Comparison of horizontal distribution of temperature and UV absorbers at the Venus cloud-tops

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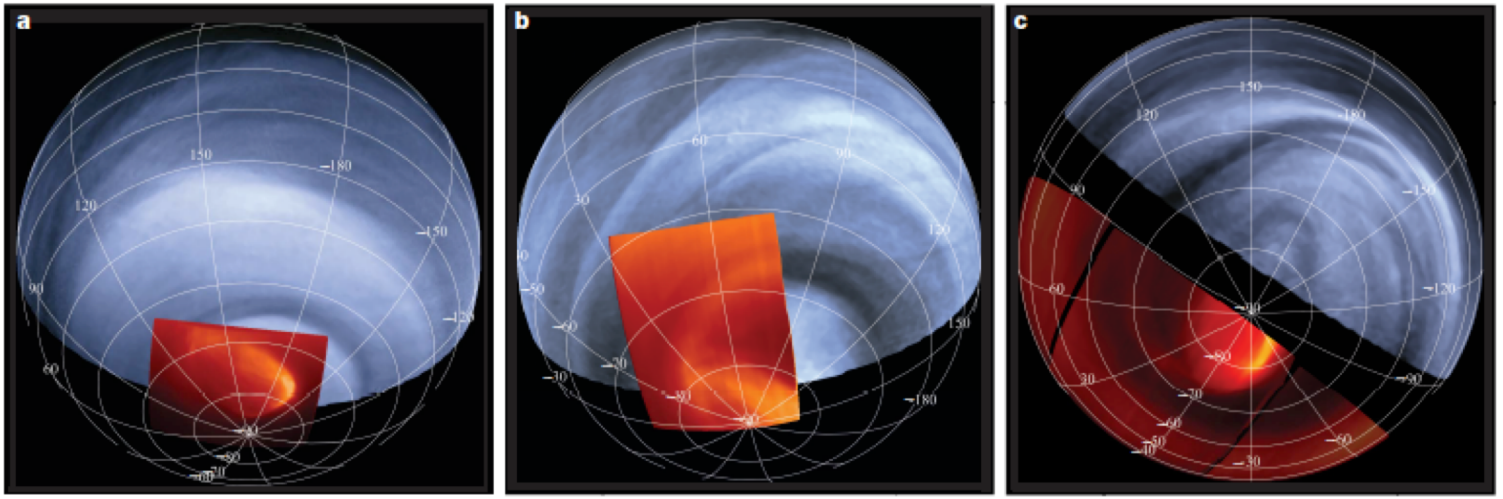
Spiral structure observed by previous study



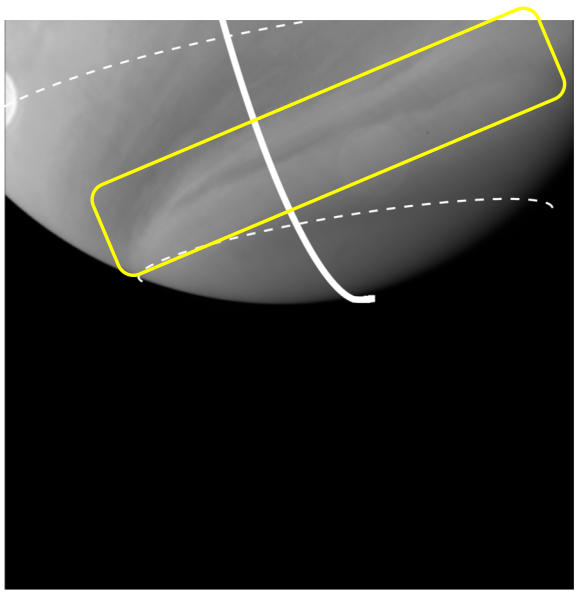
Images of Venus' cloud tops by simultaneous observation of VIRTIS (5μm) and VMC (365nm) (Titov et al., 2008)

- Red and gray images were observed by VIRTIS (5μm) and VMC (365nm), respectively
- All spiral structures extending from the polar region to mid-latitudes show negative correlation between the thermal and UV images.

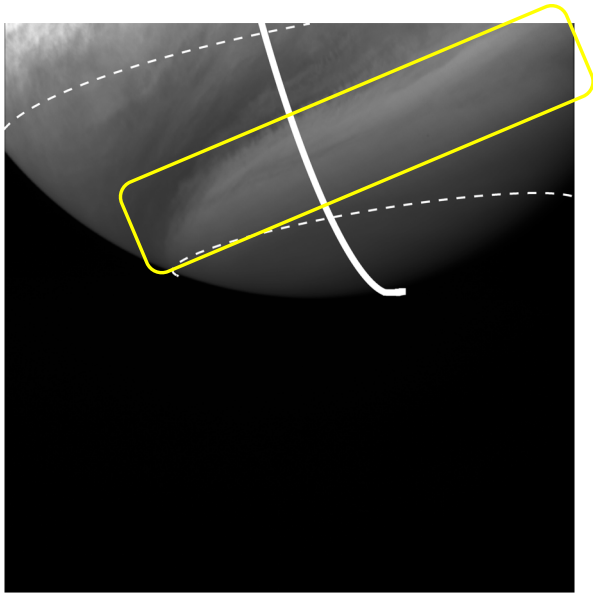
Spiral structure observed by LIR and UVI

- However, LIR (10μm) and UVI (283 and 365nm) onboard AKATSUKI often observe a bright spiral structure from the polar region to mid-latitudes.

