Astronomy in Focus - XXX
Proceedings IAU Symposium No. XXX, 2018
M. T. Lago, ed.

DOI: 00.0000/X000000000000000X

Towards an IAU Position and Statement on Terrestrial Climate Change

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Abstract. As the largest organization of astronomers in the world, the International Astronomical Union (IAU) has a responsibility to explain important astronomical findings and to communicate agreements on key definitions, fundamental standards, naming conventions, etc. The IAU typically does not take stands on terrestrial issues, unless there is a strong astronomical connection. In the case of terrestrial climate change, the connection is both strong and revealing. Earth is not alone in having an atmosphere that contains greenhouse gases. Both Venus and Mars have atmospheres that are dominated by carbon dioxide - a potent greenhouse gas. Venus, in particular, provides startling evidence for drastic surface warming due to its thick blanket of carbon dioxide. In this poster paper, I present quantitative interplanetary perspectives on terrestrial climate change, and how these perspectives could inform an IAU position and public statement on this vital topic.

Keywords. astronomy outreach, keyword2, keyword3, etc.

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1. Introduction

The signal has grown ever clearer. The Earth's atmosphere, oceans, and land masses have warmed by 0.8^o C (1.4^o F) since pre-industrial times. Most of this warming has occurred over the past 50 years. The Intergovernmental Panel on Climate Change (IPCC) has concluded that human activities have prompted the bulk of this warming. The burning of fossil fuels, in particular, has increased the concentration of atmospheric carbon dioxide on Earth from 280 ppm in pre-industrial times to more than 400 ppm today – an augmentation of this greenhouse gas by more than 44 percent. By comparing Earth with Venus and Mars, I have considered the solar irradiation of these planets, the equilibrium temperatures that they would have without their atmospheres, and the temperatures that currently characterize their surfaces due to the greenhouse gas warming produced by their atmospheres. All derived quantities are based on data listed at `https://nssdc.gsfc.nasa.gov/planetary/planetfact.html`. Through these interplanetary comparisons, I conclude that warming by greenhouse gases has played important roles on all three planets. Moreover, the percentile warming trends with the amount of carbon dioxide in each planet's atmosphere.

2. Assaying Greenhouse Gas Warming

Key to the warming effect is the total amount of greenhouse gases that overlies each planetary surface. The Martian atmosphere is dominated by carbon dioxide; however, the total amount of atmospheric gases (gauged in terms of the surface pressure) is a factor of 100 down from that on Earth. Nevertheless, the total mass of overlying carbon dioxide per unit area on Mars exceeds that on Earth's surface by a factor of 27. The observed surface

warming on Mars is reduced due to the presence of atmospheric dust which absorbs the incoming sunlight and so redistributes the warming to higher altitudes. Compensating for this effect would increase the surface warming (in Kelvins) from 4 percent to about 9 percent.

By contrast, the Venusian atmosphere is also dominated by carbon dioxide, but the atmospheric surface pressure is 100 times greater than that on Earth. The resulting runaway greenhouse effect on Venus has increased its surface temperature by 450^o C, making its surface hotter than any other planetary surface in the Solar System. Calculations of the Venusian warming are compromised by the NASA/NSSDC's black-body temperature which is based on the albedo due to the cloud tops of highly reflective sulfuric acid rather than the albedo of its rocky surface. Compensating for this effect increases the atmosphere-free surface temperature and so reduces the warming from 231 percent to a "mere" 136 percent.

Earth has a minor but influential concentration of greenhouse gases as part of its overall atmospheric suite. This has warmed the planet by a more modest 33^o C – enough to keep Earth's surface from freezing over for most of its history. Water vapor and methane account for about 60 percent of the warming. Focusing on the warming due to carbon dioxide alone reduces the warming from 14 percent to about 6 percent.

Figure 1 shows the relation between percentile warming (in Kelvins) vs. the amount of overlying carbon dioxide gas per unit area. All quantities are based on data listed at `https://nssdc.gsfc.nasa.gov/planetary/planetfact.html`. After compensating for additional greenhouse gases in Earth's atmosphere, absorbing dust in the Martian atmosphere, and the anomalously high albedo of the Venusian atmosphere, I obtain a compelling relation between the percentile warming and the carbon dioxide concentration that amounts to a power law with an exponent of about 0.29.

3. From Awareness to Action

Currently Earth's atmosphere is entering a new era of enhanced greenhouse gas concentrations and further warming. The contribution of carbon dioxide from the burning of fossil fuels, in particular, has driven the Earths atmosphere to warm by an amount that is consistent with the interplanetary relation that I have found. Restoring the concentration of greenhouse gases to significantly lower levels than the current trajectory will be critical to maintaining the quality of life for Earth's human inhabitants and the ecosystems upon which we rely.

