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LAMPIRAN

Lampiran 1. Data Rata-Rata Harian Posisi *Sunspot* di Lintang Selatan Pada Tahun 2007

Hari-ke	Posisi sunspot LS	Hari-ke	Posisi sunspot LS	Hari-ke	Posisi sunspot LS	Hari-ke	Posisi sunspot LS
1	-14	37	-16.35	73	-8	109	-10
2	-10	38	-11.5	74	-6.25	110	-10
3	-10.25	39	-12	75	-6.75	111	-12.2
4	-11.6	40	-13.3	76	-6.5	112	-11
5	-11.5	41	-13.55	77	-7.25	113	-12
6	-16.35	42	-10.7	78	-7.5	114	-11.5
7	-11.5	43	-10.38	79	-6.5	115	0
8	-12	44	-9.86	80	-10.5	116	-9.75
9	-13.3	45	-9.9	81	-11.1	117	-7.8
10	-13.55	46	-10.53	82	0	118	-7
11	-10.7	47	-7.5	83	-13.5	119	-7.5
12	-10.38	48	-7.2	84	-12	120	-8.3
13	-9.86	49	-8.27	85	-10.05	121	-7.35
14	-9.9	50	-7.83	86	-10.6	122	-7.75
15	-10.53	51	-7.3	87	-11.5	123	-6.65
16	-7.5	52	-9	88	0	124	-7.5
17	-7.2	53	-8.8	89	0	125	-7.5
18	-8.27	54	-8.6	90	0	126	-7.75
19	-7.83	55	-9.5	91	0	127	-8.5
20	-7.3	56	-10	92	0	128	-8.5
21	-9	57	-6.75	93	-6	129	-8.75
22	-8.8	58	-8.05	94	-6	130	-8.75
23	-8.6	59	0	95	-6.75	131	-8.5
24	-9.5	60	0	96	-6.65	132	-10.63
25	-10	61	0	97	-6.37	133	-12.33
26	-6.76	62	-7.8	98	-6.67	134	-12.87
27	-8.05	63	-8.2	99	0	135	-13.8
28	0	64	0	100	-24	136	-14.5
29	0	65	0	101	-7.2	137	-14
30	0	66	0	102	-7.3	138	-16
31	0	67	-5.5	103	-6.4	139	-13.7
32	0	68	-6.8	104	-7.8	140	0
33	-10	69	-5.7	105	-7.5	141	0
34	-10.25	70	-6.65	106	-6.47	142	0
35	-11.6	71	-7.15	107	-8.25	143	-7.5
36	-11.5	72	-7	108	-8	144	-7.5

Lampiran 1. (Lanjutan)

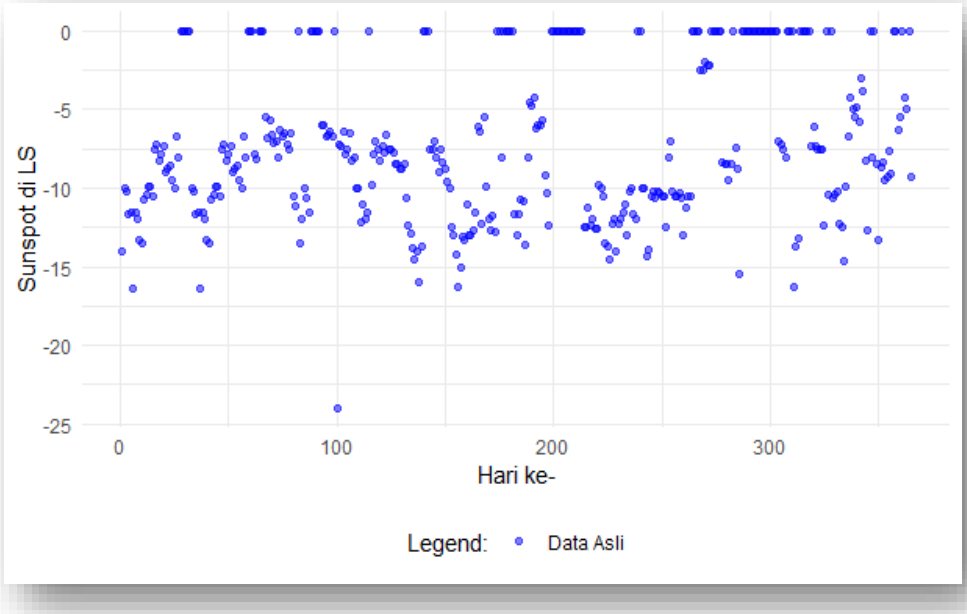
Hari-ke	Posisi sunspot LS	Hari-ke	Posisi sunspot LS	Hari-ke	Posisi sunspot LS	Hari-ke	Posisi sunspot LS
145	-7	181	0	217	-12.4	253	-12.5
146	-8	182	-11.65	218	-12	254	-8
147	-9	183	-12.97	219	-12.6	255	-7
148	-7.5	184	-11.63	220	-12.6	256	-10.2
149	-8.33	185	-10.7	221	-9.75	257	-10.5
150	-8.75	186	-10.78	222	-10	258	-10.5
151	-9.6	187	-13.58	223	-10.5	259	-10.3
152	-10	188	-8	224	-13.5	260	-10.6
153	-12.5	189	-4.55	225	-13.75	261	-13
154	-13	190	-4.75	226	-14.5	262	-11.2
155	-14.23	191	-4.25	227	-12.25	263	-10.5
156	-16.25	192	-6.2	228	-12	264	-10.5
157	-15.05	193	-6	229	-14	265	0
158	-13.1	194	-6	230	-12.25	266	0
159	-13.27	195	-5.7	231	-12	267	0
160	-11	196	-9.15	232	-11.5	268	0
161	-13	197	-10.3	233	-11	269	-2.5
162	-13	198	-12.4	234	-13	270	-2.5
163	-12.63	199	0	235	-10.2	271	-2
164	-11.5	200	0	236	-10	272	-2.2
165	-6.1	201	0	237	-11.65	273	-2.2
166	-6.4	202	0	238	-12	274	0
167	-12.25	203	0	239	0	275	0
168	-5.5	204	0	240	0	276	0
169	-9.93	205	0	241	-10	277	0
170	-12	206	0	242	-10	278	0
171	-12.7	207	0	243	-14.3	279	-8.4
172	-11.75	208	0	244	-13.9	280	-8.5
173	-12.75	209	0	245	-10.5	281	-8.5
174	0	210	0	246	-10.2	282	-9.5
175	0	211	0	247	-10.6	283	-8.5
176	-8	212	0	248	-10.2	284	0
177	0	213	0	249	-10.3	285	-7.4
178	0	214	-12.5	250	-10.5	286	-8.75
179	0	215	-12.5	251	-10.5	287	-15.5
180	0	216	-11.2	252	-12.5	288	0

