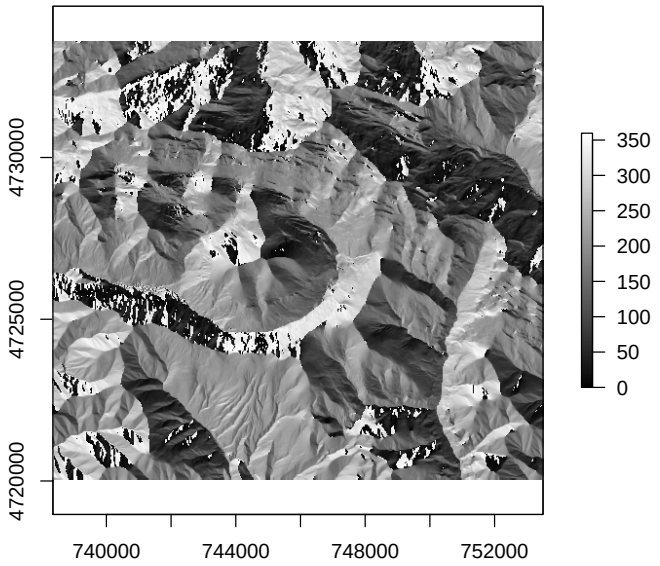
`insol` Package Vignette

Calculate the aspect of a rough mountain area in the pyrinees

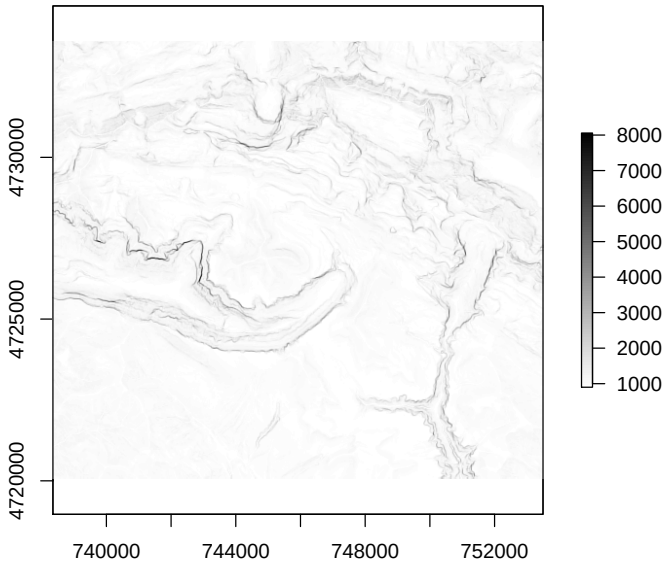
```
> require(rgdal)
> require(raster)
> require(insol)
> demfile=tempfile()
> download.file("http://www.meteoexploration.com/R/insol/data/dempyrenees.tif",demfile)
> dem=raster(demfile)
> aspectdem=aspect(cgrad(dem),degrees=TRUE)
> aspectdem=raster(aspectdem,crs=projection(dem))
> extent(aspectdem)=extent(dem)
> plot(aspectdem,col=grey(1:100/100))
> unlink(demfile)
```



Surface area of every grid cell in a mountain region Steep slopes correspond to larger surface area per grid cell

```
> require(rgdal)
> require(raster)
> demfile=tempfile()
> download.file("http://www.meteoexploration.com/R/insol/data/dempyrenees.tif",demfile)
```

```
> dem=raster(demfile)
> grd=cgrad(dem)
> grdarea=cgrad(dem,cArea=TRUE)
> rgrdarea=raster(grdarea,crs=projection(dem))
> extent(rgrdarea)=extent(dem)
> plot(rgrdarea,col=grey(100:1/100))
> # contour(dem,col='sienna1',lwd=.5,nlevels=30,add=TRUE)
> unlink(demfile)
```

