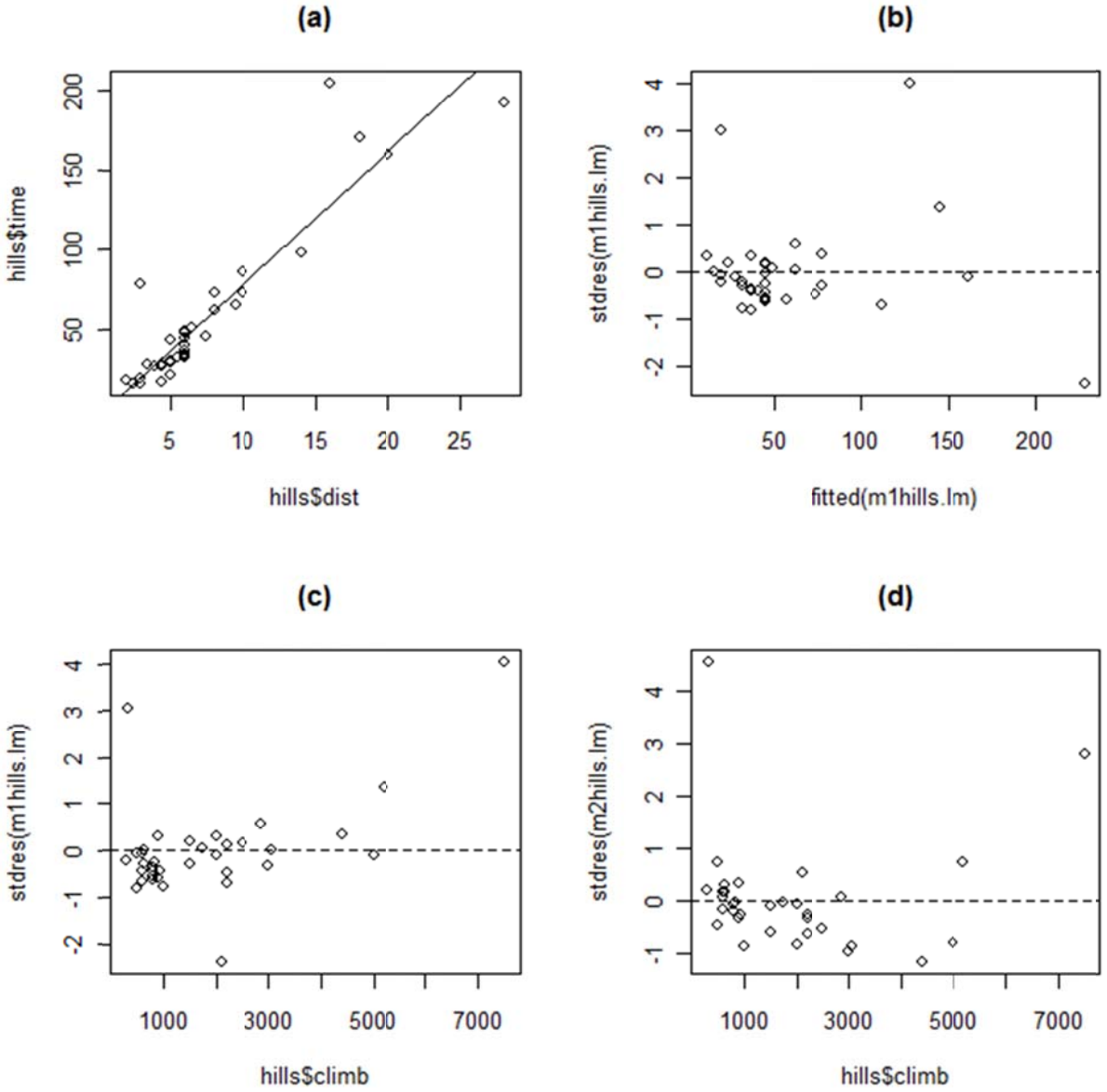
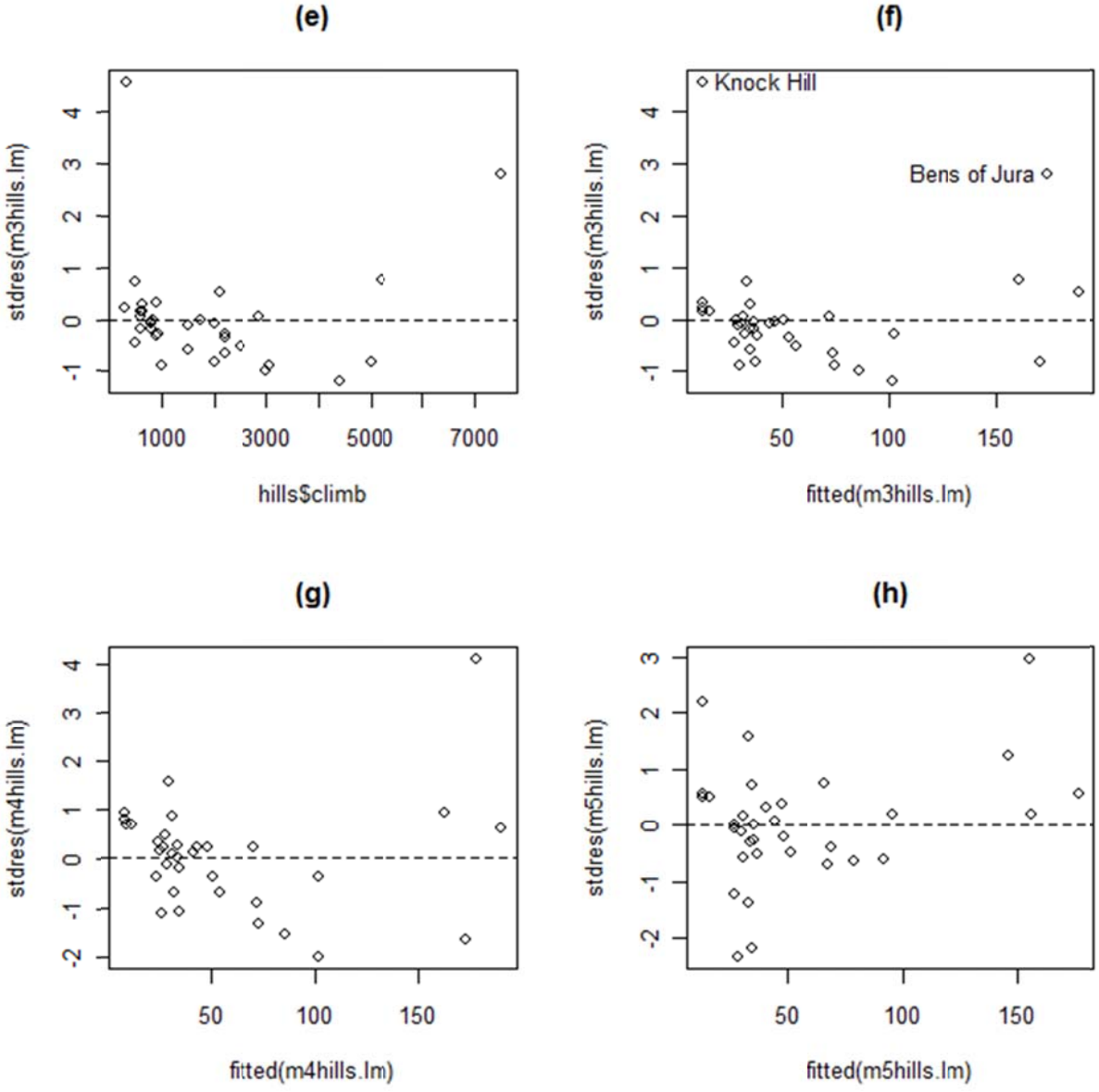
```
> ######################
> #   hills1          #
> ######################
>
> # hills1.R
> library(MASS)
> hills
              dist climb    time    ispeed      grad
Greenmantle      2.5   650  16.083  6.433200 260.00000
Carnethy         6.0  2500  48.350  8.058333 416.66667
Craig Dunain     6.0   900  33.650  5.608333 150.00000
Ben Rha          7.5   800  45.600  6.080000 106.66667
Ben Lomond       8.0  3070  62.267  7.783375 383.75000
Goatfell         8.0  2866  73.217  9.152125 358.25000
Bens of Jura    16.0  7500 204.617 12.788562 468.75000
Cairnpapple      6.0   800  36.367  6.061167 133.33333
Scolty           5.0   800  29.750  5.950000 160.00000
Traprain         6.0   650  39.750  6.625000 108.33333
Lairig Ghru     28.0  2100 192.667  6.880964  75.00000
Dollar           5.0  2000  43.050  8.610000 400.00000
Lomonds          9.5  2200  65.000  6.842105 231.57895
Cairn Table      6.0   500  44.133  7.355500  83.33333
Eildon Two       4.5  1500  26.933  5.985111 333.33333
Cairngorm       10.0  3000  72.250  7.225000 300.00000
Seven Hills     14.0  2200  98.417  7.029786 157.14286
Knock Hill       3.0   350  78.650 26.216667 116.66667
Black Hill       4.5  1000  17.417  3.870444 222.22222
Creag Beag       5.5   600  32.567  5.921273 109.09091
Kildcon Hill     3.0   300  15.950  5.316667 100.00000
