Assessing the Hydrologic Vulnerability and Adaptive Capacity at the Regional Scale from Space

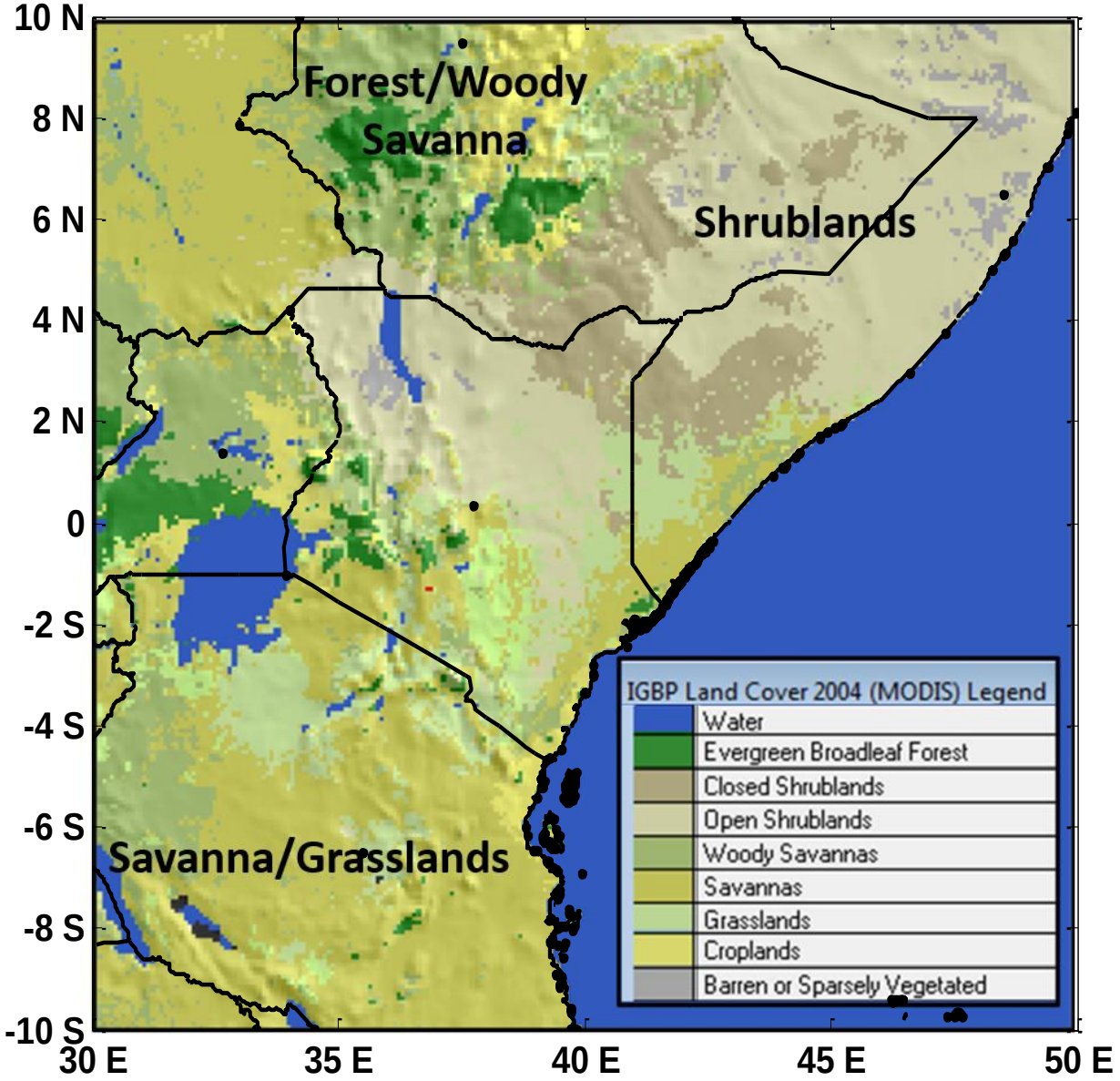
Dimitrios Stampoulis
Water & Carbon Cycles, Jet Propulsion Laboratory

- Study area: East Africa (10N-10S/30E-50E)
- Investigated period: 2003-2011
- Data used:
  - TRMM 3B42 V7 (daily precipitation/0.25 deg)
  - WindSat Vegetation Water Content (VWC) & Soil Moisture (SM) (daily/25 km EASE grid)
  - AVHRR Smoothed NDVI (7-day/~16 km)
  - MODIS IGBP 2004 Land Cover

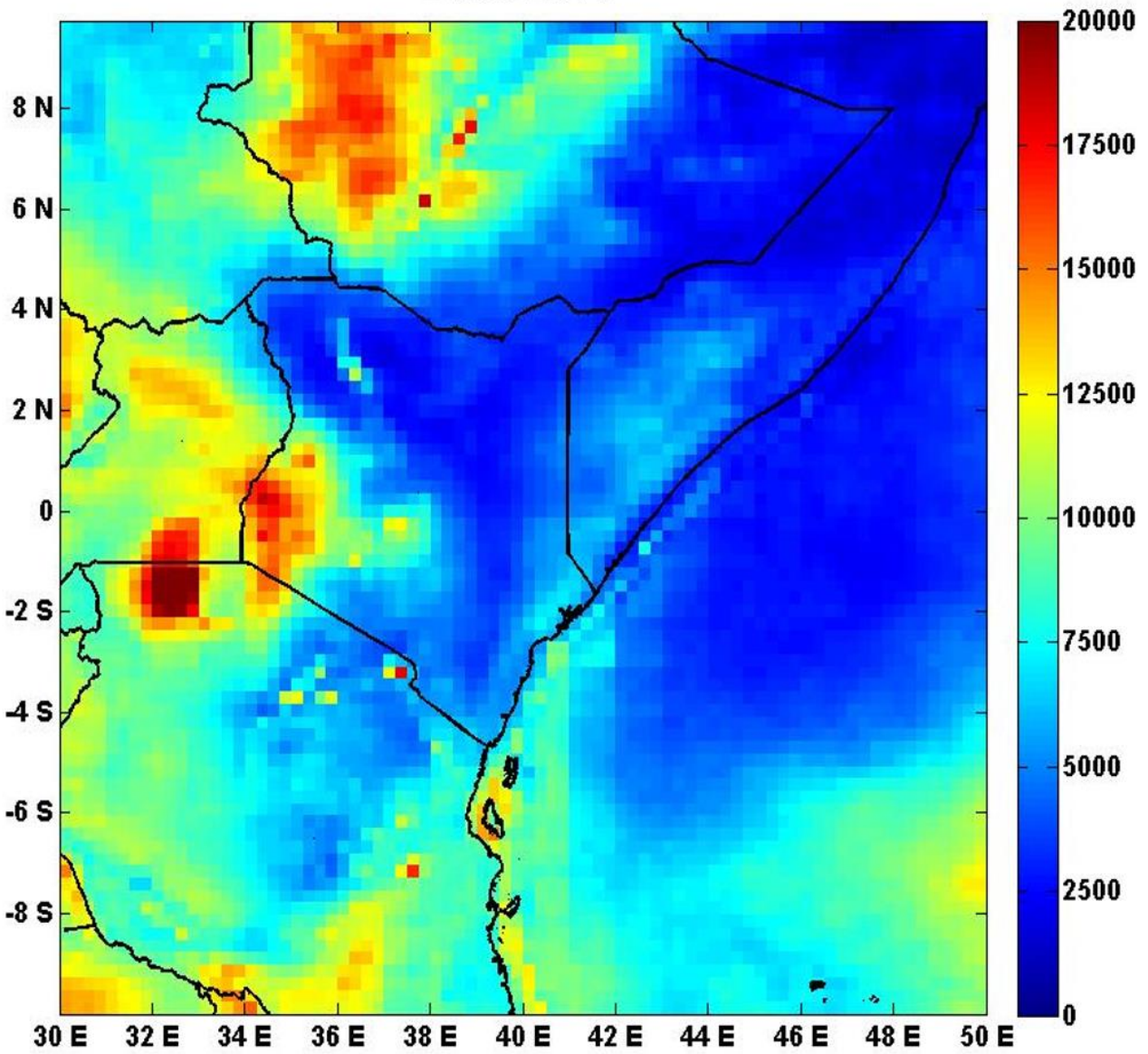
Land of extreme contrasts

Complex hydro-climatic profile

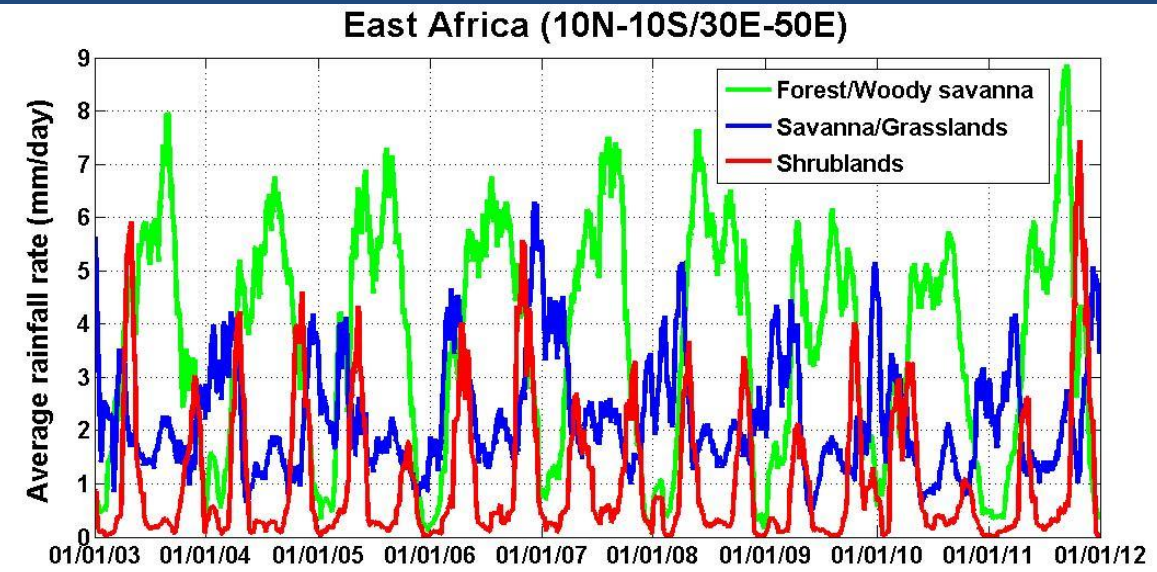
Land-cover classification in East Africa

