WEATHER MODIFICATION AS A WEAPON OF WAR

HEARING

BEFORE THE

SUBCOMMITTEE ON INTERNATIONAL ORGANIZATIONS AND MOVEMENTS

OF THE

COMMITTEE ON FOREIGN AFFAIRS
HOUSE OF REPRESENTATIVES

NINETY-THIRD CONGRESS

SECOND SESSION

ON

H. Res. 116 and 329

CALLING FOR INTERNATIONAL AGREEMENT PROHIBITING THE USE OF WEATHER MODIFICATION AS A WEAPON OF WAR

SEPTEMBER 24, 1974

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WEATHER MODIFICATION AS A WEAPON OF WAR

TUESDAY, SEPTEMBER 24, 1974

HOUSE OF REPRESENTATIVES,
COMMITTEE ON FOREIGN AFFAIRS,
SUBCOMMITTEE ON INTERNATIONAL
ORGANIZATIONS AND MOVEMENTS,
Washington, D.C.

The subcommittee met, at 2:15 p.m., in room 2255, Rayburn House Office Building, Hon. Donald M. Fraser (chairman of the subcommittee) presiding.

Mr. FRASER. The subcommittee on International Organizations and Movements will come to order. There is an amendment pending on the floor of the House on which there will be a vote soon, but I think we should proceed with the hearing now.

The subcommittee is conducting a hearing on House Resolutions 116 and 329 and calling on the U.S. Government to seek international agreements to limit the deployment of weather modification as a weapon of war.

[The resolutions follow:]

[H. Res. 116, 93d Cong., 1st sess.]

RESOLUTION

Whereas there is vast scientific potential for human betterment through environmental and geophysical controls; and

Whereas there is great danger to the world ecological system if environmental and geophysical modification activities are not controlled or if used indiscriminately; and

Whereas the development of weapons-oriented environmental and geophysical modification activities will create a threat to peace and world order; and

Whereas the United States Government should seek agreement with other governments on the complete cessation of any research, experimentation, or use of any such activity as a weapon of war: Now, therefore, be it

Resolved, That it is the sense of the House that the United States Government should seek the agreement of other governments to the following treaty providing for the complete cessation of any research, experimentation, and use of any environmental or geophysical modification activity as a weapon of war:

"The Parties to this Treaty,

"Recognizing the vast scientific potential for human betterment through environmental and geophysical controls,

"Aware of the great danger to the world ecological system of uncontrolled and indiscriminate use of environmental and geophysical modification activities,

"Recognizing that the development of weapons-oriented environmental and geophysical modification techniques will create a threat to peace and world order,

"Proclaiming as their principal aim the achievement of an agreement on the complete cessation of research, experimentation, and use of environmental and geophysical modification activities as weapons of war,

"Have agreed as follows:

"ARTICLE I

"(1) The States Parties to this Treaty undertake to prohibit and prevent, at any place, any environmental or geophysical modification activity as a weapon of war;

"(2) The prohibition in paragraph 1 of this article shall also apply to any research or experimentation relating to the development of any such activity as a weapon of war;

"(3) The States Parties to this Treaty undertake not to assist, encourage or induce any State to carry out activities referred to in paragraph 1 of this article and not to participate in any other way in such actions.

"ARTICLE II

"In this Treaty, the term 'environmental or geophysical modification activity' includes any of the following activities:

"(1) any weather modification activity which has as a purpose, or has as one of its principal effects, a change in the atmospheric conditions over any part of the earth's surface, including, but not limited to, any activity designed to increase or decrease precipitation, increase or suppress hail, lightning, or fog, and direct or divert storm systems;

"(2) any climate modification activity which has as a purpose, or has as one of its principal effects, a change in the long-term atmospheric conditions over any part of the earth's surface;

"(3) any earthquake modification activity which has as a purpose, or has as one of its principal effects, the release of the strain energy instability within the solid rock layers beneath the earth's crust;

"(4) any ocean modification activity which has as a purpose, or has as one of its principal effects, a change in the ocean currents or the creation of a seismic disturbance of the ocean (tidal wave).

"ARTICLE III

"Five years after the entry into force of this Treaty, a conference of Parties shall be held at Geneva, Switzerland, in order to review the operation of this Treaty with a view to assuring that the purpose of the preamble and the provisions of the Treaty are being realized. Such review shall take into account any relevant technological developments in order to determine whether the definition in Article II should be amended.

"ARTICLE IV

"1. Any Party may propose an amendment to this Treaty. The text of any proposed amendment shall be submitted to the Depositary Governments which shall circulate it to all Parties to this Treaty. Thereafter, if requested to do so by one-third or more of the Parties, the Depositary Governments shall convene a conference to which they shall invite all the Parties, to consider such amendment.

"2. Any amendment to this Treaty shall be approved by a majority of the votes of all the Parties to this Treaty. The amendment shall enter into force for all Parties upon the deposit of instruments of ratification by a majority of all the Parties.

"ARTICLE V

"1. This Treaty shall be of unlimited duration.

"2. Each Party shall in exercising its national sovereignty have the right to withdraw from the Treaty if it decides that extraordinary events, related to the subject matter of this Treaty, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other Parties to the Treaty three months in advance.

"ARTICLE VI

"1. This Treaty shall be open to all States for signature. Any State which does not sign this Treaty before its entry into force in accordance with paragraph 3 of this Article may accede to it at any time.

"2. This Treaty shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, , and which are hereby designated the Depositary Governments.

"3. This Treaty shall enter into force after its ratification by the States, the Governments of which are designated Depositaries of the Treaty.

"4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Treaty, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

"5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification of and accession to this Treaty, the date of its entry into force, and the date of receipt of any requests for conferences or other notices.

"6. This Treaty shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations."

[H. Res. 329, 93d Cong., 1st sess.]

RESOLUTION

Whereas the Declaration of the 1972 United Nations Conference on the Human Environment declared that nations have the responsibility to insure that their own activities do not damage the environment of other nations; and

Whereas the World Meteorological Organization has machinery to facilitate international cooperation in meteorology; and

Whereas environmental cooperation can help build a foundation for world peace; and

Whereas there is great danger to the world environment if weather modification activities are used for warfare: Now, therefore, be it

Resolved, That it is the sense of the House of Representatives that the United States Government should seek agreement with other members of the United Nations on the prohibition of research, experimentation, or use of weather modification activity as a weapon of war.

There are those who have argued that rainmaking is an effective weapon of war and that U.S. development of weather warfare should not be hampered. They maintain that rain is a far more humane way of stopping an enemy than is the use of bombs. On the other side some experts have expressed the view that at present rainmaking is ineffectual as a weapon and that military use of weather modification sets a precedent for further use of environmental and geophysical modification techniques which may lead to irreversible damage to the world environment. In this context, it is difficult to justify weather modification as a legitimate military activity.

In these hearings we hope to explore the ramifications of this controversy with regard to whether or not there should be international agreements to limit weather and environmental modification as weapons.

Today we will hear from three witnesses: Our distinguished colleague from Maryland, the Honorable Gilbert Gude; Rear Adm. Thomas D. Davies, Assistant Director for Nuclear and Advanced Weapons Technology of the Arms Control and Disarmament Agency; and Dr. Edith Brown Weiss, Brookings Institution.

Mr. Gude, we will begin with your testimony, with the understanding that when your testimony is completed that we would like to have you join the subcommittee for the balance of the testimony.

STATEMENT OF HON. GILBERT GUDE, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MARYLAND

Mr. GUDE. Thank you, Mr. Chairman.

It is a distinct pleasure to appear before this subcommittee, Congressman Fraser, and testify on behalf of our resolution calling for an agreement among members of the United Nations to prohibit the use of weather modification as a weapon of war. I am pleased to state that

since we introduced House Resolution 329 on March 28, 1973, we have been joined by 55 of our colleagues who share our concern for the harmful potential of this new weapon.

This hearing is particularly timely in view of several recent events:

First, Senate passage of a similar resolution on July 11, 1973, Senate Resolution 71;

Second, the admission of former Defense Secretary Laird in a letter to the Senate Foreign Relations Committee that, despite earlier denials, our Government had indeed spent $21.6 million between 1967 and 1972 trying to create rain for parts of Southeast Asia to inhibit movement along the Ho Chi Minh Trail;

Third, the agreement between the United States and the Soviet Union at the recent Moscow summit to meet later this year to discuss a weather warfare ban.

I first began investigating the military use of weather modification in March of 1971. As a member of the Conservation and Natural Resources Subcommittee of the Government Operations Committee, it appeared to me that this country had precipitously blundered into a most unwise use of technology by introducing weather modification as a weapon of war in Indochina.

Since that time, the weather modification technology has been constantly improving. In a 1974 publication, a National Academy of Sciences panel reported significant progress in the field and more statistically valid evidence that cloud seeding can increase precipitation under certain conditions. In addition, the panel cited an increase in our ability to understand those conditions under which cloud seeding will be most effective.

Cloud seeding—the basic weather modification technique—is also beginning to present an increasing number of possibilities:

1. In addition to the creation of rain or snow, scientists are discovering that overseeding can result in decreased precipitation.

2. Seeding which causes cloud expansion can produce pressure changes in the atmosphere below the clouds which can affect wind speed.

3. Seeding can also help to dissipate fog and change the size of hailstones.

4. Introduction of pollutants into the atmosphere through seeding can add to the already excessive air quality burdens of urban areas.

Continued progress in this field seems inevitable. The U.S. Government is continuing its research efforts, and other nations, notably the Soviet Union, have undertaken similar efforts. The scope of the Federal weather modification research is indicated in a publication of the Interdepartmental Committee for Atmospheric Sciences entitled "National Atmospheric Sciences Program Fiscal Year 1974." This report shows that, in addition to the National Science Foundation, five Federal Departments have active programs—Agriculture, Commerce, Defense, Interior, and Transportation. The total funding fiscal year 1974 was just under $20 million, not including classified military spending.

Given this developing technological potential, it is most appropriate that the United States, the leading Nation in weather modification research, take the lead in proposing a treaty to outlaw military applications of this research.

DANGERS OF WEATHER MODIFICATION—CONTROL

Why should we be so alarmed about a technique that is not nearly as lethal as other forms of warfare? First, there are distinct control and command problems associated with geophysical warfare and weather modification in particular. We simply do not have effective short or long term control over the climates of the world. We can create certain disturbances, but as civilian experiments have shown, control is not precise. In a military environment, control over the results of weather experimentation is even more uncertain in respect to military targets, and there is practically no hope of preventing military efforts from spilling over into civilian life with devastating effect, particularly in developing agricultural countries. Here, wind changes, rainfall changes, or even changes in the composition of rain could seriously disrupt the livelihood of most of the country's citizens and create severe food supply problems, all far distant from the chosen military target. This is partly due to the so-called downwind effect, carrying weather changes with weather movements. But weather unpredictability—enhanced by modification efforts themselves—may make it impossible to determine where "downwind" will be at any given time. This means that the use of weather modification is inevitably indiscriminate. We cannot flood only military targets or cause drought in areas producing only military rations. The technology will be used against people regardless of their uniform or occupation and will inevitably strike civilians harder than nearby military objectives.

The command problem is no less acute. Since the technology to date does not involve great expense or sophisticated equipment, it is not difficult to imagine the use of weather modification by many different military subunits. In fact, there have been reports that we have trained the South Vietnamese to use weather modification. There are no double-key safing mechanisms here, no exclusive possession as with nuclear weapons.

DANGERS OF WEATHER MODIFICATION—IDENTIFICATION AND DETECTION

These issues of command and control highlight another disturbing characteristic of weather modification, the difficulty of detection. Unlike other weapons, it may be possible to initiate military weather modification projects without being detected. In other words, the military results may not be visibly tied to the initiating party. This raises the possibility of the clandestine use of geophysical warfare where a country does not know if it has been attacked. The uncertainty of this situation, the fear of not knowing how another country may be altering your climate is highly destabilizing. This feeding of national paranoia—a pervading suspicion of the motives and actions of a neighboring country—could well be amplified into the laying of blame for any adverse climate conditions or weather disasters on one's neighbors.

This was clearly brought home by the recent admission of the Department of Defense that it had indeed been involved in weather modification activities in Southeast Asia from 1967 to 1972, even at a time when Department witnesses were denying such involvement in their congressional testimony.

