SYNOPTIC WIND MEASUREMENTS IN THE MARTIAN ATMOSPHERE CLOSE TO PERIHELION. V. Kaydash[1], M. Kreslavsky[1,2], Yu. Shkuratov[1], G. Videen[3], M. Wolff[3], J. Bell[4], [1]Astron. Institute of Kharkov National Univ. 35 Sumskaya St., Kharkov, 61022, Ukraine. [2]Geological Sciences, Brown Univ., Providence, RI, USA. [3]Space Sci. Institute 3100 Marine St., Suite A353, Boulder, CO 80303-1058, USA. [4]Cornell Univ., Dept. of Astron. 402 Space Sci. Building Ithaca, NY 14853-6801, USA.

Summary: We perform synoptic Martian wind measurements using global Hubble Space Telescope (HST) images in the season of perihelion. By tracking cloud movement we confirm retrograde zonal winds, poleward deflection for high southern latitudes and local deviation of wind due to topographic effects. Wind speed and direction are in general agreement with Mars GCM.

HST global Mars imaging: For measurements of wind speed and direction we use data obtained during HST observation program #9738 [1, 4]. This program was scheduled for the time of closest Earth-Mars encounter of year 2003, allowing the highest spatial resolution ever achieved from Earth. Five series of images of Mars were taken with the High-Resolution Channel of the Advanced Camera for Surveys [2] just before and after perihelion (see Table). The spatial resolution for the images is about 7 km/pix at the disk center. The observation timing provided imaging of the same hemisphere of Mars at all dates (disk center at 19°S, 20-35°W). The season was summer in the southern hemisphere (see the areocentric longitude of the Sun L_S in the table). In each spectral filter, a series of 3 images with different polarization filters was taken. The maximal time lag between consecutive images in each filter was ~3.8 min. Polarization effects are weak and were studied in detail in [4].

N	Date of Year 2003	*Ls*, deg.	Image scale, km/pix
1	Aug., 24	247.0	6.70
2	Sept., 05	254.5	6.79
3	Sept., 07	255.8	6.84
4	Sept., 12	259.0	7.01
5	Sept., 15	261.0	7.15

Data processing: The standard dark current, flat field, and geometric distortion calibrations are performed routinely by the HST data retrieval facility. Cosmic-ray-track removal (most abundant in the near-UV) is performed with an original heuristic procedure [4]. Visual inspection shows an extensive and complicated system of clouds and hazes over the surface albedo features (Valles Marineris, Terra Meridiani, Thaumasia Planum) and rather dark surface details visible through clear atmosphere. The cloud system is best seen in the wide-band UV filter (330 nm effective wavelength). Images in this filter are used in this study.

We accurately transform the images into a common projection knowing the exact orientation of the planet. Ratios of successive images reveal shifts of the cloud features due to their movement relative to the surface features during a few-minutes-long interval between exposures. We measure these shifts and infer speed and direction of cloud movement, which we consider as a proxy for wind speed and direction at their altitude.

We begin by slightly smoothing albedo images with a Gaussian filter to suppress high-spatial-frequency noise. We then perform quantitative measurements of cloud shifts by maximizing the local covariation of images in each pair. About 650 shifts in total are obtained for all five dates. The entire set of our measurements covers the area 60ºS-20ºN, 100ºW-20ºE. **Fig. 1** shows an example of the results. Deflection of the wind direction pattern from easterly to northerly near the eastern edge of Tharsis rise is seen. Individual measurements for all dates for the zonal (*U*) wind component range from -80 to 30 m/s with an average of -30 m/s; the meridional (*V*) component varies from -60 to 30 m/s with the average of -15 m/s.

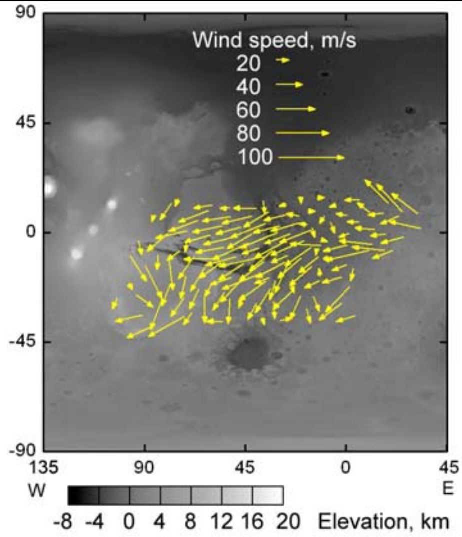

Fig. 1. Measurements of wind speed and direction for Sept. 7 projected and superposed over topographic map.

Among the sources of error is the resolution in the local covariation procedure (±0.1 pix, while the absolute values of inferred shifts are within 2 pixels), inaccuracy of scale knowledge (at 10^{-3} level), inaccuracy in the estimation of Mars disk center, and individual field of view distortion of the polarization filters (±0.3 pix). Compiling of these error sources results in a ±10 m/s accuracy of speed and ±17° in direction.

