

# Principal Component Analysis (PCA)

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1. Primer paso: cargar las librerías que necesitas.

```
library(ggplot2)
library(dplyr)
library(missMDA) # Imputate
library(ggfortify) # autoplot()
library(cluster) #pam
library(factoextra) #get_pca_var()
library(data.table) # data.table()
library(labdsv) #loadings.pca(pca)

library(devtools)

install_github("vqv/ggbiplot") #ggbiplot
library(ggbiplot)
```

2. Segundo paso: cargar los datos.

```
channel <- read.csv("data/channel_form.csv", header=TRUE)
head(channel)
```

```
##      Forma NAN_Am NADBO NAtemp  nit NASat02 Elevacion Ancho Velocidad Rocas
## 1 Trapecio  0.03  2.38  27.33 0.35   92.04         23   16          5   20
## 2 Trapecio  0.03  2.95  27.81 NA    100.03         31   11          0   20
## 3 Trapecio  0.03  3.13  24.27 NA    96.82          35   14         10   30
## 4 Trapecio  1.15  4.73  27.06 7.54   64.35          9    5          2    0
## 5 Trapecio  0.50  8.16  26.60 NA   110.39         43   11          9   10
## 6 Trapecio  0.53  8.57  23.82 NA   106.09         23   11          5   20
##      Canto grava arena Limo
## 1    25    30    20    0
## 2    45    20    15    0
## 3    30    20    10    0
## 4     0     0    50   50
## 5    40    10    20   20
## 6    60    20     0    0
```

```
tail(channel)
```

```
##      Forma NAN_Am NADBO NAtemp  nit NASat02 Elevacion Ancho Velocidad Rocas
```

```
## 133 V-Shape 0.11 13.47 21.83 0.00 102.92 952 1 14 50
## 134 V-Shape 0.03 12.34 25.95 0.79 105.50 422 2 13 30
## 135 V-Shape 0.04 1.90 26.88 NA 92.18 144 3 15 50
## 136 V-Shape 0.03 NA 26.01 NA 88.20 200 3 14 15
## 137 V-Shape 0.03 NA 24.81 NA 91.41 327 2 13 40
## 138 V-Shape 0.03 NA 25.58 NA 89.52 60 3 15 30
## Canto grava arena Limo
## 133 20 20 10 0
## 134 40 20 10 0
## 135 30 10 5 5
## 136 30 30 20 5
## 137 30 20 8 2
## 138 25 10 30 5
```

2.1 Vamos a examinar los datos

```
summary(channel)
```

```
##      Forma              NAN_Am              NADBO              NAtemp
## Length:138          Min.   :0.0200          Min.   : 1.310          Min.   :14.67
## Class :character    1st Qu.:0.0400          1st Qu.: 1.930          1st Qu.:24.30
## Mode  :character    Median :0.2150          Median : 3.000          Median :26.05
##                               Mean  :0.3201          Mean  : 6.164          Mean  :25.84
##                               3rd Qu.:0.5000          3rd Qu.: 8.585          3rd Qu.:27.70
##                               Max.   :1.5000          Max.   :34.900          Max.   :32.18
##                               NA's   :35
##      nit              NASat02              Elevacion              Ancho
## Min.   : 0.00          Min.   : 23.43          Min.   : 3.00          Min.   : 1.000
## 1st Qu.: 0.40          1st Qu.: 86.24          1st Qu.: 25.25          1st Qu.: 2.000
## Median : 0.92          Median : 94.59          Median : 53.00          Median : 3.000
## Mean   : 12.00          Mean   : 91.05          Mean   : 230.89          Mean   : 3.875
## 3rd Qu.: 1.62          3rd Qu.:100.52          3rd Qu.: 269.25          3rd Qu.: 3.000
## Max.   :324.11          Max.   :122.73          Max.   :2370.00          Max.   :16.000
## NA's   :57
##      Velocidad              Rocas              Canto              grava
## Min.   : 0.000          Min.   : 0.00          Min.   : 0.00          Min.   : 0.00
## 1st Qu.: 3.000          1st Qu.: 0.00          1st Qu.: 0.00          1st Qu.: 3.75
## Median :11.000          Median :10.00          Median :25.00          Median :20.00
## Mean   : 9.169          Mean   :16.27          Mean   :25.46          Mean   :17.86
## 3rd Qu.:14.000          3rd Qu.:30.00          3rd Qu.:40.00          3rd Qu.:25.00
## Max.   :16.000          Max.   :90.00          Max.   :80.00          Max.   :80.00
## NA's   :2              NA's   :2              NA's   :2              NA's   :2
##      arena              Limo
## Min.   : 0.00          Min.   : 0.00
## 1st Qu.:10.00          1st Qu.: 0.00
## Median :15.00          Median : 7.50
## Mean   :19.83          Mean   :20.51
## 3rd Qu.:25.00          3rd Qu.:25.00
## Max.   :100.00          Max.   :100.00
## NA's   :2              NA's   :2
```

2.1 Remover la(s) variable(s) que tiene(n) mucho(s) NAs y las Etiquetas (a la funcion lo le gusta), luego las agregamos.

```
channel_1 <- select(channel, -Forma)
summary(channel_1)
```

```
##      NAN_Am      NADBO      NAtemp      nit
## Min.   :0.0200   Min.    : 1.310   Min.    :14.67   Min.    : 0.00
## 1st Qu.:0.0400   1st Qu.: 1.930   1st Qu.:24.30   1st Qu.: 0.40
## Median :0.2150   Median : 3.000   Median :26.05   Median : 0.92
## Mean   :0.3201   Mean    : 6.164   Mean    :25.84   Mean    :12.00
## 3rd Qu.:0.5000   3rd Qu.: 8.585   3rd Qu.:27.70   3rd Qu.: 1.62
## Max.   :1.5000   Max.    :34.900   Max.    :32.18   Max.    :324.11
##                      NA's    :35                      NA's    :57
##      NASatO2      Elevacion      Ancho      Velocidad
## Min.    : 23.43   Min.     : 3.00   Min.     : 1.000   Min.     : 0.000
## 1st Qu.: 86.24   1st Qu.: 25.25   1st Qu.: 2.000   1st Qu.: 3.000
## Median : 94.59   Median : 53.00   Median : 3.000   Median :11.000
## Mean    : 91.05   Mean      :230.89   Mean      : 3.875   Mean      : 9.169
## 3rd Qu.:100.52   3rd Qu.:269.25   3rd Qu.: 3.000   3rd Qu.:14.000
## Max.    :122.73   Max.      :2370.00   Max.      :16.000   Max.      :16.000
##                      NA's    :2                      NA's    :2
##      Rocas      Canto      grava      arena
## Min.    : 0.00   Min.     : 0.00   Min.     : 0.00   Min.     : 0.00
## 1st Qu.: 0.00   1st Qu.: 0.00   1st Qu.: 3.75   1st Qu.:10.00
## Median :10.00   Median :25.00   Median :20.00   Median :15.00
## Mean    :16.27   Mean      :25.46   Mean      :17.86   Mean      :19.83
## 3rd Qu.:30.00   3rd Qu.:40.00   3rd Qu.:25.00   3rd Qu.:25.00
## Max.    :90.00   Max.      :80.00   Max.      :80.00   Max.     :100.00
## NA's    :2      NA's    :2      NA's    :2      NA's    :2
##      Limo
## Min.    : 0.00
## 1st Qu.: 0.00
## Median : 7.50
## Mean    :20.51
## 3rd Qu.:25.00
## Max.    :100.00
## NA's    :2
```

2.2 Vamos a imputar datos. Esto es comun para set de datos de campo, los cuales tienden a tener ceros (por mal funcionamiento de los equipos, condiciones climticas adversas que no podemos ir al campo). Se realiza como un paso preliminar para para realizar un PCA en un set de datos completos.

