Code Through - Whole Game (Hadley Wickham)

US building permits

```
knitr::opts_chunk$set(echo = TRUE,
                      tidy = FALSE,
                      size = "small",
                      dev = "cairo_pdf")
library(tidyverse)
library(magrittr)
library(hrbrthemes)
library(skimr)
library(Cairo)
library(extrafont)
extrafont::loadfonts()
```

Import

Download the data from this site

```
# fs::dir_ls("data")
permits_raws <- read_csv("data/MSAdataPermit_fullmo.csv")
```

```
## Parsed with column specification:
## cols(
##   area = col_character(),
##   date = col_character(),
##   f1units = col_double(),
##   f1change = col_character(),
##   f1value = col_double(),
##   f1valchange = col_character(),
##   f24units = col_double(),
##   f24change = col_character(),
##   f24value = col_double(),
##   f24valchange = col_character(),
##   f5units = col_double(),
##   f5change = col_character(),
##   f5value = col_double(),
##   f5valchange = col_character()
## )
```

```
permits_raws
```

```
## # A tibble: 92,945 x 14
##    area  date  f1units f1change f1value f1valchange f24units f24change
##    <chr> <chr>   <dbl> <chr>      <dbl> <chr>          <dbl> <chr>
##  1 Abil~ 01/1~      24 null       67900 null               4 null
##  2 Abil~ 02/1~      39 null       75900 null               0 null
##  3 Abil~ 03/1~      38 null       78000 null               4 null
##  4 Abil~ 04/1~      29 null       66500 null               0 null
##  5 Abil~ 05/1~      29 null       77600 null               0 null
##  6 Abil~ 06/1~      42 null       66500 null               0 null
```

```
##   7 Abil~ 07/1~      48 null       67600 null              18 null
##   8 Abil~ 08/1~      67 null       69000 null               0 null
##   9 Abil~ 09/1~      53 null       60800 null               2 null
##  10 Abil~ 10/1~      80 null       73000 null               2 null
## # ... with 92,935 more rows, and 6 more variables: f24value <dbl>,
## #   f24valchange <chr>, f5units <dbl>, f5change <chr>, f5value <dbl>,
## #   f5valchange <chr>
```

- area = metropolitan standard area
- date = month / year (character vector, or strings)

- f1 = 1 family, f24 = 2-4 families, f5 = 5+ families

- units = number of buildings, change in units; value = average value of building; valchange = change in value

```
permits_raws %>%
  tidyr::separate(data = .,
                  col = date,
                  into = c("month", "year"),
                  sep = "/",
                  convert = TRUE) %>% head()
```

```
## # A tibble: 6 x 15
##   area  month  year f1units f1change f1value f1valchange f24units f24change
##   <chr> <int> <int>   <dbl> <chr>      <dbl> <chr>          <dbl> <chr>
## 1 Abil~     1  1980      24 null       67900 null               4 null
## 2 Abil~     2  1980      39 null       75900 null               0 null
## 3 Abil~     3  1980      38 null       78000 null               4 null
## 4 Abil~     4  1980      29 null       66500 null               0 null
## 5 Abil~     5  1980      29 null       77600 null               0 null
## 6 Abil~     6  1980      42 null       66500 null               0 null
## # ... with 6 more variables: f24value <dbl>, f24valchange <chr>,
## #   f5units <dbl>, f5change <chr>, f5value <dbl>, f5valchange <chr>
```

```
permits <- permits_raws %>%
  tidyr::separate(data = .,
                  col = date,
                  into = c("month", "year"),
                  sep = "/",
                  convert = TRUE)
```

Basic EDA

These are just counts of the categorical data

```
permits %>% dplyr::count(year) %>% utils::head()
```

```
## # A tibble: 6 x 2
##    year     n
##   <int> <int>
## 1  1980   300
## 2  1981   300
## 3  1982   300
## 4  1983   300
## 5  1984   300
## 6  1991   300
```

```r
permits %>% dplyr::count(area) %>% utils::head()
```

```
## # A tibble: 6 x 2
##   area                           n
##   <chr>                      <int>
## 1 Abilene, TX                  392
## 2 Akron, OH                    236
## 3 Albany-Schenectady-Troy, NY   236
## 4 Albany, GA                   236
## 5 Albany, OR                   236
## 6 Albuquerque, NM              236
```

```r
permits %>% dplyr::count(area) %>% dplyr::count(n)
```

```
## # A tibble: 6 x 2
##       n    nn
##   <int> <int>
## 1   128     1
## 2   177     1
## 3   192    14
## 4   236   340
## 5   348     2
## 6   392    23
```

Create `date` variable

This will put time on the x-axis. January 2007 will be 2007, February 2007 with be 2007 plus a little bit more.

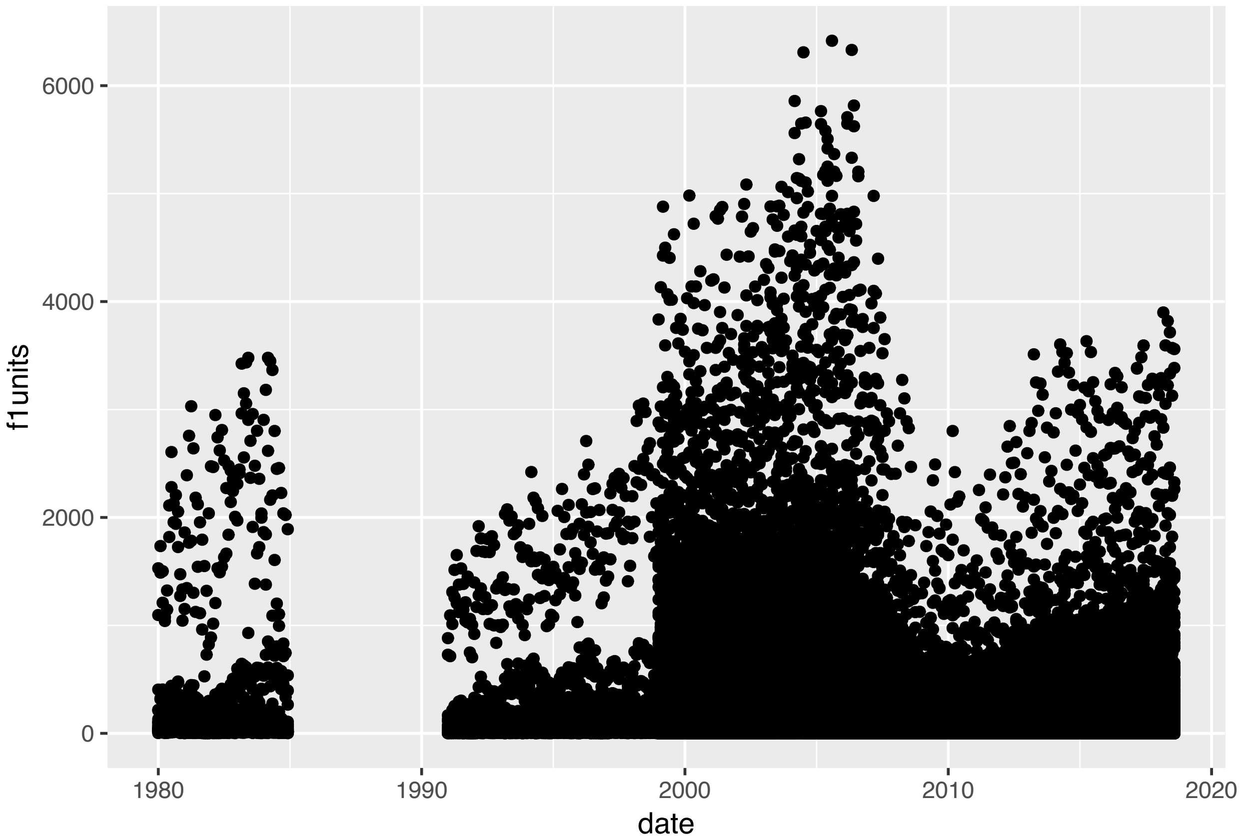
```r
permits <- permits %>%
  dplyr::mutate(date = year + (month - 1) / 12)
permits %>% dplyr::glimpse(78)
```

```
## Observations: 92,945
## Variables: 16
## $ area         <chr> "Abilene, TX", "Abilene, TX", "Abilene, TX", "Abilen...
## $ month        <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1, 2, 3, 4, 5...
## $ year         <int> 1980, 1980, 1980, 1980, 1980, 1980, 1980, 1980, 1980...
## $ f1units      <dbl> 24, 39, 38, 29, 29, 42, 48, 67, 53, 80, 44, 65, 55, ...
## $ f1change     <chr> "null", "null", "null", "null", "null", "null", "nul...
## $ f1value      <dbl> 67900, 75900, 78000, 66500, 77600, 66500, 67600, 690...
## $ f1valchange  <chr> "null", "null", "null", "null", "null", "null", "nul...
## $ f24units     <dbl> 4, 0, 4, 0, 0, 0, 18, 0, 2, 2, 0, 4, 6, 0, 0, 0, 8, ...
## $ f24change    <chr> "null", "null", "null", "null", "null", "null", "nul...
## $ f24value     <dbl> 46200, 0, 37000, 0, 0, 0, 24400, 0, 31200, 23800, 0,...
## $ f24valchange <chr> "null", "null", "null", "null", "null", "null", "nul...
## $ f5units      <dbl> 200, 0, 0, 0, 0, 0, 0, 0, 0, 152, 0, 0, 0, 0, 0, 0, ...
## $ f5change     <chr> "null", "null", "null", "null", "null", "null", "nul...
## $ f5value      <dbl> 12800, 0, 0, 0, 0, 0, 0, 0, 0, 22700, 0, 0, 0, 0, 0,...
## $ f5valchange  <chr> "null", "null", "null", "null", "null", "null", "nul...
## $ date         <dbl> 1980, 1980, 1980, 1980, 1980, 1980, 1980, 1981, 1981...
```

