# VARIABILITY IN MOISTURE TRANSPORT AND PRECIPITATION RECYCLING OVER EAST AFRICA

FUTURE CLIMATE FOR AFRICA

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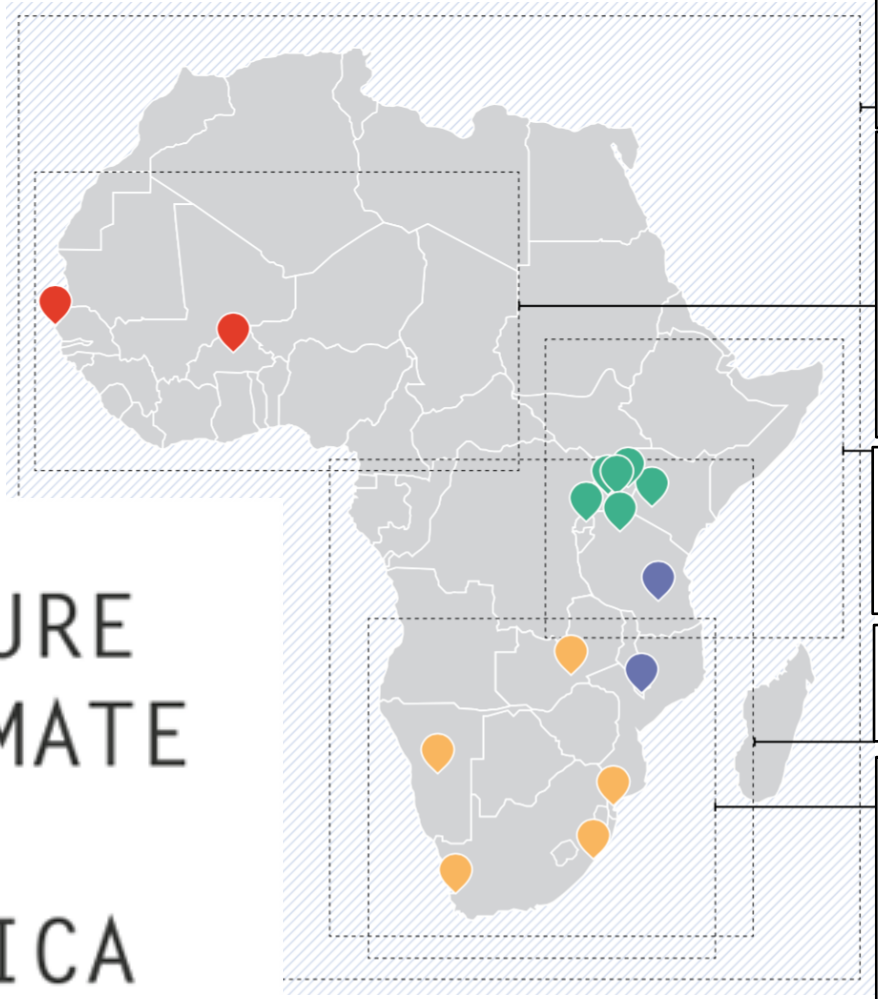
# FUTURE CLIMATE FOR AFRICA (FCFA)

