```
#Homogenized and Adjusted Canadian Climate Data (HACCD)

pathdata <- "..."

setwd(pathdata)

folder_list <- list.files(pattern = "monthly")

file_list_prec <- list.files(path = paste(pathdata,folder_list[1],sep
= "/"), pattern = ".csv")
file_list_prec.dir <- list.files(path =
paste(pathdata,folder_list[1],sep = "/"), pattern = ".csv", full.names
= TRUE)

file_list_temp <- list.files(path = paste(pathdata,folder_list[2],sep
= "/"), pattern = ".csv")
file_list_temp.dir <- list.files(path =
paste(pathdata,folder_list[2],sep = "/"), pattern = ".csv", full.names
= TRUE)


area_prec = c()
for(i in 1:length(file_list_prec))
    area_prec[i] = unlist(strsplit(unlist(strsplit(file_list_prec[i],
split = c('mt'), fixed = TRUE))[2], split = '.csv')[1])

area_temp = c()
for(i in 1:length(file_list_temp))
    area_temp[i] = unlist(strsplit(unlist(strsplit(file_list_temp[i],
split = c('mm'), fixed = TRUE))[2], split = '.csv')[1])

sum(area_prec %in% area_temp)
Area <- area_prec[area_prec %in% area_temp]

file_list_prec_selected <- file_list_prec[area_prec %in% area_temp]
file_list_temp_selected <- file_list_temp[area_temp %in% area_prec]

file_list_prec.dir_selected <- file_list_prec.dir[area_prec %in%
area_temp]
file_list_temp.dir_selected <- file_list_temp.dir[area_temp %in%
area_prec]


prec_list <- sapply(file_list_prec.dir_selected, read.csv, simplify =
FALSE,USE.NAMES = FALSE)
temp_list <- sapply(file_list_temp.dir_selected, read.csv, simplify =
FALSE,USE.NAMES = FALSE)

for(i in 1:length(temp_list))
    temp_list[[i]][temp_list[[i]]==-9999.9] <- NA

for(i in 1:length(prec_list))
```

```
    prec_list[[i]][prec_list[[i]]==-9999.9] <- NA

FFN <- function(x){
    l=length(x)
    itr=1
    while(is.na(x[1])){
        x[1] <- x[itr+1]
        itr=itr+1
    }
    itr=1
    while(is.na(x[l])){
        x[l] <- x[l-itr]
        itr=itr+1
    }
    for(j in 2:(l-1)){
        itr=1
        while(is.na(x[j])){
            x[j] = (x[j-1] + x[j+itr])/2
            itr=itr+1
        }
    }
    x
}

for(i in 1:length(prec_list)){
    prec_list[[i]] = apply(prec_list[[i]],2,FFN)
}

for(i in 1:length(temp_list)){
    temp_list[[i]] = apply(temp_list[[i]],2,FFN)
}

Year = 1967:1996

temprature <- matrix(NA, length(Area), length(Year))
for(i in 1:length(temp_list)){
    temprature[i,]<- temp_list[[i]][temp_list[[i]][,1] %in% Year,14]
}

precipitation <- matrix(NA, length(Area), length(Year))
for(i in 1:length(prec_list)){
    precipitation[i,]<- prec_list[[i]][prec_list[[i]][,1] %in%
Year,14]
}

temprature.s <- scale(temprature)
precipitation.s <- scale(precipitation)

y <- precipitation.s

tt = length(Year)
ii = length(Area)
```

```
library("coda")
library("rbugs")
library("rjags")
library("R2WinBUGS")
library("dclone")
library("cluster")
library("nlme")
library("MASS")
library("splines")

Nsp=10   # number of splines fixed knots
degree=1 # degree of Penalized spline

matXZ   <-
bs(temprature.s,df=Nsp+degree,degree=degree,intercept=FALSE)

#X<-cbind(1,c(temprature))
X<-cbind(1,matXZ[,1])

