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Climate and Tsetse:
exploring the effect of climate variability and change on vector biology, population dynamics and distribution in the Zambezi Valley

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Climate Systems Analysis Group
World Health Organization
TDR For research on diseases of poverty UNICEF • UNDP • World Bank • WHO
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Climate and Tsetse

- Tsetse flies threaten human health and livelihood by transmitting trypanosome parasites that cause sleeping sickness in humans and nagana in livestock
- The relationship between climate and a VBD like Tripansomiasis is complex.
- The correlation between climate variables and vector biology, population dynamics and distribution is often more direct
- We present a simplified example of the role temperature may have played on tsetse population dynamics in the past and how this may continue into the future

Rekomitjie Research Station

- Located in the Zambezi Valley of Zimbabwe
- Operational since 1959
- Extensive tsetse fly biological datasets
- Daily rainfall and temperature data

Tsetse life cycle


Adult emergence

Female ovulates

8-15 days

Single larva develops inside the mother

20-40 days

Larva deposited and buries itself in the ground


Larviposition


Burrowing larva

8 days

Adult emerges and matures

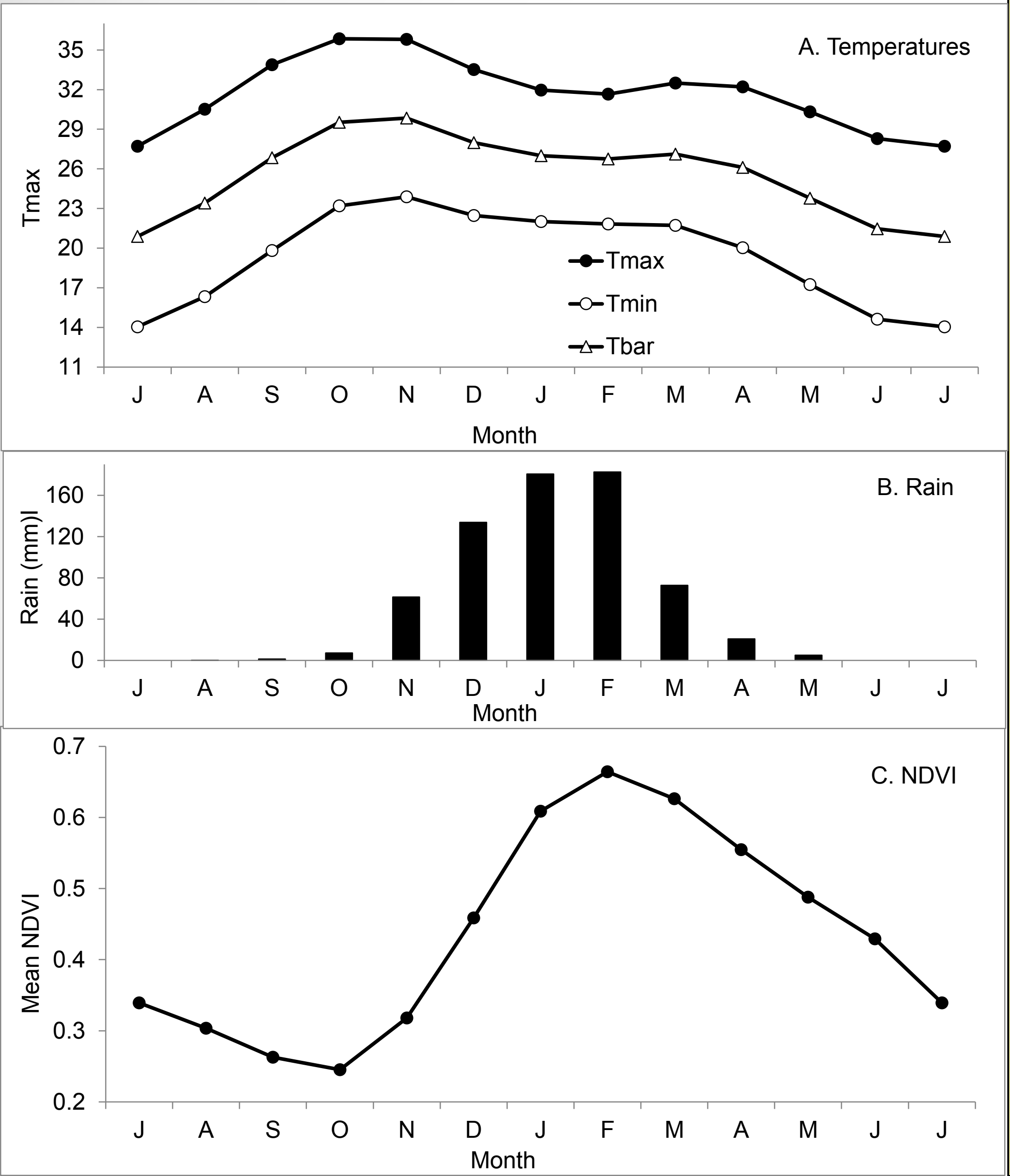
Temperature Sensitivity

Various aspects of the tsetse biology show temperature dependence:

- Adult fly development rate and inter-larval periods
- Abortion rate
- Puparial duration, fat utilisation and mortality
- Neo-natal and mature adult mortality

These sensitivities to temperature result in there being an optimal temperature range for tsetse flies ($16 < tmean < 32$ °C)

