

# USING CLEANest IN VSTAR

The CLEANest Process &  
Step-by-Step Example of  
Applying CLEANest in VStar

# CLEANest sequential Process-1

- ▣ Cleanest removes aliases of the frequencies to which it is applied and improves the frequency selection by doing local fits around all the frequencies input to CLEANest
- ▣ It is best to work with frequencies because Aliases and other interactions are linear combinations of frequencies not periods ( $P=1/f$ )
- ▣ First perform DCDFIT on the data & isolate the top pick. You don't need to perform CLEANest on the first Top Hit
- ▣ Create a model which subtracts model frequency(s) from data to produce a residual

# CLEANest Sequential Process -2

- ❑ Run a DCDFIT on the residual and identify the Top Hit
- ❑ Check the residual Top Hit significance by looking at the Power and Amplitude spectra.
- ❑ Power spectra re-scale on every residual because the scale factor is the inverse of the variance of residuals after the model was subtracted. When you subtract signal the variance goes down. Amplitudes do not re-scale. A practical lower limit for significance is amplitude peak at least 4x the average of the background “forest” of amplitudes
- ❑ Check the p value in the info dialog for residuals. Make sure the means bin size makes sense for the residuals variability of interest.

# CLEANest Sequential Process -3

- ▣ Re-run DCDFT on the data series (not residuals) using top hit(s) from the previous DCDFT on data plus the closest frequency to the new residual Top Hit<sup><1></sup>
- ▣ Run CLEANest with these frequencies selected
- ▣ Create a new model using the CLEANest output frequencies at the top of the Top Hits list
- ▣ Check the Info dialog for the ANOVA F and p values of residuals. Is the p value greater than 0.05? Did it improve substantially? Even if the p value is  $>0.05$  you aren't done if there are significant peaks left in the DCDFT spectrum.

<1> Check Slides 11-12 if there isn't a corresponding data DCDFT Top Hit

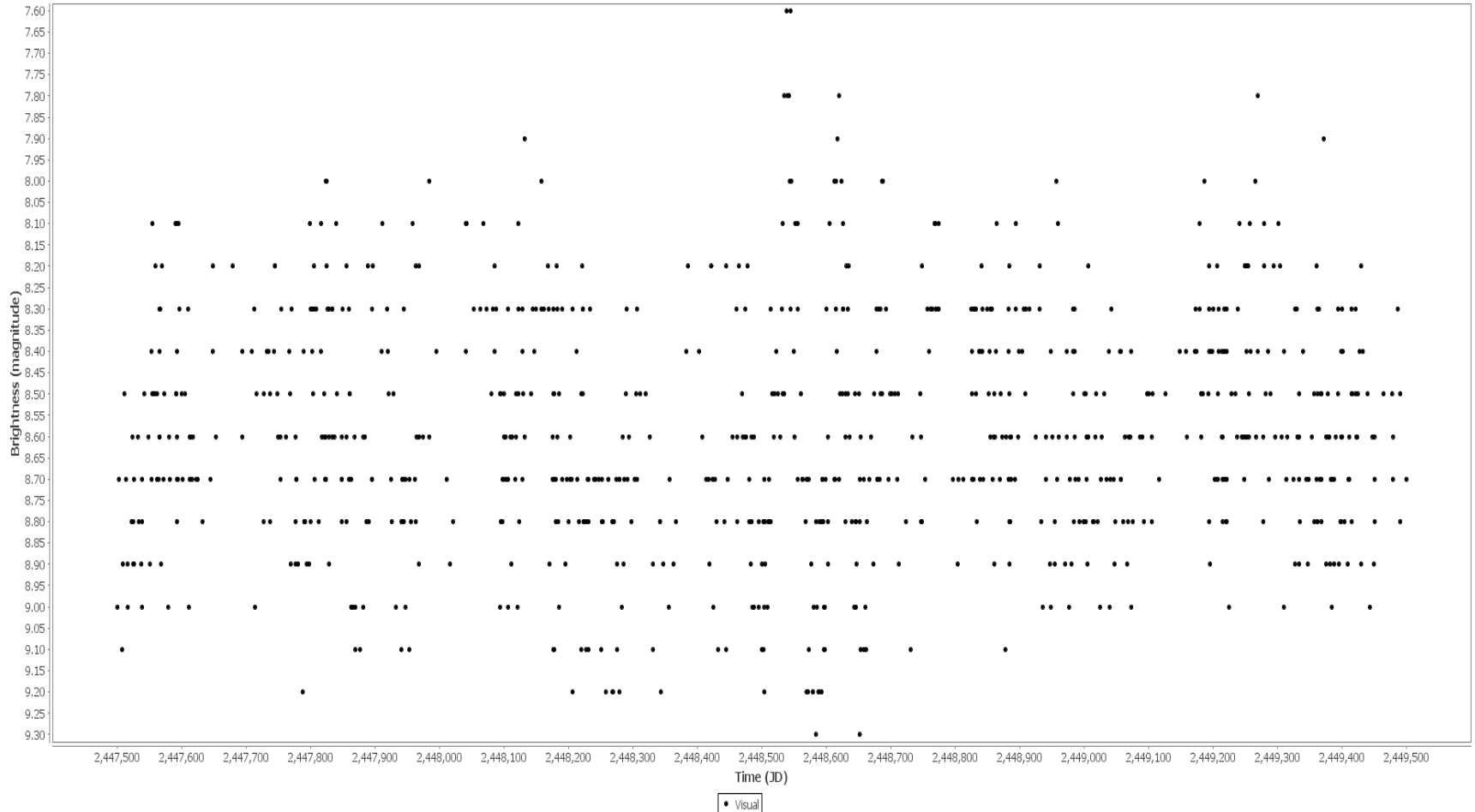
# CLEANest Sequential Process -4

- ▣ Repeat the process of getting a new Top Hit from residuals, re-running DCDFIT on the data, incorporating the new residual Top Hit (or close data DCDFIT top hits frequency to it) in the CLEANest input selections, creating the new model and checking residuals for significant peaks remaining and ANOVA p value.
- ▣ When you think you are all done: the model visually fits well, there don't appear to be any significant peaks remaining in the power or amplitude spectra and the residual info dialog p value tells you that you can't reject the null hypothesis that the residuals are the result of white noise, make a final check of the scatter of the means to see if they make sense for the type of data or reported uncertainty of the data.

