

Small Clouds

Table 2 shows the average results from the classic TITAN evaluations for the 127 small seeded clouds which obtained proper control clouds.

Table 2: Seeded Sample versus Control Sample (127 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	65.4 min	45.2 min	1.45	45 (34)
Area	70.9 km ²	42.1 km ²	1.68	68 (42)
Volume	217.2 km ³	122.2 km ³	1.78	78 (47)
Top Height	8.1 km	7.6 km	1.06	6 (2)
Max dBz	51.9	50.7	1.02	2 (0)
Top Height of max dBz	3.7 km	3.7 km	1.00	0 (0)
Volume Above 6 km	48.1 km ³	22.5 km ³	2.13	113 (52)
Prec.Flux	531.5 m ³ /s	278.6 m ³ /s	1.91	91 (52)
Prec.Mass	2313.4 kton	856.7 kton	2.70	170 (137)
CloudMass	166.0 kton	92.0 kton	1.80	80 (45)
η	13.9	9.3	1.50	50 (64)

Bold values in parentheses are modeled values, whereas η is defined as the quotient of Precipitation Mass divided by Cloud Mass, and is interpreted as efficiency. A total of **851 AgI and 41 hygroscopic flares** were used in this sub-sample with an excellent timing (**96 %**), for an effective AgI dose about **55 ice-nuclei per liter**, which might have reached slightly higher levels in some individual cells. An excellent increase of 137 % in precipitation mass together with an increase of 45 % in cloud mass illustrates that the seeded clouds grew at expenses of the environmental moisture (they are open systems) and used only a fraction of this moisture for their own maintenance. The increases in lifetime (34 %), area (42 %), volume (47 %), volume above 6 km (52 %), and precipitation flux (52 %) are notable. There were no increases in maximum reflectivity (0 %), and in top height (0 %). The seeded sub-sample seemed 64 % more efficient than the control sub-sample. Results are evaluated as **excellent** for this sub-sample.

An increase of 137 % in precipitation mass for a control value of 856.7 kton in 127 cases means:

$$\lambda_1 = 127 \times 1.37 \times 856.7 \text{ kton} \approx 149\,057 \text{ kton} \approx 120\,885 \text{ ac-f} \quad (\text{mean layer: } 0.65 \text{ in})$$

Large Clouds

The sub-sample of 33 large seeded clouds received a synergetic analysis. In average the seeding operations on these large clouds affected 75 % of their whole volume, with an excellent timing (98 % of the material went to the clouds in their first half-lifetime). A total of **538 AgI and 67 hygroscopic flares** were used in this sub-sample for an effective silver iodide average dose near **100 ice-nuclei per liter**.

Also in average, large clouds were 26 minutes old when the operations took place; the operation lasted about 40 minutes, and the large seeded clouds lived 237 minutes (3 hours and 57 minutes).

Table 3 shows the corresponding results:

Table 3: Large Seeded Sample versus Virtual Control Sample (33 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	237 min	195 min	1.22	22
Area	1231 km ²	981 km ²	1.25	25
Volume	4584 km ³	3488 km ³	1.31	31
Volume Above 6 km	1271 km ³	962 km ³	1.32	32
Prec.Flux	11 413 m ³ /s	7 184 m ³ /s	1.59	59
Prec.Mass	80 376 kton	49 905 kton	1.61	61

An increase of 61 % in precipitation mass for a control value of 49 905 kton in 33 cases may mean:

$$\lambda_2 = 33 \times 0.61 \times 49\,905 \text{ kton} \approx 1\,004\,588 \text{ kton} \approx 814\,721 \text{ ac-f} \quad (\text{mean layer: } 0.97 \text{ in})$$

Type B Clouds

The sub-sample of 77 type B seeded clouds also received a synergetic analysis. In average the seeding operations on these type B clouds affected 13 % of their whole volume with an excellent timing (84 % of the material went to the clouds in their first half-lifetime). A total of **1264 AgI and 140 hygroscopic flares** were used in this sub-sample for an effective silver iodide average dose about **100 ice-nuclei per liter** .

Also in average, type B clouds were 126 minutes old when the operations took place; the operation lasted about 31 minutes, and the type B seeded clouds lived 277 minutes (4 hours and 37 minutes)

Table 4 shows the results:

Table 4: Type B Seeded Sample versus Virtual Control Sample (77 couples, averages)

Variable	Seeded Sample	Control Sample	Simple Ratio	Increases (%)
Lifetime	277 min	269 min	1.03	3
Area	3188 km ²	3025 km ²	1.05	5
Volume	12542 km ³	11755 km ³	1.07	7
Volume Above 6 km	4134 km ³	3867 km ³	1.07	7
Prec.Flux	19 236 m ³ /s	17 771 m ³ /s	1.08	8
Prec.Mass	208 067 kton	193 885 kton	1.07	7

