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Appendix A: Wavelet analyses of Dengue Cases by Districts

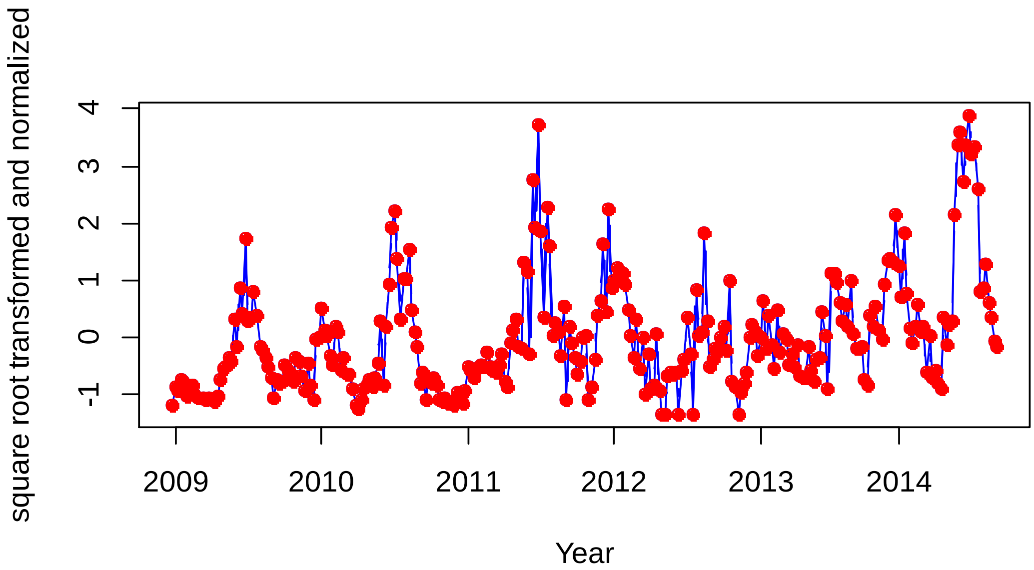

Figure A1: Time series plot of square root transformed and normalized aggregated dengue incidence in Colombo District, 2009 – September, 2014.

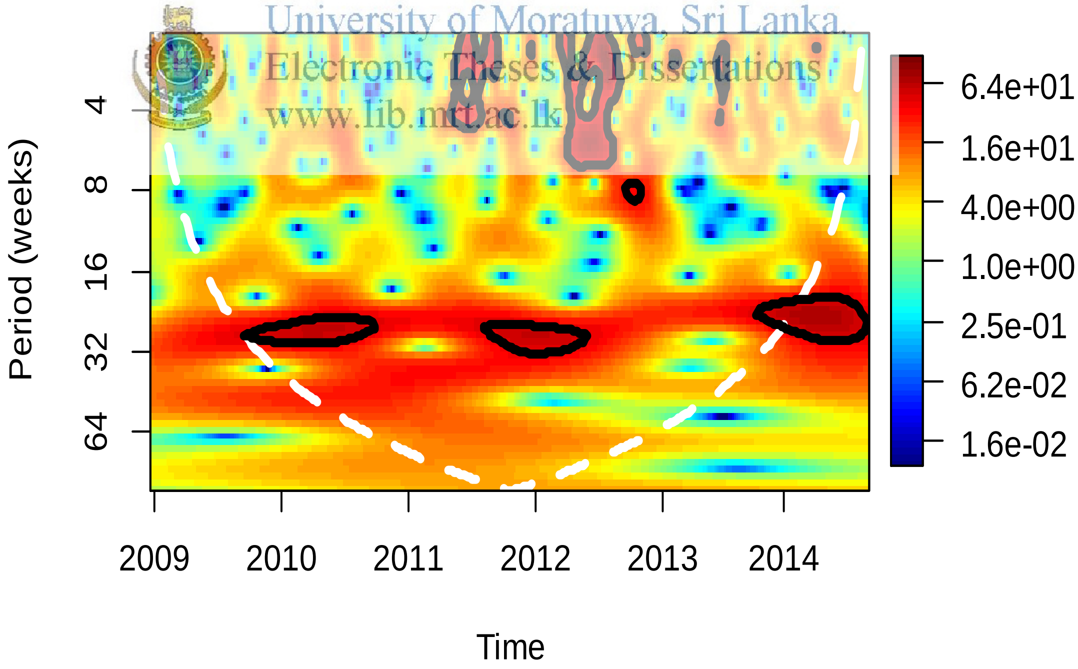

Figure A2: Wavelet power spectrum of dengue incidence in Colombo district from 2009 to September, 2014.

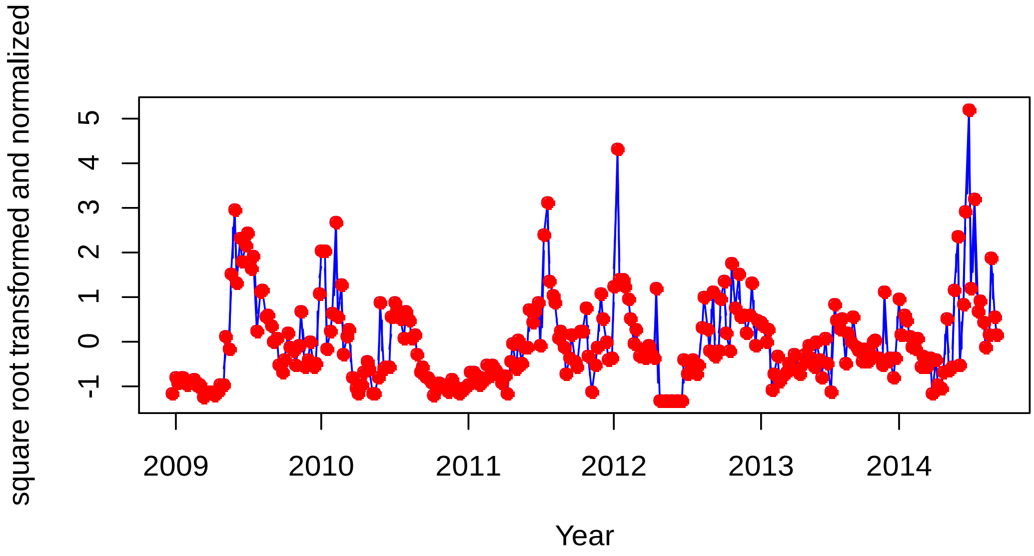

Figure A3: Time series plot of square root transformed and normalized aggregated dengue incidence in Gampaha District, 2009 – September, 2014.

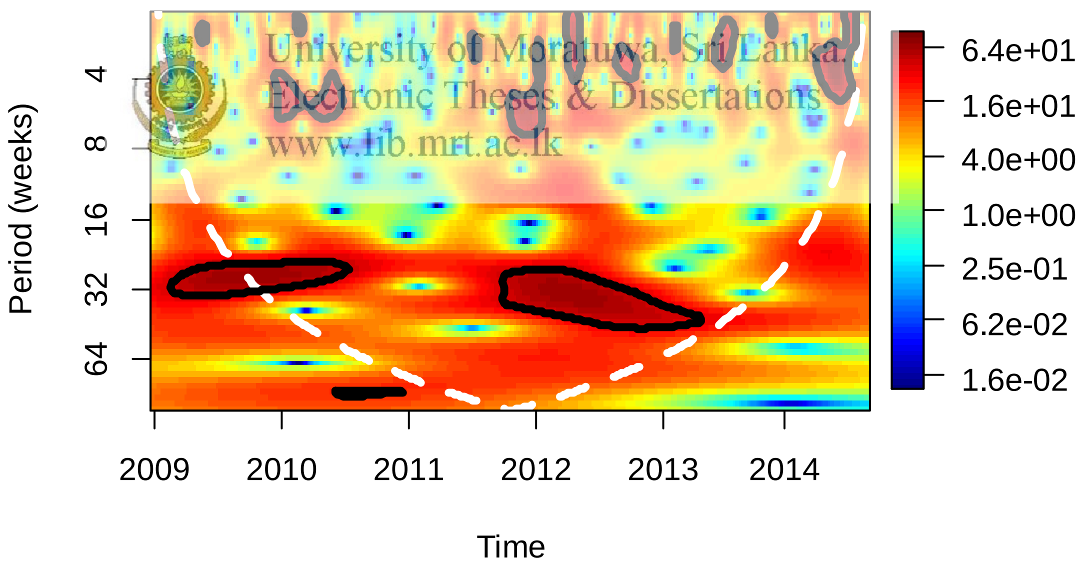

Figure A4: wavelet power spectrum of dengue incidence in Gampaha district from 2009 to September, 2014.

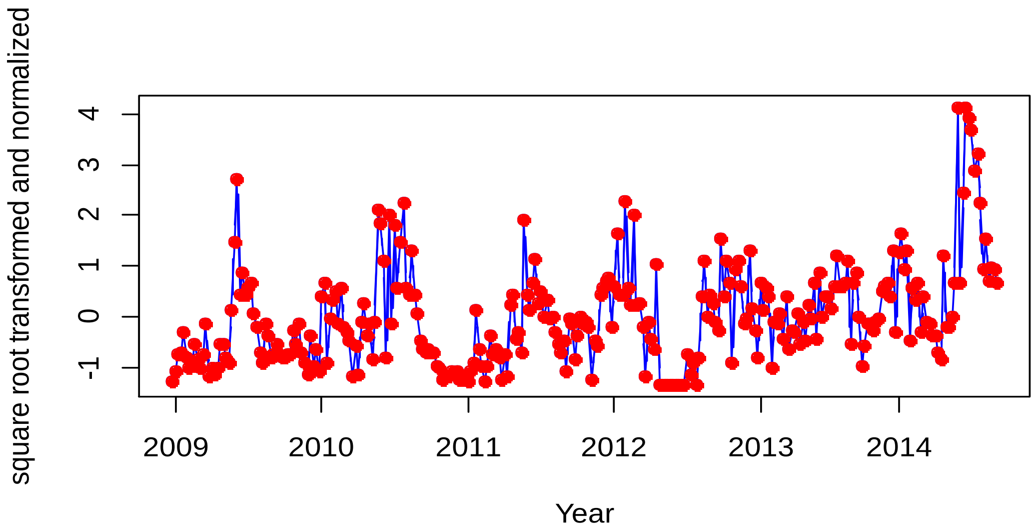

Figure A5: Time series plot of square root transformed and normalized aggregated dengue incidence in Kalutara District, 2009 – September, 2014.

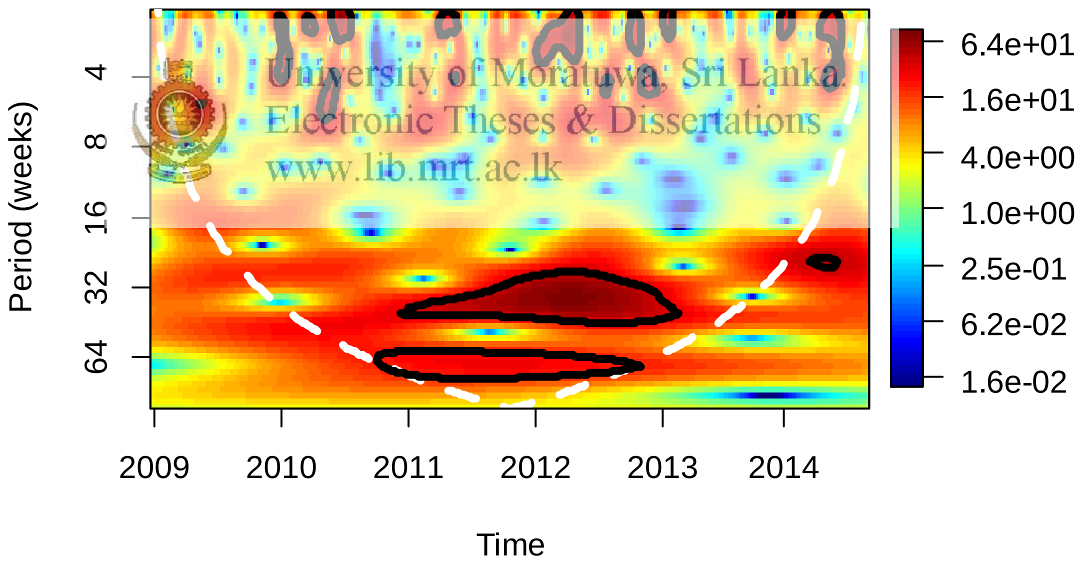

Figure A6: wavelet power spectrum of dengue incidence in Kalutara district from 2009 to September, 2014

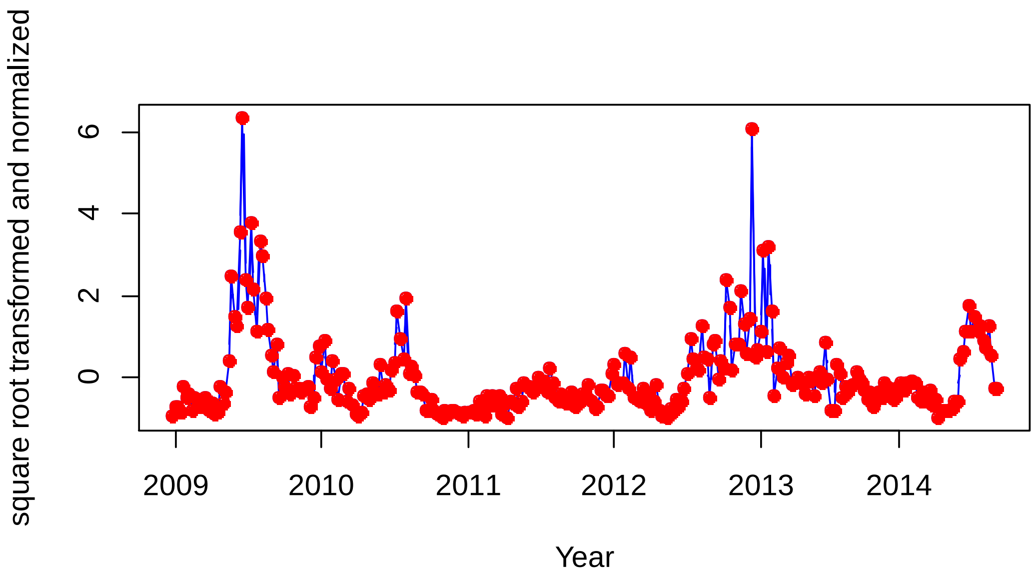

Figure A7: Time series plot of square root transformed and normalized aggregated dengue incidence in Kurunagala District, 2009 – September, 2014.

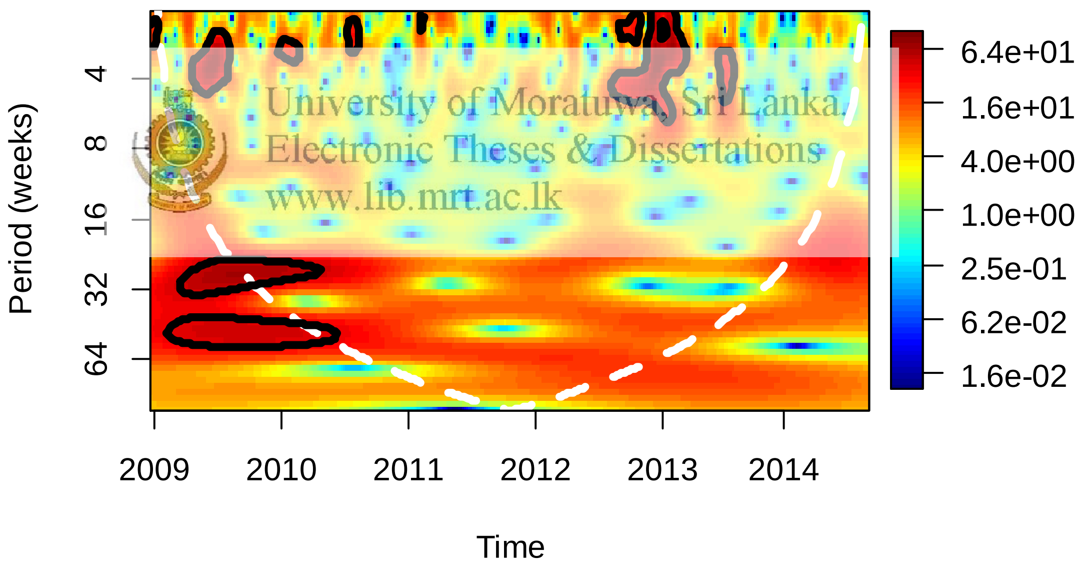

Figure A8: wavelet power spectrum of dengue incidence in Kurunalaga district from 2009 to September, 2014

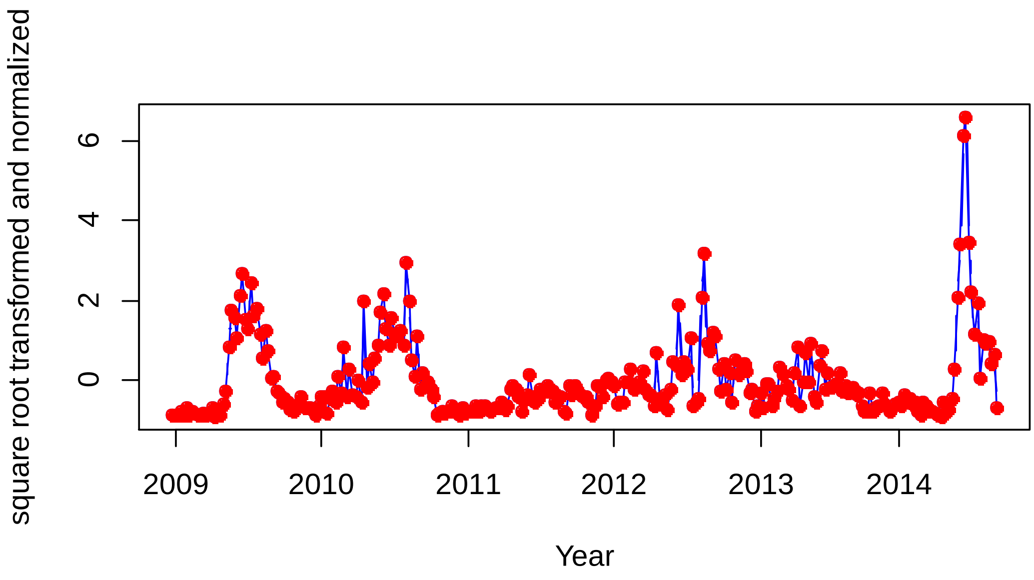

Figure A9: Time series plot of square root transformed and normalized aggregated dengue incidence in Rathnapura District, 2009 – September, 2014.

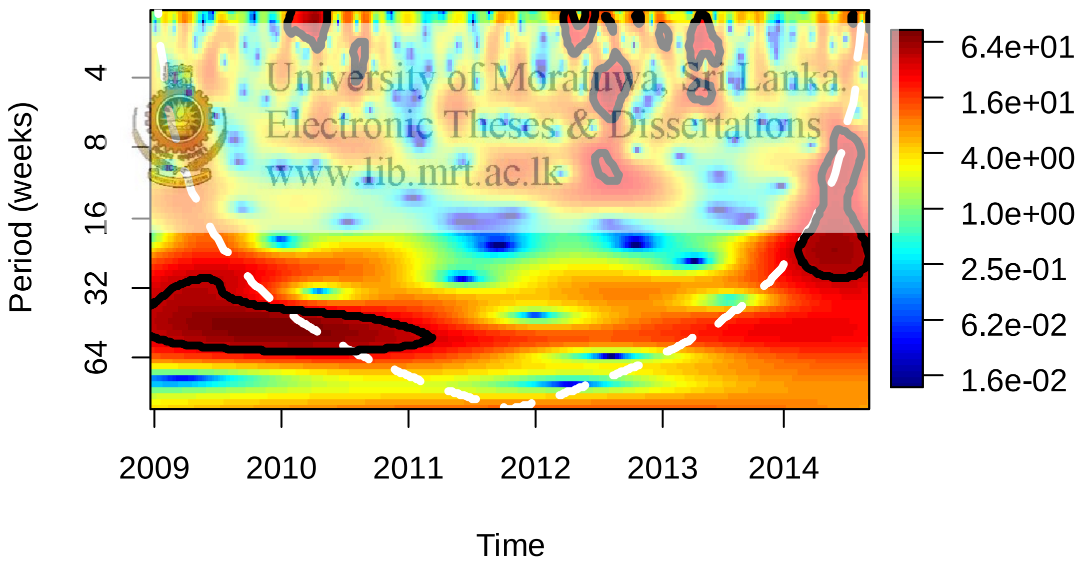

Figure A10: wavelet power spectrum of dengue incidence in Rathnapura district from 2009 to September, 2014

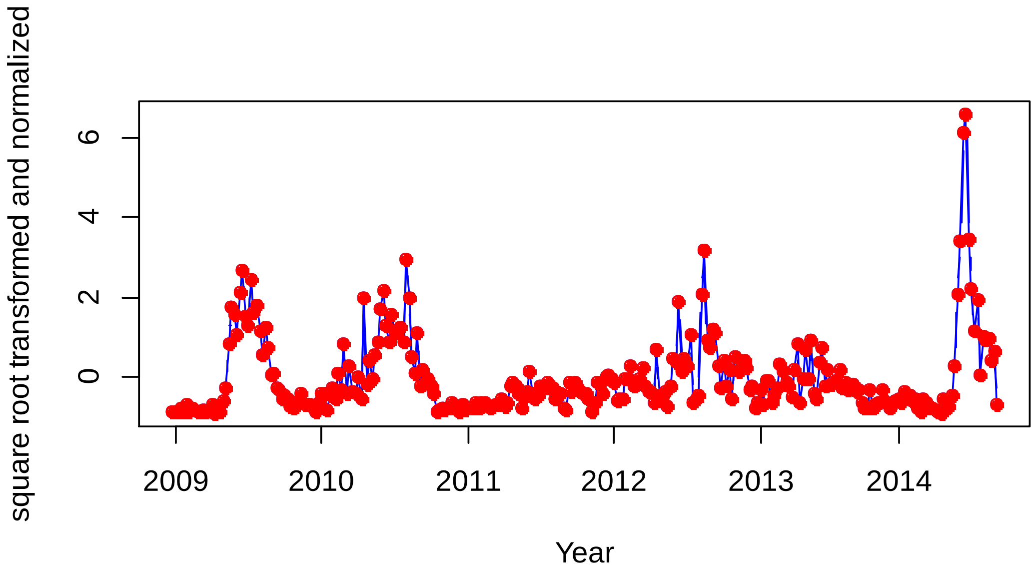

Figure A11: Time series plot of square root transformed and normalized aggregated dengue incidence in Kandy District, 2009 – September, 2014.

