Two Amplitudes Model

Martin Ueding

31 3 2020

For fitting thermal pollutions one wants to try the following model:

$$A_1 \exp(Et) + A_2 \exp(E \cdot (T - t)) \,.$$

It has two amplitudes but only one energy. I have implemented this as `TwoAmplitudesModel` and restricted it to a single correlator. One could generalize this to fit a whole correlator matrix, but I cut the corners for now.

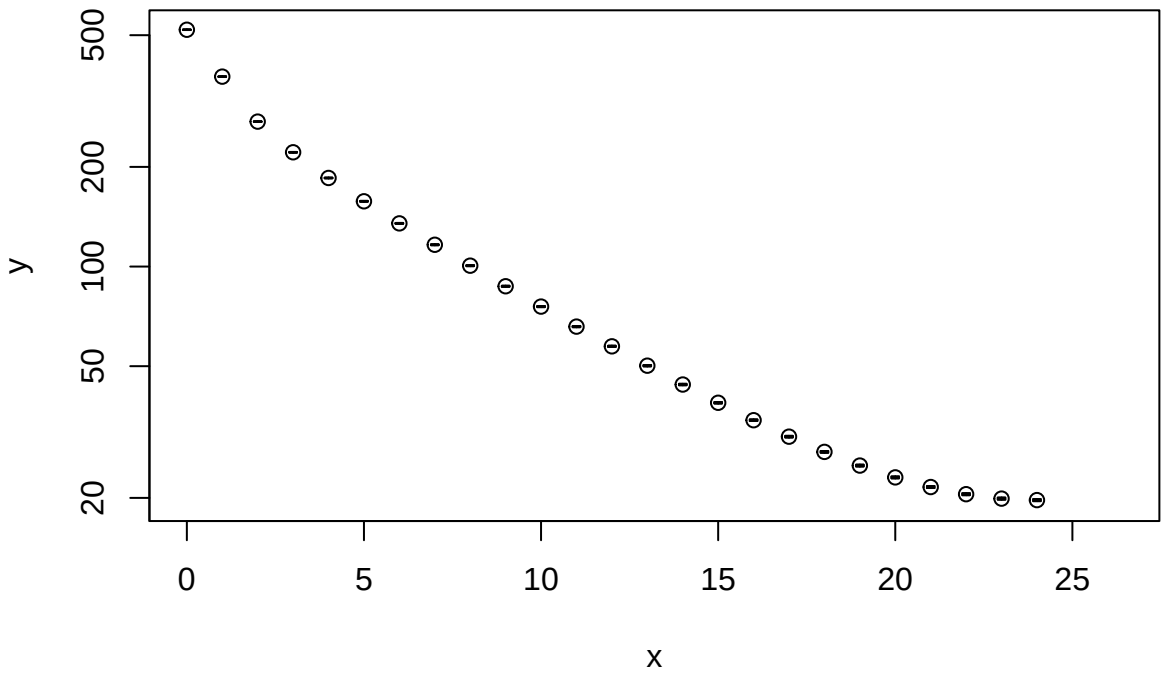
What we actually implement is the following to be consistent with the `SingleModel`:

