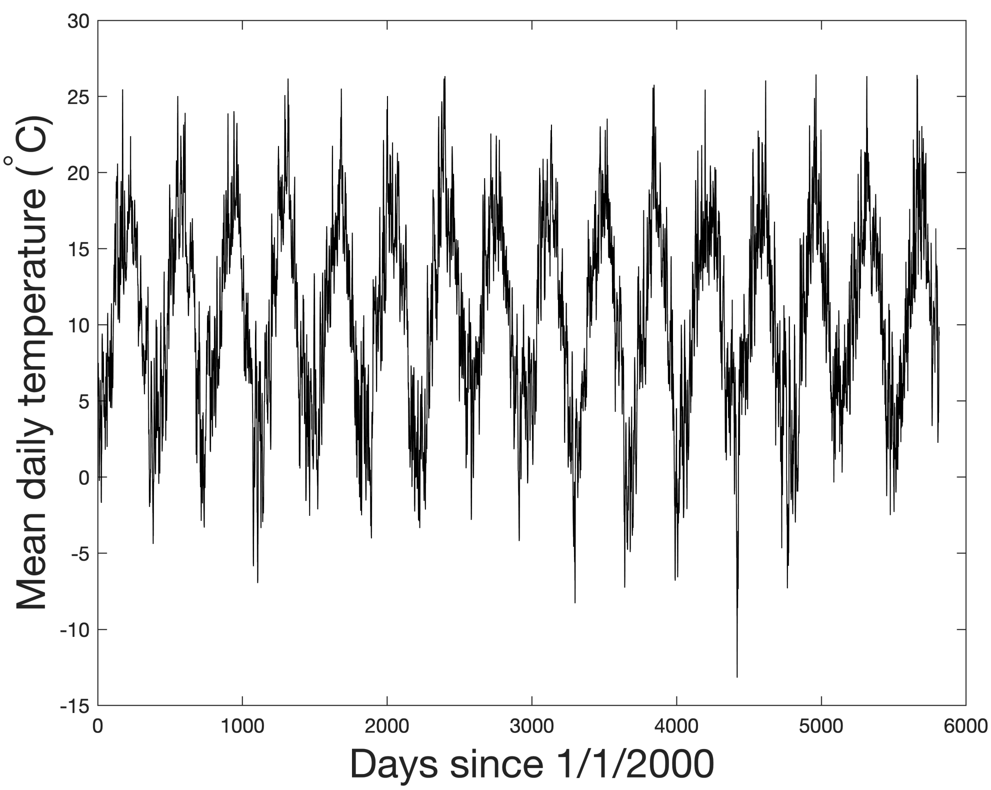
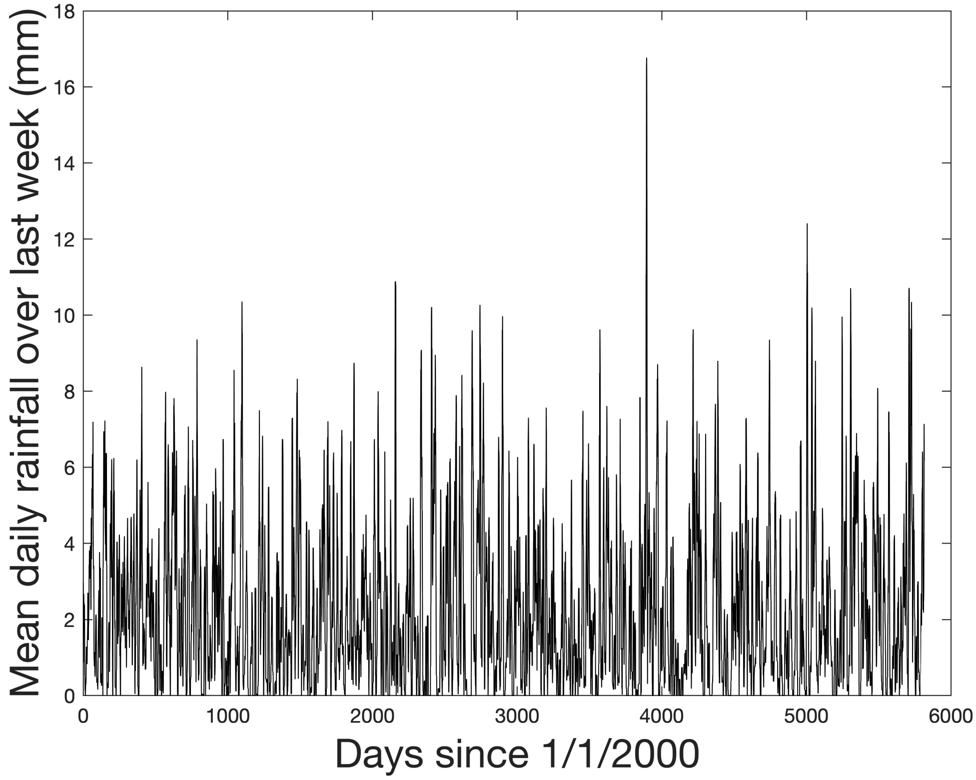
Example of Reproductive Ratio Calculation at the Netherlands trap site

