RE-EXAMINATION OF GREELEY ET AL. (2006): TOWARD AN UNDERSTANDING OF A CORRELATION BETWEEN DUST DEVIL FREQUENCY AND ATMOSPHERIC WAVES AROUND THE SPIRIT ROVER. K. Ogohara[1], [1]School of Engineering, University of Shiga Prefecture (2500, Hassaka, Hikone, Shiga, Japan, 5250045, ogohara.k@e.usp.ac.jp).

Introduction: Many dust devils have been observed by the Pathfinder, the Spirit rover, and the Phoenix lander. The most useful statistical summary of dust devils is found in the two papers by R. Greeley and co-authors [1,2]. They detected visually dust devils, counted the number of the dust devils, and measured their size, lifetime, and speed. The distributions of the diameter, speed and local time, and the seasonal variation of the dust devil frequency they reported are quality statistical information describing properties of Martian dust devils near the Spirit site because of the large number of dust devils visually detected. They showed that dust devils tended to occur in the early afternoon in the southern summer season and peaked the frequency around the southern summer solstice. This can be explained by the diurnal and seasonal variations in the thickness of the boundary layer [3].

On the other hand, there may be atmospheric phenomena that change the thickness of the boundary layer and the stability. Stationary and traveling waves in low latitudes may modify the atmospheric conditions regarding dust devil occurrences although amplitudes of the diurnal and seasonal variations are larger than those of such waves. If the atmospheric waves can modify the conditions of dust devil occurrences significantly, we can find the correlation between the phase of the waves around the Spirit rover and dust devils frequency observed by the Spirit/Navcam. However, [1,2] neither reported the number of dust devils observed on each sol nor listed time stamps of each observed dust devil. The correlation between the atmospheric waves and dust devils frequency cannot be investigated only based on information they showed in their paper. Therefore, we again detect dust devils from images the Spirit took, estimate the diameter, speed and longevity of the dust devils and record the time of the occurrences. We here show the preliminary results of the investigation of variations in dust devil frequency using the Spirit/Navcam images.

Data and preprocessing: We extract dust devils from ‘‘dust devil movies” taken by the left eye of the Navcam onboard the Spirit rover during the period from sol 443 through sol 543. Each image sequence consists of 21 images taken at intervals of about 20 sec and are recorded once a sol basically. Each image consists of 1024×256 pixels. The details of the engineering cameras aboard the Mars Exploration Rover (MER) are summarized by [4], and the calibration technique for the navigation camera instruments is described by [5]. The image data sets used were radiometrically calibrated Reduced Data Record (RDR) obtained from the Planetary Data System (PDS) (http://pds-geosciences.wustl.edu/mer/mer2-m-navcam-3-radomet ric-sci-v1/mer2nc_1xxx/), and the integer value of each pixel was transformed to a double precision brightness value using the Integrated Software for Imagers and Spectrometers (ISIS3) system (https://isis. astrogeology.usgs.gov/index.html).

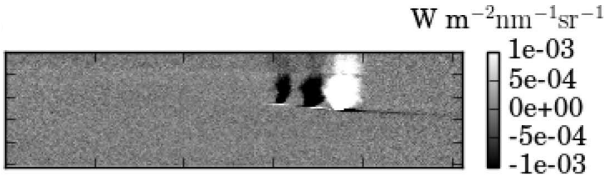

Figure 1 A sample of subtracted images used for counting dust devils in this study. The white area indicates a dust devil to be counted in the target image. The black areas are dust devils in the background image. [6]

Most dust devils are optically thin, with the result that what appears most clearly on landscape images taken by a rover or lander is the border between the sky and the ground, as well as patterns of the surface. Therefore, we emphasis dust devils by subtracting a target image in which we try to detect dust devils from a background image [6]. A dust devil is typically brighter than the ground surface and darker than the sky. Therefore, the upper part of a dust devil above the horizon on the target image and the bottom part of a dust devil below the horizon on the background image show negative signals on the difference image. In contrast, the bottom part of a dust devil below the horizon on the target image and the upper part of a dust devil above the horizon on the background image show positive signals on the difference image. This results in the false recognition of the upper part of a dust devil on the background image as a dust devil on the target image. We thus reverse the contrast of the sky in the difference image in order to display both parts of a dust devil on the sky and on the surface with the same sign based on [6]. Figure 1 shows a sample of subtracted images used for detecting dust devils in this study.

