



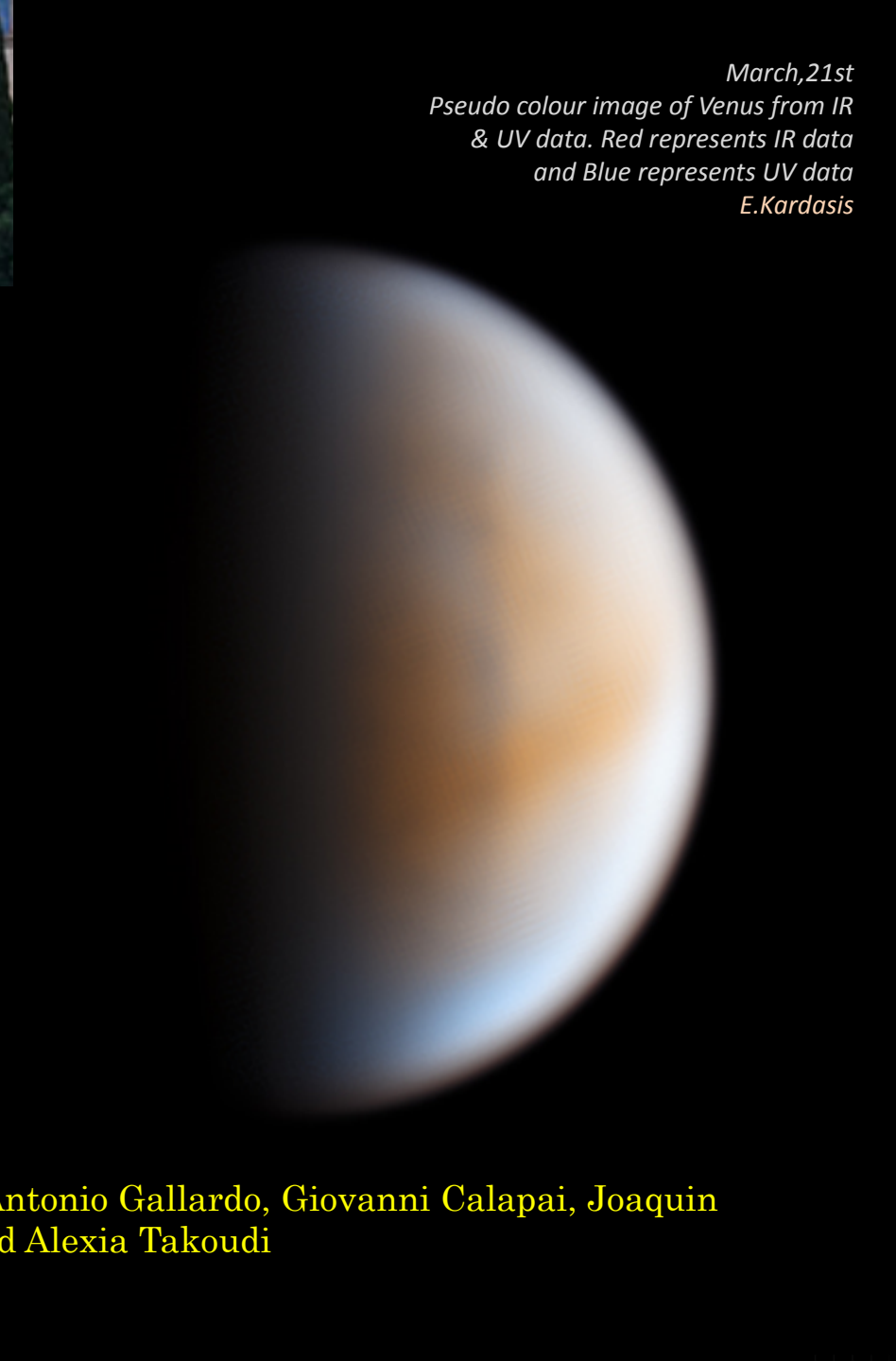
Results from the professional-amateur collaboration to investigate the Cloud Discontinuity phenomenon in Venus' atmosphere

Emmanuel (Manos) Kardasis, *Europlanet SE Hub*
Hellenic Amateur Astronomy Association, GREECE

Javier Peralta, *Departamento de FAMN, Facultad de Física,*
Universidad de Sevilla, SPAIN

Grigoris Maravelias, *IAASARS, National Observatory of Athens, GREECE*
Institute of Astrophysics, FORTH, GREECE,
Hellenic Amateur Astronomy Association, GREECE

Masataka Imai, Anthony Wesley, Tiziano Olivetti⁷, Yaroslav Naryzhnyi⁸, Luigi Morrone, Antonio Gallardo, Giovanni Calapai, Joaquin Camarena, Paulo Casquinha, Dzmitry Kananovich, Niall MacNeill, Christian Viladrich and Alexia Takoudi



2. Timeline

A) Akatsuki observed CD on the middle clouds in 2016
(First amateur captures by A.Wesley & P.Miles in October 2016)

B) 2017 EPSC, Javier Peralta informs the community



C) Nov. 2019 First re-appearance

D) March 2020 - Intense phenomenon

E) An alert was issued to worldwide observers and researchers


F) That event stimulated intense monitoring and led to the current work

G) The discovery and first analysis reported :

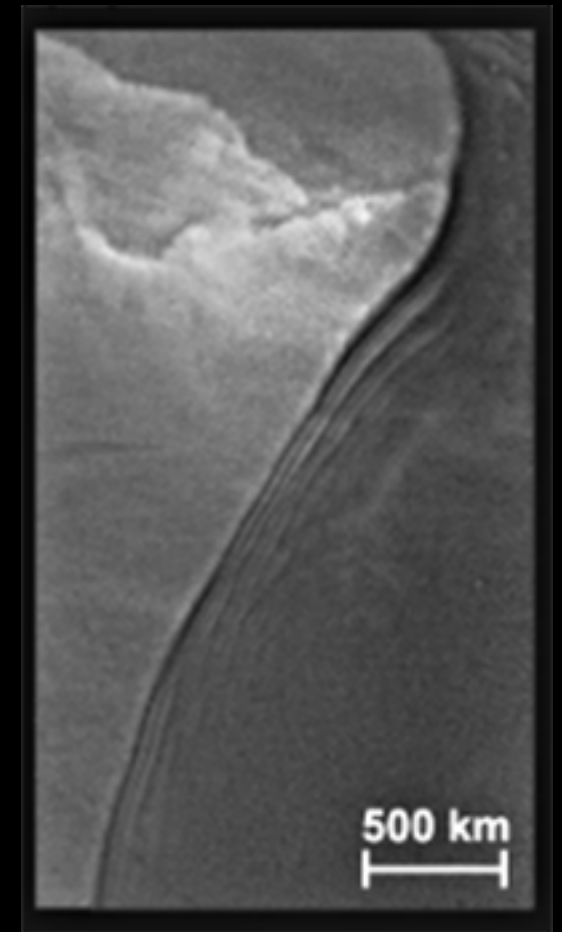
Geophysical Research Letters*

Research Letter | [Open Access](#) | [CC](#) [BY](#) [NC](#) [ND](#)

A Long-Lived Sharp Disruption on the Lower Clouds of Venus

J. Peralta , T. Navarro, C. W. Vun, A. Sánchez-Lavega, K. McGouldrick, T. Horinouchi, T. Imamura, R. Hueso, J. P. Boyd, G. Schubert, T. Kouyama, T. Satoh, N. Iwagami, E. F. Young, M. A. Bullock, P. Machado, Y. J. Lee, S. S. Limaye, M. Nakamura, S. Tellmann, A. Wesley, P. Miles ... [See fewer authors](#) ^

First published: 27 May 2020 | <https://doi.org/10.1029/2020GL087221> | Citations: 5



3. Introduction

Venus atmosphere

Main Cloud deck:

Upper clouds Observed in UV

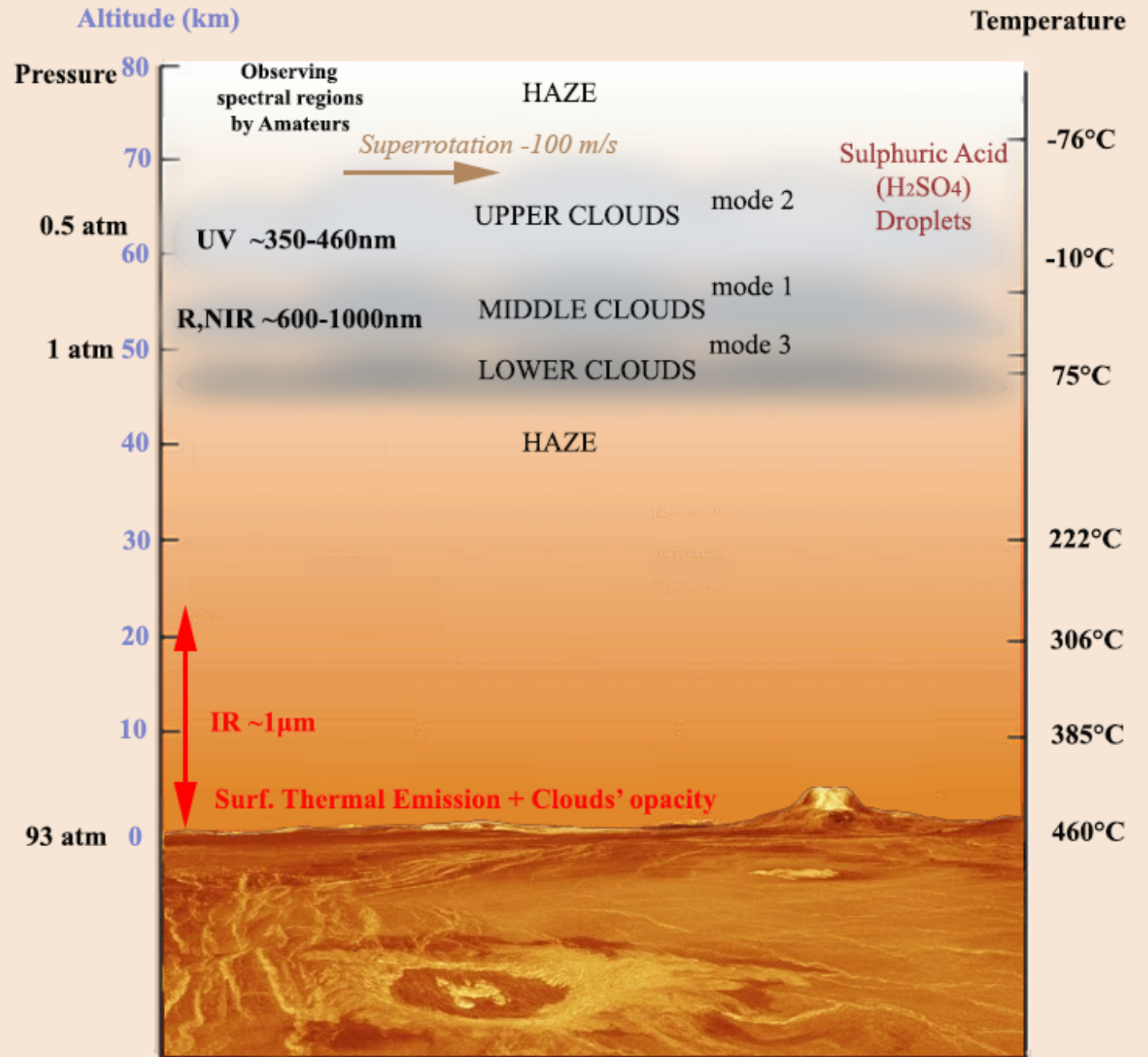
Drift to the west with velocities 60 times faster than the planet surface, a phenomenon known as superrotation. Planetary scale Y -feature

Middle clouds Observed in NIR
Morphology and dynamics revealed

Lower clouds Observed in longer infrared wavelengths on nightside images.

Middle-lower clouds > poorly studied at lower latitudes until *JAXA's Akatsuki* mission.