Meall Ant-Suidhe  3.5  1500  27.900  7.971429 428.57143
Half Ben Nevis    6.0  2200  47.633  7.938833 366.66667
Cow Hill         2.0   900  17.933  8.966500 450.00000
N Berwick Law    3.0   600  18.683  6.227667 200.00000
Creag Dubh       4.0  2000  26.217  6.554250 500.00000
Burnswark        6.0   800  34.433  5.738833 133.33333
Largo Law        5.0   950  28.567  5.713400 190.00000
Criffel          6.5  1750  50.500  7.769231 269.23077
Acmony           5.0   500  20.950  4.190000 100.00000
Ben Nevis       10.0  4400  85.583  8.558300 440.00000
Knockfarrel      6.0   600  32.383  5.397167 100.00000
Two Breweries   18.0  5200 170.250  9.458333 288.88889
Cockleroi        4.5   850  28.100  6.244444 188.88889
Moffat Chase    20.0  5000 159.833  7.991650 250.00000
> par(mfrow=c(2,2))
> plot(hills$dist, hills$time)
> title(main="(a)")
> m1hills.lm <- lm(time ~ dist, data=hills)
> m1hills.lm
```

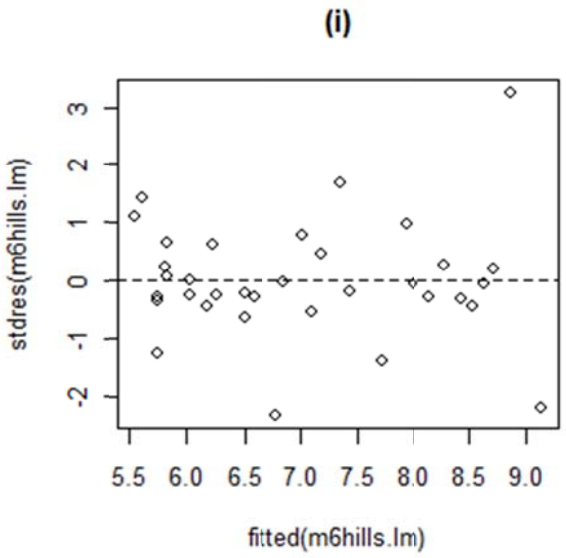
```
Call:
lm(formula = time ~ dist, data = hills)

Coefficients:
(Intercept)        dist
    -4.841       8.330

> abline(m1hills.lm)
> plot(fitted(m1hills.lm),stdres(m1hills.lm))
> title(main="(b)")
> abline(h=0,lty=2)
> plot(hills$climb, stdres(m1hills.lm))
> title(main="(c)")
> abline(h=0,lty=2)
> m2hills.lm <- lm(time ~ dist + climb,data=hills)
> anova(m1hills.lm,m2hills.lm)
Analysis of Variance Table

Model 1: time ~ dist
Model 2: time ~ dist + climb
