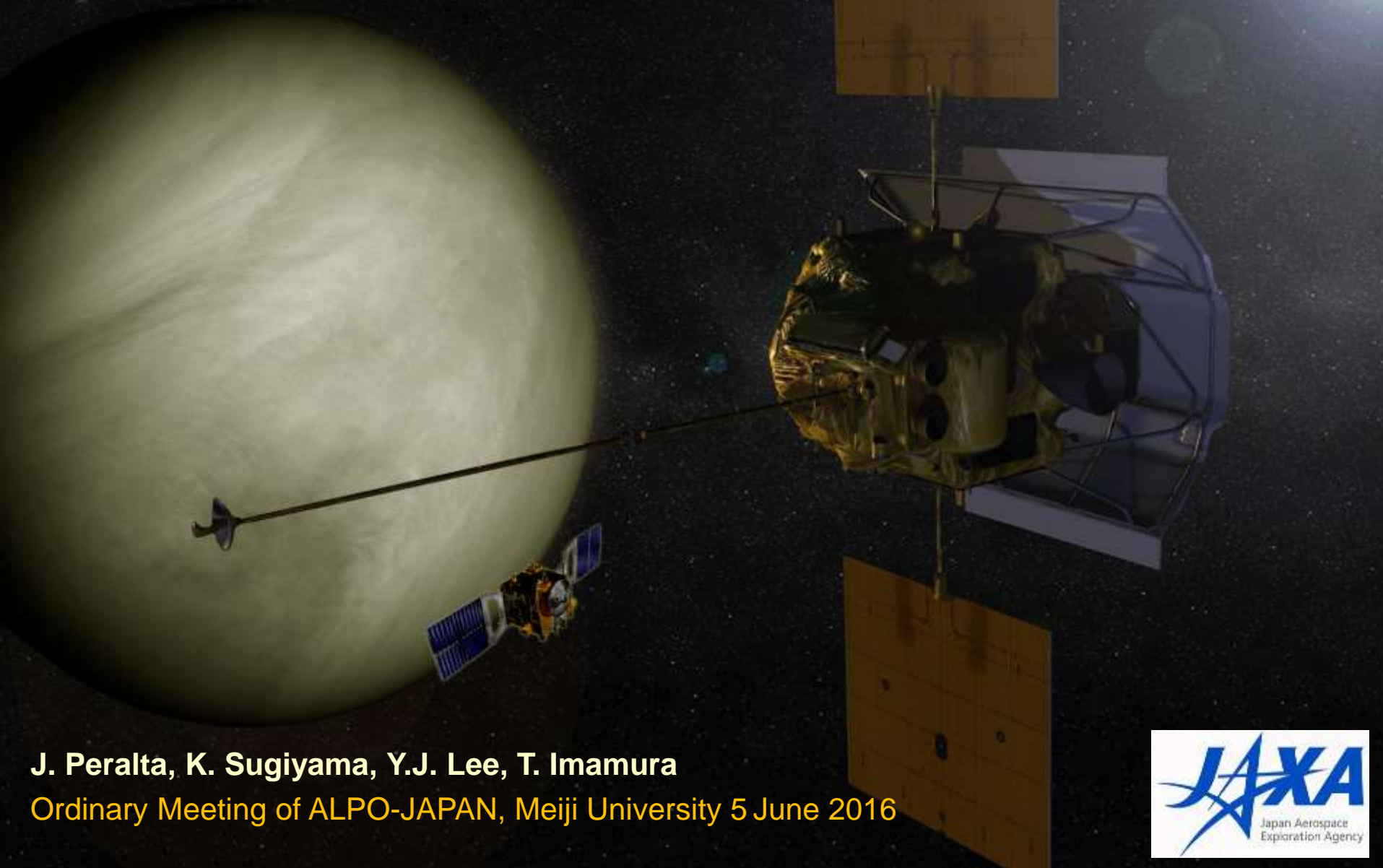


Ground-based Venus Observation of Amateur Astronomer for Akatsuki (II)



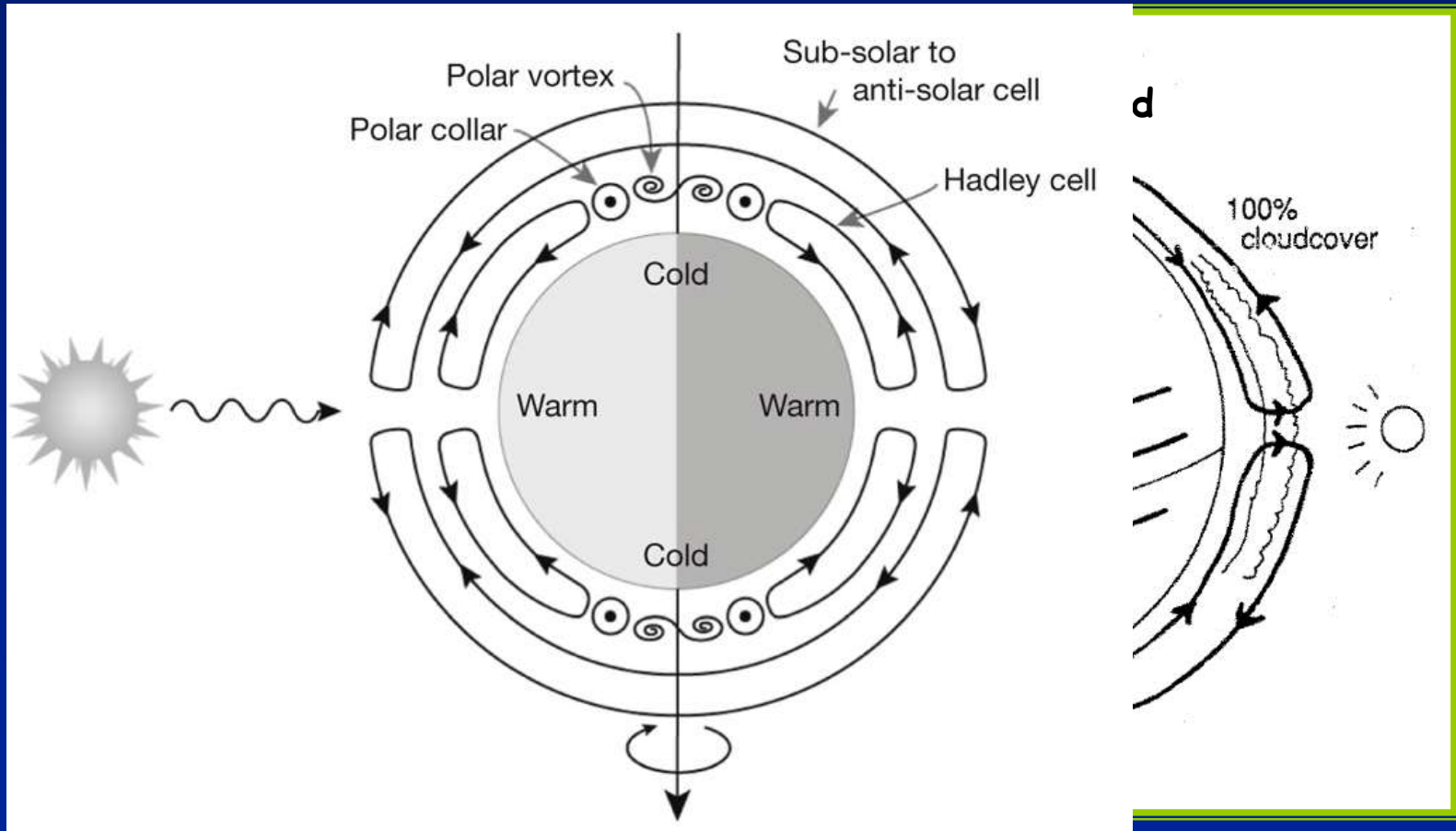
J. Peralta, K. Sugiyama, Y.J. Lee, T. Imamura

Ordinary Meeting of ALPO-JAPAN, Meiji University 5 June 2016



Zonal Circulation of Venus Atmosphere

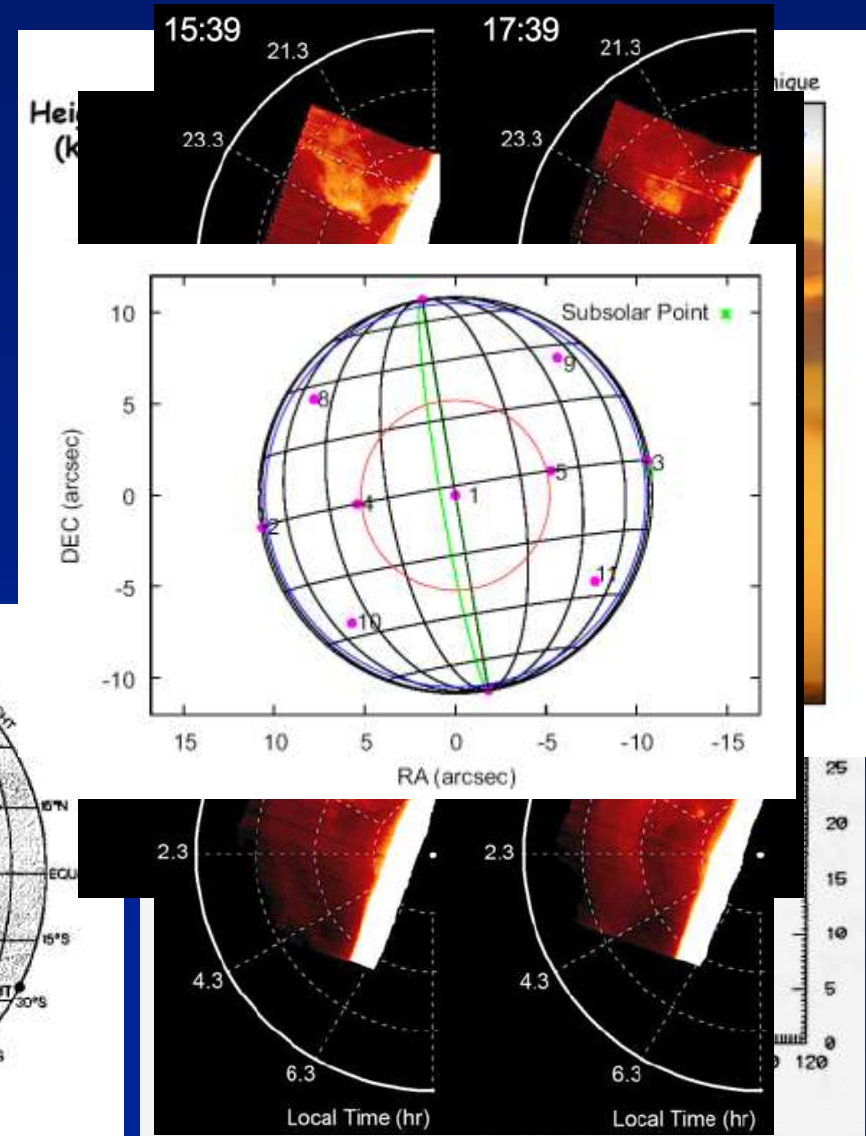
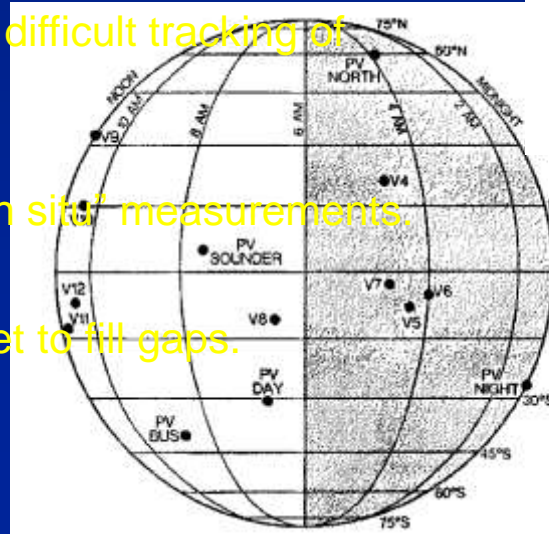
Venus is dominated by strong westward winds, which at the clouds' top reach velocities 60 times faster than the solid planet.



Unsolved issues of Venus atmospheric circulation

ZONAL WINDS

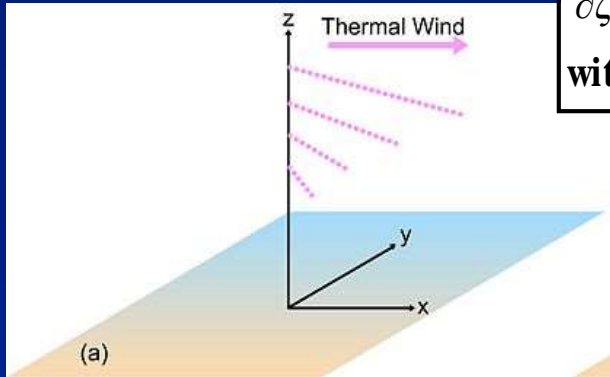
- Vertical profiles only for several entry coordinates.
- A few vertical levels allow cloud tracking.
- Cloud levels sense variable altitude.
- Above clouds:
 - Doppler measurements are sparse.
 - Radiation times difficult tracking of features.
- Below clouds: only “in situ” measurements.
- GCMs: not reliable yet to fill gaps.



How can we measure the winds on Venus?

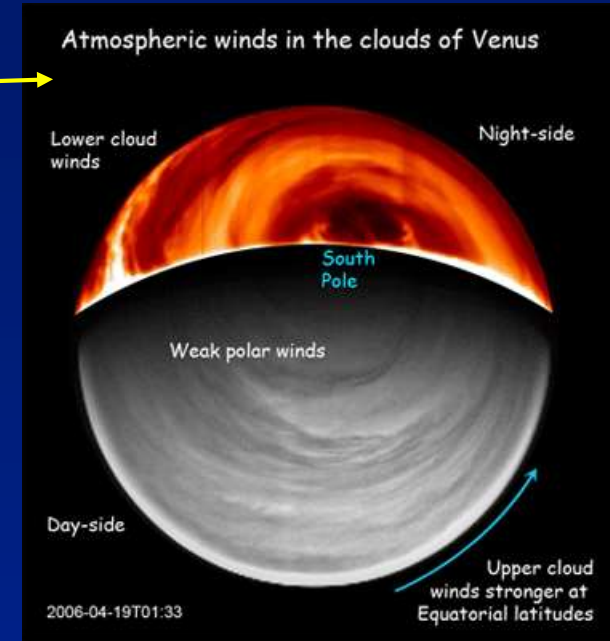
1. Tracking the features seen in remote-sensing images.