Lampiran 1. (Lanjutan)

Hari-ke	Posisi sunspot LS	Hari-ke	Posisi sunspot LS	Hari-ke	Posisi sunspot LS
289	0	315	0	341	-5.83
290	0	316	0	342	-3
291	0	317	0	343	-3.8
292	0	318	0	344	-8.25
293	0	319	-7.3	345	-12.7
294	0	320	-6.1	346	0
295	0	321	-7.3	347	-8
296	0	322	-7.5	348	0
297	0	323	-7.5	349	-8.5
298	0	324	-7.5	350	-13.25
299	0	325	-12.4	351	-8.65
300	0	326	0	352	-8.35
301	0	327	-10.45	353	-9.5
302	0	328	0	354	-9.25
303	0	329	-10.65	355	-7.67
304	-7	330	-10.4	356	-9.05
305	-7.2	331	-10.25	357	0
306	-7.5	332	-12.3	358	0
307	-8	333	-12.5	359	-6.25
308	0	334	-14.6	360	-5.45
309	0	335	-9.9	361	0
310	0	336	-6.67	362	-4.25
311	-16.3	337	-4.2	363	-4.95
312	-13.75	338	-5	364	0
313	-13.15	339	-5.5	365	-9.25
314	0	340	-4.83		

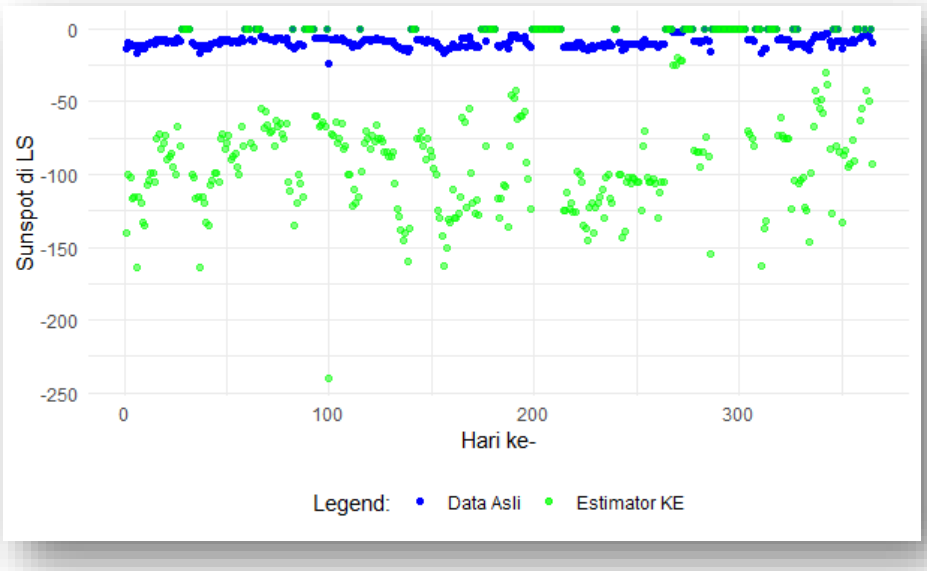
Lampiran 2.a. Source Code dan Output Grafik Data Rata-rata Harian Posisi Sunspot di Lintang Selatan.

```
dt <- read.csv('E:/lia/sunspot.csv')
x  <- dt[,1]       # data excel kolom 1 dari "sunspot.csv" #
y  <- dt[,2]       # data excel kolom 2 dari "sunspot.csv" #
n  <- length(x)    # banyaknya data
h  <- c(0.1)       # bandwidth
p  <- length(h)

I  <- c()
c1 <- c(); c2 <- c(); c3 <- c(); c4 <- c()
for (i in 1:n) {
  for (j in 1:n) {
    c1[j] <- (x[i]-x[j])/h

    if (abs(c1[j]) <=1 ){I[j] <- 1} else {I[j] <- 0}

    c2[j] <- (3/4) * (1-(c1[j])^2) * I[j]  # penyebut
    c3[j] <- c2[j] * y[j] / h              # pembilang
  }
  c4[i] <- sum(c3) / sum(c2)               # estimator kernel Epanechnikov
}

dt  <- data.frame(dt)
col <- c("Data Asli" = rgb(0, 0, 1, 0.5))
ggp <- ggplot(NULL, aes(Hari, Sunspot)) +
  geom_point(data = dt, aes(y = Sunspot, color = "Data Asli"), size = 1.3)+
  theme_minimal()+
  theme(legend.position = "bottom",legend.box = "horizontal") +
  ggtitle("Posisi Sunspot di Lintang Selatan") +
  labs(x = "Hari ke-", y = "Sunspot di LS", color = "Legend:") +
  scale_color_manual(values = col)
ggp
```



