

```
library(fpp)
```

```
#####
```

```
# Simple exponential smoothing
```

```
oildata <- window(oil, start = 1996, end = 2007)
plot(oildata, ylab = "Oil (millions of tonnes)", xlab = "Year")
fit1 <- ses(oildata, alpha = 0.2, initial = "simple", h = 3)
fit2 <- ses(oildata, alpha = 0.6, initial = "simple", h = 3)
fit3 <- ses(oildata, h = 3)
```

```
plot(fit1, plot.conf=FALSE, ylab="Oil (millions of tonnes)",
     xlab="Year", main="", fcol="white", type="o")
lines(fitted(fit1), col="blue", type="o")
lines(fitted(fit2), col="red", type="o")
lines(fitted(fit3), col="green", type="o")
lines(fit1$mean, col="blue", type="o")
lines(fit2$mean, col="red", type="o")
lines(fit3$mean, col="green", type="o")
legend("topleft", lty=1, col=c(1,"blue","red","green"), c("data", expression(alpha == 0.2), expression(alpha == 0.6), expression(alpha == 0.89)), pch=1)
```

```
#####
```

```
#Forecasting of data with a trend
```

```
air <- window(ausair, start = 1990, end = 2004)
fit1 <- holt(air, alpha = 0.8, beta = 0.2, initial = "simple", h = 5)
fit2 <- holt(air, alpha = 0.8, beta = 0.2, initial = "simple", exponential = TRUE, h = 5)
fit3 <- holt(air, alpha = 0.8, beta = 0.2, damped = TRUE, initial = "simple", h = 5)
```

```
plot(fit2, type = "o", ylab = "Air passengers in Australia (millions)", xlab = "Year",
     fcol = "white", plot.conf = FALSE)
lines(fitted(fit1), col = "blue")
lines(fitted(fit2), col = "red")
lines(fitted(fit3), col = "green")
lines(fit1$mean, col = "blue", type = "o")
lines(fit2$mean, col = "red", type = "o")
lines(fit3$mean, col = "green", type = "o")
legend("topleft", lty = 1, col = c("black", "blue", "red", "green"),
     legend=c("Data", "Holt's linear trend", "Exponential trend", "Additive damped trend"), cex=0.5)
```

```
#####
```

```
# Comparing the forecasting performance
```

```
livestock2 <- window(livestock, start = 1970, end = 2000)
fit1 <- ses(livestock2)
fit2 <- holt(livestock2)
fit3 <- holt(livestock2, exponential = TRUE)
fit4 <- holt(livestock2, damped = TRUE)
fit5 <- holt(livestock2, exponential = TRUE, damped = TRUE)
```

```
fit1$model
accuracy(fit1) # training set
accuracy(fit1, livestock) # test set
fit1$model$par
```

```
plot(fit3, type="o", ylab="Livestock, sheep in Asia (millions)",
     flwd=1, plot.conf=FALSE)
lines(window(livestock, start=2001), type="o")
lines(fit1$mean, col=2)
lines(fit2$mean, col=3)
lines(fit4$mean, col=5)
lines(fit5$mean, col=6)
legend("topleft", lty=1, pch=1, col=1:6,
     c("Data", "SES", "Holt's", "Exponential", "Additive Damped", "Multiplicative Damped"), cex=0.5)
```

```
#####
```

```
#Holt-Winters seasonal method
```

```
# International tourist visitor nights in Australia
```

```
aust <- window(austourists, start=2005)
plot(aust)
```

```
fit1 <- hw(aust, seasonal="additive")
fit2 <- hw(aust, seasonal="multiplicative")
```

```

plot(fit2,ylab="International visitor night in Australia (millions)",
     plot.conf=FALSE,type="o",fcol="white",xlab="Year")
lines(fitted(fit1),col="red",lty=2)
lines(fitted(fit2),col="green",lty=2)
lines(fit1$mean,type="o",col="red")
lines(fit2$mean,type="o",col="green")
legend("topleft",lty=1,pch=1,col=c(1,2,3),c("data","Holt Winters' Additive","Holt Winters' Multiplicative"),cex=0.5)

```

```
#####
```

```
#Forecasting with ETS models
```

```

oildata <- window(oil, start = 1996, end = 2007)
fit <- ets(oildata, model = "ANN")
plot(forecast(fit, h=3), ylab="Oil (millions of tones)")
summary(fit)
ls(fit) #list names of the objects in the specified environment
fit$par

```

```

vndata <- window(austourists, start = 2005)
fit <- ets(vndata)
summary(fit)

```

```
plot(fit)
```

```
plot(forecast(fit, h = 8), ylab = "International visitor night in Australia (millions)")
```

```
#####
```

```
#Stationarity and differencing
```

```
#Can you identify which series are stationary?
```

```

par(mfrow = c(3, 3))
plot(dj, main = "(a)", xlab = "Day")
plot(diff(dj), main = "(b)", xlab = "Day")
plot(strikes, main = "(c)", xlab = "Year")
plot(hsales, main = "(d)", xlab = "Year")
plot(eggs, main = "(e)", xlab = "Year")
plot(pigs, main = "(f)", xlab = "Year")
plot(lynx, main = "(g)", xlab = "Year")
plot(beer, main = "(h)", xlab = "Year")
plot(elec, main = "(i)", xlab = "Year")

```

```
# The ACF of the Dow-Jones index and the daily changes in the Dow-Jones index
```

```

par(mfrow = c(1, 2))
Acf(dj)
Acf(diff(dj))

```

```

# The Ljung-Box test for examining the null hypothesis of independence based on the 10th lag autocorrelation coefficient
Box.test(diff(dj), type = "L", lag = 10)

```

```
# Plot the seasonal difference of the logarithm of the monthly scripts for a10
```

```

par(mfrow=c(3,1))
plot(a10,xlab="Year")
plot(log(a10),xlab="Year")
plot(diff(log(a10),12), xlab="Year",ylab="Annual change in monthly log A10 sales")

```

```
# Plot the US net electricity generation, the log of it, t
```

```
# the seasonal difference and then apply a first difference on the data
```

```

par(mfrow=c(2,2))
plot(usmelec)
plot(log(usmelec))
plot(diff(log(usmelec),12))
plot(diff(diff(log(usmelec),12),1))

```