Lomb-Scargle Project

CAP-384

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INPE

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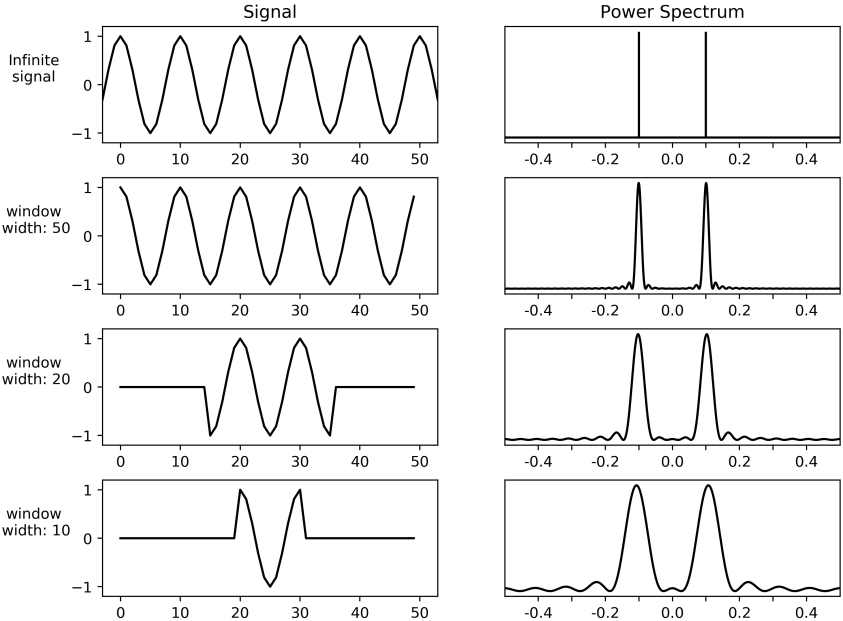
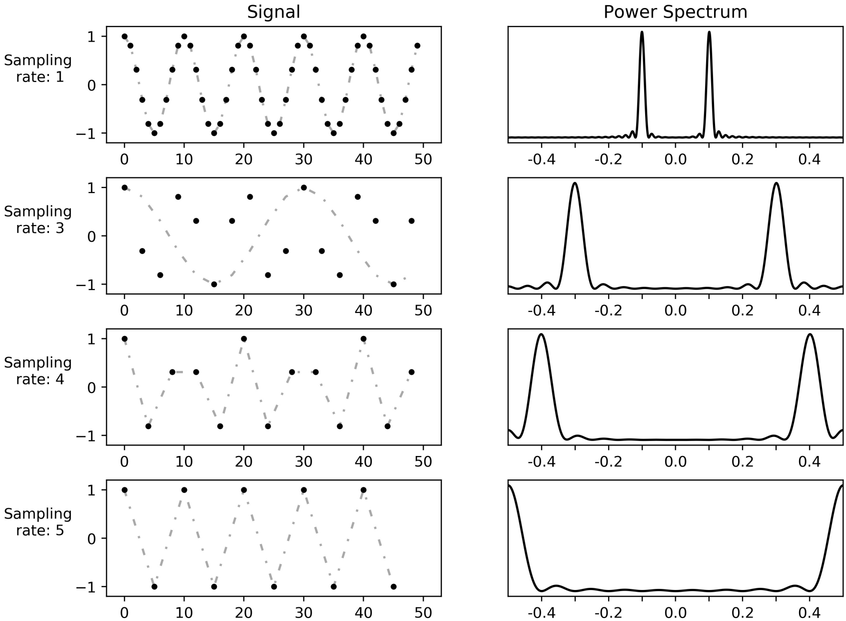
An overview of the project

- Solar flux at 10.7 cm
- Indicator of Sun's magnetic activity, and one of the oldest records of our star
- Three sets of data downloaded (11/1963 a 07/2020):
  - Daily averages (20440 entries)
  - 27-day averages (672 entries)
  - Yearly averages (56 entries)
- Simulation of random sampling (two scenarios)
- Library `astropy` with `LombScargle` class was used
- Periodogram generated and analyzed under different conditions

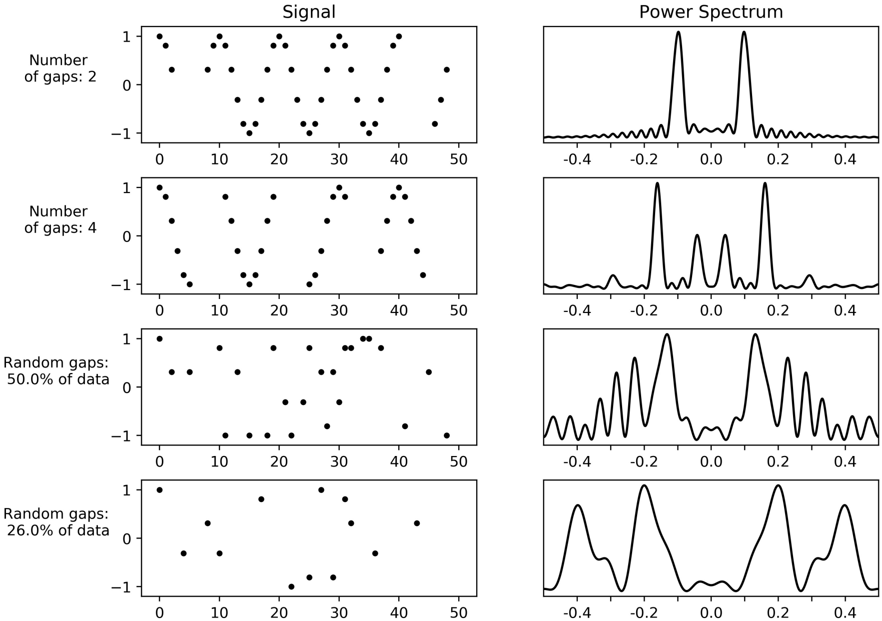
Effects of finite sampling - spectral leakage



Effects of sampling rate - aliasing (a kind of leakage)



Effects of non-uniform sampling



Lomb-Scargle periodogram

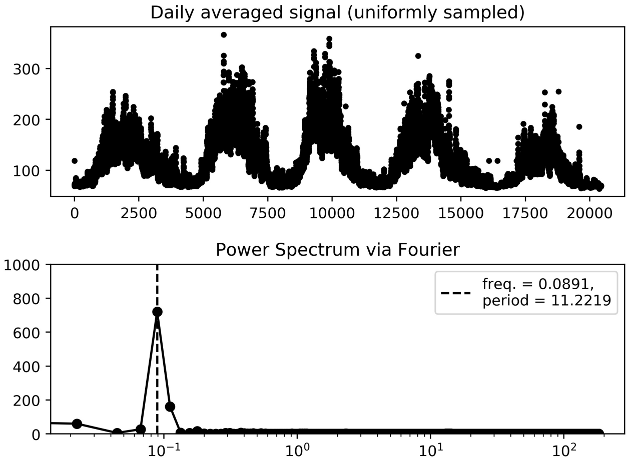
- Main tool for analysis of unevenly sampled temporal series
- Belongs to a set of tools of spectral analysis that explores the least squares method
- Estimates frequencies by fitting sinusoidal functions to the data
- Available via the library `astropy` (with $O[NlogN]$ complexity) via the class `LombScargle`:

```python
from astropy.timeseries import LombScargle
frequency, power = LombScargle(t, f).autopower()
```

