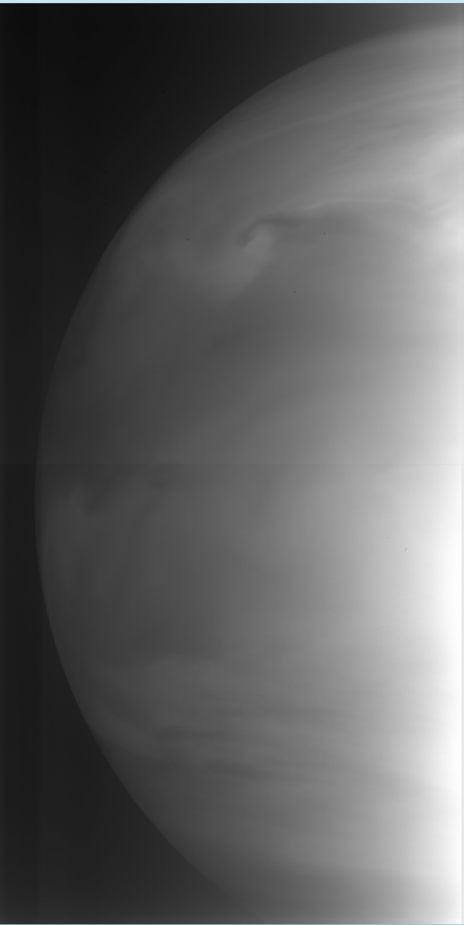


MESOSCALE VORTEX CIRCULATIONS ON VENUS OBSERVED IN AKATSUKI IR2 IMAGES



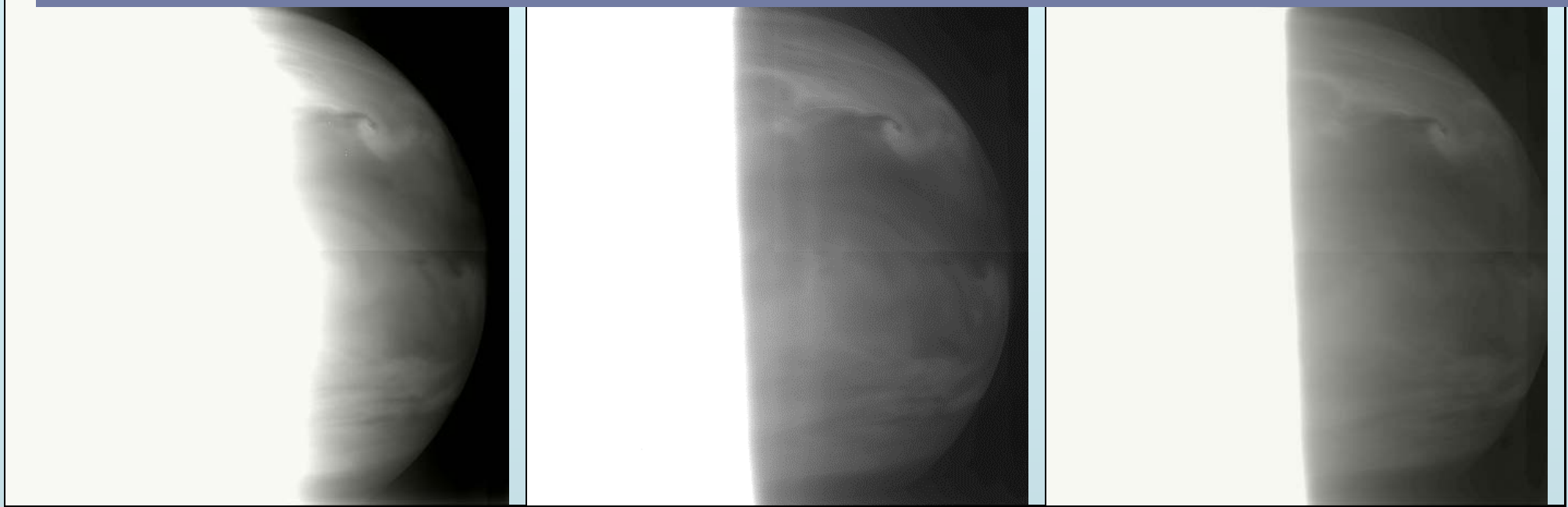
S.S. Limaye¹, T. Satoh², J. Peralta², T. Horinouchi³, T. Imamura

8th Moscow Solar System Symposium, Space Research Institute, Moscow,
Russia
9-13 October 2017

7 May 2016 04:02:11 1.74 μm

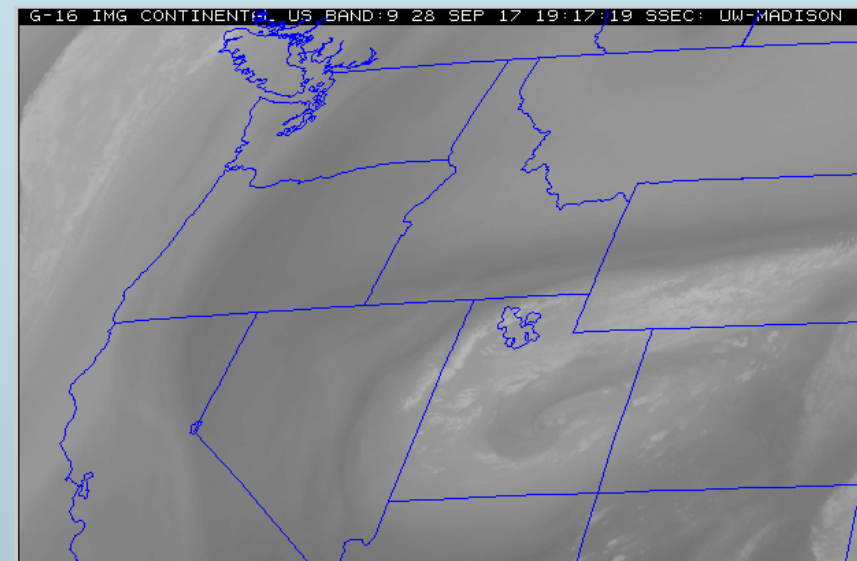
7 May 2016 04:03:33 2.26 μm

7 May 2016 04:10:36 2.32 μm



A similar “mushroom” feature, but more developed, was seen two orbits earlier at the same latitude, suggesting that it may be the same feature evolving and migrating mostly in longitude. Such features have been shown to be pairs of cyclonic and anti-cyclonic circulations

Similar vortex pair features are routinely seen in water vapor images of Earth obtained from weather satellites