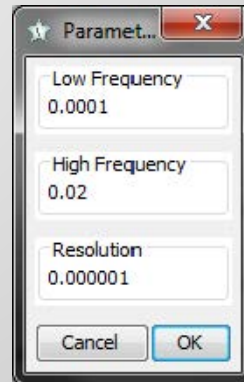
# CLEANest Example AA CAS

# Light Curve AA Cas Visual

Light Curve for AA Cas



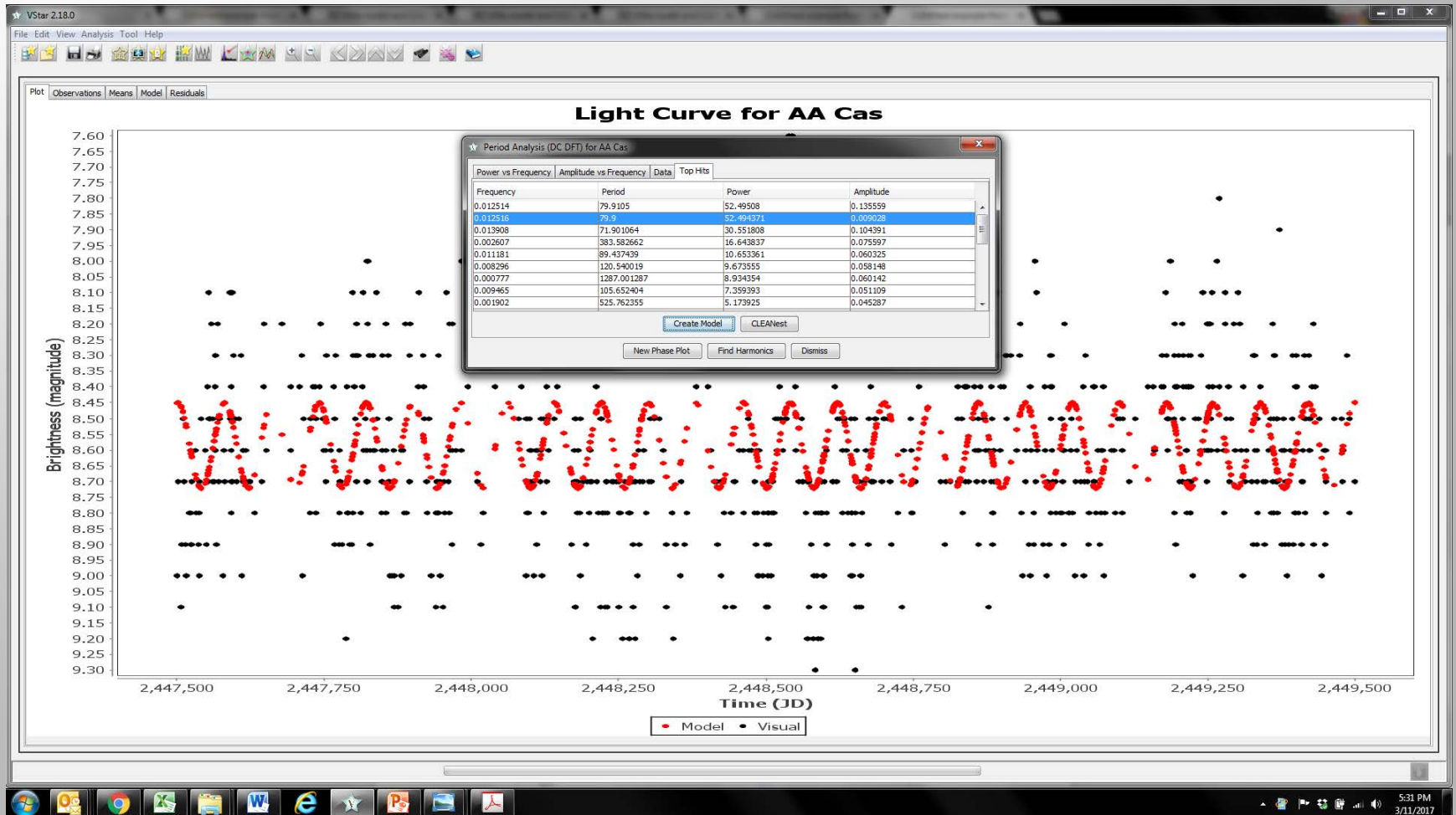
# DCDFT Parameters



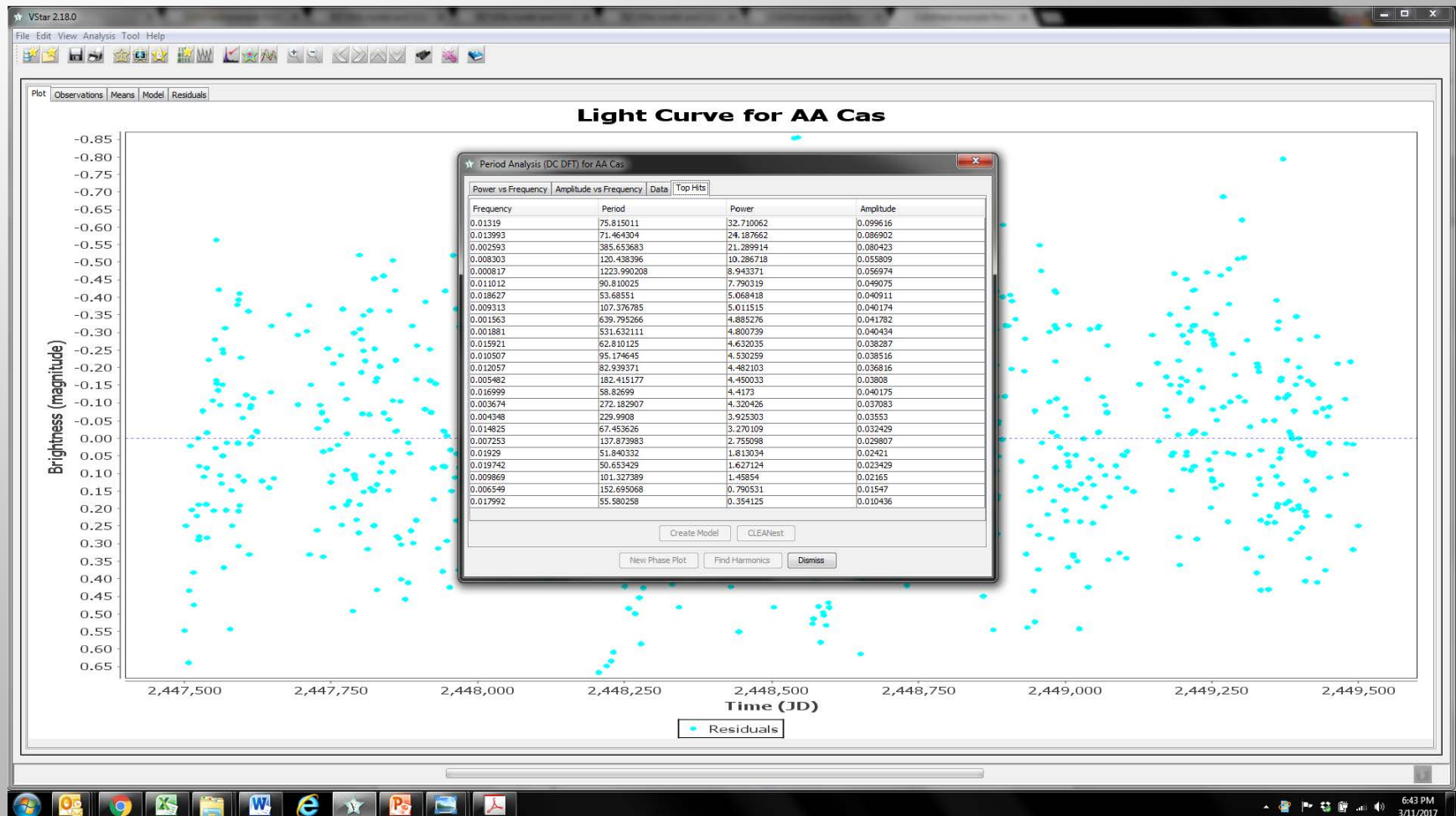
On Some of the following slides you may want to zoom  
To 200% to see some dialog box text



# 1 Frequency Model from DCDFIT-1 on Visible Using CLEANest Output



# Freq.-2 from DCDFT on Resid-1 Note: Top Hit is a New Hit Freq. Not in DCDFT-1 Top Hits



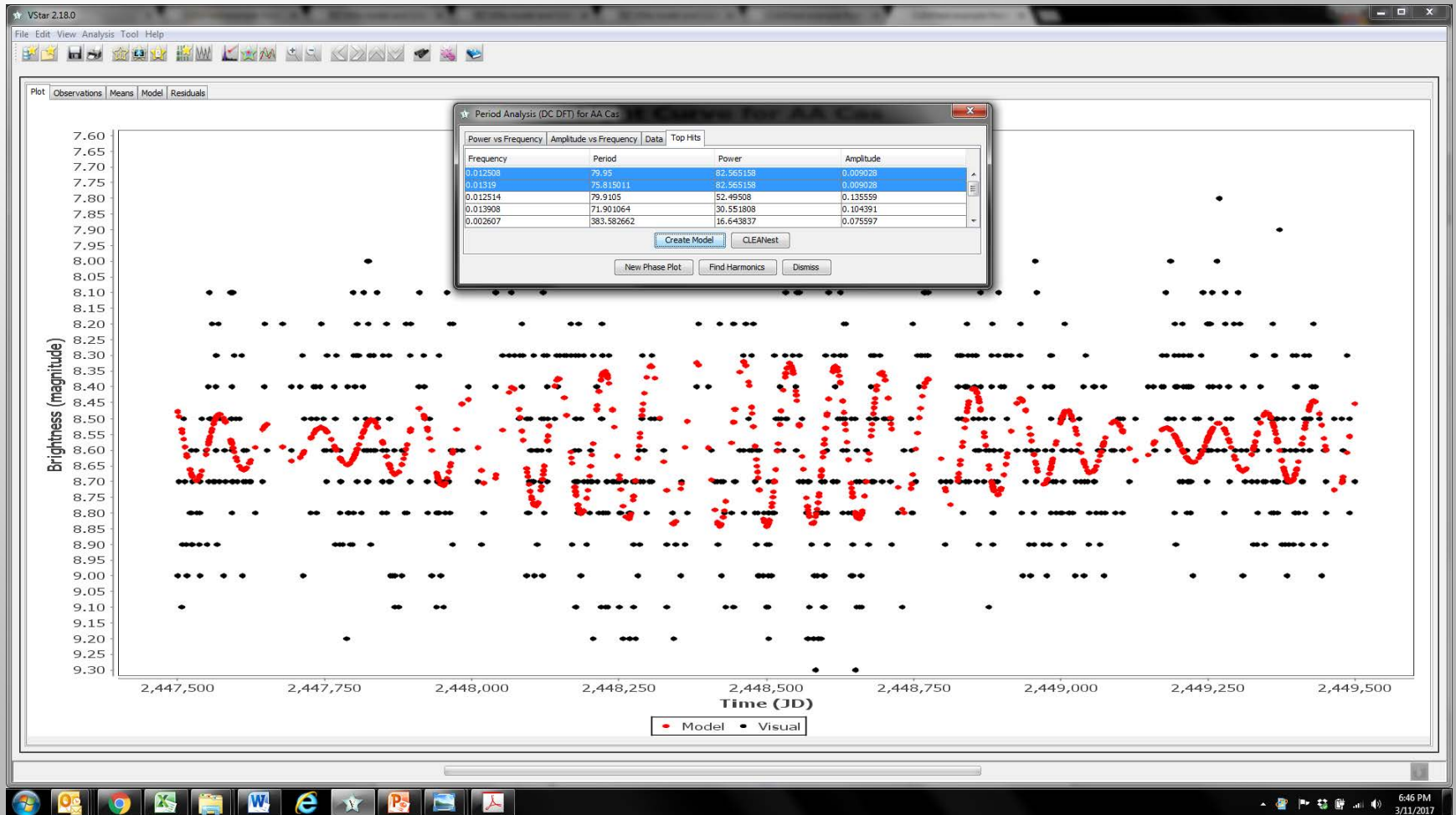
# “New” Frequency Top Hit in DCDFT-2

- ▣ The top hit in the DCDFT of Residual-1 is not on the top hits list of the initial DCDFT. The second hit in this DCDFT was also the second hit on the initial DCDFT so it is probably a separate real frequency and we can't use it as an approximation of this new one when doing the CLEANest.

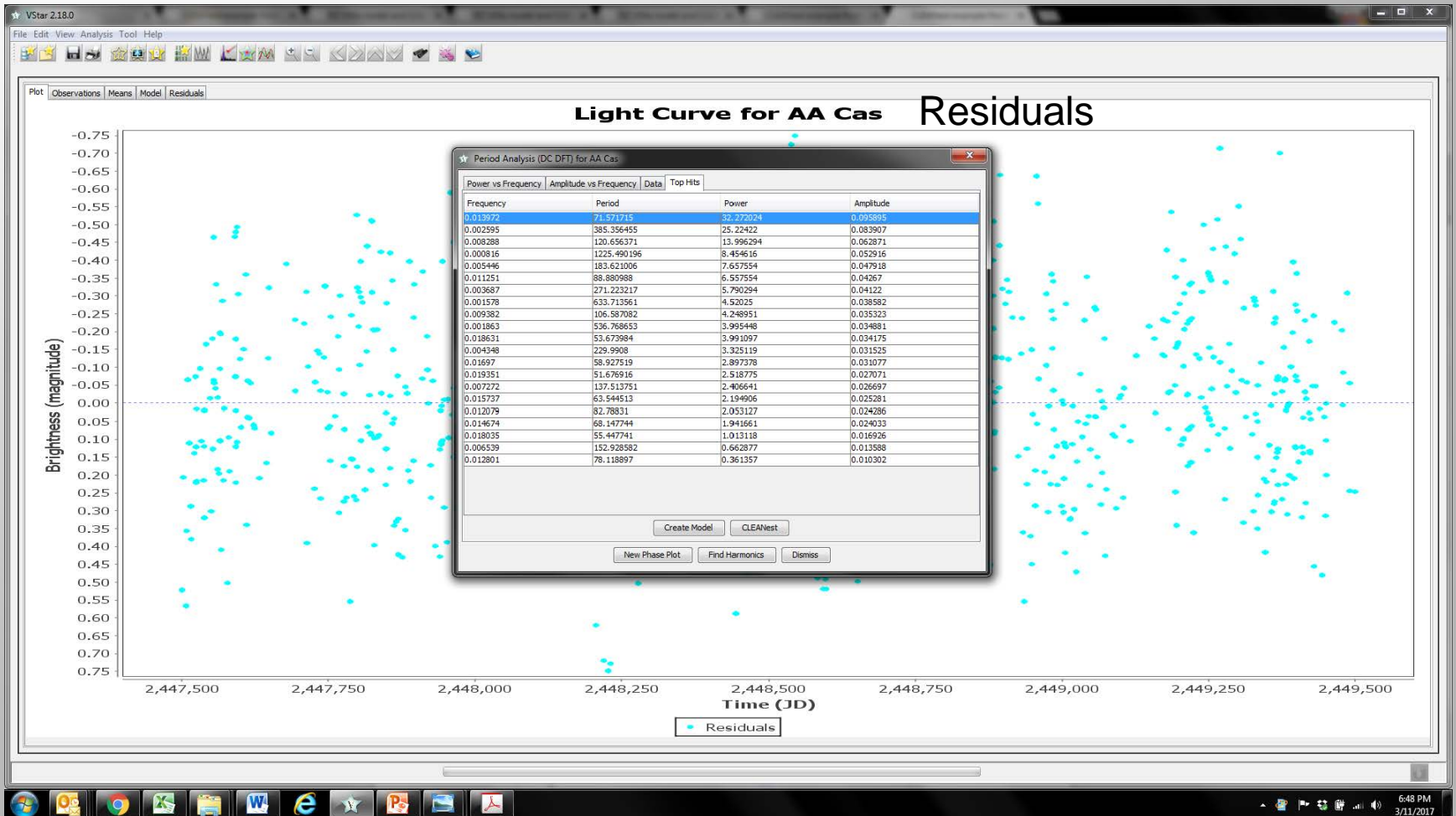
# Adding a “New Top Hit”