2. Indirectly from atmospheric temperature maps: using the Thermal Wind Equation.

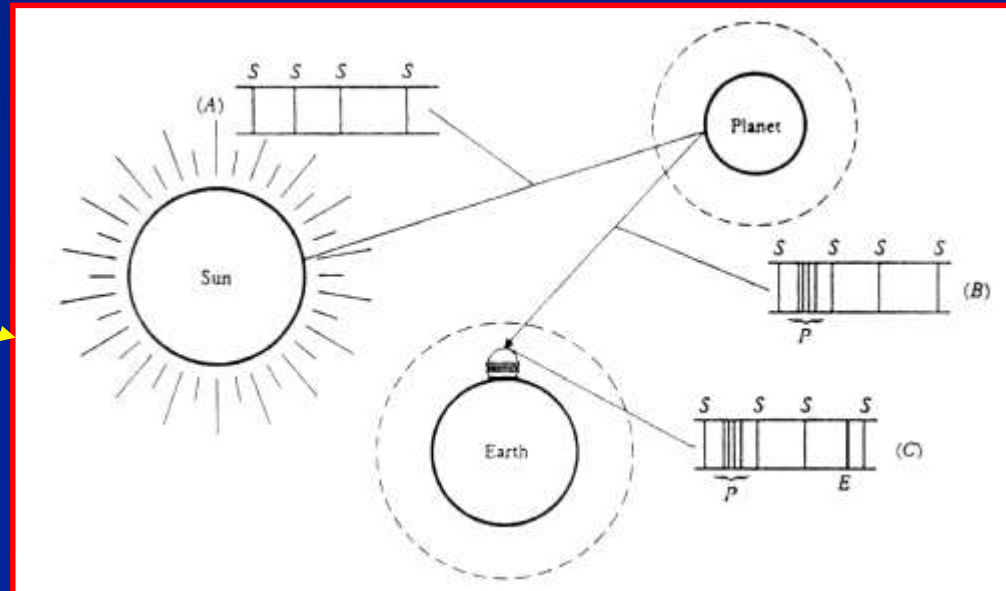


$$\frac{\partial u^2}{\partial \zeta} = -\frac{R}{\tan \phi} \cdot \frac{\partial T}{\partial \phi} \Big|_{P=\text{const}}$$

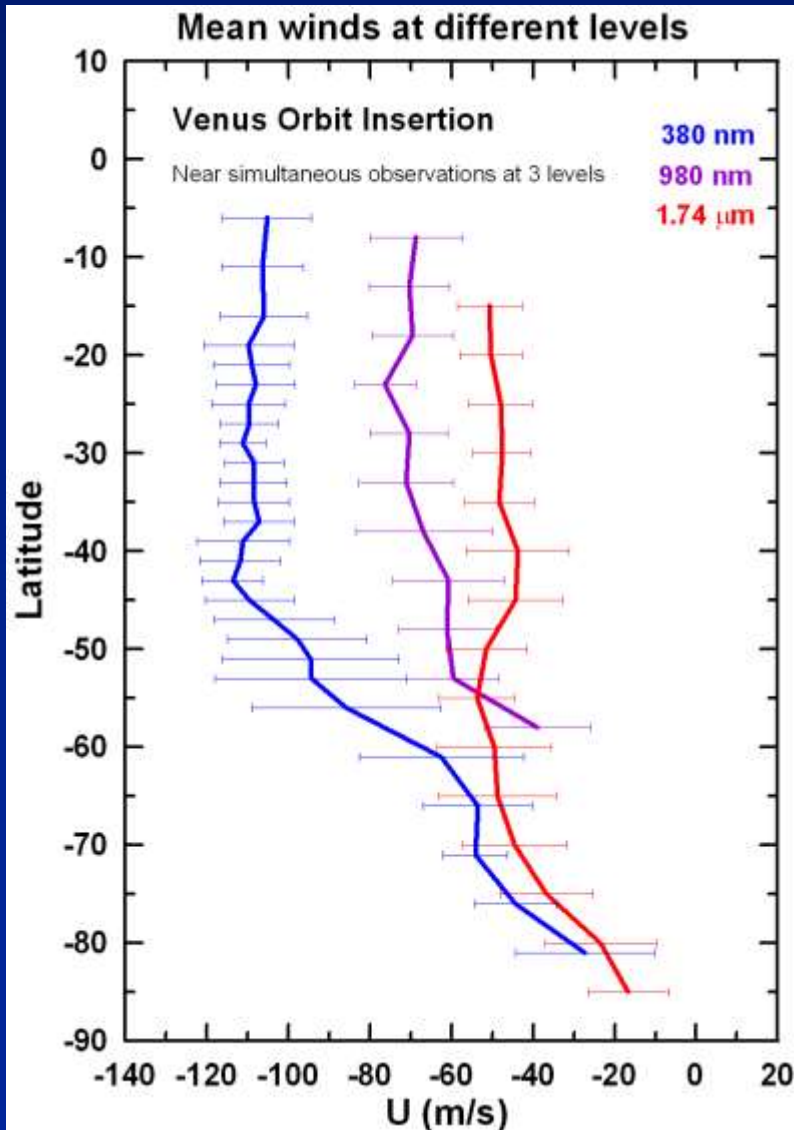
with $\zeta = -(P/P_{\text{ref}})$



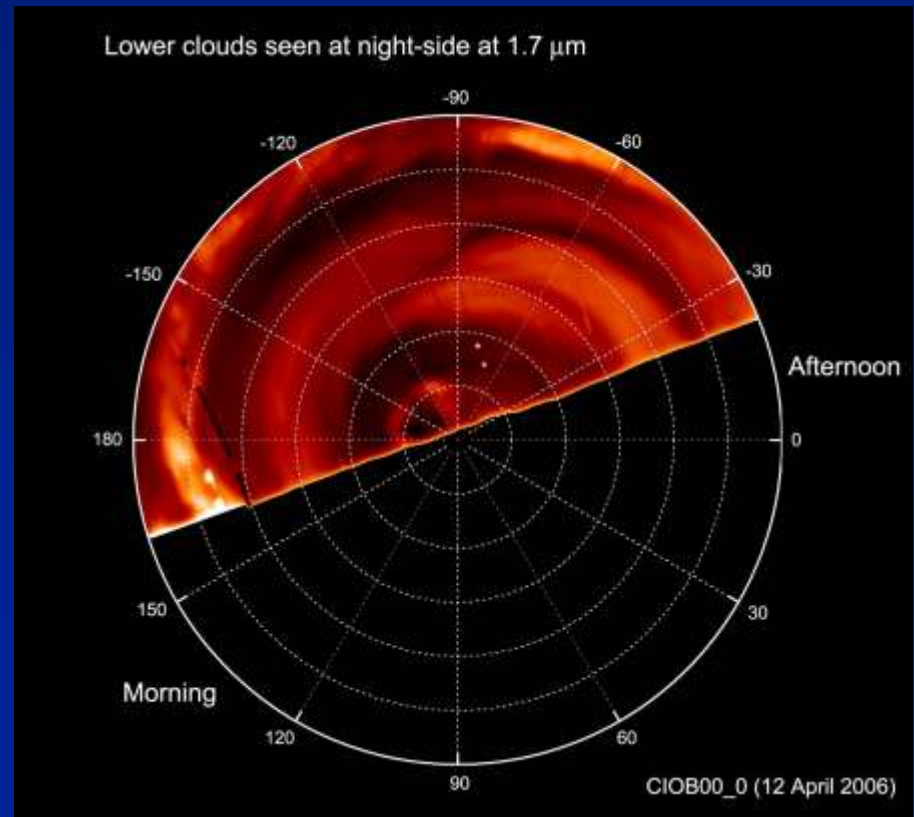
3. Measuring the Doppler-shift of solar scattered/ absorption lines in atmospheric spectra.



Different wavelengths: 3D view of Venus' winds



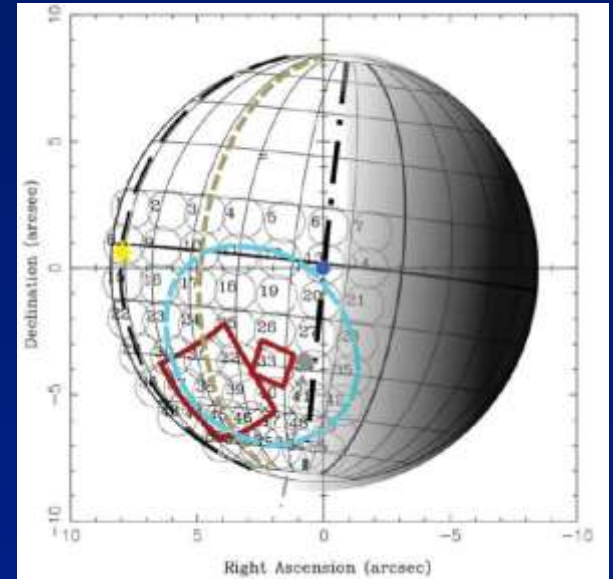
Zonal Wind Profile measured for images taken with a filter of 980nm



Why is ground-based data so important?

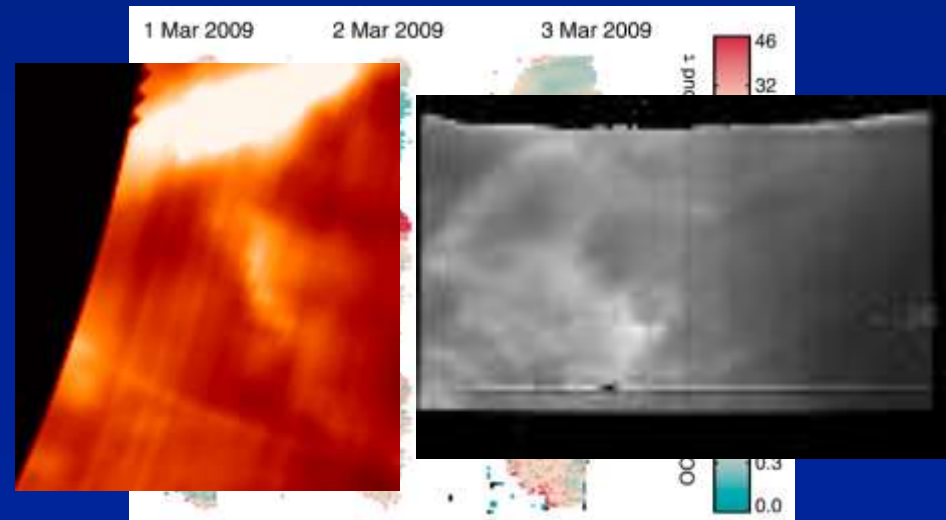
FOR SAME FILTERS AS AKATSUKI:

- Observers may provide images of Venus covering GAPS like:
 - Regions out of Akatsuki's FoV → 360° views?
 - All periods when Akatsuki doesn't acquire images.
- Simultaneous observations may be useful for CALIBRATION and confirm special events.



FOR DIFFERENT INSTRUMENTS:

- Images at different wavelengths:
 - Feature tracking above the clouds (nLTE emissions, nightglow,...)
- Atmospheric Spectra:
 - Temperature (for Thermal Wind Eq.)
 - Atmospheric compounds (DEEP!).



Example of special event: the White Spot of 2009

NORTH

Frank J Melillo



July 19, 2009
13:10 UT

CM I (surface) - 218
CM II (Atmos UV) - 185

Paul Maxson



WEST

July 20, 2009
13:00 UT

CM I (surface) - 221°
CM II (Atmos UV) - 268°

Location of an intense white spot



CM II (Atmos UV) - 153°

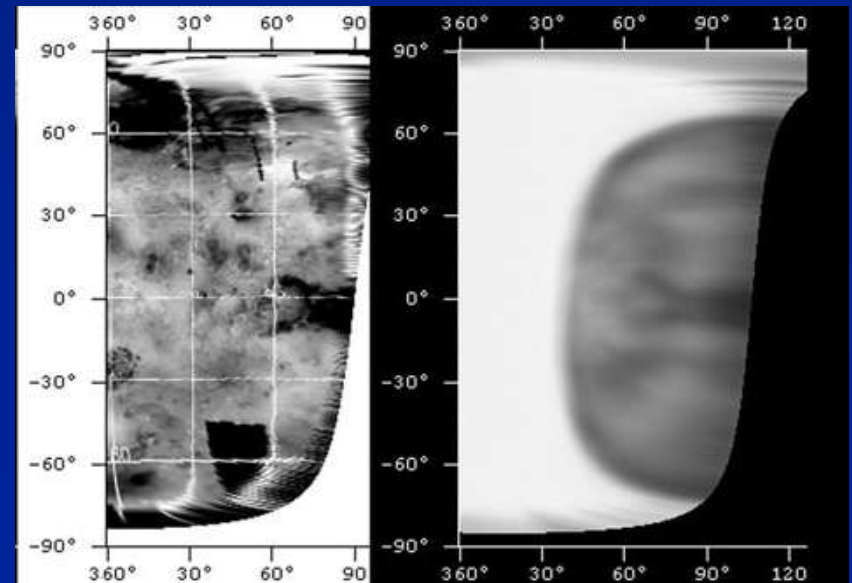
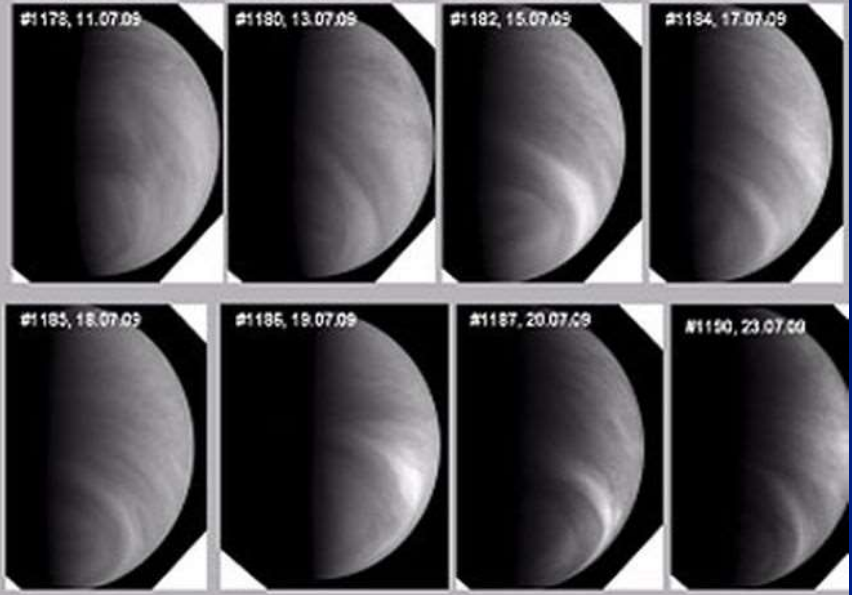
Latitude: -45° to -50°



