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Solar zenith angle dependence of the solar wind ENA and proton precipitations into the Martian exosphere

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From the Marinar 9 observations, the Martian exospheric temperature is known to be significantly higher than the temperature predicted by a solar-driven simulation of the MTGCM [Bougher et al., 1990]. Several explanations have been suggested: for example, the tidal or gravity wave activity from the lower atmosphere can heat the upper atmosphere [Bougher et al., 1992]. However, there is another contribution to the exospheric heating: the direct input of the solar wind particles. Recently, the ion spectrometer of ASPERA-3 on board Mars Express found the solar wind protons at around the height of periapsis (270 km), which is significantly below the classical solar wind stopping boundary called magnetic pileup boundary (MPB)[Lundin et al., 2004]. In addition, a part of solar wind protons are expected to be neutralized in the upstream region by charge exchanging with the extended martian corona, and the generated neutral hydrogens can penetrate below the MPB [Kallio et al., 2001]. These neutral hydrogens have almost the same energy with the solar wind protons (1 keV), and therefore they are called energetic neutral atoms (ENAs). If such penetrations occurred, a part of the ENAs would be scattered back by collisions around the exobase [Kallio et al., 1997]. The NPD instrument, a ENA detector of ASPERA-3 instrument, has detected the backscattered atoms from the exobase which can be considered to originate from the solar wind ENAs [Futaana et al., 2005]. These recent observations suggest that the solar wind protons and ENAs can directly access the neutral upper atmosphere of Mars, and therefore the exosphere can be heated by these solar wind particles. In this paper, we discuss the contribution of the solar wind particles to the neutral exosphere heating by using the backscattered ENAs observed by NPD.