Department for International Development

NERC SCIENCE OF THE ENVIRONMENT



FUTURE CLIMATE FOR AFRICA

IMPALA

AMMA-2050

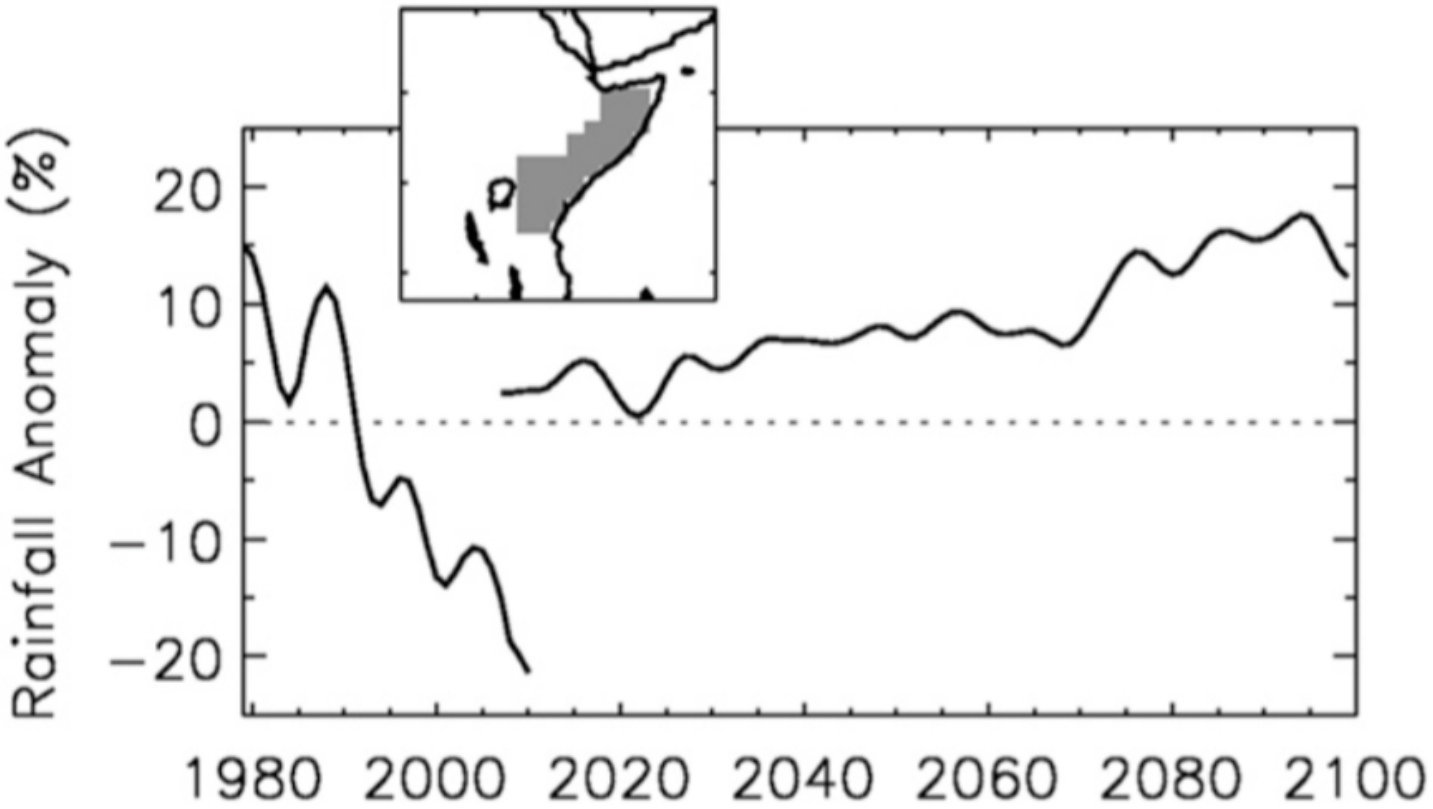
HyCRISTAL

UMFULA

FRACTAL
FUTURE RESILIENCE FOR AFRICAN CITIES AND LANDS

# RECENT DECREASE IN EAST AFRICAN RAINFALL

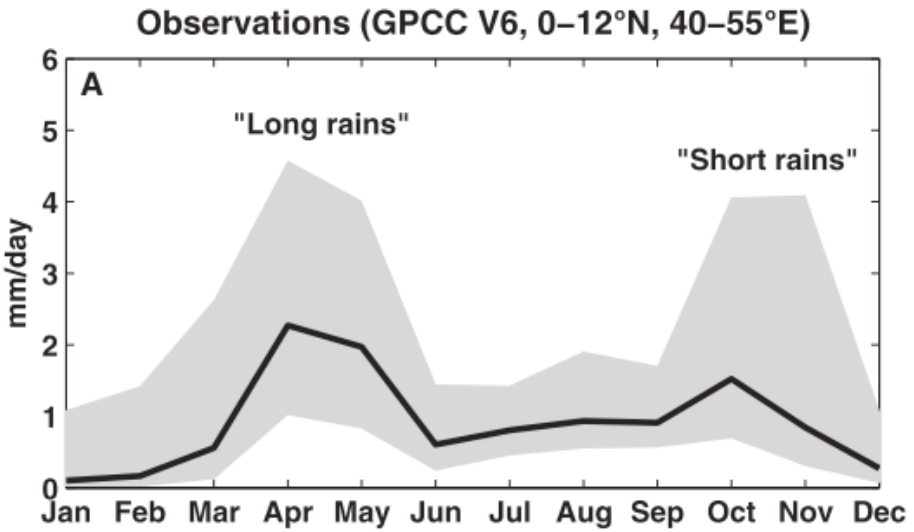
Significant reduction in East Africa (EA) long rains (March-May) since 1990s that are inconsistent with CMIP5 model projections

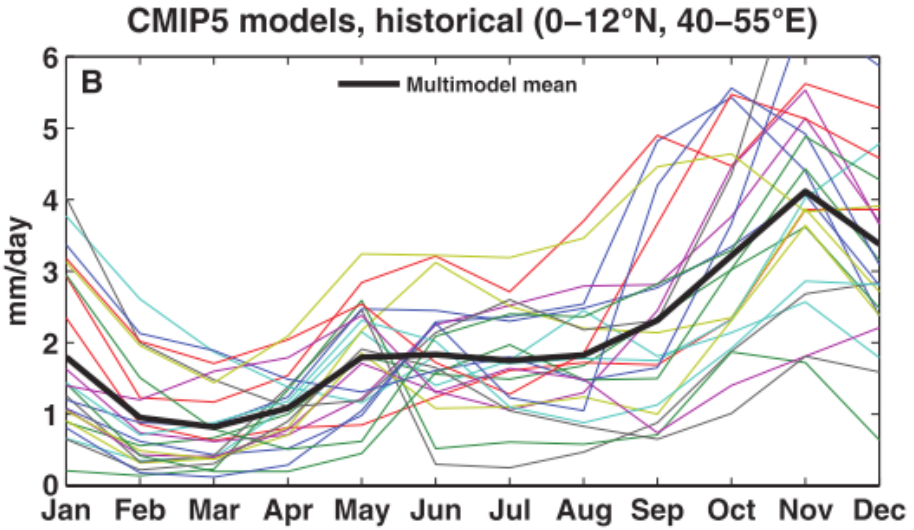



Rowell et al. (2015)

