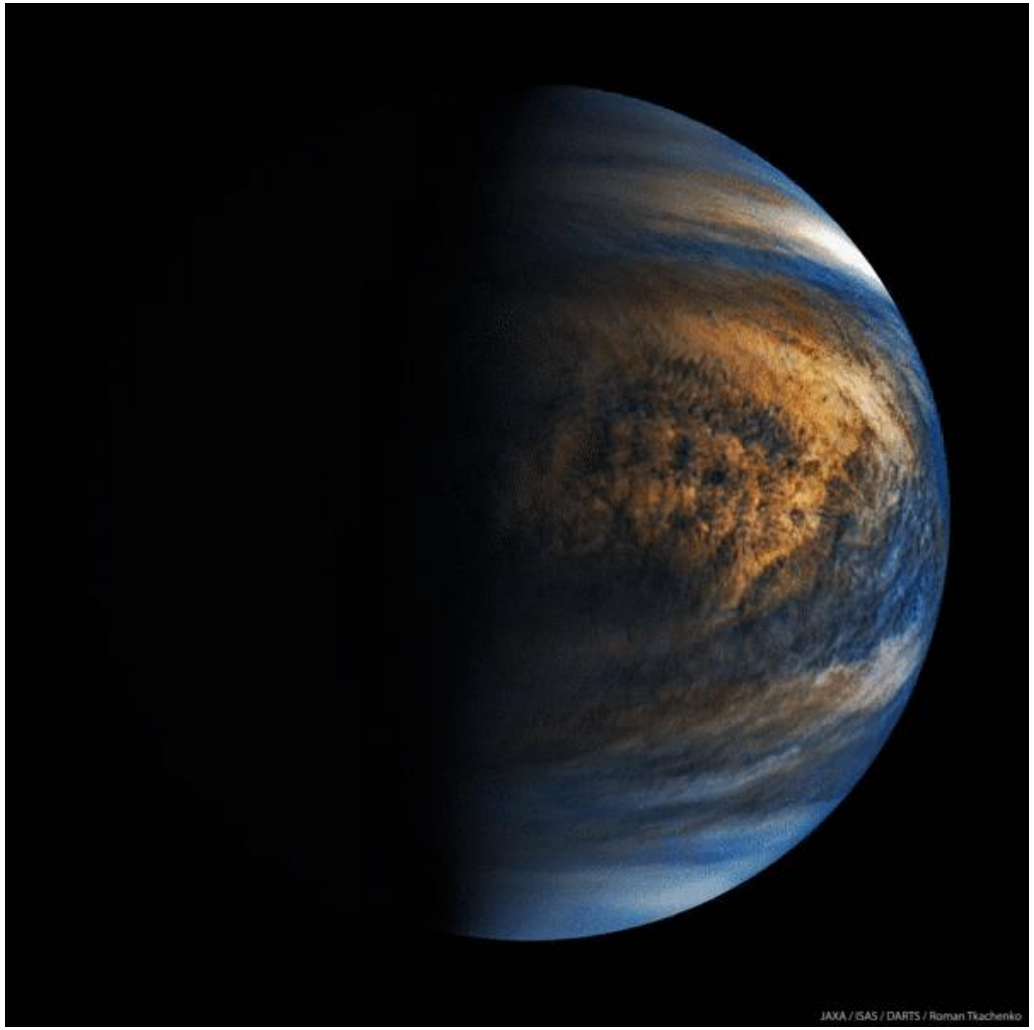
Session 03 #4
IVC, 1.06.2019

Principal Components of UV Albedo Variability in Venus' Atmosphere as seen at 283 nm (& 365 nm)

Pushkar KOPPARLA[1,2], Yeon Joo LEE[3] , Takeshi IMAMURA[1], Atsushi YAMAZAKI[4]

1. GSFS, University of Tokyo
2. JSPS Postdoctoral Fellow
3. TU Berlin
4. ISAS, JAXA

Venus UV albedo is very variable



JAXA/R. Tkachenko

Many of the physical processes behind it are now understood – atmospheric zonal flow, Rossby and Kelvin waves, overturning circulation.

But are there other undiscovered large scale processes hiding in the variability?

Questions of Interest

- What are the principal global scale repeating patterns in UV albedo?
- How do they relate to known physical processes in Venus' atmosphere?

