Applying Climate Reanalysis Data (CFSR) to Force Watershed Models in the Ethiopian Highlands

C. MacAlister¹, S. Seyoum¹, D. Fuka², Z. Easton³, T. Steenhuis²

¹ IWMI East Africa and Nile Basin
² Cornell University
³ Virginia Tech

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• Modeling landscape processes requires detailed climatic and geographic datasets
• Meteorological stations in most parts of Africa are very sparse and most watersheds are un-gauged
• Climate records are incomplete; high percentage of missing data and relevant variables
• Poor data accessibility due to lack of data sharing agreement among trans-boundary riparian countries)

→ High-resolution global reanalysis data for SWAT modeling applications in Africa
Study Area

Blue Nile: 176,000 km² (Tana Basin)
200,000 km² (all Blue Nile)

Altitude range: 500 masl @ Sudan border
1,800 masl @ Lake Tana

Annual Rainfall: 780-2,200mm
70% June-September

Tmax: 10-38°C

PET: 1,000 – 2,280mm

Flow: 1,410 - 1964 m³s⁻¹ border
(44.5 - 61.9B m³)
80% July-October
Gumera: CFSR vs. Gauge Data 1

Gumera CFSR v Station_areal_monthly: 1997-2005

[Graph showing comparison between CFSR and station data for Gumera from January 1997 to October 2005]
Applications of CFSR Data

- Weather generator files for areas with missing and incomplete climate datasets
  - Solar radiation, relative humidity, wind speed
  - Maximum half-hour rainfall
- SWAT weather input files for un-gauged watersheds
- Climate downscaling and bias correction
- Study of large-scale water and energy fluxes
Maximum Half-hour Rainfall

- **Strict sense simple scaling property**: the probability distribution of maximum rainfall depth is invariant of time scale (Burlando and Rosso, 1996)

\[ H_{\lambda D} \approx \lambda^n H_D \]

- **Wide sense simple scaling property**: extends the scale-invariant property to quantiles and moments

\[ h_t(\lambda D) = \lambda^n h_t(D) \]

- If the **reference duration is 1hr**, then \( \eta = D \)

\[ h_t(D) = D^n h_t(1) \]
Maximum Half-hour Rainfall - 2

Rainfall Scaling Property

ht(D), mm

ht(1), mm

D = 24 hr
D = 18 hr
D = 15 hr
D = 12 hr
D = 9 hr
D = 6 hr
D = 5 hr
D = 4 hr
D = 3 hr
D = 2 hr

Improving water and land resources management for food, livelihoods and nature
Maximum Half-hour Rainfall - 3

Scaling Exponent

\[ y = 0.8691e^{-0.023x} \]

\[ R^2 = 0.9505 \]
CFSR for SWAT Modeling - 2

Gumera Daily Flow (m³/s)

<table>
<thead>
<tr>
<th></th>
<th>R²</th>
<th>NSE</th>
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</thead>
<tbody>
<tr>
<td>MET</td>
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<tr>
<td>CFSR</td>
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</tbody>
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Improving water and land resources management for food, livelihoods and nature
CFSR for Spatial Downscaling
CFSR for Water Fluxes Study

(percentage of water fluxes relative to rainfall in wet season)

a) Canopy Evap

b) Transpiration

c) Bare Soil Evap

d) Surface Runoff
Conclusions

• High resolution reanalysis data had great potential to improve modeling of landscape processes

• CFSR data has comparable performance as gauged climate data for SWAT modeling in Ethiopian highlands

• The spatial pattern of CFSR data is useful for spatial downscaling and bias correction of GCM data

• The water fluxes of the CFSR data could be to study large-scale fluxes without doing cumbersome data assimilation
Thank You!