Lomé Data

In[1]:=
```
(*longitude*)lon = 1.25315;
(*latitude*) la = 6.17455;
(*elevation*)elv = 19.60;
```

In[4]:=
```
decYear = Drop[Import["/Users/student/Downloads/EnsoSST.csv"][[All, 3]], 1];
ENSO = Drop[Import["/Users/student/Downloads/EnsoSST.csv"][[All, 4]], 1];
SST = Drop[Import["/Users/student/Downloads/EnsoSST.csv"][[All, 5]], 1];
```

In[7]:=
```
year =
  Drop[Import["/Users/student/Downloads/Lome_Clean (1).xlsx"][[1]][[All, 12]], 1];
minTemp = Drop[Import["/Users/student/Downloads/Lome_Clean (1).xlsx"][[1]][[
    All, 13]], 1];
maxTemp = Drop[Import["/Users/student/Downloads/Lome_Clean (1).xlsx"][[1]][[
    All, 6]], 1];
rainfall = Drop[Import["/Users/student/Downloads/Lome_Clean (1).xlsx"][[1]][[
    All, 4]], 1];
```

Defined Functions

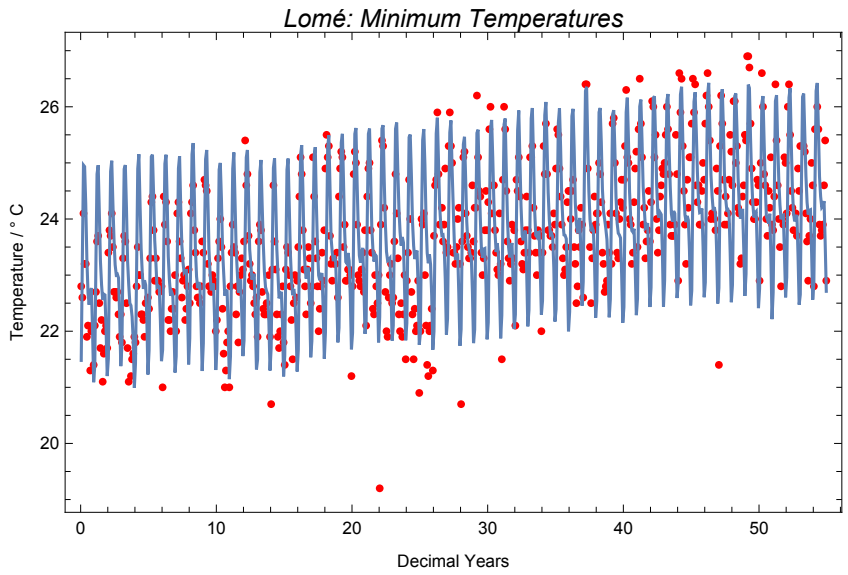
In[11]:=
```
OurSquared[real_, pred_] :=
 Module[{mean = Mean[real], nvals = Length[real]},
  1 - (Sum[(real[[i]] - pred[[i]])^2, {i, 1, nvals}])/(Sum[(real[[i]] - mean)^2, {i, 1, nvals}])
 ]
```

In[12]:=
```
TestResiduals[resids_] :=
 Module[
  {s = StandardDeviation[resids],
   m = Mean[resids], d, lp, table, show},
  d = NormalDistribution[m, s];
  lp = ListPlot[resids, PlotLabel → Lomé];
  DistributionFitTest[resids];
  ℋ = DistributionFitTest[resids, Automatic, "HypothesisTestData"];
  show = Show[
    Histogram[resids, Automatic, "ProbabilityDensity"],
    Plot[PDF[ℋ["FittedDistribution"], x], {x, -5, 5}, PlotStyle → Thick]
   ];
  table = DistributionFitTest[resids, d, {"TestDataTable", "AndersonDarling"}];
  GraphicsGrid[{{lp, show}, {table,
     ProbabilityPlot[resids, d]}}]
 ]
```

