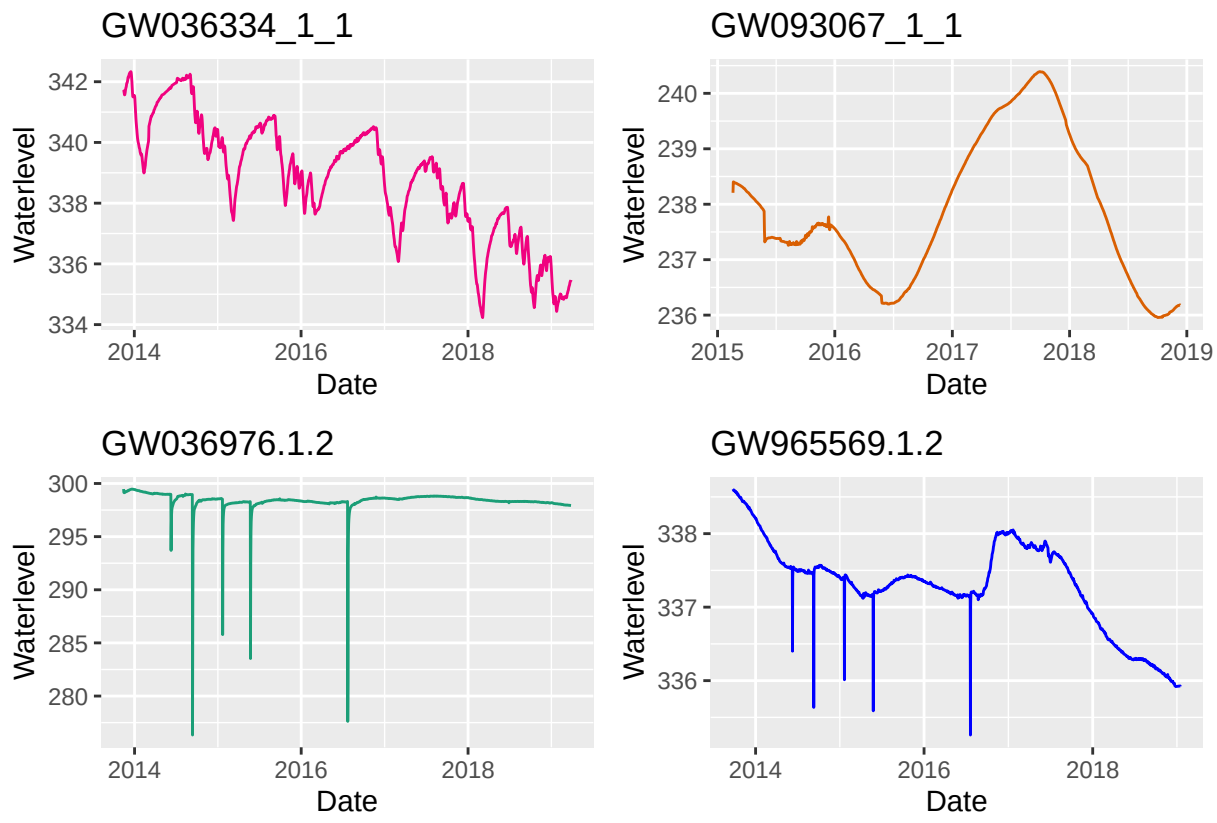
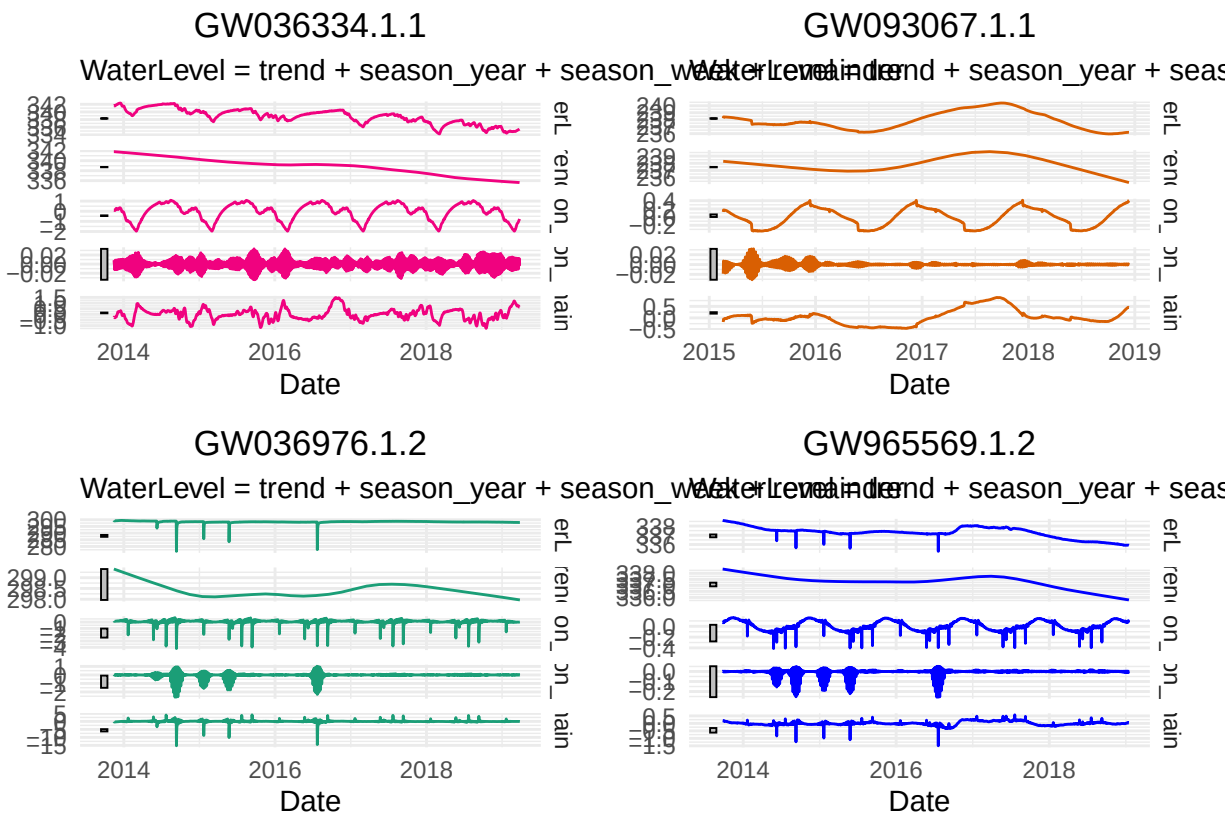
TimeSeriesForecasting_ARIMA_ETS

```
# Time Series Plots

plot_GW036334_1_1data<-GW036334_1_1data %>%  ggplot(aes(x = Date, y = WaterLevel)) +
  geom_line(col="#f0027f")+labs(y= "Waterlevel", x = "Date",title = "GW036334_1_1")

plot_GW093067_1_1data<-GW093067_1_1data %>%  ggplot(aes(x = Date, y = WaterLevel)) +
  geom_line(col="#d95f02")+labs(y= "Waterlevel", x = "Date",title = "GW093067_1_1")

plot_GW036976.1.2data<-GW036976.1.2data %>%  ggplot(aes(x = Date, y = WaterLevel)) +
  geom_line(col="#1b9e77")+labs(y= "Waterlevel", x = "Date",title = "GW036976.1.2")

plot_GW965569.1.2data<-GW965569.1.2data %>%  ggplot(aes(x = Date, y = WaterLevel)) +
  geom_line(col="blue")+labs(y= "Waterlevel", x = "Date",title = "GW965569.1.2")


(plot_GW036334_1_1data|plot_GW093067_1_1data)/(plot_GW036976.1.2data|plot_GW965569.1.2data)
```




```
# STL decomposition
dcmp_GW036334_1_1data <- GW036334_1_1data %>% model(stl = STL(WaterLevel))
```

```
STL_GW036334_1_1data<-components(dcmp_GW036334_1_1data) %>% autoplot(col="#f0027f")+labs(title ="GW0363


dcmp_GW093067_1_1data <- GW093067_1_1data %>% model(stl = STL(WaterLevel))
STL_GW093067_1_1data<-components(dcmp_GW093067_1_1data) %>% autoplot(col="#d95f02")+labs(title ="GW0930


dcmp_GW036976.1.2data <- GW036976.1.2data %>% model(stl = STL(WaterLevel))
STL_GW036976.1.2data<-components(dcmp_GW036976.1.2data) %>% autoplot(col="#1b9e77")+labs(title ="GW0369


dcmp_GW965569.1.2data <- GW965569.1.2data %>% model(stl = STL(WaterLevel))
STL_GW965569.1.2data<-components(dcmp_GW965569.1.2data) %>% autoplot(col="blue")+labs(title ="GW965569.


STL_decom_data<-(STL_GW036334_1_1data|STL_GW093067_1_1data)/(STL_GW036976.1.2data|STL_GW965569.1.2data)

STL_decom_data
```

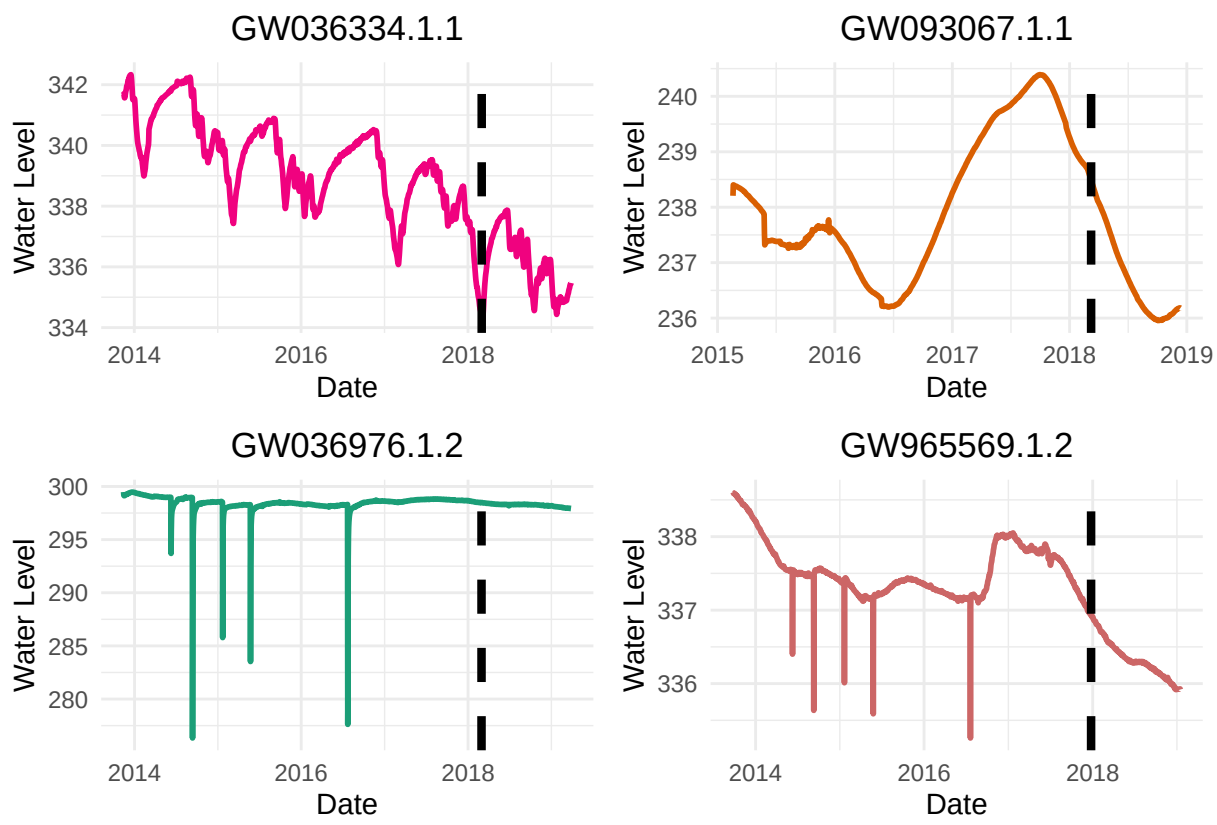


Split the data into 70% of training and 30% of testing.

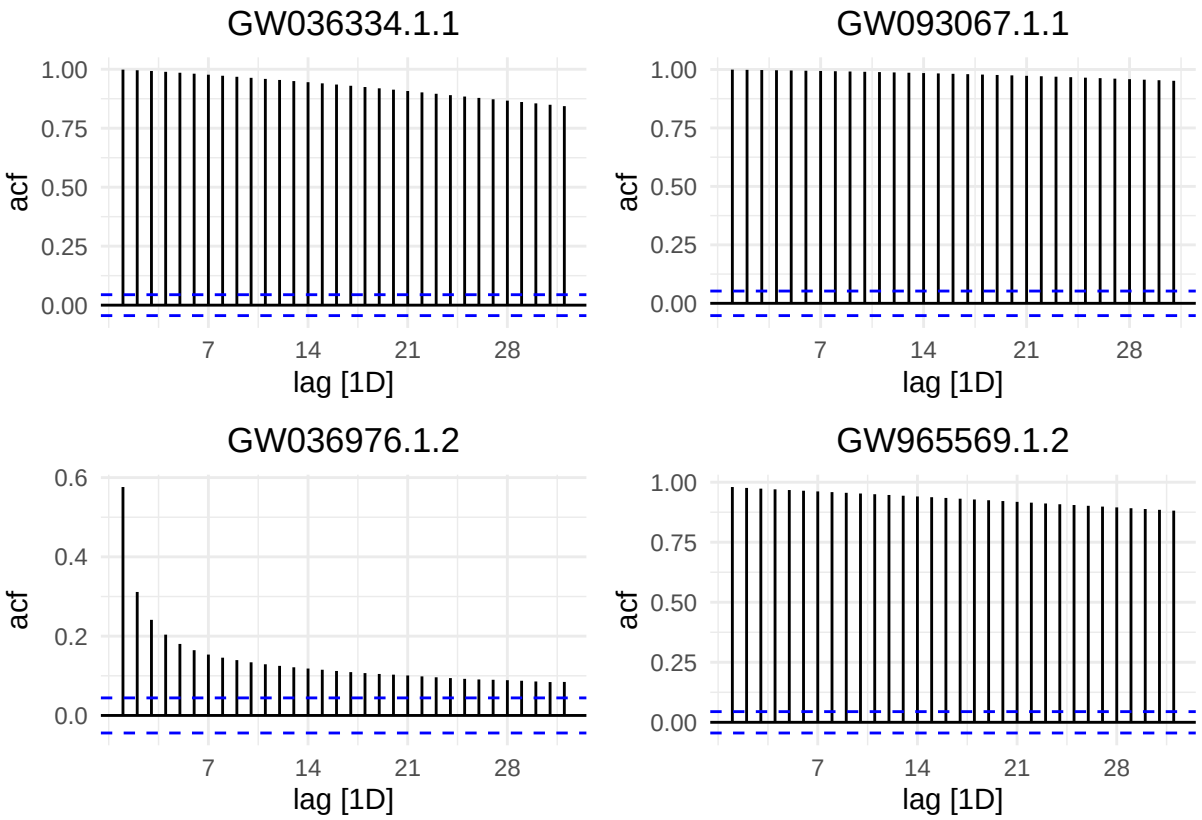
```
# Split train and test data

train_split_point <- floor(nrow(GW036334_1_1data)*0.8)
train_wl_GW036334_1_1 <- GW036334_1_1data[1:train_split_point,]
```

```
test_wl_GW036334_1_1 <- GW036334_1_1data[(train_split_point+1):nrow(GW036334_1_1data),]

train_split_point <- floor(nrow(GW093067_1_1data)*0.8)
train_wl_GW093067_1_1 <- GW093067_1_1data[1:train_split_point,]
test_wl_GW093067_1_1 <- GW093067_1_1data[(train_split_point+1):nrow(GW093067_1_1data),]

train_split_point <- floor(nrow(GW036976.1.2data)*0.8)
train_wl_GW036976.1.2 <- GW036976.1.2data[1:train_split_point,]
test_wl_GW036976.1.2 <- GW036976.1.2data[(train_split_point+1):nrow(GW036976.1.2data),]

train_split_point <- floor(nrow(GW965569.1.2data)*0.8)
train_wl_GW965569.1.2 <- GW965569.1.2data[1:train_split_point,]
test_wl_GW965569.1.2 <- GW965569.1.2data[(train_split_point+1):nrow(GW965569.1.2data),]
```

```
# Visualization of train and test set splitting
Train_Vs_Test_GW036334_1_1data <- GW036334_1_1data %>% ggplot(aes(x = Date, y = WaterLevel)) +
  geom_line(size=1,col="#f0027f")+labs(y= "Water Level", x = "Date",title = "GW036334.1.1")+
  geom_vline(xintercept = as.numeric(as.Date(test_wl_GW036334_1_1$Date[1], format="%m/%d/%Y")), linetype
             color = "black", size=1.5)+ theme_minimal()+theme(plot.title=element_text(hjust=0.5))

Train_Vs_Test_GW093067_1_1data <- GW093067_1_1data %>% ggplot(aes(x = Date, y = WaterLevel)) +
  geom_line(size=1,col="#d95f02")+labs(y= "Water Level", x = "Date",title = "GW093067.1.1")+
  geom_vline(xintercept = as.numeric(as.Date(test_wl_GW093067_1_1$Date[1], format="%m/%d/%Y")), linetype
             color = "black", size=1.5)+ theme_minimal()+theme(plot.title=element_text(hjust=0.5))

Train_Vs_Test_GW036976.1.2data <- GW036976.1.2data %>% ggplot(aes(x = Date, y = WaterLevel)) +
  geom_line(size=1,col="#1b9e77")+labs(y= "Water Level", x = "Date",title = "GW036976.1.2")+
  geom_vline(xintercept = as.numeric(as.Date(test_wl_GW036976.1.2$Date[1], format="%m/%d/%Y")), linetype
             color = "black", size=1.5)+ theme_minimal()+theme(plot.title=element_text(hjust=0.5))

Train_Vs_Test_GW965569.1.2data <- GW965569.1.2data %>% ggplot(aes(x = Date, y = WaterLevel)) +
  geom_line(size=1,col="#CC6666")+labs(y= "Water Level", x = "Date",title = "GW965569.1.2")+
  geom_vline(xintercept = as.numeric(as.Date(test_wl_GW965569.1.2$Date[1], format="%m/%d/%Y")), linetype
             color = "black", size=1.5)+ theme_minimal()+theme(plot.title=element_text(hjust=0.5))

Train_Vs_Test<-(Train_Vs_Test_GW036334_1_1data|Train_Vs_Test_GW093067_1_1data)/(Train_Vs_Test_GW036976.

Train_Vs_Test
```




```
# Checking Stationarity
# acf plot

AC1<-GW036334_1_1data %>% ACF(WaterLevel) %>% autoplot()+labs(title ="GW036334.1.1" )+ theme_minimal()+
AC2<-GW093067_1_1data %>% ACF(WaterLevel) %>% autoplot()+labs(title ="GW093067.1.1" )+ theme_minimal()+
AC3<-GW036976.1.2data %>% ACF(WaterLevel) %>% autoplot()+labs(title ="GW036976.1.2" )+ theme_minimal()+
AC4<-GW965569.1.2data %>% ACF(WaterLevel) %>% autoplot()+labs(title ="GW965569.1.2" )+ theme_minimal()+

ACF_PLOTS<-(AC1|AC2)/(AC3|AC4)
ACF_PLOTS
```