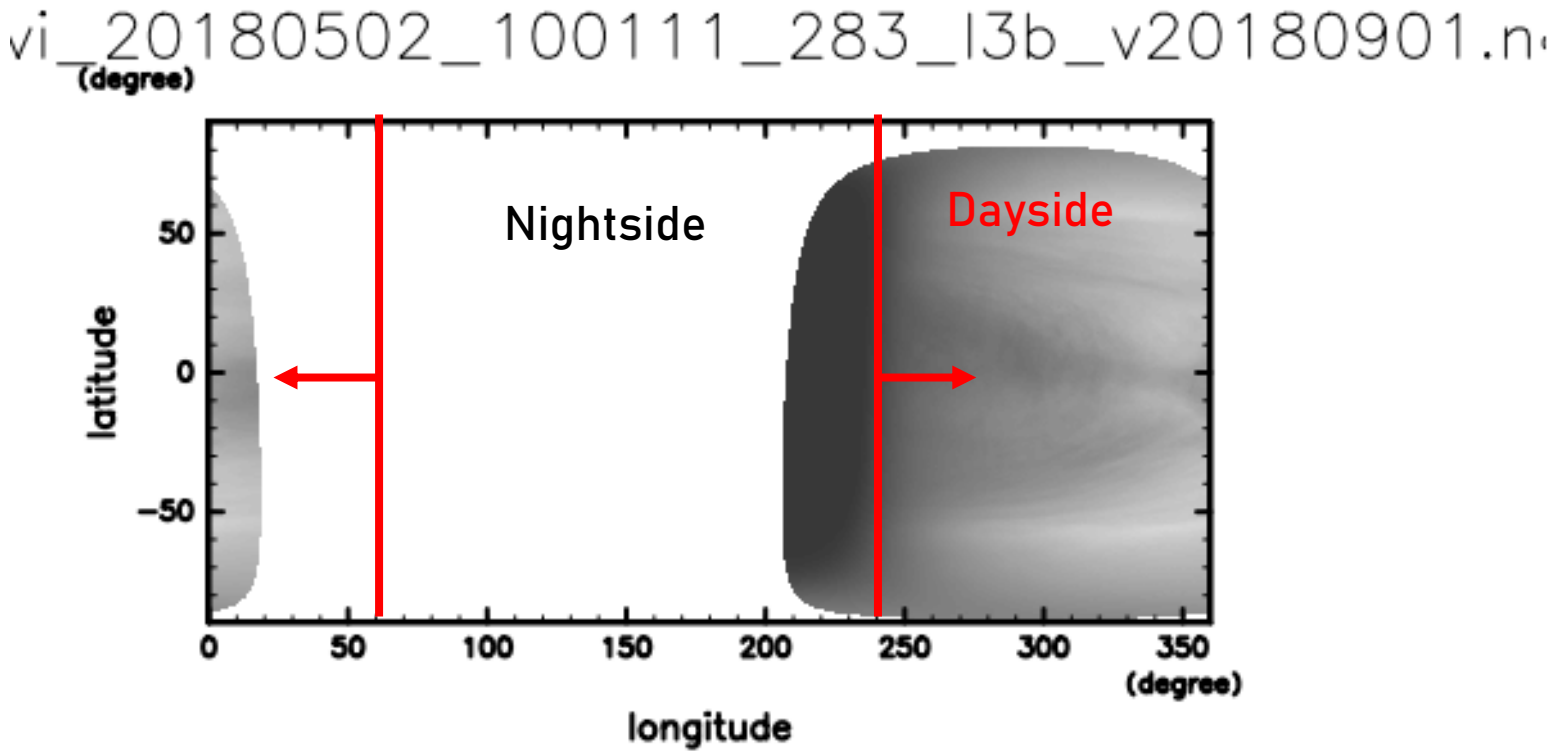
- Dataset:

UVI 283 and 365 nm Level 3b data from Dec 2016 – May 2018

(~ 1.5 years)

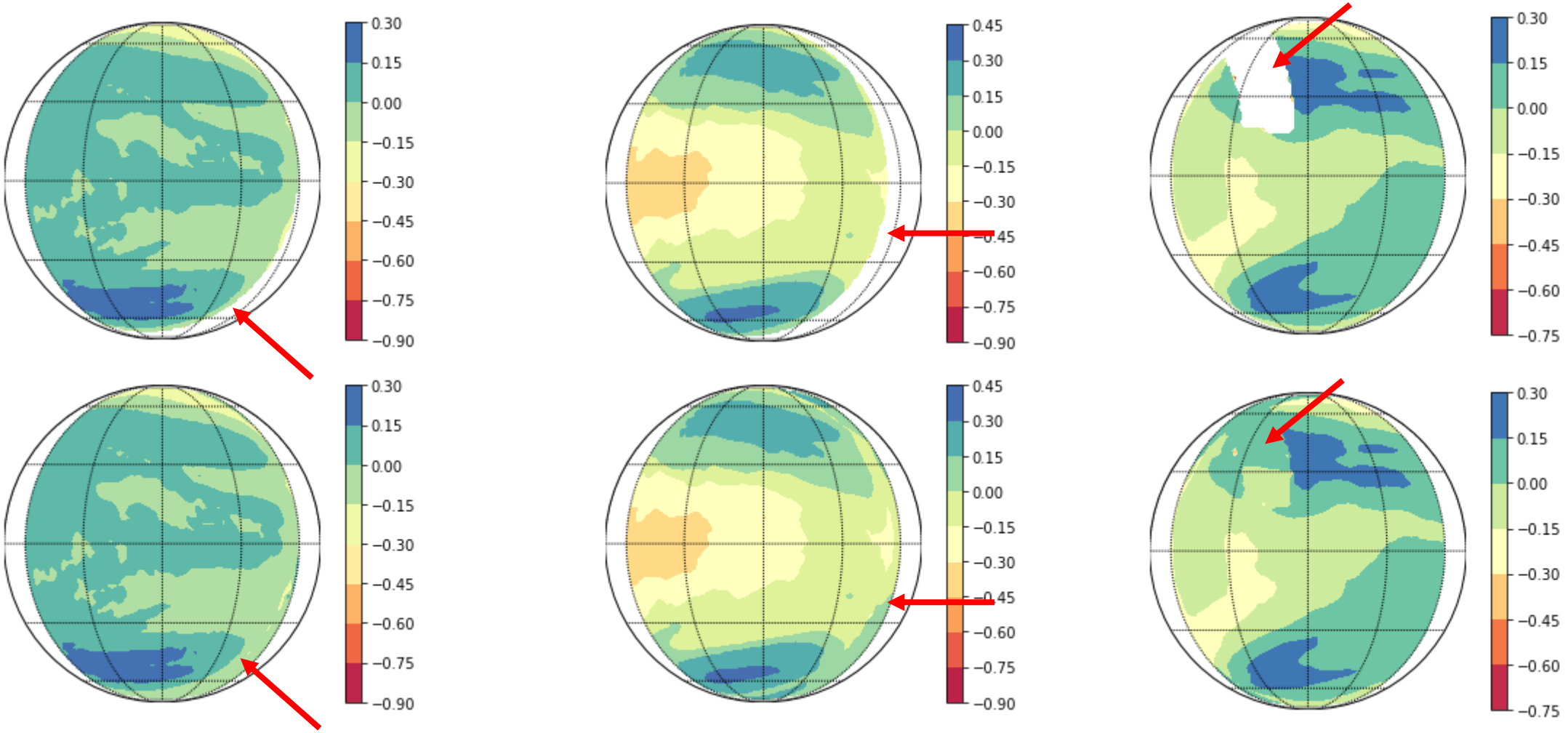
Sensitive to SO_2 and unknown UV absorber's abundance respectively