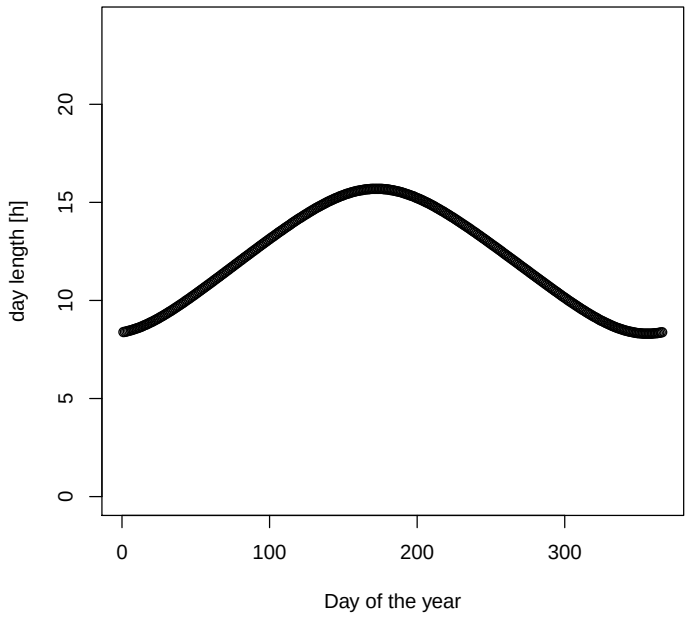


Dates to day of the year

```
> daydoy(2012,2,27:29)

[1] 58 59 60

> daydoy(ISOdate(2012,2,27:29))

[1] 58 59 60
```

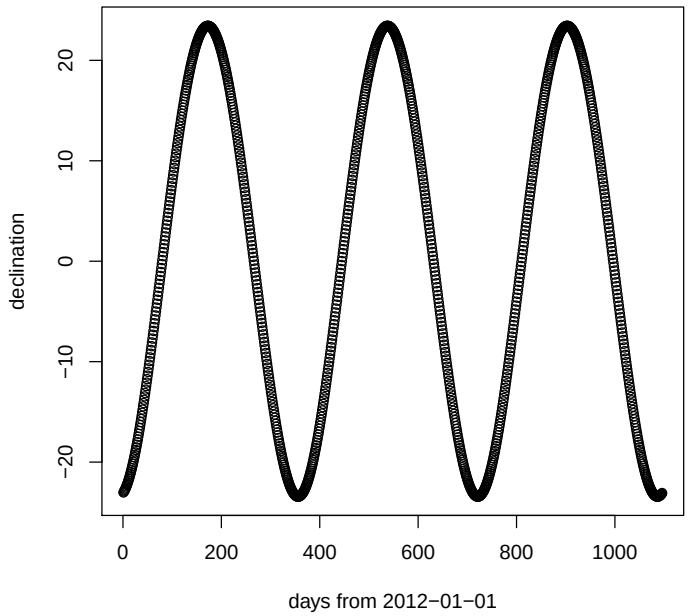
Length of the day

```
> jd2012=JD(seq(ISOdate(2012,1,1),ISOdate(2012,12,31),by='day'))
> plot(daylength(47,11,jd2012,1)[,3],xlab='Day of the year',ylab='day length [h]',ylim=c(0,24)
```



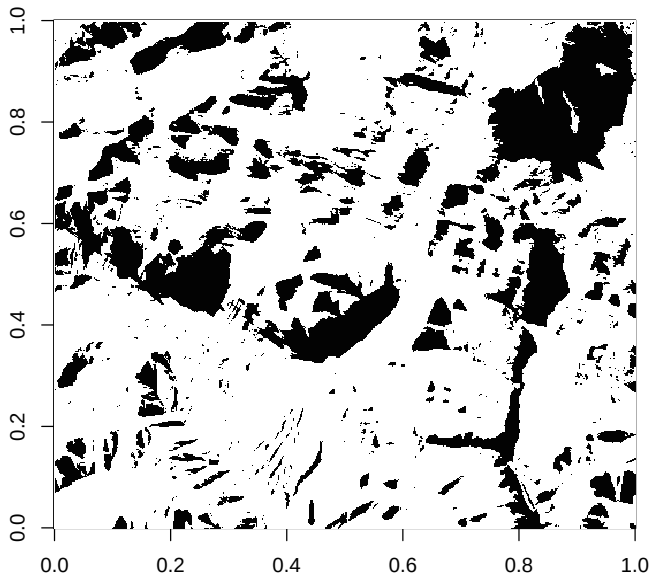
Declination

```
> # Find the solstices to the nearest hour
> jdays=JD(seq(ISOdate(2013,1,1),ISOdate(2013,12,31),by='hour'))
> decl=declination(jdays)
> wintersolstice=which(decl==min(decl))
> summersolstice=which(decl==max(decl))
> JD(jdays[c(summersolstice,wintersolstice)],inv=TRUE)

[1] "2013-06-21 07:00:00 CEST" "2013-12-21 18:00:00 CET"

> # Plot daily changes in declination from 2012 to 2014
> jdays=JD(seq(ISOdate(2012,1,1),ISOdate(2014,12,31),by='day'))
> plot(declination(jdays),xlab='days from 2012-01-01',ylab='declination')
```



