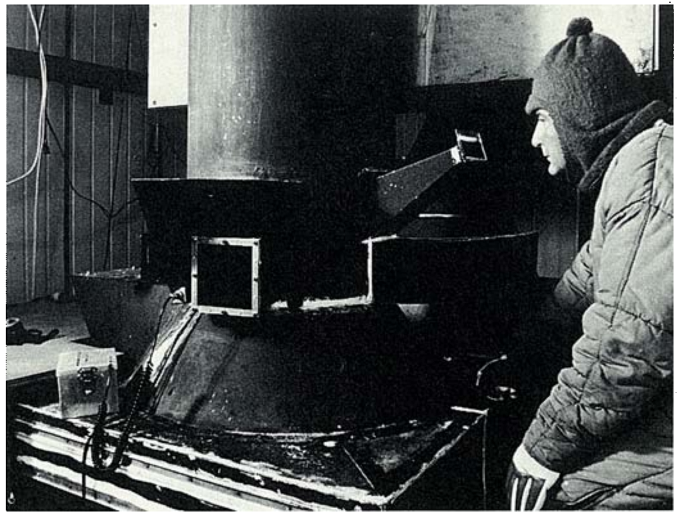
Spectrum



The scientist is in Sydney, not Antarctica. He is studying multiplication of ice crystals in cloud at about −5°C, in a cold room at the Division of Cloud Physics.

What are the best clouds to seed?

Cloud seeding got off to a spectacular start in Australia when the world's first artificially induced rain to reach the ground fell near Bathurst, N.S.W., in 1947. Since then, experiments have shown that, in some areas, well-planned seeding programs can produce useful increases in rainfall. The best results so far are from Tasmania, where CSIRO researchers have found that increases as great as 30% can be achieved in autumn.

Over most of the country, the prospects for inducing additional rain remain to be determined. The only way to assess them accurately is to conduct experiments, extending over many years, that compare rainfall in seeded target areas with that in similar, unseeded control areas. An experiment of this type is now under way in the Wimmera region of western Victoria, aimed at finding out the prospects for increasing rainfall there during the growing season for wheat (August to November).

Some idea of the likelihood of cloud seeding producing useful results in an area can be gained, however, before such an experiment is conducted. Information is generally available on how often rain-bearing clouds can be expected, where they come from, and what type they are. A considerable amount of information is now also available about the suitability of different types of cloud for seeding.

South of the tropics, most of Australia's rain starts life as ice crystals in clouds whose temperature at the top is well below 0°C. The crystals fall, and grow on their way down as they collide with water droplets. Eventually they melt, and keep falling as raindrops.

Cloud seeding works by increasing the production of ice crystals, and hence of raindrops. The silver iodide particles injected into a cloud serve as 'ice nuclei' that crystals can form around. In the absence of nuclei, water drops can be cooled to temperatures as low as −40°C without freezing. Minute particles, either naturally present or introduced by seeding, enable freezing to occur at temperatures much closer to 0°.

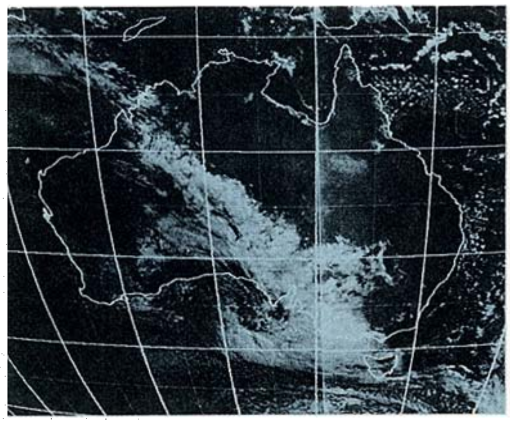
At the CSIRO Division of Cloud Physics in Sydney, scientists have studied the formation of ice crystals in artificial clouds produced by releasing steam into chambers maintained at sub-zero temperatures.

