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Fair Plan 4: Safeguarding the Climate of "This Island Earth"

Michael E. Schlesinger, Michael J. Ring, Daniela Lindner, Emily Cross, Victoria Prince

Climate Research Group, Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, Urbana, IL, USA
Email: schlesin@illinois.edu

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Abstract

Earth is the only habitable planet in the solar system and beyond in interstellar space for a distance that would take us at least 80,000 years to traverse at the speed of Voyager 1. Thus our home planet is "This Island Earth". Here we use our Simple (engineering-type) Climate Model to calculate the change in global-mean near-surface air temperature from 1765 through the third millennium for historical emissions and two scenarios of future emissions of greenhouse gases: (1) a Reference scenario of unabated emissions, and (2) our Fair Plan scenario wherein emissions are phased out to zero from 2020 to 2100. The temperature change for the Reference cases increases to 5.2˚C (9.4˚F) in 2225 and remains there for at least 40 human generations. By design, the temperature change for the Fair Plan increases only to 2˚C (3.6˚F)—the limit adopted by the UN Framework Convention on Climate Change "to prevent dangerous anthropogenic interference with the climate system"—in 2082 and thereafter decreases through the remainder of the millennium. Accordingly, we need to adopt the Fair Plan to safeguard the climate of "This Island Earth".

Keywords

Climate Change, Global Warming, Greenhouse-Gas Mitigation

1. Introduction

We live on the one-and-only habitable planet in the solar system, Earth (**Figure 1**). On Mars the average near-surface air temperature is –65˚C (–85˚F), the surface pressure is 1/160 that of Earth, and the atmosphere is nearly all carbon dioxide [1]. On Venus the average near-surface air temperature is 464˚C (867˚F), the surface pressure is 92 times that of Earth, and the atmosphere is nearly all carbon dioxide [1]. The other planets in the solar system are no more hospitable, with either no atmosphere or an atmosphere that is toxic to life.

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Figure 1. "This Island Earth". Photo taken by Harrison (Jack) Schmidt on his way from the Moon to the Earth aboard the last manned mission to the Moon, Apollo 17, December 1972. Source: http://98bowery.com/return-to-the-bowery/images/mem-earth.jpg

Astronomers have found several other planets within the "Goldilocks Zone" of other stars, the zone wherein radiation from the star is equal to that at Venus from the Sun—about twice that at Earth—to that at Mars—about half of that at Earth. While that is necessary for a planet to have liquid water, and thus life as we know it, it is not sufficient. Neither Venus nor Mars has surface liquid water or life. Why? Because Venus has too much carbon dioxide, and is thus too hot, and Mars has too little carbon dioxide, and is thus too cold. For liquid water and life to exist, a planet must not only be in the Goldilocks zone, it must also have the right amount of greenhouse gases. Earth is the one-and-only planet in the solar system that has the right amount of greenhouse gases to permit life.

The distance to the nearest star other than the Sun, Proxima Centauri, is 4.2 light years (40 trillion kilometers = 25 trillion miles) [2] (**Figure 2**). Our space probe Voyager 1, launched in 1977, has left the solar system and is traveling at 35,000 miles an hour [3]. At that speed it would take 80,000 years to reach Proxima Centauri [2]. So, even if Proxima Centauri has an Earth-like planet, it is too far away for us to reach it. Thus Earth is very likely the only planet for an enormous distance that permits life, for at least 80,000 years' travel time at the speed of our space probes. Accordingly our home planet truly is "This Island Earth" [4].

We have published three papers on how we can safeguard the Earth's climate [5]-[7]. These papers are described in the following section, as is how this paper differs from them.

2. Fair Plan to Safeguard Earth's Climate

In our three antecedent papers we used our Simple (engineering-type) Climate Model [8] to calculate the change in global-average near-surface air temperature from 1765 through year 3000 for historical emissions and two scenarios of future emissions of greenhouse gases (GHGs): (1) a Reference scenario—the Representative Concentration Pathway 8.5 scenario (RCP-8.5) and its extension (ECP-8.5) from 2100 through 2500 [9]—thereafter the emissions were kept constant through 3000; and (2) a Mitigation scenario—the Fair Plan scenario.

