

# Determining Cloud-Level Winds in the Venus Atmosphere with Telescopic Infrared Images of the Venus Nightside and a Team of Citizen Scientists

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Denver Museum of Nature & Science

November 3, 2010

# Research Problem

- How fast are the winds on Venus?
- How do they vary in time and with latitude?

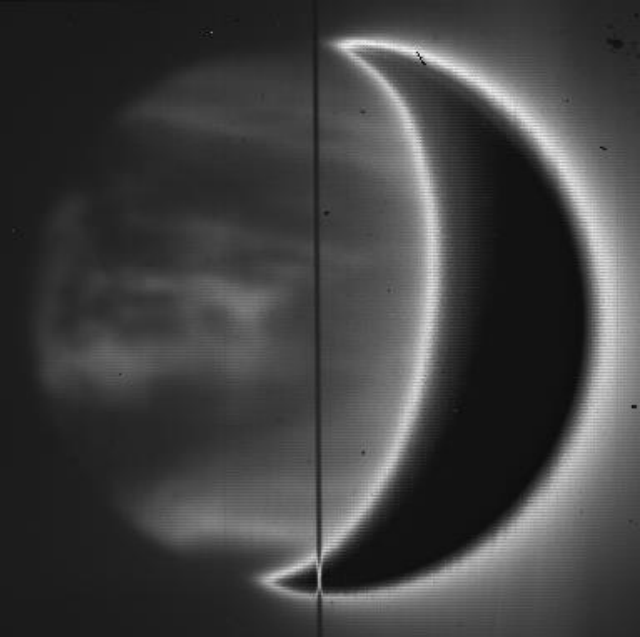
# Research Solution

- Take many, many images of the Venus clouds.
- Track cloud features and calculate velocities.

# Acquiring the Data

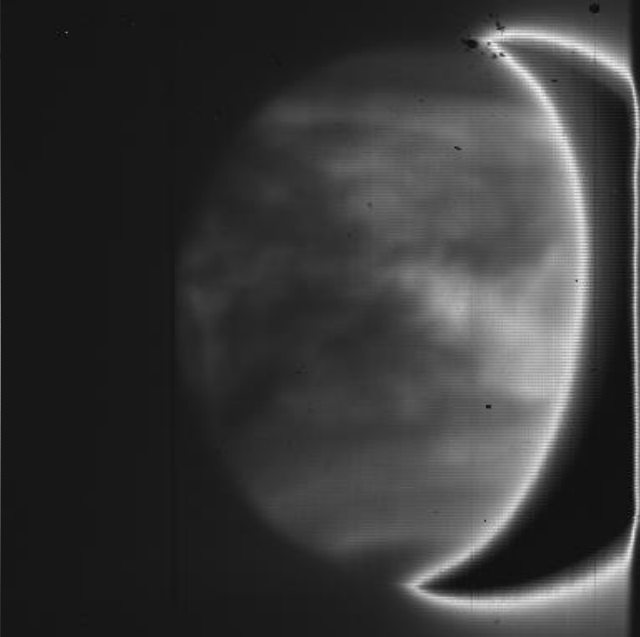
- More than 80,000  $2.3\ \mu\text{m}$  images of the nightside of Venus, 2001-2007.
- Images acquired using the SpeX imager and spectrometer on the 3-m NASA Infrared Telescope Facility (IRTF)