- ▣ The “new” frequency is included by entering its period in the Variable Periods box and clicking the adjacent “Add” button in the CLEANest dialog. You must add it in each subsequent cleanest application on visual data. Cleanest doesn’t “remember” it between runs. The Variable Periods box is used because we want CLEANest to be able to vary the period (frequency) as it does for the top hits we select. If we added it as a Locked Period, the period (frequency) would not be refined by CLEANest.

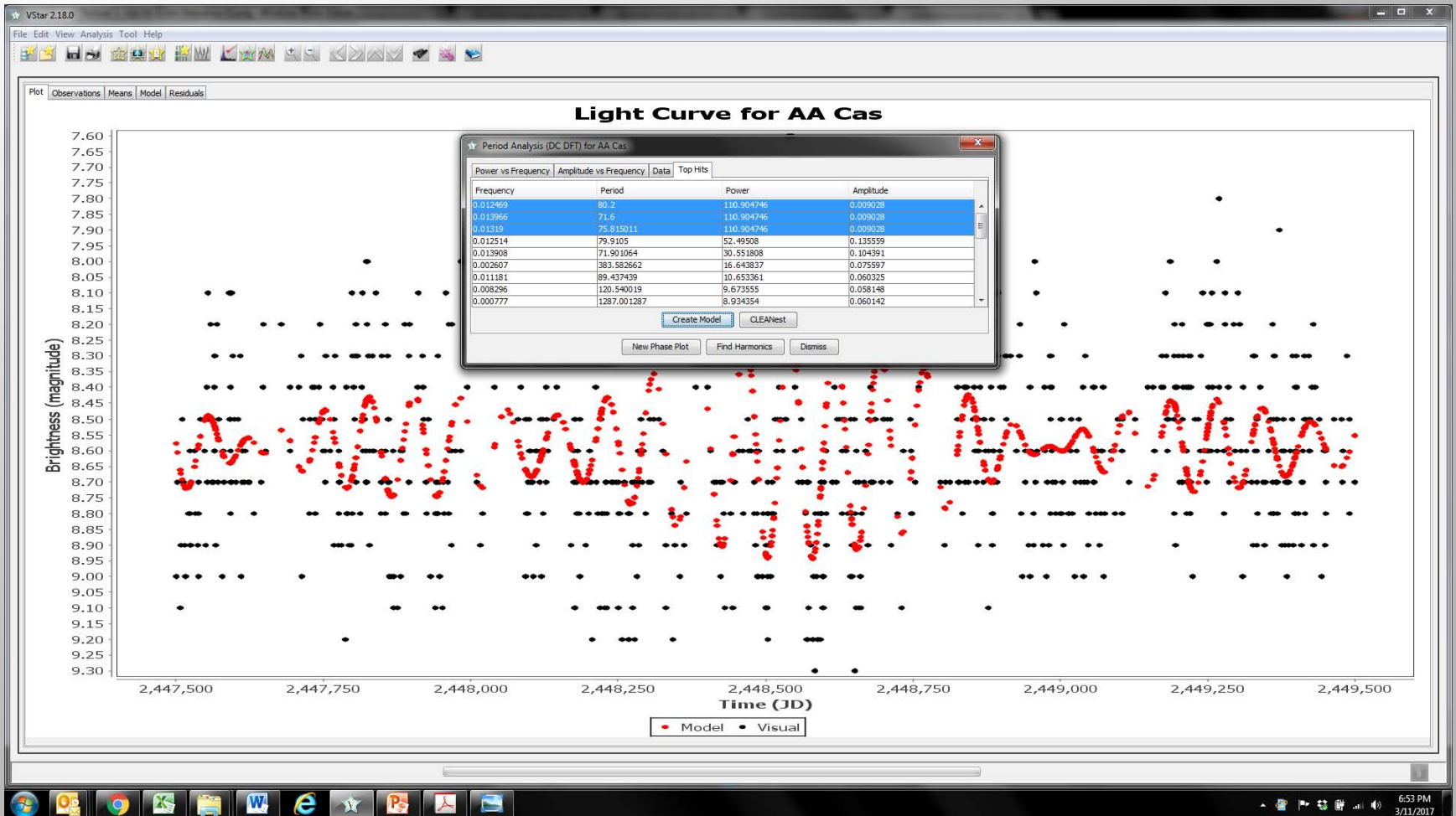
# 2 Frequency model from DCDFIT-3 on Visual Using CLEANest Output