$$\frac{1}{2} \left(A_1^2 \exp(Et) + A_2^2 \exp(E \cdot (T - t)) \right) \,.$$

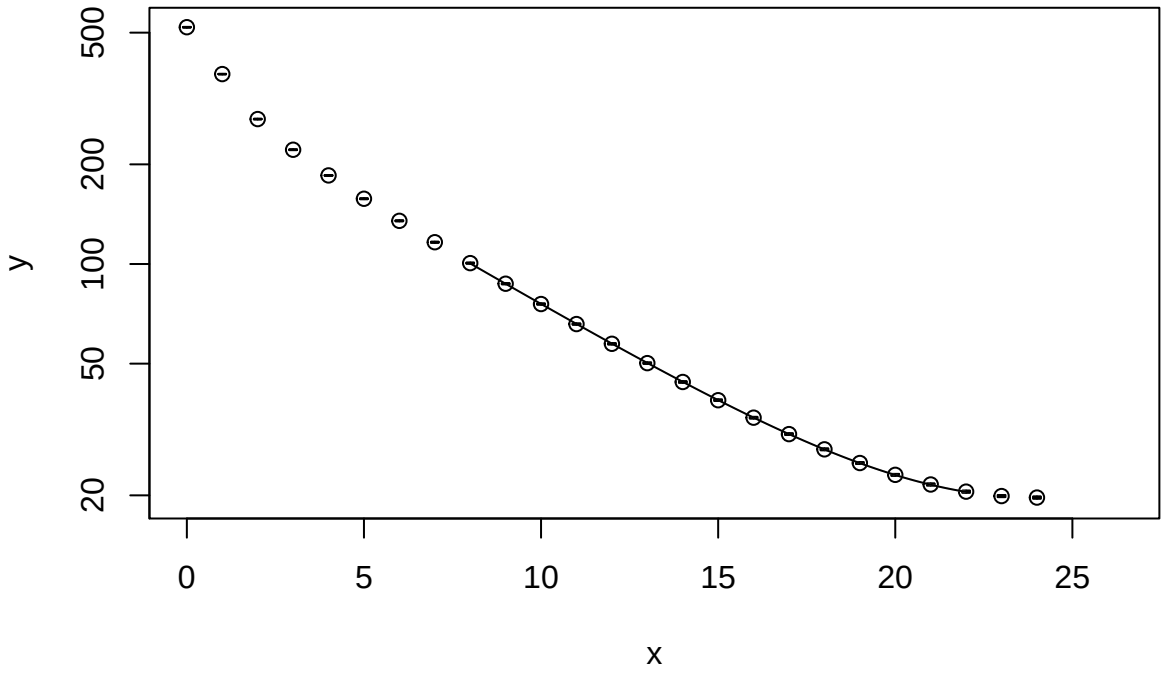
Test with samplecf

The samplecf correlation function does not have thermal pollutions. Therefore we expect the model to recover the same amplitude for forward and backward part.

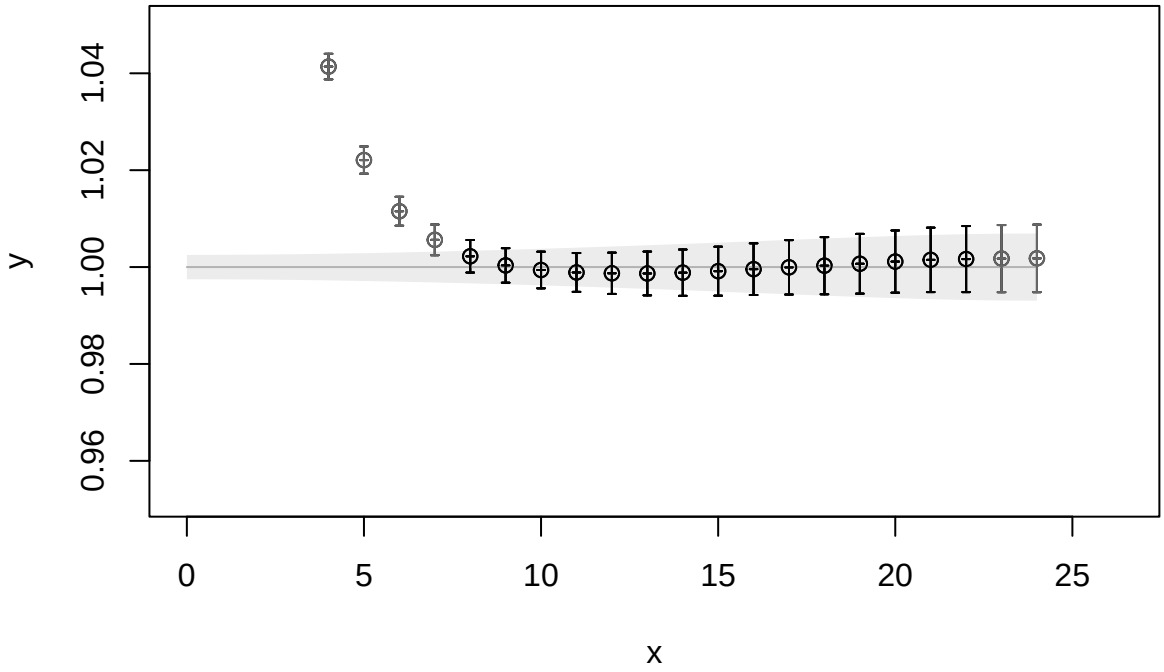
```
scf <- bootstrap.cf(samplecf)
plot(scf, log = 'y')
```



