Capricious Cytherean Clouds: How VIRTIS can help us understand the lessons taught by Akatsuki

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Goals of this Investigation

- Understand long-term evolution of cloud coverage on Venus and its relationship to particle characteristics and atmospheric constituents such as water vapor.

- Understand what the Akatsuki IR2 data can tell us about the clouds of Venus; and how that information can improve understanding of the atmospheric dynamics at global and regional scales.

Two platforms, complementary abilities

Venus Express (VIRTIS-M-IR)

- Limited spatial coverage
  - FOV ~10% of disk at apoapse
- Limited temporal coverage
  - Up to about six hours for a given region
  - Next opportunity: 24 hours later
- Significant Spectral Resolution
  - Spectral resolution ~100 from 1-5 µm

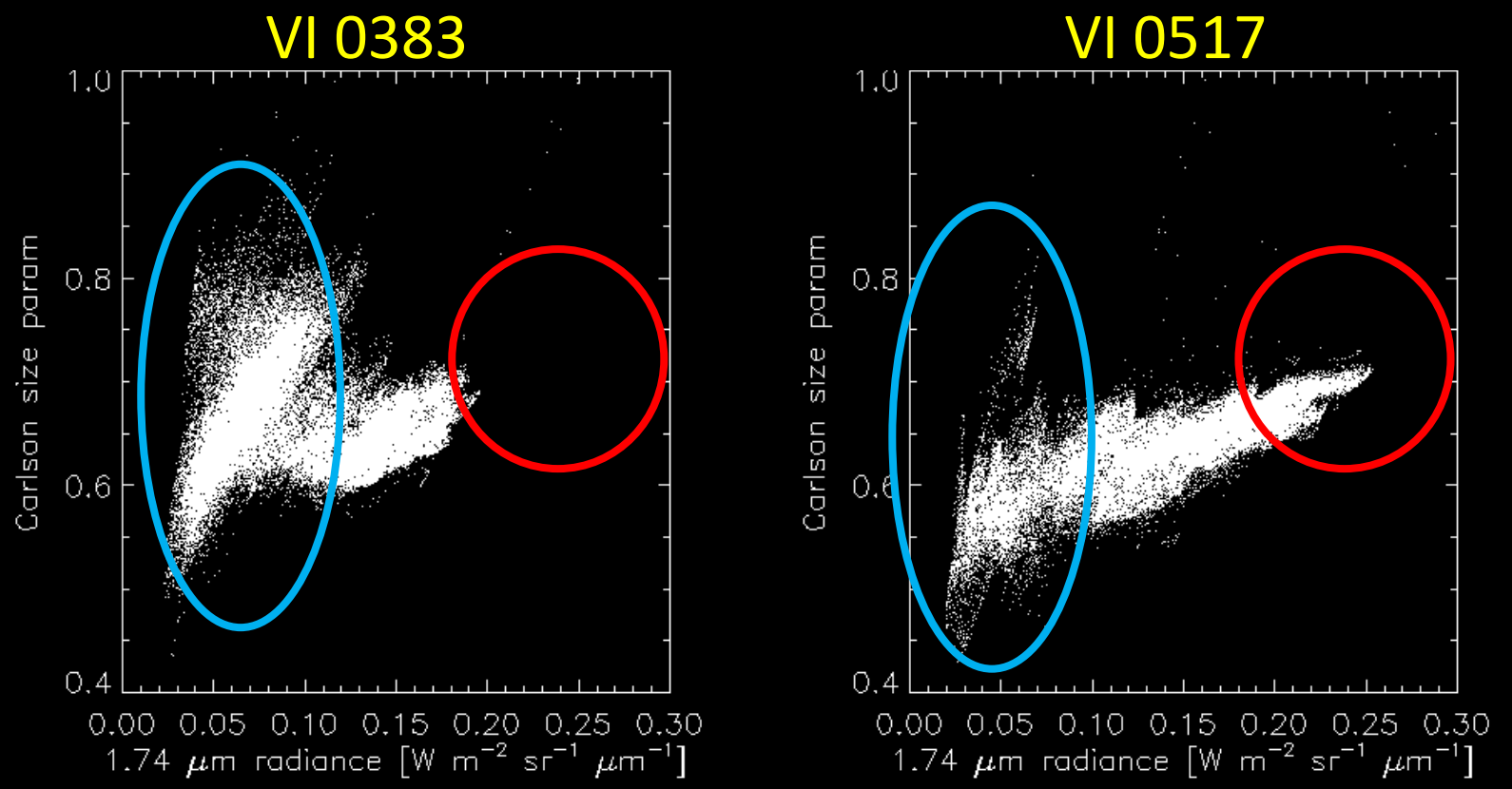
Akatsuki

- Global spatial coverage
  - FOV > angular size for most of orbit
- Continuous temporal coverage
  - Full disk view for most of orbit
- Limited spectral resolution
  - ~10 filters

- Not contemporaneous observation.
- However, if features with common characteristics can be seen in both, the information gleaned from each will be complementary, teaching us more about the nature of Venus than either independently
- Need a way of establishing consistency of features between missions
  - Size Parameter

Size parameter comparison (using VIRTIS)

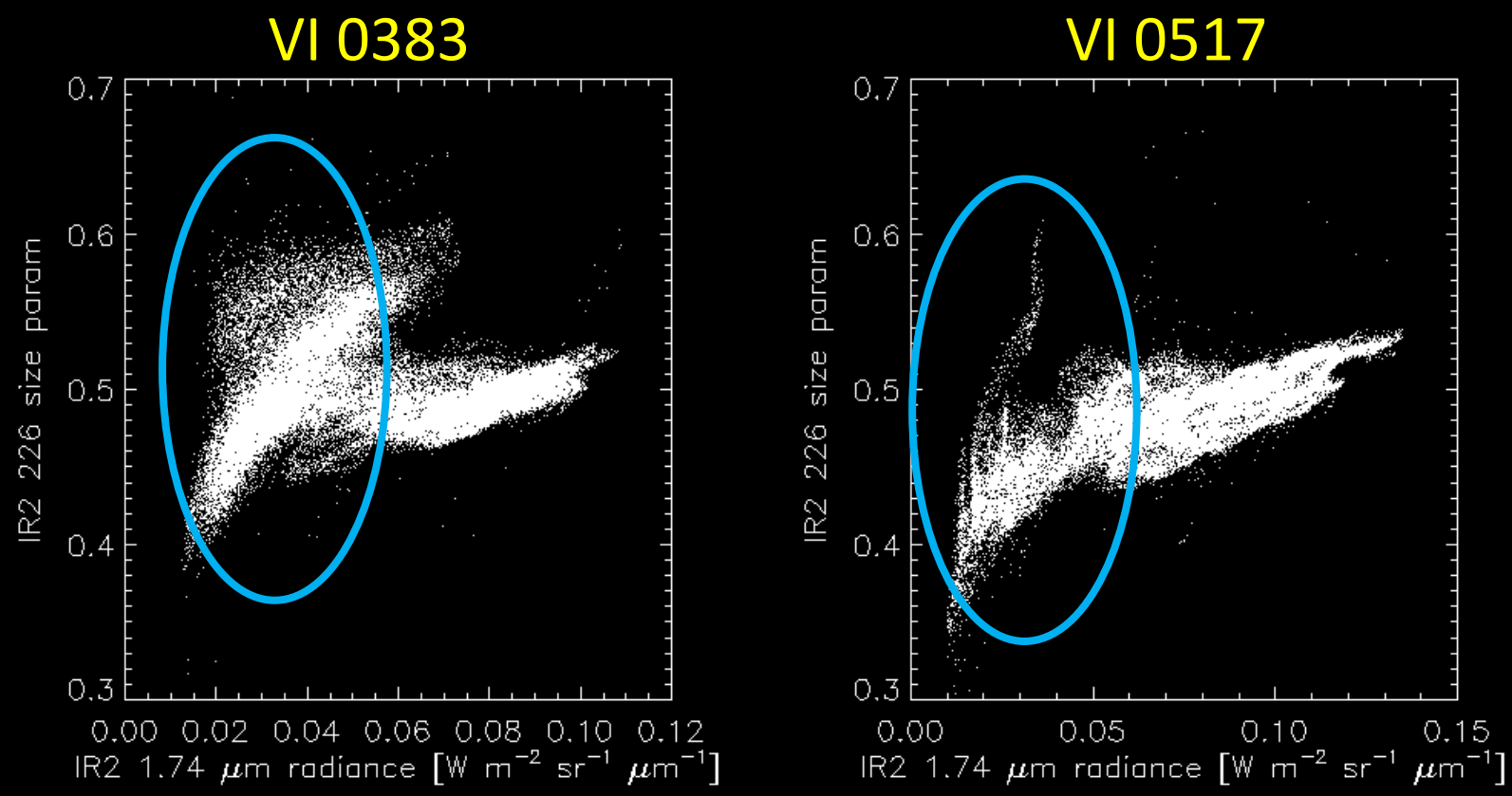
- One key difference is the almost complete **LACK** of Mode~3 particles in the 0517 observation!
- I.e., Yes, the atmosphere **IS** dominated by smaller particles during 0517.



