Seasonal Forecasts for Food Security Analysis in Kenya

SUMMARY

Key Points

- SERVIR is a joint NASA-USAID program that brings satellite data to improve environmental decisions around the world.
- SERVIR has helped the government of Kenya to use satellite and satellite-derived modeled data for food security analysis through digital food balance sheets.
- This information enables Kenya's Ministry of Agriculture, Livestock, Fisheries, and Cooperatives to focus on areas where financial and food aid is acutely needed.

Service

- Adaptation
- Agriculture
- Disaster risk reduction (DRR)
- Food security

End users

- Government agencies
- Researchers
- Other – Kenya's Ministry of Agriculture, Livestock, Fisheries, and Cooperatives

Intermediate User(s)

Regional Centre for Mapping of Resources for Development (RCMRD)Agriculture

Application(s)

Maize yield estimations and forecasts are provided as input to Kenya's National Food Balance Sheet. The forecasts provide yield estimates before measured yield becomes available, giving decision makers more time to prepare for potential shocks. The data also contribute to food security assessments to inform organizations where food aid may be needed.

Essential Climate Variables

—Atmosphere

- Precipitation
- Temperature
- Wind speed and direction

A detailed description of the GCOS Essential Climate Variables can be found here: https://gcos.wmo.int/en/essential-climate-variables/table

Models

The Regional Hydrologic Extremes Assessment System (RHEAS) model used is a NASA-supported, open-source software framework. It links the Variable Infiltration Capacity (VIC) hydrologic model and the Decision Support System for Agro-technology Transfer (DSSAT) crop model.

https://github.com/nasa/RHEAS

https://doi.org/10.1371/journal.pone.0176506

Climate Data Records

- CHIRPS precipitation (Funk et al., 2015)
- NCEP temperature and wind (Kalnay et al., 1996)
- Downscaled and bias corrected NMME precipitation and temperature (SERVIR, n.d.)

Agencies

- UCSB-CHIRPS
- OAA/OAR/ESRL PSL-NCEP
- NOAA/NASA-downscaled NMME

Satellite Observations

Tropical Rainfall Measuring Mission Multi-satellite Precipitation Analysis version 7: SSMI, SSMIS, MHS, AMSU-B and AMSR-E, IMERG (Huffman et al., 2007)

Sustainability

RHEAS is currently run by SERVIR, and the tool is available at GitHub for scaling beyond SERVIR.

DESCRIPTION

Drought and floods are two major climatic factors that endanger food security in Kenya. About 40% of Kenya's population is employed in the agriculture sector, and in many regions farms are rainfed. There are two main rainy seasons during which crops are grown: the long rains (March–June) and the short rains (October–December). Increasingly variable rainfall due to climate change exacerbates food insecurity (Kabubo-Mariara and Kabara, 2018; Mumo et al., 2018; Omoyo et al., 2015). Monitoring crop conditions through traditional crop cuts is difficult since they are conducted after the growing season ends. This approach does not allow time for preparation if there is an event that decreases yields over the season. Crop cuts can also be based on small sample sizes which may not be reflective of conditions over a broader region, such as a county. Furthermore, in the recent past, COVID-19 has made ground-based monitoring more difficult, limiting the possibilities for travel and social interactions needed for field measurements.

SERVIR is a joint NASA and USAID program that brings satellite data to improve decision making in developing countries. SERVIR is active in five regions, including Eastern and Southern Africa. SERVIR works through hubs at international, technical organizations in the regions. The SERVIR hub in eastern and southern Africa, located at the Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi, is supporting the Digital Food Balance Sheet for Kenya by providing maize yield estimates and seasonal forecasts. SERVIR's Regional Hydrologic Extremes Assessment System (RHEAS) pairs a spatially distributed hydrologic and biophysical crop modeling framework (illustrated in Figure 1) to provide forecasts of crop conditions in the near future and estimates of past season yields. The hydrologic model used is the Variable Infiltration Capacity (VIC) model and the crop yield estimation is done through the Decision Support System for Agrotechnology Transfer (DSSAT). Forecasts throughout the growing seasons are made using CHIRPS precipitation and NCEP temperature and wind data up until the latest data available, then NMME precipitation and temperature forecasts are used for the rest of the growing season. The results from the hydrologic assessment is fed into the crop model, which takes the combined information to quantify county level yields at the end of the season. Figure 2 illustrates the manner in which results are made available on SERVIR's RHEAS Viewer online visualization platform.

