

**WEATHER MODIFICATION RESEARCH**

**WMR 43**

**REGISTER OF NATIONAL WEATHER MODIFICATION  
PROJECTS  
2003 - 2004**



**WMO-TD No 1362**

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## I. INTRODUCTION

As part of the activities which WMO carries out in its Programme on the Physics and Chemistry of Clouds and Weather Modification Research, a Register of National Weather Modification Projects is kept. The Register has existed since 1975 when the Seventh World Meteorological Congress agreed that an inventory of activities within Member countries related to weather modification should be initiated and maintained. Periodic reviews have all recommended that the Register be continued. The Register is providing information also of interest to number of UN programmes outside WMO.

This present Register is based on information obtained from Member countries on experiments and operations sponsored by government agencies or private concerns that took place during 2003 and 2004.

To assist the reader in understanding the content of each of the 12 columns used in the tabular presentation found within, detailed explanations are provided in Section II.

The names of Member countries who provided the information reported in this Register are listed in Section III. Section V provides summaries of completed projects and Section VII indicates which countries reported that no weather modification activities had taken place in 2003 and 2004.

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## II. DETAILED EXPLANATION OF INFORMATION COLUMNS

### Column 1: WMO Register No.

This consists of country indicator letters (according to the ISO Standard 3166-1974) and a serial number for each project.

### Column 2: Objective of project, type of organization carrying it out

Dev.	=	Development	PE	=	Precipitation Enhancement
Ext.	=	Extend wet period	(E)	=	Emergency
Fog	=	Fog dissipation	(R)	=	Routine
Hail	=	Hail suppression	PR	=	Precipitation Redistribution
Inc.	=	Increase during wet period	Res.	=	Research
Op.	=	Operational			

### Column 3: Approximate size of project area

Given in square kilometres for target and control (if any) areas.

### Column 4: Name of project

Reference numbers are also quoted when supplied.

### Column 5: Location of project area

In some cases where co-ordinates of several points delineating the area were given, these have been replaced by a single point at approximately the centre of the area. Towns and islands may be denoted by name; A/P = Airport.

### Column 6: Year project commenced and continuity

Date	--	year project started
Every year	--	indicates project has operated every year
Interrupted	--	indicates project has not operated every year
No	--	indicates project will not be continued
Yes	--	indicates project will be continued
(?)	--	indicates project status is unknown

**Column 7: Nature of organization sponsoring project**

Indicated by abbreviations as follows:

Agr.	=	Agricultural	Muni.	=	Municipal
Def.	=	Defense	(P)	=	Private
Enr.	=	Energy	Rec.	=	Recreation
For.	=	Forestry	Res.	=	Research
(G)	=	Government	Trans.	=	Transportation
Hyd.	=	Hydrological	Wea. Serv.	=	Meteorological

**Column 8: Apparatus, seeding location**

Abbreviations are as follows:

Air	=	Airborne	G/B	=	Ground-Based
A/C	=	Aircraft	Temp.	=	Temperature

**Column 9: Agents, dispersal rates**

Self-explanatory.

**Column 10: Characteristics of clouds treated, seeding criteria**

LWC	=	Liquid Water content	Temp.	=	Temperature
Obs.	=	Observations			

**Column 11: Active period during reporting year**

Months of activity are inclusive.

Jan	=	January	July	=	July
Feb	=	February	Aug	=	August
Mar	=	March	Sept	=	September
Apr	=	April	Oct	=	October
May	=	May	Nov	=	November
June	=	June	Dec	=	December

**Column 12: Documentation**

"EIS" indicates that an environmental impact study has been made; "C/B" indicates that a costs and benefits analysis has been made.