- However, because it is difficult to distinguish Mode 2 and Mode 3 in thick cloud, it is more correct to say that the thinner clouds are more dominated by small particles at the time of orbit 517; and by larger particles at the time of 383.

Size parameter comparison (simulating Akatsuki)

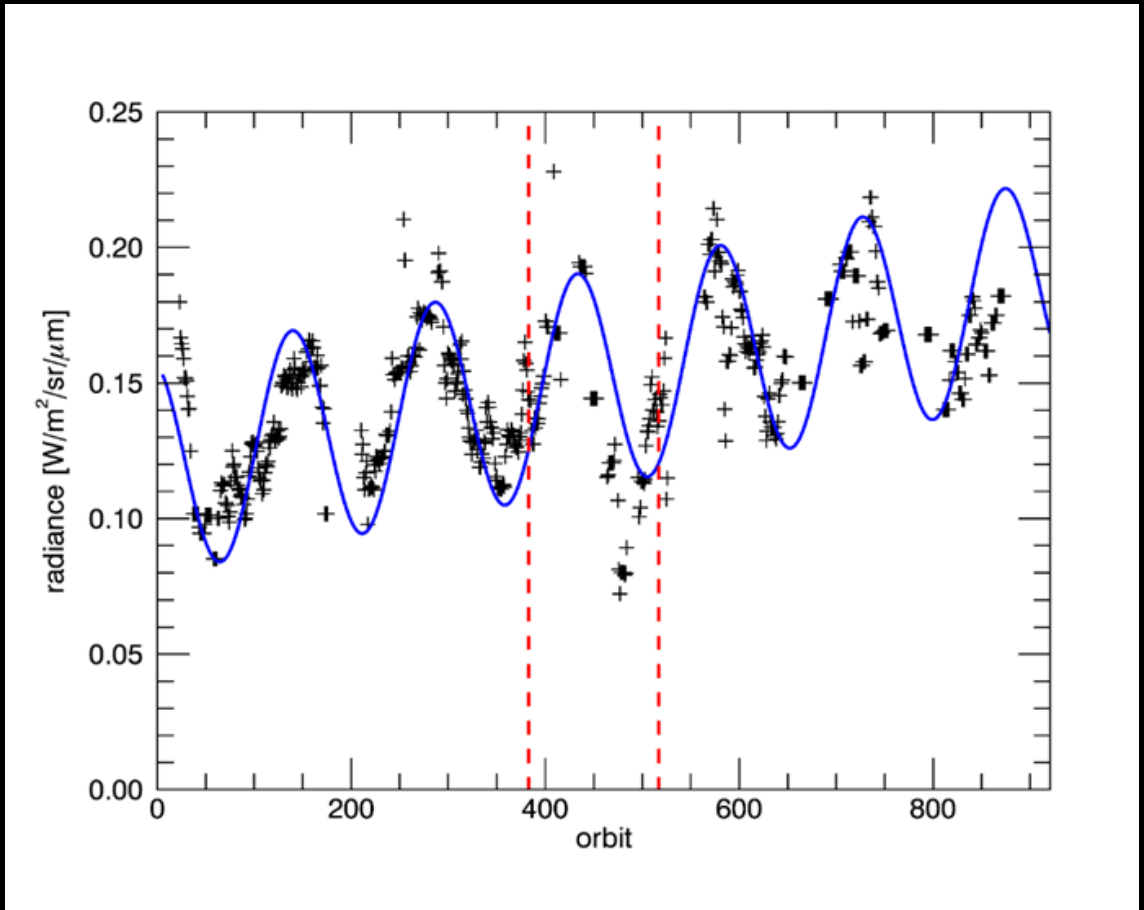
- This difference is evident in the Akatsuki:IR2-**simulated** observations, as well.
  - Possibly even more evident
- This is key to understanding morphological evolution of the cloud features.



- The manner in which Venus transitions from 383-like to (or from) 517-like will help us to understand the cloud evolution processes on Venus, which will improve knowledge of wind speeds from cloud tracking studies.

Motivation (1/2)

- Previous work showed a ~150 (Earth)-day periodicity in 1.74 µm radiance at mid-latitudes.
- There was also a slight upward trend in radiance, suggesting a decrease in total cloud opacity.
- These trends were not seen at polar latitudes
- Also not at equatorial, but data quality and coverage is poorer there

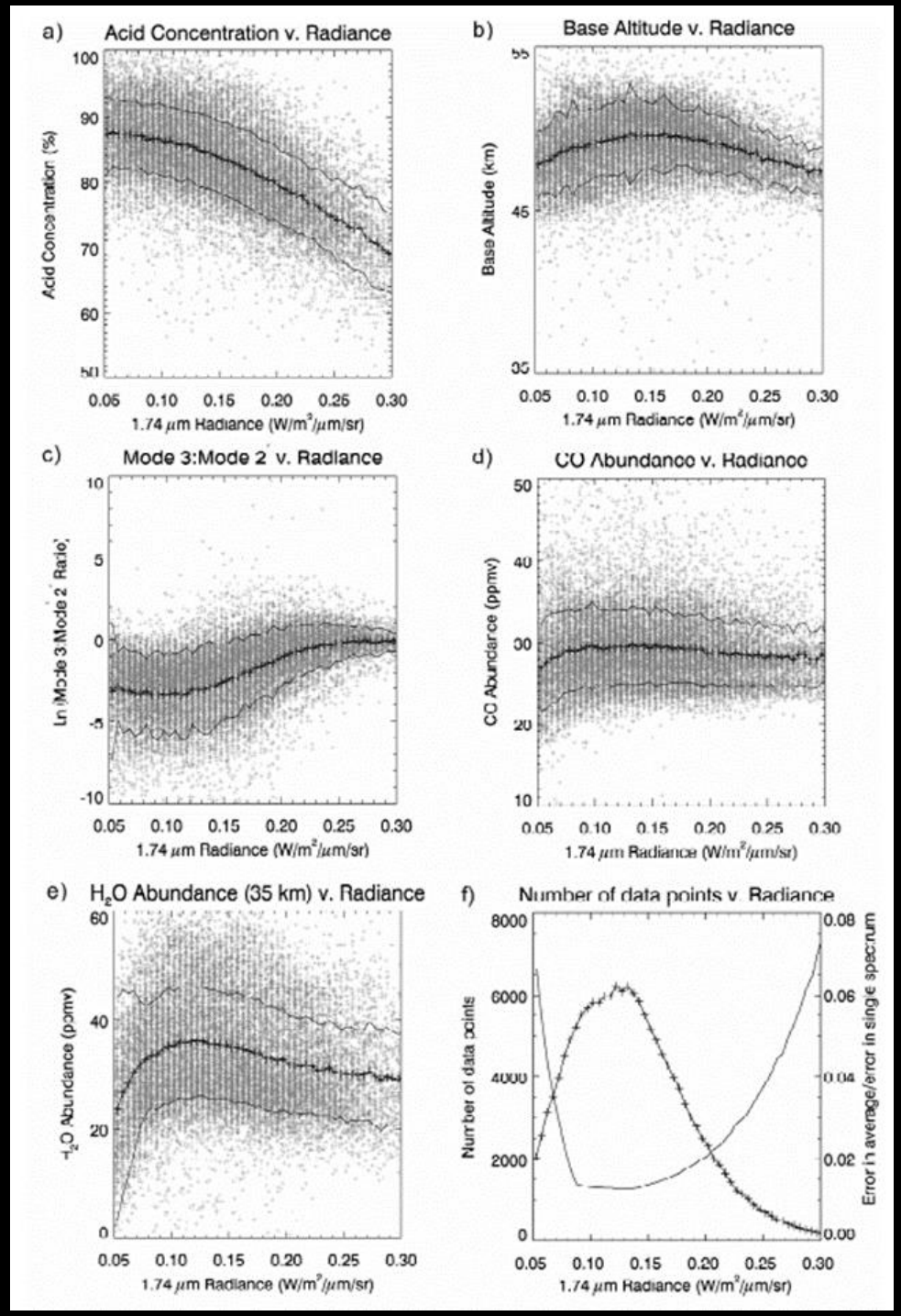


McGouldrick & Tsang, 2017

Motivation (2/2)

- Previous work showed that some atmospheric parameters can be retrieved from the VIRTIS spectral maps via polynomial fits utilizing the band ratio technique.