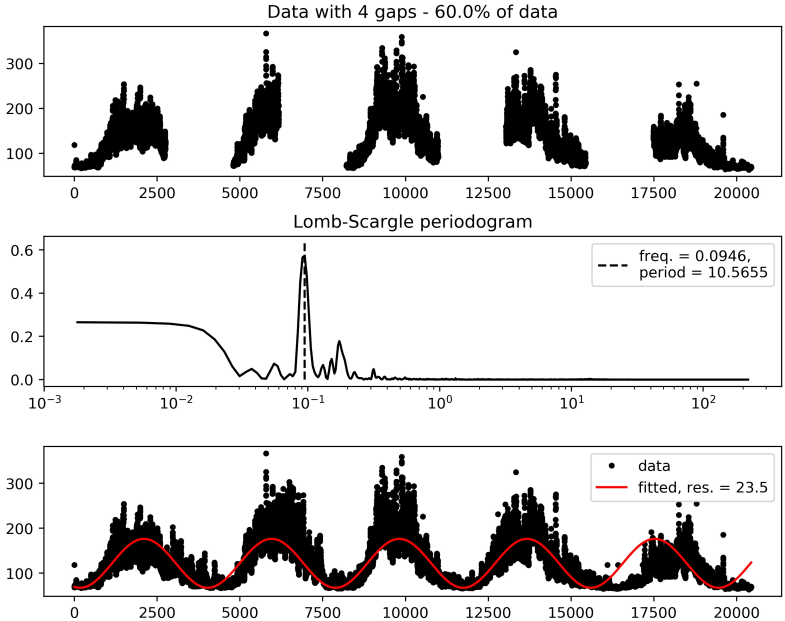
The analysis

- Scenario 1
  - Gaps (of data) randomly placed in the original series
  - Size of gaps equal to 10% of data
  - Five number f gaps tested
- Scenario 2
  - Data randomly deleted from the original series
  - Deletion of a particular percentage
  - Five percentages are tested

Power spectrum via FFT - the usual analysis



Scenario 1 - daily averages



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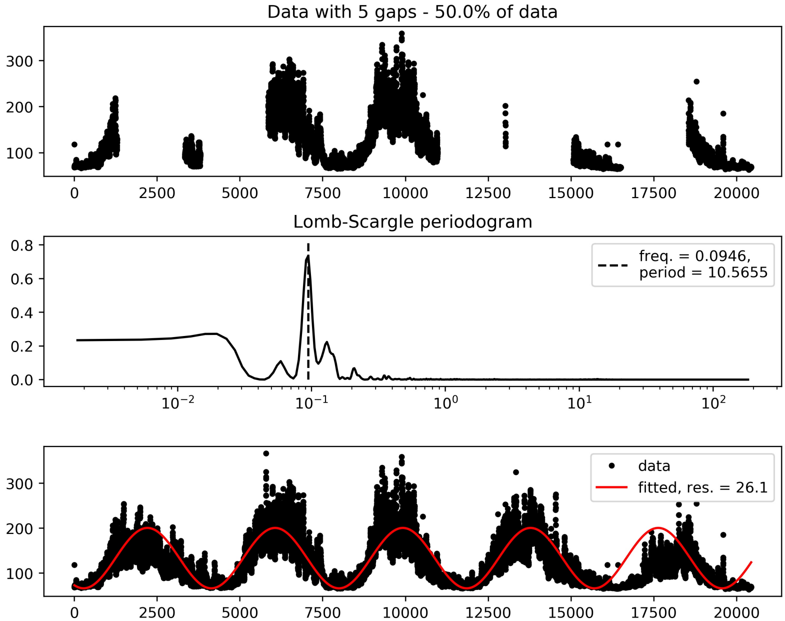

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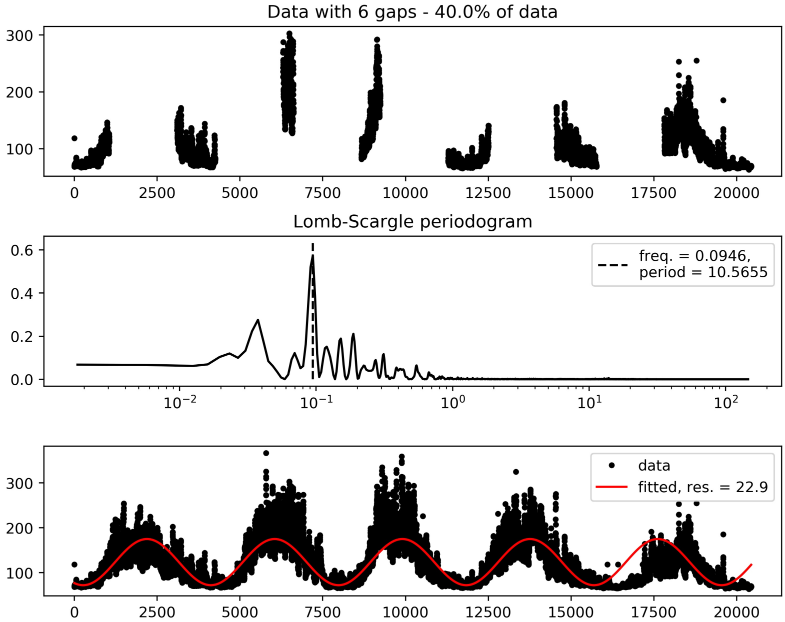

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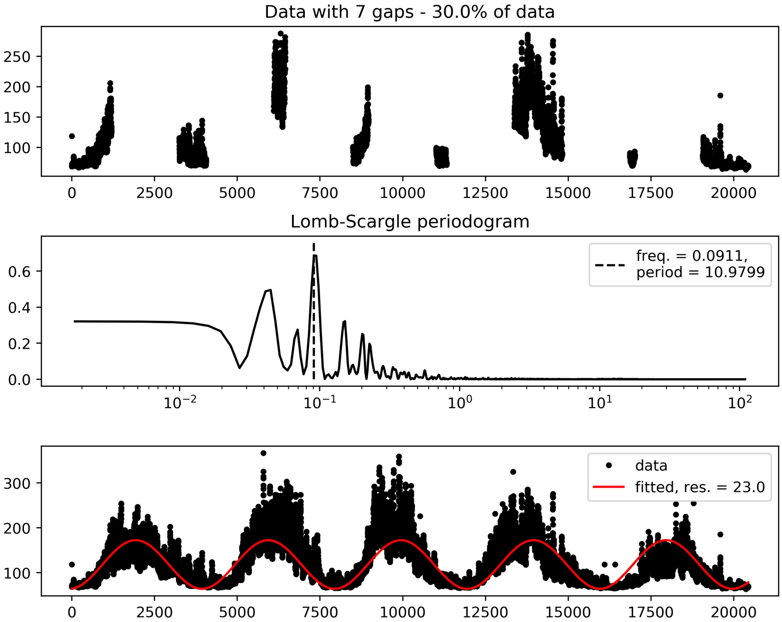