CM II (Atmos UV) - 194°

Latitude: -50°

VMC UV images before the bright spot event on July 19, 2009

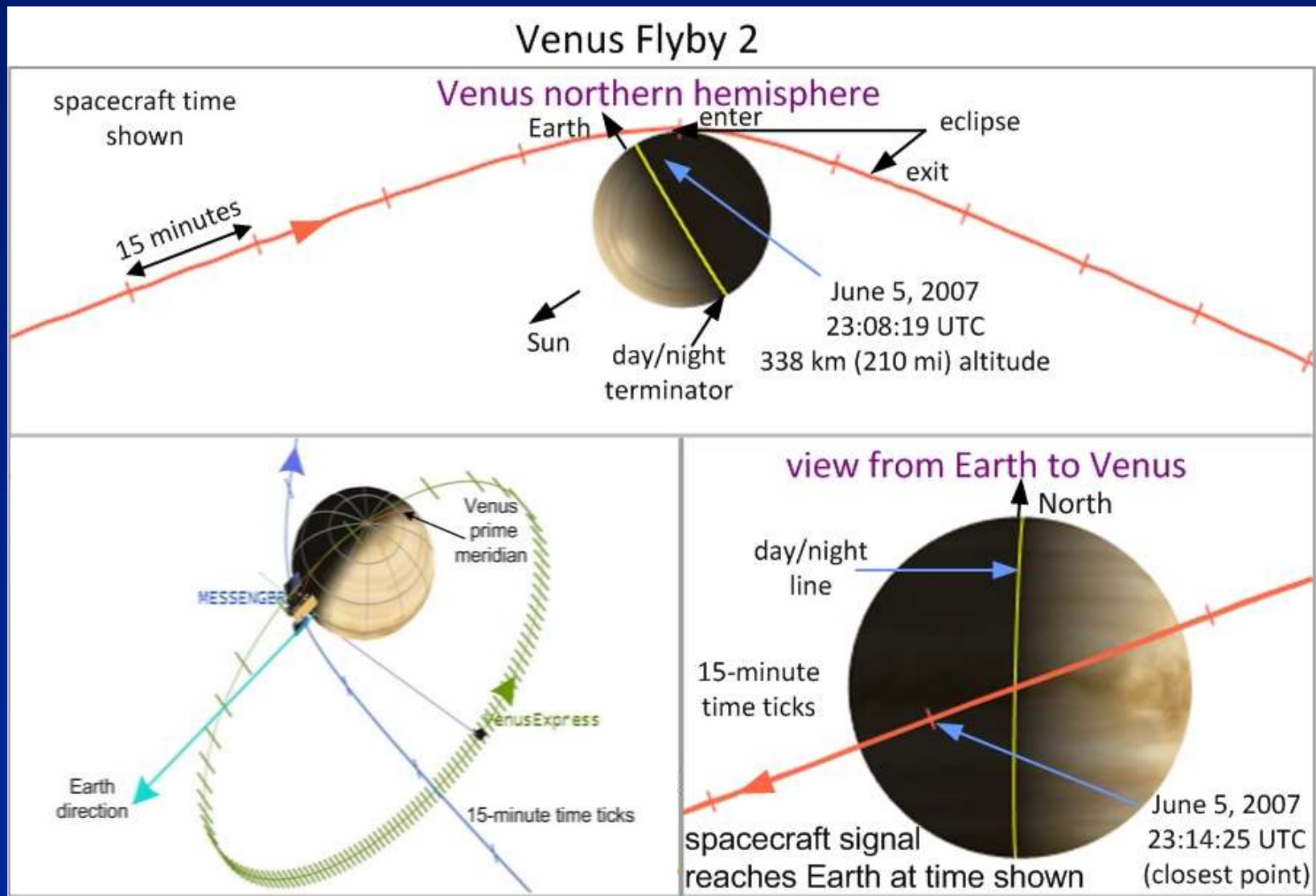


The Power of Coordinated Observations: the Messenger flyby in 2007

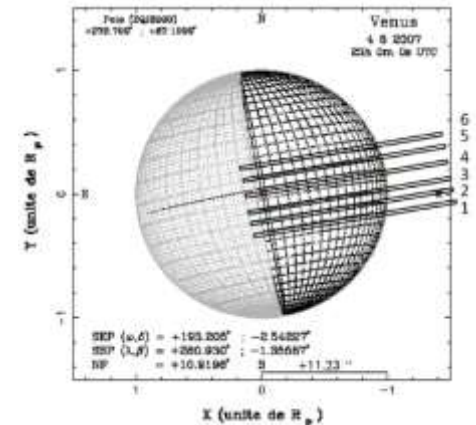
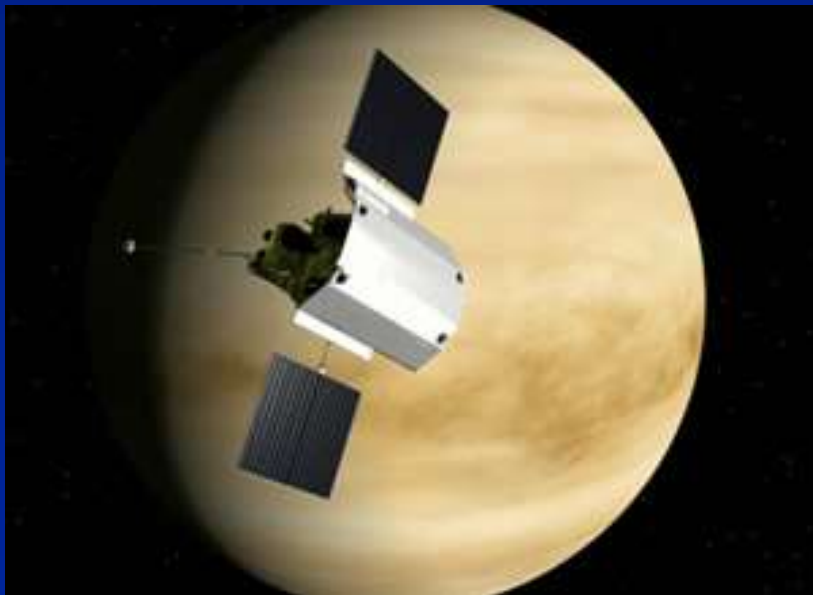
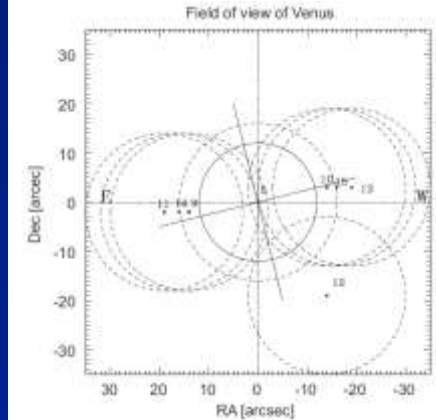
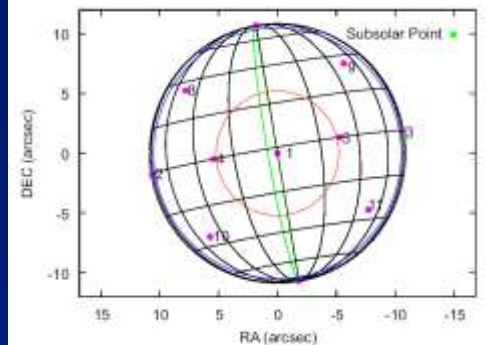
ONGOING PAPER

J. Peralta, Y. J. Lee, R. Hueso, R. T. Clancy, B. J. Sandor, A. Sánchez-Lavega, T. Imamura, M. Omino,
P. Machado, E. Lellouch, M. Rengel, S. Murakami, H. Ando, and D. Peach.

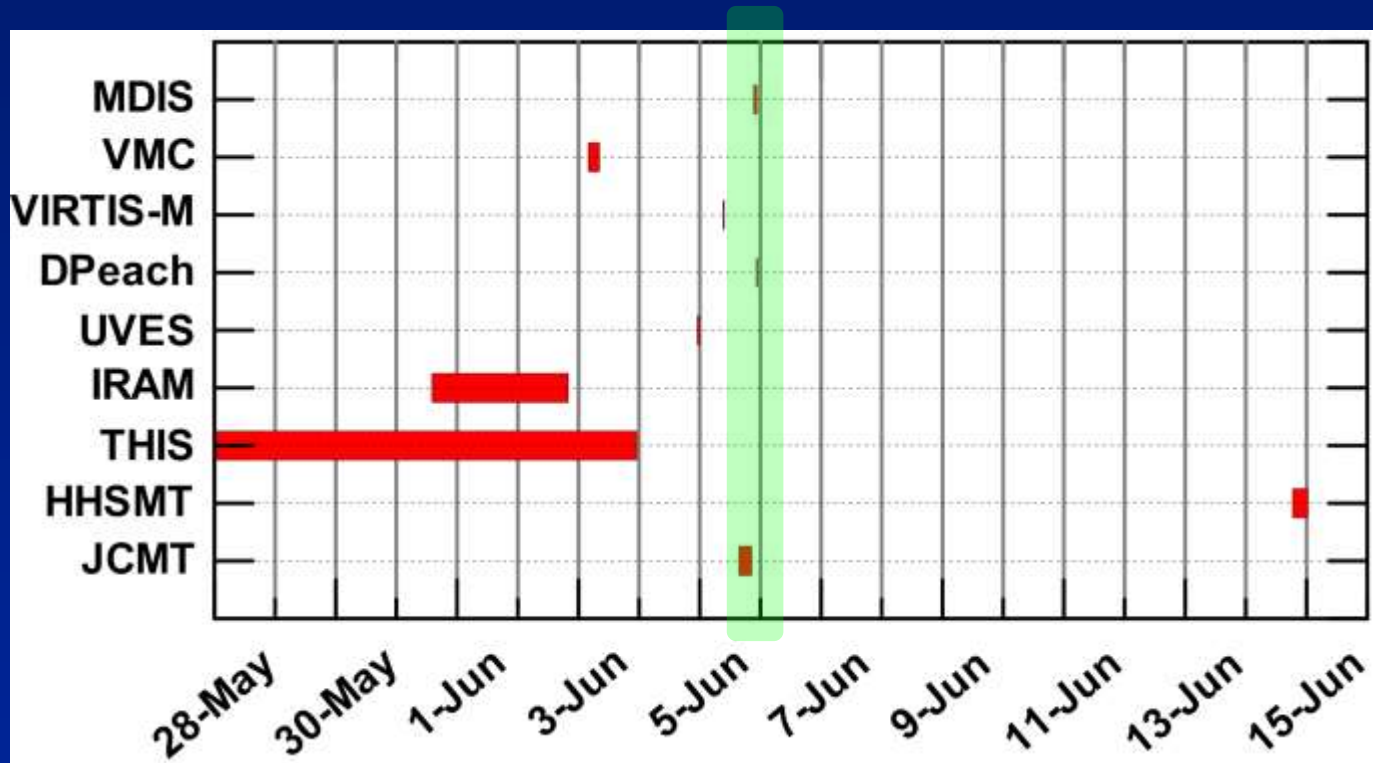
The Messenger's 2nd flyby in June 2007



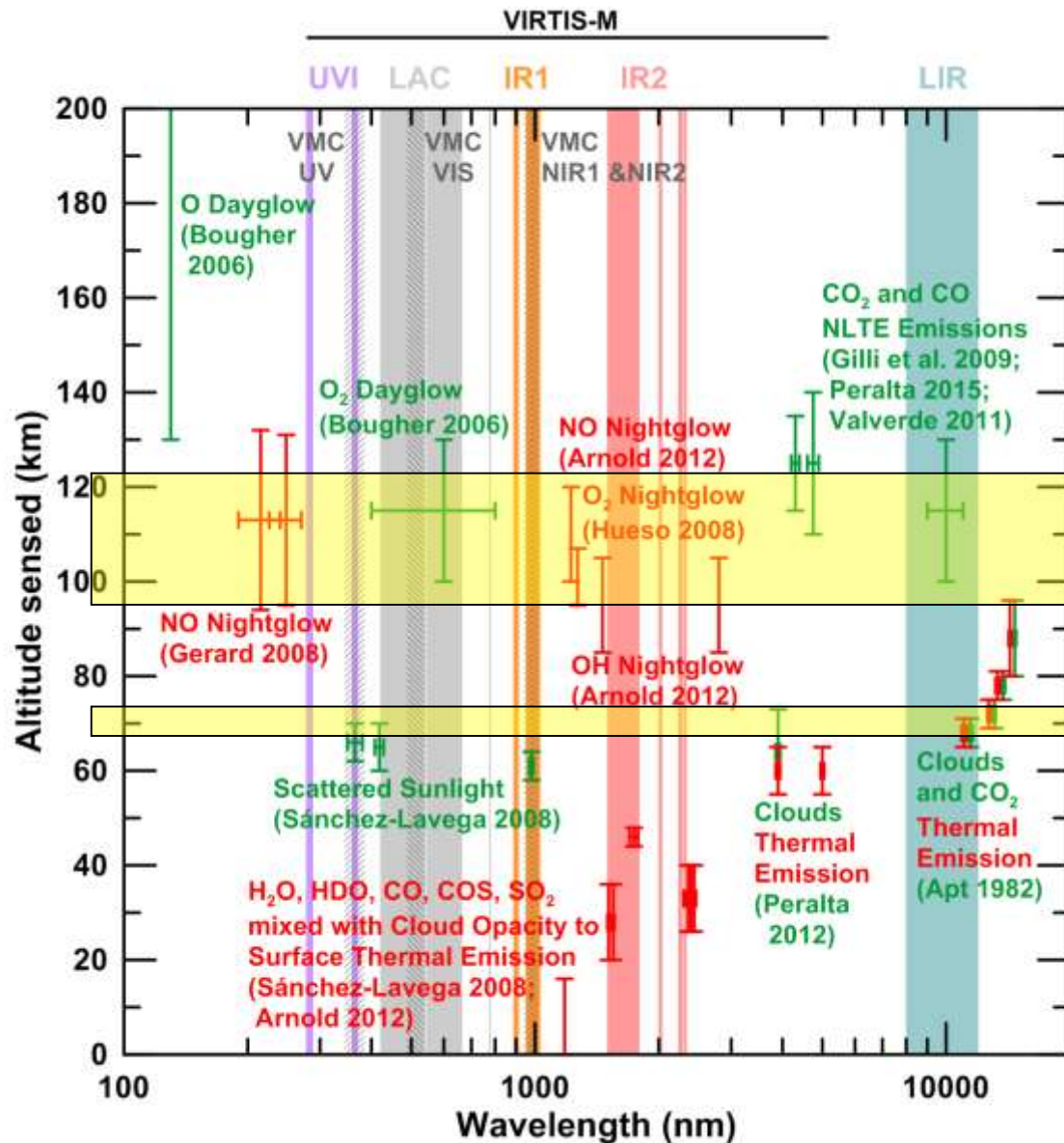
A perfect chance to get 3D “photo” of Venus winds!