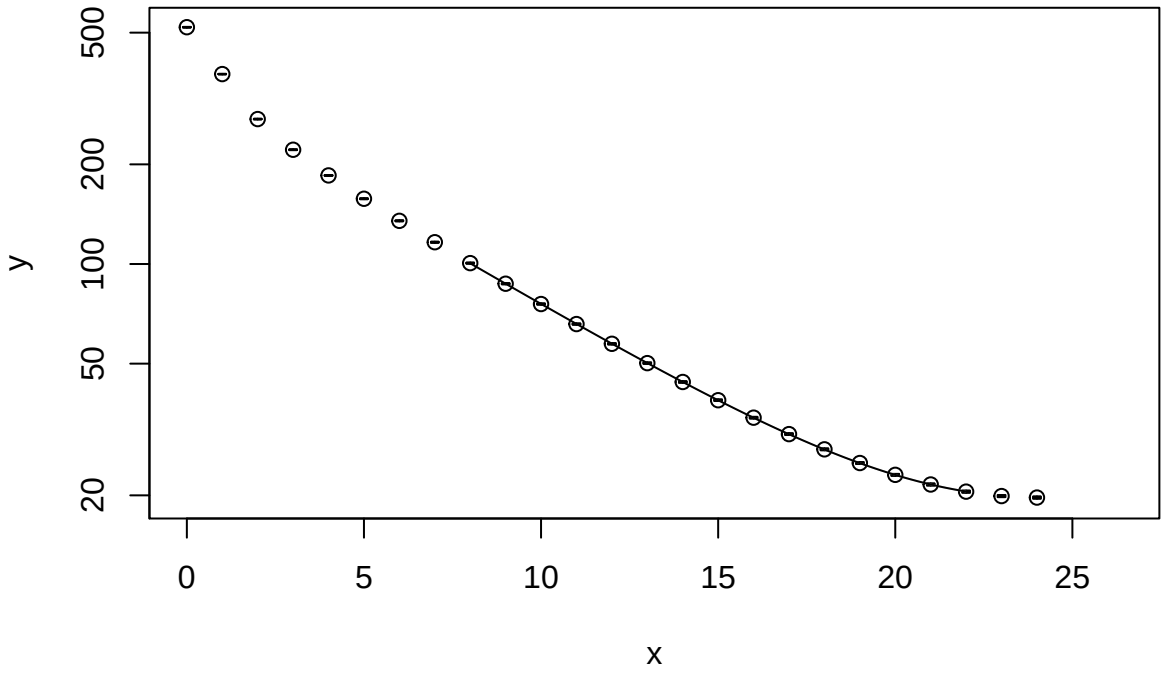

```
fit_sample <- new_matrixfit(scf, 8, 22, model = 'single')
plot(fit_sample, log = 'y')
```



