Linear model analysis for temperature difference size

2025-01-02 12:15:28.238805

```r
library(viridisLite)
```

Temperature difference.

```r
d2$dtemp <- d2$Itemp - d2$Otemp
```

Check interpretation.

```r
d2[, plot := factor(plot)]
```

Should have 0 or 1 below.

```r
table(table(d2[, .(plot, t.start)]))
```

```
##
##     0     1
## 11432  7240
```

Looks good.

```r
fit1 <- lm(Itemp ~ poly(glorad, 3) + poly(Otemp, 3) + poly(wv2, 3) + plot, data = d2)
fit2 <- lm(dtemp ~ poly(glorad, 3) + poly(Otemp, 3) + poly(wv2, 3) + plot, data = d2)
fit2e <- lm(dtemp ~ glorad + I(glorad^2) + I(glorad^3) + Otemp + I(Otemp^2) + I(Otemp^3) +
        wv2 + I(wv2^2) + I(wv2^3) + plot, data = d2)
```

Check results

```r
summary(fit1)
```

```
##
## Call:
## lm(formula = Itemp ~ poly(glorad, 3) + poly(Otemp, 3) + poly(wv2,
##     3) + plot, data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.8317 -0.5689  0.0357  0.5755  7.5907
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)      15.084995   0.055754 270.565  < 2e-16 ***
```

```
## poly(glorad, 3)1   47.930745    1.594028   30.069  < 2e-16 ***
## poly(glorad, 3)2   -6.182799    1.246392   -4.961 7.19e-07 ***
## poly(glorad, 3)3    5.058263    1.214504    4.165 3.15e-05 ***
## poly(Otemp, 3)1   472.015367    1.382576  341.403  < 2e-16 ***
## poly(Otemp, 3)2    62.942758    1.238102   50.838  < 2e-16 ***
## poly(Otemp, 3)3    37.858014    1.224645   30.913  < 2e-16 ***
## poly(wv2, 3)1      -0.856308    1.419662   -0.603 0.546410
## poly(wv2, 3)2      -1.136325    1.259987   -0.902 0.367164
## poly(wv2, 3)3      -4.743684    1.222402   -3.881 0.000105 ***
## plot10              0.007191    0.078847    0.091 0.927335
## plot11              0.015696    0.078891    0.199 0.842306
## plot12              0.018574    0.078891    0.235 0.813871
## plot13              0.005582    0.078891    0.071 0.943596
## plot14             -0.015785    0.078888   -0.200 0.841413
## plot15              0.004344    0.078886    0.055 0.956083
## plot16             -0.034357    0.081828   -0.420 0.674596
## plot2               0.001819    0.078842    0.023 0.981599
## plot3              -0.001051    0.078801   -0.013 0.989360
## plot4               0.003512    0.078804    0.045 0.964453
## plot5              -0.020237    0.078805   -0.257 0.797340
## plot6              -0.046848    0.078762   -0.595 0.551992
## plot7              -0.036003    0.078761   -0.457 0.647604
## plot8              -0.011158    0.078845   -0.142 0.887468
## plot9              -0.046847    0.081813   -0.573 0.566924
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.196 on 7215 degrees of freedom
## Multiple R-squared:  0.9607, Adjusted R-squared:  0.9606
## F-statistic:  7350 on 24 and 7215 DF,  p-value: < 2.2e-16
```

```r
summary(fit2)
```

```
##
## Call:
## lm(formula = dtemp ~ poly(glorad, 3) + poly(Otemp, 3) + poly(wv2,
##     3) + plot, data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.8317 -0.5689  0.0357  0.5755  7.5907
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       1.127169   0.055754  20.217  < 2e-16 ***
## poly(glorad, 3)1 47.930745   1.594028  30.069  < 2e-16 ***
## poly(glorad, 3)2 -6.182799   1.246392  -4.961 7.19e-07 ***
## poly(glorad, 3)3  5.058263   1.214504   4.165 3.15e-05 ***
## poly(Otemp, 3)1  80.782856   1.382576  58.429  < 2e-16 ***
## poly(Otemp, 3)2  62.942758   1.238102  50.838  < 2e-16 ***
## poly(Otemp, 3)3  37.858014   1.224645  30.913  < 2e-16 ***
## poly(wv2, 3)1    -0.856308   1.419662  -0.603 0.546410
## poly(wv2, 3)2    -1.136325   1.259987  -0.902 0.367164
## poly(wv2, 3)3    -4.743684   1.222402  -3.881 0.000105 ***
```

```
## plot10                0.007191   0.078847   0.091 0.927335
## plot11                0.015696   0.078891   0.199 0.842306
## plot12                0.018574   0.078891   0.235 0.813871
## plot13                0.005582   0.078891   0.071 0.943596
## plot14               -0.015785   0.078888  -0.200 0.841413
## plot15                0.004344   0.078886   0.055 0.956083
## plot16               -0.034357   0.081828  -0.420 0.674596
## plot2                 0.001819   0.078842   0.023 0.981599
## plot3                -0.001051   0.078801  -0.013 0.989360
## plot4                 0.003512   0.078804   0.045 0.964453
## plot5                -0.020237   0.078805  -0.257 0.797340
## plot6                -0.046848   0.078762  -0.595 0.551992
## plot7                -0.036003   0.078761  -0.457 0.647604
## plot8                -0.011158   0.078845  -0.142 0.887468
## plot9                -0.046847   0.081813  -0.573 0.566924
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.196 on 7215 degrees of freedom
## Multiple R-squared:  0.6412, Adjusted R-squared:   0.64
## F-statistic: 537.2 on 24 and 7215 DF,  p-value: < 2.2e-16
```

```
summary(fit2e)
```

```
##
## Call:
## lm(formula = dtemp ~ glorad + I(glorad^2) + I(glorad^3) + Otemp +
##     I(Otemp^2) + I(Otemp^3) + wv2 + I(wv2^2) + I(wv2^3) + plot,
##     data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.8317 -0.5689  0.0357  0.5755  7.5907
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.641e+00  2.090e-01 -12.639  < 2e-16 ***
## glorad       4.905e-03  4.345e-04  11.289  < 2e-16 ***
## I(glorad^2) -7.901e-06  1.560e-06  -5.063 4.22e-07 ***
## I(glorad^3)  6.008e-09  1.442e-09   4.165 3.15e-05 ***
## Otemp        8.528e-01  4.837e-02  17.631  < 2e-16 ***
## I(Otemp^2)  -8.293e-02  3.592e-03 -23.087  < 2e-16 ***
## I(Otemp^3)   2.561e-03  8.284e-05  30.913  < 2e-16 ***
## wv2         -1.668e-01  5.388e-02  -3.095 0.001975 **
## I(wv2^2)     8.372e-02  2.325e-02   3.600 0.000320 ***
## I(wv2^3)    -1.046e-02  2.696e-03  -3.881 0.000105 ***
## plot10       7.191e-03  7.885e-02   0.091 0.927335
## plot11       1.570e-02  7.889e-02   0.199 0.842306
## plot12       1.857e-02  7.889e-02   0.235 0.813871
## plot13       5.582e-03  7.889e-02   0.071 0.943596
## plot14      -1.578e-02  7.889e-02  -0.200 0.841413
## plot15       4.344e-03  7.889e-02   0.055 0.956083
## plot16      -3.436e-02  8.183e-02  -0.420 0.674596
## plot2        1.819e-03  7.884e-02   0.023 0.981599
```

3

```
## plot3           -1.051e-03  7.880e-02  -0.013 0.989360
## plot4            3.512e-03  7.880e-02   0.045 0.964453
## plot5           -2.024e-02  7.880e-02  -0.257 0.797340
## plot6           -4.685e-02  7.876e-02  -0.595 0.551992
## plot7           -3.600e-02  7.876e-02  -0.457 0.647604
## plot8           -1.116e-02  7.885e-02  -0.142 0.887468
## plot9           -4.685e-02  8.181e-02  -0.573 0.566924
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.196 on 7215 degrees of freedom
## Multiple R-squared:  0.6412, Adjusted R-squared:  0.64
## F-statistic: 537.2 on 24 and 7215 DF,  p-value: < 2.2e-16
```

The two models are identical. (R-squared is lower for dtemp but that is just because we have already removed a lot of the variation by calculating a difference.) Interesting and reassuring that `plot` effects are small.

Let's generate scaled predictor variables for standardized coefficients (relative to 1 standard deviation of predictor variable). This will show which predictors are the most important compared to how much they vary.

```
fit3 <- lm(Itemp ~ poly(scale(glorad), 3) + poly(scale(Otemp), 3) + poly(scale(wv2), 3) + plot, data =
```

```
summary(fit3)
```

```
##
## Call:
## lm(formula = Itemp ~ poly(scale(glorad), 3) + poly(scale(Otemp),
##     3) + poly(scale(wv2), 3) + plot, data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.8317 -0.5689  0.0357  0.5755  7.5907
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)              15.084995   0.055754 270.565  < 2e-16 ***
## poly(scale(glorad), 3)1  47.930745   1.594028  30.069  < 2e-16 ***
## poly(scale(glorad), 3)2  -6.182799   1.246392  -4.961 7.19e-07 ***
## poly(scale(glorad), 3)3   5.058263   1.214504   4.165 3.15e-05 ***
## poly(scale(Otemp), 3)1  472.015367   1.382576 341.403  < 2e-16 ***
## poly(scale(Otemp), 3)2   62.942758   1.238102  50.838  < 2e-16 ***
## poly(scale(Otemp), 3)3   37.858014   1.224645  30.913  < 2e-16 ***
## poly(scale(wv2), 3)1     -0.856308   1.419662  -0.603 0.546410
## poly(scale(wv2), 3)2     -1.136325   1.259987  -0.902 0.367164
## poly(scale(wv2), 3)3     -4.743684   1.222402  -3.881 0.000105 ***
## plot10                    0.007191   0.078847   0.091 0.927335
## plot11                    0.015696   0.078891   0.199 0.842306
## plot12                    0.018574   0.078891   0.235 0.813871
## plot13                    0.005582   0.078891   0.071 0.943596
## plot14                   -0.015785   0.078888  -0.200 0.841413
## plot15                    0.004344   0.078886   0.055 0.956083
## plot16                   -0.034357   0.081828  -0.420 0.674596
```

4

```
## plot2                          0.001819   0.078842   0.023 0.981599
## plot3                         -0.001051   0.078801  -0.013 0.989360
## plot4                          0.003512   0.078804   0.045 0.964453
## plot5                         -0.020237   0.078805  -0.257 0.797340
## plot6                         -0.046848   0.078762  -0.595 0.551992
## plot7                         -0.036003   0.078761  -0.457 0.647604
## plot8                         -0.011158   0.078845  -0.142 0.887468
## plot9                         -0.046847   0.081813  -0.573 0.566924
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.196 on 7215 degrees of freedom
## Multiple R-squared:  0.9607, Adjusted R-squared:  0.9606
## F-statistic:  7350 on 24 and 7215 DF,  p-value: < 2.2e-16
```