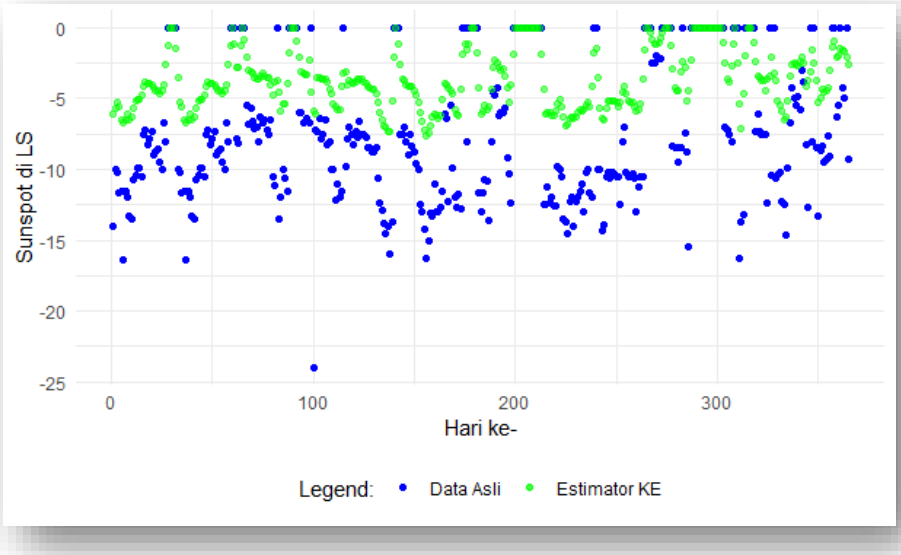
Lampiran 2.b. Source Code dan Output Kurva Regresi Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 0.1

```
dt <- read.csv('E:/lia/sunspot.csv')
x  <- dt[,1]        # data excel kolom 1 dari "sunspot.csv" #
y  <- dt[,2]        # data excel kolom 2 dari "sunspot.csv" #
n  <- length(x)     # banyaknya data
h  <- c(0.1)        # bandwidth
p  <- length(h)

I  <- c()
c1 <- c(); c2 <- c(); c3 <- c(); c4 <- c()
for (i in 1:n) {
  for (j in 1:n) {
    c1[j] <- (x[i]-x[j])/h

    if (abs(c1[j]) <=1 ){I[j] <- 1} else {I[j] <- 0}

    c2[j] <- (3/4) * (1-(c1[j])^2) * I[j]  # penyebut
    c3[j] <- c2[j] * y[j] / h              # pembilang
  }
  c4[i] <- sum(c3) / sum(c2)               # estimator kernel Epanechnikov
}

dt  <- data.frame(dt)
col <- c("Data Asli" = rgb(0, 0, 1, 0.5))
ggp <- ggplot(NULL, aes(Hari, Sunspot)) +
  geom_point(data = dt, aes(y = Sunspot, color = "Data Asli"), size = 1.3)+
  theme_minimal()+
  theme(legend.position = "bottom",legend.box = "horizontal") +
  ggtitle("Posisi Sunspot di Lintang Selatan") +
  labs(x = "Hari ke-", y = "Sunspot di LS", color = "Legend:") +
  scale_color_manual(values = col)
ggp
```



