MULTI-DECADAL DYNAMICAL DOWNSCALING OF TROPICAL CYCLONES IN EAST ASIA USING SPECTRALLY NUDGED REGIONAL CLIMATE MODELS

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I. INTRODUCTION

Tropical cyclones (TCs) can cause flooding and extreme weather conditions affecting the coastal population. In order to estimate changes of TCs in the past in location, intensity or frequency, a modelling approach was chosen. Global reanalyses data are available only at a coarse resolution, for higher resolutions downscaling is necessary. In this study the feasibility to reconstruct the weather (including typhoons) of SE Asia for the last decades using an atmospheric regional climate model was analyzed. Global National Centers for Environmental Prediction - National Center for Atmospheric Research (NCEP-NCAR) reanalysis data were dynamically downscaled to 50 km and in a double-nesting approach to 18 km grid distance using a state-of-the-art regional climate model, the COSMO model in Climate Mode (CCLM).

II. PRESENTATION OF RESEARCH

First, an ensemble of one simulated typhoon case will be presented. The regional simulations were not only driven by lateral boundary conditions, but also with a spectral nudging technique (von Storch et al., 2000) that enforced the observed large-scale state inside of the model domain. Tropical storms which are coarsely described by the reanalyses were correctly identified and tracked; considerably deeper core pressure and higher wind speeds were simulated compared to the driving reanalyses. Several sensitivity experiments with varied grid distances, different initial starting dates of the simulations and changed spectral nudging parameters were computed (Feser and von Storch, 2008a).

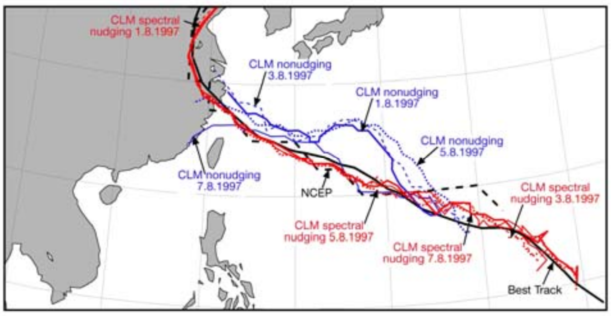

FIG. 1: Effect of spectral nudging and different initial states.

The track of Typhoon Winnie is shown in Fig. 1 for the best-track data, NCEP reanalysis, and for four simulations with spectrally nudged CCLM and four unconstrained CCLM simulations. The NCEP track deviates only in the earlier part of the development from the best-track data; the spectrally nudged RCM simulations all follow the best-track data closely, even during the phase when NCEP deviates a bit. One simulation without spectral nudging is also close to the best track data, but the other unconstrained RCM simulations deviate to the north of the typhoon track. For the tracking a simple minimum pressure search was performed for the sea level pressure field.

In a second step, an ensemble of modelled typhoon events was examined for the typhoon season 2004 for SE Asia and the western Pacific (Feser and von Storch, 2008b) . 12 typhoons between May and October of the western North Pacific typhoon season 2004 were analyzed. The selected typhoons were chosen according to the typhoons presented by Zhang et al. (2007). The comparison to Best Track data revealed improved SLP and near-surface wind values by the RCM compared to the reanalyses for most cases. The reanalyses thereby showed smaller great circle distances to the best track data than the regional model.

Typhoon	Model	RMSE SLP [hPa]	RMSE FF [kt]
Dianmu	NCEP	53.83	46.43
	CCLM 0.5°	25.49	14.34
	CCLM0.165°	23.67	14.35
Songda	NCEP	58.27	50.14
	CCLM 0.5°	48.02	39.38
	CCLM 0.165°	46.61	40.54

TABLE I: RMSE of SLP and 10m wind speed between JMA best track data and NCEP, CCLM 0.5°, and CCLM 0.165°.

