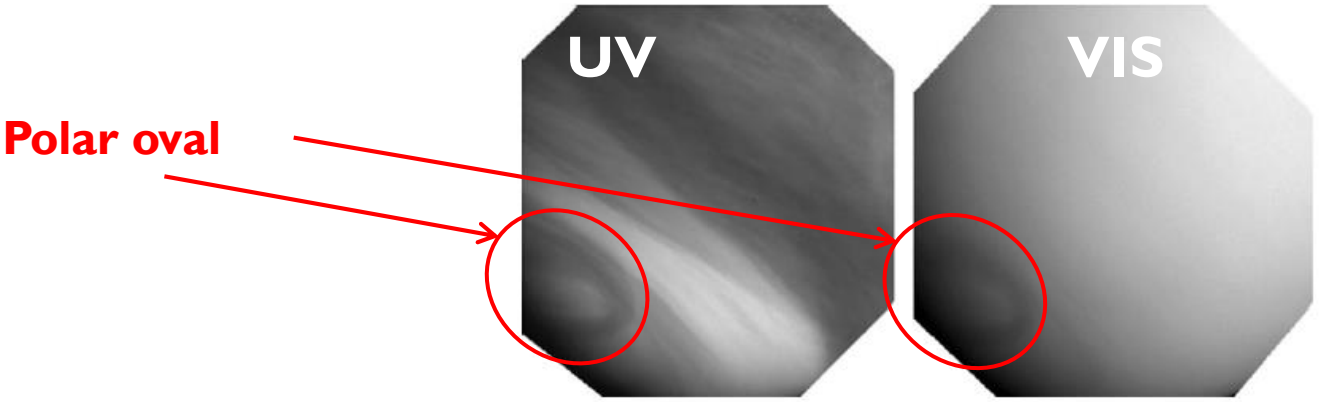
Analysis of the polar oval of Venus using VMC images

K. Muto (Univ. Tokyo) and T. Imamura(ISAS/JAXA)

Polar oval

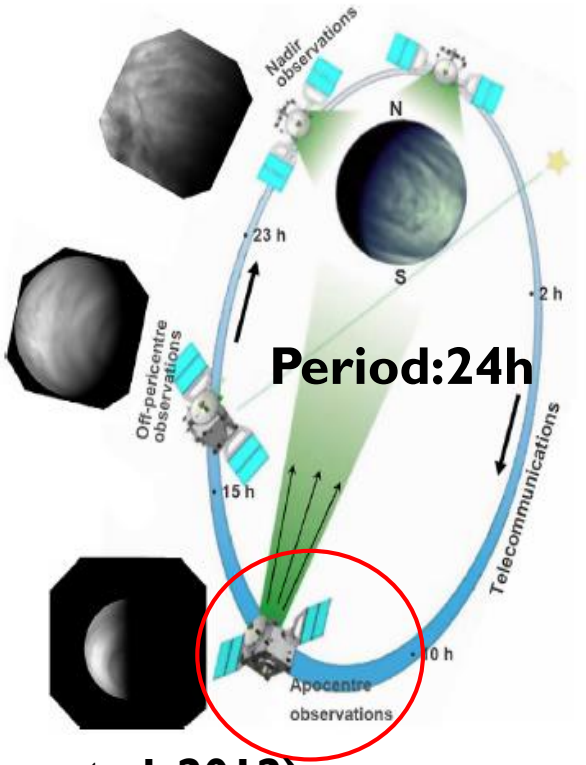
- Polar oval is a circular structure observed at least near the south Pole in visible and ultraviolet wavelengths.
- Since the oval is visible only on the dayside, its whole shape has been unknown. The mechanism producing the oval is not understood.
- We reconstruct the whole shape of the oval and study its variability.



(Titov et al. 2012)

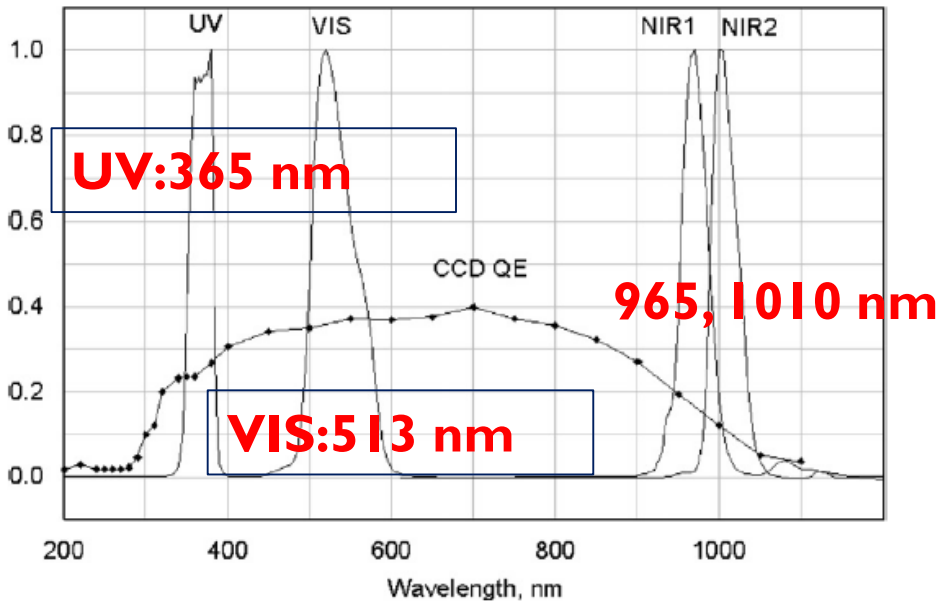
Data set

- We used images taken by VMC on Venus Express. The images have been projected onto the longitude-latitude coordinate of Venus and correction for viewing geometry was performed based on Lambert law by using the Akatsuki Level-3 data processing pipeline.
- Analysis period : 2007/09/02～2013/09/09



