REPORT FROM EXPORT TEAM ON WEATHER MODIFICATION RESEARCH FOR 2015/2016

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1. Objectives

This report provides an overview of the work of the team since the Expert Team meeting in Thailand in 2015. The mission of the Expert Team is; "To promote scientific practices in weather modification research. This is done through the WMO Expert Team on Weather Modification and through organizing the quadrennial scientific conferences on weather modification." (taken from the current website). Based on interactions with WMO and other member countries it may be important to review the mission (see Appendix B). The current list of members of the committee is attached as Appendix A.

Since 2010 the Team has been dependent on a WMO Trust Fund to support its activities. A request was sent to the Permanent Representatives of the WMO countries to request them to contribute to the fund. While the initial reaction to the request has been extremely limited, during the past year some countries have shown interest to make contributions but without contributing. Considering that weather modification activities in most countries are conducted outside the auspices of the Meteorological Services in separate government departments it is not surprising that very little response was received from the Permanent Representatives of members of WMO. Due to lack of contributions to the Trust Fund, the Expert Team is limited in its ability to organize meetings and update the WMO statement let alone organize workshops or conferences.

The WMO statements on Weather Modification are widely used around the world and WMO and the Expert Team receives regular enquiries from member countries. As water resources become more stressed and/or severe weather impacts become more frequent we expect these requests to increase.

2. Current status of countries active in Weather modification activities.

During the past year the countries active in weather modification research and operations have grown in number and individual program in several countries have also increased such as in the USA. While the total number of countries active in weather modification programs in 2013 was 47, this has now increased to 52 The Team members provided individual guidance to several countries for their research programs or to provide an assessment of operational programs.

While the list of countries active in operational weather modification programs have grown it is also important to note that more countries are focusing their efforts on research. A few interesting numbers are as follows:

1. China by far has the largest investment in both operational programs and weather modification research programs. Every province except one has an active weather modification program in China all with a research component.
2. After China the USA, Thailand, United Arab Emirates and India have the largest investment in operational and research weather modification programs. India is currently one of the largest investors in weather modification research with a major multi-year program conducted by the Indian Institute of Tropical Meteorology in Pune. Thailand and China is also embarking on a major research effort in this area.
3. Another major research program in weather modification to enhance snowpack and sponsored by the National Science Foundation and the State of Idaho in the USA will be conducted in early 2017 in Idaho in the U.S. (Including modeling and field work).
4. The United Arab Emirates have started a grant program in weather modification research in 2015 with approximately US$5 million per year available for research grants.
5. There are now several operational programs around the world that have conducted cloud seeding annually for more than 50 years without interruption. In the USA and Australia these programs are mostly supported by hydro-electric power companies. This provides for analyses of long-term trends.
6. Over the past 60 years Israel conducted three rain enhancement experiments (Israel I, II and II) and an extended operational program in the north of the country. These programs have generated extensive discussion in the scientific literature. Recently, a new research experiment (Israel IV) of randomized orographic seeding started in the north of the country.

3. Expert team activities

Since the Expert Team meeting in Thailand in March 2015 where the latest WMO statement on weather modification was drafted most of the work was related to further refine the document based on the reviews that were received. Based on these reviews it was also clear that there should be a review of the mission of the Expert Team (see Appendix A) and the WMO statement especially as it relates to operations and research in the field of weather modification and how this aligns with the needs of the National Hydro-Meteorological Services in member countries. Many member countries and especially meteorological services struggle with the weather modification activities in their country which are often conducted outside the auspices of the meteorological services. Meteorological services are often asked to evaluate these activities but also often lack the capability to evaluate these activities. The Expert Team often responds to such requests. During the last year members of the Expert Team responded to requests from Canada, Saudi Arabia and other countries.

4. Recent scientific achievements

In this section we highlight a few recent achievements in the field of weather modification research. During the past ten years with the advent of a new set of remote sensors and more

sophisticated airborne instrumentation in addition to more advanced numerical modeling capabilities new opportunities were provided to assess and quantify the results from cloud seeding experiments. Two major cloud seeding research projects have utilized some of these new capabilities recently.