2016, *Akatsuki* revealed the presence of a giant (PLANETARY SCALE) discontinuity propagating on the middle and lower clouds.



4a. Observations: Ground base from Amateurs

Most Amateurs make observations with 20-50cm telescopes and UV, R-G-B, NIR 0.685-1 μ m filters (685+,742+,807+,850+,~890,~1000 nm) and upload data at PVOL & ALPO-Japan Databases

Methodology (“*Lucky imaging*” & Software explained at *Kardasis et al. 2016*) :

1. **Fast cameras** (15 to 200 fps) capture videos over several minutes
2. **Registax / Autostakkert**
select images highest-spatial-frequency components, to align and stack them.

3. **Registax/Photoshop**
Further image processing applying wavelets, adjusting brightness-contrast

4. **WinJupos [3]**
For Maps, measurements, graphs
(used in this work)

Resolution 187-663 km in this work



Observations used for the article				
	Observer Name	NIR	UV	Total Obs
1	Emmanuel (Manos) Kardasis	15	2	17
2	Anthony Wesley	15		15
3	Tiziano Olivetti	9	3	12
4	Yaroslav Naryzhniy	5	2	7
5	Luigi Morrone	3		3
6	Antonio Gallardo	2		2
7	Giovanni Calapai	1		1
8	Joaquin Camarena	3		3
9	Raimondo Sedrani	3		3
10	Paulo Casquinha	1		1
11	Dzmitry Kananovich	1		1
12	Niall MacNeill	1		1
13	Christian Viladrich		1	1
	TOTAL NIR OBS USED	59	8	67

4b. Observations: with JAXA's Akatsuki

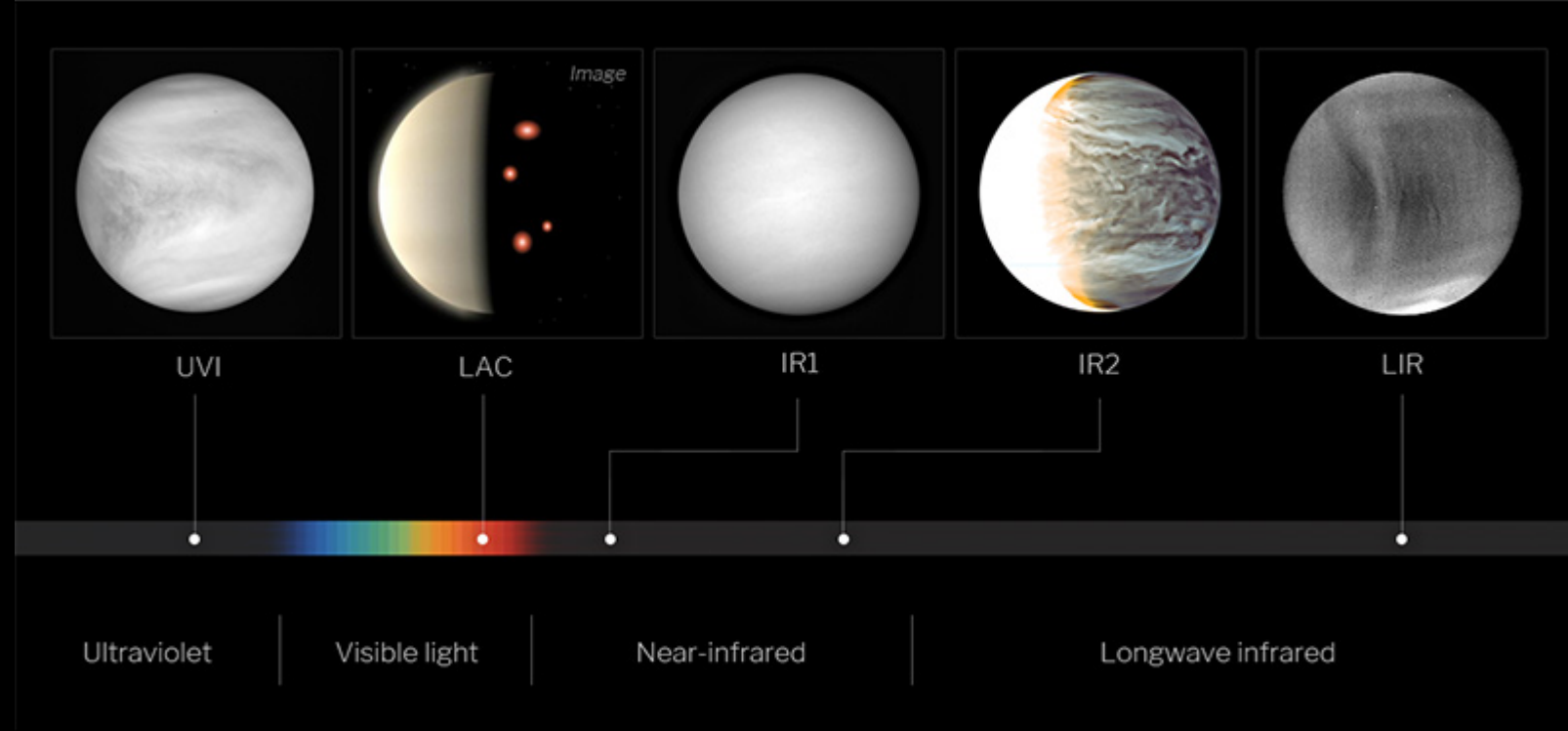
Methodology :

1. upper clouds obs
with Longwave
Infrared Camera (LIR)
and the Ultraviolet
Imager (UVI)

2. The UVI images were
photometrically corrected,
i.e. correcting for the limb-
darkening effect

3. A devoted software
written in IDL to process the
images and measure wind
speeds in the Akatsuki
images

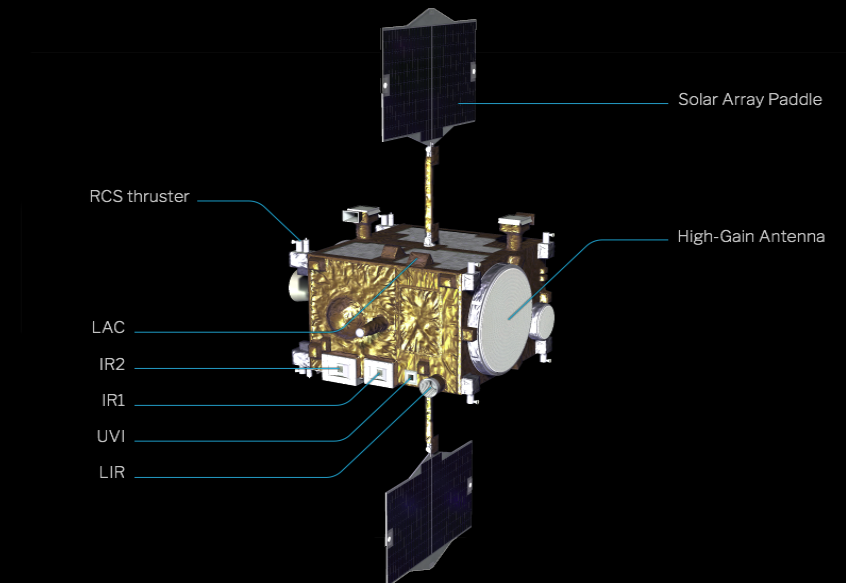
Resolution 12-360 km



Images from : <https://akatsuki.isas.jaxa.jp/en/mission/spacecraft/>

2017: Akatsuki was forced to suspend operation of IR1 and IR2 cameras due to persistent electrical problems in the system responsible for controlling the cameras

A gap that can partially covered by amateurs.