(Titov et al. 2012)

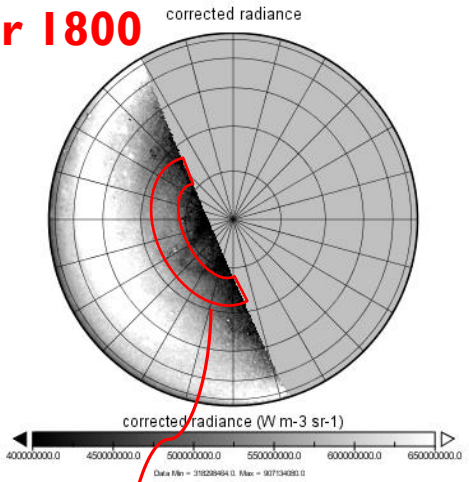
Spectral responses of VMC channels



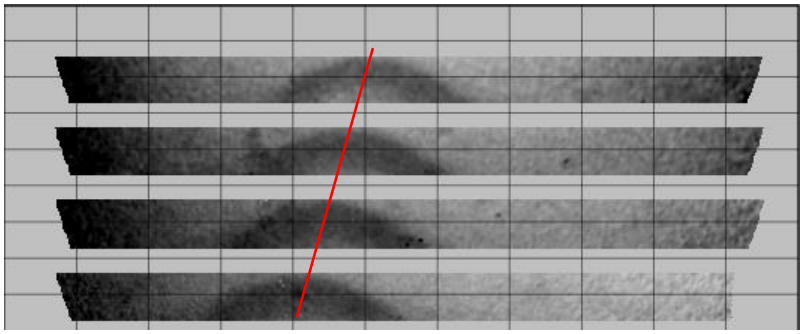
(Markiewicz et al. 2007)

Estimation of the zonal advection period

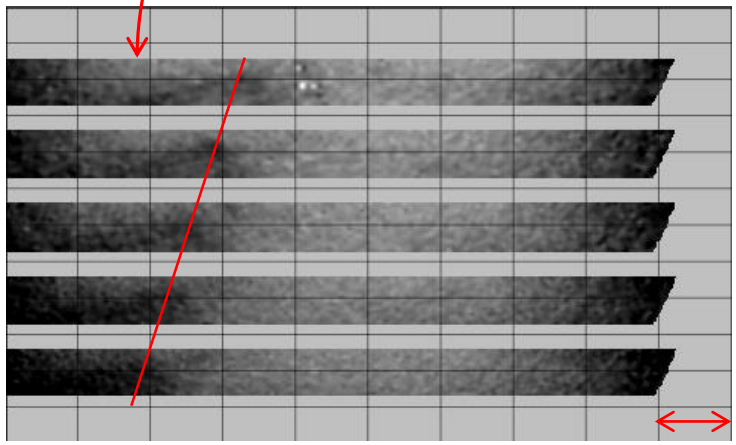
Orbit number 1800



Orbit number 1840



The period of rotation corresponding to the average zonal flow



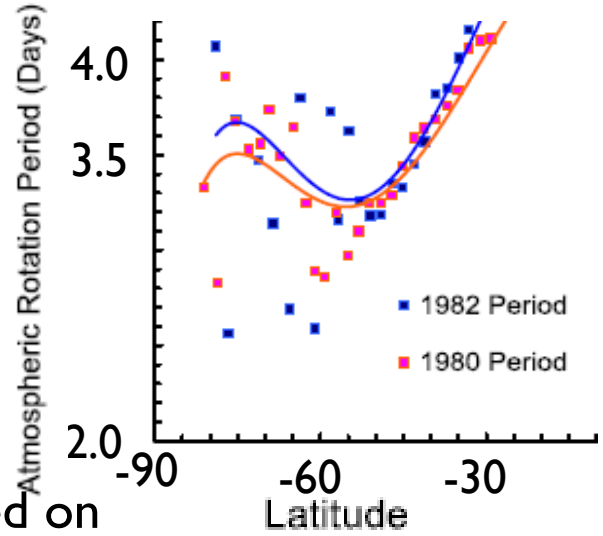
1 hour later

2 hours later

3 hours later

4 hours later

15 degrees

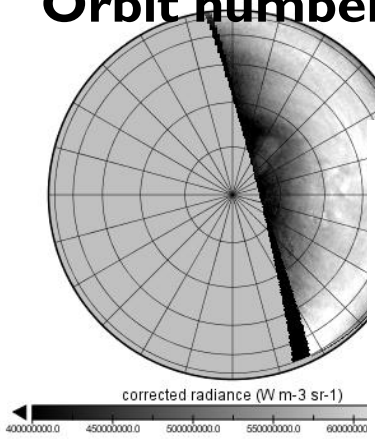


Estimated the zonal advection period is 3.5 days based on Hovmöller diagrams.