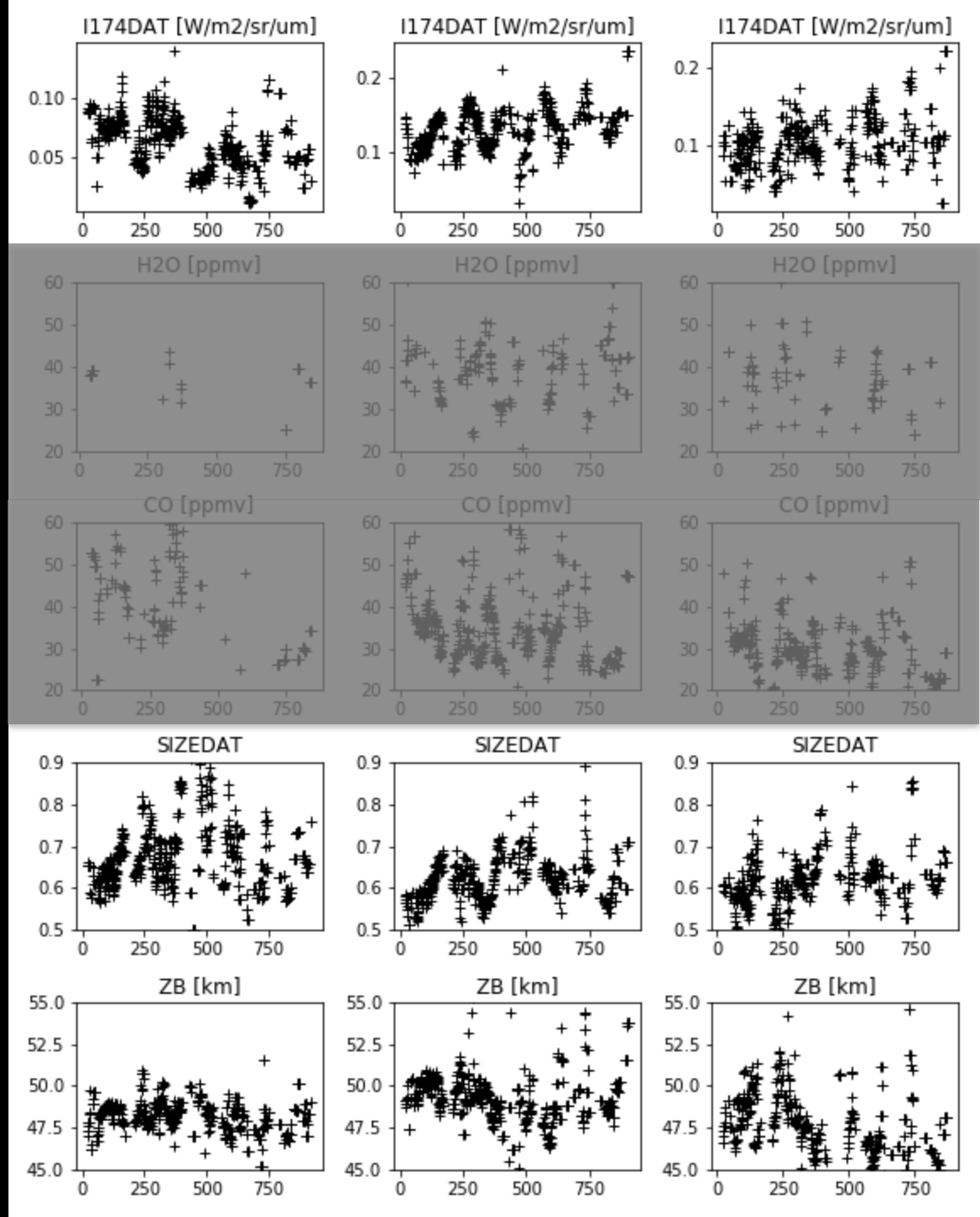
- **<u>Our plan is to apply this technique to individual cubes in the VIRTIS data, to provide additional context to the dyanmics of types of features seen in the Akatsuki data.</u>**



Barstow et al 2011

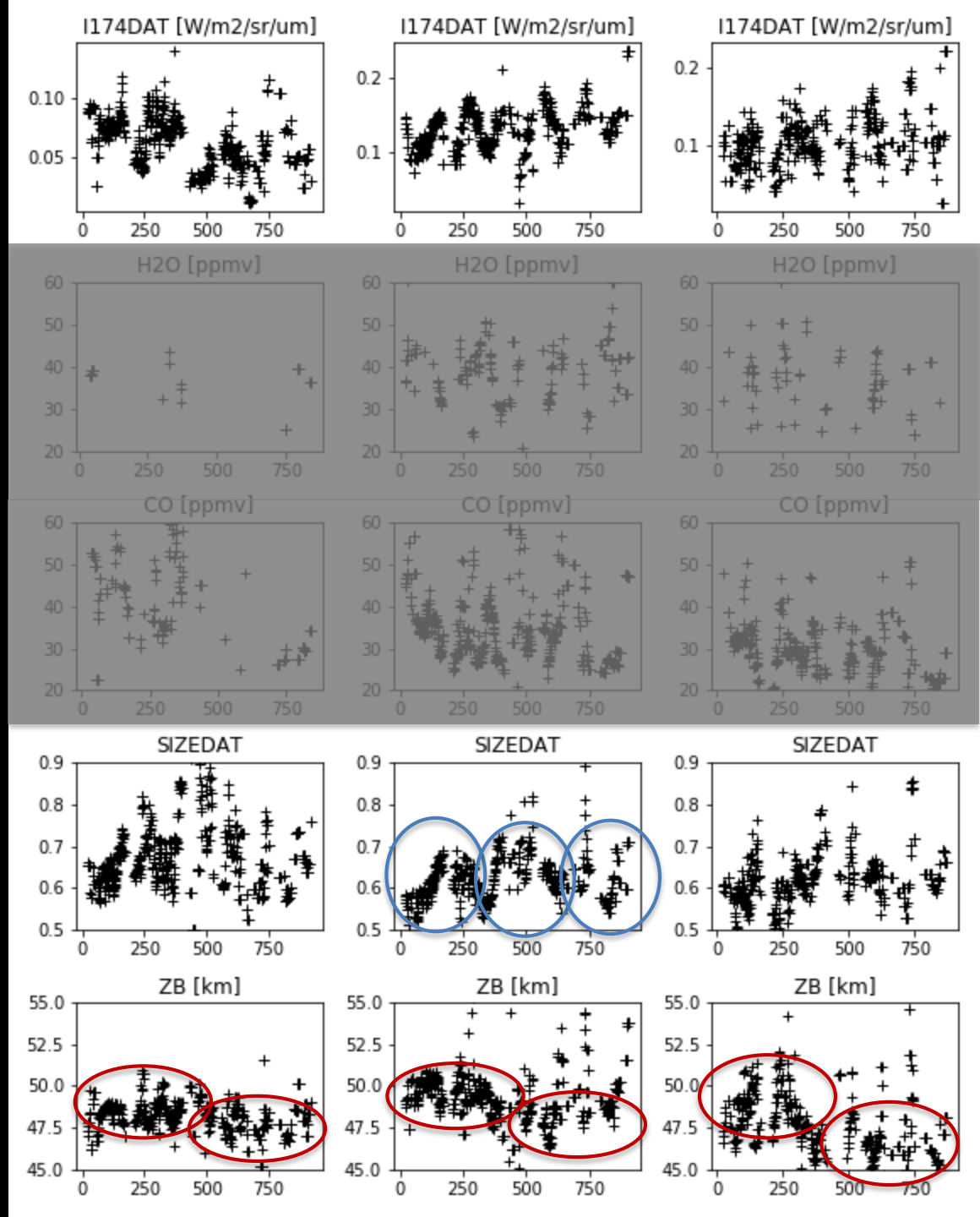
Parameter Evolution with time

- Look at evolution of H_2O, CO, size, z_{base} over time over the three latitude ranges.
- Some analysis issues: low S/N often results in bad retrievals for H_2O (e.g., 10^{300}), so we'll not consider those further in the long-term analysis.
- Similarly for CO.



