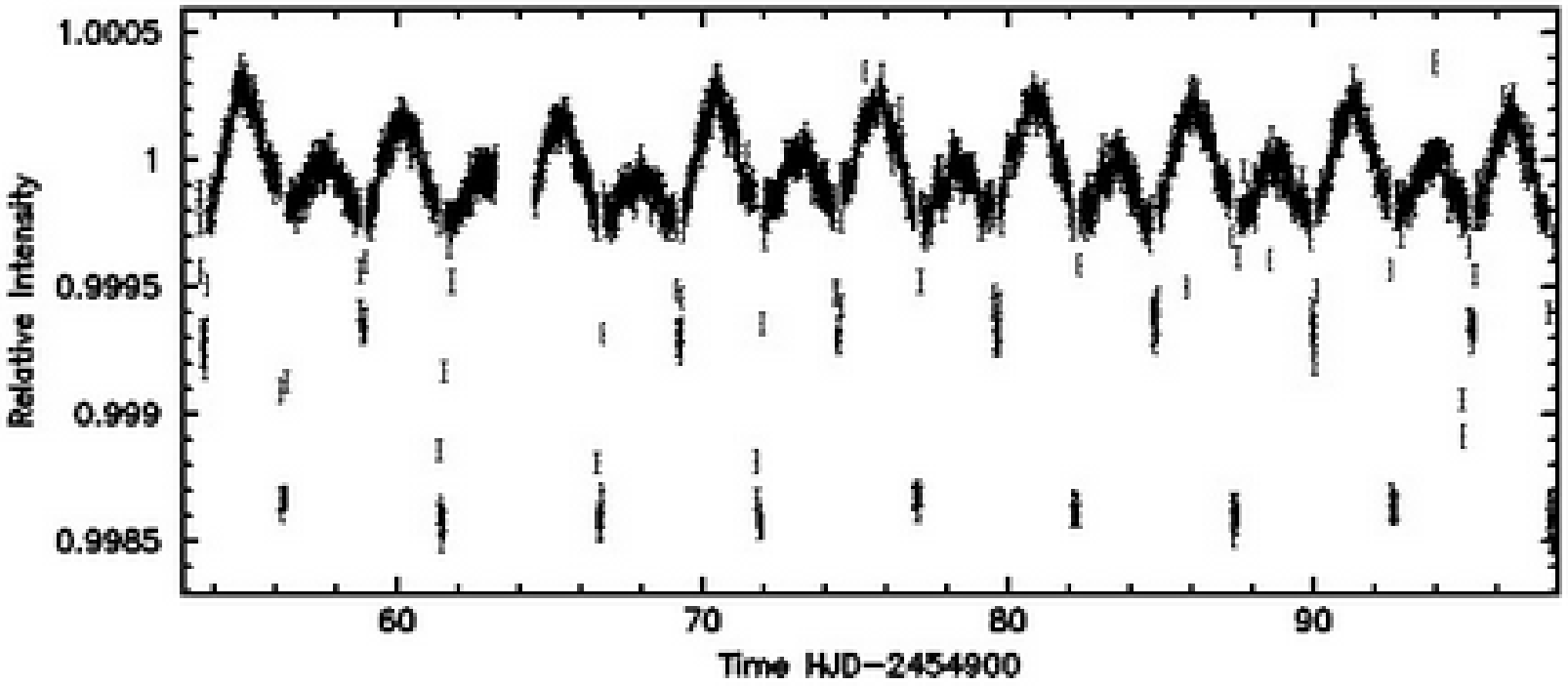
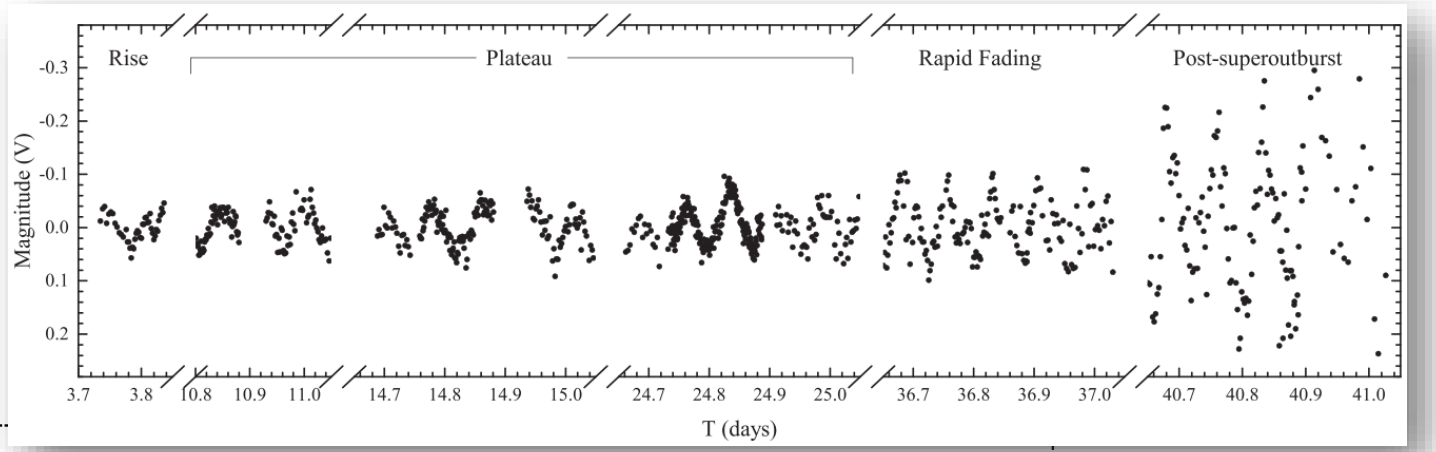
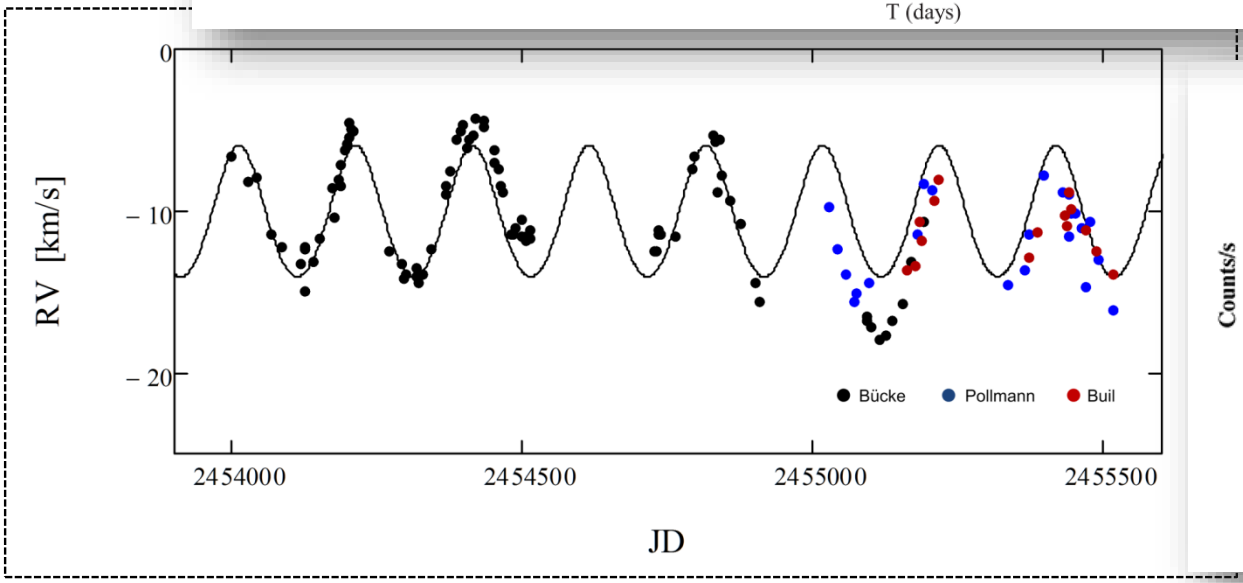
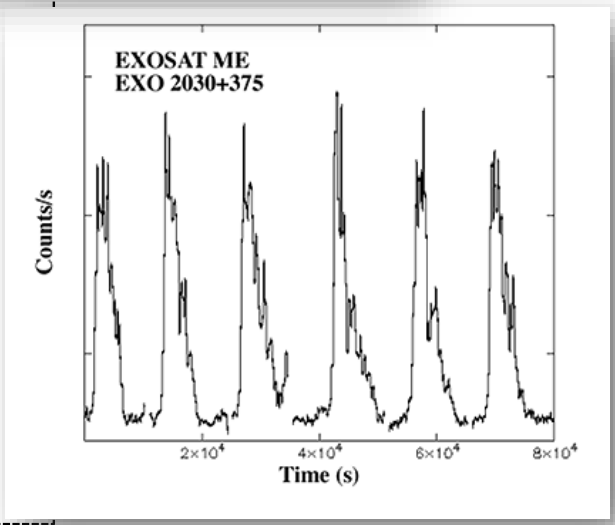
Simplest methods of Time Series Analysis