Circulation aspects of the mushroom feature on Earth

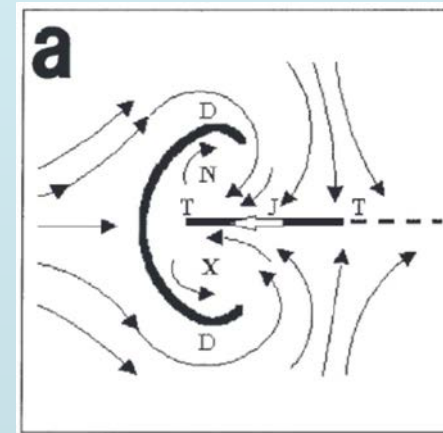
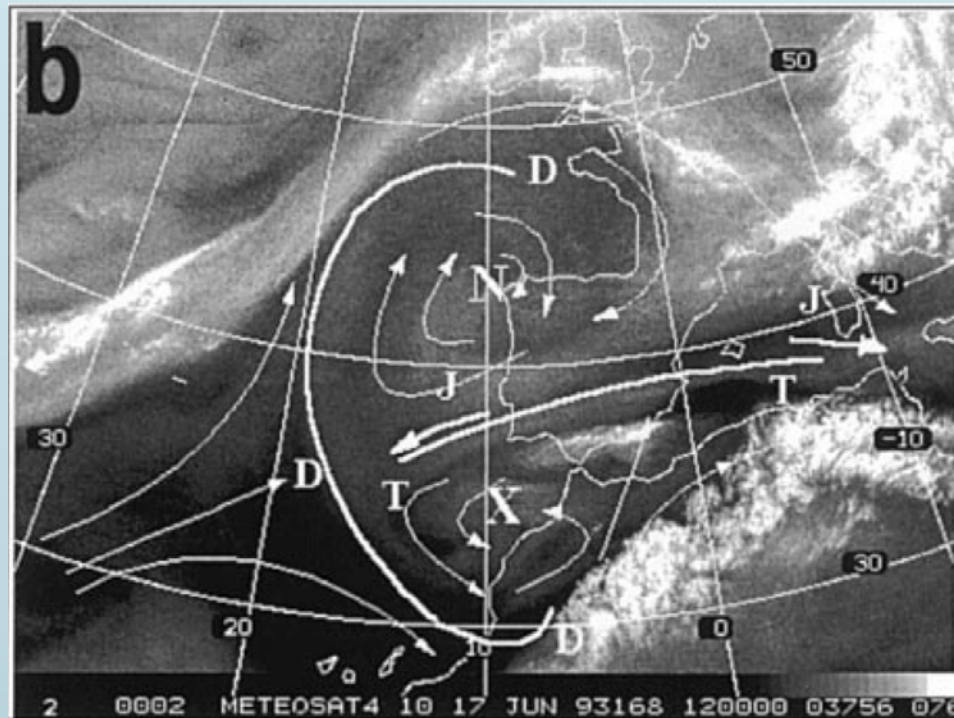
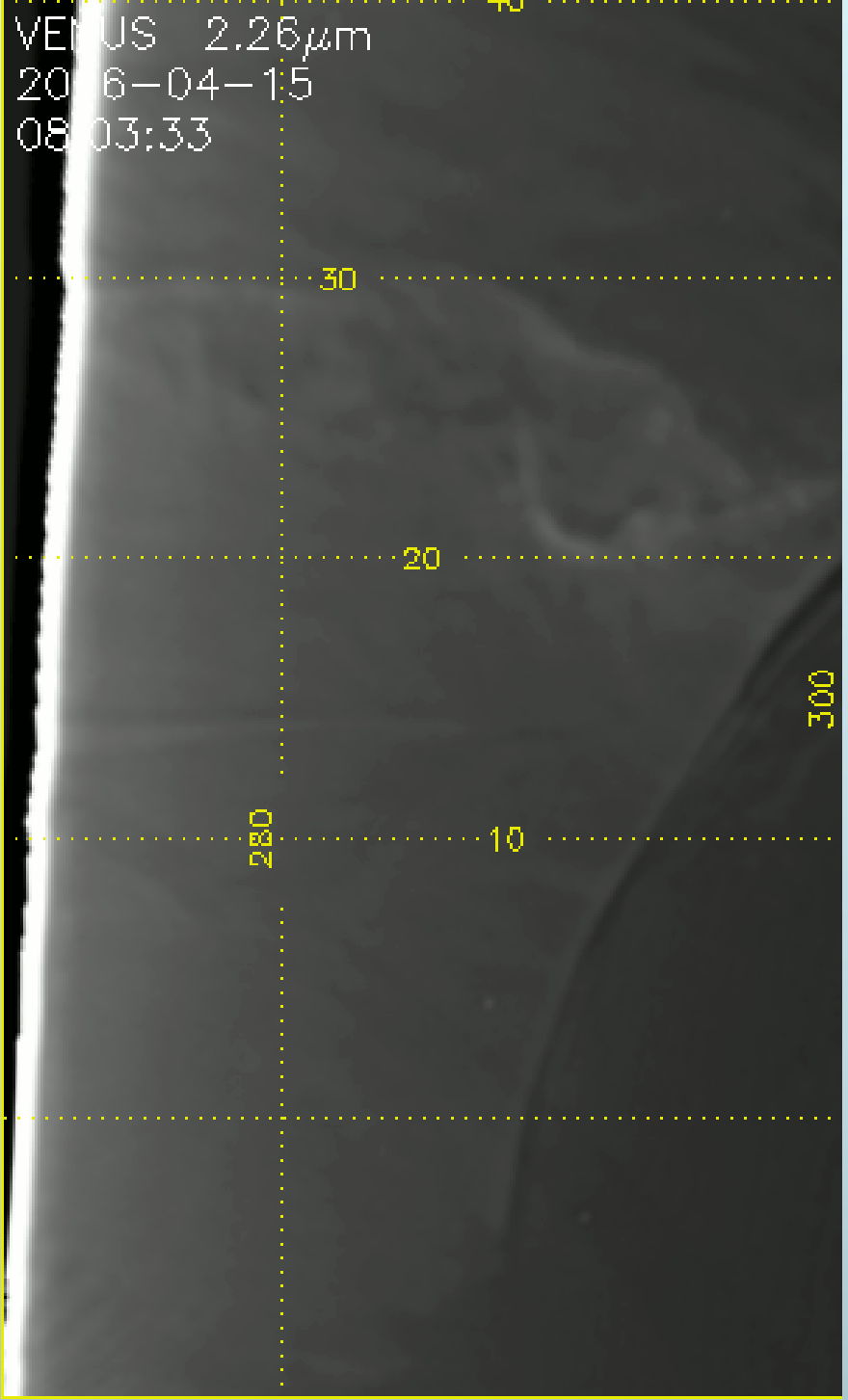


Figure 1, . (a) Idealized mushroom-like system as seen in WV imagery for an easterly flow. The two thick lines represent the deformation axes. DD represents the leading deformation zone, TT is the trailing deformation zone, X and N mark the negative and positive vorticity centers, respectively, and J indicates the local jet stream circulation. Thin solid lines are the streamlines of the relative motion of the flow. (b) METEOSAT WV imagery at 1200 UTC on 17 June 1993 showing a mushroom-like pattern close to the Iberian peninsula. A sketch of the main kinematic features, derived from a satellite imagery sequence, has been drawn.

“The mushroom configuration in water vapor imagery and operational applications”, Martin et al., Meteorol. Appl. 6, 143–154 (1999)



300° 290° 280°

Are these circulations triggered by topography?

The vertical shear of the horizontal wind can lead to transformation of vorticity through forced vertical motion over elevated features on the surface.