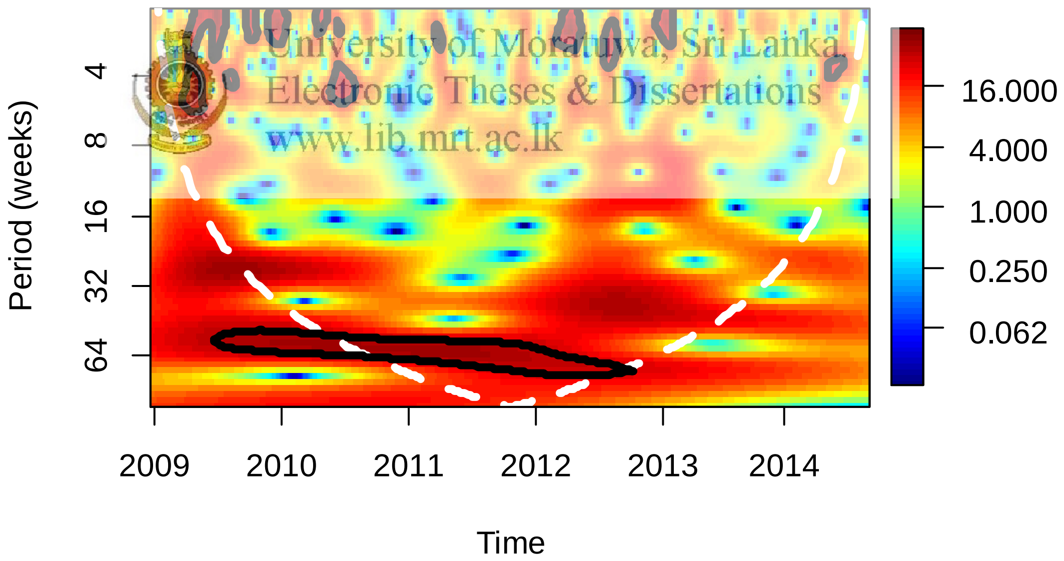

Figure A12: wavelet power spectrum of dengue incidence in Kandy district from 2009 to September, 2014

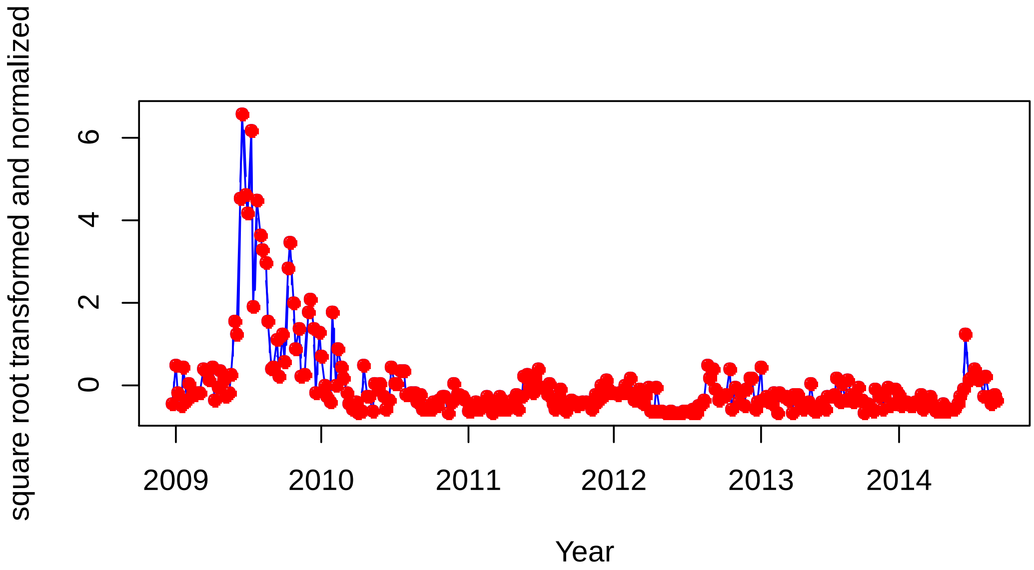

Figure A13: Time series plot of square root transformed and normalized aggregated dengue incidence in Matale District, 2009 – September, 2014.

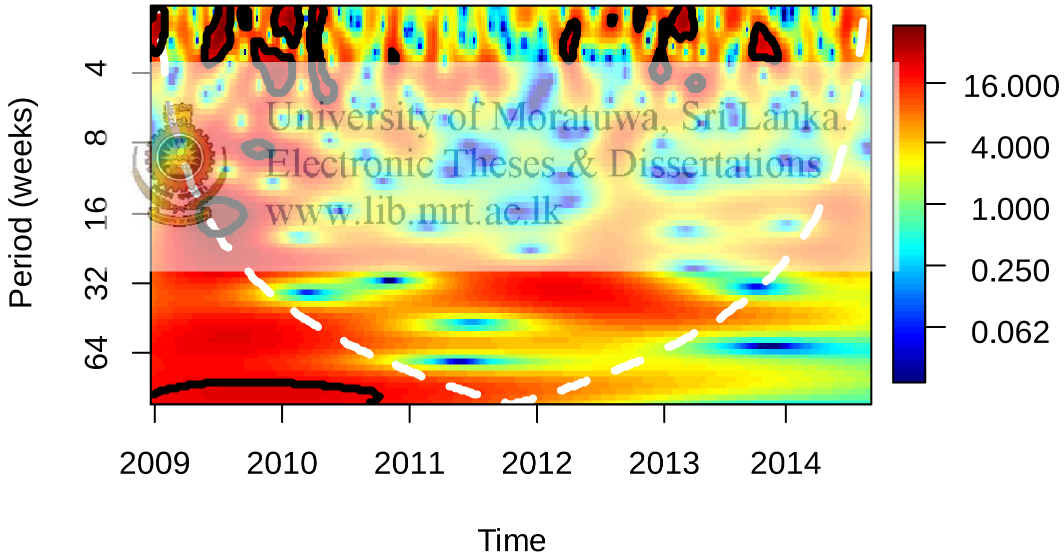

Figure A14: wavelet power spectrum of dengue incidence in Matale district from 2009 to September, 2014

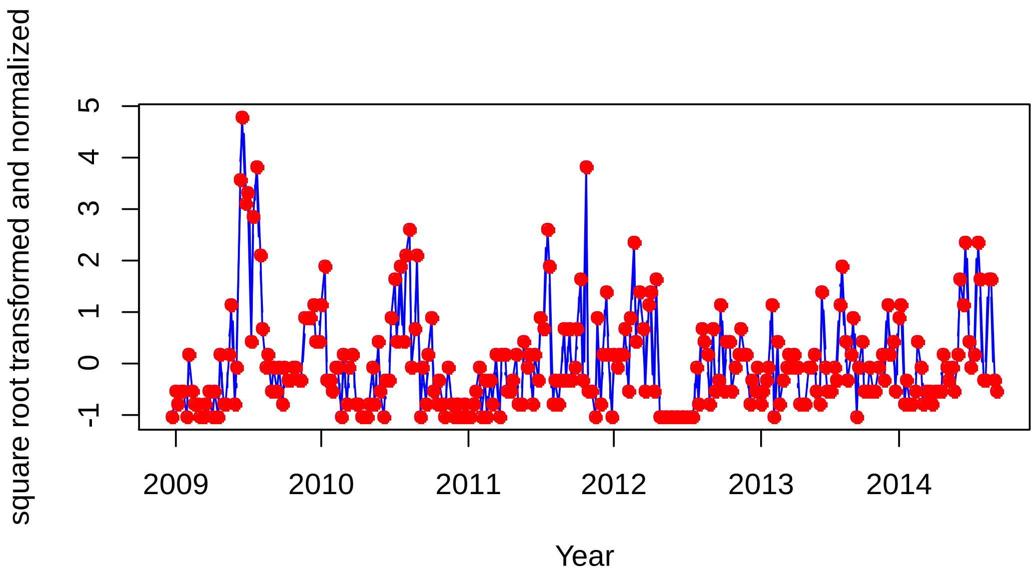

Figure A15: Time series plot of square root transformed and normalized aggregated dengue incidence in Nuwara Eliya District, 2009 – September, 2014.

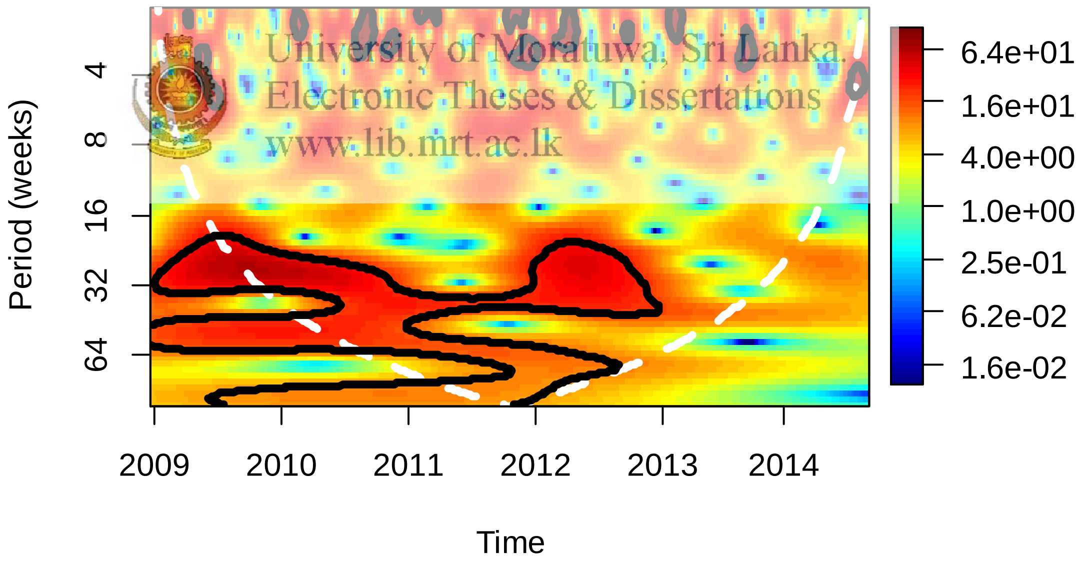

Figure A16: wavelet power spectrum of dengue incidence in Nuwara Eliya district from 2009 to September, 2014

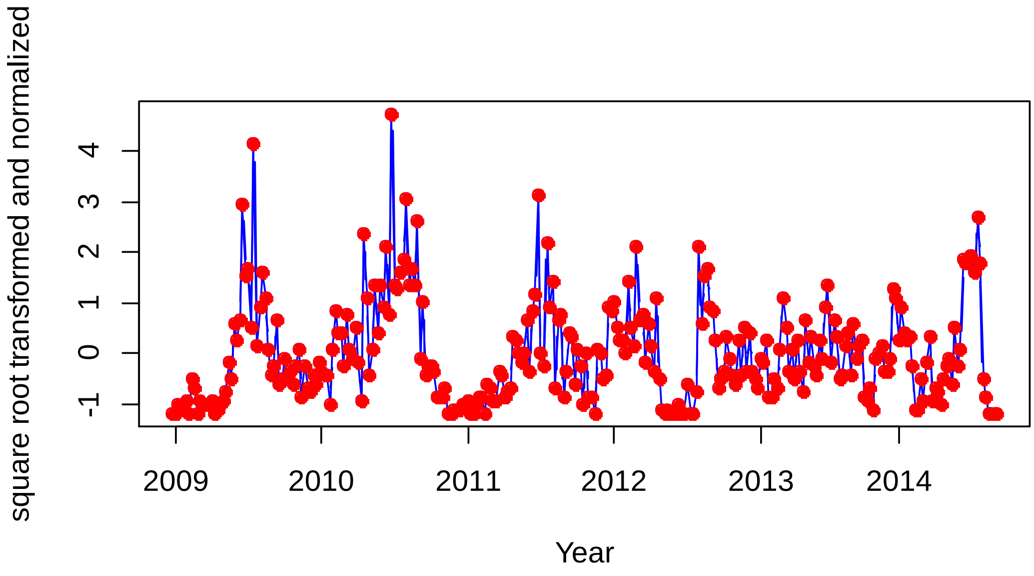

Figure A17: Time series plot of square root transformed and normalized aggregated dengue incidence in Galle District, 2009 – September, 2014.

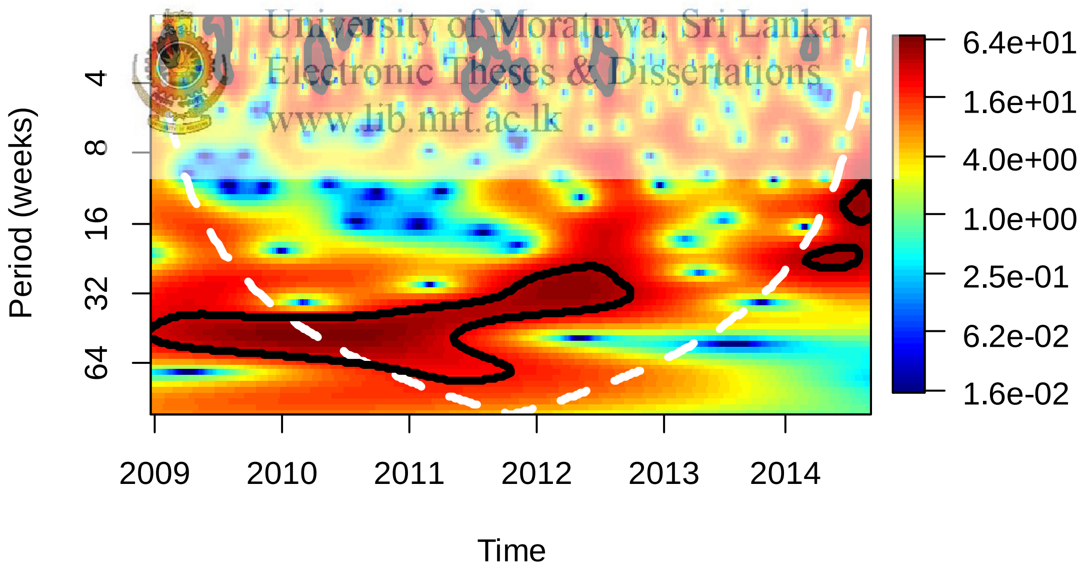

Figure A18: wavelet power spectrum of dengue incidence in Galle district from 2009 to September, 2014

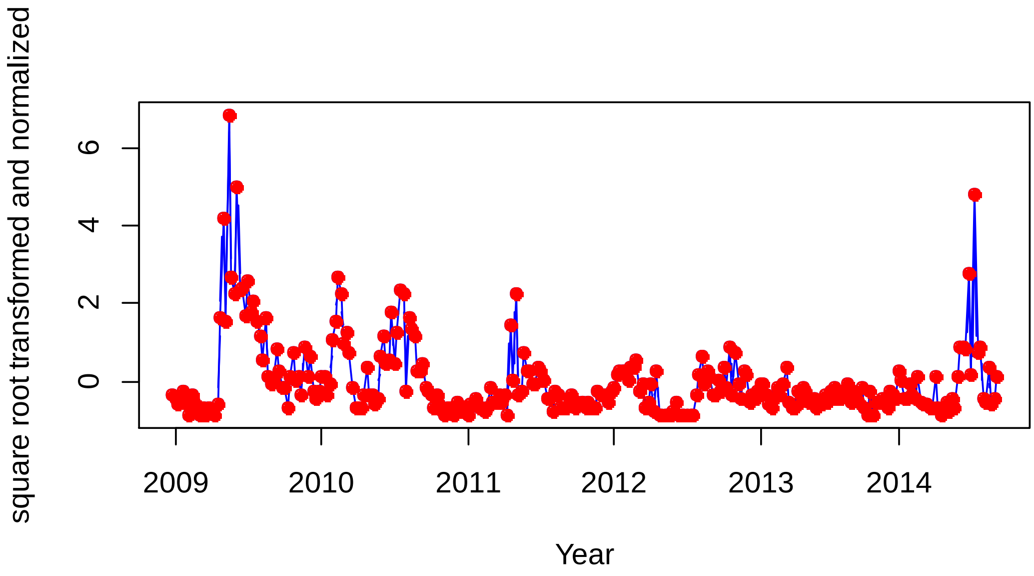

Figure A19: Time series plot of square root transformed and normalized aggregated dengue incidence in Hambantota District, 2009 – September, 2014.

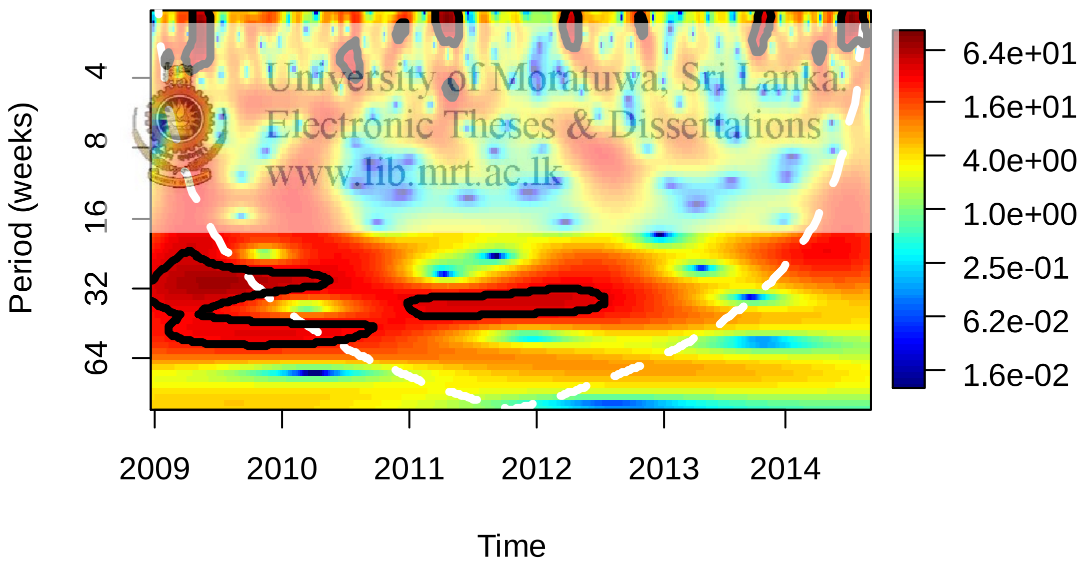

Figure A20: wavelet power spectrum of dengue incidence in Hambantota district from 2009 to September, 2014

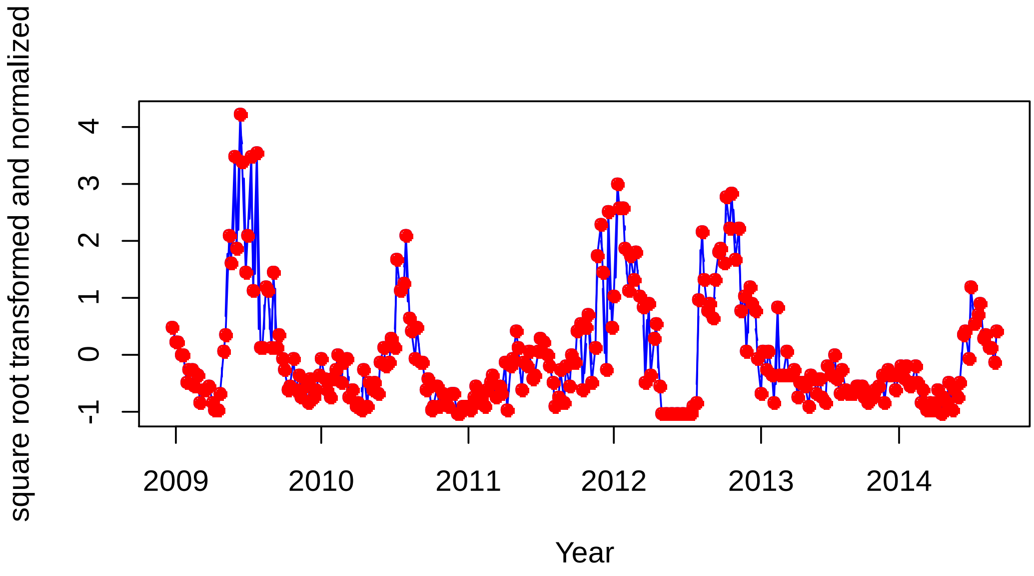

Figure A21: Time series plot of square root transformed and normalized aggregated dengue incidence in Matara District, 2009 – September, 2014.

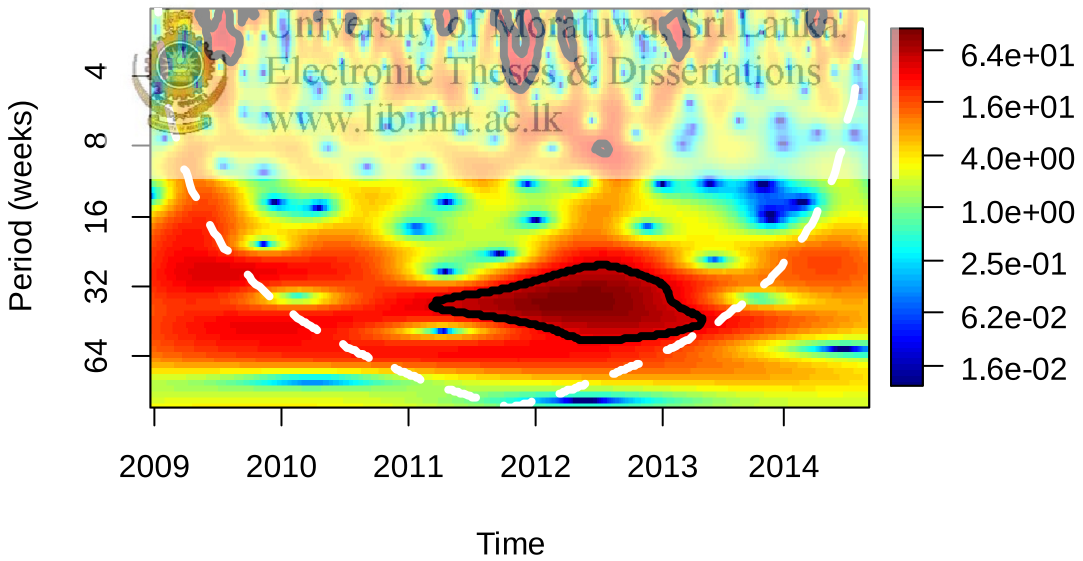

Figure A22: wavelet power spectrum of dengue incidence in Matara district from 2009 to September, 2014

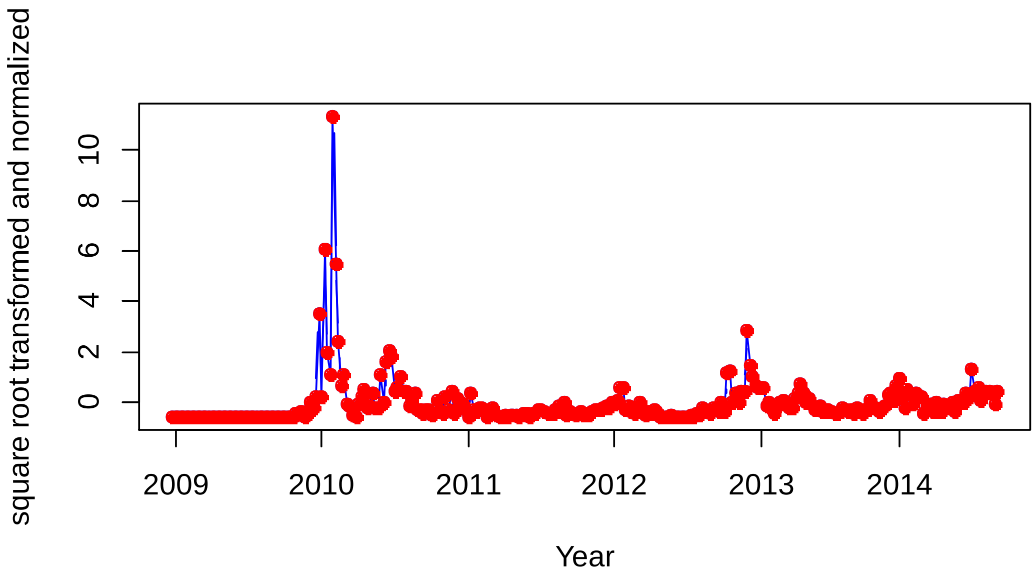

Figure A23: Time series plot of square root transformed and normalized aggregated dengue incidence in Jaffna District, 2009 – September, 2014.

