Gaia DR3, NGC 6544

Rank the globular clusters in the table by the ease of separating the cluster members from the field stars, using the Gaia DR3.

Here is the first example: NGC 6544. The database of each globular cluster can be explored here.

Variables used: source_id, ra, dec, parallax, pmra, pmdec , bp_rp, mh_gspphot, radial_velocity, phot_g_mean_mag.

Set working directory.

```
setwd("~/Desktop/AstroPhysics/Gaia-L4")

ngc_6544 <- read.csv("~/Desktop/AstroPhysics/Gaia-L4/1657065339571O-
result.csv")

library(tidyverse)

## — Attaching packages ——————————————————————— tidyverse
1.3.1 —

## ✔ ggplot2 3.3.6      ✔ purrr   0.3.4
## ✔ tibble  3.1.7      ✔ dplyr   1.0.9
## ✔ tidyr   1.2.0      ✔ stringr 1.4.0
## ✔ readr   2.1.2      ✔ forcats 0.5.1

## — Conflicts ———————————————————————————
tidyverse_conflicts() —
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()

library(readr)
library(ggplot2)
library(ggpubr)
```

Summary Statistics
```
summary(ngc_6544)

##      source_id              ra               dec              parallax
##   Min.    :4.066e+18   Min.    :271.8   Min.    :-25.03   Min.    :-5.8994
##   1st Qu.:4.066e+18   1st Qu.:271.8   1st Qu.:-25.02   1st Qu.: 0.0246
##   Median :4.066e+18   Median :271.8   Median :-25.01   Median : 0.3166
##   Mean    :4.066e+18   Mean    :271.8   Mean    :-25.01   Mean    : 0.2974
##   3rd Qu.:4.066e+18   3rd Qu.:271.8   3rd Qu.:-25.01   3rd Qu.: 0.5426
##   Max.    :4.066e+18   Max.    :271.9   Max.    :-24.98   Max.    : 5.6389
##                                                          NA's    :884
##        pmra             pmdec                 ruwe         phot_g_mean_mag
```

```
##   Min.   :-11.516   Min.   :-26.763   Min.   : 0.6191   Min.   :11.30
##   1st Qu.: -3.111   1st Qu.:-18.901   1st Qu.: 1.0156   1st Qu.:18.01
##   Median : -2.288   Median :-18.220   Median : 1.1075   Median :18.66
##   Mean   : -2.270   Mean   :-14.553   Mean   : 1.3995   Mean   :18.49
##   3rd Qu.: -1.480   3rd Qu.: -8.008   3rd Qu.: 1.3960   3rd Qu.:19.29
##   Max.   : 13.098   Max.   :  2.831   Max.   :10.1384   Max.   :20.46
##   NA's   :884       NA's   :884       NA's   :884       NA's   :6
##      bp_rp          radial_velocity   phot_variable_flag non_single_star
##   Min.   :0.3908   Min.   :-39.574   Length:2000        Min.   :0
##   1st Qu.:1.7304   1st Qu.:-37.722   Class :character   1st Qu.:0
##   Median :1.8792   Median :-31.857   Mode  :character   Median :0
##   Mean   :2.0130   Mean   :-27.274                      Mean   :0
##   3rd Qu.:2.1718   3rd Qu.:-21.378                      3rd Qu.:0
##   Max.   :4.5840   Max.   : -2.793                      Max.   :0
##   NA's   :1191     NA's   :1994
##  has_xp_continuous  has_xp_sampled      has_rvs
## has_epoch_photometry
##   Length:2000        Length:2000       Length:2000        Length:2000
##   Class :character   Class :character  Class :character   Class :character
##   Mode  :character   Mode  :character  Mode  :character   Mode  :character
##
##
##
##
##   has_epoch_rv       has_mcmc_gspphot   has_mcmc_msc        teff_gspphot
##   Length:2000        Length:2000        Length:2000        Min.   : 3368
##   Class :character   Class :character   Class :character   1st Qu.: 4239
##   Mode  :character   Mode  :character   Mode  :character   Median : 4808
##                                                            Mean   : 5409
##                                                            3rd Qu.: 5721
##                                                            Max.   :15003
##                                                            NA's   :1809
##    logg_gspphot       mh_gspphot       distance_gspphot  azero_gspphot
##   Min.   :0.4915    Min.   :-4.0890   Min.   : 338.4    Min.   :0.0056
##   1st Qu.:3.6568    1st Qu.:-3.3621   1st Qu.: 766.6    1st Qu.:1.1229
##   Median :4.2829    Median :-1.4194   Median : 958.6    Median :2.0239
##   Mean   :4.0768    Mean   :-1.8236   Mean   :1408.2    Mean   :2.5044
##   3rd Qu.:4.6778    3rd Qu.:-0.7768   3rd Qu.:1497.2    3rd Qu.:3.6508
##   Max.   :5.0177    Max.   : 0.7731   Max.   :9382.5    Max.   :8.8559
##   NA's   :1809      NA's   :1809      NA's   :1809      NA's   :1809
##    ag_gspphot        ebpminrp_gspphot
##   Min.   :0.0041    Min.   :0.0022
##   1st Qu.:0.8386    1st Qu.:0.4668
##   Median :1.5482    Median :0.8514
##   Mean   :1.8315    Mean   :1.0174
##   3rd Qu.:2.7957    3rd Qu.:1.5431
##   Max.   :5.8228    Max.   :3.3140
##   NA's   :1809      NA's   :1809
```

Model 1

    a.   Use `lm()` to regress ra on dec and save the regression as `model_1`.

```
model_1 <- lm(ra ~ dec, data = ngc_6544)
```

    b.   Regression results from the first model using `summary()`.

An increase of one unit of dec is associated with an additional -0.22698 unit decrease in ra. This relationship is statistically significant at < 0.001.

```
summary(model_1)

##
## Call:
## lm(formula = ra ~ dec, data = ngc_6544)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.032100 -0.014882  0.002286  0.013487  0.039536
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) 266.15652    1.09471 243.130  < 2e-16 ***
## dec          -0.22698    0.04376  -5.186 2.36e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01676 on 1998 degrees of freedom
## Multiple R-squared:  0.01328,    Adjusted R-squared:  0.01279
## F-statistic:  26.9 on 1 and 1998 DF,  p-value: 2.362e-07
```
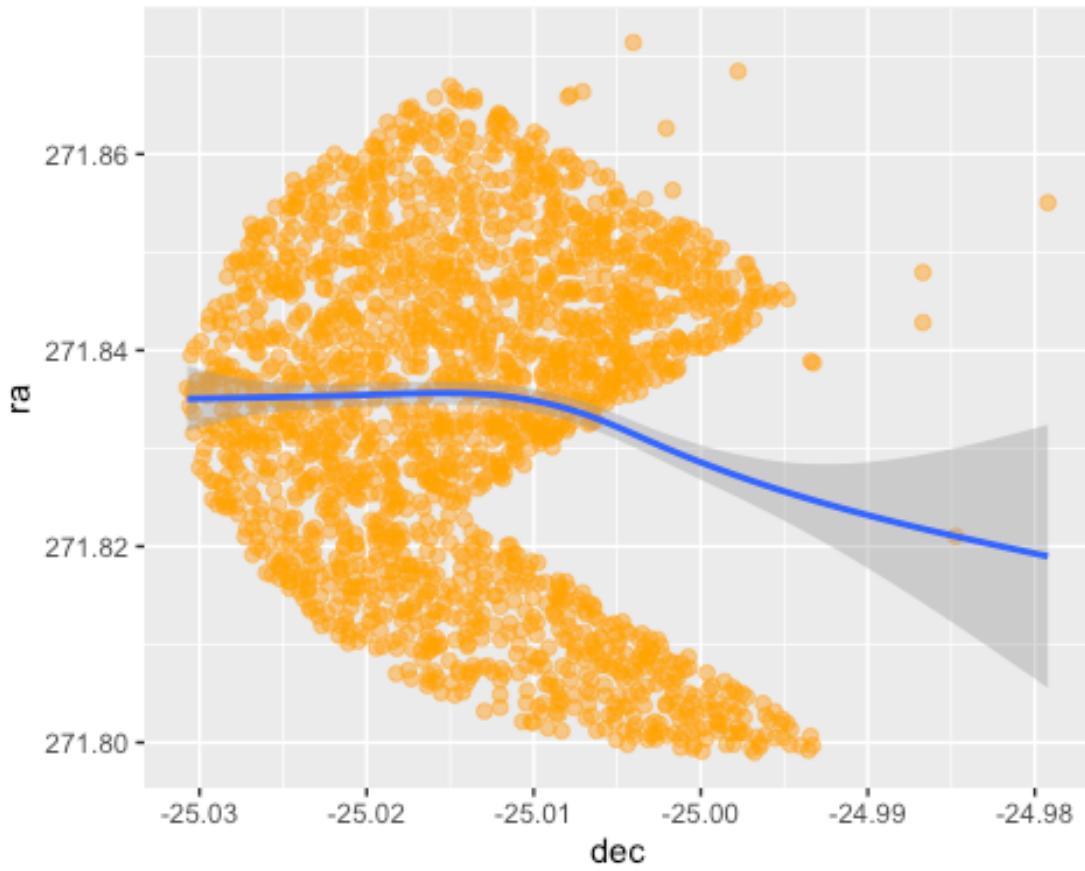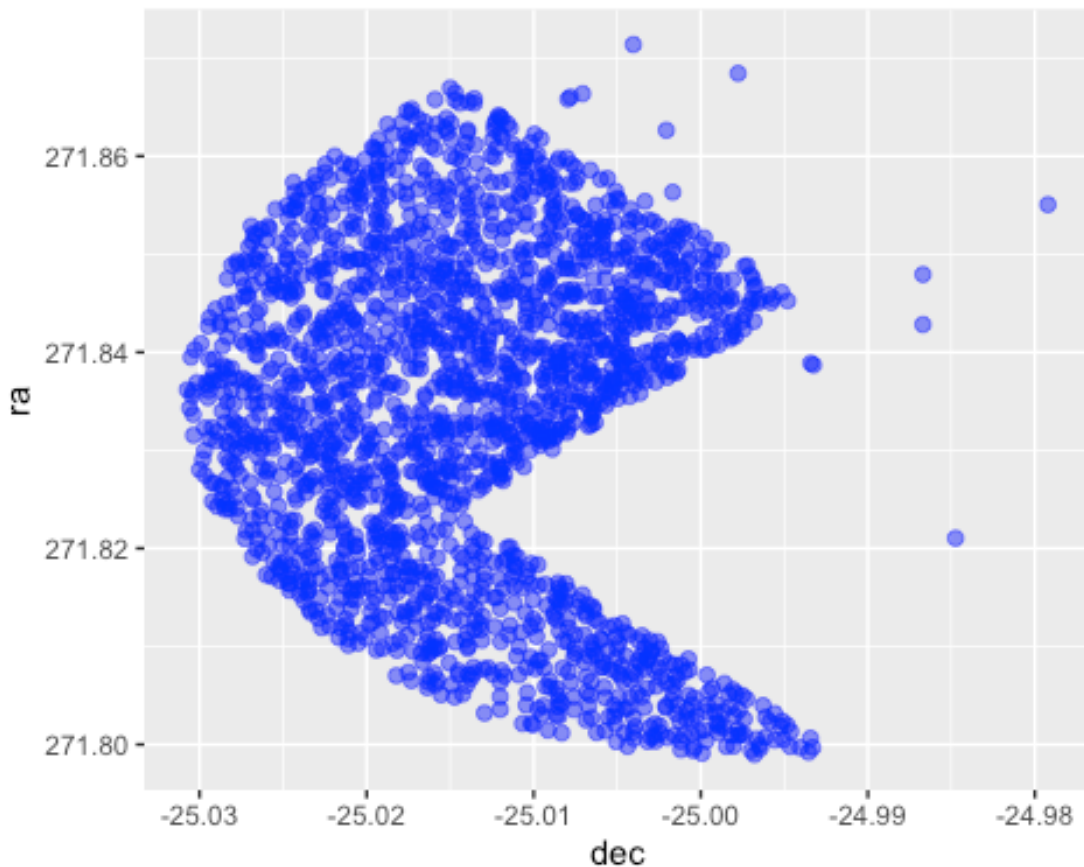
    c.   Plot results from `model_1`.

```
ggplot(data = model_1, aes(x = dec, y = ra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="ra", x="dec") +
  stat_smooth()

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

Graph

```
ngc_6544 %>%
  ggplot(aes(dec,ra)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="ra", x="dec")
```

Model 2

a.   Use `lm()` to regress pmra on pmdec and save the regression as `model_2`.

```
model_2 <- lm(pmra ~ pmdec, data = ngc_6544)
```

b.   Regression results from the second model using `summary()`.

An increase of one unit of pmdec is associated with an additional 0.058145 unit increase in pmra. This relationship is statistically significant at < 0.001.

```
summary(model_2)

##
## Call:
## lm(formula = pmra ~ pmdec, data = ngc_6544)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.1656  -0.6862   0.1299   0.8668  15.2929
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.423818   0.150293  -9.474  < 2e-16 ***
## pmdec        0.058145   0.009366   6.208 7.54e-10 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.115 on 1114 degrees of freedom
##   (884 observations deleted due to missingness)
## Multiple R-squared:  0.03344,    Adjusted R-squared:  0.03257
## F-statistic: 38.54 on 1 and 1114 DF,  p-value: 7.545e-10
```

c.   Plot results from model_2.

```
ggplot(data = model_2, aes(x = pmdec, y = pmra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="pmra", x="pmdec") +
  stat_smooth()
```
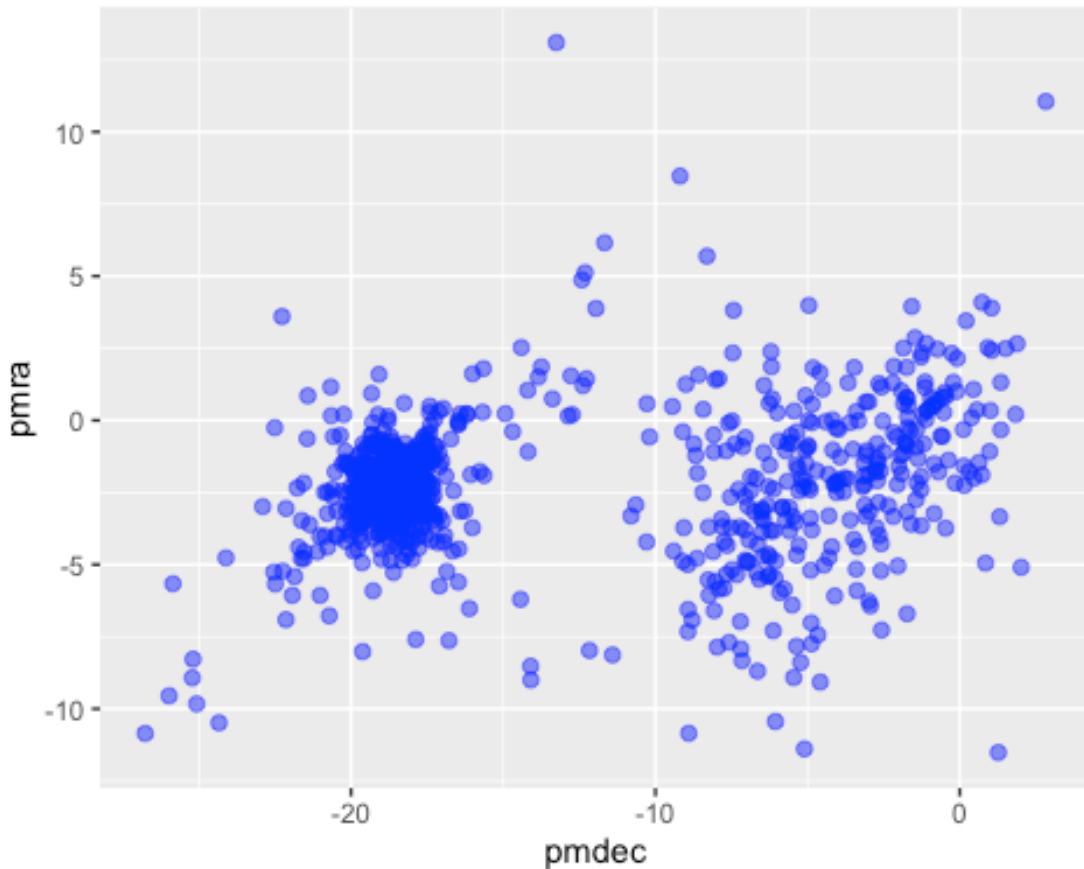
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
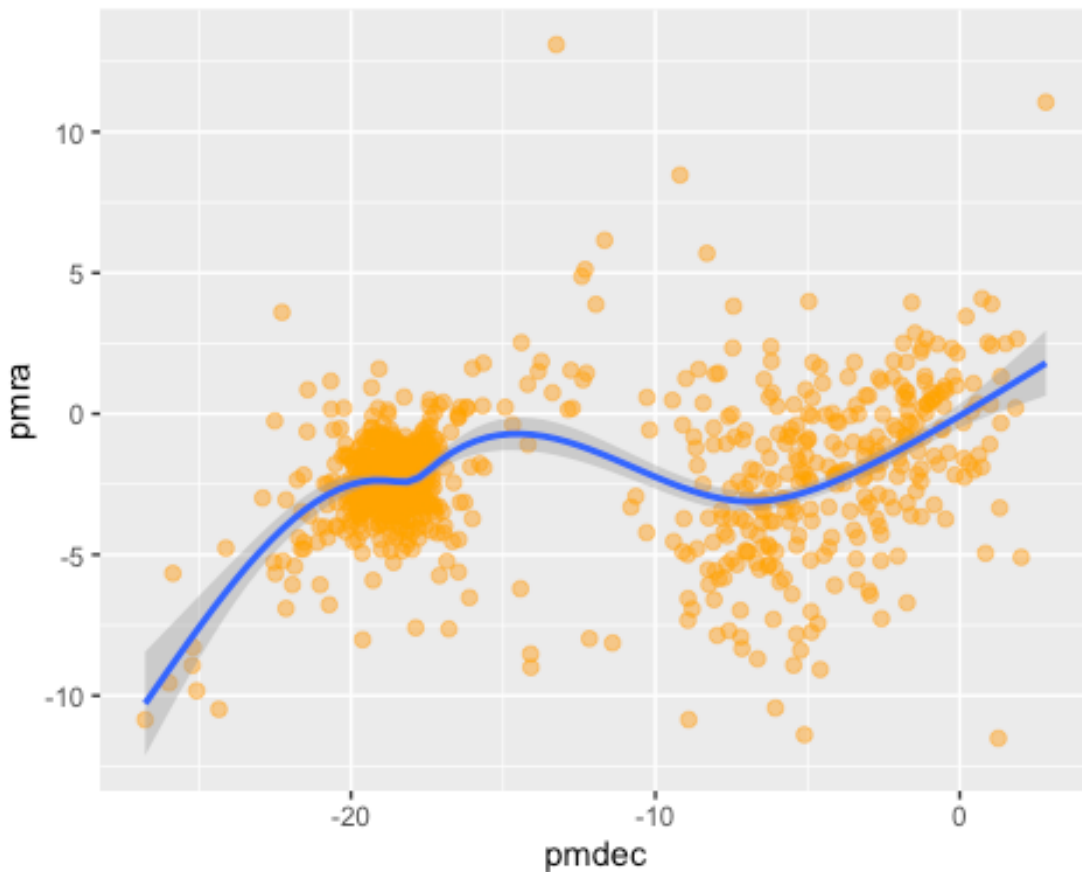

Graph

```
ngc_6544 %>%
  ggplot(aes(pmdec,pmra)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="pmra", x="pmdec")
```

```
## Warning: Removed 884 rows containing missing values (geom_point).
```

Model 3

a. Use `lm()` to regress phot_g_mean_mag on bp_rp and save the regression as `model_3`.

