The most Earth like exoplanet

KEPLER-452b

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# Abstract

Kepler 452b's finding marks a significant turning point in the search for terraforming exoplanets. Although it has been claimed that Kepler 452b is the first Earth-like exoplanet found in the habitable zone of a Sun-like star, quantitative investigations are needed to determine its climatic conditions and habitability. Only 12 Earth-sized planets (less than twice the size of Earth) had previously been found by the Kepler telescope in the habitable zone of their smaller, colder stars. The first planet to circle a star that is similar in size and temperature to the sun is Kepler-452b. The area surrounding a star known as the habitable zone has temperatures that allow water to pool on the surface, which is necessary for life as we know it. The existence of life on Kepler-452b is unknown to scientists. The orbital period of this potentially rocky  planet, which orbits its G2 host star every 384.843  days, is the longest for a tiny planet. The orbital period of this potentially rocky  planet, which orbits its G2 host star every 384.843  days, is the longest for a tiny planet, to date. The probability that this planet is composed primarily of rocks ranges from 49% and 62%. The star has a log g of 4.32 0.09 and an effective temperature of 5757 85 K. This tiny planet's typical orbital distance of 1.046 AU puts it well within the optimistic habitable 0.015 AU range zone of its star ,obtaining just 10% higher radiation from today in the Sun, just outside the conservative habitable zone (runaway greenhouse/maximum greenhouse). An ever-evolving idea, the habitable zone is here defined as the range of distances around a star where liquid water can collect on the surface of a tiny rocky planet.

## **1. Introduction**

The first super-Earth exoplanet observed in the habitable zone (HZ) of a Sun-like star is Kepler 452b (Jenkins et al. 2015). It has an orbital distance marginally more than that between the Sun and Earth, has a radius around 1.6 times that of Earth, and receives 10% more stellar radiation flux from the Sun than Earth does. The Sun is a G-type star, just like Kepler 452b, which is its parent star. The star is 20% more massive than the Sun and 1.5 billion years older. The search for worlds that support a remotely detectable biosphere is one of the driving forces behind exoplanet research. Surface life can provide atmospheric biosignatures that exoplanet atmospheric spectroscopy can detect, in contrast to life that is restricted to below the surface (e.g. Tinetti, Encrenaz & Coustenis 2013; Kasting et al. 2014; Seager 2014). Kepler 452b does not have to deal with issues like those that have previously been encountered by other exoplanets in the HZ of M dwarfs, which are too close to their parent stars and therefore probably lack water (Lissauer 2007; Luger & Barnes 2015; Tian & Ida 2015) or could suffer from intense flares and extreme ultraviolet radiation from M dwarfs (Lammer et al. 2007; Scalo et al. 2007). If it is a rocky planet, all of these factors make Kepler 452b the most habitable exoplanet that resembles Earth. It is unknown if Kepler 452b is a rocky planet because the planet's mass has not been determined. The posterior prediction chance that Kepler 452b is a rocky planet with a thin atmosphere is between 49% and 62%, according to statistics of the mass-radius relationship determined from observational samples with a radius less than 4 Earth radii (Weiss & Marcy 2014; Rogers 2015). (Jenkins et al. 2015). The existence of Kepler 452b as a planet with a thin gaseous shell enclosing a tiny rocky core is thus also a possibility. Though Kepler 452b is the closest planet to Earth that has been found so far, further research is warranted because of the possibility that our planet's environment will resemble that of Kepler 452b when the Sun becomes stronger in the future. Even if Kepler 452b turns out to be primarily gaseous, research into it will provide insight into the environment and habitability of other undiscovered rocky exoplanets with comparable planetary radii and atmospheres.

## **2. Method**

In recent years, three-dimensional AOGCMs have been used more and more to research the climates of early Earth and potentially habitable exoplanets. AOGCM models have the benefit of including heat transports by three-dimensional ocean circulations as well as both sea-ice dynamics and thermodynamics, in contrast to slab-ocean simulations, which exclude ocean heat transports and sea-ice dynamics. As a result, AOGCM results are more accurate and fundamentally sound, and as a result, they offer a superior framework for understanding physical mechanisms governing climate. However, just like with slab-ocean simulation results, these findings should not be taken at face value.

Kepler 452b's planetary parameters, which come from Kepler mission measurements, are added to the model (Jenkins et al. 2015). 384.8 Earth days, 1.63 times the size of the Earth, and 1.1 times the solar constant (1504 Wm2) are the orbital period, planetary radius, and stellar radiation flow, respectively. The rotational speed of Kepler 452b is assumed to be the same as that of the Earth (7.292 105 s1). Obliquity and eccentricity are both set to zero. The mass of Kepler 452b has never been measured, hence the gravity parameter is unknown. Here, in order to make the issue more manageable, we assume that Kepler 452b is a rocky planet with an Earth-like density.