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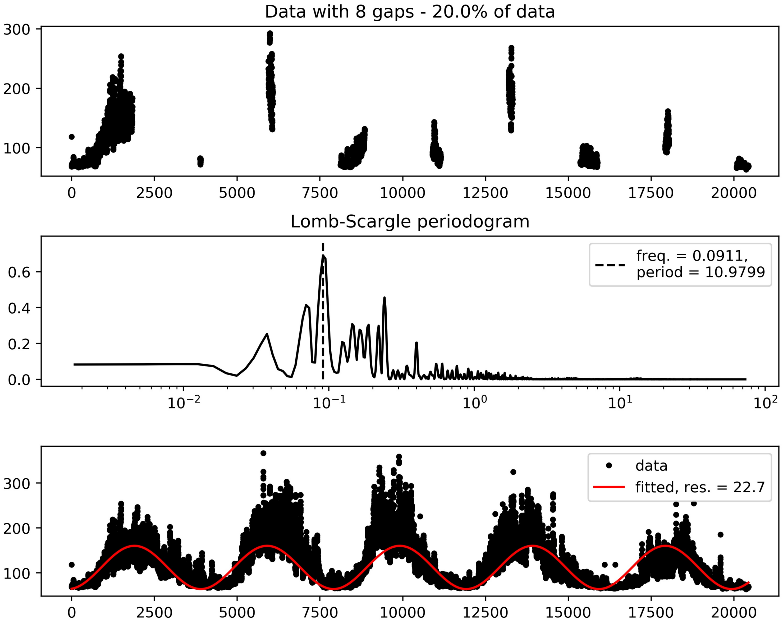

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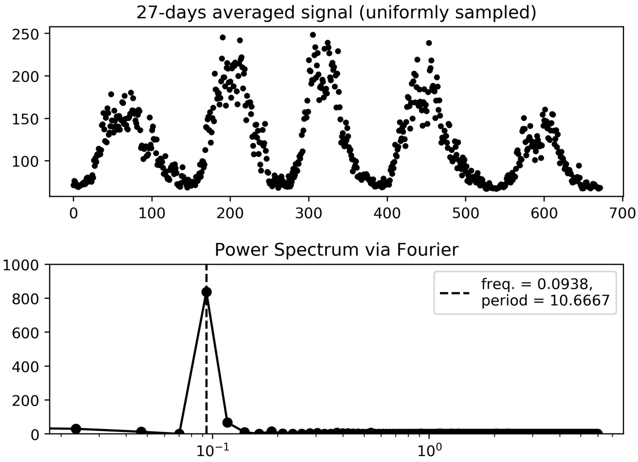
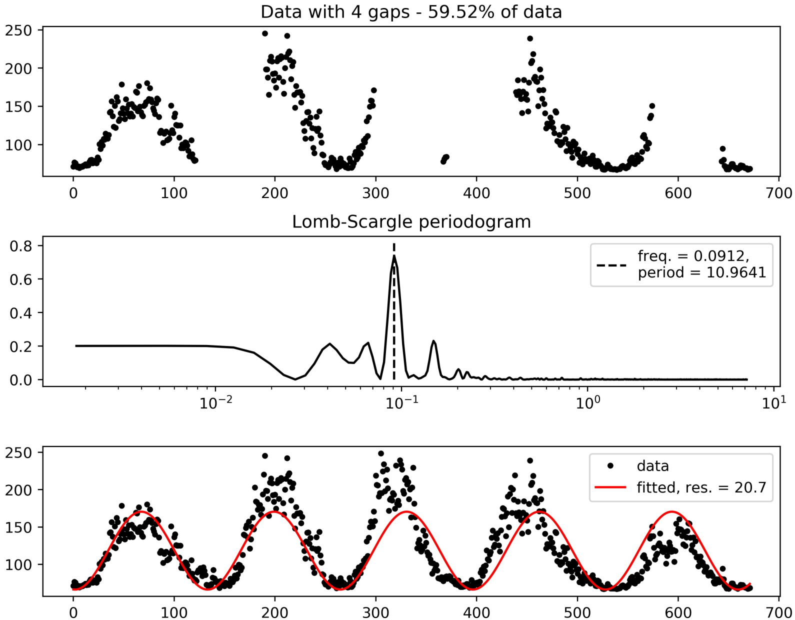


Scenario 1 - 27-day averages



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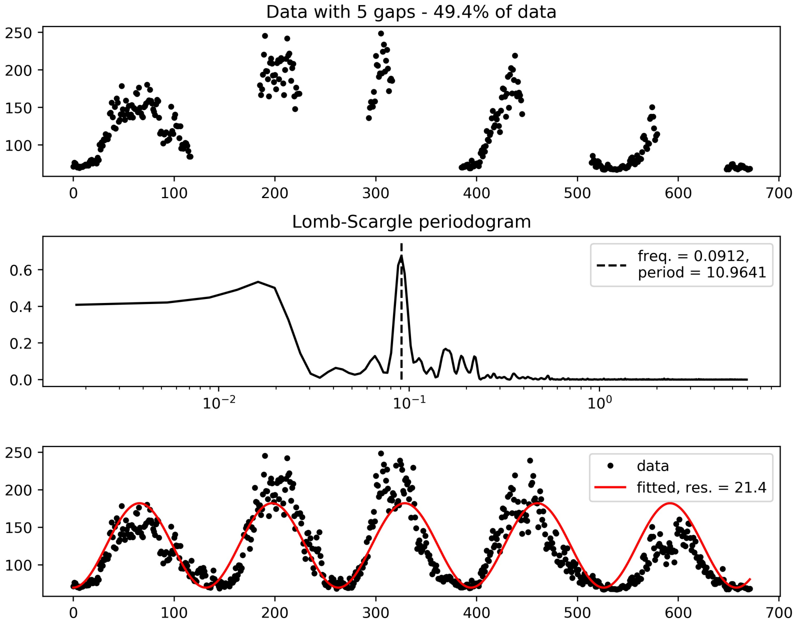

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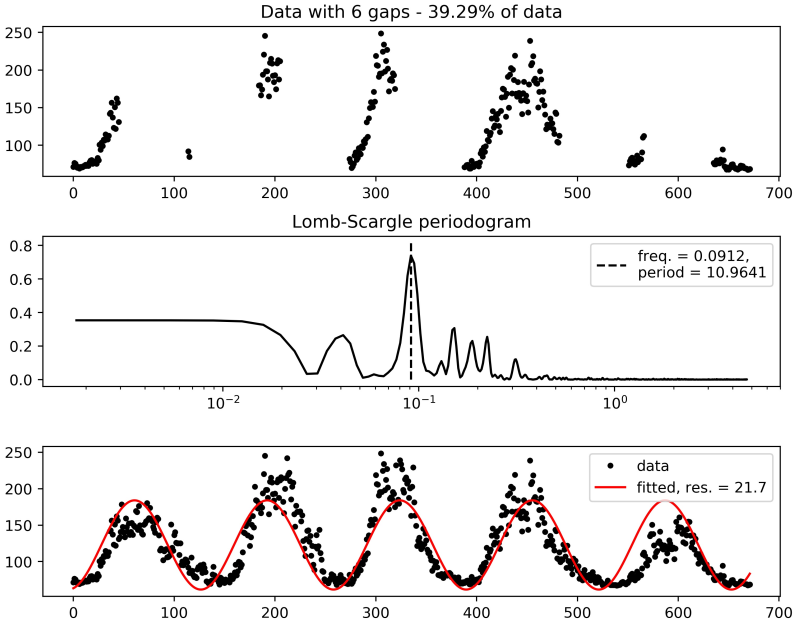

