COORDINATED GROUND-BASED MEASUREMENTS WITH VCO/AKATSUKI AND VENUS EXPRESS

3rd Sakura meeting, ISAS, Japan

21-22 Nov. 2011

Draft minutes of the meeting
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The meeting took place in ISAS building A in Sagamihara on Nov. 21-22, 2011.

I – Reports

- Report on VEXAG International Venus Workshop: August 31–September 1, 2011
Science program at : http://www.lpi.usra.edu/vexag/augSept11/ScienceProgram.pdf
- NASA's Planetary Science Subcommittee of the NASA Advisory Council (NAC) discussed opportunity for a Venus Climate Mission on Oct. 27.
- Report on several Venus ground-based presentations at the EPSC-DPS meeting held Oct. 2-7 in Nantes

  - M. Hosouchi, N. Iwagami, S. Ohtsuki, and M. Takagi, Wave signature in the Venus cloud layer at 60 km observed by ground-based dayside infrared spectroscopy
  - P. Tanga, T. Widemann, and B. Sicardy,The aureole of Venus: light refraction in the mesosphere during the solar transit of June 6, 2004
  - S. Ohtsuki, N. Iwagami, T. Kouyama, N. Hoshino, and T. Imamura, Temporal and spatial variations of the Venus 1.27-um O2 airglow observed from ground
  - M. Sornig, G. Sonnabend, D. Stupar, and T. Stangier, Ground-Based Doppler-Wind and Temperature Measurements by Infrared Heterodyne Spectroscopy
  - P. Machado, D. Luz, and T. Widemann, Characterization of Venus' cloud top dynamics using ground-based Doppler velocimetry
  - T. Stangier, M. Sornig, D. Stupar, and G. Sonnabend, Investigation of CO2 Absorption Features on Venus C.L. Gray, N.J. Chanover, and T.G. Slanger, Recent Observations of Venus' OI and O2 Emission
  - G. Sonnabend, P. Krötz, F. Schmülling, T. Kostiuk, J. Goldstein, M. Sornig, D. Stupar, T. Livengood, T. Hewagama, K. Fast, A. Mahieux, and R.T. Clancy, Thermospheric/mesospheric temperatures on Venus: comparison between ground-based high-resolution spectroscopy of CO2 and other techniques.

- Report on atmospheric waves workshop organized at ESA/ESTEC on Nov. 9-10, the scope of the workshop was to discuss the nature of waves observed in Venus atmosphere by several experiments on board Venus Express and their comparison to similar features observed on other planets (Mars, Earth). Science program at: http://www.rssd.esa.int/index.php?project=VENUSEXPRESS&page=atm_waves_programme

Venus Express – A short report on the Venus Express Science Working Team (SWT) held in Graz, Austria November 16-18 was given (T.W., S.L.) The European Space Agency orbiter is continuing its operations and no major concerns are reported. The mission is approved through December 2014 pending a review in mid-2012. ESA has made the decision to postpone aerobreaking of the spacecraft to achieve a lower orbit. P.I. reports were presented. The next Venus Express Science Working Team will be held in Svalbaard, Norway during 4-6 June 2012 in conjunction with the Venus transit.

Akatsuki. - Akatsuki (Venus Climate Orbiter) was successfully launched on 21 May 2010 by a H-IIA launch vehicle from Tanegashima Space Center. Condition of Akatsuki spacecraft and payload instruments is normal. Temperature environment an issue (increasing) as perihelion is much closer to the sun. Phase trajectory correction manoeuvers were scheduled on Nov. 1, 10, 21 (the last one during this meeting). Full support was received from NASA HQ/JPL/DSN in October and November 2011 for telemetry, orbit determination and tracking before and after corrections. Next correction is scheduled for 2015. Expected insertion orbit : various possibilities, polar or equatorial. Apoapsis should be rather high (several tens of Venus radii).

II – Science presentations

1 - Modeling

Masahiro Takagi (Univ. Tokyo) : A radiative transfer model has been incorporated into a 3D general circulation model in order to investigate the mean meridional circulation. The result obtained for the zonally averaged solar heating shows that the mean meridional circulation splits into vertically stacked cells at 30–80 km level. Mean zonal flow with mid-latitude jets is induced by the mean meridional circulation at cloud level. It remains

weak below 30 km. The model shows that the mean meridional circulation actually splits into two cells, which extend from 30 to 50 km and 50 to 80 km, respectively.

