El-NINO34 SVR Regressor

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SST GCOS Data

http://www.esrl.noaa.gov/psd/gcos_wgsp/Timeseries/Nino34/

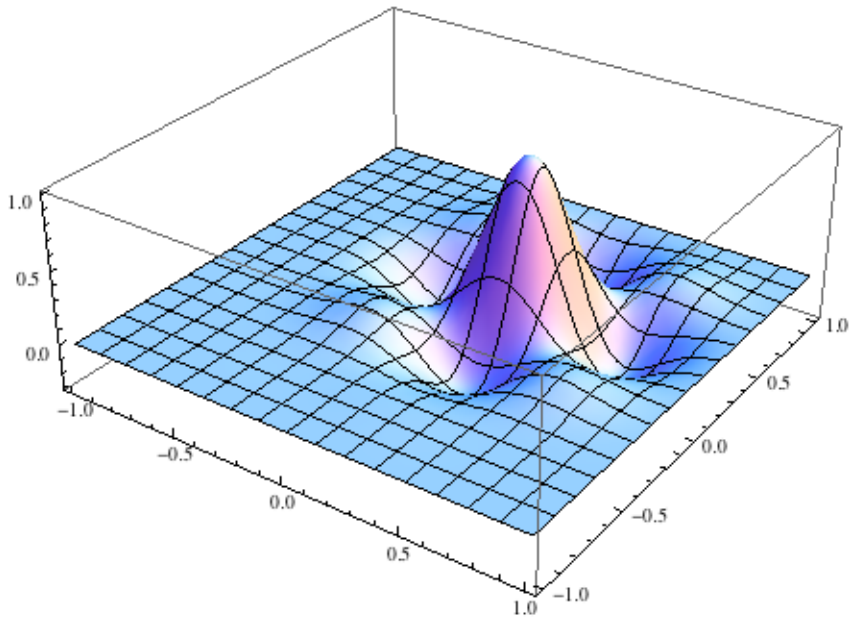
1870	25.58	26.16	26.31	27.19	28.05	26.61	26.19	25.99	26.22	25.82	25.86	25.79
1871	26.33	26.18	26.83	27.27	27.16	27.16	26.62	26.54	26.51	26.40	26.35	26.01
1872	25.86	26.14	26.76	27.00	27.25	27.16	26.91	26.02	25.73	25.79	25.86	25.71
...												
2011	24.88	25.50	26.27	27.03	27.34	27.43	27.00	26.22	25.99	25.81	25.56	25.54
2012	25.65	26.15	26.78	27.48	27.69	27.82	27.66	27.54	27.19	26.96	26.98	26.45
2013	26.16	26.36	27.12	27.69	27.59	27.36	26.94	26.59	26.66	26.49	26.64	26.50

Support Vector Regression

Kernel: Wavelet

$$K(x, y) = \prod_{i=1}^{n} \left(\cos\left[1.75 \frac{x_i - y_i}{a}\right] e^{-\frac{(x_i - y_i)^2}{2a^2}} \right)$$

3D visualization(y kept constant), note the compact support:



Past 61 months used as input for learning:

Dates format **{x_1, x_2} = {month, year}** 144 is 2013

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{{12, 139}, {1, 140}, {2, 140}, {3, 140}, {4, 140}, {5, 140}, {6, 140}, {7, 140},
 {8, 140}, {9, 140}, {10, 140}, {11, 140}, {12, 140}, {1, 141}, {2, 141},
 {3, 141}, {4, 141}, {5, 141}, {6, 141}, {7, 141}, {8, 141}, {9, 141}, {10, 141},
 {11, 141}, {12, 141}, {1, 142}, {2, 142}, {3, 142}, {4, 142}, {5, 142}, {6, 142},
 {7, 142}, {8, 142}, {9, 142}, {10, 142}, {11, 142}, {12, 142}, {1, 143},
 {2, 143}, {3, 143}, {4, 143}, {5, 143}, {6, 143}, {7, 143}, {8, 143}, {9, 143},
 {10, 143}, {11, 143}, {12, 143}, {1, 144}, {2, 144}, {3, 144}, {4, 144}, {5, 144},
 {6, 144}, {7, 144}, {8, 144}, {9, 144}, {10, 144}, {11, 144}, {12, 144}}
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The tuples above are the input to the SVR Regressor equation. The regressor has two variables x_1, x_2 as specified above for date.

