MARS CLIMATE ZONE MAP BASED ON TES DATA. H. Hargitai Eötvös Loránd University, Cosmic Materials Space Research Group, 1117 Budapest, Pázmány P. st. 1/A hargitai@emc.elte.hu

Introduction: Climate zones fist have been defined by Wladimir Köppen based on the distribution of vegetation groups [1]. Climate classification is furthermore based on temperature, rainfall, and subdivided based upon differences in the seasonal distribution of temperature and precipitation; and a separate group exists for extrazonal climates like in high altitudes. Mars has no vegetation, nor rainfall so any climate classification could be only based upon temperature; a further refinement of the system may be based on dust distribution, water vapor content, occurrence of snow. Climate zone maps are not continuous as the original datasets are: they are interpreted (generalized, simplified, classified). This way they make the climate system easier to understand, emphasizing its important characteristics, omitting the less important ones.

Solar climate zones. There are several resemblances in the climate of Mars and Earth [2]. Temperature based climate zones are basically determined by the current axial tilt and solar radiation, therefore the simplest climate zone map shows solar climate zones which does not take topography, albedo, or the atmosphere into account. The Polar zones' boundaries are defined by the Arctic and Antarctic Circles (64.9°), the Transitional Zones further by the Tropic of Pisces (corresponding to the Tropic of Cancer) in the North and the Tropic of Virgo (corresponding to the Tropic of Capricorn) in the South (25.1°). The Equatorial Zone is in between the Tropics. (Fig. 1.)

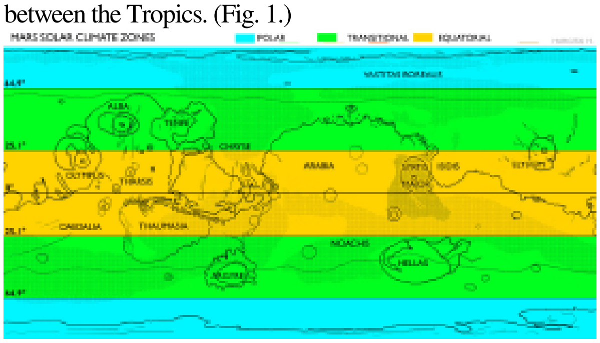

Fig. 1. Solar climate zones of Mars. *Explanation of the base map: d*otted line shows seasonal maximum frost extent; continuous lines show approximate boundaries of geographical features (they are not automatically generated contour lines), dotted areas show current approximate extent of dark sand cover (low albedo) from MGS images. Linear features are fossae or valles; and the polar cap's *topographic* (not permanent ice) boundaries.

Solar climate zones are moving north/south as seasons progress and the Thermal Equator moves. North-South seasonal differences caused by orbital excentricity make summer and winter different on the two hemispheres, therefore the two hemispheres' climate zones are not equivalent: southern hemisphere is more extreme, sublimating more CO2 during the summer and creating higher pressure, therefore giving birth to stronger winds are more dust storms. However, southern winter is colder because of larger distance from the Sun (Fig. 2, 3, 4). Asymmetry in the southern polar zone is related to the asymmetric shape of the southern permanent ice cap.

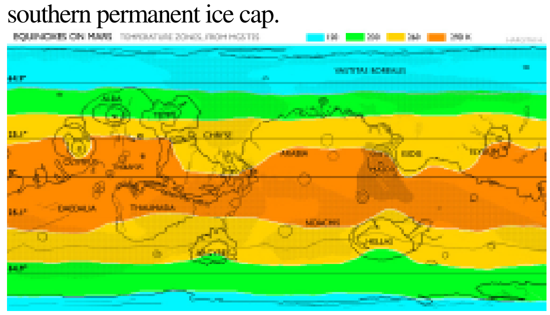

Fig. 2. Spring and Autumn Equinox (Ls=0, 180) temperature zone patterns modified by albedo and topography (Temperature values correspond to daytime maximums)