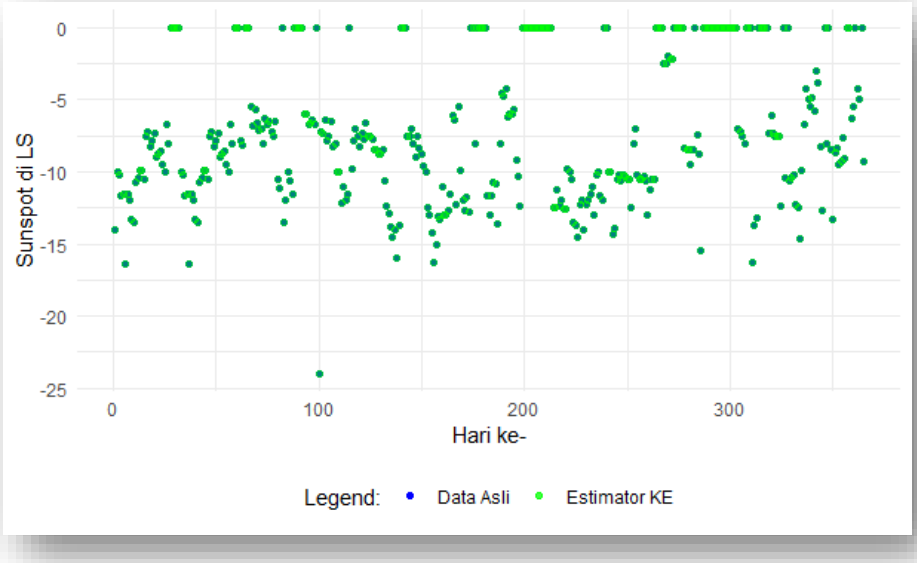
Lampiran 2.c. Source Code dan Output Kurva Regresi Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 2.0

```
dt <- read.csv('E:/lia/sunspot.csv')
x  <- dt[,1]       # data excel kolom 1 dari "sunspot.csv" #
y  <- dt[,2]       # data excel kolom 2 dari "sunspot.csv" #
n  <- length(x)    # banyaknya data
h  <- c(2.0)       # bandwidth
p  <- length(h)

I  <- c()
c1 <- c(); c2 <- c(); c3 <- c(); c4 <- c()

for (i in 1:n) {
  for (j in 1:n) {
    c1[j] <- (x[i]-x[j])/h

    if (abs(c1[j]) <=1 ){I[j] <- 1} else {I[j] <- 0}

    c2[j] <- (3/4) * (1-(c1[j])^2) * I[j]  # penyebut
    c3[j] <- c2[j] * y[j] / h              # pembilang
  }
  c4[i] <- sum(c3) / sum(c2)               # estimator kernel Epanechnikov
}

## Kurva Hasil estimasi kernel ##
library("ggplot2")
dt1 <- data.frame(dt)
dt2 <- data.frame(Hari = x, Sunspot = c4)
col <- c("Data Asli" = rgb(0, 0, 1, 1), "Estimator KE" = rgb(0, 1, 0, 0.5))
ggp <- ggplot(NULL, aes(Hari, Sunspot)) +
  geom_point(data = dt1, aes(y = Sunspot, color = "Data Asli"),size = 1.3) +
  geom_point(data = dt2, aes(y = Sunspot, color = "Estimator KE"), size = 1.3)+
  theme_minimal()+
  theme(legend.position = "bottom",legend.box = "horizontal") +
  ggtitle("Kurva Regresi Kernel Epanechnikov di Lintang Selatan") +
  labs(x = "Hari ke-", y = "Sunspot di LS", color = "Legend:") +
  scale_color_manual(values = col)
ggp
```



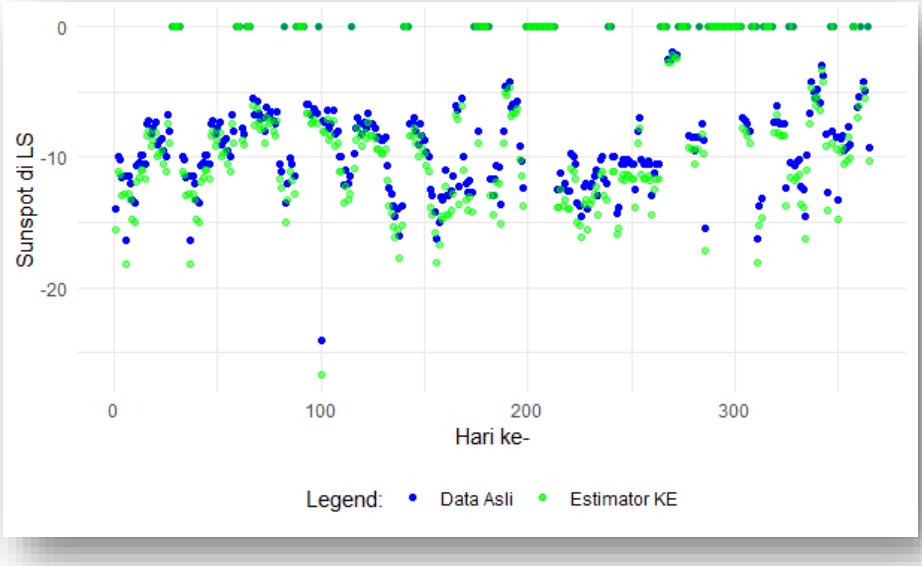
Lampiran 2.d. Source Code dan Output Kurva Regresi Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 1.0

```
dt <- read.csv('E:/lia/sunspot.csv')
x  <- dt[,1]       # data excel kolom 1 dari "sunspot.csv" #
y  <- dt[,2]       # data excel kolom 2 dari "sunspot.csv" #
n  <- length(x)    # banyaknya data
h  <- c(1.0)       # bandwidth
p  <- length(h)

I  <- c()
c1 <- c(); c2 <- c(); c3 <- c(); c4 <- c()

for (i in 1:n) {
  for (j in 1:n) {
    c1[j] <- (x[i]-x[j])/h

    if (abs(c1[j]) <=1 ){I[j] <- 1} else {I[j] <- 0}

    c2[j] <- (3/4) * (1-(c1[j])^2) * I[j]  # penyebut
    c3[j] <- c2[j] * y[j] / h              # pembilang
  }
  c4[i] <- sum(c3) / sum(c2)               # estimator kernel Epanechnikov
}

## Kurva Hasil estimasi kernel ##
library("ggplot2")
dt1 <- data.frame(dt)
dt2 <- data.frame(Hari = x, Sunspot = c4)
col <- c("Data Asli" = rgb(0, 0, 1, 1), "Estimator KE" = rgb(0, 1, 0, 0.5))
ggp <- ggplot(NULL, aes(Hari, Sunspot)) +
  geom_point(data = dt1, aes(y = Sunspot, color = "Data Asli"),size = 1.3) +
  geom_point(data = dt2, aes(y = Sunspot, color = "Estimator KE"), size = 1.3)+
  theme_minimal()+
  theme(legend.position = "bottom",legend.box = "horizontal") +
  ggtitle("Kurva Regresi Kernel Epanechnikov di Lintang Selatan") +
  labs(x = "Hari ke-", y = "Sunspot di LS", color = "Legend:") +
  scale_color_manual(values = col)
ggp
```