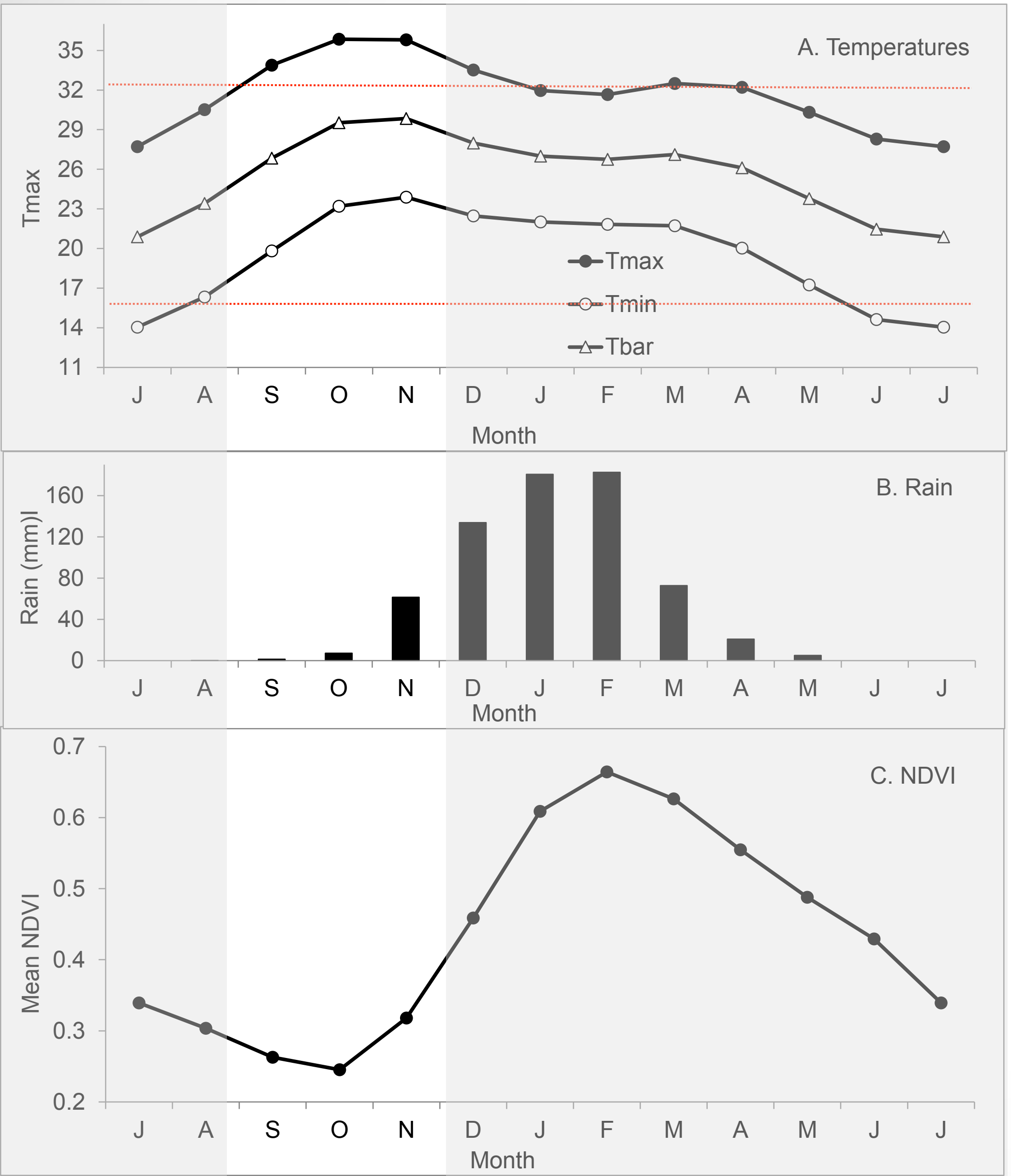
Rekomitjie Climate



Rekomitjie Research Station 1988-2000: monthly mean climatologies

- Temperatures peak in October/ November, just before the onset of the rains.
- A single summer rainfall season which peak in January/February.
- An uninterrupted dry season from June to August.
- NDVI tracks rainfall with a maximum in February after which it decreases to a minimum at the end of the dry season.

Rekomitjie Climate



The environment is stressed between September – November

- High temperatures
- Low availability of water
- Lack of vegetation

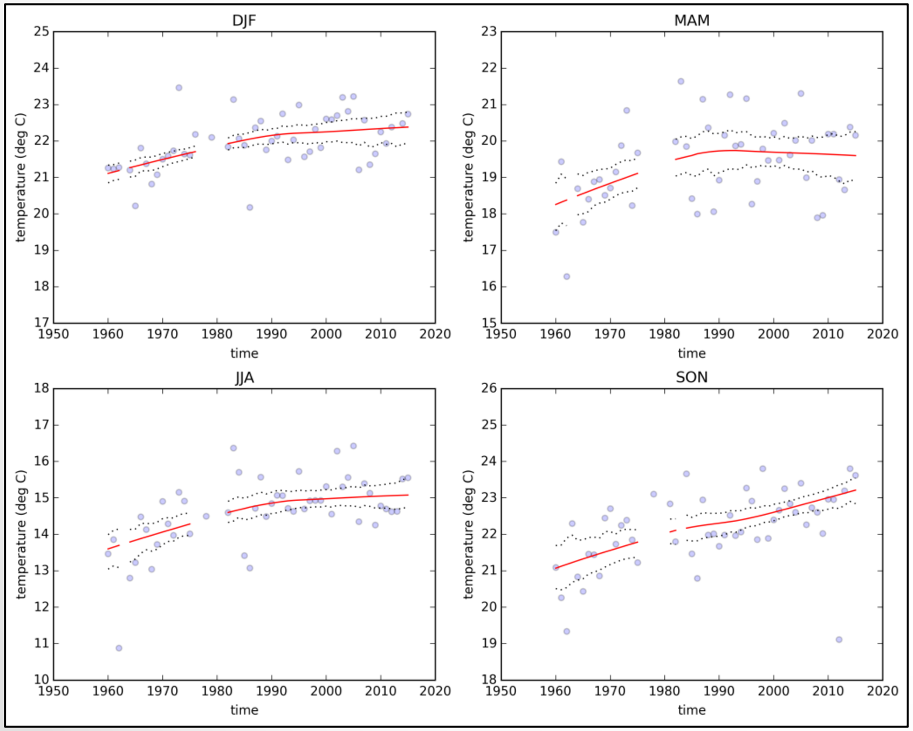
This season is associated with increased mortality rates especially in the newly emerged adult tsetse flies.

Temperature Trends

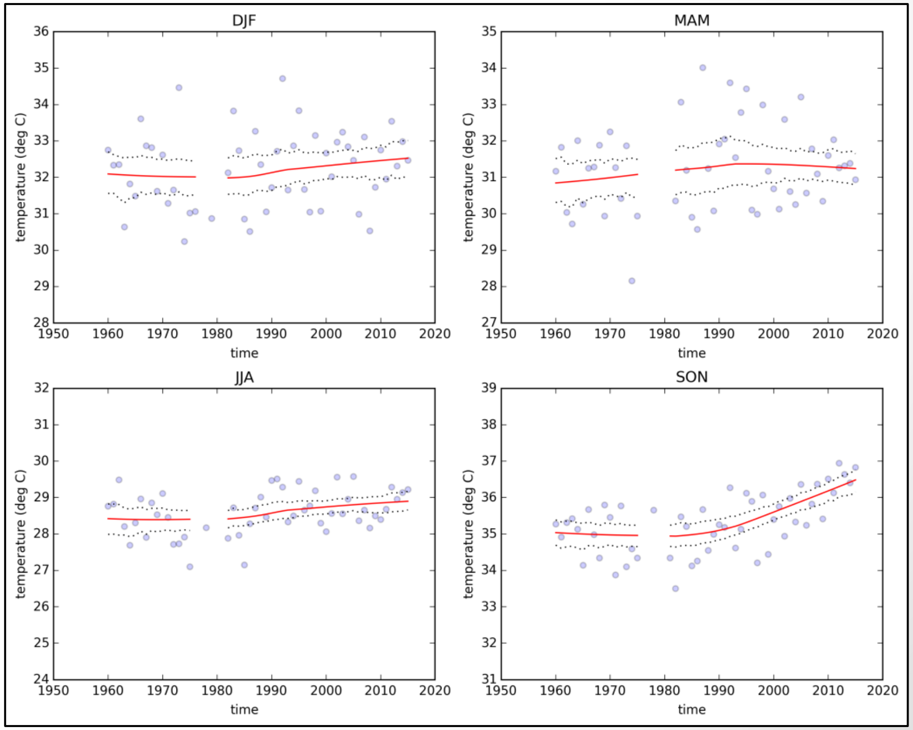
Monthly mean maximum and minimum temperatures have increased over time. However the magnitude and significance of the trends depends on the variable, the season and the historic period