# POOR REPRESENTATION OF EAST AFRICAN RAINFALL IN CLIMATE MODELS

- Poor representation of seasonal cycle in climate models (which reduces reliability of model projections)
- Long rains (MAM) underestimated while short rains (SON) overestimated



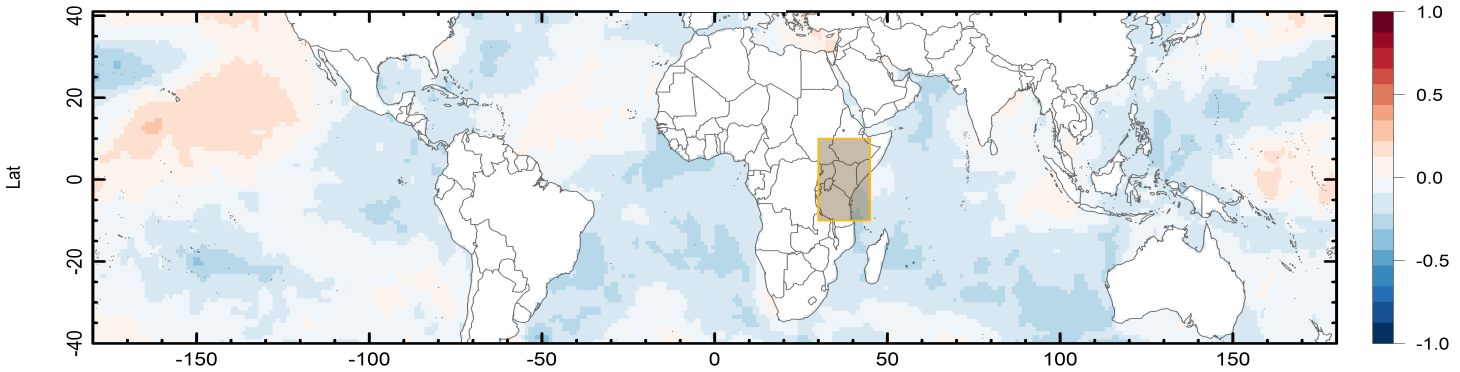




Tierney et al. (2015)

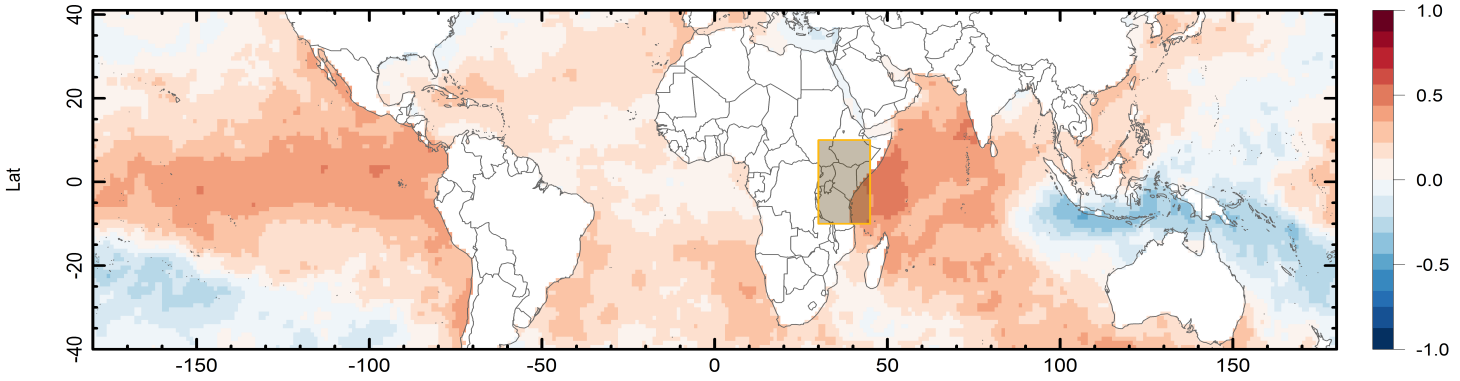
# RELATIONSHIP BETWEEN GLOBAL SST AND RAINFALL VARIABILITY

Different teleconnections between rainy season. Rainfall (averaged over box) shows high positive correlation with sea surface temperatures during October (mainly ENSO but also local SSTs), but weak correlations during April.