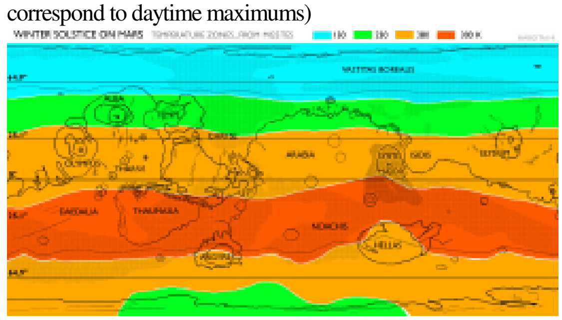

Fig. 3. North Winter Solstice (Ls=270) temperature zone patterns modified by albedo and topography and actual radiation

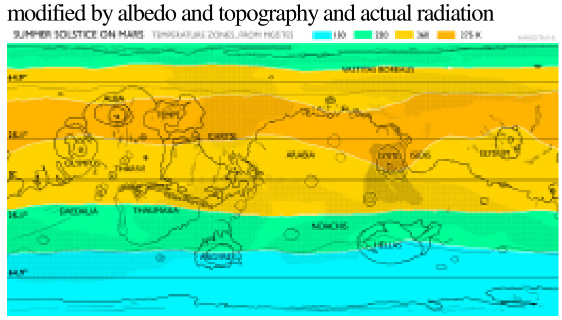

Fig. 4. North Summer Solstice (Ls=90) temperature zone patterns modified by albedo and topography and actual radiation

The actual climate pattern is much less complex that on Earth since global circulation (two Hadley cells during spring/autumn, one during summer/winter [3,4]) is more simple, there are no oceans and oceanic currents etc. The solar climatic zones are modified by topography, albedo and the presence of seasonal or permanent ice, wind patterns and the topographic dichotomy. Surface phenomena like dust devil tracks, crater wind tails are indicators of wind directions. Low albedo surfaces covered by darker sand grains has higher thermal inertia than brighter areas. Topographic lows (basins) and highs (mountains) have a topography-determined climate zone (Fig. 5.). Lowland climates are characterized by frequent fog, having a brighter average albedo.

Climate zones of Mars. Our Climate Zone Map is using temperature, albedo and topographic data combined with the data on the extent of permanent ice caps and the maximum seasonal extent of frost cover.

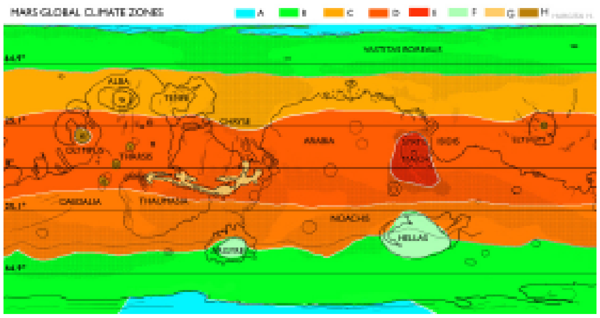

Fig. 5. Mars Global Climate Zones, based on temperature, modified by topography, albedo, actual solar radiation. **A=Glacial** (permanent ice cap); **B=Polar** (covered by frost during the winter which sublimates during the summer); **C=**North (mild) **Transitional** (Ca) and C South (extreme) Transitional (Cb); **D= Tropical**; **E= Low albedo tropical**; **F= Subpolar Lowland** (Basins); **G=Tropical Lowland** (Chasmata); **H=Subtropical Highland** (Mountain)

The temperature profiles of the particular climate zones can be represented by actual climate diagrams [5]: (Fig. 6-9) (To the left: northern hemisphere, to the right: southern hemisphere)

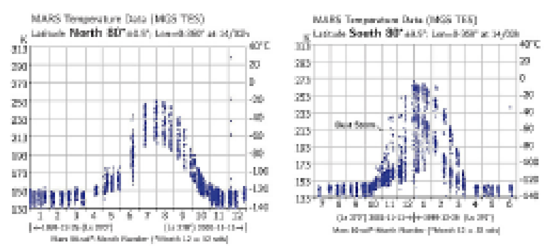

Fig. 6. Climate diagram for Glacial Zone (at 80 deg.) (showing no diurnal variation, in contrast to other diagrams)

