Forecasting seasonal agricultural droughts in East Africa using satellite based observations, land surface models and dynamical weather/climate forecasts

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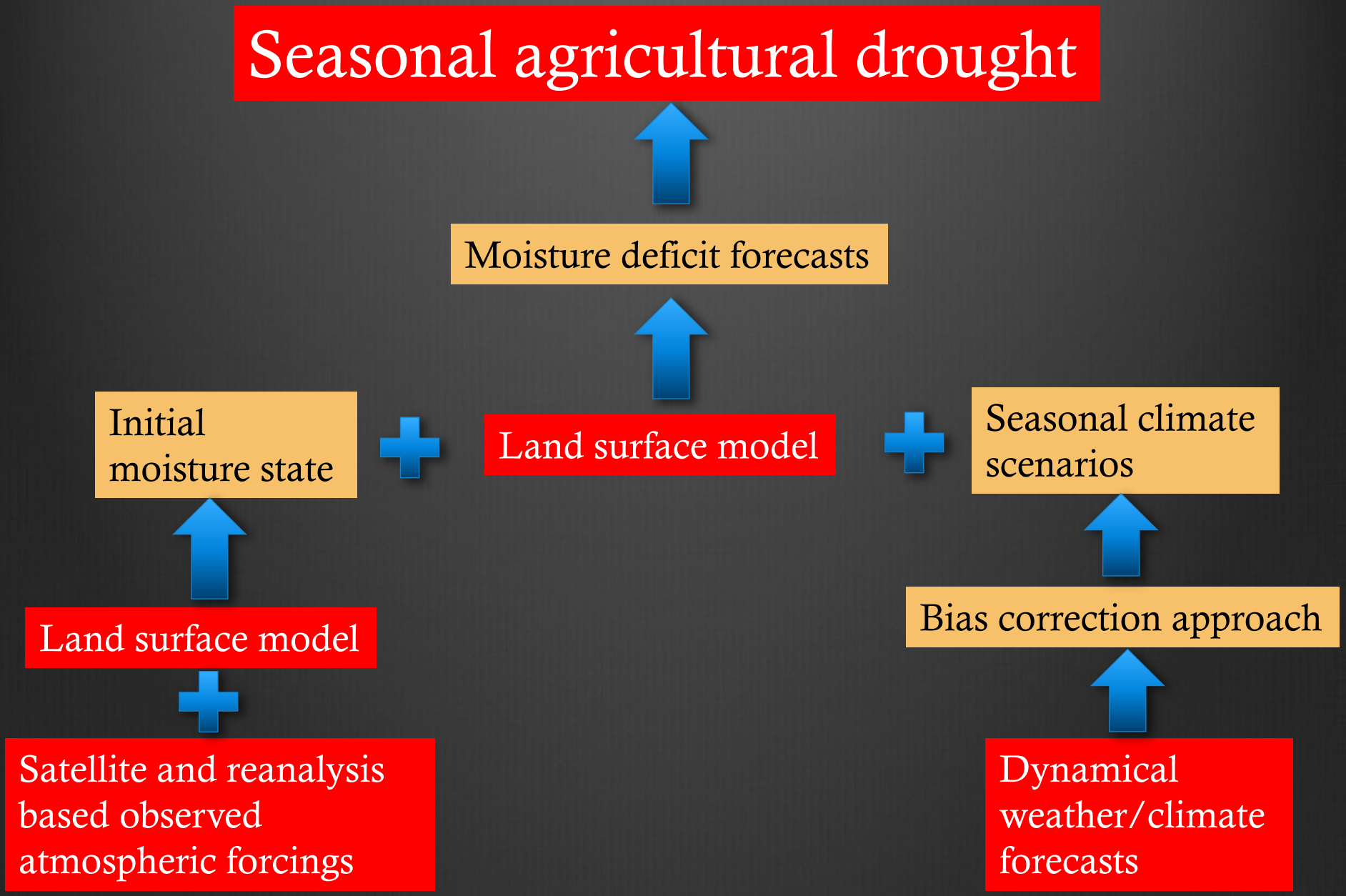

Seasonal agricultural drought
Moisture deficit forecasts
Initial moisture state
Land surface model
Seasonal climate scenarios
Land surface model
Bias correction approach
Satellite and reanalysis based observed atmospheric forcings
Dynamical weather/climate forecasts

Outline

- Evaluation of seasonal climate forecasts
- Hybrid approaches to improve precipitation forecast skill in the region
- Implementation and evaluation of a seasonal agricultural drought monitoring and forecasting system
- Concluding remarks

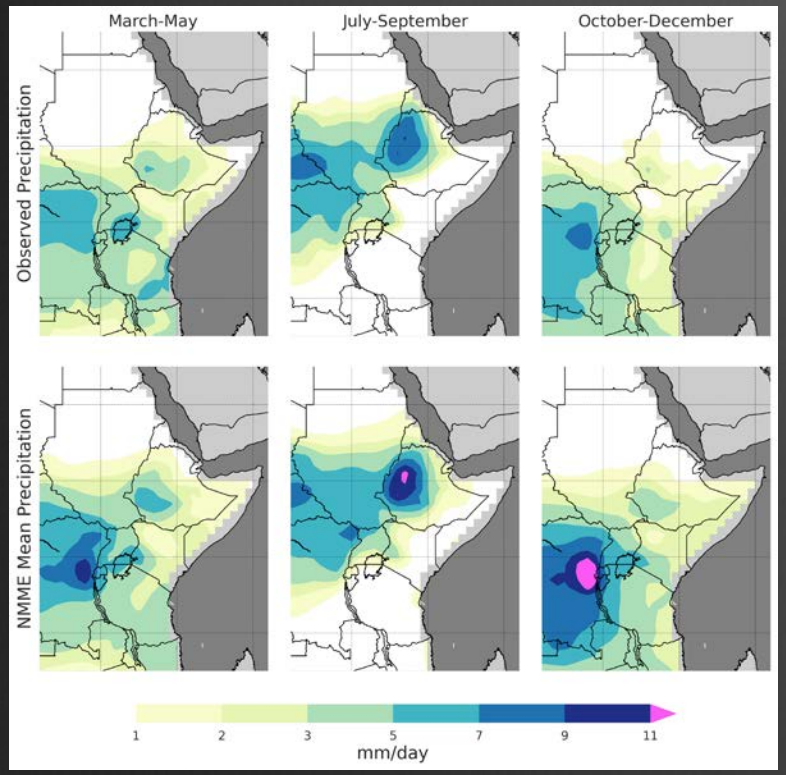
Evaluation of seasonal climate forecasts

North-American Multi-model Ensemble (NMME)

