Simulation of Crop Yield in the Amhara Region Using a Large Area Crop Model as Driven by Outputs from RegCM-4

Jemal Seid, G.Mengistu Tsidu
(jemsmom.phys@yahoo.com, gizaw_mengistu@gmx.net)
Dept. of Physics, Addis Ababa University
Addis Ababa, Ethiopia

Objectives

The general objective of this study is to asses the capability of RegCM-4 output together with a large area crop model to simulate wheat yield.

The specific objectives of the study are:

- Evaluate the RegCM4 performance in representing the climatology, seasonal variability of precipitation to use for crop model
- Asses the ability of RegCM-4 simulation to capture summer season rainfall over Ethiopia and,
- Use RCM output to drive crop model and asses the accuracy of simulated yield prediction for the projection work 2013-2050.

Data and Methodology

The General Large Area Model (GLAM) for Annual Crop(Charllinor,2004; Li,2008) and 2010 version of ICTP's Regional Climate Model(RegCM−4) are used in this thesis.

- The daily GPCP rainfall and Observed yield datasets are used for validation.
- GPCP rainfall data sets are provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd.
- Daily gridded Tmin, Tmax, rainfall and radiation data sets are taken from the simulated RegCM-4 output using the following configuration.
  - $60km$ horizontal resolution, 18 vertical σ-levels and model top at $50hpa$.
  - The domain covers 96 grid points in the y-direction and 224 grid points in the x-direction.
  - SST is derived from the OI-Weakly.
  - Surface parameters (topography, land use, vegetation, soil type etc) are determined from a 10-min archive.
  - Meteorological ICBC's are taken from ERA-Interim data.
- Soil hydrological properties were drived from FAO/UNESCO (1974) soil map of the world and datas are averaged to our model grid
- Yearly zonal-level wheat yeild for the summer season for the period 1995-2008 have been compiled by CSA, Addis Ababa, Ethiopia.