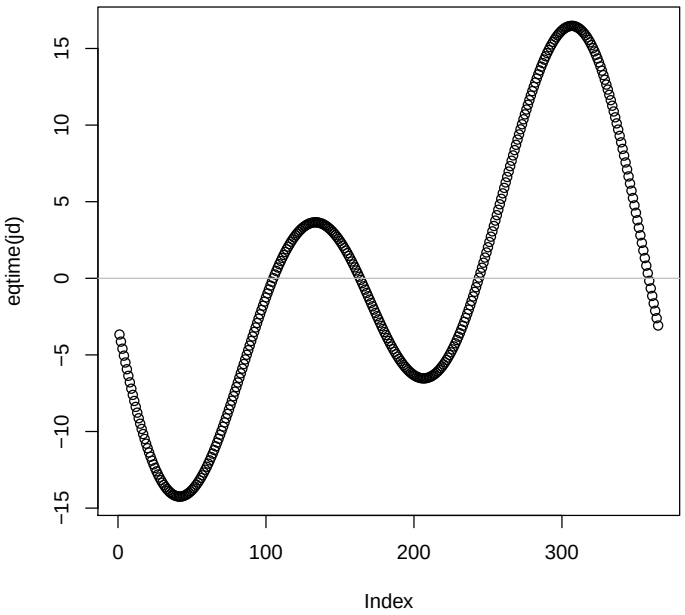
Doshade

```
> # plot cast shadows on mountain terrain, sun at NW, 25 degrees elevation
> zipfile=tempfile()
> download.file("http://www.meteoexploration.com/R/insol/data/dempyrenees.asc.zip",zipfile)
> header=read.table(unz(zipfile,'dempyrenees.asc'),nrows=6)
> dem = read.table(unz(zipfile,'dempyrenees.asc'),skip=6)
> dem=as.matrix(dem)
> unlink(zipfile)
> cellsize=header[5,2]
> sv=normalvector(65,315)
> sh=doshade(dem,sv,cellsize)
> image(t(sh[nrow(sh):1,]),col=grey(1:100/100))
```



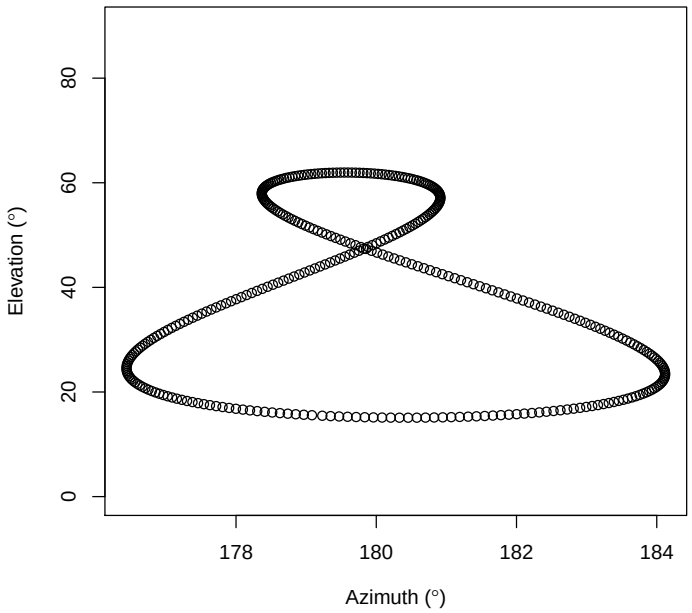
Equation of time in minutes

```
> # plot the equation of time for 2013 at daily intervals
> jdays=seq(ISOdate(2013,1,1),ISOdate(2013,12,31),by='day')
> jd=JD(jdays)
> plot(eqtime(jd))
> abline(h=0,col=8)
```