The Messenger's 2nd flyby in 5 June 2007

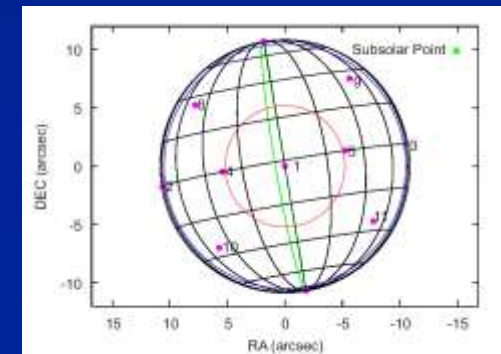
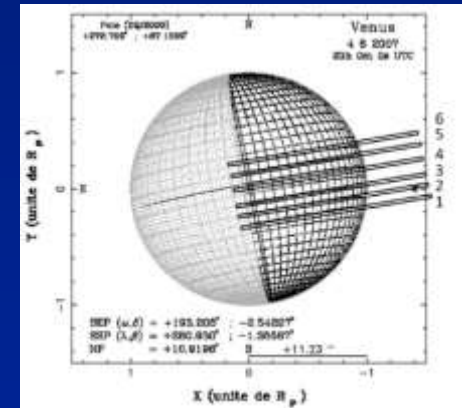


Venus' levels for nadir images (VEx & Messenger)

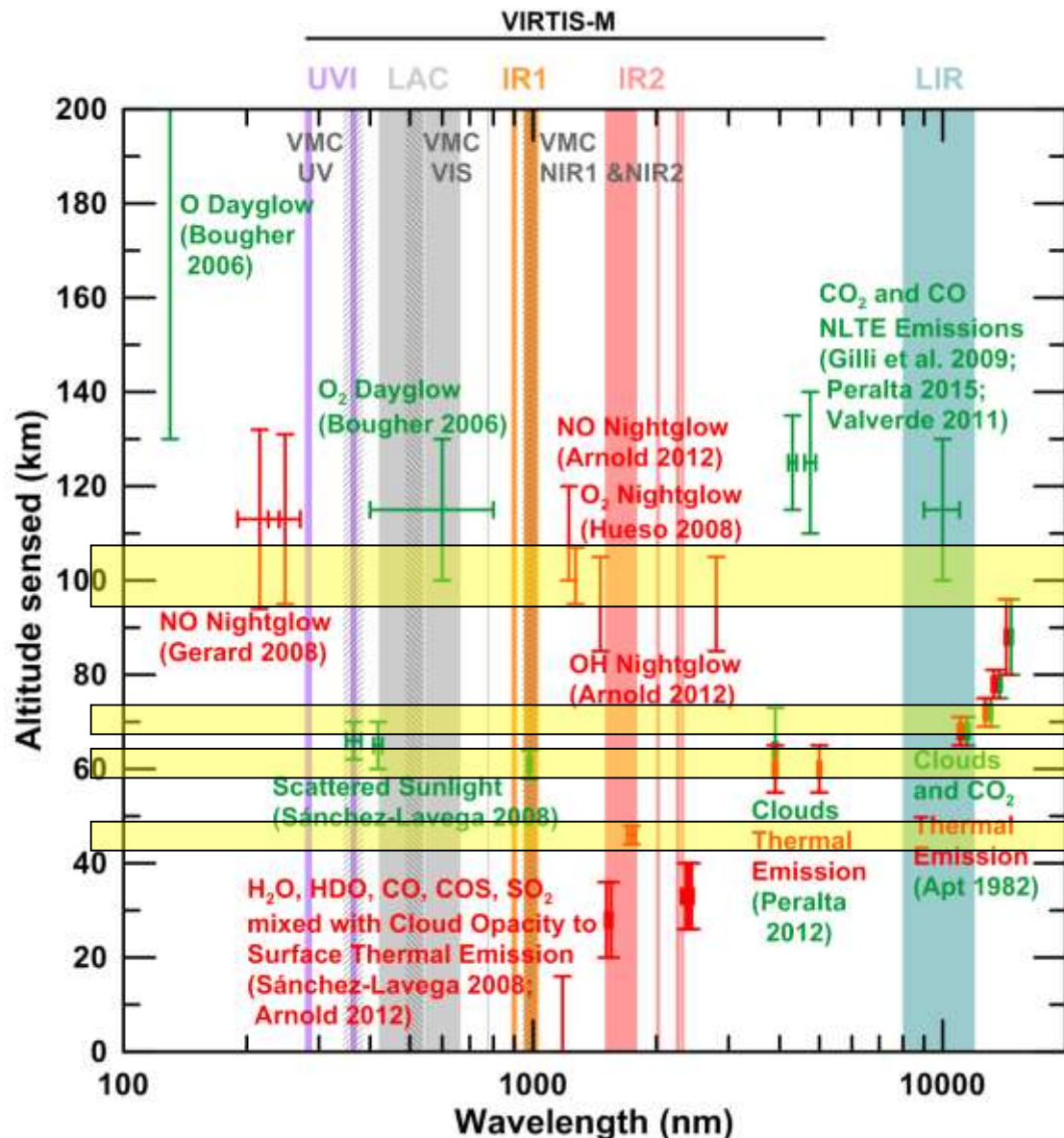


DOPPLER:

- 300-1100 nm spectra, for $z \sim 70$ km (Machado, 2012)
- 230 GHz CO(2-1), $z \sim 90$ -110 km (Lellouch, 2008)
- 210-279 and 320-375 GHz (CO), $z \sim 85$ -120 km (Rengel, 2008)



Venus' levels for nadir images (VEx & Messenger)

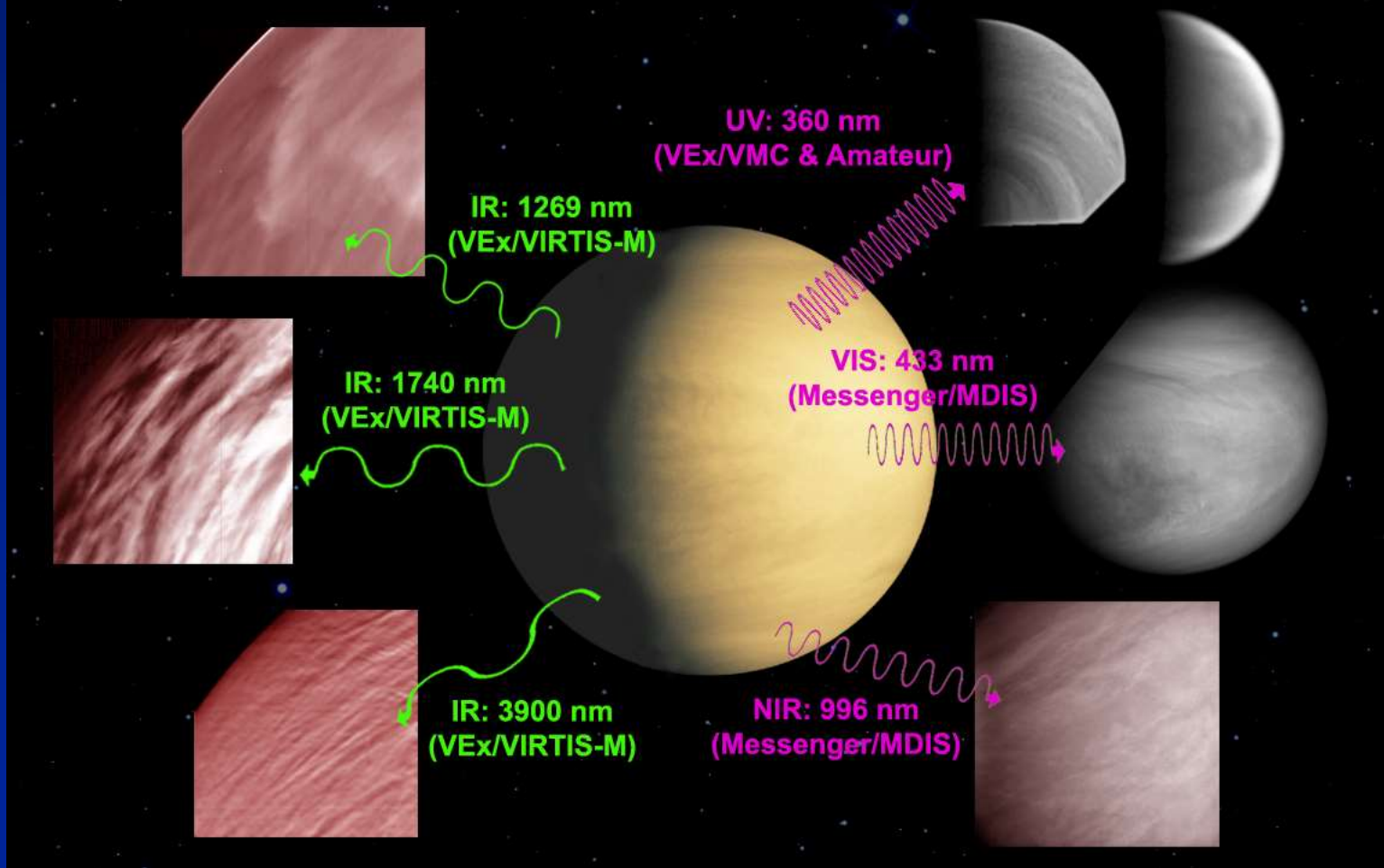


CLOUD TRACKING:

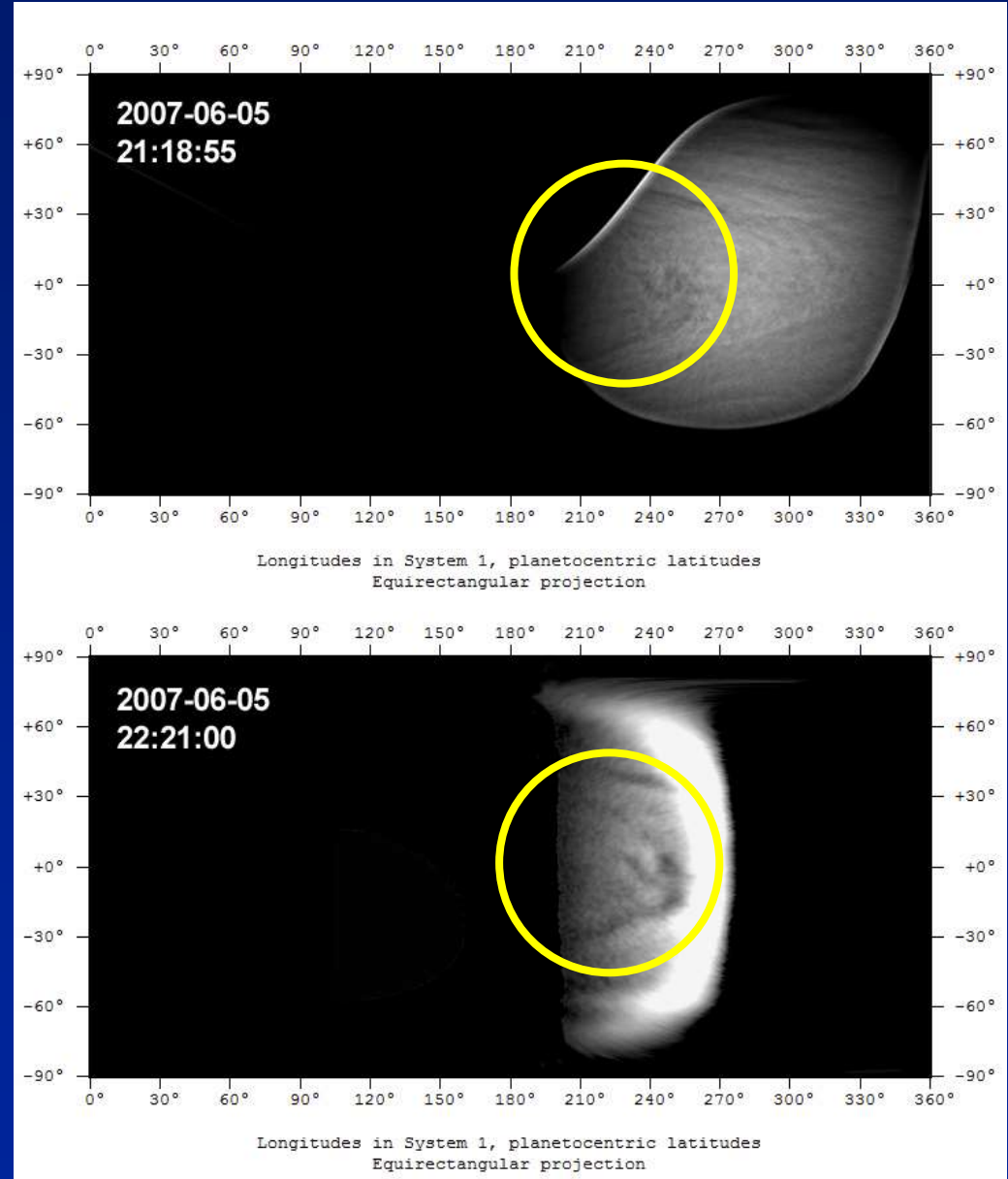
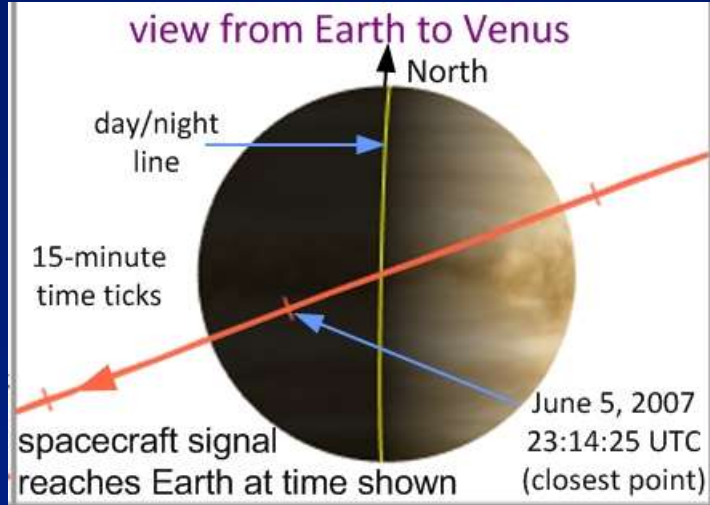
- 360 & 433 nm images, z~70 km (Messenger/MDIS & VEx/VMC)
- 1270 nm images, z~101 km (O₂ airglow, VEx/VIRTIS)
- 996 3900 nm images, z~60 km (Messenger/MDIS & VEx/VIRTIS)
- 1740 nm images, z~43 km (VEx/VIRTIS)

