AR and MA Models in R

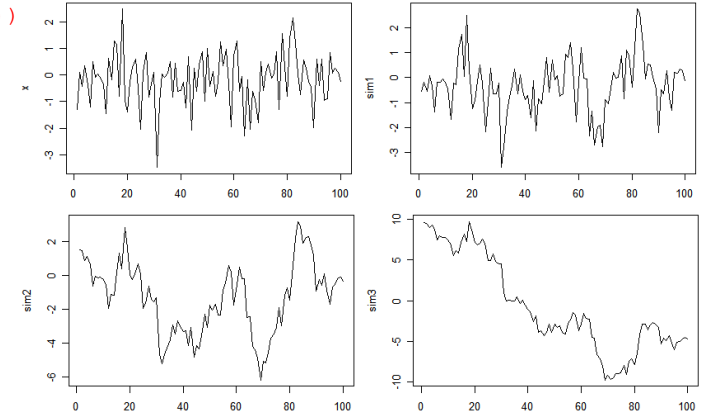## AR(1) Plots

```
x<-rnorm(100)
sim1<-arima.sim(list(ar=c(0.5)),n=100,innov=x)
sim2<-arima.sim(list(ar=c(0.9)),n=100,innov=x)
sim3<-arima.sim(list(ar=c(0.99)),n=100,innov=x)

par(mfrow=c(2,2))
ts.plot(x)
ts.plot(sim1)
ts.plot(sim2)
ts.plot(sim3)
```

AR(1) ACFs

```
acf(x); acf(sim1); acf(sim2); acf(sim3)
```
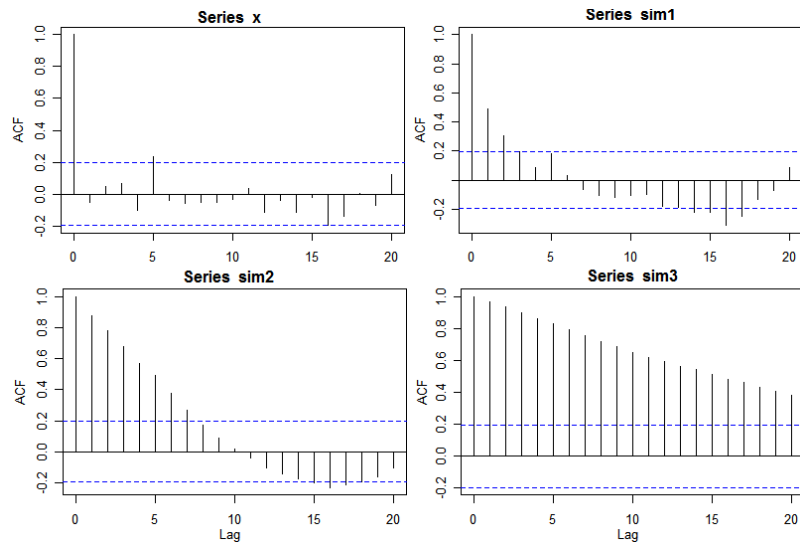
AR(1) PACFs

```
pacf(x); pacf(sim1); pacf(sim2); pacf(sim3)
```