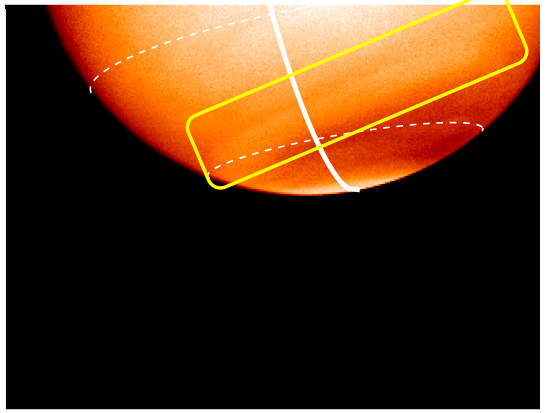
June 20, 2016



UVI (283nm)



UVI (365nm)



LIR (10μm)

Spiral structure observed by LIR and UVI

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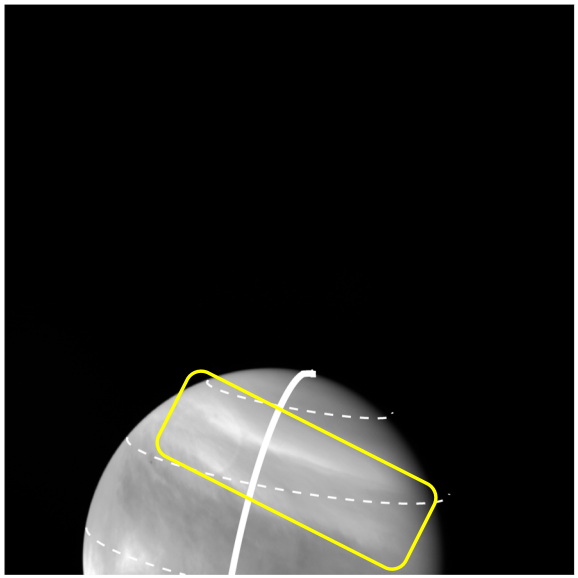
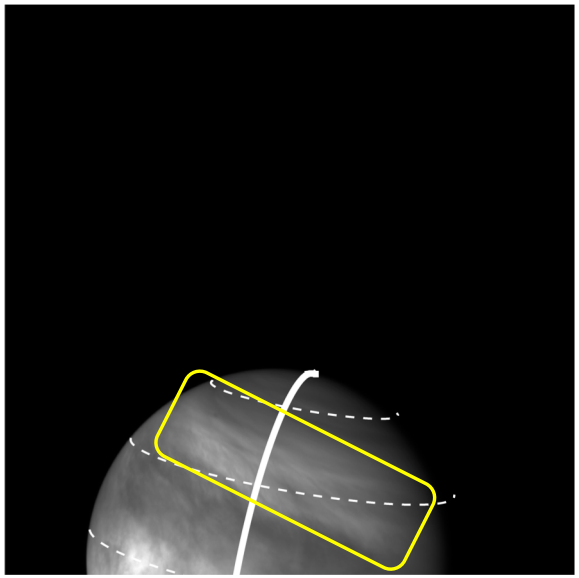
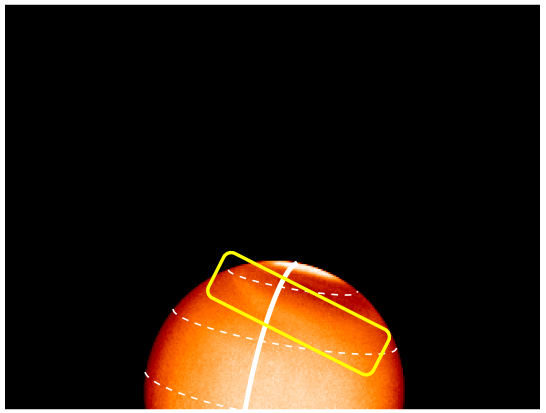
December 1, 2016



UVI (283nm)



UVI (365nm)



LIR (10μm)

