Local and Diurnal Variation of Water Outgassing on Comet 67P/Churyumov-Gerasimenko Nucleus Observed from Rosetta/MIRO. Seungwon Lee[1], Paul von Allmen[1], Mark Hofstadter[1], Gerard Beaudin[2], Nicolas Biver[3], Dominique Bockelee-Morvan[3], Mathieu Choukroun[1], Jacques Crovisier[3], Pierre Encrenaz[2,1], Therese Encrenaz[3,1], Margaret Frerking[1], Samuel Gulkis[1], Paul Hartogh[4], W.-H Ip[5], Michael Janssen[1], Christopher Jarchow[5], Stephen Keihm[1], Emmanuel Lellouch[3], Cedric Leyrat[3], Ladislav Rezac[4], F. Peter Schloerb[6], Jet Propulsion Laboratory/California Institute of Technology, Pasadena, California, USA. [2]LERMA, Observatoire de Paris, PSL Research University, UPMC Univ. Paris 06, CNRS, UMR8112, F-75014, Paris, France. [3]LESIA-Observatoire de Paris, CNRS, UPMC, Université Paris-Diderot, Meudon, France. [4]Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany. [5]National Central University, Jhongli, Taiwan. [6]University of Massachusetts, Amherst, MA, USA.

Introduction: Since it started science observations of its target comet 67P in May 2014, the Microwave Instrument on the Rosetta Orbiter (MIRO) has observed the comet in two frequency bands at 190 GHz and 562 GHz. MIRO has a spectrometer connected to the 562 GHz receiver, designed to observe molecular lines of H_2O including three oxygen isotopologues, CO, NH_3, and CH_3OH volatiles emitted by the comet nucleus. The scientific goal of the spectral measurement is to assess the abundances and isotopic ratios of cometary volatiles, and to understand the spatial and temporal evolution of the activity.

Approach: The first spectral line of comet 67P detected by MIRO is the $H_2{}^{16}O$ rotational transition line at 556.936 GHz. It was first seen on June 6, 2014 at the heliocentric distance of 3.9AU and at the MIRO-to-comet distance of 360,000 km. Since the first detection, MIRO has regularly observed this line with a nadir mode and a coma-scanning mode while it approached the comet from >100,000 km to ~10 km, allowing us to track the spatial and temporal evolution of water outgassing activity. In addition, MIRO detected the water isotopologue $H_2{}^{18}O$ line in July, 2014 and the CH_3OH line in August, 2014.

The detected $H_2{}^{16}O$ and $H_2{}^{18}O$ lines are analyzed with a Non-LTE radiative transfer model and an optimal estimation method to retrieve a H_2O outgassing rate, distribution, expansion velocity and gas kinetic temperature. The retrieved coma activity parameters are co-registered with the local environment variables such as subsurface temperatures measured from MIRO continuum bands and local solar time, illumination condition, and center-beam locations on nucleus or off nucleus. The correlations between the coma and nucleus environmental parameters are analyzed. The interactive effects of coma activity and nucleus environmental parameters are investigated.

Results: Overall an average water production rate has been increasing since the first detection in early June at ~$1x10^{25}$ molecules/sec as the comet approaches close to the sun. In addition to the general upward trend of the heliocentric distance effect, the comet shows a strong variability of outgassing activity with time of day and with location on the nucleus. MIRO spectral observation data on August 7-9 show that the water outgassing rates vary by a factor of ~20, from $7x10^{24}$ molecules/s to $1.5x10^{26}$ molecules/s, and the gas expansion velocities vary by ~0.15 km/s from 0.62 km/s to 0.77 km/s. Outgassing activity occurs mostly in the day side of the nucleus and the most active region is the "neck" region, which is the narrow part connecting the two lobes of the duck-shaped comet. The local outgassing activity is most correlated with the local solar time among local environmental parameters.

Figure 1 shows the variation of the local water outgassing rates retrieved from the August 7-9 spectral observation data. The MIRO center beam locations of the high activity points show that the most active region is in the neck region. This result is consistent with the bright icy spots in the neck region discovered in the Rosetta/OSIRIS images.

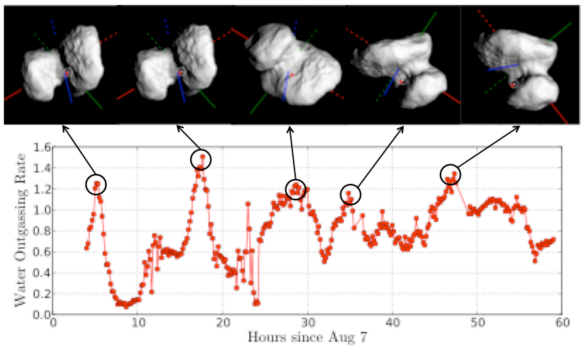

Figure 1. Local water outgassing rates retrieved from the MIRO August 7-9 spectral observation data. The high activity data are co-registered with the MIRO center beam location on nucleus.

Reference:

[1] Sierks et al, On the nucleus strcture and activety on comet 67P/Churyumov-Gerasimenko, Science, in press.

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