EXPECTED CLIMATES FOR TERRESTRIAL EXOPLANETS USING EXOPLAN3T-ARTECS EPN-TAP CONNECTIONS. F. Manni[1,2,3], L. Biasiotti[4,9], M. Giardino[1,2], S. Ivanovski[4], M. Maris[4,7,8], G Murante[4,6,7], P. Simonetti[4], G. Sindoni[2], L. Silva[4], F. Verrecchia[2,5], G. Vladilo[4], A. Zinzi[1,2], [1]Agenzia Spaziale Italiana (francesca.manni@asi.it), [2]Space Science Data Center, [3]Università degli Studi di Roma Tor Vergata ("Science and Space Technology" II level Master and "Astronomy, Astrophysics and Space Science" PhD), [4]INAF-OATS, [5]INAF-OAR, [6]CNR-IGG, [7]IFPU, [8]CNR-ICSC, [9]Università degli studi di Trieste.

Introduction: Exo-climatology is a generalization of terrestrial climatology, applied to extrasolar planets, able to produce models to interpret astronomical observations of exoplanets and derive their possible climates. From these models composed of a set of parameters characterizing the state of the planets, we obtain p/T (pressure/temperature) and compositional atmospheric profiles, together with a set of climate indices related to the state of the planet, including the habitability of the planetary surface.
Here we search for potential habitable climates modelled by the exoclimate database ARTECS (ARchive of TErrestrial-type Climate Simulations, https://wwwuser.oats.inaf.it/exobio/climates/) by using its connection with the SSDC ExoplAn3T tool (https://tools.ssdc.asi.it/exoplanet).

The connection between ExoplAn3T and ARTECS: By means of ExoplAn3T we selected exosystems with at least one planet with terrestrial characteristics (e.g., radius, semi-major axis, stellar type) in order to find inside ARTECS climate cases that can be associated with them: the link between ExoplAn3T and ARTECS has been established using EPN-TAP protocol [1].
In ARTECS the parameter variability ranges are: semi-major axis between 0.9-1.5 (AU); eccentricity 0.0-0.8; planet radius currently fixed to Earth radius; planet rotation period currently fixed to Earth value; obliquity of rotation axis 0°-45°; surface gravity currently fixed to Earth value; planet geography [2] (0: constant fraction of oceans in all latitude bands; 1: present Earth - not available for selection; 2: equatorial continent; 3: polar continent; 4: present Earth (sampled over 46 latitude strips and interpolated to the desired number of strips); constant fraction of oceans 0.1-0.9 [only applies to Planet geography = 0]; CO2 partial pressure 0.01, 10, 100 times the reference Earth value (380 ppmv) [currently all cases consider Earth geography and CH4 partial pressure currently fixed to the reference Earth value (1.8 ppmv)]; Object name: name of the simulation - not available for selection; file name: conventional file name of the simulation - not available for selection.
On ExoplAn3T tool we set some conditions such as number of planets in the system (> 1), the orbit semi-major axis (0.5-3 AU), the eccentricity (0-0.5), the stellar effective temperature (5000-7000 K) and the planet radius (0.5-3 Earth radii).
For every exoplanet found, ExoplAn3T searches inside ARTECS for exoplanets with physical and orbital characteristics mapped by the climate cases: in this very preliminary analysis we found 8 different exoplanets whose climate can be simulated by the ARTECS climate cases.
Our aim is now to inspect these output models in order to better constrain the habitability of those exoplanets, taking into consideration and making vary parameters that cannot be observed up to now, such as *ocean fraction*, *atmospheric pressure*, *mean global ice coverage*, *mean orbital cloud covering*, *geography*.
These parameters strongly influence the climate: for example, as the obliquity rises from 11 to 34 degrees a clear seasonal change occurs (a greater obliquity means higher temperatures at the poles) (comparison between Fig. 1 and Fig. 2) and at higher pressures, we observe a more uniform distribution of temperature (lower) due to the increase in thermal transport (Figure 1), whereas a homogeneous distribution of temperature at the poles and the equator is due to a larger fraction of oceans, FO_CONST (Fig. 3).
According to [3,4], the remarkable differences in surface temperature and habitability exist between the low- and high-pressure regimes, mainly because the range bracketed by extreme surface temperatures decreases with increasing pressure. They also note that at low pressures ($p \lesssim 0.3$ bar) the habitability is generally low and varies with semi-major axis. At high pressure ($p \gtrsim 1$ bar), the habitability is high and relatively constant within the habitable zone.

