Concept study for Korea’s future Venus exploration to understand the three-dimensional structures of the variable atmosphere

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Recent orbiters from ESA and JAXA have revealed an unexpected degree of temporal variability in Venus's atmosphere. Which processes have driven the reported variability in reflectivity, SO_2 gas abundance, super-rotation wind speed, and cloud structures? This question requires a better understanding of surface volcanic activity and its outgassing, cloud-formation processes, material transport between the deep atmosphere and the cloud-top level atmosphere, atmospheric wave activity, and the impacts of solar activity on the planetary atmosphere.

In Korea, the Nuri launch vehicle successfully delivered multiple spacecraft to a designed Earth orbit. As a next step toward its application to an interplanetary mission, we propose a small-scale mission to Venus. We evaluate the scientific impact, the Nuri launcher’s limited mass capacity, the country's technical capabilities, and its significant potential for international scientific collaboration. Our concept study aims to acquire an imaging spectral dataset using stereo observations, enabling characterization of three-dimensional structures and their variability at the cloud-top level over the dayside, and of deeper atmospheric structures, down to 10 km altitude, using the CO_2 atmospheric windows at the nightside. Our target wavelength range, therefore, extends from 200 nm to 2600 nm, and identical imaging spectrometers shall be used on two spacecraft to observe the same locations simultaneously on the dayside or nightside. Such stereo observations are only possible by using more than one spacecraft. We present our concept study for further international collaboration.

Our concept mission assumes a 2030 operational timeline, which may overlap with or follow ESA’s EnVision and NASA’s VERITAS and DAVINCI. Therefore, information on active volcanic areas and atmospheric properties will benefit our data interpretation and reveal the driving forces of the observed atmospheric variability. As Venus is often described as Earth's twin planet due to its physical similarities, such as radius and mass, a better understanding of this planet will enhance our general knowledge of Earth-like exoplanets with volcanism. We conduct this concept study under the Korea Aerospace Administration (KASA)’s planning research funding.

Keywords: Venus, Remote-sensing, Observations, Space exploration

