Analysis of Climate-driven Shifts in Species Composition

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9 March 2017

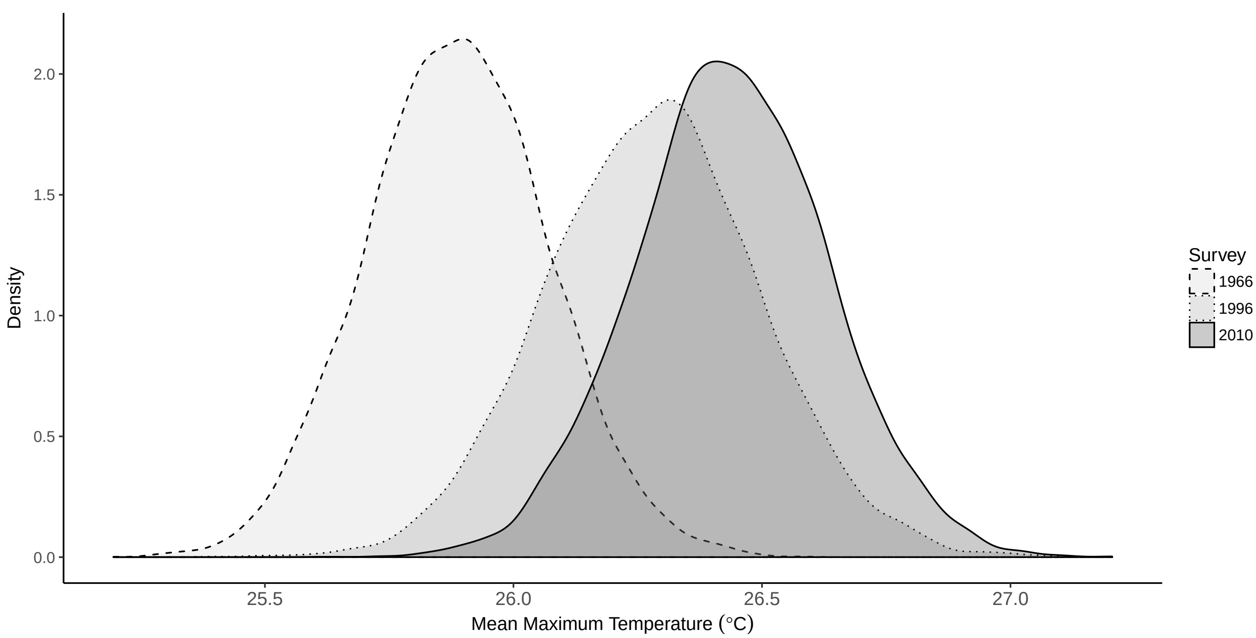
This script uses *MCMCregress()* from R library(MCMCpack) to estimate each species' mean maximum temperature tolerance and then estimate and compare the mean maximum temperature tolerance for each set of species unique to each vegetation survey. We repeat this with 3 separate climate data sources. *This entire script take ~10 minutes to run on a 2015 MacBook-Pro x86_64.*

The extracted climate data:

```
##         Species  tmax_Wi  tmax_Hi  tmax_Sc
## 1 Acacia saligna 30.78617 28.32350 30.28106
## 2 Acacia saligna 30.67951 28.34709 30.18046
## 3 Acacia saligna 30.58243 28.47810 30.07987
## 4 Acacia saligna 30.79390 28.20000 30.25791
## 5 Acacia saligna 30.82104 28.22695 30.22332
## 6 Acacia saligna 30.71092 28.37541 30.11724
```

Schulze et al. 2007

Schulze RE (2007) South African Atlas of Climatology and Agrohydrology., (Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06,), Technical report.

