Added value of limited area model results

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1. Regional Climate Model Results

Regional climate models (RCMs) of the atmosphere are widely used in climate research studies. They serve a variety of purposes, from process studies and weather forecasting to long-term simulations. Such models can process multi-year to multi-decadal large-scale weather information (for the past or for some hypothetical future, e. g. scenarios) and use high-resolution topographic details. The question is: 'Do they return more than the original forcing data's knowledge (specified at the boundaries or as well at the large scales; possibly after some simple downscaling application such as spatial interpolation)?' The additional knowledge is usually termed "added value" – and so far, efforts in determining this added value are rare. Instead general assumptions are made, e. g. that higher grid resolutions should lead to better results. But evidence that the quality of such additional detail is superior to a simple geo-statistical post-processing of the global forcing data is not often provided.

In the present talk, the efforts of our group to determine such added value in multi-decadal simulations with different regional climate models are summarized and evaluated. These simulations were mostly "reconstructions", e. g. simulations of the weather dynamics since 1948 until today of Western Europe or the Northwestern Pacific. Most of these simulations have been done with the constraint of spectral nudging. Thereby the RCM was forced to simulate the assumedly well-resolved large-scale features of the driving fields correctly, while the dynamics at smaller scales were simulated solely by the RCM (*von Storch et al.* (2000)). Conditional upon the model area and the degree of exchange via the lateral boundaries, success in simulating the "right" features at the observed time and location may depend on the constraint of the large-scale dynamics (*Rockel et al.* (2008)).

2. Added Value

We have identified several fields, where added value of RCMs emerges. The better representation of spatially distributed processes allows a more realistic description of meso-scale phenomena – examples are North Atlantic polar lows and East Asian typhoons (e. g. *Zahn and von Storch* (2008); *Feser and von Storch* (2008)).

Features resolved in numerical data are typically of the order four grid boxes or above. For global reanalysis products, this means that phenomena smaller than 800 km are not represented well. In Fig.1 the increased information gained with a RCM is shown for a SLP field including a polar low. Polar lows are meso-scale (200-1000km) sized maritime storms in the Arctic. In the DWD analysis, the polar low is visible with closed isobars off the Norwegian Coast, whereas in the NCEP/NCAR field only a weak pressure trough exists. Using these data to drive a climate mode RCM simulation, it is possible to reproduce the polar low with closed isobars (*Zahn et al.* (2008)).

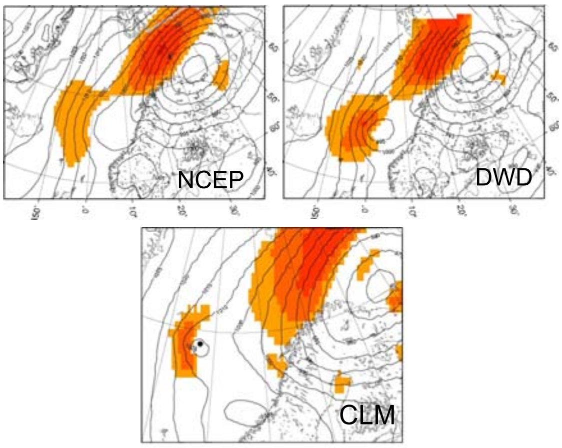

Figure 1. 10m wind speed ≥ 13.9m/s and air pressure (at mean sea level) on 15 October 1993: NCEP/NCAR analysis after interpolation onto the CLM grid, DWD analysis data, CLM simulation. The black dot indicates the positions of the polar low's pressure minimum in the CLM simulation.

The added value of this procedure becomes particularly distinct, when the meso-scale information is extracted from the full MSLP-fields (by applying a band pass filter). In Fig.2 the polar low is comprised in the DWD analysis as well as in the RCM field, but not in the NCEP/NCAR-field.