Mas informacion aca: <https://www.rdocumentation.org/packages/missMDA/versions/1.18/topics/imputePCA>

Primero separar e imputar los datos de sustrato y los fisicoquimicos por aparte.

```
# df0 <- channel_1[, 6:13]
# df0

df1 <- select(channel_1, Elevacion, Ancho, Velocidad, Rocas, Canto, grava, arena, Limo)

df1a <- imputePCA(df1, ncp=4, scale = TRUE, method = c("Regularized","EM"),
                  row.w = NULL, ind.sup=NULL, quanti.sup=NULL, quali.sup=NULL,
                  coeff.ridge = 1, threshold = 1e-06, seed = NULL, nb.init = 1,
```

```

maxiter = 1000)

df2 <- select(channel_1, Elevacion, NAN_Am, NAtemp, NASatO2, nit, NADBO)
df2a <- imputePCA(df2, ncp=4, scale = TRUE, method = c("Regularized","EM"),
  row.w = NULL, ind.sup=NULL, quanti.sup=NULL, quali.sup=NULL,
  coeff.ridge = 1, threshold = 1e-06, seed = NULL, nb.init = 1,
  maxiter = 1000)

```

Unir las dos tablas y seleccionar las columnas para hacer el PCA.

```

df1b <- as.data.frame(df1a) # Sustrata
df2b <- as.data.frame(df2a) # Physicochemical

new_channel <- do.call("merge", c(lapply(list(df1b, df2b), data.frame, row.names=NULL),
  by = 0, all = TRUE, sort = FALSE))[-1]

new_channel2 <- select(new_channel,
  completeObs.Elevacion.x, completeObs.Ancho, completeObs.Velocidad,
  completeObs.Rocas, completeObs.Canto, completeObs.grava, completeObs.arena,
  completeObs.Limo, completeObs.NAtemp, completeObs.NASatO2
)

```

### 3. Vamos a correr el PCA

```

channel.pca <- prcomp(new_channel2, center = TRUE, scale =TRUE)
summary(channel.pca)

```

```

## Importance of components:
##          PC1      PC2      PC3      PC4      PC5      PC6      PC7
## Standard deviation  1.8299 1.2868 1.1895 1.0758 0.89995 0.76399 0.70801
## Proportion of Variance 0.3349 0.1656 0.1415 0.1157 0.08099 0.05837 0.05013
## Cumulative Proportion 0.3349 0.5005 0.6419 0.7577 0.83867 0.89704 0.94717
##          PC8      PC9      PC10
## Standard deviation  0.62231 0.37269 0.04612
## Proportion of Variance 0.03873 0.01389 0.00021
## Cumulative Proportion 0.98590 0.99979 1.00000

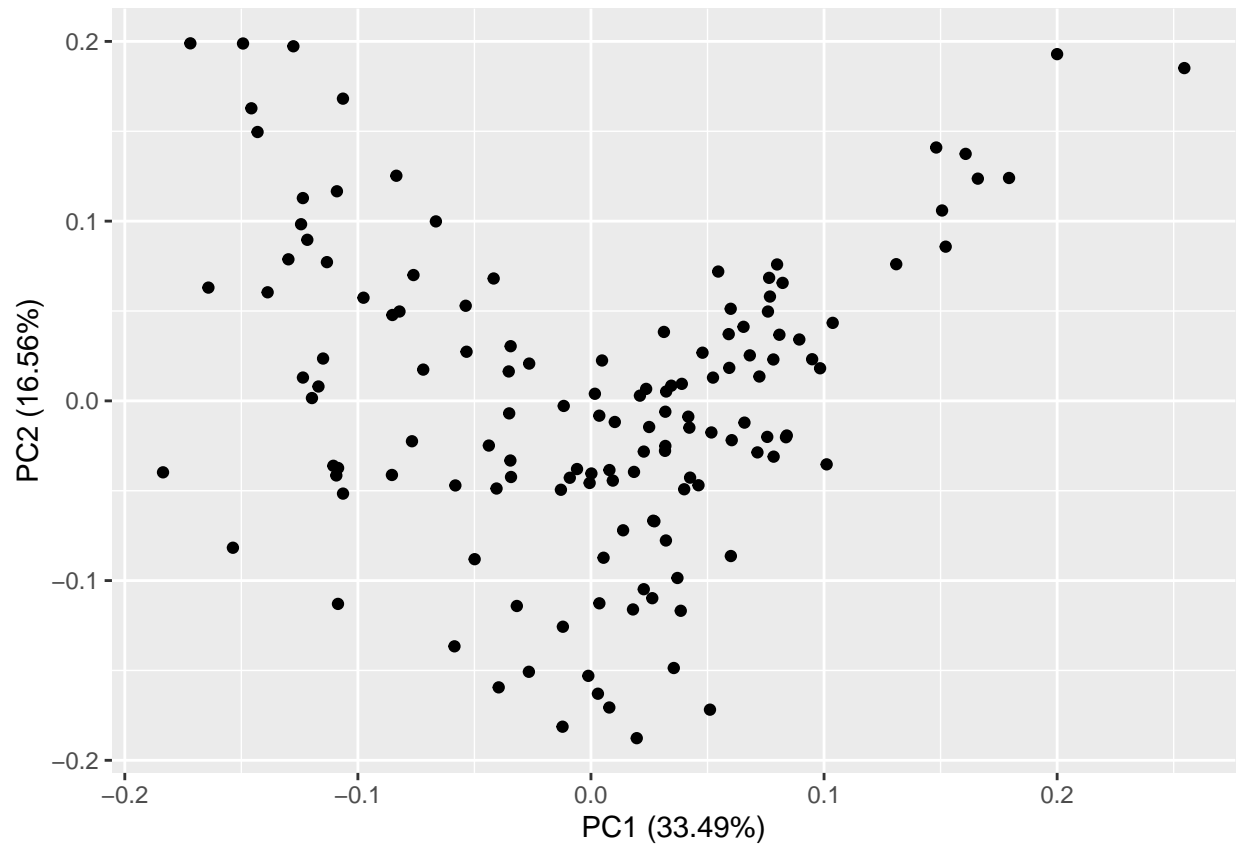
```

