Nino 3.4 from HADISST1: Wavelet Analysis

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SST GCOS Data

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

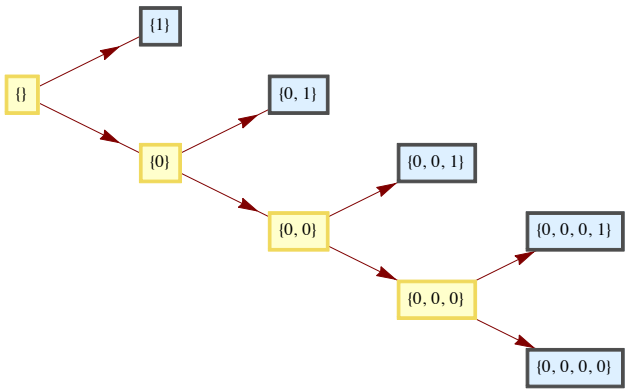
1870	25.58	26.16	26.31	27.19	28.05	26.61	26.19	25.99	26.22	25.82	25.86	25.79
1871	26.33	26.18	26.83	27.27	27.16	27.16	26.62	26.54	26.51	26.40	26.35	26.01
1872	25.86	26.14	26.76	27.00	27.25	27.16	26.91	26.02	25.73	25.79	25.86	25.71
...												
2011	24.88	25.50	26.27	27.03	27.34	27.43	27.00	26.22	25.99	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

Wavelet Decomposition

Daubechies Wavelet[4], padding extrapolated i.e. additional (interpolated) data added to match the indices in the mathematics of the wavelet e.g. to be power of 2.

Refinement Index

This tree renders how the original signal is broken into sub-signals:



Each index as an identifier e.g. {0, 1} identifies a decomposition. Examples:

{} is the original signal

The wavelet decomposes {} into two:

{1} and {0}, each signals of the same length, such that

{} = {0} + {1}

Then the wavelet decomposition decomposes the {0} to {0, 0} and {0,1}, each a signal of same length such that:

{0} = {0,0} + {0,1}

And so on.

The following is a way to measure how much each decomposition contributes to the original signal:

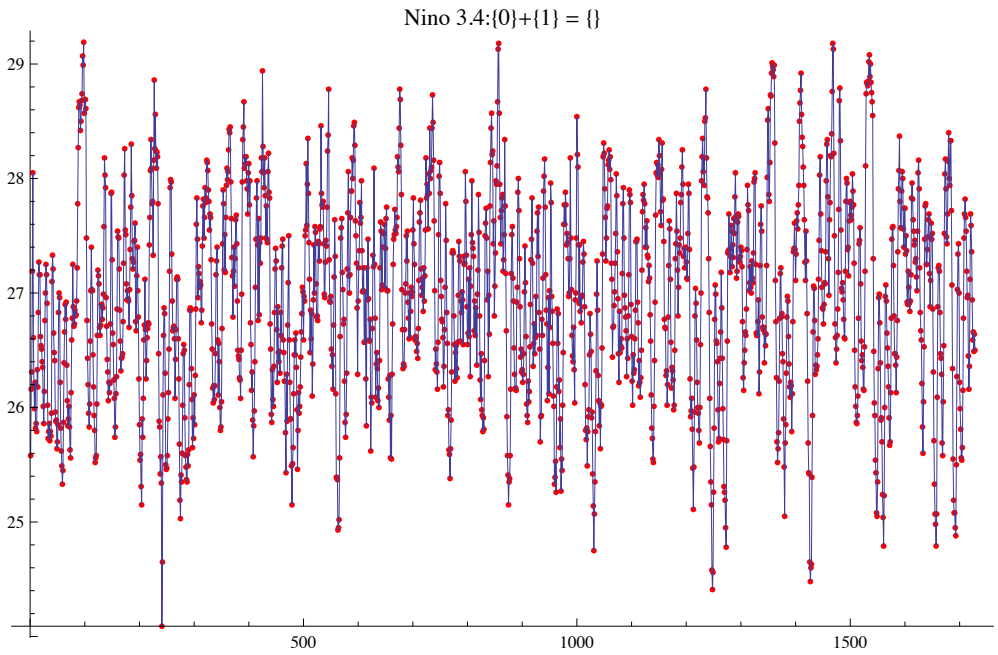
```
{{1} → 0.0000247928, {0, 1} → 0.000101315, {0, 0, 1} → 0.000211335,
 {0, 0, 0, 1} → 0.000207313, {0, 0, 0, 0} → 0.999455}
```

As you can see {0,0,0,0}→0.999455 or most of the signal is {0,0,0,0}. **Therefore the original signal really has one strong Trend and few fainter higher frequency sub-signals.**

Let's look at the said decompositions graphically:

Red dots are the original data and the blue line-segmented curve the decomposition.