First plot with points.

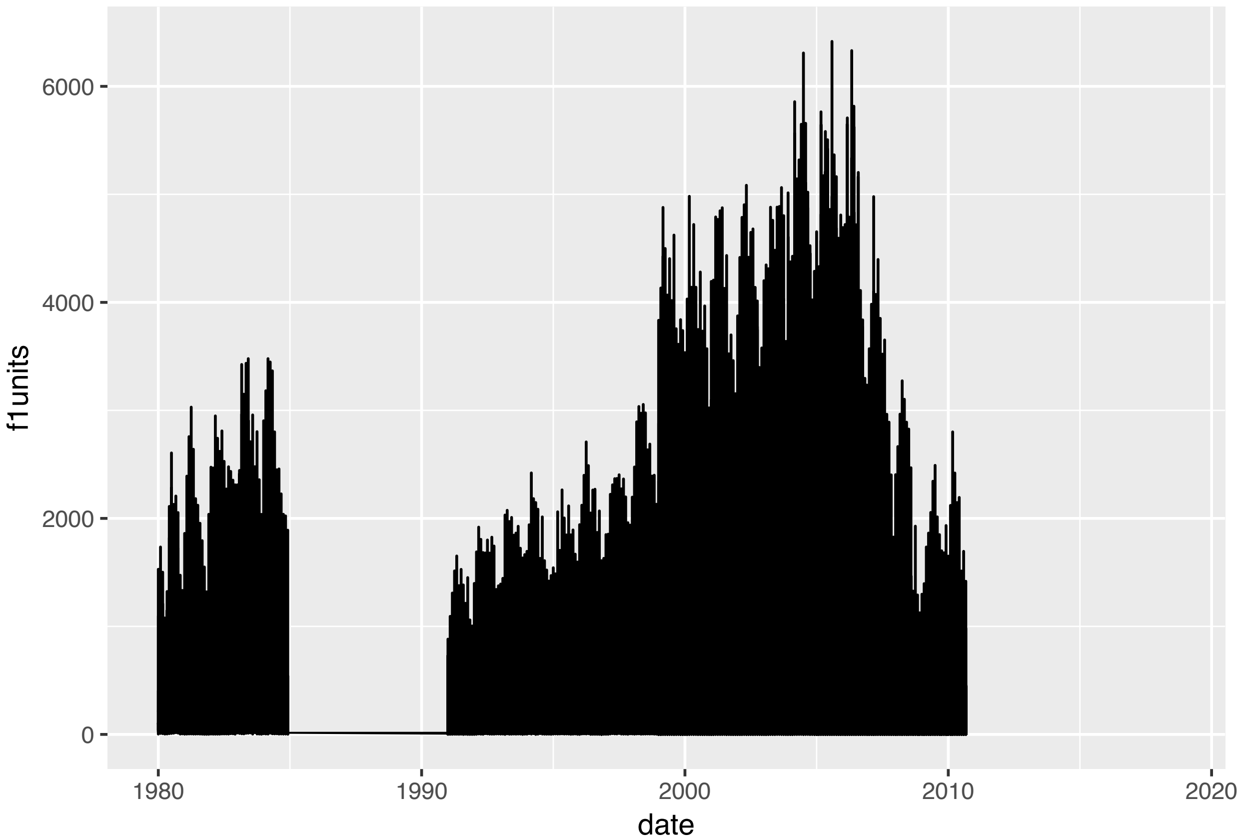
```r
permits %>%
  ggplot(aes(x = date, y = f1units)) +
```

```
    geom_point()
```



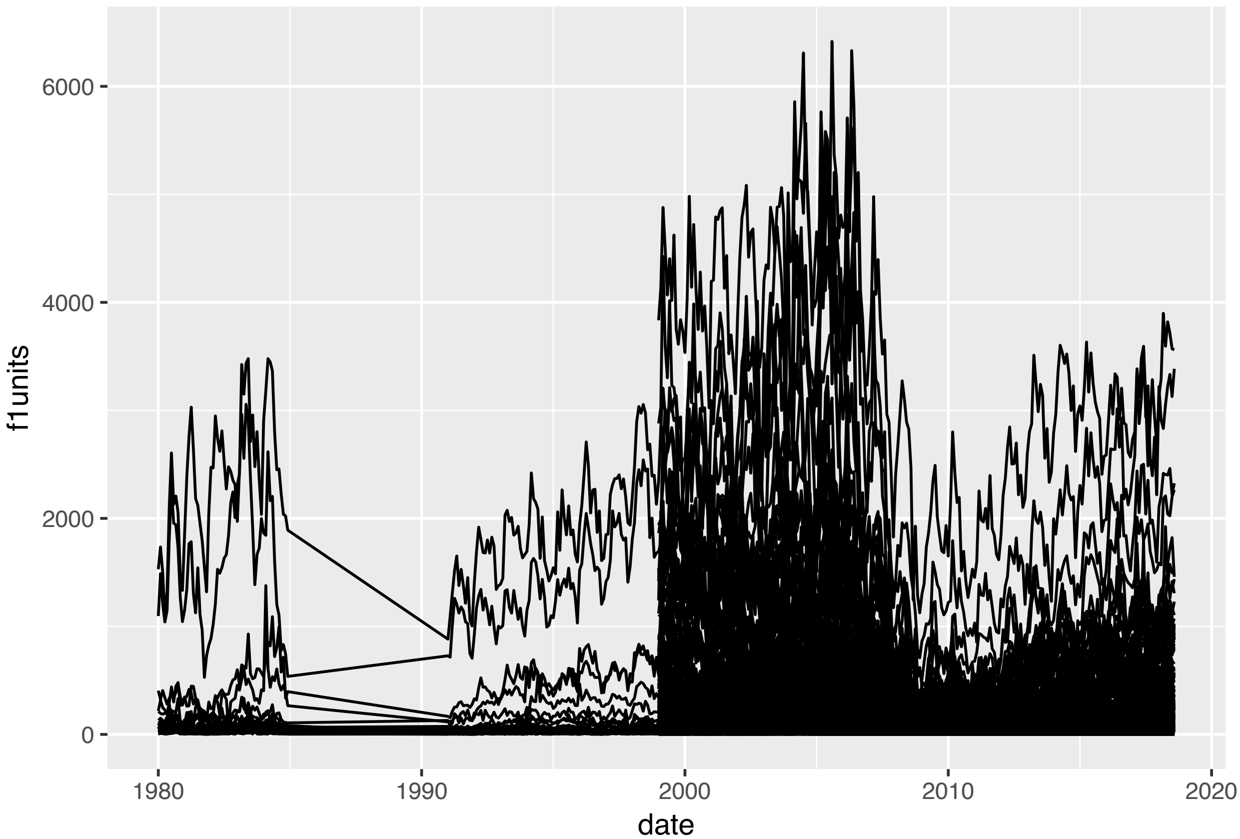
Not very useful. Try lines.

```
permits %>%
  ggplot(aes(x = date, y = f1units)) +
    geom_line()
```