Fit an AR(1)
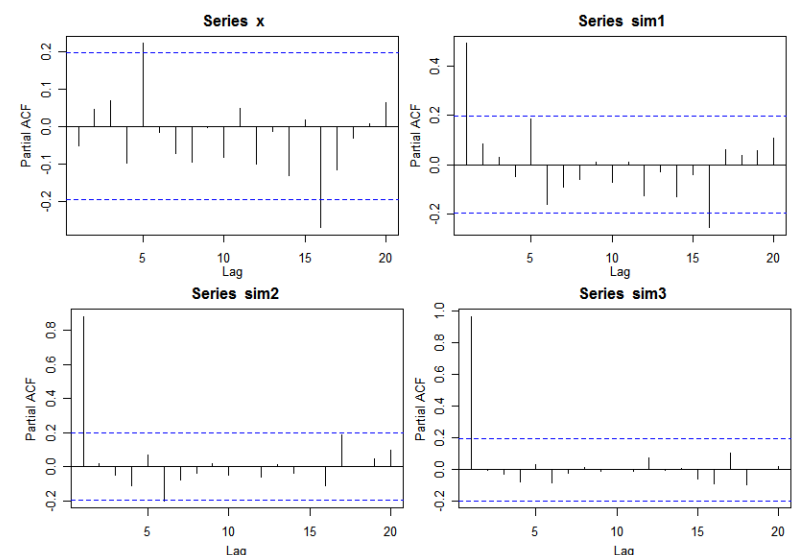
```
arima(sim1,order=c(1,0,0))
Call:
arima(x = sim1, order = c(1, 0, 0))

Coefficients:
         ar1   intercept
      0.4871    -0.3092
s.e.  0.0864     0.1865

sigma^2 estimated as 0.9327:  log likelihood = -138.54,  aic = 283.09
ar(sim1)
Call:
ar(x = sim1)

Coefficients:
     1
0.4915

Order selected 1  sigma^2 estimated as  0.952
```
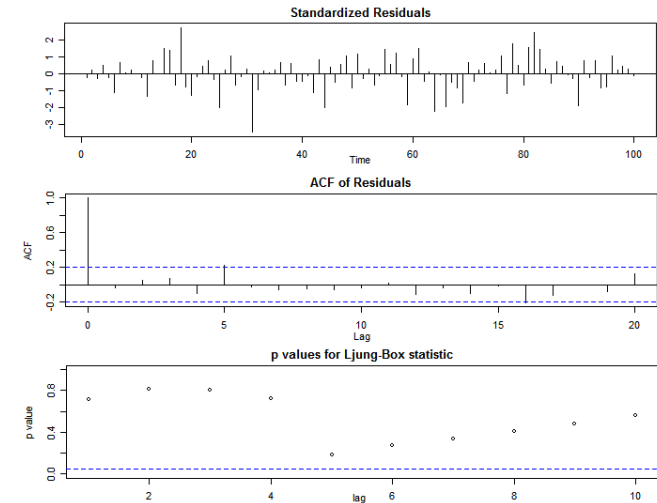
Fit Diagnostics

```
fit<-arima(sim1,order=c(1,0,0))
tsdiag(fit)
```

