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Study on Energy Limitation Based on Neural Network and ARMA

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Abstract: Nuclear weapons are immensely deadly weapons capable of releasing energy from nuclear reactions, including hydrogen bombs, atomic bombs, neutron bombastic.Nuclear weapons are extremely destructive, and their radiation and explosive power cause irreversible ecological damage. To better grasp the current situation and future trend of nuclear weapons globally and to protect the ecological environment of the earth, we built a BP neural network model and a time series model to predict the number of nuclear weapons possessing countries and the total number of nuclear weapons based on the existing number of nuclear weapons in each country in the world. After that, we modeled the detonation of nuclear weapons in different locations to analyze the damage level of nuclear weapons in different regions and to derive the limit of the number of nuclear weapons. The modeling results are combined to make recommendations for countries around the world to promote nuclear energy security development and world peace.

1. Introduction

Nuclear weapons are extremely powerful, and their existence and use pose a threat to global peace and security. Improper use can cause irreversible damage to the environment. Some countries still possess nuclear weapons, which constitute a continuous potential threat. Therefore, predicting the trends and prospects of global nuclear weapons development is urgent and requires scientific and systematic research.

2. Data and Research methods

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code.

2.1. Motivation of Employees

This paper primarily uses data on the number of nuclear weapons by country, with data from https://ourworldindata.org/nuclear-weapons

2.2. Research Methodology

First, the number of countries possessing nuclear weapons and the total number of nuclear weapons are predicted with the help of BP neural network models as well as time series models. Then, the explosions in the forest, ocean, land, and the Earth as a whole were modeled separately. We summarize four scenarios of destroying the earth's ecology: blowing up the earth, destroying the Amazon rainforest, generating a tsunami in the Pacific Ocean, and an earthquake on the continent. Then, we calculate the critical value of the number of nuclear weapons that would threaten the human existence. Finally, the corresponding control measures are given according to the derived results.

3. Establishing a model to predict the number of nuclear weapons

3.1. Time series modeling

ARIMA[3,5,7] model is to make a non-stationary series into a stationary series by transforming the trend of the removed series, he includes autoregressive model, moving average model and difference model, also called integrated moving average autoregressive model. It is one of the methods of time series forecasting analysis. The AR part of the ARIMA model makes regression based on the historical values of the study variables themselves, and the MA model is a linear combination of historical error values that appear at different time intervals.

STEP 1: Plotting the change curve of the number of nuclear weapons from 1938-2022.

Figure 1 shows the global sequence of nuclear weapons.

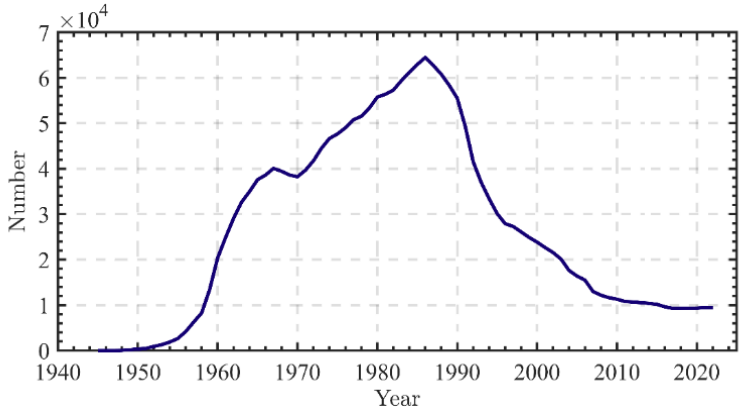

Figure 1: Global Nuclear Weapons Numbers Sequence Chart

STEP 2: Second-order differential processing of first-order differential data

From the Figure 2, we can see that the number of global nuclear weapons has a rising and falling trend, and the smoothness of the data is poor, and the smoothness is found to be improved after the first-order difference, but it is still not good enough, so the second-order difference is processed.

When differencing the first-order difference data, we have:

$$y_t'' = y_t' - y_{(t-1)}' = (y_t - y_{(t+1)}) - (y_{(t-1)} - y_{(t-2)}) = y_t - 2y_{(t-1)} + y_{(t-2)} \quad (1)$$

The result after second-order differencing is plotted as a time-time series graph as shown in.