```
model_3 <- lm(phot_g_mean_mag ~ bp_rp, data = ngc_6544)
```

b. Regression results from the third model using `summary()`.

An increase of one unit of bp_rp is associated with an additional -0.02021 unit decrease in phot_g_mean_mag. This relationship is statistically significant at < 1.

```
summary(model_3)

##
## Call:
## lm(formula = phot_g_mean_mag ~ bp_rp, data = ngc_6544)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.4813 -0.4299  0.2757  0.7987  2.3602
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 17.78717    0.17697 100.512   <2e-16 ***
## bp_rp       -0.02021    0.08514  -0.237    0.812
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.255 on 807 degrees of freedom
##   (1191 observations deleted due to missingness)
## Multiple R-squared:  6.981e-05,  Adjusted R-squared:  -0.001169
## F-statistic: 0.05634 on 1 and 807 DF,  p-value: 0.8124
```

    c.   Plot results from model_3.

```
ggplot(data = model_3, aes(x = bp_rp, y = phot_g_mean_mag)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="phot_g_mean_mag", x="bp_rp") +
  stat_smooth()
```
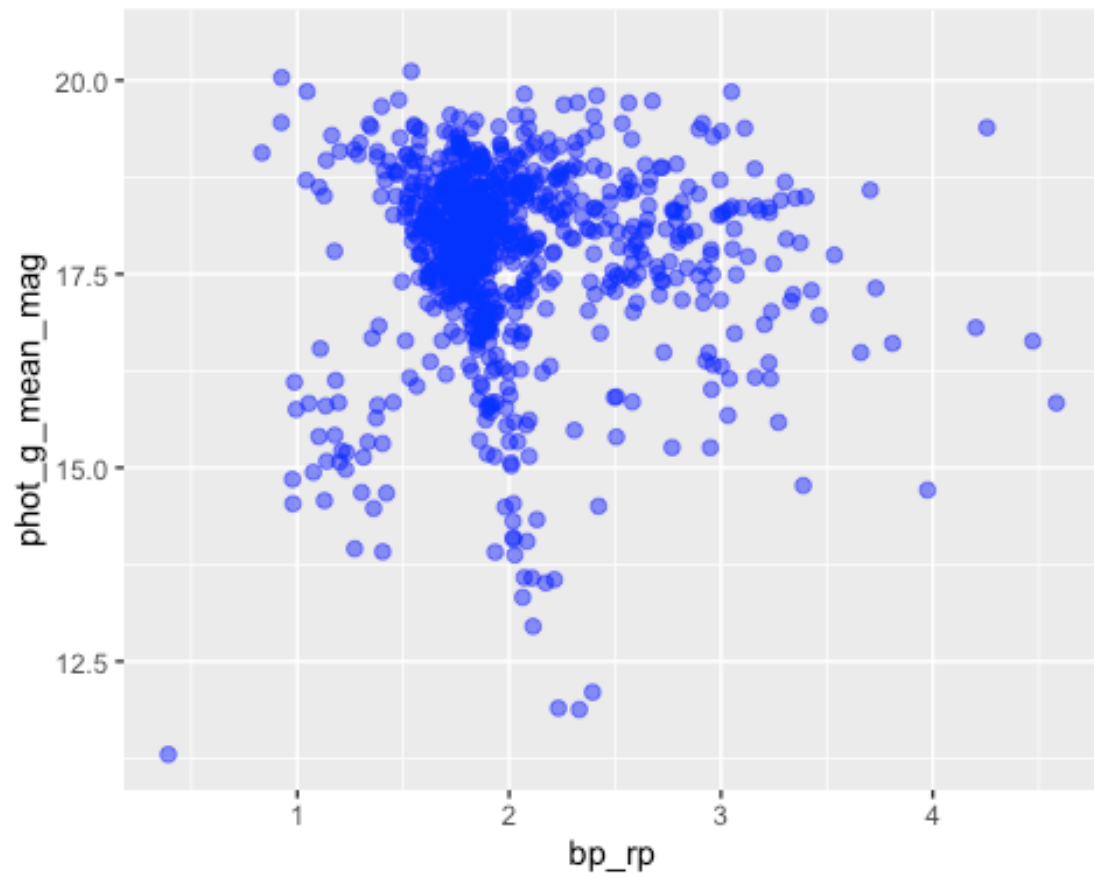
```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```
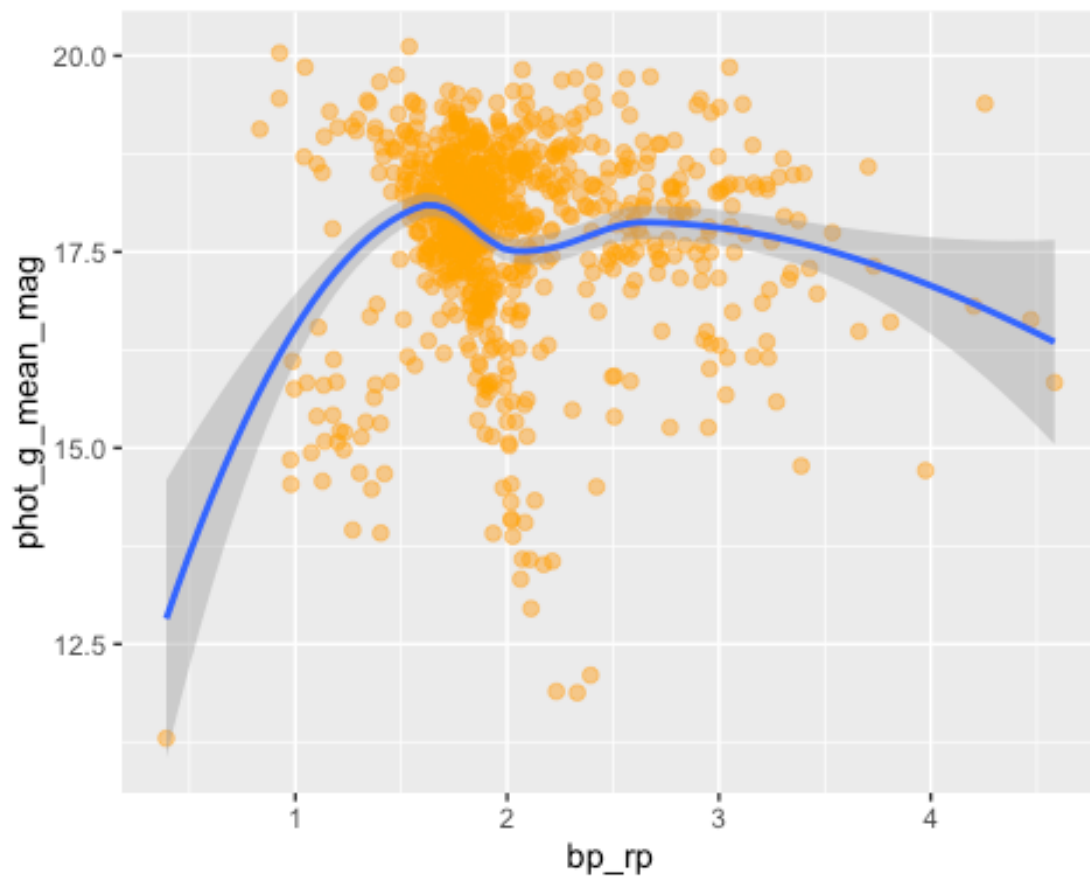

Graph

```
ngc_6544 %>%
  ggplot(aes(bp_rp,phot_g_mean_mag)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="phot_g_mean_mag", x="bp_rp")
```
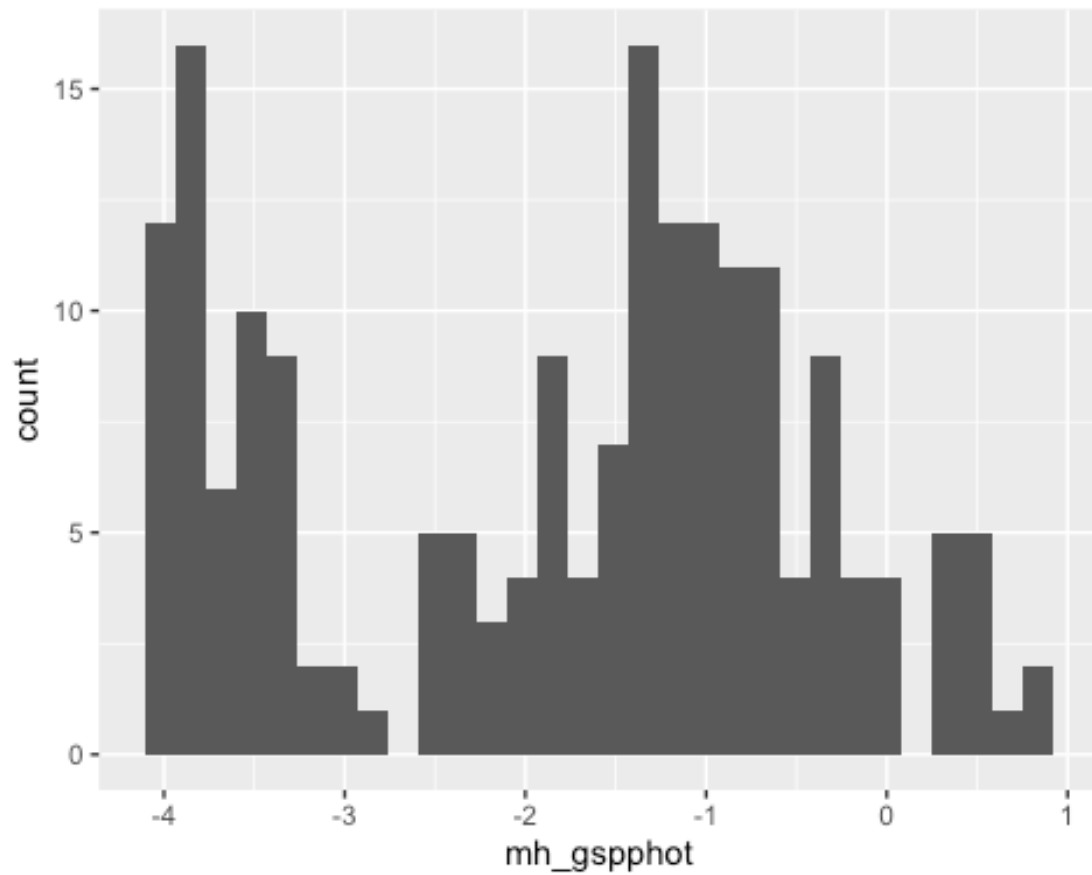
```
## Warning: Removed 1191 rows containing missing values (geom_point).
```

Metallicity Over Hydrogen

```
ggplot(ngc_6544, aes(mh_gspphot)) +
  geom_histogram(bins = 30)
```

```
## Warning: Removed 1809 rows containing non-finite values (stat_bin).
```
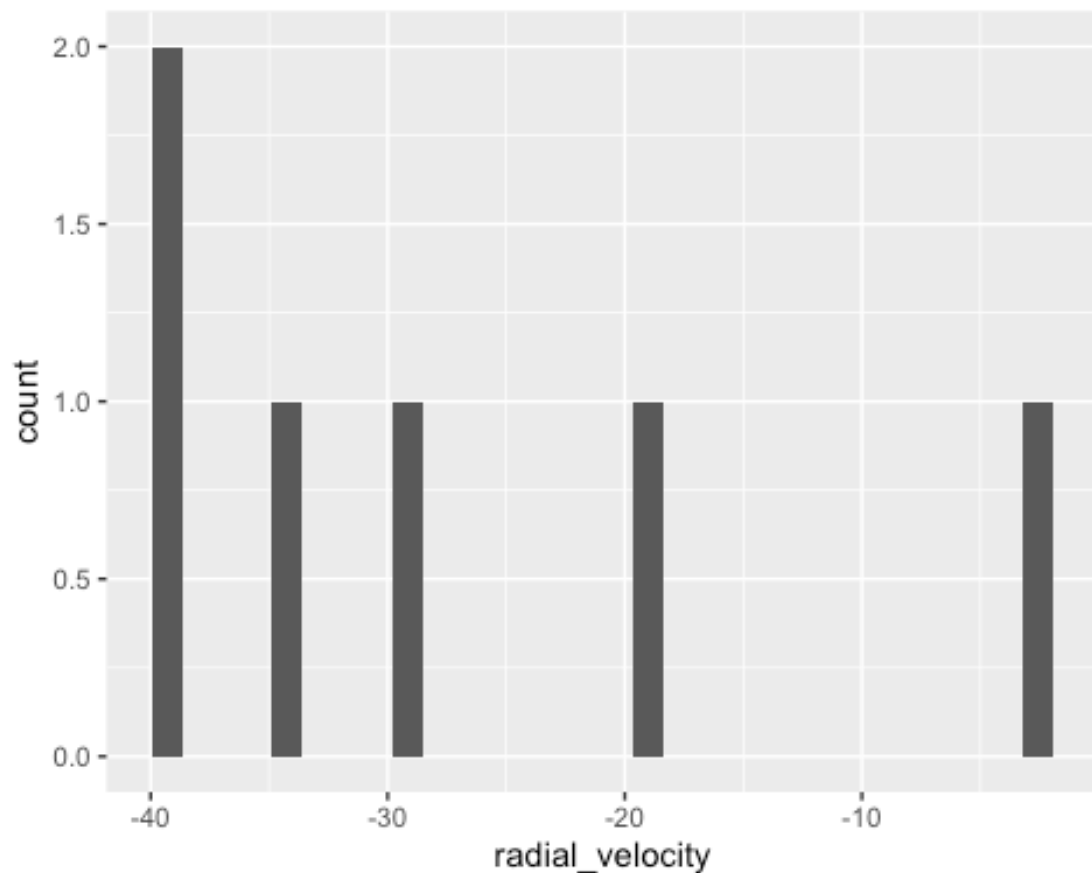
```
ggplot(ngc_6544, aes(radial_velocity)) +
  geom_histogram()
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

```
## Warning: Removed 1994 rows containing non-finite values (stat_bin).
```

Gaia DR3, NGC 6553

```r
ngc_6553 <- read.csv("~/Desktop/AstroPhysics/Gaia-L4/165716521564l0-
result.csv")
```

Summary Statistics
```r
summary(ngc_6553)
```

```
##     source_id              ra              dec            parallax
##  Min.   :4.065e+18   Min.   :272.3   Min.   :-25.94   Min.   :-8.3416
##  1st Qu.:4.065e+18   1st Qu.:272.3   1st Qu.:-25.93   1st Qu.:-0.0843
##  Median :4.065e+18   Median :272.3   Median :-25.92   Median : 0.1786
##  Mean   :4.065e+18   Mean   :272.3   Mean   :-25.92   Mean   : 0.2657
##  3rd Qu.:4.065e+18   3rd Qu.:272.3   3rd Qu.:-25.91   3rd Qu.: 0.6172
##  Max.   :4.065e+18   Max.   :272.4   Max.   :-25.89   Max.   : 8.1596
##                                                       NA's   :1027
##      pmra              pmdec            ruwe          phot_g_mean_mag
##  Min.   :-10.6486   Min.   :-13.6290   Min.   : 0.5672   Min.   :12.16
##  1st Qu.: -1.6654   1st Qu.: -3.3308   1st Qu.: 1.1090   1st Qu.:16.83
##  Median :  0.1145   Median : -0.7711   Median : 1.3851   Median :18.25
```

```
##   Mean    : -0.5553   Mean    : -1.7958   Mean    : 1.7882   Mean    :17.82
##   3rd Qu.:  0.7289   3rd Qu.: -0.1012   3rd Qu.: 1.9862   3rd Qu.:18.99
##   Max.    :  8.9418   Max.    : 10.3322   Max.    :17.6072   Max.    :19.98
##   NA's    :1027       NA's    :1027       NA's    :1027       NA's    :3
##        bp_rp            radial_velocity    phot_variable_flag non_single_star
##   Min.    :-0.1685   Min.    :-141.1828   Length:2000        Min.    :0
##   1st Qu.: 1.9018   1st Qu.:  -1.8062   Class :character   1st Qu.:0
##   Median : 2.0406   Median :   0.6087   Mode  :character   Median :0
##   Mean    : 2.0841   Mean    : -11.7559                     Mean    :0
##   3rd Qu.: 2.2114   3rd Qu.:   8.9440                     3rd Qu.:0
##   Max.    : 4.6823   Max.    :  21.6074                     Max.    :0
##   NA's    :1181       NA's    :1991
##   has_xp_continuous  has_xp_sampled        has_rvs
has_epoch_photometry
##   Length:2000        Length:2000        Length:2000        Length:2000
##   Class :character   Class :character   Class :character   Class :character
##   Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##   has_epoch_rv       has_mcmc_gspphot   has_mcmc_msc          teff_gspphot
##   Length:2000        Length:2000        Length:2000        Min.    : 3543
##   Class :character   Class :character   Class :character   1st Qu.: 4762
##   Mode  :character   Mode  :character   Mode  :character   Median : 4986
##                                                            Mean    : 5299
##                                                            3rd Qu.: 5256
##                                                            Max.    :29741
##                                                            NA's    :1870
##    logg_gspphot       mh_gspphot        distance_gspphot azero_gspphot
##   Min.    :0.0369   Min.    :-4.0553   Min.    :  416   Min.    :0.4017
##   1st Qu.:2.8365   1st Qu.:-0.9629   1st Qu.:  974   1st Qu.:2.4291
##   Median :3.3775   Median :-0.4138   Median : 1611   Median :3.0437
##   Mean    :3.2869   Mean    :-0.6261   Mean    : 2064   Mean    :3.1867
##   3rd Qu.:4.0656   3rd Qu.:-0.0277   3rd Qu.: 2141   3rd Qu.:3.8114
##   Max.    :4.9183   Max.    : 0.7808   Max.    :10902   Max.    :9.7627
##   NA's    :1870     NA's    :1870     NA's    :1870     NA's    :1870
##    ag_gspphot       ebpminrp_gspphot
##   Min.    :0.3346   Min.    :0.1828
##   1st Qu.:1.8167   1st Qu.:0.9804
##   Median :2.1996   Median :1.1942
##   Mean    :2.2988   Mean    :1.2650
##   3rd Qu.:2.7175   3rd Qu.:1.4837
##   Max.    :6.1531   Max.    :3.5492
##   NA's    :1870     NA's    :1870
```

Model 4

a. Use `lm()` to regress ra on dec and save the regression as `model_4`.

```
model_4 <- lm(ra ~ dec, data = ngc_6553)
```

b.   Regression results from the fourth model using `summary()`.

An increase of one unit of dec is associated with an additional 0.64366 unit increase in ra. This relationship is statistically significant at < 0.001.