It looks like temperature (`Otemp`) is the most important. Is that supported by the measurements?

```
pairs(d2[, .(Otemp, glorad, wv2, dtemp)])
```
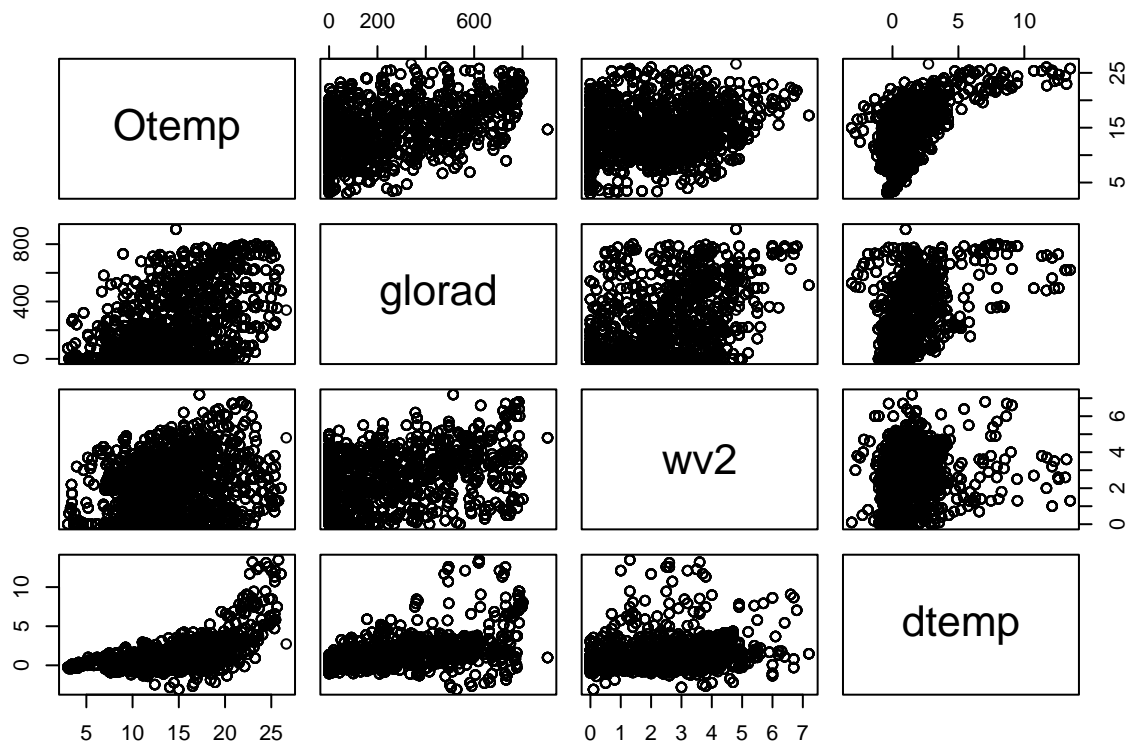

Seem so, yes.

Let's see how much worse the model is without the other two.

```
fit4 <- lm(Itemp ~ Otemp + I(Otemp^2) + I(Otemp^3)  + plot, data = d2)
```

```
summary(fit4)
```

```
##
## Call:
## lm(formula = Itemp ~ Otemp + I(Otemp^2) + I(Otemp^3) + plot,
##     data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -8.2228 -0.7465 -0.0239  0.5444  7.9011
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.079e+00  2.241e-01  -9.276   <2e-16 ***
## Otemp        1.736e+00  5.105e-02  34.010   <2e-16 ***
## I(Otemp^2)  -7.275e-02  3.787e-03 -19.210   <2e-16 ***
## I(Otemp^3)   2.384e-03  8.752e-05  27.244   <2e-16 ***
## plot10      -3.845e-03  8.530e-02  -0.045    0.964
## plot11       9.706e-03  8.535e-02   0.114    0.909
## plot12       1.519e-02  8.535e-02   0.178    0.859
## plot13       6.594e-04  8.535e-02   0.008    0.994
## plot14      -1.546e-02  8.535e-02  -0.181    0.856
## plot15       3.771e-03  8.535e-02   0.044    0.965
## plot16      -3.132e-02  8.853e-02  -0.354    0.724
## plot2        4.368e-03  8.530e-02   0.051    0.959
## plot3       -3.313e-03  8.525e-02  -0.039    0.969
## plot4        3.483e-03  8.526e-02   0.041    0.967
## plot5       -2.915e-02  8.525e-02  -0.342    0.732
## plot6       -5.523e-02  8.521e-02  -0.648    0.517
## plot7       -4.392e-02  8.521e-02  -0.515    0.606
## plot8       -2.061e-02  8.530e-02  -0.242    0.809
## plot9       -5.405e-02  8.851e-02  -0.611    0.541
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.294 on 7221 degrees of freedom
## Multiple R-squared:  0.954,  Adjusted R-squared:  0.9538
## F-statistic:  8313 on 18 and 7221 DF,  p-value: < 2.2e-16
```

```
summary(fit1)
```

```
##
## Call:
## lm(formula = Itemp ~ poly(glorad, 3) + poly(Otemp, 3) + poly(wv2,
##     3) + plot, data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.8317 -0.5689  0.0357  0.5755  7.5907
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)       15.084995    0.055754 270.565  < 2e-16 ***
## poly(glorad, 3)1   47.930745    1.594028  30.069  < 2e-16 ***
## poly(glorad, 3)2   -6.182799    1.246392  -4.961 7.19e-07 ***
## poly(glorad, 3)3    5.058263    1.214504   4.165 3.15e-05 ***
## poly(Otemp, 3)1   472.015367    1.382576 341.403  < 2e-16 ***
## poly(Otemp, 3)2    62.942758    1.238102  50.838  < 2e-16 ***
## poly(Otemp, 3)3    37.858014    1.224645  30.913  < 2e-16 ***
## poly(wv2, 3)1      -0.856308    1.419662  -0.603 0.546410
## poly(wv2, 3)2      -1.136325    1.259987  -0.902 0.367164
## poly(wv2, 3)3      -4.743684    1.222402  -3.881 0.000105 ***
## plot10              0.007191    0.078847   0.091 0.927335
## plot11              0.015696    0.078891   0.199 0.842306
## plot12              0.018574    0.078891   0.235 0.813871
## plot13              0.005582    0.078891   0.071 0.943596
## plot14             -0.015785    0.078888  -0.200 0.841413
## plot15              0.004344    0.078886   0.055 0.956083
## plot16             -0.034357    0.081828  -0.420 0.674596
## plot2               0.001819    0.078842   0.023 0.981599
## plot3              -0.001051    0.078801  -0.013 0.989360
## plot4               0.003512    0.078804   0.045 0.964453
## plot5              -0.020237    0.078805  -0.257 0.797340
## plot6              -0.046848    0.078762  -0.595 0.551992
## plot7              -0.036003    0.078761  -0.457 0.647604
## plot8              -0.011158    0.078845  -0.142 0.887468
## plot9              -0.046847    0.081813  -0.573 0.566924
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.196 on 7215 degrees of freedom
## Multiple R-squared:  0.9607, Adjusted R-squared:  0.9606
## F-statistic:  7350 on 24 and 7215 DF,  p-value: < 2.2e-16
```

Worse than 2, not that much though. So effects of radiation and wind are not huge.

Generate predictions for plotting.

```
d2$Itemp.pred <- predict(fit1)
d2$Itemp.pred2 <- predict(fit2)
d2$Itemp.pred4 <- predict(fit4)
```

And take a look.

```
ggplot(d2, aes(Otemp, Itemp, colour = glorad)) +
  geom_line(aes(Otemp, Itemp.pred), colour = 'blue') +
  geom_line(aes(Otemp, Itemp.pred4), colour = 'red') +
  geom_point() +
  scale_color_viridis_c(option = 'magma') +
  theme_bw() +
  xlab('Ambient soil surface temperature (C)') + ylab('DFC soil surface temperature (C)')
```
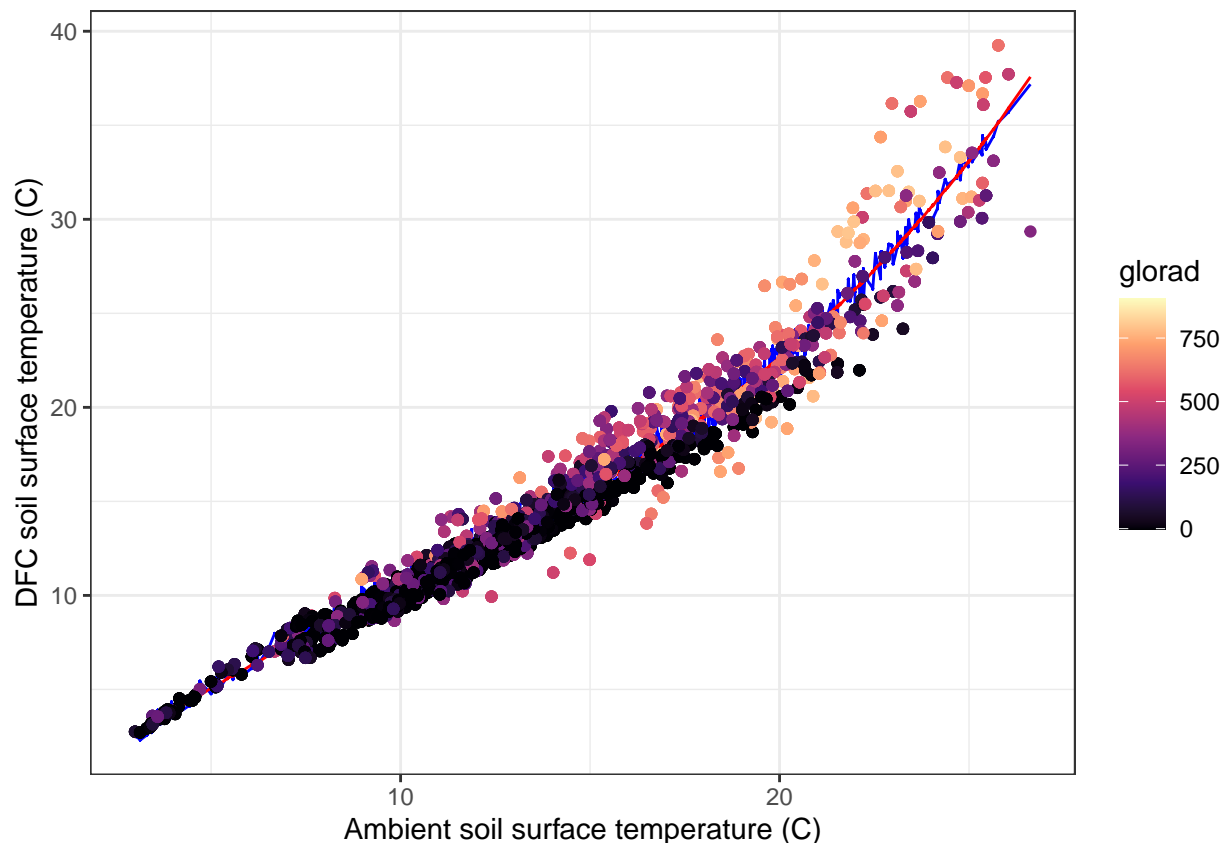
So, temperature alone indeed does as well as the most complete model. But both miss a lot of the variation. How about effects of earlier weather? For that we need to add lagged predictor variables. Try previous hour.

```
wthr <- unique(d2[, .(t.start, Otemp, glorad, wv2)])
wthr[, t.start := t.start - 3600]
d2.orig <- d2
d2 <- merge(d2, wthr, by = 't.start', suffixes = c('', '.lag1'))
wthr[, t.start := t.start - 3600]
d2 <- merge(d2, wthr, by = 't.start', suffixes = c('', '.lag2'))
```

