1.3 The Greenhouse Effect

温室效应

Although the bulk of photovoltaic devices today are used for purely practical and economic reasons, a potential benefit of photovoltaics is that PV is one of the most environmentally benign of any electricity generating source. The environmental impact of electricity generation, particularly the greenhouse effect, adds an important reason for examining photovoltaics. A brief overview of the greenhouse effect is given below.

尽管今天人们是因为其实用性和经济价值才使用光伏器件的，光伏的一个潜在益处在于在所有的发电来源中，它对于环境的影响是最小的。发电对环境产生的影响，尤其是温室效应，在一定程度上促成了对光伏的研究。下文将简介温室效应。

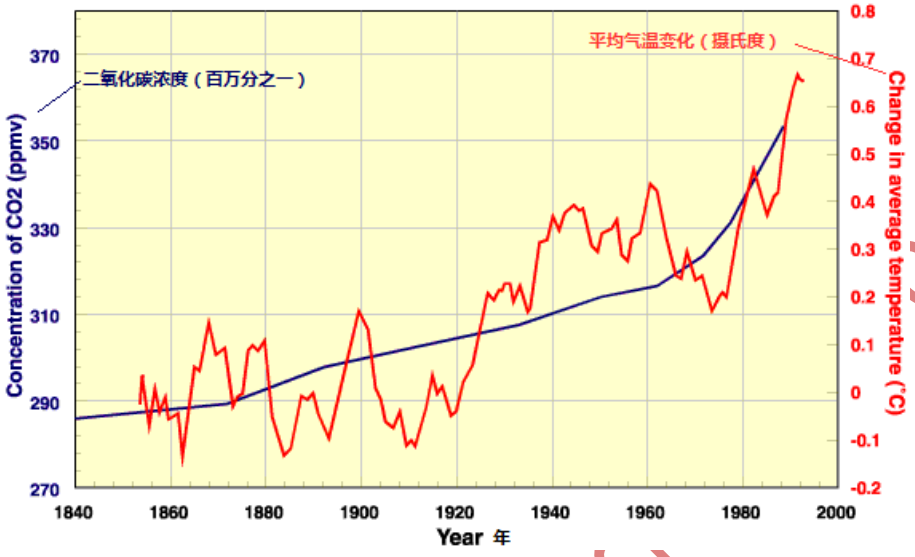
The Earth's temperature is a result of an equilibrium established between the incoming radiation from the sun and the energy radiated into space by the Earth. The outgoing radiation emitted by the Earth is strongly affected by the presence and composition of the Earth's atmosphere. If we had no atmosphere, as on the moon, the average temperature on the Earth's surface would be about -18°C. However, a natural background level of 270 ppm carbon dioxide (CO_2) in the atmosphere absorbs outgoing radiation, thereby keeping this energy in the atmosphere and warming the Earth. The atmosphere causes the Earth's temperature to be about 15°C on average, 33°C above the moon's. Carbon dioxide absorbs strongly in the 13-19 µm wavelength band and water vapour, another atmospheric gas, absorbs strongly in the 4-7 µm wavelength band. Most outgoing radiation (70%) escapes in the "window" between 7-13 µm.

地球的温度是来自太阳的辐射和地球本身向太空的辐射相平衡的结果。地球的大气层的有无和组成会在很大程度上影响地球本身的向外辐射。如果地球和月球一样没有大气层，地表的平均温度大概就是零下 18 摄氏度。但是，大气层中约为 0.027%的二氧化碳能够吸收地球的向外辐射，把能量留在大气层内使地球保暖。这使得地表平均温度保持在 15 摄氏度左右，比月球表面温度高了 33 摄氏度。二氧化碳对于 13 到 19 微米的波段的辐射的吸收很强，同时，大气中的另一种气体，水蒸气对于 4 到 7 微米的波段的辐射的吸收很强。位于这两个波段之间（7 到 13 微米）、占总能量 70%的辐射会逃逸出大气层。

Human activities are increasingly releasing "anthropogenic gases" into the atmosphere, which absorb in the 7-13 µm wavelength range, particularly carbon dioxide, methane, ozone, nitrous oxides and chlorofluorocarbons (CFC's). These gases prevent the normal escape of energy and potentially will lead to an increase in terrestrial temperature. Present evidence suggests "effective" CO_2 levels will double by 2030, causing global warming of 1~4°C. This would lead to changes in wind patterns and rainfall and as a result may cause the interior of continents to dry out and cause the Earth's oceans to rise. Further increases in the release of anthropogenic gases would, of course, cause more severe effects.