Takeshi Imamura (ISAS/JAXA) : A possible heat-induced circulation in Venus's tropical lower atmosphere is explored. Large-scale topographic rises including Aphrodite terra in the equatorial region provide heat sources in the atmosphere away from the surface (~6 km). Such heat sources might induce planetary-scale axi-asymmetric tropical circulation. Although (retrograde) rotation of Venus is slow (weaker than 1 m s^{-1} near the surface) the low static stability of the atmosphere leads to a relatively small deformation radius, enabling the circulation being trapped in the low latitude. Modeling the exact form of this anomalous thermal forcing requires information on the vertical heat transport from the surface via radiation and diffusion and the horizontal heat transport from higher latitudes via meridional circulation and horizontal mixing. The response of the circulation is amplified when the background wind speed is near the phase speed of the Rossby wave or the inertio-gravity wave.

Naoki Satoh (Gakugei Univ.) and **Toru Kouyama** (Univ. Tokyo) discussed momentum flux inferred from the VEx/VMC data and long-term variations of the superrotation and the relation with atmospheric waves.

Marie-Ève Gagné (U. Toronto/Canadian Space Agency) presented her new photochemical model of nightglow emission simulations aimed at better describing the physical and chemical processes that govern the distribution of oxygen in the mesosphere of CO_2-dominated atmospheres like Mars and Venus. The model incorporates mechanisms that control the atomic oxygen density ; the implication of O concentration for the thermal structure and the resulting energetic budget. It addresses emissions by energized O_2 and NO to infer the local temperature and atomic oxygen densities. It has been validated for consistency with observations of the emissions by spectrometers on board the two spacecrafts missions from the European Space Agency, MEx and VEx.

2 - VEx and Akatsuki observations

Hiroki Ando (U. Tokyo) analyzed temperature profiles between 35 and 95 km altitude from the Venus Express /VeRa experiment. For the purpose of testing the Akatsuki radio science system, radio waves transmitted from Venus Express were observed at UDSC and analyzed to retrieve five vertical temperature profiles. Vertical wavenumber spectra of small-vertical scale perturbations were examined based on the assumption that the temperature perturbations are associated with internal gravity waves. Power law indices of around -3 are indicative of saturated gravity waves. The spectra below clouds show less power and less spectral slopes, suggesting that the waves are not saturated in this region.

Arnaud Mahieux (Belgium Institute for Space Aeronomy, BISA) presented the VEx/SOIR activity and results in the recent year, after the Venus Express Science Working Team met in Graz, Austria. SOIR is designed to measure the atmospheric transmission of the solar light in the infrared (2.3-4.4 µm). It is a self-calibrated technique. The continuum of absorption in the SOIR spectra is primarily shaped by the extinction caused by the aerosol particles present in the upper haze (between ~ 70 and 90 km). This information allows the retrieval of the aerosol loading slant opacity in data accumulated over the years covering more latitudes. it is also possible to derive several other key parameters of the probed atmosphere: densities of CO_2 and other species, such as H_2O, CO, HCl or sulfur containing species (like SO_2, H_2S or OCS), as well as the temperature.

Tetsuya Fukuhara (Dept. Cosmosciences, Graduate School of Science, Hokkaido University) - The longwave Infrared Camera (LIR) onboard the Venus orbiter Akatsuki is designed to acquire a thermal infrared image of Venus. Temperature and wind vector fields at an altitude of Venus's upper cloud-top would have been obtained from the thermal images taken by LIR in an equatorial orbit. On Dec. 9, 2010, LIR successfully acquired 10µm infrared images of entire nightside hemisphere of Venus The reprocessed image converted into brightness temperature shows the distinct contrast due to low temperature distribution in both polar regions (polar collar).

3 - Earth orbit observations

Atsushi Yamazaki (ISAS/JAXA) presented plans for observing the Venus transit using the Hinode / Solar-B telescope. Hinode (Kosugi et al. 2007) orbits on a circular, helio-synchronous orbit at an altitude of 680 km. Its consists of three instruments : Solar Optical Telescope (SOT), X-Ray Telescope (XRT), EUV Imaging Spectrometer (EIS)in the 17-29nm range. The team considers X-ray the observation for the Venus corona via charge exchange with the solar wind plasma, this might be limited to a marginal detection as X-ray emission from Venus might be comparable with noise level.

Thomas Widemann (Obs. Paris/LESIA) presented simulations of Venus' transmission spectrum in preparation of scheduled HST observations during transit. This event is an opportunity to assess the feasibility of atmospheric characterization of an Earth-size exoplanet near or within its habitable zone presenting Venus atmospheric characteristics. This is done using a radiative transfer model, which includes the signature and latitudinal distribution of aerosols observed with VEx/SOIR. A refraction model of the aureole has been successfully applied to 2004 photometrical lightcurves. The model allows to retrieve the latitudinal dependency of scale-height at an altitude of 117 km, function of the altitude of aerosol slanted opacity $\tau = 1$. A set of specific coronographs to record the aureole photometric lightcurve using an off-the-shelf 10-cm refractor are currently designed at LESIA in Paris Observatory will be distributed in the Asia-Pacific region. The measurements will be performed in coordination with Venus-Express/SOIR solar occultation measurements during the transit of June 5-6.