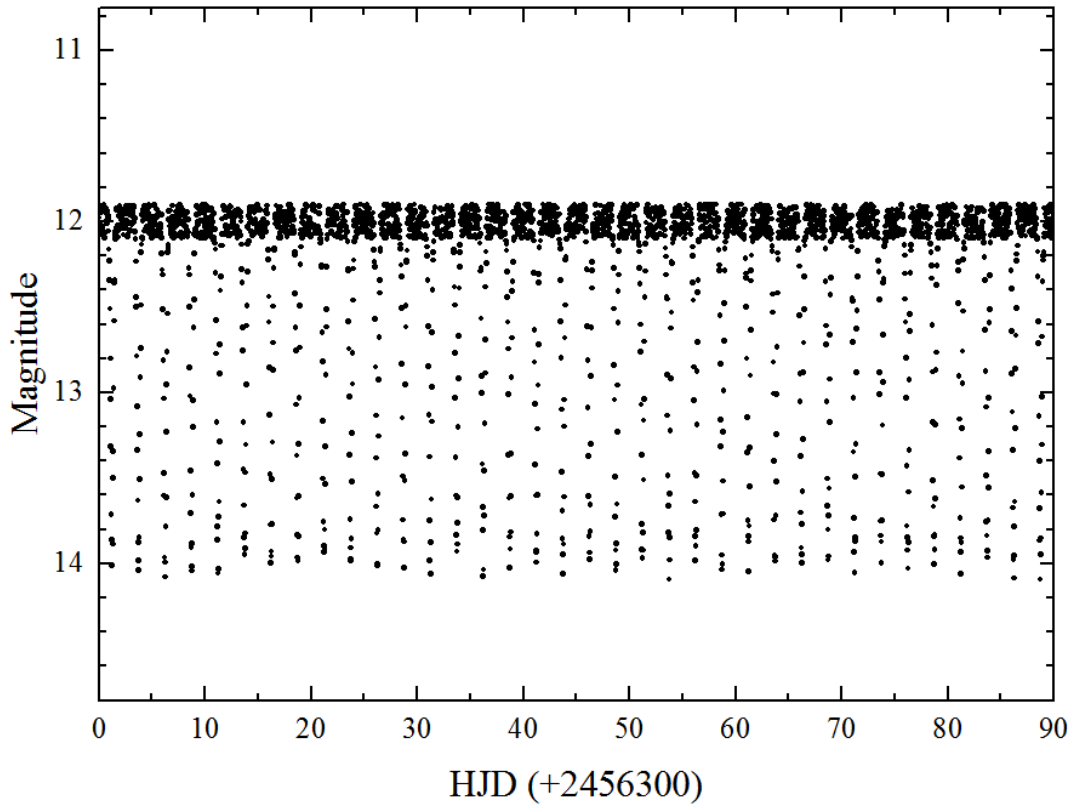
Simplest methods of Time Series Analysis





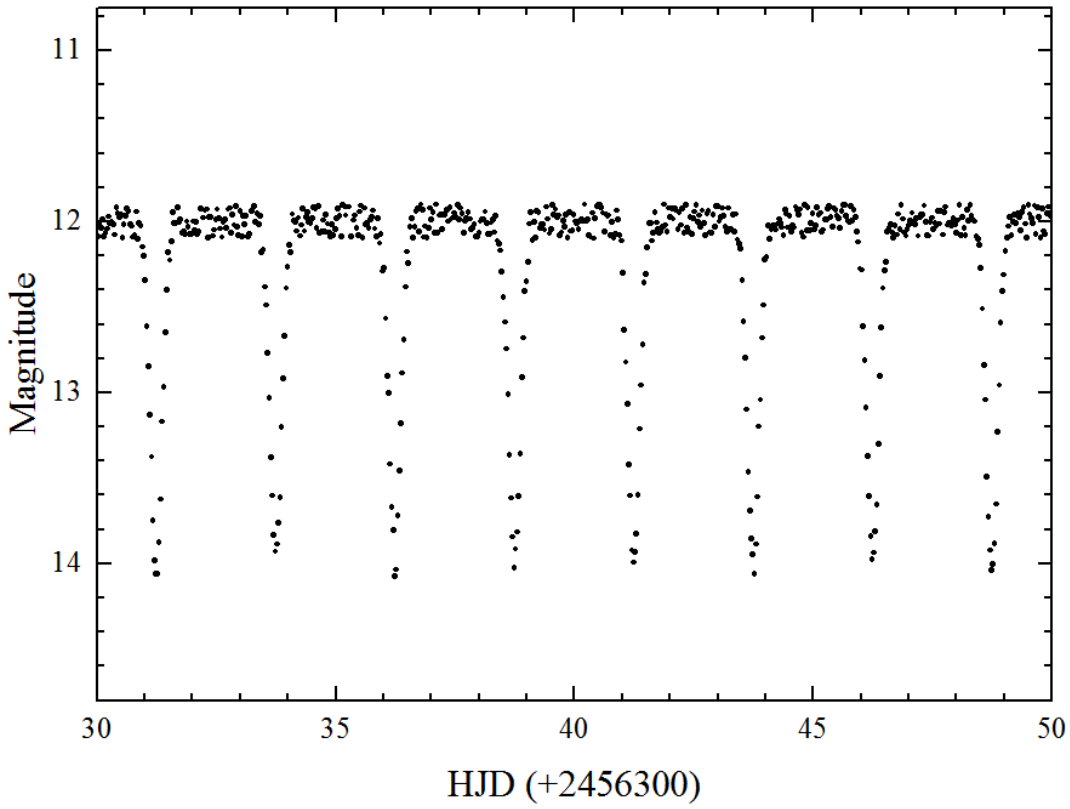


Short-term periodic events (eclipses)