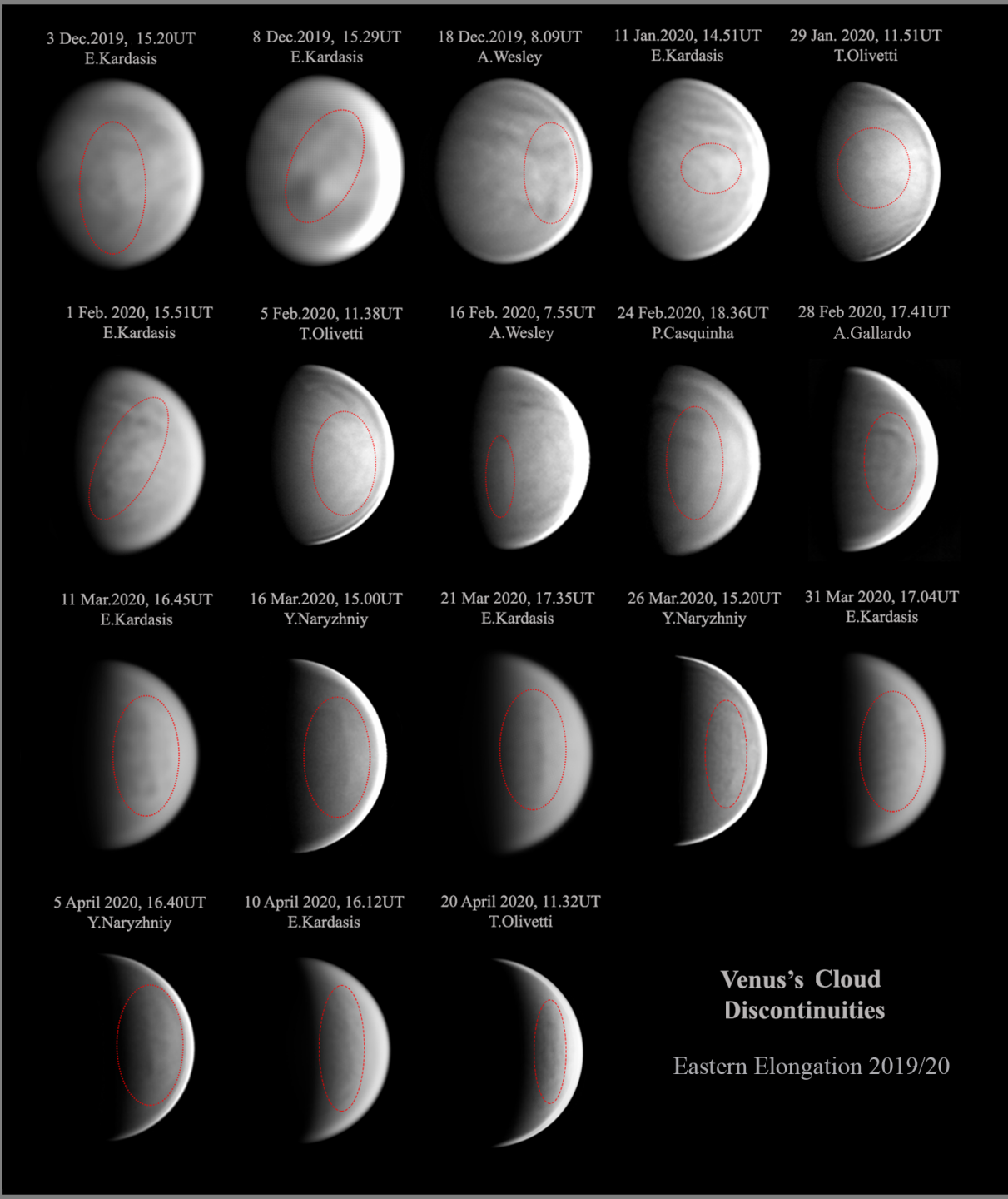
5. Eastern elongation 2019/20

We inspected the period

October 13, 2019 - April 25, 2020

Examined : 458 NIR and 552 UV obs

Detected 18 CD events

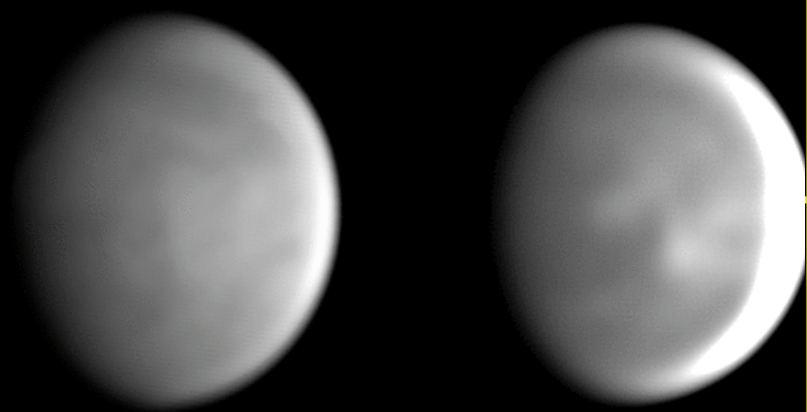


6. CD during November–December 2019 ~5d-Cycle Maps

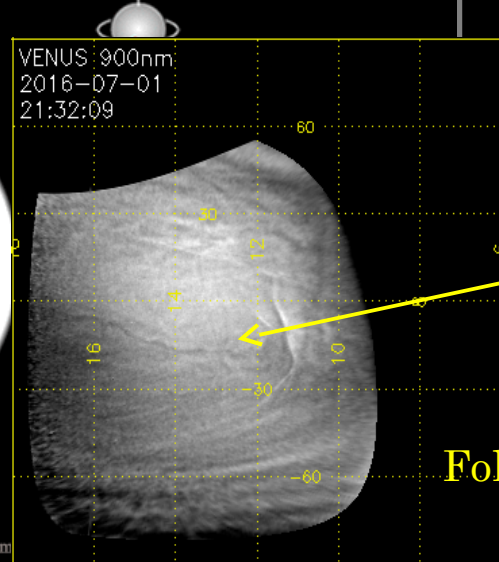
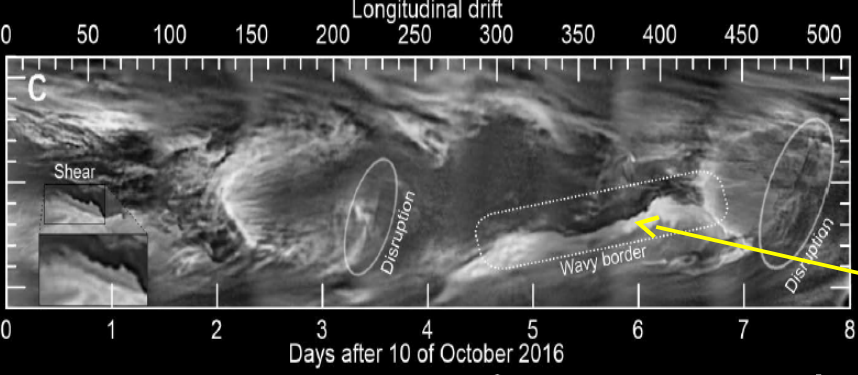
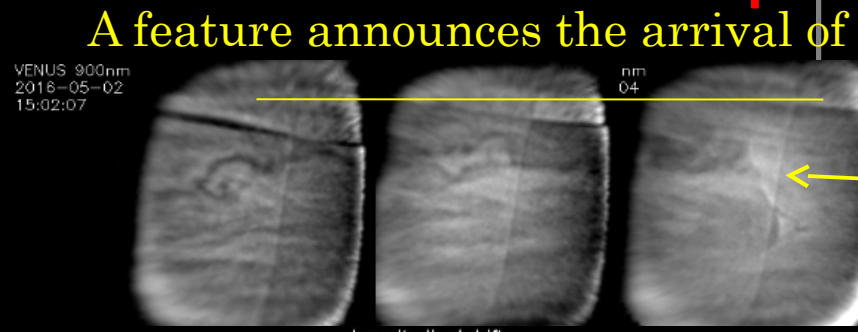
Similarities with Peralta et.al 2020

Speed ~ 94.7 m/s ± 6 m/s
(in Equator + 5,0° to - 5,0°)
Change of inclination,

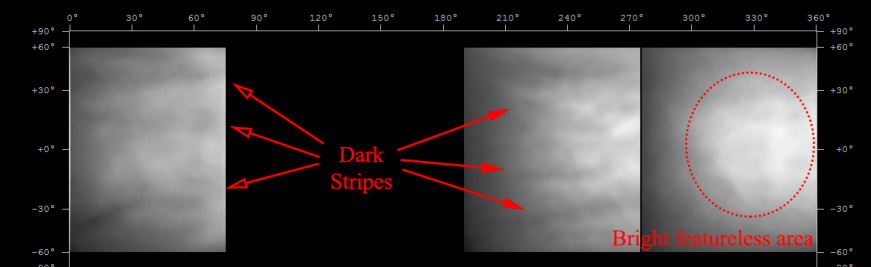
Venus
3 December 2019
14:26 UT



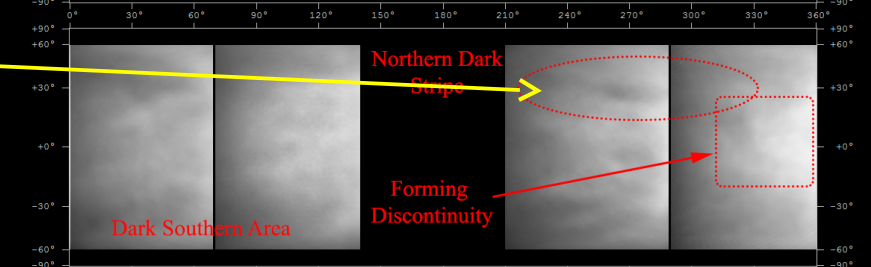
Venus
8 December 2019
13:49 UT



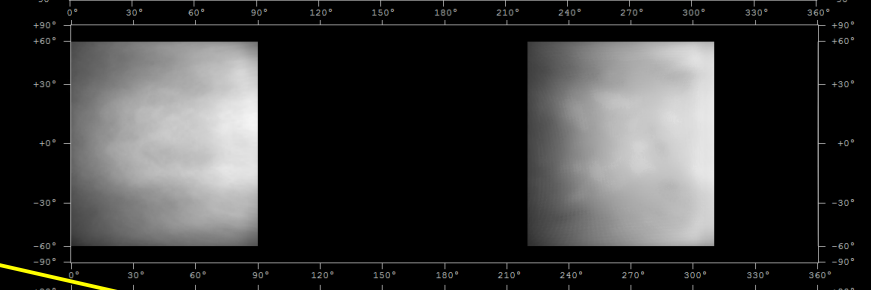
A.
Rotation 1
14 - 18 November



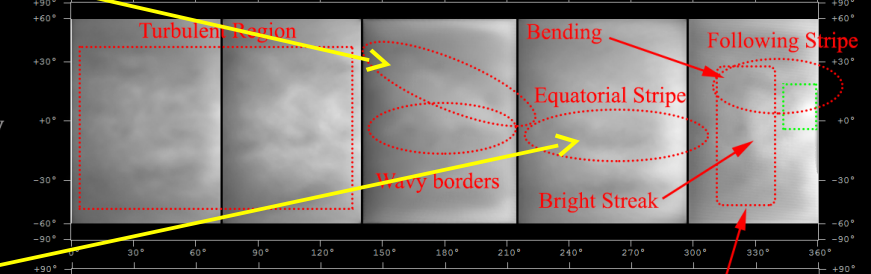
B.
Rotation 2
(Forming)
19 - 23 November



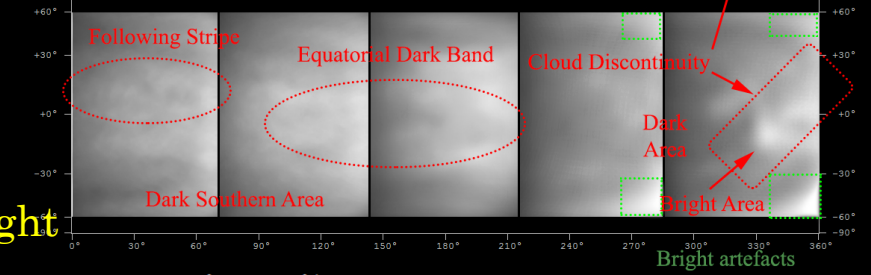
C.
Rotation 3
(Not Observed)
24 - 28 November



D.
Rotation 4
Cloud Discontinuity
Vertically Formed)
29 November
- 3 December



E.
Rotation 5
(Deformed)
4 - 8 December



Following Bright Area

Longitudes and System 2* [L' = L2 - (0,0° +15,4037°/d * (T - 2000 Jan 01,5))], planetocentric latitudes
Lambert cylindrical equal-area projection

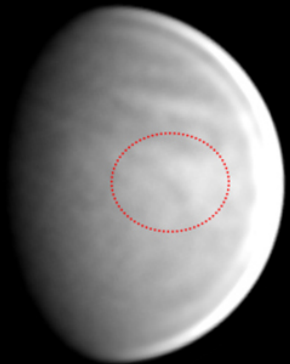
7. mid-December 2019 –early March 2020

We have gaps in the observations that prevented continuous monitoring

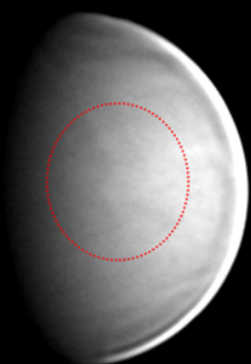
we have detected the presence of some CD events showing some

dramatic changes in the properties (speed, size, inclination)