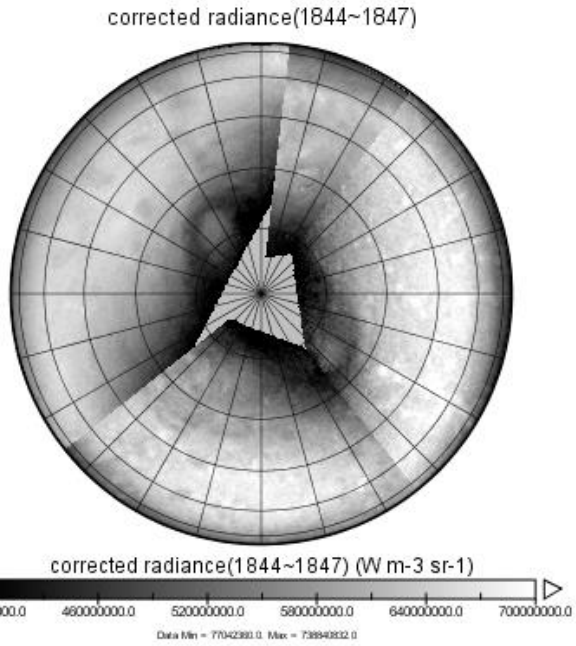
(Limaye et al. 2007)

Images are shifted eastward based on the estimated zonal advection period of 3 days.

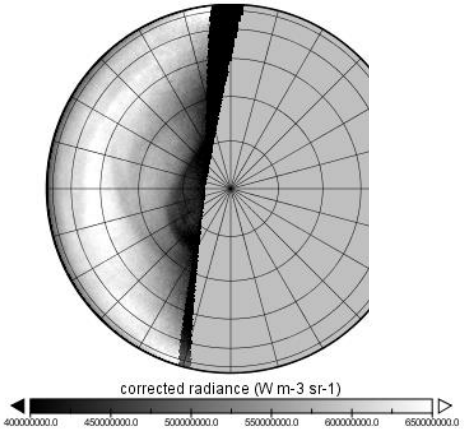
Orbit number 1844～1847



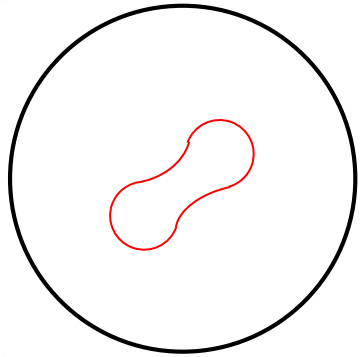
Orbit number 1844～1847

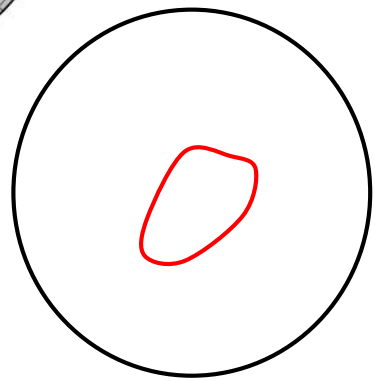


Orbit number



VIS

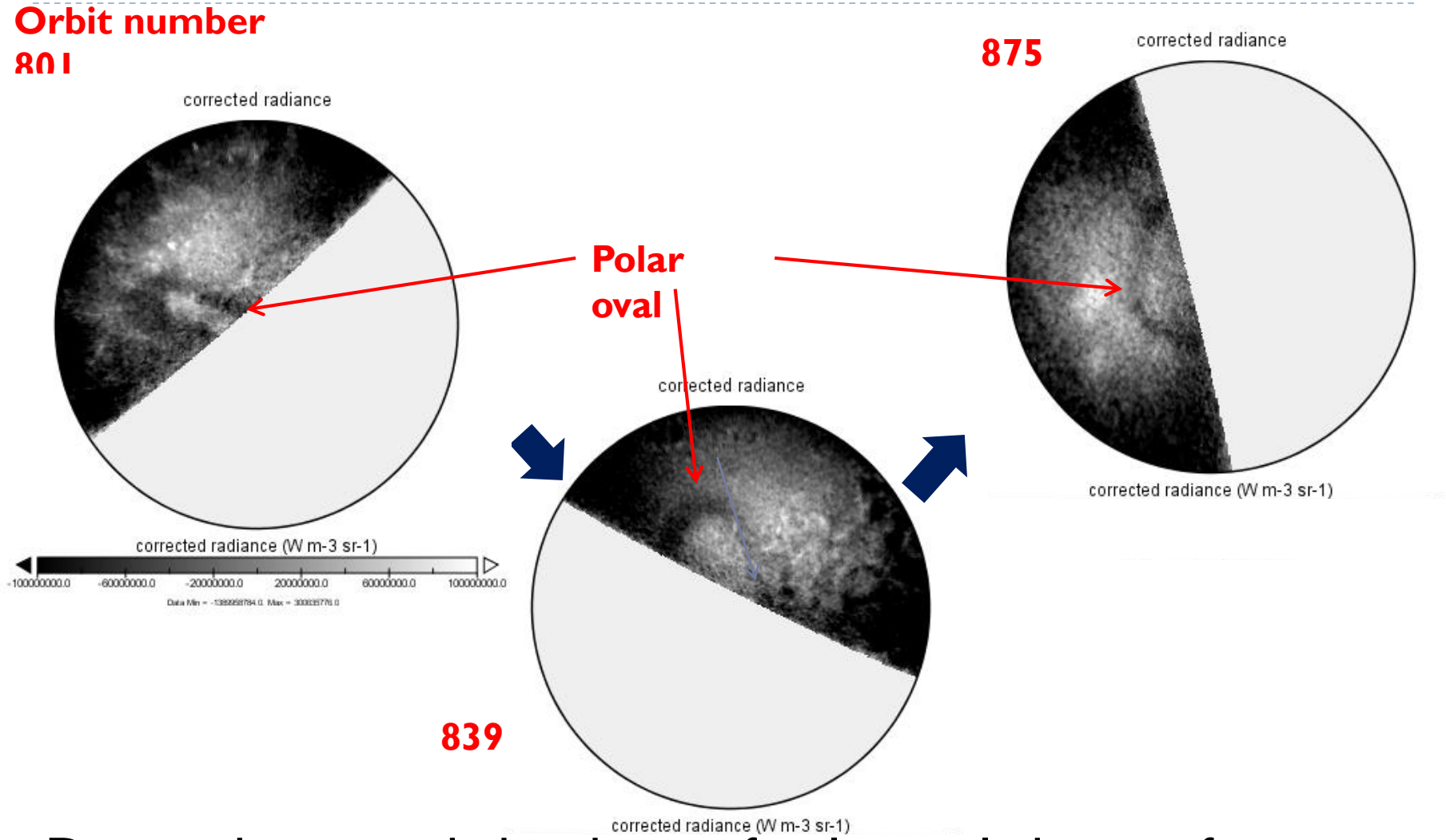




The whole shape of the oval was revealed for the first time.