- Minimum temperatures: strong warming in the 1960s-1970s in all seasons
- Maximum temperature: strong warming only in Spring from the 1990s to present

Minimum Temperature



Maximum Temperature



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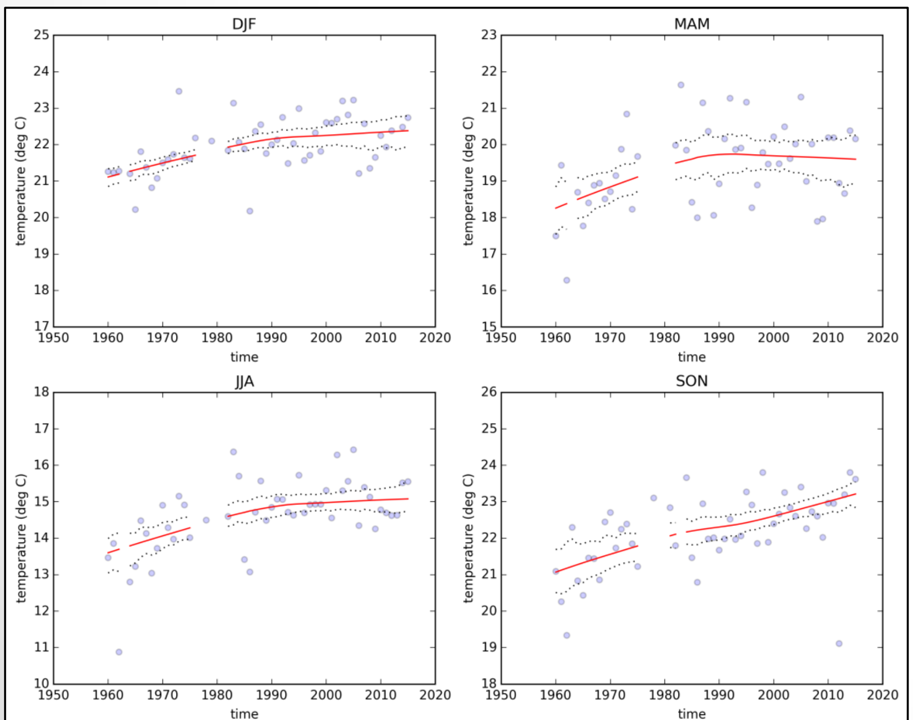
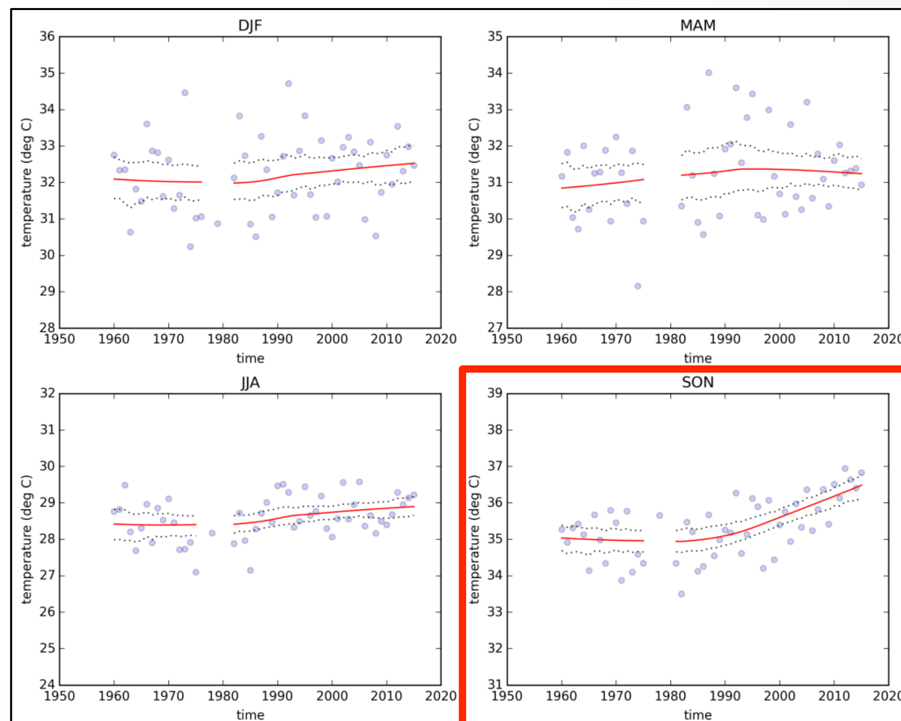
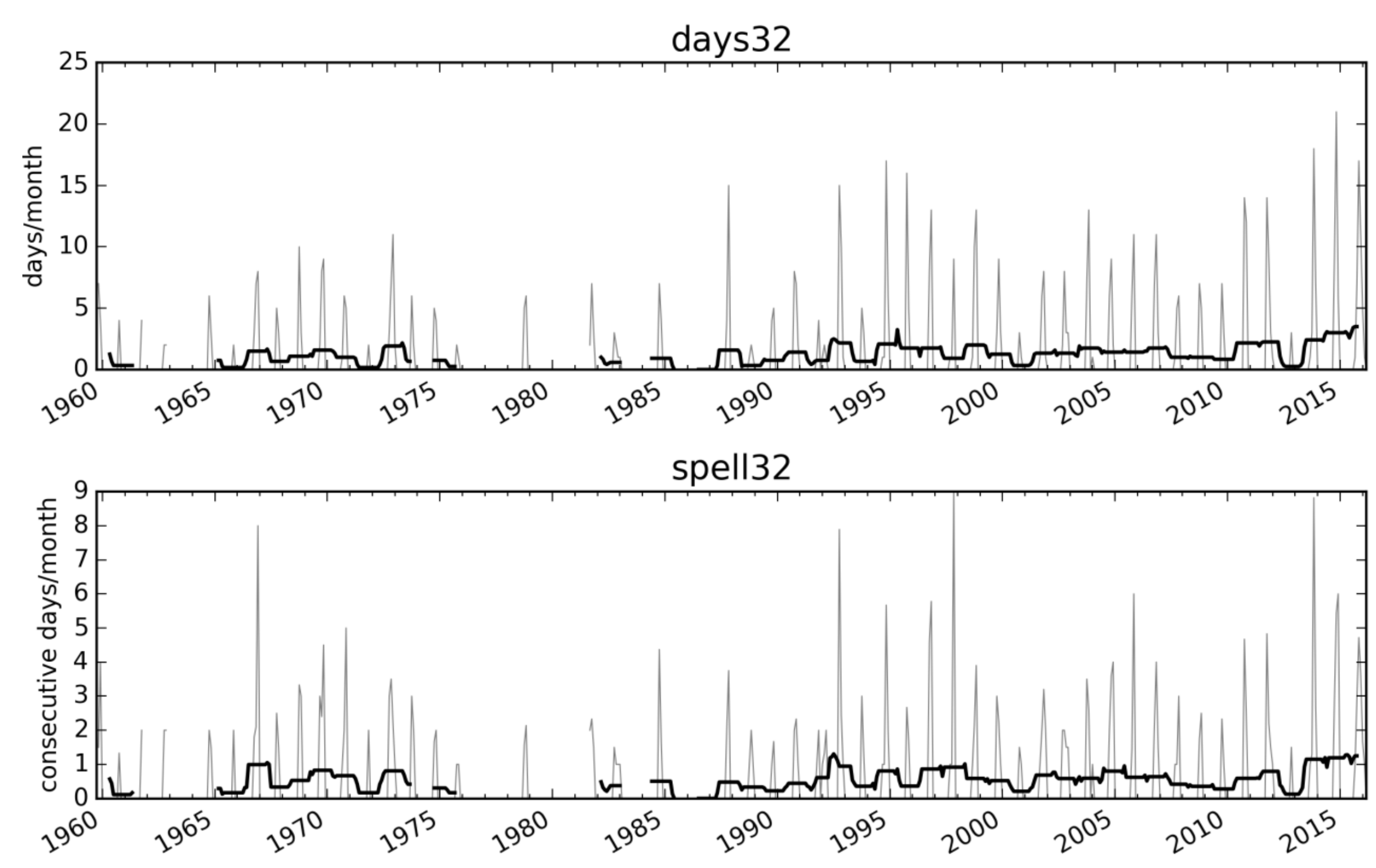