From the figure 1, we can see that the smoothn4ress of the original data is enhanced after the second-order difference, so we can build an ARIMA model. Figure 2 shows the image after quadratic difference.

STEP 3: White noise residual test

In the figure 3 green is the upper 95% confidence interval and yellow is the lower 95% confidence interval The ACF correlation coefficients are all within the confidence interval, so the ACF residuals are white noise series, and it is considered that the useful information in the time series has been extracted, and the remaining is random error.

Similarly, the PACF residuals are considered as white noise series through the Figure 3, the useful information in the time series has been extracted, and the remaining is random error. By analyzing the residuals, we get p=0, q=0, and d=2 by second-order difference, so we establish the ARIMA (0, 2, 0) model.

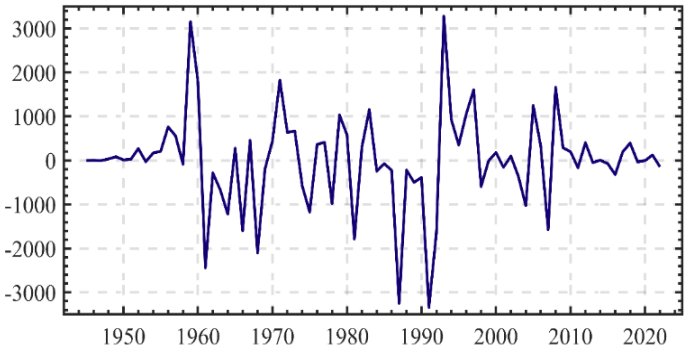

Figure 2: Image after secondary differencing

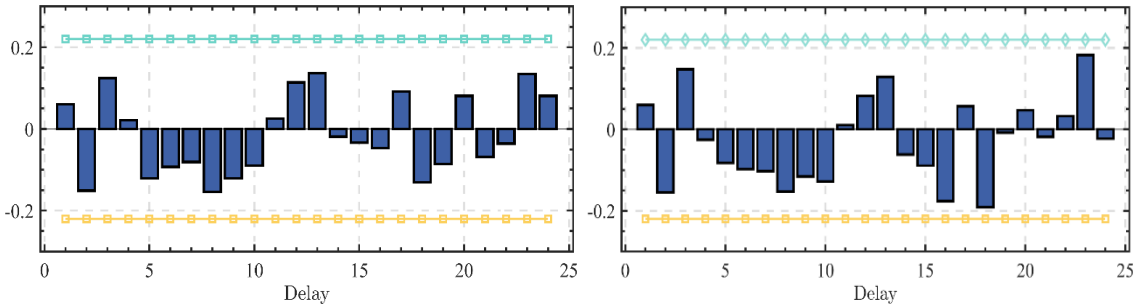

Figure 3: Model residual autocorrelation plot ACF (left) and PACF (right)

3.2. Establishment of BP neural network model

By building a prediction model for the long-term prediction of the number of nuclear weapons, and the prediction of nuclear-armed countries. For the prediction of the number of nuclear weapons, this paper uses the data from 1938 to 2022, which is rich in data, and we need to predict the number of nuclear bombs after 100 years, so this paper can build a BP neural network[4,6] model based on multiple hidden layers to predict the number of nuclear bombs. Figure 4 is the flow chart of BP neural network algorithm.

