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Flow Visualization
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Liquid Nitrogen Getting Wet

The film captured turbulent airflow due to natural variations in pressure from wind. It shows an approximate characteristic fluctuation of momentum in these conditions. This visualization is helpful in understanding gas mixing as well as systems of more industrial importance. For example, the momentum flux determines the forces on particulate matter flowing within the medium. NASA uses this general approach to generate force-based molecular-dynamics simulations of moon dust flowing from a rocket landing/take-off [Stubbs 2007].

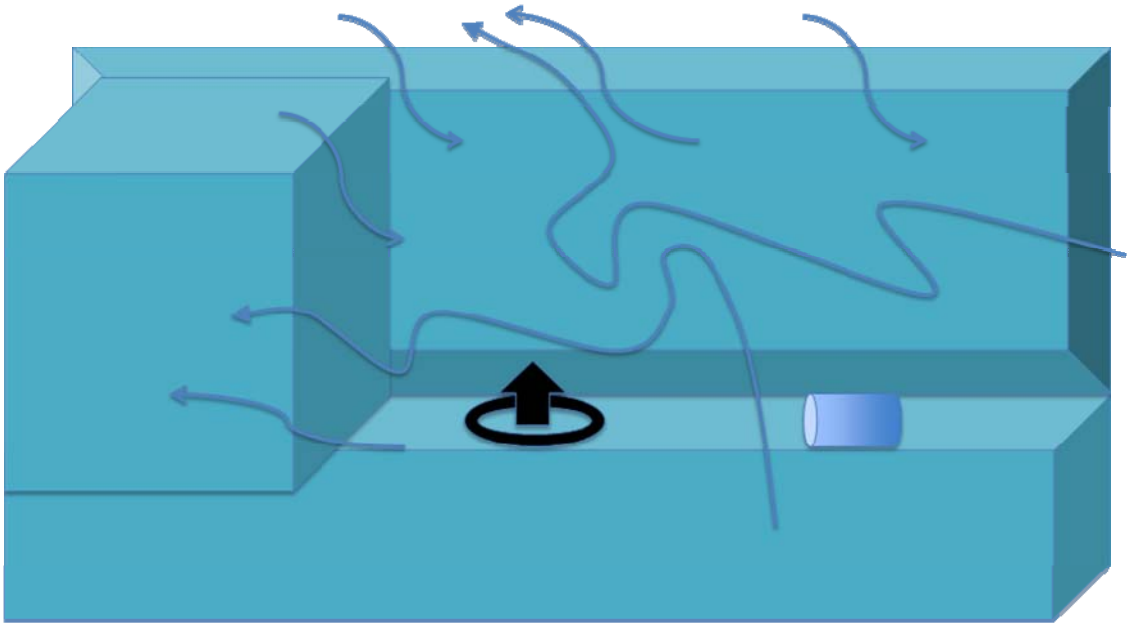

Figure 1. Turbulent airflow against a boundary. Potential streamlines for the airflow are shown. Boiling liquid nitrogen is shown in black. The camera is shown as a cylinder.

A camera resting on the ground filmed liquid nitrogen boiling from a dish as shown in figure 1. This system has convective flow, caused by variations in pressure and diffusive flow, caused by random concentration gradients as well as the induced nitrogen concentration gradient. The randomness of these driving forces causes the chaotic airflow.

The boundary can be assumed to provide enough friction to mitigate airflow, however, the nearly-invicid nature of air causes an immediate departure to bulk velocity open leaving the wall surface.

The small kinematic viscosity of air causes turbulent Reynold's numbers at nearly any velocity. Air is very close to an ideal gas (one with only inertial and no viscous forces), which is not capable of laminar flow.

The liquid nitrogen allows us to visualize the airflow by condensing water vapor into droplets that reflect light. The reduced temperature is caused by the latent heat of vaporization that is being consumed by boiling nitrogen molecules. The liquid nitrogen was obtained from the Anseth Lab.

A digital Canon DC410 video camera recorded this flow in partially sunny conditions without additional lighting. The camera was 2 feet away from the dish of nitrogen. The field of view was about 6 inches x 6 inches. The camera has a focal length of 2.6 mm - 96.2 mm and a F/2.0-5.2 aperture. I modified the contrast, field of view, and color using iMovie.

This image could be improved by varying the angle and lighting to better visualize the topology of the aerosol. Improved contrast could eliminate peripheral distractions caused by the wall.

References:

Stubbs TJ, Vondrak RR, William M. Farrell. IMPACT OF DUST ON LUNAR EXPLORATION. Solar System Exploration Division, NASA. 'Dust in Planetary Systems', Kauai, Hawaii, USA. September 2005