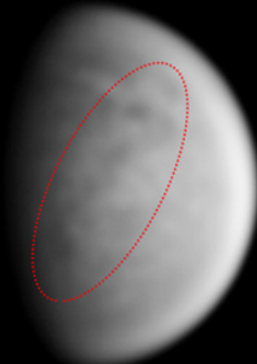
11 Jan.2020, 14.51UT
E.Kardasis



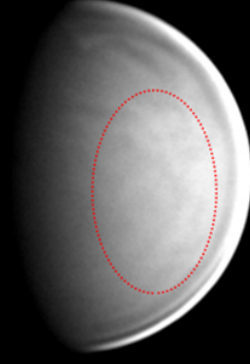
29 Jan. 2020, 11.51UT
T.Olivetti



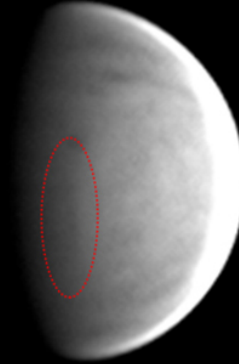
1 Feb. 2020, 15.51UT
E.Kardasis



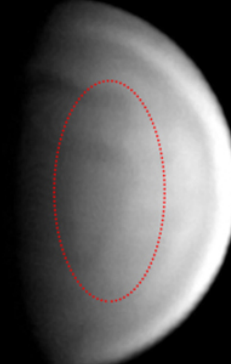
5 Feb.2020, 11.38UT
T.Olivetti



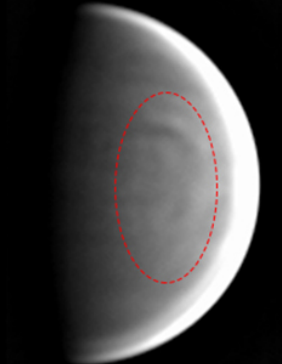
16 Feb. 2020, 7.55UT
A.Wesley



24 Feb.2020, 18.36UT
P.Casquinha



28 Feb 2020, 17.41UT
A.Castro



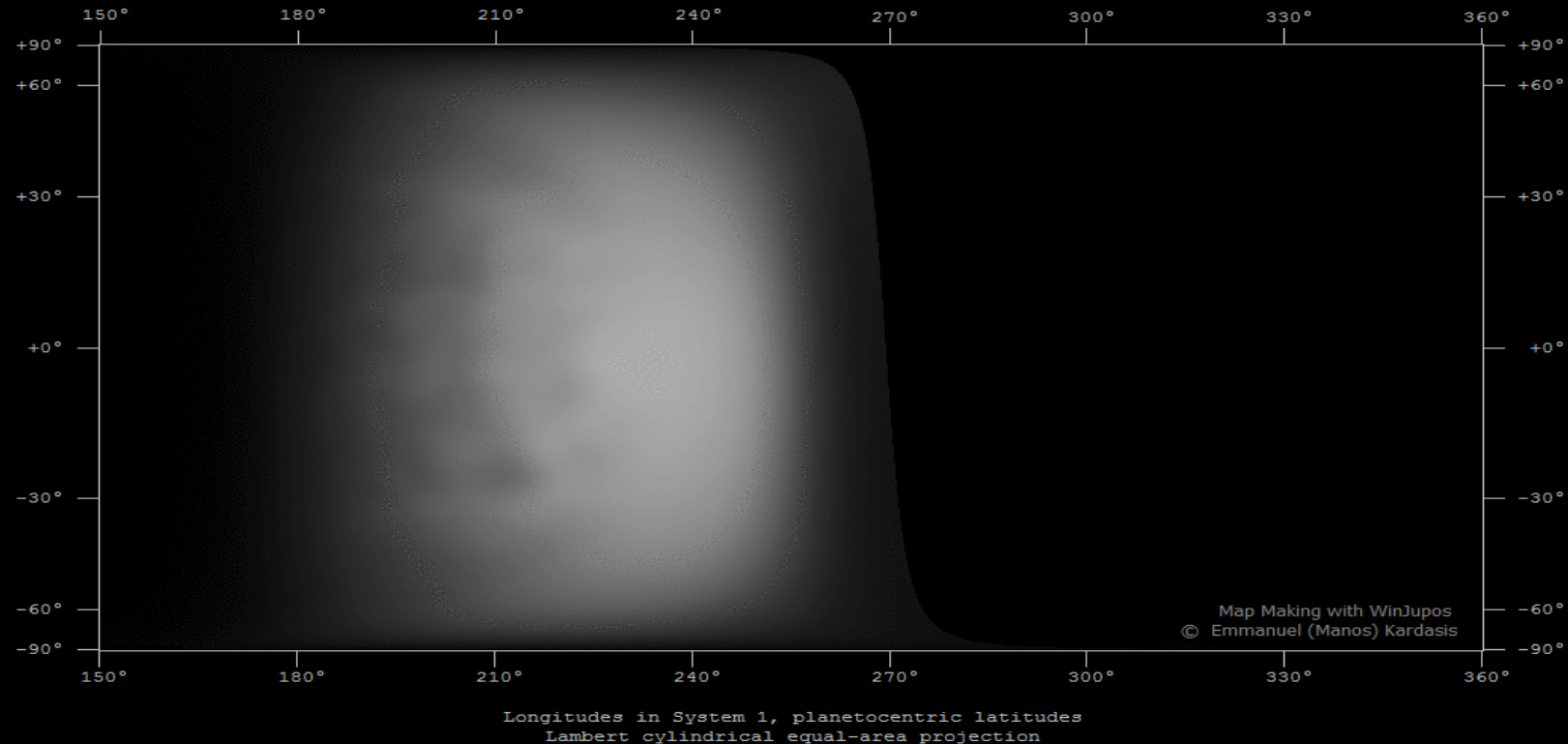
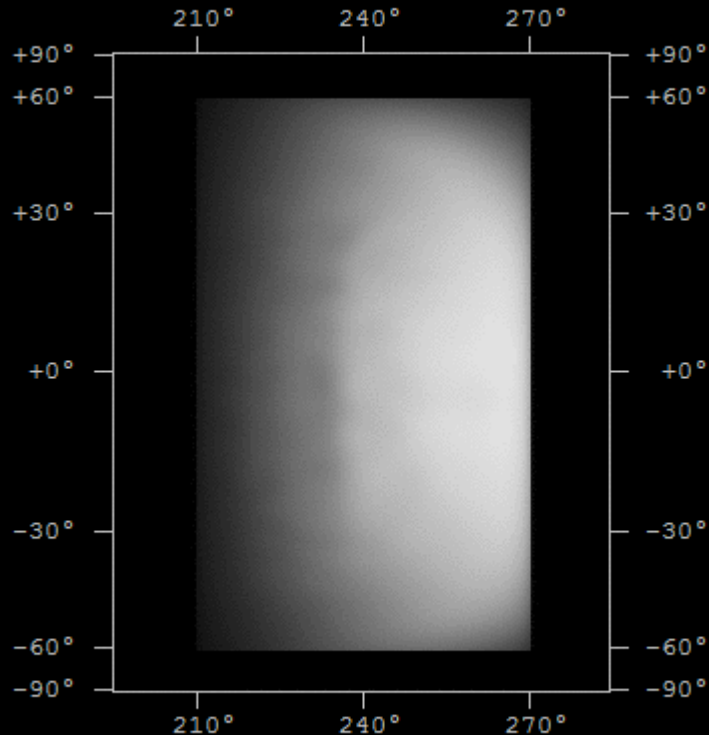
8. The March event

- March 11 > intensification of the CD.
- Apparent as a vertically-oriented long dark sharp discontinuity
 - followed by a brighter cloudy area,
- suffering distortions shape - size on the next days.
- A similar event was also reported in August 2016 .

The wave non stationary Compared to surface

Venus: Planet scale Cloud Discontinuity Evolution

Venus 11/3/2020, 16:45 UT - Manos Kardasis



9. CD Properties

Size of CD

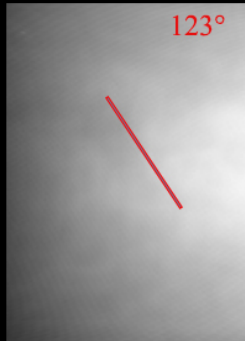
Spanned 31° N and 36° S,
3300-6500 km in length.
Width at equator ~ 600 km

CD Inclination

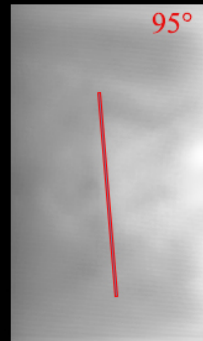
(Relative
to Equator)

2019

23 Nov.2019, 15:00UT
E.Kardasis



3 Dec.2019, 14:26UT
E.Kardasis

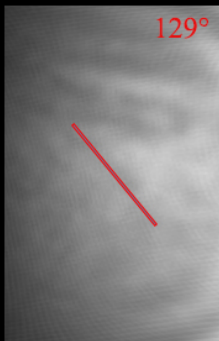


8 Dec.2019, 13:49UT
E.Kardasis

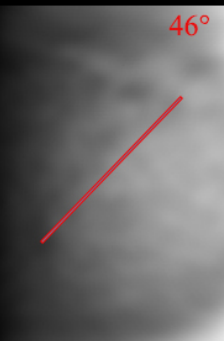


2020

11 Jan.2020, 14:51UT
E.Kardasis

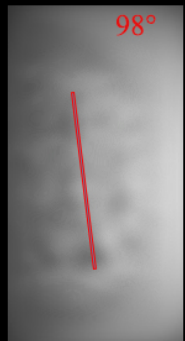


1 Feb.2020, 15:51UT
E.Kardasis

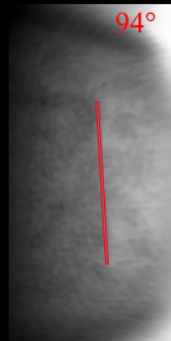


– Related with speed?

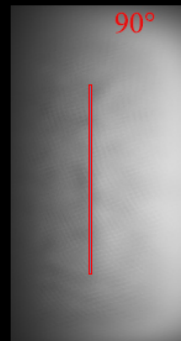
11 Mar.2020, 16:45UT
E.Kardasis



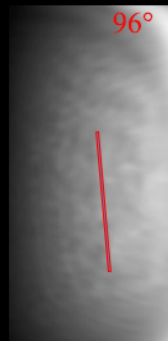
16 Mar.2020, 15:00UT
Y.Naryzhniy



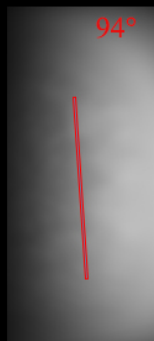
21 Mar.2020, 17:35UT
E.Kardasis



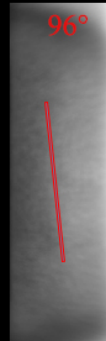
26 Mar.2020, 15:20UT
Y.Naryzhniy



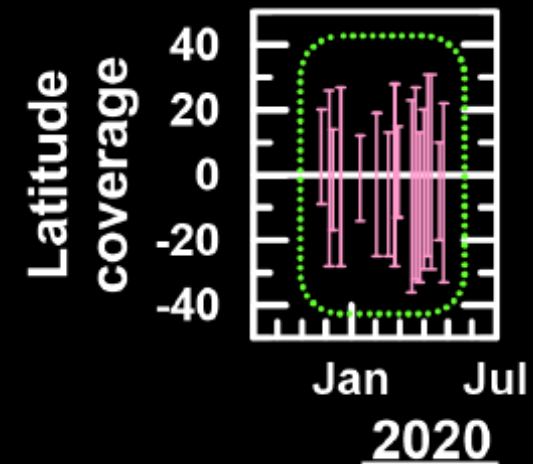
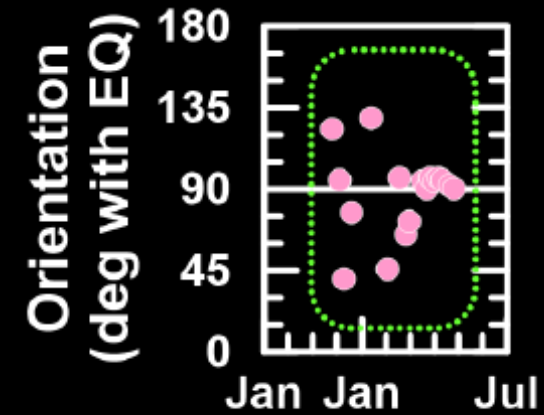
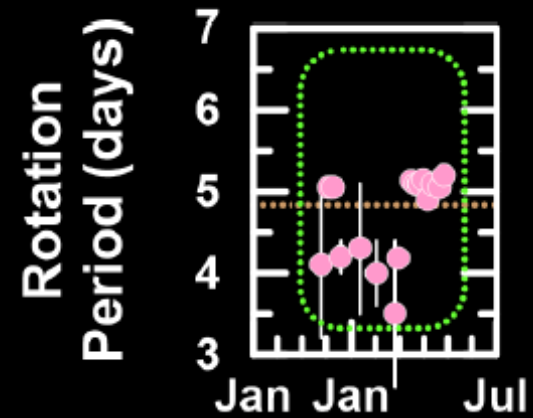
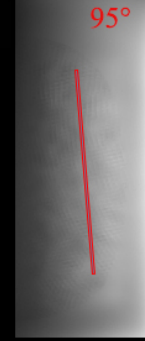
31 Mar.2020, 17:04UT
E.Kardasis