An increase of 7 % in precipitation mass for a control value of 193 885 kton in 77 cases may mean:

$$\lambda_3 = 77 \times 0.07 \times 193\,885 \text{ kton} \approx 1\,045\,040 \text{ kton} \approx 847\,528 \text{ ac-f} \quad (\text{mean layer: } 0.17 \text{ in})$$

The total increase: $\lambda = \lambda_1 + \lambda_2 + \lambda_3 = 1\,783\,134 \text{ ac-f} \approx 1.78 \text{ millions ac-f}$

Micro-regionalization

Increases in precipitation mass were analyzed county by county in an attempt to better describe the performance and corresponding results. **Table 5** below offers the details:

Table 5: Results per county

County	Initial seeding	Extended seeding	Acre-feet (increase)	Inches (increase)	Rain gage (season value)	% (increase)
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Panhandle Ground Water Conservation District Program

Armstrong	2	7	90 500	1.83	29.39 in	6.2
Carson	2	8	69 100	1.40	32.50 in	4.3
Donley	2	9	72 700	1.46	35.83 in	4.1
Gray	5	8	70 900	1.47	35.98 in	4.1
Potter	8	11	99 800	2.06	31.18 in	6.6
Roberts	3	5	41 200	0.83	27.62 in	3.0
Wheeler	2	6	63 500	1.32	36.94 in	3.6

Hutchinson		1	3 200			
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Collingsworth		3	19 800			
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Randall		3	21 200			
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Moore		2	13 500			
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Sub-total	24	63	565 400 (~10 % outside the target area)			
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Average (only for the bold values)				1.48 in	32.78 in	4.6 %
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West Texas Weather Modification Association Program

County	Initial Seeding	Extended	Acre-feet (increase)	Inches (increase)	Rain (season value)	% (increase)
Sterling	15	24	102 700	1.29	12.18 in	10.6 %
Reagan	16	20	97 600	1.55	15.01 in	10.3 %
Irion	07	17	116 600	2.07	20.54 in	10.1 %
Tom Green	07	17	109 600	2.69	18.48 in	14.6 %
Crocket	16	24	109 100	0.72	13.49 in	5.3 %
Schleicher	14	17	103 900	1.49	14.23 in	10.5 %
Sutton	13	19	108 700	1.42	18.31 in	7.8 %
Outside TA	0	6	~ 23 000	(~ 2 % of the total amount)		
Sub-total	88	144	771 200 ac-f			
Average (only for the bold values)				1.60	16.03 in	9.98 %

South Texas Weather Modification Association Program

County	Initial Seeding	Extended Seeding	Acre-feet (increase)	Inches (increase)	Rain Gage (season value)	% (increase)
Uvalde	6	9	42 800	0.50	21.52 in	2.3
Bandera	4	5	9 500	0.26	23.19 in	1.1
Medina	14	17	81 200	1.06	14.17 in	7.5
Bexar	4	15	13 900	0.21	17.23 in	1.2
Frío	9	15	15 600	0.27	23.51 in	1.1
Atascosa	15	22	74 300	1.12	31.42 in	3.6
McMullen	8	13	26 200	0.44	20.32 in	2.2
Wilson	12	16	24 300	0.57	27.98 in	2.0
Karnes	17	19	51 200	1.29	28.94 in	4.5
Live Oak	7	11	19 000	0.35	23.39 in*	1.2
Bee	21	25	34 800	0.74	26.45 in	2.8
Outside	8	12	6 300			
Sub-total	125	170	399 100			
Average				0.62	23.47 in	2.7

(**Initial seeding** means the counties where the operations began, whereas **extended seeding** means the counties favored by seeding after the initial operations took place).

(*) **Interpolated value of seasonal precipitation for Live Oak County**

(**Initial seeding** means the counties where the operations began, whereas **extended seeding** means the counties favored by seeding after the initial operations took place).

Table 6: Synoptic Summary

Program	Initial	Extended	Acre-feet	Increase	Season Rain	%
PGCD	24	63	565 400	1.48 in	32.78 in	4.6
WTWMA	88	144	771 200	1.60 in	16.03 in	9.98
STWMA	125	170	399 100	0.62 in	23.47 in	2.7
Totals	237	377	1 735 700 ac-f			
Averages				1.23 in	24.09 in	5.8 %

Outside the target areas (downwind effect): 57 900 ac-f (~ 3 % of the total increase)

Total amount of flares used: 2653 (AgI) plus 248 (Hygroscopic)

Final Comments

1) Results are evaluated as **excellent** (no miss-opportunities, 92 % average timing, 75 in/l average glaciogenic dose).

2) The micro-regionalization analysis showed increases per county; the average increase in precipitation, referred to an average seasonal value, is about **6.0 %**;

3) Radar estimations of precipitation should be considered as measurements of trend. Nevertheless, **seeding operations improved the dynamics of seeded clouds.**

4) During the 2015 cloud seeding campaign in Texas, hygroscopic seeding became an important component of the operations. When possible, **it is recommended to perform dual seeding operations in order to obtain the desire synergy** between the glaciogenic and hygroscopic effects (see details on the corresponding aforementioned regional evaluation reports).