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AUSTRALIA											
AUS-1	PE Inc. Op.	Target area 8233 km <sup>2</sup>	Tasmanian Area cloud seeding operation 2003 (TASCO 2003)	Tasmanian central highlands	1998 Sept- Every year Yes	Energy (G)	Aircraft acetone burner seeding in cloud at -10oC level or cloud tops warmer than -10oC.	AgI at 383 g/hr 14.16 kg /year	Layer clouds with bases colder than 10oC and tops colder than 0oC but warmer than -20oC. Supercooled water content 0.1 g/m <sup>2</sup> . Cloud depth >1/2 . Wind speed < 7.5 kt cloud top temp colder than -5oC.	April-Nov. 28 suitable seeded days	Evaluation based on results of 25000 ft joint HEC/CSIRO randomized. Trial of 79-83 inclusive. No documents EIS - Yes C/B Yes
AUSTRIA											
AUS-1	PE Inc. Op.	Target area 1800 km <sup>2</sup>	Hail test project - Styria	46o 30' - 47o15' N 15o30' - 16o00' E	1985 Every year Yes	Agr (P)	3 Aircrafts acetone burner and pyrotechnic flare cloud base	AgI solution 11 liter/hr Total consumption 803 l	Convective clouds with bases colder than 10oC and tops colder than -20oC. No microstructure measured, subjective criteria, regional weather forecast and C-Band raider	May - August 2003 24 days	Evaluation based on historical records Crp damage and hail pads. Evaluation available. Documents to WMO EIS -No C/B No
BULGARIA											
BG-1	Op. Res. Hail Supp.	16683 km <sup>2</sup>	Bulgarian Hail supresión project	NW Bulgaria 43o 20- 44o0 22o30E - 24040E South Bulgaria 42o-42o35'N 24'00 - 26030'E	1969 Interrrupted Yes	Agr (G)	Rocket-based pyrotechnic flares for in cloud seeding	AgI 82 kg/rocket	Convective clouds; bases warmer than +10oC and tops colder than -20oC: Seeding criteria based on radar echo, cloud heights and reflectivity.	May-Sept. 36 days	Evaluation based on comparison with historical records crop damage. Evaluation document done available to WMO. EIS-No C/B-Yes
CANADA											

CAN-1	Op. Hail	26,000 km <sup>2</sup>	Alberta hail suppression project	Province of Alberta (Lacombe to High River). Priority given to cities of Calgary and Red Deer.	1996 Every year Yes	Ins.(P)	3 aircrafts generator with acetone burner pyrotechnic flare. Seeding cloud based and cloud top between -5oC and -10oC on the upshear side of convective cells.	AgI. Flares: one 20g every 5 sec. Annual consumption 173.35 kg.	Convective clouds; bases colder than +10oC and tops colder than -20oC: Seeding criteria: radar defined cells with max. reflectivity 35 dbz, heights above -5 and are considered to be potential hail threat and urban or populated area	1 June – 15 Sept. 27 days.	Evaluation based on comparison with historical records. Document available. EIS-No C/B-Yes
CROATIA											
CR-1	Hail supp Op.	Project area 24100 km <sup>2</sup>	Hail suppression	North Croatia, between Sava and Drava rivers	1976 Every year Yes	Agr (G) Insurance (P) company	Ground rockets. Generators with acetone burners. Release is in ground -8oC to -12oC	AgI 10 kg /day 610 kgs	Convective, clouds warmer than +10oC and tops colder than -20oC. No microstructure measured Top > hight of -28oC Hight of 45dbz > hight 0oC + 1.4 km	May - Sept. 2003 153 days	No evaluation Comp historical records Hail pads Documents available EIS – No C/B-No
FRANCE											
FR-3	Hail supp Res. Op	Target area 60000 km <sup>2</sup> Control area 420000k m <sup>2</sup>	ANELFA Association Nationale d'Etude et de lutte contre les fléaux Atmosphériques	Bassin Aquitain, Bassin Rhodanien Vallée de la Loire	1952 Every year Yes	Agr Association sans but lucratif	Ground seeding 680 generators Acetone burner Ground seeding dispersal	AgI 8 g /hours/ generators 540 kg per year	Convective clouds. Temp warmer than +10oC and tops colder than -20oC Prévision des chutes de grêle au sol pouvant provoquer des dommages aux cultures.	15 April – 15 October 59 days	Hail pads Doc available In WMO EIS-Yes C/B-Yes
GERMANY											



