LAPORAN TUGAS 3

TOPIK DALAM ANALISIS DATA DERET WAKTU

GENERALIZED SPACE-TIME AUTOREGRESSIVE (GSTAR) PADA DATA SUHU RATA-RATA DI SURABAYA

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1. Deskripsi

Model *Generalized Space Time Autoregressive* (GSTAR) digunakan untuk memodelkan data *timeseries* yang juga mempunyai keterikatan antar lokasi. Salah satu permasalahan utama pada pemodelan GSTAR adalah menentukan bobot lokasi yang dapat membentuk model dengan kesalahan ramalan terkecil. Terdapat beberapa jenis bobot lokasi yang digunakan dalam GSTAR, empat diantaranya yaitu bobot seragam, bobot korelasi, bobot invers jarak, dan bobot biner.

Tujuan dari tugas ini adalah mendapatkan model GSTAR terbaik untuk peramalan berdasarkan tiga jenis bobot lokasi tersebut. Kami mengimplementasikan GSTAR menggunakan bahasa R, kemudian membandingkan hasil evaluasi dari ketiga bobot lokasi tersebut untuk mendapatkan model GSTAR terbaik.

2. Langkah Pengerjaan

2.1. Impor Dataset

Data spasiotemporal yang digunakan pada tugas ini adalah data suhu rata-rata dari Badan Meteorologi, Klimatologi, dan Geofisika (BMKG) dalam kurun waktu 1 Januari 2019 hingga 12 Mei 2020 yang diukur dari tiga stasiun meteorologi yang berbeda di Surabaya, yaitu stasiun meteorologi Perak I, Perak II, dan Juanda. Jumlah data sebanyak 528 baris, diunduh dari http://dataonline.bmkg.go.id/.

	Tanggal	Perak.I	Perak.II	Juanda
	<chr>	<dbl>	<dbl>	<dbl>
1	01-01-2019	28.9	29.5	29.0
2	02-01-2019	29.0	29.2	28.5
3	03-01-2019	27.3	27.2	25.6
4	04-01-2019	27.7	28.0	27.6
5	05-01-2019	29.1	29.7	29.2
6	06-01-2019	30.4	30.4	28.9

	Tanggal	Perak.I	Perak.II	Juanda
	<chr>	<dbl>	<dbl>	<dbl>
523	07-05-2020	29.9	30.0	28.5
524	08-05-2020	30.6	30.3	29.5
525	09-05-2020	29.0	29.1	28.7
526	10-05-2020	29.4	29.3	29.0
527	11-05-2020	29.1	28.9	27.9
528	12-05-2020	29.8	29.5	NA

2.2. Mengecek Korelasi Data

Dataset yang diambil memiliki beberapa null value, sehingga jika dicek korelasinya maka hasilnya NA. Oleh karena itu, kami mengisi *null value* nya terlebih dahulu menggunakan rata-rata. Sehingga di dapatkan korelasi sebagai berikut.

```
> cor(data)
            Perak.I  Perak.II    Juanda
Perak.I   1.0000000 0.9495863 0.8814858
Perak.II  0.9495863 1.0000000 0.8819370
Juanda    0.8814858 0.8819370 1.0000000
```

2.3. Membagi Data

Data dibagi menjadi *train set* dan *test set* dengan perbandingan 80:20

```
Train set: 422
Test set: 106
```

2.4. Mendefinisikan Bobot

2.4.1 Bobot Seragam (*Uniform*)

Bobot seragam didefinisikan sebagai $W_{ij} = {}^{1}/_{n_i}$, n_i adalah banyaknya lokasi yang berdekatan dengan lokasi i. Bobot seragam memberikan nilai bobot yang sama untuk masing-masing lokasi. Oleh karena itu, bobot lokasi ini sering digunakan pada data yang mempunyai jarak antar lokasi yang sama (homogen). Matriks bobot seragam yang digunakan adalah sebagai berikut:

```
> weight_uniform
     [,1] [,2] [,3]
[1,]  0.0  0.5  0.5
[2,]  0.5  0.0  0.5
[3,]  0.5  0.5  0.0
```

2.4.2 Bobot Korelasi

Matriks bobot korelasi menggunakan nilai korelasi antar lokasi, yakni sebagai berikut:

```
> weight_cor
           Perak.I  Perak.II    Juanda
Perak.I  0.5000000 0.4747931 0.4407429
Perak.II 0.4747931 0.5000000 0.4409685
Juanda   0.4407429 0.4409685 0.5000000
```

2.4.3 Bobot Invers Jarak

Pembobotan dengan invers jarak mengacu pada jarak antar lokasi. Jarak antara 3 lokasi stasiun meteorologi didefinisikan sebagai berikut:

- r_1 = Jarak Perak I dan Perak II
- r_2 = Jarak Perak I dan Juanda
- r_3 = Jarak Perak II dan Juanda

$$\begin{matrix} 0 & W_{12} & W_{13} \\ W_{21} & 0 & W_{23} \\ W_{31} & W_{32} & 0 \end{matrix} = \begin{matrix} 0 & \dfrac{r_2}{r_1+r_2} & \dfrac{r_1}{r_1+r_2} \\ \dfrac{r_3}{r_1+r_3} & 0 & \dfrac{r_1}{r_1+r_3} \\ \dfrac{r_3}{r_2+r_3} & \dfrac{r_2}{r_2+r_3} & 0 \end{matrix}$$

Sehingga, matriks yang terbentuk adalah sebagai berikut:

```
           [,1]       [,2]      [,3]
[1,] 0.00000000 0.44796558 0.2598018
[2,] 0.44419283 0.00000000 0.2401982
[3,] 0.05580717 0.05203442 0.0000000
```

2.4.4 Bobot Biner

Bobot biner merupakan pembobotan dengan menggunakan nilai kategorik 0 dan 1. Dengan nilai 0 dan 1 tergantung pada batasan tertentu. Jarak lokasi terdekat bernilai 1, sedangkan jarak lokasi yang lebih jauh bernilai 0. Matriks bobot biner yang digunakan adalah sebagai berikut:

0	1	1
1	0	1
1	1	0

2.5. Evaluasi Model GSTAR

Setelah melakukan *training* dan *testing* model, model GSTAR dievaluasi menggunakan *metrics Mean Squared Error* (MSE) dan *Mean Absolute Percentage Error* (MAPE). Berikut hasil ringkasan dari evaluasi *training:*

Jenis Bobot	**Metrics**	
	MSE	**MAPE**
Uniform	0.5154806	1.900834
Korelasi	0.5154706	1.900645
Invers Jarak	0.5201234	1.904706
Biner	0.5154806	1.900834

Berikut hasil ringkasan dari evaluasi *testing:*

Jenis Bobot	**Metrics**	
	MSE	**MAPE**
Uniform	0.9360444	2.748507
Korelasi	0.9327662	2.743146
Invers Jarak	**0.8413433**	**2.600861**
Biner	0.9360444	2.748507