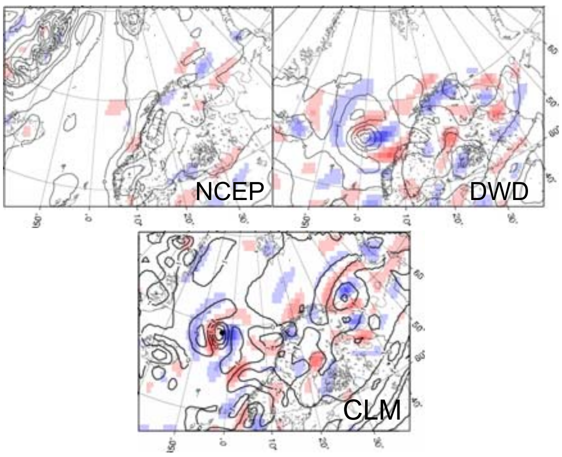

Figure 2. Band-pass filtered MSLP (isolines; hPa) and 10m wind speed anomalies on 15 October 1993: NCEP/NCAR analysis, DWD analysis data, CLM simulation. The black dot indicates the positions of the polar low's pressure minimum in the CLM simulation.

So far these findings were used to automatically detect polar lows in long-term simulations and to investigate their frequency and changing annual numbers.

The higher spatial resolution, compared to the driving large-scale data, will in general not improve the representation of the large-scale dynamics, but presumably mostly the meso-scale dynamics. This can be demonstrated by comparing statistics of meso-scale dynamics simulated in extended RCM simulations with operational regional weather analyses. To do so, suitable digital spatial filters are needed (*Feser and von Storch* (2005)). It turns out that regional models show an added value in describing meso-scale variability compared to the driving global reanalysis, in particular, when the RCM is constrained at the large spatial scales (*Feser* (2006)). Not unexpectedly, the description of the large scales is slightly deteriorated.

The higher resolved description of physiographic details, such as mountain ranges, coastal zones and details of soil properties has the potential of describing the weather and its statistics in such regions closer to reality than the global analyses or simulations. By comparing RCM simulated data with QuikSCAT satellite and with local buoy data, *Winterfeldt and Weisse* (2009) demonstrated that the usage of RCMs indeed leads to an advanced description of wind speed statistics in coastal seas, while conditions in the open ocean were not improved (Fig. 3).

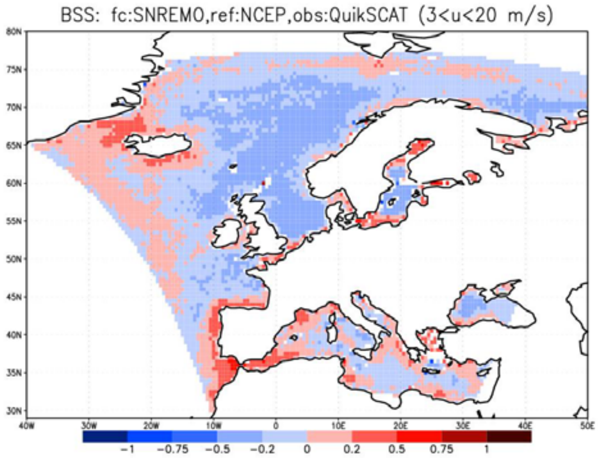

Figure 3. Modified Brier Skill Score calculated from co-locations between QuikSCAT L2B12, NRA_R1 and SN-REMO (SN stands for use of spectral nudging) in the wind speed range from 3 to 20 ms-1 and the years 2000 to 2007, where QuikSCAT L2B12 serves as ``truth``, NRA_R1 as reference ``forecast`` and SN-REMO as ``forecast``. Blue areas indicate value lost, while red areas indicate value added by dynamical downscaling.

The added value of the dynamically downscaled wind was assessed with satellite data, namely QuikSCAT Level 2B 12.5 km (L2B12) wind speed retrievals. After validating the L2B12 data with buoy winds in the eastern North Atlantic (RMSE: 1.7 m/s), L2B12, regional model data (REMO) and global NCEP/NCAR reanalysis (NRA_R1) data were co-located for the years 1999-2007.

Fig. 3 confirms the point stated by *Winterfeldt and Weisse* (2009) for a wide area including the eastern North Atlantic, the Baltic, Mediterranean and Black Sea: dynamical downscaling does not add value to NRA_R1 wind speed in open ocean areas (blue), while it does for complex coastal areas (red).

Finally, an important utility of such multi-decadal model data is that they may be used to quantitatively describe hazards and changing conditions in the regional Earth System – examples are the hydrodynamics of marginal seas, in particular currents, sea level, and thus storm surges or ocean wave conditions and related hazards (CoastDat; *Weisse et al.* (2009)).

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