Not useful–needs the `group = area`.

```
permits %>%
  ggplot(aes(x = date, y = f1units)) +
    geom_line(aes(group = area))
```



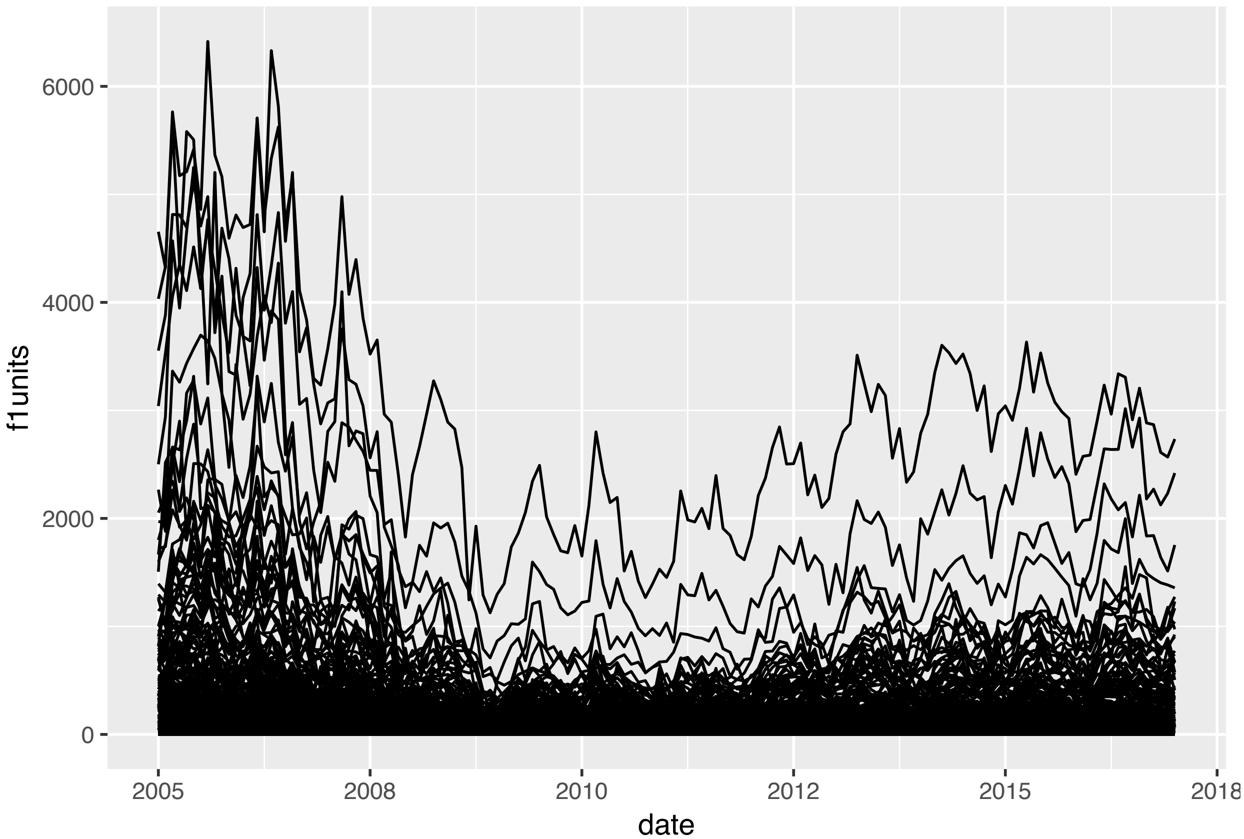
I'm going to limit my plot to 2005 - 2017 to look more like the plot in the video.

Filter data to 2005 - 2017

```
permits <- permits %>% dplyr::filter(date >= 2005 & date <= 2017)
```

Now do this plot again.

```
permits %>%
  ggplot(aes(x = date, y = f1units)) +
    geom_line(aes(group = area))
```



Focus

Focus on big cities. This might bias results (big cities are different than small cities).

```
f1units <- permits %>%
  dplyr::group_by(area) %>%
  dplyr::summarise(mean = mean(f1units)) %>%
  dplyr::arrange(desc(mean))
f1units %>% head(10)
```

```
## # A tibble: 10 x 2
##    area                                          mean
##    <chr>                                        <dbl>
##  1 Houston-The Woodlands-Sugar Land, TX         2897.
##  2 Dallas-Fort Worth-Arlington, TX              2109.
##  3 Atlanta-Sandy Springs-Roswell, GA            1813.
##  4 Phoenix-Mesa-Scottsdale, AZ                  1550.
##  5 Washington-Arlington-Alexandria, DC-VA-MD-WV 1119.
##  6 Riverside-San Bernardino-Ontario, CA         1022.
##  7 Charlotte-Concord-Gastonia, NC-SC            1010.
##  8 Chicago-Naperville-Elgin, IL-IN-WI            971.
##  9 Orlando-Kissimmee-Sanford, FL                 928.
## 10 New York-Newark-Jersey City, NY-NJ-PA         923.
```

Now filter this to those greater than 100 every month.

```
f1units %>%
  # how many cities have a mean f1units over 100?
  dplyr::filter(mean > 100) %>%
```

```r
  # use this to look at the structure of resulting 116
  dplyr::glimpse(78)
```

```
## Observations: 116
## Variables: 2
## $ area <chr> "Houston-The Woodlands-Sugar Land, TX", "Dallas-Fort Worth-A...
## $ mean <dbl> 2897.3, 2109.2, 1813.2, 1550.5, 1119.0, 1022.3, 1010.1, 971....
```

Semi join to permits

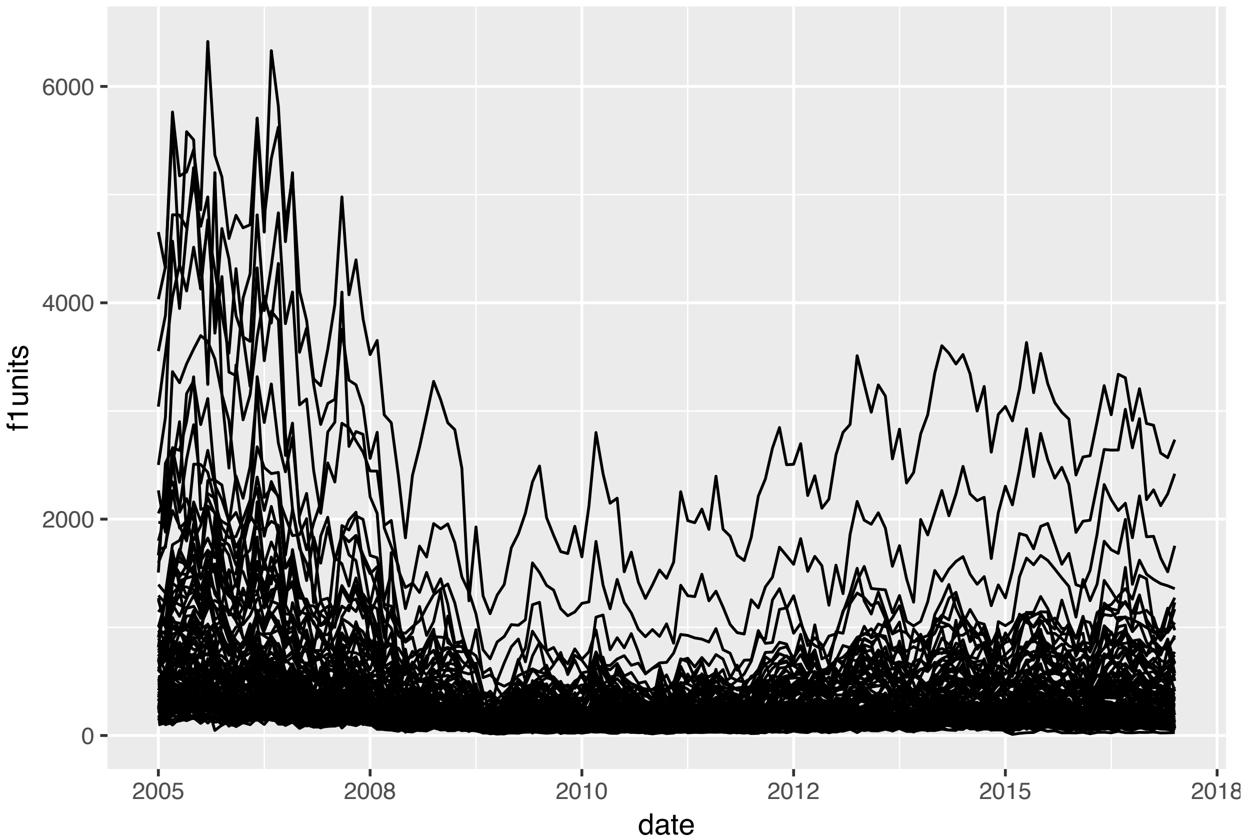
this is a cool trick to get the cities with a mean > 100 (in `f1units` data frame).

```r
permits_big <- permits %>%
  dplyr::semi_join(x = .,
                   # join this to the f1units
                   y = f1units %>%
                     # but filter this to the mean greater than 100
                     dplyr::filter(mean > 100),
                   by = "area")
permits_big %>% dplyr::glimpse(78)
```

```
## Observations: 16,820
## Variables: 16
## $ area        <chr> "Albuquerque, NM", "Albuquerque, NM", "Albuquerque, ...
## $ month       <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1, 2, 3, 4, 5...
## $ year        <int> 2005, 2005, 2005, 2005, 2005, 2005, 2005, 2005, 2005...
## $ f1units     <dbl> 387, 520, 504, 724, 576, 700, 458, 655, 637, 552, 50...
## $ f1change    <chr> "-8.1", "-27.2", "-34.6", "19.1", "-4", "18.6", "-28...
## $ f1value     <dbl> 143600, 143500, 137500, 144200, 144400, 122800, 1440...
## $ f1valchange <chr> "20.4", "29", "18.2", "20.9", "19", "3.4", "14.7", "...
## $ f24units    <dbl> 0, 3, 0, 0, 0, 6, 18, 7, 6, 7, 3, 3, 4, 4, 3, 3, 3, ...
## $ f24change   <chr> "-100", "0", "-100", "-100", "-100", "0", "0", "0", ...
## $ f24value    <dbl> 0, 29100, 0, 0, 0, 55800, 40400, 44300, 55800, 44300...
## $ f24valchange <chr> "-100", "0", "-100", "-100", "-100", "13.6", "0", "0...
## $ f5units     <dbl> 0, 13, 0, 34, 60, 26, 0, 28, 36, 24, 28, 24, 22, 36,...
## $ f5change    <chr> "-100", "0", "0", "142.9", "0", "0", "0", "0", "63.6...
## $ f5value     <dbl> 0, 50000, 0, 29400, 70900, 47900, 0, 47900, 47900, 4...
## $ f5valchange <chr> "-100", "0", "0", "-16", "0", "0", "0", "0", "-58.2"...
## $ date        <dbl> 2005, 2005, 2005, 2005, 2005, 2005, 2006, 2006, 2006...
```

