# Assignment 5

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**2) Let $y_t$ represent the global temperature series (gtemp).**

**b) Fit the state-space model defined in a. Fit the smoother $x_t^n$ with figure showing the gtemp plot, plot of the smooth gtemp and its 95% confidence interval.**

```
library(astsa)

# Model Setup
n= length(gtemp)
A=t(c(1, 0))
mu0=c(-0.26, -0.26)
Sigma0=diag(0.1, 2)
Phi=matrix(c(2, 1, -1, 0), 2)

# Likelihood Function
Likfn = function(para){
  cQ11=para[1]
  cR = para[2]
  cQ=matrix(c(cQ11,0, 0, 0), 2)
  kf = Kfilter0(n, gtemp, A, mu0, Sigma0, Phi, cQ, cR)
  return(kf$like) }

init.par = c(0.1, 0.1) # initial parameters
est = optim(init.par, Likfn, NULL, method = 'BFGS', hessian = TRUE, control=list(trace=1, REPORT=1))
```

```
## initial  value -176.833783
## iter   2 value -193.509307
## iter   3 value -210.232971
## iter   4 value -227.645984
## iter   5 value -228.149730
## iter   6 value -228.315844
## iter   7 value -228.591974
## iter   8 value -228.990437
## iter   8 value -228.990437
## final  value -228.990437
## converged
```

```
SE = sqrt(diag(solve(est$hessian)))
estoutput = cbind(estimates=est$par, SE)
rownames(estoutput) = c('cQ11', 'cR')
estoutput
```

```
##        estimates           SE
## cQ11 0.003143701 0.0008768945
## cR   0.087861942 0.0057264503
```

```
# Smoothing
cQ11=est$par[1]; cR=est$par[2]
cQ=matrix(c(cQ11, 0, 0, 0), 2)
Q = t(cQ)%*%cQ
```

```
ks = Ksmooth0(n, gtemp, A, mu0, Sigma0, Phi, cQ, cR)
xsmooth = ts(as.vector(ks$xs[1,,]), start=1880)
p=2*sqrt(ks$Ps[1,1,])
plot(xsmooth, lty=1, main='Smoothed gtemp')
lines(xsmooth-p, col='red', lty=2)
lines(xsmooth+p, col='red', lty=2)
```