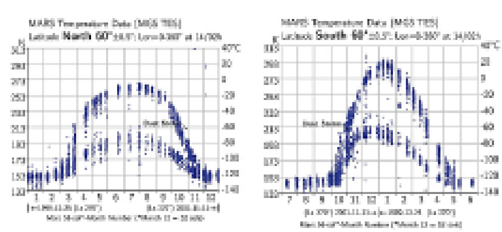

Fig. 7. Climate diagram with diurnal variation for Polar Zone

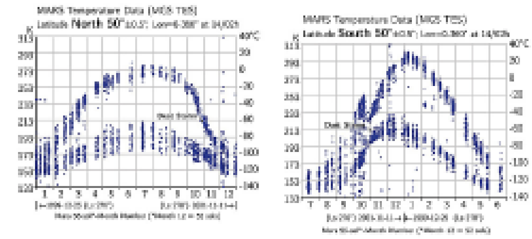

Fig. 8. Climate diagram for Transitional Zone

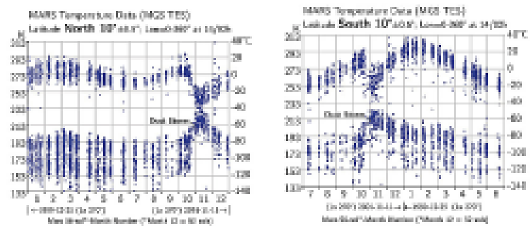

Fig. 9. Climate diagram for Equatorial Zone

Climate zones and surface features. An analogue method with Köppen's vegetation based classification system is to consider surface feature types as indicators of a climate zone. Climate zones are reflected by the current surface processes and features. However, visible surface features like valleys may reflect paleoclimatic zones of various ages [6,7]; reflecting changes in rotational axis and the atmospheric dust content for features few million years old (these include gullies, spiders, ephemeral flow-like features on steep dune slopes; polar caps, polygons); and considerable changes in atmospheric water vapor content, subsurface water, atmospheric pressure and temperature for very old (several *Ga*) features (including valley networks, channels, crater lakes) [8]. Those which reflect current climatic conditions are or have been recently active. Out future work is to combine zones defined by the distribution of specific landform types; temperature and dust (storm activity); intracrater ice/frost and snowfall [9], forming a more complex classification system for the climatic zones of Mars; as part of the ICA Commission of Planetary Cartography activities [10]. Full resolution maps are available at http://planetologia.elte.hu

References: [1] Köppen, W. (1931). *Klimakarte der Erde*. Berlin and Leipzig. [2] Kereszturi Á. (2007) *Légkör* 52/2, 12-17., 52/3, 6-9. [3] M. M. Joshi, R. M. Haberle, J. Schaeffer and J. Barnes (1997). *Advances in Space Research* 19, 8, pp. 1261-1265 [4] Mark I. Richardson and R. John Wilson (2002). *Nature* 416, 298-301 [5] H. Hargitai, Sz. Bérczi, Sz. Nagy, A. Gucsik, Á. Kereszturi (2008) LPSC XXXIX #1476 [6] Mizser, Kereszturi (2007) LPSC XXXVIII #1523, [7] Kereszturi Á (2008) *3rd Planetology Seminar,* Budapest, #D3 [8] Kereszturi A (2010): Gullies, spiders and various small flow features for climate reconstruction – idea for complex map generation. LPSC 41, *this volume*. [9] Homolya, E, Sz. Bérczi (2010) Snowings in the Solar System. LPSC 41, *this volume.* [10] Shingareva, Kira B.; J. Zimbelman, M. F. Buchroithner, H. I. Hargitai (2005) *Cartographica*, 40, 4 Winter 105-114.