ARIMA Modeling

```
# Checking number of seasonal and non-seasonal difference required-by Unit Root Test
GW036334_1_1Ndiff<-GW036334_1_1data %>%features(WaterLevel, unitroot_ndiffs)
GW036334_1_1NSdiff<-GW036334_1_1data %>%features(WaterLevel, unitroot_nsdiffs)
GW036334_1_1Ndiff
```

```
## # A tibble: 1 x 1
##   ndiffs
##    <int>
## 1      1
```

```
GW036334_1_1NSdiff
```

```
## # A tibble: 1 x 1
##   nsdiffs
##     <int>
## 1       0
```

```
GW093067_1_1Ndiff<-GW093067_1_1data %>%features(WaterLevel, unitroot_ndiffs)
GW093067_1_1NSdiff<-GW093067_1_1data %>%features(WaterLevel, unitroot_nsdiffs)
GW093067_1_1Ndiff
```

```
## # A tibble: 1 x 1
##   ndiffs
##    <int>
## 1      2
```

```
GW093067_1_1NSdiff
```

```
## # A tibble: 1 x 1
##   nsdiffs
##     <int>
## 1       0
```

```
GW036976.1.2Ndiff<-GW036976.1.2data %>%features(WaterLevel, unitroot_ndiffs)
GW036976.1.2NSdiff<-GW036976.1.2data %>%features(WaterLevel, unitroot_nsdiffs)
GW036976.1.2Ndiff
```

```
## # A tibble: 1 x 1
##   ndiffs
##    <int>
## 1      1
```

```
GW036976.1.2NSdiff
```

```
## # A tibble: 1 x 1
##   nsdiffs
##     <int>
## 1       0
```

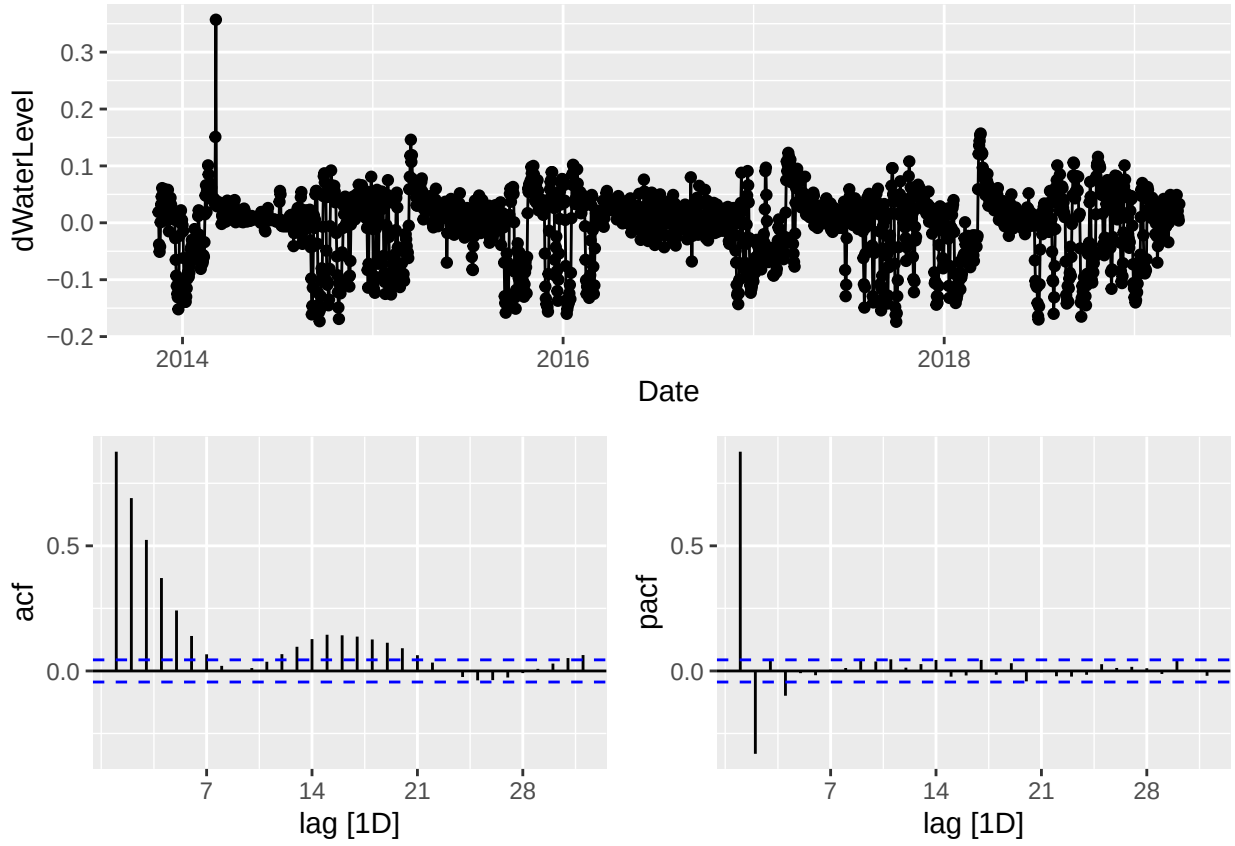
```
GW965569.1.2Ndiff<-GW965569.1.2data %>%features(WaterLevel, unitroot_ndiffs)
GW965569.1.2NSdiff<-GW965569.1.2data %>%features(WaterLevel, unitroot_nsdiffs)
GW965569.1.2Ndiff
```

```
## # A tibble: 1 x 1
##   ndiffs
##    <int>
## 1      1
```

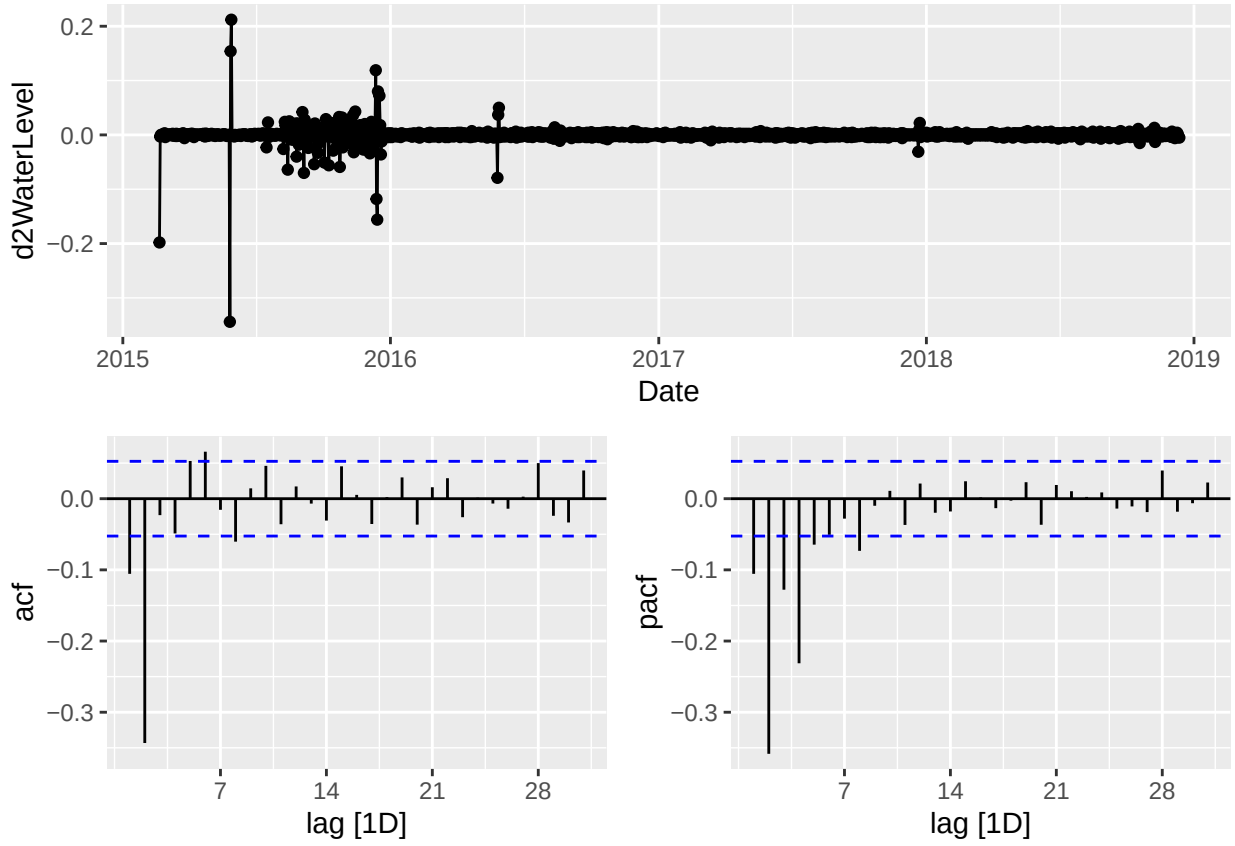
```
GW965569.1.2NSdiff
```

```
## # A tibble: 1 x 1
##   nsdiffs
##     <int>
## 1       0
```

```
# Convert the data into stationary-ACF and PACF plots-GW036334.1.1
GW036334_1_1data %>%
  mutate(dWaterLevel = difference(WaterLevel)) %>%
  gg_tsdisplay(dWaterLevel, plot_type='partial')
```



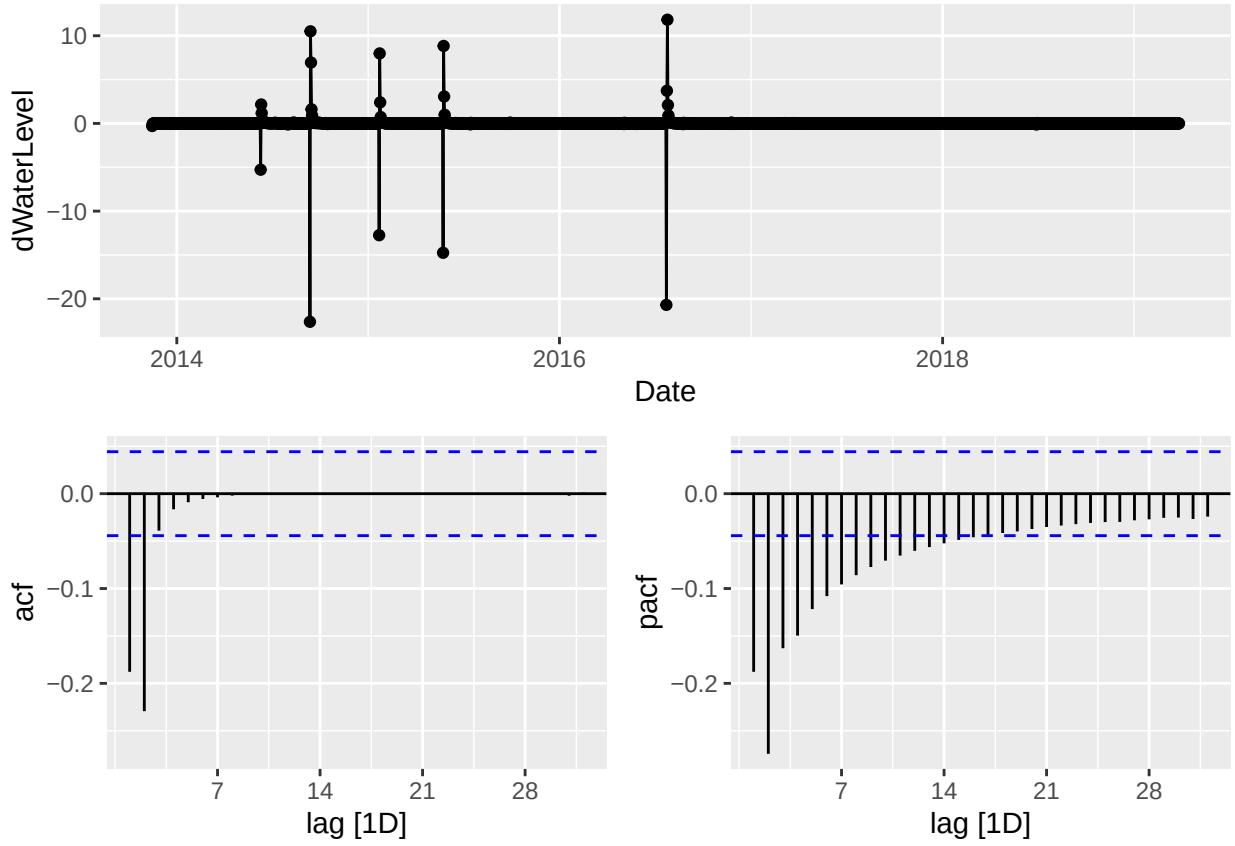

```
# Convert the data into stationary-ACF and PACF plots-GW093067.1.1
 GW093067_1_1data %>%
  mutate(dWaterLevel = difference(WaterLevel)) %>%
  mutate(d2WaterLevel = difference(dWaterLevel)) %>%
  gg_tsdisplay(d2WaterLevel, plot_type='partial')
```




```
# Convert the data into stationary-ACF and PACF plots-GW036976.1.2
GW036976.1.2data %>%
  mutate(dWaterLevel = difference(WaterLevel)) %>%
  gg_tsdisplay(dWaterLevel, plot_type='partial')
```

```
## Warning: Removed 1 row(s) containing missing values (geom_path).
```