In a January 28, 1974, letter to the Senate Foreign Relations Committee, former Defense Secretary Laird corrected his testimony of April 18, 1972, in which he stated, "We have never engaged in that type of activity over North Vietnam." Laird admitted that just such activities were conducted over North Vietnam in 1967 and 1968. It was clearly one of the most useless programs ever conceived by the Government. The rainmaking effort accomplished nothing except washing $21.6 million down the drain, and it was undertaken with no thought as to the very dangerous situations which could evolve from such a policy.

EFFECTS OF WEATHER MODIFICATION RESEARCH

There is no question that much valuable research is now being done under the heading of weather modification. Airport fog dispersal operations, cloud seeding in farm areas threatened by drought, efforts to increase the winter snow pack, and experiments in hurricane control are all legitimate scientific efforts that can meet important domestic and international needs. This work into peaceful applications of environmental modification technology should continue. Unfortunately, Pentagon involvement in weather modification research—whether classified or for peaceful purposes—has serious consequences for the U.S. civilian scientific community, the American public, and the international community.

Geophysical warfare, to use a figure of speech, can poison the atmosphere surrounding legitimate international programs such as the global atmospheric research program, the international hydrological decade and meteorology in general. We have already seen that it caused the U.S. delegation at the Stockholm Conference to water down a recommendation on climate changes. The potential for embarrassment is great.

Our scientific community could come under suspicion or attack at these international meetings. The fine work and trust built up over the years by our excellent atmospheric scientists could be dispelled in one stroke of Pentagon experimentation.

But it is not only our scientists who lose credibility—it is the Defense Department itself. Through its involvement in research which may have military applications, even though it is intended for peaceful purposes, the Pentagon has laid itself open to allegations of a variety of clandestine activities.

Two cases will illustrate the point. The Defense Department engages in considerable medical research, some of which is related exclusively to military needs, while some parallel research carried out by civilian institutions. The Navy, for example, has had a research unit in Egypt studying equatorial diseases for many years. By conducting such research "in-house," so to speak, instead of obtaining it through civilian research agencies, the Navy leaves itself open to charges that it is actually studying or developing germ warfare or the like. As unfounded as such charges may be, they are very difficult to combat, especially in the current climate of suspicion about many Pentagon activities. Yet, there is no reason why this kind of research could not be conducted by the civilian agencies of Government and its results made available to the Defense Department. In cases where Defense required information on subjects not currently under investigation, it could levy requirements on the

National Science Foundation which would in turn conduct or contract for the needed research, thus reducing the opportunities for controversy to develop, controversy which might itself hamper research, especially abroad.

In the area of weather modification, I have been assured that Air Force interest in these techniques is limited to developing methods for airfield fog dispersal or suppression and other life-saving measures. These techniques are just as important to business and civil aviation and the general public, and there is no reason why such research cannot be conducted by a civilian agency.

As a general principle, therefore, I would urge that wherever an adequate scientific base exists for conducting specific types of applied research outside of the Department of Defense and associated agencies, it would be wise policy to conduct all such research through non-defense agencies, such as NOAA, NIH, NSF or private institutions. In addition to helping resolve Pentagon credibility problems, such a procedure will tend to reduce duplication of effort and may therefore produce some cost savings.

Thus, although the subject of this hearing is an international treaty banning the use of weather modification techniques as weapons, it is important that we go beyond that and deal directly with the development of such research within our own Government, so as to clearly divorce all weather modification activities from the military and leave no doubt that American interest in this field is strictly peaceful and humanitarian.

CONCLUSION

We learned at the dawn of the atomic age that no military potential will long remain in the sole control of one power. It may be possible, for example, that as the Soviets develop their computer technology, their weather control technology will progress correspondingly. But we should not be forced into this field due to some possible Soviet interest and neither should we encourage the U.S.S.R. to increase its capability because of our experiments. It is in the best interest of both countries to avoid a technology race that could culminate in environmental disasters.

Many authorities have testified that weather modification is a Pandora's box. This is true in more ways than one. We not only do not know how far our technology will take us, but we also have no idea of what may be the permanent consequences of the experiments we have conducted thus far.

There is a growing consensus that the time is ripe for an international agreement on weather modification. The First Annual Report of the National Advisory Committee on Oceans and Atmosphere (NACOA) urged the U.S. Government to present a resolution to the United Nations General Assembly limiting weather modification activities to peaceful purposes. The Third Annual Report of NACOA expanded on that recommendation and suggested that:

We overcome the existing fragmentation of Federal R. & D. programs in weather modification by assigning a lead-agency role to NOAA.

Greater emphasis be placed on research on the physics of cloud formation and the science and technology of rainfall augmentation.

That legislative and public policy issues governing the proper use of a new technological capability be examined, and in particular, that the United States

take the initiative in establishing international agreement to insure that weather modification efforts be devoted to mutually beneficial programs * * *.

Earlier, the 18th Annual Session of the North Atlantic Assembly adopted a resolution supporting an international agreement prohibiting military uses of this science. And, as I pointed out at the beginning of my testimony, the recent United States-Soviet agreement to meet on this issue is the latest hopeful sign.

In closing I should emphasize that the future potential of weather modification is much greater than what we have the power to do now. But unless we act now to prohibit weather modification warfare and to separate weather modification research and development from military control, technology will once again outstrip our social structures, leaving us open to those flaws of human nature which have in the past turned scientific wonders into military nightmares.

Mr. Chairman, I appreciate your making it convenient to have these hearings.

Mr. FRASER. Thank you very much, Mr. Gude.

I think I will hold most of my questions until the question period for other witnesses.

I just wondered if you had any impressions as to the significance of the request by the Soviet Union to have this matter placed on the agenda of the General Assembly, and whether that is inconsistent with the understanding between the United States and Soviet Union to pursue some kind of an effort to deal with this problem.

Mr. GUDE. I don't know whether that is inconsistent. It certainly is an opportunity. I think the idea that we should go ahead and have this matter discussed by the General Assembly is good. The technology is such that we can't pretend that the Soviet Union and the United States can have a monopoly on it as in the case of other more sophisticated and expensive military techniques, and so I think it is something that would be good to have a debate on, and I think a debate and discussion on issues where we can come to an agreement such as this, we hope with relative ease, will lead to agreements in other areas.

Mr. FRASER. I think your point is well taken. This is not technology that is limited to just two countries. If the U.S.-Soviet talks were to have much meaning, they would have to be in the context of a possible multilateral undertaking at some point.

Well, thank you very much, Mr. Gude. I appreciate your statement and the fact that you brought this matter before the House and before the committee. And if you would be willing to participate in the questioning, that would be very helpful.

I would like to ask our next two witnesses to come forward to the witness table, Admiral Davies and Dr. Weiss.

Will you proceed, sir.

STATEMENT OF REAR ADM. THOMAS D. DAVIES, ASSISTANT DIRECTOR FOR NUCLEAR AND ADVANCED WEAPONS TECHNOLOGY, ARMS CONTROL AND DISARMAMENT AGENCY

Admiral DAVIES. Thank you, Mr. Chairman.

I am pleased to appear before you today to testify on the subject of arms control and environmental modification, especially the concepts and practices known as weather modification, which is the subject of House Resolution 329, the focal point of these hearings.

I would like to start by a brief technological description of the machinery that is the subject of this discussion, the oceans of air and water that surround the Earth. From the fact of their relatively unchanged existence over the eons, we can conclude that they are of the nature of a gigantic heat engine, extremely complex, but in all likelihood very stable. There are many processes within each, in which stable balances have been established for millenia. Our knowledge of the details of these systems and their functioning is far from complete. For example, even our rather extensive weather measurement and forecasting system experiences difficulty in forecasting, with a high degree of certainty, what the future action of the atmospheric machine will bring in terms of weather.

There exists a concept that there could be various techniques which would shift the atmospheric and environmental balances and produce substantial near-term results, such as causing rain, clearing fog, even controlling the force of hurricanes. This concept has acquired a substantial community of supporters and advocates, as a result of which trial efforts have been carried out during the past quarter century. The results of these trials have been almost without exception ambiguous. The precision of the basic measurements of the forces observed, such as wind, and of course the precision of predicted values, is of such low order that many of the apparently affirmative statements of results that have been made (such as "a 15-percent reduction of wind velocity") represent values the derivation of which exceed the specificity of the raw measurement data. Thus the results can only be judged over an extended period of time.

There are also those who believe that the long term stability of the ocean atmosphere system is rather more fragile and that attempts to achieve temporary alterations may have more lasting and dangerous effects. While the evidence of actions to date tends to contravene this, there could well be effects not yet completely examined or understood which could support this view.

The most promising specific technique to date has been the seeding of supercooled clouds to initiate rain. This is usually done by aerial distribution of silver iodide or other particles which serve as freezing nuclei in the cloud. They trigger the freezing of the water into ice particles which liberates heat and promotes the dynamic processes inside the cloud, thereby stimulating the production of snow or rain.

Even this technique suffers from uncertainties. Of course it only works on a particular type of cloud—"supercooled"—which might be described as a cloud "ready to rain" anyway, and since controlled and quantified experiments are exceedingly difficult with clouds, the occasions on which the technique doesn't work go unexplained and the question of whether or not the cloud would have nucleated and rained shortly anyway goes largely unresolved.

Fog clearing has been the objective of many years of effort and now seems to be possible in the case of "cold" fogs, by the utilization of a technique similar to that I have just described. The reduction of wind intensity in hurricanes by cloud seeding is postulated as a possibility. It has been attempted on a few occasions with one claimed success. "Hurricane steering," through seeding certain areas which might hopefully reduce the energy in an asymmetric way so that the system might turn, is additionally postulated as a longer term possibility.

The war use of these concepts is mostly technologically the same as the peaceful use. Rain as an inhibitor of the passage of troops and supplies is one concept and has been attempted in Southeast Asia. The attempts were not startlingly successful. There is a theory that if a hurricane could be steered it might be aimed at an adversary.

Turning to the behavior of the atmosphere as a whole, as contrasted to the more transient phenomena described above, I should point out that distinctions between various aspects of the environment, such as the weather and climate, are often a matter of semantics, although we generally conceive of the climate to be the longer term average manifestation of the atmospheric environment, which is constituted by those elements we call the weather. At this scale, aside from the inadvertent effects man is causing, any attempts to modify the Earth's climate, or the climate of a region, for peaceful or hostile purposes are simply theoretical.

Similarly of a theoretical nature are capabilities to divert ocean current, cause tsunamis or tidal waves, trigger earthquakes, or modify the ionosphere in any large-scale way.

Given the theoretical nature of most of these activities, it is difficult to realistically discuss their potential military usefulness. Our lack of knowledge about them, and, more fundamentally, about the environment itself and the interaction of its various components, dictates caution and prudence in proceeding with any modification attempts. In this context, it should be pointed out that in July 1972, and again in January 1974, at Senate hearings on the Pell resolutions, which were similar in intent to House Resolution 329, administration witnesses have stated that the United States would not use climate modification techniques for hostile purposes, even should such techniques come to be developed in the future.

In summary the environment can be said to be complex, in all likelihood very stable, and far from totally understood. While the concept that manmade efforts can modify it has gained popularity, there are still mostly ambiguous and uncertain data to support such a view. However, the possibilities of success have been evaluated as high enough to warrant continued research.

The joint statement on environmental warfare signed in Moscow on July 3 by the President of the United States and General Secretary Brezhnev advocates the most effective measures possible to overcome the dangers of using environmental modification techniques for military purposes, and expresses the intention of the two countries to discuss steps to bring about such measures. This is a most desirable course of action. Additionally, the Soviet Union has proposed that the United Nations General Assembly address this subject this fall.

While the joint statement refers to a bilateral meeting to explore the problem and discuss steps to be taken to attain the stated objectives, the Soviet U.N. proposal, of course, moves this issue into a multilateral forum, and advocates action to prohibit efforts to influence the environment for military and other purposes "incompatible with the maintenance of international security, human well-being, and health." Thus their proposal appears to broaden the issue substantially.

The U.S.S.R. goes on to point out that many nations are engaged in research in this area and that consultations and cooperation between them are necessary to insure compliance with an international conven-

tion outlawing environmental warfare. From my point of view, it certainly seems possible to combine our objectives by extension of peaceful cooperation and arms control limitations at the same time.