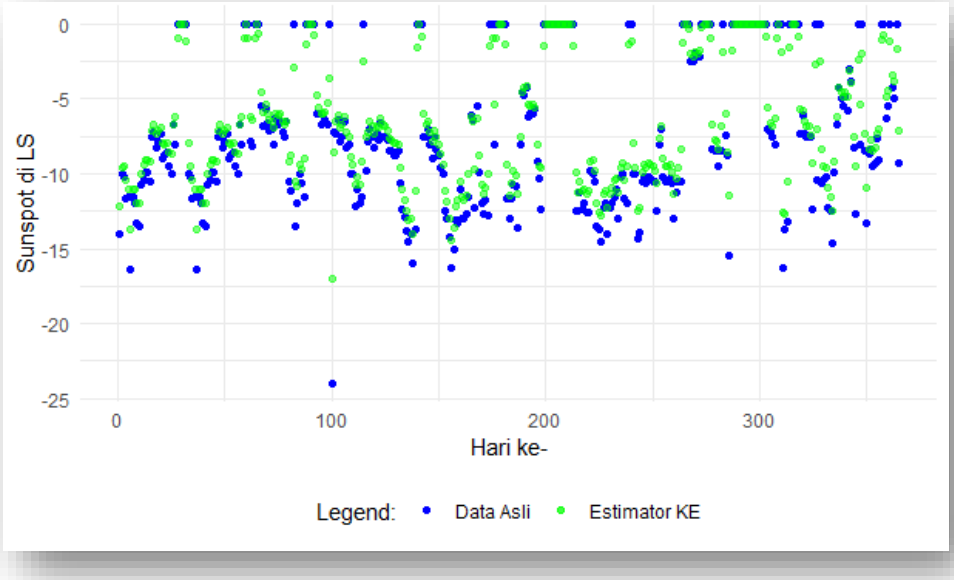
Lampiran 2.e. Source Code dan Output Kurva Regresi Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 0.9

```
dt <- read.csv('E:/lia/sunspot.csv')
x  <- dt[,1]       # data excel kolom 1 dari "sunspot.csv" #
y  <- dt[,2]       # data excel kolom 2 dari "sunspot.csv" #
n  <- length(x)    # banyaknya data
h  <- c(0.9)       # bandwidth
p  <- length(h)

I  <- c()
c1 <- c(); c2 <- c(); c3 <- c(); c4 <- c()

for (i in 1:n) {
  for (j in 1:n) {
    c1[j] <- (x[i]-x[j])/h

    if (abs(c1[j]) <=1 ){I[j] <- 1} else {I[j] <- 0}

    c2[j] <- (3/4) * (1-(c1[j])^2) * I[j]  # penyebut
    c3[j] <- c2[j] * y[j] / h              # pembilang
  }
  c4[i] <- sum(c3) / sum(c2)               # estimator kernel Epanechnikov
}

## Kurva Hasil estimasi kernel ##
library("ggplot2")
dt1 <- data.frame(dt)
dt2 <- data.frame(Hari = x, Sunspot = c4)
col <- c("Data Asli" = rgb(0, 0, 1, 1), "Estimator KE" = rgb(0, 1, 0, 0.5))
ggp <- ggplot(NULL, aes(Hari, Sunspot)) +
  geom_point(data = dt1, aes(y = Sunspot, color = "Data Asli"),size = 1.3) +
  geom_point(data = dt2, aes(y = Sunspot, color = "Estimator KE"), size = 1.3)+
  theme_minimal()+
  theme(legend.position = "bottom",legend.box = "horizontal") +
  ggtitle("Kurva Regresi Kernel Epanechnikov di Lintang Selatan") +
  labs(x = "Hari ke-", y = "Sunspot di LS", color = "Legend:") +
  scale_color_manual(values = col)
ggp
```