5 April 2020, 16:40UT
Y.Naryzhniy

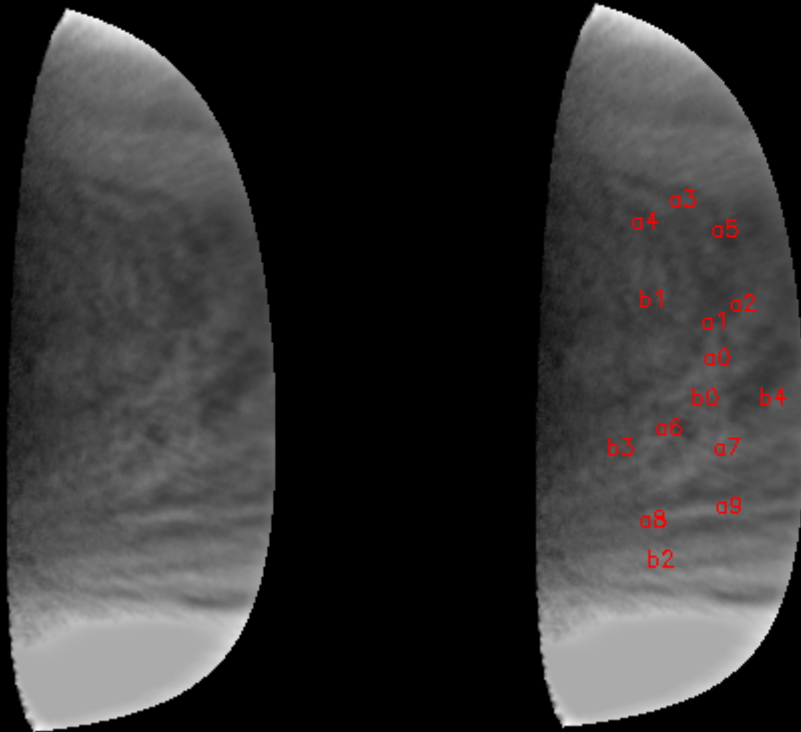


10 April 2020, 16:12UT
E.Kardasis

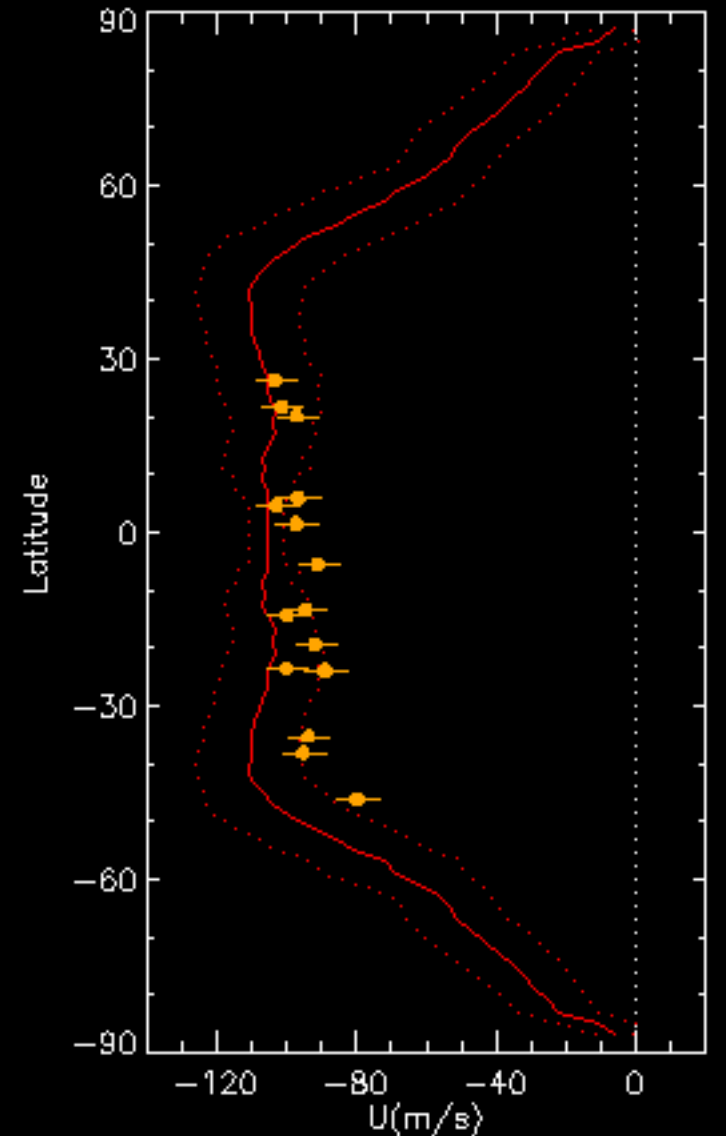
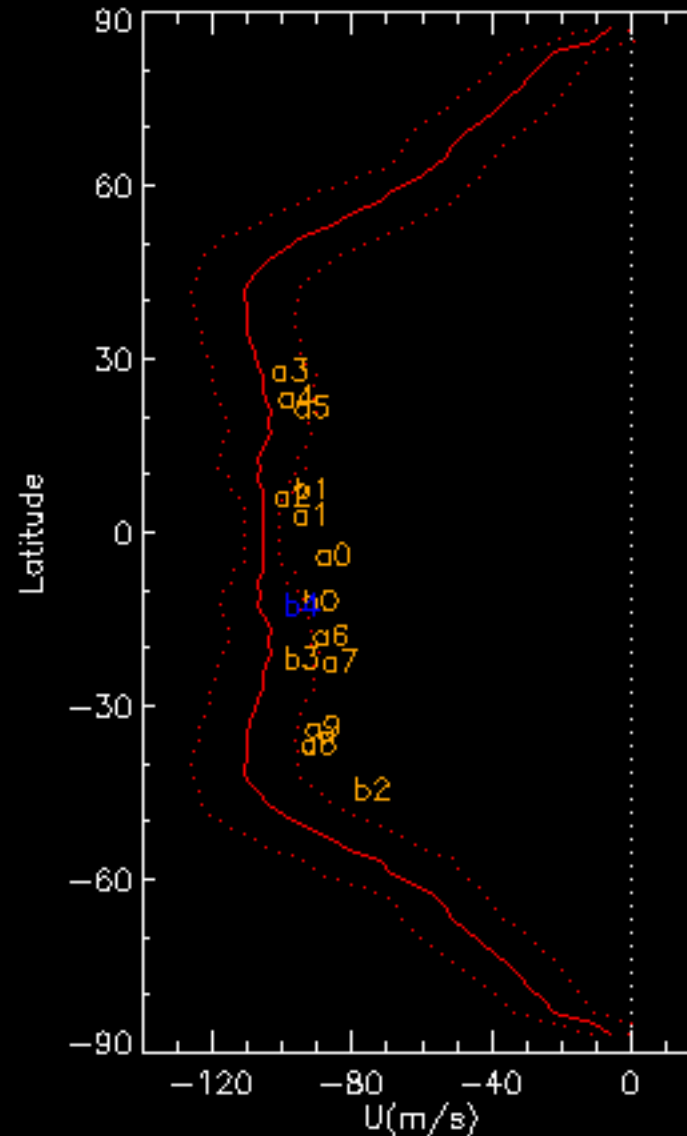


10. The cloud tops during the CD events of March 2020 (speed measur. from *Akatsuki* data)

VENUS 365.000nm
2020-03-11
18:04:43



Measurement example 11 March



Repeated for all dates 11-31 March (Purple data in next graph)

11. The March event (Zonal wind Measurements)

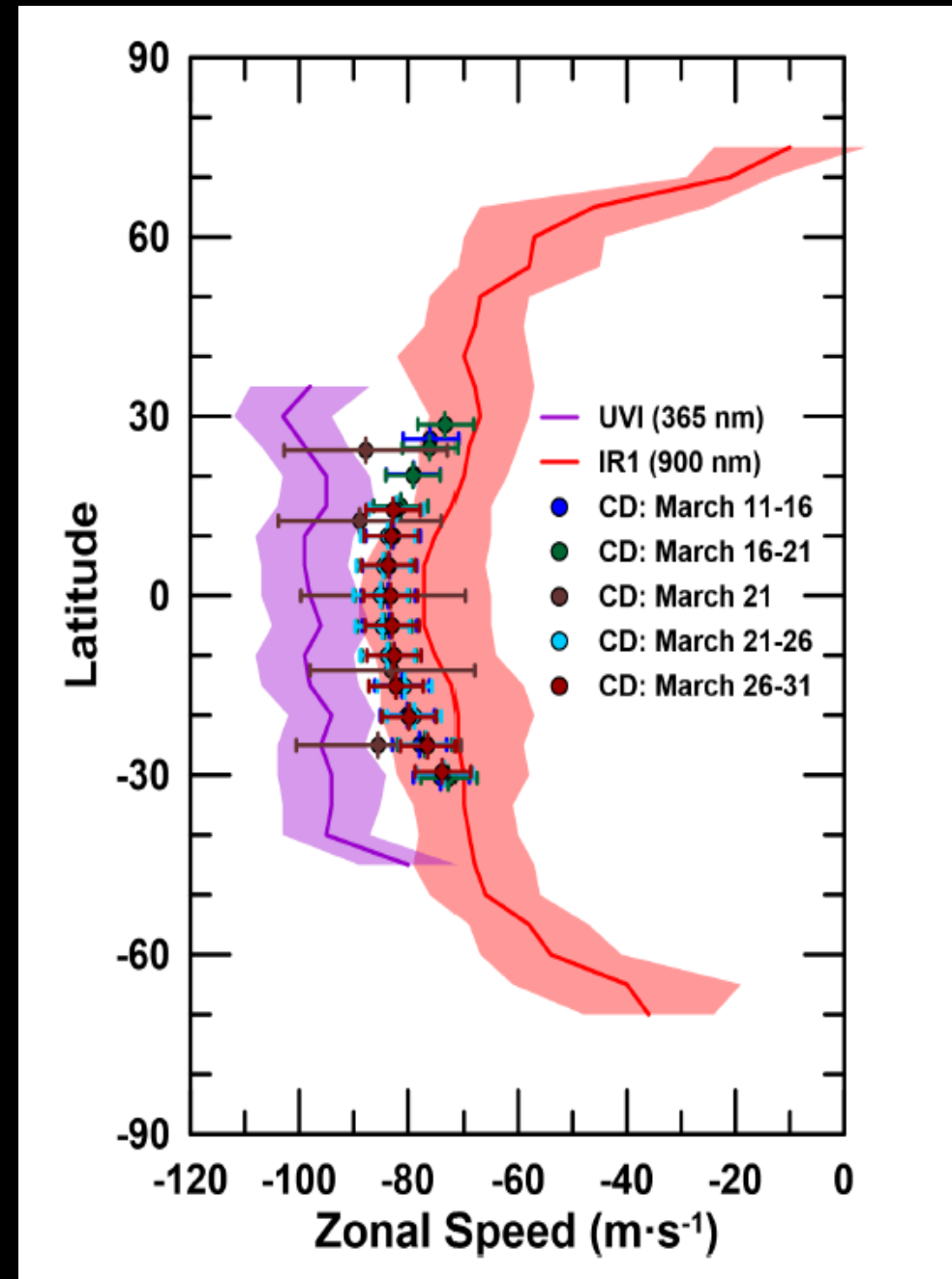
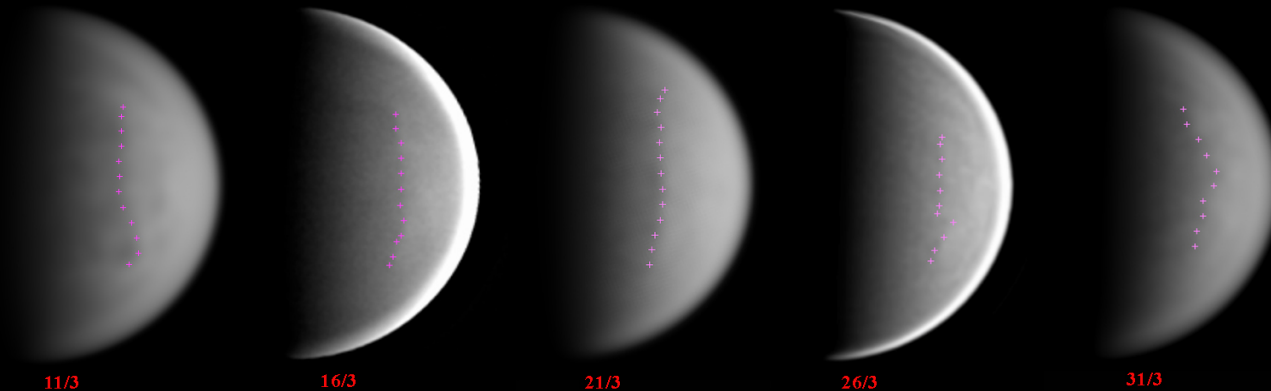
Measured speed of CD wave front from cycle to cycle (11-31 March)