In this example live script we show the climate-dependent reproductive ratio calculated for the E-OBS grid square containing the trap site in the Netherlands. Daily mean temperature and average rainfall over last week climate variables have already been gathered from the E-OBS climate dataset (see `/data_conversion` folder for scripts).

```
%Load climate data sets 2000-2015
load('temp_at_trap_siteNLDS.mat');
load('rain_at_trap_siteNLDS.mat');
plot(temp_at_trapsite_NLDS,'color','black')
xlabel('Days since 1/1/2000','FontSize',20)
ylabel('Mean daily temperature (^\circC)','FontSize',20)
```




```
plot(rain_at_trapsite_NLDS,'color','black')
xlabel('Days since 1/1/2000','FontSize',20)
ylabel('Mean daily rainfall over last week (mm)','FontSize',20)
```



Vectorial capacity per midge

First, we convert the temperature timeseries into a daily prediction of the vectorial capacity per midge. This quantity measures the expected number of livestock infected by a **single** midge arriving to bite an infectious animal on each day *t*. We calculate the capacity per vector $\widehat{C}$, which depends on the daily temperatures $\mathcal{T}_t, \mathcal{T}_{t+1}, \mathcal{T}_{t+2}, \ldots$, using a mathematical formula,

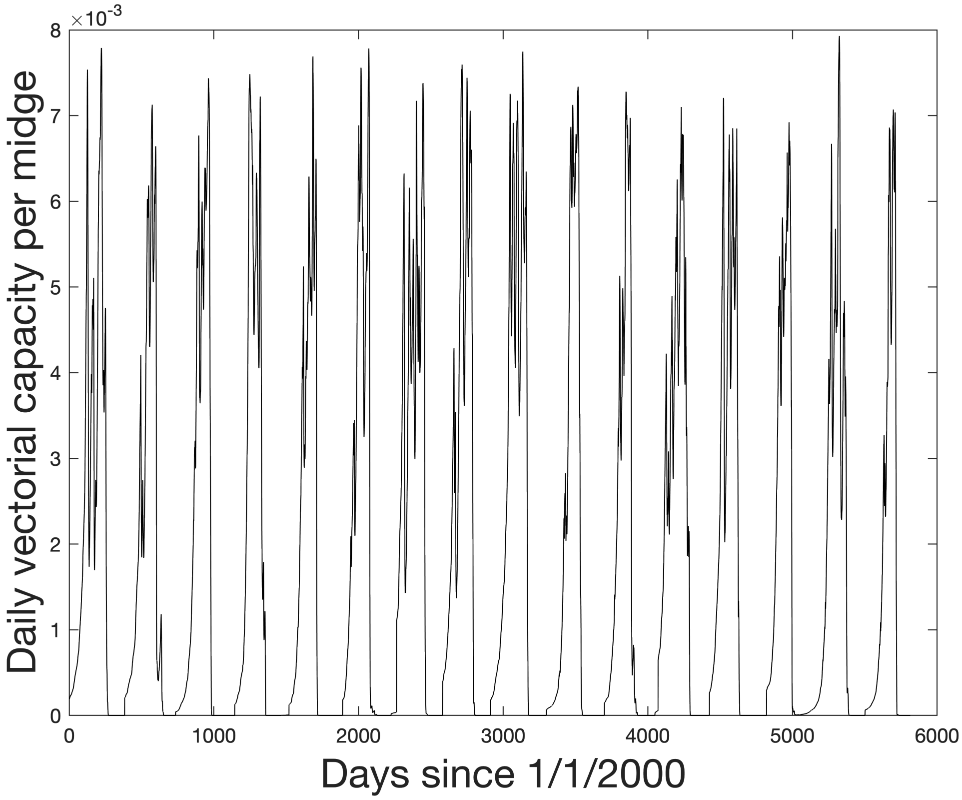
$$\widehat{C}(t|\mathcal{T}_t, \mathcal{T}_{t+1}, \ldots) = V \sum_{\tau=t+1}^{\infty} P_\alpha(\tau) S_\mu(t,\tau) T_\sigma(t,\tau).$$

