PART 1: THE WORLD METEOROLOGICAL ORGANIZATION'S ROLE IN WEATHER MODIFICATION RESEARCH
PART 2: THE SOUTH AFRICAN EXPERIENCE IN RAINFALL ENHANCEMENT RESEARCH IN A GLOBAL CONTEXT

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1. World Meteorological Organisation

Within the United Nations, it is the responsibility of WMO to be the authoritative voice on the state and behaviour of the atmosphere and climate of the Earth. To this end, the Atmospheric Research and Environment Programme (AREP) co-ordinates and stimulates research on the composition of the atmosphere, the physics and chemistry of clouds, weather modification techniques, tropical meteorology processes and weather forecasting, focusing on extreme weather events and socio-economic impacts. In addition, AREP co-ordinates the global monitoring of greenhouse gases, the ozone layer, major atmospheric pollutants as well as the urban environment. The Commission for Atmospheric Sciences is responsible for the overall development of the Programme (WMO, 2006).

The main purpose of AREP is to stimulate collaboration and participation in basic research in the physics and chemistry of clouds and encourage application of this research with particular emphasis on the needs of weather prediction, weather modification and atmospheric pollution.

As the global population growths and standards of living increase, water resources are being placed under increasing pressure and weather-related risks continue to escalate. This is one of the reasons why there is an ongoing interest in weather modification. In recent years more than 70 countries had expressed an explicit interest in information and guidance on weather modification activities. Furthermore, there are several hundred weather modification activities in progress around the world.

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AREP has an important role in documenting these activities, promote a scientific basis to these activities, provide guidance and provide opportunities for international interaction and cooperation.

Information on current world-wide weather modification activities is maintained and periodically published. Knowledge concerning the role of clouds in pollution transport and the changing composition of the atmosphere on a global scale is being increased and recommendations for future research have been identified.

2. THE SOUTH AFRICAN EXPERIENCE

2.1 Rational of the studies

Chronic water shortages in the economic and industrial heartland of South Africa, arising from excessive demand on limited water resources, prompted research into weather modification as a potential means of augmenting rainfall, river flow and reservoir storage.

Summertime convective storms provide a significant fraction of the rainfall over South Africa's interior. These storms that generally have continental microphysical characteristics has been the focus of rainfall enhancement research in South Africa.

A systematic approach was followed in South African in the development and testing of the hygroscopic flare seeding technology. Field experiments took place during period 1990 to 2000 and these were followed by benefit-cost analysis as well as identification of potential environmental impacts related to future large-scale operational application of the technology. This work was conducted in two phases under the banner of the South African National Precipitation Research and Rainfall Enhancement Programme (NPRP-SAREP).

The long-term commitment and leadership of the funding organizations in South Africa played a major role in the progress made, providing a stable working environment in which innovation and a multidisciplinary team effort could thrive.

Figure 1. Aircraft dispensing hygroscopic seeding material, resulting in a visible trail of water droplets.

The overall approach of NPRP-SAREP encompassed the following:

- Adapting and refining intervention strategies and cloud seeding techniques in accordance with the continuously evolving understanding of cloud and precipitation processes emerging from ongoing process studies;
- Subjecting refined seeding techniques to rigorous field testing and randomised experimentation, with numerical modeling support where appropriate, in order to quantitatively assess cloud-based responses to seeding;
- Investigating potential enhancement of area rainfall and associated economic, water-resource, agricultural and environmental costs and benefits.

In achieving the goals the available infrastructure of radars, instrumented aircraft, data acquisition and handling facilities, laboratories for hardware and software development, calibration facilities, statistical techniques and computational facilities were optimally used and adapted where necessary for:

- Improving the understanding of natural cloud and precipitation processes;
- Taking the above into account, developing the concept of the hygroscopic flare seeding methodology;
- Conducting a randomised cloud seeding experiment supported by microphysical and cloud modeling studies;
- Testing the requirements and logistics of possible operational applications through semi-operational pilot applications of the technology with specific reference to cloud climatology studies, benefit cost analyses and potential environmental impacts.

2.2 Results

After 5 seasons of randomized experimentation, a database of 127 storms, 62 seeded and 65 controls, had been built up. The quartile analysis of these two groups is shown in Figure 2. In addition, results showed that the mean rain mass at the lowest scan for the seeded storms was significantly larger than for the controls, particularly from 40 minutes to 50 minutes after the seeding decision. The means of the total radar-estimated rain mass between 10 minutes and 60 minutes after the seeding decision were 1812 kilotons for the seeded storms and 1231 kilotons for the non-seeded storms. This gave an estimated seeding effect of 47%. Some inadvertent bias was, however, evident in the pre-seeding mean rain mass being lower in non-seeded than in seeded storms. Compensation for this bias resulted in an estimated seeding effect of 24%.