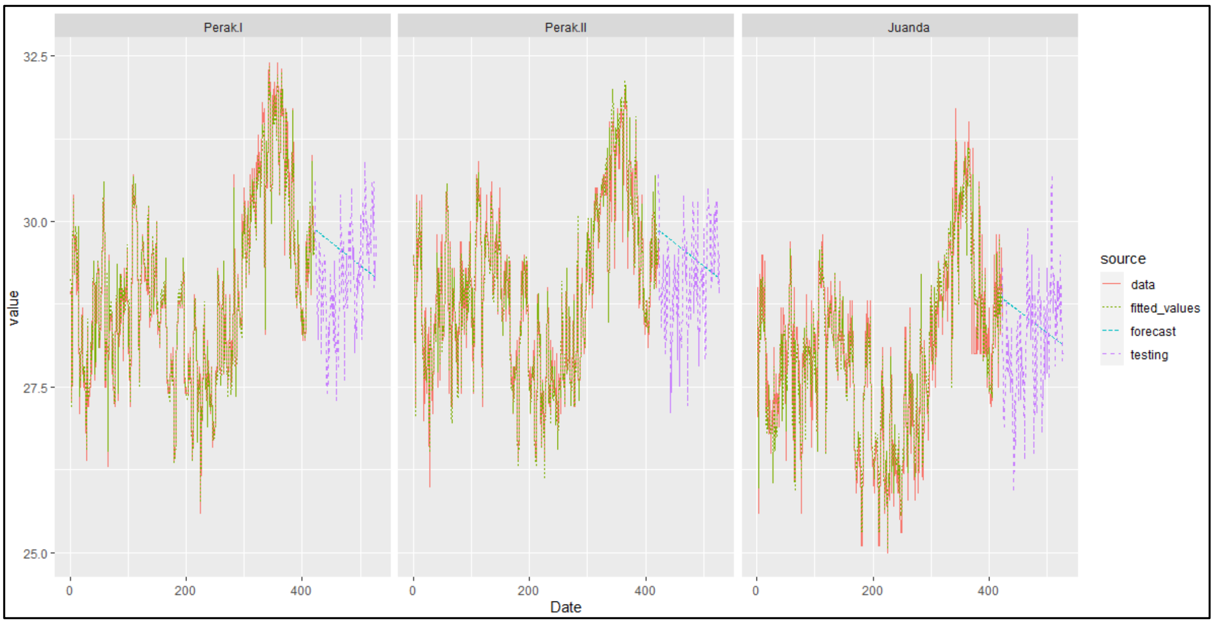
2.5.1. Bobot Seragam (*Uniform*)

2.5.1.1 Hasil *Training*

```
----------Performance training------------

MSE for all data =  0.5154806
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4822518 0.4870102 0.5771798

MAPE for all data =  1.900834
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797284 1.854074 2.051144
```

2.5.1.2 Hasil *Testing*

```
----------Performance testing-----------

MSE for all data =  0.9360444
MSE for each location :
  Perak.I  Perak.II    Juanda
0.9341923 0.8702308 1.0037101

MAPE for all data =  2.748507
MAPE for each location :
 Perak.I Perak.II   Juanda
2.762992 2.600131 2.882397
```



2.5.1.3 Prediksi 5 Data

```
> predict(fit, n = 5)
      Perak.I Perak.II   Juanda
[1,] 29.86634 29.84592 28.90100
[2,] 29.86712 29.86043 28.85422
[3,] 29.86332 29.85782 28.83606
[4,] 29.85772 29.85135 28.82586
[5,] 29.85136 29.84417 28.81797
```

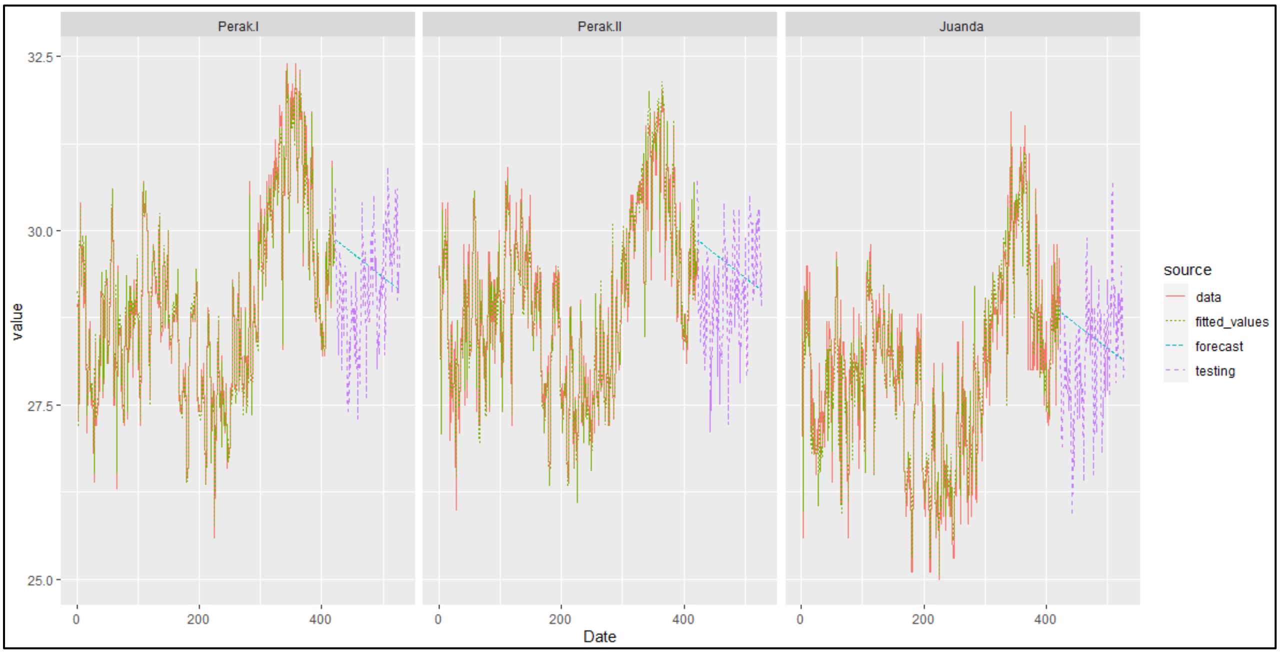
2.5.2. Bobot Korelasi

2.5.2.1 Hasil *Training*

```
----------Performance training-----------

MSE for all data =  0.5154706
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4823492 0.4868837 0.5771789

MAPE for all data =  1.900645
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797398 1.853399 2.051139
```

2.5.2.2 Hasil *Testing*

```
----------Performance testing-----------

MSE for all data =  0.9327662
MSE for each location :
  Perak.I  Perak.II    Juanda
0.9307215 0.8667233 1.0008539

MAPE for all data =  2.743146
MAPE for each location :
 Perak.I Perak.II   Juanda
2.757630 2.593201 2.878607
```



2.5.2.3 Prediksi 5 Data

```
> predict(fit2, n = 5)
      Perak.I Perak.II   Juanda
[1,] 29.86018 29.84209 28.89877
[2,] 29.86142 29.85608 28.85062
[3,] 29.85798 29.85321 28.83180
[4,] 29.85259 29.84660 28.82131
[5,] 29.84634 29.83938 28.81331
```

