Ice in the Atmosphere Transcript

00:16
Narrator: Ice. By the millions of tons each day ice crystals form in the atmosphere to be deposited in ornamental etchings, to drift gently from a winter sky, to fall violently in the heat of summer, on windswept mountaintops, and in frigid laboratories scientists are probing the mysteries of atmospheric ice.

00:56
Most precipitation comes from tiny ice particles which then grow and transform in endless variety. Yet despite all we've learned from laboratory studies of ice crystallization we still have a limited knowledge of how ice crystals grow within a cloud to produce snow, rain or hail.

01:13
These complex mechanisms are the key to a better understanding and perhaps modification of many storms. Individual molecules of water, two atoms of hydrogen and one atom of oxygen are attracted to one another by strong electrical forces called hydrogen bonds. A few degrees above freezing the molecules arrange themselves along the lines of the hydrogen bonds to form symmetrical pyramids or tetrahedrons. When freezing takes place the tetrahedrons interlock in a hexagonal pattern or crystal lattice.

02:13
In a single ice crystal 10 million molecules may be lined up along one axis but water does not always freeze at zero degrees centigrade as we would expect. In fact it may resist freezing all the way down to minus 40.

02:35
To form ice then something is needed in addition to low temperatures. After these water drops have been super cooled to about minus 10 degrees they will still be in a liquid state but observe the super cool drops under polarizing filters.

02:56
At the touch of a foreign substance the drops freeze instantly. What was needed for crystallization to occur was a solid nucleus such as a speck of dust or another ice crystal.

03:10
These processes occur regularly in the atmosphere. For many clouds extend above the freezing line and become supercooled even in summer. Photographs taken inside a supercooled cloud show that it contains a mixture of minute water droplets and ice crystals. The microscopic particles which cause the droplets to freeze are called ice nuclei. They may come from natural sources such as dust storms and volcanoes or for man-made pollutants such as industrial smoke and automobile exhaust.

03:54

Once nucleation takes place an ice crystal can grow by another process called sublimation. Since water has a higher vapor pressure than ice, water tends to evaporate from the droplets and a deposit on the surface of the ice Thus the crystal grows at the expense of the surrounding droplets. When it becomes heavy enough it begins to fall. Snow crystals have intrigued men for centuries but only in recent decades have scientists begun to decipher their patterns of growth.

04:37
One method of study is to collect actual snowflakes and preserve them in a sub-freezing bath of kerosene for examination under the microscope. Within the basic hexagonal structure imposed by the crystal lattice there is an infinite variety of forms.

05:22
[Music]

05:49
Snow crystals can also be grown artificially using techniques developed in the 1930s by Ukichiro Nakaya. Nakaya's and later experiments have shown that the form a snow crystal takes depends upon air temperature and vapor saturation.

06:08
[Music]

06:17
Once on the ground snow takes on other significance. Its high reflectivity prevents the surrounding air from warming and thus influences atmospheric circulation patterns.

06:28
Where it persists in glacial sheets it acts as a geologic force and has long-range effects on global climate. And in many regions the runoff from mountain snows is an indispensable source of water.

06:48
One way to meet growing demands for water is to increase snowfall in mountainous areas through techniques of weather modification. On Elk Mountain 40 miles west of Laramie the University of Wyoming operates a water resources observatory. Here scientists are conducting experiments to determine the effects of artificial cloud seeding on snow storms. There's no need for increased snowfall on Elk Mountain itself.

07:16
The site was selected because its eleven thousand foot summit is frequently cloud covered during winter months enabling the scientists to study cloud processes directly.
07:55
Person speaking on a radio: “[Inaudible] Ready for a 12 o’clock takeoff. Otherwise it looks to us, uh what’s the cloud basis at this point? Other person speaking: Cloud basis is holding at 19 and

14 respectively. Winds in the valley apparently have gone a little bit 280-290 already and I guess as you know Casper and Lender [inaudible] so we might have a wind problem as far as targeting goes but we should be good for the rest of the day."

08:11
Narrator: Seeding agents and tracer chemicals released at a base station are carried into the cloud cap by the air flow across Elk Mountain. Aircraft from Wyoming and from the National Center for Atmospheric Research measure large air flow patterns over the Medicine Bow and park ranges as well as in the vicinity of Elk Mountain and provide supporting meteorological data for the seeding studies.

08:45
At the summit of Elk Mountain a line of filtering devices collect samples of tracer particles. Zinc sulfide is generally used as a tracer because it is fluorescent and can be sensitively measured by correlating the concentration of zinc sulfide on the ridge.

