report

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1 Summer project 2021

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1.0.1 Introduction

This document contains a report on my work at the Institute of theoretical astrophysics at the University of Oslo (UiO) during the summer of 2021. Iris observations of Coronal bright points (CBPs) over a time period were analyzed and an atmospheric model were created for each observation in time. An optical depth of interest were chosen and light curves (LCs) were extracted for each observation time. The oscillation characteristics of the LCs were investigated using Wavelet and Fourier analysis, and the first and second dominant periods were determined. The periodicity of the LCs at different optical depths are of interest to determine if the CBPs are pulsating outward or inward. It is assumed that the reader is familiar with Iris level 2 data and the inversion method, but a brief overview will be described.

1.0.2 Data description

Level 2 data from Iris observations, each containing a slit of spectroscopic data were considered. The Iris2 data containing 660 images taken at 37 second time intervals, included windows of prominent spectral lines in the spectral range from around 1300Å to 2900Å. The two Magnesium lines h&k(~2795 and ~2803Å) were chosen for the Iris2inversion analysis.

1.0.3 Iris2 inversion

The inversion method consists of matching the time series of Mg h&k line profiles with a profile database, and extracting the corresponding atmospheric model. A principal component analysis (PCA) with 60 eigenvectors were used. Spectral window weights applied were $[1, 1/6, 1, 1/6]$. The model produced for each raster image is described by temperature, line of sight velocity (vlos), velocity turbulence (vturb) and electron density as a function of spatial position and optical depth. One pixel at index position $(y, x) = [0, 400]$ located within a CBP was chosen as a point of interest. LCs for the four parameters mentioned were extracted from an optical depth of $\log(\tau) = -5$). This optical depth was chosen because this is roughly the height of formation indicated by the four parameters in the atmospheric models.

1.0.4 Oscillation analysis

The periodicity of the LCs were analyzed using Wavelet and Fourier analysis. We were interested in repeating signs of periodic behavior. The total observation time was around ~400 minutes. Evaluating periods up to ~130 minutes makes it possible to observe three oscillations of this maximum period. The LCs were detrended with respect to the running average and normalized with respect to its standard deviation. The global wave power was determined by collapsing the power map in the time dimensions, only including contribution from inside the cone of influence (COI). The first and second dominant periods were determined for each of the parameters.

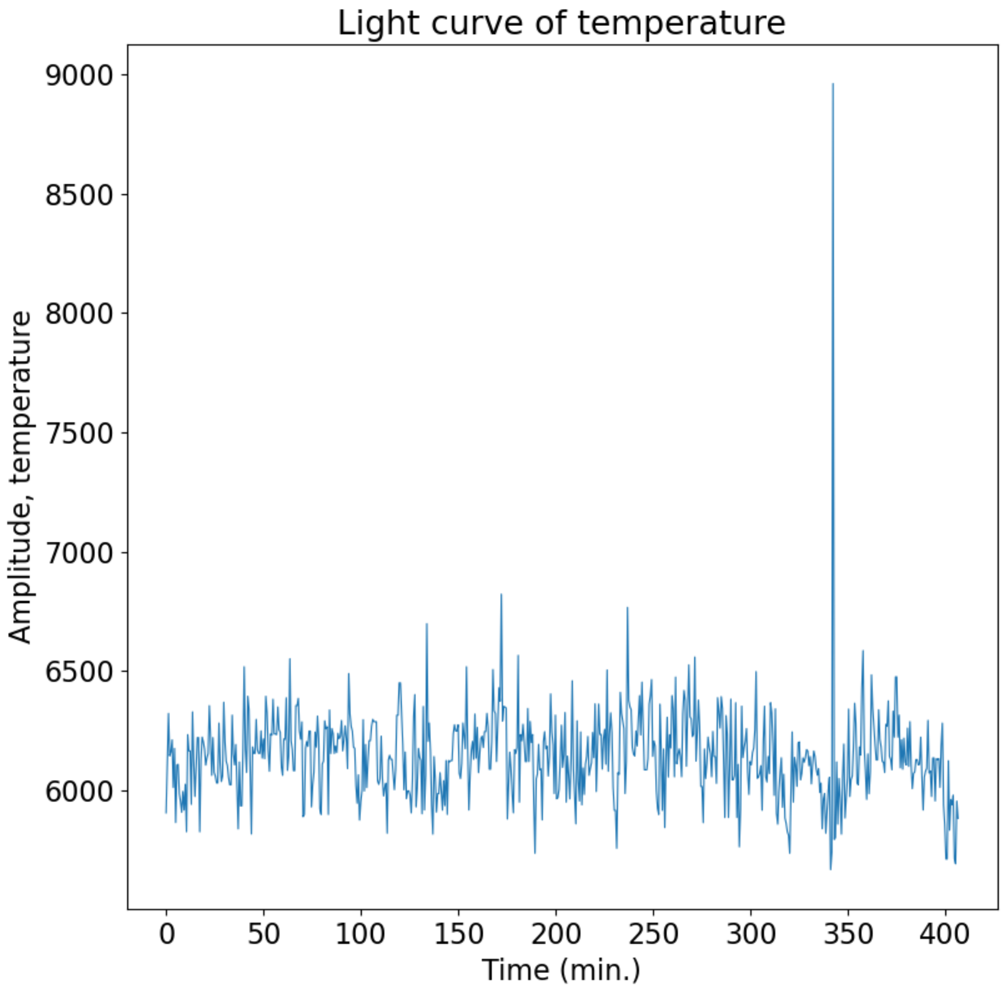
1.0.5 Plots

First we present the four light curves considered.