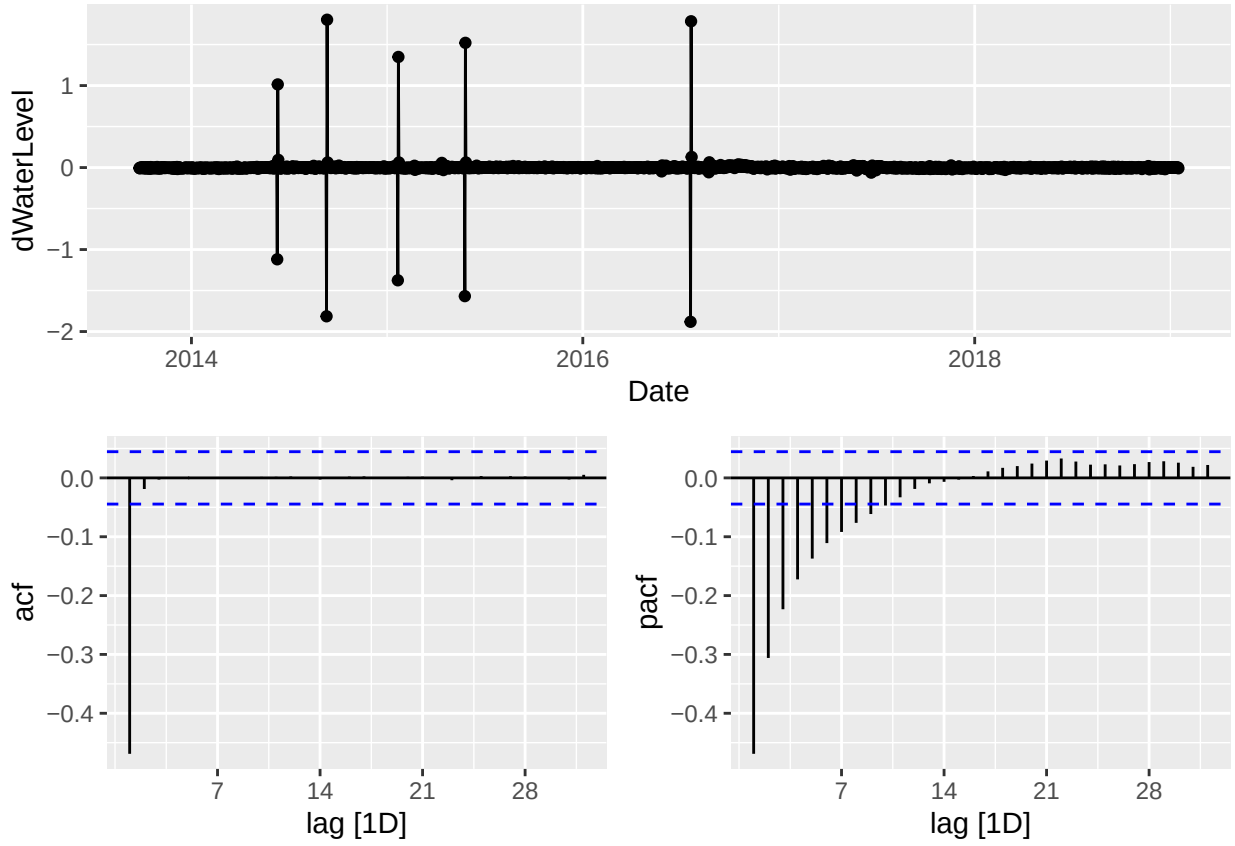
```
## Warning: Removed 1 rows containing missing values (geom_point).
```




```
# Convert the data into stationary-ACF and PACF plots-GW965569.1.2
GW965569.1.2data %>%
  mutate(dWaterLevel = difference(WaterLevel)) %>%
  gg_tsdisplay(dWaterLevel, plot_type='partial')
```

```
## Warning: Removed 1 row(s) containing missing values (geom_path).
```

```
## Warning: Removed 1 rows containing missing values (geom_point).
```




```
# ARIMA Modeling
arima_fit_GW036334_1_1 <- train_wl_GW036334_1_1 %>%
  model(  arima210 = ARIMA(WaterLevel ~ pdq(2,1,0)),
          stepwise = ARIMA(WaterLevel),
          search = ARIMA(WaterLevel, stepwise=FALSE))

# Accuracy Checking

arima_fit_GW036334_1_1 %>% forecast(h = length(test_wl_GW036334_1_1$Date)) %>% accuracy(test_wl_GW03633
```

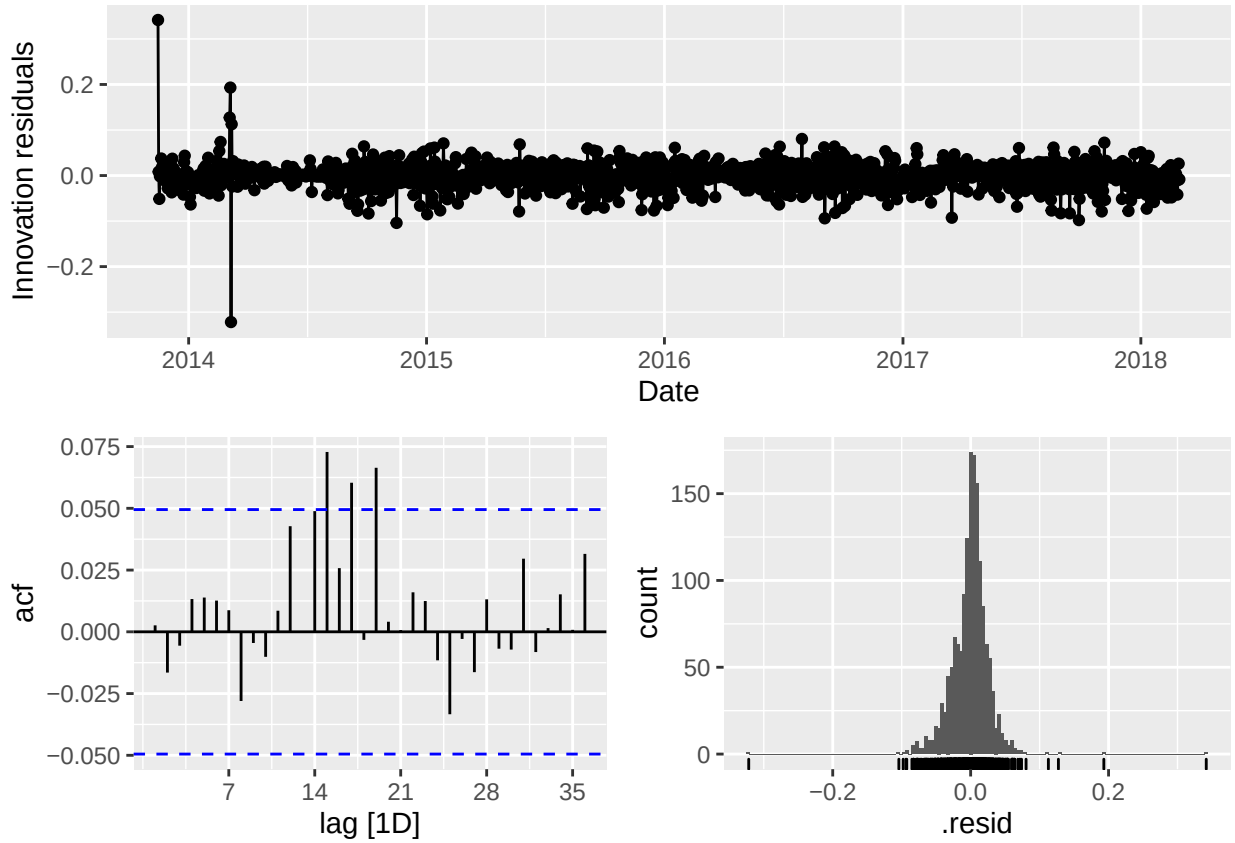
```
## # A tibble: 3 x 10
##   .model   .type    ME  RMSE   MAE   MPE  MAPE  MASE RMSSE  ACF1
##   <chr>    <chr> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1 stepwise Test   1.73  2.00  1.73 0.515 0.515   NaN   NaN 0.993
## 2 arima210 Test   1.76  2.02  1.76 0.522 0.522   NaN   NaN 0.993
## 3 search   Test   1.77  2.03  1.77 0.525 0.526   NaN   NaN 0.993
```

```
# Checking the residuals of the lowest accuracy model

report(arima_fit_GW036334_1_1 %>% select(stepwise))
```

```
## Series: WaterLevel
## Model: ARIMA(2,1,3)
##
## Coefficients:
##          ar1      ar2      ma1      ma2     ma3
##       1.4247  -0.5475  -0.2679  -0.1592  0.0838
```

```
## s.e.  0.1088   0.0853   0.1111   0.0503  0.0331
##
## sigma^2 estimated as 0.0007787:  log likelihood=3465.47
## AIC=-6918.94   AICc=-6918.89   BIC=-6886.8
```

```
# Residual Analysis

arima_fit_GW036334_1_1 %>% select(stepwise) %>% gg_tsresiduals(lag=36)
```

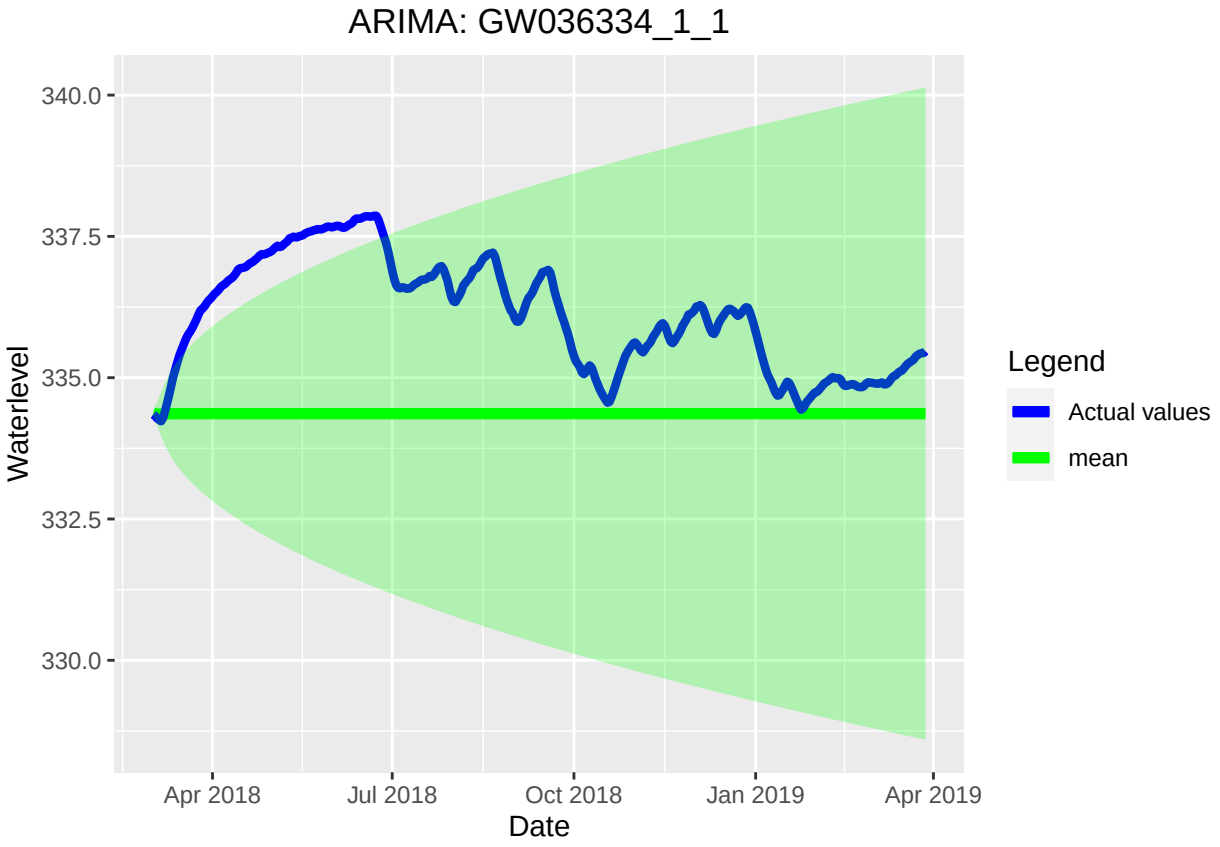



```
# Checking the hypothesis (H0: Residuals are WN vs H1: Residuals show #autocorrelation)
augment(arima_fit_GW036334_1_1) %>%
  filter(.model=='stepwise') %>%
  features(.innov, ljung_box, lag = 10, dof = 3)
```

```
## # A tibble: 1 x 3
##   .model   lb_stat lb_pvalue
##   <chr>      <dbl>     <dbl>
## 1 stepwise    2.87     0.896
```

```
# H0 is not rejected. Hence, Residuals are WN

Forecast_GW036334_1_1<-arima_fit_GW036334_1_1 %>% select(stepwise) %>%
                       forecast(h = length(test_wl_GW036334_1_1$Date))%>%hilo(level=c(95))
Actual_values<-test_wl_GW036334_1_1$WaterLevel
Forecast_GW036334_1_1$Actual_values<-Actual_values

colors <- c("Actual values" = "blue", "mean" = "green")
```

```
Plot_AvsFitted_GW036334_1_1<-Forecast_GW036334_1_1%>%ggplot(aes(x = Date))+    geom_line(aes(y = .mean,
  geom_line(aes(y = Actual_values,color="Actual values"),size=1.5)+
  geom_ribbon(aes(ymin = Forecast_GW036334_1_1$`95%`$lower, ymax =    Forecast_GW036334_1_1$`95%`$upper
  labs(y= "Waterlevel", x = "Date",color = "Legend",title = "ARIMA: GW036334_1_1")+
  scale_color_manual(values = colors)+theme(plot.title=element_text(hjust=0.5))

Plot_AvsFitted_GW036334_1_1
```




```
# ARIMA Modeling

arima_fit_GW093067_1_1 <- train_wl_GW093067_1_1 %>%
  model(  arima222 = ARIMA(WaterLevel ~ pdq(2,2,2)),
          stepwise = ARIMA(WaterLevel),
          search = ARIMA(WaterLevel, stepwise=FALSE))

# Accuracy Checking
arima_fit_GW093067_1_1 %>% forecast(h = length(test_wl_GW093067_1_1$Date)) %>% accuracy(test_wl_GW09306
```