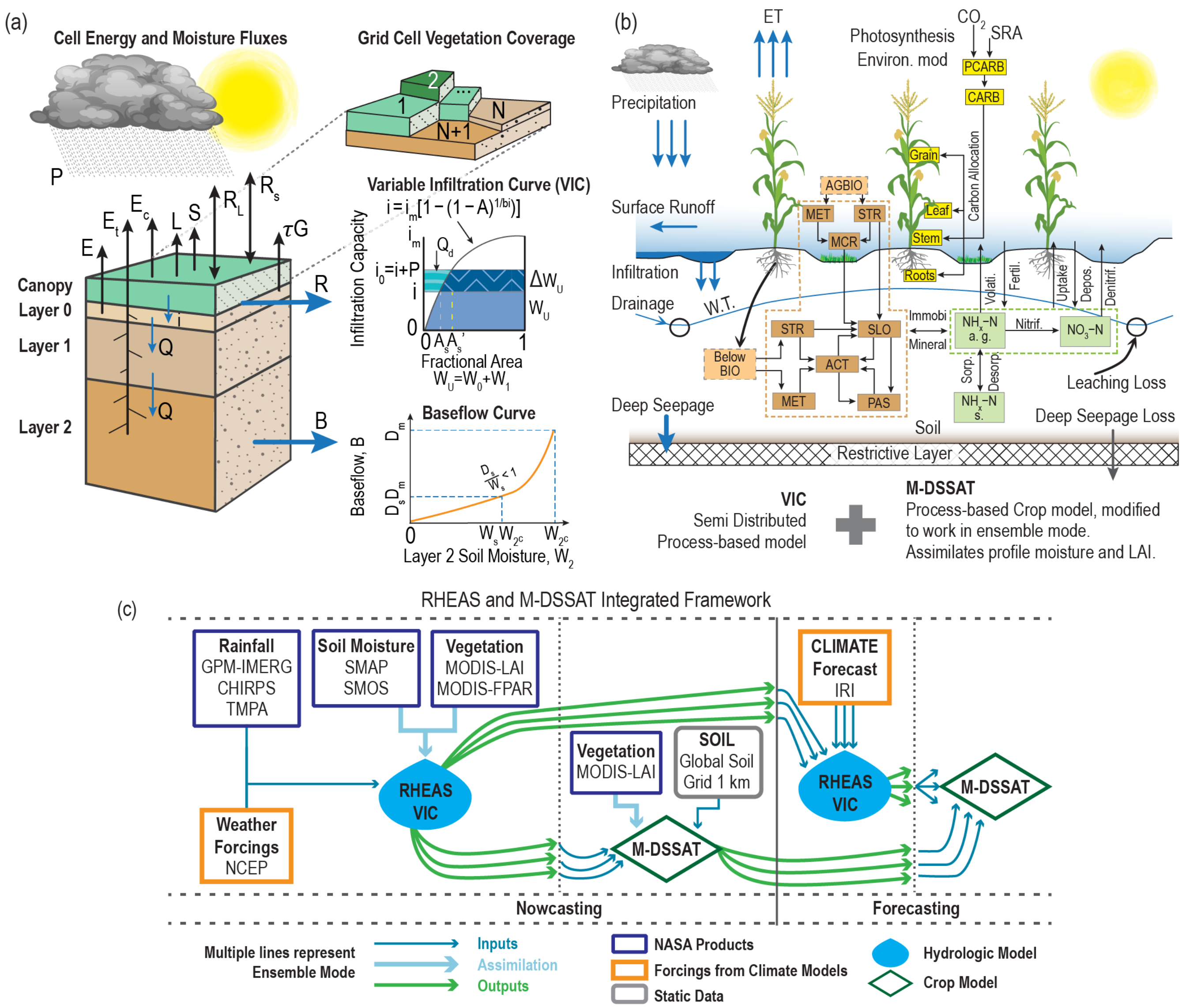


Figure 1. RHEAS schematic showing model inputs, assimilation options, and outputs for the hydrologic model VIC and crop model DSSAT.