First, try interactions. Then include lagged predictors.

```
fit5 <- lm(Itemp ~ (poly(glorad, 3) + poly(Otemp, 3) + poly(wv2, 3))^2 + plot, data = d2)
fit6 <- lm(Itemp ~ (poly(glorad, 3) + poly(Otemp, 3) + poly(wv2, 3) +
        poly(glorad.lag1, 3) + poly(Otemp.lag1, 3) + poly(wv2.lag1, 3) +
        poly(Otemp.lag2, 3))^2 + plot, data = d2)
summary(fit5)
```

```
##
## Call:
## lm(formula = Itemp ~ (poly(glorad, 3) + poly(Otemp, 3) + poly(wv2,
##     3))^2 + plot, data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -6.2561 -0.4592  0.0274  0.4865  6.0722
##
## Coefficients:
##                                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)                       1.488e+01  5.212e-02 285.488  < 2e-16 ***
## poly(glorad, 3)1                  2.338e+01  2.586e+00   9.043  < 2e-16 ***
## poly(glorad, 3)2                 -2.382e+01  2.425e+00  -9.824  < 2e-16 ***
## poly(glorad, 3)3                  1.128e+01  1.726e+00   6.538 6.68e-11 ***
## poly(Otemp, 3)1                   4.456e+02  2.432e+00 183.235  < 2e-16 ***
## poly(Otemp, 3)2                   5.171e+01  2.451e+00  21.101  < 2e-16 ***
## poly(Otemp, 3)3                   2.109e+01  1.857e+00  11.354  < 2e-16 ***
## poly(wv2, 3)1                     3.479e+01  2.487e+00  13.985  < 2e-16 ***
## poly(wv2, 3)2                     1.111e+00  3.140e+00   0.354 0.723596
## poly(wv2, 3)3                     2.344e+01  2.381e+00   9.844  < 2e-16 ***
## plot10                            7.717e-03  6.714e-02   0.115 0.908508
## plot11                            2.331e-02  6.722e-02   0.347 0.728806
## plot12                            3.283e-02  6.722e-02   0.488 0.625296
## plot13                            1.022e-02  6.722e-02   0.152 0.879116
## plot14                           -9.872e-03  6.724e-02  -0.147 0.883295
## plot15                            2.349e-02  6.723e-02   0.349 0.726805
## plot16                            1.243e-02  6.976e-02   0.178 0.858534
## plot2                             7.825e-03  6.706e-02   0.117 0.907109
## plot3                             1.655e-03  6.703e-02   0.025 0.980306
## plot4                            -1.115e-03  6.704e-02  -0.017 0.986734
## plot5                            -3.321e-02  6.704e-02  -0.495 0.620313
## plot6                            -6.559e-02  6.700e-02  -0.979 0.327681
## plot7                            -4.805e-02  6.700e-02  -0.717 0.473302
## plot8                            -2.794e-02  6.710e-02  -0.416 0.677167
## plot9                            -4.038e-02  6.968e-02  -0.579 0.562295
## poly(glorad, 3)1:poly(Otemp, 3)1  1.135e+03  2.963e+02   3.831 0.000129 ***
## poly(glorad, 3)2:poly(Otemp, 3)1 -1.226e+03  2.496e+02  -4.912 9.23e-07 ***
## poly(glorad, 3)3:poly(Otemp, 3)1 -5.651e+02  1.655e+02  -3.414 0.000643 ***
## poly(glorad, 3)1:poly(Otemp, 3)2  1.909e+03  3.096e+02   6.166 7.39e-10 ***
## poly(glorad, 3)2:poly(Otemp, 3)2  2.027e+03  2.528e+02   8.018 1.25e-15 ***
## poly(glorad, 3)3:poly(Otemp, 3)2 -8.786e+01  1.615e+02  -0.544 0.586416
## poly(glorad, 3)1:poly(Otemp, 3)3 -1.473e+02  1.908e+02  -0.772 0.440216
## poly(glorad, 3)2:poly(Otemp, 3)3  4.255e+02  1.465e+02   2.904 0.003692 **
## poly(glorad, 3)3:poly(Otemp, 3)3 -1.378e+03  1.184e+02 -11.637  < 2e-16 ***
## poly(glorad, 3)1:poly(wv2, 3)1    4.001e+03  2.009e+02  19.916  < 2e-16 ***
## poly(glorad, 3)2:poly(wv2, 3)1    1.174e+03  1.620e+02   7.250 4.62e-13 ***
## poly(glorad, 3)3:poly(wv2, 3)1   -2.370e+02  1.312e+02  -1.806 0.070960 .
## poly(glorad, 3)1:poly(wv2, 3)2   -2.426e+03  2.088e+02 -11.617  < 2e-16 ***
## poly(glorad, 3)2:poly(wv2, 3)2   -1.350e+03  1.593e+02  -8.475  < 2e-16 ***
## poly(glorad, 3)3:poly(wv2, 3)2    2.666e+02  1.273e+02   2.094 0.036314 *
## poly(glorad, 3)1:poly(wv2, 3)3    1.693e+03  1.792e+02   9.445  < 2e-16 ***
## poly(glorad, 3)2:poly(wv2, 3)3   -4.505e+02  1.375e+02  -3.275 0.001060 **
## poly(glorad, 3)3:poly(wv2, 3)3   -2.107e+02  9.971e+01  -2.113 0.034650 *
## poly(Otemp, 3)1:poly(wv2, 3)1    -2.859e+02  2.405e+02  -1.188 0.234683
## poly(Otemp, 3)2:poly(wv2, 3)1     2.149e+03  2.387e+02   9.002  < 2e-16 ***
## poly(Otemp, 3)3:poly(wv2, 3)1     9.415e+02  1.898e+02   4.961 7.19e-07 ***
## poly(Otemp, 3)1:poly(wv2, 3)2    -2.545e+03  3.061e+02  -8.313  < 2e-16 ***
## poly(Otemp, 3)2:poly(wv2, 3)2     8.242e+02  2.827e+02   2.915 0.003569 **
## poly(Otemp, 3)3:poly(wv2, 3)2     3.979e+02  2.219e+02   1.793 0.073006 .
## poly(Otemp, 3)1:poly(wv2, 3)3    -7.226e+02  2.291e+02  -3.154 0.001616 **
```

```
## poly(Otemp, 3)2:poly(wv2, 3)3     1.538e+03   1.912e+02    8.044 1.01e-15 ***
## poly(Otemp, 3)3:poly(wv2, 3)3     1.381e+03   1.583e+02    8.725  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.009 on 7078 degrees of freedom
## Multiple R-squared:  0.9723, Adjusted R-squared:  0.9721
## F-statistic:  4866 on 51 and 7078 DF,  p-value: < 2.2e-16
```

```r
summary(fit6)
```

```
##
## Call:
## lm(formula = Itemp ~ (poly(glorad, 3) + poly(Otemp, 3) + poly(wv2,
##     3) + poly(glorad.lag1, 3) + poly(Otemp.lag1, 3) + poly(wv2.lag1,
##     3) + poly(Otemp.lag2, 3))^2 + plot, data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.1900 -0.3976  0.0022  0.3832  5.1480
##
## Coefficients:
##                             Estimate Std. Error t value
## (Intercept)                1.646e+01  2.385e+00   6.903
## poly(glorad, 3)1           2.070e+02  2.672e+01   7.744
## poly(glorad, 3)2           1.082e+02  1.994e+01   5.424
## poly(glorad, 3)3           6.647e+01  8.299e+00   8.010
## poly(Otemp, 3)1           -6.025e+02  2.561e+02  -2.353
## poly(Otemp, 3)2           -6.286e+02  1.769e+02  -3.553
## poly(Otemp, 3)3           -3.239e+02  8.625e+01  -3.755
## poly(wv2, 3)1              2.148e+01  2.430e+01   0.884
## poly(wv2, 3)2             -4.939e+00  1.937e+01  -0.255
## poly(wv2, 3)3              1.434e+01  9.048e+00   1.585
## poly(glorad.lag1, 3)1     -2.611e+01  1.811e+01  -1.442
## poly(glorad.lag1, 3)2      4.989e+01  1.574e+01   3.170
## poly(glorad.lag1, 3)3      7.245e+00  7.492e+00   0.967
## poly(Otemp.lag1, 3)1       8.492e+02  3.295e+02   2.577
## poly(Otemp.lag1, 3)2      -1.383e+01  2.482e+02  -0.056
## poly(Otemp.lag1, 3)3       4.383e+02  1.535e+02   2.855
## poly(wv2.lag1, 3)1        -2.075e+01  2.845e+01  -0.729
## poly(wv2.lag1, 3)2        -3.762e+01  2.607e+01  -1.443
## poly(wv2.lag1, 3)3        -2.015e+00  1.002e+01  -0.201
## poly(Otemp.lag2, 3)1       2.774e+02  2.571e+02   1.079
## poly(Otemp.lag2, 3)2       1.623e+03  2.488e+02   6.523
## poly(Otemp.lag2, 3)3      -2.145e+01  9.539e+01  -0.225
## plot10                    -3.232e-02  5.017e-02  -0.644
## plot11                    -1.173e-02  5.019e-02  -0.234
## plot12                    -2.788e-03  5.017e-02  -0.056
## plot13                    -7.764e-03  5.008e-02  -0.155
## plot14                    -1.240e-02  4.994e-02  -0.248
## plot15                     3.634e-04  4.984e-02   0.007
## plot16                    -1.384e-02  5.170e-02  -0.268
## plot2                      3.609e-03  4.967e-02   0.073
## plot3                     -6.376e-03  4.971e-02  -0.128
```

```
## plot4                                      -1.653e-02  4.980e-02  -0.332
## plot5                                      -1.699e-02  4.994e-02  -0.340
## plot6                                      -4.033e-02  4.998e-02  -0.807
## plot7                                      -2.485e-02  5.007e-02  -0.496
## plot8                                      -3.530e-02  5.015e-02  -0.704
## plot9                                      -5.152e-02  5.211e-02  -0.989
## poly(glorad, 3)1:poly(Otemp, 3)1            5.656e+03  2.276e+03   2.485
## poly(glorad, 3)2:poly(Otemp, 3)1           -5.919e+03  1.232e+03  -4.806
## poly(glorad, 3)3:poly(Otemp, 3)1            3.200e+02  9.569e+02   0.334
## poly(glorad, 3)1:poly(Otemp, 3)2            7.069e+02  1.745e+03   0.405
## poly(glorad, 3)2:poly(Otemp, 3)2           -3.528e+01  1.068e+03  -0.033
## poly(glorad, 3)3:poly(Otemp, 3)2           -1.385e+02  7.203e+02  -0.192
## poly(glorad, 3)1:poly(Otemp, 3)3            1.444e+02  1.493e+03   0.097
## poly(glorad, 3)2:poly(Otemp, 3)3           -6.435e+02  7.247e+02  -0.888
## poly(glorad, 3)3:poly(Otemp, 3)3           -1.680e+03  5.552e+02  -3.026
## poly(glorad, 3)1:poly(wv2, 3)1             -5.364e+03  9.496e+02  -5.648
## poly(glorad, 3)2:poly(wv2, 3)1             -3.051e+03  5.601e+02  -5.447
## poly(glorad, 3)3:poly(wv2, 3)1             -1.614e+03  3.678e+02  -4.388
## poly(glorad, 3)1:poly(wv2, 3)2              9.279e+02  6.717e+02   1.382
## poly(glorad, 3)2:poly(wv2, 3)2              8.071e+01  4.093e+02   0.197
## poly(glorad, 3)3:poly(wv2, 3)2              1.924e+03  2.332e+02   8.249
## poly(glorad, 3)1:poly(wv2, 3)3             -2.155e+03  6.420e+02  -3.356
## poly(glorad, 3)2:poly(wv2, 3)3             -3.243e+03  3.316e+02  -9.782
## poly(glorad, 3)3:poly(wv2, 3)3             -3.779e+02  1.856e+02  -2.036
## poly(glorad, 3)1:poly(glorad.lag1, 3)1     -1.136e+04  1.863e+03  -6.100
## poly(glorad, 3)2:poly(glorad.lag1, 3)1     -1.133e+04  1.144e+03  -9.900
## poly(glorad, 3)3:poly(glorad.lag1, 3)1     -3.393e+03  5.784e+02  -5.866
## poly(glorad, 3)1:poly(glorad.lag1, 3)2      4.633e+03  1.042e+03   4.446
## poly(glorad, 3)2:poly(glorad.lag1, 3)2      5.035e+03  7.975e+02   6.314
## poly(glorad, 3)3:poly(glorad.lag1, 3)2      3.256e+03  3.176e+02  10.253
## poly(glorad, 3)1:poly(glorad.lag1, 3)3     -2.014e+03  5.901e+02  -3.413
## poly(glorad, 3)2:poly(glorad.lag1, 3)3     -2.052e+03  3.169e+02  -6.475
## poly(glorad, 3)3:poly(glorad.lag1, 3)3     -1.969e+01  1.122e+02  -0.176
## poly(glorad, 3)1:poly(Otemp.lag1, 3)1       6.296e+02  4.069e+03   0.155
## poly(glorad, 3)2:poly(Otemp.lag1, 3)1      -4.375e+01  2.418e+03  -0.018
## poly(glorad, 3)3:poly(Otemp.lag1, 3)1       1.693e+03  1.649e+03   1.027
## poly(glorad, 3)1:poly(Otemp.lag1, 3)2      -1.492e+04  3.270e+03  -4.562
## poly(glorad, 3)2:poly(Otemp.lag1, 3)2      -3.078e+03  1.917e+03  -1.606
## poly(glorad, 3)3:poly(Otemp.lag1, 3)2      -1.530e+03  1.333e+03  -1.148
## poly(glorad, 3)1:poly(Otemp.lag1, 3)3       7.818e+03  2.584e+03   3.025
## poly(glorad, 3)2:poly(Otemp.lag1, 3)3       2.542e+03  1.265e+03   2.009
## poly(glorad, 3)3:poly(Otemp.lag1, 3)3       3.569e+03  8.737e+02   4.086
## poly(glorad, 3)1:poly(wv2.lag1, 3)1         7.326e+03  1.038e+03   7.061
## poly(glorad, 3)2:poly(wv2.lag1, 3)1         4.900e+03  6.088e+02   8.048
## poly(glorad, 3)3:poly(wv2.lag1, 3)1         1.205e+03  3.689e+02   3.268
## poly(glorad, 3)1:poly(wv2.lag1, 3)2        -3.056e+03  8.198e+02  -3.727
## poly(glorad, 3)2:poly(wv2.lag1, 3)2        -1.787e+03  4.503e+02  -3.969
## poly(glorad, 3)3:poly(wv2.lag1, 3)2        -1.196e+03  2.511e+02  -4.764
## poly(glorad, 3)1:poly(wv2.lag1, 3)3         3.386e+03  7.153e+02   4.733
## poly(glorad, 3)2:poly(wv2.lag1, 3)3         2.559e+03  3.489e+02   7.335
## poly(glorad, 3)3:poly(wv2.lag1, 3)3         9.955e+02  1.849e+02   5.383
## poly(glorad, 3)1:poly(Otemp.lag2, 3)1      -4.486e+03  3.057e+03  -1.467
## poly(glorad, 3)2:poly(Otemp.lag2, 3)1       9.146e+03  2.050e+03   4.462
## poly(glorad, 3)3:poly(Otemp.lag2, 3)1      -2.604e+03  1.110e+03  -2.345
```

```