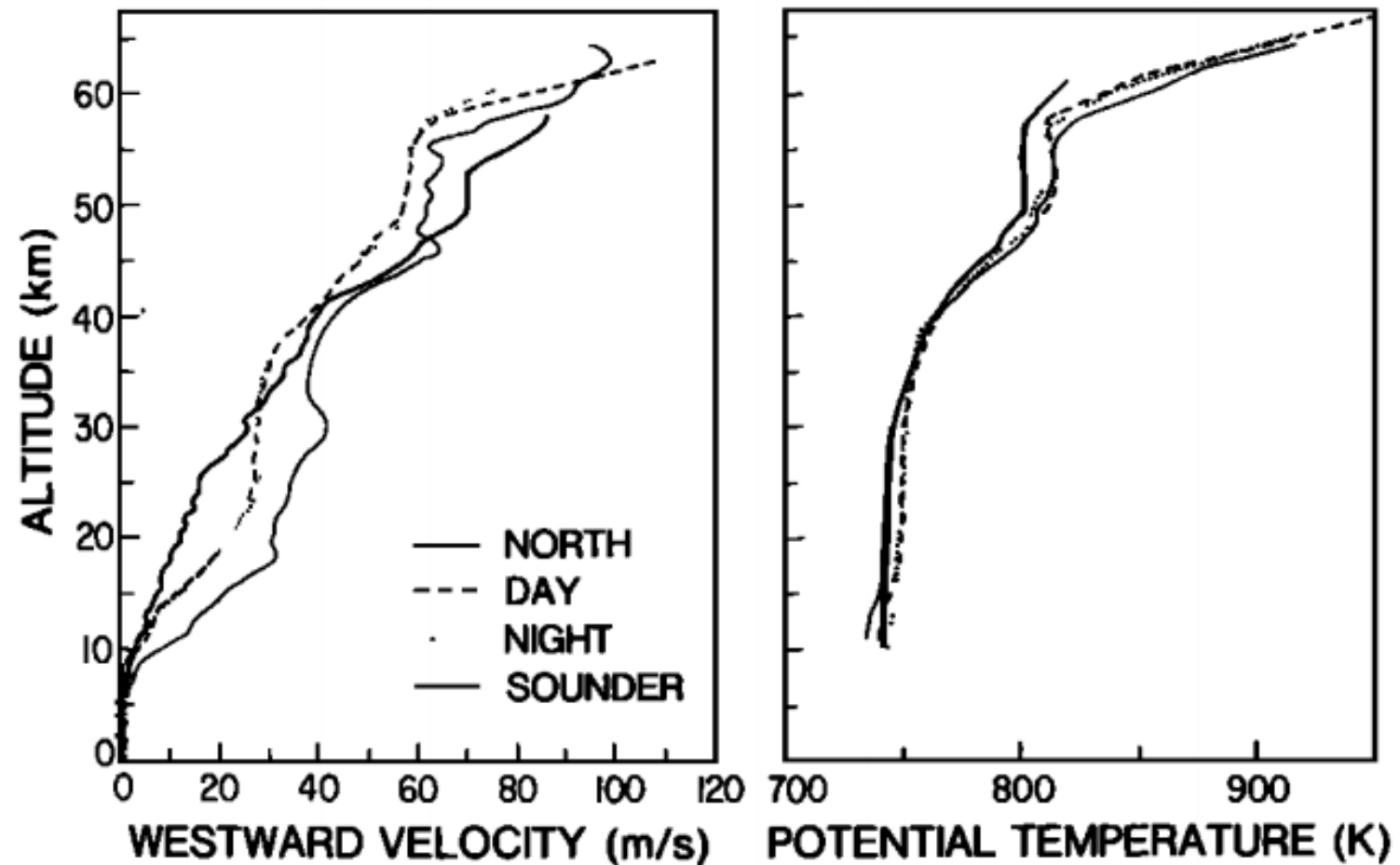
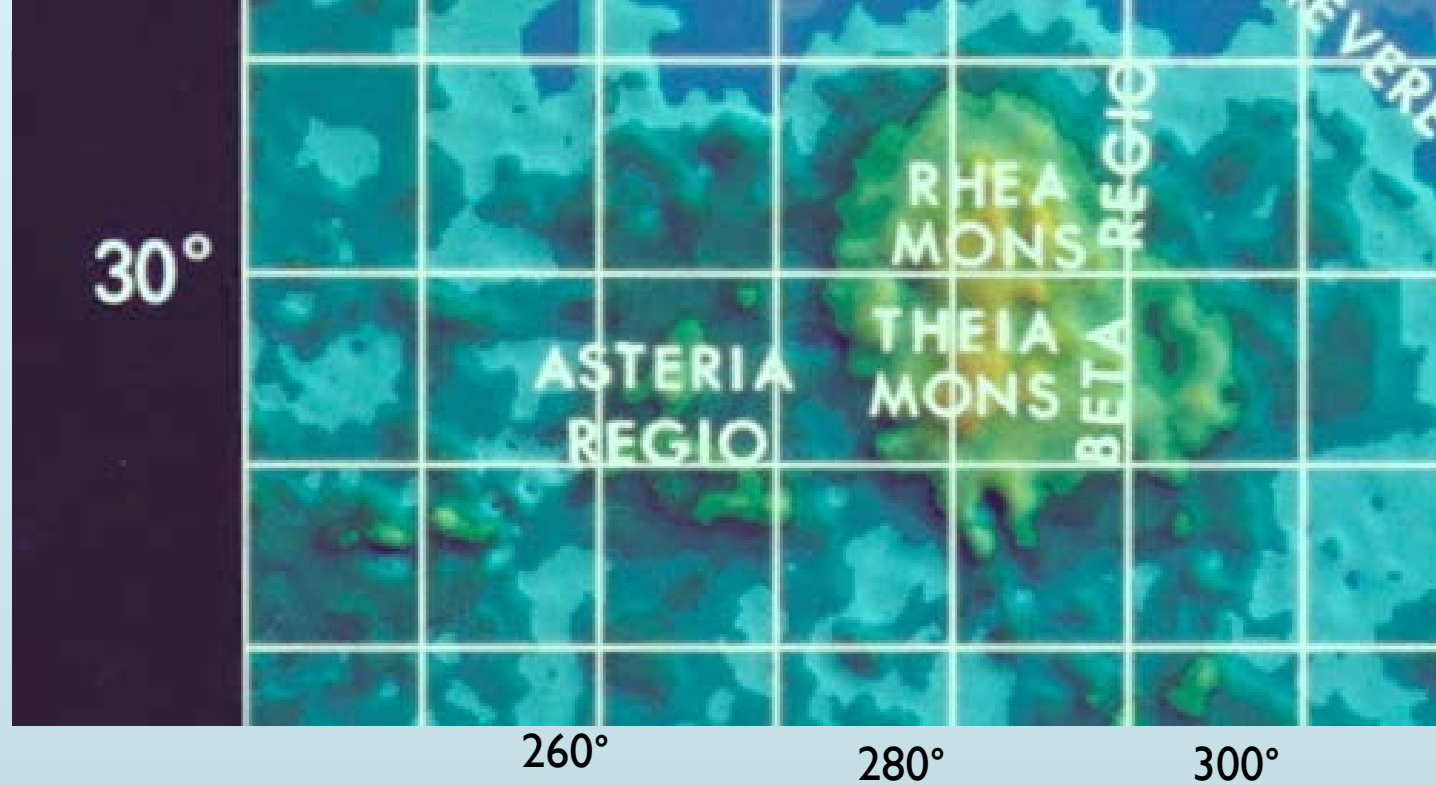
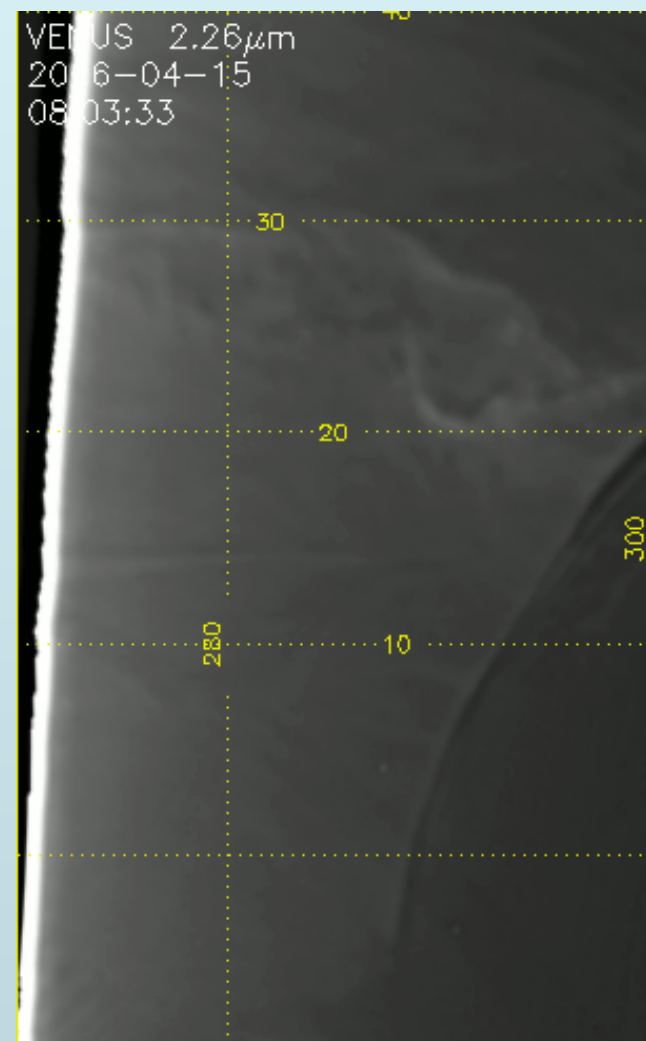