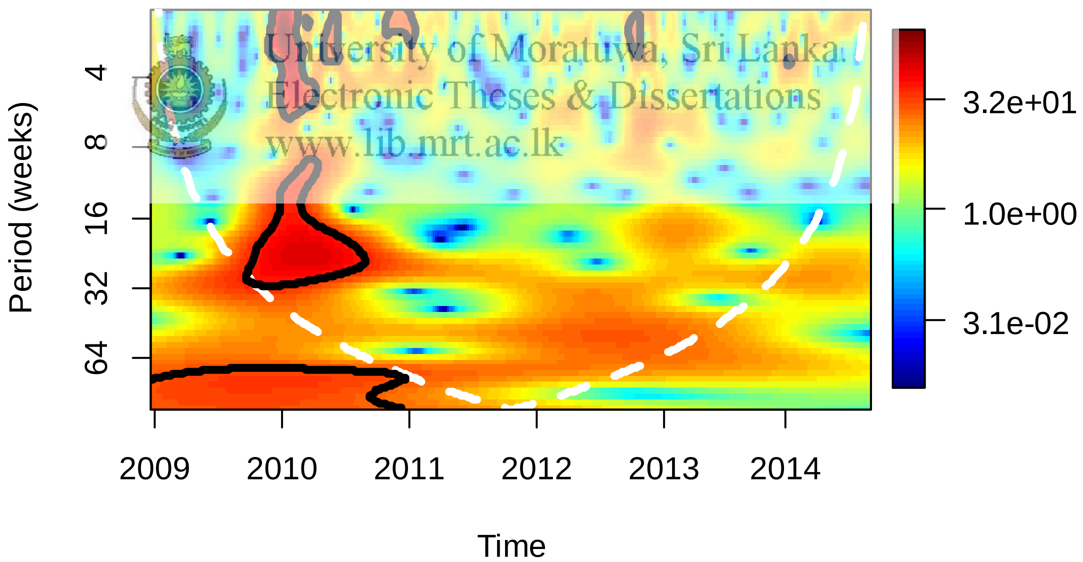

Figure A24: wavelet power spectrum of dengue incidence in Jaffna district from 2009 to September, 2014

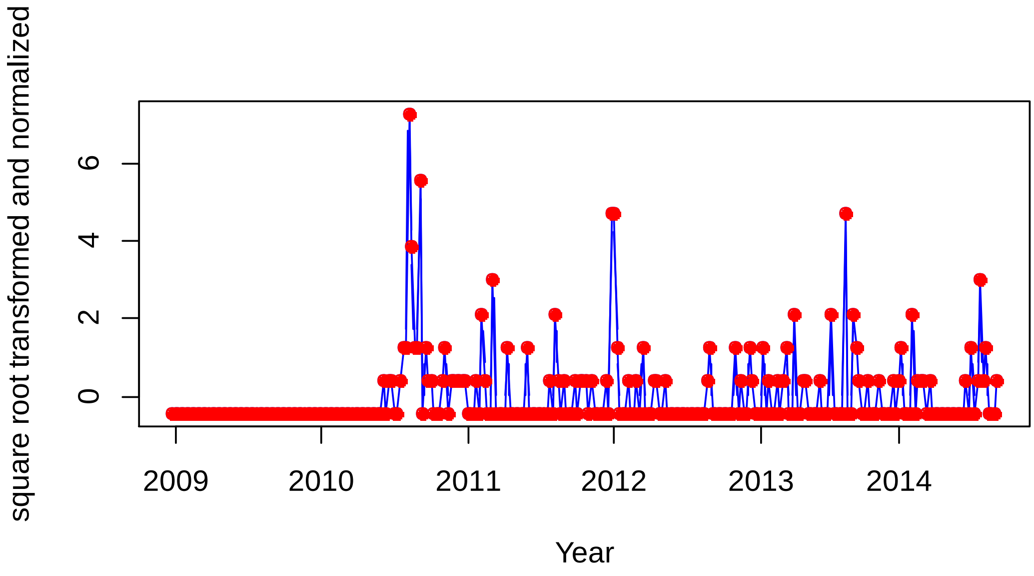

Figure A25: Time series plot of square root transformed and normalized aggregated dengue incidence in Killinochchie District, 2009 – September, 2014.

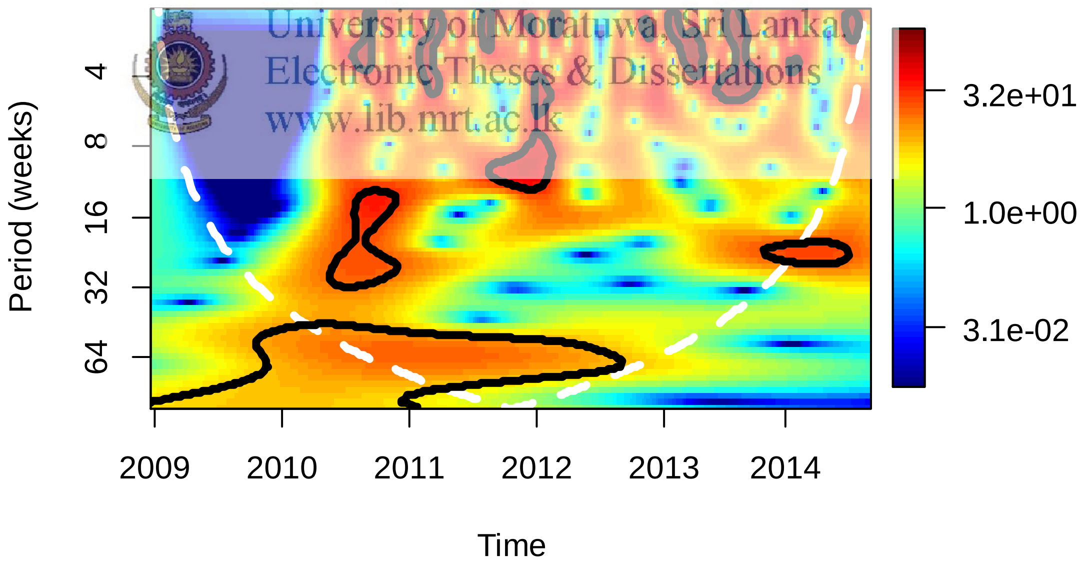

Figure A26: wavelet power spectrum of dengue incidence in Killinochchie district from 2009 to September, 2014

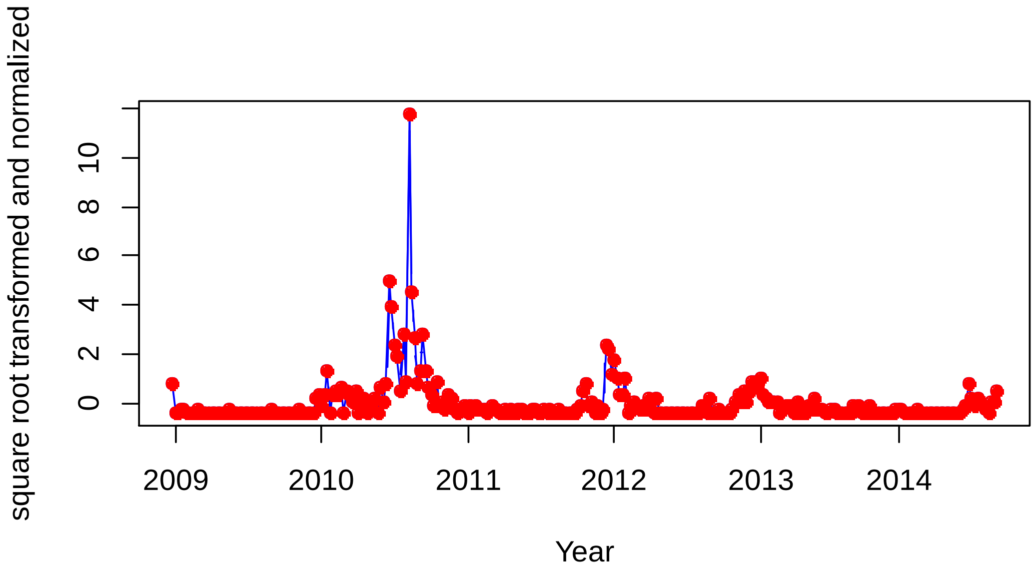

Figure A27: Time series plot of square root transformed and normalized aggregated dengue incidence in Mannar District, 2009 – September, 2014.

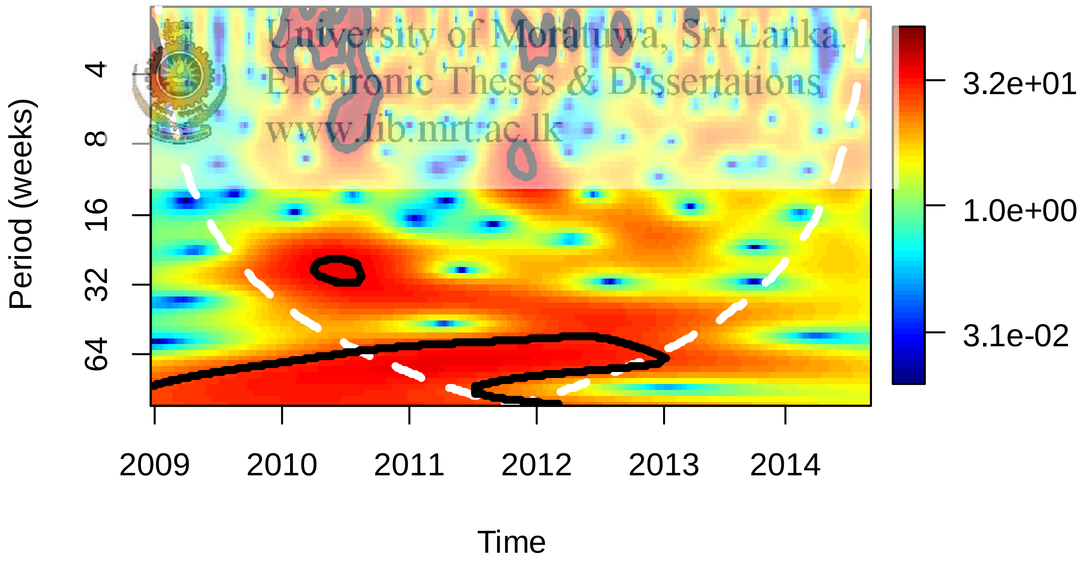

Figure A28: wavelet power spectrum of dengue incidence in Mannar district from 2009 to September, 2014

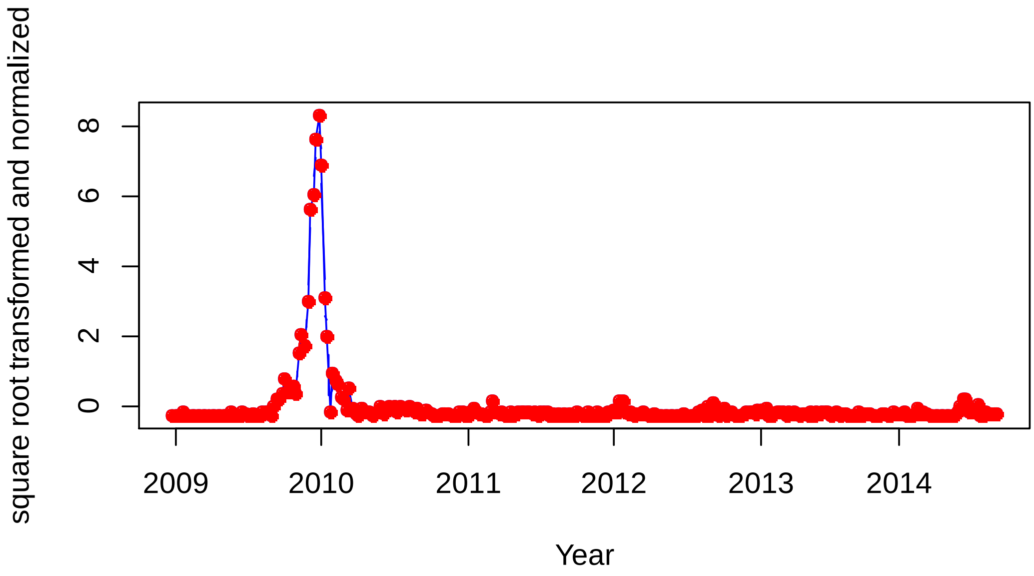

Figure A29: Time series plot of square root transformed and normalized aggregated dengue incidence in Vavuniya District, 2009 – September, 2014.

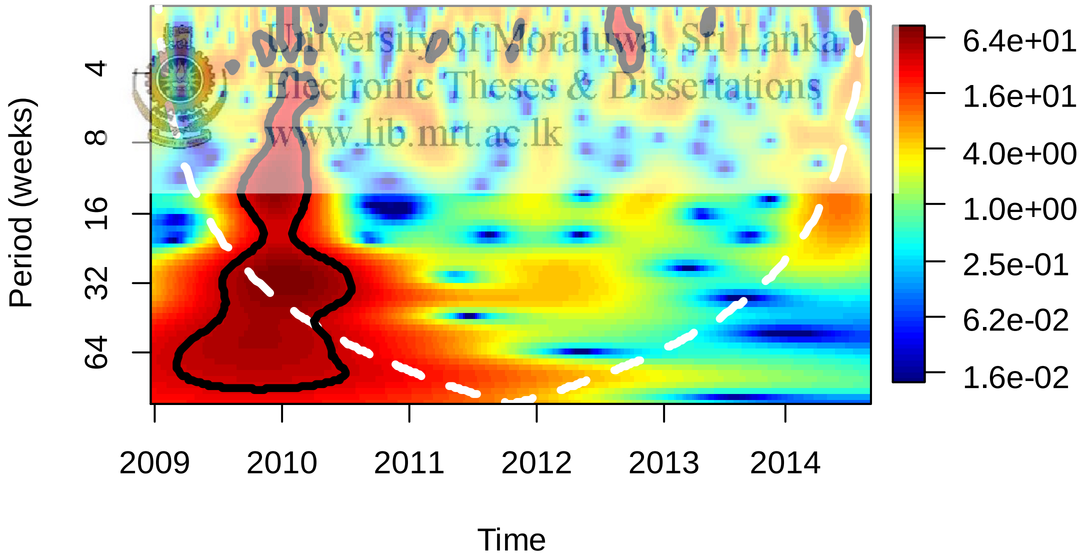

Figure A30: wavelet power spectrum of dengue incidence in Vavuniya district from 2009 to September, 2014

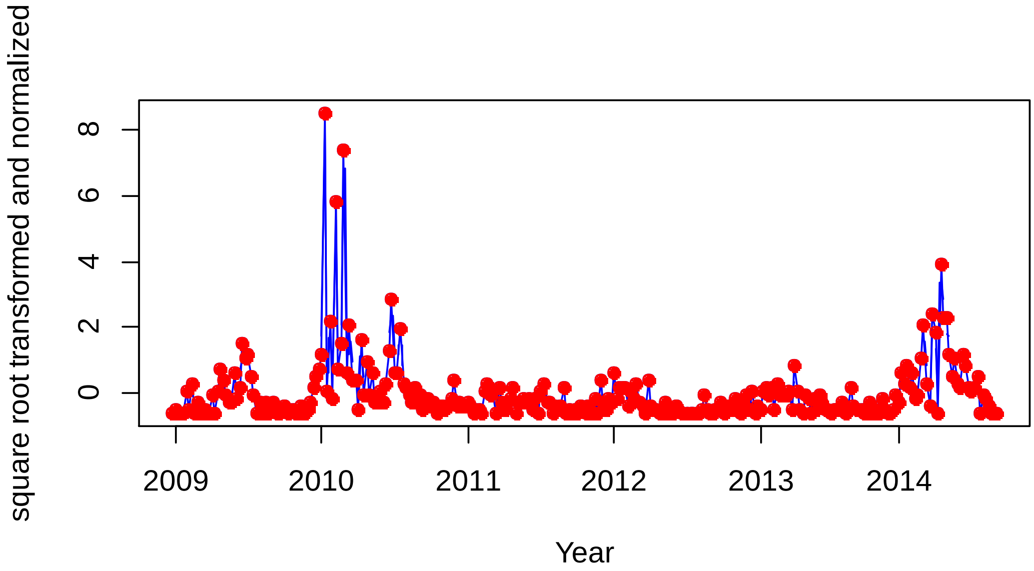

Figure A31: Time series plot of square root transformed and normalized aggregated dengue incidence in Trincomalee District, 2009 – September, 2014.

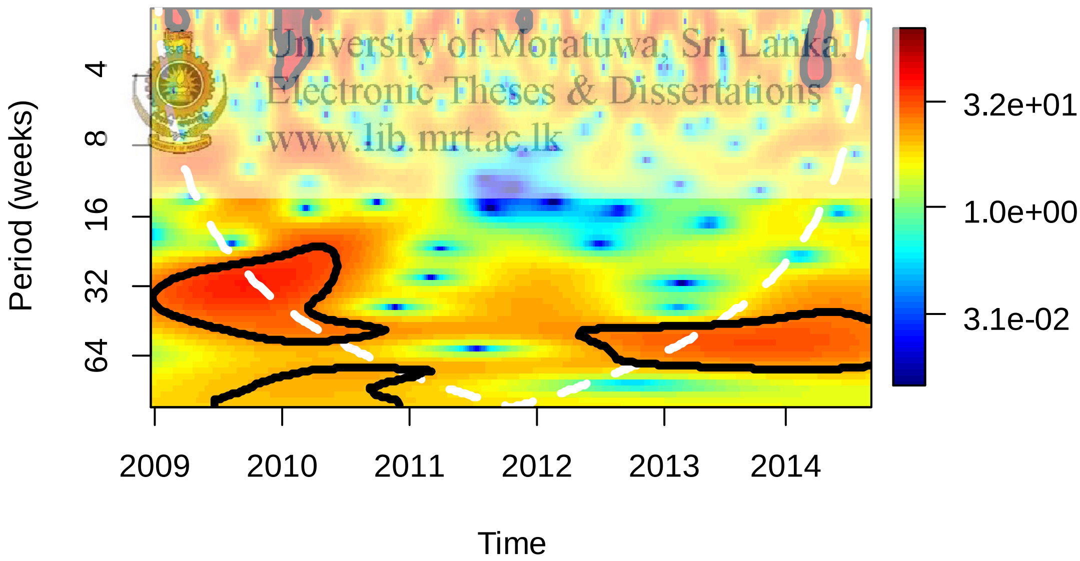

Figure A32: wavelet power spectrum of dengue incidence in Trincomalee district from 2009 to September, 2014

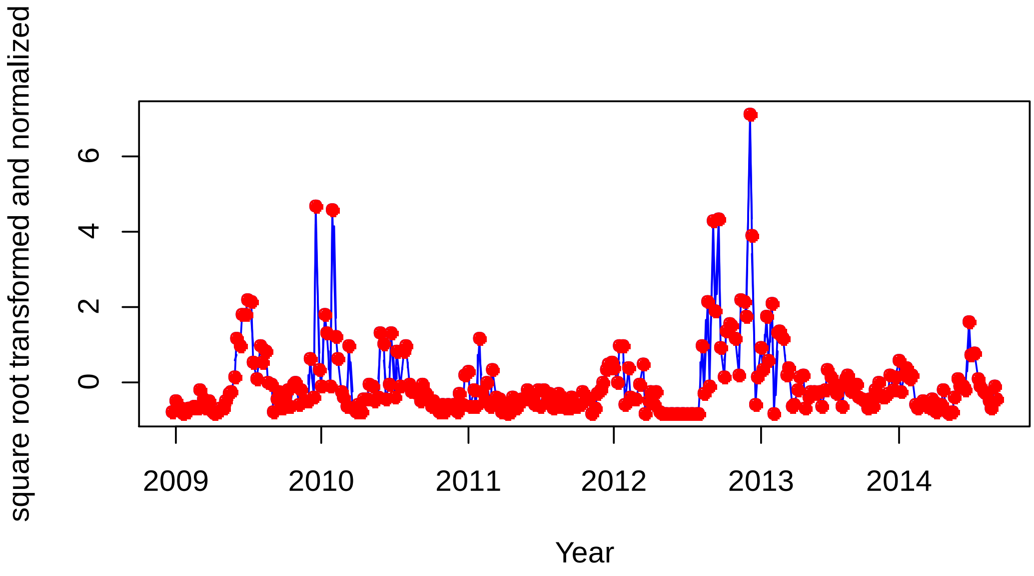

Figure A33: Time series plot of square root transformed and normalized aggregated dengue incidence in Puttalam District, 2009 – September, 2014.

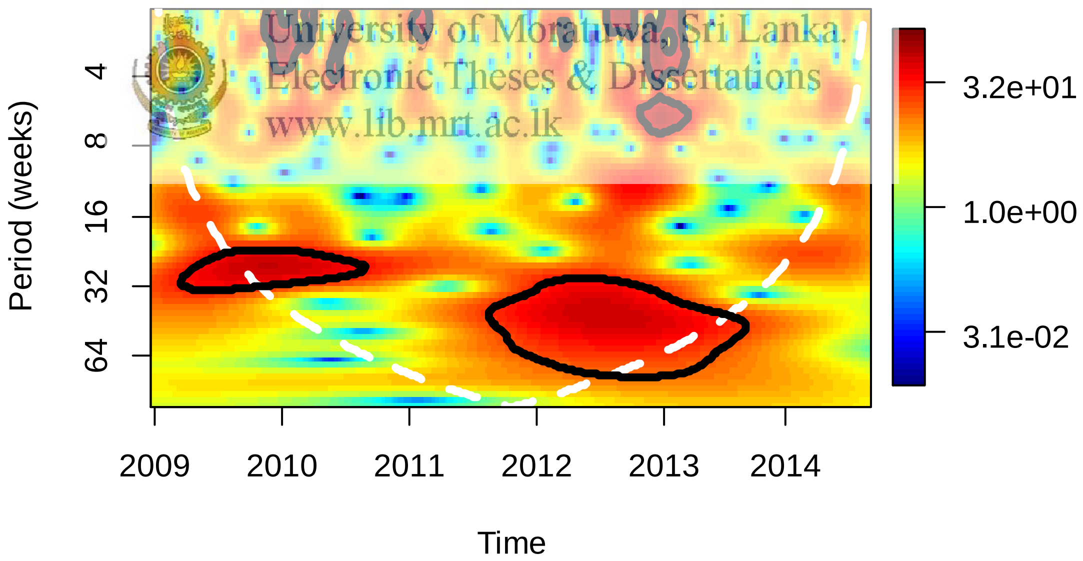

Figure A34: wavelet power spectrum of dengue incidence in Puttalam district from 2009 to September, 2014

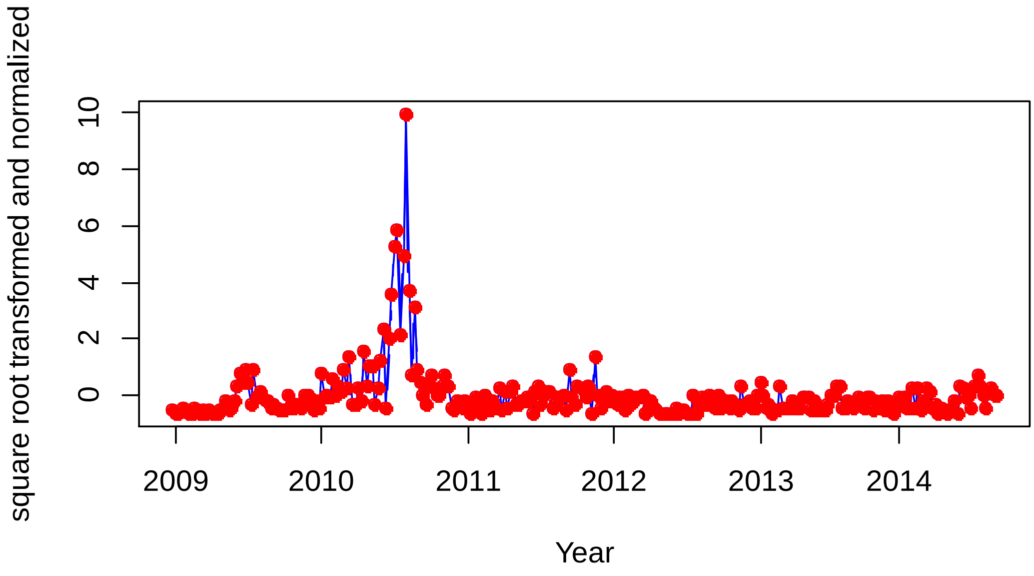

Figure A35: Time series plot of square root transformed and normalized aggregated dengue incidence in Monaragala District, 2009 – September, 2014.