```
summary(model_4)

##
## Call:
## lm(formula = ra ~ dec, data = ngc_6553)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0293835 -0.0080779 -0.0003821  0.0079258  0.0215398
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) 289.01202    0.52899  546.34   <2e-16 ***
## dec           0.64366    0.02041   31.54   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01013 on 1998 degrees of freedom
## Multiple R-squared:  0.3324, Adjusted R-squared:  0.332
## F-statistic: 994.6 on 1 and 1998 DF,  p-value: < 2.2e-16
```

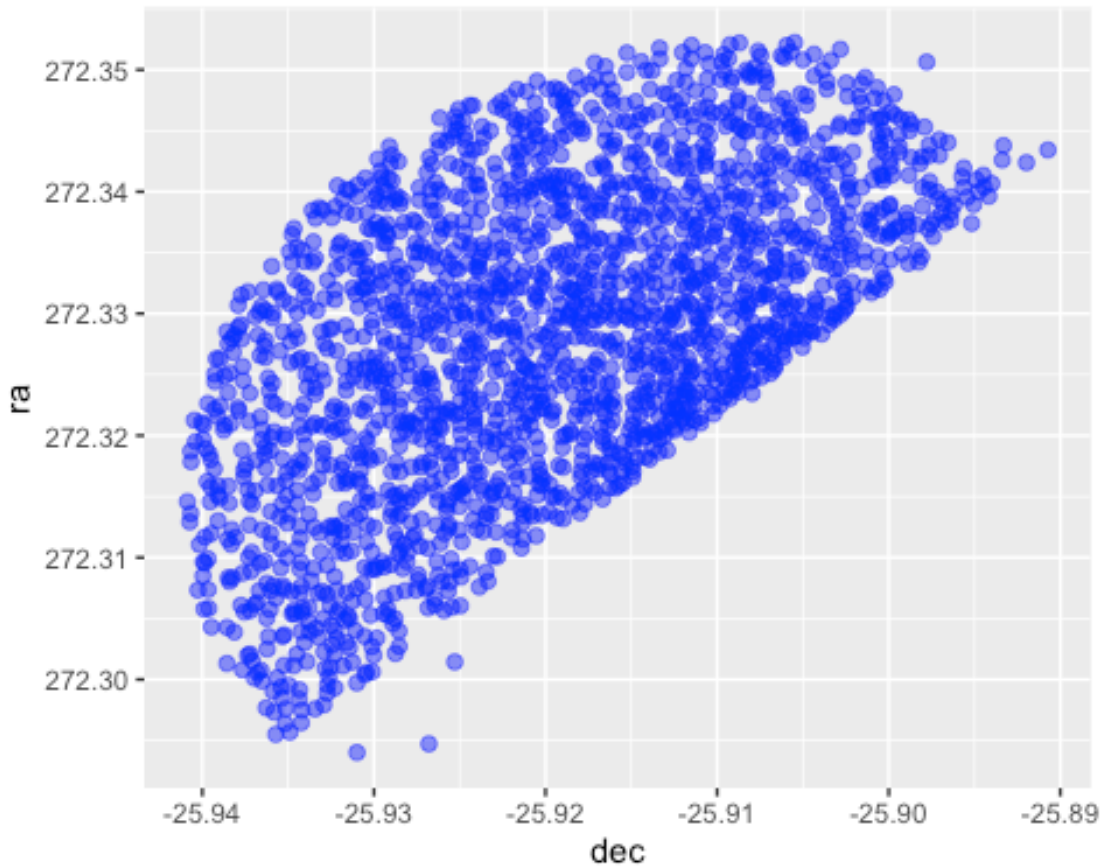c.   Plot results from `model_4`.

```
ggplot(data = model_4, aes(x = dec, y = ra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="ra", x="dec") +
  stat_smooth()

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
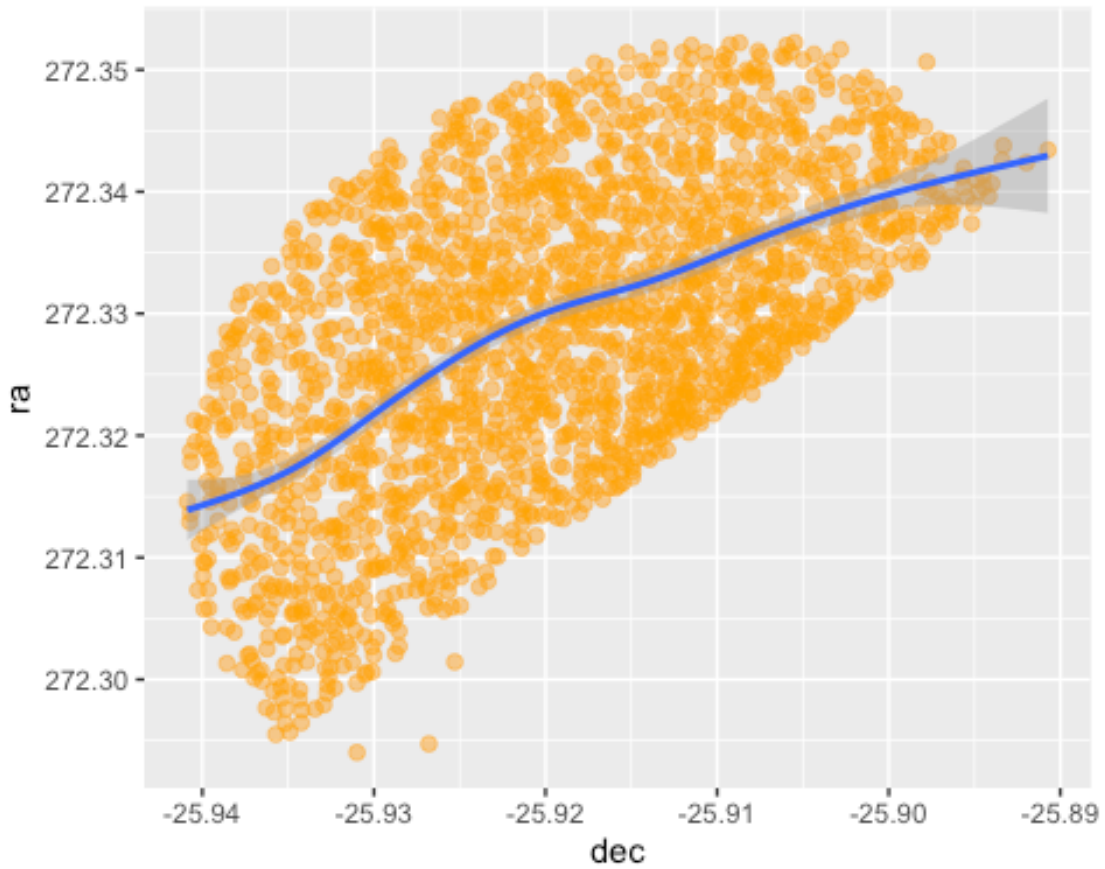
Graph

```
ngc_6553 %>%
  ggplot(aes(dec,ra)) +
  geom_point(alpha=0.5, size= 2, color = 'blue') +
  labs(y="ra", x="dec")
```

####

Model 5

a. Use `lm()` to regress pmra on pmdec and save the regression as `model_5`.

```
model_5 <- lm(pmra ~ pmdec, data = ngc_6553)
```

b. Regression results from the fifth model using `summary()`.

An increase of one unit of pmdec is associated with an additional 0.46002 unit increase in pmra. This relationship is statistically significant at < 0.001.

```
summary(model_5)

##
## Call:
## lm(formula = pmra ~ pmdec, data = ngc_6553)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -11.1661  -0.6839   0.1666   0.8702   9.5786
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.27083    0.08168   3.316 0.000948 ***
## pmdec        0.46002    0.02357  19.514  < 2e-16 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.179 on 971 degrees of freedom
##    (1027 observations deleted due to missingness)
## Multiple R-squared:  0.2817, Adjusted R-squared:  0.2809
## F-statistic: 380.8 on 1 and 971 DF,  p-value: < 2.2e-16
```

c.Plot results from model_5.

```
ggplot(data = model_5, aes(x = pmdec, y = pmra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="pmra", x="pmdec") +
  stat_smooth()
```
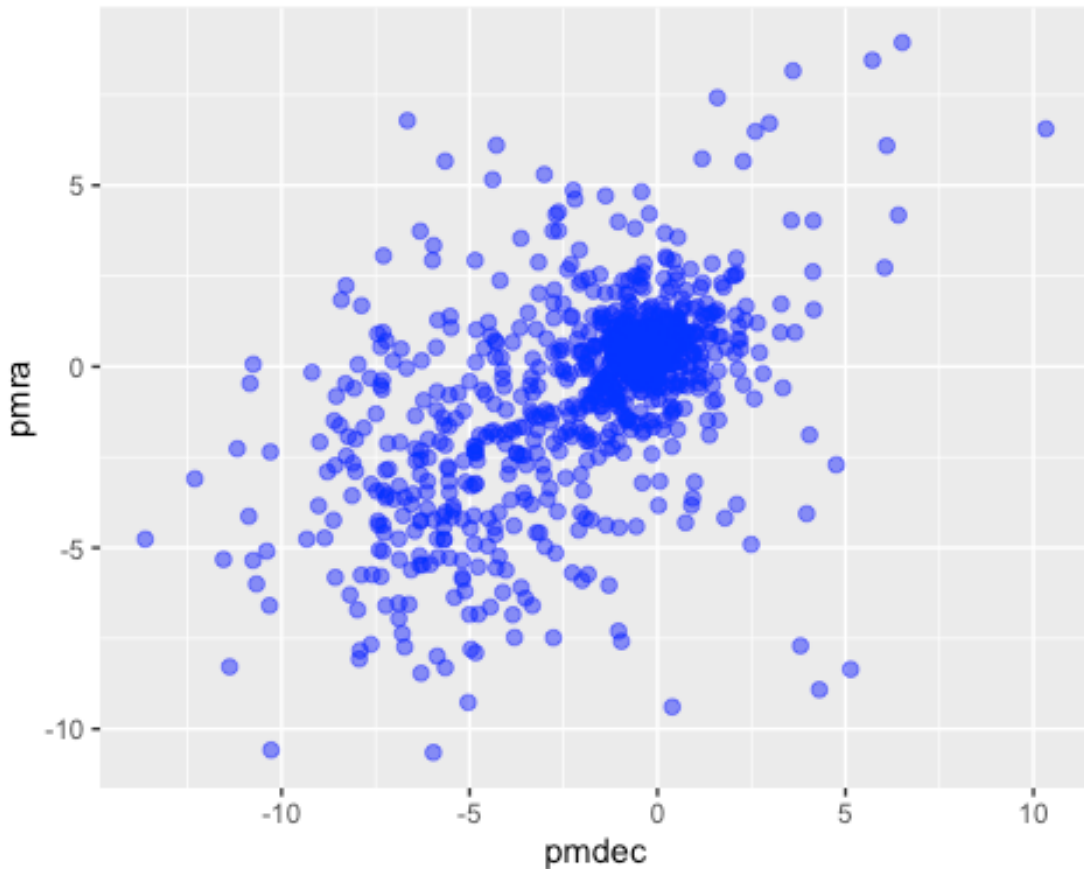
```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```
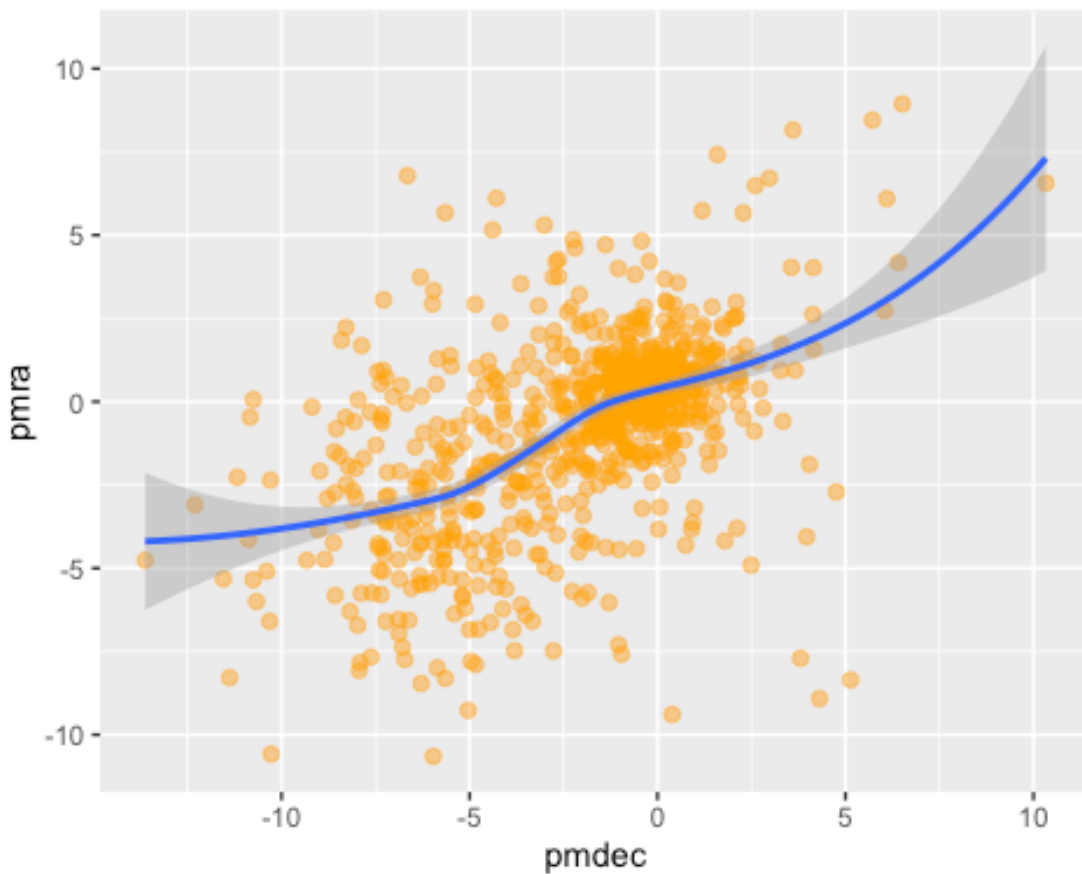

Graph
```
ngc_6553 %>%
  ggplot(aes(pmdec,pmra)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="pmra", x="pmdec")
```

```
## Warning: Removed 1027 rows containing missing values (geom_point).
```

Model 6

a. Use `lm()` to regress pmra on pmdec and save the regression as `model_6`.

```
model_6 <- lm(phot_g_mean_mag ~ bp_rp, data = ngc_6553)
```

b. Regression results from the fifth model using `summary()`.

An increase of one unit of pmdec is associated with an additional -1.8339 unit decrease in pmra. This relationship is statistically significant at < 0.001.

```
summary(model_6)

##
## Call:
## lm(formula = phot_g_mean_mag ~ bp_rp, data = ngc_6553)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.0832 -1.0476  0.0901  0.9477  3.8523
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  20.7853     0.2251   92.35   <2e-16 ***
## bp_rp        -1.8339     0.1059  -17.32   <2e-16 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.263 on 817 degrees of freedom
##   (1181 observations deleted due to missingness)
## Multiple R-squared:  0.2685, Adjusted R-squared:  0.2676
## F-statistic: 299.9 on 1 and 817 DF,  p-value: < 2.2e-16
```

c. Plot results from `model_6`.

```
ggplot(data = model_6, aes(x = bp_rp, y = phot_g_mean_mag)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="phot_g_mean_mag", x="bp_rp") +
  stat_smooth()
```
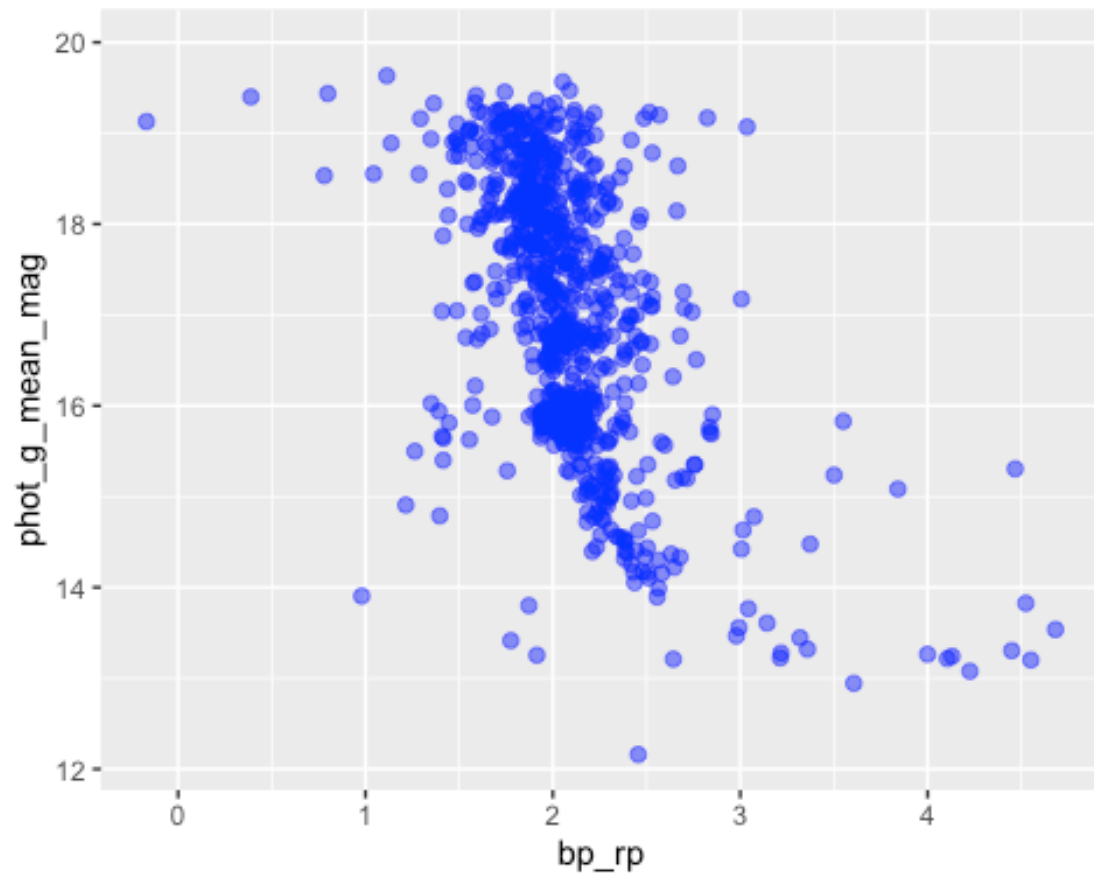
```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```
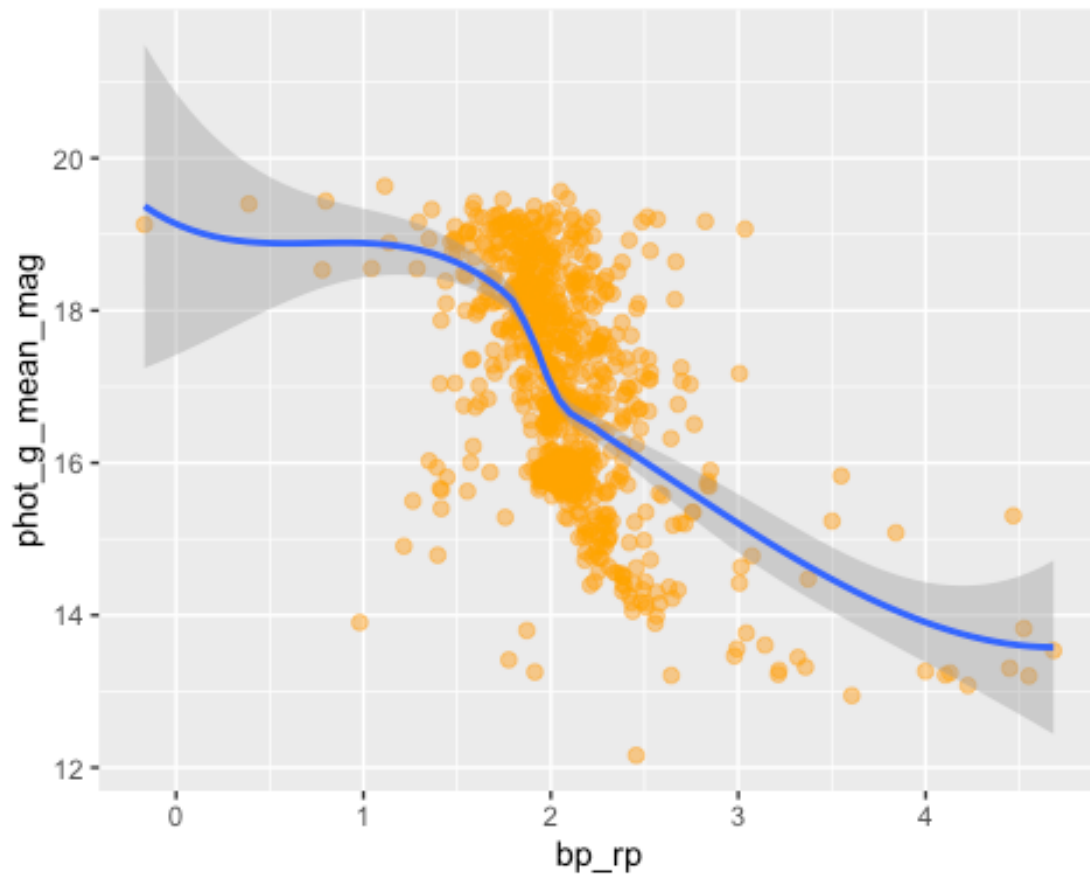