nbetas<-dim(X)[2]

Z<-matXZ[,-c(1)]
colnames(Z)<-1:Nsp


#------------ preparing data ------------

K=1
parameters.hb <- c("beta","mu", "rho", "sigma2.e", "sigma2.nu",
"sigma2.sp")
parameters.dc <- c("beta", "rho", "sigma2.e", "sigma2.nu",
"sigma2.sp")
parameters.p <- c("mu")

model <- function() {
    for(k in 1:K){
        for(i in 1:I){
            y[(i+I*(k-1)),1:T] ~ dmnorm(mu[(i+I*(k-1)),1:T],tauE[,])
            mu[(i+I*(k-1)),1:T] ~ dmnorm(mmu[(i+I*(k-1)),1:T],tauG[,])
            for(t in 1:T){
                mmu[(i+I*(k-1)),t]<-inprod(X[(i+(t-
1)*I),],beta[1,])+inprod(Z[(i+(t-1)*I),],sp[,k])+nu[i,k]
            }
        }
    }

    for(l in 1:nbetas){beta[1,l]~dnorm(0.0,1.0E-6)}
    rho ~ dunif(-1,1)
    tau.e ~ dgamma(1.0E-3,1.0E-3)
    tau.nu~dgamma(1.0E-3,1.0E-3)
    tau.sp~dgamma(1.0E-3,1.0E-3)
```

```
sigma2.e<-1/tau.e
sigma2.sp<-1/tau.sp
sigma2.nu<-1/tau.nu

for(k in 1:K){
    for(i in 1:Nsp){
        sp[i,k] ~ dnorm(0,tau.sp)
    }}

for(k in 1:K){
    for(i in 1:I){
        nu[i,k]~dnorm(0,tau.nu)
    }}

for(i in 1:T){tauE[i,i]<-1}
for(i in 1:(T-1)){tauE[i,i+1]<-0
tauE[i+1,i]<-0}
for(i in 1:(T-2)){tauE[i,i+2]<-0
tauE[i+2,i]<-0}
for(i in 1:(T-3)){tauE[i,i+3]<-0
tauE[i+3,i]<-0}
for(i in 1:(T-4)){tauE[i,i+4]<-0
tauE[i+4,i]<-0}
for(i in 1:(T-5)){tauE[i,i+5]<-0
tauE[i+5,i]<-0}
for(i in 1:(T-6)){tauE[i,i+6]<-0
tauE[i+6,i]<-0}
for(i in 1:(T-7)){tauE[i,i+7]<-0
tauE[i+7,i]<-0}
for(i in 1:(T-8)){tauE[i,i+8]<-0
tauE[i+8,i]<-0}
for(i in 1:(T-9)){tauE[i,i+9]<-0
tauE[i+9,i]<-0}
for(i in 1:(T-10)){tauE[i,i+10]<-0
tauE[i+10,i]<-0}
for(i in 1:(T-11)){tauE[i,i+11]<-0
tauE[i+11,i]<-0}
for(i in 1:(T-12)){tauE[i,i+12]<-0
tauE[i+12,i]<-0}
for(i in 1:(T-13)){tauE[i,i+13]<-0
tauE[i+13,i]<-0}
for(i in 1:(T-14)){tauE[i,i+14]<-0
tauE[i+14,i]<-0}
for(i in 1:(T-15)){tauE[i,i+15]<-0
tauE[i+15,i]<-0}
for(i in 1:(T-16)){tauE[i,i+16]<-0
tauE[i+16,i]<-0}
for(i in 1:(T-17)){tauE[i,i+17]<-0
tauE[i+17,i]<-0}
for(i in 1:(T-18)){tauE[i,i+18]<-0
tauE[i+18,i]<-0}
```

```
for(i in 1:(T-19)){tauE[i,i+19]<-0
tauE[i+19,i]<-0}
for(i in 1:(T-20)){tauE[i,i+20]<-0
tauE[i+20,i]<-0}
for(i in 1:(T-21)){tauE[i,i+21]<-0
tauE[i+21,i]<-0}
for(i in 1:(T-22)){tauE[i,i+22]<-0
tauE[i+22,i]<-0}
for(i in 1:(T-23)){tauE[i,i+23]<-0
tauE[i+23,i]<-0}
for(i in 1:(T-24)){tauE[i,i+24]<-0
tauE[i+24,i]<-0}
for(i in 1:(T-25)){tauE[i,i+25]<-0
tauE[i+25,i]<-0}
for(i in 1:(T-26)){tauE[i,i+26]<-0
tauE[i+26,i]<-0}
for(i in 1:(T-27)){tauE[i,i+27]<-0
tauE[i+27,i]<-0}
for(i in 1:(T-28)){tauE[i,i+28]<-0
tauE[i+28,i]<-0}
tauE[1,T]<-0
tauE[T,1]<-0

for(i in 1:T){gam[i,i]<-1/(1-rho*rho)}
for(i in 1:(T-1)){gam[i,i+1]<-rho/(1-rho*rho)
gam[i+1,i]<-rho/(1-rho*rho)}
for(i in 1:(T-2)){gam[i,i+2]<-pow(rho,2)/(1-rho*rho)
gam[i+2,i]<-pow(rho,2)/(1-rho*rho)}
for(i in 1:(T-3)){gam[i,i+3]<-pow(rho,3)/(1-rho*rho)
gam[i+3,i]<-pow(rho,3)/(1-rho*rho)}
for(i in 1:(T-4)){gam[i,i+4]<-pow(rho,4)/(1-rho*rho)
gam[i+4,i]<-pow(rho,4)/(1-rho*rho)}
for(i in 1:(T-5)){gam[i,i+5]<-pow(rho,5)/(1-rho*rho)
gam[i+5,i]<-pow(rho,5)/(1-rho*rho)}
for(i in 1:(T-6)){gam[i,i+6]<-pow(rho,6)/(1-rho*rho)