#### 3.1 Vamos a ver el grafico.

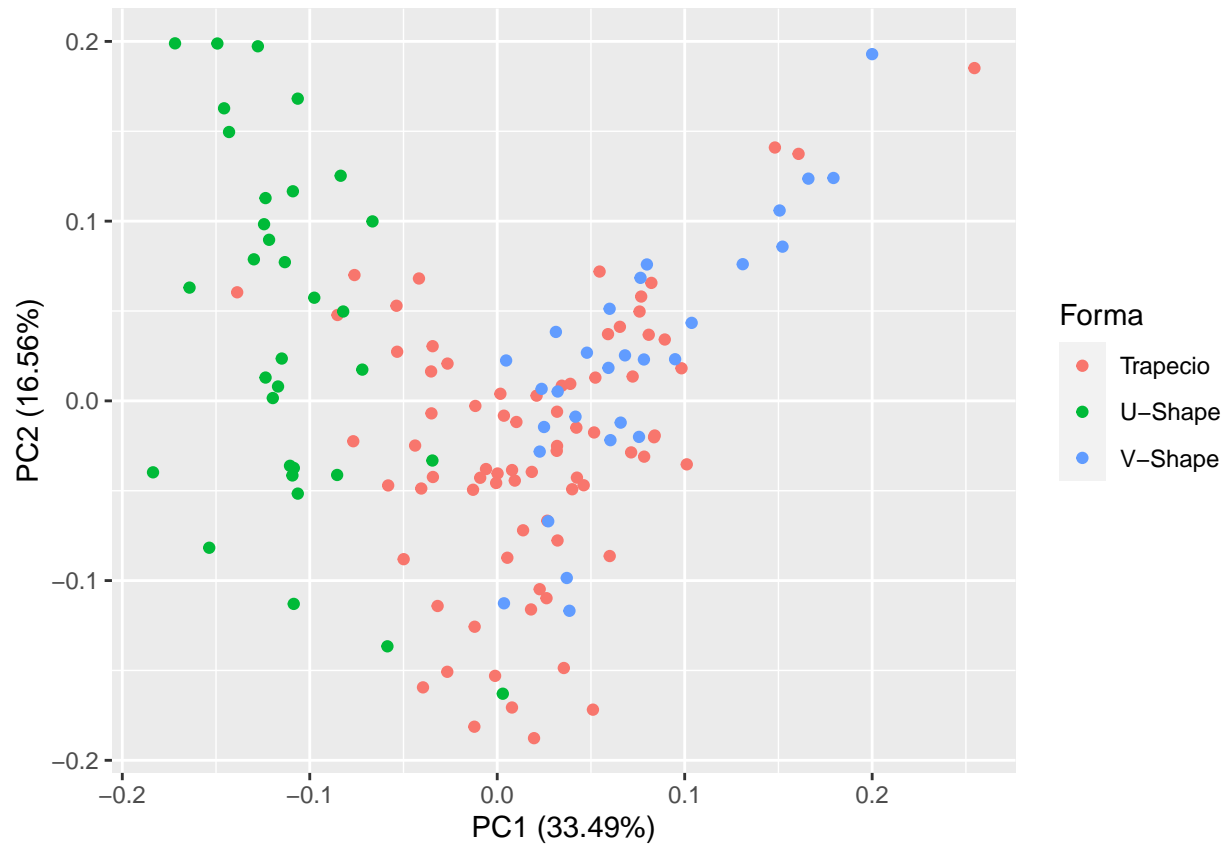
```

autoplot(channel.pca)

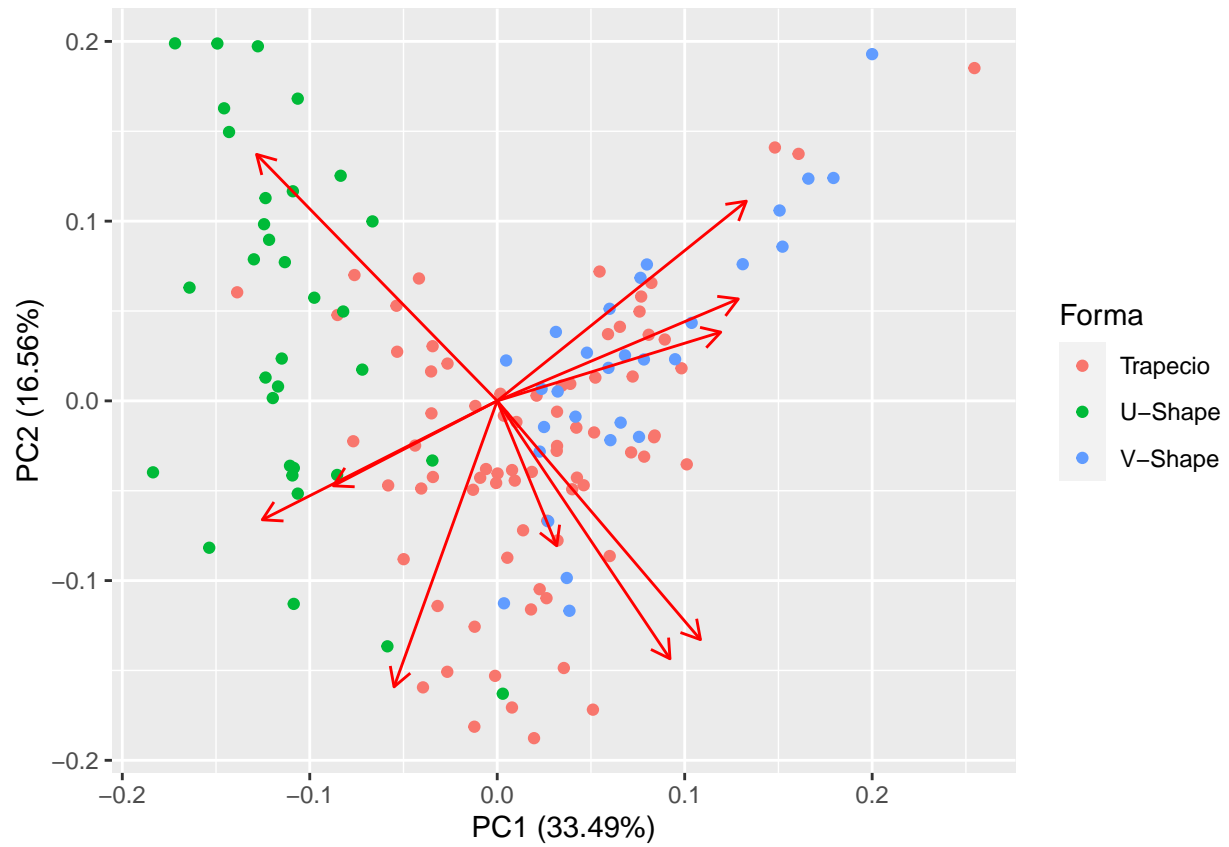
```