Graph

```
ngc_6553 %>%
  ggplot(aes(bp_rp,phot_g_mean_mag)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="phot_g_mean_mag", x="bp_rp")
```
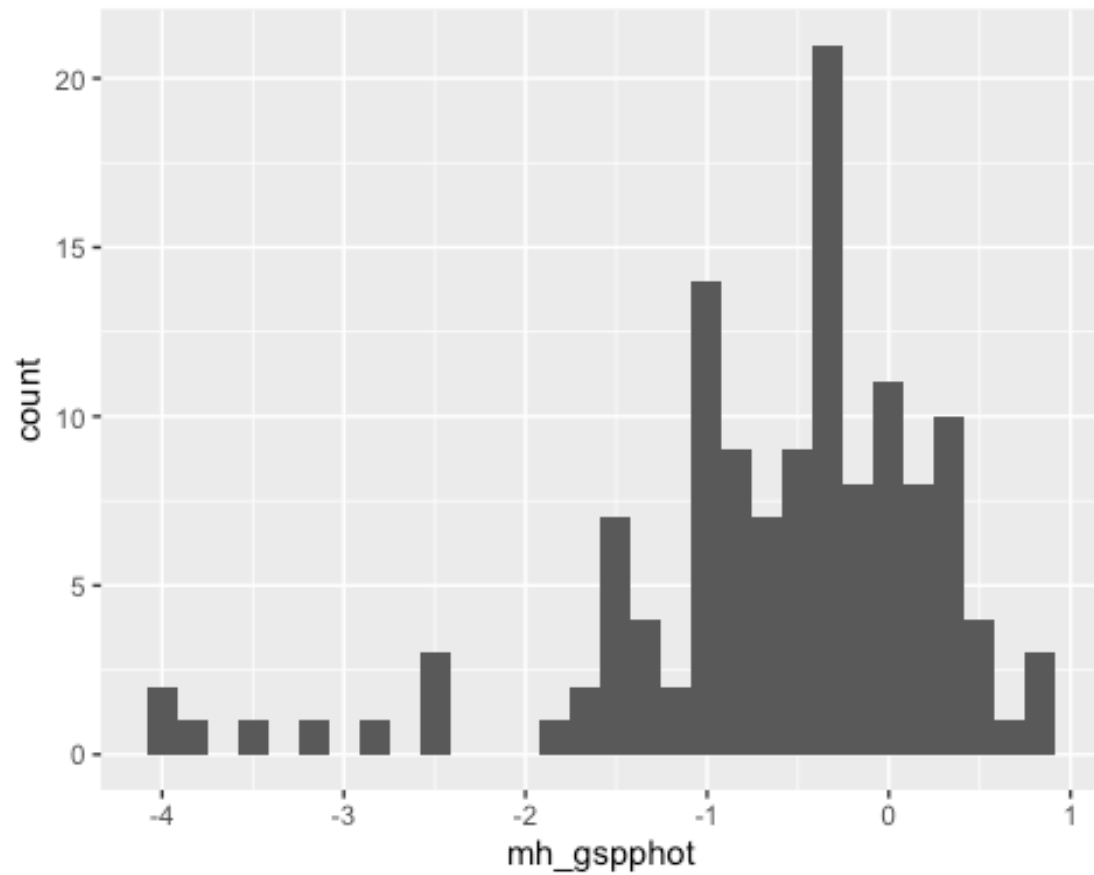
```
## Warning: Removed 1181 rows containing missing values (geom_point).
```

```
ggplot(ngc_6553, aes(mh_gspphot)) +
  geom_histogram(bins = 30)
```
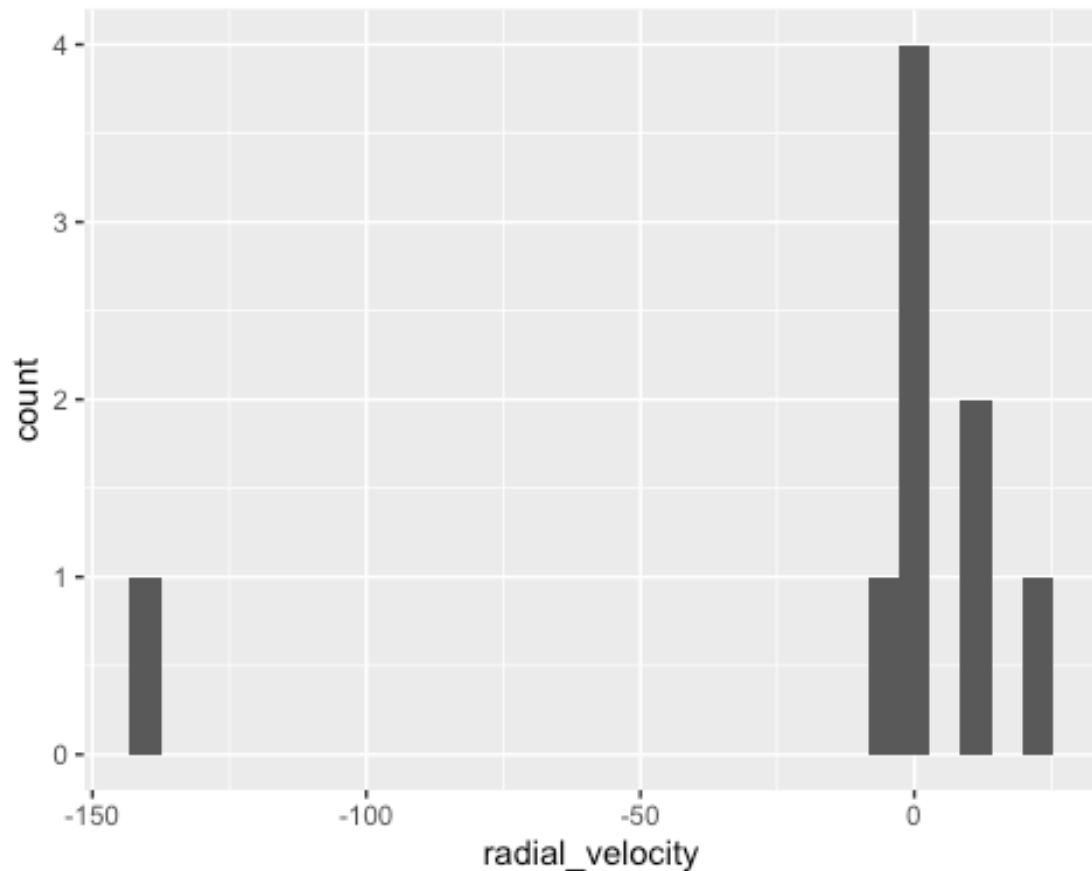
```
## Warning: Removed 1870 rows containing non-finite values (stat_bin).
```

Radio Velocity

```
ggplot(ngc_6553, aes(radial_velocity)) +
  geom_histogram(bins = 30)
```

```
## Warning: Removed 1991 rows containing non-finite values (stat_bin).
```

Gaia DR3, Terzan 12

```
terzan_12 <- read.csv("~/Desktop/AstroPhysics/Gaia-L4/1657165792389O-
result.csv")
```

Summary Statistics
```
summary(terzan_12)
```

```
##    source_id              ra              dec            parallax
##  Min.   :4.067e+18   Min.   :273.0   Min.   :-22.78   Min.   :-7.4591
##  1st Qu.:4.067e+18   1st Qu.:273.1   1st Qu.:-22.75   1st Qu.:-0.0605
##  Median :4.067e+18   Median :273.1   Median :-22.74   Median : 0.2401
##  Mean   :4.067e+18   Mean   :273.1   Mean   :-22.74   Mean   : 0.3113
##  3rd Qu.:4.067e+18   3rd Qu.:273.1   3rd Qu.:-22.73   3rd Qu.: 0.6288
##  Max.   :4.067e+18   Max.   :273.1   Max.   :-22.71   Max.   : 9.1725
##                                                       NA's   :330
##      pmra             pmdec            ruwe         phot_g_mean_mag
##  Min.   :-14.0406   Min.   :-16.476   Min.   :0.7628   Min.   :13.49
##  1st Qu.: -6.1099   1st Qu.: -5.272   1st Qu.:1.0056   1st Qu.:18.77
##  Median : -3.7502   Median : -3.277   Median :1.0593   Median :19.67
```

```
##   Mean    : -3.2932    Mean    : -3.822    Mean    :1.0987    Mean    :19.43
##   3rd Qu.: -0.7696    3rd Qu.: -2.516    3rd Qu.:1.1222    3rd Qu.:20.40
##   Max.    : 13.0895    Max.    :  8.646    Max.    :7.9593    Max.    :21.31
##   NA's    :330    NA's    :330    NA's    :330    NA's    :18
##        bp_rp           radial_velocity    phot_variable_flag non_single_star
##   Min.    :-1.595    Min.    :-56.708    Length:1416    Min.    :0
##   1st Qu.: 2.646    1st Qu.:-28.504    Class :character    1st Qu.:0
##   Median : 3.212    Median :  4.224    Mode  :character    Median :0
##   Mean    : 3.165    Mean    : 26.071                       Mean    :0
##   3rd Qu.: 3.713    3rd Qu.: 90.723                       3rd Qu.:0
##   Max.    : 6.977    Max.    :121.787                       Max.    :0
##   NA's    :380    NA's    :1403
##   has_xp_continuous  has_xp_sampled         has_rvs
has_epoch_photometry
##   Length:1416         Length:1416         Length:1416         Length:1416
##   Class :character    Class :character    Class :character    Class :character
##   Mode  :character    Mode  :character    Mode  :character    Mode  :character
##
##
##
##
##   has_epoch_rv        has_mcmc_gspphot    has_mcmc_msc            teff_gspphot
##   Length:1416         Length:1416         Length:1416         Min.    : 3133
##   Class :character    Class :character    Class :character    1st Qu.: 3976
##   Mode  :character    Mode  :character    Mode  :character    Median : 4528
##                                                               Mean    : 4689
##                                                               3rd Qu.: 4799
##                                                               Max.    :15012
##                                                               NA's    :1157
##    logg_gspphot        mh_gspphot        distance_gspphot azero_gspphot
##   Min.    :0.2009    Min.    :-3.7779    Min.    : 306.4    Min.    : 0.0498
##   1st Qu.:3.2127    1st Qu.:-0.8198    1st Qu.: 512.4    1st Qu.: 5.1394
##   Median :4.0442    Median :-0.3749    Median : 868.7    Median : 6.7906
##   Mean    :3.5905    Mean    :-0.3844    Mean    :1107.3    Mean    : 6.2606
##   3rd Qu.:4.1676    3rd Qu.: 0.2052    3rd Qu.:1175.7    3rd Qu.: 8.1680
##   Max.    :4.7671    Max.    : 0.7830    Max.    :8928.4    Max.    : 9.9999
##   NA's    :1157    NA's    :1157    NA's    :1157    NA's    :1157
##    ag_gspphot        ebpminrp_gspphot
##   Min.    :0.0377    Min.    :0.0201
##   1st Qu.:3.3614    1st Qu.:1.8909
##   Median :4.3724    Median :2.4866
##   Mean    :4.0440    Mean    :2.2990
##   3rd Qu.:5.2477    3rd Qu.:2.9979
##   Max.    :6.6393    Max.    :3.8421
##   NA's    :1157    NA's    :1157
```

Model 7

a. Use `lm()` to regress ra on dec and save the regression as `model_7`.

```
model_7 <- lm(ra ~ dec, data = terzan_12)
```

b.   Regression results from the first model using `summary()`.

An increase of one unit of dec is associated with an additional 0.01603 unit increase in ra. This relationship is statistically significant at < 1.

```
summary(model_7)

##
## Call:
## lm(formula = ra ~ dec, data = terzan_12)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.03239 -0.01213 -0.00112  0.01108  0.03927
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 273.42692    0.64806 421.918   <2e-16 ***
## dec           0.01603    0.02850   0.562    0.574
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01648 on 1414 degrees of freedom
## Multiple R-squared:  0.0002237,  Adjusted R-squared:  -0.0004834
## F-statistic: 0.3164 on 1 and 1414 DF,  p-value: 0.5739
```

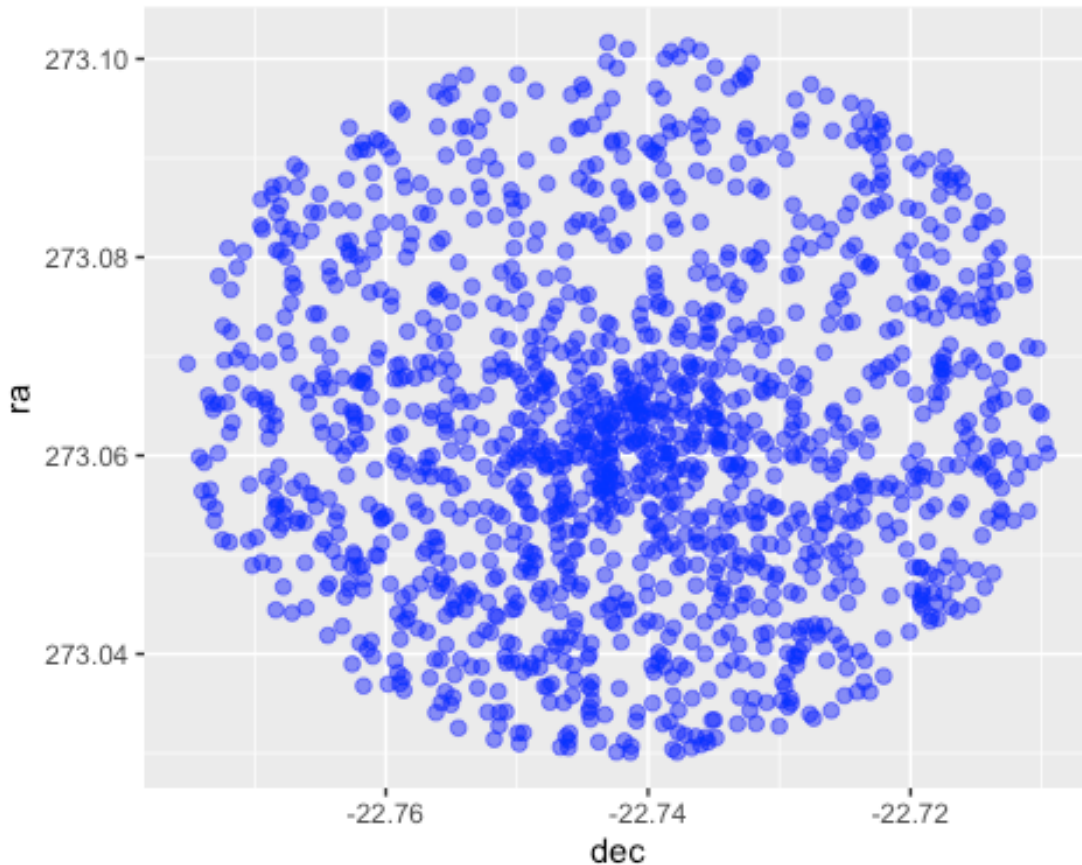c.   Plot results from `model_7`.

```
ggplot(data = model_7, aes(x = dec, y = ra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="ra", x="dec") +
  stat_smooth()

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
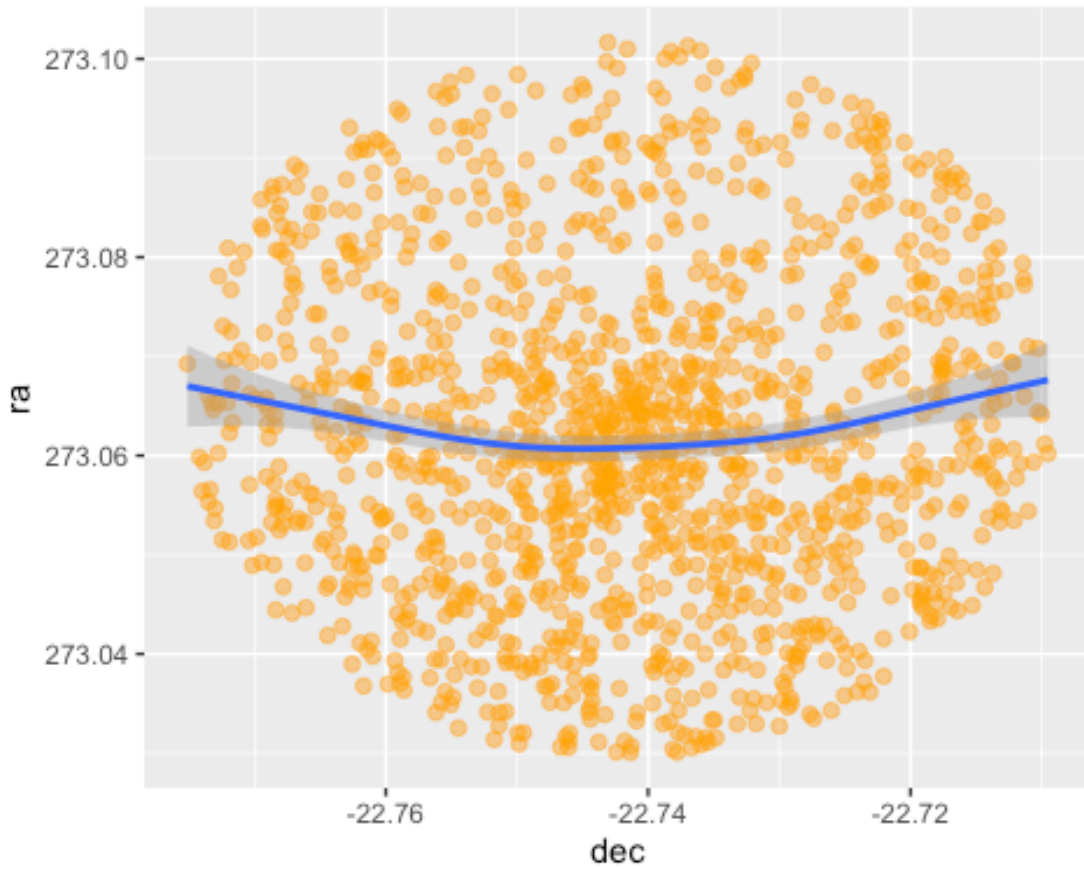
Graph

```
terzan_12 %>%
  ggplot(aes(dec,ra)) +
  geom_point(alpha=0.5, size= 2, color = 'blue') +
  labs(y="ra", x="dec")
```

Model 8

    a.   Use `lm()` to regress pmra on pmdec and save the regression as `model_8`.

