Influence of regional scale information on the global circulation: A two-way nesting climate simulation

Philip Lorenz and Daniela Jacob

Max-Planck-Institute for Meteorology, Hamburg, Germany

philip.lorenz@dkrz.de

Introduction

A two way nested climate model system has been setup using a global and a regional atmospheric climate model. Within the domain of the regional model the global model is updated every timestep by the aggregated corresponding results of the regional model for this timestep. There is a feedback from the regional model to the global model.
A 10-year simulation has been carried out with this two way nested climate model system using a two way nested domain covering the equatorial Western Pacific region ("warm pool").

The two way coupled model system

To address a two-way-nesting (TWN) approach for coupling a regional atmospheric climate model with a global climate model, the Max Planck Institute for Meteorology (MPI-M) models REMO (Jacob, 2001) and ECHAM4 (Roeckner et al., 1996) were used. The ECHAM4 model is a global atmospheric general circulation model with a spectral representation of the prognostic variables except the water components. It is used in this work with a T42 horizontal resolution and a corresponding time step of 24 minutes.

Global Atmospheric Climate model ECHAM4		
•Resolution:	Horizontal: T42	Vertical: 19 Levels
•Time step:	24 minutes	
•Prognostic variables:		
Temperature		spectral
Divergence		spectral
Vorticity		spectral
spec. Humidity		grid
liquid water		grid
surface pressure		spectral
Regional Atmospheric Climate Model REMO		
•Resolution:	Horizontal: 1/2°	Vertical: 19 Levels
•Time step:	4 minutes	
•Prognostic variables:		
Temperature		grid
horizontal wind components (U,V)		grid
spec. Humidity		grid
liquid water		grid
surface pressure		grid

Table 1: Characteristics of the used models

REMO is a regional hydrostatic atmospheric climate model, the set of physical parameterizations of this model is absorbed from the global ECHAM4 model. It is used in this work with a 0.5° horizontal resolution with a corresponding time step of 4 minutes. The characteristics of the used models are shown in table 1.
In an (up to now used) one-way-nesting mode REMO is initialized and driven at the lateral boundaries using data from (Re)-Analysis products resp. global model output; there is no feedback from the regional model to the global model. Within the presented two-way-nesting approach, every time-step all the prognostic variables of the ECHAM4 model are updated within the regional model domain by the corresponding results of the REMO model for this time step. A schematic flow diagram of the two way nested system is shown in figure 1.

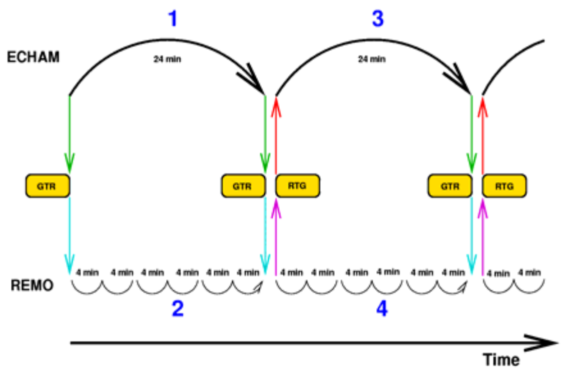

Fig. 1: Schematic flow diagram of the two way nested system. GTR: global to regional interpolation RTG: regional to global aggregation

Results of a 10 year Integration

A two-way-nested REMO-ECHAM4 run (ECHAM4(TWN)) and an ECHAM4 stand alone run (ECHAM4(ORI)), both initialized at the 1st of January 1980, were integrated for 10 years using observed SST data (AMIP); the two-way-nested regional domain covers the Western Pacific / Indonesian Warm Pool (110° E – 155° E; 12° S – 12° N; 91 x 49 grid points). Figure 2 shows the orography and land-sea-mask of the two-way-nested domain in the REMO 0.5°-horizontal resolution against the ECHAM4-T42 horizontal resolution.

The "warm pool" region has been chosen because it is an area with a very large energy input into the atmosphere. The poorly represented land-sea distribution and orography in the global model with the T42 horizontal resolution is much more realistic in the REMO 0.5° resolution.