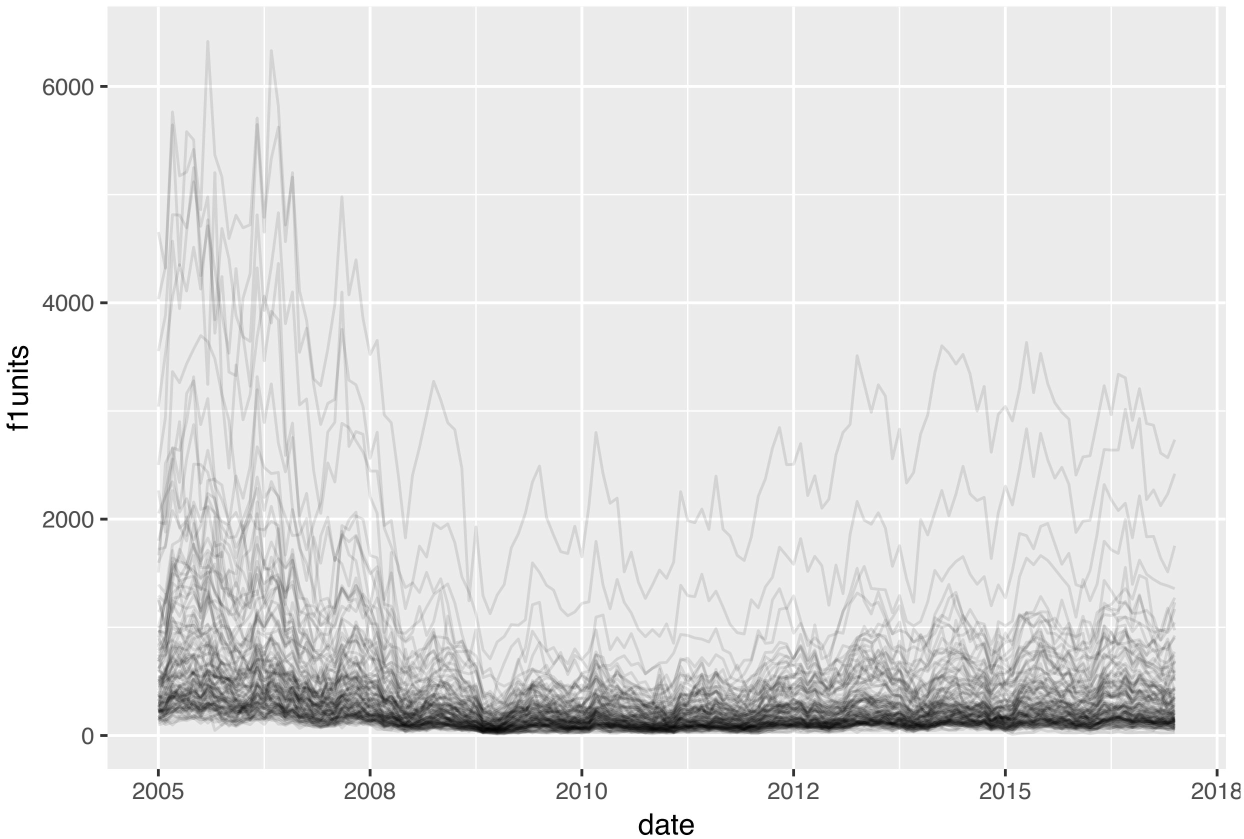
Now redo the plot with `ggplot2::geom_line()` with only big cities.

```r
permits_big %>%
  ggplot2::ggplot(aes(x = date, y = f1units)) +
    ggplot2::geom_line(aes(group = area))
```



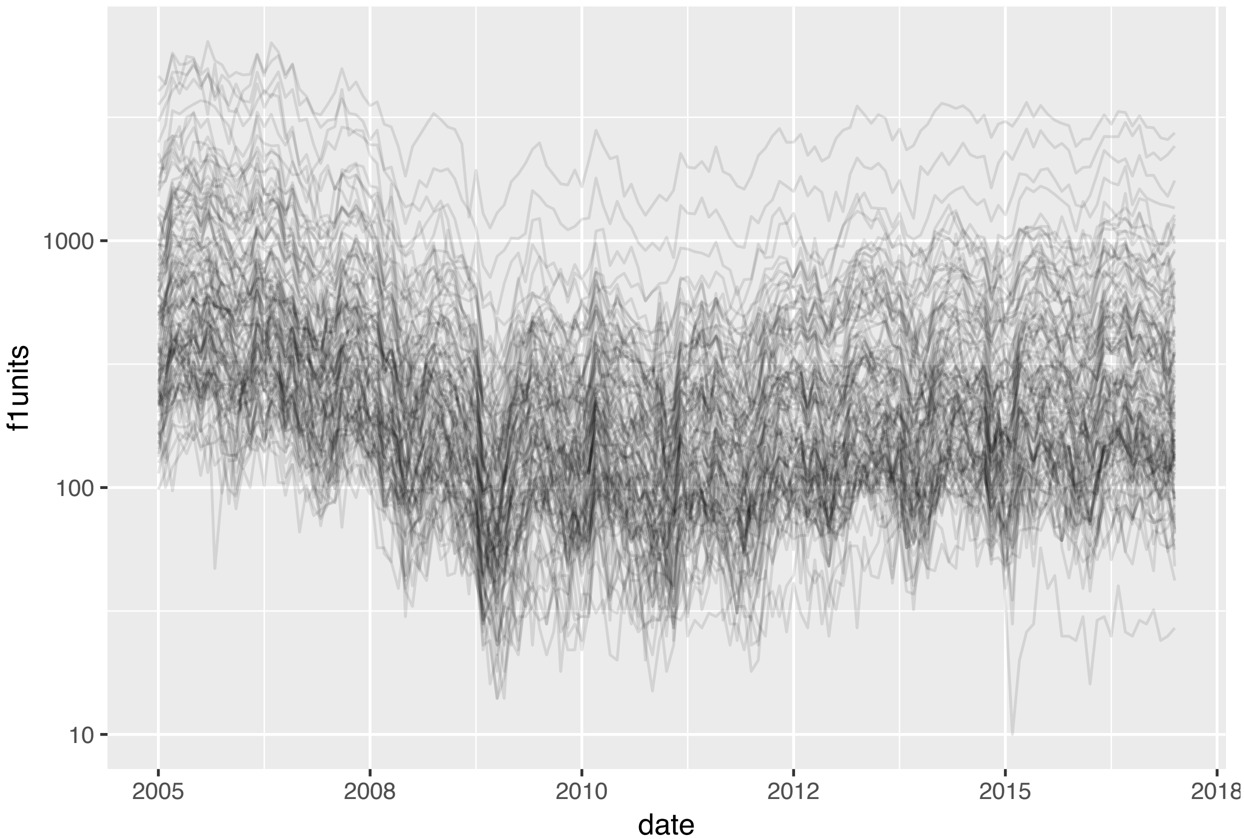
Add the `alpha = 1/10` to see the lines a little clearer…

```
permits_big %>%
  ggplot2::ggplot(aes(x = date, y = f1units)) +
    ggplot2::geom_line(aes(group = area), alpha = 1/10)
```