With your permission, I would like to submit a copy of the joint statement and of the Soviet proposal for the record.

With respect to the course of action urged by H. Res. 329, that the United States should seek an international agreement banning weather modification activities related to the use of such techniques as weapons of war, this action would largely overlap the aims of the joint statement.

Gentlemen, I will be pleased to respond to your questions on this subject.

Mr. FRASER. Thank you very much, Admiral Davies.

Without objection, we will include the joint statement and the text of the Soviet proposal in the record.

[The joint statement and the Soviet proposal follows:]

JOINT STATEMENT ON ENVIRONMENTAL WARFARE

The United States of America and the Union of Soviet Socialist Republics:

Desiring to limit the potential danger to mankind from possible new means of warfare;

Taking into consideration that scientific and technical advances in environmental fields, including climate modification, may open possibilities for using environmental modification techniques for military purposes;

Recognizing that such use could have widespread, long-lasting, and severe effects harmful to human welfare;

Recognizing also that proper utilization of scientific and technical advances could improve the inter-relationship of man and nature;

1. Advocate the most effective measures possible to overcome the dangers of the use of environmental modification techniques for military purposes.

2. Have decided to hold a meeting of United States and Soviet representatives this year for the purpose of exploring this problem.

3. Have decided to discuss also what steps might be taken to bring about the measures referred to in paragraph 1.

MOSCOW, JULY 3, 1974.

For the United States of America:
The President of the United States of America.

For the Union of Soviet Socialist Republics:
General Secretary of the Central Committee of the CPSU.

AUGUST 7, 1974, LETTER FROM USSR MINISTER OF FOREIGN AFFAIRS A. GROMYKO TO THE SECRETARY GENERAL OF THE UNITED NATIONS

The Soviet Government proposes the inclusion of the agenda of the twenty-ninth session of the United Nations General Assembly of the following item as an important and urgent matter: "Prohibition of action to influence the environment and climate for military and other purposes incompatible with the maintenance of international security, human well-being and health."

The twenth-ninth session of the United Nations General Assembly is opening at a time when, as a result of the efforts of all progressive and peace-loving forces, considerable progress is being made on the international scene towards improving the political climate, and the policy of détente is receiving increasing support. In the practice of international relations between states with different social systems such basic norms of inter-state relations as respect for independence and sovereignty, equality, territorial integrity, abstention from the use of threat of force, and noninterference in domestic affairs are becoming even more widely and firmly established, détente has played a decisive part in the trend towards the political settlement of conflict situations in many parts of the world. Active negotiations are being held on a number of complex international problems.

Recent years have seen the conclusion and entry into force of such major international agreements limiting the scale of the arms race as the Moscow Treaty banning nuclear weapons tests in the atmosphere, in outer space and under water,

the Treaty on the Non-Proliferation of Nuclear Weapons, and others. Wide international recognition has been accorded to the Convention on Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, signed by more than 100 states.

The agreement between the Soviet Union and the United States on the prevention of nuclear war, strategic arms limitation and the limitation of underground nuclear tests constitute an important contribution to the strengthening of peace and control of the arms race.

Other concrete measures for the limitation of armaments including measures for the reduction of armed forces and armaments in Central Europe, are being actively discussed.

However it has not yet proved possible to stop the arms race completely. States are still spending vast sums on the improvement of weapons and on stocking their military arsenals. There is a real danger that the achievement of science and technology will be used to create new types of weapons of mass destruction and to devise new means of waging war.

In the opinion of the Soviet Government, present-day conditions require that the activities of the United Nations should concentrate on the study of ways and means to consolidate and expand the positive processes taking place in the world of today, to back up political détente by military détente and achieve new concrete results in the field of the limitation of the arms race and disarmament.

The Soviet Union believes that an important step in this direction would be the prohibition of action to influence the environment and climate for military and other purposes incompatible with the maintenance of international security, human well-being and health.

For many centuries mankind has been seeking to discover how to influence natural elements in a positive way, and mitigate the deleterious effects of natural disaster. At present, with this end in view, many states are carrying out scientific research and practical work in an attempt, for example, to create artificial rain, disperse clouds, etc. Activities in this field, pursuing peaceful and constructive ends, should, of course, be encouraged and welcomed in every way. However, the results of this research could also be used for destructive military purposes, and thus present an extreme danger to world peace, and to human well-being and health.

It is urgently necessary to draw up and conclude an international convention to outlaw action to influence the environment for military purposes. Compliance with the provisions of such a convention could be ensured by the adoption by each state, in accordance with its constitutional procedures, of measures to prohibit activities contrary to the convention and also by means of consultations and co-operation between states, inter alia within the framework of the United Nations. The conclusion of such a convention would be not only a measure to limit the scope of the arms race but also an important means of preserving the environment. All states of the world without exception, and all peoples, would stand to gain from the implementation of this measure.

Needless to say, such an agreement should on no account restrict scientific research and practical work on the alteration of natural conditions to meet the peaceful needs of states for the benefit of mankind.

The adoption by the General Assembly of a resolution approving the idea of concluding a broad agreement on the prohibition of action to influence the environment and climate for military and other purposes incompatible with the maintenance of international security, human well-being and health, and the preparation of a draft international agreement on the subject, would certainly be in the interest of strengthening peace and make a substantial contribution to the cause of preserving mankind from the danger of the use of new means of waging war, and also serve the interests of limiting the arms race and of disarmament.

I should be grateful, sir, if you would consider this letter an explanatory memorandum pursuant to Rule 20 of the Rules of Procedure of the United Nations General Assembly and issue it as an official document of the United Nations General Assembly.

Mr. FRASER. We will withhold questions until we have heard from our next witness, Dr. Edith Brown Weiss from Brookings.

STATEMENT OF DR. EDITH BROWN WEISS, BROOKINGS INSTITUTION

Mrs. WEISS. Thank you, Mr. Chairman, for the opportunity to testify today. I'd like to just highlight the written statement which I have submitted to the committee.

Mr. FRASER. All right. Your full statement will appear in the record.

Mrs. WEISS. Mr. Chairman, we face a new danger—that of weather wars. Over 60 countries have already used weather modification for peaceful purposes. The danger is that states will use techniques of weather and climate modification as weapons of war against each other. This may cause irreversible changes in weather and climate patterns. It will lead people to suspect that bad weather conditions are not naturally caused. It will endanger peaceful international meteorological programs, such as that for weather forecasting. In brief, it will turn the global weather system into a highly contentious political arena.

Mr. Chairman, we need a ban on the future use of weather and climate modification for hostile purposes. The United States-Soviet statement of last July on the use of environmental modification for military purposes is a useful initiative. But we need to be careful that we do not end up with a partial agreement with the Soviets which bans the techniques neither side was planning to use and legitimizes the use in warfare of the weather modification techniques that are more nearly ready for use.

The July statement called for "the most effective measures possible to overcome the dangers of the use of environmental modification techniques for military purposes" and indicated that U.S. and Soviet representatives would meet to discuss the problem further. We urgently need to indicate what these effective measures would be and to get agreement to such measures not only between the United States and the U.S.S.R. but between all states.

We also need to recognize the limits of the statement. The statement calls only for the "most effective measures possible to overcome the dangers of the use of environmental modification techniques for military purposes." This implicitly suggests that it is possible to use techniques of environmental modification for military purposes in acceptable ways. The problem is that the statement explicitly refers to climate modification in the text and not to weather modification which is the more imminent problem. It is left ambiguous in the statement whether the use of weather modification techniques raises "dangers" which need to be overcome.

My testimony today is directed to the reasons why we should try to prohibit the use of weather and climate modification for hostile purposes and to the measures we might initiate to manage the development of the technology for peaceful purposes. A significant step would be a comprehensive multilateral ban on the use of the technology for hostile purposes.

There are a number of reasons to forgo using weather modification for hostile purposes.

1. The techniques are still unpredictable in their effects. Either individually or together they could trigger irreversible changes in weather and climate, which no state could control. Hostile uses are more likely than other uses to get out of control, because decisions will be made on the basis of military exigencies, with probably little regard for environmental considerations.

2. Weather modification in war, and even more so climate modification, may affect the weather of nearby neutral states, which would widen and intensify the conflict. States doing the modification may be unable to convince downwind neighbors that any bad weather conditions are in fact due to natural fluctuations, and not to their activities.

3. In many circumstances the use of weather modification techniques as a weapon would implicitly involve an attack on civilians and their facilities, which would violate international law.

4. Accepting weather modification techniques as legitimate weapons would further undermine the already shaky distinction between conventional and unconventional means of warfare. It would legitimize techniques of environmental modification as weapons of war. This is particularly undesirable in a world which is becoming increasingly vulnerable to unconventional means of warfare.

5. One of the most important reasons for banning hostile uses is that even the chance that states would use these techniques in this way casts suspicion on the development and use of the technology for peaceful purposes. Even more importantly, it can endanger the international cooperative programs we already have in weather forecasting and atmospheric research. It can hinder efforts to understand and use weather and climate for the benefit of mankind.

6. If one state develops and uses these techniques for hostile purposes, she invites others to do so. There is an internal momentum to the development and use of weapons, which is often keyed to the perception by states that others will acquire and use the weapons. A ban on the use of these techniques for hostile purposes averts this interaction.

7. Finally, from the point of view of the state employing these techniques as weapons of war, there are significant disadvantages. The technology does not appear to offer an effective way to limit the resources of a country without bombing it. At least at the present time we cannot predict precisely or with certainty the effects of weather modification operations. It is difficult to limit the effects of the techniques or the areas affected. Since techniques of cloud-seeding, for example, are comparatively accessible, many countries could potentially use the techniques as weapons. It would be difficult to contain such proliferation.

It is true that if we are to have an acceptable arms control agreement in the weather field, we need to be able to detect violations. However, it is not important that we detect every violation, of whatever kind, but only that we detect major violations of the agreement. The ability to detect the use of these techniques as weapons of war will vary with the techniques used. We should be able to detect larger-scale modifications. For methods on a smaller scale, detection will be more difficult.

We need to engage in more research to enhance our ability to detect these operations and, above all, make the results of this research openly available on a global basis.

In any measures which we initiate, the pyschological perception that other states do not intend to use the technology as a weapon is important. This is particularly true where the perception of whether a state has caused bad weather can be more important than the scientific assessment.

A ban on hostile pruposes will be one step in giving this assurance to states. A necessary corollary will be arrangements which regulate the peaceful uses of weather modification. Essentially we need to reduce the chance that states could use the techniques covertly against other states and the fear that others had done so. This requires a continuation and expansion of international programs for monitoring atmospheric and oceanic conditions, for forecasting weather, and for conducting atmospheric and oceanic research. It also suggests the need to initiate periodic international appraisals of the state of development of weather and climate modification technology and to ensure that all states have access to this information.

In addition to greater international efforts to improve our understanding of weather and climate, we need to begin to develop new rules and procedures to implement the principles of the Declaration of the United Nations Conference on the Human Environment and the recommendations of this Conference.

Specifically, it is essential to develop principles of advance notification, open dissemination of information, and consultation between states, in conducting any weather modification experiments and operations which could have effects outside national borders. Large-scale experiments and projects which could have a significant effect on weather or climate should be prohibited in the absence of approval from the international community. In many cases compensation for any damage which may occur to neighboring states from weather or climate modification programs will either be impossible to provide or inadequate. For this reason, we should give priority to developing procedures for ensuring that the interest of all affected states are taken into consideration before the activity takes place. Since all states share a common global climatic system and common weather systems, it is in everyone's interest to join in arrangements insuring an orderly development and use of techniques for changing weather and climate conditions.

Unfortunately, weather modification is only one of several potential techniques for modifying the environment which have at least been mentioned as future weapons. We need to view the development and use of weather and climate modification techniques for hostile purposes as but a first step in the potential development of new and unconventional environmental weapons, which threaten the environmental integrity of our planet Earth.

I view the resolution now before the committee, which focuses on prohibiting weather modification as a weapon of war, as a useful step in beginning to control environmental weapons in the future.

Thank you.

[Prepared statement of Dr. Weiss follows:]

PREPARED STATEMENT OF DR. EDITH BROWN WEISS*

WEATHER WARS ARE COMING?