gam[i+6,i]<-pow(rho,6)/(1-rho*rho)}
for(i in 1:(T-7)){gam[i,i+7]<-pow(rho,7)/(1-rho*rho)
gam[i+7,i]<-pow(rho,7)/(1-rho*rho)}
for(i in 1:(T-8)){gam[i,i+8]<-pow(rho,8)/(1-rho*rho)
gam[i+8,i]<-pow(rho,8)/(1-rho*rho)}
for(i in 1:(T-9)){gam[i,i+9]<-pow(rho,9)/(1-rho*rho)
gam[i+9,i]<-pow(rho,9)/(1-rho*rho)}
for(i in 1:(T-10)){gam[i,i+10]<-pow(rho,10)/(1-rho*rho)
gam[i+10,i]<-pow(rho,10)/(1-rho*rho)}
for(i in 1:(T-11)){gam[i,i+11]<-pow(rho,11)/(1-rho*rho)
gam[i+11,i]<-pow(rho,11)/(1-rho*rho)}
for(i in 1:(T-12)){gam[i,i+12]<-pow(rho,12)/(1-rho*rho)
gam[i+12,i]<-pow(rho,12)/(1-rho*rho)}
for(i in 1:(T-13)){gam[i,i+13]<-pow(rho,13)/(1-rho*rho)
gam[i+13,i]<-pow(rho,13)/(1-rho*rho)}
for(i in 1:(T-14)){gam[i,i+14]<-pow(rho,14)/(1-rho*rho)
gam[i+14,i]<-pow(rho,14)/(1-rho*rho)}
```

```
for(i in 1:(T-15)){gam[i,i+15]<-pow(rho,15)/(1-rho*rho)
gam[i+15,i]<-pow(rho,15)/(1-rho*rho)}
for(i in 1:(T-16)){gam[i,i+16]<-pow(rho,16)/(1-rho*rho)
gam[i+16,i]<-pow(rho,16)/(1-rho*rho)}
for(i in 1:(T-17)){gam[i,i+17]<-pow(rho,17)/(1-rho*rho)
gam[i+17,i]<-pow(rho,17)/(1-rho*rho)}
for(i in 1:(T-18)){gam[i,i+18]<-pow(rho,18)/(1-rho*rho)
gam[i+18,i]<-pow(rho,18)/(1-rho*rho)}
for(i in 1:(T-19)){gam[i,i+19]<-pow(rho,19)/(1-rho*rho)
gam[i+19,i]<-pow(rho,19)/(1-rho*rho)}
for(i in 1:(T-20)){gam[i,i+20]<-pow(rho,20)/(1-rho*rho)
gam[i+20,i]<-pow(rho,20)/(1-rho*rho)}
for(i in 1:(T-21)){gam[i,i+21]<-pow(rho,21)/(1-rho*rho)
gam[i+21,i]<-pow(rho,21)/(1-rho*rho)}
for(i in 1:(T-22)){gam[i,i+22]<-pow(rho,22)/(1-rho*rho)
gam[i+22,i]<-pow(rho,22)/(1-rho*rho)}
for(i in 1:(T-23)){gam[i,i+23]<-pow(rho,23)/(1-rho*rho)
gam[i+23,i]<-pow(rho,23)/(1-rho*rho)}
for(i in 1:(T-24)){gam[i,i+24]<-pow(rho,24)/(1-rho*rho)
gam[i+24,i]<-pow(rho,24)/(1-rho*rho)}
for(i in 1:(T-25)){gam[i,i+25]<-pow(rho,25)/(1-rho*rho)
gam[i+25,i]<-pow(rho,25)/(1-rho*rho)}
for(i in 1:(T-26)){gam[i,i+26]<-pow(rho,26)/(1-rho*rho)
gam[i+26,i]<-pow(rho,26)/(1-rho*rho)}
for(i in 1:(T-27)){gam[i,i+27]<-pow(rho,27)/(1-rho*rho)
gam[i+27,i]<-pow(rho,27)/(1-rho*rho)}
for(i in 1:(T-28)){gam[i,i+28]<-pow(rho,28)/(1-rho*rho)
gam[i+28,i]<-pow(rho,28)/(1-rho*rho)}
gam[1,T]<-pow(rho,29)/(1-rho*rho)
gam[T,1]<-pow(rho,29)/(1-rho*rho)

sigmaG<-sigma2.e*gam
invG<-inverse(sigmaG)

for(i in 1:T){tauG[i,i]<-invG[i,i]}
for(i in 1:(T-1)){tauG[i,i+1]<-(invG[i,i+1]+invG[i+1,i])/2
tauG[i+1,i]<-(invG[i,i+1]+invG[i+1,i])/2}
for(i in 1:(T-2)){tauG[i,i+2]<-(invG[i,i+2]+invG[i+2,i])/2
tauG[i+2,i]<-(invG[i,i+2]+invG[i+2,i])/2}
for(i in 1:(T-3)){tauG[i,i+3]<-(invG[i,i+3]+invG[i+3,i])/2
tauG[i+3,i]<-(invG[i,i+3]+invG[i+3,i])/2}
for(i in 1:(T-4)){tauG[i,i+4]<-(invG[i,i+4]+invG[i+4,i])/2
tauG[i+4,i]<-(invG[i,i+4]+invG[i+4,i])/2}
for(i in 1:(T-5)){tauG[i,i+5]<-(invG[i,i+5]+invG[i+5,i])/2
tauG[i+5,i]<-(invG[i,i+5]+invG[i+5,i])/2}
for(i in 1:(T-6)){tauG[i,i+6]<-(invG[i,i+6]+invG[i+6,i])/2
tauG[i+6,i]<-(invG[i,i+6]+invG[i+6,i])/2}
for(i in 1:(T-7)){tauG[i,i+7]<-(invG[i,i+7]+invG[i+7,i])/2
tauG[i+7,i]<-(invG[i,i+7]+invG[i+7,i])/2}
for(i in 1:(T-8)){tauG[i,i+8]<-(invG[i,i+8]+invG[i+8,i])/2