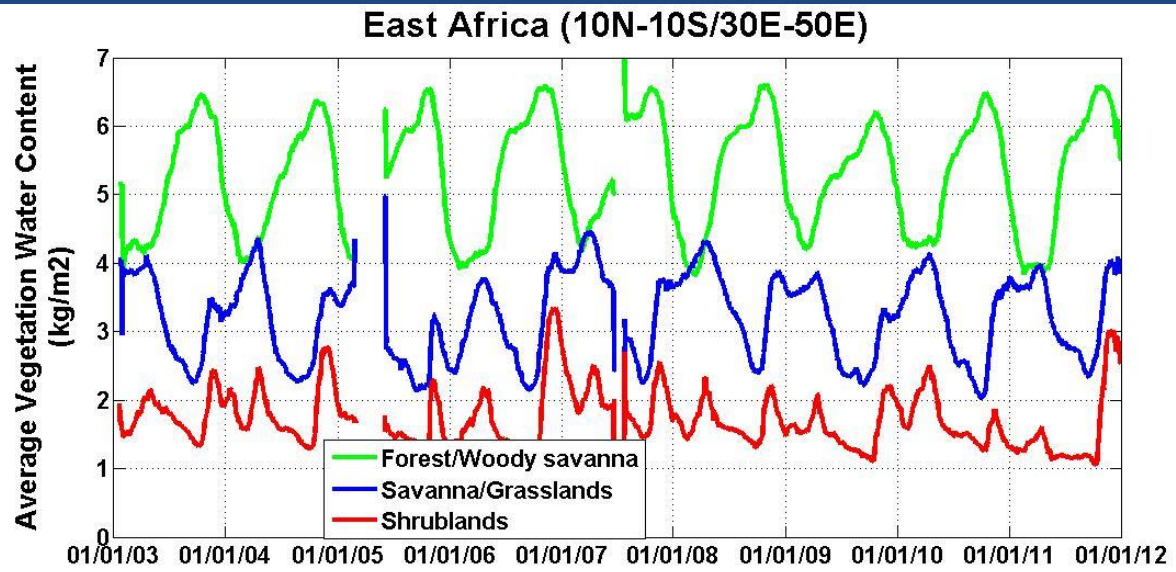


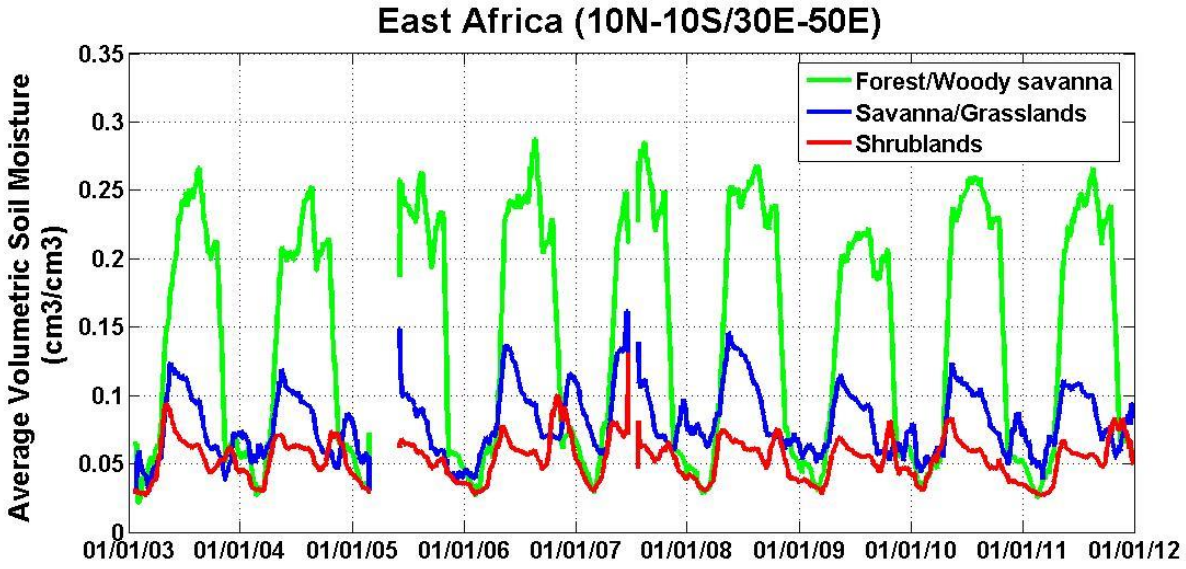
TRMM 3B42 V7 accum. rainfall (mm) 2003-2011

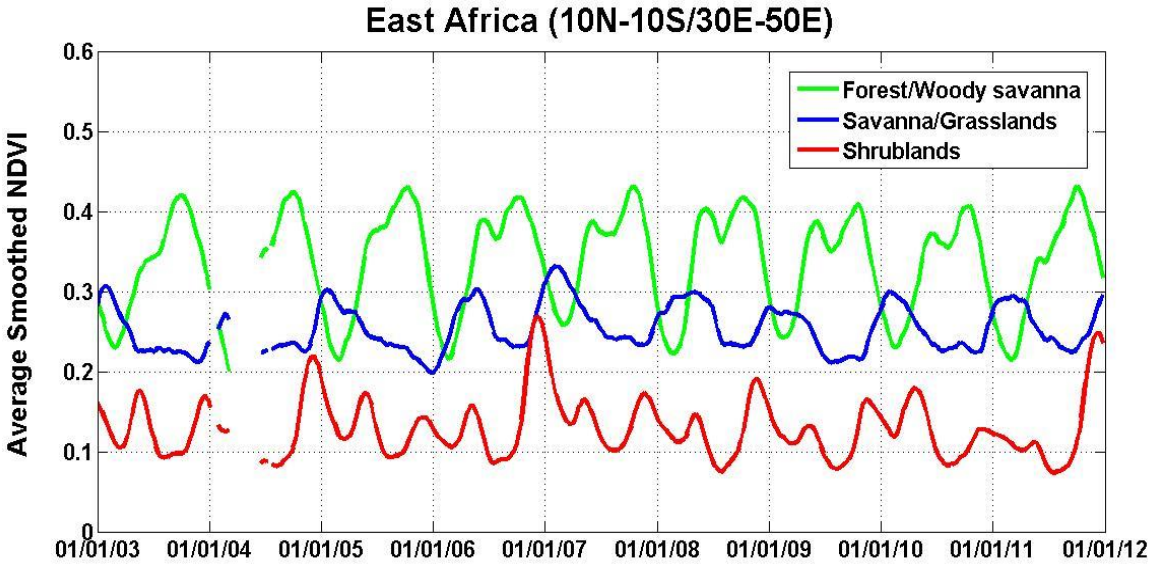


Qualitative assessment of the hydrologic properties of East Africa's major vegetation regimes

