# ASSESSMENT OF NEW LARGE-SCALE CLOUD COVER AND RAINFALL PARAMETERIZATIONS FOR REGIONAL CLIMATE MODELING OVER THE UPPER BLUE NILE BASIN

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# Introduction

In this study we investigate the performance of new parameterizations of large-scale cloud and rainfall for use with climate models. Here, we apply these new parameterizations within MIT Regional Climate Model (MRCM), a modified version of Regional Climate Model, version 3 (RegCM3) including the land surface scheme Integrated Biosphere Simulator (IBIS) and recently developed parameterizations for the convective cloud cover and convective rainfall. The performance of the new parameterizations with MRCM is evaluated using 21-years regional climate model simulations over the Upper Blue Nile basin. The new parameterizations improve the simulations of the cloud cover and downward shortwave and net radiation at the surface.

# Model Description

The MIT Regional Climate Model (MRCM) is a modified version of the Regional Climate Model, version 3 (Regcm3) (Pal et al., 2007). It is coupled to a new land surface scheme Integrated Biosphere Simulator (IBIS) by Winter et al., (2009) and includes recently developed parameterizations for the convective cloud and rainfall (Gianotti, and Eltahir, 2014a, 2014b). It is a three-dimensional, hydrostatic, compressible, primitive equation, sigma-coordinate regional climate model. Regcm3 maintains much of the dynamical core of the fifth-generation Pennsylvania State University– NCAR Mesoscale Model (MM5) and employs NCAR's Community Climate Model version 3 (CCM3) atmospheric radiative transfer scheme. Planetary boundary layer dynamics follow the formulation of Holtslag et al. (1993). Ocean surface fluxes are handled by Zeng's bulk aerodynamic ocean flux parameterization scheme (Zeng et al. 1998), where sea surface temperatures are prescribed. The Subgrid Explicit Moisture Scheme (SUBEX) is used to handle large-scale, resolvable, non-convective clouds and precipitation (Pal et al. 2000).

# Data Used

The following datasets are used to provide boundary and initial conditions for MRCM and for verification of the simulations results.

i. Lateral boundary conditions (i.e. Wind speed, relative humidity and air temperature at different pressure levels) from European Center for Medium-Range Weather Forecasts (ECMWF) Reanalysis (ERA-Interim).

ii. Sea surface temperatures (SSTs) are prescribed using the National Ocean and Atmospheric Administration (NOAA) optimally interpolated SST (OISST) dataset (Reynolds et al. 2002).

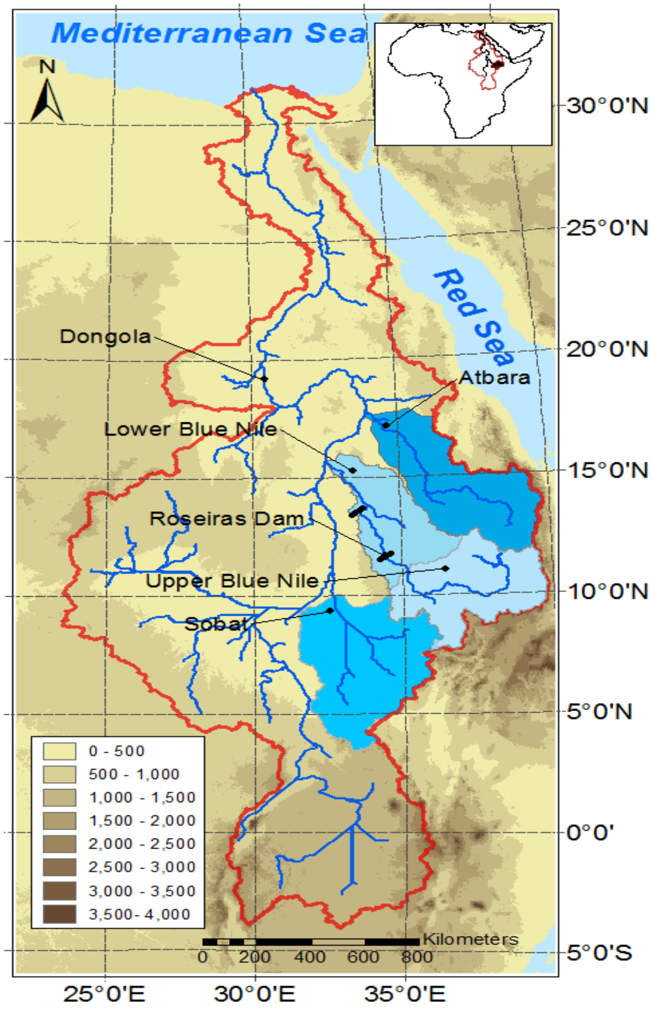
iii. Vegetation biomes are based on the potential global vegetation dataset (Ramankutty, 1999), which are used with the monthly mean and minimum climatology of temperature (New et al. 1999, Bartlein 2000) to populate each grid cell with the suitable plant functional types.