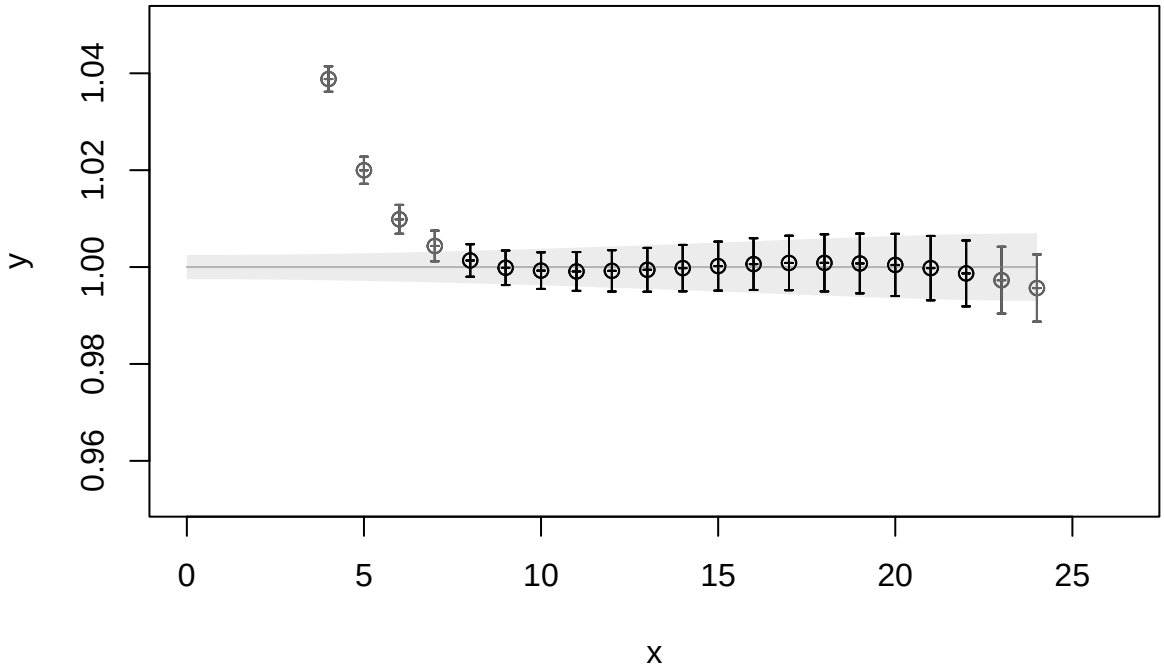

```
residual_plot(fit_sample, ylim = c(1/1.05, 1.05))
```




```
fit_sample_2 <- new_matrixfit(scf, 8, 22, model = 'two_amplitudes')
plot(fit_sample_2, log = 'y')
```




```
residual_plot(fit_sample_2, ylim = c(1/1.05, 1.05))
```



Looking at the results from both fits, we see that the first fit produces (E, A) which is reproduced by the second as (E, A_1, A_2) pretty well:

```
mapply(tex.catwitherror, fit_sample$t0, fit_sample$se, with.dollar = FALSE)
```

```
## Loading required namespace: errors
```

```
## [1] "0.1446(3)" "25.15(3)"
```

```
mapply(tex.catwitherror, fit_sample_2$t0, fit_sample_2$se, with.dollar = FALSE)
```