The Fair Plan is fair in two ways. First, it uses trade-adjusted emissions, that is, the GHG emissions incurred by country E in producing goods and services imported therefrom by country I are considered as the GHG emissions of country I, not country E. Second, the intensity of GHG emissions [10] of the developed (so-called Annex B or AB) countries and developing (non-Annex B or nAB) countries are decreased differently from unity

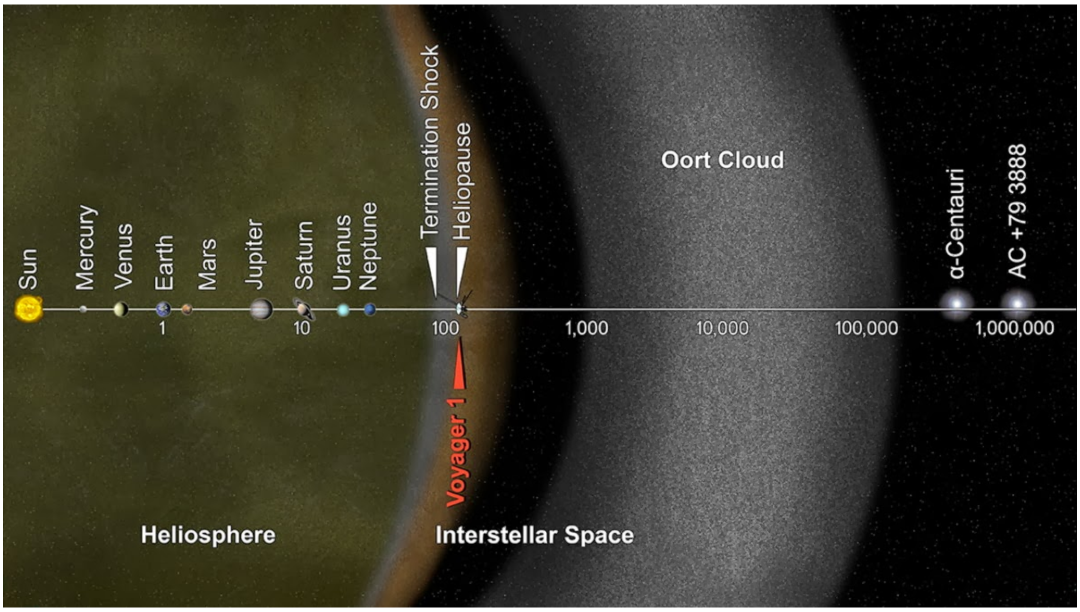

Figure 2. The distance from the Sun to the planets of the solar system, the edge of which is the Heliopause, and α-Centauri, which is in the cluster of three Centauri stars. The units are "Astronomical Units" (AU), one of which is equal to the average distance of the Earth from the Sun. The distance scale is logarithmic, with each numeral shown being ten times farther from the Sun than the preceding numeral. Source: http://beyondearthlyskies.blogspot.com/2013/10/searching-for-far-flung-objects.html

starting in year YS to zero in year YE such that: (1) the cumulative GHG emissions for AB and nAB countries are equal, and (2) the maximum increase in global-mean near-surface air temperature does not exceed the 2˚C (3.6˚F) limit adopted by the United Nations Framework Convention on Climate Change (UNFCCC) "to prevent dangerous anthropogenic interference with the climate system" [11] [12]. The GHG intensity decreases from unity in YS to zero in YE linearly for AB countries and more slowly at first for nAB countries, thereby allowing their continuing economic development.

In our first Fair Plan paper (FP1) [5] we prescribed YS = 2015 and YE = 2100, that is a phase-out duration D = YE – YS = 85 years. In FP2 [6] we examined the effects of increasing YS from 2015 to 2030 in 5-year intervals, and D from 50 to 100 years in 10-year intervals. We found that phase-out during 2020-2100 is optimal. In FP3 [7] we added to the human-caused temperature changes through 2100 the natural temperature changes caused by three quasi-periodic oscillations that are predictable on a year-to-year basis by sine waves, and random variations that are not predictable on a year-to-year basis, but are represented by their 90% confidence interval. In this our fourth Fair Plan paper we do not consider these natural temperature variations, and we again examine the entire millennium.