To study the global distribution of martian wind over the studied region we average individual measurements within the 10º latitude zones (**Fig. 2**). The zonal (U) component confirms domination of westward winds (negative values) with maximal amplitude at the equator, decreasing at northern and southern latitudes down to near-zero values at 50ºS. The *V* component shows a prominent latitudinal trend from negative (southward) values to zero and then positive values for low northern latitudes.

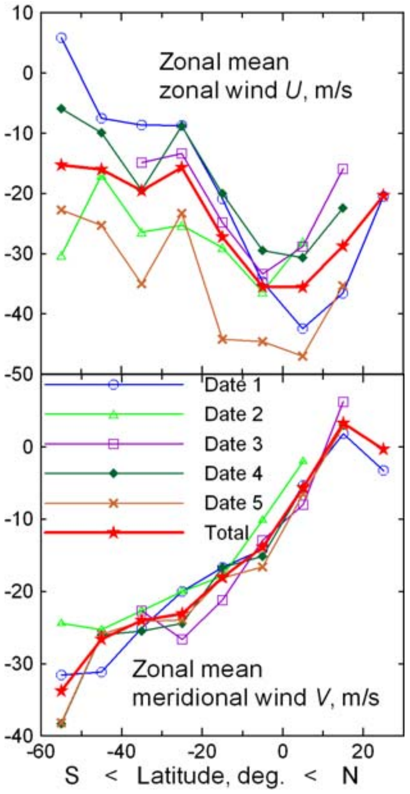

Fig. 2. Zonal averages for both *U* and *V* wind components.

Comparison with global circulation models. We compare our wind measurements with the European Mars Climate Database (EMCD) v 4.0 available at http://www.lmd.jussieu.fr/mars.html. The EMCD data are calculated with a global circulation model (GCM) [3] with parameter choice providing the best fit to the observed surface and atmospheric temperatures. We compare our results with the "MGS dust scenario" at different altitudes for the time of local noon in the "MGS dust scenario" conditions. **Fig. 3** compares our individual measurements of *U* and *V* with latitudinal profiles from EMCD for four altitudes from 20 to 40 km. The closest agreement of *U* observations with the database is observed for 40 km altitude for equator and low northern latitude and for 30 km altitude for low southern latitudes. For higher southern latitudes, the observed zonal speed is shifted to positive values in comparison to the model. *V* estimates also show the best fit with 30 km model profile for equator and low northern latitudes and 40 km profile for low southern latitudes. For higher southern latitudes the observational point scattering is high.

Our inferred 30-40 km cloud altitude is in agreement with [5], where 35-40 km altitude water vapor condensation level was mentioned for the season of observations.

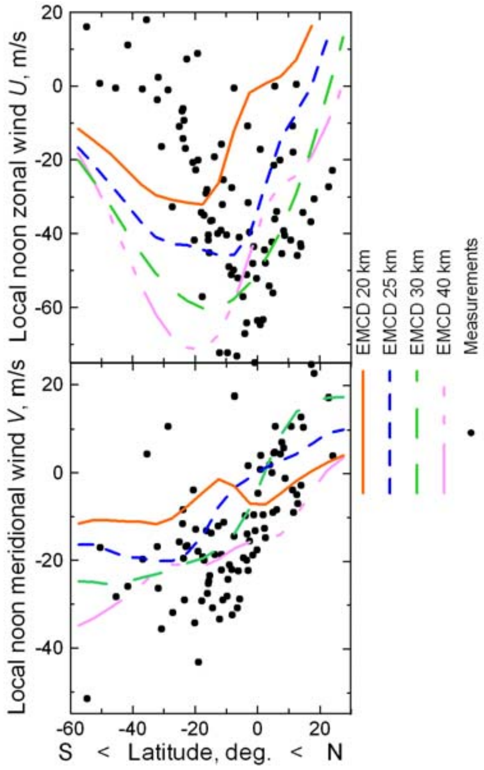

Fig. 3. Comparison of our (*U*,*V*) estimates with EMCD model calculations.

Conclusions. We found general agreement between movement of cloud features observed with HST for mid-day times during the perihelion season and GCM-inferred winds at 30-40 km altitude. The discrepancies, especially for the zonal wind component in the southern hemisphere, are a subject of future analysis.

Our results show that "fast" (at time intervals of minutes) synoptic cloud tracking is a powerful source of new data on wind speed useful for further understanding Martian climate system. These data are complimentary to orbital measurements. Such observations can be carried out with HST or any suitable out-of-the-atmosphere astronomical facility with proper capabilities (high resolution in the near UV).

References: [1] Bell, J., et al. (2003) *Eos Trans. AGU, 84*(46), Fall Meet. Suppl., Abstract P12C-01. [2] Pavlovsky, C., et al. 2002. *ACS Instrument Handbook*, Version 3.0, Baltimore: STScI. [3] Forget., F. et al. (1999) *JGR 104*, 24155-241576. [4] Shkuratov, Yu. et al. (2005) *Icarus 176*, 1-11. [5] Smith, M.D. (2002) *JGR 107*, CiteID 5115.