Time Series HW 2

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September 9, 2016

```
## Allison's code

rawbozemandata <- read.csv("https://dl.dropboxusercontent.com/u/77307195/rawbozemandata.csv",
                           header = T)

library(dplyr, quietly = T)
library(zoo, quietly = T)

rawd <- tbl_df(rawbozemandata) %>%
  mutate(DATE = as.yearmon(as.character(DATE), "%Y%m"))

rawd2 <- mutate(rawd, YEAR = as.numeric(format(DATE, "%Y"))) %>%
  mutate(MONTH = as.factor(format(DATE, "%m")))

rawd2 <- mutate(rawd2, YEARFRAC = YEAR + (as.numeric(MONTH) - 1)/12)
```

```
## Andrea's code
setwd("C:/Users/Andrea Mack/Desktop/mack_hub/course_work/Time Series/Homework/HW2")
rawbozemandata <- read.csv("rawbozemandata.csv", stringsAsFactors = FALSE)
rawd <- NULL
rawd <- data.frame(rawbozemandata)
rawd$year <- as.numeric(substring(rawd$DATE, 1,4))
rawd$month <- as.numeric(substring(rawd$DATE, 5,6))
rawd$month.dec <- rawd$month/12
rawd$date.new <- rawd$year + rawd$month.dec
rawd$month <- month.abb[((rawd$month))]
rawd$temp <- rawd$MMXT
```

1.

The model using the linear time trend for year and month is:

$$\widehat{temp_i} = -69.2902 + 0.0517 \text{ Year}_i + 3.7058 \text{ I(February)} + 11.198 \text{ I(March)} + 21.9902 \text{ I(April)} + 31.2412 \text{ I(May)} + 39.7299 \text{ I(June)} + 49.5908 \text{ I(July)} + 48.496 \text{ I(August)} + 37.6638 \text{ I(September)} + 25.8609 \text{ I(October)} + 10.3582 \text{ I(November)} + 1.7802 \text{ I(December)}$$

2.

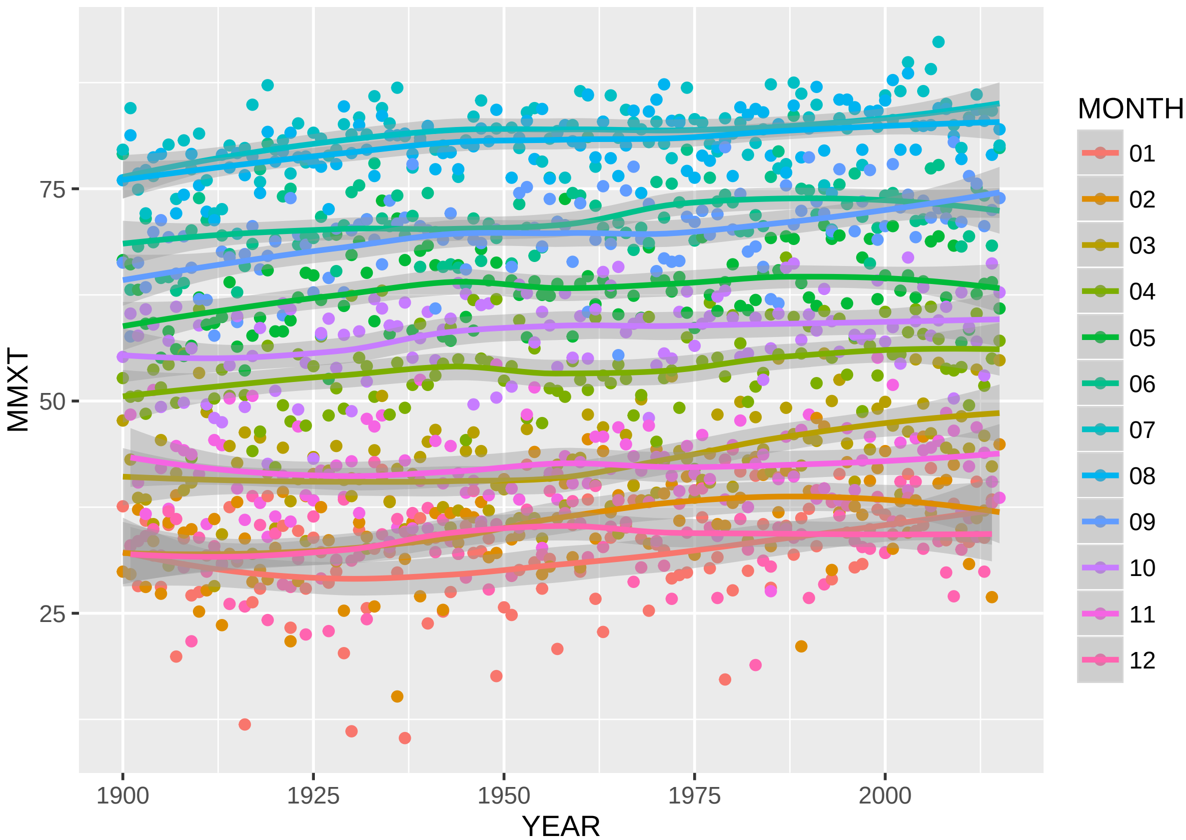
The model for January is as follows:

$$\widehat{temp_i} = -69.2902 + 0.0517 \text{ Year}_i$$

The model for July is as follows:

$$\widehat{temp_i} = -19.6994 + 0.0517 \text{ Year}_i$$

3.



It appears that December and November average temperatures have not changed much from 1900 to 2015, while January and March appear to have the most substantial increases over the 115 year period. It appears that average monthly temperature increased about 5 ° F over the 115 years, which is quite similar to the average rate of increase we discussed in the Oregon State temperature data in class.

4.

Below is the ANOVA table for testing if the the effect of time differs by month, using Type II sums of squares. We see in the table that there is strong evidence that the relationship between time and the mean temperature differs by month (F-stat = 2.1295 on an F(11, 1350) distribution, p-value = 0.016).

Table 1: Anova Table (Type II tests)

	Sum Sq	Df	F value	Pr(>F)
YEAR	4108	1	196.1	1.034e-41
MONTH	408393	11	1773	0
YEAR:MONTH	490.6	11	2.129	0.01603
Residuals	28276	1350	NA	NA

5.

```
  01   02   03   04   05   06   07   08   09   10   11   12 
 "a"  "b"  "c"  "d"  "f"  "h"  "i"  "i"  "g"  "e"  "c" "ab" 


     Simultaneous Confidence Intervals

Multiple Comparisons of Means: Tukey Contrasts


Fit: lm(formula = MMXT ~ YEAR + MONTH, data = rawd2)

Quantile = 3.2712
95% family-wise confidence level
 

Linear Hypotheses:
             Estimate  lwr       upr      
02 - 01 == 0   3.70575   1.72673   5.68477
03 - 01 == 0  11.19799   9.21897  13.17701
04 - 01 == 0  21.99024  20.01122  23.96925
05 - 01 == 0  31.24123  29.25793  33.22453
06 - 01 == 0  39.72992  37.74662  41.71322
07 - 01 == 0  49.59080  47.59871  51.58289
08 - 01 == 0  48.49598  46.50831  50.48365
09 - 01 == 0  37.66381  35.67177  39.65586
10 - 01 == 0  25.86088  23.87325  27.84852
11 - 01 == 0  10.35817   8.37049  12.34585
12 - 01 == 0   1.78021  -0.21184   3.77227
03 - 02 == 0   7.49224   5.51752   9.46696
04 - 02 == 0  18.28448  16.30976  20.25920
05 - 02 == 0  27.53548  25.55647  29.51449
06 - 02 == 0  36.02417  34.04516  38.00318
07 - 02 == 0  45.88505  43.89725  47.87285
08 - 02 == 0  44.79023  42.80685  46.77360
09 - 02 == 0  33.95806  31.97028  35.94585
10 - 02 == 0  22.15513  20.17176  24.13850
11 - 02 == 0   6.65242   4.66904   8.63579
12 - 02 == 0  -1.92554  -3.91332   0.06225
04 - 03 == 0  10.79224   8.81752  12.76696
05 - 03 == 0  20.04323  18.06422  22.02224
06 - 03 == 0  28.53193  26.55292  30.51094
07 - 03 == 0  38.39281  36.40501  40.38061
08 - 03 == 0  37.29798  35.31461  39.28136
09 - 03 == 0  26.46582  24.47803  28.45361
10 - 03 == 0  14.66289  12.67952  16.64625
