THERMAL MAPPING OF THE MARTIAN SURFACE

Marta Ciążela[1], Daniel Mège[1], Jakub Ciążela[1], Pierre-Antoine Tesson[1], and Bartosz Pieterek[2]

(1) Space Research Centre, Polish Academy of Sciences (2) Institute of Geology, Adam Mickiewicz University

Thermal data usefully complement other datasets used in geological interpretations, with the capability of mapping, for instance, the distribution of rock types of distinct thermophysical properties, the distribution of polar ice caps, and its seasonal variations, or variations of dust thickness. Using THEMIS data, the apparent thermal inertia (ATI) and differential apparent thermal inertia (DATI) methods make it possible to map thermal inertia of the surface of Mars using available data only, with no data interpolation in contrary to conventional thermal inertia mapping, and is particularly efficient at mapping thermophysical contrasts on slopes > 10°.

DATI

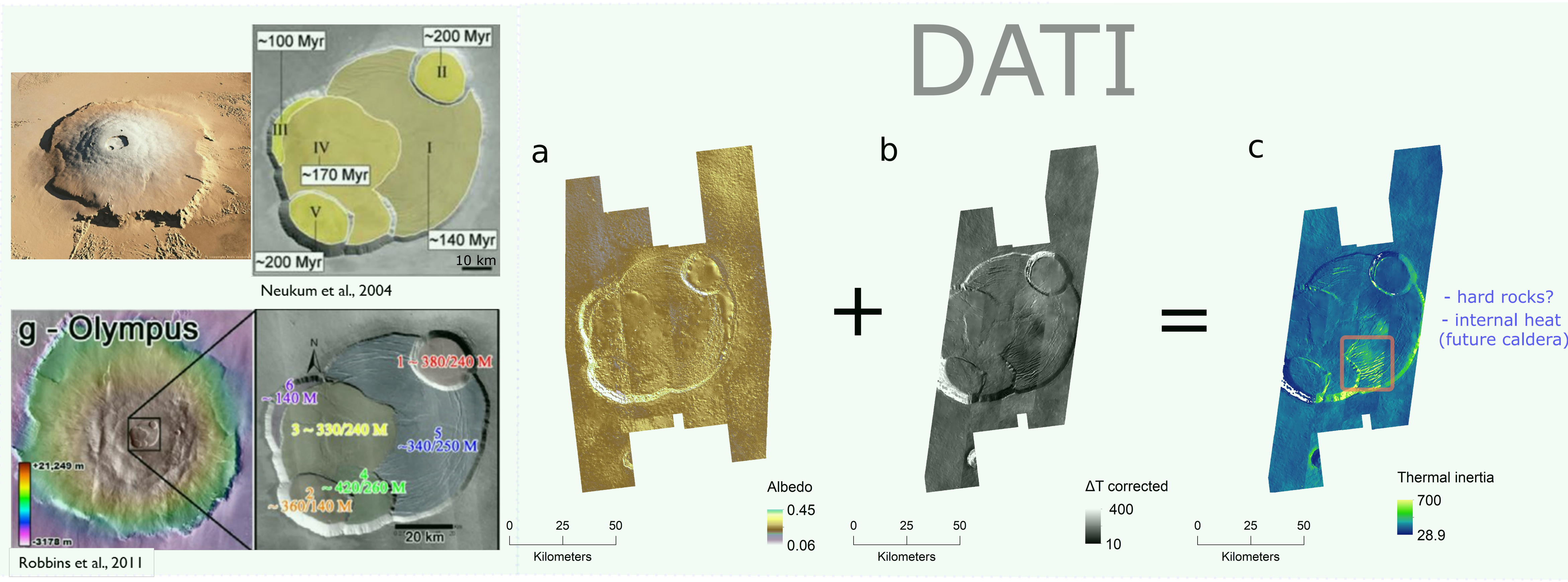
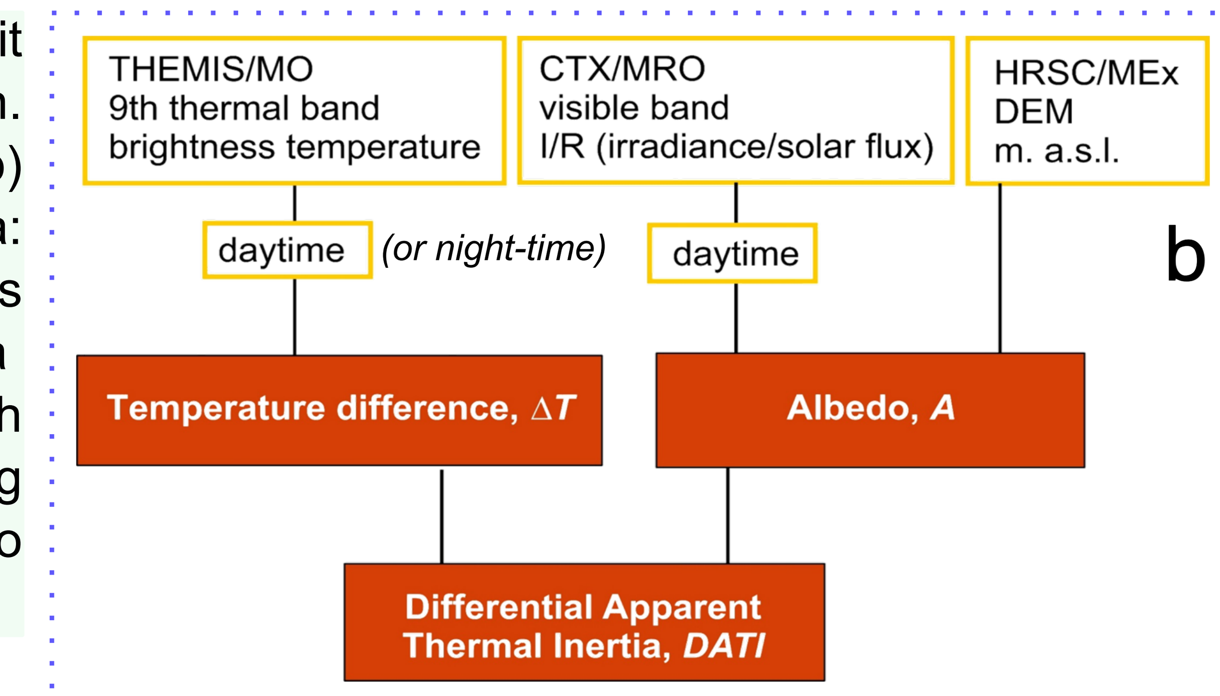
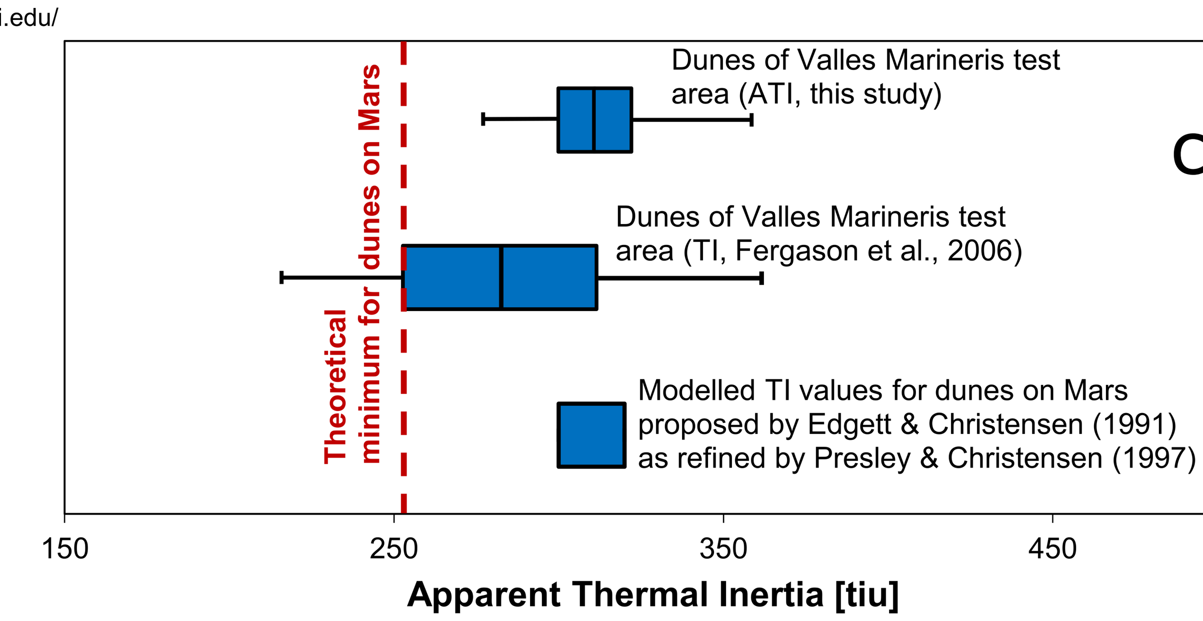