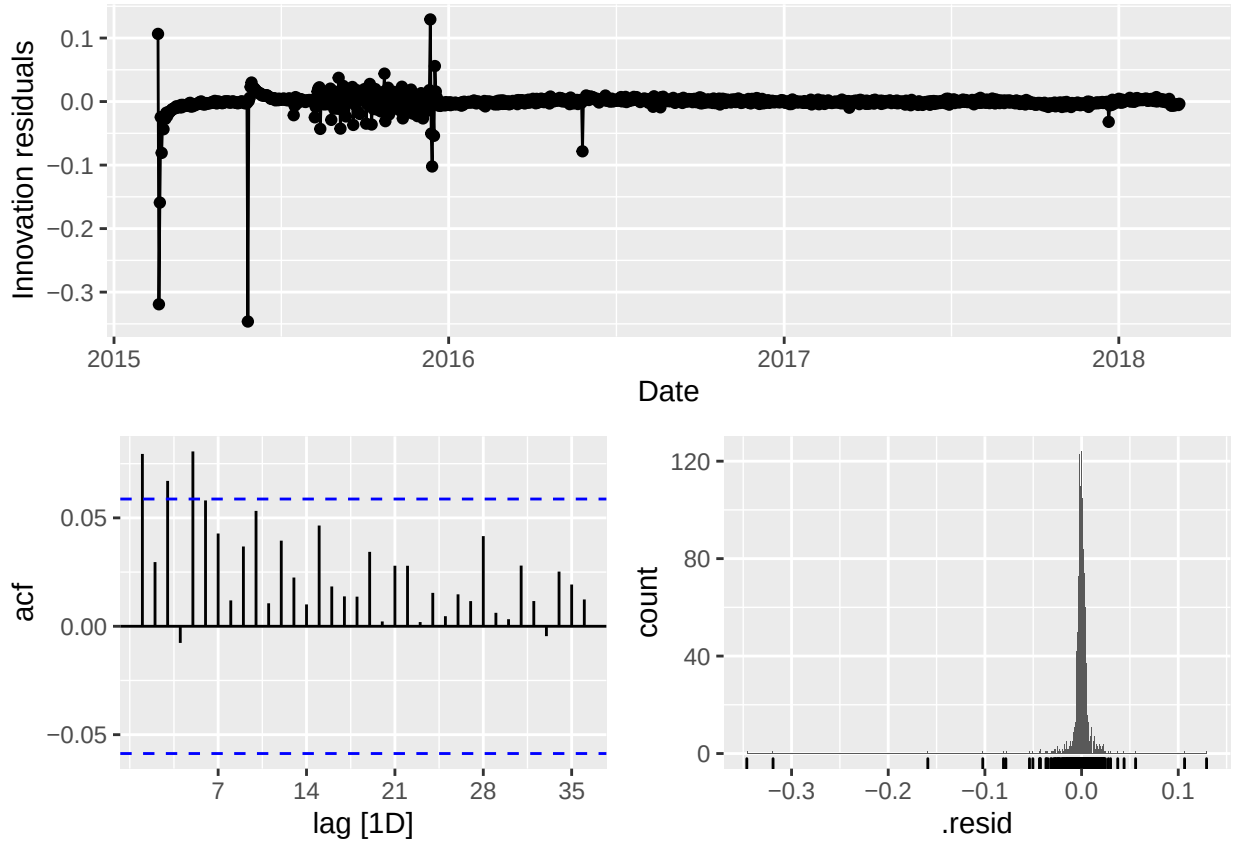
```
## # A tibble: 3 x 10
##   .model   .type      ME  RMSE   MAE     MPE  MAPE  MASE RMSSE  ACF1
##   <chr>    <chr>   <dbl> <dbl> <dbl>   <dbl> <dbl> <dbl> <dbl> <dbl>
## 1 arima222 Test  0.00678 0.413 0.316 0.00309 0.134   NaN   NaN 0.985
## 2 stepwise Test  0.0513  0.436 0.319 0.0219  0.135   NaN   NaN 0.985
## 3 search   Test  0.0540  0.437 0.319 0.0231  0.135   NaN   NaN 0.985
```

```
# Checking the residuals of the lowest accuracy model
```

```
report(arima_fit_GW093067_1_1 %>% select(arima222))
```

```
## Series: WaterLevel
## Model: ARIMA(2,2,2)
##
## Coefficients:
##           ar1      ar2      ma1      ma2
##       -0.0360  -0.0878  -0.4024  -0.5250
## s.e.   0.0958   0.0598   0.0931   0.0909
##
## sigma^2 estimated as 0.0003271:  log likelihood=3095.85
## AIC=-6181.7   AICc=-6181.64   BIC=-6156.62
```

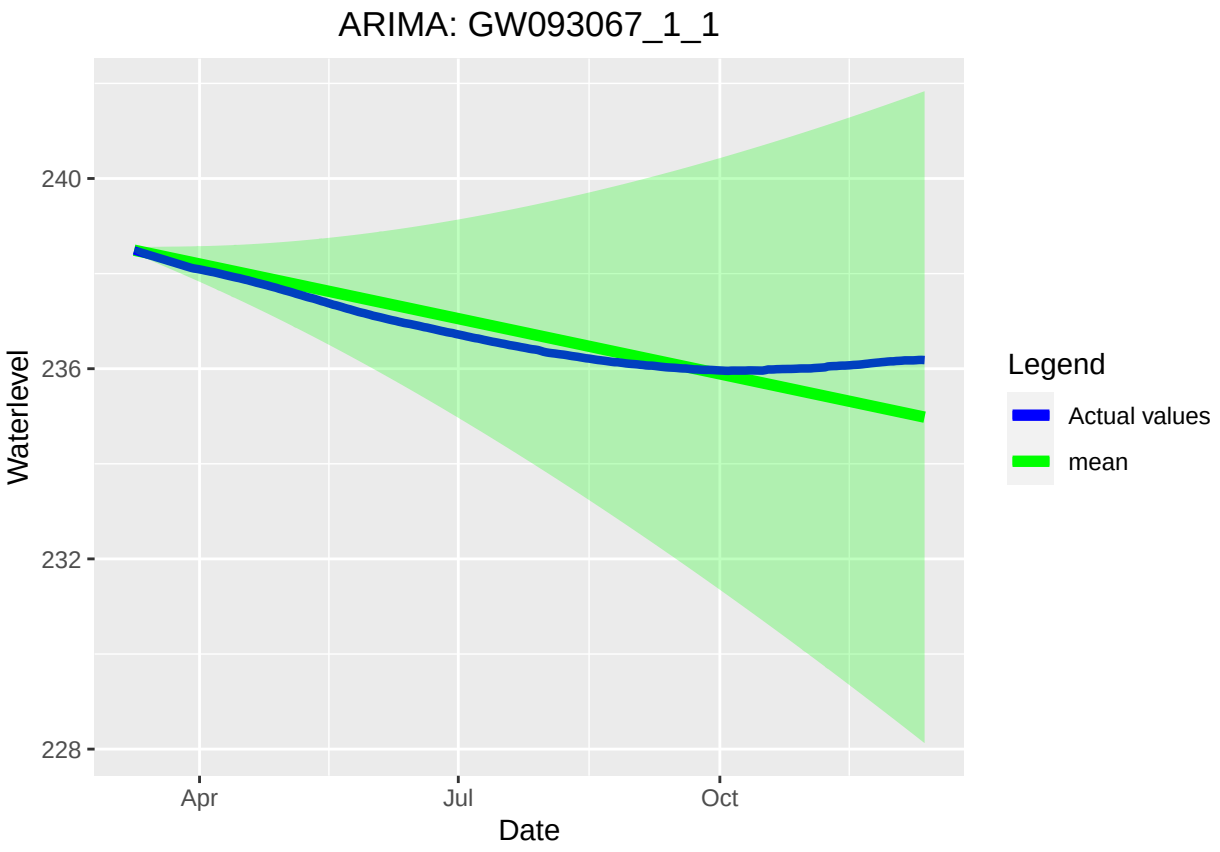
```
# Residual Analysis

arima_fit_GW093067_1_1 %>% select(arima222) %>% gg_tsresiduals(lag=36)
```




```
# Checking the Hypothesis
augment(arima_fit_GW093067_1_1) %>%
  filter(.model=='arima222') %>%
  features(.innov, ljung_box, lag = 10, dof = 3)
```

```
## # A tibble: 1 x 3
##   .model   lb_stat lb_pvalue
##   <chr>      <dbl>     <dbl>
## 1 arima222    31.2 0.0000580
```

```
# Reject HO. Hence, residuals are not WN.
Forecast_GW093067_1_1<-arima_fit_GW093067_1_1 %>% select(arima222) %>%
  forecast(h = length(test_wl_GW093067_1_1$Date))%>%hilo(level=c(95))
Actual_values<-test_wl_GW093067_1_1$WaterLevel
Forecast_GW093067_1_1$Actual_values<-Actual_values

colors <- c("Actual values" = "blue", "mean" = "green")

Plot_AvsFitted_GW093067_1_1<-Forecast_GW093067_1_1%>%ggplot(aes(x = Date))+
  geom_line(aes(y = .mean,color="mean"),size=2)+
  geom_line(aes(y = Actual_values,color="Actual values"),size=1.5)+
  geom_ribbon(aes(ymin = Forecast_GW093067_1_1$`95%`$lower, ymax = Forecast_GW093067_1_1$`95%`$upper), a
  labs(y= "Waterlevel", x = "Date",color = "Legend",title = "ARIMA: GW093067_1_1")+
  scale_color_manual(values = colors)+theme(plot.title=element_text(hjust=0.5))
Plot_AvsFitted_GW093067_1_1
```



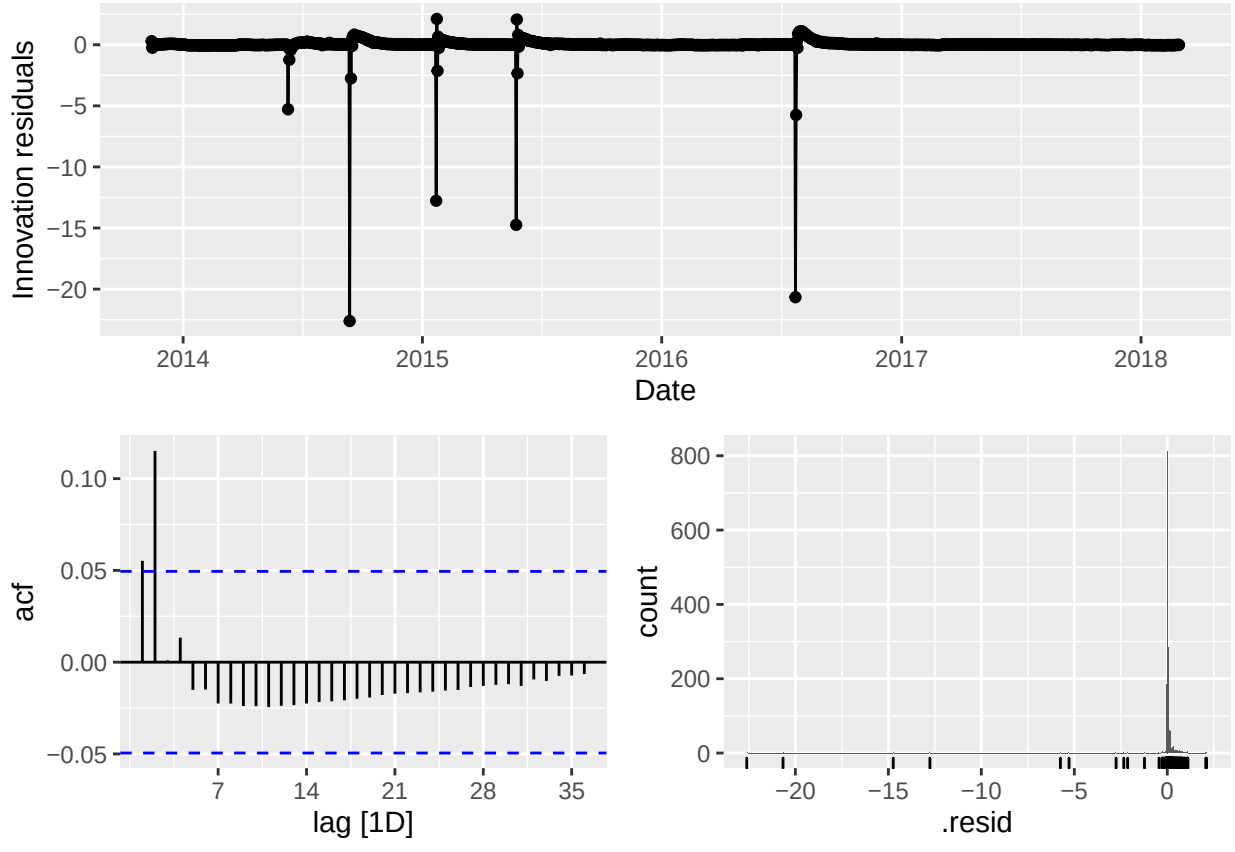

```
# ARIMA Modeling

arima_fit_GW036976.1.2 <- train_wl_GW036976.1.2 %>%
  model(  arima012 = ARIMA(WaterLevel ~ pdq(0,1,2)),
          stepwise = ARIMA(WaterLevel),
          search = ARIMA(WaterLevel, stepwise=FALSE))

# Accuracy Checking
arima_fit_GW036976.1.2 %>% forecast(h = length(test_wl_GW036976.1.2$Date)) %>% accuracy(test_wl_GW03697
```

```
## # A tibble: 3 x 10
##   .model    .type      ME  RMSE   MAE      MPE   MAPE  MASE RMSSE  ACF1
##   <chr>     <chr>   <dbl> <dbl> <dbl>    <dbl>  <dbl> <dbl> <dbl> <dbl>
## 1 arima012 Test  -0.260 0.291 0.260 -0.0874 0.0874   NaN   NaN 0.985
## 2 search   Test  -0.361 0.383 0.361 -0.121  0.121    NaN   NaN 0.983
## 3 stepwise Test  -0.361 0.383 0.361 -0.121  0.121    NaN   NaN 0.983
```

```
# Checking the residuals of the lowest accuracy model

report(arima_fit_GW036976.1.2 %>% select(arima012))
```

```
## Series: WaterLevel
## Model: ARIMA(0,1,2)
##
## Coefficients:
##           ma1      ma2
##       -0.4591  -0.4313
## s.e.   0.0227   0.0248
##
## sigma^2 estimated as 0.9247:  log likelihood=-2161.79
## AIC=4329.59   AICc=4329.6   BIC=4345.66
```

```
# Residual Analysis

arima_fit_GW036976.1.2 %>% select(arima012) %>% gg_tsresiduals(lag=36)
```

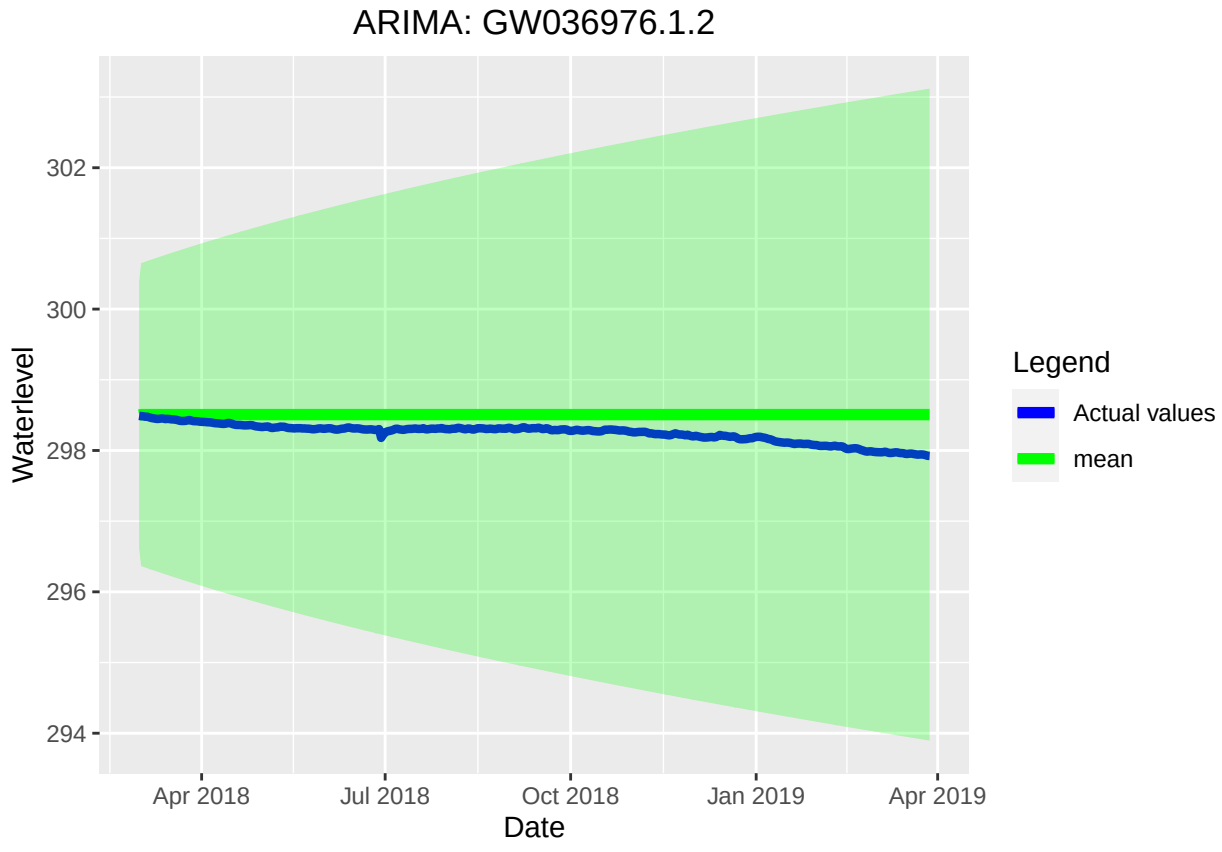



```
# Hypothesis testing
augment(arima_fit_GW036976.1.2) %>%
```

```
  filter(.model=='arima012') %>%
  features(.innov, ljung_box, lag = 10, dof = 3)
```

```
## # A tibble: 1 x 3
##   .model   lb_stat lb_pvalue
##   <chr>      <dbl>     <dbl>
## 1 arima012    30.0 0.0000947
```

```
# Reject HO. Hence, residuals are WN.

Forecast_GW036976.1.2<-arima_fit_GW036976.1.2 %>% select(arima012) %>%
  forecast(h = length(test_wl_GW036976.1.2$Date))%>%hilo(level=c(95))
Actual_values<-test_wl_GW036976.1.2$WaterLevel
Forecast_GW036976.1.2$Actual_values<-Actual_values

colors <- c("Actual values" = "blue", "mean" = "green")

Plot_AvsFitted_GW036976.1.2<-Forecast_GW036976.1.2%>%ggplot(aes(x = Date))+
  geom_line(aes(y = .mean,color="mean"),size=2)+
  geom_line(aes(y = Actual_values,color="Actual values"),size=1.5)+
  geom_ribbon(aes(ymin = Forecast_GW036976.1.2$`95%`$lower, ymax = Forecast_GW036976.1.2$`95%`$upper), a
  labs(y= "Waterlevel", x = "Date",color = "Legend",title = "ARIMA: GW036976.1.2")+
  scale_color_manual(values = colors)+theme(plot.title=element_text(hjust=0.5))
Plot_AvsFitted_GW036976.1.2
```




```
# ARIMA Modeling
arima_fit_GW965569.1.2 <- train_wl_GW965569.1.2 %>%
```