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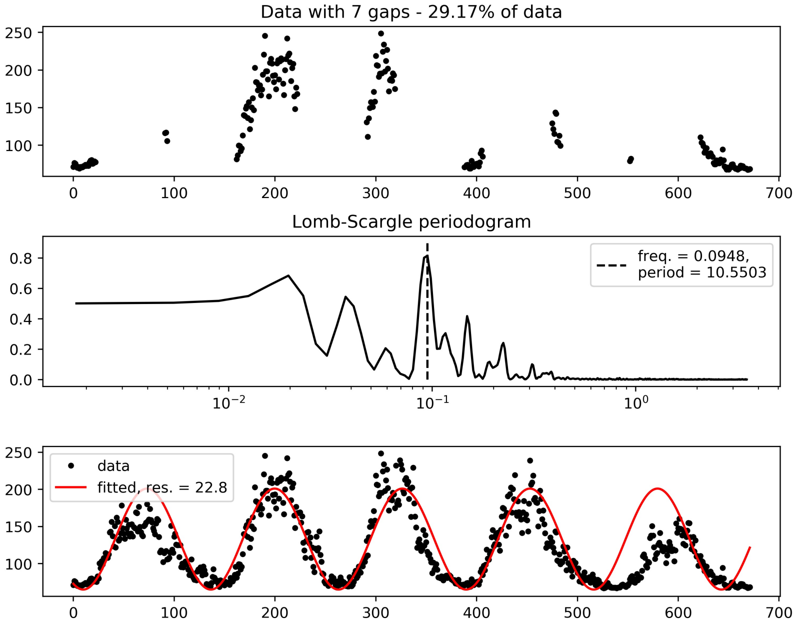

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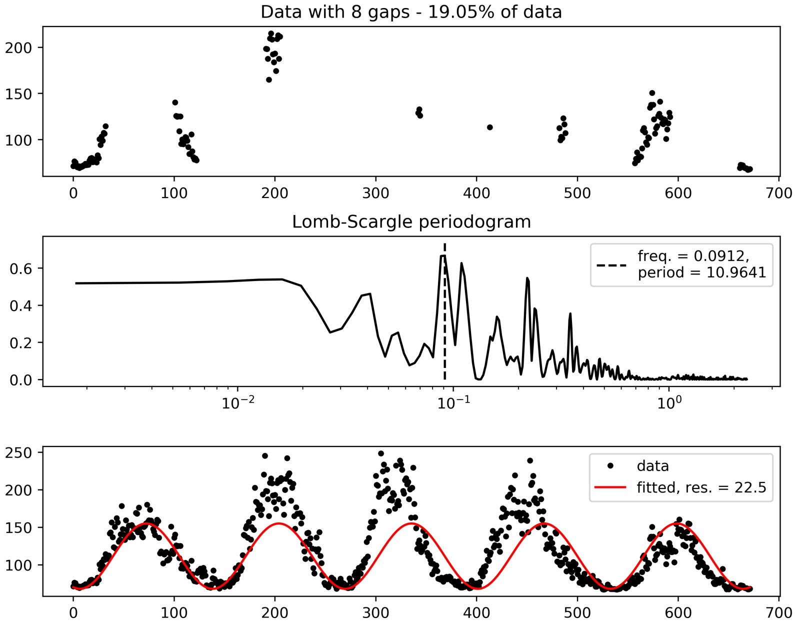

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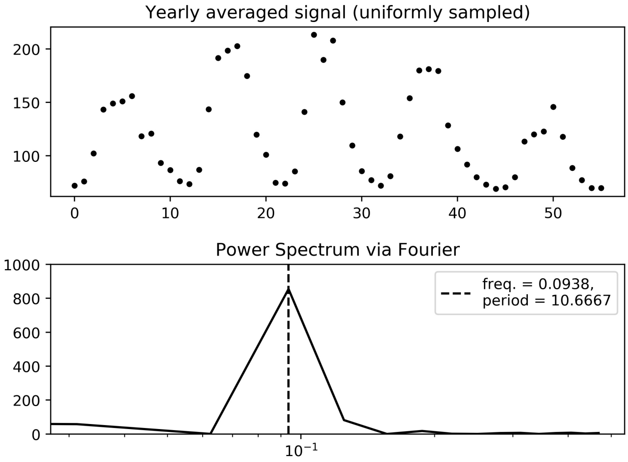
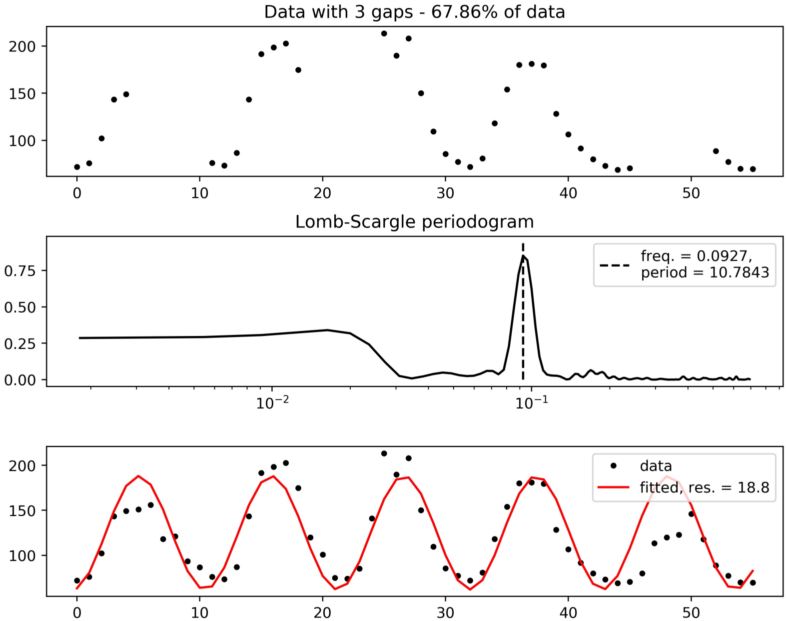


Scenario 1 - yearly averages



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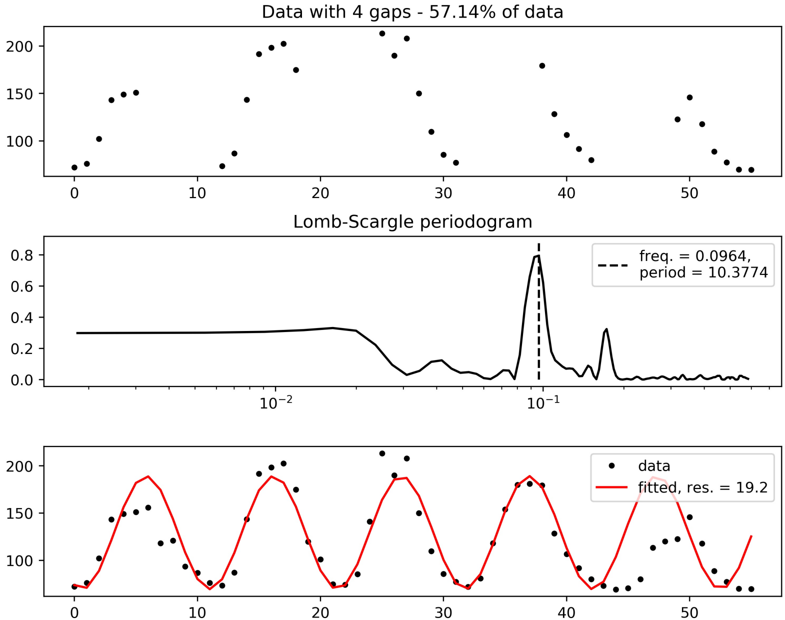