Figure 1. a) albedo map of the Olympus Mons caldera: it indicates the presence of dust and fine sand in this region. Albedo map has been corrected against topography; b) temperature difference map (K) of the Olympus Mons caldera: ΔT corrected map includes topography correction, darker regions indicates the presence of hardrocks exposures; c) thermal inertia map of the Olympus Mons caldera. One can see the area with higher thermal inertia values with numerous fractures exposing hard rocks. White zones excluded from calculations are related to incidence angles higher than 79°.





ATI

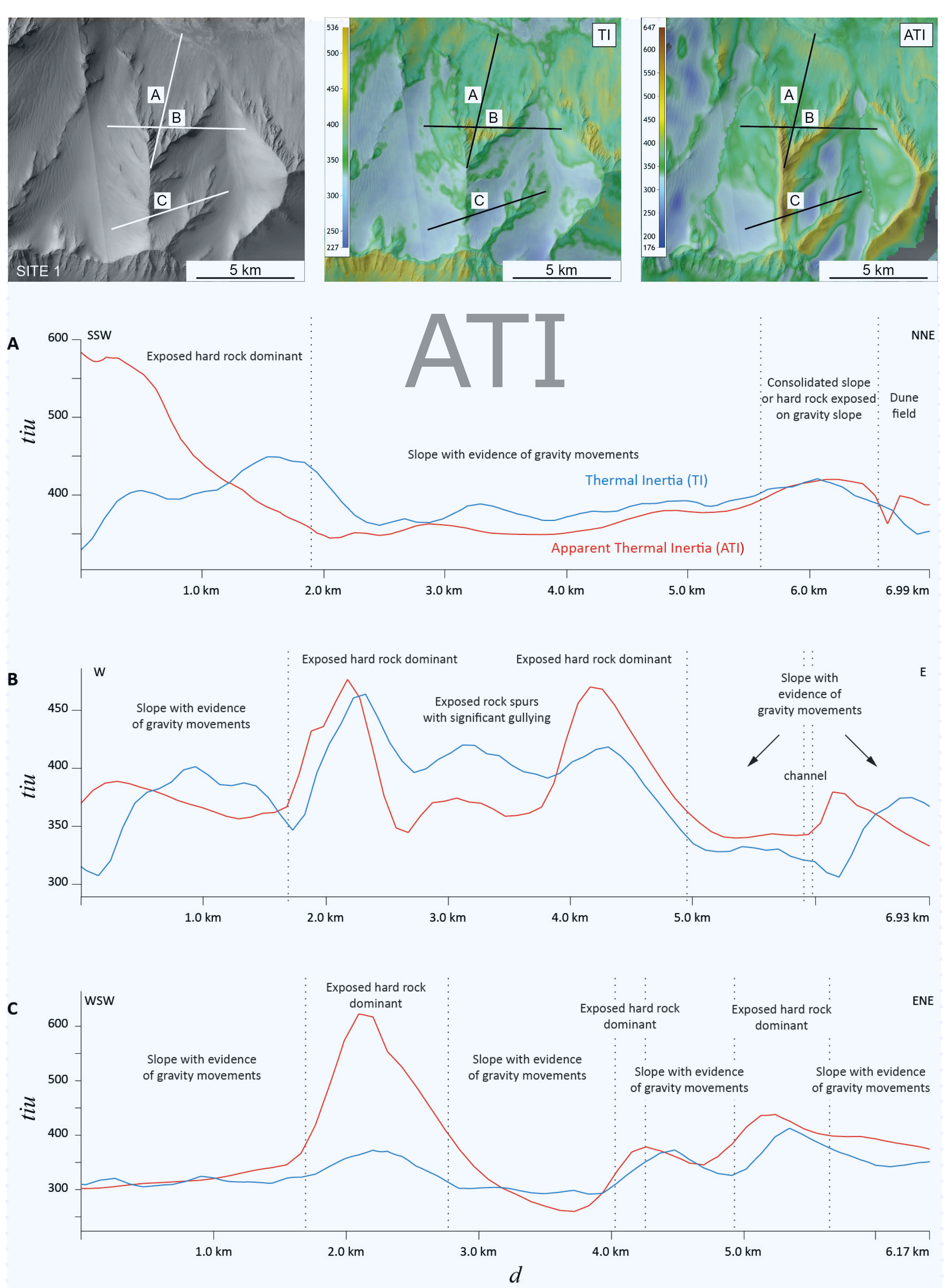


Figure 2. Comparison between TI and ATI (in tiu: J m^{-2} K^{-1}s$^{-1/2}$) values obtained on various slopes along profiles A to C. Maps at the bottom: MRO/CTX image; TI map; ATI map. TI and ATIc are overlain onto the MRO/CTX image

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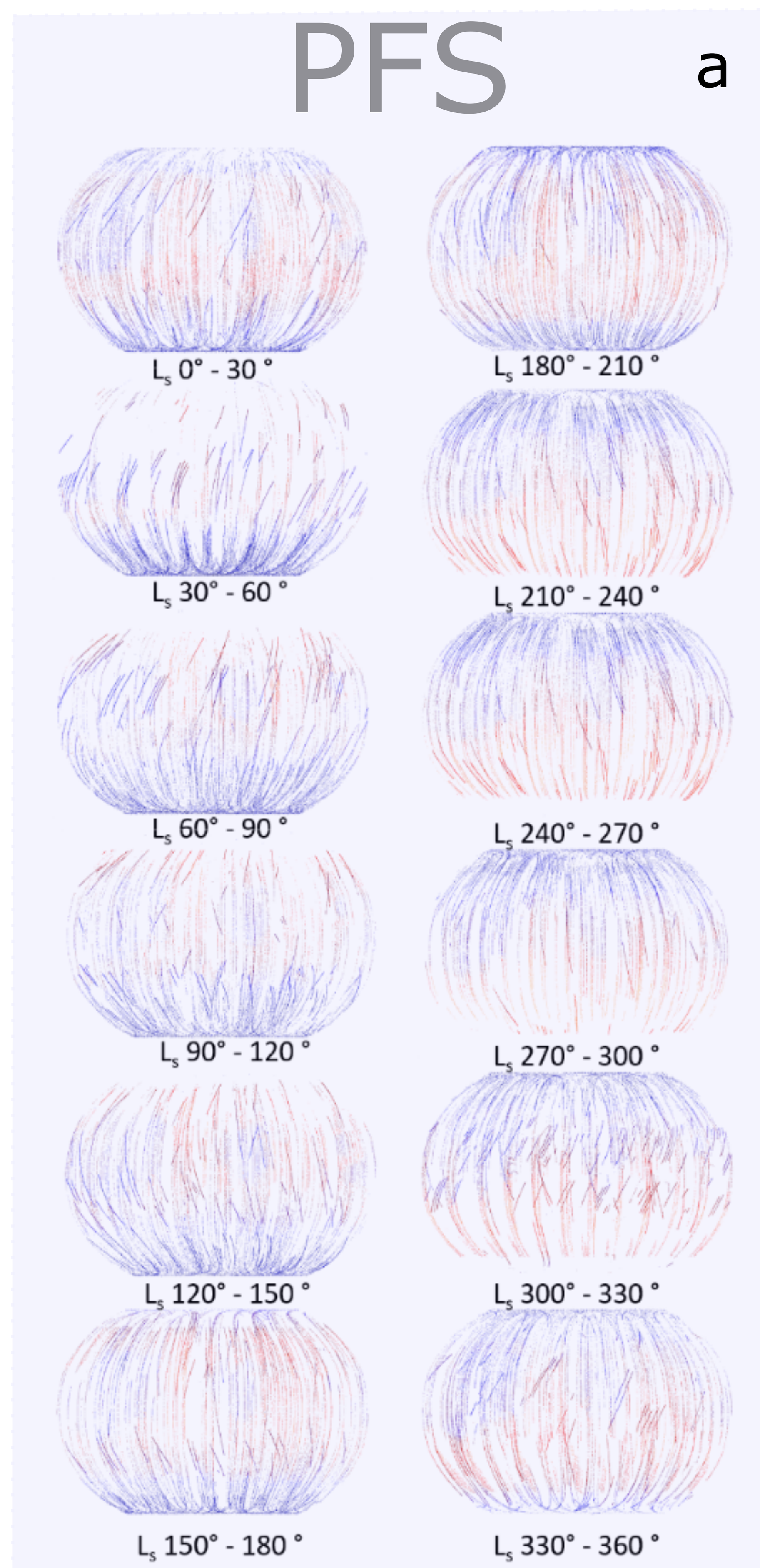
PFS