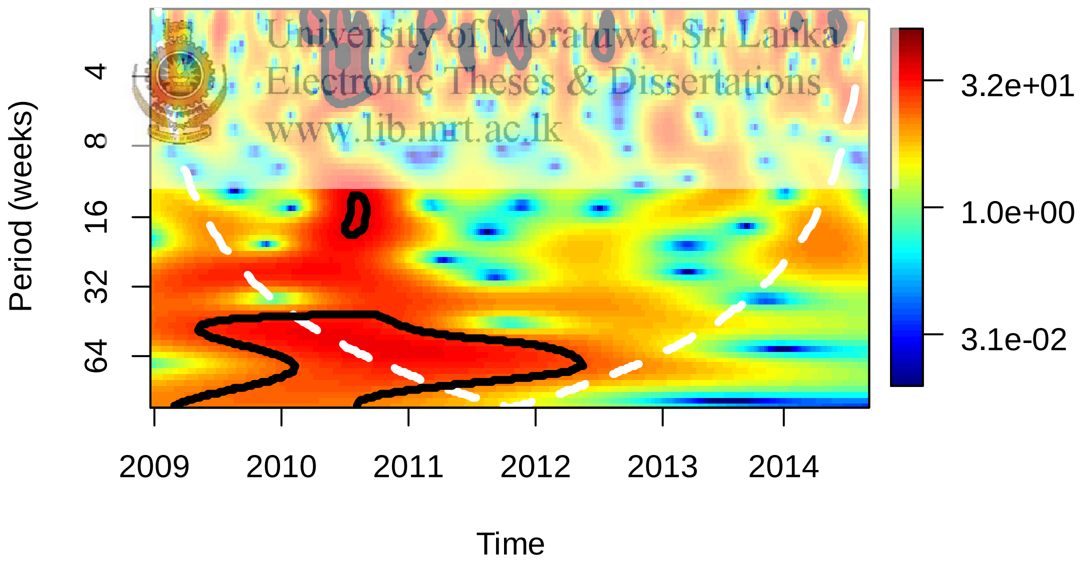

Figure A36: wavelet power spectrum of dengue incidence in Monaragala district from 2009 to September, 2014

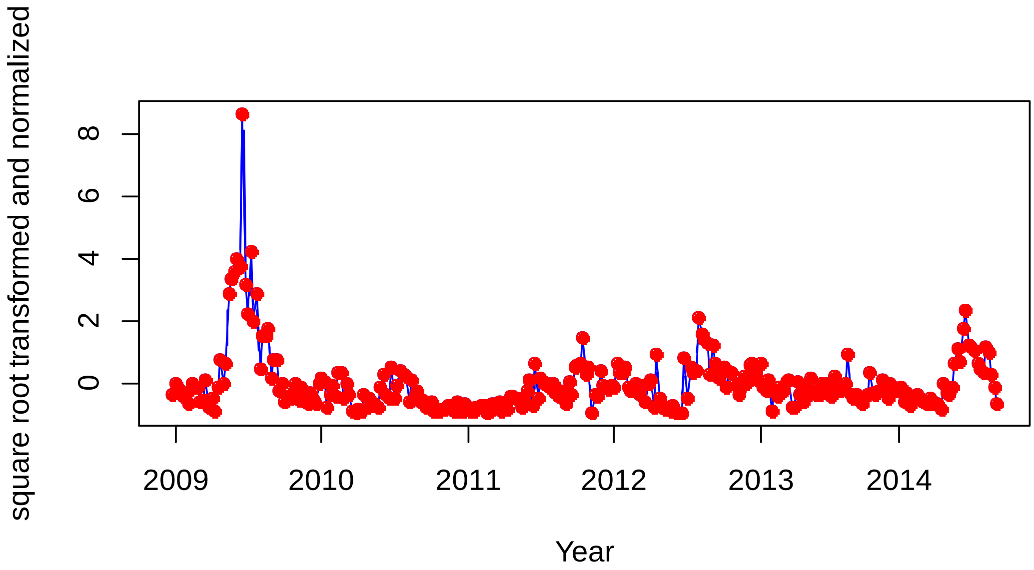

Figure A37: Time series plot of square root transformed and normalized aggregated dengue incidence in Kegalle District, 2009 – September, 2014.

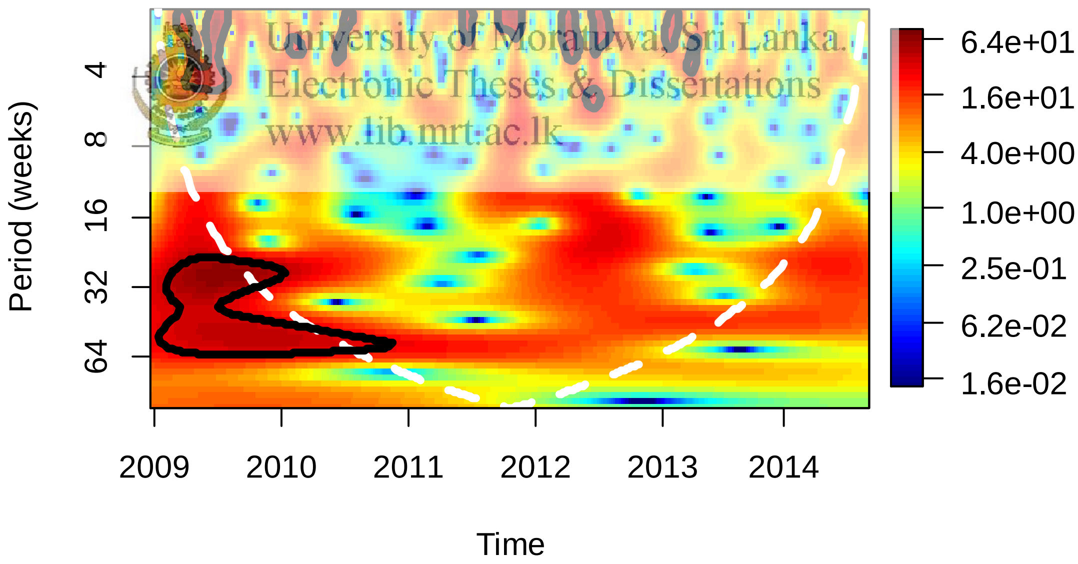

Figure A38: wavelet power spectrum of dengue incidence in Kegalle district from 2009 to September, 2014

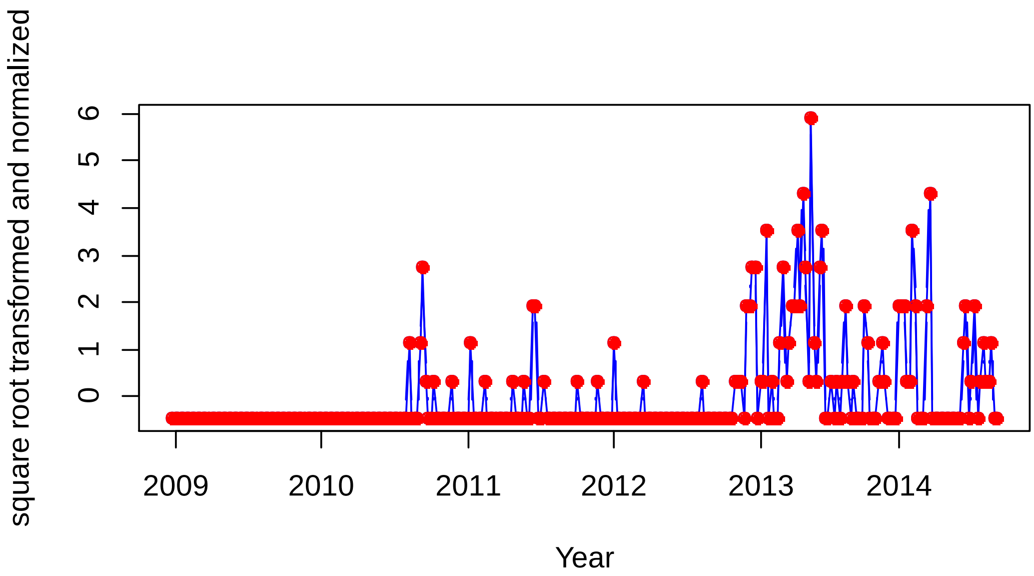

Figure A39: Time series plot of square root transformed and normalized aggregated dengue incidence in Mulative District, 2009 – September, 2014.

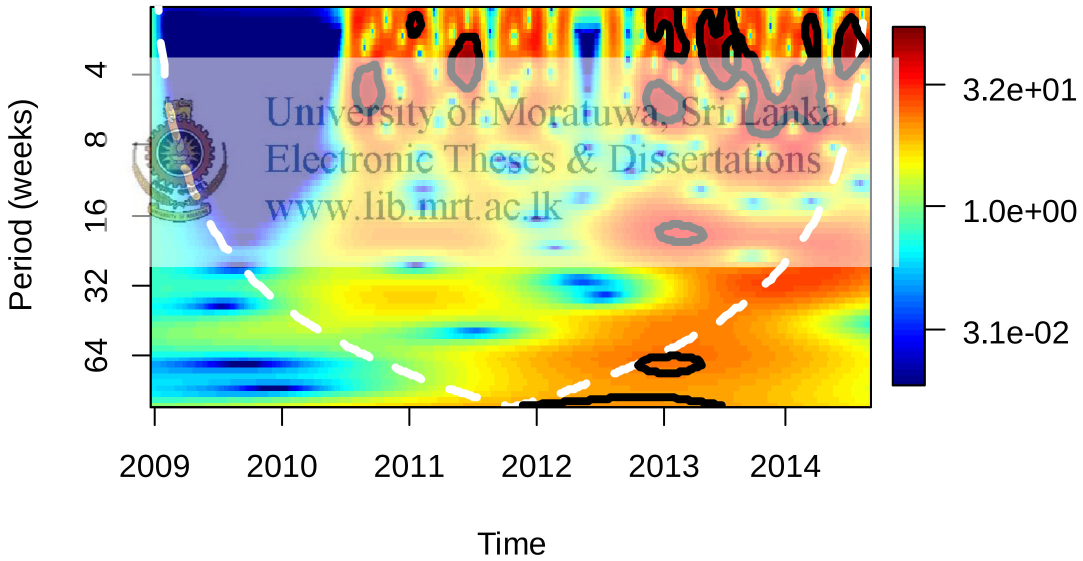

Figure A40: wavelet power spectrum of dengue incidence in Mulative district from 2009 to September, 2014

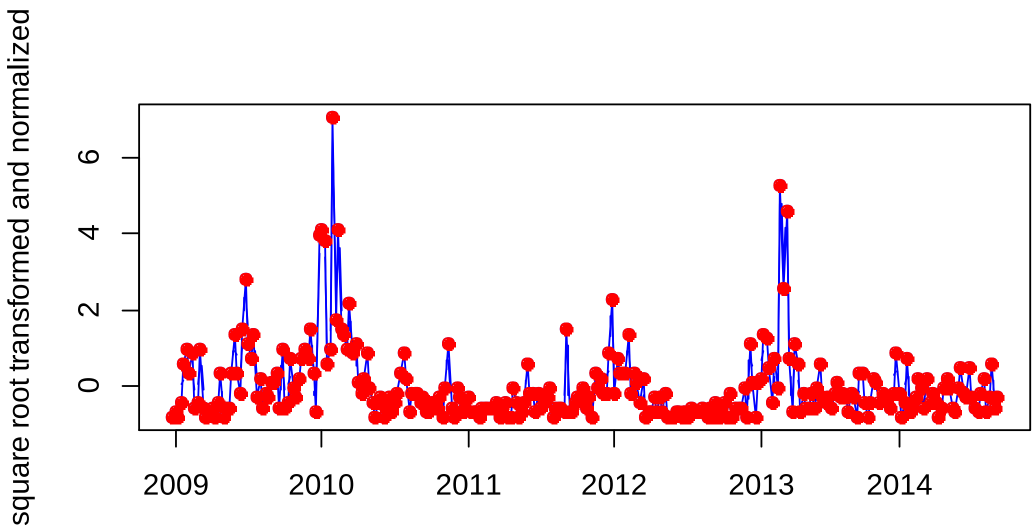

Figure A41: Time series plot of square root transformed and normalized aggregated dengue incidence in Ampara District, 2009 – September, 2014.

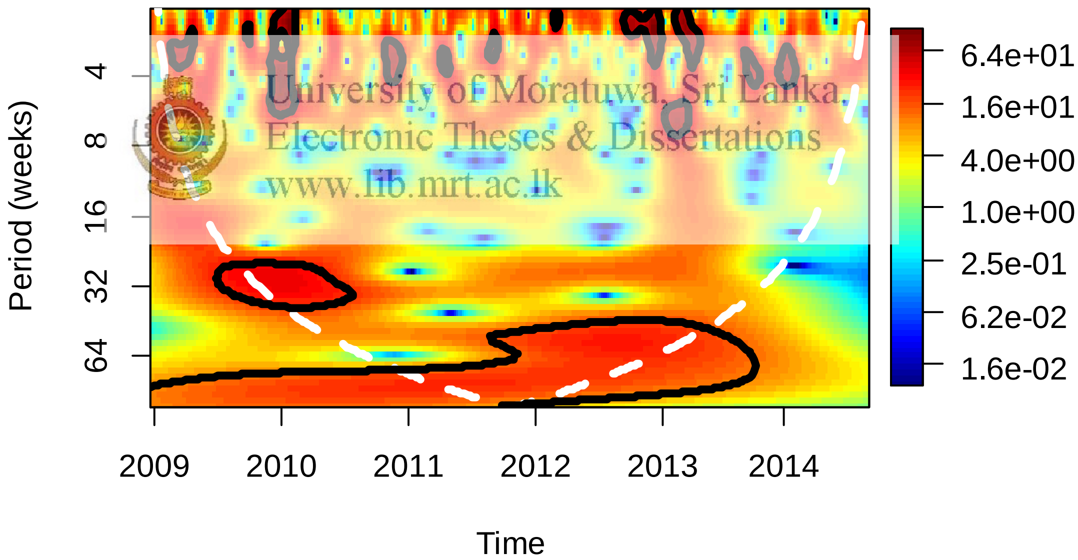

Figure A42: wavelet power spectrum of dengue incidence in Ampara district from 2009 to September, 2014

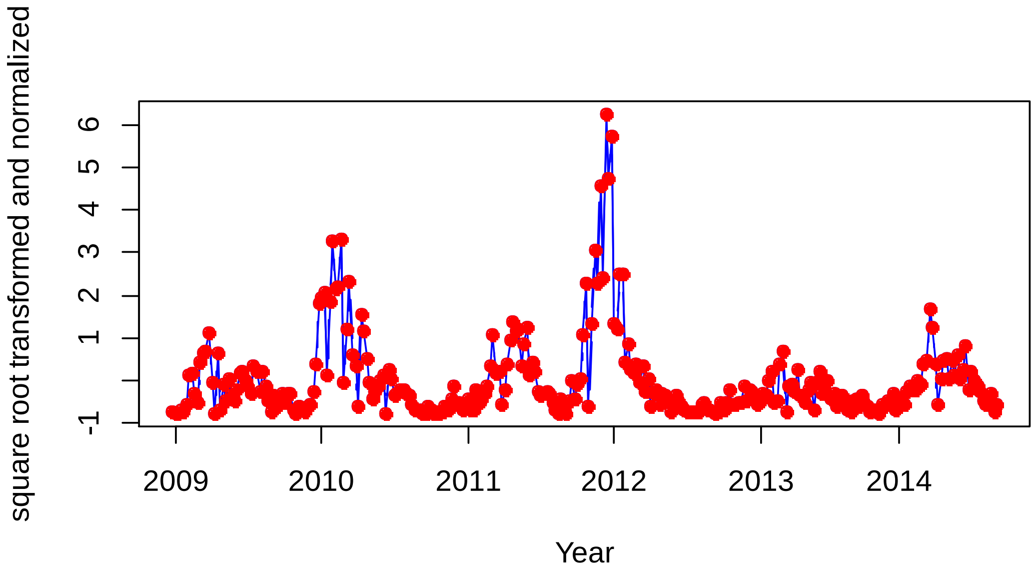

Figure A43: Time series plot of square root transformed and normalized aggregated dengue incidence in Batticalo District, 2009 – September, 2014.

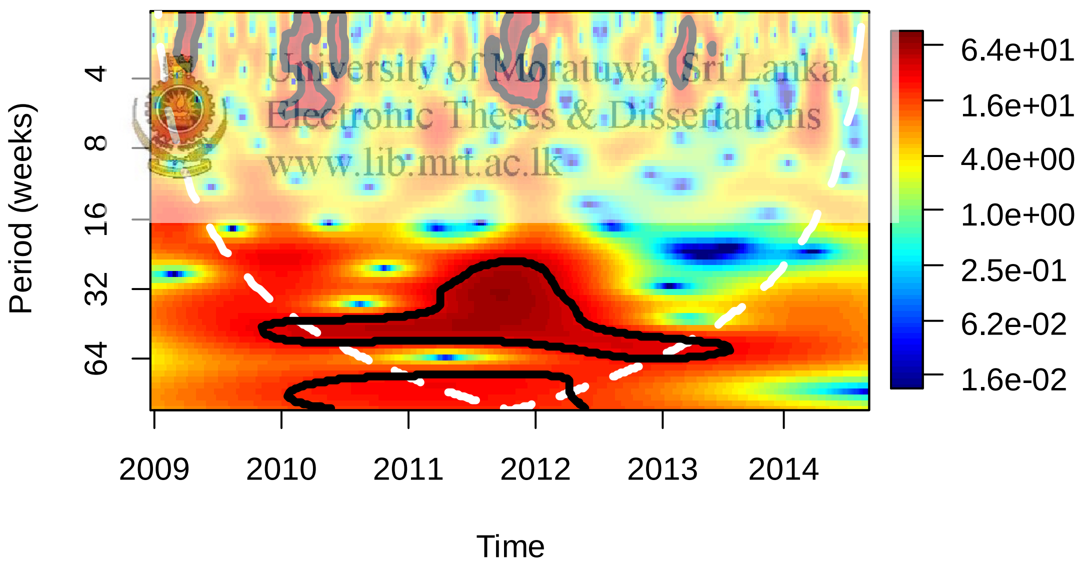

Figure A44: wavelet power spectrum of dengue incidence in Batticalo district from 2009 to September, 2014

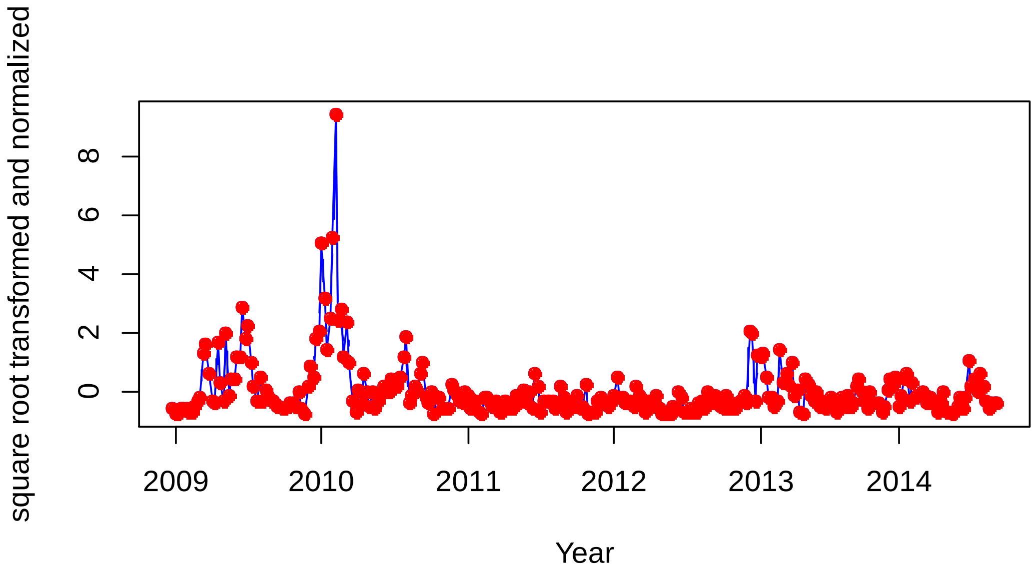

Figure A45: Time series plot of square root transformed and normalized aggregated dengue incidence in Anuradapura District, 2009 – September, 2014.

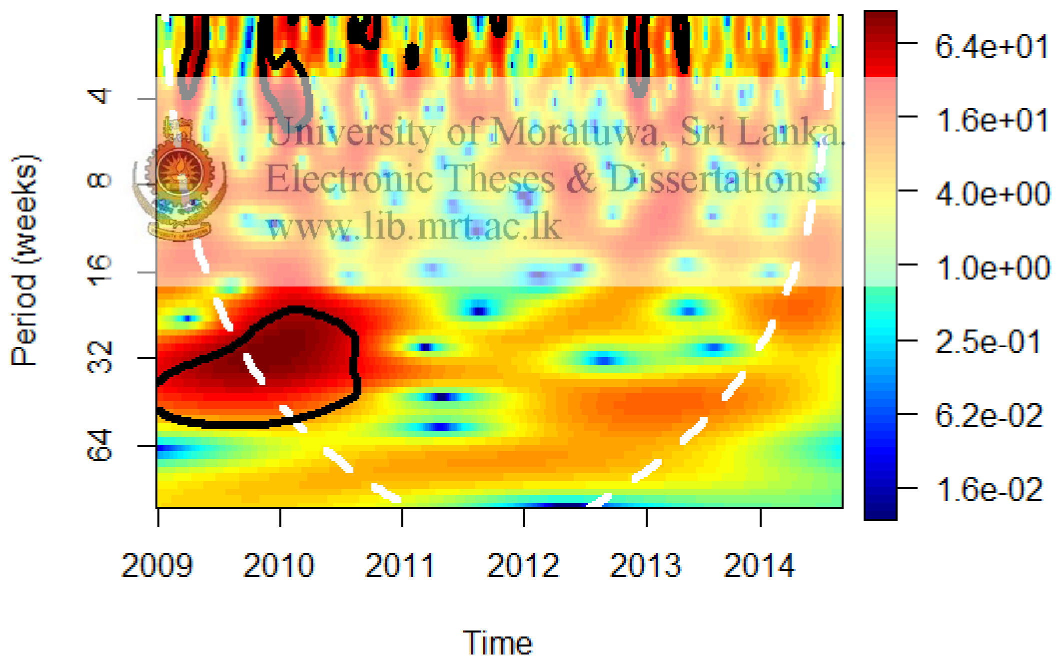

Figure A46: wavelet power spectrum of dengue incidence in Anuradapura district from 2009 to September, 2014

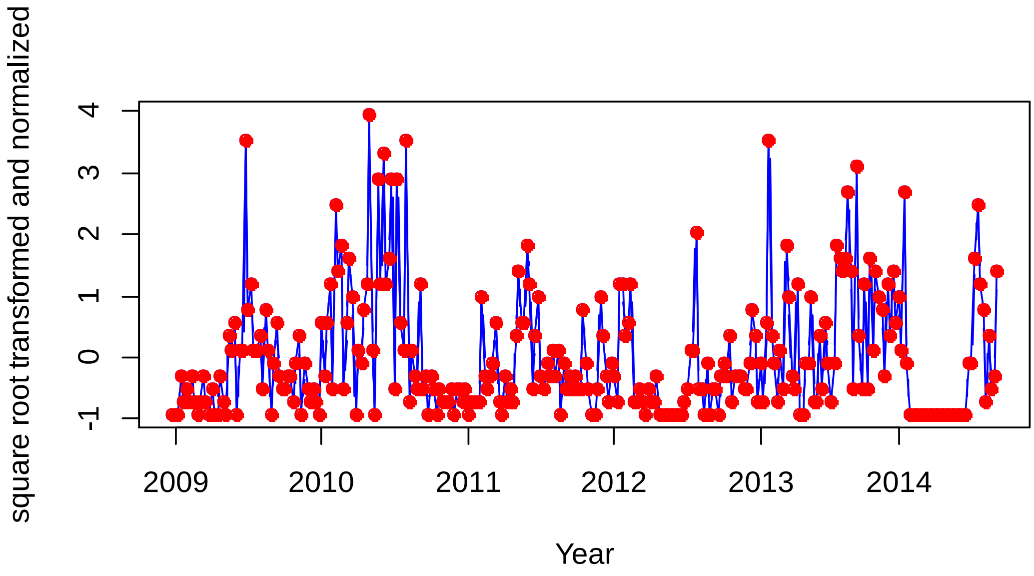

Figure A47: Time series plot of square root transformed and normalized aggregated dengue incidence in Polonnaruwa District, 2009 – September, 2014.