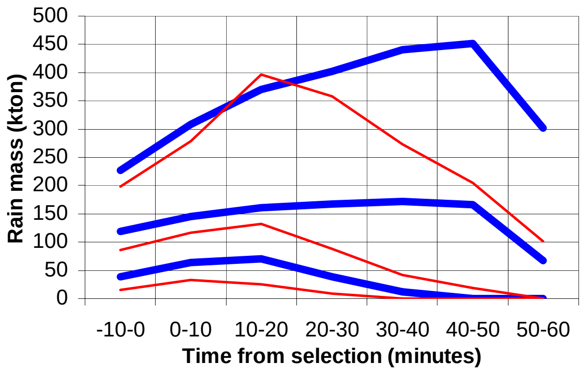

Figure 2. Quartile analysis of the NPRP randomized experiment – 62 seeded and 65 controls. *(Thick blue lines represent the seeded group, thin red lines the control group)*

Semi-operational cloud seeding in Limpopo (formerly Northern) Province had its origin in a request from the provincial government to the NPRP funding agencies and research team to undertake cloud seeding in an effort to alleviate a crippling drought in the province. In acceding to the request to seed as many storms as possible in an effort to meaningfully enhance rain over the target area, the decision was also taken to continue to treat individual convective storms as experimental units and to record detailed radar observations for each (Terblanche, Steffens, Fletcher, Mittermaier and Parsons, 2000). This approach and associated data collection was done with a view to facilitate development of scientific verification techniques, knowing that successful verification on the basis of rainfall or streamflow measurement would be unlikely in the short term, given the large natural spatial and temporal variability of these quantities.

The general approach to semi-operational seeding in Limpopo Province (NPRP-SAREP) was thus to define the target area and maintain a database of radar-observed storm track characteristics of all storms within the target area. Within logistical and funding constraints, as many as possible of these storms were seeded as early as possible in their lifetime. Approaches to analysis and interpretation of data, however, differed between the NPRP and SAREP phases.

The results of the quartile analysis on radar-derived rain mass of the 37 paired seeded and non-seeded cases are shown in Figure 3 (Terblanche, Mittermaier, Burger, de Waal and Ncipha, 2005). It is clear that the storms that were selected for SAREP were considerably larger than those in the NPRP.

For the 100-minute interval from time of origin, the ratio between accumulated arithmetic mean rain mass for the seeded and control storms was 2.08, indicating an average increase in rain mass of 108% or just more than a doubling.

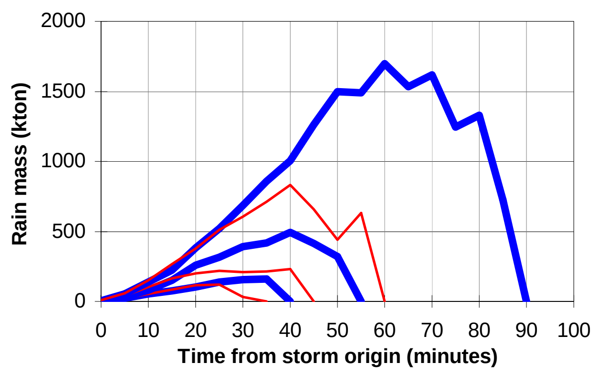

Figure 3. As in Figure 2 but quartile analysis of radar estimated rain mass of 37 paired storms observed under SAREP during 1997 – 2000.

Cloud climatology studies undertaken by 24-h radar observations in the Polokwane-Tzaneen target area during the 2000/2001 season revealed that approximately 290 potentially seedable clouds out of a total of more than 2000 may be expected in a season, and that at least 75 of these would have to be successfully seeded in order to achieve a 7-10% increase in rainfall over the target area.

2.3 Conclusion

The main outcome of the NPRP-SAREP was a new approach to rainfall enhancement that holds considerable promise as a viable technology for integrated water resource management schemes in areas with suitable rainfall formation processes. Mather et al. (1997), Terblanche et al. (2001) and Terblanche et al (2005) describe the development of the NPRP-SAREP and the results obtained during the program. It is believed that considerable insights can be gained by governments, funding agencies and scientists alike from the stepwise approach followed by the NPRP-SAREP. Without stable, long-term support, the relevant expertise, as well as a sound and systematic scientific approach, such programs will not succeed.

3. REFERENCES

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