Measuring mars sand flux seasonality from a time series of HiRISE images

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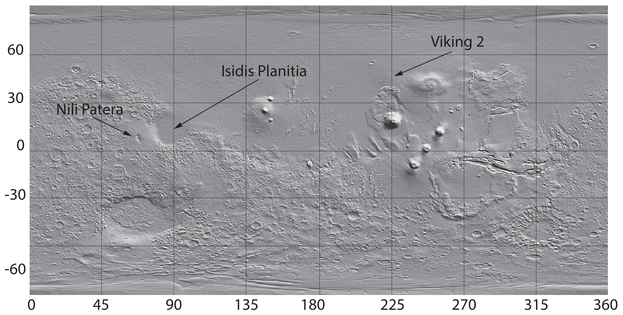
Abstract

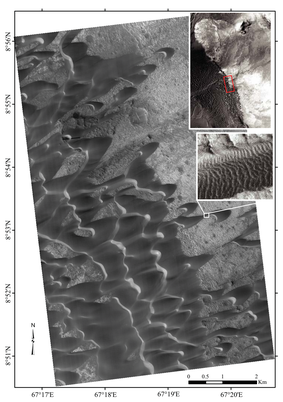
Using high resolution satellite imagery, displacement of sand ripples laying on top of dunes have been detected and quantified, leading to the conclusion that several dune fields on Mars are active in the present time. Here, we present an extended study using a time series of images over the Nili Patera dune field (8N, 67E), and quantify the seasonal variation of the sand flux derived from the ripple migration measurement.

Around southern summer a threefold increase of the sand flux is observed. This variability correlates well with the atmospheric circulation model estimation, as well as with the air density, which raise the question of the contribution of the variation of wind shear velocity and air density in the overall sediment transport.

Data & Situation



Nili Patera dune field is located next to Idisis Planitia crater which creates diurnal winds in Nili Patera area from solar input. Annual variation of air density recorded by Viking 2 is compared against the sand flux variation measured in this study.

