Prediction of Hydro-Climatic Extremes in the Greater Horn of Africa (GHA)

NASA GHA PROJECT
OVERVIEW AND BRIEF PROGRESS REPORT

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UNIVERSITY OF NEBRASKA

NASA IDS: Seasonal Prediction of Hydro-Climatic Extremes for the Greater Horn of Africa (GHA)
The Third Participatory Research Workshop and Project Meeting
24th October 2017

Outline

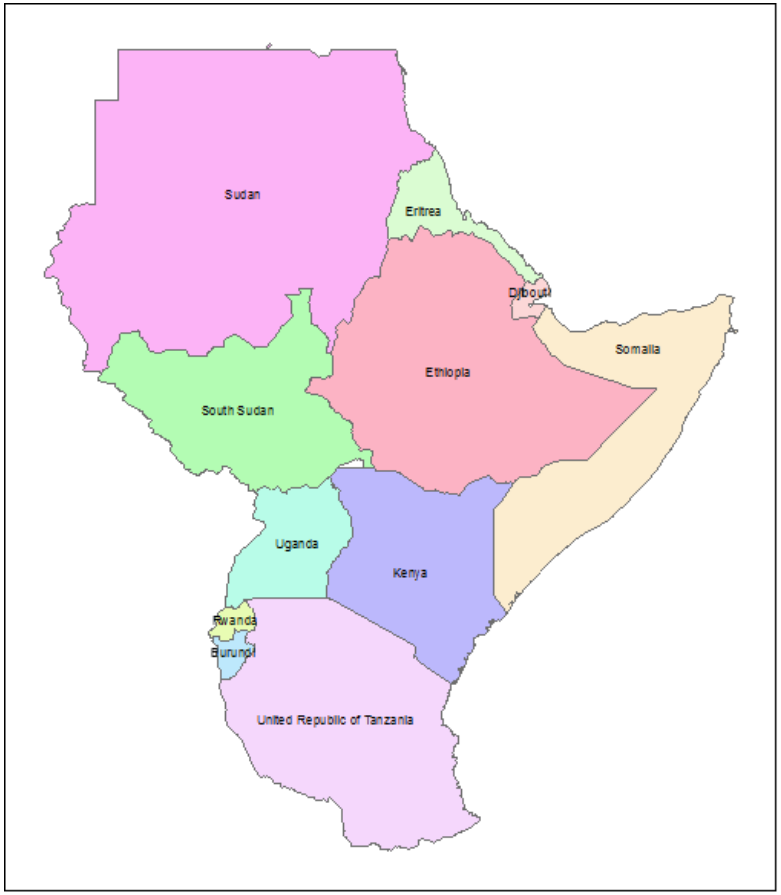
1. NASA GHA Project Goal and Objectives
2. Brief Progress Report
3. Final thoughts: the way forward

NASA GHA Project Goal

"To understand and, where possible, extend the predictive time horizons for extreme drought and flood in the GHA given the challenges of an evolving climate baseline and diverse information needs to support mitigation strategies."

NASA Theme: Understanding Earth system Vulnerabilities to Climate Extremes

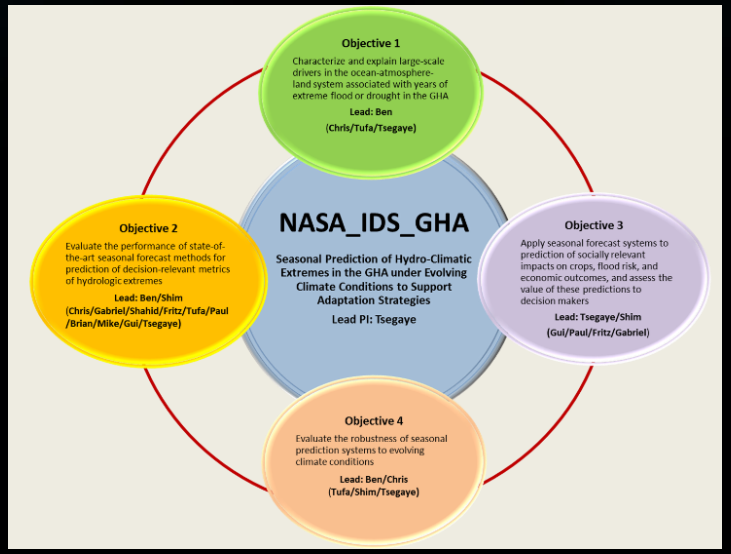
GHA Countries



GHA Countries	
1	Burundi
2	Djibouti
3	Eritrea
4	Ethiopia
5	Kenya
6	Rwanda
7	Somalia
8	South Sudan
9	Sudan
10	Tanzania
11	Uganda