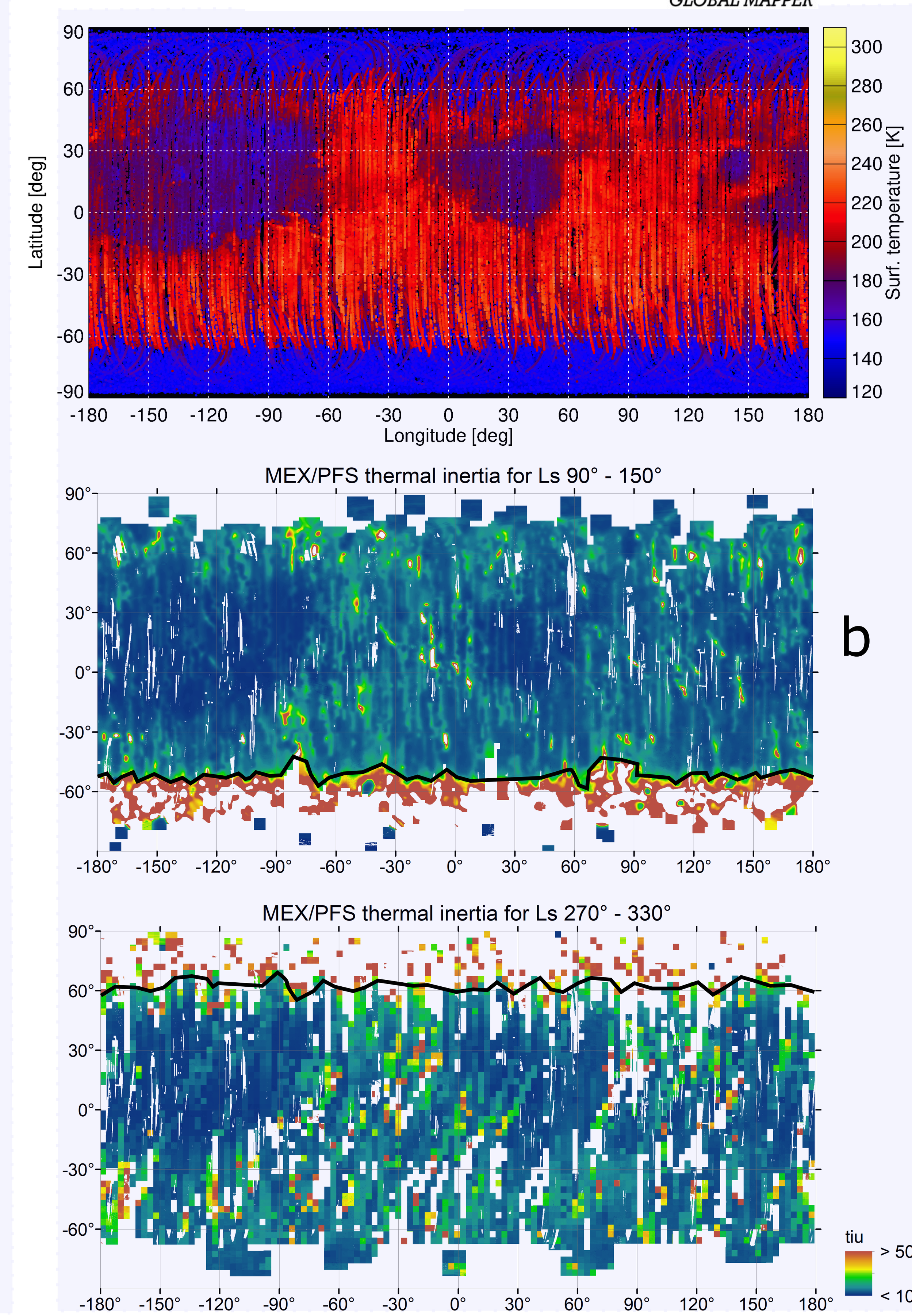


Figure 3. a) PFS/MEX nighttime surface temperature on Mars in 12 different time intervals from 9 martian years (MY26-34); b) nighttime surface temperature distribution on Mars averaged over 9 martian years (MY26-34) and thermal inertia maps for Ls=90° – 150° and Ls=270° – 330° following ATI approach. The black lines indicate the the global boundary (along ~ 1000 tiu) between the high thermal inertia values interpreted as polar ice (the red domains) and the lower thermal inertia values representing martian soils (the blue domains)

Figure 4. a) data and software used for thermal inertia calculation; b) research scheme of the ATI and DATI methods; c) TI values from Fergason et al., 2006 and ATIc values from this study for dune areas on Mars presented as box and whisker plots. Here, whiskers represent total range of values for test dune fields from our test areas, whereas the blue boxes span from the arithmetic mean to ± 1 standard deviation. The value of the red line (251 tiu) is calculated from the theoretical minimum dune grain size of 215 μm based on grain trajectory calculations and the particle size transition between suspension and saltation in Martian conditions (Edgett and Christensen, 1991) and empirical relationship between thermal conductivity and grain size derived by Presley and Christensen (1997) assuming a specific heat of 850 J·kg^{-1}/·K^{-1} and a bulk density of 1650.0 kg·m^{-3} as proposed by Mellon et al., 2008. Similarly, the modelled TI values are derived assuming typical 470-600 μm grain size provided by Edgett and Christensen (1991)

SUMMARY