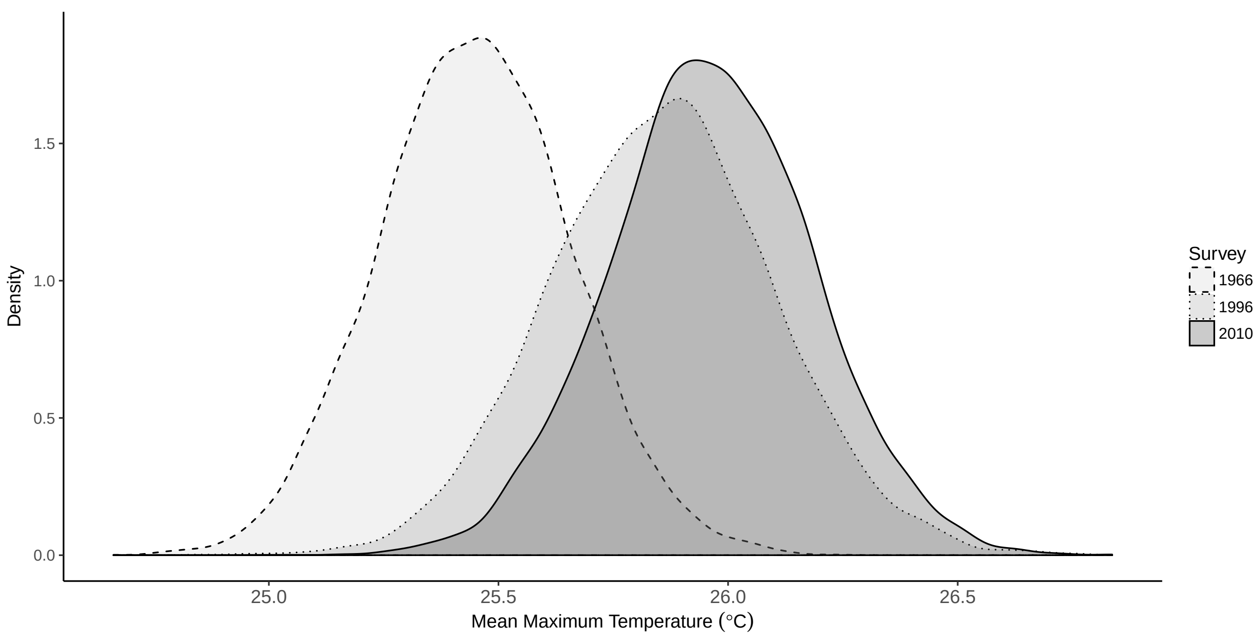



```
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
```

```
##    plus standard error of the mean:
##
##                Mean     SD Naive SE Time-series SE
## (Intercept) 25.8875 0.1826 0.001826       0.001833
## Survey1996   0.3935 0.2817 0.002817       0.002817
## Survey2010   0.5501 0.2657 0.002657       0.002715
## sigma2       1.3415 0.1920 0.001920       0.002001
##
## 2. Quantiles for each variable:
##
##                 2.5%     25%     50%     75%   97.5%
## (Intercept) 25.53735 25.7643 25.8872 26.0094 26.2477
## Survey1996  -0.15381  0.2018  0.3979  0.5827  0.9421
## Survey2010   0.03092  0.3724  0.5492  0.7298  1.0661
## sigma2       1.01741  1.2041  1.3231  1.4557  1.7686
```

Hijmans et al. 2005

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A (2005) Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25(15):1965– 1978.

