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Wind Tunnel Reveals Mysteries of Drifting Snow

Swiss researchers are uncovering the physics at play in drifting snow -- critical for precisely assessing the mass balances of snow-covered regions of the world

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WASHINGTON, D.C., November 22, 2015 -- Drifting snow is a complicated and poorly understood process that is important to fathom because it accounts for a major fraction of wind-blown snow redistribution within polar and mountainous regions of the world.

It's critical to gain a better grasp of the physics at play behind this process because mass snow redistribution can increase the risks of avalanches, cause unusual snow accumulations in urban areas, as well as significantly reduce visibility, thus affecting travel.

To this end, a group of Swiss researchers at the WSL-Institute for Snow and Avalanche Research (SLF), led by Prof. Michael Lehning, is exploring mass and momentum fluxes during drifting snow events, pursuing an improved understanding of the link between snow cover erosion and deposition. During the American Physical Society's 68th Annual Meeting of the Division of Fluid Dynamics, Nov. 22-24, 2015 in Boston, Philip Crivelli, a Ph.D. student working on the project, will share their findings.

"Drifting snow is a complex phenomenon that includes several different processes occurring on different timescales," said Enrico Paterna, a postdoc researcher at SLF. "Observing the process in a controlled cold wind tunnel provides a greatly improved perspective on these mechanisms and enables better characterization of them."

To do this, the group operates a wind tunnel that enables experiments under subfreezing temperatures because it's in an unheated facility located in the Swiss Alps at an altitude of 1,670 meters (5,479 feet). "We try to observe the phenomena under controlled conditions as closely as possible and with the highest accuracy," he added.

Outside the lab, snow cover is allowed to naturally accumulate on metal trays. "We then move these trays into the wind tunnel, which we run at a desired speed, and measure the dynamics of drifting snow," said Paterna.

The purpose of these experiments is to measure the mass flux of the drifting snow and characterize the turbulent boundary layer, which provides data about the spatial and temporal statistics of the "saltation" -- i.e., how the snow is carried by the wind.

The group uses a variety of measurement techniques such as sonic anemometers, hot wires, snow particle counters and shadowgraphy, which involves illuminating the flow with snow particles from one side of the tunnel -- the walls are made of glass -- and obtaining images with a high-speed camera from the other side.

"Particles appear dark in the images, and by computing the dimension and displacement of these particles, data about the mass flux can be obtained," noted Paterna.

The group also measures the turbulent air flow to understand how it interacts with the drifting snow. They then monitor the spatial and temporal variations of snow depth during saltation via infrared sensors. "We continuously observe these three quantities: snow saltation, snow cover, and the turbulent flow," he said.

What They Are Discovering

"Drifting snow is more intermittent than drifting sand -- a better known, simpler process," said Paterna. "This clearly demands a deeper understanding of the mechanisms involved."

So the researchers are exploring how intermittency is related to changing snow cover properties and turbulent flow by running controlled experiments to measure both.

In terms of applications, accurately representing drifting snow in meteorological models is a key aspect of precisely assessing the mass balances of snow-covered regions -- it's critical for predicting snow-depth variations, avalanche danger and even forecasting drifting snow.

A solid understanding of the physics of drifting snow is, of course, extremely helpful.

"There is a general understanding of the effects of drifting snow on the mean quantities – i.e., results averaged in time," explained Paterna. "In some cases, this is even derived from drifting sand experiments. But there's a lack of knowledge about the driving mechanisms behind the process and how the turbulent flow, drifting snow, and snow cover all interact."

Thanks to the group's advances in understanding these interactions, their work is now being used to help validate numerical models of the Laboratory of Cryospheric Sciences research group at Ecole Polytechnique Fédérale de Lausanne, led by Prof. Michael Lehning.

"Overall, our work is helping to explain the mass balance of the big glaciers and ice sheets from the mountains to the poles worldwide," Paterna said. "Drifting and blowing snow is one of the biggest unknowns in assessing the current mass of snow and ice in Antarctica. Only by gaining a better understanding of the process will we be able to make precise predictions about the changes regarding this delicate mass balance problem."

Presentation #A21.9, "Experimental investigation of drifting snow in a wind tunnel," is authored by Philip Crivelli, Enrico Paterna, Stefan Horender and Michael Lehning. It will be at 9:44 a.m. on Sunday, Nov. 22, 2015 in Room: 209 of the Hynes Convention Center in Boston. ABSTRACT: http://meetings.aps.org/Meeting/DFD15/Session/A21.9

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MEETING INFORMATION

The 68th Annual Division of Fluid Dynamics Meeting will be held at Hynes Convention Center in Boston from Nov. 22-24, 2015. More meeting information: https://apsdfd2015.mit.edu/

REGISTERING AS PRESS

Any journalist, full-time or freelance, may attend the conference free of charge. Please email: <jbardi@aip.org> and <dfdmedia@aps.org> and include "DFD Press Registration" in the subject line.

ON-SITE AND ONLINE PRESS ROOMS

Workspace will be provided on-site during the meeting. The week before the meeting, news, videos and graphics will be made available on the Virtual Press Room: http://www.aps.org/units/dfd/pressroom

LIVE MEDIA EVENT

A press briefing featuring a selection of newsworthy research talks will be streamed live from the conference at 1:00 p.m. ET on Monday, Nov. 23. For more information, email jbardi@aip.org.

ABOUT THE APS DIVISION OF FLUID DYNAMICS

The Division of Fluid Dynamics (DFD) of the American Physical Society (APS) exists for the advancement and diffusion of knowledge of the physics of fluids with special emphasis on the dynamical theories of the liquid, plastic and gaseous states of matter under all conditions of temperature and pressure. DFD Website:
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Image captions:

1. View of the cold wind tunnel laboratory in Davos, Switzerland, used by the group. CREDIT: WSL/SLF
2. These metal trays are used by the researchers to collect snow after it accumulates during snowfalls. CREDIT: Enrico Paterna/WSL/SLF
3. Image acquired via digital shadowgraphy applied to drifting snow. The dark objects shown in the image are the shadows of the saltating snow particles; blurred objects are the particles outside of the depth of field; and the lower dark region is snow cover. CREDIT: Enrico Paterna/WSL/SLF
4. Drifting snow near the SLF Weissfluhjoch measurement site (2,540 m), near Davos, Switzerland. CREDIT: Groot Zwaaftink/WSL/SLF

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Video: Digital shadowgraphy applied to drifting snow. The dark objects shown in the video are the shadows of the saltating snow particles; blurred objects are the particles outside of the depth of field; and the lower dark region is snow cover. CREDIT: Enrico Paterna/WSL/SLF