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

Mark A. Bullock, Vincent Corbett, Dennis Green, David H. Grinspoon, Sarah Hink, Marta Lindsay, Kevin McGouldrick, Larry Stearns, Carver Thomason, and Ching-Hsuan Tseng, Jonathan Nickerson, Art Tarr, Carlos Romero, Michael Davison, Debra Davis

Denver Museum of Nature & Science

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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 μm 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)
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

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 μm. 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 jets, 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.

Contents

1 Introduction
   1.1 Contacts
   1.2 Schedule
   1.3 Example Images
2 Project Goals
3 Software Tools
4 Processing Steps
5 Data Download & Upload
6 Products
7 Links
8 Bibliography

Contacts
Analysis Example

July 13 2004

July 12 2004
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.

| Step 2: Calculate the time interval between two points (Use Time_OBS fields) |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Date | Hour | Minutes | Seconds | Date | Hour | Minutes | Seconds | Date | Hour | Minutes | Seconds |
| July 12, 2004 | 15 | 46 | 52.251578 | July 13, 2004 | 15 | 28 | 15.406058 | Delta | 1 | 0 | -18 | -36.84552 (Observation 2-Observation 1) |
| Delta (second) | 86,400.000000 | 0 | -1080 | -36.84552 (Convert each number to second) |
| Delta (second) | 85,283.154480 (sum up all the numbers) |

Result: the winds speed

- Vew: 55.8140705 <-------- Answer 1: the wind velocity in the east-west direction, in meters per second
- Vns: 0.35176935 <-------- 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