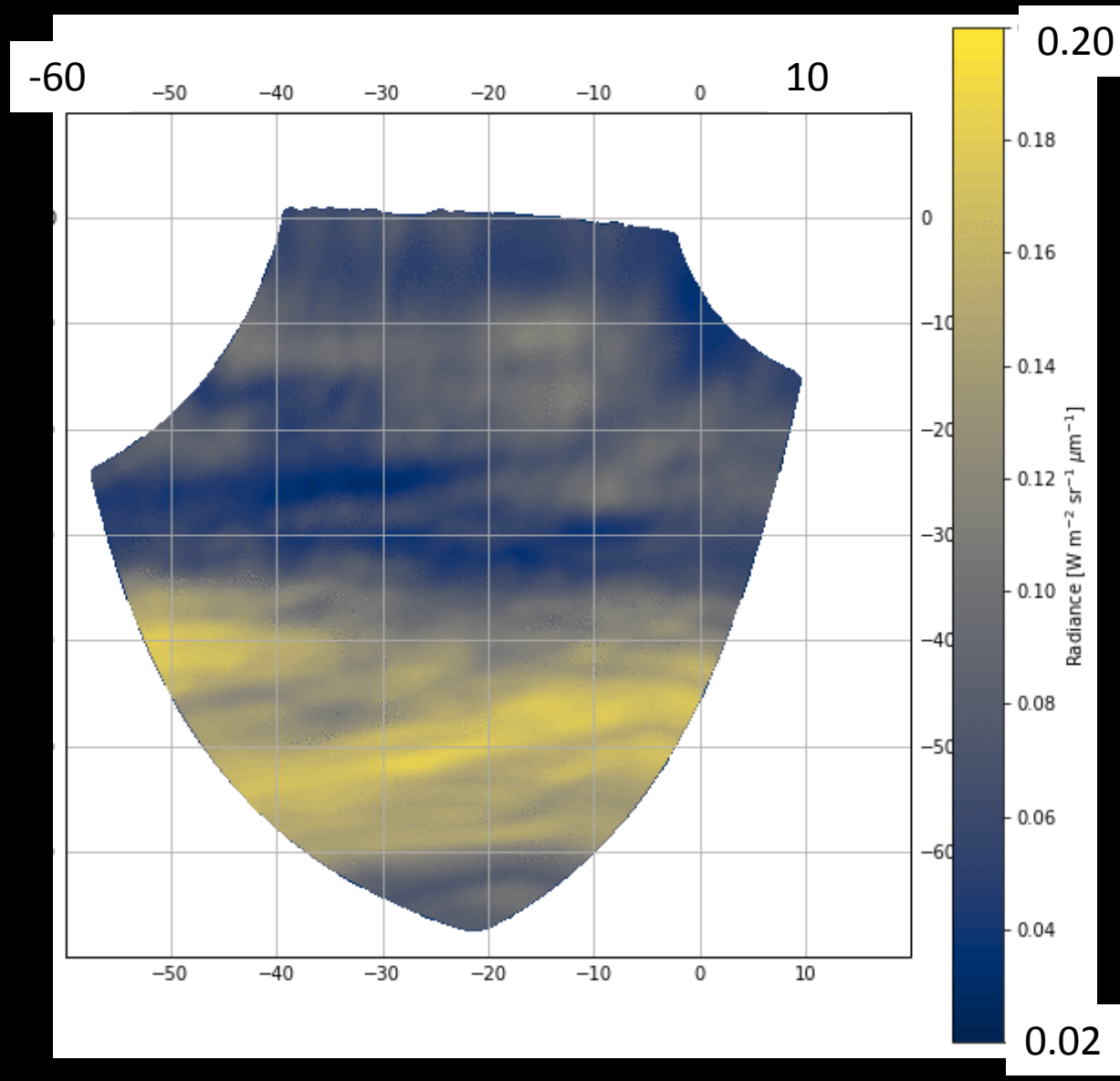
Parameter Evolution with time

- Periodicity in 1.74 µm radiance is still evident, as are long term trends.
- A possible periodicity in the size parameter also exists, but with a different (longer) period)
- No clear trends at equ due to poor S/N
  - Though, a possible very large decrease in cloud base altitude at equatorial regions after orbit ~400
- No obvious links between these parameters and observed radiance period; but frequency analysis is still ongoing.



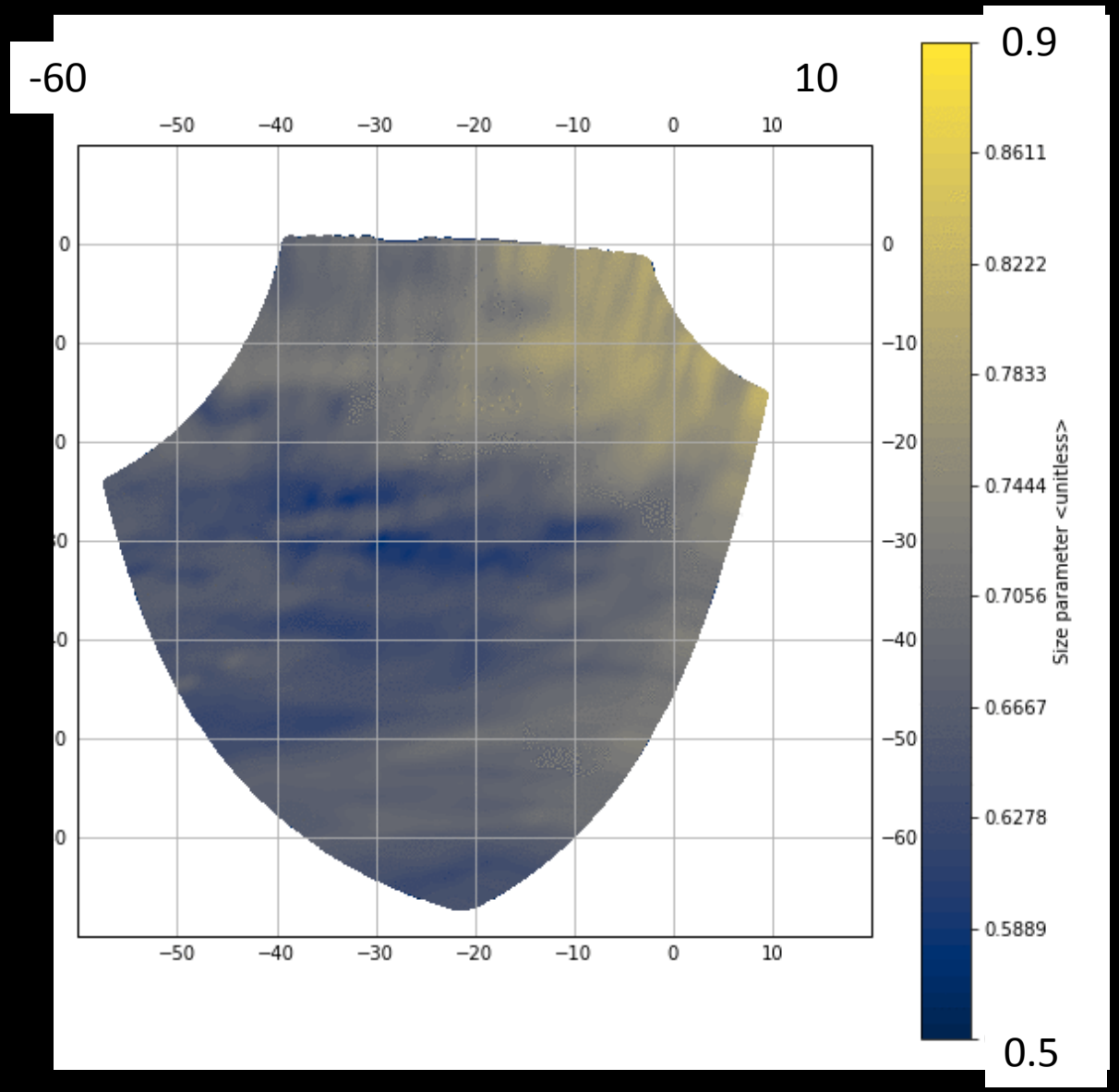
Short Term Evolution

- A goal of characterizing the mesoscale cloud behavior is to determine its effects on the measurement of winds through cloud tracking.
- To demonstrate this, we can correct observational data for the estimated zonal super-rotation wind component and examine only the perturbations.
- This can also be applied to the parameters extracted from the VIRTIS spectra…