  Res.Df     RSS Df Sum of Sq      F    Pr(>F)
1     33 13141.6
2     32  6891.9  1    6249.7 29.018 6.445e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> plot(hills$climb, stdres(m2hills.lm))
> title(main="(d)")
> abline(h=0,lty=2)
> m3hills.lm <- lm(time ~ dist + climb+climb^2,data=hills)
> m3hills.lm

Call:
lm(formula = time ~ dist + climb + climb^2, data = hills)

Coefficients:
(Intercept)        dist       climb
   -8.99204      6.21796      0.01105

> anova(m2hills.lm,m3hills.lm)
Analysis of Variance Table

Model 1: time ~ dist + climb
Model 2: time ~ dist + climb + climb^2
  Res.Df    RSS Df Sum of Sq F Pr(>F)
1     32 6891.9
2     32 6891.9  0        0
> plot(hills$climb, stdres(m3hills.lm))
```

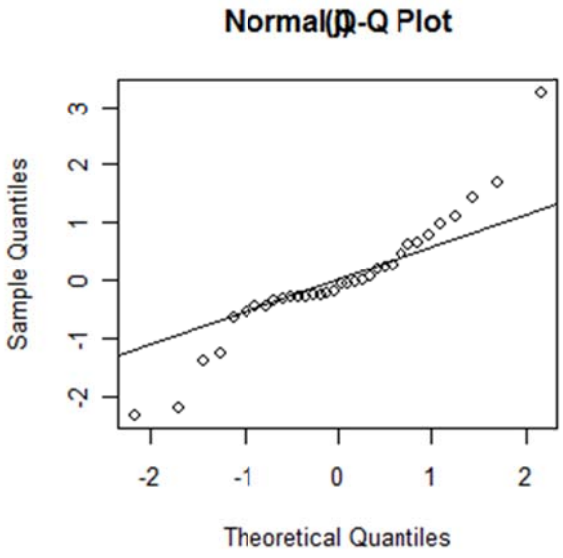
```
> title(main="(e)")
> abline(h=0,lty=2)
> plot(fitted(m3hills.lm),stdres(m3hills.lm))
> title(main="(f)")
> abline(h=0,lty=2)
> identify(fitted(m3hills.lm), stdres(m3hills.lm), row.names(hills))
[1]  7 18
> cbind(hills, pred = predict(m3hills.lm))["Knock Hill",  ]
           dist climb  time   ispeed     grad     pred
Knock Hill    3   350 78.65 26.21667 116.6667 13.52860
> m4hills.lm <- lm(time ~ dist + climb + climb^2, data = hills[-18,  ])
> m4hills.lm

Call:
lm(formula = time ~ dist + climb + climb^2, data = hills[-18,     ])

Coefficients:
(Intercept)         dist        climb
  -13.53035      6.36456      0.01185