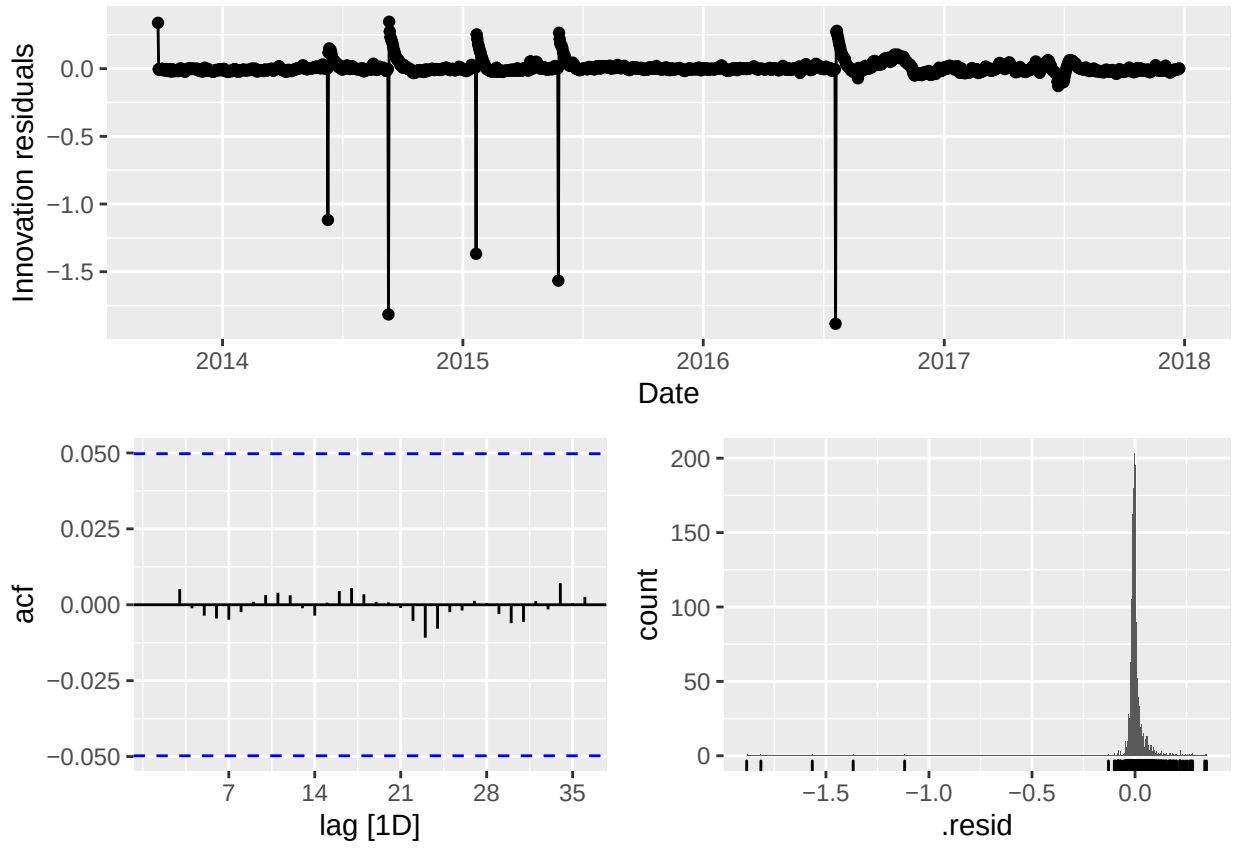
```
  model(  arima011 = ARIMA(WaterLevel ~ pdq(0,1,1)),
          stepwise = ARIMA(WaterLevel),
          search = ARIMA(WaterLevel, stepwise=FALSE))

# Accuracy Checking
arima_fit_GW965569.1.2 %>% forecast(h = length(test_wl_GW965569.1.2$Date)) %>% accuracy(test_wl_GW96556
```

```
## # A tibble: 3 x 10
##   .model   .type     ME  RMSE   MAE     MPE   MAPE  MASE RMSSE  ACF1
##   <chr>    <chr>  <dbl> <dbl> <dbl>   <dbl>  <dbl> <dbl> <dbl> <dbl>
## 1 search   Test  -0.229 0.252 0.229 -0.0682 0.0682   NaN   NaN 0.988
## 2 arima011 Test  -0.409 0.434 0.409 -0.122  0.122    NaN   NaN 0.987
## 3 stepwise Test  -0.409 0.434 0.409 -0.122  0.122    NaN   NaN 0.987
```

```
# Checking the residuals of the lowest accuracy model

report(arima_fit_GW965569.1.2 %>% select(search))
```

```
## Series: WaterLevel
## Model: ARIMA(1,1,4) w/ drift
##
## Coefficients:
##          ar1      ma1     ma2     ma3     ma4  constant
##       0.9851  -1.7875  0.7542  0.0246  0.0154         0
## s.e.  0.0080   0.0264  0.0526  0.0522  0.0254         0
##
## sigma^2 estimated as 0.00958:  log likelihood=1412.05
## AIC=-2810.09   AICc=-2810.02   BIC=-2772.67
```

```
# Residual Analysis

arima_fit_GW965569.1.2 %>% select(search) %>% gg_tsresiduals(lag=36)
```

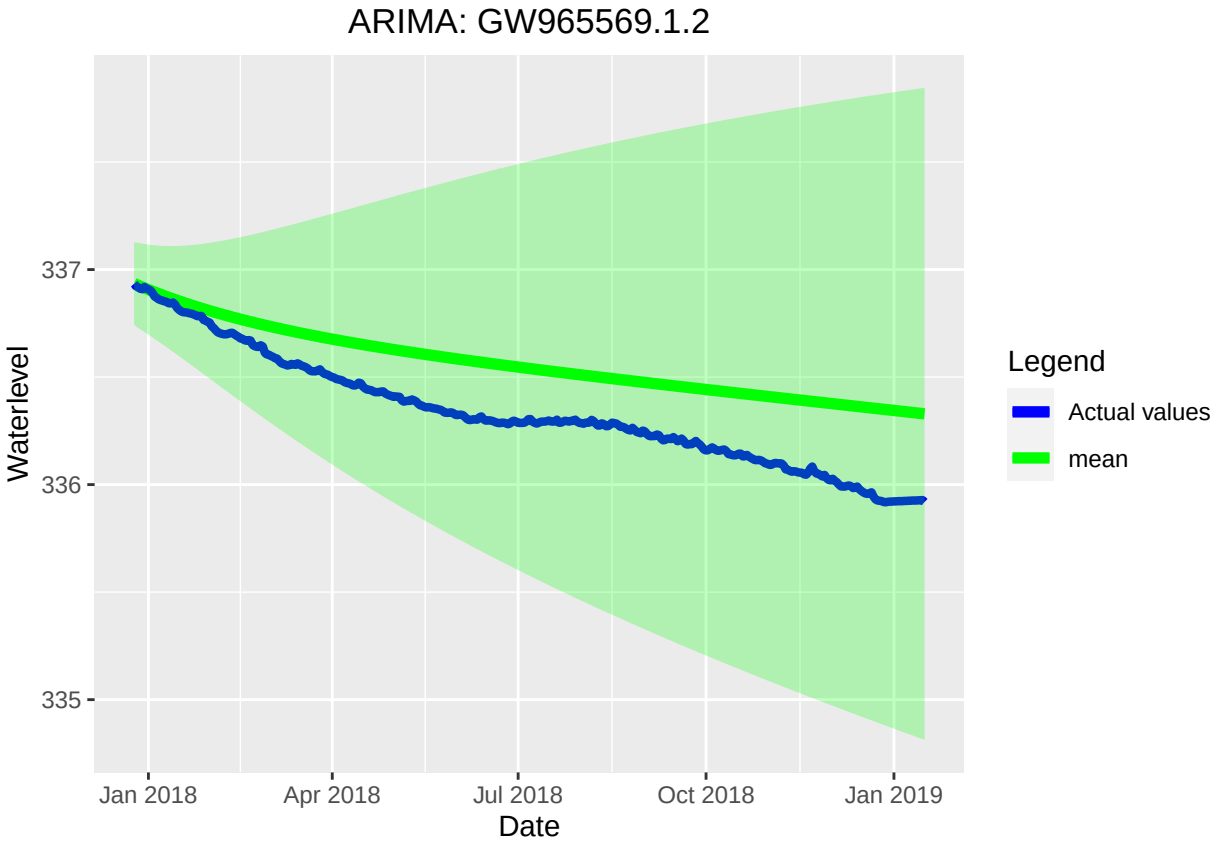



```
# Hypothesis Testing

augment(arima_fit_GW965569.1.2) %>%
  filter(.model=='search') %>%
  features(.innov, ljung_box, lag = 10, dof = 3)
```

```
## # A tibble: 1 x 3
##   .model lb_stat lb_pvalue
##   <chr>    <dbl>     <dbl>
## 1 search   0.160      1.00
```

```
# Does not reject H0. Hence, residuals are WN.

Forecast_GW965569.1.2<-arima_fit_GW965569.1.2 %>% select(search) %>%
  forecast(h = length(test_wl_GW965569.1.2$Date))%>%hilo(level=c(95))
Actual_values<-test_wl_GW965569.1.2$WaterLevel
Forecast_GW965569.1.2$Actual_values<-Actual_values

colors <- c("Actual values" = "blue", "mean" = "green")

Plot_AvsFitted_GW965569.1.2<-Forecast_GW965569.1.2%>%ggplot(aes(x = Date))+
  geom_line(aes(y = .mean,color="mean"),size=2)+
  geom_line(aes(y = Actual_values,color="Actual values"),size=1.5)+
  geom_ribbon(aes(ymin = Forecast_GW965569.1.2$`95%`$lower, ymax = Forecast_GW965569.1.2$`95%`$upper), a
  labs(y= "Waterlevel", x = "Date",color = "Legend",title = "ARIMA: GW965569.1.2")+
  scale_color_manual(values = colors)+theme(plot.title=element_text(hjust=0.5))
```

```
Plot_AvsFitted_GW965569.1.2
```



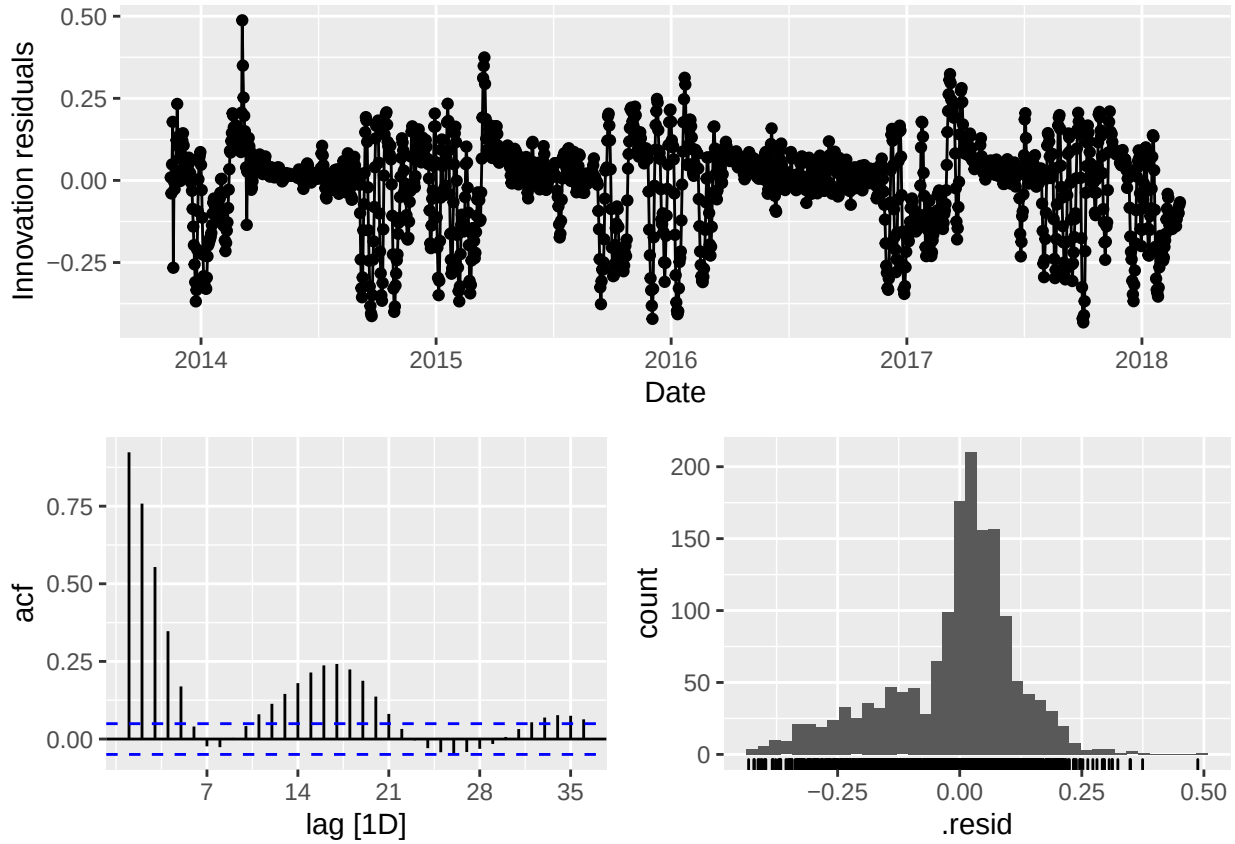
ETS Modeling

```
fit1<-train_wl_GW036334_1_1 %>%
  model(ses = ETS(WaterLevel ~ error("A") + trend("N") + season("N")),
        hlm = ETS(WaterLevel ~ error("A") + trend("N") + season("A")),
        ahw = ETS(WaterLevel ~ error("A") + trend("A") + season("A")),
        auto1 = ETS(WaterLevel ~ error("A") + trend("N") + season("M")),
        auto2 = ETS(WaterLevel ~ error("A") + trend("A") + season("N")),
        auto3 = ETS(WaterLevel ~ error("A") + trend("A") + season("M")),
        auto4 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("N")),
        auto5 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("A")),
        auto6 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("M")),
        ses1 = ETS(WaterLevel ~ error("M") + trend("N") + season("N")),
        hlm1 = ETS(WaterLevel ~ error("M") + trend("N") + season("A")),
        ahw1 = ETS(WaterLevel ~ error("M") + trend("A") + season("A")),
        auto11 = ETS(WaterLevel ~ error("M") + trend("N") + season("M")),
        auto21 = ETS(WaterLevel ~ error("M") + trend("A") + season("N")),
        auto31 = ETS(WaterLevel ~ error("M") + trend("A") + season("M")),
        auto41 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("N")),
        auto51 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("A")),
        auto61 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("M"))
  )
```

```
fit1 %>% forecast(h = length(test_wl_GW036334_1_1$Date)) %>% accuracy(test_wl_GW036334_1_1) %>% arrange
```

```
## # A tibble: 18 x 10
##    .model .type    ME  RMSE   MAE   MPE  MAPE  MASE RMSSE  ACF1
##    <chr>  <chr> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
##  1 auto1  Test   1.68  1.95  1.68 0.498 0.499   NaN   NaN 0.993
##  2 auto11 Test   1.70  1.97  1.70 0.505 0.506   NaN   NaN 0.993
##  3 hlm1   Test   1.70  1.97  1.71 0.506 0.507   NaN   NaN 0.993
##  4 ses    Test   1.71  1.97  1.71 0.506 0.507   NaN   NaN 0.993
##  5 ses1   Test   1.71  1.97  1.71 0.506 0.507   NaN   NaN 0.993
##  6 hlm    Test   1.71  1.97  1.71 0.507 0.507   NaN   NaN 0.993
##  7 auto41 Test   1.87  2.12  1.87 0.554 0.555   NaN   NaN 0.993
##  8 auto4  Test   1.88  2.13  1.88 0.559 0.559   NaN   NaN 0.993
##  9 auto51 Test   1.90  2.15  1.90 0.565 0.565   NaN   NaN 0.993
## 10 auto6  Test   2.40  2.63  2.40 0.714 0.714   NaN   NaN 0.991
## 11 auto5  Test   2.63  2.82  2.63 0.781 0.781   NaN   NaN 0.989
## 12 auto61 Test   3.02  3.20  3.02 0.898 0.898   NaN   NaN 0.987
## 13 auto2  Test   6.02  6.36  6.03 1.79  1.79    NaN   NaN 0.984
## 14 auto21 Test   6.03  6.36  6.03 1.79  1.79    NaN   NaN 0.984
## 15 ahw1   Test   8.83  9.52  8.83 2.63  2.63    NaN   NaN 0.988
## 16 ahw    Test   9.96 10.8   9.96 2.97  2.97    NaN   NaN 0.989
## 17 auto31 Test  10.6  11.6  10.6  3.16  3.16    NaN   NaN 0.989
## 18 auto3  Test  12.1  13.2  12.1  3.60  3.60    NaN   NaN 0.990
```