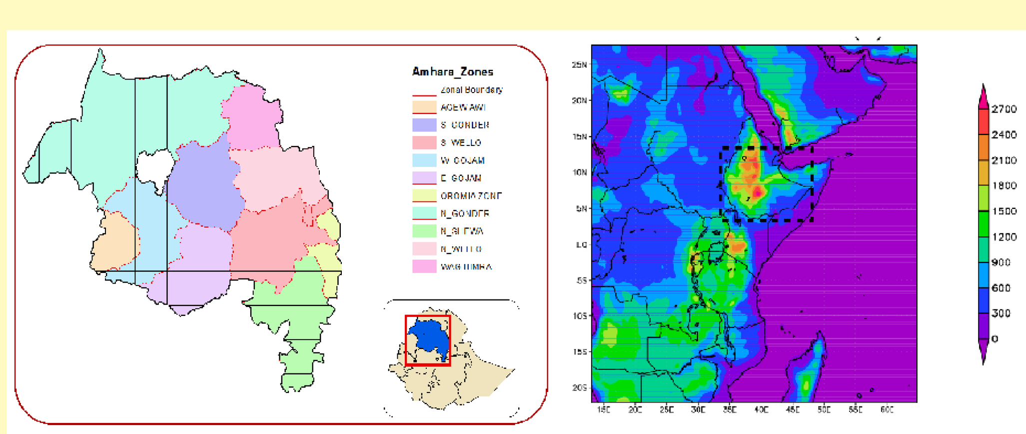
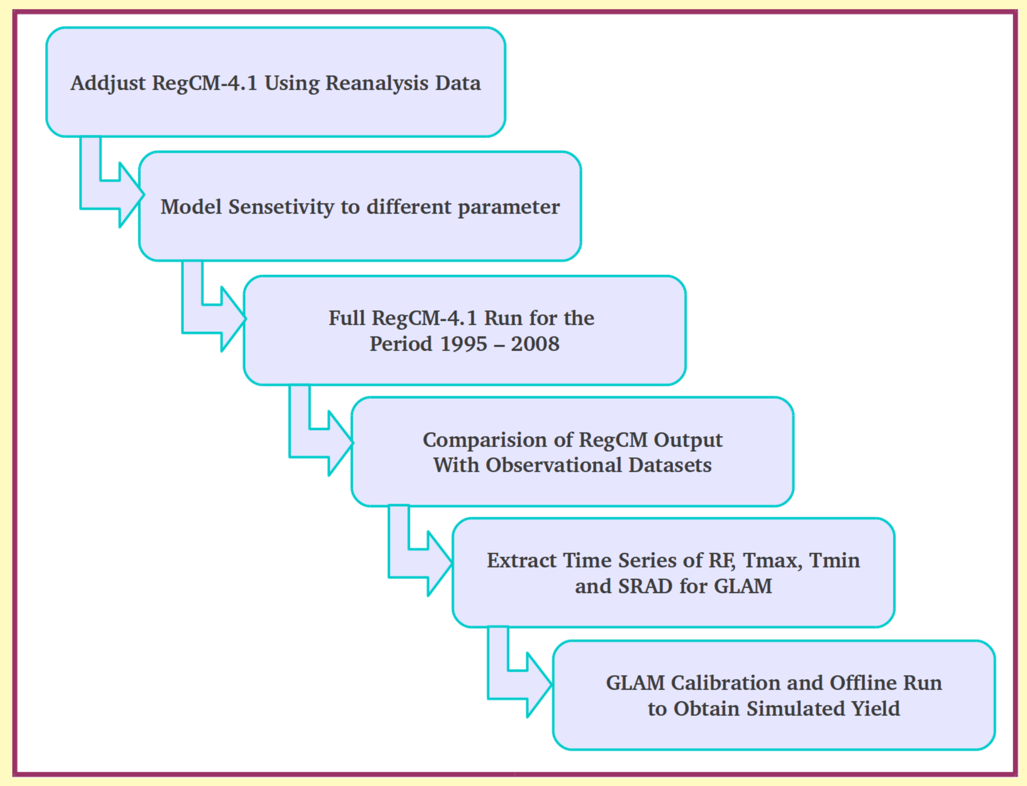


Fig 1: Geographical features Amhara Regional states and locations of GLAM gridcell inside Amhara region, and also in the right side the RegCM-4 domian to simulated climate variablity.

- The performance of GLAM and RegCM-4 models are evaluated quantitatively by analyzing
  (a) Correlation coefficient
  (b) Bias
  (c) RMSE

Modeling Approach



RegCM-4 Results

Mean Rainfall climatology over Ethiopia

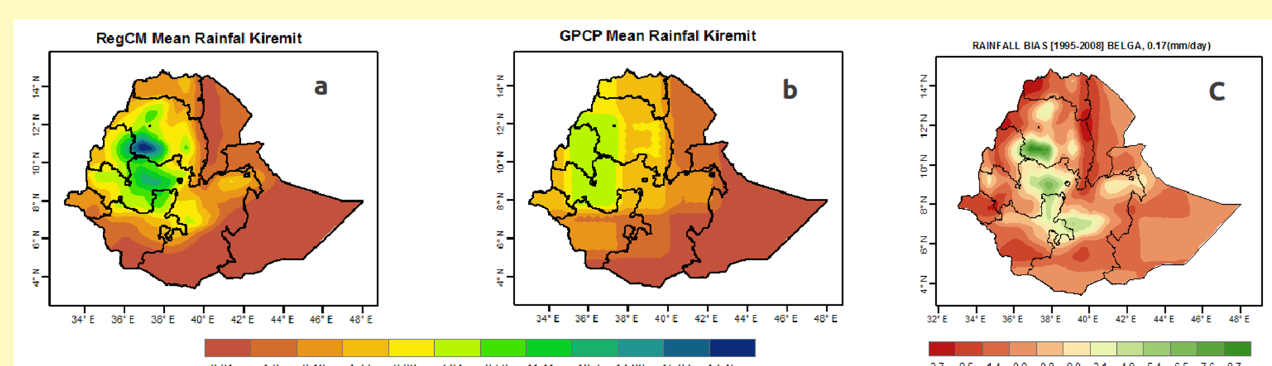


Fig 2: Comparison of spatial distribution rainfall for Summer season during the period 1995-2008 (mm/day) (a) model simulated rainfall (b) GPCP rainfall (c) Differences between model and GPCP rainfall.