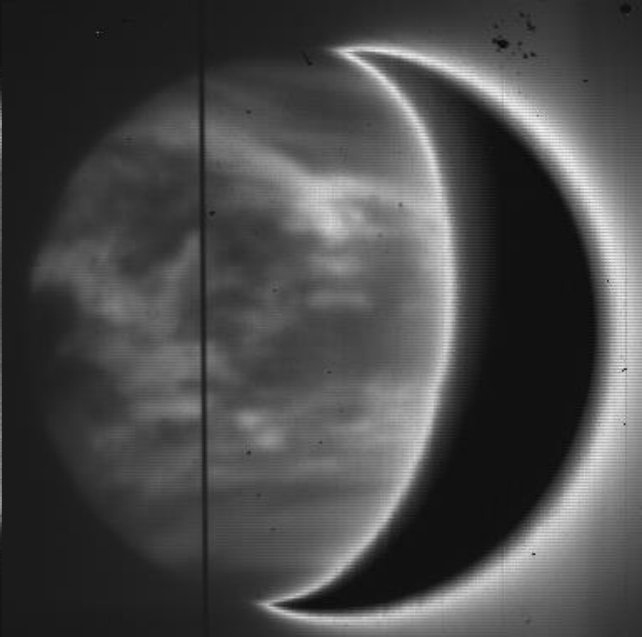
May 4, 2004

Venus 2.3  $\mu\text{m}$



May 5, 2004

IRTF

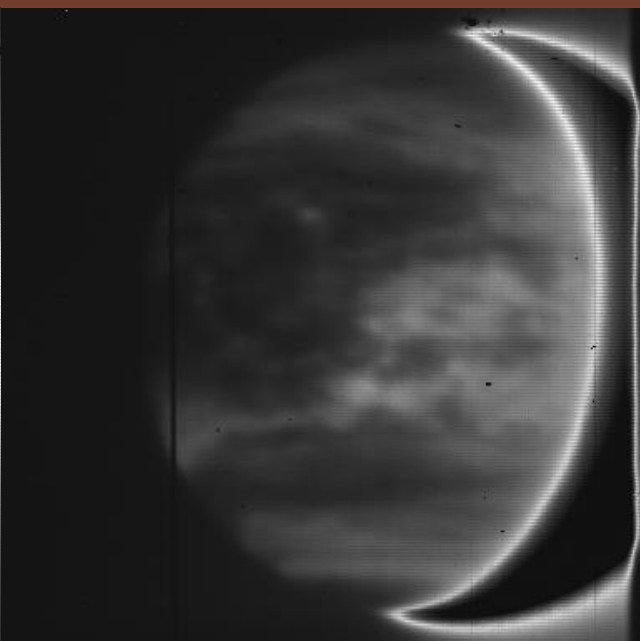


May 6, 2004



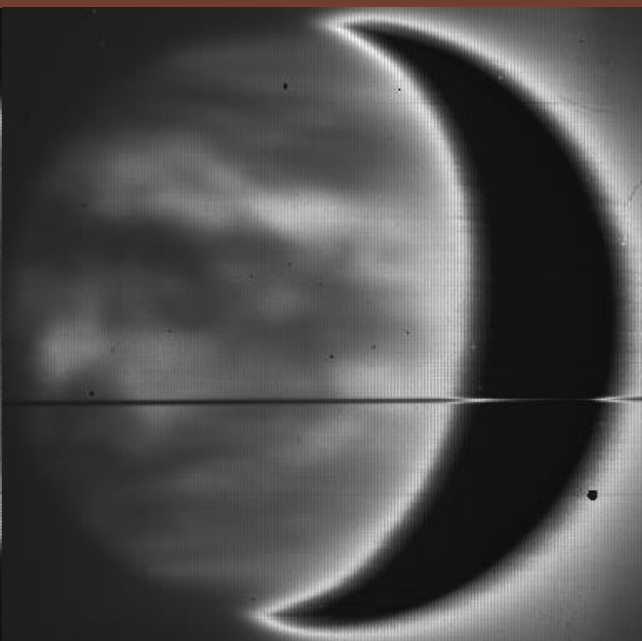
May 8, 2004

Eliot Young



May 9, 2004

Mark Bullock



May 10, 2004

# Research Implementation Problem

- How do we analyze 80,000 images?
  - Sort by image quality
  - Flat field the images
  - Remove spectrometer slit
  - Co-register the images
  - Remove scattered sunlight
  - Co-add images for best contrast
  - Choose fiducial points and calculate velocities

# Research Implementation Solution

- Put together a team of citizen scientists who are willing to pore over the images, process them, and calculate velocities.
- Make movies of Venus cloud motion.