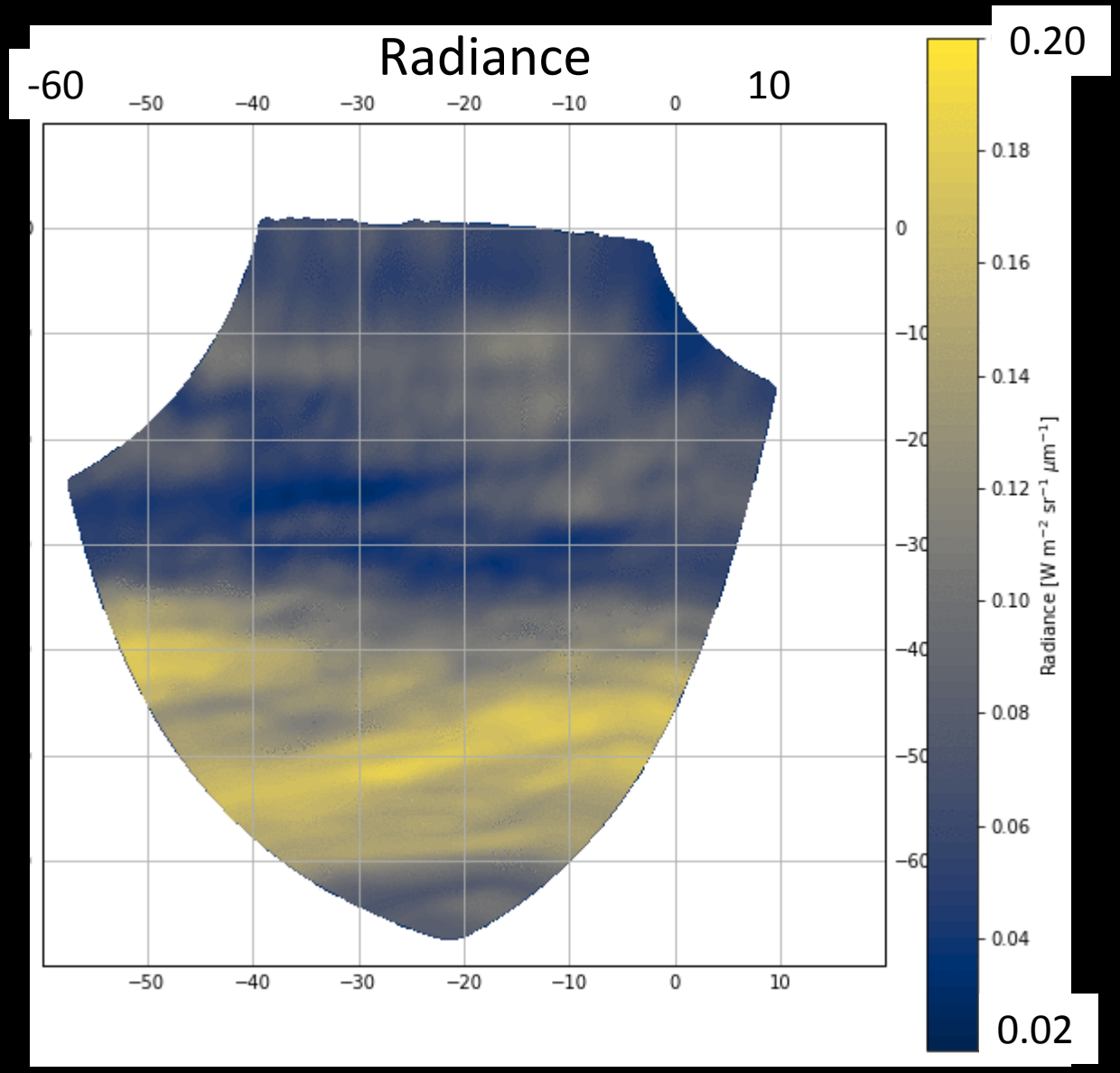


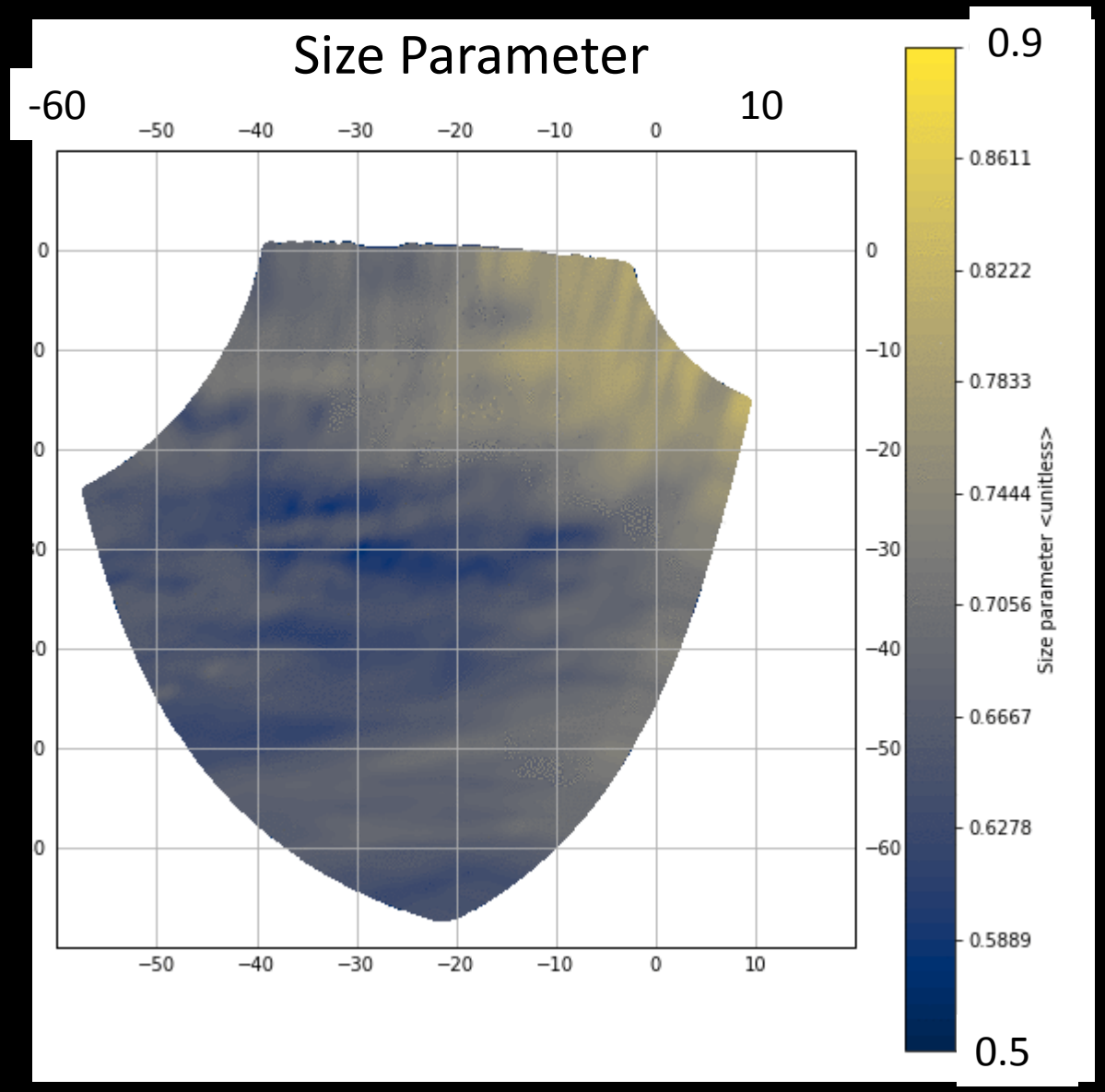
Short Term Evolution

- Here, in data from orbit 383, we see what is perhaps typical size parameter distribution (recall the scatterplot from earlier).
- We see some areas of thick cloud having large size parameter (upper right), and some thick cloud regions with small size parameter.