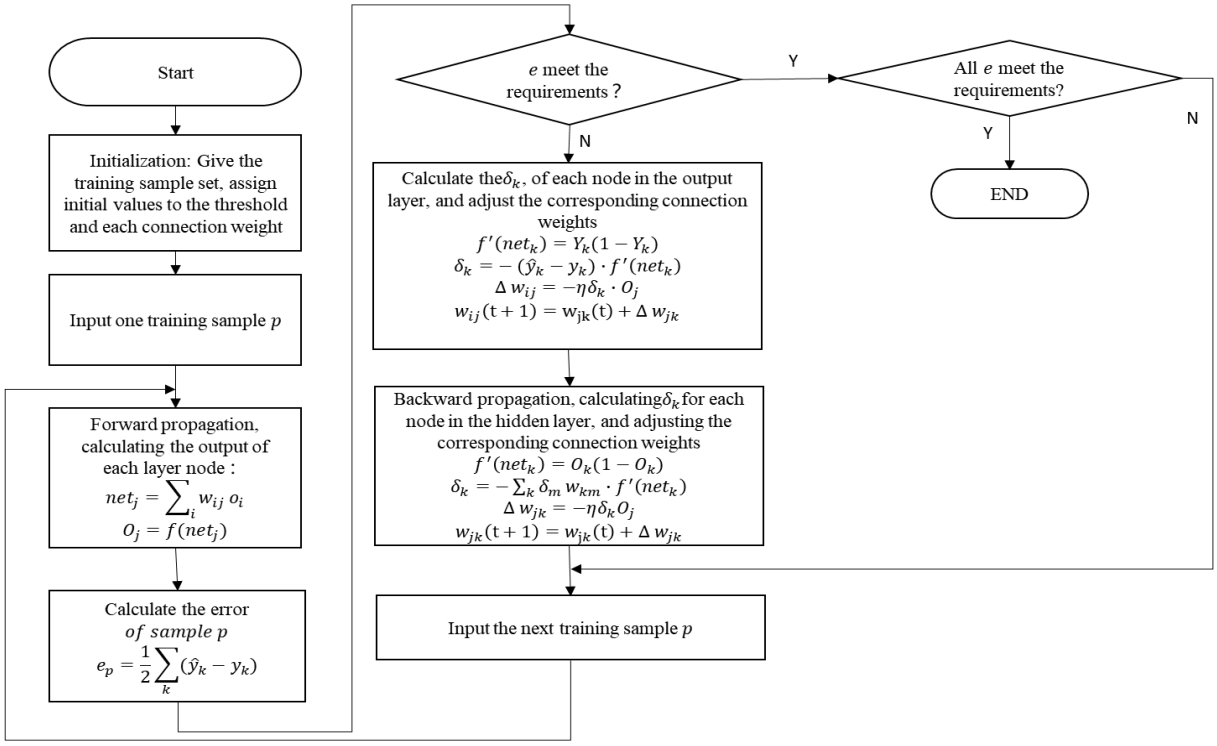

Figure 4: Flow chart of BP neural network algorithm

The number of nuclear weapons in each country in the world shows a decreasing and stabilizing trend. For the prediction of the total number of nuclear bombs in the world, the prediction trends and the prediction results of the two models are consistent, indicating that the number of nuclear weapons in the world also shows a decreasing and stable trend. This is conducive to the peaceful development of all countries in the world.

3.3 Projections of the world's nuclear-armed states and the number of nuclear weapons

Based on the number of nuclear bombs of each country from 1938 to 2022 and the total number of nuclear bombs in the world. The following results are obtained by BP neural network model as well as time series model. The left graph of Figure 5 shows the development trend of nuclear weapons by country and the right graph of Figure 5 shows the forecast curve of the ARIMA model. Figure 6 shows the projected number of nuclear weapons.

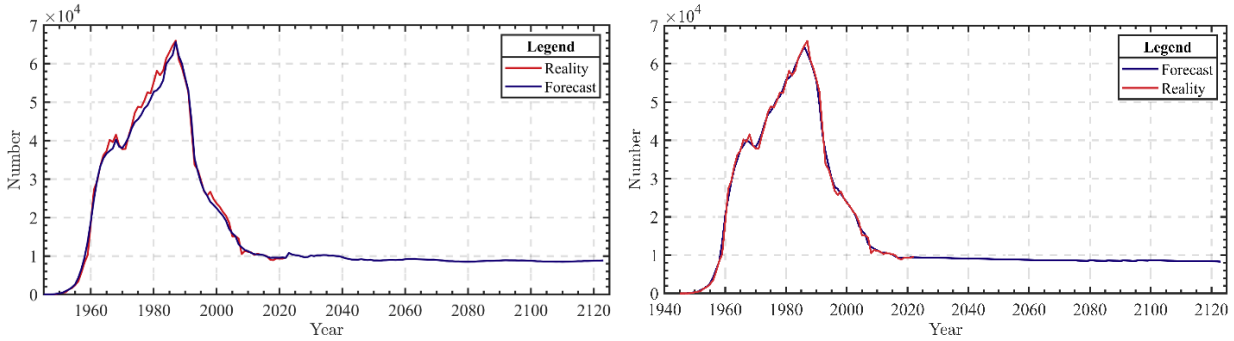

Figure 5: Trends in nuclear weapons by country (left) and ARIMA model prediction curve (right)