Mr. Chairman, in the coming decades the United States and the international community could face a great threat from the use of techniques for changing weather and climate as weapons of war. If we are to avoid this, it is important to begin now to prohibit this use and to channel research and development in weather and climate to peaceful purposes. Our scientific understanding of weather and climate patterns is still relatively primitive, which makes it hard to distinguish artificial changes from naturally occurring ones. However, our *perception* of what changes man's intervention has caused are often more important than the facts. If we let techniques for modifying weather and climate be used as weapons of war, it will turn the global weather systems into a highly contentious political arena. It will make it more difficult for people to regard bad weather and climate conditions as naturally induced. It can hinder the application for peaceful purposes of any techniques developed to modify weather conditions.

Ironically we have begun to recognize the danger of those techniques which are least developed—techniques for climate modification. In testimony before the Senate, a representative of the State Department indicated that the U.S. would not use climate modification for hositle purposes. However, techniques of weather modification, such as cloud-seeding, are much nearer being effective. The Department of Defense has finally admitted that it indeed already used cloud-seeding techniques extensively during the Viet Nam War, although public scrutiny quickly disclosed claims of dubious scientific validity regarding their effectiveness. Yet despite the fact that cloud-seeding techniques have been used in military operations, the United States Government has still not taken any policy position on the use of these techniques as weapons of war. I view the resolution now before the Committee on Foreign Affairs, which focuses on prohibiting weather modification activity as a weapon of war, as a useful first step in filling this gap.

On July 3, 1974, the U.S. and the U.S.S.R. issued a joint statement on the use of environmental modification for military purposes, which expressly referred to climate modification. The statement called for "the most effective measures possible to overcome the dangers of the use of environmental modification techniques for military purposes" and indicated that U.S. and Soviet representatives would meet to discuss the problem further.[1] This statement is certainly a commendable first step, but future discussions are urgently needed to indicate what these effective measures would be and to get agreement to such measures not only between the U.S. and the U.S.S.R. but between all states.

It is also important to recognize the limitations of the Statement. The Statement calls only for the "most effective measures possible to overcome the *dangers* of the use of environmental modification techniques for military purposes." This implicitly suggests that it is possible to use techniques of environmental modification for military purposes in acceptable ways. The explicit reference to climate modification, and not to weather modification, which is the more imminent problem, suggests some uncertainty as to whether any future agreement would cover techniques for modifying weather. It is left ambiguous whether the use of weather modification techniques raises "dangers" which need to be overcome. We need to guard against a "partial" U.S./Soviet arms control agreement on environmental modification which has the effect of legitimizing the use in warfare of some techniques for modifying weather.

My testimony today is directed to the reasons why we should try to prohibit the use of weather and climate modification for hostile purposes and to the measures we might initiate to manage the development of the technology for peaceful purposes. There are a number of possible initiatives for controlling the use of weather and climate modification techniques as weapons of war. These range from an agreement between the U.S. and U.S.S.R., a U.N. General Assembly Resolution calling for a ban on the use of these techniques for hostile purposes, followed by an agreement implementing the resolution. Institutional arrangements for controlling the use of these techniques as weapons of war while facilitating peaceful uses, perhaps analogous to the IAEA arrangements.

A significant step would be a comprehensive multilateral ban on the use of the technology for hostile purposes.

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*The views expressed are those of the author only.

[1] The text of the Statement on the Environment appears in *The New York Times*, July 4, 1974, p. 2, col. 8.

There are a number of reasons to forego using weather modification for hostile purposes.

1. The techniques are still unpredictable in their effects. Either individually or in the aggregate, they could trigger irreversible changes in weather and climate, which no state could control. Hostile uses are more likely than other uses to get out of control, because decisions will be made on the basis of military exigencies, with probably little regard for environmental considerations. If several states resort to these techniques in war, they could together provoke unanticipated changes adverse to many states.

2. Weather modification in war, and even more so climate modification, may affect the weather of nearby neutral states, which would widen and intensify the conflict. States doing the modification may be unable to convince downwind neighbors that any bad weather conditions are in fact due to natural fluctuations, and not to their activities.

3. In many circumstances the use of weather modification techniques as a weapon would implicitly involve an attack on civilians and their facilities. Judge Lauterpacht has described as an "absolute rule of law" the prohibition against making civilians an "avowed or obvious object of attack." [2]

4. Accepting weather modification techniques as legitimate weapons would further undermine the already shaky distinction between conventional and unconventional means of warfare and would legitimize techniques of environmental modification as weapons of war. This is particularly undesirable in a world which is becoming increasingly vulnerable to unconventional means of warfare.

5. One of the most important reasons for banning the use of weather and climate modification techniques for hostile purposes is that even the chance that states would use these techniques in such a way casts suspicion on the development and use of the technology for peaceful purposes. It can endanger the international cooperative programs which now exist in weather forecasting and atmospheric research, and thus hinder efforts to understand and use weather and climate for the benefit of mankind.

6. If one state develops and uses these techniques for hostile purposes, she invites others to do so. There is an internal momentum to the development and use of weapons, which is often keyed to the perception by states that others will acquire and use the weapons. A ban on the use of these techniques for hostile purposes averts this interaction.

7. Finally, from the point of view of the state employing these techniques as weapons of war, there are significant disadvantages. The technology does *not* appear to offer an effective way to limit the resources of a country without bombing it. At least at the present time we cannot predict precisely or with certainty the effects of weather modification operations. The various techniques are only useful under certain meteorological conditions, which occur only at certain times of the year and only in certain regions. None of these variables are under the control of states relying upon weather modification technology as a weapon. It is difficult to limit the effects of the techniques or the areas affected. Since techniques of cloud-seeding, for example, are comparatively inexpensive and accessible, many countries could potentially use the techniques as weapons. It would be difficult to contain such proliferation.

In drafting an agreement prohibiting the use of weather and climate modification techniques as weapons of war, we can anticipate certain problems, which are analogous to ones that have arisen in efforts to control chemical and biological weapons. The first is whether such a ban should extend to the use of fog dispersal techniques in warfare. The analogy can be drawn between fog dispersal techniques and tear gas. In the latter case, a primary argument against distinguishing tear gas from other gases has been that by sanctioning the use of tear gas we may be opening a Pandora's box to the use of other chemical agents. By analogy, the use of fog dispersal in warfare, which in some cases involves techniques essentially similar to those for cloud-seeding operations, invites escalation to other forms of weather modification. Indeed the justification given by the Executive Branch for excepting tear gas from the Geneva Protocol of 1925, namely that it was commonly used domestically throughout the world to control riots, applies to cloud-seeding techniques, which may also be used to dampen domestic riots. A more effective approach would be to prohibit all applications of weather and climate modification techniques for hostile purposes, and if an exception is deemed necessary, to very carefully limit it to the dispersal of fog to facilitate landings on one's own

[2] Lauterpacht, "The Problem of the Revision of the Law of War," *BRIT, Y.B.I.L.*, Vol. 29 (1952), pp. 360–69.

or an allied airfield or ship. This approach would ban, for example, the use of fog dispersal to facilitate the effectiveness of other weapons.

An agreement prohibiting weather and climate modification techniques as weapons of war should cover all hostile uses, whether covert or overt, whether large or small in scale, whether in active combat or in a slow program of subversion. It should explicitly cover the use of these techniques to undermine or destroy the economies of other states. The latter is important in shaping perceptions about the intentions of other states and the applications of any techniques developed to change the weather.

We also need to consider having the agreement cover the use of weather modification techniques domestically for hostile purposes, as for civil wars, secessionist movements, or riots. Traditionally such matters have been regarded as ones of domestic jurisdiction. However, weather systems are oblivious to political boundaries. This makes the issue acute between states with narrow territorial limits. The problem is that these techniques are likely to be used under conditions making it difficult to ensure that there would be no effects on the weather beyond the state's own borders. More pressing goals of hampering the enemy would be likely to overcome any checks which might normally operate to protect the integrity of the weather system. Thus extending a ban to the use of these techniques domestically for hostile purposes may be the only viable approach.

If we are to have an acceptable arms control agreement in the weather field, we need to be able to detect violations. However, it is not important that we detect every violation, of whatever kind, but only that we detect major violations of the agreement. The ability to detect the use of these techniques as weapons of war will vary with the techniques used. We should be able to detect larger-scale modifications by using satellite photography, ground observations, and modeling techniques. For methods on a smaller scale, detection will be more difficult. We need to engage in more research to enhance our ability to detect smaller-scale operations and, above all, make the results of this research openly available on a global basis.

In any measures which are initiated, the psychological perception that other states do not intend to use the technology as a weapon is important. The agreement reached between the United States and the Soviet Union on averting nuclear war, as part of the SALT–I agreements, is important for the psychological assurance that it provides against the use of nuclear weapons. Particularly where the perception of whether a state has caused bad weather can be more important than the scientific assessment, we need to develop effective measures to give assurance to states that the technology will only be used for peaceful purposes.

An agreement prohibiting the use of weather and climate modification techniques for hostile purposes will only be one step in giving this assurance to states. A necessary corollary will be arrangements which regulate the peaceful uses of weather modification. Essentially we need to reduce the chance that states could use the techniques covertly against other states and the fear that others had done so. This requires a continuation and expansion of international programs for monitoring atmospheric and oceanic conditions, for forecasting weather, and for conducting atmospheric and oceanic research. It also suggests the need to initiate periodic international appraisals of the state of development of weather and climate modification technology and to ensure that all states have access to information on weather and climate and on techniques developed for modifying it. An international registry of all experiments and programs designed to modify weather or climate should, if respected, minimize suspicion between states.

In addition to greater international efforts to improve our understanding of weather and climate, we need to begin to develop new rules and procedures to implement principles 21 and 22 of the Declaration of the United Nations Conference on the Human Environment and recommendation 70 of this Conference.[3]

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[3] These provide as follows:

Principle 21.—"States have, in accordance with the Charter of the United Nations and the principle of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction."

Principle 22.—"States shall co-operate to develop further the international law regarding liability and compensation for the victims of pollution and other environmental damage caused by activities within the jurisdiction or control of such States to areas beyond their jurisdiction."

Recommendation 70.—"It is recommended that Government be mindful of activities in which there is an appreciable risk of effects on climate, and to this end:

"(a) Carefully evaluate the likelihood and magnitude of climate effects and disseminate their findings to the maximum extent feasible before embarking on such activities;

"(b) Consult fully other interested States when activities carrying a risk of such effects are being contemplated or implemented."

Specifically, it is essential to begin to develop principles of advance notification, open dissemination of information, and consultation between states, as guidelines for conducting any weather modification experiments and operations which could have effects outside national borders. Large-scale experiments and projects which could have a significant effect on weather or climate should be prohibited in the absence of approval from the international community. In many cases compensation for any damage which may occur to neighboring states from weather or climate modification programs will either be impossible to provide or inadequate. For this reason, we should give priority to developing procedures for ensuring that the interest of all affected states are taken into consideration before the activity takes place. All states share a common global climatic system and common weather systems. Hence it is in everyone's interest to join in arrangements insuring an orderly development and use of techniques for changing weather and climate conditions.

There is a growing awareness of the problem of using weather and climate modification techniques as weapons, which could help stimulate policy initiatives. The international environmental movement and the international scientific community have been in the forefront in voicing this concern. Nationally, atmospheric scientists together with other scientists and environmentalists have been urging the dedication of weather modification techniques to peaceful purposes, and their prohibition for hostile purposes. In 1972, the Sierra Club and the Federation of American Scientists jointly wrote to the President urging him to announce that the United States would seek an agreement banning the military uses of weather modification. The National Academy of Sciences has called for dedicating the technology to peaceful purposes. The president of the American Meteorological Society has testified before the Senate in favor of prohibiting military uses of weather modification.

Internationally, scientists and environmentalists have also expressed concern about the budding technology. At the Pugwash Conference on Science and World Affairs in Oxford in September 1972, a Soviet and an American scientist jointly proposed an international treaty prohibiting the military use of weather modification. There have been informal bilateral talks between U.S. scientists and Soviet counterparts about arms control initiatives in weather modification. The Stockholm Conference on the Human Environment in 1972, while not explicitly concerned with this issue, did urge all governments "to be mindful of activities in which there is an appreciable risk of effects on climate." The United Nations Environmental Program has expressed continuing interest in the field of weather and climate modification. What is needed is an international initiative which could serve as a catalyst for a national decision to forego developing and using weather modification as a weapon. The talks scheduled between U.S. and Soviet representatives later in this year could be a step in this direction.