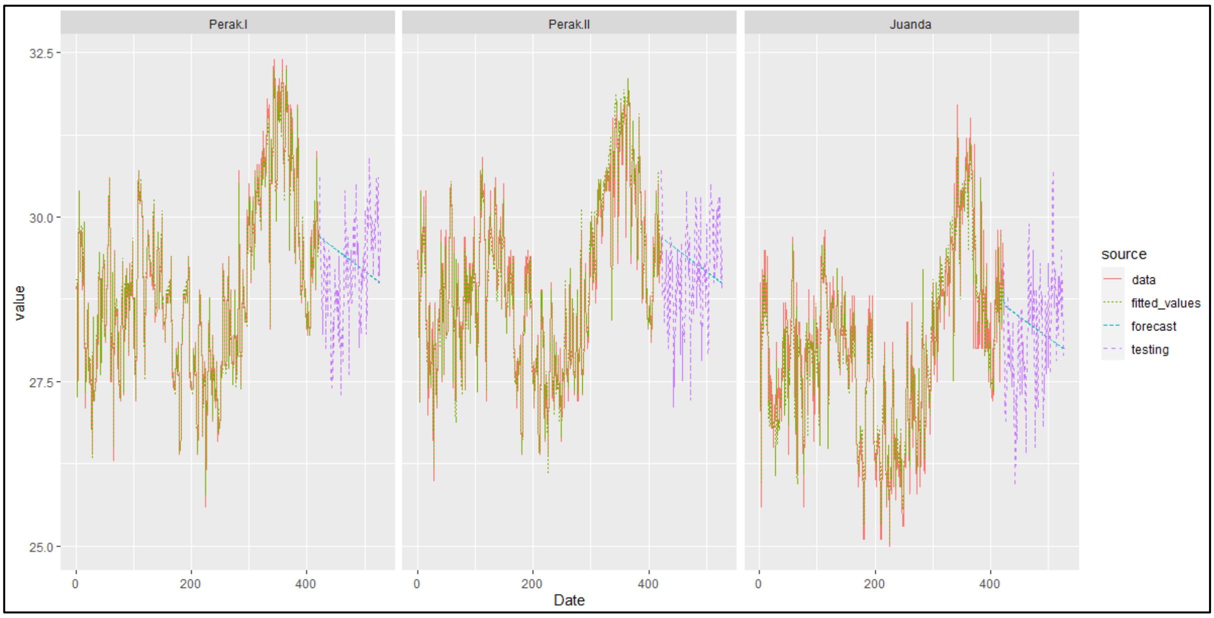
2.5.3. Bobot Invers Jarak

2.5.3.1 Hasil *Training*

```
----------Performance training------------

MSE for all data =   0.5201234
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4874847 0.4955482 0.5773372

MAPE for all data =   1.904706
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797519 1.864729 2.051869
```

2.5.3.2 Hasil *Testing*

```
----------Performance testing-----------

MSE for all data =  0.8413433
MSE for each location :
  Perak.I  Perak.II    Juanda
0.8334035 0.7631673 0.9274590

MAPE for all data =  2.600861
MAPE for each location :
 Perak.I Perak.II   Juanda
2.592533 2.411467 2.798583
```



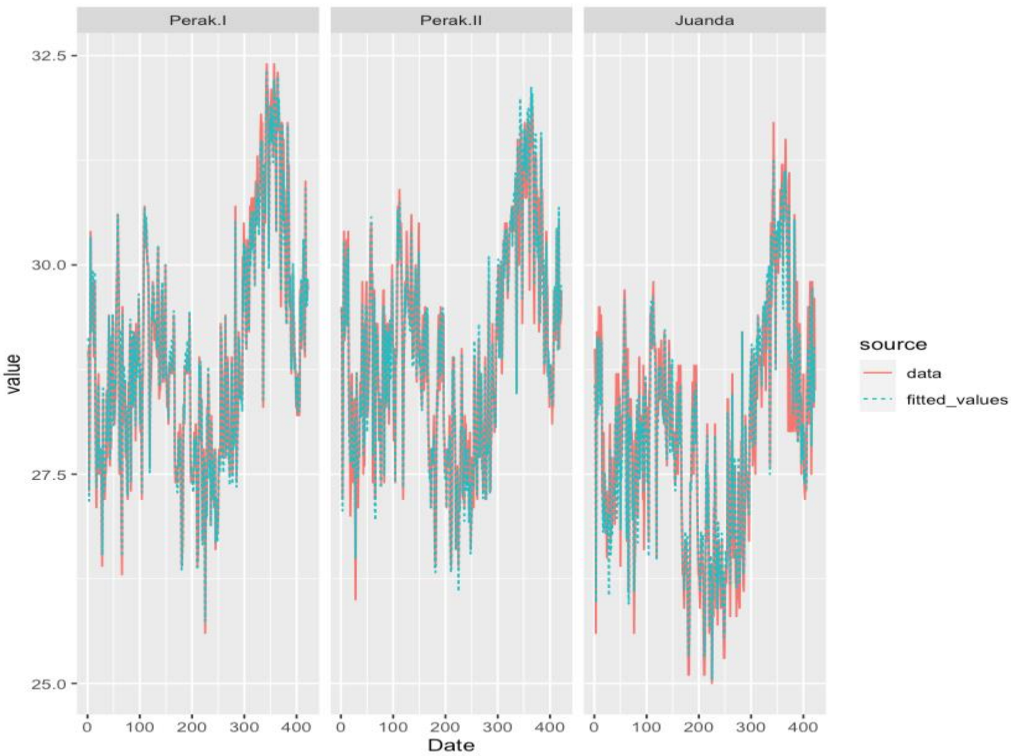
2.5.3.3 Prediksi 5 Data

```
> predict(fit3, n = 5)
      Perak.I Perak.II   Juanda
[1,] 29.70760 29.64885 28.83002
[2,] 29.69430 29.66885 28.73078
[3,] 29.68558 29.67201 28.68522
[4,] 29.67833 29.66891 28.66215
[5,] 29.67152 29.66349 28.64856
```