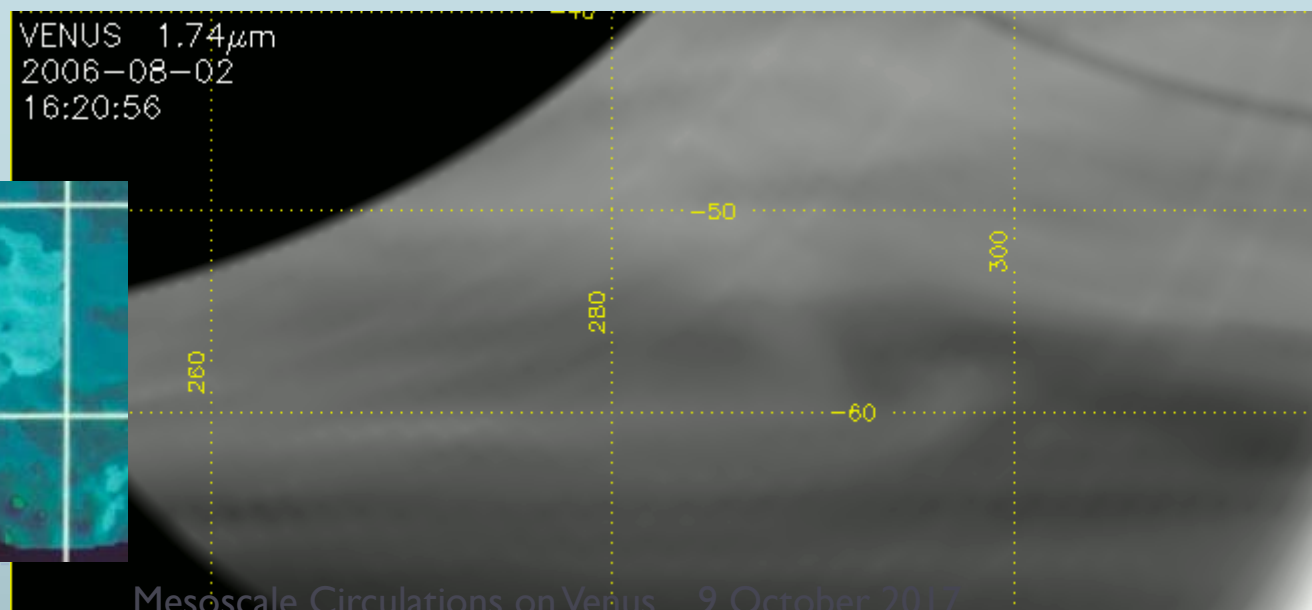
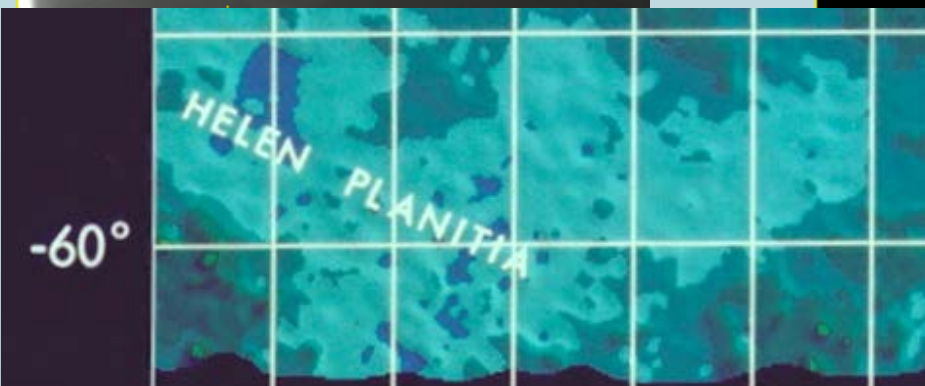