Spiral structure observed by LIR and UVI

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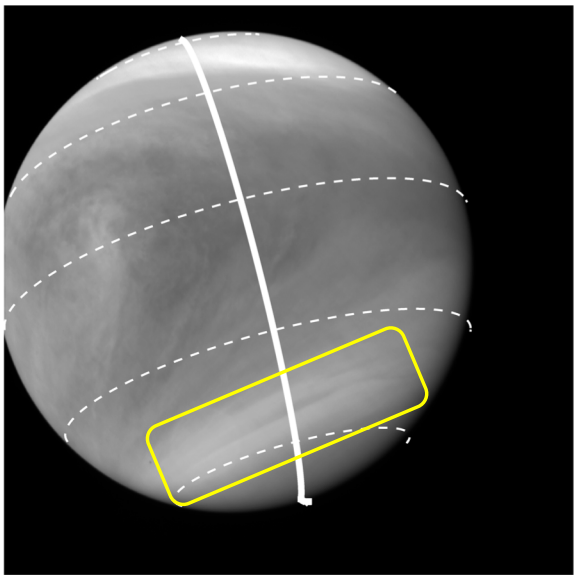
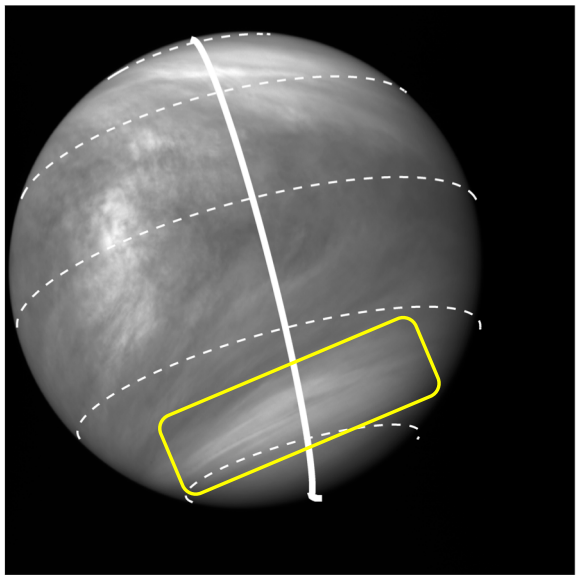
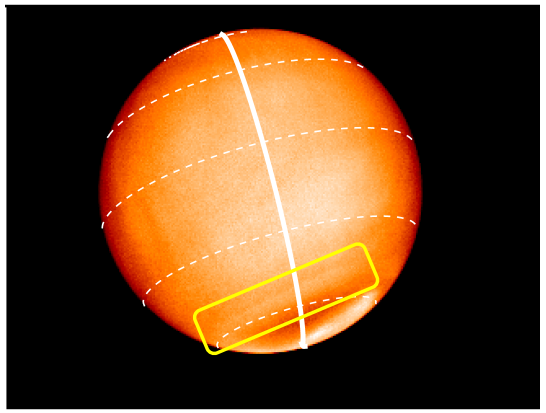
January 26, 2017



UVI (283nm)



UVI (365nm)



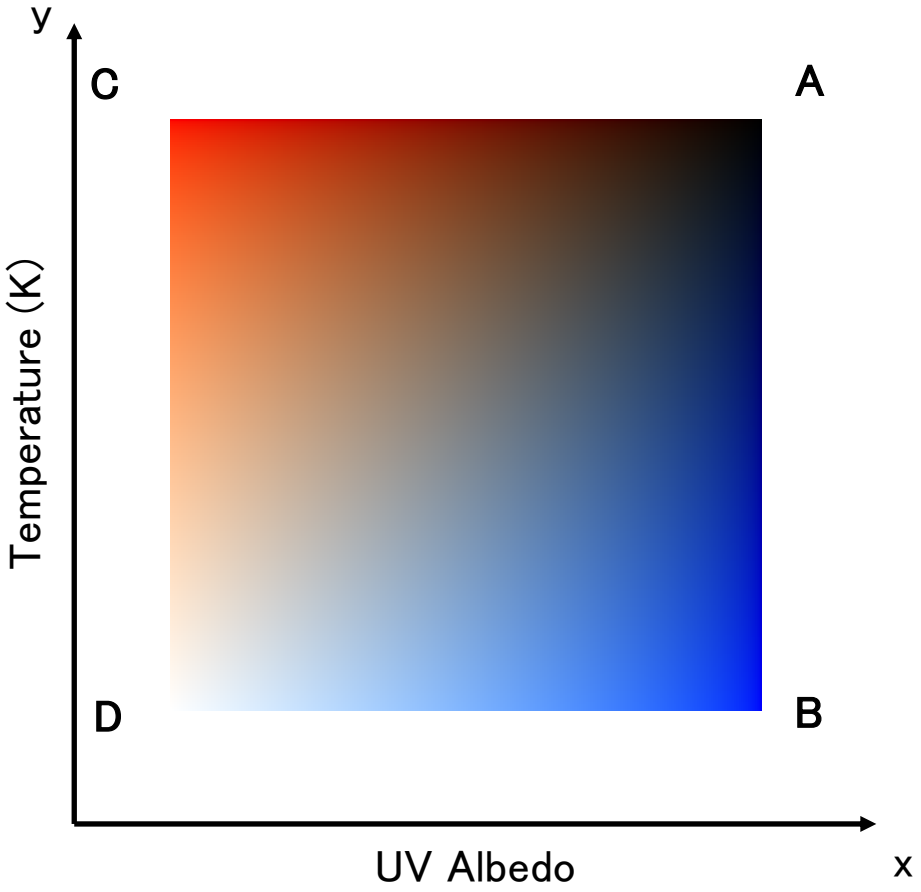
LIR (10μm)