Akatsuki Level-3 Data



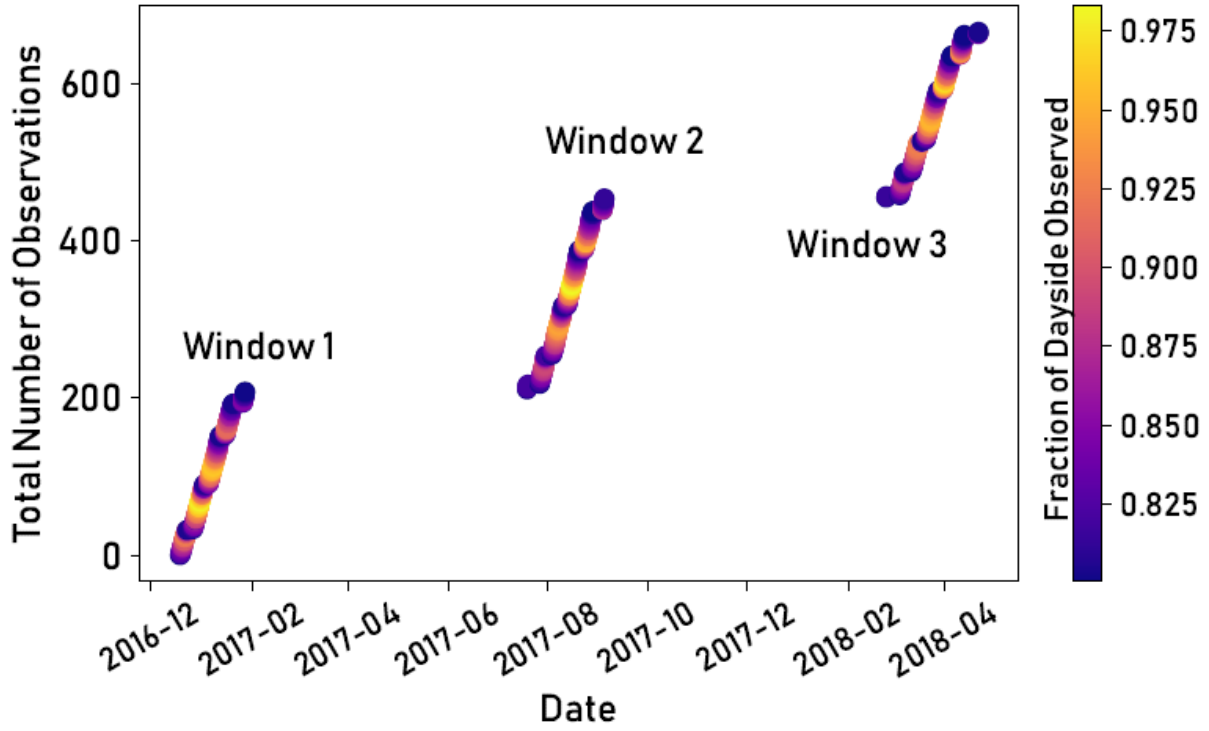
Different thresholds for image selection: 80, 60, 40, 20 and 10% coverages of the dayside were explored. Lower thresholds necessitated more infilling of missing data and therefore more artifacts.

Missing Data Infilling (Mean-removed normalized albedos)



We used an iterative PCA based interpolation method: DINEOF (Beckers & Rixen, 2003)

Image Selection: >80% coverage of the dayside (696 images)

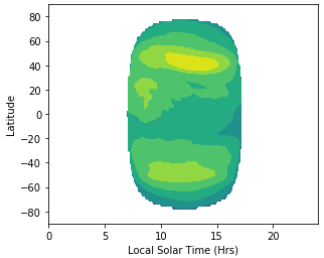


Different thresholds for image selection: 80, 60, 40, 20 and 10% coverages of the dayside were explored. Lower thresholds necessitated more infilling of missing data and therefore more artifacts.

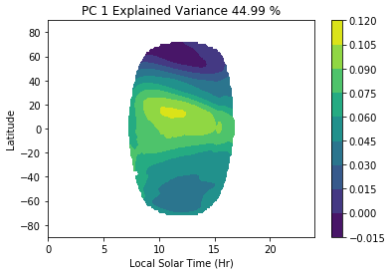
Principal Component Analysis (PCA)

Observations (UV Albedo)

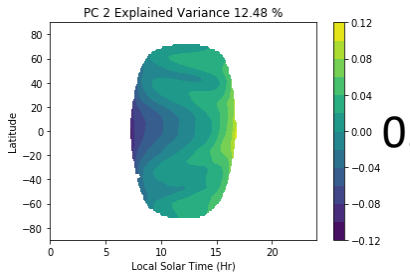
Approx. expressed as linear summations of a few 2d albedo patterns (or "Principal Components")



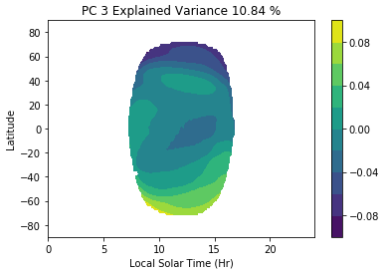
~= 0.5 x



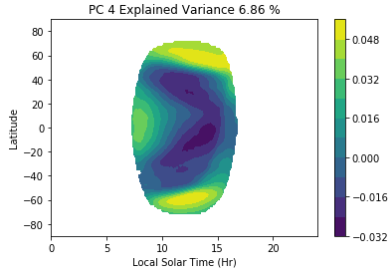
+ 0.15 x



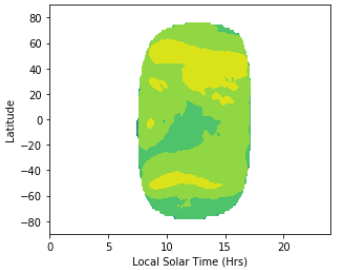
- 0.1 x



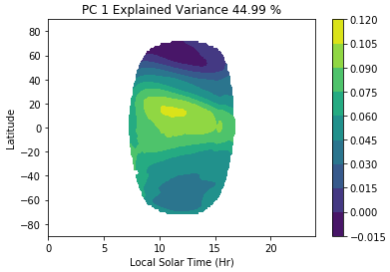
+ 0.03 x



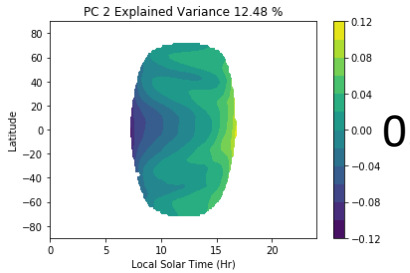
.
.
.