## poly(glorad, 3)1:poly(Otemp.lag2, 3)2      1.054e+04  2.477e+03   4.257
## poly(glorad, 3)2:poly(Otemp.lag2, 3)2      1.909e+03  1.601e+03   1.192
## poly(glorad, 3)3:poly(Otemp.lag2, 3)2      3.710e+02  9.494e+02   0.391
## poly(glorad, 3)1:poly(Otemp.lag2, 3)3     -4.629e+03  1.936e+03  -2.391
## poly(glorad, 3)2:poly(Otemp.lag2, 3)3      1.453e+03  1.021e+03   1.423
## poly(glorad, 3)3:poly(Otemp.lag2, 3)3     -2.876e+03  5.134e+02  -5.603
## poly(Otemp, 3)1:poly(wv2, 3)1             4.035e+02  2.170e+03   0.186
## poly(Otemp, 3)2:poly(wv2, 3)1            -1.240e+04  1.743e+03  -7.116
## poly(Otemp, 3)3:poly(wv2, 3)1             8.806e+02  1.267e+03   0.695
## poly(Otemp, 3)1:poly(wv2, 3)2             1.345e+03  1.961e+03   0.686
## poly(Otemp, 3)2:poly(wv2, 3)2            -1.316e+04  1.659e+03  -7.928
## poly(Otemp, 3)3:poly(wv2, 3)2             1.024e+03  9.870e+02   1.038
## poly(Otemp, 3)1:poly(wv2, 3)3             1.487e+03  1.623e+03   0.916
## poly(Otemp, 3)2:poly(wv2, 3)3            -6.683e+03  1.203e+03  -5.555
## poly(Otemp, 3)3:poly(wv2, 3)3             3.468e+01  7.672e+02   0.045
## poly(Otemp, 3)1:poly(glorad.lag1, 3)1    -2.203e+02  1.993e+03  -0.111
## poly(Otemp, 3)2:poly(glorad.lag1, 3)1     2.950e+03  1.594e+03   1.851
## poly(Otemp, 3)3:poly(glorad.lag1, 3)1    -4.011e+03  1.379e+03  -2.908
## poly(Otemp, 3)1:poly(glorad.lag1, 3)2     1.076e+03  1.092e+03   0.985
## poly(Otemp, 3)2:poly(glorad.lag1, 3)2     5.865e+03  9.643e+02   6.083
## poly(Otemp, 3)3:poly(glorad.lag1, 3)2    -2.435e+03  7.066e+02  -3.447
## poly(Otemp, 3)1:poly(glorad.lag1, 3)3    -1.376e+03  9.272e+02  -1.484
## poly(Otemp, 3)2:poly(glorad.lag1, 3)3     2.598e+03  7.276e+02   3.570
## poly(Otemp, 3)3:poly(glorad.lag1, 3)3     3.181e+02  5.248e+02   0.606
## poly(Otemp, 3)1:poly(Otemp.lag1, 3)1      2.562e+05  3.955e+04   6.478
## poly(Otemp, 3)2:poly(Otemp.lag1, 3)1      6.184e+04  1.979e+04   3.125
## poly(Otemp, 3)3:poly(Otemp.lag1, 3)1      3.801e+04  6.669e+03   5.699
## poly(Otemp, 3)1:poly(Otemp.lag1, 3)2     -9.035e+04  2.053e+04  -4.401
## poly(Otemp, 3)2:poly(Otemp.lag1, 3)2     -9.905e+04  1.967e+04  -5.035
## poly(Otemp, 3)3:poly(Otemp.lag1, 3)2      1.360e+03  3.879e+03   0.351
## poly(Otemp, 3)1:poly(Otemp.lag1, 3)3      1.167e+05  2.173e+04   5.372
## poly(Otemp, 3)2:poly(Otemp.lag1, 3)3     -1.465e+03  4.449e+03  -0.329
## poly(Otemp, 3)3:poly(Otemp.lag1, 3)3      2.509e+02  2.311e+02   1.086
## poly(Otemp, 3)1:poly(wv2.lag1, 3)1       -1.631e+03  1.988e+03  -0.821
## poly(Otemp, 3)2:poly(wv2.lag1, 3)1        1.391e+04  1.578e+03   8.819
## poly(Otemp, 3)3:poly(wv2.lag1, 3)1       -2.717e+02  1.204e+03  -0.226
## poly(Otemp, 3)1:poly(wv2.lag1, 3)2       -3.562e+03  1.820e+03  -1.957
## poly(Otemp, 3)2:poly(wv2.lag1, 3)2        1.461e+04  1.543e+03   9.467
## poly(Otemp, 3)3:poly(wv2.lag1, 3)2       -2.301e+03  1.100e+03  -2.093
## poly(Otemp, 3)1:poly(wv2.lag1, 3)3       -7.512e+03  1.498e+03  -5.014
## poly(Otemp, 3)2:poly(wv2.lag1, 3)3        1.003e+04  1.128e+03   8.895
## poly(Otemp, 3)3:poly(wv2.lag1, 3)3       -1.931e+03  7.825e+02  -2.467
## poly(Otemp, 3)1:poly(Otemp.lag2, 3)1     -1.244e+05  1.537e+04  -8.097
## poly(Otemp, 3)2:poly(Otemp.lag2, 3)1     -8.301e+03  9.345e+03  -0.888
## poly(Otemp, 3)3:poly(Otemp.lag2, 3)1     -2.242e+04  5.293e+03  -4.235
## poly(Otemp, 3)1:poly(Otemp.lag2, 3)2      3.242e+04  9.033e+03   3.589
## poly(Otemp, 3)2:poly(Otemp.lag2, 3)2      5.077e+04  8.147e+03   6.232
## poly(Otemp, 3)3:poly(Otemp.lag2, 3)2     -1.001e+03  3.838e+03  -0.261
## poly(Otemp, 3)1:poly(Otemp.lag2, 3)3     -6.234e+04  7.939e+03  -7.852
## poly(Otemp, 3)2:poly(Otemp.lag2, 3)3     -4.981e+01  4.245e+03  -0.012
## poly(Otemp, 3)3:poly(Otemp.lag2, 3)3     -8.193e+02  4.842e+02  -1.692
## poly(wv2, 3)1:poly(glorad.lag1, 3)1       5.414e+03  8.457e+02   6.401
## poly(wv2, 3)2:poly(glorad.lag1, 3)1      -1.802e+03  6.516e+02  -2.765
## poly(wv2, 3)3:poly(glorad.lag1, 3)1       1.638e+03  6.230e+02   2.630
```

```
## poly(wv2, 3)1:poly(glorad.lag1, 3)2                2.487e+03  4.972e+02   5.002
## poly(wv2, 3)2:poly(glorad.lag1, 3)2                1.350e+02  3.827e+02   0.353
## poly(wv2, 3)3:poly(glorad.lag1, 3)2                1.624e+03  3.276e+02   4.957
## poly(wv2, 3)1:poly(glorad.lag1, 3)3                1.786e+03  3.568e+02   5.004
## poly(wv2, 3)2:poly(glorad.lag1, 3)3               -2.158e+03  2.686e+02  -8.033
## poly(wv2, 3)3:poly(glorad.lag1, 3)3               -9.033e+02  2.074e+02  -4.355
## poly(wv2, 3)1:poly(Otemp.lag1, 3)1                 4.963e+03  3.877e+03   1.280
## poly(wv2, 3)2:poly(Otemp.lag1, 3)1                -6.167e+03  3.460e+03  -1.782
## poly(wv2, 3)3:poly(Otemp.lag1, 3)1                -3.227e+03  2.899e+03  -1.113
## poly(wv2, 3)1:poly(Otemp.lag1, 3)2                 1.720e+04  2.940e+03   5.849
## poly(wv2, 3)2:poly(Otemp.lag1, 3)2                 1.804e+04  2.746e+03   6.570
## poly(wv2, 3)3:poly(Otemp.lag1, 3)2                 1.300e+04  1.996e+03   6.514
## poly(wv2, 3)1:poly(Otemp.lag1, 3)3                -3.578e+03  2.156e+03  -1.659
## poly(wv2, 3)2:poly(Otemp.lag1, 3)3                -3.576e+03  1.648e+03  -2.170
## poly(wv2, 3)3:poly(Otemp.lag1, 3)3                 5.763e+02  1.277e+03   0.451
## poly(wv2, 3)1:poly(wv2.lag1, 3)1                   3.338e+03  2.997e+03   1.114
## poly(wv2, 3)2:poly(wv2.lag1, 3)1                  -1.539e+03  1.669e+03  -0.922
## poly(wv2, 3)3:poly(wv2.lag1, 3)1                   3.120e+02  8.404e+02   0.371
## poly(wv2, 3)1:poly(wv2.lag1, 3)2                   2.881e+03  2.054e+03   1.403
## poly(wv2, 3)2:poly(wv2.lag1, 3)2                  -1.034e+03  1.491e+03  -0.694
## poly(wv2, 3)3:poly(wv2.lag1, 3)2                   8.087e+02  3.740e+02   2.162
## poly(wv2, 3)1:poly(wv2.lag1, 3)3                   7.565e+02  9.438e+02   0.802
## poly(wv2, 3)2:poly(wv2.lag1, 3)3                  -1.665e+03  3.863e+02  -4.311
## poly(wv2, 3)3:poly(wv2.lag1, 3)3                  -3.044e+01  1.035e+02  -0.294
## poly(wv2, 3)1:poly(Otemp.lag2, 3)1                -2.949e+03  2.312e+03  -1.275
## poly(wv2, 3)2:poly(Otemp.lag2, 3)1                 3.640e+03  1.983e+03   1.836
## poly(wv2, 3)3:poly(Otemp.lag2, 3)1                 1.638e+03  1.600e+03   1.024
## poly(wv2, 3)1:poly(Otemp.lag2, 3)2                -4.990e+02  1.618e+03  -0.308
## poly(wv2, 3)2:poly(Otemp.lag2, 3)2                -2.979e+03  1.435e+03  -2.075
## poly(wv2, 3)3:poly(Otemp.lag2, 3)2                -4.075e+03  1.054e+03  -3.866
## poly(wv2, 3)1:poly(Otemp.lag2, 3)3                 2.339e+03  1.273e+03   1.837
## poly(wv2, 3)2:poly(Otemp.lag2, 3)3                -5.953e+02  9.972e+02  -0.597
## poly(wv2, 3)3:poly(Otemp.lag2, 3)3                -2.367e+03  7.375e+02  -3.209
## poly(glorad.lag1, 3)1:poly(Otemp.lag1, 3)1 -6.795e+03  3.548e+03  -1.915
## poly(glorad.lag1, 3)2:poly(Otemp.lag1, 3)1  5.030e+02  2.325e+03   0.216
## poly(glorad.lag1, 3)3:poly(Otemp.lag1, 3)1  1.928e+03  1.676e+03   1.151
## poly(glorad.lag1, 3)1:poly(Otemp.lag1, 3)2 -5.975e+03  2.852e+03  -2.095
## poly(glorad.lag1, 3)2:poly(Otemp.lag1, 3)2 -7.509e+03  1.797e+03  -4.178
## poly(glorad.lag1, 3)3:poly(Otemp.lag1, 3)2 -6.927e+03  1.400e+03  -4.948
## poly(glorad.lag1, 3)1:poly(Otemp.lag1, 3)3 -2.212e+03  2.159e+03  -1.024
## poly(glorad.lag1, 3)2:poly(Otemp.lag1, 3)3  3.472e+03  1.343e+03   2.585
## poly(glorad.lag1, 3)3:poly(Otemp.lag1, 3)3 -2.365e+03  9.203e+02  -2.570
## poly(glorad.lag1, 3)1:poly(wv2.lag1, 3)1    -4.966e+03  9.302e+02  -5.339
## poly(glorad.lag1, 3)2:poly(wv2.lag1, 3)1    -2.406e+03  5.419e+02  -4.440
## poly(glorad.lag1, 3)3:poly(wv2.lag1, 3)1    -1.614e+03  3.742e+02  -4.312
## poly(glorad.lag1, 3)1:poly(wv2.lag1, 3)2     1.889e+03  7.871e+02   2.399
## poly(glorad.lag1, 3)2:poly(wv2.lag1, 3)2     7.230e+02  4.384e+02   1.649
## poly(glorad.lag1, 3)3:poly(wv2.lag1, 3)2     1.709e+03  2.948e+02   5.797
## poly(glorad.lag1, 3)1:poly(wv2.lag1, 3)3    -2.392e+03  6.849e+02  -3.492
## poly(glorad.lag1, 3)2:poly(wv2.lag1, 3)3    -1.422e+03  3.430e+02  -4.145
## poly(glorad.lag1, 3)3:poly(wv2.lag1, 3)3    -7.458e+02  2.088e+02  -3.572
## poly(glorad.lag1, 3)1:poly(Otemp.lag2, 3)1  8.624e+03  2.864e+03   3.011
## poly(glorad.lag1, 3)2:poly(Otemp.lag2, 3)1 -4.648e+03  2.167e+03  -2.145
## poly(glorad.lag1, 3)3:poly(Otemp.lag2, 3)1 -9.899e+02  1.252e+03  -0.791
```

```
## poly(glorad.lag1, 3)1:poly(Otemp.lag2, 3)2   5.175e+03   2.216e+03    2.336
## poly(glorad.lag1, 3)2:poly(Otemp.lag2, 3)2   2.402e+03   1.598e+03    1.503
## poly(glorad.lag1, 3)3:poly(Otemp.lag2, 3)2   5.649e+03   1.031e+03    5.480
## poly(glorad.lag1, 3)1:poly(Otemp.lag2, 3)3   6.813e+03   1.572e+03    4.334
## poly(glorad.lag1, 3)2:poly(Otemp.lag2, 3)3  -3.512e+03   1.123e+03   -3.126
## poly(glorad.lag1, 3)3:poly(Otemp.lag2, 3)3   9.022e+02   5.770e+02    1.564
## poly(Otemp.lag1, 3)1:poly(wv2.lag1, 3)1     -2.198e+03   3.716e+03   -0.592
## poly(Otemp.lag1, 3)2:poly(wv2.lag1, 3)1     -1.627e+04   2.917e+03   -5.578
## poly(Otemp.lag1, 3)3:poly(wv2.lag1, 3)1      1.944e+03   2.078e+03    0.935
## poly(Otemp.lag1, 3)1:poly(wv2.lag1, 3)2      4.278e+03   3.408e+03    1.255
## poly(Otemp.lag1, 3)2:poly(wv2.lag1, 3)2     -2.055e+04   2.839e+03   -7.238
## poly(Otemp.lag1, 3)3:poly(wv2.lag1, 3)2      2.387e+03   1.830e+03    1.305
## poly(Otemp.lag1, 3)1:poly(wv2.lag1, 3)3      1.077e+04   2.739e+03    3.931
## poly(Otemp.lag1, 3)2:poly(wv2.lag1, 3)3     -1.406e+04   1.978e+03   -7.108
## poly(Otemp.lag1, 3)3:poly(wv2.lag1, 3)3      2.715e+03   1.282e+03    2.117
## poly(Otemp.lag1, 3)1:poly(Otemp.lag2, 3)1   -2.356e+05   5.514e+04   -4.273
## poly(Otemp.lag1, 3)2:poly(Otemp.lag2, 3)1    5.125e+04   1.992e+04    2.573
## poly(Otemp.lag1, 3)3:poly(Otemp.lag2, 3)1   -1.547e+05   2.667e+04   -5.803
## poly(Otemp.lag1, 3)1:poly(Otemp.lag2, 3)2   -3.493e+04   1.950e+04   -1.792
## poly(Otemp.lag1, 3)2:poly(Otemp.lag2, 3)2    1.472e+05   2.855e+04    5.156
## poly(Otemp.lag1, 3)3:poly(Otemp.lag2, 3)2    2.708e+03   4.995e+03    0.542
## poly(Otemp.lag1, 3)1:poly(Otemp.lag2, 3)3   -1.829e+04   1.144e+04   -1.598
## poly(Otemp.lag1, 3)2:poly(Otemp.lag2, 3)3   -1.835e+03   4.798e+03   -0.382
## poly(Otemp.lag1, 3)3:poly(Otemp.lag2, 3)3   -6.282e+02   3.349e+02   -1.876
## poly(wv2.lag1, 3)1:poly(Otemp.lag2, 3)1      2.815e+03   2.362e+03    1.192
## poly(wv2.lag1, 3)2:poly(Otemp.lag2, 3)1     -1.902e+03   2.161e+03   -0.880
## poly(wv2.lag1, 3)3:poly(Otemp.lag2, 3)1     -3.680e+03   1.591e+03   -2.313
## poly(wv2.lag1, 3)1:poly(Otemp.lag2, 3)2      1.690e+03   1.769e+03    0.955
## poly(wv2.lag1, 3)2:poly(Otemp.lag2, 3)2      6.657e+03   1.693e+03    3.933
## poly(wv2.lag1, 3)3:poly(Otemp.lag2, 3)2      5.442e+03   1.133e+03    4.802
## poly(wv2.lag1, 3)1:poly(Otemp.lag2, 3)3     -1.338e+03   1.262e+03   -1.060
## poly(wv2.lag1, 3)2:poly(Otemp.lag2, 3)3      8.414e+01   1.121e+03    0.075
## poly(wv2.lag1, 3)3:poly(Otemp.lag2, 3)3      4.205e+02   7.516e+02    0.559
##                                             Pr(>|t|)
## (Intercept)                                 5.56e-12 ***
## poly(glorad, 3)1                            1.10e-14 ***
## poly(glorad, 3)2                            6.02e-08 ***
## poly(glorad, 3)3                            1.34e-15 ***
## poly(Otemp, 3)1                             0.018656 *
## poly(Otemp, 3)2                             0.000384 ***
## poly(Otemp, 3)3                             0.000174 ***
## poly(wv2, 3)1                               0.376807
## poly(wv2, 3)2                               0.798756
## poly(wv2, 3)3                               0.113074
## poly(glorad.lag1, 3)1                       0.149282
## poly(glorad.lag1, 3)2                       0.001530 **
## poly(glorad.lag1, 3)3                       0.333550
## poly(Otemp.lag1, 3)1                        0.009984 **
## poly(Otemp.lag1, 3)2                        0.955578
## poly(Otemp.lag1, 3)3                        0.004315 **
## poly(wv2.lag1, 3)1                          0.465835
## poly(wv2.lag1, 3)2                          0.149012
## poly(wv2.lag1, 3)3                          0.840641
## poly(Otemp.lag2, 3)1                        0.280700
```

```
