SPECIAL PROJECT INTERIM REPORT

Interim Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year 2008/2009

Project Title: Regional downscaling of ERA40 and validation of the hydrological cycle…

…………………………………………………………………………

Computer Project Account: SP DESVHC…..……

Principal Investigator(s): Stefan Hagemann
…………………………………………………………………………

Affiliation: Max Planck Institute for Meteorology…

Name of ECMWF scientist(s) collaborating to the project (if applicable) ERA40 team.……

…………………………………………………………………………

Start date of the project: ……2009…(current phase of special project) …

Expected end date: ……2011……………………………………..……

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	157000	111506		
Data storage capacity	(Gbytes)	3200	3589		

Summary of project objectives

(10 lines max)

The main objective of the regional down-scaling is to analyze to what extent problems in ERA40 are transported into the regional domain, and to what extent the regional model may yield an improved simulation of the regional climate due to the higher resolution and its own model parameterizations. This analysis will mainly focus on the hydrological cycle.

Summary of problems encountered (if any)

(20 lines max)

Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

……see attached document………………………………………………………………

List of publications/reports from the project with complete references

Summary of plans for the continuation of the project

(10 lines max)

……see attached document……………………

Principal Investigator(s):

Stefan Hagemann

Project Title: Regional Downscaling of ERA40 data and validation of the hydrological cycle

ECMWF special project interim report

Stefan Hagemann, Lennart Bengtsson and Daniela Jacob

The main objective of the regional down-scaling is to analyze to what extent problems in ERA40 are transported into the regional domain, and to what extent the regional model may yield an improved simulation of the regional climate due to the higher resolution and its own model parameterizations. This analysis will mainly focus on the hydrological cycle.

Regional downscaling of the ERA40 data has been conducted with the regional climate model REMO (Jacob 2001) over several regions to study the climate of the last 40 years. The regions comprise South Africa, the Indian monsoon region, Canada and the Nile catchment.

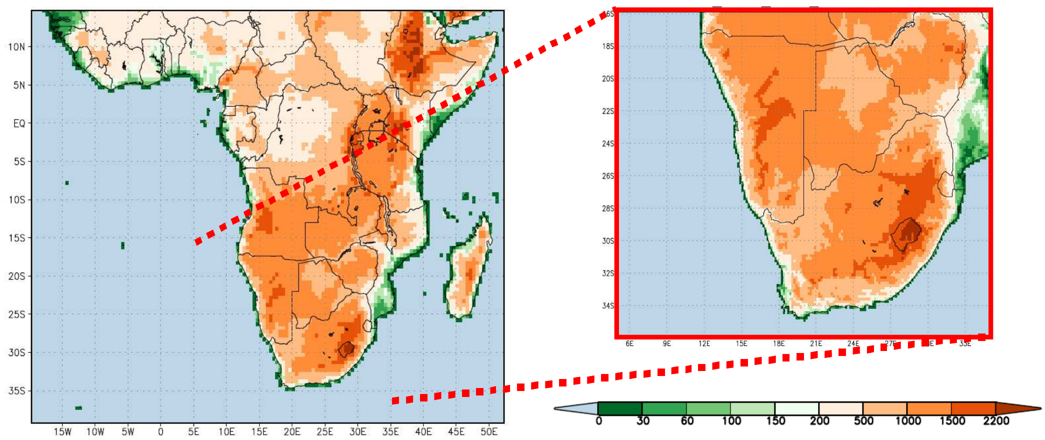

Figure 1 REMO model domain for the southern Africa 1/2º domain and the nested 1/6º domain

The regional domain for the 0.5° (about 50 km) resolution simulation over South Africa covers the area between 15°N and 39° S and 20°W to 52°O (Figure 1 – left panel). In this 0.5° domain, a smaller 1/6° (about 18 km) domain (Figure 1 – right panel) was nested and a REMO simulation has been conducted for 1958-2007 (ERA40 + ECMWF operational analyses) forced by the model output from the 0.5° simulation. We investigated the capability of REMO to adequately simulate the local and regional climate patterns of southern Africa, with a focus on South-West Africa. The present study is the first long-term dynamical downscaling study for southern Africa on a very high horizontal resolution. To evaluate the model results we use a set of different observations to compare with model output data. This analysis indicates that the model results agree rather well with observations for both spatial as well as temporal patterns. Especially along the focus region in South-West Africa, REMO results are very close to observations. In this region it clearly can be shown, that the dynamical downscaling of the ERA40 reanalysis data with the REMO model leads to an improved description of the seasonal precipitation characteristics in the data. Remaining deficits which mainly occur in the simulation of the 2m air temperature can be explained with the setup of the models soil routine and will be investigated further. Based on the findings of this study we conclude that the model is well suited for the simulation of the regional climate over the southern African region. High resolution model output implies more detailed climate information and can lead to a significant improvement in the representation of spatial patterns. It is therefore beneficial to use regional climate model data when assessing climate change induced impacts on a regional scale.