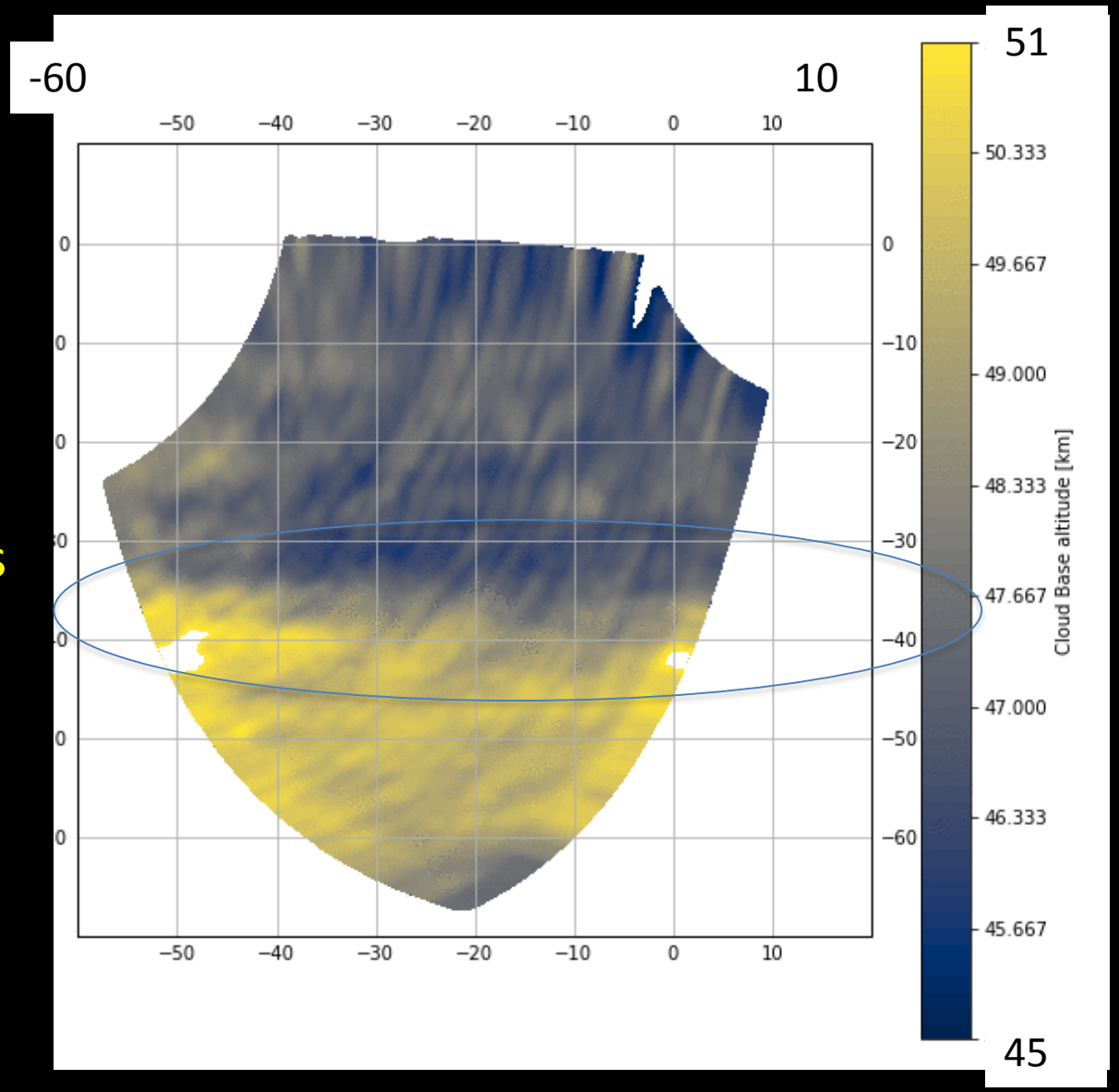
Short Term Evolution (6hr duration)





Short Term Evolution

- However, we also see a sharp transition in cloud base altitude occurring near 35-40 degrees latitude.
- This is consistent with the change in radiance at the same latitudes
  - Note that the somewhat brighter radiances at equatorial latitudes are not correlated with changes in cloud base altitude.
- The proximity of this feature to the boundary between equatorial and mid latitudes in the previous work is interesting.