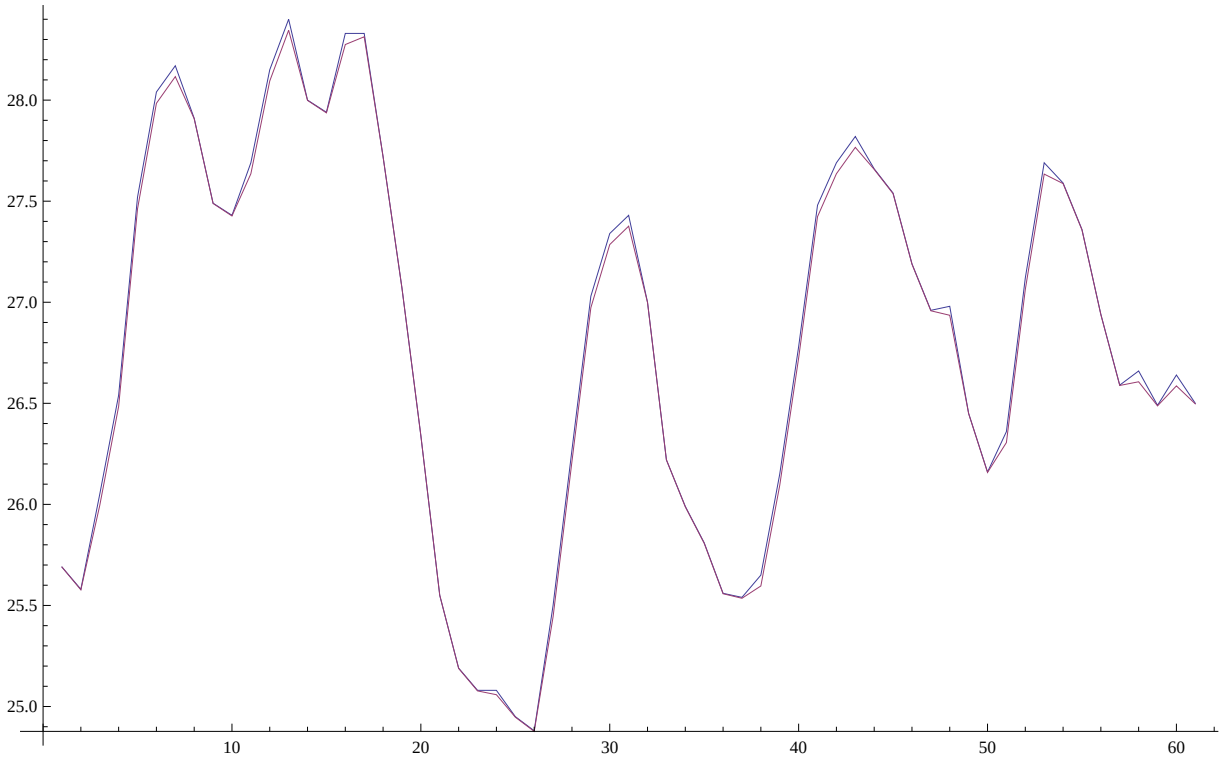
El-Nino 3.4 data:

```
{25.69, 25.58, 26.05, 26.54, 27.52, 28.04, 28.17, 27.91, 27.49, 27.43,
 27.69, 28.15, 28.4, 28., 27.94, 28.33, 28.33, 27.72, 27.07, 26.34, 25.55,
 25.19, 25.08, 25.08, 24.95, 24.88, 25.5, 26.27, 27.03, 27.34, 27.43,
 27., 26.22, 25.99, 25.81, 25.56, 25.54, 25.65, 26.15, 26.78, 27.48,
 27.69, 27.82, 27.66, 27.54, 27.19, 26.96, 26.98, 26.45, 26.16, 26.36,
 27.12, 27.69, 27.59, 27.36, 26.94, 26.59, 26.66, 26.49, 26.64, 26.5}
```

Regressor forecasts **next month's** El Nino 3.4 given **this month's** i.e. 1-month ahead:

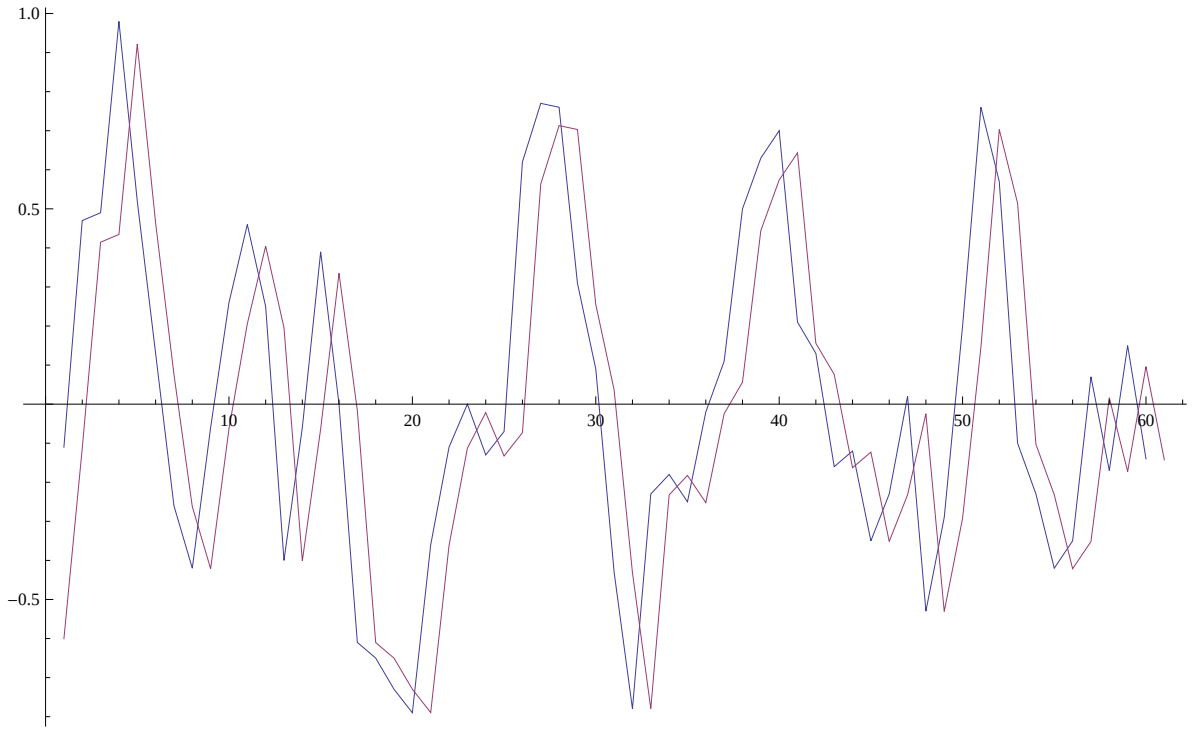
```
{25.6896, 25.5772, 25.9946, 26.4844, 27.462, 27.9843, 28.1162, 27.9079, 27.4887,
 27.4268, 27.6356, 28.0945, 28.3456, 27.9987, 27.9369, 28.275, 28.3134, 27.7196,
 27.0698, 26.3402, 25.5505, 25.1884, 25.0772, 25.0584, 24.9473, 24.8769, 25.4438,
 26.213, 26.9731, 27.2853, 27.3764, 26.9987, 26.2205, 25.9878, 25.8075, 25.5579,
 25.5354, 25.5963, 26.0944, 26.7238, 27.4234, 27.6358, 27.7662, 27.6574, 27.5372,
 27.1884, 26.9578, 26.9355, 26.4493, 26.1581, 26.3059, 27.0631, 27.6341,
 27.5871, 27.3578, 26.9387, 26.5883, 26.6065, 26.4874, 26.5862, 26.4973}
```

Blue El Nino 3.4, Red Regressor based forecast 1-month before:



Monthly Error average 0.025.