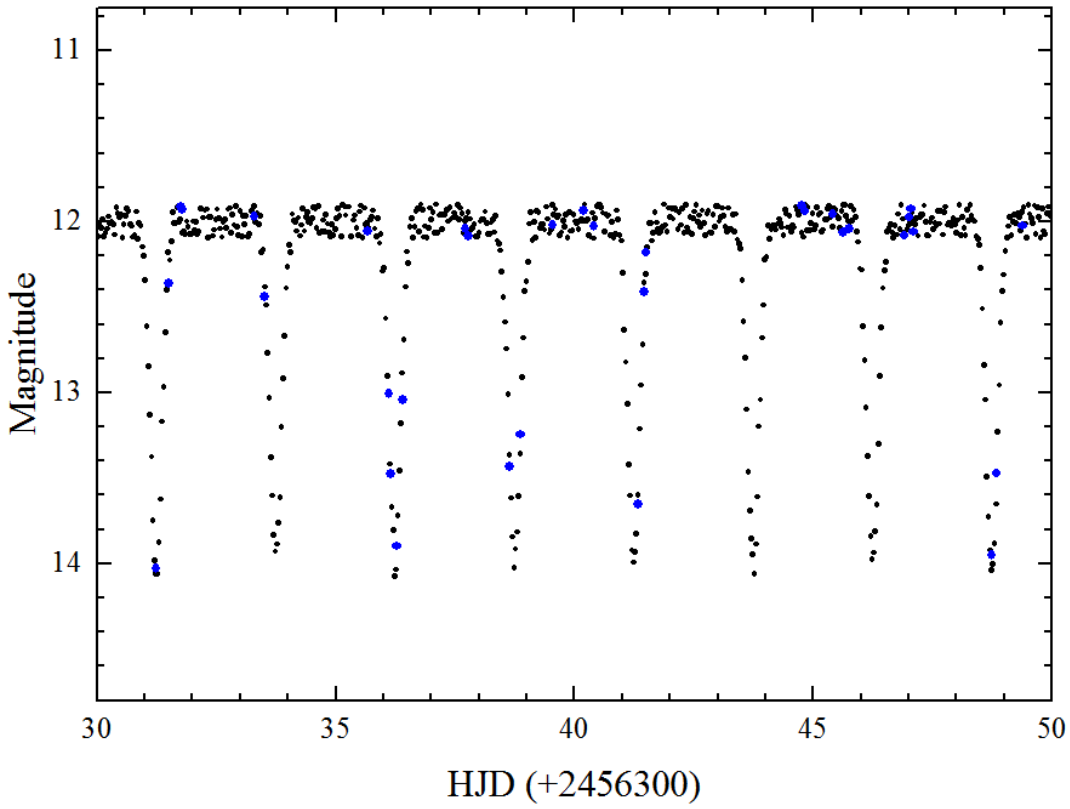
Short-term periodic events (eclipses)

Zoom in

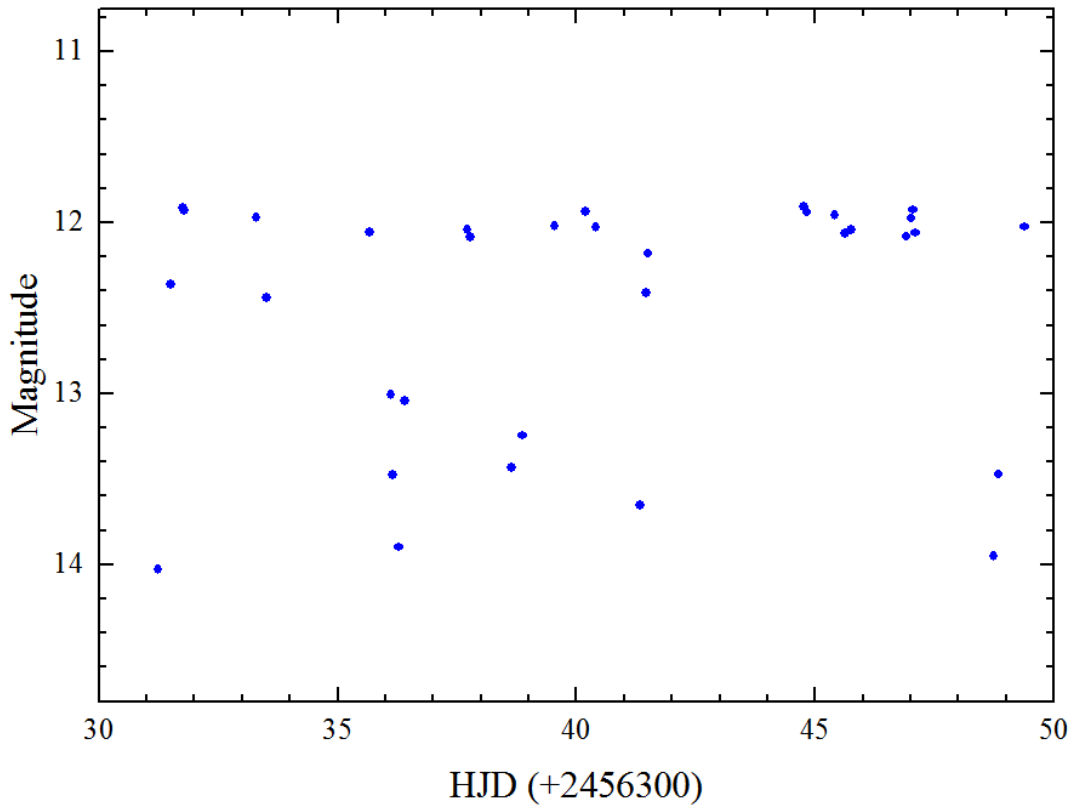


Short-term periodic events (eclipses)