CD speeds are consistent with the manifestation of a **Kelvin wave**

with phase speeds **faster than the middle clouds** winds

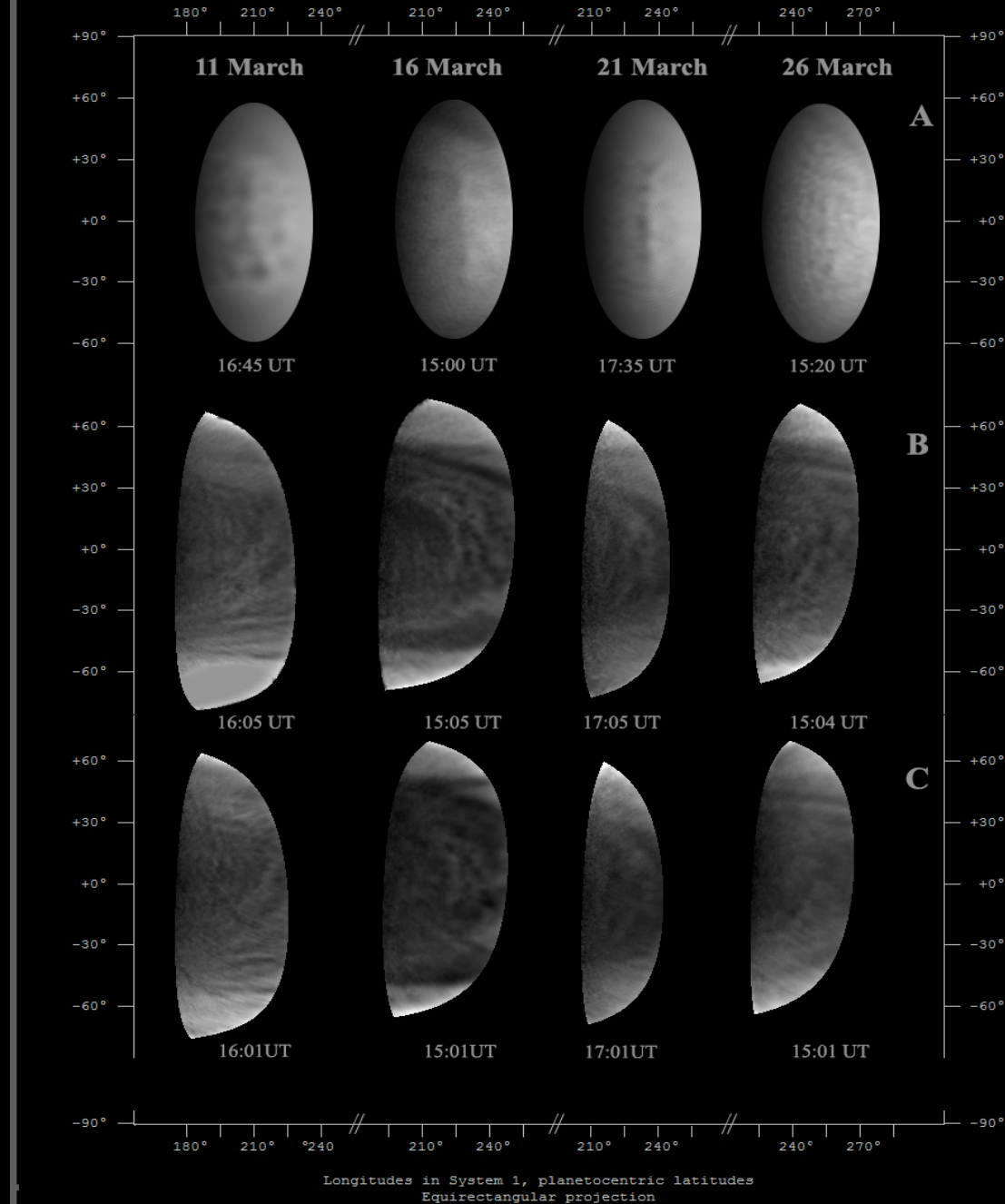
Phase speeds **slower than the winds measured in the** upper clouds,

CD cannot be observed at the clouds' top because
it becomes dissipated during its vertical propagation



12. The cloud tops during the CD events of March 2020

Contemporaneous views of
NIR amateur set ($\sim 700\text{-}1000\text{ nm}$)
where the cloud discontinuity is observed (A),
along with Akatsuki /UVI at
365 nm (B), UVI at 285 nm (C)
where the Cloud Discontinuity seems absent.

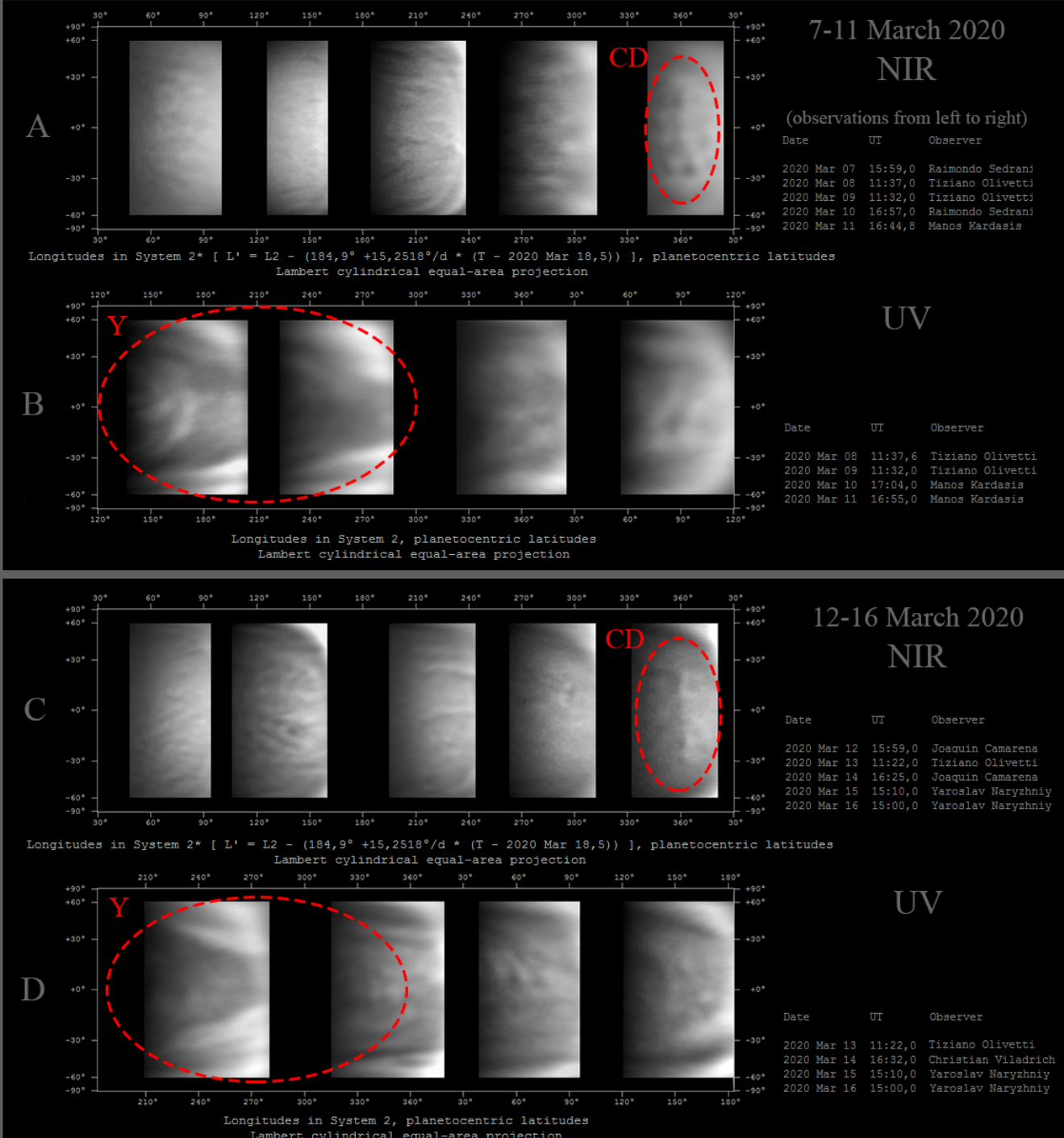


13. The cloud tops during the CD events of March 2020 – Y feature

Comparison among simultaneous NIR & UV amateur maps showing the CD position in the days observed in relation to Y-feature.

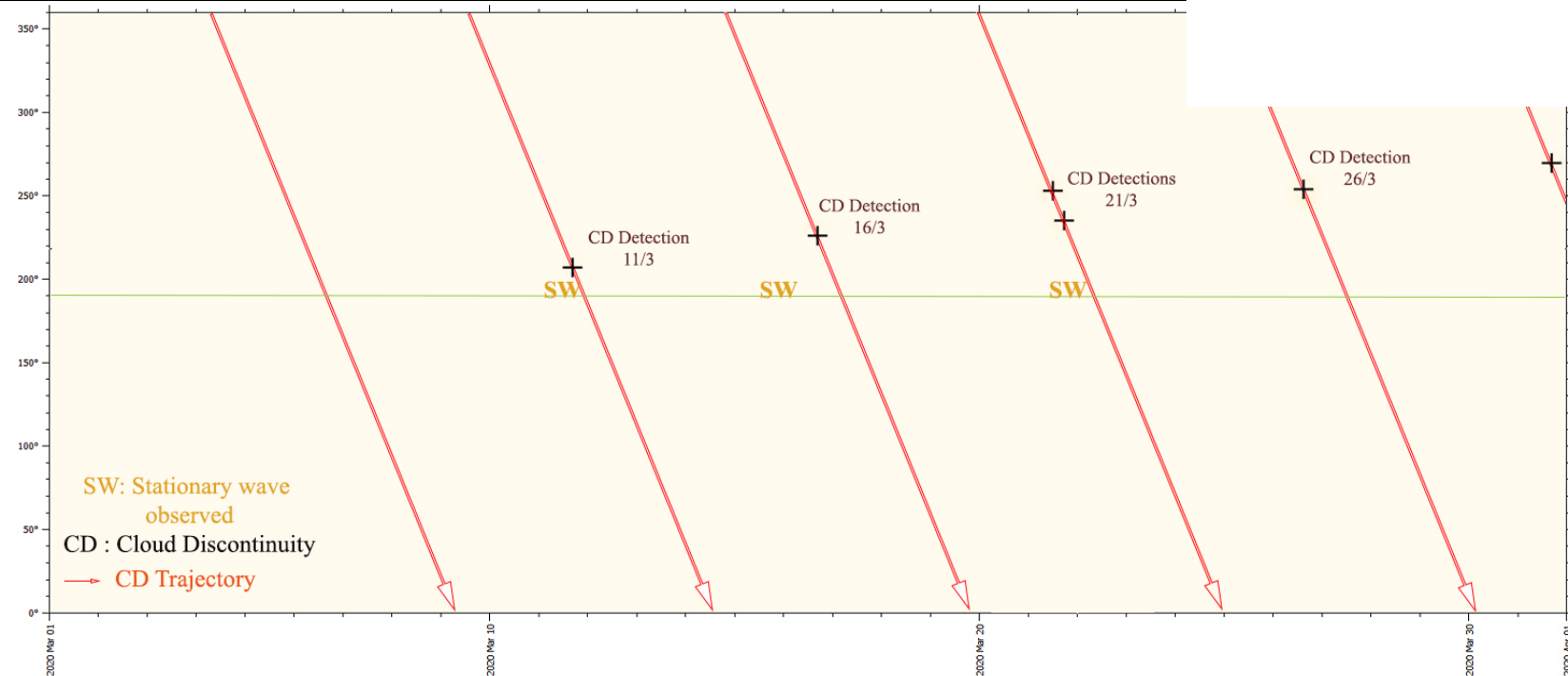
The sharp vertical streak-form of the CD does not seem linked to the propagation of the Y-feature in UV images or to any specific cloud pattern in its cycle.

