FIRST EVIDENCE FOR BRIGHT-TONED MEGARIPPLE MIGRATION ON MARS. S. Silvestro[1,2], M. Chojnacki[3], D.A. Vaz[4] , M. Cardinale[5] and F. Esposito[1] INAF Osservatorio Astronomico di Capodimonte, Napoli, Italy (simone.silvestro@inaf.it), [2]SETI Institute, Carl Sagan Center, Mountain View, CA, USA, [3]Lunar and Planetary Lab., U.A., Tucson, AZ, USA, [4]Centre for Earth and Space Research of the University of Coimbra, Coimbra, Portugal, [5]DiSPUTer, Univ. G. d'Annunzio, Chieti, Italy.

Introduction: The action of the wind has accumulated vast fields of aeolian bedforms on the surface of Mars [1-3]. Due to the paucity of surface wind measurements [4], orbital analysis of these aeolian features is fundamental to constrain present and past climatic conditions. Along with the dunes, two other types of aeolian bedforms have been identified [5]: 1) dark toned ripples (DTRs), 1-5 m spaced and ~40 cm high which overprint the dune's slopes [6] or form vast isolated fields [7-9], and 2) Transverse Aeolian Ridges (TARs), which are bright-toned features 10-100 m spaced and ~1-14 m tall [10]. Active DTRs found on dune slopes have been interpreted as normal ripples [7, 11] or fluid-drag ripples [12], whereas inactive DTRs not associated with dunes have been suggested to be megaripples [8, 9]. TARs are static features that have been interpreted as megaripples or small dunes [10, 13]. Prior investigation concluded TARs are inactive under current climatic conditions [14, 15]. In this report we investigate the nature and activity of 8-18 meter-spaced bright-toned bedforms which have sizes in between DTRs and TARs (Fig. 1).

Methods: We investigated the activity of bright-toned bedforms on overlapping HiRISE images orthorectified over stereo-derived topography in SOCET SET [15]. Where identified, bedform migration was derived with COSI-Corr and compared with dune fluxes and migration rates in ArcMap [16, 17] (Fig. 2). Other important morphometric parameters like bedform wavelength and length were derived through automated routines [2].

Results: We have identified large bright-toned bedforms in several areas of Mars including the North polar erg and some mid-latitude areas (Hellaspontus, Nili Fossae and McLaughlin) (Fig. 1). The bright-toned bedforms are preferentially located behind or in between dunes suggesting a megaripple origin. They can be in continuity with nearby DTRs (Fig. 1a, b) or less frequently stratigraphically below nearby dunes and DTRs (Fig. 1c). The megaripples normally have a rectilinear shape and orientation similar to nearby DTRs (Fig. 1a, b). However, more complex star-like shapes are also observed. The bright-toned megaripples show unambiguous modifications on a temporal baseline of ~8-10 Earth years (Fig. 2). In some cases the whole crest is moving while in others only the ripple's terminal edges (defects) are changing (Fig. 2b). Like the active DTRs found on the dune slope [18, 19], the megaripples can migrate obliquely and seem to be associated with high sand flux dunes [20]. In the example showed in Fig. 1b the dunes are moving back and forth in response to opposite wind directions which are smoothing the dune crests. However, the megaripples are only moving toward the east suggesting stronger and/or more frequent winds from the west combined with a sheltering effect from the dune slopes. In Fig. 2 we show barchan-shaped dunes in Nili Fossae with associated 2-to-20-meter spaced (5.5 m on average) bright-toned megaripples. The dunes have two different slip faces but the bright-toned bedforms lagging behind are only moving toward the NW. The migration rates of the megaripples (1 to 4 meters/Earth year) is strongly controlled by the local topography and scale with dune migration rates (Fig. 2a).

Discussion and conclusion: In this report we presented the first evidence of bright-toned megaripple migration on Mars. These features have wavelengths in between DTRs and small TARs and their activity come as a surprise. The megaripples are migrating in the present-day climate in areas characterized by complex topography at the regional and local scale. The presence of these migrating megaripples together with inactive bedforms suggest a complex aeolian scenario characterized by strong winds and bedform induration. Additionally, some larger TARs may be active under current climatic conditions but require more time for detection. Most of the detected active megaripples form a continuum with active DTRs found on dune slopes suggesting common formative processes (saltation, creep and grain size segregation). Their migration rates and direction can be used to track strong Martian winds and will provide further ground truth for atmospheric models.