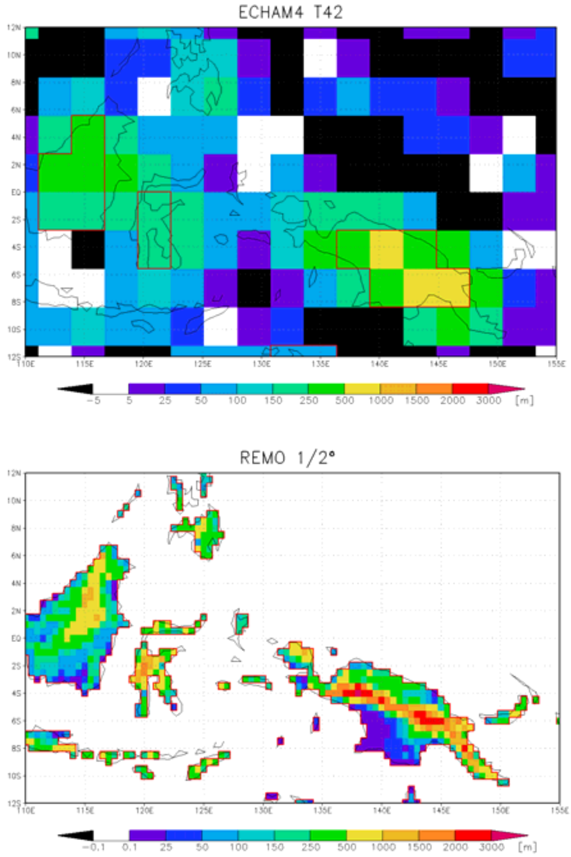

Fig. 2: Orography [m] and land-sea-mask (red line) of the two-way-nested region covering the Western Pacific "warm pool" region in the ECHAM4-T42 horizontal resolution (upper panel) and in the REMO 0.5° horizontal resolution (lower panel)

The comparison of the ECHAM4(ORI) run against the ERA 15 reanalysis data (figure 3; upper panel) shows the known systematic error of ECHAM4 (Roeckner et al., 1996): there is a significant cold bias in the polar upper troposphere and a warm bias of the tropical troposphere of the ECHAM4 model in T42 resolution. Figure 3 (lower panel) shows the influence of the two way nesting approach (ECHAM4(TWN) -ECHAM4(ORI): the relative warming of the polar upper troposphere and the cooling of the tropical troposphere indicates a reduction of the systematic temperature biases for the whole troposphere due to the two way nesting approach.

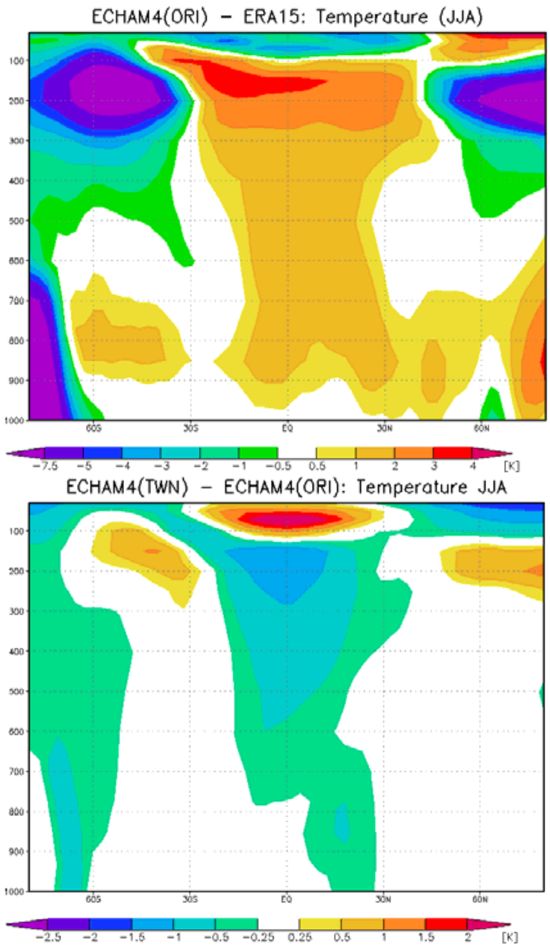

Fig. 3: 10 year seasonal (JJA) zonal mean temperature difference [K] ECHAM4(ORI) – ERA15 (upper panel) resp. ECHAM4(TWN) – ECHAM4(ORI) (lower panel).

Conclusions

The two way nested ECHAM4 – REMO atmospheric climate model system has been setup and can be integrated numerically stable for a 10-year period. Preliminary results show an influence on the simulated global climate, even in regions not covered by the two-way-nest domain. There are indications that the systematic error can be reduced by the finer resolution of specific regions that are important for the global circulation.

The results of the performed 10-year integrations will be analyzed in more detail.

References

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Roeckner, E., K. Arpe, L. Bengtsson, M. Christoph, M. Claussen, L. Dümenil, M. Esch, M. Giorgetta, U. Schlese, U. Schulzweida: The Atmospheric General Circulation Model ECHAM-4: Model description and simulation of present-day-climate. Max Planck Institute for Meteorology, Hamburg, , Report No. 218, 1996