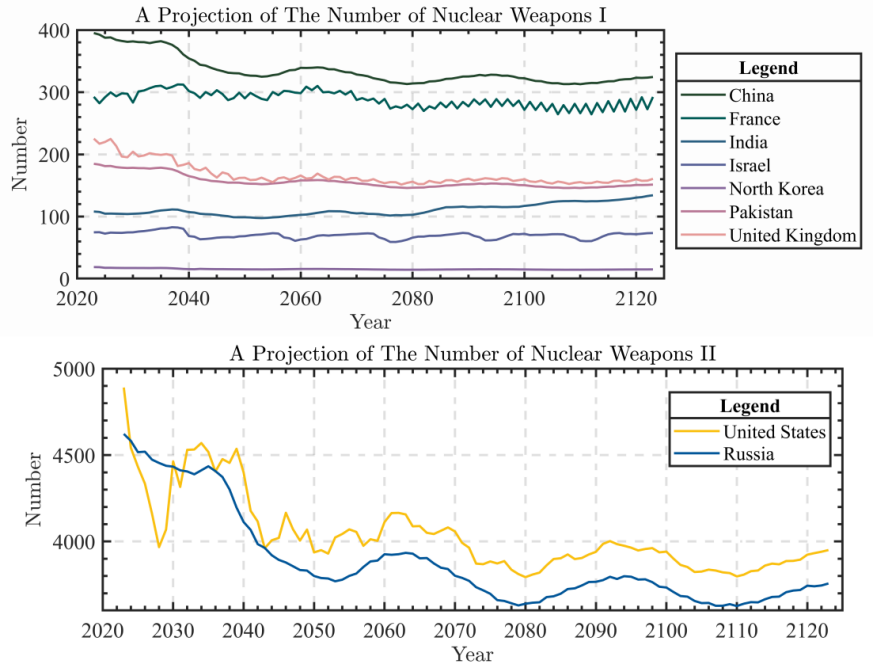

Figure 6: Projected number of nuclear weapons chart

3.4 Establish mathematical models of detonations in different areas

Situation 1:

For the Earth as a whole, a huge explosion will produce a huge thrust on the Earth, and when a certain value is reached, two states will result.

$$\begin{cases} G1, F \leqslant 2.9 \times 10^{31} J \\ G2, F > 5.9 \times 10^{31} J \end{cases} \tag{2}$$

$G1$: blow up the earth, the wreckage stay on the original orbit

$G2$: blow up the earth, the wreckage fly out of the orbit.

Energy required for the Earth to overcome the Sun's gravity: Energy required for the Earth to overcome the Sun's gravity.

$$E = \frac{3GM^2}{5R} \tag{3}$$

Earth's acceleration Earth's acceleration coefficient:

$$g = \frac{GM}{R^2} \tag{4}$$

Equation 3, 4 is derived as follows:

$$E = \frac{3GMR}{5} \tag{5}$$

The algorithm for calculating the energy produced by the explosion of 1 ton of TNT is given below:

$$W_T NT = (\alpha \cdot W \cdot Q_V) / Q_T NT \tag{6}$$

where, α is the efficiency factor of steam cloud explosion is generally taken as 3% or 4%

W is the mass of substance $A(kg)$, QV is the calorific value of substance $A(\mathrm{J/kg})$. Q_{TNT} is the heat of explosion of TNT, generally $4.184 \times 10^6 \mathrm{J/kg}$.

Situation 2:

For the ocean, when a nuclear weapon explodes in the ocean, it will rapidly squeeze the seawater and the resulting shock wave will propagate within the water body. The height of tsunami formation can be expressed by fitting the equation[1-2]:

$$h = C\left(\frac{Y}{10}\right)^{0.54}\frac{1000}{r} \tag{7}$$

Where h is the height of the tsunami, Y is the energy generated by the explosion in GT, and R is the distance from the explosion point.

Situation 3:

A nuclear weapon explosion can cause an earthquake, and the literature [3] gives a relationship between the Richter magnitude at the source and the impact energy, here we modify it slightly by applying equation 8 to calculate the relationship between the Richter magnitude at the source and the energy of the explosion[1-2].

$$M = 3.9 + 0.7\lg\left(\frac{P}{Kt}\right) \tag{8}$$

Where M is the number of Richter magnitude, P is the total energy of the explosion, k is the impact parameter, and t is the propagation time.

