Evaluation of Season-Ahead Precipitation Predictions at Various Scales: Koga Watershed, Blue Nile Basin, Ethiopia

Sarah Alexander, Paul Block, Solomon Erkyihun

Department of Civil and Environmental Engineering, University of Wisconsin - Madison, United States

✉ salexander6@wisc.edu

I. Abstract

Skillful season-ahead precipitation forecasts conditioned on climatic variables may provide valuable knowledge to farmers and reservoir operators, enabling informed water resource allocation and management decisions. Forecast skill, scale, and uncertainty are common critiques cited in lack of adoption by targeted stakeholders. This research examines precipitation predictions at regional and local scales for the Koga Watershed in the Blue Nile Basin, Ethiopia, to better understand the value of predictions at multiple scales. Based on deterministic, categorical, and probabilistic evaluation, predictions at the local scale do not always increase value.

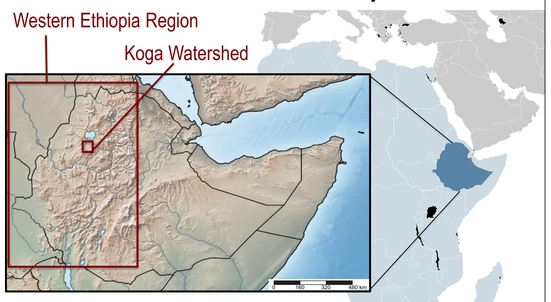
II. Background

Motivation

- Ethiopia's predominately rain-fed agricultural society is greatly impacted by seasonal and inter-annual variability in precipitation
- Skillful season-ahead forecasts may complement current potential for advancing economic growth through irrigated agriculture and hydropower

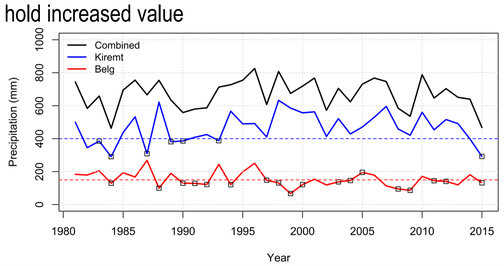
Region and season of interest

- 75% precipitation during *Kiremt*, June-September rainy season (JJAS)
- ENSO influence on inter-annual variability



Belg rainfall as pre-indicator

- Country level food shortages when *Belg* and *Kiremt* total season precipitation are below 150 and 400 mm, respectively
- Years with *Belg* rainfall lower than 150 mm provide advanced warning of possible drought; *Kiremt* predictions hold increased value



III. Data and Methods

Data

Observational Dataset (1983-2011)

- 0.1° x 0.1° gridded precipitation data, National Meteorological Agency (NMA) of Ethiopia[1]

Existing Precipitation Predictions Evaluated (1982-2010)

- Cluster Analysis of Western Ethiopia[2]
- Empirical ENSO model[3]
- NOAA, NCEP, Climate Forecast System version 2[4]
- National Multi-Model Ensemble (NMME), 8 members[5]

Precipitation predictions

- Regional Scale (Western Ethiopia)
- Local Scale (Koga Watershed)

Downscale

Predictions downscaled to local Koga Watershed scale using quantile mapping

Evaluate Skill

1. Deterministic (Pearson Correlation)
2. Categorical (Hit and Extreme Miss Scores)

$$Hit\ Score = \sum \frac{Hits}{N\ years} x\ 100$$

$$Extreme\ Miss\ Score = \sum \frac{Extreme\ Misses}{N\ years} x\ 100$$

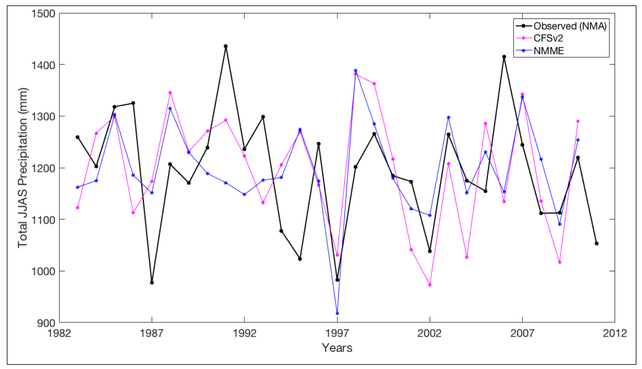
3. Probabilistic (Rank Probability Skill Score)