The DSSAT model could be further calibrated if more historical yield data were obtained. Remotely sensed leaf area index and soil moisture could also possibly be assimilated into the crop model, or the seasonal precipitation forecasts could be bias-corrected specifically for East Africa to attempt to get more accurate forecasts earlier in the season.

RHEAS enhances traditional field monitoring, especially in areas that are difficult to access or where field observations are sparse. Forecasts are made twice monthly throughout the growing seasons as data inputs to the model (current conditions and seasonal forecast) are updated. Uncertainties in yield forecasts are larger early in the season, as seasonal weather forecasts tend to overestimate rainfall frequency and underestimate intensity. The yield forecasts become more reliable close to the end of the season as more observed weather data replaces the forecasted precipitation, as shown in Figure 3. Even forecasts close to the end of the season provide yield estimates before measured yields become available, giving decision makers more time to prepare if below-average yields are projected.

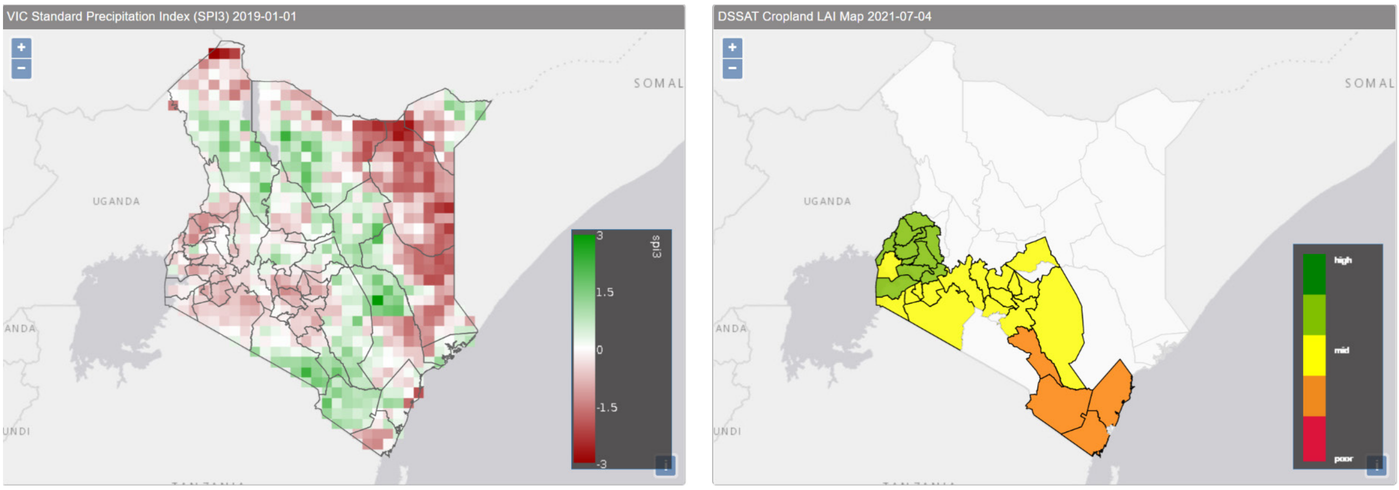


Figure 2. Example of RHEAS outputs on the visualization platform: (left) the standardized precipitation index for a selected day, with drier-than-average areas shown in red and wetter-than-average areas shown in green; (right) the leaf area index over agricultural counties for a selected day.