Maximum Temperature



Changes in the frequency, duration and sequencing of extreme temperature events

- The warming trends result in the upper threshold being exceeded more often and for longer periods, especially in the 1990s and after 2010.
- This has severe implications for the survival of immature stages and newly emerged adults.



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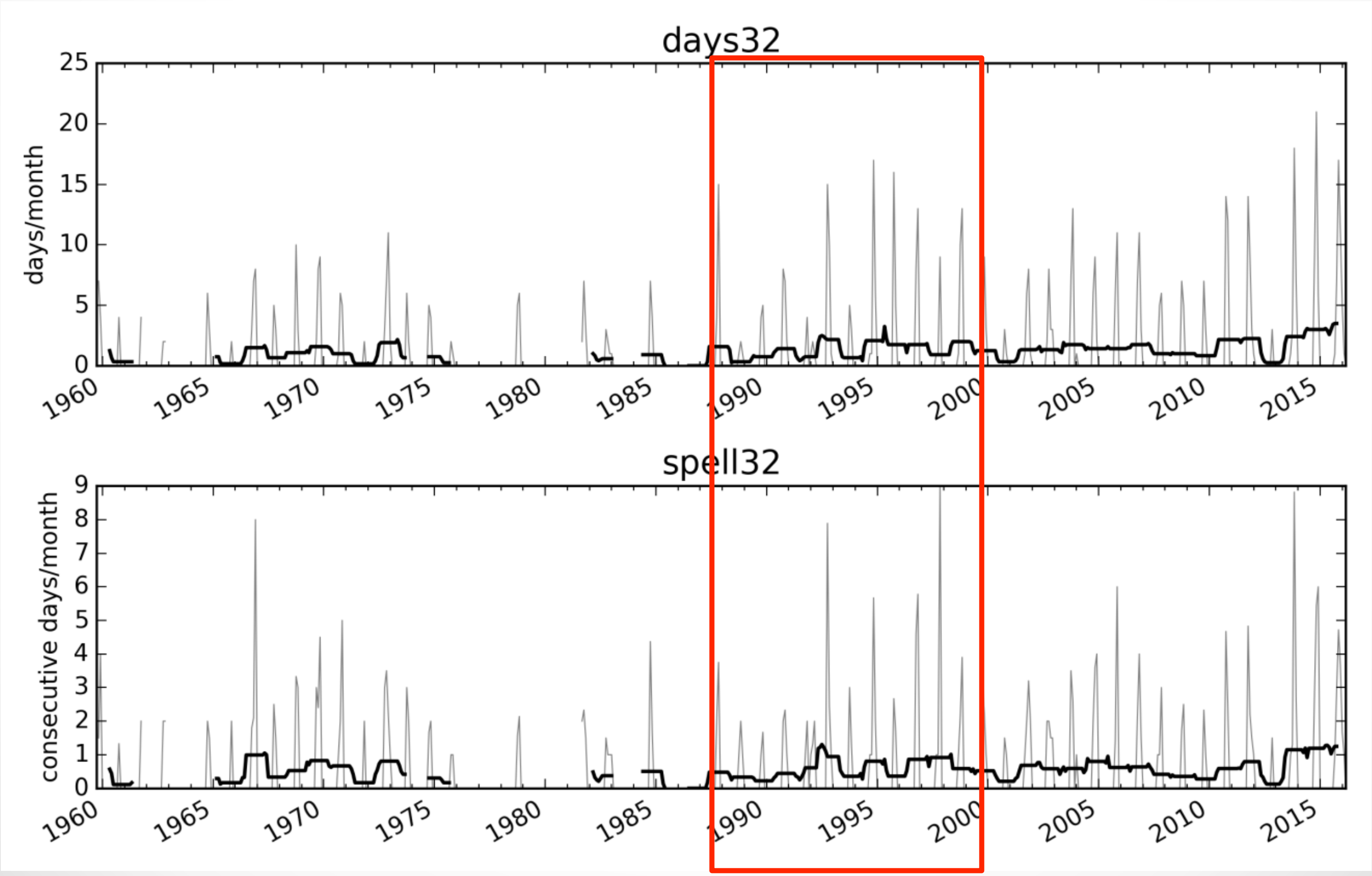
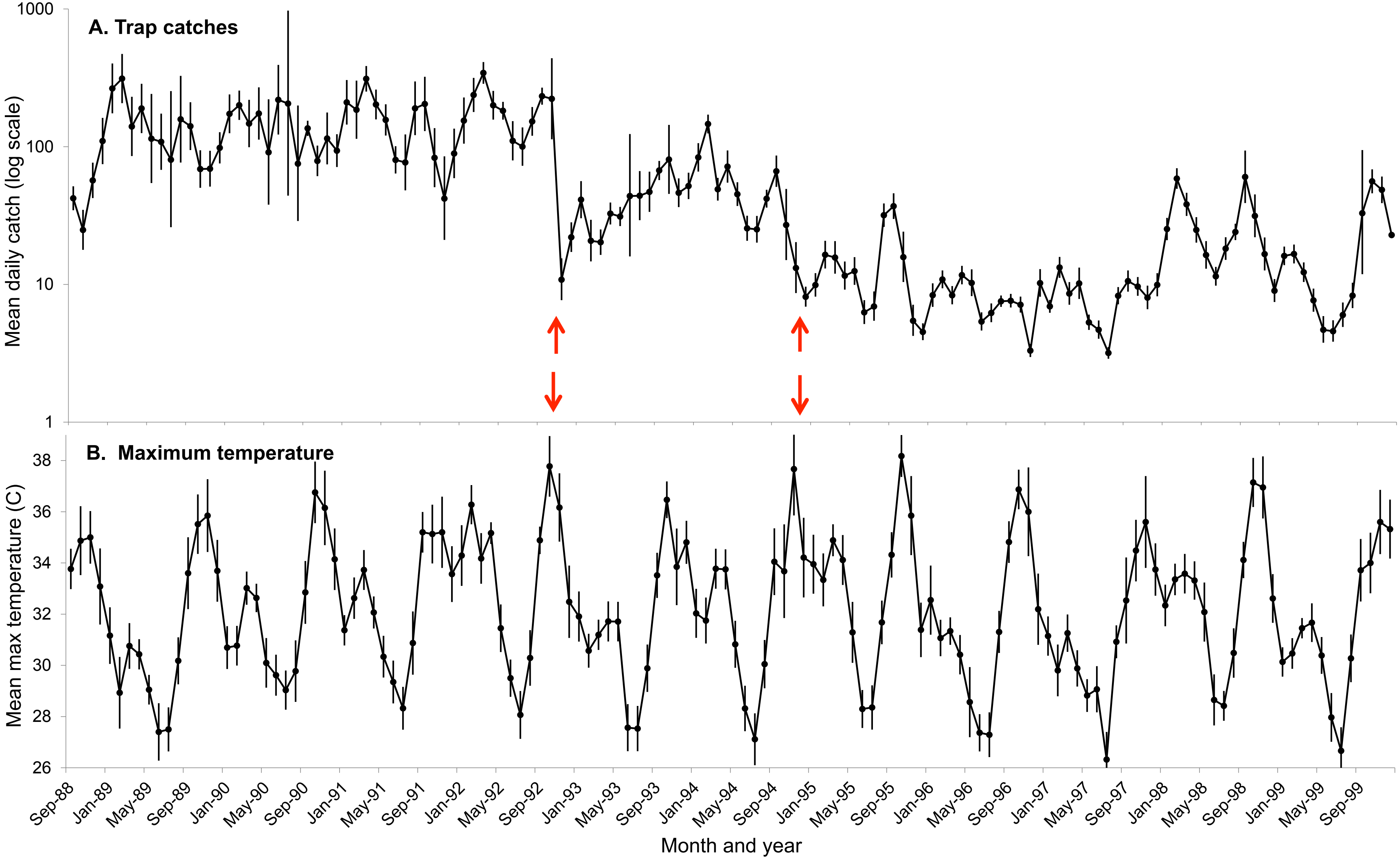


