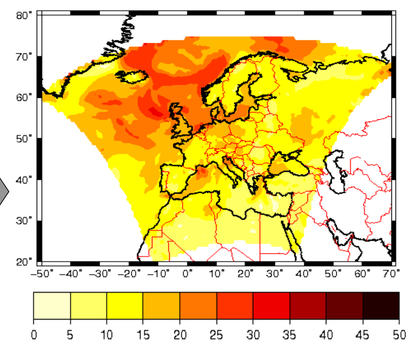

Fig. 5: Dynamical downscaled wind signature for the exemplary episode shown in Fig. 4a, derived as 72h maximum wind gust.

Recombination to PDFs

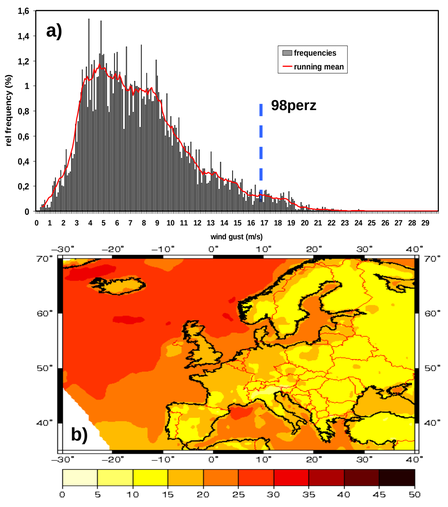

Fig. 6: a) Recombined wind gust distribution for a CCLM grid point near Hamburg. b) spatial distribution of the 98th percentile of downscaled gusts derived from SDD applied to NCEP.

Decadal predictibility

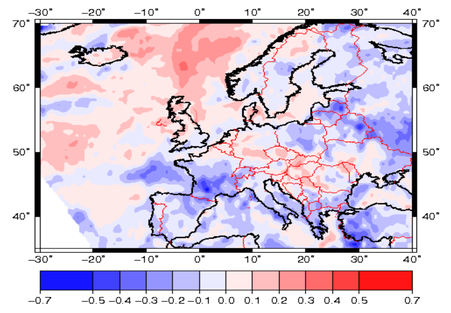

Fig. 7: Skillscore of the 98th percentile of downscaled wind gusts for 2-5yr lead times of the MPI-ESM-LR decadal runs.

The SDD approach is also used to consider single decades/periods. For example, we evaluated in how far the MPI-ESM-LR realisations of decadal1990 indicate a peak of storm activity in the early 1990s, as known from history. We compare it to the early 2000s, which is known to have a comparatively lower storm activity. The application of a storm index (*SI*) analysis reveals, that the 50 strongest events of most decadal1990 realisations show a higher *SI* than the 50 strongest events of decadal2000. To analyse the impact of increased large-scale storm activity on local wind gusts, the strongest events of the exemplary 2nd realisation of both decades are statistically downscaled (Fig. 8). Differences between the obtained 90th percentiles of both decadal MPI-ESM-LR realisations indicate indeed higher wind gusts in the early 1990s of over most of Europe and the North Sea than in the early 2000s (Fig. 9).

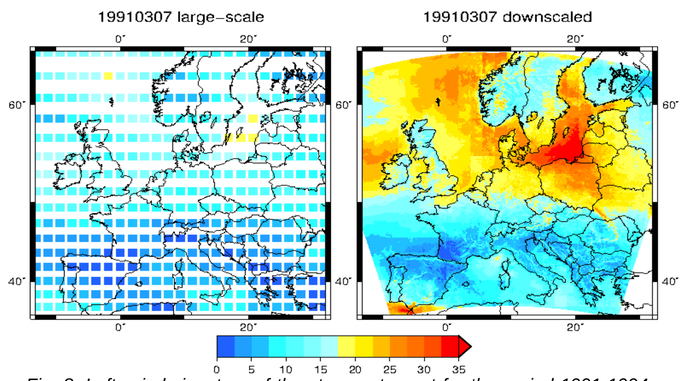

Fig. 8: Left: wind signature of the strongest event for the period 1991-1994 (decadal1990 r2i1p1). Right: statistical downscaled wind gusts of the same event.

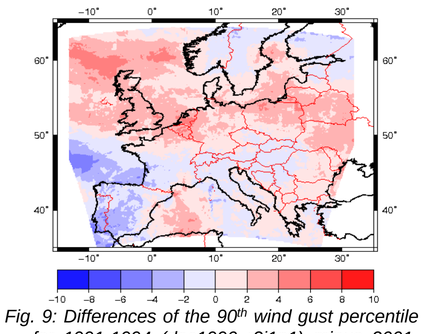

Fig. 9: Differences of the 90th wind gust percentile for 1991-1994 (dec1990 r2i1p1) minus 2001-2004 (dec2000 r2i1p1).

Workplan for DS2

- Complete establishment of *SDD* method for severe convective rainfall events
- Dynamical downscaling of two decadal hindcasts of the MPI-ESM baseline 1 to cover the full spectrum of potential weather types; increasing horizontal resolution to 7km
- Application of the *SDD* to the full ensemble of MPI-ESM-LR and MPI-ESM-MR of baseline 1
- Homogenisation of observations for comparison with/evaluation of the *SDD* approach with respect to surface wind and precipitation
- Provision of an evaluated prototype of the *SDD* tool to the MiKlip forecast system

Reference: Pinto JG, Neuhaus CP, Leckebusch GC, Reyers M, Kerschgens M (2010): Estimation of wind storm impacts over West Germany under future climate conditions usng a statistical-dynamical downscaling approach. *Tellus A*, 62: 188-201