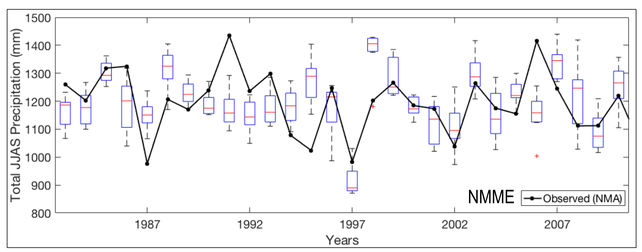
$$Rank\ Probability\ Score = \frac{1}{n}\sum_{i=1}^{n}(Pcumfct_i - Pcumobs_i)^2$$

$$Rank\ Probability\ Skill\ Score = 1 - \frac{RPS_{forecast}}{RPS_{climatology}}$$

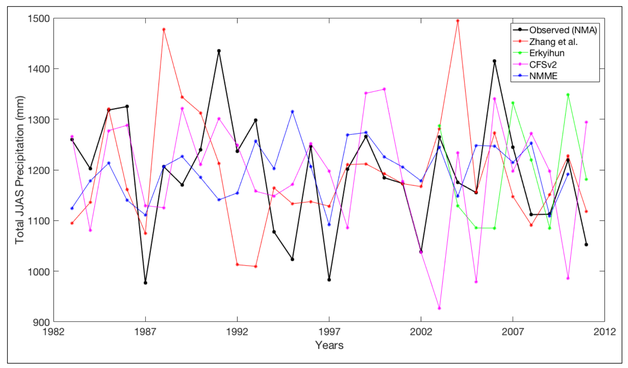
IV. Evaluation of Existing Precipitation Models

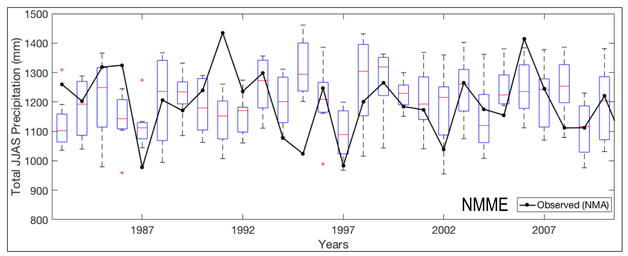
Predictions at Western Ethiopia (Regional) Scale





Predictions at Koga Watershed (Local) Scale





Summary of model skill for regional scale predictions

Prediction Model	Correlation with observed	Hit Score	Extreme Miss Score	RPSS
Zhang et al. (2017)	0.30	-	-	0.13
Erkyihun (2017)	-	-	-	-
NOAA NCEP CFSv2	0.32	35.7%	25.0%	-0.003
NMME Ensemble	0.32	39.3%	14.3%	-0.04

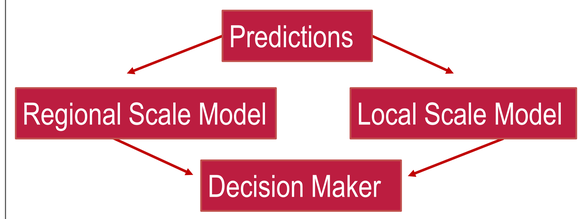
Summary of model skill for local scale predictions

Prediction Model	Correlation with observed	Hit Score	Extreme Miss Score	RPSS
Zhang et al. (2017)	0.23	55.2%	20.7%	-0.11
Erkyihun (2017)	0.08	44.0%	11.1%	-0.04
NOAA NCEP CFSv2	0.28	48.3%	17.2%	0.01
NMME Ensemble	0.26	35.7%	17.9%	-0.05

Note: regional and local scale predictions are both evaluated against local (Koga Watershed) scale observations to assess model skill at the decision-making scale

V. Value to Stakeholders

How can the skill of regional scale models be leveraged to enhance local scale decision-making?



- Value in skillful models at the decision-making scale
- Research shows a mismatch between the scale of skillful predictions and the scale of local decision-making

VI. Key Findings

1. *Belg* observations coupled with *Kiremt* predictions can serve as a useful predictor of drought conditions
2. Prediction models demonstrate superior skill at the regional scale as compared to the local (Koga Watershed) scale
3. Skillful prediction models tailored to the local scale are needed to match decision-making scales

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4. Saha, S., S. Moorthi, X. Wu, J. Wang, and Coauthors, 2014: The NCEP Climate Forecast System Version 2. Journal of Climate, 27, 2185–2208.
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