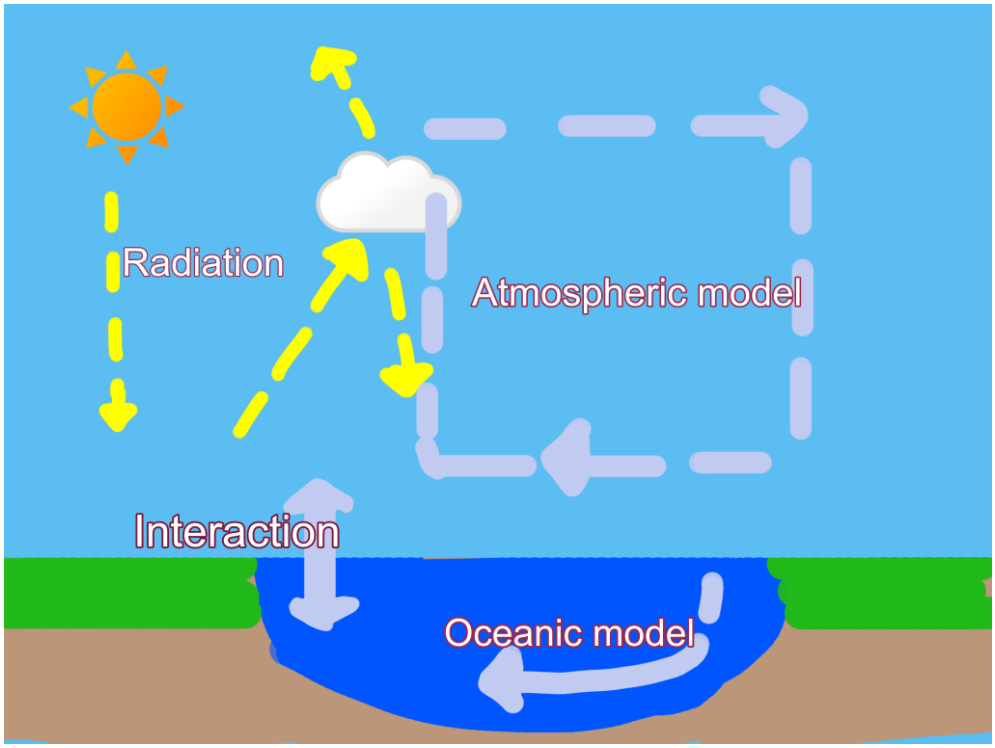
# Make Earth in computer to know the future climate and effects of our activity on it.

Kenzaburo Kawaguchi

Have you ever studied meteorology? Unfortunately, only a few people may have studied it, since meteorology falls under the field of earth science which is currently rarely taught in Japanese high schools. However, weather forecasting will be used by many. Current weather forecasts accurately predict the weather for the next few days and trends for the next few months due to numerical calculations based on the laws of physics. Then, do you know what factors determine climate?

There are lots of factors which effect climate (for example, radiation and convection). The sun's radiation warms the atmosphere and the earth's surface. Infrared radiation from the earth's surface also warms the atmosphere. This effect from the earth's surface also causes temperatures to decrease with altitude in the troposphere. In contrast, above the troposphere, in the stratosphere, the temperature increases with altitude as ozone and other gases absorb UV radiation and warm the atmosphere. Water vapor absorbs radiation well, so, the state of the Earth's surface and oceans also influences climate. Temperature distribution is also caused by atmospheric convection as well as radiation. As the climate is determined by such diverse factors, it has been difficult to accurately predict future climate. Although climate prediction is challenging, it is important for our lives because such simulations can estimate the impact of human activities, such as CO2 emissions.




In 1955, numerical prediction of the next day's weather using hydrodynamic calculations was apparently in practical use in the USA, but this only provided relatively short-term predictions using current data as initial conditions and ignoring slow-acting processes such as the propagation of infrared radiation in the atmosphere, convection and so on. Of course, for everyday weather forecasting, it is sufficient to know what the weather will be like the next day, but simulating more long-term weather condition, or the climate, on a computer is important not only for everyday life, but also for environmental issues. By predicting the climate months, years and decades ahead, we can learn about the impact of our industrial activities on the environment and take countermeasures.

In 1964, Manabe et al. devised a one-dimensional climate model that incorporated the absorption of infrared radiation from atmospheric greenhouse gases (gases that absorb radiation and act to raise temperatures), emissions, absorption of solar radiation from ozone, and atmospheric convection [1]. This model was the first to predict medium- to long-term climate change using calculations based on physical laws. The model was found to successfully reproduce the actual climate, converging to realistic results in a finite amount of time, even given extreme initial conditions such as

temperatures of -100°C or 100°C. When the amount of carbon dioxide concentration was changed to double what it was at the time, the temperature was found to increase by 2.3 degrees Celsius. This was the first demonstration in the world that carbon dioxide emissions led to global warming.

Subsequently, improvements were made to the model, such as making it a three-dimensional model that also considers the state of the oceans. This improvement was also quite significant. These became the original climate models used for future projections of climate change in the assessments of the UN's Intergovernmental Panel on Climate Change (IPCC), but Prof. Manabe's model was simpler than those currently in use, based on the idea that simple models are useful for a deeper understanding of the complexity of the climate system. and was based on the idea that. Most physicist think that the simpler the theory is, the better it is. In this case, it is very interesting that the original simple model can reproduce and predict the actual climate.

Climate models can now be used to calculate, for example, the magnitude of the impact of industrial activities on the climate. Famous examples include the estimation that, if greenhouse gas emissions are not curbed, the average temperature in 2100 will be 5.7°C higher than the pre-industrial level, and that the Antarctic ice sheet will shrink [2]. The availability of such predictions has led to a global move to curb greenhouse gas emissions and increased momentum for environmental protection. Climate models that reproduce the Ice Age 20,000 years ago can be used to find out why temperatures fell by changing parameters.

The applications of physics-based numerical climate modelling are wide-ranging, including in everyday life, economic activities and other research fields. Many researchers are now developing climate models, and as the performance of computers is increasing, we expect further improvement in accuracy in the future.

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## Reference

[1] Manabe, Syukuro, and Robert F. Strickler. "Thermal Equilibrium of the Atmosphere with a Convective Adjustment". Journal of Atmospheric Sciences 21.4 (1964): 361-385. https://doi.org/10.1175/1520-0469(1964)021<0361:TEOTAW>2.0.CO;2 Web.

[2] "Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." IPCC, 2021, https://www.ipcc.ch/report/ar6/wg1/. Accessed 22 May 2023.

Followings are assistive technologies I used for draft.

- DeepL
- DeepL Write
- Grammarly

I wrote draft in Japanese, translated it to English, and rewrite by myself.

For this final version, I used ChatGPT to check my English with this prompt
“perform as if you are professional english teacher.
score the sentence out of 100. If there are room of improvement, list them all.”