RGB composite map

- We would like to investigate how these bright spiral structures correlate, but the correlation coefficients can not be distinguished.
- We created a two-dimensional RGB composite map as shown in the right figure.

$$\text{C. Coeff.} = \frac{(x-\bar{x})(y-\bar{y})}{\sqrt{(x-\bar{x})^2}\sqrt{(y-\bar{y})^2}}$$

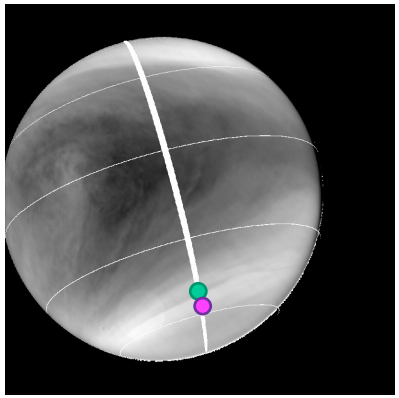
	A	B	C	D
Albedo	High	High	Low	Low
Temp.	High	Low	High	Low
C. Coeff.	High	Low	Low	High
Color	Black	Blue	Red	White



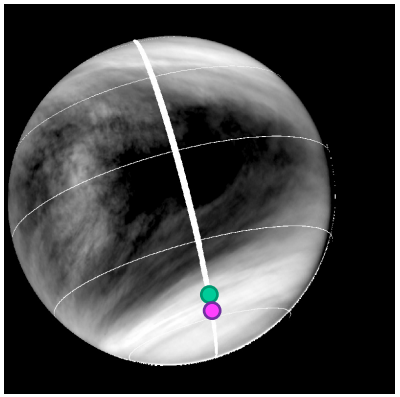
Relationship of temperature and albedo

Correlation between temperature and UV albedo

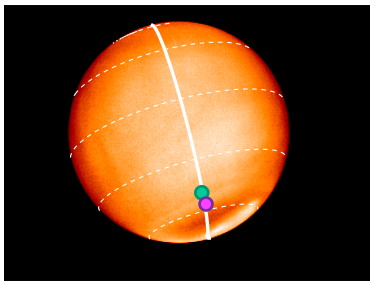
2017/01/26



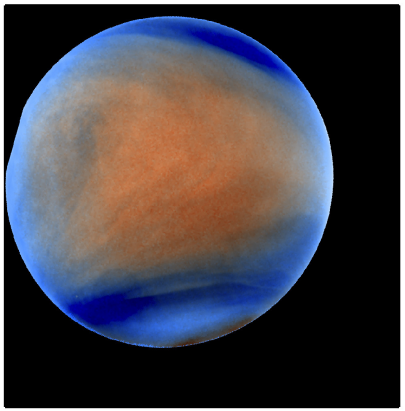
UVI (283nm)



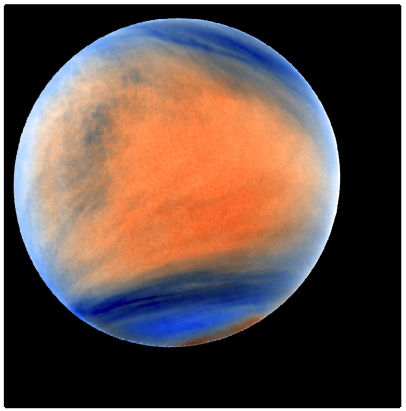
UVI (365nm)



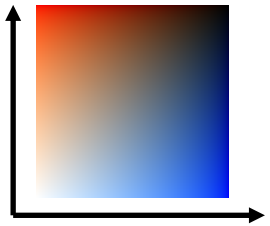
LIR (10μm)