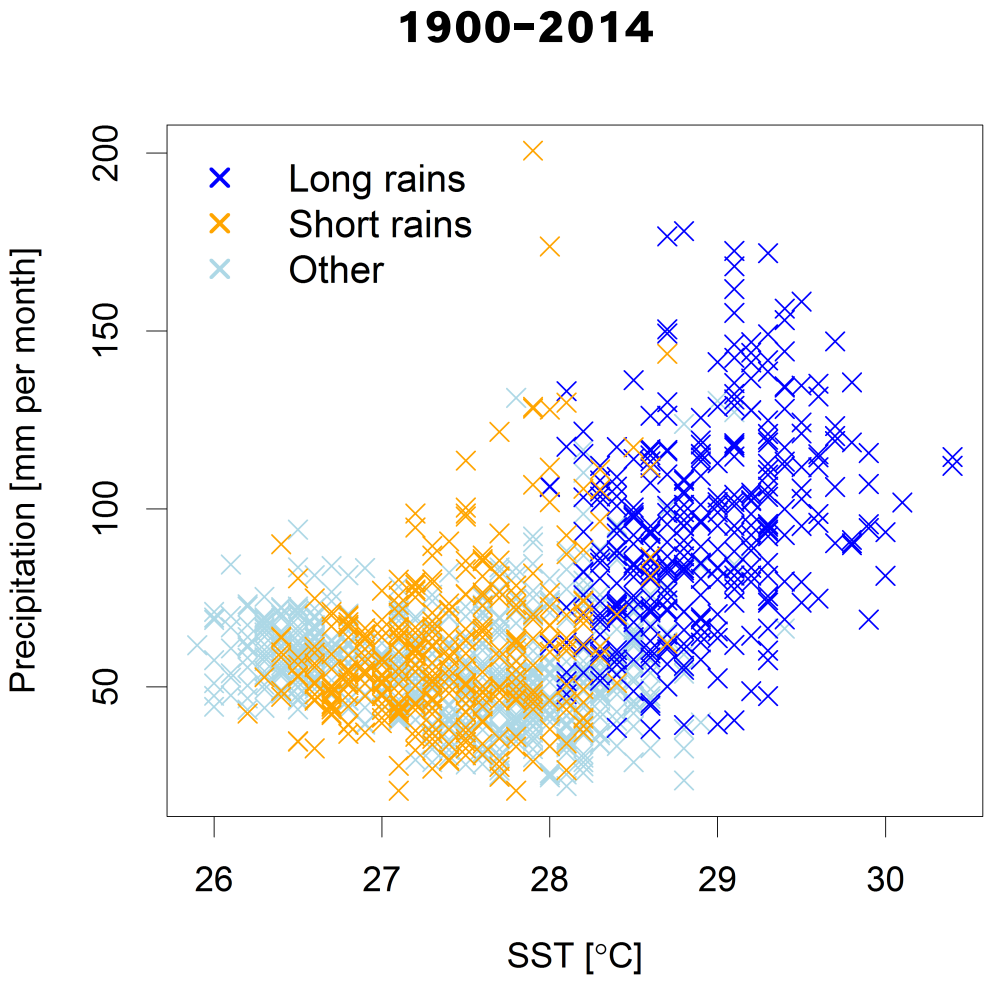
April

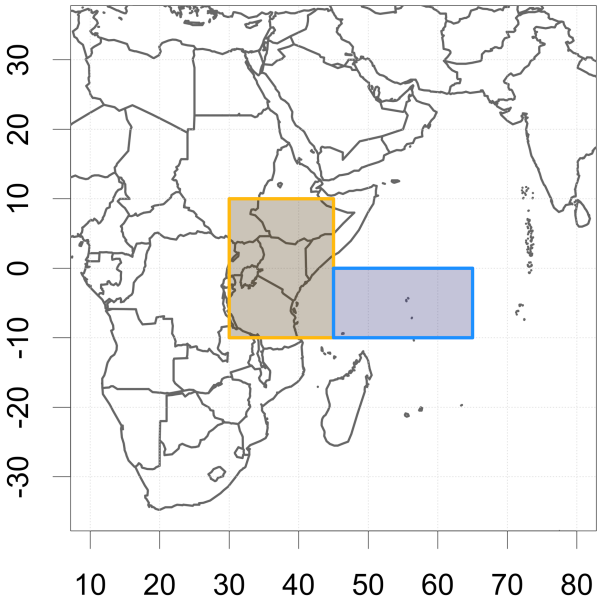



October



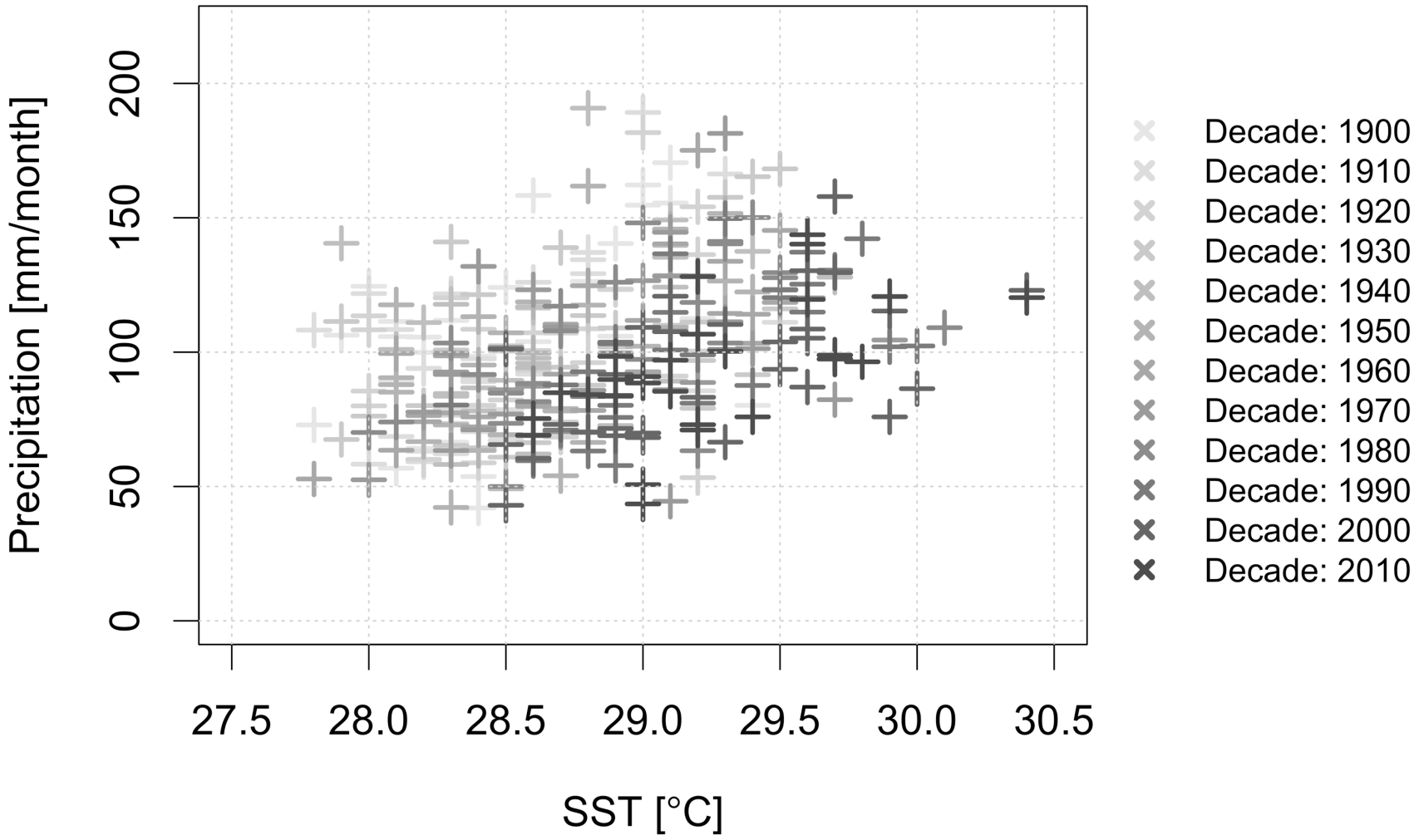
# RELATIONSHIP BETWEEN LOCAL SST AND RAINFALL SEASONAL CLIMATOLOGY




- Long rains associated with warmer SSTs
- Short rains associated with colder SSTs