We present the three ways of using thermal data in the planetary mapping of the martian surface: 1) the distribution of rock and other materials (dust, sand) of distinct thermophysical properties in sloping areas of Valles Marineris, Mars; 2) the distribution and seasonal variation of ice in the martian polar caps based on the PFS/MEX data; 3) looking for the potential internal heat sources in thev olcanic area on Mras (Olympus Mons caldera) using DATI (Christensen et al., 2004).

References: Edgett, K.S. & Christensen, P.R. (1991). The particle size of Martian Aeolian dunes, Journal of Geophysical Research, 96, Issue E5, 22765-22776; Christensen, P. R. et al. (2004), The Thermal Emission Imaging System (THEMIS) for the Mars 2001 Odyssey Mission, Space Sci. Rev., 110, 85–130 Fergason, R.L. et al. (2006). High resolution thermal inertia derived from the Thermal Emission Imaging System (THEMIS): Thermal model and applications, Journal of Geophysical Research, 111 E12004. doi:10.1029/2006JE002735; Mellon, M.T. et al. (2008). The thermal inertia of the surface of Mars. In: J. Bell, ed., The Martian Surface: Composition, Mineralogy, and Physical Properties. Cambridge University Press, New York, ISBN: 978-0-511- 41372-8, 978-0-521-86698-9, 399- 427; Neukum, G. et al. (2004). Mars: recent and episodic volcanic, hydrothermal, and glacial activity revealed by the Mars Express High Resolution Stereo Camera (HRSC), Nature 432, 971–979; Presley, M. A., & Christensen, P. (1997). The effect of bulk density and particle size sorting on the thermal onductivity of particulate materials under Martian atmospheric pressures, Journal of Geophysical Research: Planets, 102(E4), 9221-9229 [97JE00271]; Robbins, S. J. et al. (2011). The volcanic history of Mars: High-resolution crater-based studies of the calderas of 20 volcanoes, Icarus 211, 1179–1203.