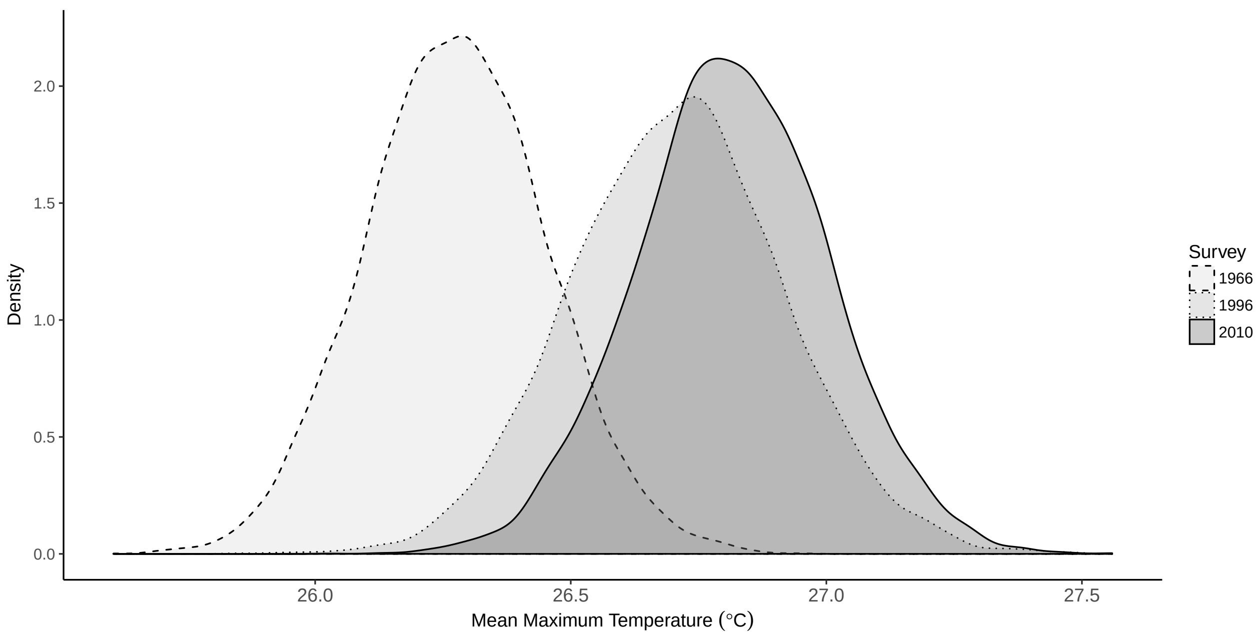



```
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                Mean     SD Naive SE Time-series SE
## (Intercept) 25.4494 0.2078 0.002078       0.002086
## Survey1996   0.4060 0.3206 0.003206       0.003206
```

```
## Survey2010   0.5142 0.3023 0.003023       0.003090
## sigma2       1.7374 0.2486 0.002486       0.002591
##
## 2. Quantiles for each variable:
##
##                 2.5%     25%     50%     75%  97.5%
## (Intercept) 25.05095 25.3092 25.4491 25.5882 25.859
## Survey1996  -0.21688  0.1878  0.4110  0.6213  1.030
## Survey2010  -0.07669  0.3119  0.5131  0.7187  1.101
## sigma2       1.31766  1.5595  1.7136  1.8853  2.290
```

Wilson and Silander 2014

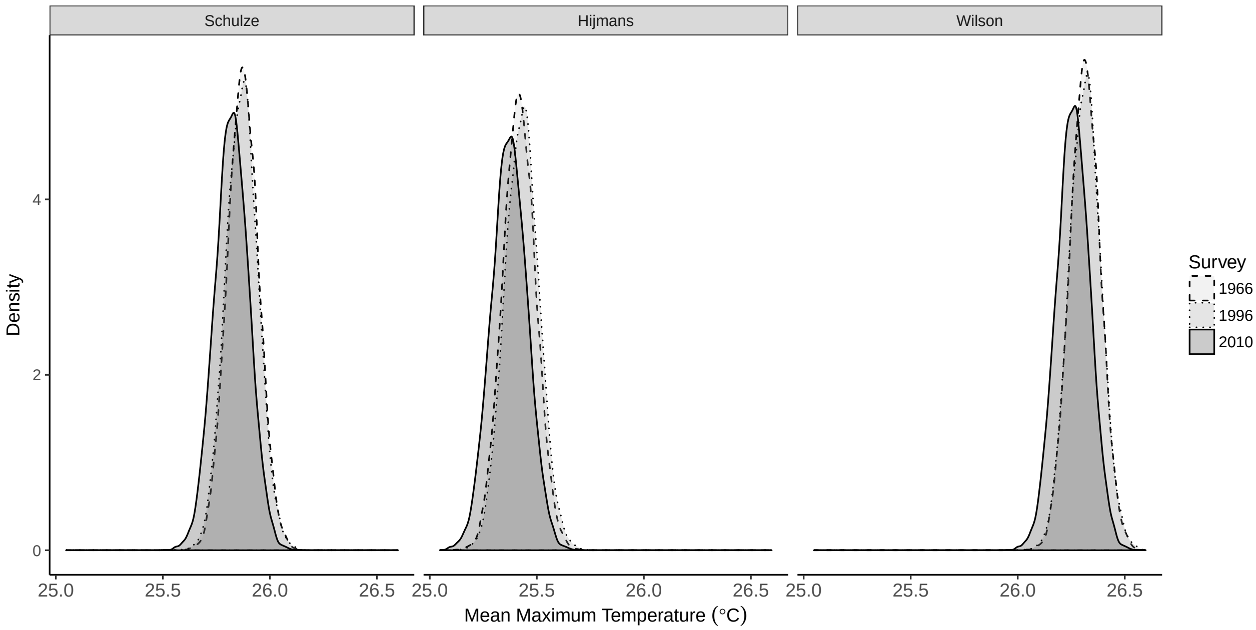
Wilson AM, Silander JA (2014) Estimating uncertainty in daily weather interpolations: a Bayesian framework for developing climate surfaces. International Journal of Climatology 34(8):2573–2584.




```
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##               Mean     SD Naive SE Time-series SE
## (Intercept) 26.2761 0.1769 0.001769       0.001776
## Survey1996   0.4321 0.2730 0.002730       0.002730
## Survey2010   0.5400 0.2574 0.002574       0.002631
## sigma2       1.2593 0.1802 0.001802       0.001878
##
## 2. Quantiles for each variable:
##
```

```
##                 2.5%     25%     50%     75%   97.5%
## (Intercept) 25.93688 26.1568 26.2758 26.3942 26.6252
## Survey1996  -0.09822  0.2463  0.4363  0.6154  0.9636
## Survey2010   0.03694  0.3678  0.5391  0.7141  1.0399
## sigma2       0.95506  1.1303  1.2421  1.3665  1.6602
```