The IAU can play an important role in both affirming the reality of anthropogenic greenhouse-gas warming of Earth's atmosphere, and in raising awareness that Earth is not the only planet that has been subject to surface warming by greenhouse gases in its atmosphere. We astronomers have key expertise regarding planets and their varying responses to solar irradiation. We should not shirk from communicating our insights. Towards these ends, I propose that the IAU adopt a resolution similar to the 2012 resolution that was crafted by the American Geophysical Union (AGU) (see `https://sciencepolicy.agu.org/files/2013/07/AGU-Climate-Change-Position-Statement_August-2013.pdf`) and the resolution's official endorsement by the American Astronomical Society (AAS) in 2013 (see `https://aas.org/governance/society-resolutions#climate`). The protocol for crafting and submitting an IAU Resolution can be found at `https://www.iau.org/administration/statutes_rules/working_rules/#WorkRulIV`. To provide input and track further progress in these regards, please contact me at `williamhwaller@gmail.com`.

4. Related Websites

https://nssdc.gsfc.nasa.gov/planetary/planetfact.html

https://sciencepolicy.agu.org /files/2013/07/
AGU-Climate-Change-Position-Statement_August-2013.pdf

https://aas.org/governance/society-resolutions#climate

https://www.iau.org/administration/statutes_rules/working_rules/#WorkRulIV

http://galacticinquirer.net/article/planetary-perspectives-on-terrestrial-climate-change-2/

Greenhouse Relationships.pdf

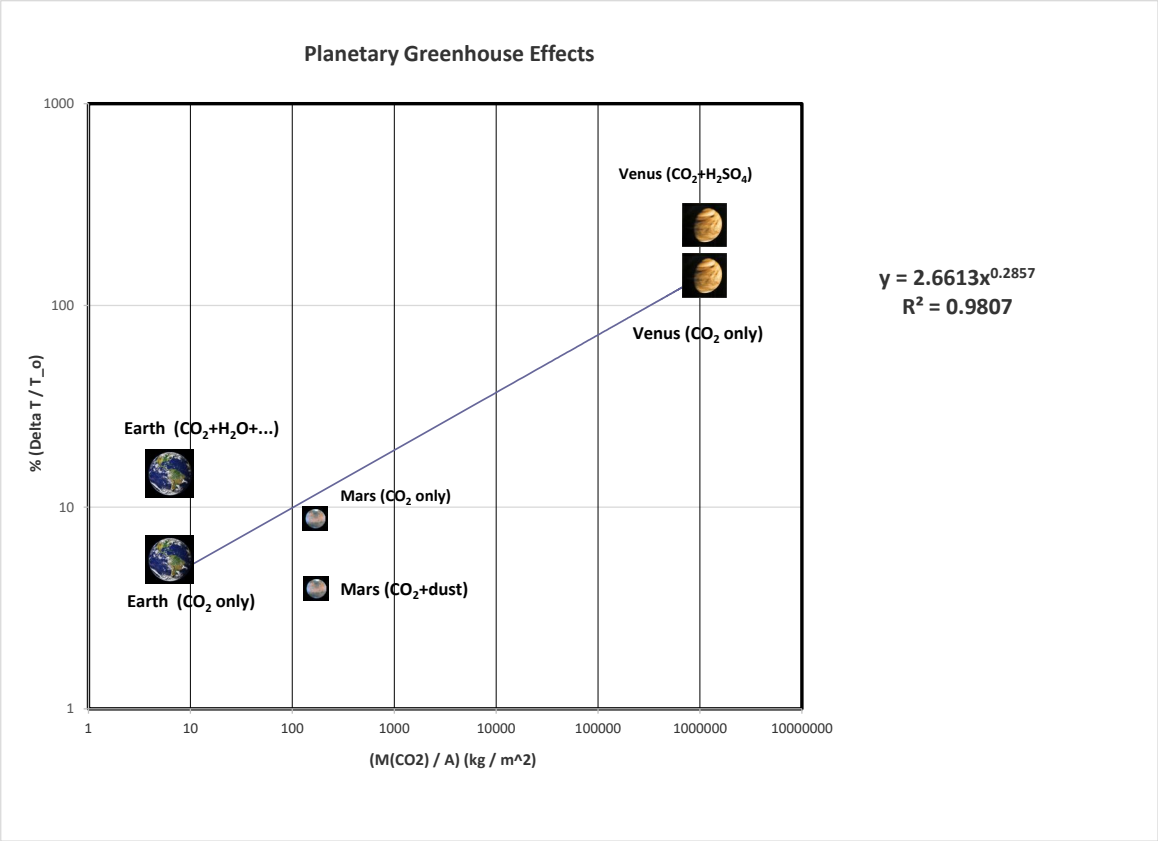

Figure 1. Relation between a planet's percentile warming (compared to its atmosphere-free average surface temperature) and the overlying CO_2 gas content (in kg/m^2). Both the actual and adjusted (CO_2 only) percentile warmings are shown (see text).