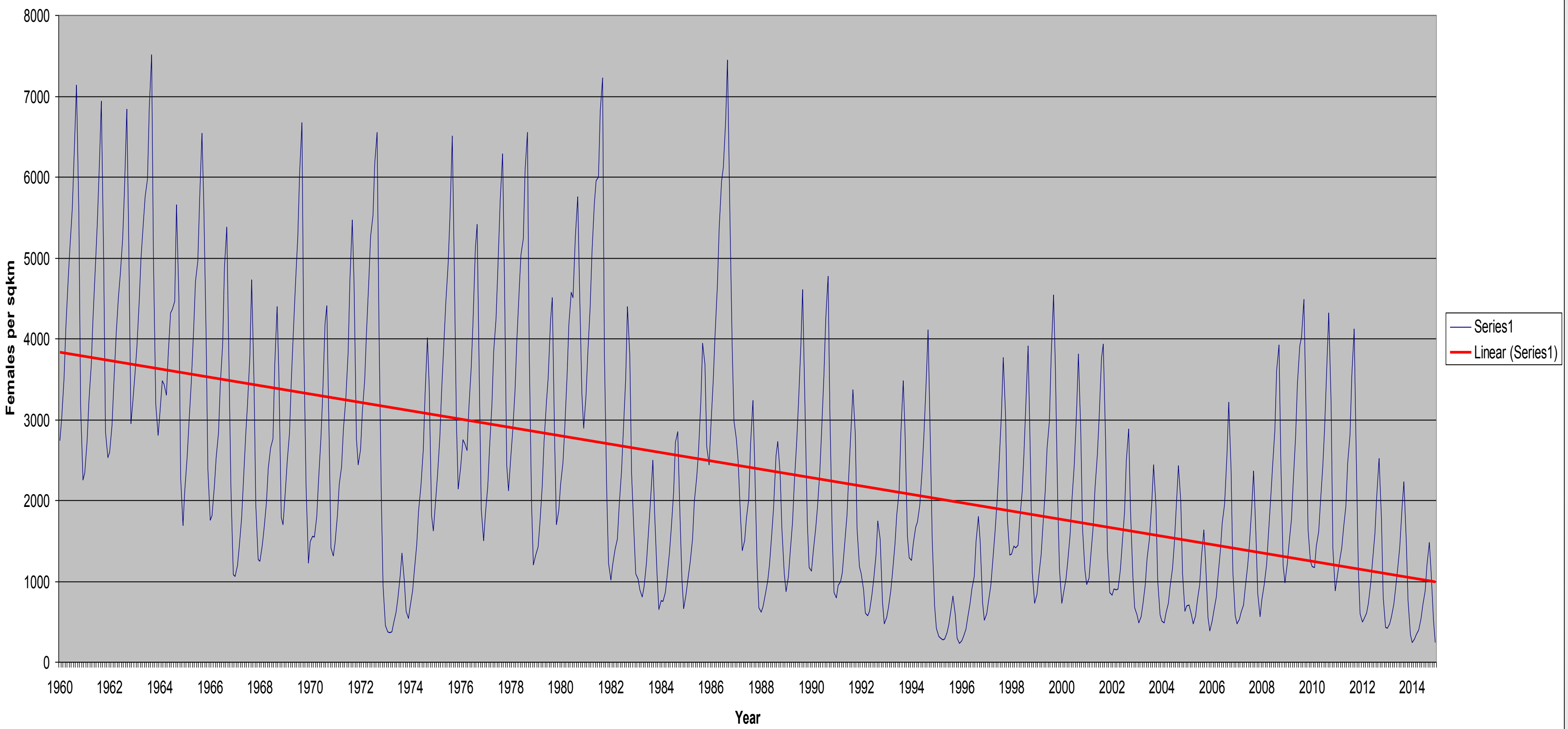
Work in Zimbabwe and elsewhere has led to the identification of a number of odour attractants for tsetse. When used in conjunction with a trap this can produce large catches of tsetse

We gauge vector population levels by the numbers of flies caught in odour-baited traps, run for three hours each afternoon



The protracted hot spell in October 1992 saw a spectacular decline in tsetse catches. This was followed in 1994 by a further heat-wave, coupled with the lowest annual rainfall on record. The tsetse population has, so far, never recovered to the levels of the late 1980s.