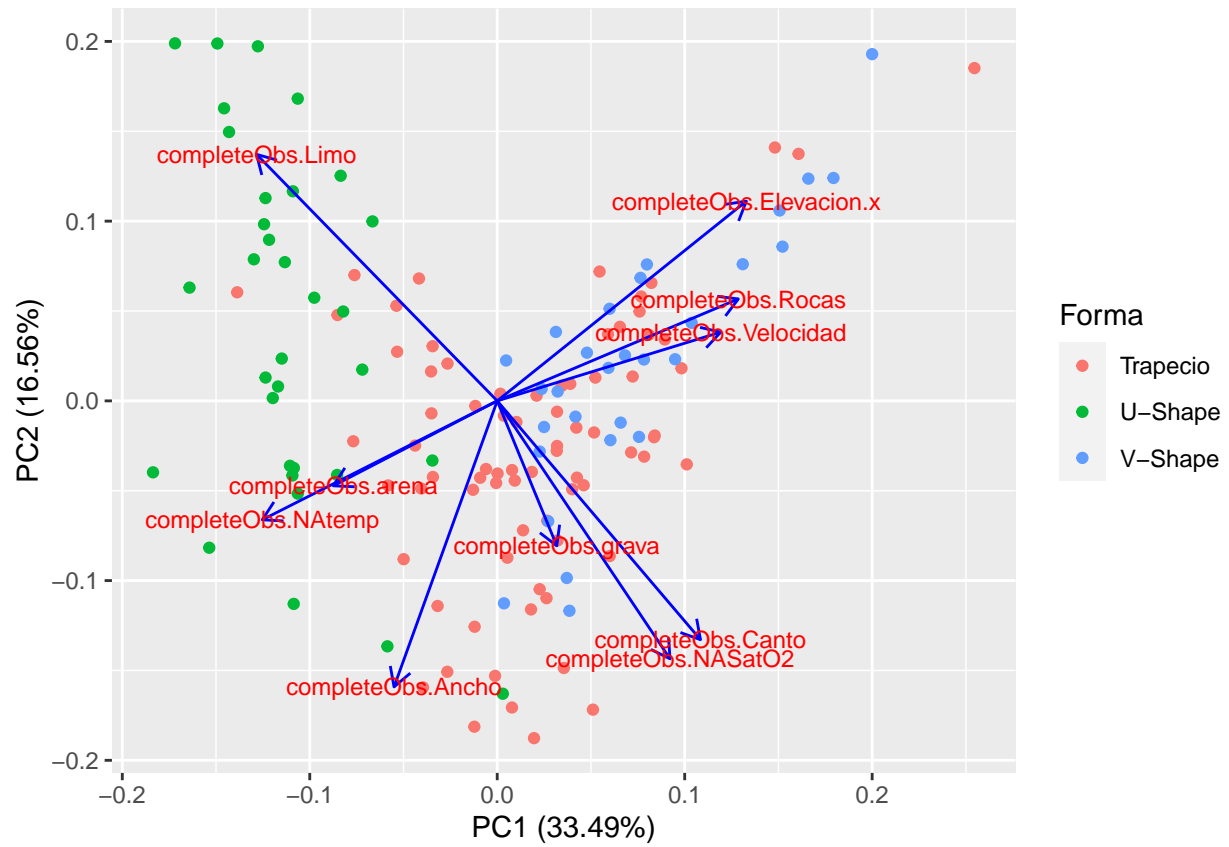
```
autoplot(channel.pca, data = channel, colour = 'Forma')
```



```
autoplot(channel.pca, data = channel, colour = 'Forma', loadings = TRUE)
```



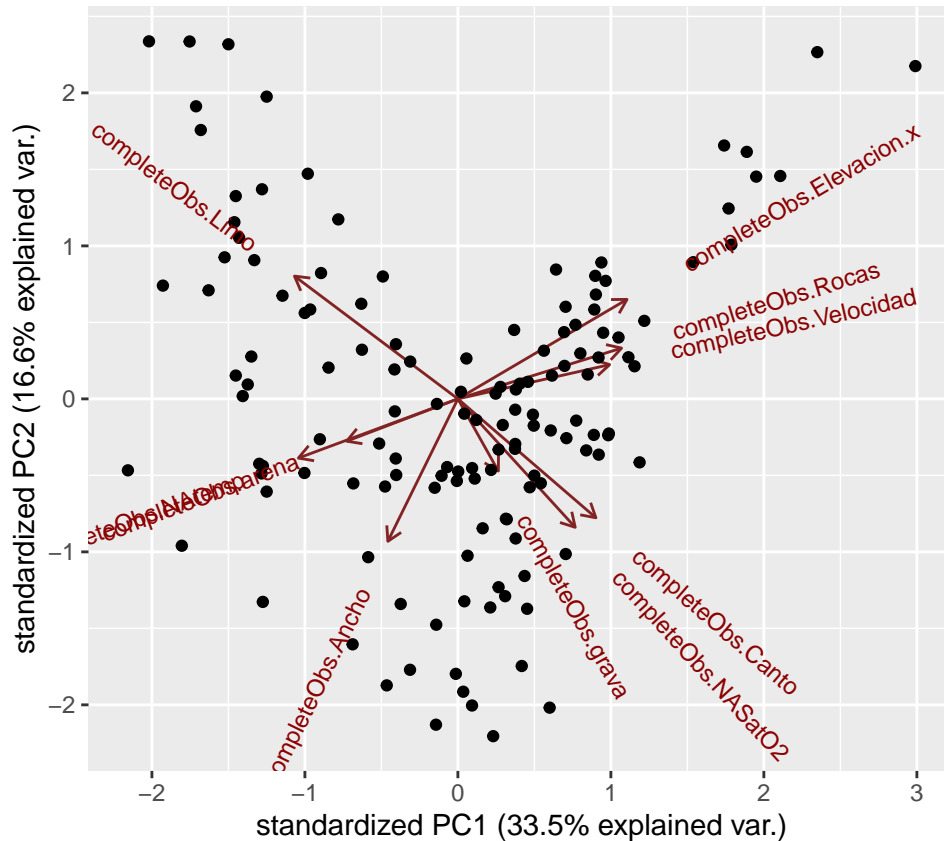
```
autoplot(channel.pca, data = channel, colour = 'Forma', loadings = TRUE,
         loadings.colour = 'blue',
         loadings.label = TRUE, loadings.label.size = 3)
```