Results: The number of dust devils on each sol was counted visually by the author. Note that the number of

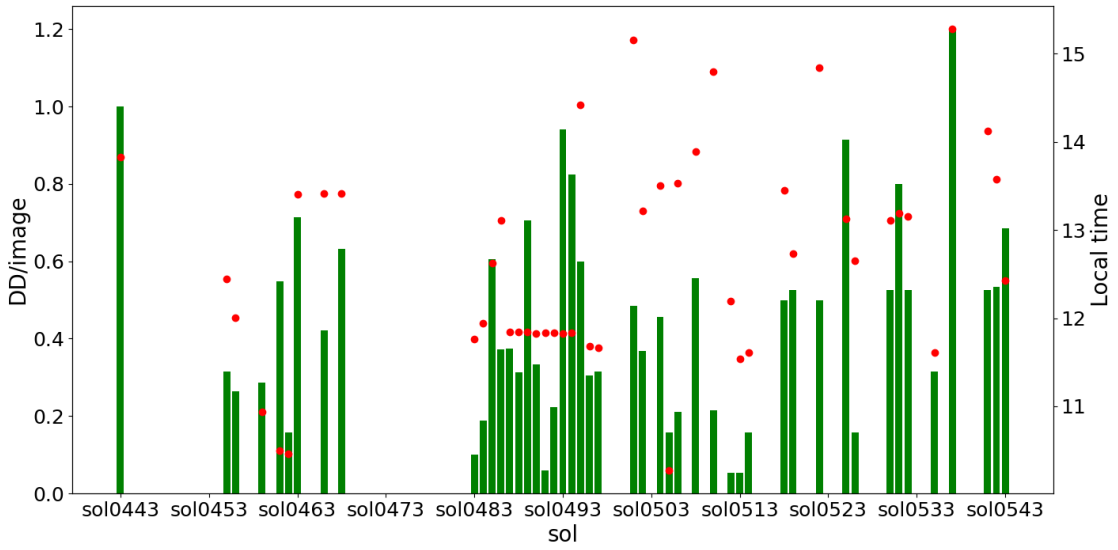

Figure 2 Time series of the number of dust devils visually detected per image from sol 0443 through sol 0543 (green bars). Each red dot indicates the median of local time (hour) of observed image sequences on each sol.

the detected dust devils is just the number of those seen during one or two image sequences (about seven or fifteen minutes) on the sol. One dust devil can be seen in multiple frames due to the longevity longer than 20 sec. I did not recognize such several signals of the same dust devils as different dust devils but as one dust devil. Figure 2 shows variations in the number of dust devils detected per image and the local time of the image sequences. The correlation coefficient between them is 0.44. There seems to be no clear relation between them. The number of dust devils per image varies largely for about 15 sols from sol 483 though local time of observations is approximately constant during that period. Therefore, something that explains the variation in the number of dust devils per image has to be considered instead of the diurnal variation.

In the near future, I will extract atmospheric waves dominant in low latitudes from the re-analysis data of the Mars atmosphere (e.g. the Mars Analysis Correction Data Assimilation, [7]) through the spatio-temporal spectral analysis. Wave components that can explain the variation in the number of dust devils per image in Figure 2 may be found.

References: [1] Greeley et al. (2006) *JGR, 111,* E12S09, 1–16. [2] Greeley et al. (2010) *JGR, 115,* E00F02, doi:10.1029/2010JE003608. [3] Rennó et al. (1998) *JAS, 55*, 3244–3252. [4] Maki et al. (2003) *JGR, 108*, E12, doi:10.1029/2003JE002077. [5] Soderblom et al. (2008) *JGR*, *113*, E06S19, doi:10.1029/2007JE003003. [6] Ogohara et al. (2018) *ASR*, *61*, 1158-1169. [7] Montabone et al. (2014), *GDJ*, doi: 10.1002/gdj3.13.