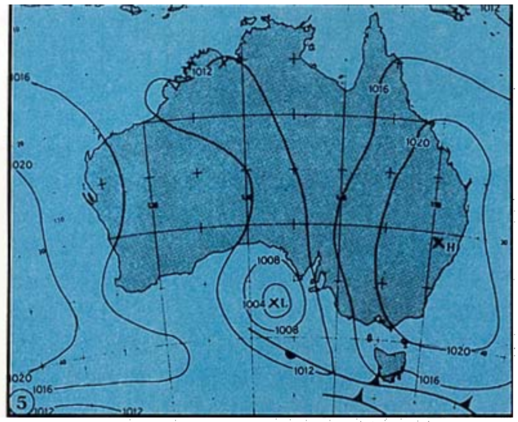
An early discovery was that crystals do not normally form in the concentrations needed to produce rain — one to ten per litre — unless the temperature is −20°C or lower. This suggested that the potential for increasing crystal formation, and hence rainfall, by seeding was very great, as the tops of many potentially rain-producing clouds are no colder than −10°.

After 1966, however, when the Division began using its instrumented DC3 aircraft to study the size and concentration of ice crystals in real clouds, the picture became much less clear. In small cumulus clouds, at temperatures as high as −5°, they found crystals present in concentrations more than 1000 times greater than the laboratory experiments had led them to expect. It became very clear that clouds of this type are well able to produce all the ice they need to initiate rain without any help from cloud seeders.

How do they do it? After much experimentation in the Division's cloud chambers, Dr Stan Mossop and Dr John Hallett discovered a mechanism that enables the few ice crystals formed at about −10° to rapidly reproduce themselves at temperatures between −3° and −8°.

It seems that, when a crystal is growing as a result of collisions with water droplets, a droplet sometimes lands on an ice protuberance and begins to freeze from the outside in, forming a shell. Shortly afterwards, apparently, the shell cracks and splinters of ice are ejected. These then grow to become crystals. Before they fall far enough to melt and become raindrops, they too may produce ice splinters and start the process going again.





The band of cloud in this satellite picture is associated with a 'closed low' off the South Australian coast, shown in the weather map. Such conditions may favour cloud seeding.

The scientists' experiments show that, while growing to become a raindrop, a crystal can produce about 300 new ice particles within 20 minutes. That rate of multiplication is sufficient to account for the large numbers of crystals found in cumulus clouds.

Recently, Dr Mossop conducted an experiment designed to check that it really is a shell-cracking process that produces the new ice particles. This involved injecting ammonia into a laboratory-made cloud. As ammonia weakens ice, he expected it to reduce the pressure build-up in the ice shells that is assumed to cause the splintering. The results supported the theory; production of new particles decreased substantially.

One conclusion from all these findings is that it is generally pointless to seed cumulus clouds that form in clean air from over the sea. Clouds of this type, moving in from the south-west behind cold fronts, produce showery rain over the coastal belt of southern Australia. Evidently the multiplication process makes them perfectly capable of producing rain without human intervention.

The fibrous appearance of the small cumulus cloud suggests that the multiplication process has produced a high concentration of ice crystals.

Much better candidates for seeding are clouds that form in air that has spent a long time over land. The numbers of ice crystals found in them correspond much more closely to the numbers that the early cloud-chamber experiments led the scientists to expect, indicating that little crystal multiplication takes place.

One reason for this appears to be that the greater number of particles in the air over land increases the concentration and reduces the size of water droplets in clouds. Apparently the droplets are generally too small to sustain the splintering process that multiplies ice crystals in maritime cumulus clouds.

If a cloud is composed of layers, seeding it can be effective even if it has travelled over the sea. Rain-makers have had considerable success with maritime layered (stratiform) clouds over Tasmania. Whatever ice multiplication occurs in them is apparently often insufficient to produce the maximum number of crystals able to grow to become raindrops.

When a low-pressure cell forms over north-western Australia and moves south-east, a large band of cloud sometimes extends right across the continent, from north to south. The southern section is associated with a rain depression, or 'closed low' (see the weather map and satellite photo). As it moves east, it can deposit rain over very large areas.

The type of cloud involved is both continental and layered, and appears to offer good prospects for seeding. Closed lows forming over the Southern Ocean also may provide good seeding targets. In western Victoria, where the chances of boosting spring rainfall through cloud seeding are now being assessed, closed lows occur an average of five times each spring and produce 30% of the season's rainfall. The scientists believe it may be possible to boost precipitation from the layered clouds associated with them by up to 50%.

The mechanism of ice splinter production during riming. S. C. Mossop. *Geophysical Research Letters*, 1980, 7 (in press).

'Research Activities.' CSIRO Division of Cloud Physics. (CSIRO: Sydney 1979.)