Otra manera de ver el grafico

```
ggbiplot(channel.pca, labels=rownames(channel$Forma))
```





3.2 Vamos a ver la contribucion de cada una de las variables.

```
variance <- (channel.pca$sdev)^2
```

```
# Cargar los loadings
loadings <- channel.pca$rotation
round(loadings, 2)[ , 1:3]
```

```
##          PC1   PC2   PC3
## completeObs.Elevacion.x  0.40  0.33 -0.19
## completeObs.Ancho       -0.16 -0.47 -0.44
## completeObs.Velocidad   0.36  0.11  0.41
## completeObs.Rocas       0.38  0.17 -0.18
## completeObs.Canto       0.32 -0.40 -0.10
## completeObs.grava       0.09 -0.24  0.63
## completeObs.arena      -0.26 -0.14 -0.11
## completeObs.Limo       -0.38  0.41 -0.10
## completeObs.NAtemp     -0.37 -0.20  0.36
## completeObs.NASatO2     0.27 -0.43 -0.12
```

```
print(channel.pca)
```

```
## Standard deviations (1, ..., p=10):
## [1] 1.82992315 1.28683255 1.18946223 1.07584685 0.89995265 0.76399277
## [7] 0.70801267 0.62231167 0.37268728 0.04612058
```

```
##
## Rotation (n x k) = (10 x 10):
##
```

|                            | PC1         | PC2        | PC3         | PC4         |
|----------------------------|-------------|------------|-------------|-------------|
| ## completeObs.Elevacion.x | 0.39615124  | 0.3312904  | -0.19490883 | 0.28422267  |
| ## completeObs.Ancho       | -0.16405478 | -0.4744099 | -0.43650902 | 0.10139348  |
| ## completeObs.Velocidad   | 0.35548809  | 0.1140191  | 0.41306910  | -0.00700442 |
| ## completeObs.Rocas       | 0.38339344  | 0.1690205  | -0.18090196 | -0.08759678 |
| ## completeObs.Canto       | 0.32322298  | -0.3960706 | -0.09665874 | -0.34691126 |
| ## completeObs.grava       | 0.09466745  | -0.2403600 | 0.62978697  | 0.31374507  |
| ## completeObs.arena       | -0.26046769 | -0.1408860 | -0.10693686 | 0.67881136  |
| ## completeObs.Limo        | -0.38269942 | 0.4088553  | -0.09718531 | -0.30305650 |
| ## completeObs.NAtemp      | -0.37358516 | -0.1972495 | 0.35775624  | -0.32980922 |
| ## completeObs.NASat02     | 0.27474489  | -0.4278434 | -0.11521405 | -0.14501367 |

|                            | PC5         | PC6           | PC7          | PC8          |
|----------------------------|-------------|---------------|--------------|--------------|
| ## completeObs.Elevacion.x | -0.24462464 | 0.0872553041  | -0.184651840 | 0.130557822  |
| ## completeObs.Ancho       | -0.29139434 | 0.2302480810  | 0.239558001  | -0.561635255 |
| ## completeObs.Velocidad   | 0.03227524  | -0.4860783571 | 0.124372396  | -0.655162051 |
| ## completeObs.Rocas       | 0.52380817  | 0.4012932650  | 0.414132060  | -0.077544103 |
| ## completeObs.Canto       | -0.33332751 | -0.3829257400 | 0.167112732  | 0.351218850  |
| ## completeObs.grava       | -0.27257872 | 0.4743647187  | -0.114860543 | 0.004670724  |
| ## completeObs.arena       | 0.33215022  | -0.4081015160 | 0.009855948  | 0.087775229  |
| ## completeObs.Limo        | -0.16583016 | -0.0003924146 | -0.351986218 | -0.268395095 |
| ## completeObs.NAtemp      | 0.31146226  | 0.0456037467  | 0.178964077  | 0.098098723  |
| ## completeObs.NASat02     | 0.39949081  | 0.0422275691  | -0.724156487 | -0.139749138 |

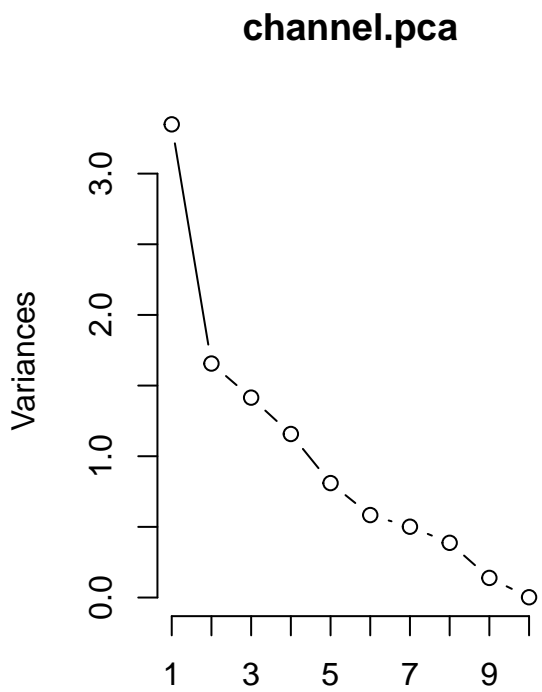
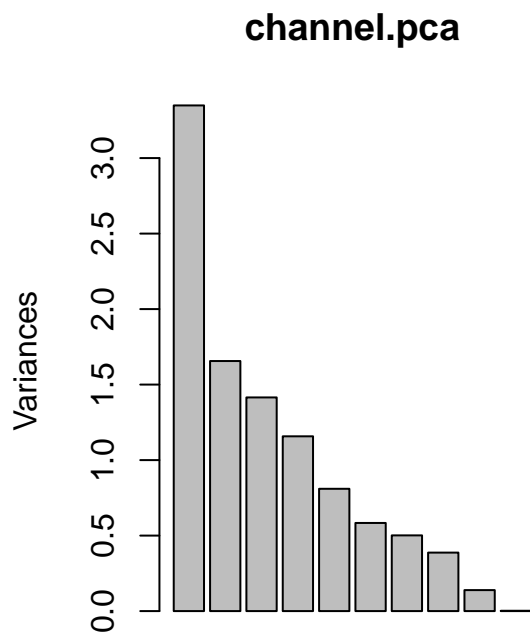
  

|                            | PC9         | PC10          |
|----------------------------|-------------|---------------|
| ## completeObs.Elevacion.x | 0.70423149  | -0.0007661306 |
| ## completeObs.Ancho       | 0.19091217  | -0.0024515868 |
| ## completeObs.Velocidad   | 0.08905142  | 0.0017012657  |
| ## completeObs.Rocas       | -0.05514873 | -0.4099655074 |
| ## completeObs.Canto       | 0.02763742  | -0.4462960258 |
| ## completeObs.grava       | -0.07731897 | -0.3459530412 |
| ## completeObs.arena       | 0.06106687  | -0.3894687964 |
| ## completeObs.Limo        | 0.01761358  | -0.6011239899 |
| ## completeObs.NAtemp      | 0.66634430  | -0.0029056115 |
| ## completeObs.NASat02     | 0.04292839  | 0.0032717814  |

```
rownames(loadings) <- colnames(new_channel2)
scores <- channel.pca$x
```