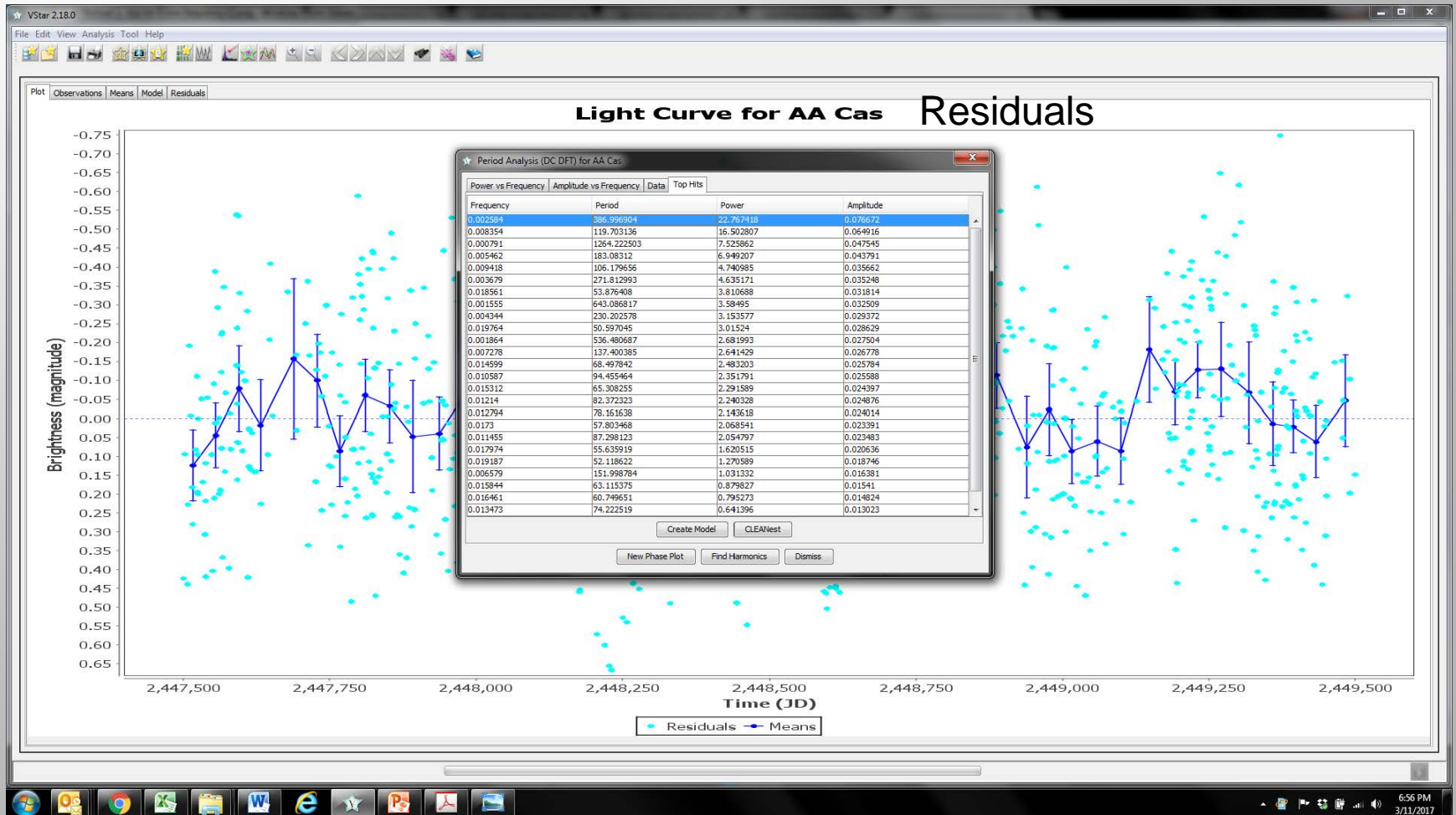
# DCDFT-4 on Residual-2 Top Hit



# 3 Frequency model from DCDFIT-5 on visual using CLEANest output

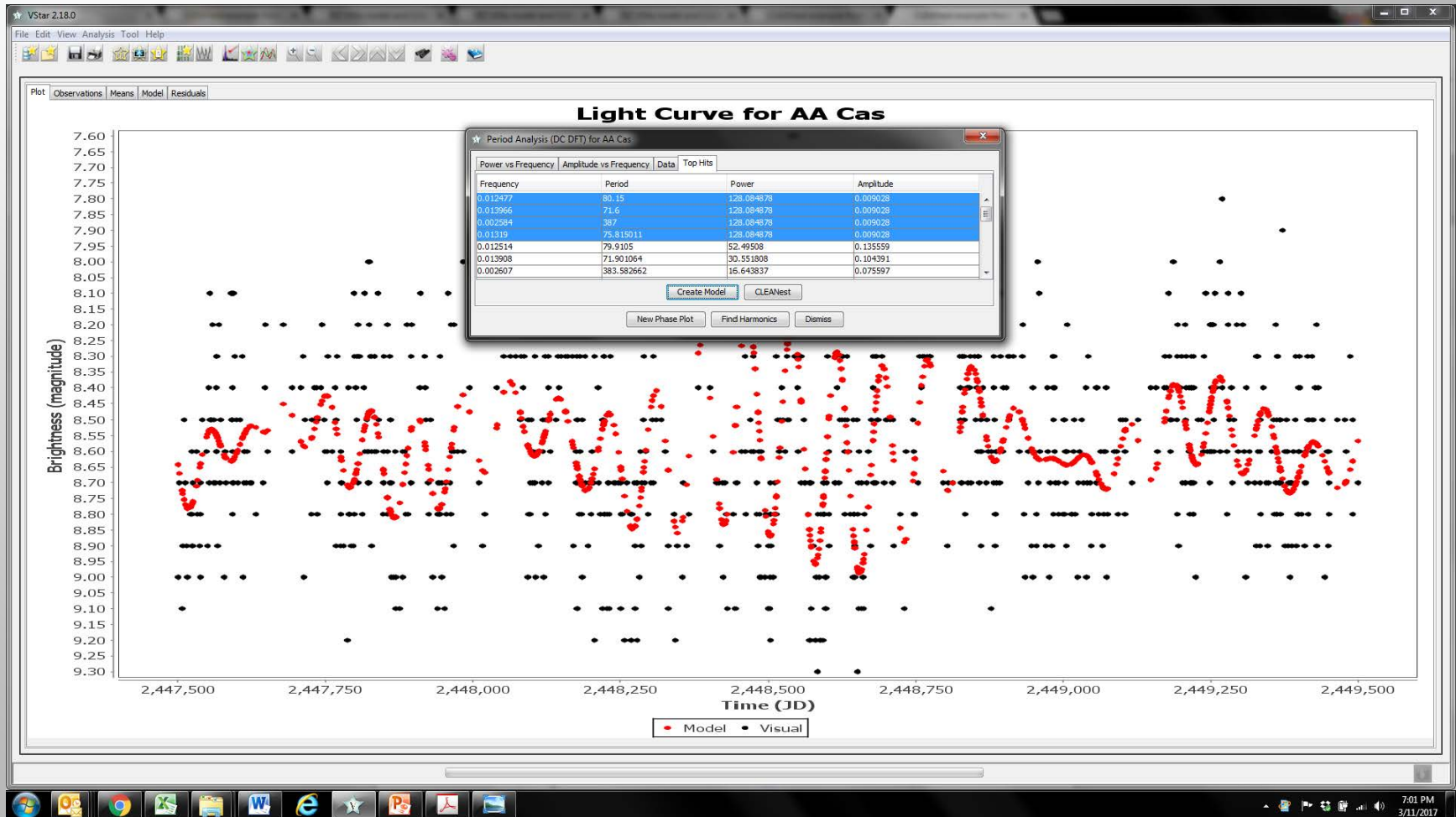


# DCDFT-6 on Residual-3 Top Hit

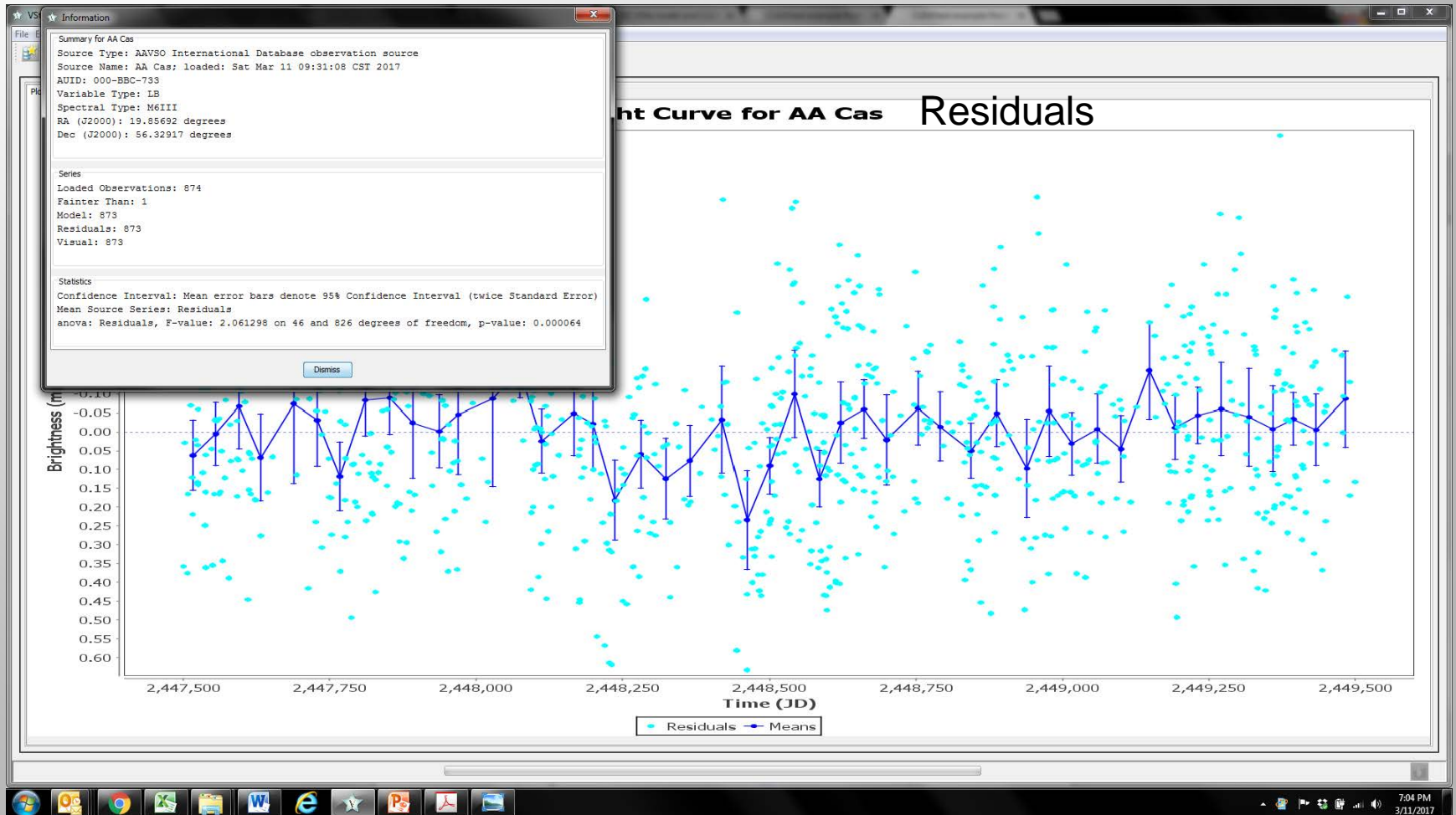




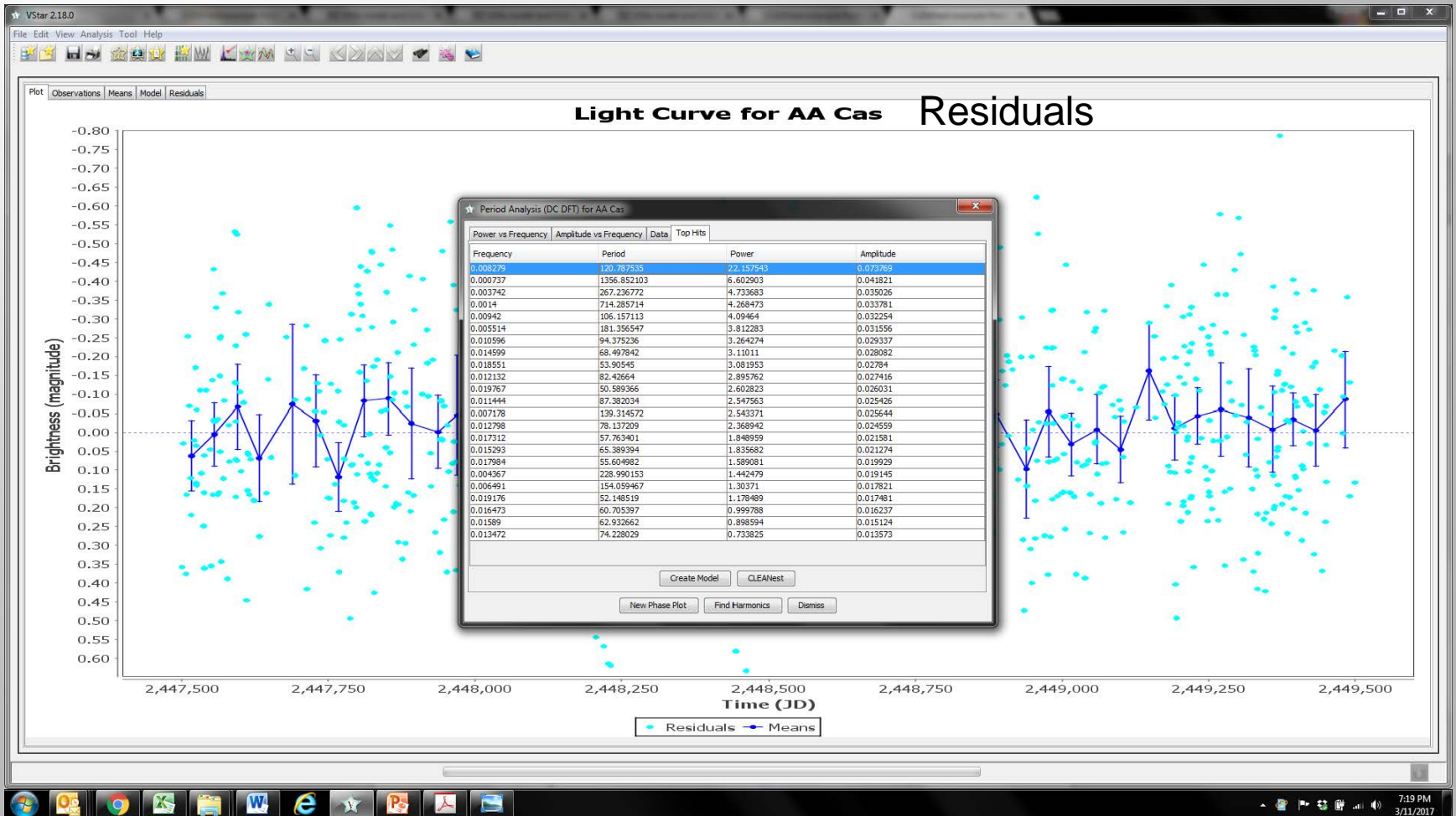
# 4 Frequency model from DCDFIT-7 on visual using CLEANest output