Summer Seasonal Seasonal Cycle

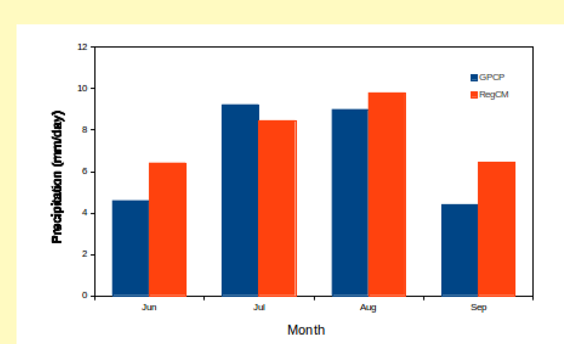


Fig 3: Comparison of Seasonal Cycle rainfall for Summer season during the period 1995-2008 (mm/day)

Summer (JJAS) Rainfall Variability

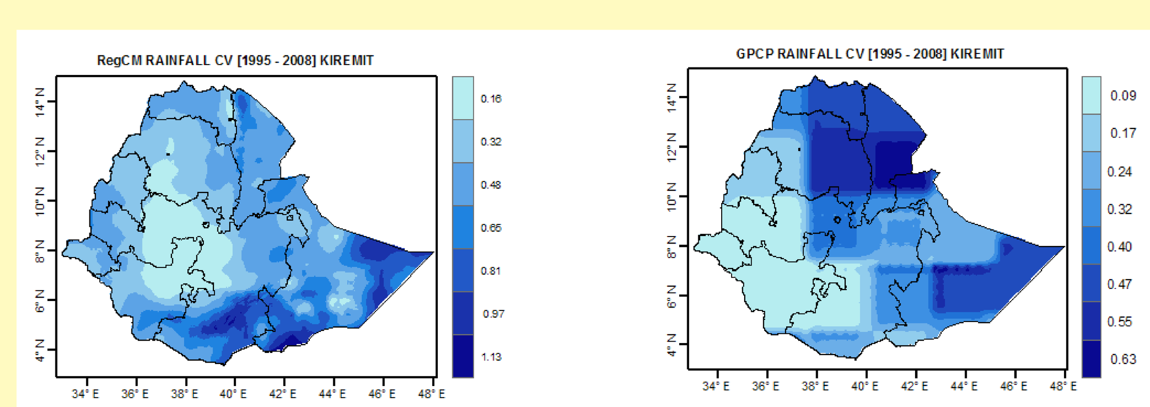


Fig: 4 Comparison of modeled Coefficient of variation of rainfall (%) with the observed data in Ethiopia during the period 1995 - 2008.