Select 5% of data points

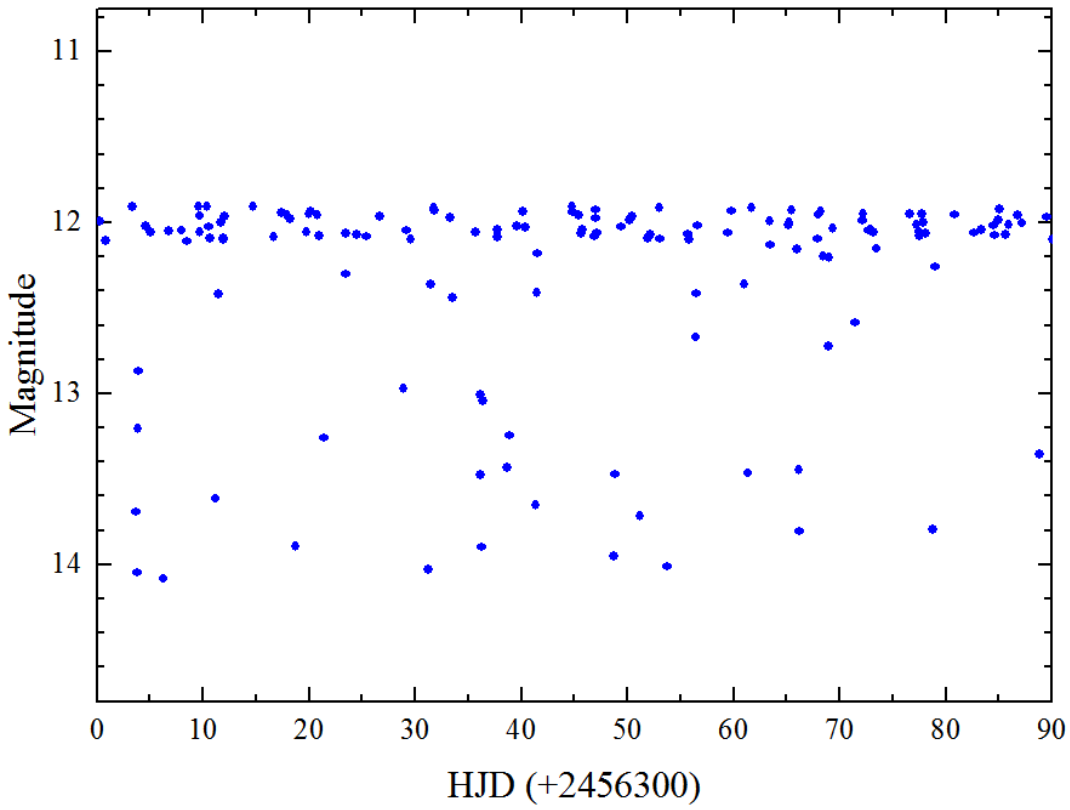


Short-term periodic events (eclipses)

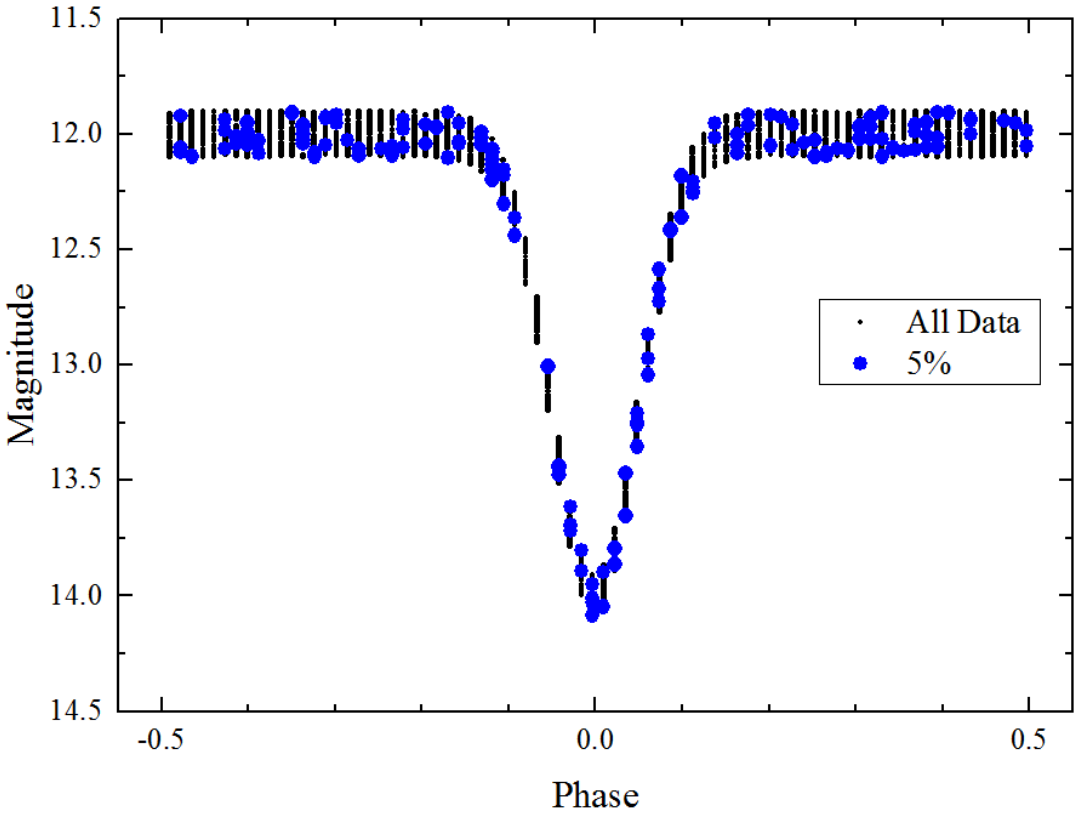


Short-term periodic events (eclipses)