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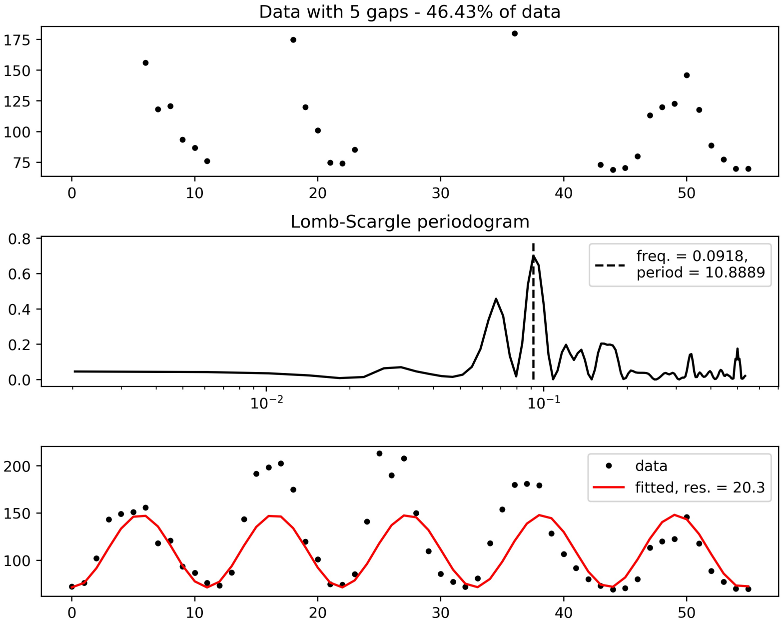

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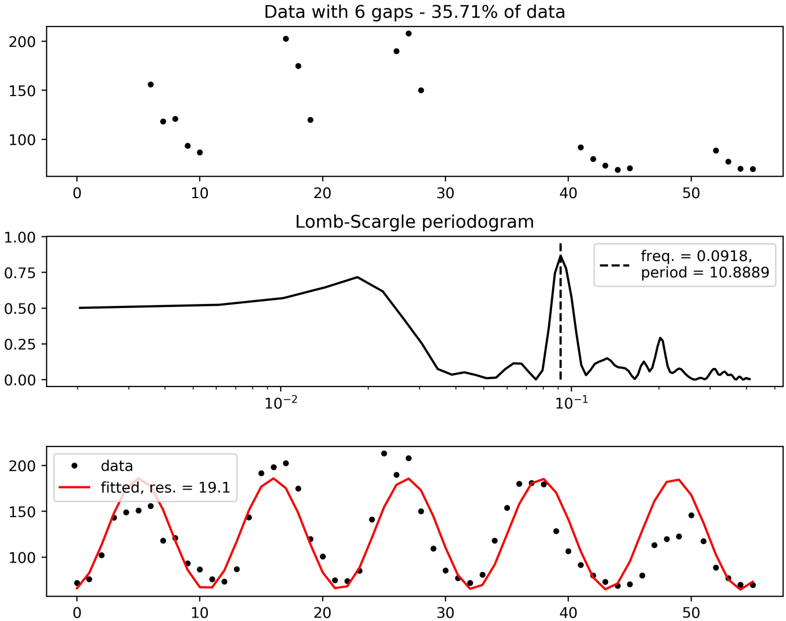

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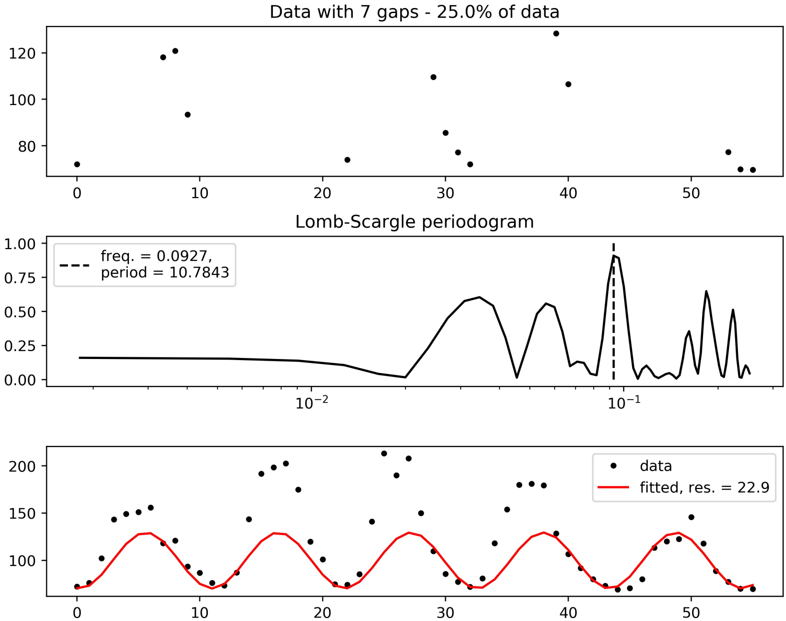
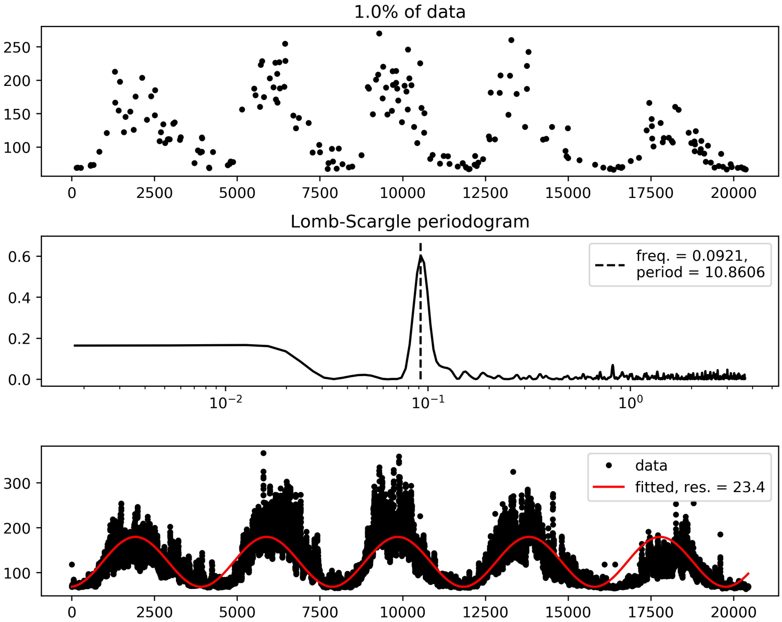


Scenario 2 - daily averages



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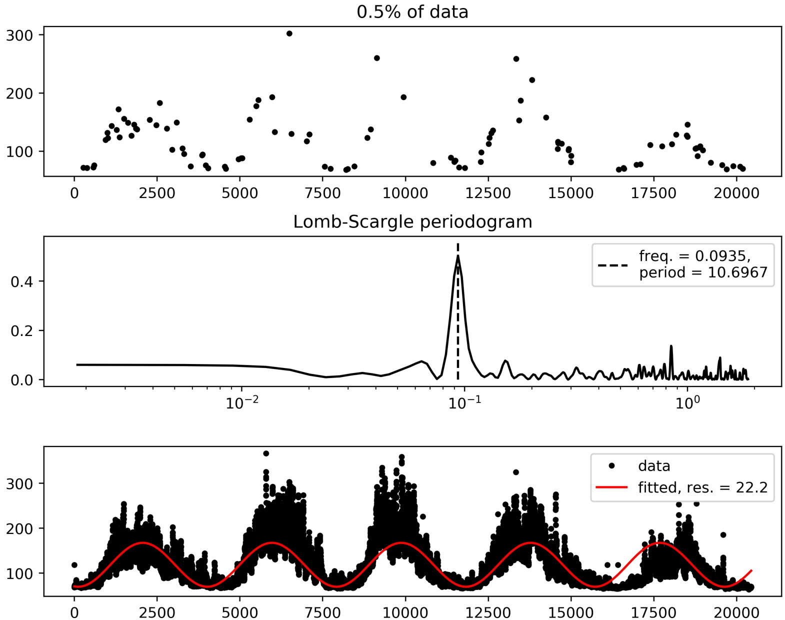

