require(jagsUI)

require(loo)

library(R2OpenBUGS)

library(MCMCvis)

require(INLA)

# Ontario Road Fatalities, 1931-2001, Table 2.19 in Ontario Road Safety Annual Report 2001

# DR are Licensed Drivers in Millions

# SB, Indicator for Seat Belt Law Introduced 1 Jan 1976

data=list(T=71,y=c(571,502,403,512,560,546,766,640,652,716,801,567,549,

498,598,688,734,740,830,791,949,1010,1082,1045,1111,

1180,1279,1112,1187,1166,1268,1383,1421,1424,1611,1596,1719,1586,1683,1535,1769,1934,1959,1748,1800,1511,1420,1450,1560,1508,1445,1138,1204,1132,1191,1102,1229,1237,1286,1120,1102,1090,1135,999,999,929,899,854,

868,849,845),

DR=c(0.67,0.65,0.64,0.67,0.71,0.76,0.80,0.87,0.90,0.94,0.99,0.96,0.92,0.91,

0.97,1.09,1.14,1.21,1.28,

1.37,1.46,1.56,1.66,1.75,1.86,1.97,2.09,2.18,2.27,2.36,2.41,2.47,2.56,2.69,

2.74,2.82,3.00,3.13,3.25,

3.42,3.56,3.69,3.84,3.97,4.16,4.32,4.56,4.73,4.86,4.99,5.12,5.25,5.38,5.51,

5.66,5.82,5.98,6.12,6.29,

6.45,6.57,6.69,6.82,6.98,7.09,7.26,7.54,7.73,7.92,8.12,8.27),SB=c(rep(0,45),rep(1,26)))

attach(data)

E=numeric(T)

E=DR\*sum(y)/sum(DR)

D=list(T=71,y=y,E=E,SB=SB)

**#**

**# ACP(1,1) Model**

**#**

**cat("**model { for (t in 1:T) {y[t] ~ dpois(mu.star[t]);

mu.star[t] <- exp(eta[t])\*mu[t]\*lambda[t]

# predictive check

ynew[t] ~ dpois(mu.star[t])

ch[t] <- step(ynew[t]-y[t])-0.5\*equals(ynew[t],y[t])

y0[t] <- equals(y[t],0)+(1-equals(y[t],0))\*y[t]

mu0[t] <- equals(y[t],0)+(1-equals(y[t],0))\*mu.star[t]

# deviance and log-likelihood terms

dv[t] <- 2\*(y[t]\*log(y0[t]/mu0[t])-(y[t]-mu.star[t]))

LL[t] <- -mu.star[t]+y[t]\*log(mu.star[t])-logfact(y[t])

lambda[t] ~ dlnorm(0,tau)

# regression term including intervention

eta[t] <- log(E[t])+beta\*SB[t]}

for (t in 2:T) {mu[t] <- omega+phi\*y[t-1]+gamma\*mu[t-1]}

# initial condition

mu[1] <- mu1

mu1~ dgamma(1,0.001)

# priors

omega ~ dgamma(1,0.001)

Dv <- sum(dv[])

for (j in 1:3) {kap.s[j] ~ dgamma(1,0.001)}

tau ~ dgamma(1,0.001)

beta ~ dnorm(0,0.01)

phi <- kap.s[1]/sum(kap.s[])

gamma <- kap.s[2]/sum(kap.s[])}

**", file="model1.jag")**

**# Initial values and estimation**

init1=list(kap.s=c(1,1,1),omega=1,beta=-0.1,mu1=1)

init2=list(kap.s=c(2,2,2),omega=2,beta=-0.05,mu1=2)

inits=list(init1,init2)

pars <- c("phi","gamma","beta","omega","Dv","LL","ch","mu","LL")

R1 <- autojags(D, inits, pars,model.file="model1.jag",2,iter.increment=5000, n.burnin=500,Rhat.limit=1.1, max.iter=100000, seed=1234, codaOnly=c("LL"))

R1$summary

# select log-likelihood samples in samps

LOO=loo(as.matrix(R1$sims.list$LL))

waic(as.matrix(R1$sims.list$LL))

**# plots and listing, pointwise LOO**

loocase <- as.vector(LOO$pointwise[,3])

year=seq(1931,2001,1)

plot(loocase,x=year,xlab="Year",ylab="Pointwise LOO-IC")

list.loocase <- data.frame(year,loocase)

list.loocase=list.loocase[order(-list.loocase$loocase),]

head(list.loocase,10)

