Regionally coupled ocean atmosphere modeling in Tropical Atlantic

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1. PROJECT OVERVIEW

This project is part of the integrated project "Decadal Prediction of African Rainfall and Atlantic Hurricane Activity" (DEPARTURE) which is part of the BMBF funded research programme "Medium term climate prediction" (MiKlip) and a contribution to Module C (Regionalisation). The aim of the integrated project is to assess decadal climate predictability in the West African monsoon region and the Atlantic region of tropical cyclogenesis.

The contribution of DEPARTURE REMO will be the coupling of the regional climate model REMO to an ocean model with high-resolution in the tropical Atlantic. The purpose of the coupling is to assess the importance of an interactive ocean for the skill of decadal predictions.

It has been shown that decadal predictions provide high SST-related decadal predictability with respect to sub-Saharan precipitation in West Africa (Paeth and Hense 2004). This predictability is likely to be associated with low-frequency variations of the AMO (Sutton and Hodson 2005). In addition there is a potential for predictive skill of hurricane activity. Therefore, the most important region for tropical cyclogenesis in the Atlantic will be included into the REMO domain.

2. MODEL

The REgional atmosphere MOdel **REMO** (25, 37, 50, 100 km resoluton) is coupled to the global ocean – sea ice model **MPIOM** with increased resolution in the Atlantic Ocean. The models are coupled via **OASIS** coupler.

Exchange between ocean and atmosphere was made with 3 hours coupled time step. Lateral atmospheric and upper oceanic boundary conditions outside the coupled domain were prescribed using ERA40 reanalysis data for the model spin-up and MPI-ESM data (MiKlip Baseline 1 simulations) for the study of the decadal predictability in the Tropical Atlantic.

A global Hydrological Discharge model (**HD**), which calculates river runoff (0.5º horizontal grid resolution), is coupled to both the atmosphere and ocean components.

3. TROPICAL CYCLONE ACTIVITY. NORTH ATLANTIC SETUP

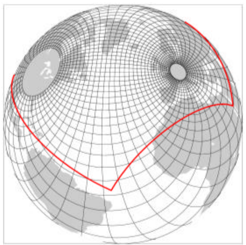


Fig.1 *Coupled REMO/MPI-OM configuration. Red rectangle indicates the domain of coupling. Only every tenth line of the ocean grid is shown*

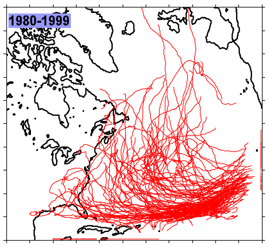


Fig.2 *Modeled TC tracks in the North Atlantic from 1980-1999, JASON.*

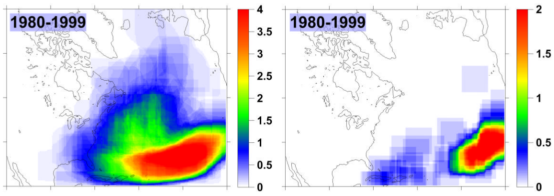


Fig.3*: Mean 1980-1999 JASON TC track densities (left) and genesis (right) (number per season per unit area equivalent to 5º spherical cap)*

To assess the ability of REMO/MPIOM in reproducing tropical cyclones (TC) we used an existing ocean model setup which was taken from the BMBF project NORDATLANTIK (Fig.1). In this setup, REMO resolution was 1/3˚ (37 km).

Preliminary results demonstrate that the coupled model is able to simulate the generation and propagation of TCs (Fig.2). Here, TCs are defined as the maximum 850hPa vorticity systems existing more than 2 days, having the warm core between 850hPa – 200 hPa, winds above 17 m/s and generated over the ocean only.

Both, the atmosphere and ocean model resolutions used in this setup are not high enough to obtain a proper simulation of tropical cyclone genesis and their further propagation (Fig.3). Although the resolution of the atmospheric model permits the generation of hurricanes, it takes into account only the strong preconditioning of their origin. Thereafter, the number of tropical cyclones generated in the hurricane season is underestimated in our simulations by about 35%, i.e. on average (1980-1999) we obtain 7 vs 10-11 from July – November (Manganello, et al.).

4. TROPICAL ATLANTIC MODEL SETUPS

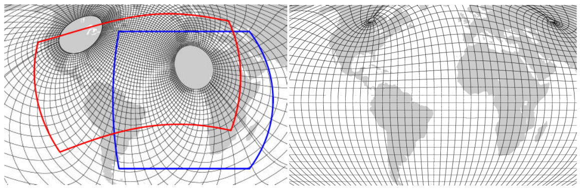


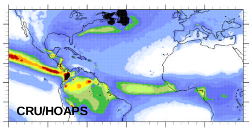
Fig.4*: Left: MPIOM TR04 setup (black lines), standard REMO-DEP setup (blue line) and REMO-ARR setup (red line). Right: MiKlip MPIOM MR (TP04) setup. In both the MPIOM setups every 12th grid line is shown.*

One MPIOM (MPIOM-TR04) and two REMO (REMO-DEP and REMO-ARR) setups were prepared (Fig.4, left) to focus the coupled simulations on the Tropical Atlantic. Despite the new MPIOM grid contains only 30% more nodes then TP04 it has at least four times higher resolution in the North Atlantic, particularly in the tropical cyclones generation region. (ca. 10-15 km). Considering the size of the REMO domain a resolution of 0.44˚ (~50 km) is envisaged for DEPARTURE. Additionally, coarser setups for model tuning and for sensitivity studies were prepared: 100 km resolution REMO and MPIOM-TR08 (2 times coarser then TR04). For further investigation of TC activity, additional experiments with higher REMO resolution (~25 km) are in progress.