Prediction

```
predict(fit,n.ahead=8)

$pred
Time Series:
Start = 101
End = 108
Frequency = 1
[1] -0.2117165 -0.2617271 -0.2860852 -0.2979491 -0.3037274
[6] -0.3065418 -0.3079126 -0.3085803

$se
Time Series:
Start = 101
End = 108
Frequency = 1
[1] 0.9657447 1.0742043 1.0983631 1.1040167 1.1053536 1.1056705
[7] 1.1057457 1.1057635
```
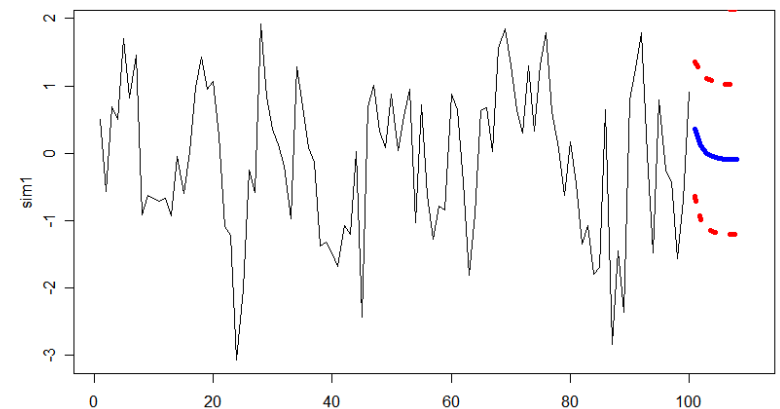
Prediction Plot

```
pred<-predict(fit,n.ahead=8)
plot(sim1,xlim=c(1,110))
lines(pred$pred,col="blue", lwd=5)
lines(pred$pred+2*pred$se,col="red",lty=3, lwd=5)
lines(pred$pred-2*pred$se,col="red",lty=3, lwd=5)
```
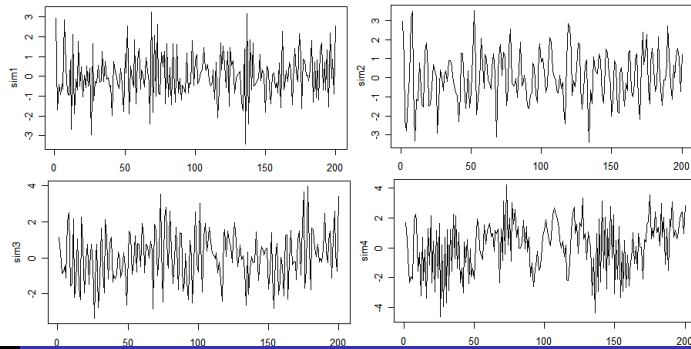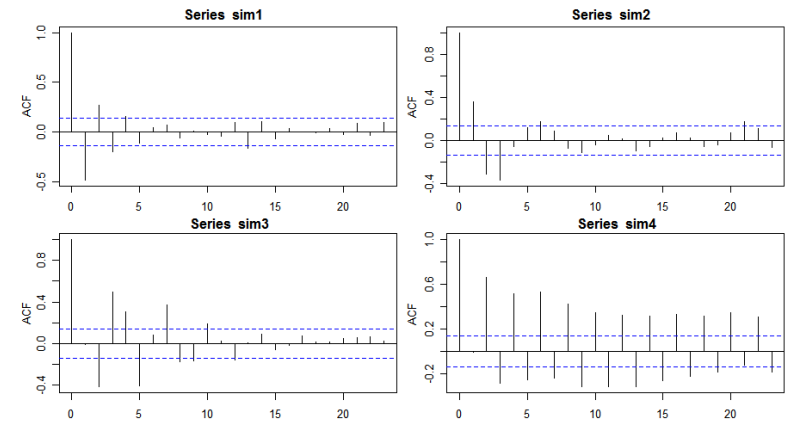
Slide 1 (page 11/25)

AR(*p*) Plots

```
x<-rnorm(200)
sim1<-arima.sim(list(ar=c(-0.5)),n=200,innov=x)
sim2<-arima.sim(list(ar=c(.5,-0.5)),n=200,innov=x)
sim3<-arima.sim(list(ar=c(.2,-.4,.6)),n=200,innov=x)
sim4<-arima.sim(list(ar=c(.5,.4,-.6,.4)),n=200,innov=x)

par(mfrow=c(2,2))
ts.plot(sim1); ts.plot(sim2); ts.plot(sim3); ts.plot(sim4)
```
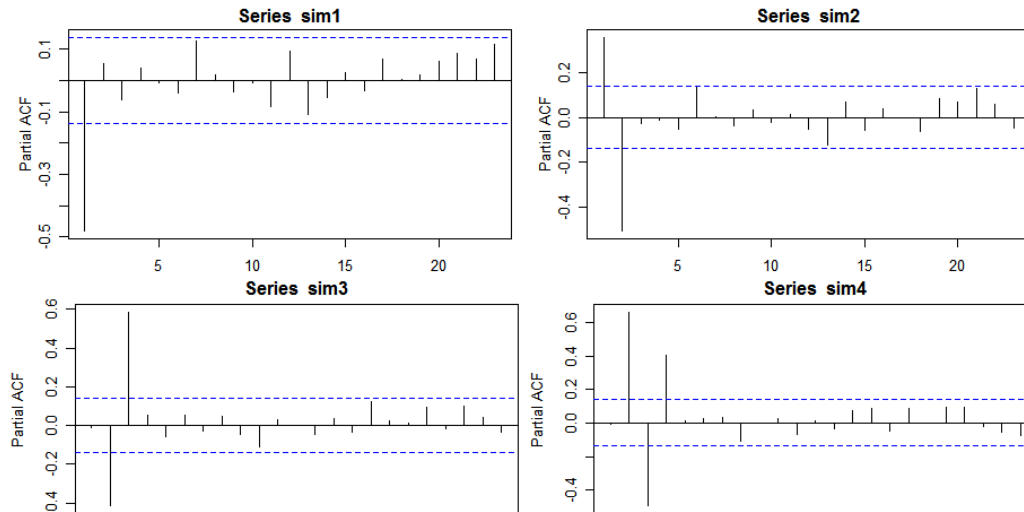
Slide 2 (page 12/25)