人类的活动正在增加大气层中“人为气体”排放，这些气体，尤其是二氧化碳，甲烷，臭氧，一氧化二氮和氟氯烃，会吸收 7-13 微米波段的辐射。这些气体阻碍了能量的正常逃逸，可能导致地表温度升高。当前的证据表明有效二氧化碳含量在 2030 年将翻倍，使得全球温度升高

1 到 4 摄氏度。这一变暖导致的风的流动模式和降雨量的改变将使得大陆的内部变得干旱，海平面也会上升。显而易见，人为气体的进一步增加将会导致更严重的后果。



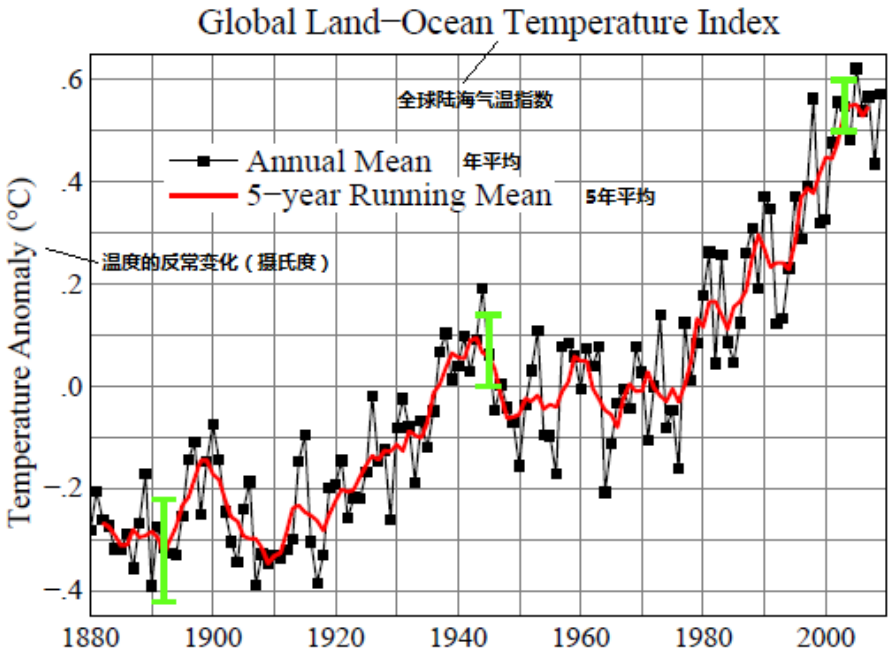
Correlation of the rise in atmospheric carbon dioxide concentration (blue line) with the rise in average temperature (red line)[1].

大气中的二氧化碳含量（蓝线）上升和平均气温（红线）上升之间的关系

The graph above only goes to the mid-90s since that was the time we started writing the PVCDROM. At the time there was considerable discussion about whether the warming was a trend or a statistical fluctuation. There was some hope that the average temperatures would go down again to the level of the statistical average. In the intervening years the temperature of the earth has continued to rise as shown in the graph below:

上图的数据值只涵盖到 20 世纪 90 年代中叶，那时我们已经开始撰写 PVCDROM 了。当时对于大气的变暖还有很大争论，有人认为变暖是一种趋势，也有人认为变暖只是统计数据的浮动。当时人们对于平均温度降回统计数据的平均值还抱有希望。但是这些年来，地球的气温还是一直在上升（如下图所示）。

原文地址：http://www.pveducation.org/pvcdrom/introduction/greenhouse-effect
PDF 版本下载地址：https://dl.dropboxusercontent.com/u/52743103/PVCDROM/1.3%20The%20Greenhouse%20Effect.pdf
博主邮箱： nkukarl@gmail.com



Average surface temperature of the earth. Temperatures are continuing their upward rise[2,3].

地表平均温度变化。温度一直在上升[2,3]。

Clearly, human activities have now reached a scale where they are impacting on the planet's environment and its attractiveness to humans. The side-effects could be devastating and technologies with low environmental impact and no "greenhouse gas" emissions are likely to be of increasing importance over the coming decades. Since the energy sector is the major producer of "greenhouse gases" via the combustion of fossil fuels, technologies such as photovoltaics, which can substitute for fossil fuels, must increasingly be used[4].

很明显，人类活动的规模已经达到可以影响地球环境以及地球环境对人类的吸引力的程度了。这些影响的副作用是毁灭性的。在接下来的几十年中，对环境影响很小和不排放温室气体的技术将愈发重要。温室气体的主要制造者，能源领域燃烧的是化石能源，因此像光伏这样可以替代化石能源的技术就需要更多的应用。

参考文献

1. Kerr RA. Sun's Role in Warming Is Discounted. Science. 1995;268:28 - 29.

2. NASA. GISS Surface Temperature Analysis. [Internet]. 2010. Available from: http://data.giss.nasa.gov/gistemp/graphs/

3. Hansen J. Global temperature change. Proceedings of the National Academy of Sciences. 2006;103:14288 - 14293.

4. Blakers A, Green MA, T. L, H. O, B. R. The Role of Photovoltaics in Reducing Greenhouse Gas Emissions. Canberra: Australian Government Publishing Service; 1991.