Lampiran 2.f. Source Code dan Output Kurva Regresi Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 1.1

```
dt <- read.csv('E:/lia/sunspot.csv')
x  <- dt[,1]       # data excel kolom 1 dari "sunspot.csv" #
y  <- dt[,2]       # data excel kolom 2 dari "sunspot.csv" #
n  <- length(x)    # banyaknya data
h  <- c(1.1)       # bandwidth
p  <- length(h)

I  <- c()
c1 <- c(); c2 <- c(); c3 <- c(); c4 <- c()

for (i in 1:n) {
  for (j in 1:n) {
    c1[j] <- (x[i]-x[j])/h

    if (abs(c1[j]) <=1 ){I[j] <- 1} else {I[j] <- 0}

    c2[j] <- (3/4) * (1-(c1[j])^2) * I[j]  # penyebut
    c3[j] <- c2[j] * y[j] / h              # pembilang
  }
  c4[i] <- sum(c3) / sum(c2)               # estimator kernel Epanechnikov
}

## Kurva Hasil estimasi kernel ##
library("ggplot2")
dt1 <- data.frame(dt)
dt2 <- data.frame(Hari = x, Sunspot = c4)
col <- c("Data Asli" = rgb(0, 0, 1, 1), "Estimator KE" = rgb(0, 1, 0, 0.5))
ggp <- ggplot(NULL, aes(Hari, Sunspot)) +
  geom_point(data = dt1, aes(y = Sunspot, color = "Data Asli"),size = 1.3) +
  geom_point(data = dt2, aes(y = Sunspot, color = "Estimator KE"), size = 1.3)+
  theme_minimal()+
  theme(legend.position = "bottom",legend.box = "horizontal") +
  ggtitle("Kurva Regresi Kernel Epanechnikov di Lintang Selatan") +
  labs(x = "Hari ke-", y = "Sunspot di LS", color = "Legend:") +
  scale_color_manual(values = col)
ggp
```

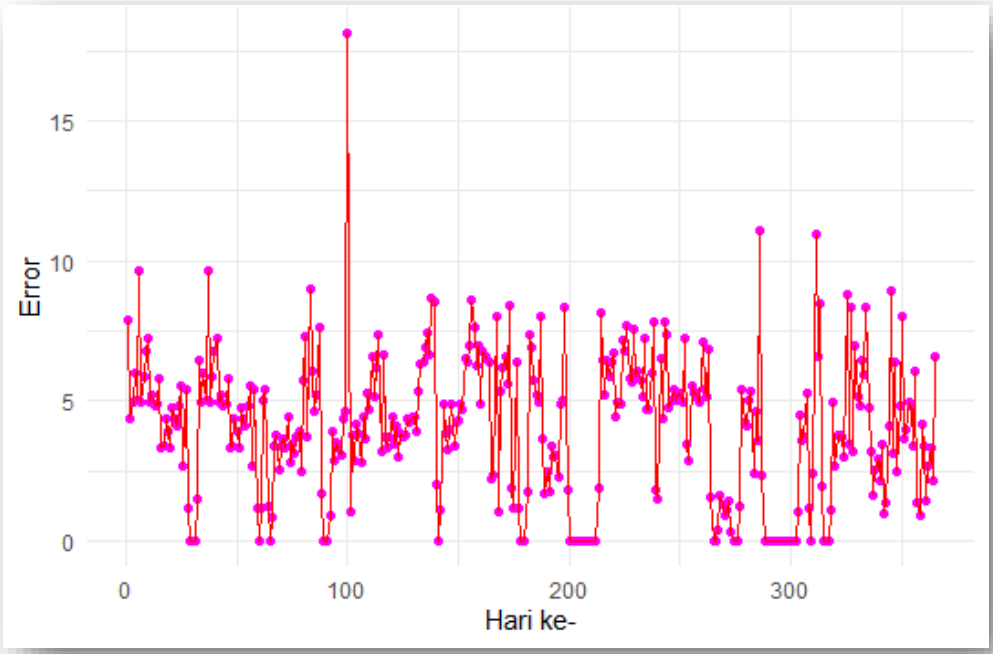


Lampiran 2.g. Source Code dan Output Kurva Eror Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 0.1

```
## kurva error ##
dt3 <- data.frame(x,vm)
col <- c("c1" = rgb(1, 0, 1, 1),"c2" = rgb(1, 0, 0, 1))
ggp <- ggplot(dt1, aes(x,vm)) +
  geom_point(aes(color = "c1"),size = 1.3)+
  geom_line(aes(color = "c2")) +
  ggtitle("Kurva Error dari Regresi Kernel Epanechnikov") +
  labs(x = "Hari ke-", y = "Error", color = "Legend:") +
  theme_minimal()+
  theme(legend.position = "not",legend.box = "horizontal") +
  scale_color_manual(values = col)
ggp
```