Mean and STDV difference of rainfall over Amhara Region

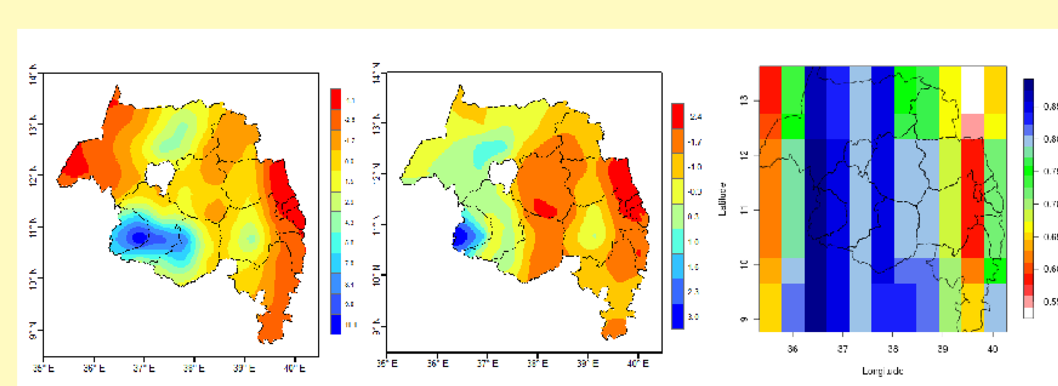


Fig 5: The difference between RegCM-4 and GPCP data in (a) mean and (b) Standared devation of JJAS rainfall(mm/day) (c) Spatial Correlation between the two datasets.

GLAM Crop Model Evaluation

Assessment of GLAM internal consistency

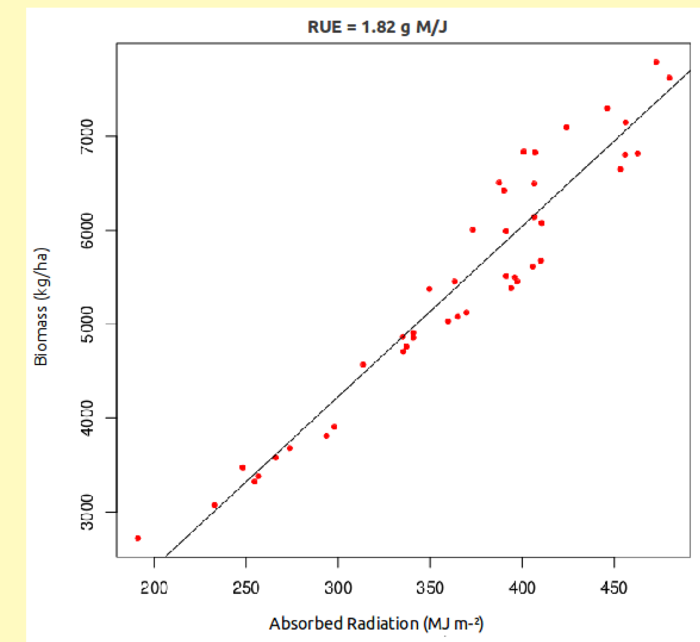


Fig 6: End-of-season above-ground biomass vs. cumulative absorbed radiation for Amhara region grid cells.