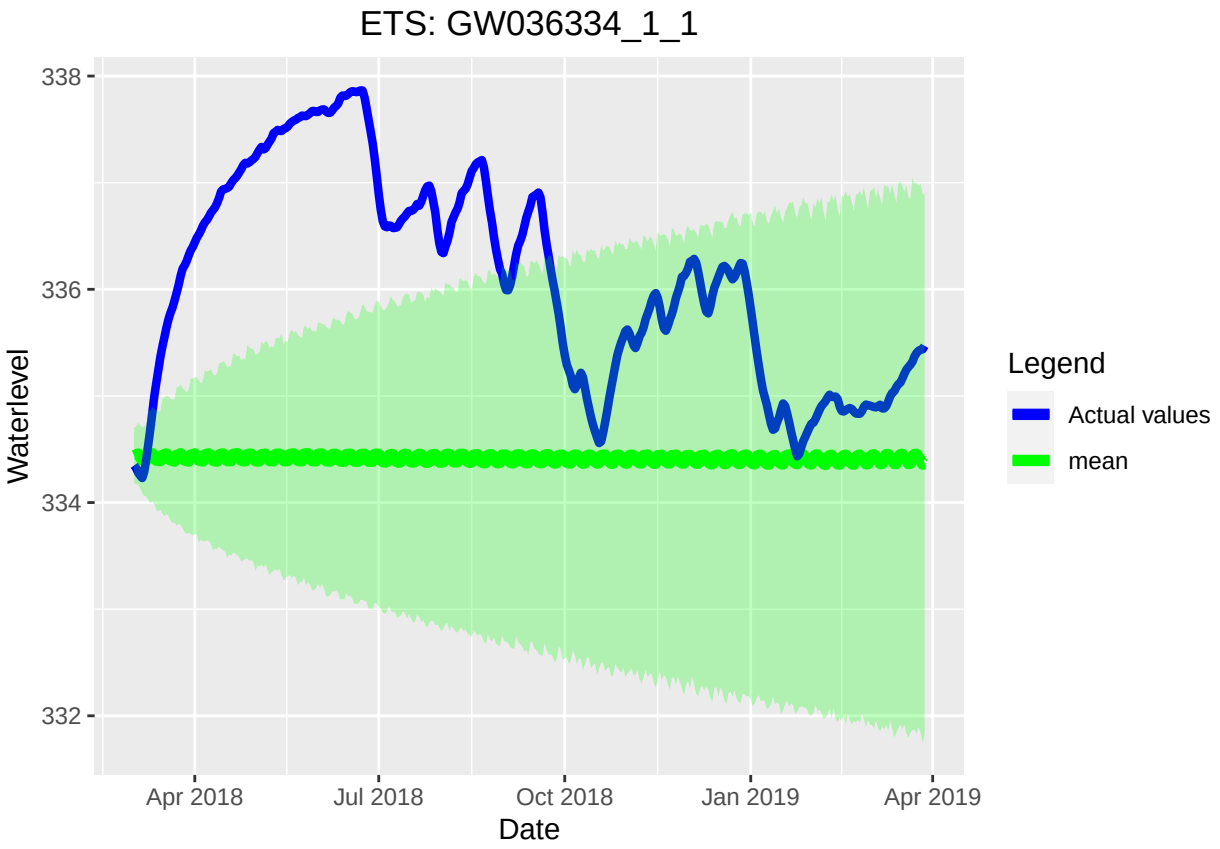
```
fit1 %>% select(auto1) %>% gg_tsresiduals(lag=36)
```



```
augment(fit1) %>%
  features(.innov, ljung_box, lag=24, dof=4)
```

```
## # A tibble: 18 x 3
##    .model lb_stat lb_pvalue
##    <chr>    <dbl>     <dbl>
##  1 ahw      1587.         0
##  2 ahw1     1320.         0
##  3 auto1    3518.         0
##  4 auto11   2461.         0
##  5 auto2     262.         0
##  6 auto21    262.         0
##  7 auto3    2775.         0
##  8 auto31   1457.         0
##  9 auto4     255.         0
## 10 auto41    259.         0
## 11 auto5    1060.         0
## 12 auto51   1269.         0
## 13 auto6     977.         0
## 14 auto61   1421.         0
## 15 hlm      2507.         0
## 16 hlm1     2508.         0
## 17 ses      3084.         0
## 18 ses1     3088.         0
```

```
# auto1 is the best model, but residuals are not WN

Forecast_GW036334_1_1_ETS<-fit1 %>% select(auto1) %>%
  forecast(h = length(test_wl_GW036334_1_1$Date))%>%hilo(level=c(95))
Actual_values<-test_wl_GW036334_1_1$WaterLevel
Forecast_GW036334_1_1_ETS$Actual_values<-Actual_values

colors <- c("Actual values" = "blue", "mean" = "green")

Plot_AvsFitted_GW036334_1_1_ETS<-Forecast_GW036334_1_1_ETS%>%ggplot(aes(x = Date))+
  geom_line(aes(y = .mean,color="mean"),size=2)+
  geom_line(aes(y = Actual_values,color="Actual values"),size=1.5)+
  geom_ribbon(aes(ymin = Forecast_GW036334_1_1_ETS$`95%`$lower, ymax = Forecast_GW036334_1_1_ETS$`95%`$u
  labs(y= "Waterlevel", x = "Date",color = "Legend",title = "ETS: GW036334_1_1")+
  scale_color_manual(values = colors)+theme(plot.title=element_text(hjust=0.5))

Plot_AvsFitted_GW036334_1_1_ETS
```

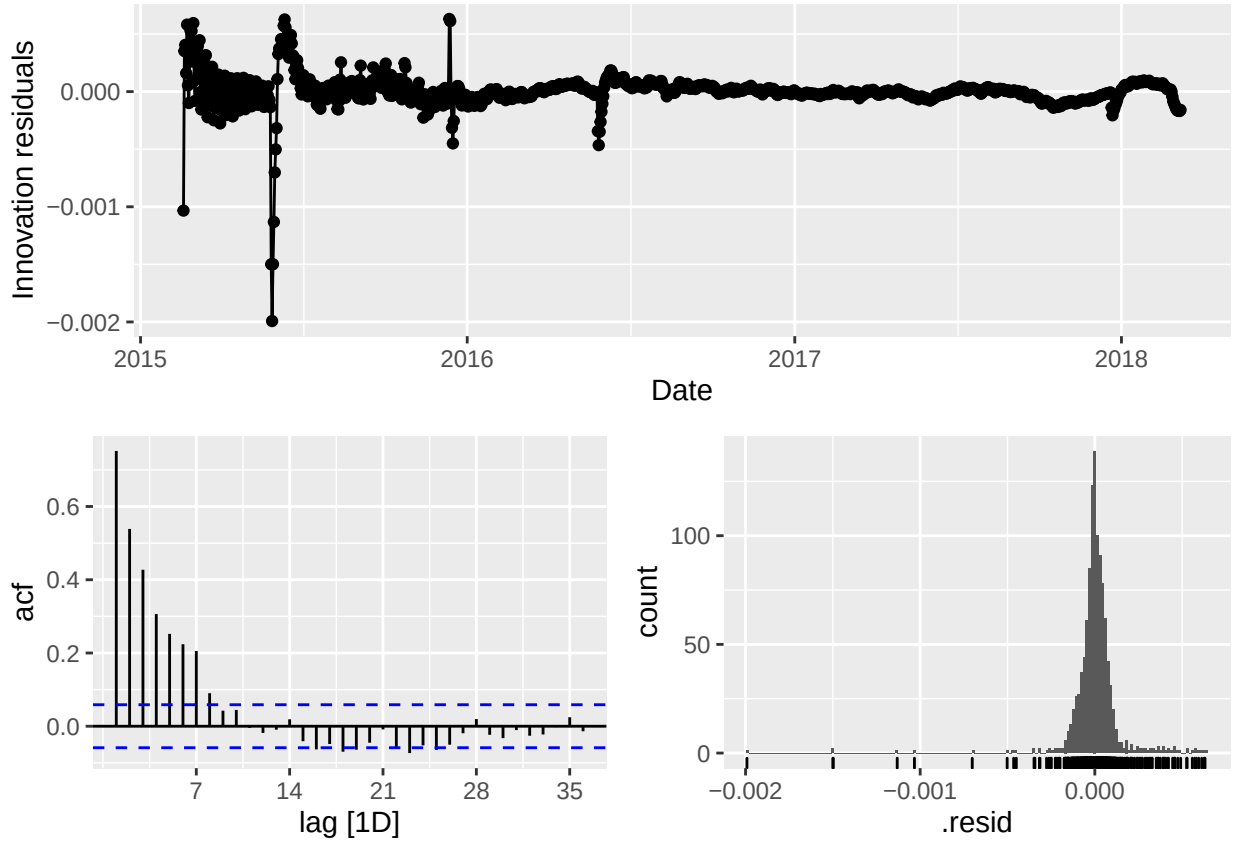



```
fit2<-train_wl_GW093067_1_1 %>%
  model(ses = ETS(WaterLevel ~ error("A") + trend("N") + season("N")),
        hlm = ETS(WaterLevel ~ error("A") + trend("N") + season("A")),
        ahw = ETS(WaterLevel ~ error("A") + trend("A") + season("A")),
        auto1 = ETS(WaterLevel ~ error("A") + trend("N") + season("M")),
        auto2 = ETS(WaterLevel ~ error("A") + trend("A") + season("N")),
        auto3 = ETS(WaterLevel ~ error("A") + trend("A") + season("M")),
        auto4 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("N")),
        auto5 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("A")),
        auto6 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("M")),
        ses1 = ETS(WaterLevel ~ error("M") + trend("N") + season("N")),
        hlm1 = ETS(WaterLevel ~ error("M") + trend("N") + season("A")),
        ahw1 = ETS(WaterLevel ~ error("M") + trend("A") + season("A")),
        auto11 = ETS(WaterLevel ~ error("M") + trend("N") + season("M")),
        auto21 = ETS(WaterLevel ~ error("M") + trend("A") + season("N")),
        auto31 = ETS(WaterLevel ~ error("M") + trend("A") + season("M")),
        auto41 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("N")),
        auto51 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("A")),
        auto61 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("M"))
  )


fit2 %>% forecast(h = length(test_wl_GW093067_1_1$Date)) %>% accuracy(test_wl_GW093067_1_1) %>% arrange
```

```
## # A tibble: 18 x 10
##    .model .type      ME  RMSE   MAE     MPE  MAPE  MASE RMSSE  ACF1
```