Unfortunately, weather modification is only one of several potential techniques for modifying the environment which have at least been mentioned as future weapons. We need to view the development and use of weather and climate modification techniques for hostile purposes as but a first step in the potential development of new and unconventional environmental weapons, which threaten the environmental integrity of our planet Earth.

Mr. FRASER. Thank you very much, Dr. Weiss.

We will take about an 8-minute recess now to answer the vote on the floor, and then we will be back.

[A recess was taken from 2:53 p.m. to 3:15 p.m.]

Mr. FRASER. The subcommittee will come to order.

We are holding these hearings at a time when the floor is unusually active. We have another amendment pending over there, so that we may be interrupted again soon.

Admiral, in your statement you cited the testimony of the executive branch in both the 1972 and 1974 hearings in the Senate, and you referred to the fact that that testimony, in effect, committed the U.S. Government not to use weather modification——

Admiral DAVIES. Climate modification, sir.

Mr. FRASER. Well, perhaps that is the first distinction I need to pin down.

I said weather modification, and you said climate modification. Would you enlarge on the significance of the difference?

Admiral DAVIES. This is a semantic problem, as I mentioned, sir. If there are such things as climate modifications and weather modifications, the distinction is that climate modification is a long term, permanent effect; weather modification is a short term, temporary effect.

The length of those terms might be weeks or days for the short term and years and decades for the long term.

Mr. FRASER. What do you take to be the significance of the statements that the United States would not use climate modification techniques for hostile purposes? What does that mean?

Admiral DAVIES. That would say that in anticipation of some techniques being developed, and I think the testimony actually said if it were ever developed, that in anticipation of that, the executive department was saying they did not intend to use any such techniques as weapons of war.

Mr. FRASER. At the time that testimony was given, was it intended then to differentiate between weather modification techniques and climate-changing techniques?

Admiral DAVIES. I don't know directly from personal knowledge about the witnesses, but there has been for a number of years in the research and development community that sort of differentiation, so I would assume that they were making that difference.

Mr. FRASER. And through those statements they were not saying anything with reference to modification techniques?

Admiral DAVIES. Weather modification?

Mr. FRASER. Weather modification.

Admiral DAVIES. That would be my understanding, sir.

Mr. FRASER. And then you have made the point that at the moment we don't think we know how to do climate modification?

Admiral DAVIES. That is right.

Mr. FRASER. So that problem at the moment is conjectural?

Admiral DAVIES. That is right.

Mr. FRASER. With respect to weather modification techniques, where do we stand?

Admiral DAVIES. The weather modification techniques, as I pointed out, are fairly conjectural, too, although there is a community of people who believe that they are scientifically sound, possible, and even have been achieved.

I think, to give you some idea of the status of them, I might with your permission read from the weather and climate modification report of the National Academy of Sciences.

Mr. FRASER. But my inquiry didn't go so much to the efficacy of it, but rather the policy issue, whether it is still the executive branch position that this is an acceptable option in conducting military operations. So far as you know, it is the position of the executive branch today that weather modification techniques are an option which may be pursued under appropriate circumstances?

Admiral DAVIES. Well, I am not sure that the executive department has ever taken such a stand except in the obverse. At the summit, as you know, in the joint statement, the President, jointly with the Soviet Union, said that we intended to do something to prohibit the use of these techniques as a weapon of war.

Mr. FRASER. Well, that goes to the question of the specific statement which was made. I think Dr. Weiss made this observation in precise language, that the joint communique was dealing with the "most effective measures possible to overcome the dangers of the use of environmental modification techniques for military purposes."

I assume these communiques are drafted rather carefully and would suggest that we weren't necessarily looking for ways to eliminate the use of environmental modification techniques, but only dealing with some of the dangers that might flow from their use. Can you enlighten us on that?

Admiral DAVIES. I am afraid I can't add much to that, sir. I have to stay with the words of this communique, and you have stated it correctly, that you could read it as the fact that we are committed to overcoming the dangers, and this could conceivably be by some immunization process rather than actually limiting them, although the second sentence says, "desiring to limit the potential" again "danger to mankind."

There is that ambiguity about it.

Mr. FRASER. Within the Arms Control Agency is there work underway to examine the possibilities of an agreement to outlaw the use of environmental modification?

Admiral DAVIES. Yes, sir, we have been working on this for some time in various arenas. We have done papers on it and made recommendations, and it's hard to say exactly how events happen in anything like the summit.

But certainly it has been one of our recommendations for some time that we do move in this direction.

Mr. FRASER. The recommendation of the Arms Control Agency?

Admiral DAVIES. Yes, sir.

Mr. FRASER. Dr. Weiss, maybe I should ask you first if you have any comment on the questions that I have raised with Admiral Davies.

Mrs. WEISS. I think they have been right to the point, Mr. Chairman. They have pointed out that the United States has been willing to take a policy position on climate modification techniques which are still conjectural, but the United States has not been willing to take a formal policy position on weather modification techniques, which are the more imminent.

Mr. FRASER. You have probably looked carefully at the language of the Soviet proposal for placing this matter on the agenda of the General Assembly. Is their proposal more broadly stated so that it would embrace weather modification techniques?

Mrs. WEISS. The proposal for the United Nations General Assembly appears to be more broadly stated.

Mr. FRASER. So that, if one is reading these two statements carefully, it would look as though the Soviet proposal goes further than the joint communique?

Mrs. WEISS. That is correct.

Mr. FRASER. I am having some difficulty here figuring out exactly where we go from here. Admiral, I don't want to put on you a larger responsibility than you are prepared to accept. What is the administration position on these resolutions? Do you know?

Admiral DAVIES. On the Soviet resolution?

Mr. FRASER. No. The ones that are pending before the committee.

Admiral DAVIES. Oh, I am sorry. Here?

Mr. FRASER. Yes.

Admiral DAVIES. I don't know the administration position on it. In general this matter is under study within the executive department as to how to follow up on the summit communique, and how to respond to the Soviet resolution. There are complications, of course, in dealing with any international forum, and it's taking time to do it, and getting anything done through the ponderous mechanism of the U.S. Government is slow, but we are moving, and I think that you can look forward to some results here in the next few months.

Mr. FRASER. We are not able to know now whether the U.S. Government is prepared to enter into an agreement with other countries that would ban weather modification techniques in warfare, assuming that the related problems of clarification and so on could be resolved.

Admiral DAVIES. Well, certainly the summit indication is an indication of a desire to examine the problem with an attempt to move into that sort of situation, and if I can express my personal judgment on the thing, I think this is desirable, and it is my personal judgment that we probably will do it.

Now, the exact way and the timing and so on, we will have to let events work those out.

Mr. FRASER. Do we now, as a matter of military preparedness, maintain weather modification devices in place? For example, onboard our ships?

Admiral DAVIES. That is a question, sir, that I can't give you an up-to-date and positive answer on. From my experience of a year or more ago, I would say the answer is no. However, I am out of date and it's possible we do, but I would be surprised if it were true.

Mr. FRASER. The reason I asked the question is Congressman Aspin had made a statement in the middle of August in which he charged that the Navy was planning to put weather modification devices aboard its ships, and he referred to an item in the military budget, what the Navy called "cold cloud modification," and he says that in Navy documents part of the money requested was to be used for the fleet introduction of the basic cold cloud modification subsystem. It goes on to say that it would provide an operational capability for modification of the atmospheric environment in which naval operations are conducted.

Do you have a copy of that statement?

Admiral DAVIES. Yes, sir, I have.

Mr. FRASER. This is not a matter which you are at the moment——

Admiral DAVIES. Not at the moment, I am not conversant with it. I can say, however, that in my previous incarnation as the Chief of Naval Development I was aware of this project. First of all, these are requests for moneys, and the culmination of any such request would be probably 2 years away, so I would estimate that there is nothing but paper anywhere now, and before any fleet introduction or anything like that would transpire, it would have to be reviewed and approved by authorities at a very high level within the Navy and that I can't answer as to whether it's been done or not. It had not as of the end of 1973.

Mr. FRASER. Let me ask a question of both of you, if I may.

Assuming that we took the approaches outlined in the joint communique, which would be to provide a limit to dangers from the use of weather modification techniques or environmental modification

techniques, let's assume that it was possible to limit the dangers. Is there a valid reason, is it important that we outlaw environmental modification altogether?

Admiral Davies. Your assumption there is that you can limit the danger from it?

Mr. Fraser. For example, as in the case of bombing, you set up certain guidelines in the international rules of warfare that you don't bomb civilian centers. In other words, there is an international set of standards within which violence is carried on as part of military operations.

Assuming that some standards would be developed that would seek to limit some of the unfortunate consequences of weather modification, is there any reason inherently that weather environmental modifications should be outlawed by international agreement?

Admiral Davies. The assumptions you have made I think are a flaw in the argument. I don't frankly believe it is possible to limit danger, (A), and (B), it's been my opinion that it's so uncertain as to be not very useful as a weapon, and how to decide whether or not there is any reason not to limit it or to limit it under those circumstances is a very difficult hypothetical question.

If you could restrict the damage by some means, we would have to think in terms of a possible adversary doing it to us, and if it were an effective weapon, we should worry about that, and we should take steps to do everything we could to prevent it.

If it's not an effective weapon, then we don't need to worry about it. So I would conclude from that, if we were able to restrict it, it would not be important to attempt to prohibit it.

Mr. Fraser. What you are saying is that it may not be possible to restrict the damage?

Admiral Davies. I am very dubious of any ability to restrict the damage from it.

Mr. Fraser. Dr. Weiss?

Mrs. Weiss. In looking at this question I think it is important to distinguish the use by the military of weather modification techniques for essentially civilian purposes, from the use in warfare. I would argue that eliminating the dangers from using these techniques for military purposes is tantamount to banning the use of these techniques in warfare.

Mr. Fraser. Supposing, for example, that there were major military forces assembling in an area and by causing increased rainfall you could limit the scope of their operations in some manner. Why isn't that a legitimate option in the carrying on of hostilities?

Mrs. Weiss. There are several reasons. First, we have to view its use in a broader context. If one state uses it, she invites others to do so, with the result of potentially great uncertainty in weather conditions. These techniques can affect nearby neutral areas. They can affect civilians and their facilities and noncombatants. It is difficult, if not impossible, to control the effects of these techniques or the areas covered by them.

Second, one of the main arguments for banning the use of weather modification techniques in warfare is to prevent the weather system from essentially becoming a political arena in which people doubt whether bad weather conditions are in fact naturally caused.

These techniques can be used either covertly or overtly. If we allow them to be used as acceptable weapons in war, then we only help encourage the perception that the weather system is up for grabs to use against those you oppose.

Mr. FRASER. So, you are saying inherent in this possible use are these problems?

Mrs. WEISS. That is correct.

Mr. FRASER. So that you can't limit the problem so as to make it a useful option without bringing along all these other difficulties.

Mrs. WEISS. That is my view on it.

Mr. FRASER. We have to recess again. There is another vote.

[A recess was taken from 3:38 p.m. to 3:55 p.m.]

Mr. FRASER. The subcommittee will come to order.

Admiral Davies, I understand that the ACDA was not kept informed of the DOD weather modification activities in the 1967 to 1972 period in Southeast Asia. Do you have any information as to why that was so?

Admiral DAVIES. I have no direct information of it during that period, sir. I also have that understanding, but I am not in any position to be certain of it, or to know why.

Mr. FRASER. Dr. Weiss, do you have any inside information on that?

Mrs. WEISS. Anything I said would be speculation.

Mr. FRASER. Well, be free to speculate; that won't be the first time.

Mrs. WEISS. I pass.

Mr. FRASER. Mr. Gude.

Mr. GUDE. Admiral Davies, do you think there are credibility problems associated with the Pentagon being involved in weather modification research and weather modification activities?

Admiral DAVIES. Well, sir, that would be passing a judgment in a field that I am not very expert in. I could understand how some people could feel that way. I think that the publicity that has gone on in the last 6 months or so has certainly had some unfortunate aspects, but I really am not the one to pass judgment on the Pentagon's credibility.

Mr. GUDE. Dr. Weiss, there are some weather modification activities which we have discussed which have application to, say, aviation, both commercial and military in peacetime. For example, clearing fogs from airport facilities. Such activities would merely permit the military to carry out its usual peacetime activities?