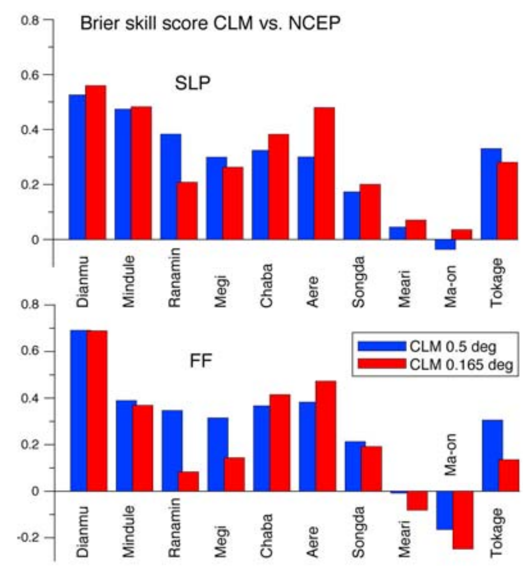

FIG. 2: Brier Skill Score between JMA best track data and NCEP, CCLM 0.5°, and CCLM 0.165°.

Table 1 shows the root mean square error (RMS) for sea level pressure (SLP) and wind at a height of 10 meters for two sample typhoons. The RMS is for both typhoons and both wind speed and SLP larger for the global reanalyses than for the regional model at both 50 and 18 km resolution. The regional model runs show only slightly deviating results.

Figure 2 shows the Brier Skill Score between best track data of the Japan Meteorological Agency (JMA) and NCEP, CCLM 0.5◦, and CCLM 0.165◦, for SLP (upper panel) and 10 m wind speed (lower panel) for the analysed typhoons. For values larger than 0 CCLM is closer to the best track than NCEP, 0 means CCLM is equally close to the best track as NCEP, for values smaller than 0 NCEP is closer to the best track than CCLM. In 7 out of the 10 cases, the high-resolution (0.165◦) CCLM performs better than the coarse grid (0.5◦) CCLM; in 3 cases the improved resolution does not lead to better results in terms of SLP. The result is less good for wind speed. In terms of this variable, CCLM is not performing better than NCEP in 2 out of 10 cases; Usage of 0.165◦ grid-sizes leads to results closer to the best track numbers than 0.5◦ grid-sizes only in 3 out of 10 cases. In 7 of the 10 cases, the 0.5◦ CCLM is performing better than the 0.165◦ CCLM.

III. RESULTS AND CONCLUSIONS

Some typhoons can be described at least partly realistically by dynamical downscaling of coarse-grid NCEP reanalyses with regional atmospheric models. The presented experiments indicate that lateral boundary control is not always sufficient to reconstruct the numbers and tracks of typhoons. Of course, this depends on the size of the domain, for smaller domains the lateral control is more efficient. The inclusion of large-scale constraints, as for instance spectral nudging, is helpful in forming the storms along the right track.

Using a double-nesting approach has an effect on the simulation, which is believed to be a slight improvement compared to the 50-km simulation in terms of core pressure development and near-surface wind speed. But the typhoon tracks were very similar. Precipitation patterns and rainfall amounts were simulated more realistically by the RCM using the higher resolution compared to the 50 km run. The location of the typhoon tracks is already well represented in the reanalyses.

A comparison of typhoon core pressure along the track revealed RCM values which were closer to the JMA best track data than the global reanalyses for 9 out of 10 cases. Some SLP developments in the RCM followed closely the JMA best track values, but some showed a time lag as e.g. typhoon Songda. In 7 out of 10 cases the highest resolution simulation was closest to the best track SLP. For near-surface wind speed CCLM was closer to the best track wind speed in 8 out of 10 cases compared to NCEP. Still, for all analysed typhoons the RCM underestimated the low pressure values and the strength of the maximum winds.

It is concluded that regional models can improve simulated typhoon developments from global forcing reanalyses data not by altering the track, but by giving lower core pressure and higher wind speeds and more realistic precipitation patterns even though these values still do not reach observed values.

IV. AKNOWLEDGMENTS

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