2.5.4. Bobot Biner

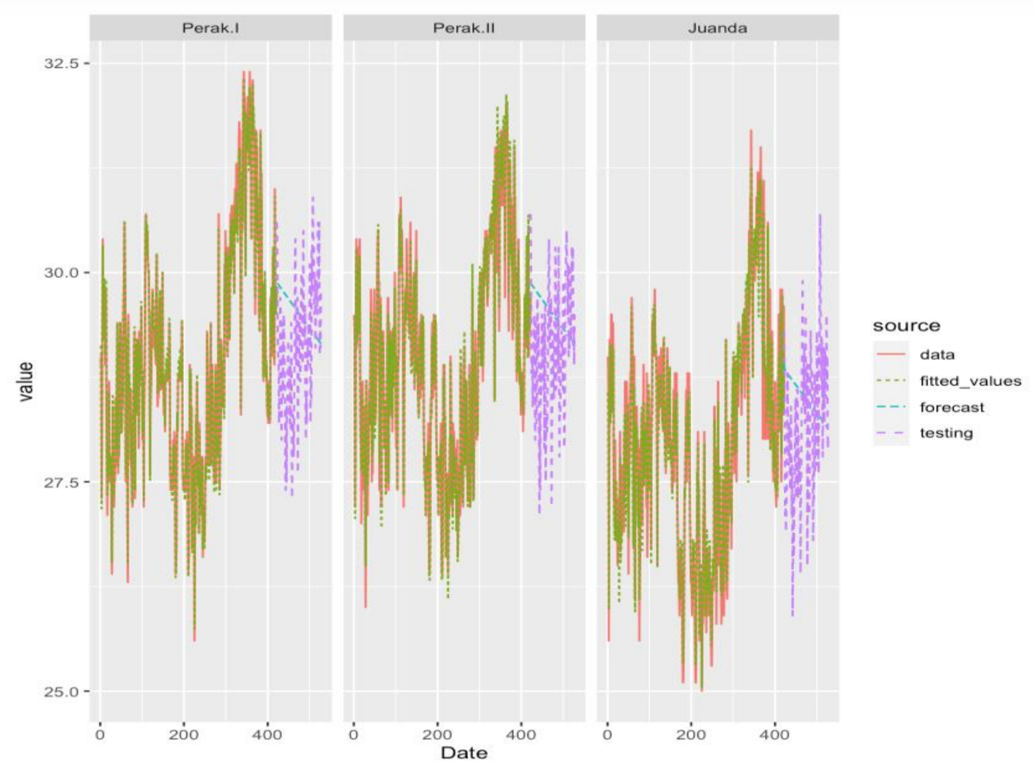
2.5.4.1 Hasil *Training*

```
----------Performance training-----------

MSE for all data =  0.5154806
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4822518 0.4870102 0.5771798

MAPE for all data =  1.900834
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797284 1.854074 2.051144
```



2.5.4.2 Hasil *Testing*

```
----------Performance testing-----------

MSE for all data =  0.9360444
MSE for each location :
  Perak.I  Perak.II    Juanda
0.9341923 0.8702308 1.0037101

MAPE for all data =  2.748507
MAPE for each location :
 Perak.I Perak.II   Juanda
2.762992 2.600131 2.882397
```



2.5.4.3 Prediksi 5 Data

Perak.I	Perak.II	Juanda
29.86634	29.84592	28.90100
29.86712	29.86043	28.85422
29.86332	29.85782	28.83606
29.85772	29.85135	28.82586
29.85136	29.84417	28.81797

2.6. Kesimpulan

Berdasarkan hasil evaluasi di atas, bobot invers jarak mendapatkan hasil MSE dan MAPE yang paling kecil pada saat *testing* dibandingkan bobot lainnya. Sehingga model GSTAR yang paling baik adalah model yang menggunakan bobot Invers Jarak.

3. Referensi

https://www.rdocumentation.org/packages/gstar/versions/0.1.0/topics/gstar

1. Import Dataset

In [1]:

```
library(xlsx)
library(Metrics)
library(ggplot2)
library(gstar)
```

In [2]:

```
data <- read.xlsx(("data-temperature-2019-2020.xlsx"),1, header=TRUE)
head(data)
tail(data)
```

A data.frame: 6 × 4

	Tanggal	Perak.I	Perak.II	Juanda
	<chr>	<dbl>	<dbl>	<dbl>
1	01-01-2019	28.9	29.5	29.0
2	02-01-2019	29.0	29.2	28.5
3	03-01-2019	27.3	27.2	25.6
4	04-01-2019	27.7	28.0	27.6
5	05-01-2019	29.1	29.7	29.2
6	06-01-2019	30.4	30.4	28.9

A data.frame: 6 × 4

	Tanggal	Perak.I	Perak.II	Juanda
	<chr>	<dbl>	<dbl>	<dbl>
523	07-05-2020	29.9	30.0	28.5
524	08-05-2020	30.6	30.3	29.5
525	09-05-2020	29.0	29.1	28.7
526	10-05-2020	29.4	29.3	29.0
527	11-05-2020	29.1	28.9	27.9
528	12-05-2020	29.8	29.5	NA

In [3]:

```
# mendapatkan jumlah data
nrow(data)
```

528

In [4]:

```
# drop kolom tanggal
data$Tanggal <- NULL
head(data)
```

A data.frame: 6 × 3

	Perak.I	Perak.II	Juanda
	<dbl>	<dbl>	<dbl>
1	28.9	29.5	29.0
2	29.0	29.2	28.5

	Perak.I	Perak.II	Juanda
	<dbl>	<dbl>	<dbl>
3	27.3	27.2	25.6
4	27.7	28.0	27.6
5	29.1	29.7	29.2
6	30.4	30.4	28.9

In [5]:

```
# mendapatkan korelasi
cor(data)
```

A matrix: 3 × 3 of type dbl

	Perak.I	Perak.II	Juanda
Perak.I	1	NA	NA
Perak.II	NA	1	NA
Juanda	NA	NA	1

In [6]:

```
# mengisi null value dengan rata-rata

data$Juanda[is.na(data$Juanda)] <- mean(data$Juanda, na.rm = TRUE)
data$Perak.I[is.na(data$Perak.I)] <- mean(data$Perak.I, na.rm = TRUE)
data$Perak.II[is.na(data$Perak.II)] <- mean(data$Perak.II, na.rm = TRUE)
```

In [7]:

```
# mendapatkan korelasi
cor(data)
```

A matrix: 3 × 3 of type dbl

	Perak.I	Perak.II	Juanda
Perak.I	1.0000000	0.9495863	0.8814858
Perak.II	0.9495863	1.0000000	0.8819370
Juanda	0.8814858	0.8819370	1.0000000

In [8]:

```
## split data menjadi training and testing (80:20)

split_data <- round(nrow(data) * 0.8)
x_train <- data[1:split_data, ]
x_test <- data[-c(1:split_data),]

cat("Train set:",  nrow(x_train), "\n")
cat("Test set:",  nrow(x_test))
```

```
Train set: 422
Test set: 106
```

2. Define Weight

Kami membandingkan bobot uniform, bobot biner, dan bobot invers jarak

2.1 Bobot Uniform

In [9]:

```
# weight uniform
```

```
# weight uniform

weight_uniform = matrix(c(0,1,1,
                          1,0,1,
                          1,1,0), ncol = 3, nrow = 3)

#the sum of weight is equal to 1 every row
weight_uniform = weight_uniform/(ncol(data) - 1)

weight_uniform
```

A matrix: 3 × 3
of type dbl

0.0	0.5	0.5
0.5	0.0	0.5
0.5	0.5	0.0

2.2 Bobot Correlation

In [10]:

```
# weight based on correlation
weight_cor = cor(data)
weight_cor = weight_cor/(ncol(data) - 1) #the sum of weight is equal to 1 every row
weight_cor
```

A matrix: 3 × 3 of type dbl

	Perak.I	Perak.II	Juanda
Perak.I	0.5000000	0.4747931	0.4407429
Perak.II	0.4747931	0.5000000	0.4409685
Juanda	0.4407429	0.4409685	0.5000000

2.3 Bobot Invers Jarak

In [11]:

```
# fungsi hitung euclidean

euclidean_dist <- function(locA, locB){
    dist <- sqrt((locB[1]-locA[1])^2 + (locB[2]-locA[2])^2)
    return(dist)
}
```