Project Objectives

1. Characterize and explain large-scale drivers in the ocean-atmosphere-land system associated with years of extreme flood or drought in the GHA.
2. Evaluate the performance of state-of-the-art seasonal forecast methods for prediction of decision-relevant metrics of hydrologic extremes.
3. Apply seasonal forecast systems to prediction of socially relevant impacts on crops, flood risk, and economic outcomes, and assess the value of these predictions to decision makers.
4. Evaluate the robustness of seasonal prediction systems to evolving climate conditions.

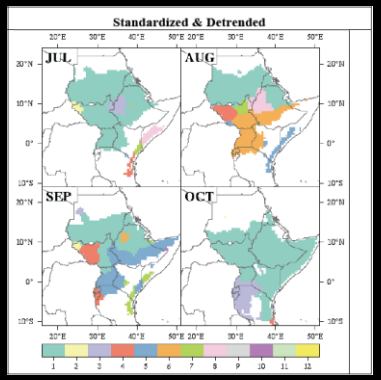


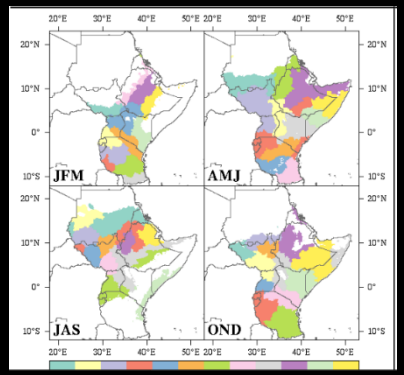
Objective 1

Characterize and explain large-scale drivers in the ocean-atmosphere-land system associated with years of extreme flood or drought in the GHA

Objective Regionalization

Analysis of Large-scale Drivers





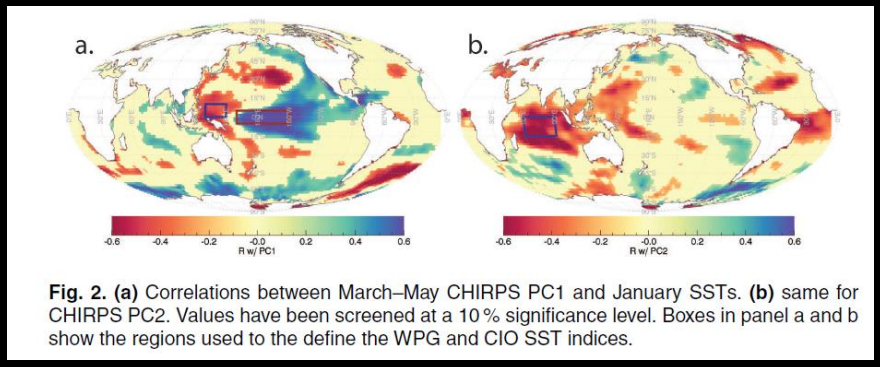


Fig. 2. (a) Correlations between March–May CHIRPS PC1 and January SSTs. **(b)** same for CHIRPS PC2. Values have been screened at a 10 % significance level. Boxes in panel a and b show the regions used to the define the WPG and CIO SST indices.