To simulate the change in global-mean near-surface air temperature, ΔT_s, with our Simple Climate Model, the climate sensitivity, ΔT_{2x}, must be specified. ΔT_{2x} is the change in the equilibrium (net incoming radiation at the top of Earth's atmosphere R = 0) ΔT_s due to the radiative forcing resulting from a doubling of the preindustrial CO_2 concentration (R = 3.71 Wm^{-2}). We have determined ΔT_{2x} from the observed ΔT_s compiled by four research groups: (1) Hadley Centre/Climate Research Unit (ΔT_{2x} = 1.61˚C); (2) NASA (ΔT_{2x} = 1.45˚C); (3) NOAA (ΔT_{2x} = 1.99˚C); and (4) Japan Meteorological Agency (ΔT_{2x} = 2.01˚C) [13]. In FP1 we presented ΔT_s individually for the ΔT_{2x} values of (1) - (3), while in FP2 and FP3 we did so individually for all four ΔT_{2x} values. Here we combine those four ΔT_s values into an expected value for ΔT_s, this to simplify and accentuate the message of FP1 - FP3. The expected value of ΔT_s is taken as the average of the four ΔT_s values.

3. Expected Value of Temperature Changes for the Reference and Fair Plan Scenarios

The CO_2 emissions for the Reference and Fair Plan scenarios are shown in **Figure 3**. In the Reference scenario the CO_2 emission rises from about 10 billion tonnes of carbon per year (GtC/year) in 2010 to 29 GtC/year in

2100, remains essentially constant until 2150, and then decreases to 2 GtC/year in 2300, where it remains essentially constant throughout the remainder of the millennium. The CO_2 emissions for the Fair Plan scenario are the product of the CO_2 emissions for the Reference scenario and the intensity of GHG emissions shown in **Figure 4**. These emissions rise from about 10 GtC/year in 2010 to 13.5 GtC/year in 2046, and then decrease to zero in 2100. For the emissions of the other GHGs we took the curves from RCP-8.5 and applied the same intensities for AB and nAB as we did for CO_2.

The resulting CO_2 concentrations are shown in **Figure 5**. For the Reference scenario the CO_2 concentration increases to 1928 parts per million by volume (ppmv) in 2237—more than six times the pre-industrial concentration of 277 ppmv—and then slowly decreases to about 1750 ppmv by the end of the millennium due to natural carbon sinks. For the Fair Plan scenario the CO_2 concentration increases to 612 ppmv in year 2087—just over twice the pre-industrial concentration—and then decreases to 406 ppmv by the end of the millennium.

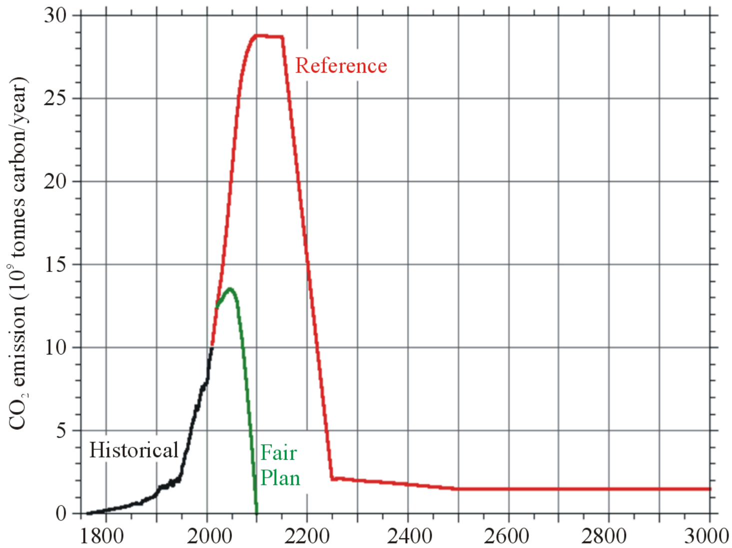

Figure 3. Historical (black curve) and future CO_2 emissions, the latter for both the Reference scenario (red curve) and Fair Plan scenario (green curve).