# Citizen Science Collaboration

Venus Winds Wiki - SwRI

http://wikivm.boulder.swri.edu/mediawiki/index.php/Venus\_Winds\_Wiki

Wiki NSPRS NSF DoSS NWS NCAR RTD WF NYT CNN Wiki Scopus ADS UClips IE Tab Other bookmarks Log in

page discussion view source history

## Venus Winds Wiki

### Introduction

The Venus Winds project at the [Denver Museum of Nature & Science](#) seeks to determine wind speeds in the Venus atmosphere by analyzing infrared images taken by the [NASA Infrared Telescope Facility \(IRTF\)](#). The atmosphere of Venus rotates up to 60 times faster than its solid body. The mechanism that drives this atmospheric 'superrotation' is not understood. A corps of volunteers is processing and analyzing more than 80,000 images of Venus taken since 2001. These images are of the night side of Venus, where heat from the deep atmosphere is observed at a wavelength of  $2.3\mu\text{m}$ . The patchy lower clouds of Venus appear as silhouettes, blocking the outgoing radiation where the clouds are thickest. Images are assembled into movies of the motion of Venus' lower cloud deck. The movies are then used to calculate wind speeds and direction across the planet. Variability in the wind field, such as the appearance and disappearance of jet streams, eddies, and waves, holds clues to the origin of Venus' atmospheric superrotation. This project is partly supported by a grant from the [National Science Foundation](#). A set of introductory slides can be found here [File:DMNS Wind Speeds 3-08.pdf](#).

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### Contacts

navigation

- Main Page
- Community portal
- Current events
- Recent changes
- Random page
- Help