The explosion of nuclear weapons will not only affect the safety of buildings and human life, but also have an impact on forests, especially forests such as the Amazon rainforest, which will produce irreversible damage to human life if attacked by nuclear weapons, according to a study by the United Nations in 2007, if the Amazon rainforest disappears, the global ecological environment will be out of balance, so that humans may cease to exist.

$$R = C\sqrt[3]{D} \tag{9}$$

R is the blast radius, C= 1.49, and D is the nuclear weapon equivalent.

3.4.1 Solving of the model

Situation 1:

If the Earth is blown up then the energy generated by the Sun's gravity needs to be overcome and the energy generated by the Sun's gravity is $E = 2.23 \times 10^{32}$

Through the formula 6 to find $W_{TNT} = 4 \times 10^6 \mathrm{J/kg}$, that is, a ton of TNT explosion generated $4.184 \times 10^9 \mathrm{J}$ of energy.

Thus the energy to be overcome to overcome the Earth's gravity is

$$E_1 = \frac{2.23 \times 10^{32}}{4.19 \times 10^9} J = 5.32 \times 10^{14} Billions\ of\ tons \tag{10}$$

The world's most energetic nuclear weapon tsar bomb explosion generated by the energy 5×10^{14}Billions of tons. 10.6 billion tsar bombs are needed to overcome the gravitational force of the sun.

Situation 2:

If a nuclear weapon is detonated in the atmosphere above the ocean, as shown in Figure 7, it can

be seen that the tsunami impact within 4km is extremely large, enough to destroy an entire city. The first figure is calculated using a 1 million ton nuclear bomb, and the total yield of 94,400 nuclear bombs is 94,400,000,000 tons. If they were detonated in one location, the tsunami would affect an area within 100km of the explosion. The Pacific Ocean is approximately 15,900 km long from north to south and 19,000 km wide from east to west. Therefore, most of the ionizing radiation can be quickly absorbed by seawater after the explosion, and detonating a nuclear bomb in the ocean will not cause catastrophic damage to the earth.

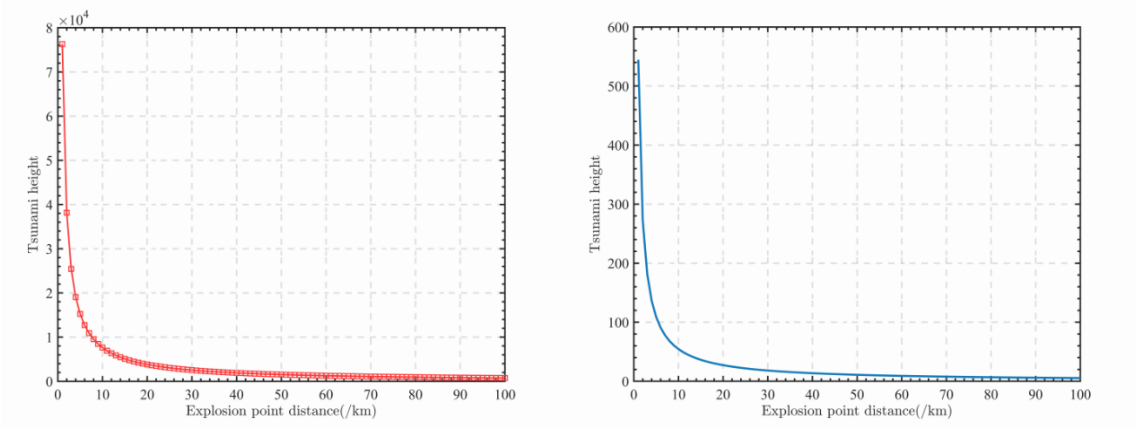

Figure 7: Distance from the center of the explosion in relation to the height of the tsunami

If the number of nuclear weapons is increased by ten times, it will cause huge tsunamis within a range of 1000-1500km from the explosion center, resulting in immeasurable losses to coastal countries, but it cannot destroy the earth. When the number of nuclear weapons is increased to 100 times (944,000), more than 300 massive tsunamis will occur within a range of 1500-3000km from the explosion center. The water in the Pacific Ocean will inundate most of the land, causing enormous impact on human survival. Figure 8 shows the relationship between the number of atomic bombs and the height of the tsunami.