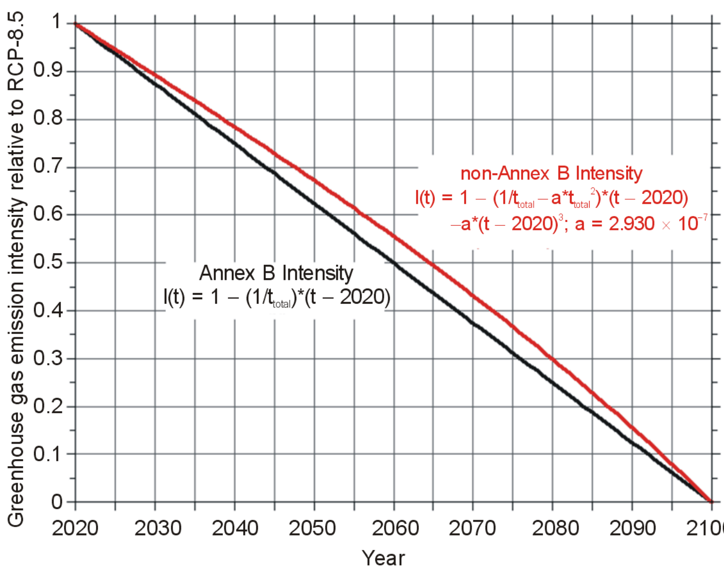

Figure 4. The GHG emissions intensity for Annex B (black curve) and non-Annex B (red curve) countries relative to the Reference RCP-8.5 scenario from 2020 through 2100.

The expected value of the change in global-average near-surface air temperature from 1765 for the historical greenhouse-gas emissions (black curve) and the Reference (red curve) and Fair Plan (green curve) emission scenarios are shown in **Figure 6**. The UNFCCC limit of 2˚C (3.6˚F) "to prevent dangerous anthropogenic interference with the climate system" is shown by the dashed grey line.

The temperature change for the Reference scenario increases to 5.2˚C (9.4˚F) in 2225 and remains essentially constant through the remainder of the millennium, that is, for 40 human generations. The temperature change for the Fair Plan scenario peaks very near the 2˚C (3.6˚F) UNFCCC limit in 2082 and decreases through the remainder of the millennium.

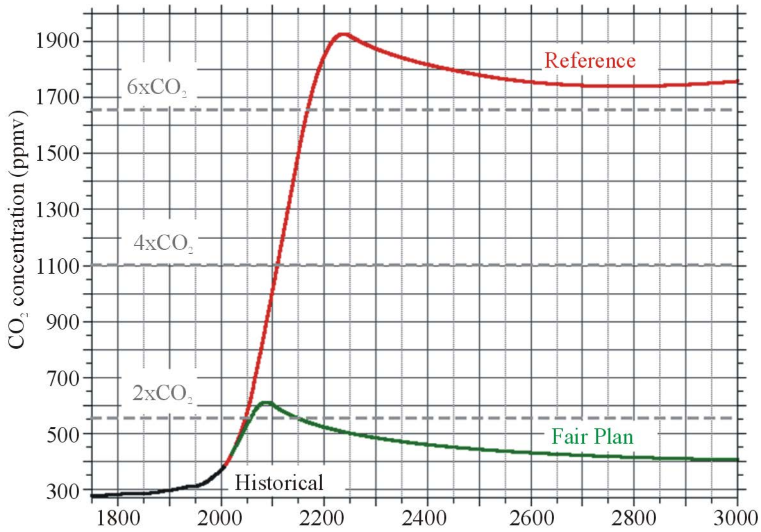

Figure 5. Historical (black curve) and future CO_2 concentrations, the latter for the Reference scenario (red curve) and Fair Plan scenario (green curve). Two, four and six times the pre-industrial CO_2 concentrations are shown by the dashed grey curves.

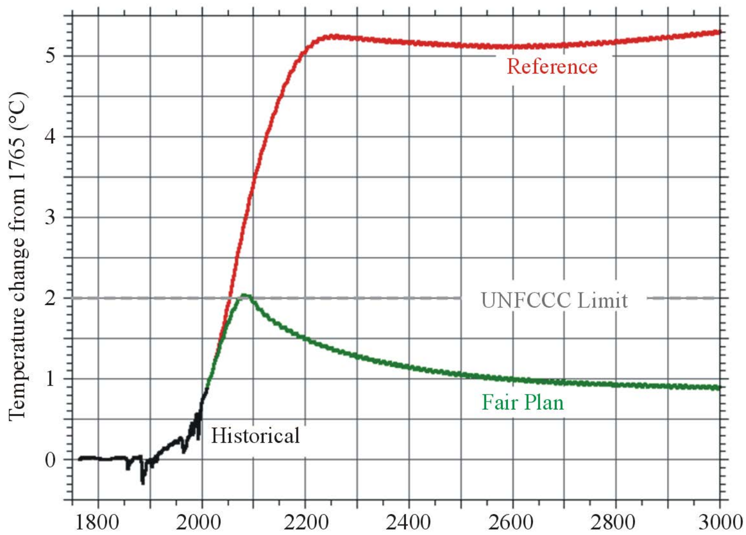

Figure 6. Expected values of the changes in global-mean near-surface air temperature from 1765 for the historical emissions (black curve) and future emissions for the Reference scenario (red curve) and Fair Plan scenario (green curve). The 2˚C (3.6˚F) limit adopted by the United Nations Framework Convention on Climate Change limit "to prevent dangerous anthropogenic interference with the climate system" is shown by the dashed grey line.