11 - 03 == 0  -0.83982  -2.82320   1.14355
12 - 03 == 0  -9.41778 -11.40556  -7.42999
05 - 04 == 0   9.25099   7.27198  11.23000
06 - 04 == 0  17.73969  15.76068  19.71870
07 - 04 == 0  27.60056  25.61277  29.58836
08 - 04 == 0  26.50574  24.52237  28.48912
09 - 04 == 0  15.67358  13.68579  17.66137
```

```
10 - 04 == 0   3.87065   1.88728   5.85401
11 - 04 == 0 -11.63206 -13.61544  -9.64869
12 - 04 == 0 -20.21002 -22.19781 -18.22224
06 - 05 == 0   8.48870   6.50541  10.47198
07 - 05 == 0  18.34957  16.35752  20.34163
08 - 05 == 0  17.25475  15.26711  19.24239
09 - 05 == 0   6.42259   4.43054   8.41463
10 - 05 == 0  -5.38035  -7.36798  -3.39271
11 - 05 == 0 -20.88306 -22.87070 -18.89541
12 - 05 == 0 -29.46101 -31.45306 -27.46897
07 - 06 == 0   9.86088   7.86882  11.85293
08 - 06 == 0   8.76605   6.77841  10.75370
09 - 06 == 0  -2.06611  -4.05816  -0.07406
10 - 06 == 0 -13.86904 -15.85668 -11.88140
11 - 06 == 0 -29.37175 -31.35940 -27.38411
12 - 06 == 0 -37.94971 -39.94175 -35.95766
08 - 07 == 0  -1.09482  -3.09119   0.90155
09 - 07 == 0 -11.92699 -13.92777  -9.92620
10 - 07 == 0 -23.72992 -25.72632 -21.73352
11 - 07 == 0 -39.23263 -41.22900 -37.23626
12 - 07 == 0 -47.81059 -49.81136 -45.80981
09 - 08 == 0 -10.83216 -12.82855  -8.83577
10 - 08 == 0 -22.63510 -24.62709 -20.64311
11 - 08 == 0 -38.13781 -40.12978 -36.14584
12 - 08 == 0 -46.71576 -48.71214 -44.71939
10 - 09 == 0 -11.80293 -13.79930  -9.80656
11 - 09 == 0 -27.30564 -29.30204 -25.30925
12 - 09 == 0 -35.88360 -37.88437 -33.88284
11 - 10 == 0 -15.50271 -17.49470 -13.51072
12 - 10 == 0 -24.08067 -26.07704 -22.08429
12 - 11 == 0  -8.57796 -10.57434  -6.58158
```

Using the above compact letter display, we see that the following months are not detectalbly different from each other, after accounting for the linear relationship between average temperatures and year.

- January and December
- February and December
- November and March

Overall, there is strong evidence that August and July were the warmest months on average and after accounting for yearly temperature changes. There was strong evidence that June was the next warmest, followed by September, then May, then October, then April, then March, and then November on average and after accounting for yearly temperature changes. There is strong evidence that December and Feburary were the coolest months on average and after accounting for yearly temperature changes with no evidence of a difference between January and December under similar model conditions.

6.

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-316	477	-0.663	0.507
MONTH02	3.71	0.605	6.13	1.18e-09