GER-1	Hail Supp Res Op.	Target area 4400 km2	Halgelab wehr Hagel forschung Rosenheim	Mountainous to hilly terrain from 1900 MSL to 500 MSL on Northern Side of Alps	1975 Every year Yes	County	2 aircrafts with acetone burner seeding at cloud base	AgI 6l/hour 37 kg	Convective clouds cloud base warmer than +10oC tops colder than -20oC temp.advection, vertical windspeed humidity altitude of troposphere radar echos infrared satellite photos.	April - Sept 19 days	Doc of hail fall document planned available EIS-No C/B-No
GREECE											
GR-1	Op. Res. Hail Supp	5000 km2 Target area	Hellenic National Hail suppression project	NW Greece	1984 Interrupted Yes	Agr (G)	3 aircraft. Hail sound canons and sound shock waves.	AgI 4 gr/sec	Convective and orographic clouds with bases colder than 10oC and tops colder than -20oC. Seeding criteria cloud tops higher 5 km and radar reflectivity higher than 35 dbz.		Evaluation based on comparison with historical records, crop damage and hail pads. Doc available EIS-Yes C/B-Yes
HUNGARY											
HU-1	Op. Hail	Target 13,000 km2	NEFELA Hail Suppression Associaiton	Baranya Somogy Tolna counties	1991 Every year Yes	Agr (G) (P)	141 ground generators acetone burnners.	AgI 8 gr/l Total consumption 230 Kg	Convective clouds with bases warmer than +10oC, tops both warmer and colder than -20oC. No microstructure measured. Hail forecast	May-Sept. 40 days	No evaluation No doc. EIS-No C/B-No
MALAYSIA											

MAL-1	Op. PE (E)	Whole country No control area	Drought operation	Whole country	1997 Every year Yes	Wea. Serv. (G)	In cloud seeding with liquid spray from 2 A/C. Seeding in moderate size cumulus (tops 10-1200 feet)	NaCl, 200 kg per day Total annual consumption 6,000 kg	Convective clouds with bases warmer than +10oC, tops colder than 0oC but warmer -20oC 10,000 ft and in moderate size seeding level in cloud 5,000 ft	Periods from 27 Feb to 2 April 2003; 8 May to 6 June 2003; 16 Sept to 6 Nov 2003 58 days	No evaluation provision EIS-No C/B-No
MACEDONIA, REPUBLIC OF											
	Op Hail	8000 km2	Hail supression project	Whole country	1971 Every year Yes	Wea Ser (G)	Rockets In cloud seeding	Ag l 400 gr Total 58.4 kg	Convective clouds with with bases warmer than +10oC, tops colder than 0oC . Criteria: Hzmax > H0o Hzmax - 25 dbz > H -14 o H echo top > H -28 o	May - September 20 days	Comp with historical records Doc available EIS - No C/B - No
MOROCCO											
MOR-1	PE E Prec Inc. Res. Op.	Target 14,300 km2	ALGHAIT	Haut Atlas Between 31o-25o 32o50 N and 5o 25 and 7o 25W	1984 every year Yes	Wea Serv (G)	Ground seeding Cloud top material 15 generators 2 aircrafts	AgI 16g/l acetone. Total consumption 80 kg. Propane 1 btl of 35 kg/10 hrs total: 500 btls	Convective clouds and orographic cloud base To colder than +10oC. Colder than 0oC but wamer than -20oC.	1er Nov 2002 - 30 April 2003. 30 jours	Evaluation with historical records. Document available EIS-Yes C/B-Yes
RUSSIAN FEDERATION											
RF-1	PE (E) Op. Dev Res Water supply PR Fire sup	Target 90,000 km2	Regulation of precipitation Airplane laboratory	Republic Saha	1986 Every year Yes	Agr (G) Met Serv (G)	rockets, generator with pyrotechnic flare. Release of seeding is cloud base and in-cloud..	AgI 50 kg/year.	Convective clouds with base colder than +10oC, top temp colder than - 20oC Tobr < -10oC and Δ h> 2km	April-September 97 days	Comparison historical records. Crop damage Hail pads Doc available in WMO. EIS-Yes C/B-Yes
SERBIA AND MONTENEGRO											