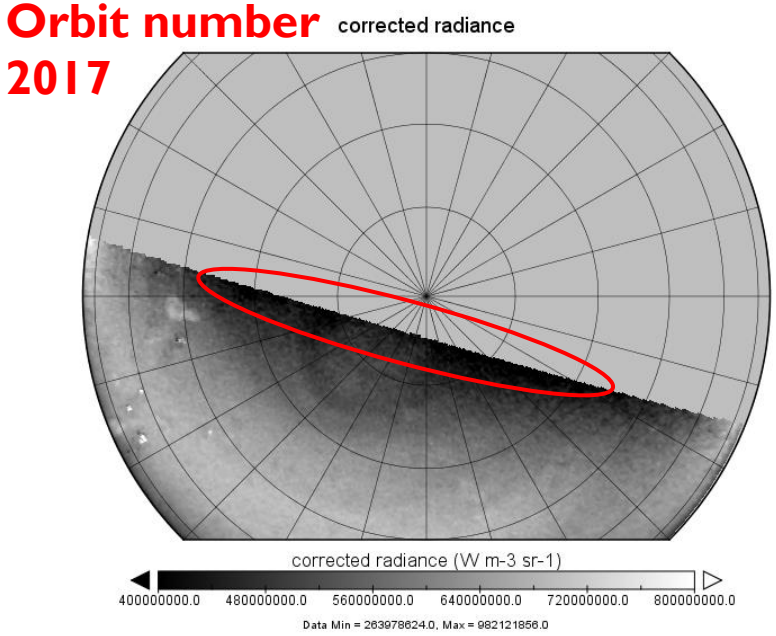
The shape of Polar oval is changing over time.

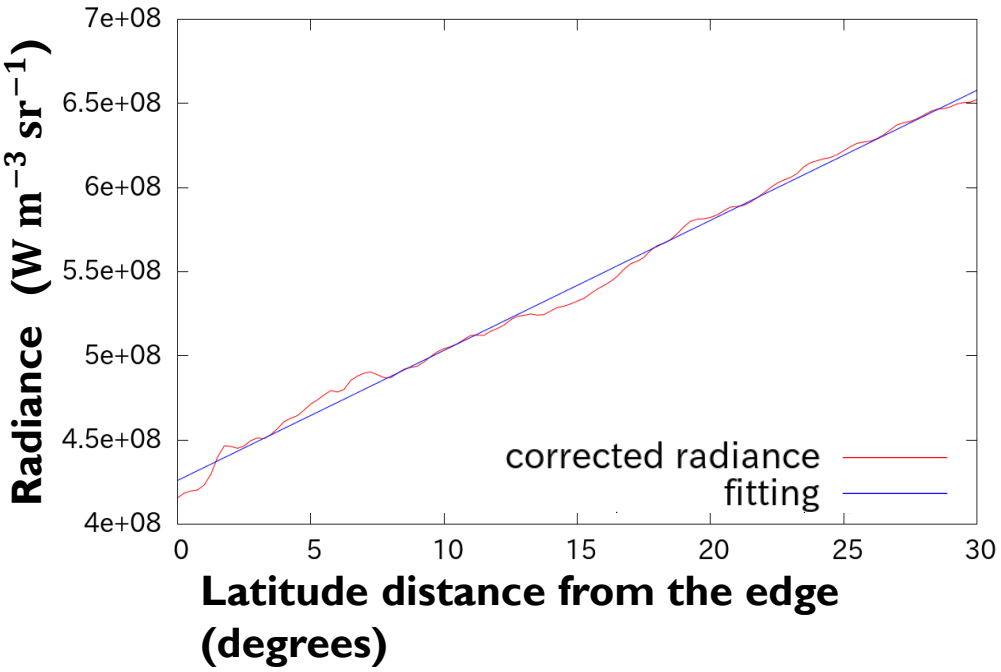
Time change of Polar oval (orbit number 801～875)



- During this period, the shape of polar oval changes from an elongated shape to a near-circular one.

