The internal constitution of rocky exoplanets can be inferred indirectly via their atmospheric composition. To address this issue with confidence requires the coupling of interior and atmospheric models to each other. In the past, various atmospheric redistribution models were developed to determine the composition of exoplanetary atmospheres by varying element abundance, temperature and pressure. One example for such a model was published by Woitke et al., 2021, they used a simple stoichiometric approach to calculate chemical equilibrium in the C-H-O-N system and proposed a classification of exoplanet atmospheres based on their 4 most abundant gases: type A atmospheres contain H2O, CH4, NH3 and N2 (A1 or A2). Type B Atmospheres contain CO2, H2O, CO and N2 and type C atmospheres contain H2O, CO2, CH4 and N2, these types are visualized in Fig. 1. However, this model as well as similar work neglect that present-day atmospheres were formed via volcanic degassing and, consequently, element abundances are limited by thermodynamic processes accompanying magma ascent and volatile release. Here we combine a volcanic outgassing with the model used by Woitke et al., 2021 to simulate the evolution of C-H-O-N atmospheres in thermal equilibrium below 650 K. For the present study we built a basic model to calculate possible atmospheric compositions by varying oxygen fugacity, melt and surface temperature and volatile abundances. Furthermore, we consider the solubility of each phase, atmospheric processes such as water condensation, graphite precipitation, hydrogen escape and the effect an already existing atmosphere may have on further degassing.

We have developed a model which allows us to calculate the influence of volcanic degassing on the evolution of atmospheres on terrestrial planets in the C-H-O-N system below 650 K. The mantle and therefore melt redox state have a significant influence on the composition of planetary atmospheres. Type B and type D2 atmospheres are never formed in our calculations, since O2 and N2 are always enough hydrogen or carbon in the atmospheres to form other molecules. Intriguingly we see another atmospheric type not described in their work a theoretical Carbon dominated atmosphere in the case we are reaching the limitations of the atmospheric redistribution model and more work is needed to confirm this. Woitke et al., 2021 mentioned in their work a theoretical Carbon dominated atmosphere in which graphite clouds occur (referred to as D1), but graphite was never formed in our calculations, because such a composition would need high amounts of Carbon and low amounts of Oxygen which are two prerequisites not described. The most common atmospheric type are type C atmospheres. Reduced mantles can lead to a formation of A1 or A2 atmospheres. O2 dominated Type B atmospheres are never produced via degassing since O2 does not degas by itself but always as CO2, CO or H2O, hence there is always enough hydrogen or carbon in the atmospheres to form other molecules. 

In the next degassing step, to simulate atmospheric build up over a long period of time, the routine is repeated 100 times equaling a melt production the weight of 4 times of Earth’s crust.