Add the `ggplot2::scale_y_log10()` to reduce the difference in the biggest and smallest `big` cities.

```
permits_big %>%
  ggplot2::ggplot(aes(x = date, y = f1units)) +
    ggplot2::geom_line(aes(group = area), alpha = 1/10) +
      ggplot2::scale_y_log10()
```

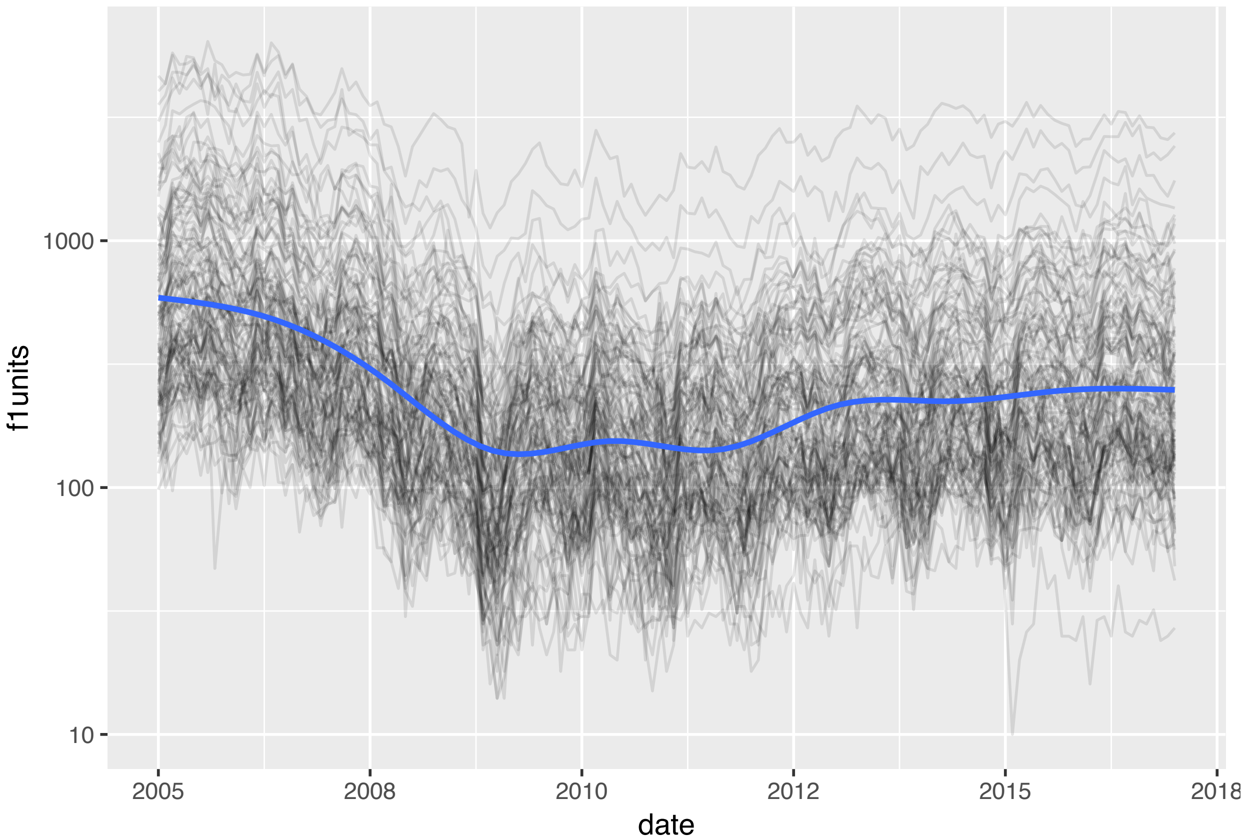


Now we can see a bit of a pattern in the data.

Add a ggplot2::geom_smooth() line to see the long term trends.

```
permits_big %>%
  ggplot2::ggplot(aes(x = date, y = f1units)) +
    ggplot2::geom_line(aes(group = area), alpha = 1/10) +
      ggplot2::scale_y_log10() +
        ggplot2::geom_smooth(se = FALSE)
```

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



Model

Models are a great way to partition the signal into a monthly component.

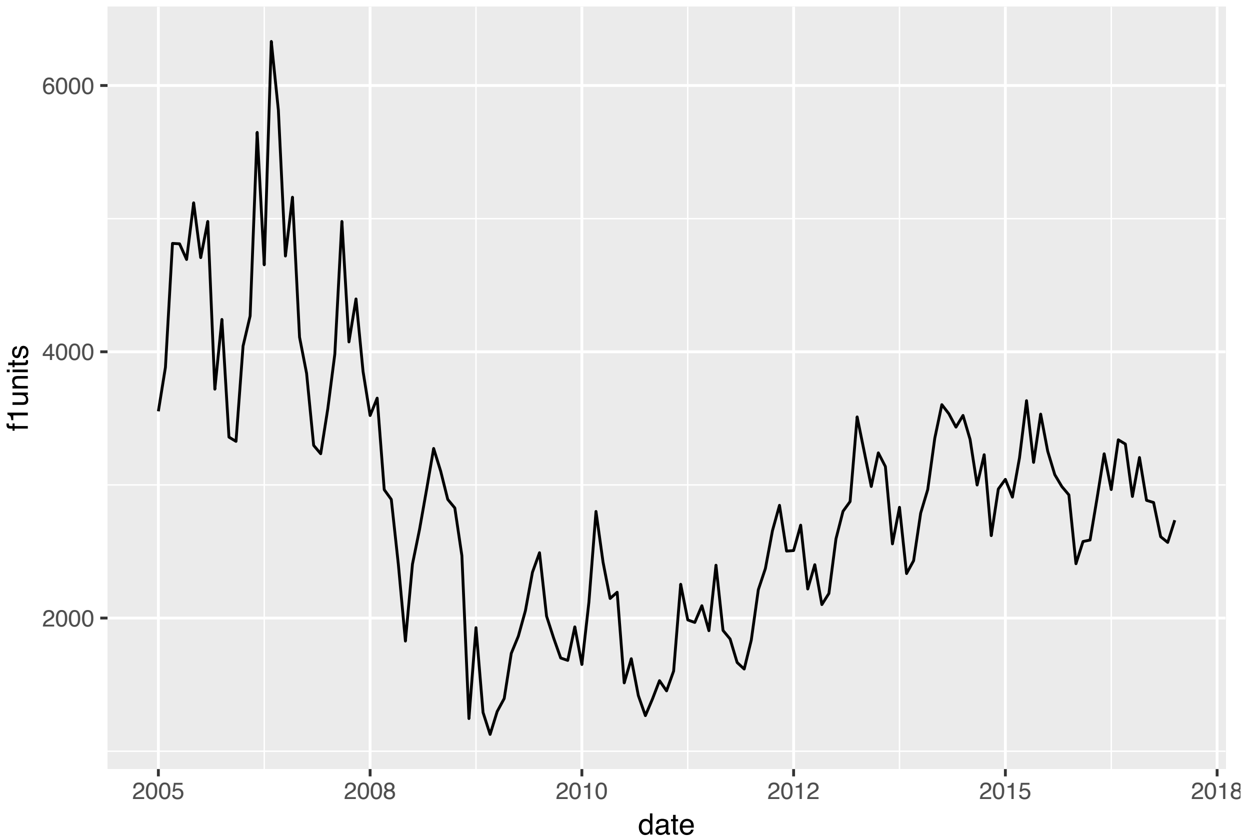
Start with one city "Houston".

```
houston <- permits %>% dplyr::filter(stringr::str_detect(area, "Houston"))
houston %>% dplyr::count(area)
```

```
## # A tibble: 1 x 2
##   area                                    n
##   <chr>                               <int>
## 1 Houston-The Woodlands-Sugar Land, TX   145
```