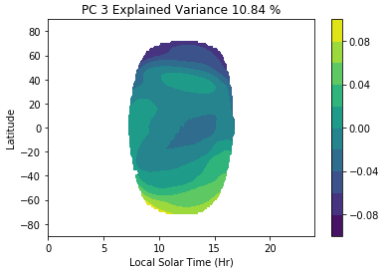
~= 0.6 x



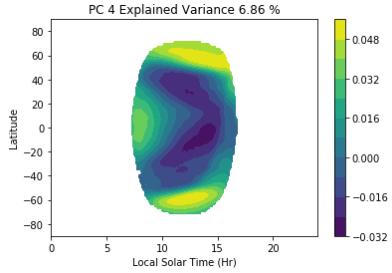
- 0.23 x



+ 0.2 x

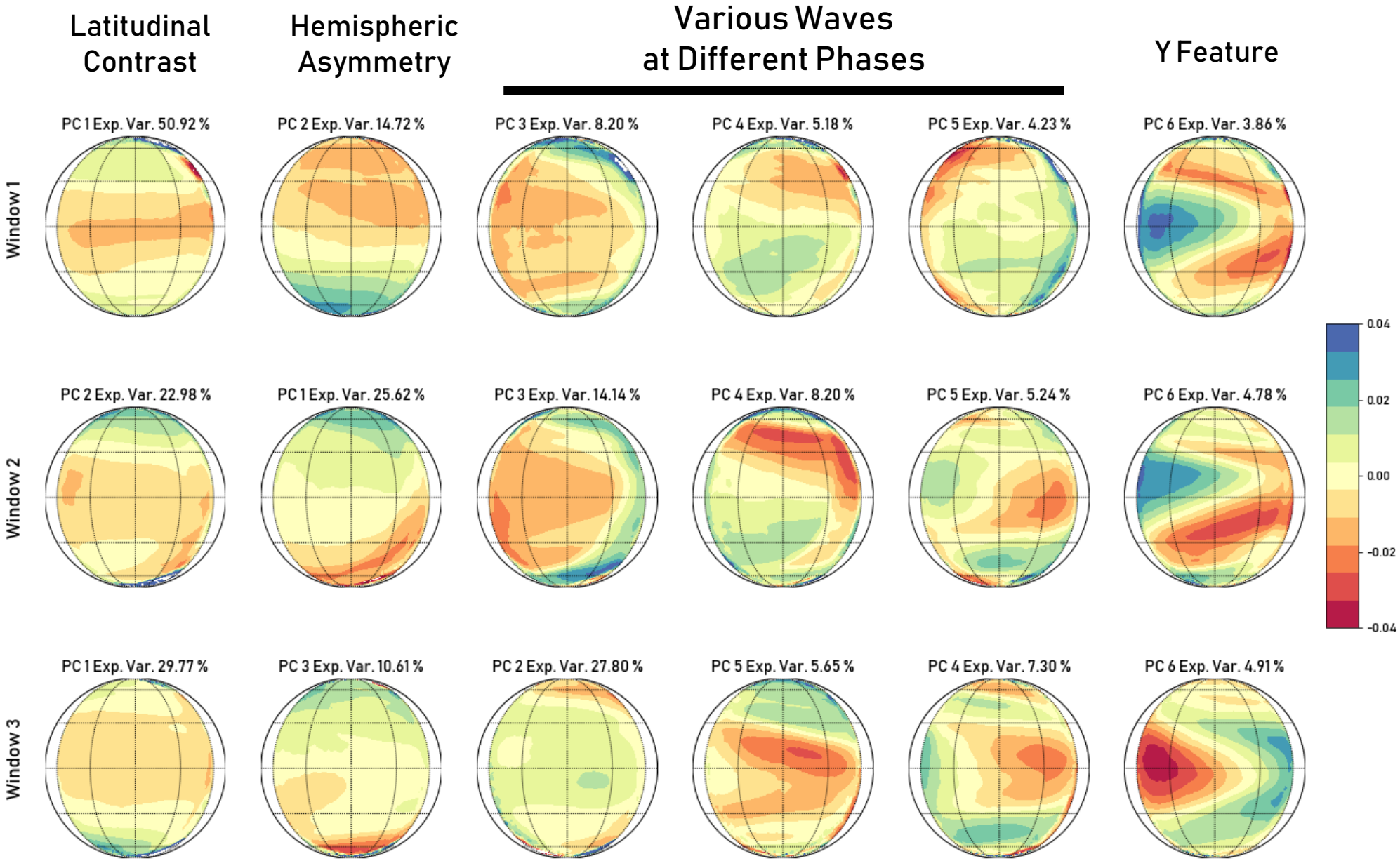


+ 0.05 x



We want to find a few patterns that can approximately reproduce the dataset.
Each pattern hopefully corresponds to a physical process.

First Six Albedo Patterns from PCA (283 nm)



Each row is one observation window.

Each column contains similar patterns.

Similar patterns have different PC ordering in various windows.