iii. Soil properties, such albedo and porosity were determined based on the relative proportions of clay, silt and sand in each grid based on the Global Soil Dataset (Global Soil Data Task 2000).

iv. The topographic information are obtained from the U.S. Geological Survey's global elevation dataset (GTOP30) (U.S. Geological Survey 1996).

v. Surface Radiation Budget (SRB) dataset release 3.0, obtained from NASA Langley Atmospheric Sciences Data Center.

# Study Area




Topographic map of the Nile basin showing the Blue Nile, Sobat and Atbara rivers.

# Model Modifications

The new parametrizations of large scale cloud and rainfall follow the work of Gianotti (2014a and 2014b) in the formulation of the convective cloud and rainfall using the cloud liquid water (CLW) simulated by the convection model. Here, we use instead the large scale value of the CLW simulated by the large scale model and incorporate it in the following parameterizations of large scale cloud and rainfall as follows:

$$FC = \frac{CLW}{CLW_{clim}}$$

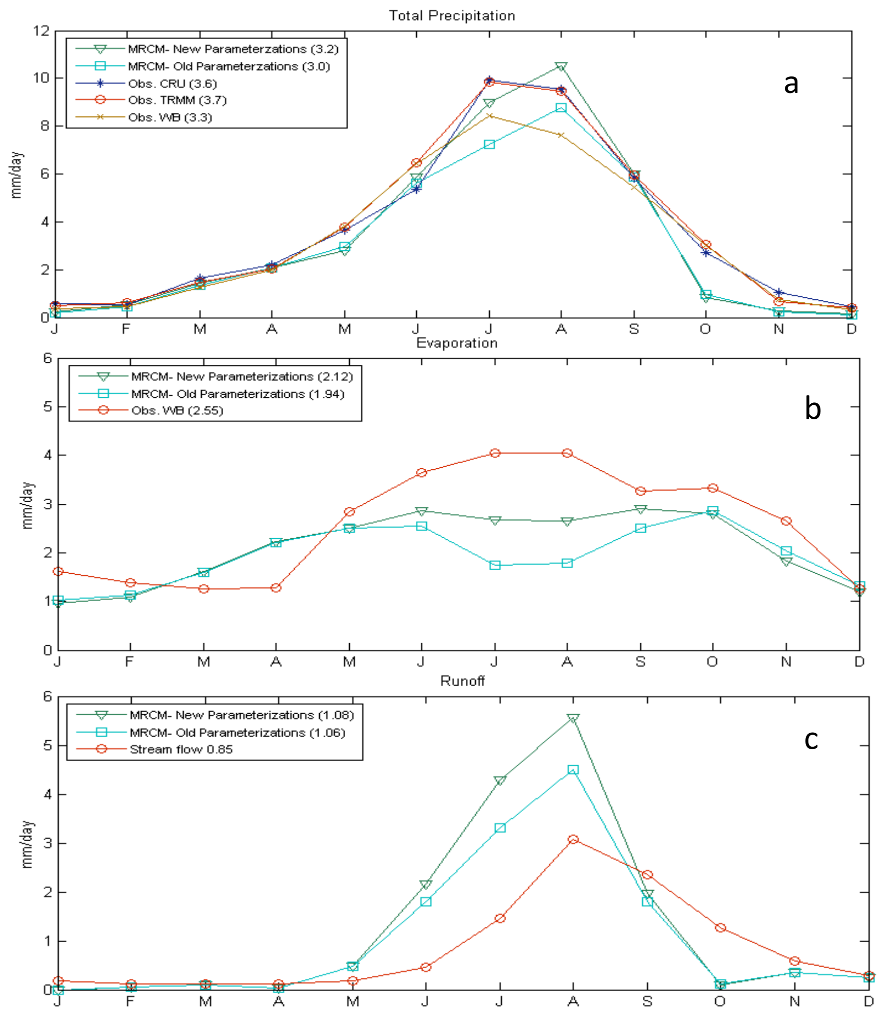
$$R(Land) = CLW^{0.9} 0.96 \, exp\left(-\frac{CLW_{clim}}{CLW}\right)$$

$$R(Ocean) = CLW^{0.94} 0.97 \, exp\left(-\frac{CLW_{clim}}{CLW}\right)$$

Where FC is the fraction of cloud cover, R is the large scale precipitation, CLW is the average CLW simulated of the grid cell, $CLW_{clim}$ is the climatological mean of CLW and may be specified according to the typical values CLW over land or ocean. These values for $CLW_{clim}$ fall within (0.1-3) $gm^3$ and (0.25-1.3) $gm^3$ over land and ocean respectively (Gianotti 2014a and 2014b) .