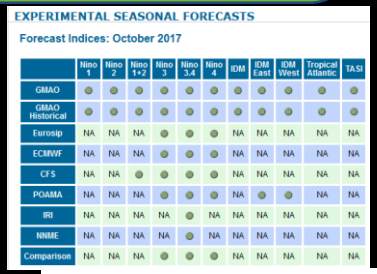
Objective 2

Evaluate the performance of state-of-the-art seasonal forecast methods for prediction of decision-relevant metrics of hydrologic extremes

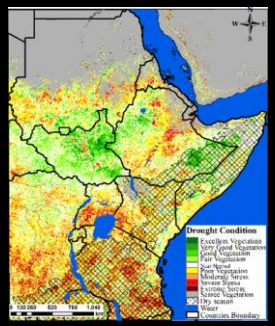
Participatory System Design and Evaluation

- NOAA Coupled Forecast System (CFS, v2)
- NASA GMAO Experimental Seasonal Forecasts (ESF)
- NDMC VegOut Experimental Forecast Tool
- CFS-Statistical Hybrid
- Statistical Regression
- Machine Learning Algorithms

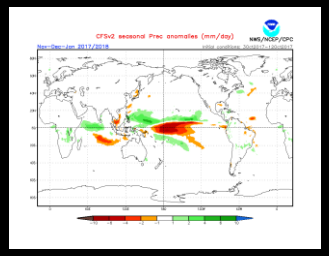
Retrospective Forecast Experiment

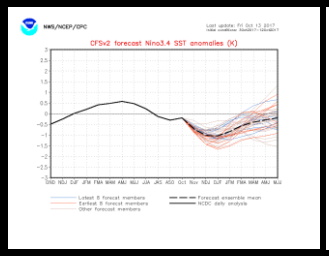


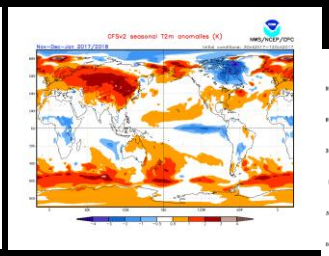
VegOut-GHA



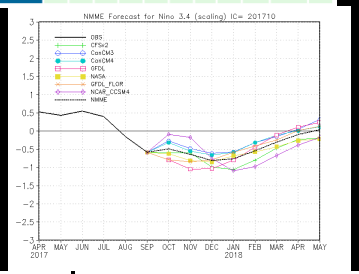
CFS v2: Nov-Dec-Jan 2017/2018

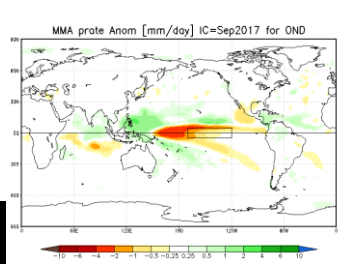


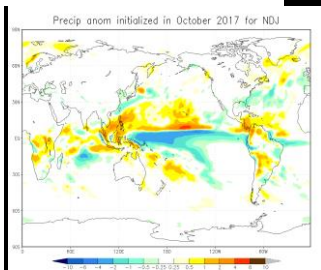




NASA GMAO: Oct-Nov- Dec 2017







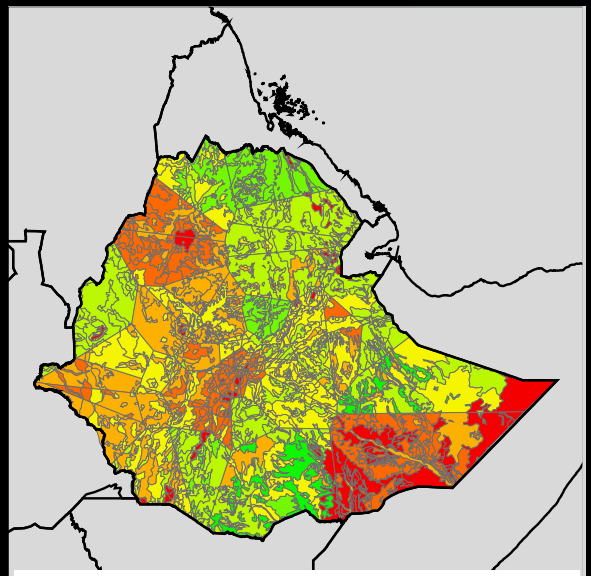
Objective 3

Apply seasonal forecast systems to prediction of socially relevant impacts on crops, flood risk, and economic outcomes, and assess the value of these predictions to decision makers