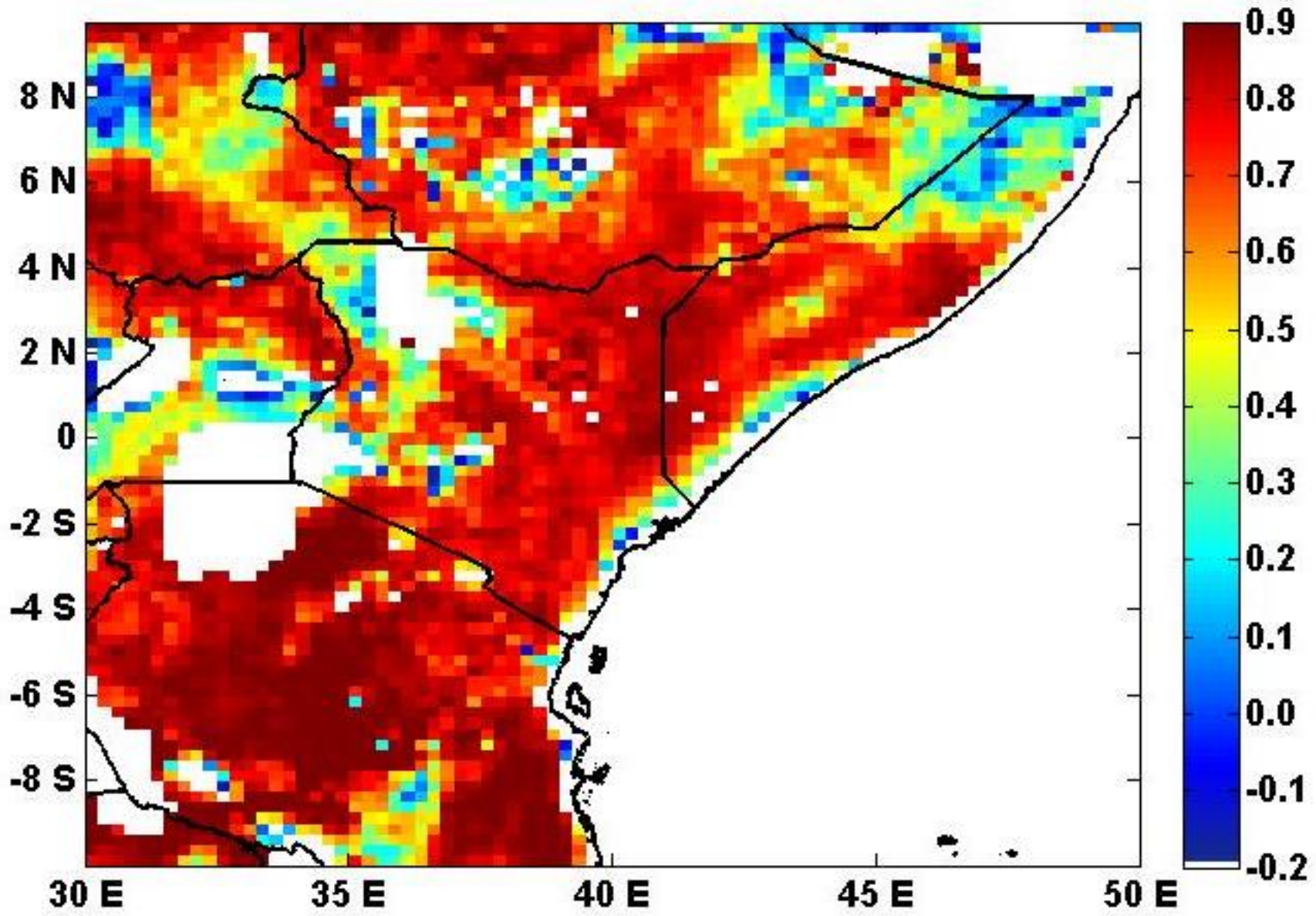






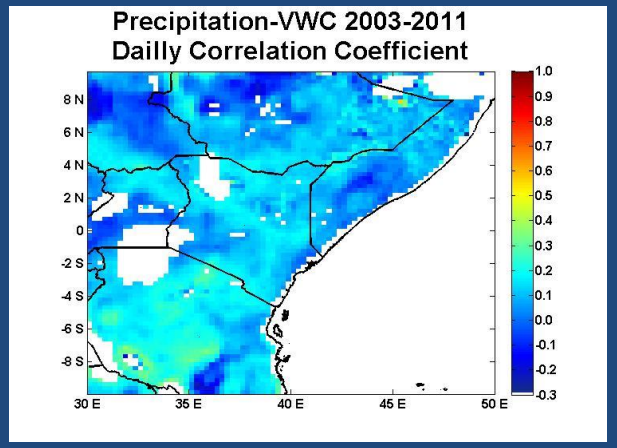


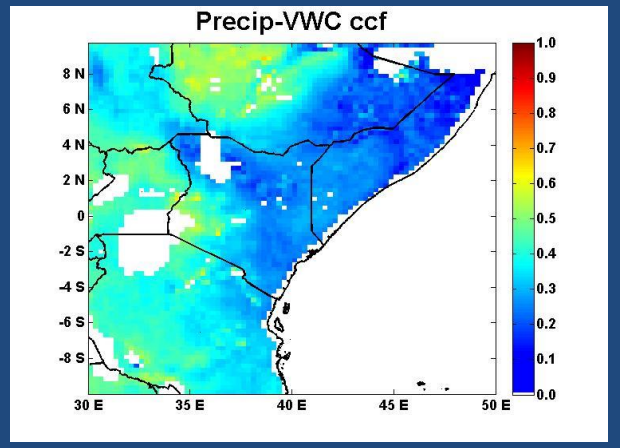
VWC-Smoothed NDVI Correlation Coefficient 2003-2011

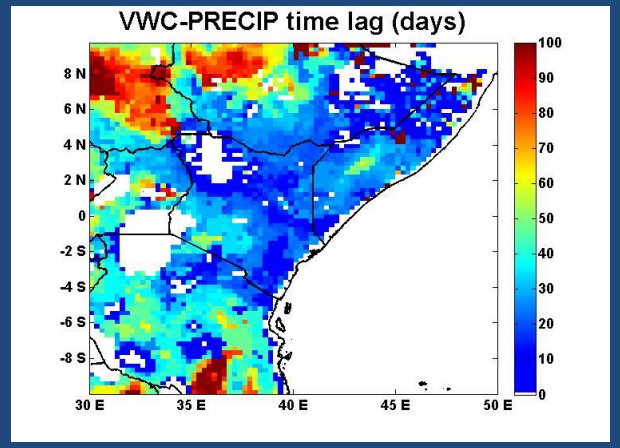


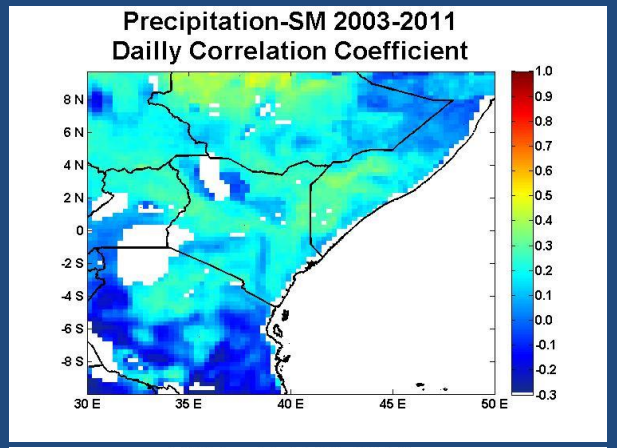
Correlation coefficient between each pair of area-average daily time series of the investigated hydrologic variables for each of the major land-cover categories in East Africa.

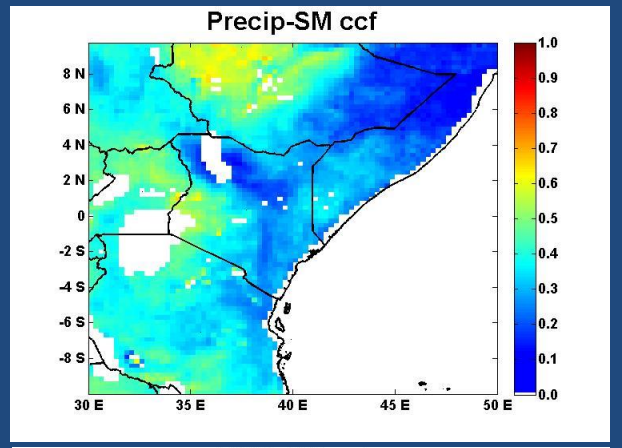
Correlation coefficient	Precip-VWC	Precip-SM	VWC-SM
Forest/Woody Savanna	0.37	0.86	0.55
Savanna/Grasslands	0.55	-0.15	-0.05
Shrublands	0.41	0.58	0.30