# Simulations Results

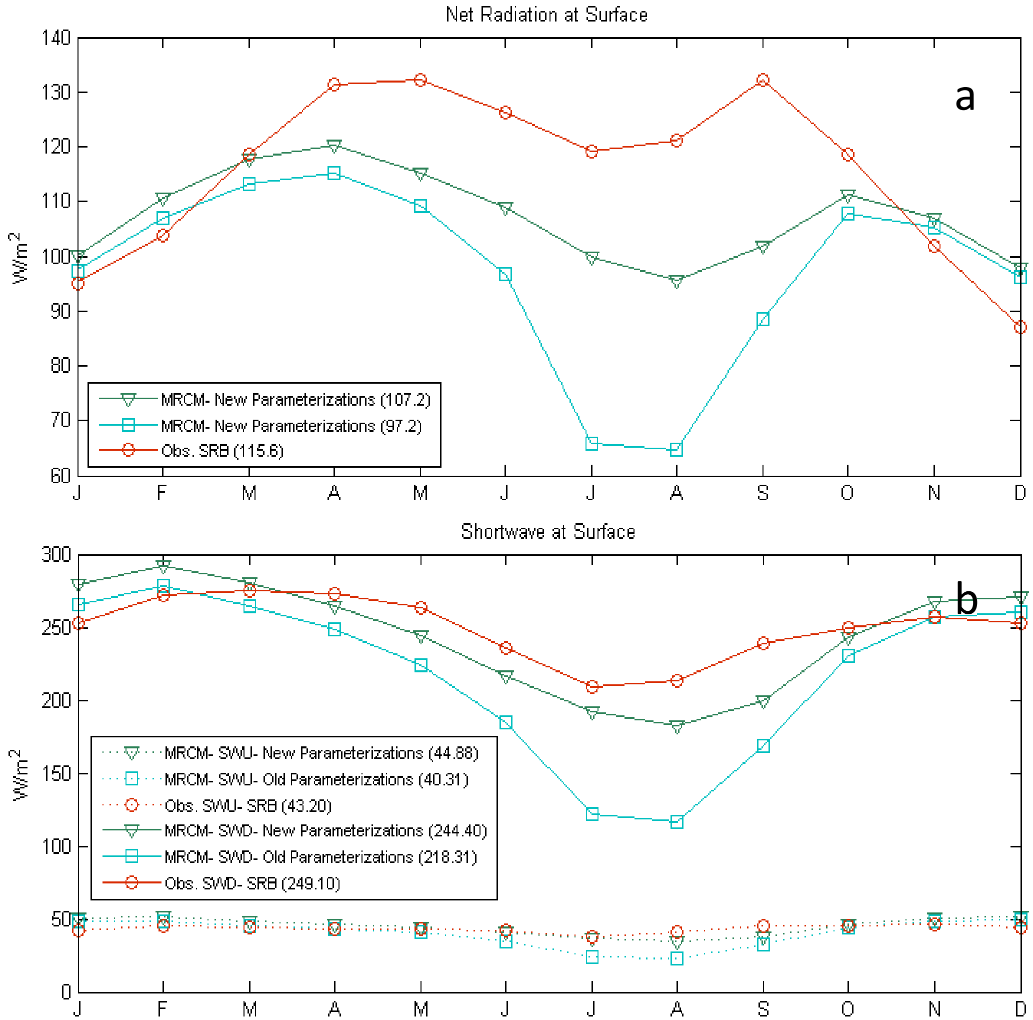
The new parameterizations of the large scale cloud and rainfall resulted in better simulation of the hydrological cycle over the Upper Blue Nile basin. The shape of the seasonal cycle and long term averages of the rainfall and evaporation over the basin are closer to observations (Figure a, b).




Monthly 21-years (1990-2010) averages values for: (a) rainfall, (b) evaporation and, (c) runoff simulated by the old and new parameterizations of large scale cloud and rainfall over the Upper Blue Nile basin.