Conclusions and future works: At the end of this study we should be able to better define a classification of climates that are favourable for habitability. So far, some models coherent with the Earth parameters have been found. Analysing these cases will be useful to select the best candidates for future searches for life on exoplanets. Modifyng ExoplAn3T to better integrate ARTECS one should have to look for real exo-systems modelled by ARTECS and determine a classification. Adding constraints to provide quantitative criteria for future studies of the Galactic habitable zone it will be possible exploring the habitability for complex life [5] for a wide range of planetary and stellar parameters. Therefore, studying the exoclimatology and its connection with actual exoplanet characteristcs, could result in progressing towards a full understanding of the effects of temperature trend related to physical parameters and will clarify the potential of terrestrial life as a reference in the quest for complex life in the universe.

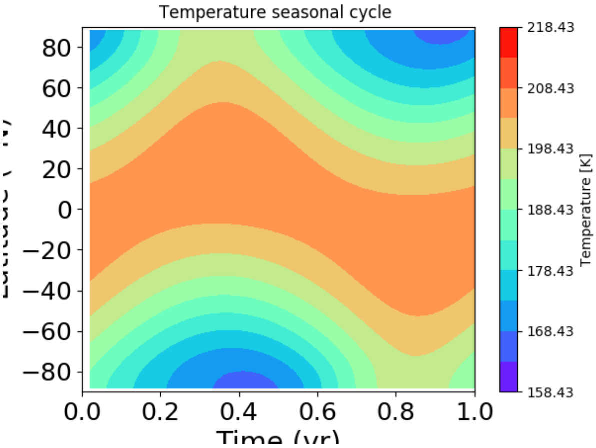

Figure 1: map of the model ESTM1.1.01-11.04.2017-0076. We note an increasing temperature due to a low pressure.

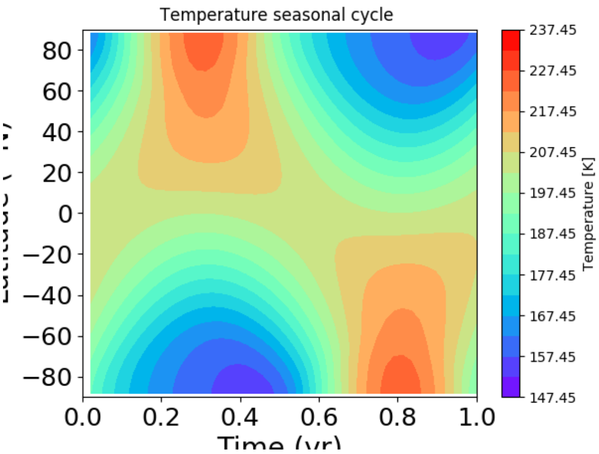

Figure 2: map of the model ESTM1.1.01-11.04.2017-0159. The major obliquity implies an increase of the temperature. In this case the equator-pole temperature difference is larger than previous map. Here the temperature is greater closest to the poles.

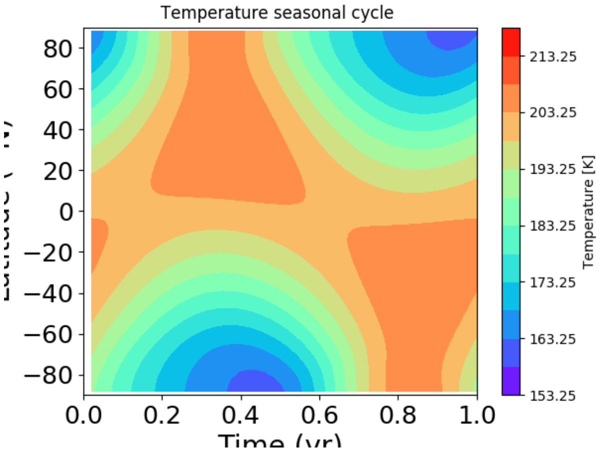

Figure 3: map of the model ESTM1.1.01-21.02.2017-0118. The obliquity increases and the temperature is greater. In particular the temperature is more homogenous distributed between the poles and equator due to lower FO_CONST. The temperature decreases at greater pressure.

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