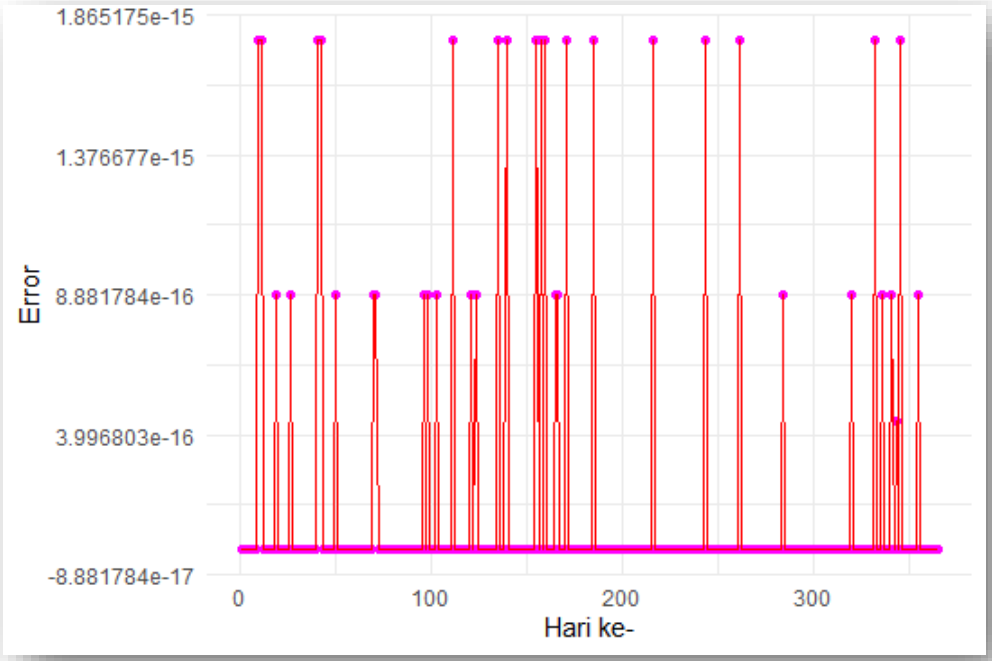
Lampiran 2.h. Source Code dan Output Kurva Eror Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 2.0

```
## kurva error ##
dt3 <- data.frame(x,vm)
col <- c("c1" = rgb(1, 0, 1, 1),"c2" = rgb(1, 0, 0, 1))
ggp <- ggplot(dt1, aes(x,vm)) +
  geom_point(aes(color = "c1"),size = 1.3)+
  geom_line(aes(color = "c2")) +
  ggtitle("Kurva Error dari Regresi Kernel Epanechnikov") +
  labs(x = "Hari ke-", y = "Error", color = "Legend:") +
  theme_minimal()+
  theme(legend.position = "not",legend.box = "horizontal") +
  scale_color_manual(values = col)
ggp
```



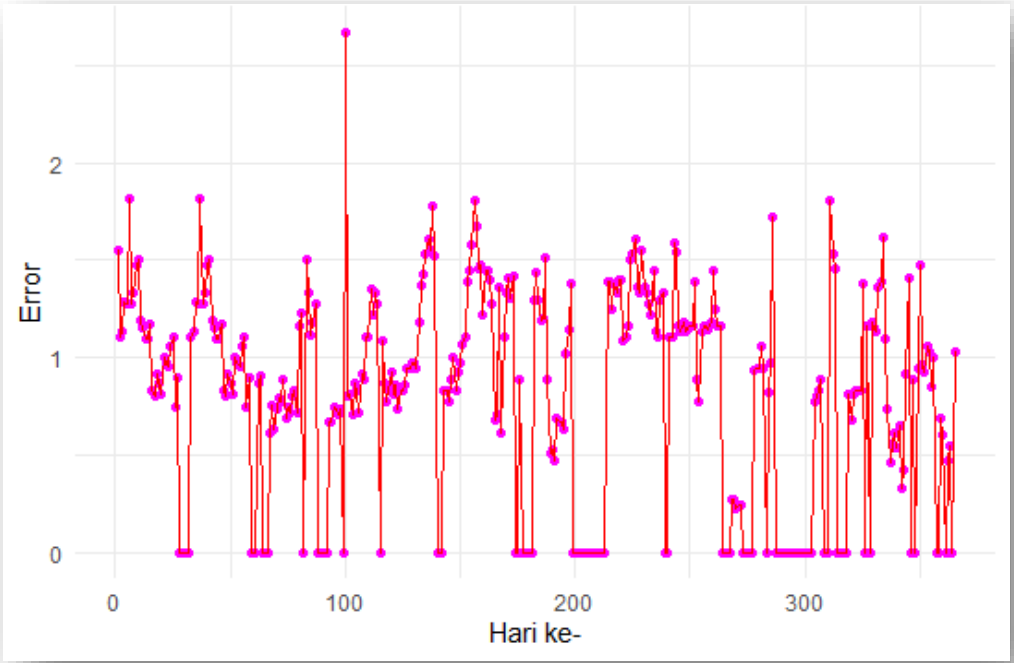
Lampiran 2.i. Source Code dan Output Kurva Eror Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 1.0

```
## kurva error ##
dt3 <- data.frame(x,vm)
col <- c("c1" = rgb(1, 0, 1, 1),"c2" = rgb(1, 0, 0, 1))
ggp <- ggplot(dt1, aes(x,vm)) +
  geom_point(aes(color = "c1"),size = 1.3)+
  geom_line(aes(color = "c2")) +
  ggtitle("Kurva Error dari Regresi Kernel Epanechnikov") +
  labs(x = "Hari ke-", y = "Error", color = "Legend:") +
  theme_minimal()+
  theme(legend.position = "not",legend.box = "horizontal") +
  scale_color_manual(values = col)
ggp
```



