Solar and inner heliospheric conditions during an unusual Venus polar brightening

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Space weather events are very well known on the Sun-Earth system. During solar activity maximum the main sources for space weather events are eruptive solar drivers such as, flares and coronal mass ejections. During solar minimum when these phenomena are less present, high speed streams, emanating from coronal holes, play a major role in the variability of space weather. The main manifestations of these forcing in the Earth system are magnetic storms and substorms. Space weather is not exclusive of the Sun-Earth system. All the solar system objects inside the heliosphere respond to solar variability. Different bodies react in distinct ways to this variability depending on their dynamical position, magnetic field intensity, atmospheric structure and composition. The influence of solar magnetic variability on Earth's climate is an important research topic intending to estimate the natural contributions to climate change. The solar influence on the lower atmospheric regions has been observed on different atmospheric parameters in different time scales, but a plausible mechanism to explain these observations remains unclear. Here we present a case that a changing in the global appearance of the Venus upper cloud deck could be related with the January 2007 inner heliospheric conditions. Using an unprecedented set of space and ground based observations of the inner Solar System (Sun, Venus, Earth and inner heliosphere) we observed a strong coupling between a CME, two high speed streams and the Venusian magnetosphere and upper atmosphere. On January 2007, the inner heliosphere structure was dominated by the presence of two coronal holes, separated by approximately 180 degrees. They extended from the Sun's South Pole equatorward and persisted during several solar rotations. Emanating from these coronal holes, corotating high speed streams were detected near Earth by the ACE, SOHO and STEREO spacecrafts during January 2007. The interaction of these high speed streams with Earth's magnetosphere triggered High-Intensity, Long-Duration, Continuous AE Activity (HILDCAA) events, which are characterized by an intense AE index lasting for more than 2 days. Due to solar rotation and to the relative position of

Earth and Venus, these high speed streams interacted previously with Venus. On January 8, a Coronal Mass Ejection (CME) was observed on the solar corona, probably related to the off-limb active region 10938. This CME was released in the direction of Venus. The CME was observed by SOHO's LASCO C2/C3 and STEREO SECCHI COR1A- B/2A-B and HI1A. Based on these observations and propagation models we predicted the arrival date of the CME on Venus between January 11 -12. Instruments on board Venus Express, around planet Venus, detected changes in the plasma parameters that could be related to the CME passage and a change in the upper atmosphere conditions. ASPERA-4 observed an increase in the magnetosheath temperature and density of the ions and electrons on January 12. In the same time window, Venus Monitoring Camera observed a catastrophic change in its upper cloud deck appearance. Brightener clouds appeared on January 12 in the South Pole and expanded to lower latitudes, changing the global atmospheric appearance till January 13. Curiously the comet McNaught, crossed northward the ecliptic plane on January and it was imaged by STEREO HI1A - HI1B and SOHO LASCO C3 during its southward descending from January 11 to 18. Although the comet McNaught was present in the inner heliosphere, it is not likely that particles from the comet tail reached the Venus orbit and contributed to the observed changes in the venusian atmosphere. But we don't rule out the possibility that particles from the comet reached Venus. These observations show how the solar variability can drive changes on the cloud coverage on Venusian atmosphere driven by the space weather conditions in the inner heliosphere. With the expected increase of the solar activity throughout the ascending phase of solar cycle, Venus Express and STEREO missions can investigate furthermore the physical coupling between the Sun-Venus system. These future observations can evaluate the importance of heliospheric structures in the observed space weather. Events reported here provide insight knowledge of atmospheric response to space weather, with pivotal importance for our planet.

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