Unraveling East Africa’s Climate Paradox

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The Region

The map indicates the region affected by different rainfall patterns. Two main periods are highlighted:

- **Long Rains**: Occur during the months of June to October, with significant precipitation.
- **Short Rains**: Occur during the months of November to December, with moderate precipitation.

The graph below shows the total precipitation [mm/month] for each month, with a peak during the "Long Rains" period and a more moderate peak during the "Short Rains" period.
The Region

March-May “Long Rains” Season

Observed 1999-2014

Projected 2020-2050

The Paradox

Long Rains

Short Rains

The Region

March-May “Long Rains” Season

Observed 1999-2014

Projected 2020-2050

“Long Rains”

“Short Rains”

Total Precipitation [mm/month]

Rainfall Depart. (mm)

Prec. depart. [mm/mo.]
East Africa: A Climate Paradox?

Hypotheses

• Anthropogenic forcing is driving the recent drying and the CMIP5 models are missing, or misrepresenting, key aspects of the ACC signal.
  → CMIP5 models are wrong, the future will be drier, not wetter.

• What paradox? The recent drying is associated with “natural” processes that are masking the climate change signal of a wetter future.
  → The paradox is a mismatch of timescales; the future will become wetter (in both the short- and long-term).

• The recent drying is largely due to natural variability, but the models are still not capturing the climate change signal correctly.
  → In the short-term it will likely become wetter. After that…???
HINT: Evidence for a Recent and Abrupt Long Rains Decline

East Africa Rainfall Index (GPCC)

Leading EOF, Mar-May Rainfall (GPCP v2.2)

East Africa OLR Index (NOAA)
Evidence for a Recent and Abrupt Long Rains Decline

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Evidence for a Recent and Abrupt Long Rains Decline

East Africa Rainfall Index (GPCC)

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East Africa OLR Index (NOAA)
"CHIRPS" Daily Rainfall Depart. from Feb-Jun Avg.

An early demise to the Mar-May "long rains"
Associated Changes in SSTs

West Pacific SST Gradient Anomaly

a) Std MAM SST Diff.

b) Pac Warm Pool SST

SST Anomaly (deg. C)


-0.4 -0.2 0 0.2 0.4

1999

West Pacific SST Gradient Anomaly


-0.8 -0.4 0 0.4 0.8 1.2

1999

c) Pac Warm Pool PRCP

Rainfall Anomaly [mm/day]

1980 1990 2000 2010

-4 -2 0 2

1999

GPCPv2.2

CMAP

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Linkage to Pacific Multi-Decadal SST Variability

EOF1 Pac. SST (remove ENSO, Trend)

Lyon (2014, J. Climate)

\[ r = 0.72 \]

\[ p < 0.05 \]
Linkage to Pacific Multi-Decadal SST Variability

EOF1 Pac. SST (remove ENSO, Trend)

PRCP Anomaly Cold PDO Phases

\[ r = 0.72 \]
\[ p < 0.05 \]

\[ r_p = 0.53 \]
\[ p < 0.01 \]

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**Linkage to Pacific Multi-Decadal SST Variability**

**MODEL FORCING**

- Observed, global SST $\rightarrow$
- Observed, Tropical Pac. SST $\rightarrow$
- De-trended, global SST, GHG = 1880 $\rightarrow$

*Thanks to Marty Hoerling, NOAA/ESRL for 1880 runs…*
CMIP5 Model Simulations of the Current Climate

Climatological “Short” and “Long” rain seasons are reversed in CMIP5 model simulations.

Obs. show less warming than CMIP5 in the eq. East Pacific in the current climate.

SST: (Historical Simulations) – (Observations)

CMIP5 SSTs are too warm in the western Indian Ocean Rel. to Obs.

Yang et al. (2014, J. Climate)
CMIP5 Model SST Projections

CMIP5 models amplify current SST biases in projections

Yang et al. (2014, J. Climate)

Lyon (2015, AGU Book Chapter)
Conclusions

• Recent drying during the long rains primarily due to decadal variability of Tropical Pacific SSTs. NOTE: This represents about 10% of variance.

• Its possible ACC may have acted to enhance the severity of recent droughts, but it cannot account for the abrupt nature of the recent decline or past decadal periods of drought, such as 1914-1925.

• CMIP5 models exhibit major errors in simulating the obs. East African climate and large scale SST patterns. These errors are amplified in projections → Little confidence in current projections of EA climate.

References

• Lyon, B., and N. Vigaud, 2015: Unraveling East Africa’s Climate Paradox. Ch. in *Climate Extremes, Trends and Mechanisms*. AGU