Impacts Models

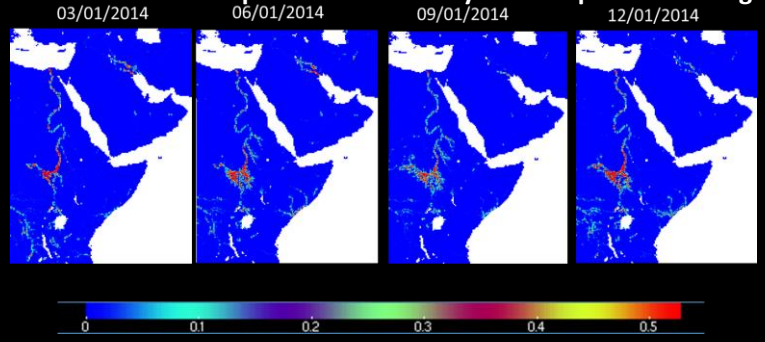
- Crop System Modeling-Decision Support System for Agro-technology Transfer (CSM-DSSAT)
- Land Information System (LIS) Model or Coupled Routing and Excess Storage (CREST)
- Ethiopia Multi-market Model (EMM)
- FEWS NET Food Security Projections

Participatory System Design and Evaluation



CSM-DSSAT: Crop Production 1980-2010 (Gui Baigorria, UNL)

Flooded Fraction Map in the GHA: LIS-HyMAP output at 0.25 deg



(Hahn Chul Jung, Augusto Getirana at NASA GSFC & SSAI, UMD)

Objective 4

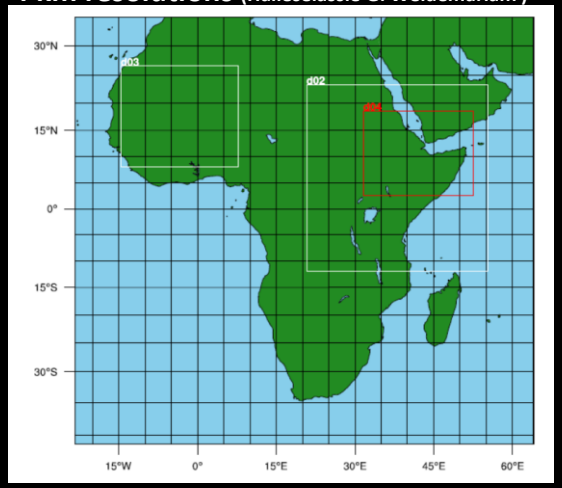
Evaluate the robustness of seasonal prediction systems to evolving climate conditions.

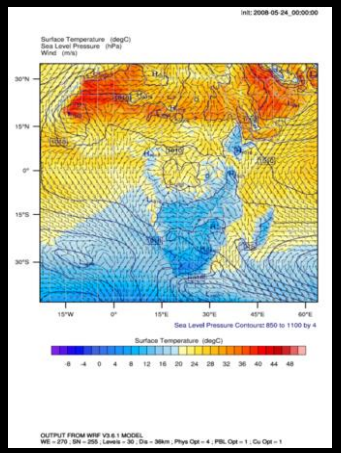
Evolving Climate Conditions

CMIP5 Projections

Stakeholder engagement

Simulations are configured for 36,12, & 4 km resolutions (Haileselassie G. Weldemariam)