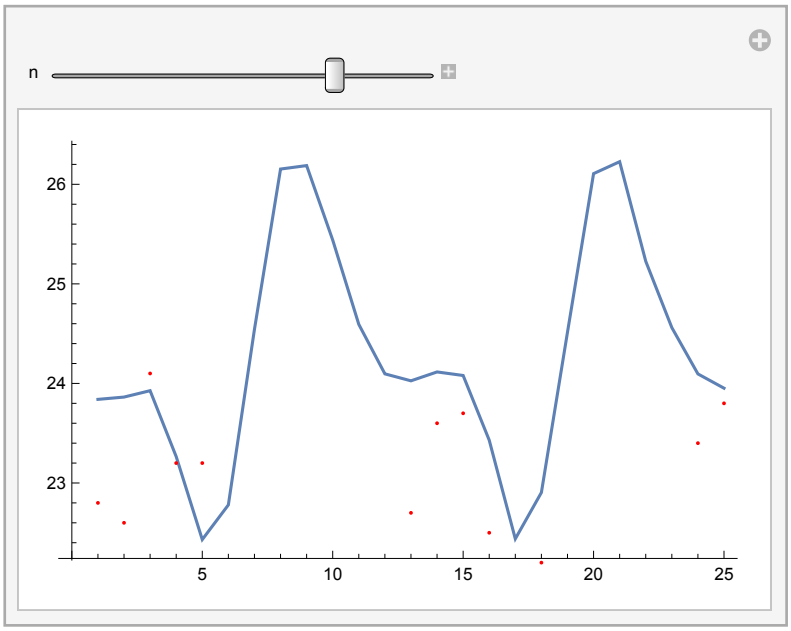
Minimum Model

In[22]:=
```
minModel[x_, sst_, enso_] :=
 31.172254103120295` + 0.027385855676568465` * x + -0.8751637764024659` * Cos[4 π x] +
  0.12959795880303776` * Sin[4 π x] + -1.0016316224214348` * Cos[2 π x] +
  0.5793239334602998` * Sin[2 π x] + -0.22622842355713688` * Cos[6 π x] +
  -0.10277000253591956` * Sin[6 π x] + -0.041988410325544255` * Cos[(2 π x)/13] +
  -0.06166305743032638` * Sin[(2 π x)/13] + 0.07458703707988648` * Cos[(π x)/10] +
  0.028493990756426047` * Sin[(π x)/10] + -0.8802337198643833` * la * lon +
  0.4169986582275888` * la^2 + -3.698245146577038` * lon^2 + -6.224750893928698` * la +
  15.071356816096722` * lon + -0.0015133234173910037` * elv +
  0.2945134843073395` * sst + -0.006160260581052885` * enso
```

Out[24]=



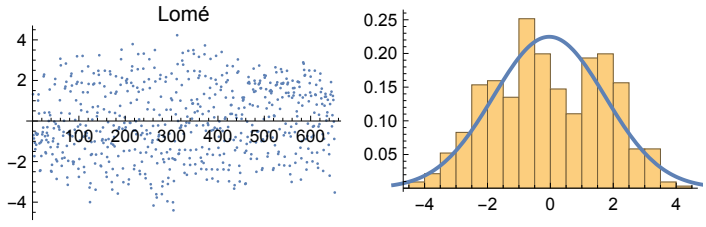
Out[49]=



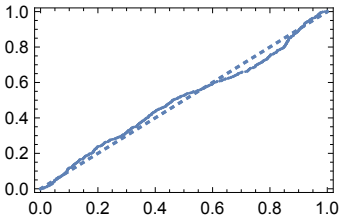
In[25]:=
```
OurSquared[minTemp, minModel[decYear, SST, ENSO]]
```

