CLOUDWATCH:
NRC's National Aeronautical Establishment and Acid Rain

Airborne research, a specialty of the National Aeronautical Establishment's Flight Research Laboratory, is critical to the understanding of acid precipitation. The atmosphere, after all, is the medium for the long range transportation of air pollutants; clouds can "pump" pollutants into higher levels of the atmosphere, and it is in the clouds that the complex transformations occur which make precipitation acidic. Without a better understanding of cloud-pollutant interactions, long range transport models will remain incomplete. And accurate computer modelling is one of the major steps in developing effective acid rain control.

Atmospheric motion includes not only broad horizontal movements of air masses but complex vertical dynamics as well. For example, the air at 3000 m over a given area may come from an entirely different source than the air at 1500 m. Pollutants are transported horizontally, vertically and at the same time may be scavenged by cloud particles and precipitation.

The main objective of the Laboratory in its joint programs with the Atmospheric Environment Service is to look into cloud dynamics and the microphysical processes taking place in clouds to determine their role in the long range transportation of air pollutants, and also to investigate the chemical processes occurring within clouds. For this, the two agencies have developed an effective, sophisticated flying laboratory, the Twin Otter C-FPOK.

Since 1974, the Twin Otter has carried increasingly refined and expanded instrumentation systems to explore the dynamics, microphysics and chemistry of the atmosphere. It has, for example, real time computation and display of

atmospheric motion and four laser particle spectrometers capable of "imaging" thousands of snowflakes and millions of droplets; these data are providing more detailed knowledge of exactly what happens inside clouds. The Laboratory's most recent and "home-built" instrument is the Cyclone Snow Collector, which separates air from snow by centrifugal force, probably a world "first" for use in the air.

Several acid precipitation field studies have involved two other Canadian aircraft as well. The Laboratory's Beech 18 has carried instruments to measure gaseous and particulate pollutants as well as precipitation; and the Canada Centre for Remote Sensing's DC-3, a larger aircraft capable of carrying an expanded array of atmospheric research equipment, has also been pressed into acid rain service.

From 1981 to the present, the Laboratory has flown four acid rain experiments, including last year's CAPTEX-83 plume tracer study (see text, page 13). The latest and longest operation was carried out in January and February of this year called the Acid Snow Experiment. The six-week, intensive field operation in the northern Algonquin Park–Parry Sound area is a prime example of the sharing of resources and expertise which is required to meet the acid rain challenge. Besides the Atmospheric Environment Service and the Flight Research Laboratory the program also involved the U.S. Brookhaven National Laboratory, the Ontario Ministry of the Environment, the Canada Centre for Remote Sensing, York University and Ontario Hydro.

Airborne research was launched from the airport at the Canadian Forces Base in North Bay, Ontario. Several ground monitoring stations and a mobile monitoring van were integrated into the data gathering, providing a profile of what was happening in the region between the Earth's surface and an altitude to 6000 metres. The weather cooperated by providing not only several major pollution episodes, precipitation, and clear weather periods but also the bonus of a thaw which allowed the ground research team to sample spring-type meltwater run-off. The analyses of this new data should provide answers to some of the many questions surrounding acid precipitation.

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The Forest Outlook

Trees, like all forms of life, are subject to assaults from disease, insects, inclement weather, poor nutrition, and poisons such as toxic metals from the soil. The big challenge posed by acid rain research, therefore, is to discern its true impact in the light of these other natural stresses on the forest ecosystem.

"Tree growth is the most important parameter," explains Dr. Peter Rennie of the Canadian Forestry Service. "Except around point sources like Flin Flon, Manitoba, Trail, B.C., and Sudbury, Ontario, we don't feel that there is a problem with tree growth. This is also the case for Norway and Sweden, which experience about the same acid rain loadings as we do; they too have not been able to identify an acid rain effect by examinations of the yearly growth rings of trees. But there could be trouble sooner or later, because our forest soils are basically nutrient poor, very acid, and not highly buffered with reserves of nutrients. To get forest harvests from these soils at all is quite demanding and calls for an absence of external stresses like those associated with acid rain.

"Heavy metals like lead, cadmium, arsenic, and mercury are being deposited in increasing amounts by acid rain. These metals are tenaciously held by humic materials, and can affect fungi and bacteria, which dictate the rate of decomposition of humus and the release of nutrients. If that process is upset," warns Rennie, "we're in trouble."

He points out that Canada derives about 23 billion dollars a year in economic benefits from its forests, and that we invest considerable sums to meet the increasing demand for their products. We cannot afford to have forest yields decline. Potentially toxic elements such as aluminum and manganese, for example, may be taken up in increased quantities as soil acidity intensifies, and this could affect roots and seedlings. It is generally felt, however, that the pH of rain over Canada's forests is not so low as to cause obvious tissue damage, and visual symptoms are not being observed. But there is recent evidence that lowering the average pH of rain may affect the wax of conifers, damage their needles, and leach nutrients from their sap. Tree physiologists and pathologists are looking at trees subjected to acid rain and attempting to assess changes in disease resistance, alterations in insect depredation, and even effects on photosynthesis.