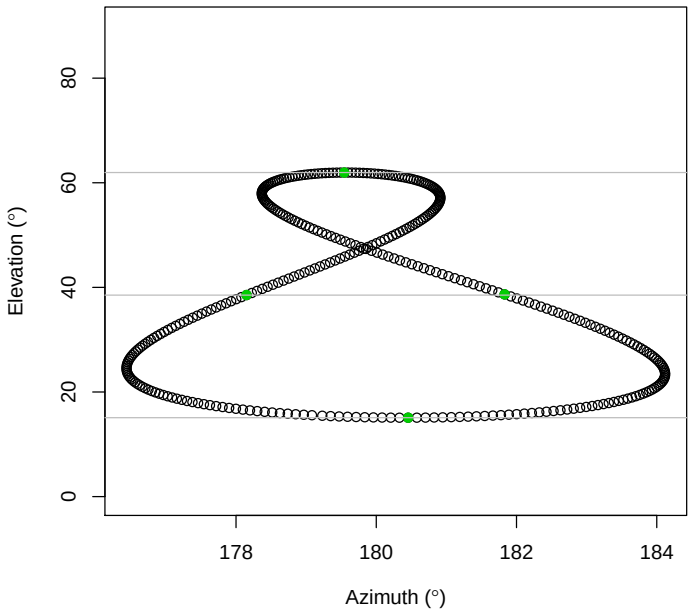
Analema

```
> # Analema from Greenwich Observatory
> jdays=seq(ISOdate(2013,1,1),ISOdate(2013,12,31),by='day')
> jd=JD(jdays)
> latGwch=51.4791
> x = 180+eqtime(jd)*15/60
> y = 90-latGwch+declination(jd)
> plot(x,y,ylim=c(0,90),xlab=expression(paste('Azimuth (',degree,')')),
+          ylab=expression(paste('Elevation (',degree,')')))
```



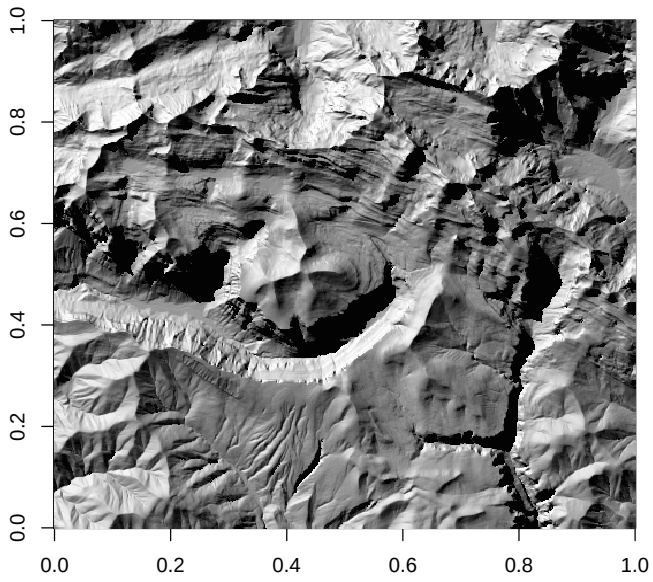
solstices and equinoxes

```
> ## plot the solstices and equinoxes (nearest day, see ?declination for more precision)
> jdays=seq(ISOdate(2013,1,1),ISOdate(2013,12,31),by='day')
> jd=JD(jdays)
> decl=declination(jd)
> latGwch=51.4791
> x = 180+eqtime(jd)*15/60
> y = 90-latGwch+declination(jd)
> wintersolstice=which(decl==min(decl))
> summersolstice=which(decl==max(decl))
> ## spring equinox: when declination becomes zero in the first part of the year
> springeqx=uniroot(declination,jd[c(1,180)])$root
> springeqx=daydoy(JD(springeqx,inv=TRUE))
> autumeqx=uniroot(declination,jd[c(180,360)])$root
> autumeqx=daydoy(JD(autumeqx,inv=TRUE))
> nodeseqx=c(springeqx,summersolstice,autumeqx,wintersolstice)
> plot(x,y,ylim=c(0,90),xlab=expression(paste('Azimuth (',degree,')')),
+          ylab=expression(paste('Elevation (',degree,')')))
> points(x[nodeseqx],y[nodeseqx],pch=19,col=3)
> abline(h=c(90-latGwch,90-latGwch+max(decl),90-latGwch+min(decl)),col=8)
```