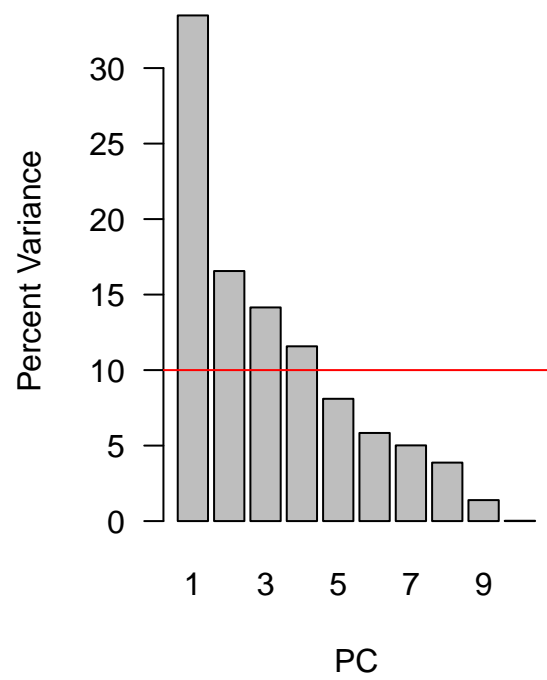
3.3 Ver graficamente lo que explica cada axis.

```
layout(matrix(1:2, ncol=2))
screeplot(channel.pca)
screeplot(channel.pca, type="lines")
```



```
varPercent <- variance/sum(variance) * 100
barplot(varPercent, xlab='PC', ylab='Percent Variance',
names.arg=1:length(varPercent), las=1, col='gray') +
abline(h=1/ncol(new_channel2)*100, col="red")
```