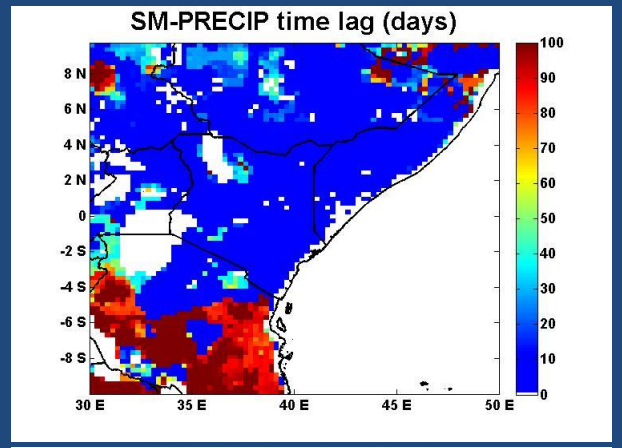


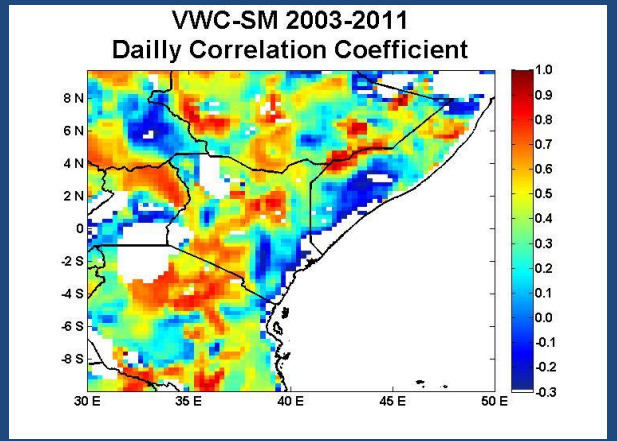


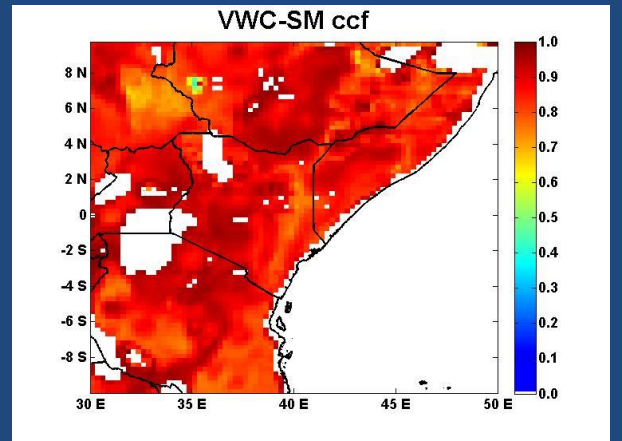


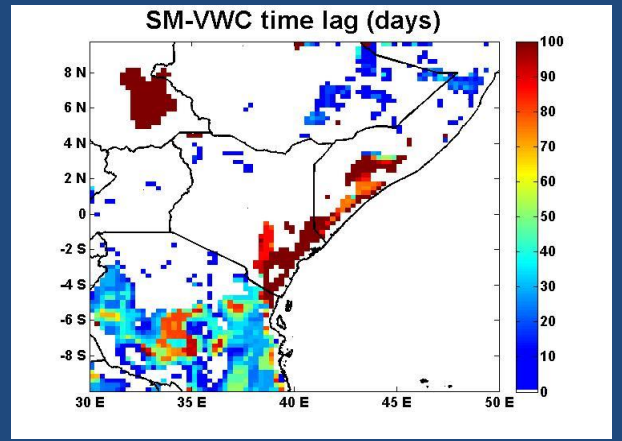










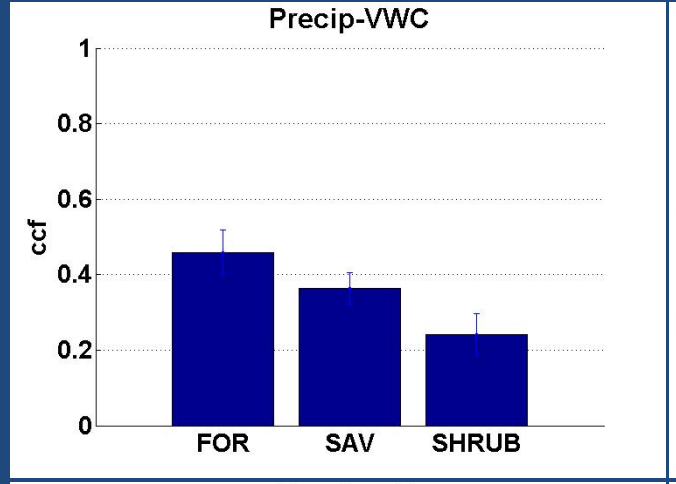


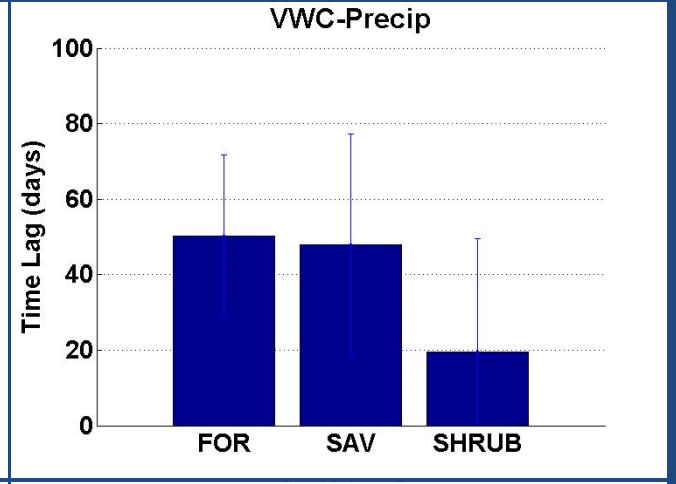
Left column: **daily correlation coefficient (cc)**

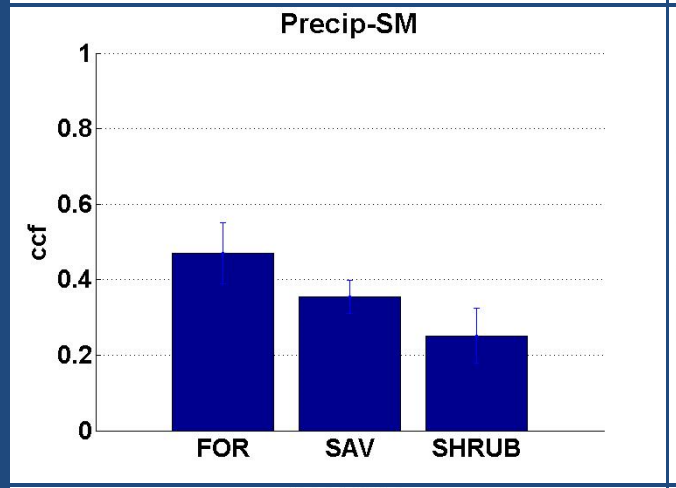
Middle column: **max cc** calculated from cross correlation function

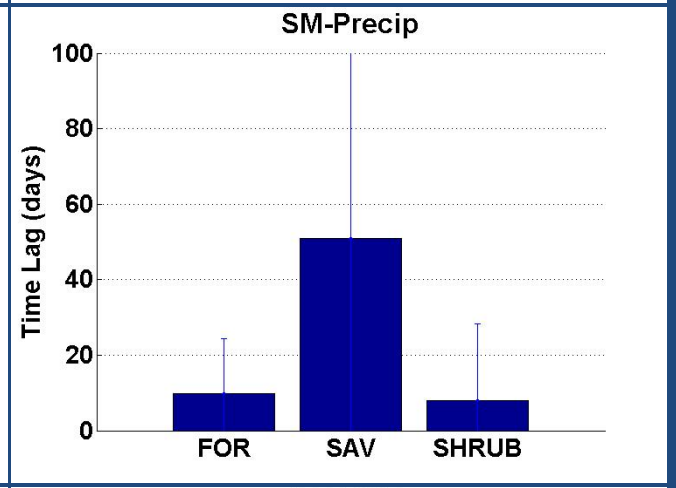
Right column: **time lag** at which max cc occurs

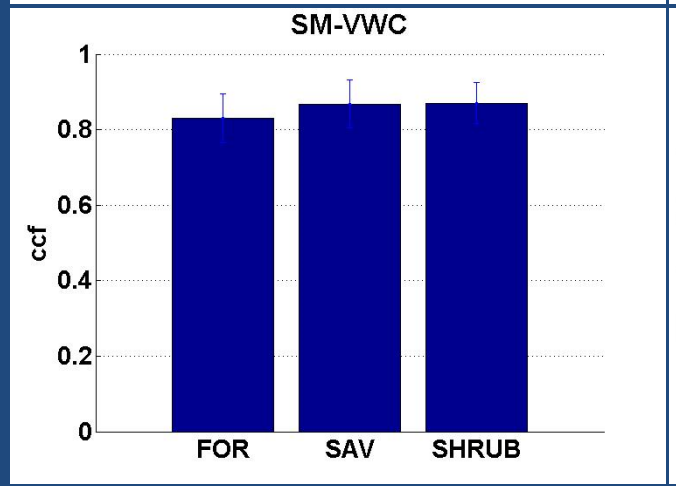
Low correlations and high spatial variability of the time lags → Multitudinous climatological landscape of the region

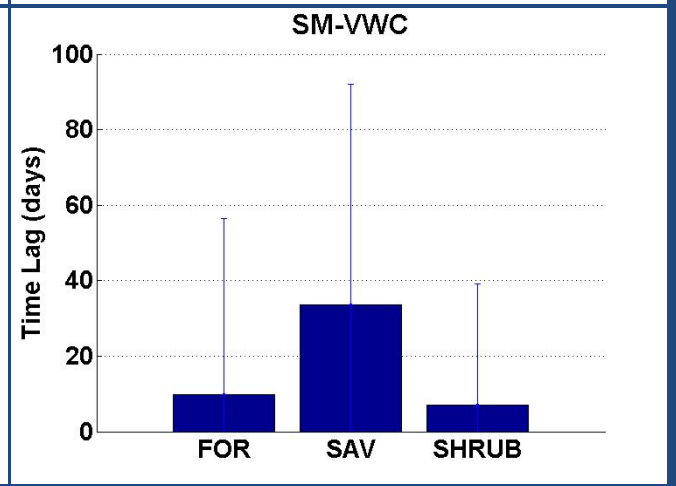








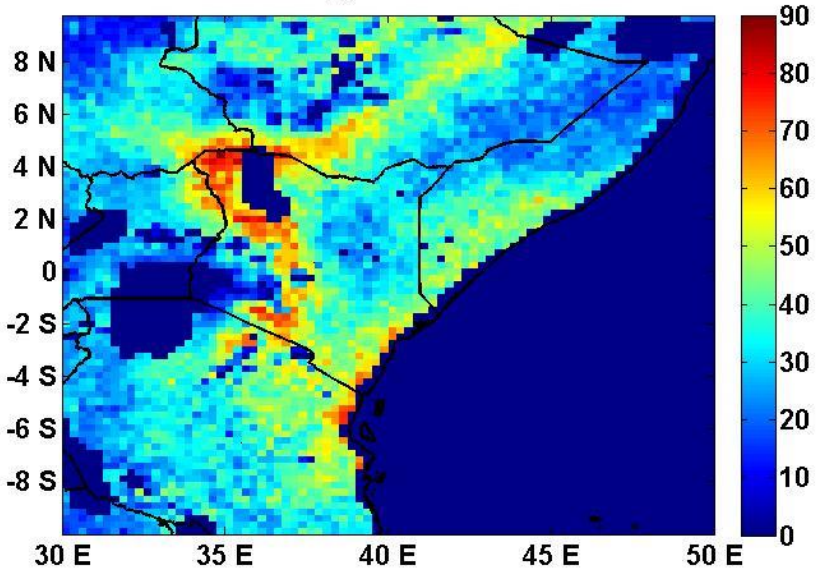




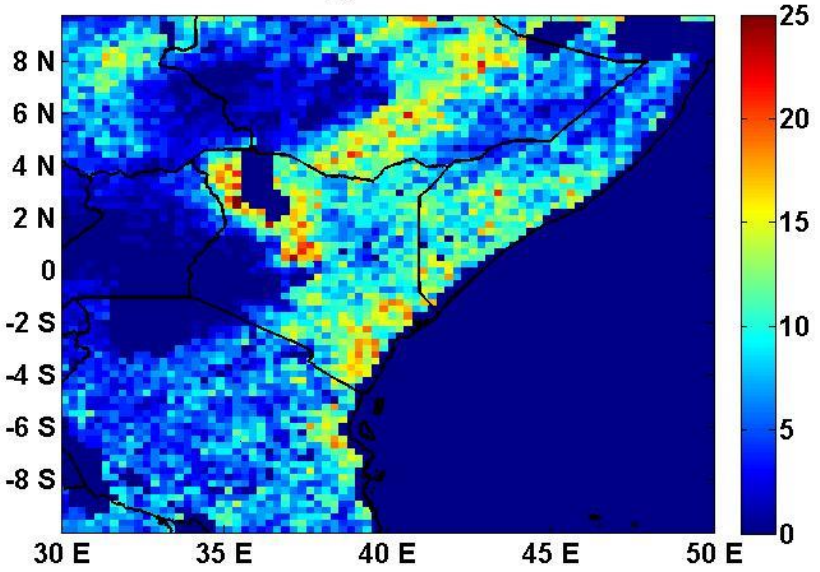
Investigating the complex inter-relations among the various components of the natural ecosystems of the region