SM-1	Hail Supp Op	Target Area 77 134 km2	Hail supp system in Serbia	The territory of Republic of Serbia	1967 Every year Yes	Agr (P) Wea. Serv	Rockets, In cloud seeding from -4oC to -12oC.	AgI 8.36 kg/units 4065.2 kg	Convective clouds colder than +10oC top temperatures colder than -20oC. Radar reflectivity log>4.5. Max radar reflectivity height above 0oC. Height of increase radar echo above -14oC and radar echo to height above -28oC.	15 April – 15 October 54 days	Comparison historical records. Crop damage Doc available in WMO. EIS-No C/B-Yes
UBEKISTAN											
UZ-1	Hail Supp Op	Target area 7380 km2	Hail prevention of agriculture of crops on the teriitory of Rep of Uzbekistan	Namangan, Andijan, Samakand, Kashkadarya, Surkhandarya districts	1969 Every year Yes	Agr Gov	Rockets Pyrotechnic flare In cloud seeding	Ag I 20gr/km3 56.7 kg	Convective clouds Temp at cloud base above +10oC. Top below -20oC Measured cloud microstructure.	1 April 31 Aug. 37 days	Comparison with historical records Doc yes EIS-No C/B-Yes
ZIMBABWE											
ZIM-1	PE Water supply aug Increase precip During wet period Op	Target area 390 757 km2	National cloud seeding operation (NASCO)	Harare	1968 Interrupted Yes	Wea Serv Gov	Aircraft Potassium/ Sodium, lithium carbonate/ magnesium oxide flares (burner)	NaCl 19% of flares KCl 65%; liCO3 1%; MgO 15%.	Convective clouds Temp at cloud base above +10oC. Temperature, updraft, type of clouds, height of clouds	Dec-March 70 days	Evaluation carried out before project implementation Doc yes Not available EIS-No C/B-No

## V - MEMBER COUNTRIES REPORTING ON COMPLETED PROJECTS 2003-2004

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LOCATION AND TERRAIN	PURPOSE AND DURATION	AGENT AND ALTITUDE OF SEEDING	REFERENCES TO PUBLISHED RESULTS	<b>COMMENTS AND CONTACT FOR INFORMATION</b>
<b>FRANCE</b>				
ANELFA Bassin Aquitain – Bassin Rhodanien – Vallée de la Loire 60000km <sup>2</sup>	Hail suppression Cumulus clouds 51 years 15 April – 15 October	Agl. Ground generators 680. Fixed area definition. 9 départements du sud ouest de la France 2 départements du centre de la France 4 départements du sud-est de la France Hilly terrain. Target area. 60000km <sup>2</sup> Mesure physique des chutes de grêle à l'aide d'un réseau de 1086 grêlimètres installés sur la zone cible. 1 jour unité expérimentale journées ensemencées en moyenne pour chaque département Seeding period : 8 h/day Etude des correlation entre : quantité de substance active dispersée dans les cellules à grêle et intensité des chutes de grêle (nb des grêlons de plus 7mm diamètre) 42% diminution du nombre de grêlons de diamètre supérieurs à 7mm 1% signification statistique	Dessens J., 1998 : A physical evaluation of hail suppression project with silver iodide ground burners in South western France. J. Applied meteo, 37, 1588-1599  Dessens J. and R. Fraile, 2000. The effect of silver iodide seeding on hail stone size distribution. J. Weather modification, 32, 26-30.  Dessens J. and C. Berthet and J.L. Sanchez. 2003, The French hail prevention programme ANELFA: Results updating and proposal for duplication: 8 <sup>th</sup> WMO scientific conference on Wea Mod (Casablanca, Morocco, 7-12 April 2003) WMO No. 39 pp 295-298.	L'Evaluation du programme ANELFA de prevention de la grêle par générateur au sol ne suit pas la procedure classique par triage au sort utilise en mofication du tps. Cette evaluation porte sur l'étude des distributions dimentionnelles des grêlons en fonction du taux d'ensemencement.  Dr Claude Berthet ANELFA 52 rue Alfred Duménil 31400 TOULOUSE