Here, *V* is the vector competence of midges transmitting BTV serotype 8 (the product of the transmission probability from host to vector and vector to host), $P_\alpha(\tau)$ is the temperature dependent probability that the midge bites on day τ, $S_\mu(t,\tau)$ is the temperature dependent probabiltiy that a midge survives between day *t* and day τ, and $T_\sigma(t,\tau)$ is the temperature dependent probability that a midge infected with BTV on day *t* has completed its EIP (the period during which although *infected* with BTV the midge is not yet *infectious*). We assumed that the EIP at constant temperature has a 10-stage Erlang distribution.

Intuitively, $\widehat{C}$ measures the expected number of bites a midge will make in the rest of her life-time with each bite being weighted by the probability it *actually* causes transmission. This was implemented using the function `VC_per_biting_vector_array`:

```
C_hat = VC_per_biting_vector_array(0.1,temp_at_trapsite_NLDS,length(temp_at_trapsite_NLDS));
plot(C_hat,'color','black')
```

```
xlabel('Days since 1/1/2000','FontSize',20)
ylabel('Daily vectorial capacity per midge','FontSize',20)
```



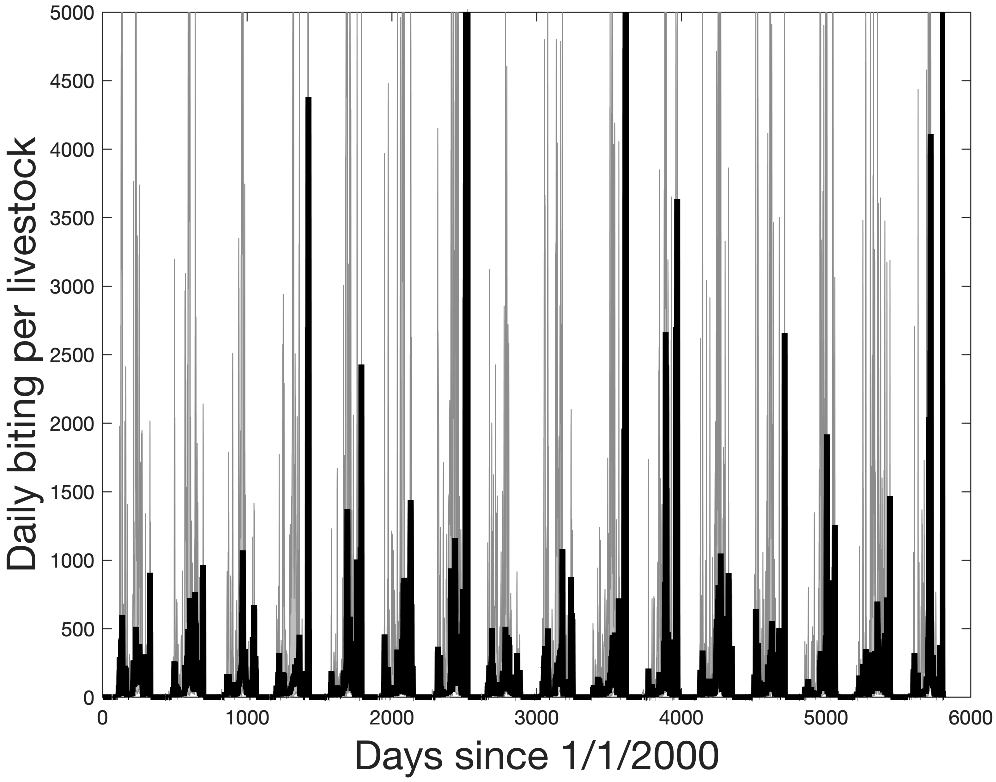
Note that $\widehat{C}$ is a small quantity ($\sim \mathcal{O}(10^{-3})$), which indicates that any single midge is a poor vector of BTV. BTV transmission is sustained by large numbers of bites on infectious livestock over several days.