# Simulations Results

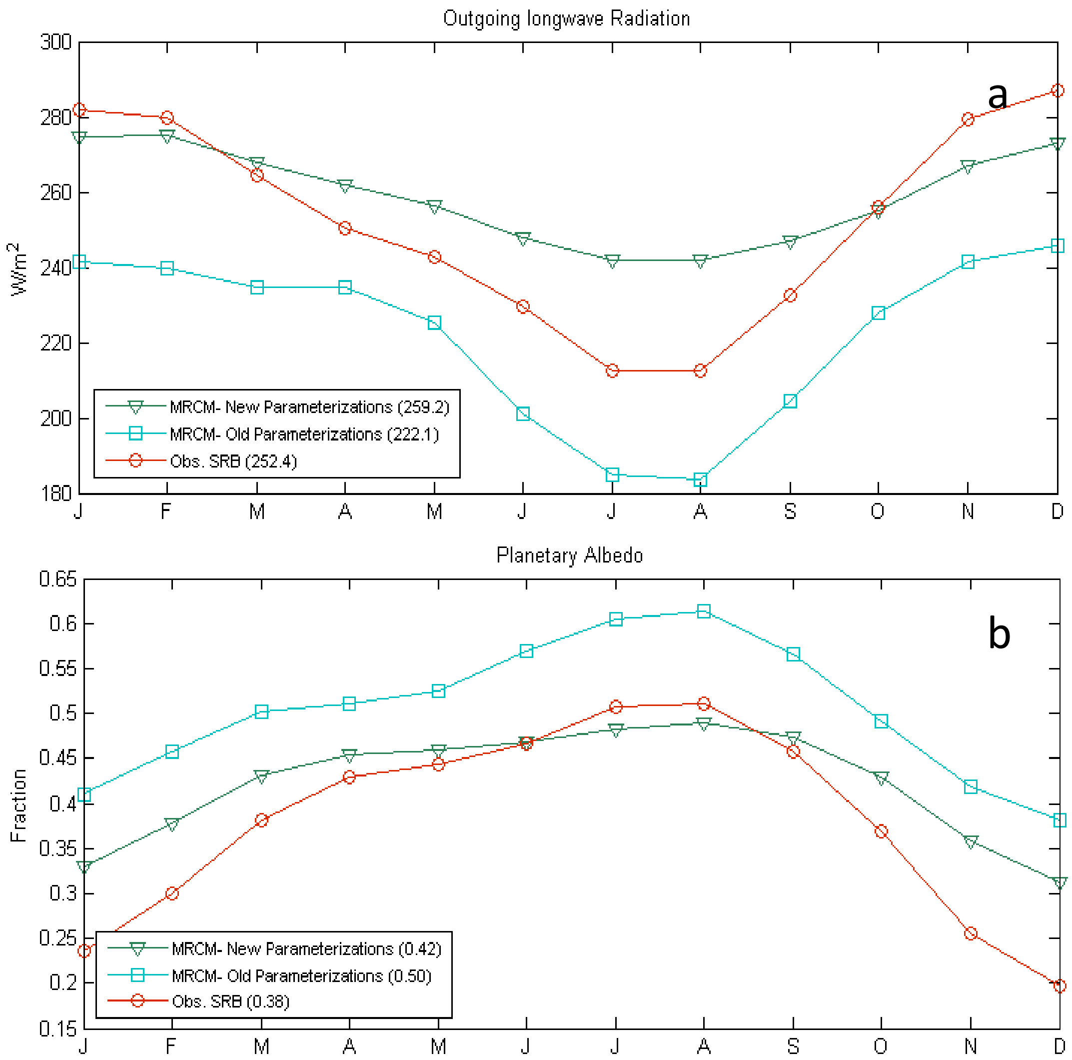
The increase in the evaporation, particularly during July and August, as shown in previous slide is due to the increase of the net surface radiation because of the increased downward shortwave reaching the surface (Figure a, b).




Monthly 21-years (1990-2010) averages values for: (a) net radiation, and (b) shortwave at the surface simulated by the old and new parameterizations of large scale cloud and rainfall over the Upper Blue Nile basin.

# Simulations Results

The increase of the downward shortwave at the surface is due to the reduction of clouds as reflected by the increase of outgoing longwave radiation and decrease of planetary albedo (Figure a, b).




Monthly 21-years (1990-2010) averages values for: (a) outgoing longwave radiation, and (b) planetary albedo simulated by the old and new parameterizations of large scale cloud and rainfall over the Upper Blue Nile basin.

# Summary

The performance of the new parameterizations with MRCM is evaluated using 21-years regional climate model simulations over the Upper Blue Nile basin. The new parameterizations resulted in consistent and significant improvements of the simulated cloud cover and radiation over the basin. The decrease of the cloud cover, as reflected in the increase of outgoing longwave radiation and decrease of the planetary albedo, resulted in increase of the downward shortwave and net radiation at the surface.

# References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