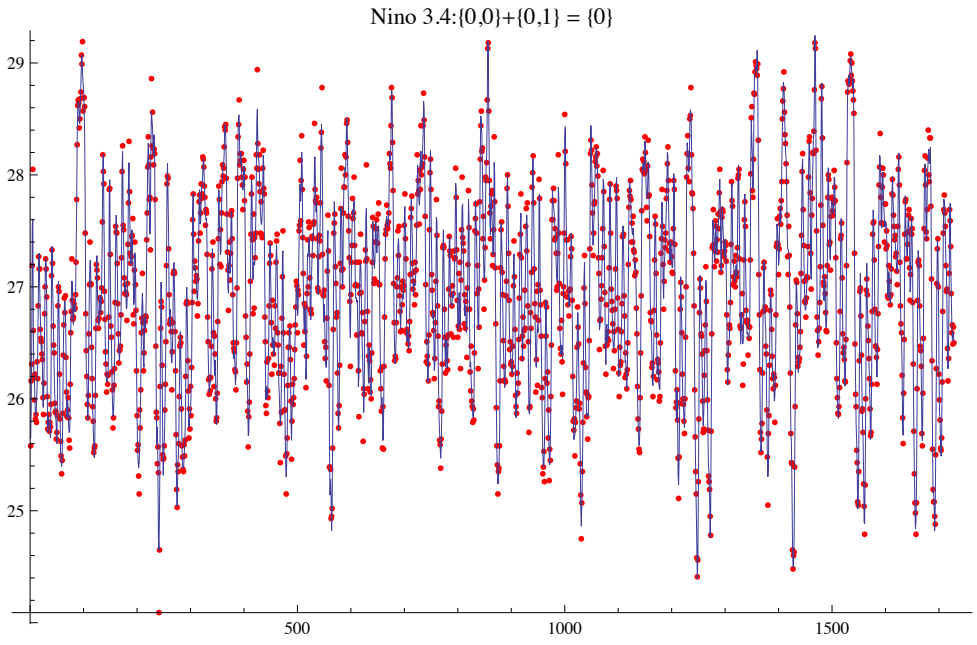
Level {}



Note: *0 is 1866, 1728 is 2013, units month*

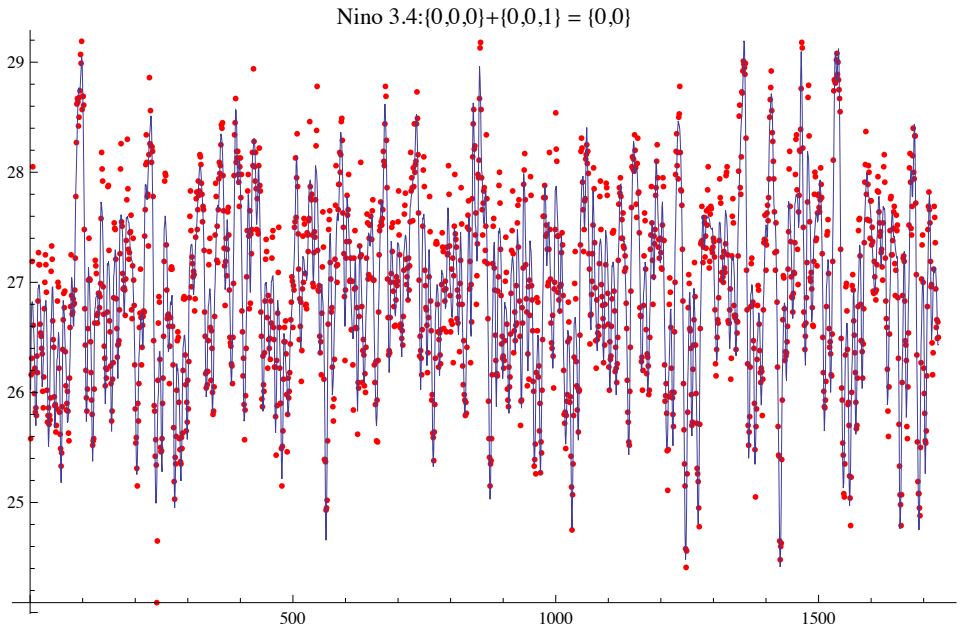
Level {0}

The blue curve is a bit off and not matching the data but still oscillating fast like the original signal



