2022 Asia and Pacific Mathematical Contest in Modeling

Problem E

How Many Nuclear Bombs can Destroy the Earth?

On August 6, 1945, the Second World War was drawing to a close. In order to end the war as soon as possible, the United States dropped the next atomic bomb called "Little Boy" in Hiroshima, Japan. Such an atomic bomb killed 200000 people in Hiroshima, and all buildings in Hiroshima collapsed. This is the first time in human history that the atomic bomb has been put into practice, and it also makes many people realize the terrible power of the atomic bomb for the first time.

Figure 1. Simulation diagram of atomic bomb explosion.

Nuclear weapons refer to huge lethal weapons related to nuclear reaction, including hydrogen bombs, atomic bombs, neutron bombs, etc. Nuclear weapons are one of the most powerful weapons ever developed by human beings, and they often remind people of the scene of destroying heaven and earth. The instantaneous explosion temperature of an atomic bomb can reach tens of millions of degrees. The explosive yield of the atomic bomb is about tens of thousands to hundreds of thousands of tons of TNT equivalent. The explosion of an atomic bomb and the area of its radiation can destroy a city.

Because of the terrible power of the atomic bomb, many countries hope to use it to deter other countries and protect their countries from foreign invasion. After World War II, all

countries in the world began to research and manufacture atomic bombs crazily, and even created destructive weapons such as "Big Ivan".

The "Big Ivan" is the most powerful nuclear bomb known in the world at present, that is, the "czar bomb" built in the Soviet period. It is not only the most powerful nuclear bomb in the world, but also the largest nuclear bomb. How big is the "Tsar Bomb"? The data shows that its length is 8 meters, diameter is 2.1 meters, weight is up to 27 tons, and design TNT equivalent is 50 megatons. The Soviet Union originally planned to design an equivalent of 100 megatons, but because the destructive force was too great to find a suitable test site, the power was reduced by half. Even so, the Czar Bomb is still the most powerful nuclear weapon in the world. The explosive power of the "little boy" is about 14000 tons of TNT equivalent, making Hiroshima a ruin, while the power of the "tsar bomb" is comparable to dozens or even hundreds of "little boys". After the test explosion of the "Tsar Bomb" on the Soviet Union's Xindi Island, even in some states as far away as the United States, an earthquake of about magnitude 5 was detected, resulting in a 9 mm southward movement of Eurasia.

Many people believe that these nuclear weapons can destroy the earth several times. Is this really the case? As far as the power of nuclear weapons developed by mankind is concerned, if they destroy the earth, they do not mean that they can blow the earth into pieces, but that the living environment of human beings and creatures on the earth has been destroyed.

The APMCM Organizing Committee requires your team to address the current report and future nuclear weapons projections. They provided data set 2022_APMCM_E_Data.csv to help you with your research. Please collect the corresponding data, establish a mathematical model and answer the following questions.

Requirements

1. Basic data analysis

a) Which countries have ever possessed nuclear weapons?

b) Which country has the largest reduction or increase in its nuclear weapons stockpiles in the last 20 years?

c) During which five years did nuclear weapon tests occur the most?

d) Which country has been the most active in nuclear weapons research in the last 10 years?

e) Which country has made the fastest transition from "not considering nuclear weapons" to "possessing nuclear weapons"?

2. Predict the number of nuclear weapons

a) According to the attached data or the data you collected, establish a mathematical model to predict the number of nuclear weapons, and predict the countries with nuclear weapons in the next 100 years;

b) Predict the change trend of the number of nuclear weapons in the next 100 years, the total number of nuclear weapons in 2123, and the number of nuclear weapons in each country.

3. Protect our planet

a) Establish an mathematical model for the detonation position of nuclear weapons, and calculate how many nuclear bombs are required at least to destroy the earth?

b) According to the mathematical model, what is the maximum destructive power of the nuclear bomb currently possessed? Is it enough to destroy the earth?

c) In order to protect the earth and the environment on which we live, what should the total number of nuclear bombs in the world be limited to, and what should the countries that already have nuclear weapons be limited to theoretically?

4. Prepare a non-technical article (1 page maximum). Please write a non-technical article (1 page at most) to the United Nations (U.N.), explaining your team's findings and putting forward several suggestions for all countries.

Attachment

Data Source: Our World in Data https://ourworldindata.org/nuclear-weapons

2022_APMCM_E_Data.xlsx

Position sheet status: 0-Does not consider, 1-Considers, 2-Pursues, 3-Possesses