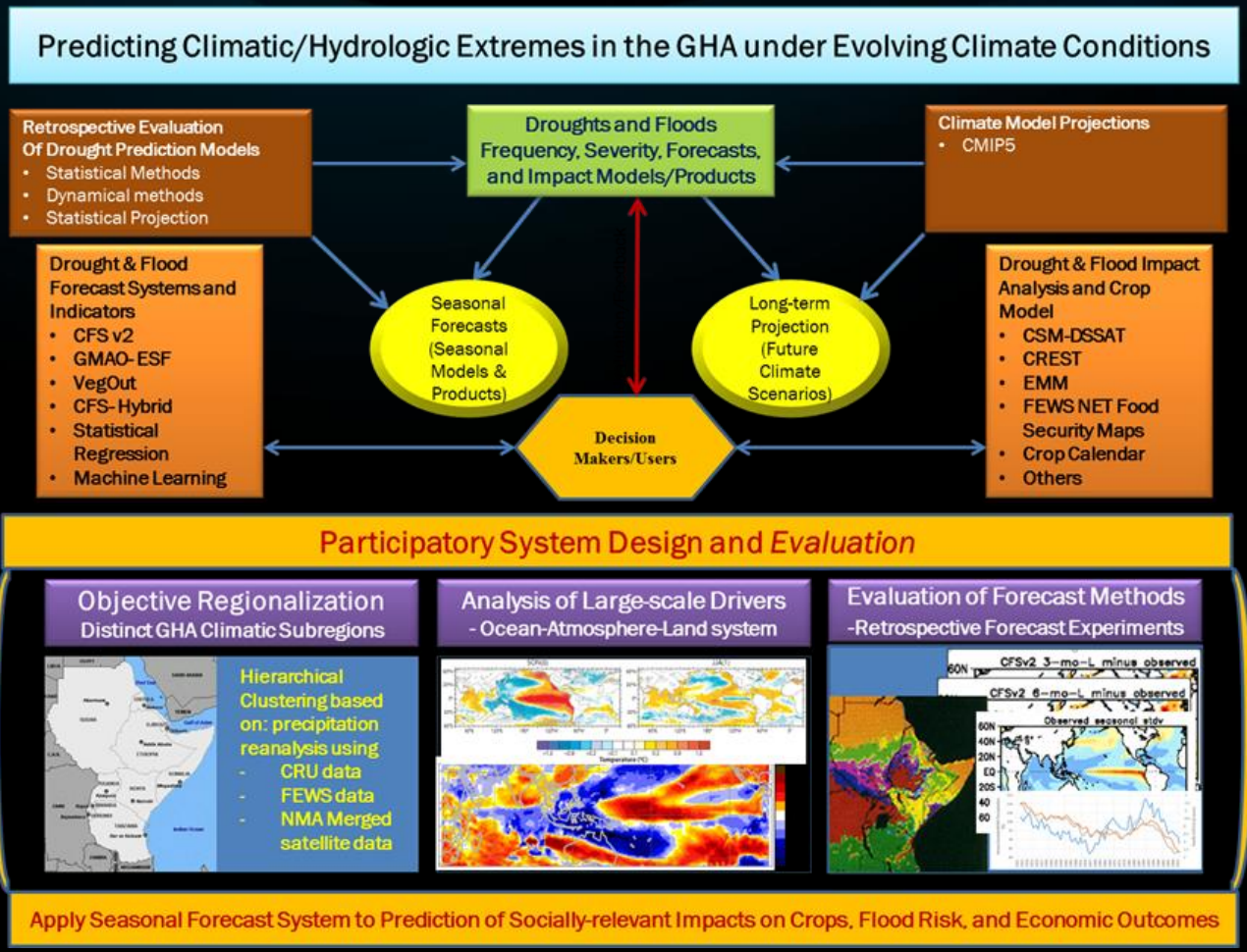




Simulation of 10 years each under RCP4.5 and RCP8.5

- Model verification (2001-2010),
- baseline (2010-2020) and
- change detection(2061-2070)

Schematic diagram of the project



Publications and Presentations

Profession Journal Publications (Peer Reviewed) n = 21

Zhang, Y., Moges, S. and **Block, P**., Does objective cluster analysis serve as a useful precursor to seasonal precipitation prediction at local scale? Application to western Ethiopia, Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2017-70, 2017

Alemayehu, T., Griensven, A.V., **Senay, G.B.** and Bauwens, W., 2017. Evapotranspiration Mapping in a Heterogeneous Landscape Using Remote Sensing and Global Weather Datasets: Application to the Mara Basin, East Africa. *Remote Sensing*, *9*(4), p.390.