Fig. 4. Zonal wind velocity and potential temperature profiles. The wind velocities are derived from the Pioneer Venus DLBI and Doppler tracking data. Potential temperatures are derived from temperature measurements by the probes, assuming an atmosphere of 96.5% CO₂ and 3.5% N₂. In the potential temperature representation, adiabats are vertical lines, positive slopes indicate statically stable subadiabatic regions, and negative slopes indicate unstable super-adiabatic regions.



Similar features in VIRTIS Data

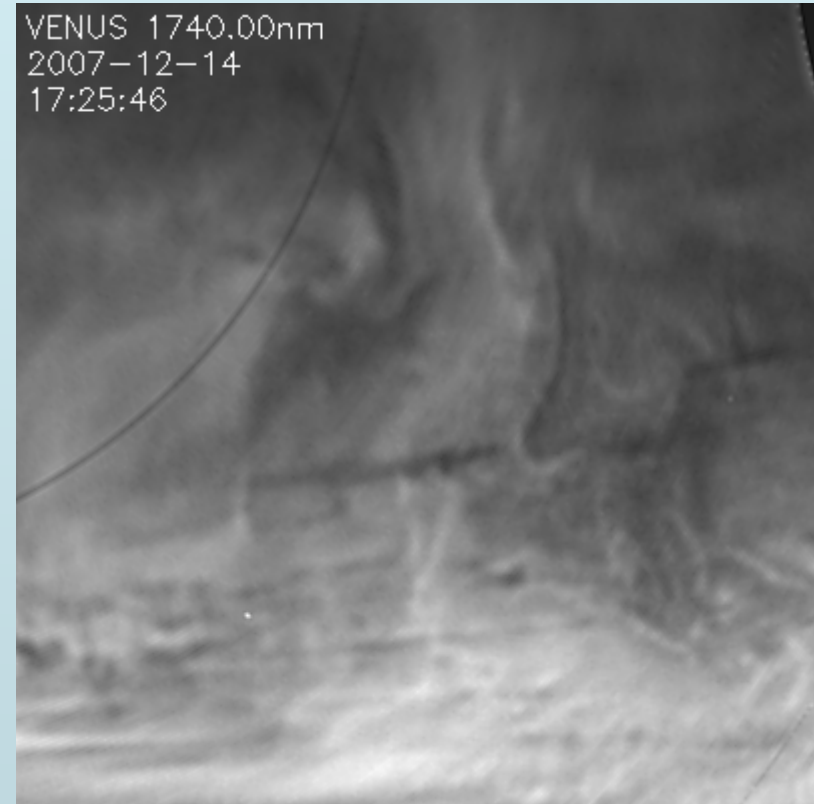
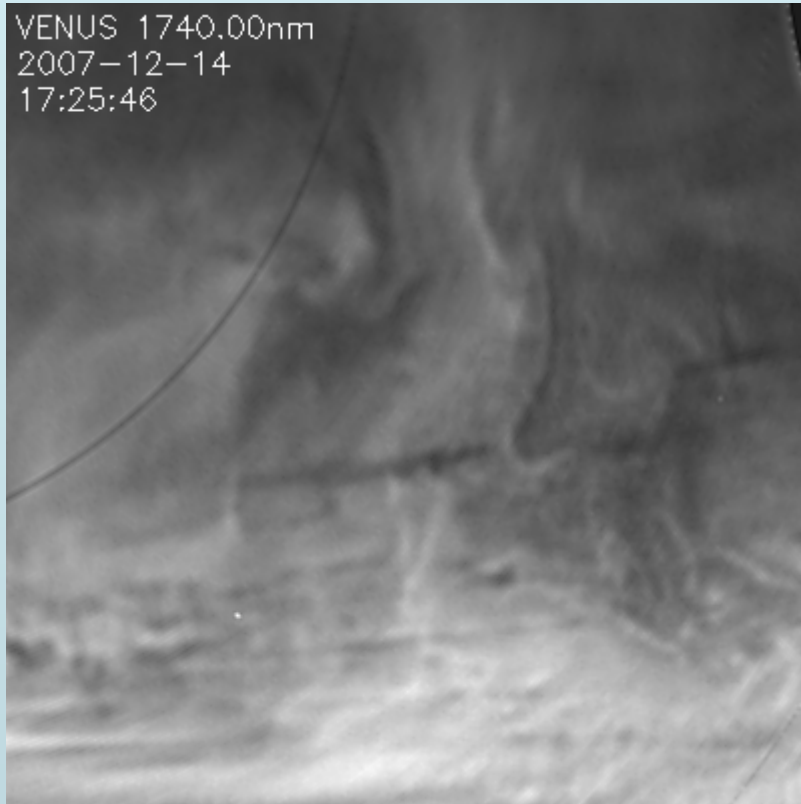


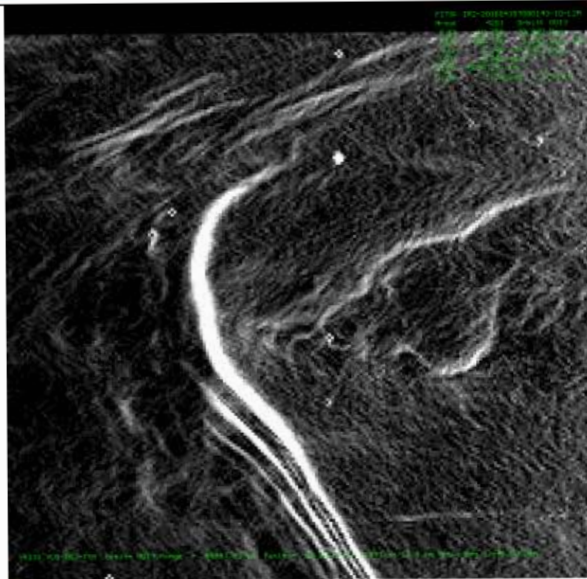
Mesoscale Circulations on Venus 9 October 2017