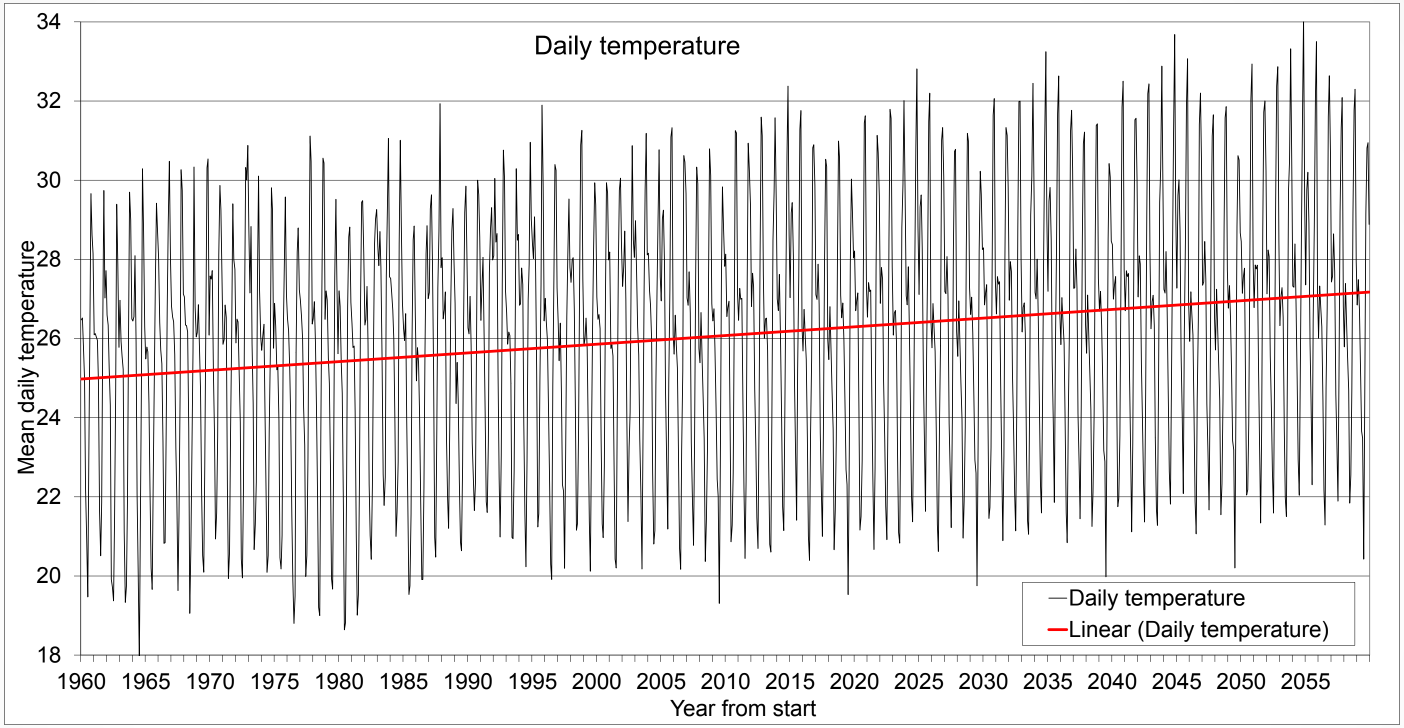
Cohort modelling of tsetse populations:
Can the declining tsetse population be attributable to increasing temperatures?



Catches of *G. m. morsitans* have declined by at least 75% over the past 55 years

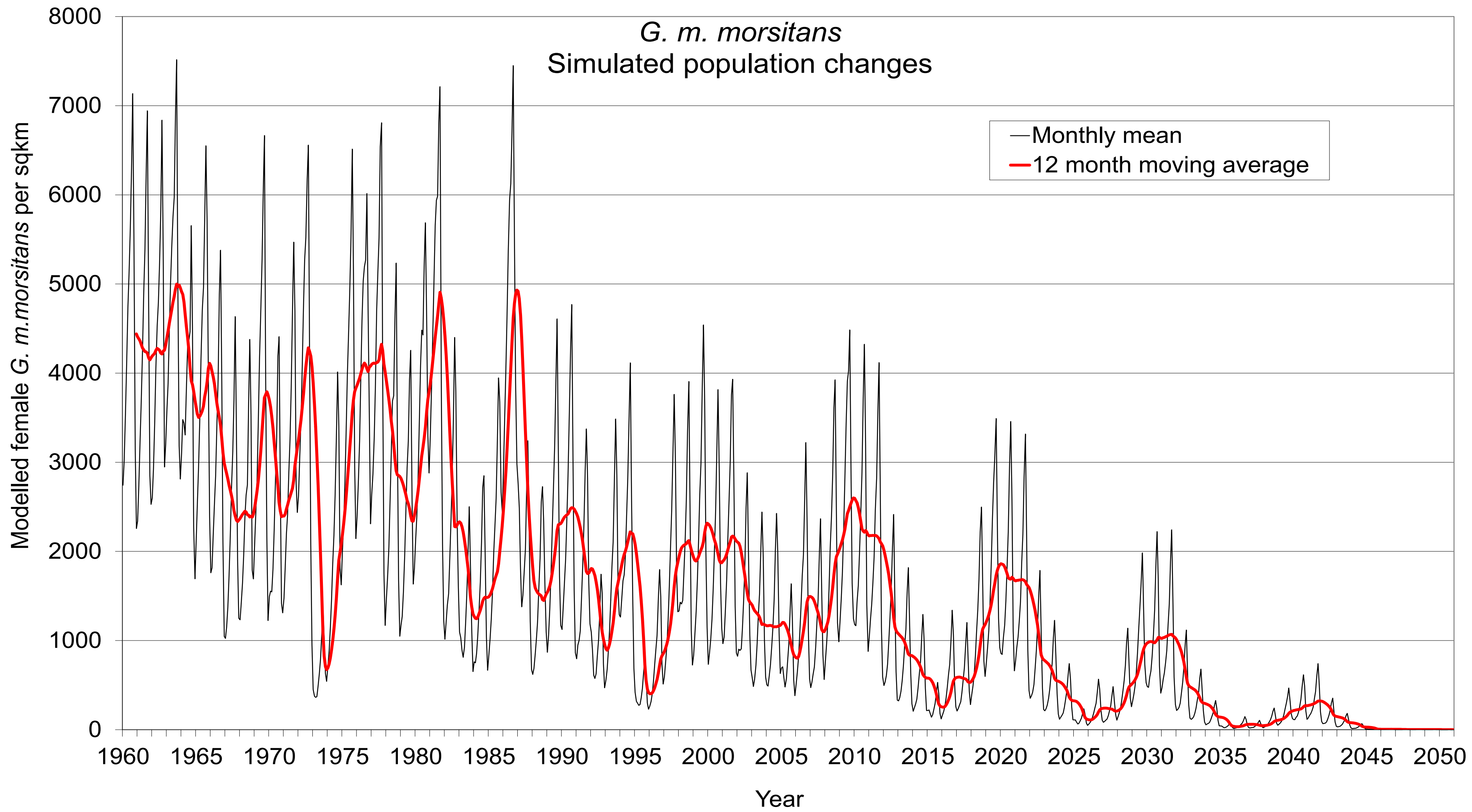
Using the estimated effects of temperature on mortality derived from Antelope, and adding also density dependent mortality, simulation studies suggest that this population decline may indeed be attributable to increased temperature

What about the future?