# RECENT WARM YEARS ASSOCIATED WITH LESS RAINFALL



# PRECIPITATION RECYCLING

## Brubaker Model

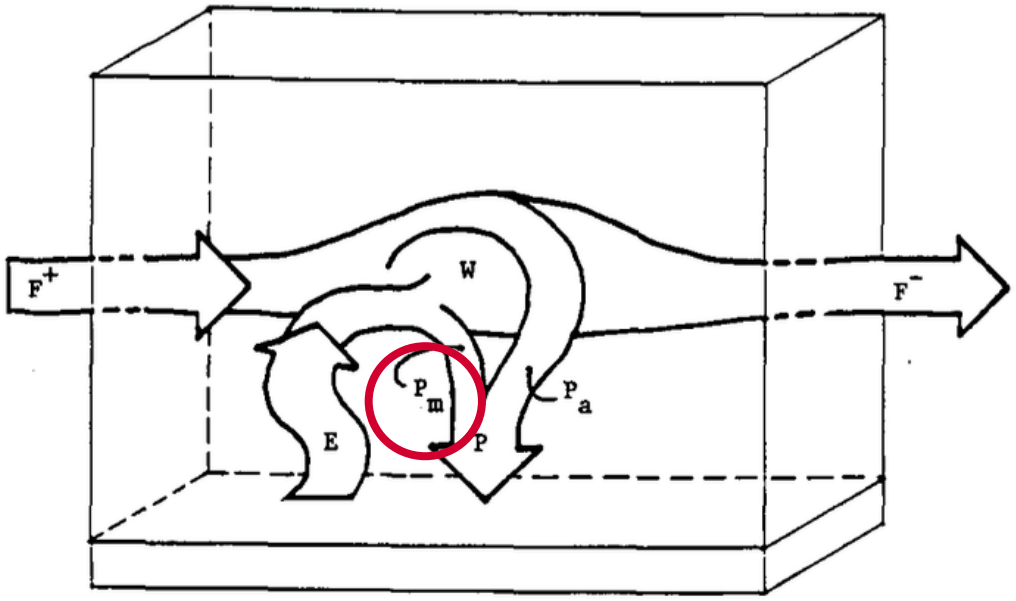



FIG. 1. Conceptual model of the atmospheric moisture fluxes over a land region. Terms $P_m$ and $P_a$ are precipitation of local evaporative and advective origin, respectively.