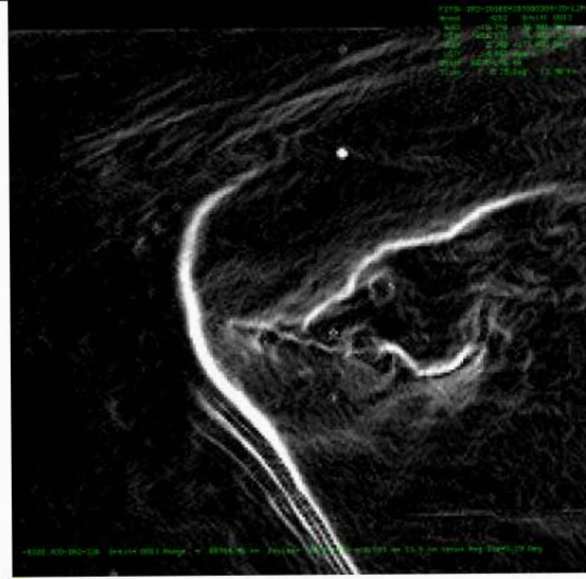
6

260°

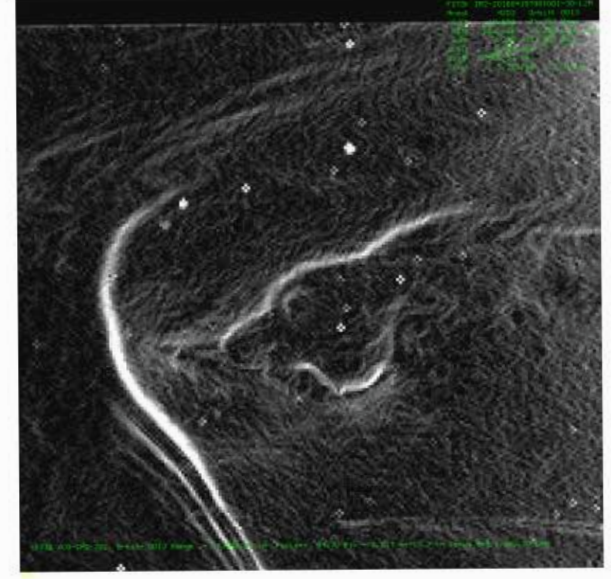




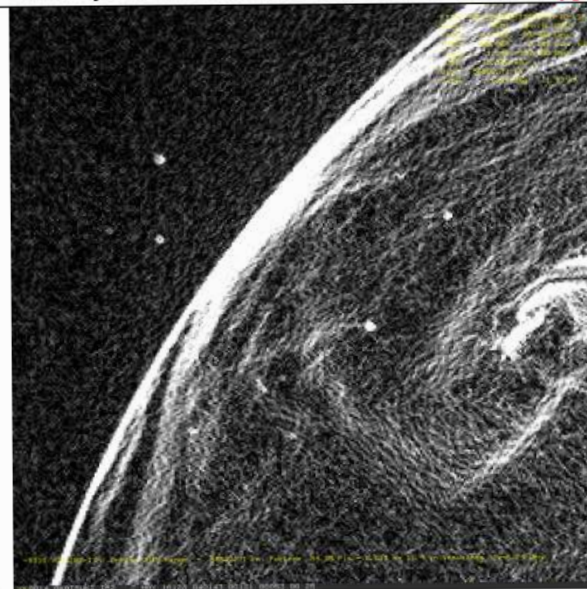
15 April 2016 08:10:38 - 2.32 μ



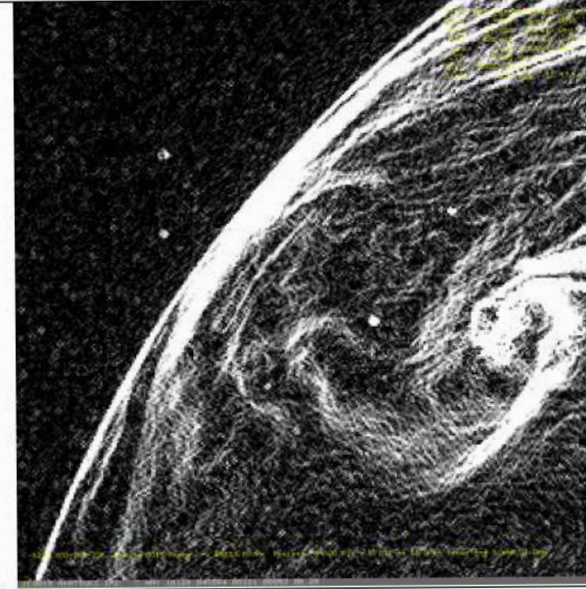
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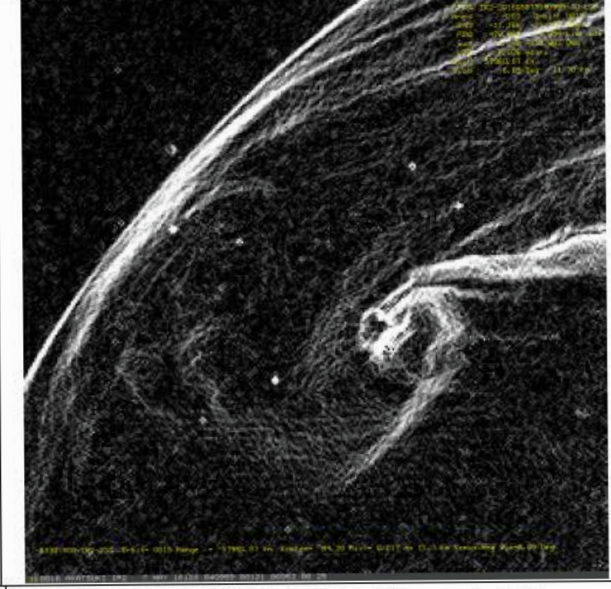
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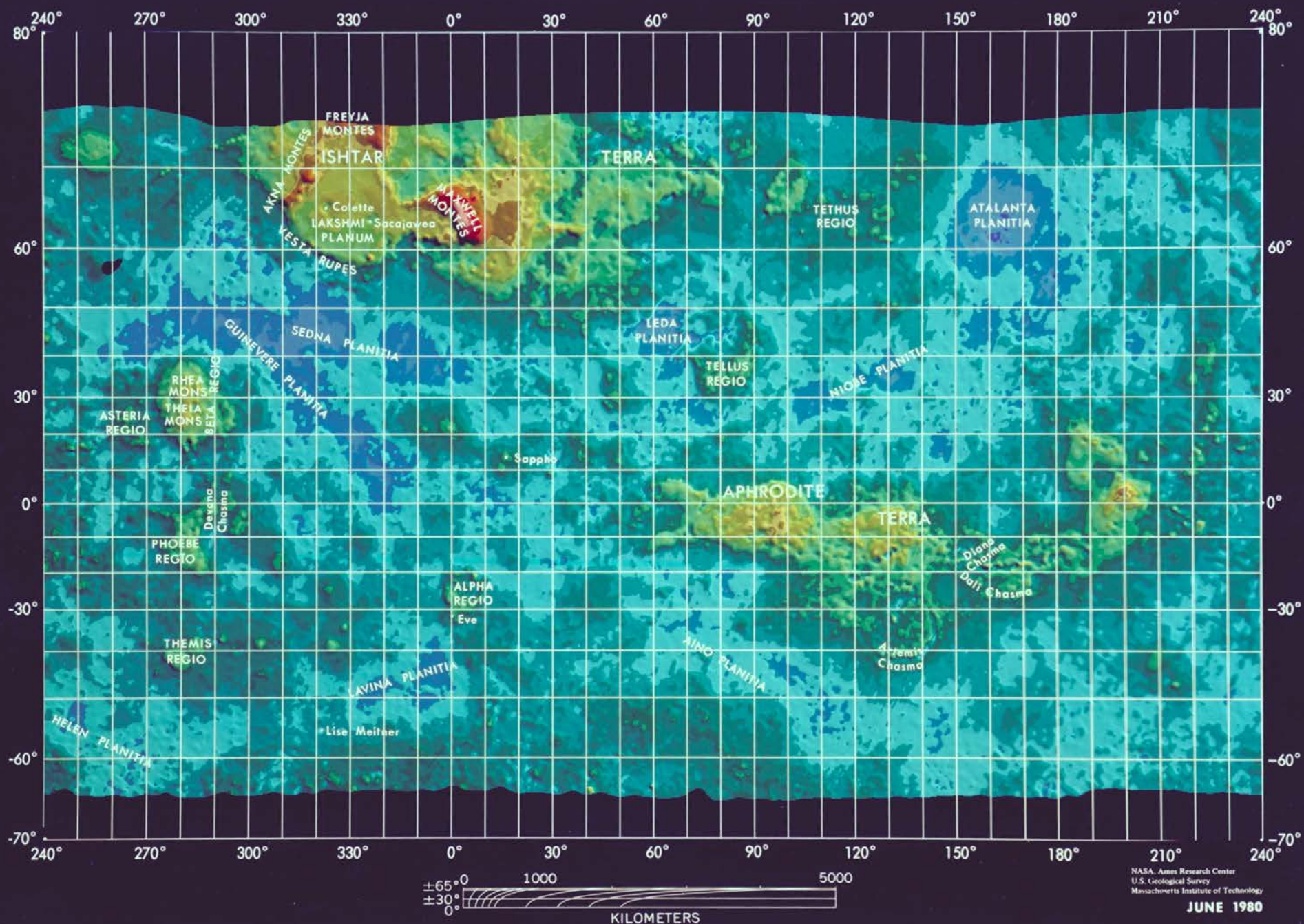


7 May 2016 04:03:33 - 2.26 μ



7 May 2016 04:02:11 - 1.74 μ

Figure 4. A sequence of gradient filtered images shown in Figure 1 reveals the intricate structure within and around the mushroom feature.