Bayissa, Y. A., **Tadesse, T., Demisse, G., Shiferaw,** A., 2017. Evaluation of Satellite-Based Rainfall Estimates and Application to Monitor Meteorological Drought for the Upper Blue Nile Basin, Ethiopia. Remote Sensing (9), 669. http://www.mdpi.com/2072-4292/9/7/669/html

Demisse, G., Tadesse, T., Atnafu, S., **Bayissa, Y. A., Shiferaw**, A., Hill, S., 2017. Information Mining from Heterogeneous Data Sources: A Case Study on Drought Predictions. Information, 8(3), 79; doi: 10.3390/info8030079. http://www.mdpi.com/2078-2489/8/3/79/htm

Satti, S., **Zaitchik, B.,** Badr, H., **Tadesse, T.** (2017). Enhancing Dynamical Seasonal Predictions through Objective Regionalization. Journal of Applied Meteorology and Climatology, 56(5), 1431–1442. http://journals.ametsoc.org/doi/abs/10.1175/JAMC-D-16-0192.1

Demisse, G., **Tadesse, T., Bayissa, Y.**, 2017. Data mining attribute selection approach for drought modelling: a case study for Greater Horn of Africa. International Journal of Data Mining & Knowledge Management Process (IJDKP), Vol.7, No.4, DOI: 10.5121/ijdkp.2017.7401.

Tadesse, T., **T. Haigh, N. Wall, A.S. Shiferaw**, **B. Zaitchik, S. Beyene**, G. Berhan, and J. Petr, 2016. Linking seasonal predictions into decision-making and disaster management in the Greater Horn of Africa. *Bulletin of the American Meteorological Society*, ES89–ES92, doi: http://dx.doi.org/10.1175/BAMS-D-15-00269.1.

Taye, M., **T. Tadesse, G. Senay, and P. Block**, 2016. The Grand Ethiopian Renaissance Dam: A source of cooperation or contention? *Journal of Water Resources Planning and Management*, 10.1061/(ASCE)WR.1943-5452.0000708 , 02516001.

Zhang, Y., S. Moges, and **P. Block**, 2016: Optimal Cluster Analysis for Objective Regionalization of Seasonal Precipitation in Regions of High Spatial-Temporal Variability: Application to Western Ethiopia, *Journal of Climate* (DOI: 10.1175/JCLI-D-15-0582.1.

Shukla, S., Roberts, J., Hoell, A., **Funk, C.**C., Robertson, F. and Kirtman, B., 2016. Assessing North American multimodel ensemble (NMME) seasonal forecast skill to assist in the early warning of anomalous hydrometeorological events over East Africa. Climate Dynamics, pp.1-17.

Zhang, Y., S. Erkyihun, and **P. Block**, 2016: Filling the GERD: Evaluating hydroclimatic variability and impoundment strategies on Blue Nile riparian countries, *Water International (Invited, special issue)* DOI: 10.1080/02508060.2016.1178467.

Berhan, G., T. Tadesse, and S. Atnafu, 2015. Drought spatial object prediction approach using artificial neural network. *Journal of Geoinformatics & Geostatistics: An Overview* 3 (2):1-7, http://dx.doi.org/10.4172/2327-4581.1000132.

Tadesse, T., **G.B. Senay**, **G. Berhan**, T. Regassa, and **S. Beyene**, 2015. Evaluating a satellite-based seasonal evapotranspiration product and identifying its relationship with other satellite-derived products and crop yield: A case study for Ethiopia. *International Journal of Applied Earth Observation and Geoinformation*, 40:39-54; doi:10.1016/j.jag.2015.03.006

Tadesse, T., **D. Bathke, N. Wall**, J. Petr, and **T. Haigh**, 2015. Participatory Research Workshop on Seasonal Prediction of Hydro-climatic Extremes in the Greater Horn of Africa. *Bulletin of the American Meteorological Society*, doi: http://dx.doi.org/10.1175/BAMS-D-14-00280.1.

Nam, W.H., Hayes, M.J., Svoboda, M.D., Tadesse, T. and Wilhite, D.A., 2015. Drought hazard assessment in the context of climate change for South Korea. Agricultural Water Management, 160, pp.106-117.

Bayissa, Y.A., S.A. Moges, U. Xuan, S.J. VanAndel, S. Maskey, D.P. Solomatine, A. Van Griensven, and **T. Tadesse**, 2015. Spatio-temporal assessment of meteorological drought under the influence of varying record length: The case of Upper Blue Nile Basin, Ethiopia. *Hydrological Sciences Journal*, http://dx.doi.org/10.1080/02626667.2015.1032291.

Davenport, F. and **Funk, C.,** 2015. Using time series structural characteristics to analyze grain prices in food insecure countries. Food Security, 7(5), pp.1055-1070.