Cross-correlations (max. correlation coefficients) along with the corresponding time lags for each vegetation regime

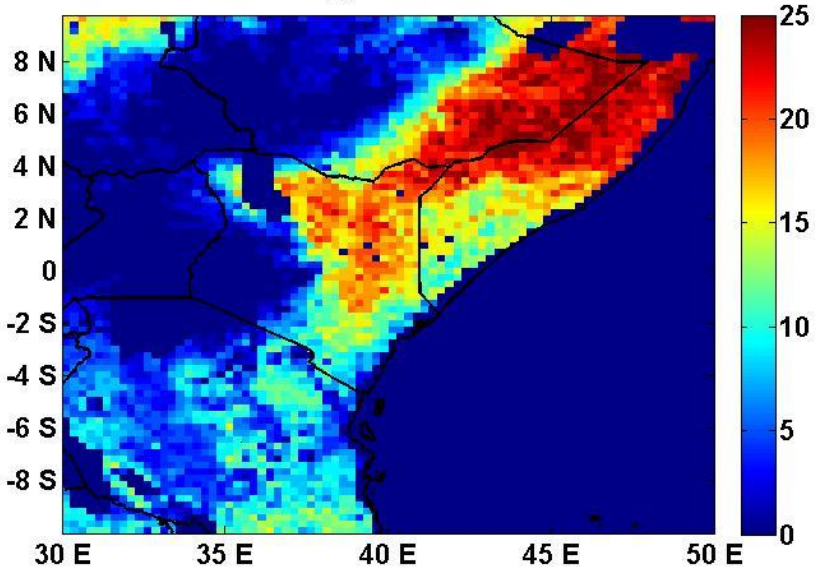
Number of dry spells (duration: 10-30 days) during 2003-2011

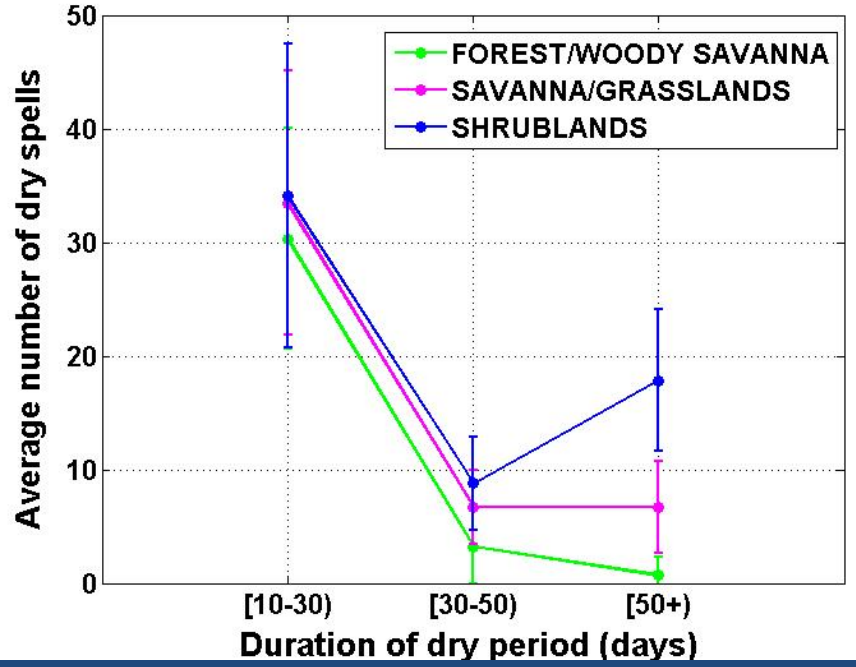


Number of dry spells (duration: 30-50 days) during 2003-2011



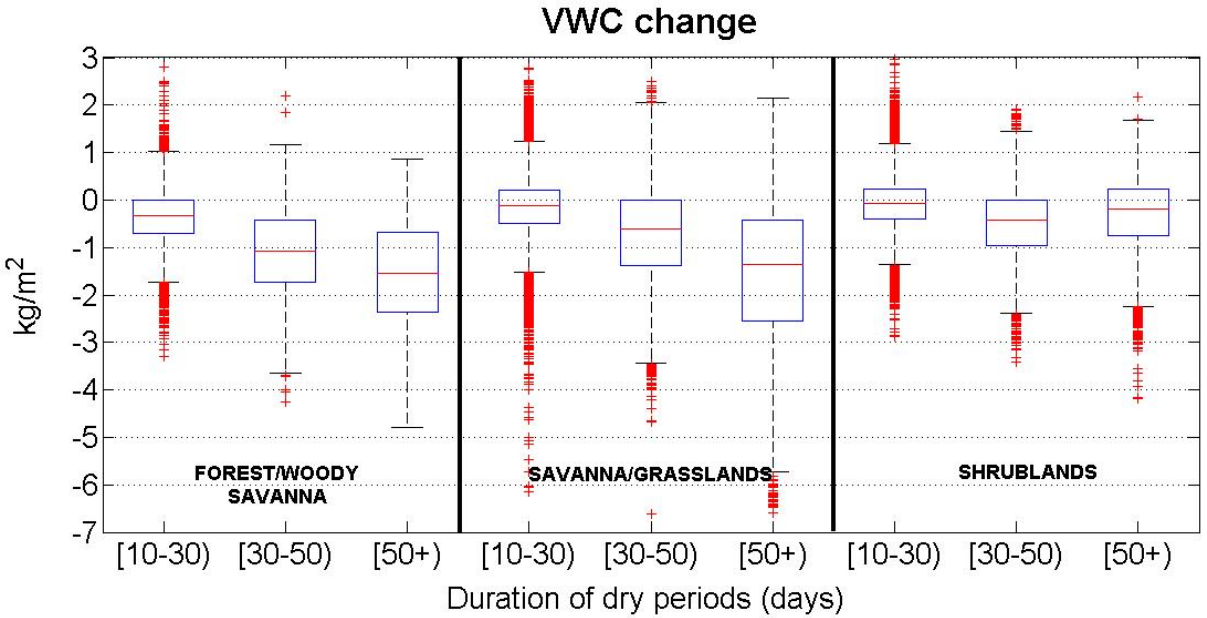
Number of dry spells (duration: 50+ days) during 2003-2011