tauG[i+8,i]<-(invG[i,i+8]+invG[i+8,i])/2}
for(i in 1:(T-9)){tauG[i,i+9]<-(invG[i,i+9]+invG[i+9,i])/2
```

```
    tauG[i+9,i]<-(invG[i,i+9]+invG[i+9,i])/2}
    for(i in 1:(T-10)){tauG[i,i+10]<-(invG[i,i+10]+invG[i+10,i])/2
    tauG[i+10,i]<-(invG[i,i+10]+invG[i+10,i])/2}
    for(i in 1:(T-11)){tauG[i,i+11]<-(invG[i,i+11]+invG[i+11,i])/2
    tauG[i+11,i]<-(invG[i,i+11]+invG[i+11,i])/2}
    for(i in 1:(T-12)){tauG[i,i+12]<-(invG[i,i+12]+invG[i+12,i])/2
    tauG[i+12,i]<-(invG[i,i+12]+invG[i+12,i])/2}
    for(i in 1:(T-13)){tauG[i,i+13]<-(invG[i,i+13]+invG[i+13,i])/2
    tauG[i+13,i]<-(invG[i,i+13]+invG[i+13,i])/2}
    for(i in 1:(T-14)){tauG[i,i+14]<-(invG[i,i+14]+invG[i+14,i])/2
    tauG[i+14,i]<-(invG[i,i+14]+invG[i+14,i])/2}
    for(i in 1:(T-15)){tauG[i,i+15]<-(invG[i,i+15]+invG[i+15,i])/2
    tauG[i+15,i]<-(invG[i,i+15]+invG[i+15,i])/2}
    for(i in 1:(T-16)){tauG[i,i+16]<-(invG[i,i+16]+invG[i+16,i])/2
    tauG[i+16,i]<-(invG[i,i+16]+invG[i+16,i])/2}
    for(i in 1:(T-17)){tauG[i,i+17]<-(invG[i,i+17]+invG[i+17,i])/2
    tauG[i+17,i]<-(invG[i,i+17]+invG[i+17,i])/2}
    for(i in 1:(T-18)){tauG[i,i+18]<-(invG[i,i+18]+invG[i+18,i])/2
    tauG[i+18,i]<-(invG[i,i+18]+invG[i+18,i])/2}
    for(i in 1:(T-19)){tauG[i,i+19]<-(invG[i,i+19]+invG[i+19,i])/2
    tauG[i+19,i]<-(invG[i,i+19]+invG[i+19,i])/2}
    for(i in 1:(T-20)){tauG[i,i+20]<-(invG[i,i+20]+invG[i+20,i])/2
    tauG[i+20,i]<-(invG[i,i+20]+invG[i+20,i])/2}
    for(i in 1:(T-21)){tauG[i,i+21]<-(invG[i,i+21]+invG[i+21,i])/2
    tauG[i+21,i]<-(invG[i,i+21]+invG[i+21,i])/2}
    for(i in 1:(T-22)){tauG[i,i+22]<-(invG[i,i+22]+invG[i+22,i])/2
    tauG[i+22,i]<-(invG[i,i+22]+invG[i+22,i])/2}
    for(i in 1:(T-23)){tauG[i,i+23]<-(invG[i,i+23]+invG[i+23,i])/2
    tauG[i+23,i]<-(invG[i,i+23]+invG[i+23,i])/2}
    for(i in 1:(T-24)){tauG[i,i+24]<-(invG[i,i+24]+invG[i+24,i])/2
    tauG[i+24,i]<-(invG[i,i+24]+invG[i+24,i])/2}
    for(i in 1:(T-25)){tauG[i,i+25]<-(invG[i,i+25]+invG[i+25,i])/2
    tauG[i+25,i]<-(invG[i,i+25]+invG[i+25,i])/2}
    for(i in 1:(T-26)){tauG[i,i+26]<-(invG[i,i+26]+invG[i+26,i])/2
    tauG[i+26,i]<-(invG[i,i+26]+invG[i+26,i])/2}
    for(i in 1:(T-27)){tauG[i,i+27]<-(invG[i,i+27]+invG[i+27,i])/2
    tauG[i+27,i]<-(invG[i,i+27]+invG[i+27,i])/2}
    for(i in 1:(T-28)){tauG[i,i+28]<-(invG[i,i+28]+invG[i+28,i])/2
    tauG[i+28,i]<-(invG[i,i+28]+invG[i+28,i])/2}
    tauG[1,T]<-(invG[1,T]+invG[T,1])/2
    tauG[T,1]<-(invG[1,T]+invG[T,1])/2
}

model.p <- function() {
    for(k in 1:K){
        for(i in 1:I){
            y[(i+I*(k-1)),1:T] ~ dmnorm(mu[(i+I*(k-1)),1:T],tauE[,])
            mu[(i+I*(k-1)),1:T] ~ dmnorm(mmu[(i+I*(k-1)),1:T],tauG[,])
            for(t in 1:T){
                mmu[(i+I*(k-1)),t]<-inprod(X[(i+(t-
1)*I),],beta[1,])+inprod(Z[(i+(t-1)*I),],sp[,k])+nu[i,k]
            }
```

```
        }
    }

    tmp[1:(nbetas+4)] ~ dmnorm(param[], prec[,])
    for(l in 1:nbetas){beta[1,l] <- tmp[l]}
    rho <- (1-step(tmp[(nbetas+1)]+1))*(-0.9999)+step(tmp[(nbetas+1)]-