The first was the Wyoming Weather Modification Pilot Project (WWMPP) sponsored by the State of Wyoming (Breed et al., 2013) with participation of the University Wyoming and the National Center for Atmospheric Research (NCAR). This program had a major observational component (Breed et al, 2013; Geerts et al., 2010), a numerical modeling component (Breed et al., 2013; Xue et al., 2013a and 2013b) and a randomized cloud seeding experiment that started in 2006 and was be completed in 2015. A paper on the final results is currently being prepared.

The second is the CAIPEEX program being conducted by the Indian Institute of Tropical Meteorology (IITM) in Pune. During the first phase of the program the emphasis was on understanding aerosol-cloud interactions and several papers have been published in the scientific literature. Based on these results CAIPEEX is currently preparing to move to the next phase that will also include a statistical experiment.

5. Conclusions and future work

Based on the previous paragraphs it is clear that weather modification activities are still abounding around the world and several major research programs in this field have been initiated in the past few years which emphasizes the legitimacy and need for the Expert Committee. Although the contributions to the WMO trust fund for this activity have been very limited this is to some extent to be expected for reasons mentioned earlier. In the meantime, the committee has been working with the CMA and their course on weather modification and has now been approached by the Department of Royal Rainmaking and Agricultural Aviation (DRRAA) to help with training and the design of a research program with international participation. The Team may attempt to organize the next meeting in conjunction with this effort. The immediate plans for the work of the committee are as follows:

a. Review the mission of the Team and purpose of the of the WMO statement on Weather Modification.
b. Continue to provide advice to member countries upon their request and participate in research programs organized by individual countries.
c. Continue to solicit funds for the trust fund and possibly from WMO solely for the meetings of the Expert Team.

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Appendix A

Expert Team on Weather Modification Research

Position	Family Name	Given Name	Affiliation	Country	Starting Date	email
Chair	BRUINTJES	Roelof	NCAR	USA	April 2011	roelof@ucar.edu
Member	ABSHAEV	Ali	High Mountain Geophysical Institute	Russian Federation	January 2016	abshaev.ali@mail.ru
Member	ALUSA	Alex	Government	Kenya	October 2011	alexalusa@gmail.com
Member	FLOSSMAN	Andrea	Observatoire de Physique du Globe de Clermont Ferrand	France	January 2016	a.flossmann@opgc.univ-bpclermont.fr
Member	KHANTIYANAN	Warawut	DRRAA	Thailand	October 2011	warawutkun@gmail.com
Member	KOREN	Ilan	Tel Aviv University	Israel	January 2016	Ilan.Koren@weizmann.ac.il
Member	MANTON	Michael	U of Monash	Australia	2007	michael.manton@sci.monash.edu.au
Member	MURAKAMI	Masataka	JMA	Japan	2007	mamuraka@mri-jma.go.jp
Member	THARA	Prabhakaran	Indian Inst of Tropical Meteorology	India	January 2016	thara@tropmet.res.in
Member	YAO	Zhanyu	CMA	China	January 2016	yaozy@cams.cma.gov.cn

Appendix B

WMO DOCUMENTS ON WEATHER MODIFICATION

EXECUTIVE SUMMARY OF THE WMO STATEMENT ON WEATHER MODIFICATION,
WMO STATEMENT ON WEATHER MODIFICATION
GUIDING PRINCIPLES FOR THE PLANNING OF WEATHER MODIFICATION ACTIVITIES

1. Background

The World Meteorological Organization has issued statements on the status of weather modification for more than 50 years. This was mostly in response to the growth of weather modification projects (both operational and research in the 1950's and 1960's) around the world. While there was a large amount of excitement after the discovery of silver iodide as a seeding material, it became clear in the 1970's and 1980's based on research that the scientific basis for such experiments still needed to be developed and by and large the results from those initial experiments were inconclusive. While the WMO statement on Weather Modification was initially intended to only provide a summary of the status of research in this field, due to the growth in operational programs in the world a section on the guiding principles for planning weather medication activities was added to provide countries that had no background knowledge in this field some guidance on how to proceed if they wanted to start such activities. Over the past fifty years the statement has largely maintained the same format and addressing both the research status and operational programs.