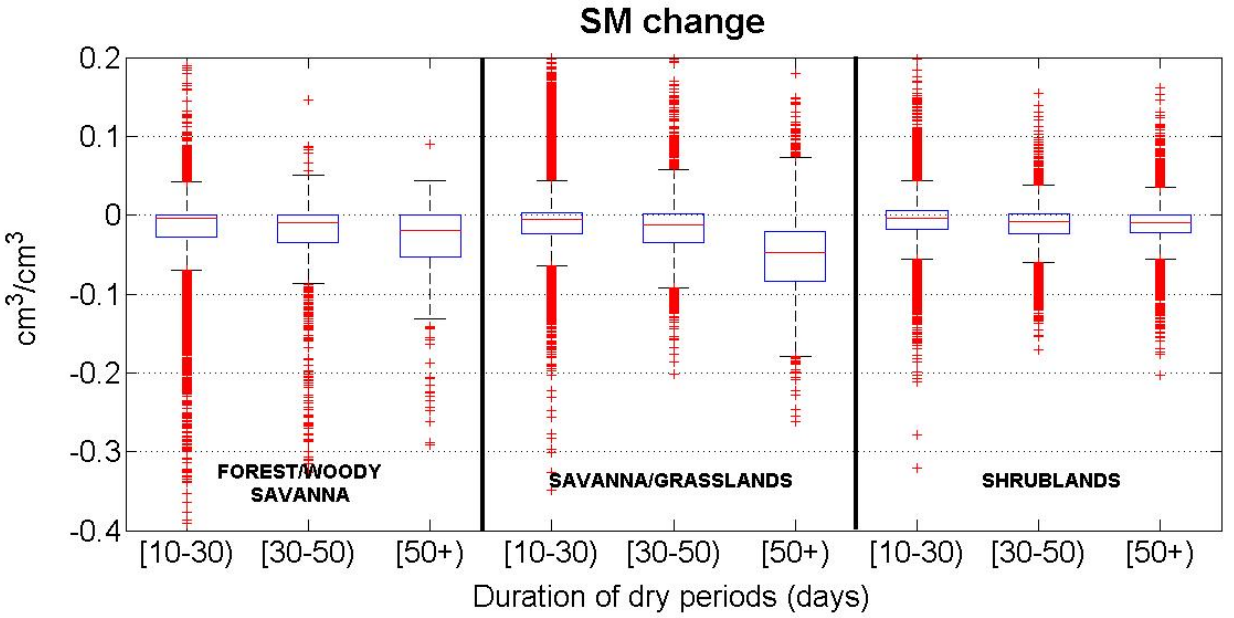


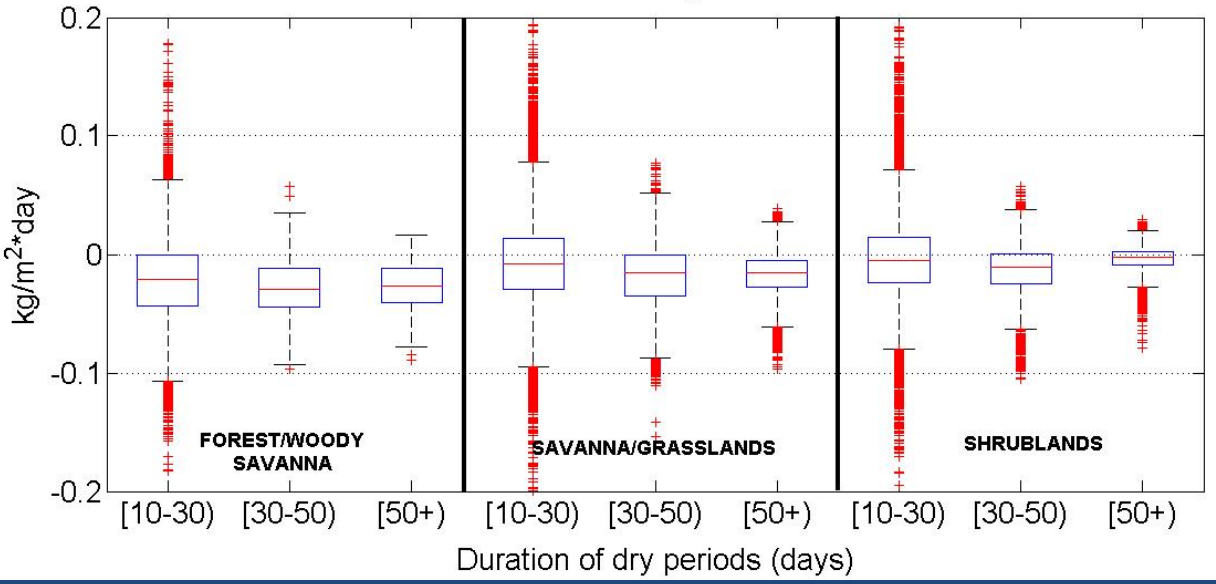


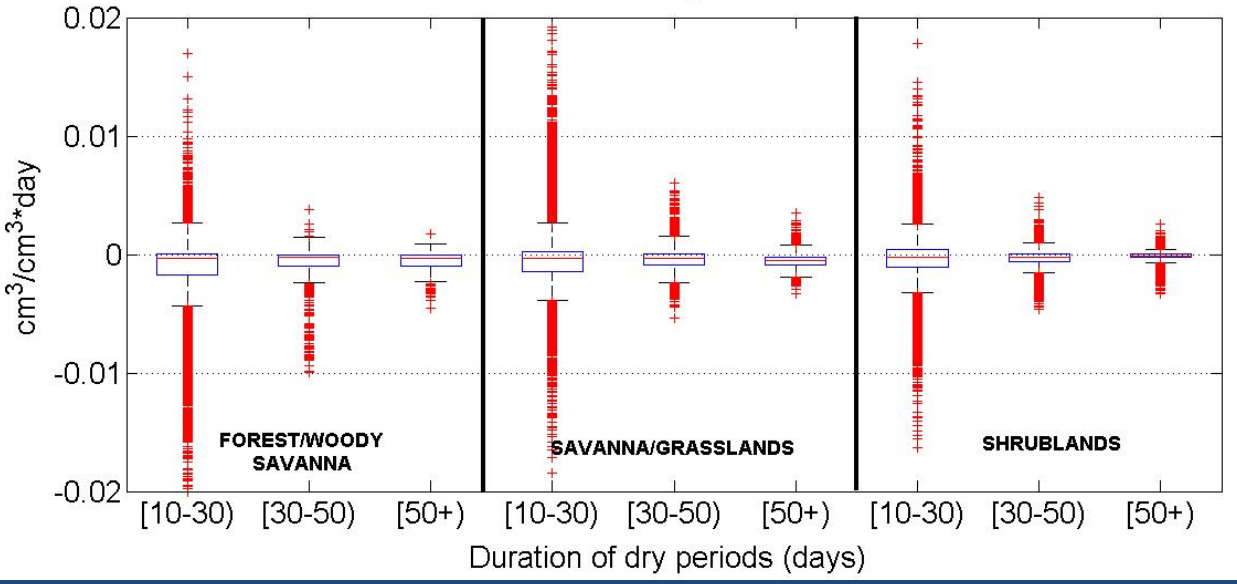
Identifying periods of extreme hydrologic conditions (droughts) within the period 2003-2011