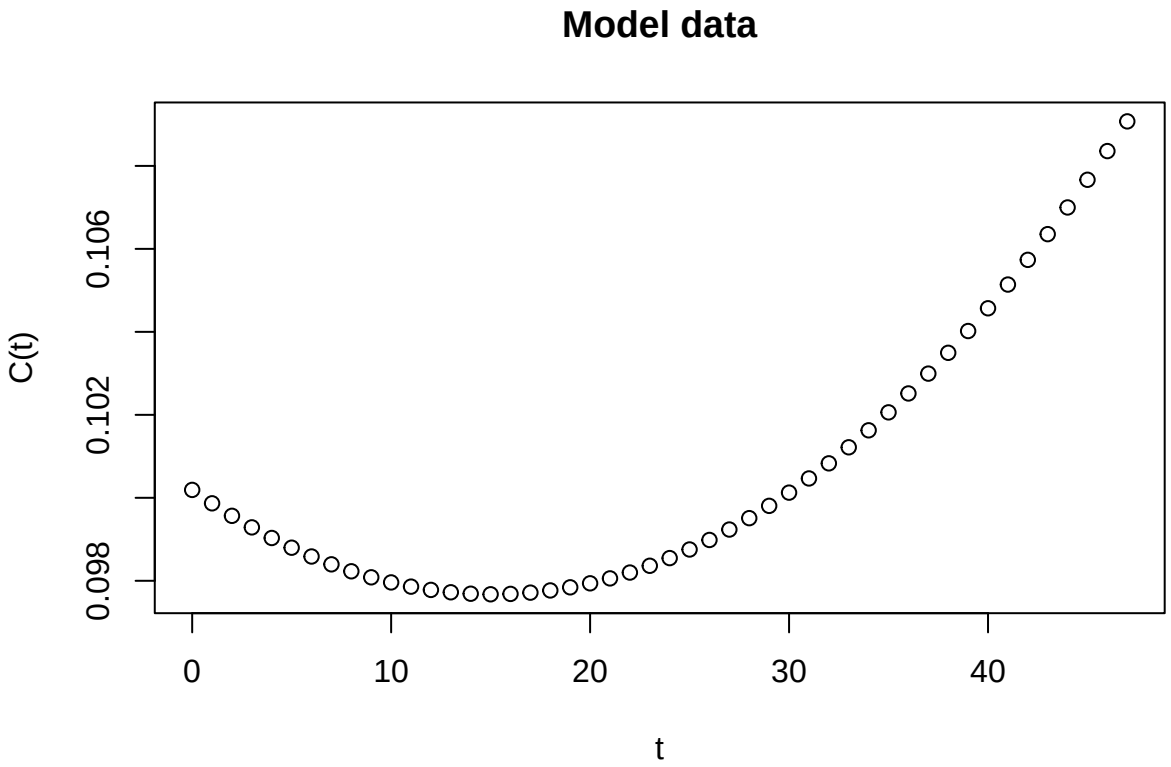
```
## [1] "0.1450(3)" "25.20(3)"  "0.785(5)"
```