References: [1] Hayward R.K. et al. (2007) *JGR, 112,* E11007. [2] Vaz D.A. and Silvestro S. (2014) *Icar., 230,* 151–161. [3] Banks M.E. et al. (2018) *JGR, 123.* [4] Martinez G.M. et al. (2017) *SSR, 212.* [5] Malin M.C. and Edgett K.S. (2001) *JGR, 106,* E10. [6] Bridges N.T. et al. (2007) *GRL, 34,* L23205. [7] Sullivan R. et al. (2008) *JGR, 113,* E06S07. [8] Golombek M. et al. (2010) *JGR, 115,* E00F08. [9] Fenton L.K. et al. (2018) *JGR, 123*. [10] Zimbelman J.R. et al. (2013) *Aeol. Res., 11*. [11] Kok J. et al. (2012) *RPP, 75,* 106901. [12] Lapotre M.G. et al. (2016) *Sci., 353,* 6294. [13] Hugenholtz C.H. et al. (2016), *Icar., 286,* 193-201. [14] Berman D.C. et al. (2018) *Icar., 312* [15] Chojnacki M. et al. (2018) *JGR, 123*. [16] Bridges N.T. et al. (2012) *Nat., 485*. [17] Urso A. et al. (2018) *JGR, 123*. [18] Silvestro S. et al. (2016) *GRL, 43*. [19] Vaz D.A. et al. (2017) *Aeol. Res, 26*-116. [20] Chojnacki M. et al. (2017) 5th Dune Work., Abstract #1961.