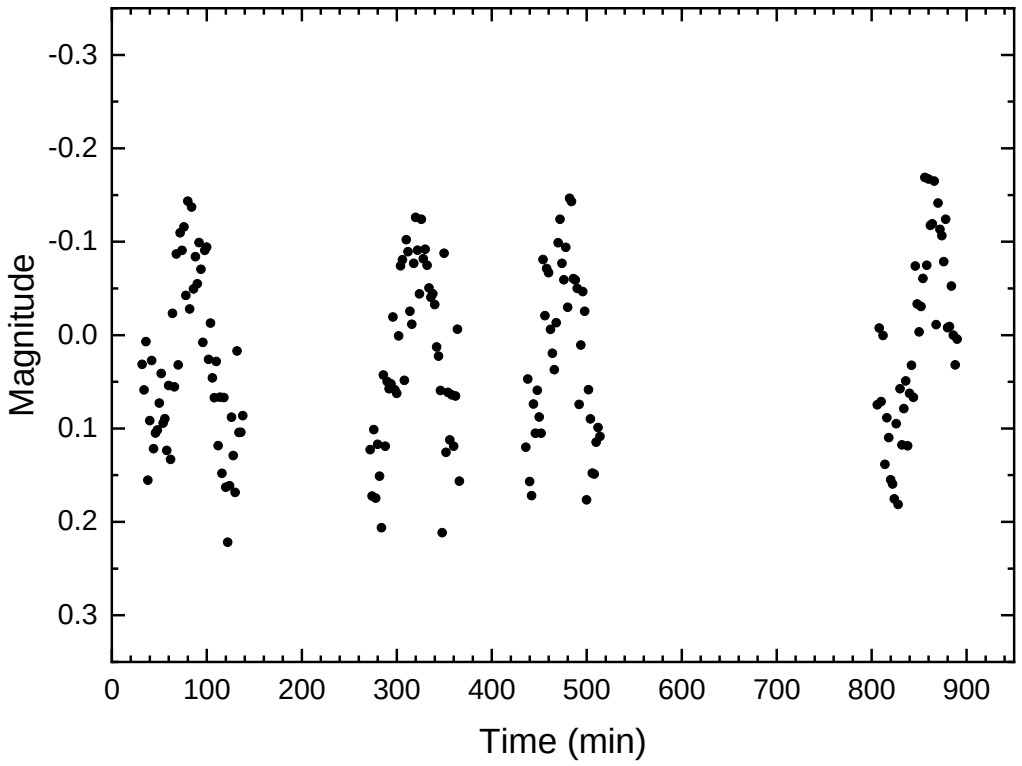
Zoom out



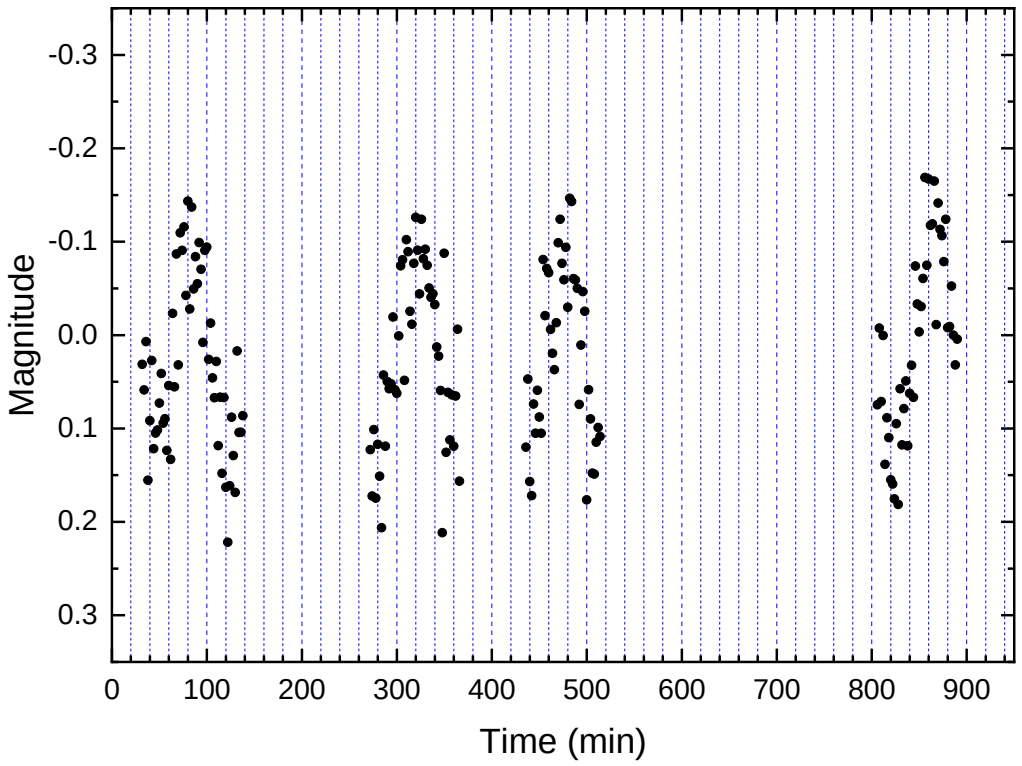
Period-folded light curve (phase diagram)



Gapped light curve



What is the period?

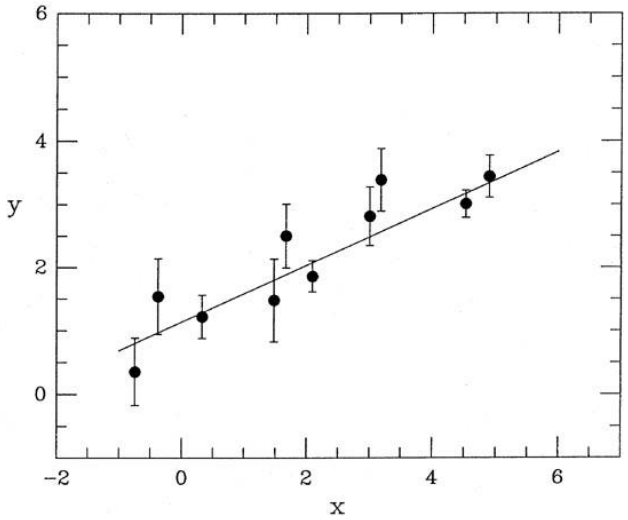


Method of least-squares

- One of the most common tasks in observational astronomy is to derive the "best" numerical relationship between observable quantities, where some or all of the data that you are analyzing contain measuring errors.
- The most widely used and best understood tool is the "**method of least-squares**."

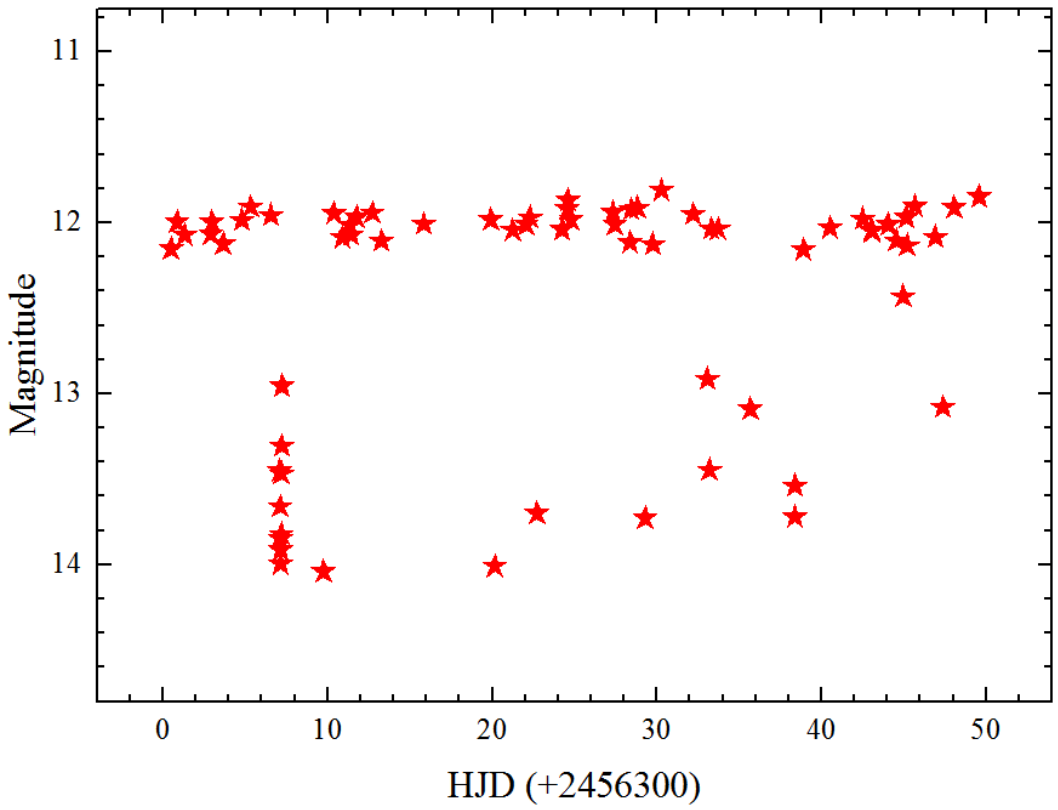
  - We want to find the straight line of the form $y = mx + b$ that "best" describes our data set, which consists of the N observed data points $(x_1, y_1), \ldots, (x_N, y_N)$. Data points contain errors: $\varepsilon_i = mx_i + b - y_i$
  - The principle of least squares leads to the minimization of