Do you see any problem with the military modifying weather in this context provided that the techniques were developed by nonmilitary agencies?

Mrs. WEISS. I do not.

Mr. GUDE. But you would feel that there should be surveillance of those types of activities? You mentioned the importance of surveillance if the techniques could be developed?

Mrs. WEISS. That is correct, Mr. Gude. We need to insure that information about the state of the art of the techniques and information on how one detects their use is widely available to all. We need to have an open monitoring program to insure that they are not used covertly for hostile purposes. Within these bounds, it would be permissible to use them in the capacities which you have suggested, in peacetime.

Mr. GUDE. No more questions, Mr. Chairman.

Mr. FRASER. How effective are the weather modification techniques now? I know, Dr. Weiss, you indicate that cloud-seeding techniques, for example, apparently are becoming more effective.

Mrs. WEISS. I would correct that slightly to say that these techniques have been used and that they are nearer to becoming effective or ready for use than are climate modification techniques or the larger scale weather modification techniques.

Mr. FRASER. For example—I address this question to either of you—is there much cloud seeding going on today, inside the United States, to try to deal with the short fall of rain for agricultural purposes?

Admiral DAVIES. There are some experiments that have been made and attempts made from time-to-time in the United States, and of course, in the Philippines, there is an effort of several years back, which you are familiar with.

I would say these are very few and far between. They are not multitudinous or anything like that. Their effectiveness, I guess—I don't have the statistics, but the last time I reviewed them, they were still ambiguous as to whether we were really achieving anything or not.

Mr. FRASER. Dr. Weiss.

Mrs. WEISS. My understanding is that within the United States, commercial companies are conducting a number of cloud-seeding operations to increase rainfall. This is particularly true in the West and the Midwest.

One company, for example, has conducted cloud-seeding projects in much of Oklahoma. It is also the private entrepreneurs, who conduct many of the cloud-seeding operations abroad,

Over 55 countries at one time have had some effort in cloud seeding.

Mr. FRASER. Why, with that much cloud seeding, hasn't there been a much firmer baseline established with respect to the effectiveness? Why don't we know more about whether it really works or not?

Mrs. WEISS. First, many of the operations have not been designed and conducted so as to allow for scientific evaluation of the results. Second, we have no established way to exchange information on what is taking place across the globe. We have no international registry of weather modification activities. Weather modification has been done largely by private entrepreneurs, by other governments and in some cases by the U.S. Government with little coordination between any of these.

This is further complicated by the fact that within a given country different parties may be engaged in weather modification, with little coordination between, or, even knowledge of each other's activities. The Ministry of Agriculture may be supporting weather modification projects. University scientists may be conducting scientific experiments. Agricultural cooperatives may hire private entrepreneurs to service their own needs.

Mr. FRASER. Admiral, I would suppose, if there were an international agreement outlined for limiting weather modification techniques, that one of the requirements for the successful enforcement of this agreement would be some kind of a monitoring device. In other words, I would suppose in order for us to know whether these things were going on covertly without prenotification and without being registered, that we would have to have some way of measuring this.

Has there been any research along this line, do you know?

Admiral DAVIES. You are right in the sense that verification we use as a part of an arms control agreement so that the parties are sure that it's being complied with, and verification in areas like this is very difficult. Sometimes the verification provisions or the provision of verification is regarded as less important when it is determined that the motivation of another party to depart from the agreement is not very strong.

The verification in the area of weather modification has been thought about. There are some visual ways of observing that experiments might be carried on if they were large-scale. Unfortunately they can be small-scale.

In my judgment probably the best way of insuring verification is to work jointly with people who are interested in doing something on a peaceful-uses basis. The research and development done for peaceful uses, if it were ever successful, could be used in a warlike use, and so you would be keeping up on what the possibilities that the discipline or the art offered by simply your peaceful research and development; and if this were done jointly with other nations, then you would know generally what each one of them were doing. That, I think, is the best opportunity for verification.

Mr. FRASER. So far the thing we seem to have focused on, I think, is probably the use of cloud seeding to produce more rain. Are there other environmental modification techniques? I am staying away now from climate modification. Are there other kinds of techniques that are in use or under active study of which you are aware?

Admiral DAVIES. There are proposals and speculations. A few things have been carried a little further than that, but generally speaking 99 percent of it is cloud seeding and seeding of cold fogs, and that sort of thing.

I don't think there is anything that anybody has ever carried forward.

As I say, there are plenty of speculations like triggering earthquakes and so forth, but no one has ever triggered an earthquake, and even the speculation involves moving the San Andreas Fault under some possible adversary and then triggering an earthquake. So they are not very realistic.

Mr. FRASER. One of you—and I have forgotten which—referred particularly to ocean environment as a problem, and I didn't fully understand why that was a special problem.

Mrs. WEISS. More and more scientists are beginning to regard the oceans as an essential part of the climatic system, as essentially the storehouse of energy for the climate and hence an important influence in determining climatic patterns. The more you move from the daily weather condition of a given hour to climatic conditions, the more you involve the oceans.

Hence, if we are to gain an understanding of the climatic system and of global atmospheric circulation patterns it is essential that we understand oceanic circulation patterns and particularly the interface between the oceans and atmosphere.

The significance of this for our purposes here is that the research network and the system for gathering and disseminating information must cover both the oceans and the atmosphere. In particular, there

needs to be open dissemination of the data gathered about the interface process between the oceans and the atmosphere.

Mr. FRASER. I don't know if I understand your reference to the ocean as being energy storage. Oceans, I gather, are a large source of the water vapor that is brought up into the atmosphere. Is that what is meant by the storage of energy or is there something more than that?

Admiral DAVIES. Well, the ocean is part of this gigantic heat engine and it does store energy. It absorbs it under one set of conditions; releases it under another. So it acts as a storage and the atmosphere also stores energy, however, and it is what is generally called conservative; that is, it changes very slowly.

You can get a temperature change in a mass of air flowing over the ocean. If the temperature is 1 degree higher, the heat transfers from the air into the water. If the temperature goes 1 degree lower, then the heat transfers from the water into the air, and these are the kinds of things that make this great system so difficult to cope with in any way, even to understand in detail.

There are the ocean currents that transport energy. The Gulf Stream is a tremendous transporter of energy and affects the climate of where we are sitting right now and many other places in the world. There are vertical currents, deep currents that run in the Indian Ocean, there is a set of currents running from the Antarctic Sea up into the Indian Ocean. Then they come back on the surface and this affects the weather because when the warm water is on the surface, you are warming air. If cold water is on the surface, you are taking energy out of the air.

There have been people who—in fact, to this day, there are great efforts to build a mathematical model of the atmosphere and the ocean, and these models even with the greatest computers turn out to be totally inadequate to deal with the machine itself on any kind of a scale that is interesting.

It is full of processes going in both directions, the balance of which is what we read as temperature or rainfall, or wind, and how these are generated, and what they do and what they are going to do if we try a particular experiment with them, is anybody's guess.

So I think that the ocean is part of this system and it is an important part of it, and to the degree that we study the ocean, we contribute to our knowledge, but I simply would say that our knowledge is a pinhead compared to what we need to know before we can really do much with these.

Mr. FRASER. In the references earlier to climate changes which are, I gather, the long term permanent or nearly permanent alterations, what kinds of activities have been examined or hold the prospect of introducing those kinds of end results?

Admiral DAVIES. Well, I can think of one thing that was mentioned by Dr. Lukasic of ARPA in his testimony—it was 1972. I have forgotten the date. We will get that.

There was a mathematical model built in a very, very crude sense to look at what sort of thing would affect the climate of North America, and it led to the conclusion that altering the Arctic icecap was the most effective thing you could do.

Now, since no one has any idea of how to alter the Arctic icecap, it wasn't a particularly useful outcome, but that sort of thing has been done. I don't know of any real experiments.

Now, people have taken, of course, measurements. The oceanographic program, of not only the United States but other nations of the world, and the joint one that has been run for a number of years, have measured all sorts of data within the ocean itself. We have had buoys deployed into both the Atlantic and Pacific that radio back the conditions at their location for a number of years now.

But all of this has simply provided us with some faint knowledge of what the thing is, but no real detailed ability to do anything to change it.

Mr. FRASER. Dr. Weiss, can you throw any further light on the climate modification problem?

Mrs. WEISS. I would make a political point if I may. Your questioning has brought out that we are talking about the climatic system, which is a strongly interacting process between the air, land, and water. It is impossible to artificially separate one out and call it the climate.

From a political and institutional perspective, it is important to recognize its commonality to all states and its physical basis as a system involving complicated interactions and feedback mechanisms.

Mr. FRASER. I gather from what you are saying—you have said it before, but just to see if I have got it right—that the weather system is a part of a total global environment, is a common system which doesn't recognize national boundaries, so we have to treat it really as an international system that, among other considerations, adds force to the notion that we should take it out of the area of use for military purposes.

Mrs. WEISS. That is correct.

Mr. FRASER. Apparently you introduce many problems inherently that spill over national boundaries.

Mrs. WEISS. I think that is correct. One of the strongest reasons for prohibiting the use of weather and climate modification for hostile purposes trigger irreversible changes in the weather and climate systems.

Mr. FRASER. Mr. Gude, do you have anything more?

Mr. GUDE. Just one last question.

To the extent that the peaceful activities of man have had a much more profound influence on the weather and climate than military efforts, I would hope that this agreement on banning military activities will draw attention to the much more profound peaceful efforts.

Usually we try to start in areas where agreement is easy. In this case we are trying to limit the use of weather modification for military purposes.

You have written a book on this, Dr. Weiss. Are there examples of nations trying to use weather modification for military purposes other then the Vietnam war?

Mrs. WEISS. I know of none between states. There is an example of where another country tried to use it domestically to combat insurgency.

Mr. GUDE. Was it successful?

Mrs. WEISS. I have no way of telling.

Mr. FRASER. Where was that?

Mrs. WEISS. In Thailand.

Mr. FRASER. The Thais tried to use this against the guerrillas in the northeast.

Mrs. WEISS. I think that is correct.

Mr. FRASER. I assume they must have used U.S. assistance in that?

Mrs. WEISS. I do not know.

Admiral DAVIES. I have never heard of that. That surprises me.

Mr. FRASER. Well, I want to thank both of you.

We are now faced with another vote and I apologize for the interrupted nature of the hearing, but it's been enormously helpful to us, both the witnesses' statements and the oral testimony.

We thank you.

With that, we will adjourn this hearing.

[Whereupon, at 4:20 p.m., the subcommittee adjourned, subject to the call of the Chair.]

APPENDIX

Statement Submitted by Joanne Simpson, Ph. D., Professor of Environmental Sciences, University of Virginia, Charlottesville, Va.

The atmosphere recognizes no national boundaries. The deepening of a storm in the Gulf of Alaska can affect the weather over England, by altering the large wind systems that meander in a jet at altitudes of 8 miles or so above the earth.

Weather modification is in its infancy and holds vast immediate potential to benefit man. As a weapon, it is unlikely to be cost-effective in the foreseeable future. Weather forecasting, on the other hand, is in its adolescence. Accurate forecasts are vital to the human life and economy of all nations. The rapid strides in weather prediction, its very continuation, are crucially dependent upon the cooperation of all nations, particularly in supplying weather observations to be fed into computers to process the advanced prediction models now in use and those to come.

In World War II, when I was trained in meteorology, we were taught, as part of the war-time emergency, to forecast the weather as best we could using only the observations at our own station, assuming that the enemy had blocked out distant weather observations or their communication to us. This was called "single station" forecasting, and at best, it was not very good. *Refusal to take and transmit weather data is a powerful weapon of warfare, far more damaging to an enemy than any weather modification technique that I can envisage may become usable in my lifetime.*

International cooperation is the lifeblood of meteorology, both in operations, modification and in the research that is vitally necessary to make these applications successful. Meteorologists of all nations have had both a necessity and a tradition of close collaboration and completely free exchange of data, of ideas, and of technology. Continuation of this cooperation and exchange is in the best interests of the United States and of every other nation in the world.

I chose meteorology as a profession in large part because of its international nature, because by helping develop atmospheric science I could serve my country, not only by learning how to modify our clouds and precipitation but also by playing a small role in cementing international communications and exchanges which are so vital if peace is to be maintained.