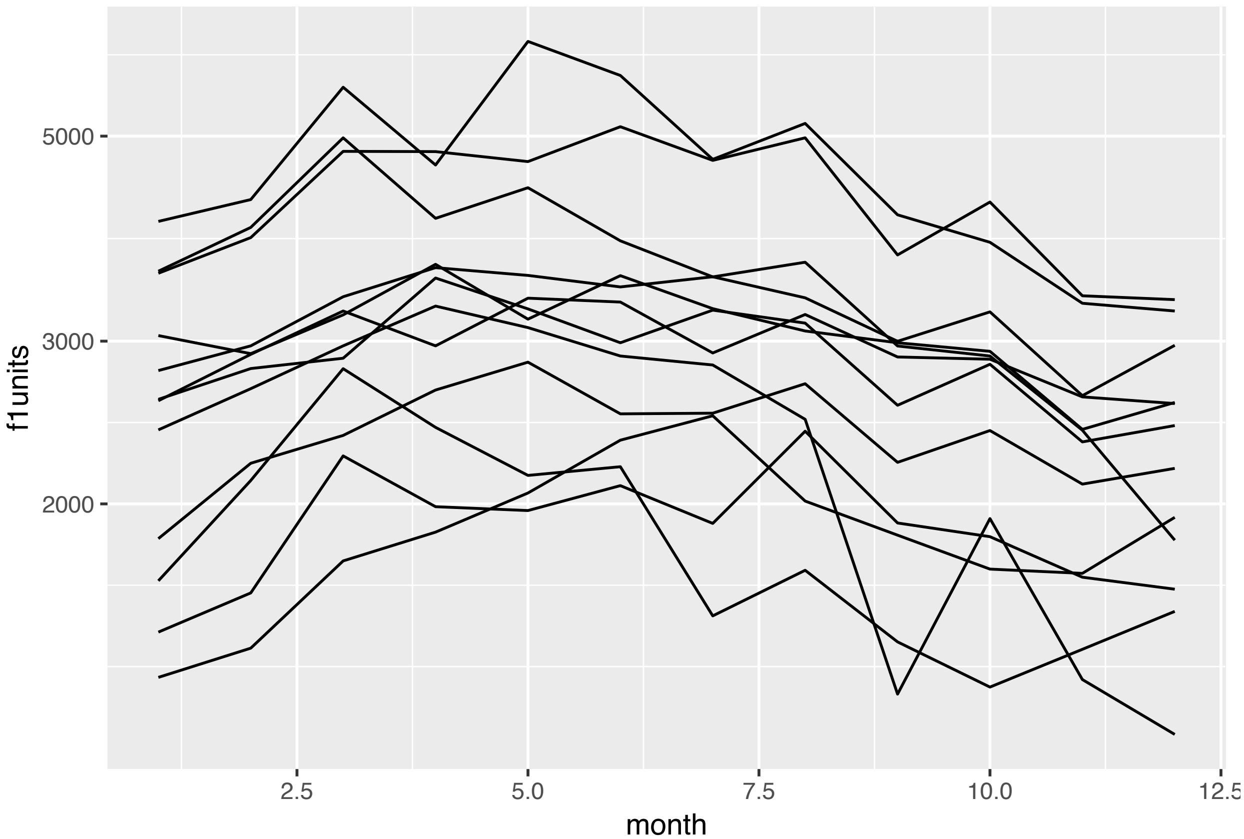
Now plot only Houston.

```
houston %>%
  ggplot2::ggplot(aes(x = date, y = f1units)) +
    ggplot2::geom_line(aes(group = area))
```



Check this again by putting the `month` on the `x` and `group` = `year`.

```
houston %>%
  ggplot2::ggplot(aes(x = month, y = f1units)) +
    ggplot2::geom_line(aes(group = year)) +
      ggplot2::scale_y_log10()
```



This shows more building permits earlier in the year than later in the year.

Questions:

- is this pattern the same everywhere?
- what drives this? is it the weather?
- Houston in July is less pleasant than Houston in December.

We build a model.

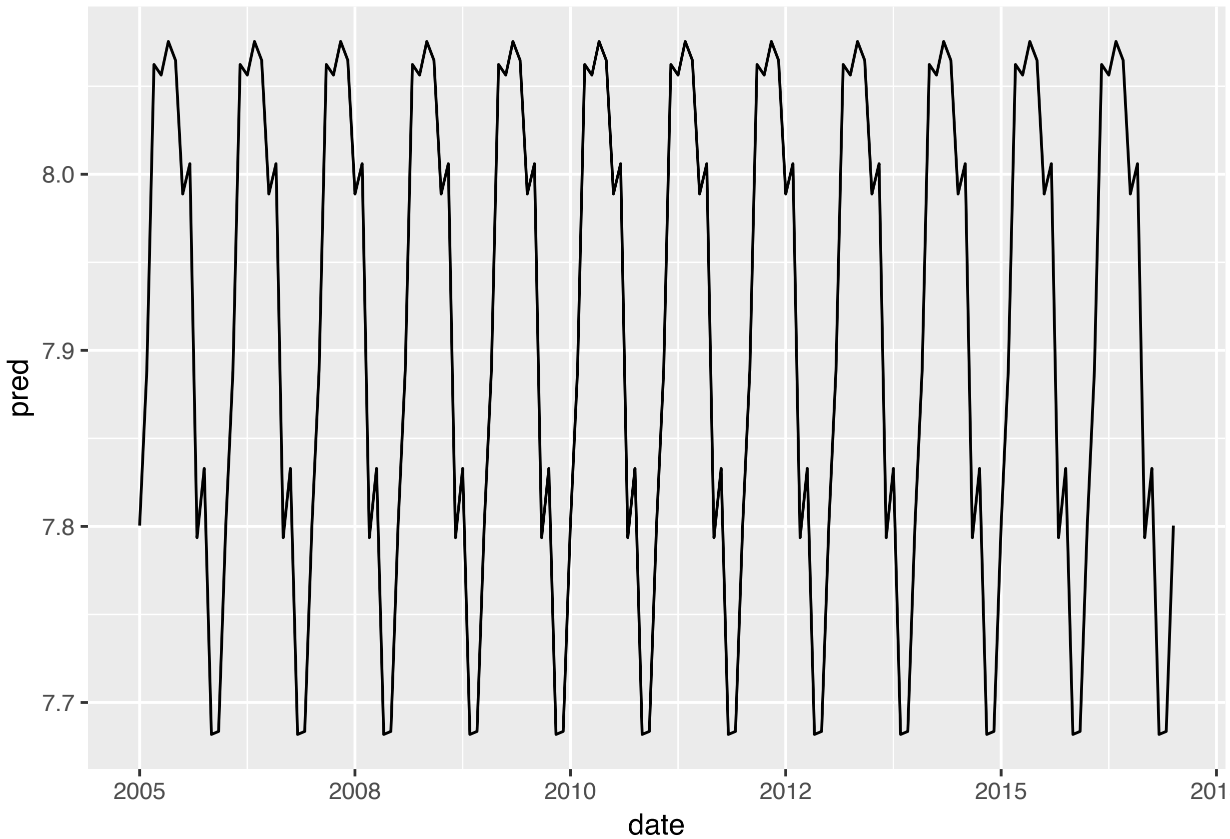
"I don't believe this is a good model, I'm just going to use it to partition this signal into a monthly effect".

```
library(modelr)
houston_mod <- lm(log(f1units) ~ factor(month), data = houston)
```

Look at the predictions

Add the predictions to the model with `modelr::add_predictions()`

```
houston %>%
  # adds a column of predictions to the model
  modelr::add_predictions(houston_mod) %>%
  ggplot2::ggplot(aes(x = date, y = pred)) +
  ggplot2::geom_line()
```