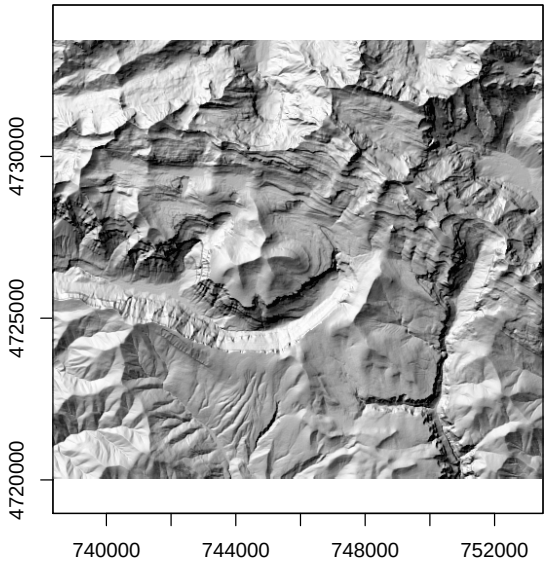
Hillshading

```
> # Hillshading on mountain terrain, sun at NW, 35 degrees elevation
> zipfile=tempfile()
> download.file("http://www.meteoexploration.com/R/insol/data/dempyrenees.asc.zip",zipfile)
> header=read.table(unz(zipfile,'dempyrenees.asc'),nrows=6)
> dem = read.table(unz(zipfile,'dempyrenees.asc'),skip=6)
> dem=as.matrix(dem)
> unlink(zipfile)
> cellsize=header[5,2]
> sv=normalvector(55,315)
> grd=cgrad(dem,cellsize)
> hsh=grd[,,1]*sv[1]+grd[,,2]*sv[2]+grd[,,3]*sv[3]
> ## remove negative incidence angles (self shading)
> hsh=(hsh+abs(hsh))/2
> sh=doshade(dem,sv,cellsize)
> hshsh=hsh*sh
> image(t(hshsh[nrow(sh):1,]),col=grey(1:100/100))
```



Hillshading with raster

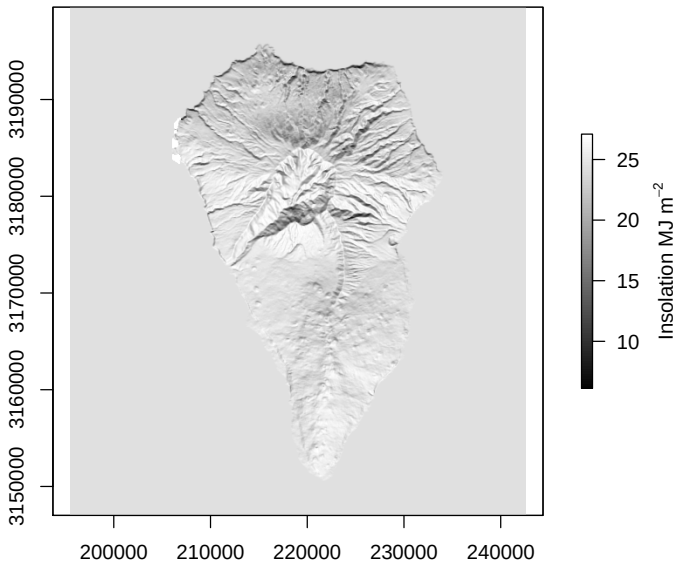
```
> # Hillshading on mountain terrain, sun at NW, 45 degrees elevation. Using raster
> require(rgdal)
> require(raster)
> sv=normalvector(45,315)
> demfile=tempfile()
> download.file("http://www.meteoexploration.com/R/insol/data/dempyrenees.tif",demfile)
> dem=raster(demfile)
> grd=cgrad(dem)
> hsh=grd[,,1]*sv[1]+grd[,,2]*sv[2]+grd[,,3]*sv[3]
> ## remove negative incidence angles (self shading)
> hsh=(hsh+abs(hsh))/2
> hsh=raster(hsh,crs=projection(dem))
> extent(hsh)=extent(dem)
> plot(hsh,col=grey(1:100/100),legend=FALSE)
> unlink(demfile)
```



insolation Computes direct and diffuse solar irradiance perpendicular to the beam, for a given zenith angle, Julian Day, altitude and atmospheric conditions