2. Current status of weather modification around the world

During the past year the countries active in weather modification activities have grown in number and individual program in several countries have also increased. The total number of countries active in weather modification programs in 2015 was 52. In addition, several new programs were started in individual countries including the USA. Most of these programs are operational programs with little or no evaluation and often initiated without a feasibility study as suggested by WMO. These data illustrate the point that although scientific cloud seeding experiments have shown mixed results many operational cloud seeding programs are still ongoing and increasing. These activities are often times initiated in times of drought when desperate water needs exist. On many occasions the programs are discontinued when the drought is over. Apart from the question of whether these programs have any success because it is nearly impossible to evaluate, the question may be asked if this is the right time to start or conduct a program. In addition, many operational programs, have now been conducted for more than 50 years. These programs usually require resources such as weather radars and other equipment that are often procured for the purpose of such a program. In some countries these programs are conducted under the auspices of the National Meteorological Service while in others, other institutions conduct these programs. In some cases, the resources from these programs are not shared with the National Meteorological Services. Many of these operational programs are still conducted in the same manner than when they started more than 30 or 40 years ago. The decision of continuing these operational programs are often political and not necessarily based on a sound scientific feasibility study. In addition, most operational programs lack a sound scientific evaluation component. The resources that are required for these activities are in some instances at the expense of the resources that could be used by the meteorological services, especially in developing countries.

While funding for research in the field of weather modification has grown substantially in the past ten years and new results are providing more confidence in certain areas there is still uncertainty in the quantitative effects of cloud seeding to enhance precipitation and even more so to suppress hail or mitigate severe weather. Major research programs in this field are now ongoing in the United Arab Emirates, India, Thailand, China and the USA.

3. Role of Expert Team and WMO Statement on Weather Modification

The current WMO mission statement for the Expert Team reads as follows: "To promote scientific practices in weather modification research. This is done through the WMO Expert Team on Weather Modification and through organizing the quadrennial scientific conferences on weather modification." (taken from the current website). It is clear that this mission statement solely addresses practices in weather modification research. With this in mind it is clear that the statement should be adapted to reflect this mission. It is true that the statement has mostly been used by countries to decide if they should proceed with a weather modification project. In most cases this turns out to be an operational project because especially in the developing world they neither have the infrastructure nor the human capacity to conduct a sound scientific feasibility study or the costs are too high and they proceed immediately to an operational project.

Based on these considerations it seems best to adapt the statement to and to re-organize the statement to align better with the mission of the Expert team. One question that remains then is on how to address operational programs and what WMO's role and guidance should be. This will need to be further discussed.

Another issue that the Expert Team has been struggling with is that it is dependent for its work on a Trust fund. Countries in general have not contributed to this fund over the past several years. This has limited the ability of the Team to conduct its work. However, some countries have contributed to the support of Expert Team meetings in their countries such as the recent meeting in Thailand in 2015. However, the mission also states that the Expert Team would organize quadrennial scientific conferences on weather modification. This has not been possible since 2012. In this regard it is important to note that recent conferences have mostly attracted attendees form the operational community or countries that have large operational programs. One option in the future, if these meetings are to continue, might be to change the format to a workshop where results can be shared from major research programs in the world to provide a status report to member countries. A summary of these workshops could then be published in the WMO journal. However, without funding and depending only on the Trust Fund may make it difficult to organize such events.

In summary:

1. The WMO statements on Weather Modification are widely used around the world and WMO and the Expert Team receives regular enquiries from member countries.
2. Due to lack of contributions to the Trust Fund, the Expert Team is limited in its ability to organize meetings and update the WMO statement let alone organize workshops or conferences.
3. Funding for research in this field is at a new peak since the 1980's with major investments in the USA, China, India UAE and other countries.
4. Operational projects with little or no scientific basis and without an evaluation component are abounding around the world.
5. There is a need to review the mission of the Expert Team and to re-organize the WMO

statement to align more clearly with its mission