evident phase-lag between both phenomena > independent waves which propagate at different vertical levels

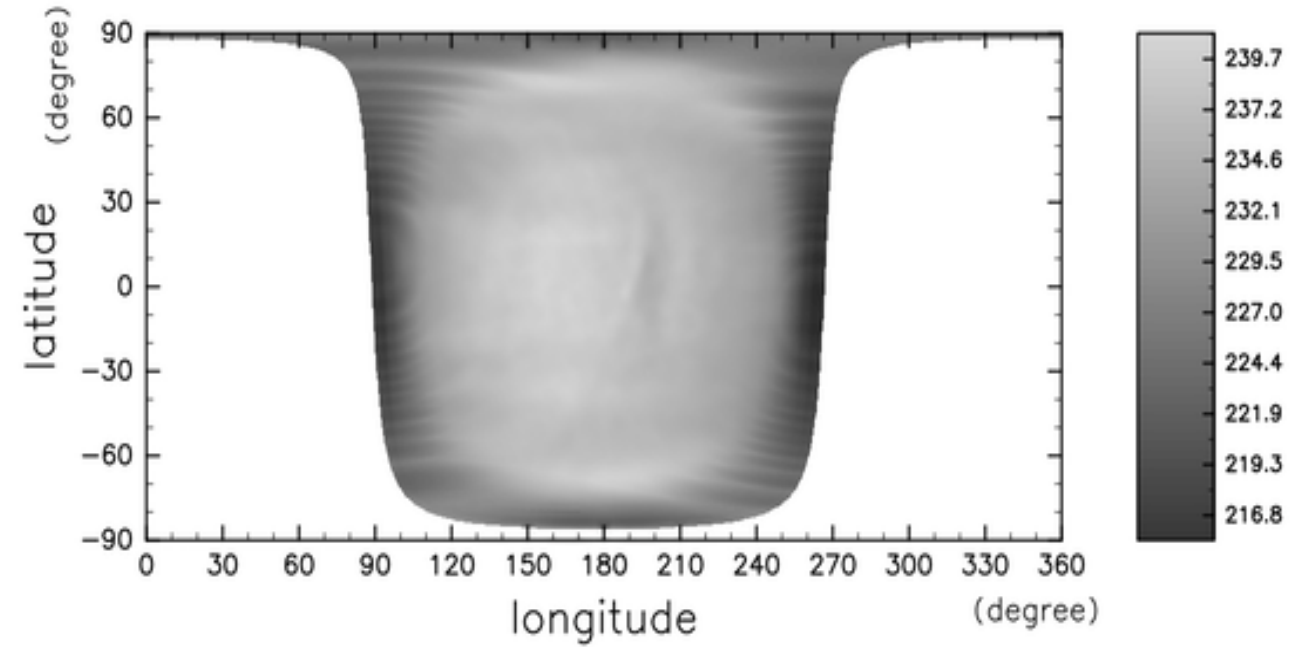


14. Thermal emission from the upper clouds during the CD events of March 2020

During March 2020, Akatsuki /LIR exhibits clear stationary waves visible on 11-16-21 March above Alta Regio

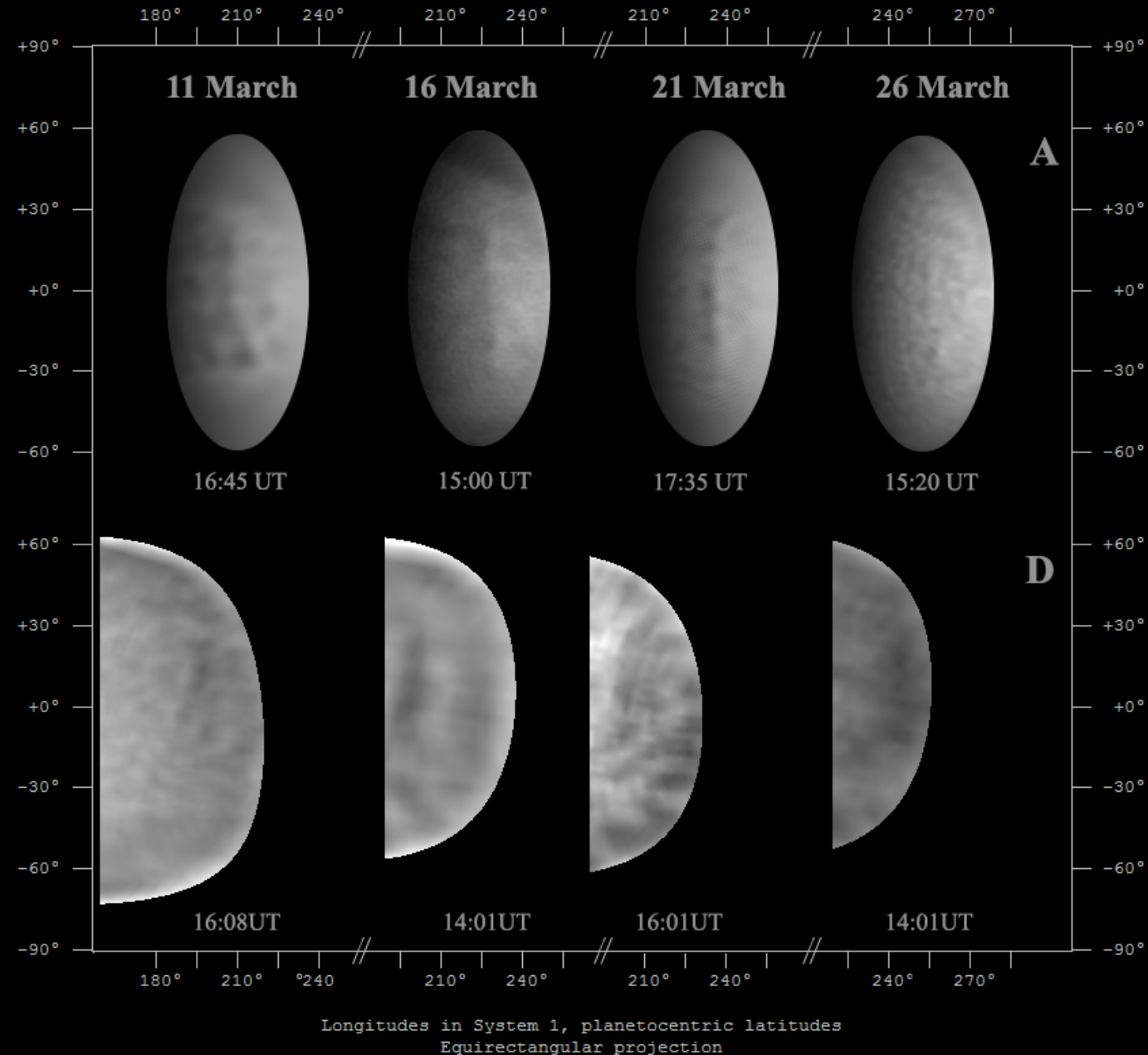


20200316 stack _pic_l3b_v20200601.



15. Thermal emission from the upper clouds during the CD events of March 2020

CD is not apparent in LIR images acquired in almost the same time as the CD events, while the LIR image taken in 26 of March does not cover the region where the CD was observed at the middle clouds with ground-based observations



16. Long term Evolution *Akatsuki*, NASA's *Infrared Telescope Facility* and small telescopes (this work)

This work > a period of 4.8 ± 0.2 days considering the averaged zonal speed ($92.1 \pm 4.6 \text{ m} \cdot \text{s}^{-1}$)

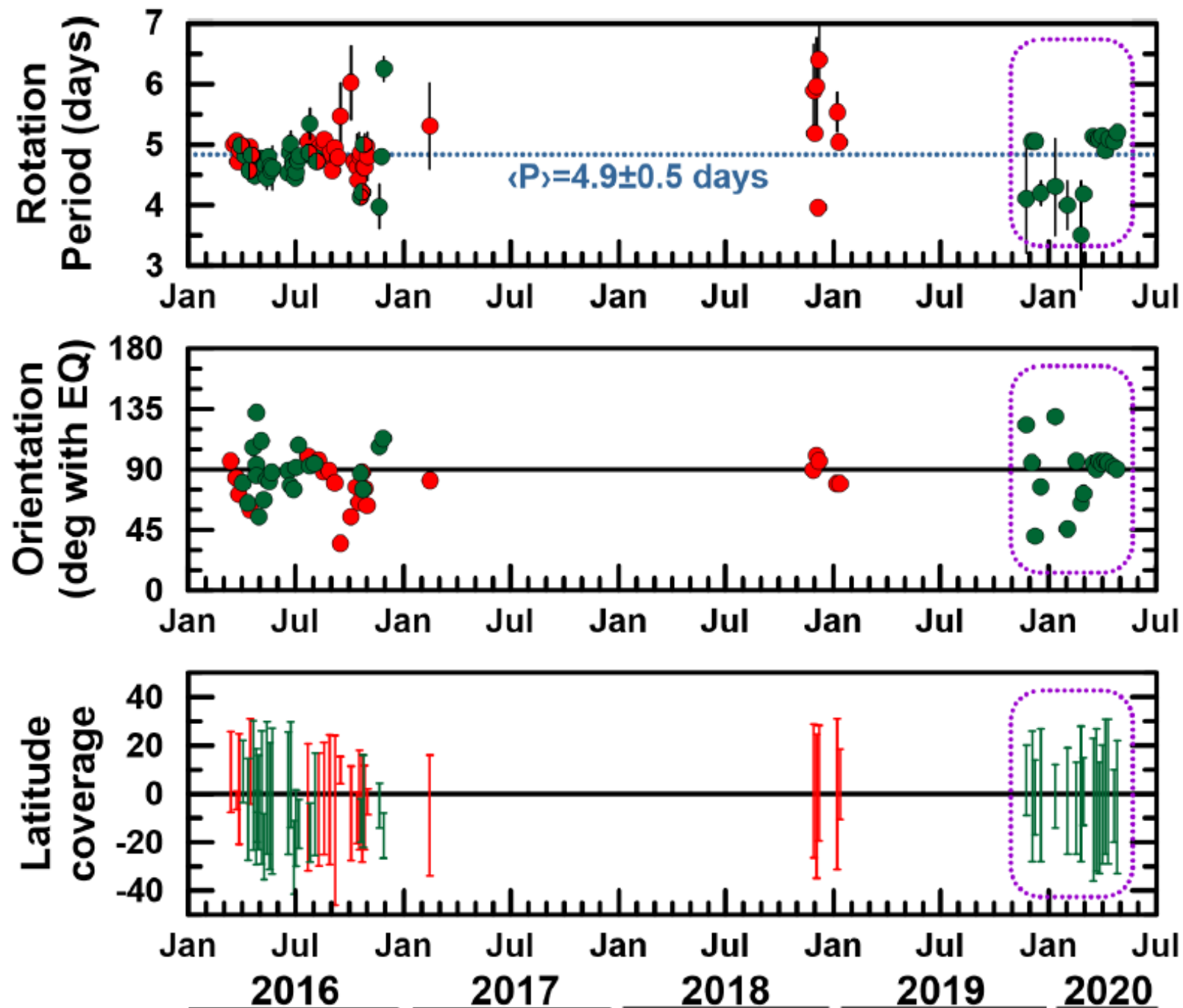
Mean rotation period 2016 to 2020
 4.9 ± 0.5 days,
(the same as estimated by Peralta et al.).