In [12]:

```
# define jarak
loc_perak_1 = c(-7.22360, 112.72390)
loc_perak_2 = c(-7.20530, 112.73530)
loc_juanda = c(-7.38460, 112.78330)

# r1 jarak Perak I - Perak II
r1 <- euclidean_dist(loc_perak_1, loc_perak_2)
# r2 jarak Perak I - Juanda
r2 <- euclidean_dist(loc_perak_1, loc_juanda)
# r2 jarak Perak II - Juanda
r3 <- euclidean_dist(loc_perak_2, loc_juanda)

cat("Jarak Perak I - Perak II:", r1, "\n")
cat("Jarak Perak I - Juanda:", r2, "\n")
cat("Jarak Perak II - Juanda:", r3, "\n")
```

```
Jarak Perak I - Perak II: 0.02156038
Jarak Perak I - Juanda: 0.1716082
Jarak Perak II - Juanda: 0.1856138
```

In [13]:

```
# hitung weight
w12 <- r2/(r1+r2)
w13 <- r1/(r1+r2)
w21 <- r3/(r1+r3)
w23 <- r1/(r1+r3)
w31 <- r3/(r2+r3)
w32 <- r2/(r2+r3)

weight_dist = matrix(c(0,w12,w13,
                       w21,0,w23,
                       w31,w32,0), ncol = 3, nrow = 3)

#the sum of weight is equal to 1 every row
weight_dist = weight_dist/(ncol(data) - 1)

weight_dist
```

A matrix: 3 × 3 of type dbl

0.00000000	0.44796558	0.2598018
0.44419283	0.00000000	0.2401982
0.05580717	0.05203442	0.0000000

2.4 Bobot Biner

In [14]:

```
# weight binary

weight_biner = matrix(c(0,1,1,
                        1,0,1,
                        1,1,0), ncol = 3, nrow = 3)
weight_biner
```

A matrix:
3 × 3 of
type dbl

0	1	1
1	0	1
1	1	0

3. Train Model

3.1 Bobot Uniform

In [15]:

```
fit <-  gstar(x_train, weight = weight_uniform, p = 1, d = 0, est = "OLS")
summary(fit)
```

```
Coefficients:
                Estimate Std.Err t value Pr(>|t|)
psi10(Perak.I)    0.7335  8.1693   0.090    0.928
psi10(Perak.II)   0.5482  9.8647   0.056    0.956
psi10(Juanda)     0.4716  5.0730   0.093    0.926
psi11(Perak.I)    0.2710  8.4600   0.032    0.974
psi11(Perak.II)   0.4594 10.2108   0.045    0.964
psi11(Juanda)     0.5099  4.7310   0.108    0.914


AIC: 2761
```

3.2 Bobot Correlation

In [16]:

```
fit3 <-  gstar(x_train, weight = weight_cor, p = 1, d = 0, est = "OLS")
summary(fit3)
```

```
Warning message in gstar(x_train, weight = weight_cor, p = 1, d = 0, est = "OLS"):
“the sum of weight is equal to 1 every row”
```

```
Coefficients:
                Estimate Std.Err t value Pr(>|t|)
psi10(Perak.I)    0.5827 20.1828   0.029    0.977
psi10(Perak.II)   0.2891 24.3336   0.012    0.991
psi10(Juanda)     0.1824 12.1496   0.015    0.988
psi11(Perak.I)    0.2979 10.2942   0.029    0.977
psi11(Perak.II)   0.5074 12.4034   0.041    0.967
psi11(Juanda)     0.5784  6.0856   0.095    0.924


AIC: 2761
```

3.3 Bobot Invers Jarak

In [17]:

```
fit2 <-  gstar(x_train, weight = weight_dist, p = 1, d = 0, est = "OLS")
summary(fit2)
```

```
Coefficients:
                Estimate Std.Err t value Pr(>|t|)
psi10(Perak.I)    0.7708  9.9810   0.077    0.938
psi10(Perak.II)   0.6022 10.5249   0.057    0.954
psi10(Juanda)     0.4728  5.1043   0.093    0.926
psi11(Perak.I)    0.4598 40.2459   0.011    0.991
psi11(Perak.II)   0.7978 42.3902   0.019    0.985
psi11(Juanda)     1.0175 19.0408   0.053    0.957


AIC: 2773
```

3.4 Bobot Biner

In [18]:

```
fit4 <-  gstar(x_train, weight = weight_biner, p = 1, d = 0, est = "OLS")
summary(fit4)
```

```
Warning message in gstar(x_train, weight = weight_biner, p = 1, d = 0, est = "OLS"):
“the sum of weight is equal to 1 every row”
```

```
Coefficients:
                Estimate Std.Err t value Pr(>|t|)
psi10(Perak.I)    0.7335  8.1693   0.090    0.928
psi10(Perak.II)   0.5482  9.8647   0.056    0.956
psi10(Juanda)     0.4716  5.0730   0.093    0.926
psi11(Perak.I)    0.1355  2.1150   0.064    0.949
psi11(Perak.II)   0.2297  2.5527   0.090    0.928
psi11(Juanda)     0.2550  1.1828   0.216    0.829


AIC: 2761
```

4. Evaluate Model

4.1 Bobot Uniform

In [19]:

```
## to check the performance with testing data
performance(fit, x_test)
```

```
----------Performance training------------

MSE for all data =  0.5154806
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4822518 0.4870102 0.5771798

MAPE for all data =  1.900834
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797284 1.854074 2.051144

----------Performance testing------------

MSE for all data =  0.9360444
MSE for each location :
  Perak.I  Perak.II    Juanda
0.9341923 0.8702308 1.0037101

MAPE for all data =  2.748507
MAPE for each location :
 Perak.I Perak.II   Juanda
2.762992 2.600131 2.882397
```

4.2 Bobot Correlation

In [20]:

```
performance(fit3)

## to check the performance with testing data
performance(fit3, x_test)
```

```
----------Performance training------------

MSE for all data =  0.5154706
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4823492 0.4868837 0.5771789

MAPE for all data =  1.900645
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797398 1.853399 2.051139

----------Performance training------------

MSE for all data =  0.5154706
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4823492 0.4868837 0.5771789

MAPE for all data =  1.900645
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797398 1.853399 2.051139

----------Performance testing------------

MSE for all data =  0.9327662
MSE for each location :
  Perak.I  Perak.II    Juanda
0.9307215 0.8667233 1.0008539

MAPE for all data =  2.743146
```

```
MAPE for each location :
 Perak.I Perak.II   Juanda
2.757630 2.593201 2.878607
```

4.3 Bobot Invers Jarak

In [21]:

```
performance(fit2)

## to check the performance with testing data
performance(fit2, x_test)
```

```
----------Performance training------------

MSE for all data =  0.5201234
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4874847 0.4955482 0.5773372

MAPE for all data =  1.904706
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797519 1.864729 2.051869

----------Performance training------------

MSE for all data =  0.5201234
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4874847 0.4955482 0.5773372

MAPE for all data =  1.904706
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797519 1.864729 2.051869

----------Performance testing------------

MSE for all data =  0.8413433
MSE for each location :
  Perak.I  Perak.II    Juanda
0.8334035 0.7631673 0.9274590

MAPE for all data =  2.600861
MAPE for each location :
 Perak.I Perak.II   Juanda
2.592533 2.411467 2.798583
```