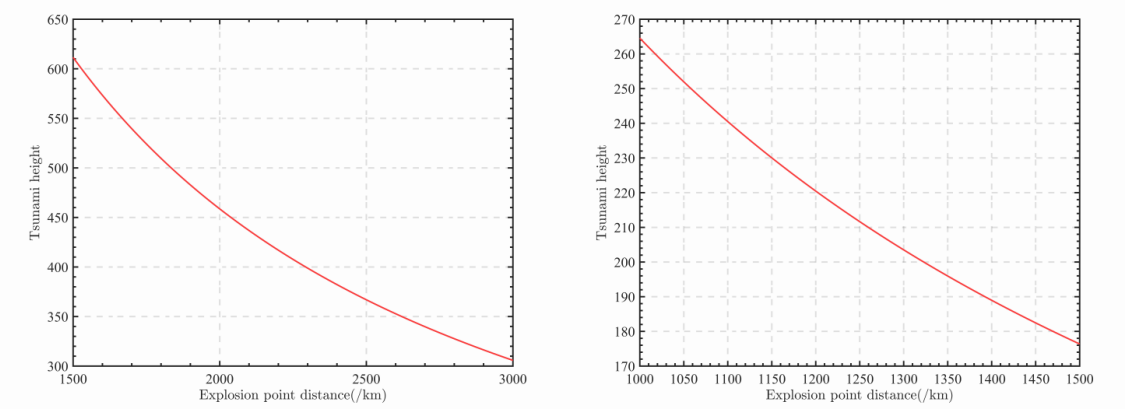

Figure 8: Relationship between the number of atomic bombs and the height of the tsunami

Situation 3:

A nuclear weapon detonated in the Amazon rainforest would affect $160km^2$ of the rainforest, destroying 1/3 of the Earth's oxygen and 30% of its purification capacity. However, the simultaneous detonation of 9440 nuclear weapons would affect only one province of China and would not be enough to "destroy the earth". The shock waves from the detonation of a nuclear weapon have the probability of detecting an earthquake, but may not have the potential to cause a real earthquake. Figure 9 shows the curves of the magnitudes that might be detected by the Little

Boy and Tsar bombs versus the distance from the center of the explosion.

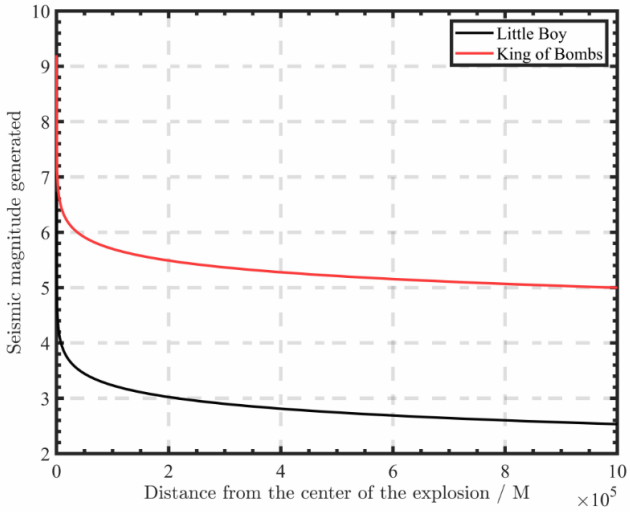

Figure 9: Curves of earthquake magnitude versus distance from the explosion center

4. Conclusions

The current manufacturing capacity of countries and the raw materials for nuclear weapons that exist on Earth are not sufficient to support this approach.

The existing 9440 nuclear bombs, if dropped in the ocean, would not result in the destruction of humanity or the destruction of the Earth. But the seismic damage generated may be incalculable, and the huge shock waves would cause the plates to shift, which would seriously affect human life.

Therefore:

1) The existing nuclear bombs should not be increased but converted to industrial and energy use.

2) Non-nuclear countries should ban nuclear development and develop other energy sources. Nuclear states should control and gradually reduce existing weapons.

3) Limit the total number of nuclear weapons to less than 9440, with annual transitional reductions and agreements not to increase them. Slowly reduce to 5,000 over 1,000 years because nuclear weapons have a military deterrent capability.

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