AR(*p*) ACFs

```
acf(sim1); acf(sim2); acf(sim3); acf(sim4)
```

Slide 3 (page 13/25)

AR(*p*) PACFs

```
pacf(sim1); pacf(sim2); pacf(sim3); pacf(sim4)
```

Slide 4 (page 14/25)
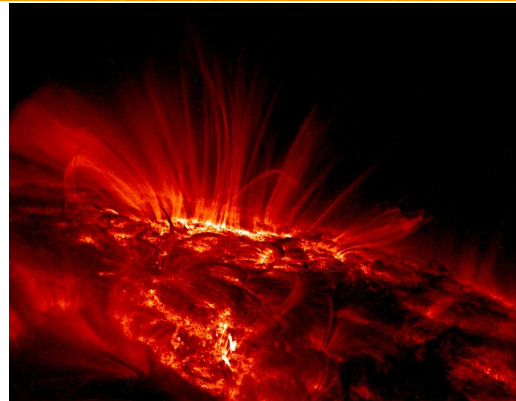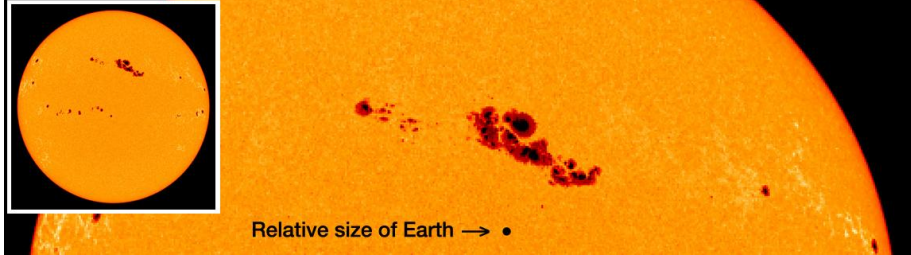
AR(*p*) Estimates

```
ar(sim1); ar(sim2); ar(sim3); ar(sim4)

ar(x = sim1)
        1
-0.4803
Order selected 1   sigma^2 estimated as   1.099

ar(x = sim2)
       1        2
 0.5361  -0.5045
Order selected 2   sigma^2 estimated as   1.102

ar(x = sim3)
       1        2        3
 0.2287  -0.4078   0.5845
Order selected 3   sigma^2 estimated as   1.098

ar(x = sim4)
       1        2        3        4
 0.5283   0.3938  -0.6295   0.4041
Order selected 4   sigma^2 estimated as   1.115
```
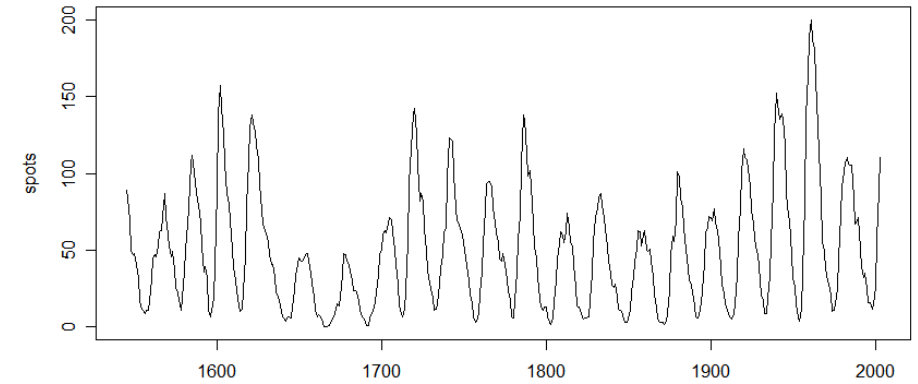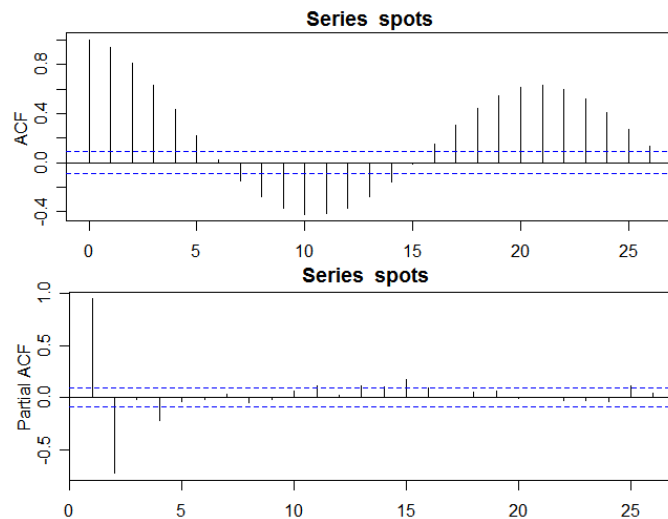
Relative size of Earth → ●