4.4 Bobot Biner

In [22]:

```
performance(fit4)

## to check the performance with testing data
performance(fit4, x_test)
```

```
----------Performance training------------

MSE for all data =  0.5154806
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4822518 0.4870102 0.5771798

MAPE for all data =  1.900834
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797284 1.854074 2.051144

----------Performance training------------
```

```
MSE for all data =  0.5154806
MSE for each location :
  Perak.I  Perak.II    Juanda
0.4822518 0.4870102 0.5771798

MAPE for all data =  1.900834
MAPE for each location :
 Perak.I Perak.II   Juanda
1.797284 1.854074 2.051144

----------Performance testing------------

MSE for all data =  0.9360444
MSE for each location :
  Perak.I  Perak.II    Juanda
0.9341923 0.8702308 1.0037101

MAPE for all data =  2.748507
MAPE for each location :
 Perak.I Perak.II   Juanda
2.762992 2.600131 2.882397
```

5. Predict

5.1 Bobot Uniform

In [23]:

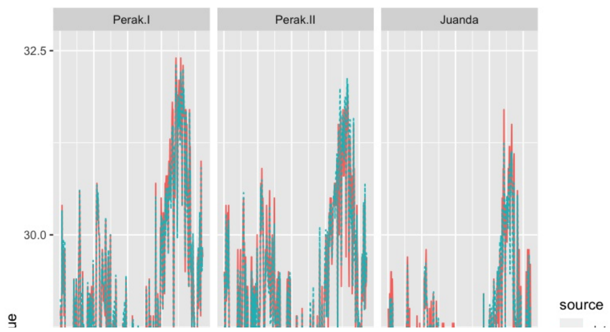
```
#forecast 10 data ahead
predict(fit, n = 10)
```

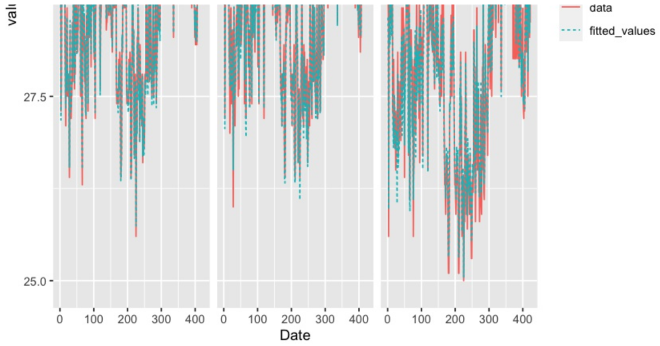
A matrix: 10 × 3 of type dbl

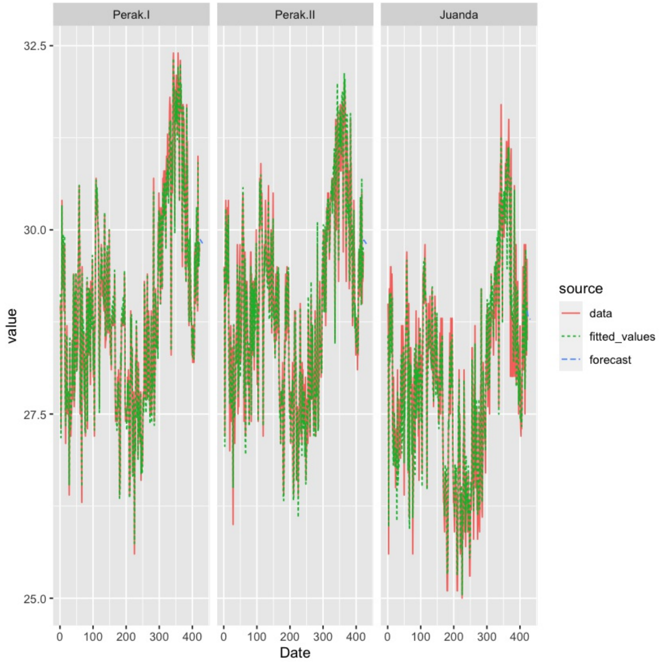
Perak.I	Perak.II	Juanda
29.86634	29.84592	28.90100
29.86712	29.86043	28.85422
29.86332	29.85782	28.83606
29.85772	29.85135	28.82586
29.85136	29.84417	28.81797
29.84464	29.83696	28.81080
29.83777	29.82982	28.80387
29.83083	29.82273	28.79702
29.82384	29.81568	28.79022
29.81684	29.80865	28.78343

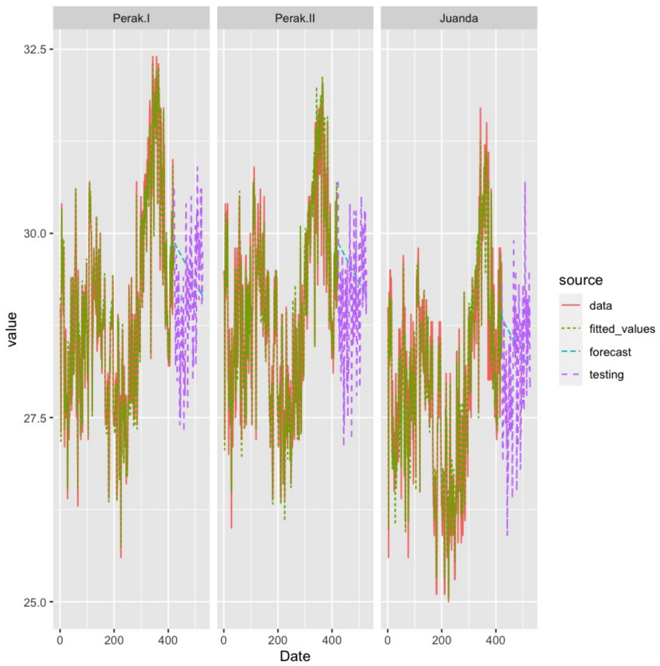
In [24]:

```
#plot with 10 forecasting data
plot(fit)
plot(fit, n_predict = 10)
plot(fit, testing = x_test)
```