4. Conclusion

Because there is nowhere else for humanity to live within at least 40 trillion kilometers (25 trillion miles)—a distance that would take us 80,000 years to reach at the velocity of Voyager 1—we live on "This Island Earth". If humanity does not abate its emissions of greenhouse gases, the expected value of global-mean near-surface air temperature will increase by 5.2˚C (9.4˚F) for at least 40 human generations. If we phase out our emissions of greenhouse gases from 2020 to 2100 following our Fair Plan, the expected value of the increase in global-mean near-surface air temperature peaks very near the 2˚C (3.6˚F) limit adopted by the UNFCCC "to prevent dangerous anthropogenic interference with the climate system". Accordingly we must safeguard the climate of "This Island Earth".

References

[1] NASA, Planetary Fact Sheet. http://nssdc.gsfc.nasa.gov/planetary/factsheet/

[2] Closest Star. http://www.universetoday.com/102920/what-is-the-closest-star/

[3] National Geographic Society (2013) Voyager 1 Leaves Solar System, NASA Confirms. http://news.nationalgeographic.com/news/2013/13/130911-voyager-interstellar-solar-system-nasa-science-space/.

[4] Universal Studios (1955) This Island Earth. http://www.imdb.com/title/tt0047577/

[5] Schlesinger, M.E., Ring, M.J. and Cross, E.F. (2012) A Fair Plan to Safeguard Earth's Climate. *Journal of Environmental Protection*, **3**, 455-461, http://dx.doi.org/10.4236/jep.2012.36055

[6] Schlesinger, M.E., M.J. Ring, and E.F. Cross (2012) A Revised Fair Plan To Safeguard Earth's Climate. *Journal of Environmental Protection*, **3**, 1330-1335, http://dx.doi.org/10.4236/jep.2012.310151

[7] Schlesinger, M.E., Lindner, D., Ring, M.J. and Cross, E.F. (2013) A Fair Plan to Safeguard Earth's Climate: 3. Outlook for Global Temperature Change throughout the 21st Century. *Journal of Environmental Protection*, **4**, 653-664. http://dx.doi.org/10.4236/jep.2013.46075

[8] Schlesinger, M.E., Andronova, N.G., Entwistle, B., Ghanem, A., Ramankutty, N., Wang, W. and Yang, F. (1997) Modeling and Simulation of Climate and Climate Change. In: Castagnoli, G.C. and Provenzale, A., Eds., *Past and Present Variability of the Solar-Terrestrial System*: *Measurement*, *Data Analysis and Theoretical Models*: *Proceedings of the International School of Physics* "*Enrico Fermi*" *CXXXIII*, Amsterdam, IOS Press, 389-429.

[9] Meinshausen, M., Smith, S.J., Calvin, K.V., Daniel, J.S., Kainuma, M., Lamarque, J.-F., Matsumoto, K., Montzka, S.A., Raper, S.C.B., Riahi, K., Thomson, A.M., Velders, G.J.M. and van Vuuren, D. (2011) The RCP Greenhouse Gas Concentrations and Their Extension from 1765 to 2500. *Climatic Change*, **109**, 213-241. http://dx.doi.org/10.1007/s10584-011-0156-z

[10] Hegerl, G.C. and Bindoff, N.L. (2005) Warming the World's Oceans. *Science*, **309**, 254-255. http://dx.doi.org/10.1126/science.1114456

[11] United Nations (1992) United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/convkp/conveng.pdf.

[12] United Nations Framework Convention on Climate Change (2010) Report of the Conference of the Parties on Its Sixteenth Session. Cancun, Mexico, 31 p. http://unfccc.int/meetings/cancun_nov_2010/meeting/6266/php/view/reports.php.

[13] Ring, M.J., Lindner, D., Cross, E.F. and Schlesinger, M.E. (2012) Causes of the Global Warming Observed Since the 19th Century. *Atmospheric and Climate Sciences,* **2**, 401-415. http://dx.doi.org/10.4236/acs.2012.24035