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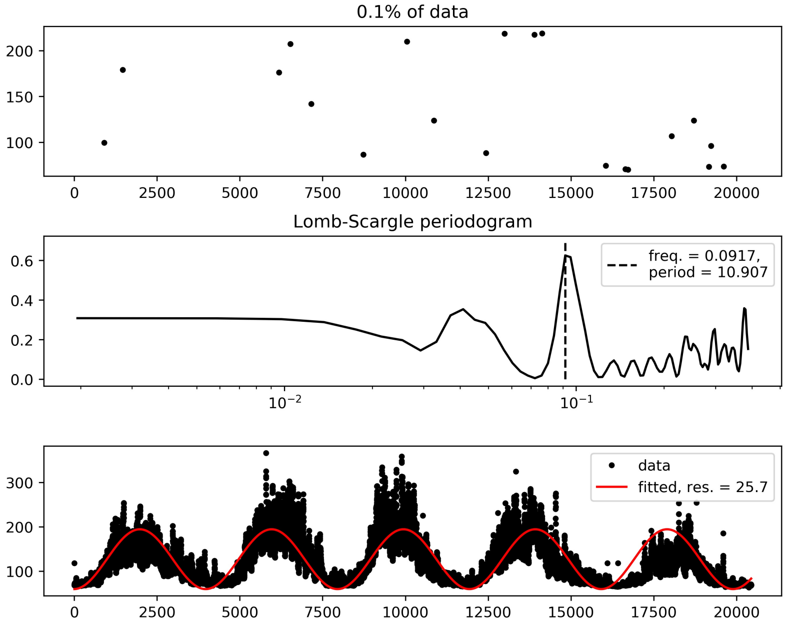

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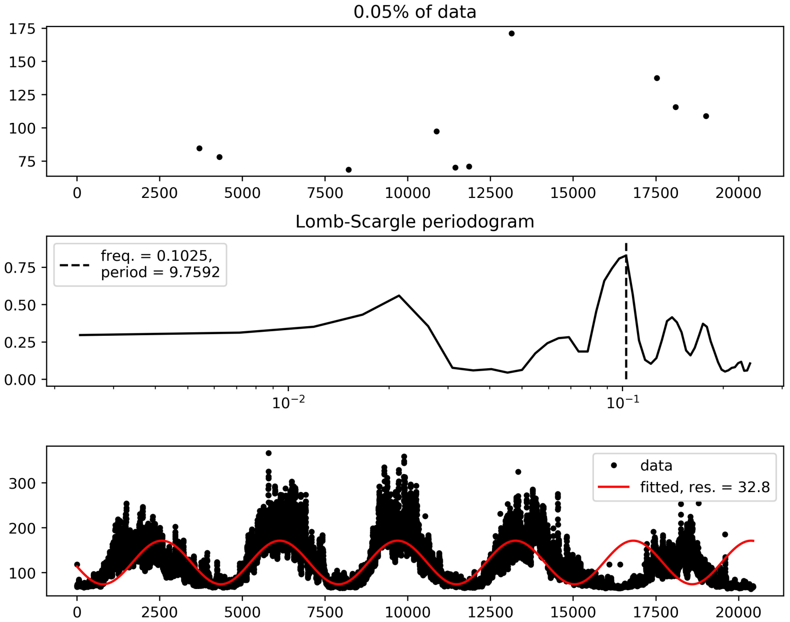

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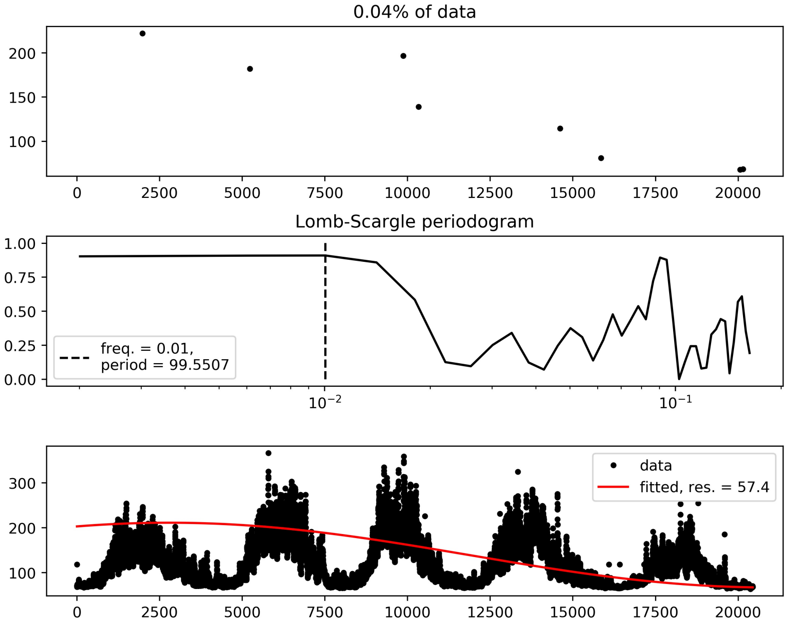

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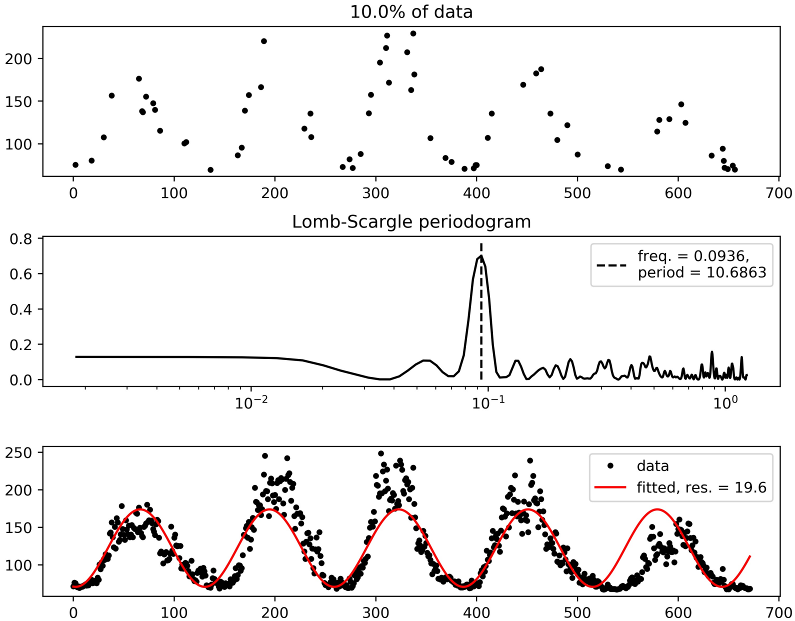