1)*(0.9999)+(1-step(abs(tmp[(nbetas+1)])-1))*(tmp[(nbetas+1)])
    sigma2.e  <- abs(tmp[(nbetas+2)])
    sigma2.nu <- abs(tmp[(nbetas+3)])
    sigma2.sp <- abs(tmp[(nbetas+4)])

    tau.e  <- 1/sigma2.e
    tau.nu <- 1/sigma2.nu
    tau.sp <- 1/sigma2.sp

    for(k in 1:K){
        for(i in 1:I){
            nu[i,k] ~ dnorm(0,tau.nu)
        }}

    for(k in 1:K){
        for(i in 1:Nsp){
            sp[i,k] ~ dnorm(0,tau.sp)
        }}

    for(i in 1:T){tauE[i,i]<-1}
    for(i in 1:(T-1)){tauE[i,i+1]<-0
    tauE[i+1,i]<-0}
    for(i in 1:(T-2)){tauE[i,i+2]<-0
    tauE[i+2,i]<-0}
    for(i in 1:(T-3)){tauE[i,i+3]<-0
    tauE[i+3,i]<-0}
    for(i in 1:(T-4)){tauE[i,i+4]<-0
    tauE[i+4,i]<-0}
    for(i in 1:(T-5)){tauE[i,i+5]<-0
    tauE[i+5,i]<-0}
    for(i in 1:(T-6)){tauE[i,i+6]<-0
    tauE[i+6,i]<-0}
    for(i in 1:(T-7)){tauE[i,i+7]<-0
    tauE[i+7,i]<-0}
    for(i in 1:(T-8)){tauE[i,i+8]<-0
    tauE[i+8,i]<-0}
    for(i in 1:(T-9)){tauE[i,i+9]<-0
    tauE[i+9,i]<-0}
    for(i in 1:(T-10)){tauE[i,i+10]<-0
    tauE[i+10,i]<-0}
    for(i in 1:(T-11)){tauE[i,i+11]<-0
    tauE[i+11,i]<-0}
    for(i in 1:(T-12)){tauE[i,i+12]<-0
    tauE[i+12,i]<-0}
    for(i in 1:(T-13)){tauE[i,i+13]<-0
    tauE[i+13,i]<-0}
```

```
for(i in 1:(T-14)){tauE[i,i+14]<-0
tauE[i+14,i]<-0}
for(i in 1:(T-15)){tauE[i,i+15]<-0
tauE[i+15,i]<-0}
for(i in 1:(T-16)){tauE[i,i+16]<-0
tauE[i+16,i]<-0}
for(i in 1:(T-17)){tauE[i,i+17]<-0
tauE[i+17,i]<-0}
for(i in 1:(T-18)){tauE[i,i+18]<-0
tauE[i+18,i]<-0}
for(i in 1:(T-19)){tauE[i,i+19]<-0
tauE[i+19,i]<-0}
for(i in 1:(T-20)){tauE[i,i+20]<-0
tauE[i+20,i]<-0}
for(i in 1:(T-21)){tauE[i,i+21]<-0
tauE[i+21,i]<-0}
for(i in 1:(T-22)){tauE[i,i+22]<-0
tauE[i+22,i]<-0}
for(i in 1:(T-23)){tauE[i,i+23]<-0
tauE[i+23,i]<-0}
for(i in 1:(T-24)){tauE[i,i+24]<-0
tauE[i+24,i]<-0}
for(i in 1:(T-25)){tauE[i,i+25]<-0
tauE[i+25,i]<-0}
for(i in 1:(T-26)){tauE[i,i+26]<-0
tauE[i+26,i]<-0}
for(i in 1:(T-27)){tauE[i,i+27]<-0
tauE[i+27,i]<-0}
for(i in 1:(T-28)){tauE[i,i+28]<-0
tauE[i+28,i]<-0}
tauE[1,T]<-0
tauE[T,1]<-0

for(i in 1:T){gam[i,i]<-1/(1-rho*rho)}
for(i in 1:(T-1)){gam[i,i+1]<-rho/(1-rho*rho)
gam[i+1,i]<-rho/(1-rho*rho)}
for(i in 1:(T-2)){gam[i,i+2]<-pow(rho,2)/(1-rho*rho)
gam[i+2,i]<-pow(rho,2)/(1-rho*rho)}
for(i in 1:(T-3)){gam[i,i+3]<-pow(rho,3)/(1-rho*rho)
gam[i+3,i]<-pow(rho,3)/(1-rho*rho)}
for(i in 1:(T-4)){gam[i,i+4]<-pow(rho,4)/(1-rho*rho)
gam[i+4,i]<-pow(rho,4)/(1-rho*rho)}
for(i in 1:(T-5)){gam[i,i+5]<-pow(rho,5)/(1-rho*rho)
gam[i+5,i]<-pow(rho,5)/(1-rho*rho)}
for(i in 1:(T-6)){gam[i,i+6]<-pow(rho,6)/(1-rho*rho)
gam[i+6,i]<-pow(rho,6)/(1-rho*rho)}
for(i in 1:(T-7)){gam[i,i+7]<-pow(rho,7)/(1-rho*rho)
gam[i+7,i]<-pow(rho,7)/(1-rho*rho)}
for(i in 1:(T-8)){gam[i,i+8]<-pow(rho,8)/(1-rho*rho)
gam[i+8,i]<-pow(rho,8)/(1-rho*rho)}
for(i in 1:(T-9)){gam[i,i+9]<-pow(rho,9)/(1-rho*rho)
gam[i+9,i]<-pow(rho,9)/(1-rho*rho)}
```

```
for(i in 1:(T-10)){gam[i,i+10]<-pow(rho,10)/(1-rho*rho)
gam[i+10,i]<-pow(rho,10)/(1-rho*rho)}
for(i in 1:(T-11)){gam[i,i+11]<-pow(rho,11)/(1-rho*rho)
gam[i+11,i]<-pow(rho,11)/(1-rho*rho)}