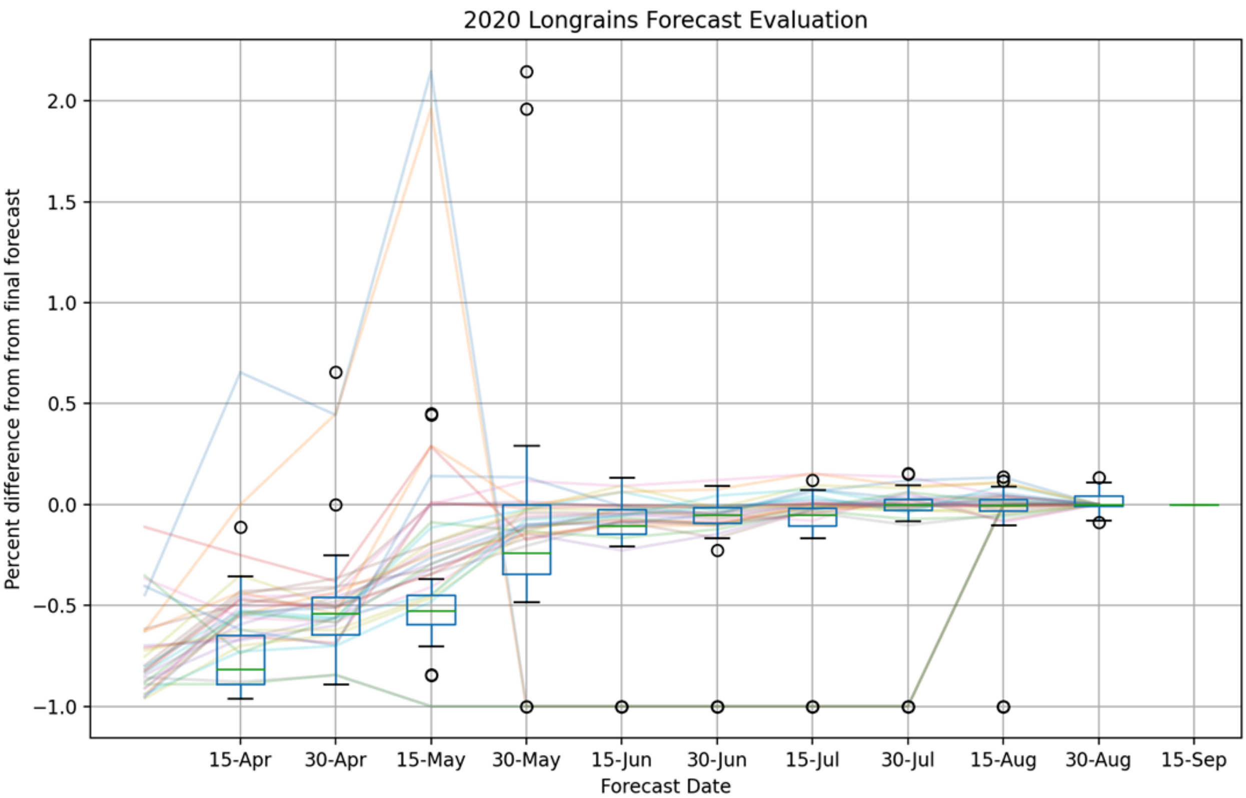
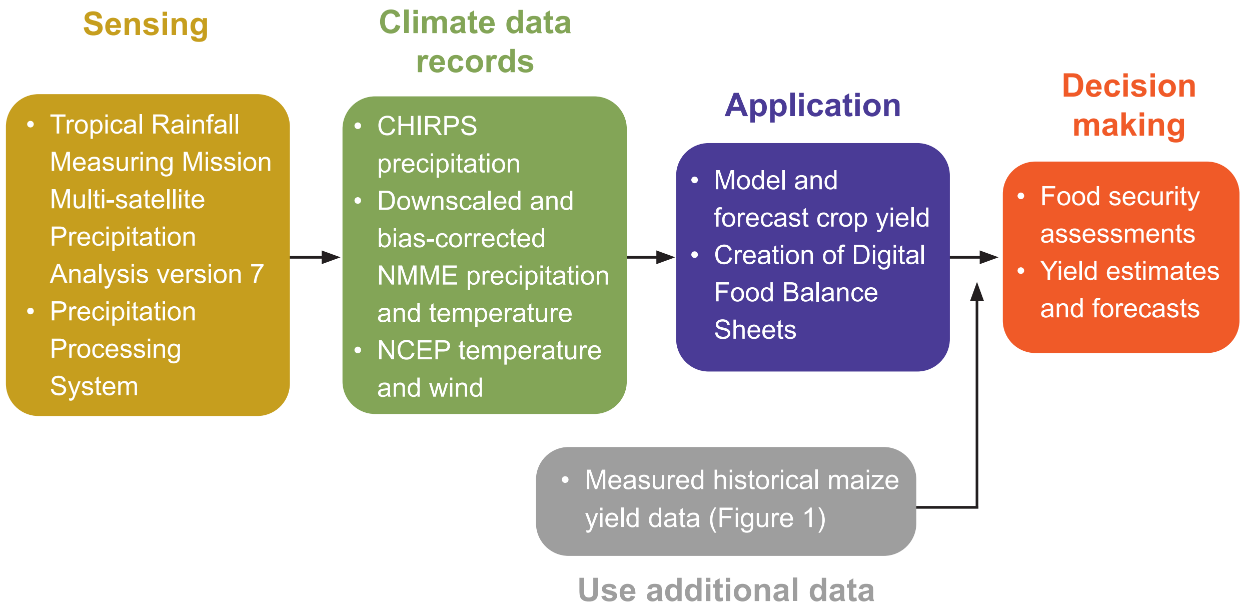