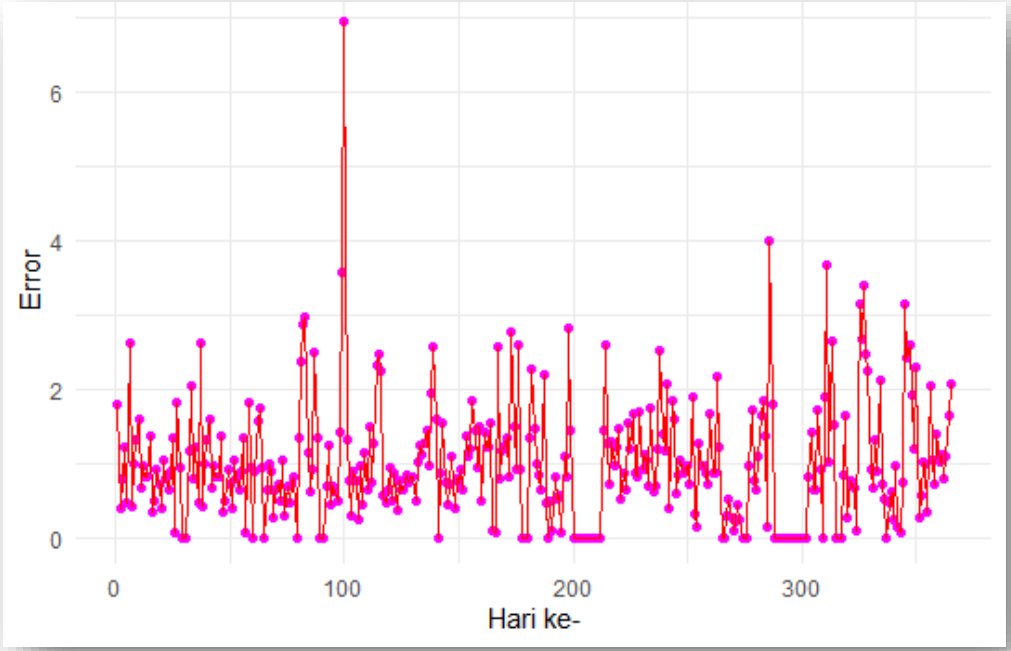
Lampiran 2.j. Source Code dan Output Kurva Eror Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 0.9

```
## kurva error ##
dt3 <- data.frame(x,vm)
col <- c("c1" = rgb(1, 0, 1, 1),"c2" = rgb(1, 0, 0, 1))
ggp <- ggplot(dt1, aes(x,vm)) +
  geom_point(aes(color = "c1"),size = 1.3)+
  geom_line(aes(color = "c2")) +
  ggtitle("Kurva Error dari Regresi Kernel Epanechnikov") +
  labs(x = "Hari ke-", y = "Error", color = "Legend:") +
  theme_minimal()+
  theme(legend.position = "not",legend.box = "horizontal") +
  scale_color_manual(values = col)
ggp
```



Lampiran 2.k. Source Code dan Output Kurva Eror Estimator *Nadaraya-Watson* Menggunakan Fungsi Kernel *Epanechnikov* dengan Nilai *Bandwidth* = 1.1

```
## kurva error ##
dt3 <- data.frame(x,vm)
col <- c("c1" = rgb(1, 0, 1, 1),"c2" = rgb(1, 0, 0, 1))
ggp <- ggplot(dt1, aes(x,vm)) +
  geom_point(aes(color = "c1"),size = 1.3)+
  geom_line(aes(color = "c2")) +
  ggtitle("Kurva Error dari Regresi Kernel Epanechnikov") +
  labs(x = "Hari ke-", y = "Error", color = "Legend:") +
  theme_minimal()+
  theme(legend.position = "not",legend.box = "horizontal") +
  scale_color_manual(values = col)
ggp
```



Lampiran 3. Nilai MSE, RMSE, dan MAD untuk *bandwidth* 0.1 sampai 2.0

Bandwidth	MSE	RMSE	MAD	Bandwidth	MSE	RMSE	MAD
0.1	6203.68	78.76	65.4	1.1	1.64	1.28	0.98
0.2	1225.42	35.01	29.07	1.2	4.21	2.05	4.23
0.3	416.98	20.42	16.96	1.3	6.86	2.62	6.9
0.4	172.32	13.13	10.9	1.4	9.48	3.01	2.55
0.5	76.59	8.75	7.27	1.5	11.99	3.46	2.89
0.6	34.04	5.83	4.85	1.6	14.4	3.8	14.48
0.7	14.07	3.75	3.11	1.7	16.69	4.09	3.43
0.8	4.79	2.19	1.82	1.8	18.86021	4.34	18.96
0.9	0.95	0.97	0.81	1.9	20.91	4.57	21.02
1	2.02E-31	4.49E-16	1.35E-16	2	2.28E+01	4.77E+00	2.30E+01