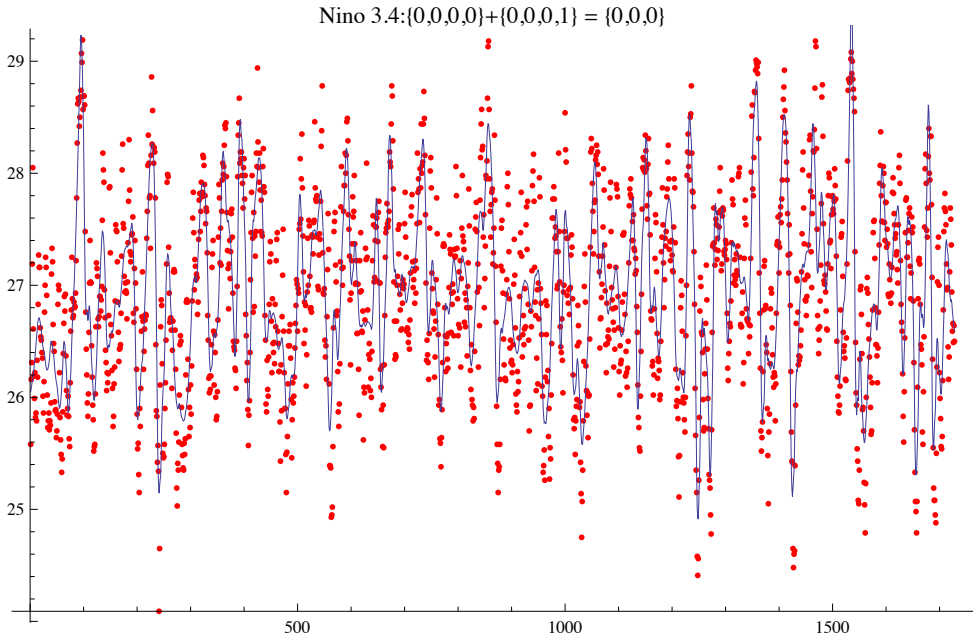
Level {0,0}

A little bit less oscillation and further away from the original data



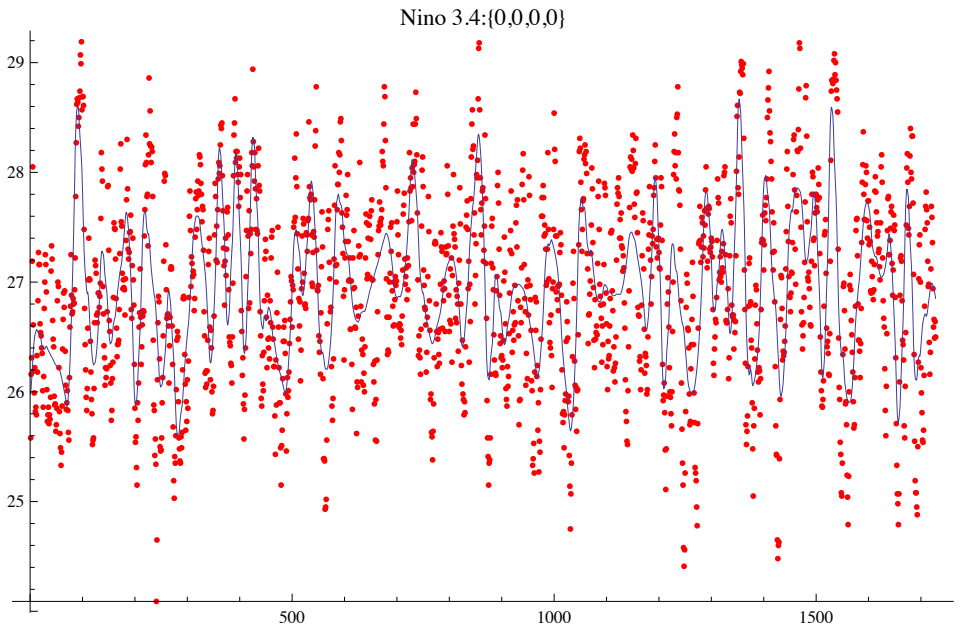
Level {0,0,0}

Way off and much less oscillation:



Level {0,0,0,0}

Finally the Trend!