Kopparla et al, 2019 A&A, accepted

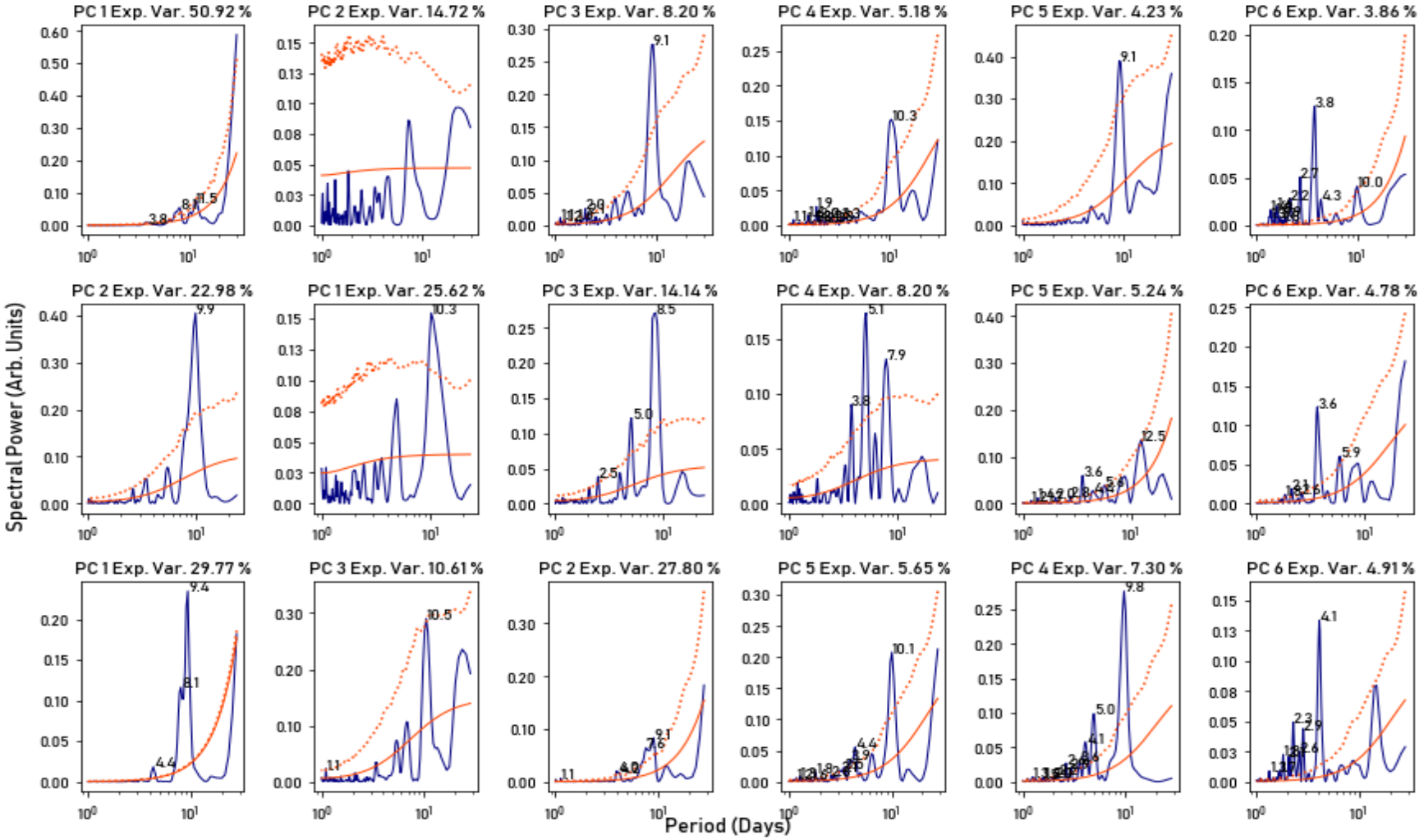
Associated Periodicities (Lomb-Scargle Periodograms)

Latitudinal Contrast

Hemispheric Asymmetry

Various Waves at Different Phases

Y Feature



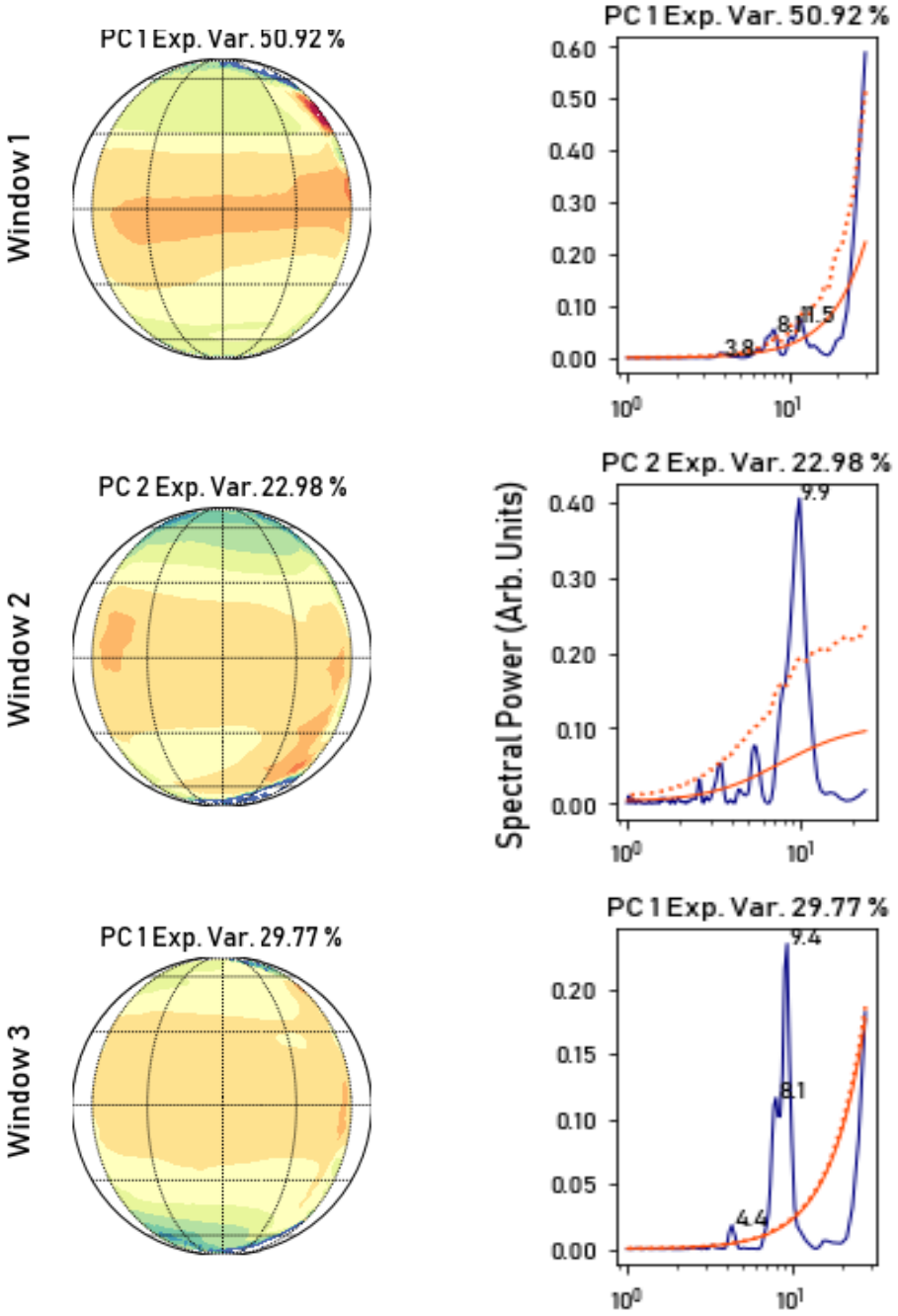
Noise is modeled as a lag-1 autocorrelated process (red noise, Schulz & Mudelsee, 2002).