## poly(Otemp.lag2, 3)2                          7.39e-11 ***
## poly(Otemp.lag2, 3)3                          0.822135
## plot10                                        0.519395
## plot11                                        0.815230
## plot12                                        0.955677
## plot13                                        0.876804
## plot14                                        0.803858
## plot15                                        0.994183
## plot16                                        0.788884
## plot2                                         0.942081
## plot3                                         0.897933
## plot4                                         0.739908
## plot5                                         0.733712
## plot6                                         0.419734
## plot7                                         0.619631
## plot8                                         0.481527
## plot9                                         0.322875
## poly(glorad, 3)1:poly(Otemp, 3)1              0.012967 *
## poly(glorad, 3)2:poly(Otemp, 3)1              1.57e-06 ***
## poly(glorad, 3)3:poly(Otemp, 3)1              0.738049
## poly(glorad, 3)1:poly(Otemp, 3)2              0.685386
## poly(glorad, 3)2:poly(Otemp, 3)2              0.973650
## poly(glorad, 3)3:poly(Otemp, 3)2              0.847474
## poly(glorad, 3)1:poly(Otemp, 3)3              0.922962
## poly(glorad, 3)2:poly(Otemp, 3)3              0.374636
## poly(glorad, 3)3:poly(Otemp, 3)3              0.002491 **
## poly(glorad, 3)1:poly(wv2, 3)1               1.69e-08 ***
## poly(glorad, 3)2:poly(wv2, 3)1               5.30e-08 ***
## poly(glorad, 3)3:poly(wv2, 3)1               1.16e-05 ***
## poly(glorad, 3)1:poly(wv2, 3)2                0.167168
## poly(glorad, 3)2:poly(wv2, 3)2                0.843691
## poly(glorad, 3)3:poly(wv2, 3)2                 < 2e-16 ***
## poly(glorad, 3)1:poly(wv2, 3)3                0.000795 ***
## poly(glorad, 3)2:poly(wv2, 3)3                 < 2e-16 ***
## poly(glorad, 3)3:poly(wv2, 3)3                0.041781 *
## poly(glorad, 3)1:poly(glorad.lag1, 3)1       1.12e-09 ***
## poly(glorad, 3)2:poly(glorad.lag1, 3)1        < 2e-16 ***
## poly(glorad, 3)3:poly(glorad.lag1, 3)1       4.68e-09 ***
## poly(glorad, 3)1:poly(glorad.lag1, 3)2       8.87e-06 ***
## poly(glorad, 3)2:poly(glorad.lag1, 3)2       2.89e-10 ***
## poly(glorad, 3)3:poly(glorad.lag1, 3)2        < 2e-16 ***
## poly(glorad, 3)1:poly(glorad.lag1, 3)3       0.000645 ***
## poly(glorad, 3)2:poly(glorad.lag1, 3)3       1.02e-10 ***
## poly(glorad, 3)3:poly(glorad.lag1, 3)3       0.860653
## poly(glorad, 3)1:poly(Otemp.lag1, 3)1        0.877040
## poly(glorad, 3)2:poly(Otemp.lag1, 3)1        0.985562
## poly(glorad, 3)3:poly(Otemp.lag1, 3)1        0.304547
## poly(glorad, 3)1:poly(Otemp.lag1, 3)2        5.17e-06 ***
## poly(glorad, 3)2:poly(Otemp.lag1, 3)2        0.108361
## poly(glorad, 3)3:poly(Otemp.lag1, 3)2        0.250930
## poly(glorad, 3)1:poly(Otemp.lag1, 3)3        0.002492 **
## poly(glorad, 3)2:poly(Otemp.lag1, 3)3        0.044535 *
## poly(glorad, 3)3:poly(Otemp.lag1, 3)3        4.45e-05 ***
## poly(glorad, 3)1:poly(wv2.lag1, 3)1          1.81e-12 ***
```

```
## poly(glorad, 3)2:poly(wv2.lag1, 3)1      9.86e-16 ***
## poly(glorad, 3)3:poly(wv2.lag1, 3)1      0.001089 **
## poly(glorad, 3)1:poly(wv2.lag1, 3)2      0.000195 ***
## poly(glorad, 3)2:poly(wv2.lag1, 3)2      7.29e-05 ***
## poly(glorad, 3)3:poly(wv2.lag1, 3)2      1.93e-06 ***
## poly(glorad, 3)1:poly(wv2.lag1, 3)3      2.25e-06 ***
## poly(glorad, 3)2:poly(wv2.lag1, 3)3      2.47e-13 ***
## poly(glorad, 3)3:poly(wv2.lag1, 3)3      7.56e-08 ***
## poly(glorad, 3)1:poly(Otemp.lag2, 3)1    0.142290
## poly(glorad, 3)2:poly(Otemp.lag2, 3)1    8.26e-06 ***
## poly(glorad, 3)3:poly(Otemp.lag2, 3)1    0.019047 *
## poly(glorad, 3)1:poly(Otemp.lag2, 3)2    2.10e-05 ***
## poly(glorad, 3)2:poly(Otemp.lag2, 3)2    0.233313
## poly(glorad, 3)3:poly(Otemp.lag2, 3)2    0.695970
## poly(glorad, 3)1:poly(Otemp.lag2, 3)3    0.016848 *
## poly(glorad, 3)2:poly(Otemp.lag2, 3)3    0.154774
## poly(glorad, 3)3:poly(Otemp.lag2, 3)3    2.19e-08 ***
## poly(Otemp, 3)1:poly(wv2, 3)1            0.852494
## poly(Otemp, 3)2:poly(wv2, 3)1            1.23e-12 ***
## poly(Otemp, 3)3:poly(wv2, 3)1            0.486961
## poly(Otemp, 3)1:poly(wv2, 3)2            0.492718
## poly(Otemp, 3)2:poly(wv2, 3)2            2.57e-15 ***
## poly(Otemp, 3)3:poly(wv2, 3)2            0.299516
## poly(Otemp, 3)1:poly(wv2, 3)3            0.359711
## poly(Otemp, 3)2:poly(wv2, 3)3            2.87e-08 ***
## poly(Otemp, 3)3:poly(wv2, 3)3            0.963949
## poly(Otemp, 3)1:poly(glorad.lag1, 3)1    0.911982
## poly(Otemp, 3)2:poly(glorad.lag1, 3)1    0.064205 .
## poly(Otemp, 3)3:poly(glorad.lag1, 3)1    0.003651 **
## poly(Otemp, 3)1:poly(glorad.lag1, 3)2    0.324513
## poly(Otemp, 3)2:poly(glorad.lag1, 3)2    1.24e-09 ***
## poly(Otemp, 3)3:poly(glorad.lag1, 3)2    0.000571 ***
## poly(Otemp, 3)1:poly(glorad.lag1, 3)3    0.137904
## poly(Otemp, 3)2:poly(glorad.lag1, 3)3    0.000359 ***
## poly(Otemp, 3)3:poly(glorad.lag1, 3)3    0.544454
## poly(Otemp, 3)1:poly(Otemp.lag1, 3)1     9.92e-11 ***
## poly(Otemp, 3)2:poly(Otemp.lag1, 3)1     0.001784 **
## poly(Otemp, 3)3:poly(Otemp.lag1, 3)1     1.25e-08 ***
## poly(Otemp, 3)1:poly(Otemp.lag1, 3)2     1.09e-05 ***
## poly(Otemp, 3)2:poly(Otemp.lag1, 3)2     4.89e-07 ***
## poly(Otemp, 3)3:poly(Otemp.lag1, 3)2     0.725824
## poly(Otemp, 3)1:poly(Otemp.lag1, 3)3     8.03e-08 ***
## poly(Otemp, 3)2:poly(Otemp.lag1, 3)3     0.741969
## poly(Otemp, 3)3:poly(Otemp.lag1, 3)3     0.277674
## poly(Otemp, 3)1:poly(wv2.lag1, 3)1       0.411945
## poly(Otemp, 3)2:poly(wv2.lag1, 3)1        < 2e-16 ***
## poly(Otemp, 3)3:poly(wv2.lag1, 3)1       0.821421
## poly(Otemp, 3)1:poly(wv2.lag1, 3)2       0.050383 .
## poly(Otemp, 3)2:poly(wv2.lag1, 3)2        < 2e-16 ***
## poly(Otemp, 3)3:poly(wv2.lag1, 3)2       0.036409 *
## poly(Otemp, 3)1:poly(wv2.lag1, 3)3       5.46e-07 ***
## poly(Otemp, 3)2:poly(wv2.lag1, 3)3        < 2e-16 ***
## poly(Otemp, 3)3:poly(wv2.lag1, 3)3       0.013644 *
## poly(Otemp, 3)1:poly(Otemp.lag2, 3)1     6.60e-16 ***
```

```
## poly(Otemp, 3)2:poly(Otemp.lag2, 3)1        0.374439
## poly(Otemp, 3)3:poly(Otemp.lag2, 3)1        2.31e-05 ***
## poly(Otemp, 3)1:poly(Otemp.lag2, 3)2        0.000334 ***
## poly(Otemp, 3)2:poly(Otemp.lag2, 3)2        4.87e-10 ***
## poly(Otemp, 3)3:poly(Otemp.lag2, 3)2        0.794138
## poly(Otemp, 3)1:poly(Otemp.lag2, 3)3        4.71e-15 ***
## poly(Otemp, 3)2:poly(Otemp.lag2, 3)3        0.990639
## poly(Otemp, 3)3:poly(Otemp.lag2, 3)3        0.090663 .
## poly(wv2, 3)1:poly(glorad.lag1, 3)1         1.64e-10 ***
## poly(wv2, 3)2:poly(glorad.lag1, 3)1         0.005701 **
## poly(wv2, 3)3:poly(glorad.lag1, 3)1         0.008569 **
## poly(wv2, 3)1:poly(glorad.lag1, 3)2         5.81e-07 ***
## poly(wv2, 3)2:poly(glorad.lag1, 3)2         0.724216
## poly(wv2, 3)3:poly(glorad.lag1, 3)2         7.34e-07 ***
## poly(wv2, 3)1:poly(glorad.lag1, 3)3         5.75e-07 ***
## poly(wv2, 3)2:poly(glorad.lag1, 3)3         1.11e-15 ***
## poly(wv2, 3)3:poly(glorad.lag1, 3)3         1.35e-05 ***
## poly(wv2, 3)1:poly(Otemp.lag1, 3)1          0.200638
## poly(wv2, 3)2:poly(Otemp.lag1, 3)1          0.074734 .
## poly(wv2, 3)3:poly(Otemp.lag1, 3)1          0.265746
## poly(wv2, 3)1:poly(Otemp.lag1, 3)2          5.16e-09 ***
## poly(wv2, 3)2:poly(Otemp.lag1, 3)2          5.41e-11 ***
## poly(wv2, 3)3:poly(Otemp.lag1, 3)2          7.82e-11 ***
## poly(wv2, 3)1:poly(Otemp.lag1, 3)3          0.097105 .
## poly(wv2, 3)2:poly(Otemp.lag1, 3)3          0.030075 *
## poly(wv2, 3)3:poly(Otemp.lag1, 3)3          0.651686
## poly(wv2, 3)1:poly(wv2.lag1, 3)1            0.265423
## poly(wv2, 3)2:poly(wv2.lag1, 3)1            0.356501
## poly(wv2, 3)3:poly(wv2.lag1, 3)1            0.710448
## poly(wv2, 3)1:poly(wv2.lag1, 3)2            0.160784
## poly(wv2, 3)2:poly(wv2.lag1, 3)2            0.487956
## poly(wv2, 3)3:poly(wv2.lag1, 3)2            0.030641 *
## poly(wv2, 3)1:poly(wv2.lag1, 3)3            0.422820
## poly(wv2, 3)2:poly(wv2.lag1, 3)3            1.65e-05 ***
## poly(wv2, 3)3:poly(wv2.lag1, 3)3            0.768740
## poly(wv2, 3)1:poly(Otemp.lag2, 3)1          0.202302
## poly(wv2, 3)2:poly(Otemp.lag2, 3)1          0.066458 .
## poly(wv2, 3)3:poly(Otemp.lag2, 3)1          0.306009
## poly(wv2, 3)1:poly(Otemp.lag2, 3)2          0.757768
## poly(wv2, 3)2:poly(Otemp.lag2, 3)2          0.038002 *
## poly(wv2, 3)3:poly(Otemp.lag2, 3)2          0.000112 ***
## poly(wv2, 3)1:poly(Otemp.lag2, 3)3          0.066221 .
## poly(wv2, 3)2:poly(Otemp.lag2, 3)3          0.550534
## poly(wv2, 3)3:poly(Otemp.lag2, 3)3          0.001339 **
## poly(glorad.lag1, 3)1:poly(Otemp.lag1, 3)1 0.055496 .
## poly(glorad.lag1, 3)2:poly(Otemp.lag1, 3)1 0.828713
## poly(glorad.lag1, 3)3:poly(Otemp.lag1, 3)1 0.249875
## poly(glorad.lag1, 3)1:poly(Otemp.lag1, 3)2 0.036187 *
## poly(glorad.lag1, 3)2:poly(Otemp.lag1, 3)2 2.98e-05 ***
## poly(glorad.lag1, 3)3:poly(Otemp.lag1, 3)2 7.68e-07 ***
## poly(glorad.lag1, 3)1:poly(Otemp.lag1, 3)3 0.305679
## poly(glorad.lag1, 3)2:poly(Otemp.lag1, 3)3 0.009756 **
## poly(glorad.lag1, 3)3:poly(Otemp.lag1, 3)3 0.010205 *
## poly(glorad.lag1, 3)1:poly(wv2.lag1, 3)1    9.66e-08 ***
```

```
## poly(glorad.lag1, 3)2:poly(wv2.lag1, 3)1     9.14e-06 ***
## poly(glorad.lag1, 3)3:poly(wv2.lag1, 3)1     1.64e-05 ***
## poly(glorad.lag1, 3)1:poly(wv2.lag1, 3)2     0.016446 *
## poly(glorad.lag1, 3)2:poly(wv2.lag1, 3)2     0.099124 .
## poly(glorad.lag1, 3)3:poly(wv2.lag1, 3)2     7.07e-09 ***
## poly(glorad.lag1, 3)1:poly(wv2.lag1, 3)3     0.000482 ***
## poly(glorad.lag1, 3)2:poly(wv2.lag1, 3)3     3.44e-05 ***
## poly(glorad.lag1, 3)3:poly(wv2.lag1, 3)3     0.000357 ***
## poly(glorad.lag1, 3)1:poly(Otemp.lag2, 3)1 0.002616 **
## poly(glorad.lag1, 3)2:poly(Otemp.lag2, 3)1 0.031956 *
## poly(glorad.lag1, 3)3:poly(Otemp.lag2, 3)1 0.429173
## poly(glorad.lag1, 3)1:poly(Otemp.lag2, 3)2 0.019530 *
## poly(glorad.lag1, 3)2:poly(Otemp.lag2, 3)2 0.132900
## poly(glorad.lag1, 3)3:poly(Otemp.lag2, 3)2 4.41e-08 ***
## poly(glorad.lag1, 3)1:poly(Otemp.lag2, 3)3 1.49e-05 ***
## poly(glorad.lag1, 3)2:poly(Otemp.lag2, 3)3 0.001779 **
## poly(glorad.lag1, 3)3:poly(Otemp.lag2, 3)3 0.117950
## poly(Otemp.lag1, 3)1:poly(wv2.lag1, 3)1     0.554130
## poly(Otemp.lag1, 3)2:poly(wv2.lag1, 3)1     2.53e-08 ***
## poly(Otemp.lag1, 3)3:poly(wv2.lag1, 3)1     0.349696
## poly(Otemp.lag1, 3)1:poly(wv2.lag1, 3)2     0.209412
## poly(Otemp.lag1, 3)2:poly(wv2.lag1, 3)2     5.06e-13 ***
## poly(Otemp.lag1, 3)3:poly(wv2.lag1, 3)2     0.192057
## poly(Otemp.lag1, 3)1:poly(wv2.lag1, 3)3     8.53e-05 ***
## poly(Otemp.lag1, 3)2:poly(wv2.lag1, 3)3     1.30e-12 ***
## poly(Otemp.lag1, 3)3:poly(wv2.lag1, 3)3     0.034285 *
## poly(Otemp.lag1, 3)1:poly(Otemp.lag2, 3)1 1.95e-05 ***
## poly(Otemp.lag1, 3)2:poly(Otemp.lag2, 3)1 0.010089 *
## poly(Otemp.lag1, 3)3:poly(Otemp.lag2, 3)1 6.82e-09 ***
## poly(Otemp.lag1, 3)1:poly(Otemp.lag2, 3)2 0.073213 .
## poly(Otemp.lag1, 3)2:poly(Otemp.lag2, 3)2 2.59e-07 ***
## poly(Otemp.lag1, 3)3:poly(Otemp.lag2, 3)2 0.587735
## poly(Otemp.lag1, 3)1:poly(Otemp.lag2, 3)3 0.110059
## poly(Otemp.lag1, 3)2:poly(Otemp.lag2, 3)3 0.702113
## poly(Otemp.lag1, 3)3:poly(Otemp.lag2, 3)3 0.060718 .
## poly(wv2.lag1, 3)1:poly(Otemp.lag2, 3)1     0.233375
## poly(wv2.lag1, 3)2:poly(Otemp.lag2, 3)1     0.378867
## poly(wv2.lag1, 3)3:poly(Otemp.lag2, 3)1     0.020730 *
## poly(wv2.lag1, 3)1:poly(Otemp.lag2, 3)2     0.339556
## poly(wv2.lag1, 3)2:poly(Otemp.lag2, 3)2     8.47e-05 ***
## poly(wv2.lag1, 3)3:poly(Otemp.lag2, 3)2     1.61e-06 ***
## poly(wv2.lag1, 3)1:poly(Otemp.lag2, 3)3     0.289072
## poly(wv2.lag1, 3)2:poly(Otemp.lag2, 3)3     0.940181
## poly(wv2.lag1, 3)3:poly(Otemp.lag2, 3)3     0.575860
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7459 on 6904 degrees of freedom
## Multiple R-squared:  0.9852, Adjusted R-squared:  0.9847
## F-statistic:  2045 on 225 and 6904 DF,  p-value: < 2.2e-16
```

```r
summary(fit2)
```

```
##
```