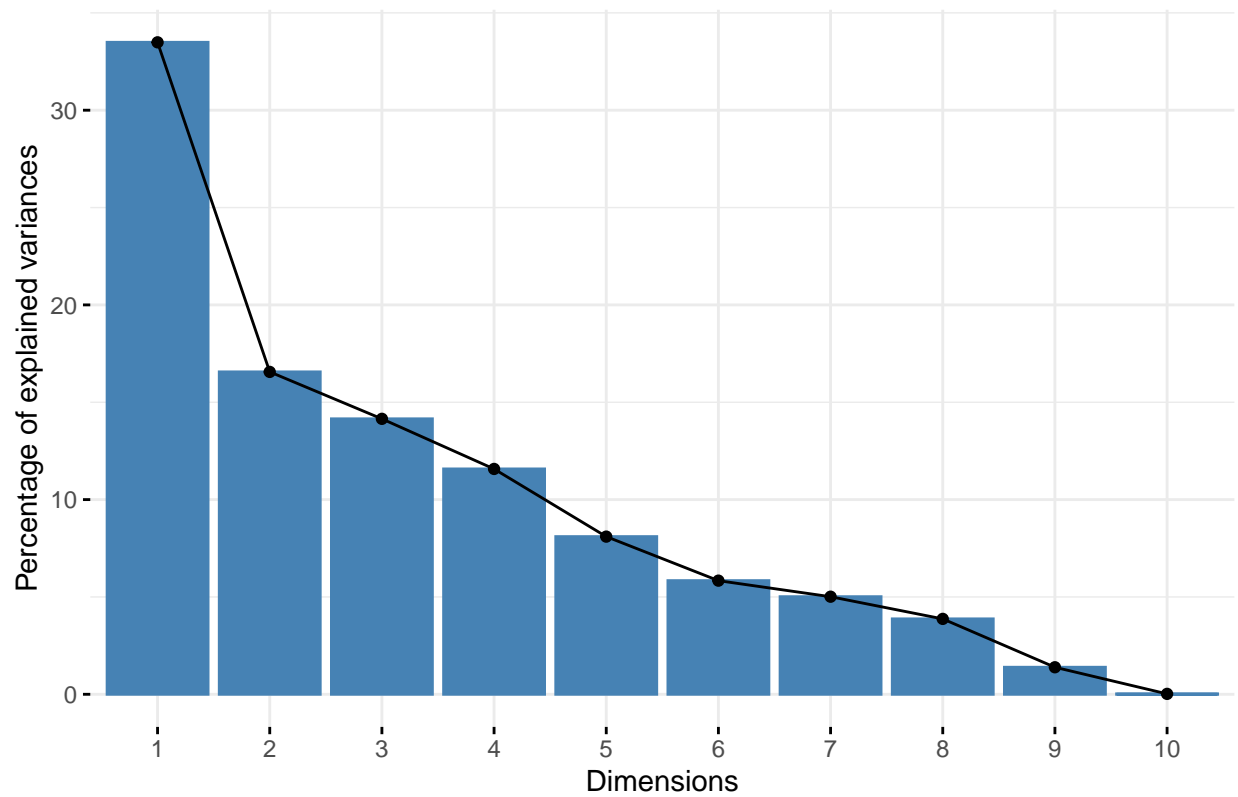
```
## numeric(0)
```



4 Otras formas de visualizar los datos.

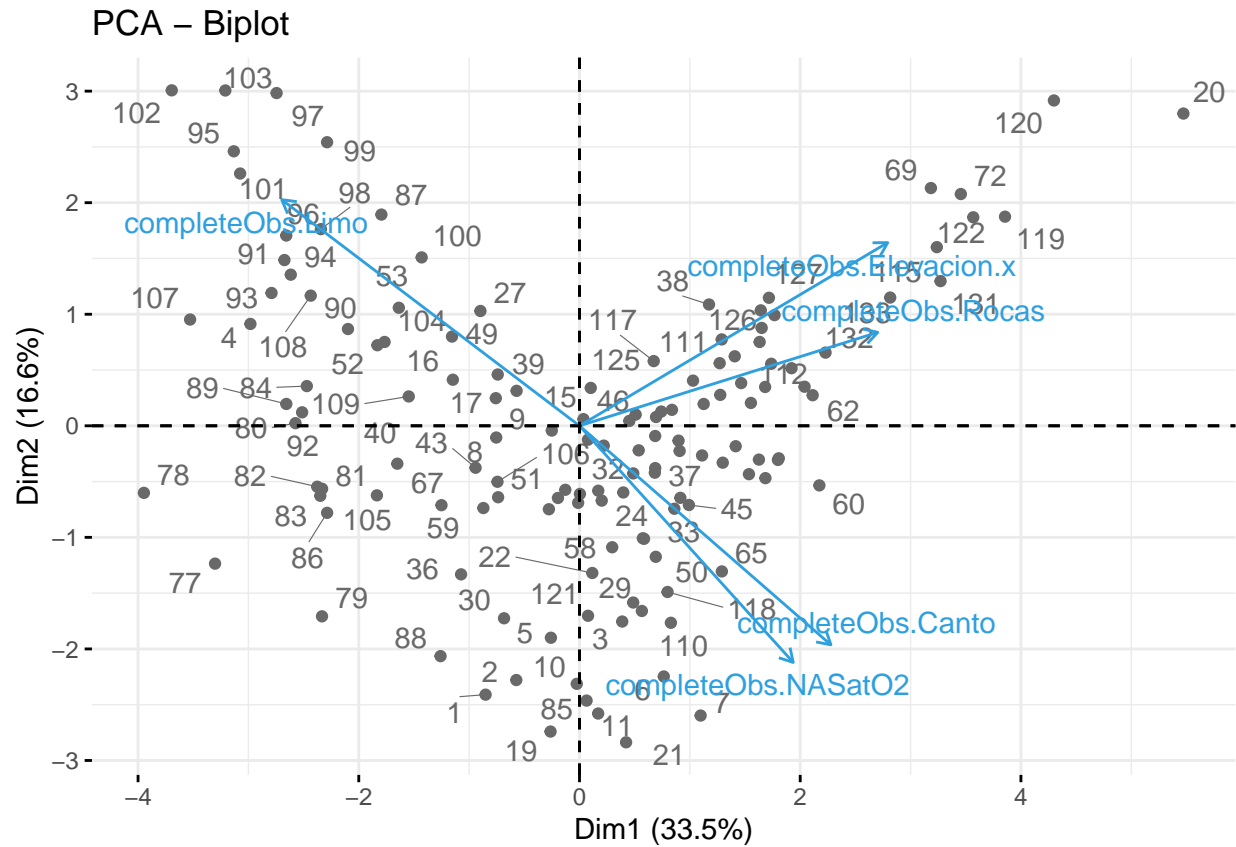
```
fviz_eig(channel.pca)
```

Scree plot



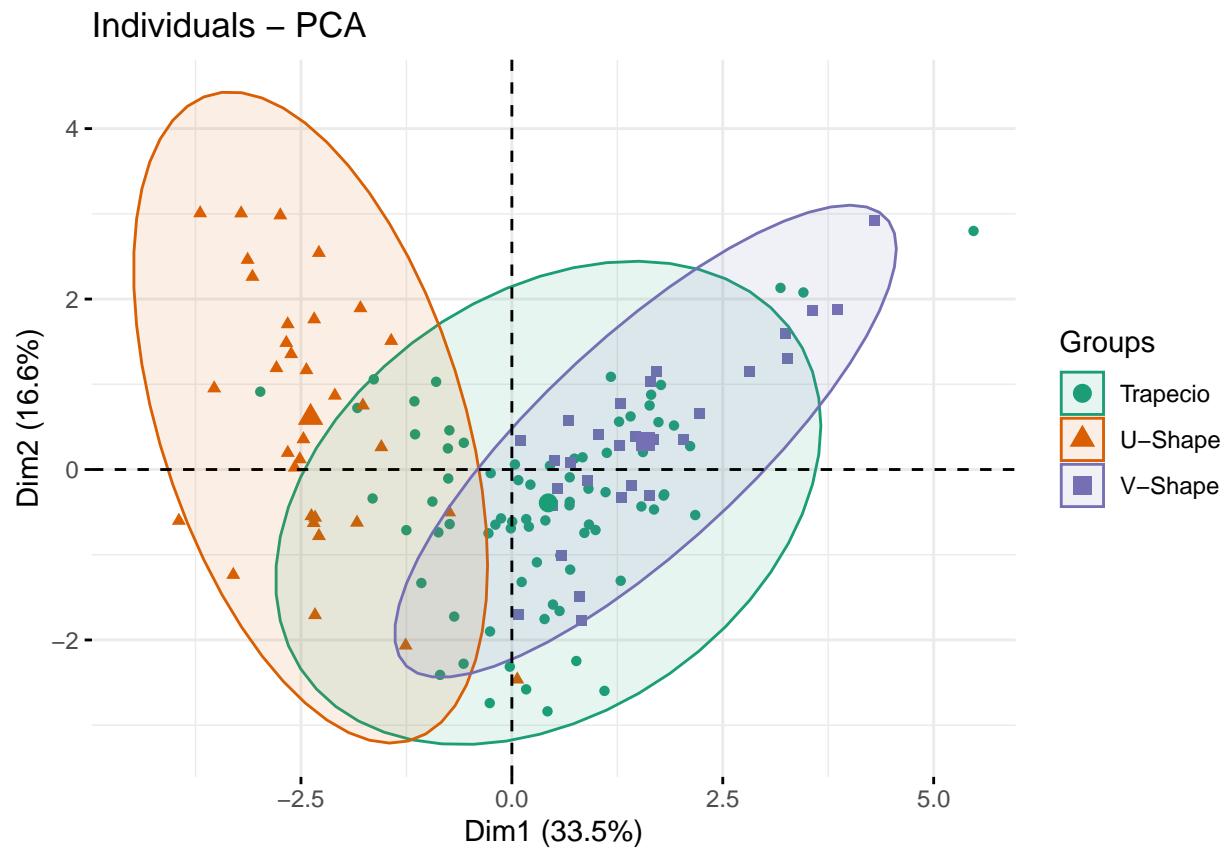
```
fviz_pca_biplot(channel.pca, repel = TRUE,
  col.var = "#2E9FDF", # Variables color
  col.ind = "#696969", # Individuals color
  select.var = list(contrib = 5))
```

```
## Warning: ggrepel: 44 unlabeled data points (too many overlaps). Consider
## increasing max.overlaps
```