Funk, C. and A. Hoell, 2015. The leading mode of observed and CMIP5 ENSO-residual sea surface temperatures and associated changes in Indo-Pacific climate. *Journal of Climate*, 28, 4309-4329, http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-14-00334.1

Funk, C., S.E. Nicholson, M. Landsfeld, D. Klotter, P. Peterson, and L. Harrison, 2015. The Centennial Trends Greater Horn of Africa Precipitation Dataset. *Scientific Data*, 2, 150050. doi:10.1038/sdata.2015.50.

Funk, C., Shukla, S., Hoell, A. and Livneh, B., 2015. Assessing the contributions of East African and west Pacific warming to the 2014 boreal spring East African drought. Bulletin of the American Meteorological Society, 96(12), pp.S77-S82.

Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., **Shukla, S.,** Husak, G., Rowland, J., Harrison, L., Hoell, A. and Michaelsen, J., 2015 climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes. Scientific data, 2, p.150066

Publications and Presentations

Book Chapters (Peer Reviewed) n = 3

Tadesse, T., **T. Haigh, N. Wall, M.J. Hayes, B. Zaitchik, and B. Wardlow**, 2015. Lessons learned in monitoring and predicting hydroclimatic extremes in the Greater Horn of Africa. In Evaluation of Drought and Drought Impacts through Interdisciplinary Methods. Miroslav Trnka and Michael J. Hayes (Eds.), pp. 36-41. Academy of Sciences of the Czech Republic.

Funk C., Hoell A., Shukla S., Husak G., Michaelsen J., 2016. The East African Monsoon System: Seasonal Climatologies and Recent Variations. In: de Carvalho L., Jones C. (eds) The Monsoons and Climate Change. Springer Climate. Springer, Cham

Wardlow, B., T. Tadesse, J.F. Brown, **M. Svoboda**, **M.J. Hayes**, K. Callahan, C. Poulsen, C. Hain, M. Anderson, M. Rodell, and D. Mocko, 2015. A satellite-based composite index approach for agricultural drought monitoring – Current work and future directions. In Evaluation of Drought and Drought Impacts through Interdisciplinary Methods. Miroslav Trnka and Michael J. Hayes (Eds.), pp. 30-35. Academy of Sciences of the Czech Republic.

Publications Under Revision (n = 7)

Ayehu, G. T., **Tadesse, T.,** Gessesse, B., **Dinku, T**. Validation of new satellite rainfall products over the Upper Blue Nile Basin, Ethiopia. Atmospheric Measurement Techniques (AMT). **Status:** Accepted.

Demisse, G., Tadesse, T. et al. Vegetation Condition Prediction for Drought Monitoring in Pastoralist Areas: A Case Study in Ethiopia, International Journal of Remote Sensing. **Status:** Accepted

Jung, H. C., Getirana, A., **Policelli, F.,** McNally, A., Arsenault, K. R., Kumar, S., **Tadesse, T.,** Peters-Lidard, C. D. Upper Blue Nile Basin Water Budget from a Multi-Model Perspective. Journal of Hydrology. Mucia, A., Allen, M., **Tadesse, T.,** Mamo, M., Abreha, S. Climate Change Perception of Smallholder Farmers in South Wollo, Ethiopia. *Global Environmental Change*. **Status:** Accepted.

Demisse, G., Tadesse, T., Bayissa, Y. A., Haigh, T., Wall, N., Shiferaw, A. Linking Seasonal Vegetation Condition Outlook Information to Decision Makers in a Data-sparse Region: A Case Study in the Greater Horn of Africa. *Remote Sensing Applications: Society and Environment*. Status: Minor Revision.

Bayissa, Y. A., Maskey, S., van Andel, S. J., Moges, S. A., **Tadesse, T.,** Van Griensven, A., Solomatine, D. P. Inter-comparison of the performance of five drought indices to assess and characterize historic drought events in the Upper Blue Nile basin of Ethiopia. *Journal of Hydrology*. **Status:** Submitted.

Dinku, T., Funk, C., Peterson, P., **Tadesse, T.,** Ceccato, P. Evaluation of the CHIRPS Satellite-based Rainfall Products over Eastern of Africa. *Journal of Hydrometeorology*. **Status:** Submitted.