Images taken during the Messenger flyby

Images of Venus by Messenger, Venus Express and Amateur observers during 5 June 2007



Amateur and Messenger observations: coherent



Temperatures: VEx/VIRTIS (night) and JCMT (day)

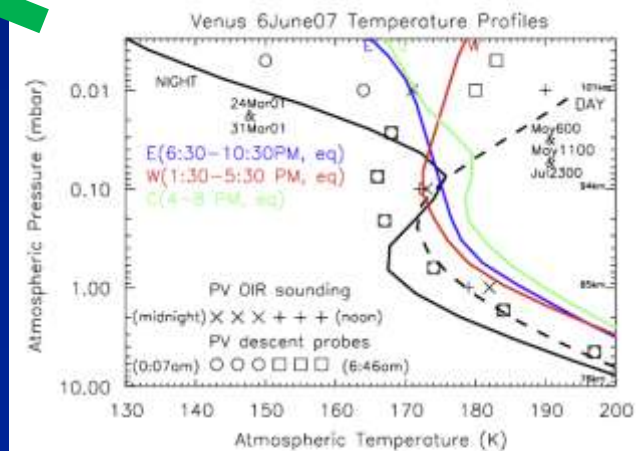
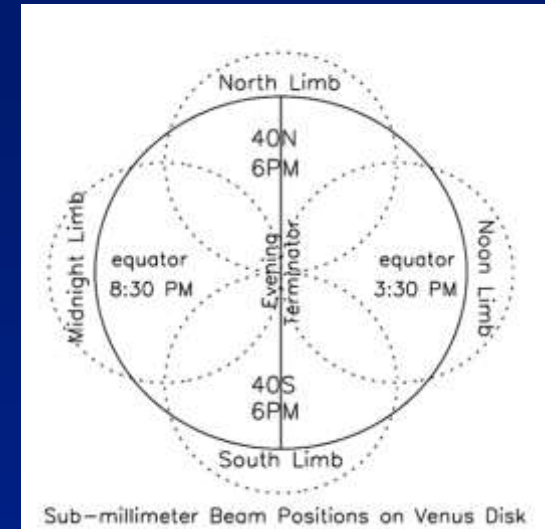
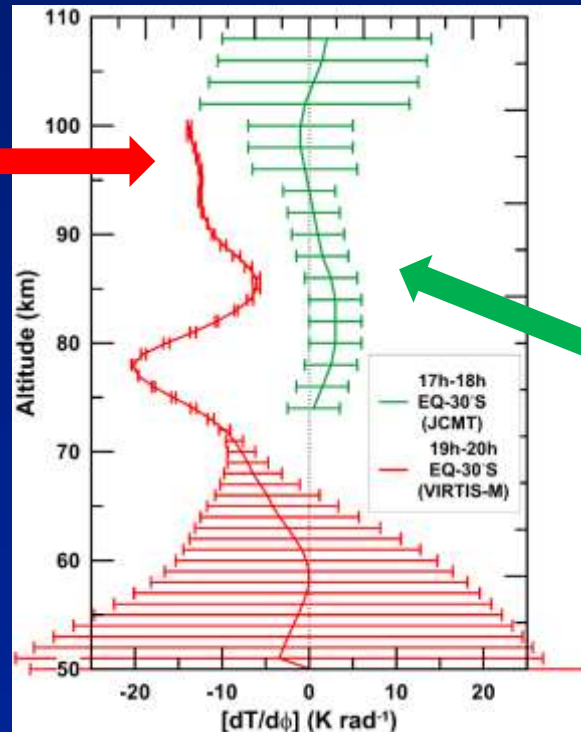
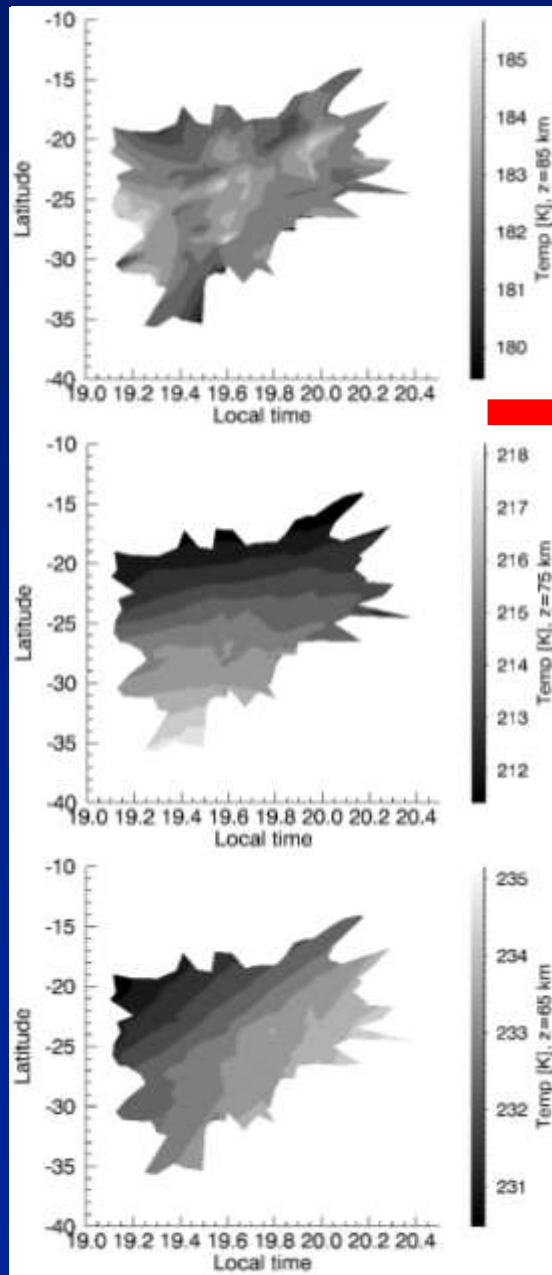
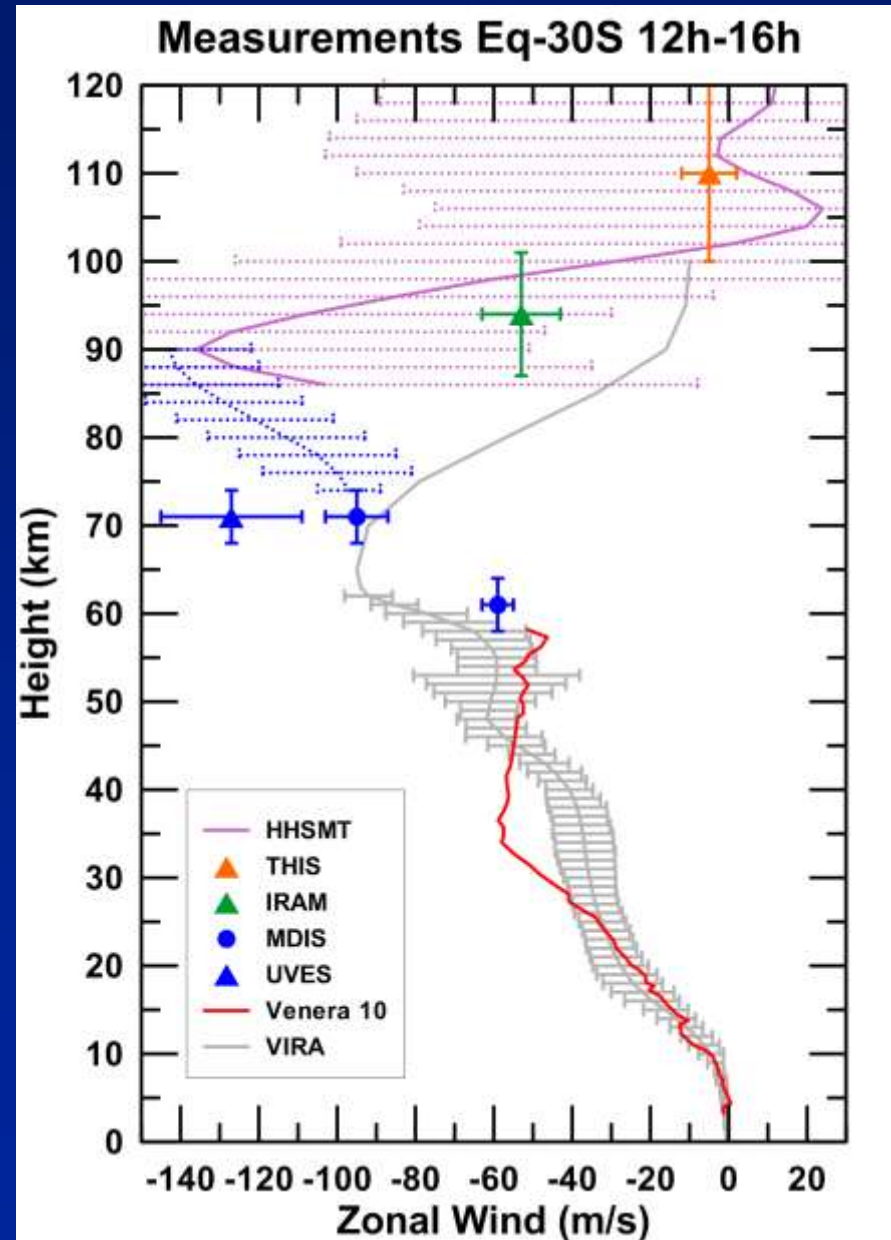
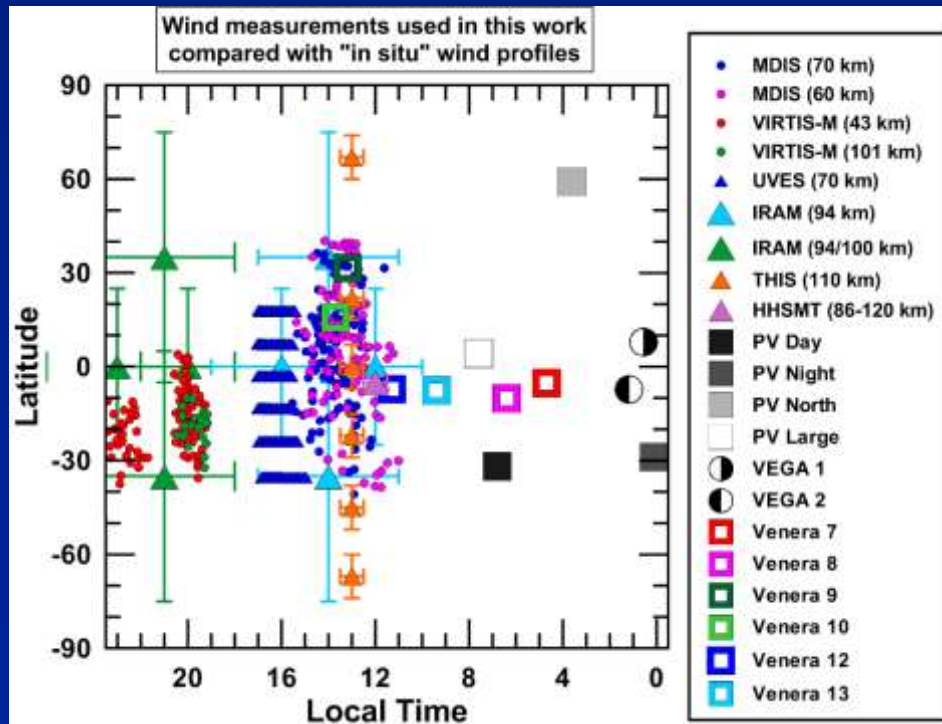


Fig. 11. The figure description is similar to that for Fig. 9, but pertains to June 6 temperature profile retrievals. However, only three disk positions for ^{12}CO spectral line measurements support temperature retrievals on this date; for afternoon (W, red, 3:30 p.m.), evening (E, blue, 8:30 p.m.), and terminator (C, green, 6 p.m.) local times of observation.

Preliminar winds' results during flyby

VERTICAL PROFILE FOR THE ZONAL WIND.

1. We can constrain the vertical variation of the winds at locations of Lat/Ltime, as well as compare with past "in situ" measurements.
2. Variability + Errors → difficult characterization for altitudes above the clouds.
3. Finishing the calculation of winds at vertical gaps using atmospheric temperatures from VIRTIS-M infrared cubes (Thermal Wind Equation)



How to coordinate ground-based
observations with Akatsuki mission?

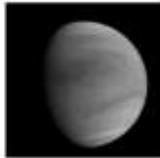
A website to coordinate with ground-based observers

AKATSUKI Project, coordination with ground-based observations

CAUTION! CAUTION! THIS WEB SITE IS UNDER CONSTRUCTION (2016/03/12)

Purpose of the coordination

- The AKATSUKI (Planet-C, Venus Climate Orbiter) team intend to create a worldwide network of amateur and professional observers to support the AKATSUKI observations to be carried out during the years 2016-2017.
- The AKATSUKI team will consider observers' instrumentation (spectrometers, filters for imaging, ...) in order to suggest specific campaigns to cover relevant gaps in the mission's dataset.
 - Venus images taken with filters not included in the spacecraft payload are of great value to the mission.
 - Atmospheric spectra and tables with high-level products (such as winds from Doppler-shift techniques) will be also welcome both prior or after their corresponding publication.



"VENUS image of the week"
(2015/12/07, AKATSUKI UVI)

Roles of observers

- Registered observers will receive information about specific campaigns by e-mail.
 - The information about orbit and observation schedule of AKATSUKI is available in this website.
- The observers will be able to upload own past and future observations (images, spectra, ...).
- The observers also have the chance of participating in the papers to be published by the AKATSUKI team by sharing their own data.
 - The AKATSUKI team will transform the images into the same format as the AKATSUKI images to make them ready-to-use for the incoming works. Those observers whose images were finally selected by the members of the AKATSUKI team will be invited to participate as co-authors in the corresponding articles to be published.

Information about AKATSUKI

- Calendar of AKATSUKI observations: Venus coverage

USC
02/05-02/07 NIGHT SIDE
02/08-02/10 DEDOT
02/11-02/13 NIGHT SIDE

- The geometry of Venus observations from the Earth

- Visibility of Akatsuki from the Usuda deep space center (USDC), satisfying elevation of Akatsuki $\times 14$ degree.