Localized Time-Frequency Map

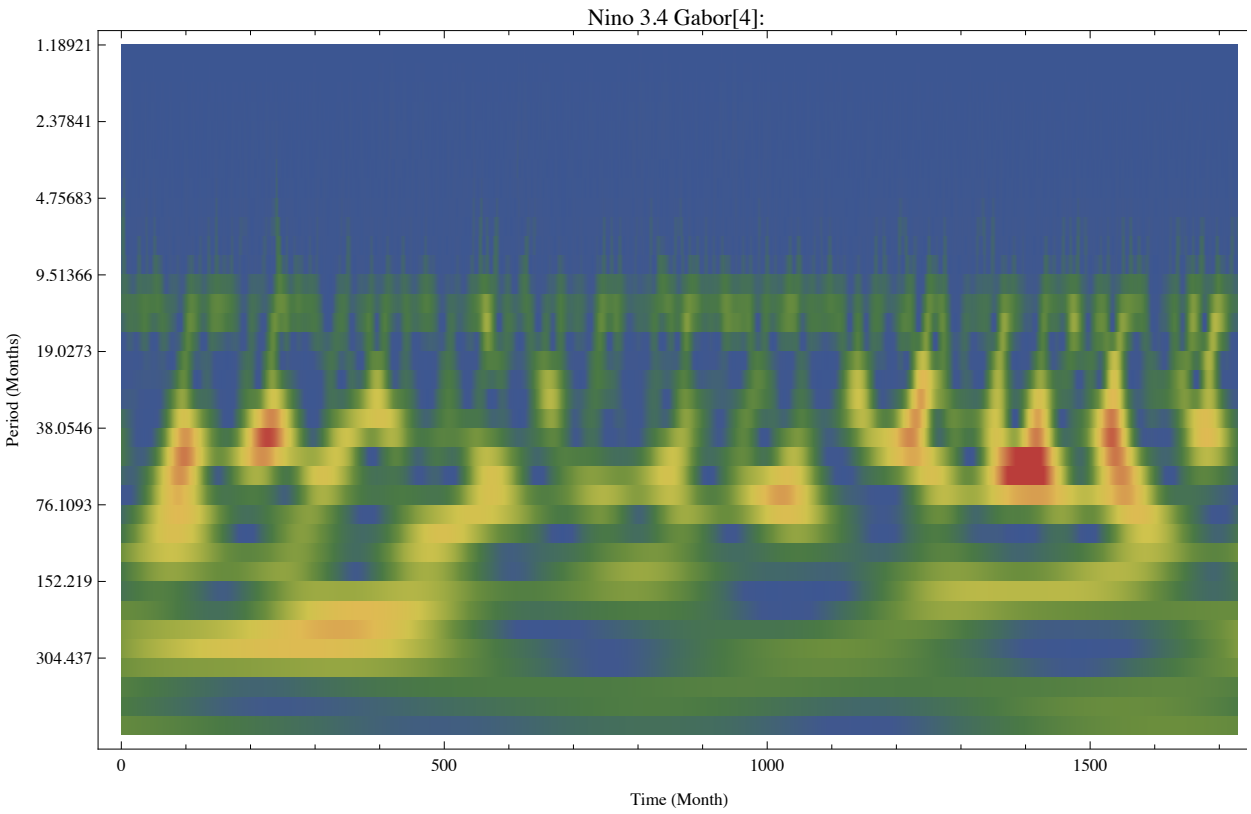
Scalograms

Gabor Wavelet [4] , un-padded.

Color Scheme: Blue Min, Red Max

Scalogram is an innovation that allows for reading the results of the Wavelet decompositions in a speedy visual manner.

x-axis is time and y-axis frequency (Periodicity). At each point (x, y), pixel, on the 2D canvas the amplitude for a particular frequency y at time x is color coded into the pixel.



12-20 month periodicity is quite visible which tell tales of planetary yearly periods.

20-38 month periodicity is on & off has strong amplitude specially the past 500 months.