Vectorial capacity per livestock

The vectorial capacity of an infected livestock measures the number the expected **future** number of secondary infections amongst livestock due to midge biting per day *t*, which we denote *C*. In this paper, we derived a model for the number of midges biting an animal per day ($B(t)$) given the relevant climatic variables using both midge catch data and comparison to livestock serological data (maximum bites per day were capped at 5000). However, we found that location specific random effects were a significant factor in midge biting; that is that there was intrinsic unexplained difference in the rate of midge biting activity from place to place. For the wider spatial analysis we used the `create_biting_array_from_background_midge_population` function, which is suitable for the multi-dimensional arrays of the pan-European climate dataset. For this example we use `create_biting_vector_from_background_midge_population`, which gives the **median** prediction of midge biting over possible underlying location-specific random effects. This can be converted into other percentiles using the `BitingForEachLevelOfP` function (background shading in plot below gives 5th-95th percentile prediction intervals).

```
DN = datenum([1999,12,31]) + (1:length(temp_at_trapsite_NLDS));%Days in MATLAB datenum format
B_median = create_biting_vector_from_background_midge_population(0.51,2.66,temp_at_trapsite_NLD
B_low =  BitingForEachLevelOfP(B_median,temp_at_trapsite_NLDS,2.66,0.05);%5th percentile
```

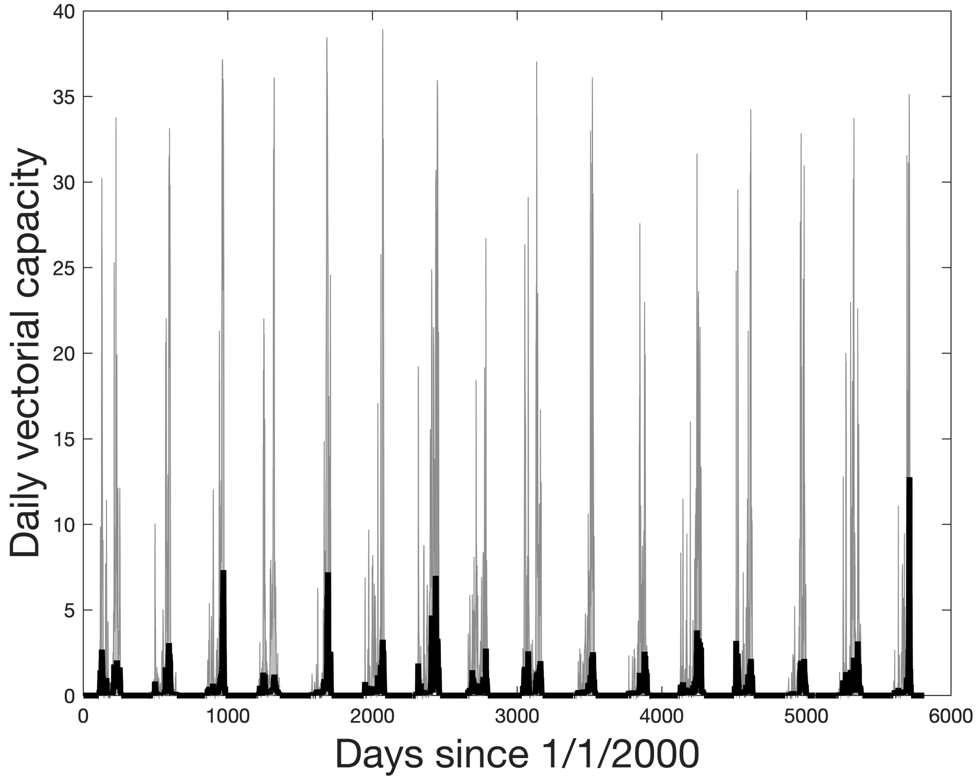
```
B_high =  BitingForEachLevelOfP(B_median,temp_at_trapsite_NLDS,2.66,0.95);%95th percentile
shadedErrorBar(1:length(temp_at_trapsite_NLDS),B_median,[(B_high-B_median)'; (B_median - B_low)
xlabel('Days since 1/1/2000','FontSize',20)
ylabel('Daily biting per livestock','FontSize',20);
```



Having calculated $\widehat{C}$, and *B*, calculating *C* is simply a rescaling by the number of midges expected to bite a livestock on that day,

$$C(t) = B(t)\widehat{C}(t)$$

```
C_low = B_low.*C_hat;
C_median = B_median.*C_hat;
C_high = B_high.*C_hat;
shadedErrorBar(1:length(temp_at_trapsite_NLDS),C_median,[(C_high-C_median)'; (C_median - C_low)
xlabel('Days since 1/1/2000','FontSize',20)
ylabel('Daily vectorial capacity','FontSize',20);
```



Reproductive ratio per livestock