Integrated Activity IA-3: Global High-Resolution Climate Reconstruction

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Introduction

Long-term reanalysis data already exist in coarse resolution. However, for advanced climate studies downscaling is needed. In a global high resolution atmospheric model the downscaling is performed by using the spectral nudging technique. This kind of data assimilation conserves large scale structures but provides in addition details at a finer resolution.

Method

A global spectral atmospheric model with high spatial resolution is run with “observed” SST and sea-ice conditions. Additionally, divergence and vorticity above 750 hPa are constrained to follow NCEP-reanalysis by employing the “spectral nudging” method.

- **Model:** ECHAM6 (T255L95) of MPI-M Hamburg.
- **Forcing:** NCEP1-reanalysis (T62L18)
- **Nudging:** Adding a spectral correction term

\[ dX/dt = G_n (X_{n,NCEP1} - X_n) + F(X_n) \]

- \( G_n \) is the weights (nudging coefficient)
- \( n \) is a subscript of the total wavenumber
- \( F \) = dynamical model (ECHAM6)
- \( X \) = state variable of the model
- \( X_{NCEP} \) = state variable of NCEP re-analysis

In the framework of an extended sensitivity study, best nudging parameters (described by the relaxation time, its vertical profile and the horizontal spectral wavenumber space) were determined for the recently finalized simulation from 1948 to 2015 (April).

- \( G_n = 33.33 \times 10^{-5} \) [1/s] for wavenumbers \( n < n_{edge}=30 \) (light blue region)
- \( G_n = 0 \) [1/s] for wavenumbers \( n > n_{edge} \) (the blue region).

Results

**All scales:** The spectra of kinetic energy at 500hPa, Fig. 2, reveal nearly identical results for total wavenumbers \( n \leq 30 \). For higher wave-numbers ECHAM6 has larger amount of kinetic energy.

![Figure 2: Kinetic energy spectra for ECHAM6 (light blue) and NCEP1(blue) for October 2004.](image)

**Small scale:** The added value in regional and local scales feature can be stated by a close similarity of locally observed data (temperature at 2m and wind speed at 10m) at the DWD station Hamburg-Fuhlsbüttel, Fig. 3.

![Figure 3: Time series for temperature at 2m [K] (top) and wind speed at 10m [m/s] (bottom) in the year 2004 derived from the observed dataset (DWD = German Weather Service, light blue) and nudged ECHAM6 simulation (blue).](image)

**Synoptic scale:** This is also true for the similarity of the NAO-indices, Fig. 4, whereas large-scale features are supposed to be mostly unchanged.

![Figure 4: For the complete simulation period the curves of the NAO-indices (DJF) of nudged ECHAM6 (red) and NCEP1 reanalysis (blue) follows closely the observational CRU data (grey).](image)

**Meso scale:** The Hamburg storm surge was an extreme event in the year 1962, triggered by the winter storm “Vincinette” on 16/17th of February. Snapshots of wind field at 10 m height and sea level pressure distribution over Europe (Fig. 5) indicate more realistic details in the ECHAM6 (left) than in the NCEP1 (right).

![Figure 5: Snapshots of the winterstorm “Vincinette” on 1962/02/16 at 16:00 UTC including fields of the wind speed at 10m [m/s] and sea level pressure derived from ECHAM6 (left) and NCEP1 (right).](image)

**Figure 6:** Track of “Wilma” based on the best track data, NCEP and ECHAM6. The latter track gets closer to best track compared to NCEP although the intensity is still too low.

Conclusions

A global regionalization of the atmospheric weather since 1948 was performed by using a global downscaling approach suggested by Yoshimura and Kanamitsu (2008). Main points are:

- A mostly homogeneous description of the global weather phenomena at all scales.
- The intensity of simulated tropical storms is lower than those of best track data.

This work is the result of an “integrated” CliSAP project. This new data set are presently made available by ICDC at DKRZ.


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