"World Map of Observers"

Registration

- Please contact "J00G@J00J000" with following information. On-line registration form will be available.

First name
Last name
Affiliation
E-mail
Observer Lat. (deg)
Observer Long. (deg)
Venus coverage: Day, Night, Day & Night
Data type: Images, Spectra (XXXX-XXXX), Tables
Filter (if any)
Spectrograph (if any)
Can coordinate with observers in other locations? y/n



TO ARRIVE SOON!!

Documentation:

- List of useful filters
- Free software for Acquisition & Stacking
- Instructions for Unexperienced Users
- Contact Scientists of Akatsuki Team

Arrange for a List of
COORDINATED OBSERVERS

AKATSUKI papers
requiring ground-based

Akatsuki's collaborators



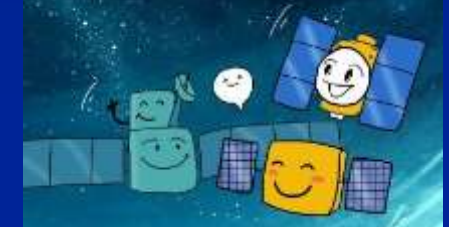
Recent submissions

 6 June 2015 Image #470 - Observers Observer: G. Hoshino Submitted: 1 June 2015 Status: accepted	 16 April 2015 Image #471 - Observers Observer: G. Hoshino Submitted: 10 April 2015 Status: accepted
 6 July 2013 Image #474 - Observers Observer: G. Hoshino Submitted: 30 July 2013 Status: accepted	 20 March 2012 Image #475 - Observers Observer: G. Hoshino Submitted: 10 March 2012 Status: accepted
 28 March 2012 Image #476 - Observers Observer: G. Hoshino Submitted: 10 March 2012 Status: accepted	 28 March 2012 Image #477 - Observers Observer: G. Hoshino Submitted: 10 March 2012 Status: accepted
 25 March 2012 Image #478 - Observers Observer: G. Hoshino Submitted: 10 March 2012 Status: accepted	 23 March 2012 Image #479 - Observers Observer: G. Hoshino Submitted: 10 March 2012 Status: accepted

Most active observers

1. G. Hoshino	114 Images
2. G. Hoshino	80 Images
3. G. Hoshino	37 Images
4. G. Hoshino	24 Images
5. G. Hoshino	19 Images
6. G. Hoshino	11 Images
7. G. Hoshino	11 Images

Latest News from Akatsuki!!



Network (for now) of Observers to support Akatsuki

OBSERVATORIO ASTRONOMICO
DE SANTANA AÇORES
(AÇORES ISLANDS, PORTUGAL)



ROBOTIC TELESCOPE WITH
PLANETCAM IN CALAR ALTO
(ALMERÍA, SPAIN)



SMALL OBSERVATORIES AND
AMATEUR OBSERVERS
(CANARY ISLANDS, SPAIN)



OBSERVATORY AT THE
UNIVERSITY OF NARIÑO
(TENERIFE, COLOMBIA)



ENTOTO OBSERVATORIES (ETHIOPIA)
MANAGED BY UNIVERSITY OF RWANDA



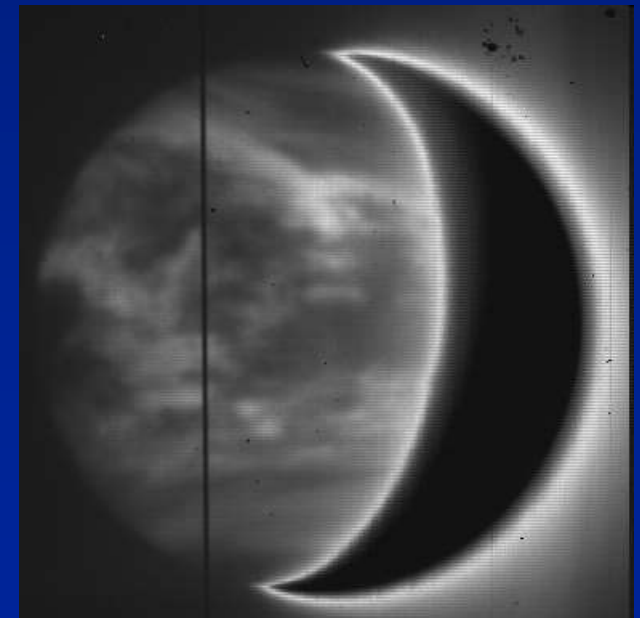
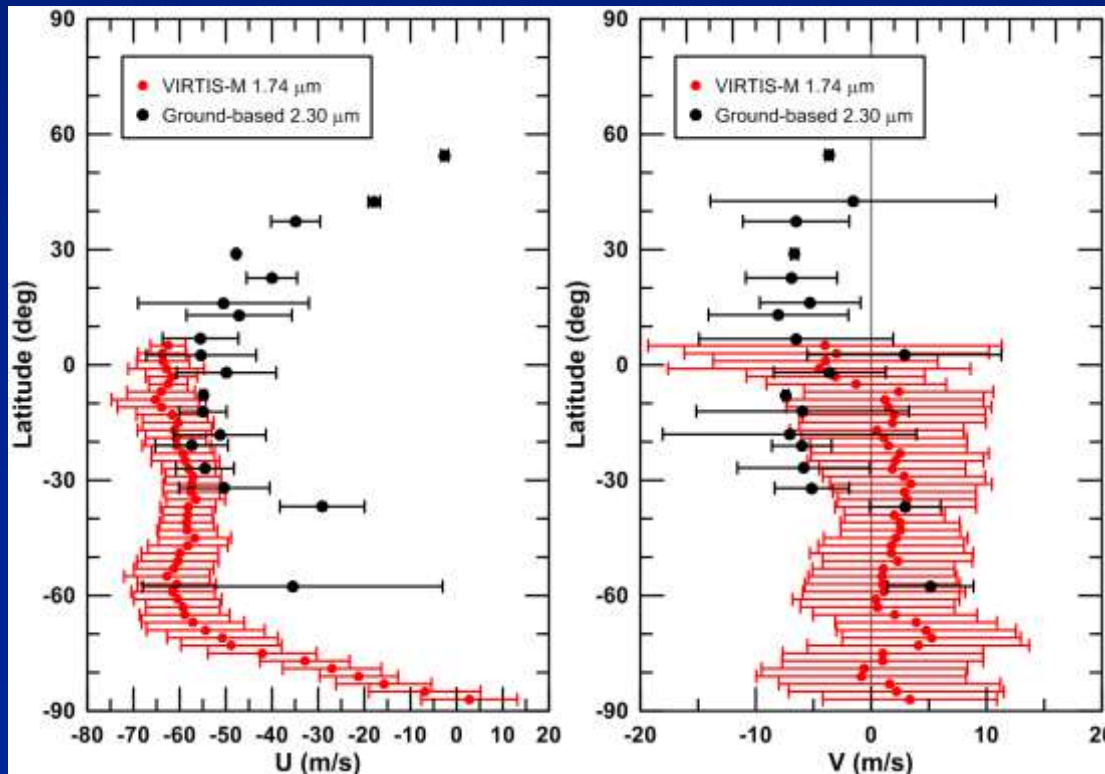
"OISTER" AND
AMATEUR OBSERVERS
(JAPAN)

Ground-based observations: cloud tracking results



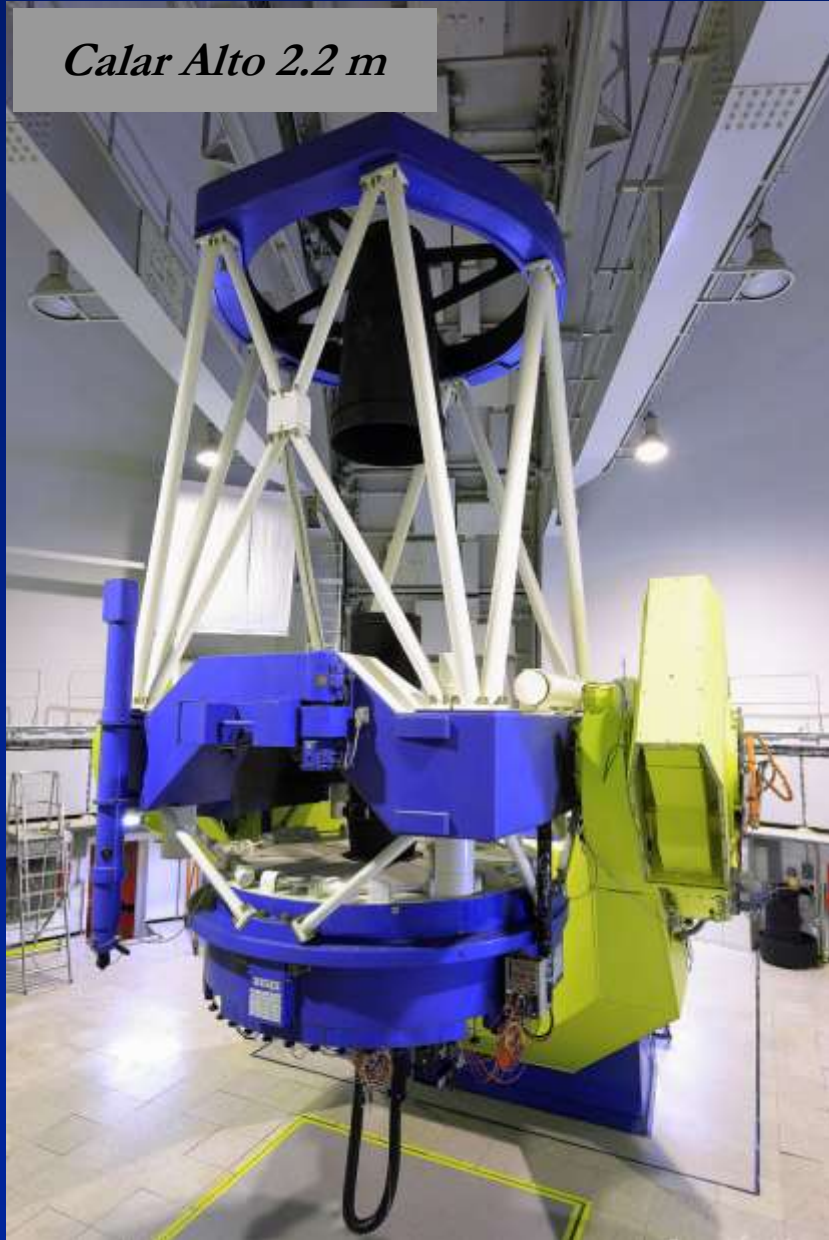
COMPARISON:

- 2.30 μm images (Limaye 2006)
- 1.74 μm images (Hueso 2012)



The role to be played by PlanetCam (UPV/EHU)

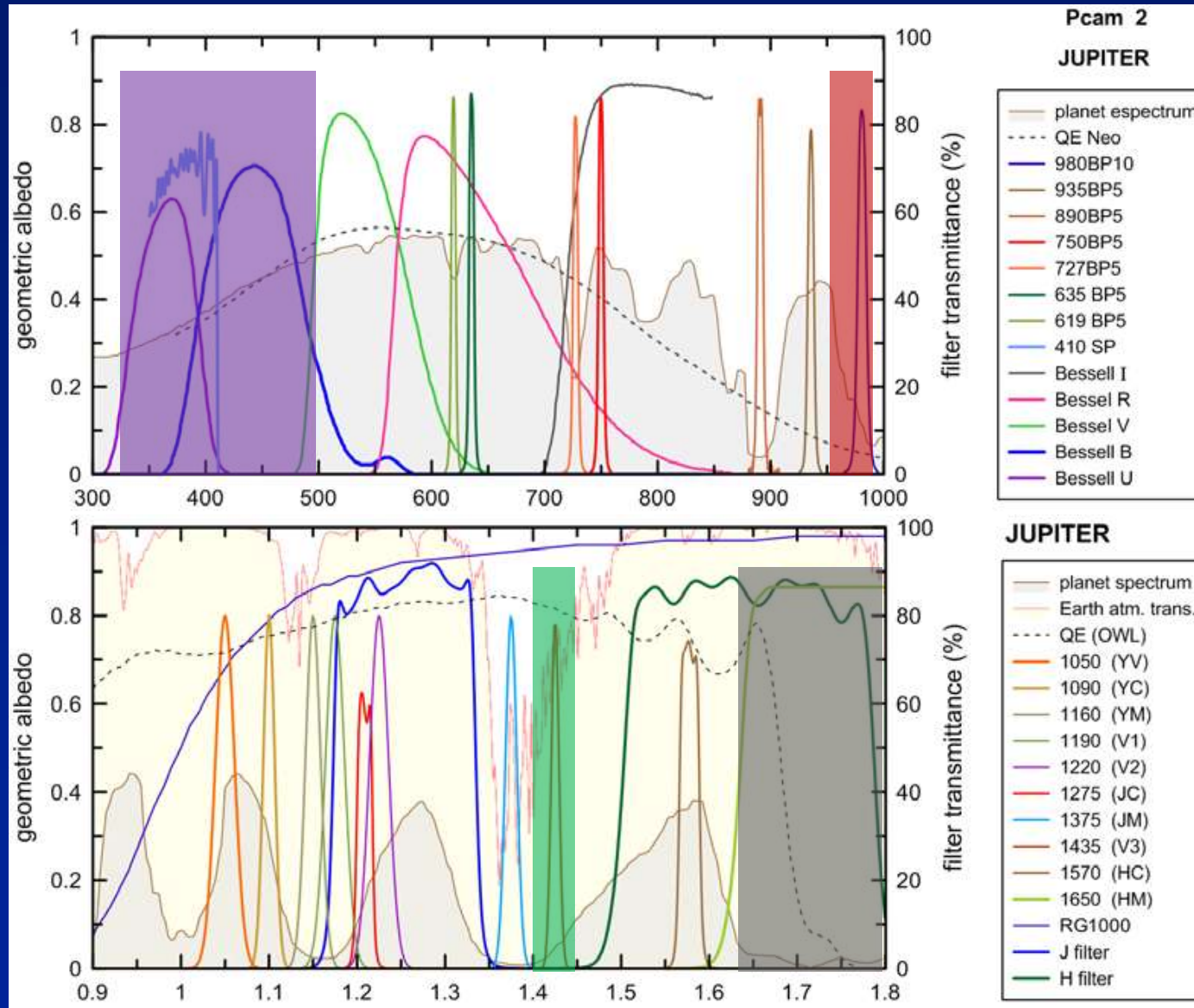
Calar Alto 2.2 m



Calar Alto 1.2 m



The role to be played by PlanetCam (UPV/EHU)