Model skill at 0.5^o Spatial Scale

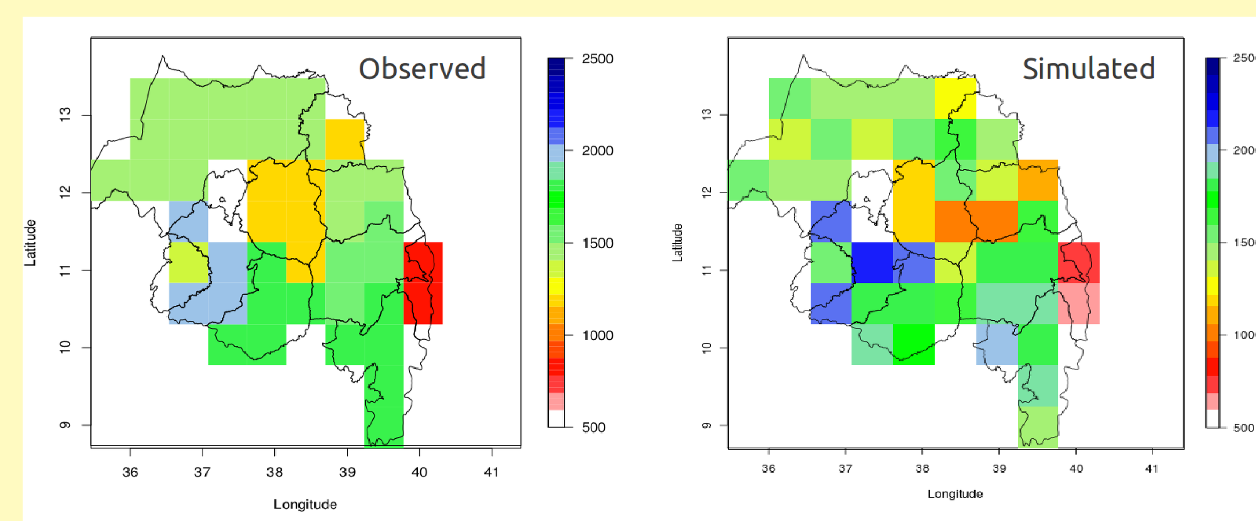


Fig 7: Comparison simulated and observed wheat yield (kgha^{-1}) at 0.5^o scale from 1995-2008 in Amhara region

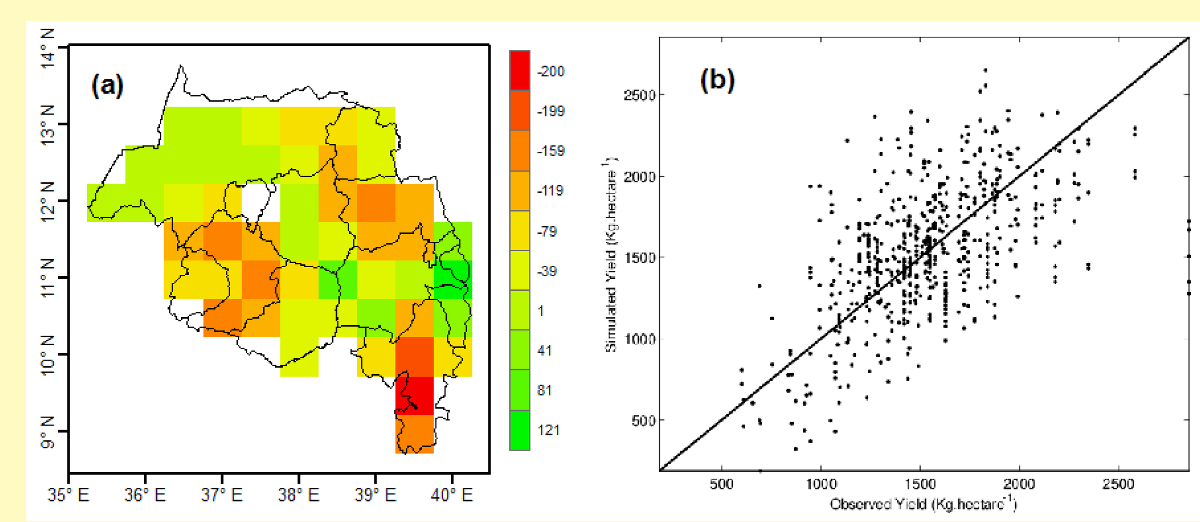


Fig 8: (a) Difference between simulated and observed wheat yield (kgha^{-1}) (b) Comparison of simulated and observed mean wheat yields (r=0.76, p $\leq$ 0.001) at 0.5^o scale from 1995 to 2008 over the Amhara region (kgha^{-1})

Conclusions

- RegCM-4 has the ability to downscale and simulate rainfall distribution and it's interanual varaiblity ove Ethiopia.
- Downscaled climate data can be use to explore sources of uncertainty in yield simulation.
- The internal cosistancy checks that are used to ensure the performance of the crop model proves that GLAM performs magnificently.
- Correlations between simulated yields and wheather agreas with the obsereved.
- Evaluation of 14-yrs simulated yield revealed that GLAM-Wheat model combined with RegCM-4 wheather data has simulated over study area with high correlation. This support the hypothesis that GLAM-Wheat can reasonably simulated the variablity of wheat yield over Amhara region.