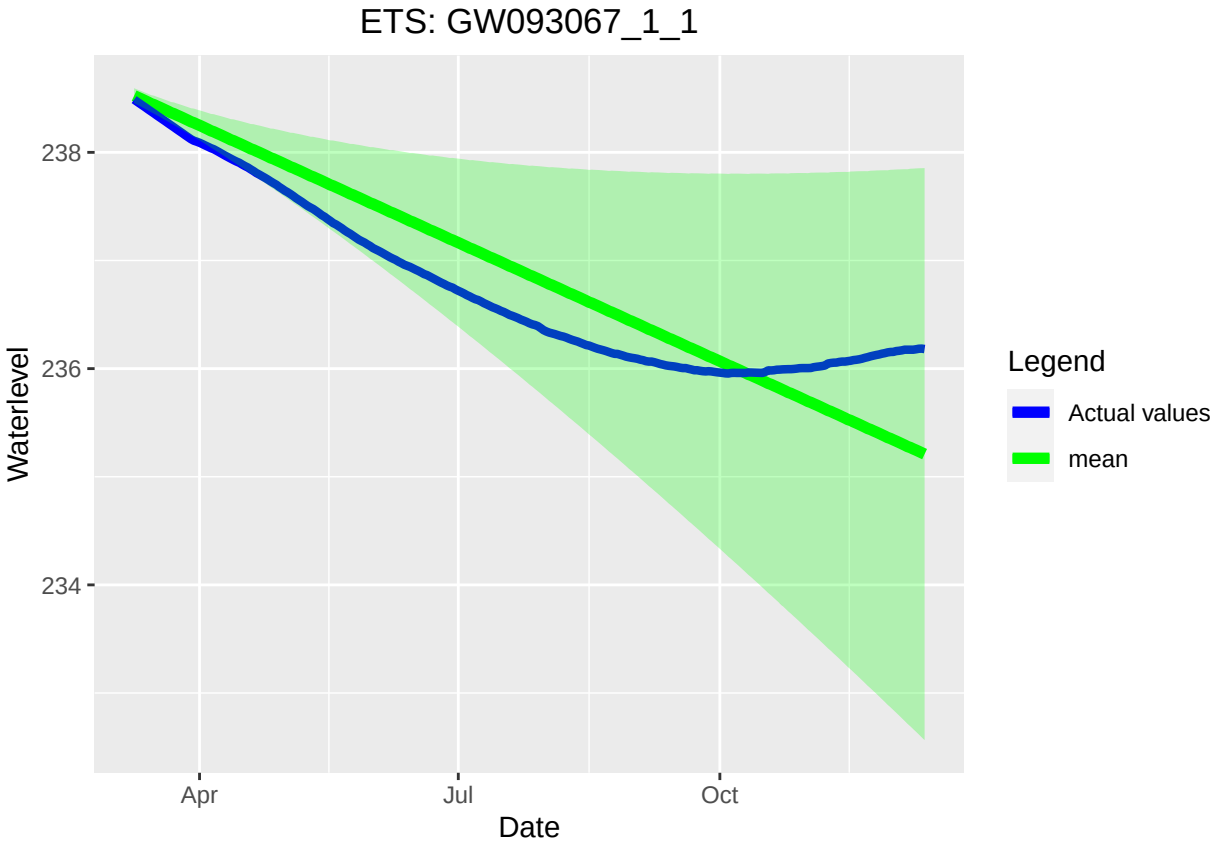
```
##    <chr>  <chr>   <dbl> <dbl> <dbl>   <dbl> <dbl> <dbl> <dbl> <dbl>
##  1 auto31 Test  -0.123  0.394 0.342 -0.0518 0.144   NaN   NaN 0.984
##  2 ahw    Test  -0.0412 0.397 0.320 -0.0172 0.135   NaN   NaN 0.985
##  3 auto2  Test   0.0990 0.463 0.321  0.0421 0.136   NaN   NaN 0.985
##  4 auto21 Test   0.102  0.465 0.322  0.0435 0.136   NaN   NaN 0.985
##  5 ahw1   Test   0.718  1.04  0.719  0.304  0.304   NaN   NaN 0.987
##  6 auto3  Test   0.970  1.33  0.970  0.411  0.411   NaN   NaN 0.987
##  7 auto41 Test  -1.36   1.53  1.36  -0.575  0.575   NaN   NaN 0.992
##  8 auto4  Test  -1.37   1.54  1.37  -0.580  0.580   NaN   NaN 0.992
##  9 auto51 Test  -1.42   1.58  1.42  -0.599  0.599   NaN   NaN 0.992
## 10 auto5  Test  -1.43   1.59  1.43  -0.604  0.604   NaN   NaN 0.992
## 11 auto61 Test  -1.46   1.62  1.46  -0.616  0.616   NaN   NaN 0.991
## 12 auto6  Test  -1.46   1.62  1.46  -0.616  0.616   NaN   NaN 0.991
## 13 ses    Test  -1.76   1.93  1.76  -0.746  0.746   NaN   NaN 0.990
## 14 ses1   Test  -1.76   1.93  1.76  -0.746  0.746   NaN   NaN 0.990
## 15 hlm    Test  -1.76   1.93  1.76  -0.746  0.746   NaN   NaN 0.990
## 16 hlm1   Test  -1.77   1.94  1.77  -0.748  0.748   NaN   NaN 0.990
## 17 auto11 Test  -1.77   1.94  1.77  -0.749  0.749   NaN   NaN 0.990
## 18 auto1  Test  -1.86   2.01  1.86  -0.785  0.785   NaN   NaN 0.990
```

```
fit2 %>% select(auto31) %>% gg_tsresiduals(lag=36)
```




```
# auto31 is the best model, but fails the WN

Forecast_GW093067_1_1_ETS<-fit2 %>% select(auto31) %>%
  forecast(h = length(test_wl_GW093067_1_1$Date))%>%hilo(level=c(95))
Actual_values<-test_wl_GW093067_1_1$WaterLevel
```

```
Forecast_GW093067_1_1_ETS$Actual_values<-Actual_values

colors <- c("Actual values" = "blue", "mean" = "green")

Plot_AvsFitted_GW093067_1_1_ETS<-Forecast_GW093067_1_1_ETS%>%ggplot(aes(x = Date))+
  geom_line(aes(y = .mean,color="mean"),size=2)+
  geom_line(aes(y = Actual_values,color="Actual values"),size=1.5)+
  geom_ribbon(aes(ymin = Forecast_GW093067_1_1_ETS$`95%`$lower, ymax = Forecast_GW093067_1_1_ETS$`95%`$u
  labs(y= "Waterlevel", x = "Date",color = "Legend",title = "ETS: GW093067_1_1")+
  scale_color_manual(values = colors)+theme(plot.title=element_text(hjust=0.5))
Plot_AvsFitted_GW093067_1_1_ETS
```

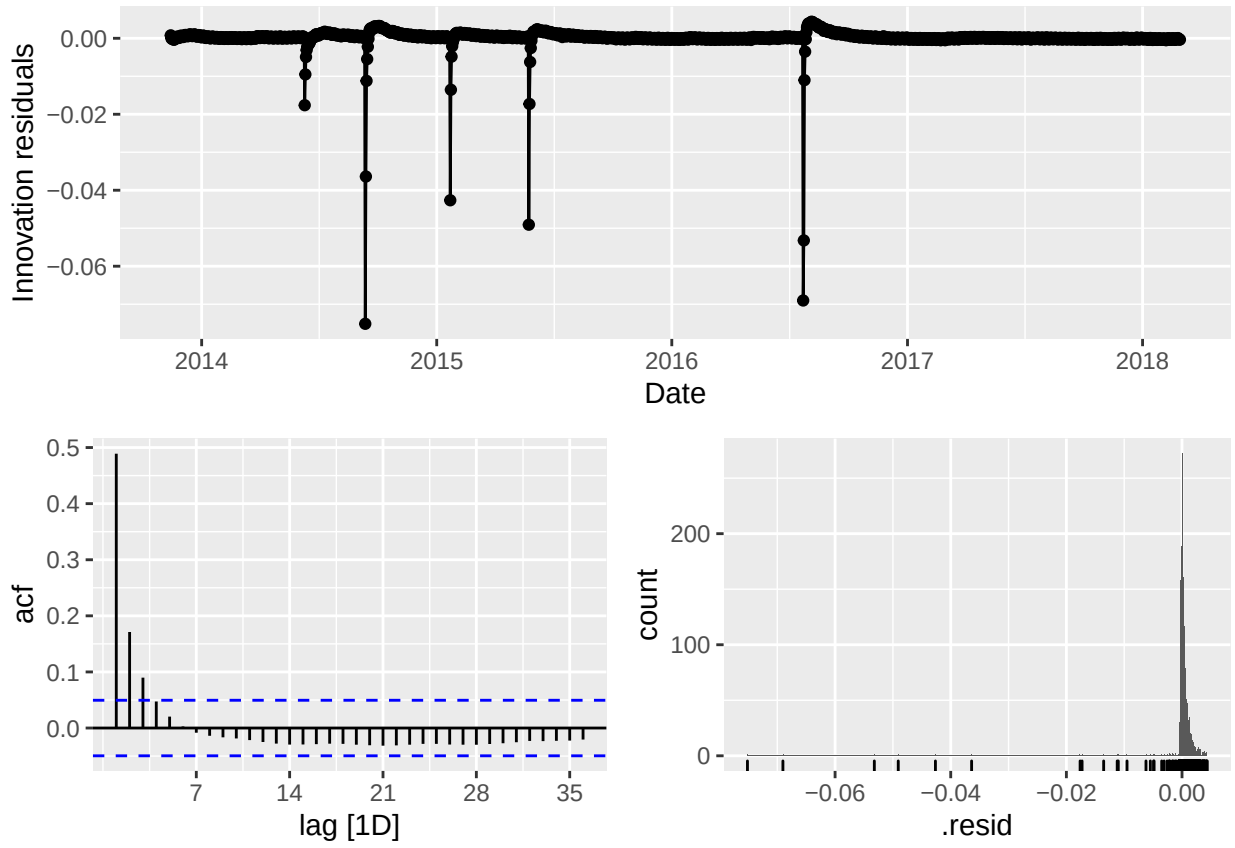



```
fit3<-train_wl_GW036976.1.2 %>%
  model(ses = ETS(WaterLevel ~ error("A") + trend("N") + season("N")),
        hlm = ETS(WaterLevel ~ error("A") + trend("N") + season("A")),
        ahw = ETS(WaterLevel ~ error("A") + trend("A") + season("A")),
        auto1 = ETS(WaterLevel ~ error("A") + trend("N") + season("M")),
        auto2 = ETS(WaterLevel ~ error("A") + trend("A") + season("N")),
        auto3 = ETS(WaterLevel ~ error("A") + trend("A") + season("M")),
        auto4 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("N")),
        auto5 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("A")),
        auto6 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("M")),
        ses1 = ETS(WaterLevel ~ error("M") + trend("N") + season("N")),
        hlm1 = ETS(WaterLevel ~ error("M") + trend("N") + season("A")),
        ahw1 = ETS(WaterLevel ~ error("M") + trend("A") + season("A")),
        auto11 = ETS(WaterLevel ~ error("M") + trend("N") + season("M")),
```

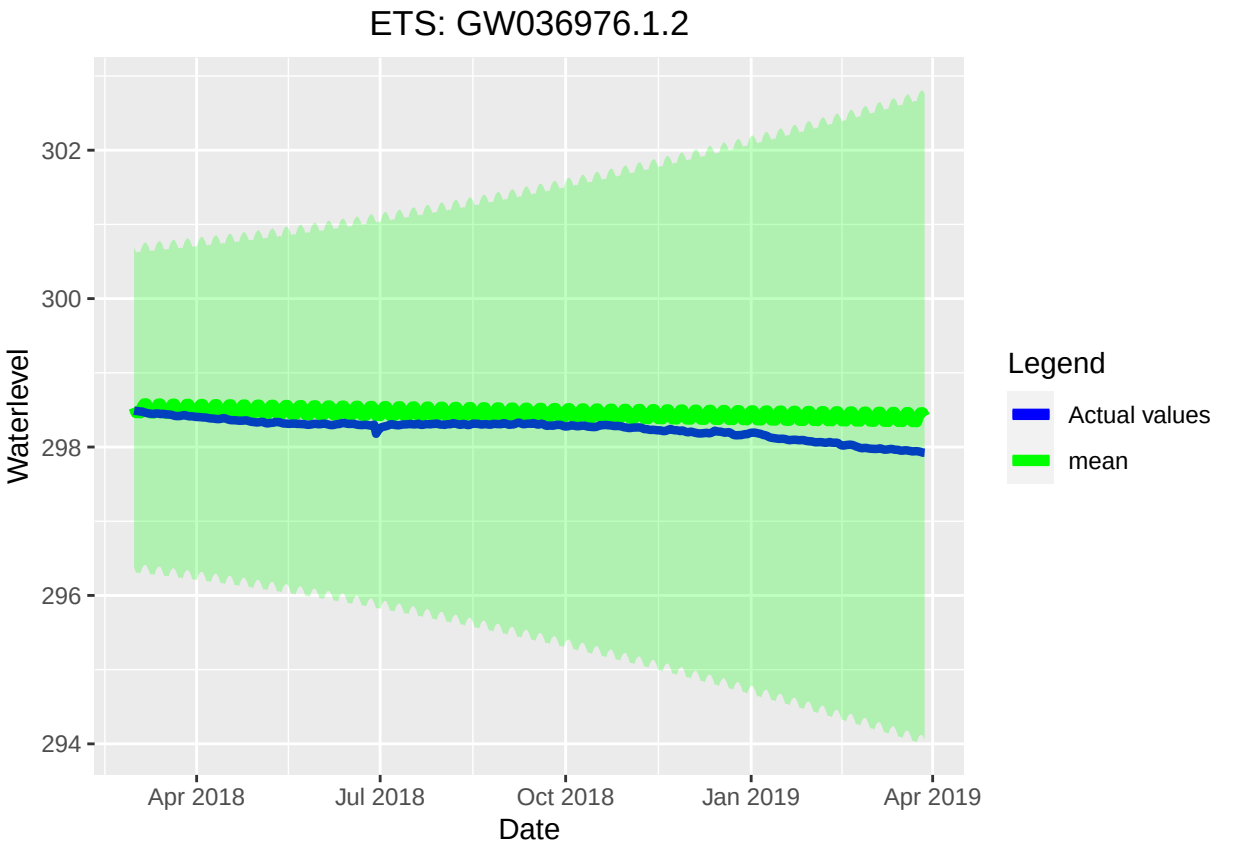
```
        auto21 = ETS(WaterLevel ~ error("M") + trend("A") + season("N")),
        auto31 = ETS(WaterLevel ~ error("M") + trend("A") + season("M")),
        auto41 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("N")),
        auto51 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("A")),
        auto61 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("M"))
  )


fit3 %>% forecast(h = length(test_wl_GW036976.1.2$Date)) %>% accuracy(test_wl_GW036976.1.2) %>% arrange
```

```
## # A tibble: 18 x 10
##    .model .type     ME  RMSE   MAE     MPE   MAPE  MASE RMSSE  ACF1
##    <chr>  <chr>  <dbl> <dbl> <dbl>   <dbl>  <dbl> <dbl> <dbl> <dbl>
##  1 auto31 Test  -0.212 0.239 0.212 -0.0710 0.0711   NaN   NaN 0.897
##  2 hlm    Test  -0.194 0.241 0.199 -0.0649 0.0668   NaN   NaN 0.880
##  3 hlm1   Test  -0.199 0.243 0.203 -0.0666 0.0680   NaN   NaN 0.911
##  4 auto61 Test  -0.200 0.244 0.204 -0.0670 0.0683   NaN   NaN 0.919
##  5 auto5  Test  -0.203 0.247 0.207 -0.0681 0.0694   NaN   NaN 0.920
##  6 ahw1   Test   0.205 0.248 0.211  0.0687 0.0707   NaN   NaN 0.923
##  7 auto51 Test  -0.209 0.251 0.212 -0.0703 0.0712   NaN   NaN 0.929
##  8 auto1  Test  -0.238 0.269 0.238 -0.0799 0.0800   NaN   NaN 0.967
##  9 auto4  Test  -0.243 0.275 0.243 -0.0814 0.0814   NaN   NaN 0.985
## 10 auto41 Test  -0.243 0.275 0.243 -0.0814 0.0814   NaN   NaN 0.985
## 11 ses    Test  -0.243 0.275 0.243 -0.0815 0.0815   NaN   NaN 0.985
## 12 ses1   Test  -0.243 0.275 0.243 -0.0815 0.0815   NaN   NaN 0.985
## 13 auto3  Test  -0.257 0.285 0.257 -0.0860 0.0860   NaN   NaN 0.944
## 14 auto11 Test  -0.263 0.293 0.263 -0.0881 0.0881   NaN   NaN 0.984
## 15 auto21 Test  -0.308 0.349 0.308 -0.103  0.103    NaN   NaN 0.987
## 16 auto2  Test  -0.316 0.358 0.316 -0.106  0.106    NaN   NaN 0.987
## 17 auto6  Test  -0.351 0.405 0.356 -0.118  0.119    NaN   NaN 0.956
## 18 ahw    Test  -0.430 0.503 0.433 -0.144  0.145    NaN   NaN 0.962
```

```
fit3 %>% select(auto31) %>% gg_tsresiduals(lag=36)
```




```
# auto31 is the best model

Forecast_GW036976.1.2_ETS<-fit3 %>% select(auto31) %>%
  forecast(h = length(test_wl_GW036976.1.2$Date))%>%hilo(level=c(95))
Actual_values<-test_wl_GW036976.1.2$WaterLevel
Forecast_GW036976.1.2_ETS$Actual_values<-Actual_values

colors <- c("Actual values" = "blue", "mean" = "green")

Plot_AvsFitted_GW036976.1.2_ETS<-Forecast_GW036976.1.2_ETS%>%ggplot(aes(x = Date))+
  geom_line(aes(y = .mean,color="mean"),size=2)+
  geom_line(aes(y = Actual_values,color="Actual values"),size=1.5)+
  geom_ribbon(aes(ymin = Forecast_GW036976.1.2_ETS$`95%`$lower, ymax = Forecast_GW036976.1.2_ETS$`95%`$u
  labs(y= "Waterlevel", x = "Date",color = "Legend",title = "ETS: GW036976.1.2")+
  scale_color_manual(values = colors)+theme(plot.title=element_text(hjust=0.5))

Plot_AvsFitted_GW036976.1.2_ETS
```