Figure 3. Ensemble crop yield uncertainty from RHEAS shows reduction as the crop season progresses and new observations become available. Notice at the beginning of the season, yield forecasts are much lower and have higher variability indicated by the large blue boxes; as the season progresses and more observed weather data becomes available, the blue boxes become smaller, indicating less uncertainty in yield estimates.

This information enables Kenya's Ministry of Agriculture, Livestock, Fisheries, and Cooperatives (MoALFC) to focus where financial and food aid are needed, and allows some preparation for potential food security threats. The information provided by SERVIR is used to inform advisories for farmers, market traders and other value chain actors. The continuous information provided by SERVIR, at the formal request of the Permanent Secretary (PS), as part of the national COVID-19 Committee, was used to develop actionable information for the PS on expected production and coping mechanisms, as well as to assess impacts of COVID-19 impacts on the national food security. The maize yield and total production estimates and forecasts, provided as an input to the Digital Food Balance Sheet, were used to monitor projections for food demand and supply throughout the long rain season and the COVID-19 emergencies.

INFORMATION FLOW



References

Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., Shukla, S., and Michaelsen, J. (2015). The climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes. *Scientific data*, 2(1), 1-21.

Huffman, G. J., Bolvin, D. T., Nelkin, E. J., Wolff, D. B., Adler, R. F., Gu, G., and Stocker, E. F. (2007). The TRMM Multisatellite Precipitation Analysis (TMPA): Quasi-global, multiyear, combined-sensor precipitation estimates at fine scales. *Journal of hydrometeorology*, 8(1), 38-55.

Kabubo-Mariara, J.,and Kabara, M. (2018). *Climate change and food security in Kenya* (pp. 55-80). Routledge.

Kalnay, E., Kanamitsu, M., Kistler, R., Collins, W., Deaven, D., Gandin, L., and Joseph, D. (1996). The NCEP/NCAR 40-year reanalysis project. *Bulletin of the American Meteorological Society*, 77(3), 437-472.

Mumo, L., Yu, J., and Fang, K. (2018). Assessing impacts of seasonal climate variability on maize yield in Kenya. *International Journal of Plant Production*, 12(4), 297-307.

Omoyo, N. N., Wakhungu, J., and Oteng'i, S. (2015). Effects of climate variability on maize yield in the arid and semi-arid lands of lower eastern Kenya. *Agriculture & Food Security*, 4(1), 1-13.

SERVIR. (n.d.). ClimateSERV Product Catalogue. Retrieved August 13, 2021, from http://catalogue.servir-global.net/Product?product_id=138