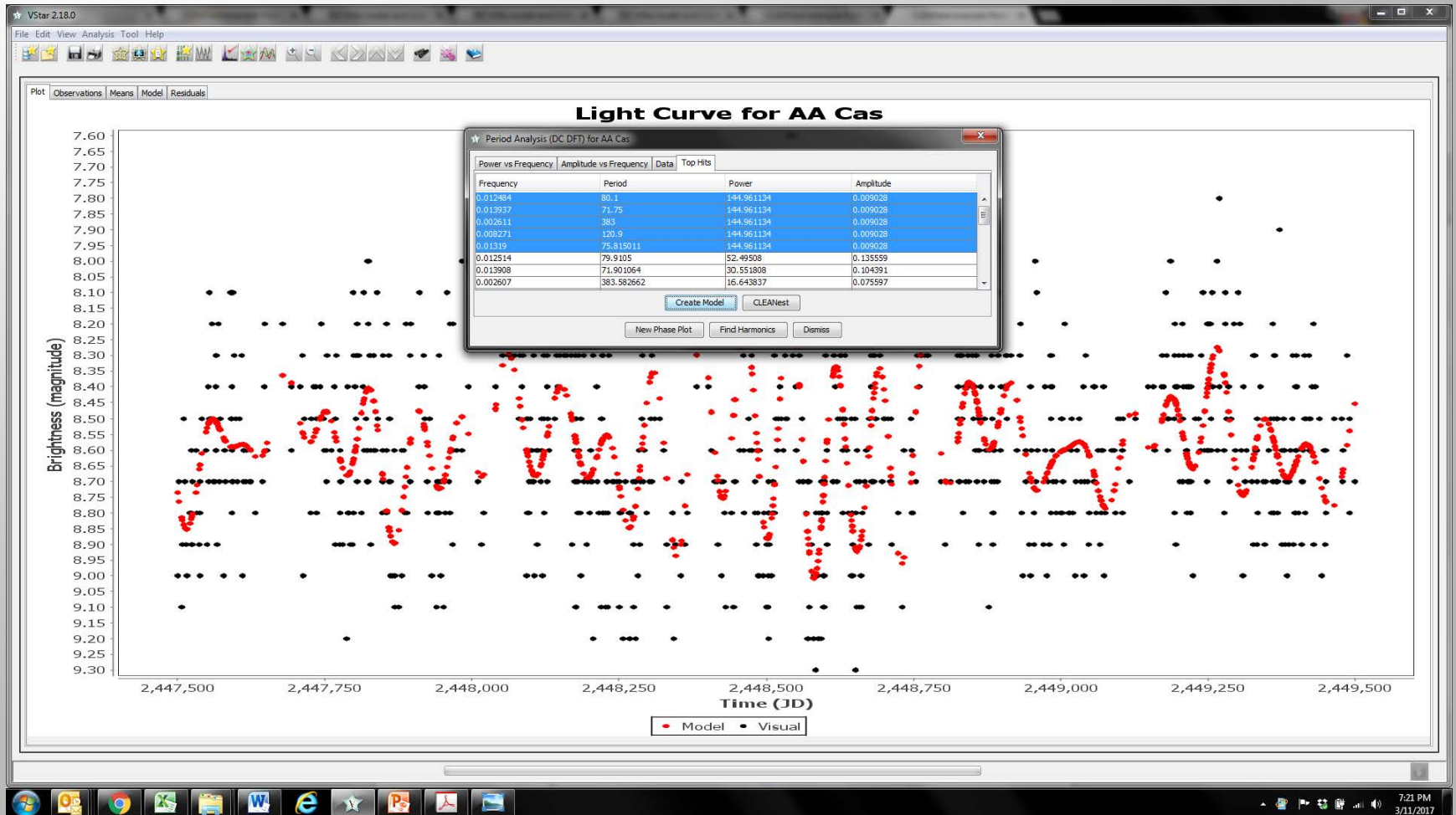
# Residual-4 Info Dialog After 4 Frequency Fit: $P = 0.00044$



