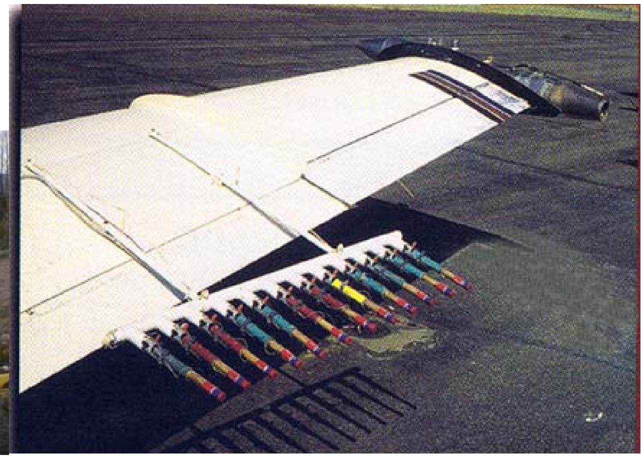
WET International
Hydro-meteorology for the 21st century



Ground-based vs. Aircraft Seeding

The question frequently arises: Which of these two means of delivery of seeding materials is most effective? The answer requires more research, and it also depends on the local situation. One may describe this complex situation in terms of cloud physics, terrain, and meteorology (including local airflow and its effect on the transport and diffusion (T&D) of seeding materials). Despite this complexity, one major variable is at the heart of the decision of "air vs ground" - the availability of **supercooled liquid water (SLW)**. This availability is treated in detail on our "How Seeding Works" page, which explains that SLW is the "fuel" needed to for seeding to work. In the current context, it is *imperative* that enough seeding material must reach regions with substantial SLW; otherwise seeding will not be effective. Therefore the two delivery methods must be judged by how well they meet this criterion. The ensuing discussion relates only to winter seeding of orographic (mountain) clouds to augment snowpack; warm-season convective cloud seeding over flat terrain is usually done with aircraft only.

SLW Facts

Research has shown that in mountainous regions that are targets for winter seeding to augment snowpack, ***SLW is largely confined to within 3000 feet (1 km) above ground level (AGL).*** Also, SLW is usually found above the windward slopes and crests of the mountains. This location is the result of the forced uplift of moist air by the mountain slopes.

Atmospheric conditions are usually stable in winter, resulting in relatively small vertical air motion from the forced uplift over mountains. More unstable conditions sometimes arise, especially over ranges near oceans, such as in California. During such conditions, vertical motion is greater than normal and convective clouds will develop. If they grow large and strong enough, these clouds form thunderstorms (usually in warmer months). In winter, however, convection is usually less vigorous and is imbedded in the typical stratiform (layered) cloud mass caused by lift over the mountains. These vertical motions can transport seeding materials higher than the usual 3000 foot AGL limit.

Even during stable conditions, atmospheric phenomena known as *gravity waves* can occur. These waves produce substantial vertical motion that can in turn generate large amounts of SLW at unusually high altitudes (greater than 3000 feet AGL). Mountain ranges themselves can induce atmospheric gravity waves, directly over the mountain crest or just downwind. Unfortunately, gravity waves are highly transient in time and space, so their existence is difficult to predict.

Implications of SLW Facts and Other Factors for

Choice of Seeding Method

Given the character of SLW as described above, how best to achieve T&D that will routinely reach the SLW regions with seeding material? This is no simple task, regardless of delivery mechanism. Several review articles in the scientific literature state that ***achieving adequate T&D is probably the most difficult problem facing winter cloud seeding***. This T&D is influenced by winds, turbulence, and cloud microphysics, but the delivery mode also determines where seeding materials will be transported and in what concentrations. The differences between these delivery modes are explored in Page 2.

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