Further photometric correction for removing darkening near the terminator

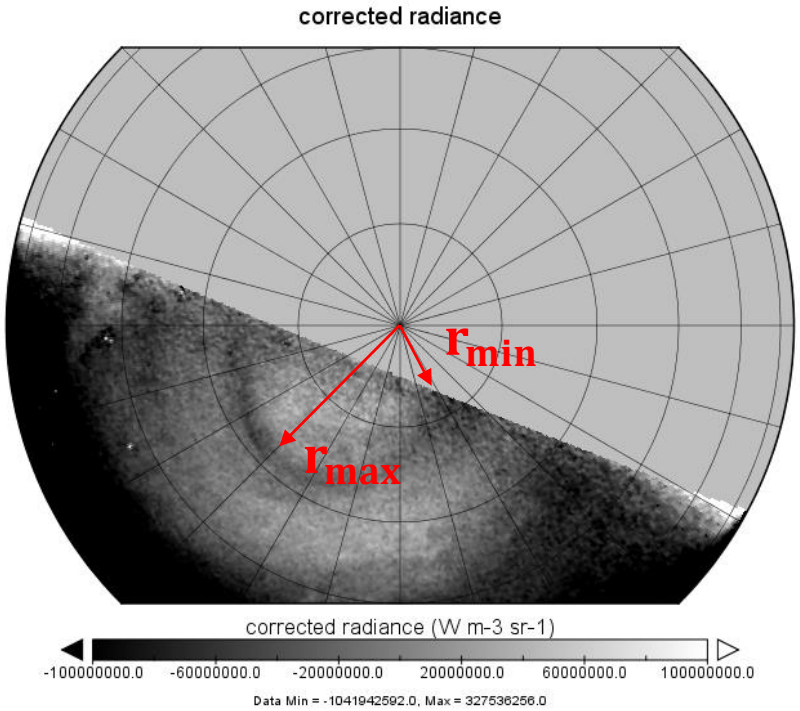




- To clearly observe the shape of the oval, the remaining darkening near the terminator is removed by subtracting a liner function fitted to the latitudinal variation of the brightness.

Parameters characterizing the shape of the oval

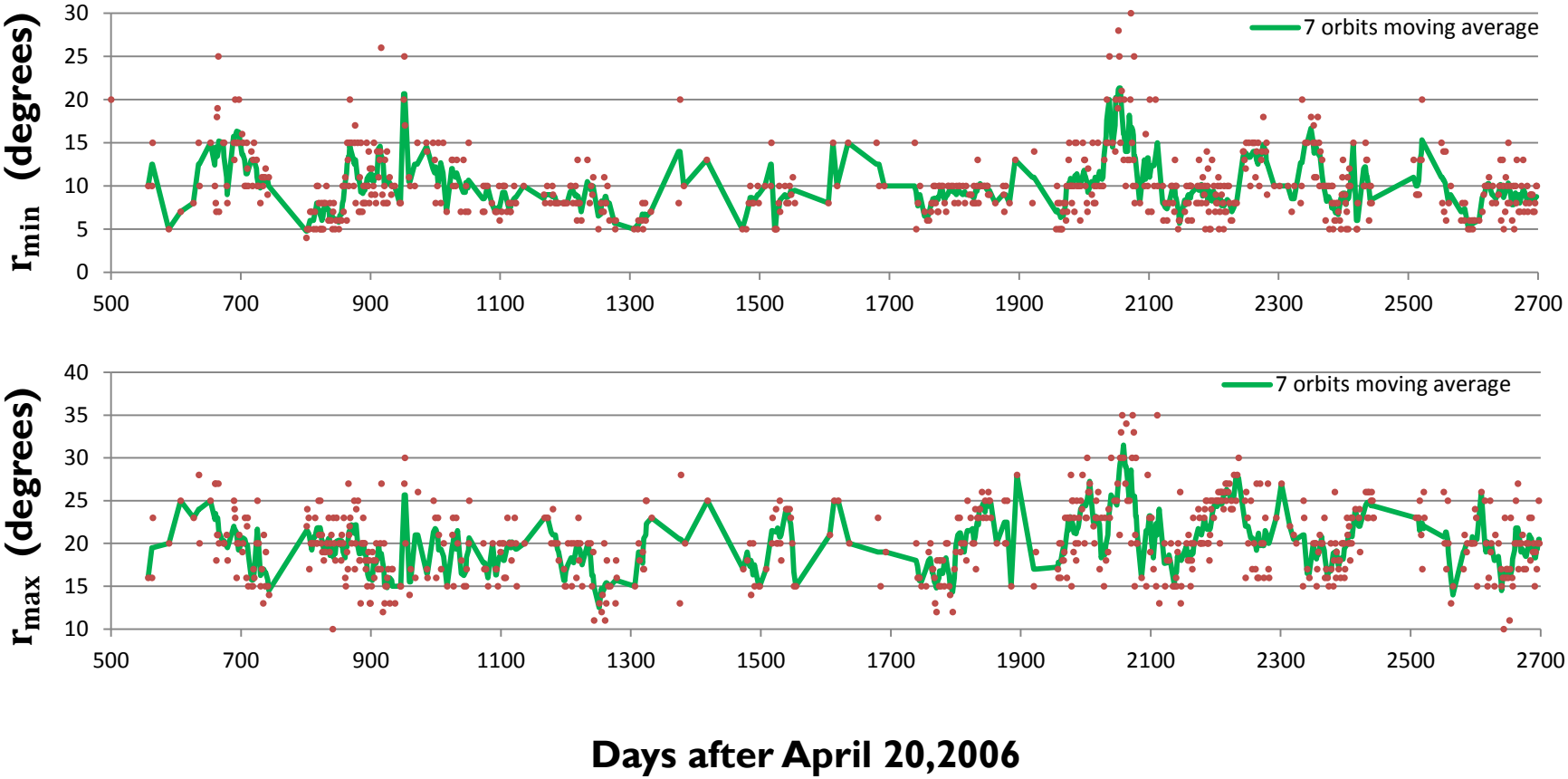
Orbit number 2019



Although the limited longitudinal coverage in each image introduces errors in the estimation of r_{max} and r_{min}, zonal advection with a period of 3.5 days allows evaluation of long-term changes.