This is the plot of delta values, Blue is the actual El-Nino 3.4 data and the Red is based on the SVR regressor, as you can see the Red lags behind a bit since it is learning from the progress of the signal onwards and adjusts like in a chase:



Regressor's Equation

$$
\begin{aligned}
&-0.0215953 - 0.579568\, e^{-5.55556\,(12-x_1)^2-5.55556\,(139-x_2)^2}\cos[5.83333\,(12-x_1)]\cos[5.83333\,(139-x_2)] - \\
&0.0914334\, e^{-5.55556\,(1-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(1-x_1)]\cos[5.83333\,(140-x_2)] + \\
&0.435062\, e^{-5.55556\,(2-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(2-x_1)]\cos[5.83333\,(140-x_2)] + 0.450012\, e^{-5.55556\,(3-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(3-x_1)]\cos[5.83333\,(140-x_2)] + \\
&0.940359\, e^{-5.55556\,(4-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(4-x_1)]\cos[5.83333\,(140-x_2)] + 0.484311\, e^{-5.55556\,(5-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(5-x_1)]\cos[5.83333\,(140-x_2)] + \\
&0.0991191\, e^{-5.55556\,(6-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(6-x_1)]\cos[5.83333\,(140-x_2)] - \\
&0.237045\, e^{-5.55556\,(7-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(7-x_1)]\cos[5.83333\,(140-x_2)] - 0.396083\, e^{-5.55556\,(8-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(8-x_1)]\cos[5.83333\,(140-x_2)] - \\
&0.0397926\, e^{-5.55556\,(9-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(9-x_1)]\cos[5.83333\,(140-x_2)] + \\
&0.226128\, e^{-5.55556\,(10-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(10-x_1)]\cos[5.83333\,(140-x_2)] + \\
&0.424602\, e^{-5.55556\,(11-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(11-x_1)]\cos[5.83333\,(140-x_2)] + \\
&0.21814\, e^{-5.55556\,(12-x_1)^2-5.55556\,(140-x_2)^2}\cos[5.83333\,(12-x_1)]\cos[5.83333\,(140-x_2)] - \\
&0.379098\, e^{-5.55556\,(1-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(1-x_1)]\cos[5.83333\,(141-x_2)] - \\
&0.0449544\, e^{-5.55556\,(2-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(2-x_1)]\cos[5.83333\,(141-x_2)] + \\
&0.352593\, e^{-5.55556\,(3-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(3-x_1)]\cos[5.83333\,(141-x_2)] - \\
&9.42951\times 10^{-9}\, e^{-5.55556\,(4-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(4-x_1)]\cos[5.83333\,(141-x_2)] - \\
&0.589253\, e^{-5.55556\,(5-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(5-x_1)]\cos[5.83333\,(141-x_2)] - \\
&0.624673\, e^{-5.55556\,(6-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(6-x_1)]\cos[5.83333\,(141-x_2)] - 0.701155\, e^{-5.55556\,(7-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(7-x_1)]\cos[5.83333\,(141-x_2)] - \\
&0.760264\, e^{-5.55556\,(8-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(8-x_1)]\cos[5.83333\,(141-x_2)] - 0.336164\, e^{-5.55556\,(9-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(9-x_1)]\cos[5.83333\,(141-x_2)] - \\
&0.0902757\, e^{-5.55556\,(10-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(10-x_1)]\cos[5.83333\,(141-x_2)] - \\
&3.97519\times 10^{-9}\, e^{-5.55556\,(11-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(11-x_1)]\cos[5.83333\,(141-x_2)] - \\
&0.11191\, e^{-5.55556\,(12-x_1)^2-5.55556\,(141-x_2)^2}\cos[5.83333\,(12-x_1)]\cos[5.83333\,(141-x_2)] - \\
&0.0524428\, e^{-5.55556\,(1-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(1-x_1)]\cos[5.83333\,(142-x_2)] + \\
&0.581586\, e^{-5.55556\,(2-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(2-x_1)]\cos[5.83333\,(142-x_2)] + 0.726829\, e^{-5.55556\,(3-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(3-x_1)]\cos[5.83333\,(142-x_2)] + \\
&0.718913\, e^{-5.55556\,(4-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(4-x_1)]\cos[5.83333\,(142-x_2)] + 0.275632\, e^{-5.55556\,(5-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(5-x_1)]\cos[5.83333\,(142-x_2)] + \\