09:01
With the release rate at the base station the scientists can tell how much of the seeding agent has actually reached the cloud. The principle behind cloud seeding is relatively simple. Just as a foreign particle causes super cool drops to freeze in the laboratory, particles introduced into a supercooled cloud may also act as ice nuclei turning millions of cloud droplets into minute ice crystals which grow to become snowflakes.

09:34
But of all the particles in the atmosphere natural or artificial only certain ones can cause freezing and of those each has a different threshold temperature at which it begins to work. A special nucleus counter measures the concentration of particles in the air which can act as nuclei at various temperatures within a cloud. After water droplets have been cooled to a specific temperature outside air is drawn over them.

10:15
Attracted by a 5000 volt electric field, particles in the air rush to the lower plate and collide with the droplets. At the moment of freezing thermocouples beneath each droplet record the release of latent heat.

10:32
The lid is open for demonstration only.

10:38
Strangely the number of snowflakes falling during a heavy storm often far exceeds the number of available nuclei. What accounts for this surplus of crystals? No one knows as yet. In some storms cirrus clouds may play a role.

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Made up entirely of microscopic ice particles and forming at great altitudes cirrus clouds are difficult to study but cirrus type crystals can be grown in the laboratory for analysis.

11:20
At extremely low temperatures, the minus 40 or lower found at high altitudes, ice crystals will form spontaneously without nuclei. Drifting downward these crystals act as nuclei themselves seeding the storm cloud below, or so the theory goes.

11:37
But such inquiries into the nature of the cirrus crystal or the problem of crystal multiplication are still in an early stage. One of the more spectacular forms of atmospheric ice found on Elk Mountain is a feathery coating called rime. Driven by the wind, super cool cloud droplets freeze on every exposed object.

12:11
Rime is collected on the ridge top to see how much seeding agent it contains from moisture in the cloud.

12:25
[Music]

12:36
Muffled speaking about the sample collection and wind speed.

12:39
[Music]

12:49
Other scientists study rime because it represents an important growth process in clouds.

13:01
A snowflake falling through the supercooled liquid cloud will also accumulate rime.

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When it gathers so much rime that it is no longer recognizable it is called graupel.

13:29
Many summer downpours come from graupel which melts on its way to earth. Graupel also acts as an embryo or central core for the growth of hail stones.

13:41
Hail falls only from giant thunderstorms whose powerful updrafts can suspend the heavy balls of ice while they grow.

14:14
Hail storms are one of the most widely occurring of all natural disasters. While the toll of death and injury is small, dollar losses each year run into the hundreds of millions around the world.

14:35
The ability to control these storms is still in the future, but in northeastern Colorado a major effort is being conducted, the National Hail Research Experiment. Under the leadership of the National Center for Atmospheric Research, researchers from many organizations and disciplines have joined in the most comprehensive study of hail ever undertaken.

14:57
Speaker: Yes, a storm at 0-4-0-55

15:01
Narrator: Their purpose is two-fold: to investigate the mechanisms of convective storms which produce hail and to determine the feasibility of cloud seeding as a means of hail suppression.

15:13
Speaker: It feels that we need one more on this line. Uh seven whiskey papa Grover. A lot of ice in this one, Kevin.

15:25
Narrator: One key to the hail forming conditions inside a storm is the record contained in the stones themselves. So thin sections of hailstones examined under polarized light reveal layers of growth and crystal structure.

16:17
These give clues to the moisture, temperature and winds inside hail storms. But our ability to decipher this coded storm history is still elementary.

16:47
The destructive power of hail depends mainly upon size. It is not hard to imagine the deadliness of stones like this one which fell in Coffeyville, Kansas. On the other hand small stones may be more beneficial than rain since the melt water seeps into the soil rather than running off.

17:15
Seeding to suppress hail works the same way as seeding to increase snowfall, by nucleating supercooled cloud droplets to form ice crystals. With a greater number of ice crystals competing for the remaining water in the cloud, no ice particle can grow as large. In theory this will produce more but smaller hailstones that will melt before reaching the ground.

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But successful seeding is very complicated. To achieve results requires seeding in the right place at the right time with the right amount. Until now much of our knowledge has come through trial and error.

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If ultimately hail suppression proves to be feasible, the current experiments will provide a more thorough scientific base for any future attempts.

18:00
Whether we seek to control or merely to understand the power and grandeur of the storm, many of its secrets lie in the microcosm of its inner core, in the birth and growth of individual ice crystals.

18:19
[Music]