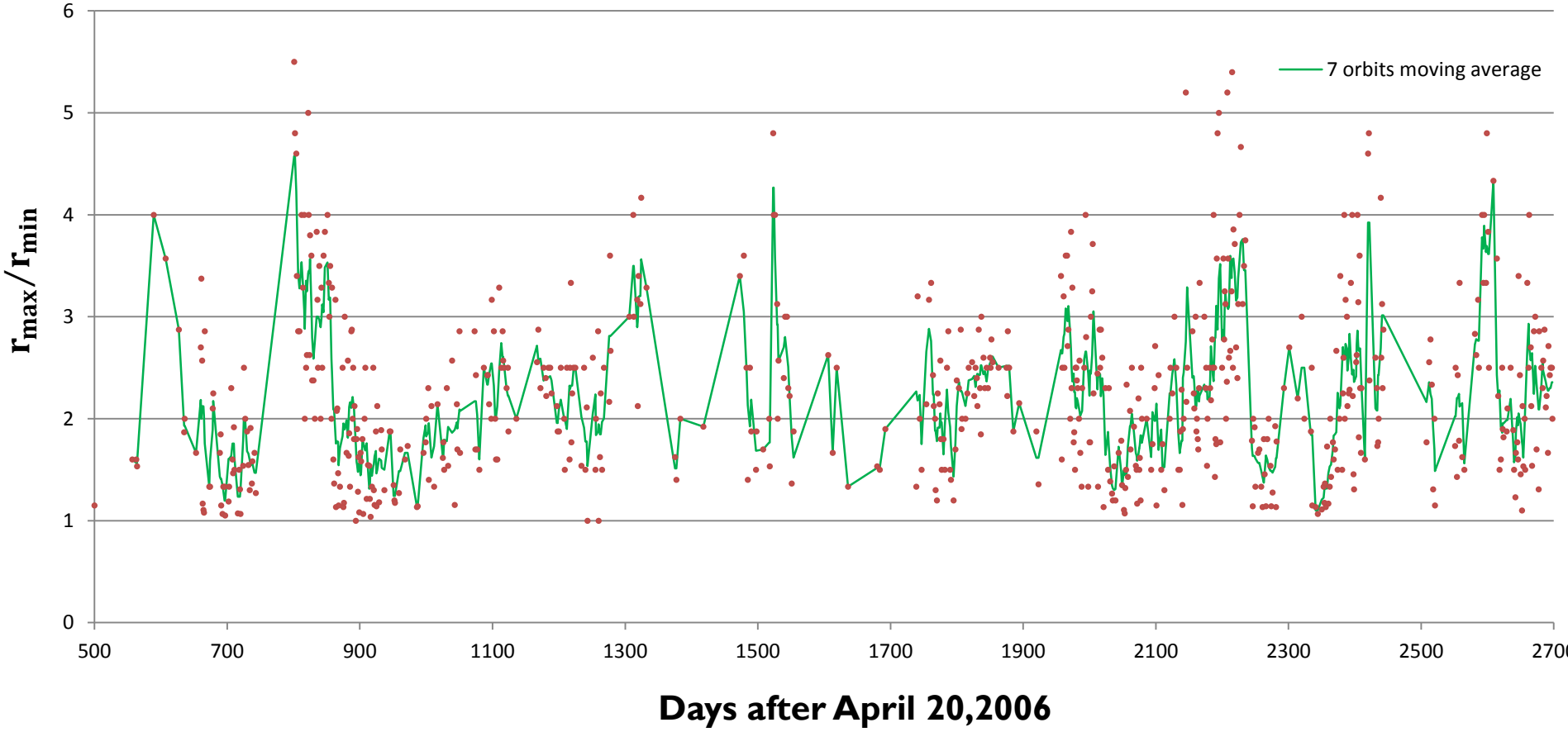
- Maximum(r_{max}) and minimum(r_{min}) distances between the oval and the Pole in each image are chosen as the parameters characterizing the oval shape.
- r_{max}/ r_{min} represents the index the oblateness.
- r_{max} and r_{min} are determined visually.

Time changes of r_{max} and r_{min}



- Changes of oval in 2007/09/02～2013/09/09
- r_{max} and r_{min} show significant temporal changes with timescales of hundreds of days.