18

```
## Call:
## lm(formula = dtemp ~ poly(glorad, 3) + poly(Otemp, 3) + poly(wv2,
##     3) + plot, data = d2)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.8317 -0.5689  0.0357  0.5755  7.5907
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)        1.127169   0.055754  20.217  < 2e-16 ***
## poly(glorad, 3)1  47.930745   1.594028  30.069  < 2e-16 ***
## poly(glorad, 3)2  -6.182799   1.246392  -4.961 7.19e-07 ***
## poly(glorad, 3)3   5.058263   1.214504   4.165 3.15e-05 ***
## poly(Otemp, 3)1   80.782856   1.382576  58.429  < 2e-16 ***
## poly(Otemp, 3)2   62.942758   1.238102  50.838  < 2e-16 ***
## poly(Otemp, 3)3   37.858014   1.224645  30.913  < 2e-16 ***
## poly(wv2, 3)1     -0.856308   1.419662  -0.603 0.546410
## poly(wv2, 3)2     -1.136325   1.259987  -0.902 0.367164
## poly(wv2, 3)3     -4.743684   1.222402  -3.881 0.000105 ***
## plot10             0.007191   0.078847   0.091 0.927335
## plot11             0.015696   0.078891   0.199 0.842306
## plot12             0.018574   0.078891   0.235 0.813871
## plot13             0.005582   0.078891   0.071 0.943596
## plot14            -0.015785   0.078888  -0.200 0.841413
## plot15             0.004344   0.078886   0.055 0.956083
## plot16            -0.034357   0.081828  -0.420 0.674596
## plot2              0.001819   0.078842   0.023 0.981599
## plot3             -0.001051   0.078801  -0.013 0.989360
## plot4              0.003512   0.078804   0.045 0.964453
## plot5             -0.020237   0.078805  -0.257 0.797340
## plot6             -0.046848   0.078762  -0.595 0.551992
## plot7             -0.036003   0.078761  -0.457 0.647604
## plot8             -0.011158   0.078845  -0.142 0.887468
## plot9             -0.046847   0.081813  -0.573 0.566924
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.196 on 7215 degrees of freedom
## Multiple R-squared:  0.6412, Adjusted R-squared:    0.64
## F-statistic: 537.2 on 24 and 7215 DF,  p-value: < 2.2e-16
```