Quantitative assessment of VWC and SM response during dry spells

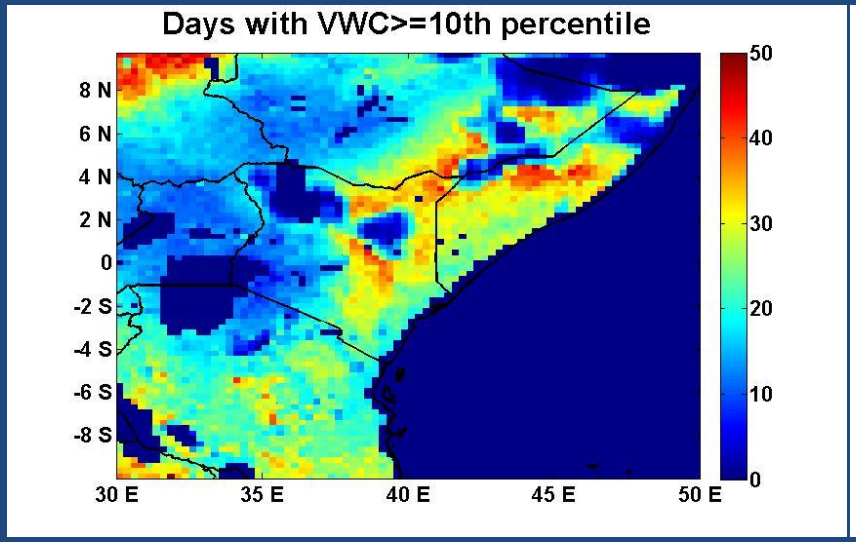


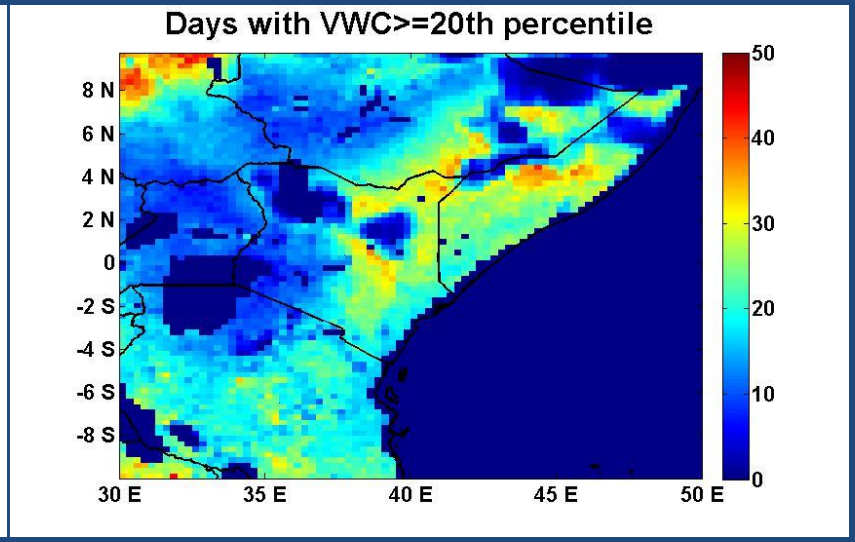


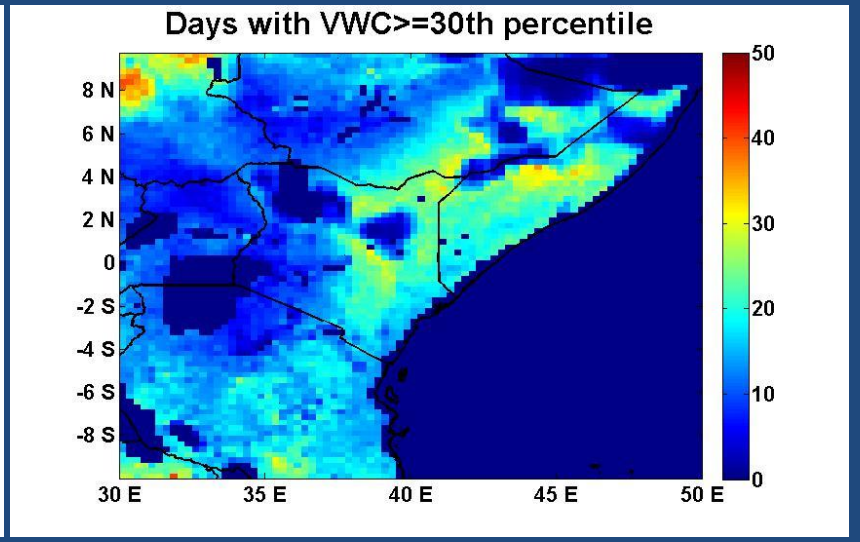


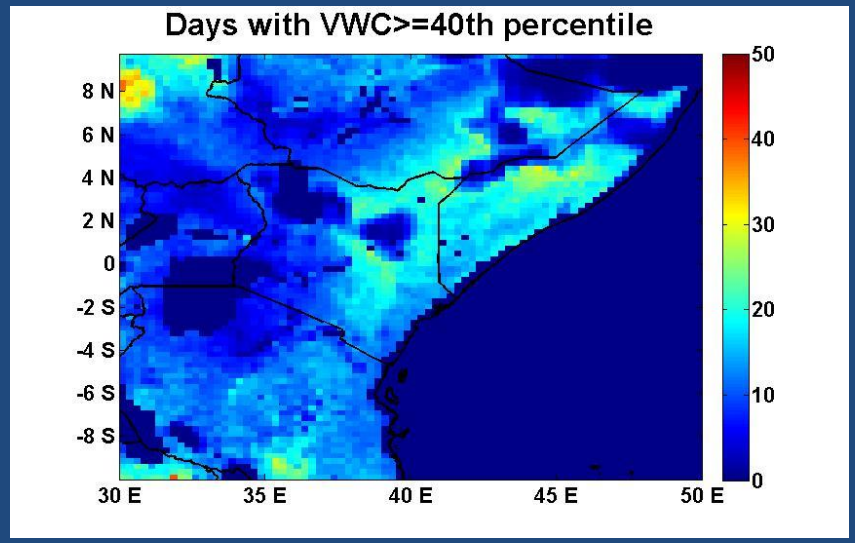


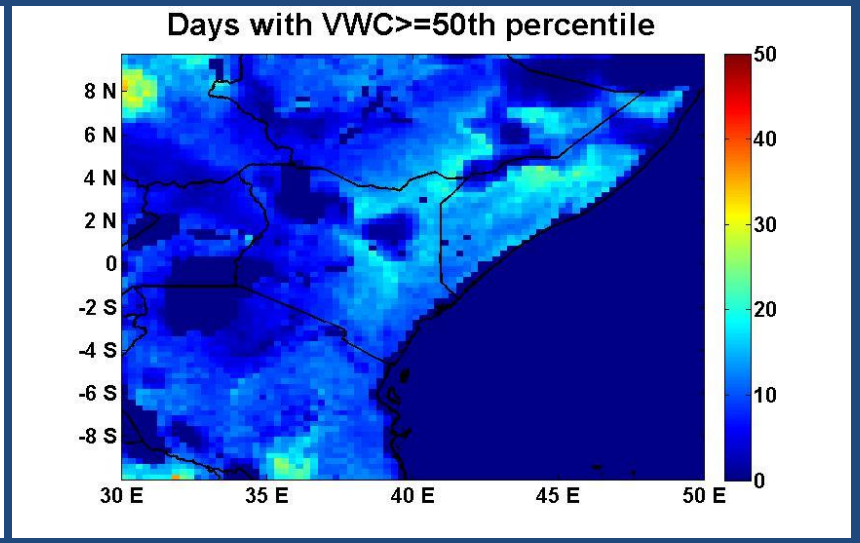
VWC resilience for various thresholds



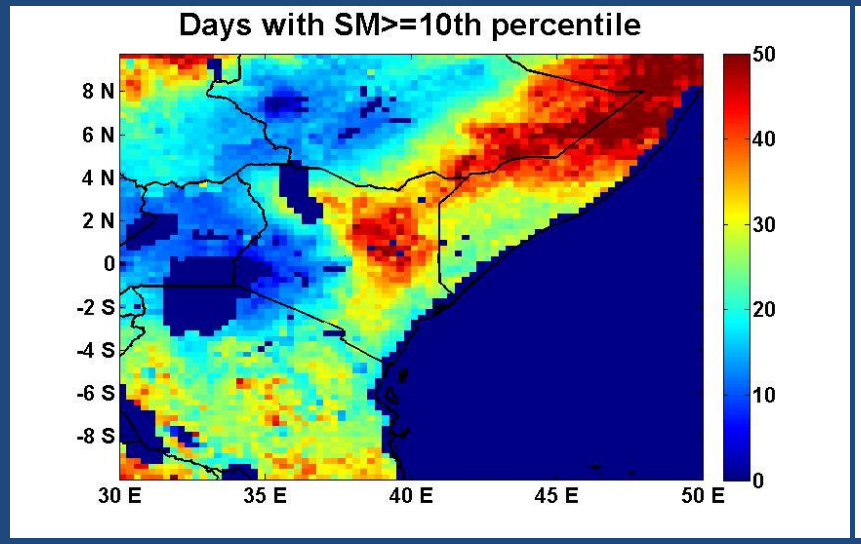


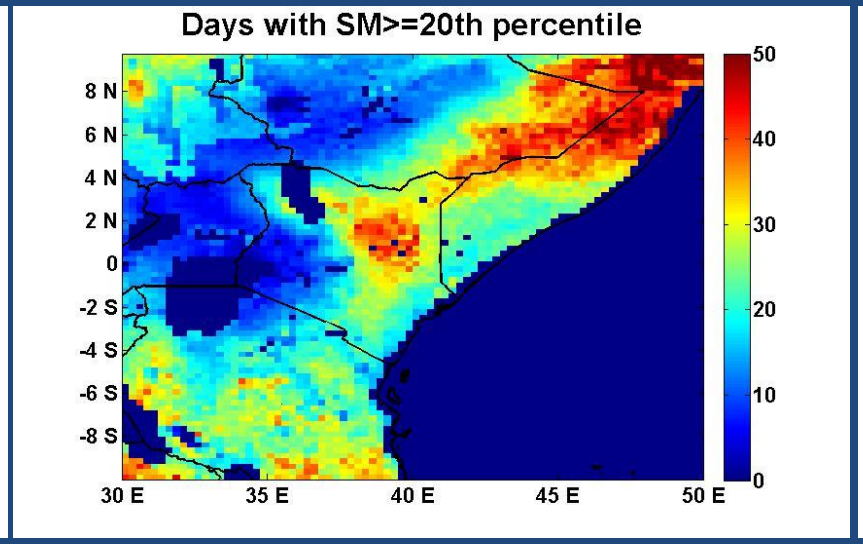


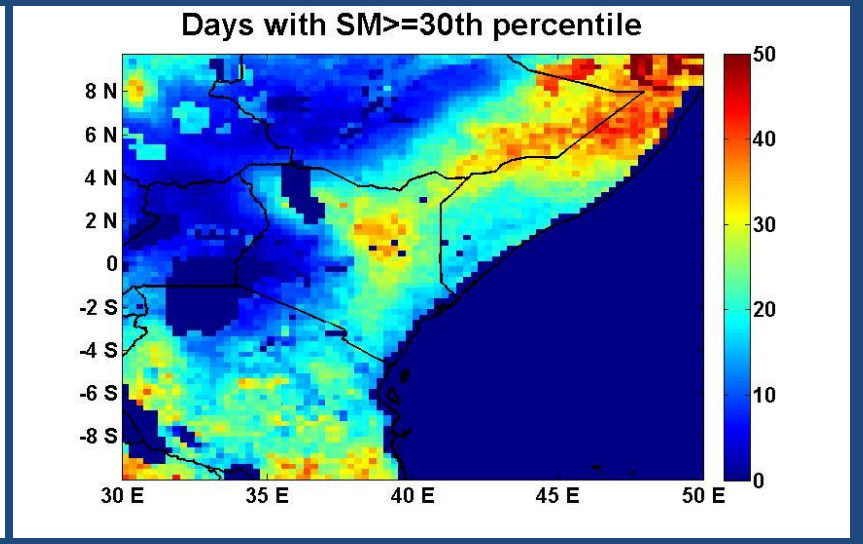


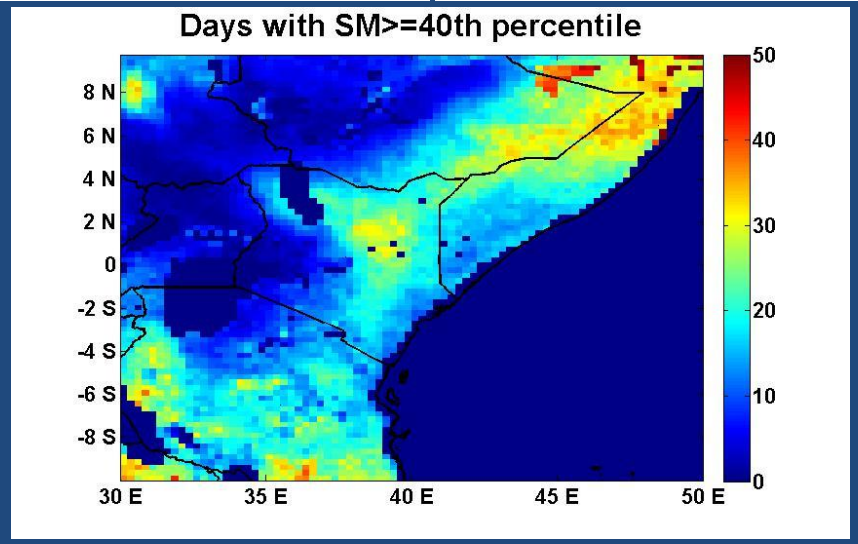


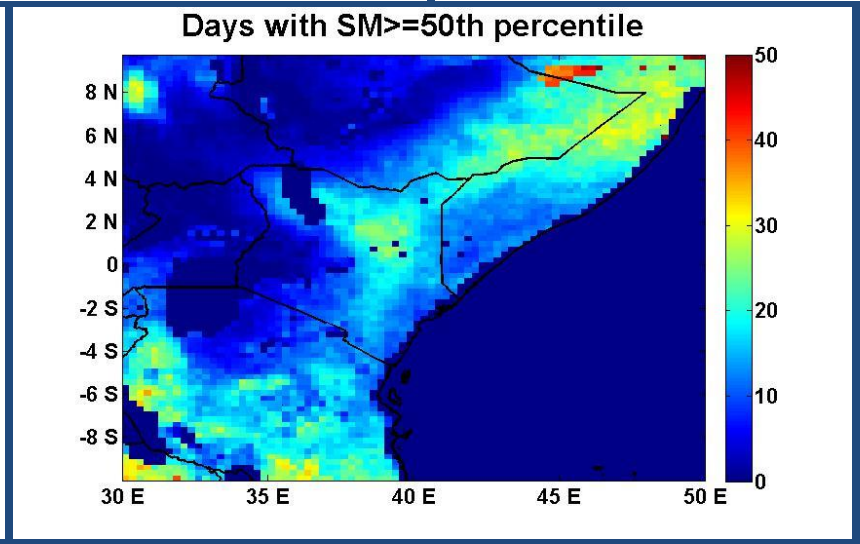
SM resilience for various thresholds



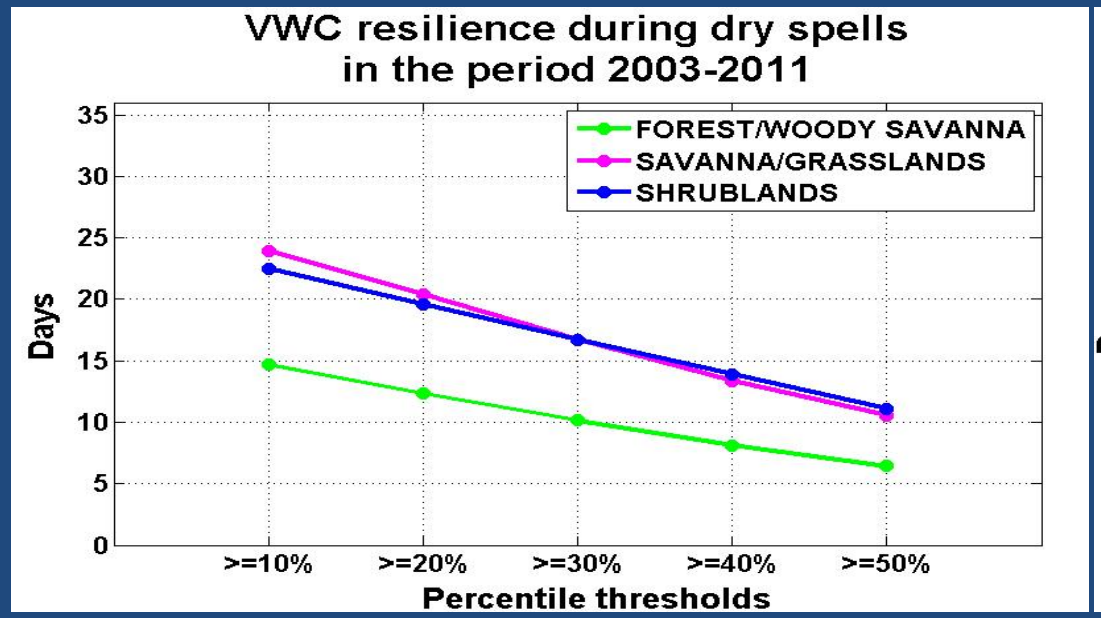


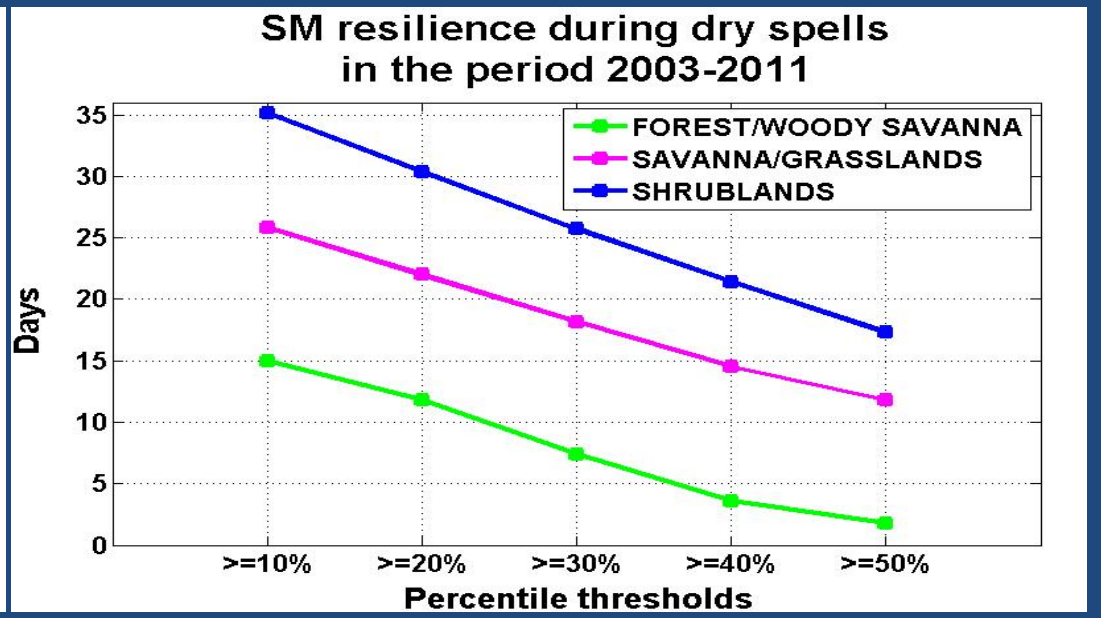


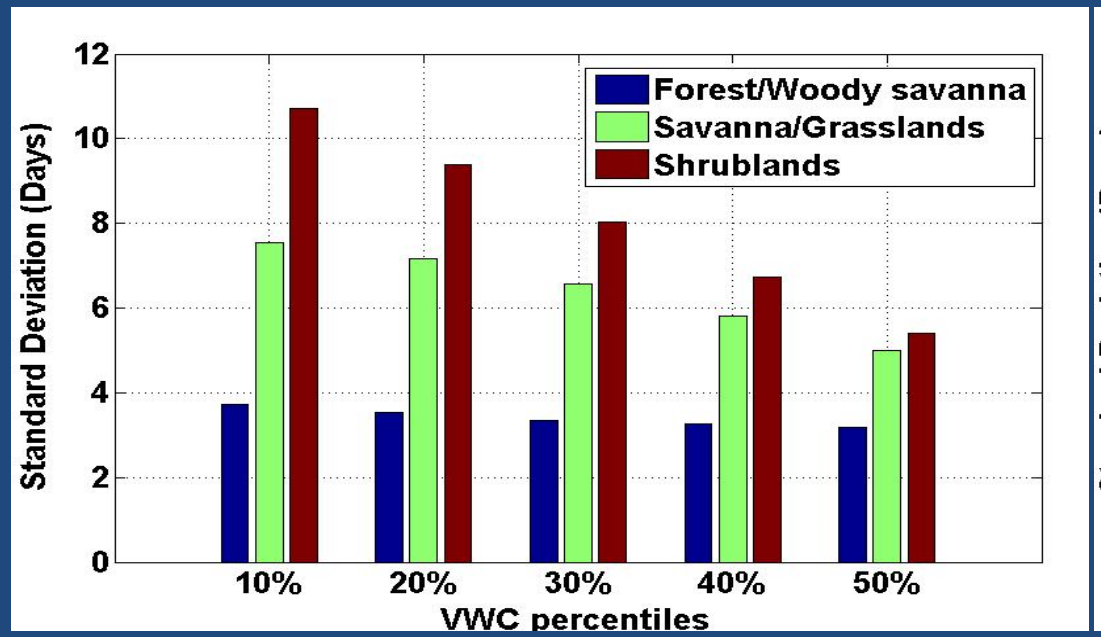


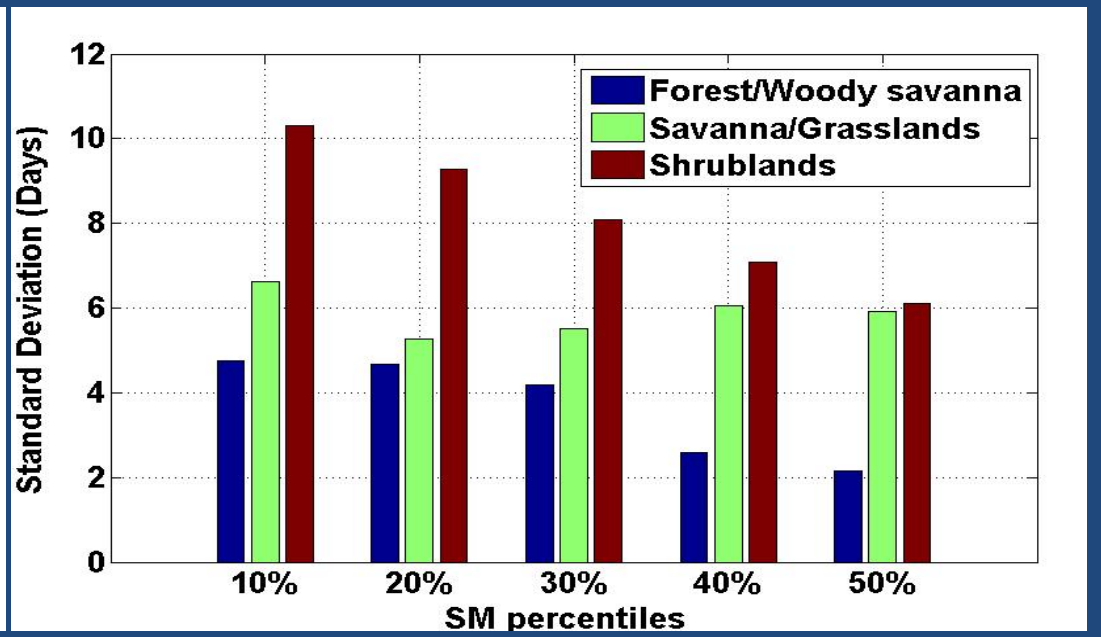


How does VWC/SM resilience change among the different vegetation types and for various VWC/SM thresholds?









Conclusions

- Shrublands (climatologically being the driest region of the study domain) are characterized by the least direct response of both vegetation and soil moisture to the temporal variations of precipitation (lowest cross correlations between VWC/SM and precip).
- Regions covered by shrublands are the least impacted by droughts; the xerophytic type of vegetation along with the soils that support it exhibit great resistance to precipitation deficiencies, resulting in the sustained existence of mesic environmental conditions.
- The drier regions of East Africa are characterized by higher VWC and SM resilience, whereas the wetter ones are more quickly affected by precipitation deficiencies.
- SM is more resilient than VWC in dry regions and less resilient than VWC in the wet regions.

General remarks

- Topographic and climatological complexity emphasize the need to investigate and understand the dynamics of the hydrologic cycle at regional scales, through the integrated understanding of the inter-relations among the various components of natural ecosystems.
- This study yields useful information about the hydrologic properties, the dynamics of different ecosystem processes, as well as the mechanisms that drive biodiversity patterns.
- Understanding ecosystem responses under conditions driven by the intensifying hydrological cycle, resulting from the ongoing climate change, can lead to a more sustainable management of water and carbon resources in future climates.