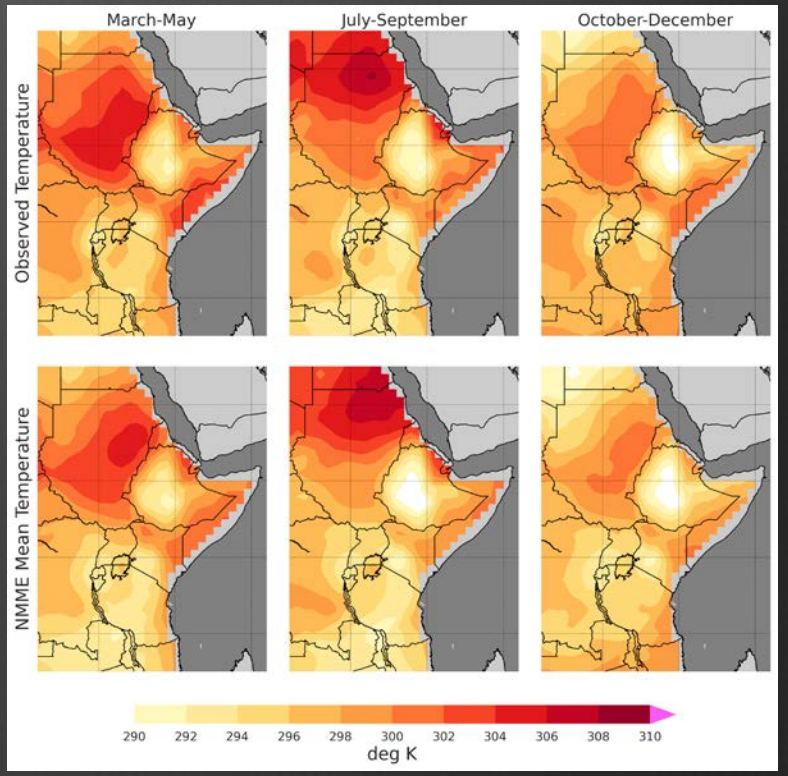
- Total 99 ensemble members
- Models used:
  - CMC1-CanCM3
  - CMC2-CanCM4
  - CCSM4
  - GFDL-CM2p1-aer04
  - GFDL-CM2p5-FLOR-A06
  - GFDL-CM2p5-FLOR-B01
  - GMAO
  - CFSv2
- Hindcast available for 1982-2010 at 1 deg X 1 deg spatial resolution.
- Evaluation performed for 1982-2010 period with respect to The Climate Hazards Group Infrared Precipitation with Stations (CHIRPS) precipitation and the Climate Research Unit (CRU's) temperature data.

Evaluation of monthly mean climatology

Precipitation



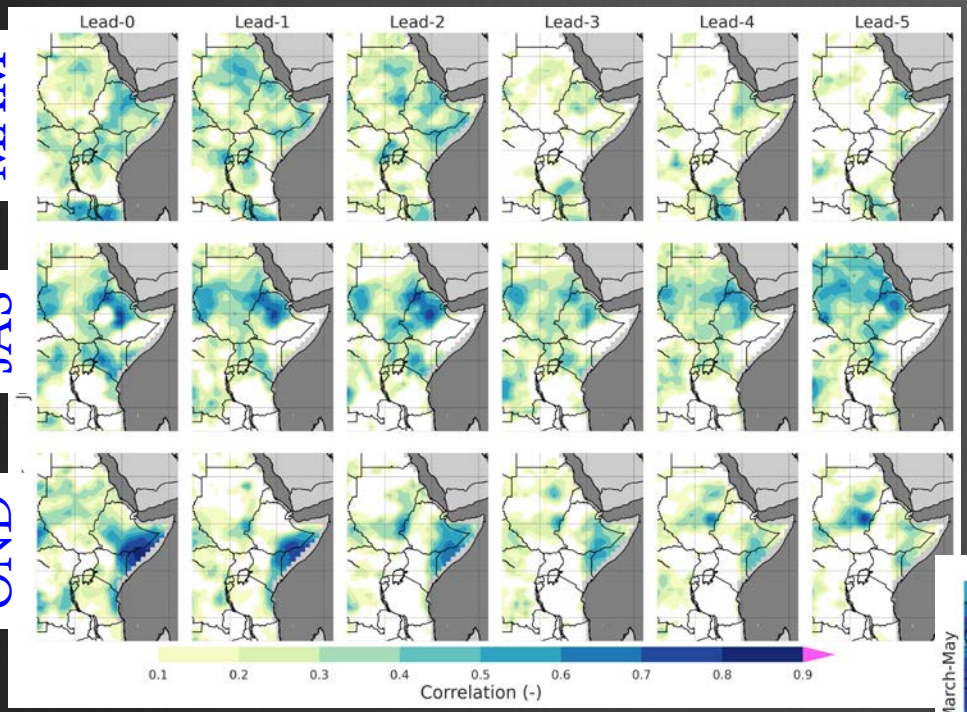
Temperature



The NMME mean in general captures the spatial differences in the climatological mean of both precipitation and temperature. However in general the NMME mean is wetter and colder than the observations.

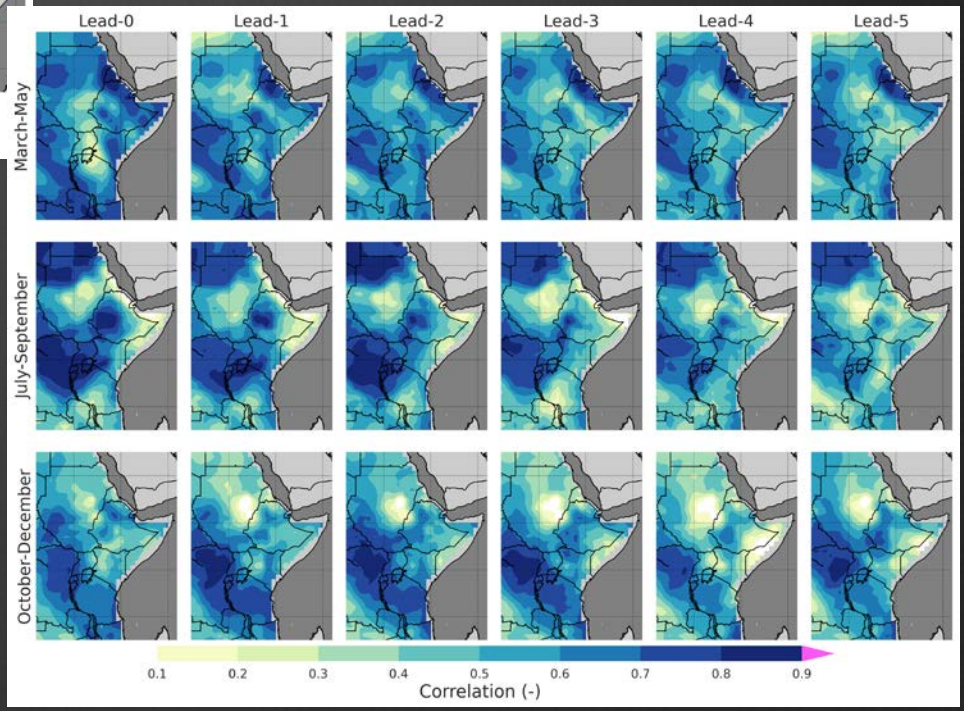
Evaluation of interannual variability

Precipitation



- Precipitation forecast skill in this region is generally limited.
- The temperature forecast skill is generally greater than the precipitation forecast skill and correlation score greater than 0.50 is apparent over a large part of the domain in case of all seasons.