Sunspot Numbers Plot

Sunspot ACF and PACF

```
par(mfrow=c(2,1)); acf(spots); pacf(spots)
```

Sunspot AIC Estimate

```
ar(spots)
```

```
ar(x = spots)
       1         2         3         4         5         6         7
  1.5411   -0.7843    0.3014   -0.1899    0.0468   -0.0953    0.0925
       8         9        10        11        12        13        14
 -0.0099   -0.0012   -0.1035    0.1529   -0.0960    0.0567   -0.1003
      15        16
  0.0326    0.0934
Order selected 16   sigma^2 estimated as   73.8
```

```
ar(spots)$aic
```

| 0	1	2	3	4
1378.428868	368.309331	33.918302	35.778188	15.473046
5	6	7	8	9
16.835290	18.648307	20.076758	21.203283	23.138921
10	11	12	13	14
23.308489	19.733752	21.460238	17.972118	14.815274
15	16	17	18	19
2.023314	0.000000	1.988068	2.717709	2.983692
20	21	22	23	24
4.980137	6.977965	8.568843	10.250600	11.531306

MA(q) Plots

```
x<-rnorm(200)
sim1<-arima.sim(list(ma=c(1)),n=200,innov=x)
sim2<-arima.sim(list(ma=c(1,-1)),n=200,innov=x)
sim3<-arima.sim(list(ma=c(1,1,1)),n=200,innov=x)
sim4<-arima.sim(list(ma=c(1/4,1/4,1/4,1/4)),n=200,innov=x)

par(mfrow=c(2,2))
ts.plot(sim1); ts.plot(sim2); ts.plot(sim3); ts.plot(sim4)
```
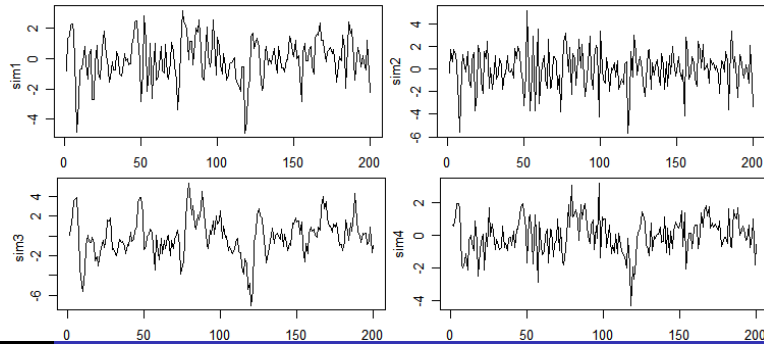
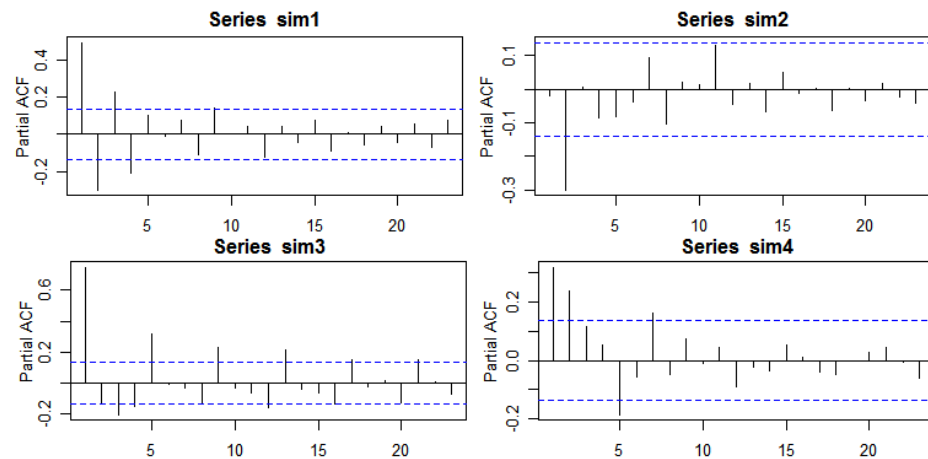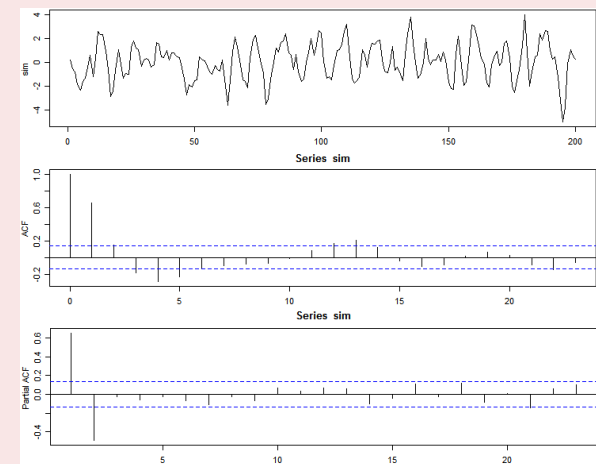# MA(q) ACFs

```
acf(sim1); acf(sim2); acf(sim3); acf(sim4)
```
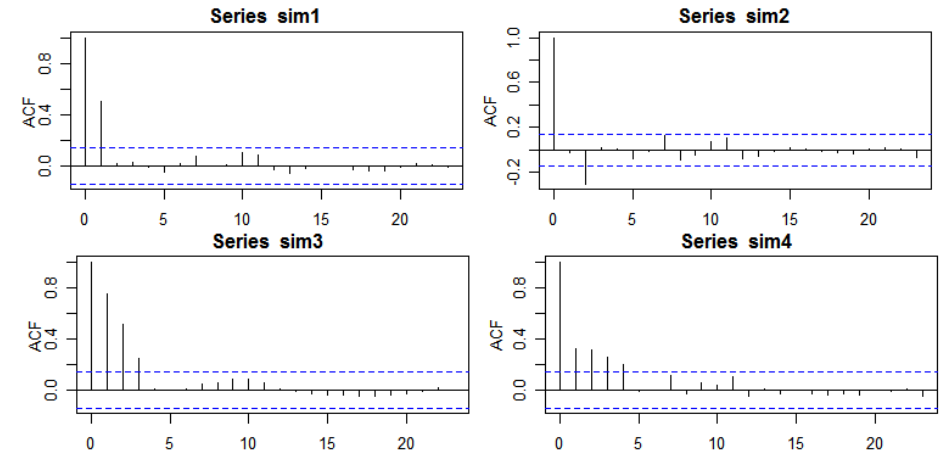
MA(q) PACFs

```
pacf(sim1); pacf(sim2); pacf(sim3); pacf(sim4)
```

Challenge!

Which model is it?

$$Z_t = Z_{t-1} - \frac{1}{2}Z_{t-2} + a_t$$