```
model_8 <- lm(pmra ~ pmdec, data = terzan_12)
```

    b.   Regression results from the second model using `summary()`.

An increase of one unit of pmdec is associated with an additional 0.17153 unit increase in pmra. This relationship is statistically significant at < 0.001.

```
summary(model_8)

##
## Call:
## lm(formula = pmra ~ pmdec, data = terzan_12)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.9358 -2.8916 -0.3413  2.4903 17.9565
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.63767    0.16686 -15.807  < 2e-16 ***
## pmdec        0.17153    0.03461   4.956 8.33e-07 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.352 on 1084 degrees of freedom
##    (330 observations deleted due to missingness)
## Multiple R-squared:  0.02216,    Adjusted R-squared:  0.02126
## F-statistic: 24.56 on 1 and 1084 DF,  p-value: 8.334e-07
```

c.   Plot results from model_8.

```
ggplot(data = model_8, aes(x = pmdec, y = pmra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="pmra", x="pmdec") +
  stat_smooth()
```
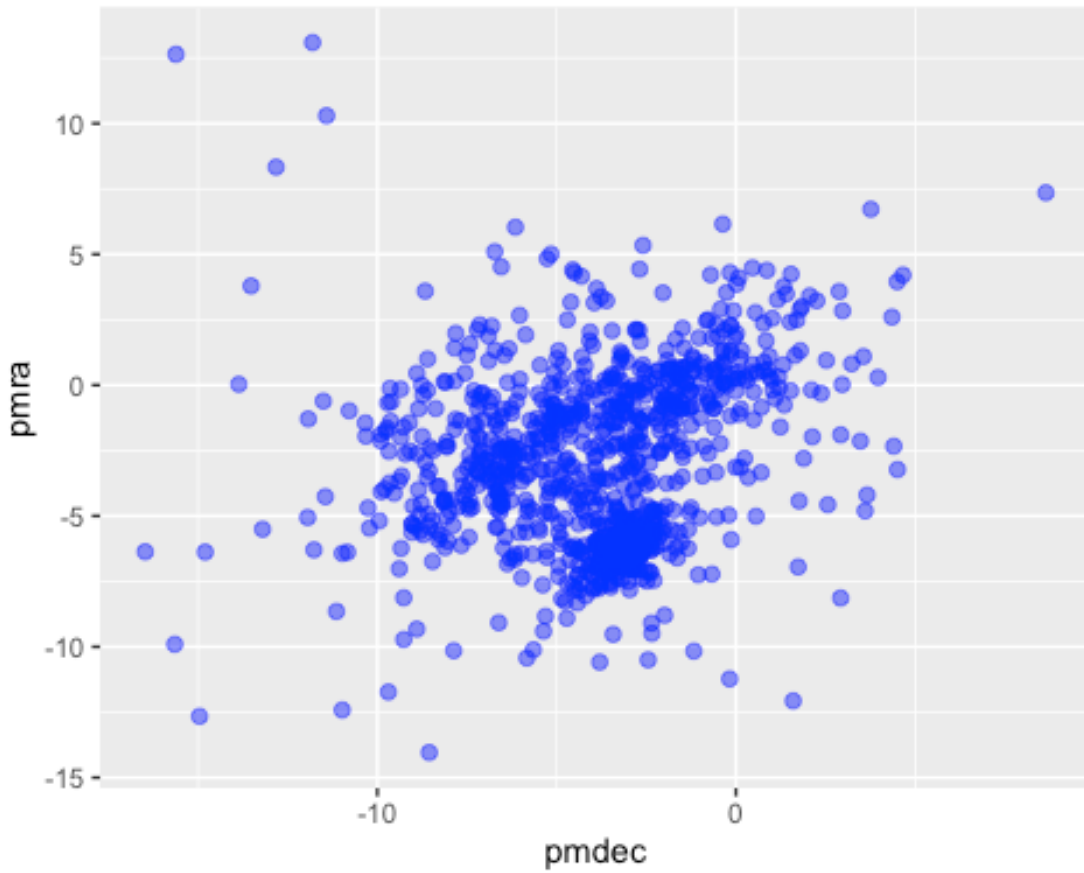
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
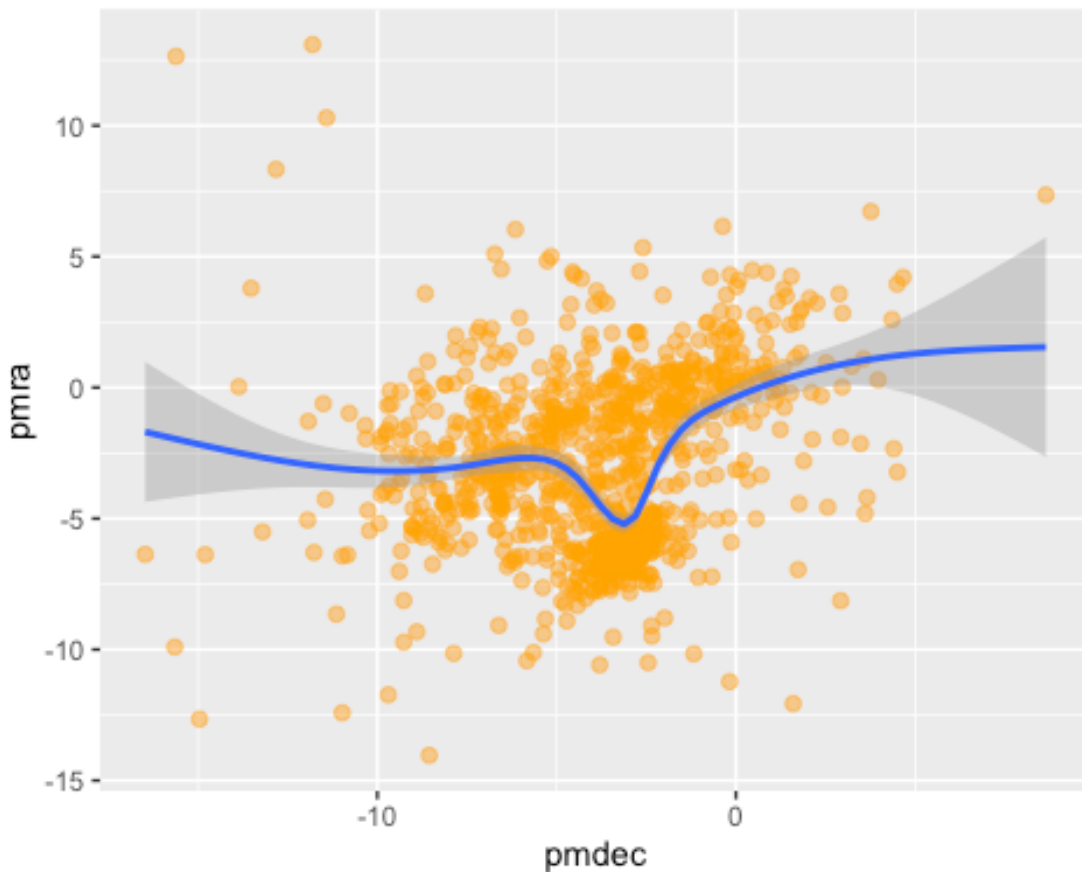

Graph

```
terzan_12 %>%
  ggplot(aes(pmdec,pmra)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="pmra", x="pmdec")
```
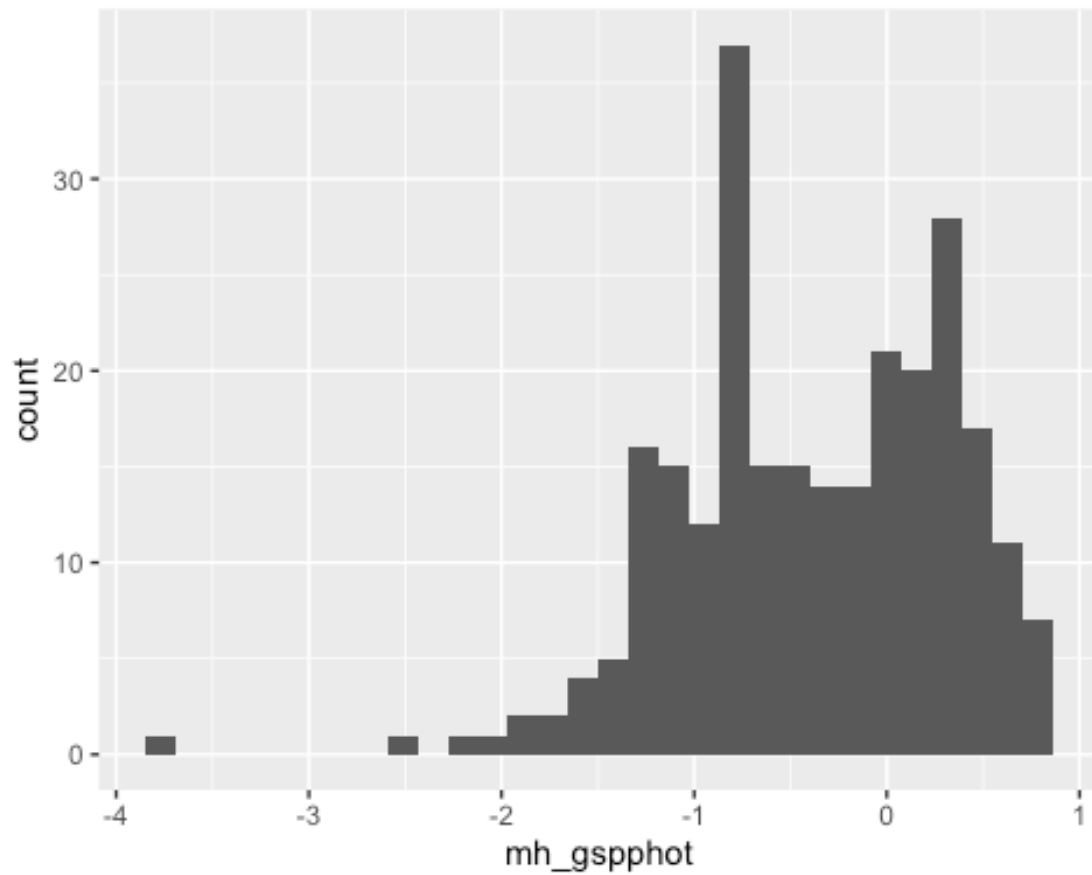
```
## Warning: Removed 330 rows containing missing values (geom_point).
```

Metallicity Over Hydrogen

```
ggplot(terzan_12, aes(mh_gspphot)) +
  geom_histogram(bins = 30)

## Warning: Removed 1157 rows containing non-finite values (stat_bin).
```
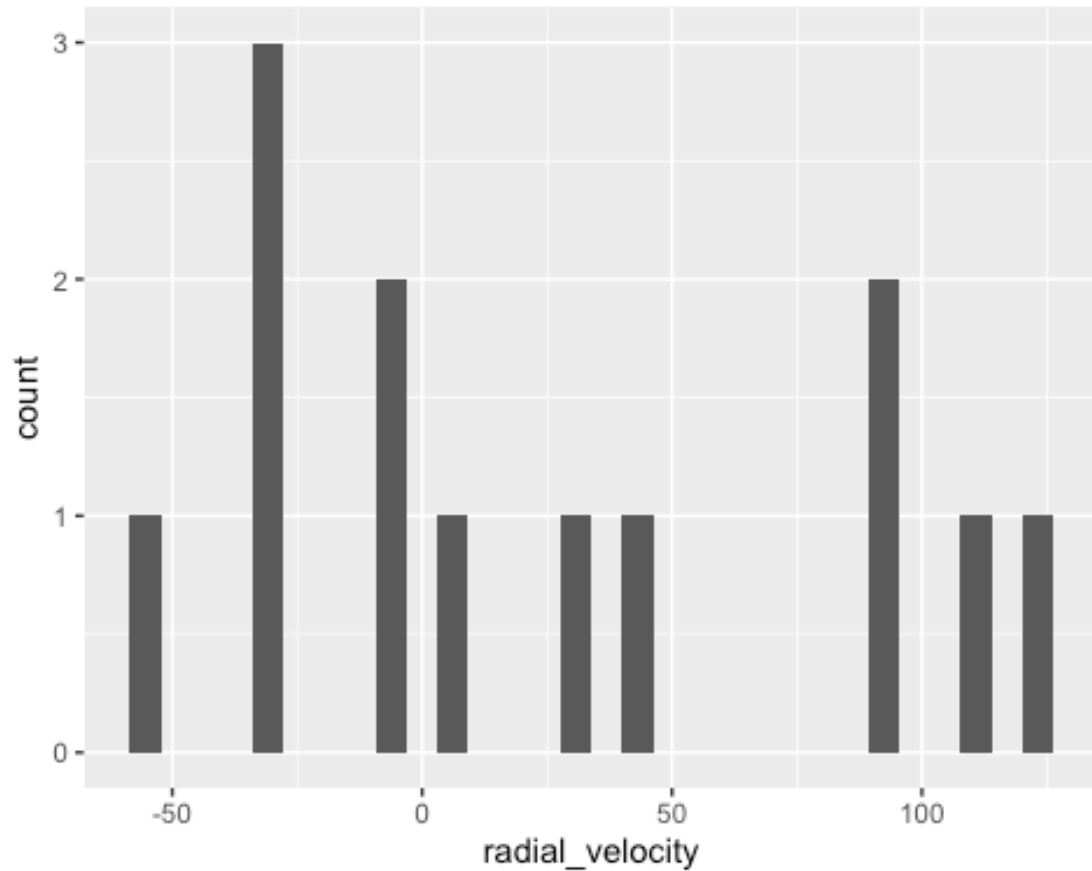
```
ggplot(terzan_12, aes(radial_velocity)) +
  geom_histogram(bins = 30)
```

```
## Warning: Removed 1403 rows containing non-finite values (stat_bin).
```

Gaia DR3, NGC 6380

```
ngc_6380 <- read.csv("~/Desktop/AstroPhysics/Gaia-L4/1657166932125O-
result.csv")
```

Summary Statistics
```
summary(ngc_6380)
```

```
##    source_id              ra             dec            parallax
##  Min.   :5.962e+18   Min.   :263.6   Min.   :-39.10   Min.   :-10.4104
##  1st Qu.:5.962e+18   1st Qu.:263.6   1st Qu.:-39.08   1st Qu.: -0.2638
##  Median :5.962e+18   Median :263.6   Median :-39.07   Median :  0.0929
##  Mean   :5.962e+18   Mean   :263.6   Mean   :-39.08   Mean   :  0.0708
##  3rd Qu.:5.962e+18   3rd Qu.:263.6   3rd Qu.:-39.07   3rd Qu.:  0.4979
##  Max.   :5.962e+18   Max.   :263.7   Max.   :-39.05   Max.   :  9.7858
##                                                       NA's   :785
##       pmra            pmdec             ruwe         phot_g_mean_mag
##  Min.   :-16.750   Min.   :-17.015   Min.   :0.7097   Min.   : 9.705
##  1st Qu.: -2.776   1st Qu.: -4.196   1st Qu.:1.0160   1st Qu.:18.206
##  Median : -2.127   Median : -3.345   Median :1.0820   Median :19.232
##  Mean   : -1.929   Mean   : -3.492   Mean   :1.2662   Mean   :19.055
```

```
##    3rd Qu.: -1.087    3rd Qu.: -2.739    3rd Qu.:1.2366    3rd Qu.:20.150
##    Max.    : 14.119    Max.    :  6.418    Max.    :9.3613    Max.    :21.159
##    NA's    :785        NA's    :785        NA's    :785        NA's    :5
##         bp_rp          radial_velocity    phot_variable_flag non_single_star
##    Min.    :-1.396    Min.    :-208.995  Length:2000        Min.    :0
##    1st Qu.: 2.259    1st Qu.:  -4.916   Class :character    1st Qu.:0
##    Median : 2.590    Median :   5.294   Mode  :character    Median :0
##    Mean    : 2.510    Mean    : -12.601                     Mean    :0
##    3rd Qu.: 2.769    3rd Qu.:  13.563                       3rd Qu.:0
##    Max.    : 5.867    Max.    :  51.103                      Max.    :0
##    NA's    :972       NA's    :1982
##   has_xp_continuous  has_xp_sampled        has_rvs
has_epoch_photometry
##   Length:2000        Length:2000        Length:2000        Length:2000
##   Class :character    Class :character    Class :character    Class :character
##   Mode  :character    Mode  :character    Mode  :character    Mode  :character
##
##
##
##
##   has_epoch_rv        has_mcmc_gspphot    has_mcmc_msc          teff_gspphot
##   Length:2000        Length:2000        Length:2000        Min.    : 3417
##   Class :character    Class :character    Class :character    1st Qu.: 3893
##   Mode  :character    Mode  :character    Mode  :character    Median : 4300
##                                                               Mean    : 4738
##                                                               3rd Qu.: 4789
##                                                               Max.    :15017
##                                                               NA's    :1755
##    logg_gspphot        mh_gspphot        distance_gspphot azero_gspphot
##   Min.    :0.4522    Min.    :-3.1950   Min.    : 330.3    Min.    :0.0159
##   1st Qu.:4.0714    1st Qu.:-1.3783    1st Qu.: 566.5    1st Qu.:2.2810
##   Median :4.2419    Median :-1.0010    Median : 677.6    Median :3.1939
##   Mean    :4.0669    Mean    :-0.9318   Mean    : 977.2    Mean    :3.3982
##   3rd Qu.:4.4333    3rd Qu.:-0.5022    3rd Qu.:1048.5    3rd Qu.:4.3835
##   Max.    :4.9295    Max.    : 0.7855   Max.    :7690.7    Max.    :9.9591
##   NA's    :1755      NA's    :1755      NA's    :1755      NA's    :1755
##    ag_gspphot        ebpminrp_gspphot
##   Min.    :0.0111    Min.    :0.0060
##   1st Qu.:1.6090    1st Qu.:0.8926
##   Median :2.2064    Median :1.2149
##   Mean    :2.3579    Mean    :1.3079
##   3rd Qu.:3.0044    3rd Qu.:1.6493
##   Max.    :6.0713    Max.    :3.4802
##   NA's    :1755      NA's    :1755
```

Model 9

a. Use `lm()` to regress ra on dec and save the regression as `model_9`.

```
model_9 <- lm(ra ~ dec, data = ngc_6380)
```

b. Regression results from the first model using `summary()`.

An increase of one unit of dec is associated with an additional 0.35053 unit increase in ra.
This relationship is statistically significant at < 0.001.