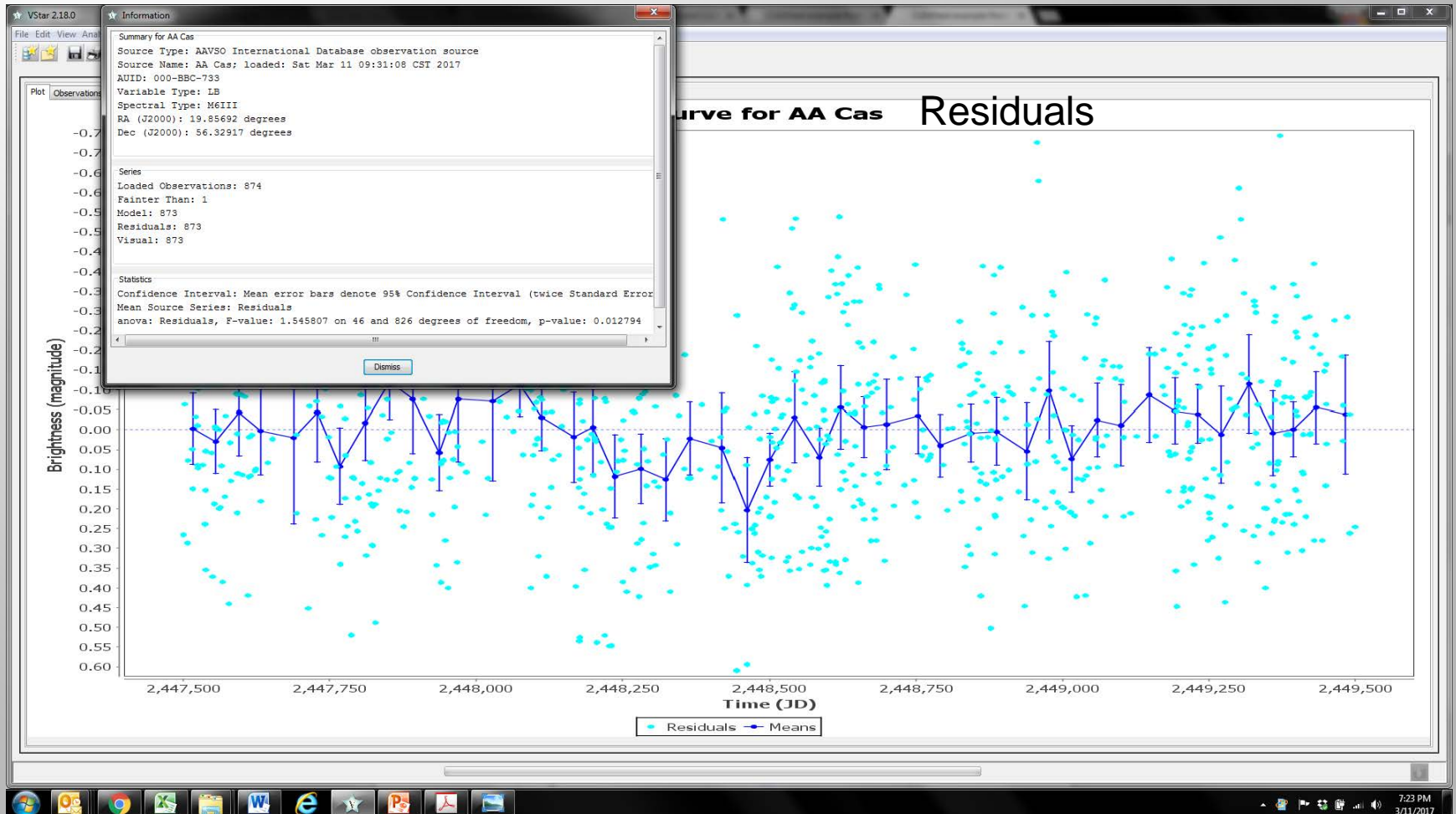
# DCDFT-8 on Residual-4 Top Hit



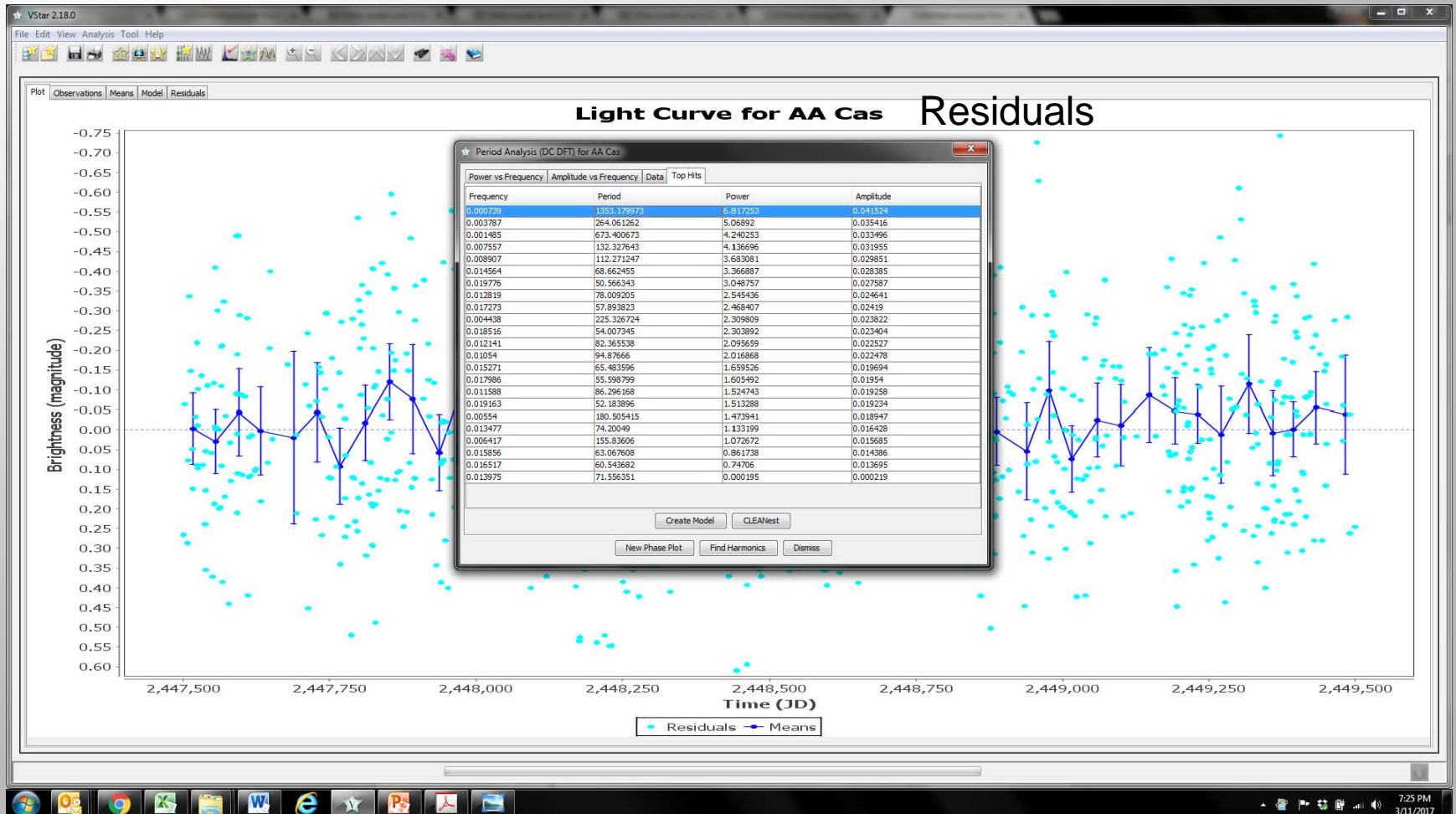
# 5 Frequency model from DCDFIT-9 on visual using CLEANest output



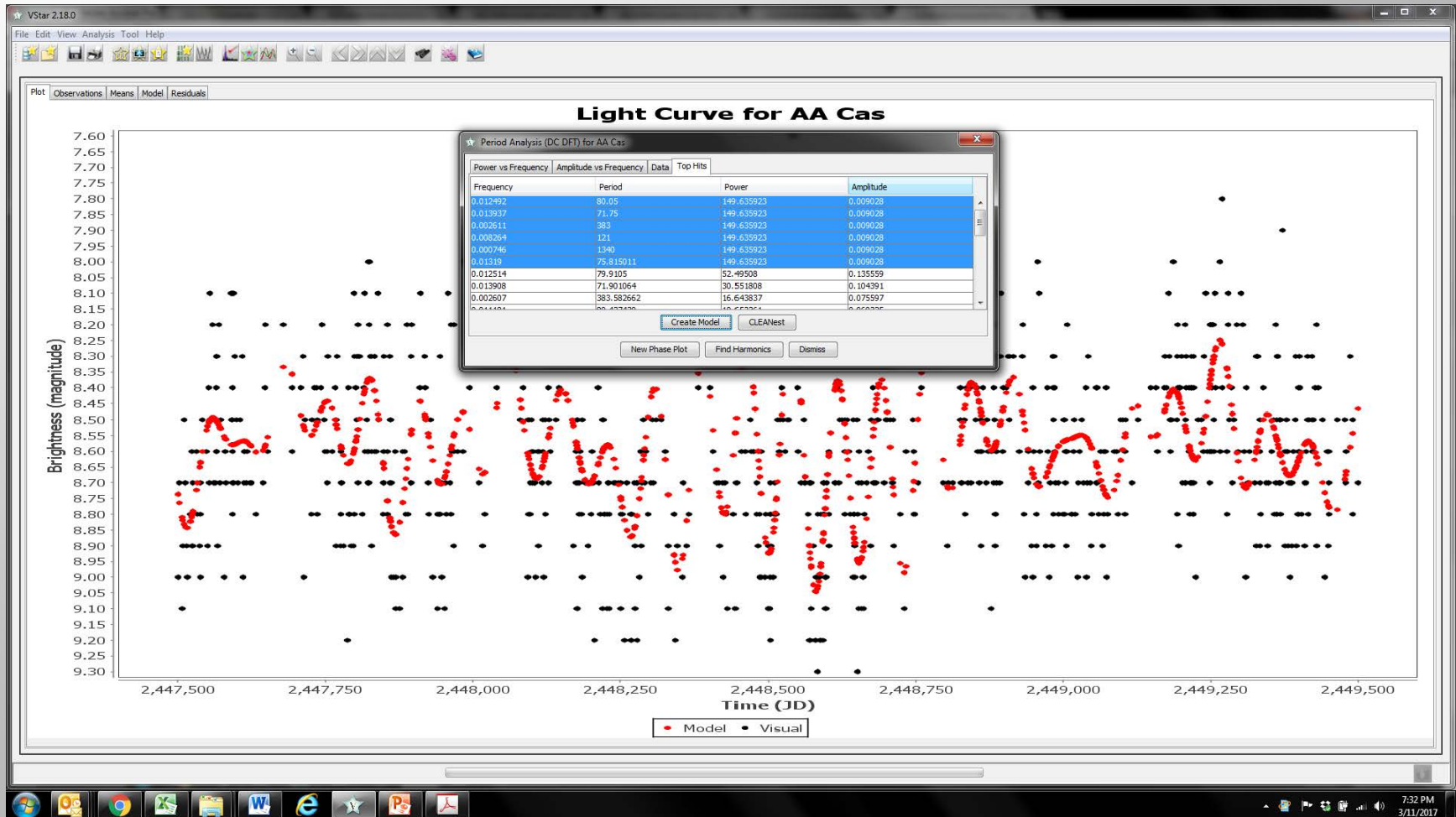
# Residual-5 Info Dialog After 5 Frequency Fit: $P = 0.013$