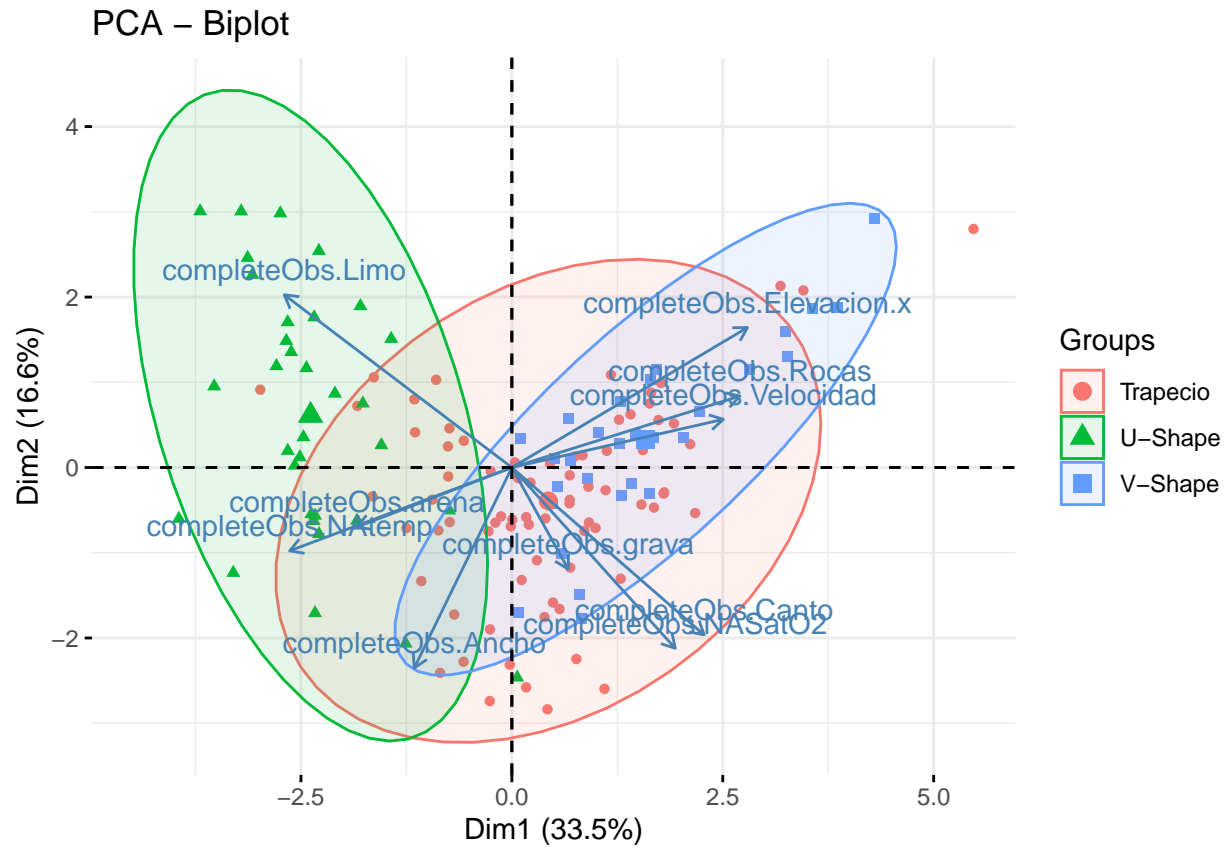
4.1 Con las elipses.

```
fviz_pca_ind(channel.pca, label="none", habillage=channel$Forma,
  addEllipses=TRUE, ellipse.level=0.95, palette = "Dark2")
```



4.2

```
fviz_pca_biplot(channel.pca, label = "var", habillage=channel$Forma,  
  addEllipses=TRUE, ellipse.level=0.95,  
  ggtheme = theme_minimal())
```

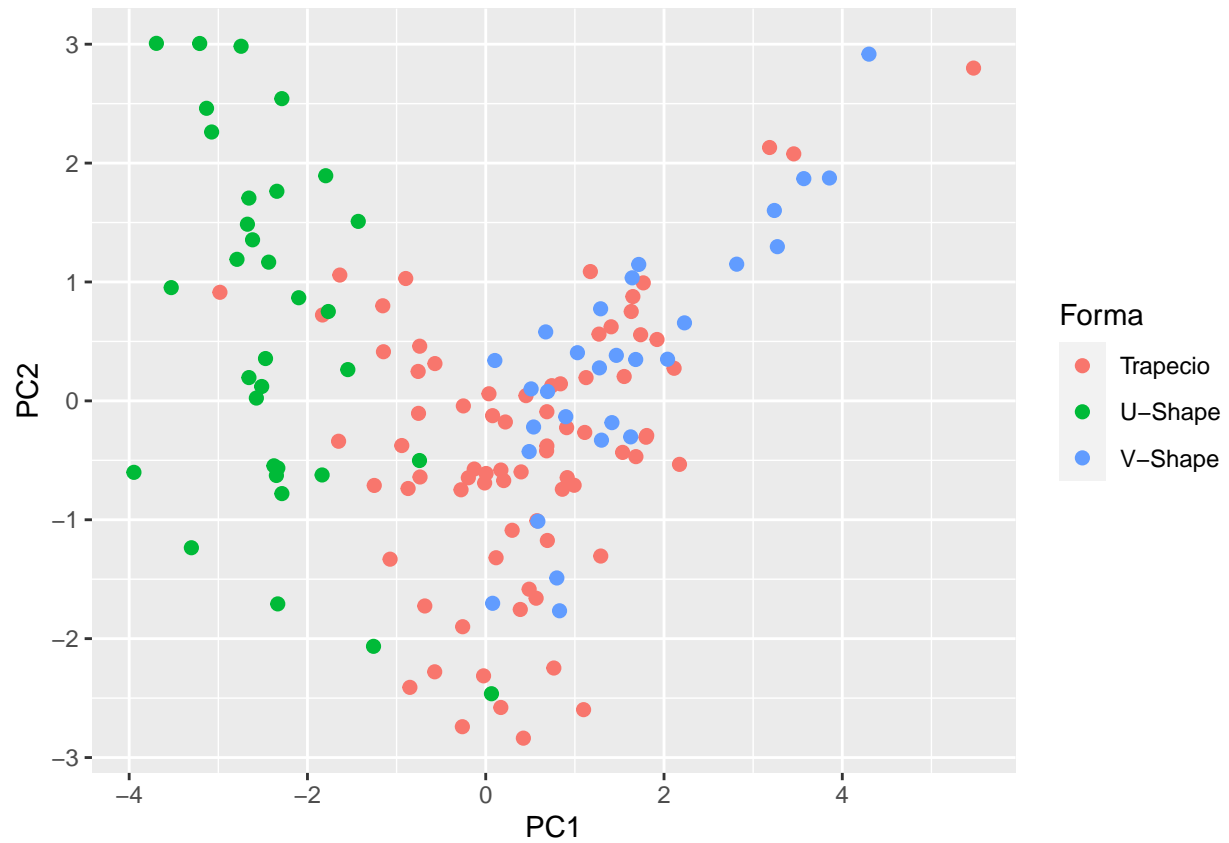


5. Convertirlo en una data.frame para trabajarlo en ggplot2

```
data <- data.table(PC1=channel.pca$x[,1], PC2=channel.pca$x[,2], Forma= channel[,1])
data <- data[order(channel$Forma),]

ggplot(data, aes(x=PC1,y=PC2)) +
  geom_point(size = 2, aes(color=Forma))
```





6. Otras enlaces de interes.

# <http://www.sthda.com/english/articles/31-principal-component-methods-in-r-practical-guide/118-princip>