Time changes of r_{max}/r_{min}

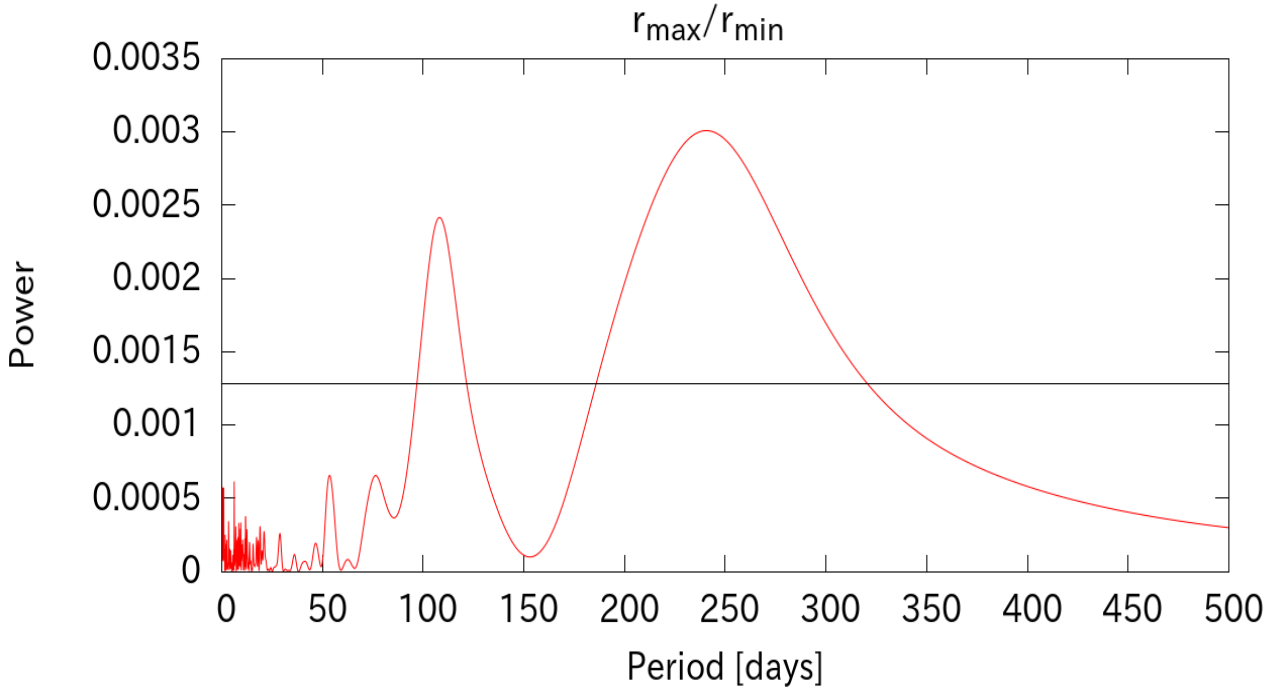


- The ratio changes with time scales of hundreds of days.

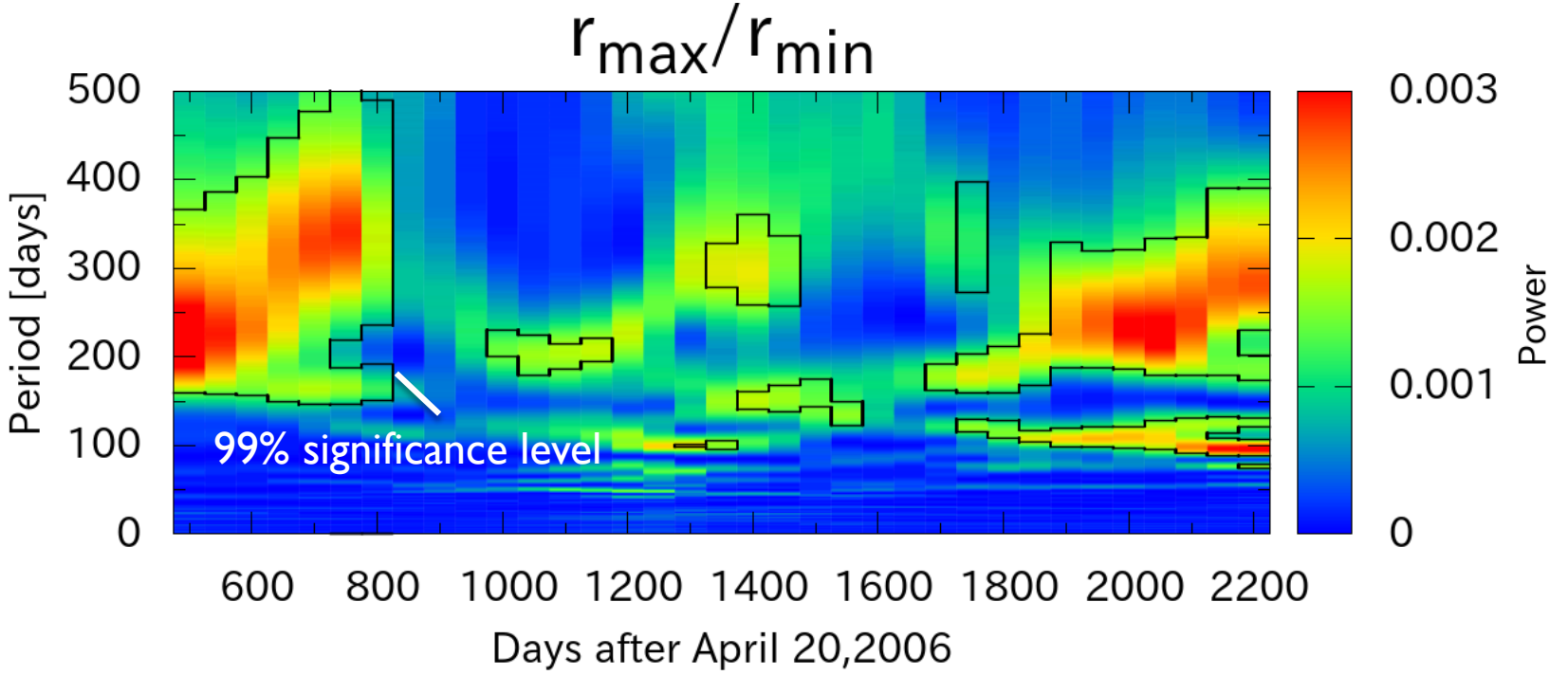
Spectral analysis of temporal evolution

- Lomb-Scargle method allows us to obtain power spectra from unevenly sampled data with data gaps.
- This method is equivalent to least-squares fitting of sine and cosine functions to the data.