<b>MACEDONIA, THE FORMER YUGOSLAV REPUBLIC OF</b>				
Hail suppression project	Hail suppression Cumulus 31 year May to September AgI Target only. Fixed area: Hilly terrain. 8000 km <sup>2</sup> Radar reflectivity			PR
<b>MOROCCO</b>				
Haut Atlas. Programme Al-Ghait. Hilly terrain.	Precipitation Augmentation rainfall and snow. Orographics cumulus, stratiform and system frontal clouds 19 years 1 November – 30 April.	AgI. Iodure de sodium + acetone G/B and airborne seeding from 15 G/B generators. 3000 m altitude. 200 to 260 km longueur de la trajectoire Zone cible. Target zone. Radar. LWC > 0.1/m <sup>3</sup> sur 1 distance de 10 km. ACP, MRPP, regression linéaire. Augmentation des precipitations: 17% statistique.		Dr Grana Laidi Direction de la Météorologie Nationale BP 8106 Casa-Oasis CASABLANCA
<b>UZBEKISTAN</b>				

<p>Hail prevention of agriculture crops of the territory of Rep of Uzbekistan.</p>	<p>Hail suppression. Cumulus clouds: 34 years from 1 April to 31 August Agl seeding Target only. Fixed area. Mountainous terrain. 7380 km<sup>2</sup> target area. Precipitation gauges 58 Radar reflectivity, riding round territories caused by hail to fix the size of hailstones and defining of damage.</p>		<p>Imamdjanov Kh. A.. Parametrical model of hailstorms clouds /SANI. 1982. Issue 100 (181)pp. 14-20 Djuraev A.D. Imandjanov Kh. A., NazarovB. Sh. Use of radar data in calculation of economical effectiveness of hail prevention activity /SANI 1988 – Issue (126 207) pp.83-86. Imamdjanov Kh. A. Kamalov B.A. Weather modification in Uzbekistan SANIGMI 2001 p.120</p>	<p>The administration on Weather Modification of Glavgidromet of the Republic of Uzbekistan, Taskent.</p> <p>Experimental Unit:</p> <p>Duration of 2-30 minutes, maximum 1.5 hour; Conditions if the unit is seedable – RL should be</p> <p><math>10^{-8} \text{ cm}^{-1}</math>, vertical extent of the zone in the cloud with reflectivity 10-9 cm should be 2.5 km and more;</p> <p>Total number of seeded units is 128, including 68 on hail prevention and 60 on hail interruption. Standard seeding period was from 2 minutes to 1.5 hours; Transformation for each test – decrease of radar reflectivity and geometrical characteristics of cloudiness.</p>
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**VII. MEMBER COUNTRIES REPORTING NO WEATHER MODIFICATION PROJECTS IN 2003-2004**

Algeria  
Argentina  
Bahrain  
Barbados  
Belize  
Benin, République du  
Brunei Darussalam  
Colombia  
Costa Rica  
Cote d'Ivoire  
Cyprus  
Denmark  
Dominican Republic  
Ecuador  
Egypt  
Estonia  
Finland  
Gambia  
Georgia  
Guyana  
Hong Kong, China  
Iceland  
India  
Japan  
Kazakhstan, Republic of  
Kyrgyz Republic  
Liban  
Lithuania  
Maldives  
Malta  
Mauritius  
Mexico  
Myanmar  
The Netherlands  
New Zealand  
Niger  
Papua New Guinea  
Pakistan  
Paraguay  
Peru  
Poland  
Qatar  
Republica Dominica  
Salvador El  
Saudi Arabia  
Singapore  
Slovakia  
Slovenia  
South Africa  
St Lucia  
Sudan  
Sweden  
Switzerland



Trinidad and Tobago  
Turkey  
Uganda, Republic of  
United Kingdom  
Uruguay  
USA, NOAA