Temperature

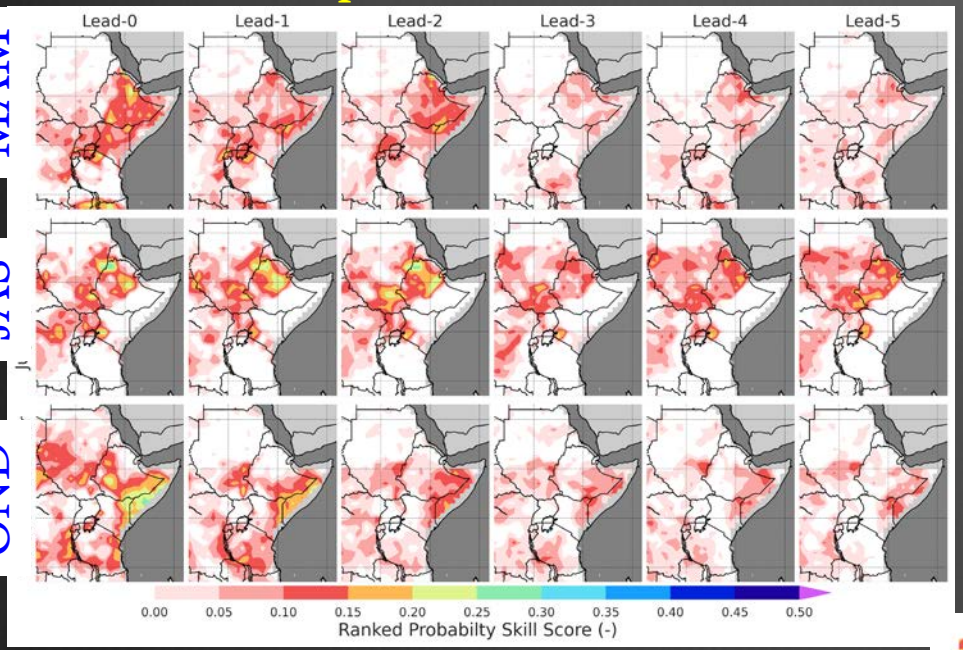


Forecast lead 0 months to 5 months

- In case of precipitation the correlation value is generally the lowest for MAM season and highest for the OND season.

Evaluation of probabilistic forecast

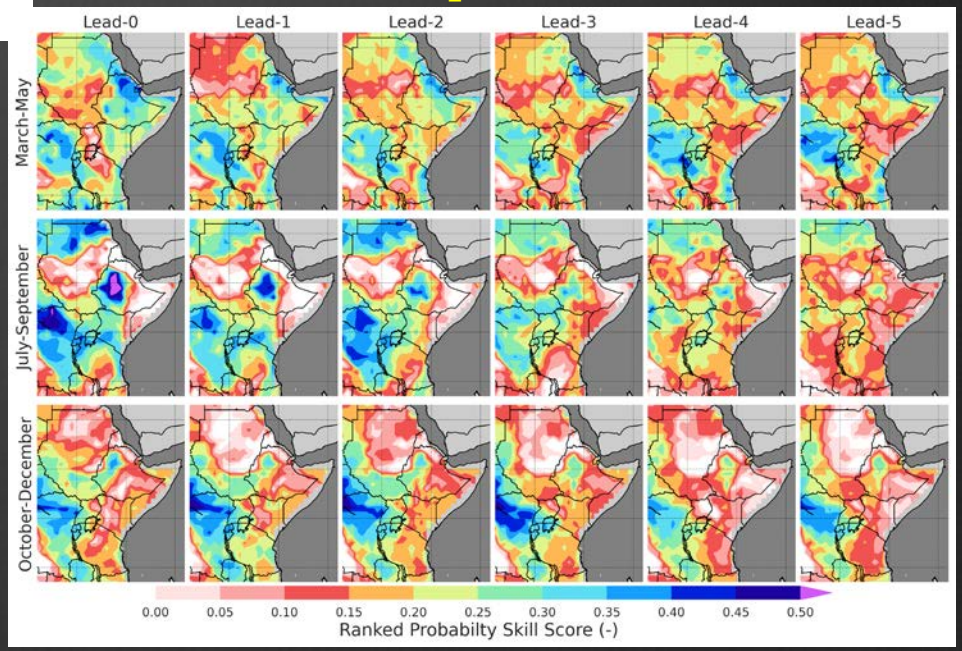
Precipitation



Forecast lead 0 months to 5 months

- The Ranked Probability Skill Score (RPSS) presented here, evaluates the distance between the forecast probability and observed probability.
- The RPSS for temperature is much higher than the precipitation and greater than 0.30 RPSS is apparent over a much larger part of the domain.

Temperature

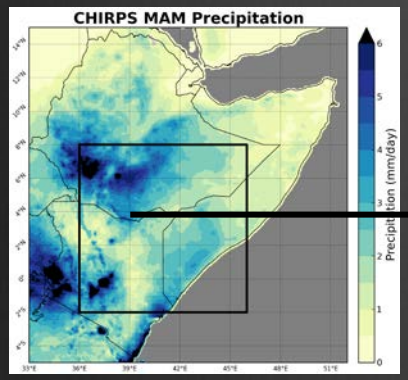


Hybrid approaches to improve precipitation forecast skill in the region

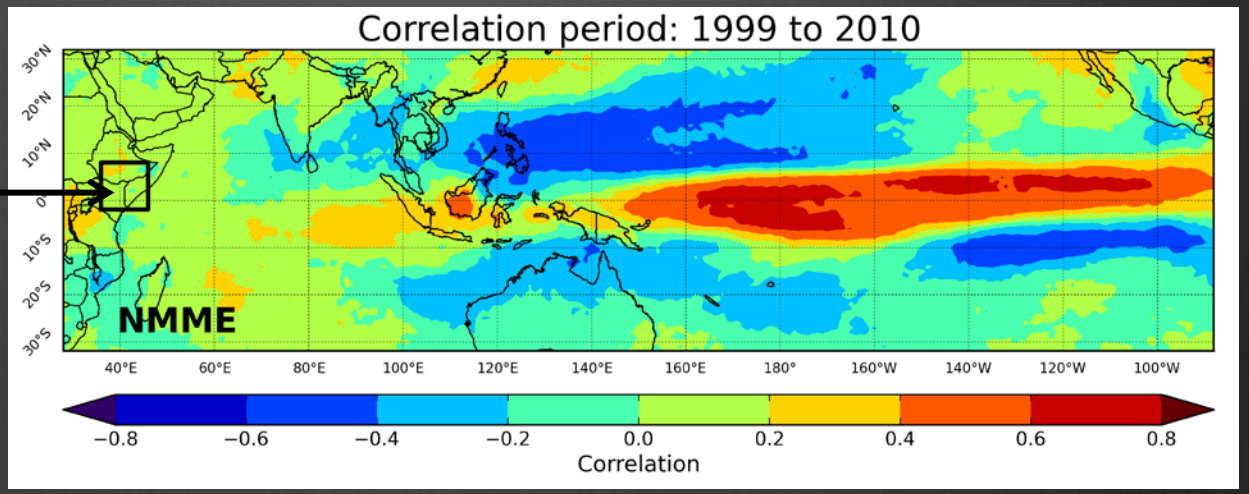
What is a hybrid approach?

- A combination of statistical method and dynamical climate forecasts that harnesses recent teleconnection between EA MAM rainfall over the focus domain and Indo-Pacific Precipitation. Shukla et al., 2014 (HESS) and Shukla et al., 2014 (ERL)
- Thus far only implemented and evaluated for the MAM season and over equatorial East Africa.
- Similar approaches for other seasons and regions are to be explored in future.