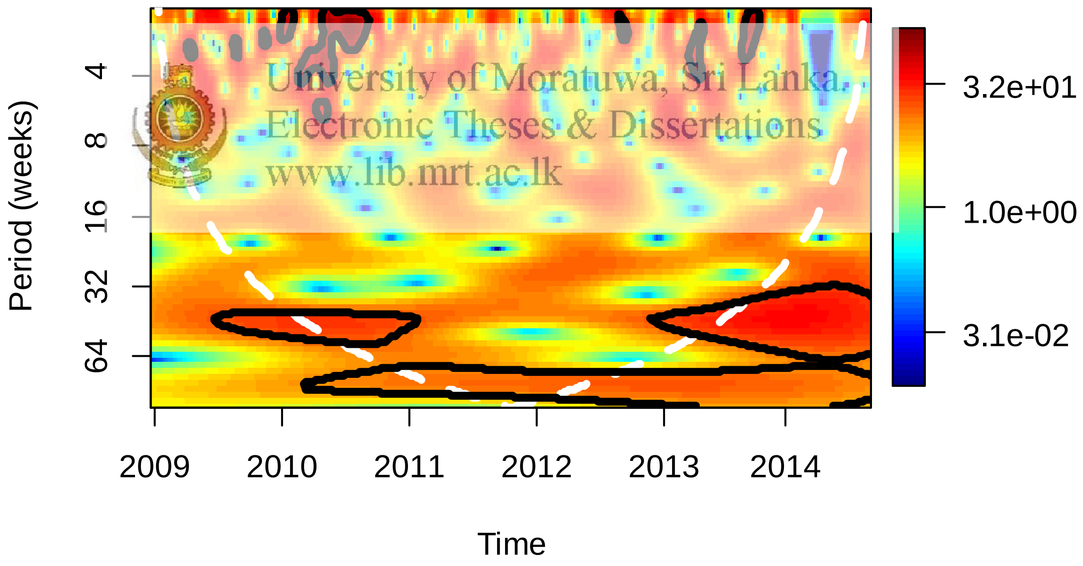

Figure A48: wavelet power spectrum of dengue incidence in Plonnaruwa district from 2009 to September, 2014

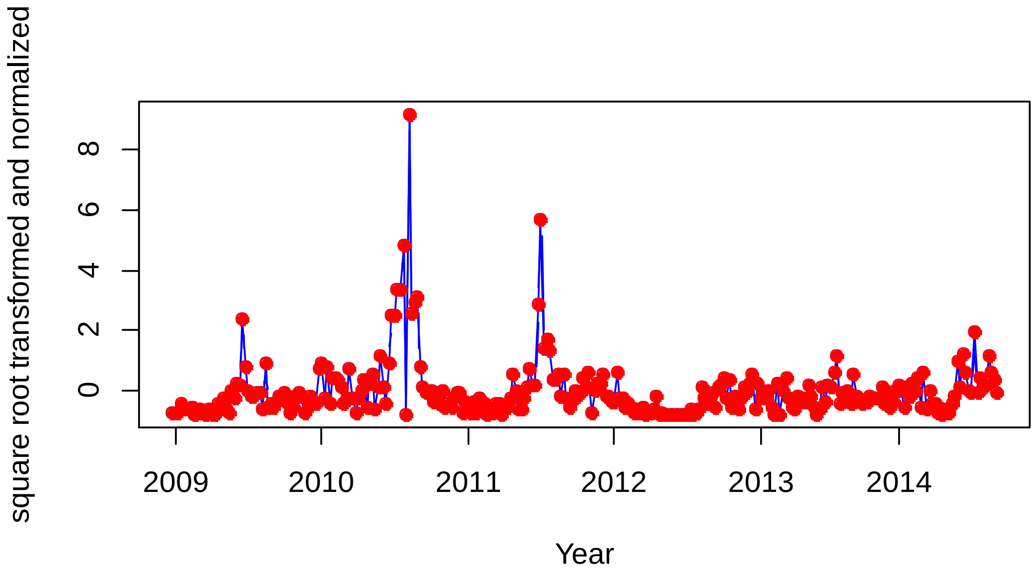

Figure A49: Time series plot of square root transformed and normalized aggregated dengue incidence in Badulla District, 2009 – September, 2014.

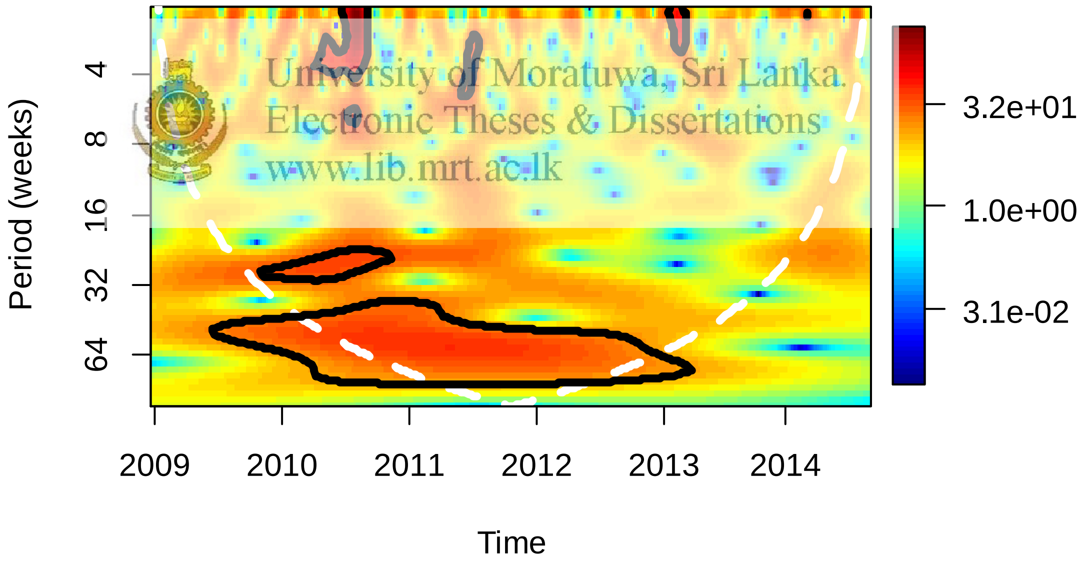

Figure A50: wavelet power spectrum of dengue incidence in Badulla district from 2009 to September, 2014

Appendix B: Wavelet analyses of Climatic Variables

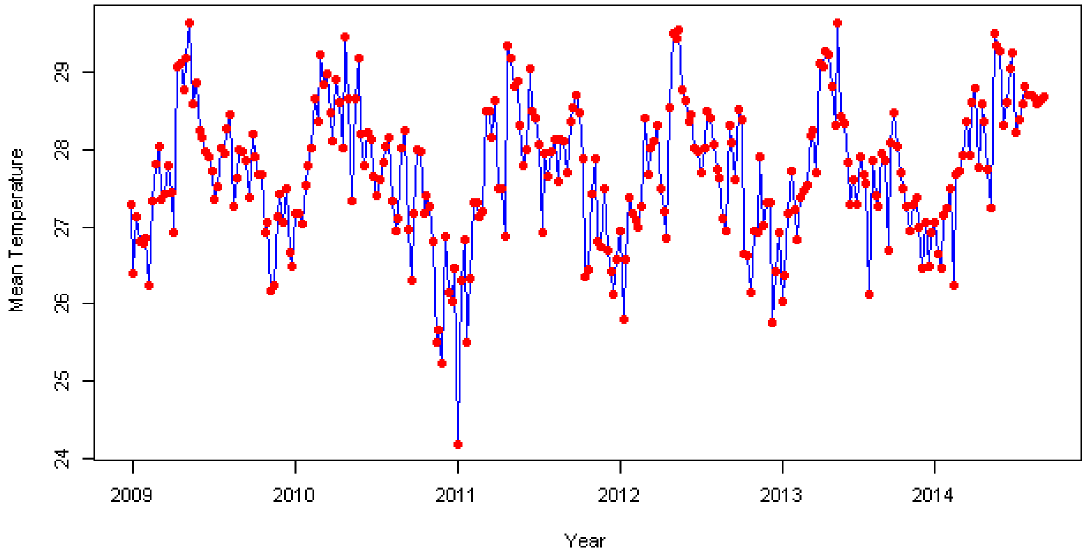

Figure B1: Time series plot of weekly mean temperature (^{0}C) from January 2009 – September 2014

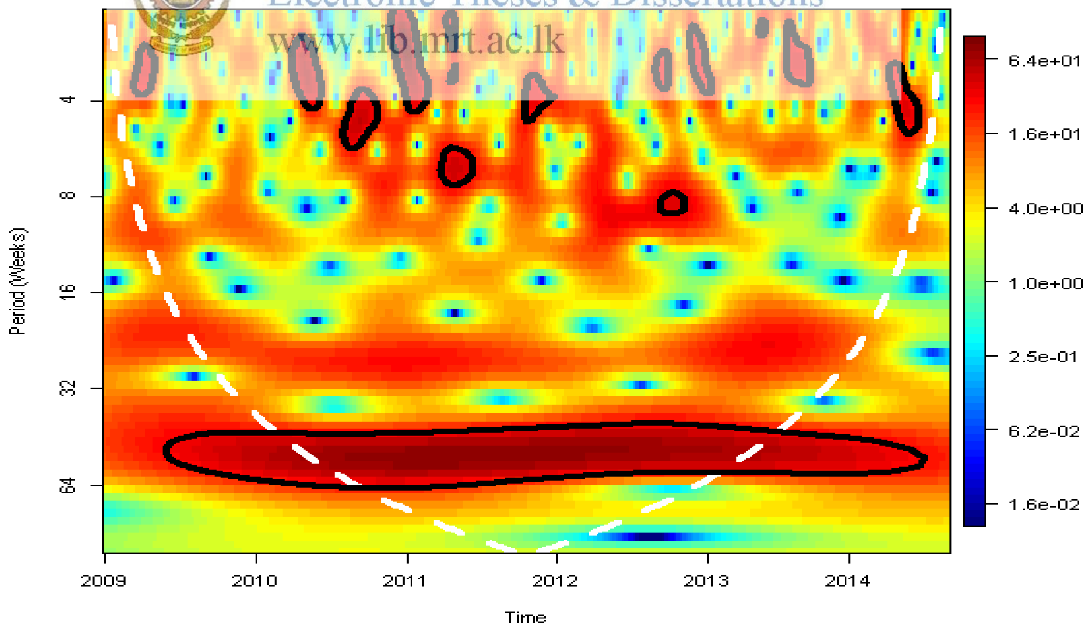

Figure B2: Wavelet power spectrum of mean temperature in Colombo district from 2009 to September, 2014

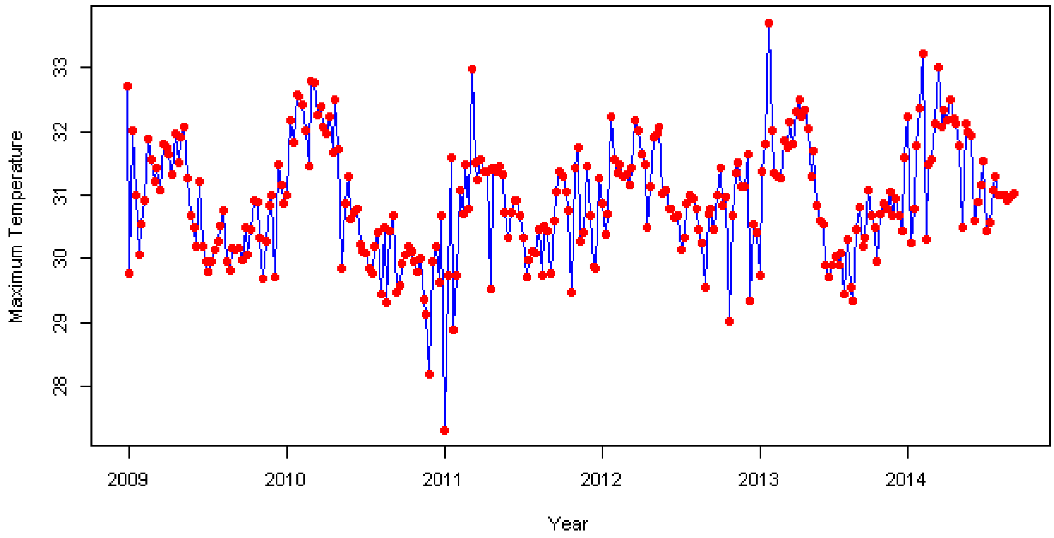

Figure B3: Time series plot of weekly maximum temperature (^{0}C) from January 2009 – September 2014

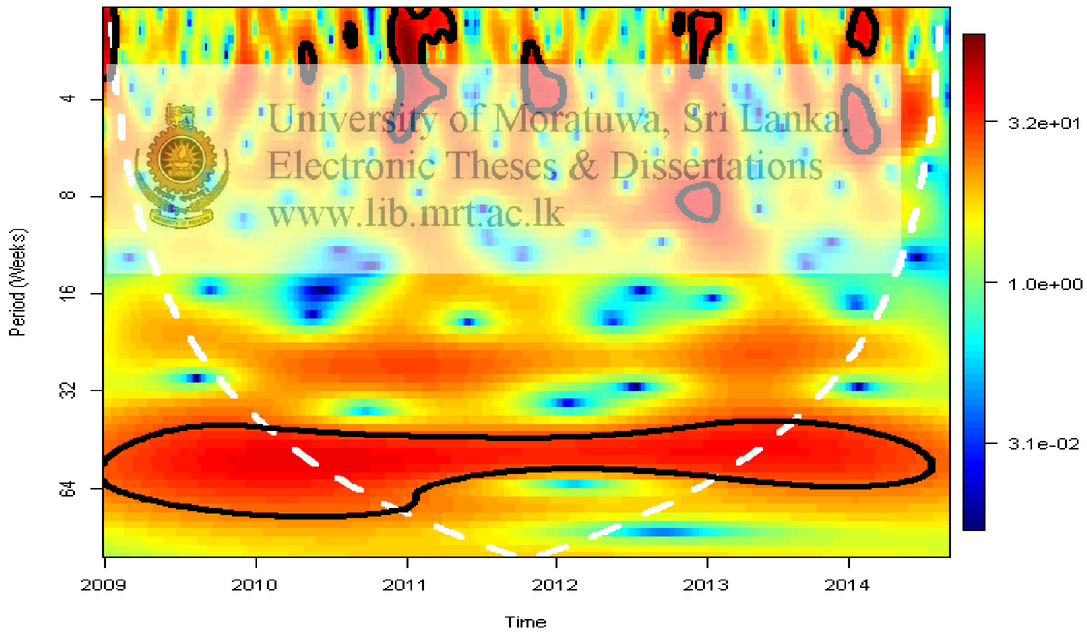

Figure B4: Wavelet power spectrum of maximum temperature in Colombo district from 2009 to September, 2014

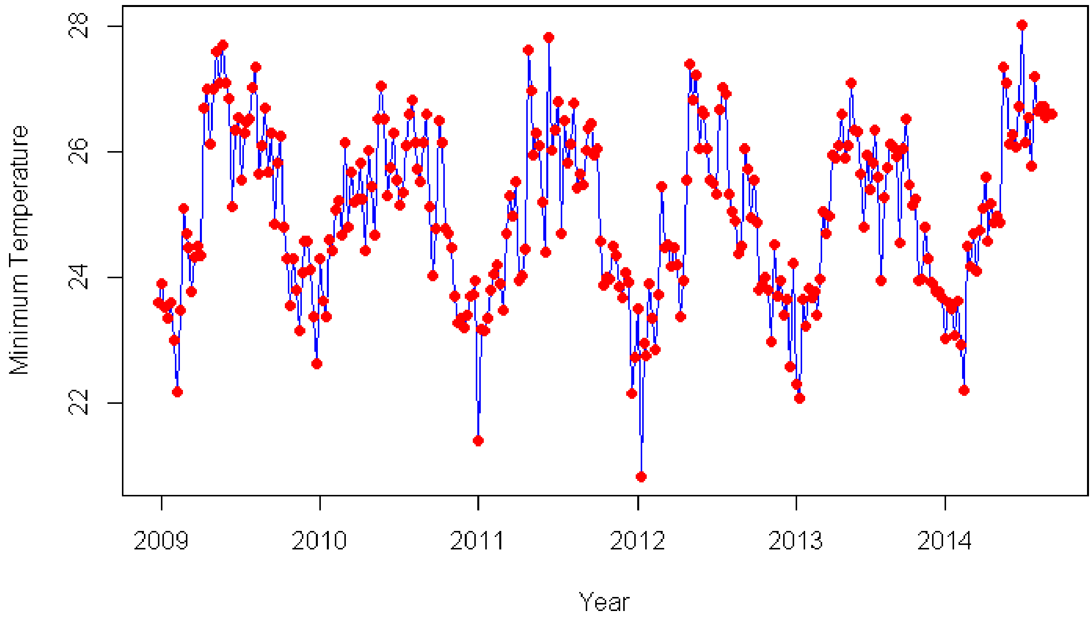

Figure B5: Time series plot of weekly minimum temperature (^{0}C) from January 2009 – September 2014

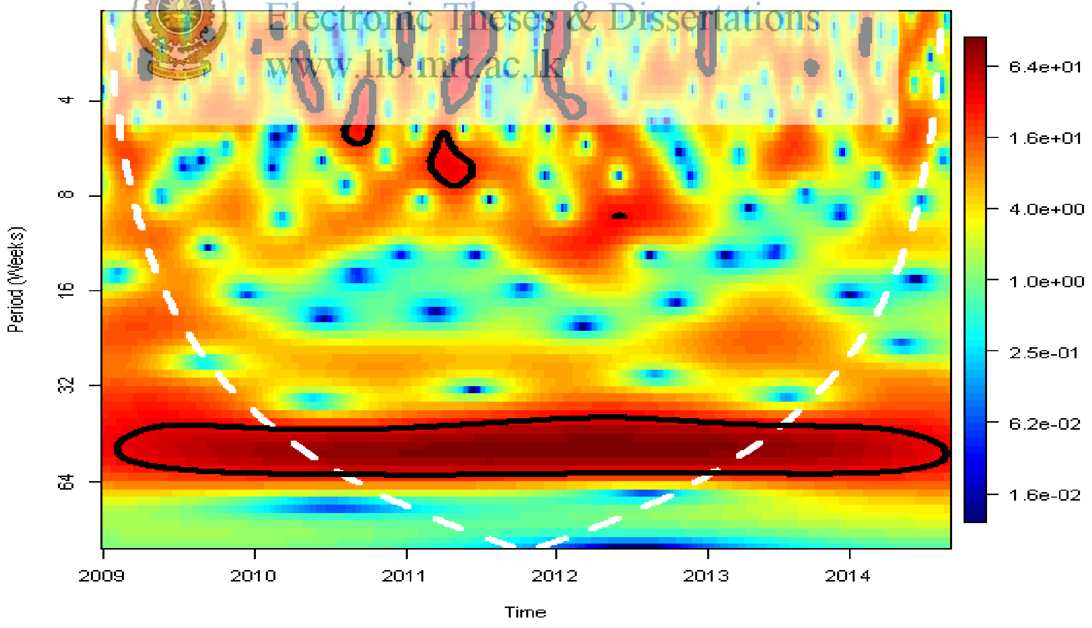

Figure B6: Wavelet power spectrum of minimum temperature in Colombo district from 2009 to September, 2014

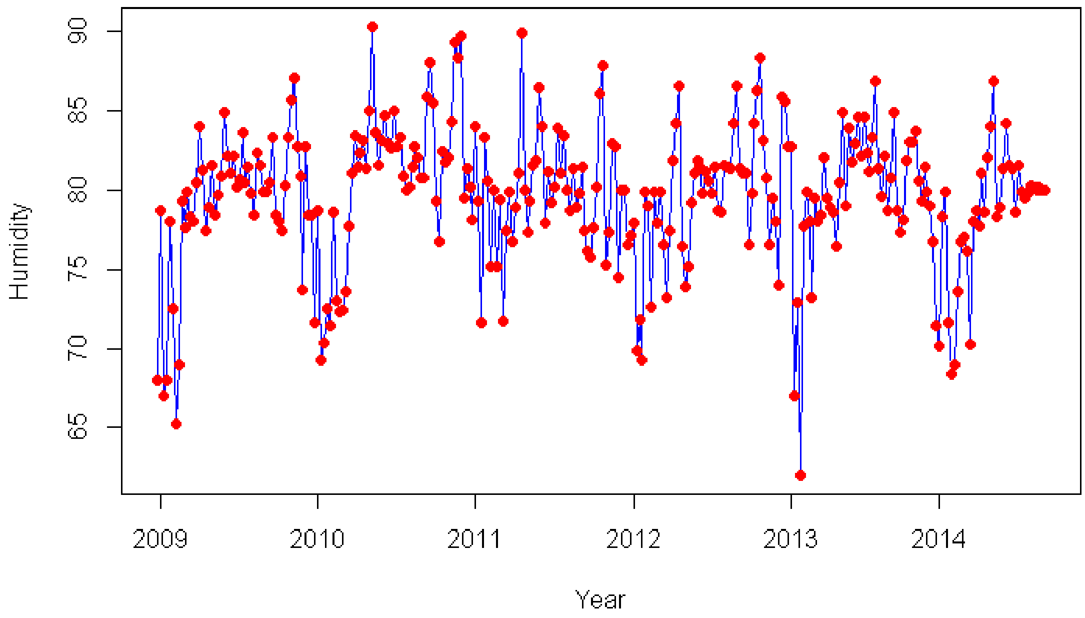

Figure B7: Time series plot of weekly relative humidity (%) from January 2009 – September 2014