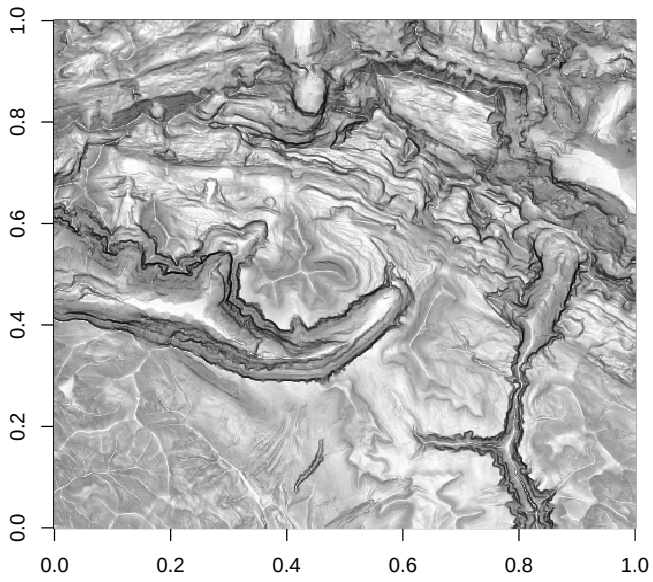
```
> # Calculate insolation on the island of La Palma, Spain on the 21.03.2013
> # reduced resolution DEM from SRTM, http://www2.jpl.nasa.gov/srtm/
> #  using raster
> require(rgdal)
> require(raster)
> demfile=tempfile()
> download.file("http://www.meteoexploration.com/R/insol/data/demlapalma.tif",demfile)
> dem=raster(demfile)
> cgr=cgrad(dem)
> demm=raster:::as.matrix(dem)
> dl=res(dem)[1]
> ## Isolation at 30 min interval over the length of the day
> ## RH and temp would cahnge over the dy, here we use a constant value for simplicity
> height=750
> visibility=30
> RH=80
> tempK=288
> tmz=0
> year=2013
```

```
> month=3
> day=21
> timeh=12
> jd=JDymd(year,month,day,hour=timeh)
> Iglobal=array(0,dim=dim(demm))
> deltat=0.5
> lat=28.135
> lon=-17.247
> dayl=daylength(lat,lon,jd,0)
> for (srs in seq(dayl[1],dayl[2],deltat)){
+         jd=JDymd(year,month,day,hour=srs)
+         sv=sunvector(jd,lat,lon,tmz)
+         hsh=hillshading(cgr,sv)
+         sh=doshade(demm,sv,dl)
+         zenith=sunpos(sv)[2]
+         Idirdif = insolation(zenith,jd,height,visibility,RH,tempK,0.002,0.15)
+         ## direct radiation modified by terrain + diffuse irradiation (skyviewfactor ignor
+         ## values in J/m^2
+         Iglobal = Iglobal + (Idirdif[,1] * hsh + Idirdif[,2] )*3600*deltat
+ }
> ## rasterize to plot nicely
> Iglobal=raster(Iglobal,crs=projection(dem))
> extent(Iglobal)=extent(dem)
> plot(Iglobal*1e-6,col=grey(1:100/100),
+          legend.args=list(text=expression(paste('Insolation MJ ',m^-2)), side=4,line=2.5))
> # contour(dem,lwd=.5,col='sienna1',add=TRUE,levels=seq(0,2500,500))
> # contour(dem,lwd=.25,col='sienna1',add=TRUE,levels=seq(0,2500,50),drawlabels=FALSE)
> unlink(demfile)
```