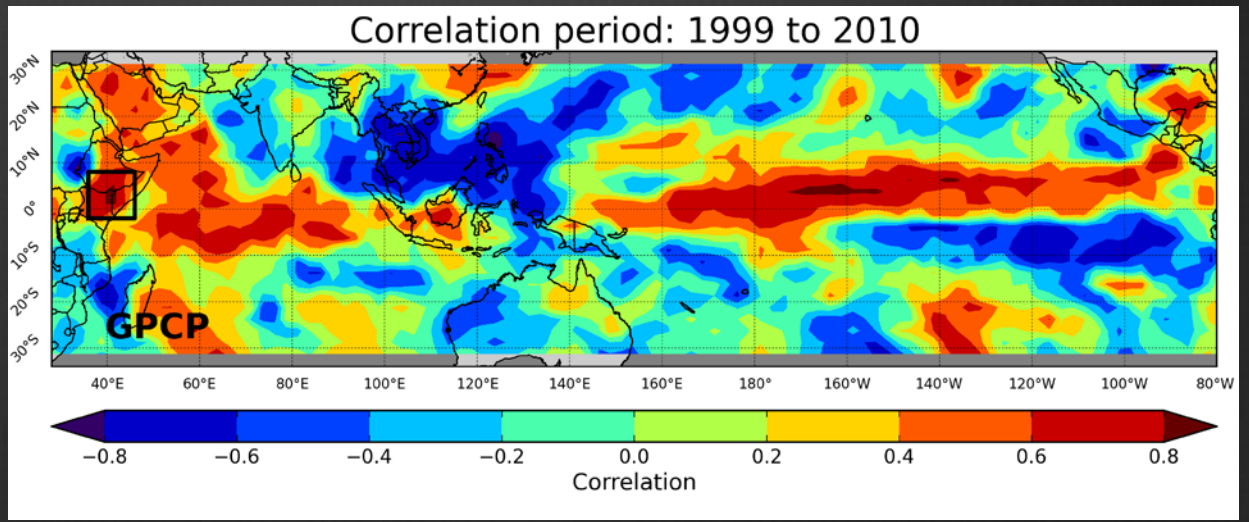
A Hybrid approach



Median of the correlation with each of NMME precipitation forecast superensemble

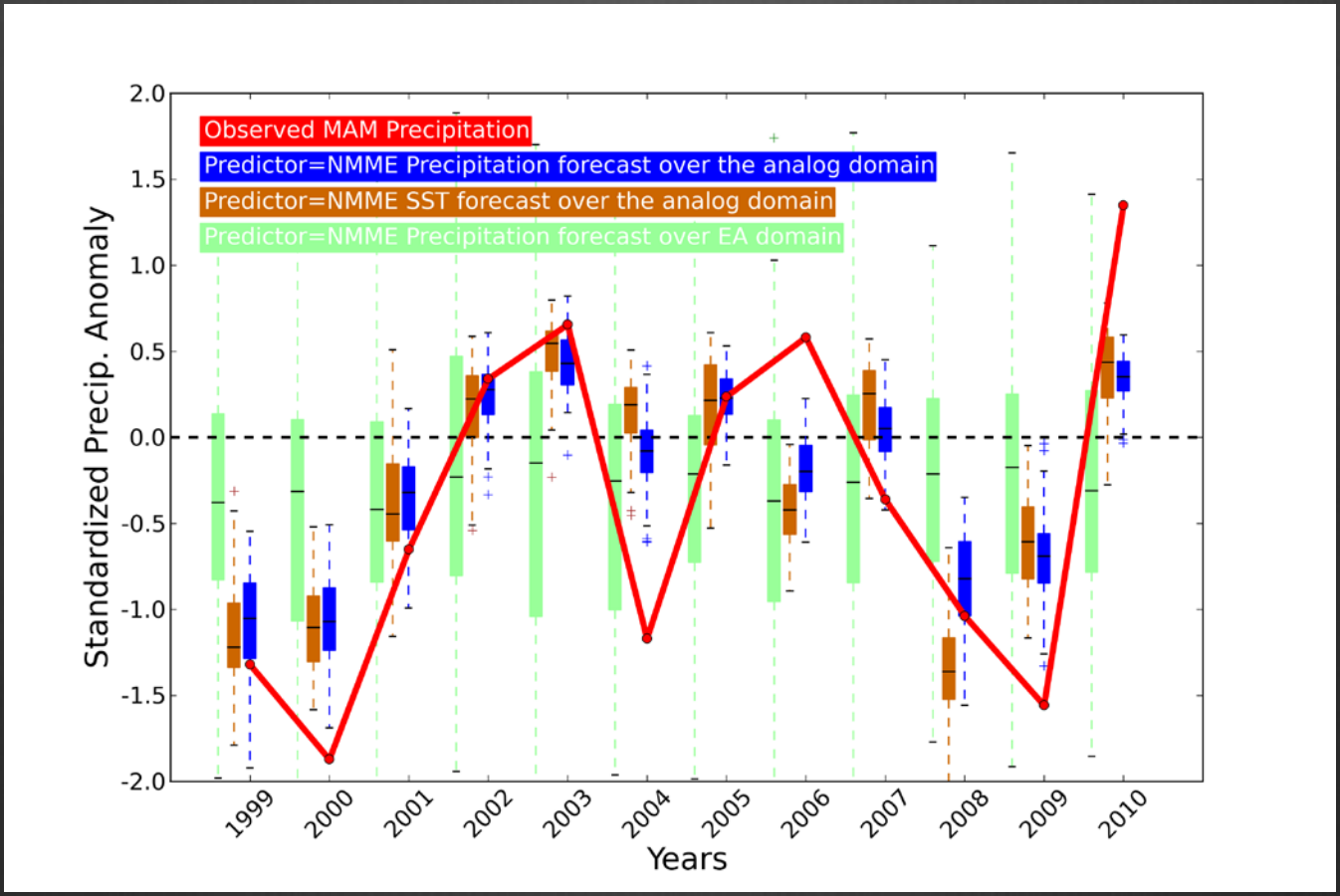


Correlation with GPCP



Shukla et al., 2014 (ERL)