Run all 3 models for the sets of all species from each survey




```
## $Schulze
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                  Mean      SD  Naive SE Time-series SE
## (Intercept) 25.874267 0.07252 0.0007252      0.0007268
## Survey1996  -0.005403 0.10414 0.0010414      0.0010562
## Survey2010  -0.052262 0.10719 0.0010719      0.0010951
## sigma2       1.558784 0.07711 0.0007711      0.0007711
##
## 2. Quantiles for each variable:
##
##                2.5%      25%      50%      75%   97.5%
## (Intercept) 25.7338 25.82507 25.87379 25.92346 26.0167
## Survey1996  -0.2076 -0.07632 -0.00427  0.06607  0.1997
## Survey2010  -0.2680 -0.12358 -0.05120  0.01999  0.1538
## sigma2       1.4146  1.50534  1.55614  1.60875  1.7179
##
```

```
##
## $Hijmans
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                  Mean      SD  Naive SE Time-series SE
## (Intercept) 25.41742 0.07668 0.0007668      0.0007685
## Survey1996   0.01306 0.11011 0.0011011      0.0011168
## Survey2010  -0.04592 0.11335 0.0011335      0.0011580
## sigma2       1.74286 0.08621 0.0008621      0.0008621
##
## 2. Quantiles for each variable:
##
##                2.5%      25%      50%      75%   97.5%
## (Intercept) 25.2689 25.36540 25.41691 25.46944 25.5680
## Survey1996  -0.2008 -0.06193  0.01426  0.08863  0.2300
## Survey2010  -0.2740 -0.12134 -0.04480  0.03048  0.1719
## sigma2       1.5817  1.68311  1.73991  1.79873  1.9208
##
##
## $wilson
##
## Iterations = 1001:11000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 10000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##                    Mean      SD  Naive SE Time-series SE
## (Intercept)  2.631e+01 0.07141 0.0007141      0.0007157
## Survey1996   4.314e-05 0.10255 0.0010255      0.0010401
## Survey2010  -5.555e-02 0.10556 0.0010556      0.0010784
## sigma2       1.512e+00 0.07477 0.0007477      0.0007477
##
## 2. Quantiles for each variable:
##
##                2.5%      25%       50%      75%   97.5%
## (Intercept) 26.1759 26.26576 26.313741 26.36265 26.4545
## Survey1996  -0.1991 -0.06979  0.001159  0.07042  0.2021
## Survey2010  -0.2680 -0.12578 -0.054502  0.01560  0.1473
## sigma2       1.3718  1.45975  1.509006  1.56003  1.6659
```

There are very small differences among years (0.02 to 0.05 of a degree C) with no confidence in them differing between years. Note that a large proportion of species (72%) were stable across time periods at the study level, overwhelming any signal of change in the macro-climatic tolerances. We do not expect species that have not encountered fire and/or unfavorable post-fire weather conditions during the study period to have responded to changes in climate. Similarly, climatic variation among plots and cooler sites within the study area may have allowed species with lower temperature tolerance to persist. It thus makes most sense to compare only species unique to each survey (i.e. those that that did turnover at the study level).