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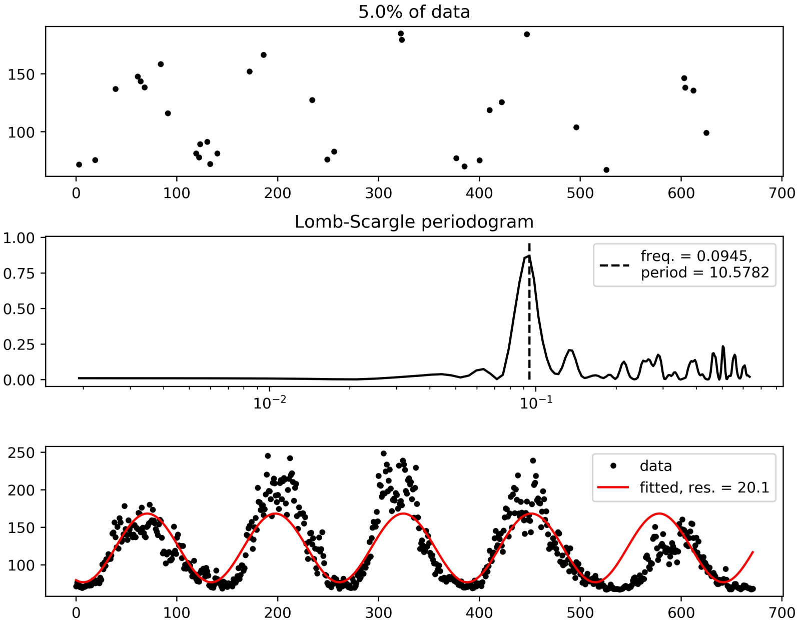

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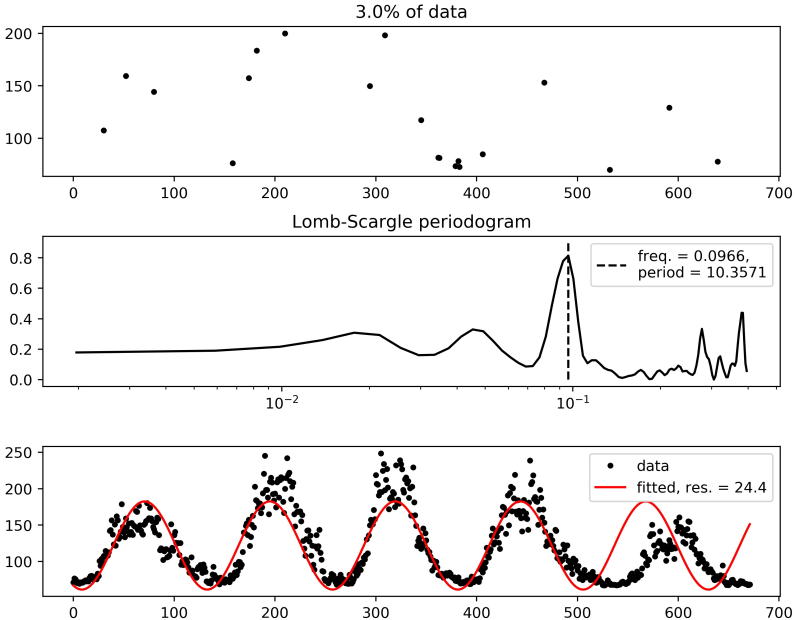

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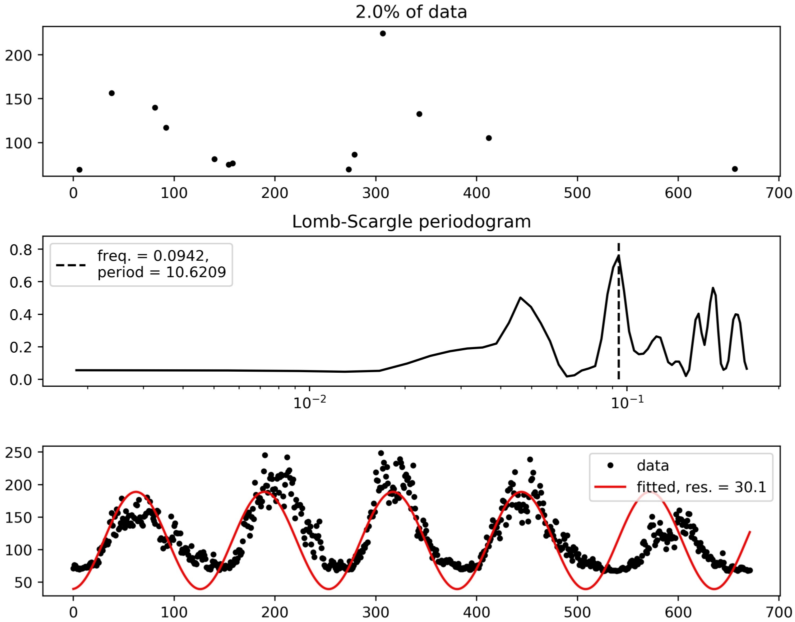

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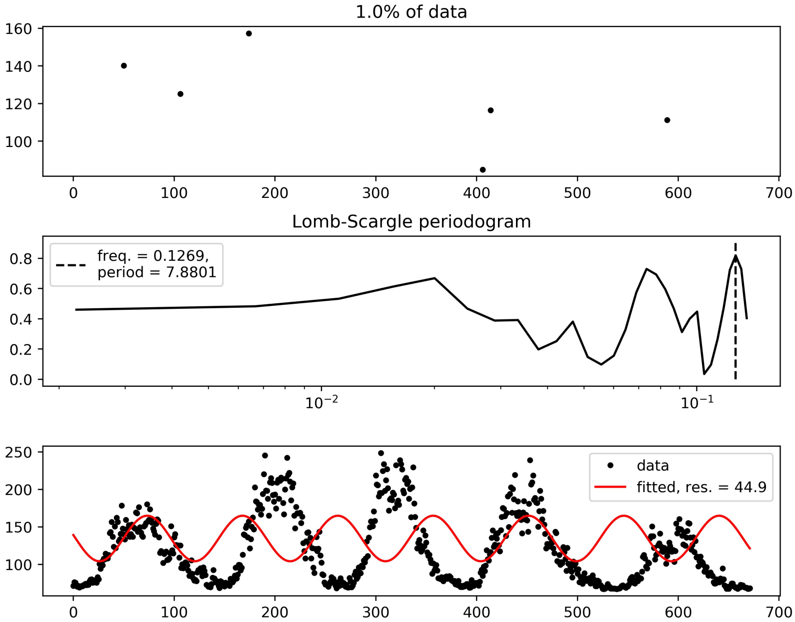

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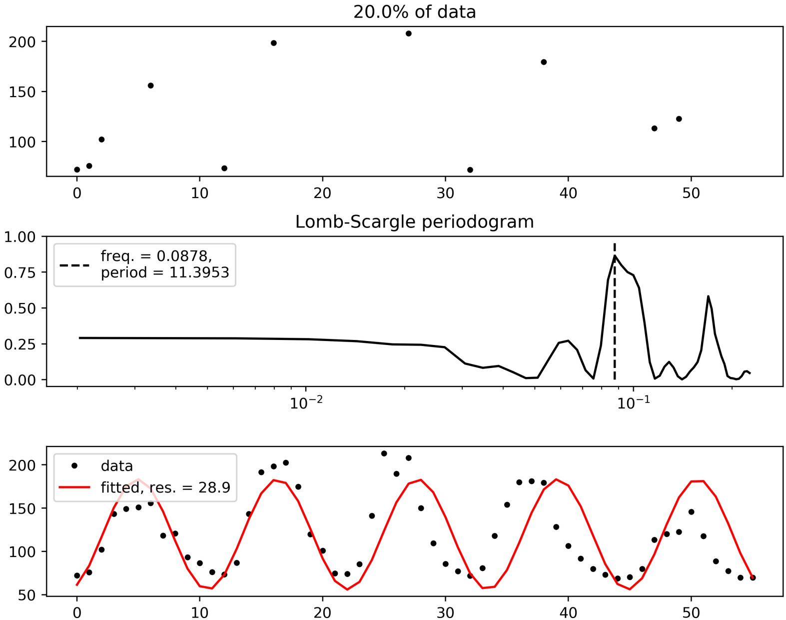