Red solid line = mean of 1000 Monte Carlo runs
Red dotted line = 2 sigma

Latitudinal Contrast

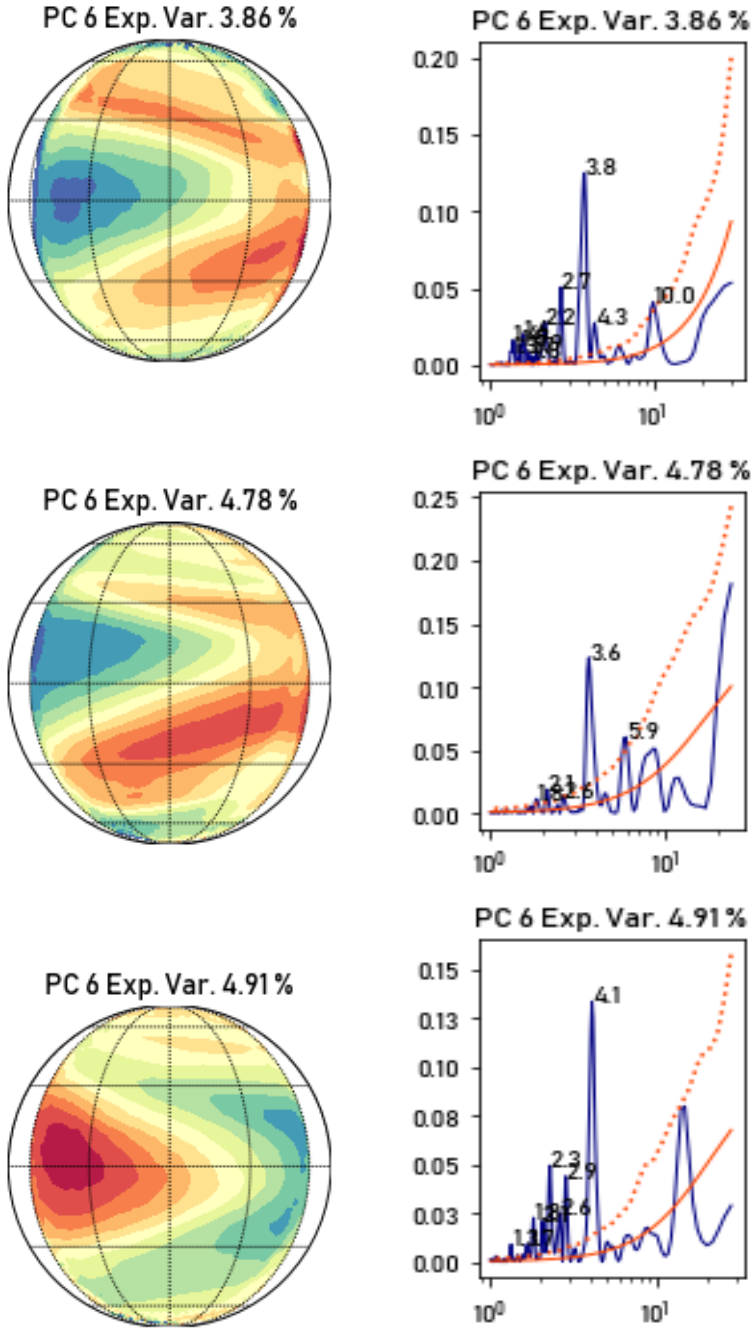
Likely related to slow changes in the meridional circulation. Some contribution from atmospheric rotation (~ 4 days).

10 day period probably from spacecraft orbit.