Out[25]=
```
-1.08348
```

Out[28]=



	Statistic	P-Value
Anderson-Darling	3.56148	0.0143276



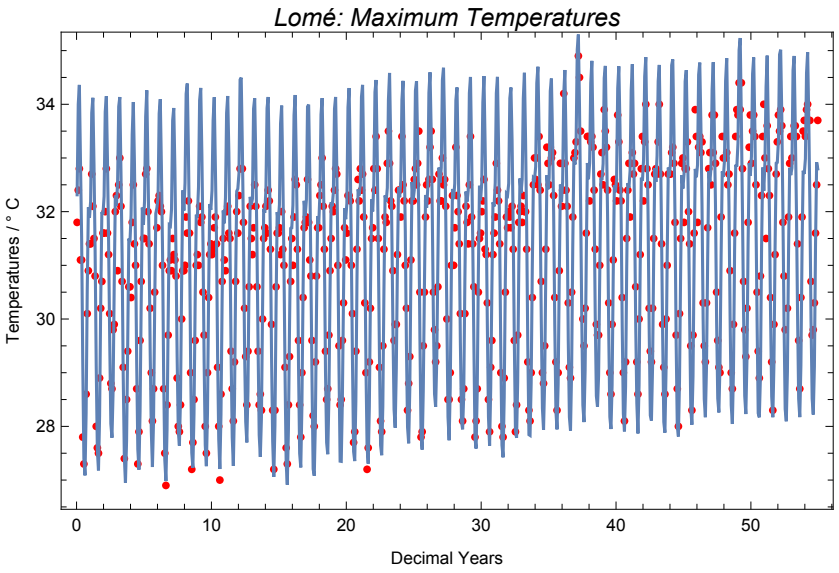
```
minModel["ParameterTable"]
```

	Estimate	Standard Error	t-Statistic	P-Value
1	31.1723	1.6195	19.248	3.60868×10^{-80}
x	0.0273859	0.00105096	26.0578	6.31727×10^{-142}
Cos[4 π x]	−0.875164	0.0213397	−41.011	$1.82840876322 \times 10^{-324}$
Sin[4 π x]	0.129598	0.0334465	3.87479	0.00010785
Cos[2 π x]	−1.00163	0.0378466	−26.4656	4.19076×10^{-146}
Sin[2 π x]	0.579324	0.0655297	8.84064	1.23171×10^{-18}
Cos[6 π x]	−0.226228	0.0201792	−11.211	6.95124×10^{-29}
Sin[6 π x]	−0.10277	0.0201825	−5.09203	3.6503×10^{-7}
$\text{Cos}\left[\frac{2\pi x}{13}\right]$	−0.0419884	0.0214546	−1.95708	0.0503844
$\text{Sin}\left[\frac{2\pi x}{13}\right]$	−0.0616631	0.020688	−2.98063	0.00288811
$\text{Cos}\left[\frac{\pi x}{10}\right]$	0.074587	0.0210807	3.53817	0.000405945
$\text{Sin}\left[\frac{\pi x}{10}\right]$	0.028494	0.0214273	1.3298	0.183634
la lon	−0.880234	0.0783086	−11.2406	5.00596×10^{-29}
la^2	0.416999	0.017142	24.3262	9.22745×10^{-125}
lon^2	−3.69825	0.235169	−15.7259	1.21466×10^{-54}
la	−6.22475	0.284058	−21.9136	1.78139×10^{-102}
lon	15.0714	1.05806	14.2443	2.63051×10^{-45}
elv	−0.00151332	0.000233167	−6.49029	9.25086×10^{-11}
sst	0.294513	0.0386293	7.6241	2.83845×10^{-14}
enso	−0.00616026	0.0013993	−4.40239	0.0000108914

