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Simulated hydroclimatic variability of the greater horn of Africa during the transition between bimodal rainfall regimes

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Greater Horn of Africa climate:
Transition between bimodal regimes

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Contributors:
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Motivation

• Characterize mechanisms and primary moisture sources and sinks linked to GHA climate (rainfall) variability/anomalies

• Analyze behavior of climate patterns during the transition periods between the two PRIMARY rainfall seasons, especially during anomalous years.
Outline

- Overview of GHA climate
- Why Transition Periods?
- Some Diagnostic Analysis
- RegCM3 Simulations (Present and Future)
- Summary & Conclusions
Greater Horn of Africa (climate drivers)
Monthly mean rainfall (mm) over East Africa

- **Long Rains**
- **Short Rains**

Nyenzi (1992)
Implications of changes in vegetation cover on GHA Climate
Major river basins in Africa

1. Nile
2. Senegal
3. Niger
4. Volta
5. Lake Chad
6. Congo
7. Rufiji
8. Ganane
9. Zambezi
10. Okavango
11. Limpopo
12. Orange

Maarten de Wit and Jacek Stankiewicz (Science, 2006)
SST anomalies and GHA Climate

SST DIFERENCE BETWEEN ANOMOLOUS YEARS (IOD.WEST)

- 1982-1988
- 1982-1961
- 1982-2005
- 1997-1988
- 1997-2005
- 1997-1961
- 1961-1988

EQUATORIAL INDIAN OCEAN

SST DIFERENCE BETWEEN ANOMOLOUS YEARS (NINO 3.4 REGION)

- 1982-1988
- 1982-1961
- 1982-2005
- 1997-1988
- 1997-2005
- 1997-1961
- 1961-1988

CENTRAL EQUATORIAL PACIFIC OCEAN
Can RegCM3 preserve spatio-temporal variability associated with large scale forcing?
RegCM3 simulations preserve features of large scale ENSO-related interannual variability
Spatial Correlations between rainfall IOD and Nino3.4 indices
Annual mean rainfall evolution over the Greater Horn of Africa

Bowden, 2008
North-south rainfall evolution during short rains RegCM3
- Unrealistically strong SE/SW monsoons off East Africa coast in OCT in NCAR-CAM3
- Northward shift of the ITCZ (NOT RAINBELT) position in GCM
RegCM3 Rainfall Climatology (1981-2000)

RegCM3

CRU
Incorporating role large inland Lakes

Initialization of Lake model:

- Lake bathymetry (lake points $[x,y,z(d)]$)
- Define number of layers over entire depth
- 9 uniform 5m layers for L. Victoria (shallow)
- Read in LSTs (or initialize with homogeneous LST distribution)

- Western coastline, which is relatively shallower is warmer compared to rest of lake
Simulated vs Observed Rainfall (mm): Transition months

CRU

RegCM3
RegCM3 simulated rainfall variability over different homogeneous climate zones

- **CST(OND)**: 
  - Correlation coefficient: \( r = 0.54 \)

- **NUG(OND)**: 
  - Correlation coefficient: \( r = 0.60 \)
RegCM3 simulated rainfall variability over different homogeneous climate zones

INTERANNUAL VARIABILITY OF RAINFALL OVER CKE(OND)

r = 0.20

INTERANNUAL VARIABILITY OF RAINFALL OVER CTZ(OND)

r = 0.64
Future Projections?
Mean surface temperature projections

FEBRUARY

APRIL

JULY

NOVEMBER
Delayed transition of flow from SW to NE off the Somalia/East Africa coast during short rains in GCM simulations leading to northward shift in regions of rainfall maximum

Intra-seasonal to inter-annual variability well reproduced over a number of homogeneous climate sub-regions (in RegCM3 simulations)

Rainfall variability over central highlands of East Africa (Kenya) and Northeast Kenya poorly reproduced

Simulated climate using GCM and NCEP lateral boundary forcings are coherent (comparable)

Both land regions north and south of the equator over the GHA consistently warmed during the period beginning 1990 through 2040. The steepest warming trends during that period occurred in January and July in the A2 scenario simulations by CMIP3 models
Ongoing and Future Work

• Computation of backward trajectories of moisture flux convergence/divergence (Reanalysis and RegCM3) to trace the different moisture sources critical for setting up precipitation anomalies over the Greater Horn of Africa

• Conduct a suite of RegCM3 simulations with imposed (prescribed) SST anomalies over western Indian Ocean

• A suite of regional model simulations with prescribed (satellite-derived) historical land use and cover changes (especially over the tropical-Congo rainforest and parts of GHA region)

• Dynamics of Somali jet in relation to the Indian monsoon and low pressure cell over Sudan and it’s relation to rainfall over northern GHA during extreme events
THANK YOU!
DJF 1961-1997 CRU Precipitation difference, velocity potential (10^5 m^2/s) and divergent wind (m/s) difference for (a) NCEP at 850 hPa, (b) ERA40 at 850 hPa (c) NCEP at 200 hPa and (d) ERA40 at 200 hPa.