**#**

**# Antedependence AD(1)**

**#**

cat("model { for (t in 1:71) {

y[t] ~ dpois(mu[t])

# scaled deviance and likelihood terms

yts[t] <- equals(y[t],0)+(1-equals(y[t],0))\*y[t]

mus[t] <- equals(y[t],0)+(1-equals(y[t],0))\*mu[t]

dv[t] <- 2\*(y[t]\*log(yts[t]/mus[t])-(y[t]-mu[t]))

LL[t] <- -mu[t]+y[t]\*log(mu[t])-logfact(y[t])

# predictive checks

ynew[t] ~ dpois(mu[t])

ch[t] <- step(ynew[t]-y[t])-0.5\*equals(ynew[t],y[t])

# regression

log(mu[t]) <- log(E[t])+beta\*SB[t]+g[t]}

Dv <- sum(dv[1:71])

# AD(1) parameter

phi ~ dnorm(0,1)

g[1] ~ dnorm(0,1/omega[1])

g.m <- mean(g[])

for (t in 2:71) {g[t] ~ dnorm(phi\*g[t-1],1/omega[t])}

# variance model

for (t in 1:71) { log(omega[t]) <- alpha[1]+alpha[2]\*t/100+alpha[3]\*t\*t/10000 }

for (j in 1:3) {alpha[j] ~ dnorm(0,1)}

beta ~ dnorm(0,0.1)}

", file="model2.jag")

# Initial values and estimation

init1= list(beta=-0.1,alpha=c(-3,0,0),phi=0.8)

init2= list(beta=-0.1,alpha=c(-3,0,0),phi=0.7)

inits=list(init1,init2)

pars = c("beta","alpha","LL","Dv","phi","g","omega","ch","LL")

R2 = autojags(D, inits, pars,model.file="model2.jag",2,iter.increment=5000, n.burnin=500,Rhat.limit=1.1, max.iter=50000, seed=1234, codaOnly=c("LL"))

R2$summary

**# select log-likelihood samples in samps**

LOO=loo(as.matrix(R2$sims.list$LL))

waic(as.matrix(R2$sims.list$LL)

**# plots and listing, pointwise LOO**

loocase <- as.vector(LOO$pointwise[,3])

plot(loocase,x=year,xlab="Year",ylab="Pointwise LOO-IC")

list.loocase <- data.frame(year,loocase)

list.loocase=list.loocase[order(-list.loocase$loocase),]

head(list.loocase,10)

**#**

**# Antedependence, Decay Intervention**

**#**

cat("model { for (t in 1:71) {

y[t] ~ dpois(mu[t])

# scaled deviance and likelihood terms

yts[t] <- equals(y[t],0)+(1-equals(y[t],0))\*y[t]

mus[t] <- equals(y[t],0)+(1-equals(y[t],0))\*mu[t]

dv[t] <- 2\*(y[t]\*log(yts[t]/mus[t])-(y[t]-mu[t]))

LL[t] <- -mu[t]+y[t]\*log(mu[t])-logfact(y[t])

# predictive checks

ynew[t] ~ dpois(mu[t])

ch[t] <- step(ynew[t]-y[t])-0.5\*equals(ynew[t],y[t])

# regression

log(mu[t]) <- log(E[t])+beta[t]\*SB[t]+g[t]

# relative risk after control for intervention

RR[t] <- exp(g[t])}

Dv <- sum(dv[1:71])

g.m <- mean(g[])

# priors

phi ~ dnorm(0,1)

g[1] ~ dnorm(0,1/omega[1])

for (t in 2:71) {g[t] ~ dnorm(phi\*g[t-1],1/omega[t])}

# variance model

for (t in 1:71) { log(omega[t]) <- gam[1]+gam[2]\*t/100+gam[3]\*t\*t/10000 }

for (j in 1:3) {gam[j] ~ dnorm(0,1)}

# intervention effect

for(r in 1:26) {b[r] ~ dnorm(0,tau.b)}

tau.b ~ dexp(1)

# sort ascending order

bsort <- sort(b)

for (j in 1:45) {beta[j] <- 0}

# decay in effect from year of introduction

for (j in 46:71) {betas[j] <- bsort[j-45]

# retain negative coefficients

beta[j] <- betas[j]\*step(-betas[j])

# probability that SB effect still relevant

decay.prob[j-45] <- step(-betas[j]) }}

", file="model3.jag")