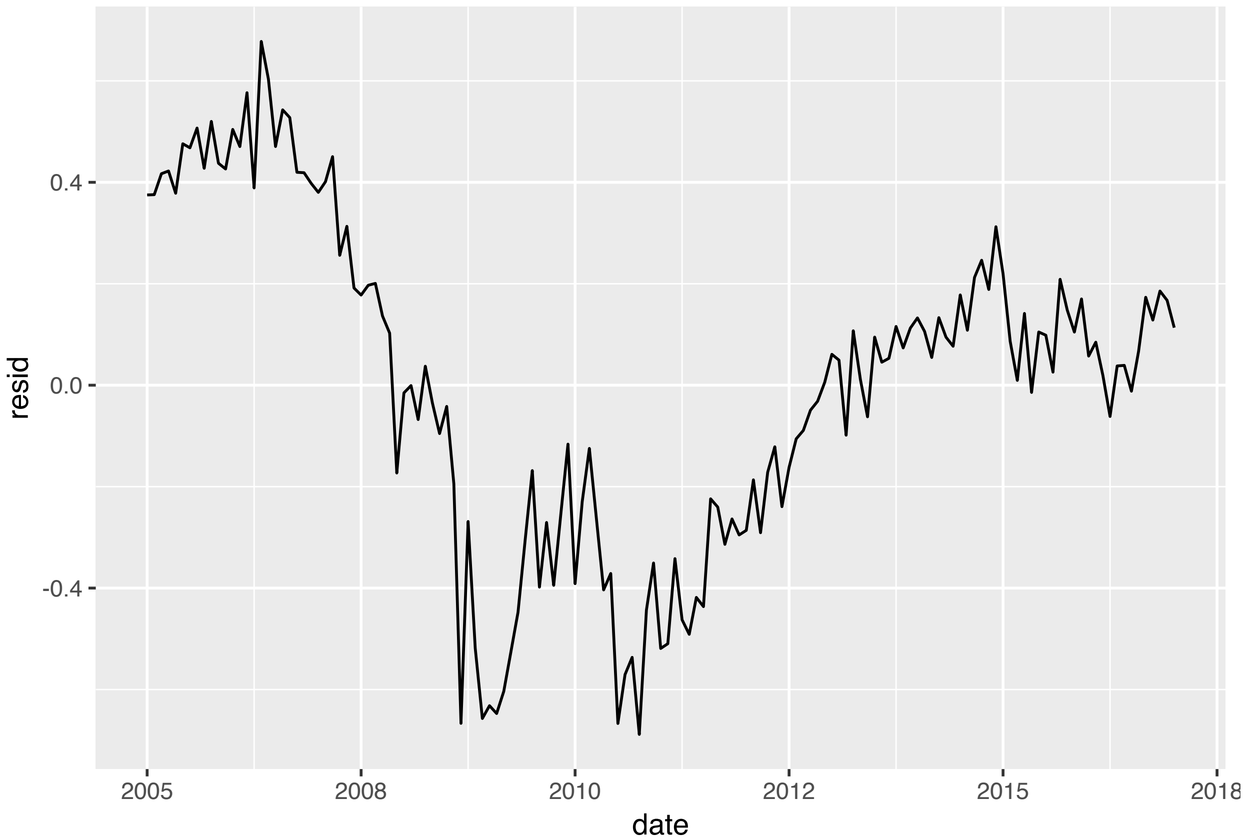


The model has captured the seasonal pattern of the permits.

Look at the residuals

Now look at the residuals or "what remains after we remove the monthly signal" with `modelr::add_residuals()`.

```
houston %>%
  # adds a column of predictions to the model
  modelr::add_residuals(houston_mod) %>%
  ggplot2::ggplot(aes(x = date, y = resid)) +
  ggplot2::geom_line()
```



Now we can see what the pattern is with the monthly pattern removed.

Questions:

- What is driving this trend?
- What happened in 2010?

Extend the model to every city

Now use `dplyr`, `tidyr`, and `purrr` to extend the model to every city in the data set.

The `tidyr::nest()` function works like so:

> `nest()` creates a list of data frames containing all the nested variables: this seems to be the most useful form in practice.

```
by_area <- permits_big %>%
  dplyr::group_by(area) %>%
  tidyr::nest()
by_area %>% utils::head(10)
```

```
## # A tibble: 10 x 2
##    area                                data
##    <chr>                               <list>
##  1 Albuquerque, NM                     <tibble [145 x 15]>
##  2 Allentown-Bethlehem-Easton, PA-NJ <tibble [145 x 15]>
##  3 Asheville, NC                       <tibble [145 x 15]>
##  4 Atlanta-Sandy Springs-Roswell, GA <tibble [145 x 15]>
##  5 Augusta-Richmond County, GA-SC    <tibble [145 x 15]>
```

```
##  6 Austin-Round Rock, TX             <tibble [145 x 15]>
##  7 Bakersfield, CA                   <tibble [145 x 15]>
##  8 Baltimore-Columbia-Towson, MD     <tibble [145 x 15]>
##  9 Baton Rouge, LA                   <tibble [145 x 15]>
## 10 Bend-Redmond, OR                  <tibble [145 x 15]>
```

This dataset has two columns: `area` is a character vector, and `data` is a column that contains a tibble in each row.

```
by_area %>%
  dplyr::select(data) %>%
  utils::head(1) %>%
  utils::str()
```

```
## Classes 'tbl_df', 'tbl' and 'data.frame':    1 obs. of  1 variable:
##  $ data:List of 1
##   ..$ :Classes 'tbl_df', 'tbl' and 'data.frame': 145 obs. of  15 variables:
##   .. ..$ month       : int  1 2 3 4 5 6 7 8 9 10 ...
##   .. ..$ year        : int  2005 2005 2005 2005 2005 2005 2005 2005 2005 2005 ...
##   .. ..$ f1units     : num  387 520 504 724 576 700 458 655 637 552 ...
##   .. ..$ f1change    : chr  "-8.1" "-27.2" "-34.6" "19.1" ...
##   .. ..$ f1value     : num  143600 143500 137500 144200 144400 ...
##   .. ..$ f1valchange : chr  "20.4" "29" "18.2" "20.9" ...
##   .. ..$ f24units    : num  0 3 0 0 0 6 18 7 6 7 ...
##   .. ..$ f24change   : chr  "-100" "0" "-100" "-100" ...
##   .. ..$ f24value    : num  0 29100 0 0 0 55800 40400 44300 55800 44300 ...
##   .. ..$ f24valchange: chr  "-100" "0" "-100" "-100" ...
##   .. ..$ f5units     : num  0 13 0 34 60 26 0 28 36 24 ...
##   .. ..$ f5change    : chr  "-100" "0" "0" "142.9" ...
##   .. ..$ f5value     : num  0 50000 0 29400 70900 47900 0 47900 47900 47900 ...
##   .. ..$ f5valchange : chr  "-100" "0" "0" "-16" ...
##   .. ..$ date        : num  2005 2005 2005 2005 2005 ...
```

`area_model` is the function we will build to extend the model.

```
area_model <- function(df) {
  lm(log10(f1units + 1) ~ factor(x = month), data = df)
}
```

Now we use `purrr::map()` and `purrr::map2()` to extend the model function to each tibble in the `by_area` data frame.

```
detrended <- by_area %>% dplyr::mutate(
  model = purrr::map(.x = data, .f = area_model),
  # add_residuals is from modelr
  resids = purrr::map2(.x = data, .y = model, .f = add_residuals)
) %>% tidyr::unnest(resids)
detrended %>% glimpse(78)
```

