Mini Grant project

Radiative models for the paleoatmospheres of Earth, Mars and Venus

Paolo Matteo Simonetti, INAF-OATs

Naples, 19/10/2022

Scientific rationale and goals

General goals:

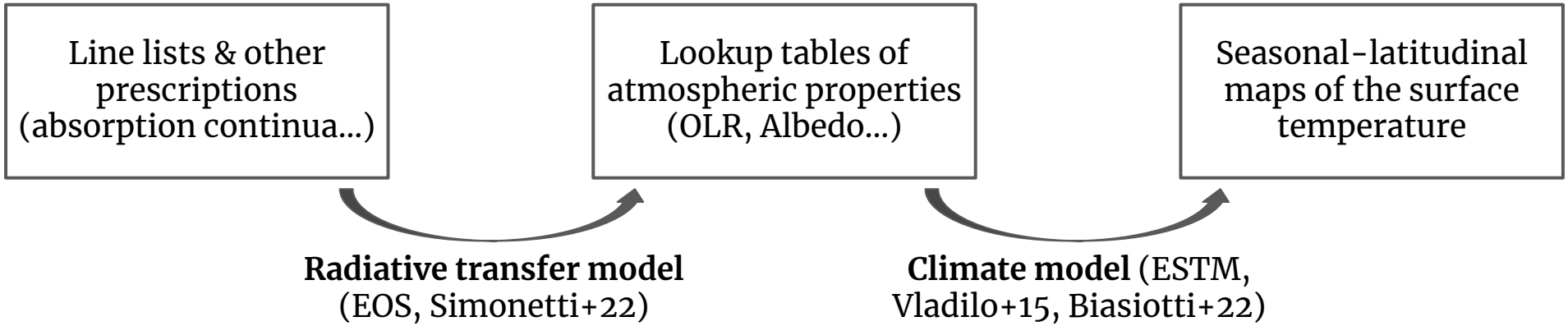
- interpreting under a unified picture the increasing amount of empirical data about Archean Earth and Noachian Mars climates
- narrowing down the planetary parameter space region that gave rise to life on Earth (and possibly other planets)

In specific:

- studying the effects of space weather-produced nitrogen oxides and HCN on the Archean Earth climate
- exploring the Noachian Mars climate for a broad range of atmospheric compositions

In order to achieve this we will make use of novel radiative transfer (RT) and energy balance (EBM) climate models

Methods



EOS:

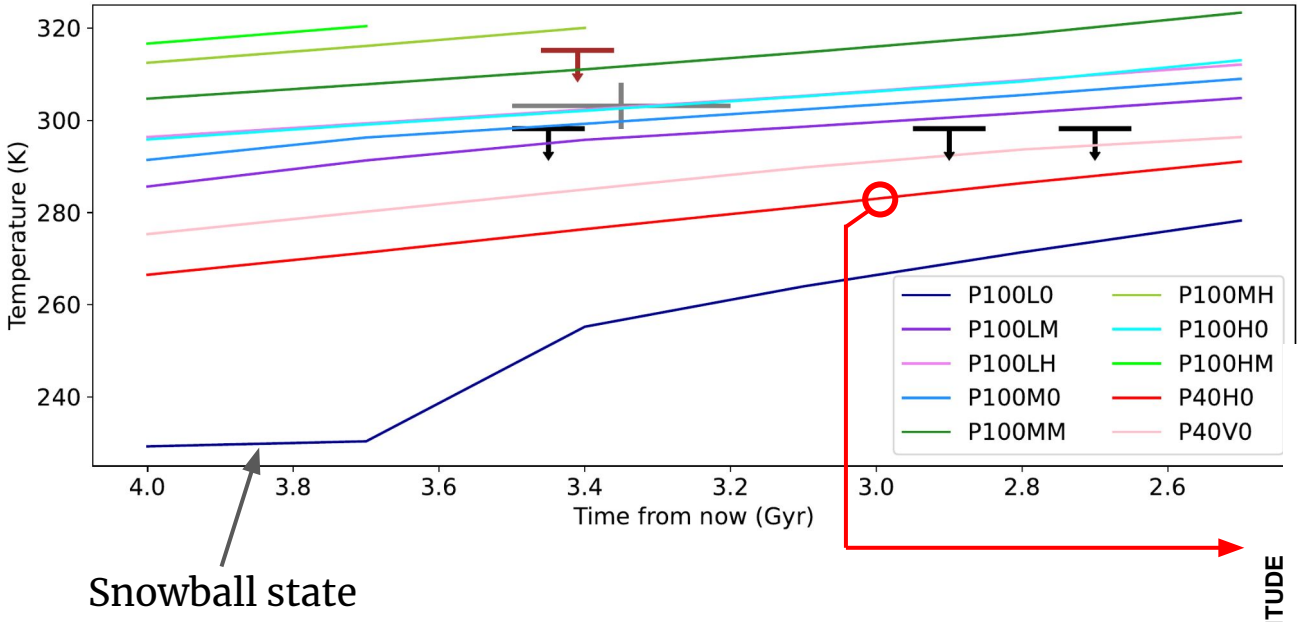
- derived from the HELIOS and HELIOS-K
- line-by-line, two-stream approximation
- GPU-accelerated
- primed to be coupled to photochemical models (Vulcan, FastChem...)

ESTM:

- energy balance model
- enhanced parameterization of latitudinal heat diffusion
- already used in climate bistability studies (Murante+20)

Fast and **flexible**, efficient exploration of the parameter space!

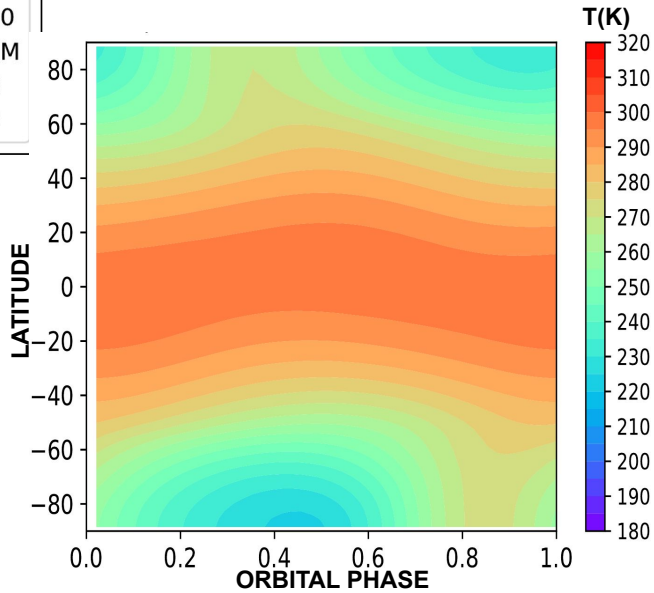
Preliminary results



Snowball state

Avg. temperature evolution of Earth during the Archean using different atmospheres

Changed pCO2, pCH4 and pTOT



Next step: include NOx and HCN produced by space weather to study their impact on Earth climate

Current development

Work in progress on:

- including the effects of clouds (currently: parameterized at the climate model level)
- coupling and validating the photochemical model
- studying ionizing radiation fluxes at surface during the Archean with GEANT4
- keeping CIA prescriptions and line lists updated

Deliverables:

- one paper on the impact of space weather-produced gases in the Archean Earth atmosphere
- one paper exploring the climate state of Noachian Mars under a wide variety of atmospheric chemical compositions
- a publicly available photochemical-radiative-climate model to study planetary habitability in our Solar System and beyond