That is the double reason I am so pleased to be here today. I believe the greatest contribution that I could make from the 32 years I have devoted to atmospheric science would be to help in any way, however small, to bring about an international resolution aimed at using the atmosphere and oceans for peaceful purposes only. This specifically implies an agreement upon the part of all the nations involved not to use weather, climate and/or ocean modification as a weapon of warfare. In my opinion, to concur to and to keep this agreement would give rise to a very large benefit to the United States and little if any loss, even to the military arsenal which is already replete with deadly weapons. On the other hand, failing to make or to keep such an agreement will surely lead to irreparable harm to the interests of the United States.

I have stronger and better reasons to back this statement than some of the bugbears raised by a few of my fellow scientists. I do not particularly dread possible harmful "side effects" of weather modification. Although there could possibly be some, their effects on weather are likely to be small compared to natural oscillations in flood and drought, storm tracks and wind patterns. Some degree of direct "poisoning" of the atmosphere, earth, or water bodies is also possible, but is not likely to be comparable to the pollutants introduced by peacetime living, industry, jet aircraft and automobiles.

Nor do I fear that some Dr. Strangelove in an enemy nation is going to invent a machine to steer hurricanes, hurl tornadoes at us, dry up our crops with drought, or inundate our cities with floods. This sort of science fiction often appears in the Sunday supplements, but belongs more properly in the comic pages. The atmosphere is infinitely more powerful than man and infinitely harder to modify than almost everyone, including many meteorologists, believe. Just for one example, an ordinary run-of-the-mill mature hurricane releases as much condensation heat energy through its cloud systems in one day as the nuclear fusion energy of about 400 20 megaton hydrogen bombs. Some people have been naive enough to suggest trying to dissipate a hurricane by dropping a hydrogen bomb in it! The intensity and track of a hurricane often varies more in a day all on its own, than any change man might desire to try.

Hard facts on weather modification are needed for your group to make a decision. What is the actual status of weather modification today? Could any weather modification technique now or foreseeably be used cost-effectively in warfare and if so, what would be the price of actual or developmental use of it? When I say price I do not mean just cost in dollars, but the negative contribution as a whole, to the national interest.

A paramount hard fact about weather modification is that there are today only about a half-dozen programs over the whole world that have conclusively demonstrated that the treatment works. These programs nearly all involve cloud seeding with silver iodide, or a similar chemical, to increase precipitation. Three types of cloud situation have been demonstrated amenable to precipitation increase by seeding, when the right circumstances are very carefully selected by theory, measurement and computer model. Years of research and unsuccessful experimentation preceded the successful experiments. The treatable cloud conditions to date are as follows: First, certain orographic cloud systems, particularly in the mountainous regions of the western United States and in Australia. Second, some winter cyclonic storm systems, particularly in Israel, and the west coast of the United States. In both these situations, economically useful average precipitation increases of about 10–50% have been established. The third cloud situation consists of isolated tropical cumulus clouds, where a different principle of silver iodide seeding is involved. This is called "dynamic seeding" because under the right conditions the cloud growth is increased and prolonged. Development of this approach has been the aspect of weather modification to which I personally have contributed, particularly during my government employment in NOAA, the National Oceanic and Atmospheric Administration of the Department of Commerce. With isolated tropical cumulus clouds, we have shown that, under the right conditions, the precipitation from an individual cloud can be increased by a factor of about 2 or 3, that is to say, doubled or tripled. Whether or not dynamic seeding can be used economically to increase the precipitation over a sizeable area is still in the early stages of investigation and is unlikely to be established before 3 to 5 years from now at best

All these modification techniques require not only pre-existing clouds, but also that some portions of these clouds must contain droplets which are cooled below the freezing temperature (namely supercooled) for silver iodide to work. In increasing precipitation by other techniques than silver iodide, which might work on clouds not large enough to be supercooled, some progress has been made in accelerating or increasing precipitation by means of hygroscopic substances such as common salt or the fertilizer urea. These methods are still in the experimental stage, although encouraging progress is reported in the Dakotas program. At present, and in the foreseeable future, there is no reliable method to create sizeable clouds out of a clear sky, except under rare conditions, or with great expenditure and/or when nature is on the verge of making a cloud anyway.

Increasing precipitation by 10–20% over a whole area over an entire season is thus possible under restricted conditions, but causing deliberate precipitation on a limited target at a strategically desired time is a horse of a very different color. On rare occasions, targetting may be successfully achieved, when suitable clouds just happen to be found over or upwind of the chosen spot. For example, in south Florida, we have managed to get a seeded cloud over a 200 sq. mile instrumented target on roughly about 10% of the occasions when seedable clouds were found over a 5000 sq. mile seeding target. Since seedable clouds are available over south Florida on roughly 30% of summer days, this means that one or more clouds might be targetted there onto a chosen 5% of the area about 3% of the time. This figure *may* be typical for flat land areas in tropical air masses. Near mountains or islands, targetting might be more or less difficult, depending on how the preferred locations for cloud growth relate to the target and to the prevailing air flow. This whole subject is just now becoming amenable to productive research and experimentation.

So far, in this testimony, I have attempted to assess for you that aspect of weather modification related to precipitation increases from existing clouds. Clearly, in the present state of knowledge and development, this aspect is unlikely to be a cost-effective weapon, though an enemy in some places could be inconvenienced on a small fraction of sorties. The employment of rain-making as a weapon, however, would in my opinion be much worse than a waste of resources, because of the damage to international cooperation in meteorology. I will return to that most important aspect in my conclusion.

Let us continue now with the hard facts about scientific feasibility. What about decreasing precipitation? This is a frontier for research and development, some of which is underway in the Soviet Union. I am unaware of any demonstrated results of properly controlled experiments, nor of any applications even claimed to be successful.

The next topic of major concern, on which real progress has been made, is in the modification of severe storms, in particular lightning, hail and the tropical hurricane. Tornadoes are still in the research phase and have not reached the stage of field modification experiments, nor even good theories or models upon which to base them.

Lightning suppression is in the controlled field experiment stage and appears promising. Hurricane experimentation has been intermittently underway by the United States beginning in 1947 and more seriously and knowledgeably since 1961. The project is a United States Government program called Stormfury. Its design is to determine whether storm winds can be reduced in intensity. There is no intention to and no good ideas how either to steer or to dissipate these storms, despite some media reports to the contrary. The Stormfury experiments are in their infancy. Either many years of effort or hugely increased resources will be necessary to pin down the feasibility of this one aspect of hurricane modification. No experiments have been attempted on incipient or developing storms, for reasons too long to cite here.

In hail suppression, the Soviet Union leads the world, although their claims of 70–90% reduction in damage and benefit-to-cost ratios of ten or more are not fully accepted in our scientific community. The reason is that their experiments, although backed by fine instrumentation and extensive theory, have not been double-blind. In the United States, a similar program, the National Hail Research Experiment, is underway in Colorado with the proper statistical controls. It began in 1972 and it is not expected that suppression results of just one method of treatment can be definitely evaluated prior to 1977. Concerning hail instigation or augmentation, various madcap schemes have been suggested, but to my knowledge none have been backed by research or tested in the field.

The final aspect of weather modification I shall address is fog. I am unfamiliar with any successful efforts to create fogs, although it would seem a possible area of investigation under calm conditions when nature was close to fog production anyhow. On the other hand, the dispersal of cold or supercooled fogs has long ago been demonstrated successful in calm or light winds and has been in economic operation at more than a dozen airfields over the world for many years. With warm fogs, significant progress has been made on their dissipation by helicopter downwash, the heat from burners, or, by seeding with hygroscopic substances.

Much of the work on fog dispersal has been developed and used by the United States military services. Whether or not the dispersal of a fog at an airport landing military aircraft (carrying bombs *or* wounded persons) constitutes a use of weather modification for warfare I will leave to the people, their representatives in Congress and on international bodies, and their lawyers, to decide and negotiate with their counterparts in other nations.

My strong recommendation is that it is in the national interest to lean more on the side of eliminating marginal uses of weather modification at some short-range cost than to slide in the other direction. This leads me to my conclusion.

In conclusion, this country and the world face food and energy shortages. Beneficial use of the atmosphere, which must be based on international cooperation, with free exchange of data and information, could make a major, even crucial difference in our economy and in the livelihoods of multitudes. Much more is at stake than the deliberate modification of the atmosphere, potentially valuable as that surely is. Weather prediction is at stake, air and water quality, the extraction of some forms of energy and many aspects of agriculture and fisheries. Hostile use, or attempts at hostile use, of weather modification would inevitably undermine that international cooperation which is mandatory to predict, conserve and manage man's environment on this planet.

The International Global Atmospheric Research Program's Tropical Atlantic Experiment (GATE) is now going on in and above the Atlantic Ocean west of Africa. More than six nations are pooling talent, expertise and expensive facilities to surmount the key roadblocks in global weather prediction and related problems involving the air-sea interface and cloud and storm systems. The fragile basis of these cooperative efforts is painfully clear to me. This special pooling of resources and also their routine, day-to-day pooling in global weather networks are essentials for civilization that could readily be jeopardized. Major jeopardy would threaten if one or more powerful nations began to use or condone weather modification as a weapon. Is any person going freely to contribute to a neighborhood project to build a machine if he thinks one of his neighbors may use the machine to harm or to kill him?

For this priceless benefit of environmental cooperation, a price is exacted. But the price is fortunately low. We must renounce use of the current state of weather modification for warfare. Today, most aspects of weather modification are promising for peaceful use but do not provide cost-effective weapons. The avoidance of those few techniques which might be cost-effective as weapons, such as fog dispersal, constitutes a loss incomparably less harmful to our national interest than would be the loss incurred by adopting the opposite alternative.

For the future of weather modification, the national interest, backed by the hardest facts and soundest science available, dictates that we dedicate our developmental resources into open, unclassified scientific and technological programs for which the foreseeable and intended application is the peaceful betterment of man and his environment. This dedication is not just noble and desirable, but in fact is coldly and practically necessary, because the atmosphere covers the whole planet in its complex turbulent motions; its nature and problems are global. To understand, predict and control it is so difficult, that only by pooling resources, by international cooperation can man improve his life on this earth, or perhaps even maintain his very existence.

"Weather Warfare: Pentagon Concedes 7-Year Vietnam Effort", Article by Deborah Shapley, From Science Magazine, Vol. 184, June 7, 1974

On 20 March, several high-ranking officials of the Department of Defense (DOD) told members of the Senate Foreign Relations Committee in detail about a $21.6 million 7-year program of cloud-seeding to induce rain over the trails of Laos, North Vietnam, South Vietnam, and Cambodia. There had been persistent allegations that the military was carrying out such operations in Southeast Asia. Their briefing, therefore, constitutes the first public description of weather modification techniques as a weapon of war.* Senator Claiborne Pell (D-R.I.), who asked for the briefing, recently released the text of it, of which excerpts follow.

The use of rainmaking as a weapon of war has long been a subject of controversy among weather scientists and arms control experts. Some of the scientists have objected that military use of weather modification will inhibit international cooperation in the atmospheric sciences. Their work, they add, should be used for humanitarian ends such as increasing the world's food supply. Some arms control experts fear that weather modification indiscriminately hurts noncombatants and enemy troops; they also argue that U.S. use of it in Vietnam could lead to proliferation of this relatively simple weapon to other countries (*Science*, 16 June 1972).

In any event, the Pentagon's briefing to Pell is far and away the most complete statement DOD has made to date of its role in weather warfare. [Even former DOD Secretary Melvin Laird hedged on the issue (*Science*, 5 April).] While it furnishes many new details, some other information is still missing. For example, there is only vague discussion of whether agencies other than DOD have engaged or are engaging in weather warfare—yet the Central Intelligence Agency (CIA) is alleged to have started Vietnam cloud-seeding with a rainmaking project over Saigon in 1963. There is some discussion of an ongoing National Security Council review of weather modification policies, but no statement of DOD's position on future military weather modification programs. Finally, the military's claim that they succeeded in inducing from 1 to 7 inches of rain in Southeast Asia is not supported with the kind of data that civilian scientists would need for verifying it. Hence the DOD's claim that weather modification is "a valuable tactical weapon" is not proven.