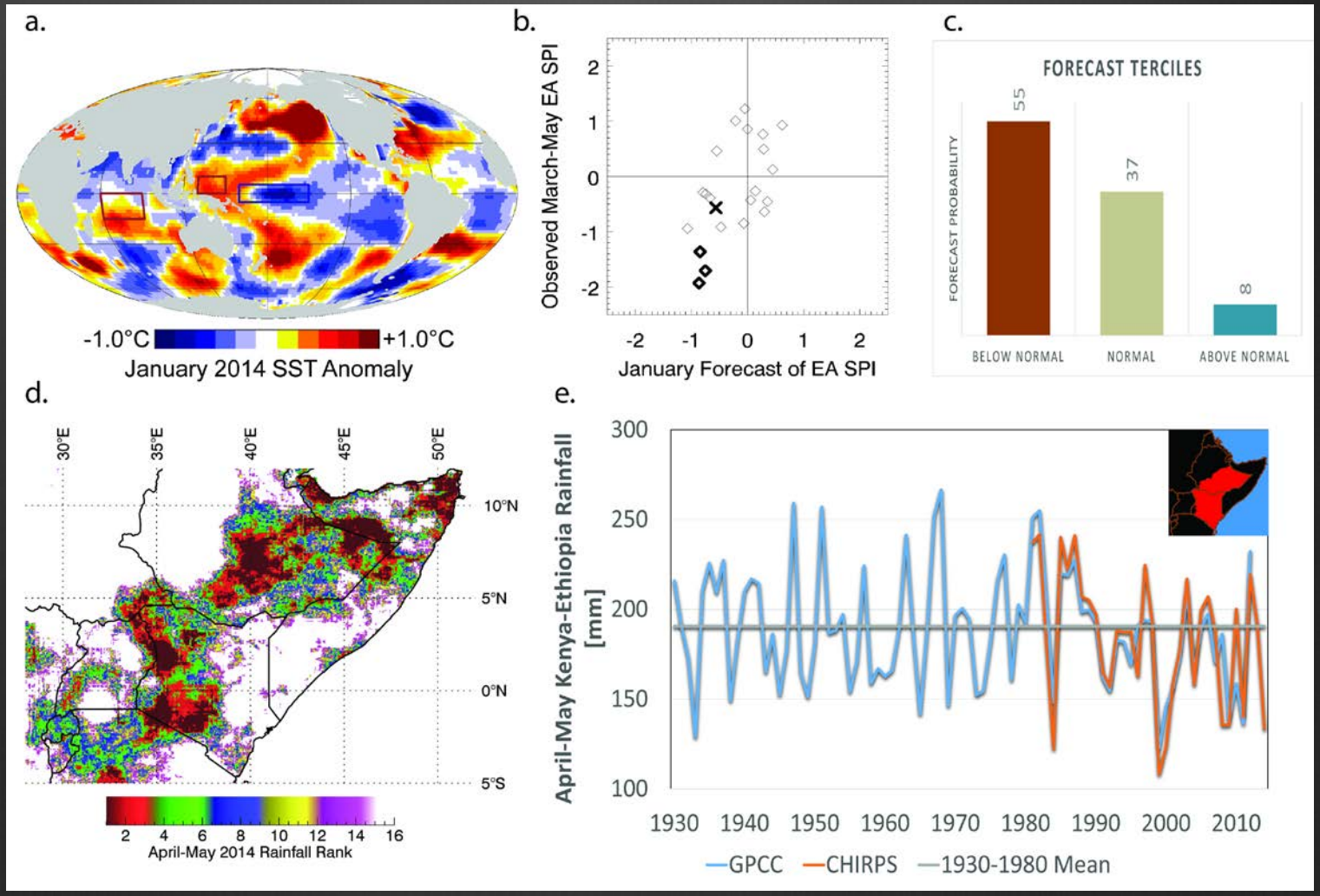
A Hybrid approach



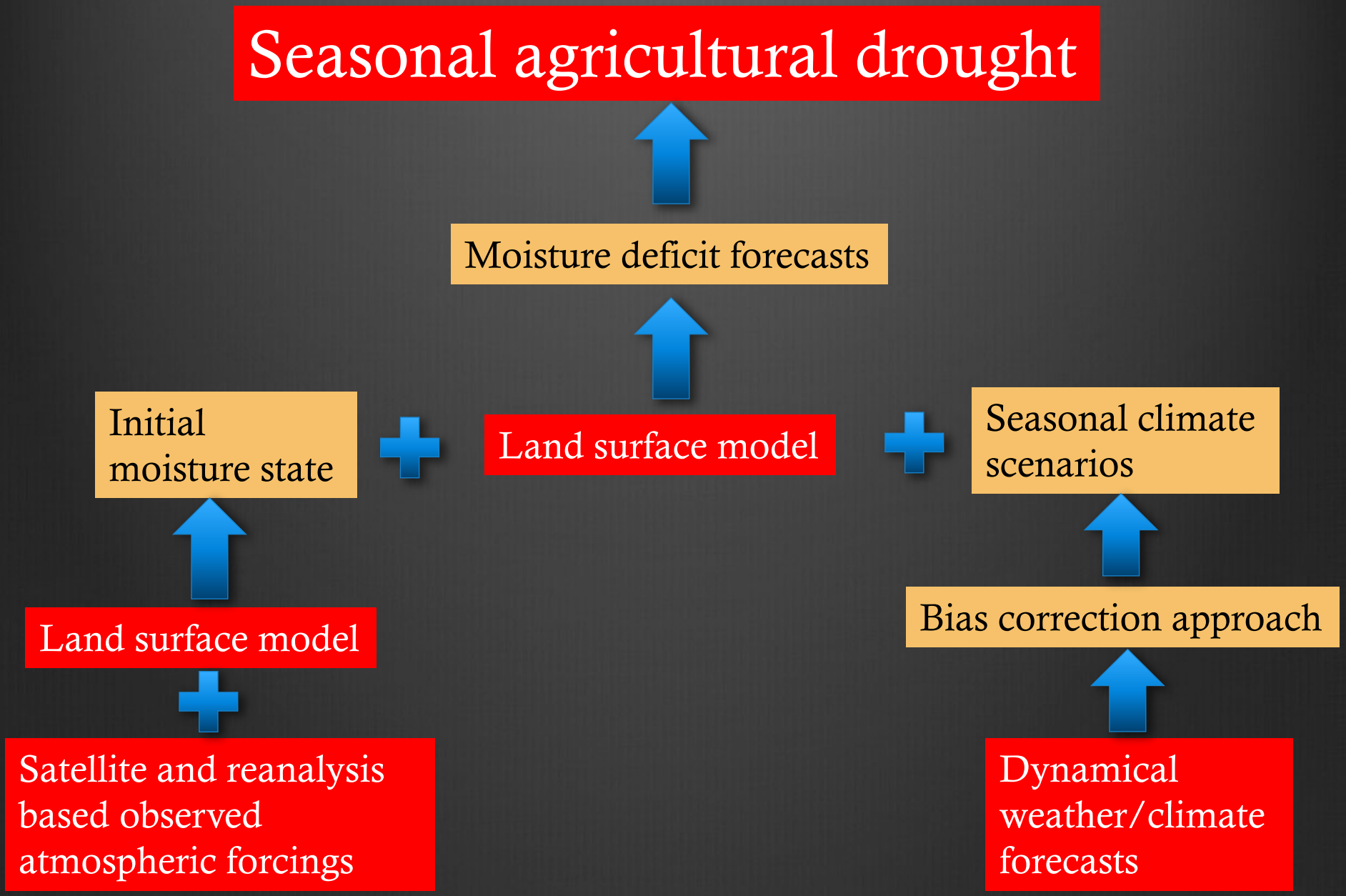
- Large scale predictors (e.g. Indo-Pacific precipitation and SST) result in greater equatorial EA MAM rainfall skill than the local scale predictor.

