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A2 8: From Sandworms to Saplings: Cooling Arrakis with Trees

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Abstract

In this paper, we investigate the feasibility of terraforming Arrakis through planting trees like how it is done in the Dune Franchise. We have determined that due to the change in albedo, despite the evapotranspirational effect, the temperature of the planet would increase to approximately 325 °C, proving that other methods of terraforming were undertaken but not described.

Introduction

In the Dune franchise, the barren desert of Arrakis is adapted to better suit humans through the large-scale terraformation of the planet using trees [1]. In this paper, we outline an investigation into this method and its feasibility.

Trees naturally have a cooling effect on the surrounding air and surfaces through their evapotranspiration effect. This is where energy that would normally be absorbed into the surface is instead used to evaporate water that is moved into the atmosphere, therefore giving a cooling effect on the surface of a planet [2].

Terraforming

Since we do not know the type of trees that are native to Arrakis, we are forced to assume a tree that has a known evapotranspirational value. In our case we assume they use a young beech tree, which has an evapotranspirational effect of 123.5Wm^2 [3]. This would mean that through the process of evaporating water given off by a young beech tree, we can decrease the amount of energy from the solar constant we derived in A2 7 Dune Part I: Charting the Oasis [4]. Since we have previously found this to be 1500Wm^{-2} [4], if we assume that 100% of Arrakis is covered in trees, as described in the literature, we can make the new solar constant to be approximately 1375Wm^{-2}. From this we can derive a new temperature using equation 3 from the previous paper:

$$T = \sqrt[4]{\frac{(n+1)S_{\odot}(1-\alpha)}{4\epsilon_s\sigma}} \tag{1}$$

where T is the surface temperature in Kelvin; n represents the number of greenhouse gases in an atmosphere; α is the albedo of the planet; ϵ_s is the surface emissivity, which is given as one as it is assumed to be in unity; σ is the Boltzmann constant.

$$\sigma = \frac{2\pi^5 k^4}{15c^2h^3} = 5.67 \times 10^{-8}\text{Wm}^{-2}\text{K}^{-4} \tag{2}$$

We can therefore use the previous assumptions of $n = 24, \epsilon_s = 1$, alongside the use of the new albedo of a deciduous tree (0.15 to 0.18) of which we have assumed to be 0.165 [5]. Since Arrakis is oxygen rich enough for animals and humans to breathe, we believe that the oxygen given off by these new trees would be minimal and therefore

would not result in any change of the n value. This determines that the new surface temperature of Arrakis would be 600K.

Discussion

This would mean Arrakis would have an average temperature of a cool 325 °C, a temperature that we believe would be inhospitable for life on the planet, despite the temperature difference between the poles and the equator. This temperature could possibly be hot enough to even auto-ignite some trees [6], which suggests to us that Arrakis may have also used other methods to bring about the cooling of the planet.

One possible cooling method would be the destruction of the large ozone (O_3) layer of which we know is abnormally high on the planet of Arrakis.

The Ozone Hole

We are told that Dune has a largely ozone dominated troposphere, acting as its primary insulating greenhouse gas. In normal situations, tropospheric ozone would have a lifespan of days or weeks, but on Arrakis, this ozone does not break down. This would explain the high temperatures that we face on the surface of Arrakis.

One solution to this, that Earth knows too well, would be the use of Chlorofluorocarbons (CFCs), which could be dispersed over the planet, breaking down into Chlorine atoms which destroy ozone [7]. On Earth the destruction of our stratospheric ozone layer led to higher amounts of UV radiation reaching the Earth, causing increasing temperatures. On Arrakis however, the destruction of ozone would give a cooling effect, as the tropospheric ozone would not be able to internally absorb the UV radiation, leading to more UV radiation being reflected away [8]. As the ozone layer has such a choking effect on Arrakis, the removal could make it feasible for them to terraform the planet.

Conclusion

We have determined that the planting of trees would fail to provide a cooling effect on Arrakis, and would in fact heat up the planet due to the new lower albedo, absorbing more radiation from its star. This therefore proves that Arrakis must have been terraformed through the use of other methods like CFC dumping in order to destroy its ozone layer. This method is unfortunately far too complex to investigate in such a short paper, but we would encourage further research into this.

References

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