Results from this study will soon be submitted to Int. J. Climatology (A. Hänsler, S. Hagemann and D. Jacob: Dynamical downscaling of ERA40 reanalysis data over southern Africa: added value in the representation of the seasonal rainfall characteristics).

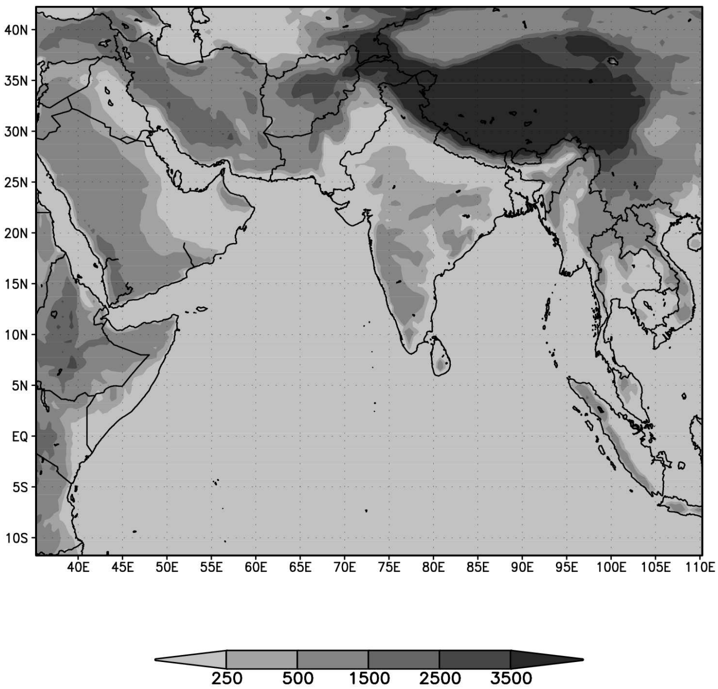

Figure 2 Model topography (m) for the Indian monsoon region at ½ degree resolution

REMO has been used to downscale ERA40 at a resolution of ½ degree (~ 55 km) over the Indian monsoon region. The domain is shown in Figure 2. It approximately encompasses 12° S to 42°N and 35°E to 110°E with 109 grid points along the latitude and 151 grid points along the longitudinal direction. The validation of the downscaled simulation showed that important sea level pressure features were captured such as the principal heat low over Pakistan and the trough off the southwestern coast of India, with a slightly underestimated sea level pressure over the Indian plains in comparison to ERA40. Simulated temperatures show a warm bias over Indian plains in comparison with CRU data, however temperatures over the Tibetan Plateau and along the coast are ably simulated. The model captures the pattern of precipitation over Western Ghats and over the plains but overestimates the precipitation in Northern India and Bangladesh.

Results from the validation motivated a sensitivity study that takes into account effects of irrigation. The Indian subcontinent is one of the most intensely irrigated regions of the world and its climate is highly influenced by the south Asian summer monsoon and associated rainfall patterns. State of the art climate models do not account for the representation of irrigation. A sensitivity study with the regional climate model REMO shows distinct feedbacks between the simulation of the monsoon circulation with and without irrigation processes. We find that the temperature and sea level pressure, where the standard REMO version without irrigation shows a significant bias over the areas of Indus basin, is highly sensitive to the water used for irrigation. In our sensitivity test we find that removal of this bias has caused less differential heating between land and sea masses. This in turns reduces the westerlies entering into land from Arabian Sea, hence creating conditions favorable for currents from Bay of Bengal to intrude deep into western India and Pakistan that have been unrealistically suppressed before. We conclude that the representation of irrigated water is unavoidable for realistic simulation of south Asian summer monsoon and its response under global warming. This study has been submitted to Geophys. Res. Letters (F. Saeed, S. Hagemann and D. Jacob): Impact of irrigation on the South Asian Summer Monsoon).

A downscaling simulation over the Nile catchment was conducted at 0.5° resolution. The domain is shown in Fig. 3 and covers the region between 0°E to 64.5°E and 11.5°S to 39°N with 129x101 gridboxes. The validation of this simulation partially focused on the overlap region of this simulation (NR) and the Southern African 0.5° simulation (SAR). More details on other parts of the domain are summarized in a Diploma thesis by Katharina Klehmet.