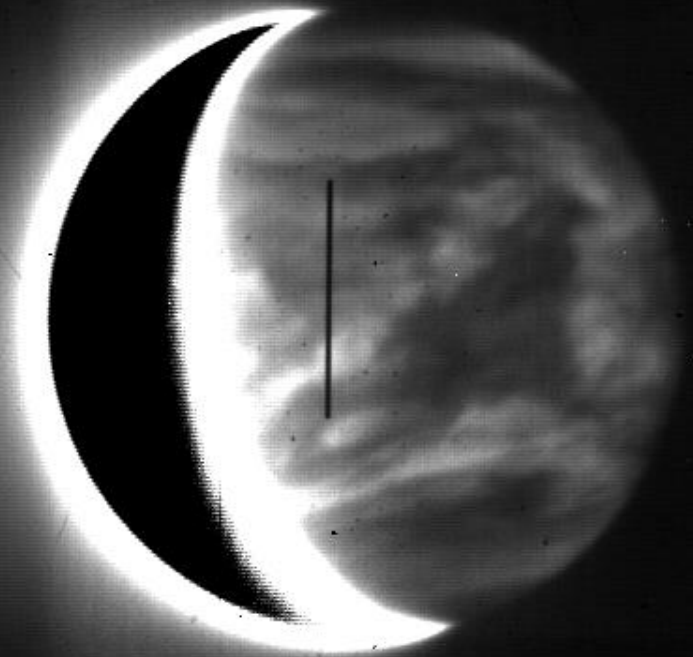
search

Go Search

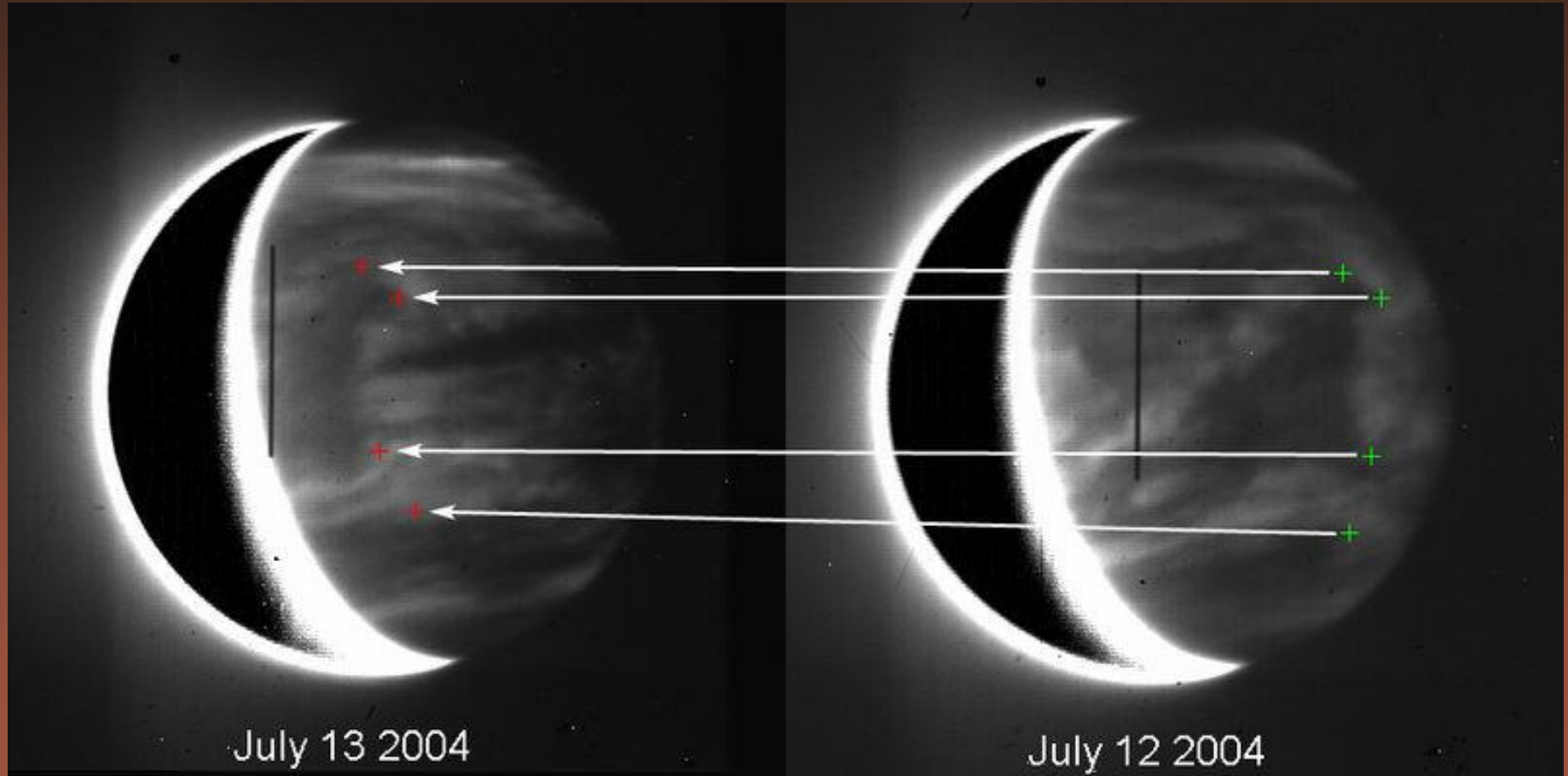
toolbox

- What links here
- Related changes
- Special pages
- Printable version
- Permanent link

# Example Images



# Analysis Example





# Wind Velocity Calculations

- Precise co-registration done by Carver Thomason using FITSRegister (in house software).
- All participants found points and calculated wind speeds using Excel spreadsheet by Ching-Hsuan Tseng.