*(Brubaker et al. 1993)*

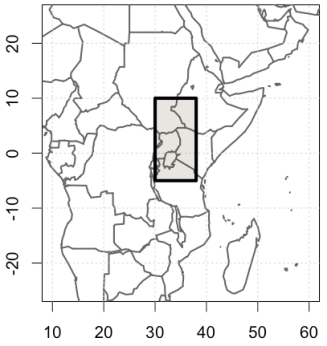
- Simple 2D bulk model
- Assumes water vapour from both external and local sources are well mixed
- Recycled precipitation (*RP*) estimated as:

$$RP = \frac{E}{(E + 2F^{+})}$$

where *E* is the net local evapotranspiration and $F^{+}$ is the net moisture flux entering the control volume

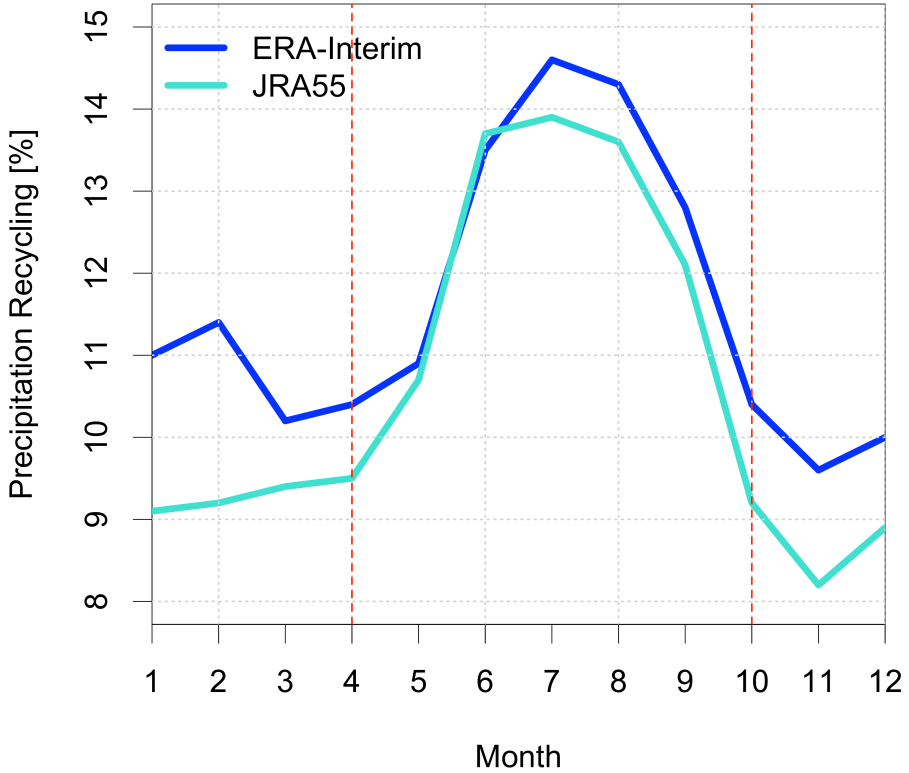
# SEASONAL CHANGES IN MOISTURE TRANSPORTS OVER EAST AFRICA (EA)

Figure shows the annual cycle in the fraction of rainfall that comes from recycled moisture (i.e. via local evaporation) as opposed to moisture that is advected into the region.

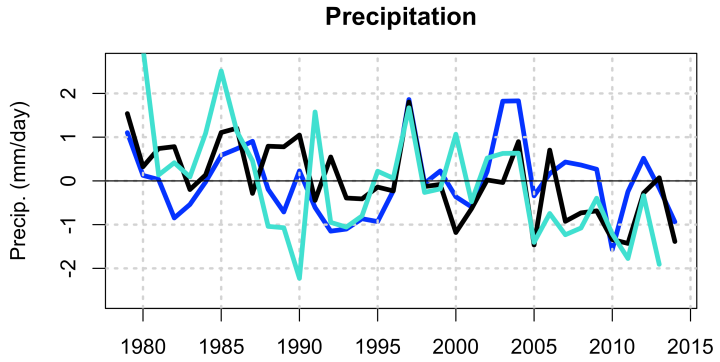


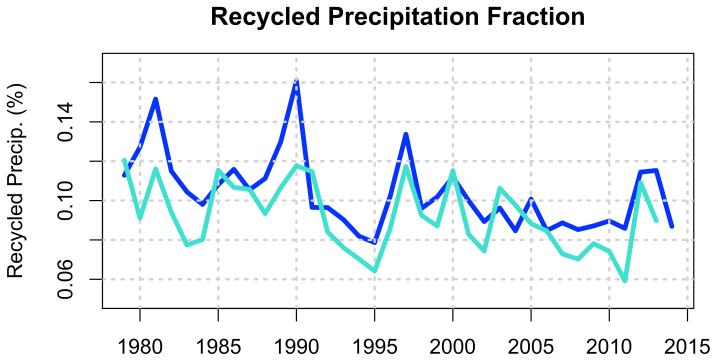

Lower values over EA suggest advected water vapour plays a more important role in EA precipitation than locally evaporated water vapour.