Most of the presentation was made by Lieutenant Colonel Ed Soyster of the Joint Chiefs of Staff. Other DOD spokesmen were: Dennis J. Doolin, Deputy Assistant Secretary of Defense (East Asia and Pacific Affairs); Major General Ray Furlong, Deputy Assistant Secretary of Defense (Legislative Affairs).

Soyster began by describing the regular Southeast Asian monsoon seasons. He explained that the southwest monsoon begins with a transitional period from April to June and ends with a similar period in September. During these transitional times, unpaved roads in Southeast Asia can sometimes become impassable due to sudden rains or floods: during the monsoon itself such roads are muddy all the time.

The program was to increase rainfall sufficiently in carefully selected target areas to further soften the road surfaces, cause landslides along roadways, and to wash out river crossings. These events normally * * * occur anyway during the height of the rainy season. By seeding it was intended to extend the period of occurrence beyond the normal rainy season and to supplement the natural rainfall as required to maintain the resultant poor traffic conditions.

He then described some principles of tropical cumulus cloud growth and development, and how, in general, cloud-seeding works. As to the specific technique DOD cloud-seeders used:

The seeding units used to seed were developed at the Naval Weapons Center, China Lake, Calif. and are not classified. The seeding units and technique are identical to those used in publicized rainmaking projects—for example, Philippines, Okinawa, Texas—and the Stormfury research project.

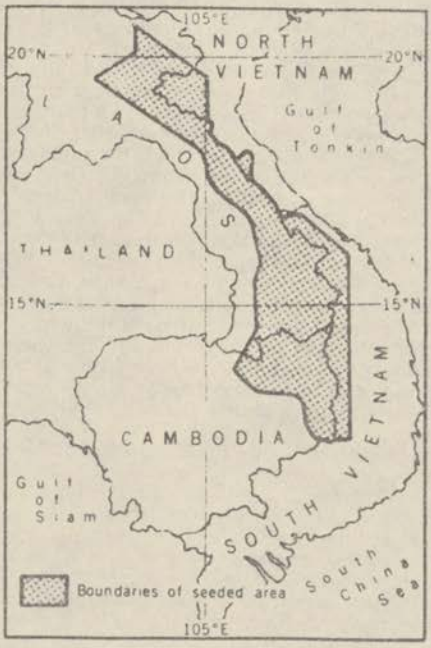
**Weather Modification*, hearings before the Subcommittee on Oceans and International Environment, Committee on Foreign Relations, U.S. Senate (Government Printing Office, Washington, D.C., 1974).

The seeding units consist of a 40 mm aluminum photoflash-type cartridge case with primer and a candle assembly. The candle assembly includes a plastic container 3 inches long with the seeding material and necessary delayed firing mechanism to ignite the free falling container. The silver iodide or lead iodide is produced as the chemical mixture burns.

The burning time is about 36 seconds for the most commonly used type. The unit drops about 3,000 feet during its functional burn. The units are dropped inside the cloud in the active updrafts at intervals of approximately one-half mile.

The release is normally controlled by the pilot. . . . Two types of aircraft were used—the WC–130 weather reconnaissance aircraft and the RF–4C reconnaissance aircraft. The WC–130 carried pods containing 104 units each on both sides of the aircraft fuselage. . . . The RF–4C carried a total of 104 units in the photo cartridge compartments. Typically, these aircraft could influence an average of 4–5 clouds or groups of clouds per day during the southwest monsoon.

. . . Under nearly perfect conditions, effects last possibly 6 hours maximum. Normally, the effect is about one-half hour. . . . The effects are . . . limited in area, perhaps [to a] 20-mile diameter under ideal conditions and continuous seeding where groups of clouds could be knitted together to form one large storm center. . . .



The above is a composite of DOD maps showing where different cloudseeding missions were flown during the 1966–1972 weather war in Southeast Asia. According to the Pentagon, only selected sections of the above area were seeded during any one rainy season.

Soyster then went into the origins of the classified program.

In 1966, the Office of Defense Research and Engineering proposed a concept of using these known weather modification techniques in selected areas of Southeast Asia as a means of inhibiting enemy logistical operations.

During October 1966, a scientifically controlled test of the concept and seeding techniques was conducted in the Laos Panhandle. The test was conducted under the technical supervision and control of personnel from the Naval Ordnance Test Station (now Naval Weapons Center), China Lake, Calif., using in-theater resources. Fifty-six seedings were conducted, and over 85 percent of the clouds tested reacted favorably. On November 9, 1966, the Commander in Chief, Pacific [CINCPAC] reported the test completed and concluded that cloud-seeding to induce additional rain over infiltration routes in Laos could be used as a valuable tactical weapon.

The timing of the Laos tests correlates with one of the few previous DOD statements about its Vietnam weather program, which appears in the *Pentagon Papers* (Beacon Press, Boston, Gravel ed., 1971, pp. 420–424). The *Pentagon Papers* explains that "various separate proposals" for ways of expanding the air war were made by the Joint Chiefs of Staff (JCS) in December 1966 and January 1967. In February 1967, these were incorporated in a single memo JCS sent to then President Lyndon B. Johnson. It said "Laos Operations * * * Authorization required to implement operational phase of weather modification process previously successfully tested and evaluated in area." The JCS evidently also agreed with CINCPAC's evaluation that the weather weapon was feasible, for it added, "Risks/Impact—Normal military operational risks."

During the recent Senate briefing, Soyster explained that the program of cloud-seeding began in March 1967—a date shortly after the *Pentagon Papers* states that the JCS request went to the President. It appears then, that some approval at the Presidential level ordered the program in February or March 1967.

CIVILIANS SAID TO BE SAFE

Soyster also explained why military commanders thought that civilian inhabitants of the seeded regions would not be in danger.

Intelligence analysis of the area indicated that there would be no significant danger to life, health, or sanitation in the target areas. The sparsely populated areas over which seeding was to occur has a population very experienced in coping with the seasonal heavy rainfall conditions. Houses in the area are built on stilts and about everyone owns a small boat. . . .

The operation was closely monitored and controlled. When reconnaissance indicated that objectives were attained in one area, the limited resources were shifted to other areas. Seeding was not conducted during periods of tropical storms when large amounts of rainfall were falling naturally and accomplishing the military objectives.

Soyster then expressed confidence that the operation had had no undesirable side effects—such as severe storms or drought in neighboring regions. The risk of undesirable side effects is one argument put forth by advocates of a ban on weather warfare.

It is the consensus of the scientific community that the techniques employed could not be used to create large uncontrolled storm systems accidentally or purposely.

Conversely, seeding to the extent conducted in Southeast Asia did not cause drought in neighboring areas. There is simply too much moisture in the air in that part of the world, and operations affected only a small percent of it—probably less than 5 percent. The desired effect was simply to control where that small percentage fell to the ground.

. . . [T]he operational phase began on March 20, 1967, and was conducted each subsequent year during the rainy southwest monsoon; that is the period March through November until July 5, 1972, when we flew the last mission.

The 5 July date of the last mission is 2 weeks after articles began appearing in the scientific and general press alleging that such a war was being or had been conducted.

Soyster displayed on maps where the missions were flown.

. . . [T]hese aircraft . . . operated out of Thailand . . . The annual cost of the total program was approximately $3.6 million covering operation and maintenance, temporary duty pay, and seeding materials.

According to DOD maps, the first operations in 1966 and 1967 were conducted primarily in the Laos panhandle area. The missions were then expanded to the north to include parts of North Vietnam, and south to include portions of Cambodia and South Vietnam. When President Johnson announced a halt in the bombing of North Vietnam above the 19th parallel in March 1968, weather modification operations above the 19th parallel were also stopped. By 1971, at the height of the program, the missions were being flown in a large portion of northern Cambodia.

RAINMAKING AND FLOODS

And, as to allegations that military cloud-seeding was responsible for the devastating floods, North Vietnam experienced in 1971, the following exchange took place:

Senator Pell. Was there any relationship between the rainmaking that went on in Southeast Asia and the extraordinarily high floods that occurred at that time in North Vietnam?

Mr. DOOLIN. There were not, sir. At the time of the heavy flooding in North Vietnam there were no rainmaking operations conducted. . . . The flooding in North Vietnam, as you will recall, generated widespread civilian suffering and that was never the intention nor the result of this program.

As to the effectiveness of the cloud seeding, Soyster stated the following:

The results of the project cannot be precisely quantified. This is due to the lack of sufficient ground stations to report. . . .

Subjectively, it is believed that this rainfall was heavier than that which would have fallen normally and that it did contribute to slowing the flow of supplies into South Vietnam along the Ho Chi Minh trail.

Methods used to determine whether the seeding units affected the clouds or whether roads had been muddied included: aircraft "crews' judgment"; "visual or photographic reconnaissance"; and "intelligence information." In addition, remote sensors located along the trails monitored ground troop movements. There is no explanation of how rainfall was measured.

Soyster's presentation provided no data on how much rain falls normally or how much rain fell from unseeded control clouds—information which many civilian weather scientists consider crucial to judging success or failure in rainmaking. This kind of information appears nowhere in the briefing transcript. Instead, the argument that the program was effective was made on the basis that enemy movements seemed to decrease during periods of active cloud-seeding. For 1971, Soyster claimed:

. . . [A]t the beginning of April remote sensors were detecting over 9,000 enemy logistic movers per week in eastern Laos. By the end of June this number was less than 900.

TABLE 1.—SOUTHEAST ASIA CLOUD-SEEDING EFFORTS. THE DATA WERE SUPPLIED BY THE DEPARTMENT OF DEFENSE

Year	Sorties flown	Units expended
1967	591	6,570
1968	734	7,420
1969	528	9,457
1970	277	8,312
1971	333	11,288
1972	139	4,362
Total	2,602	47,409

Two of the most significant weekly drops in detected traffic movement occurred during June. One of these weeks was June 2 to 9 during which a typhoon was increasing rainfall and the second was during June 16 to 23 when we were most active with seeding activities during the month.

Soyster noted that 1391 units were dropped over eastern Laos during June and 1275 of these were judged by the crews to be successful.

. . . which is to say that they had a positive effect on the cloud and either increased rainfall rate or caused cloud growth or development.

To substantiate the effectiveness claimed for the cloud-seeding, DOD submitted two isoline charts of the Laos region for June 1971. One chart showed "total rainfall" with variations from 2 to 28 inches. The other claimed to show "induced rainfall" with variations from 1 to 7 inches.

These claims of success were made by Soyster, who is part of the JCS which had advocated the rainmaking in the first place. Pell then asked Doolin, who is in the Office of the Secretary of Defense, for his opinion of the program's effectiveness. Doolin agreed to Pell's characterization of the program: "an elephant labored and a mouse came forth," and also said:

When you look at those isolines, and the amount of rainfall that was in these given areas anyway, and what was added to it possibly by these extra seedings, it looks to me like when you are getting 21 inches in a given area, and we add 2 inches, if I was on the bottom, I do not think I would know the difference between 21 and 23.

Who knew about the program? Why was it kept so secret? Even Doolin confessed that although he had been a deputy assistant secretary of defense with responsibility for that part of the world for 5 years, he first learned of it by reading a column by Jack Anderson in 1971, Soyster said:

Because the program was considered sensitive, reporting procedures were instituted to limit knowledge of the program. . . .

The crews performed weather reconnaissance and made normal factual weather reports through regular unclassified worldwide weather channels. . . . In addition to these reports, special reports to provide information to higher headquarters and to allow evaluation of the project were transmitted through special communications channels. . . .

Periodic reports were prepared by the Joint Staff and submitted through the chairman, Joint Chiefs of Staff, to the Secretary of Defense. In order to conduct the operation approximately 1400 personnel had to be given access to project information over a 6-year period.

DOD also submitted its "best estimate" of who among nonmilitary officials knew about the program. It included the White House, the Secretary of State and limited supporting staff, including the Under Secretary for Political Affairs, the Director of the CIA and limited supporting staff, and the chairmen of the House and Senate appropriations and armed services committees. The Thai government was not informed and the Laotian government was only told that a general interdiction campaign was being waged. No one at the Arms Control and Disarmament Agency was informed.

Pell, at the close of the briefing, also inquired about a related, long-standing rumor that someone dropped emulsifiers, the substances used by oil drillers to make mud retain its slipperiness, on the Ho Chi Minh Trail.

Senator PELL. So it may have been attempted, but it was not under the Defense Department's jurisdiction[?]

General FURLONG. No. sir, . . . we did not want to do it.

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