MODEL-BASED CLIMATE ZONE MAP AND CLIMATE DIAGRAMS OF MARS. H. I. Hargitai
ELTE University Dept of Media and Communications, 1088 Budapest, Múzeum krt. 8. hargitai.henrik@btk.elte.hu

Introduction: Climatic conditions on Mars are known to an extent that enables to production of Global Circulation Models [1]. However, to visually characterize distinct climatic patterns, we use thematic climatic maps and climate diagrams. Previously we have produced climate diagrams based on TES data measured between 1999 and 2001 [2] based on the Walter-Lieth Climate Diagram standard [3]. Now we have developed a climate zone map and climate diagrams using the climate zones we defined. In contrast to [2], this work is based on temperature data calculated in the Martian Global Circulation Model, using the average of MY 24-31 scenarios, in the Mars Climate Database version 5.3 [1]. This provided us a tool where temperature and other data could be determined at any location at any time.

Approach: First we surveyed MARCI images to determine the patterns of clouds (orographic, polar hood and other), and seasonal polar frost/now. Then we determined temperature patterns. For the calculations, we produced daily temperature maps for every Ls=10° periods, several times during the day. We derived data tables for every approx. 5 degrees latitude, along the 0 longitude, for every Ls=15° period, with the following data: highest daily temperature at 0m and at 2m, and lowest daily temperature at 0m. From this temperature database of Ls=15° temporal and lat=5° spatial resolution (Fig. 1), we determined the change of temperature between each cell (every Ls=5°).

We decided that the climate zones are best characterized by their patterns of the seasons. We did not define seasons based neither on temperature (“warm”, “cold”), nor or precipitation. Instead, we defined “seasons” based on the change of temperature, as follows: Winter is the season when the change between the highest daily temperatures are less than 5K/Ls=15° before and after the lowest annual temperature occurs. Summer is the same, but before and after the annual highest temperatures. Spring and Autumn are the seasons after winter and summer, respectively, when the change between daily highest temperatures are larger than 5K/Ls=15° (Fig. 2). In the temperature curve this is seen as summer high plateau and winter lows, with steep changes in temperature in the transitional seasons.

To determine the best distinction between latitudinal patterns, we created latitudinal cross-sectional diagrams and global thematic maps of following parameters: mean annual temperature, annual temperature range, and annual range of the daily highest temperatures on Mars, at 0 cm model height (Fig. 3).

We combined the temperature seasonal data and the frost data to determine the final boundaries of the climate zones. These roughly correspond to isolines of the annual range of the daily highest daily tempera-
tures that we found the most indicative of the temperature patterns on Mars. We defined 13 climate zones (Fig. 4). We assigned climate zone names following the terrestrial tradition, however, the correspondence between actual tropic and polar circles is less strict than on Earth. Based on the global temperature maps, we defined subclimate regions in the low latitude zones where the highest maximum and minimum temperatures had significant differences between high and low albedo regions and at different elevations. For example, Hellas is more temperate and warmer than the same latitudinal zone while Tempe Terra is colder and more extreme. We defined extreme and temperate zones (the extreme calculated at high elevation and/or high albedo regions) and warm and cold subzones (warm at lower elevations or lower albedo regions).

![Climate zones](image)

Figure 4. Climate zone map of Mars

We then created climate diagrams for each climate zone. The main element of the climate diagrams are the daily lowest and highest temperatures at 0m and the daily highest temperatures at 2m height. Earth climate diagrams contain mean temperatures, but on Mars, the daily range of temperatures is very high that should be visualized in the diagram. The change of temperature with height above the surface is also much higher than on Earth. This is represented by the two maximum temperature diagrams, one at ground level and one at “head level”. Precipitation data is not a characteristic part of the climate pattern, because polar deposition of CO$_2$ or H$_2$O is a well-predictable function of latitude and significant cloud cover mostly occur around the large shield volcanoes, only seasonally, and are not providing precipitation. The effect of seasonal clouds on the temperature is not significant in the model.

The climate diagrams include the following parameters: Latitudinal limits of the Climate Zone, Months of polar hood, Cloudy months, Dusty months, Location of measurement in the climate model (latitude, longitude), Yearly range of temperatures (all data in °C), Yearly range of highest temperatures, Average yearly temperature, Highest temperature, Lowest temperature, Water ice column (kg/m$^2$), Surface CO$_2$ ice layer (kg/m$^2$), Months of seasonal polar frost cover (Figs. 5-6).

![Climate diagram samples](image)

Figure 5, 6. Climate diagram samples.

The temporal axis of the climate diagrams displays terrestrial months that are not officially used on Mars. However, this unit makes them comparable to terrestrial climate diagrams and also to our everyday perception of the seasons (As a rough approximation, on the diagrams Ls=270 corresponds to the beginning of January).

**Further work.** The making of the presented diagrams is a preparatory work for climate diagrams using actual measurements. The maps and diagrams presented here are calculated from model data. Further work is needed to confirm the zone boundaries and climate zone characteristics using actual orbiting spacecraft measurements (such as TES). On the diagrams, the effects of global dust storms are not shown, this is another element that should be added in the future.

**Publication.** The climate diagrams have been developed for the Pocket Atlas of Mars [4] that is intended to be used by Astronomy Club members and students in Central Europe.

**References:**