A lot of improvement (with interactions included).

```
d2$Itemp.pred5 <- predict(fit5)
d2$Itemp.pred6 <- predict(fit6)
```

```
ggplot(d2, aes(Otemp, Itemp, colour = glorad)) +
  geom_line(aes(Otemp, Itemp.pred), colour = 'blue') +
  geom_line(aes(Otemp, Itemp.pred4), colour = 'red') +
  geom_line(aes(Otemp, Itemp.pred5), colour = 'orange') +
  geom_line(aes(Otemp, Itemp.pred6), colour = 'skyblue') +
  geom_point() +
```

```
    scale_color_viridis_c(option = 'magma') +
    theme_bw() +
    xlab('Ambient soil surface temperature (C)') + ylab('DFC soil surface temperature (C)')
```
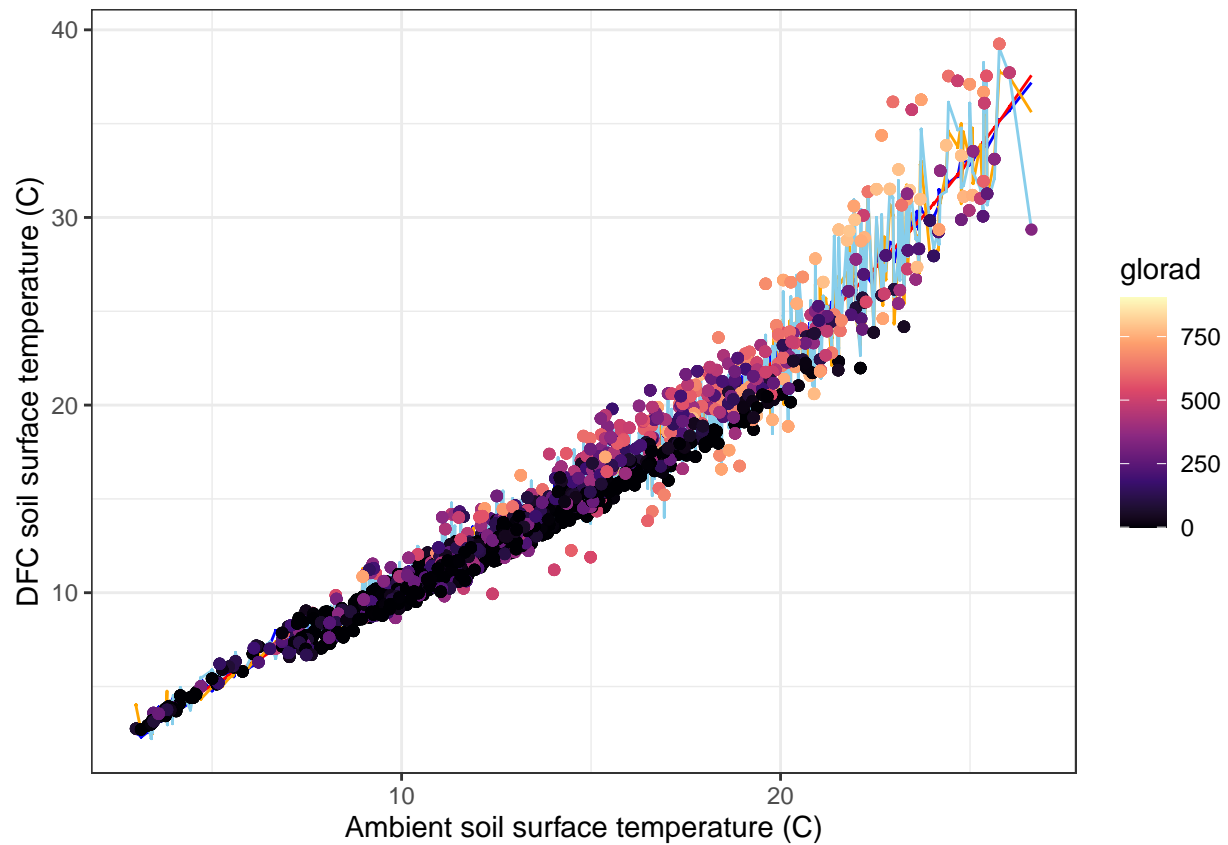


```
ggplot(d2) +
  geom_point(aes(Itemp, Itemp.pred), colour = 'blue', alpha = 0.2) +
  geom_point(aes(Itemp, Itemp.pred4), colour = 'red', alpha = 0.2) +
  geom_point(aes(Itemp, Itemp.pred5), colour = 'orange', alpha = 0.2) +
  theme_bw()
```
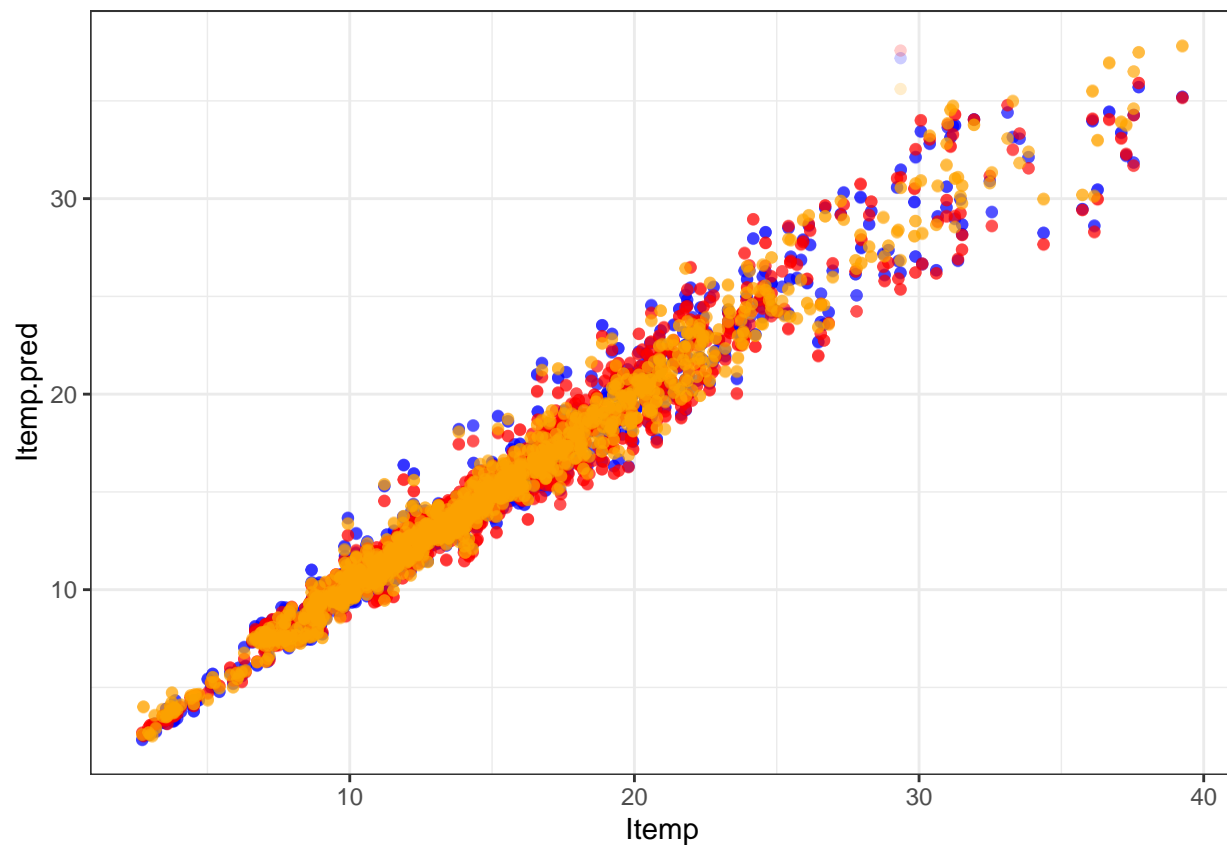
```
#newdat <- expand.grid(glorad = 0:10 * 100, Otemp = 0:10 * 3, wv2 = 2)
#setDT(newdat)
#newdat$dtemp.pred5 <- predict(fit2, newdata = newdat)
#newdat[dtemp.pred5 > 5, ]
```