Microsoft Excel - VenusWindSpeedCalculation\_Sean.xls

File Edit View Insert Format Tools Data Window Help Adobe PDF

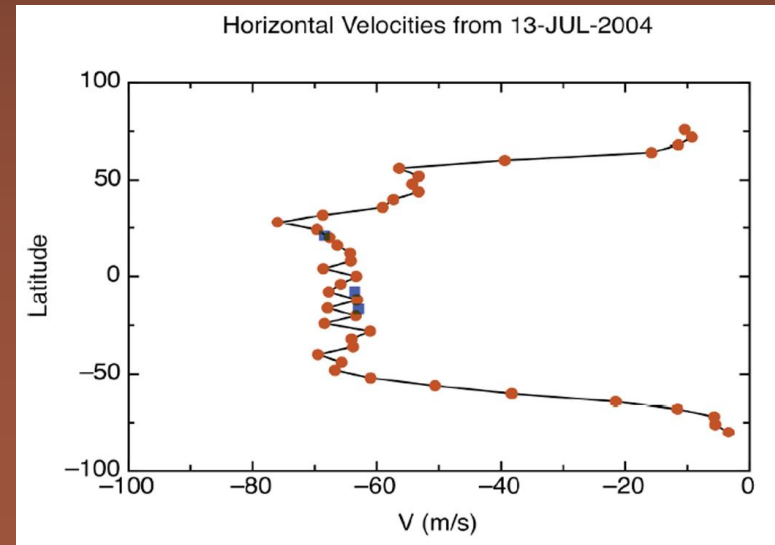
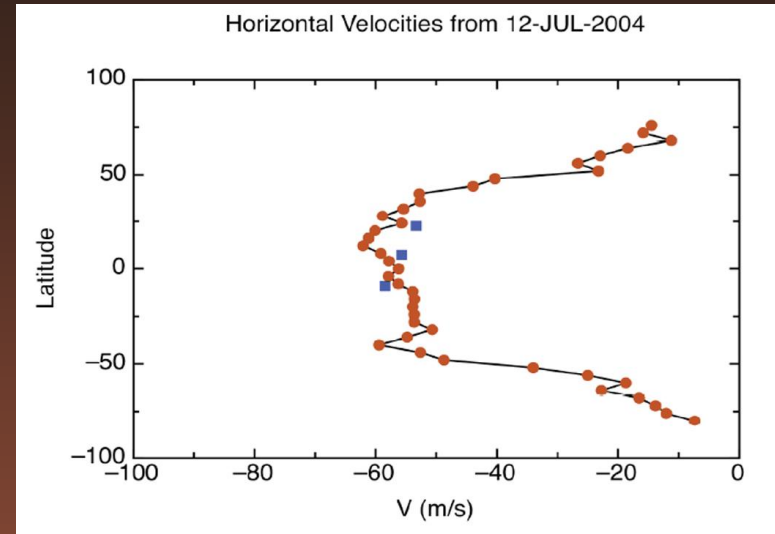
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	A	B	C	D	E	F	G	H	I	J	K	L	
7													
8	<b>Step 2: Caculate the time interval between two points (Use Time_OBS fields)</b>							56,812.251578					
9		Date	Hour	Minutes	Seconds		55,695.406058	85,283.154480					
10	Observation 1	July 12, 2004		15	46		52.251578						
11	Observation 2	July 13, 2004		15	28		15.406058						
12	Delta		1	0	-18		-36.84552						
13	Delta (second)	86,400.00000		0	-1080		-36.84552						
14	Delta (second)						<b>85,283.154480</b>						
15													
16	<b>Result: the winds speed</b>												
17	Vew	<b>55.8140705</b>											
18	Vns	<b>0.35176935</b>											
19													

1) fill in the time of the first image by date, hour, minute, and second  
 2) fill in the time of the second image by date, hour, minute, and second  
 (Observation 2-Observation 1)  
 (Convert each number to second)  
 (sum up all the numbers)  
 Answer 1:the wind velocity in the eastwestdirection, in meters per second  
 Answer 2: the wind velocity in the north-south direction, in meters per second

# Conclusions

- A diverse group of motivated, involved citizen-scientists can work with large datasets to produce new scientific discoveries.
- We saw that equatorial west-east winds are around 60 m/s.
- Winds taper off towards the poles.
- Some nights show evidence of mid-latitude jets.
- Next steps: Movies and a publication.



# Future Work – Analyzing Spectra