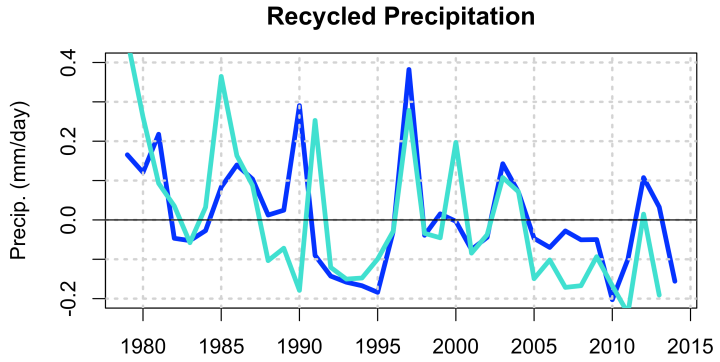
| Region | Recyc. Prec. (%) | Length scale (km) |
|---|---|---|
| East Africa | 12 % / 11 % | ~1400 |
| Sahel | 35 % | ~1500 |
| Central Africa | 38 % | ~ 1700 |

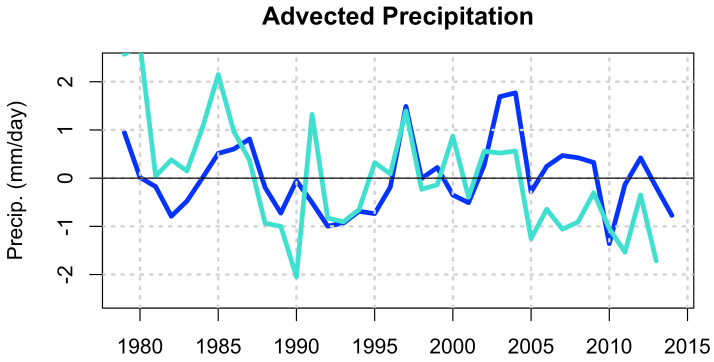


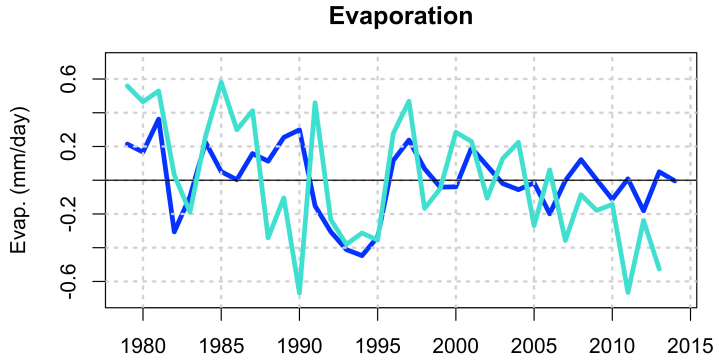
# CHANGES IN ATMOSPHERIC WATER BUDGET COMPONENTS DURING APRIL

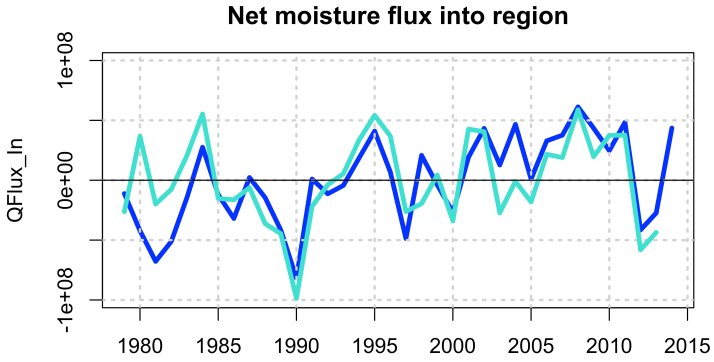


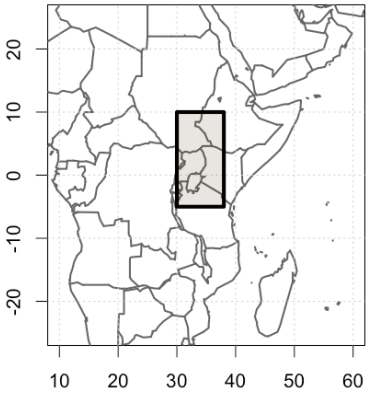



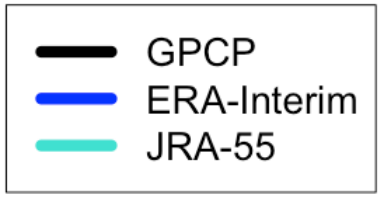



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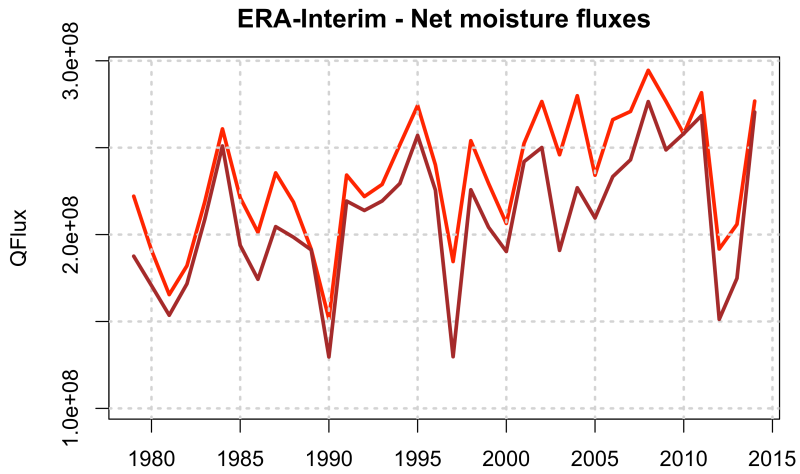