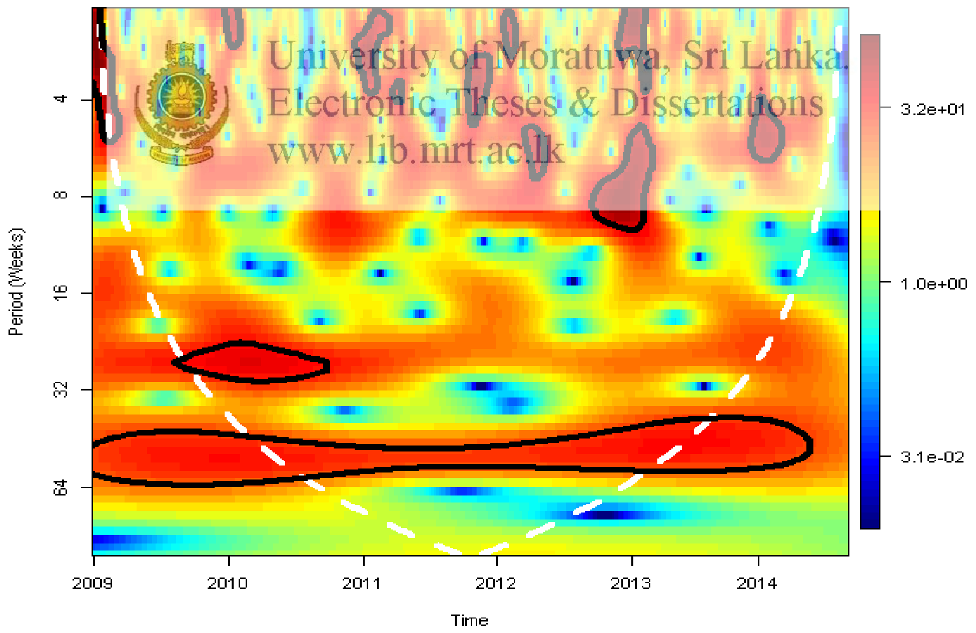

Figure B8: Wavelet power spectrum of humidity in Colombo district from 2009 to September, 2014

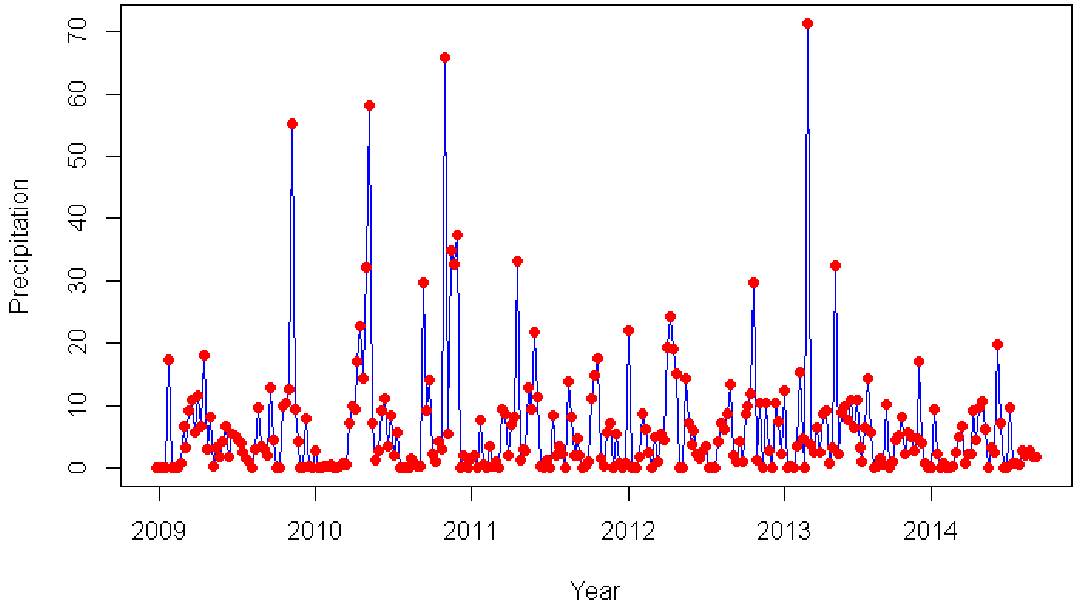

Figure B9: Time series plot of weekly precipitation (mm) from January 2009 – September 2014

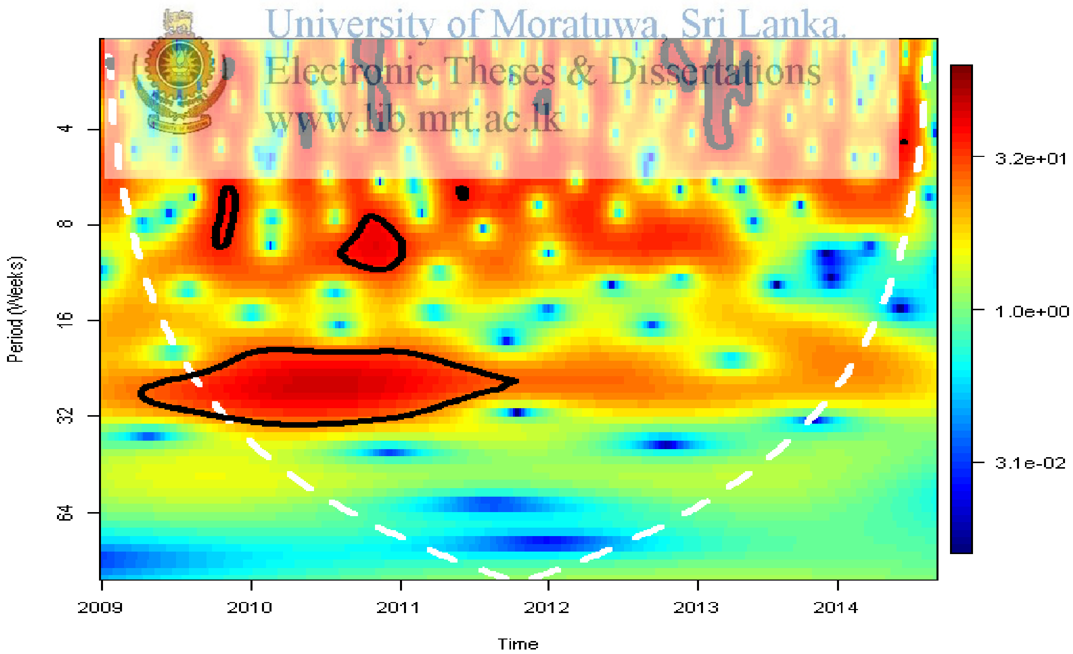

Figure B10: Wavelet power spectrum of precipitation in Colombo district from 2009 to September, 2014

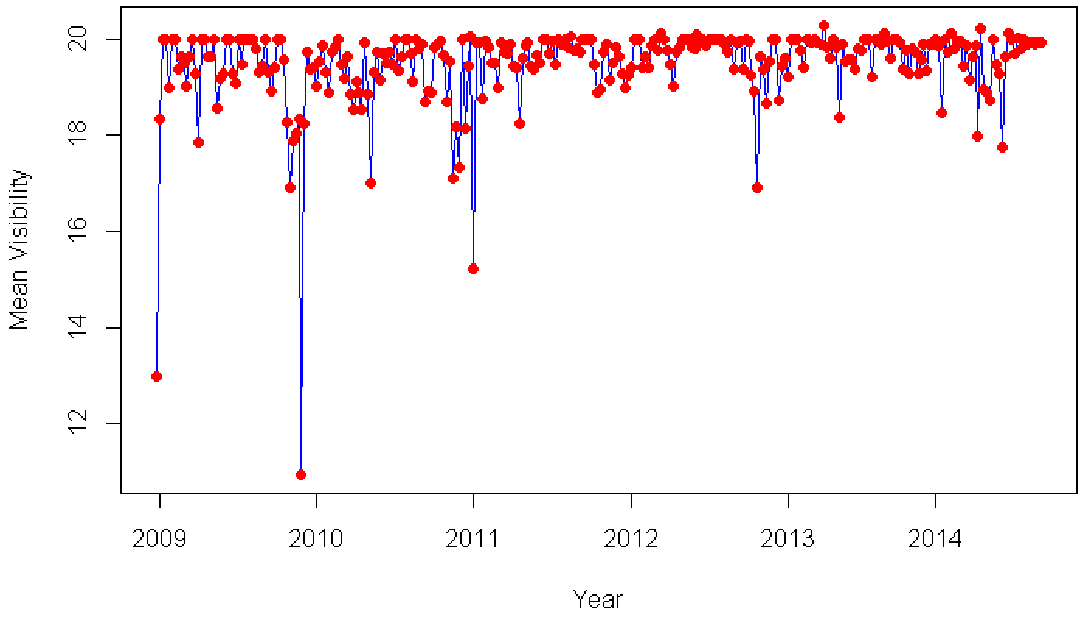

Figure B11: Time series plot of weekly mean visibility (km) from January 2009 – September 2014

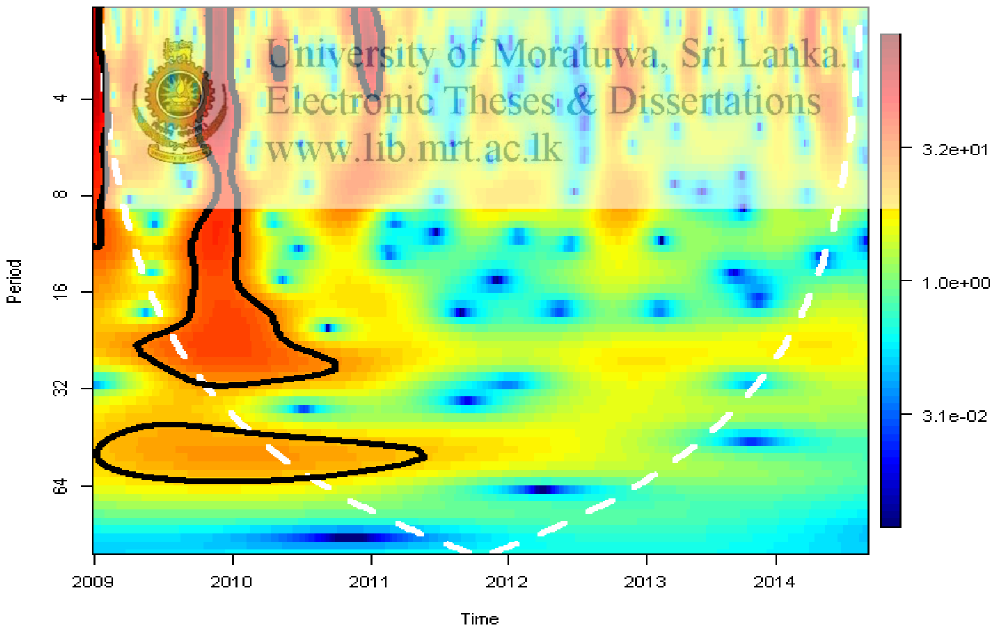

Figure B12: Wavelet power spectrum of mean visibility in Colombo district from 2009 to September, 2014

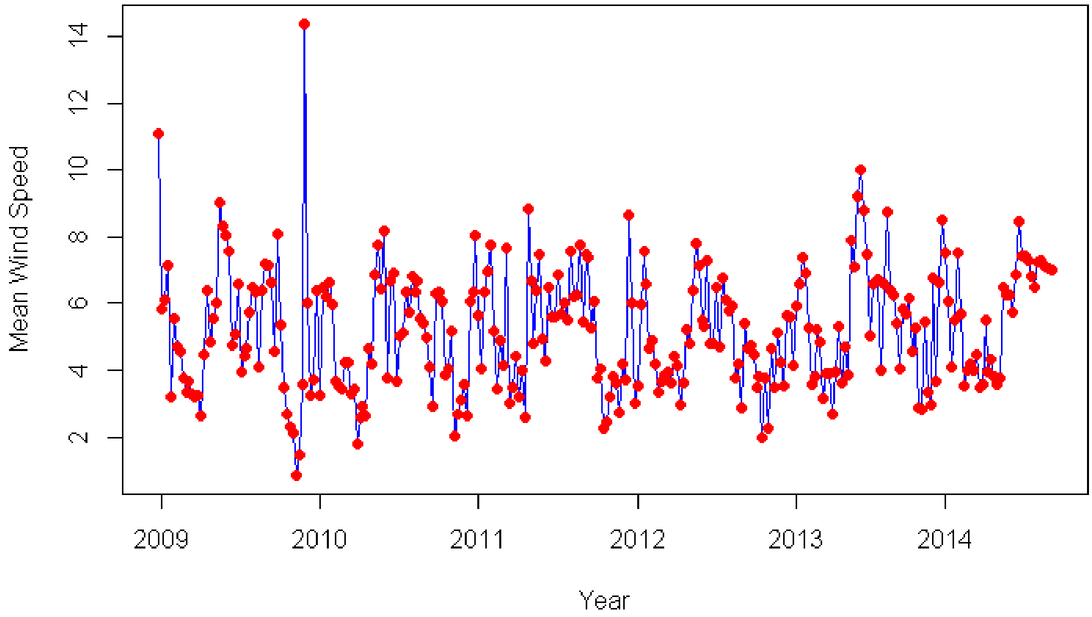

Figure B13: Time series plot of weekly mean wind speed (km/h) from January 2009 – September 2014

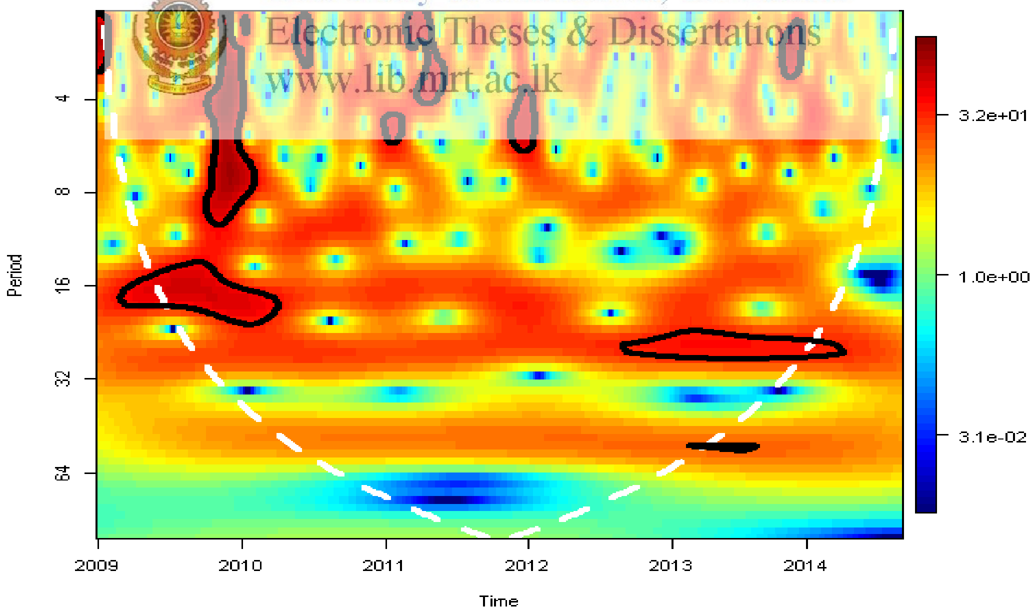

Figure B14: Wavelet power spectrum of mean wind speed in Colombo district from 2009 to September, 2014

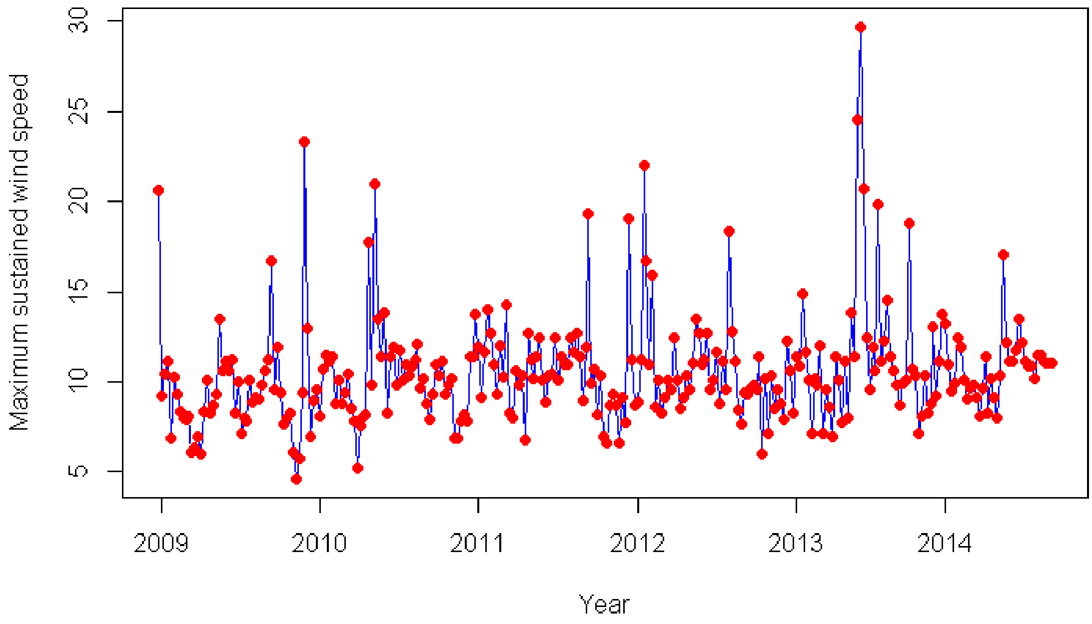

Figure B15: Time series plot of weekly maximum sustained wind speed (km/h) from January 2009 – September 2014

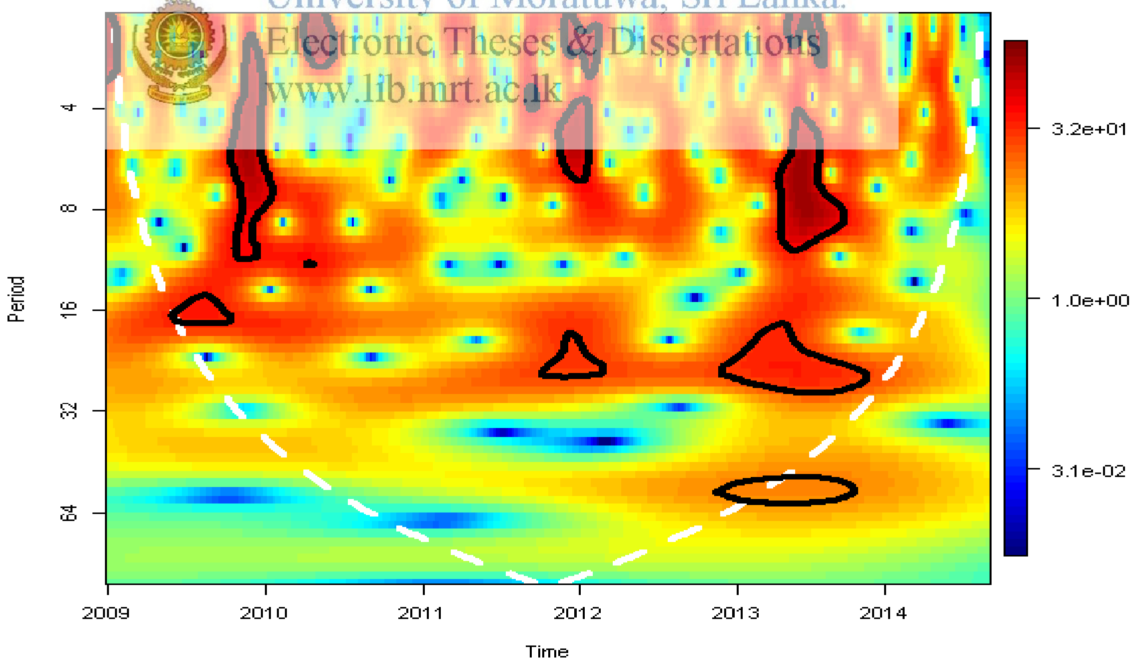

Figure B16: Wavelet power spectrum of maximum sustained wind speed (km/ h) in Colombo district from 2009 to September, 2014