[16]:
```
plot_folder = '/home/efredborg/Documents/summer_project2021/plots/'
from IPython.display import Image
```

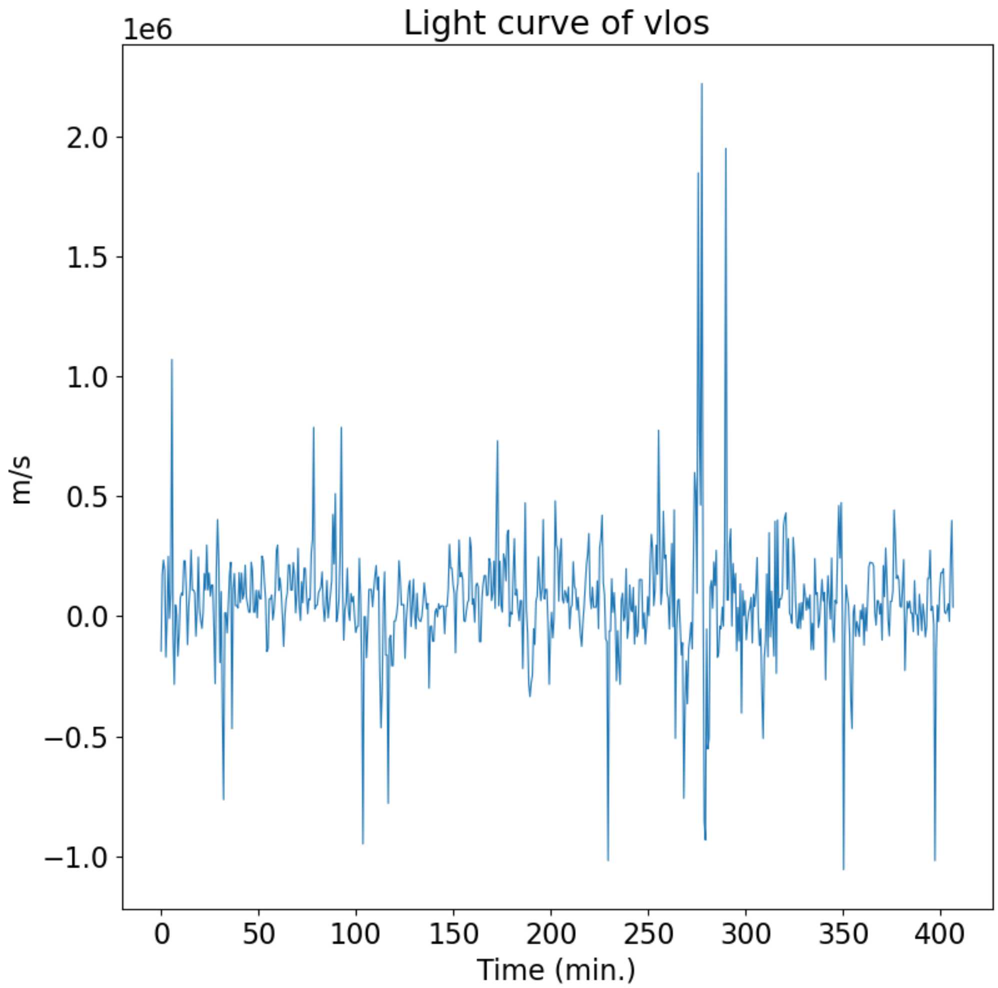
[17]:
```
Image(filename=plot_folder+'LC_temperature.png')
```

[17]:



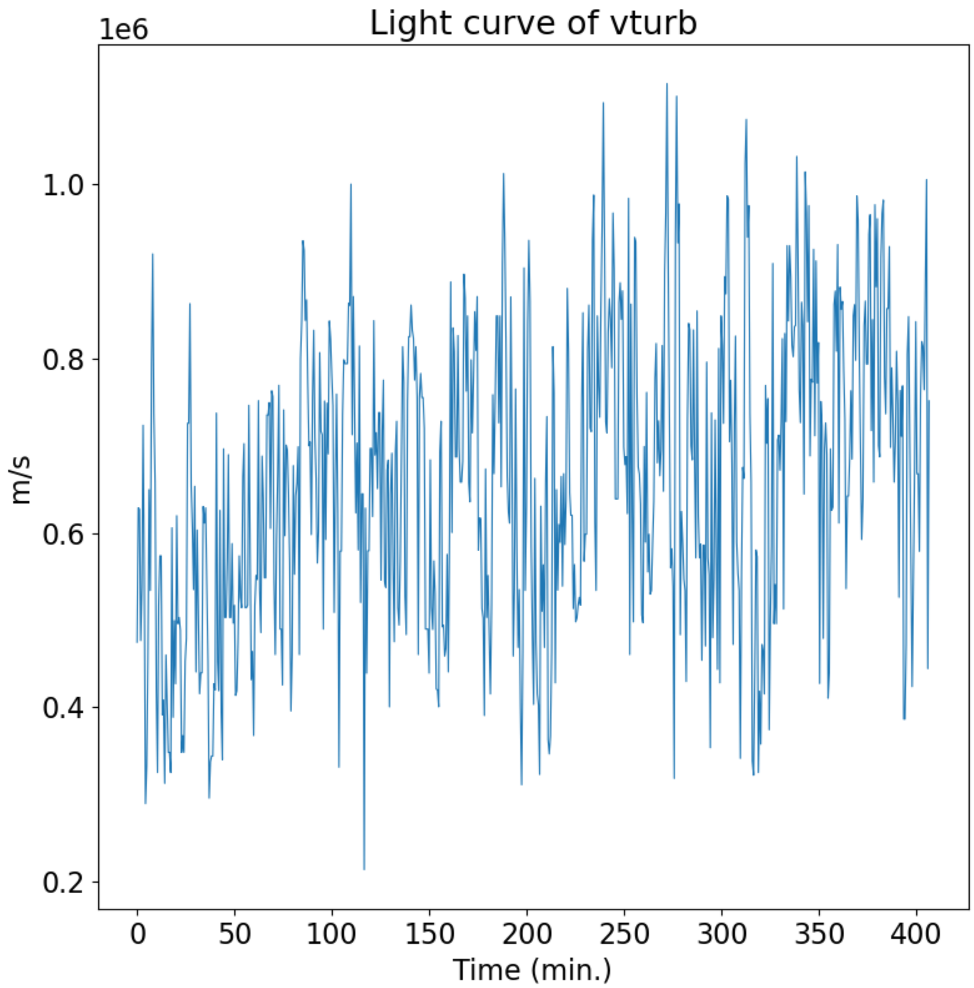
[18]:
```
Image(filename=plot_folder+'LC_vlos.png')
```