Test with artificial data

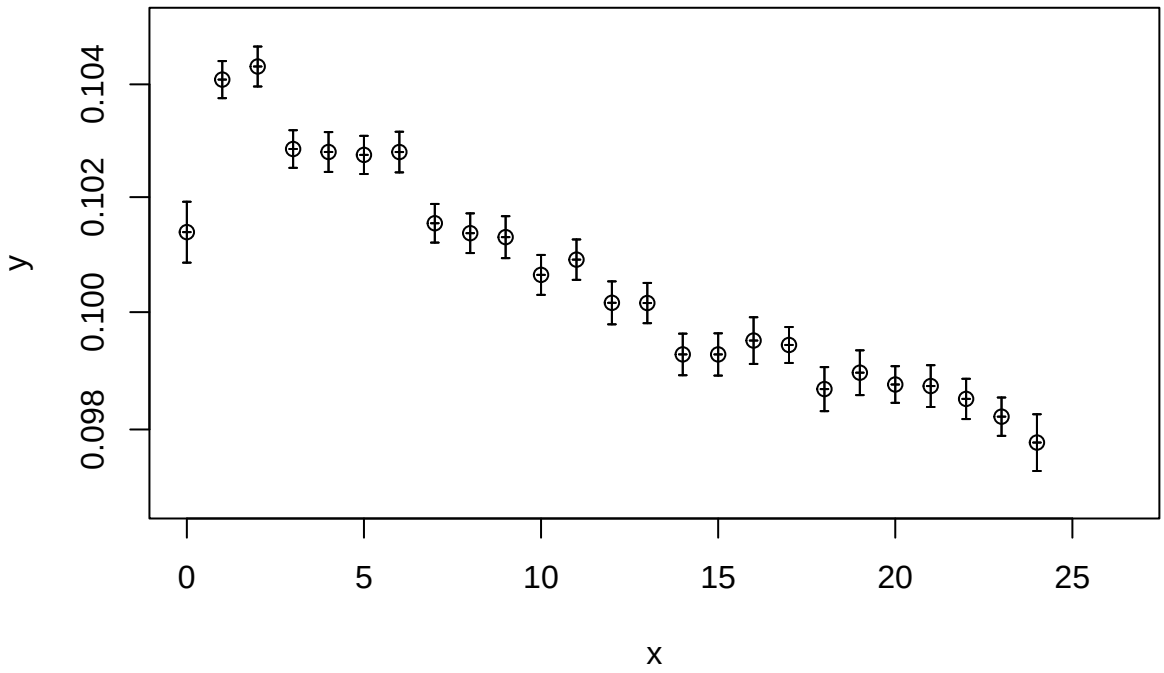
We can make up an example which has different forward and backward amplitudes and constant noise.

```
extent_time <- 48
time <- seq(0, extent_time - 1, by = 1)
model_E <- 0.015
model_A1 <- 0.35
model_A2 <- 0.4
val <- 0.5 * model_A1^2 * exp(-model_E * time) + 0.5 * model_A2^2 * exp(-model_E * (extent_time - time))
```

```
plot(time, val,
     main = 'Model data',
     xlab = 't',
     ylab = 'C(t)')
```

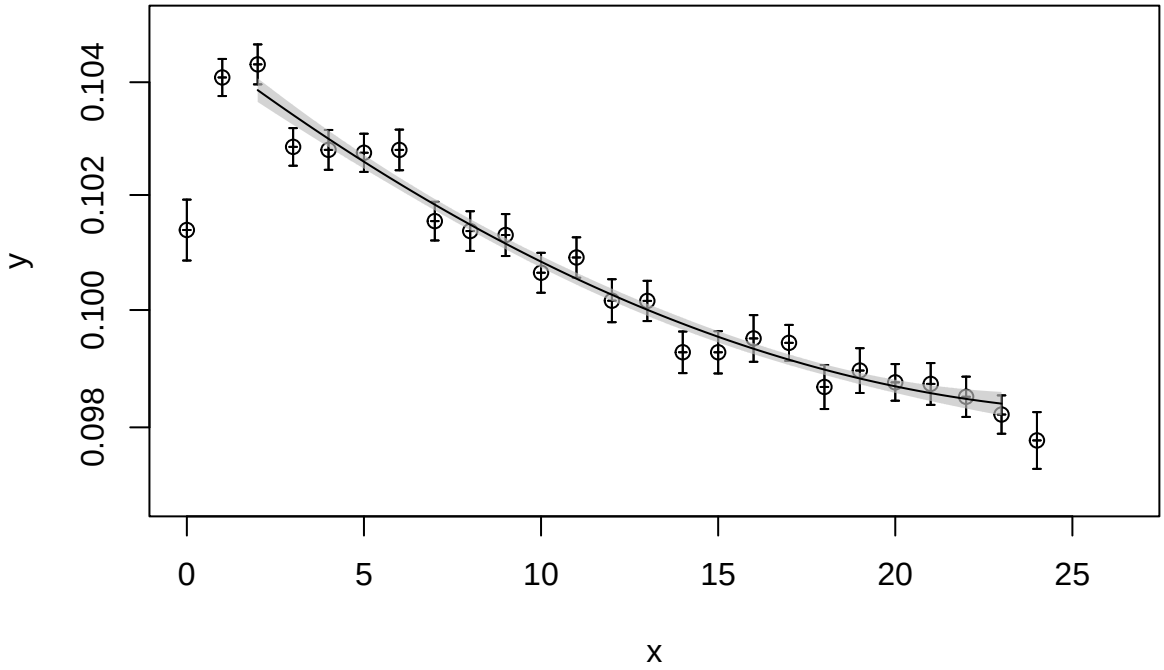



```
measurements <- do.call(cbind, lapply(val, function (v) rnorm(400, v, 0.01)))

cf <- cf_orig(cf_meta(Time = extent_time), cf = measurements)
cf <- symmetrise.cf(cf)
cf_boot <- bootstrap.cf(cf)

plot(cf_boot, log = 'y')
```