4 - Earth stratospheric balloon observations

Eliot Young (SouthWest Research Institute, Boulder, CO) introduced plans for Venus investigations from a NASA balloon-borne stratospheric observatory. A 42-day record-breaking flight went three times around the South Pole was successfully operated in 2004 - 2005. The Wallops Arc Second Pointer (WASP) Project demonstrated sub-arcsecond pointing stability in a typical flight environment. Altitude is about 35 km. There are frequent opportunities to observe Venus near inferior conjunction (every 19 months). During such flight (e.g. Jan 2014) Venus will be continuously visible from Antarctica with access to important wavelengths (e.g., at 2.5 - 2.55 µm (to assess cloud altitudes) and 4.3 µm (to determine the vertical profile of CO_2 gas from limb imaging). Using the facility for Venus observations will be addressed at the January 25-26 2012, Cleveland Ohio Aerospace Institute Balloon conference (EY and YT will participate).

Yukihiro Takahashi (Dept. Cosmosciences, Graduate School of Science, Hokkaido University), first mentioned the full availability of "Pirka" Nayoro telescope in Hokkaido, for Venus observations during the coming maximum elongation periods of March-April and August 2012. Two instruments are available at the telescope: an EMCCD detector (0.4-1µm) and the NICE infrared spectrograph (0.9-2.5µm, R~3,000). A further Echelle high-resolution spectrograph (1-4µm, R ~70,000) is developed by Tohoku University and will be implemented in the future. A balloon borne telescope and its instrumentation is also developed by his team. Gondola characteristics are 1x1x3 m^3 for a weight of 780 kg. The main telescope is a Schmidt Cassegrain 300 mm, f = 9m. The optical system comprises dichroic filters to distribute the incoming signal to an IR camera 750-1200 nm, a UV camera 350-450 nm and photomultipliers. First flight experiments occurred in 2009, observation tests in May-June 2011, and next scheduled flight in August 2012 from Taiki Aerospace Research Field (Japan).

5 - Ground-based observations

Hiroki Matsui (graduate student, Univ. of Tokyo) / Naomoto Iwagami (Univ. of Tokyo) / George L. Hashimoto (Okayama Univ.) discussed the abundance of HDO in the dayside atmosphere above the clouds obtained by ground-based 2.3 um spectroscopy. Although the latitudinal distribution shows no significant structure, a ratio of HDO/H_2O in the 62-67 km altitude range is measured at 160 times that on Earth and additional constraints are given on the vertical distribution. The mixing ratio at a height of 62-67 km is consistent with previous measurements. According to previous measurements constrained with Pollack's model, the HDO/H_2O ratio in the altitude region 30-40 km and above 80 km is 120 times and 250 times the terrestrial value, respectively.

Shoko Ohtsuki (ISAS/JAXA) presented a brief introduction to next IRTF observations of 1.27 um airglow scheduled for July 2012. Spatially resolved molecular oxygen spectra are taken on the Venus nightside disk. The airglow intensity and rotational temperature maps are derived from the observations. The temperature shows weak positive correlation with the airglow intensity. However, there are some regions of almost same intensities but with different temperatures. In observations carried out from 2002 to 2010, intensities tend to decrease from the anti-solar point to the terminator. Combining results from Venus Express instruments (VIRTIS O_2 IR maps, SPICAV thermal profiles) and ground-based airglow observations allow a significant improvement in constraining underlying emission mechanisms, their spatial and temporal variability.

Brad Sandor (Space Science Institute, Boulder), presented the two main aspects of his continuing millimeter and sub-millimeter wave observations from the James Clerk Maxwell telescope (JCMT): 70-100 km photochemical studies of HCl, H_2SO_4, SO_2, SO, ClO trace molecules; 70-115 km atmospheric dynamics using CO, temperature vertical profiles and Doppler winds. These measurements are compared with several techniques : ground-based telescopes. In most recent comparisons non-LTE 10 µm CO_2 Doppler winds generally display different distributions of SSAS versus zonal wind fields than sub-mm/mm nightside Doppler wind measurements – as well as from from VEx/SPICAV stellar occultation data. In particular, direct SOx/aerosol comparison is challenged by strong differences in sub-mm vs VEx spatial scales and temporal sampling. New sub-millimeter observations are scheduled during December 2011 during the planet's eastern (evening) elongation.