Linearly interpolated temperatures for the future at Rekomitjie Research Station

- If the current rate of temperature increase continues then we can expect a temperature **increase of about 2^{0}C by 2050** relative to1960
- What effect will that have on tsetse in the mid-Zambezi Valley?



Simulations suggest that *Glossina morsitans* may actually go extinct if temperatures continue to increase at current rates

Conversely, with a warmer climate, we ***might*** expect tsetse to invade suitable habitat in highveld of countries such as Zimbabwe

What's next?

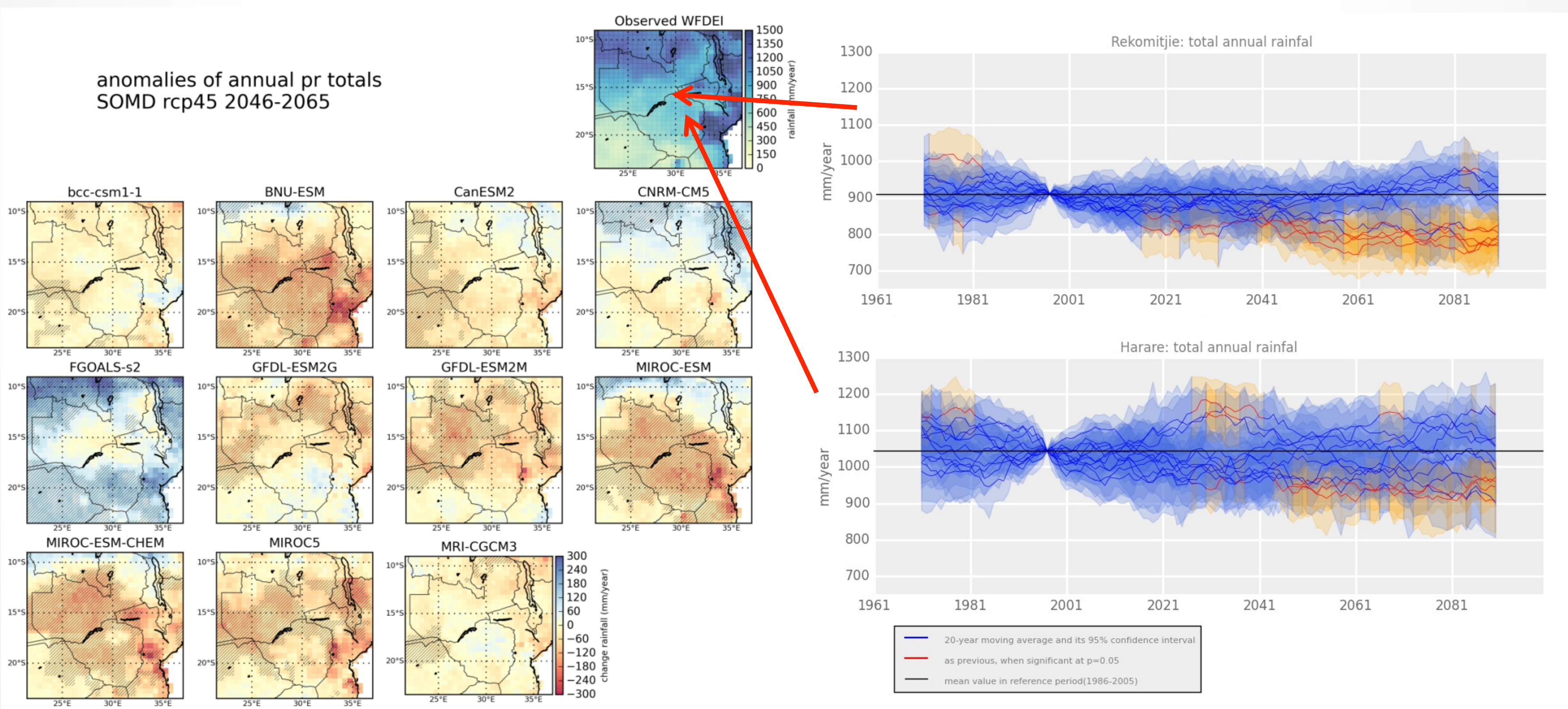
Can the results from this study site be transferable to other locations?

Can we do a better job of modelling the projected future tsetse population using more robust climate information?

Before we tackle this we undertook a simple climate suitability mapping exercise to explore how climate change may alter the location of suitable areas for tsetse flies