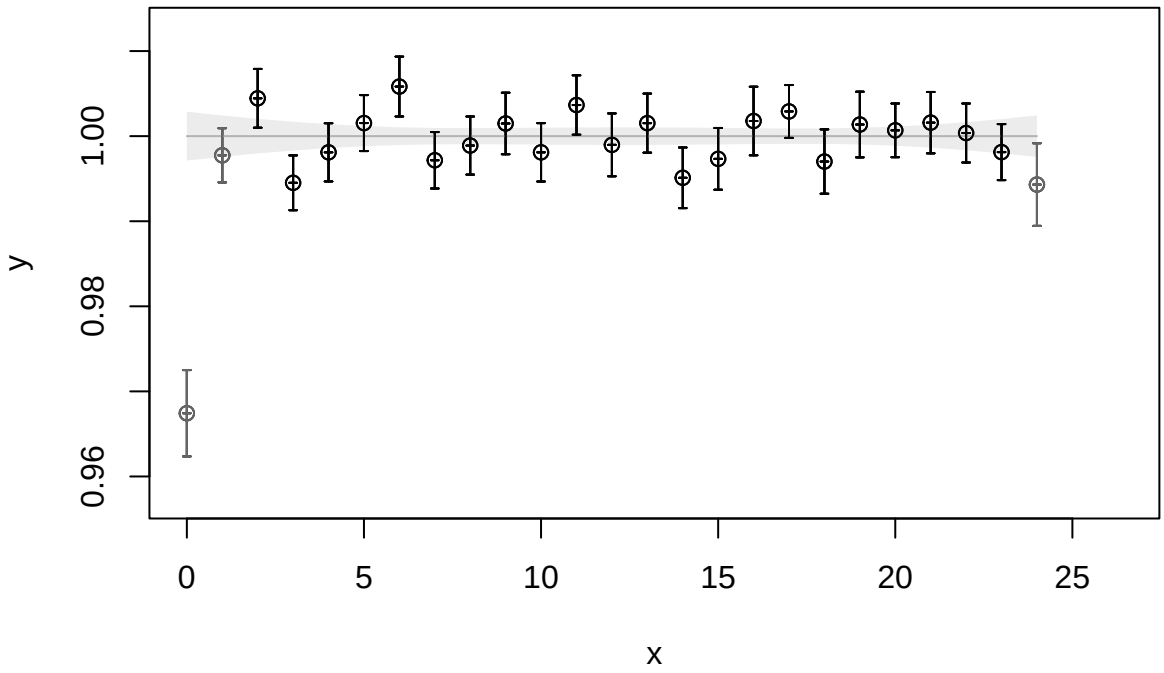


We fit that using the new model and

```
fit <- new_matrixfit(cf_boot, 2, 23, model = 'two_amplitudes')
plot(fit, log = 'y')
```




```
residual_plot(fit)
```



Comparing with the input from the model gives a reasonable result:

```
print(c(model_E, model_A1, model_A2))
```

```
## [1] 0.015 0.350 0.400
```

```
mapply(tex.catwitherror, fit$t0, fit$se, with.dollar = FALSE)
```

```
## [1] "-0.013(2)" "-0.261(2)" "-0.376(2)"
```