For the 2m - temperature, precipitation, bucket-soil moisture & evaporation, the two REMO simulations have been compared. For the 2m-temperature and precipitation, also the difference to CRU is discussed. Boundary effects have been neglected in this summary. Note that two different versions of REMO were used in these simulations. The largest difference is that for the NR simulation an initial version of a five layer scheme for soil moisture was used instead of the bucket scheme of the SAR simulation.

- *2m Temperature*
  - REMO Runs: Mostly minor differences between the two simulations. NR rather colder, by about 1-2K. Two features very dominant: First, checkerboard pattern over the Ethiopian Highlands. Second, rather strong warming signal (up to 5 K) introduced by the 5 soil layers over the Chad/northern Congo region. In these areas, the soil is very shallow.
  - REMO vs. CRU: Patchy structure, but mostly below +-1K. Also significant warm bias over the shallow soil zones.
- *Precipitation*
  - REMO Runs: Wet bias in NR, especially over the Congo basin (~ 40 %). Checkerboard pattern over Ethiopian Highlands.
  - REMO vs. CRU: Also wet bias of NR over the Congo basin. Dry bias over Ghana (~ 40%)
- *Evaporation*
  - REMO Runs: NR shows more evaporation over the tropical Atlantic, which may be related to boundary effects, and towards the Kenyan lowlands. Over the shallow soil areas, a strong decrease of evaporation compared to SAR is visible.

- *Soil Moisture*
  - REMO Runs: Rather more soil moisture in NR than in SAR, but a very strong reduction of soil moisture over the shallow soil areas.

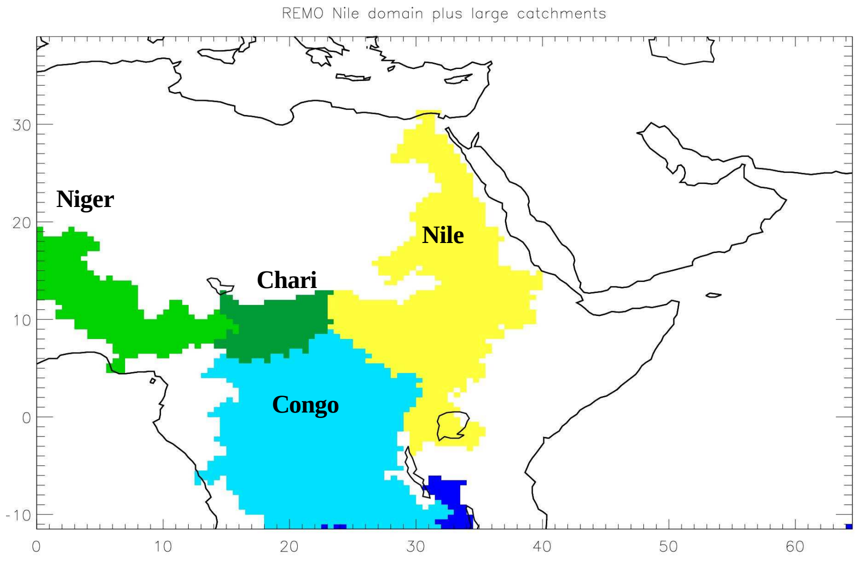

Figure 3 Large catchments in the REMO 0.5° Nile domain.

Further downscaling simulations will be performed and analysed over West Africa, Siberia and a further downscaling to 0.2° will be performed over India. For all regions, validation studies will be conducted and comparisons to ERA40 data will be added.

Moreover it is planned to validate the simulated hydrological cycle of the ECMWF Interim Re-analysis that will cover the period 1989-today. It is known that ERA40 has problems with the hydrological cycle in the tropics, which are expected to influence the regional results via the lateral boundary conditions. As we expect this to be less of a problem in the Interim Re-analysis, it is planned to perform a regional down-scaling for potentially affected regions of both ERA40 and the Interim Re-analysis in the ERA40 satellite period (1989-2001). A detailed comparison between the Interim Re-analysis and the results from the down-scaling will be conducted.

Acknowledgements

We thank Andreas Hänsler (South Africa, Nile) and Fahad Saeed (Indian Monsoon region) from the Max Planck Institute for Meteorology for their contributions to this report.

References

Jacob, D., 2001: A note to the simulation of the annual and inter-annual variability of the water budget over the Baltic Sea drainage basin. Met. & Atm. Phys., 77, 61-73.