$$\chi^2 = \sum_{i=1}^{N} \varepsilon_i^2$$



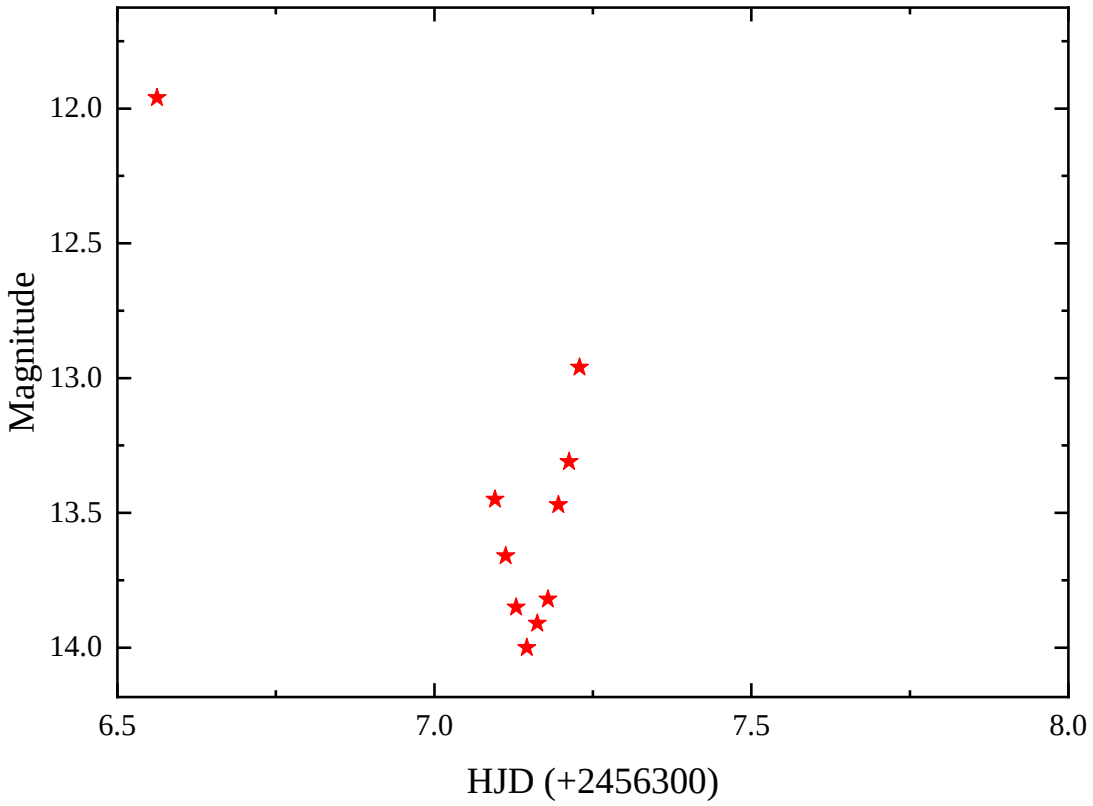
Short-term periodic events (eclipses)

Now 2% of data points

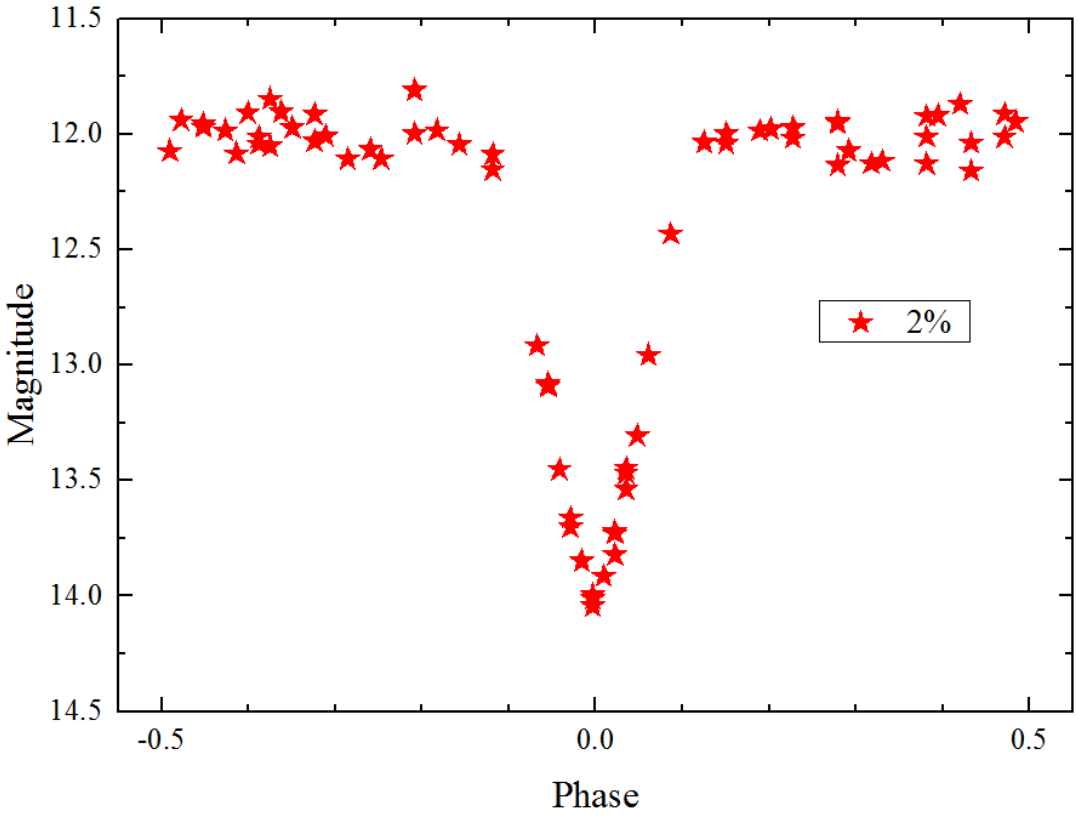


Short-term periodic events (eclipses)