for(i in 1:(T-12)){gam[i,i+12]<-pow(rho,12)/(1-rho*rho)
gam[i+12,i]<-pow(rho,12)/(1-rho*rho)}
for(i in 1:(T-13)){gam[i,i+13]<-pow(rho,13)/(1-rho*rho)
gam[i+13,i]<-pow(rho,13)/(1-rho*rho)}
for(i in 1:(T-14)){gam[i,i+14]<-pow(rho,14)/(1-rho*rho)
gam[i+14,i]<-pow(rho,14)/(1-rho*rho)}
for(i in 1:(T-15)){gam[i,i+15]<-pow(rho,15)/(1-rho*rho)
gam[i+15,i]<-pow(rho,15)/(1-rho*rho)}
for(i in 1:(T-16)){gam[i,i+16]<-pow(rho,16)/(1-rho*rho)
gam[i+16,i]<-pow(rho,16)/(1-rho*rho)}
for(i in 1:(T-17)){gam[i,i+17]<-pow(rho,17)/(1-rho*rho)
gam[i+17,i]<-pow(rho,17)/(1-rho*rho)}
for(i in 1:(T-18)){gam[i,i+18]<-pow(rho,18)/(1-rho*rho)
gam[i+18,i]<-pow(rho,18)/(1-rho*rho)}
for(i in 1:(T-19)){gam[i,i+19]<-pow(rho,19)/(1-rho*rho)
gam[i+19,i]<-pow(rho,19)/(1-rho*rho)}
for(i in 1:(T-20)){gam[i,i+20]<-pow(rho,20)/(1-rho*rho)
gam[i+20,i]<-pow(rho,20)/(1-rho*rho)}
for(i in 1:(T-21)){gam[i,i+21]<-pow(rho,21)/(1-rho*rho)
gam[i+21,i]<-pow(rho,21)/(1-rho*rho)}
for(i in 1:(T-22)){gam[i,i+22]<-pow(rho,22)/(1-rho*rho)
gam[i+22,i]<-pow(rho,22)/(1-rho*rho)}
for(i in 1:(T-23)){gam[i,i+23]<-pow(rho,23)/(1-rho*rho)
gam[i+23,i]<-pow(rho,23)/(1-rho*rho)}
for(i in 1:(T-24)){gam[i,i+24]<-pow(rho,24)/(1-rho*rho)
gam[i+24,i]<-pow(rho,24)/(1-rho*rho)}
for(i in 1:(T-25)){gam[i,i+25]<-pow(rho,25)/(1-rho*rho)
gam[i+25,i]<-pow(rho,25)/(1-rho*rho)}
for(i in 1:(T-26)){gam[i,i+26]<-pow(rho,26)/(1-rho*rho)
gam[i+26,i]<-pow(rho,26)/(1-rho*rho)}
for(i in 1:(T-27)){gam[i,i+27]<-pow(rho,27)/(1-rho*rho)
gam[i+27,i]<-pow(rho,27)/(1-rho*rho)}
for(i in 1:(T-28)){gam[i,i+28]<-pow(rho,28)/(1-rho*rho)
gam[i+28,i]<-pow(rho,28)/(1-rho*rho)}
gam[1,T]<-pow(rho,29)/(1-rho*rho)
gam[T,1]<-pow(rho,29)/(1-rho*rho)

sigmaG<-sigma2.e*gam
invG<-inverse(sigmaG)

for(i in 1:T){tauG[i,i]<-invG[i,i]}
for(i in 1:(T-1)){tauG[i,i+1]<-(invG[i,i+1]+invG[i+1,i])/2
tauG[i+1,i]<-(invG[i,i+1]+invG[i+1,i])/2}
for(i in 1:(T-2)){tauG[i,i+2]<-(invG[i,i+2]+invG[i+2,i])/2
tauG[i+2,i]<-(invG[i,i+2]+invG[i+2,i])/2}
for(i in 1:(T-3)){tauG[i,i+3]<-(invG[i,i+3]+invG[i+3,i])/2
tauG[i+3,i]<-(invG[i,i+3]+invG[i+3,i])/2}
for(i in 1:(T-4)){tauG[i,i+4]<-(invG[i,i+4]+invG[i+4,i])/2
```

```
    tauG[i+4,i]<-(invG[i,i+4]+invG[i+4,i])/2}
    for(i in 1:(T-5)){tauG[i,i+5]<-(invG[i,i+5]+invG[i+5,i])/2
    tauG[i+5,i]<-(invG[i,i+5]+invG[i+5,i])/2}
    for(i in 1:(T-6)){tauG[i,i+6]<-(invG[i,i+6]+invG[i+6,i])/2
    tauG[i+6,i]<-(invG[i,i+6]+invG[i+6,i])/2}
    for(i in 1:(T-7)){tauG[i,i+7]<-(invG[i,i+7]+invG[i+7,i])/2
    tauG[i+7,i]<-(invG[i,i+7]+invG[i+7,i])/2}
    for(i in 1:(T-8)){tauG[i,i+8]<-(invG[i,i+8]+invG[i+8,i])/2
    tauG[i+8,i]<-(invG[i,i+8]+invG[i+8,i])/2}
    for(i in 1:(T-9)){tauG[i,i+9]<-(invG[i,i+9]+invG[i+9,i])/2
    tauG[i+9,i]<-(invG[i,i+9]+invG[i+9,i])/2}
    for(i in 1:(T-10)){tauG[i,i+10]<-(invG[i,i+10]+invG[i+10,i])/2
    tauG[i+10,i]<-(invG[i,i+10]+invG[i+10,i])/2}
    for(i in 1:(T-11)){tauG[i,i+11]<-(invG[i,i+11]+invG[i+11,i])/2
    tauG[i+11,i]<-(invG[i,i+11]+invG[i+11,i])/2}
    for(i in 1:(T-12)){tauG[i,i+12]<-(invG[i,i+12]+invG[i+12,i])/2