Another example of a Hybrid Approach

Funk et al., 2014



Implementation and evaluation of a seasonal agricultural drought monitoring and forecasting system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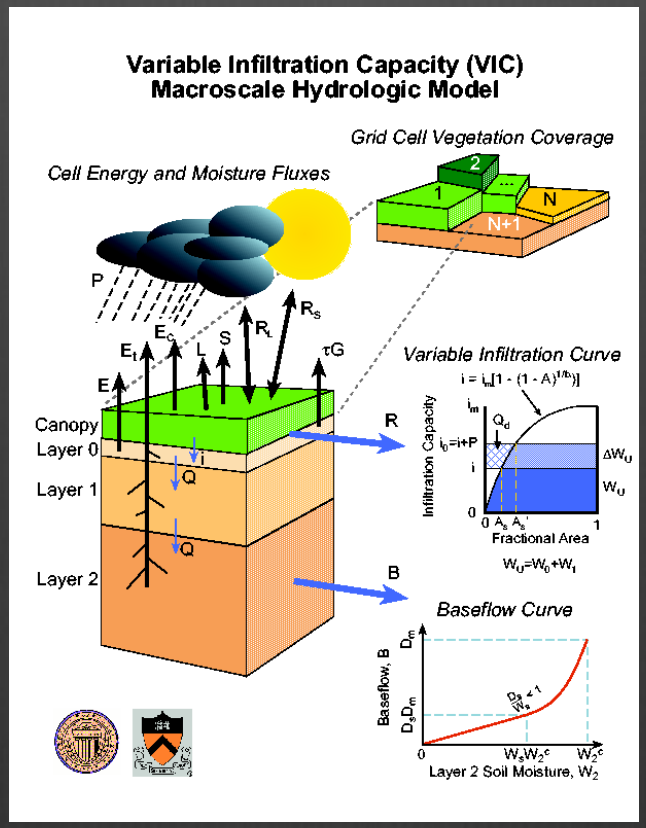
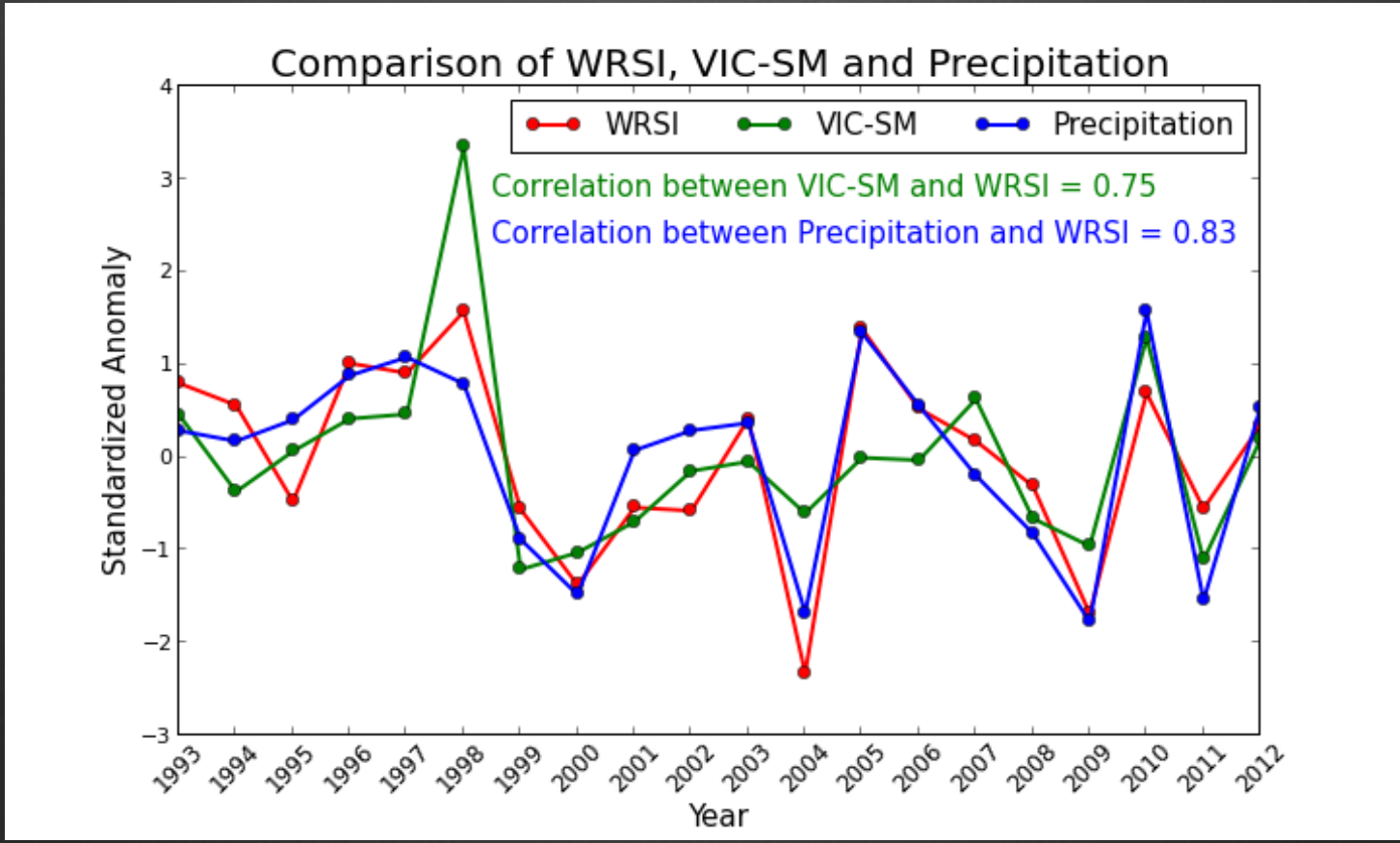
Land Surface Modeling Framework

The Variable Infiltration Capacity Model



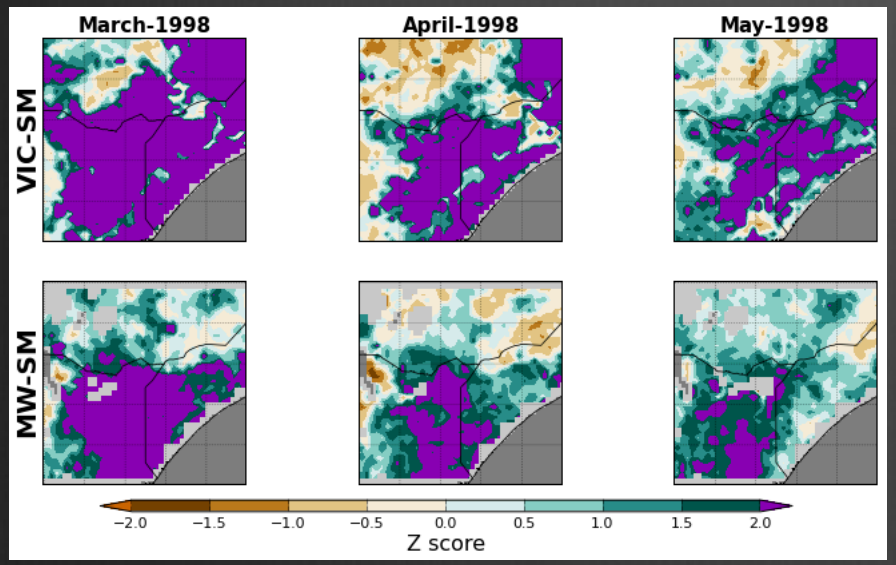
Currently we are using the VIC model for the drought monitoring and forecasting system however the system will be transferred to FEWS NET's Land Data Assimilation System (FLDAS i.e. an instance of NASA's LIS) in coming months.

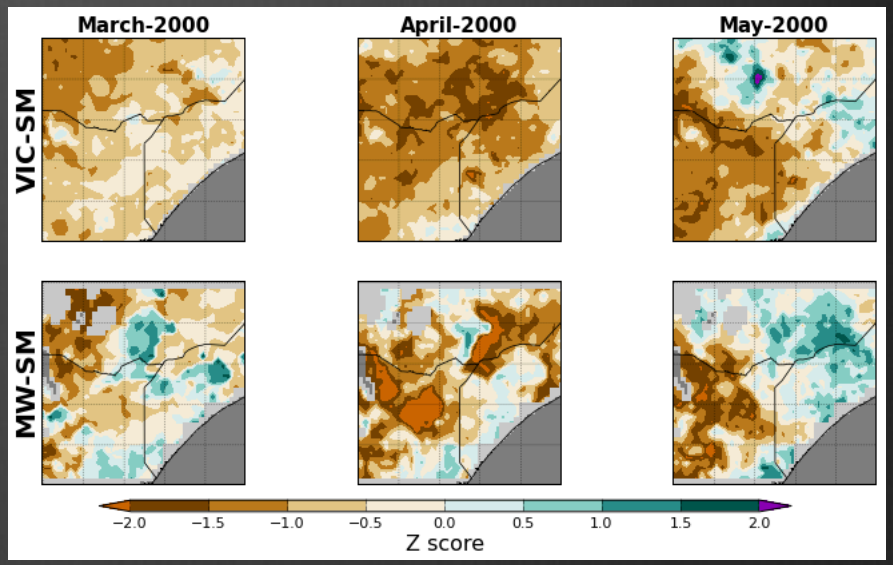
Monitoring



Comparison of MAM precipitation, VIC-soil moisture (VIC-SM) and End-of-Season Water Requirement Satisfaction Index (WRSI) for crop zones in the focus domain for each year between 1993-2012.