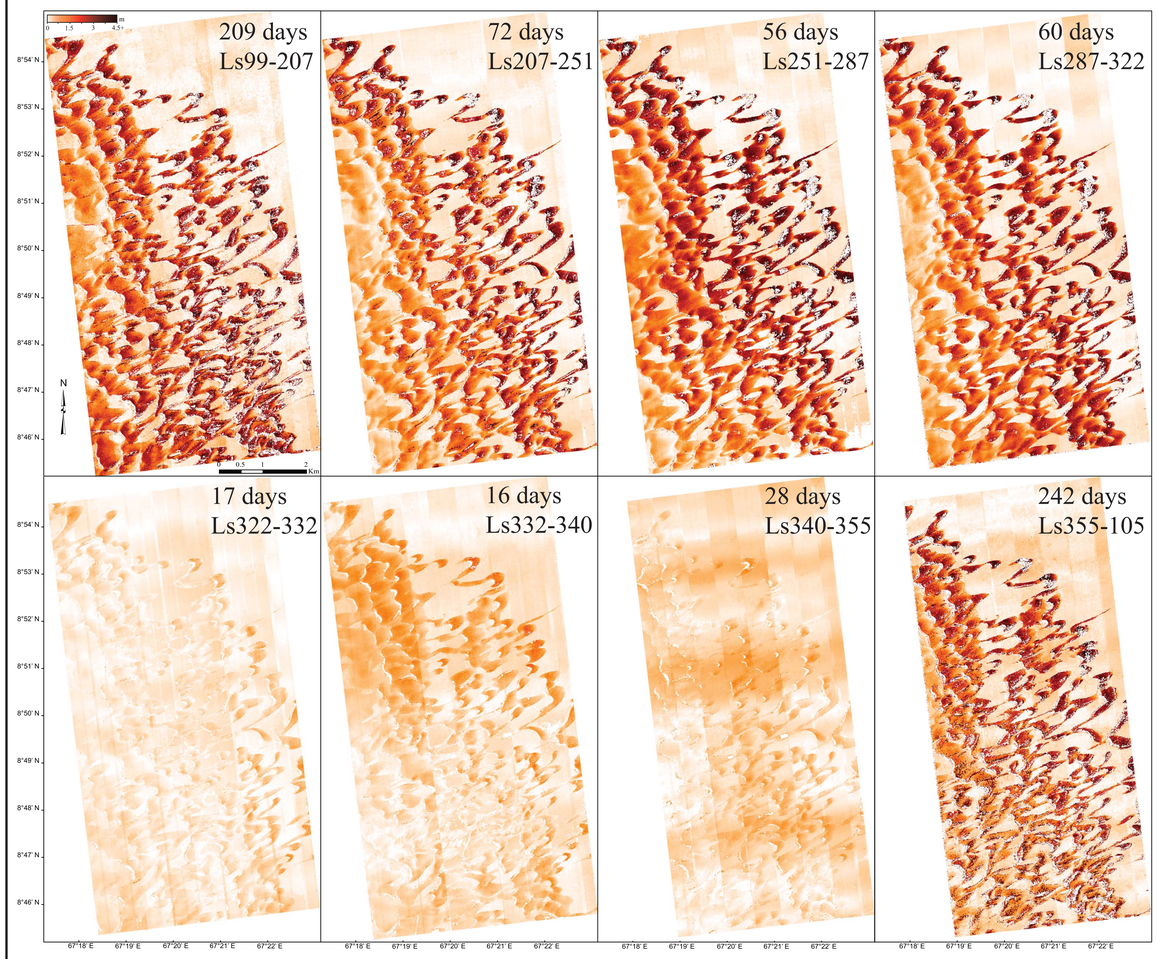


HiRISE image showing a part of the Nili Patera dune field study area. Upper inset shows the location of this area (red box) with respect to the entire dune field. Lower inset is a close-up of one og the dunes, showing the rippled surface whose migration over time is tracked with COSI-Corr.

Img. ID	Ls	Date		Sand flux
18039	98.8	06/02/10	-	-
20729	206.9	12/28/10	209	0.42
21652	251.8	03/10/11	72	1.16
22364	286.6	05/05/11	56	1.77
23142	322.4	07/04/11	60	1.52
23353	331.6	07/21/11	17	0.94
23564	340.4	08/06/11	16	1.98
23920	354.8	09/03/11	28	0.73
27032	105.0	05/02/12	242	0.29

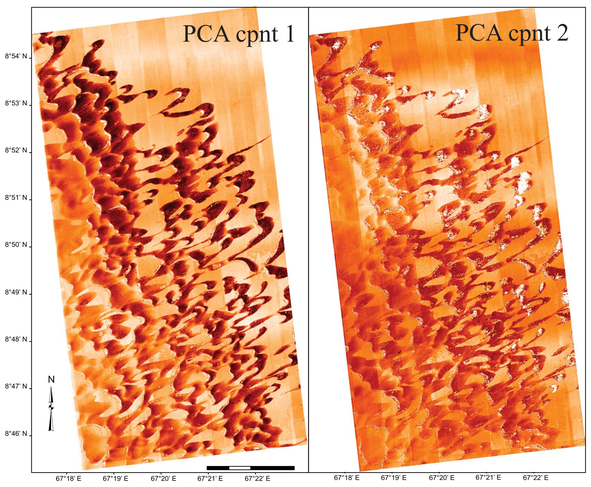
HiRISE image ID: ESP_XXXXX_1890.
Sand flux represents the mean sand flux in $m^3/m/year$

Data processing



Amplitude of the sand ripple displacements in the Nili Patera dune field derived from correlating eight HiRISE pairs of images acquired over a Mars year. Residual of HiRISE CCD misalignment and MRO jitter can be observed.

All images were pre-processed using ISIS (USGS) to stich back the CCD stripes to provide reconstructed, distortion-free, full images. The images were then processed into COSI-Corr, i.e., 1) sub-pixel coregistration of orthorectified images on a 25 cm ground grid, 2) precise correlation of the ortho-images to extract the sand ripple migration that occured between the acquisition time.