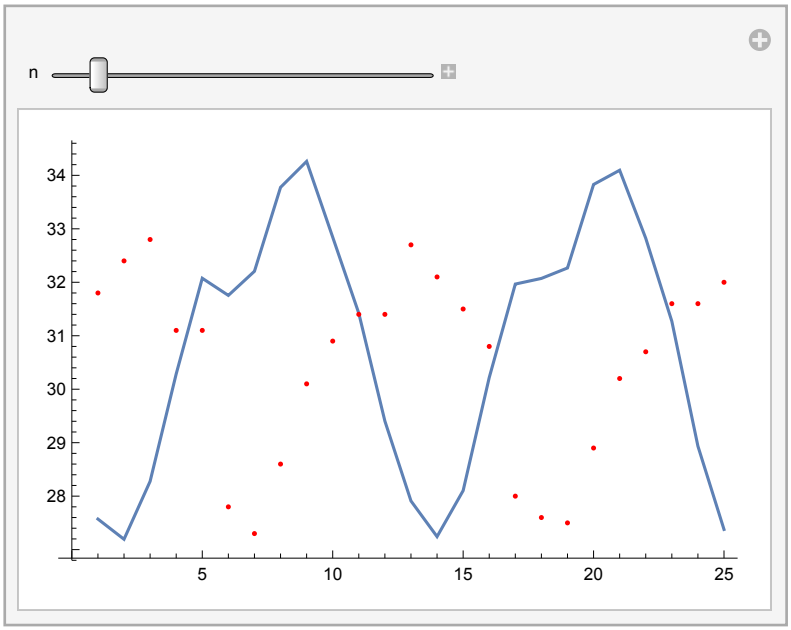
Maximum Model

In[13]:=
```
maxModel[x_, sst_, enso_] :=
 -8.370217764387549` + 0.01284224134394846` * x + -0.5997217902578864` * Cos[4 π x] +
  -0.21332860261725842` * Sin[4 π x] + 1.787110064643319` * Cos[2 π x] +
  1.3408081122027204` * Sin[2 π x] + -0.3963867521214663` * Cos[6 π x] +
  -0.0760526314408311` * Sin[6 π x] + 0.10259139882343443` * Cos[2 π x / 13] +
  -0.06705672848541308` * Sin[2 π x / 13] + -0.16545991546044095` * Cos[8 π x] +
  -0.05782000874783142` * Sin[8 π x] + 0.6296608959862009` * la * lon +
  3.126751308042088` * lon^2 + -0.44202079315121207` * la^2 + 7.723651317866367` * la +
  -11.281035421388053` * lon + -0.008816619804524244` * elv +
  0.47106166411044276` * sst + -0.006627219227896763` * enso
```

Out[15]=



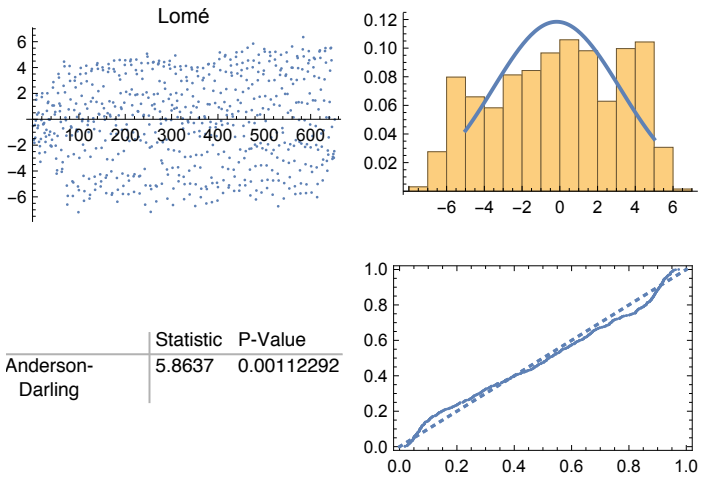
Out[50]=



In[16]:=
```
OurSquared[maxTemp, maxModel[decYear, SST, ENSO]]
```

Out[16]= −2.75327

Out[18]=



	Statistic	P-Value
Anderson-Darling	5.8637	0.00112292

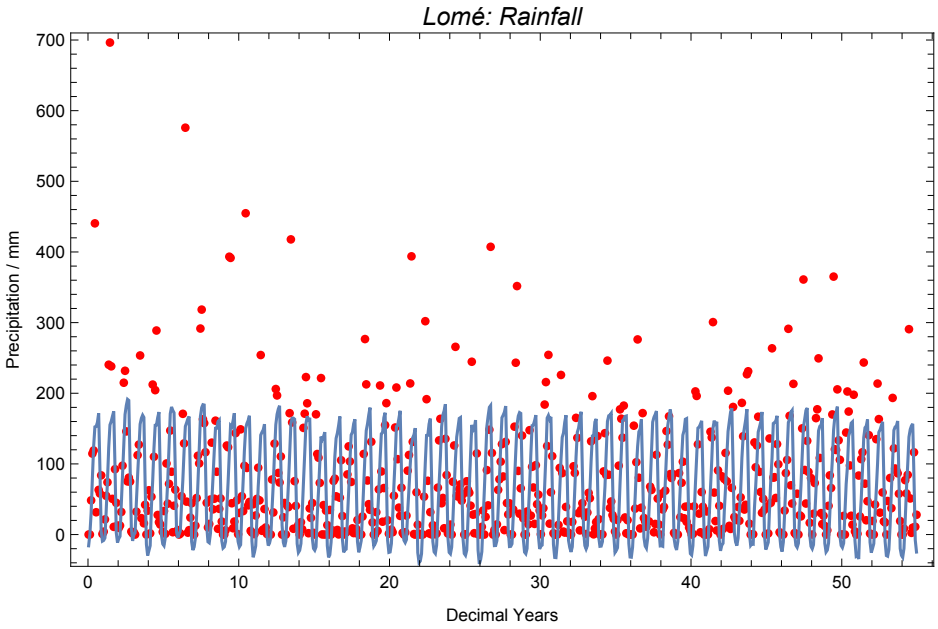
maxModel["ParameterTable"]