Professional Conference/Workshop Presentations (> 10)

Block, P., Zhang, Y. and You, L., 2017, April. Integrating predictive information into an agro-economic model to guide agricultural planning. In EGU General Assembly Conference Abstracts (Vol. 19, p. 18513).

Tadesse, T., Demisse, G., Bayissa, Y. A., **Wardlow, B.,** 2016. Vegetation Outlook for the Greater Horn of Africa (VegOut-GHA): Preliminary Results, The 2016 AGU Fall Meeting, AGU, San Francisco, California, December 15, 2016.

Shiferaw, A. and Tadesse, T., Evaluating NOAA's Climate Forecast System Version 2 retrospective forecast over Ethiopia", 2016 Water for Food Global Conference, Lincoln, NE, March 24, 2016

Tadesse, T., 2016. Connecting Seasonal Predictions into Decision-making in the Greater Horn of Africa. The 14th Annual Climate Prediction Applications Science Workshop (CPASW), Burlington, VT, March 23, 2016.

Zhang, Y., S. Moges, and **P. Block**, 2015. Regionalization and Prediction of Seasonal Precipitation in Ethiopia. *World Environmental & Water Resources Congress (EWRI)*, Austin, Texas, May 2015.

Tadesse, T., W. Nam, and G. Berhan, 2015. Seasonal Predictions of Vegetation in the Greater Horn of Africa: Experimental Vegetation Outlook (VegOut-GHA) Model. Food Security Implications of a Changing Arctic, Lincoln, NE, 12-13 November 2015.

Tadesse, T., T. Haigh, N. Wall, A. Shiferaw**, B. Zaitchik, S. Beyene,** and G. Berhan, 2015. Building a Framework in Improving Drought Monitoring and Early Warning Systems in Africa. 2015 AGU Fall Meeting, San Francisco, CA, Dec. 14-18 (oral presentation).

Funk, C., A. Hoell, S. Shukla, C. Kelley, G. Husak, and L. Harrison, 2015. Recent Potentially Predictable Droughts Associated with the West Pacific Warming Mode and ENSO. 2015 AGU Fall Meeting, San Francisco, CA, Dec. 14-18 (oral presentation).

Berhane, F., **B.F. Zaitchik, and T. Tadesse**, 2015. An Interactive Tool for Semi-automated Statistical Prediction Using Earth Observations and Models. 2015 AGU Fall Meeting, San Francisco, CA, Dec. 14-18 (poster presentation).

Publications and Presentations

Profession Journal Publications

1. Bulletin of the American Meteorological Society (3)
2. Remote Sensing (2)
3. Scientific Data (2)
4. Journal of Climate (2)
5. Journal of Applied Meteorology and Climatology
6. International Journal of Applied Earth Observation and Geoinformation
7. Agricultural Water Management
8. Hydrology and Earth System Sciences
9. Hydrological Sciences Journal
10. Journal of Water Resources Planning and Management
11. Journal of Geoinformatics & Geostatistics
12. Water International
13. International Journal of Data Mining & Knowledge Management Process (IJDKP)
14. Climate Dynamics
15. Information
16. Food Security

Books

1. The East African Monsoon System: Seasonal Climatologies and Recent Variations. In: de Carvalho L., Jones C. (eds) The Monsoons and Climate Change. Springer Climate. Springer, Cham
2. Evaluation of Drought and Drought Impacts through Interdisciplinary Methods. Miroslav Trnka and Michael J. Hayes (Eds.), pp. 30-35. Academy of Sciences of the Czech Republic.

- **Several presentations at Professional Meetings, Workshops, & Seminars**

Final Thoughts: the Way forward

- We have all these encouraging research outputs:
  (New and improved models, published papers, etc.)
  - Then what?
    - What efforts should be done to implement?
    - What should be the focus or priority?
  - How do we use the new models?
    - National Met/Hydro-services and Regional Centers?
  - How do we pursue our research?
    - International and local experts collaboration
  - How do we get human and financial resources

NDMC NATIONAL DROUGHT MITIGATION CENTER
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Thank You

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