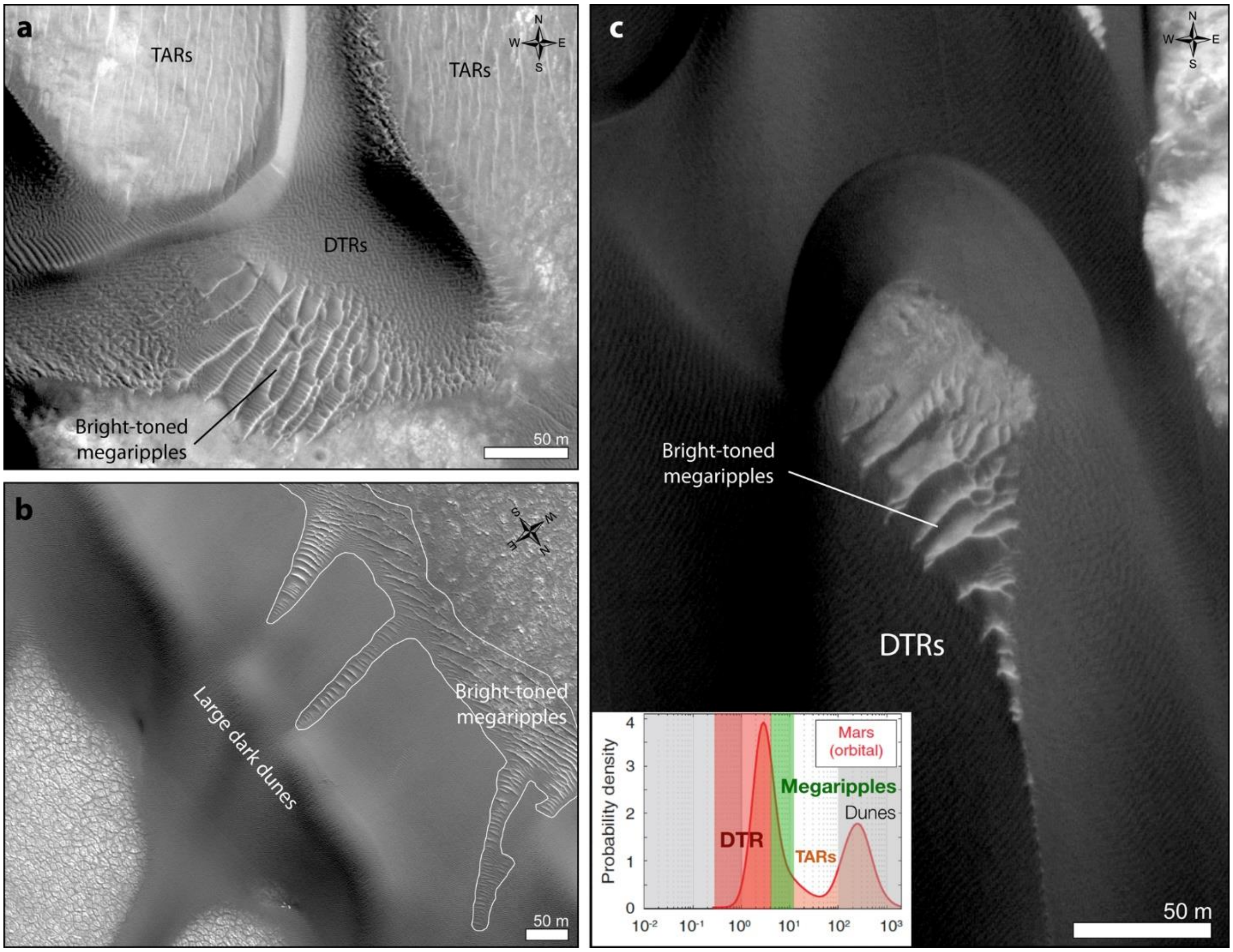

Fig. 1: Active bright-toned megaripples on Mars imaged by the HiRISE camera in **(a)** Nili Fossae (ESP_047049_2015), **(b)** North Pole (ESP_027369_2580) and **(c)** McLaughlin crater (ESP_045312_2020). The megaripples have wavelength in between Dark Toned Ripples (DTRs) and Transverse Aeolian Ridges (TARs). **(Inset)** Histogram of bedform wavelengths (modified from [12]).

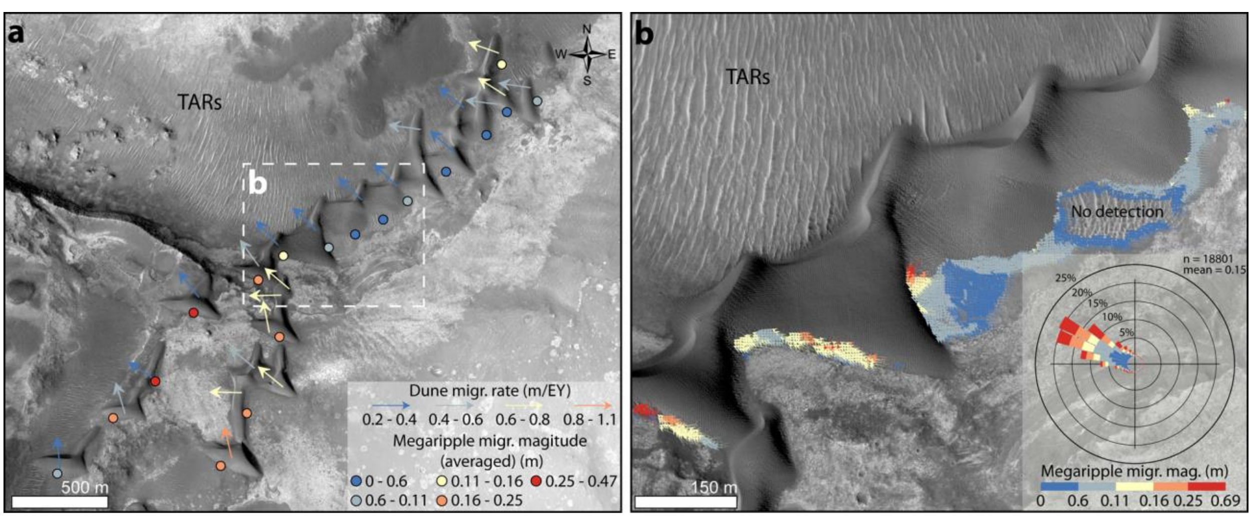

Fig. 2: Bright-toned megaripple migration obtained by comparing PSP_003086_2015 and ESP_047049_2015 (2007-2016). **(a)** Note the topographic control on the migration of the megaripples (circles) which fairly matches with the dune migration rates (arrows). Each circle represents the average migration of the COSI-Corr vectors for each dune. **(b)** Megaripple COSI-Corr migration vectors used to obtain the averages show in panel a. **(Inset)** Circular distribution for the COSI-Corr megaripple migration vectors.