Zoom in to the best covered eclipse

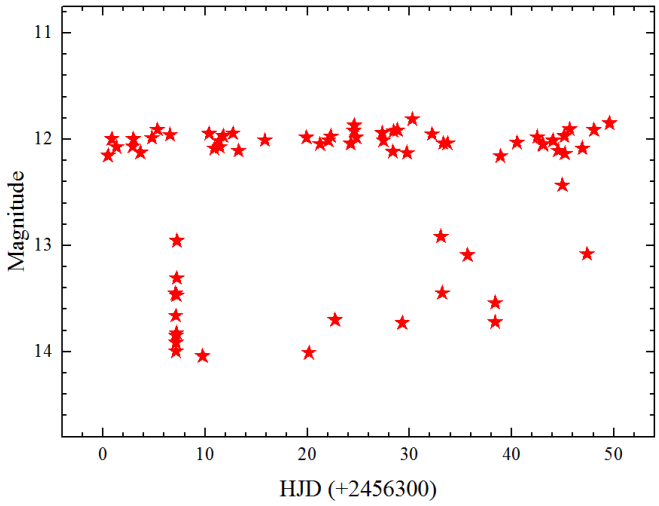


Period-folded light curve (phase diagram)



If you know the period and fold with it, the phase diagram looks pretty.

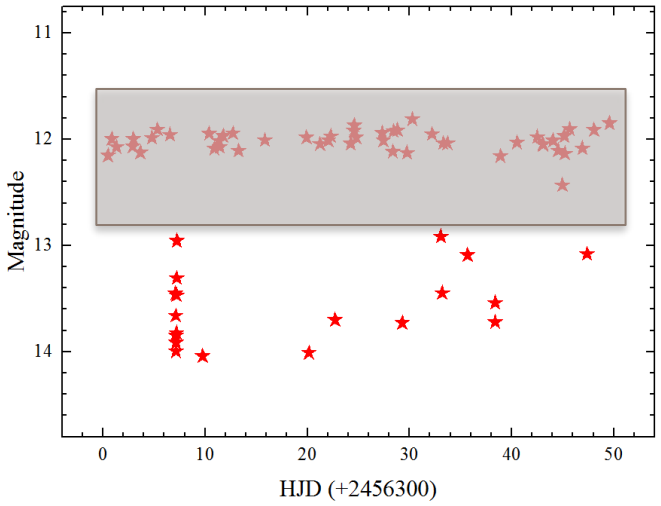
Short-term periodic events (eclipses)



What is the period?

HJD	Magnitude	HJD	Magnitude
+2456300		+2456300	
0.49583	12.15	24.59583	11.87
0.84583	12.00	24.79583	11.98
1.31250	12.07	27.32917	11.94
2.91250	12.07	27.44583	12.01
3.66250	12.13	28.37917	12.12
4.79583	11.99	28.44583	11.92
5.32917	11.91	28.82917	11.92
6.56250	11.96	29.27917	13.73
7.09583	13.45	29.74583	12.13
7.11250	13.66	30.27917	11.81
7.12917	13.85	32.21250	11.95
7.14583	14.00	33.06250	12.92
7.16250	13.91	33.19583	13.45
7.17917	13.82	33.31250	12.04
7.19583	13.47	35.67917	13.09
7.21250	13.31	38.37917	13.72
7.22917	12.96	38.39583	13.54
9.74583	14.04	38.91250	12.16
10.37917	11.95	40.52917	12.03
10.89583	12.09	42.51250	11.98
11.34583	12.02	43.04583	12.04
12.71250	11.94	44.04583	12.01
13.27917	12.11	44.52917	12.11
15.84583	12.01	44.96250	12.43
19.91250	11.98	45.14583	11.97
20.14583	14.01	45.21250	12.13
21.24583	12.04	45.67917	11.90
22.29583	11.97	46.91250	12.08
22.71250	13.70	47.37917	13.08
24.24583	12.04	48.06250	11.91

Short-term periodic events (eclipses)



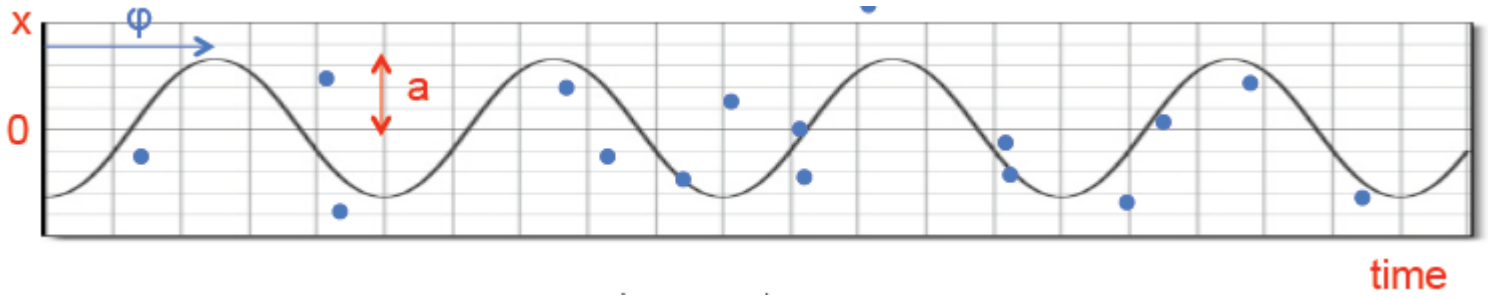
HJD	Magnitude	T[i]-T[i-1]
+2456300		
7.14583	14.00	-
9.74583	14.04	2.600
20.14583	14.01	10.400
22.71250	13.70	2.567
29.27917	13.73	6.567
33.19583	13.45	3.917
35.67917	13.09	2.483
38.37917	13.72	2.700
47.37917	13.08	9.000

What is the period?