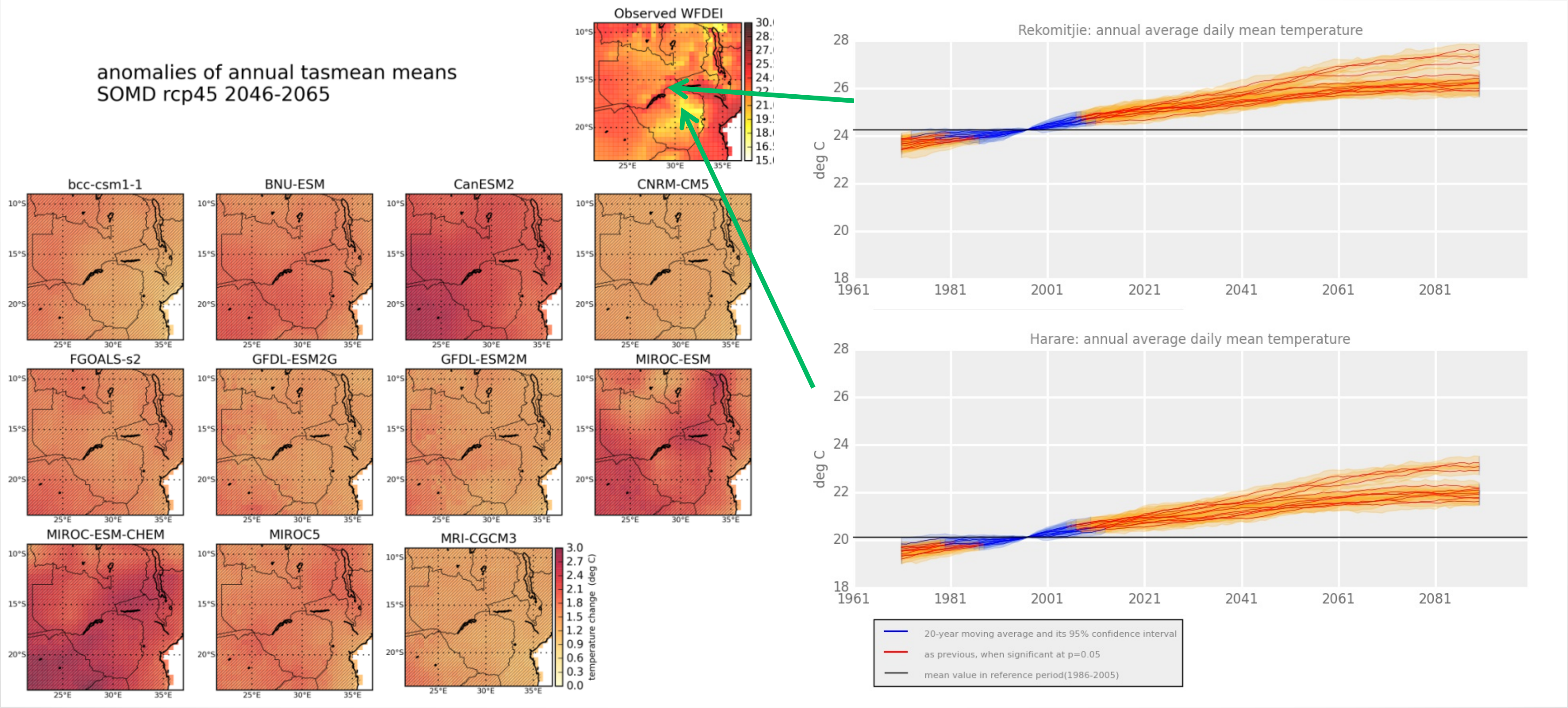
Downscaled projected rainfall anomalies

- Models still disagree on the magnitude and direction of change
- No significant change relative to model variability is evident in many models
- Some models do show significant drying in the second half of the century.



Downscaled mean temperature anomalies

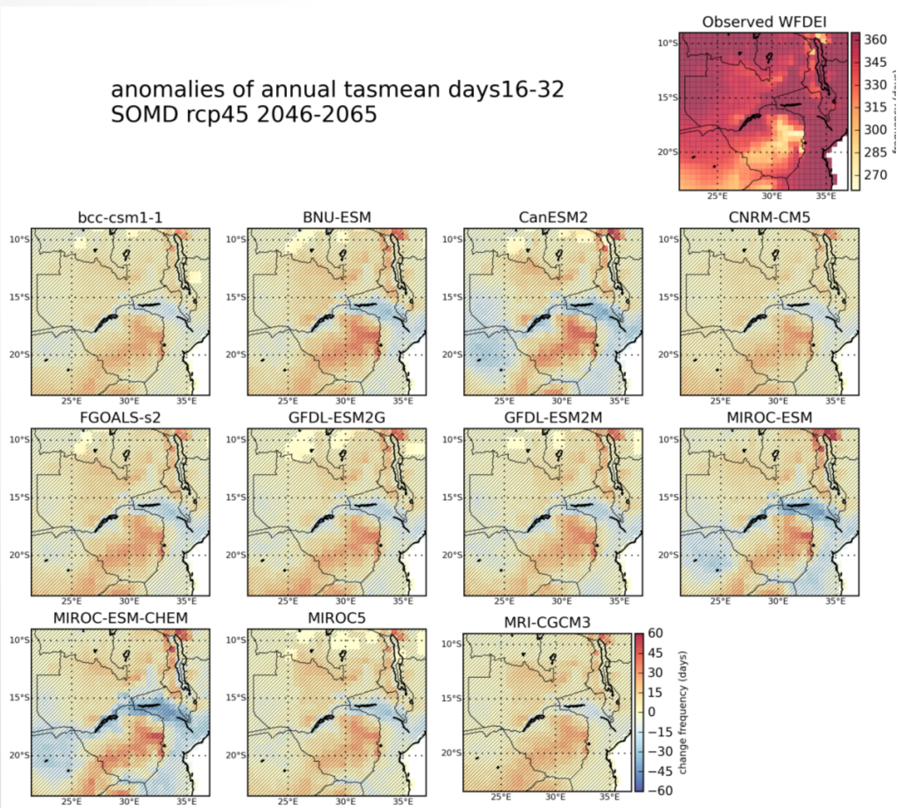
- Projected trends in downscaled projected mean temperature are all positive and significant.
- Anthropogenic signal emerges from the model's variability
- The absolute anomalies vary primarily in magnitude.
- Possible bifurcation of models response towards the end of the century

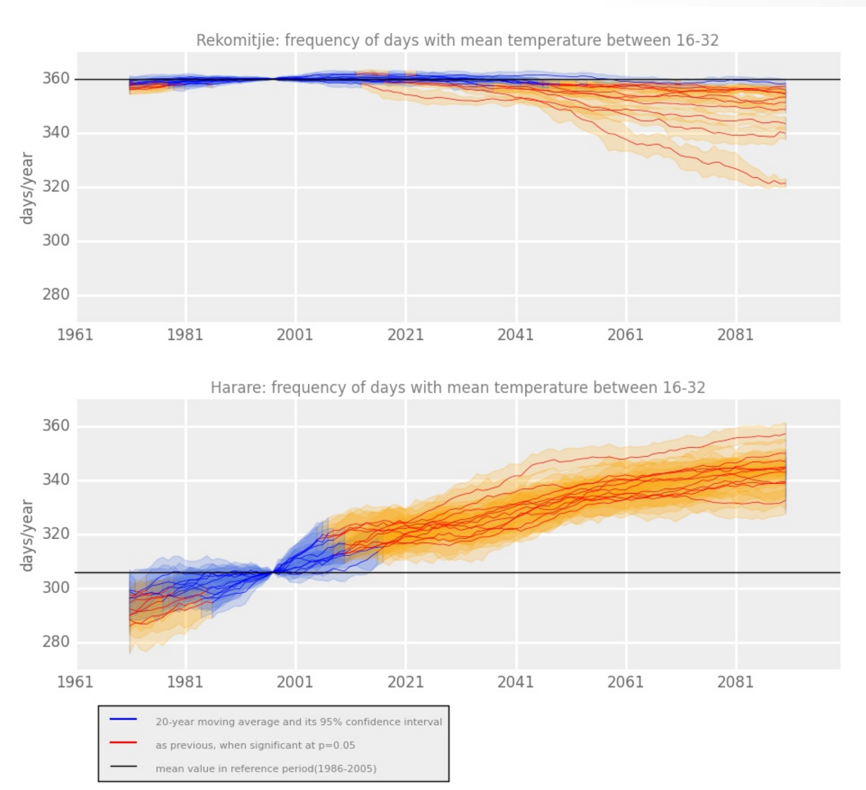


Mean temperature: Frequency of days within the ideal temperature range

A consistent message of decreasing frequency of days within the ideal temperature range within the Zambezi River, and increasing frequency in the highveld of Zimbabwe.

Note: This is **just climate suitability** and does not take into account vegetation type , animal numbers, vector control measures etc.





Summary

- There is a strong relationship between temperature and tsetse fly population dynamics.
- The Rekomitjie research stations provides an ideal opportunity to obtain more evidence and to test this relationship in the field.
- Results can be used to improve the modelling of the fly dynamics.
- Using climate change information, it is possible to explore if the projected increase in temperature could lead to a local extinction of tsetse.
- Furthermore, it is possible to explore the projected shift in “climate suitability” for tsetse flies into the future.
- The results presented here are still “work in progress” and represent just one thread within a much larger research project.

Thank You

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