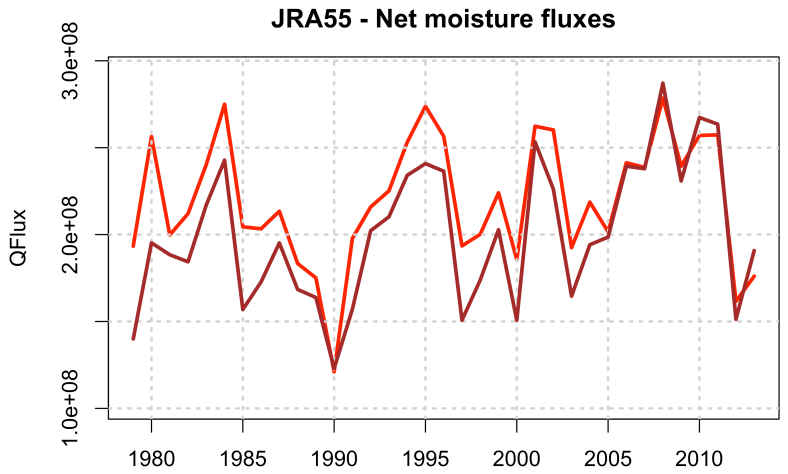


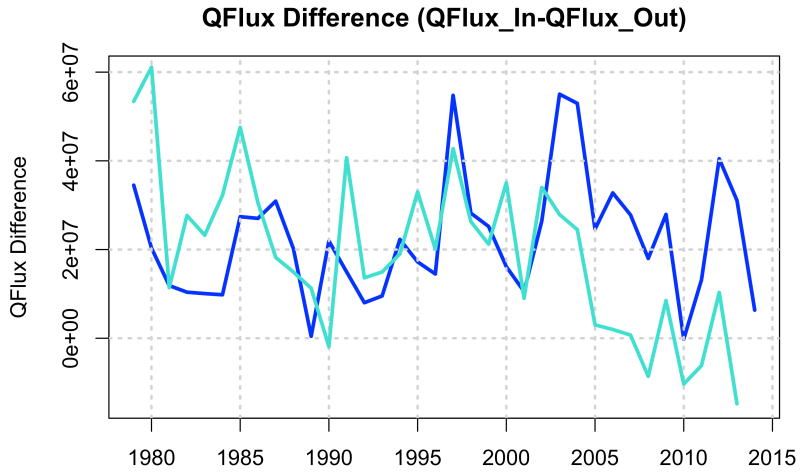


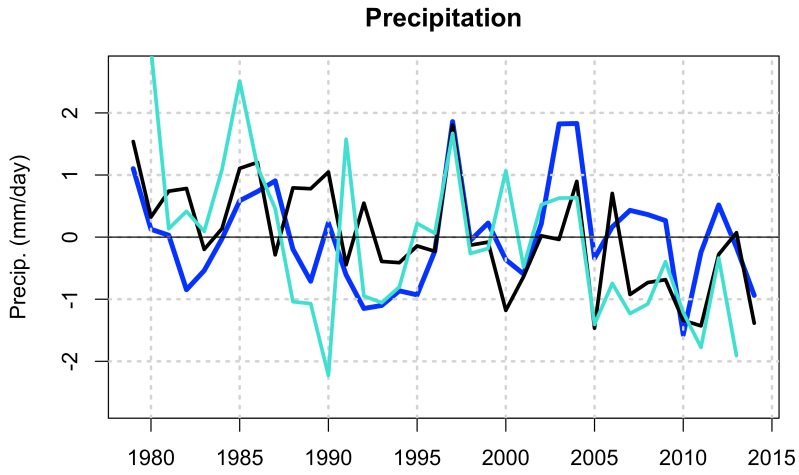


# SUMMARY

- East Africa has experienced a significant reduction in rainfall during the ”long rains” and rainfall patterns are poorly represented in climate models
- Seasonal changes in local SSTs coincide with seasonal changes in rainfall and long-term changes in rainfall coincide with warming of the western Indian Ocean
- On average, fraction of recycled precipitation is lower than other parts of Africa, ranging between 11% (JRA 55) and 12% (ERA-Interim)
- Preliminary results indicate the amount of recycled precipitation and advected precipitation have both decreased. Local evaporation and difference in the incoming and outgoing moistures fluxes into the region have also decreased (especially in JRA data).
- Future work will consider other reanalysis datasets and methods looking at tracing the origin of water that precipitates over East Africa.