Curve-Fitting Approach

- The simplest periodic data are those consisting of a single cosine (sine) wave:

$$x(t) = a\cos(\omega t - \varphi) = A\cos\omega t + B\sin\omega t$$



Frequency

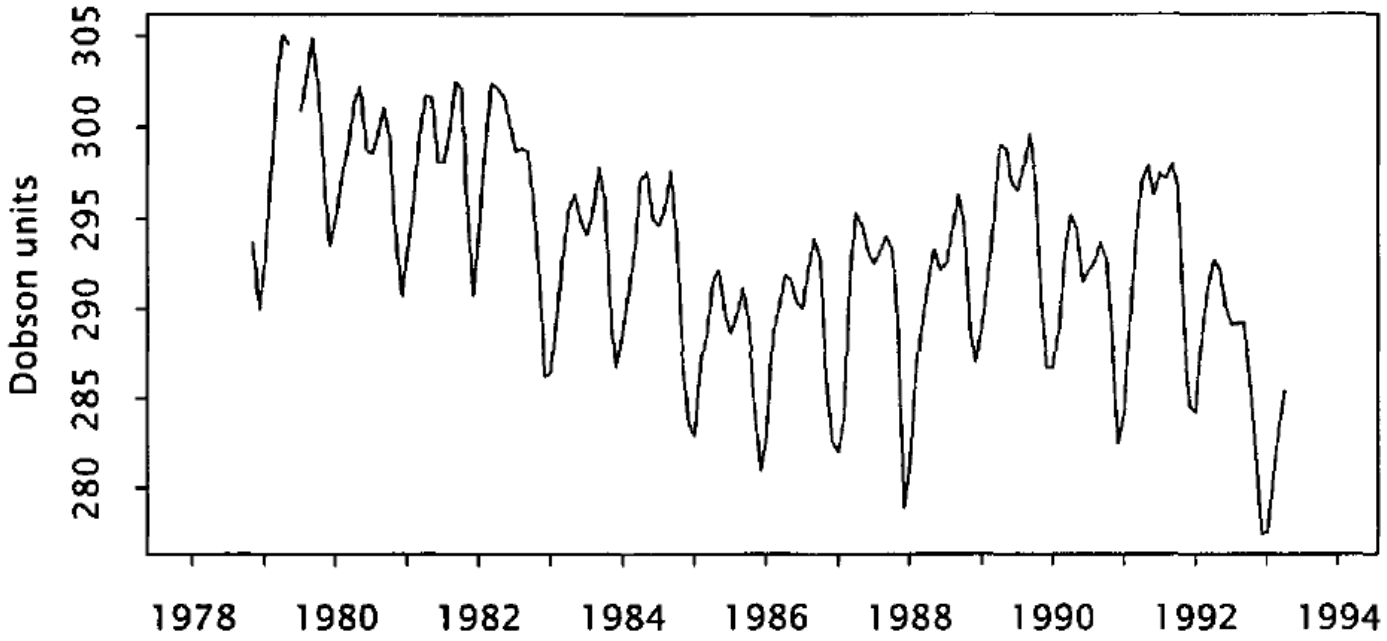
- The basic relation:

$$Frequency = \frac{1}{Period} \quad \text{or} \quad \nu = \frac{1}{P}$$

- If the Period is in seconds, then Frequency will be in Herz [Hz]
- If the Period is in days, then Frequency will be in 1/day [Cycles per day]

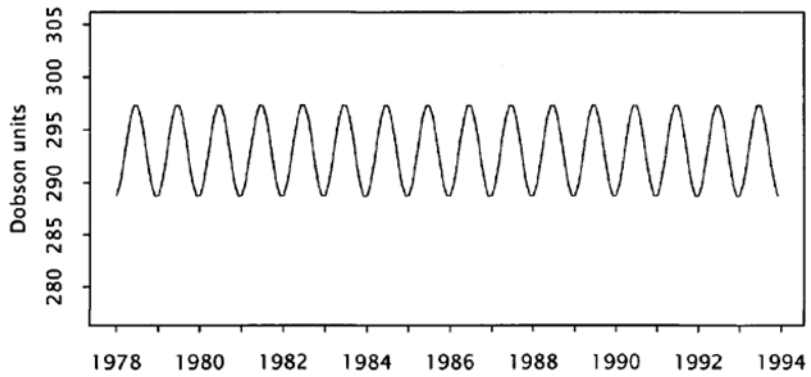
- Angular frequency $\omega = 2\pi\,\nu$ [radiands per second]

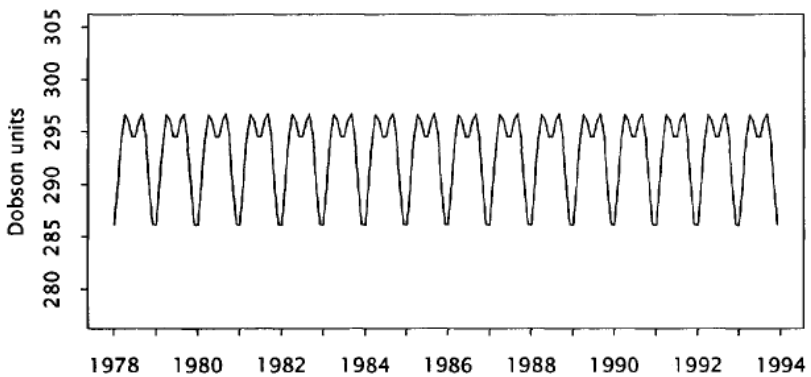
Curve-Fitting Approach

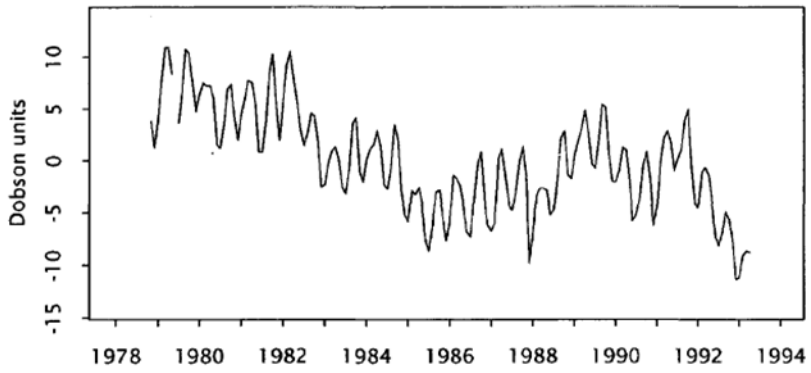


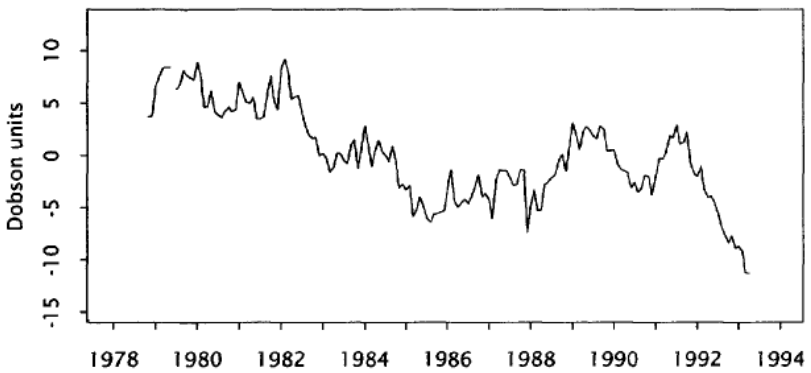
Monthly average total ozone levels, 65° S to 65° N

Curve-Fitting Approach









Fitting one (left) and two (right) sinusoids with **known** periods.

If the period is unknown then the fitting is not simple.