```
summary(model_9)

##
## Call:
## lm(formula = ra ~ dec, data = ngc_6380)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.043668 -0.010389 -0.001172  0.011399  0.037492
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 277.31808    1.34662  205.94   <2e-16 ***
## dec           0.35053    0.03446   10.17   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01671 on 1998 degrees of freedom
## Multiple R-squared:  0.04923,    Adjusted R-squared:  0.04876
## F-statistic: 103.5 on 1 and 1998 DF,  p-value: < 2.2e-16
```

   c.   Plot results from `model_9`.

```
ggplot(data = model_9, aes(x = dec, y = ra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="ra", x="dec") +
  stat_smooth()

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
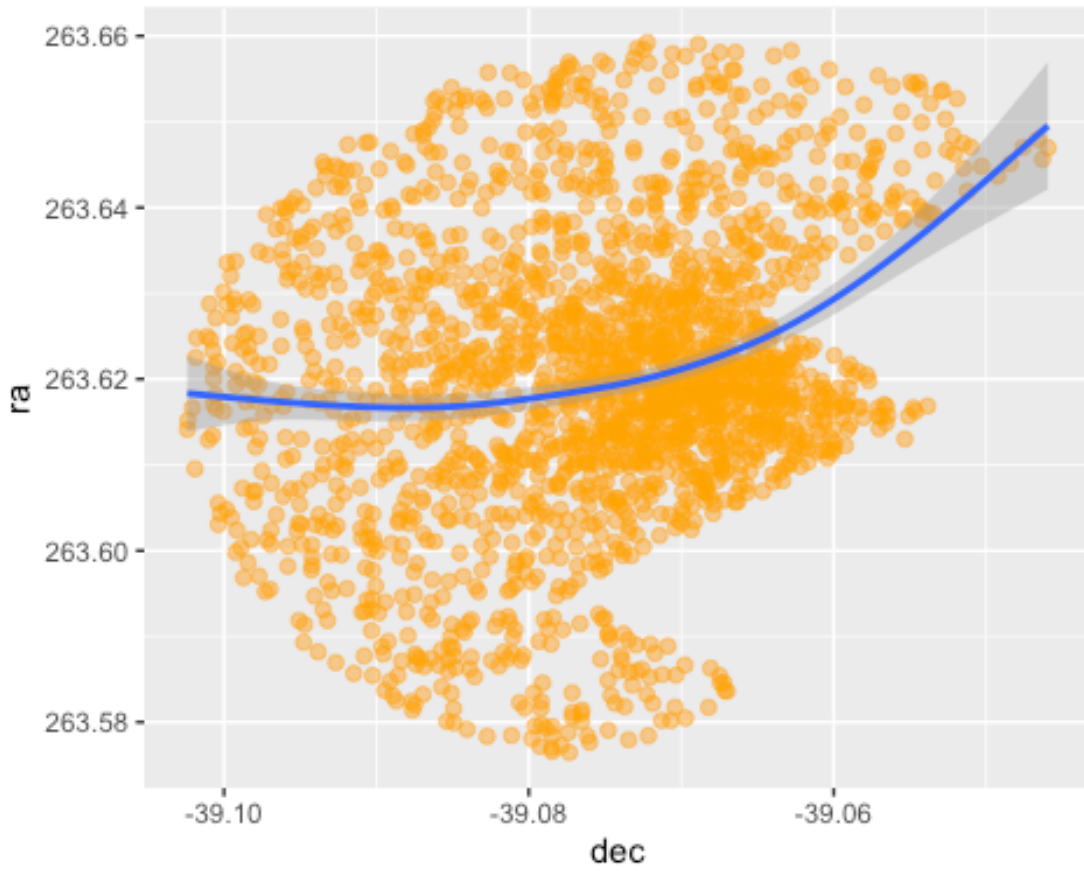
```
ngc_6380 %>%
  ggplot(aes(dec,ra)) +
  geom_point(alpha=0.5, size= 2, color = 'blue') +
  labs(y="ra", x="dec")
```
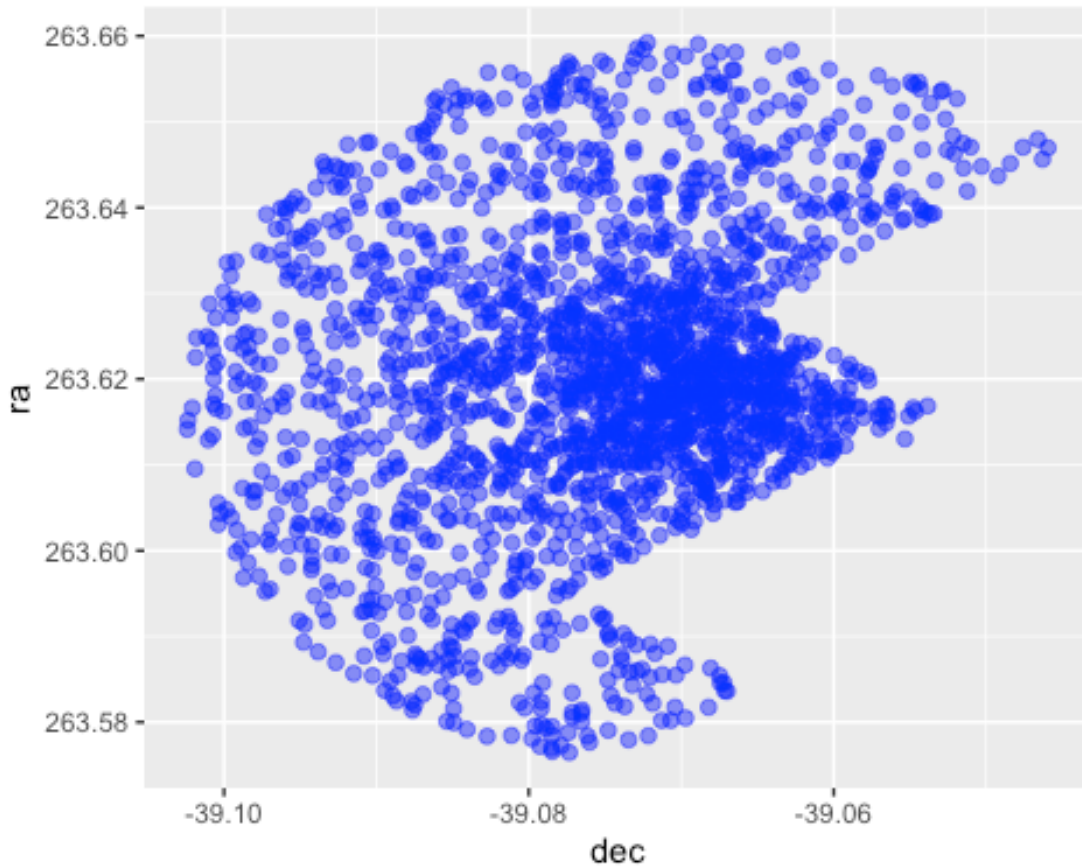
Model 10

a. Use `lm()` to regress pmra on pmdec and save the regression as `model_10`.

```
model_10 <- lm(pmra ~ pmdec, data = ngc_6380)
```

b. Regression results from the second model using `summary()`.

An increase of one unit of pmdec is associated with an additional 0.17272 unit increase in pmra. This relationship is statistically significant at < 0.001.

```
summary(model_10)

##
## Call:
## lm(formula = pmra ~ pmdec, data = ngc_6380)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -15.0337  -0.9047  -0.2010   0.8336  15.0940
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.32546    0.12673 -10.459  < 2e-16 ***
## pmdec        0.17272    0.03098   5.576 3.03e-08 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.302 on 1213 degrees of freedom
##    (785 observations deleted due to missingness)
## Multiple R-squared:  0.02499,    Adjusted R-squared:  0.02419
## F-statistic: 31.09 on 1 and 1213 DF,  p-value: 3.034e-08
```

c.   Plot results from model_10.

```
ggplot(data = model_10, aes(x = pmdec, y = pmra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="pmra", x="pmdec") +
  stat_smooth()
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
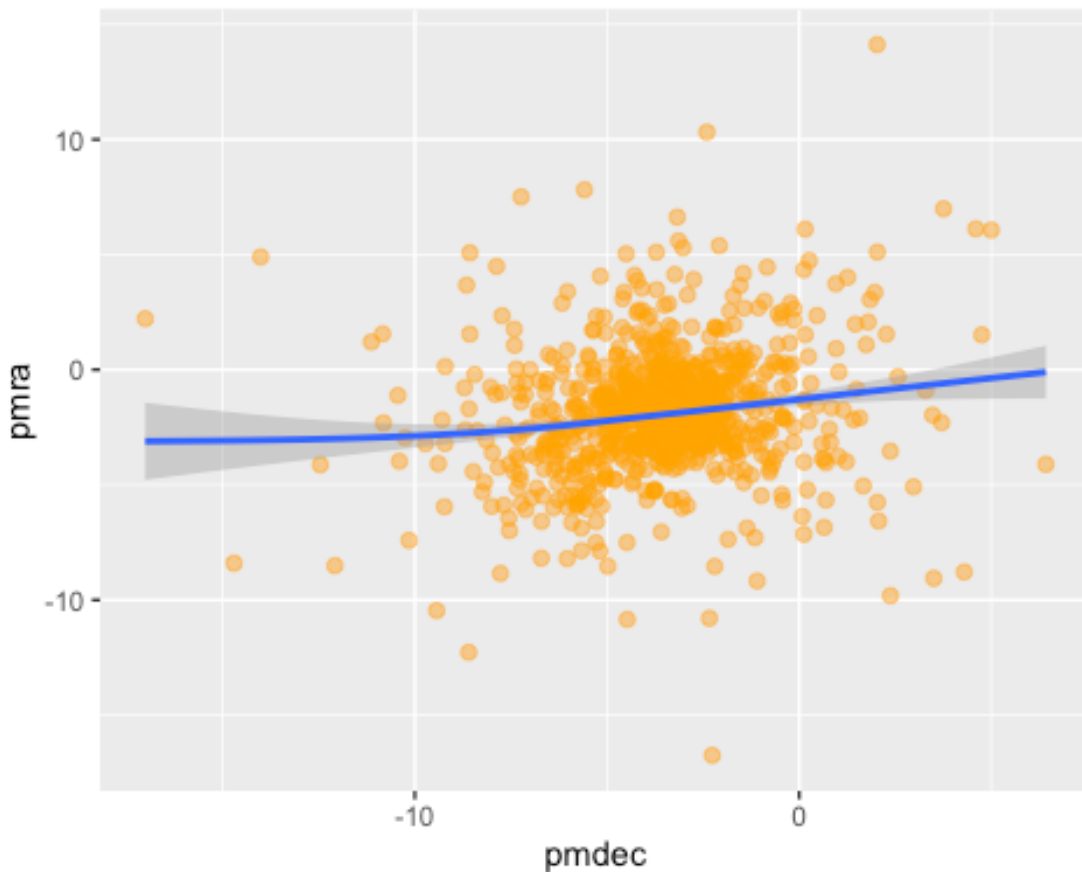

Graph

```
ngc_6380 %>%
  ggplot(aes(pmdec,pmra)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="pmra", x="pmdec")
```

```
## Warning: Removed 785 rows containing missing values (geom_point).
```
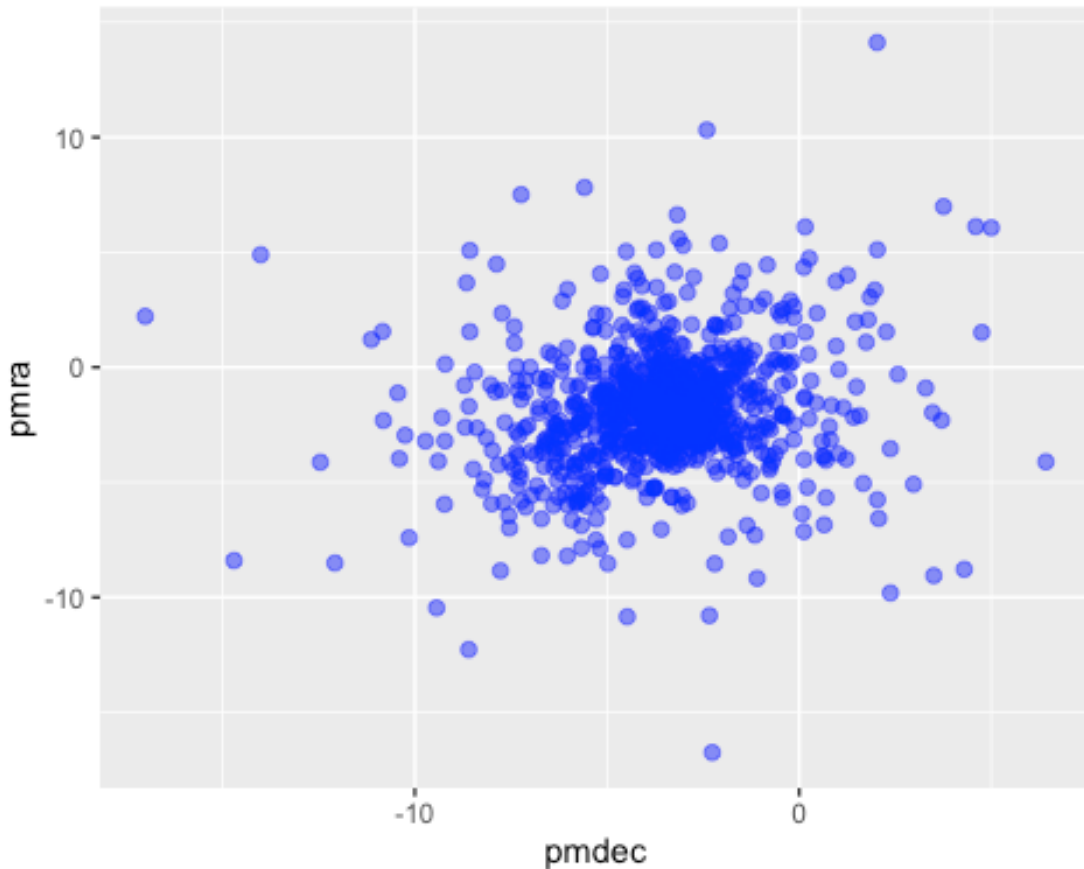
a. Use `lm()` to regress phot_g_mean_mag on bp_rp and save the regression as model_11.

```
model_11 <- lm(phot_g_mean_mag ~ bp_rp, data = ngc_6380)
```

b. Regression results from the third model using `summary()`.

An increase of one unit of bp_rp is associated with an additional -1.02741 unit decrease in phot_g_mean_mag. This relationship is statistically significant at < 0.001.

```
summary(model_11)

## 
## Call:
## lm(formula = phot_g_mean_mag ~ bp_rp, data = ngc_6380)
## 
## Residuals:
##      Min       1Q   Median       3Q      Max
## -11.0059  -0.6643  -0.0116   0.9888   3.5449
## 
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 21.18548    0.22031   96.16   <2e-16 ***
```

```
## bp_rp          -1.02741     0.08615  -11.93    <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.356 on 1026 degrees of freedom
##   (972 observations deleted due to missingness)
## Multiple R-squared:  0.1217, Adjusted R-squared:  0.1209
## F-statistic: 142.2 on 1 and 1026 DF,  p-value: < 2.2e-16
```

   c.   Plot results from `model_11`.

```
ggplot(data = model_11, aes(x = bp_rp, y = phot_g_mean_mag)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="phot_g_mean_mag", x="bp_rp") +
  stat_smooth()
```
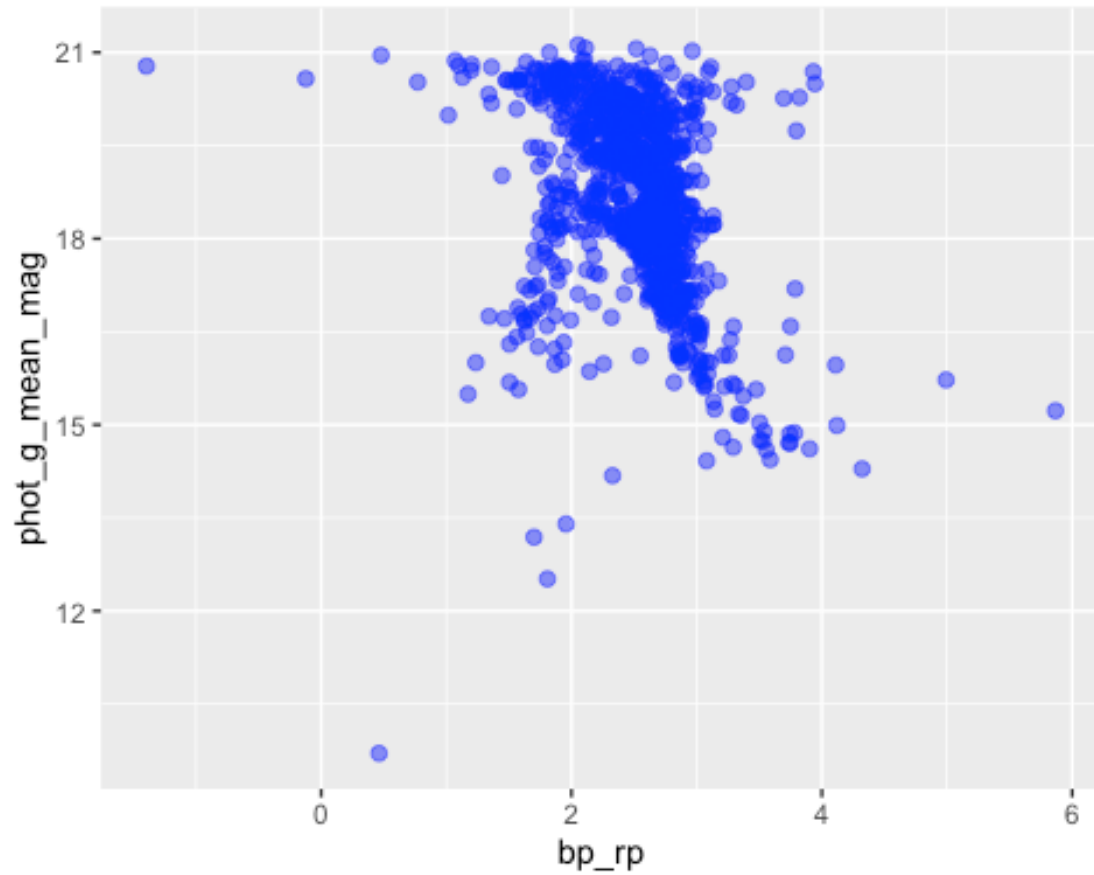
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
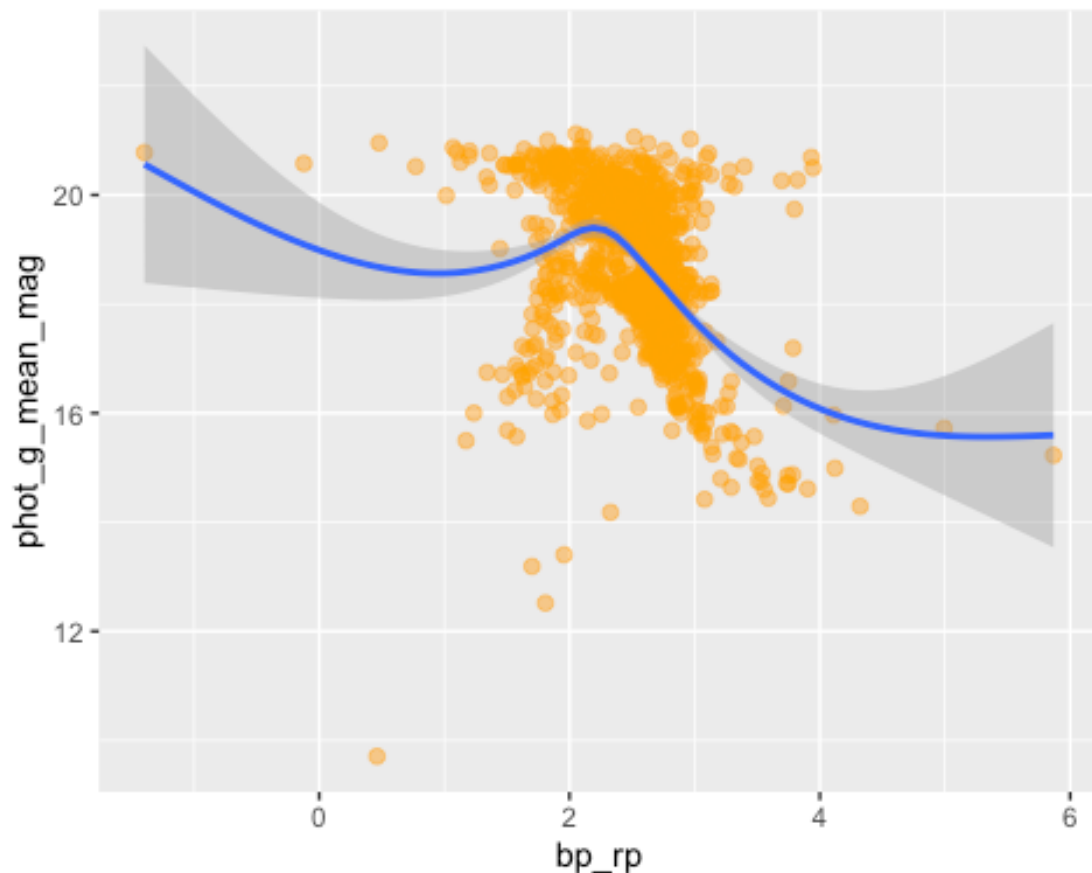

Graph