5.2 Bobot Correlation

In [25]:

```
#forecast 10 data ahead
predict(fit3, n = 10)
```

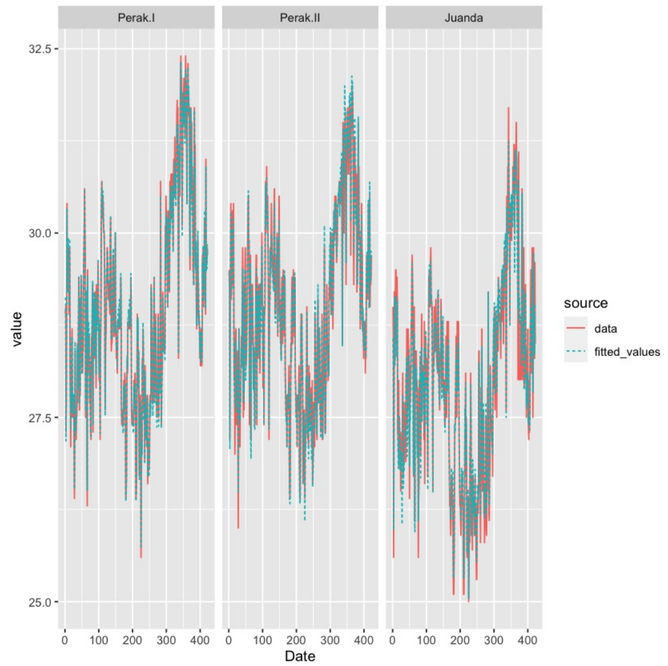
A matrix: 10 × 3 of type dbl

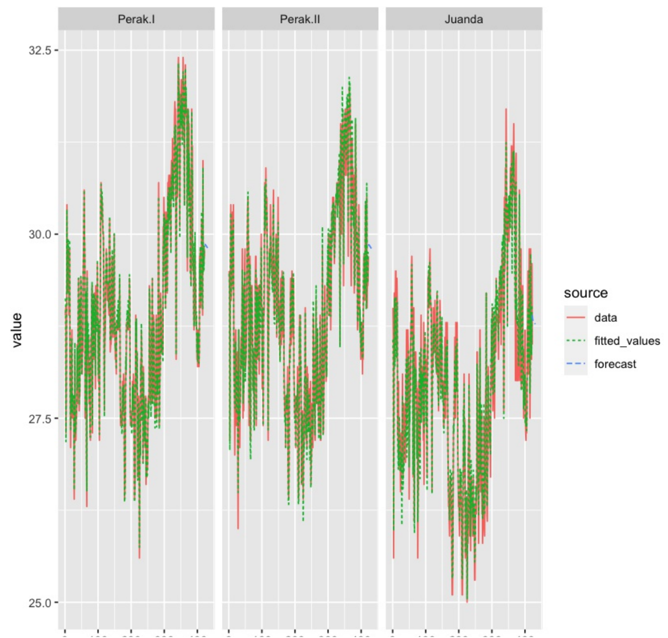
A matrix: 10 × 3 of type dbl

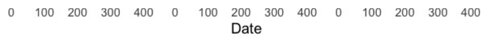
Perak.I	Perak.II	Juanda
29.86018	29.84209	28.89877
29.86142	29.85608	28.85062
29.85798	29.85321	28.83180
29.85259	29.84660	28.82131
29.84634	29.83938	28.81331
29.83969	29.83216	28.80610
29.83285	29.82502	28.79916
29.82593	29.81795	28.79233
29.81897	29.81092	28.78554
29.81199	29.80390	28.77877

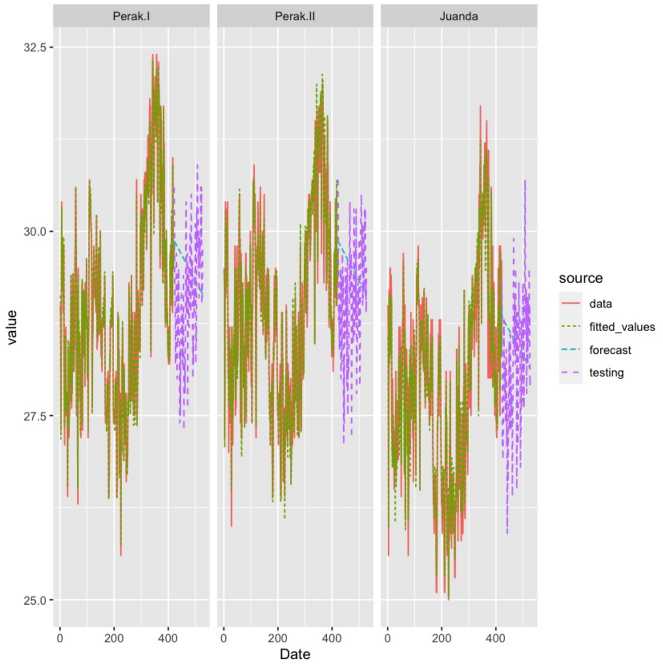
In [26]:

```
#plot with 10 forecasting data
plot(fit3)
plot(fit3, n_predict = 10)
plot(fit3, testing = x_test)
```









5.3 Bobot Invers Jarak

In [27]:

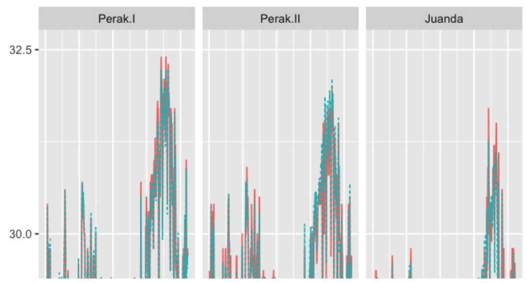
```
#forecast 10 data ahead
predict(fit2, n = 10)
```

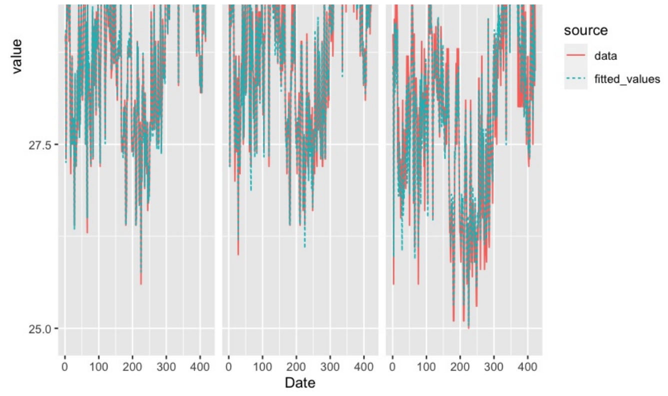
A matrix: 10 × 3 of type dbl

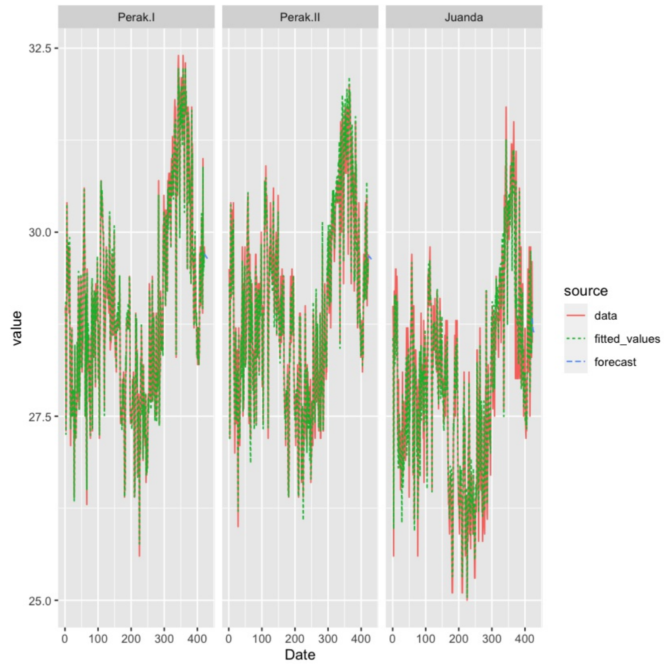
Perak.I	Perak.II	Juanda
29.70760	29.64885	28.83002
29.69430	29.66885	28.73078
29.68558	29.67201	28.68522
29.67833	29.66891	28.66215
29.67152	29.66349	28.64856
29.66482	29.65723	28.63902
29.65813	29.65067	28.63120
29.65143	29.64400	28.62413
29.64472	29.63730	28.61739
29.63801	29.63059	28.61079