	Estimate	Standard Error	t-Statistic	P-Value
1	−8.37022	1.30616	−6.40825	1.58378×10^{-10}
x	0.0128422	0.000833022	15.4164	1.27596×10^{-52}
Cos[4 π x]	−0.599722	0.0174505	−34.367	1.7685×10^{-236}
Sin[4 π x]	−0.213329	0.0269959	−7.90227	3.23376×10^{-15}
Cos[2 π x]	1.78711	0.0305377	58.5214	$4.4364510357 \times 10^{-591}$
Sin[2 π x]	1.34081	0.0525468	25.5165	1.90024×10^{-136}
Cos[6 π x]	−0.396387	0.016529	−23.9812	1.89394×10^{-121}
Sin[6 π x]	−0.0760526	0.0165305	−4.60073	4.29643×10^{-6}
$\text{Cos}\left[\frac{2\pi x}{13}\right]$	0.102591	0.017169	5.97537	2.42721×10^{-9}
$\text{Sin}\left[\frac{2\pi x}{13}\right]$	−0.0670567	0.0167478	−4.00391	0.0000630534
Cos[8 π x]	−0.16546	0.0167302	−9.88988	6.88164×10^{-23}
Sin[8 π x]	−0.05782	0.0164572	−3.51335	0.000445743
la lon	0.629661	0.064053	9.83031	1.23389×10^{-22}
lon^2	3.12675	0.193161	16.1873	1.01584×10^{-57}
la^2	−0.442021	0.0139783	−31.622	3.75068×10^{-203}
la	7.72365	0.231659	33.3407	8.54474×10^{-224}
lon	−11.281	0.866221	−13.0233	2.95944×10^{-38}
elv	−0.00881662	0.00018995	−46.4154	$2.95101436728 \times 10^{-402}$
sst	0.471062	0.0309032	15.2432	1.66271×10^{-51}
enso	−0.00662722	0.00114548	−5.78553	7.59258×10^{-9}

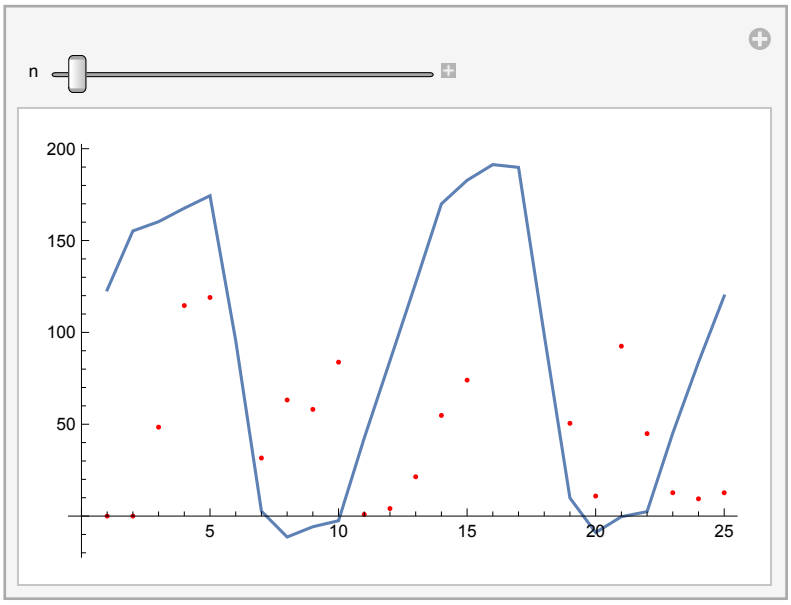
Rainfall Model

In[19]:=
```
rainfallModel[x_, sst_, enso_] :=
 -765.0902446275039` + -0.12388985589997356` * x + -33.96626612793046` * Sin[2 π x] +
  -66.7649721921797` * Cos[2 π x] + 19.589235176494007` * Sin[4 π x] +
  -20.833393871896597` * Cos[4 π x] + 8.985167676158206` * Sin[6 π x] +
  -1.0239431053431751` * Cos[6 π x] + -6.430606755528327` * Sin[8 π x] +
  6.175963585212828` * Cos[8 π x] + 231.44501875965295` * la +
  28.922922751700945` * la * lon + -14.194553415250773` * la^2 +
  -495.8774868055935` * lon + 130.9220050919206` * lon^2 +
  -0.135764075867611` * elv + 3.1135832174648366` * minModel[x, sst, enso] +
  -23.472635997948792` * maxModel[x, sst, enso] +
  0.15615745123884783` * enso + 29.330300300689828` * sst
```

