Uncertainty analyses of Evapotranspiration using Global Climate Models

Seungwoo Chang*, Wendy Graham*,, Syewoon Hwang****

* Dept. of Agricultural and Biological Engineering, University of Florida, ** University of Florida Water Institute

01 Abstract

Understanding climate change and its potential impacts on regional hydrology and water demand is important to reduce risks and increase resilience in water supply. This research will quantify and evaluate the uncertainties of evapotranspiration using CMIP5 and will develop a framework to estimate uncertainties associated with global climate change projections and future water demand projections for the Tampa Bay Region of West Central Florida.

02 Introduction

- Climate change will result in significant impact on hydrologic processes.
- The 2007 Fourth Assessment Report of Intergovernmental Panel on Climate Change (IPCC4) projected that climate change will significantly affect precipitation, temperature and evapotranspiration in the future.
- In order to predict future water supply and demands, assessment of future evapotranspiration is needed.
- Analysis of relative uncertainties of evapotranspiration and GCMs is necessary to understand for future water management challenges.
- The Coupled Model Intercomparison Project Phase 5 (CMIP5) is a new set of coordinated climate model experiments which build on previous CMIP3 projections (Taylor et al., 2012; Knutti and Sedláček, 2012), however there are only a few impact studies to date that have evaluated and analyzed CMIP5.

Objective

To develop a framework to use CMIP5 climate change projections to analyze the relative uncertainties of evapotranspiration estimates due to different GCMs and ET estimation methods and to to predict future hydrological change.

03 Methods

- Data: CMIP5 retrospective climate model predictions (1950-2005) and future climate projections for 12 different GCMs and 4 future scenarios (RCP 2.6, 4.5, 6.0, 8.5, 2006-2100).
- Reference ET estimation methods: Penman-Monteith, Hargreaves, Irmak-Rn, Irmak-Rs, Blaney-Criddle and Hamon methods.
- Compare retrospective ET predictions to reanalysis ET estimates (R2 reanalysis) and evaluate the relative uncertainty of GCMs and ET calculation methods.
- Use monthly CMIP5 data for 4 RCP scenarios to evaluate ET at the GCM grid scale for the future period (2006-2100) under the 4 RCP scenarios.

04 Preliminary Results

1) Uncertainties between different GCMs and potential ET methods.

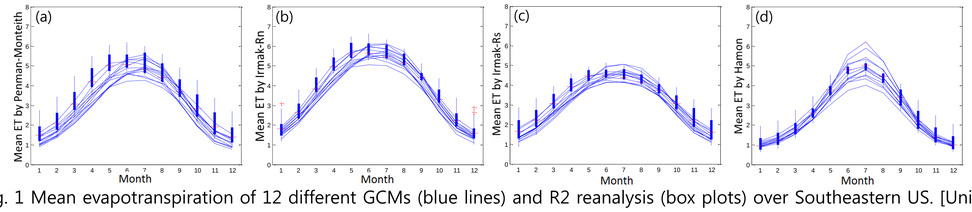

Fig. 1 Mean evapotranspiration of 12 different GCMs (blue lines) and R2 reanalysis (box plots) over Southeastern US. [Unit: mm]

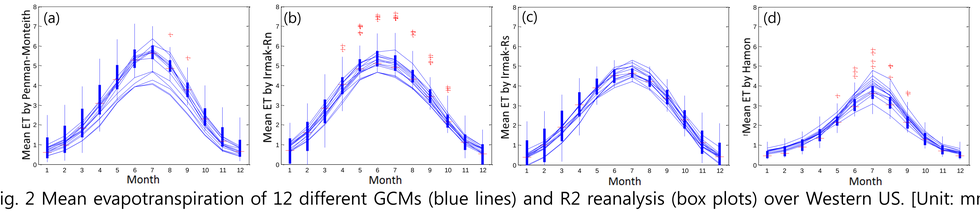

Fig. 2 Mean evapotranspiration of 12 different GCMs (blue lines) and R2 reanalysis (box plots) over Western US. [Unit: mm]

2) Relative change in mean evapotranspiration for different scenarios for bcc_csm1 model

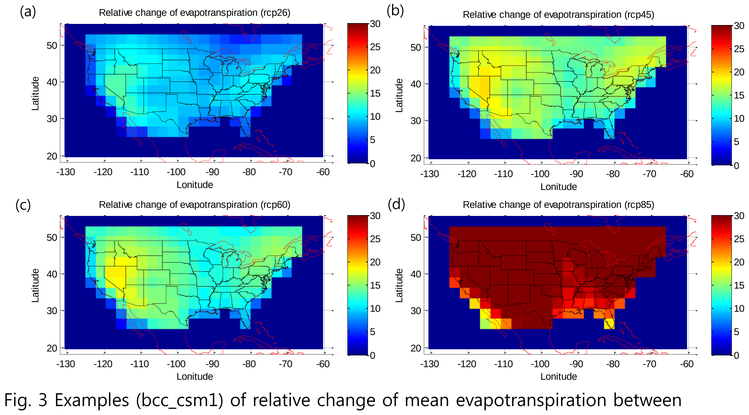

Fig. 3 Examples (bcc_csm1) of relative change of mean evapotranspiration between retrospective period (1950-2005) and future scenarios (2006-2100) by Penman-Monteith equation [Unit: % of change].

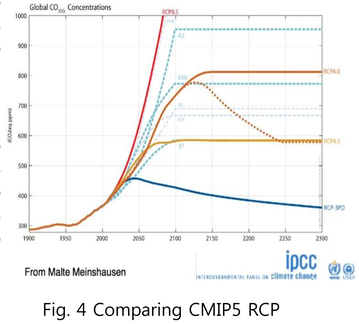

Fig. 4 Comparing CMIP5 RCP scenarios and CMIP3 scenarios (Meinshausen, 2011)

05 Discussion

- Uncertainties between different GCMs and different ET estimation methods are significant for predicting reference ET (Fig. 1 and Fig. 2).
- The changes between projected ET (future) and predicted ET (Retrospective) show that future ET changes are affected by CO_2 emission scenarios (RCP scenarios) (Fig. 3).
- Also, the relative changes of ET projections depend on choosing GCMs. These effects are significant to project future climate variables.
- Different with RCP scenarios (Fig. 4), differences between RCP 4.5 and RCP 6.0 in changes of mean ET are not significant in some models.

06 Future Work

- Quantify the relative uncertainties of evapotranspiration for different GCMs and different ET estimation methods.
- Develop statistically-downscaled future temperature, rainfall and ET projections for Tampa Bay Region and quantify the uncertainty of these variables for the Tampa Bay Region among the GCMs and RCMs.
- Estimate agricultural and urban irrigation demand projections for retrospective and future CMIP5 climate projections in the Tampa Bay Region.
- Quantify uncertainties in future water demand.
- Develop a framework for decision making such as RDM (Robust Decision Making) to determine robust strategies for future water resources management.

07 Acknowledgement

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Contacts

Seungwoo (Jason) Chang: swjason@ufl.edu
Wendy Graham: wgraham@ufl.edu
Syewoon Hwang: aceace111@ufl.edu