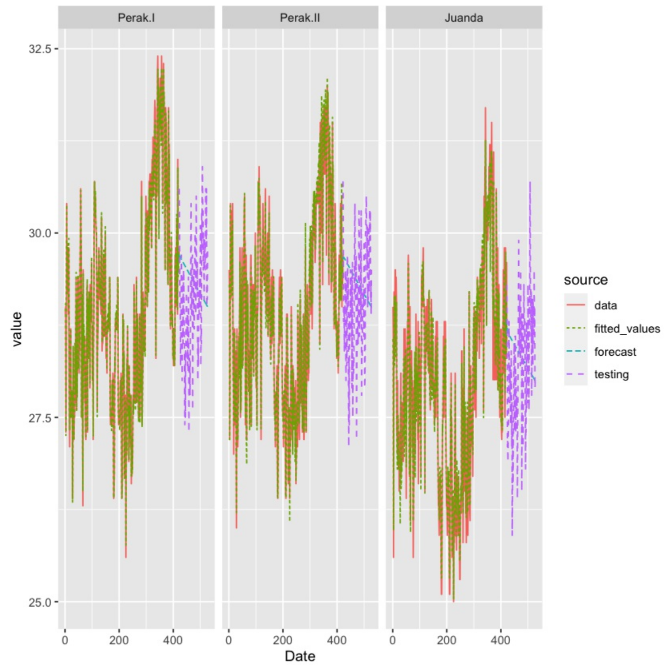
In [28]:

```
#plot with 10 forecasting data
plot(fit2)
plot(fit2, n_predict = 10)
plot(fit2, testing = x_test)
```









5.4 Bobot Biner

In [29]:

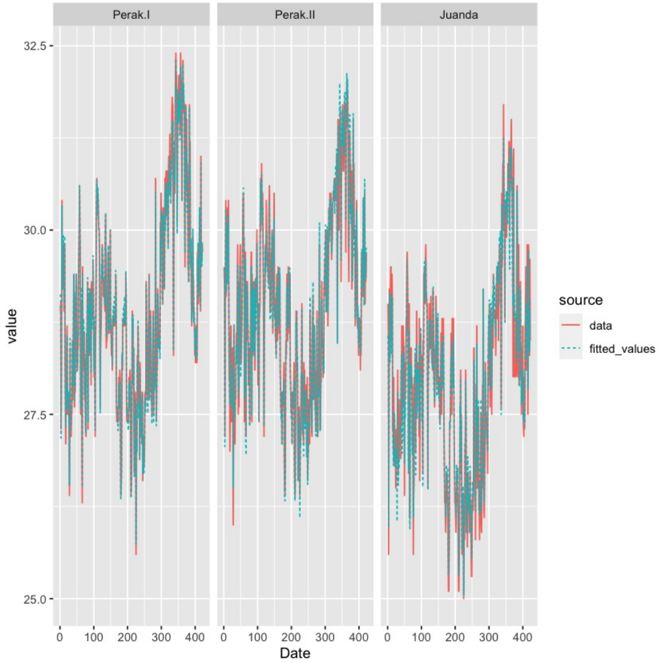
```
#forecast 10 data ahead
predict(fit4, n = 10)
```

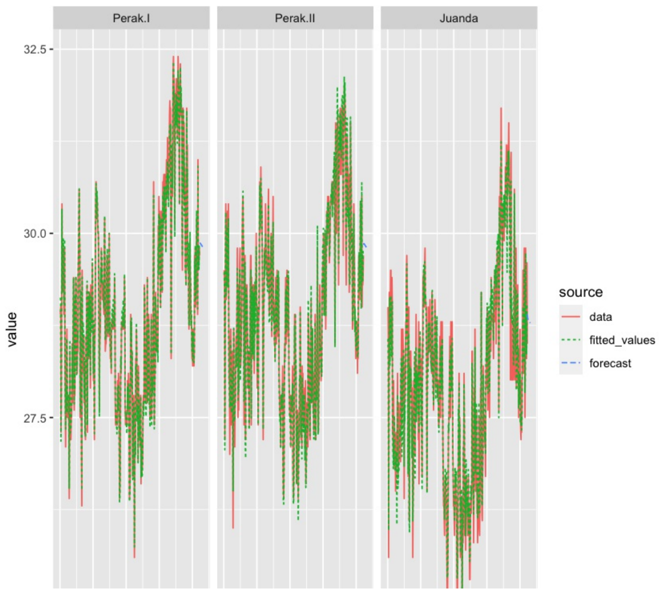
A matrix: 10 × 3 of type dbl

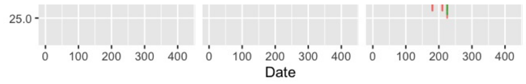
Perak.I	Perak.II	Juanda
29.86634	29.84592	28.90100
29.86712	29.86043	28.85422
29.86332	29.85782	28.83606
29.85772	29.85135	28.82586
29.85136	29.84417	28.81797
29.84464	29.83696	28.81080
29.83777	29.82982	28.80387
29.83083	29.82273	28.79702
29.82384	29.81568	28.79022
29.81684	29.80865	28.78343

In [30]:

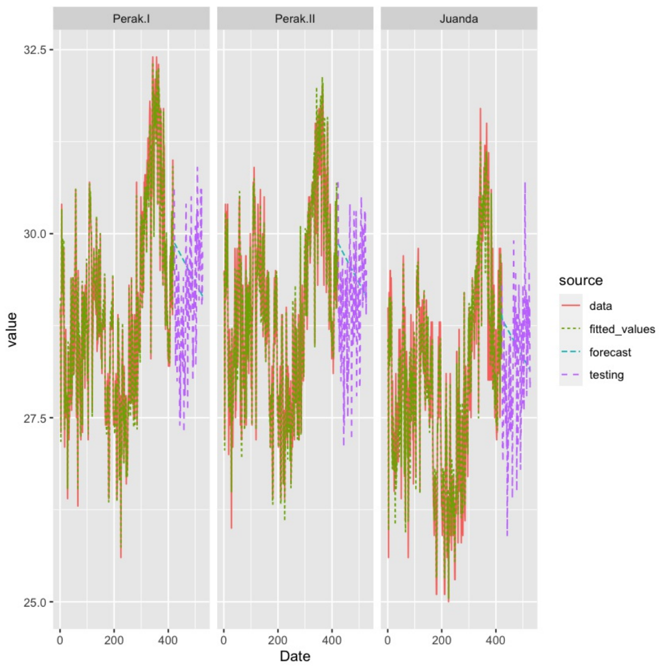
```
#plot with 10 forecasting data
plot(fit4)
plot(fit4, n_predict = 10)
plot(fit4, testing = x_test)
```







25.0
0 100 200 300 400
0 100 200 300 400
0 100 200 300 400
Date



Perak.I
Perak.II
Juanda
32.5
30.0
27.5
25.0
value
0 200 400
0 200 400
0 200 400
Date
source
data
fitted_values
forecast
testing