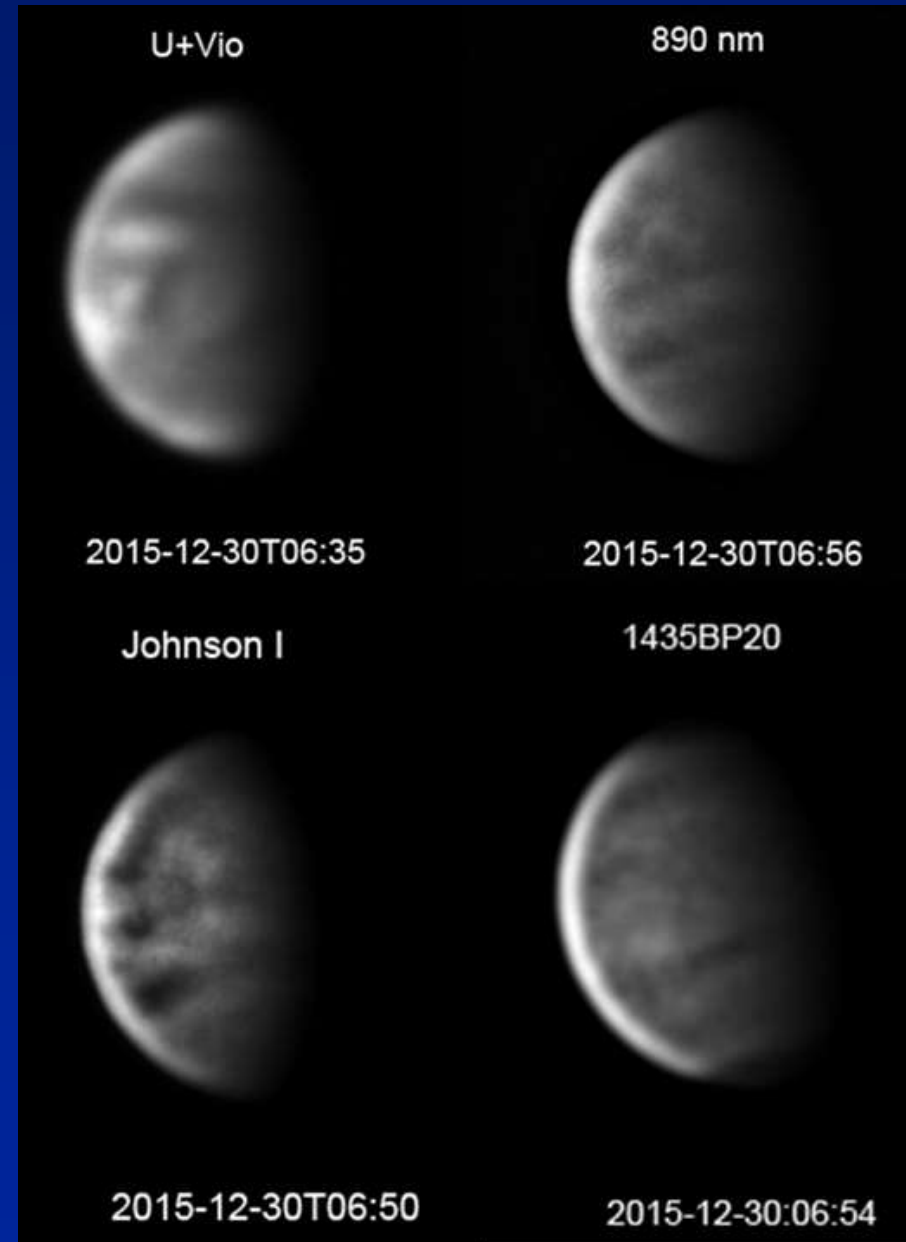
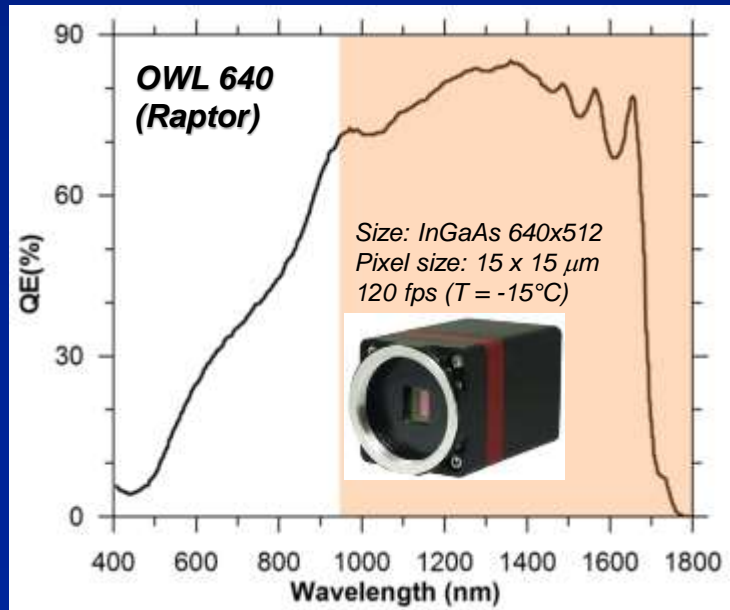
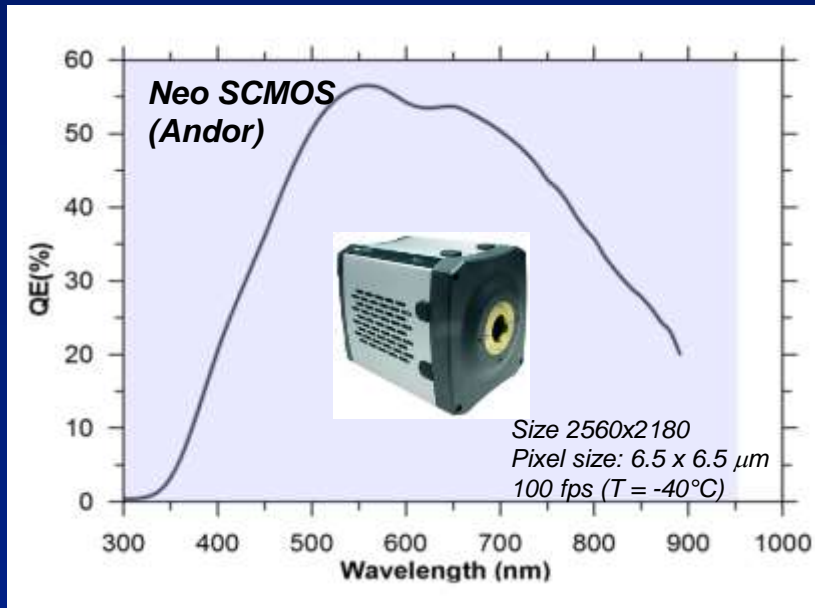
Bessell U & B: winds and scattering at 70 km (DAY, cloud tops).

980BP10: winds at about 60 km (DAY).

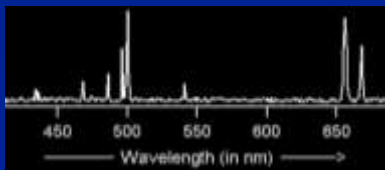
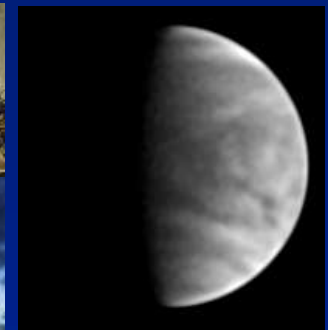
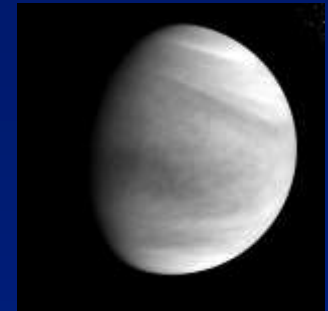
1435(V3): height of the cloud tops (DAY).

1650(HM): winds and cloud opacity at 43 km (NIGHT, lower clouds).

First ground-based observations during Akatsuki



How do we expect collaboration to be?



Date	Wind Speed (m/s)
2015-09-10 00:00	1.5
2015-09-10 01:00	0.9
2015-09-10 02:00	0.4
2015-09-10 03:00	1.1
2015-09-10 04:00	2
2015-09-10 05:00	1.4
2015-09-10 06:00	0.7
2015-09-10 07:00	0.6

OBSERVER UPLOADS DATA TO TEMPORAL SERVER:

- Raw images (CROPPED)
- Calibrated images/spectra
- Bright STAR ("seeing")
- Tables of data
- Observation Time (UTC)
- Observer coordinates
- Filter used
- Time for sequence of images in stacking

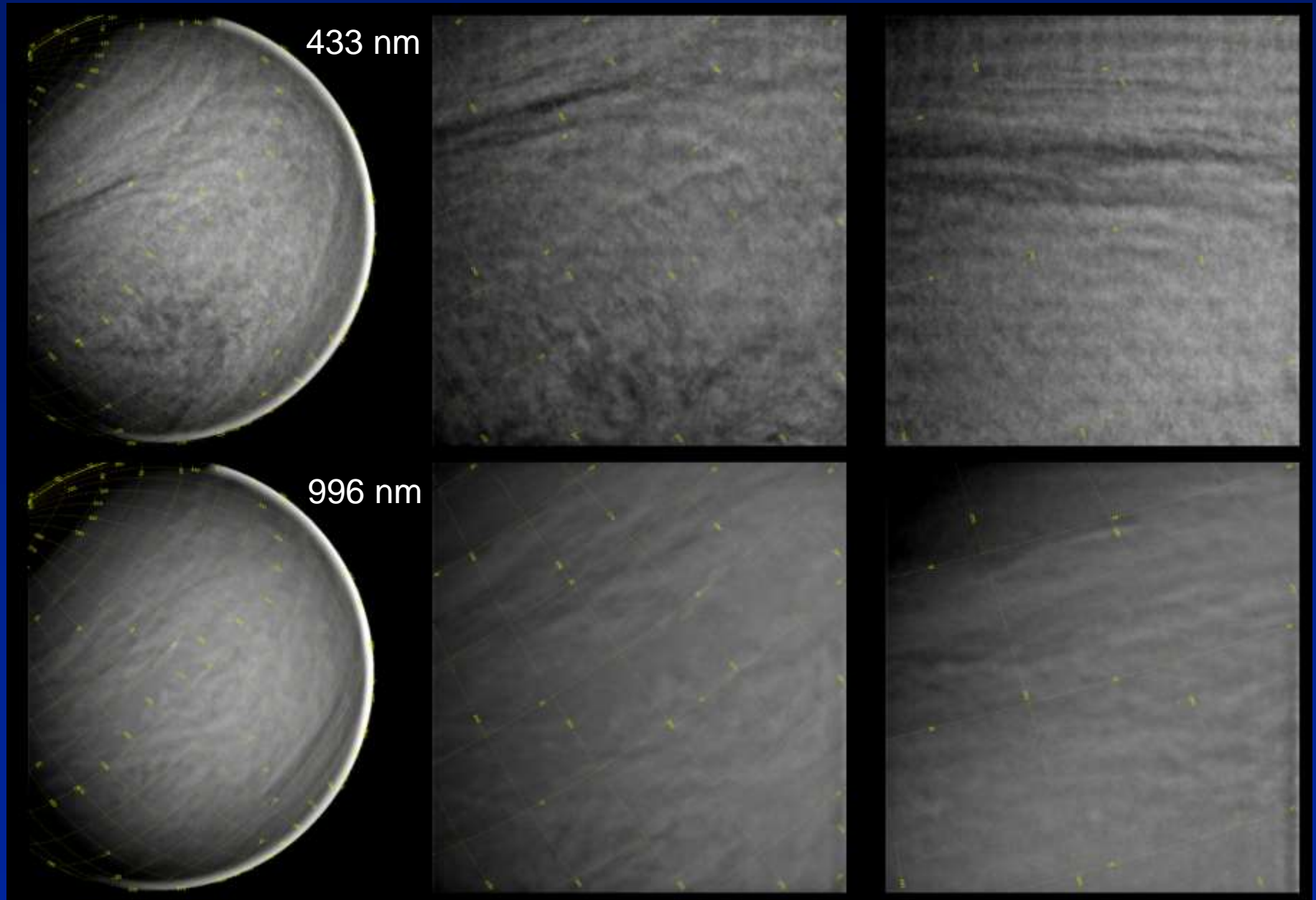
AKATSUKI TASKS:

- Quality check
- Navigation (SPICE)
- Transform into FITS:
 - RAW, CAL and GEO
- Upload to Akatsuki server
- Update Calendar/Log file
- ...
- Observers co-author papers if their images/data are used by Akatsuki team.