[18]:



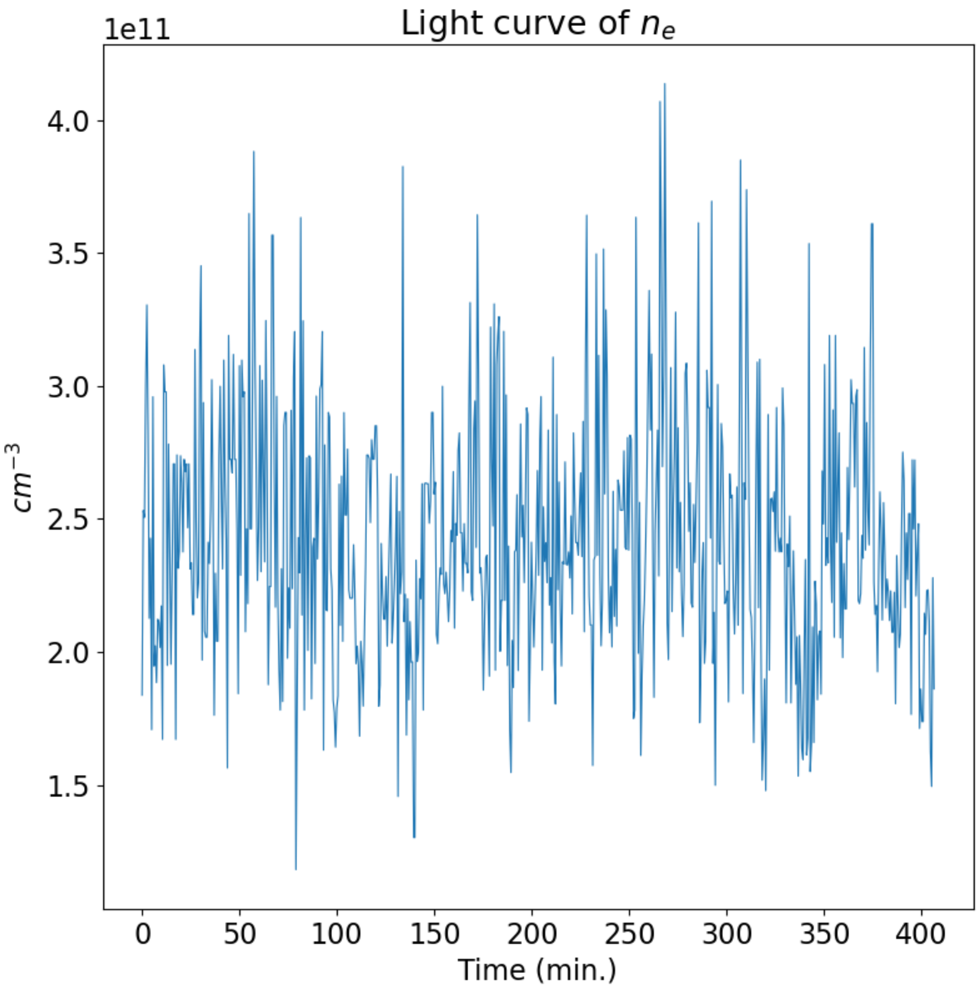
[19]:
```
Image(filename=plot_folder+'LC_vturb.png')
```

[19]:



[20]:
```
Image(filename=plot_folder+'LC_$n_e$.png')
```

[20]:

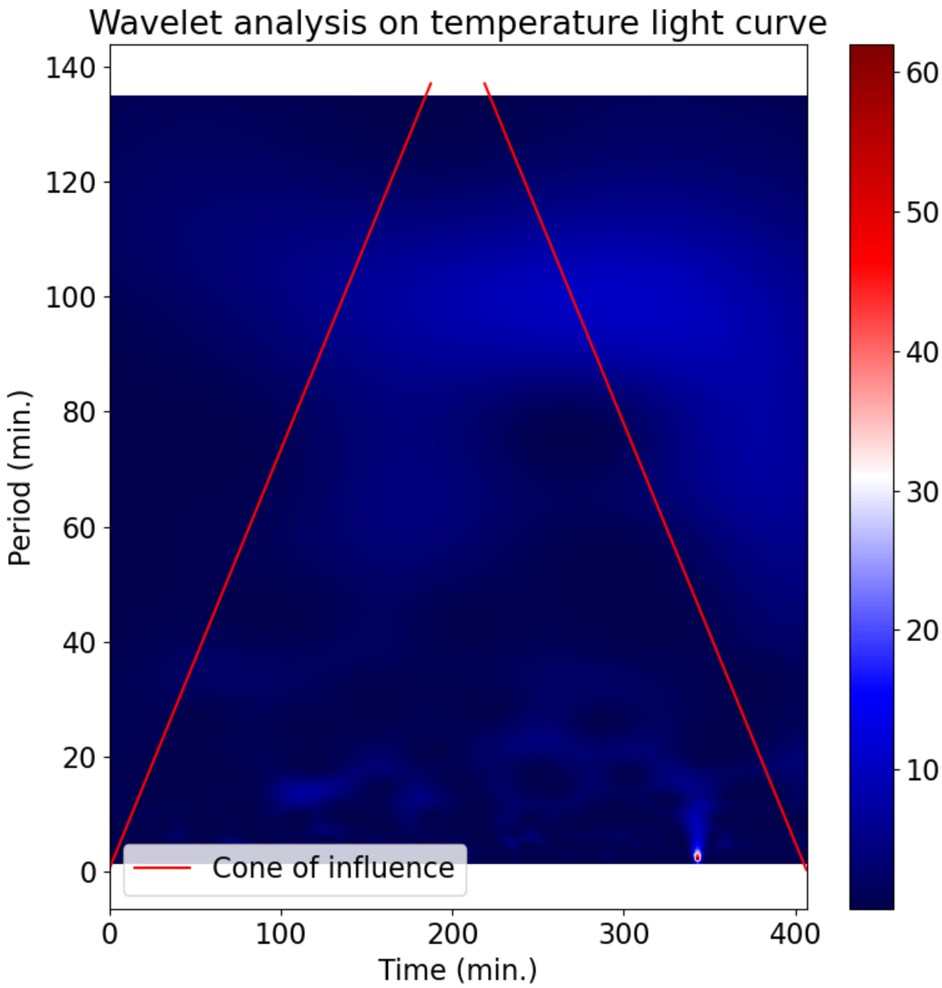


The wave power for each of the four parameters are presented below containing an illustration of the COI. The area outside the cone is subject to edge effects.

[1]:
```
plot_folder = '/home/efredborg/Documents/summer_project2021/plots/'
from IPython.display import Image
```

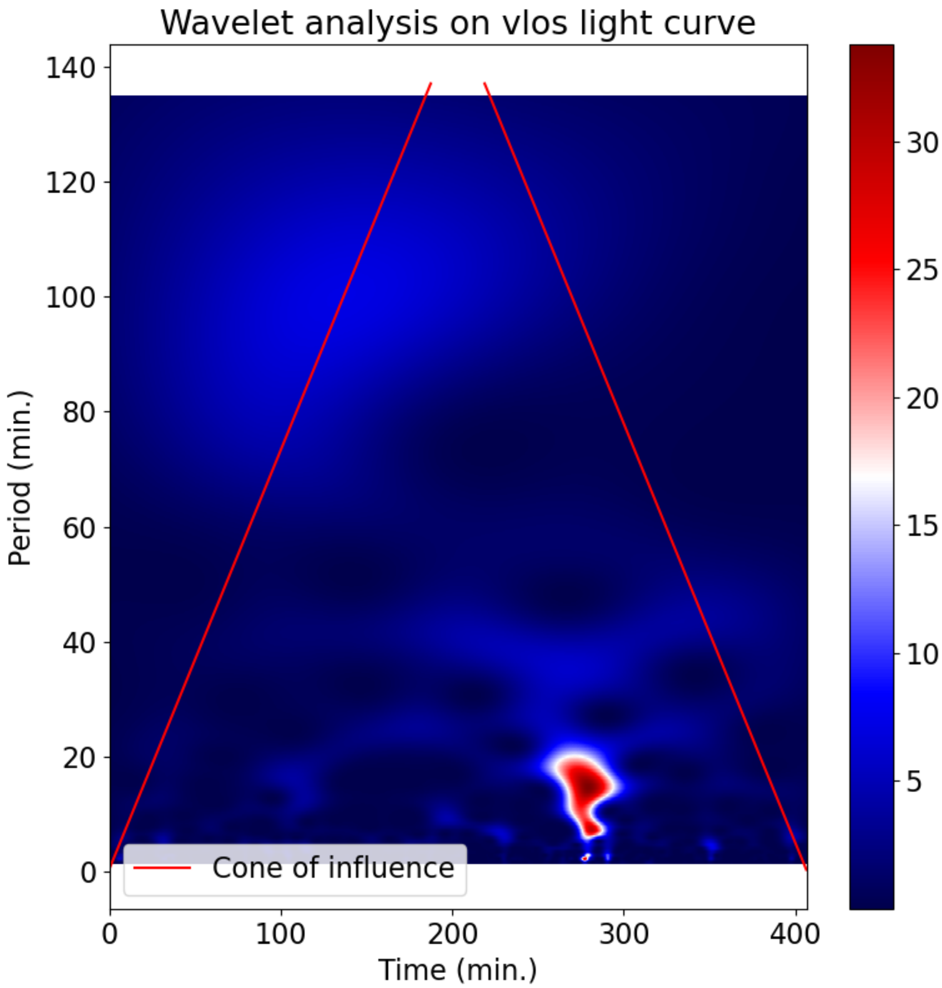
[21]:
```
Image(filename=plot_folder+'wavelet_p135_temperature.png')
```

[21]:



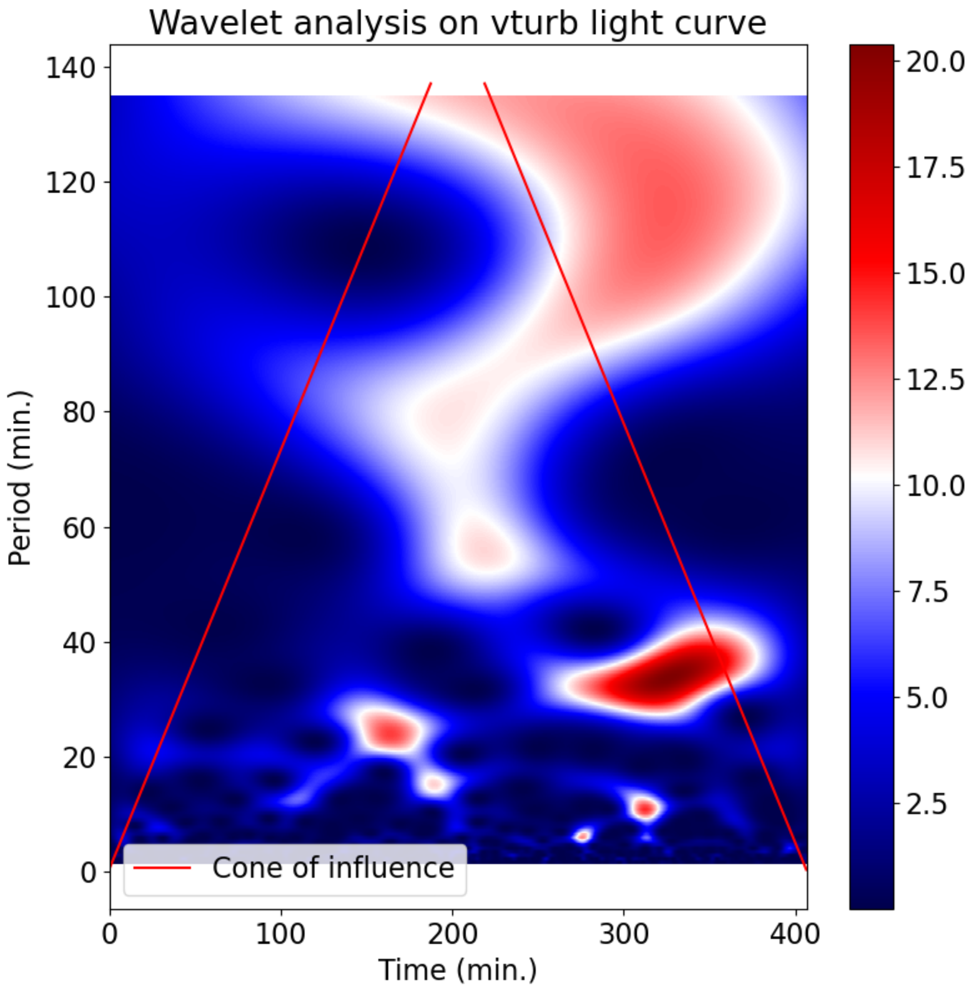
[22]:
```
Image(filename=plot_folder+'wavelet_p135_vlos.png')
```

[22]:



[23]:
```
Image(filename=plot_folder+'wavelet_p135_vturb.png')
```

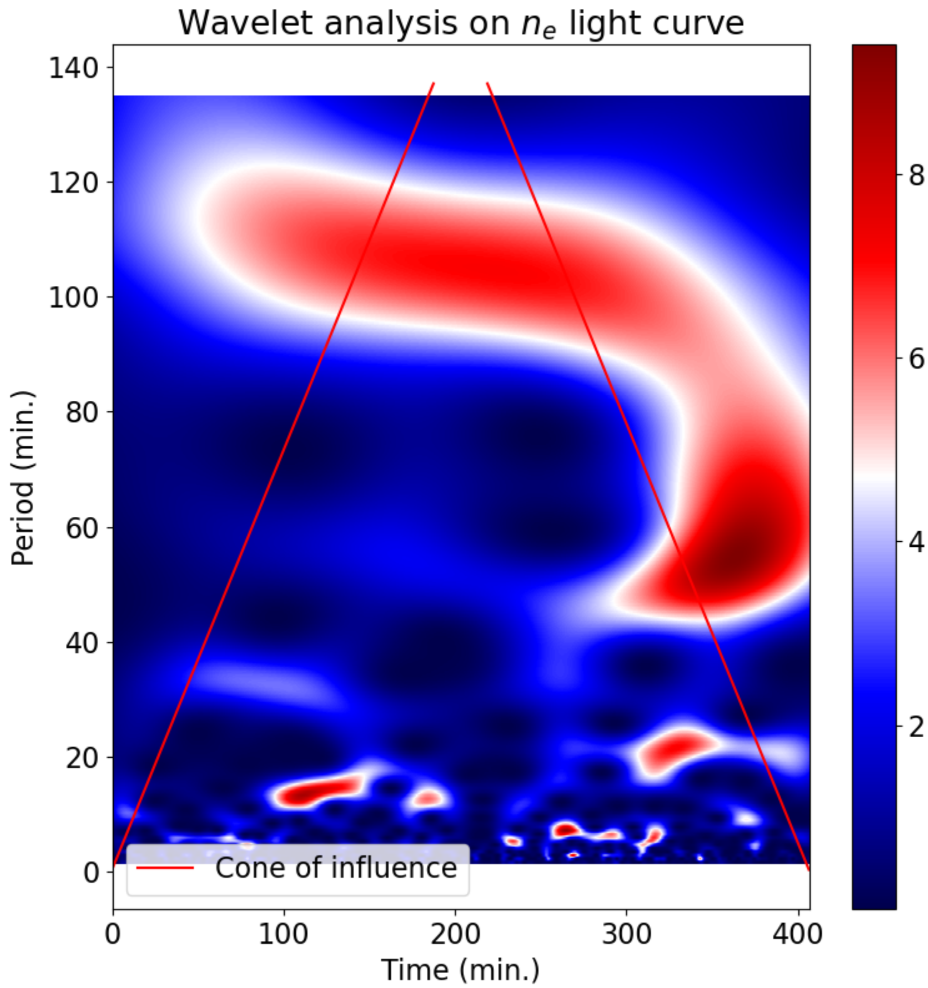
[23]:



[24]:

```
Image(filename=plot_folder+'wavelet_p135_$n_e$.png')
```

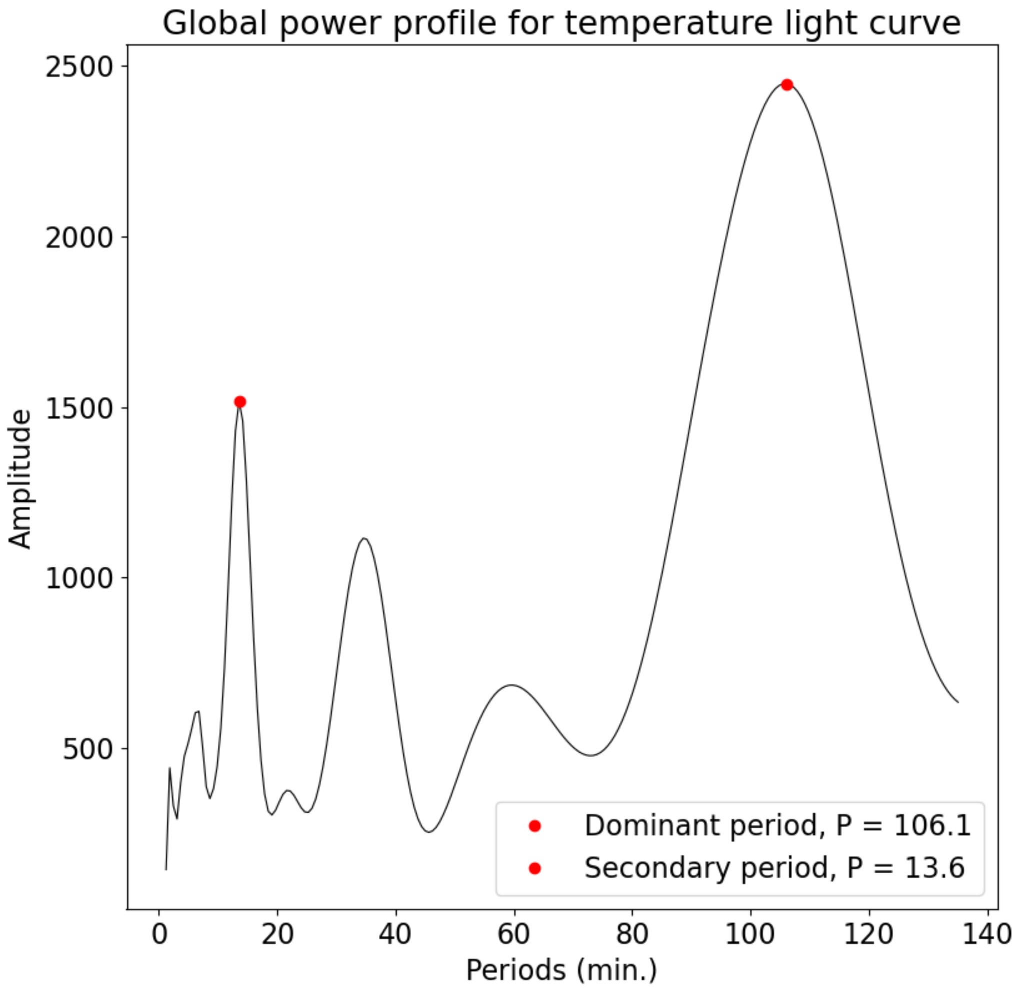
[24]:



The four plots above show the wave power as as function of period and observation time. The wave power is the squared of the correlation coefficients from the wavelet analysis. Red areas indicate stronger correlation for a period at a certain time in the observations. The images show no sign of repeating oscillations at long periods. There is however sign of long periods occurring once that would dominate the global wave power. This is illustrated in the figure below.

[25]:
```
Image(filename=plot_folder+'glbl_power_p135_LC_temperature.png')
```

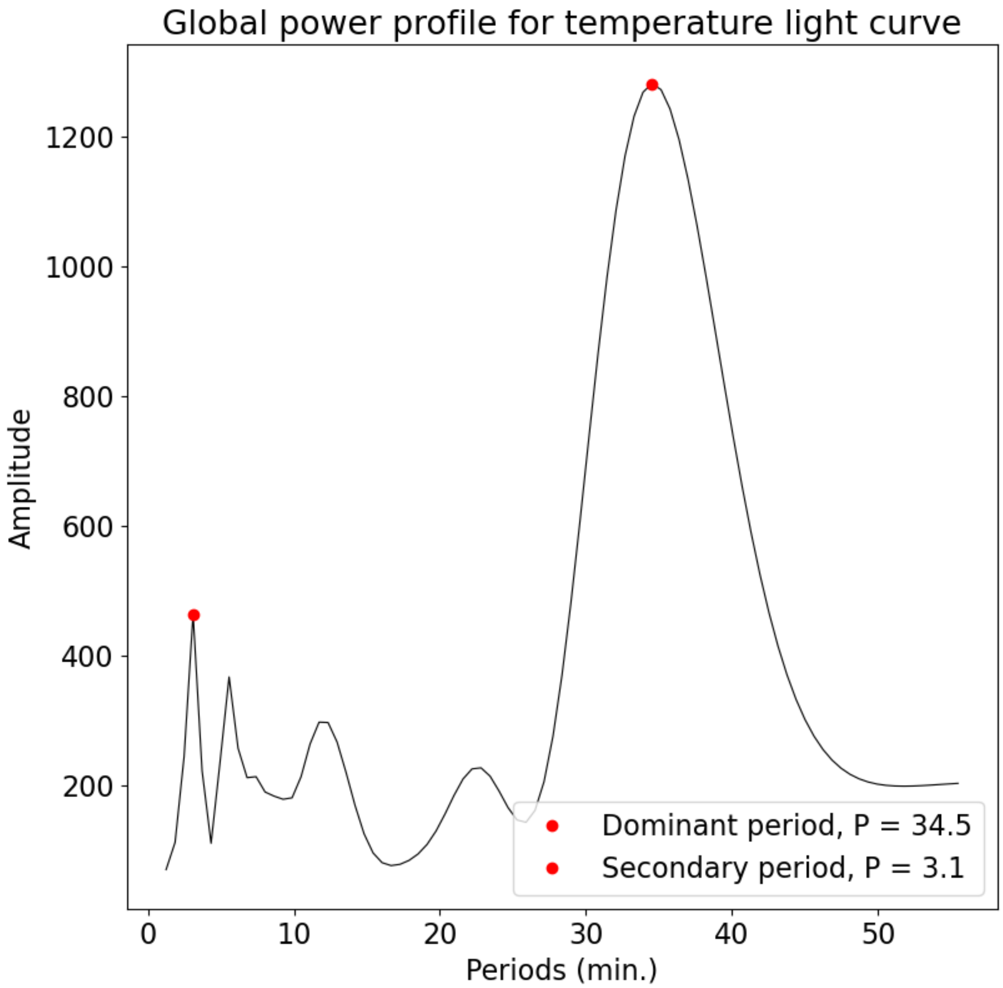
[25]:



The power from the long period occurring just once is dominating in the global power profile. For that reason, only periods up to 55 minutes were considered when determining the dominant periods. Global power plots containing the dominant periods for all four LCs are presented below.

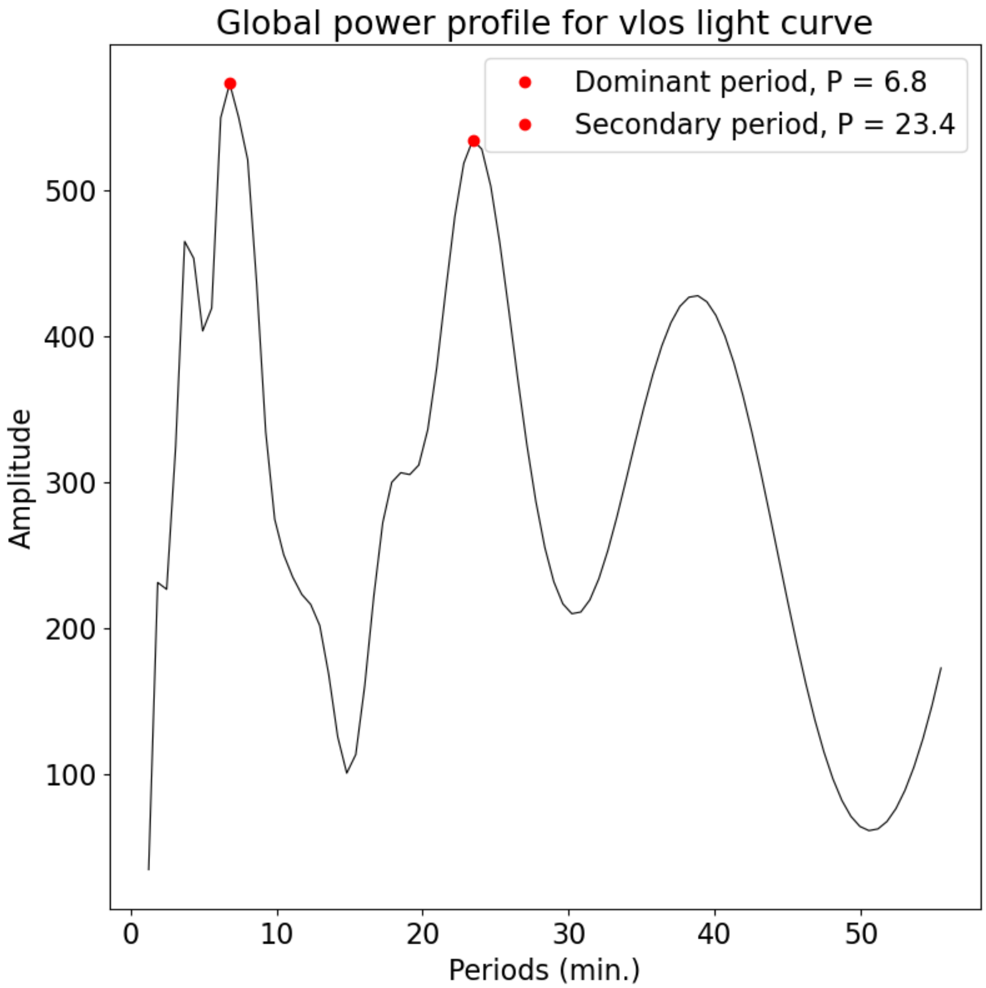
[26]:
```
Image(filename=plot_folder+'glbl_power_p55_LC_temperature.png')
```

[26]:

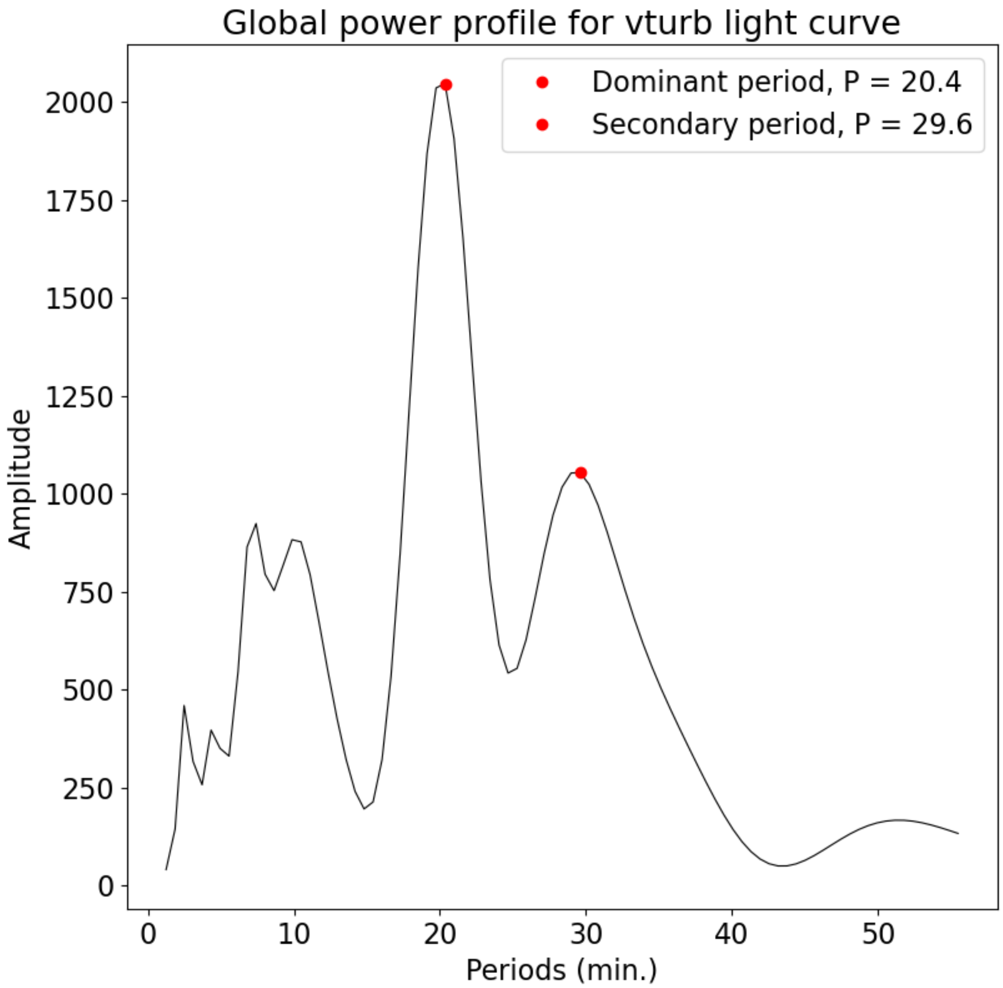



```
[27]: Image(filename=plot_folder+'glbl_power_p55_LC_vlos.png')
```

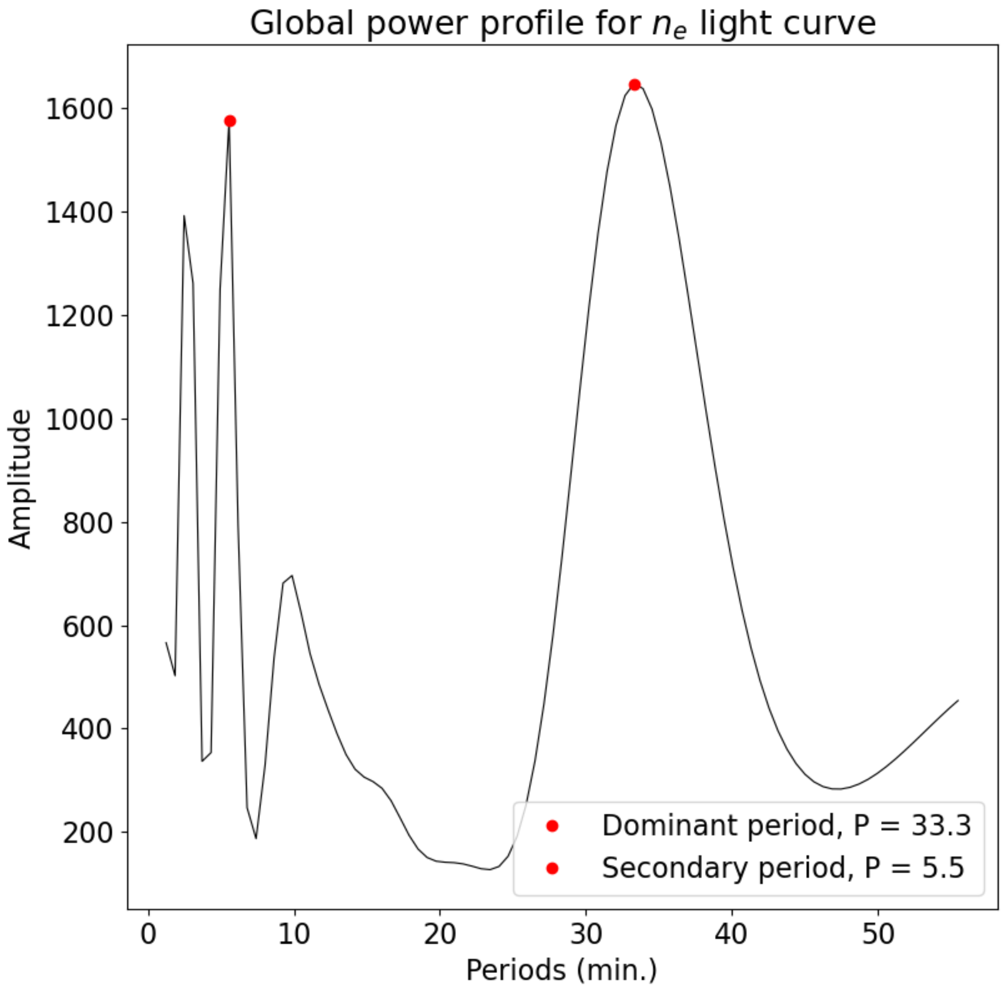
[27]:



[28]:
```
Image(filename=plot_folder+'glbl_power_p55_LC_vturb.png')
```
[28]:



[29]:
```
Image(filename=plot_folder+'glbl_power_p55_LC_$n_e$.png')
```
[29]:



The global wave powers for the four parameters indicate significant periods around ~5, 20 and 30 minutes.

1.0.6 Summary

A time series of Iris level 2 data was inverted and model atmospheres were created. Light curves were extracted from an optical depth of $log(\tau) = -5$. Wavelet analysis was performed on the four LCs and the dominant periods was determined to be around ~ 5, 20 and 30 minutes.

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[ ]:
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