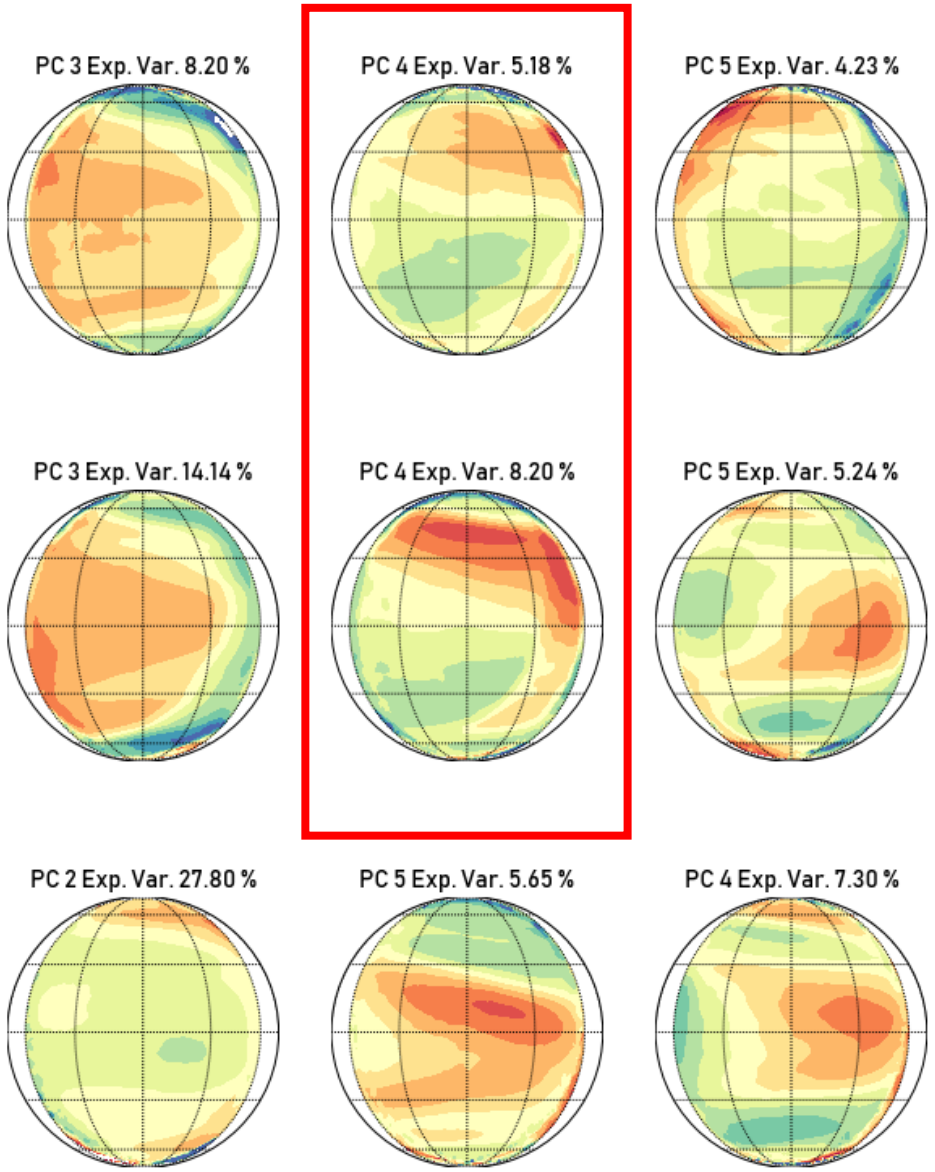


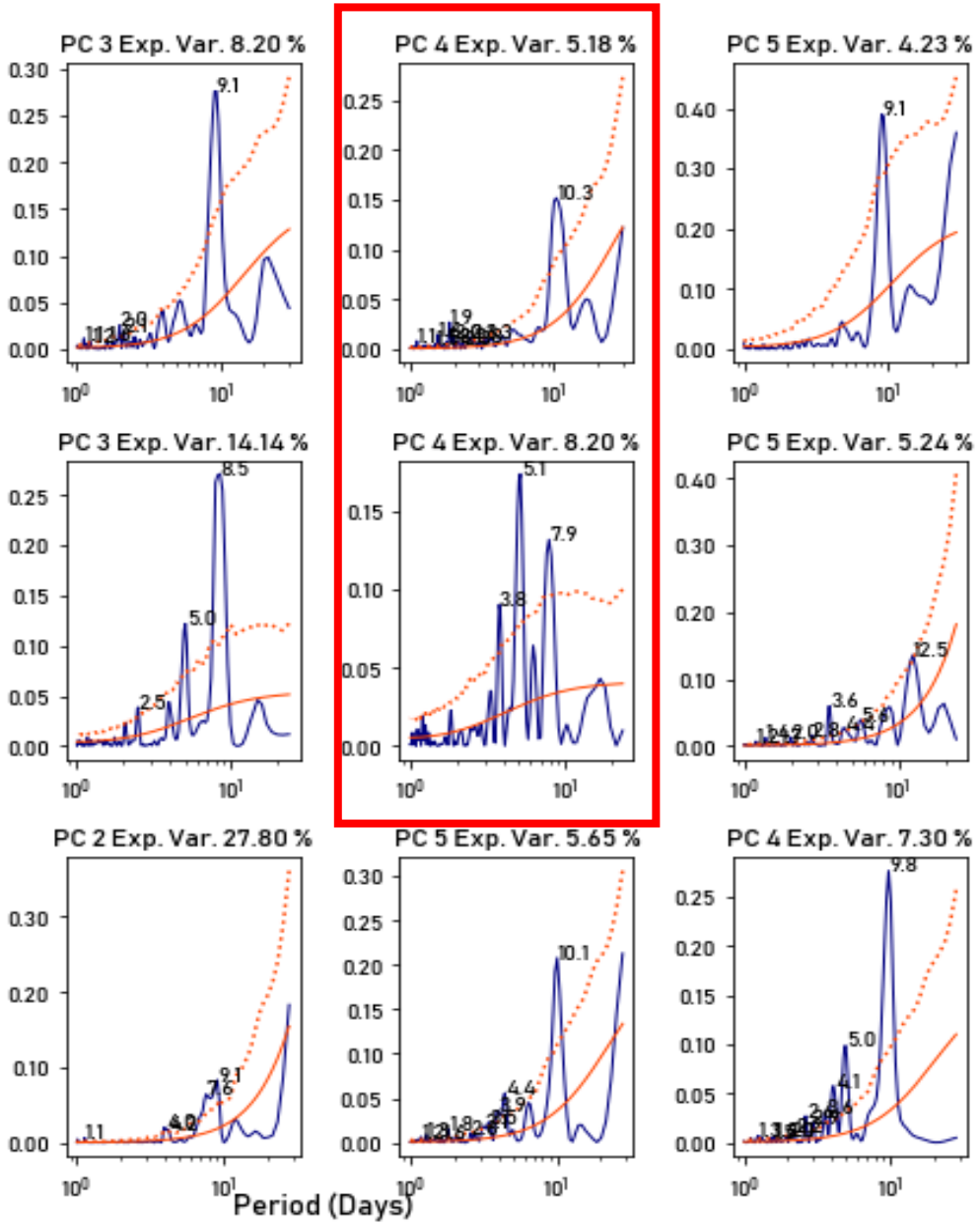
Y-Feature

Very prominent periodicity of approximately 4 days, related to the Kelvin wave. Consistent with previous literature (e.g., Del Genio & Rossow, 1990, Kouyama et al 2012, Peralta et al 2015). Lots of high frequency noise.



Various waves?
Just noise?



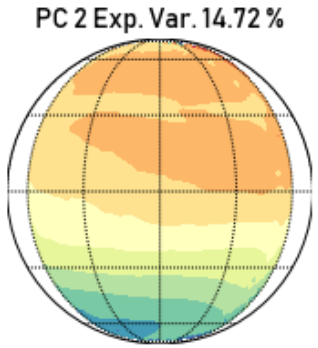


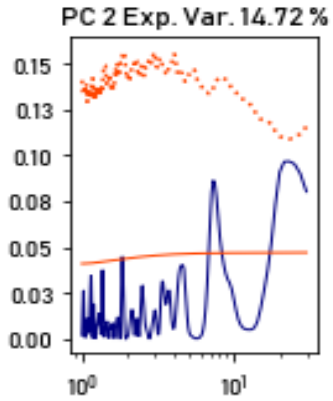
Hemispheric Asymmetry

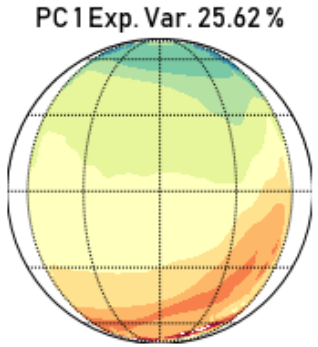
Does not show a significant periodicity: either aperiodic or must have a longer period than observation window.

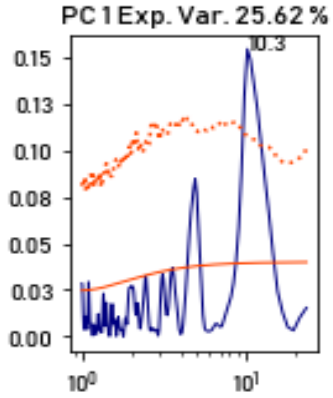
Consistent with SO_2 hemispheric asymmetries that vary over timescale of months (Marcq et al 2006, Tsang et al 2009, Arney et al 2014)
Mechanism unknown.

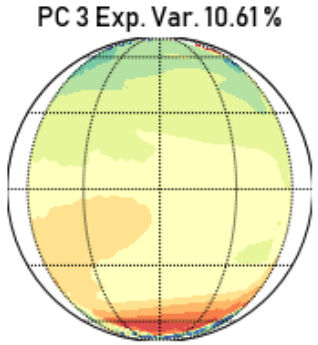
*10 day period is spacecraft orbit

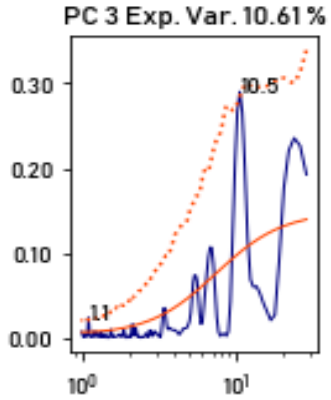






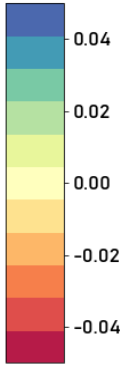






First Six Albedo Patterns from PCA (365 nm)

	Latitudinal Contrast		Hemispheric Asymmetry		Midlatitude Bands		Y Feature	