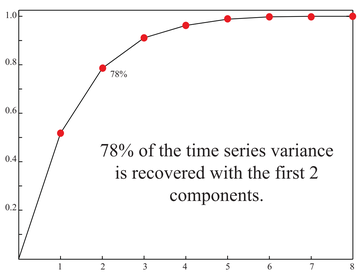


Principal Component Analysis on the ripple migration time series

Objectives:

- Filter out non-systematic noise in the maps

- Have an easy-to-use linear expression of the migration temporal variation

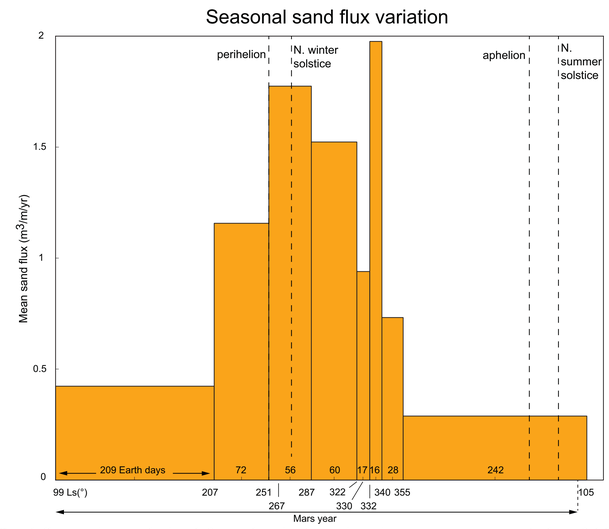


$$Q_{ripple} = \frac{\frac{1}{2} H_{ripple} D_{ripple}}{\Delta_t}$$

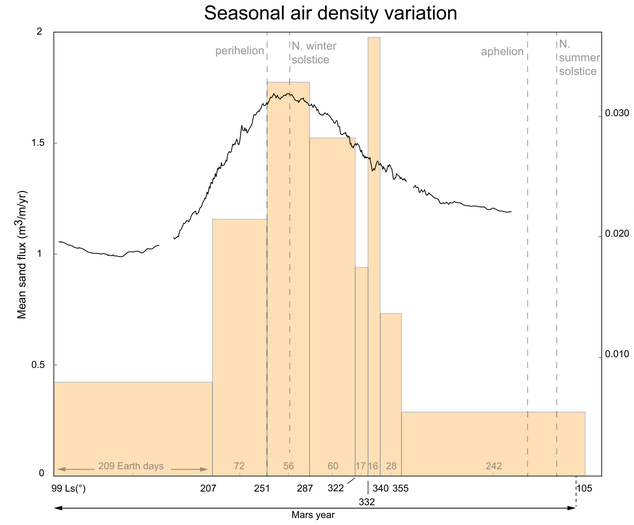
$$H_{ripple} \approx 40cm$$

The sand flux (in reptation) is estimated for each valid measurements according to the equation on the left. The ripple height has been estimated from the Digital Elevation Model and pseudo-photoclinometry.

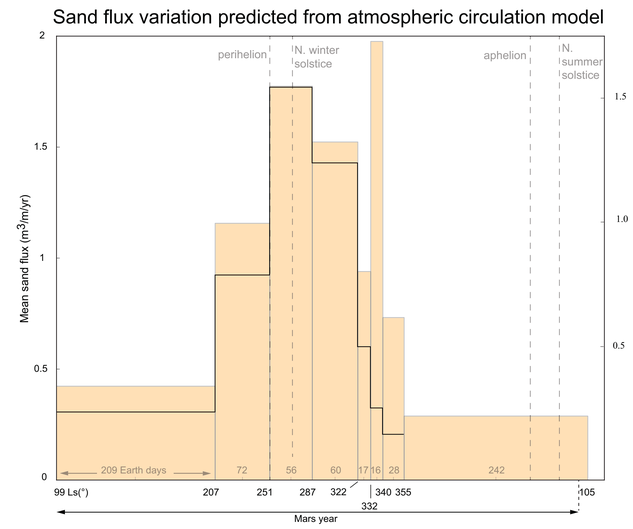
Observations



Sand flux estimate derived from the ripples migration measurements. A threefold sand flux increase around perihelion season is observed.



The black profile represents the air density measured by Viking 2 lander. The air density is assumed to be stable annualy. The correlation between the air density and the sand flux raises the question of its contribution to the sand flux variation.



The black profile represents the sand flux (arbitrary unit) as estimated from the Planet-WRF circulation model (ashimaresearch.com) using a sand threshold stress of $0.008 N/m^2$.