終り



Cloud morphology at 70 km and 60 km



Techniques for Tracking Atmospheric features (II)

1. Manual Tracking.

1. Trustable when experience acquired.
2. Avoid outliers as tracers.
3. Very slow. Demands learning stage.

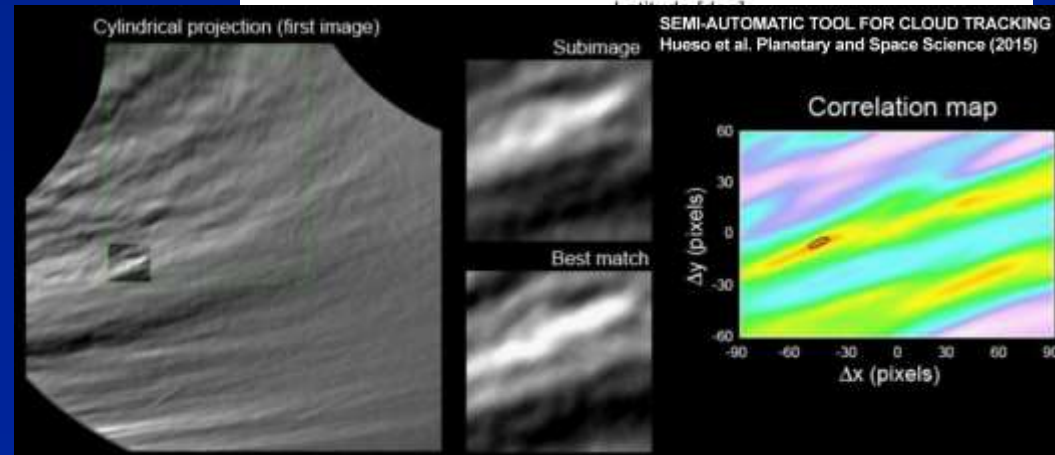
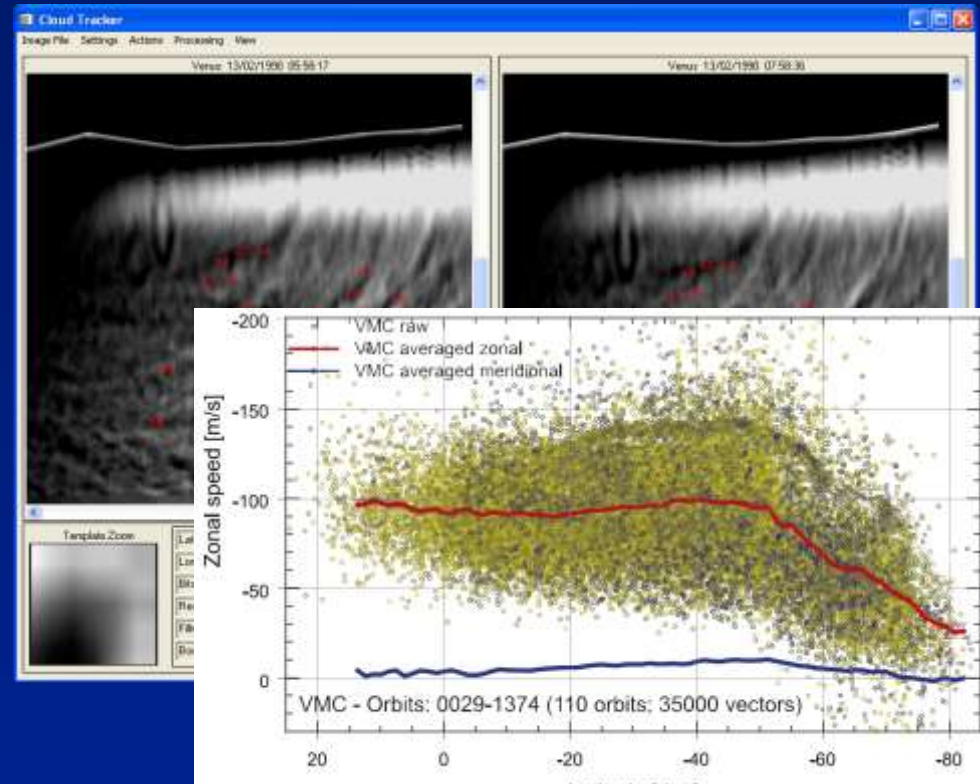
2. Automatic Tracking.

1. Blind: includes outliers and bad measurements.
2. Hundreds times more measurements.
3. Fastest method.

3. Semi-Automatic Tracking.

1. Human operator accepts/rejects each automatic measurement.
2. High number of measurements in a short time.

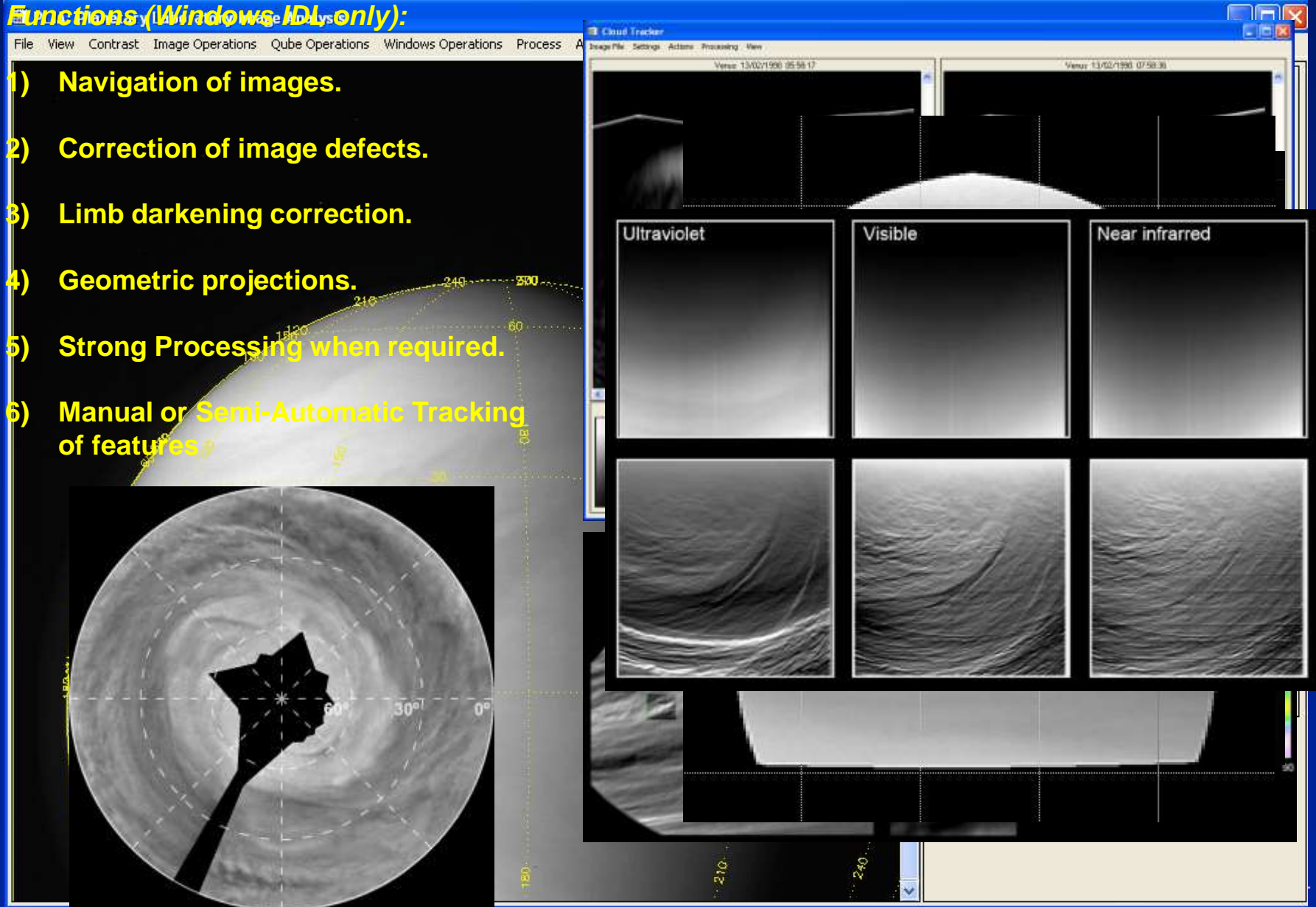
$$u = (R + H) \cdot \cos \phi \cdot \frac{\Delta \lambda}{\Delta t}$$
$$v = (R + H) \cdot \frac{\Delta \phi}{\Delta t}$$



Planetary Laboratory for Image Analysis (PLIA)

Functions (Windows IDL only):

- 1) Navigation of images.
- 2) Correction of image defects.
- 3) Limb darkening correction.
- 4) Geometric projections.
- 5) Strong Processing when required.
- 6) Manual or Semi-Automatic Tracking of features.



Ground-based observations: mandatory comparison

observational astronomy

SCIENCE & TECHNOLOGY OBSERVATIONAL ASTRONOMY

VENUS AMATEUR OBSERVING PROJECT

INTRODUCTION

The Venus Amateur Observing Project (VAOP) is an opportunity to contribute scientifically useful images and data to complement the Venus Express (VEX) spacecraft observations of Venus. The project will focus on utilising the capabilities of advanced amateurs to obtain images of the atmosphere of Venus; specifically filtered monochrome images obtained with CCD based cameras in the 350nm to 1000nm (near ultraviolet, visible and near infrared range).

23-Apr-2015 11:16:10

Shortcut URL
<http://sci.esa.int/VAOP/>

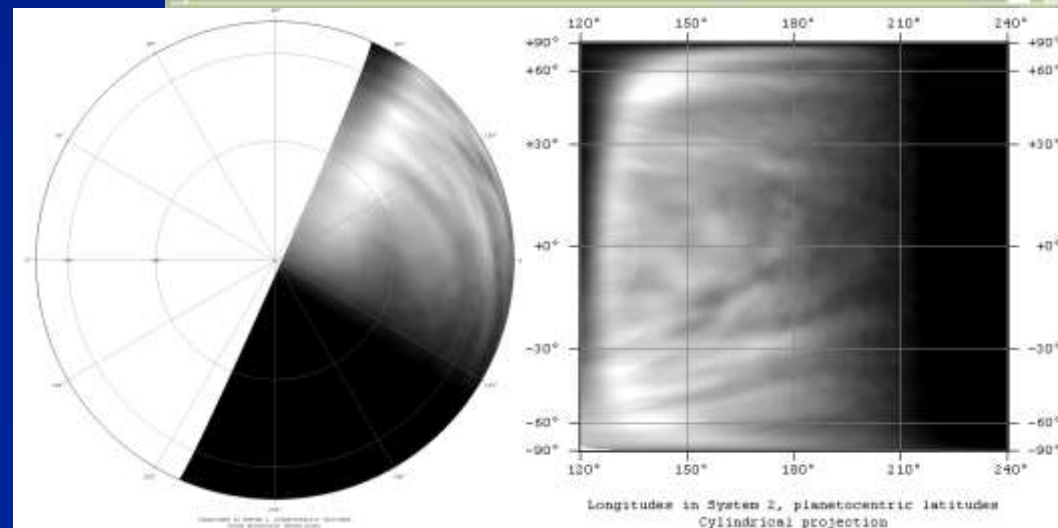
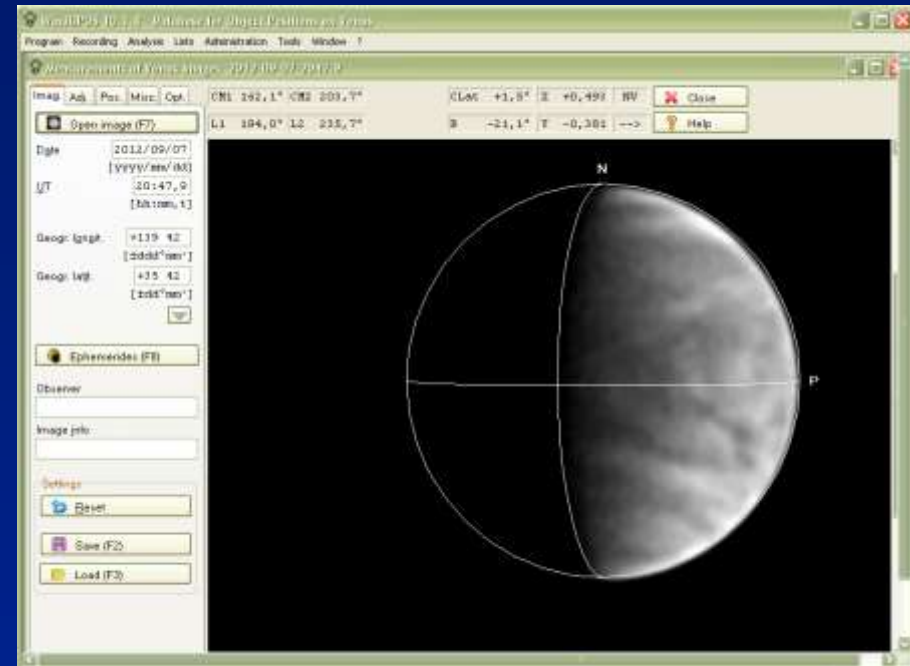
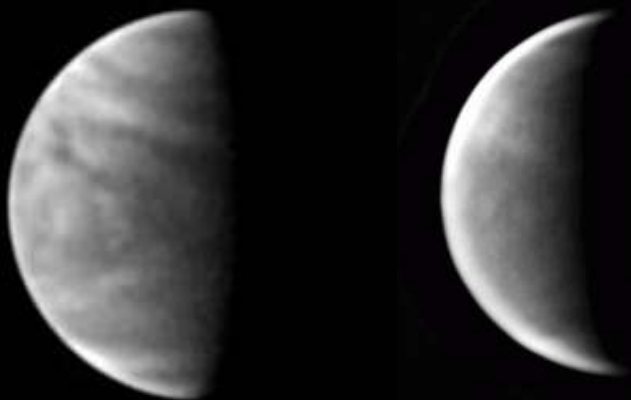
Related Articles
- Introduction
- Equipment

2012/09/07 - 20:47.9 , UV

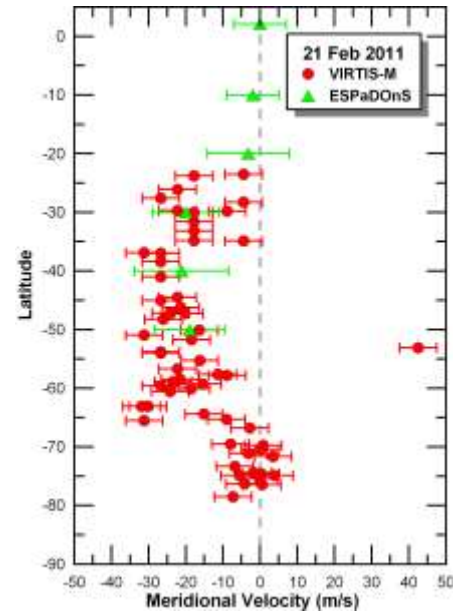
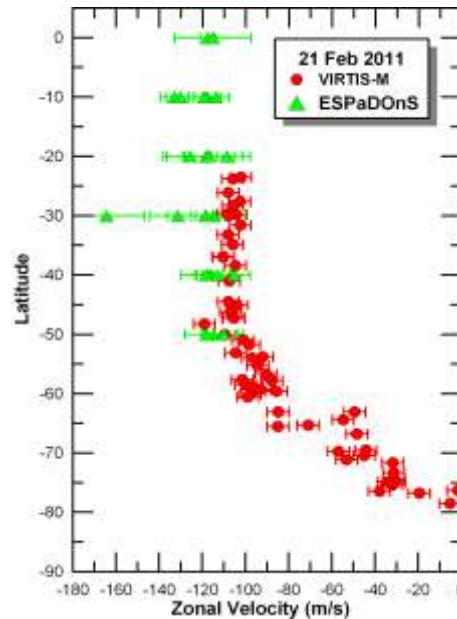
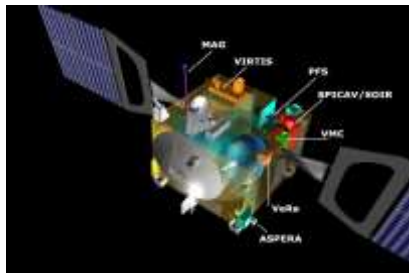
(355nm/60nm)

UV 32msec (120sec)

A.Yamazaki : Machida Tokyo Japan



Ground-based observations: Doppler results



COMPARISON:

- 380 nm images (Machado 2014)
- UV/VIS spectra (Machado 2014)