Looks at some subsets.

```
#newdat[dtemp.pred5 > 3, ]
#newdat[dtemp.pred5 > 5, ]
#newdat[dtemp.pred5 > 8, ]
```

How common were the high temperatures and temperature differences?

```
quantile(d2.orig$Otemp)
```

```
##        0%      25%      50%      75%     100%
##   2.99250 10.79750 13.58917 17.04000 26.62083
```

```
quantile(d2.orig$Itemp)
```

```
##         0%       25%       50%       75%      100%
##   2.710833 10.985417 14.083333 18.284167 39.250833
```

```r
quantile(d2.orig$dtemp)
```

```
##          0%         25%         50%         75%        100%
## -3.0908333   0.0225000   0.6333333   1.5491667  13.4783333
```

Mean difference by plot.

```r
summ <- d2[, .(dtemp.mean = mean(dtemp), dtemp.med = median(dtemp)), by = plot]
summ
```

```
##         plot dtemp.mean dtemp.med
##       <fctr>      <num>     <num>
## 1:         5  1.1243463 0.6295833
## 2:         6  1.0895574 0.6041667
## 3:         7  1.1038755 0.6266667
## 4:         8  1.1417271 0.6258333
## 5:         9  1.1792947 0.6083333
## 6:        10  1.1513668 0.6333333
## 7:        11  1.1688969 0.6333333
## 8:        12  1.1647081 0.6466667
## 9:        13  1.1472820 0.6450000
## 10:       14  1.1353537 0.6537500
## 11:       15  1.1577463 0.6608333
## 12:       16  0.9020823 0.6875000
## 13:        1  1.1643252 0.6566667
## 14:        2  1.1471979 0.6475000
## 15:        3  1.1544723 0.6408333
## 16:        4  1.1615126 0.6350000
```

```r
t.test(summ$dtemp.med)
```

```
##
##  One Sample t-test
##
## data:  summ$dtemp.med
## t = 126.17, df = 15, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.6288807 0.6504943
## sample estimates:
## mean of x
## 0.6396875
```

```r
t.test(summ$dtemp.mean)
```

```
##
##  One Sample t-test
##
## data:  summ$dtemp.mean
## t = 69.148, df = 15, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
```

```
## 95 percent confidence interval:
##  1.096001 1.165717
## sample estimates:
## mean of x
##  1.130859
```

Quantiles above and below 20C. And make sure each plot (mostly) has some high temperature measurements.

```
d2.orig[, .(quantile(dtemp)), by = Otemp < 20]
```

```
##       Otemp         V1
##      <lgcl>      <num>
##  1:   TRUE -3.09083333
##  2:   TRUE -0.06333333
##  3:   TRUE  0.52083333
##  4:   TRUE  1.11250000
##  5:   TRUE  6.85416667
##  6:  FALSE -1.33250000
##  7:  FALSE  2.30416667
##  8:  FALSE  3.51000000
##  9:  FALSE  6.59083333
## 10:  FALSE 13.47833333
```

```
d2.orig[, .N, by = Otemp < 20]
```

```
##      Otemp     N
##     <lgcl> <int>
## 1:   TRUE  6418
## 2:  FALSE   822
```

```
d2.orig[, .N, by = .(plot, Otemp < 20)]
```

```
##        plot  Otemp     N
##       <fctr> <lgcl> <int>
##  1:       5   TRUE   407
##  2:       6   TRUE   409
##  3:       7   TRUE   408
##  4:       8   TRUE   406
##  5:       9   TRUE   348
##  6:      10   TRUE   406
##  7:      11   TRUE   406
##  8:      12   TRUE   407
##  9:      13   TRUE   406
## 10:      14   TRUE   405
## 11:      15   TRUE   405
## 12:      16   TRUE   370
## 13:       1   TRUE   408
## 14:       2   TRUE   409
## 15:       3   TRUE   409
## 16:       4   TRUE   409
## 17:       1  FALSE    52
## 18:      13  FALSE    53
```

```
## 19:     14  FALSE     54
## 20:     15  FALSE     54
## 21:     16  FALSE     29
## 22:      2  FALSE     51
## 23:      3  FALSE     52
## 24:      4  FALSE     52
## 25:      5  FALSE     54
## 26:      6  FALSE     53
## 27:      7  FALSE     54
## 28:      8  FALSE     54
## 29:     10  FALSE     54
## 30:     11  FALSE     53
## 31:     12  FALSE     52
## 32:      9  FALSE     51
##       plot  Otemp      N
```

822 / 6418

```
## [1] 0.1280773
```

```r
ggplot(d2, aes(Otemp, Itemp, colour = plot)) +
  geom_abline(intercept = 0, slope = 1, colour = 'gray55', lty = 2) +
  geom_point() +
  coord_fixed() +
  theme_bw() +
  labs(x = expression('Ambient soil surface temperature'~(degree*C)),
       y = expression('DFC soil surface temperature'~(degree*C)),
       colour = 'Radiation')
```