# Initial values and estimation

init1= list(gam=c(-3,0,0),phi=0.8)

init2= list(gam=c(-3,0,0),phi=0.7)

inits=list(init1,init2)

pars <- c("beta","gam","LL","Dv","phi","RR","ch","decay.prob","LL")

R3 = autojags(D, inits, pars,model.file="model3.jag",2,iter.increment=5000, n.burnin=500,Rhat.limit=1.1, max.iter=50000, seed=1234,

codaOnly=c("RR","LL"))

R3$summary

**# Fit**

LOO=loo(as.matrix(R3$sims.list$LL))

**# relative risks after controlling for intervention**

RR=as.matrix(R3$sims.list$RR)

plot(apply(RR,2,mean),x=year,xlab="Year",ylab="Relative Risks")

**# plots and listing, pointwise LOO**

loocase <- as.vector(LOO$pointwise[,3])

plot(loocase,x=year,xlab="Year",ylab="Pointwise LOO-IC")

year=seq(1931,2001,1)

list.loocase <- data.frame(year,loocase)

list.loocase=list.loocase[order(-list.loocase$loocase),]

head(list.loocase,10)

#

**# CLAR(1) model**

#

model1 <- function() { for (t in 2:71) {y[t] ~ dpois(mu[t])

LL[t] <- -mu[t]+y[t]\*log(mu[t])-logfact(y[t])

mu[t] <- rho[1]\*y[t-1] + exp(log(E[t])+beta\*SB[t] + eta[t])

eta[t] ~ dnorm(eta.m[t],tau)

eta.m[t] <- rho[2]\*eta[t-1]

**# predictions**

ynew[t] ~ dpois(mu[t])}

**# period 1 model**

y[1] ~ dpois(mu[1])

LL[1] <- -mu[1]+y[1]\*log(mu[1])-logfact(y[1])

mu[1] <- eps + exp(log(E[1])+beta\*SB[1] + eta[1])

eps ~ dlnorm(0,0.01)

**# predictions**

ynew[1] ~ dpois(mu[1])

**# error autocorrelation**

for (t in 2:71) { e[t] <- (y[t]-mu[t])/sqrt(mu[t])

e\_1[t] <- (y[t-1]-mu[t-1])/sqrt(mu[t-1])

p1[t] <- e[t]\*e\_1[t]

p2[t] <- e[t]\*e[t]}

error.auto <- sum(p1[2:71])/sum(p2[2:71])

**# predictive check on overdispersion**

Diagobs <- pow(sd(y[1:71]),2)/mean(y[1:71])

Diagnew <- pow(sd(ynew[1:71]),2)/mean(ynew[1:71])

PrCh <- step(Diagnew-Diagobs)

**# priors**

eta[1] ~ dnorm(0,tau1)

tau ~ dgamma(1,0.001)

tau1 <- (1-rho[2]\*rho[2])\*tau

rho[1] ~dunif(0,1)

rho[2] ~dunif(-1,1)

beta ~ dnorm(0,0.01)}

**# Initial values and estimation**

init1= list(rho=c(0.1,0.98),tau=1,beta=-0.3,eta=rep(0,71),ynew=y,eps=10)

init2= list(rho=c(0.15,0.95),tau=2,beta=-0.35,eta=rep(0,71),ynew=y,eps=20)

inits=list(init1,init2)

pars = c("beta","rho","LL","error.auto","PrCh","eps")

n.iters=50000; n.burnin =1000; n.chains=2

R4 = bugs(D,inits,pars,n.iters,model1,n.chains, n.burnin,debug=T,

codaPkg = F,bugs.seed=10)

**# Fit**

LOO=loo(R4$sims.list$LL)

loocase <- as.vector(LOO$pointwise[,3])

plot(loocase,x=year,xlab="Year",ylab="Pointwise LOO-IC")

**#**

**# Random Walk (RW1) Level**

**#**

Data=list(y=D$y,T=71,E=D$E,year=seq(1931,2001,1), trend=seq(1:71))

# define model

formula = y ~ SB + f(trend,model="rw1",param=c(1,0.0005))

# estimation

mod = inla(formula, family="poisson", data=Data, control.compute=list(graph=T, waic=T), offset= log(E))

# intercept and intervention effect

mod$summary.fixed

# plot of actual against fitted values

plot(D$y,mod$summary.fitted[,1])

# estimated trend

rand <- matrix(unlist(mod$summary.random), ncol = 8)

plot(1930+Data$trend,rand[,2],xlab="Year",ylab="Trend")

# pointwise WAIC

plot(mod$waic$local.waic)

# fit

mod$waic