Manuela Sornig (I.Physikalisches Institut, U. Cologne) presented first results of Doppler winds measurements of June 2011 using the University of Cologne Tuneable Heterodyne Infrared Spectrometer (THIS) at the NOAO McMath Telescope at Kitt Peak, Arizona. The instrument operates in the 7-13µm range at a resolution > 10^7 @ 10µm. The 100-120 km altitude range is the transition region between the decrease of super-rotating zonal flow and the SS–AS flow. In addition to the search for local as well as temporal variations, wind and temperature measurements in non-LTE CO_2 emission are compared to other ground-based investigations (millimeter and sub-millimeter wave) as well as VEx/SOIR and VEx/VeRa measurements. New campaigns at McMath-Pierce/THIS in Kitt Peak, AZ and Goddard GSFC IRTF/HIPWAC on Mauna Kea are scheduled in the two coming elongation periods starting in December 2011.

Pedro Machado (Obs. Paris / Univ. Lisbon) presented dayside high-resolution spectroscopy of winds, using the solar diffused Fraunhofer lines at cloud top to retrieve the zonal wind field and its detailed meridional structure using data from UVES (Ultraviolet and Visual Echelle Spectrograph) instrument at ESO's Very Large Telescope.
His analysis reveals detailed direct Doppler winds velocity maps in the longitudinal and meridional directions, as well as smaller scale horizontal wave structures, possibly compatible with eastward propagating inertio-gravity waves at cloud tops.

Hideo Sagawa (NiCT) presented an introduction to a proposal for next ground-based observations in sub-mm. The authors introduce a tuning parameter for the relative contribution of SSAS (sub-solar to anti-solar) and RZF (retrograde zonal flow) depending on the solar zenith angle. The purpose is to propose an Inferior Conjunction observation with CARMA which updated its receiver system and now we can observe 12CO(1-0) and 13CO(1-0) simultaneously. Also try simultaneous observations at 10 micron using a Heterodyne instrument newly developed in Tohoku Univ. (Hiromu Nakagawa, et al.) in collaboration with Cologne University.

III – Strategy for cooperation with Japan

2012 is an important year for the joint observing of Venus from a spacecraft (ESA's Venus Express extended mission) and from a number of ground-based facilities due to an exceptional year with two maximum elongations (March 27, 2012 and August 15, 2012) as well as the rare transit of Venus of June 6, 2012. The Japanese balloon borne telescope and its instrumentation will be launched in Aug. 2012, with its IR camera 750-1200 nm, and UV camera 350-450 nm. Science objectives should be addressed during the January 25-26 2012, Cleveland Ohio Aerospace Institute Balloon conference. Characterization and measurement of meridional circulation cells could be the science case for a coordinated ground-based or balloon-based campaign investigation proposal. Several coordinated observations and data is already assigned to the period, including use of the Hubble Space Telescope and Japan's Hinode solar telescope for the transit.

The Belgium Institute for Space Aeronomy (BISA) is developing a very active exchange program with the University of Tokyo (Dr. N. Iwagami). BISA will host Japanese researchers (Seiko Tagaki, Mayu Hosouchi, Hiro Matsui) and researchers from BISA will join the observation campaign of Venus organized by our Japanese colleagues. Other ongoing collaborations include the coordination and the comparison of SOIR results with ground-based JCMT observations (Dr. B. J. Sandor and Dr. R.T. Clancy) and with HST observations (Dr. K. L. Jessup).

IV - Future meetings

- Workshop on Exploring the Planetary Science Achievable from a Balloon Based Observatory, January 25-26 2012, Cleveland Ohio Aerospace Institute. E.Y. and Y.T. will attend.
- Fourth JSPS/PHC Sakura meeting, France, during week of Feb. 20-24, 2012 (tentative date).
- Japan Geoscience Union (JpGU) Meeting, 20-25 May, 2012 : Venus session.
- Science Conference on Comparative Climatology of the Terrestrial Planets, Boulder, June 25-28 organized by VEXAG, the Outer Planets Assessment Group (OPAG), and the Mars Exploration Analysis Group (MEPAG)
Topics for this international conference include:
    - Climate and Atmosphere
    - Clouds, Hazes, and Precipitation
    - Interior-Surface-Atmosphere Interactions
    - Solar-Atmosphere Interactions
    -Exoplanets and Climate
- 10th VEXAG Meeting, Boulder, Colorado, 29 June 2012
- Exploration of Venus Session at COSPAR, Mysore, India, 14-22 July 2012 (M. Nakamura and H. Svedhem conveners).
Abstract deadline is 10 February 2012. Conference URL http://www.cospar2012india.org/
- Probable VEXAG Science Workshop in 2013 in Washington DC area
- Venus International Reference Atmosphere II - publish the updated model by 2014

Tuesday, Nov. 29, 2011

T. Widemann