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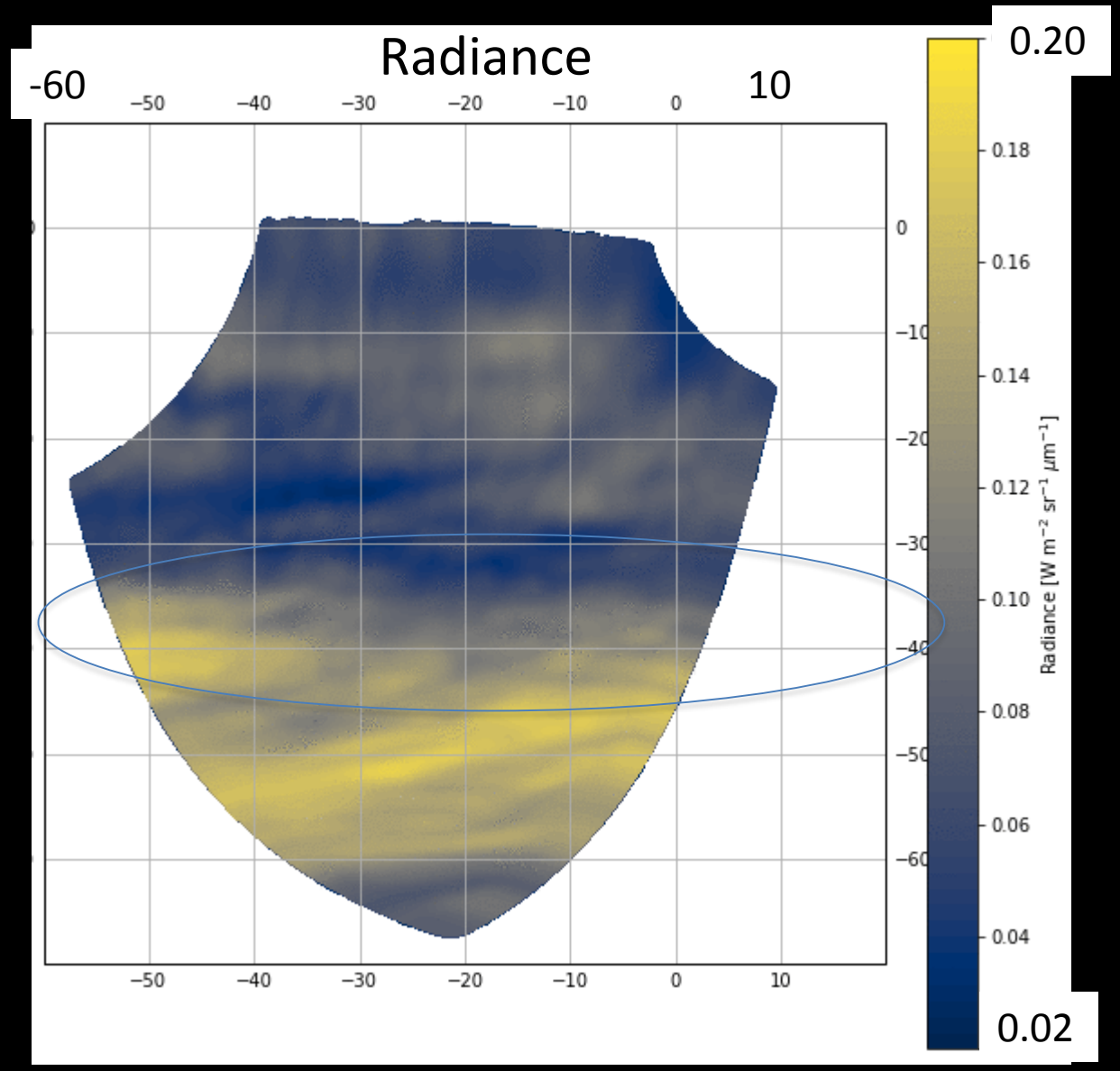
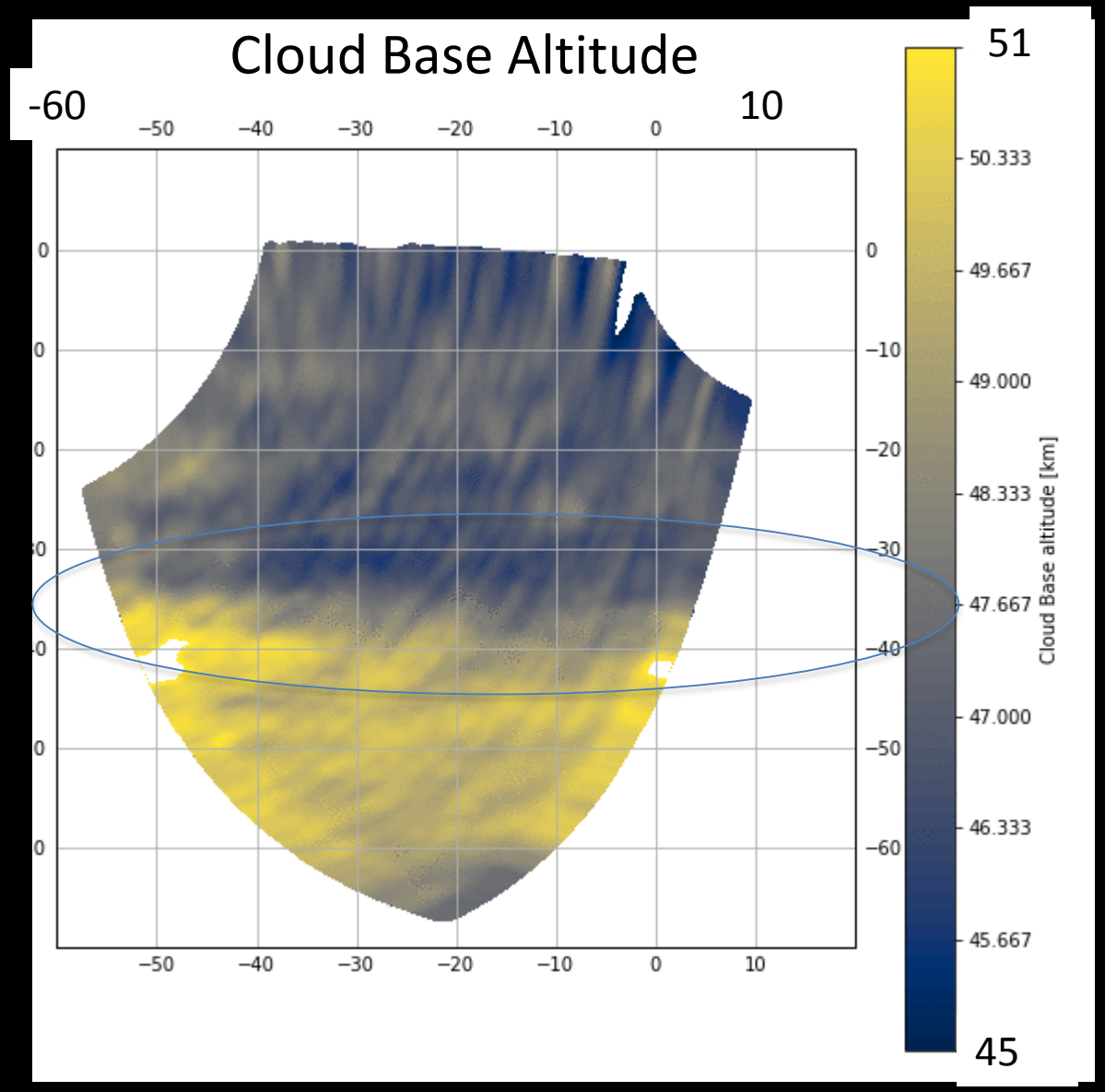
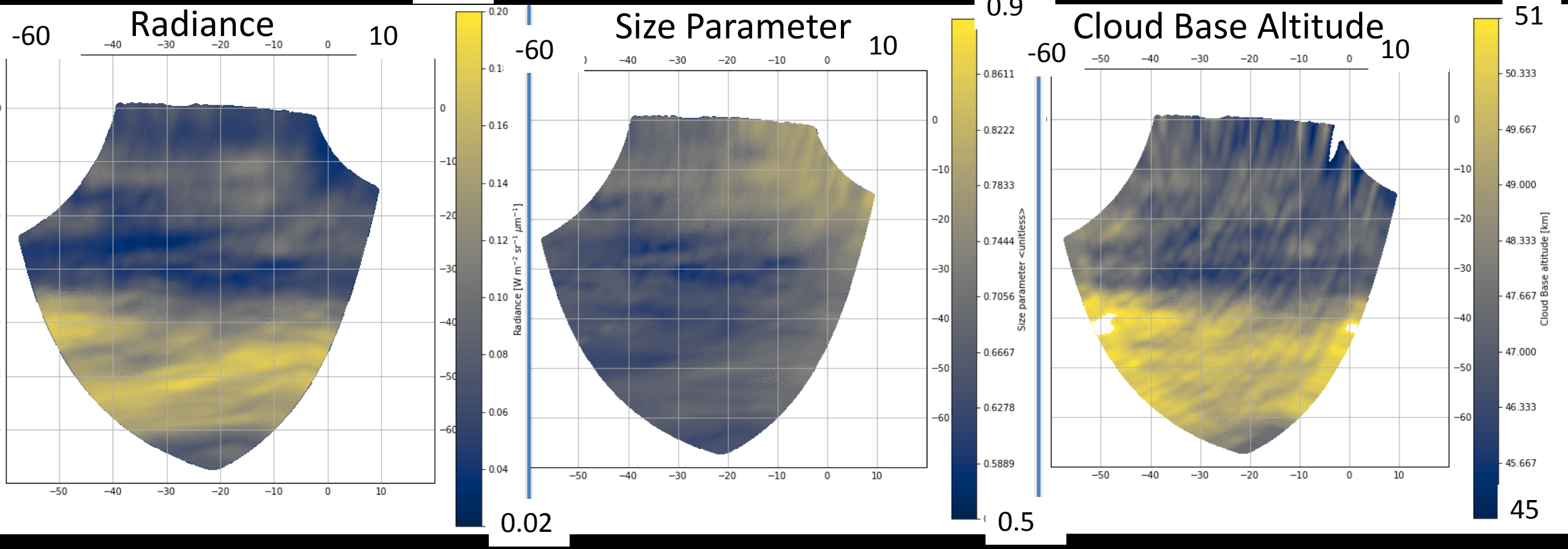