Monitoring



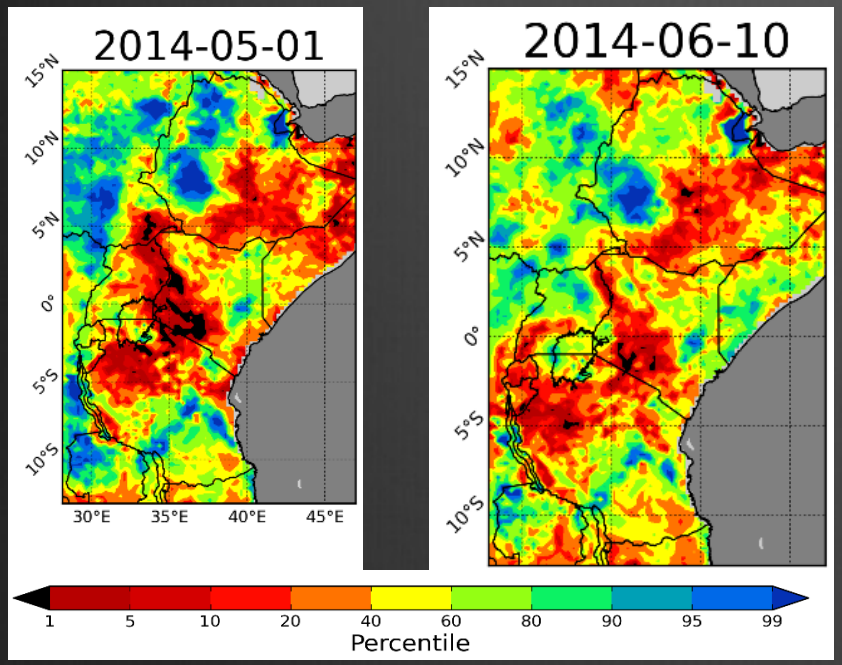


http://www.esa-soilmoisture-cci.org/

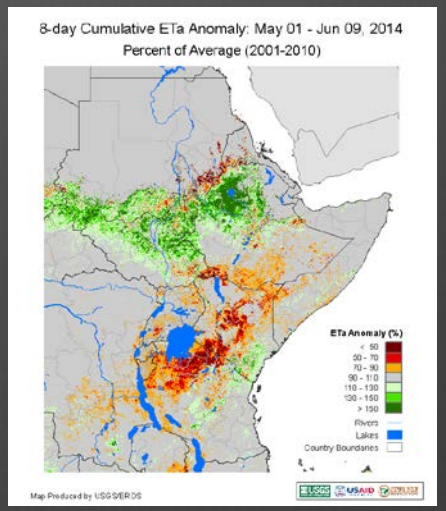
Comparison of VIC-SM with ESA's ECV soil moisture dataset for a wet and a dry years indicate reasonable agreement in both products. Longer terms comparisons have been documented in Mcnally et al., 2015 (*in review*)

March-June 2014

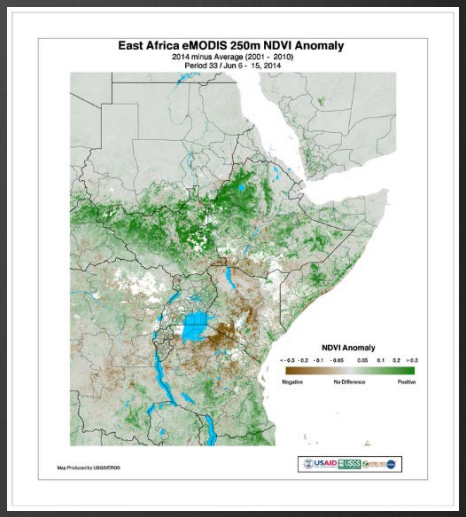
VIC SM percentile



Eta Anomaly

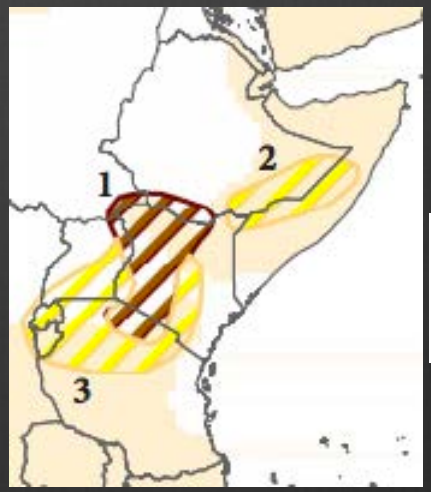


eModis NDVI



http://earlywarning.usgs.gov/

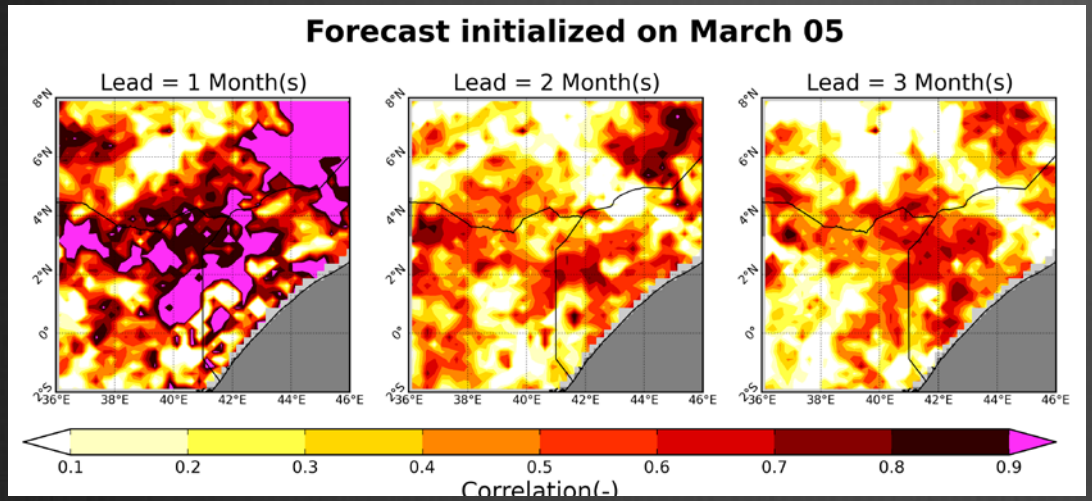
FEWS NET Weather Hazards Summary, June 6-12th, 2014