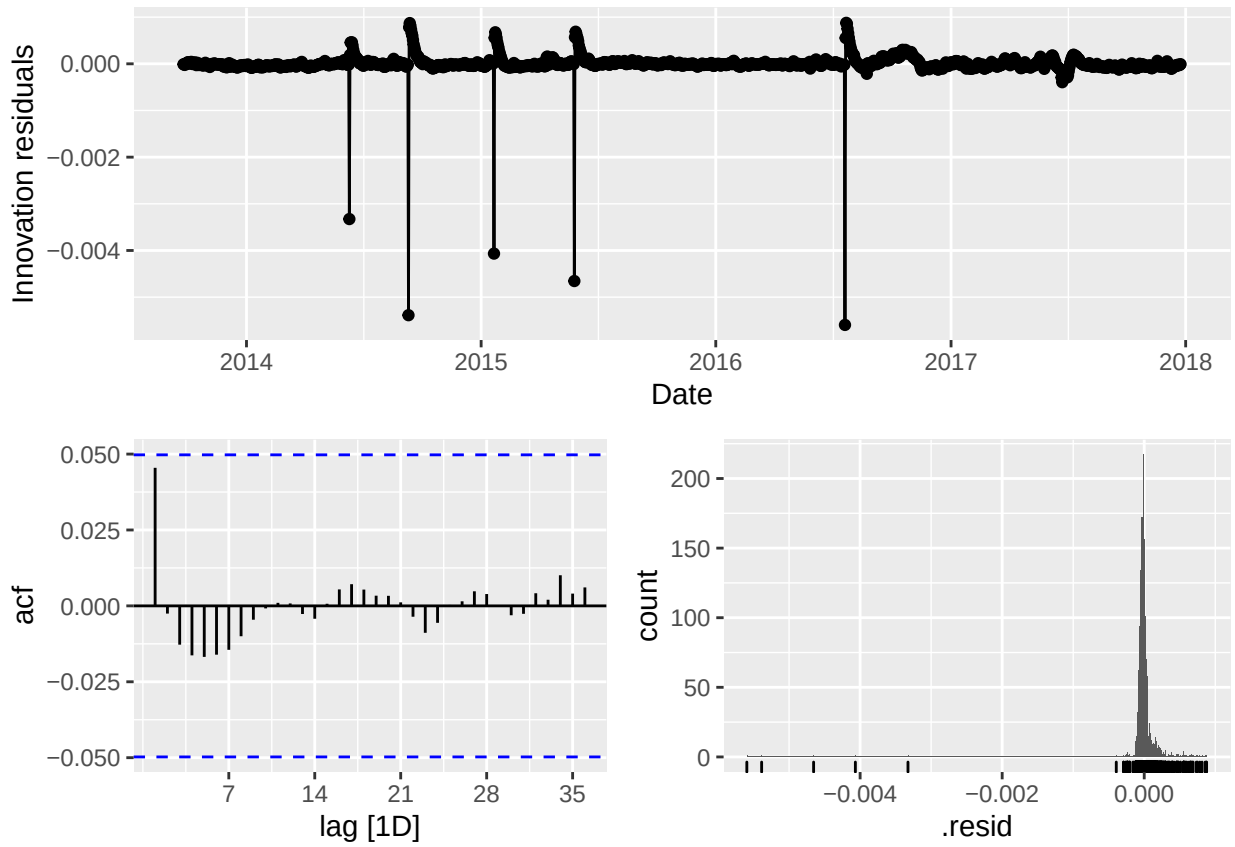

```
fit4<-train_wl_GW965569.1.2 %>%
  model(ses = ETS(WaterLevel ~ error("A") + trend("N") + season("N")),
        hlm = ETS(WaterLevel ~ error("A") + trend("N") + season("A")),
        ahw = ETS(WaterLevel ~ error("A") + trend("A") + season("A")),
        auto1 = ETS(WaterLevel ~ error("A") + trend("N") + season("M")),
        auto2 = ETS(WaterLevel ~ error("A") + trend("A") + season("N")),
        auto3 = ETS(WaterLevel ~ error("A") + trend("A") + season("M")),
        auto4 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("N")),
        auto5 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("A")),
        auto6 = ETS(WaterLevel ~ error("A") + trend("Ad") + season("M")),
        ses1 = ETS(WaterLevel ~ error("M") + trend("N") + season("N")),
        hlm1 = ETS(WaterLevel ~ error("M") + trend("N") + season("A")),
        ahw1 = ETS(WaterLevel ~ error("M") + trend("A") + season("A")),
        auto11 = ETS(WaterLevel ~ error("M") + trend("N") + season("M")),
        auto21 = ETS(WaterLevel ~ error("M") + trend("A") + season("N")),
        auto31 = ETS(WaterLevel ~ error("M") + trend("A") + season("M")),
        auto41 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("N")),
        auto51 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("A")),
        auto61 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("M"))
  )
```

```
fit4 %>% forecast(h = length(test_wl_GW965569.1.2$Date)) %>% accuracy(test_wl_GW965569.1.2) %>% arrange
```

```
## # A tibble: 18 x 10
```

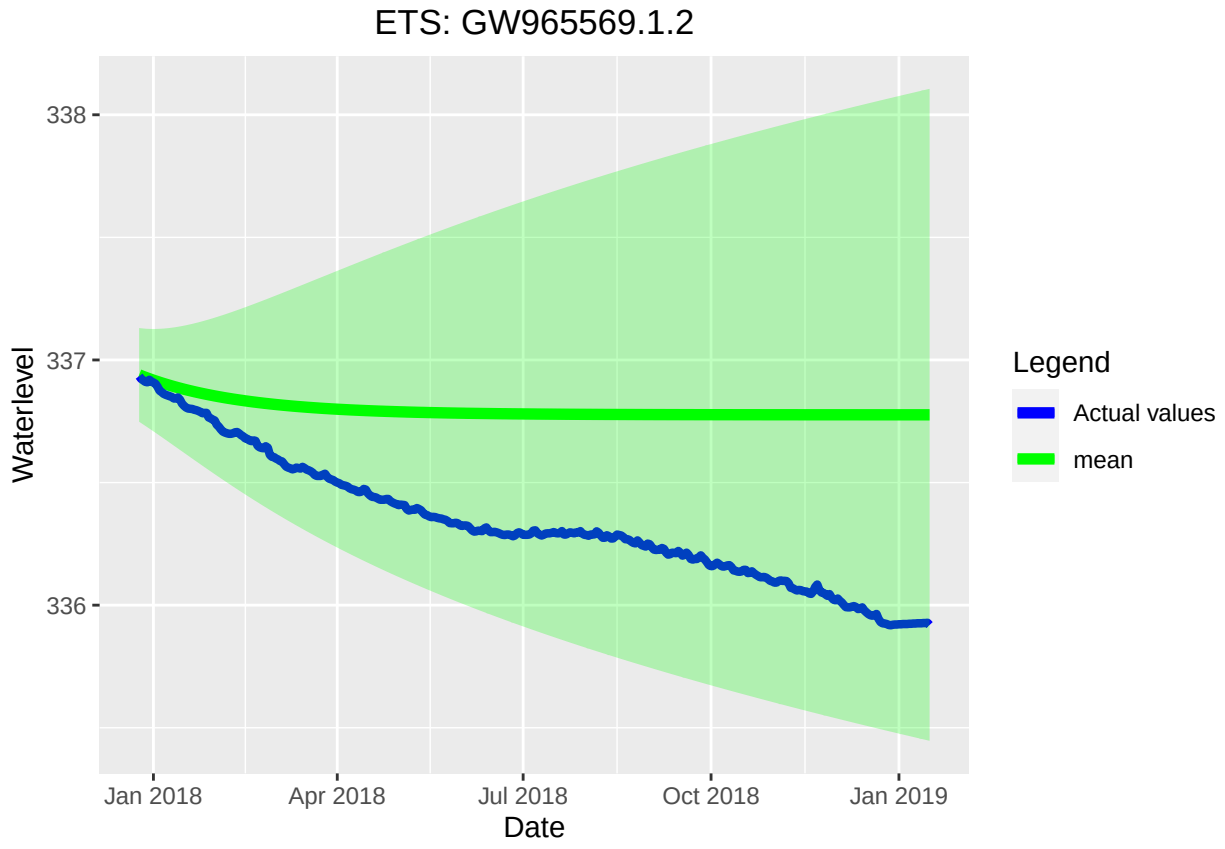
```
##    .model .type     ME  RMSE   MAE    MPE  MAPE  MASE RMSSE  ACF1
##    <chr>  <chr>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl> <dbl> <dbl>
##  1 auto41 Test  -0.462 0.516 0.462 -0.138 0.138   NaN   NaN 0.991
##  2 auto4  Test  -0.468 0.522 0.468 -0.139 0.139   NaN   NaN 0.991
##  3 auto61 Test  -0.468 0.523 0.468 -0.139 0.139   NaN   NaN 0.990
##  4 auto5  Test  -0.472 0.526 0.472 -0.140 0.140   NaN   NaN 0.990
##  5 auto6  Test  -0.476 0.529 0.476 -0.142 0.142   NaN   NaN 0.990
##  6 auto51 Test  -0.505 0.561 0.505 -0.150 0.150   NaN   NaN 0.990
##  7 auto31 Test   0.461 0.584 0.461  0.137 0.137   NaN   NaN 0.994
##  8 ahw    Test   0.466 0.590 0.466  0.139 0.139   NaN   NaN 0.993
##  9 auto3  Test   0.469 0.594 0.469  0.140 0.140   NaN   NaN 0.994
## 10 auto2  Test   0.479 0.606 0.479  0.143 0.143   NaN   NaN 0.994
## 11 auto21 Test   0.480 0.606 0.480  0.143 0.143   NaN   NaN 0.994
## 12 ahw1   Test   0.491 0.619 0.491  0.146 0.146   NaN   NaN 0.993
## 13 hlm1   Test  -0.613 0.666 0.613 -0.182 0.182   NaN   NaN 0.989
## 14 hlm    Test  -0.617 0.669 0.617 -0.183 0.183   NaN   NaN 0.989
## 15 ses    Test  -0.619 0.671 0.619 -0.184 0.184   NaN   NaN 0.990
## 16 ses1   Test  -0.619 0.671 0.619 -0.184 0.184   NaN   NaN 0.990
## 17 auto1  Test  -0.625 0.677 0.625 -0.186 0.186   NaN   NaN 0.989
## 18 auto11 Test  -0.625 0.677 0.625 -0.186 0.186   NaN   NaN 0.990
```

```
fit4 %>% select(auto41) %>% gg_tsresiduals(lag=36)
```




```
# auto41 is the best model


Forecast_GW965569.1.2_ETS<-fit4 %>% select(auto41) %>%
```

```
  forecast(h = length(test_wl_GW965569.1.2$Date))%>%hilo(level=c(95))
Actual_values<-test_wl_GW965569.1.2$WaterLevel
Forecast_GW965569.1.2_ETS$Actual_values<-Actual_values

colors <- c("Actual values" = "blue", "mean" = "green")

Plot_AvsFitted_GW965569.1.2_ETS<-Forecast_GW965569.1.2_ETS%>%ggplot(aes(x = Date))+
  geom_line(aes(y = .mean,color="mean"),size=2)+
  geom_line(aes(y = Actual_values,color="Actual values"),size=1.5)+
  geom_ribbon(aes(ymin = Forecast_GW965569.1.2_ETS$`95%`$lower, ymax = Forecast_GW965569.1.2_ETS$`95%`$u
  labs(y= "Waterlevel", x = "Date",color = "Legend",title = "ETS: GW965569.1.2")+
  scale_color_manual(values = colors)+theme(plot.title=element_text(hjust=0.5))

Plot_AvsFitted_GW965569.1.2_ETS
```



Comparision of best modeling structure out of ARIMA and ETS

```
# Time Series Cross Validation

train_wl_GW036334_1_1 %>%
  slice(-n()) %>%
  stretch_tsibble(.init = 1560,.step = 1) %>%
  model(
    stepwise = ARIMA(WaterLevel),
```

```
    auto1 = ETS(WaterLevel ~ error("A") + trend("N") + season("M"))
  ) %>%
  forecast(h = 1) %>%
  accuracy(train_wl_GW036334_1_1,by=c(".model")) %>%
  select(.model, RMSE:MAPE) %>%
  arrange(MAPE)
```

```
## Warning in sqrt(diag(best$var.coef)): NaNs produced

## Warning in sqrt(diag(best$var.coef)): NaNs produced

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## Warning in sqrt(diag(best$var.coef)): NaNs produced
```

```
## # A tibble: 2 x 5
##   .model     RMSE    MAE      MPE    MAPE
##   <chr>     <dbl>  <dbl>    <dbl>   <dbl>
## 1 stepwise 0.0188 0.0133 -0.00174 0.00397
## 2 auto1    0.0837 0.0826 -0.0247  0.0247
```

```
########################################################################
# Time Series Cross Validation

train_wl_GW093067_1_1 %>%
  slice(-n()) %>%
  stretch_tsibble(.init = 1107,.step = 1) %>%
  model(
    arima222 = ARIMA(WaterLevel ~ pdq(2,2,2)),
    auto31 = ETS(WaterLevel ~ error("M") + trend("A") + season("M"))
  ) %>%
  forecast(h = 1) %>%
  accuracy(train_wl_GW093067_1_1,by=c(".model")) %>%
  select(.model, RMSE:MAPE) %>%
  arrange(MAPE)
```

```
## # A tibble: 2 x 5
##   .model      RMSE     MAE      MPE    MAPE
##   <chr>      <dbl>   <dbl>    <dbl>   <dbl>
## 1 arima222 0.00510 0.00504 -0.00211 0.00211
## 2 auto31   0.0391  0.0378  -0.0159  0.0159
```

```
########################################################################
# Time Series Cross Validation

train_wl_GW036976.1.2 %>%
  slice(-n()) %>%
  stretch_tsibble(.init = 1544,.step = 1) %>%
  model(
    arima012 = ARIMA(WaterLevel ~ pdq(0,1,2)),
    auto31 = ETS(WaterLevel ~ error("M") + trend("A") + season("M"))
  ) %>%
  forecast(h = 1) %>%
  accuracy(train_wl_GW036976.1.2,by=c(".model")) %>%
  select(.model, RMSE:MAPE) %>%
```

```
  arrange(MAPE)
```

```
## # A tibble: 2 x 5
##   .model     RMSE    MAE      MPE    MAPE
##   <chr>     <dbl>  <dbl>    <dbl>   <dbl>
## 1 arima012 0.0267 0.0256 -0.00857 0.00857
## 2 auto31   0.0683 0.0604 -0.0202  0.0202
```

```
######################################################################
# Time Series Cross Validation

train_wl_GW965569.1.2 %>%
  slice(-n()) %>%
  stretch_tsibble(.init = 1544,.step = 1) %>%
  model(
    search = ARIMA(WaterLevel, stepwise=FALSE),
    auto41 = ETS(WaterLevel ~ error("M") + trend("Ad") + season("N"))
  ) %>%
  forecast(h = 1) %>%
  accuracy(train_wl_GW965569.1.2,by=c(".model")) %>%
  select(.model, RMSE:MAPE) %>%
  arrange(MAPE)
```

```
## # A tibble: 2 x 5
##   .model    RMSE     MAE      MPE    MAPE
##   <chr>    <dbl>   <dbl>    <dbl>   <dbl>
## 1 search 0.00585 0.00494 -0.00130 0.00147
## 2 auto41 0.0100  0.00921 -0.00273 0.00273
```

```
# Residual plots

res1<-arima_fit_GW036334_1_1 %>% select(stepwise) %>% residuals()
res1_PLOT1<-res1 %>% ACF() %>% autoplot(size = 3)+
  labs(y= "acf", x = "lag",title = "GW036334.1.1")+
  theme(plot.title=element_text(hjust=0.5))
```

```
## Response variable not specified, automatically selected `var = .resid`
```

```
res2<-arima_fit_GW093067_1_1 %>% select(arima222) %>% residuals()
res2_PLOT1<-res2 %>% ACF() %>% autoplot(size = 3)+
  labs(y= "acf", x = "lag",title = "GW093067.1.1")+
  theme(plot.title=element_text(hjust=0.5))
```

```
## Response variable not specified, automatically selected `var = .resid`
```

```
res3<-arima_fit_GW036976.1.2 %>% select(arima012) %>% residuals()
res3_PLOT1<-res3 %>% ACF() %>% autoplot(size = 3)+
  labs(y= "acf", x = "lag",title = "GW036976.1.2")+
  theme(plot.title=element_text(hjust=0.5))
```

```
## Response variable not specified, automatically selected `var = .resid`
```

```
res4<-arima_fit_GW965569.1.2 %>% select(search) %>% residuals()
res4_PLOT1<-res4 %>% ACF() %>% autoplot(size = 3)+
  labs(y= "acf", x = "lag",title = "GW965569.1.2")+
  theme(plot.title=element_text(hjust=0.5))
```

```
## Response variable not specified, automatically selected `var = .resid`
```

```
Residual_Plots<-(res1_PLOT1|res2_PLOT1)/(res3_PLOT1|res4_PLOT1)

Residual_Plots
```