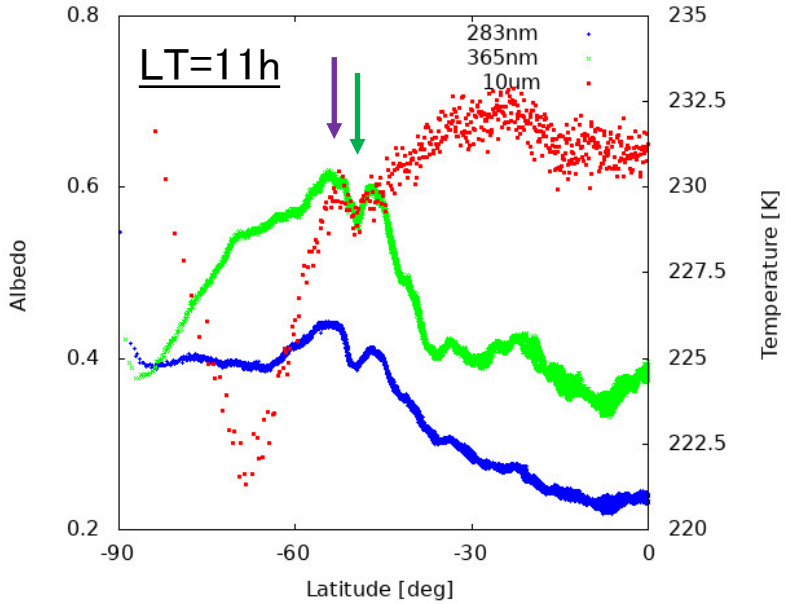


283nm & 10μm



365nm & 10μm



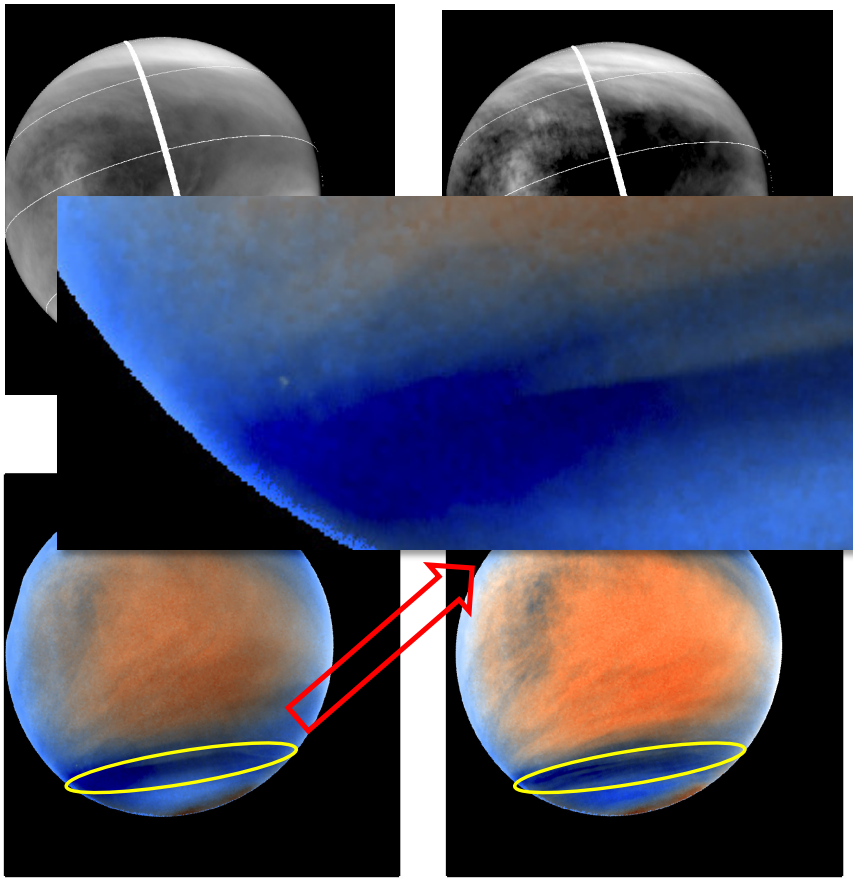


Plots for each local time at 11

- All three data increase/decrease in the purple/green region.
- As the blackish region in two lower images shows, the bright spiral structure is co-located and has a positive correlation.

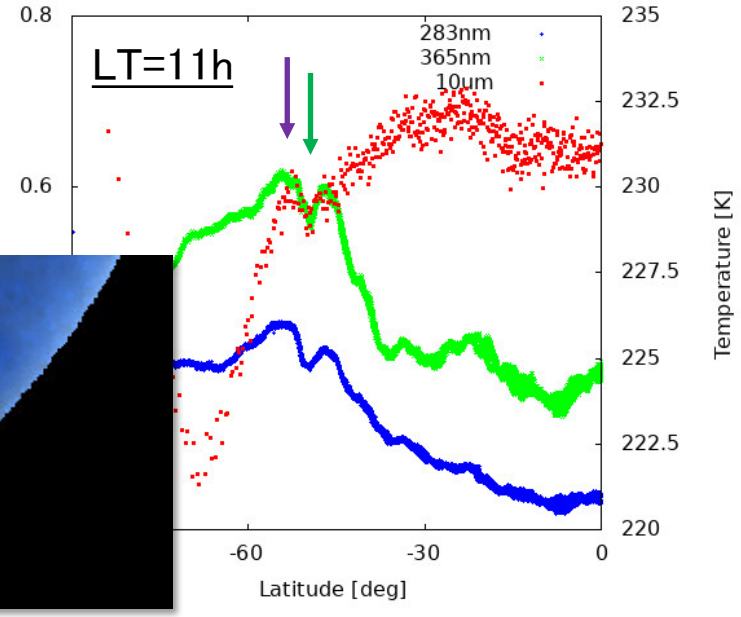
Correlation between temperature and UV albedo

2017/01/26



283nm & 10μm

365nm & 10μm



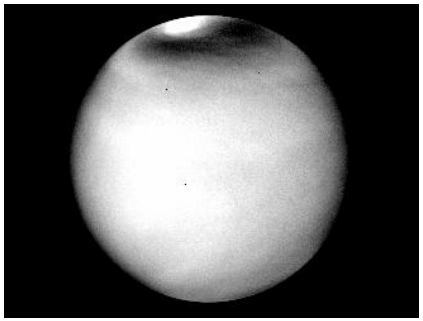
Temperature and UV albedo fluctuation

- All three data increase/decrease in the purple/green region.
- As the blackish region in two lower images shows, the bright spiral structure is co-located and has a positive correlation.

