Applications of Satellite-Based Rainfall Estimates for Drought Early Warning and Agro-Meteorological Risk Assessment

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Applications of Satellite-Based Rainfall Estimates

• Drought early warning (food security context) and agro-meteorological risk assessment (weather index-based insurance)

Too little / too much rainfall = f(region, season) over time (from dekadal to monthly, seasonal, and annual)

Drought Indicators = Earth observations (EO)+ water budget models

Examples: USAID’s FEWS NET; UN’s WFP Seasonal Monitor and recent Agro-Meteorological DataViz platform, among others.
EO Data Input: Satellite-Based Rainfall Estimates

- Long-term and near-real time operational products
- Frequent repeat coverage at high spatial resolution (geostationary)
- In situ observations play a key role in rainfall retrieval algorithms
- Dekadal (~10-daily) totals, and more recently, pentad and daily totals
- Used for: SPI, SOS, wet/dry days, dry days, days since rain, anomalies

<table>
<thead>
<tr>
<th>Product</th>
<th>Spatial Res. &amp; Extent</th>
<th>Time Period</th>
<th>Input Data</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHIRPS</td>
<td>0.05°, quasi-global</td>
<td>1981-present</td>
<td>TIR, TRMM 3B42, gauges</td>
<td>Daily, pentad, dekadal</td>
</tr>
<tr>
<td>ARC2</td>
<td>0.1°, Africa</td>
<td>1983-present</td>
<td>TIR, gauges</td>
<td>Daily</td>
</tr>
<tr>
<td>TAMSAT</td>
<td>0.0375°, Africa</td>
<td>1983-present</td>
<td>TIR, gauges</td>
<td>Daily, dekadal</td>
</tr>
<tr>
<td>RFE2.0</td>
<td>0.1°, Africa</td>
<td>2001-present</td>
<td>TIR, gauges, PMW</td>
<td>Daily, dekadal</td>
</tr>
</tbody>
</table>

TIR – thermal infra-red; PMW – passive microwave
WRSI - Water Requirements Satisfaction Index

- Developed by UN’s FAO in the 1980s to monitor seasonal crop performance
- Empirically calibrated for key staple crops ($K_c$)
- Dekadal time step: rainfall & ET$_0$ inputs, soil & crop params
- Shows percentage crop water requirement that is met by rainfall during the crop season
WRSI Model Applications

• Widely used in drought early warning and food security analyses, agro-met risk management (weather index-based insurance), USGS GeoWRSI, FAO AgroMetShell, and Ethiopia’s LEAP system

• WRSI (anomaly), SM/soil water index, AET (anomaly), and crop yield monitoring and projections
Risk Management Services for Cross-Sector Users

• WHO

• WHAT In partnership with humanitarian sector, (re)insurance industry experts and global food traders, build risk management products and services that protect both producers and food buyers from weather- and climate-driven risks

• WHY Risk sharing along food supply chains, i.e. farmer to global retailer

• HOW Translate weather risk to crop production impacts, design equitable and efficient risk sharing contracts, tailor contracts to sourcing sites, improve accuracy of predicted crop losses, model price volatility, minimise basis risk, increase farmers’ income, promote healthy regulatory framework
Translate Weather Risk to Crop Yield Impacts

• Aim: Translate weather-related risk (rainfall deficit, heat stress) into agricultural risk (drought, crop production reduction/loss) to develop probabilistic crop yield outcomes and to inform index design

• Pilot: WFP Patient Procurement Platform (PPP) for maize growers in Tanzania

• Multi-model crop yield ensembles of historical weather risk
  • Models: WRSI and AgMIP crop growth models (DSSAT, APSIM, EPIC)
  • Scenarios: crop drought tolerance, SOS definition methods, LGPs, inputs,..
  • Evaluate rainfall product performance and WRSI sensitivity to products
Average SOS dekad

- Rainfall threshold approach: 25 mm in a dekad, then 20 mm in next 2 dekads
WRSI outcomes with different rainfall products
WRSI outcomes with different rainfall products

• Choice of rainfall product (ARC2, CHIRPS, TAMSAT) impacts on model outputs such as SOS, as well as on seasonal WRSI and simulated production (results not shown)

• Rainfall products and model-based analyses need to capture key drought diagnostics and factors that determine crop production

• Planned work over includes developing a tool for benchmarking and inter-comparison of rainfall products’ skill based on metrics tailored to drought early warning and risk analysis applications

Data through validation and to applications, including feedback from applications to develop better data
Thank you!

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