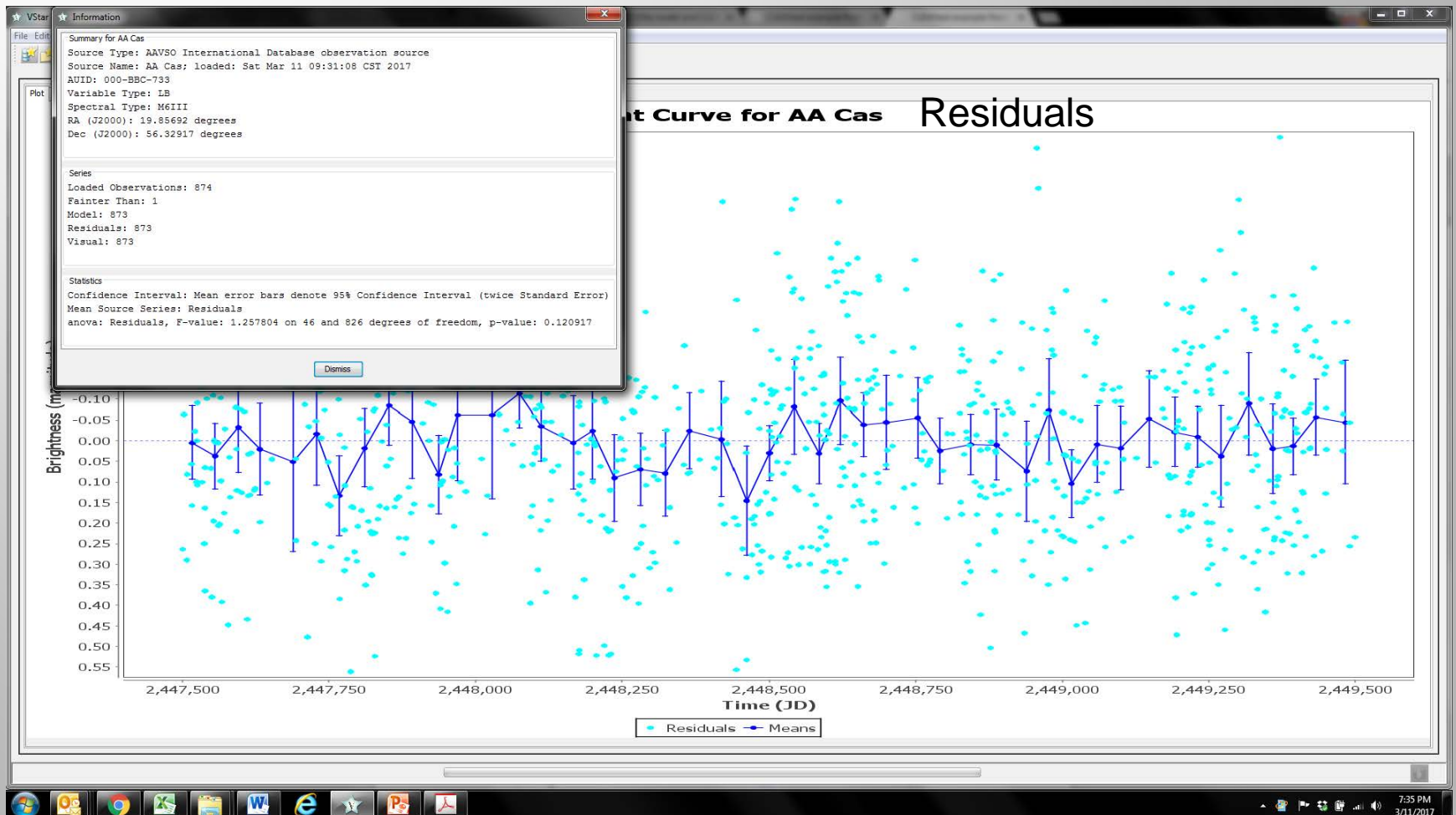
# DCDFT-10 on Residual-5 Top Hit



# 6 Frequency model from DCDFE-11 on visual using CLEANest output

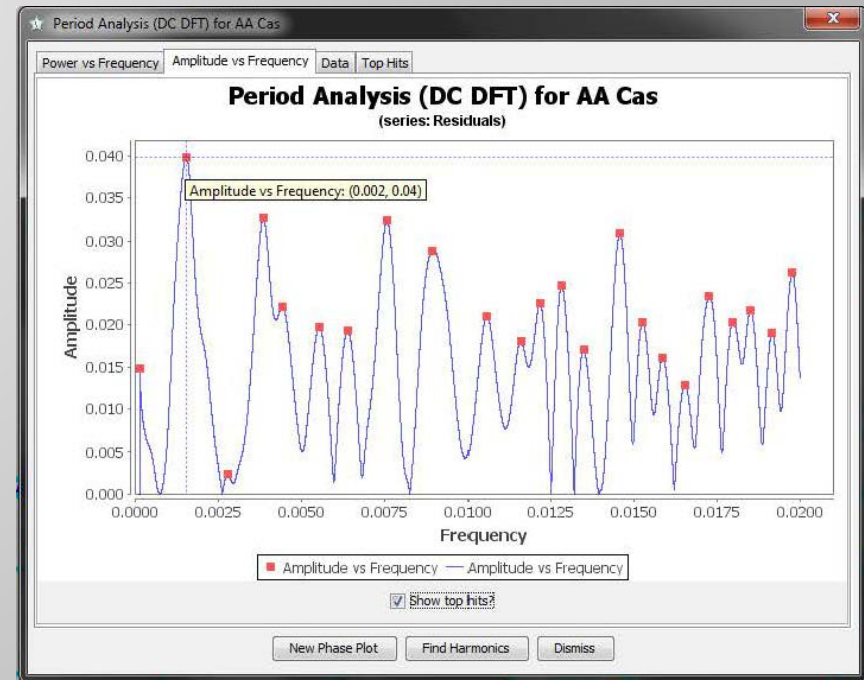
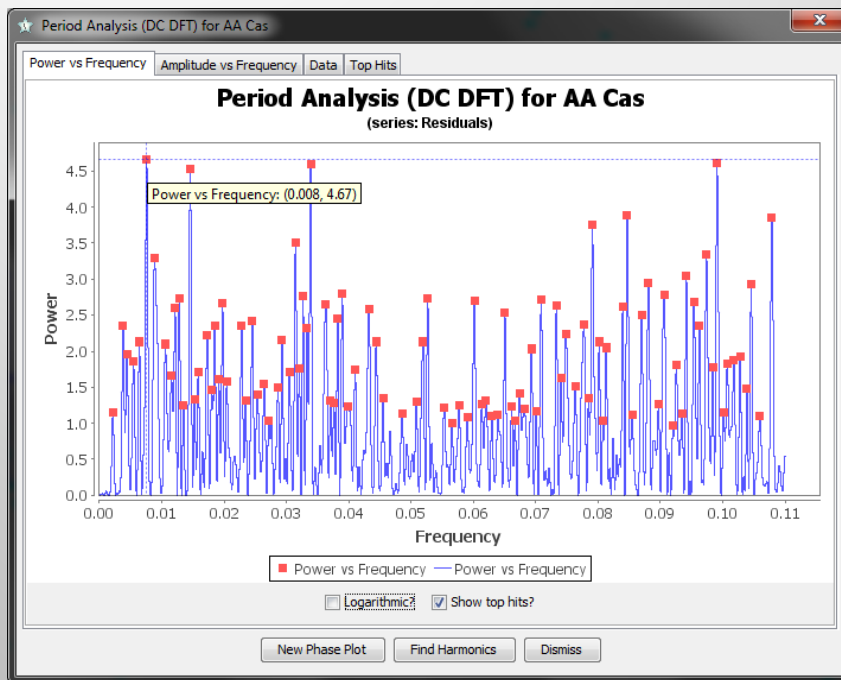


# Residual-6 Info Dialog After 6 Frequency Fit: $P = 0.131$

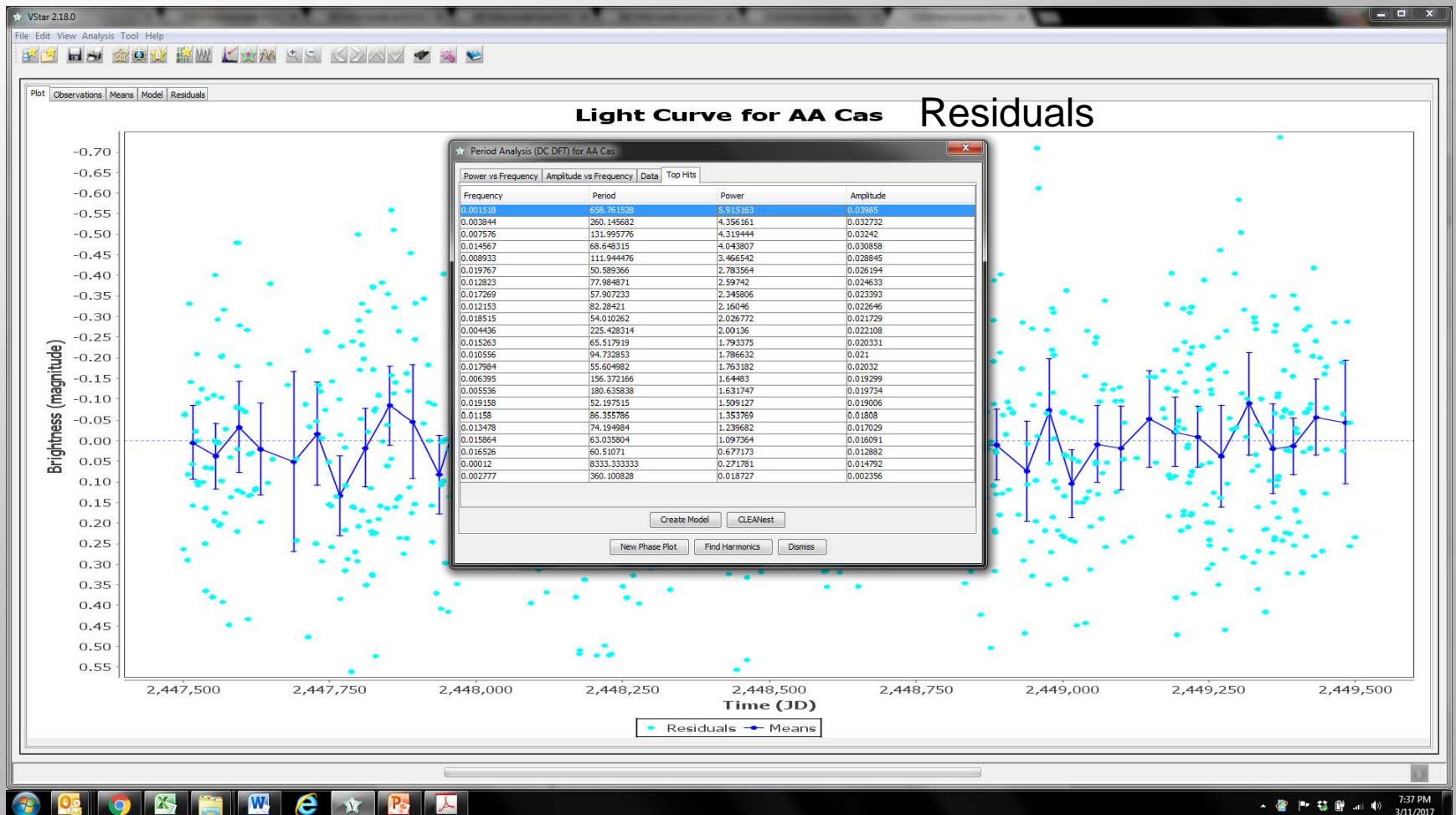




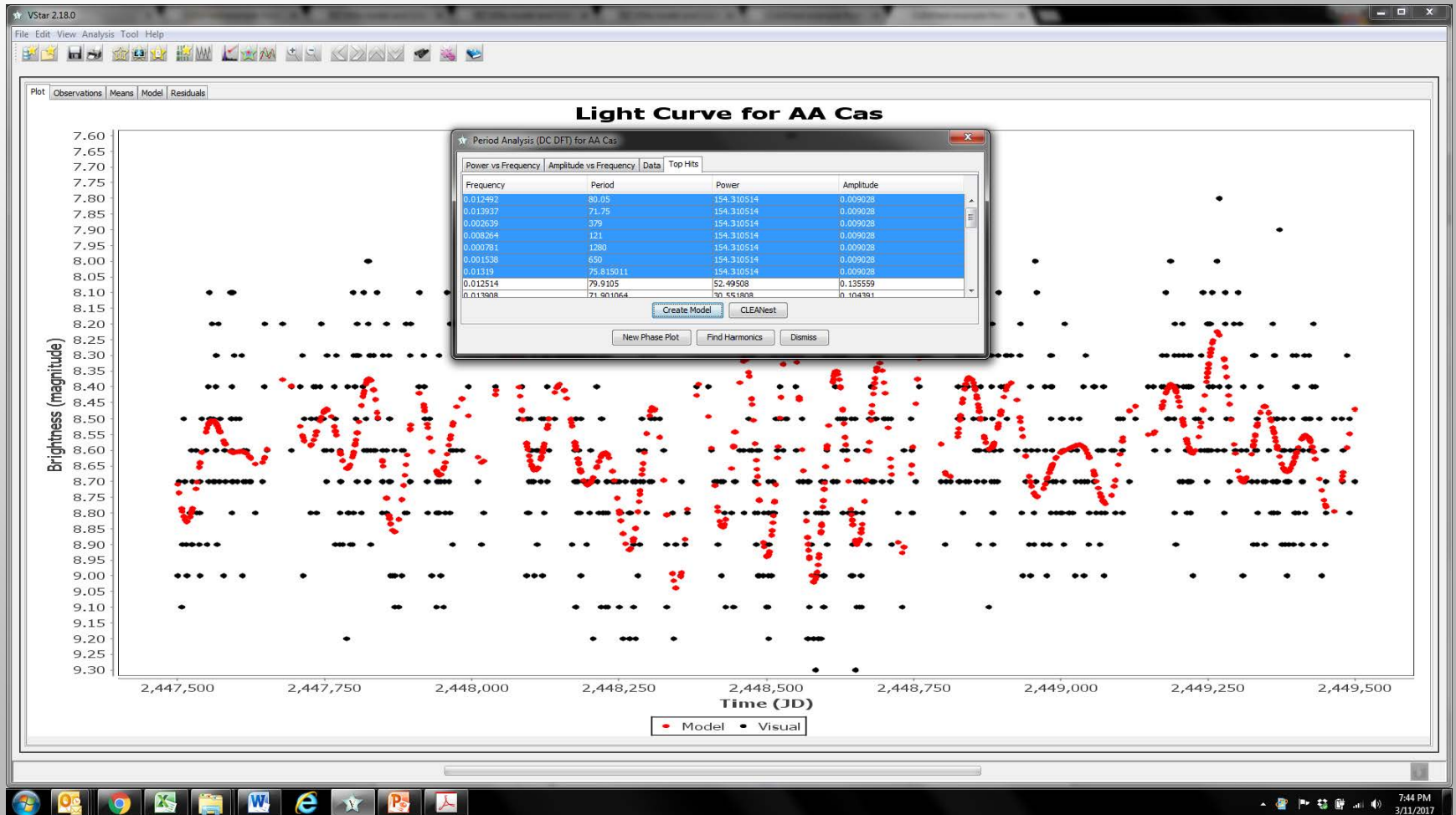
# Residual-6 Power and Amplitude Spectra After 6 Frequency Fit