```
ngc_6380 %>%
  ggplot(aes(bp_rp,phot_g_mean_mag)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="phot_g_mean_mag", x="bp_rp")
```
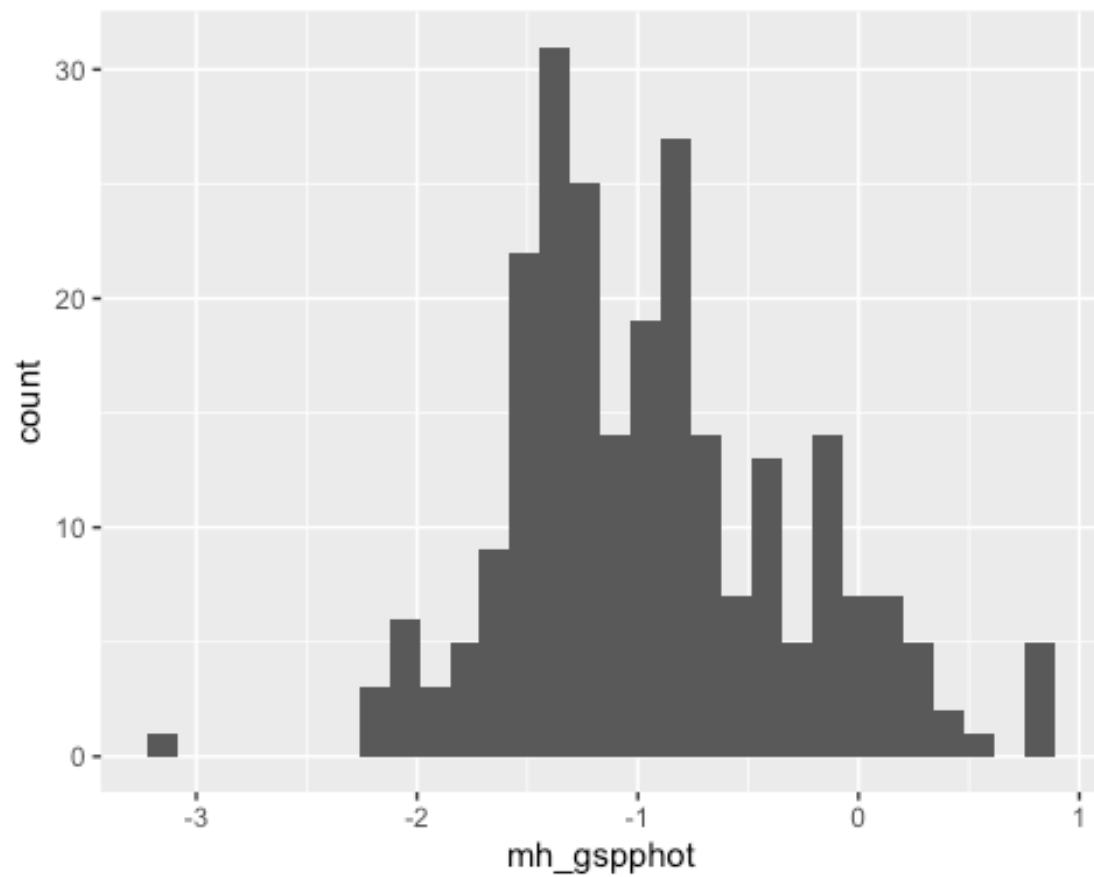
```
## Warning: Removed 972 rows containing missing values (geom_point).
```


Metallicity Over Hydrogen

```
ggplot(ngc_6380, aes(mh_gspphot)) +
  geom_histogram(bins = 30)
```
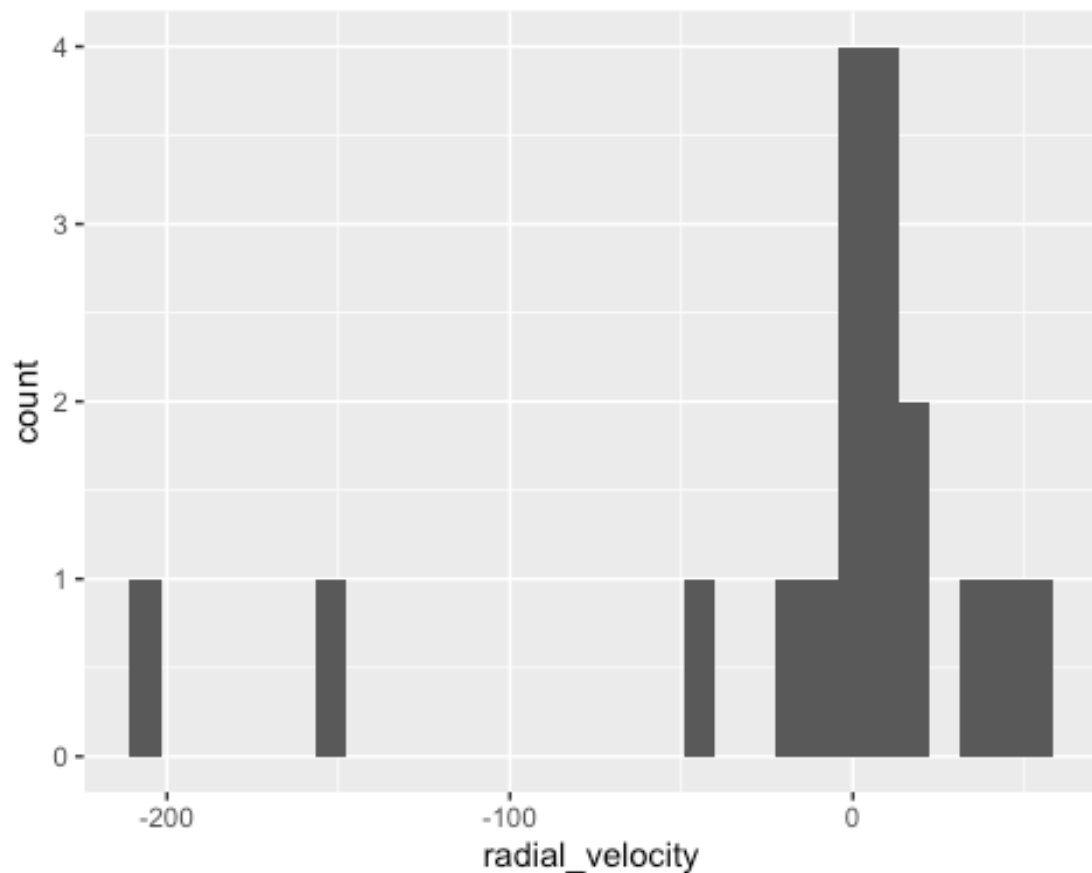
```
## Warning: Removed 1755 rows containing non-finite values (stat_bin).
```

```
ggplot(ngc_6380, aes(radial_velocity)) +
  geom_histogram(bins = 30)
```

```
## Warning: Removed 1982 rows containing non-finite values (stat_bin).
```

Gaia DR3, FSR 1758

```
fsr_1758 <- read.csv("~/Desktop/AstroPhysics/Gaia-L4/1657248340808O-
result.csv")
```

Summary Statistics
```
summary(fsr_1758)

##    source_id              ra              dec             parallax
## Min.   :5.962e+18   Min.   :262.8   Min.   :-39.86   Min.   :-12.0892
## 1st Qu.:5.962e+18   1st Qu.:262.8   1st Qu.:-39.84   1st Qu.: -0.2286
## Median :5.962e+18   Median :262.8   Median :-39.83   Median :  0.1495
## Mean   :5.962e+18   Mean   :262.8   Mean   :-39.83   Mean   :  0.2072
## 3rd Qu.:5.962e+18   3rd Qu.:262.8   3rd Qu.:-39.82   3rd Qu.:  0.6315
## Max.   :5.962e+18   Max.   :262.8   Max.   :-39.80   Max.   : 10.7769
##                                                      NA's   :990
##      pmra             pmdec             ruwe          phot_g_mean_mag
## Min.   :-19.8029   Min.   :-20.186   Min.   : 0.7775   Min.   :13.19
## 1st Qu.: -3.6099   1st Qu.: -5.225   1st Qu.: 1.0009   1st Qu.:18.82
## Median : -2.5601   Median : -2.874   Median : 1.0634   Median :19.87
## Mean   : -2.2823   Mean   : -2.319   Mean   : 1.2112   Mean   :19.40
```

```
## 3rd Qu.: -0.6576   3rd Qu.:  1.918   3rd Qu.: 1.1871   3rd Qu.:20.31
## Max.   : 19.9996   Max.   :  8.181   Max.   :15.3358   Max.   :21.06
## NA's   :990         NA's   :990       NA's   :990       NA's   :10
##      bp_rp         radial_velocity   phot_variable_flag non_single_star
## Min.   :-1.160    Min.   :-220.418   Length:2000        Min.   :0
## 1st Qu.: 1.628    1st Qu.: -34.066   Class :character   1st Qu.:0
## Median : 1.868    Median :  -6.326   Mode  :character   Median :0
## Mean   : 1.836    Mean   :  48.350                      Mean   :0
## 3rd Qu.: 2.059    3rd Qu.: 217.536                      3rd Qu.:0
## Max.   : 4.722    Max.   : 230.887                      Max.   :0
## NA's   :970       NA's   :1981
## has_xp_continuous  has_xp_sampled       has_rvs
has_epoch_photometry
## Length:2000        Length:2000       Length:2000       Length:2000
## Class :character   Class :character  Class :character  Class :character
## Mode  :character   Mode  :character  Mode  :character  Mode  :character
##
##
##
##
## has_epoch_rv       has_mcmc_gspphot  has_mcmc_msc         teff_gspphot
## Length:2000        Length:2000       Length:2000       Min.   : 3275
## Class :character   Class :character  Class :character  1st Qu.: 3934
## Mode  :character   Mode  :character  Mode  :character  Median : 4431
##                                                        Mean   : 4616
##                                                        3rd Qu.: 4923
##                                                        Max.   :15013
##                                                        NA's   :1717
##   logg_gspphot       mh_gspphot      distance_gspphot azero_gspphot
## Min.   :1.628     Min.   :-4.1148    Min.   : 351.1   Min.   :0.0008
## 1st Qu.:4.180     1st Qu.:-1.5883    1st Qu.: 615.8   1st Qu.:0.4348
## Median :4.521     Median :-1.1630    Median : 751.2   Median :1.2773
## Mean   :4.338     Mean   :-1.1496    Mean   :1119.6   Mean   :1.4542
## 3rd Qu.:4.811     3rd Qu.:-0.5429    3rd Qu.:1374.4   3rd Qu.:2.2539
## Max.   :5.055     Max.   : 0.7718    Max.   :9314.1   Max.   :5.1196
## NA's   :1717      NA's   :1717       NA's   :1717     NA's   :1717
##    ag_gspphot       ebpminrp_gspphot
## Min.   :0.0007    Min.   :0.0004
## 1st Qu.:0.3161    1st Qu.:0.1708
## Median :0.9321    Median :0.5068
## Mean   :1.0716    Mean   :0.5831
## 3rd Qu.:1.6457    3rd Qu.:0.8967
## Max.   :4.2022    Max.   :2.3293
## NA's   :1717      NA's   :1717
```

Model 12

a. Use `lm()` to regress ra on dec and save the regression as `model_12`.

```
model_12 <- lm(ra ~ dec, data = fsr_1758)
```

b. Regression results from the first model using `summary()`.

An increase of one unit of dec is associated with an additional 0.59648 unit increase in ra. This relationship is statistically significant at < 0.001.

```
summary(model_12)

##
## Call:
## lm(formula = ra ~ dec, data = fsr_1758)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.055624 -0.009150  0.004288  0.015665  0.033606
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 286.57239    1.47722  193.99   <2e-16 ***
## dec           0.59648    0.03709   16.08   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.02136 on 1998 degrees of freedom
## Multiple R-squared:  0.1146, Adjusted R-squared:  0.1142
## F-statistic: 258.6 on 1 and 1998 DF,  p-value: < 2.2e-16
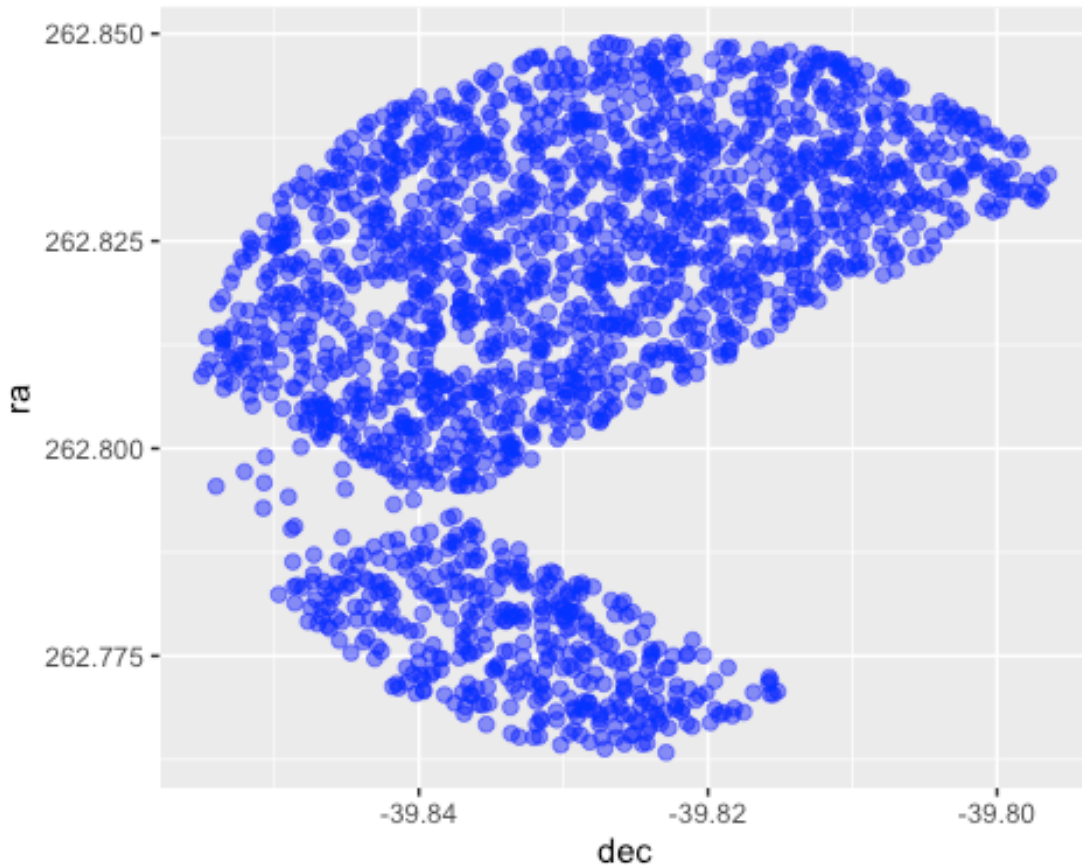```

   c.    Plot results from model_12.

```
ggplot(data = model_12, aes(x = dec, y = ra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="ra", x="dec") +
  stat_smooth()

## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
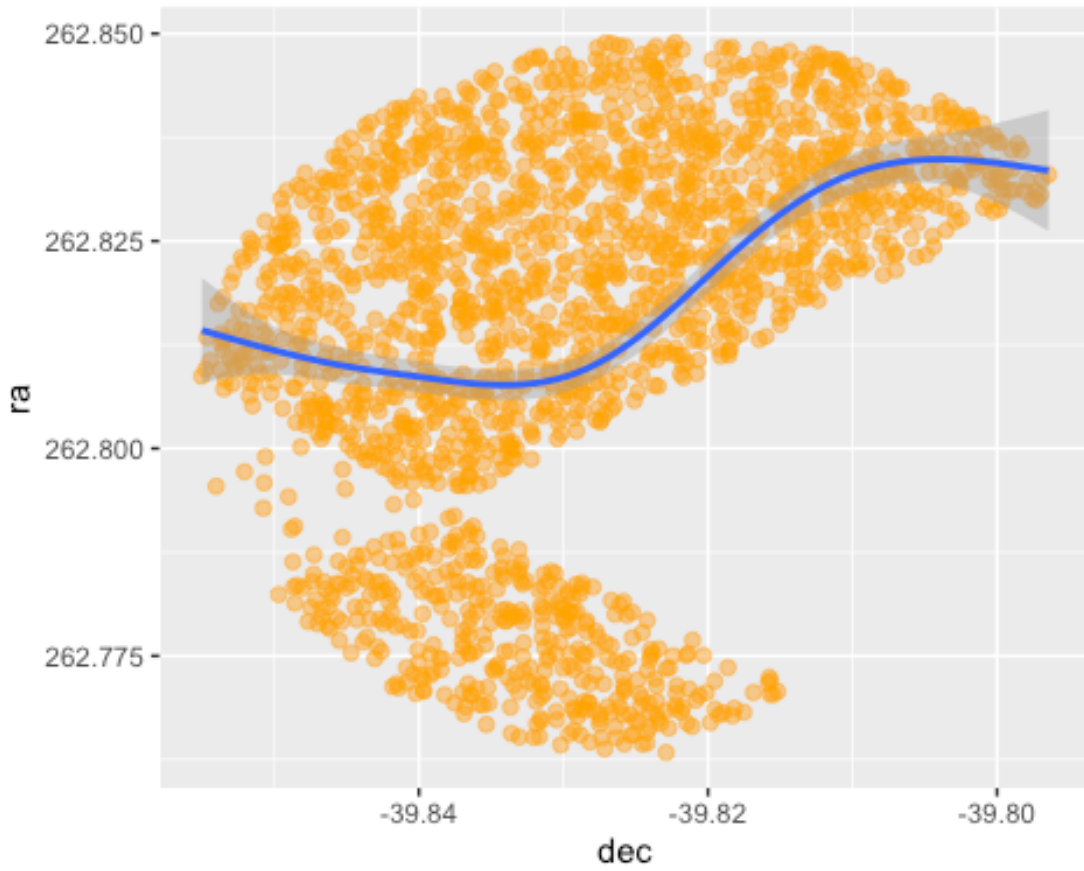
Graph

```
fsr_1758 %>%
  ggplot(aes(dec,ra)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="ra", x="dec")
```

Model 13

a.   Use `lm()` to regress pmra on pmdec and save the regression as `model_13`.