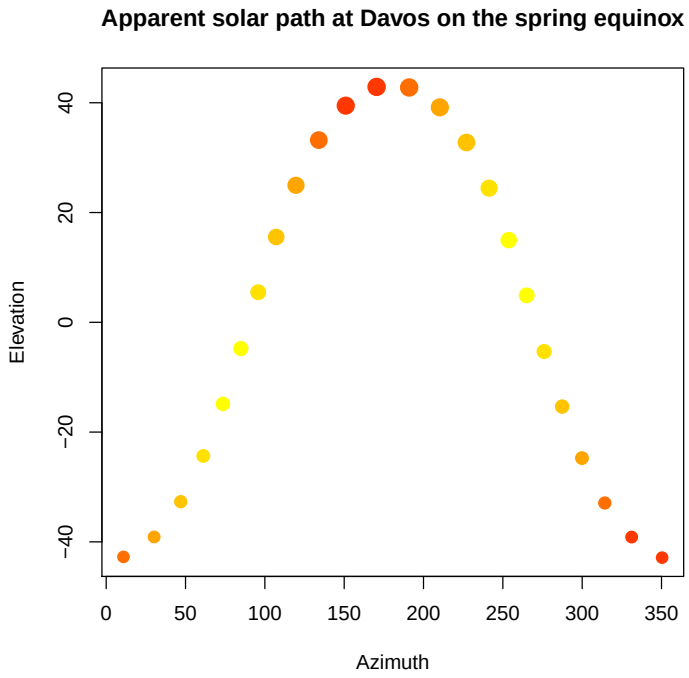
Slope of grid cells in a DEM

```
> # Calculate the slope of a rough mountain area in the pyrinees
> zipfile=tempfile()
> download.file("http://www.meteoexploration.com/R/insol/data/dempyrenees.asc.zip",zipfile)
> header=read.table(unz(zipfile,'dempyrenees.asc'),nrows=6)
> dem = read.table(unz(zipfile,'dempyrenees.asc'),skip=6)
> dem=as.matrix(dem)
> unlink(zipfile)
> cellsize=header[5,2]
> slopedem=slope(cgrad(dem,cellsize),degrees=TRUE)
> image(t(slopedem[nrow(slopedem):1,]),col=grey(100:1/100))
> unlink(demfile)
```



sunpos Azimuth and zenith of the Sun

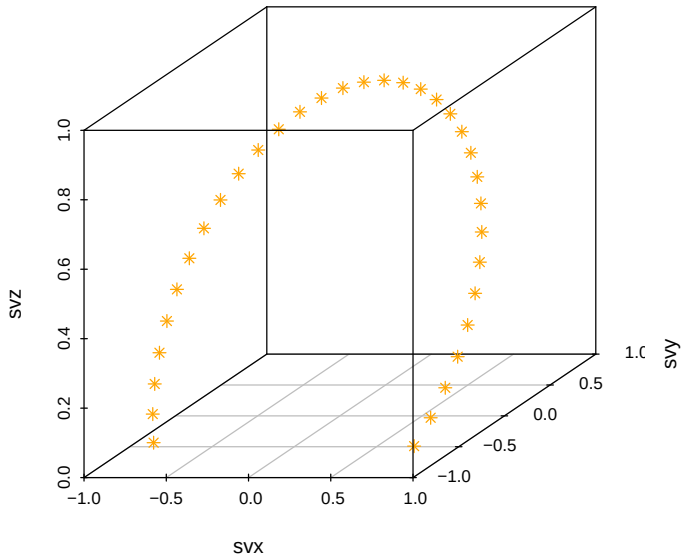
```
> # Julian Day hourly intervals at spring equinox
> jd=JD(seq(ISOdate(2012,3,20,0),ISOdate(2012,3,20,23),by="hour"))
> # sun position
> sp=sunpos(sunvector(jd,46.813,9.844,1))
> # Plot the apparent solar path at Davos on the spring equinox
> ramp = colorRamp(c("red", "orange","yellow"))
> crmp=c(rgb(ramp(seq(1/6,1,1/6)), max = 255),rgb(ramp(seq(1,1/6,-1/6)), max = 255))
> plot(sp[,1],90-sp[,2],xlab='Azimuth',
+         ylab='Elevation',main='Apparent solar path at Davos on the spring equinox',
+         pch=20,col=crmp,cex=(300-sp[,2])/90)
> # 3D plot
> require(plotrix)
> polar.plot(90-sp[,2],sp[,1],start=90,clockwise=TRUE,rp.type='s',
+         point.symbols=20,point.col=2,cex=2,radial.lim=c(0,90),
+         main='Apparent solar path at Davos on the spring equinox')
```