&0.0602791\, e^{-5.55556\,(6-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(6-x_1)]\cos[5.83333\,(142-x_2)] - \\
&0.404324\, e^{-5.55556\,(7-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(7-x_1)]\cos[5.83333\,(142-x_2)] - \\
&0.752805\, e^{-5.55556\,(8-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(8-x_1)]\cos[5.83333\,(142-x_2)] - 0.205146\, e^{-5.55556\,(9-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(9-x_1)]\cos[5.83333\,(142-x_2)] - \\
&0.158312\, e^{-5.55556\,(10-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(10-x_1)]\cos[5.83333\,(142-x_2)] - \\
&0.229949\, e^{-5.55556\,(11-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(11-x_1)]\cos[5.83333\,(142-x_2)] - \\
&1.78777\times 10^{-6}\, e^{-5.55556\,(12-x_1)^2-5.55556\,(142-x_2)^2}\cos[5.83333\,(12-x_1)]\cos[5.83333\,(142-x_2)] + \\
&0.0774218\, e^{-5.55556\,(1-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(1-x_1)]\cos[5.83333\,(143-x_2)] + \\
&0.461074\, e^{-5.55556\,(2-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(2-x_1)]\cos[5.83333\,(143-x_2)] + 0.586415\, e^{-5.55556\,(3-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(3-x_1)]\cos[5.83333\,(143-x_2)] + \\
&0.657977\, e^{-5.55556\,(4-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(4-x_1)]\cos[5.83333\,(143-x_2)] + 0.174108\, e^{-5.55556\,(5-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(5-x_1)]\cos[5.83333\,(143-x_2)] + \\
&0.0981947\, e^{-5.55556\,(6-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(6-x_1)]\cos[5.83333\,(143-x_2)] - \\
&0.138204\, e^{-5.55556\,(7-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(7-x_1)]\cos[5.83333\,(143-x_2)] - \\
&0.0958093\, e^{-5.55556\,(8-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(8-x_1)]\cos[5.83333\,(143-x_2)] - \\
&0.328345\, e^{-5.55556\,(9-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(9-x_1)]\cos[5.83333\,(143-x_2)] - \\
&0.208401\, e^{-5.55556\,(10-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(10-x_1)]\cos[5.83333\,(143-x_2)] + \\
&6.92875\times 10^{-13}\, e^{-5.55556\,(11-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(11-x_1)]\cos[5.83333\,(143-x_2)] - \\
&0.508692\, e^{-5.55556\,(12-x_1)^2-5.55556\,(143-x_2)^2}\cos[5.83333\,(12-x_1)]\cos[5.83333\,(143-x_2)] - \\
&0.271201\, e^{-5.55556\,(1-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(1-x_1)]\cos[5.83333\,(144-x_2)] + 0.164289\, e^{-5.55556\,(2-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(2-x_1)]\cos[5.83333\,(144-x_2)] + \\
&0.720208\, e^{-5.55556\,(3-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(3-x_1)]\cos[5.83333\,(144-x_2)] + 0.53114\, e^{-5.55556\,(4-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(4-x_1)]\cos[5.83333\,(144-x_2)] - \\
&0.0830489\, e^{-5.55556\,(5-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(5-x_1)]\cos[5.83333\,(144-x_2)] - \\
&0.209318\, e^{-5.55556\,(6-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(6-x_1)]\cos[5.83333\,(144-x_2)] - \\
&0.39735\, e^{-5.55556\,(7-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(7-x_1)]\cos[5.83333\,(144-x_2)] - 0.328492\, e^{-5.55556\,(8-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(8-x_1)]\cos[5.83333\,(144-x_2)] + \\
&0.0409516\, e^{-5.55556\,(9-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(9-x_1)]\cos[5.83333\,(144-x_2)] - \\
&0.150784\, e^{-5.55556\,(10-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(10-x_1)]\cos[5.83333\,(144-x_2)] + \\
&0.118706\, e^{-5.55556\,(11-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(11-x_1)]\cos[5.83333\,(144-x_2)] - \\
&0.11976\, e^{-5.55556\,(12-x_1)^2-5.55556\,(144-x_2)^2}\cos[5.83333\,(12-x_1)]\cos[5.83333\,(144-x_2)]
\end{aligned}
$$