Flooding
Abnormal Dryness
Drought
Severe Drought

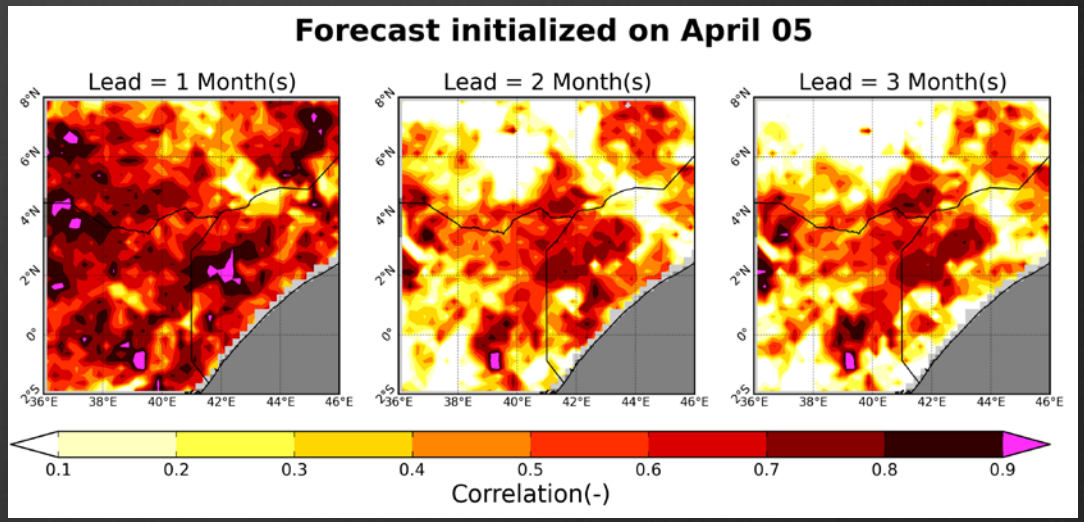
www.fews.net

Forecasts

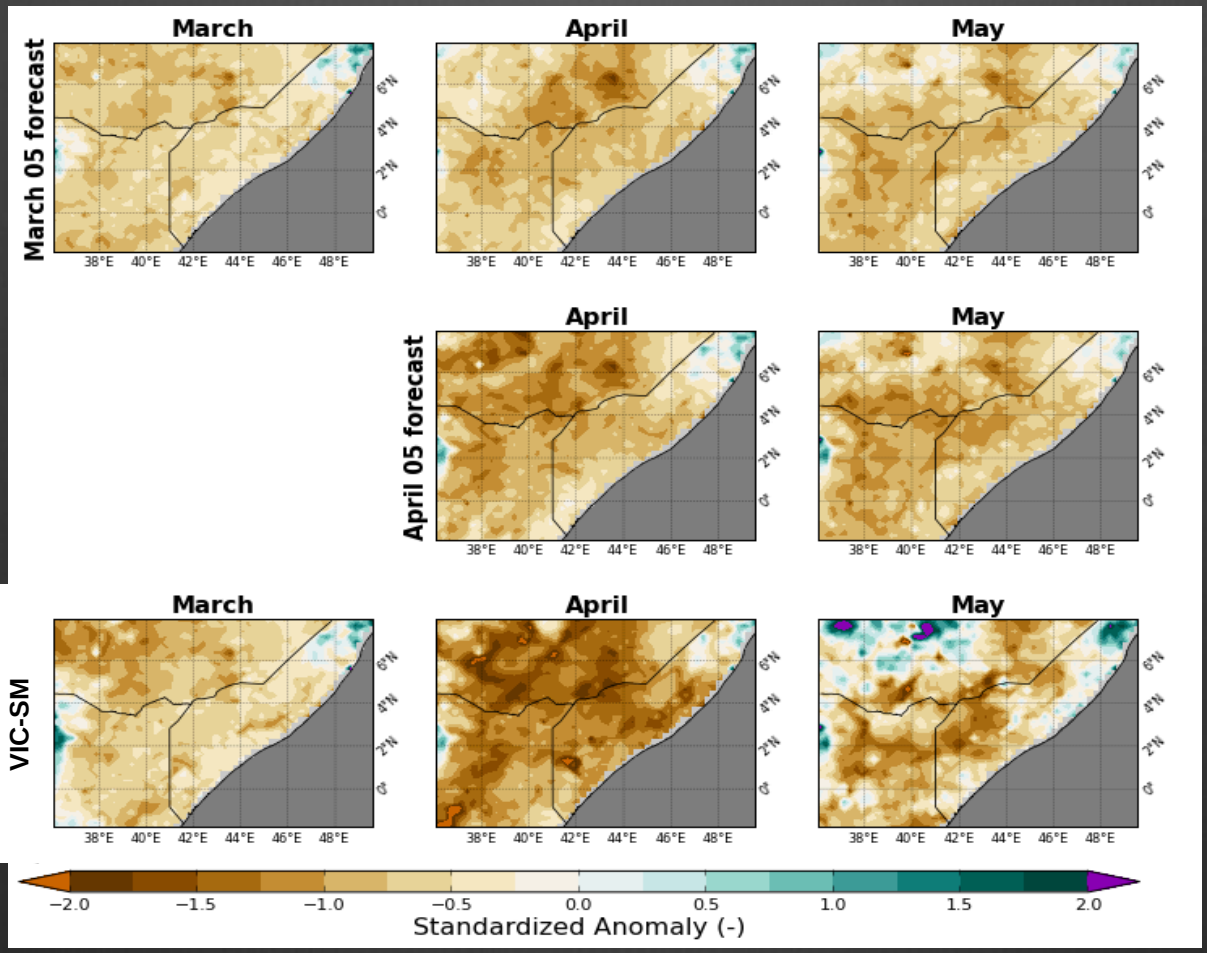


- Correlation between ensemble median SM forecasts (generated using the hybrid approach based climate scenarios) and VIC-SM

- The skill through the rest of the season, is the highest when the SM forecast was initialized in the middle of the season.



2011 MAM Forecast



- The system would have successfully forecasted the 2011 MAM drought as early on March 5th however the drought intensity would have been underestimated (likely due to the small analog sample used to generate climate scenarios)

Concluding Remarks

Concluding remarks

- The NMME precipitation forecast skill in East Africa is limited at best. Temperature forecast is generally much more skillful across the region.
- The hybrid approach proposed in this study results in improved MAM precipitation forecast skill in the region.
- VIC model derived SM values are suitable for providing agricultural drought outlook assessment in the region.
- SM forecasts initialized at the beginning of the season are skillful across the domain at 1-month lead and for some parts over 3-month lead.
- Contribution from the antecedent SM state to SM forecast skill during rest of the season could be most useful when the forecast is initialized in the middle of the season.

Acknowledgement

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For further details see:

Shukla, S., McNally, A., Husak, G., and Funk, C.: A seasonal agricultural drought forecast system for food-insecure regions of East Africa, Hydrol. Earth Syst. Sci. Discuss., 11, 3049-3081, doi:10.5194/hessd-11-3049-2014, 2014.

Shukla S., Funk, C., and Hoell, A.,: Using constructed analogs to improve the skill of National Multi-Model Ensemble March-April-May precipitation forecasts in equatorial East Africa. Enviorn. Res. Lett. 9, 094009. 2014

Funk, C., Hoell, A., Shukla, S., Bladé, I., Liebmann, B., Roberts, J. B., Robertson, F. R., and Husak, G.: Predicting East African spring droughts using Pacific and Indian Ocean sea surface temperature indices, Hydrol. Earth Syst. Sci., 18, 4965-4978, doi:10.5194/hess-18-4965-2014, 2014.

Shukla, S., Roberts, J., Hoell, A., Funk, C., and Robertson F.: Assessing North American Multi-model Ensemble (NMME) Seasonal Forecast Skill to Assist in the Early Warning of Hydrometeorological Extremes over East Africa. BAMS (to be submitted)

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Thank you!