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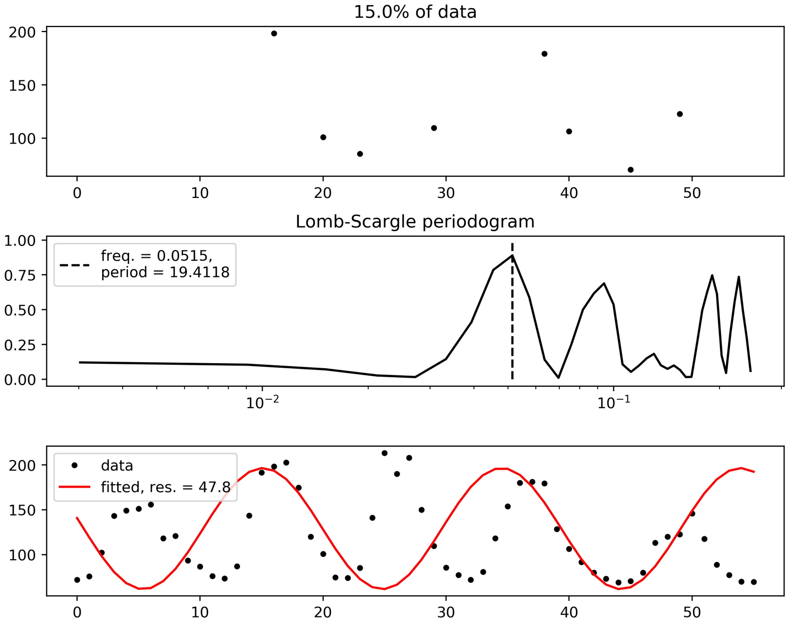

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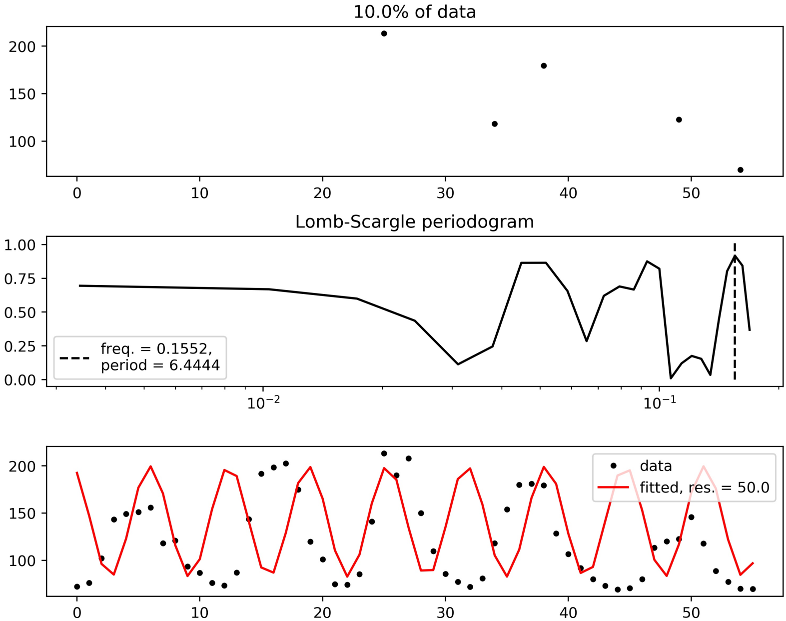

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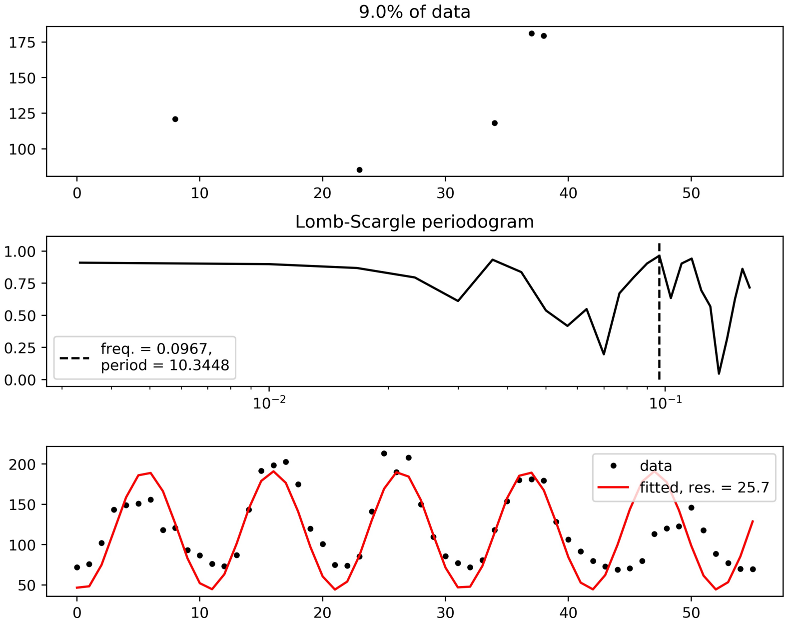

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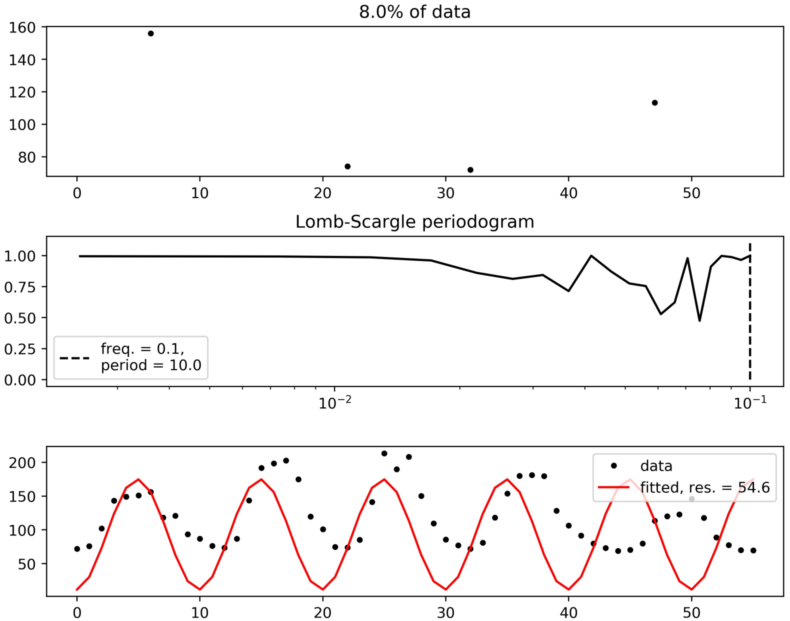

Final remarks

- Effects of sampling discussed
- Experiments undertaken with two scenarios of uneven sampling
- Lomb-Scargle periodogram introduced and applied via `LombScargle` class (from `Python`'s package `astropy`)
- Parameter `nyquist_factor` tuned during analysis
- The tool was successfully implemented

Links

Source of the data:

omniweb.gsfc.nasa.gov/form/dx1.html

Documentation of the tool (`astropy`'s `LombScargle` class):

docs.astropy.org/en/stable/timeseries/lombscargle.html

This project's repository:

github.com/leosattler/projeto-lomb-scargle.git

Thank you!