Its gravity is roughly 1.6 times that of the Earth. In addition, we consider Kepler 452b to be an aquaplanet with a constant ocean depth of 4 km. Because ocean heat transports are mostly carried out by the top layer of the ocean, which is around 1 km deep, further increasing the ocean depth has little effect on these simulation results (Hu & Yang 2014; Yang et al. 2014). In order to give the ocean time to spin up, the model is initially run for 1000 Earth years. To establish equilibrium, the three simulations are each run for a further 500 Earth years. The Letter's monthly mean outcomes were taken from the previous ten years. Different CO2 concentrations are present in the three scenarios. One has a 1 bar nitrogen atmosphere with 355 ppmv of CO2, which is the amount of CO2 in the atmosphere on Earth right now. In the second simulation, the CO2 concentration is incredibly low and there is a nitrogen atmosphere at 1 bar (5 ppmv). A 0.2 bar CO2 addition is made to the 1 bar nitrogen atmosphere in the third simulation. The following abbreviations for the three scenarios are Earth CO2 concentration (E-CO2), Low CO2 Concentration (L-CO2), and High CO2 Concentration (H-CO2).

## **3. Results**

The monthly mean surface air temperatures (SATs) for the E-CO2 simulation are distributed globally in Figure 1(a). The SAT in the tropics is roughly 310 K, while in the polar zones, it is roughly 240 K. The global-mean SAT is 293 K, about 5 K hotter than the current Earth's temperature (288 K). Kepler 452b is warmer than Earth despite having similar atmospheric compositions because it receives about 10% more stellar radiation than Earth.

 The E-global-mean CO2simulation's SAT is similar to one from a prior study that mimics Earth's future climate with a 10% higher solar constant (Wolf & Toon 2014). However, it is significantly lower than the results of two other investigations and roughly 14 K lower than that in other research (Shields et al. 2014; Wolf & Toon 2015). (Leconte et al. 2013; Popp et al. 2016). The reason why our findings and those of Wolf & Toon (2014) are consistent is because the atmospheric component of CCSM3 uses the Community Atmospheric Model version 3 (CAM3) (2014). As a result, their cloud albedo is comparable.

lower SAT. But even with CAM4, Kepler 452b is still livable. The thickest ice is around 24 meters thick over both poles. According to the findings, Kepler 452b can sustain life even if sea-floor silicate weathering is effective in bringing atmospheric CO2 levels down to extremely low levels. Given that Kepler 452b has a significantly longer lifetime and is probably warmer than Earth, it is also a major issue whether all of its water has been lost. The global-mean SAT is just 5 K higher than that of Earth, as shown by the E-CO2 simulation. It implies that the cold trapping zone should remain close to the tropical tropopause for CO2 concentrations like those in the Earth's atmosphere and that there shouldn't be any significant changes in stratospheric water mixing ratios. So long as Kepler 452b has a comparable amount of water to Earth, the planet's diffusion-limited escape rate of water should not be much different from that of our planet today

## **4. Discussion and Conclusions**

If Kepler 452b's atmospheric CO2 concentrations are similar or lower than those of the Earth's atmosphere, then our modeling results show that it is a habitable exoplanet. The models also demonstrate that if Kepler 452b once had seas at depths equal to Earth's, it could still maintain its water inventory even for global-mean SAT as high as 322 K. Kepler 452b could become uninhabitable if there isn't enough carbonate-silicate weathering to control the amount of CO2 in the atmosphere. If Kepler 452b is an ocean-covered planet with a CO2 content limited by carbonate-silicate weathering over continents, it should be habitable (Cowan & Abbot 2014). The degree of sea-floor weathering will determine how habitable Kepler 452b is if it is an aqua-planet. It's possible that super-Earth exoplanets like Kepler 452b have atmospheres that are denser and richer in hydrogen (H2) and nitrogen (N2) than Earth's atmosphere (H2). The radiative impacts of numerous atmospheric components have a big impact on Kepler 452b's climate. Higher N2 concentrations, on the other hand, have the propensity to stabilize the planet's temperature by increasing the Rayleigh scattering of stellar radiation and, as a result, the planet's albedo (Kopparapu et al. 2014). High-level N2, however, will increase the pressure broadening of CO2, which intensifies the greenhouse effect, and H2-N2 collision-induced IR radiation absorption may result in a significant increase in global warming (Wordsworth & Pierrehumbert 2013b). Because the current model cannot analyze these radiative impacts, they are not here.

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