Tab.1 *Coupled REMO/ MPIOM setups*

	REMO-DEP (km)		REMO-ARR (km)		
	100	50	100	50	25
MPIOM -TR08	X		X		
MPIOM-TR04		X		X	X

5. TROPICAL ATLANTIC MODEL VALIDATION. REMO



In Figure 5 we represent the precipitation simulated by the REMO-ARR/MPIOM-TR04 setup for different resolutions with the REMO standard parametrization (**first run**). The coupled model reproduces the main features of the Tropical Atlantic rainfall. However, the model precipitation is too strong over the ITCZ, eastern South America and the African rain belt

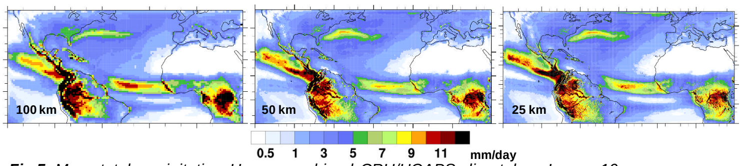


Fig.5 *Mean total precipitation. Upper: combined CRU/HOAPS climatology. Lower: 10 years mean obtained from different model resolution, first run.*

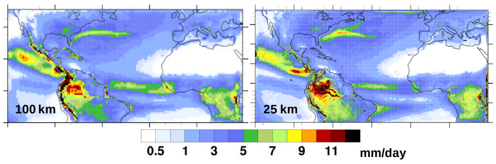


Fig.6 *Total precipitation. 10 years mean obtained from different model resolution, second run.*

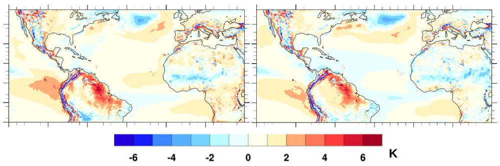


Fig.7 *10 years mean 2m temperature difference: Model (REMO-ARR 25 km) – ERA40. Left: first run, Right: second run*

To reduce the modelled precipitation over ITCZ some parameters in the subgrid scale cloud formation were changed and a second simulation was carried out (**second run**).

Figure 6 shows the total precipitation in two runs with the changed cloud parametrization. We can see an overall decrease of precipitation, with its significant improvement over the eastern South America and the African rain belt.

On Figure 7 we can see the impact of cloud parametrization changes on the 2m temperature. The temperature in the northern tropical Atlantic becomes cooler and the warm bias over Guinea Coast and Central Africa is reduced.

6. TROPICAL ATLANTIC MODEL VALIDATION. MPIOM

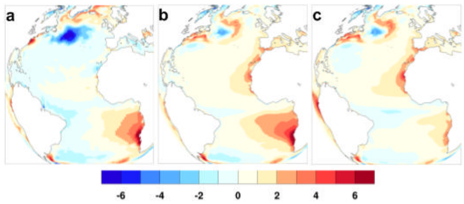


Fig.8 *Mean (1980-1999) SST difference (Model – PHC). ECHAM6/MPIOM CMIP5 (a), REMO-DEP/MPIOM-TR08 (b), REMO-ARR/MPIOM-TR08 (c).*

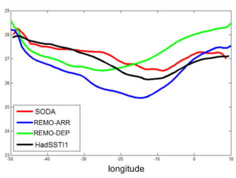


Fig.9 *Mean (1980-1999) equatorial SST*

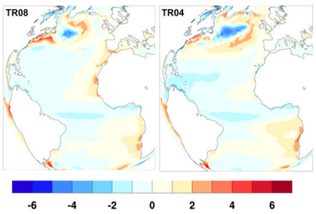


Fig.10 *Mean SST difference (Model – PHC). Second run.*

The mean SST bias is less than 1K in most of the domain in the three configurations (Fig.8). The differences seen in the northern North Atlantic reflect the southward shift of the North Atlantic current in MPIOM. The influence of the location of coupled area on the simulated SST at the southeastern tropical is illustrated on Figure 8 b, c.

As shown in Figure 9, the model simulates the sign and magnitude of the SST gradient (42.5W - 7.5W) well, even if the mean SST is lower than the observed.

Fig.10 shows a significant reduction of the bias in the southeastern tropical Atlantic region due to the changes in the cloud parametrization

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Aknowlegments

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