Window 1	PC 1 Exp. Var. 57.63 %	PC 3 Exp. Var. 6.02 %	PC 2 Exp. Var. 13.62 %	PC 5 Exp. Var. 3.84 %	PC 4 Exp. Var. 4.76 %		PC 6 Exp. Var. 2.16 %	
Window 2	PC 1 Exp. Var. 34.92 %	PC 3 Exp. Var. 11.56 %	PC 2 Exp. Var. 23.26 %	PC 6 Exp. Var. 3.66 %	PC 4 Exp. Var. 5.89 %	PC 5 Exp. Var. 4.32 %		
Window 3	PC 1 Exp. Var. 33.25 %	PC 2 Exp. Var. 17.94 %			PC 5 Exp. Var. 6.19 %	PC 6 Exp. Var. 4.94 %	PC 3 Exp. Var. 10.60 %	PC 4 Exp. Var. 8.21 %



Study Summary

- We conducted principal component analyses on the Akatsuki UVI 283-nm and 365-nm data from Dec 2016 – May 2018
- 283-nm [SO2] patterns show a latitudinal gradient, a hemispheric asymmetry, Y-feature and several wave patterns which are broadly consistent over three observing periods.
- 365-nm [unknown UV] patterns are much more variable across different periods.
- We suggest differences may be explained if 365-nm is probing altitudes below cloud top, while 283-nm is above, along with contributions from unknown UV absorbers' variability.
- Paper is on arxiv: 1904.07413