> plot(fitted(m4hills.lm),stdres(m4hills.lm))
> title(main="(g)")
> abline(h=0,lty=2)
> m5hills.lm <- lm(time ~ dist + climb + climb^2, data = hills[-18,  ],
+   weight = 1/dist^2)
> plot(fitted(m5hills.lm),stdres(m5hills.lm))
> title(main="(h)")
> abline(h=0,lty=2)
> AIC(m4hills.lm)
[1] 249.2575
> AIC(m5hills.lm)
[1] 237.1327
> #BIC(m4hills.lm) # works in S-PLUS, but not R
> #BIC(m5hills.lm) # works in S-PLUS, but not R
> AIC(m4hills.lm,k=log(nrow(hills))) #produces BIC
[1] 255.4789
> AIC(m5hills.lm,k=log(nrow(hills[-18,  ]))) #produces BIC
[1] 243.2381
> hills <- hills
> hills$ispeed <- hills$time/hills$dist
> hills$grad <- hills$climb/hills$dist
> m6hills.lm <- lm(ispeed ~ grad, hills[-18,  ])
> m6hills.lm

Call:
lm(formula = ispeed ~ grad, data = hills[-18, ])

Coefficients:
```

```
(Intercept)        grad
   4.899985    0.008472

> plot(fitted(m6hills.lm),stdres(m6hills.lm))
> title(main="(i)")
> abline(h=0,lty=2)
> qqnorm(stdres(m6hills.lm))
> qqline(stdres(m6hills.lm))
> title(main="(j)")
>
>
```




(e)
stdres(m3hills.lm)
hills$climb
1000
3000
5000
7000
(f)
Knock Hill
Bens of Jura
stdres(m3hills.lm)
fitted(m3hills.lm)
50
100
150
(g)
stdres(m4hills.lm)
fitted(m4hills.lm)
(h)
stdres(m5hills.lm)
fitted(m5hills.lm)


(i)
stdres(m6hills.lm)
fitted(m6hills.lm)
-2
-1
0
1
2
3
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0


Normal Q-Q Plot
Sample Quantiles
Theoretical Quantiles
-2
-1
0
1
2
3