Purpose of study

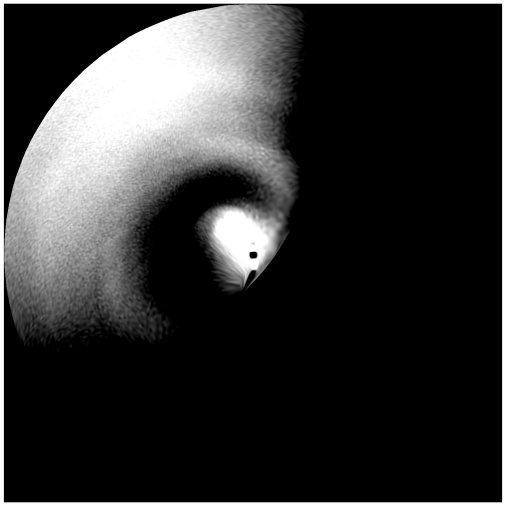
- LIR and UVI often observe bright spiral structures that flow from the polar region to mid-latitudes.
- We found positive correlation between thermal and UV images.
- We suppose that
  - the bright spiral structure connects to the polar region, and
  - the frequency of its emergence depends on latitude and local time.

Polar mapping



LIR (10μm)

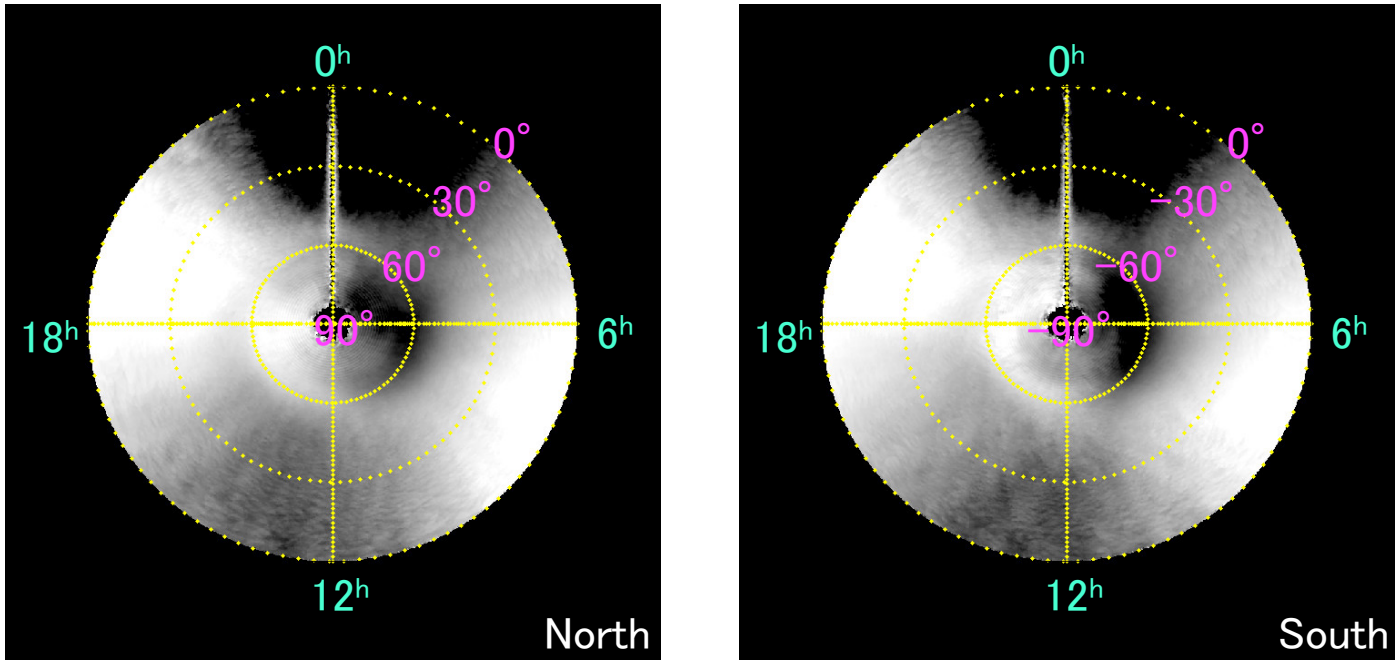
1. Polar mapping
2. Akima interpolation



Polar map centered at the North or South pole

- We projected the observed values on a polar plot in order to see how the bright spiral structure connects to the polar region (Kouyama et al., 2017).
- We used the Akima interpolation method to display images without artifacts like a fringe.