Appendix C: Results of DLNM

Call:

```
glm(formula = Cases ~ cb.TEM + cb.TMAX + cb.PP + cb.H4 + cb.VM
+ cb.VV + as.factor(Year) + as.factor(Week), family =
quasipoisson())
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-12.9271	-1.8347	-0.2185	1.9783	8.4264

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	2.575496	2.454822	1.049	0.2959
cb.TEMv1.l1	0.161887	1.021405	0.158	0.8743
cb.TEMv1.l2	-0.808253	1.337494	-0.604	0.5466
cb.TEMv1.l3	1.318652	1.326758	0.994	0.3220
cb.TEMv1.l4	0.717818	1.106650	0.649	0.5176
cb.TEMv1.l5	0.071412	0.746380	0.096	0.9239
cb.TMAXv1.l1	-0.731850	0.986271	-0.742	0.4593
cb.TMAXv1.l2	1.303715	1.944450	0.670	0.5037
cb.TMAXv1.l3	-2.274978	1.438795	-1.581	0.1161
cb.TMAXv1.l4	-0.514038	0.953365	-0.539	0.5906
cb.TMAXv1.l5	-0.318340	0.698409	-0.456	0.6492
cb.PPv1.l1	-0.041687	0.134587	-0.310	0.7572
cb.PPv2.l1	0.576822	0.473007	1.219	0.2247
cb.PPv3.l1	-0.521393	1.222512	-0.426	0.6704
cb.PPv4.l1	-1.490459	1.849657	-0.806	0.4217
cb.PPv5.l1	0.283484	0.596299	0.475	0.6352
cb.PPv1.l2	1.560629	1.495528	1.044	0.2985
cb.PPv2.l2	0.819295	6.726087	0.122	0.9032
cb.PPv3.l2	-0.900930	15.944428	-0.057	0.9550

cb.PPv4.l2	8.612236	20.806189	0.414	0.6796	
cb.PPv5.l2	10.366726	6.301800	1.645	0.1022	
cb.PPv1.l3	-2.927583	3.337170	-0.877	0.3818	
cb.PPv2.l3	-1.226584	15.875310	-0.077	0.9385	
cb.PPv3.l3	1.146546	38.276038	0.030	0.9761	
cb.PPv4.l3	1.181488	51.652315	0.023	0.9818	
cb.PPv5.l3	-33.969521	17.556674	-1.935	0.0550	.
cb.PPv1.l4	1.304292	2.122377	0.615	0.5399	
cb.PPv2.l4	-0.454676	10.018507	-0.045	0.9639	
cb.PPv3.l4	0.899360	24.426967	0.037	0.9707	
cb.PPv4.l4	-7.648432	34.500371	-0.222	0.8249	
cb.PPv5.l4	23.198909	12.206558	1.901	0.0594	.
cb.H4v1.l1	-0.087631	0.988158	-0.089	0.9295	
cb.H4v2.l1	-0.405079	0.562179	-0.721	0.4724	
cb.H4v1.l2	-0.537331	1.273626	-0.422	0.6738	
cb.H4v2.l2	-0.920131	0.558005	-1.649	0.1014	
cb.H4v1.l3	3.137602	1.557569	2.014	0.0459	*
cb.H4v2.l3	0.531748	0.719368	0.739	0.4610	
cb.H4v1.l4	-3.336076	1.448590	-2.303	0.0228	*
cb.H4v2.l4	-2.058437	1.065131	-1.933	0.0553	.
cb.H4v1.l5	-0.200602	1.317641	-0.152	0.8792	
cb.H4v2.l5	-0.707887	0.693928	-1.020	0.3094	
cb.H4v1.l6	0.701396	0.883439	0.794	0.4286	
cb.H4v2.l6	-0.142374	0.455941	-0.312	0.7553	
cb.VMv1.l1	-0.596839	0.598257	-0.998	0.3202	
cb.VMv2.l1	0.216810	0.528602	0.410	0.6823	
cb.VMv1.l2	0.079761	0.669837	0.119	0.9054	
cb.VMv2.l2	0.583206	0.635194	0.918	0.3601	
cb.VMv1.l3	0.233236	1.110923	0.210	0.8340	

cb.VMv2.l3	0.811982	0.858955	0.945	0.3461	
cb.VMv1.l4	0.009704	0.964934	0.010	0.9920	
cb.VMv2.l4	-1.035043	0.614454	-1.684	0.0943	.
cb.VMv1.l5	0.581911	0.722671	0.805	0.4221	
cb.VMv2.l5	1.177928	0.565911	2.081	0.0392	*
cb.VMv1.l6	0.492381	0.636870	0.773	0.4408	
cb.VMv2.l6	-0.602758	0.465919	-1.294	0.1979	
cb.VVv1.l1	3.050401	2.194891	1.390	0.1668	
cb.VVv2.l1	0.223482	0.523647	0.427	0.6702	
cb.VVv1.l2	1.749661	2.526520	0.693	0.4898	
cb.VVv2.l2	-0.843500	0.544625	-1.549	0.1237	
cb.VVv1.l3	5.409396	3.032733	1.784	0.0766	.
cb.VVv2.l3	0.123604	0.763015	0.162	0.8715	
cb.VVv1.l4	-0.802995	4.068487	-0.197	0.8438	
cb.VVv2.l4	-1.217167	0.917718	-1.326	0.1869	
cb.VVv1.l5	5.448858	2.415345	2.256	0.0256	*
cb.VVv2.l5	-1.045113	0.543457	-1.923	0.0565	.
cb.VVv1.l6	0.361965	1.913471	0.189	0.8502	
cb.VVv2.l6	-0.112037	0.563082	-0.199	0.8426	
as.factor(Year)2010	0.644255	0.969502	0.665	0.5074	
as.factor(Year)2011	1.015308	0.900469	1.128	0.2614	
as.factor(Year)2012	1.554259	1.042632	1.491	0.1383	
as.factor(Year)2013	2.288741	1.246380	1.836	0.0684	.
as.factor(Year)2014	2.249348	1.506726	1.493	0.1377	
as.factor(Week)2	0.044785	0.332218	0.135	0.8930	
as.factor(Week)3	0.191546	0.556413	0.344	0.7312	
as.factor(Week)4	0.154200	0.838943	0.184	0.8544	
as.factor(Week)5	0.069523	1.110472	0.063	0.9502	
as.factor(Week)6	0.271021	1.376369	0.197	0.8442	

as.factor(Week)7	0.644636	1.648196	0.391	0.6963
as.factor(Week)8	0.714294	1.924640	0.371	0.7111
as.factor(Week)9	1.003582	2.191565	0.458	0.6477
as.factor(Week)10	0.779856	2.379966	0.328	0.7436
as.factor(Week)11	0.609344	2.564880	0.238	0.8126
as.factor(Week)12	0.484967	2.730466	0.178	0.8593
as.factor(Week)13	0.204299	2.874102	0.071	0.9434
as.factor(Week)14	-0.129080	2.988529	-0.043	0.9656
as.factor(Week)15	-0.659673	3.061023	-0.216	0.8297
as.factor(Week)16	-0.210571	3.113451	-0.068	0.9462
as.factor(Week)17	-0.167475	3.145608	-0.053	0.9576
as.factor(Week)18	-0.409174	3.151776	-0.130	0.8969
as.factor(Week)19	-0.395857	3.084539	-0.128	0.8981
as.factor(Week)20	0.104383	2.999590	0.035	0.9723
as.factor(Week)21	0.949203	2.924290	0.325	0.7460
as.factor(Week)22	1.153124	2.833597	0.407	0.6847
as.factor(Week)23	1.202118	2.783027	0.432	0.6664
as.factor(Week)24	1.725927	2.675882	0.645	0.5200
as.factor(Week)25	1.917063	2.511227	0.763	0.4465
as.factor(Week)26	2.572721	2.362135	1.089	0.2780
as.factor(Week)27	2.664733	2.274028	1.172	0.2433
as.factor(Week)28	2.752624	2.176142	1.265	0.2080
as.factor(Week)29	2.632909	2.130308	1.236	0.2186
as.factor(Week)30	2.924052	2.106576	1.388	0.1673
as.factor(Week)31	2.813014	2.105265	1.336	0.1837
as.factor(Week)32	2.923913	2.124817	1.376	0.1710
as.factor(Week)33	2.902987	2.179235	1.332	0.1850
as.factor(Week)34	2.577762	2.229195	1.156	0.2495
as.factor(Week)35	2.224697	2.317001	0.960	0.3386

as.factor(Week)36	1.658310	2.360789	0.702	0.4836
as.factor(Week)37	2.137877	2.386563	0.896	0.3719
as.factor(Week)38	1.695302	2.360851	0.718	0.4739
as.factor(Week)39	1.818521	2.388858	0.761	0.4478
as.factor(Week)40	1.731428	2.384401	0.726	0.4690
as.factor(Week)41	1.342164	2.345245	0.572	0.5680
as.factor(Week)42	1.451757	2.277326	0.637	0.5249
as.factor(Week)43	1.155952	2.206702	0.524	0.6012
as.factor(Week)44	0.538456	2.143537	0.251	0.8020
as.factor(Week)45	0.737854	2.029040	0.364	0.7167
as.factor(Week)46	0.704693	1.895953	0.372	0.7107
as.factor(Week)47	0.833471	1.713526	0.486	0.6274
as.factor(Week)48	0.740750	1.510222	0.490	0.6246
as.factor(Week)49	0.879011	1.238490	0.710	0.4790
as.factor(Week)50	0.469140	0.980194	0.479	0.6330
as.factor(Week)51	0.348745	0.742414	0.470	0.6393
as.factor(Week)52	0.332881	0.502842	0.662	0.5091
as.factor(Week)53	0.245855	0.831679	0.296	0.7680

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasipoisson family taken to be 16.03292)

Null deviance: 16541.7 on 263 degrees of freedom

Residual deviance: 2501.7 on 140 degrees of freedom

Number of Fisher Scoring iterations: 5

Appendix D: R codes

```
# Exploratory Data Analysis - Time series plots of dengue
# incidence

C_District=read.csv(file.choose(),header=T)

attach(C_District)

a=as.matrix(C_District)

rr=as.ts(a,start=c(2008,52),frequency=c(1,52,52,52,52,49,
36))

for (i in 5 to 29){

win.graph(width=6.5, height=2.5,pointsize=8)

plot(a[,i],type="b",bg=66,col="blue",ylab="Dengue
Cases",xaxt="n",xlab="Year")

lines( a[,i], col="blue")

points( a[,i], col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

}
```



```
#*******************************************************

# Chapter 5 - Wavelet Analyses

# Figure 5.1

C_District=read.csv(file.choose(),header=T)

attach(C_District)

a=as.matrix(C_District[30])

rr=as.ts(a,start=c(2008,52),frequency=c(1,52,52,52,52,49,
21))


All=sqrt(All)

ta=cbind(1:294, (All-mean(All))/sd(All))
```

```
rr2=as.ts(ta[,2],start=c(2008,52),frequency=c(1,52,52,52,
52,49,21))

win.graph(width=6.5, height=2.5,pointsize=8)

plot(rr2,type="b",bg=66,col="blue",ylab="square root
transformed and normalized",xaxt="n")

lines( rr2, col="blue")

points( rr2, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#*********************************************************

#Wavelet transformation of dengue cases

C_District=read.csv(file.choose(),header=T)

attach(C_District)

##--------------- Compute wavelet spectra------------------

library(biwavelet)

Colombo=sqrt(Colombo)

Gampaha=sqrt(Gampaha)

Kalutara=sqrt(Kalutara)

Kandy=sqrt(Kandy)

Matale=sqrt(Matale)

Nuwara.Eliya=sqrt(Nuwara.Eliya)

Galle=sqrt(Galle)

Hambantota=sqrt(Hambantota)

Matara=sqrt(Matara)

Jaffna=sqrt(Jaffna)

Kilinochchi=sqrt(Kilinochchi)

Mannar=sqrt(Mannar)
```

```
Vavuniya=sqrt(Vavuniya)

Mulative=sqrt(Mulative)

Batticalo=sqrt(Batticalo)

Ampara=sqrt(Ampara)

Trincomalee=sqrt(Trincomalee)

Kurunagala=sqrt(Kurunagala)

Puttalam=sqrt(Puttalam)

Anuradhapura=sqrt(Anuradhapura)

Polonnaruwa=sqrt(Polonnaruwa)

Badulla=sqrt(Badulla)

Monaragala=sqrt(Monaragala)

Ratnapura=sqrt(Ratnapura)

Kegalle=sqrt(Kegalle)
```



```
t1=cbind(1:294,(Colombo-mean(Colombo))/sd(Colombo))

t2=cbind(1:294,(Gampaha-mean(Gampaha))/sd(Gampaha))

t3=cbind(1:294, (Kalutara-mean(Kalutara))/sd(Kalutara))

t4=cbind(1:294, (Kandy-mean(Kandy))/sd(Kandy))

t5=cbind(1:294,(Matale-mean(Matale))/sd(Matale))

t6=cbind(1:294, (Nuwara.Eliya-
mean(Nuwara.Eliya))/sd(Nuwara.Eliya))

t7=cbind(1:294,(Galle-mean(Galle))/sd(Galle))

t8=cbind(1:294, (Hambantota-
mean(Hambantota))/sd(Hambantota))

t9=cbind(1:294,(Matara-mean(Matara))/sd(Matara))

t10=cbind(1:294,(Jaffna-mean(Jaffna))/sd(Jaffna))
```

```
t11=cbind(1:294,(Kilinochchi-
mean(Kilinochchi))/sd(Kilinochchi))

t12=cbind(1:294, (Mannar-mean(Mannar))/sd(Mannar))

t13=cbind(1:294,(Vavuniya-mean(Vavuniya))/sd(Vavuniya))

t14=cbind(1:294, (Mulative-mean(Mulative))/sd(Mulative))

t15=cbind(1:294, (Batticalo-
mean(Batticalo))/sd(Batticalo))

t16=cbind(1:294,(Ampara-mean(Ampara))/sd(Ampara))

t17=cbind(1:294, (Trincomalee-
mean(Trincomalee))/sd(Trincomalee))

t18=cbind(1:294, (Kurunagala-
mean(Kurunagala))/sd(Kurunagala))

t19=cbind(1:294,(Puttalam-mean(Puttalam))/sd(Puttalam))

t20=cbind(1:294, (Anuradhapura-
mean(Anuradhapura))/sd(Anuradhapura))

t21=cbind(1:294, (Polonnaruwa-
mean(Polonnaruwa))/sd(Polonnaruwa))

t22=cbind(1:294,(Badulla-mean(Badulla))/sd(Badulla))

t23=cbind(1:294,(Monaragala-
mean(Monaragala))/sd(Monaragala))

t24=cbind(1:294, (Ratnapura-
mean(Ratnapura))/sd(Ratnapura))

t25=cbind(1:294, (Kegalle-mean(Kegalle))/sd(Kegalle))


wt.t1=wt(t1)

wt.t2=wt(t2)

wt.t3=wt(t3)

wt.t4=wt(t4)

wt.t5=wt(t5)
```

```
wt.t6=wt(t6)

wt.t7=wt(t7)

wt.t8=wt(t8)

wt.t9=wt(t9)

wt.t10=wt(t10)

wt.t11=wt(t11)

wt.t12=wt(t12)

wt.t13=wt(t13)

wt.t14=wt(t14)

wt.t15=wt(t15)

wt.t16=wt(t16)

wt.t17=wt(t17)

wt.t18=wt(t18)

wt.t19=wt(t19)

wt.t20=wt(t20)

wt.t21=wt(t21)

wt.t22=wt(t22)

wt.t23=wt(t23)

wt.t24=wt(t24)

wt.t25=wt(t25)

# Figure 5.4

par(mfrow=c(4,2),mai=c(0.3,0.7,0.2,0.2))

plot(wt.t1, plot.cb=F,
plot.phase=F,xaxt="n",main="a",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```

```
plot(wt.t2, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="b",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t3, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="c",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t4, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="d",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t5, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="e",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t6, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="f",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t7, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="g",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t8, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="h",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t9, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Matara",ylab="Period
(weeks)")
```

```
axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t10, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Jaffna",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t11, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Killinochchi",ylab="Perio
d (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t12, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Mannar",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```



```
plot(wt.t13, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Vavuniya",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t14, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Mulative",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t15, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Batticalo",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```

```
plot(wt.t16, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Ampara",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t17, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Trincomalee",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t18, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Kurunagala",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))


plot(wt.t19, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Puttalam",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t20, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Anuradhapura",ylab="Perio
d (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t21, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Polonnaruwa",ylab="Period
(weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.t22, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="Badulla",ylab="Period
(weeks)")
```

```
axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011,2012,2013,2014))

plot(wt.t23, plot.cb=F, plot.phase=FALSE,xaxt="n",main="Monaragala",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011,2012,2013,2014))

plot(wt.t24, plot.cb=F, plot.phase=FALSE,xaxt="n",main="Ratnapura",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011,2012,2013,2014))


plot(wt.t25, plot.cb=F, plot.phase=FALSE,xaxt="n",main="Kegall",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011,2012,2013,2014))

#-----------------Figure 5.5--------------------------------

par(mfrow=c(5,5),mai=c(0.3,0.3,0.2,0.2))

b=wt.t1$period

a=apply(wt.t1$power.corr,1,mean)

plot(b,a,type="l",main ="Colombo",mai=c(0.001,0.001,0.001,0.001))

b=wt.t2$period

a=apply(wt.t2$power.corr,1,mean)

plot(b,a,type="l",main ="Gampaha",mai=c(0.001,0.001,0.001,0.001))

b=wt.t3$period

a=apply(wt.t3$power.corr,1,mean)
```

```
plot(b,a,type="l",main
="Kalutara",mai=c(0.001,0.001,0.001,0.001))

b=wt.t4$period

a=apply(wt.t4$power.corr,1,mean)

plot(b,a,type="l",main
="Kandy",mai=c(0.001,0.001,0.001,0.001))

b=wt.t5$period

a=apply(wt.t5$power.corr,1,mean)

plot(b,a,type="l",main
="Matale",mai=c(0.001,0.001,0.001,0.001))

b=wt.t6$period

a=apply(wt.t6$power.corr,1,mean)

plot(b,a,type="l",main ="Nuwara
Eliya",mai=c(0.001,0.001,0.001,0.001))

b=wt.t7$period

a=apply(wt.t7$power.corr,1,mean)

plot(b,a,type="l",main
="Galle",mai=c(0.001,0.001,0.001,0.001))

b=wt.t8$period

a=apply(wt.t8$power.corr,1,mean)

plot(b,a,type="l",main
="Hambantota",mai=c(0.001,0.001,0.001,0.001))

b=wt.t9$period

a=apply(wt.t9$power.corr,1,mean)

plot(b,a,type="l",main
="Matara",mai=c(0.001,0.001,0.001,0.001))

b=wt.t10$period

a=apply(wt.t10$power.corr,1,mean)
```

```
plot(b,a,type="l",main
="Jaffna",mai=c(0.001,0.001,0.001,0.001))

b=wt.t11$period

a=apply(wt.t11$power.corr,1,mean)

plot(b,a,type="l",main
="Killinochchie",mai=c(0.001,0.001,0.001,0.001))

b=wt.t12$period

a=apply(wt.t12$power.corr,1,mean)

plot(b,a,type="l",main
="Mannar",mai=c(0.001,0.001,0.001,0.001))

b=wt.t13$period

a=apply(wt.t13$power.corr,1,mean)

plot(b,a,type="l",main
="Vavuniya",mai=c(0.001,0.001,0.001,0.001))

b=wt.t14$period

a=apply(wt.t14$power.corr,1,mean)

plot(b,a,type="l",main
="Mulative",mai=c(0.001,0.001,0.001,0.001))

b=wt.t15$period

a=apply(wt.t15$power.corr,1,mean)

plot(b,a,type="l",main
="Batticalo",mai=c(0.001,0.001,0.001,0.001))

b=wt.t16$period

a=apply(wt.t16$power.corr,1,mean)

plot(b,a,type="l",main
="Ampara",mai=c(0.001,0.001,0.001,0.001))

b=wt.t17$period

a=apply(wt.t17$power.corr,1,mean)
```

```
plot(b,a,type="l",main
="Trincomalee",mai=c(0.001,0.001,0.001,0.001))

b=wt.t18$period

a=apply(wt.t18$power.corr,1,mean)

plot(b,a,type="l",main
="Kurunagala",mai=c(0.001,0.001,0.001,0.001))


b=wt.t19$period

a=apply(wt.t19$power.corr,1,mean)

plot(b,a,type="l",main
="Puttalam",mai=c(0.001,0.001,0.001,0.001))

b=wt.t20$period

a=apply(wt.t20$power.corr,1,mean)

plot(b,a,type="l",main
="Anuradhapura",mai=c(0.001,0.001,0.001,0.001))

b=wt.t21$period

a=apply(wt.t21$power.corr,1,mean)

plot(b,a,type="l",main
="Polonnaruwa",mai=c(0.001,0.001,0.001,0.001))

b=wt.t22$period

a=apply(wt.t22$power.corr,1,mean)

plot(b,a,type="l",main
="Badulla",mai=c(0.001,0.001,0.001,0.001))

b=wt.t23$period

a=apply(wt.t23$power.corr,1,mean)

plot(b,a,type="l",main
="Monaragala",mai=c(0.001,0.001,0.001,0.001))

b=wt.t24$period

a=apply(wt.t24$power.corr,1,mean)
```

```
plot(b,a,type="l",main
="Rathnapura",mai=c(0.001,0.001,0.001,0.001))

b=wt.t25$period

a=apply(wt.t25$power.corr,1,mean)

plot(b,a,type="l",main
="Kegalle",mai=c(0.001,0.001,0.001,0.001))


# Wavelet Cluster Analysis

C_District=read.csv(file.choose(),header=T)

attach(C_District)

C_District=read.csv(file.choose(),header=T)

C_District[2]

names(C_District)

attach(C_District)

apply(C_District,2,length)

apply(C_District,2,mean,na.rm=T)


library(biwavelet)

Colombo=sqrt(Colombo)

Gampaha=sqrt(Gampaha)

Kalutara=sqrt(Kalutara)

Kandy=sqrt(Kandy)

Matale=sqrt(Matale)

Nuwara.Eliya=sqrt(Nuwara.Eliya)

Galle=sqrt(Galle)

Hambantota=sqrt(Hambantota)

Matara=sqrt(Matara)
```

```
Jaffna=sqrt(Jaffna)

Kilinochchi=sqrt(Kilinochchi)

Mannar=sqrt(Mannar)

Vavuniya=sqrt(Vavuniya)

Mulative=sqrt(Mulative)

Batticalo=sqrt(Batticalo)

Ampara=sqrt(Ampara)

Trincomalee=sqrt(Trincomalee)

Kurunagala=sqrt(Kurunagala)

Puttalam=sqrt(Puttalam)

Anuradhapura=sqrt(Anuradhapura)

Polonnaruwa=sqrt(Polonnaruwa)

Badulla=sqrt(Badulla)

Monaragala=sqrt(Monaragala)

Ratnapura=sqrt(Ratnapura)

Kegalle=sqrt(Kegalle)


t1=cbind(1:294, (Colombo-mean(Colombo))/sd(Colombo))

t2=cbind(1:294,(Gampaha-mean(Gampaha))/sd(Gampaha))

t3=cbind(1:294, (Kalutara-mean(Kalutara))/sd(Kalutara))

t4=cbind(1:294, (Kandy-mean(Kandy))/sd(Kandy))

t5=cbind(1:294,(Matale-mean(Matale))/sd(Matale))

t6=cbind(1:294, (Nuwara.Eliya-
mean(Nuwara.Eliya))/sd(Nuwara.Eliya))

t7=cbind(1:294,(Galle-mean(Galle))/sd(Galle))

t8=cbind(1:294, (Hambantota-
mean(Hambantota))/sd(Hambantota))
```

```
t9=cbind(1:294,(Matara-mean(Matara))/sd(Matara))

t10=cbind(1:294,(Jaffna-mean(Jaffna))/sd(Jaffna))

t11=cbind(1:294,(Kilinochchi-
mean(Kilinochchi))/sd(Kilinochchi))

t12=cbind(1:294, (Mannar-mean(Mannar))/sd(Mannar))

t13=cbind(1:294,(Vavuniya-mean(Vavuniya))/sd(Vavuniya))

t14=cbind(1:294, (Mulative-mean(Mulative))/sd(Mulative))

t15=cbind(1:294, (Batticalo-
mean(Batticalo))/sd(Batticalo))

t16=cbind(1:294,(Ampara-mean(Ampara))/sd(Ampara))

t17=cbind(1:294, (Trincomalee-
mean(Trincomalee))/sd(Trincomalee))

t18=cbind(1:294, (Kurunagala-
mean(Kurunagala))/sd(Kurunagala))

t19=cbind(1:294,(Puttalam-mean(Puttalam))/sd(Puttalam))

t20=cbind(1:294, (Anuradhapura-
mean(Anuradhapura))/sd(Anuradhapura))

t21=cbind(1:294, (Polonnaruwa-
mean(Polonnaruwa))/sd(Polonnaruwa))

t22=cbind(1:294,(Badulla-mean(Badulla))/sd(Badulla))

t23=cbind(1:294,(Monaragala-
mean(Monaragala))/sd(Monaragala))

t24=cbind(1:294, (Ratnapura-
mean(Ratnapura))/sd(Ratnapura))

t25=cbind(1:294, (Kegalle-mean(Kegalle))/sd(Kegalle))

wt.t1=wt(t1)

wt.t2=wt(t2)

wt.t3=wt(t3)

wt.t4=wt(t4)
```

```
wt.t5=wt(t5)

wt.t6=wt(t6)

wt.t7=wt(t7)

wt.t8=wt(t8)

wt.t9=wt(t9)

wt.t10=wt(t10)

wt.t11=wt(t11)

wt.t12=wt(t12)

wt.t13=wt(t13)

wt.t14=wt(t14)

wt.t15=wt(t15)

wt.t16=wt(t16)

wt.t17=wt(t17)

wt.t18=wt(t18)

wt.t19=wt(t19)

wt.t20=wt(t20)

wt.t21=wt(t21)

wt.t22=wt(t22)

wt.t23=wt(t23)

wt.t24=wt(t24)

wt.t25=wt(t25)

## Store all wavelet spectra into array

w.arr=array(NA, dim=c(25, NROW(wt.t1$wave),
NCOL(wt.t1$wave)))

w.arr[1, , ]=wt.t1$wave

w.arr[2, , ]=wt.t2$wave
```

```
w.arr[3, , ]=wt.t3$wave
w.arr[4, , ]=wt.t4$wave
w.arr[5, , ]=wt.t5$wave
w.arr[6, , ]=wt.t6$wave
w.arr[7, , ]=wt.t7$wave
w.arr[8, , ]=wt.t8$wave
w.arr[9, , ]=wt.t9$wave
w.arr[10, , ]=wt.t10$wave
w.arr[11, , ]=wt.t11$wave
w.arr[12, , ]=wt.t12$wave
w.arr[13, , ]=wt.t13$wave
w.arr[14, , ]=wt.t14$wave
w.arr[15, , ]=wt.t15$wave
w.arr[16, , ]=wt.t16$wave
w.arr[17, , ]=wt.t17$wave
w.arr[18, , ]=wt.t18$wave
w.arr[19, , ]=wt.t19$wave
w.arr[20, , ]=wt.t20$wave
w.arr[21, , ]=wt.t21$wave
w.arr[22, , ]=wt.t22$wave
w.arr[23, , ]=wt.t23$wave
w.arr[24, , ]=wt.t24$wave
w.arr[25, , ]=wt.t25$wave
## Compute dissimilarity and distance matrices
w.arr.dis=wclust(w.arr)
```

```
plot(hclust(w.arr.dis$dist.mat, method="ward"), sub="",
main="", ylab="Dissimilarity", hang=-1)

#Figure 5.8

par(mfrow=c(4,2),mai=c(0.3,0.7,0.2,0.2))

plot(wt.TEM, plot.cb=F,
plot.phase=F,xaxt="n",main="a",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.TMAX, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="b",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.Tm, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="c",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.H, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="d",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.PP, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="e",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.VV, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="f",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(wt.V, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="g",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```