VENUS

Mesoscale Circulations on Venus 9 October 2017

NOTES ON BASE

This chart is based on a series of aerial photographs of the surface of Venus at a resolution of 1:100,000,000. The photographs were taken by the Soviet Venera 15 and Venera 16 spacecraft in 1975 and 1976. The photographs were processed by the National Aeronautics and Space Administration (NASA) and the United States Geological Survey (USGS) to produce this chart. The chart is based on the best available data and is subject to change as more data becomes available.

ADJUSTED FIGURE

The figure of Venus used in the construction of this map is based on a sphere with a mean radius of 6,051.8 km. The figure of Venus is based on the best available data and is subject to change as more data becomes available.

PROJECTION

The Mercator projection is used for this chart with a scale of 1:50,000,000 at 45° N. Due to the spherical nature of Venus, lengths measured from west to east are accurate with error of the International Astronomical Union (IAU), 1976.

CONTROL

Planimetric control is derived from the tracked paths of the spacecraft. The line between points through the center of a planetary feature is used to determine the "true" position of the feature. The planimetric control is based on the best available data and is subject to change as more data becomes available.

MAPPING TECHNIQUES

Data for the surface relief and features were derived from altimetric processing of radar altimetry and correlation altimetry, received from NASA's Venus Research Center. The altimetric data were processed by the National Aeronautics and Space Administration (NASA) and the United States Geological Survey (USGS) to produce this chart.

NOTES ON BASE

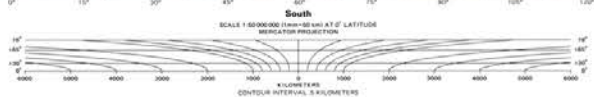
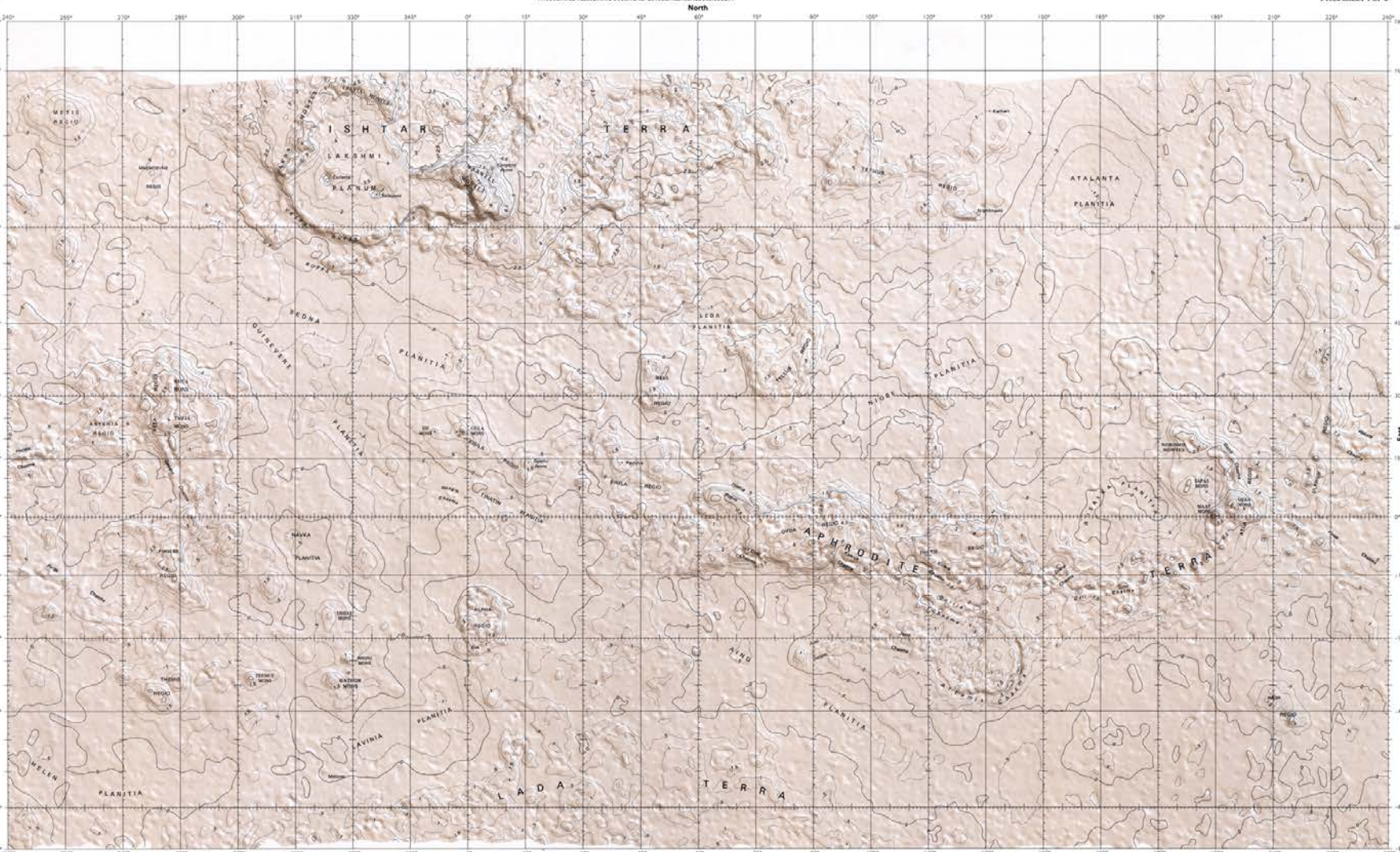
Computer methods described by Hansen and others (1971) were used to make the shaded relief. The shaded relief is based on the best available data and is subject to change as more data becomes available.

NOTES ON BASE

Radius on this chart is defined by the International Astronomical Union (IAU), 1976. The radius of Venus is 6,051.8 km. The radius of Venus is based on the best available data and is subject to change as more data becomes available.