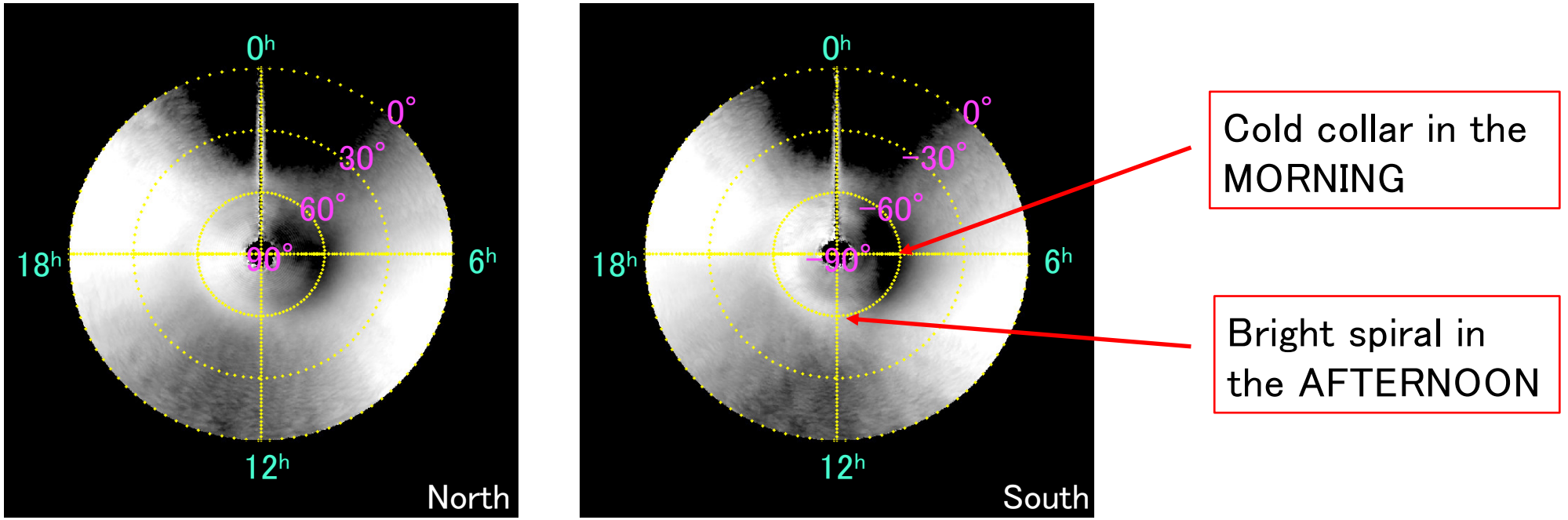
Spiral structure dependency of latitude / local time



Brightness temperature anomalies during the period of two years
(2016/10/29～2018/10/13)

- Data for about two years are averaged on a latitude and local time map.
- These images show anomaly of the zonal mean value of each latitude.