Out[30]=



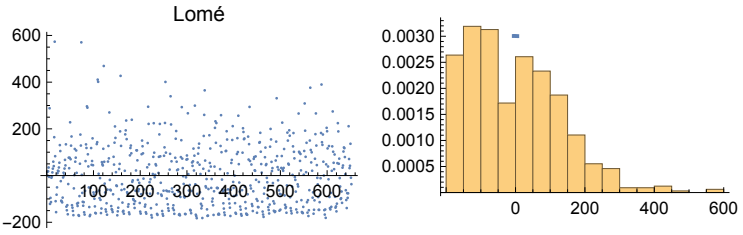
Out[51]=



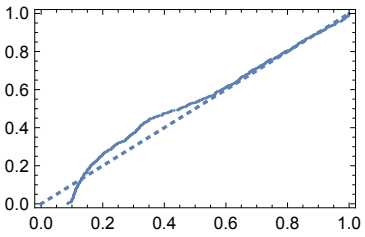
In[31]:=
```
OurSquared[rainfall, rainfallModel[decYear, SST, ENSO]]
```

Out[31]= −1.3854

Out[33]=



	Statistic	P-Value
Anderson-Darling	8.88789	0.0000454479



```
finalrain["ParameterTable"]
```

	Estimate	Standard Error	t-Statistic	P-Value
1	−765.09	92.6331	−8.25936	1.79429×10^{-16}
x	−0.12389	0.0597381	−2.07389	0.0381336
Sin[2 π x]	−33.9663	3.74731	−9.06417	1.68258×10^{-19}
Cos[2 π x]	−66.765	2.79576	−23.8808	2.37816×10^{-120}
Sin[4 π x]	19.5892	1.84317	10.628	3.81773×10^{-26}
Cos[4 π x]	−20.8334	1.39075	−14.9799	8.25143×10^{-50}
Sin[6 π x]	8.98517	1.12061	8.01808	1.2869×10^{-15}
Cos[6 π x]	−1.02394	1.17173	−0.87387	0.382225
Sin[8 π x]	−6.43061	1.11477	−5.76856	8.40481×10^{-9}
Cos[8 π x]	6.17596	1.13936	5.42054	6.17957×10^{-8}
lat	231.445	18.1894	12.7242	1.3217×10^{-36}
lat long	28.9229	4.43949	6.51492	7.8801×10^{-11}
lat^2	−14.1946	1.09944	−12.9107	1.27351×10^{-37}
long	−495.877	60.8717	−8.14627	4.54947×10^{-16}
$long^2$	130.922	13.6987	9.55728	1.73387×10^{-21}
elev	−0.135764	0.0150682	−9.00995	2.74382×10^{-19}
mint	3.11358	0.735383	4.23396	0.0000233127
maxt	−23.4726	0.894904	−26.2292	1.84799×10^{-143}
enso	0.156157	0.0749559	2.08332	0.037265
sstt	29.3303	2.14765	13.6569	7.99257×10^{-42}

Summary

Lomé's maritime climate due to its location on the coast of the Atlantic Ocean leads us to expect a narrower range of temperatures and higher amounts of precipitation through its two-rainy season system. The minimum monthly temperatures spanned 19.2-26.9°C, and the maximum monthly temperatures spanned 26.9-34.9°C. Lome had consistent levels of precipitation across months with the "driest" months being January and December and the "wettest" being May and June. The country model generated for minimum temperatures runs through the center of the temperature data points, excluding the more extreme points both above and below its range. Upon closer examination it is apparent the oscillations within the minimum temperature dataset are ill-matched to the model's. The OurSquared value was -1.08348 and the produced residuals were not normal, as they failed the Anderson-Darling Test. The country model for maximum temperatures better enveloped the data within its range and the oscillations within the data were more accurately captured by this model. However, the OurSquared value was -2.75327 and the residuals were not normal as decided by the Anderson-Darling Test. Out of all of the models produced, the rainfall model appeared to yield the worst results. While its range captured data points on the lower end, it left points above 200mm to be outliers. Rainfall levels above 200 mm are common during the height of first rainy season, and thus are important for the model to capture in order to accurately depict rainfall in Lomé. The OurSquared value for the fit was -1.3854 and the residuals were decidedly not normal as they failed the Anderson-Darling Test.