sunvector Calculates a unit vector in the direction of the sun from the observer position

```
> # Current solar vector at Greenwich observatory
> sunvector(JD(Sys.time()),51.4778,-0.0017,0)

                svx            svy            svz
[1,] 0.348012735933 0.575817540146 0.739811662579

> juneday=JD(seq(ISOdate(2012,6,21,0),ISOdate(2012,6,21,23,30),by='30 min'))
> # Path of the sun over Greenwich in summer
> require(scatterplot3d)
> scatterplot3d(sunvector(juneday,51.4778,-0.0017,0),
+         ylim=c(-1,1),zlim=c(0,1),pch=8,color='orange')
> # print values
> options(digits=12)                # make sure decimals are printed
> sunvector(juneday,51.4778,-0.0017,0)

                   svx              svy              svz
 [1,] -0.00710434439184 -0.9655162667439 -0.2602457817979
 [2,]  0.11269280218770 -0.9601025803690 -0.2559362567202
 [3,]  0.23056234060243 -0.9425034054744 -0.2419263064759
 [4,]  0.34448811072194 -0.9130197723456 -0.2184555718614
```

```
 [5,]  0.45252140226299 -0.8721559956549 -0.1859255220168
 [6,]  0.55281429587634 -0.8206110481914 -0.1448925873221
 [7,]  0.64365127787309 -0.7592666004393 -0.0960586380791
 [8,]  0.72347857064449 -0.6891719465983 -0.0402589845881
 [9,]  0.79093071782755 -0.6115260539434  0.0215519127959
[10,]  0.84485394387226 -0.5276570485416  0.0883167744421
[11,]  0.88432588040572 -0.4389995081567  0.1588935778528
[12,]  0.90867134937855 -0.3470699191977  0.2320750956192
[13,]  0.91747391228661 -0.2534407307033  0.3066095502330
[14,]  0.91058299023976 -0.1597134699913  0.3812220158771
[15,]  0.88811644297778 -0.0674913424794  0.4546362308515
[16,]  0.85045855000799  0.0216481972572  0.5255964328968
[17,]  0.79825344072511  0.1061804154736  0.5928888291580
[18,]  0.73239407675926  0.1846593864378  0.6553623633749
[19,]  0.65400697225685  0.2557427297929  0.7119484085224
[20,]  0.56443293391272  0.3182145615233  0.7616790373571
[21,]  0.46520412343215  0.3710062978340  0.8037035837355
[22,]  0.35801784239582  0.4132149360569  0.8373031954709
[23,]  0.24470751341321  0.4441184935925  0.8619031247932
[24,]  0.12721131361163  0.4631883622520  0.8770825632536
[25,]  0.00753901382916  0.4700983504490  0.8825818399308
[26,] -0.11226238265669  0.4647302603836  0.8783068612530
[27,] -0.23014366185597  0.4471759125651  0.8643307226572
[28,] -0.34408845870308  0.4177355730926  0.8408924565962
[29,] -0.45214773120229  0.3769128202328  0.8083929459816
[30,] -0.55247310729676  0.3254059309647  0.7673880672820
[31,] -0.64334850748459  0.2640959326655  0.7185791788431
[32,] -0.72321948508881  0.1940315403130  0.6628011298660
[33,] -0.79071982307499  0.1164112159228  0.6010079784858
[34,] -0.84469490686566  0.0325626630531  0.5342566679884
[35,] -0.88422146530398 -0.0560798729474  0.4636889562475
[36,] -0.90862336951747 -0.1480001422109  0.3905118823701
[37,] -0.91748319869286 -0.2416258322567  0.3159771151564
[38,] -0.91064937723324 -0.3353554499727  0.2413595531946
[39,] -0.88823877112306 -0.4275857212063  0.1679355129038
[40,] -0.85063468636222 -0.5167390209101  0.0969608922521
[41,] -0.79848031601777 -0.6012903461019  0.0296496984275
[42,] -0.73266773886728 -0.6797934077391 -0.0328467230882
[43,] -0.65432265504232 -0.7509053744110 -0.0894593861989
[44,] -0.56478514021527 -0.8134098311568 -0.1392199409910
[45,] -0.46558672078106 -0.8662375925900 -0.1812772424111
[46,] -0.35842416977337 -0.9084849942808 -0.2149119114636
[47,] -0.24513049720535 -0.9394293432122 -0.2395486348357
[48,] -0.12764359073454 -0.9585412844902 -0.2547660096484
```


svz
1.0
0.8
0.6
0.4
0.2
0.0
−1.0
−0.5
0.0
0.5
1.0
svx
svy
0.5
0.0
−0.5
−1.0