```
plot(wt.VM, plot.cb=F,
plot.phase=FALSE,xaxt="n",main="h",ylab="Period (weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#Figure 5.9

par(mfrow=c(2,4),mai=c(0.3,0.3,0.2,0.2))

b=wt.TEM$period

a=apply(wt.TEM$power.corr,1,mean)

plot(b,a,type="l",main
="a",mai=c(0.001,0.001,0.001,0.001))

b=wt.TMAX$period

a=apply(wt.TMAX$power.corr,1,mean)

plot(b,a,type="l",main
="b",mai=c(0.001,0.001,0.001,0.001))

b=wt.Tm$period

a=apply(wt.Tm$power.corr,1,mean)

plot(b,a,type="l",main
="c",mai=c(0.001,0.001,0.001,0.001))

b=wt.H$period

a=apply(wt.H$power.corr,1,mean)

plot(b,a,type="l",main
="d",mai=c(0.001,0.001,0.001,0.001))

b=wt.PP$period

a=apply(wt.PP$power.corr,1,mean)

plot(b,a,type="l",main
="e",mai=c(0.001,0.001,0.001,0.001))

b=wt.VV$period

a=apply(wt.VV$power.corr,1,mean)
```

```
plot(b,a,type="l",main
="f",mai=c(0.001,0.001,0.001,0.001))

b=wt.Vperiod

a=apply(wt.V$power.corr,1,mean)

plot(b,a,type="l",main
="g",mai=c(0.001,0.001,0.001,0.001))

b=wt.VM$period

a=apply(wt.VM$power.corr,1,mean)

plot(b,a,type="l",main
="h",mai=c(0.001,0.001,0.001,0.001))


#Figure 5.10

rm(list=ls())

library(biwavelet)

Colombo=read.csv(file.choose(),header=T)

attach(Colombo)

head(Colombo)

names(Colombo)

attach(Colombo)

apply(Colombo1,2,length)

par(mfrow=c(4,2),mai=c(0.6,0.7,0.4,0.2))

#ccf(mdeaths, fdeaths, ylab = "cross-correlation")

ccf(TEM, Cases, main = "a", ylab = "cross-correlation",
xlab="lag")

ccf(TMAX, Cases, main = "b", ylab = "cross-correlation",
xlab="lag")

ccf(Tm, Cases, main = "c", ylab = "cross-correlation",
xlab="lag")
```

```
ccf(H, Cases, main = "d", ylab = "cross-correlation", xlab="lag")

ccf(PP, Cases, main = "e", ylab = "cross-correlation", xlab="lag")

ccf(VV, Cases, main = "f", ylab = "cross-correlation", xlab="lag")

ccf(V, Cases, main = "g", ylab = "cross-correlation", xlab="lag")

ccf(VM, Cases, main = "h", ylab = "cross-correlation", xlab="lag")


#Figure 5.12 – Figure 5.26 and Appendix B

rm(list=ls())

library(biwavelet)

Colombo=read.csv(file.choose(),header=T)

attach(Colombo)

head(Colombo)

names(Colombo)

attach(Colombo)

apply(Colombo1,2,length)

TEM1=sqrt(TEM)

TMAX1=sqrt(TMAX)

Tm1=sqrt(Tm)

H1=sqrt(H)

PP1=sqrt(PP)

VV1=sqrt(VV)

V1=sqrt(V)

VM1=sqrt(VM)
```

```
Cases1=sqrt(Cases)

TEM2=cbind(1:294, (TEM1-mean(TEM1))/sd(TEM1))

TMAX2=cbind(1:294,(TMAX1-mean(TMAX1))/sd(TMAX1))

Tm2=cbind(1:294, (Tm1-mean(Tm1))/sd(Tm1))

H2=cbind(1:294,(H1-mean(H1))/sd(H1))

PP2=cbind(1:294, (PP1-mean(PP1))/sd(PP1))

VV2=cbind(1:294,(VV1-mean(VV1))/sd(VV1))

V2=cbind(1:294, (V1-mean(V1))/sd(V1))

VM2=cbind(1:294,(VM1-mean(VM1))/sd(VM1))

Cases2=cbind(1:294,(Cases1-mean(Cases1))/sd(Cases1))

wt.TEM=wt(TEM2)

wt.TMAX=wt(TMAX2)

wt.Tm=wt(Tm2)

wt.H=wt(H2)

wt.PP=wt(PP2)

wt.VV=wt(VV2)

wt.V=wt(V2)

wt.VM=wt(VM2)

wt.Cases=wt(Cases2)

## Store all wavelet spectra into array

w.arr=array(NA, dim=c(9, NROW(wt.TEM$wave),
NCOL(wt.TEM$wave)))

w.arr[1, , ]=wt.TEM$wave

w.arr[2, , ]=wt.TMAX$wave

w.arr[3, , ]=wt.Tm$wave

w.arr[4, , ]=wt.H$wave
```

```
w.arr[5, , ]=wt.PP$wave

w.arr[6, , ]=wt.VV$wave

w.arr[7, , ]=wt.V$wave

w.arr[8, , ]=wt.VM$wave

w.arr[9, , ]=wt.Cases$wave


# time series

plot(TEM,type="o",bg=66,col="blue",xlab="Year",ylab="
Mean Temperature",main = " ",xaxt="n")

points( TEM, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(TMAX,type="o",bg=66,col="blue",xlab="Year",ylab="Max
imum Temperature",main = " ",xaxt="n")

points( TMAX, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(Tm,type="o",bg=66,col="blue",xlab="Year",ylab="Minim
um Temperature",main = " ",xaxt="n")

points( Tm, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(H,type="o",bg=66,col="blue",xlab="Year",ylab="Humidi
ty",main = " ",xaxt="n")

points( H, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(PP,type="o",bg=66,col="blue",xlab="Year",ylab="Preci
pitation",main = " ",xaxt="n")
```

```
points( PP, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(VV,type="o",bg=66,col="blue",xlab="Year",ylab="Mean
Visibility",main = " ",xaxt="n")

points( VV, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(V,type="o",bg=66,col="blue",xlab="Year",ylab="Mean
Wind Speed",main = " ",xaxt="n")

points( V, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(VM,type="o",bg=66,col="blue",xlab="Year",ylab="Maxim
um sustained wind speed",main = " ",xaxt="n")

points( VM, col="red", pch=19 )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#########################################################

#mean temperature

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.TEM, plot.cb=TRUE,
plot.phase=FALSE,xaxt="n",ylab="Period (Weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

# maximum temperature

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.TMAX, plot.cb=TRUE,
plot.phase=FALSE,xaxt="n",ylab="Period (Weeks)")
```

```
axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

# minimum temperature

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.Tm, plot.cb=TRUE,
plot.phase=FALSE,xaxt="n",ylab="Period (Weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#Humidity

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.H, plot.cb=TRUE,
plot.phase=FALSE,xaxt="n",ylab="Period (Weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

# minimum precipitation

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.PP, plot.cb=TRUE,
plot.phase=FALSE,xaxt="n",ylab="Period (Weeks)")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#VV

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.VV, plot.cb=TRUE, plot.phase=FALSE,xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

# V

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.V, plot.cb=TRUE, plot.phase=FALSE,xaxt="n")
```

```
axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011,2012,2013,2014))

#VM

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.VM, plot.cb=TRUE, plot.phase=FALSE,xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011,2012,2013,2014))

# Cases

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(wt.Cases, plot.cb=TRUE, plot.phase=FALSE,xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011,2012,2013,2014))

########################################################

######## Cross-wavelet transform #######################

x <- 1:294

Cases <- Cases

par(mar = c(5, 4, 4, 4) + 0.3)  # Leave space for z axis

plot(x,Cases,type="o",xaxt="n",col="red",xlab="Year",pch=20)

par(new = TRUE)

plot(x, TEM, type = "o", axes = FALSE, bty = "n", xlab = "Year", ylab = "",xaxt="n",col="blue",pch=20)

axis(side=4, at = pretty(range(TEM)))

mtext("Mean temperature", side=4, line=3)

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011,2012,2013,2014))

#---------------------------------------------------------

xwt.t1=xwt(Cases2,TEM2)
```

```
par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(xwt.t1, plot.cb=TRUE,
plot.phase=TRUE,ylab="Period(Weeks)",xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#*********************************************************

x <- 1:294

Cases <- Cases

## second data set on a very different scale

par(mar = c(5, 4, 4, 4) + 0.3)  # Leave space for z axis

plot(x,
Cases,type="o",xaxt="n",col="red",xlab="Year",pch=20) #
first plot

par(new = TRUE)

plot(x, Tm, type = "o", axes = FALSE, bty = "n", xlab =
"Year", ylab = "",xaxt="n",col="blue",pch=20)

axis(side=4, at = pretty(range(Tm)))

mtext("Minimum temperature", side=4, line=3)

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#---------------------------------------------------------

xwt.t1=xwt(Cases2,Tm2)

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(xwt.t1, plot.cb=TRUE,
plot.phase=TRUE,ylab="Period(Weeks)",xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#*********************************************************

x <- 1:294
```

```
Cases <- Cases

## second data set on a very different scale

par(mar = c(5, 4, 4, 4) + 0.3)  # Leave space for z axis

plot(x,
Cases,type="o",xaxt="n",col="red",xlab="Year",pch=20) #
first plot

par(new = TRUE)

plot(x, TMAX, type = "o", axes = FALSE, bty = "n", xlab =
"Year", ylab = "",xaxt="n",col="blue",pch=20)

axis(side=4, at = pretty(range(TMAX)))

mtext("Maximum temperature", side=4, line=3)

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#--------------------------------------------------------

xwt.t1=xwt(Cases2,TMAX2)

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(xwt.t1, plot.cb=TRUE,
plot.phase=TRUE,ylab="Period(Weeks)",xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#********************************************************

x <- 1:294

Cases <- Cases

## second data set on a very different scale

par(mar = c(5, 4, 4, 4) + 0.3)  # Leave space for z axis

plot(x,
Cases,type="o",xaxt="n",col="red",xlab="Year",pch=20) #
first plot

par(new = TRUE)
```

```
plot(x,H, type = "o", axes = FALSE, bty = "n", xlab =
"Year", ylab = "",xaxt="n",col="blue",pch=20)

axis(side=4, at = pretty(range(H)))

mtext("Humidity", side=4, line=3)

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))


#---------------------------------------------------------

xwt.t1=xwt(Cases2,H2)

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(xwt.t1, plot.cb=TRUE,
plot.phase=TRUE,ylab="Period(Weeks)",xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#*********************************************************

x <- 1:294

Cases <- Cases

## second data set on a very different scale

par(mar = c(5, 4, 4, 4) + 0.3)  # Leave space for z axis

plot(x,
Cases,type="o",xaxt="n",col="red",xlab="Year",pch=20) #
first plot

par(new = TRUE)

plot(x,PP, type = "o", axes = FALSE, bty = "n", xlab =
"Year", ylab = "",xaxt="n",col="blue",pch=20)

axis(side=4, at = pretty(range(PP)))

mtext("Precipitation", side=4, line=3)

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```

```
#---------------------------------------------------------

xwt.t1=xwt(Cases2,PP2)

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(xwt.t1, plot.cb=TRUE,
plot.phase=TRUE,ylab="Period(Weeks)",xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#*********************************************************

x <- 1:294

Cases <- Cases

## second data set on a very different scale

par(mar = c(5, 4, 4, 4) + 0.3)  # Leave space for z axis

plot(x,
Cases,type="o",xaxt="n",col="red",xlab="Year",pch=20) #
first plot

par(new = TRUE)

plot(x,VV, type = "o", axes = FALSE, bty = "n", xlab =
"Year", ylab = "",xaxt="n",col="blue",pch=20)

axis(side=4, at = pretty(range(VV)))

mtext("Visibility", side=4, line=3)

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#---------------------------------------------------------

xwt.t1=xwt(Cases2,VV2)

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(xwt.t1, plot.cb=TRUE,
plot.phase=TRUE,ylab="Period(Weeks)",xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```

```
#*********************************************************

x <- 1:294

Cases <- Cases

## second data set on a very different scale

par(mar = c(5, 4, 4, 4) + 0.3)  # Leave space for z axis

plot(x,
Cases,type="o",xaxt="n",col="red",xlab="Year",pch=20) #
first plot

par(new = TRUE)

plot(x,V, type = "o", axes = FALSE, bty = "n", xlab =
"Year", ylab = "",xaxt="n",col="blue",pch=20)

axis(side=4, at = pretty(range(V)))

mtext("Wind Speed", side=4, line=3)

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#---------------------------------------------------------

xwt.t1=xwt(Cases2,V2)

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(xwt.t1, plot.cb=TRUE,
plot.phase=TRUE,ylab="Period(Weeks)",xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#*********************************************************

x <- 1:294

Cases <- Cases

## second data set on a very different scale

par(mar = c(5, 4, 4, 4) + 0.3)  # Leave space for z axis
```

```
plot(x,
Cases,type="o",xaxt="n",col="red",xlab="Year",pch=20) #
first plot

par(new = TRUE)

plot(x,VM, type = "o", axes = FALSE, bty = "n", xlab =
"Year", ylab = "",xaxt="n",col="blue",pch=20)

axis(side=4, at = pretty(range(VM)))

mtext("Maximum Sustained Wind Speed", side=4, line=3)

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#--------------------------------------------------------
xwt.t1=xwt(Cases2,VM2)

par(oma=c(0, 0, 0, 1), mar=c(5, 4, 4, 5) + 0.1)

plot(xwt.t1, plot.cb=TRUE,
plot.phase=TRUE,ylab="Period(Weeks)",xaxt="n")

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#########################################################
##

# Change point analysis

rm(list=ls())

ls()


library(changepoint)

library(zoo)


cpdata=read.csv(file.choose(),header=T)

attach(cpdata)

head(cpdata)
```

```
##### change point detection using PELT method

Cases.pelt <- cpt.var(diff(Cases,difference=1),method =
"PELT")

TEM.pelt <- cpt.var(diff(TEM,difference=1),method =
"PELT")

TMAX.pelt <- cpt.var(diff(TMAX,difference=1),method =
"PELT")

Tm.pelt <- cpt.var(diff(Tm,difference=1),method = "PELT")

H.pelt <- cpt.var(diff(H,difference=1),method = "PELT")

PP.pelt <- cpt.var(diff(PP,difference=1),method = "PELT")

VV.pelt <- cpt.var(diff(VV,difference=1),method = "PELT")

V.pelt <- cpt.var(diff(V,difference=1),method = "PELT")

VM.pelt <- cpt.var(diff(VM,difference=1),method = "PELT")

logLik(Cases.pelt)

logLik(TEM.pelt)
```



```
#--------------------------------------------------------

par(mfrow=c(2,1))

plot(Cases.pelt,ylab="Dengue Cases" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))


plot(TEM.pelt,ylab="Mean Temperature" ,xlab="Time",main =
" ",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```

```
#-------------------------------------------------------

par(mfrow=c(2,1))

plot(Cases.pelt,ylab="Dengue Cases" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(TMAX.pelt,ylab="Maximum Temperature"
,xlab="Time",main = " ",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#-------------------------------------------------------

par(mfrow=c(2,1))

plot(Cases.pelt,ylab="Dengue Cases" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(Tm.pelt,ylab="Minimum Temperature" ,xlab="Time",main
= " ",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#-------------------------------------------------------

par(mfrow=c(2,1))

plot(Cases.pelt,ylab="Dengue Cases" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(H.pelt,ylab="Humidity" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```

```
#-------------------------------------------------------

par(mfrow=c(2,1))

plot(Cases.pelt,ylab="Dengue Cases" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(PP.pelt,ylab="Precipitation" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))


#-------------------------------------------------------

par(mfrow=c(2,1))

plot(Cases.pelt,ylab="Dengue Cases" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))


plot(VV.pelt,ylab="Visibility" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

#-------------------------------------------------------

par(mfrow=c(2,1))

plot(Cases.pelt,ylab="Dengue Cases" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))
```

```
plot(V.pelt,ylab="Wind Speed" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))


#----------------------------------------------------------

par(mfrow=c(2,1))

plot(Cases.pelt,ylab="Dengue Cases" ,xlab="Time",main = "
",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

plot(VM.pelt,ylab="Maximum Sustained Wind Speed"
,xlab="Time",main = " ",xaxt="n" )

axis(1,at=c(2,54,106,158,210,259),labels=c(2009,2010,2011
,2012,2013,2014))

##########################################################

# DLNM

########last model#######################

rm(list=ls())

Colombo=read.csv(file.choose(),header=T)

attach(Colombo)

names(Colombo)

head(Colombo)

library(dlnm)

library(splines)

lagknots1 <- logknots(30, 4)

lagknots <- logknots(30, 3)
```

```
cb.PP <- crossbasis(PP,lag=25,
argvar=list("bs",df=5,degree=4,cen=median(PP)),arglag=lis
t(fun="poly",degree=3))

cb.TEM <- crossbasis(TEM, lag=30,
argvar=list(df=1,cen=median(TEM)),
arglag=list(knots=lagknots))

cb.TMAX <- crossbasis(TMAX, lag=30,
argvar=list(df=1,cen=median(TMAX)),

arglag=list(knots=lagknots))

cb.H4<- crossbasis(H, lag=20,
argvar=list(df=2,cen=median(H)),

arglag=list(knots=lagknots1))

cb.V<- crossbasis(V, lag=20,
argvar=list(df=2,cen=median(V)),

arglag=list(knots=lagknots1))

cb.VV<- crossbasis(VV, lag=20,
argvar=list(df=2,cen=median(VV)),

arglag=list(knots=lagknots1))

cb.VM<- crossbasis(VM, lag=20,
argvar=list(df=2,cen=median(VM)),

arglag=list(knots=lagknots1))

model5 <- glm(Cases ~
cb.TEM+cb.TMAX+cb.PP+cb.H4+cb.VM+cb.VV+as.factor(Year)+as
.factor(Week),family=quasipoisson())

AIC.cc<- -2*sum( dpois( model5$y, model5$fitted.values,
log=TRUE))+

2*summary(model5)$df[3]*summary(model5)$dispersion

AIC.cc

n=294

QIC.cc<- -2*sum( dpois( model5$y, model5$fitted.values,
log=TRUE))+
```

```
log(n)*summary(model5)$df[3]*summary(model5)$dispersion

QIC.cc

pred.TEM <- crosspred(cb.TEM, model5)

plot(pred.TEM, xlab="Mean Temperature", zlab="RR")

plot(pred.TEM, "contour", xlab="Mean Temperature",
key.title=title("RR"),

plot.title=title("Contour plot",xlab="Mean
Temperature",ylab="Lag"))

#pred.TEM2 <- crosspred(cb.TEM, model5,by=1)

#plot(pred.TEM2, "slices", var=27, ci="bars", type="p",
pch=19, ci.level=0.95,

#main="Association with a 1 - unit increase above
threshold (95%CI)",ylab="RR")


#---------MAximum Temperature -------------

pred.TMAX <- crosspred(cb.TMAX, model5)

plot(pred.TMAX, xlab="Maximum Temperature", zlab="RR")

plot(pred.TMAX, "contour", xlab="Maximum Temperature",
key.title=title("RR"),

plot.title=title("Contour plot",xlab="Maximum
Temperature",ylab="Lag"))

#plot(pred.TMAX, "slices", var=c(30,32,34),

#lag=c(15,20,25),ylab="RR")

#pred.TMAX2 <- crosspred(cb.TMAX, model5,by=1)

#plot(pred.TMAX2, "slices", var=30, ci="bars", type="p",
pch=19, ci.level=0.95,

#main="Association with a 1 - unit increase above
threshold (95%CI)",ylab="RR")
```

```
#----------Precipitation---------------

pred.PP <- crosspred(cb.PP, model5)

plot(pred.PP, xlab="Precipitation", zlab="RR")

plot(pred.PP, "contour", xlab="Precipitation",
key.title=title("RR"),

plot.title=title("Contour
plot",xlab="Precipitation",ylab="Lag"))

#pred.PP2 <- crosspred(cb.PP, model5,by=1)

#plot(pred.PP2, "slices", var=10, ci="bars", type="p",
pch=19, ci.level=0.95,

#main="Association with a 1 - unit increase above
threshold (95%CI)",ylab="RR")


#----------Humidity---------------

pred.H4 <- crosspred(cb.H4, model5)

plot(pred.H4, xlab="Humidity", zlab="RR")

plot(pred.H4, "contour", xlab="Humidity",
key.title=title("RR"),

plot.title=title("Contour
plot",xlab="Humidity",ylab="Lag"))

#pred.H42 <- crosspred(cb.H4, model5,by=1)

#plot(pred.H42, "slices", var=65, ci="bars", type="p",
pch=19, ci.level=0.95,

#main="Association with a 1 - unit increase above
threshold (95%CI)",ylab="RR")


#####################----------VV---------------

pred.VV <- crosspred(cb.VV, model5)

plot(pred.VV, xlab="Visibility", zlab="RR")
```

```
plot(pred.VV, "contour", xlab="Visibility",
key.title=title("RR"),

plot.title=title("Contour
plot",xlab="Visibility",ylab="Lag"))

pred.H42 <- crosspred(cb.H4, model5,by=1)

plot(pred.H42, "slices", var=65, ci="bars", type="p",
pch=19, ci.level=0.95,

main="Association with a 1 - unit increase above
threshold (95%CI)",ylab="RR")

####################-----------VM---------------

pred.VM <- crosspred(cb.VM, model5)

plot(pred.VM, xlab="Maximum sustained wind speed",
zlab="RR")

plot(pred.VM, "contour", xlab="Maximum sustained wind
speed", key.title=title("RR"),

plot.title=title("Contour plot",xlab="Maximum sustained
wind speed",ylab="Lag"))

pred.H42 <- crosspred(cb.H4, model5,by=1)

plot(pred.H42, "slices", var=65, ci="bars", type="p",
pch=19, ci.level=0.95,

main="Association with a 1 - unit increase above
threshold (95%CI)",ylab="RR")

acf(model5$resid)

library(car)

qqPlot((model5$resid-
mean(model5$resid))/sd(model5$resid))

ks.test(rnorm(294),(model5$resid-
mean(model5$resid))/sd(model5$resid))
```