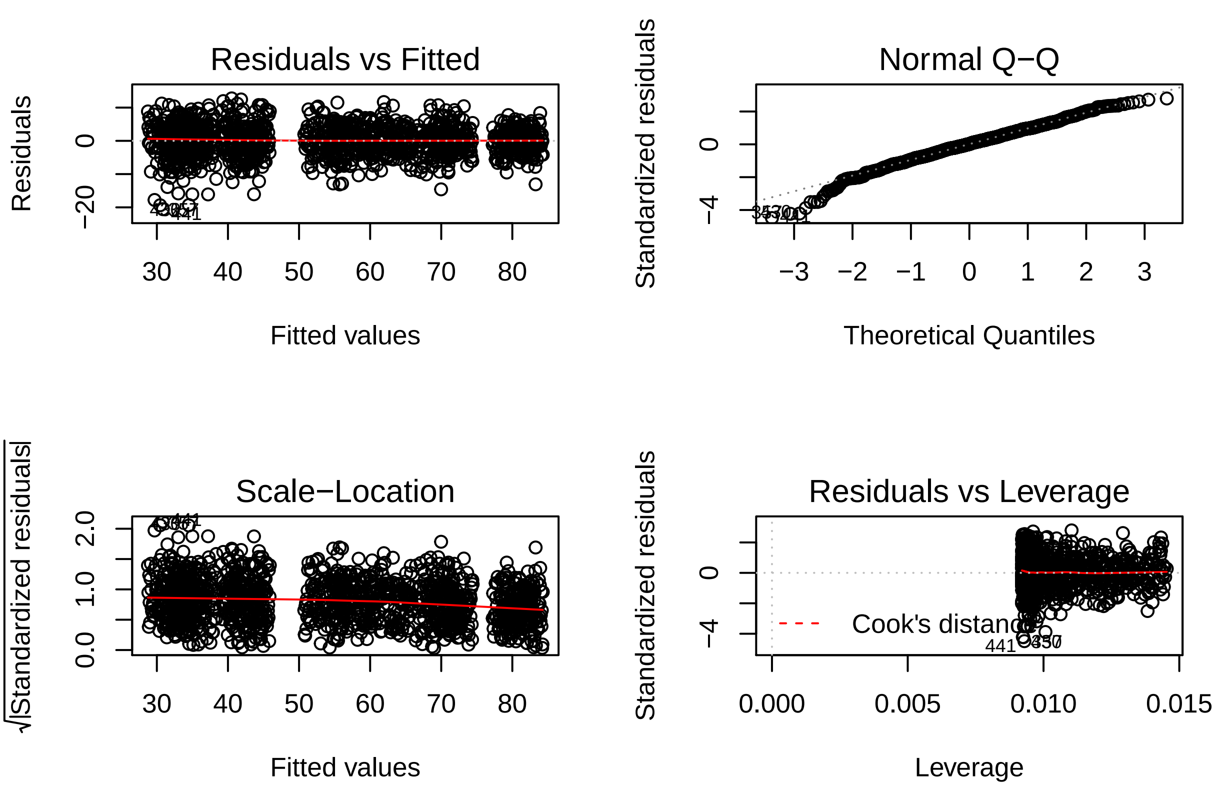
	Estimate	Std. Error	t value	Pr(>|t|)
MONTH03	11.2	0.605	18.5	2.24e-68
MONTH04	22	0.605	36.3	1.24e-202
MONTH05	31.2	0.606	51.5	6.32e-322
MONTH06	39.7	0.606	65.5	0
MONTH07	49.6	0.609	81.4	0
MONTH08	48.5	0.608	79.8	0
MONTH09	37.7	0.609	61.8	0
MONTH10	25.9	0.608	42.6	3.03e-252
MONTH11	10.4	0.608	17	3.5e-59
MONTH12	1.78	0.609	2.92	0.00354
YEAR	0.304	0.487	0.624	0.533
I(YEAR^2)	-6.45e-05	0.000125	-0.518	0.604

Testing for evidence of a quadratic relationship between average temperatures and year, after accounting for monthly variation and a linear year trend, we have the following hypothesis:

$H_0 : \beta_{year^2} = 0$ $H_A : \beta_{year^2} \neq 0$

Using the above model output, there is no evidence of a quadratic relationship between average temperatures and year, after accounting for monthly variation and a linear year trend (t-stat = -0.518 $\sim t_{1360}$, p-value = 0.604).

7.



The monthly discreteness is apparent in the clumps in the residuals vs. fitted plot. It does appear that there is less spread in the larger fitted values than the smaller. Hence, the fitted values for the summer months show less variability than the fitted values for the cooler months. We also note the scale of the residuals, with residuals near -20 occurring in the cooler months. Observation 441, a January measurement in 1937 with a MMXT of 10.3, differs from all other January measurements by nearly 10 units.

8.

```r
## Allison's R Version
getRversion()
```

```
## [1] '3.3.1'
```