Exploring the Atmosphere of Mars with Remote Observations: Activities in Japan for the Belgium-Japan partnership (AMAVERO)

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Recent successful explorations of Mars and Venus atmospheres by numerous spacecraft and ground-based telescopes have suggested their active photochemistry and dynamics on the planets. Characteristics of spatial and temporal variations of temperature, wind, and atmospheric constituents are essential to understand the photochemistry and dynamics.
From April 2017 to March 2019, Japan-Belgium collaboration program, AMAVERO (Exploring the Atmosphere of MArs and VEnus with Remote Observations: A Belgium-Japan partnership) is running. In this project, we study the following aspects. (1) 3D distributions (i.e., spatial variation + vertical profiles) of temperature, wind, and trace gases on Mars, and (2) those at the middle atmosphere (from the cloud top to the upper atmosphere, 60-140 km) of Venus.

These objectives are achieved by collecting observational datasets from Belgium and Japan. Belgian side provides the data taken by European Mars orbiter Mars Express (MEx) and Trace Gas Orbiter (TGO), and Venus Orbiter Venus Express (VEx). From Japan, we provide the data taken by ground-based and space-borne telescopes with Japanese Venus Orbiter Akatsuki. Moreover, we share tools to analyze the observational datasets, and develop the numerical models of the atmospheres to interpret the observational results.
In the spring in 2017, we sent scientists from Japan to Belgium and initiated the following researches based on the exchange of young research staffs, postdocs, and graduate school students:
(1) Collaboration of ground-based observation data, taken by ALMA sub-mm array, SOFIA IR airborne telescope, and MIRAHI IR heterodyne spectrometer. (for Mars + Venus)
(2) Development of Limb retrieval code JACOSPAR for the utilization to ExoMars Trace Gas Orbiter and its test application for H_2O vertical profile derived from Mars Express data. (for Mars: to be appeared in this meeting as *Toyooka et al.*)
(3) Distribution and dynamics of Venusian atmosphere observed by Akatsuki IR imagers. (Venus)
(4) The intercomparison of Venusian and Martian GCMs with cloud and water cycles in different approaches. (for Mars + Venus)

This project was generated from the long-term collaborations between Japan and European groups for Mars and Venus sciences associated with Mars Express (2003-), Venus Express (2005-2015), CrossDrive project (Collaborative Virtual Environments for Mars Science Analysis and Rover Target Planning, 2014-2016), ExoMars Trace Gas Orbiter (2016-), with ground-based and numerical simulation works. In this meeting, we show the 1st year results from this project related to Mars Express and ExoMars. Any proposals and collaborations which enhance the activities are welcomed.

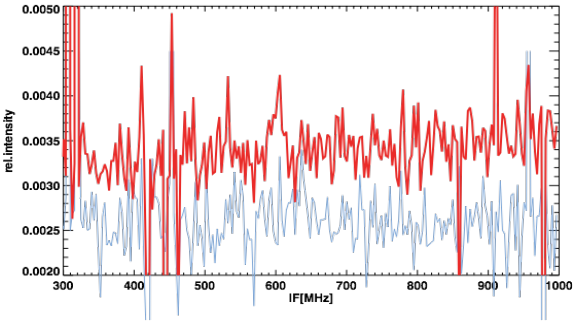

Figure 1: CO_2 non-LTE line observed by MILAHI (MIR Laser Heterodyne Instrument) attached to Tohoku Univ. 60cm telescope at Haleakala, Hawaii (Sep 2017).

Table 1: Acronyms for the missions or instruments to be used in the project, with the corresponding PI

Satellite observations			
Acronym	Full name	Platform	Instrument/mission PI*
PFS / MEx	Planetary Fourier Spectrometer	Mars Express (MEx)	M. Giuranna
OMEGA / MEx	Visible and Infrared Mineralogical Mapping Spectrometer	Mars Express (MEx)	J. P. Bibring
SOIR / VEx	Solar Occultation in the InfraRed	Venus Express (VEx)	A.C. Vandaele
LIR / Akatsuki	Longwave Infrared Camera	Akatsuki	M. Tagushi
NOMAD / TGO	Nadir and Occultation for MArs Discovery sounder	ExoMars Trace Gas Orbiter (TGO)	A.C. Vandaele
Earth-based observations			
Acronym	Full name	Telescope	Instrument/mission PI*
EXES / SOFIA	Echelon-Cross-Echelle Spectrograph	Stratospheric Observatory for Infrared Astronomy telescope	S. Aoki for the measurements to be used here
COMICS / SUBARU	Cooled Mid Infrared Camera and Spectrometer	SUBARU telescope in Mauna Kea, Hawaii,	T. Sato for the measurements to be used here
MILAHI / T60	Mid-infrared laser heterodyne spectrometer	T60 60 cm telescope in Haleakala, Hawaii	H. Nakagawa, Tohoku University
ALMA	Atacama Large Millimeter Array		S. Aoki for the measurements to be used here
Models			
Acronym	Full name or short description		Responsible scientists*
ATMOSPHIT	Versatile line-by-line radiative transfer model with various retrieval schemes. Accommodates different geometries, line shapes etc Developed initially for Earth, it was successfully tested on PFS / MEx data		P. Coheur and ULB team
ASIMUT	Line-by-Line radiative transfer code allowing for different observational geometries and instruments. Allow simulation and retrieval. Developed for Earth, Mars and Venus.		A.C. Vandaele and BIRA-IASB team
GEM-Mars	3D GCM for the atmosphere of Mars from the surface up to 170 km. Builds on the GEM standard weather forecast model of Environment Canada		F. Daerden, BIRA-IASB
DRAMATIC-MGCM	Dynamics, RAdiation, MAterial Transport and their mutual InteraCtions; Mars General Circulation Model		T. Kuroda

* Underlined when part of the proposing consortium

Table 1: Missions and Instruments related to this project.