REFERENCES

- Barnes, R. W., 1977, Computer generated shaded relief maps of Venus, U.S. Geological Survey, Reston, Va., 1:50,000,000, 1:100,000,000, and 1:200,000,000.
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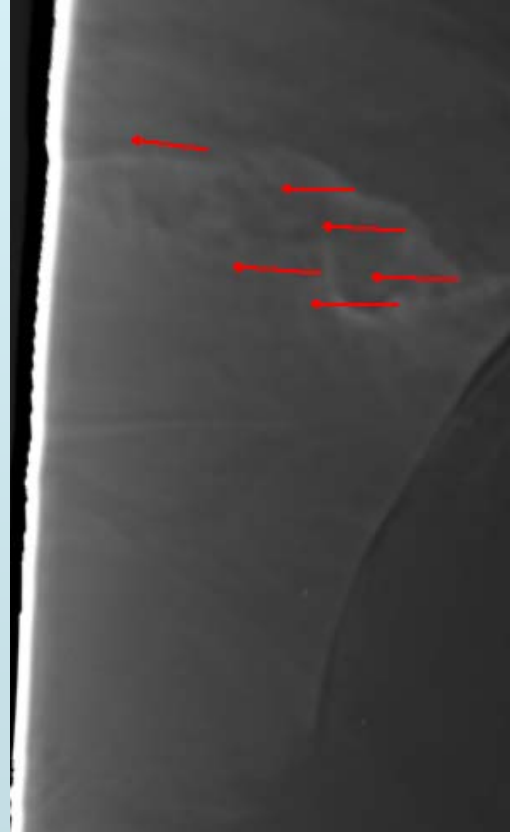
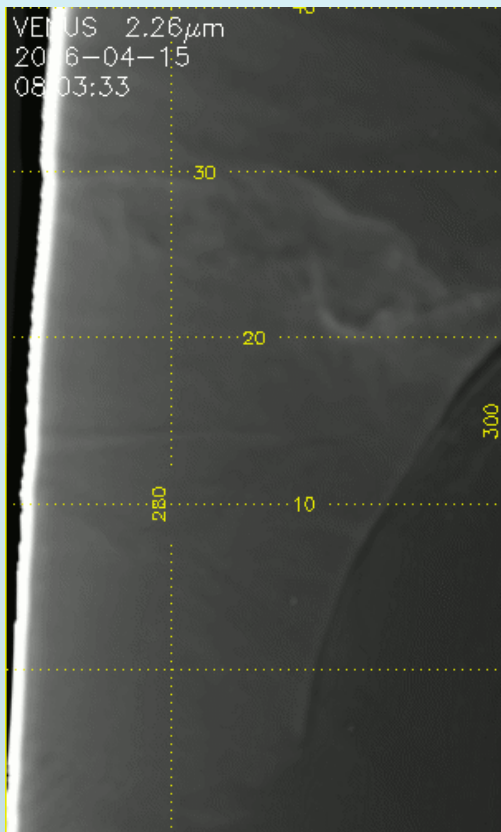
TOPOGRAPHIC MAP OF VENUS
VRM PLANNING CHART
V 50M 6/60 RT
1984

Prepared on behalf of the Planetary Geology Program,
Planetary Division, Office of Space Science, National Aeronautics and Space Administration under contract N-11,105.

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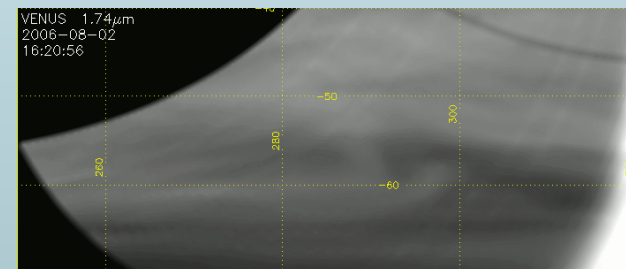
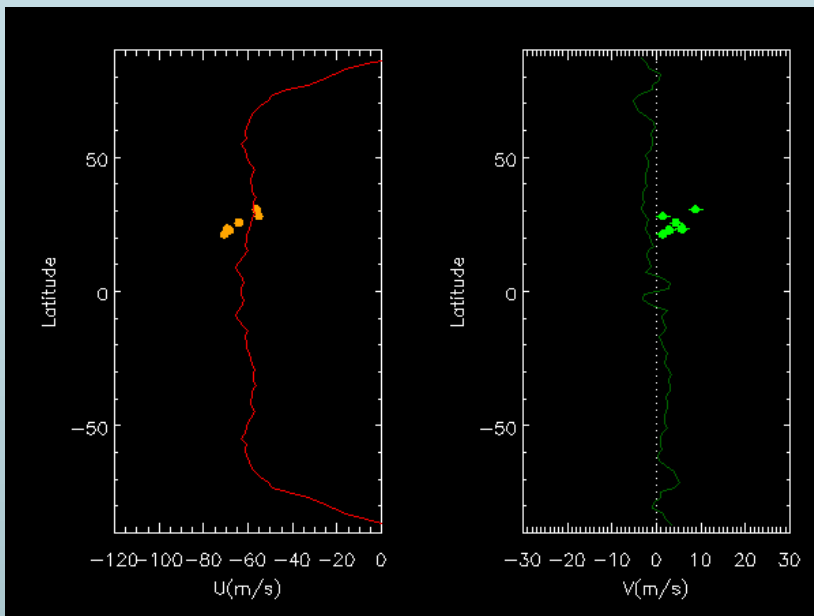
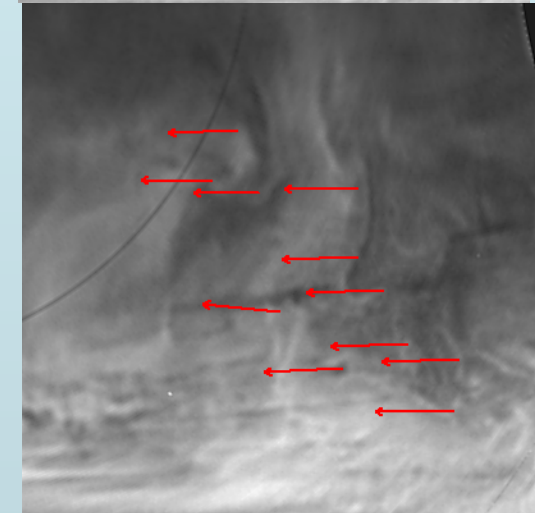
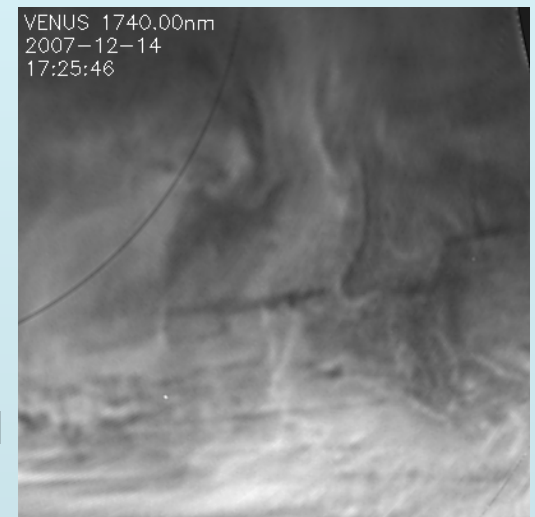
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Good temporal
and coverage is
not available at
high resolution to
measure rotational
motions.

Only zonal
displacement is
measurable due
to low resolution



Puzzles

- Some questions to ponder:
 - Is there any difference in radiances of the cyclonic and anti-cyclonic features?
 - What makes them detectable?
 - What is the sharp boundary seen in the April 15 discovery frame?

Summary

- This is the first instance of meso-scale circulations on Venus in low and mid latitude regions, as only in the “eye” of the hemispheric vortex have meso-scale features arising out of dynamical instability have been observed
- The morphology indicates strong meridional flows and opposite to the ambient zonal flows.
- The vortex pair are often found in stratospheric extrusion events on Earth (cold dry air fingers sinking fast) which run into “blocking” high pressure regions causing the flows to bifurcate and form a vortex pair with opposite vorticities
- The same location suggests that local topography could induce such flows by creating a blocking feature over mountain tops.
- No time sequences are available on those two orbits, only three IR 2 filter images, so measuring cloud motions is not very feasible
- IR2 images show many amazing and perplexing non zonal flows
- Earth vortex pairs are short lived – only about a day or less, but the Venus vortex pairs may last longer?