    tauG[i+12,i]<-(invG[i,i+12]+invG[i+12,i])/2}
    for(i in 1:(T-13)){tauG[i,i+13]<-(invG[i,i+13]+invG[i+13,i])/2
    tauG[i+13,i]<-(invG[i,i+13]+invG[i+13,i])/2}
    for(i in 1:(T-14)){tauG[i,i+14]<-(invG[i,i+14]+invG[i+14,i])/2
    tauG[i+14,i]<-(invG[i,i+14]+invG[i+14,i])/2}
    for(i in 1:(T-15)){tauG[i,i+15]<-(invG[i,i+15]+invG[i+15,i])/2
    tauG[i+15,i]<-(invG[i,i+15]+invG[i+15,i])/2}
    for(i in 1:(T-16)){tauG[i,i+16]<-(invG[i,i+16]+invG[i+16,i])/2
    tauG[i+16,i]<-(invG[i,i+16]+invG[i+16,i])/2}
    for(i in 1:(T-17)){tauG[i,i+17]<-(invG[i,i+17]+invG[i+17,i])/2
    tauG[i+17,i]<-(invG[i,i+17]+invG[i+17,i])/2}
    for(i in 1:(T-18)){tauG[i,i+18]<-(invG[i,i+18]+invG[i+18,i])/2
    tauG[i+18,i]<-(invG[i,i+18]+invG[i+18,i])/2}
    for(i in 1:(T-19)){tauG[i,i+19]<-(invG[i,i+19]+invG[i+19,i])/2
    tauG[i+19,i]<-(invG[i,i+19]+invG[i+19,i])/2}
    for(i in 1:(T-20)){tauG[i,i+20]<-(invG[i,i+20]+invG[i+20,i])/2
    tauG[i+20,i]<-(invG[i,i+20]+invG[i+20,i])/2}
    for(i in 1:(T-21)){tauG[i,i+21]<-(invG[i,i+21]+invG[i+21,i])/2
    tauG[i+21,i]<-(invG[i,i+21]+invG[i+21,i])/2}
    for(i in 1:(T-22)){tauG[i,i+22]<-(invG[i,i+22]+invG[i+22,i])/2
    tauG[i+22,i]<-(invG[i,i+22]+invG[i+22,i])/2}
    for(i in 1:(T-23)){tauG[i,i+23]<-(invG[i,i+23]+invG[i+23,i])/2
    tauG[i+23,i]<-(invG[i,i+23]+invG[i+23,i])/2}
    for(i in 1:(T-24)){tauG[i,i+24]<-(invG[i,i+24]+invG[i+24,i])/2
    tauG[i+24,i]<-(invG[i,i+24]+invG[i+24,i])/2}
    for(i in 1:(T-25)){tauG[i,i+25]<-(invG[i,i+25]+invG[i+25,i])/2
    tauG[i+25,i]<-(invG[i,i+25]+invG[i+25,i])/2}
    for(i in 1:(T-26)){tauG[i,i+26]<-(invG[i,i+26]+invG[i+26,i])/2
    tauG[i+26,i]<-(invG[i,i+26]+invG[i+26,i])/2}
    for(i in 1:(T-27)){tauG[i,i+27]<-(invG[i,i+27]+invG[i+27,i])/2
    tauG[i+27,i]<-(invG[i,i+27]+invG[i+27,i])/2}
    for(i in 1:(T-28)){tauG[i,i+28]<-(invG[i,i+28]+invG[i+28,i])/2
    tauG[i+28,i]<-(invG[i,i+28]+invG[i+28,i])/2}
    tauG[1,T]<-(invG[1,T]+invG[T,1])/2
    tauG[T,1]<-(invG[1,T]+invG[T,1])/2
}
```

```
stats.hb<-list()
stats.dc<-list()
stats.p<-list()

modelout.sim<-modelout.mcmc<-list()
data.sim<-list(y=y, X=X, Z=Z, I=ii, T=tt, Nsp=Nsp,nbetas=nbetas, K=1)
print(paste("---------------- HB model-----------"))
modelout.sim<- jags.fit(data=data.sim,parameters.hb,
model,n.chains=2,thin = 5, n.iter=50000, n.adapt=50000)
update(updated.model(modelout.sim),50000)
modelout.mcmc<-
coda.samples(updated.model(modelout.sim),parameters.hb,n.iter=50000,th
in=5)
num<-0
while( (max ((gelman.diag(modelout.mcmc))$psrf[,1]) >1.05) & num<40){
    update(updated.model(modelout.sim),50000)
    modelout.mcmc<-
coda.samples(updated.model(modelout.sim),parameters.hb,n.iter=50000,th
in=5)
    num<-num+1
}

print(paste("Gelman"))
print(max((gelman.diag(modelout.mcmc))$psrf[,1]))
stats.hb<-
summary(modelout.mcmc,quantiles=c(0.005,0.01,0.025,0.05,0.95,0.975,0.9
9,0.995))
print(stats.hb)
print(stats.hb$statistics)

lambda.hb<-as.numeric(lambdamax.diag(modelout.mcmc))
#lambda.hb<-0.0288606776485366
print(paste("lambda.hb",lambda.hb))