Spiral structure dependency of latitude / local time



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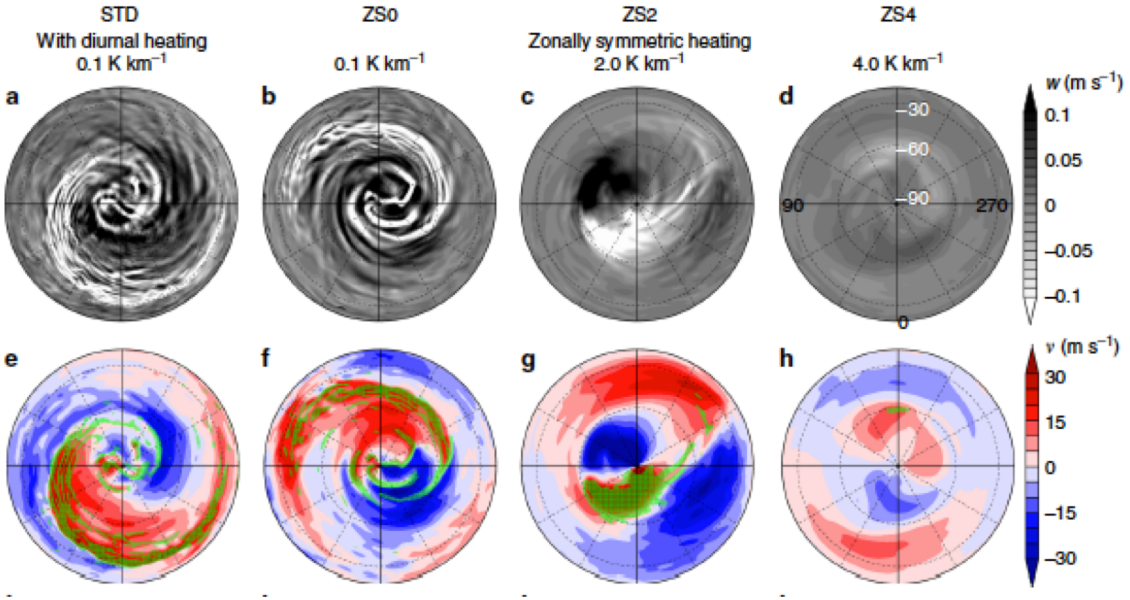
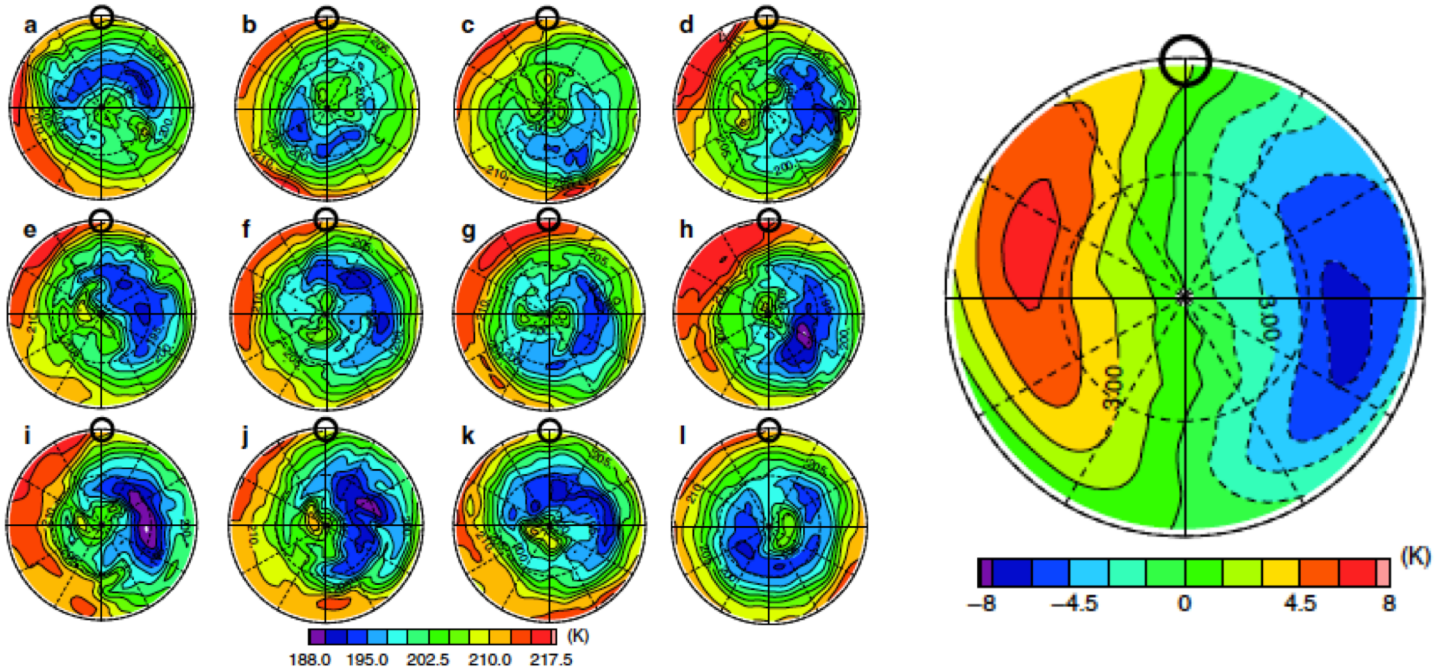
Numerical simulation (Bright spiral in the AFTERNOON)



Distributions of vertical velocity (a–d) and meridional velocity (e–h) at 60 km (Kashimura et al., 2019)

- Kashimura et al. (2019) argues that the following three components might be related to the formation of the spiral structure.
  - The high-latitude disturbances and associated jets
  - The mid-latitude baroclinic disturbances
  - The equatorial Rossby-like waves

Numerical simulation (Cold collar in the MORNING)



(Left) Time dependency of cold collar at 68 km (Ando et al. 2016)
(Right) Deviation associated with the thermal tide (Ando et al. 2016)

- Ando et al. (2016) shows that the cold collar is always standing in the morning.
- The cold collar is created by the RMMC (residual mean meridional circulation) that is enhanced by the thermal tide.

Conclusions

- The spiral structures observed in the infrared and UV regions show negative correlation between them in the past study, however, we found the bright spiral structures with positive correlation between the images obtained by LIR and UVI.
- From analysis of the thermal images obtained by LIR it is found that the spiral structure extends from the polar region to middle latitudes in the afternoon and that the cold collar mostly exists in the morning side hemisphere.
- The observed local time of the cold collar is consistent with the simulation result by Ando et al. (2016). On the other hand, the observed localization of the spiral structure in the afternoon does not seem to agree with those simulated by Kashimura et al. (2019).

Future work

- We should compare more observed cases with the results of two numerical calculations, and clarify the dynamics of the cold collar and the spiral structure.
- By analyzing the UVI images in the same way and comparing them with the result of LIR images, we can infer the dynamics of UV absorbers in the nightside that can not be seen by UVI.