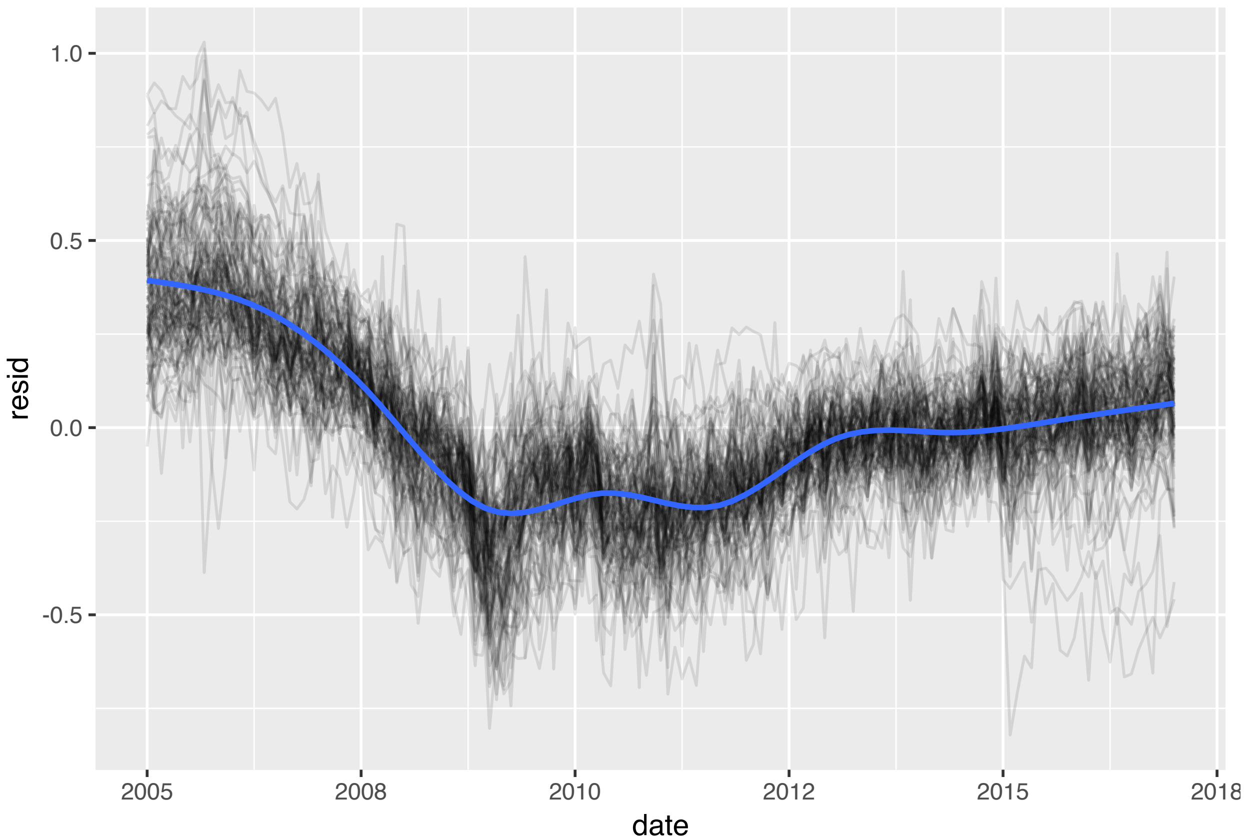
```
## Observations: 16,820
## Variables: 17
## $ area         <chr> "Albuquerque, NM", "Albuquerque, NM", "Albuquerque, ...
## $ month        <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1, 2, 3, 4, 5...
## $ year         <int> 2005, 2005, 2005, 2005, 2005, 2005, 2005, 2005, 2005...
## $ f1units      <dbl> 387, 520, 504, 724, 576, 700, 458, 655, 637, 552, 50...
## $ f1change     <chr> "-8.1", "-27.2", "-34.6", "19.1", "-4", "18.6", "-28...
## $ f1value      <dbl> 143600, 143500, 137500, 144200, 144400, 122800, 1440...
```

```
## $ f1valchange  <chr> "20.4", "29", "18.2", "20.9", "19", "3.4", "14.7", "...
## $ f24units     <dbl> 0, 3, 0, 0, 0, 6, 18, 7, 6, 7, 3, 3, 4, 4, 3, 3, 3, ...
## $ f24change    <chr> "-100", "0", "-100", "-100", "-100", "0", "0", "0", ...
## $ f24value     <dbl> 0, 29100, 0, 0, 0, 55800, 40400, 44300, 55800, 44300...
## $ f24valchange <chr> "-100", "0", "-100", "-100", "-100", "13.6", "0", "0...
## $ f5units      <dbl> 0, 13, 0, 34, 60, 26, 0, 28, 36, 24, 28, 24, 22, 36,...
## $ f5change     <chr> "-100", "0", "0", "142.9", "0", "0", "0", "0", "63.6...
## $ f5value      <dbl> 0, 50000, 0, 29400, 70900, 47900, 0, 47900, 47900, 4...
## $ f5valchange  <chr> "-100", "0", "0", "-16", "0", "0", "0", "0", "-58.2"...
## $ date         <dbl> 2005, 2005, 2005, 2005, 2005, 2005, 2006, 2006, 2006...
## $ resid        <dbl> 0.3797, 0.4849, 0.3871, 0.5310, 0.4183, 0.4724, 0.36...
```

Now we plot the new model data in `resid` column.

```r
detrended %>%
  ggplot2::ggplot(aes(x = date, y = resid)) +
    ggplot2::geom_line(aes(group = area), alpha = 1/10) +
        ggplot2::geom_smooth(se = FALSE)
```

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

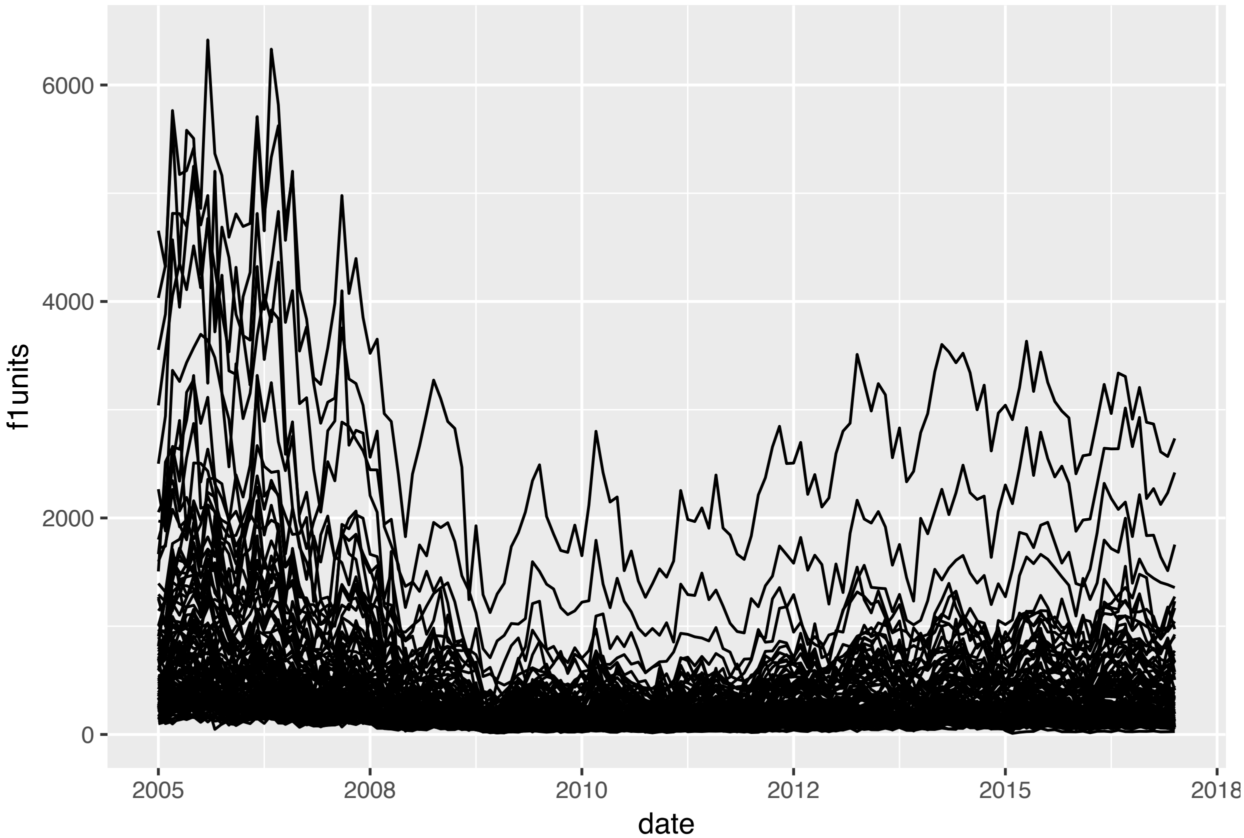


This final plot tells us this pattern affects all cities in the data set.

Final thoughts

1. Great problem solving strategy: You have a big problem to solve, start with one small piece (Houston), solve it, then generalize this to the rest of the problem.
2. The entire analysis was motivated by this plot:

```
permits_big %>%
  ggplot2::ggplot(aes(x = date, y = f1units)) +
    ggplot2::geom_line(aes(group = area))
```



After the manipulations, log transformations, and adding `ggplot2::geom_smooth()`, we can build a model to see how much the seasonal pattern contributes to the overall variation.