REPORT FROM EXPORT TEAM ON WEATHER MODIFICATION RESEARCH FOR 2016/2017

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1. Objectives

This report provides an overview of the work of the team since the last SSC meeting in 2016 in Geneva.. 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). The current list of members of the committee is attached as Appendix A.

During 2016 the WMO statement on Weather Modification has been updated after an extensive review. 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 56. 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. In addition, China has continued to acquire advanced measurement and research capabilities including its fourth fully instrumented research aircraft. These new capabilities also provide the opportunity for the first time to conduct extensive airborne studies of air pollution and aerosol-cloud interactions. Air pollution and the associated effect on clouds and precipitation is one of the main challenges in China. These new facilities have already proven to improve their studies in these areas and will help assess the weather

modification activities in the future and provide for a better understanding of aerosol-cloud interactions and their effects on clouds and precipitation.

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). Initial results from this program have been submitted to Nature and AMS journals and provide new insights into winter orographic cloud seeding to enhance rainfall.
4. The United Arab Emirates continued a program in weather modification research with approximately US$5 million per year available for research grants. Six awards have been made over the past few years for a variety of proposals that range from aerosol-cloud interactions, electrical effects on precipitation development, numerical modeling, and in-situ observations with instrumented aircraft studying the interactions between water and ice processes.
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. During the past year, the Expert Team was tasked to conduct a review of the science of cloud seeding to enhance rainfall. This project was sponsored by the National Center for Meteorology in the United Arab Emirates. The Team had an initial meeting in June in Geneva to discuss the outline of the report and determine writing assignments. An initial draft of the report should be completed by the end of October. The final report with recommendations for future research should be available by the middle of next year.
7. During the past year members of the Expert Team also participated in the assessment of two Hail Mitigation Programs. The first assessment was sponsored by the World Food and Agricultural Organization of the United Nations and was conducted for the hail mitigation activities in Moldova. The other was for the Insurance Industry in Alberta, Canada for a hail mitigation project that is sponsored by the Insurance Industry.
8. Members of the Expert Team also provided advice to several countries that either had ongoing projects or wanted to start new projects.

3. Expert team activities

The new Statement on Weather Modification Research was finalized in 2016. Based on the process to develop and review the statement, it was also clear that there should be a review of the mission of the Expert Team and the WMO statement especially as it relates to operations and research, 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. In addition, many of the observing systems utilized by these weather modification programs are not shared with 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, Mexico, Peru 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. Three 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 has started the next phase that will also include a statistical experiment.

The Third is the recent SNOWIE research project sponsored by the National Science Foundation in the USA in the State of Idaho. This program focused on understanding the effects of cloud seeding to enhance snowpack. Several papers have been submitted and some new insights have been gained.

5. Conclusions and future work

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.

Based on these considerations the Expert Team recommends:

1. To not organize the quadrennial scientific conferences on weather modification anymore but rather focus on specific workshops in different regions of the world focusing on specific topics related to that region and to enhance collaboration between weather modification programs and National Hydro-Meteorological Services (NHMS's) (e.g. Hail workshop in Balkans, Rainfall enhancement in Africa, etc.)
2. Organize annual meetings with every second year the meeting as part of a workshop. The annual meetings would focus on updating the WMO statement and the interactions with the other Working Groups (some of these meetings could be organized in conjunction with meetings of other Working Groups), while during the workshops the focus would be on a specific topic related to a specific region. The Team has had several requests over the years to organize these meetings in specific regions to help countries understand the status of research in the field of weather modification and how this applies to their cloud seeding programs.
3. While we recommend not to continue with the quadrennial scientific conferences on weather modification the Team could interact with the American Meteorological Society which still organizes these conferences and potentially co-organize these conferences.

6. References

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Appendix A

Expert Team on Weather Modification Research

Position	Family Name	Given Name	Affiliation	Country	Starting Date	email
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Member	KOREN	Ilan	Tel Aviv University	Israel	January 2016	Ilan.Koren@weizmann.ac.il
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