print(paste("--------------------------------- Data cloning number----
----------------"))

K1<-0 #initial number of clones
r2<-1
mse<-1
lambda.ratio<-1
r.hat<-2
num<-0
while( ( r2>0.01 | mse>0.01 ) &   ( lambda.ratio>=0.05 & num<5)){
    K1<-K1+10
    dcmod<-dc.fit(list(y=dclone(y,K1), X=X, Z=Z, I=ii, T=tt, Nsp=Nsp,
nbetas=nbetas, K=1),
                  parameters.dc, model,
n.clones=c(K1),multiply=c("K"),
                  unchanged=c("I","T","Nsp","nbetas"), n.chains=2,
n.adapt=50000, n.update=50000,n.iter=50000, thin=5)
```

```
    dcd<-dcdiag(dcmod)
    print(dcd)
    r2<-dcd[1,4]
    mse<-dcd[1,3]
    lambda.ratio<-dcd[1,2]/lambda.hb
    num<-num+1
}
print(paste("num",num))
stats.dc<-
summary(dcmod,quantiles=c(0.005,0.01,0.025,0.05,0.95,0.975,0.99,0.995)
)
print(stats.dc)

#------------------------Prediction of random effects based on MLE:
print(paste("Prediction for Data cloning model="))
prec <- make.symmetric((K1)*solve(vcov(dcmod)))
prdat <-list(y=y, X=X, Z=Z, I=ii, T=tt, Nsp=Nsp, nbetas=nbetas, param
= coef(dcmod), prec = prec, K=1)
mod1.1.pr <- jags.fit(prdat, parameters.p, model.p, n.chains=2,
n.adapt=50000, n.update=50000, n.iter=50000, thin=5)

update(updated.model(mod1.1.pr), 50000)
mod1.2.pr <- coda.samples(updated.model(mod1.1.pr), parameters.p,
n.iter=50000, thin = 5)

num<-0
while( (max ((gelman.diag(mod1.2.pr))$psrf[,1]) >1.05) & num<40){
    update(updated.model(mod1.1.pr), 50000)
    mod1.2.pr <- coda.samples(updated.model(mod1.1.pr), parameters.p,
n.iter=50000, thin = 5)
    num<-num+1
}
print(paste("num",num))
stats.p<-
summary(mod1.2.pr,quantiles=c(0.005,0.01,0.025,0.05,0.95,0.975,0.99,0.
995))

date()

#save(list = ls(all=TRUE), file =
paste(pathdata,"/PerTempCanada.RData",sep=""))

library(ggplot2)
attributes(data.sim)


data.sim2 <- data.frame(Location = paste("L",1:29, sep = ""), Y =
data.sim$y)
colnames(data.sim2) <- c("Location" ,rep(c(1967:1996),sep = ""))
library(reshape2)
data.sim3 <- melt(data.sim2, id.vars=1)
```

```
data.sim3$Location= factor(data.sim3$Location,
levels=paste("L",1:29,sep = ""))
colnames(data.sim3) <- c("Location", "Year", "Precipitation")
head(data.sim3)

#data.sim4 = data.sim3[data.sim3$Gender=="Female",]
data.sim5 = data.sim3[which(data.sim3$Location %in%
c(paste("L",c(1:16),sep = ""))),]

pdf("../AHCCDper.pdf")
ggplot(data.sim5, aes(x = Year, y = Precipitation, colour=Location)) +
    geom_line(aes(group=Location)) +
    facet_wrap(~ Location) +
    theme(legend.position="none", text = element_text(size=10),
          axis.text.x = element_text(angle=90, hjust=1))+
    ggtitle("Precipitation in some location in Canada, 1967-1996")
dev.off()

I=29
T=30
res.data1 <- data.frame(Precipitation = stats.p$statistics[(I*T-
I+1):(I*T),1],
                        LCI = stats.p$quantiles[(I*T-I+1):(I*T),3],
                        UCI = stats.p$quantiles[(I*T-I+1):(I*T),6]
)

library("gplots")

pdf(file="../AHCCDper2.pdf")
plotCI(x=res.data1[,1],
ui=res.data1[,3],li=res.data1[,2],xlab="Location",ylab="Precipitation"
,pch=20,lwd=2,gap=0.1)
dev.off()
```