noticeable variations in its orientation
(November 2019 - February 2020),

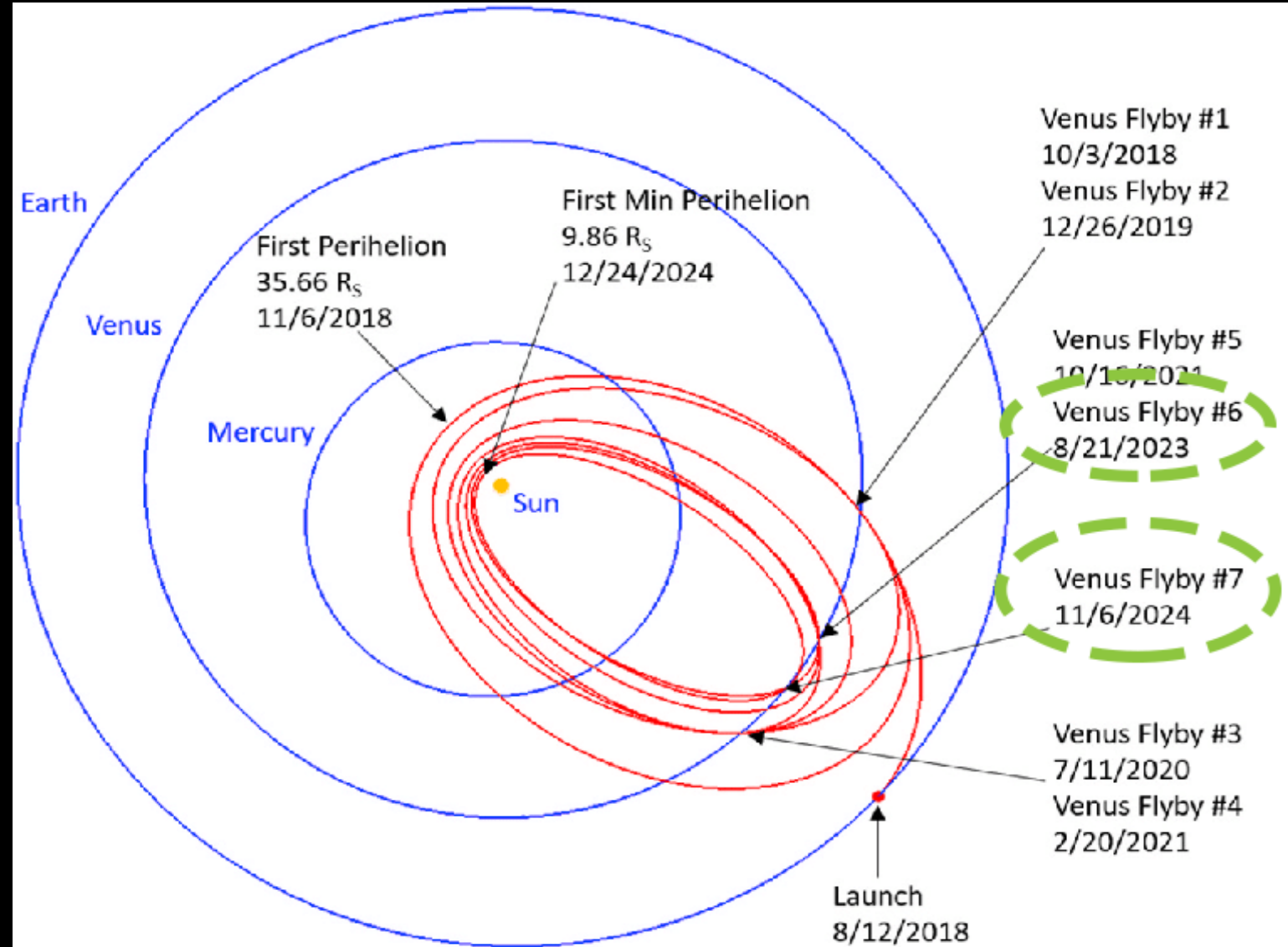
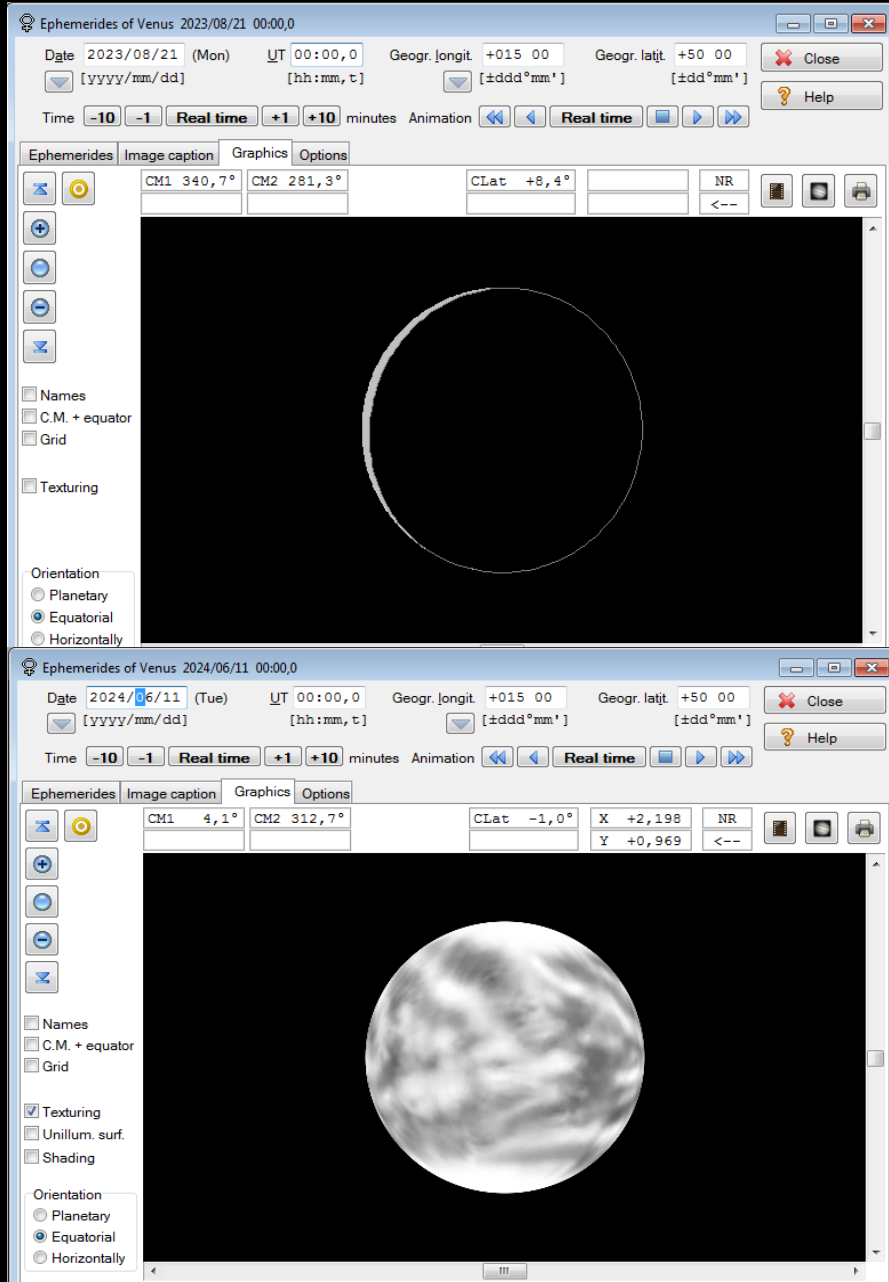
perpendicular to the equator in
March - April 2020.

~ 30N to 40S

hemispherical asymmetry



17. Future coordinated observing campaigns (NASA's PARKER flybys 21 of August 2023 and 6 of November 2024)



Graph Source, Yanping Guo et al. 2021, *Execution of Parker Solar Probe's unprecedented flight to the Sun and early results*

Summary

Detection and evolution of a planetary-scale Cloud Discontinuity during 2019/2020, for the first time after the discovery in 2016

First time that a CD is tracked and studied with ground-based telescopes.

In agreement with previous reports, CD exhibited temporal variations in its properties and its effect over the clouds' albedo

Compared with Akatsuki UVI and LIR data and confirmed that the discontinuity is not visible on the upper clouds' albedo or thermal emission

Zonal speeds indicate that this is a Kelvin wave that might transport momentum up to upper clouds

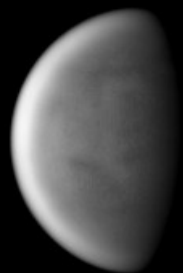
Amateur observations can play an important role especially when used complementary to professional ones.

18. The CD after this work....

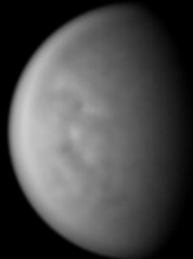
.....and in 2022!

Excellent coverage by
Antonio Cidadao,
Luigi Morrone
and Clyde Foster

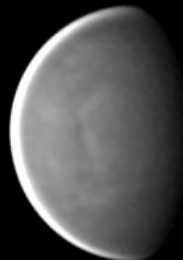
Venus' Cloud Discontinuity 15-25 May 2022



742+nm
15-5-2022, 4:39 UT
Clyde Foster
Centurion, SOUTH AFRICA

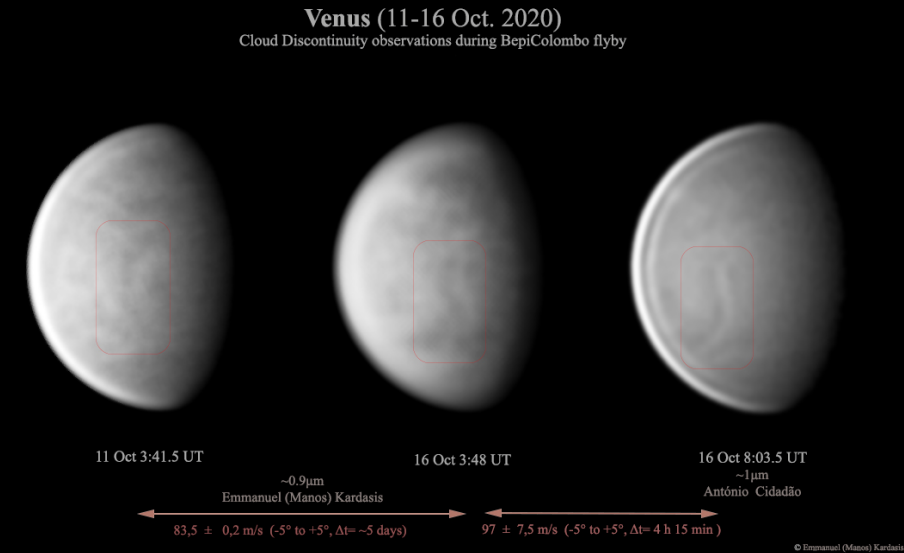


1000-1050nm
20-5-2022, 5:07 UT
Luigi Morrone
Agerola, ITALY



820-920nm
25-5-2022, 7:12 UT
Antonio Cidadao
Carcavelos, PORTUGAL

..... in October 2020
Antonio Cidadao,
Manos Kardasis



.....a new paper is on the way !!!!
Peralta et al.....

Thanks to

Grischa Hahn, Developer of WinJupos Software for his valuable contribution

JAXA/Akatsuki team for providing data

All amateur observers (especially Raimondo Sedrani) for their painful efforts

ALPO-Japan/PVOL databases.

My wife Dimitra for her continuous support

We are grateful to the Spanish Society of Astronomy for selecting our work to be awarded the "II Premio

Javier Gorosabel de Colaboración ProAm en Astrofísica"!

References

ALPO-Japan, Database of planetary observations: <http://alpo-j.sakura.ne.jp/indexE.htm>

WinJUPOS software, available at: <http://jupos.org/gh/download.htm>

Peralta J. et al., 2019, “Morphology and dynamics of Venus's middle clouds with Akatsuki/IR1”, Geophysical Research Letters, 46, doi:10.1029/2018GL081670

Peralta et al. 2020, "A Long-Lived Sharp Disruption on the Lower Clouds of Venus" Geophysical Research Letters, 47(11), e2020GL087221

Kardasis et al. 2016, “The need for PRO-AM collaborations in studies of Jupiter & Saturn”, JBAA 126

McKim R.J., Abel P. G. & Kardasis E. I., 2020, "Short paper: Remarkable waves observed in the atmosphere of Venus, 2015-2020", JBAA, vol.130, no.4, p.228-233