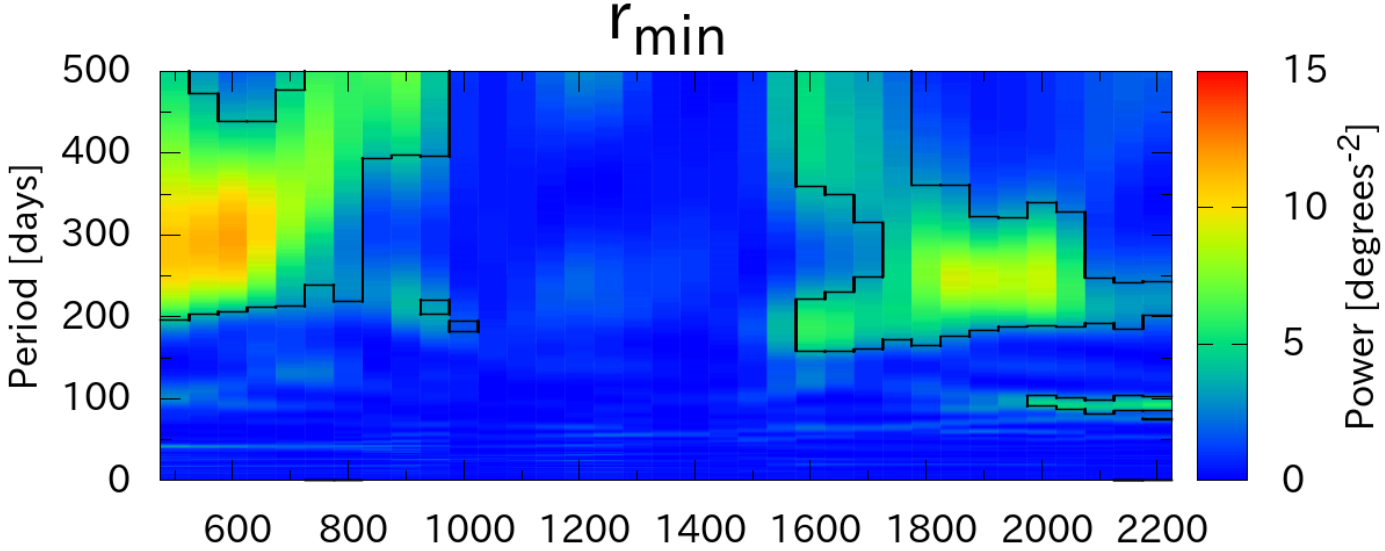
Power spectrum of the time series of in orbit 2000-2500. The 99% statistical significance level are also shown (black line).

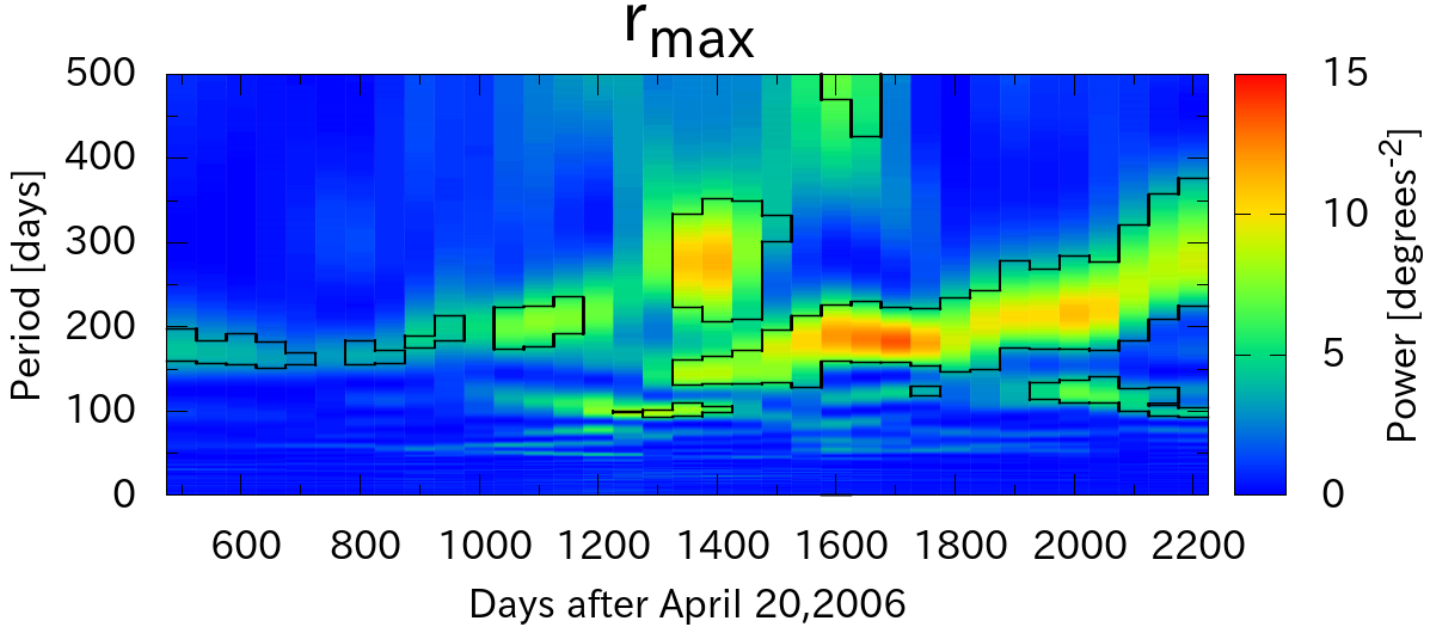


Temporal evolution of the spectrum



- The dominant period (100-400 days) changes with time and does not coincide with a Venus year (255 days), the rotation period(243 days) and a Venus day (117 days).
- Self-exciting mechanism rather external forcing is suggested.





- The peaks found in r_{max}/r_{min} are a combination of those of r_{max} and r_{min}.

Summary

- The whole shape of the polar oval was revealed for the first time using Venus Express/VMC visible images.
- The shape of the oval was found to be changing over time between elongated shape and near-circular shape.
- The period of the variation of the oval shape is variable. It does not seem to coincide with a Venus year, the rotation period and a Venus day, suggesting a self-exciting mechanism.