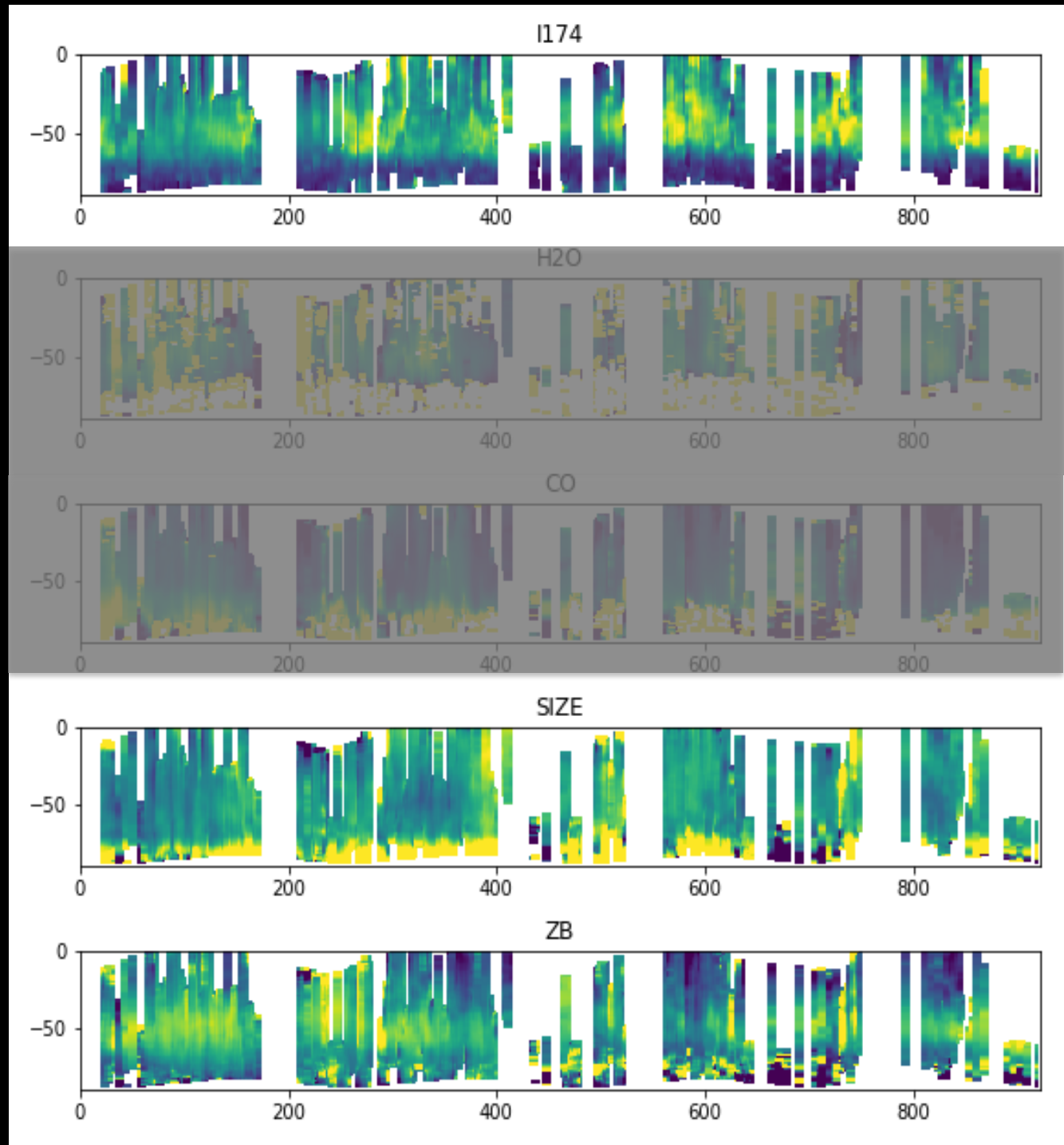
Short Term Evolution



- Regions of large radiance and large size parameter near center (evidence of larger particles)
- Regions of low radiance and low size parameter near high lat: cold collar before the poles.
- Cloud base altitude trends with mid-lat transition; but no correlation with radiance at equ, and no clear change in size parameter.

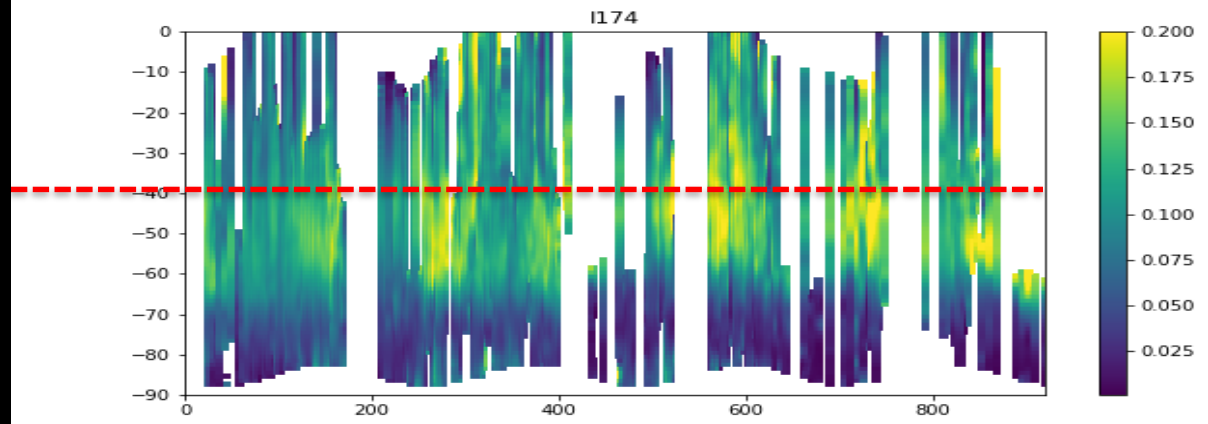
Parameter Evolution with time

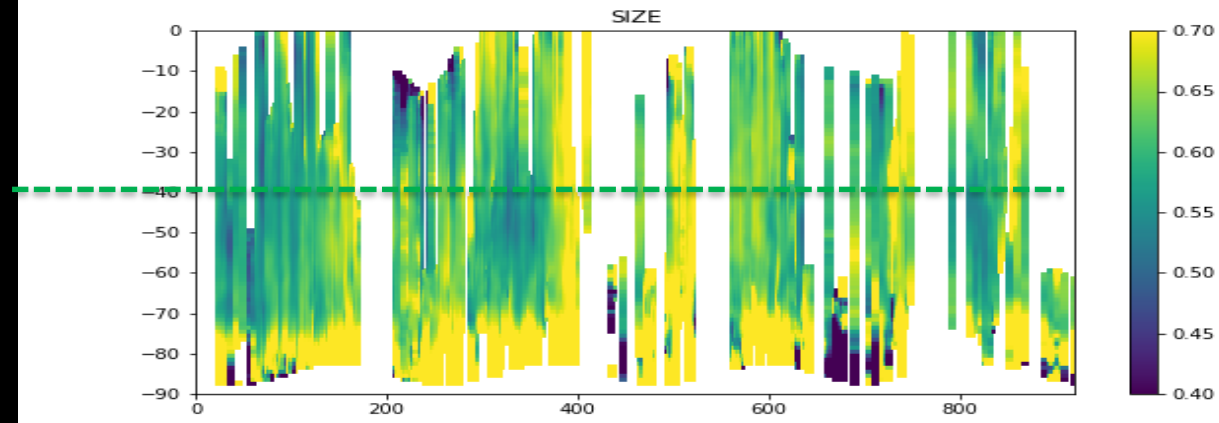
- Explore the effect of the possible temporal excursion of cloud base altitude transition latitude with time.
- I.e., could a subtle movement of this transition region across the mid-latitude equatorial latitude boundary be driving the variations seen previously?
- Look at 10° latitude resolution data
  - Unfortunately, there was a bug in the analysis, so we'll skip this and go to the 1° latitude resolution data.

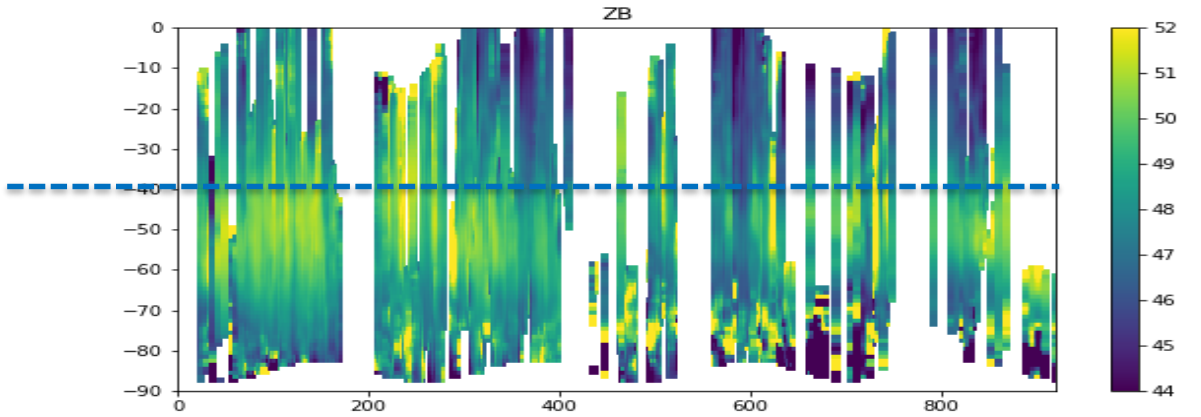


Parameter Evolution with time

- Variations seen in radiance not tied to the observational geometry (note differing period of polar cutoff due to Venus year.
- Latitudinal ‘excursions’ of radiance boundary at mid-lat are apparent.
- Possibly also a variation in cloud base altitude, but are less clear.
- No obvious change to size parameter







Conclusions

- Akatsuki IR2 images are capable of distinguishing cloud particle size variations.
  - Excellent correlation in radiance; fair in size parameter
- Initial applications of Barstow parameter retrievals from individual cubes look promising
- North/south migration of bright/dark gradient at mid latitudes, coupled with changes in cloud base altitude possibly responsible for previously observed radiance variations.
- More evidence of Weather and Climate on Venus!