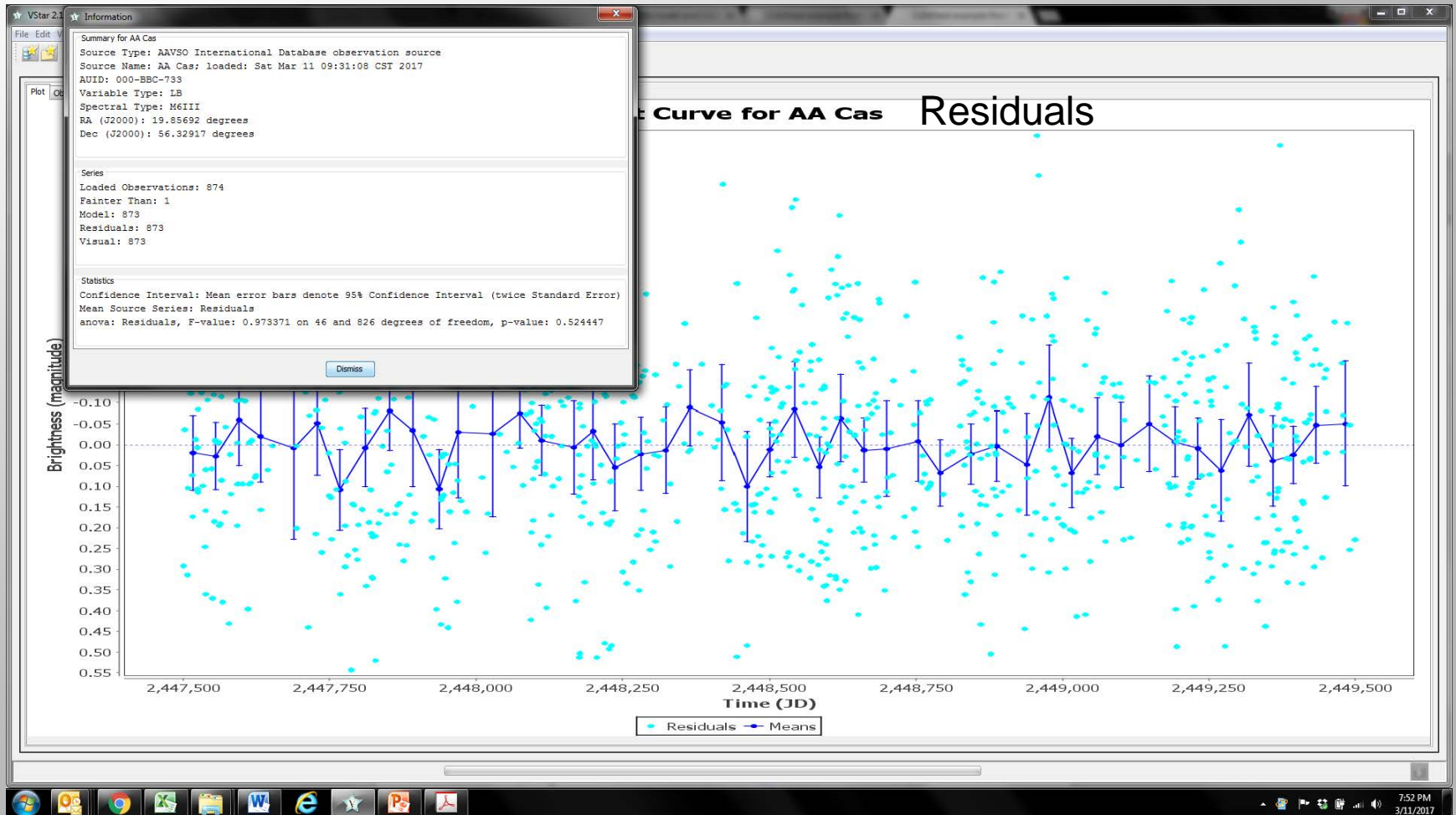
# DCDFT-12 on Residual-6 Top Hit



# 7 Frequency model from DCDFE-13 on visual using CLEANest output

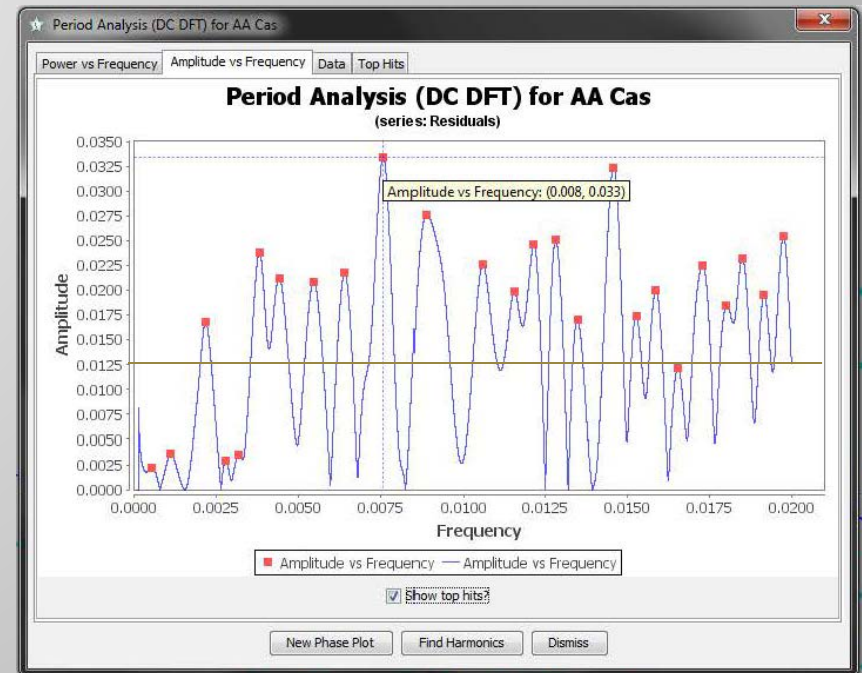
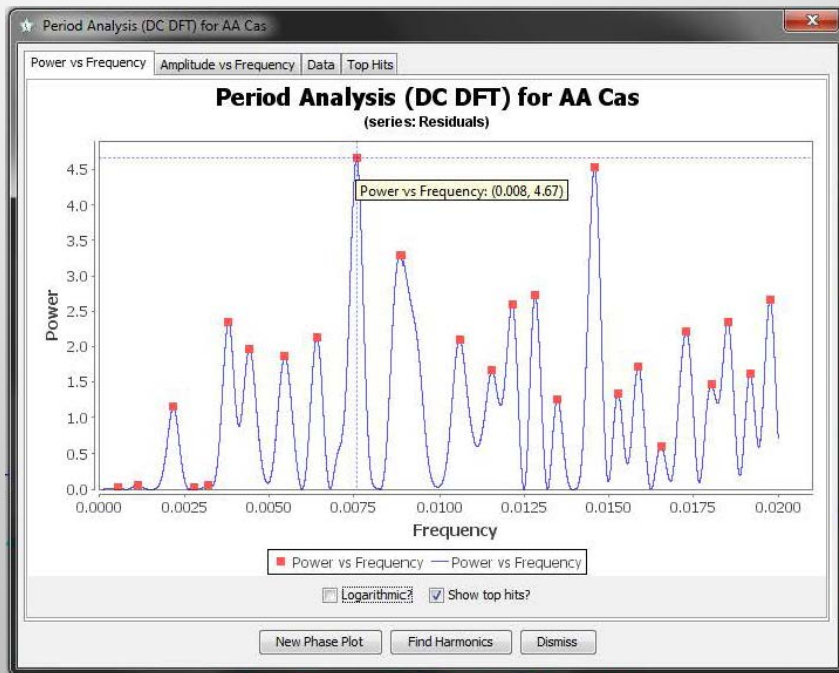


# Residual-7 Info Dialog After 7 Frequency Fit: $P = 0.52$



Scatter of residual means is consistent with visual data  $< \pm 0.1$  mag 28

# Residual-7 Power and Amplitude Spectra After 7 Frequency Fit



No high peaks left in power or Amplitude spectra. Highest amplitude Peaks are less than 4x the background level.

# CLEANest When a Ghost (Alias) is the Strongest Signal -1

- ▣ It is possible that an Alias (ghost signal) is the strongest peak. This can come from an interaction between two real signals or a real signal and periodicity (including periodic gaps) in the timing of measurements
- ▣ If you remove the prominent Ghost and its aliases you remove real signal because just as a ghost is an alias of a signal, the signal is an alias of the ghost. It just depends on which one you chose as real.
- ▣ That is not very common but it is real problem for the sequential CLEANest application we have just gone through.

# CLEANest When a Ghost (Alias) is the Strongest Signal -2

- ▣ The solution is to apply CLEANest to as many of the Top Hits as the program will accept down to some arbitrary, low power level of say 2.0 or 3.0, depending on the number of peaks, in the DCDFFT power spectrum of the original data. If the spectrum is dominated by a small number of prominent peaks you may be able to just use all of the dominant ones. That will usually weed out the false peaks that would mask the real ones that create the more powerful ghost. It is still a good idea to do the sequential CLEANest for better accuracy, but now you can leave out the false peaks that might otherwise cause CLEANest to eliminate real signal.