```
model_13 <- lm(pmra ~ pmdec, data = fsr_1758)
```

b.   Regression results from the second model using `summary()`.

An increase of one unit of pmdec is associated with an additional 0.04283 unit increase in pmra. This relationship is statistically significant at < 0.1.

```
summary(model_13)

##
## Call:
## lm(formula = pmra ~ pmdec, data = fsr_1758)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -17.0701  -1.3090  -0.3629   1.5897  22.7883
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.18301    0.11378 -19.187   <2e-16 ***
## pmdec        0.04283    0.02417   1.772   0.0766 .
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.147 on 1008 degrees of freedom
##   (990 observations deleted due to missingness)
## Multiple R-squared:  0.003107,   Adjusted R-squared:  0.002118
## F-statistic: 3.141 on 1 and 1008 DF,  p-value: 0.07663
```

c.   Plot results from `model_13`.

```
ggplot(data = model_13, aes(x = pmdec, y = pmra)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="pmra", x="pmdec") +
  stat_smooth()
```
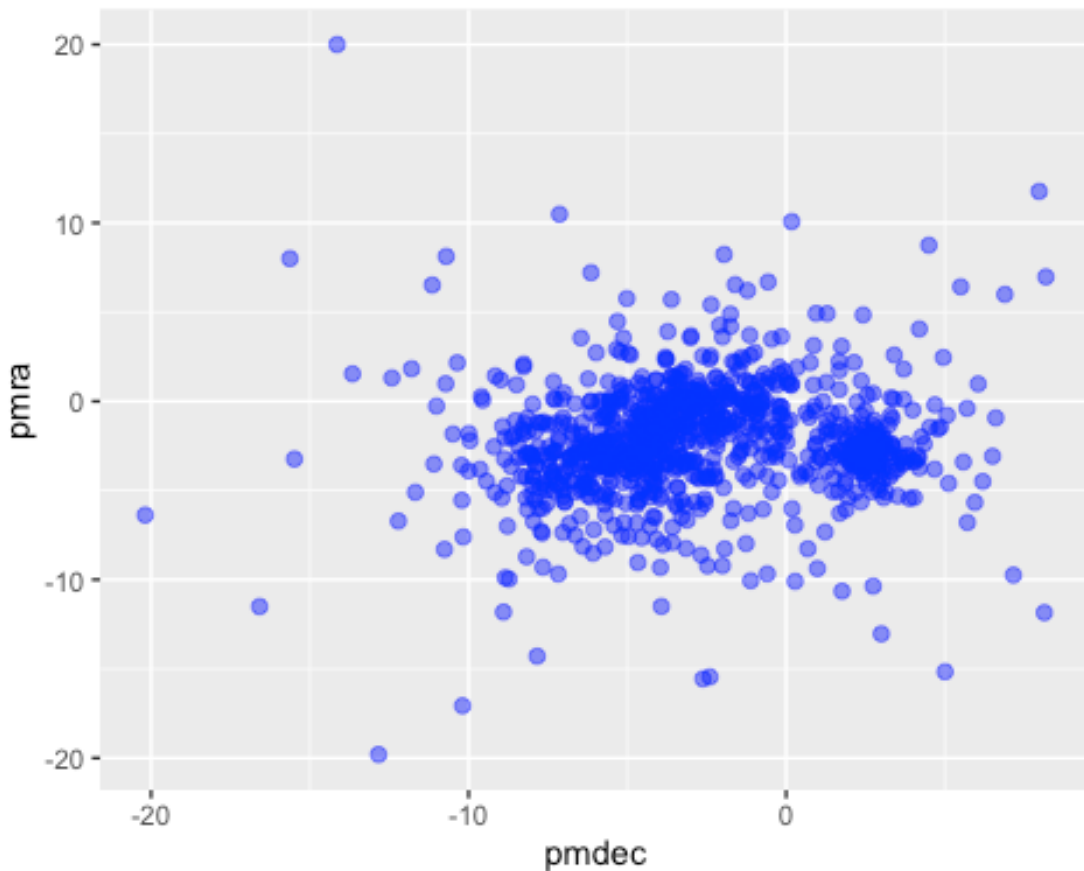
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
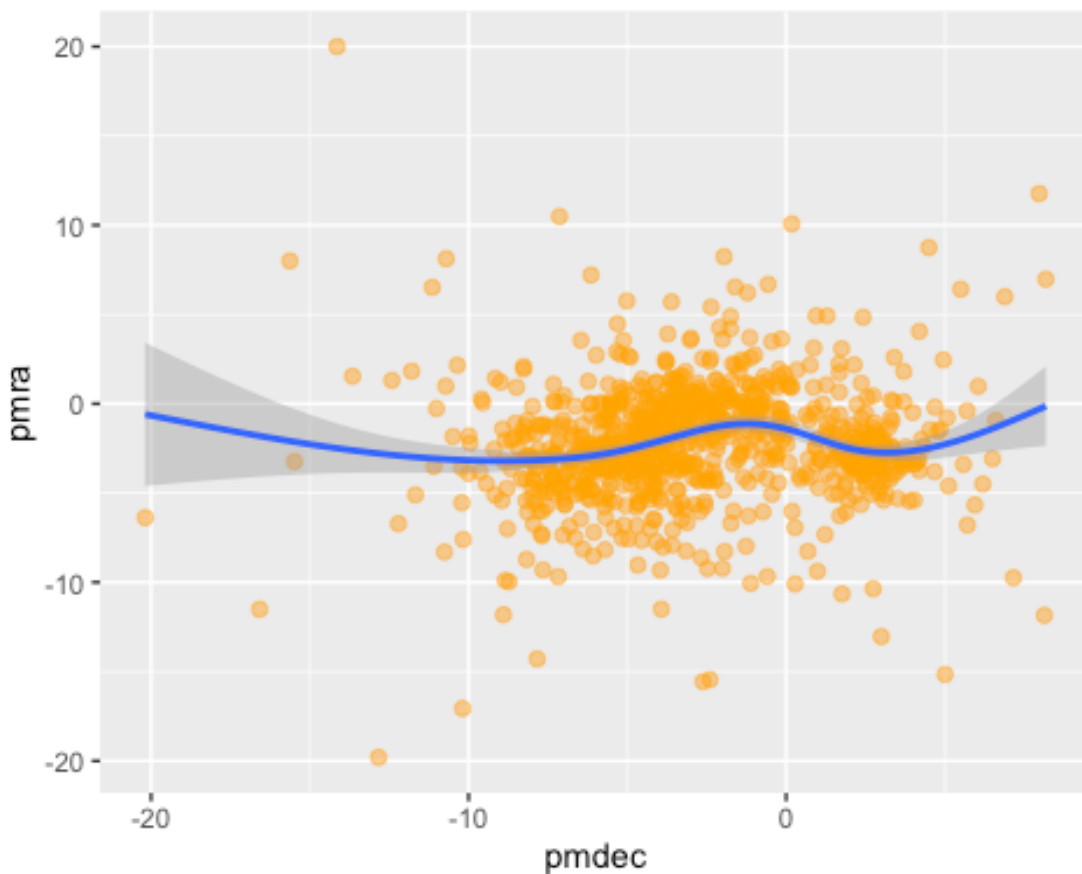

Graph

```
fsr_1758 %>%
  ggplot(aes(pmdec,pmra)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="pmra", x="pmdec")
```

```
## Warning: Removed 990 rows containing missing values (geom_point).
```

Model 14

    a.   Use `lm()` to regress phot_g_mean_mag on bp_rp and save the regression as model_14.

```
model_14 <- lm(phot_g_mean_mag ~ bp_rp, data = fsr_1758)
```

    b.   Regression results from the third model using `summary()`.

An increase of one unit of bp_rp is associated with an additional -0.44855 unit decrease in phot_g_mean_mag. This relationship is statistically significant at < 0.001.

```
summary(model_14)

##
## Call:
## lm(formula = phot_g_mean_mag ~ bp_rp, data = fsr_1758)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.0683 -0.8107  0.2927  1.0721  2.9958
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 19.59730    0.17930  109.30  < 2e-16 ***
```

```
## bp_rp         -0.44855      0.09484     -4.73 2.56e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.373 on 1028 degrees of freedom
##    (970 observations deleted due to missingness)
## Multiple R-squared:  0.0213, Adjusted R-squared:  0.02034
## F-statistic: 22.37 on 1 and 1028 DF,  p-value: 2.565e-06
```

c.   Plot results from model_14.

```
ggplot(data = model_14, aes(x = bp_rp, y = phot_g_mean_mag)) +
  geom_point(alpha=0.5, size=2, color = 'orange') +
  labs(y="phot_g_mean_mag", x="bp_rp") +
  stat_smooth()
```
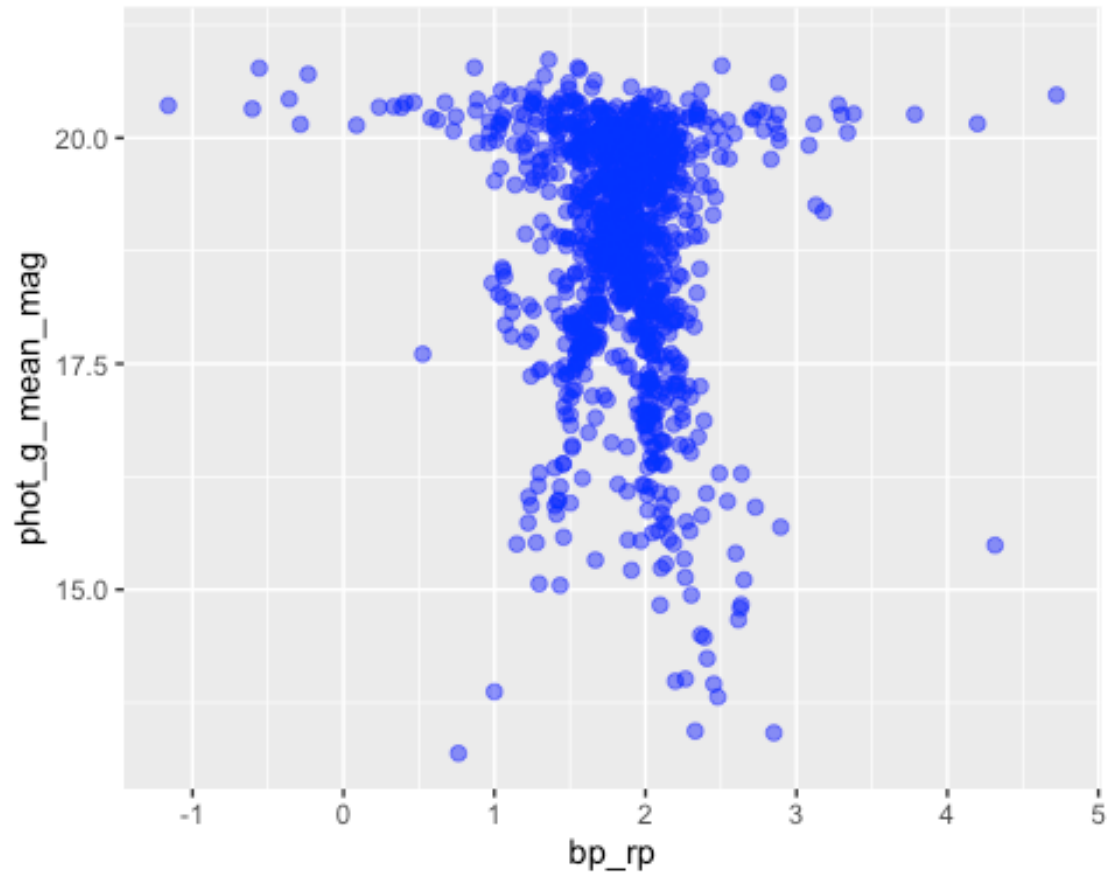
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```
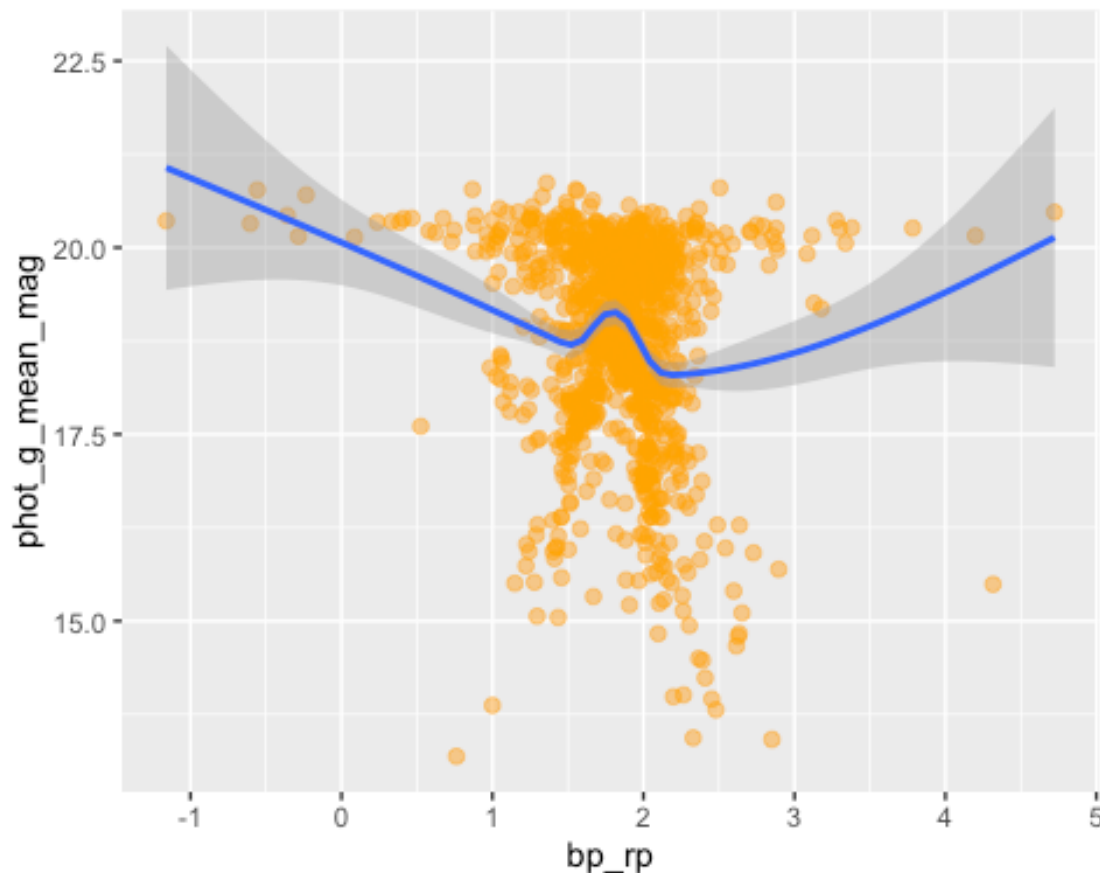

Graph
```
fsr_1758 %>%
  ggplot(aes(bp_rp,phot_g_mean_mag)) +
  geom_point(alpha=0.5, size=2, color = 'blue') +
  labs(y="phot_g_mean_mag", x="bp_rp")
```
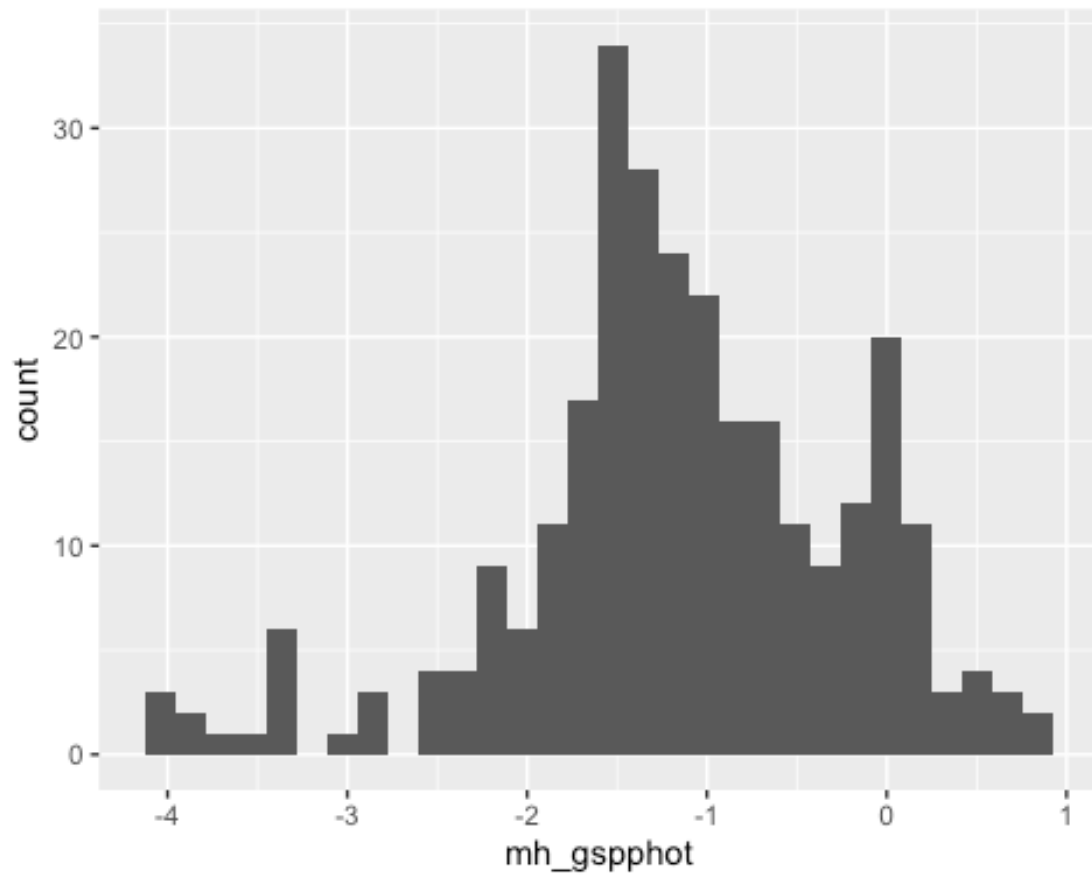
```
## Warning: Removed 970 rows containing missing values (geom_point).
```


Metallicity Over Hydrogen

```
ggplot(fsr_1758, aes(mh_gspphot)) +
  geom_histogram(bins = 30)
```

```
## Warning: Removed 1717 rows containing non-finite values (stat_bin).
```

```
ggplot(fsr_1758, aes(radial_velocity)) +
  geom_histogram(bins = 30)
```

```
## Warning: Removed 1981 rows containing non-finite values (stat_bin).
```