NEWS HOME

Hydro Tasmania asked to explain cloud seeding in catchment day before flooding

THE WORLD TODAY – BY WILL OCKENDEN

UPDATED FRI JUN 10 17:57:06 EST 2016



PHOTO Hydro Tasmania's website indicates cloud seeding was carried out on June 5.

ABC NEWS: ALEX BLUCHER

Tasmania's government-owned energy company has been asked to explain why it conducted cloud seeding over the Derwent River catchment the day before flooding began this week.

Key points:

- Hydro Tasmania authorised cloud seeding, which increases rain, in a catchment hit hard by floods
 - Premier seeks explanation from Hydro
 - Hydro says inappropriate to comment, pending inquiries
 - Search continues for Ouse farmer
-

The catchment flooded on Monday near Ouse in southern Tasmania, where the search continues for a missing farmer.

In the state's north, one person was killed and another remains missing.

Cloud seeding is a technique used to increase rain to bolster dams and involves the addition of a substance to suitable clouds to encourage the growth of ice crystals or raindrops.

Premier Will Hodgman said he was told Hydro Tasmania authorised cloud seeding on Sunday morning in the Upper Derwent catchment, even though heavy falls were forecast.

Mr Hodgman told 936 ABC Hobart Hydro's decision was difficult to fathom at face value but Energy Minister Matthew Groom was seeking answers.

"That's why we've sought the explanation from Hydro Tasmania as to those matters, the Minister has sought that," he said.

"It's certainly my expectation that will be provided at the earliest opportunity to respond to those matters."

Hydro Tasmania has confirmed it flew a cloud seeding flight the day huge storms approached the country's east coast.

Documents show the flight took place on Sunday morning while there were flood warnings in place in the north.

The flight seeded clouds for more than an hour and a half just north of Great Lake, one of the largest water storage dams in the state.

The flight was targeting the Upper Derwent catchment, which mainly feeds water to several hydro electric dams which lie downstream.

Farmers demand answers

Farmers in the Ouse area, like Scott Ashton-Jones, want to know why the cloud seeding went ahead while flood warnings were in place for the northern half of Tasmania.



PHOTO Ouse in the Derwent River catchment was one of the hardest hit areas in this week's floods.
AUDIENCE SUBMITTED: DAVID BRADLEY

"The extent to which cloud seeding has exaggerated the flood is still to be determined of course, but the evidence from previous cloud seeding operations is that it works and therefore it will have exaggerated the flood to some extent," he said.

"The Hydro has always claimed positive results from cloud seeding."

George Mills said he could hear the flight on Sunday morning, and wondered what was going on.

"We want to understand whether the cloud seeding has helped to create this massive flood from the local rivers which we've never ever seen," he said.

"If the Hydro have had something to do with that with their cloud seeding, well we want to understand that because in the future we need to have closer information."

Hydro 'not in position' to comment

Hydro Tasmania will not answer questions about both Sunday's cloud seeding flight and its policies on using the technique when there are current flood warnings.

What is cloud seeding?

- Hydro Tasmania describes cloud seeding as a technique for increasing precipitation (eg. rain or snow) using naturally occurring clouds
 - "It involves the introduction of additional particles into suitable clouds to encourage the formation and growth of ice crystals or raindrops and thus increase the amount of precipitation that will fall from the cloud"
-

A spokeswoman said it would be inappropriate to comment.

"At this point Hydro Tasmania is not in a position to provide more information," she said.

"Experience suggests that in the aftermath of a severe natural disaster such as this some form of government inquiry follows.

"In light of the unfortunate death of one person, and with grave fears for two people still missing, there is likely to be at least a coronial inquest."

The community of Ouse has been left devastated by the floods, which arrived with little warning in the early hours of Monday morning.

Farmers in the district have reported the loss of hundreds of sheep and cattle, and significant infrastructure losses.

Bureau had flood warnings in place

The Bureau of Meteorology has confirmed flood warnings were in place for regions of Tasmania when the flight took place.

"The first media release alerting the Tasmanian community to likely impacts of the event was issued on Friday 3 June," a weather bureau spokesperson said.





PHOTO Dozens of sheep and cattle have been washed away throughout the state.
ABC NEWS: EDITH BEVIN

"Detailed updates have been provided directly to the local media throughout the event."

The spokesperson said the first flood watch for Tasmania was issued at midday on Friday, with warnings following on Saturday.

"The first flood warnings were issued on Saturday afternoon: six to 12 hours before significant rain began to fall across northern Tasmania," they said.

The first minor flood warning for the Ouse and Derwent rivers was issued at 10:36pm on Sunday, after the cloud seeding flight took place.

The next day, unprecedented rainfall resulted in major flood warnings for seven Tasmanian rivers, including the Derwent and Ouse.

EXTERNAL LINK

[Map of cloud seeding route](#)

POSTED FRI JUN 10 10:31:17 EST 2016

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